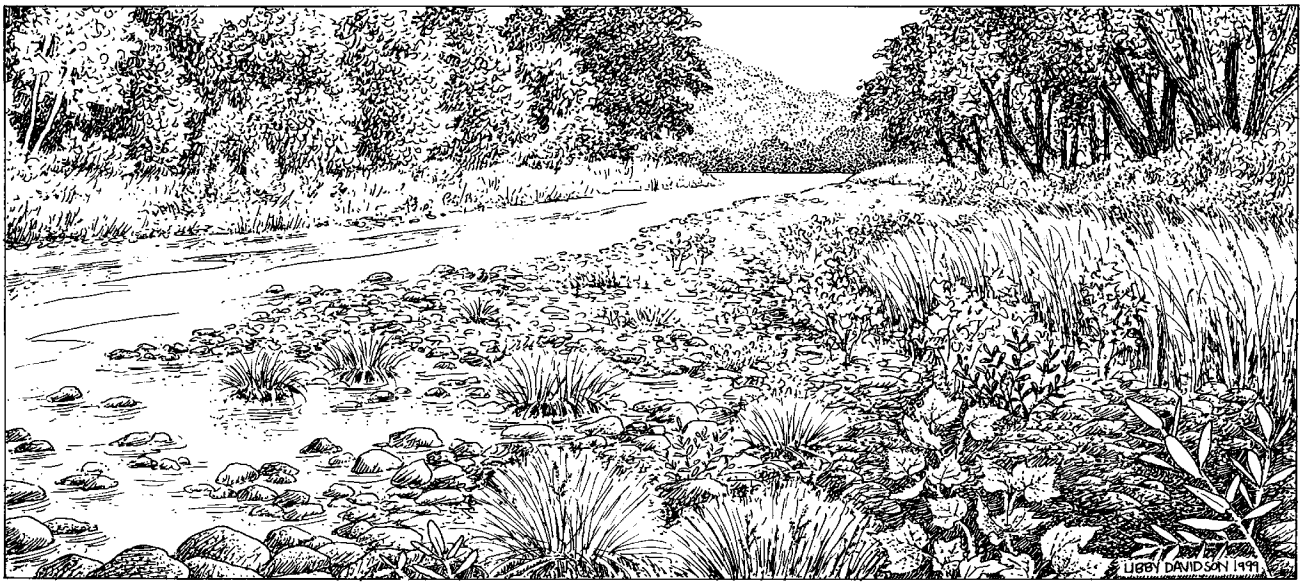
Basin 8 - Winooski River Watershed

Water Quality and Aquatic Habitat

Assessment Report

April 28, 2008



Vermont Agency of Natural Resources
Department of Environmental Conservation
Water Quality Division

Table of Contents

Organization of the Winooski River Assessment Report

The following report on the Winooski River watershed is a compilation of information and data gleaned from numerous sources. The information comes from state agencies especially the Vermont Agency of Natural Resources (ANR) Department of Environmental Conservation Water Quality Division but also from the ANR Department of Fish and Wildlife and ANR Department of Environmental Conservation's Facilities Engineering Division, Waste Management Division, and Wastewater Management Division. There is also information from watershed organizations, lay monitoring groups, and environmental consultants. Statewide studies on special water features such as waterfalls, cascades, and gorges as well as special natural communities were reviewed for information pertaining to the Winooski River watershed.

As comprehensive as this reports tries to be, needless to say, there is inevitably data and information that were not found and incorporated. The ANR DEC Water Quality Division welcomes any additional information and any suggestions or corrections to this report.

General Description

The Winooski River has its source in the northeast corner of Washington County in the town of Cabot then courses for approximately 90 miles northwesterly and flows into Lake Champlain in the town of Colchester just north of Burlington. It has a drainage area of approximately 1,080 square miles or about 11.9 percent of Vermont. The basin occupies all of Washington County, a little less than half of Chittenden County and small parts of Lamoille and Orange Counties. For a river length of 33 miles from the mouth to Jonesville, the valley is not more than 12 miles wide, but just to the east at Bolton where the river cuts through the Green Mountains, the valley spreads out to a width of over 30 miles.

The Winooski River has seven important tributaries, three of which enter from the north: the Little River joining below the village of Waterbury; the North Branch joining at the city of Montpelier; and Kingsbury Branch joining in East Montpelier. The four branches flowing from the south are the Huntington River coming in at the village of Jonesville, the Mad River joining in Middlesex; the Dog River entering just west of the city of Montpelier, and the Stevens Branch just north of Montpelier.

The land use and land cover of the Winooski watershed is very diverse from cities such as Burlington, Winooski, Barre, and Montpelier to the farmland of Cabot and resort and ski areas of Stowe and the Mad River valley. Table 1 below gives the relative percentages of land area in different uses or with different land cover types. The information is based on relatively old satellite photographs now but can be compared to other basin or watersheds because the same photographs were used to determine their land use/land cover.

Table 1. Land Use and Land Cover for the Winooski River Watershed[1]

Land Use	Acres	% of Total
Forested	492,480.9	72.4
Agriculture	78,841.9	11.6
Surface Water	33,544.8	4.9
Transportation	32,004.1	4.7
Developed Land[2]	30,021.6	4.4
Wetlands	12,451.7	1.8
Old Field & Barren	1,036.6	0.2
Total:	680,381.6	100.0

1 Vermont Land Cover Classification Project, 1997 (based on satellite photographs from 1991 - 1993).
2 Developed land = residential, commercial, industrial but not transportation, which is listed separately

Housing development and population growth rates in most of the towns of the Winooski River watershed were high from 1990 to 2000. Williston, as would be expected, led the way with a huge 62% increase in housing units and a 57% increase in population from 1990 to 2000. Over 1100 new housing units were added to the landscape, mostly former farmland, in this watershed town alone. Duxbury, Cabot, and Jericho followed Williston in

terms of percent increase in housing units (29%, 28%, 27% respectively) although the actual numbers of houses added were hundreds less than those built in Williston. Many of the other towns in the watershed had housing growth rates from 11% to 20%. Unfortunately for water quality and other natural resource protection as well as for the accomplishment of stated goals in many town plans, the lowest growth of housing and population was in the cities of Barre, Montpelier, Burlington, and Winooski. Housing growth from 1990 to 2000 ranged from 3% to 6% in these four cities while population growth was -3% to 2%. Three of the four cities had negative population growth while surrounding towns increased substantially. See Appendix B for more of the population and housing numbers and rates over the past few decades.

In the Vermont DEC River Assessment Database, the waters of the Winooski River watershed are divided into 20 river or stream waterbodies. Lakes and ponds are identified also within those 20 waterbodies. For purposes of this report, however, the waterbodies have been combined and the watershed is portrayed in nine sections. See Table 2 below for the waterbody identification number, waterbody name, and then the portion of the watershed in which that waterbody is discussed.

Table 2. Waterbodies Assigned to Winooski River Subwatershed Areas

WBID	Waterbody Name	Portion of the Watershed
08-01	Lower Winooski River mainstem	Lower Winooski River watershed
08-02	Tributaries to Lower Winooski	Lower Winooski River watershed
08-03	Lower Mid-Winooski River mainstem	Lower Winooski River watershed
08-04	Tributaries to Lower Mid-Winooski	Lower Winooski River watershed
08-05	Upper Mid-Winooski River mainstem	Middle Winooski River watershed
08-06	Tributaries to Upper Mid-Winooski	Middle Winooski River watershed
08-07	Upper Winooski River mainstem	Upper Winooski River watershed
08-08	Tributaries to Upper Winooski	Upper Winooski River watershed
08-09	Winooski River headwaters	Upper Winooski River watershed
08-10	Huntington River	Huntington River watershed
08-11	Lower Little River	Little River watershed
08-12	Upper Little River	Little River watershed
08-13	North Branch Winooski River	North Branch watershed
08-14	Kingsbury Branch Winooski River	Upper Winooski River watershed
08-15	Jail Branch Winooski River	Stevens Branch watershed
08-16	Stevens Branch Winooski River	Stevens Branch watershed
08-17	Dog River	Dog River watershed
08-18	Mad River mainstem	Mad River watershed
08-19	Lower Mad River tributaries	Mad River watershed
08-20	Upper Mad River tributaries	Mad River watershed

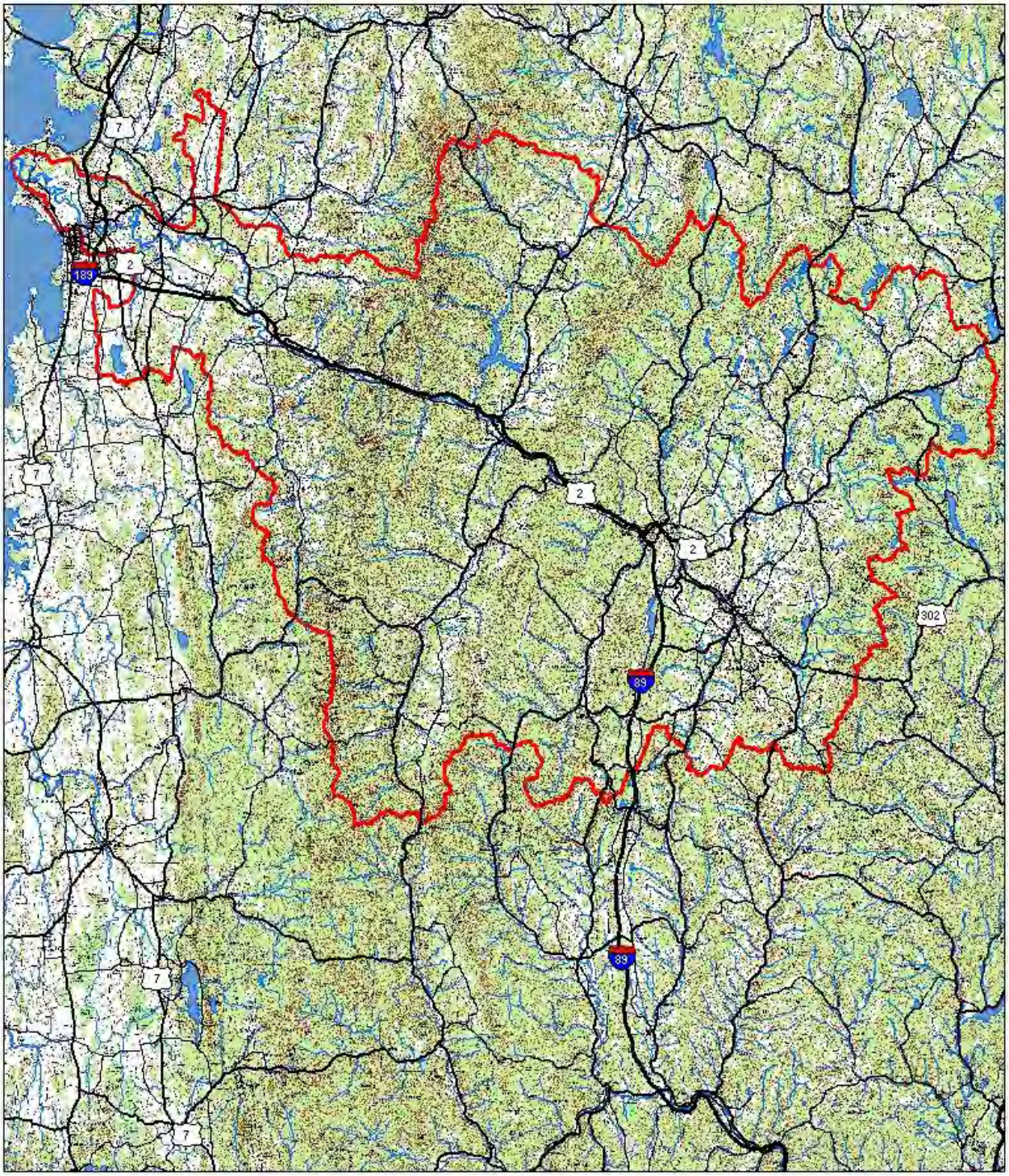


Figure 1. Winooski River watershed

Upper Winooski River watershed

General Description

The Upper Winooski River watershed as defined in this assessment report includes the Winooski River mainstem from the Stevens Branch confluence upstream. The watershed area at this point is 314 square miles. The watershed drains much of the towns of East Montpelier, Calais, Plainfield, Marshfield, Cabot, and Woodbury. The largest tributaries to the Upper Winooski include: the Kingsbury Branch with a length of about 12 miles and a watershed of 53 square miles; Mollys Brook with a length of six and a half miles and a watershed of 26 square miles; and Great Brook with a length of seven and a half miles and a watershed of 16 square miles.

Uses and Values

Waterfalls, Cascades, and Gorges

The *Waterfalls, Cascades and Gorges of Vermont* (WC&G) study describes four cascades or falls in this Upper Winooski watershed. Two of them, Blake Falls on the Kingsbury Branch in Woodbury and East Calais Cascades also on the Kingsbury Branch but in Calais, are small sites and only of local importance. Marshfield Falls on Marshfield Brook is a 300-foot long cascades over a sloping granite face and is a fairly well known local scenic attraction. Mollys Falls on Molly Brook in Marshfield was one of the two or three highest woodland falls in the state (a steep continuous cascade about 150 feet long) but the brook is dammed above the falls and the water diverted for hydro-electric power production. Significant amounts of water apparently flow over the falls only in spring. The study concluded that Mollys Falls is an “altered and degraded site” but “important if restored.”

Field survey sheets of the tributaries in the Kingsbury Branch watershed in July 2001 noted a "very pretty series of cascades" about 500 long and a small waterfall on Dugar Brook below Apple Hill Road and Dugar Brook Road. Cascades and a gorge were also noted on the Curtis Pond outlet stream where it drops steeply below Kents Corner.

Swimming

The *Vermont Swimming Hole Study* identified two small swimming holes on tributaries in the Upper Winooski River watershed. One site is on Nasmith Brook in Plainfield and the other is on the Kingsbury Branch in Calais.

Boating

The Whitewater Rivers of Vermont report identifies the 24 mile stretch of the Winooski River from Marshfield to Montpelier as a boatable quickwater stream with several stretches of Class II whitewater as well as several dams. In the spring, there is the annual “Fiddlehead Slalom” on a Class II+ whitewater stretch of the river in East Montpelier below the Winooski 8 dam.

Fishery

Winooski headwaters to the confluence with Molly's Brook

On the Winooski mainstem in this segment there are abundant wild brook trout populations from Cabot Village upstream. The temperature and habitat conditions deteriorate downstream from the village with the maximum temperature of 78°F observed above the Green Mountain Power Co (GMP) powerhouse in 2004. The GMP hydro-electric generation results in extreme daily fluctuations in flow as well as rapid temperature changes of >5 degrees F.

Confluence with Molly's Brook to confluence with Kingsbury Branch

On the Winooski mainstem in this section, there is a mix of wild brown trout and rainbow trout with supplemental stockings of both species. There are low levels of wild brook trout. The three trout populations vary in abundance with local habitat conditions which vary widely in this reach. Unregulated hydro generation substantially alters natural flow and temperature regimes. Aquatic habitat is isolated between mainstem dams: Marshfield 8 and Plainfield Village.

There has been a slow recovery of wild rainbow trout below the Marshfield 8 dam following the 2005 fish kill. There has been no recovery of wild rainbow or brown trout observed above Marshfield 8 as of 2007 due to this barrier, which prevents downstream populations from accessing habitats above Marshfield 8.

The Vermont Department of Fish and Wildlife owns three parcels of riparian land along mainstem in Plainfield and Marshfield.

Confluence with Kingsbury Branch to Stevens Branch

In this section of the Winooski, there is a mix of wild brown trout and rainbow trout with supplemental stockings of rainbow trout. Again the trout populations vary with the local habitat conditions. Several dams fragment and degrade the habitat within this reach. The large size of the river prevents direct population sampling although angler creel surveys were conducted in 1999.

The Vermont Department of Fish and Wildlife owns extensive riparian land along the Winooski River directly above the dam in East Montpelier.

Tributaries

On Jug Brook, there is a wild brook trout population and on Molly's Brook, there are wild brook and brown trout above Marshfield Reservoir. The extreme flow reduction below the reservoir due to the hydro bypass and unregulated minimum flow and high temperatures (a maximim temperature of 77°F in 2004) limits wild trout populations downstream of dam. Kidder (Hooker) Brook has wild brook and brown trout.

The Creamery Road Brook has wild brook trout; the Marshfield Brook has wild brook trout; Nasmith Brook has wild brook and rainbow trout; King Brook has wild brook and rainbow trout; and Great Brook has wild brook, brown and rainbow trout. Nasmith Brook is important rainbow trout spawning tributary for mainstem populations and Great Brook is an important rainbow and brown trout spawning tributary for mainstem populations.

The Kingsbury Branch has wild brook trout in East Calais and upstream. The access is limited and the sampling conditions are difficult from East Calais to mouth. The surface area of North Montpelier Pond increases water temperatures downstream.

Pekin Brook, a tributary to the Kingsbury Branch, has wild brook trout and Dugar Brook, a tributary to Pekin Brook, also has wild brook trout.

Sodom Pond Brook has wild brook, brown and rainbow trout. It is an important rainbow and brown trout spawning tributary for Winooski River mainstem populations. Bennett Brook has wild brook trout.

Ponds:

- Coits Pond – chain pickerel, yellow perch, brown bullhead, VDFW access
- West Hill Pond – largemouth bass, chain pickerel, yellow perch, brown bullhead, VDFW access.
- Molly's Falls Pond (Marshfield Reservoir) – northern pike, smallmouth bass, yellow perch, rainbow trout (stocked), brown trout (stocked), brown bullhead. VDFW access. The late fall and winter drawdown impacts littoral zone productivity and may affect spawning tributary access.
- Peacham Pond – brown trout (stocked), yellow perch, rainbow smelt, VDFW access. The late fall, winter drawdown impacts littoral zone productivity and may affect spawning tributary access.
- Molly's Pond – chain pickerel, yellow perch
- Buck Lake – brook trout (stocked), smallmouth bass, yellow perch, brown bullhead, pumpkinseed, seasonal VDFW access.
- Greenwood Lake – brown trout (stocked), smallmouth bass, yellow perch, chain pickerel, brown bullhead, pumpkinseed,VDFW access.
- Valley Lake – smallmouth bass, yellow perch, chain pickerel, brown bullhead, pumpkinseed,VDFW access.
- Cranberry Meadow Pond – smallmouth bass, yellow perch, pumkinseed.
- Nelson Pond – lake trout (wild & stocked), rainbow trout (stocked), brown trout (stocked) rainbow smelt, smallmouth bass, yellow perch, chain pickerel, brown bullhead, pumpkinseed, VDFW access
- Mirror Lake (No. 10 Pond) – lake trout (stocked), rainbow trout (stocked), rainbow smelt, smallmouth bass, yellow perch, chain pickerel, brown bullhead, pumpkinseed, VDFW access.
- Woodbury Lake - rainbow trout (stocked), brown trout (stocked), smallmouth bass, largemouth bass, rainbow smelt, smallmouth bass, yellow perch, chain pickerel, brown bullhead, pumpkinseed, VDFW access
- Curtis Pond – largemouth bass, chain pickerel, yellow perch, brown bullhead, pumpkinseed, VDFW access.
- Bliss Pond – largemouth bass, yellow perch, chain pickerel, brown bullhead.
- North Montpelier Pond – chain pickerel, yellow perch, brown bullhead, pumpkinseed.

Significant Natural Communities

A riverine floodplain forest is located along the Kingsbury Branch downstream of North Montpelier Pond. The relatively young forest with its sparse canopy has butternut, box elder, and scattered elm. Many of the butternut were dead or dying at the time of the survey of this community in 1997. The shrub layer is sparse too but the herbaceous layer is typical and robust with ostrich fern dominating. White boneset, virgin's bower, giant goldenrod, sensitive fern, wood nettle, and dropseed are all associates of the ostrich fern.

Specific Rivers and Streams

Upper Winooski River

The Winooski River originates in dendritic-patterned headwaters that flow from wetlands and ponds in the vicinity of the Cabot/Walden town line. The two branches which are formed from the headwater streams join about a mile upstream of Cabot village becoming what is officially labelled as the Winooski River. The river flows generally south through the western half of Cabot and into the town of Marshfield. In Marshfield, the flow from Peacham Pond and Mollys Falls Pond enter the Winooski River. These two ponds and Mollys Falls Brook are part of a hydroelectric system described briefly under Mollys Falls Brook below. Drainage from this subwatershed enlarges the Winooski River, however, because of the hydro operation, the flow to the Winooski is highly manipulated.

Below the mouth of Mollys Falls Brook, the Winooski River flows southwesterly winding its way through a fairly broad valley to the northern tip of Plainfield. In Plainfield, it flows westerly for about a mile and a half then turns northerly, enters East Montpelier, and then turns south again after the Kingsbury Branch comes in. Shortly, the river flows westerly again through East Montpelier and at the Berlin, Montpelier, East Montpelier junction, the Stevens Branch enters from the south.

Biological Monitoring

Some biological monitoring has been done on the upper Winooski River with a number of samples taken following an ammonia spill from Cabot Creamery in 2005. The Winooski River at rivermile (rm) 59.9 and at rm 63.1, the macroinvertebrate community was in "very good" health and at rm 70.7, it was in "good" health in 2000. At rm 83.1, there was a "very good-good" macroinvertebrate assessment in 2005; rm 83.8 had a "very good" macroinvertebrate community in 2000 and 2005 and a "fair" fish community in 2000; rm 85.5 had a "good" macroinvertebrate community in 2005; rm 85.7 had a "good-fair" macroinvertebrate community and a "very good" fish community in 2006; rm 85.9 had a "good-fair" macroinvertebrate community in 2005 and 2006 (just below the Cabot plant stormwater pipe); rm 86.0 had a "very good" macroinvertebrate community in 2005 and a "good-fair" macroinvertebrate community in 2006 (above Cabot plant discharges) and rm 86.5 had an "excellent" fish community in 2005.

Rivermile 83.1 is "located about 3/4 miles above the Marshfield-Cabot line"; rm 83.8 is "located just below storage building in Durrant Cemetary in Lower Cabot, about 0.9 miles below the Cabot WWTF"; rm 85.7 is "located .25 miles below Cabot Creamery and

stormwater discharge pipe at creamery"; rm 85.9 is "located 20m below stormwater discharge pipe from Cabot Creamery"; and rm 86.0 is "located approximately 75 meters above stormwater discharge pipe from Cabot Cheese plant."

Geomorphic Assessment

The upper Winooski River and three tributaries in the town of Cabot were assessed for physical stability and condition by Bear Creek Environmental and lay assistants in the spring and summer of 2004. The river and tributaries were divided into 23 reaches for the Phase 1 assessment. The Winooski River mainstem from just above the confluence of Mollys Falls Brook upstream to Coits Pond was divided into 11 reaches, Jug Brook into 4 reaches, the next tributary upstream into 3 reaches, and the last tributary upstream into 5 reaches for the Phase 1 assessment. The goal of the Phase 1 work was to determine which reaches were in adjustment based on current and historic physical information and then which reaches should be part of a Phase 2 assessment.

The Phase 1 study found that the reaches on the Winooski River mainstem from Tributary 3 (near Houston Hill Road) down to the study starting point (above Mollys Falls Brook), which are reaches M1 through M7, are in fair to poor condition with several channel adjustment processes underway. One reach of the four on Jug Brook, one reach of the three on Tributary 2, and two reaches of the five on Tributary 3 were either in fair or poor condition. The recommendation was to collect Phase 2 field data on M02 to M07, seven of the mainstem reaches.

The seven reaches for which Phase 2 data was collected were divided further into a total of 17 segments for the purposes of assessment. Summaries of the characteristics of all the segments in this stretch of the Winooski River are in the Bear Creek report cited below. Some of the gross conclusions include: 1) all but one segment was in "fair" or "poor" condition (although predominately "fair" with M04B in "good" condition); 2) degradation and planform adjustment are described as the "primary adjustment processes"; 3) generally the river in this stretch is in stage III of the channel evolution model; 4) all cross-sections done (12 of them) were incised; and 5) the reference stream type for much of the Winooski in Cabot appears to be an E-type stream which depends on streamside vegetation for stability and so re-establishment of riparian vegetation in a protected corridor will be important to the river's long-term health.

Other

The ammonia spill from Cabot Creamery occurred on July 17 and 18, 2005. The spill killed thousands of fish for about 5 miles downstream. The macroinvertebrate impact was estimated at a mile and a half or so. The length of time for a recovery of the aquatic community is from a year to several years.

In late summer 1998, a contact recreation survey was done on an approximately 2.2 mile stretch of the upper Winooski River from lower Cabot village to the Green Mountain hydroelectric facility in Marshfield. From this survey, which included discussions with local residents who knew or used the sites themselves, five of the six locations initially identified are used for swimming. Three of the sites used are in the lower Cabot village area and the other two sites were downstream in the vicinity of the hydroelectric plant.

The Winooski River from Marshfield Village downstream to Nasmith Brook has very little to no streamside vegetation and unstable banks. Mollys Falls Hydro regulates water in Mollys Falls Brook and the cycling at Mollys Falls is likely contributing to the eroding banks. Flows are reduced in the Winooski down to the confluence of Kingsbury Branch.

Kingsbury Branch

The Kingsbury Branch originates in Calais at the outlet of Woodbury Lake (Sabin Pond). Upstream of Woodbury Lake are eight named ponds, a number of unnamed ponds and large wetlands, and their watershed areas thus the Kingsbury Branch is the conduit for this significant watershed area. The Kingsbury winds south through Calais becoming especially sinuous in the two mile stretch before the river is impounded at North Montpelier Pond. Downstream of the pond dam and now in East Montpelier, the branch continues winding south until it enters the Winooski River.

The dam on Kingsbury Branch at North Montpelier Pond is operated as a peaking hydro-electric facility owned by two partners. It has a FERC exemption for which ANR DEC issued a 401 and later amended for peaking operation. There is a minimum flow requirement for the facility. Water from the pond at the dam is taken to just below the dam where the water passes through a small turbine to harness the power before the specified minimum flow is put into the river channel. Because the water for minimum flows in the stream is not spilled over the dam, the aesthetics of the spilling water at the dam is gone except during high flows. The rest of the flow goes through the penstock to the other side of Route 14 to the powerhouse below. This dam was originally constructed in 1920. The dam breached during a flood in June 1984 and was subsequently repaired. It again breached during another flood in July 1990 and was repaired. Both times, nearby Factory Street was washed out. Vermont Department of Fish and Wildlife fishery biologists have noted that there is a water temperature problem below dam. This has been reiterated by anglers who say the water is warm and the habitat poor below the dam.

There are a number of slumping banks (one very steep) along the Kingsbury Branch from just below East Calais village to at least the Max Gray Road bridge. There is active and old pasture land on much of this reach but it is not clear if the eroding banks are related to this activity or not.

Pekin Brook

Pekin Brook or Branch is a significant tributary to the Kingsbury Branch. It begins where Dugar Brook and the stream draining Wheelock, Tabor, and Watson Ponds join in Gospel Hollow in Calais. It winds south through a large alder swamp and then southeast through a mix of forest and agricultural land until it joins the Kingsbury Branch.

The maroinvertebrate community was sampled on Pekin Brook in September 1998. The community was assessed as "good" at rm 2.4 (0.2 miles below Stevens Farm) and "excellent" at rm 3.5 (bridge below Singleton Road).

The fish community was sampled in 1997 and 1999 although no final assessment was made. Among the fish species found during sampling was burbot, an uncommon fish

species known from only 29 locations in Vermont to date.

Great Brook in Plainfield

The seven and a half mile-long Great Brook begins in Groton east of Colby Mountain and flows west into the town of Plainfield. Near the Plainfield/Orange town line, a tributary joins from the south as the Great Brook turns strongly to the north. It flows north for approximately 5.4 miles before flowing through part of the Plainfield village and entering the Winooski River just downstream of the village dam. Two tributaries enter the Great Brook from the east during its flow north: one of the two originating at Bancroft Pond whose water level is maintained by a beaver dam.

Some biological sampling has occurred on Great Brook in Plainfield. Fish sampling from September 1998 at rm 1.3 resulted in an assessment of "very good" but macroinvertebrate sampling that same year and location resulted in a "fair" assessment. Macroinvertebrate sampling results from October 2000 at rm 1.3 and rm 5.3 were "excellent".

The biological sampling results do not indicate well the changes in aquatic habitat that Great Brook has experienced over the last 150 years. Great Brook has had decades of problems with streambed and streambank erosion and extreme scour as a result of floods, flood "repair" work, and the road, numerous bridges, and houses in the brook's narrow valley. A very thorough and fascinating history of the floods of Great Brook was written in 2001 by Lori Barg, an environmental consultant, and George Springston, geologist, both of Plainfield.

The history described the severe floods and heavy damage that have occurred on Great Brook in 1857, 1869, 1927, 1938, 1973, 1984, 1989 and 1990. Despite the effect of agricultural land clearing in the 1800s and the floods that occurred prior to 1973, the brook was known as an excellent trout fishery with deep pools for fishing and swimming. After the 1973 flood, the town bulldozed out the channel clearing not only flood debris but also large boulders that had previously not been moved by earlier floods and that had provided some streambed stability. After the bulldozing and channel straightening, the streambed has eroded down severely, sediment has built up in other places, re-directed flow has eroded the steep, high streambanks more, and the stream has widened.

