Technical Report No. 16

Background Technical Information for: *Opportunities for Action - An Evolving Plan for the Future of the Lake Champlain Basin*

Lake Champlain
Basin Program

Prepared by the
Lake Champlain Basin Program

for
Lake Champlain Management Conference

June 1996

PUBLICATION SERIES

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This technical report is the sixteenth in a series of reports prepared under the Lake Champlain Basin Program. Those in print are listed below.

Lake Champlain Basin Program Technical Reports

1. *A Research and Monitoring Agenda for Lake Champlain.* Proceedings of a Workshop, December 17-19, 1991, Burlington, VT. Lake Champlain Research Consortium. May, 1992.

2. *Design and Initial Implementation of a Comprehensive Agricultural Monitoring and Evaluation Network (CAMEN) for the Lake Champlain Basin.* New York - Vermont Strategic Core Group. February, 1993.

3. (A) *GIS Management Plan for the Lake Champlain Basin Program.* Vermont Center for Geographic Information, Inc., and Associates in Rural Development. March, 1993.

   (B) *Handbook of GIS Standards and Procedures for the Lake Champlain Basin Program.* Vermont Center for Geographic Information, Inc. March, 1993.

   (C) *GIS Data Inventory for the Lake Champlain Basin Program.* Vermont Center for Geographic Information, Inc. March, 1993.

4. (A) *Lake Champlain Economic Database Project. Executive Summary.* Holmes & Associates. March 1993.

   (B) *Socio-Economic Profile, Database, and Description of the Tourism Economy for the Lake Champlain Basin.* Holmes & Associates. March 1993.

   (B) *Socio-Economic Profile, Database, and Description of the Tourism Economy for the Lake Champlain Basin - Appendix.* Holmes & Associates. March 1993.

   (C) *Potential Applications of Economic Instruments for Environmental Protection in the Lake Champlain Basin.* Anthony Artuso. March 1993.

   (D) *Conceptual Framework for Evaluation of Pollution Control Strategies and Water Quality Standards for Lake Champlain.* Anthony Artuso. March 1993.

5. *Lake Champlain Sediment Toxics Assessment Program. An Assessment of Sediment - Associated Contaminants in Lake Champlain - Phase 1.* Alan McIntosh, Editor, UVM School of Natural Resources. February 1994.

   (A) *Lake Champlain Sediment Toxics Assessment Program. An Assessment of Sediment - Associated Contaminants in Lake Champlain - Phase 1. Executive Summary.* Alan McIntosh, Editor, UVM School of Natural Resources. February 1994.

6. (A) *Lake Champlain Nonpoint Source Pollution Assessment.* Lenore Budd, Associates in Rural Development Inc. and Donald Meals, UVM School of Natural Resources. February 1994.

   (B) *Lake Champlain Nonpoint Source Pollution Assessment. Appendix.* Lenore Budd, Associates in Rural Development Inc. and Donald Meals, UVM School of Natural Resources. February 1994.

7. *Internal Phosphorus Loading Studies of St. Albans Bay. Executive Summary.* VT Dept of Environmental Conservation. March 1994.

   (A) *Dynamic Mass Balance Model of Internal Phosphorus Loading in St. Albans Bay, Lake Champlain.* Eric Smeltzer, Neil Kamman, Karen Hyde and John C. Drake. March 1994.

   (B) *History of Phosphorus Loading to St. Albans Bay, 1850 - 1990.* Karen Hyde, Neil Kamman and Eric Smeltzer. March 1994.

   (C) *Assessment of Sediment Phosphorus Distribution and Long-Term Recycling in St. Albans Bay, Lake Champlain.* Scott Martin, Youngstown State University. March 1994.

8. *Lake Champlain Wetlands Acquisition Study.* Jon Binhammer, Vermont Nature Conservancy. June 1994.

9. *A Study of the Feasibility of Restoring Lake Sturgeon to Lake Champlain.* Deborah A. Moreau and Donna L. Parrish, Vermont Cooperative Fish & Wildlife Research Unit, University of Vermont. June 1994.

10. *Population Biology and Management of Lake Champlain Walleye.* Kathleen L. Newbrough, Donna L. Parrish, and Matthew G. Mitro, Fish & Wildlife Research Unit, University of Vermont. June 1994.

