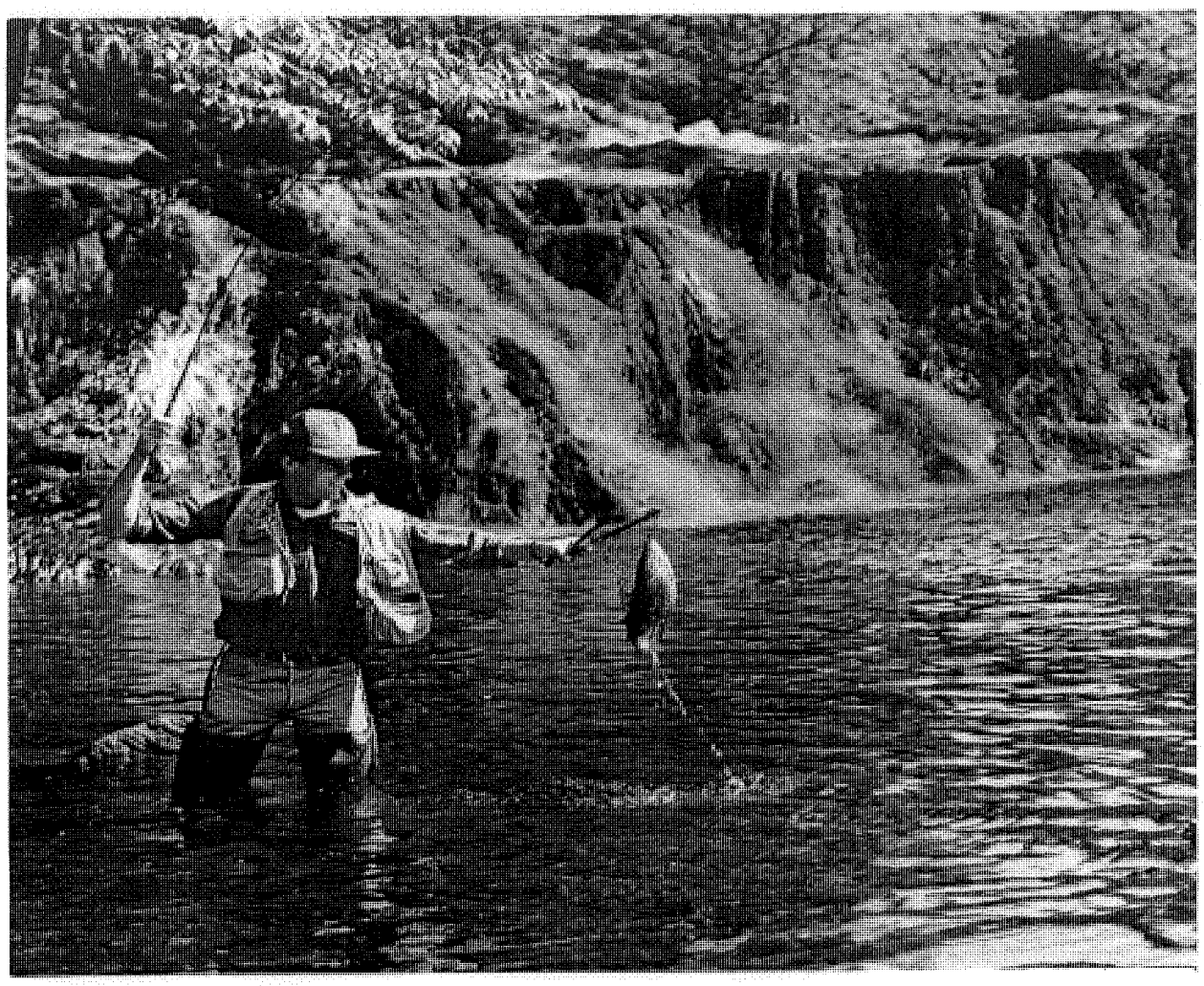
STATE OF VERMONT

2004 WATER QUALITY ASSESSMENT REPORT (305B REPORT)



A fishing success story in Worcester. North Branch, Winooski River. Photo Credit: Vermont Travel Division.

Prepared by:
Vermont Department of Environmental Conservation
Water Quality Division
Building 10 North
103 South Main Street
(802) 241-3770
(802) 241-3287 FAX
www.vtwaterquality.org

June 2004

STATE OF VERMONT

2004 WATER QUALITY ASSESSMENT

CLEAN WATER ACT SECTION 305B REPORT

Vermont Agency of Natural Resources
Department of Environmental Conservation
Water Quality Division
Waterbury, Vermont 05671-0408
www.vtwaterquality.org

June 2004

The Vermont Department of Environmental Conservation is an equal opportunity agency and offers all persons the benefits of participating in each of its programs and competing in all areas of employment regardless of race, color, religion, sex, national origin, age, disability, sexual preference or other non-merit factors.

This document is available upon request in large print, braille or audio cassette.

VT Relay Service for the Hearing Impaired
1-800-253-0191 TDD > Voice
1-800-253-0195 Voice > TDD

Vermont Department of Environmental Conservation
consisting of:

Commissioners Office
Air Pollution Control Division
Department Laboratory Services
Environmental Assistance Division
Facilities Engineering Division
Geology & Mineral Resources Division
Waste Management Division
Wastewater Management Division
Water Quality Division
Water Supply Division

Central Office: Waterbury
Regional Offices: Barre, Essex, Pittsford, Springfield, St. Johnsbury

DEPARTMENT VISION

We envision a Vermont where people can live in harmony with diverse and healthy natural systems;
appreciate and enjoy our natural resources;
understand the environment;
work together responsibly to reduce waste and risks to human health and the environment;
and prosper without significant degradation of natural systems.

We envision a Vermont where people breathe clean air;
drink clean water;
eat safe food;
and live in a sustained and healthy environment.

DEPARTMENT MISSION

To preserve, enhance, restore, and conserve Vermont's natural resources,
and protect human health, for the benefit of this and future generations.

Table of Contents

Foreword.....i

Part One: **Executive Summary/Overview**.....1

Part Two: **Introduction**.....5

Part Three: **Background**.....7
Summary Description of Vermont's Water Quality
Atlas/Total Waters
Effectiveness of Pollution Control Programs
Nature & Extent of Nonpoint Source Pollutants
Environmental Impact/Economic & Social Costs/Economic & Social Benefits of Effective Water Programs
Strategy to Achieve Comprehensive Monitoring & Assessment Coverage

Part Four: **Surface Water Monitoring & Assessments**.....15
Current Surface Water Quality Monitoring Program
Assessment Methodology
Rivers & Streams Water Quality Assessment (Statewide)
Lakes & Ponds Water Quality Assessment (Statewide)
Wetlands Assessment (Statewide)

Part Five: **Public Health Related Assessments**.....50
Size of Water Affected by Toxicants
Fish Consumption Monitoring
Mercury Monitoring
Cyanobacteria
Small Community Untreated Waste Discharges
Sites of Known Sediment Contamination
Restrictions on Bathing Areas During the 2004 Reporting Period
Restrictions on Surface Drinking Water Supplies During the 2004 Reporting Period
Chronic or Recurring Fish Kills

Part Six: **Summary of Impaired Waters**.....56
Total Maximum Daily Load Program
Overview of Vermont 2004 Priority Waters List – including Section 303d List of Waters

Part Seven: **Groundwater Monitoring & Assessments**.....60
Groundwater Strategy & Management
Cooperation & Coordination
Groundwater Investigations
Information & Public Education
State of Groundwater Quality
State of Groundwater Assessment & Use

Part Eight: **Accessing & Managing Data Used in Decision-Making on the Status of Waters...72**
Water Quality Data
Assessment Information
Mapping
Data Access

Part Nine: **Concerns & Recommendations.....74**
Lakes & Ponds
Rivers & Streams
Groundwater

Appendices
A. Basin Planning Progress.
B. Point Source Control Program Update.
C. 2004 Surface Water Assessment and Listing Methodology.
D. Fish Consumption Advisory (Vermont Department of Health, 6/2000).
E. Report on the Status of Groundwater & Aquifer Mapping in the State of Vermont.

FOREWORD

Section 305b of the Federal Water Pollution Control Act (also known as the Clean Water Act or CWA) requires each state to submit a biennial report to the US Environmental Protection Agency (EPA) which provides information about the quality of the state's surface and ground waters. The Year 2004 Water Quality Assessment Report [often called the *305b Report*] summarizes water quality conditions throughout Vermont during the January 1, 2002 through December 31, 2003 reporting period. Also included is water resources program information for rivers and streams, lakes and ponds, wetlands and groundwater. The report contains information on certain costs and benefits, monitoring progress, swimming beach closures and special concerns. The Year 2004 305b Report, like reports from earlier years, is meant to provide the reader with an understanding of the programs designed to assess water quality problems, as well as put forth particular water quality based recommendations.

A rotating basin schedule is used when assessing the state's waters, assessing roughly one-fifth of the state each year. The Year 2004 305b Report contains updated water quality information for portions of Round Four and Five of the rotating river basin assessments. These specific basins are Basin #1 (Batten Kill, Walloomsac, Hoosic), Basin #5 (upper Lake Champlain direct), Basin #12 (Deerfield) and Basin #13 (lower Connecticut River). This report also contains a summary of the entire state's water quality, which has been updated with the aforementioned rotating basin water quality information.

The 2004 Water Quality Assessment Report describes whether or not the state's surface water uses as defined by EPA and the State Water Quality Standards fall into one of four use support categories. The four use support categories are *full support, stressed, altered,* or *impaired.* The four use support categories are introduced below.

Full Support - This assessment category includes waters of high quality that meet all use support standards for the water's classification and water management type.

Stressed - These are waters that support the uses for the classification but the water quality and/or aquatic habitat have been disturbed to some degree by point or by nonpoint sources of human origin and the water may require some attention to enhance its usefulness or the water quality and/or aquatic habitat may be at risk of not supporting uses in the future. Data or other information that is available confirms water quality or habitat disturbance but not to the degree that any designated or existing uses have become altered or impaired.

Altered - These are waters where a lack of flow, water level or flow fluctuations, modified hydrology, physical channel alterations, documented channel degradation or stream type change is occurring <u>and</u> arises from some human activity, OR where the occurrence of exotic species has had negative impacts on designated uses. The aquatic communities are altered from the expected ecological state. This category includes those waters where there is a documentation of water quality standards violations for flow and aquatic habitat but EPA does not consider the problem(s) caused by a pollutant or where a pollutant results in water quality standards not being met due to historic or previous human-caused channel alterations that are presently no longer occurring.

Impaired - These are surface waters where there are chemical, physical and/or biological data collected from quality assured and reliable monitoring efforts that reveal 1) an ongoing violation of one or more of the criteria in the Water Quality Standards and 2) a pollutant of human or human-induced origin is the most probable cause of the violation.

Water uses include, but are not limited to, drinking, aquatic life, recreation, fish consumption and agriculture. A determination of use support may be made from *monitored*[1] information or from *evaluated*[2] information gathered and provided to the Department of Environmental Conservation (DEC) by water resources personnel, fish and wildlife biologists, aquatic biologists, lake association members and other qualified individuals or groups. The 2004 Water Quality Assessment Report identifies the distance (in miles) of rivers and streams and area (in acres) of lakes and ponds that were either monitored or evaluated.

For CWA Section 305b reporting purposes, river or stream segments and lakes and ponds where one or more uses are not fully supported (i.e. either altered or impaired) are considered not to be meeting the Water Quality Standards. However, and for CWA Section 303d[3] listing and reporting purposes, impaired waters are those where one or more criteria of the Water Quality Standards are violated. Violations of Water Quality Standards are substantiated by chemical, physical or biological water quality data collected through monitoring. In accordance with EPA 303d guidance (December 2001), waters reported for 303d purposes in the year 2004 list of waters are certain impaired waters that need a Total Maximum Daily Load.

The 305b Report is a highly visible mechanism for communicating to Congress, Vermont residents and the Vermont General Assembly the progress made in maintaining and restoring the state's water quality and describing the extent of the remaining problems. The 305b Report has become increasingly important to support funding decisions to the state at the federal level under the CWA Section 106 formula. EPA's Index of Watershed Indicators relies heavily on 305b reports. Also, the 305b reporting process is an important tracking tool for the performance of water quality protection initiatives under the Core Performance Measures of the Performance Partnership Agreements and the Government Performance for Results Act. Finally, the 305b water quality assessments are one of several important sources which assist in the identification of impaired waters under Section 303d of the Clean Water Act. This report, as well as the last previous biennial Vermont Section 305b Report, can be found through the internet at <http://www.vtwaterquality.org/waterq/planassess.htm>

EPA's vision for State 305b reports is the "...reports will characterize water quality and the attainment of water quality standards at various geographic scales." EPA's more detailed vision states that the 305b reports will:

- Comprehensively characterize the waters of the States, Tribes, Territories and the Nation, including surface water, ground water and wetlands. Progress should result in full coverage by 2002.
- Use data of known quality from multiple sources to make assessments
- Indicate progress toward meeting water quality standards and goals.

---

[1] Water quality assessment based on environmental data (biological, chemical or physical) less than 5 years old.

[2] Information used for assessments includes desktop modeling, some lay monitoring data, best professional judgement of resource managers and known sources of pollution. Also, information based on water quality sampling data which is five years old or older.

[3] Section 303d of the Act requires each state to identify those waters for which technology-based pollution controls are not stringent enough to attain or maintain compliance with applicable State water quality standards.

- Describe causes of polluted waters and where and when waters need special protection.
- Support watershed and environmental policy decision-making and resource allocation to address these needs.
- Describe the effects of prevention and restoration programs as well as associated cost and benefits.
- In the long term, describe assessment trends and predict changes.
- Initiate development of a comprehensive inventory of water quality that identifies the location and causes of polluted waters and that helps States, Tribes, Territories direct control programs and implement management decisions.

In order to achieve the vision and long-term goals for the 305b process and to coordinate reporting efforts among the States, Territories, Interstate Commissions and Tribes, EPA requested that the following goals be addressed in 305b reporting:

- *Adopt 2004 Integrated Water Quality Monitoring & Assessment Report Guidance*
  For the Year 2004 305b report, DEC was able to partially adopt EPA's guidance document. For this report, DEC has not been able to convert its assessment approach to the 'assessment unit' type/level of approach advocated by EPA guidance. Rather, DEC has continued to rely upon the well established and functional 'waterbody' as its unit of assessment and reporting. The Department, nonetheless, considers its assessment approach and findings to be largely consistent with the five categorical listings defined in EPA guidance. DEC's assessment process identifies surface waters in full use support (full support and stressed) and less than full use support (altered and impaired). DEC's assessment and listing processes result in the identification of waters considered as "impaired" (consistent with guidance's category 4A, 4B and 5) and in the identification of other waters either in need of assessment (category 3). DEC has identified waters altered by exotic species, altered by flow regulation or altered by historic physical channel changes. These are waters altered by a non-pollutant and except for being labeled as "impaired" could be equivalent to waters for category 4C.

- *Expand use of biological indicators and reporting*
  DEC has completed documentation of bio-criteria development and implementation procedures for macroinvertebrate and fish communities in wadeable streams (refer to documents entitled *"Wadeable Stream Biocriteria Development for Fish and Macroinvertebrate Assemblages in Vermont Streams and Rivers"* and *"Procedures for Determining Aquatic Life Use Status in Selected Wadeable Streams Pursuant to Applicable Water Quality Management Objectives and Criteria for Aquatic Biota Found in Vermont Water Quality Standards (VWQS) Chapter 3 §3-01, as Well as Those Specified in 3-02(A1 and B3), 3-03(A1 and B3), and 3-04(A1 and B4: a-d)"*). The language of these procedures is consistent with the Vermont Water Quality Standards revisions that became effective July 2, 2000. These procedures are currently used by the Department to make a variety of water quality management decisions. The role of biological indicators of ecological health has continued to expand throughout Department programs including: NPDES and Indirect discharge permitting; CERCLA and RCRA hazardous materials site assessments; surface water biological classifications; accidental release and spill damage assessments; 303d listing and the development of TMDLs and restoration plans; non-target impact assessments for pest management programs; distribution of aquatic species in Vermont; and the development of water quality standards for a variety of water body types.

DEC continues to build upon its biological assessment database. In the last two years, more than 450 biological site assessments have been added to its biological database. Summary reports of annual assessment results for wadeable streams are compiled for purposes including but not limited to: Section 303d listing and TMDL development; Section 305b reporting; rotating watershed assessments and watershed planning initiatives. With assistance from EPA, DEC is assessing the use of biological assessments for establishing biological criteria for temporary (vernal) pools and white cedar swamps. Field data have been collected and data are being analyzed for final reporting. With the assistance of EPA, DEC continues to conduct research on indicators of amphibian malformations among northern leopard frogs in the Lake Champlain Valley. Development of bio-criteria for lakes is continuing.

The Water Quality Division of the Department has recently completed an updated version of its web site (http://www.vtwaterquality.org) which includes information on biological monitoring programs and indicators within DEC.

- *Improve data management, increase the documentation of data quality, and increase the use of electronic databases and geographic information systems.*
  DEC's analytical laboratory conducts its business under the auspices of EPA's Quality Assurance/Quality Control Plan (QA/QC), and monitoring is carried out under QA/QC Project Plans. DEC now uses an Access© database for improved 305b information management and has increased the documentation of data quality. Regarding electronic reporting, DEC annually submits rotating assessment data to EPA as each one-fifth of the state is completed. As to geographic information systems (GIS), Vermont is presently phasing in the ability to spatially locate water quality information for rivers and streams. At this time, lakes and ponds data have been spatially located for water quality reporting purposes. For certain nonpoint source projects, DEC has begun expanding its use of EPA's Grants Reporting and Tracking System.

- *Demonstrate a significant expansion in the number of waters assessed across all waterbody types and uses and improve the quality of monitoring and assessment data and reporting.*
  Vermont has responded to this goal by implementing a rotational assessment process such that the rivers and streams and lakes and ponds of all seventeen major basins in the state are assessed once every five years. This has resulted in much more detailed assessments and many more miles/acres of waterbodies being assessed each year, as well as specific follow-up action to monitor suspected problem sites and correct impairments.

- *Increase assessments of drinking water use support*
  This remains a goal for DEC. Until sufficient resources are available to specifically perform drinking water use source support assessments, they will be performed as part of the DEC's yearly rotational basin assessments. It is conceivable that drinking water use source support assessments can be done via the on-going Source Water Assessment and Protection Program.

- *Develop a process for reporting by hydrologic unit (geo-referencing)*
  DEC uses waterbody identification numbers (WBID) for reporting by hydrologic unit. All waterbodies in the state are assigned waterbody identification numbers and are geo-referenced. The WBID consists of the state two-letter abbreviation followed by a two-digit basin number, then a two-digit (river) or five-digit (lake) waterbody number. Waterbodies may consist of

several small tributaries, a lake or a portion of the mainstem of a river. There are 556 lake and pond waterbodies and 210 river and stream waterbodies designated in Vermont. All 766 designated waterbodies have been spatially referenced onto a GIS. DEC has developed a database table to link hydrologic unit codes (HUC-14s) to all WBIDs. This linkage allows DEC to exchange data between the two systems. The Department will soon be converting to a system that is based on the National Hydrography Database (NHD).

PART ONE: EXECUTIVE SUMMARY/OVERVIEW

Overall description

The water quality of Vermont's rivers and streams and lakes and ponds is considered good. This overall water quality rating has not changed from the overall rating level reported in the 2002 305b Report. The US Environmental Protection Agency has requested states to also assess the state's water quality considering the fish consumption advisory for mercury which was issued by the Vermont Department of Health in June 1995 and most recently revised in June 2000. The advisory was issued as the result of fish tissue sampling that showed mercury in the tissue of all fish, particularly in walleye and lake trout, and also PCBs in lake trout[1] in Lake Champlain. Taking the fish consumption advisory into consideration, the overall water quality of all the state's waterbodies would be rated as fair. Deposition of mercury from the atmosphere is the predominant source believed to be responsible for elevated levels of mercury in fish.

For Vermont's wetlands, their water quality is believed to be generally good. This characterization is speculative as Vermont does not have a specific program of assessing and monitoring wetland water quality. Since personnel and financial resources are limited, it has been incumbent upon the state to insure important wetland functions and values are protected from being lost or compromised to development or other destructive practices.

No comprehensive studies have been completed on the quality of Vermont's groundwater. The quality of this vast resource is believed to meet drinking water standards for most of its consumers. An accurate assessment of groundwater quality, however, requires a program with sufficient staff and other resources to characterize the resource.

Assessment Findings

Three basin assessment reports were completed and a fourth was essentially completed in the two years since the 2002 305b report. An assessment report for Basin 13 (the Lower Connecticut River watershed) was completed in April 2002; a report for Basin 1 (the Battenkill, Walloomsac, Hoosic watershed) was completed in August 2002; and a report for Basin 12 (the Deerfield River watershed) was completed in March 2003. Each basin assessment report is available upon request. Basin 5 (the Northern Lake Champlain watershed) is undergoing final revisions as of this writing.

Rivers & streams

The assessment of Vermont's river and stream surface water quality and aquatic habitat conditions has been updated from the 2002 305b assessment with water quality information and data from waters monitored and assessed during the 1/1/01 to 12/31/03 reporting period. There is a substantial difference, however, between the use support determinations in the 2004 statewide assessment summary and those of past 305b reports. As described above and in the

[1] The 1989 advisory issued for PCBs (polychlorinated biphenyls) in Lake Champlain remains in effect.

appendix containing the Assessment Methodology, miles of rivers and streams are placed into one of four categories by degree of support to designated uses – full support, stressed, altered or impaired. This categorization differs from the categories of full support, full support/threatened, partial support, and non-support used in all earlier 305b assessment reports. The 2004 biennial report contains rivers and streams that have been re-assigned to the new categories to the extent possible. However, the current assessment categories do not directly equate to the former categories across all rivers and streams. The assessment category of these rivers and streams will be determined as DEC gets to them in the assessment rotation. *The numbers provided in use support categories as well as the miles of rivers and streams affected by different causes and sources need to be considered as transitional until a complete re-assignment and re-assessment has been done.*

Vermont has approximately 7,100 miles of perennial rivers and streams. Of the 5,479 river and stream miles assessed for this report, overall approximately 88% of those miles are in compliance with the state's water quality standards and support designated uses, and 12% do not meet water quality standards or do not fully support the designated uses. About 1,636 river and stream miles were not assessed for this report.

Lakes & ponds

Inland lakes & ponds
All lakes and ponds within the borders of Vermont are considered as inland lakes or ponds except for the 11 segments of Lake Champlain. Moore Reservoir and Comerford Reservoir (found along the upper Connecticut River), Lake Memphremagog and Wallace Pond are transboundary waters that are reported as "inland lakes."

Of the 55,342 inland lake/pond acres that were assessed for this report, 35,908 inland lake acres support uses and 19,434 inland lake acres do not support uses.

Although all inland lake/pond waters are impacted by mercury pollution and are subject to fish consumption advisories, Vermont's assessment methodology indicates the need for waterbody-specific tissue data to indicate non-support of fish consumption. Accordingly, when assessed following the methodology, 85% of inland lake acres support fish consumption use. This proportion reflects that there are only a relatively small number of Vermont lakes from which actual fish tissue data are available.

Lake Champlain
In Lake Champlain and due to the combined effects of trace metal contamination, nutrient accumulation and non-native species, none of Lake Champlain's 174,175 acres found in Vermont fully support designated uses.

No acres in the Vermont portion of Lake Champlain support fish consumption use due to elevated levels of mercury and polychlorinated biphenyls (PCB) in fish tissue.

Wetlands

The Vermont Wetlands Program within DEC administers the Vermont Wetland Rules which regulate most palustrine wetlands that have been mapped on the Vermont Significant Wetland Inventory maps. Mapped wetlands have a higher level of protection than unmapped wetlands.

Some years ago, the Vermont Agency of Natural Resources digitized all the National Wetland Inventory (NWI) maps for the state. This effort identified a statewide total of 232,000 acres of palustrine wetlands. These wetland areas are considered significant and are designated as Class Two wetlands under the Vermont Wetland Rules. Wetland inventories conducted in selected towns around Vermont indicate there is considerably more acres of wetland than identified by the NWI project. The wetlands that do not appear on the NWI maps are considered Class Three by the Vermont Wetland Rules. The area of Class Three wetlands is estimated as 90,000 acres.

A recent analysis of all completed projects reviewed by DEC showed there has been a total of 330 acres of documented wetland loss and 491 acres of documented wetland impairment over the period between 1990 and 2002. The analysis also showed there were about 590 acres of wetlands saved during the same period.

Groundwater

During the reporting period, a variety of groundwater concerns were addressed. These concerns included the occurrence of naturally occurring arsenic and radionuclides. The wastewater disposal issue regarding radionulcides at public drinking water systems is particularly problematic. MTBE (an additive by refiners to gasoline) is also of major concern regarding groundwater and about 75,000 private wells near hazardous waste sites have been sampled for MTBE. More than 250 wells have MBTE detections across the state.

Approximately 80 public community water systems were identified during the 2001-2003 period with simple 3,000 foot radius circles for Source Protection Areas. Appropriate hydrogeologic calculations and principles were used to provide a hydrogeologically-based Source Protection Area for some water systems. Of the 80 areas identified, 9 reports have been completed and another 10 are under development.

In 2002, the on-site sewage statute was reformed to provide universal jurisdiction over all on-site sewage (septic) systems. This was a major event in the protection and improvement of Vermont's groundwater quality.

Listings of Waters

Development of the Year 2004 List of Impaired Waters (a reporting requirement under Section 303d of the Clean Water Act) is a concurrent process to the development of the 2004 305b report. Consequently, the final 2004 303d List of Impaired Waters is not included in this report. The 2004 303d List of Impaired Waters will be finalized and made available separately.

Vermont's 2002 303d List of Impaired Waters was approved by the New England regional office of EPA during the reporting period (approval on July 28, 2003). The 2002 listing identified a total of 182 waters as being impaired (111 river/streams and 71 lakes/ponds).

During the 2004 305b reporting period, the New England regional office of EPA approved 41 Total Maximum Daily Load determinations completed by DEC.

Concerns & Recommendations

There are several concerns and recommendations that have been identified which relate to the management and improvement of Vermont's water quality and water resources. Concerns and recommendations have been prepared for the following topics and are described in Chapter 9:

Atmospheric deposition of pollutants
Hydrologic modifications in lakes and rivers
Exotic aquatic species as pollutants
Eutrophication of lakes
Nutrient criteria
Stormwater management
Polluting discharges from large farms
Lack of strategic statewide vegetated buffer requirements
Groundwater

PART TWO: INTRODUCTION

Within its borders, Vermont has approximately 7,100 miles of rivers and streams, 300,000 acres of fresh water wetlands and 810 lakes and ponds (those at least 5 acres in size or those named on US Geological Survey maps) totaling 230,789 acres. Surface waters (not including wetlands) are classified as Class A or Class B with an overlay Waste Management Zone in Class B waters for public protection below sanitary wastewater discharges. Class A waters are managed for enjoyment of water in its natural condition, as public drinking water supplies (with disinfection when necessary) or as high quality waters which have significant ecological values. Class B waters, which are managed for high quality, may have minimal, minor or moderate change to aquatic biota or habitat according to the water's management type B1, B2 or B3.

There are approximately 165 miles of Class A rivers and streams and 1,736 acres of Class A lakes and ponds in Vermont (these figures do not include rivers/streams above 2,500 feet elevation which are also Class A). In addition, there are close to 6,935 miles of Class B rivers/streams and 229,053 acres of Class B lakes/ponds. Approximately 315 miles of the Class B rivers and about 15 acres of Class B lakes have a Waste Management Zone. The Waste Management Zone, similar in effect to a zoning overlay, is created on a site-specific basis to accommodate the direct discharge of treated sewage effluent to surface waters.

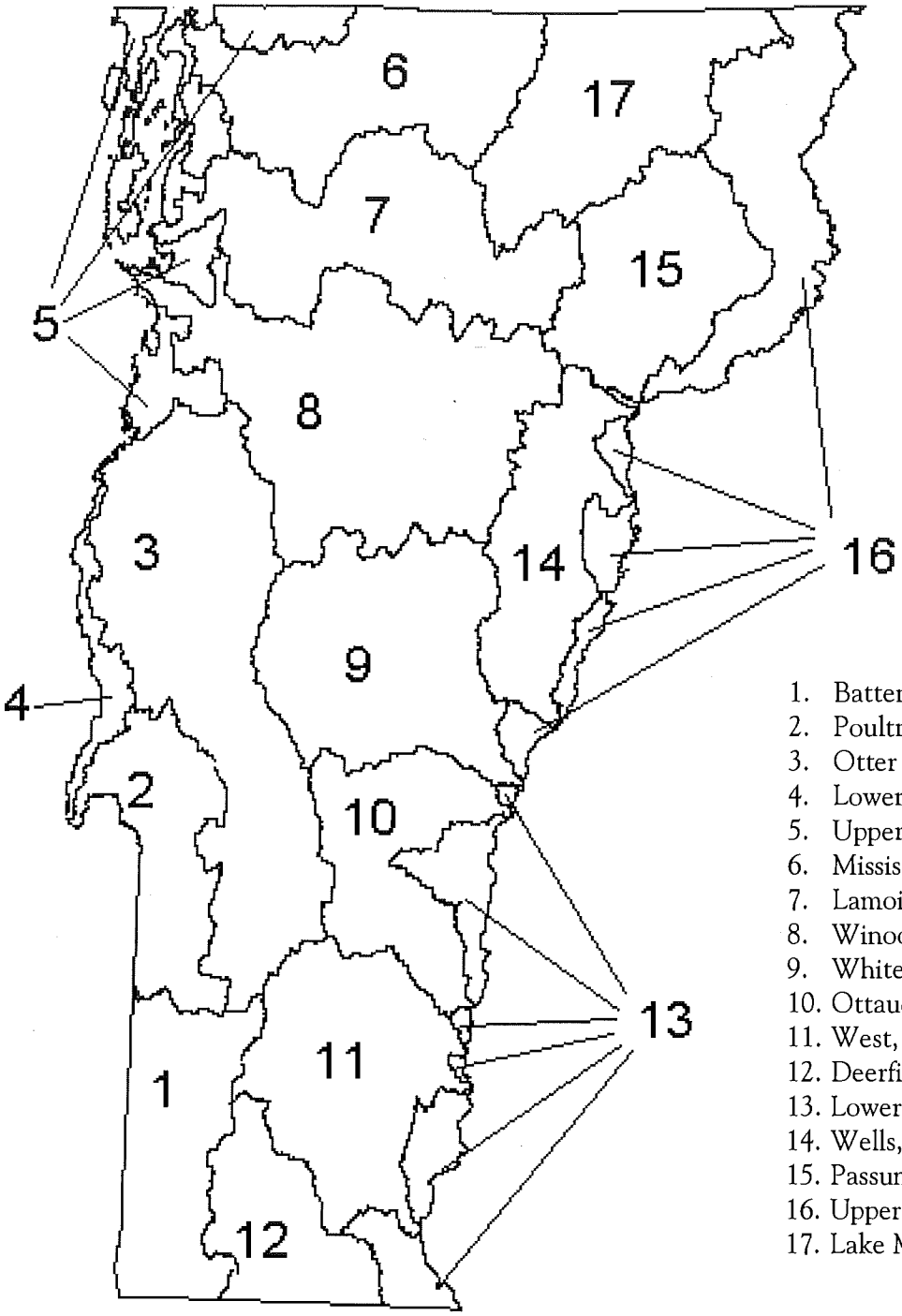
The Vermont portion of the Batten Kill along with the West Branch of the Batten Kill (totaling about 33 miles), the Lower Poultney River (about 22 miles), a 3.8 mile segment of the Ompompanoosuc River and a 1.3 mile segment involving Pikes Falls on the North Branch of Ball Mountain Brook have each been designated by the Vermont Water Resources Board as an Outstanding Resource Water (ORW). The 3.8 mile segment of the Ompompanoosuc was designated ORW in 1996. All other ORWs noted above were designated in 1991.

Wetlands within Vermont are classified as Class One, Class Two or Class Three. Class One wetlands are considered exceptional or irreplaceable in their contribution to Vermont's natural heritage and are afforded the highest level of protection. Class Two wetlands are considered significant. Class One and Class Two wetlands are those shown on the National Wetlands Inventory maps. Class Three wetlands are areas that do not appear on the maps. The majority of wetlands within Vermont are Class Two.

Surface water quality monitoring undertaken by the Department during the 2004 305b reporting period (January 1, 2002 through December 31, 2003) continued to support an assortment of water program activities. Long-term monitoring programs are designed to assess trends in water quality, as well as to generate baseline water quality information. DEC also maintains a strong presence on Lake Champlain and conducts a variety of short-term lake and stream-specific monitoring projects. Monitoring data is used to manage and protect Vermont waters in a pro-active manner. The reader is referred to Part Four of the report for a more detailed description of DEC's surface water quality monitoring program and for the results of monitoring and assessment activities. Appendix C contains DEC's Assessment and Listing Methodology.

For the wide range of water quality management and planning purposes, there are 17 major river basins found in Vermont. These rivers drain into one of four large regional drainages: Hudson River, Lake Champlain, Lake Memphremagog and the Connecticut River. A map illustrating the 17 basins is provided on the following page.

Vermont's Watersheds



1. Battenkill, Walloomsac, Hoosic
2. Poultney-Mettawee
3. Otter Creek, Little Otter, Lewis
4. Lower Lake Champlain
5. Upper Lake Champlain
6. Missisquoi
7. Lamoille
8. Winooski
9. White
10. Ottauquechee, Black
11. West, Williams, Saxtons
12. Deerfield
13. Lower Connecticut
14. Wells, Waits, Ompompanoosuc
15. Passumpsic
16. Upper Connecticut
17. Lake Memphremagog

PART THREE: BACKGROUND

An Overall Description of Vermont's Water Quality & Surface Water Resources

Summary Description of Vermont's Water Quality

The water quality of all Vermont's rivers and streams and lakes and ponds is considered good. This overall water quality rating has not changed from the overall rating level that was reported in the 2002 305b Report. The US Environmental Protection Agency (EPA) has requested states to also assess the state's water quality considering the fish consumption advisory for mercury which was issued in June 1995 and most recently revised in June 2000. The advisory was issued as the result of fish tissue sampling that showed mercury in the tissue of all fish, particularly in walleye and lake trout, and also PCBs in lake trout[1] in Lake Champlain (see updated advisory as Appendix B). Taking the fish consumption advisory into consideration, the overall water quality of all the state's waterbodies would be rated as fair. A statewide assessment of mercury in sediments, waters, and biota of Vermont lakes was completed during the reporting period. Results of this project are discussed in Part Four.

With regard to Vermont's wetlands, their water quality is believed to be generally good. Since Vermont does not have a specific program of assessing and monitoring wetland water quality, this characterization is somewhat speculative. It has been incumbent upon the state's limited resources to insure important wetland functions and values are protected from being lost to development or other destructive practices.

No comprehensive studies have been completed on the quality of Vermont's groundwater. In most cases it is believed that groundwater quality meets drinking water standards. A thorough evaluation of groundwater is needed, however, to provide a factual characterization of this important resource.

Atlas/Total Waters

Vermont has approximately 7,100[2] miles of rivers and streams, 230,790 acres of lakes, reservoirs and ponds and 300,000 acres of freshwater wetlands. The surface area of lakes, ponds and wetlands represent approximately 828 square miles of water or about 8.6% of the state's total 9,609 square mile area.

Vermont's border waters include the Connecticut River on the east (border with New Hampshire), Lake Memphremagog on the north (partial border with the Province of Quebec) and the Poultney River and Lake Champlain on the west (border with New York).

There are 17 major river basins in Vermont, which drain to one of four large regional drainages: Lake Champlain, the Connecticut River, Lake Memphremagog, or the Hudson River. Additional surface water resource information is contained in Table 3.1 below.

---

[1] Still in effect is the 1989 advisory for PCBs (polychlorinated biphenyls) in Lake Champlain.

[2] Source of 7,100 mile figure is EPA's Total Waters Database. Earlier 305b reports relied upon Don Webster's list of Vermont waters prepared in 1962 that showed a total of 4,936 miles. A number of omissions have been discovered in Webster's listing with many small streams overlooked and the lengths of some rivers and streams significantly underestimated. The total mile figure is likely to change once the Vermont Hydrography Dataset becomes functional.

Table 3.1. Atlas.

State population	608,827 (2000 Census)
State population change (1990 - 2000)	8.2 % increase
State surface area	9,609 square miles
State population density	63.36 persons/sq mi
Number of water basins	17
Miles of perennial rivers & streams[3]	7,099
Border miles of shared rivers/streams (subset)[4]	262
Number of lakes, reservoirs & ponds (at least 20 acres)	287
Number of lakes, reservoirs & ponds (at least 5 acres but less than 20 acres)	317
Number of significant, lakes, reservoirs & ponds (less than 5 acres)	206
Acres of lakes, reservoirs & ponds[5]	230,813
Acres of freshwater wetlands[6]	300,000

There are no coastal waters, estuaries or tidal wetlands in Vermont. However, due to the size of Lake Champlain (approximately 120 miles long and 12 miles wide at its widest), the lake is considered an inland sea by residents of Vermont, New York and Quebec. The Atlantic Ocean and Inland Waterway are accessible to the south from Lake Champlain via the New York Barge Canal. The Richelieu River, St. Lawrence River and the Atlantic Ocean are accessible to the north through Canada.

Effectiveness of Pollution Control Programs

The Vermont Department of Environmental Conservation (DEC) within the Agency of Natural Resources has been designated as the lead water quality management agency for the State of Vermont. In that role, DEC administers a wide variety of programs that are intended to control, reduce or prevent pollution from point and nonpoint sources to the State's surface and ground water resources. These programs are effective at maintaining, protecting and restoring water quality and aquatic habitat conditions. For the purpose of describing water program effectiveness, DEC's water pollution control programs can be summarized into three categories: General, Point Sources and Nonpoint Sources.

GENERAL PROGRAM

Water Quality Standards

The Water Quality Standards are the foundation of the state's water pollution control and water quality protection efforts. The Water Quality Standards (Standards or WQS) are promulgated by the Vermont Water Resources Board and provide the specific criteria and policies for the management and protection of Vermont's surface waters. The classification of waters (rivers, streams, lakes and ponds) as Class A, Class B or Class B with Waste Management Zone are the management goals to be attained

[3] Includes the Connecticut River.

[4] Connecticut River - 238 miles; Poultney River - 24 miles.

[5] Figure includes the Vermont portion of Lake Champlain, some private waters and some waters less than 5 acres in size. This figure also accounts for two large CT River impoundments, Moore and Comerford Reservoirs, which are 1,255 and 777 acres in size, respectively. These were not previously tracked in Vermont's Lake Inventory Database.

[6] Figure does not include wetlands found on agricultural lands that are actively used for agricultural purposes.

and maintained. The classification also specifies the designated water uses for each class. Class A waters are either A1 (ecological waters) or A2 (public water supplies). Class B waters fall within one of three water management types (B1, B2 or B3) after consideration by the Water Resources Board. The current Vermont WQS (go to www.state.vt.us/wtrboard, click on "Rules") were adopted June 10, 1999 and became effective July 2, 2000.

The Vermont WQS establish narrative and numeric criteria to support designated and existing uses. Designated uses, as established in Sections 3-02(A), 3-03(A) and 3-04(A) of the Standards, mean any value or use, whether presently occurring or not, that is specified in the management objectives for each class of water. The following table serves to indicate applicable designated uses.

Table 3.2. Designated Uses for Water Classifications.

Designated Uses	Class A(1) – Ecological Waters	Class A(2) – Public Water Supplies	Class B Waters
Aquatic Biota, Wildlife & Aquatic Habitat	√	√	√
Aesthetics	√	√	√
Swimming & Other Primary Contact Recreation	√		√
Boating, Fishing & Other Recreation Uses	√		√
Public Water Supplies		√	√
Irrigation of Crops & Other Agricultural Uses			√

Class A Re-classifications
The 1986 "Pristine Streams Act" created the opportunity for any waterbody supporting habitat that is ecologically significant and has water quality that meets at least Class B standards to be re-classified to Class A. A re-classification is a rule making procedure before the Water Resources Board where a public interest determination must be made pursuant to Vermont's Water Pollution Control Statute, Title 10 VSA Section1253. No streams have been re-classified to Class A since the 1998 305b Report.

Outstanding Resource Waters
An overlay of both Class A and Class B waters is the designation of Outstanding Resource Water (ORW). ORWs are waters of the State designated by the Water Resources Board as having exceptional natural, recreational, cultural or scenic values. To gain an ORW designation, the petitioners must, in a contested case hearing before the Board, provide evidence and testimony that the waters in question have exceptional natural, cultural, scenic, or recreational values. The following waters have been designated as ORWs: the Batten Kill and its West Branch, Pikes Falls on the North Branch of Ball Mountain Brook, the lower Poultney River and Great Falls on the Ompompanoosuc River. No ORWs were designated during the 2004 reporting period.

Watershed Approach
Vermont has adopted and is implementing a watershed approach to surface water quality planning. The DEC-prepared document, *Guidelines for Watershed Planning* (refer to 2002 305b report or to www.vtwaterquality.org) calls for basin surface water plans to be developed on a periodic basis.

The watershed planning process is an inclusive public process that takes into account current and past assessment, planning, and implementation activities at the state and local levels. Assessments are followed by the basin plans that will summarize current and past (within five years) water pollution or water quality management activities. This rotational planning process will also identify topics or areas

of special importance in the basin, identify available management tools to address those topics, and make specific recommendations on how to address key topics, including recommendations for continuing community-based planning or implementation action. Each basin plan updates previous basin plans. Each basin is unique in its problems and opportunities. Nevertheless, assessment, planning and implementation are constantly occurring at many different levels from the activities of landowners to municipal, state and federal levels and evolving with public participation. The *Guidelines for Watershed Planning* looks at all of these activities including the condition of the waters in a given point in time and makes conclusions and recommendations for the future.

For a summary update on progress of activities in the six river basins where water quality management plans have been or are being developed, the reader should refer to Appendix A.

POINT SOURCE CONTROL PROGRAM

Vermont administers a well-planned and comprehensive direct discharge water pollution control program, consisting of planning loans and advances, construction grants and loans, permitting and compliance monitoring. In March 1974, Vermont received from EPA the delegation authority to administer discharge permits under the National Pollutant Discharge Elimination System. Within Vermont there are 33 facilities considered as "major" and 132 "minor" facilities.

With the construction of the state's last originally identified municipal waste water treatment facility (WWTF) and completion of the upgrades from primary to secondary, the program has continued to place emphasis on refurbishment of existing WWTFs, the completion of phosphorus reduction upgrades (refer to Appendix B, Table B.1), advanced waste treatment, correction of combined sewer overflows (CSO) (see Appendix B, Table B.2), control of toxics, pollution prevention activities and facility enlargements.

During the reporting period, construction commenced on CSO corrections, sewer line rehabilitations and extensions, sewer system improvements, wastewater treatment plant upgrades, and phosphorus reductions. Various new projects, located in three of the four major drainages within Vermont, received funding from state, federal and local sources in 2002 and 2003, totaling approximately $26 million in new funding (refer to Table 3.3 below). Many projects that received funding during the reporting period are also under continued construction.

Of the 31 facilities with planned phosphorus reduction projects in the Vermont portion of the Lake Champlain basin, 30 have been or are close to being completed. Phosphorus reduction projects required in the Vermont portion of the Lake Memphremagog drainage basin were completed by 2001.

Of the 33 planned CSO correction projects, 24 have been completed, 5 are underway and 4 are pending.

Vermont's TMDL planning for Lake Champlain, including a new lower tier of phosphorus limits, anticipates over $5 million in new construction projects at existing municipal wastewater treatment plants in the coming years.

Approximately $26.5 million dollars were spent during the 2002 - 2003 reporting period on waste water treatment facility upgrades, combined sewer overflow corrections, sewer line extensions and rehabilitations and other waste water treatment system improvements in nine communities.

NONPOINT SOURCE (NPS) CONTROL PROGRAM

Vermont has been able to effectively target areas, design work plans, compete for and capture funding and implement NPS projects directed at restoring and protecting water uses and values. In the fourteen years of Clean Water Act Section 319 NPS implementation funding (1990-2004), Vermont has received about $16 million to implement a variety of activities. The goal of the NPS management program is to encourage the successful implementation of best management practices (also referred to as "BMPs") by diverse interests such as farmers, developers, municipalities, lakeshore residents, landowners and riparian landowners in order to prevent or reduce the runoff of pollutants. Effective BMPs can be structural or vegetative, regulatory or advisory.

Some notable activities carried out with Section 319 funding during this 305b reporting period include youth-based watershed restoration efforts, enabling nutrient management services for farm operators, further water quality characterization to remediate elevated temperatures on one waterbody, locally-led efforts to improve water quality for Allen Brook, the West River and Gully Brook and funding assistance targeted at municipalities for reducing sediment runoff from unpaved backroads.

Because of the diffuse but widespread nature of NPS source pollution, there are several other important aspects that are prominent features of Vermont's nonpoint program. Some management elements are part of DEC while others elements are conducted outside of DEC. Examples of the former include construction sediment and erosion control, hazardous and solid waste management, spills and leaks and control of stormwater. Examples of the latter include logging erosion control carried out by the Vermont Department of Forests, Parks and Recreation and agricultural runoff control by the Vermont Agency of Agriculture, Food and Markets. The US Department of Agriculture is an important partner in both forestry and agriculture arenas.

Specific details regarding the NPS program and project activities are available from DEC. The Department has maintained a listing of 319-assisted project titles by funding year. Vermont will continue to pursue and apply Section 319 NPS funding in targeted areas that are likely to result in the successful implementation of BMPs and programs and in the improvement of water quality.

Nature & Extent of Nonpoint Sources of Pollutants

Pollution from nonpoint sources of pollutants continues to be the major source of water use impairment to Vermont surface and ground water resources. It is estimated that close to 90% of the miles and acres of the state's impaired surface waterbodies are the result of NPS pollution. Water quality impacts due to NPS and the threat of impact from NPS are apparent in each of Vermont's 17 drainage basins. The reader is referred to Part Four (Surface Water Monitoring and Assessment) and Part Seven (Groundwater Monitoring and Assessment), for further details regarding the causes and sources of NPS pollution within Vermont.

Environmental Impact/Economic & Social Costs/Economic and Social Benefits of Effective Water Programs

Point Sources

The total expenditure of state, federal and local funds for all municipal wastewater treatment facilities and appurtenances to date has been approximately $560 million. These facilities have improved the quality of 58 rivers and 3 lakes for such uses as swimming, fishing, boating and aquatic life. The $560

million figure includes the $26.5 million in improvements constructed during the 2004 305b reporting period. The reader is referred to Table 3.3 below for the location and estimated cost of these improvements.

Table 3.3. Municipal Pollution Control Project Starts.
(January 1, 2002 to December 31, 2003)

Community	Description	Est. Project Cost
****** LAKE CHAMPLAIN DRAINAGE ******		
Colchester	Subsurface drainage system for Belwood Park subdivision.	$1,034,000
Milton	Extension of wastewater collection system along U.S. Route 7.	$3,378,000
Montpelier	Septage and leachate receiving facilities and headworks improvements.	$3,170,000
Montpelier	Combined sewer overflow abatement; Phase 2, Contract 8.	$1,437,000
Montpelier	Combined sewer overflow abatement; Phase 2, Contracts 9 & 10.	$2,086,000
Northfield	Upgrade of wastewater treatment facility for phosphorus removal improvements.	$6,924,000
Shelburne	Pump stations, force mains and gravity sewers for the Shoreline, Route 7 and Falls Road Cemetery areas.	$1,645,000
Stowe	Village area force main extension.	$590,000
Warren	New sewers, subsurface and on-site disposal systems.	$4,399,000
****** LAKE MEMPHREMAGOG DRAINAGE ******		
Newport	Fyfe Drive and Gateway pump stations.	$275,000
****** CONNECTICUT RIVER DRAINAGE ******		
Randolph	Sewer extensions to 4 areas of Town; School & Brook Streets, Randolph Avenue, Pearl & Shattuck Streets and Montague golf course.	$1,557,000
TOTAL COST		**$26,495,000**

Nonpoint Sources

Quantifying the financial resources expended on nonpoint source control of pollutants is not as easy to determine or link to specific river miles/lake acres of improvement as contributions of resources occur from various state, federal and local agencies as well as from landowners, volunteer groups, foundations, businesses and even corporations. There are, however, two Clean Water Act (CWA) programs under DEC administration and a single state-funded program that address nonpoint source pollution control which can be highlighted. The CWA programs are the Section 604b Pass Though Program and the Section 319 Program and the state-funded program is the Vermont Conservation License Plate Program. Funding for the two CWA programs from 1989 through 2004 has amounted to approximately $780,000 (604b) and over $16 million (319). The 604b Program has assisted the 12 Vermont regional planning commissions conduct a wide variety of water quality planning related activities. A portion of the 319 Program has provided funding assistance to a wide variety of

governmental and non-profit organizations to carry out nonpoint source implementation efforts. In the six years of its existence (1998-2004), the Vermont Conservation License Plate Program has awarded close to $352,000 to many diverse groups. Many of the funded license plate projects provide water quality and/or habitat benefits. As a way to offset some of these cost-benefit uncertainties, the remainder of this section is devoted to mentioning five recently conducted socio-economic evaluations related to recreational water use or water quality conditions.

In the fall of 2002, the Center for Rural Studies at the University of Vermont conducted a survey of 1,338 Vermont households regarding their opinions of recreation resources. The survey[7] was done for the Vermont Department of Forests, Parks and Recreation as one component for the 2005 Vermont Outdoor Recreation Plan. Noteworthy water and water quality-related findings from the survey are summarized below:

Quality of Resources

* Almost 85% of Vermonters agreed that the outdoor recreation opportunities now offered in Vermont satisfy their needs. However, nearly 66% of Vermonters agree that additional public access to natural swimming areas need to be developed.

* The average grade for the quality of Vermont's recreation resources is a "B." Both recreation resource categories of lakes and ponds and rivers and streams were graded as "B-" in 2002. The mean grade point value for lakes and ponds, however, showed a significant improvement between 1992 and 2002.

Recreational Issues

* The top two issues that were indicated to be a "big problem" by the largest percent of Vermonters in 2002 were the presence of nuisance (aquatic) plants and the presence of nuisance (invasive) aquatic animals at 69% and 66%, respectively. The former was also considered to be more of a problem in 2002 than in 1992.

In the Year 2000 Vermont Angler Survey[8], about 83% of Vermont residents believed that access to fishing was not a problem and about 45% thought that contaminant levels in fish was either not a problem or a minor problem. In the survey, Vermont residents also believed excessive aquatic plant growth, poor water quality, barriers to fish migration, over-fishing and erosion/silation were the top five factors affecting fish health and fishing quality. The average number of days that Vermont resident anglers go fishing has not changed between 1990 and 1999 (open water is 27 days, ice fishing is 11). Finally, overall fishing satisfaction levels (on a scale of 1 to 4) held by resident and non-resident anglers were found to have increased since 1991 to 2.51 and to 2.92, respectively.

According to the Year 2001 National Survey[9], fish and wildlife continue to be important to Vermont residents (and visitors) and greatly contribute to the state's economy. Nationally, Vermonters ranked second to Alaskans in enjoying wildlife resources. About 67% of the state's population was reported to have gone fishing, hunting or wildlife watching (or a combination of these) as compared to 70% of Alaskans. Vermont's economy receives a major boost from sportfishing. Resident and non-resident anglers fished slightly over 2.3 million days in Vermont during 2001 – an average of 14 days per angler – and spent a total of about $92.5 million in fishing expenses. Between 1991 and 2001 there were no significant changes in total anglers, fishing days, expenditures and the number of Vermont resident anglers. Between 1996 and 2001, while fishing expenditures by Vermont anglers decreased, the number of Vermont resident anglers was reported to have markedly increased.

---

7 Center for Rural Studies. 2003. The 2002 Vermont Outdoor Recreation Survey Report and An Analysis of Change Since 1992. University of Vermont. Burlington, VT.

8 Vermont Department of Fish & Wildlife. 2000. The 2000 Vermont Angler Survey. Prepared by the University of Vermont, School of Natural Resources. Waterbury, VT.

9 US Fish & Wildlife Service. 2003. 2001 National Survey of Fishing, Hunting and Wildlife-Associated Recreation in Vermont. Washington, DC.

In an article appearing in the fall 2003 issue of *LakeLine*[10], Boyle and Bouchard examine property sales prices and water quality relationships of lakes in 3 New England states (ME, NH, VT) to provide some understanding of the social value of environmental quality and the risk of degraded environmental quality. Using 336 observations (involving 29 lakes from the Northeast Kingdom, Rutland County and separate bays near St. Albans), the authors found that the property price effects from a one-meter increase (i.e. improvement) in minimum water transparencies ranged from increases of 1.7% (Northeast Kingdom) to 5.9% (St. Albans). A one-meter decrease in transparency was predicted to result in negative price effects ranging from 2% to 4.6%. While results may have been expressed as losses and gains in property value, the study does serve to indicate the benefits to protect and maintain good water quality rather than to experience a decline in clarity and suffer economic loss.

In 2002, a report was issued describing a study of visitors to Vermont State Parks.[11] The study was conducted to improve current knowledge of the values and functions of the 47-state park system. Notably, the gross annual value of Vermont State Parks is $58.8 million. The most popular recreation activities of surveyed campers were reported as camping, hiking, swimming and picnicking while the most popular activities of day visitors were picnicking, swimming, hiking and boating. Water and water related recreational opportunities contributed to park popularity by campers and day visitors.

Strategy to Achieve Comprehensive Monitoring & Assessment Coverage

DEC has completed an initial draft of a comprehensive water quality program monitoring strategy. This strategy consists of ten parts, addressing major elements necessary for monitoring the quality of ambient waters for the purpose of water quality assessment, planning and management. As of January 31, 2004, the strategy document has been provided to EPA as a draft for comment.