The brook is still an important trout spawning stream for the Winooski River fishery.

Nasmith Brook

Nasmith Brook is a clear, cold, bedrock or boulder, and cobble/gravel stream. There are several popular local spots for bathing, sitting, and picnicking. One area, known as “Paradise”, is just north of Laird Pond Road and consists of a series of small cascades and pools. The pools are not too deep but deep enough for cooling down on a hot summer day and is a good spot for families with small children. Under the old railroad bed, there is also a spot for picnicking and wading and enjoying the brook’s cold water. As described above, the brook is an important trout spawning stream.

Mollys Brook

Mollys Brook originates at Mollys Pond in eastern Cabot then flows west and south through East Cabot and South Cabot into the reservoir called Mollys Falls Pond. Below the dam on the reservoir, Mollys Brook (with little to no water, see below) continues westerly until it meets the Winooski River.

Macroinvertebrates were sampled on Mollys Brook at rm 5.5 in Cabot in September 2000. The community at that time and location was assessed as "excellent." This site is located above the Route 2 bridge that is above Mollys Falls Pond.

Mollys Brook below Mollys Falls Reservoir has little to no flow due to the operation of the Mollys Falls hydroelectric facility. The *Hydropower in Vermont, Volume II* report summarizes information about the Mollys Falls hydroelectric facility: "Mollys Falls is a storage reservoir and hydroelectric development located on Mollys Brook and the Winooski River in the town of Marshfield. It consists of Peacham Pond, which is a storage reservoir; Mollys Falls Pond; an 8293 foot long penstock bypassing the lower two miles of Mollys Brook; and a powerhouse on the Winooski River. The project operates as a daily peaking facility. The reservoir is maintained near full pool during the summer months and drawn down from December through early spring. Maximum drawdown is reported by the utility to be 39 feet. Under normal conditions, the only flow maintained in the 2-mile bypassed section of stream is leakage through the stoplog structure across the spillway. There is also leakage through the project's penstock..The project operates with no minimum flow requirement.." Mollys Falls is an unlicensed project (by FERC) but it is state jurisdictional so the Vermont DEC can start a process to determine what to do and how. Nothing has been done to date but the hydropower report referenced above lists studies and recommendations that should occur including a determination of any impacts below the powerhouse on the Winooski River (water quality or fishery impacts).

River and Stream Assessment Summary Upper Winooski River

Altered Miles

Molly's Brook: 2.0 - below the hydroelectric dam down to confluence of the Winooski River - all uses altered due to no water in this segment (flow is diverted through the penstock).

Sucker Brook: 1.0 - from Peacham Pond to Molly's Pond - aquatic biota/habitat and secondary contact recreation altered due to fluctuating flows from hydro storage on Peacham Pond.

Great Brook: 7.5 – from its mouth upstream - aquatic habitat, secondary contact recreation, and aesthetics altered due to sedimentation, turbidity, and habitat destruction from flooding in a confined channel with riprapped banks, narrow bridges, instability.

Beaver Meadow Brook: 1.0 - Route 2 upstream - aquatic biota/habitat also altered due to flooding of last several years - habitat destroyed, streambanks eroding.

Creamery Brook: lowest 2.0 - aquatic biota/habitat and secondary contact recreation altered due to heavy sedimentation, habitat destruction, alteration of stream course due to 1984 flood and previous floods.

Stressed Miles

Winooski River: 6.0 miles - from the confluence with Mollys Brook upstream to a tributary coming from the north - aquatic habitat, aesthetics stressed due to habitat alterations, sedimentation from lack of riparian vegetation, channel adjustments, channel straightening effects, river's loss of access to its floodplain.

Winooski River: 20.4 miles - from Mollys Falls Brook confluence downstream to Stevens Branch confluence (whole segment) - aquatic biota/habitat, aesthetics, and secondary contact recreation stressed due to habitat alteration, low and fluctuating flows, sedimentation, turbidity, nutrient enrichment due to operation of Mollys Brook hydro, streambank erosion, channel instability, gravel road runoff, loss of riparian vegetaion, agricultural activities (cropland, pastures).

Kingsbury Branch: 3.5 miles - from outlet of North Montpelier Pond to mouth - aquatic biota/habitat stressed due to warm water discharges from the pond.

Stevens Branch Watershed

General Description

The Stevens Branch is 14.7 miles long; drains a watershed of 129 square miles; and flows through three towns on its way to join the Winooski River east of Montpelier. The Stevens Branch is first named downstream of Cutter Pond in Williamstown. The river flows north into Williamstown village with several tributaries adding flow from both the east and west. The outfall of the Williamstown wastewater treatment facility (WWTF) is on one of these small tributaries but the waste management zone extends 1.2 miles down the Stevens Branch itself also. North and downstream of Williamstown, the brook flows northeasterly for a few miles in Williamstown then into the town of Barre where it flows through South Barre and into Barre City. Martin Brook, Cold Spring Brook, and several unnamed tributaries join the Stevens Branch in this segment. Then in Barre City, the 14-mile long Jail Branch with its 49 square mile watershed joins the Stevens.

The Stevens Branch, now as a larger stream, flows through the western side of Barre City where it is channelized to protect all the adjacent development (roads, commercial and industrial buildings, houses). North and downstream of the city, there is the Barre WWTF and below the plant, the river flows for another 3 miles. The 3-mile stretch includes a 2.6-mile long waste management zone designation below the WWTF.

Uses and Values

Waterfalls, Cascades, and Gorges

The *Waterfalls, Cascades and Gorges of Vermont* report describes two sites with cascades or falls in the Stevens Branch watershed. One site is Nelson Brook Gorge on Nelson Brook, a tributary to Thurman Dix Reservoir in the Jail Branch sub-watershed in Orange. The site includes a 100-foot long cascade, an eight-foot high waterfall that is about 30 feet wide, and a 600-foot long gorge with rock walls 30 to 40 feet high.

The second site is Benjamin Falls on Berlin Pond Brook in Berlin. The Falls is actually a series of cascades that begin just below a small dam at 860 feet elevation and descend about 320 feet over a distance of 2400 feet to the floodplain of the Stevens Branch. The W,C&G report described the falls as “a very striking water feature – a long, nearly continuous series of cascades, coming down a steep ravine, remarkable for their length and power...”

Swimming

The Vermont Swimming Hole Study has no sites listed for the Stevens Branch or Jail Branch, however, a tragic accident brought to light a popular swimming hole on the Jail Branch called Spaulding Falls. There are a series of cascades and then a pool where there is a rope to swing into the water. Neighborhood people and students from Spaulding High School frequent this spot. Three children drown in high water in the falls spring 2005.

Fishery

On the Stevens Branch, the fishery is exclusively wild brook trout above Route 63 in South Barre and downstream, the brook supports a mix of wild brook, brown and rainbow trout. Despite urbanization and associated impacts, the branch still supports good levels of wild trout populations in areas. Gunner Brook has wild brook, brown and rainbow trout. It is an important rainbow and brown trout spawning tributary for Stevens Branch populations.

On the Jail Branch, a tributary to the Stevens, the upper reaches in Washington support exclusively wild brook trout. From East Barre to the mouth, the stream supports a mix of wild brook, brown and rainbow trout. There is very low trout abundance below the East Barre dam and the reason is not yet known.

Specific Rivers and Streams

Stevens Branch

Biological Sampling

Macroinvertebrate sampling results on the Stevens Branch are as follows:

Table 3: Macroinvertebrate sampling results on the Stevens Branch 1990 – 2005

	rm 0.6	rm 2.6	rm 3.3	rm 4.7-4.9	rm 11.9
1990	-----	fair	-----	-----	-----
1991	-----	fair	fair	-----	good
1992	poor	-----	-----	-----	-----
1996	-----	good	-----	good	-----
2000	good	fair	-----	-----	-----
2001	-----	fair	good	-----	-----
2005	-----	good-fair	-----	-----	good

Fish sampling results on the Stevens Branch were: rivermile (rm) 2.8, "good" in 1991, at rms 4.7 - 4.9, "good" in 1996. Rm 0.6 is above the small bridge near the AOT Highway Garage (at Partridge Hill subdivision) in Berlin. Rm 2.6 is below the Barre WWTF about 1200 meters. Rm 3.3 is above the WWTF and adjacent to Route 302. Rm 4.7 is below Granite St. bridge 50 meters; rm 4.8 is just above Granite Street bridge adjacent to Barre Coal Tar site; and rm 4.9 is 100 meters upstream from Granite Street bridge below a small tributary. Rm 11.9 is 50 meters below the confluence of Trib #23 with Stevens Branch.

Some water quality sampling that was done by Vermont DEC on Stevens Branch at the same time that Websterville Baptist school also sampled yielded the following data: at Bridge Street near Howard's Market, 29 col/100 ml *E. coli*, 5°C temperature, 9.7 mg/liter D.O., conductivity of 444, 30 ug/liter total phosphorus; at Blackwell Street, 49 col/100 ml *E. coli*, 6°C temperature, 9.5 mg/liter D.O., conductivity of 368, and 8 ug/liter TP; and below the WWTF and above Legares Market, 45 col./100 ml., 5°C, 10.2 mg/liter D.O., conductivity of 401 and 9 ug/liter TP.

Macroinvertebrate sampling results from Stevens Branch Trib 23 in Williamstown are as follows: at rivermile 0.3, "poor" in 1988 and 1991; "good" in 1994; "poor" in 2000, and "very good" in 2002. The fish sampling results at rivermile 0.3 were: "poor" in 1988; "very good" in 1994; "excellent in 2000" and "good" in 2003. This site is below the WWTF discharge point and the groundwater pipe. Macroinvertebrate sampling at rivermile 0.4 in 1988 was poor and fish sampling at this same site in 1991 was poor but then "very good" in 1994 and "excellent" in 2000 and 2002. Rivermile 0.4 is above the WWTF discharge but still below the groundwater drain pipe. At rivermile 0.5, which is above both the discharge and the pipe, the macroinvertebrate community was "excellent" in 2002 and the fish community was "very good" in 1988 and "excellent" in 1991. A chlorine leak at the WWTF that got into the groundwater was the suspected cause of the harm to the aquatic community in the late 1980s and early 1990s. The leak was fixed and the fish and macroinvertebrate communities are recovered from that impact.

Macroinvertebrate sampling results from Gunners Brook are as follows: at rivermile 0.1, "good" in 1996; at rm 0.2, "fair" in 2000, "excellent" in 2002, "fair" in 2003; and at rm 0.4, "fair" in 2001 and 2002. Fish sampling results from Gunners Brook are as follows: at rm 0.1, "very good" in 1996, "good" in 2000, "poor" in 2002 and "very good" in 2003.

Sampling results from Knapp Brook in Berlin found a “poor” macroinvertebrate community at rivermile 1.1 in 2002 although the sample was taken in April outside the standard fall sampling period.

Hazardous Waste Sites

The Farwell Street Dump (DEC site # 77-0027) near Gunners Brook was first in use as a municipal dump by the City of Barre in 1947. It was used as an open dump for 27 years and then closed in 1974. The dump took all of Barre's trash including granite industry waste, capacitors and resin from an electric facility, and solvents from a dry cleaning facility. Numerous site investigations and sampling events have occurred at this site since 1970: the most recent took place in 2000 and 2001 by Weston Solutions Inc. Superfund Technical Assessment and Response Team 2000 (START). The “Final Expanded Site Inspection Report for Farwell Street Dump, Barre, Vermont” dated September 2002 summarizes their findings.

In May 2001, START personnel collected seven soil/source samples from six potential source areas at the Farwell Street Dump, three leachate/seep samples from two locations on the banks of Gunners Brook, and eight sediment samples from seven locations in Gunners Brook. "No organic compounds were detected above SQLs (sample quantification limits) in sediment samples. Two inorganic substances, arsenic and mercury, were detected in the sediment samples at concentrations greater than three times the reference sample concentration or greater than or equal to the reference sample's sample detection limit (SDL). Two volatile organic compounds (VOCs), 11 semi-volatile organic compounds (SVOCs), two pesticides, and two inorganic elements, including lead and zinc, were detected in soil samples at concentrations greater than three times the reference sample concentration or greater than or equal to the reference sample's SQL or SDL. Four VOCs were detected in leachate samples above SQLs, and three of these VOCs were detected at concentrations exceeding Vermont standards for

ambient groundwater quality. Endrin aldehyde was the only pesticide detected above its SQL in leachate samples. Aluminum, chromium, and iron were detected in leachate samples at concentrations equal to or exceeding Vermont standards for ambient groundwater quality."

The Barre Coal Tar site (DEC site # 770206) is a significant source of contaminants to the Stevens Branch. This site was the location of coal gasification from the late 1800s until 1954 and then it served as a liquid propane storage facility from 1954 to 1983. Two aboveground liquid propane tanks were discovered to be leaking in 1983. This same year, coal tar was found to be discharging to the Stevens Branch. The propane tanks were removed in 1986.

In 1987, the results of a subsurface investigation warranted the installation of a groundwater pumping and bioventing system. At this same time, concrete barriers were placed along the north bank of the Stevens Branch to collect seepage of the coal tar. In 1990, the site owners went bankrupt and DEC took over the recovery system. Some time later, the system deteriorated and was discontinued.

In 1997, EPA and START (Superfund Technical Assistance and Response Team) did a Removal Program Preliminary Assessment/Site Investigation. In November 2000, EPA and START monitored a state-led demolition of a building on the site and studies of site soils contamination. In 2001, Twin State Environmental sampled and found volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), and a number of metals in sediments and soils. Benzene, toluene, ethylbenzene and xylenes were found in groundwater.

Most recently, EPA and START, with representatives from Vermont DEC and the U.S. Fish and Wildlife Service present, sampled sediments, surface water and sediment pore water at two different times - August 31 to September 2, 2005 and November 2 and 3, 2005. The sediment sample results were compared to NOAA Screening Quick Reference Tables (SQuiRTs) threshold effects level (TELs) and/or the NJ DEP Guidance for Sediment Quality Evaluations chronic values. The surface water sample results were compared to the EPA Maximum Contaminant Levels (MCL) and the Vermont Water Quality Standards (effective July 2000).

In September 2005, four VOCs (all in sediment sample SD-08) exceeded the SQuiRTs/NJ DEP screening values and fourteen SVOCs exceeded the screening values at two to nine of the sediment sampling sites! No VOCs were above the MCL or standards in the surface water samples although ten SVOCs exceeded the Vermont water quality standards in one to nine surface water samples. Two VOCs in the soil pore water samples exceeded Vermont groundwater standards In November 2005, two VOCs in SD-08 exceeded the screening values and eleven SVOCs exceeded the screening values at one to five sediment sampling sites. No VOCs or SVOCs were above the surface water standards. Two VOCs in the soil pore water samples exceeded Vermont groundwater standards on this date as well. "A sheen and petroleum odor were observed/noted when sediment was disturbed along Stevens Branch downstream of the site at sediment locations SD-03 and SD-08." A persistent and fairly strong petroleum odor was noted

again in September 2007 in this same area when water chemistry and macroinvertebrate sampling was conducted by Vermont DEC Water Quality Division. No sheens were seen.

It is important to note that the reference sample for the site is located about 1100 feet upstream and does itself show the presence of VOCs and SVOCs. However, "analytical results of the sediment and sediment pore water samples collected during both sampling events indicated that impacts to Stevens Branch from subsurface coal tar product seeps originating from the Barre Coal Tar site continue to be documented."

At the former Unifirst Plant site on Brush Hill Road in Williamstown (DEC site #77-0087), there is now an underground drain to collect the contaminated water from this site. It passes through carbon filtration at a small treatment "plant". This treated wastewater is sampled monthly and is regulated through a discharge permit (NPDES# VT0000850). There is semi-annual groundwater sampling at the site and annual surface water sampling. A tributary to Rouleau Brook, which goes to the Stevens Branch, is the surface water. Surface water samples in July 2003 did not detect organics in the four samples taken. The most recent sampling at the Unifirst Plant Site was conducted in April 2006 by Waite Environmental Management. Water samples were collected from six seeps, two unused springs, one bedrock monitoring well, and five water supply wells. No target compounds were found above quantification limits in the bedrock monitoring well and in any of the water supply wells. The target compounds PCE and TCE were reported above detection limits in two seeps (Seep-1A and SS-3), an unused spring (SP-4), and overburden groundwater monitoring well W-23. PCE was also above detection limits in unused spring (SP-3). Of most significance is that PCE was found in amounts above the VGES in seep SS-3, spring SP-4 and groundwater monitoring well W-23 and this April 2006 concentration in SS-3 is the highest detected to date. The concentration of PCE in SP-4 is the highest in nine years.

The Williamstown Landfill was used to dump sludge that had dry cleaning (Unifirst) contaminants. According to a site investigation report received in summer 1989, organics were found in the soils, but no surface water organics were found at that time. In the summer of 2005, Stone Environmental did a site investigation at the Williamstown landfill. Per their report dated Feb 16, 2006, "the purpose of the investigation was to assess the degree and extent of groundwater contamination by tetrachloroethene emanating from the Unifirst wastes within and around the landfill... No detectable levels of contamination were found as part of this investigation." After these initial results, Stone installed 4 new monitoring wells and did a full round of groundwater sampling at these and 5 of the old wells. Again they found no contamination. Their conclusions included among others: "PCE and its degradation products are not present above detection limits in the groundwater immediately down gradient of suspected source areas or where groundwater discharges to surface water on site" and "contaminant flux from the suspected source areas has decreased significantly since the previous study (1989), resulting in reduced groundwater concentrations that are below the laboratory's detection limits and below the VGES."

The South Barre MiniMart/Barre Home Supply hazardous waste site (DEC site #96-1970) has not been sampled since 1996 when ATC Environmental did a Phase II subsurface

environmental assessment. The site is located between Route 14 and the Stevens Branch in South Barre and there are several businesses located on the site including a laundramat, hardware store, minimart that sells gasoline and an automotive repair shop. The east part of the site is paved and relatively flat while the western side slopes to a drive and parking area used by the car repair shop. The land drops sharply to the Stevens Branch. Staining and sheens on the ground adjacent to the repair shop led to the Phase II environment assessment that was done.

As part of the Phase II environmental assessment, samples were taken from the Stevens Branch upstream and midstream (just downgradient of contaminated soils onsite). The upstream and midstream samples showed no VOCs and TPH but the upstream sample had 0.51 mg/ml ethylene glycol and 0.0062 mg/liter of barium. The midstream samples had 0.61 mg/ml ethylene glycol, 0.0042 mg/liter barium, and 0.50 mg/liter (500 ug/liter) selenium. The selenium concentration was well above the Vermont Water Quality Standard for selenium, which is 20 ug/liter as the maximum allowable concentration (acute criteria) and 5 ug/liter average allowable concentration (chronic criteria). It was also above the U.S. EPA risk-based concentration for selenium for drinking water (180 ug/liter).

The site owners were supposed to follow-up with additional monitoring and further definition of the degree and extent of the soil contamination. That has not been done to date although the DEC Waste Management Division will be pursuing it.

The Depot Square (formerly Howe Cleaners) hazardous waste site (DEC site #99-2631) is contaminated from years of dry cleaning chemicals and waste. A March 2006 report from the consultants for the site owners concludes still that "a significant mass of PCE remains directly beneath the concrete floor of the current pool room/former equipment room of the former Hower Cleaners building. The presence of this significant contaminant souce mass will continue to generate the elevated vapor levels seen within the subject building and the extensive dissolved phase contaminant plume if unremediated." The contaminant plume is towards the Stevens Branch. MW-106A, which is between the contaminated source and the river, had high levels of tetrachloroethene, trichloroethene, and cis-1,2-dichloroethene on sampling dates in March 2005, June 2005, November 2005, and March 2006. No VOCs were detected, however, in the two surface water samples collected from the Stevens Branch in March 2006.

The EPA Pre-remedial Program is beginning an evaluation of the Depot Square site that will likely include work to determine if the site is affecting the Stevens Branch. The EPA Removals Program is also evaluating the site for a possible removal action involving installing remediation systems to treat vapors entering buildings if affected. Groundwater sampling is not being conducted at this time due to lack of state funds.

The Bonacorsi and Sons property hazardous waste site (DEC site# 2002-3048) has been monitored quarterly per a Corrective Action Plan. The June 2006 monitoring results found that 11 monitoring wells had increased PCEs, 10 wells had decreased levels, and 2 wells remained non-detect. Chlorinated hydrocarbons were detected in 20 out of 23 wells monitored in June 2006 with the Vermont Groundwater Enforcement Standards (VGES) exceeded in 17 of the 20 wells that had detectable concentrations. The four monitoring

wells closest to the Stevens Branch (MW-11D, MW-11R, MW-12, MW-15) were not sampled during the June 2006 monitoring event. During the February 2006 monitoring event, two of the chlorinated hydrocarbons exceeded the VGES in two of the four wells.

Perry's Bulk Oil Storage in Berlin is another hazardous waste site (DEC site# 95-1852) where groundwater flow from the site is towards the Stevens Branch. The groundwater monitoring well closest to the Stevens Branch for this site, however, had "no detect" for the 8 compounds sampled. Two of the four monitoring wells had 3 compounds (1,3,5-TMB, 1,2,4-TMB and naphthalene) above the groundwater enforcement standards.

The Berlin Mobil Short Stop site (DEC site# 94-1690) is located on Route 302 in Berlin. Four site monitoring wells and a culvert, which drains the site, were sampled in April 2006. The groundwater flow on this site is northeasterly into the Stevens Branch. Three of eight compounds tested exceeded the VGES in monitoring well 2 (MW-2) while 5 of 8 compounds exceeded the standards in MW-4. These two wells are between the short stop facility and the river. However, MW-6, which is closest to the river only had a trace of MTBE in the sample. "MW-1 and the culvert samples were both clean." The culvert catches water from a curtain drain that is upslope of the facility as is MW-1.

During the period from August 2004 to June 2005, the Quarry Hill Quick Stop site (DEC site# 1998-2388) had two chemical oxidant injections and was sampled four times. A multi-phase extraction remediation system operated at the site from August 2001 to December 2004 recovering an estimated 8,383 pounds of hydrocarbons. The average site-wide concentration of target VOCs from key wells went from 977 ug/liter in August 2004 to 420 ug/liter in November 2004 (following the chemical oxidant injections) back up to 1848 ug/liter in February 2005 and up to 1854 ug/liter in June 2005. The VGES were exceeded for one or more compounds in several of the key wells. No target VOCs were found in the surface water samples. Injection of another product in conjunction with the chemical oxidant that was temporarily successful was to be tried fall 2006.

Outfall Monitoring

The Friends of the Winooski River have conducted a study on the outfalls to the streams and river of Barre City. There are approximately 130 outfalls from the City's stormwater drainage system and in 2003, the Friends did a visual assessment of 112 discharge points, some being part of the City's system (about 80%) and some being private. In 2006, 78 discharge points were monitored as follow-up. Of the 78 outfalls evaluated, 60 had dry weather flows and, of the 60, 21 had test results that indicated some type of pollution. The following is from a March 2007 report. "Seven of the outfalls.... had *E. coli* levels above 500 colonies/100 mL. Of these outfalls, six also tested positive for optical brighteners. An additional four outfalls tested positive for optical brighteners but did not have elevated *E. coli* levels. Three had a potassium level equal to or exceeding 6 parts per million. One of these also had a high *E. coli* count. Six outfalls had high conductivity. One of those also had a high *E. coli* count. Two outfalls had a water temperature of greater than 22º centigrade. Two outfalls did not have field or laboratory tests that indicated a problem but one had a sudsy discharge and the other a very strong smell of solvents."

Jail Branch

The headwaters of the Jail Branch begin in the hills of the town of Washington. The stream flows north through Washington village and into the town of Orange. It meanders northerly through Orange and then northwesterly into Barre through shrub swamp and old field that is the undeveloped land behind the U.S. Army Corps of Engineers East Barre flood control dam. Orange Brook and its tributaries, Baker Brook, Nelson Brook, and Nate Smith Brook enter the Jail Branch before it flows into Barre. The Jail Branch continues a northwesterly flow through East Barre and Honey Brook and its tributaries enter from the north. Then the Jail Branch flows into the southern part of Barre City before it joins the Stevens Branch.

Fish community sampling occurred on the Jail Branch at 2 locations in September 2005. At both rivermile 0.3 and rivermile 8.1, the fish community was found to be in "very good" condition. The water temperature on that date at rm 8.1 was 10 C, alkalinity was 131, turbidity was 1.43, and pH 7.6. The flow was moderate.

The macroinvertebrate community was sampled at three locations on the Jail Branch in September 2005. At rivermile 0.3 (above a railroad bridge adjacent to Spaulding HS track), the community was "good"; at rm 2.8 (above the Route 302 bridge), the bugs were "very good-good"; and at rm 8.1 (upstream of Tucker Road), the community again was "very good-good".

Petroleum-related contamination was discovered during the removal of four underground storage tanks in September 1997 at Roland's MiniMart in East Barre (Vermont DEC site# 97-2295.) During the July 2005 replacement of the site underground storage tanks, limited soil contamination was discovered and approximately two cubic yards of soil was removed and stockpiled. No groundwater contamination was reported on the April 17, 2007 sample date. The site is scheduled for closure pending notification of proper soil disposal.

Baker Brook

Baker Brook originates in Foster Notch in Orange. It flows westerly for about 3 ½ miles before joining Orange Brook not long before it joins the Jail Branch. Baker Brook has sand/gravel substrate and clear, gold-tinged water. Baker Brook and a tributary that joins it from the north are part of a large mapped wetland complex that is comprised of forested and shrub swamp. The forested wetland may largely be cedar swamp.

Baker Brook was sampled for lead and hardness (as calcium carbonate) above, along, and below the property of Bull's Eye Sporting Center to make sure there wasn't an impact from activities at the site (which needed an Act 250 permit). Sampling occurred from 1997 through 2005 and at all three sample sites, lead was below the analytical detection limit. The detection limit is below the chronic criteria concentration so it was possible to conclude that the sporting center activities were not causing a lead impact in the brook.

Honey Brook and tributaries

Honey Brook and its tributaries rise on the slopes of East Hill and The Pinnacle in Barre Town and flow southerly or southwesterly down to the Jail Branch. The Honey Brook flows through a relatively long, linear stretch of mapped and significant wetland. Several tributaries flow through rural residential and forested land.

Heavy rains in July 2007 in addition to poor planning and development practices severely damaged the lower portion of the brook. Much of the damage was indeed preventable or, at the very least, damage could have been minimized if towns had appropriate driveway ordinances, armored road drainages, and properly sized and installed culverts.

Development and increased impervious surfaces on steep soils on smaller streams in this watershed have led to several "landslide or gully mass failures" as formerly vegetated areas now concentrate flows on these sandy and clay terraces. As a number of the steep roads, ditches, and driveways were washed away in Barre, they were deposited on the lower and flatter areas overwhelming the existing channels, bridges and culverts, causing channel braiding or multiple channel formation, property damage, and road washouts.

Unnamed Tributary to the Stevens Branch

This high gradient tributary to the Stevens Branch along Sterling Hill Road in Barre Town alternates between a boulder-bottom step pool system along the steepest part of the road to a cobble-bottom plane bed system on the upstream and downstream most portions of the brook. The road has filled the original stream flood plain causing frequent stream and road conflicts such as severe road embankment erosion. Numerous undersized stream crossings are in place from the Cherrywood Road to Howard Street. The stream has been channelized and armored in several areas.

Approximately 4-6 inches of rain fell in the 24 hour period between noon on July 11th and 12th 2007 causing significant streambank erosion, road embankment and shoulder washouts, culverts and bridges to be overtopped and outflanked, and enormous amounts of sediment and debris to be deposited along private residential property.

As a result of the flood, some of the crossings have been upgraded. ANR recommendations to the town in further addressing river-road conflicts include: additional stream crossing upgrades in culvert size and bridge spans; the installation of additional cross culverts and culvert outlet stabilization; road ditch armoring; road shoulder armoring; and reducing the road width thus increasing stream floodplain area.

River and Stream Assessment Summary Stevens Branch

Impaired Miles

Gunners Brook: 0.5 miles - below Farwell Street Dump - aquatic biota/habitat, aesthetics, secondary contact recreation impaired due to siltation, habitat alteration, nutrient enrichment, and metals from urban runoff and inactive landfill leachate.

Stevens Branch: 0.3 miles (at least-no samples downstream further)(subset of stressed reach below) - from just above Prospect Street bridge downstream about 1700 feet +/- - aquatic habitat, contact recreation, aesthetics impaired due to levels of semi-volatile and volatile organic compounds in stream sediments and surface water standards above screening values and water quality standards respectively. Petroleum odors and sheens.

Altered Miles

Honey Brook and first tributary to it: 1.0 miles - mouth of Honey upstream to first tributary and up first tributary to at least Nuissle Road - aquatic habitat blown out by the severe rainstorm and consequences of poorly planned development, road washouts, undersized culverts, steep driveway washouts.

Sterling Hill Brook: 0.6 miles - mouth upstream - aquatic habitat blown out by physical alteration due to a severe rainstorm combined with steep road washouts, undersized culverts and bridges, development.

Stressed Miles

Stevens Branch: 5.5 miles - mouth to confluence of Jail Branch - aquatic biota/habitat, aesthetics, secondary contact recreation stressed due to nutrient enrichment, siltation/sedimentation, turbidity, garbage, and habitat alterations due to urban runoff, highway runoff, asphalt, granite and other material put on streambanks, removal of riparian vegetation.