11. (A) *Report on Institutional Arrangements for Watershed Management of the Lake Champlain Basin. Executive Summary.* Yellow Wood Associates, Inc. January 1995.

    (B) *Report on Institutional Arrangements for Watershed Management of the Lake Champlain Basin.* Yellow Wood Associates, Inc. January 1995.

    (C) *Report on Institutional Arrangements for Watershed Management of the Lake Champlain Basin. Appendices.* Yellow Wood Associates, Inc. January 1995.

12. (A) *Preliminary Economic Analysis of the Draft Plan for the Lake Champlain Basin Program. Executive Summary.* Holmes & Associates and Anthony Artuso. March 1995.

(B) *Preliminary Economic Analysis of the Draft Plan for the Lake Champlain Basin Program.* Holmes & Associates and Anthony Artuso. March 1995.

13. *Patterns of Harvest and Consumption of Lake Champlain Fish and Angler Awareness of Health Advisories.* Nancy A. Connelly and Barbara A. Knuth. September 19995.

14. (A) *Preliminary Economic Analysis of the Draft Plan for the Lake Champlain Basin Program - Part 2. Executive Summary.* Holmes & Associates and Anthony Artuso. November 1995.

    (B) *Preliminary Economic Analysis of the Draft Plan for the Lake Champlain Basin Program - Part 2.* Holmes & Associates and Anthony Artuso. November 1995.

15. *Zebra Mussels and Their Impact on Historic Shipwrecks.* Lake Champlain Maritime Museum. January 1996.

16. *Background Technical Information for Opportunities for Action: An Evolving Plan for the Future of the Lake Champlain Basin.* Lake Champlain Basin Program. June 1996.

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Preface

This document provides background information on the issues addressed in 1996 editions of *Opportunities for Action*, the Pollution Prevention, Control and Restoration Plan for the Lake Champlain Basin. It includes ten issue papers organized into three broad categories: water quality, living natural resources, and the human component. Developed by the Lake Champlain Basin Program's Technical Advisory Committee, its subcommittees and the Plan Formulation Team (see Appendix A), these papers summarize best available information and present the major management issues for each topic. Intended as a companion document to *Opportunities for Action* (the Plan), this report provides a detailed description of the problems, issues and opportunities that form the basis for the recommendations included in the Plan. This document does not contain management recommendations; all recommendations can be found in *Opportunities for Action*.

Additional information is available in the Lake Champlain Basin Program report series. A list of LCBP technical reports is included on page I, and demonstration and education reports are listed in Appendix B.

Introduction

Although Lake Champlain is a vital lake with many assets, there are several serious environmental problems that demand action. These problems include high phosphorus levels in some parts of the Lake, elevated levels of certain toxic substances, and the presence of nuisance nonnative aquatic species such as zebra mussels and water chestnut.

Levels of phosphorus in parts of Lake Champlain are so high that they cause excessive algal growth which turns the water green, inhibits recreational use of the water, and can reduce oxygen levels and cause other problems for the aquatic life in the Lake. The phosphorus that is causing these problems is coming from both sewage treatment plant discharges and runoff from urban and agricultural surfaces.

Toxic substances such as polychlorinated biphenyls (PCBs) and mercury have resulted in health advisories about consuming certain fish from Lake Champlain. There are also three particular sections of Lake Champlain (Cumberland Bay, Inner Burlington Harbor, and Outer Malletts Bay) that are contaminated with toxic substances at levels known to cause problems for aquatic biota or human health.