Following an introductory section, there is narrative related to the regulatory justification for the strategy and a series of goals and associated objectives. Designated and existing uses are discussed in this section as they relate to Vermont Water Quality Standards (Standards or WQS). The next section discusses monitoring designs used in Vermont to achieve comprehensive coverage and includes subsections describing project designs, current projects within the monitoring program, emerging threats, and partnerships with non-DEC entities. This and each subsequent section also presents relevant strategies and recommendations. Section 4 of the strategy discusses core and supplemental indicators of water quality, and discusses how these indicators relate to Vermont's Standards. A section on quality assurance provides information on how DEC assures that monitoring data are of sufficient quality for making attainment decisions, and for achieving the other objectives established by the strategy. A section on data management discusses how DEC archives water quality data and how it manages those data, along with other information tracking databases, to support the goals of the strategy. Section 7 elaborates on how data are analyzed, how waterbodies are assessed in light of the core and supplemental indicators, and how these data are used to support listing of waters under Section 303d of the Clean Water Act and Vermont priority waters lists. Reporting of assessment findings are discussed in the next section of the strategy, which describes, among other reports and documents, this Integrated Report. Section 9 of the strategy provides for periodic strategy review, while Section 10 discusses general program and infrastructure support needs.

The monitoring strategy is written with a ten-year lifespan and includes annual and mid-term progress evaluations. Strategy implementation is envisioned to begin during 2004.

---

10 K.Boyle & Bouchard.R. 2003. Water Quality Effects on Property Prices in Northern New England. LakeLine. Journal of North American Lake Management Society. Pages 24-27.

11 A.Gilbert & Manning.R. 2002. Economic and Social Values of Vermont State Parks.

PART FOUR: SURFACE WATER MONITORING & ASSESSMENTS

A) Current Surface Water Quality Monitoring Program

The following section is a description of the Water Quality Division's (WQD) current ambient monitoring program that is comprised of numerous discrete projects. The WQD's monitoring efforts are classified herein as physical/chemical, biomonitoring, volunteer and other. Within each of these classes, monitoring projects are further described as core, or long-term projects; diagnostic studies, which identify the causes of particular water quality problems; and special studies, which provide information and data on specific water quality issues. Other projects coordinated by close partners of the WQD are also included in this listing.

1) Physical and chemical monitoring

Core Programs

The Spring Phosphorus Program collects spring overturn nutrient and physical and chemical data on Vermont lakes and ponds that are 20 acres in size or larger. Parameters include total phosphorus, total nitrogen, alkalinity, calcium, magnesium, hardness, Secchi disk transparency, and multi-probe profiles (temperature, dissolved oxygen, conductivity and pH). Since 1977, 236 lakes have been monitored in conjunction with this program. Forty-eight lakes have 10 or more years of data and 18 of these have 15 years or more. The Spring Phosphorus Database contains over 1,700 records.

The Lake Assessment Program is designed to rapidly assess the extent to which lakes meet designated uses and to gather information to focus lake management and protection efforts. The sampling intensity for assessment lakes varies with the degree to which impairment is evident or must be documented. In general, lakes are circumnavigated and detailed assessment observations are made regarding in-lake and shoreline conditions with respect to designated uses and threats to water quality. Detailed notes are made regarding the extent and species composition of the macrophyte community. Sampling is performed for total phosphorus, alkalinity, Secchi disk transparency, and multi-probe profiling. Additional sampling may be performed as necessary to determine compliance with Vermont Water Quality Standards. Since 1989, close to 280 comprehensive assessments and 60 cursory assessments have been performed.

The River Assessment Program is designed to assess the extent to which rivers and streams support designated uses to focus management and protection efforts. Rivers and streams in the basins of focus are visited to look for obvious sources of pollution from the land or indicators of problems or threats in the water such as sedimentation, heavy algae growth, or water with unnatural color or odor. The Ambient Biomonitoring Program (described below) provides most of the information used to determine a waterbody's aquatic life use support and compliance with Vermont Water Quality Standards. Temperature, nutrients, pH, conductivity and alkalinity are parameters commonly measured concurrently with the biological sampling.

The Water Level Monitoring Program monitors lake surface elevations to establish mean water levels for a variety of purposes, most notably to determine the jurisdictional boundary of the State's lakes and ponds under the shoreland encroachment permit program and Vermont's Public Trust Doctrine.

The Lake Champlain Long-Term Monitoring Program surveys the quality of Lake Champlain waters on a biweekly basis from May to November at 13 locations throughout the lake. Eighteen major tributaries are sampled on an event basis as well. The program's large physico-chemical parameter list includes: species of phosphorus, nitrogen and organic carbon; chlorophyll-a; base cations; alkalinity; total suspended solids; dissolved oxygen; conductivity; and pH. As of April 2003, this program had assembled a database comprising 6,366 lake and 4,282 tributary sampling events. The reader is referred to Part Six of this report, the section entitled Lake Champlain Phosphorus TMDL, for information concerning the Lake Champlain Clean and Clear Initiative.

The Long-Term Monitoring (LTM) Acid Lakes Program collects chemical and biological data on lakes located in low alkalinity regions to determine the effects of acid deposition on Vermont's lakes. Initially, nearly 200 lakes statewide were surveyed during the winters of 1980 through 1982 to identify the acid sensitive areas of the state. Eleven lakes selected from these areas are now included in the LTM and are sampled at least eight times every year for 16 chemical parameters related to acidification. These data are used to classify lakes according to their acidification status, evaluate spatial and temporal variability in measured parameters, track changes in acidification status over time as related to reductions in atmospheric emissions of acid precursors (e.g., oxides of sulfur and nitrogen), and evaluate impacts of acidification on aquatic communities. As of April 2003, the LTM data archive comprised 1,857 in-lake and 405 lake-outlet sampling records. This project contributed data to a seminal article describing long-term acidification trends across northeast North America, which was published in the journal Nature in 2000.

The Stream Geomorphic Assessment Program collects geomorphologic data on streams throughout the state to assess stream geomorphic condition and develop regime relations for Vermont's streams. Geomorphic assessments enable the prediction of expected rates of river adjustment and an evaluation of the effects of various land and river management practices on geomorphic condition and physical habitat quality. Regime relations guide stream protection, management, and restoration projects and assist in the establishment of Vermont-specific physical criteria for water quality classification and use attainment determinations. Parameters measured include channel dimension (cross section), pattern (meander geometry), longitudinal profile, channel substrate conditions, structure and composition of riparian vegetation, and floodplain and valley morphology. Geomorphic assessment protocols have been developed and promoted by the Agency of Natural Resources. Geomorphic assessments are done according to different levels of complexity. The map on the following page illustrates the location and level of completed or ongoing stream geomorphic assessment efforts.

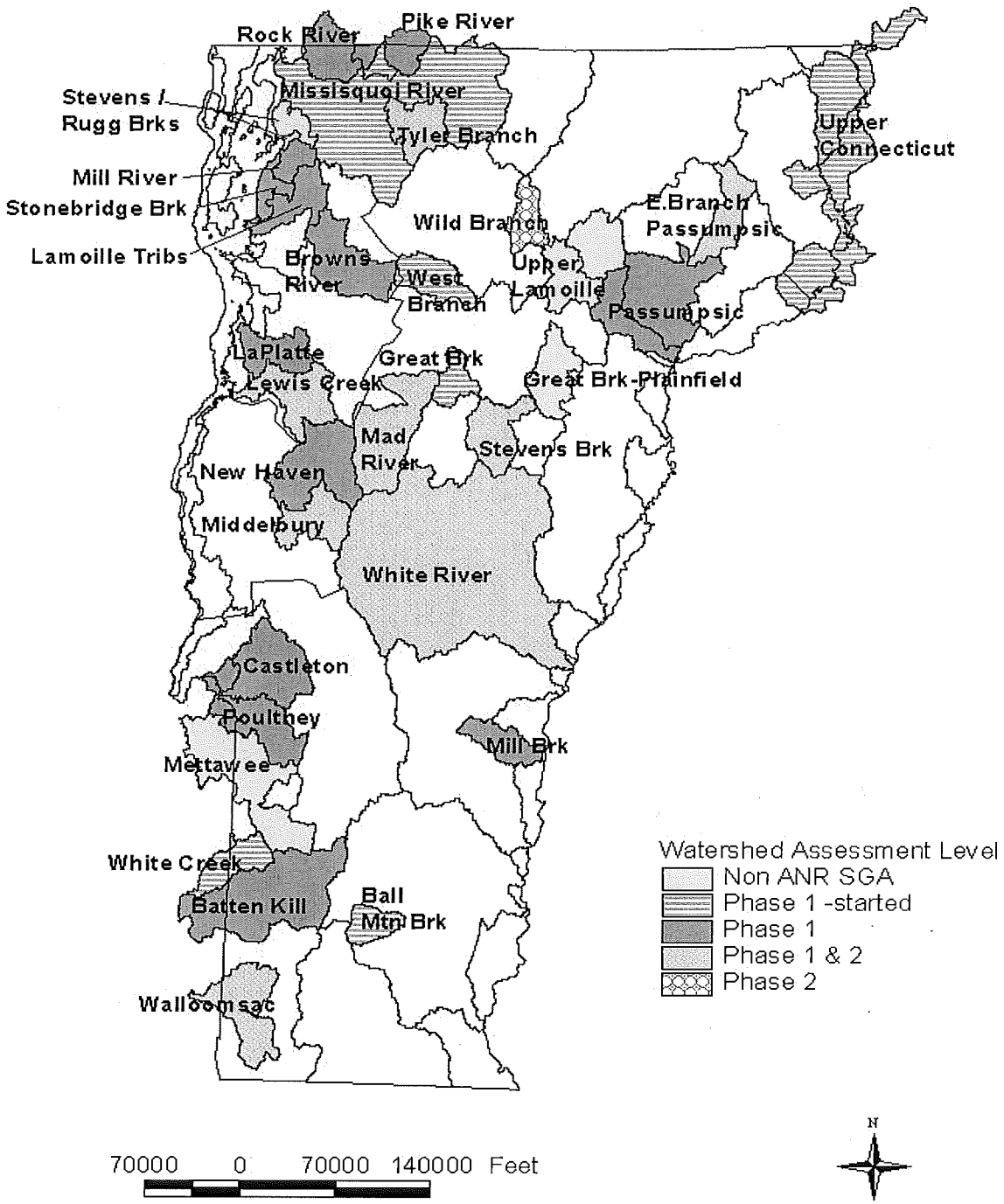


Figure 4.A.1. Location & Level of Stream Geomorphic Assessments (April 2004).

Lake Diagnostic Studies
Diagnostic studies are typically aimed at identifying the cause of eutrophication in Vermont lakes. Over the past 20 years, Vermont has performed numerous such monitoring studies, and the results of these studies have led to remediation steps. Lakes on which diagnostic studies have been performed include Harveys Lake (Barnet), Lake Morey (Fairlee), Lake Iroquois (Hinesburg), Fairfield Pond (Fairfield), Lake Parker (Glover), Lake Carmi (Franklin), and Lake Champlain. Presently, the DEC is investigating the possible initiation of a new diagnostic study for Ticklenaked Pond, a nutrient-impaired lake in Ryegate.

A wide variety of parameters are sampled in conjunction with lake diagnostic studies, and the actual tests performed are specific to the project. Standard eutrophication parameters (total phosphorus, Secchi disk transparency, and dissolved oxygen) are always measured. Other parameters taken from sediments and the water column can be measured as needed.

Special Studies
Special studies are those performed to gain more information about a particular environmental issue of importance to DEC. There are four special studies noted below.

The EPA-sponsored **REMAP Assessment of Mercury** in Sediments, Waters and Biota of Vermont and New Hampshire Lakes Project is a three-year effort to identify lake types occurring in the two states that have elevated levels of mercury in fish and upper trophic level biota. The parameter list for this integrated collaborative monitoring project is large, and includes standard limnological measurements and mercury in total and methyl phases in sediment, water, and biota. There is also a paleolimnological component that has determined the extent to which atmospherically deposited mercury has entered lakes in the study set. Two peer-reviewed journal articles have been produced from this study that was completed in 2003.

The Best Management Practices Effectiveness Demonstration Project is a long term stream monitoring effort (1999–2007) designed to assess the efficacy of best management practices in controlling pollutants in nonpoint source runoff in tributaries of Lake Champlain.[1] This cooperative DEC-USGS project differs from the project described immediately above in that it uses an upstream-downstream approach to pinpoint reductions in pollutant runoff attributable to specific installed Best Management Practices. The project is being carried out simultaneously on one agricultural and one urban stream in the Lake Champlain basin (Little Otter Creek and Englesby Brook, respectively). Sampling is focused on nutrients and sediment and sampling is conducted monthly and during storm events. Minor BMP structures were installed during 2002 in both watersheds. Larger implementation projects are scheduled for 2004.

In conjunction with the **Paleolimnology of Vermont Lakes Project**, DEC is collaborating with the University of Vermont to develop a set of indicators of present and historical trophic status

[1] During 1994-2001, a similar study was conducted known as **the Lake Champlain Agricultural Best Management Practices Monitoring Project.** This comparative observational study was carried out to evaluate the efficacy of both low- and high-intensity reach specific BMP implementation strategies related to livestock grazing. Parameters measured included total phosphorus, total and Kjeldahl nitrogen, total suspended solids and *E. coli* along with biological assessments. Even though the project has been completed and results published, biological assessments conducted by DEC are continuing.

based on the paleolimnology of carbon and nitrogen stable isotopes ($\delta^{13}C$ and $\delta^{15}N$). Using cores from the sediments of several lakes, DEC is working to identify the extent to which the present trophic condition in these lakes deviates from the historic background. Such information is instrumental in understanding the extent to which productivity (and thus phosphorus) has been elevated since the lake watersheds were first cleared in the early 1800's.

2) Biological monitoring

Core Programs

The **Ambient Biomonitoring Program** was established in 1982 to 1) monitor long-term trends in water quality as revealed by changes in ambient aquatic biological communities over time; 2) evaluate potential impacts on aquatic biological communities from permitted direct and indirect discharges, ACT 250 (10 V.S.A. 151) projects, nonpoint sources, and spills; and 3) establish a reference database to facilitate the generation of Vermont-specific biological criteria for water quality classification and use attainment determinations. Since 1985, DEC has used standardized methods for sampling fish and macroinvertebrate communities, evaluating physical habitat, processing samples, and analyzing and evaluating data. The program has led to the development of two Vermont-specific fish community Indexes of Biotic Integrity (IBI) and several macroinvertebrate metrics. Guidelines have been developed to determine water quality standards attainment using both macroinvertebrate community biological integrity metrics and the IBI. Approximately 75 sites per year are assessed using fish and/or macroinvertebrate assemblages. Alkalinity, pH, conductivity, temperature and such measurements as substrate composition, embeddedness, canopy cover, percent and type of periphyton cover, and approximate velocity are routinely monitored. From 1985 to April 2003, well over 1,700 stream assessments were completed using macroinvertebrate and/or fish from 1229 stream reaches.

The Aquatic Macrophyte Monitoring Program collects baseline information on aquatic plant communities in Vermont lakes by conducting descriptive surveys using a pre-established plant cover scale. This program has been active since the late 1970's, and information is available from 177 discrete surveys.

The WQD conducts numerous **Aquatic Nuisance Species Searches and Surveys** each year to search for new populations and monitor existing populations of nuisance aquatic species, primarily Eurasian watermilfoil (*Myriophyllum spicatum*), water chestnut (*Trapa natans),* zebra mussels (*Dreissena polymorpha*), and the wetland invasive purple loosestrife (*Lythrum salicaria*).

One interesting component of these aquatic nuisance species efforts is the Lake Champlain Zebra Mussel Monitoring Program. For this effort, 13 in-lake and 12 shoreline stations in Lake Champlain are monitored for larval and settler zebra mussel presence and density every two weeks from April through November. In addition, adult zebra mussel surveys are performed at selected shoreline locations during late summer. Notably, this is the only such zebra mussel monitoring project of it's kind in the United States. As of April 2003, there were 2,220 veliger records and 1,013 settler records within this program's nine years of data records.

Special Studies

The Biodiversity Monitoring Program evaluates the status of selected biological species and communities in Vermont. Specific activities include 1) distribution surveys of aquatic plant, fish and macroinvertebrate species listed by the Vermont Endangered Species Committee as rare, threatened, endangered, or of special concern; 2) distribution surveys of communities having species considered likely candidates for future listing (e.g., snails); and 3) monitoring of biological communities or community types, the diversity of which is threatened (e.g., Lake Champlain mussel and cobble/shale macroinvertebrate communities threatened by zebra mussels). Data are used to describe species distribution, identify species/communities at risk, and develop management plans for the protection of identified species/communities.

The Lake Bioassessment Project was initiated in 1995 to begin developing biological criteria for Vermont lakes. This monitoring effort was launched as a cooperative project with the State of New Hampshire. The goal of the project is to develop numeric measurements of the phytoplankton, macrophyte, and macroinvertebrate communities in reference lakes for use in assessing aquatic life use attainment in lakes. Consistent protocols have been developed to measure these biological assemblages, and to date, 12 New Hampshire and 41 Vermont lakes have been included in the project. Statistically-validated multimetric indices have been developed for the phytoplankton and macroinvertebrate communities. To date, data describing macrophyte commbnities have proven insufficiently precise to develop macrophyte criteria.

The **Vermont Wetlands Bioassessment Project** is a coordinated effort between the DEC and the Vermont Department of Fish and Wildlife's Nongame and Natural Heritage Program to document and understand the biological and physical characteristics associated with seasonal pools (vernal pools) and northern white cedar swamps in Vermont. Since 1999, the project has collected biological, physical and chemical data from 28 seasonal pools throughout the state. Information collected on the invertebrates, amphibians, algae, and plants associated with seasonal pools has been used to assess and monitor the ecological health of seasonal pools in Vermont. This project was completed in 2002 and efforts at using these data to develop vernal pool biocriteria have seen limited success. DEC plans to modify this project for 2004 by adopting protocols and sampling strategies consistent with the Lake Bioassessment Project, to include more rigorous procedures for monitoring marginal wetland macrophytes.

The Lake Champlain Long-Term Monitoring Program described above also includes biological sampling, which is primarily aimed at assessing phytoplankton, zooplankton, and macroinvertebrate communities. Data from this element of the project resides in the New York State Natural History Museum with copies available only in spreadsheet form in Vermont. These data have been underanalyzed and underutilized as of this writing, but should provide a baseline for evaluating changes in ecosystem structure given implementation of the Lake Champlain TMDL for phosphorus.

The Northern Leopard Frog Surveys in the Lake Champlain Basin Project was initiated in response to reports of malformed frogs in the Lake Champlain basin in Vermont in the summer of 1996. Malformed frogs were reported from 12 sites in five counties within the Lake Champlain basin. Systematic field surveys were initiated in 1997, targeting the northern leopard frog (*Rana pipiens*). These surveys recorded the frequency and morphological characteristics of

gross abnormalities among newly metamorphosed northern leopard frog populations at 20 sites within the Lake Champlain basin. With subsequent support through the USEPA REMAP program, DEC has examined over 6,000 northern leopard frogs since 1996, and external malformations have been detected in 7.5% of the frogs examined. Data characterizing the gross abnormalities and describing the frequency and occurrence of abnormalities within northern leopard frog populations continues to be gathered at 10 established sites within the Lake Champlain basin. All findings are reported to the North American Reporting Center for Amphibian Malformations (http://www.npwrc.usgs.gov/narcam/). DEC also continues to collaborate with the National Institute of Environmental Health and Sciences, the National Wildlife Health Center, and other researchers, providing environmental samples and specimens to help further malformed frog investigations.

Other Biological Monitoring Projects either ongoing or conducted on a periodic basis include:

- monitoring nontarget impacts to aquatic biota in lakes chemically treated with the aquatic herbicide Sonar® (fluridone) to control Eurasian watermilfoil infestations;
- monitoring the effects on both target and nontarget organisms of copper sulfate treatments to small recreational lakes and water supply reservoirs; and
- monitoring impacts to nontarget fish and macroinvertebrates in rivers treated with lampricide (TFM) to control sea lamprey (*Petromyzon marinus*) in Lake Champlain..

The Fish Contaminant Monitoring Program is managed by the WQD and performed in cooperation with the Vermont Department of Fish and Wildlife and the Vermont Department of Health. Edible tissue from game fish acquired throughout the state is analyzed for mercury and other contaminants. These data are then used to set and subsequently refine fish consumption advisories issued by the Vermont Department of Health.

3) Volunteer monitoring

Citizen groups have become increasingly involved in monitoring, education, protection, and restoration projects in Vermont. DEC provides assistance and training to volunteers whenever possible. Watershed and lake associations are presently active on numerous rivers and lakes in the state. In fact, there are over 100 such associations statewide. DEC has developed a directory listing various watershed associations and their activities in "Current Programs of Vermont Watershed Associations – 2002," with a lake association addendum listing active lake groups.

Core programs

The Vermont Lay Monitoring Program equips and trains local lake users to measure the nutrient enrichment of lakes by collecting water quality data following a rigorously documented and quality assured methodology. This citizen monitoring program is based on trophic parameters and monitors approximately 40 inland lakes and 25 Lake Champlain stations per year. All Lake Champlain stations and many inland lakes in the program are sampled for chlorophyll-a, total phosphorus, and Secchi disk transparency. Other lakes are sampled only for Secchi disk transparency. All sampling occurs on a weekly basis during the summer. Since the development of the Lay Monitoring Program in 1979, data has been generated on 84 lakes and 36 Lake Champlain stations. Seventy-two inland lakes and 30 Lake Champlain stations have five or more years of full season data. In addition to their standard monitoring, Vermont's

citizen lake monitors also assist in the ANS Watchers Program (see below), and in collecting data for the Lake Bioassessment Project.

The Citizen Lake and Watershed Survey Program provides survey sheets and technical training to volunteers, lake and watershed associations, and other interested groups to enable them to perform screening level assessments to identify potential nonpoint sources of pollution to lakes by conducting in-lake, lakeshore, and lake watershed surveys.

The Aquatic Nuisance Species (ANS) Watchers Program trains citizen volunteers to monitor for the presence of invasive nonnative aquatic species. The program is currently focusing on monitoring for Eurasian watermilfoil, water chestnut, and zebra mussels. There are presently 110 ANS Watchers throughout Vermont.

The Volunteer Acid Precipitation Monitoring Program was initiated in 1980 to monitor changes in precipitation chemistry. Dedicated volunteers at six sites around Vermont (Holland, Morrisville, Mt. Mansfield, St. Albans, St. Johnsbury, and Underhill) collect precipitation samples on an event basis. The volume and pH of each storm event is recorded. Additional parameters such as conductivity and wind direction are recorded at individual stations. The data are used to assess spatial and temporal variability in the pH of bulk precipitation and assess changes in the pH of bulk precipitation over time and as related to reductions in atmospheric emissions of acid precursors (e.g., oxides of sulfur and nitrogen).

Other volunteer initiatives

The Water Quality Division collaborates with the LaRosa Laboratory (described below) on a novel program to assist citizen monitoring groups statewide. Beginning in 2003, the Water Quality Division and LaRosa Laboratory began issuing analytical services grants to volunteer organizations, based on a competitive proposal process. The project was very successful in 2003. Eleven projects were supported. These projects ranged in scope from small, single-lake studies to large, multi-year and multi-parameter watershed assessment initiatives. In 2003, the program produced in excess of 1,800 viable, quality-assured data records across Vermont.

4) Monitoring partnerships

Federal

The US Army Corps of Engineers (ACOE) manages several flood control reservoirs in Vermont. These are monitored routinely for flow and stage, and periodically for a variety of physico-chemical constituents. ACOE reservoirs with designated swimming beaches are also monitored for *E. coli* regularly during the swimming season. ACOE reports on it's monitoring activities annually, and shares these reports with WQD. ACOE sampling results are used in conjunction with Integrated Assessment reporting.

The US Environmental Protection Agency (EPA) coordinates regional water quality monitoring projects of a variety of types. In recent years, projects which WQD has been involved include the REMAP New England Wadeable Streams Project and the National Study of Chemical Residues in Fish. EPA was also the principal sponsor of the REMAP Assessment of Mercury in Waters, Sediments and Biota of Vermont and New Hampshire Lakes project. WQD

plans to participate in the upcoming REMAP New England Lakes Project. Results of these studies are used for a variety of purposes in addition to Integrated Assessment reporting.

The US Fish and Wildlife Service (FWS) sponsors projects across New England dealing with toxic contamination of aquatic biota. WQD has collaborated with FWS on several projects, and data are freely shared. In addition, FWS co-sponsored toe REMAP mercury project discussed above.

The US Geological Survey (USGS) operates a network of gauging stations on Vermont waters, which are supported by a cooperative agreement with DEC. This gauging network provides water flow data that are critical for numerous applications, both within and outside of DEC. USGS also coordinates several water quality studies throughout Vermont in a variety of disciplines, and the results and data are commonly shared with DEC for numerous uses including permitting and integrated Assessment reporting.

State

The Vermont Department of Forests, Parks, and Recreations operates a comprehensive beach monitoring program for all of it's public use beaches on State Park lands. Twenty-nine beaches are monitored on a weekly basis following established protocols. Swim advisories are posted based on results of the testing, when *E. coli* sample values exceed the Vermont standard for Class B waters of 77 *E. coli* /100ml. These data are openly shared with DEC. They are used for assessments as well as for identifying beaches subject to chronic, controllable bacterial contamination.

The Vermont Department of Health (DOH) operates a program whereby appointed Town Health Officers are trained to collect water quality samples at designated beaches. This program is suitable for small municipalities with informally-used swim beaches. Data reported back to Town Health Officers from the DOH laboratory take the form "safe for swimming," or "violates Vermont's standard unsafe for swimming." These data are not reported not tracked as numeric results. Town Health Officers commonly use these data to post warnings at swim beaches. Owing to resource constraints, samples collected in conjunction with that program cannot follow the strict quality assurance procedures required by DEC and the Department of Forests, Parks and Recreation in their *E. coli* monitoring projects. As such, this program provides useful and preliminary screening information to determine where swim beach water quality may need further assessment.

The Vermont Monitoring Cooperative (VMC) is a collaborative organization in which scientists collect and pool information and data for the purpose of improving our understanding, protection, and management of Vermont's forested ecosystems. Participating cooperators from government, academic and private sectors, conduct research projects on a variety of topics including forest health, air quality and meteorology, wildlife, aquatic systems and others. The VMC helps make the data and results from these projects available to other scientists, educators, resource managers and the general public. The VMC was initiated in 1990 as a state, university, and federal partnership, with a one-hundred year envisioned lifespan. The centerpiece of the VMC is the data library and card catalogue system that allow data to be shared, archived, and accessed by scientists and other interested parties via the VMC website. The data archive

contains data and ancillary textual material from over 100 projects, and is geographically referenced.

Academic

DEC maintains ties with several academic institutions interested in water quality monitoring. A partial list of these include Dartmouth College, Middlebury College, the University of Vermont, and member schools of the Vermont State College System. Collectively, these institutions carry out numerous projects and resultant data are commonly used by DEC for assessment purposes. The University of Vermont also carries out several larger-scale research and monitoring projects cooperatively with or of significant interest to DEC. A non-inclusive list of University of Vermont projects includes paired assessments of geomorphic and macroinvertebrate biometrics on streams, research into natural background levels and strategies to mitigate *E. coli* in Vermont waters, assessment of cyanotoxins in Lake Champlain and elsewhere, impacts of non-native species on aquatic food webs.

Local

The Addison County Collaborative (ACC) is a volunteer-based consortium of local volunteer organizations that monitor waters in several watersheds in Addison County. The ACC has monitored approximately 45 sites across four watersheds for *E. coli* and eutrophication-related parameters. ACC provides data and summary reports to DEC on an annual basis for assessment purposes. These data are also being used to assist in development of the Otter Creek and Lower Direct Champlain Basin Plans. The ACC received a LaRosa Laboratory services grant in 2003. This organization plans to launch a new monitoring project, in partnership with DEC, during 2004, to assist in the development of nutrient criteria.

The White River Partnership (WRP) is a private, non-profit organization dedicated to helping local communities balance the long-term cultural, economic and environmental health of the watershed through active citizen participation. The WRP has established a monitoring program for the watershed using several volunteer "stream-teams." Activities include geomorphic assessment, priority site mapping, and water quality sampling for a variety of constituents including temperature, turbidity, conductivity, and *E. coli*. WRP's volunteer monitors generate quality-assured data that are used to identify priority reaches for protection or remediation. DEC is periodically provided data summaries for use in implementation of the DEC-prepared White River Basin Plan, for assessment purposes, and in other joint special studies.

The West River Watershed Alliance (WRWA) is another watershed group dedicated to similar goals as the ACC and WRP but whose focus is on the waters in the West River watershed. The Alliance has re-established a monitoring program in the West River watershed that for many years was run by the Bonnyvale Environmental Education Center (BEEC). BEEC data were provided annually to DEC for assessment purposes for many years. The WRA also received a LaRosa laboratory services grant in 2003.

The City of Burlington and Town of Colchester collectively monitor several heavily-used swimming beaches, by measuring *E. coli* on a regular basis. These data are made publicly in near real-time via the "Burlington Eco-Info" website (www.burlingtonecoinfo.net).

The Watershed Alliance of the University of Vermont and **River Network** have been active in promoting surface water quality monitoring for elementary and high schools throughout Vermont. Such monitoring is valuable from an educational and student/community involvement standpoint. When monitoring results are shared with DEC, the information can be considered during assessment reporting.

The Friends of the Mad River (FMR) is a non-profit organization sharing similar goals to the above noted groups. The FMR has undertaken a number of planning and implementation projects along with a long-standing water quality monitoring program which includes *E. coli* and a number of other parameters. DEC is periodically provided data for use in assessment reporting.

B) Assessment Methodology

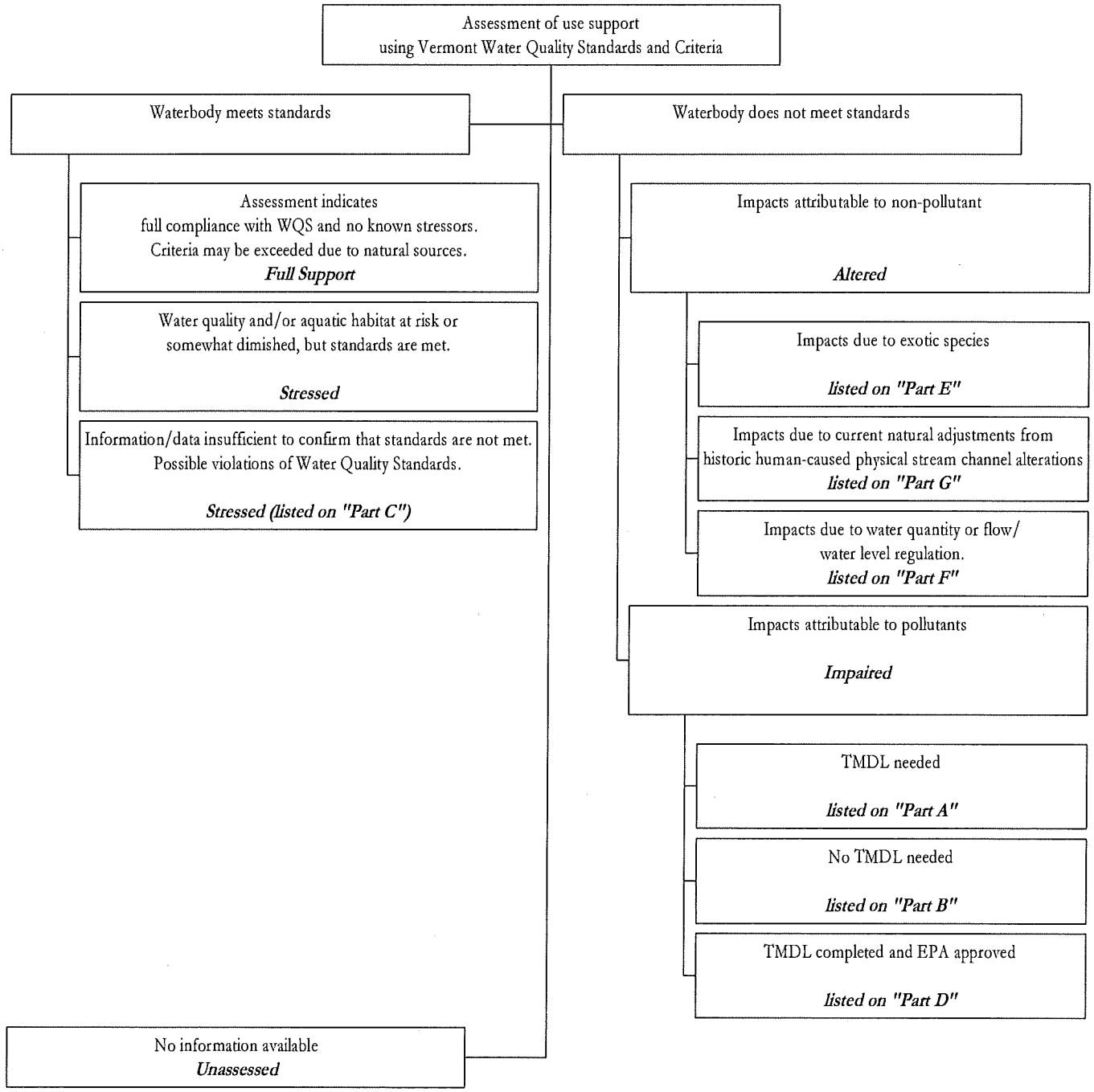
The following section describes the manner in which the WQD regularly gathers data and other information to make informed decisions about the status, integrity or condition of surface waters.

The collection, analysis and evaluation of water quality monitoring data and other information represent the assessment of a water's condition. The assessment of a water is most accurate when judgements about the water's condition are made using chemical, physical and/or biological data of known reliability collected through monitoring. While not as definitive as data collected though monitoring, an assessment of a water's condition can also take into account field observations or other qualitative information.

The Vermont Water Quality Standards, periodically revised and promulgated by the Vermont Water Resources Board, provide the basis used by DEC in determining the condition of surface waters including whether the water meets (attains) or does not meet (exceeds or violates) certain criteria. The assessment of a water's condition within the context of the Water Quality Standards requires consideration of the water's classification and management type, a variety of designated or existing uses, and a series of criteria which can be numerical or narrative. The outcome of an assessment conducted by the DEC is to categorize Vermont's surface waters as either "full support," "stressed," "altered," or "impaired." Waters determined to be "impaired" or "altered," and certain "stressed" waters are presented for water quality management purposes on one or more listings. Over time, DEC is gradually reducing the number of waters characterized as "unassessed." The organizational chart appearing on the following page illustrates the major components of DEC's surface water assessment and listing process.

The reader is referred to Appendix C for the entire 2004 Assessment and Listing Methodology.

Chart Depicting Organization of Vermont's Water Quality Assessment & Listing Methodology.



C) Rivers & Streams Water Quality Assessment (Statewide)

Three basin assessment reports were completed and a fourth was essentially completed in the last two years since the 2002 305b Report. A report for Basin 13 (the Lower Connecticut River watershed) was completed in April 2002; a report for Basin 1 (the Battenkill, Walloomsac, Hoosic watershed) was completed in August 2002; and a report for Basin 12 (the Deerfield River watershed) was completed in March 2003. Each completed assessment report noted above and those completed previously are available from DEC on request. Basin 5 (the Northern Lake Champlain watershed) is undergoing final revisions at the time of this writing. The data and information gathered prior to production of these reports are incorporated into the rivers and streams and lakes and ponds discussions and reporting numbers which follow below.

1) Assessment of use support

The assessment of Vermont's statewide river and stream surface water quality and aquatic habitat conditions has been updated from the 2002 305b statewide assessment with water quality information and data from waters monitored and assessed during the last two years. There is a substantial difference, however, between the use support determinations in this statewide assessment summary and those of past 305b reports. As described above and in the appendix containing the Assessment Methodology, miles of river or stream are placed in one of four categories by designated use – full support, stressed, altered or impaired. This categorization differs from the categories of full support, full support/threatened, partial support, and non-support used in all earlier 305b assessment reports. This biennial report contains rivers and streams that have been re-assigned to the new categories to the extent possible. However, the current assessment categories do not directly equate to the former categories and there are a number of waters where the data and information are too old to permit a decision about the proper assessment category for the river or stream miles. The assessment category of these rivers and streams will be determined as Vermont DEC gets to them in the assessment rotation. *The numbers given below in use support categories as well as the miles of rivers and streams affected by different causes and sources need to be considered as transitional until a complete re-assignment and re-assessment has been done.*

Determination of use support is based on data and information from biological monitoring, chemical monitoring, physical assessments, modeling results, and known sources of problems such as channelization work, combined sewer overflows (CSOs), or flow fluctuations, non-singular incidences of fish kills or spills.

According to EPA, Vermont has approximately 7,100 miles of perennial rivers and streams. Of the approximate 5,464 river and stream miles assessed for this report, overall approximately 88% of those miles are in compliance with the state's water quality standards and support designated uses, and 12% do not meet water quality standards or do not fully support the designated uses.

Table 4.C.1 below is a summary of the number of miles of rivers and streams throughout Vermont which support or do not support the water quality standards or designated uses of the waters. For each river use or value that is assessed, the miles of river or stream fully supported, stressed, altered, or impaired are determined. For example, river miles that are supported for aquatic biota have macroinvertebrate and fish communities in good to excellent health based on a

number of metrics for each community. River miles that are supported for swimming have no known high levels of *E. coli*, a bacteria that is used as an indicator for pathogens. Overall use support, expressed as proportion of miles meeting/not meeting uses, by waterbody, is shown in Figure 4.C.1 on the following page.

The number of miles in each support category are provided for six uses or values: aquatic biota and/or habitat, contact recreation (swimming, tubing), secondary contact recreation (boating, fishing), aesthetics, fish consumption, and drinking water supply. The use called "overall" reflects the miles for which one or more of the uses are fully supported, stressed, altered, or impaired. The fish consumption use is not factored into the "overall" category because all miles of river and stream are at least stressed for fish consumption due to a statewide fish consumption advisory. If taken into account in "overall", this status would mask the extent of other stresses.

Table 4.C.1. Statewide Overall & Individual Use Support Summary (miles) for Rivers & Streams.

Designated Use	Full support	Stressed	Altered	Impaired	Total assessed
Overall	4003	848	317	311	5479
Aquatic biota/habitat	4099	836	317	227	5479
Contact recreation	4734	455	8	151	5348
Secondary contact recreation	4509	645	141	70	5365
Aesthetics	4461	692	171	149	5473
Drinking water supply	244	16	10	9	279
Fish consumption	0	5870	0	53	5923

2) Summary of Causes and Sources

A cause is a pollutant or condition that results in a water quality or aquatic habitat impairment, alteration or stress; a source is the origin of the cause and can be a facility, a land use, or an activity. The sources are subdivided into point and nonpoint, and a nonpoint source is defined as any pollutant not discharged directly from the end of a pipe. Tables 4.C.2 and 4.C.3 summarize the miles of rivers and streams affected by various causes and sources, respectively.

Because a stretch of river or stream may be affected by more than one cause or source, the same mileage may be tallied in several places in Tables 4.C.2 and 4.C.3. For this reason, the two columns on each table are not additive because the total would overestimate the total number of miles affected by all causes and sources in Vermont. The purpose of these summaries is to give natural resource managers and the public an idea of the relative size of the impact from different pollutants or conditions on Vermont's waters and from which land uses or activities they may originate.

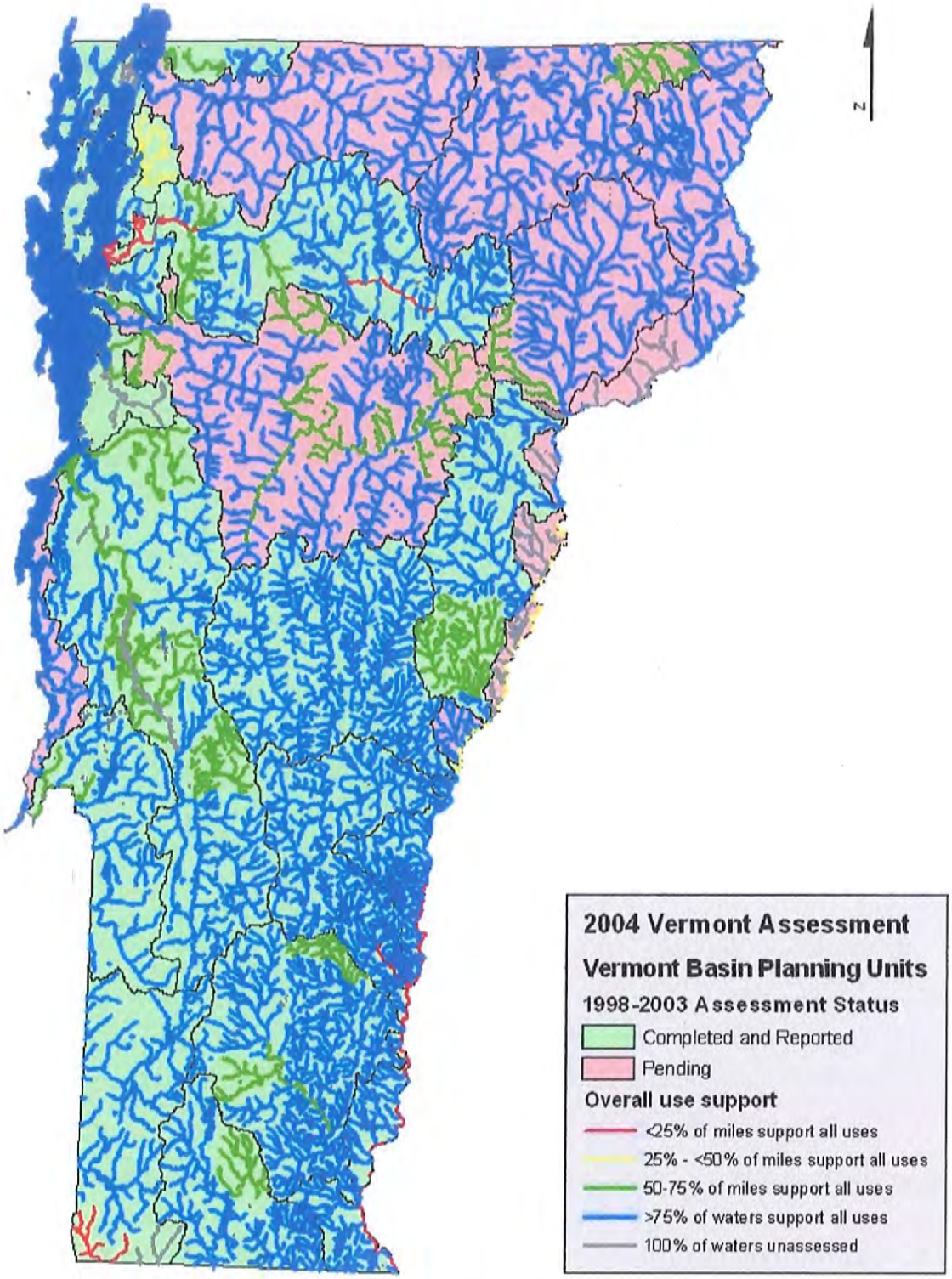


Figure 4.C.1. Overall Use Support for Rivers and Streams.

Causes

Sedimentation/siltation is the largest cause of stresses and impairments to river or stream water quality or aquatic habitat in Vermont. Sedimentation/siltation has long been the leading pollutant of our flowing waters. Unnatural levels of sediment alter or destroy macroinvertebrate habitat and fish spawning areas, fill in swimming holes, and cause the river or stream channel to become unstable. Sedimentation results in approximately 333 miles of river and stream not meeting standards and stresses another 700 miles based on the information available at this time.

The second largest documented cause of impacts and impairments is flow alteration. This problem affects about 264 miles and stresses another 67 miles.

The cause affecting the third largest number of miles in terms of pollutants or conditions is nutrient loading to waters. Nutrients contribute to 225 miles of river and stream not meeting standards and to over 440 stressed river or stream miles.
Physical habitat alterations affect the fourth largest number of miles of river and stream causing 195 miles of not full support and stressing another 433 miles.

The other substantial causes identified include: pathogens affecting about 140 miles and stressing over 260 miles; thermal modifications affecting 126 miles and stressing over 475 miles (the second largest stressor identified); turbidity affecting 130 miles and stressing 138 miles; and metals affecting about 90 miles and stressing another 150 miles.

Past assessments have generally had similar results in terms of which pollutants or conditions have the most impact on water quality or aquatic habitat. Sedimentation was the most extensive cause of pollution in the 2000, 1998 and 1996 305b assessments. The eight most significant causes of river and stream impairments, alterations, or stresses are given in Table 4.C.2 below.

Table 4.C.2. Total River and Stream Miles Affected by Cause Category.

Cause of impairment, alteration, or stress	Magnitude (miles)	
	Not meeting standards	Meeting standards but stressed
Sedimentation	333.0	721.0
Flow alterations	264.0	67.1
Nutrients	224.7	449.2
Physical habitat alterations	194.9	433.5
Pathogens	141.7	261.3
Thermal modifications	126.0	478.4
Turbidity	130.2	138.2
Metals	91.0	151.6

Sources
The four sources of pollution identified as having the greatest impacts or causing the greatest stresses on miles of river and stream are flow alteration from hydroelectric facilities, snowmaking water withdrawals and other sources; streambank erosion; agricultural land uses and activities; and removal of riparian vegetation. In some situations, all three latter sources could be interrelated and affecting one given stretch of river and stream at the same time.

Flow fluctuations or reductions alter about 284 miles and stress another 60 miles. The number of miles attributed to flow modification as a source are less than in the 2002 305b assessment cycle due to licenses issued at hydroelectric facilities and snowmaking withdrawal changes. Federal Energy Regulatory Commission (FERC) licenses have been issued for the Vergennes, Middlebury Lower and Weybridge hydroelectric projects on the Otter Creek. The Fifteen Mile Falls Project on the Connecticut River has been licensed now as well and so the waters involved (many miles of river and impoundment) comply with the Vermont and New Hampshire Water Quality Standards. The Clyde River Project also has a new FERC license and so the streamflows in this watershed (a portion of the Clyde River itself, Echo Lake outlet stream, and Seymour Lake outlet stream) have been improved as well. Killington snowmaking water withdrawals are now complying with the water quality standards on the portions of the Ottauquechee River and two tributaries.

Streambank erosion has been identified as the cause of about 247 miles of impact and 587 miles of stresses. Streambank erosion is described as a source in and of itself, but this 'source' results from other 'sources' such as riparian vegetation removal and channel instability.

Agricultural land uses and activities have an impact on 187 miles and stress another 524 miles of river or stream. As mentioned above, the interrelationship between agricultural activities, riparian vegetation loss, streambank erosion, and channel instability as sources makes the attribution of miles stressed, altered, or impaired to each of these sources an imprecise task. The relative contribution of each source should be the focus.

Approximately 154 miles of impact and 526 miles of stress have been attributed to the removal of riparian vegetation. Removal of riparian vegetation continues to be a growing problem in the state. Individual residential and commercial landowners, farmers, town road crews and the Agency of Transportation all encroach on the riparian zone with their activities and the result is the loss of the trees and shrubs protecting rivers and riverbanks. Flooding and channel instability also result in loss of riparian vegetation, but the loss of riparian vegetation also increases a stream's vulnerability to channel changes in an unstable system.

Atmospheric deposition is primarily responsible for mercury and acidified conditions in Vermont's surface waters. While these conditions are most exacerbated in lake systems, stream biological communities do exhibit quantifiable impacts, particularly due to acidification. Atmospheric deposition has an impact on 106 miles of river and stream and stress about 17 miles.

Urban/developed land runoff, road and bridge runoff, and land development are three other separately identified sources of impairments and stresses that are also interrelated.

Urban/developed land as a source includes runoff from any urban, suburban, village or other developed areas. Developed land changes the amount and timing of runoff reaching rivers and streams and the runoff contains many pollutants including sediment, metals, nutrients and organic compounds. Most of the road/bridge runoff water quality problems come from gravel town roads that drain toward streams and discharge silt to them. Runoff from bridges over streams goes directly into streams. Road runoff also goes to slopes adjacent to the bridge abutments, which causes the slopes to erode to the streams. In addition, highway maintenance often includes washing pollutants off bridges into adjacent rivers and streams. Land development includes clearing, grading, excavation and filling, done in many cases with no or improperly maintained erosion control devices.

Land development has an effect on 83 miles and stresses about 62. Urban/developed land runoff affects about 80 miles of river and stream and stresses about 129 miles as determined in this assessment. Road and bridge runoff contributes to 44 miles of impairment and over 180 miles of stressed conditions

Other sources specifically tracked include: channel instability, upstream impoundments, onsite wastewater systems, hazardous waste sites, and resource extraction among others.

Table 4.C.3. Total Miles of Rivers & Streams Affected by Source Category.

Source of impairment	Magnitude (miles)	
	Not Meeting Standards	Meeting standards but stressed
Flow modification	283.7	60.0
Streambank erosion	246.9	586.9
Agriculture	187.4	523.9
Removal of riparian vegetation	154.5	526.1
Atmospheric deposition	106.2	17.0
Land development	82.6	62.1
Urban/developed land runoff	80.1	128.6
Channel instability	64.6	147.9

D) Lakes & Ponds Water Quality Assessment (Statewide)

1) Assessment of use support for inland lakes

A statewide summary of inland lake use support is provided in Table 4.D.1. Inland lakes are considered all waters within the borders of the State, except for all eleven segments of Lake Champlain. Moore and Comerford Reservoirs, Lake Memphremagog, and Wallace Pond are transboundary waters that are reported as "inland lakes." Overall, 35,908 inland lake acres

support uses, and 19,434 acres do not support uses. Proportionally, aesthetics use is most highly supported in inland lakes (88% of acres), followed by swimming (87%) and drinking water supply. Although all waters are impacted by mercury pollution and are subject to consumption advisories, Vermont's assessment methodology indicates the need for waterbody-specific tissue data to indicate non-support of fish consumption. Accordingly, when assessed following the methodology, 85% of inland lake acres support fish consumption use. However, based on research conducted specifically in Vermont, all waters are subject to atmospheric mercury contamination, and many waters have the potential be impaired for fish consumption, were data available to support such assessments. The reader is referred to Section 4.D.5 for a comprehensive discussion of mercury impacts in Vermont, including a probability-based estimate of the proportion of lakes that are not likely to support fish consumption use.

Table 4.D.1. Acres of Vermont Inland Lakes Supporting or Not Supporting Uses.

Use	Full Support	Stressed	Total Meeting WQS	Altered	Impaired	Total Not Meeting WQS	Not Assessed
Overall Uses	15026	20882	35908	8874	9910	19434	162
Aesthetics	37517	11180	48697	4216	2529	6645	162
Agricultural Water Supply	-	-	-	-	-	-	53492
Aquatic Life Use Support	22614	16933	39547	8916	6979	15795	162
Drinking Water Supply	1268	0	1268	0	123	123	123
Fish Consumption	41054	5966	47020	0	8115	8115	369
Secondary Contact Uses	36721	9380	46101	5719	2559	8178	1225

Note: All Vermont waters are subject to contamination by atmospheric mercury.

Overall use support, expressed as proportion of lake/pond acres supporting/not supporting uses, by assessed waterbody, is shown in Figure 4.D.1 on the following page.

2) Summary of causes and sources for inland lakes

The causes and sources of impairments, alterations, and stresses to Vermont lakes are shown simultaneously in Table 4.D.2 beginning on the next page. In spite of the small amount of lake-specific fish tissue monitoring data available, metals and mercury remain the greatest cause of impairment to Vermont lakes, causing 8,115 inland lake acres not to meet fish consumption uses. This is due to the fact that mercury (Hg) contamination is quite elevated in fish tissues of the component reservoirs within the Fifteen Mile Falls (Connecticut River near St. Johnsbury, VT – Littleton, NH) and Deerfield River hydroelectric projects. Atmospheric deposition is the most important source of Hg to Vermont's landscape and, accordingly, is listed as the most important source category. Flow alteration is the second most important cause of alterations to aquatic life and other uses in Vermont, resulting in loss of use to 7,773 acres, due largely to hydromodification. Lake acidification, caused by low pH, it the third most prevalent cause of impairment and the source of this low pH is atmospheric deposition of acid precursors, along with natural factors such as low catchment buffering capacity. In Vermont, 4,420 lake acres are impaired by cultural acidification and an additional 6,883 acres are stressed. A TMDL addressing acid deposition to 30 Vermont lakes was issued by DEC during the reporting period.