Jail Branch: 1.5 miles - mouth upstream to Barre City limits - aquatic biota/habitat, aesthetics, and secondary contact recreation due to nutrient enrichment, siltation, turbidity, habitat alteration, and algae due to discharges from granite settling lagoons, possibly industrial floor drains, urban runoff, channelization, and trash thrown in river.

Jail Branch: 3.0 miles - Barre City limits upstream to East Barre - aquatic habitat, aesthetics stressed at least due to turbidity, sedimentation, and habitat alteration from high unstable glacial till banks ("the Cliffs") slumping into the river and runoff from parking lots, roads, buildings too close to the river and no buffers or controls.

North Branch Watershed

General Description

The North Branch of the Winooski River originates in a large, linear wetland complex in the valley east of the Worcester Mountains in Elmore. Barnes Brook joins the North Branch at the southern end of the wetland. The North Branch flows south from the forested and shrub wetland complex in a narrow valley which widens briefly as it flows through a shrub wetland before it narrows again and continues south-southeasterly into Worcester. A few miles downstream of the Elmore/Worcester border, Russ Pond Brook enters from the northeast.

The North Branch continues southerly in a slightly wider valley and then makes a wide turn and heads southwesterly. Catamount Brook, rushing down off the slopes of the Worcester Mountains, joins the North Branch from the west. Catamount Brook is a 3-mile long stream with a drainage area of three square miles. The North Branch continues generally southwesterly through the town of Worcester for several more miles and then Hancock Brook joins from the west. The headwaters of Hancock Brook are also in the Worcester Mountains.

South of the Hancock Brook confluence, the North Branch valley is wider and the stream larger. A couple of miles downstream, Worcester Brook joins from the east and Minister Brook joins the North Branch from the west just north of the village of Worcester. From here, the valley is a bit wider still as it flows through the southern part of Worcester. The North Branch then continues generally south into the town of Middlesex and into the impoundment behind the Wrightsville dam known as Wrightsville Reservoir. Wrightsville Reservoir, a permanent impoundment directly behind the dam, is a popular swimming and boating spot. Martin Brook and Long Meadow Brook are tributaries in this stretch. Below the dam, the North Branch flows through Montpelier and into the Winooski River. The North Branch is approximately 18 miles long.

Uses and Values

Waterfalls, Cascades, and Gorges

The Waterfalls, Cascades and Gorges of Vermont report describes two sites on the North Branch of the Winooski River. North Branch Falls in Worcester consists of a falls 40 to 50 feet wide that are about nine feet high. Below the falls is a nice pool for swimming. Wrightsville Gorge is an 80-foot deep gorge that is below the outlet of Wrightsville dam and has a lot of rubble and masonry. It is not currently used due to its poor condition.

Swimming

The Vermont Swimming Hole Study identified five sites in the North Branch watershed: three of the sites on the North Branch itself and two sites on tributaries. One site, North Branch Falls, was described above as it was also listed in the W,C&G report. A second site, North Branch East, is located upstream of North Branch Falls. This site has three

sections to it: an upper section with a 50-foot wide, 4-foot deep pool; a middle section with several cascades, 3-foot falls, and a 40-foot wide, 4-foot deep pool; and a lower section with a massive boulder, ledge cascades and falls and a 3-foot deep pool below. North Branch Gorge is the third site described in the *Vermont Swimming Hole Study* on the North Branch itself. This site has a 20-foot high falls spilling into a deep channel that has high rock walls. Below there is a cascade and a 30 by 100-foot pool.

The two swimming holes described on tributaries to the North Branch are on Minister Brook and Hancock Brook. The Minister Brook Mills site off Minister Brook Road is above and below an old concrete dam. There are small cascades and falls and a 30-foot wide, 8-foot deep pool below the dam. Local children frequent this spot throughout the summer. "The Pots" is a relatively small spot close to Hancock Road. It has a 40-foot wide, 4-foot deep pool with a small cascade and falls. In addition to this is site, there is another nice swimming area below The Pots where there are small falls, a good jumping rock, a pool, and sculptured rocks. This stretch of stream is also well-known locally for its clear, cold, clean water.

Fishery

On the North Branch mainstem, there are wild brook trout in the upper elevations (>1000') only and brown trout below Wrightsville (stocked). The water temperatures increase as you move downstream on the North Branch based on data obtained during fish sampling. Wrightsville Reservoir has a surface release and therefore does not moderate temperatures.

Maximum temperatures recorded June 26-27, 2003 ranged from 72.4°F at benchmark 1038 feet to 82.5°F in Putnamville. However, four of the five temperatures recorded were 79° to the 82.5°F.

Tributaries

On Martins Brook, Patterson Brook and Herrick Brook, there are wild brook trout and wild brown trout in the lower reaches of each. Both Minister Brook and Hancock have wild brook trout. Worcester Brook has wild brook trout and wild brown trout in the lower reaches and Catamount Brook has wild brook trout.

Ponds:

- Wrightsville Reservoir – Largemouth and smallmouth bass, yellow perch, chain pickerel, pumpkinseed, brown bullhead. VDEC Access area.

Specific Rivers and Streams

North Branch

A general description of the North Branch is given above.

A windshield survey of the North Branch Winooski River in May 2001 noted turbid conditions, urban/suburban impacts (rip-rap, loss of riparian vegetation, trash) in the lower reaches, dam and farm impacts in mid-reaches, and clear water, buffers, cascades and falls, and wetlands in the upper reaches.

The macroinvertebrate community on the North Branch Winooski River Tributary 2 (below Montpelier stump dump) was in "fair" condition in 2005. Iron precipitate coated the stream substrate at the sample site but not above the stump dump.

Hancock Brook

The headwaters of Hancock Brook tumble down the eastern side of the Worcester Mountains forming Hancock Brook, which flows southeasterly into the North Branch. Hancock Brook is four miles long and has a four square mile watershed. Hancock Brook is a well-shaded, cold, and crystal-clear brook. It has a stretch with some locally-used pools, small falls, sculptured rock (see above).

Biological sampling was done on Hancock Brook in 2003 and 2005. The macroinvertebrate community was in "good-fair" condition at rivermile 0.2 in 2003 and "good" in 2005. The fish community was in "poor" condition at the same station in 2003 but it was sampled in July and then "good" in 2005.

Minister Brook

Minister Brook is a five mile long brook with a drainage area of nine square miles. Headwater streams off the slopes of the Worcester Mountains combine to form Minister Brook, which then flows southeasterly to the North Branch. It enters the North Branch upstream of Worcester village.

Minister Brook is also a clear, cold, gold-tinted brook with boulder-cobble or cobble-gravel channel. A swimming hole at “the mill” and at a stretch above the mill is well-used locally (see above under Uses and Values). Steep roads and road maintenance as well as driveways are threats to the brook.

River and Stream Assessment Summary North Branch

Impaired Miles

North Branch: lowest 1.0 miles - contact recreation, secondary contact recreation (fishing), aquatic habitat, and aesthetics impaired due to pathogens, turbidity, temperature, habitat alteration and junk from urban stormwater runoff, a CSO, rip-rapped banks, channelization and loss of riparian vegetation.

Stressed Miles

Minister Brook: 3.0 miles and *Hancock Brook*: 4.0 miles - aquatic biota/habitat and fishing stressed due to acid precipitation on top of low to no buffering, low alkalinity and pH.

Dog River Watershed

General Description

The Dog River is approximately 20 miles long and drains a watershed of about 94 square miles. It originates from several intermittent streams off the west side of the Northfield Mountains. The river flows southeasterly down off the mountains and foothills until it reaches the valley in which Route 12A runs. The river then begins a northerly flow in the vicinity of Roxbury village. After flowing north for approximately two miles, the river, now in the town of Northfield, begins an easterly flow. Felchner Brook enters from the north in this stretch. After another approximately two miles, the river begins to flow northeasterly and then northerly. Stony Brook joins the Dog from the north and Bull Run joins from the south. Stony Brook is five and a half miles long and drains a nine square mile watershed. Bull Run is approximately six miles long and drains a ten square mile watershed. Downstream about one-half mile, Sunny Brook and its watershed also joins the Dog River. The Dog River is substantially larger after these tributaries join it.

As a larger river now, the Dog River flows north into Northfield's downtown where Union Brook joins it. The Dog continues north into Northfield Falls where Cox Brook enters. Cox Brook is about five and a half miles long and drains an eleven mile watershed. After Northfield Falls, the river flows into the town of Berlin and then continues north and northeasterly for over six miles until the Dog River enters the Winooski River near Montpelier Junction. Chase Brook and a number of unnamed tributaries enter the Dog River in the town of Berlin.

Uses and Values

Waterfalls, Cascades, and Gorges

The Waterfalls, Cascades, and Gorges of Vermont report lists one site in the Dog River watershed and that is Northfield Falls on Cox Brook. This site is upstream of the covered bridges in Northfield Falls and is right along the road. It consists of a set of cascades but there are no pools for swimming. It is used lightly as a picnicking or gathering spot.

Swimming

The Vermont Swimming Hole Study describes two swimming holes in the Dog River watershed – one on the Dog River itself and one on Stony Brook, a tributary. The site on the Dog River is in Riverton at a closed bridge on a road west of Route 12. Below the bridge is a 60-foot long, 8-foot deep pool. A jumping chain was attached to the bridge at the time the site was visited. The other site is on Stony Brook below an old bridge foundation. There are step cascades and several pools including one about 30 feet long and 12 feet deep in part of it.

Fishing

The Dog River mainstrem and all tributaries are managed as "wild trout waters". There are exclusively wild brook trout above Route 12A in Roxbury and a mix of wildbrook,

brown and rainbow trout downstream. Wild rainbows and brown trout dominate below Northfield Falls. In 2001, following a year of a full season angler creel survey and several trout population surveys to gather good baseline data, special regulations (reduced harvest) were set for the 4.3 mile long stretch on the Dog River from the West Berlin railroad bridge to the first Route 12 bridge above the mouth in Berlin. The regulations were to improve the size structure of the wild trout in the river.

On the tributaries to the Dog River, there are wild brook, brown and rainbow trout on: Felchner Brook below the falls (wild brook above), lower reaches of Bull Run (wild brook and rainbow above), Sunny Brook, Union Brook, Cox Brook, and Chase Brook. Stony Brook has wild brook and rainbow trout. Chase Brook is managed as a spawning water with special regulations that close fishing until June 1. The dam on Cox Brook that some years restricts the movement of spawning fish is scheduled to be breached in 2008.

Baker Pond has largemouth bass, yellow perch, pumpkinseed, brown bullhead, and stocked brook trout. The Vermont Department of Fish and Wildlife owns surrounding land, the dam and an access area on the pond.

Specific Rivers and Streams

Dog River

A general description of the Dog River is given above.

Macroinvertebrate sampling results on the Dog River are as follows:

Table 5. Macroinvertebrate sampling results on the Dog River 2000 – 2005.

	2000	2001	2002	2003	2004	2005
Rm 0.7	-----	good	-----	-----	-----	-----
Rm 0.9	-----	-----	good	-----	-----	-----
Rm 5.7	-----	-----	vgood-good	-----	-----	-----
Rm 7.0	-----	good-fair	good	-----	-----	-----
Rm 8.6	-----	-----	fair	-----	poor	good
Rm 8.8	fair	poor	-----	poor	fair-poor	vgood
Rm 9.0	vgood	good	-----	-----	vgood	-----
Rm 14.0	-----	exc	-----	-----	-----	-----
Rm 14.8	-----	vgood	-----	-----	-----	-----

Rivermile 0.7 is in Montpelier upstream from the recreation field under the utility line, rm 0.9 is in Montpelier above power station bridge about 500 meters; rm 5.7 is in Berlin below the Riverton Route 12 bridge about 1 mile, rm 7.0 is in Berlin located above the Route 12 bridge in Riverton, rm 8.6 is in Northfield located above Slaughterhouse covered bridge in Northfield Falls, rm 8.8 is in Northfield located 100 meters below the Northfield WWTF, rm 9.0 is in Northfield located 200 meters above the WWTF, rm 14.0 is located below the golf course, and rm 14.8 is located above the golf course . Site rm 8.8 below the Northfield WWTF was "fair" in 1994 and 1995 in addition to the above.

The Dog River was sampled in 2005 and meets and exceeds Class B criteria at two reaches below the wastewater treatment plant with much less dominance by nutrient tolerant taxa in the community than in previous years. There is only this one year of compliance data but significant upgrades to the Northfield WWTF would explain the improved macroinvertebrate community, which should remain healthy barring any other problem. The impaired status was removed in February 2006 due to the known improvements.

Gross Landfill in Roxbury had not been monitored since 1990 (groundwater was monitored, not surface water) until last summer in August 2006. It is a private landfill and back when it was closed, there were closure funds but not post closure funds. Mr. Gross operated the landfill but now the issue has come to his children. Norwich University, which has used the Gross gravel pit and Gross landfill for classwork (geology and sampling), offered to sample for the constituents that DEC Waste Management Division would like monitored to return the favor for using the Gross land all these years. In August 2006, the univeristy began sampling groundwater. Another round will occur this summer 2007. The Gross Landfill is near the Northfield/Roxbury town line and is separated from the Dog River by ledge. It appears that the groundwater flow is not towards the river.

Sunny Brook

Sunny Brook is six and a half miles long and drains an 18 square mile watershed. The brook originates in Brookfield, flows west into Roxbury, and then turns north flowing through the corner of Roxbury and into Northfield. It continues northerly for a few miles in Northfield before turning west again and into the Dog River south of Northfield's center.

An oil spill from a tanker truck accident flowed into Sunny Brook on September 5, 2003. The hundreds of gallons of No. 6 oil affected the macroinvertebrate community downstream and is documented in a memorandum dated December 3, 2003.

Macroinvertebrates were sampled at 2 sites on Sunny Brook in 2003 following the spill. At rm 0.5, the community was assessed as "good-fair" during a September sample and "fair" from an October sample. At control site rm 0.9, it was "excellent-very good". In 2004, at rm 0.5, it was"very good" and at rm 0.9 "excellent-very good". In 2005, at rm 0.5, it was "very good" for the second year in a row and at rm 0.9, it was "excellent-very good" for the third year in a row. The fish community was sampled on Sunny Brook at rm 0.3 in June 2003 and was assessed as "very good."

River and Stream Assessment Summary Dog River

There are no stretches of river and stream in this watershed currently in impaired, altered, or stressed categories.

Mad River Watershed

General Description

The Mad River is 26 miles long and drains an area of 143 square miles. It flows south to north in a valley bounded on the west by the Green Mountains and on the east by the Northfield Mountains.

The Mad River originates in Granville Notch in the town of Granville and begins a northerly flow in a narrow, forested valley. It turns westerly along the Granville/Warren town line then flows primarily north again going into the town of Warren. Austin Brook enters the Mad from the west just downstream of the Warren town line and then in less than a mile, Mill Brook, which drains Blueberry Lake, joins the Mad River from the east. Then in another approximately half a mile, Stetson Brook joins the Mad River from the west.

The Mad River continues flowing north in a relatively narrow valley until it reaches the village area of Warren. Lincoln Brook comes out of the mountains into the Mad River from the west; Freeman Brook comes into the Mad in Warren Village from the east; and then downstream of the village, Bradley Brook joins the river from the west. Further north and downstream still, Clay Brook with its tributary, Rice Brook, enters the Mad River from the west.

The Mad River continues its northerly journey into the town of Waitsfield where first Charles Folsom Brook then Mill Brook with Slide, Lockwood, and Chase Brooks rising in Fayston to the west and then High Bridge Brook from the east enter the Mad River. Further downstream but still in Waitsfield, Pine Brook joins the Mad River then Shepard Brook with French and Deer Brooks also enters.

The Mad River continues northerly still and Welder Brook with Cunningham Brook and Dowsville Brook rising in Duxbury enters the Mad in Moretown. Further downstream, the Mad River is impounded by a dam and then not far below the dam, the Mad River joins the Winooski River.

Uses and Values

Waterfalls, Cascades, and Gorges

The Waterfalls, Cascades, and Gorges of Vermont report describes Moretown Gorge on the Mad River, which is visible from the road and road bridge on a portion of the gorge. The gorge has rock walls up to 25 feet high and the water crashes through among boulders. There is swimming hole at a pool at the foot of the gorge.

Swimming

The *Vermont Swimming Hole Study* lists nineteen swimming holes on the Mad River and its tributaries including Moretown Gorge described above. The authors of the swimming hole inventory conclude that the Mad River watershed “has as high a concentration of fine

swimming holes as any stream in the state." Of the nineteen documented in the study, fifteen are on the mainstem and four are on the tributaries: Stetson Brook, Lincoln Brook, and Shepard Brook. See the table below for sites identified in the watershed.

The swimming hole study rates each site in terms of natural features (rocks, water features), environmental quality (water quality, distance from a road, natural vegetation), swimming quality (size and depth of pools, jumping or sunning spots), and amount of use. The swimming holes in the Mad River watershed appear on a number of lists of sites of highest significance or state significant quality. Three sites were rated "state significant for natural features"; two sites are "highest significance or state significant for environmental quality"; three sites are "state significant or highest significance for swimming"; eight sites are rated "highest significance or state significant" for the amount of use they receive.

Table 6. Identified Swimming Holes in the Mad River Watershed

Waterbody id	Swimming Hole Name	Brief Description
VT08-18	Picnic Area Cascades	Small cascades where Austin Brook joins the Mad near the Warren/Granville town line at a public picnic area
VT08-20	Stetson Brook Cascades	Small cascades and sculptured rock on Stetson Brook just into GMNF
VT08-18	Warren Falls	Spectacular gorge, falls, cascades, pools, and sculptured rock chutes on the Mad south of Warren village. Significant, popular site.
VT08-20	Hartshorn Falls	Scenic, 25-foot high falls on Lincoln Brook in GMNF with bathing in pool below falls.
VT08-20	Bobbin Mill Cascades	Discontinuous cascades, small falls, small pools for bathing/limited swimming on Lincoln Brook in Warren.
VT08-18	Warren Gorge	Pretty gorge, cascades, and pool in Warren village on the Mad River – good, local swimming hole.
VT08-18	Punch Bowl	Good swimming holes with 2-part cascades on a wide bend of the Mad River in Waitsfield.
VT08-18	Lareau's Swimming Hole	Excellent swimming hole with sand beach on one side and a ledge for jumping on the other just south of Waitsfield village on the Mad.
VT08-18	Laundry Swimming Hole	Nice swimming hole with ledge on one side and a cobble and sand beach on the other where Mill Brook empties into the Mad behind the laundramat at Fiddlers Green.
VT08-10	Recreation Field Swimming Hole	Nice, popular hole with ledge and small sand beach behind Couples Club Recreation Field right near Waitsfield village.
VT08-18	Waitsfield Covered Bridge Swimming Hole	Popular swimming hole under a covered bridge right in Waitsfield village

VT08-18	Meadow Road Bridge Swimming Hole	Typical Mad River swimming hole with ledge on one side and a sand/cobble beach on the other just upstream of Meadow Road
VT08-19	The Flume	A series of cascades with small pools suitable for bathing on Shepard Brook in Fayston.
VT08-18	Moretown Gorge	Narrow gorge with boulders in channel, small cascades, a few pools at the south end of Moretown village below Route 100B bridge.
VT08-18	Fulton's Swimming Hole	Large, deep swimming hole with ledges at a big bend in the river in Moretown
VT08-18	Clapboard Mill Swimming Hole	Long, deep pool below a gorge, small cascades, small falls over old dam. Second of two very popular swimming holes in Moretown village.
VT08-18	Ward Access (Palisades)	Long, deep river channel with sandy beach, good boulders and ledges at a Fish and Wildlife Access area in Moretown.

Boating

The Whitewater Rivers of Vermont report describes two stretches of the Mad River for good boating. The first stretch is from Warren to Moretown about 12 miles in length. The run begins below a bridge in Warren that is the bottom of Warren Gorge. The first four miles are mixed Class I – Class II with two sets of ledges below the Warren-Waitsfield town line that are dangerous and should only be run by experts. One area is the Punchbowl listed above as a swimming hole and the other is about a quarter mile north of the Punchbowl and is especially dangerous. The authors of the report recommended carrying at that spot. The lower six to eight miles of this stretch are more quickwater and Class I than they are whitewater but the reach has "nice rocks and places to eddy" and is considered " a very pretty tour". The take-out is above the Route 100 bridge in Moretown. The stretch is popular with local boaters. It is also used heavily by anglers.

The second stretch described in the Whitewater Report is from Moretown Gorge down to the Winooski River about seven miles. Moretown Gorge and then a second gorge farther downstream are the two most difficult parts of the stretch, the latter being a place even the author thought "it looked very easy to get killed." Flatwater, quickwater, and a few short Class II rapids are between. It is a very important and popular stream especially with expert boaters. It is also popular for fishing.

Fishery

The upper reach of the Mad River supports wild brook, brown and rainbow trout and is managed for wild trout. Below Warren village, increasing temperature and habitat deficiencies limit trout production to "pocket populations" associated with large pools or nearby tributaries. Rainbow trout are stocked here to supplement the recreational fishery.

The dams in Warren and Moretown fragment and degrade the habitat.

On the tributaries to the Mad River: Austin, Mills, Stetson, Lincoln, Freeman, and Bradley Brooks have wild brook trout with possible wild rainbow trout in lower reaches; Mill Brook has wild brook, brown and rainbow trout; Rice, Clay, Chase, Slide, Lockwood Brooks have wild brook trout; Folsom Brook has wild brook, brown and rainbow trout; High Bridge Brook has wild brook trout with possible wild rainbow and brown trout in the lower reaches and Shepard and Dowsville Brooks have wild brook brown and rainbow trout.

Specific Rivers and Streams

Mad River mainstem

The macroinvertebrate community was sampled on the Mad River in Waitsfield at rm 12.1 and in 1998, it was assessed as "good"; in 2000, it was "excellent"; and in 2003, it was "good". Rivermile 12.1 is below the Waitsfield Elementary School. Rivermile 23.6 (upstream of the bridge at the Warren/Granville town line) was also sampled for macroinvertebrate health and the community in 2005 was "excellent-very good."
Mad River Watch data from 2004, 2005, and 2006 include the following geometric means (gm) for each year with the number of samples above 77 E.coli/100ml to the total number of samples per season in parentheses:

Table 7. *E. coli* sampling results on the Mad River mainstem 2004 – 2006.

Site	2004 gm	2005 gm	2006 gm
1	9.5 (1/6)	9.3 (0/6)	17 (1/6)
3	10.5 (1/6)	8.1 (0/6)	43 (2/6)
5	11.3 (1/6)	22.9 (0/6)	35 (0/6)
7	24.5 (1/6)	24.0 (2/6)	56 (2/6)
9	20.0 (1/6)	21.9 (1/6)	7 (0/6)
19	31.3 (1/6)	10.7 (2/6)	3 (1/6)
19.2	37.2 (1/6)	9.5 (1/6)	5 (1/6)
20	33.1 (1/6)	20.9 (2/6)	8 (1/6)
21	29.5 (1/6)	31.6 (2/6)	11 (2/6)
23	23.4 (1/6)	84.1 (3/6)	33 (2/6)
26	79.4 (1/6)	76.7 (3/6)	62 (2/6)
27	74.1 (4/6)	107.2 (3/6)	58 (2/6)
28	87.1 (5/6)	95.5 (3/6)	121 (3/6)
29	100.0 (3/6)	151.3 (4/6)	174 (4/6)
31	158.5 (4/5)	222.2 (5/6)	133 (2/6)

Site 1 is Warren Falls, Site 3 is at the Warren Covered Bridge, Site 5 is downstream of Warren Village, Site 7 is Warren Riverside Park, Site 9 is the Punch Bowl, Site 19 is the Lareau Swim Hole, Site 19.2 is the Couples Recreation Field, Site 20 is Waitsfield Covered Bridge, Site 21 is the Waitsfield Elementary School, Site 23 is Meadow Road Bridge, Site 26 is Moretown above Dowsville Brook, from River Road, Site 27 is Moretown Village Swim Access, Site 28 is Ward Clapboard Mill, Site 29 is Ward Swimhole, and Site 31 is below the breached wooden dam below Moretown #8 dam (from Lover's Lane).

The Department of Fish & Wildlife has conducted trout population surveys of the Mad River mainstem in both 1991 and 1996. According to the district fisheries biologist "the Mad River above Warren Village can generally be described as having excellent trout habitat typical of high gradient, forested upland streams." This upper reach (Warren Village and upstream) has the highest trout populations in the river (1506 mean total trout per mile sampled at Warren Village). Between Warren Village and Waitsfield, the Mad River loses gradient and is characterized by wide, shallow riffles or flats with occasional deep pools. Overall, the riparian area is generally well vegetated although some long stretches do lack streamside vegetation. Wild trout populations were found to be fairly low in this stretch. Below Waitsfield Village, the Mad River is also characterized by wide shallow riffles or flats, a high proportion of fine substrate (sand, silt) and a poorly vegetated riparian area. Wild trout populations are low although pockets of good habitat may hold greater trout densities.

The Keith & Keith Drycleaner site (currently Fiddler's Green Laundromat) was once listed as a threat based on groundwater monitoring results from 1985 showing tetrachloroethene, trichloroethene, and trans 1,2 dichloroethene contamination at monitoring point 3 located between the Fiddler's Green leachfield and the Mad River. The leachfield is only 200 feet away from the river and was one of the locations where dry cleaning waste was disposed until 1987 when the drycleaning part of the business was closed. Surface water sampling was also done in 1985 and the analyses showed "no detectable levels of VOCs" in the Mad River east of monitoring points 1,2 & 3.

The soil from the three laundromat leachfields was sampled in August 1995 by consultants hired to design a new septic system for Fiddler's Green and replace the current system. The soil was sampled to determine whether it had to be treated as hazardous or solid waste when disposing of it. Only toluene in the leachfield soil and acetone and toluene in the ammeration chamber sludge were found. The levels were not cause for concern. The acetone could even have been a laboratory error.

A Stone & Webster "Final Site Inspection Prioritization Report" on Keith & Keith was completed on March 12, 1996. The report summarized all the activity on the site and is the source of most of the above information. Following submittal of the report to EPA, EPA determined that a decision of "No Further Remedial Action Planned" was appropriate.

There are still low levels of PCE in the groundwater in a small area of the site. While groundwater enforcement standards are not yet met within the property, contaminated groundwater is not migrating off site. Annual monitoring has been occurring since 2004.

The site appears to, in recent years, be more of a problem for its septic system failures than for its hazardous content. In January 1991, November 1994, and April 1995, Notices of Alleged Violation were issued to Fiddler's Green for waste disposal system failures. Surfacing sewage was observed during Stone & Webster's site reconnaissance in June 1995. Since the dates of the information found in the file (March 1996), the leachfield has presumably been replaced (summer 1996) resulting in a functioning wastewater disposal system and the removal of soils that were affected by the disposal of drycleaning waste.

The excessive streambank and streambed erosion seen from Warren Village downstream is in part due to past gravel excavation and flood events as well as development encroachments and removal of riparian vegetation.

The Warren wastewater system is a septic tank-leachfield system with the leachfield located at Brooks Field near the Warren Elementary School. This site at Brooks Field formerly had the leachfield for just the Pitcher Inn but it was expanded to the present permitted capacity (the system is sized at 30,000 gallons) to handle systems from Warren village. Most of the connections from the village occurred in 2004 and 2005. Consultants are collecting data on the system and the effluent and if they can show compliance with the Aquatic Permitting Crietera of the Indirect Discharge Rules then the reserve capacity of the system can be used for new sources of sewage.

Clay Brook

Clay Brook begins on the slopes of Lincoln Mountain between Lincoln Peak to the south and Cutts Peak to the north. Rice Brook and several unnamed tributaries join Clay Brook before its confluence with the Mad River.

The macroinvertebrate community at sites on Clay Brook from 1991 through 2006 (8 samples) has been either fair or poor. Specifically the macroinvertebrate assessments were as follows: at rivermile 1.8, "fair" in 1991 and 2005; at rm 2.0, “good-fair” in 2006; and at rivermile 2.3, "poor" in 1991, "fair" in 1992, "poor in 1996, "fair" in 2000, "fair" in 2005, and "good-fair” in 2006. Rivermile 1.8 is located above the Rice Brook confluence about 50 meters; rm 2.0 is located below a proposed leachfield for Sugarbush; and rm 2.3 is located 50 meters above Inferno Road bridge and below a small maintenance shed.

Rice Brook

Rice Brook originates on the southeastern slope of Lincoln Mountain in Warren and flows southeasterly to Clay Brook. Rice Brook measures about 1.3 miles on the USGS topographic map.

The macroinvertebrate community on Rice Brook has been sampled extensively from 1993 to the present at five sites:

Table 8. Macroinverbrate sampling results on Rice Brook 1993 – 2004.