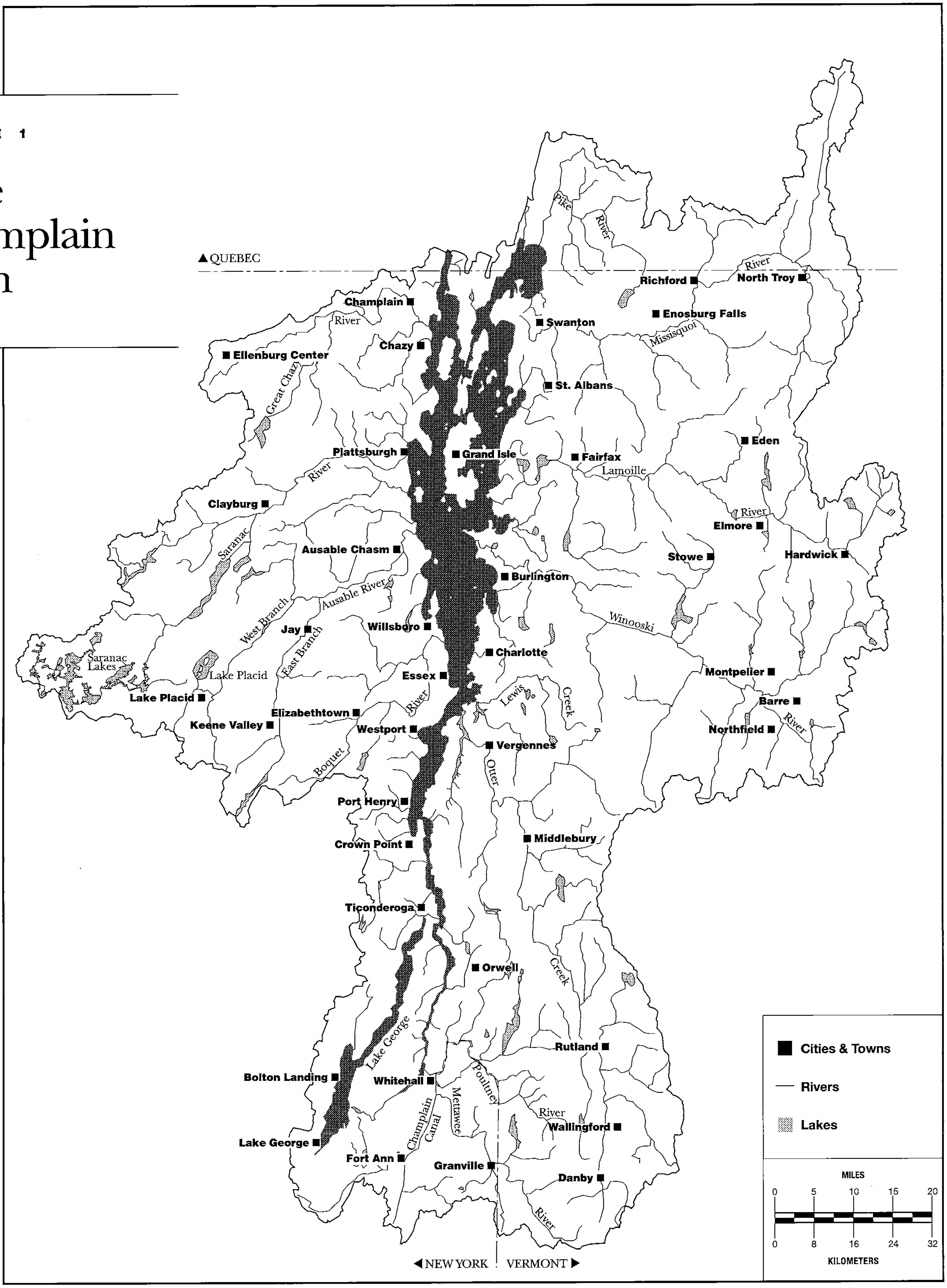
The fish, wildlife, and other living resources of the Lake Champlain Basin have been impacted by the introduction of nuisance nonnative aquatic species such as sea lamprey, water chestnut, Eurasian watermilfoil, and, most recently, zebra mussels. These species also interfere with recreational use of the Lake, and zebra mussels can clog residential, municipal, and industrial water intake pipes, foul boat hulls and engines, and obscure priceless underwater archeological artifacts.

There are other resource issues in the Lake Champlain Basin as well, including continued wetland loss and habitat fragmentation, inadequate public access to the Lake, recreational user conflicts, and loss of cultural heritage resources.

This document presents background information and management considerations associated with all of these issues. It also includes an overview of the physical, cultural, and socio-economic characteristics of the Basin as a whole in Chapter 1. A summary of related economic considerations is presented in Chapter 5. Additional information on these topics is available from the LCBP Technical Report Series and the Plan itself.

FIGURE 1

Lake Champlain Basin



Source: USGS Topographic Maps

Chapter 1. The Setting

Native Americans referred to the Lake by several names. Mohawks called it *Caniadari Guarunte*, which means "lake with a bulge in it," or "door of the country." Abenakis are known to have used the name *Petonbowk*, meaning "waters that lie between," a reference to the Adirondacks and Green Mountains rising to the west and east. After Samuel de Champlain's exploration in 1609, the Lake became known as Lake Champlain.