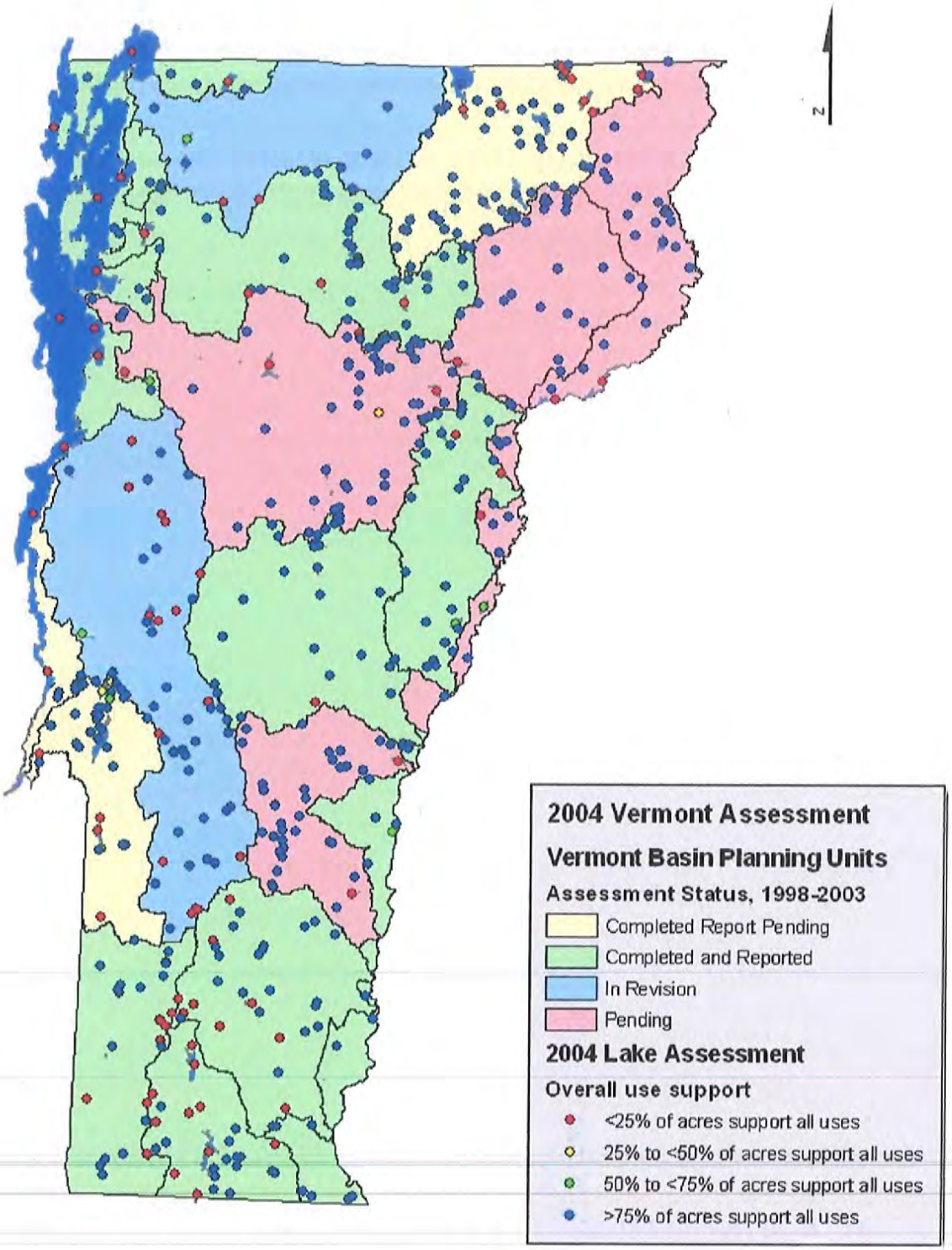


Figure 4.D.1. Overall Use Support for Lakes and Ponds.

Phosphorus and nutrients the fourth most important cause of impairment, limiting or precluding uses on 2,515 lake acres and stressing approximately additional 4,900 acres. Siltation is tracked separately from phosphorus, but is the result of similar sources. Siltation impairs 1,833 acres and stresses an additional 3,365. Several sources simultaneously account for nutrients, phosphorus, and siltation, including agricultural, silvicultural, and developed land, road runoff, unstable streams, and residential property management. Finally, non-native species (largely the Eurasian milfoil *Myriophyllum spicatum*) alter several uses and is spread by recreational lake uses. Non-native species currently alter 1,697 acres and stress an additional 5,182 acres.

Table 4.D.2. Causes & Sources of Impacts to Inland Vermont Lakes.
Causes and sources are ranked in decreasing order of total acreage impaired/altered.
(Note: listed causes and sources are not linked)

Cause of impact	Magnitude of **Cause**		**Source** of impact	Magnitude of **Source**	
	Not meeting WQS	Use stressed		Not meeting WQS	Use stressed
0500 Metals	8115	0	8100 Atmospheric deposition	16178	5702
0560 Mercury	8115	0	7400 Flow regulation/modification	9785	4884
1500 Flow alteration	7773	4813	7000 Hydromodification	7773	4859
1000 pH	4420	6883	8600 Natural sources	4420	7774
2210 Noxious aquatic plants - algae	2537	3294	1000 Agriculture	2413	2277
0900 Nutrients	2515	4926	1100 Nonirrigated crop production	2378	858
0910 Phosphorus	2515	4951	9070 Inspecified nonpoint source	2151	841
1100 Siltation	1831	3365	1800 Animal holding/management area	1926	796
2600 Exotic Species	1697	5182	1400 Pasture grazing-riparian and/or upland	1908	967
1200 Organic enrichment - DO	1187	1150	7900 Marinas and recreational boating	1797	5211
2200 Noxious aquatic plants - native	554	1405	7910 In-water releases	1734	5235
2400 Total Toxics	1		7550 Habitat modification	612	446
0000 Cause unknown	0	7	7700 Streambank modification/destabilization	612	472
0800 Other inorganics	0	6	0200 Municipal point sources	521	
1300 Salinity - TDS - chlorides	0	9	0400 Combined sewer overflow	470	
1700 Pathogens	0	808	6000 Land disposal	452	456
2300 Filling and draining	0	49	6400 Industrial land treatment	452	446
2500 Turbidity	0	51	3000 Construction	200	3342
			3200 Land development	200	3322
			7600 Removal of riparian vegetation	85	1131

Cause of impact	Magnitude of Cause		Source of impact	Magnitude of Source	
	Not meeting WQS	Use stressed		Not meeting WQS	Use stressed
			8530 Internal nutrient cycling (lakes)	54	72
			8300 Highway maintenance and runoff	51	3186
			2000 Silviculture	35	1393
			2100 Harvesting, restoration, residue management	35	1098
			4000 Urban runoff/storm sewers	1	1115
			0100 Industrial point sources	0	17
			1410 Pasture grazing-riparian	0	5
			2300 Logging road construction/maintenance	0	20
			3100 Highway/road/bridge construction	0	4
			4300 Other urban runoff	0	148
			4500 Highway/road bridge runoff	0	166
			4600 Erosion and sedimentation	0	3
			5000 Resource extraction	0	21
			5100 Surface mining	0	21
			6300 Landfills	0	14
			6500 Onsite wastewater systems (septic tanks)	0	54
			7300 Dam construction	0	37
			8520 Debris and bottom deposits	0	20
			8700 Recreational and tourism activities (not boating)	0	105
			9000 Source unknown	0	1026

3) Assessment of use support for Lake Champlain

A summary of Lake Champlain use support is provided in Table 4.D.3. In Lake Champlain, due to the combined effects of trace metal contamination, nutrient accumulation and non-native species, none of Lake Champlain's 174,175 acres fully support all designated uses. Proportionally, aquatic life use is most highly supported (88% of Champlain waters), followed by secondary contact (83%). Due to phosphorus concentrations in excess of Vermont Water Quality Standards in most areas of the lake, only 23% of Lake Champlain fully supports

swimming uses, and only 20% supports aesthetics. No acres support fish consumption use due to mercury and polychlorinated biphenyls (abbreviated as PCBs) in fish tissue.

Table 4.D.3. Lake Champlain Acres Supporting or Not Supporting Uses.

Use	Full Support	Stressed	Total Meeting WQS	Altered	Impaired	Total Not Meeting WQS	Not Assessed
Overall Uses	0	0	0	13201	174175	174175	0
Aesthetics	35290	0	35290	11394	132053	138885	0
Aquatic Life Use Support	152672	0	152672	21503	5388	21503	0
Drinking Water Supply	121872	0	121872	15673	0	12904	0
Fish Consumption	0	0	0	0	174175	174175	0
Secondary Contact Uses	144300	0	144300	12994	0	29875	0
Swimming Uses	39271	0	39271	15595	132063	134904	0

Note: all segments of Lake Champlain are considered impaired for fish consumption use due to fish tissue mercury data which show elevated Hg concentrations for various fish species, in all sections of the lake.

4) Summary of causes and sources for Lake Champlain

The causes and sources of impairments, alterations, and stresses to Lake Champlain are shown simultaneously in Table 4.D.4 below. Mercury is the greatest cause of impairment to Lake Champlain, precluding fish consumption use on the entire lake for a subset of Vermont's citizens. Priority organics (PCBs) also impair fish consumption use on the majority of Lake Champlain acres. Atmospheric deposition is the most important source of mercury to Vermont's landscape and is listed as the most important source of mercury to Lake Champlain. The source of PCBs in lake trout was identified in 1994 as a residual "dump" of PCBs in the vicinity of the Wilcox Dock in Plattsburg Bay, New York. The PCB source and contaminated sediments were cleaned up in the late 1990s by the New York State Department of Environmental Conservation.

Nutrients, phosphorus, and associated algal growth impair 132,053 acres of Lake Champlain, and related siltation contributes to that impairment, by stressing uses on 5,388 acres. Unspecified nonpoint sources of nutrients are the largest source of the nutrient pollution, although a suite of sources also contribute nutrients to Lake Champlain, as discussed above (Section 4.D.2). Urban runoff, including stormwater, is also an important nutrient and sediment source in certain segments of Lake Champlain. During the reporting period, a comprehensive TMDL for phosphorus was finalized for Lake Champlain. The Lake Champlain TMDL is the centerpiece of Vermont Governor Douglas' *Clean and Clear Water Action Plan*, which is beginning to be implemented as of this writing. Exotic species are a significant problem in Lake Champlain, impairing several uses on 21,503 acres. In Lake Champlain, there is a mix of Eurasian milfoil, water chestnut (*Trapa natans*) and zebra mussel (*Dreissena polymorpha*) infestations which all impact aquatic life, aesthetics, swimming, boating, and drinking water uses.

Table 4.D.4. Causes & Sources of Impacts to Lake Champlain (acres). Causes and sources are ranked in decreasing order of total area impaired/altered. (Note: listed causes and sources are not linked)

Cause of impact	Magnitude of **Cause**		**Source** of impact	Magnitude of **Source**	
	Not meeting WQS	Use stressed		Not meeting WQS	Use stressed
0500 Metals	174175		8100 Atmospheric deposition	174175	
0560 Mercury	174175		9070 VT-unspecified nonpoint source	132053	
0300 Priority organics	163678		0200 Municipal point sources	73869	
0900 Nutrients	132053		1000 Agriculture	31859	
0910 Phosphorus	132053		7910 In-water releases	24803	
2210 Noxious aquatic plants - algae	132053		7900 Marinas and recreational boating	21503	
2600 Exotic Species	21503		0100 Industrial point sources	21362	
1700 Pathogens	19	222	4000 Urban runoff/storm sewers	13744	
1100 Siltation	0	5388	3000 Construction	13725	
2200 Noxious aquatic plants - native	0	500	8300 Highway maintenance and runoff	13725	
			8600 Natural sources	5388	6
			9000 Source unknown	0	216

5) Probabilistic statewide assessment of mercury contamination in lakes

The material presented in the following section summarizes technical findings from a large study of mercury contamination in Vermont and New Hampshire lakes that was undertaken by DEC and other partners during the period 1998-2002 and reported in 2003. This project was supported by EPA Region 1 and EPA's Office of Research and Development, under the Regional Environmental Monitoring and Assessment Program (REMAP). Comprehensive results of the study are available online as reported by Kamman et al. (2003)[2] at www.vtwaterquality.org/lakesremap.htm. Results of the study have also been published in the journals *Atmospheric Environment*[3] and *Environmental Toxicology and Chemistry*[4] and are in–press in several additional manuscripts to publish in the journal Ecotoxicology in 2005. In this Integrated Report, a summary of the raw data findings from the project is presented in Tables 4.D.5.a-c and in Figure 4.D.5. Findings from a suite of detailed statistical analyses are provided in Section 5.e. The statistical analyses are outside the scope of this report, but summary tabular data are provided for readers who have an interest in the dataset developed by the project.

[2]Kamman, N.C., C.T. Driscoll, R. Estabrook, D.C. Evers, and E. Miller. 2003. Biogeochemistry of Mercury in Vermont and New Hampshire Lakes-An Assessment of Mercury in Waters, Sediments and Biota of Vermont and New Hampshire Lakes. Vermont Department of Environmental Conservation. Waterbury VT USA.

[3] Kamman and Engstrom, 2002. Current and historical fluxes of Hg to VT and NH lakes inferred from 210Pb-dated sediment cores. *Atmos. Environ.* 36: 1599-1609

[4] Kamman *et al.*, 2004. Assessment of mercury in waters, sediments, and biota of New Hampshire and Vermont lakes sampled using a geographically randomized design. *Env. Tox. Chem.* 23:5

a) VT-NH probabilistic assessment of mercury (Hg) and other chemical parameters in waters.
Water chemistry results are summarized by lake strata (epilimnion and hypolimnion, denoted as "EPI" and "HYP" in Table 4.D.5.a), and are presented based on geographically weighted data. Statistics based on weighted datapoints provide statistically unbiased estimates of all measured parameters for the population of lakes in Vermont and New Hampshire. Water chemistry results for aqueous parameters are presented below by lake strata in Table 4.D.5.a.

Table 4.D.5.a. Summary of Water Chemistry Data Based on Weighted Sampling Results for Vermont & New Hampshire Lakes.

Parameter	Lake strata	Count	Mean	95% lower C.L.	95% upper C. L.
Acid Neut. Capacity	EPI	127	19.1	17.1	21.1
Acid Neut. Capacity	HYP	75	24.1	21.2	27.0
CL^-_mg/l	EPI	129	8.09	7.46	8.72
CL^-_mg/l	HYP	80	7.84	6.93	8.76
Diss. Color PtCo units	EPI	90	27.10	24.46	29.74
Diss. Color PtCo units	HYP	55	41.24	36.11	46.38
DOC mg/l	EPI	130	4.31	4.18	4.44
DOC mg/l	HYP	80	3.91	3.75	4.07
Total mercury (HgT)_ng/l	EPI	129	1.78	1.68	1.88
HgT_ng/l	HYP	68	11.52	10.62	12.41
Methylmercury (MeHg)_ng/l	EPI	129	0.299	0.281	0.318
MeHg_ng/l	HYP	68	0.829	0.738	0.921
NO_X_mg/l	EPI	128	0.03	0.03	0.04
NO_X_mg/l	HYP	80	0.04	0.04	0.04
SO4_mg/l	EPI	129	4.11	4.03	4.19
SO4_mg/l	HYP	80	3.96	3.82	4.10
Sulfide_mg/l	EPI	44	0.12	0.09	0.14
Sulfide_mg/l	HYP	72	0.13	0.12	0.15
Total Color PtCo units	EPI	127	39.75	37.48	42.01
Total Color PtCo units	HYP	78	65.94	61.15	70.73

b) VT-NH probabilistic assessment of Hg and other chemistry parameters in sediments.
Sediment chemistry summary statistics are presented using geographically weighted data, for percent solids and loss on ignition, total mercury (HgT), methylmercury (meHg), and percent of HgT as meHg. These statistics are presented in Table 4.D.5.b below.

Table 4.D.5.b. Summary of Sediment Chemistry Data Based on Weighted Sampling Results for Vermont and New Hampshire Lakes.

Parameter	Count	Mean	St. error	95% lower C.L.	95% upper C. L.
Sediment HgT - ug/g	129	0.24	0.00	0.23	0.25
Sediment meHG - ug/g	78	0.004	0.0001	0.004	0.004
Sediment meHG, % of HgT	78	1.713	0.054	1.607	1.818
Solid content %	129	8.35	0.19	7.97	8.72
Loss on ignition %	129	32.17	0.39	31.40	32.95

c) VT-NH probabilistic assessment of mercury and other chemistry parameters in biota.
Summary statistics are presented for: HgT in yellow perch fillets, bulk macrozooplankton (≥ 201 μ) and avian piscivore blood, feathers, and eggs; HgT and meHg in prey-sized (≤5cm) yellow perch composites; and, physical characteristics of tissue samples. Summary statistics are provided in Table 4.D.5.c.

Table 4.D.5.c. Summary of Sediment Chemistry Data Based on Weighted Sampling Results for Vermont and New Hampshire Lakes.

Parameter	Count	Mean	95% lower C.L.	95% upper C. L.
Filet Length_cm	278	20.6	20.4	20.8
Filet Weight_g	278	114.59	110.69	118.49
Fish Age	232	4.6	4.5	4.7
Yellow Perch Fillet HgT_ug/g ww	278	0.239	0.232	0.246
Yellow Perch Prey weight_g	45	80.99	76.35	85.62
Yellow Perch Prey HgT ug/g w.w.	45	0.098	0.092	0.103
Yellow Perch Prey meHg ug/g w.w.	30	0.0914	0.0846	0.0983
Zooplankton % Solid	41	0.24	0.22	0.26
Zooplankton HgT ug/g d.w.	38	0.432	0.387	0.478
Zooplankton HgT ug/g w.w.	38	0.091	0.082	0.101
Loon blood HgT ppm w.w.	18	1.356	1.184	1.528
Loon egg HgT ppm w.w.	15	0.762	0.699	0.825
Kingfisher blood HgT ppm w.w.	10	0.759	0.623	0.895

Note: Zooplankton HgT values are given as both dry and wet weight to facilitate comparison to other biological matrices.

*d) Probabilistic assessment of mercury risk to common loon (*Gavia immer*) across northern New England.*

Tissue samples acquired from common loons permit assessment of the overall risk to loons posed by mercury bioaccumulation. Risk characterizations were derived using either adult or juvenile blood, or abandoned eggs. The type of sample acquired was determined in the field based on availability and opportunity. Risk attributions followed the protocols of Evers et al. (2000)[5]. Based on these characterizations, samples collected from lake in this study were evaluated by state, and in relation to loon tissues acquired from the Maine REMAP study lakes (MEDEP, 1995)[6]. Results are provided in Figure 4.D.5.

Fifty percent of loons from Vermont study lakes and 70% of loons from NH study lakes have sufficient mercury in their tissues so as to pose a moderate or greater risk to the animals themselves. In Maine, the proportion is 78%. The total percentage of birds at high or extra high

[5] Evers, D. C., C. DeSorbo, and L. Savoy. 2000. Assessing the impacts of methylmercury on piscivorous wildlife as indicated by the Common Loon, 1998-99. Maine Dept. Environ. Protection, Augusta, Maine).
[6] Maine Department of Environmental Protection. 1995. Fish tissue contamination in Maine lakes, data report. Regional environmental monitoring and assessment program (REMAP). Augusta, Maine, USA.

risk increases from 20% in Vermont to 27% in Maine. A geographic gradient is apparent in these data with a clear increase from west to east. This is consistent with the findings of Evers, et al. (2000).

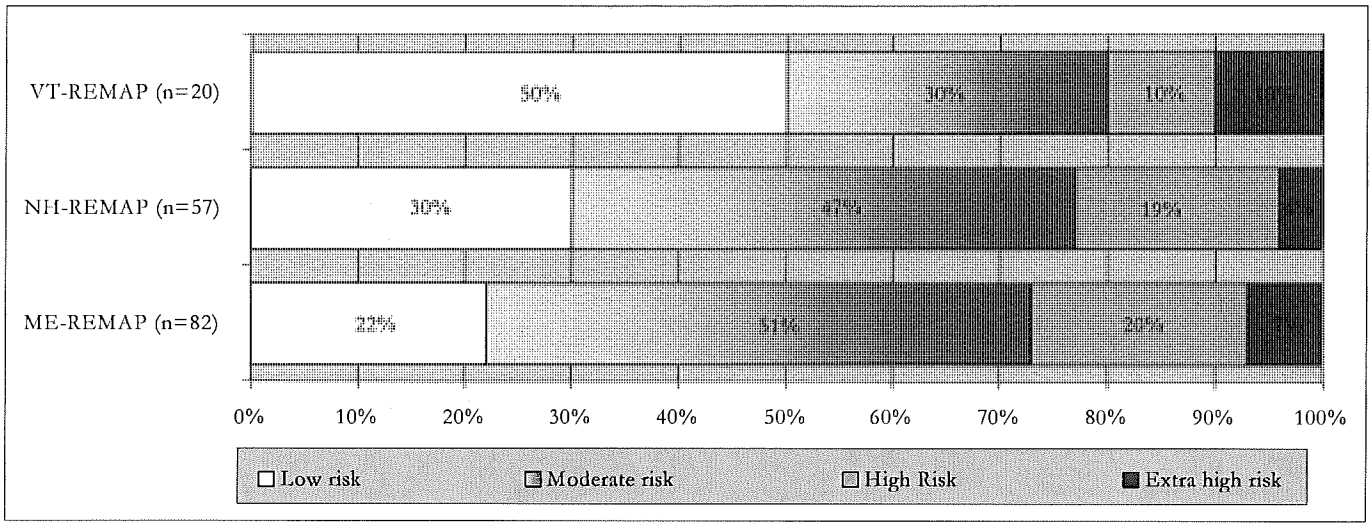


Figure 4.D.5. Mercury risk to breeding Common Loons (*Gavia immer*), based on adult and juvenile blood and egg Hg levels.

Evers (2003)[7] further indicates that these proportions are sufficient so as to threaten entire loon populations. The present hypothesis regarding population-level impacts to loons is that chronic mercury exposure impacts to loons is reducing the ability of loon pairs to successfully produce chicks, owing to impacts to individual birds within the parent pair (Evers, personal comm.). Individual-level impacts include reduced ability to acquire food for chicks, and reduced ability to defend nesting territories from predators and other loons. However, in the field, observations regarding loon nesting habits from citizen monitoring groups show continuing increases in overall numbers of nesting loon pairs. While these two phenomena seem at odds, they are in fact consistent, when the effect of the male loon "buffer population" is accounted for. The "buffer population" is that group of male birds (typically juvenile or sub-adult, lone birds) which are available to fill in for a nesting male bird, if that bird is unable to successfully defend it's territory, or is lost due to disease or other factors. It is the decline in the "buffer population" which is cause for concern. Declines in actual nesting loon pair and reared chicks are expected to accompany further reductions in the buffer population.

e) Summary of REMAP project data analyses

In the following paragraphs, results of detailed statistical analyses using the REMAP project data are excerpted from Kamman et al. (2003).

[7] Evers, D.C.. 2003 in prep. Development of a wildlife criterion value to protect against methylmercury exposure to piscivorous wildlife in Maine. Maine Dept. Environ. Protection, Augusta, Maine.

"Yellow perch fillet mean HgT concentrations for the present study lakes are most accurately estimated using age as a covariate. The overall VT-NH average yellow perch fillet HgT concentration, adjusted to an age 4.6 year fish, is 0.225 $\mu g\ g^{-1}$ w.w.

"Reviewed geographically, the raw data on mercury in waters, sediments, and biota indicate that New Hampshire lakes have elevated epilimnetic meHg, and hypolimnetic HgT and meHg. Concentrations of hypolimnetic meHg are highest in southern NH. There is a 'hotspot' in yellow perch fillet HgT (age-adjusted means) in southwestern NH. The same hotspot is reflected in sediment meHg concentrations, and may reflect a localized Hg source.

"Cumulative frequency diagrams based on weighted individual lake mean observations show the distribution of mercury in water, sediment, and biota across the region, as well as by state. Based on these diagrams, approximately 25% of lakes across the region possess yellow perch which violate the EPA criterion of 0.3 $\mu g\ g^{-1}$ w.w. meHg in fish tissues. Significant differences between hypolimnetic HgT and meHg, prey and fillet tissue HgT, and zooplankton HgT are apparent between the states, with New Hampshire displaying generally higher overall values. Comparisons are available from the Maine REMAP project, which indicate that while sediment HgT concentrations in Maine are lower than in the Vermont-New Hampshire region, yellow perch tissue concentrations are generally consistent with those of New Hampshire lakes.

"A formal statistical evaluation of the role of trophic status on Hg in waters, sediments, and biota indicated that: 1) epilimnetic HgT and meHg was elevated in both eutrophic and dystrophic lakes; 2) yellow perch fillet HgT are greatest in dystrophic lakes, and lowest in eutrophic lakes; and, 3) in general, dystrophic lakes can be expected to have HgT fillet concentrations that are 0.218 $\mu g\ g^{-1}$ w.w. greater than in all other lake types. These findings support the hypothesis that mercury is biodiluted in lakes with significant algal production.

"Mean log-bioconcentration factors range from a low of 4.37 for concentration from hypolimnetic HgT to yellow perch fillets, to a high of 6.94 from epilimnetic meHg to loon blood. The bioconcentration factors calculated from this studies' data re consistent with those published elsewhere in the literature.

"Numerous water chemistry parameters show significant ($p<0.05$) correlations to a variety of mercury measurements, in both waters and sediments. Data reduction techniques such as principal components analysis are useful to reduce the variability in the dataset, and show how covariance among parameters influences mercury in the study lakes. Such an analysis showed that while HgT and meHg concentrations are higher both in more acidic lakes and more eutrophic lakes, tissue HgT only becomes enhanced in lakes of increased acidity. Sediment HgT increases with increasing lake acidity, and decreases with increasing productivity. This is either the result of bloom dilution and subsequent accumulation to the broad trophic webs characteristic of eutrophic lakes, or related to the reduced ability of algal-derived DOC to bind mercury relative to the higher molecular-weight allocthonous DOC characteristic of acidic lake watersheds.

"Land use characteristics also influence Hg in the present study lakes. As is characteristic of numerous studies, meHg and tissue HgT is elevated in lakes with larger forested and wetland areas. Age-adjusted perch fillet mean HgT is reduced in developed watersheds. Sediment HgT decreases with increasing agricultural area and increased watershed building count."

Of specific interest from a fish consumption use assessment standpoint are the following statistical modeling results describing the likelihood that fish tissues of all Vermont-New

Hampshire lakes, and of any individual Vermont or New Hampshire lake, would exceed the 2001 USEPA §304(a) water quality criterion of 0.3 $\mu g\ g^{-1}$ methylmercury in fish tissue:

"Statistical models were developed to predict whether a lake would attain or violate the 0.3 $\mu g\ g^{-1}$ w.w fish tissue meHg criterion, with only a 13% likelihood of misclassifying an individual lake. Application of this model to lakes across the Vermont-New Hampshire region indicated that 40.2% of lakes would violate the criterion (54% in NH, 25% in VT). Evaluation of model performance using the independently derived Maine REMAP dataset produced mixed results, which were poor when performance was evaluated using Maine yellow perch data, but better when Maine smallmouth and largemouth bass data were used. This can be explained by several factors, and does not indicate that the model is overly flawed for use in the Vermont-New Hampshire region. Overall, the statistical models capture those factors which the present study indicates are important in estimating whether lakes will have fish tissues in excess of the EPA criterion. Lacking a more detailed, mechanistic model, the statistical model can be used to select lakes outside of the REMAP study set for future sampling, both to verify model performance, and to refine fish tissue advisories."

E) Wetlands Assessment (Statewide)

Background

Vermont wetlands are significant resources that contribute to the economic, cultural, and physical well being of its residents. Wetlands provide numerous ecological functions and social values, including habitat for fish and wildlife, recreational and educational opportunities, habitat for threatened and endangered species, temporary storage of flood waters, and they aid in the maintenance of water supply and quality. However, these resources have been significantly affected by human land and water use activities.

The primary function of the Vermont Wetlands Program within DEC is to administer the Vermont Wetland Rules, which regulate most palustrine wetlands that have been mapped on the Vermont Significant Wetland Inventory maps, and therefore have a higher level of protection than unmapped wetlands. The Wetlands Program also provides comment on Act 250 applications that involve wetland issues and conducts pre-Act 250 determinations to assist potential developers in meeting the requirements of the Act. Wetlands Program staff provide comment and advice to other state agencies and they are called upon as wetland experts wherever testimony is deemed appropriate. DEC reviews projects that involve wetland filling under Section 401 of the Clean Water Act based on compliance with the Vermont Water Quality Standards and other applicable provisions of State law. On January 23, 1996, the Vermont Water Quality Standards included the statement that the Standards shall apply to "all waters of the United States," as defined in 40 C.F.R. §122.2 (1995). This wording, therefore, includes wetlands as being part of "all water..." with respect to having met the goals of the Water Quality Standards.

Extent of Wetland Resources

The Vermont Agency of Natural Resources digitized all the National Wetland Inventory (NWI) maps for the state. For Vermont, a total of 232,000 acres of palustrine wetlands are depicted on the maps. These wetland areas are considered significant and are designated as Class Two wetlands under the Vermont Wetland Rules. Wetland inventories conducted in selected towns around Vermont indicate there are considerably more acres of wetland than identified by the

NWI project. A comparison of NRCS mapped hydric soils versus Class Two wetlands in the Lamoille River Watershed found that hydric soils covered approximately 3% more of the landscape than VSWI mapped wetlands, bringing total coverage of total wetland acreage in the watershed to 7%. The wetlands that do not appear on the NWI maps are considered Class Three by the Vermont Wetland Rules. Extrapolating the soil information in the Lamoille Watershed to the rest of the state indicates there may be approximately 90,000 acres of Class Three wetlands in Vermont. Class One wetlands are considered exceptional or irreplaceable in their contribution of Vermont's natural heritage and are therefore are afforded the highest level of protection under the Vermont Wetland Rules. In order for a wetland to be given Class One status, it must be petitioned for reclassification through the Water Resources Board. Four wetland complexes, totaling 2,138 acres, have been evaluated and given the status of Class One since 1990. Dorset Marsh in Dorset is a 200 acre wetland complex that was successfully petitioned to Class One by the Dorset Citizens for Responsible Growth in 1991, and was also given a 100 foot buffer zone. The North Shore Wetland in Burlington is a 15 acre wetland complex on Lake Champlain that was petitioned by the Vermont Natural Resources Council (VNRC) and given Class One status and a 300 foot buffer zone in 2000. Tinmouth Channel in Tinmouth was reclassified to Class One in 2001. This 1,473 acre wetland complex was petitioned by VNRC, and in addition to Class One status, now contains a buffer zone that is 300 feet on the North End, and 100 feet on the southern end. The Lake Bomoseen Wetland was successfully petitioned to Class One by VNRC in 2003. This 450 acre wetland complex in Hubbarton was given a 100 foot buffer in most places, but retained a 50-foot buffer zone in one heavily developed area.

Wetland Loss

A recent analysis of all completed projects reviewed by DEC shows that there has been a total of 330 acres of documented wetland loss and 491 acres of documented wetland impairment over the period between 1990 and 2002 (see Table 4.E.1 below). The analysis was based on the Wetland Program's database that tracks wetland losses associated with projects reviewed by the program. Only Class 3 wetlands under review for 401 Water Quality Certification, Act 250 or voluntary review are included in this table.

These figures do not represent all wetland impacts as they are based only on summaries of projects that have been completed for each year. There is a certain lag phase between when a project is started and completed. The year in the table listed above represents the year a project was started, but not necessarily completed. It is likely that many of the projects which have not been completed are larger projects and may represent substantial areas of wetland impacts. Also, it is clear there are many wetland alterations still occurring that are not reported to DEC and are not included in this database.

Table 4.E.1. Acres of Wetland Loss & Impairment 1990 through 2002.[8]

	'90	'91	'92	'93	'94	'95	'96	'97	'98	'99	'00	'01	'02
# of Completed Projects	474	483	559	455	394	379	324	371	362	340	374	398	389
Acres of Wetland Loss													
Class One & Two Wetlands	21.6	18.6	14.3	26.3	9.0	20.4	7.6	7.3	3.8	6.7	11.8	7.8	2.2
Class Three Wetlands	27.0	15.0	12.8	19.0	16.8	32.0	13.0	7.8	2.7	6.0	12.9	4.3	3.2
Acres of Wetland Impair.													
Class One & Two Wetlands	115.5	45.4	114.5	26.7	30.3	25.8	13.3	4.2	3.0	17.8	21.1	6.5	8.0
Class Three Wetlands	6.3	12.9	16.4	6.5	19.7	3.8	9.0	1.6	0	0.5	7.6	2.3	8.0

The database analysis also shows that there were over 588 acres of wetlands saved during the 1990-2002 period. This was achieved by encouraging developers to move their projects out of wetlands or to reconfigure them so as to have little or no impact on wetlands.

Wetlands Protection Mechanisms

On October 15, 1997, the State of Vermont and the US Army Corps of Engineers issued the State General Permit for projects in waters of the United States that occur in Vermont. Under this program, any fill under 3,000 square feet (except in Class Two wetlands, or special wetlands, or wetlands adjacent to international bodies of water, or in the towns of Athens, Brookline, Grafton, Newfane, Putney, Rockingham, or Townshend) do not have to report their fill activity to either the Corps of Engineers or the State of Vermont. Fills between 3,000 square feet and 43,560 square feet (between 0.068 and 1 acre) are reviewed by an interdisciplinary team. The Vermont Water Quality Standards are the basis for review of projects under Section 401 Water Quality Certification. The Vermont Water Quality Standards do not specifically address wetlands. The Standards address discharges to open water and impacts to surface water which are used by the Wetlands program to evaluate wetland impacts. DEC works closely with the US Army Corps of Engineer's Vermont Field Office staff on many projects.

A Conditional Use Determination (CUD) is used to allow reasonable development in and around Class One and Two wetlands while protecting the functions and values of this natural resource. CUDs are issued by the Vermont Wetlands Program only when it is determined that undue adverse impacts will not result from a proposed project.

Geographically, Chittenden County is the area of the state with the highest acreage of wetland alteration (refer to Figure 4.E.1). Chittenden County remains the area of the state with the largest number of Department site visits and the largest area of wetland loss.

[8] Figures are based on the projects that have been completed. (Source: Wetlands Office Database).

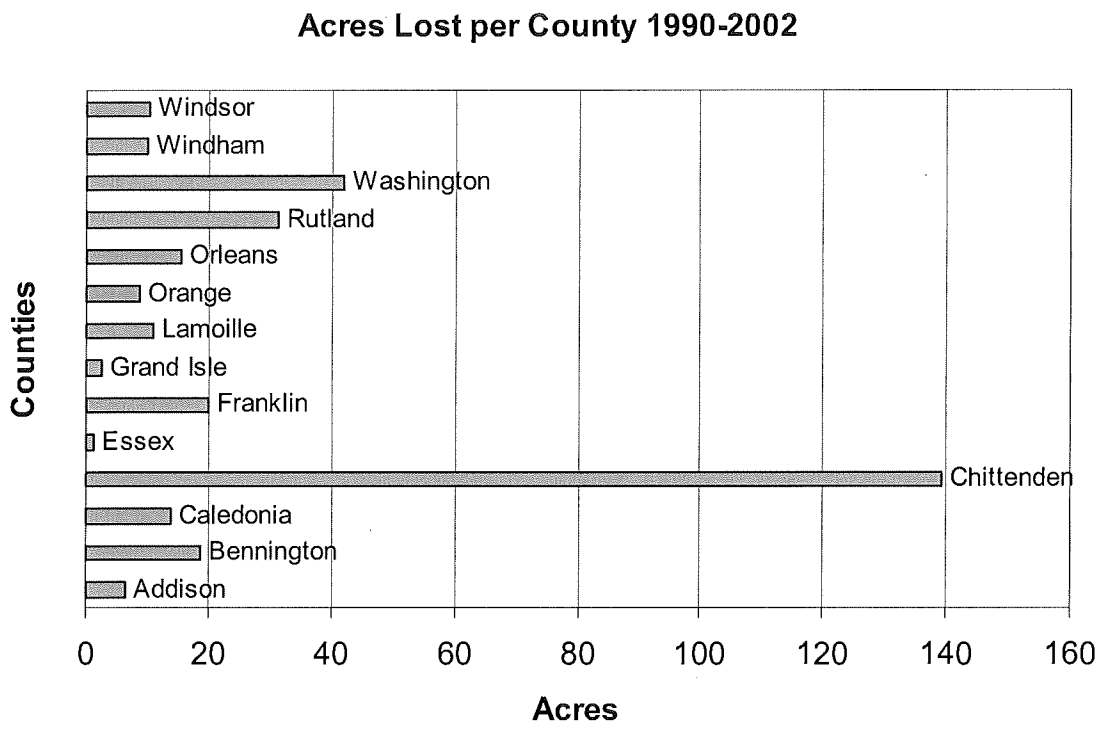


Figure 4.E.1. Wetland loss (in acres) by county 1990 – 2002.

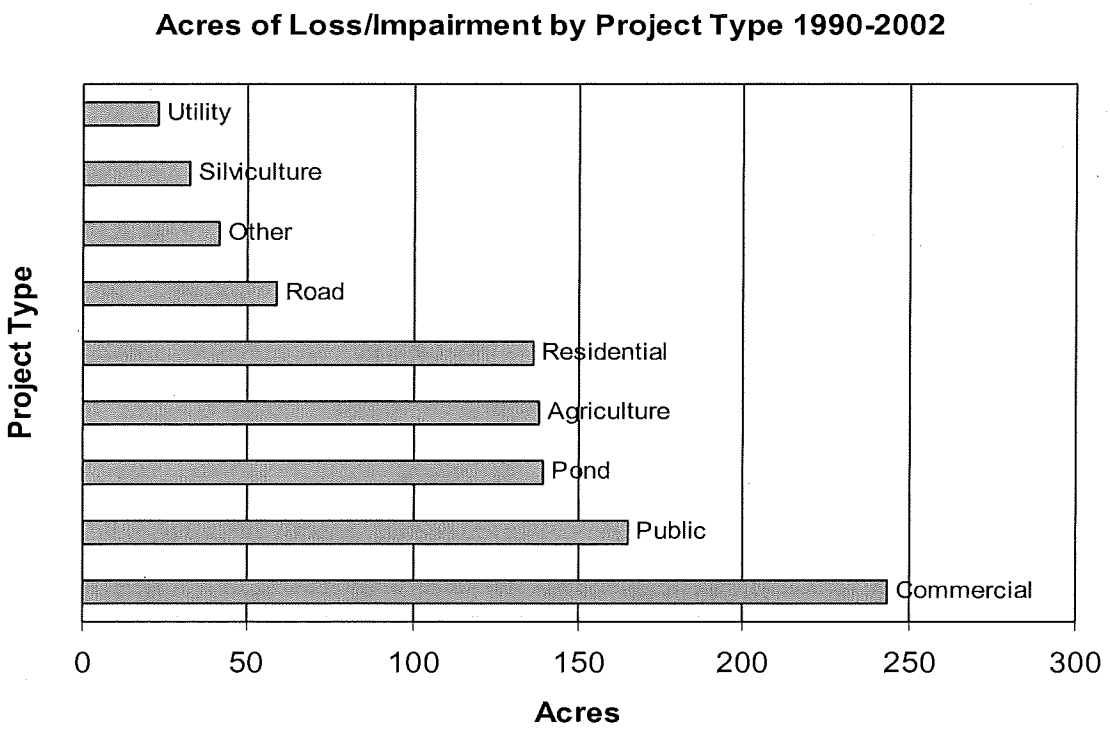


Figure 4.E.2 Wetland loss & impairment by project type (1990 – 2002).

For projects completed during the 1990-2002 period, DEC's database shows that of the project types, public projects (165 acres) and commercial/industrial development (243 acres) resulted in the greatest area of wetland loss and impairment (refer to Figure 4.E.2 above). Residential, agricultural, and pond related projects all resulted in 136 to 139 acres of wetland impact and impairment. Commercial/industrial development, residential development and road construction generally result in mostly wetland loss with small areas of wetland impairment.

Figure 4.E.3 below shows the area of wetland loss and impairment over the period from 1990 to 2002 based on the functions identified to be present in each altered wetland. A particular wetland, where an alteration occurred, may provide one or many of the ten functions and values listed, the documented area of alteration for that wetland is included in the totals for each function and value provided by that wetland. The surface water quality protection and wildlife habitat functions were the most frequently occurring functions in altered wetlands.

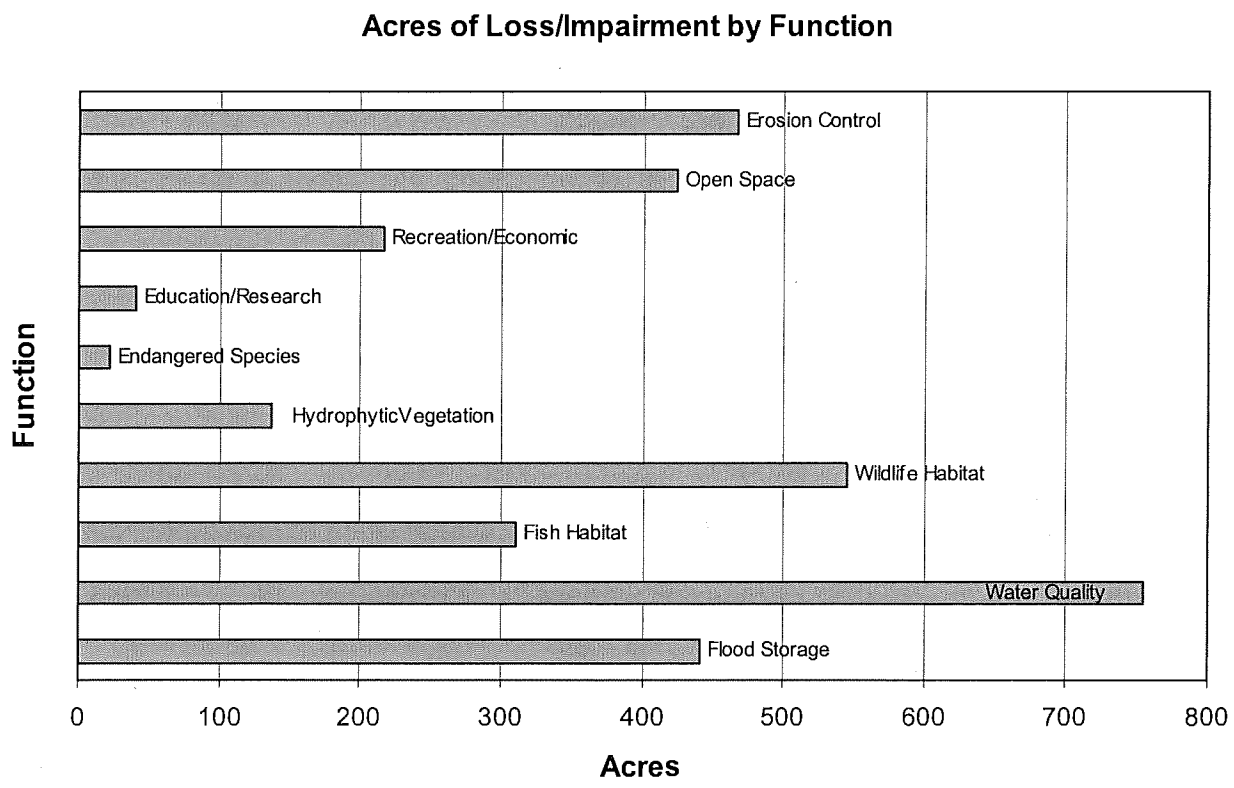


Figure 4.E.3 Wetland loss in relation to wetland function (1990 – 2002).

Table 4.E.4 below, shows the percentage of projects reviewed by the Vermont Wetlands Program by wetland type. As shrub swamps are the most common wetland type, this type has the highest percentage of reviewed project. Emergent marsh and forested wetlands have the next highest percentage of projects.

Table 4.E.4. Percentage of Projects by NWI Wetland Type.

NWI Wetland Type	Wetland Type Description	Percentage of Projects
PEM	Palustrine – emergent	16.3
PFO/PEM	Palustrine - forested/emergent	1.1
PFO/PSS	Palustrine - forested/scrub-shrub	7.7
PFO1	Palustrine - forested (broad leaved deciduous)	16.6
PFO2	Palustrine - forested (needle leaved deciduous)	0.5
PFO4	Palustrine - forested (needle leaved evergreen)	4.2
PFO5	Palustrine - forested (dead)	0.5
POW	Palustrine - open water	13.5
POW/PEM	Palustrine - open water/emergent	1.2
POW/PFO	Palustrine - open water/forested	0.4
POW/PSS	Palustrine - open water/scrub-shrub	0.5
PSS/PEM	Palustrine - scrub-shrub/emergent	18.1
PSS1	Palustrine - scrub-shrub (broad leaved deciduous)	19.1
PSS3	Palustrine - scrub-shrub (broad leaved evergreen)	0.5

In 1998, DEC began carrying out a wetland biomonitoring pilot project, a collaborative effort ion with the Vermont Fish and Wildlife Nongame and Natural Heritage Program. The focus of the project was to determine biological indicators of the ecological health of vernal pools and northern white cedar swamps. The initial task was to describe the reference condition for both wetland types and to examine a subset of disturbed sites. The assemblages that were studied included macroinvertebrates, amphibians, and algae for vernal pools and birds and plants for cedar swamps. The project also included study of the 150 meters (492 feet) around vernal pools to characterize the surrounding upland.

Data for the biomonitoring project was collected over two field seasons (1999 and 2000). After data analysis, a report was completed in June 2003. The project demonstrated methods that can be successfully employed for future wetland monitoring, but failed to detect indicators or metrics that could be used to assess wetland health. There was a great deal of variability in the vernal pools from year to year and season to season, both within pools and among pools, that may have

masked any significant relationships between vernal pool disturbance and potential metrics. The northern white cedar swamps appear to be robust wetlands that are not suitable for traditional bioassessment methods used for aquatic systems. However, the Nature Conservancy's method of community characterization is more suitable for this and other forested wetlands. Future work will focus on integrating wetland monitoring with on-going stream and lake bioassessments.

The Wetlands Office has again sponsored work on bio-control of purple loosestrife *(Lythrum salicaria)*, a non-native invasive plant species. The goal of the program is to reduce purple loosestrife in Vermont by ninety percent. To accomplish this goal, the program's work has been divided into three main aspects: biological control, documentation of purple loosestrife populations, and education and outreach. Since 1996, approximately 318,979 beetles have been released at 127 sites throughout Vermont for biological control purposes. In 2003, approximately 72,203 beetles were released on 178.25 acres of purple loosestrife infested land. An ongoing monitoring program was also initiated and has enlisted the help of the Vermont Agency of Transportation. Through education and outreach, the program strives to help prevent the intentional spread of purple loosestrife by informing the community of the consequences of this invasive species.

The Vermont Wetlands Program has actively participated in voluntary wetland restoration efforts with NRCS, EPA, the Army Corps of Engineers, Ducks Unlimited, Vermont Fish and Wildlife Department, and the Vermont Waterfowl Stamp Advisory Committee. Past projects have been located along Otter Creek, in Whiting Swamp, West Rutland Marsh, and along Lower Otter Creek. Several meetings were held to determine the restoration and management plan for the 356 acre Pomainville Farm located in Pittsford. Ground work will start in the spring of 2004 and restoration efforts will be monitored by the Wetlands Program. The Zelazny site (located directly across Otter Creek from the Pomainville site) will offer an opportunity to restore an additional 69 acres of previously drained wetlands. This will be accomplished through various partners and USDA's Wetland Reserve Program.

Education is an important approach in dealing with issues related to beaver populations in Vermont. In 2001, the Vermont Wetlands Program developed an Educational Plan with the Water Resources Board. In 2002, DEC in conjunction with the Vermont Department of Fish and Wildlife published *Best Management Practices for Resolving Human-Beaver Conflicts in Vermont*. Also in 2002 and in collaboration with the Natural Resources Conservation Service, EPA and the Army Corps of Engineers, the Vermont Wetlands Program undertook an outreach program specifically targeting Vermont's agricultural community. In 2003, the Vermont Wetlands Program held a training workshop for environmental consultants who work on wetlands in Vermont.

PART FIVE: PUBLIC HEALTH RELATED ASSESSMENTS

Size of Water Affected by Toxicants

With the exception of fish consumption advisories described in Appendix D, there are no waterbodies where toxicants are known to be impairing uses related to public health. Nonetheless, NPDES monitoring and water supply monitoring continue to provide data and other information related to environmental occurrences of toxicants in permitted municipal and industrial discharges and public water supplies, respectively.

Fish Consumption Monitoring

During the reporting period, approximately 150 individual fishes were acquired from Lake Champlain waters for the purpose of revising fish consumption advisories. Samples composited from these fishes are presently undergoing analysis in the DEC LaRosa Laboratory located in Waterbury. DEC is interested in testing a subset of fishes for polybrominated diphenyl ether flame retardants and has approached EPA for potential assistance in this regard. In addition, DEC scientists have provided testimony to Vermont legislative committees regarding formalization of fish tissue monitoring approaches. Ideally, a modified tissue monitoring program for all Vermont waters would incorporate new scientific findings from New England and elsewhere and identify waters where the public can have greater confidence over consumption of freshwater fishes with lesser risk of ingesting mercury.

Mercury Monitoring

The following text summarizes monitoring and analytical activities related to mercury contamination in Vermont during the 2004 305b reporting period (1/1/02 to 12/31/03). Some of these items are not specifically from Vermont, but all bear on Vermont's future approach to dealing with the mercury problem. The reader is also directed to Part 4.D.5 appearing earlier in this report for information regarding a probabilistic survey of mercury contamination.

Underhill Mercury Monitoring Station
Through the efforts of EPA, the University of Vermont, the Vermont Monitoring Cooperative, and Vermont's senatorial delegation, funding appears stable for an additional five years of atmospheric mercury monitoring at Underhill, Vermont. This world-class monitoring station is the longest running mercury monitoring site in the world.

Vermont Mercury Emissions Inventory
DEC has recently completed revisions to the statewide mercury emissions inventory. Vermont's emissions are the lowest of all New England states.

Lake Champlain
St. Lawrence University is continuing to refine its model of mercury accumulation in Lake Champlain. This model will be useful to determine the influence of changes in atmospheric deposition rates and wastewater discharges on the concentrations of mercury in the lake's waters. This is a joint project between St. Lawrence University, USGS and DEC.

United States Geological Survey (USGS)
The USGS continues to actively monitor mercury in selected Vermont watersheds. The newest research findings indicate that upland areas of small streams may be important areas for the methylation (toxification) of mercury. This is a new finding which may bear national relevance. For 2004, USGS will place more of its mercury monitoring emphasis on Lake Champlain.

Vermont Institute of Natural Sciences (VINS)
VINS is presently making measurements of mercury in the blood of the threatened Bicknell's thrush, an insectivorous neo-tropical bird of high elevation mountainous forests. Results of this work suggest that mercury in these birds is elevated in some sites and that the birds acquire additional mercury burdens as they age. This indicates that the mercury problem is not limited to aquatic environments. The purpose of this work is to establish an upland biological indicator of mercury contamination.

Southeast New Hampshire Mercury Hotspot
Southeast New Hampshire is a known mercury hotspot. The region is surrounded by several municipal waste combustors and coal-burning power plants. Recent monitoring of fish and loon tissues in this region indicate that fishes and loons there are among the Nation's most contaminated by mercury. Routine annual measurements of mercury in loons have, however, shown a decline in contamination, coincident with the mercury reductions from municipal and medical waste combustion. The levels of contamination in this area are still too high, and controls on the nearby coal-fired plants in New Hampshire and Massachusetts will be necessary to restore this area.

Paleolimnological studies
New data available from lakes in and near southern Vermont indicate that: 1) the declines in mercury delivered to sediments appear to hold in this geographically focused study area; 2) accumulation in these lakes may be as much as four times that of the VT-NH lakes previously sampled and reported in Vermont; 3) a core from a reservoir near Albany shows world-class mercury contamination. The source of the enhanced mercury delivery to southern Vermont and of the elevated concentrations in sediments near Albany may be attributable to the presence of a mercury recycling facility in the Albany, New York area called MARECO. New sediment core results are also available from three Lake Champlain segments. These cores indicate that while the source of mercury to Lake Champlain is largely atmospheric, this mercury is highly processed by the lakes large watershed. Land disturbance events are well reflected by "spikes" in mercury accumulation to lake sediments in all three segments tested.

EPA Fish Tissue Criterion
In 2001, EPA promulgated a new fish tissue criterion under Section 304a of the Clean Water Act. States are required by this section of the Act to either adopt the EPA recommended criteria, or to propose criteria that are more stringent, to be adopted into the state's Water Quality Standards. Vermont has not yet adopted a specific criterion for mercury.

Wildlife Criterion Value for Mercury
The State of Maine is actively developing a wildlife criterion value (WCV) to protect wildlife from mercury they consume through the food web. A WCV is essentially a water-column

mercury concentration above which fish are expected to bioaccumulate mercury to levels above those considered safe for humans and wildlife that consume the fish. Maine's WCV, to be formally promulgated in March 2004, is expected to be approximately one-tenth Vermont's current most conservative criterion. Vermont should keep apprised of the work being done in Maine, as it may provide a suitable and simple approach to managing mercury in Vermont waters.

Analytical Capacity
The DEC LaRosa Laboratory located in Waterbury now has the ability to perform relatively low-level mercury analyses in waters. The current method detection limit for mercury is approximately 5 parts per trillion.

Cyanobacteria

During the summer of 2003, the University of Vermont, in collaboration with DEC and others, implemented a "Tiered Sampling and Analytical" monitoring program for assessing the occurrence of potentially toxic cyanobacteria and associated toxins at selected locations in Lake Champlain. Results of weekly sampling were distributed immediately to stakeholders, including health agencies in New York, Vermont and Quebec. The intent of the program was to coordinate data gathering efforts and to provide real time information that would be useful in formulating management response to occurrences of potential toxic cyanobacteria blooms. Monitoring and data updates continued through September along with the decline of significant concentrations of cyanobacteria in the Lake. In late August, microcystin levels at several locations on Mississquoi Bay exceeded 1 ug/l, resulting in the release of health alert notices suggesting that activities be restricted in those areas where cyanobacteria blooms are intense. By mid-September, microcystin levels had fallen to less than 1 ug/l. The monitoring and communication network was successful in generating and distributing relevant cyanobacterial information in an efficient and timely manner, allowing for appropriate management responses. Planning for 2004 activities is in progress. In addition, researchers at the University of Vermont with funding from their Water Resources Research Center, are investigating the use of satellite images for providing real time information on the status of cyanobacterial populations in Vermont surface waters. This investigation is ongoing.

Small Community Untreated Waste Discharges

Several small communities throughout the state have been discharging untreated wastes to waters of the state due to lack of treatment facilities. The discharges from these areas constitute threats to public health. The villages of Shoreham and Cabot have completed the construction of their wastewater treatment facilities and both surface discharging facilities are now fully operational. The villages of East St. Johnsbury, Pownal and Warren have completed their planning and design work for pollution abatement facilities during this reporting period. Warren Village began construction of its indirect discharge project in 2003 and will complete it in 2004. The villages of East St. Johnsbury and Pownal will begin construction of their indirect and surface discharging systems, respectively, in 2004.

DEC is providing direct funding and technical assistance to several other communities to help them evaluate and plan for their wastewater needs. It is anticipated there will be a steady demand by several small communities for wastewater evaluations and planning in the coming years. These communities have not been identified in the past as being the sources of surface water pollution, but residents are now realizing that they may have problems with their small lot and older on-site sewage systems. Part of the impetus for this interest appears to be a change in state law which will require designs and permits for all failed septic system repairs beginning in 2007. Currently, repairs at single family houses require no permitting or compliance with design standards.