	Rm 0.3	Rm 0.4	Rm 0.6	Rm 0.7	Rm 1.1
1993	poor	poor	fair	poor	fair
1994	poor	poor	poor	fair	fair
1995	fair	poor	fair	poor	fair
2000	fair	fair	fair	fair	fair
2001	fair	fair	fair	good	good
2002	good/fair	fair	fair	fair	fair
2003	good/fair	fair	fair	good/fair	good/fair
2004	----	----	----	good	----

The Clay/Rice Brook Watershed stormwater project included an investigation of the sources of erosion and stormwater in the watershed and construction of mini-timber crib dams and rock dams on three small streams to control erosion and sediment transport. A report on the project was finalized in June 1998. The abnormally heavy rains of the summer of 1998 really tested the structures which held despite major damage to the upland streams and the Mad River itself. The conclusions and recommendations from the study and project are well-stated and need follow-up: "...erosion control measures must be applied in all areas of the watershed where stormwater channelling occurs. This means revegetating or otherwise armoring all vulnerable exposed areas, from driveways and ditches to large parking lots and roads... The only way to do this, it seems, is to gain everyone's cooperation in developing and implementing a watershed stormwater and erosion control management plan... We must also pay attention to new development to ensure that the current situation is not being aggravated by increasing or redirecting stormwater flows."

Chase Brook

Chase Brook begins on the southeastern slopes of Stark Mountain and flows generally easterly (primarily east and northeast flow) to join with Mill Brook, which then flows to the Mad River. Chase Brook is approximately three miles long measured from the USGS topographic map with the blue line starting at about 2700 feet.

The macroinvertebrate community health on the Chase Brook site 1.2, which was sampled in September 1993 and 1994 and then in September 1998 had been rated fair. The brook had a low density of organisms and a high percentage of Oligocheata indicating “a continued chronic problem with bacteria laden organic silt." The source of the problem was identified as parking lot drainage at Sugarbush. In the late 1990s, Summit Ventures NE of the the Sugarbush Resort re-graded the gravel parking lots at Sugarbush North base lodge, which included drainage through grass islands and sediment traps, and increased the buffer width to Chase Brook. In 2000, the macro-invertebrate community at this same site was in "very good" condition and in 2002, it was in "good" condition. In the 2004 303d list preparation process, this stream was removed. In 2006, the macroinvertebrate community at rm 1.2 was still "good".

Slide Brook

Slide Brook originates on the slopes of Lincoln Mountain below Cutts Peak. It flows north-easterly and then northerly for about 2.4 miles to join Chase Brook. As described above, Chase Brook flows to Mill Brook, which enters the Mad River in Irasville.

Slide Brook's macroinvertebrate community at rivermile 0.7 was rated as good in 1991 but fair at the same site in 1993. Both years it was near the fair/good line. Again parking lot runoff was implicated and the situation has now been corrected. In 2000, the sample from the same site was in "excellent" condition and in 2002, it was in "very good" condition. This stream was also removed from the 2004 303d impaired waters list.

Other Tributaries to the Mad River

There was macroinvertebrate sampling on Shepard Brook, Dowsville Brook, Dowsville Tributaries #1, #5, #7, and Kewvasseur Brook in the last 8 years.

Shepard Brook was sampled at rivermile 5.7 in 1995 and the community was assessed as "good" and it was sampled at rm 4.3 in 2005 and had an excellent-very good macroinvertebrate community.

Kewvasseur Brook was sampled in 2000 and the macroinvertebrate community was "good" at rivermile 2.4 and "excellent" at rivermile 2.5.

Dowsville Brook at rivermile 1.0 was "excellent" in 1995; at rivermile 3.3 was "good" in 1995; at rivermile 3.4 was "excellent" in 1996 and "good" in 1997. Dowsville trib#1 at rivermile 1.7 was "fair" in 1997. Dowsville trib #5 at rivermile 0.3 was "good" in 1995 and "good" in 1996. Dowsville trib #7 at rivermile 0.1 was "good" in 1995. Dowsville Brook trib #11 at rivermile 0.1 was "excellent" in 1996 but "fair" in 1997.

The macroinvertebrate community in Bradley Brook was sampled in 2006 at rm 1.7 and was assessed as "good-fair".

E. coli sampling in 2004, 2005 and 2006 by the Mad River watershed group found the following geometric means and then the number of samples above standard out of the total number of samples (in parentheses) on tributaries to the Mad River:

Table 9. E. coli sampling results on Mad River tributaries 2004 to 2006.

Site	2004	2005	2006
4 - Freeman Brook	12 (1/6)	23 (1/6)	35 (2/6)
4.5 - Freeman Brook (up)	6 (0/6)	17 (1/6)	35 (1/6)
6 - Bradley Brook	10 (1/6)	21 (0/5)	18 (1/6)
8 - Clay Brook	17 (1/6)	17 (0/6)	31 (1/6)
10 - Folsom Brook	17 (1/6)	45 (1/6)	8 (1/6)
10.6 - North Branch Folsom Brook	6 (0/6)	19 (0/6)	11 (1/6)
10.7 - South Branch Folsom Brook	10 (1/6)	63 (2/5)	49 (2/6)
11 - Rice Brook	9 (1/6)	8 (0/6)	7 (1/6)
12 - Clay Brook (Inferno Road)	6 (1/6)	7 (0/6)	14 (1/6)
13.1 - Slide Brook	21 (1/6)	5 (0/5)	23 (1/6)
16 - Chase Brook	5 (1/6)	5 (0/6)	14 (1/6)
17 - Mill Brook	13 (1/6)	10 (0/6)	24 (1/6)
17.1 - Mill Brook	30 (1/6)	11 (0/4)	15 (1/6)
18.1 - Mill Brook	30 (1/6)	11 (0/6)	35 (1/6)
20.1 High Bridge Brook	22 (1/6)	17 (2/6)	10 (2/6)
22 Pine Brook	17 (1/6)	14 (1/6)	16 (2/6)
24 Shepard Brook	20 (2/6)	60 (3/6)	24 (1/6)
25 Dowsville Brook	28 (2/6)	16 (1/5)	30 (1/6)
27.1 Doctors Brook	28 (1/6)	35 (2/6)	71 (2/6)
28.05 Welder Brook	65 (3/6)	53 (3/6)	135 (4/6)

The 3.5-mile Austin Brook in Granville was visited in November 2000 by Vermont DEC staff. This stream begins high in the mountains in the Green Mountain National Forest and flows northeasterly to finally meet the Mad River. The stream was described as a clear, cold, boulder-cobble stream in a forested setting. No problems or threats were noted: to the contrary, it was described as "beautiful."

Lockwood Brook, a tributary to Slide Brook described above, in Fayston and Warren was also visited in November 2000 and the water was clear and cold, the riparian area was forested and no bank erosion or other problems were noted.

High Bridge Brook was visted in October 2000 by a DEC staff person. The lower part of the brook looked good - clear, cold water, forested land adjacent, no obvious impacts. Further upstream, however, the brook flows through pasture land and the water temperature was 11°F higher and sediment was present on the channel bottom. This stream should be re-visited and perhaps sampled.

Welder Brook was visted in October 2000 by a DEC WQ staff person. No direct impacts were noted, however, encroachment of houses and lawns and the close proximity of a gravel road in stretches were cited as threats. A beaver dam and small cascades and gorges were also noted.

River and Stream Assessment Summary Mad River watershed

Impaired Miles
Clay Brook: 2.3 - above Inferno Road down to mouth - aquatic biota/habitat and aesthetics impaired due to sedimentation and iron deposits due to erosion from construction activities, ski area gravel parking lot and increased stormwater flows and changed watershed hydrology from ski area-related land development

Rice Brook: 1.1 - aquatic biota/habitat impaired from sedimentation and physical habitat changes due to surface runoff and land development.

Dowsville Brook Tributaries (1 & 11): 0.7 (0.2 on trib 1 & 0.5 on trib 11) - aquatic biota/habitat and aesthetics impaired from sediment and watershed hydrology changes due to heavy logging and a logging road in the watershed.

Mad River: 6.2 - from the mouth to Ward Clapboard Mill in Moretown - contact recreation impaired due to pathogens from failing septic systems

Altered Miles
Slide Brook: 0.8 - from the confluence of Chase and Slide Brooks downstream on Slide - aquatic habitat altered due to flow alterations from a snowmaking water withdrawal.

Mill Brook: 2.1 - from Slide Brook confluence downstream - aquatic habitat altered due to flow alterations from a snowmaking water withdrawal.

Stressed Miles

Mad River: 9.5 - from the mouth to Warren (overlaps with 6.2 miles above) - aquatic habitat, secondary contact recreation (fishing) stressed due to habitat alterations, temperature and sedimentation from loss of riparian vegetation, streambank erosion and past gravel mining, current instability.

Little River Watershed

General Description

The Little River begins where Sterling Brook and Moss Glen Brook join in the northern part of the town of Stowe. Flowing south and southwesterly, the river soon meanders through a large wetland complex that is largely shrub swamp. It winds to and through the village of Stowe where the West Branch of the Little River joins it.

The West Branch is a substantial stream in and of itself. It begins on the eastern slopes of Mt. Mansfield and flows for 10 miles draining a 29 square mile watershed before joining the Little River in Stowe Village. Ranch Brook and Peterson Brook are two of the West Branch's main tributaries.

Below the West Branch confluence, the Little River is much larger. It flows southwesterly from this junction and then turns abruptly to the west for about a mile, makes another large turn, and flows southwesterly again soon leaving Stowe and flowing into the town of Waterbury. Gold, Barrows, and Miller Brooks join the Little River in this stretch.

Downstream of the Stowe/Waterbury town line, the Little River flows into the impoundment that is the Waterbury Reservoir. The reservoir dam is being re-built at the time of this writing. Cotton Brook and Stevenson Brook flow into the reservoir from the west.

From the Waterbury Dam, an Army Corps of Engineers structure, the Little River flows another two and a half to three miles entering the Winooski River just downstream of the village of Waterbury.

Uses and Values

Waterfalls, Cascades, and Gorges

The Waterfalls, Cascades and Gorges of Vermont report describes three gorges or falls in the Little River watershed in Stowe: Sterling Brook Gorge, Bingham Falls, and Moss Glen Falls II. The Sterling Brook Gorge is set in a wooded mountainous area and consists of a series of falls, cascades, and pools. The largest pool is approximately 15 by 25 feet wide and five to six feet deep. The use is largely by local people.

Bingham Falls on the West Branch of the Little River is a site with dramatic and beautiful falls and a deep pool for swimming. There are ledges and rocks lining the pool for good jumping. Because of its 20-foot falls, sculptured rocks, undeveloped site, clean water, and heavy use, this site rated "highest significance" by the authors of the swimming hole study.

Moss Glen Falls II on Moss Glen Brook in Stowe is a well-known, very beautiful and heavily-visited site. It consists of a deep, narrow gorge then a 20-foot falls with pool below then a 100-foot long cascade and then another 20-foot falls. It is a scenic and dramatic feature and is good for picnicking and bathing. The site is a state natural area.

Swimming
The Vermont Swimming Hole Study describes the three sites in Stowe discussed above as well as a fourth site in Stowe known as Fosters. Fosters is on the West Branch of the Little River about a mile below Bingham Falls. There is a nice pool on the bend of the river that is about 30 by 40 feet in area and 15 feet deep.

Fishery/Fishing
On the Little River mainstem, there are wild brook trout in the higher elevations and wild brown and rainbow trout below confluence with West Branch. The river above the reservoir provides spawning habitat for migrating brown trout, rainbow trout, rainbow smelt and other species. Downstream of Waterbury Dam, the river supports wild brown and rainbow trout. The populations are limited by regular and extreme flow and temperature fluctuations associated with the hydroelectric release.

On the tributaries to the Little River: the West Branch has wild brook trout above the confluence with Ranch Brook and wild brook trout and brown trout below; Ranch Brook has wild brook trout and has wild brown trout in the lowest reaches; Moss Glen and Sterling Brooks have wild brook trout; Gold Brook has wild brook, brown and rainbow trout; and Miller Brook, Cotton Brook and Stevenson Brook have wild brook trout, brown trout and rainbow trout and serve as spawning habitat for migrating brown trout, rainbow trout, rainbow smelt and other species from Waterbury Reservoir in lower reaches.

Specific Rivers and Streams

Gold Brook
Gold Brook originates on the west slope of the Worcester Mountains and flows westerly for about 5 miles to join the Little River downstream of Stowe village.

The macroinvertebrate community was sampled on Gold Brook at rivermile 0.4, which is about 100 feet above the Route 100 bridge over the brook off of Gold Brook Road. The sampling found the density moderate and richness and EPT high. The biotic index value and EPT/EPTc ratio indicated "slight enrichment stress."

Stevenson Brook
Stevenson Brook originates on the slopes of Ricker and Woodward Mountains (the peaks are on the Bolton/Waterbury line) and flows southeasterly through forest into Waterbury Reservoir.

Fish sampling on Stevenson Brook at rivermile 0.4 found a community in "very good" condition in 2000 and "excellent" condition in 2001 and 2005. Macroinvertebrate sampling on the Little River at rm 0.7 in 2000 resulted in a community assessment of "good-fair."

Miller Brook
Miller Brook begins at the outlet of Lake Mansfield, an artificial lake owned by the Mt. Mansfield Trout Club. The brook winds down the mountain valley flowing through several

beaver wetlands. It flows into the Little River just upstream of Waterbury Reservoir. A microburst in Nebraska Valley in July 2004 sent a surge of water down Miller Brook to the Little River. Culverts were unable to handle the water and sediment and blew out. Road erosion and runoff contributed to damage. Site visits of Miller Brook in May 2006 noted additional eroding banks and new material on point bars. Excessive grading on a town road has resulted in gravel pushed and washed into tributaries to Miller Brook.

West Branch Little River

The West Branch Little River begins on the eastern slopes of Mount Mansfield and flows easterly for just over three-quarters of a mile. It then turns south and flows down the narrow valley that begins at Smugglers Notch. As it flows south-southeasterly, Sterling Pond Brook enters from the east; Ranch Brook joins from the west; and the Peterson Brook joins from the northeast. The West Branch joins the Little River mainstem in Stowe village.

The West Branch of the Little River Corridor Management Plan, Stowe, Vermont summarizes the West Branch situation well. "Beginning in June of 2005, fluvial geomorphic assessments of the West Branch, using Vermont Agency of Natural Resources protocols, were conducted by the Lamoille County Planning Commission and Bear Creek Environmental...These assessments concluded that the West Branch is undergoing active adjustment processes. On the majority of the West Branch, historic down cutting has lowered the elevation of the river bed leaving the floodplain inaccessible. As a result, high flows that would normally access the floodplain are contained within the channel; causing extensive bank erosion, channel widening, loss of aquatic habitat, and general channel instability. Highly erodible soils are a major contributor to these dynamics of the channel adjustment process. In an attempt to control this erosion, bank armoring (rip-rap) was employed on the West Branch. Bank armoring, however, led to further instability in the system. Also, there are many encroachments to the river corridor from residential and commercial development, as well as roads and the Stowe Recreation Path. The result is a decreased amount of area [for] creation of a lower floodplain."

The Phase 2 Stream Geomorphic Assessment on the West Branch of the Little River, done in 2005, focused on six reaches from the West Branch confluence with the Little River upstream to the mouth of Ranch Brook. The six reaches were divided into nine segments during the assessment. The results of the rapid habitat assessment (RHA) were seven segments in fair condition and two segments in poor condition. The rapid geomorphic assessment (RGA) found six segments in fair condition and three segments in poor condition.

According to the data from Vermont Dept. of Fish & Wildlife, trout population levels decline as one proceeds down the watershed, particularly below their Station 30 (above the confluence with Peterson Brook). The trout populations at Stations 20 and 30 are considered on the low side for upland brook trout streams even though physical habitat looks good. Limited flow is probably having its effect at these sites. At the two lowest stations (Station 40 and 50), flow as well as sedimentation, wide shallow channels, unstable streambanks, and a lack of riparian vegetation all affect the physical habitat for trout. Elevated water temperatures are also probably limiting the trout population.

Macroinvertebrate sampling has occurred at 10 sites over the last ten plus years on the West Branch. Rivermile (rm) 6.5 is immediately above the confluence of Pinnacle Brook; rm 7.2 is downstream 200 meters from a stormwater/snowmaking pond; rm 7.5 is just below Stowe Mountain Resort's parking lot; rm 8.0 is located below confluence with Longtrail Tributary, above the stormwater discharge from Stowe parking lot baselodge. A fuel oil spill in 2003 got into the storm drain and into the West Branch in 2003 on this stretch.

Table 10. Macroinvertebrate sampling results from the West Branch Little River

	1997	1998	2000	2001	2002	2003	2004	2005	2006
Rm 1.9	---	good	---	---	---	---	---	---	---
Rm 3.1	fair	---	---	---	---	---	---	---	---
Rm 3.7	good	---	---	---	---	---	---	---	---
Rm 4.2	exc	---	---	---	---	---	---	---	---
Rm 6.5	---	---	good	---	good	fair-poor	good-fair	vgood	fair
Rm 7.2	---	---	---	---	---	---	---	---	good
Rm 7.5	---	---	fair	fair	good-fair	poor	fair	fair	---
Rm 8.0	---	---	---	---	---	vgood-good	---	good-fair	---
Rm 8.3	---	---	good-fair	fair	good	---	---	---	---
Rm 8.8	---	---	---	---	good	---	---	---	---

A stream water supply withdrawal exists on the West Branch Little River below Notchbrook Condos but the strength of its contribution to impacts, if any, is not known.

Inn Brook

Inn Brook is a small stream that begins on the lower slopes of Mount Mansfield and flows easterly for about one-half mile and then southerly for another 1.3 miles into Ranch Brook. Where the stream flows south, it is along the Mountain Road of Stowe.

Macroinvertebrate sampling results from Inn Brook were assessed as follows: at rm 0.3, "poor" in 2000 and "fair" in 2001; at rm 0.6 "poor" in 2000, 2001, 2005, and 2006; and at rm 0.7, "fair" in 2006. There are moderate levels of iron and manganese in the water column. There is also heavy iron precipitate on channel bottom at the rm 0.6 site, which is below a pond and a culvert that carries the stream under a parking lot. Rm 0.7 site was set up to be a control although it appears to have its own issues because the assessment there was fair.

Ranch Brook

Ranch Brook headwaters begin near the ridgeline of Mount Mansfield and come together to flow easterly as Ranch Brook at around 1900 feet elevation. Ranch Brook flows east for about 3.5 miles into the West Branch Little River. Ranch Brook is a clear, high gradient reference stream and has many small cascades.

Macroinvertebrate sampling results from Ranch Brook were assessed as follows: at rm 1.5, "very good" in 2000, "excellent" in 2001, "excellent-very good" in 2002, "very good" in 2003, "excellent" in 2004, "excellent" and "very good" in 2005 (there were two September

sample dates - the second after a large storm to look at the impact to macroinvertebrates post-storm in a reference stream), and "very good" in 2006. The site at rm 1.5 is below the first bridge crossing in Mansfield State Park.

Other Streams

Macroinvertebrate sampling results from Pinnacle Brook were assessed as follows: at rm 0.2, "excellent" in 2000; "good" in 2003; "very good-good" in 2004; and "very good-good" in 2005. An assessment done at rm 1.3 in 2005 found a "good" community.

Macroinvertebrate sampling results from Longtrail Tributary were assessed as follows: at rivermile 0.1, "good-fair" in 2000.

Macroinvertebrate sampling results from Little River were assessed as follows: at rivermile 10.3, "good" in 1996.

Macroinvertebrate sampling results from Big Spruce Brook were assessed as follows: at rm 0.2, "fair" in 2000, "good-fair" in 2003, "fair" in 2004, and "fair" in 2005. The site at rm 0.2 is located above the confluence with the West Branch Little River about 100 meters and below the Little Spruce Brook trib.

Macroinvertebrate sampling results from Little Spruce Brook were assessed as follows: at rm 0.2, "fair" in 2003.

Sterling Brook was identified in 1988 as 1 of 18 most sensitive streams to acid impacts due to medium to no buffering capacity, low alkalinity and pH.

River and Stream Assessment Summary Little River watershed

Impaired Miles

Inn Brook: from rm 0.3 to 0.6 - aquatic biota/habitat and aesthetics impaired due to iron from land development/disturbance

West Branch Little River: 0.3 - from rm 7.5 to about rm 7.2 - aquatic biota/habitat impaired due to sedimentation from land development (ski resort), development runoff.

Little River: 0.8 - below GMP hydro (below Waterbury Reservoir)(subset of 2.6 miles below) - aquatic biota/habitat impaired due to low D.O. from hypolimnetic withdrawal.

Altered Miles

West Branch Little River: 5.8 - from mouth upstream to Ranch Brook confluence - aquatic habitat, secondary contact recreation and aesthetics altered due to steambank erosion, land development, watershed hydrology changes, stream channel manipulation, floodplain encroachment, floods, streambed degradation and stresses in this same stretch to same uses from sedimentation, temperature from loss of riparian vegetation, developed land runoff.

West Branch Little River: 8.0 - below ski area water withdrawal point (just downstream of the State Ski dormitory)(overlaps with the 5.8 miles above) - aquatic biota/habitat altered due to artificial and insufficient flows from snowmaking water withdrawals.

Sterling Brook: 0.8 - below Smuggler's Notch snowmaking withdrawal - aquatic biota/habitat altered due to low flows due to ski area snowmaking.

Little River: 2.6 - below GMP hydro - aquatic biota/habitat, fishing, aesthetics due to low and fluctuating flows below GMP hydroelectric facility.

Little River: 2.0 - below confluence with West Branch (subset of 5.5 miles below) - aquatic biota/habitat due to snowmaking water withdrawal up on West Branch.

Stressed Miles

West Branch Little River: 0.8 - from rm 7.5 upstream about 0.8 miles - aquatic biota and habitat stressed likely due to springtime pH shock and some sedimentation - needs further sampling and investigation.

Big Spruce Brook: 0.3 - mouth upstream about 0.3 miles - aquatic biota and habitat stressed due to sedimentation, turbidity, hydrologic modification and acidification.

Little Spruce Brook: 0.1 - mouth upstream - aquatic biota and habitat stressed due to sedimentation, turbidity.

Longtrail Tributary: 0.1 - mouth upstream 0.1 miles - aquatic biota and habitat stressed due to sedimentation, acidification.

Sterling Brook: 7.0 - aquatic biota/habitat and secondary contact recreation stressed due to low alkalinity conditions and acidity from atmospheric deposition.

Little River: 5.5 - from confluence of West Branch downstream to reservoir - aquatic habitat at least stressed due to upstream land development, watershed hydrology changes and West Branch channel instability/erosion

Gold Brook: 5.0 - from headwaters to mouth - aquatic habitat, secondary contact recreation (fishing), and aesthetics stressed due to siltation, turbidity, habitat alteration from rapid land development, poor erosion controls, recreational gold mining at least in the past.

Huntington River Watershed

General Description

The Huntington River mainstem is approximately 21 miles long and drains a watershed of about 66 square miles. It begins with upland streams that flow down the western slopes of the Stark Mountains in Buels Gore and join the northerly flowing Huntington River in Starksboro. Continuing north, Stave, Beaver Meadow, and Bakers Brooks also flow off the western slopes of the mountains and meet the Huntington River in Starksboro.

The river continues north into the town of Huntington. Jones Brook and Cobb Brook join from the east; Carpenter Brook joins from the west; and Brush Brook enters from the east below Huntington Center. The river winds northerly still with Hollow Brook joining from the west and a number of unnamed brooks coming in from the east and west. The river winds into Richmond and shortly begins a northeasterly flow and continues in this general direction until it meets the Winooski River at Jonesville.

Uses and Values

Waterfalls, Cascades, and Gorges

Waterfalls, Cascades and Gorges of Vermont describes two sites on the Huntington River. Huntington Gorge is a well known site not only for its carved rocks and potholes, spectacular beauty, great swimming, and popularity as a gathering spot but also for the danger at the upper part of the gorge where a number of people have drowned. The lower part has a beautiful pool and good swimming and sunning opportunities. It is a very significant recreational site. Seven Falls of the Huntington is on a stretch of the Huntington River in Starksboro where it is only ten to fifteen feet wide. The site consists of small falls (two to three feet high) and small pools in a series. The WC&G report describes it as a “pretty place” and “an attractive local stream”.

Swimming

The Vermont Swimming Hole Study describes seven swimming holes on the Huntington River, two of which are already mentioned above. Seven Falls of the Huntington, also known as Hanksville Potholes, is considered state significant for its cascades and gorge as well as for its clean water and natural setting. The pools and potholes are generally five feet deep or less so there is more bathing and wading but some limited swimming.

The Hanksville Swimming Hole is a small swimming hole downstream of Seven Falls that is locally popular with families. It is located on the Huntington between Hanksville and Huntington Center. It has a 5-foot deep, 20 by 40 foot pool with a small ledge on one side.

The Horseshoe Bend Swimming Hole is further downstream of the two Hanksville swimming spots mentioned above and near a parking area for the Audubon Center trails. It has two pools upstream and downstream of rivershore ledge that protrudes into the river. It has good swimming and is locally important.

Downstream still, the Audubon River Trail Swimming Hole or Audubon Hemlock is on a wooded bend in the river a few minutes in from the road on Audubon Center trails. There is a sand beach, a 3-foot ledge on the other side of the river, and a 3 to 4-foot deep pool adjacent to the ledge. This is another locally popular spot for families.

A third swimming hole that can be accessed from Audubon Center land is the River Loop Trail Swimming Hole or Lower Audubon swimming hole. It is downstream of the above site and just below the confluence of Hollow Brook. There is a pool that is four to six feet deep, a 6-foot ledge adjacent and a strip of gravel and sand beach.

The seventh swimming area described in the swimming hole study is the Huntington Gorge Cascade Chain, which is directly below Huntington Gorge. There is good bathing throughout the chain and good swimming in the larger pools. There are beaches on the gravel bars, small cascades, and small cliffs (5 to 15 feet high) at the edge of the channel. This area is heavily used.

Boating

The Whitewater Rivers of Vermont Report describes a stretch of the Huntington that starts in Hanksville and ends just before Huntington Gorge. The stretch is about ten miles. The authors compare the Mad River and the Huntington River:

> "The Huntington and the Mad are the two gems of the Winooski watershed. The Huntington is much more rural than the Mad, lacks the Mads gorges and difficult water, but is swift and has more continuous Class II water. It is a great stream for learning or teaching Class II boating. And on an early spring day when the blackbirds have just come and the skiing is turning to slush, it is as perfect a place to be as I can imagine." Jerry Jenkins in the Whitewater report.

The whitewater run ends before Huntington Gorge where obviously it is critical to know the takeout, especially at high water, so one doesn't go into the gorge and kill oneself.

Specific Rivers and Streams

Huntington River

The Huntington Conservation Commission has been sampling the Huntington River and tributaries for 5 seasons and found some instances of elevated and high *E. coli* numbers. Below in Table 11 are the sites they most consistently sampled from upstream to down with the geometric mean of the samples given (and the number of samples on which the mean is based in parentheses).

In 2006, only the Brace Bridge site on the Huntington River had a geometric mean above the state standard of 77 and even so it is barely above (78). The sites that were used to define an impaired stretch in 2005 had low geometric means for the 2006 season and the impaired stretch should be re-evaluated following 2007 data collection. The 2006 data showed a strong relationship between *E. coli* geometric mean and water level (higher water level and higher geometric mean of each site - Figure 3 of the group's report).

Table 11. Sites sampled for E. coli on the Huntington River (2003 to 2006):

	2003	2004	2005	2006
7 Falls	23 (4)	19 (15)	42 (14)	---
Carse Bridge	90 (4)	43 (15)	82 (15)	---
Sheldrake	45 (13)	33 (15)	89 (15)	43 (14)
Brent Field	56 (4)	36 (15)	104 (15)	---
Shaker Mountain	40 (5)	37 (15)	113 (15)	49 (12)
Rec Field	48 (4)	40 (15)	129 (14)	---
Brace Bridge	68 (5)	59 (15)	114 (14)	78 (14)
Spence Bridge	56 (6)	66 (13)	115 (14)	66 (12)
East Street	65 (7)	67 (15)	114 (15)	55 (12)
Bridge Street	115 (12)	60 (15)	129 (15)	57 (14)
Cemetery Bank	162 (4)	76 (13)	167 (13)	55 (14)
Audubon Horseshoe	71 (6)	61 (15)	124 (14)	65 (13)
Audubon Hemlock	95 (14)	60 (15)	115 (15)	59 (14)

The Huntington River Conservation Commission extended the scope of Huntington River sampling in 2006 to include 7 sites in Richmond and Richmond volunteers and so the study is now a two town effort. The data from the June 20 to September 19 2006 sampling is included in the report produced by the group, but not yet shown above because there is only one season's data. Of the seven Richmond sample sites on the Huntington River, Dugway West and Yaggy sites had geometric means for the season that were above the 77 state standard although both were below the federal standard of 126.

In 2005, the Commission also measured temperatures and determined conductivity at two sample sites on each of the 15 sampling dates. On August 3 and 10, the water temperatures at Bridge Street were 24.8° and 22.1°C respectively and at the Horseshoe Bend site, it was 27.5°(!) and 21.5°C respectively.

The Huntington River was sampled for macroinvertebrate community health and integrity at rm 10.6 in September 2000 and was assessed as "very good." The fish community was also sampled in September 2000 but at rm 0.7 and rm 5.8. The community was assessed as "excellent" and "very good" respectively.

A Phase 1 geomorphic assessment of the Huntington River mainstem and fourteen tributaries was done in the winter and spring of 2005. The Huntington and the tributaries studied were divided into 118 stream reaches total. Of these, 24 stream reaches were given an overall assessment of "fair" condition. Eight of the reaches that were fair were on the Huntington mainstem and 16 were on the tributaries of Texas Hill Brook, Fargo Brook, Hollow Brook, Johns Brook, and Owls Head Brook.