In order to understand the resource and management issues facing Lake Champlain Basin residents today, the physical, social, and economic setting in which the issues evolved must also be understood. This section summarizes these features, and how they set the stage for the complex management issues addressed in each of the following chapters.

The Physical Setting

Spanning from the High Peaks of the Adirondacks to the west, the Green Mountains to the east, the Taconic Mountains to the southeast, and the St. Lawrence Valley to the north, the **Lake Champlain Basin** is the entire watershed or drainage area for Lake Champlain (see Figure 1). The Lake itself flows from Whitehall, New York north almost 120 miles (193 kilometers) across the U.S.-Canadian border to its outlet at the Richelieu River in Quebec. From there, the water joins the St. Lawrence River, which eventually drains into the Atlantic Ocean at the Gulf of St. Lawrence (Figure 2). For much of its length, Lake Champlain defines the state border between Vermont and New York. Its watershed is bounded to the east by the Connecticut River Basin, and the southwest by the Hudson River Basin, to which it is connected by the Champlain Canal.

Lake Champlain is one of the largest freshwater lakes in the United States, with 435 square miles (1127 square kilometers) of surface water, over 70 islands, volume of 6.8 trillion gallons (25.8 million cubic meters), and 587 miles (945 kilometers) of shoreline. But Lake Champlain is unique, in part because of its narrow width (measuring only 12 miles or 19 kilometers at its widest point), great depth (some parts are over 400 feet or 122 meters deep) and the size of the land area, or watershed, through which 90% of the water delivered to the Lake flows. The total area of the Basin is 8,234 square miles (21,326 square kilometers), 56 percent of which is in Vermont, 37 percent in New York, and 7 percent in Quebec.