Sites of Known Sediment Contamination

The remediation of contaminated sediments at the Lake Memphremagog-South Bay railyard site in Newport, Vermont is complete.

Risk assessment activities are being conducted by EPA in regard to elevated contaminant levels found in sediments in and around the confluence of the Ompompanoosuc River with the Connecticut River. Contaminants are thought to be related to historical mining activities (but no longer occurring) at certain locations within the Ompompanoosuc watershed. The Elizabeth Mine site in Strafford is undergoing remediation.

Sediment testing in the Hoosic River has found PCB concentrations up to 0.041 mg/kg. The sediments tested are in the vicinity of the former Pownal tannery. Sediment sampling on the Hoosic River upstream in Massachusetts also found PCBs as well as a number of metals.

Hewitt Brook and Pond B at the old Bennington landfill site were analyzed for metals and PCBs. Twenty sediment samples were taken. Five metals were found at concentrations above the Low Effects Level (LEL). Arsenic was found at three sample locations above the Severe Effects Level (SEL). PCB concentrations were above the LEL in 14 of the 20 sediment samples. Monitoring is continuing at this site.

A number of compounds have been found in the sediments of Stevens Brook in St. Albans. Near the former St. Albans Gas & Light Property, one volatile organic compound, eight semi-volatile organic compounds, and four inorganics (cadmium, cyanide, barium, and zinc) were found in the sediments at three times or more the reference value.

Arsenic has been found in the sediments of Jewell Brook, a tributary to the upper Black River in Ludlow. Further investigation of the Jewell Brook Mill site is being conducted by DEC and others.

Restrictions on Bathing Areas During 2004 Reporting Period

Lake Champlain

Bayside Beach (Colchester) was closed on several occasions during the reporting period due to the presence of indicator bacteria in excess of Vermont's standard of 77 *E. coli* / 100ml. In the Burlington area, two beaches were closed once during the reporting period (Leddy and Oakledge beaches), and one beach (North Beach) was closed twice.

The beaches at Grand Isle and at Knight Point Vermont State Parks were both closed on two separate occasions during the reporting period.

These six Lake Champlain beaches noted above were re-opened for bathing after closure when follow up monitoring revealed safe levels of indicator bacteria.

Blanchard Beach (Burlington) continues to remain closed to swimming.

Inland Lakes
The following five inland lake beaches, located at the respective Vermont State Park, were closed on one or more occasions during the reporting period:

Lake Bomoseen:	1 closure	Lake Carmi:	5 closures
Crystal Lake:	2 closures	Lake Elmore:	3 closures
Shaftsbury Lake:	2 closures		

Each one of these beaches re-opened for bathing after closure when follow up monitoring revealed safe levels of indicator bacteria.

The following 3 inland reservoir beaches, located at facilities owned and operated by the US Army Corps of Engineers, were reported as closed for swimming (expressed as estimated number of days) during the reporting period:

Facility Name	10/1/02-9/30/03	10/1/01-9/30/02
Ball Mountain Lake	8	0
Townsend Lake	4	0
Union Village Dam	30	37

With the exception of one facility, each Army Corps beach was re-opened after closure when follow up monitoring revealed safe levels of indicator bacteria. At Union Village Dam, when a sample collected after Labor Day 2003 also exceeded standards, the beach there was closed for the remainder of the bathing season.

Restrictions on Surface Drinking Water Supplies During 2004 Reporting Period

There are two restrictions to report. The first is a standing boil water notice issued for users of the Allen Point water treatment supply system that draws its water from Malletts Bay of Lake Champlain. The second restriction is a standing boil water notice affecting several homes that are connected to the Montpelier City Water Treatment distribution system but are located upstream of the water treatment facility, effectively drawing untreated water as it is piped to the treatment facility. This water is drawn from Berlin Pond in Berlin, Vermont.

Chronic or Recurring Fish Kills

There were no known chronic or recurring fish kills in Vermont during the reporting period, save the commonly observed, natural mortality associated with post-spawning stress. Such fish mortality often occurs on lakes and ponds in Vermont during late spring and early summer. The Vermont Department of Fish and Wildlife maintains a fish pathology laboratory which responds to reports of fish kills.

During the reporting period, however, there were three fish kills documented by the fish pathology laboratory that were more than incidental magnitude and exceeded typical mortality associated with post-spawning stress. These three fish kills and details are as follows:

1) Lake Champlain-Inland Sea. June through July 2002. Moderate mortality was observed, largely on small yellow perch. This fish kill occurred during a period of maximum thermal change in the lake during a very hot spell in the beginning of the summer. According to the fish pathology laboratory, mortality was attributed to a combination of spawning stress, potential low dissolved oxygen, water temperature changes and secondary bacterial infection by the organism *Columnaris sp.* (Note: monitoring data from one Lake Champlain-Inland Sea monitoring station does not support dissolved oxygen as a cause of the mortality).

2) Dead Creek in Addison-Panton. July 2002. Low mortality was observed, mostly to carp. The fish pathology laboratory attributed this mortality to low dissolved oxygen in this vast wetland system and to post-spawning stress.

3) Gunner Brook in Barre. October 4, 2002. An illegal discharge of ammonia caused a high mortality event affecting many fish species. This event is currently under investigation by the Enforcement Division of the Vermont Agency of Natural Resources.

PART SIX: SUMMARY OF IMPAIRED WATERS

Total Maximum Daily Load (TMDL) Program

Under Section 303d of the Clean Water Act, all states are required to develop lists of impaired surface waters. These impaired waters are lakes, ponds, rivers and streams that do not meet the water quality standards developed by each individual state. In Vermont, these waters are described on the state's Part A 303d List of Impaired Waters in Need of a TMDL. The Clean Water Act requires that a Total Maximum Daily Load (TMDL) be developed for impaired waters on Part A of the list and the list provides a schedule as to when TMDLs will be completed.

A TMDL is the calculation of the maximum amount of a pollutant that a waterbody can receive and still meet the water quality standards. A TMDL serves as a plan that identifies the pollutant reductions a waterbody needs to meet Vermont's Water Quality Standards and develops a means to implement those reductions. TMDL determinations are unique to each individual waterbody but the general process by which they are developed can be summarized in the following manner:

Problem Identification - the pollutant for which the TMDL is developed must first be identified. Examples might include sediment that impacts habitat for aquatic organisms, nutrients that cause excessive algal growth, or bacteria that creates an unsafe environment for swimming.

Identification of Target Values - this establishes water quality goals for the TMDL. These may be given directly in the Water Quality Standards or may need to be interpreted.

Source Assessment - all significant sources of the pollutant in question must be identified in the watershed. This often requires additional water quality monitoring.

Linkage Between Targets and Sources - this process establishes how much pollutant loading can occur while still meeting the water quality standards. This step can vary in complexity from simple calculations to development of complex watershed models.

Allocations - once the maximum pollutant loading is established, the needed reductions must be divided among the various sources. This is done for both point sources and nonpoint sources.

Public Participation - stakeholder involvement is critical for the successful outcome of TMDLs. Draft TMDLs are also released for public comment prior to their completion.

EPA Approval - EPA approval is needed for all TMDLs as required by the Clean Water Act.

Follow-up Monitoring - additional monitoring may be needed to ensure the TMDL is effective in restoring the waters.

Table 6.1 on the following page is provided as a summary update of overall TMDL progress and an expression of future TMDL direction for Vermont. Immediately after Table 6.1 is a brief summary of two significant developments regarding approved TMDLs that occurred during the 2004 305b reporting period.

Table 6.1. Update on Vermont TMDL Projects.

Segment	Pollutant & Waterbody ID number	Project Status	Projected TMDL Submittal
Acid Impaired Waterbodies	pH 30 ponds	TMDLs complete. 7 acid impaired ponds remain for TMDL development pending data collection	EPA Approved (9/03)
Lake Champlain	Phosphorus 9 segments	TMDL Complete	EPA Approved (11/02)
Styles Brook (Stratton)	Sediment 11-15	TMDL Complete	EPA Approved (6/02)
Trib #1, N. Branch Ball Mtn. Brook (Stratton)	Sediment 11-15	TMDL Complete	EPA Approved (6/02)
Black River (Ludlow)	Phosphorus 10-14	TMDL Complete	EPA Approved (5/01)
Winooski River (Cabot)	Pathogens 08-09	TMDL Complete	EPA Approved (3/01)
Stormwater Impaired Waters	Approx. 20 segments	Developing TMDL protocols based on setting hydrological targets vs. relying solely on pollutant loading targets	Initial submittals expected during 2004

Lake Champlain Phosphorus TMDL

The Lake Champlain Phosphorus TMDL, developed by DEC, was approved by EPA Region 1 on November 4, 2002. This document sets forth the phosphorus allocations for Vermont (and for New York) in order to meet the numeric water quality criteria. Allocations were made to both point sources (includes developed land stormwater and treatment facilities) and broad nonpoint source categories (agricultural and forested). The implementation plan associated with the TMDL identifies extensive and specific actions deemed necessary for the achievement of the phosphorus allocations and ultimately the water quality criteria in the lake. Implementation is underway within Vermont on a variety of point source and nonpoint source fronts.

In December 2003, Governor Douglas announced plans to request over $6 million in state funds and over $8 million in federal funding to support his Clean and Clear Water Action Plan to improve statewide water quality in lakes, ponds, rivers and streams. The initiative will also accelerate implementation to clean up polluted areas of Lake Champlain. Nine funding items specific to the Lake Champlain TMDL Clean and Clear effort include:

- Phosphorus removal from certain wastewater treatment plant discharges
- Watershed planning coordinators
- Stream stability in the basin, with emphasis to Missisquoi and St. Albans Bay watersheds

- Sediment and erosion control from unpaved backroads in the basin, with emphasis to Missiquoi and St. Albans Bay watersheds
- Erosion control at construction sites
- Technical assistance for municipal actions
- Wetland protection and restoration
- Monitoring
- Program administration

Acid Lakes TMDL

On September 30, 2003, EPA Region 1 approved a TMDL prepared by DEC that determined annual acid loading limits for 30 of the 37 acid impaired lakes identified on the 2002 303d List. Because the source and type of the problematic loading was similar for all the lakes, a single analytical approach was used to determine each lake's acid loading capacity, or critical load. This approach allowed the packaging of all the lake loading determinations into a single document.

The critical loads establish the necessary levels of acidic deposition to each watershed to allow recovery, however, more needs to be known about distant sources and transport in order to initiate proper controls. The critical loads provide a framework from which to "backtrack" and trace the origin and magnitude of the acidity sources to the atmosphere and their transport to Vermont. Combined with atmospheric transport and deposition modeling, they will provide a basis for evaluating the environmental effectiveness of alternative national or regional emissions control programs, or of quantifying the adverse contributions from specific emission sources if effective national legislation is not forthcoming. They also provide an environmental "benchmark" from which the effects of future changes in emissions and deposition can be quantitatively evaluated.

Overview of the Vermont 2004 Priority Waters List - including Section 303d List of Waters

Development of the 2004 Section 303d List of Impaired Waters is a process that is ongoing and concurrent to the development of the 2004 305b report. Consequently, the final 2004 303d list has not been included in this report. The 2004 303d List of Impaired Waters will be finalized and made available separately. Appendix C describes Vermont's 2004 Listing Methodology.

A brief summary of the Vermont Priority Waters List, which identifies and tracks both impaired and non-impaired waters is given in Table 6.2 below. It should be noted that the Section 303d List of Impaired Waters is only a portion of the overall Vermont Priority Waters List. Much of the Priority Waters List process occurs outside the scope of Section 303d. It is important to be aware of the overall listing process because it is indirectly involved with and directly referred to in the 303d listing process. Table 6.2 below gives an overview of all the sections of the Priority Waters List. Part A, the single component of the 303d List of Impaired Waters, has been highlighted.

Table 6.2. Overview of Vermont Priority Waters List.

Vermont Priority List Section	Description	Included as Part of 303d Listing?
Part A	Impaired Waters in Need of a TMDL	***Yes***
Interim List	Candidate Waters for Section 303d De-listing	Yes, until EPA approval; after approval these waters are removed from 303d; EPA approved 303d list does not include de-listed waters
Part B	Impaired Waters - No TMDL Required or Needed	No
Part C	Surface Waters in Need of Further Assessment	No
Part D	Waters with Completed and EPA Approved TMDL	No
Part E	Surface Waters Altered by Exotic Species	No
Part F	Surface Waters Altered by Flow Regulation	No
Part G	Surface Waters Altered by Physical Channel Changes/Adjustments	No

A summary of the number of waterbody segments listed as impaired on year 2002 listings is given in Table 6.3. The Vermont Year 2002 303d List of Impaired Waters was approved by EPA on July 28, 2003.

Table 6.3. Number of Impaired Segments (from Year 2002 listings).

Impaired Segments	Lakes & Ponds	Streams & Rivers	Total
Listed in Part A – impaired waters needing a TMDL (newly listed waters in 2002 are given in parentheses)	71 (5)	111 (3)	182 (8)
Listed in Part B – impaired waters not needing a TMDL (newly listed waters in 2002 are given in parentheses)	0	11 (3)	11 (3)
Total number of impaired segments	71 (5)	122 (6)	193 (11)

Part Seven: Groundwater Monitoring & Assessment

It is the policy of the state of Vermont to protect its groundwater resources (Chapter 48: Groundwater Protection). To this end, the Secretary of the Vermont Agency of Natural Resources is responsible for the development of a comprehensive groundwater management program and has established a Groundwater Coordinating Committee with representation from the private sector as well as other departments and agencies. The Committee's role is to advise the Secretary regarding the development of the groundwater program and its corresponding implementation. Also, the Secretary shall, after review by the Groundwater Coordinating Committee, adopt rules for the protection of public water source protection areas (Chapter 56: Public Water Supply). The administrative arm of the Committee is the Water Supply Division (WSD) of DEC.

The purpose of the groundwater program is to protect the quality of groundwater through a variety of mechanisms. Such mechanisms include the development of a strategy for the management and protection of the state's groundwater. This strategy is to be integrated with other regulatory programs administered by the Secretary. Continuing studies and investigation of groundwater, identifying and mapping groundwater, and classifying groundwater per technical criteria and standards, are also components of the program. Cooperation with the federal government in the development of groundwater protection programs along with cooperating with other government agencies in collecting and compiling data on the quantity and quality of groundwater and location of aquifers are yet additional aspects of the groundwater program. Finally, the strategy also includes developing public information and education materials along with providing technical assistance to municipalities for the purpose of protecting the groundwater resources.

Groundwater Strategy and Management

During 2003, the WSD and the Groundwater Coordinating Committee (GWCC) focused on revising the Groundwater Rule and Strategy (GWR&S). The GWR&S is required under 10 VSA §1392(d) of the Groundwater Protection statute. This same statute establishes the GWCC in 10 VSA §1392(c). The purpose of the rule and strategy as well as the committee is, in part, to develop and implement a groundwater program. Improvements to the existing groundwater program were thought attainable by revising the GWR&S. Because groundwater quality standards are continuously changing the rule was updated to include these changes. Revisions to the GWR&S include updates to water quality standards that establish groundwater remediation requirements. Protection of groundwater is sought through compliance with the groundwater quality standards. Compliance with these standards can require remediation of groundwater contamination.

Related to the strategy and management of groundwater and during 2002, the state's on-site sewage statute was comprehensively reformed to provide universal jurisdiction over all on-site sewage (i.e. septic) systems. Existing sewage ordinances and bylaws regulating private water supplies and wastewater systems are superceded by the uniform statewide technical standards beginning July 1, 2007. There were several other provisions contained in the legislation, one of which required the Agency of Natural Resources to develop a model groundwater protection ordinance that municipalities may use as part of their municipal planning efforts. The legislation affecting sewage reform is considered a major event in the protection and improvement of Vermont's groundwater quality.

Cooperation and Coordination

Under the provisions of 10 VSA, §1392(c), the GWCC has the responsibility of advising the Secretary on groundwater issues. The Committee consists of representatives of all state agencies whose

programs impact groundwater, plus members of outside organizations interested in groundwater issues. In 2003, the Committee met on a monthly basis and has provided significant coordination with the Waste Management Division (WMD) of DEC regarding the classification of groundwater. In particular, several groundwater areas identified by the WMD as contaminated were subsequently classified as Class IV groundwater areas. This designation defines the groundwater area as non-potable.

State and federal regulations govern drinking water, wastewater, and waste disposal as related to groundwater. The GWCC provides input to these regulations and has focused on a number of recent regulations. Included in this review is the *Groundwater Rule and Strategy.* This rule has been updated to include198 primary groundwater quality standards and14 secondary groundwater quality standards. These standards are listed with Enforcement Standards and Preventative Action Levels in the 2003 revised rule. Other regulations recently revised, with input from the GWCC, include the Environmental Protection Rules, Chapter 1, *Wastewater System and Potable Water Supply Rules*: Chapter 1 and the *Water Supply Rule*: Chapter 21. Updates to Appendix A, Parts 11 and 12, *Small Scale Water Systems* and *Construction & Isolation Standards for Wells,* of Chapter 21 are also being considered.

It is expected that the federal Groundwater Rule is to be promulgated by EPA in the fall 2004. DEC anticipates this rule will require that sanitary surveys be conducted every three years for community water systems and every five years for the remaining systems. The Rule will likely increase state efforts to identify sources of fecal contamination, require source water microbial sampling for non-disinfecting systems, and require the state to conduct hydrogeological sensitivity assessments for non-disinfecting public water systems that are vulnerable to contamination.

Proposed state legislation in 2003 was discussed among GWCC members. The proposed legislation included requiring testing of private water supplies at the time of property sale is being considered and a separate legislation requiring the permitting of certain groundwater withdrawals.

Members of WSD and the Vermont Geological Survey (VGS) provided a report outlining a proposed strategy for mapping Vermont's aquifers. The report, requested by the Legislature, contains information on the current status of groundwater reclassification and groundwater mapping in Vermont along with proposed strategies for mapping the state's aquifers by 2007. The report is provided as Appendix E.

The VGS coordinated with the WSD and the Agency of Agriculture, Food, and Markets regarding the nitrate contamination of groundwater near a farm in East Montpelier. Elevated nitrate has been found in several private residential wells near some of the farm's fields. In April 2003, VGS and WSD submitted a nonpoint source pollution control grant proposal and obtained $30,000 in Clean Water Act Section 319 funding for VGS to continue its work. Plans include using a borehole camera down 10-12 residential wells to look at the well construction and identify fractures, bedding, and water-bearing zones. A subset of wells will be sampled for major and trace element geochemistry, nitrogen and oxygen isotopes, and chlorofluorocarbon dates. A tracer study using fluorescent dyes is also under consideration.

Throughout 2003, experts from DEC and others addressed a variety of GWCC concerns. These concerns included the occurrence of naturally occurring arsenic and radionuclides. The wastewater disposal issue regarding radionulcides at public drinking water system is particularly problematic. MTBE is also of major concern regarding groundwater. In Vermont, about 75,000 private wells near

hazardous waste sites have been sampled for MTBE. More than 250 wells have detections across the state. The GWCC agreed that this topic warrants further investigation. In some cases, depending on the extent of contamination and the hydrogeological setting, a Class IV designation could be appropriate.

The GWCC has examined its own roles and responsibilities and determined that to be an effective committee it must have a stronger relationship with the Secretary of the Agency of Natural Resources. To strengthen its role in protecting groundwater, Vermont must better coordinate groundwater concerns and design an educational strategy.

Groundwater Investigations

Investigations between 2001-2003 were pursued by WSD's Water Resource Management staff. The staff identified approximately 80 public community water systems with simple 3000 foot radius circles for Source Protection Areas (SPAs). WSD staff identified existing data for water systems in an effort to hydrogeologically delineate a corresponding SPA. Data examined often included well completion reports, pump tests or aquifer analysis data, bedrock and surficial geology information, along with orthophoto and topographic maps. In addition, a site visit was conducted at the corresponding water system. With this data in mind, appropriate hydrogeologic calculations and principles were used to provide a hydrogeologically based SPAs for the water systems. A rationale explaining the SPA was also provided. Of the 80 SPAs identified, 9 reports have been completed and another 10 are being drafted. The result of this work has been to optimize data provided by WSD's permitting programs.

The WSD's 30 year old water level monitoring program was discontinued in 1995 due to lack of resources. The program provided water level trends for about twenty wells throughout the State. The WSD has entered into a contract with the US Geological Survey to continue monitoring 12 of the 20 monitoring wells to continue this program.

Information and Public Education

Each of the above SPA delineations includes a public notice. The town, residents or property owners in the SPA, and officials of the water system were contacted. An opportunity for a hearing regarding the SPA was also provided. This process is also provided in the reclassification of groundwater. The outcome of both processes includes the identification of the groundwater resources along with an excellent rapport developed with concerned citizens at the town level. Groundwater planning at the local level can be better afforded through such efforts. It is hoped that such studies will go a long way with respect to educating the public and protecting the resource.

Staff of the WSD met with town officials of Brandon, Vermont regarding their SPA. Brandon officials are considering enhancing the protective measure of the SPA by reclassifying their aquifer as Class II groundwater. They are also considering whether their aquifer would benefit from a Federal Sole Source Aquifer designation. The WSD and EPA Region I have discussed the requirements of this designation and plan to work with the town to explore this designation.

EPA Region I, the Vermont Department of Health and the WSD have collaborated on groundwater support documents, such as *Guide to Water Quality Testing in Private Wells* and *Private Well Brochure for New England Real Estate Agents.* In addition, a groundwater protection handbook for local officials, the *Ounce of Prevention*, is being updated and will include a groundwater model ordinance. The Vermont Department of Health (DOH) continues to provide groundwater related fact sheet to other departments and agencies as well as the public. Websites specific to groundwater in Vermont include those maintained by WSD, VGS, WMD, and DOH. These sites contain information

regarding regulations, groundwater, geology, and provides access to the well completion report data base.

The WSD annually sponsors Drinking Water Day at the Statehouse. The event provides a number of exhibits that explains the importance of drinking water and its protection. Attendance often includes students, the general public, interested parties, and members of the legislature.

The remainder of this chapter is devoted to a summary discussion of significant aspects concerning the status of groundwater in Vermont.

State of Groundwater Quality

The quality of Vermont's groundwater varies due to both natural and human influences. No comprehensive studies have been completed on the quality of the resource. The WSD requires water quality monitoring at public community and non-transient non-community water systems. A map showing the approximate location of the public community and non-transient waters systems[1] in Vermont is provided at the end of this chapter. Below are results of the monitoring as it pertains to water systems on increased monitoring:

> In 2003, 113 groundwater supplied public water systems received boil-water notices mostly due to bacterial contamination. Boil-water requirements were also due to leaks in the distribution system, water system infrastructure deficiencies, lack of water, or other reasons. Of these 113 systems, 28 were Transient Non-community water systems, 28 were Non-transient Non-community water systems, and 59 were Public Community water systems (WSD, 2003).
>
> 5 public water systems are on increased monitoring due to arsenic levels equal to or above the Maximum Contaminant Level (MCL) concentration of 0.010 ppm (WSD, 2003). A map of arsenic detections appears at the end of this chapter.
>
> 9 public water systems are on increased monitoring because either the gross alpha particle radiation was above 10 pCi/l (the gross alpha MCL is 15 pCi/L) or was above the MCL of 5pCi/l for radium (WSD, 2003). A map of gross alpha values is provided at the end of this chapter.
>
> 9 public water systems have nitrate concentrations equal to or above the 5 mg/l limit which triggers increased monitoring. The MCL for nitrate is 10 mg/l (WSD, 2003).
>
> 28 public water systems are required to perform increased monitoring because these systems have had VOC detections over the 5 ug/l limit (WSD, 2003).

Vermont's Agency of Agriculture, Food, and Markets oversees agricultural activities and promotes best management practices with respect to groundwater protection. As part of this effort the Agency found:

> There are 1,294 private agricultural monitoring wells. All of the wells do not necessarily serve farms but all are subject to agricultural land use. Of these 1,294 monitoring wells (863 are farm wells and 431 are neighboring wells), 78 wells (6%) exceed the MCL for nitrate-N of 10 mg/l (Vermont Agency of Agriculture, 2003).

---

[1] A **Public Community System** means a water system which serves at least 15 service connections used by year-round residents or regularly serves at least 25 year-round residents. A **Non-transient System** means a system that regularly serves at least 25 of the same persons daily for more than 6 months per year (e.g. schools, factories, office buildings).

Of the 1,294 agricultural monitoring wells, 55 wells (4.2%) tested positive for herbicides but only one well exceeded the MCL or Health Advisory. (Vermont Agency of Agriculture, 2003).

The Waste Management Division (WMD) of DEC regulates and manages a wide variety of hazardous waste along with the groundwater clean-up that occurs regarding this waste. The WMD reports that:

> There are approximately 1,400 petroleum or hazardous waste sites in Vermont which have degraded or have the potential to degrade groundwater to the point where it is non-potable. There are approximately 1,600 sites where the WMD has addressed the existing potential release of hazardous substances and completed site management (WMD, 2003). A map showing the approximate location of known hazardous waste sites in Vermont appears at the end of this chapter.
>
> There are 2,476 underground storage tanks (UST) in Vermont that could each individually pose a threat to groundwater quality in the event of a leak (WMD, 2003). A map showing the approximate location of known USTs in Vermont is provided at the end of this chapter.

In 2003, the WSD provided the VGS with data regarding the occurrence of radionuclides and arsenic at public water systems. VGS mapped the location of this information and determined the geologic characteristics of corresponding problem areas. As part of this investigation it was determined that:

> Approximately 90% of the state has been mapped for elevated radioactivity, however, areas of elevated radioactivity may or may not correlate to contamination in groundwater (VGS, 2003).

The USGS for New England examined data on arsenic levels for 1,600 public and private water sources. The study focused primarily on the eastern part of the region, which contains the highest population density and where large amounts of groundwater are used for the water supply. Although there are some water supplies with high arsenic levels in western New England, the problem is not as extensive as it is in the eastern part of the region (USGS, 2003). As mentioned, only five water systems in Vermont require increased monitoring due to arsenic.

State of Groundwater Assessment and Use

Public groundwater sources are expected to supply sufficient water quantities. However, other than those regulated as public water sources, groundwater withdrawals are not regulated. Likewise, the significance of groundwater to the ecosystem is not routinely evaluated. Groundwater assessments are driven by the rules mentioned above and by several interested parties such as the USGS. Information from these assessments provides the basis for characterizing groundwater in the State. The following provides some facts regarding groundwater:

> About 50 million gallons of groundwater is withdrawn on a daily basis in Vermont. Withdrawals from public and private groundwater sources account for 33 million gallons per day. Agricultural withdrawal accounts for 2 million gallons daily, another 12 million is used for commercial and industrial purposes, and the remaining groundwater withdrawals are used for mining and the generation of thermoelectric power. (USGS, 1997)
>
> Groundwater is currently used for drinking water by approximately 70% of Vermont's population. About 46% of the population are self supplied while about 24% are served by public water systems using groundwater (USGS, 1997). In 2003, there were 22 new or modified groundwater sources that required a source permit from WSD.
>
> Of the 2,078 active farms within Vermont, 85-90% rely on groundwater for agriculture use (Vermont Agency of Agriculture, 2003).

It is estimated that 320,000 of Vermonters get their drinking water from about 93,500 private wells. This number does not include dug wells or springs. Approximately 2,000 new private wells were drilled and reported to the WSD in 2003.

It is estimated that 80% of the private wells are completed in bedrock and 20% in gravel aquifers. The mean well depth is about 200 feet and the mean yield is about 6 gallons per minute (WSD, 2003).

Groundwater levels in Vermont are measured at 12 monitoring wells located throughout the state. For the year 2003, groundwater levels were normal from 1/03 to 6/03 and above normal from 7/03 to 12/03 (USGS, 2003).

Six public water supplies currently lack sufficient water quantity to meet their water demands. Water shortages have occurred at Jericho Heights (Jericho), Oglewood (Milton), Magic Village (Londonderry), Deep Rock Water FD#8 (Barre Town), Eatons Mobile Home Park (Royalton), and Windy Hill Acres located in Springfield (WSD, 2003).

87% of the public community water systems in the State have their corresponding Source Protection Areas or aquifer recharge areas mapped. The remaining public community water systems are using 3,000 foot radius circles as their Source Protection Areas (WSD, 2003).

Existing aquifer maps include the *Groundwater Favorability Maps* (1966 to 1968) which cover the entire state, the *Geology for Environmental Planning* series (1975) that covers 66% of Vermont and was primarily based on data from the *Surficial Geologic Map of Vermont* (1970) and the *Centennial Geologic Map of Vermont* (1961). In the 1980s, ANR provided aquifer maps to 20 towns for planning purposes while just 2 years ago VGS produced an aquifer map in Arlington. These maps included a depth to groundwater map, a thickness of overburden map, and an aquifer yield maps. (Report on the Status of Groundwater and Aquifer Mapping in the State of Vermont, 2003).

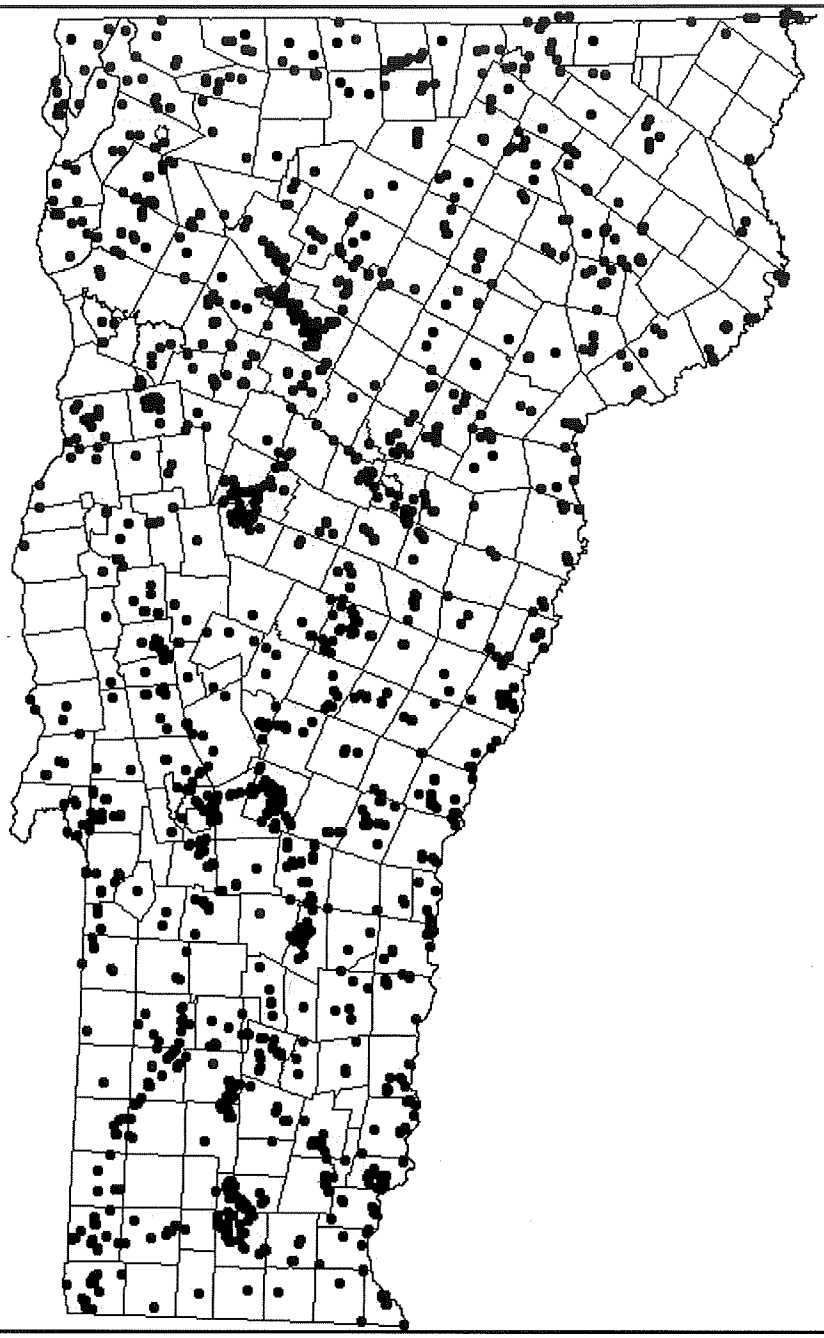
Vermont's groundwater classification systems defines Class I groundwater as suitable for a public water supply with character that is uniformly excellent and is not exposed to any activities that pose a risk to its use. Currently, there are no Class I groundwater areas classified in Vermont.

Vermont's groundwater classification system defines Class II groundwater as suitable for public water supply with character that is uniformly excellent but exposed to activities that may pose a risk to its use. There are no Class II groundwater areas in Vermont although one area is currently being proposed as a Class II groundwater area (Brandon, Vermont).

Vermont's groundwater classification system defines Class IV groundwater as not suitable as a source of potable water but suitable for some agricultural, industrial, and commercial uses. There are 8 areas classified as Class IV groundwater areas in Vermont, including the Burgess Brothers Landfill (Bennington), Parker Landfill (Lyndon), Transitor Electronics (Bennington), UniFirst Sites (Williamstown, Brookfield, and Randolph), Pine Street Barge Canal (Burlington), Maska Inc. (Bradford), Windham Solid Waste District Unlined Landfill (Brattleboro), and the Bennington Landfill located in Bennington.

With the exception of the 8 Class IV groundwater areas, Vermont's remaining groundwater is classified as Class III. Class III groundwater is defined as suitable as a source of water for individual water supply, irrigation, agricultural use, and general industrial and commercial use.

Groundwater is a critical resource for the State of Vermont and continues to be vulnerable to numerous man-made and natural risks. It supplies a significant portion of the drinking water to Vermont's population. While drinking water is a top priority environmental concern in the State, the clear connection between drinking water and groundwater is lacking. Groundwater efforts, however, are most limited regarding its interaction with surface water. Specifically, the contribution groundwater makes to wetlands, streams, rivers, ponds and lakes receives little attention. Its importance to sustaining the drinking water needs of the State along with Vermont's flora and fauna appears to be taken for granted. The lack of attention given to groundwater when compared to the attention given to surface waters may be due, in part, to the lack of public education regarding groundwater and the associated costs required to comprehensively evaluate this resource.



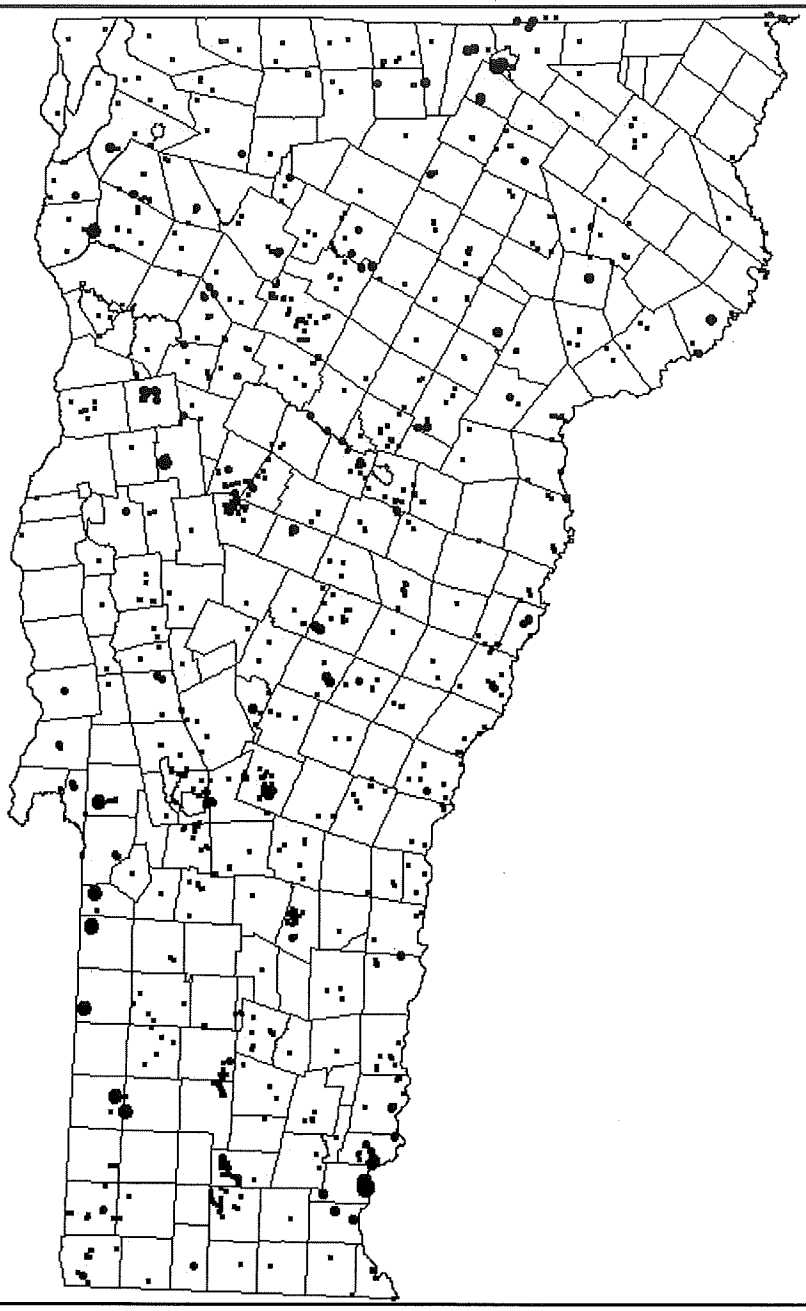
PUBLIC COMMUNITY & NON-TRANSIENT
WATER SYSTEMS
IN VERMONT

N

• Source

Town Boundary

This map is based on sources of data
from the ANR GIS office and VCGI, Inc.
Reference should be made to the ANR GIS office
for information on the limitations of the map data
1:5000 Orthophotography from VT Tax Mapping Department
1:24000 USGS Topomaps from VCGI
Map created on 4/27/2004



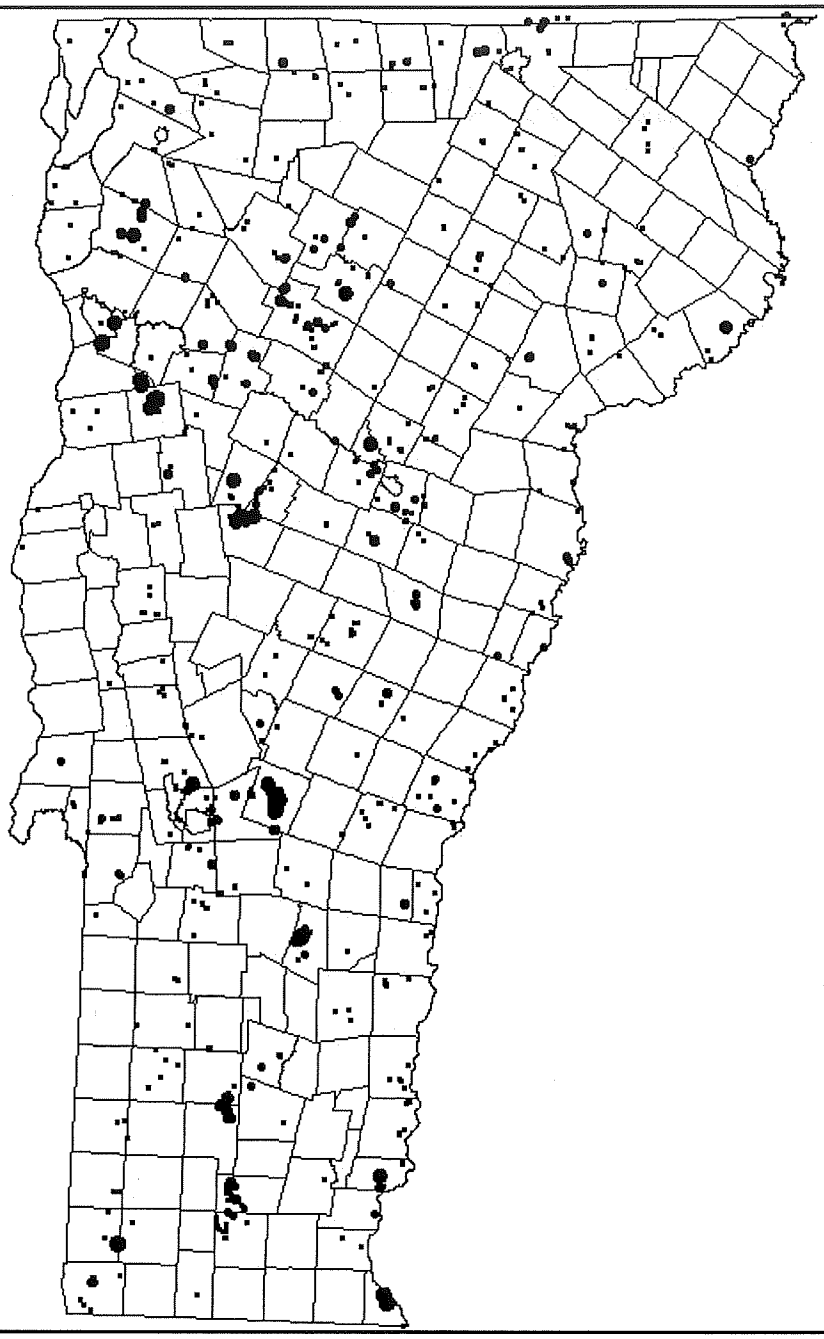
Arsenic Values in ppb

- 0 - 3
- 3 - 8
- 8 - 17
- 17 - 43
- 43 - 175
- Town boundary

ARSENIC DETECTIONS AT VERMONT PUBLIC WATER SYSTEMS

This map is based on sources of data from the ANR GIS office and VCGI, Inc. Reference should be made to the ANR GIS office for information on the limitations of the map data. 1:5000 Orthophotography from VT Tax Mapping Department 1:24000 USGS Topomaps from VCGI Map created on 4/27/2004

N



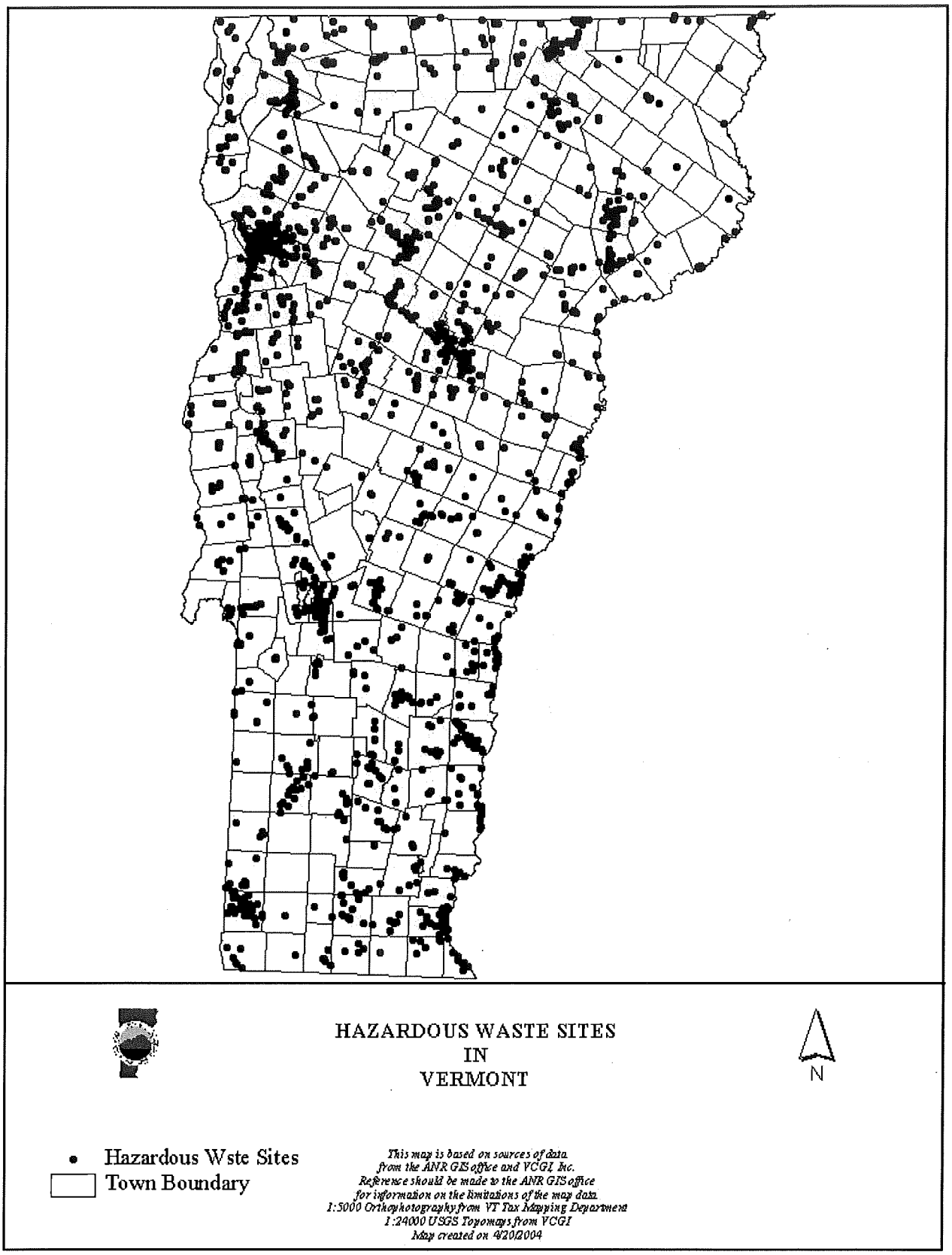
Gross Alpha Values in pCi/l

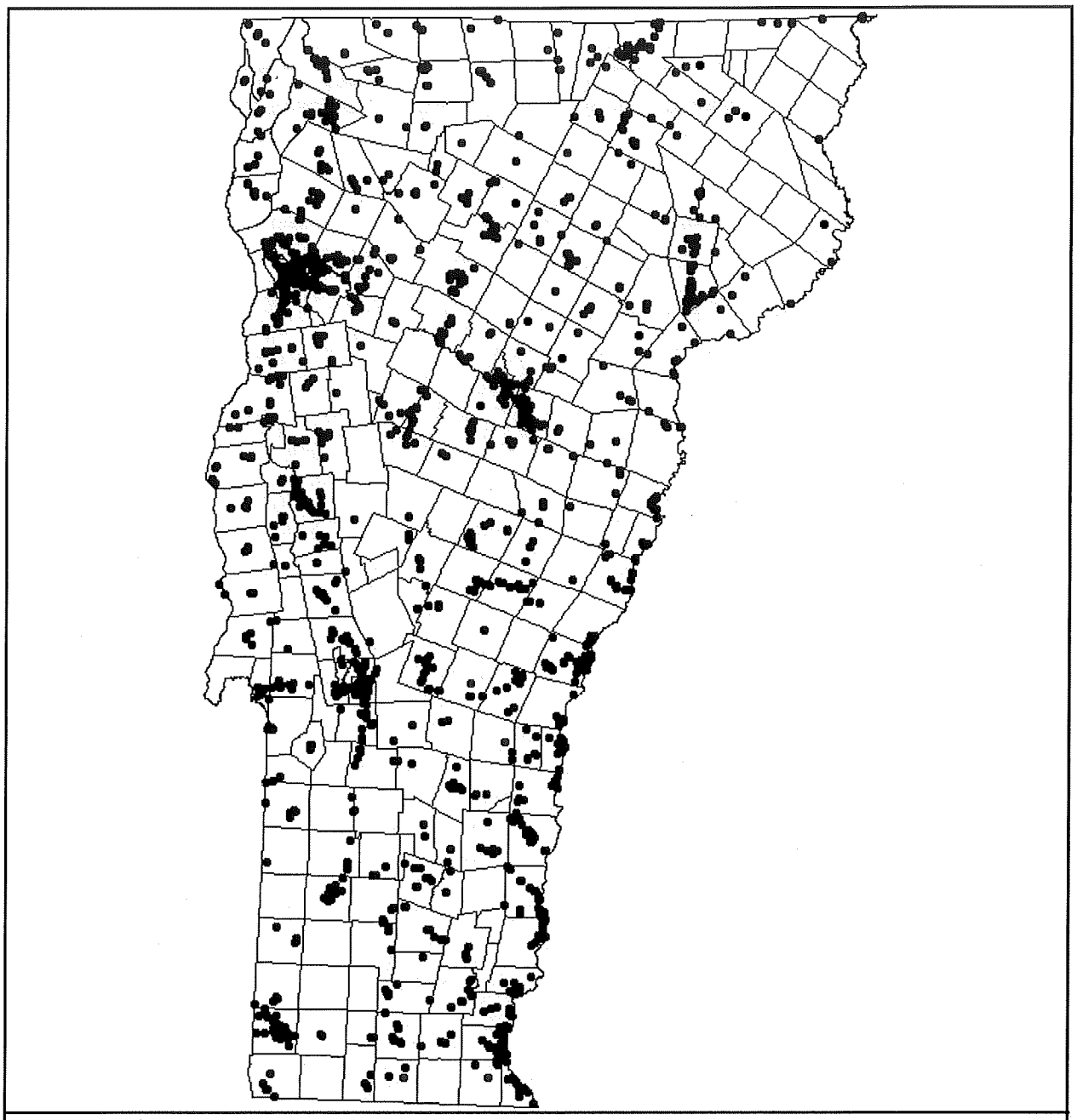
- 1 - 4.33
- 4.33 - 8.57
- 8.57 - 15.5
- 15.5 - 39.7
- 39.7 - 101.9
- Town boundary

GROSS ALPH DECTECTIONS
AT VERMONT
PUBLIC WATER SYSTEMS

This map is based on sources of data from the ANR GIS office and VCGI, Inc. Reference should be made to the ANR GIS office for information on the limitations of the map data. 1:5000 Orthophotography from VT Tax Mapping Department 1:24000 USGS Topomaps from VCGI Map created on 4/19/2004

N


HAZARDOUS WASTE SITES
IN
VERMONT
N
Hazardous Wste Sites
Town Boundary
This map is based on sources of data
from the ANR GIS office and VCGI, Inc.
Reference should be made to the ANR GIS office
for information on the limitations of the map data.
1:5000 Orthophotography from VT Tax Mapping Department
1:24000 USGS Topomaps from VCGI
Map created on 4/20/2004



UNDERGROUND STORAGE TANKS
IN
VERMONT

Underground Storage Tanks
Town Boundary

This map is based on sources of data from the ANR GIS office and VCGI, Inc. Reference should be made to the ANR GIS office for information on the limitations of the map data.
1:5000 Orthophotography from VT Tax Mapping Department
1:24000 USGS Topomaps from VCGI
Map created on 4/20/2004

PART EIGHT: ACCESSING & MANAGING DATA USED in DECISION-MAKING on the STATUS of WATERS

A) Water Quality Data

i) Chemical data

Data collected in conjunction with DEC monitoring programs, as well as some volunteer-based data, are archived to DEC's dedicated water quality data storage system. As of January 2004, this archive contains in excess of 280,000 individual data records, beginning prior to 1970. Data from all core chemical monitoring programs are archived on an annual basis, following quality assurance screening. In certain instances, project-specific data will be held outside of the data archive until a project is completed prior to submission. The Water Quality Data Archive is intended to be DEC's final repository for water chemistry and associated data.

The Water Quality Data Archive is presently maintained in a Microsoft Access© database which is carried on DEC's central file server. This database is backed up on a daily or more frequent basis with archive media also protected off-site.

ii) Biological data

Data collected in conjunction with all DEC biological monitoring programs are archived to a dedicated biomonitoring database, which is a component of the Water Quality Data Archive. As of January 2004, this database contains in excess of 99,000 individual macroinvertebrate occurrence records from 2,873 discrete sampling events. The database also holds 5,606 individual fish occurrence records representing 851 discrete sampling events. Data from all core bio-monitoring programs are archived as data become available from the laboratory, following quality assurance screening. In certain instances, project-specific data will be held outside of the data archive until a project is completed prior to submission. The Water Quality Data Archive is intended to be DEC's final repository for biomonitoring and associated data.

iii) Storet

DEC began implementing a local Storet archive in 2003. In response to USEPA requests, and with support from the National Environmental Information Exchange Network, DEC has been able to develop the largest Storet archive of all New England States, with some 231,522 records presently archived across numerous programs. The DEC Storet archive is limited to water chemistry information, although the addition of a subset of the data contained in the bio-monitoring database is currently under consideration.

B) Assessment Information

i) Lake water quality inventory

DEC maintains a database containing physical and cultural characteristics and water quality data summaries for 918 inventoried Vermont lakes. The so-named Lake Inventory is used to track information such as waterbody classification, known existing uses, lake physical attributes, counts of shoreline dwellings, and characteristics relevant to lake protection prioritization. Much of the data contained in the lake inventory database is available online through the Vermont Water Quality Division website (www.vtwaterquality.org). These data are updated on an annual basis or as warranted based on new information.

ii) Assessment database

DEC currently maintains two discrete databases that are used to track use support: one for lakes and ponds, and the other for rivers and streams. No such assessment dataset is available for wetlands. These databases are updated continually throughout the year, and each year, the database is archived prior to fulfilling EPA-required assessment data submissions. In this way, static archive copies of assessment databases for lakes and streams are maintained annually. These assessment databases are structured to be compliant with the current EPA "Assessment DataBase" database architecture. These databases are presently housed in Microsoft Access©.

iii) Priority & impaired waters database

DEC presently maintains a database of priority and impaired waters that is separate from the assessment databases. This database is presently maintained in Microsoft Access© and is relationally linked to the assessment databases. Waterbodies are identified by their priority listing status and TMDL status, as identified within the Assessment Databases.

C) Mapping

Late in 2003, the Vermont Center for Geographic Information finalized the Vermont Hydrographic Dataset (VHD). VHD is a GIS-based waterbody coverage which is based on the National Hydrographic Dataset (NHD) architecture. The VHD is fully compliant with NHD and includes all metadata requirements and reach coding. VHD differs from NHD in that it is a 1:5,000 scale water coverage. NHD is presently available in all New England states but at a 1:100,000 scale resolution.