A Phase 2 geomorphic assessment was done on the Huntington River mainstem reaches labelled M06 through M15 during the Phase 1 assessment. These comprise a stretch of the river approximately 9.7 miles long from Hanksville downstream to the Richmond-Huntington town line. The Phase 2 work was completed in fall 2005 and some of the Phase 1 reaches were divided further into segments. Of the fourteen Phase 2 segments assessed, thirteen segments were considered to be only in “fair” condition and only M09-C was considered “good” based on the rapid geomorphic assessment results. Some reaches that were considered good during the Phase 1 assessment became “fair” after more detailed work. Thirteen of the fourteen segments were also rated as in "fair" condition using the rapid habitat assessment, however, twelve of the fourteen segments had both the RGA and RHA as “fair”. Segment M09-C had a “good” RGA and Segment M15-B had a “good” RHA.

There is no information about the wastewater and water supply systems at Roberts Trailer Park on the Huntington River upstream of Bridge Street in Huntington. According to a page from a Mobile Home Park Inventory dated February 23, 1973, this park had three sites listed in 1970 and 19 in 1973. In 1973, two of the 19 sites were owned by the occupants so Roberts had 17 site occupants renting lots. An undated but later Mobile Home Park List stated that the Roberts Trailer Park doesn't have any permits and, according to the town clerk, each mobile home owner owns his own lot. The park was sold to an attorney. Investigation of the status of the septic systems might be warranted depending on the *E. coli* sampling results of the next sample year at the Bridge Street site.

River and Stream Assessment Summary Huntington River watershed

Impaired Miles
Huntington River: 0.5 - from Bridge Street in Huntington downstream to Cemetary Bank sample site - contact recreation impaired due to elevated to high levels of E. coli - source possibly failed septic systems, domestic animals, other.

Stressed Miles
Huntington River: 6.7 miles - from Carse Bridge in Hanksville downstream to Bridge Street in Huntington - contact recreation stressed due to elevated to high levels of E. coli - source unknown.

Huntington River: 2.3 - Cemetary Bank sample site through Audubon sample sites - contact recreation and aquatic habitat stressed due to elevated to high levels of E. coli (source unknown) and at times high water temperatures.

Huntington River: 9.7 miles - from Richmond/Huntington town line upstream to Hanksville - aquatic habitat stressed due to habitat alterations from loss of riparian vegetation, channel straightening, gravelling all causing channel instability.

Middle Winooski River Watershed

General Description

From the Stevens Branch mouth in the town of Berlin, the Winooski River flows through the City of Montpelier where it is confined and lacks most of its riparian vegetation. Just downstream of Montpelier below the interstate crossing, the Dog River enters from the south. See the Dog River watershed description above.

The Winooski River continues northwesterly first forming the Middlesex/Berlin border and then the Middlesex/Moretown border. Below Middlesex village, the river goes through Middlesex Gorge, a deep gorge flooded by a hydroelectric dam. Just below the gorge, the Mad River joins the Winooski from the southwest. See the Mad River watershed description above.

The Winooski River continues northwesterly still forming the Waterbury/Moretown and the Waterbury/Duxbury borders. First the four-mile long Crossett Brook and its tributaries from the south then the ten-mile long Thatcher Brook and its tributaries from the north then the large Little River watershed also from the north all add their flow to the Winooski River. A separate Little River watershed description is on previous pages.

Specific Rivers and Streams

Mid-Winooski River

Macroinvertebrate sampling on the upper Mid-Winooski River yielded the following results: at rivermile (rm) 42.7 in September 2000, the community was "good"; at rm 44.6 in June 1997, the community was "good-fair"; at rm 47.2 in October 2000, the community was "good"; and at rm 55.7 in October 2000, the macroinvertebrate community was "very good".

On the Mid-Winooski mainstem from the Stevens Branch mouth to the Little River mouth, there is a mix of wild brown trout and rainbow trout with supplemental stockings of brown trout. The populations vary in abundance with local habitat conditions which vary widely in this reach. The large size of the river limits direct population sampling, although angler creel surveys were conducted in 1999. Several dams, including Middlesex dam, fragment and degrade habitat within this reach. Waterbury Reservoir hydroelectric releases result in dramatic flow and temperature fluctuations.

The Cumberland Farms site (DEC site #99-2692) and the former Utton's Muffler site (DEC site #96-1953) are now one hazardous waste site under Cumberland Farms. Groundwater is sampled four times a year and most recently, in July 2006, five of eight wells were sampled. Two of the eight were not sampled because separate phase hydrocarbons were present in the wells and a third well had insufficient water. Volatile organic compounds were above the Vermont Groundwater Enforcement Standards (VGES) in 2 of the wells, MW-4 and MW-1UT. In MW-4, benzene, toluene, ethylbenzene, 1,3,5 trimethylbenzene, 1,2,4 trimethylbenzene, naphthalene, and MTBE were, in most cases, orders of magnitude above the standard.

The two wells with samples above VGES are between the site and U.S. Route 2/Berlin Street with the Winooski River on the other side of the road. An August 11, 2006 work plan approval from Vermont DEC calls for installing another monitoring well on the eastern or river side of Route 2 to test the likelihood of these compounds getting to the river and at what concentration.

Petroleum contamination at the Walker Motors hazardous waste site (DEC site #2003-3108) was discovered during removal of a fuel oil underground storage tank next to the autobody shop in April 2003. A separate contamination plume was found adjacent to the parts department of the main facility during removal of a second fuel oil tank. Some soil has been excavated from the area north of the autobody shop and monitoring wells are in place and sampled quarterly.

Ten groundwater monitoring wells were sampled in September 2005. The VGES were exceeded for one or more petroleum-related compounds in six of the ten wells: three wells near the parts department, two wells near the autobody shop soil excavation area; and one well in the swale between Route 2 and the railroad tracks toward the Winooski River from the site.

Twelve groundwater monitoring wells were sampled in December 2005. VGES were exceeded for one or more petroleum products in six of the twelve wells. All six wells were onsite: off-site monitoring wells MW-15 and MW-19 had no VOCs detected. No VOCs were detected in surface water samples, SW-1 and SW-2, collected along the swale and railroad tracks downgradient of the site across Route 2 towards the Winooski River.

Montpelier's Gateway Park along the Winooski River near the mouth of the Dog River and under the interstate bridge provides a canoe launch area and a picnic/rest spot along the middle Winooski River. It also provides access for the crane that loosens ice jams in attempts to prevent Montpelier from flooding. A successful effort to prevent flooding occurred in spring 2007.

Crossett Brook

Crossett Brook is a four mile long stream that flows generally east down from Crossett Hill and then turns north to continue into the Winooski River. There are several tributaries to the stream that is labelled Crossett Brook on the USGS maps that look as if they should have been the named brook because of their greater lengths. All together the streams of the Crossett Brook watershed total approximately 13 miles.

Crossett Brook in Duxbury was sampled for macroinvertebrate community health in 1995 at rivermile 3.8 and was found to be in excellent condition. A tributary to the brook was sampled in 2000 at rivermile 0.1 and was assessed as “fair”. There should be more sampling at this tributary and an evaluation of upstream conditions if the brook's size warrants more information.

Crossett Brook has wild rainbow and brown trout.

Thatcher Brook
Thatcher Brook has been sampled at three sites over the last 10 years. At rivermile 0.1, just below the Route 2 bridge, the macroinvertebrate community was in "good" health and the fish community was assessed as "very good" in 1997; the macroinvertebrates were "very good" in 2000 and the macroinvertebrates were "good" and the fish "very good" in 2005. At rivermile 0.6, off Stowe Street, just south of the I-89 overpass, the macro-invertebrates were "very good-good" in 2005. At rivermile 5.3, at first bridge above Waterbury Center, both the bug and fish community were assessed as "good" in 1997.

A set of falls are on Thatcher Brook just before the brook comes under the interstate at the edge of downtown Waterbury. A grist mill was once at the edge of the brook by the waterfall. Thatcher Brook has wild brook trout above the falls and wild brook, brown and rainbow trout below the falls.

Graves Brook
Graves Brook was sampled in 2000. The macroinvertebrate community was assessed as "good" at rivermile 0.1 but the fish community as this same location was assessed as "poor". The stream has heavy sedimentation at least at this lower site and will run turbid with a light rain. In 1999, it stopped flowing for a little while for the first known time and hence part of the poor assessment for fish. The sedimentation and turbidity also affects the fish community though.

Jones Brook
The macroinvertebrate community in Jones Brook was sampled in 2000 at rivermile 0.1 and was assessed as "good".

Great Brook
Great Brook in Middlesex was sampled for fish in 2000 at rivermile 0.8 and the community was considered "very good".

Bryant Brook
Bryant Brook in Waterbury Center, which flows south then west into Waterbury Reservoir, was visited at several locations by DEC staff in October 2000. Some turbidity and sedimentation were noted as well as stretches with algae covering the channel bottom. Macroinvertebrate sampling was recommended.

River and Stream Assessment Summary Middle Winooski watershed

Impaired Miles
Winooski River: 2.0 - impoundment above Middlesex #2 dam - aquatic habitat and fishery impaired due to low D.O., habitat alteration, and siltation due to impoundment.

Winooski River: 2.0 - below Montpelier and its CSOs - aquatic habitat, contact recreation, secondary contact recreation, and aesthetics impaired due to nutrients, organic enrichment, pathogens, turbidity from CSOs, urban runoff, streambank erosion.

Altered Miles

Great Brook: 4.2 - from mouth upstream - aquatic life use and non-contact recreation altered due to severe sedimentation and physical habitat alteration from road and culvert washouts, and erosion due to the August 1995 floods as well as from ongoing improper road construction (improper culvert sizes for example) and maintenance and no erosion control during house and road construction.

Tribs to Thatcher Brook (Tyler and Miriam Brooks): 0.1 - all uses altered due to dewatering during part of the summer for Waterbury Village's water supply.

Thatcher Brook: 10.0 - whole length - aquatic habitat altered due to sedimentation and habitat alteration from historic channelization, streambank erosion.

Stressed Miles

Winooski River: 11.0 - all remaining miles (below Middlesex dam and above Montpelier CSO outlets) - aquatic biota/habitat, contact and non-contact recreation, aesthetics stressed due to nutrients, sediments, components of urban runoff, habitat modifications resulting from stormwater runoff, riverbank erosion, channelization, highway, railroad, road confinement of channel.

Lower Winooski River Watershed

General Description

The Lower Winooski River watershed for the purposes of this assessment is the area from the confluence of the Little River with the Winooski River downstream to the mouth of the Winooski at Lake Champlain. The subwatershed described below includes the Winooski mainstem plus any tributary and its watershed except for the Huntington River watershed.

Downstream from the mouth of the Little River, the Winooski flows over the hydroelectric dam at Bolton Falls near the Waterbury/Bolton town line and then below the dam, Ridley Brook and its tributaries join the river from the south. The Winooski continues its northwesterly flow with Pinneo Brook, Gleason Brook, Joiner Brook, Preston Brook, and Duck Brook, among others, converging on the Winooski in the town of Bolton.

The Winooski then flows into Richmond where soon the Huntington River and its mountain tributaries enter. See the Huntington River watershed description in previous pages. Snipe Island Brook from the north and Johnnie Brook from the south also flow into the Winooski in the town of Richmond.

Just past the village of Richmond, the river goes into a wide bend and begins a more northerly track, which it maintains as it flows between Williston and Jericho forming the border of those two towns. Then, where the Winooski forms the Essex and Williston border, the flow, albeit through large meanders, is generally westerly in its course. Within this stretch, from North Williston to the pool of Essex 19 dam, the river deepens and widens. Below the dam is Williston (Essex) Gorge that is 15 to 35 feet deep and 150 to 200 yards long.

The Winooski River between Essex and South Burlington jogs north then south in a relatively tight loop then settles back to a northwesterly flow. It forms the Colchester/ South Burlington border and in this stretch flows through the 700 to 800 foot-long Lime Kiln Gorge. About a half-mile downstream, the river flows through the Winooski Gorge. Here the river forms the Winooski/Burlington border and next the Colchester/Burlington border then loops around Derway Island and into Lake Champlain.

More description of the Lower Winooski River watershed can be found in the report for the *Lower Winooski Basin: An Inventory of Uses, Values and Goals* done by Jerry McArdle of the ANR DEC Water Quality Division in April 1992.

Uses and Values

Waterfalls, Cascades, and Gorges

The Waterfalls, Cascades and Gorges of Vermont report describes nine sites with either falls, cascades, a gorge, some or all of these features. Four of these sites are on tributaries and five of these sites are on the Winooski mainstem.

Duck Brook Falls in Bolton are in a ravine in the mountains near a Long Trail shelter. The site includes about 150 feet of low gradient cascades and then a seven-foot waterfall. It is used a lot by hikers and the clean, cool water is great for bathing.

Devils Pothole is on Joiner Brook in Bolton and consists of a 15-foot waterfall, two sets of cascades, and a large pothole considered “striking”. It is used for bathing and parties. The site is compromised by an overhead powerline, trash in the woods, and view of a trailer park.

Allen Brook Cascades in Williston are 200 feet long and drop a total of 20 feet with some small (one foot across or less) potholes. There are no falls or pools. The stream and cascades are surrounded by houses and commercial buildings so it is not an attractive site but a trail does lead to the water so some people view it at least.

Frazier Falls, which are really large cascades, are located on an unnamed stream in a wooded ravine in Williston. The brook passes through a 5-foot high, relatively narrow rock chute and then drops about 20 feet in a short cascade before it enters a floodplain.

On the Winooski River mainstem, Bolton Falls were once at the end of a large gorge in Waterbury and Duxbury. However, a large hydroelectric dam is now located where the falls once flowed. The current hydroelectric facility, owned by Green Mountain Power, was licensed in 1982 and constructed in 1985-86. It operates as a peak generation facility using the highly managed flows from Green Mountain Power’s upstream facilities in Marshfield and Peacham and at Waterbury Dam. The powerhouse is located at the base of the dam; consequently none of the river is penstock bypassed. Conservation flows are provided as required in the federal license and water quality certification.

Middlesex Gorge is a 1000-foot long gorge with rock walls that are 20 to 60 feet high. There are no falls or cascades because the gorge was dammed shortly before the construction of Bolton Falls Dam, and the upper two-thirds of the gorge is now flooded by the dam. The dam was destroyed by the 1927 flood and then reconstructed. With flashboards in place, the dam backwaters much of the river reach between Montpelier and Middlesex. The hydroelectric station operates on a peak power schedule often using managed flows from Marshfield Station.

The Williston Gorge is a low limestone gorge below a dam and a bridge between Williston and Essex Junction and so its surroundings are urban/suburban. There is a picnic area on the south side of the bridge and trails from there down to the river below the gorge.

Lime Kiln Gorge is a dramatic gorge with near-vertical walls through which the Winooski River itself flows. The walls of the gorge are from 15 to 70 feet high. It used to be a site of a number of rare plants but most haven’t been found here recently.

Winooski Falls in the city of Winooski include cascades over a broad series of ledges upstream of the Route 7 bridge then downstream the river is bordered by limestone cliffs and drops about 20 feet over an old dam. People visit the falls, picnic, or take a trail to fish below the falls. Winooski re-development projects have built views of the cascades

and falls into their plans although unfortunately not adequate riverside tree protection.

Boating
The AMC River Guide Third Edition describes a stretch of boating between Montpelier and Jonesville on the Winooski. In this stretch are 2 portages around the Middlesex Dam and Bolton Falls Dam.

Fishing
There is a lot of fishing use on the lower Winooski River. Durting the spring spawning run, people fish for walleye in the stretch from the Salmon Hole below Winooski Falls to the lake. They also fish for salmon and steelhead in this reach in season. As part of the Lake Champlain salmonid restoration program, a fish trap-and-truck operation was established at the Winooski One Hydroelectric Project (the American Woolen Mill Dam) when that facility was licensed and constructed in the1980s.

Trout fishermen can be seen in the Winooski all the way from Montpelier to Essex using pull-offs along Route 2 to access the river. The Bolton Falls access area is popular for fishing to the point of often being overcrowded.

Smallmouth bass fishing occurs from Essex down to the lake on the Winooski.

Significant Natural Communities

In the Lower Winooski River watershed, there are a number of significant natural communities identified in inventory reports of the Vermont Natural Heritage Program. Following is a brief summary of the floodplain forests, northern white cedar swamps, and hardwood swamps that have been described to date in these natural community reports.

Floodplain Forests
Derway Island in Burlington is not technically an island but it is “almost an island because of the way the river makes a strong loop around the site just before it empties into Lake Champlain.” The ‘island’ is 120 acres of silver maple floodplain forest affected by both the Winooski River’s high waters and Lake Champlain’s flooding. Swamp white oak and green ash are also part of this largely mature forest as is viburnum, wood nettle, sensitive fern, and jewelweed. This is quite a large floodplain forest for Vermont. There is a significant shallow emergent marsh at this site as well.

The Halfmoon Cove site is a large floodplain forest and wetland complex adjacent to the Winooski River and to the Derway Island site. Both sites, although described separately, are a single ecological system formed and maintained by Winooski River and Lake Champlain flooding. The floodplain forest community consists of silver maple and ostrich fern along the river levee and silver maple, green ash, and sensitve fern along small ridges out from the river (remnants of earlier river edges). An alder swamp and other wetland community types are also part of this 300-acre area (both sites combined).

The Route 127 Floodplain Forest grows north of the Winooski River just east of Route 127

although this small site is hydrologically and ecologically connected to the larg floodplain forest and wetland complex to the west at Halfmoon Cover. This 15-acre forest has 130-foot tall cottonwoods overtopping a closed canopy of silver maple and green ash that are about 100 feet tall. Five foot plus high ostrich fern and wood nettle dominate the understory and groundcover. A rare plant, rough avens, is present in the forest.

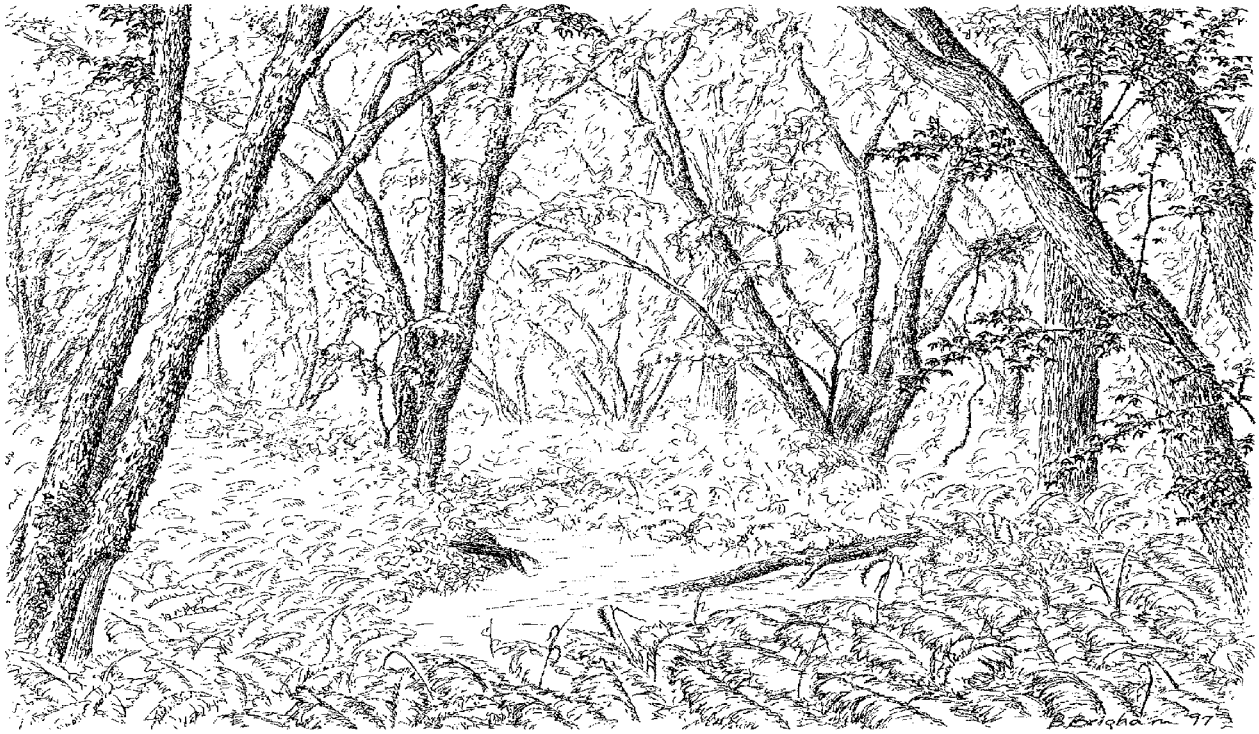
Pine Island Floodplain is a 25-acre mature floodplain forest occupying an island and two point bars on the northern side of the Winooski River in Colchester. On the flat, wide edges of the island, the forest is classic silver maple floodplain forest with occasional elm in the understory and a lush herbaceous layer of ostrich fern and wood nettle. The interior of the island is slightly higher and drier and is dominated by green ash with cottonwood, silver maple and occasional large red oaks as part of the canopy layer. The understory includes green ash, elms, northern hackberry, boxelder, and the nonnative common buckthorn. The herb layer here is ostrich fern and wood nettle but includes other species as well.

Gorge Island is another silver maple floodplain forest community in the Lower Winooski River. This site is a 25-acre island in the middle of the river below the Winooski Gorge next to Interstate 89 and under a powerline right-of-way. Despite the urban insults, the floodplain forest was described as “well-developed and elegant.” In addition to the silver maple, tree species in the floodplain forest include cottonwood, basswood, both red and American elm, white and green ash, and hackberry. The understory is largely ostrich fern. The site called “68 Acres” is a silver maple-ostrich fern floodplain forest along the river upstream of Winooski Gorge and in the southwest corner of Essex. The forest has a closed canopy of large cottonwood and green ash. Silver maple, butternut, and black willow are also part of the canopy but less common. Box elder is in the subcanopy and ostrich fern dominates the herbaceous layer. This forest is part of the Winooski Valley Park District.

The Allen Brook North – Winooski Island site is a small ten-acre site but it has a “magnificent grove of cottonwood” as well as box elder and silver maple. Some of the cottonwoods are up to 3 feet in diameter and up to 110 feet tall. Ostrich fern dominates the ground layer.

Deluge Forest is the name of another floodplain forest site along the Lower Winooski River. This mature 15-acre forest is dominated by large silver maples, box elder, and eastern cottonwoods. The understory has no shrubs but consists of “waist-high” ostrich fern as well as jewelweed, wood nettle, and dame’s rocket.

Just upstream of Deluge Forest is another Silver Maple-Ostrich Fern Floodplain Forest. This forest site called Jericho Bend is over 24 acres and the canopy is dominated by box elder interspersed with large silver maple. The herbaceous layer is the typical ostrich fern with some wood nettle and jewelweed. There is also the invasive exotic goutweed. A population of the uncommon Wiegand’s wild rye is also found in this floodplain community.



Silver Maple-Ostrich Fern Floodplain Forest by Betsy Brigham from Wetland Woodland Wildland 2000

Downstream of Richmond village on the Winooski River floodplain near the mouth of Johnnie Brook are three patches of silver maple-ostrich fern floodplain forest. The forest is 50 to 75 years old. The canopy is dominated by silver maple and box elder with red and American elms, hackberry, cottonwood, and basswood.

The Richmond Riparian Corridor is a 4-mile long stretch of floodplain upstream of Richmond village that includes several areas of floodplain forests about 13, 16, 32, and 33 acres in size. The higher terrace floodplain forest is less common with hackberry as the dominant overstory tree or co-dominant with butternut. In the lower floodplain, silver maple dominates or co-dominates with eastern cottonwood. Box-elder is dense in the understory of this forest. On the discontinuous levee that is also part of this stretch, sugar maple with box-elder, cottonwood, and silver maple define the floodplain community.

Specific Rivers and Streams

Winooski River mainstem

The IBM hazardous waste site (DEC site#770012) contamination was first found in the late 1970s/early 1980s. There have been remediation systems in place for a number of years and all contamination is contained onsite - it doesn't get to the river according to DEC Waste Management Division Sites Management Section. The remediation systems include pumping and treating groundwater, containment and collection and soil vapor extraction.

Two field visits, one by Army Corps of Engineers staff and one by a state representative from Winooski, noted debris (car parts, bridge pieces, shopping carts), heavy siltation, and eroding banks among other problems in the lowest mile plus of the Winooski.

There are four municipal wastewater treatment facilities, IBM and its numerous discharges, a number of landfill leachate pretreatment to WWTFs, many stormwater discharges, and a number of indirect discharges in this reach of the river.

A macroinvertebrate sample was taken in the Winooski River in Essex at rivermile 15.5 in October 2000 and the community was assessed as "good". A macroinvertebrate sample was taken on the Winooski River at rivermile 25.5 in Jericho on August 30,1999 and the assessment found a community in "good" condition.

The stretch of the Winooski River from Alder Brook upstream to the Bolton Falls dam has walleye in it, but according to the Vermont Fish and Wildlife Department, these are not walleye from Lake Champlain. These walleye have not been sampled and tested for mercury levels and so fish consumption is not considered impaired per Vermont DEC Assessment and Listing Methodology.

Bolton Falls Dam was re-developed for hydroelectric power in 1987 (it failed in 1927 flood, was re-built and then the generator was de-commissioned in the 1930s) and is operated by GMP. It has a water quality certificate with a minimum flow requirement in agreement with Vermont DEC. There is a tunnel through the rock of the adjacent hill as a diversion when the dam needs repair and otherwise, the flow of the river is through the powerhouse. There is no requirement for spillage over the dam. The dam is constructed downstream of the natural falls.

A windshield survey in September and October 2000 located at least seven fishing access locations, three swimming holes (upstream of the Duck Brook mouth, Jonesville, downstream from Richmond but above interstate overpass) and one canoe access point (between Jonesville and Richmond) in this stretch of the Winooski. These locations are likely an underestimate.

Tributary to Winooski River

Surface water samples from a tributary to the Winooski River on the South Burlington landfill site showed iron and arsenic above standards in four surface water samples. The tributary once flowed through the area that is now the capped landfill. The tributary was put into a culvert under the landfill but the pipe got crushed. Now the stream goes into a pond that is above the landfill and the pond water is piped around the landfill and back into the original stream channel. The upstream pond surface water sample and the stream samples downgradient of the landfill all had the arsenic and iron violations.

Muddy Brook

Muddy Brook originates in the wetlands northeast of Shelburne Pond. The brook winds in an east-of-north direction up along the South Burlington/Williston border. Allen Brook flows into Muddy Brook just before it enters the Winooski River. Muddy Brook is about 7

miles long and drains a 26 square mile watershed.

Muddy Brook and tributaries had at least 235 permitted stormwater discharges as of November 2007.

Macroinvertebrate sampling on Muddy Brook found the following results: at rivermile 1.2 "poor" in 1988, "good" in 1990, "very good-good" in 1993, "fair" in 2000 and "good" in 2003. Fish sampling on Muddy Brook found the following results: at rivermile 1.2 "poor" in 1988, "poor" in 1993 and "good" in 2003.

Muddy Brook Trib #4

Fish community sampling results were assessed as follows: at rivermile 0.2, "good" in 1993, "good" in 1995, "good" in 1997, "fair" in 1999, and "good" in 2002. The conclusion after analyzing samples was that "the assemblage at this site shows some impact from human activity... but the level of stress on the fish community is not enough to consistently suppress biological integrity below Class B standards."

"Historical macroinvertebrate sampling at a culvert riffle in 1993 and 1994 indicated a community in fair condition. The community was dominated by filter feeding Trichoptera in 1993 and Chironomidae Diptera in 1994. Filamentous algae and blue green algae was abundant along with a high percentage of moss. The immediate stream reach above the site was agricultural pasture and cows were noted in the stream. These data indicate some level of impairment ot the stream. However, due to dramatic land use changes in the watershed since the time the assessment were made and the limited amount of "riffle" habitat in the stream, these data should not be used to determine the present condition of the stream." Another sample was taken in 1997 but could not be scored because of the stream type. The metrics indicated that "extreme toxic, habitat or sediment impacts are not likely." However, the absence of sensitive species and perhaps the dominance of taxa moderately tolerant of nutrient enrichment indicates that there is some level of stress on the community.

Unnamed tributary to Muddy Brook

An unnamed tributary to Muddy Brook is impaired due to tetra and trichloroethylene as well as other VOCs discharging to the brook from the Commerce Street plume that originates at the former Mitec parcel in Alling Industrial Park in Williston. The site (DEC site #77-0120) is now a Superfund site (proposed 9/2004 and listed in 4/2005). The following information is taken from EPA's website.

The one acre site was home to manufacturing and electroplating operations from 1960 to 1986 - Mitec leased the site from 1979 to 1986. Between 1979 and 1984, Mitec discharged rinse water and sludge wastes associated with electroplating into an unlined lagoon. A concerned Mitec employee first told the Vermont Agency of Environmental Conservation, as it was then called, about the waste in 1982. Sampling in 1984 by AEC found chromium in groundwater below the lagoon and sampling by the Department of Health found six residential drinking wells contaminated with TCE and PCE. Indoor air samples also showed high VOCs. Numerous sampling events occurred between 1984 and 2002 - groundwater, surface water, sediment, soil, and residential air. DCE at 180

ppb, TCE at 170 ppb, chromium at 3.4 ppb, and vinyl chloride at 11 ppb were found in wetlands and the unnamed tributary to Muddy Brook in 1996. Groundwater samples downgradient of the site had TCE at levels as high as 90,00 ppb in 1999. In 2002, EPA found elevated levels of 11 VOCs and 13 metals in monitoring wells through the industrial park and surrounding residential area. EPA held a public meeting about the Superfund site in January 2006 and is in the process of determining the responsible parties. More work will follow.