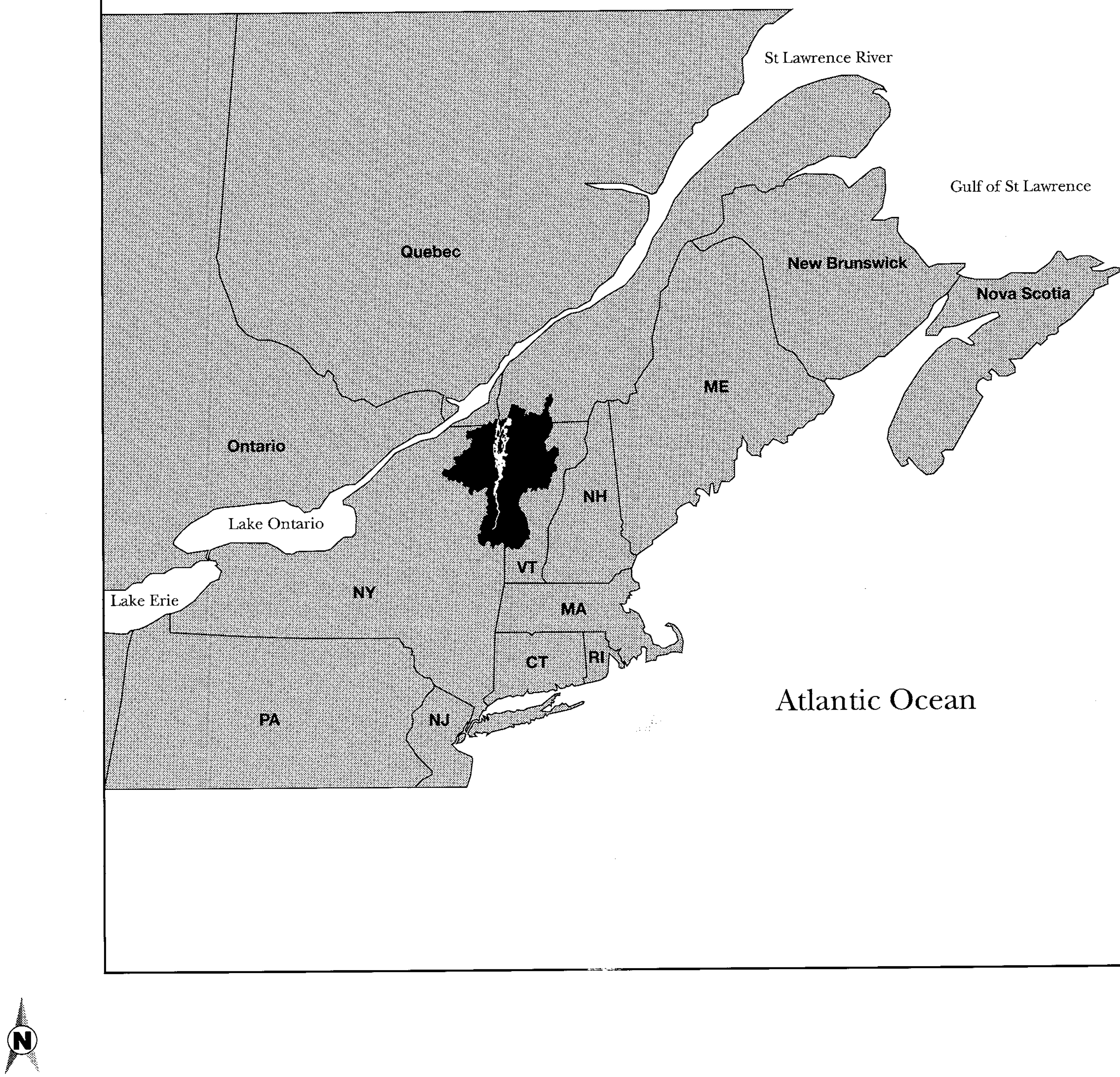
Lake Segments

Unlike many other lakes which are shaped like bowls and tend to be more evenly mixed, Lake Champlain is made up of five distinct areas or lake segments, each with different physical and chemical characteristics. These areas are shown in Figure 3, and described briefly below:

> **South Lake** - from the mouth of the Poultney River to Crown Point. This segment is narrow and shallow, acting much like a river.
>
> **Main Lake** (Broad Lake) - from Crown Point north to Rouses Point and west of the Champlain Islands. This segment contains about 81% of the volume of the entire Lake, including the deepest, coldest water.

FIGURE 2

Location of the Lake Champlain Basin



Malletts Bay - along the Colchester shoreline and to the southeast of Grand Isle. Because this area lies between causeways built to the north and west, it has the most restricted circulation of any of the segments.

Inland Sea (Northeast Arm) - to the east of the Champlain Islands, stretching from the Sand Bar causeway north to Missisquoi Bay, and including the Gut between South and North Hero, and the Alburg Passage. Water generally flows south from Missisquoi and north from Malletts Bay to pass through the Gut and Alburg Passage.

Missisquoi Bay - from the causeway and bridge between East Alburg and Swanton, and into Quebec. This area is very shallow, has relatively warm water, and somewhat restricted circulation. Water from the Bay flows southwest into the Inland Sea.

These physical characteristics partly explain the differences in water quality in these different parts of the Lake. For example, pollutants collect in shallow areas or bays where flushing and water circulation is reduced, and at the mouths of rivers where runoff carrying sediment and other pollutants from the watershed is discharged. These areas are also where human development is concentrated, increasing the potential for pollutant accumulation.

Topography and Geology of the Basin

The topography, or landforms visible today throughout the Basin, is largely a product of ancient mountain building processes, and the erosional forces of glaciers that gouged the valley and scoured the surface of the mountains. The Basin is made up of five distinct physical/geographic regions: the Champlain Lowlands (also called the "Champlain Valley"), the Green Mountains, the Adirondacks, the Taconic Mountains and the Vermont Valley.