As of this writing, Vermont's existing 210 river/stream and 558 lake/pond waterbodies have been geo-referenced to the 1:5000 VHD, permitting the development of very high resolution maps displaying assessment and listing status. For reporting purposes, the maps shown earlier in Part 4 are mapped at 1:100,000 scale.

D) Data Access

As mentioned above, lake information summaries including monitoring data summaries for two major monitoring programs are available online. Data for any specific lake, pond, river, or stream are available on request by contacting appropriate Water Quality Division staff. Appropriate contact persons can be identified in the staff listing provided by www.vtwaterquality.org. Copies of assessment information summaries can also be provided on request, and the Vermont lists of priority and impaired waters are available at the same web site noted immediately above.

PART NINE: CONCERNS & RECOMMENDATIONS

Lakes & Ponds

Atmospheric Deposition of Pollutants

Deposition of pollutants to the Vermont landscape from the atmosphere is principally responsible for the partial support of fish consumption and aquatic life uses of 15,414 inland lake acres, all 174,175 acres of Lake Champlain, and all Vermont river and stream miles. Atmospheric deposition is the principal source of two major causes of use loss in Vermont: elevated mercury and low pH. The two causes are linked, since in many instances, lakes that are vulnerable to acidification are also those which transfer atmospherically deposited mercury to the aquatic food web in the toxic methyl- form. However, other lakes that are not at risk of acidification do retain the ability to transfer mercury into the trophic chain via alternate geochemical pathways, as is discussed in Section 4.D.5.

Atmospheric deposition of mercury has resulted in the issuance of fish consumption advisories for many Vermont lakes and rivers, particularly those containing walleye. Specific advisories are in place for the five Deerfield River reservoirs, and for Moore and Comerford Reservoirs within the Fifteen Mile Falls Project (Connecticut River). The method by which the Department assesses fish consumption uses has been further refined during the reporting period, and is provided in detail in the Assessment Methodology (refer to Appendix C).

The impacts of mercury deposition are not, however, limited to loss of fish consumption uses. Reproductive and behavioral impacts to wildlife that feed on fish are common to a subset of New England lakes, including the reservoirs along the Deerfield River and Connecticut River (Fifteen Mile Falls). Potential impacts to upper trophic level biota continue to be monitored by the Vermont Institute of Natural Sciences, in collaboration with the Biodiversity Research Institute.

Loss of uses associated with atmospheric deposition result from regional and long-range emissions of acid-forming precursors. The atmospheric deposition of nitrous oxide (NO_x) and sulfate (SO_4) from Midwestern sources has resulted in acidification (low pH) of 34 lakes and six streams within Vermont. In Vermont, the potential for acidification is measured by direct measurement of pH as well as corollary measures such as acid neutralizing capacity, NO_x, SO_4 and others. Deposition of SO_4 and in-lake SO_4 concentrations are presently decreasing. During the reporting period, DEC completed and EPA approved an acidification TMDL affecting 30 lakes/ponds.

Vermont continues to work at the local, regional and national scale, to research the environmental effects associated with atmospherically deposited pollutants, reduce Vermont's locally-generated emissions, and influence the development of Federal legislation aimed at reducing atmospherically-derived pollution. Specifically, DEC has recently completed a revised mercury emissions inventory and has completed the REMAP mercury research project for Vermont and New Hampshire lakes. DEC is currently participating in several regional mercury monitoring, research, and assessment projects including a new "round" of fish tissue testing in Lake Champlain; a mass-balance modeling effort for mercury in Lake Champlain; a compilation, synthesis, and analysis of environmental mercury monitoring information across northeastern North America (the so-called "NERC" mercury workgroup); participation in a regional modeling and TMDL analysis of mercury fate and transport in New England; and a regional study to ascertain the covarying influence of water level fluctuation and trophic state on mercury bioaccumulation in fluctuated reservoirs. With significant assistance and

support from DEC, the Vermont Advisory Committee on Mercury Pollution continues to identify areas in Vermont where mercury use and emissions can be reduced, and is active in advising the Vermont General Assembly in its efforts to develop mercury-related legislation for Vermont. Finally, DEC staff continued to interact with the congressional delegation to address this issue from a national perspective.

Despite these many efforts, there remains a significant need to properly assess inland Vermont waters for mercury contamination. Specifically, funding is needed to implement a lake and stream tissue monitoring program, designed based on findings from the REMAP project, to better estimate mercury levels in fish tissue in particular lakes and to estimate overall statewide levels of contamination for species other than yellow perch. Currently, Vermont dedicates no specific funding for fish tissue monitoring. The work that DEC cooperatively implements along with the Vermont Department of Fish and Wildlife and Department of Health is essentially done as time permits, and accordingly is conducted at a modest scale. Under an optimal program, funding would be available to support temporary field and laboratory staff to implement a five-year rotating tissue assessment program that would coincide with rotating basinwide assessments. Any augmented fish testing program should also include testing for new tissue contaminants such as poly-brominated diphenyl-ethers.

Hydrologic Modifications in Lakes

Water level manipulations are another important source of use impact to lakes. There are 34 lakes and ponds (about 9,000 acres) in Vermont for which one or more uses are altered due to water level manipulations. Flow alteration affects aquatic life uses due to littoral habitat loss. In some instances, flow alteration can also affect aesthetic, swimming, and even boating uses, depending on the severity and/or timing of the drawdown.

During the upcoming biennium, DEC's Lake Bioassessment Program plans to obtain more precise and quantitative estimates of aquatic life use impairments in flow-altered lakes and reservoirs. Absent these anticipated biological data, the Assessment and Listing Methodology (refer to Appendix C) contains a decision-making tree to make preliminary assessments of use support in fluctuated lakes and reservoirs in a uniform fashion.

Exotic Aquatic Species as Pollutants

Vermont has a history of impacts related to non-native nuisance plants and animals in its lakes and, unfortunately, the number of non-native introductions to inland Vermont lakes continues to increase. During the 2004 305b reporting period, Eurasian watermilfoil was discovered in two new lakes (Deweys Mill Pond in Hartford and Lake Elmore in Elmore). If Vermont is to be successful in slowing the rate of spread of this nuisance species, continued personnel and financial resources will need to be directed toward spread prevention efforts. Water chestnut (*Trapa natans*) was discovered in one new waterbody, North Springfield Reservoir. Of continued concern is the discovery in 2001 of a water chestnut infestation in the Pike River in Quebec. This new infestation places Missisquoi Bay of Lake Champlain in extreme jeopardy of an infestation. At the present time, zebra mussels are pervasive in Lake Champlain and Lake Bomoseen. The mussels also threaten aquatic life and swimming uses in a small set of inland lakes. One interesting hypothesized consequence of zebra mussel infestation in Lake Champlain has been the development of a declining trend in aqueous calcium concentrations lakewide, the onset of which is temporally coincident with the flourishing of zebra mussels throughout the lake during the mid-1990's.

On a more positive note, sustained hand pulling efforts appear to have eliminated the water chestnut populations in Rood Pond (Williamstown/Brookfield) and Lake Bomoseen (Castleton). The

population in Lake Paran (Bennington/Shaftsbury) is nearly eradicated as well. It is essential that DEC receive continued funding for water chestnut control at or above existing levels to maintain the ground gained in the last two years in the battle against water chestnut in Lake Champlain and the inland lakes.

During the reporting period, Beebe Pond (Hubbardton) was treated with a low concentration of the aquatic herbicide *Sonar*™ to selectively manage a dense Eurasian watermilfoil population there. Unfortunately, while recreational uses that had been severely impaired for years in Lake Hortonia (Hubbardton/Sudbury) and Burr Pond (Sudbury) showed short-term restoration following a *Sonar*™ treatment of those lakes in 2000, Eurasian watermilfoil has now fully rebounded there, and plans are being made for another *Sonar*™ treatment of those lakes perhaps as early as 2004. Lake St. Catherine (Wells/Poultney) and the associated Little Pond and Lily Pond will also be treated using *Sonar*™ in the early summer of 2004. Star Lake (Mt. Holly) may be treated with the same herbicide in 2004 as well. All of these treatments would be at a target fluidone concentration of 8 parts per billion (ppb) with 5-8 ppb of fluridone maintained in the waterbodies for a minimum of 90 days.

Herbicide treatments are expensive and time-consuming projects for local lake associations. If more than 2-3 years of relief from the impacts of dense Eurasian watermilfoil growth cannot be obtained from an herbicide treatment without unacceptable impacts to non-target organisms, it is doubtful that local groups can continue to afford to use this control method, both from a financial and a personnel resources standpoint. Vermont would like to see a national focus on enhanced research into other methods to control Eurasian watermilfoil, including potential biological control agents.

Eutrophication of Lakes

DEC commits significant resources to the management of human-caused eutrophication affecting Vermont lakes. Vermont has relatively unproductive lakes as compared to other parts of the country. This is attested to by the fact that only three inland lakes appear on Vermont's draft Year 2004 303d list as impaired due to excessive eutrophic conditions (Lake Carmi, and Shelburne Pond and Ticklenaked Pond in Franklin, Shelburne and Ryegate, respectively). Implementing protective actions to reduce human impacts on lake trophic state before impairments develop is more efficient and effective than waiting until restoration is needed. Toward this end, several lake protection projects are described elsewhere in this document, with moderate success noted in some waters. Indeed, even though the Lake Carmi TMDL has not yet been prepared, there have been notable improvements in the summer nutrient concentrations, transparency, and algal populations in the lake owing to significant watershed restoration efforts already underway there.

Eutrophication can simultaneously affect aesthetics, aquatic life, swimming, and in some instances even boating uses. The major causes related to eutrophication for inland Vermont lakes are nutrients, siltation, and organic enrichment. The major sources of these pollutants are construction, urban and suburban runoff, road maintenance and runoff, agriculture, silviculture and other nonpoint sources.

Nutrient Criteria

During the reporting period, DEC finalized its nutrient criteria development plan, and has obtained EPA funding to partially implement the plan, beginning in the 2004 field season. Vermont's nutrient criteria development plan focuses on developing quantitative relationships between nutrient parameters and designated uses such as recreation, aesthetics, aquatic habitat, and public water supply, in lakes and rivers.

Rivers & Streams

Hydrologic Modifications

As humans develop watersheds more intensely, remove stream gravel and alter the stream channel, increased flooding, impaired water quality, and impacts to aquatic resources are the unwanted results. Land use changes and instream management activities and their relationship to adverse impacts on rivers and streams are the focus of studies either completed or currently being undertaken by DEC. The recommendations of the studies have caused DEC to develop the *Stream Geomorphic Assessment Handbook* and are likely to result in changes to the *Stormwater Management Procedures*.

It is recommended that DEC encourage municipalities to incorporate the future revised management procedures in their plans and ordinances through workshops sponsored by regional planning commissions meeting with selectboards, conservation commissions and local planning commissions. In addition, additional resources are needed to assist with channel restoration of flood-damaged rivers and streams.

Stormwater Management

Urban stormwater continues to be a focal point in Vermont for permitting, litigation and legislation. The Watershed Improvement Permit methodology developed by DEC was described in the 2002 305b Report as the principle means for water quality remediation in stormwater affected areas. The Watershed Improvement Permit process was subsequently overturned on appeal to the Water Resources Board during the 2004 305b reporting period and an investigative docket process was then initiated by the Board. The Water Resources Board's collaborative stormwater investigative docket focused on the science of stormwater management. The participants developed an innovative approach to reducing scientific uncertainty regarding clean up plans to restore biological health to stormwater-impaired streams. Participants concluded that the major adverse impact of stormwater was hydrologic – there is simply too much water flowing off the areas occupied by impervious surfaces that in turn causes excessive stream channel erosion. The collaborative recommended rigorous, detailed assessment of impaired watersheds and setting hydrologic targets for reducing water flows in impaired waters based on comparisons with "attainment streams" that are meeting standards even though development is found in their watersheds.

The Vermont Legislature enacted House Bill number 785 that implements the Water Resources Board's Docket recommendations by:

- Continuing to allow the Agency of Natural Resources to issue the existing watershed improvement general permit (WIP) without a detailed planning process in those rare circumstances where the Agency is confident that actions required by the general permit will result in attainment of water quality standards within five years.

- Requiring a rigorous hydrology-based, planning process leading to the development of either a Total Maximum Daily Load (TMDL) load allocation plan or a similarly detailed Water Quality Remediation Plan (WQRP) for each of the 17 stormwater-impaired watersheds.

- Authorizing ANR to issue watershed specific general permits implementing a TMDL or WQRP. There is no requirement that permits based on a TMDL or WQRP result in attainment of water quality standards in five years or any other fixed period of time.

DEC is currently developing new techniques, based upon hydrological model targets, to remediate these impaired streams. It is anticipated that all 17 stormwater-impaired receiving waters will have water quality remediation plans developed for them by the end of 2007.

An overview of the new stormwater remediation process as a collaborative long-term solution is provided below.

- Focus on altered hydrology as the principal source of impacts.
- Solution must be Adaptive Management based.
- Watershed-wide source modeling of hydrology.
- Watershed specific analysis for sources and stream regime.
- Watershed remediation plans – pseudo TMDL determination.
- BMP based program – not site-specific effluent limitations.
- "Stormwater Impact Area" type analysis to provide details on cost effective watershed solutions.
- Engineering Feasibility Analyses on individual properties.
- Use of Stormwater Offset Fees to fund watershed-level remediation projects.
- Selection of initial round of stormwater upgrades.
- Baseline watershed monitoring.
- Long-term monitoring and adjustment.

Polluting Discharges from Large Farms

From a water quality perspective, concerns continue to exist regarding shifts in agricultural production from a large number of smaller farms to increasing numbers of larger farms. The water pollution potential from such large farming operations is equivalent to the waste generated by a small to medium sized city. It is recommended and essential that waste management and pollution prevention efforts are well coordinated between farm operators and state and federal agencies. The Large Farm Operation Rules, regulating farms with greater than 950 animals and administered by the Vermont Agency of Agriculture, Food and Markets, will help ensure animal wastes on these larger facilities are managed effectively.

Changes at the federal level are soon to affect the Concentrated Animal Feeding Operation permit program, currently administered by DEC under the National Pollutant Discharge Elimination System. Farms that have between 200 and 750 animals will soon need a General Permit and will need to demonstrate compliance. Farms with greater than 750 animals will soon need an Individual Permit.

In order to achieve the greatest possible environmental protection benefit while supporting an important ingredient of Vermont's landscape and way of life, it is recommended these permit programs be developed or modified in a coordinated manner with various technical and financial assistance programs to address waste and nutrient management.

Lack of Strategic Statewide Vegetated Buffer Requirements

Undisturbed vegetation along rivers and streams (as well as along lake shorelines) is effective at reducing pollutants from reaching surface water. Other than Act 250 development constraints and a few regulations adopted by a small number of municipalities, there are no strategic statewide requirements that riparian landowners maintain a minimum width of vegetation along bodies of water as there are in other states. As a result, many miles and acres of Vermont's surface waters are negatively influenced by urban runoff, sediment, increased temperature, fertilizers, manure, and other pollutants which can be reduced or eliminated by properly maintained vegetated buffers.

As the result of the recognized importance of riparian buffers to water quality in certain strategic locations, a Buffer Procedure Action Team was created in October 1999. The Team was charged with developing a revised Agency buffer policy and procedure, including general and site specific standards. The revised Buffer Procedure, once finalized, would be used by the Agency in the Act 250 process and as guidance to riparian landowners, including public and quasi-public agencies.

DEC continues to make some strides in the educational effort to inform the public and municipal planning commissions about the environmental benefits of riparian vegetation. DEC and Regional Planning Commissions (and in some cases local watershed groups) have been working with municipalities to strengthen their municipal plans and zoning regulations to maintain streamside vegetation. Workshops for town officials and the general public have been conducted regarding strategies to encourage the maintenance of existing riparian vegetation as well as promoting the planting of riparian areas lacking vegetative buffers. DEC, the Vermont Youth Conservation Corps, the various Natural Resources Conservation Districts, watershed groups and other volunteer groups have worked on many streamside planting projects around the state. However, there is still need for additional public education about the need to maintain riparian buffers for water quality protection and wildlife habitat.

It is recommended that the Agency continue to make more use of the print media, TV and radio to draw the public's attention to the benefits of maintaining riparian vegetation.

Groundwater

Groundwater is fundamental to the ecosystem and as a drinking water resource. It recharges wetlands, rivers and streams, and lakes and ponds, making it critical to wildlife. It is also source of drinking water for most of Vermont's population. While groundwater is addressed through the federal Safe Drinking Water Act, the Act's prime focus has been on treatment, operation, and infrastructure needs of public water systems. Additional regulations that address groundwater are often created in reaction to contamination. Yet, the characteristics of groundwater remain largely unknown. Characterizing the groundwater resource is overdue relative to the continuing threat of contamination, the pressures and pace of development, and the resource's importance.

To appropriately address groundwater and elevate its standing to a level that other natural resources enjoy requires a continuous commitment. Required in this commitment is a groundwater program with sufficient personnel that would define Vermont's groundwater resources. Central to this mission is a proactive approach to aquifer mapping. This mapping would not only identify potential future aquifers but would also update existing Source Protection Areas that were insufficiently delineated. Recognized in this approach is the connection between surface water and groundwater that is so often ignored. In addition, there is a need for education and technical assistance at the state level and, most importantly, at the local level.

The above approach is based on a philosophy that a comprehensive understanding of groundwater is needed to provide effective, preventative strategies to protect the resource. Without this understanding assumptions regarding groundwater remain ill conceived or the resource is taken for granted altogether which results in inadequate groundwater protection efforts. Conversely, a groundwater program based on data that describes the resource can appropriately protect the resource for present and future needs.

APPENDIX A

Vermont River Basin Planning Progress

(Progress in Basins with DEC-led Planning)

Basin 2 – Poultney/Mettowee Basin Progress Summary

The Poultney Mettowee Watershed Partnership

The Poultney Mettowee Watershed Partnership (PMWP) is a project of the Poultney-Mettowee Natural Resources Conservation District in Vermont and the Washington County Soil and Water Conservation District in New York with funding from the Lake Champlain Basin Program. The mission of the partnership is to bring together citizens and organizations that share the common vision of conserving, protecting, and enhancing the natural and cultural resources of the watershed. A steering committee representing various stakeholder groups makes recommendations to these conservation districts concerning the activities they should undertake.

Since the Watershed Planning Initiative commenced in the Poultney Mettowee watershed in summer 2001 with the arrival of the DEC Watershed Coordinator, the Steering Committee of the PMWP has expanded to include representatives from lake associations, river stewardship groups, municipal and regional officials, and other stakeholders.

The Partnership began in summer 1998 with a few people talking together and realizing that their organizations were working towards many of the same conservation goals. As a result, this unique, bi-state partnership began, focusing on mutual concerns for protection of natural resources and water quality. The Partnership has completed many projects throughout the watershed.

Some projects currently underway, or still in the planning stages, include:

- Water quality monitoring of the Poultney River;
- Producing stock in the native plant nursery to supply material for floodplain and clayplain forest restoration projects in partnership with The Nature Conservancy;
- A landowner outreach project that supplies trees for riparian landowners to address high water temperatures in the Mettowee River;
- Conducting a detailed geomorphic assessment of local rivers using volunteers;
- Leading environmental service learning projects for youth in the watershed; and
- Increasing nutrient management assistance to agricultural producers in the watershed.

Highlights for 2003 include riparian buffer plantings in four towns, leading summer programs for local youth, maintaining the native plant nursery in cooperation with The Nature Conservancy, volunteer work days, and scientific data collection and monitoring of water quality in the watershed's rivers with the assistance of the Vermont Agency of Natural Resources, Water Quality Division. It should be noted that the Poultney Mettowee Watershed Partnership has agreed to implement many strategies identified in the *draft* Poultney Mettowee Basin Plan where the Partnership is designated either as the lead agency and/or a primary partner.

Public Outreach and Communication

The basin planning public process included a survey of residents to identify water quality concerns held by the public throughout the Poultney Mettowee Watershed. This survey provided an assessment of landowners' knowledge, behaviors, and attitudes with respect to water quality and related land use. In the long-term, the survey findings serve as a benchmark by which to evaluate progress in addressing public concerns. Several major water quality problems, their sources, and impacts were identified from the many public meetings and focus group discussions. Major concerns regarding water quality identified in this ranking process included:

- Health risks from pathogenic bacteria runoff from agriculture, urban sources, and overflows from wastewater treatment plants;
- Nutrient enrichment from agriculture, urban runoff and eroding streambanks;
- Sedimentation from road runoff, agriculture, stream instability (resulting from channelization and dredging), urban stormwater runoff, and other activities;
- Excessively warm waters due to loss of riparian vegetation, and channel widening from streambank destabilization, road maintenance, agricultural use, and land development; and
- Waters impaired by nonpoint source pollution.

It is evident from this study that public education and outreach are critical to gaining participation in future water quality restoration. Ultimately, a public that understands water quality and related resource management problems and possible solutions make informed decisions about long-term protection and restoration. For public outreach to be effective, the messages must be clear, frequent, and identifiable. For this reason, the Partnership and District have focused on maintaining consistency throughout their public outreach efforts. When the Partnership first formed, considerable time was taken to make its existence and that of the District known. By promoting the organizations, it was correctly anticipated that the public would be aware of where to go for assistance, information and education.

Summer youth education programs
The Partnership participated in two summer educational programs. The first was Castleton's SCAMP camp. During this weeklong day camp students learned about water quality, wildlife, watersheds, and ways they could help the environment at home.

The second program was part of Poultney's Summer Recreation program. Students in Poultney helped out with projects around town and also learned about the environment. Projects included working in the educational garden at the elementary school, maintaining the Poultney Educational Trail, and picking up litter along the Poultney River.

Stream Team service learning opportunities
The Partnership is planning to form a team of area youth to complete projects around the watershed. In addition to accomplishing project goals, the formation of a youth team serves several other purposes. First, it is a great way to both reach and teach young people about the issues that affect the watershed. Through education and accomplishment, area youth will be instilled with a sense of pride in a job well done.

The team members are also likely to come away from their project work with a great deal of excitement; and will educate their peers and families with their newly acquired knowledge. Working in the watershed will give youth a sense of place as members of the watershed community and add an increased appreciation for the environment in which they live. In addition, many local youth have difficulty finding employment in this area and the Stream Team will provide additional jobs in the community. The Vermont Youth Conservation Corps will be a major partner in this project – assisting with funding and training for team leaders for corps members.

Strategies
Through focus group discussions and public forums, water quality impairments were identified. The basin planning process emphasizes collaborative efforts to correct water quality problems through voluntary cooperation with landowners and the district.

Remediation strategies currently being undertaken by the Watershed Partnership in collaboration with ANR to control non-point sources of pollution include:

- Addressing thermal pollution through projects to re-plant trees and shrubs along the river
- Controlling pathogens
- Stabilizing streambanks
- Addressing issues of channel instability where areas of concern have been identified
- Increasing public awareness of water quality concerns through outreach and education
- Addressing impact to fisheries
- Assessing the impact of agricultural runoff

Current Projects
Over the past four years the PMWP has completed many great projects, a few of which are noted below.

Poultney River Monitoring Project
A group of high school-aged students from Middletown Springs volunteered during the summer of 2003 to help the Watershed Partnership collect water quality samples. The youth sampled at eight popular swimming areas on the Poultney River in their community and downstream in Poultney and monitored a number of different water quality

parameters including temperature, depth, turbidity, odors, algae growth, and bacterial contamination. This new water quality monitoring program is a good example of the Partnership at work. In addition to the youth group, other partners in the project are the Water Quality Division, and the Towns of Middletown Springs and Poultney.

Once the water samples were collected, they were analyzed by the DEC at the LaRosa Analytical Laboratory in Waterbury. The Watershed Partnership was awarded a laboratory services grant through a new program designed by the state to help Vermont's many volunteer watershed associations and water quality monitoring groups. Until last summer the Watershed Partnership had not been able to conduct detailed water quality monitoring because of the high cost of laboratory analyses.

Results of *E. coli* monitoring showed that the levels were widely varied by site and reached the highest levels after a heavy rain at the beginning of August. Future monitoring will look into the sites where levels were high throughout the summer and narrow down the possible sources of contamination.

Champlain Valley Clayplain Forest Restoration

Vermont's clayplain forests, now considered a rare natural community, were cleared more than 200 years ago and today cover only about 14 percent of the land in the Champlain Valley south of the Winooski River. The major limiting factor to restoration of the native clayplain and floodplain habitats has been a lack of plant material generated from local genetic stock. In 2002, the Nature Conservancy's Southern Lake Champlain Valley Program and the PMWP started a small native plant nursery, called the Poultney Mettowee Restoration Nursery. The native plant nursery is located on one of The Nature Conservancy's properties in Whitehall. Start-up funds for the nursery were provided by a collaboration of public and private sources including a grant to the Poultney Mettowee Watershed Partnership from the National Fish and Wildlife Foundation and a private grant to the Conservancy's Southern Lake Champlain Valley Program.

When grown to size, plants will be planted on riverbanks and floodplains located on Conservancy property and local farms that are enrolled in federally funded cost-share programs. In April 2003, the first seedlings grown in the Poultney Mettowee Restoration Nursery were planted onto riverbanks in Whitehall, New York and Benson, Vermont. The plantings fulfill two important goals: mitigating the impacts of agricultural practices on water quality and restoring clayplain and floodplain forest. Additional benefits of the plantings include expanding the river wildlife corridor system, stabilizing streambanks to decrease erosion and subsequent sedimentation that has an impact on native mussel and sand darter populations, and mitigating threats of invasive species by using native plant materials for restorations.

Hubbardton River Restoration Project

This restoration project is to re-establish the clayplain forest natural community along the mainstem of the Hubbardton River through long-term conservation and perpetual easements. The restoration project will also address a second goal of the Partnership: to reduce the high sediment load that characterizes the entire mainstem of the Hubbardton. Several landowners in the Hubbardton River watershed have entered into land trust agreements or enrolled in long-term conservation easements such as the Conservation Reserve Program (CRP). In addition, the USDA-NRCS is pursuing an opportunity to allow landowners currently participating in long-term conservation easements to enroll in federal cost-share perpetual easements without penalty, which would provide for long-term watershed scale restoration of the rare, clayplain forest natural community. The project will be used as a demonstration of effective stream corridor management practices for municipal officials, farmers, anglers, ecologists, business entities, and other landowners. The restoration effort will also expand the wildlife corridor along rivers and streams, lessen the impact of invasive species, and stabilize riverbanks by decreasing erosion and sedimentation that has an impact on aquatic habitat and biota, including native fish nurseries.

Other Watershed Restoration Projects: 2003

Riparian Buffer Initiative

Over 150 volunteers helped the PMWP complete important conservation projects this spring. About 70 volunteers were Green Mountain College students who planted trees to establish riparian buffers along the Poultney, Mettowee, and Hubbardton Rivers. Not only did these students accomplish high priority jobs for the Partnership, they also learned about the watershed.

Eurasian water milfoil control and spread prevention
Milfoil spread prevention efforts are underway on several lakes and ponds in the basin. The PMWP has assisted with milfoil spread prevention by installing interpretive signs about invasive species at recreational access areas throughout the basin. Vermont DEC has provided technical assistance and grants-in-aid to the Lake Bomoseen Association, Beebe Lake Association, Lake Hortonia Association, Burr Pond Association, Sunrise-Sunset-Perch Property Owners Association, Lake St. Catherine Association as well as other smaller pond owners in an effort to control the spread of this aquatic invasive exotic species within the lake and to nearby waters.

Castleton River Watershed and Gully Brook in Castleton
Gully Brook is a flashy, steep gradient tributary to the Castleton River in Castleton. Historically, the Gully Brook has had good access to its floodplain once it reached the valley floor coming down the northern flanks of Bird Mountain. In 1959, the Army Corps of Engineers straightened the Gully Brook through its alluvial fan in order to "stabilize" the dynamic sinuosity that had perpetuated itself during high flows. As a result, the brook experienced higher water velocities and a corresponding increase in sediment load that was carried down through the system until it reached the confluence with the Castleton River where it has since deposited much of this bed material. Consequently, a tremendous amount of gravel outwash has accumulated at, around, or downstream of this confluence. With the increased sediment load, there has been a corresponding instability exhibited by both the Gully Brook and the Castleton River adjacent to this confluence.

Since the 1960's, the floodplains along the Gully Brook and Castleton River have been bermed as a result of the continuous gravel removal done to alleviate the flooding at this confluence. There are several conditions that are now self-perpetuating as a result of continually dredging these stream/river systems: (1) the bed of the Gully Brook is becoming more incised in response to higher water velocities and sediment supply, (2) a large gravel pile at the confluence of the Gully and Castleton continues to grow as an indirect effect of the gravel removal, and (3) the confluence becomes an impediment to water passage when gravel effectively dams up the river during higher flows which floods out upstream reaches of the river.

There are several potential remedies to this situation that have been discussed among landowners and state and local officials. Recently, there has been agreement that the best alternative management scenario is to modify the channel to allow the Gully Brook to regain access to its historic floodplain along the valley floor through removal of the eastern berm and lower portion of the western berm.

Mettowee River Temperature TMDL
Relatively high water temperatures were found in an 8.2-mile segment of the river by the Vermont Fish and Wildlife Department in 1995 and again in 2001 as part of a thermal monitoring project conducted by the Vermont DEC. Due to the temperature impairment, the river did not meet water quality standards requiring the state to develop a Total Maximum Daily Load (TMDL). The TMDL allocation project was initiated in the summer of 2001 and resulted in recommendations for management action to reduce the temperature impairment. The recommendations presented for action include:

- Increase shading through riparian planting;
- Modify the channel to provide deeper, cooler pools for fish; and
- Reduce water temperatures of Flower Brook tributary.

Since public input is a requirement of the TMDL process in Vermont, the PMWP hosted several community forums and focus groups and is leading efforts to secure grant funding that supports education, riparian planting, temperature monitoring, and settling basin construction on gravel roads. A buffer outreach project is planned for riparian landowners along the Mettowee River and its tributaries. Stream channel modification projects have also been identified and scheduled to address critical areas along the river that may be contributing to the thermal impairment issue. A public meeting is also planned for early 2004 to update Mettowee River watershed residents about the thermal impairment, monitoring efforts, and buffer planting opportunities.

Regional Planning & Geomorphic Assessments
The Watershed Partnership is working on mapping projects with the help of the Rutland Regional Planning Commission, DEC, and Green Mountain College. Mapping is used in planning stream projects and assessments of

rivers. Maps are also useful to map where projects have been done and to identify gaps where work needs to be done.

The partnership will undergo a large scale mapping project of the Mettowee River next summer to help complete a Phase 2 geomorphic assessment. Phase 2 is the field assessment phase that involves the collection of data from measurements and observations at the reach or sub-reach (segment) scale. The Phase 2 assessment is ideal for flagging reaches for protection and restoration projects and the completion of Phase 3.

Municipal Planning

The Basin Planning Process has provided many opportunities to collaborate with the Rutland Regional Planning Commission and the 18 municipalities in the watershed. The Water Resources section of the Rutland Regional Plan was updated to incorporate the objectives of the basin planning process and other initiatives such as the revised Stormwater Program, Source Water Protection Program and the new On-Site Wastewater Program. This will encourage municipalities to address these issues as they update municipal plans and zoning regulations. In addition, the Watershed Coordinator worked closely with regional planners to conduct outreach and assistance to towns in the basin. As part of this outreach, technical assistance has been provided and/or is planned for specific municipal projects including stormwater runoff assessment (Castleton), agricultural lands assessment (Middletown Springs), source protection planning for public water supplies (Danby and Castleton), transportation projects that relate to water quality (Poultney and Castleton) and assessment of potential landfill leachate to surface waters (Fair Haven and Poultney. The Watershed Coordinator and the District Manager of the Poultney Mettowee Natural Resource Conservation District also have visited every town planning commission and/or selectboard in the basin to discuss the management goals of the classification and typing process and assist these towns in identifying the water resources they wish to protect.

Plans for 2004

- Submit draft Basin Plan for public review and comment (April 2004)
- Continued outreach with towns and the Regional Planning Commission (ongoing)
- Continued efforts to secure grants and move forward on proposed projects.
- Continued collaboration with all partners in the basin on priority issues.
- Ongoing education and outreach with residents of the watershed.
- Adopt Poultney Mettowee Basin Plan and submit proposed Water Quality Management Types and Classes as a petition to the Water Resources Board.

Basin 3 - Otter Creek Basin Progress Summary

The Upper Otter Creek Watershed Council
In November and December of 2002, the Rutland Natural Resources Conservation District (RNRCD) in cooperation with DEC sponsored five meetings for the general public to assist in identifying the existing potential causes and sources of pollution that can influence surface waters of the Otter Creek basin. Since February of 2003, the RNRCD and ANR have sponsored meetings with a group interested in prioritizing the issues and concerns that were identified at these public meetings. This group is called the Upper Otter Creek Watershed Council (UOCWC). The Council is currently meeting every third Wednesday of the month.

A strategy will now be developed through a continuing public process for restoring the quality of waters identified by the public and the state.

The UOCWC is a project of the Rutland Natural Resources Conservation District and DEC with funding provided by the Natural Resource Conservation Council. The Watershed Council represents various stakeholder groups and makes recommendations to the conservation districts for priorities and activities. The mission of the UOCWC is to bring together citizens and organizations that are committed to improve water quality of the Otter Creek Watershed.

The Council began meeting when it was recognized that there was a lack of opportunity to discuss water quality issues in the Rutland County portion of the Otter Creek basin. At the same time it was recognized that organizations were working toward many of the same conservation goals. As a result, this collaborative effort began focusing on mutual concerns for protection of natural resources and water quality.

Some projects currently underway, or still in the planning stages, include:
- Water quality monitoring of the Otter Creek and its tributaries;
- Enhancing public access to water-related recreation;
- Working with towns to conduct erosion inventories of their back road infrastructure;
- Collaborating with Rutland City and surrounding municipal officials to help monitor and assess the stormwater-impaired Moon and Mussey Brooks; and
- Coordinating with UVM's Watershed Alliance and schools in the watershed to develop water quality monitoring programs and related curricula.

Highlights for 2003 include the completion of a comprehensive assessment of East Creek, investigations of high levels of pathogenic bacteria at swimming holes, collaboration with Smokey House in Danby with water quality assessment of Mill Brook, and coordination with stakeholder groups in the Addison County portion of Otter Creek to initiate a basin-wide coordinating committee to oversee basin planning for the Otter Creek.

Public Outreach and Communication
Five public forums were held in various locations in the Rutland County portion of Otter Creek to solicit ideas and involvement from constituents and stakeholder groups with an interest in water quality issues during the winter of 2002 and 2003. From these forums, a list of water quality issues and concerns were compiled and ranked by the participants of each public forum. The ten highest ranked issues were (in order of highest listed first):
- Streambank erosion,
- Stormwater runoff and impacts from erosion in the Moon Brook watershed,
- The need for greater education and awareness regarding water quality issues,
- Conservation/protection of water resources,
- Agricultural nonpoint source pollution,
- Sedimentation,
- Regulatory permitting and enforcement,
- Dams and hydropower facilities,
- Flooding,
- Fisheries

Public relations efforts have expanded recently to promote the organization and keep the public informed. A website was created for the UOCWC and District. It is updated monthly to include meeting announcements as well as the notes from previous meetings (refer to http://www.vacd.org/rutland/uocwc.html). The District Manager of the Rutland NRCD and the ANR Watershed Coordinator have appeared on a local radio program to promote the basin planning initiative underway for the Upper Otter Creek, as well as the activities of the District. Also, articles, meeting announcements, and press releases are submitted regularly to *The Rutland Herald.*

Summer youth education programs
The UOCWC participated in a summer 2003 educational program. The Year End Studies Program (YES) of the Rutland High School provides students with an opportunity to enrich their learning beyond what has traditionally been offered through the regular school year. The program director, George Hooker (Rutland NRCD Conservation Teacher of the Year), chose East Creek, a tributary to the Otter Creek, as the subject of an intensive water quality monitoring and assessment project. Members of the UOCWC assisted with this project, and later enjoyed several presentations by YES regarding the assessment and findings. Results of this effort led to additional assessment and monitoring conducted by the UOCWC with sample analysis provided by the Rutland Wastewater Treatment Facility. The 2004 YES project will supplement project assessment and monitoring.

Strategies
Through focus group discussions and public forums, water quality issues and concerns were identified and ranked. The basin planning process emphasizes collaborative efforts to correct water quality problems through voluntary cooperation with landowners and the district. The Council anticipates the development of strategies to address water quality concerns in the basin through a collaborative process that will be reflected in the basin plan.

Current Projects
Over the past year, the Upper Otter Creek Watershed Council has initiated two projects.
Otter Creek Water Quality Monitoring Project
Members of the UOCWC completed a water monitoring program on some tributaries to the Otter Creek in the summer of 2003. The project samples were analyzed through a partnership with the Rutland Wastewater Treatment Facility. The Watershed Council collected samples for six weeks starting in early August 2003 from Furnace Brook, East Creek and the Mill River. The samples were tested for *E. coli* bacteria, phosphorus and nitrate concentrations. The results of these tests showed water qualities that met or were better than state and federal standards for contact recreation like swimming or wading. Only the Mill River showed slightly elevated *E. coli* counts. This water quality monitoring program is only the first of many projects that this group plans to undertake in its efforts to improve the health of the Otter Creek watershed.

Moon Brook Assessment & Restoration Project
The UOCWC met with representatives from the Rutland City Department of Public Works to offer support for assessment and monitoring of the stormwater impaired Moon Brook and to develop a restoration plan for Moon and Mussey Brooks that flow through Mendon, Rutland, and Rutland City. DEC and local school groups monitored the water quality (chemical and biological) of Moon and Mussey Brooks in 2003 and plan to continue this assessment in 2004. A preliminary assessment of the Moon/Mussey watershed has revealed many potential sources of sediment as well as areas that would benefit from riparian corridor restoration. Strategies to address these issues include riparian buffer plantings, stormwater diversion and retention, and general education and outreach. One proposal would fund the Vermont Youth Conservation Corps to initiate restoration projects on Moon Brook in the summer of 2004. Cleanup of debris west of Route 7 would be a first task followed by riparian plantings and other riparian corridor restoration activities. UOCWC will provide logistical support, and will continue to conduct assessment and monitoring for water quality conditions in partnership with the UVM Watershed Alliance.

Plans for 2004
- Continued development of strategies to address top-ranked issues and concerns through panel discussions, focus group discussions, and general meetings.
- Continued outreach with towns and the Regional Planning Commission (ongoing)
- Continued efforts to secure grants and move forward on proposed projects.
- Continued collaboration with all partners in the basin on priority issues.
- Ongoing education and outreach with residents of the watershed.

Basin 5 - Northern Lake Champlain Basin Progress Summary

The Watershed Planning Process and Public Participation
A watershed council met for the first time on April 29, 2003. The DEC Watershed Coordinator and the watershed council committed themselves to developing the watershed plan and assisting in the implementation of watershed restoration projects. The council supported the coordinator's proposal to hold three public meeting to identify the communities' most prominent concerns. The council also agreed that local groups would develop the first draft of strategies for each of the community's concerns.

The three public meetings in May and June 2003 were scheduled. Meeting summaries can be found at the Water Quality Division's web site http://www.vtwaterquality.org.

The second watershed council meeting was held on July 31, 2003. The meeting summary can be found at the web site noted above. Discussions resulted in the following consensus decisions regarding the planning process:

- Concerns from public meetings that would be addressed in the basin plan:
  - Algal blooms
  - Aquatic nuisance species
  - General water quality (toxins and pathogens)
  - Maintaining and improving the lake as a drinking water supply
  - Restriction of flows through Islands that result in water quality problems
  - Health/stability of river corridors
- The watersheds of the Rock and Pike Rivers will be included in the Missisquoi River Basin planning process instead of Northern Lake Champlain if citizens of these watersheds agreed. Subsequently, the Franklin County Natural Resource District met with the Missisquoi River Basin Association to discuss the option. The group agreed with this approach. The Rock River and Pike River communities are more closely tied with those of the Missisquoi River.
- The Champlain Water District and the DEC Water Supply Division representatives would discuss the possibility of including water supply as a separate topic in the plan. The discussion included different approaches for including concerns about water supply in the basin plan.
- Fishing opportunities along rivers and streams should be investigated as a concern based on information from Trout Unlimited. Subsequent conversations with the organization revealed that the streams on which TU was interested in securing access were not in this basin.

Development of Strategies To Date
River stability
On October 27, 2003, the DEC coordinator developed draft strategies for the LaPlatte River based on the LaPlatte River Partnership's goals and objectives and their recent work. The Partnership revised the strategies which will next be reviewed by the watershed council.

Managing aquatic nuisance species
October 22, 2003, Pelots Bay Association set up a meeting with the DEC watershed coordinator to discuss overall goals and strategies based on its members' experiences. The coordinator developed a first draft of strategies for further discussion with the watershed council.

Drinking water supply
The DEC watershed coordinator worked with the Champlain Water District (CWD) and the DEC Water Supply Division to develop a process for addressing water supply concerns in the basin plan. CWD's concern is the disconnection between source water protection plans and watershed plans.

Addressing pathogens
The DEC watershed coordinator and the Town of Colchester's Director of Public Works agreed that the first draft of strategies should be based on the Town's water quality strategic plan which was developed by a citizen board. The Green Mountain Institute for Environmental Democracy has a grant to help organize additional discussions with the community where the strategies could receive additional review. The Town would like to see these discussions occur in spring 2004.

Agricultural Issues
On October 23, 2003, the Natural Resources Conservation District, USDA-NRCS and the Vermont Agency of Agriculture, Food and Markets organized an agricultural meeting in Swanton with assistance and participation by the St. Albans Area Watershed Association and the DEC watershed coordinator. The meeting resulted in an airing of concerns regarding agriculture and water quality from both the agricultural community and the watershed group. The NRCD will invite the coordinator to discuss strategies for the basin plan at the agricultural community's next quarterly meeting.

Surface Water Typing and Classification
As required by Vermont statute, surface water typing and classification will be proposed as part of the basin planning process to set management goals for all of the Northern Lake Champlain basin's surface waters. Existing, attainable, and desired water quality criteria will be used to develop the proposal. Chittenden County RPC staff is assisting DEC to determine desired water quality criteria in Chittenden County based on town plans and zoning.

Watershed Assessments
Geomorphic assessment of the LaPlatte River
The DEC watershed coordinator is working with community-led watershed groups, the LaPlatte River Partnership, Chittenden County RPC and towns to complete a geomorphic assessment of the LaPlatte River. The group has hired a consultant to complete Phase I of the assessment. A grant application is pending to complete Phase II in the Hinesburg area. The assessments will be used to target unstable stream segments for flood remediation and infrastructure protection and to identify reference stream segments for protection.

Carry Bay hydrodynamic and water quality modeling
DEC coordinated the review of proposals with the Carry Bay Advisory Committee to conduct a legislatively funded study to model the hydrodynamics and water quality of the causeway removal at Carry Bay in Lake Champlain. Binkerd Environmental, Inc. received the contract and presented preliminary findings of the study to the public on December 18, 2003. The advisory committee will make recommendations regarding any revisions to the report by the end of the year. The report should be finalized and released in February 2004.

Watershed Restoration Projects
Pesticide and fertilizer reduction in residential lawn care
On December 4, 2003, the DEC watershed coordinator organized and facilitated a meeting with groups and individuals interested in leveraging existing resources to educate the community about lake-friendly lawn and garden practices. The coordinator worked with the group to develop a grant proposal to the Lake Champlain Basin Program to do a neighborhood education and outreach project on lawn and garden-related pollution in the St. Albans Stevens Brook watershed.

Aquatic nuisance species control projects in St. Albans Bay
During the summer 2003, DEC worked with the St. Albans Area Watershed Association to determine the extent of the aquatic nuisance species problem and provided advice as to how to best manage the problem. On July 30, 2003 the DEC watershed coordinator organized and the St. Albans Area Watershed Association hosted a meeting to discuss possible solutions to problems. DEC and Lake Champlain Basin Program staff participated. On September 15, 2003, DEC and St. Albans Area Watershed Association representatives toured St. Albans Bay by boat.

Reducing phosphorus concentrations/algal blooms in the water of St. Albans Bay
The DEC watershed coordinator and other DEC staff have participated at St. Albans Area Watershed Association meetings to explain the reasons behind the algal blooms in the bay. The association expressed appreciation for DEC's summary of research on phosphorus loading in St. Albans Bay.

The coordinator and other DEC staff have also participated on the Stevens Brook and Ruggs Brook watershed steering committee to review studies and proposed actions to alleviate flooding and improve water quality in the area. The coordinator has used the resulting study to support a grant application to study the hydrology of the

brooks. The coordinator also helped the Association obtain a grant to pay an expert on nutrient issues to speak at a public forum and an agricultural meeting.

Plans for 2004

- Continued outreach with watershed groups, towns, regional planning commissions and other stakeholders in a basin planning process and development of a watershed council.
- Completion of a water quality assessment for the basin.
- Continue to secure grants and move forward on projects in the basin.
- Continued collaboration with all partners in the basin on priority issues.
- Ongoing education and outreach with residents of the watershed.
- Development of a typing and classification proposal.

Basin 7 - Lamoille River Basin Progress Summary

The Watershed Planning Process and Public Participation

A Watershed Council was formed representing a diverse mix of stakeholders within the watershed. The Council members represent watershed constituents from various backgrounds including farmers, foresters, loggers, business owners, municipal officials, anglers, local watershed organizations, environmental groups, teachers, utility companies, regional planners, and a ski area. The DEC watershed coordinator and the Watershed Council developed the watershed plan and will assist in the implementation of watershed restoration projects. The Watershed Council met monthly to formulate a collaborative approach to resolving water quality issues of high priority. Council membership and attendance at these meetings was continually open to the public. Technical advisors provided the Council and watershed coordinator with information necessary to develop strategies to be included within the watershed plan.

Surface Water Typing and Classification

The basin plan must recommend surface water typing and classification to set management goals for all of the Lamoille basin's surface waters. Existing, attainable, and desired water quality criteria have been used to in the draft proposal. The Lamoille Watershed Council assisted DEC in developing a proposal for all waters within the watershed. DEC's watershed coordinator presented the proposal and updated Lamoille watershed planning activities to 16 selectboards within the watershed to solicit their recommendations.

Formation of a Volunteer Lamoille Watershed Organization

A grant was secured from the Lake Champlain Basin Program to hire a part time coordinator to form and lead a volunteer-based Lamoille Watershed Association.

Assessments

Stream Stability Assessments

Stream stability assessments have been completed for Lamoille, Caledonia, and Orleans County portions of the Lamoille River watershed sponsored by FEMA Project Impact and the four Natural Resource Conservation Districts located within the watershed. The assessments will be used to target unstable stream segments for flood remediation and infrastructure protection and to identify reference stream segments for protection. A watershed-wide stream stability assessment is also underway in the Browns River watershed (see below).

Lamoille River Buffer Inventory

Inventories of woody buffers were completed for the entire 85-mile Lamoille River. The inventory of buffer conditions will assist in future stream restoration and protection projects. The Lamoille, Chittenden, Northwest and Northeast Regional Planning Commissions with 604(b) funding conducted the inventories.

Erosion Hazard Map for the Towns of Wolcott and Craftsbury

A FEMA Project Impact-sponsored stream stability assessment has been completed in the Wild Branch watershed. The watershed stream stability assessment has determined the causes of stream instability and will prioritize protection, management, and restoration efforts. The Vermont Geologic Survey undertook this assessment to develop an erosion hazard map for the Towns of Wolcott and Craftsbury for future town planning guidance. The Wild Branch has been severely affected by flood events in the 1990s causing extensive damage to private and public infrastructure as well as aquatic habitat.

Bridge and Culvert Surveys

DEC's watershed coordinator provided training and project oversight for bridge and culvert surveys in the upper Lamoille (Caledonia and Orleans County portions of the watershed), Kenfield Brook, and Browns River sub-watersheds. Bridges and culverts were mapped and crossing structures assessed for structural integrity, fish passage, water quality, stream stability, and fish and wildlife habitat values. Several structures have been identified for replacement or upgrades. The Northeast Development Association, Vermont Fish and Wildlife Department, the Lamoille River Anglers Association, and Winooski Natural Resources Conservation District conducted the surveys.

Watershed Restoration Projects

Johnson State College Dam Removal and Stream Restoration

DEC's watershed coordinator assisted the college in removal of an in-stream dam located on campus. The dam was structurally unsound, hindered fish passage, and was responsible for sediment discharges. The dam removal project included the re-construction of the former natural stream channel.

Trees for Streams

DEC's watershed coordinator participated in several riparian buffer establishment projects along the Lamoille River and tributaries assisting the Lamoille River Anglers Association and Lamoille County Natural Resources Conservation District in its *Trees for Streams* program.

Wildlife Habitat Improvement Program

Two sites along the Lamoille River were enrolled in the WHIP program after site evaluations by DEC's watershed coordinator, the DEC River Management chief and NRCS district conservationist for Lamoille County. The team will design both passive and active stream restoration projects using the principles of natural channel design.

Impaired Waters Remediation Efforts

Deer Brook (Georgia)

Numerous site visits and meetings were held to identify and reduce nonpoint source pollutants to Deer Brook, which is an impaired stream. Georgia and Milton town officials, VTrans staff, and DEC technical staff from Wetlands, Stormwater, Planning, and Hydrology have been involved in this process. Stormwater best management practices and erosion control measures have recently been implemented to divert stormwater runoff to an intermittent stream and stabilize an eroding gully. VTrans has completed temporary repairs to an interstate culvert that has contributed to a discharge of iron to the stream. DEC is working with VTrans to secure funding for replacement of the failing structure. Additional sites were monitored for chemical and biological criteria in an effort to better bracket pollutant sources.

Mill Brook (Fairfax)

Mill Brook is impaired by sediment and nutrient pollutants. Sediment and nutrients from agricultural and industrial park activities and several gravel pit operations within the watershed appear to be the cause of the water quality impairment. Additional sites were monitored for chemical and biological criteria in an effort to better bracket pollutant sources.

A collaborative partnership has been developed between DEC and all relevant agricultural partners to formulate strategies to improve water quality in the impaired waters of Mill Brook due to agricultural activities. The Franklin County Natural Resources Conservation Districts hosted a public forum for watershed farmers discussing the impairments and voluntary cost share programs that are available.

The Composting Association of Vermont (CAV) and its partners were recently awarded a 319 grant to initiate a pilot-composting project. Initially, project partners will hold a series of local meetings to educate farmers in the Lamoille River basin on the benefits of composting their manure and managing their nutrients. Recruited farms will receive technical composting assistance throughout the project period. A special focus area, Mill Brook, with a relatively small watershed, has been chosen to enlist two to five farmers for on-farm composting.

Browns River (Chittenden County)

Two and a half miles of cropland will be converted to a filter strip along the Browns River through the Conservation Reserve Enhancement Program. Two grants, totaling $16,000, have been secured from the Lake Champlain Basin Program to undertake two levels of stream stability assessments of the entire watershed. A watershed assessment using the Agency of Natural Resources Phase 1 protocols was recently completed to identify existing stream conditions at the watershed scale using GIS tools and ground truthing methods. Partners include DEC, Williston NRCS staff, Winooski Natural Resource Conservation Districts, and Vermont Agency of Agriculture, Food and Markets, Chittenden County RPC, and municipal officials.

Unnamed tributary to the Brewster River (Cambridge)

Smugglers Notch Resort completed underground well monitoring to determine possible sources of pollutants to an impaired tributary to the Brewster River in Cambridge. Iron bacteria are having an impact on the waterway. The assessment has determined that the source of the iron discharge is from the adjacent road. A meeting between the resort, DEC's watershed coordinator, and VTrans took place last winter to proceed with remediation efforts. DEC's watershed coordinator assisted Smugglers Notch consultants in designing a small dam removal, stream restoration, and stream buffer establishment near the resort's main entrance.

Lamoille Rail Corridor
DEC's watershed coordinator and stream alteration engineer visited several sites along the Lamoille River adjacent to the Lamoille Rail Corridor with a VAST representative. They provided technical assistance for projects that will improve stream stability, remove flood plain encroachments, re-establish flood plain connection, increase woody riparian buffers, and provide for waterway crossings that effectively transport both stream flow and sediment for the proposed conversion of the former rail line to a recreational path.

Lakes and Ponds Issues
Eurasian water milfoil control and spread prevention
Milfoil was recently discovered on Lake Elmore. DEC has provided technical assistance to the Lake Elmore Association in an effort to control the spread of this aquatic nuisance species. The lake association has initiated an aggressive milfoil control program consisting of hand pulling techniques and the installation of bottom barriers.

Elimination of lake and pond draw downs
DEC's Watershed Coordinator, Hydrology Section, and Lakes and Ponds Section Chiefs negotiated with a municipal utility company to eliminate current water level fluctuations and draw downs on three lakes and ponds in the upper watershed. Reduction and elimination of these drawdowns will enhance aquatic biota and habitat.

Plans for 2004
Formation of a Volunteer Lamoille Watershed Organization
The formation of such a volunteer watershed organization was proposed in the spring of 2003. A part time, local Watershed Coordinator was hired to lead this organization.

Bridge and Culvert Assessments
Bridge and culvert assessments will continue at the sub-watershed level to identify structures that impede fish passage or contribute to stream instability.

Browns River
Initiate Phase 2 rapid geomorphic assessments throughout the watershed to determine the sources of instability and prioritize stream protection and restoration efforts. The stream stability assessment will begin in spring of 2004 using data collected during the recently completed GIS-level assessment. The condition of 30 stream reaches will be evaluated on the Browns River and major tributaries.

Mill Brook
Initiate targeted agricultural best management practices to improve water quality in cooperation with local landowners, DEC, AAF&M, NRCS, and Franklin County Conservation District.

Unnamed tributary to the Brewster River in Cambridge
Implement a remediation project on this waterway. Possible solutions include injections of lime into the soils to reduce acidity in which iron bacterium flourishes. DEC will continue assisting Smugglers Notch with removing a dam on this stream to further improve its water quality.