Allen Brook

Allen Brook originates in the southern part of the town of Williston. It flows north to the village in Williston then west and then northwest before joining Muddy Brook just before it reaches the Winooski River. The brook is about 10 miles long and drains an 11 mile watershed that includes part of the interstate.

Geomorphic Assessment Results

In the absence of pervasive beaver impacts, current day stressors like urbanization appear to dominate in the lower portion of Allen Brook in addition to historic impacts from flood plain encroachment, road crossings, and agricultural impacts. In the lower watershed, below Route 2A near the Muddy Brook confluence, the channel has gone through historic straightening and agricultural impacts to riparian vegetation. However the channel maintains a high degree of sinuosity, with low incision, suggesting that it has recovered from previous direct impacts. Immediately upstream some bank mass failures and a high number of stormwater inputs have lead to some aggradation and planform changes within the lower reach as well as incision and aggradation within the reach itself.

Upstream of Route 2A in the mid-watershed, there is a change in slope and stream type. The reach immediately above Route 2A is undergoing a high degree of adjustments dominated by channel incision, bank erosion, mass failures, and planform changes. A high degree of stormwater inputs may be responsible for these adjustments. Near the Old Stage Road crossing, historic encroachment and armoring of the road has led to entrenchment. Some recent and historic beaver activity in the reach immediately upstream has lead to bank erosion and planform changes in this low gradient, sinuous, sand bottomed reach. Upstream of North Williston Road, the channel slope increases and riffle pool bottom dominates. Between Route 2 and the Interstate 89 crossing, significant channel adjustments were noted including aggradation, debris jams, and multiple flood chutes.

Immediately upstream of I-89 in the upper watershed, the channel gradient increases significantly and the stream type changes to a cobble bottomed, plane bed system and is well buffered with high RGA and RHA scores. The next upstream reach is a lower gradient, gravel bottomed channel that has undergone significant straightening and encroachment from historic agricultural uses. Reaches above and below Mud Pond are susceptible to beaver activity with some related alteration to the channel. A small, high gradient tributary enters along the Old Creamery Road contributing large amounts of sediment. Above Mud Pond, a stream departure from reference condition has occurred due to historic channel straightening and berming.

Biological Monitoring
Macroinvertebrate sampling on Allen Brook found the following results:

Table 12. Macroinvertebrate sampling on Allen Brook from 1999 to 2006.

	1999	2000	2001	2002	2003	2004	2005	2006
Rm 2.4	fair	good	-----	good	good	good-fair	good	-----
Rm 4.3	-----	-----	-----	fair	fair&vg-good	good	fair&good	-----
Rm 6.0	-----	-----	-----	good-fair	vgood	good	vgood	-----
Rm 6.5	-----	-----	-----	good-fair	vgood	vgood	vgood	-----
Rm 8.2	-----	exc	-----	-----	-----	-----	good	-----

Fish sampling on Allen Brook found: at rivermile 0.6 "good" in 1997, "good" in 1998, and "good" in 2000; at rm 2.4, "poor" in 2002 and 2003; at rm 2.9, "poor" in 1987 and 1991; at rm 4.3, "good" in 1999, 2002, and 2003; at rm 4.6, "fair' in 1989; at rm 6.5, " good" in 1989 and 2002; and at rm 7.6, "fair" in 1989.

E. coli sampling at 10 sites on Allen Brook in 2002 had the following results (in colonies per 100 ml.) (from downstream up): at River Cove Road - 548 on 7/31/02, 126 on 8/8/02; at Industrial Avenue - 687 on 7/31/02, 488 on 8/8/02; below Brennon Woods pump station - 1200 on 7/31/02; above Brennon Woods pump station - 1050 on 7/31/02; at Talcott - 1120 on 7/31/02, 117 on 8/8/02; Southridge - 66 on 8/8/02; School East Fork - 53 on 8/8/02; School South Fork - 46 on 8/8/02; Route 2 - 69 on 8/8/02; South Road - 60 on 8/8/02.

As of November 2007, there were 135 stormwater discharges to Allen Brook and tributaries.

Centennial Brook
Centennial Brook is a small tributary to the Winooski River about 2.1 miles in length with a southern branch that is an additional 0.8 miles long. It originates where Burlington Airport has been built and flows northwesterly to the Winooski River. It joins the Winooski about ½ mile above the Winooski Dam. The watershed includes an interstate exchange, part of the airport, urban/suburban land uses, and the 100-acre Centennial Woods Natural Area.

Macroinvertebrate sampling results from Centennial Brook were assessed as follows: at rivermile 0.1, "poor" in 1993, 1994, 2003, 2004, and 2005; at rm 1.2, "poor" in 1994. Fish sampling results were assessed as follows: at rivermile 0.1, "fair" in 1993; "good" in 1994; and "good" in 2003; at rm 0.4, "fair" in 2004 and 2005. High levels of silt in 1993 and 2000 and a significant amount of algae in 2003 were noted when sampling. The chloride levels were above EPA chronic and acute concentrations for aquatic life protection in almost all samples taken at rm 0.1.

As of November 2007, there were at least 30 stormwater discharges to Centennial Brook.

Sunderland Brook

Sunderland Brook flows west to east for about 6.4 miles spanning the towns of Essex Junction and Colchester. The watershed drainage area is approximately 5.5 square miles and discharges about 6.9 cfs at the mouth (Essex Waterways Association (EWA) report 2006). The watershed has three diverse areas. Agricultural land dominates the lower watershed. The middle watershed is forested, while the upper watershed is surrounded by urban areas. The lower watershed reaches below Mallets Bay Avenue, approximately 1.5 miles, have been historically channelized, re-located, dredged, and riparian vegetation altered. The most downstream reach is significantly incised and undergoing a stream type departure from dune ripple to plane bedform. The reach immediately above this one is actively aggrading.

The middle Sunderland Brook watershed flows through forested areas associated with Camp Johnson and are protected and minimally disturbed. This area of the watershed is dominated by slow-winding E-Type channels with the exception of one 350 foot long reach of high gradient bedrock cascade and the lowest reach in this section, immediately above Mallets Bay Avenue, has been historically straightened and is actively incising. Beaver activity was frequently observed in this area.

The upper zone of the watershed, in the area of Suzie Wilson Road, has been impacted by urban areas. Poor habitat conditions, disequilibrium conditions, bank erosion, mass failures, and stream departures were noted in this zone.

Overall of the 13 stream reaches and segments assessed, two segments (one reach) and two reaches have stream type departures, nine of thirteen RHA scores were fair or poor (three not evaluated), and nine of thirteen RGA scores were fair or poor (three not evaluated).

Sunderland Brook was sampled by EWA during the summer 2006 at the TetraTech/UVM gauging station upstream of the Route 7 culvert. The site is downstream of a beaver pond and wetlands and downstream of the Vermont DEC biomonitoring site. Temperature, dissolved oxygen, turbidity, total suspended solids (TSS), specific conductivity, chlorides, total nitrogen (TN), total phosphorus (TP), and pH were all measured. Sunderland Brook's seasonal means were: temperature of 20°C; D.O. saturation 99.7%; turbidity was 12.2 NTU; TSS found was 7.12 mg/liter; TP was 36.4 ug/liter; and pH mean was 7.93.

Results from another study, a chloride assessment on six urban streams in Chittenden County, showed that Sunnyside Brook, a tributary to Sunderland Brook, had average daily chloride concentration means above the EPA chronic criterion 79% of the time while Sunderland Brook itself didn't have any average daily mean choride concentrations above the chronic criterion. The mean daily choride value in milligrams per liter for Sunnyside Brook was 261 with the range being 82 to 449. For Sunderland Brook, it was a mean of 103 with the range 3 to 199 mg/liter.

Macroinvertebrate sampling on Sunderland Brook found: at rivermile 3.5, "fair-poor" in 1995 and "fair" in 2002. Fish sampling on Sunderland Brook found the following results: at rivermile 1.0 "poor" in 1988, "fair" in 1989, "good" in 1999, "very good" in 2000, and

"good in 2003; at rm 1.1 "very good" in 2003; at rm 2.2 "good" in 1988; and at rm 3.5 "fair" in 2002.

Sunnyside Brook (a tributary to Sunderland Brook)
Macroinvertebrate sampling results were assessed as follows: at rivermile 0.2, "good" in 2002. Fish sampling at rm 0.1, "fair" in 2003. Chloride data were also gathered (see paragraph above) and average daily chloride concentration means were above the EPA chronic criterion the season that this parameter was sampled in this brook.
Sunnyside Brook Trib #1 (a tributary to the tributary to Sunderland Brook)
Macroinvertebrate sampling results were assessed as follows: at rivermile 0.1, "good-fair" in 2004.

Tributary to Sunderland Brook
The tributary to Sunderland Brook near Hercules Drive in Colchester was once threatened by industrial wastes from wire and cable manufacturing that was dumped into the ground by Champlain Cable (DEC site #77-0046). Old data had shown organic contaminants exceeded "water and fish ingestion" and "fish consumption" levels. However, in 1998, a permeable reactive barrier (PRB) groundwater treatment system was installed to treat the groundwater contaminated with 1,1,1-TCA and other chlorinated volatile organic compounds (CVOCs). It has worked to decrease the CVOCs generally below the treatment system.

The May 2005 sampling event found the VGES exceeded for one or more of the CVOCs from 11 of the 35 sitewide monitoring wells located both upgradient and downgradient of the treatment system though. The November 2005 sampling also found the VGES exceeded - in 12 of the 34 site wells monitored. Again the standards were exceeded in wells downgradient of the treatment system. 1,1-DCA concentration exceeded standards below "Gate A" of the system and 1,1-DCE exceeded standards below "Gate D". The DEC WMD site manager asked the consultant to do a study to evaluate the system to ensure that the treatment system was operating optimally and the consultant did further work on site investigating the presence of the contaminants downgradient of the PRB. The investigation found that the contaminants were not migrating through or below the PRB but were contaminants that had been present in the downgradient area prior to installation of the barrier. These contaminants are still present in the area below the PRB due to sorption to organic carbon in the soils, but additional contaminants are not migrating through. No further investigation is likely needed at this time.

Tributary to Sunderland Brook
The tributary to Sunderland Brook near Morse Drive in Essex Junction was at least threatened by organic compounds from the Hampden Color & Chemical hazardous waste site (DEC site #77-0103). The last time the site was sampled was in August 2000. At that time, PCE was the only VOC found exceeding the VGES and it was found in only one of the three wells sampled. Sampling was supposed to continue in 2001 but it didn't. A letter was sent from Vermont DEC in 2004 reminding the owner that sampling was supposed to occur but the letter was apparently ignored. Next time the site is sampled, a stream sediment sample should be taken and analyzed as well as the groundwater sampling.

As of November 2007, there were at least 127 stormwater discharges to Sunderland Brook and tributaries.

Alder Brook

Alder Brook is an 11.6 mile-long stream that flows from north to south from its headwaters in Westford through the town of Essex and empties into the Winooski River upstream of Essex Junction. The watershed area is about 10.4 square miles. The upper section of the stream is in relatively steep, forested terrain in Westford. The middle section of the brook consists of a winding, low-gradient stream flowing through agricultural, residential and some forested land. The lower section, below the village of Essex Center, again drops more steeply where it is cut into deep, sandy ravines.

Fascinating historical information reveals that Alder Brook once flowed north to the Browns River and first a mill diversion and then the flood of 1830 permanently diverted the stream into its present path south to the Winooski River. This significant change in course resulted in a severe loss of stream stability in this lower section of brook and large amounts of sediment went downstream and into the Winooski River for decades as a result. Over 175 years later, as the stream showed recovery from the extreme channel change of the diversion and flood, new insults were affecting the lower watershed. Uncontrolled stormwater discharges from suburban areas and impacts from the construction of Route 289 (the Circumferential Highway) have once again de-stabilized lower Alder Brook.

A report done by Fitzgerald Environmental Associates in December 2006 summarizes the Phase 1 and 2 geomorphic assessment data that were gathered on Alder Brook. The brook was initially divided into 15 reaches and three watershed zones. The lower watershed zone (reaches M01-M07) is below Route 15 (the location of the 1830 diversion of Alder Brook from the Browns River watershed to the Winooski) to the mouth. The valley is narrow in this area where " the channel has historically formed deep ravines through the sand delta deposits." The average slope of the channel is 1.2% and the channel is cobble and gravel-bottomed with riffle-pool bedform. In this lower watershed, reaches M02 and MO3A had "good" rapid habitat assessment (RHA) and rapid geomorphic assessment (RGA) ratings while the other reaches M01-M07 including M03B had only fair RHAs and RGAs. Even though M02 RHA and RGA scores reflect good stability and habitat in the reach, there was also severe aggradation in the stretch leading to lateral adjustment of the channel. Erosion due to the sandy soils and poorly planned development on sandy flats above the stream valley with its uncontrolled stormwater runoff as well as floodplain encroachment from the Circumferential Highway has led to more water and more sediment going to the brook and going there more quickly. Deep gullies from the runoff from the dense housing development on the sand plateaus continue to erode and alter the stream stability and habitat.

The middle watershed zone (reaches M08-M13) is in a much wider valley and has sand-bottomed channels with a slope of only 0.2%. The stream is very sinuous here. The impacts in this zone are largely from historical straightening during past agricultural uses except for reach M08-A, which is affected by dense residential development.

In the upper zone above Rollin Irish Road in Jericho, the valley is narrow again and the average channel slope of the two headwater reaches (M14 and M15) is 3.3%. The channel bottom is cobble and gravel again. The headwaters reaches were affected by historical straightening and some agricultural land uses but due to re-forestation in the corridor and watershed, there has been a recovery of instream habitat.

Macroinvertebrate sampling results from the Vermont DEC biomonitoring program were assessed as follows: at rivermile 0.3, "good" in 1996, "good-fair" in 2001, "vg-good" in 2003, and "good" in 2004. Fish sampling results were assessed as follows: at rivermile 0.3 "good" in 1996, "good-fair" in 2001, "good" in 2003 and 2004; and at rivermile 2.8 "fair" in 1993.

Alder Brook was sampled by the Essex Waterways Association (EWA) at 2 sites on nine dates in summer 2006. The upper site is at the beginning of the "Essex Center Gulch" behind the library and is cobble-bottomed and shaded. The lower site is about a quarter mile upstream of the brook's confluence with the Winooski River and is sandy-bottomed and open. Temperature, dissolved oxygen, turbidity, total suspended solids, specific conductivity, chlorides, total nitrogen, total phosphorus, and pH were all sampled.

Temperatures at the downstream Alder Brook site were lower on each of the sampling dates except for one - the day there was high flow and much stormwater runoff. Groundwater input to the brook is the likely explanation for the cooler water temperatures downstream during low flow conditions. Upper Alder Brook appears to have water temperatures that could be stressful for a coldwater fishery. On the mid-July sampling date, the water temperature was about 24°C and on the late July sampling day, it was about 21°C.

Total suspended solids and turbidity both spiked at the upper Alder Brook site on the July 2 sampling date that had high flows. The turbidity value reached 120 NTUs on that date. None of the other sites (lower Alder Brook, upper and lower Indian Brook, and Sunderland Brook) showed the large spike that upper Alder did.

Stream discharge was recorded at the lower Alder Brook site (as well as the lower Indian Brook and Sunderland Brook sites) beginning in mid-June. The data showed Alder Brook to be very flashy with the discharge increasing ten fold during the July 2 rainfall. In comparison, Sunderland Brook discharge barely increased because of its wetlands and beaver ponds and Indian Brook discharge increased about five fold.

A specific storm study was done on Alder Brook as part of EWA's 2006 assessment before, during and after a 1.37 inch, 11 ½ hour rainfall event on September 29. Before the storm, Alder Brook was clear with a TSS concentration of 1.9 mg.liter and turbidity of 8 NTU. The highest levels of these parameters reached TSS of 344 mg.liter and 373 NTU. Chloride concentration and conductivity declined during the storm as a result of dilution. Total phosphorus concentrations tracked with TSS reaching a peak of 428 ug/liter.

As of November 2007, there were at least 107 stormwater discharges to Alder Brook and tributaries.

Mill Brook

Mill Brook originates in the Green Mountains east of West Bolton. It is about 9.5 miles long and drains a watershed of 17 square miles. The brook flows in a westerly direction generally through West Bolton and through the town of Jericho meeting the Winooski River on the western edge of Jericho. The stream is well-shaded with largely forested buffers. According to the 1992 Lower Winooski Basin Plan, Mill Brook has a naturally sustaining population of brook, rainbow, and brown trout. A set of small waterfalls, cascades, rapids are located on Mill Brook in the vicinity of the UVM Research Forest.

Macroinvertebrate sampling was done at Mill Brook in Jericho in 1993, 2000, and 2004. The community's health at rivermile 0.6 in 1993 was found to be “excellent”. In 2000 and 2004, at rivermile 0.3, it was “very good”. Fish community sampling on Mill Brook in 2004 at rm 0.4 found a community in “excellent” health and integrity.

Morehouse Brook

Morehouse Brook is drained by a small, highly urbanized watershed straddling the town boundary between Colchester and Winooski, with a drainage area of approximately 0.5 square miles. A stream geomorphic assessment was conducted on three main stem reaches and one tributary reach, totalling six reaches/segments assessed. Of the six assessed reaches and segments (one not evaluated), four were experiencing stream departure types, five were rated as poor or fair in both the RHA and RGA scores.

The lower reaches are characterized by high stream gradients and steep valley walls. Within these areas are significant mass failures, aggravated by upslope stormwater inputs, which are contributing large amounts of sediment downstream. The lowest reach of Morehouse Brook, downstream of Mallets Bay Avenue, received the lowest RGA scores due to its high degree of adjustment and stream type departure from severe historic incision and the resulting mass failures. Failing slopes on the steep valley walls contiguous with the channel were observed along approximately 75% of the reach. Most of the side slopes in the reach range between 30-60%. Both degradation and aggradation are occurring simultaneously.

The reach immediately upstream of the one described above also received a poor RGA score. Aggradation, widening, and planform adjustments were all noted in this reach. A network of catch basins culverts associated with a stormwater outfall entering from the south has increased the overall drainage area of the watershed by 20%. As the result, multiple debris jams and mass failures and a significant headcut were observed.

Morehouse Brook has been channelized through a culvert in the vicinity of Landry Park and could not be assessed. Protection of the intact river corridor above the piped reach was identified as a recommendation as was addressing the entire watershed’s hydrologic regime prior to any active channel management projects.

Macroinvertebrate sampling results were assessed as follows: at rivermile 0.3 "poor" in 1997, 2002, and 2004; at rivermile 0.6 "poor" in 1990 and 2000.

Macroinvertebrate sampling on Sand Hill Brook in Essex at rivermile 0.4 in 2004 yielded

an assessment of "good-fair." Fish sampling on Sucker Brook in 1998 at rm 1.7 resulted in an assessment of "good."

Johnnie Brook
Johnnie Brook originates in the northeast corner of Hinesburg and flows north/northeasterly to Fays Corner in Richmond. It then flows easterly to the Winooski River. Johnnie Brook is five miles long and drains a watershed of nine square miles.

Snipe Island Brook
Snipe Island Brook originates in southeast Jericho and flows south/southwesterly through the northern part of Richmond into the Winooski River. The brook is approximately three and a half miles long and drains a four and a half square mile watershed. A tributary that arises from Preston Pond in Bolton joins Snipe Island Brook from the west. According to the 1992 Lower Winooski Basin Plan, Shipe Island Book has natural populations of brown and brook trout throughout its length. A stretch of the brook has small, pretty cascades and swim holes.

A gravel road follows this brook for a substantial portion of its length and the road and residential development and activities threaten the water quality and aquatic habitat.

Preston (Honey Hollow) Brook
Preston Brook originates in Camels Hump State Park in Huntington and flows north through Bolton emptying into the Winooski River. Preston Brook is four miles long and drains six and a half square miles. Native brook trout are in this brook according to information gained during the Lower Winooski Basin plan process in 1991 and 1992. Field observations from September 2000 included finding a stretch of stream with a "beautiful small gorge, waterfalls, cascades!"

Honey Hollow Road and some residential development up along this road are threats to this brook.

Joiner Brook
Joiner Brook flows south from the mountains in Bolton down to the Winooski River. It is approximately 5 miles long and drains a watershed 10 square miles. The brook has a series of pools, cascades, and waterfalls that are popular for swimming. Brook trout occur naturally in the brook and rainbow and brown trout from the Winooski spawn at the mouth of Joiner Brook.

The Bolton Valley ski resort access road follow the brook up and the road, residential development, and the ski area are all threats to the brook.

Macroinvertebrate sampling and a habitat assessment were done on a tributary to Joiner Brook in 1997. The community was assessed as poor at rivermile 0.4 and fair at rivermile 0.1. In 2000, sampling at rivermile 0.4 again found the community in fair health. The community in 1997 had low density and EPT richness. Embeddedness of the channel was high. Logging and logging roads are the sources of the problems (degraded habitat and the impact on macroinvertebrates).

Ridley Brook

Ridley Brook is boulder and cobble stream that arises high up in Camels Hump State Park and flows north through the town of Duxbury to the Winooski River. It is 5.5 miles long and drains 13 square miles. The 1992 Lower Winooski Basin Plant noted that Ridley Brook is enjoyed for " fishing, swimming, and scenic value."

River and Stream Assessment Summary Lower Winooski watershed

Impaired Miles

Winooski River: 10.2 miles - from mouth to dam in Winooski - fish consumption impaired due to mercury primarily from atmospheric depostion.
Allen Brook: 2.6 - from rm 2.4 upstream to rm 5.0 - aquatic life/habitat impaired due to sediment, nutrient enrichment, high temperatures, habitat alterations from stormwater runoff from developed areas, erosion, and lack of streambank vegetation and 7.0 - from the mouth upstream to Route 2 - contact recreation impaired due to E coli numbers above standard due to stormwater runoff, occasional malfunctioning sewage systems, beaver.

Centennial Brook: 1.2 - from the mouth upstream to its origin east of Airport Road in South Burlington - aquatic biota/habitat impaired due to sediments and flow changes from land development, erosion, developed land runoff.

Morehouse Brook: 0.6 - aquatic biota/habitat impaired due to sediment, other pollutants from erosion and stormwater runoff.

Sunderland Brook: 1.8- from rm 3.5 upstream to rm 5.3 - aquatic biota/habitat and aesthetics impaired due to nutrient enrichment, siltation, turbidity, thermal increases, poor taste and odor, and habitat alterations from urban runoff and lack of streambank vegetation.

Muddy Brook: 1.2 - from the mouth at the Winooski River upstream - aquatic biota/habitat and aesthetics impaired due to heavy sedimentation, increased temperatures, nutrients from urban and agricultural runoff. Most of the fish were diseased. Unnamed trib to

Muddy Brook: 2.0 - drinking water supply, fish consumption, contact recreation impaired due to TCE, PCE, other VOCs and metals from the Commerce Street plume

Trib to Winooski River: 0.4 miles - from South Burlington landfill downstream to Winooski - aquatic biota/habitat and drinking water supply impaired due to arsenic and iron in concentrations above standards from the landfill

Joiner Brook tributary: 0.5 - aquatic biota/habitat impaired due to sedimentation, habitat alteration from logging activities including logging road impacts.

Altered Miles

Winooski River: spillage over Gorge #18 dam limited

Alder Brook: 5.1 - from the mouth upstream to the end of SGA segment M08C which is upstream of Route 15 and Essex center -aquatic habitat altered due to dense suburban development with no or poor stormwater controls, highway development into a floodplain, former channel straightening.

Joiner Brook: 2.9 - snowmaking water withdrawal point - aquatic biota/habitat altered due to snowmaking water withdrawals.

Stressed Miles

Winooski River: 21.2 - from mouth upstream to Alder Brook confluence - aquatic biota/habitat, aesthetics, contact recreation and secondary contact recreation stressed due to nutrients, sediments, temperature increases, junk (shopping carts, parts of cars..), and mixed toxic compounds from stormwater runoff from urban areas and industry; eroding streambanks, many upstream sources, some contributions from ag land use.

Winooski River: 11.0 - from Winooski dam up to Alder Brook confluence (subset of above) - fish consumption stressed due to mercury primarily from atmospheric depostion

Winooski River: 20.0 - from the confluence of Alder Brook to the confluence of the Little River - aquatic biota/habitat and aesthetics due to presence of nutrient enrichment, siltation and turbidity, habitat alteration resulting from agricultural activities (crop and pasture lands), urban runoff (including impervious surfaces, roads and construction areas), gravel road runoff, and eroding and devegetated streambanks.

Winooski River: 10.5 - from confluence of Alder Brook upstream to Bolton Falls dam - fish consumption stressed due to mercury from atmospheric deposition

Muddy Brook Tributary #4: 0.3 - mouth upstream 0.3 miles - aquatic biota/habitat stressed to enrichment and other stressors from urban runoff, other sources?

Lakes, Ponds, and Reservoirs in the Winooski River Watershed

The Winooski River watershed has, relatively speaking, one of Vermont's richest populations of lakes. In total, Vermont ANR inventories 91 lakes, ponds or reservoirs, comprising 4,440 acres. In addition to these are myriad very small backyard or private small ponds (typically < one acre), which are not inventoried by the Agency. Of the 91 inventoried lakes and ponds, 55 (4,225 acres) are considered "assessed," meaning that some form of monitoring data or other information has been obtained, permitting a determination of whether these ponds meet water quality standards. Figure 2 provides locations for all lakes in the basin, and provides the names of those in excess of 20 acres in size.

Lake Monitoring

There are several water quality monitoring programs that provide data on specific lakes and ponds. Monitoring efforts include the Spring Phosphorus, Lakes Lay Monitoring, Aquatic Plant Surveys, Lake Assessment, Fish Contaminant, and other projects. Descriptions of these projects can be found in the Vermont Water Quality Monitoring Program Strategy, and results for individual lakes can be found on the ANR Water Quality Division website (http://www.vtwaterquality.org/cfm/lakerep/lakerep_select.cfm) or by request to the Water Quality Division. The ANR also tests swim water quality at the State Park beaches at Waterbury Reservoir and at the Buck Lake Conservation Camp beach.

Count of lakes monitored by VTANR project

Lay Monitoring	*11*
Spring Phosphorus	*31*
Lake Assessment	*25*
Fish Contaminant	*6*
Plant Survey	*24*

In addition to these Agency-led monitoring efforts, watershed associations and conservation commission have also carried out in-lake, lakeshore, and lake-watershed assessments. The largest of these has been a comprehensive assessment of the shoreline and watershed conditions for lakes in the Calais-Woodbury area. Through the LaRosa Partnership Program, the Calais Conservation Commission has also monitored the quality of swim waters in several areas of Curtis Pond.

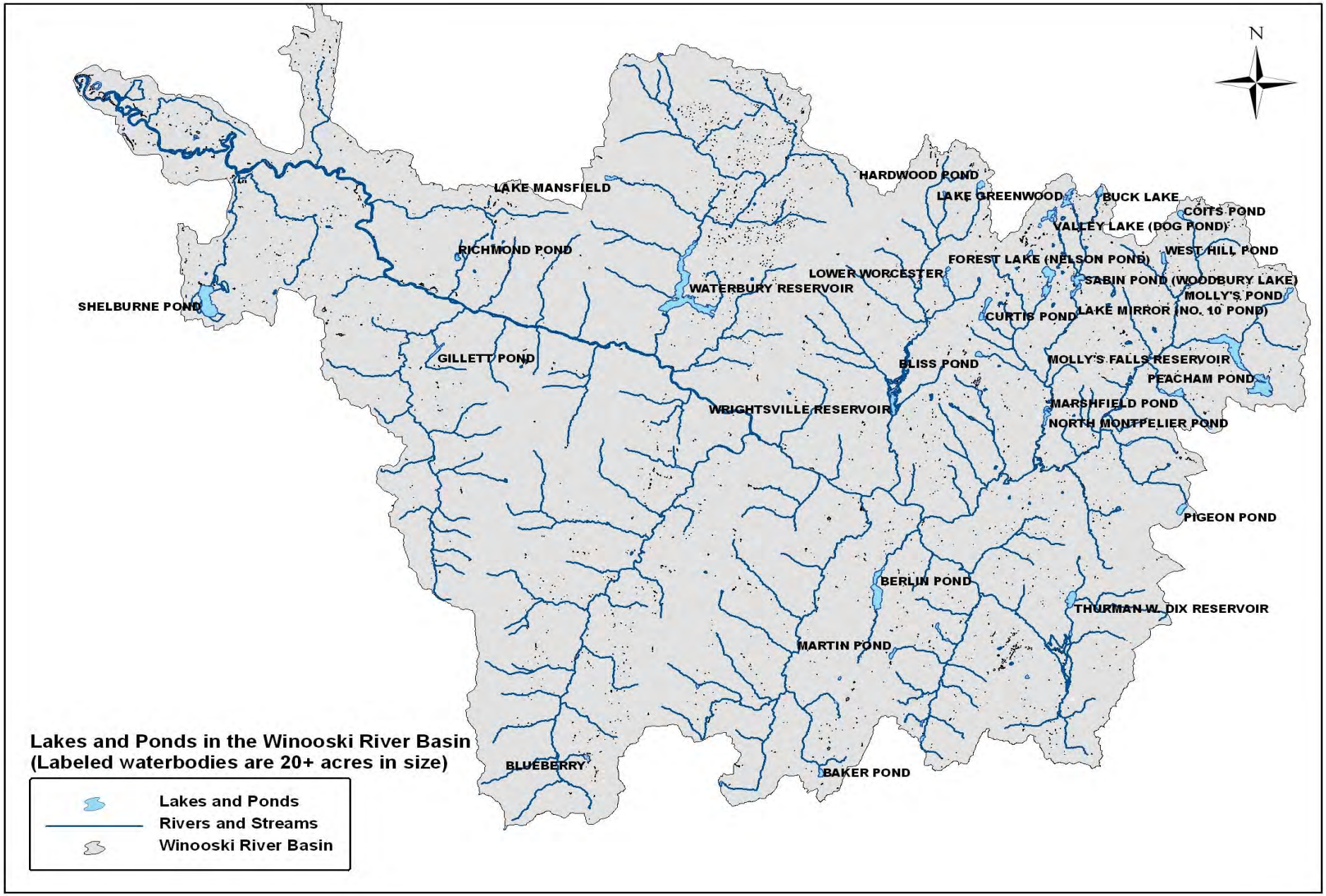


Figure 2. Lakes and ponds in the Winooski River watershed.