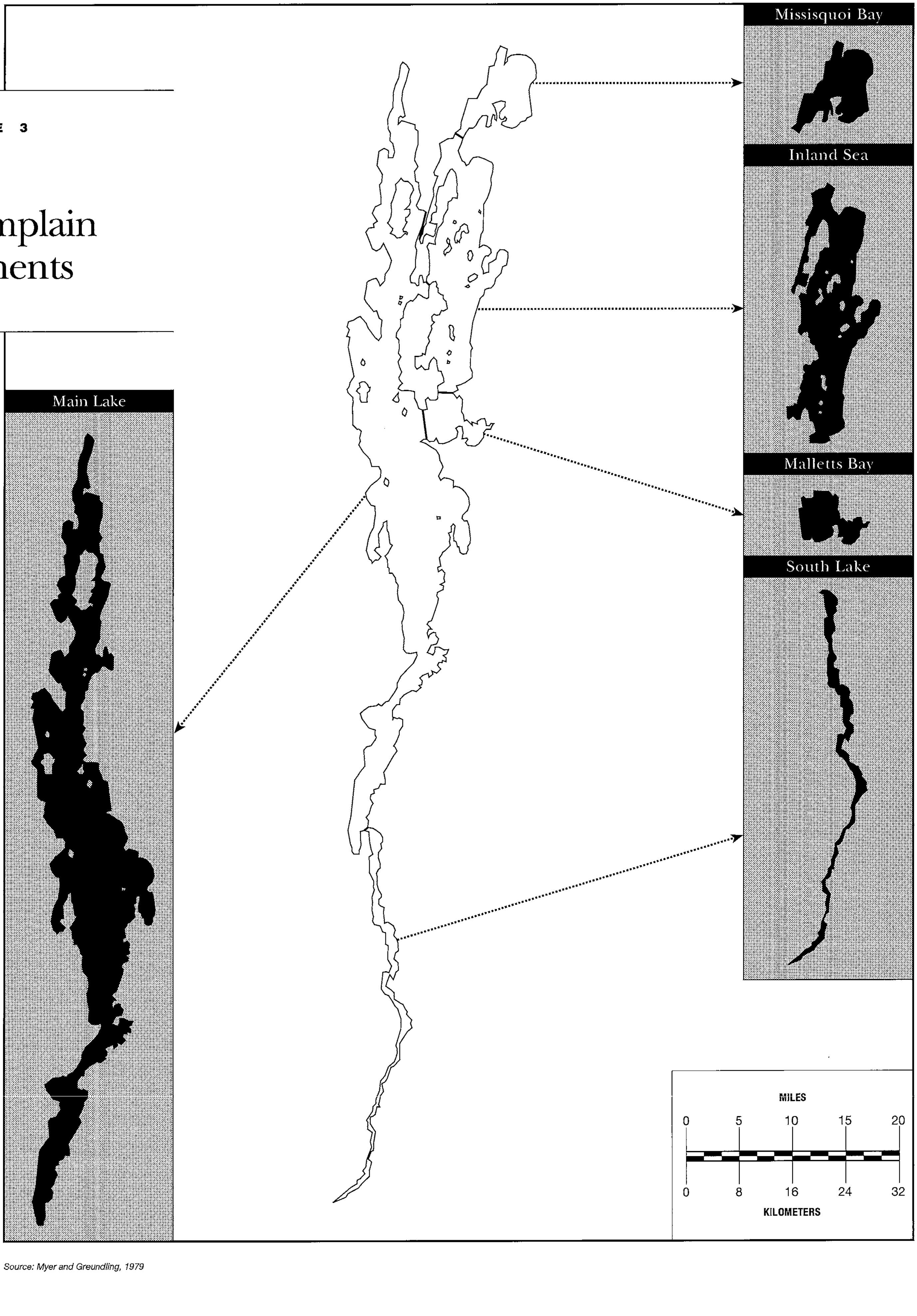
The Green Mountains, Taconic Mountains, and Adirondack Mountains contain the highest points surrounding Lake Champlain and form the headwater areas of tributaries entering the Lake. Most of the water which falls on these mountains as rain and snow will eventually end up in the Lake. The Vermont Valley is a small section of rich agricultural lands in Vermont between the Green Mountains and the Taconic Mountains that also feeds water to Lake Champlain.

The Adirondack Mountains were formed over 1 billion years ago and are one of the world's oldest mountain ranges. These mountains were bordered to the east by the Iapetus Ocean, an ocean over 500 million years older than the present day Atlantic. Evidence for this ancient ocean in the Champlain Basin includes sedimentary rocks such as sandstone and limestone and marine fossils, such as ancient reef deposits.

For several million years sediment eroded off the Adirondack Mountains and was deposited on the broad coastal plain bordering the Iapetus Ocean. Over 400 million years ago the Iapetus Ocean closed, and the sedimentary rocks of the shoreline and continental shelf were folded and faulted to form the Green Mountains. The great stresses involved in building mountains altered the older sedimentary rocks by heat and pressure into metamorphic rocks such as schist, marble and slate. The huge compressive stresses of mountain building also caused portions of the earth's crust to break and move as large fault blocks. The sedimentary rocks of western Vermont and the Taconic Mountains are examples of these large fault blocks, where younger rocks have been pushed up and over older metamorphosed continental shelf rocks beneath.