Riparian Buffer Initiative
The Lamoille County Natural Resources Conservation District's *Trees for Streams* buffer initiative has been funded for spring of 2004. Several thousand riparian tree seedlings have already been ordered for buffer plantings in the Lamoille River Watershed. The program will be expanded to include buffer implementation along lakes and ponds.

Eurasian water milfoil control and spread prevention
DEC will assist local lakes and ponds organizations, utilities, and state park employees in the implementation of invasive species watcher programs, outreach, spread prevention, and control efforts.

Watershed Plan Completion, Public Comments, Distribution and Submittal
The watershed plan will be completed, presented to the public, and submitted to the Secretary of ANR and the Water Resources Board for final approval. The Watershed Coordinator will work closely with the Watershed Council and various partners during this process. The surface water typing and classification management goals will be forwarded to the Water Resources Board for consideration and codification of proposed water classifications and water quality management types. Presentation of these proposals to most selectboards within the watershed will be completed as part of this process.

Morristown's Lamoille River Oxbow Park Initiative
DEC's watershed coordinator will work closely with the Morristown Conservation Commission in funding and developing a natural resource plan for the management of the Oxbow Park that will address streambank erosion, buffer plantings, possible re-location of recreation fields and the snow disposal site, outreach and education, and the initiation of a pilot composting project. The collaborative effort will also work together to the preserve access to Terrill Gorge, and initiate the replacement or upgrade of stream crossings in the Kenfield Brook watershed.

Basin 9 - White River Basin Progress Summary

The Watershed Planning Process and Public Participation
Background

DEC did not form a watershed council in the White River basin, but instead, based the plan on its collaborative work with the White River Partnership. The concept of a separate watershed council guiding the planning process in each watershed did not develop until after the work on the White River Basin Plan was well underway.

The White River Partnership formed in 1995 as a group of local citizens interested in preserving the quality of life in the White River Basin. It has become a forum for bringing together the community, local, state, and federal government agencies, and their resources to protect common interests.

To identify common interests or concerns in the community, the Partnership held a series of public forums in 1996. The public forum results and public input during the basin planning process provided the primary local concerns addressed in the White River Basin Plan. The primary concerns were as follows:

- Stream channel instability and streambank erosion
- Lack of awareness of water quality problems
- Extent and quality of public access to recreational opportunities on the water
- Impacts to fisheries

Public input during the basin planning process included four public forums on basin planning hosted by the White River Partnership in November/December 2000. During the forums, the basin planning process was discussed and over 125 attendees were asked to identify water quality problems in the basin and propose solutions. In January 2001, the DEC Watershed Coordinator summarized the input received and sent the summary to all attendees and town governments in the basin. A meeting with the agricultural community was also held in December 2000 in Randolph at the initiation of the planning process.

In the spring of 2001, individuals who attended the public forums, state agencies, federal agencies, local governments, and non-government entities participated in five focus groups based on the local concerns previously identified during the public forums in 1996 and 2000. The goal of each of the groups was to review and revise goals, objectives and strategies for resolving water quality problems.

DEC incorporated the work of the focus groups in the White River Basin Plan Working Draft. In September 2001, the draft was distributed widely to further engage the public in the continuing development of strategies.

Based on the public input, including four public hearings, the White River Basin Plan was revised, approved by the Secretary, and released in December 2002. A link to an electronic version of the plan can be found at the following address on the Water Quality Division's web site (http://www.vtwaterquality.org). In 2003, DEC formally submitted the typing and classification proposal for the basin to the Vermont Water Resources Board. Action on the proposal is pending.

Watershed Restoration Projects
River Restoration

The DEC River Management Program continues to work with the Partnership and the US Forest Service to assess and develop restoration plans for rivers in the basin.

Hartford Conservation Commission's Work

The DEC watershed coordinator continued to assist the conservation commission in drafting a water resources overlay district for the town's zoning regulations and provided technical information in support of the overlay district at two public hearings. DEC and the Department of Fish and Wildlife presented information on the importance of riparian buffers at a conservation commission sponsored workshop.

White River Partnership Water Quality Monitoring Project

The DEC watershed coordinator provided information to the White River Partnership to help develop an article on the results of the Partnership's *E. coli* testing program in the basin.

Outstanding Resource Waters
The DEC watershed coordinator provided information to an interested town official on the process for developing an Outstanding Resource Water proposal for a section of the White River and DEC's commitment to assist.

Buffer Restoration
The Department of Fish and Wildlife planted trees along portions of its riparian properties in the basin. DEC also plans to locate signs identifying these properties as state lands.

Erosion Hazard Maps
The Vermont Geologic Survey continues to work on erosion hazard maps for towns on the Third Branch. In addition, it has worked with the White River Partnership and the Two Rivers-Ottauquechee Planning Commission to discuss the process for helping towns use the maps.

Spawning Habitat Restoration
The Connecticut River Watershed Council is continuing its efforts to restore fish passage and spawning habitat to 2.5 miles of the First Branch of the White River by removing the Lower Eaton Dam.

Impaired or Altered Waters - Remediation Efforts
Cold Brook & Open Meadow Brook
The DEC watershed coordinator, NRCS, Vermont Agency of Agricultural, Food and Markets, and the White River Partnership discussed a process for addressing water quality problems in these two brooks. Staff from the Agency of Agriculture, Food and Markets and NRCS met with landowners in the basin to discuss opportunities to implement water quality improvement projects.

Adams Brook
The Natural Resource Conservation Service continues to work with several farmers on improvements in the formerly impaired Adams Brook watershed. Water quality monitoring indicates that the work with Vtrans and farmers has paid off. The stream now has met Vermont Water Quality Standards on two occasions and is a candidate for removal from the 2004 Section 303d list.

Plans for 2004
- Continued outreach with towns and the Regional Planning Commission.
- Continued efforts to secure grants and move forward on strategies in the basin plan.
- Continued collaboration with all partners in the basin on priority issues.
- Ongoing education and outreach with residents of the watershed. The focus will be on river dynamics and impacts from dams.
- Preparation and presentation to the Water Resources Board of the classification and typing proposal.

Basin 14 - Wells, Waits, Stevens and Ompompanoosuc River Basin Progress Summary

The Watershed Planning Process and Public Participation

Public Participation

Two public forums were held in the basin in late fall 2003 to discuss DEC's upcoming watershed planning initiative and recruit watershed stakeholders in forming local Watershed Councils.

Watershed Council Formation

A meeting of key stakeholders was held to make preliminary decisions on how Watershed Councils will be formed in the basin. Four separate Watershed Councils will be formed, each representing one of the four sub-watersheds within basin 14. Stakeholders included include, among others, NRCS St. Johnsbury and Berlin field office staff, Caledonia and White River NRCD directors, the Connecticut River Joint Commissions, Connecticut River Watershed Council, and Two Rivers, NVDA, and Upper Valley Regional Planning Commissions.

Assessments

Bridge and Culvert Survey

Funding has been secured to undertake a comprehensive bridge and culvert survey of structures within the Caledonia portions of the watershed. Assessments will identify structures that are impeding fish passage or contribute to stream instability. An educational component will be included using Lyndon State College engineering students. Lead partners also include DEC, Vermont Fish and Wildlife staff, and NVDA.

Plans for 2004

Watershed Councils and Watershed Plan Development

DEC's watershed coordinator and the four Watershed Councils within basin 14 will develop water quality improvement and protection strategies that will be incorporated into a single watershed plan.

Dam Inventory and Assessment

DEC's watershed coordinator will work with local partners to secure funding to undertake a comprehensive dam inventory and assessment. The results of the assessment will prioritize dams for removal or upgrades to enhance fish passage, water quality, and mitigate catastrophic failure during flood events.

Strafford Buffer Initiative

DEC's watershed coordinator will assist the Town of Strafford in the implementation of stream buffer initiative for the West Branch of the Ompompanoosuc River.

Watershed GIS-level Assessments

DEC will secure funding to initiate GIS-level stream stability assessments at the sub-watershed level. The GIS level assessment will delineate sub-watersheds and stream reaches, determine reference stream types and identify anthropogenic disturbances to the river channels and corridors.

Agricultural Best Management Practices (BMP's)

DEC will work closely with the Agency of Agriculture, Natural Resource Conservation Districts, and NRCS offices in identifying priority areas for agricultural BMPs within the Harveys Lake and Ticklenaked Pond sub-watersheds.

Junk Cleanup

DEC's watershed coordinator and various partners will initiate a cleanup of un-designated junkyards along river corridors throughout the basin. This issue has already been identified as a top priority at the preliminary public meetings.

Preservation of the Working Landscape

DEC's watershed coordinator will work with area regional planning commissions, land trusts, Vital Communities, Agency of Agriculture, and Natural Resource Conservation Districts in protecting working farm and forestlands through easement purchases. Agricultural lands and forests discharge far less non-point source pollution when compared to developed lands.

APPENDIX B

Vermont Point Source Control Program Update

Table B.1. Status of Phosphorus Removal/Reduction Projects.

Municipality	Construction Status	Comments
***** LAKE CHAMPLAIN DRAINAGE *****		
Barre City	completed	
Brandon	completed	
Burlington (North)	completed	
Burlington (Main)	completed	
Burlington (East)	completed	
Cabot	completed	
Castleton	completed	
Enosburg Falls (Phase 1 - chem)	completed	
Enosburg (Phase 2 - bio)	completed	
Essex Junction	completed	
Fair Haven	completed	
Hinesburg	completed	
Johnson	completed	
Middlebury	completed	
Milton	construction in 2005	
Montpelier (Phase 1)	completed	
Montpelier (Phase 2)	completed	
Morrisville	completed	
Northfield	construction underway	Completion 2005
Poultney	completed	
Richmond	construction underway	Completion 2005
Rutland City	completed	
South Burlington (Bartlett Bay)	completed	
South Burlington (Airport Parkway)	completed	
Shelburne (Plant #1)	completed	
Shelburne (Plant #2)	completed	
St. Albans City & NW Corrections	completed	
Stowe	completed	
Swanton	completed	

Municipality	Construction Status	Comments
Vergennes	completed	
West Rutland	completed	
Winooski	completed	
*** LAKE MEMPHREMAGOG DRAINAGE ***		
Barton Village	completed	
Newport City	completed	
Orleans	completed	

Table B.2. Construction Status - Combined Sewer Overflow (CSO) Projects.

Municipality	Construction Status	Comments
****** LAKE CHAMPLAIN DRAINAGE ******		
Brandon	completed	
Burlington	completed	
Enosburg Falls	completed	
Hardwick	completed	
Middlebury	completed	
Montpelier (Phase 1)	completed	
Montpelier (Phase 2)	started fall 1999	partially done; balance by 2004
Northfield	completed	
Poultney	completed	
Richford	underway by Village	
Rutland City (Phase 1)	completed	
Rutland City (Phase 2A)	construction 2004	completion 2006
Rutland City (Phase 2B)	pending	monitoring Phase 2A
Swanton	completed	
Vergennes	completed	
****** LAKE MEMPHREMAGOG DRAINAGE ******		
Barton	completed	project completed but overflow events still occur; evaluation study underway
Newport City	completed	
Orleans	completed	
****** CONNECTICUT RIVER DRAINAGE ******		
Bellows Falls	completed	
Hartford	completed	project completed but Order issued to abate remaining overflows
Ludlow	completed	
Lunenburg	completed	
Lyndon	completed	
Randolph	construction underway	completion 2005
Springfield (Phase 1)	complete	
Springfield (Phase 2)	initiate 2004	completion by 2006

Municipality	Construction Status	Comments
St. Johnsbury (Phase 1)	complete	
St. Johnsbury (Phase 2)	initiate spring 2004	
St. Johnsbury (Phase 3A)	initiate spring 2005	
St. Johnsbury (Phase 3B)	initiate spring 2006	
St. Johnsbury (Phase 4)	initiate spring 2007	
Wilmington	completed	
Windsor	completed	

Appendix C

Assessment & Listing Methodology

2004

VERMONT SURFACE WATER ASSESSMENT METHODOLOGY

including

VERMONT LISTING METHODOLOGY

In accordance with
USEPA 2004 Guidance

Prepared by:
Vermont Department of Environmental Conservation
Water Quality Division
103 South Main Street
Building 10 North
Waterbury, VT 05671
802-241-3770 or -3777
www.vtwaterquality.org

May 12, 2004

Table of Contents

Executive Summary

Chapter One. **Introduction to Surface Water Assessment Methodology.....5**

Chapter Two. **Vermont Water Quality Standards.....6**
2.1. Overview
2.2. Surface Water Classification and Typing

Chapter Three. **Monitoring Designs for Surface Water Assessment Purposes.....8**
3.1. Rotational Watershed Assessment Approach
3.2. Fixed Station Monitoring Approach
3.3. Probability-based Monitoring Approach
3.4. Special Studies and TMDL-related Studies

Chapter Four. **Surface Waters Assessment Methodology.....12**
Part I. 2004 Overall Methodology
1. Overview & Data Sources
2. Biological Monitoring and Assessments
3. Stream Geomorphic Assessment
4. Data Solicitation
5. Data Quality
6. Statistical Analyses
7. Vermont Surface Water Assessment Categories

Part II. Assessment Use Support Determinations
1. Aquatic Biota/Habitat (Aquatic Life) Use
2. Fish Consumption Use
3. Swimming/Contact Recreation Use
4. Secondary/Non-Contact Recreation Use
5. Drinking Water Supply Use
6. Aesthetics Use
7. Agricultural Water Supply Use

Chapter Five. **Listing and De-Listing Methodologies.....28**
5.1. Impaired Waters
5.2. Altered Waters
5.3. Stressed Waters
5.4. Full Support Waters
5.5. Comparison to EPA's Listing Categories

Chapter Six. **References.....34**

Appendix A **Listing of Water Quality Division Monitoring Programs**

Executive Summary

The federal Water Pollution Control Act, also known as the Clean Water Act, requires the State of Vermont and each of the other forty-nine states to develop and submit to the US Environmental Protection Agency two surface water quality-related documents. The documents, to be prepared every two years, arise out of two sections of the Act. Section 305b of the Act requires submittal of a report that describes the quality of the State's surface waters and that contains an analysis of the extent to which its waters provide for the protection and propagation of a balanced population of fish, shellfish and wildlife. This analysis is also referred to as the extent to which Vermont's waters achieve the Act's fishable and swimmable goals. The biennial Vermont Water Quality Assessment Report is commonly known as the "305b Report."

The second document, developed in response to Section 303d of the Act, is a listing of surface waters that:

1) are impaired or threatened by one or more pollutants; and,
2) are not expected to meet Water Quality Standards within a reasonable time even after the application of best available technology standards for point sources of pollution or best management practices for nonpoint sources of pollution; and,
3) require development and implementation of a pollutant loading and reduction plan, called a Total Maximum Daily Load, which is designed to achieve Water Quality Standards.

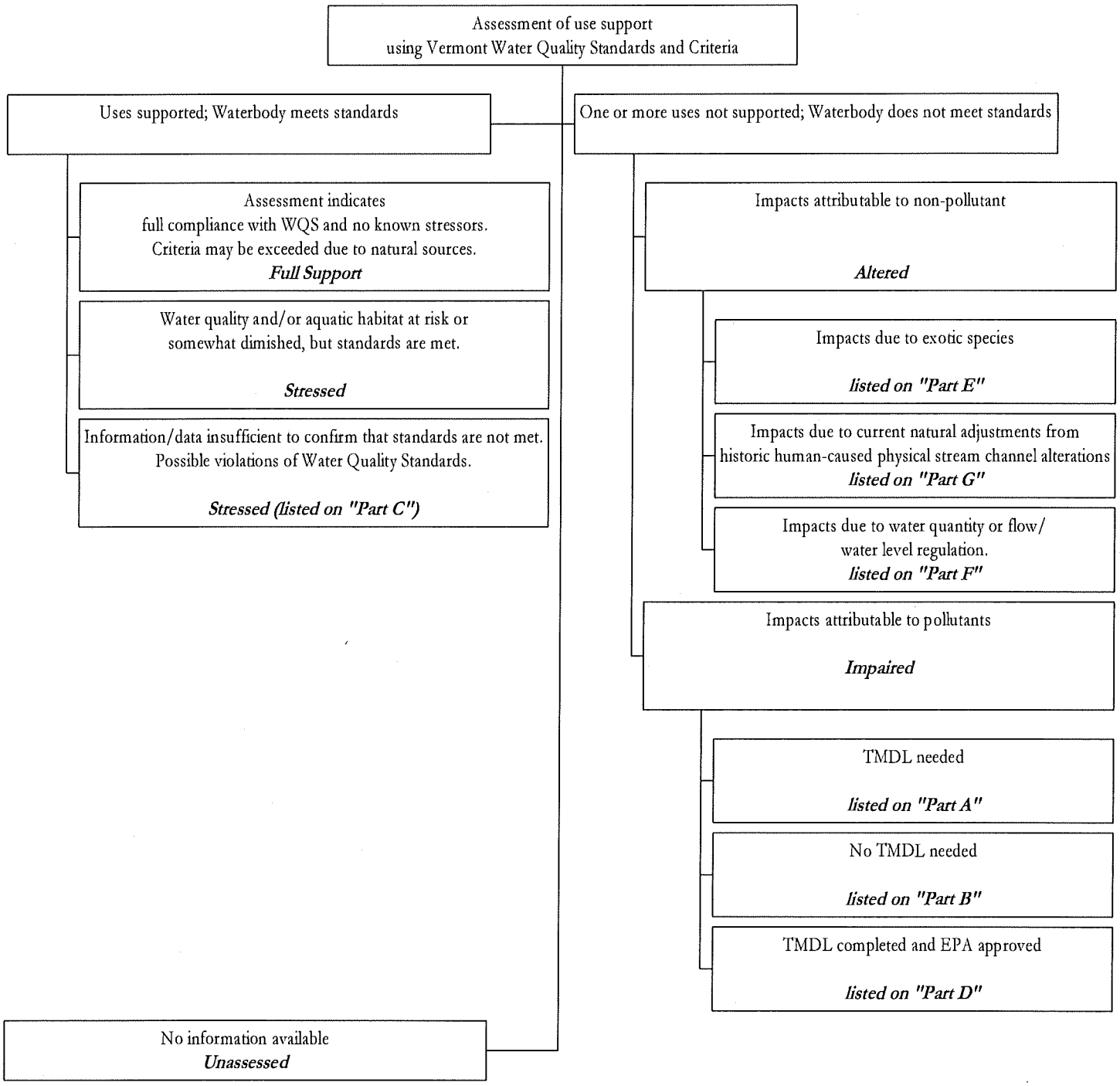
The collection, analysis and evaluation of water quality monitoring data and other information represent the assessment of a water's condition. The assessment of a water is most accurate when judgements about the water's condition are made using chemical, physical and/or biological data of known reliability collected through monitoring. While not as reliable as data collected though monitoring, an assessment of a water's condition can also take into account opinions, observations or other qualitative information.

The Vermont Water Quality Standards, periodically revised and promulgated by the Vermont Water Resources Board, provide the basis used by the Vermont Department of Environmental Conservation in determining the condition of surface waters including whether the water meets (attains) or does not meet (exceeds or violates) certain criteria. The assessment of a water's condition within the context of the Water Quality Standards requires consideration of the water's classification and management type, a variety of designated or existing uses, and a series of criteria which can be numerical or narrative. The outcome of an assessment conducted by the Department is to categorize Vermont's surface waters as either "full support," "stressed," "altered," or "impaired." Over time, the Department is gradually reducing the number of waters characterized as "unassessed."

This document describes the process used by the Department of Environmental Conservation when making water quality attainment decisions to fulfill 305b reporting and 303d listing requirements. The document contains an overview of the Water Quality Standards (Chapter 2); a description of water quality monitoring approaches that are utilized and their linkage to assessment efforts (Chapter 3); the four assessment categories and the factors and decision principles applied when evaluating data and other information to determine if a water meets the Standards (Chapter 4); and, the rationale when deciding where and how to list a particular water (Chapter 5). The chart that appears on the following page illustrates the major components of VTDEC's assessment and listing process.

This document has been the subject of a public meeting conducted by VTDEC on March 30, 2004 and held in Waterbury, Vermont. A three-week period for comment followed the meeting and a comment responsiveness summary was developed. The responsiveness summary can be obtained upon request.

Chart Depicting Organization of Vermont's Water Quality Assessment and Listing Methodology



Chapter One. Introduction to Surface Water Assessment Methodology

The Vermont Department of Environmental Conservation is charged with implementing the Vermont Water Quality Standards. As part of this responsibility, the Department must characterize the quality of Vermont's surface waters and determine what factors or stressors may be bringing about observed changes. In Vermont and nationwide, significant emphasis is placed on how the condition of surface waters is determined and whether waters are in compliance with the applicable water quality standards. The methods used for making these determinations are important as the determination of whether the waters meet or do not meet the water quality standards informs and directs water quality management strategies for each waterbody and may lead to significant regulatory consequences. It is essential that determinations are accurate and defensible.

Surface water assessment is part science and part careful observation of the causes of the measured conditions. Assessment begins with an examination of the water's chemical, physical and biological condition, and the causality of the conditions observed. Data is used to estimate the water quality standards "attainment status"of waters. Selecting representative data with known and quantifiable precision is the first step in assessing standards attainment. If a waterbody is determined not to attain one or more criteria of the Vermont Water Quality Standards, then it is first necessary to determine whether or not the impact to the surface water is of natural or anthropogenic origin. Identifying the actual cause of impairment will also have considerable bearing on decisions about what approach to initiate to restore the waterbody. The Department studies what is unique about a waterbody to enable it to rank restoration and protection activities and to understand how waterbodies will respond to management actions. The Department also seeks to provide avenues for Vermont's citizenry to contribute in a meaningful way to the protection and improvement of waters.

This document is part of the year 2004 biennial water quality assessment reporting and listing process. The document explains how the Vermont Department of Environmental Conservation (VTDEC) carries out surface water quality monitoring and assessment activities and how it makes decisions on a regular basis regarding a water's condition based on the Vermont Water Quality Standards. It also describes how VTDEC considers certain factors and how VTDEC makes decisions when interpreting the meaning of samples and observations obtained through monitoring efforts, whether monitoring information is generated by VTDEC or by others. This document does not describe VTDEC's broad array of monitoring programs.

Throughout the Assessment and Listing Methodology document, the terms "waters" and "water resources," are used generically and mean lakes and ponds, streams and rivers, wetlands and even watersheds. The Department does not conduct or carry out any systematic monitoring on many types of waterbodies including wetlands, vernal pools, lakes and ponds less than five acres, closed trout waters, rivers and streams not considered "wadeable," ephemeral or intermittent streams. This Assessment and Listing Methodology document is evolving and reflects the ever-improving methods available for water quality monitoring and interpretation. Vermont's citizenry, Federal and academic collaborators, and regulated entities are encouraged to view the Assessment and Listing Methodology with an eye towards where and how they can improve or add to the quality of data and other information used to understand, protect, and improve Vermont's water resources.

Chapter Two. Vermont Water Quality Standards

2.1. Overview

The Vermont Water Quality Standards are the foundation for the state's surface water pollution control and surface water quality management efforts. The Water Quality Standards (Standards or WQS) are promulgated by the Vermont Water Resources Board and provide the specific criteria and policies for the management and protection of Vermont's surface waters. The classification of waters (rivers, streams, lakes and ponds) as Class A, Class B or Class B with Waste Management Zone are the management goals to be attained and maintained. The classification also specifies the designated water uses for each class. The current Vermont WQS were adopted June 10, 1999 and became effective July 2, 2000.

The Vermont WQS establish narrative and numeric criteria to support designated and existing uses. Designated uses, as established in Sections 3-02(A), 3-03(A) and 3-04(A) of the Standards, mean any value or use, whether presently occurring or not, that is specified in the management objectives for each class of water. The following table serves to indicate applicable designated uses.

Table 2.1. Designated Uses for Water Classifications.

Designated Uses	**Class A(1) – Ecological Waters**	**Class A(2) – Public Water Supplies**	**Class B Waters**
Aquatic Biota, Wildlife & Aquatic Habitat	√	√	√
Aesthetics	√	√	√
Swimming & Other Primary Contact Recreation	√		√
Boating, Fishing & Other Recreation Uses	√		√
Public Water Supplies		√	√
Irrigation of Crops & Other Agricultural Uses			√

Existing uses of waters and the level of water quality necessary to protect those uses is to be maintained and protected regardless of the water's classification. Existing water uses are those uses which have actually occurred on or after November 28, 1975 in or on a waterbody whether or not the uses are included in the standard for classification of the particular waterbody and whether or not the use is presently occurring. Determinations of what constitute existing uses of a particular water are made either during the basin planning process or on a case-by-case basis during consideration of an application by the Secretary of the Vermont Agency of Natural Resources (VTANR). In making a determination of existing uses, the VTANR shall consider at least the following factors:

a) aquatic biota and wildlife that utilize or are present in the waters;
b) habitat that supports existing aquatic biota, wildlife, or plant life;
c) the use of the waters for recreation or fishing;
d) the use of water for water supply, or commercial activity that depends directly on the preservation of an existing high level of water quality; and,
e) with regard to the factors considered under paragraphs (a) and (b) above, evidence of the use's ecological significance in the functioning of the ecosystem or evidence of the use's rarity.

Chapter Four of this Assessment Methodology describes VTDEC's approach towards assessing the level of support of these designated and existing uses, in light of the criteria established in the Water Quality Standards.

2.2. Surface Water Classification & Typing

All surface waters in Vermont are presently classified either Class A or Class B. Waters designated as Class A(1) are Ecological Waters, managed to maintain an essentially natural condition. Waters designated as Class A(2) are Public Water Supplies. There may be a change from the aquatic biota, wildlife and aquatic habitat reference condition due to the fluctuations in reservoir water level and in the reduction in streamflow that result from water withdrawals for water supply purposes.

Class B waters comprise approximately 97% of all waters in the State. Class B waters are managed to achieve and maintain a level of quality that is compatible with designated uses. The Standards contain a requirement that all Class B waters shall eventually be designated as Water Management Type B1, Type B2 or Type B3. In designating a Water Management Type, the Vermont Water Resources Board must take into account attainable uses and the level of water quality already existing. Recommendations for Water Management Typing are developed during VTDEC's basin planning process. Once a basin plan is adopted by the Secretary of VTANR, a petition for classification and Water Management Typing is prepared by VTDEC and submitted to the Water Resources Board for their consideration and adoption.

IMPORTANT NOTE: This chapter and its two sections are meant to provide only a summary overview of the Water Quality Standards. Readers seeking additional and more detailed information about the Vermont Water Quality Standards, management objectives, specific criteria, classifications, and water management typing are encouraged to reference the Water Quality Standards. Copies of the Standards may be obtained from the Water Resources Board or from the Water Quality Division. Persons may also access the Standards by visiting the web site of the Vermont Water Resources Board (refer to www.state.vt.us/wtrboard, click on "Rules").

Chapter Three. Monitoring Designs for Surface Water Assessment Purposes

There is no single way, on a statewide and ongoing basis, to assess the water quality conditions of every Vermont surface water in the context of the Water Quality Standards.[1] Consequently, the VTDEC water quality assessment methodology relies on a number of monitoring designs and approaches to determine the status of use support. This chapter provides a brief description of the four principle assessment approaches used by VTDEC. An abbreviated description of monitoring efforts conducted by the Water Quality Division and by its partners is described in Appendix A.

3.1. Rotational Watershed Assessment Approach

For the purposes of water quality management planning and implementation, which includes assessing and reporting water quality information, Vermont has been divided into seventeen major river drainage basins. Each major basin has from four to twenty-two river sub-basins or river mainstem segments. These sub-basins and mainstem segments and the various lakes and ponds are known as "waterbodies." There are a total of 208 river and stream waterbodies (37 as mainstem segments) and 574 lake and pond waterbodies designated throughout Vermont.[2] The seventeen major river basins are located in one of the four large regional drainages: Lake Champlain, Connecticut River, Lake Memphremagog, or Hudson River. The seventeen basins are presented in Figure 3.1 below.

In order to more comprehensively and thoroughly assess the State's surface waters and to take advantage of all existing and readily available sources of water quality information[3], the VTDEC Water Quality Division has designed and is carrying out a rotational watershed assessment process such that lakes, ponds, rivers and streams of all seventeen major basins are evaluated once every five years. To the extent possible, wetland function and value assessments also follow this rotation schedule. By focusing evaluations on selected basins each year, more systematic and intensive efforts can be made to collect and evaluate information related to the sources and causes of pollution. A focus on a limited number of watersheds also provides the opportunity for VTDEC to identify water quality trends, involve the general public and provide avenues for interagency coordination.

The rotation and schedule for each basin assessment is shown in Figure 3.1 below. The criteria used to determine which basins would be assessed in each year of the five-year cycle includes:

- Basins from more than one of the four regional drainage areas of the state (Lake Champlain, Connecticut River, Lake Memphremagog, Hudson River) are represented each year with special attention to including at least one Lake Champlain basin and one Connecticut River basin in most years;

- The sum of the basin areas assessed during any given year are roughly equivalent;

- The order of assessments in the next five-year cycle reflects known projects where an assessment is needed or where projects or major assessment studies are occurring (examples of projects needing assessment include hydroelectric facility re-licensing, basin planning with respect to point and nonpoint phosphorus reduction, and municipal wastewater facility upgrades or enlargements); and

- The order of the assessments considers watershed planning taking place in the adjacent jurisdictions of Massachusetts, New Hampshire, New York and the Province of Quebec.

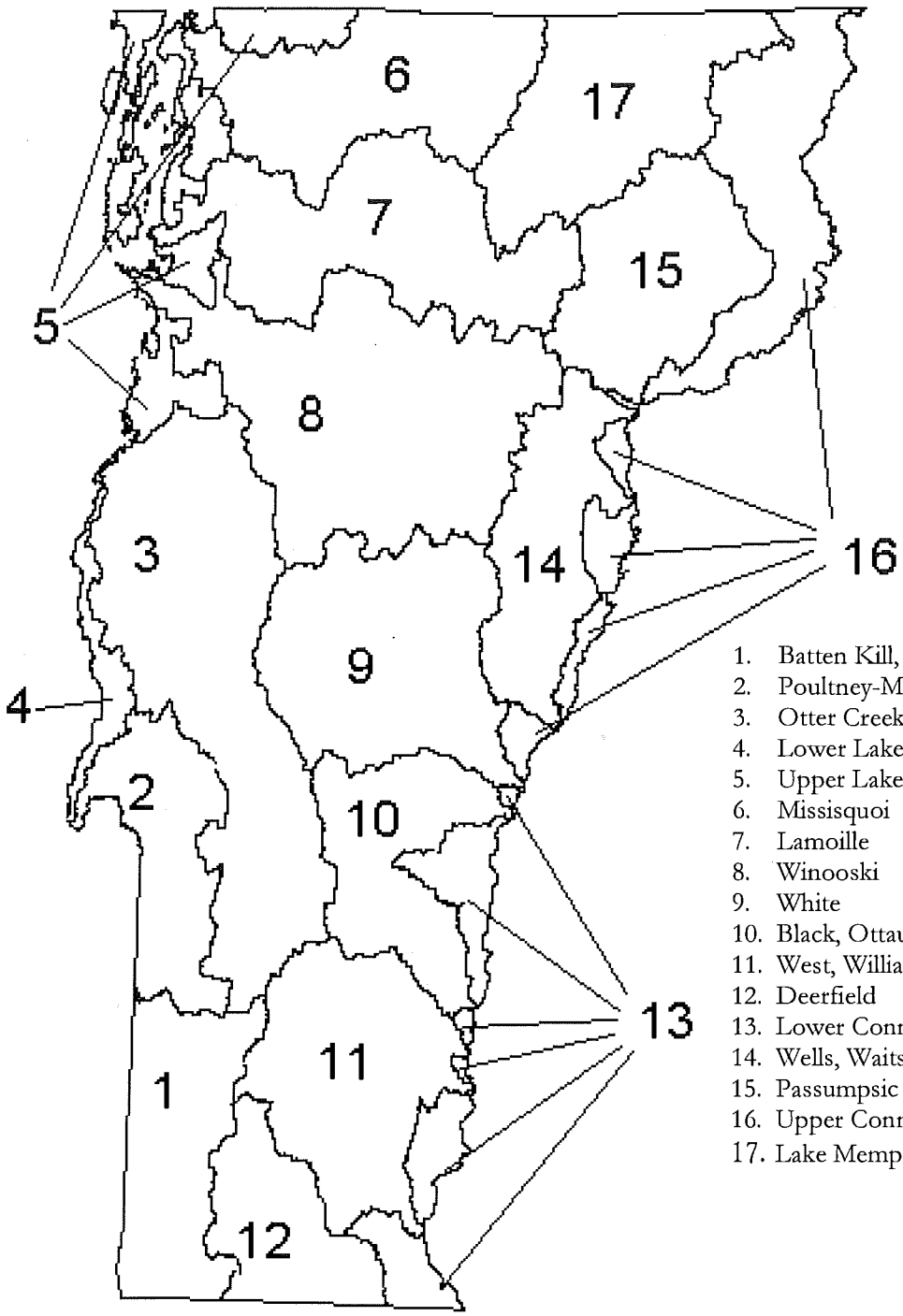
---

[1] Within Vermont there are some 7,100 miles of rivers and streams, about 230,800 acres of lakes and ponds and over 300,000 acres of wetlands. Many wetlands contain standing water for only a portion of the year.

[2] A 21.5 inch by 16.5 inch map showing river basins with surface waterbodies can be obtained from the Water Quality Division.

[3] For the predominant sources of data used in this regard, refer to the listing appearing on page 12.

Vermont's Major River Basins



1. Batten Kill, Hoosic, Walloomsac 2003-04
2. Poultney-Mettowee 2002-03
3. Otter Creek 2001-02
4. Lower Lake Champlain direct 2001-02
5. Upper Lake Champlain direct 2004-05
6. Missisquoi 2004-05
7. Lamoille 2002-03
8. Winooski 2005-06
9. White 2001-02
10. Black, Ottauquechee 2002-03
11. West, Williams, Saxtons 2003-04
12. Deerfield 2003-04
13. Lower Connecticut 2003-04
14. Wells, Waits, Ompompanoosuc 2002-03
15. Passumpsic 2005-06
16. Upper Connecticut 2005-06
17. Lake Memphremagog 2004-05

Figure 3.1. Vermont's 17 major river basin groupings with rotation assessment schedule.

Under the rotational watershed assessment process, VTDEC staff compile and evaluate all water quality and aquatic habitat data and information and determine impacts to designated and existing uses. This process relies on data and supporting information that is considered to be reliable whether collected from VTDEC, other water-related agencies, schools/colleges/universities or citizen-based groups. Once the data and other information for each waterbody in a particular basin is assessed, a basin assessment report is prepared. The information contained in each basin assessment report is an early and vital piece of the basin planning process. The assessment results are the first up-to-date overview of the conditions and issues in the basin and its watersheds. Following completion of the basin assessment report, the basin planning process can stimulate more detailed assessments, propose re-classifications and/or typing, or outline protection or restoration activities that could be incorporated in a river basin water quality management plan. As of the date of this document, an assessment report has been prepared for 11 of the 17 basins (refer to Table 3.1 below).

Table 3.1. Drainage Basin Areas with Completed Rotation Assessment Reports.

Basin Number	Basin Name	Report Completion
1	Batten Kill, Walloomsac, Hoosic	August 2002
2	Poultney, Mettowee	December 1999
3	Otter Creek, Little Otter, Lewis Creek	June 1998
5	Upper Lake Champlain direct	December 2003
7	Lamoille	February 2001
9	White	November 1997
10	Ottauquechee, Black	June 2000
11	West, Williams, Saxtons	November 2001
12	Deerfield	March 2003
13	Lower Connecticut	April 2002
14	Waits, Wells, Ompompanoosuc	April 1999

3.2. Fixed Station Monitoring Approach

VTDEC coordinates a large number of fixed-station monitoring projects, incorporating river and lake water quality projects. Projects considered as fixed station in Vermont are long-term, recurring efforts that VTDEC has operated (or intends to operate) for several years. Some of these projects, such as the Ambient Biomonitoring Network and Lake Assessment Program (both of which incorporate several individual monitoring projects and studies) achieve dense statewide spatial coverage. The total number of river/stream and lake monitoring stations established under these two well-established programs exceed 1,500 and 650, respectively.

Fixed-station monitoring also includes monitoring done by other groups, schools or agencies. To be considered a part of the fixed-station approach, VTDEC must have knowledge of the particular monitoring plan (e.g. sampling site location, sampling frequency, parameters being collected and tested). Data generated by these other fixed-station monitoring efforts must have a quality assurance plan in order for VTDEC to characterize the data as reliable.

VTDEC's and the other fixed-station monitoring networks are designed to assess the status of current water quality conditions and to detect trends or changes in water quality condition. One of Vermont's major lake monitoring programs is a fixed-station, volunteer-based initiative. A listing of fixed station monitoring projects done by the Water Quality Division is provided in Appendix A.

3.3. Probability-based Monitoring Approach

Probability surveys are useful when determining statewide water quality conditions in regard to some uses and are appropriate for statistically estimating use attainment levels on a resource-wide basis (typically statewide or basin-wide). VTDEC recognizes the value of probability-based monitoring initiatives especially where predictability of use attainability is inherent in the project design. Such designs permit the use of statistically-derived models for inferring use attainment in appropriately selected waters where sampling was not performed. The on-going Regional Environmental Monitoring and Assessment Project (REMAP) assessment of mercury in waters, sediments, and biota of Vermont and New Hampshire lakes is a good example of one such project.

VTDEC believes, however, that probability-based surveys are of limited utility and of lower value where prediction outside the sample frame is not inherent in the project design, despite the benefits of bias-free, resource-wide attainment information. Accordingly, VTDEC strives to maximize the benefits of probability-based surveys by working only on those survey efforts in which there is confidence that a predictive system can be part of the outcome. Following this logic, VTDEC has undertaken four probability-based projects in collaboration with the New England regional office of US Environmental Protection Agency (EPA Region 1) in recent years and is planning to participate in a fifth project in the near future.

The probability-based monitoring surveys VTDEC has implemented or had some level of involvement with include:

- A REMAP assessment of mercury concentration in sediments, waters, and biota of 46 Vermont lakes and 47 New Hampshire lakes using a spatially randomized design (1998-2003).
- Characterization of use attainment for aquatic life using a spatially randomized draw of existing Ambient Biomonitoring Network data at varying site intensities (2001). The reader is referred to the Vermont 2002 Section 305b Report for a further description of this effort.
- A REMAP assessment of aquatic life use attainment in New England Wadeable Streams (2002-2006).
- Participation in the National Study of Chemical Residues in Fishes (2002-2005).

Other probability-based monitoring surveys that VTDEC considers appropriate in the future for determining use attainment on a statewide or basin-wide level, where predictability is an anticipated outcome of the project, are as follows:

- Development of a reproducible, indicator-based assessment of fish tissue contaminants (primarily mercury) across Vermont. Using lessons learned from the 1998-2003 REMAP assessment of mercury in waters, sediments and biota project (see below), the sampling units selected for such an assessment should be stratified by trophic state, acidity, and degree of water level manipulation.
- Assessment of aquatic life use support inferred by physical, chemical, habitat, and biological data for lakes across Vermont. (Note: this project is in the planning and development stages as a regional REMAP project, to occur 2004-2006).
- Assessment of sediment-based toxics in large-order rivers and developed lakes.

3.4. Special Studies and TMDL-related Studies

VTDEC undertakes monitoring associated with special and Total Maximum Daily Load (TMDL) studies as needed, in response to compelling data and information supplied under the rotational assessment and fixed-station and probability-based projects. The number and nature of special studies is commonly dictated by the nature of issues and problems that are reported as needing further monitoring or that may arise as interest or funding permit. These types of studies include detailed sampling to assess use support or standards violations, diagnostic-feasibility studies, effectiveness evaluations of pollution control practices/measures and watershed-based surveys and evaluations. TMDL studies are scheduled as needed consistent with the timeline established in Vermont's 303d List of Waters and dependent on available resources.

Chapter Four. Surface Waters Assessment Methodology

Part I. 2004 Overall Methodology

1. Overview and Data Sources

The assessment process involves identifying, compiling and evaluating all existing and readily available water quality data and information as well as evident point and nonpoint source pollution impacts on designated and existing uses specific to the basins and waters being assessed in any given year. The data and other information are maintained in databases specifically designed to be consistent with EPA's current Assessment Database package. Vermont relies on the following sources of reliable data and information when assessing use support:

1) VTDEC Water Quality Division (monitoring data)
2) VTDEC Wastewater Management Division (National Point Source Discharge Elimination System permit compliance, indirect discharge permit compliance, residuals management)
3) VTDEC Waste Management Division (solid and hazardous waste sites monitoring data)
4) VTDEC Geology and Mineral Resources Division (fluvial and surficial mapping, hazard identification)
5) VTDEC Water Supply Division (surface drinking water supplies water quality data)
6) VTDEC Laboratory Services at the R.A.LaRosa Laboratory (quality assurance, analytical services, pollutant data)
7) Vermont Agency of Natural Resources Enforcement Division (violations of water quality standards)
8) Vermont Department of Fish & Wildlife (data on game fish and temperature, habitat studies)
9) Vermont Department of Health (beach closure information, fish consumption risk assessments)
10) Vermont Department of Forests, Parks, and Recreation (bacteriological testing, beach closure information)
11) Vermont Agency of Agriculture, Food and Markets (agricultural water quality violations)
12) Vermont Regional Planning Commissions (known locations of problems)
13) US Department of Agriculture, Natural Resource Conservation Service (agricultural nonpoint sources, locations of pollution abatement projects)
14) Citizens and citizen associations (citizen monitoring data, location of sources, complaints)
15) US Geological Survey Water Resources Division (monitoring and research)
16) US Forest Service (fish habitat and water quality data and information)
17) US Environmental Protection Agency (monitoring and research)
18) US Army Corps of Engineers (environmental assessments of project waters)
19) University of Vermont, Vermont State Colleges System and other colleges (monitoring and research)

The VTDEC River Management and Biomonitoring and Aquatic Studies Sections provide much of the data used in the assessment of monitored river miles. The VTDEC Lakes and Ponds Management and Protection Section provides much of the data used in the assessment of monitored lake acres. The other sources noted immediately above provide fewer and less widespread, but nevertheless important, data points.

2. Biological Monitoring and Assessments

Assessment of biological integrity is conducted on the state's rivers and streams for the purpose of trend detection and site-specific impact evaluation. Macroinvertebrate and/or fish populations of rivers and streams considered to be "wadeable" are assessed by comparing a series of biometrics measuring community structure and function to a set of biocriteria that represent the biological potential for the ecoregion/habitat being evaluated. The biomonitoring activities carried out by VTDEC can be placed into three categories; 1) long-term monitoring of reference level sites, 2) site-specific impact evaluations and 3) statewide probability-based surveys.

Individual site surveys and subsequent processing steps are detailed in *"Methods for Determining Aquatic Life Use Status in Selected Wadeable Streams Pursuant to Applicable Water Quality Management Objectives and Criteria for Aquatic Biota Found in Vermont Water Quality Standards (WQS) Chapter 3, Section 3-01, as well as those specified in Section 3-02(A1 and B3), Section 3-03(A1 and B3), and Section 3-04(A1 and B4, parts a-d)"* (a.k.a. biocriteria procedure). Using the biocriteria procedure, the integrity of the aquatic biota inhabiting the sites in question is attributed a rank of excellent, very good, good, fair or poor. Rankings are indicative of aquatic life use support status for each water quality classification and water management type.

DEC has no specific protocol for determining what assemblage to sample at a site. VTDEC attempts to sample both fish and macroinvertebrate assemblages at all sites that it evaluates for biologic condition. However, DEC does not require both assemblages fail to meet aquatic life support expectations in order to declare support or non-support of aquatic life uses. Decisions not to assess one or the other assemblage are most usually based on the availability (or lack) of appropriately representative habitat at the assessment site, although available resources are sometimes a factor as well. In situations where data are available from only one assemblage, DEC uses best professional judgement to determine whether or not those data are representative of the biologic condition at the assessment site prior to making aquatic life support decisions. If yes, a decision is made; if no, additional information or data are gathered.

The biological potential for various sites is established through statewide reference site monitoring. Information from this program element also serves to refine existing biocriteria and detect trends in baseline biological integrity. The long-term goal of reference site monitoring is to gather information on a set of known reference sites on a 5-year rotating basis, so as to generate five years of continuous data for each site. Sites are stratified across stream ecotypes differing in drainage area size, elevation, and alkalinity. Human activity in reference site drainages is considered to be minimal relative to other streams in the ecoregion.

Where site-specific impact assessments are conducted (including an evaluation of the appropriate chemical and physical data), potential pollution sources that are not of natural origin are spatially bracketed (i.e. above and below) with sample sites to determine effects on the aquatic biota attributable to the pollution source. Either macroinvertebrate or fish populations or both may be sampled. Approximately 50 river sites are assessed each year in the late summer-early fall (September to October 15) on a five-year rotational watershed basis. VTDEC has evaluated over 1,200 sites since 1990.

The Department implements biocriteria only when appropriate reference conditions have been described. The Department recognizes differences between biological expectations for different waterbodies including lakes and ponds, wetlands, large and small rivers and perennial and intermittent streams. Biological management decisions are made accordingly.

Until recently, very little biological assessment data has been available for lakes, except for a rather comprehensive, long-term database describing the distribution of aquatic macrophytes in lakes. Past assessments often relied on qualitative observations of habitat conditions, in some cases using the aquatic macrophyte data. VTDEC, with cooperative funding from EPA, is now finalizing a multi-metric biological index based on phytoplankton communities, and is also developing a multi-metric index to describe the condition of macroinvertebrate communities within lakes. It is anticipated that future aquatic life use assessments will be more directly based on biological data for phytoplankton, macrophyte, and macroinvertebrate assemblages. Where data are available, results of phytoplankton, macrophyte, and macroinvertebrate community assessments are being incorporated into the assessments of individual lakes. As part of the cooperative agreement with EPA, a lake biological criteria implementation procedure should be finalized as early as 2005. Macroinvertebrate and amphibian community indices are

also currently being evaluated for use as indicators of aquatic life use support for selected types of wetlands.

3. Stream Geomorphic Assessment

Data collected during stream geomorphic assessments according to recognized procedures provide a better understanding of the physical processes and features shaping a watershed; help characterize erosion and flood hazards; help identify high quality habitat; and contribute to understanding the effects of watershed land use activities on stream condition.

The VTDEC stream geomorphic assessment program objectives are:

1) To create a data collection protocol for the physical assessment of streams and rivers that is scientifically sound and produces repeatable results, so that data can be compared not only within a watershed, but also between watersheds and regions.
2) To create a state Geographic Information System (GIS) and database system of fluvial geomorphic data that is accessible to users inside and outside the Agency of Natural Resources.
3) To create a method for predicting stream channel and flood plain evolution in Vermont that will technically support the resolution of river/land use conflicts and allow for sound land use practices and planning at the watershed scale.
4) To create a geomorphological river assessment methodology that will help lay people understand how human activities over time within a watershed can be conducted in a manner that is both ecologically and economically sustainable.

The Vermont Stream Geomorphic Assessment Protocols (VTDEC, 2003b) help river planners and managers take the first steps in applying channel form, adjustment process, and channel evolution data by providing a method for assigning a geomorphic and physical habitat condition to stream reaches. The term "departure from reference" is used synonymously with stream geomorphic condition throughout the protocols. The degree of departure is captured by the following three terms:

In Regime – a stream reach in *reference and good* condition that:

- Is in dynamic equilibrium which involves localized change to its shape or location while maintaining the fluvial processes and functions of its watershed over time and within the range of natural variability; and
- Provides high quality aquatic and riparian habitat with persistent bed features and channel forms that experience periodic disturbance as a result of erosion, deposition, and woody debris.

In Adjustment – a stream reach in *fair* condition that:

- Has experienced changes in channel form and fluvial processes outside the expected range of natural variability; may be poised for additional adjustment with future flooding or changes in watershed inputs that would change the stream type; and
- Provides aquatic and riparian habitat that may lack certain bed features and channel forms due to increases or decreases in the rate of erosion and deposition-related processes.

Active Adjustment and Stream Type Departure – a stream reach in *poor* condition that:

- Is experiencing adjustment outside the expected range of natural variability; is exhibiting a new stream type; is expected to continue to adjust, either evolving back to the historic reference stream type or to a new stream type consistent with watershed inputs; and
- Provides aquatic and riparian habitat that lacks certain bed features and channel forms due to substantial increases or decreases in the rate of erosion and deposition-related processes. Habitat features may be frequently disturbed beyond the range of many species' adaptability.

Phase 1 of the VTDEC protocols is the remote sensing phase and involves the collection of data from topographic maps and aerial photographs, from existing studies, and from very limited field studies. Geomorphic reaches and provisional reference stream types are established based on valley land forms

and their geology. Predictions of channel condition (departure from reference), adjustment process, and reach sensitivity are based on evaluations of watershed and river corridor land use and channel and floodplain modifications.

Phase 2 of the VTDEC protocols is known as the rapid field assessment phase and involves the collection of field data from measurements and observations at the reach or sub-reach (segment) scale. Existing stream types are established based on channel and floodplain cross-section and stream substrate measurements. Stream geomorphic condition, physical habitat condition, adjustment processes, reach sensitivity, and stage of channel evolution are based on a qualitative field evaluation of erosion and depositional processes, changes in channel and floodplain geometry, and riparian land use/land cover. At least Phase 1 and Phase 2 stream geomorphic data will be used in determining stressed or altered waters due to physical problems.

Phase 3 is the survey-level field assessment phase and involves the collection of detailed field measurements at the sub-reach or site scale. Existing stream types and adjustment processes are further detailed and confirmed based on quantitative measurements of channel dimension, pattern, profile, and sediments. Phase 3 assessments are completed with field survey and other accurate measuring devices.

4. Data Solicitation

In conjunction with the 2004 assessment process, VTDEC conducted a solicitation for data to further enhance the quantity and spatial coverage of water quality data and other information that is used in assessing surface waters. The solicitation for water quality data, issued as a press release, has also been posted to the WQD website (refer to http://www.vtwaterquality.org/announcements.htm) and was posted on the web pages of VTDEC and the Vermont Agency of Natural Resources. The solicitation sought data and information to be submitted on or before October 31, 2003 in order to be considered for the 2004 reporting cycle. Data and other information submitted after that date will be considered for the 2006 reporting cycle. VTDEC intends to continue similar notices in advance of future reporting efforts.

5. Data Quality

Data employed must be of known quality and should be representative of the water's condition. All data generated by VTDEC in conjunction with WQD monitoring programs are subject to quality assurance planning using USEPA quality assurance guidance. Moreover, any and all data generated in part or whole using funding from USEPA must be subject to a USEPA-approved quality assurance project plan (QAPP). All data generated in conjunction with any active and/or approved QAPP are considered readily available and reliable data (subject to data limitations identified in the quality assurance/quality control validation and verification process for each project), and are considered in determining use support. Data can be rejected from consideration in the event that it does not meet data quality objectives established by individual QAPPs. VTDEC's Quality Management Plan and draft Water Quality Monitoring Program Strategy provide listings of project-specific QAPPs. Guidance and assistance regarding quality assurance is also provided from the R.A. LaRosa Laboratory.

For data provided by organizations other than VTDEC and WQD such as colleges, universities and citizen-based activities, data quality must be assured prior to considering it in the determination of use support. The number of samples, the length of the sampling period, the antecedent weather conditions, degree of compliance or violation and other factors are all considered when evaluating data from other organizations. Where data of unknown or unquantifiable quality are at odds with companion data of quantified quality, the higher quality data will be accorded higher weight in determining use support. Where data of unknown or suspect quality are the only information available, the waterbody is scheduled for additional monitoring prior to determining use support.

6. Statistical Analyses

VTDEC has expertise in statistical analyses, including non-parametric, parametric, and multi-variate methods. In most instances, it cannot be decided a-priori what type of statistical analysis may be used to assess use support, except for experimentally designed studies. For certain data types, long-term trend detection using linear, non-linear, or non-parametric regression approaches is appropriate. For designed studies aimed at determining the level of use support in an experimental framework (e.g., lakes that are likely to display elevated fish tissue mercury concentrations), parametric analyses of variance, covariance, and/or linear discriminant analysis are most appropriate. To classify waterbodies into meaningful biological groupings to compare biometrics to reference biological communities, linear discriminant analysis, principal components and factor analysis, canonical correspondence and non-metric multidimensional scaling analysis are appropriate. Simple T-tests and ANOVA tests (or non-parametric equivalents) are appropriate where data are being compared to a criterion value or to a set of reference waters. Consequently, these last two tests are more commonly or routinely performed during VTDEC assessment efforts. Where a statistically parametric method is used to evaluate hypotheses concerning standards attainment, consideration is accorded as to whether "attainment" is established as the null or alternative hypothesis.

VTDEC does not, on a unilateral basis, subscribe to the notion that a pre-determined proportion of samples exceeding a criterion value automatically equates to impairment, particularly where the total number of samples is low. The proportion of violations or frequency of exceedance in an array of data are treated and used by VTDEC on an individualized and case-specific basis to determine use support.

In general, VTDEC believes waters must be proven to be impaired using scientifically defensible methods, and thus statistical hypothesis tests, when necessary, are most often structured in that fashion. In the interest of maintaining solidly defensible and repeatable use support decisions, a decision call resulting in a finding of impairment will be accorded to the null or alternate, depending on which test provides the greatest statistical power while maintaining the type-I error rate (i.e. concluding a water is impaired when in reality it is not) to a pre-established level (typically 5% to 10%).

7. Vermont Surface Water Assessment Categories

Vermont's rivers, streams, lakes, and ponds have been designated into "waterbodies" which serve as the cataloging units for the overall statewide assessment. Waterbodies are typically entire lakes, subwatersheds of river drainages or segments of major rivers. Using data that is quality assured along with other contextual information that is reliable, the Water Quality Division determines whether each waterbody meets or does not meet Vermont Water Quality Standards, and then places waters into one of four assessment categories, taking into account the waterbody classification and water management type. The four categories used in Vermont's surface water assessment are **full support, stressed, altered** and **impaired**.[4] Waters that support designated and existing uses and meet Water Quality Standards are attributed to the full support or stressed categories. Waters that do not support uses and do not meet standards are placed into the altered or impaired category. Waters can also be put into an **unassessed** category. These assessment categories are described below.