Lake Water Quality Issues

The collective information yielded by the monitoring and assessment activities, in concert with information obtained through various regulatory programs relevant to lakes, yields a cohesive assessment of use patterns and use support for lakes and ponds in the Winooski River watershed. While lakes and ponds in this watershed are in good to excellent condition, there are several water quality issues affecting lakes, including eutrophication, exotic species, water level management, cumulative lakeshore development, and atmospheric deposition.

Accelerated Eutrophication

Lake eutrophication is the process of nutrient and organic matter accumulation in lakes over time. While this is a natural phenomenon common to all lakes, it generally occurs over time scales of hundreds to thousands of years. Eutrophication can be accelerated by human activity in lake watersheds, resulting in an excess of phosphorus and nitrogen, producing excessive algae blooms, and occasionally, a proliferation of aquatic plants. When conditions are sufficiently problematic, eutrophic lakes will be identified as impaired, and placed on the Vermont Impaired Waters List. In the Winooski River watershed, seven lakes show substantiated signs of cultural eutrophication:

Lake:	*Severity of Eutrophication:*
CRANBERRY MEADOW	*Minor*
BLISS	*Moderate*
CURTIS	*Moderate*
DOBSON	*Moderate*
GREENWOOD	*Moderate*
NORTH MONTPELIER	*Moderate*
SHELBURNE	*Impaired*

Of these waterbodies, Shelburne Pond is most severely impacted by excessive phosphorus concentrations, which result in severe blooms of toxin-forming cyanobacteria (also known as blue-green algae). Many uses of Shelburne Pond are compromised by these conditions, and the pond is listed on the Vermont 303(d) list of impaired waters as polluted by elevated phosphorus concentrations. In addition to the algae blooms, Shelburne Pond has seen periodic fish kills during the 1980s and 1990s.

Greenwood Lake, and Curtis and Bliss Ponds, show signs of elevated nutrient concentrations, although conditions in those lakes are not sufficiently problematic to impair uses on the lake. Users of these lakes may occasionally be inconvenienced by algae and/or plant growth. There are also some areas of sediment accumulation in these lakes from upstream watershed activities, due to land development and to cumulative lakeshore development (see below). Cranberry Meadow Pond is affected only to a minor degree, and largely by potential erosion from adjacent dirt roads. North Montpelier Pond is a small impoundment relative to the upstream drainage. It acts as a settling basin, resulting in occasional to common algae blooms.

Exotic Species

Aquatic invasive species such as Eurasian watermilfoil are a significant stressor to waters statewide. Where invasive species densities are sufficient to significantly alter uses, these lakes are identified on the “Part E” list of waters considered altered by invasive species.

Other species, such as water chestnut and zebra mussels, can also alter uses. When uses are altered, the lake is considered not meeting water quality standards, due to a non-pollutant.

While no waters in the Winooski River watershed have altered uses due to invasive species, most lakes are considered stressed by Eurasian watermilfoil. This is due either to their proximity to other waters with known infestations, or to infestations that are minor in impact and/or actively managed. Given the density of lakes in this watershed, particularly in the Kingsbury and North Branch watersheds, it is remarkable that only three lakes have documented Eurasian watermilfoil infestations: Berlin Pond; North Montpelier Pond; and Shelburne Pond.

Water Level Management

In reservoirs with large water level fluctuations, the dewatering and re-inundation of the littoral zone can preclude or limit swimming and boating access, affect aesthetic quality, and cause impacts to aquatic communities that cascade through the food chain. In addition, water level fluctuation across the littoral zone can impact wetland communities, enhance sediment loss from steep or unstable shorelines, and even cause an increase in the amount of atmospheric mercury that accumulates in fishes (see mercury articles in References below).

The Waterbury Reservoir is the single largest waterbody in the Winooski River watershed, and water level fluctuations there result in impairment to the littoral areas of the reservoir due to sedimentation and erosion, and alteration of the remainder of the reservoir, due to cascading effects to the aquatic community. Molly's Falls Reservoir, in Cabot, is also considered altered due to water level fluctuations. At West Hill Pond (Cabot), the dam spillgate is known to be in poor condition, and water levels have been low in this pond in recent years as a result. Other ponds are considered stressed by water level fluctuations.

Cumulative Development

The effects of cumulative watershed and shoreline development on in-lake water quality are sometimes difficult to pinpoint, but can be considerable. Recent research in lakes throughout Vermont shows that while the chemical composition of waters may or may not be significantly influenced by cumulative development, the quality of littoral habitat can be very significantly affected. In lakes with lakeshore development, nearshore habitat can be affected in several ways. Due to lakeshore buffer removal, light and temperature can increase, resulting in enhanced algae and plant growth. Fish habitat structure can be lost due to removal of in-lake materials like logs, snags, and aquatic plants. The habitat can also be compromised by the illegal importation of sand, or improperly planned shoreland alterations. These effects can be apparent on lakes that are completely developed around the shoreline, or in the developed lakeshores of otherwise undeveloped lakes. In the Winooski River watershed, the effects of shoreline development have been studied on Sabin and Curtis Ponds. These and other several other lakes in the watershed may exhibit cumulative lakeshore development effects. Lakeshore development and eutrophication are related issues that are managed collectively.

Atmospheric deposition: acid rain and mercury

The rates of atmospheric deposition of acid-forming precursors and mercury are relatively uniform across lakes and ponds in the Winooski River watershed. However, individual waterbodies have different responses to this deposition, largely due to lake and watershed characteristics. Mercury accumulation in fishes is exacerbated in lakes in higher-elevation watersheds, watersheds with poorly buffered soils, and where water levels are actively manipulated.

Deposition of acid-forming sulfates and nitrogen oxides result in one lake, Hardwood Pond, being impaired by acid rain, and fish consumption uses in all lakes in the basin being stressed by deposition of mercury. Monitoring data for fish mercury is sparse in this watershed, limited to: Waterbury Reservoir; Hardwood Pond; Sabin Pond; Cranberry Meadow; Sterling Pond; and, Shelburne Pond. Of these, Hardwood Pond and Waterbury Reservoir exhibit elevated mercury levels in fish, while the remaining ponds, due to their water chemistry, are low or very low in mercury in fish tissue.

Lake Assessment Summary

The information provided above is summarized into the following tables portraying lake acres supporting, stressed, or not supporting uses throughout the Winooski River watershed, along with the causes and sources for impaired or altered acres.

Impaired, Altered, and Stressed Lakes

Table 13 shows the number of acres in various use support categories for all assessed lakes in the Winooski River watershed. Not all lakes are always assessed for all uses, and where altered acres co-exist with impaired acres, as is the case for Waterbury Reservoir, these acres are reported as impaired. The term “stressed” implies that effects have been observed on waters (such as moderate, non-impairing algae growth), or there are significant threats (such as the proximity of Eurasian watermilfoil-infested waters).

This information shows that while stresses exist on these lakes and ponds, a relatively small proportion of the lakes are impaired by pollutants (Shelburne Pond and Waterbury Reservoir), while a somewhat larger proportion of waters are altered due to flow alterations (Waterbury Reservoir and Molly’s Falls Reservoir).

Table 13. Summary of use support for lakes in the Winooski River watershed.

Use	Fully Supporting	Fully Supporting but Stressed	Not Supporting Impaired	Not Supporting Altered	Not Assessed
Aesthetic	2130	1043	552	397	103
Aquatic Biota, Wildlife, and Aquatic Habitat	698	1692	596	1136	103
Boating, Fishing, and Other Recreational Uses	1780	948	552	397	119
Fish Consumption		4225			
Public Water Supply	424	5			
Swimming and Other Primary Contact Recreation	1952	776	552	397	119

Causes and Sources

Table 14 shows the number of acres affected by various causes for all assessed lakes in the Winooski River watershed. Causes are reported for impaired, altered, and stressed acres. Again, where altered acres co-exist with impaired acres, the cause reported for those areas is that pertaining to the impaired acreage. In order of decreasing importance, the top causes of use support loss to lakes in this basin are flow alteration, phosphorus pollution, and sedimentation. The top stresses are Eurasian watermilfoil threats, sedimentation, flow alteration, and algae and plant growth.

Table 14. Causes of Impacts to lakes in the Winooski River watershed.

Assessment of Waterbody	Cause of Impact	Aesthetic	Aquatic Biota, Wildlife, and Aquatic Habitat	Boating, Fishing, and Other Recreational Uses	Fish Consumption	Swimming and Other Primary Contact Recreation
Impaired	pH		44			
	Phosphorus	452	452	452		452
	Sedimentation/Siltation	100	100	100		100
Altered	Flow alteration	397	1,136	397		397
Stressed	Myriophyllum spicatum	1,101	649	1,003		1,003
	Flow alteration	190	676	190		
	Mercury in Fish Tissue				4,220	
	Noxious Aquatic Plants - Algae	235	235	682		682
	Noxious Aquatic Plants - Native	78	78	530		530
	Nutrients	328	328	277		323
	Organic Enrichment - DO		543			
	pH		245			
	Phosphorus	328	328	277		323
	Sedimentation/Siltation	822	945	822		822

Table 15 summarizes the sources of pollution for altered and impaired lakes in the Winooski River watershed. Sources of phosphorus-related impairments on Shelburne Pond result from nonpoint source agricultural activities and residential conversion of agricultural lands. The source of sedimentation in the Waterbury Reservoir is lakeshore destabilization due to water-level manipulation.

Table 15. Sources of impact to lakes in the Winooski River watershed

Assessment of Waterbody	Source of Impact	Aesthetic	Aquatic Biota, Wildlife, and Aquatic Habitat	Boating, Fishing, and Other Recreational Uses	Swimming and Other Primary Contact Recreation
Impaired	Atmospheric Depositon - Acidity		44		
	Managed Pasture Grazing	452	452	452	452
	Natural Sources		44		
	Non-irrigated Crop Production	452	452	452	452
	Post-development Erosion and Sedimentation	452	452	452	452
	Streambank Modifications/destablization	100	100	100	100
Altered	Flow Alterations from Water Diversions	397	1136	397	397
Stressed	Sources are not attributed to stressed waters				

Individual Lake Use Support

Table 16. Individual use support determinations for lakes and ponds in the Winooski River watershed.

Tributary	Lake	Lake Area	Full Support	Stressed	Altered	Impaired
Dog River	BAKER (BRKFLD)	35	0	35	0	0
Dog River	BEAVER (ROXBRY)	10	0	10	0	0
Dog River	FELCHNER;	12	6	6	0	0
Huntington River	GILLETT	30	0	30	0	0
Jail Branch Winooski River	LOWER ORANGE	8	8	0	0	0
Jail Branch Winooski River	THURMAN W. DIX	123	0	123	0	0
Jail Branch Winooski River	WILLIAMSTOWN-NE;	7	7	0	0	0
Kingsbury Branch Winooski River	BLISS	46	0	46	0	0
Kingsbury Branch Winooski River	BUCK	39	31	8	0	0
Kingsbury Branch Winooski River	CRANBERRY MEADOW	28	0	28	0	0
Kingsbury Branch Winooski River	CURTIS	72	0	72	0	0
Kingsbury Branch Winooski River	DOBSON	9	0	9	0	0
Kingsbury Branch Winooski River	FOREST (CALAIS)	133	106	27	0	0
Kingsbury Branch Winooski River	GREENWOOD	96	0	96	0	0
Kingsbury Branch Winooski River	MIRROR	85	68	17	0	0
Kingsbury Branch Winooski River	MUD (WOODBY)-SE	18	0	18	0	0
Kingsbury Branch Winooski River	NORTH MONTPELIER	72	35	37	0	0
Kingsbury Branch Winooski River	SABIN	142	55	87	0	0
Kingsbury Branch Winooski River	VALLEY	88	24	64	0	0
Lower Little River	MANSFIELD	38	0	38	0	0
Lower Little River	WATERBURY	839	0	0	739	100
Lower Winooski River	LILY PAD	2	0	2	0	0
Lower Winooski River	LOWER WINOOSKI;	4	0	4	0	0
North Branch Winooski River	HARDWOOD	44	0	0	0	44
North Branch Winooski River	LITTLE (ELMORE)	14	0	14	0	0
North Branch Winooski River	LOWER WORCESTER	35	0	35	0	0
North Branch Winooski River	RUSS	7	0	7	0	0
North Branch Winooski River	UPPER WORCESTER	11	0	11	0	0
North Branch Winooski River	WRIGHTSVILLE	190	0	190	0	0
Stevens Branch Winooski River	BERLIN	293	293	0	0	0
Stevens Branch Winooski River	BOLSTER	5	0	5	0	0
Stevens Branch Winooski River	DRY	2	2	0	0	0
Stevens Branch Winooski River	MARTIN;	28	0	0	0	0
Stevens Branch Winooski River	PECKS	16	16	0	0	0
Stevens Branch Winooski River	ROBINSON;	7	0	0	0	0
Stevens Branch Winooski River	ROULEAU	1	1	0	0	0
Tributaries to Lower Mid-Winooski	GOOSE	2	0	0	0	0
Tributaries to Lower Mid-Winooski	RICHMOND	24	0	0	0	0
Tributaries to Lower Winooski	HALFMOON COVE	14	0	14	0	0
Tributaries to Lower Winooski	SHELBURNE	452	0	0	0	452
Tributaries to Lower Winooski	UPPER WINOOSKI;	10	0	10	0	0
Tributaries to Upper Winooski	BAILEY	17	17	0	0	0
Tributaries to Upper Winooski	LAIRD	12	12	0	0	0
Tributaries to Upper Winooski	PIGEON	69	0	69	0	0
Tributaries to Upper Winooski	SODOM	21	0	21	0	0
Tributaries to Upper Winooski	TURTLEHEAD	69	0	69	0	0
Upper Little River	STERLING	8	0	8	0	0
Upper Mad River tributaries	BLUEBERRY	48	48	0	0	0
Upper Mid-Winooski River	CUTTER	16	16	0	0	0
Upper Mid-Winooski River	LIMEHURST	13	13	0	0	0
Winooski River Headwaters	COITS	40	0	40	0	0
Winooski River Headwaters	MOLLYS	38	38	0	0	0
Winooski River Headwaters	MOLLYS FALLS	397	0	0	397	0
Winooski River Headwaters	PEACHAM	340	273	67	0	0
Winooski River Headwaters	WEST HILL	46	0	46	0	0

References and Resources

1) *Alder Brook Watershed Phase I and II Stream Geomorphic Assessment Report*, December 29, 2006. Prepared for the Essex Waterways Association by Fitzgerald Environmental Associates, LLC, Colchester, Vermont.

2) *Allen Brook Phase 2 Documentation and QA/QC Notes,* 2006. Prepared by Evan Fitzgerald, UVM/ANR Stream Geomorphic Assessment Project, Chittenden County, VT

3) *AMC River Guide: New Hampshire/Vermont*, Third Edition, 2002. Appalachian Mountain Club, Boston, Massachusetts.

4) *2006 Assessment of Water Quality in Alder, Indian and Sunderland Brooks, Essex Town, Vermont*, 2006. Annual Report of the Essex Waterways Association to the Vermont Agency of Natural Resources Department of Environmental Conservation. Prepared by Suzanne Levine, Chair of Aquatic Ecology and Watershed Science UVM and President of the EWA.

5) *Biological and Aquatic Life Use Attainment Assessment of Allen Brook*, March 6, 2006. Vermont DEC Water Quality Division, Biomonitoring and Aquatic Studies Section, Waterbury, Vermont.

6) *Biological and Aquatic Life Use Attainment Assessment of Centennial Brook*, January 30, 2007. Vermont DEC Water Quality Division, Biomonitoring and Aquatic Studies Section, Waterbury, Vermont.

7) *Biological and Aquatic Life Use Attainment Assessment of Tributary Four to Muddy Brook,draft,* July 17, 2005. Vermont DEC Water Quality Division, Biomonitoring and Aquatic Studies Section, Waterbury, Vermont.

8) *Biological and Aquatic Life Use Attainment Assessment of Sunderland Brook*, February 18, 2004. Vermont DEC Water Quality Division, Biomonitoring and Aquatic Studies Section, Waterbury, Vermont.

9) *Biological Mercury Hotspots in the Northeastern U.S. and Southeastern Canada*, 2007. Evers et al., *Bioscience* 57(1).

10) *A Chloride Assessment of Select Urban Streams in Chittenden County, Vermont*, July 2007. Vermont ANR DEC Water Quality Division, Biomonitoring and Aquatic Studies Section, Waterbury, Vermont.

11) *Detection and Elimination of Non-Stormwater Discharges to the Streams of the City of Barre*, March 2007. Friends of the Winooski River, Montpelier, Vermont.

12) *Floodplain Forests of Vermont: Some Sites of Ecological Significance*, July 1998. Eric Sorenson, Marc Lapin, Brett Engstrom and Robert Popp, Nongame and Natural Heritage

Program, Vermont ANR Department of Fish and Wildlife, Waterbury, Vermont.

13) *Hydropower in Vermont: An Assessment of Environmental Problems and Opportunities, Volume II Project Site Reports*, 1988. Vermont Agency of Natural Resources, Department of Environmental Conservation, Water Quality Division.

14) *Mercury Contamination in Remote Forest and Aquatic Ecosystems in the Northeastern U.S.: Sources, Transformations and Management Options*. Dirscoll et al., *Bioscience* 57(1)

15) *Morehouse Brook Phase 2 Documentation and QA/QC Notes,* 2006. Prepared by Evan Fitzgerald, UVM/ANR Stream Geomorphic Assessment Project, Chittenden County, Vermont

16) *The Preliminary Project Report for the Lower Winooski River Basin: An Inventory of Uses, Values, and Goals*, April 1992. Jerome McArdle, Agency of Natural Resources Department of Environmental Conservation, Water Quality Division.

17) *Sunderland Brook Phase 2 Documentation and QA/QC Notes,* 2006. Prepared by Evan Fitzgerald, UVM/ANR Stream Geomorphic Assessment Project, Chittenden County, Vermont.

18) *Vermont Ambient Water Quality Monitoring Program Strategy*. 2005. Vermont Agency of Natural Resources. http://www.vtwaterquality.org/lakes/docs/lp_monitoringstrat.pdf

19) *Vermont Swimming Hole Study*, 1992, Jerry Jenkins, Deborah Benjamin, and Jane Dorney for Vermont DEC, Water Quality Division.

20) *Waterfalls, Cascades and Gorges of Vermont*, 1985. Jerry Jenkins & Peter Zika for the Vermont Department of Environmental Conservation and Department of Forests, Parks and Recreation.

21) *Wetland Woodland Wildland: A Guide to the Natural Communities of Vermont*, 2000. Elizabeth H. Thompson and Eric R. Sorenson. Published by the Vermont Department of Fish and Wildlife and The Nature Conservancy.

22) *Whitewater Rivers of Vermont*, 1989. Jerry Jenkins for Vermont DEC.

Appendix A:

Winooski River Watershed Biological Sampling Sites 1994 – 2006

Table A.1.a. Macroinvertebrate Sampling Sites on Upper Winooski River Tributaries including the North Branch watershed 1994 to 2006

WBID	River or Stream	Station	Date	Assessment
08-07	Winooski River	58.5	10/11/2006	exc-vgood
08-07	Winooski River	59.0	10/11/2006	exc
08-07	Winooski River	59.9	09/20/2000	very good
08-07	Winooski River	63.1	09/20/2000	very good
08-07	Winooski River	70.7	09/20/2000	very good
08-08	Great Brook	1.3	09/04/1998	fair
08-08	Great Brook	1.3	10/02/2000	excellent
08-08	Great Brook	5.3	10/02/2000	excellent
08-09	Winooski River	83.1	09/22/2005	v. good-good
08-09	Winooski River	83.8	09/26/2000	very good
08-09	Winooski River	83.8	09/21/2005	very good
08-09	Winooski River	85.5	09/22/2005	good
08-09	Winooski River	85.7	09/15/2006	good-fair
08-09	Winooski River	85.9	09/21/2005	good-fair
08-09	Winooski River	85.9	09/15/2006	good-fair
08-09	Winooski River	86.0	09/22/2005	vgood-good
08-09	Winooski River	86.0	09/15/2006	good-fair
08-09	Winooski River	86.5	10/15/1994	excellent
08-09	Molly's Brook	5.5	09/21/2000	excellent
08-13	Hancock Brook	0.2	09/03/2003	good-fair
08-14	Pekin Brook	2.6	09/25/1998	good
08-14	Pekin Brook	3.5	09/25/1998	excellent

Table A.1.b. Fish Community Sampling Sites - Upper Winooski River watershed including the North Branch watershed 1994 to 2006

08-09	Winooski River	83.8	9/26/2000	fair
08-09	Winooski River	86.5	9/13/2005	excellent
08-13	Hancock Brook	0.2	7/28/2003	poor
08-13	Hancock Brook	0.7	8/25/2005	good
08-13	Patterson Brook	0.7	6/24/2000	good

Table A.2.a. Macroinvertebrate Sampling - Stevens Branch Watershed 1994 to 2006

WBID	River or Stream	Station	Date	Assessment
08-16	Stevens Branch	0.6	09/14/2000	good
08-16	Stevens Branch	2.6	09/17/1996	good
08-16	Stevens Branch	2.6	09/14/2000	fair
08-16	Stevens Branch	2.6	09/07/2001	fair
08-16	Stevens Branch	3.3	09/06/2001	good
08-16	Stevens Branch	4.7	09/11/1996	good
08-16	Stevens Branch	4.8	09/10/1996	good
08-16	Stevens Branch	4.9	09/11/1996	good
08-16	Stevens Branch Trib	0.3	09/16/1994	good
08-16	Stevens Branch Trib	0.3	09/14/2000	poor
08-16	Stevens Branch Trib	0.3	10/03/2002	very good
08-16	Stevens Branch Trib	0.5	10/03/2002	excellent

08-16	Gunner Brook	0.1	09/13/1996	good
08-16	Gunner Brook	0.2	10/02/2000	fair
08-16	Gunner Brook	0.2	10/03/2002	excellent
08-16	Gunner Brook	0.4	09/07/2001	fair

Table A.2.b. Fish Sampling Sites - Stevens Branch Watershed 1994 to 2006

08-16	Stevens Branch Trib23	0.3	9/25/2000	excellent
08-16	Stevens Branch Trib23	0.3	10/03/2002	good
08-16	Stevens Branch Trib23	0.3	09/23/2005	very good
08-16	Stevens Branch Trib23	0.3	09/19/2006	fair
08-16	Stevens Branch Trib23	0.4	09/25/2000	excellent
08-16	Stevens Branch Trib23	0.4	10/03/2002	excellent
08-16	Stevens Branch Trib23	0.5	09/19/2006	good-fair
08-16	Gunner Brook	0.1	9/13/1996	very good
08-16	Gunner Brook	0.1	9/18/2000	good
08-16	Gunner Brook	0.1	10/03/2002	poor
08-16	Gunner Brook	0.1	9/15/2003	very good
08-16	Stevens Branch	4.7	9/12/1996	good
08-16	Stevens Branch	4.9	9/13/1996	good
08-15	Jail Branch	0.3	9/30/2005	very good
08-15	Jail Branch	8.1	9/30/2005	very good

Table A.3.a. Macroinvertebrate Sampling Sites - Dog River Watershed 1994 to 2006

WBID	River or Stream	Station	Date	Assessment
08-17	Dog River	0.7	09/13/2001	good
08-17	Dog River	0.9	09/24/2002	good
08-17	Dog River	1.4	09/13/1994	good
08-17	Dog River	5.7	09/24/2002	vgood-good
08-17	Dog River	7.0	09/13/2001	good-fair
08-17	Dog River	7.0	09/24/2002	good
08-17	Dog River	8.6	09/13/1994	excellent
08-17	Dog River	8.6	09/24/2002	fair
08-17	Dog River	8.6	07/30/2004	poor
08-17	Dog River	8.8	09/13/1994	fair
08-17	Dog River	8.8	10/10/1995	good
08-17	Dog River	8.8	09/20/2000	fair
08-17	Dog River	8.8	09/07/2001	poor
08-17	Dog River	8.8	09/11/2003	poor
08-17	Dog River	8.8	07/30/2004	fair-poor
08-17	Dog River	8.8	10/17/2006	exc
08-17	Dog River	8.9	09/13/1994	poor
08-17	Dog River	9.0	09/13/1994	excellent
08-17	Dog River	9.0	10/10/1995	good
08-17	Dog River	9.0	09/20/2000	very good
08-17	Dog River	9.0	09/07/2001	good
08-17	Dog River	9.0	07/30/2004	very good
08-17	Dog River	14.0	09/20/2000	excellent
08-17	Dog River	14.8	09/24/2001	very good

08-17	Sunny Brook	0.5	09/11/2003	good-fair
08-17	Sunny Brook	0.5	10/24/2003	fair
08-17	Sunny Brook	0.9	10/24/2003	exc-vgood

Table A.3.b. Fish Sampling Sites - Dog River Watershed 1994 to 2006

08-17	Sunny Brook	0.3	6/25/2033	very good

Table A.4.a. Macroinvertebrate Sampling Sites - Mad River watershed 1994 to 2006

WBID	River or Stream	Station	Date	Assessment
08-18	Mad River	12.1	10/06/1998	good
08-18	Mad River	12.1	09/20/2000	excellent
08-18	Mad River	12.1	09/11/2003	good
08-18	Mad River	23.6	09/13/2006	very good
08-19	Dowsville Brook	1.0	09/27/1995	excellent
08-19	Dowsville Brook	3.3	09/27/1995	good
08-19	Dowsville Brook	3.4	09/09/1996	excellent
08-19	Dowsville Brook	3.4	10/09/1997	good
08-19	Dowsville Brook Trib 1	1.7	09/26/1997	fair
08-19	Dowsville Brook Trib 5	0.3	09/27/1995	good
08-19	Dowsville Brook Trib 5	0.3	09/09/1996	good
08-19	Dowsville Brook Trib 7	0.1	09/27/1995	good
08-19	Dowsville Brook Trib 11	0.1	09/09/1996	excellent
08-19	Dowsville Brook Trib 11	0.1	10/09/1997	fair
08-19	Shepard Brook	5.7	09/27/1995	good
08-19	Kewvasseur Brook	2.4	10/26/2000	good
08-19	Kewvasseur Brook	2.5	10/26/2000	excellent
08-20	Rice Brook	0.1	09/18/2000	fair
08-20	Rice Brook	0.3	09/09/1994	poor
08-20	Rice Brook	0.3	09/07/1995	fair
08-20	Rice Brook	0.3	09/10/2000	fair
08-20	Rice Brook	0.3	09/03/2001	fair
08-20	Rice Brook	0.3	09/02/2002	good-fair
08-20	Rice Brook	0.3	09/07/2003	good-fair
08-20	Rice Brook	0.4	09/09/1994	poor
08-20	Rice Brook	0.4	09/07/1995	poor
08-20	Rice Brook	0.4	09/10/2000	fair
08-20	Rice Brook	0.4	09/03/2001	fair
08-20	Rice Brook	0.4	09/02/2002	fair
08-20	Rice Brook	0.4	09/07/2003	fair
08-20	Rice Brook	0.6	09/09/1994	poor
08-20	Rice Brook	0.6	09/07/1995	fair
08-20	Rice Brook	0.6	09/10/2000	fair
08-20	Rice Brook	0.6	09/03/2001	fair
08-20	Rice Brook	0.6	09/02/2002	fair
08-20	Rice Brook	0.6	09/07/2003	fair
08-20	Rice Brook	0.7	09/09/1994	fair
08-20	Rice Brook	0.7	09/07/1995	poor
08-20	Rice Brook	0.7	09/10/2000	fair