7.1. Designated and/or existing uses under the Vermont Water Quality Standards are supported

7.1.1. Full Support Waters

This assessment category includes waters of high quality that meet all use support standards for the water's classification and water management type.

[4] The four assessment categories formerly used by VTDEC were known as full support, full support/threatened, partial support, and non-support. Not all new categories are directly equivalent to the four categories used in former assessments.

In Vermont, there are many waters, such as intermittent streams, that are a lower priority for sampling visits given resource constraints, lack of public access or interest, and competing needs within VTDEC's water quality monitoring program. VTDEC therefore makes preliminary assessments, where practical, by considering five factors that address the likelihood that significant stressors exist within the subject watershed. Waters that meet all these factors are then considered to support their uses. The factors VTDEC uses to develop preliminary, screening-level assessments for these waters are:

- no discharges or contaminated sites in proximity to the waterbody;
- low probability of habitat degradation as evaluated by "Phase One" geomorphic assessments or other remote sensing evaluations;
- nearby sites have biological assessment findings compliant with Vermont Water Quality Standards, for like class and water management type;
- no problems are uncovered during outreach efforts associated with the rotational assessment process and basin planning; and
- no known water level manipulations.

7.1.2. Stressed Waters

These are waters that support the uses for the classification but the water quality and/or aquatic habitat have been disturbed to some degree by point or by nonpoint sources of human origin and the water may require some attention to enhance its usefulness or the water quality and/or aquatic habitat may be at risk of not supporting uses in the future. Data or other information that is available confirms water quality or habitat disturbance but not to the degree that any designated or existing uses have become altered or impaired (i.e. not supported).

Some stressed waters have documented disturbances or impacts and the water needs further assessment.

The stressed waters assessment category includes some of the waters in the formerly used category known as "full support/threatened." The stressed category also captures many of those waters in the formerly used category "partial support – evaluated" where there was evidence of problems and disturbances but current water quality data were lacking.

7.2. One or more designated and/or existing uses under the Vermont Water Quality Standards are not supported

7.2.1. Altered Waters

These are waters where a lack of flow, water level or flow fluctuations, modified hydrology, physical channel alterations, documented channel degradation or stream type change is occurring and arises from some human activity, OR where the occurrence of exotic species has had negative impacts on designated uses. The aquatic communities are altered from the expected ecological state.

This assessment category includes those waters where there is a documentation of water quality standards violations for flow and aquatic habitat but EPA does not consider the problem(s) caused by a pollutant OR where a pollutant results in water quality standards not being met due to historic or previous human-caused channel alterations that are presently no longer occurring.

7.2.2 Impaired Waters

These are surface waters where there are chemical, physical and/or biological data collected from quality assured and reliable monitoring efforts (refer to section 5 of this chapter) that reveal 1) an ongoing violation of one or more of the criteria in the Water Quality Standards and 2) a pollutant of human origin

is the most probable cause of the violation. These are waters that have been in the formerly used "partial or non-support - monitored" category.

7.3. Unassessed Waters

Waters for which VTDEC has no monitoring data and only limited information and knowledge is available are considered unassessed.

Part II. Assessment Use Support Determinations

The following pages provide specific criteria, principles for making decisions, and other information that VTDEC applies when making an assessment of water quality conditions and determining whether individual designated and existing uses are fully supported, stressed, altered, impaired or unassessed (described above generally in Part I). Information below is presented by each of the seven designated uses to show how relevant, representative and reliable water quality monitoring data and other information relates directly to the degree of use support for assessment reporting purposes. Additional considerations for lakes are included under aquatic life use where the assessment methodology differs from riverine environments.

1. Aquatic Biota/Habitat (Aquatic Life) Use

In assessing Aquatic Life Use, the VTDEC Water Quality Division uses several types of water quality and water quantity data and information to determine use support. The specific data types are biological monitoring, habitat assessment, conventional pollutants, and toxicants. For lakes, additional assessment guidelines are used for conventional pollutants, non-native nuisance aquatic species, nutrients, and information regarding water-level impacts. Specific decision-making criteria are as follows:

1.1. Biological Monitoring (refer also to earlier discussion on biological monitoring)

Full Support: Biological assessments for fish and/or macroinvertebrate communities demonstrate compliance with appropriate threshold criteria as described in DEC biocriteria implementation methodologies. In the absence of applicable biocriteria, all available information and data are used to make scientifically defensible weight-of-evidence findings that designated aquatic life uses are fully supported. In most cases, biological condition ratings of *excellent, very good,* and *good* will indicate full support status for Class A(1), Class B(1), and Classes A(2) B, B(2) and B(3) respectively.

Stressed: Biological assessments for fish and/or macroinvertebrate communities and/or habitat assessments indicate that impacts have occurred but are inconclusive with regard to support status determination or demonstrate that the biological condition is at risk of making a transition between support and non-support. In the absence of applicable biocriteria, all available information and data are used to make scientifically defensible weight-of-evidence findings that designated aquatic life uses are stressed. Additional biological assessment may be needed. In most cases, biological condition ratings of *"excellent-to-very good"* will indicate stressed status for Class A(1) waters, *"very good-to-good"* will indicate stressed status for Class B(1) waters and *"good-to-fair"* will indicate stressed status for Class A(2), B, B(2) and B(3) waters.

Altered: Biological assessments for fish and/or macroinvertebrate communities demonstrate non-compliance with appropriate threshold criteria as described in DEC biocriteria implementation methodologies and the cause is not a pollutant (e.g. flow regulation or non-native species). In the absence

of applicable biocriteria, all available information and data are used to make scientifically defensible weight-of-evidence findings that designated aquatic life uses are not fully supported. In most cases, biological condition ratings of *very good or lower, good or lower,* and *fair or lower* will indicate altered status for Class A(1), Class B(1), and Classes A(2), B, B(2) and B(3) respectively. Generally, biological data from a minimum of two hydrological years are necessary in order to determine this condition.

Impaired: Biological assessments for fish and/or macroinvertebrate communities demonstrate non-compliance with appropriate threshold criteria as described in DEC biocriteria implementation methodologies and the cause is due to a pollutant of human origin. In the absence of applicable biocriteria, all available information and data are used to make scientifically defensible weight-of-evidence findings that designated aquatic life uses are not fully supported. In most cases, biological condition ratings of *very good or lower, good or lower,* and *fair or lower* will indicate impaired status for Class A(1), Class B(1), and Classes A(2), B, B(2) and B(3) respectively. Generally, biological data from a minimum of two hydrological years are necessary in order to determine impairment.

1.2. Habitat Assessment

Full Support: Depending on the water's classification and typing {A(1), A(2), B, B(1), B(2), B(3)}, high quality habitat with up to a moderate change from natural or reference condition exists "consistent with the full support of all aquatic biota and wildlife uses."

Stressed: Stream or river physically under stress – in adjustment with stresses greater than as naturally occurs to a "fair" condition derived from a geomorphic assessment completed using recognized protocols.

Altered: Changes to the habitat are greater than minimal to a moderate change from reference, depending on the water's classification and typing. There is an undue adverse effect on the physical nature of the substrate. Aquatic habitat surveys show significant changes from the reference condition due to human origin and/or geomorphic assessment indicated fair to poor conditions. All life cycle functions, including over-wintering and reproductive requirements, are not adequately maintained and protected due to the physical habitat changes.

Impaired: A pollutant of human origin is shown to cause more than the allowable change to aquatic habitat as defined by Vermont Water Quality Standards.

1.3. Conventional Pollutants (defined by USEPA as: temperature, pH, D.O., turbidity, nitrate-nitrogen, phosphorus)

Full Support: Waters that are not stressed or impaired due to conventional pollutants, assessed using the Vermont Water Quality Standards. For example, the total increase from the ambient temperature due to all discharges and activities is not known to exceed 1.0 degree F for a coldwater fishery and the total increase from ambient temperature due to all discharges and activities shall not exceed the temperature criteria derived from tables 1 or 2 in Section 3-01.B.1.c. except as provided for in Section 3-01 B.1.d. of the Vermont Water Quality Standards (pertaining to both a coldwater and warmwater fishery).

Stressed: Waters where the level of a conventional pollutant or a combination of conventional pollutants of human origin may be resulting in some disturbance. For example, temperatures are such that in coldwater fishery waters, one or more trout species are reduced in number or biomass as compared to reference condition. Waters with alkalinities between 2.5 and 5.0 mg/l (as CaCO3), and pH values may occasionally drop below 6.5. Coldwater fishery waters where dissolved oxygen may be between 6 and 7 mg/l and 75 to 85% saturation.

Altered: This assessment category is not used in this context.

Impaired: Temperatures are too high as a result of human activities to fully support coldwater fish species in waters designated as a coldwater fishery OR the total increase from the ambient temperature due to all discharges and activities exceeds 1.0 F for a coldwater fishery and the total increase from ambient temperature due to all discharges and activities exceeds the temperature criteria derived from tables 1 or 2 in Section 3-01.B.1.c. except as provided for in Section 3-01 B.1.d. of the Vermont Water Quality Standards (pertaining to both a coldwater and warmwater fishery).
Reliable, representative monitoring indicates that pH values repeatedly fall below 6.5 standard units or exceed 8.5 standard units across a range of weather conditions, and values are not due to natural sources.
Reliable, representative monitoring indicates D.O. values or percent saturation repeatedly fall below the standard for the water's classification and type except as noted in section 1.5.1 below.
Reliable, representative monitoring shows that turbidity values are more than occasionally above the standard for the water's classification and type as measured across a range of weather conditions and values are not due to natural sources.
Reliable, representative monitoring shows that nitrate-nitrogen and/or phosphorus repeatedly and/or consistently exceeds the standard for the water's classification, type, and elevation except as noted in section 1.5.1 below.

1.4. Toxicants (priority pollutants, metals, chlorine & ammonia)

Full Support: Waters that are not stressed or impaired due to toxicants, as described below.

Stressed: Water quality monitoring or sediment samples reveal the presence of toxics below criteria or there are no relevant criteria and the source of the pollutants has not been remediated. Groundwater data in wells adjacent to the stream shows levels of pollutants above the Vermont Groundwater Enforcement Standards but no in-stream data exists or no sediment samples have been taken.

Altered: Toxicants are considered pollutants, therefore, the category "altered" is not applicable.

Impaired: In most cases, the following exposure presumptions are applicable to compliance determinations: for any one pollutant, an acute aquatic biota criterion is exceeded more than once within a 3-year period, for longer than one hour, above ten-year, seven-day flow minimum (7Q10) flows; or a chronic aquatic biota criterion is exceeded for more than four consecutive days in a three year period, above 7Q10 flows.[5]

1.5. Additional Aquatic Life Use Considerations for Lakes

1.5.1. Lakes - Conventionals (alkalinity, dissolved oxygen, nitrate-nitrogen)

Full Support: Waters that are not stressed or impaired.

[5] DEC recognizes that the literal interpretation of the exposure scenario cited would be difficult to replicate in a field situation. The language cited reflects the exposure conditions used to develop the numerical criterion that is the water quality standard. It is likely that available monitoring data would be collected under a variety of temporal and spatial formats. In evaluating data, DEC uses the exposure assumptions of the criterion development as guidelines in the interpretation of data and uses empirical and judgmental means to assess whether or not there is reasonable potential for those exposure assumptions to be violated. Given the variable nature of available information, evaluations will vary on a case-by-case basis. DEC takes into consideration guidance provided by EPA when evaluating toxicants in surface waters (see "Technical Support Document for Water Quality-based Toxics Control." EPA/505/2-90-001).

Stressed: Reliable long-term monitoring data indicates that a lake's alkalinity routinely drops below 12.5 mg/l (as CaCO3) during the spring runoff period.
Reliable long-term monitoring data indicates that a lake's hypolimnetic dissolved oxygen concentration periodically falls to (or near) 0 mg/l or 0% saturation during peak summer stratification, but macroinvertebrates are present. The area designated as stressed, as a result of human disturbance, is limited to the lake acreage underlain by the hypolimnetic oxygen-deficient area.

Altered: This assessment category is not used in this context.

Impaired: Reliable monitoring data indicates that alkalinity routinely drops below 2.5 mg/l (as acid neutralizing capacity) during the spring runoff period.
Reliable monitoring data indicates that a lake's hypolimnetic dissolved oxygen concentration falls to (or near) 0 mg/l or 0% saturation for a period of greater than 50% of the summer stratification period, **and** the hypolimnetic sediments are devoid of a macroinvertebrate community. The area designated as impaired, as a result of human disturbance, is limited to the lake acreage underlain by the hypolimnetic oxygen-deficient area. However if, in the best professional judgement of VTDEC scientists, the dissolved oxygen deficit is due to natural causes, aquatic life uses will be considered instead as fully supported.
The epi- and metalimnetic lake waters will be considered impaired if dissolved oxygen concentrations fall below Water Quality Standards in greater than or equal to 10% of samples, and the anoxia is not a natural phenomenon.
Reliable monitoring data indicates nitrates in excess of 5.0 mg/l in 10% or more of samples collected.
A minimum of four evenly-spaced sampling events across the summer stratification period are commonly used to make a determination regarding conventional pollutants in lakes, except for alkalinity, which is most commonly measured in spring, which corresponds to peak acidity loading for lakes.

1.5.2. Lakes Conventionals (phosphorus)

Vermont is working under a cooperative funding agreement with the New England regional office of USEPA to develop scientifically-based nutrient criteria that are relevant to Vermont waters, for inclusion in Vermont's Water Quality Standards. Pending development of these new criteria, the following is used to assess use support for lakes using phosphorus data.

Full Support: Vermont's Water Quality Standards provide that full support lakes have experienced no acceleration of eutrophication or stimulation of the growth of aquatic biota in a manner that prevents the full support of uses.

Stressed: Photic-zone and/or whole column total phosphorus concentrations are elevated in relation to statewide norms, resulting in stimulation of growth of aquatic plant species that results in no more than a minor to moderate change in aquatic biota, depending on water management type.

Altered: Phosphorus is a pollutant, therefore this category is not applicable.

Impaired: Photic-zone or whole column total phosphorus concentrations, as determined by the VTDEC Spring Phosphorus Monitoring Program, the Vermont Lay Monitoring Program, or other special studies, have increased significantly, or are significantly elevated relative to statewide norms, and resultant algal blooms produce more than a moderate change in the aquatic biota. For Lake Champlain, Lake Memphremagog and South Bay of Lake Memphremagog, summer average phosphorus concentrations exceed criteria expressed in §3-01(A)(2)(c) of the Water Quality Standards.

1.5.3. Lakes – Non-Native Species

Non-native species such as Eurasian watermilfoil (*Myriophyllum spicatum*), water chestnut (*Trapa natans*), alewives (*Alosa pseudoharengus*) or zebra and quagga mussels (*Dreissena spp.*) have significant impacts on existing aquatic plant and animal communities. Information on the extent and distribution of these species is used to assess aquatic life use support in lakes.

Full Support: No established population of an invasive, non-native nuisance species.

Stressed: Non-native invasive species are present but in low densities (e.g. scattered areas of plant growth in limited areas of the littoral zone). In the case of Eurasian milfoil, lakes within a 10-mile radius of an infested lake are considered stressed, unless access to the lake is remote or inaccessible by conventional means.

Altered: Non-native invasive species present in densities sufficient to alter native biological communities. For example, overall plant density is classified as "moderate," indicating locally abundant (50% or greater coverage) growth, or "heavy," (75% or greater littoral cover overall) indicating growth in most shoreline areas.

Impaired: Non-native invasive species are not considered pollutants. Therefore, this category is not applicable.

1.5.4. Lakes - Aquatic Life Use Assessments for Fluctuated Reservoirs

Reservoirs present special cases in regards to assessment of aquatic life use support (ALUS). In the absence of direct biological measurements beyond routine aquatic plant survey data, ALUS can be assessed using the following decision-making 'tree.' In order to use this decision tree, several pieces of information regarding the reservoir are useful. These include bathymetry, maximum and mean waterbody depth, the limnological shoreline development index, and the magnitude and timing of the drawdown. These data can be used collectively to estimate the proportion of the littoral zone likely to be affected by the drawdown regimen. Where available, biological data (in particular the presence and distribution of aquatic macrophytes within the littoral zone) are also useful.

1) Can the level of the waterbody be regulated by an artificial structure (e.g. dam, sluice, weir)?
   Answer is NO: no alteration or stress to ALUS due to water level fluctuation. ***Full Support.***
   Answer is YES: go to 2.
2) Is the waterbody connected to a licensed or unlicensed hydroelectric generating system, a flood control system, or subject to promulgated Vermont Water Resources Board rules regulating the fluctuation?
   Answer is NO: a stress or alteration to ALUS could potentially exist, but must be verified by direct assessment before the waterbody can be correctly assessed; go to 4.
   Answer is YES: go to 3.
3) Is the waterbody regulated by a federal Clean Water Act Section 401 water quality certification issued by VTDEC after January 1, 1990?
   Answer is NO: go to 4.
   Answer is YES: ***no alteration or stress to ALUS due to water level fluctuation if operated in accordance with the license.***
4) Is the waterbody in fact subject to periodic fluctuations that are attributable to operation or manipulation of the outflow structure?

Answer is NO: ***a stress to ALUS is presumed to exist***, due to the ability of the outflow operators to fluctuate water levels if the need arises, which can negatively impact littoral zone communities. Such littoral zone impacts have the potential to cause cascading changes within the trophic web of the waterbody but cause no more than a minor change in habitat or moderate change in aquatic biota from the reference condition. The entire waterbody acreage will be assessed as stressed for ALUS.

Answer is YES: Go to 5.

5) Does there exist a sufficient area of littoral habitat below the drawdown zone to enable establishment of a viable and stable aquatic community, with all expected functional groups, while accommodating the drawdown regimen, **or**, does available biological data suggest that such a community exists within the drawdown zone?

Answer is NO: ***ALUS is altered.*** These alterations create more than a moderate change to aquatic habitat. Littoral zone impacts of this magnitude will have cascading impacts throughout the trophic web, resulting in more than a moderate change in aquatic biota from the reference expectation. Aquatic macroinvertebrate and fish assemblages exhibit more than moderate changes in the relative proportions of tolerant, intolerant, taxonomic and functional components. Accordingly, the entire acreage is assessed as altered.

Answer is YES: ***ALUS is stressed.*** These stresses cause no more than a moderate change to aquatic habitat. Littoral zone impacts of this magnitude could have cascading effects within the trophic web of the waterbody, but these are presumed to create no more than a moderate change to aquatic biota from the reference expectation based on the relative proportions of tolerant, intolerant, taxonomic and functional groups. The waterbody's entire acerage is presumed to be stressed for ALUS.

2. Fish Consumption Use

Vermont interprets the USEPA guidance on fish consumption use attainment to indicate that no waters fully support fish consumption. This is due to well-documented contamination of varying levels of lakes by mercury in waters, sediments, and aquatic biota arising from atmospheric deposition. In the tissues of fish inhabiting Lake Champlain (and elsewhere), other contaminants including polychlorinated biphenyls, polyaromated hydrocarbons, and "DDT" derivatives have been identified.

VTDEC does not, however, subscribe to the notion that fish tissue consumption is impaired on a statewide basis. This is because most fish species can, indeed, be consumed from most Vermont waters, albeit at a reduced rate. Fish consumption use is considered impaired only in the event that the fish species subject to the consumption advisory is documented to exist in the waterbody and contaminant data exist for that species from the particular waterbody. This approach is consistent with current EPA guidance.

Full Support: No fish consumption advisory in effect.

Stressed: "Restricted consumption" of fish is in effect (restricted consumption is defined as limits on the number of meals or size of meals consumed per unit time for one or more fish species).

Altered: Tissue contaminants are derived from the deposition or release of pollutants into the aquatic environment. Accordingly, this assessment category is not relevant.

Impaired: Fish consumption use is considered impaired only in the event that the fish species subject to the consumption advisory is documented to exist in the waterbody and contaminant data exist for the

species from the particular waterbody. For a given fish species present in a waterbody, a 'no-consumption' advisory is in place for a designated sub-population (e.g., children or women of childbearing age) or for the general population.

3. Swimming/Contact Recreation Use

For assessment of Swimming/Contact Recreation Use, the VTDEC Water Quality Division uses one or more types of data to determine whether this use is supported. The specific data types are bacterial monitoring and nuisance aquatic species growth. Decision-making criteria are as follows:

3.1. Indicator Bacteria

E. coli (an abbreviation for the scientific name of the bacterium *Escherichia coli*) concentrations are known to vary considerably over space and time in response to natural and human-related factors. In order to assess waters for support of swimming and contact recreation using *E. coli* monitoring data, a minimum number of data points are necessary, and supporting contextual data such as antecedent weather and flow conditions must be considered. VTDEC considers at least five (5) reliable and quality assured sample results over a swimming season and gathered across a range of weather/flow conditions to be the minimum practical number of samples necessary to document representative conditions and to assess attainment of contact recreational uses. In a practical sense, weekly or more frequent *E. coli* data across the swimming season is most useful to determine impairment and observe weather-related patterns in bacterial concentrations. If there are questions regarding the representativeness of the data, the water is identified as needing monitoring and is recommended for follow-up *E. coli* sampling in the next season.

Very few strains of *E. coli* are themselves pathogenic. Rather, they are indicators of the presence of fecal material of warm-blooded animal origin. This fecal material may contain harmful pathogens. *E. coli*-based criteria are expressed either as geometric mean values, or as one-time, instantaneous single-sample values. These values equate to a likelihood of developing gastrointestinal illness from exposure to waterborne pathogens associated with *E. coli*. EPA originally (1986) derived its freshwater criterion recommendations using a set of statistical relationships relating geometric mean *E. coli* levels to observed gastrointestinal illness rates directly attributable to the *E. coli* exposure. Using these relationships, EPA has recommended that the most conservative *E. coli*-based criterion be a geometric mean of 126 *E. coli* /100ml. At highly populated freshwater beaches (defined as greater than or equal to 2,427 swimmers/day on average) that are subject to direct sewage effluent contamination, exceedance of this criterion means that on a season-wide average basis, 8 in 1,000 swimmers will develop gastrointestinal illness due to *E. coli* exposure. In 2002, EPA reaffirmed it's 126 *E. coli* /100ml geometric mean recommendation considering the most available data and studies.

Vermont's standards have criteria for bacteria that reflect a high level of protection for swimmers and other forms of contact recreation use. The current criteria are far more conservative than those recommended by EPA. Vermont's current criteria are not to exceed a three-sample geometric mean of 18 *E. coli* /100ml (or a single sample maximum of 33) for Class A(1) and A(2) waters, and not to exceed 77 *E. coli* /100ml for Class B waters in all management types. Interpreted using EPA's statistical relationships, a single instantaneous concentration of 77 *E. coli* /100ml equates to a 75% likelihood that a beach closure will prevent swimmers from incurring a 3.4 in 1,000 risk of developing gastrointestinal illness. Such an interpretation must be treated cautiously as any illness rate attributed to *E. coli* exposure less than 8 in 1,000 is below the level quantifiable using EPA's statistical relationships.

Recent research conducted within Vermont indicates that the present Vermont Class B criterion can be exceeded in low to moderate streamflows issuing from forested watersheds due to natural background sources. Based on calculations using EPA's statistical relationships, 77 *E. coli* /100ml, expressed as a geometric mean of several samples, results in a projected illness rate of 6 in 1,000 swimmers. While this level of risk approaches the EPA minimum recommendation, it is consistent with the intent of current and prior Vermont water quality criteria for bacteria, beginning in 1985. In addition, new EPA guidance (USEPA, 2003b) on the application of water quality criteria for pathogens allows that impairment determinations can be based on geometric seasonal means or some number of single sample exceedances. EPA expresses preference for use of a longer-term indicator (geometric mean) for reporting use attainment. Given these considerations, a common-sense approach must be applied when assessing waters using *E. coli* monitoring data. The following guidelines are applied during the assessment process:

Full Support: Waters are suitable for swimming.

Stressed: Individual samples only occasionally exceed the class-specific single-sample criteria values. The geometric mean does not exceed the criterion value.

Altered: *E. coli* indicator bacteria are considered a pollutant. This assessment category is not applicable.

Impaired: For class B waters in all water management types, the geometric mean of 77 *E. coli* /100 ml is exceeded in a given segment or area and the contamination can be attributed to sources other than natural background. DEC accepts a weight-of-evidence approach to confirm that *E. coli* values are or are not of natural origin. A minimum of five samples collected regularly over the swimming season is needed, and flow and antecedent precipitation are accounted for in this determination. For class A(1) and A(2) waters, the geometric mean of a minimum 3 samples exceeds 18 *E. coli* /100ml, and the contamination can be attributed to sources other than natural background (i.e. human, livestock, domestic animal sources). Generally, data from at least two swimming seasons are needed to assess waters as impaired for swimming.

3.2. Nutrients and Nuisance Aquatic Species

Full Support: Waters are not stressed, altered, or impaired by nuisance aquatic species (includes Eurasian watermilfoil, water chestnut, zebra mussels).

Stressed: Nuisance species are present but not at levels where a nuisance has been documented or in low densities (scattered areas of growth in limited areas of the littoral zone). In the case of Eurasian milfoil, lakes within a 10-mile radius of an infested lake are considered stressed, unless access to the lake is remote or inaccessible by conventional means.

Altered: Nuisance species present in such densities such that swimming uses are not met. For aquatic macrophytes, typically these conditions are characterized by greater than 75% cover of the non-native macrophyte and are designated as "moderate" or "heavy" infestations. For species other than aquatic macrophytes such as zebra mussels, colonies would be present in such densities and at such depths as to impact swimming uses due to potential for injury to bare feet. Nutrients are not applicable in this category.

Impaired: An on-going record of public complaint concerning the algal conditions in the water has been established. For cyanobacteria (blue-green algae), waters display on-going summer blooms of toxin-producing cyanobacteria and have microcystin concentrations at elevated levels in excess of the World Health Organization guideline of 1 ug/l. Nuisance aquatic species are not applicable in this category.

4. Secondary Contact/Non-Contact Recreation Use

For assessment of Secondary Contact/Non-Contact Recreation Use, the VTDEC Water Quality Division uses information regarding water quantity and water quality, data and other information regarding the game fishery and records of public feedback and complaint to determine levels of support.

Full Support: Water quantity and quality sufficient for boating and fishing.

Stressed: Odor, color, plant growth, low water conditions occasionally discourage boating or fishing.

Altered: Fishing and/or boating are limited due to insufficient or diminished or lack of water, aquatic nuisance species or channel alterations. Boating is not feasible to the degree deemed achievable for the water's Water Management Type.

Impaired: Fishing and/or boating are limited due to water quality or aquatic habitat impairment(s) caused by pollutants from human sources.

5. Drinking Water Supply Use

Drinking water supply use is assessed using data on toxicants and bacteria; information on water treatment plant operation and operating costs; and, data describing cyanobacterial (blue-green algae) toxin concentrations.

Full Support: Water quality suitable as a source of public water supply with disinfection and filtration.

Stressed: This category is not applicable.

Altered: A well-established zebra mussel infestation is known to increase cost or effort to produce water that is suitable for drinking.

Impaired: In rivers, streams, brooks and riverine impoundments the exceedance, due to human sources, of any one human health-based toxic pollutant criteria listed in Appendix C of the Water Quality Standards (or as otherwise determined by the Natural Resources Agency Secretary in accordance with the Toxic Discharge Control Strategy) at flows equal to or exceeding the median annual flow for toxic substances that are classified as "non-threshold toxicants" or at flows meeting or exceeding the 7Q10 flow for toxic substances that are classified as "threshold toxicants." In all other waters, the exceedance, due to human sources, of any one human health-based toxic pollutant criteria listed in Appendix C (or as otherwise determined by the Secretary in accordance with the Toxic Discharge Control Strategy) at any time. (Note: "non-threshold toxicants" are probable or possible human carcinogens and "threshold toxicants" are not known or probable human carcinogens).
Criteria established by the Federal Safe Drinking Water Act can be met only by employing treatment practices that operationally or financially supercede customary practices that include filtration and disinfection.
Finally, waters display on-going summer blooms of toxin-producing cyanobacteria and have microcystin concentrations in excess of the World Health Organization guideline of 1 μg/l.

6. Aesthetics Use

For assessment of Aesthetic Use, the VTDEC Water Quality Division uses water quality and water quantity information from field surveys and public feedback and complaints to determine levels of support.

Full Support: Water character, flows, water level, riparian and channel characteristics, all exhibit good to excellent aesthetic value consistent with the waters classification. Water clarity and substrate condition is good. No floating solids, oil, grease or scum. Limited or no record of public concern.

Stressed: Aesthetic quality is compromised somewhat. Water unnaturally turbid at times. Moderate levels of plant growth above the expectation for natural communities. Small or disturbed riparian zone. Some record of public concern or complaint.

Altered: Aesthetic quality is poor due to a diminished amount of water to no water in the channel or lake resulting from human activities or due to moderate or heavy densities of nuisance non-native species.

Impaired: Aesthetic quality of water is poor. Water is frequently and unnaturally turbid. Excessive plant growth above the expectation for natural communities covers the channel or lake bottom, rocks or water surface. Substrate is unnaturally silt-covered, mucky, or otherwise changed so as to adversely affect the aesthetics in an undue manner. Presence of solid waste, floating solids, scum, oil or grease occurs frequently and persistently.

7. Agricultural Water Supply Use

There are no EPA definitions for agricultural water supply. Consequently, this use is unassessed and the four assessment categories are not used.

Chapter Five. Listing and De-Listing Methodology

Following the assessment process where waters are determined to be impaired, altered, stressed, or in full support of existing uses or designated uses associated with class and water quality management type, waters may then be categorized and placed onto one or more listings for tracking purposes. The listing of waters is undertaken for Section 303d of the Federal Clean Water Act and, outside the scope of the Act's requirements, VTDEC maintains several other lists for tracking and management purposes. The sum of listings maintained by VTDEC is collectively known as the Vermont Priority Waters List. This chapter describes how waters are assigned to the various lists based on their assessment categorization.

5.1. Impaired Waters

All waters determined to be impaired are placed on one of the following listings: Part A-303d List (impaired waters scheduled for TMDL development), Part B (impaired waters for which TMDLs are not required), and Part D (impaired waters for which TMDLs have been completed).

Determination of Pollutant

An important piece of information required in order for a water to be listed as impaired is the determination that the pollutant(s) causing the condition is a result of human activity and not of natural origin. The pollutant becomes the basis for loading determinations and TMDL development or for the control measures to be implemented. VTDEC attempts to be as accurate as possible as to causal pollutant determination. Where appropriate, VTDEC subscribes to EPA's Stressor Identification Methodology (USEPA, 2000b). In the absence of EPA's Stressor Identification Methodology or pollutant data, VTDEC may use biological assessment indicators (refer to previous chapter on biocriteria and biomonitoring) to identify by inference most probable causal pollutants or stressors.

Where there is monitoring data that identifies a violation of a numeric standard, the pollutant may be identifiable. For example, long-term monitoring data may identify a segment of Lake Champlain as exceeding the numeric criterion for total phosphorus as opposed to measured below standard dissolved oxygen which does not necessarily identify a pollutant. Where there is monitoring data that identifies a violation of a narrative standard, the identification of the causal pollutant is more complex. An example of this would be where biological data taken from a stream indicates non-support of aquatic life.

One of VTDEC's methods of determining compliance with water quality standards is by assessing the biological integrity of the aquatic biota. The benefits of using biocriteria as a *direct* measure of waterbody health are that the approach takes into account the impact of all stressors on a waterbody and provides an overall assessment of the water's health and its ability to support aquatic life. Biological assessment data provide generalized guidance on the nature and extent of the stressor(s) when a problem is detected. The poor condition of a waterbody's biotic community is often related to several factors. Evaluation of the biological data combined with the implementation of stressor identification methodologies can result in the development of a defensible list of most probable stressor candidates or suites of pollutants/stressors of common origin (e.g. stormwater).

In the 2002 version of the Vermont 303d List, and previous years' iterations, the term "undefined" was used under the "Pollutant(s)" column to either suggest a broad suite of potential pollutants or when there was uncertainty about whether the standards violation was caused by a pollutant. For 2004, VTDEC will use a more rigorous method to determine the causal pollutant. Using current data, knowledge of the specific situations, and best professional judgment, it will be determined whether there is sufficient evidence that the standards violation is caused by the discharge of a pollutant to the water, and if so, the pollutant will be identified. There remain instances whereby the specific pollutant may not be identifiable

but a particular class of discharge, known to contain pollutants, is still determined to be responsible for the impairment. An example of this instance is the discharge of collected stormwater runoff from impervious surfaces. In this example, if the evidence from an on-site investigation suggested that "stormwater" and its associated pollutants was the cause of the impairment, then "stormwater" would be cited as the pollutant on the 303d List. Often accompanying "stormwater" are the instream effects from the altered hydrology stemming from impervious surface runoff. However, since a discharge of pollutants, not altered hydrology, is the primary factor in a water being listed on Part A, there must be some indication of pollutants being discharged. At this time, since it is unknown to what degree either of the problems (pollutants or hydrology) have on these waters, they are listed as impaired by "stormwater" because of the likelihood of pollutants being discharged and that they contribute to the failure to meet water quality standards. Only when there is sufficient evidence that a Standards violation is the result of pollutants discharged to the water will the water be identified as impaired.

In instances where monitoring data identified a water as impaired based on *E. coli* bacteriological data, the causal pollutant in past versions of the 303d List identified "Pathogens" as the pollutant. This procedure was followed because *E. coli* is used and recognized as an indicator of potential illness-causing pathogens. VTDEC now identifies *E. coli* as the pollutant if there is no monitoring data identifying the existence of other pathogens. The source(s), however, must be confirmed not to be of natural origin.

Part A - 303d List

Part A of the 2004 List of Waters identifies impaired surface waters that are scheduled for total maximum daily load (TMDL) development. Certain impaired surface waters may have TMDLs developed as a group of waters due to the similarity of problems. Part A of the List has been prepared in accordance with current EPA 2004 Guidance and the Environmental Protection Regulations 40 CFR 130.7 ("Total maximum daily loads (TMDL) and individual water quality-based effluent limitations"). A TMDL is deemed necessary for these waters in order to establish the maximum amount of a pollutant that may be introduced into the water after the application of required pollution controls and to ensure the Water Quality Standards are attained and maintained. Waters appearing in Part A are equivalent to "Category 5" waters described in EPA's 2004 Guidance.

In addition to identifying the waterbody, the 303d list identifies the pollutant(s) causing the impairment, the priority ranking for TMDL development and which water use(s) are impaired. VTDEC has also described the specific water quality problem.

TMDL Scheduling

Priority ranking for TMDL development was developed considering: (1) health issues, (2) the nature, extent, and severity of the pollutant(s), (3) the use or uses that are impaired, (4) the availability of resources to restore the water, and (5) the degree of public interest in problem abatement.

Public Comment Opportunity, Submittal to EPA and EPA Approval

Upon compilation of the draft Part A-303d List, it is made available to the public for review and comment. Notification of availability is at a level sufficient to allow broad coverage of the general public and may include notices in newspapers, State web sites and direct notification through email or mailing lists. In addition to notification, public meetings are conducted to further the public's understanding of the document and to receive verbal comments. Following receipt of public comments, a responsiveness summary is developed that describes how the comments were addressed. Appropriate changes are made to the list. A final version of the Part A-303d List is then sent to the New England regional office of EPA for review and approval.

De-listing - Interim List

During development of the 2004 Part A-303d List there may arise the need to propose for de-listing water(s) previously identified on the year 2002 Part A-303d List. Waters proposed for de-listing will be presented on the 2004 Interim List. This list is termed "interim" because it only exists during the period of Part A-303d List development - the period between release of the 2004 Part A-303d List for public comment and the list's final approval by EPA. The sole purpose of this interim listing is to notify the public and EPA of the de-listing proposals and to provide the rationale and justification for such proposals.

On the Interim List, each entry contains specific information for that particular waterbody as to why it is being proposed for de-listing. The waterbody-specific rationale is intended to provide "good cause" for de-listing. The three scenarios below cover the broad range of circumstances for which waters may be proposed for de-listing in the 2004 list cycle.

- **Scenario 1. Absence of previously known impairment shown by water quality monitoring data.**

  Where there is water quality data confirming the absence of a previous impairment or where a waterbody has been improperly listed due to a lack of sufficient water quality data, VTDEC will propose to de-list waters that appeared in the EPA-approved 2002 Part A-303d List. The absence of impairment can be substantiated by data of a comparable quantity and quality as the data that was required to assess the water as impaired (for example, 2 years of biological or chemical data needed to establish impairment generally means 2 years of data needed to establish attainment).

- **Scenario 2. Impaired waters that do not need or require a TMDL determination.**

  Current EPA guidance for the 2004 303d List includes a category of impaired waters whereby a TMDL is not required because existing pollution control requirements are reasonably expected to result in the attainment of the water quality standard in the near future. In light of this, VTDEC can propose to de-list impaired waters that do not need or require a TMDL. It is important for the reader to understand these waters remain assessed as impaired (until water quality is restored) but will, after EPA approval for de-listing, be shown in Part B of the Vermont Priority Waters List.

  In order to de-list certain impaired waters from Part A (and move them to Part B), VTDEC must be convinced that other pollution control requirements, such as best management practices, will result in the attainment of Vermont Water Quality Standards. Specifically, VTDEC needs to show that (1) there are legal requirements in place (e.g. regulations, permits implementing regulations) that apply to the source(s) causing the water quality impairment and (2) that such legally required pollution control practices are specifically applicable to the impairment in question **and** are sufficient to cause the water to meet water quality standards within a reasonable time.

- **Scenario 3. Impaired waters with an EPA approved TMDL.**

  Impaired waters for which an EPA-approved TMDL exists can be de-listed from Part A according to EPA's 2004 Guidance. These waters will then be found in Part D of the Vermont Priority Waters List. Each water covered by an EPA-approved TMDL will continue to be listed in Part D whether the impairment continues to exist or not.

Part B List

All waters listed in Part B are assessed as impaired and do not require development of a TMDL as described in 40 CFR 130.7. Section 303d of the Federal Clean Water Act does not govern these waters. Impaired waters that do not need a TMDL are those where other pollution control requirements (such as best management practices) required by local, state or federal authority are expected to address all water-pollutant combinations and the Water Quality Standards are expected to be attained in a reasonable period

of time. VTDEC will provide information to show that (1) there are legal requirements in place (e.g. regulations or permits implementing regulations) that apply to the source(s) causing the water quality impairment and (2) that such legally required pollution control practices are specifically applicable to the impairment in question **and** are sufficient to cause the water to meet water quality standards within a reasonable time. Waters shown in Part B are equivalent to "Category 4b" waters of EPA's 2004 Guidance. If, in the future, it is determined that waters are no longer impaired, they will be removed from Part B without formal notice.

Part D List

All waters identified on Part D have appeared on a previous version of the Part A-303d List and also have completed and approved TMDLs in place. If future assessments show the impairment has been eliminated, the waters will remain on Part D as a means of TMDL tracking, however, the current assessment status of the water will be noted. Waters shown in Part D are equivalent to "Category 4a" waters of EPA's 2004 Guidance.

5.2. Altered Waters

All waters determined to be altered are placed on one of several lists that track altered waters. These lists include: Part E List (water altered by exotic species), Part F (waters altered by flow regulation), and Part G (waters altered due to physical channel changes). The listing methodology for each list is given below.

Part E List

Waters appearing in Part E are assessed as "altered." They represent situations to be given priority for management where aquatic habitat and/or other designated uses have been altered to the extent that one or more designated uses are not supported due to the presence of exotic aquatic species. This list currently includes waters altered by the proliferation of Eurasian watermilfoil, water chestnut, zebra mussels or the presence of alewives. Waters shown in Part E are equivalent to "Category 4c" waters of EPA's 2004 Guidance.

Waters will be removed from the Part E List when the population of the exotic species declines and the water is assessed as either "stressed" or in "full support" of the designated uses.

Part F List

Waters appearing in this part of the Vermont Priority Waters List are assessed as "altered." They represent priority management situations where aquatic habitat and/or other designated uses have been altered by flow regulation to the extent that one or more designated uses are not supported. Alterations arise from flow fluctuation, obstructions, or other manipulations of water levels that originate from hydroelectric facilities or other dam operations or from water withdrawals for industrial or municipal water supply or snowmaking purposes. Waters shown in Part F are equivalent to "Category 4c" waters of EPA's 2004 Guidance.

Waters will be removed from the Part F List as corrective actions are implemented.

Part G List

Waters appearing in Part G have been assessed as "altered" where the geomorphic assessment condition (derived from Phase 1 and Phase 2 data) is predominantly the result of in-stream human-induced channel management activities. These waters include stream or river reaches with significant impacts due to physical channel alterations, documented channel degradation or a change in stream type that have resulted from human activities such as gravel mining, dredging, channelization, improper bridge or culvert placement, or floodplain encroachments. In these situations, the aquatic habitat is altered from the stable ecological state due to changes in bedload movement and habitat feature loss so that one or

more designated uses are not supported. In these altered reaches, the changes in bedload and habitat features result from an instability of the system itself as streams naturally realign themselves into a new natural equilibrium. Waters shown in Part G are equivalent to "Category 4c" waters of EPA's 2004 Guidance.

Waters will be removed from the Part G List when the aquatic habitat reaches a stable ecological state naturally or as a result of channel management efforts which reduce bedload transport and the water is assessed as either "stressed" or in "full support" of the designated uses.

The Part G listing is not intended for waters that are subject to myriad discharges or multiple stressors or in watersheds subject to unremediated stormwater discharge(s). Part G is inappropriate for waters that are subject to influxes of washload arising from continuing watershed perturbations.

5.3. Stressed Waters

A subset of waters assessed as "stressed" are listed on the Part C List (waters in need of further assessment).

Part C List

All waters appearing in this component of the Vermont Priority Waters List are assessed as "stressed" and have been identified as needing further assessment to confirm the presence of a violation of one or more criteria of the Vermont Water Quality Standards. A violation has not been documented by sufficient data (i.e. there is an insufficient weight of evidence). Part C waters are considered high priority waters for assessment and monitoring.

In the event a violation is substantiated and determined to exist, VTDEC will assess the water as "impaired" or "altered," depending on whether or not the cause of the violation is a pollutant, and then assign the water to either Part A (impaired needing a TMDL), Part B (impaired not needing a TMDL), Part E (altered by exotic species), Part F (altered by flow regulation), or Part G (altered by physical channel changes). In the event, however, further monitoring is conducted and the weight of evidence becomes sufficient to show compliance with the Vermont Water Quality Standards, the water will be removed from the Part C listing.

5.4. Full Support Waters

Waters that fully support designated uses are not tracked on the Vermont Priority Waters List.

5.5. Comparison to EPA's Listing Categories

The development of this most recent listing methodology relies upon EPA guidance that outlines a consolidated report regarding the status of all the waters in the state. For comparative purposes, the table below shows how the various VTDEC listing components correspond to EPA listing categories.

Table 5.1. Comparison between VTDEC Listing Components and EPA Listing Categories.

Vermont DEC Listing Components	EPA Listing Categories
Full support waters. Not tracked on the Vermont Priority Waters List	Category 1
Part C waters	Category 2
Unassessed waters. Not tracked on Vermont Priority Waters List	Category 3
Part D waters	Category 4a
Part B waters	Category 4b
Part E, Part F and Part G waters	Category 4c
Part A waters	Category 5

Chapter Six. References

Government Printing Office. 2001a. Federal Register 66:6, 1671-1674.

Government Printing Office. 2001b. Federal Register 66:5, 1344-1359.

USEPA. 2003a. Guidance for 2004 Assessment, Listing and Reporting Requirements Pursuant to Sections 303d and 305b of the Clean Water Act. Washington, D.C.

USEPA. 2003b. Implementation Guidance for Ambient Water Quality Criteria for Bacteria. November 2003 DRAFT. EPA-823-B-03-XXX. Washington, D.C.

USEPA. 2001a. Guidelines for Preparation of the Comprehensive State Water Quality Assessments (305b Reports) and Electronic Updates. EPA-841-B-97-002A and EPA-841-B-97-002B. Washington, D.C.

USEPA. 2001b. Water Quality Criteria for Methylmercury. EPA-823-R-01-001. Washington, D.C.

USEPA. 2000a. Guidance: Use of Fish and Shellfish Advisories and Classifications in 303(d) and 305(b) Listing Decisions. EPA WQSP-00-03. Washington, D.C.

USEPA. 2000b. Stressor Identification Guidance Manual. EPA-822-B-00-025. Washington, D.C.

Vermont Water Resources Board. 2000. Vermont Water Quality Standards (effective 7/2000). Montpelier, Vermont.

Vermont Department of Environmental Conservation. 2003a. Final EPA-approved 2002 Part A–303d List of Waters. Waterbury, Vermont.

Vermont Department of Environmental Conservation. 2003b. Stream Geomorphic Assessment Protocols. Waterbury, Vermont.

Vermont Department of Environmental Conservation. 2002. 2002 Water Quality Assessment Section 305b Report. Waterbury, Vermont.

Vermont Department of Environmental Conservation. 2000a. 2000 Water Quality Assessment Section 305b Report. Waterbury, Vermont.

Vermont Department of Environmental Conservation. 2000b. Interim Procedures for Determining the Biological Condition of Wadeable Streams. Waterbury, Vermont.

APPENDIX A

Summary Description of
Vermont Water Quality Division Monitoring Programs

Vermont Department of Environmental Conservation
A Descriptive Listing of Water Quality Division Monitoring Programs

The Water Quality Division (WQD) is responsible for conducting much of the Department's ambient surface water quality monitoring activities. WQD efforts in this regard are comprised of numerous discrete projects and programs. The Division's monitoring efforts can be classified as physical/chemical, biological, volunteer and other. Within each of these broad classes, monitoring projects are further described as core, or long-term projects; diagnostic studies, which identify the causes of particular water quality problems; and special studies, which provide information and data on specific water quality issues. There are, in addition, other projects coordinated by close partners of the WQD which tend to broaden the scope and geographic extent of assessment data collection. Analysis of samples for organic and inorganic compounds and heavy metals would not be possible without the analytical services of the R.A. LaRosa Environmental Laboratory.

A. Physical & Chemical Monitoring

1. Core Programs

The Spring Phosphorus Program collects during the spring overturn (typically late March to May 10) nutrient and physical and chemical data on Vermont lakes and ponds that are 20 acres in size or larger. On average, 50 to 60 lakes are sampled each year. Ten lakes are customarily sampled every year. Parameters include total phosphorus, total nitrogen, alkalinity, calcium, magnesium, hardness, Secchi disk transparency, and multi-probe profiles (temperature, dissolved oxygen, conductivity, and pH). Since 1977, 236 lakes have been monitored in conjunction with this program. Forty-eight lakes have 10 or more years of data, and 18 of these have 15 years or more. The Spring Phosphorus Database contains over 1,700 records.

The Lake Assessment Program is designed to rapidly assess the extent to which lakes meet designated uses and to gather information to focus lake management and protection efforts. The sampling intensity for assessment lakes varies with the degree to which impairment is evident or must be documented. Lakes being evaluated under this program are those found in the basins being examined under the rotational watershed assessment approach. In general and during the summer months, lakes are circumnavigated and detailed assessment observations are made regarding in-lake and shoreline conditions with respect to designated uses and threats to water quality. Detailed notes are made regarding the extent and species composition of the macrophyte community. Sampling is performed for total phosphorus, alkalinity, Secchi disk transparency, and multi-probe profiling. Additional sampling may be performed as necessary to determine compliance with Water Quality Standards. Since 1989, 281 comprehensive assessments and 59 cursory assessments have been performed under this program.

The River Assessment Program is designed to assess the extent to which rivers and streams support designated uses to focus management and protection efforts. The assessments themselves involve collecting, compiling, analyzing and evaluating all water quality data and information as well as point and nonpoint source pollution impacts on designated uses specific to the basins being assessed in any given year under the rotational watershed assessment approach. Rivers and streams in the basins of the rotation focus are visited in the spring, summer and fall to look for obvious sources of pollution from

the land or indicators of problems or threats in the water such as sedimentation, heavy algae growth, or water with unnatural color or odor. The Ambient Biomonitoring Program (described on page 5 below) provides most of the information used to determine a waterbody's aquatic life use support and compliance with Vermont Water Quality Standards. Temperature, nutrients, pH, conductivity, and alkalinity are parameters commonly measured concurrently with any biological sampling.

The Water Level Monitoring Program monitors lake surface elevations (June 1 to September 15) to establish mean water levels for a variety of purposes, most notably to determine the jurisdictional boundary of the State's lakes and ponds under the shoreland encroachment permit program and Vermont's Public Trust Doctrine. On average, 40 lakes are visited each year.

The Lake Champlain Long-Term Monitoring Program surveys the quality of Lake Champlain waters on a bi-weekly basis (May to November) at 12 locations throughout the lake. The mouths of eighteen major tributaries are sampled on an event basis as well. The program's large physical and chemical parameter list includes species of phosphorus, nitrogen and organic carbon; chlorophyll-a; base cations; alkalinity; total suspended solids; dissolved oxygen; conductivity; and pH. As of April 2003, this program had assembled a database comprising 6,366 lake and 4,282 tributary sampling events.

The Long-Term Monitoring (LTM) Acid Lakes Program collects chemical and biological data on lakes located in low alkalinity regions (those sensitive to acidification based on the bedrock buffering capacity) to determine the effects of acid deposition on Vermont's lakes. Nearly 200 lakes statewide were surveyed during the winters of 1980 through 1982 to identify the acid sensitive areas of the state. Eleven lakes selected from these areas are now included in the LTM and are sampled at least eight times every year for sixteen chemical parameters related to acidification. This data is used to: 1) classify lakes according to their acidification status; 2) evaluate spatial and temporal variability in measured parameters; 3) track changes in acidification status over time as related to reductions in atmospheric emissions of acid precursors (e.g., oxides of sulfur and nitrogen); and 4) evaluate impacts of acidification on aquatic biological communities. As of April 2003, the LTM data archive comprises 1,857 lake and 405 outlet sampling records.

The Stream Geomorphic Assessment Program collects geomorphologic data on streams throughout the state to assess stream geomorphic stability and develop regime relations for Vermont's streams. Stability assessments enable the prediction of expected rates of river adjustment and an evaluation of the effects of various land and river management practices on geomorphic stability and physical habitat quality. Regime relations guide stream protection, management, and restoration projects and assist in the establishment of Vermont-specific physical criteria for water quality classification and use attainment determinations. Parameters measured in this program, typically during low flow periods, include channel dimension (cross section), pattern (meander geometry), longitudinal profile, channel substrate conditions, structure and composition of riparian vegetation, and floodplain and valley morphology.

This Program has also produced a Stream Geomorphic Assessment Handbook containing recommended protocols and procedures for completing such work. The Handbook's protocols, produced in cooperation with Vermont Department of Fish and Wildlife and VTDEC's Geology and Mineral Resources Division, are for Phase 1, Phase 2 and Phase 3 assessments. The Handbook's protocols are being used by VTDEC and by other groups gathering geomorphologic data.

As of August 2003, the Program has obtained or is aware of geomorphic assessments concerning 17 rivers/streams located in 12 of Vermont's 17 river basins. Phase 1 assessments have been conducted for approximately 1,200 reaches. About 200 reaches have a Phase 2 assessment.

2. Lake Diagnostic Studies

Diagnostic studies are typically aimed at identifying the cause of eutrophication in Vermont lakes. Over the past 20 years, VTDEC has performed numerous such monitoring studies, and the results of these studies have led to concrete remediation steps. Lakes on which notable diagnostic studies have been performed include Harveys Lake (Barnet), Lake Morey (Fairlee), Lake Iroquois (Hinesburg), Fairfield Pond (Fairfield), Lake Parker (Glover), Lake Carmi (Franklin), and Lake Champlain. A diagnostic study was recently completed on Ticklenaked Pond (Ryegate).

A wide variety of parameters are sampled throughout the year in conjunction with diagnostic studies, with the actual tests performed being specific to the project's objectives. Standard eutrophication parameters (total phosphorus, Secchi disk transparency, and dissolved oxygen) are always measured. Other parameters from both the sediment and the water column are measured as needed.

3. Special Studies

Special studies are those performed to gain more information about a particular environmental issue of importance to VTDEC and the Agency of Natural Resources. There are three such projects being cooperatively managed by the WQD. A fourth special study project was completed in June 2001.

The EPA-sponsored **REMAP Assessment of Mercury in Sediments, Waters and Biota of Vermont and New Hampshire Lakes Project** is a three-year effort to identify lake types occurring in the two states that have elevated levels of mercury in fish and upper trophic level biota. The parameter list for this integrated collaborative monitoring project is large, and includes standard limnological measurements and mercury in total and methyl phases in sediment, water, and biota. There is also a paleolimnological component that has determined the extent to which atmospherically deposited mercury has entered lakes in the study set. Two peer-reviewed journal articles have been produced from this study.

The Best Management Practices Effectiveness Demonstration Project is a stream monitoring effort designed to assess the efficacy of best management practices in controlling pollutants in nonpoint source runoff. This cooperative VTDEC-USGS project employs an upstream-downstream approach to pinpoint reductions in pollutant runoff attributable to specific installed BMPs. The multi-year project is being carried out in one agricultural stream (Little Otter Creek) and one urban stream (Englesby Brook) in the Lake Champlain basin.

In conjunction with **the Paleolimnology of Vermont Lakes Project**, the WQD is collaborating with the University of Vermont to develop a set of indicators of present and historical trophic status based on the paleolimnology of carbon and nitrogen stable isotopes ($\delta^{13}C$ and $\delta^{15}N$). Using cores from the sediments of several lakes, the WQD is working to identify the extent to which the present trophic condition in these lakes deviates from the historic background. Such information will be instrumental in understanding the extent to which productivity (and thus phosphorus) has been elevated since the lake watersheds were first disturbed.

The Lake Champlain Agricultural Best Management Practices Monitoring Project was a seven-year special water quality monitoring project completed in 2001. This comparative observational study used a three-way paired watershed experimental design using a single control and two treatment watersheds. The goal was to evaluate the efficacy of both low- and high-intensity whole-watershed BMP implementation strategies. Parameters measured included total phosphorus, total and Kjeldahl

nitrogen, total suspended solids, and *E. coli*. Biological assessments of fish and macroinvertebrate communities were also performed on each of the three watersheds.

B. Biological Monitoring

1. Core Programs

The Ambient Biomonitoring Program was established in 1982 to: 1) monitor long-term trends in water quality as revealed by changes in ambient aquatic biological communities over time; 2) evaluate potential impacts on aquatic biological communities from permitted direct and indirect discharges, Act 250 projects, nonpoint sources, and spills; and 3) establish a reference database to facilitate the generation of Vermont-specific biological criteria for water quality classification and use attainment determinations. Since 1985, VTDEC has used standardized methods for sampling fish and macroinvertebrate communities, evaluating physical habitat, processing samples, and analyzing and evaluating data. The program has led to the development of two Vermont-specific fish community Indexes of Biotic Integrity (IBI) and several macroinvertebrate metrics. Guidelines have been developed to determine water quality standards attainment using both macroinvertebrate community biological integrity metrics and the IBI. Approximately 75 sites per year are assessed, typically during the fall season, using fish and/or macroinvertebrate assemblages. Alkalinity, pH, conductivity, temperature and such measurements as substrate composition, embeddedness, canopy cover, percent and type of periphyton cover, and approximate velocity are routinely monitored. This program provides much of the biological data used in the rotational watershed assessment program for rivers. From 1985 to April 2003, well over 1,700 stream assessments were completed using macroinvertebrate and/or fish from 1,229 stream reaches.

The Aquatic Macrophyte Monitoring Program collects baseline information on aquatic plant communities in Vermont lakes by conducting descriptive surveys using a pre-established plant cover scale. This program has been active since the late 1970's and information is available from 177 discrete surveys.

The WQD conducts numerous Aquatic Nuisance Species Searches and Surveys each year to search for new populations and monitor existing populations of nuisance aquatic species, primarily Eurasian watermilfoil (*Myriophyllum spicatum*), water chestnut (*Trapa natans),* zebra mussels (*Dreissena polymorpha*), and the wetland invasive purple loosestrife (*Lythrum salicaria*).

An interesting component to these aquatic nuisance species efforts is the longest ongoing zebra mussel monitoring program in the nation, the **Lake Champlain Zebra Mussel Monitoring Program**. In conjunction with this effort, 12 in-lake and 12 shoreline stations in Lake Champlain are monitored for larval and settler zebra mussel presence and density every two weeks (April through November). In addition, adult zebra mussel surveys are performed at selected shoreline locations during late summer. This is the only such zebra mussel monitoring project of its kind in the United States. As of April 2003, there were 2,220 veliger records and 1,013 settler records within this program's nine years of data records.

2. Special Studies

The Biodiversity Monitoring Program evaluates the status of selected biological species and communities in Vermont. Specific activities include: 1) distribution surveys of aquatic plant, fish and macroinvertebrate species listed by the Vermont Endangered Species Committee as rare, threatened, endangered, or of special concern; 2) distribution surveys of communities having species considered likely candidates for future listing (e.g., snails); and 3) monitoring of biological communities or community types whose diversity is threatened (e.g., Lake Champlain mussel and cobble/shale macroinvertebrate communities threatened by zebra mussels). Data are used to describe species distribution, identify species/communities at risk, and develop management plans for the protection of identified species/communities.

The Vermont Wetlands Bioassessment Project is a coordinated effort between VTDEC and the Vermont Department of Fish and Wildlife's Non-game and Natural Heritage Program to document and understand the biological and physical characteristics associated with seasonal pools (vernal pools) and northern white cedar swamps in Vermont. Since 1999, the project has collected biological, physical and chemical data from 28 seasonal pools throughout the state. Information collected on the invertebrates, amphibians, algae, and plants associated with seasonal pools has been used to assess and monitor the ecological health of seasonal pools in Vermont. Preliminary efforts at using these data to develop vernal pool biocriteria have seen limited success.

The Lake Bioassessment Project was initiated in 1995 to begin developing biological criteria for Vermont lakes. This monitoring effort was launched as a cooperative project with the State of New Hampshire. The goal of the project is to develop numeric measurements of the phytoplankton, macrophyte, and macroinvertebrate communities in reference lakes for use in assessing aquatic life use attainment in lakes. Consistent protocols have been developed to measure these biological assemblages, and to date, 12 New Hampshire and 38 Vermont lakes have been included in the project. Statistically-validated multimetric indices have been developed for the phytoplankton macroinvertebrate communities, and remain under development for macrophytes.

The Lake Champlain Long-Term Monitoring Program (see also above) includes biological sampling, which is primarily aimed at assessing phytoplankton, zooplankton, and macroinvertebrate communities. Data from this element of the project resides in the New York State Natural History Museum, with copies available only in spreadsheet form in Vermont. These data, which have been underanalyzed and underutilized, should provide a baseline for evaluating changes in ecosystem structure anticipated owing to zebra mussel infestation.

The Northern Leopard Frog Surveys in the Lake Champlain Basin Project was initiated in response to reports of malformed frogs in the Vermont portion of the Lake Champlain basin during the summer of 1996. Malformed frogs were reported from 12 sites in five Vermont counties. Systematic field surveys were initiated in 1997, targeting the northern leopard frog (Rana pipiens). These surveys recorded the frequency and morphological characteristics of gross abnormalities among newly metamorphosed northern leopard frog populations at 20 sites within the basin. With subsequent support through the USEPA REMAP program, WQD has examined over 6,000 northern leopard frogs since 1996, and external malformations have been detected in 7.5% of the frogs examined. Data characterizing the gross abnormalities and describing the frequency and occurrence of abnormalities within northern leopard frog populations continues to be gathered at 10 established sites within the lake basin. All findings are reported to the North American Reporting Center for Amphibian Malformations (http://www.npwrc.usgs.gov/narcam/). VTDEC continues to collaborate with the National Institute of Environmental Health and Sciences, the National Wildlife Health Center, and

other researchers, providing environmental samples and specimens to help further malformed frog investigations.

The Fish Contaminant Monitoring Program is managed by the WQD and performed in cooperation with the Vermont Department of Fish and Wildlife and the Vermont Department of Health. Edible tissue from game fish acquired throughout the state is analyzed for mercury and other contaminants. These data are then used to set and subsequently refine fish consumption advisories issued by the Vermont Department of Health.

Other Biological Monitoring Projects either ongoing or conducted on a periodic basis include:

* monitoring non-target impacts to aquatic biota in lakes chemically treated with the aquatic herbicide Sonar® (fluridone) to control Eurasian watermilfoil infestations;
* monitoring the effects on both target and non-target organisms of copper sulfate treatments to small recreational lakes and water supply reservoirs; and
* monitoring impacts to non-target fish and macroinvertebrates in rivers treated with lampricide (TFM) to control sea lamprey (*Petromyzon marinus*) in Lake Champlain.

C. Volunteer Monitoring

Citizen groups are becoming increasingly involved in monitoring, education, protection, and restoration projects in Vermont. VTDEC provides assistance and training to volunteers whenever possible. Watershed and lake associations are presently active on numerous rivers and lakes in the state. In fact, there are over 100 such associations statewide. The WQD has developed a directory listing various watershed associations and their activities in "Current Programs of Vermont Watershed Associations – 2002," with a lake association addendum listing active lake groups which can be inspected at WQD's web site (www.vtwaterquality.org, click on "lakes and ponds," click on directory).

1. Core programs

The Vermont Lay Monitoring Program equips and trains local lake users to measure the nutrient enrichment of lakes by collecting water quality data following a rigorously documented and quality assured methodology. This citizen monitoring program is based on trophic parameters and monitors approximately 40 lakes and 25 Lake Champlain stations per year. All Lake Champlain stations and many inland lakes in the program are sampled for chlorophyll-a, total phosphorus, and Secchi disk transparency. The remaining inland lakes in the program, from which more limited data are needed, are sampled only for Secchi disk transparency. All sampling occurs on a weekly basis during the summer months. Since development of the Lay Monitoring Program in 1979, data has been generated on 84 inland lakes and 36 Lake Champlain stations. Seventy-two inland lakes and 30 Lake Champlain stations have five or more years of full season data. In addition to their standard monitoring, Vermont's citizen lake monitors also assist in the ANS Watchers Program (see below), and in collecting data for the Lake Bioassessment Project.

The Citizen Lake and Watershed Survey Program provides survey sheets and technical training to volunteers, lake and watershed associations, and other interested groups to enable them to perform screening level assessments to identify potential nonpoint sources of pollution to lakes by conducting in-lake, lakeshore, and lake watershed surveys.

The Aquatic Nuisance Species (ANS) Watchers Program trains citizen volunteers to monitor for the presence of invasive non-native aquatic species. The program is currently focusing on monitoring for Eurasian watermilfoil, water chestnut, and zebra mussels. There are presently 129 ANS Watchers throughout Vermont.

The Volunteer Acid Precipitation Monitoring Program was initiated in 1980 to assess the impact of the 1970 Clean Air Act (and it's 1990 amendments), which mandated nationwide reductions in SO_4 emissions. Dedicated volunteers at six sites around Vermont (Holland, Morrisville, Mt. Mansfield, St. Albans, St. Johnsbury, and Underhill) collect precipitation samples on an event basis. The volume and pH of each storm event is recorded. Additional parameters such as conductivity and wind direction are recorded at individual stations. The data are used to: 1) assess spatial and temporal variability in the pH of bulk precipitation; and 2) assess changes in the pH of bulk precipitation over time and as related to reductions in atmospheric emissions of acid precursors (e.g., oxides of sulfur and nitrogen).

2. Other volunteer initiatives

In 2003, the WQD and the R.A. LaRosa Environmental Laboratory launched a new initiative to foster volunteer monitoring by providing laboratory analytical services cost-free to volunteer organizations under a competitive grant program. While this program is just beginning, it does provide an opportunity to significantly enhance the monitoring of waters of joint importance to volunteer organizations and WQD. Grantees under this program are required to prepare, submit, and adhere to an USEPA pre-approved 'checkoff' QAPP prepared by USEPA Regions 1 and 2 in collaboration with VTDEC and New York State DEC, for volunteer-based projects funded by the Lake Champlain Basin Program. These projects promise to provide a wide array of data of known quality and reliability to be used for assessment reporting.

D. Other Monitoring Partnerships

1. Federal

The US Army Corps of Engineers (ACOE) manages several flood control reservoirs in Vermont. These are monitored routinely for flow and stage, and periodically for a variety of physical and chemical constituents. ACOE reservoirs with designated swimming beaches are also monitored for *E. coli* regularly during the swimming season. ACOE reports on its monitoring activities annually and shares these reports with WQD. ACOE sampling results are used in conjunction with assessment reporting.

The US Environmental Protection Agency (EPA) coordinates regional water quality monitoring projects of a wide variety. In recent years, projects that WQD has collaborated on include the REMAP New England Wadeable Streams Project and the National Study of Chemical Residues in Fish. EPA was also the principal sponsor of the REMAP Assessment of Mercury in Waters, Sediments and Biota of Vermont and New Hampshire lakes project and in the survey of pharmaceuticals in certain Vermont waters. WQD plans to participate in the upcoming REMAP New England Lakes Project. Results of these studies are used for a variety of purposes in addition to assessment reporting.

The US Fish and Wildlife Service (USFWS) sponsors projects across New England dealing with toxic contamination of aquatic biota. WQD has collaborated with USFWS on several projects and data are freely shared. In addition, USFWS co-sponsored the REMAP mercury project discussed above.

The United States Geological Survey (USGS) operates a network of gauging stations on Vermont waters which are supported by a cooperative agreement with VTDEC. This gauging network provides water flow data that are critical for numerous applications, both within and outside of VTDEC. USGS also coordinates several water quality studies throughout Vermont in a variety of disciplines, and the results and data are commonly shared with VTDEC for numerous uses including permitting and assessment reporting.

2. State

The Vermont Department of Forests, Parks, and Recreation (DFP&R) operates a comprehensive beach monitoring program for all public use beaches on State Park lands. Twenty-nine beaches are monitored on a weekly basis during the summer (June – August) following established protocols. Swim advisories are posted by DFP&R based on results of the testing when *E. coli* sample values exceed the Vermont criterion for Class B waters of 77/100ml. These data are openly shared with WQD, who uses the data for the purpose of assessment reporting and for identifying beaches subject to potentially chronic bacterial contamination.

The Vermont Monitoring Cooperative (VMC) is a collaborative organization in which scientists collect and pool information and data for the purpose of improving our understanding, protection, and management of Vermont's forested ecosystems. Participating cooperators from government, academic and private sectors, conduct research projects on a variety of topics including forest health, air quality and meteorology, wildlife, aquatic systems and others. The VMC helps make the data and results from these projects available to other scientists, educators, resource managers and the general public. The VMC was initiated in 1990 as a state, university, and federal partnership, with an envisioned one-hundred year lifespan. The centerpiece of the VMC is the data library and card catalogue system that allow data to be shared, archived, and accessed by scientists and other interested parties via the VMC website. The data archive contains data and ancillary textual material from over 100 projects and is geographically and temporally linked.

The Vermont Geological Survey (VGS), also known as the Geology and Mineral Resources Division of VTDEC, conducts research and surveys related to the geology, mineral and groundwater resources of Vermont. VGS serves as a clearinghouse for the State's topographical information.

3. Local

The Addison County Collaborative (ACC) is a volunteer-based consortium of local volunteer organizations that monitor waters in several watersheds in the vicinity of Addison County. Partial funding is typically allocated through the Addison County Regional Planning Commission. ACC has monitored approximately 45 sites across four watersheds for *E. coli* and eutrophication-related parameters. ACC provides data and summary reports to VTDEC on an annual basis. These data are used to assist development and implementation of the Otter Creek and Lower Direct Champlain Basin Plans and in assessment reporting.

The Lewis Creek Association (LCA) is a private, non-profit organization dedicated to protect, maintain and restore ecological health while promoting social values that support sustainable community development in the six-town watershed region as well as other areas of Vermont. LCA is a member organization of the ACC noted above.

The White River Partnership (WRP) is a private, non-profit organization dedicated to helping local communities balance the long-term cultural, economic and environmental health of the watershed

through active citizen participation. The WRP, using US Department of Agriculture funding leveraged by private donations, has established a monitoring program for the watershed, comprised of multiple elements and several volunteer "stream-teams." Activities include geomorphic assessment, priority site mapping, and water quality sampling for a variety of constituents including temperature, turbidity, conductivity, and *E. coli*. WRP's active base of volunteer monitors generate quality-assured data that is used to identify priority reaches for protection or remediation. VTDEC is periodically provided data summaries for use in implementation of the White River Basin Plan, in assessment Reporting, and in other joint special studies.

The West River Association (WRA) is a newly forming group dedicated to similar goals as the WRP and ACC, for waters in the West River watershed. This organization plans to launch a new monitoring project in partnership with WQD during 2003. Project data will be used for several purposes including assessment reporting.

The Friends of the Mad River (FMR) is a non-profit organization sharing similar goals to the above noted groups. The FMR has undertaken a number of planning and implementation projects along with a long-standing water quality monitoring program which includes *E. coli* and a number of other parameters. VTDEC is periodically provided data for use in assessment reporting.

The Watershed Alliance of the University of Vermont and **River Network** have been active in promoting surface water quality monitoring for elementary and high schools. Such monitoring is valuable from an educational and student/community involvement standpoint. When monitoring results are shared with VTDEC, the information can be considered during assessment reporting.

Appendix D

Fish Consumption Advisory

(Vermont Department of Health, 6/2000)

HEALTH ALERT

The Vermont Department of Health recommends that people limit their consumption of some fish caught in Vermont waters.

The advisory is based on tests of hundreds of fish caught in Vermont waters in the past 10 years and on scientific information about the harmful effects of mercury and, in the case of large lake trout in Lake Champlain and all fish in the Hoosic River, of PCBs (polychlorinated biphenyls).

To minimize exposure to these potentially harmful contaminants and to protect your health, follow the guidelines below when eating fish caught in Vermont. Eating the total monthly limit within a single week is not recommended. (One meal equals 8 ounces of raw fish fillet.)

General Advisory:	**WOMEN OF CHILDBEARING AGE** (particularly pregnant women, women planning to get pregnant, and breastfeeding mothers) and **CHILDREN AGE 6 OR YOUNGER**	**ALL OTHER INDIVIDUALS**
Brown Bullhead, Pumpkinseed	No Advisory	No Advisory
Walleye	0 Meals	No more than 1 meal/month
Lake Trout, Smallmouth Bass, Chain Pickerel, American Eel	No more than 1 meal/month	No more than 3 meals/month
Largemouth Bass, Northern Pike	No more than 2 meals/month	No more than 6 meals/month
Brook Trout, Brown Trout, Rainbow Trout, Yellow Perch	No more than 3-4 meals/month	No Advisory
All Other Fish	No more than 2-3 meals/month	No more than 9 meals/month
Special Advisories:		
Lake Carmi – Walleye	No more than 4 meals/month	No Advisory
Lake Champlain - Lake Trout larger than 25 inches	0 Meals **(includes all children under age 15)**	No more than 1 meal/month
Hoosic River - All Fish	0 meals	0 meals

15 Mile Falls Chain (Comerford Reservoir and Moore Reservoir) - All Fish	0 meals	No more than 2 meals/month
15 Mile Falls Chain (McIndoes Reservoir) - Yellow Perch	No more than 2 meals/month	No more than 6 meals/month
15 Mile Falls Chain (McIndoes Reservoir) - All Other Fish	No more than 1 meal/month	No more than 3 meals/month
Special Advisory: Deerfield Chain (Grout Pond, Somerset Reservoir, Harriman Reservoir, Sherman Reservoir, Searsburg Reservoir)		
Brown Bullhead, Brook Trout	No Advisory	No Advisory
Rainbow Trout, Brown Trout (smaller than 14 inches), Rock Bass, Rainbow Smelt, Yellow Perch	No more than 1 meal/month	No more than 3 meals/month
Brown Trout (larger than 14 inches), All Other Fish	0 Meals	No more than 1 meal/month

For more information call: 1-800-439-8550

Issued: June 2000

Appendix E

Report on the Status of Groundwater & Aquifer Mapping in the State of Vermont

Report on the Status of Groundwater and Aquifer Mapping in the State of Vermont January 2003

Submitted to the Chairs of the
Senate and House Committees on Natural Resources and Energy

As Required in Act 133 of the 2002 Vermont Legislative Session

Developed by:
Department of Environmental Conservation
Division of Geology and Division of Water Supply

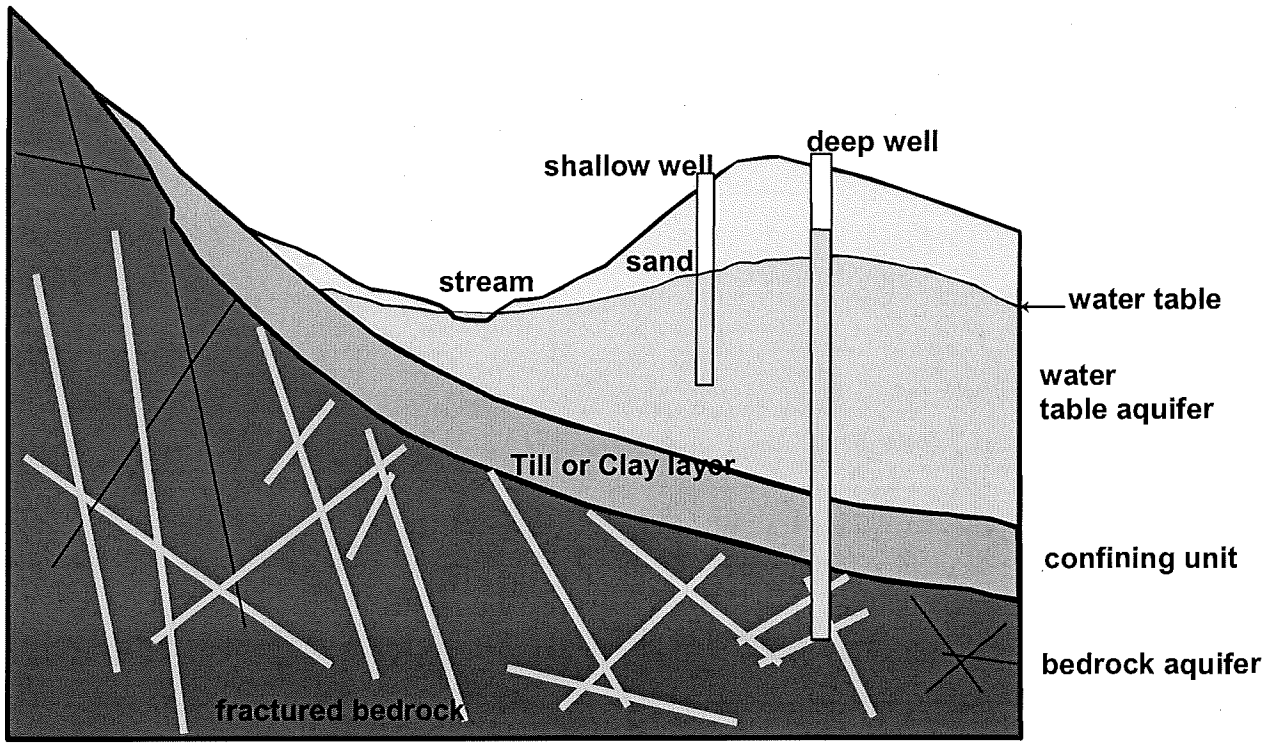


Diagram showing a cross-section through the water table and bedrock aquifers

Table of Contents

Executive Summary 3
Introduction 5
Background 5
Status of Aquifer Mapping 7
Status of Statewide Groundwater Classification 8
Status of Mapping Naturally-occurring Contaminants of Concern That May Preclude the Use of an Aquifer for Drinking Water Supplies 9
Potential Obstacles and Difficulties in Completing Aquifer Mapping Statewide 10
Completing Aquifer Mapping of the State 10
Basic Mapping 10
Basic Mapping Timeline, Resources, and Partners 11
Expanded Mapping 11
Expanded Mapping Timeline, Resources, and Partners 12
Premium Mapping 12
Premium Mapping Timeline, Resources, and Partners 12
Potential Funding Sources and Partners 13
Appendix 1 Explanation of Terms 15
Appendix 2 Groundwater Resources Relevant Data 17
Appendix 3 Scales 20
Appendix 4 Bedrock and Surficial Geologic Information 21
Appendix 5 Selected Text from Act 133 of the 2001-2002 Vermont Legislative Session 22
Appendix 6 10 VSA, Chapter 48 23
Appendix 7 References 33

Executive Summary

Groundwater is one of Vermont's most important and least understood natural resources. The science of groundwater and aquifers—hydrogeology—is a growing field of knowledge. To better assess these resources, Vermont needs to apply new science and tools for mapping groundwater. Act 133 of the 2002 Legislative Session recognized the importance of the resource and requires the Secretary of the Agency of Natural Resources to prepare a report on the status of groundwater and aquifers in Vermont.

Sixty-six percent of Vermont's population depends on groundwater for their drinking water supply. Groundwater is also used for manufacturing, agriculture, commercial enterprises, and to support aquatic habitat. Following a drought in the mid-1960s, Vermont took the first steps towards understanding the groundwater resource. This work includes research on the sand and gravel aquifers in the valley bottoms. Since the 1960s, mapping has been performed at increasing levels of detail and decreasing degrees of coverage.

Under 10 V.S.A., Chapter 48, the Secretary of the Agency of Natural Resources is responsible for groundwater classification. The Secretary has reclassified several areas as Class IV (non-potable), but has not completed any Class I or Class II designations. The Agency of Natural Resources has established protective measures for Source Protection Areas that are comparable to Class II Groundwater Areas. Source Protection Areas have been identified for all of the Public Community Water Systems in the state.

Naturally-occurring contaminants of concern pose a health risk to Vermonters. The location and severity of these threats in groundwater are not well understood. The Vermont Geological Survey has completed some initial research and mapping on radioactivity, arsenic, and radon.

Existing maps and data can be used to create rudimentary aquifer maps for some parts of the state. However, the most obvious obstacle to completing aquifer mapping statewide is the lack of a dedicated funding source for employing people to analyze and compile data, to provide contracts and grants to partners, and to purchase scientific equipment to collect data. This report identifies three levels of research to develop groundwater and aquifer maps of increasing accuracy. Each level builds upon the previous level in detail and time using increasingly sophisticated tools, technical expertise, and scientific evaluation.

The proposed Basic Mapping effort relies upon the use, analysis, and interpretation of existing data. This work will result in a series of maps showing groundwater recharge potential, groundwater levels, groundwater availability, surficial material thickness, regional areas of concern for naturally-occurring contaminants, and classification of existing public water sources. These maps can be used for regional planning purposes to identify areas for groundwater protection and growth opportunities. The basic mapping work could be completed by July 1, 2007 assuming that at least 9 positions are filled starting in July 2003 and are fully funded through July 1, 2007. The total cost of personnel, equipment, contracts, and grants is estimated at $2.7 million.

The second level, Expanded Mapping, would develop all of the maps and information discussed in the basic level and also develop aquifer maps for planning and protection at a town level. The maps of naturally-occurring contaminants would identify specific areas of concern. Due to the complexity of this work, the Expanded Mapping Program would take seven years. The cost to complete the Basic and Expanded work, including personnel, equipment, grants, and contracts, is $4.7 million.

The Premium Mapping would produce maps that support appropriate regional development, sustainable economies, protection of future drinking water resources, and environmental health. In addition to the work identified in the Basic and Expanded Mapping, the Agency of Natural Resources would identify Class I and II Groundwater Areas that would be suitable for potential future public water supply sources; identify Class IV Groundwater Areas for naturally-occurring contaminants of concern; and research and map groundwater and surface water interaction studies. This entire set of work, Basic, Expanded, and Premium, would take ten years and cost $6.9 million.

The existing grants from EPA to Agency of Natural Resources have the flexibility to fund groundwater research; however, funding would have to be moved from existing base programs. These base programs include permitting, technical assistance and outreach on other statutorily required programs. A number of scientific organizations would be interested in partnering with the State of Vermont to complete aquifer or groundwater mapping in the state. These organizations could provide scientific, technical, and administrative expertise. Usually, these organizations seek financial support as part of their work.

Introduction

Groundwater is one of Vermont's most important and least understood natural resources. The science of groundwater and aquifers—hydrogeology—is a growing field of knowledge. To better assess these resources, Vermont needs to apply new science and tools for mapping groundwater. Act 133 of the 2002 Legislative Session recognized the importance of the resource and requires the Secretary of the Agency of Natural Resources to prepare a report on the status of groundwater and aquifers in Vermont.

This report addresses the status of aquifer mapping, statewide groundwater classification, and mapping of naturally occurring contaminants of concern that may preclude use of an aquifer for drinking water supplies. The potential obstacles, difficulties, and resources needed to complete the mapping and other work by July 1, 2007 are discussed in this report, along with potential funding sources and partners. A time frame is included for completing the work, assuming that the necessary resources are provided.

Background

Sixty-six percent of Vermont's population depends on groundwater for their drinking water supply. Groundwater is also used for manufacturing, agriculture, and commercial enterprises. Groundwater contributes flow to surface water that in turn protects and supports wildlife. Lakes, streams, and wetlands are recharged by groundwater. While Vermont appears to have an abundance of groundwater, Vermonters need to be vigilant to maintain our apparent good water quality and quantity. As Vermont's population and economy grow, the demands for groundwater increase. Understanding Vermont's groundwater system can help predict the location of useable groundwater supplies. Without the knowledge of aquifers and the groundwater system, this valuable resource may not be sustainable for the multiple uses in the future.

In Vermont, the groundwater system is complex due to the state's unique geology. Figure 1 and 2 show simplified views of the water cycle and how groundwater can be intercepted by wells.

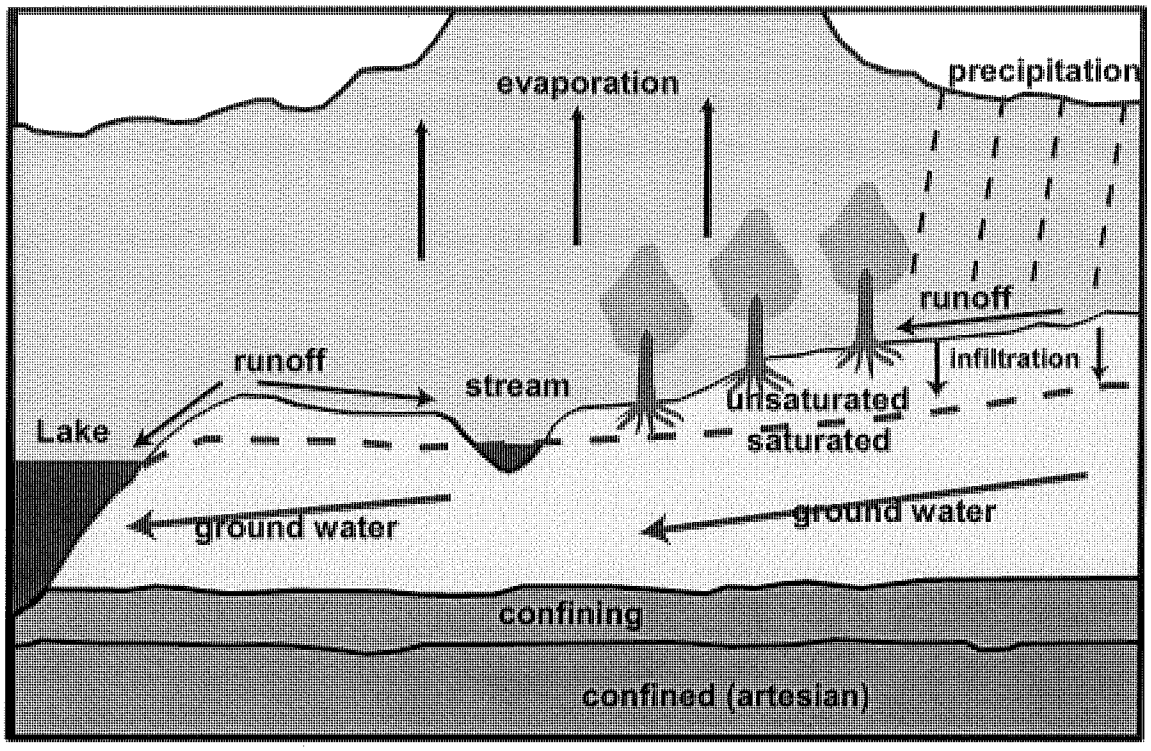


Figure 1- Diagram showing a cross-section through the earth's surface and the water cycle

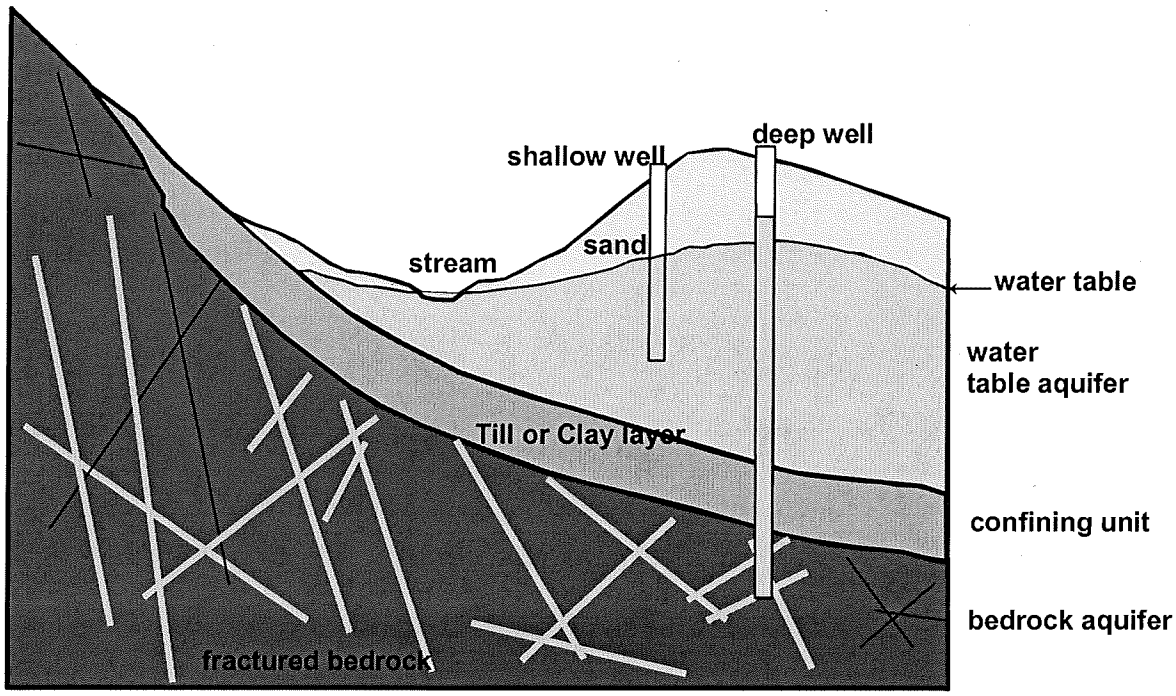


Figure 2- Diagram showing a cross-section through the water table and bedrock aquifers

Under all of Vermont lies the state's bedrock geology. These rocks are tightly folded and broken as a result of the uplift of the Green Mountains. On top of the bedrock are earth materials—boulders, gravel, sand and clay—deposited as the glaciers retreated more than 12,000 year ago. Since that time, the landscape has been reworked by water. All of these layers comprise the vessel that contains Vermont's groundwater.

In order to understand Vermont's aquifers, studies are needed on a statewide basis to reveal the complex dynamics of groundwater. The level of detail will determine the appropriate uses of the data. The data may be suitable for regional and town planning, locating wells for new development, or protecting areas for future uses. Even with well-researched locations, the predicted water quality and quantity may be difficult to achieve. However, with every added level of detail, the probability of finding high quality and quantity increases.

Status of Aquifer Mapping

Following a drought in the mid-1960s, Vermont took the first steps towards understanding the groundwater resource. This work includes research on the sand and gravel aquifers in the valley bottoms. Geologic work completed in the 1950s and 1960s supports more recent hydrogeologic work. Starting in 1966, well drillers have been completing and submitting a report on each well drilled in the state with information on the well characteristics, the owner's name, general location, depth, rock and soil types, and yield. The locations of many of these wells are not accurate and therefore the corresponding data is impractical to use. Since the 1960s, mapping has been performed at increasing levels of detail and decreasing degrees of coverage. The appendices contain a comprehensive list of major groundwater studies in the state.

By 1975, the Vermont Geological Survey completed work on a map series known as *Geology for Environmental Planning*. This series includes groundwater potential maps for seven regions of the State that covers 66% of Vermont's land area. Potential groundwater quantities are characterized on these maps. These data can be used for a general picture of groundwater potential, but they are not suitable for regional or town planning due to the scale and no topographic detail. In the series, the primary data used to enhance groundwater designations include the *Surficial Geologic Map of Vermont* (1970) and the *Centennial Geologic Map of Vermont* (1961).

Between 1976 and 1982, four additional studies were completed -- the *Ground-water Resources* maps for the White River Junction Area, the Rutland Area, the Barre-Montpelier Area, and Upper Winooski River Basin. These studies cover 11.2% of the state's land area and were conducted by the Vermont Department of Water Resources and the United States Geological Survey (USGS). These maps added detail largely gained through locating a significant number of water well logs; interpreting sand, gravel, and bedrock favorability from well logs; and geologic information. At least two of these reports lack the level of detail and information necessary to conduct adequate regional and town planning. A significant number of wells have been drilled since 1982. Locating new wells and analyzing the data could provide a useful product for regional planning.

In addition to the regional studies conducted above, all Public Community Water Systems have identified their Source Protection Areas. Most of the areas are based on located water wells, geology, and groundwater flow parameters derived from tests performed when public groundwater sources are located. A small subset of the Source Protection Areas are 3000 foot radius circles.

Since the 1980s, towns have requested groundwater information for planning purposes. The Agency of Natural Resources has provided assistance to almost twenty towns using the existing information and resources to create maps for town planning purposes. Two years ago, the Vermont Geological Survey produced an aquifer recharge map, a groundwater surface map, a thickness of overburden map, and aquifer delineations for part of Arlington using federal State Map Grant monies. This effort created new surficial geologic maps and located water wells. Due to resource constraints, the Agency of Natural Resources has only been able to assistance one or two towns per year with detail information and mapping.

Status of Statewide Groundwater Classification

The Secretary of the Agency of Natural Resources is responsible for reclassifying groundwater. According to 10 V.S.A., Chapter 48 (see Appendix 6), four classes of groundwater exist. Class I is suitable as a public water supply source with no risk associated with it. Class II is suitable as a public water supply source with some risk associated with it. Class III is suitable for private water supplies, agricultural, industrial, and commercial use. Class IV is considered non-potable, but may be suitable for some other uses. The statute also provides for all groundwater to be Class III until the Secretary reclassifies it.

In order to define the method of reclassification, the Agency of Natural Resources developed a process in the Groundwater Protection Rule and Strategy and established procedures for mapping Class I and II Groundwater Areas and for mapping Class IV Groundwater Areas.

In the Groundwater Protection and Management Report to the Legislature for 1988, the Agency noted that it had identified and mapped nine potential Class I areas. A separate report on these areas was submitted to the legislature with the Report for Calendar Year 1990. Class I Groundwater Areas require legislative approval. No Class I Groundwater Areas have been designated. In the Report to the Legislature for 1992, the Agency stated, "The mapping of groundwater resources for future use has been deferred pending available resources . . . " At this point in time, the Water Supply Division began to implement the federal Wellhead Protection Program and Source Approval process required by 10 V.S.A., Chapter 56 for protecting public drinking water supplies. The Agency of Natural Resources has established protective measures for Source Protection Areas that are comparable to Class II Groundwater Areas. Source Protection Areas, also known as Wellhead Protection Areas, have been identified for all of the Public Community Water Systems in the state.

Since 1993, the Secretary has approved four areas to be reclassified from Class III to Class IV. These areas are the Pine Street Barge Canal in Burlington; Tansitor Electronics in Bennington; Bennington Landfill in Bennington; and Windham Solid Waste Management District Landfill in Brattleboro. The Secretary is reviewing five proposed Class IV groundwater areas.

Status of Mapping Naturally-occurring Contaminants of Concern That May Preclude the Use of an Aquifer for Drinking Water Supplies

Naturally-occurring contaminants of concern are found in all rocks, soil, and water. While some naturally-occurring elements do not pose a risk to public health, others can cause serious health problems. The United State Environmental Protection Agency has established a number of maximum contaminant levels for the elements that occur in drinking water. Additionally, the Vermont Department of Health has established Health Advisories for Drinking Water for additional contaminants of concern. The naturally-occurring contaminants of concern include radon, arsenic, radionuclides, and a variety of metals. Additionally, some elements cause concern because of appearance and odor problems, but they do not lead to health problems.

Radioactivity can be naturally-occurring. Vermont rocks contain radioactive elements such as, Uranium. Radioactive elements decay releasing atomic particles and energy.

The Vermont Geological Survey released a statewide map on radioactivity in September 2002. This map, *Compilation and Assessment of Radioactivity Data in Vermont*, is a compilation of areas where historical ground and air surveys have indicated the presence of elevated naturally-occurring radioactivity relative to surrounding areas. Public water systems with elevated radioactivity are also shown. The map does not show where bedrock wells will have elevated radioactivity; it only provides a compilation of historical data. The impetus for the statewide map was the discovery of elevated radioactivity in domestic wells in Milton and Colchester. Further work in Milton and Colchester is the basis of a map series showing the bedrock geology, a cross-section of the geology, a fracture map, a draft radioactivity hazard map, detailed Geiger counter grids, and a well yield map. These maps enable local officials to understand the geologic context of the elevated radioactivity in bedrock and serve as a framework from which to propose further action.

Radon, a naturally occurring contaminant in air and groundwater, is under investigation by the Vermont Geological Survey. A draft statewide map of radon in air shows the number of radon tests per town and the percentage of tests equaling or exceeding the EPA level of concern. A second version of this map is currently being scientifically reviewed and will incorporate over 6000 radon analyses. The EPA published a report, *EPA's Map of Radon Zones--Vermont*, in 1993. The Vermont Department of Health published a report on radon in public water supplies in 1986 (Manning and Ladue, 1986).

The Water Supply Division collects arsenic data from public water supplies and has constructed a GIS database from these data. Statewide maps showing public drinking water systems that are above and below a level of concern have been prepared using town and geologic maps. The Vermont Geologic Survey is investigating the connection between bedrock and arsenic as part of the map preparation. A draft version of the map is under scientific review.

Although no statewide specific studies have been completed on any of the other naturally occurring contaminants of concern, such as asbestos, barium, cadmium, chromium, copper, lead, mercury, selenium, antimony, beryllium, cyanide, nickel, thallium, or natural gas, the Water

Supply Division maintains a database of chemicals and elements sampled for by public water supplies that can be used for future studies.

Potential Obstacles and Difficulties in Completing Aquifer Mapping Statewide

The Agency of Natural Resources currently collects a wide variety of data on groundwater quality and quantity. This includes well log data for 90,000 wells, water quality from public water supplies, pump test data from public water sources, water quality from hazardous sites, geologic studies, source protection areas for public water supplies, and identification of Class IV Groundwater Areas.

These data exist in a variety of formats, including paper, mylar, GIS datalayers, and computer spreadsheets. The accuracy of the data varies significantly depending upon the methods and tools used to collect the data, the scale of the map, and other factors. In some locations, a great deal of information exists to produce aquifer maps and in many other areas of the state little to no information exists on which to base an aquifer map on. Additionally, the information is spread between several divisions in the Agency of Natural Resources. Existing maps and data can be used to create rudimentary aquifer maps for some parts of the state. However, the most obvious obstacle to completing aquifer mapping statewide is the lack of a dedicated funding source for employing people to analyze and compile data, to provide contracts and grants to partners, and to purchase scientific equipment to collect data.

Completing Aquifer Mapping of the State

Groundwater mapping can be very broad and used for regional planning purposes or more detailed and used for locating a specific well. This report includes three levels of research to develop groundwater and aquifer maps of increasing accuracy. The three levels are presented to provide a broad picture of the work that could be completed given the available resources. Each level builds upon the previous level in detail and time using increasingly sophisticated tools, technical expertise, and scientific evaluation.

Basic Mapping

The basic level of effort relies upon the use, analysis, and interpretation of existing data. The data to be used includes the well log database, the statewide surficial and bedrock maps, public water system pump test data, and water quality data. The Agency of Natural Resources would field verify and analyze this information, in particular the water well data, using Geographical Information Systems, computer databases, and hydrogeologic studies to produce a generalized assessment and delineation of the surficial and bedrock aquifers.

This work will result in a series of maps showing groundwater recharge potential, groundwater levels, groundwater availability, and surficial material thickness. These maps can be used for regional planning purposes to identify areas for groundwater protection and growth opportunities. This approach would also collate existing data for other contaminants of concern to produce maps of similar detail to the statewide radioactivity map completed by the Vermont Geologic Survey in 2002. The naturally-occurring maps could then be used as guidance for

testing private wells for specific contaminants of concern. The existing Public Water System Source Protection Areas would be reviewed to determine which are appropriate for proposing as Class I and II Groundwater Areas. Additionally, pilot studies in selected growth areas would be conducted to gather detailed information on bedrock aquifers, surficial aquifers and radionuclides.

Basic Mapping Timeline, Resources, and Partners

The basic mapping work can be completed by July 1, 2007 assuming that at least 9 positions are filled starting in July 2003 and are fully funded through July 1, 2007. These positions would include field personnel to verify data, professional hydrogeologists to analyze and interpret the data, administrative support, computer and project oversight personnel. Contracts or grants with the United States Geological Survey would be necessary to provide expertise in select areas. Additional expenses in computer, office and field equipment are expected to be significant because the Agency of Natural Resources currently lacks the equipment to conduct the necessary level of research.

Basic Mapping Costs Timeframe: July 2003-July 2007		
Personnel Costs (Salary, Travel, Office Equipment Fringe, Indirect, Other Service Charges)	$564,250 year x 4 years	$2,257,000
Scientific Equipment (gamma ray spectrometer, map plotter, GPS units, etc.)	$35,000	$35,000
Grants & Contracts	$100,000/year x 4 years	$400,000
TOTAL		$2,692,000

Expanded Mapping

The second level of effort would develop aquifer details to a more predictable and reliable level for planning and protection at a town level. The Agency of Natural Resources would prioritize areas for in-depth studies due to pressures from economic growth, environmentally sensitive areas, and concurrent studies within the Agency of Natural Resources. Using field research, the aquifer boundaries and characteristic would be identified and mapped. This work would build upon the work completed under the Basic Mapping Program.

The Agency would partner with scientific organizations, such as the USGS and EPA, to develop comprehensive maps. These maps would involve geophysical studies, test drilling to verify subsurface characteristics, extensive geologic and orthophotograph map analysis, groundwater sampling, statistical assessments, and fieldwork to verify rock types and structures. The maps of naturally-occurring contaminants would be developed using in-depth research to provide maps on specific areas of concern identified during the Basic Mapping. These maps could be used by homeowners, health and real estate professionals to identify areas that may warrant additional testing for potential health risks.

Expanded Mapping Timeline, Resources, and Partners

Due to the complexity of this work, the initial assessment discussed under Basic Mapping could be completed by July 1, 2007, but the Expanded Mapping Program would take until July 2010. Additional costs include the continuation of the nine positions identified in the Basic Mapping Program for another three years, continued grants and contracts with scientific partners, and purchasing additional scientific equipment.

Expanded Mapping Costs Timeframe: July 2003-July 2010		
Personnel Costs (Salary, Travel, Office Equipment Fringe, Indirect, Other Service Charges)	$564,250 year x 7 years	$3,949,750
Scientific Equipment & Water Testing (gamma ray spectrometer, map plotter, GPS units, lab costs, geophysical equipment, etc.)	$160,000	$160,000
Grants & Contracts	$100,000/year x 7 years	$600,000
TOTAL		$4,709,750

Premium Mapping

The most intensive level of effort to map groundwater and aquifers would produce maps that support appropriate regional development, sustainable economies, protection of future drinking water resources, and environmental health. This work would build on the Basic and Expanded Mapping discussed above and would focus on the high growth and environmentally sensitive areas. The Agency would conduct pump tests and monitor wells to investigate the three-dimensial aspects of aquifers and groundwater flow. Additionally, computer modeling would be used to further define aquifer characteristics.

The Agency of Natural Resources would use the information to identify and map Class I and II Groundwater Areas that would be suitable for potential future public water supply sources using the criteria discussed in 10 VSA§1394(h). Future public water supply sources can be critical to identifying reliable water supplies for planned growth areas. The Agency would also identify and establish Class IV Groundwater Areas for naturally-occurring contaminants of concern. Finally, groundwater maps and groundwater and surface water interaction studies would be conducted for the watershed and basin planning processes.

Premium Mapping Timeline, Resources, and Partners

This Premium Mapping Program will build upon the Basic and Expanded Mapping Program. In order to complete the work through the premium level, ten years of funding is necessary. Additionally, the work with scientific partners will need to continue and additional scientific and technical equipment will be necessary.

Premium Mapping Costs Timeframe: July 2003-July 2013		
Personnel Costs (Salary, Travel, Office		

Equipment Fringe, Indirect, Other Service Charges)	$564,250 /year x 10 years	$5,642,500
Scientific Equipment and Water Testing (gamma ray spectrometer, map plotter, GPS units, lab costs, geophysical equipment, etc.)	$210,000	$210,000
Grants & Contracts	$100,000/year x 10 years	$1,000,000
TOTAL		$6,852,500

Potential Funding Sources and Partners

When the Groundwater Protection Statute was created in 1985, a mix of federal grants and state general fund dollars funded the work of groundwater protection and mapping. Over the years, funding sources for groundwater protection work at the state level have been reduced. Concurrently, the USGS and EPA have also seen a decrease in their resources for groundwater and aquifers.

The existing grants from EPA to Agency of Natural Resources have the flexibility to fund groundwater research; however, funding would have to be moved from existing base programs. These base programs include permitting, technical assistance and outreach on other statutorily required programs. The state general fund dollars are no longer committed to work on groundwater mapping with the exception of some of the state geologist's funding and matching funds provided for the state public water supply program.

The Vermont Geological Survey applies annually for a competitive federal grant to map basic geologic formations with added resources for groundwater mapping. This work is comparable to the level of detail discussed under Expanded Mapping without all of the in-depth scientific research. Typically, the Survey receives $50,000 to fund one or two groundwater-related projects each year and an equal state match is required. The Agency of Natural Resources provides the administrative and technical support for groundwater reclassification reviews. In 2002, the Agency estimated that less than 10% of a position was available for reclassification review. These funds and resources have not been sufficient to support a large groundwater mapping and reclassification program.

The Water Supply Division has a loan program for developing new public drinking water sources. The loan monies can be used to delineate the Source Protection Area for a new public community water system source, but not a groundwater classification area. The loan program is based on a priority system and the amount of federal funding varies each year.

A number of scientific organizations would be interested in partnering with the State of Vermont to complete aquifer or groundwater mapping in the state. The two primary organizations are the United States Environmental Protection Agency (EPA) and the United States Geological Survey (USGS). The EPA does not typically fund large groundwater and aquifer mapping projects. They do provide technical expertise in naturally-occurring contaminants of concern and drinking water sources. The USGS welcomes opportunities to work with states in a variety of

groundwater, surface water, and geologic areas. They work on a cost-share basis which is typically 50-50.

In addition to the EPA and USGS, partnerships could be developed with the Regional Planning Commissions, colleges, and universities. The Vermont Geological Survey has already developed partnerships with some of these organizations as part of current mapping efforts. These efforts could include data analysis, data gathering, and report review.

Appendix 1 Explanation of Terms

Aquifer - A water bearing stratum of permeable rock, sand, gravel or other alluvial soils. (Definition in Vermont Statute)

Bedrock - A general term for any consolidated rock.

Confining unit or layer - Geological material through which significant quantities of water can not move; located below unconfined aquifers, above and below confined aquifers. Also known as a confining bed.

GPS (Global Positioning System) - A satellite navigation system. GPS is funded by and controlled by the U. S. Department of Defense (DOD). GPS provides specially coded satellite signals that can be processed in a GPS receiver, enabling the receiver to compute position, velocity and time.

Geiger counter - Geiger counters are instruments that can detect and measure radioactivity. Survey meters convert electrons ionized by radiation into a current that produces the clicks popularly associated with the instrument.

Groundwater - Water below the land surface, but does not include surface waters within the meaning of 10 V.S.A. § 1251(13). (13) - "Waters" includes all rivers, streams, creeks, brooks, reservoirs, ponds, lakes, springs and all bodies of surface waters, artificial or natural, which are contained within, flow through or border upon the state or any portion of it; (Definition in Vermont Statute)

Groundwater potential - Refers to potential well yield in any given area.

Hydrogeology - The science that deals with subsurface waters and with related geologic aspects of surface waters.

Orthophotograph - An overlapping pair of aerial photographs mathematically and optically corrected so the result is an accurate map with the pictorial quality of an aerial photograph.

Overburden – The loose soil, silt, sand, gravel, or other unconsolidated material overlying bedrock, either transported or formed in place.

Radionuclide - A radioactive nuclide. An unstable isotope of an element that decays or disintegrates spontaneously, emitting radiation.

Recharge - The processes involved in the addition of water to the zone of saturation; also the amount of water added.

Recharge areas - The area of land that allow water to replenish an aquifer; this process occurs naturally when rainfall filters down through the soil or rock into an aquifer, usually in the higher

gradient section overlying the aquifer; artificial recharge is through injection wells or by spreading water over ground water reservoirs reservoir for any given area.

Unconfined aquifer - An aquifer in which the water table is at or near atmosphere pressure. A permeable geologic bed, only partially filled with water that overlies a relatively impervious underground layer.

Unsaturated zone - The area between the land surface and the water table where the soil is not fully saturated with water, although some water may be present.

Water table - The water level of an unconfined aquifer, below which the pore spaces are generally saturated. The top of the zone of saturation.

Appendix 2 Groundwater Resources Relevant Data

TYPE	KIND	LEVEL OF DETAIL	% OF LAND AREA OF STATE	FORMAT
Aquifer Information	Groundwater Favorability Maps - generalized maps (Vermont in cooperation with USGS)	Scale 1:125,000[1]- reconnaissance map, some sand and gravel wells, bedrock wells, & bridge borings located	100%; 11 River Basins	Image files on CD
Aquifer Information	Geology for Environmental Planning Series - includes Groundwater Potential Maps (Vermont Geological Survey)	Scale 1:100,000[1]- integrated favorability map data above, with additional well logs, seismic lines, and 1970 Surficial Geologic Map of Vermont; shows polygons for sand and gravel with addition of bedrock potential and interpretation of buried channels.	66%; Six Printed Volumes, One Additional Unpublished	Paper & Image files on CD
Aquifer Information	Groundwater Resources of White River Jct., Barre-Montpelier, Upper Winooski and Rutland Areas, (Vermont in cooperation with USGS)	Scale 1:48,000[1]- numerous well logs located and some yield data assessed, some borings from engineered projects, seismic lines, existing pump tests considered, chemical analyses for some wells, groundwater availability in unconsolidated materials and bedrock.	11.2%; Four complete reports, One report on Lower Connecticut River that focuses on public water supply withdrawals and seismic lines	Paper
Aquifer Information - Aquifer Recharge, Pieziometric Surface	Arlington Quadrangle Open File Report (Vermont Geological Survey)	Scale 1:24,000[1] - Surface Overburden Aquifer, Bedrock Aquifer Pieziometric Surface, Aquifer Recharge Potential Map, Surficial Geologic Map, and located water well database.	One 7.5 minute quadrangle[2]	Paper & GIS