08-20	Rice Brook	0.7	09/03/2001	good
08-20	Rice Brook	0.7	09/02/2002	fair
08-20	Rice Brook	0.7	09/07/2003	good-fair
08-20	Rice Brook	1.1	09/09/1994	fair
08-20	Rice Brook	1.1	09/07/1995	fair
08-20	Rice Brook	1.1	09/10/2000	fair
08-20	Rice Brook	1.1	09/03/2001	good
08-20	Rice Brook	1.1	09/02/2002	fair
08-20	Rice Brook	1.1	09/07/2003	good-fair
08-20	Clay Brook	2.0	09/07/1995	fair
08-20	Clay Brook	2.0	09/05/2006	good-fair
08-20	Clay Brook	2.1	09/07/1995	poor
08-20	Clay Brook	2.1	09/05/2006	good-fair
08-20	Clay Brook	2.3	10/07/1996	poor
08-20	Clay Brook	2.3	09/18/2000	fair
08-20	Clay Brook	2.3	09/05/2006	good-fair
08-20	Slide Brook	0.7	09/18/2000	excellent
08-20	Slide Brook	0.7	09/07/2002	very good
08-20	Slide Brook	0.7	09/05/2006	vgood-good
08-20	Chase Brook	1.2	09/20/1994	fair
08-20	Chase Brook	1.2	10/06/1998	fair
08-20	Chase Brook	1.2	09/03/2002	good
08-20	Chase Brook	1.2	09/05/2006	good
08-20	Mad River Trib 46	0.2	06/08/1995	good
08-20	Bradley Brook	1.7	09/27/1994	excellent
08-20	Bradley Brook	1.7	09/05/2006	good-fair
08-20	Folsom Brook	0.8	09/23/2000	very good

Table A. 4.b. Fish Sampling Sites - Mad River and Tributaries 1994 to 2006

08-18	Mad River	23.6	9/15/2005	fair
08-19	Shepard Brook	5.8	10/02/2000	excellent

Table A.5.a. Macroinvertebrate Sampling Sites - Little River Watershed 1994 to 2006

WBID	River or Stream	Station	Date	Assessment
08-11	Gold Brook	0.4	09/29/2005	very good
08-11	Little River	0.7	10/18/2000	good-fair
08-12	Little River	10.3	09/17/1996	good
08-12	West Branch Little River	1.9	09/09/1998	good
08-12	West Branch Little River	3.1	06/07/1997	fair
08-12	West Branch Little River	3.7	09/26/1997	excellent
08-12	West Branch Little River	3.7	09/26/1997	good
08-12	West Branch Little River	4.2	09/26/1997	excellent
08-12	West Branch Little River	6.5	09/14/2000	good
08-12	West Branch Little River	6.5	09/04/2002	good
08-12	West Branch Little River	6.5	09/09/2003	fair-poor
08-12	West Branch Little River	6.5	09/07/2004	good-fair
08-12	West Branch Little River	6.5	09/28/2005	
08-12	West Branch Little River	6.5	10/10/2006	fair

08-12	West Branch Little River	7.0	09/11/1006	good
08-12	West Branch Little River	7.5	09/14/2000	fair
08-12	West Branch Little River	7.5	09/04/2001	fair
08-12	West Branch Little River	7.5	09/04/2002	good-fair
08-12	West Branch Little River	7.5	09/09/2003	fair-poor
08-12	West Branch Little River	7.5	10/10/2006	fair
08-12	West Branch Little River	8.0	09/12/2003	vgood-good
08-12	West Branch Little River	8.0	10/10/2006	fair
08-12	West Branch Little River	8.3	09/14/2000	good-fair
08-12	West Branch Little River	8.3	09/04/2001	fair
08-12	West Branch Little River	8.3	09/04/2002	good
08-12	West Branch Little River	8.8	09/04/2002	good
08-12	Inn Brook	0.3	09/14/2000	poor
08-12	Inn Brook	0.3	09/04/2001	fair
08-12	Inn Brook	0.6	09/14/2000	poor
08-12	Inn Brook	0.6	09/04/2001	poor
08-12	Inn Brook	0.6	09/14/2006	poor
08-12	Inn Brook	0.7	09/14/2006	fair
08-12	Ranch Brook	1.5	09/14/2000	very good
08-12	Ranch Brook	1.5	09/04/2001	excellent
08-12	Ranch Brook	1.5	09/09/2002	exc-vgood
08-12	Ranch Brook	1.5	09/09/2003	very good
08-12	Ranch Brook	1.5	09/11/2006	very good
08-12	Big Spruce Brook	0.2	09/14/2000	fair
08-12	Big Spruce Brook	0.2	09/12/2003	good-fair
08-12	Big Spruce Brook	0.2	10/10/2006	fair
08-12	Big Spruce Brook	0.3	10/10/2006	fair
08-12	Little Spruce Brook	0.2	09/12/2003	fair
08-12	Longtrail Tributary	0.1	09/14/2000	good-fair
08-12	Pinnacle Brook	0.2	09/14/2000	excellent
08-12	Pinnacle Brook	0.2	10/10/2006	vgood-good

Table A.5.b. Fish Community Sampling Sites - Little River Watershed 1994 to 2006

08-11	Stevenson Brook	0.4	9/25/2000	very good
08-11	Stevenson Brook	0.4	9/19/2001	excellent
08-11	Stevenson Brook	0.4	8/30/2005	excellent

Table A.6.a. Macroinvertebrate Sampling Sites - Huntington River watershed 1994 to 2006

WBID	River or Stream	Station	Date	Assessment
08-10	John Brook	2.3	09/19/1996	good
08-10	John Brook	2.4	09/19/1996	good
08-10	Huntington River	10.6	09/13/2000	very good

Table A.6.b. Fish Community Sampling Sites - Huntington River watershed 1994 to 2006

08-10	Huntington River	0.7	9/22/2000	excellent
08-10	Huntington River	5.8	9/22/2000	very good

Table A.7.a. Macroinvertebrate Sampling Sites on Lower Winooski River and Tributaries 1995 to 2006

WBID	River or Stream	Station	Date	Assessment
08-01	Winooski River	15.5	10/03/2000	good
08-02	Sunderland Brook	86.0	10/02/2006	
08-02	Sunnyside Brook	0.2	10/03/2006	fair
08-02	Sunnyside Brook Trib #1	0.1	10/03/2006	exc-vgood
08-02	Allen Brook	2.4	10/12/1999	fair
08-02	Allen Brook	2.4	10/05/2000	good
08-02	Allen Brook	2.4	10/21/2002	good
08-02	Allen Brook	2.4	09/05/2003	good
08-02	Allen Brook	2.4	10/04/2003	vg-good
08-02	Allen Brook	2.4	10/13/2004	good-fair
08-02	Allen Brook	2.4	10/04/2005	good
08-02	Allen Brook	2.4	10/12/2005	good
08-02	Allen Brook	4.3	09/05/2003	fair
08-02	Allen Brook	4.3	10/04/2003	vg-good
08-02	Allen Brook	4.3	10/13/2004	good
08-02	Allen Brook	4.3	10/04/2005	fair
08-02	Allen Brook	4.3	10/12/2005	good
08-02	Allen Brook	6.0	10/21/2002	good-fair
08-02	Allen Brook	6.0	10/04/2003	vgood
08-02	Allen Brook	6.0	10/13/2004	good
08-02	Allen Brook	6.0	10/12/2005	vgood
08-02	Allen Brook	6.5	10/21/2002	good-fair
08-02	Allen Brook	6.5	10/04/2003	vgood
08-02	Allen Brook	6.5	10/13/2004	vgood
08-02	Allen Brook	6.5	10/06/2005	vg-good
08-02	Allen Brook	6.5	1012/2005	vgood
08-02	Allen Brook	8.2	10/11/1995	vg-good
08-02	Allen Brook	8.2	10/05/2000	excellent
08-02	Allen Brook	8.2	10/04/2005	good
08-02	Muddy Brook	1.2	10/05/2000	fair
08-02	Muddy Brook	1.2	10/14/2003	good
08-02	Muddy Brook Trib 4	0.3	10/13/1994	fair-poor
08-02	Centennial Brook	0.1	09/13/2000	poor
08-02	Centennial Brook	0.1	10/13/2003	poor
08-02	Centennial Brook	1.2	10/13/1994	poor
08-02	Alder Brook	0.3	10/17/1996	good
08-02	Alder Brook	0.3	10/10/2001	good-fair
08-02	Alder Brook	0.3	10/02/2003	vg-good
08-02	Alder Brook	0.3	10/04/2006	good
08-02	Alder Brook	1.1	10/27/2006	

08-02	Morehouse Brook	0.3	09/29/1997	poor
08-02	Morehouse Brook	0.3	10/11/2002	poor
08-02	Morehouse Brook	0.3	10/20/2004	poor
08-02	Morehouse Brook	0.6	09/13/2000	poor
08-03	Winooski River	25.5	08/30/1999	good
08-04	Joiner Brook Trib	0.1	10/20/1997	fair
08-04	Joiner Brook Trib	0.4	10/20/1997	poor
08-04	Joiner Brook Trib	0.4	10/05/2000	fair
08-04	Joiner Brook Trib	0.4	09/11/2006	good-fair
08-04	Crossett Brook	3.8	09/27/1995	excellent
08-04	Crossett Brook Trib 7	0.1	09/05/2000	fair
08-04	Mill Brook	0.3	10/03/2000	vgood
08-05	Winooski River	42.7	09/22/2000	good
08-05	Winooski River	44.6	06/27/1997	good-fair
08-05	Winooski River	47.2	10/03/2000	good
08-05	Winooski River	55.7	10/03/2000	very good
08-06	Thatcher Brook	0.1	09/11/1997	good
08-06	Thatcher Brook	0.1	09/21/2000	very good
08-06	Thatcher Brook	5.3	09/11/1997	good
08-06	Graves Brook	0.1	09/21/2000	good
08-06	Jones Brook	0.1	09/21/2000	good

Table A.7.b. Fish Community Sampling Sites on Lower Winooski River and Tributaries 1994 to 2006

WBID	River or Stream	Station	Date	Assessment
08-02	Allen Brook	0.6	9/24/1997	good
08-02	Allen Brook	0.6	08/28/1998	good
08-02	Allen Brook	0.6	10/17/2000	good
08-02	Allen Brook	2.4	10/22/2002	poor
08-02	Allen Brook	2.4	09/05/2003	poor
08-02	Allen Brook	2.4	10/04/2003	poor
08-02	Allen Brook	2.4	10/13/2004	fair
08-02	Allen Brook	2.4	10/04/2005	fair
08-02	Allen Brook	4.3	10/12/1999	fair
08-02	Allen Brook	4.3	10/22/2002	fair
08-02	Allen Brook	4.3	09/05/2003	fair
08-02	Allen Brook	4.3	10/04/2003	fair
08-02	Allen Brook	4.3	10/13/2004	fair
08-02	Allen Brook	4.3	10/06/2005	fair
08-02	Allen Brook	6.0	10/22/2002	good
08-02	Allen Brook	6.0	10/04/2003	good
08-02	Allen Brook	6.0	10/13/2004	good
08-02	Allen Brook	6.0	10/12/2005	good
08-02	Allen Brook	6.5	10/22/2002	good

08-02	Allen Brook	6.5	10/04/2003	good
08-02	Allen Brook	6.5	10/13/2004	good
08-02	Allen Brook	6.5	10/06/2005	good
08-02	Allen Brook	6.5	10/12/2005	good
08-02	Muddy Brook	1.2	10/14/2003	good
08-02	Muddy Brook Trib 4	0.2	09/22/1997	good
08-02	Muddy Brook Trib 4	0.2	10/13/1999	fair
08-02	Muddy Brook Trib 4	0.2	09/30/2002	good
08-02	Centennial Brook	0.1	10/13/2003	good
08-02	Centennial Brook	0.2	10/07/2004	fair
08-02	Centennial Brook	0.2	10/03/2005	fair
08-02	Alder Brook	0.3	10/02/2003	good
08-02	Alder Brook	0.3	08/24/2004	good
08-02	Sucker Brook	1.7	08/26/1998	good
08-02	Sunderland Brook	1.0	10/04/2000	very good
08-02	Sunderland Brook	1.0	10/10/2003	good
08-02	Sunderland Brook	1.1	10/10/2003	very good
08-04	Mill Brook	0.4	08/26/2004	excellent
08-06	Thatcher Brook	0.1	09/11/1997	very good
08-06	Thatcher Brook	0.1	08/30/2005	very good
08-06	Thatcher Brook	5.3	09/11/1997	good
08-06	Great Brook	0.8	06/24/2000	very good
08-06	Graves Brook	0.1	09/18/2000	poor
08-08	Great Brook	1.3	09/04/1998	very good

Appendix B

Housing and Population Growth in the Winooski River watershed

Table B.1. Population of Winooski River Watershed Towns

Town	Pop 1970	Pop 1980	Pop 1990	Pop 2000	% change 1970-1980	% change 1980-1990	% change 1990 - 2000
Barre	6509	7090	7411	7602	9	5	3
Barre City	10209	9824	9482	9291	-4	-3	-2
Berlin	2050	2454	2561	2864	20	4	12
Bolton	427	715	971	971	67	36	0
Buels Gore	10	9	2	12	-10	-78	500
Burlington	38633	37712	39127	39824	-2	4	2
Cabot	663	958	1043	1213	44	9	16
Calais	749	1207	1521	1529	61	26	1
Colchester	8776	12629	14731	16986	44	17	15
Duxbury	621	877	976	1289	41	11	32
East Montpelier	1597	2205	2239	2578	38	2	15
Essex	10951	14392	16498	18626	31	15	13
Fayston	292	657	846	1141	125	29	35
Huntington	748	1161	1609	1861	55	39	16
Jericho	2343	3575	4302	5015	53	20	17
Marshfield	1033	1267	1331	1496	23	5	12
Middlesex	857	1235	1514	1729	44	23	14
Montpelier	8609	8241	8247	8035	-4	0	-3
Moretown	904	1221	1415	1653	35	16	17
Northfield	4870	5435	5610	5791	12	3	3
Orange	540	752	915	965	39	22	5
Plainfield	1399	1249	1302	1286	-11	4	-1
Richmond	2249	3159	3724	4090	40	18	10
Roxbury	354	452	575	576	28	27	0
St. George	477	677	705	698	42	4	-1
South Burlington	10032	10679	12809	14879	6	20	16
Stowe	2388	2991	3433	4339	25	15	26
Waitsfield	837	1300	1422	1659	55	9	17
Warren	588	956	1172	1681	63	23	43
Waterbury	4614	4465	4589	4915	-3	3	7
Williamstown	1822	2284	2839	3225	25	24	14
Williston	3187	3843	4887	7650	21	27	57
Winooski	7309	6318	6649	6561	-14	5	-1
Woodbury	399	573	766	804	44	34	5
Worcester	505	727	906	902	44	25	0

Table B.2. Housing Units of Winooski River Watershed Towns

Town	Housing Units 1980	Housing Units 1990	Housing Units 2000	% Change 1980-1990	% Change 1990-2000
Barre	2335	2747	3046	18	11
Barre City	4152	4321	4477	4	4
Berlin	918	1022	1172	11	15
Bolton	359	543	412	51	-24
Buels Gore	8	4	8	-50	100
Burlington	13763	15480	16398	12	6
Cabot	449	496	634	10	28
Calais	573	679	773	18	14
Colchester	4566	5922	6727	30	14
Duxbury	403	442	569	10	29
East Montpelier	730	896	1055	23	18
Essex	4826	6310	7170	31	14
Fayston	701	787	900	12	14
Huntington	448	622	744	39	20
Jericho	1079	1489	1774	38	19
Marshfield	494	540	686	9	27
Middlesex	484	604	719	25	19
Montpelier	3437	3769	3899	10	3
Moretown	544	639	727	17	14
Northfield	1704	1877	1958	10	4
Orange	276	359	422	30	18
Plainfield	457	512	520	12	2
Richmond	1071	1391	1528	30	10
Roxbury	229	335	362	46	8
St. George	241	274	277	14	1
South Burlington	3972	5437	6496	37	19
Stowe	1823	2830	2728	55	-4
Waitsfield	684	831	908	21	9
Warren	1337	1949	2078	46	7
Waterbury	1658	1956	2106	18	8
Williamstown	861	1133	1318	32	16
Williston	1284	1874	3036	46	62
Winooski	2403	2926	3015	22	3
Woodbury	523	564	659	8	17

Appendix C

Dams in the Winooski River Watershed

Table C.1. Dams in the Winooski River Watershed

Dam Name	Stream	Town	Status	Use *	Built	Re-con+	State ID
West Hill Pond	Trib to Jug Brook	Cabot	In Service	R	1820		39.01
Mamet Pond	Jug Brook-TR	Woodbury	In Service	R	1994		252.17
Marshfield No. 6	Mollys Brook	Cabot	In Service	HR	1927	1935	39.02
Milne	Trib to Mollys Falls Reservoir	Cabot					39.03
Clarks Saw Mill	Winooski River	Cabot					39.04
Cabot-6	Winooski River	Cabot	Breached				39.06
Peacham Pond	Sucker Brook	Peacham	In Service	HR	1930		151.03
Goslants Pond	Trib to Peacham hollow Brook	Peacham	Deleted				151.08
Mud Pond	Trib to South Peacham Brook	Peacham	Breached				151.11
Richards	Trib to Winooski River	Marshfield	In Service	R	1969		123.01
Bailey Pond	Marshfield Brook	Marshfield	In Service	R			123.02
Marshfield Pond	Marshfield Brook	Marshfield					123.03
Laird Pond	Nasmith Brook	Marshfield	Partially Breached	R	1900	1959	123.04
Farrington	Winooski River	Marshfield					123.05
Marshfield-6	Winooski River	Marshfield	Breached				123.06
Marshfield-7	Winooski River	Marshfield	Breached				123.07
Marshfield-8	Winooski River	Marshfield					123.08
Marshfield-9	Winooski River	Marshfield	Breached				123.09
Old Batchelder Mill	Winooski River	Plainfield					155.01
Valley Lake	Dog Pond Brook	Woodbury	Breached (Partial)	R	1900		252.04
Woodbury-5	Dog Pond Brook	Woodbury					252.05
Woodbury Upper	Dog Pond Brook	Woodbury	Breached (Partial)	R	1949	1973	252.06
Woodbury Lower	Dog Pond Brook	Woodbury	Breached (Partial)				252.07
Woodbury	Dog Pond Brook	Woodbury					252.08
South Woodbury Pond	Trib to Sabin Pond	Woodbury	In Service	R	1875		252.09
Daniels Mill	Trib to Woodbury Lake	Woodbury					252.10
Woodbury-11	Trib to Nelson Pond	Woodbury					252.11
Woodbury-12	Trib to Nelson Pond	Woodbury					252.12
Benjamin	Trib to Woodbury Lake	Woodbury					252.13
Dam Name	Stream	Town	Status	Use *	Built	Re-con+	State ID

Woodbury-14	Trib to Woodbury Lake	Woodbury					252.14
Woodbury-15	Trib to Nelson Pond	Woodbury					252.15
King Pond (Lower)	Trib to Forest Lake	Woodbury					252.16
Sabin Pond	Kingsbury Branch	Calais	Breached				40.02
East Calais Mill	Kingsbury Branch	Calais	In Service	R	1900	1975	40.08
Nelson Pond	Trib to Mirror Lake	Calais	Breached				40.01
No. 10 Pond	Trib to Dugar Brook	Calais	In Service	R	1820		40.03
North Calais Mill	Mirror Lake Brook	Calais					40.06
Calais-7	Mirror Lake Brook	Calais					40.07
Scribner	Mirror Lake Brook	Calais					40.14
Curtis Pond	Curtis Pond Brook	Calais	In Service	R	1900		40.09
Robinsons Sawmill	Curtis Pond Brook	Calais	In Service				40.10
Elmslie	Pekin Brook	Calais	In Service	R	1989		40.17
Adamant Pond	Beaver Meadow Brook	Calais	In Service	R	1870	1975	40.11
Hatch's Mill	Beaver Meadow Brook	Calais					
Rogers	Trib to Sodom Pond Brook	Calais			1962		40.13
North Montpelier Pond	Kingsbury Branch	East Montpelier	In Service	R	1920	1984	65.02
Sodom Pond	Sodom Pond Brook	East Montpelier	Breached				65.04
Crystal Pool	Sodom Pond Brook	East Montpelier					65.06
Chapels Pond	Trib to Sodom Pond Brook	East Montpelier					65.07
East Montpelier	Winooski River	East Montpelier					65.05
Montpelier No. 5	Winooski River	East Monpelier					65.01
Brooklyn Street	Stevens Branch	Barre City	Breached				13.01
Jones Brothers	Stevens Branch	Barre City	Breached				13.03
Jockey Hollow	Stevens Branch	Barre Town					14.04
Phelps Mill	Jail Branch	Barre City					13.04
East Barre	Jail Branch	Barre Town	In Service	C	1935	1956	14.02

Dam Name	Stream	Town	Status	Use *	Built	Re-con+	State ID
Barre-3	Jail Branch	Barre Town					14.03
Sargents Mill	Jail Branch	Barre Town					14.05
Hands Mill	Jail Branch	Washington	Abandoned	O	1860	1928	225.01
Green	East Orange Branch-TR	Washington					225.02
Creamery	Jail Branch	Washington					225.04
Giacherio	Gunners Brook	Barre Town					14.09
Whitcomb	Stevens Branch-TR	Williamstown			1933		244.01
Rouleau	Stevens Branch-TR	Williamstown			1945		244.02
Limehurst Pond	Stevens Branch-TR	Williamstown					244.03
Sorimaini	Stevens Branch-TR	Williamstown					244.07
Williamstown-9	Stevens Branch-OS	Williamstown					244.09
Williamstown-10	Martin Brook	Williamstown					244.10
Martin Brook	Martin Brook	Williamstown	Not in Use	S			244.13
Thurman W. Dix Reservoir	Orange Brook	Orange	In Service	S	1950	1968	147.01
Upper Orange Reservoir	Orange Brook	Orange					147.02
Lower Orange Reservoir	Orange Brook	Orange	In Service	S	1910	1996	147.03
Orange-11	Orange Brook	Orange	Breached				147.11
Orange-12	Orange Brook	Orange					147.12
East Orange (Upper)	Trib to East Orange Branch	Orange					147.08
East Orange (Lower)	Trib to East Orange Branch	Orange					147.09
Bennetts Mill	Nelson Brook	Orange	Abandoned				147.06
Bolster Reservoir	Trib to Stevens Branch	Barre Town	Abandoned	S	1910		14.01
Barre-8	Trib to Stevens Branch	Barre Town					14.08
Berlin-2	Trib to Stevens Branch	Berlin					20.02
Dry Pond	Berlin Pond-TR	Northfield	Breached		1905		143.01
Berlin Pond	Trib to Stevens Branch	Berlin	In Service	S	1920		114.09
Berlin-1	Trib to Winooski River	Berlin					20.01
Montpelier Reservoir (Lower)	Benjamin Falls Brook	Berlin					20.04
Montpelier Reservoir (Upper)	Benjamin Falls Brook	Berlin					20.09

Dam Name	Stream	Town	Status	Use *	Built	Re-con+	State ID
Montpelier No. 4	Winooski River	Berlin	In Service	H	1909	1985	20.05
Montpelier No. 3	Winooski River	Montpelier					131.03
Worcester Pond	Worcester Brook	Worcester	Breached (Partial)	R	1933		255.01
Ladds Mill	North Branch Winooski River	Worcester	In Service	H	1928		255.02
Janawics	North Branch Winooski River	Worcester					255.03
Chandler Sawmill	Minister Brook	Worcester					255.04
Worcester Brook	Worcester Brook	Worcester					255.05
Worcester-6	North Branch Winooski River	Worcester	Breached				255.06
Middlesex-3	Trib to Great Brook	Middlesex					126.03
Wrightsville	North Branch	Middlesex	In Service	CH R	1935		126.01
North Branch	North Branch	Montpelier					131.07
Lane	North Branch	Montpelier	Not in Use	O	1920		131.01
Dodge-Roya	North Branch	Montpelier	Breached				131.04
Trestle	North Branch	Montpelier					131.05
Middlesex No. 2	Winooski River	Middlesex	In Service	H	1928		126.02
Roxbury-2	Trib to Dog River	Roxbury					170.02
Beaver Pond	Trib to Dog River	Roxbury	In Service		1933		170.04
Northfield-12	Felchner Brook	Northfield					143.12
Camp Wihakowi	Bull Run	Northfield	Breached				143.08
Baker Pond	Sunny Brook	Brookfield	In Service	R	1956	1995	32.01
Wardner Pond	Sunny Brook	Brookfield	Breached				32.06
Cooks Mill	Sunny Brook	Northfield					143.09
Vatters Pond	Robinson Brook	Northfield		R			143.02
Boutwell	Robinson Brook	Northfield					143.03
Towne	Trib to Robinson Brook	Northfield		R			143.07
Union Brook	Union Brook	Northfield	In Service				143.13
Cox Brook	Cox Brook	Moretown					132.07
Pierson	Cox Brook	Northfield					143.06
Northfield Mills	Dog River	Northfield					143.04
Cross Brothers	Dog River	Northfield	Breached			1924	143.05
Randall Wood Products	Dog River	Northfield	Breached				143.11
Riverton	Dog River	Berlin	Breached				20.08
Newbrough Upper	Trib to Dog River	Berlin	In Service	R	1965	1967	20.06
Newbrough Lower	Trib to Dog River	Berlin					20.07

Dam Name	Stream	Town	Status	Use *	Built	Re-con+	State ID
Sugarbush Snowmaking Pond	Mad River-OS	Waitsfield	In Service	R	1996		217.03
Plenge		Warren					223.01
Warren Lake	Mills Brook	Warren	In Service	R	1983	2004	223.02
Warren Village	Mad River	Warren				1984	223.03
Sugarbush Tank	Rice Brook-TR-OS	Warren	In Service	O	1989		223.05
Moretown No. 8	Mad River	Moretown	In Service	H	1910		132.01
USGS Gage No. 2880	Mad River	Moretown					132.02
Eight Trout Club	Welder Brook	Moretown	Breached	R	1935		132.03
Ward Lower	Mad River	Moretown	Breached (Partial)				132.04
Ward (Upper)	Mad River	Moretown	Breached				132.05
Moretown-6	Mad River	Moretown	Breached				132.06
Bolton Falls No. 1	Winooski River	Duxbury	In Service	H	1899	1986	63.01
Duxbury Mill	Crossett Brook	Duxbury					63.02
Kimibakw	Trib to Sterling Brook	Morristown	In Service	R	1964		134.05
Schwartz	Trib to Sterling Brook	Morristown	In Service	R	1989		134.08
Lake Mansfield	Miller Brook	Stowe	In Service	R	1900	1980	199.01
Culver Mill	Miller Brook	Stowe					199.02
Feed Company (Upper)	Thatcher Brook	Waterbury	Breached				226.02
Ice Pond	Thatcher Brook	Waterbury	Breached (Partial)				226.03
Adams	Little River	Stowe	Breached	O			199.03
Moscow Mills	Little River	Stowe	In Service	H			199.04
Pike	Little River	Stowe					199.05
Sylvan Park	Trib to Little River	Stowe		R	1966		199.06
Bloch	Trib to Barrows Brook	Stowe	In Service	R	1967		199.07
Barrows Brook	Barrows Brook	Stowe					199.08
Heath		Stowe					199.09
Mount Mansfield Corp.	West Branch Waterbury River	Stowe	In Service	R	1979		199.10
Stowe-11	Little River-TR-OS	Stowe					199.11
Beaver Pond	Miller Brook	Stowe					199.12
Stowe Upper Golf Course	Winooski River-OS	Stowe	In Service	R	2004		199.16
Waterbury	Little River	Waterbury	In Service	CR H	1938	1985	226.01
Ice Pond	Trib to Winooski River	Duxbury	Breached (Partial)				63.03
Colbyville Upper	Thatcher Brook	Waterbury		H			226.04

Dam Name	Stream	Town	Status	Use *	Built	Re-con+	State ID
Colbyville Lower	Thatcher Brook	Waterbury					226.05
Brisco	Bryant Brook-OS	Waterbury		R	1971	1973	226.06
Waterbury-7	Trib to Alder Brook	Waterbury					226.07
Gillette Pond	Johns Brook	Richmond		R	1900	1960	166.01
Richmond Pond	Trib to Snipe Island Brook	Richmond					166.02
Pechie	Trib to Hollow Brook	Starksboro	In Service	R	1971		197.02
Saxon Hill Reservoir (North)	Trib to Winooski River	Essex		S			69.03
Saxon Hill Reservoir (South)	Trib to Winooski River	Essex					69.04
Essex No. 19	Winooski River	Essex	In Service	H	1917		69.05
IBM Lagoon	Winooski River-OS	Essex	In Service		1983		69.06
Essex Town Reservoir	Trib to Winooski River	Essex					69.08
Gorge No. 18	Winooski River	South Burlington	In Service	H	1914	1928	192.01
Winooski One	Winooski River	Burlington	In Service	H	1876	1992	38.01
Chace Mills No. 21	Winooski River	Burlington					38.02
Howe Farm WMA	Winooski River-OS	Burlington	In Service	F	1985		38.03
Burlington Electric WMA	Winooski River-OS	Burlington	In Service		1985		38.04
Winooski Water Supply Upper	Trib to Winooski River	Winooski	Breached	R	1900	1983	250.01
Winooski Water Supply Lower	Trib to Winooski River	Winooski					250.02
Kelly Pond	Trib to Winooski River	Winooski					250.03

*H = hydroelectric, R = recreation, C = flood control, S= water supply, O = other, blank = unknown

+ date re-constructed