FIGURE 3

Lake Champlain Segments



Source: Myer and Greundling, 1979

Millions of years passed, marked by the erosion of both the Adirondack and Green Mountains. The passage of these years left little record in the Basin. Some volcanic rocks in the Basin record the opening of the present day Atlantic Ocean approximately 60 million years ago.

The last significant geologic event in the Basin occurred in relatively recent geologic time with the beginning of the Great Ice Age. This period of the Earth's history records a global cooling which resulted in the advance of glaciers over much of eastern North America, scouring broad valleys and depositing sand and gravel around the ice margins. As the ice descended into the Basin about 12,500 years ago, proglacial Lake Vermont formed from ponded glacial waters. This lake left behind a record of layered lake bottom clays. Approximately 10,000 years ago, subsequent retreat of the glaciers allowed marine waters from the St. Lawrence estuary to flood the Basin, forming the Champlain Sea, an inland arm of the Atlantic Ocean. Removal of the weight of glacial ice allowed the earth's surface to rebound, cutting off the supply of water. The Champlain Sea gradually evolved back into freshwater and the present day Lake Champlain. The Basin is rimmed with sand and gravel deposits which record the shorelines and deltas of both Lake Vermont and the Champlain Sea.

Sub-basins and Major Tributaries

The Basin can be divided into 34 "sub-basins" corresponding to Lake tributaries draining at least 26 square kilometers. These sub-basins are listed in Table 6 (p.53) in Chapter 2, and are important planning units for water quality improvement projects. Major tributaries include the Ausable, Great Chazy and Saranac rivers in New York, the Lamoille, Missisquoi, Otter Creek and Winooski rivers in Vermont and the Pike River in Quebec. A detailed map of the 34 sub-basins is available at the Lake Champlain Basin Program office. These sub-basins are sometimes grouped into larger watersheds for planning purposes. For example, phosphorus reduction targets for the Lake have been established for groups of sub-basins feeding into each lake segment. These groups of sub-basins, called lake segment watersheds, are shown in Figure 8 (page xx).

Climate

The climate in the Lake Champlain Basin varies geographically, and is affected by four main factors: the location of the Basin relative to the North Atlantic Coast; air masses from other regions; the mountains to the east and west; and the moderating influence of the Lake itself. When the prevailing winds from the west reach the mountains and rise to move over them, the air is cooled, causing rain in summer and snow in winter. Higher elevations in the Basin receive greater amounts of precipitation. For example, the average annual precipitation in the mountains reaches over 50 inches (127 centimeters), compared with about 30 inches (76 centimeters) in the valley. The growing season also varies in different parts of the Basin, from only 105 days in the higher, cold pockets of the Basin to 150 days along the Lake. The longer growing season coupled with fertile soils makes the lowlands a rich agricultural area. The north-facing slopes of the mountains have the shortest growing seasons along with the coldest temperatures in the Basin.

The Lake itself also influences the climate. Summer sunshine warms the surface layer of the Lake. During the fall and winter, the water releases this heat, moderating the temperatures in the Champlain Valley. Conversely, in the spring, warmer air and increased sunshine melts the snow and lake ice, but the Lake takes longer to warm than the surrounding land. Breezes off the Lake keep the shoreline areas cooler, extending cool conditions well into May.

Lake Temperatures and Stratification
As seen in other deep lakes, Lake Champlain stratifies in the spring and summer into water layers with distinctly different temperatures. In the spring, the sun warms the surface of the Lake. This warmer water is less dense than the colder, deeper water, so it floats on the surface, forming a layer called the "epilimnion." This layer is typically about 33 feet (10 meters) in the Main Lake during the summer (Watzin, 1992). Below this layer, there is a sharp transition in temperature, called the "metalimnion" or "thermocline," to the much colder waters below, called the "hypolimnion".

This process of thermal stratification affects lake water quality in several ways. Layering restricts mixing of the oxygen-rich surface waters with the colder, deeper waters below, and pollutants from discharges and surface runoff may not be well mixed. Pollutants also tend to be held in near-shore areas for short periods of time during spring warming due to temperature gradients that create a "thermal bar" between warmer, shallow areas and the open Lake. Annual lake turnover does, however, mix these layers, replenishing the oxygen supply and preventing very low oxygen conditions harmful to aquatic life.

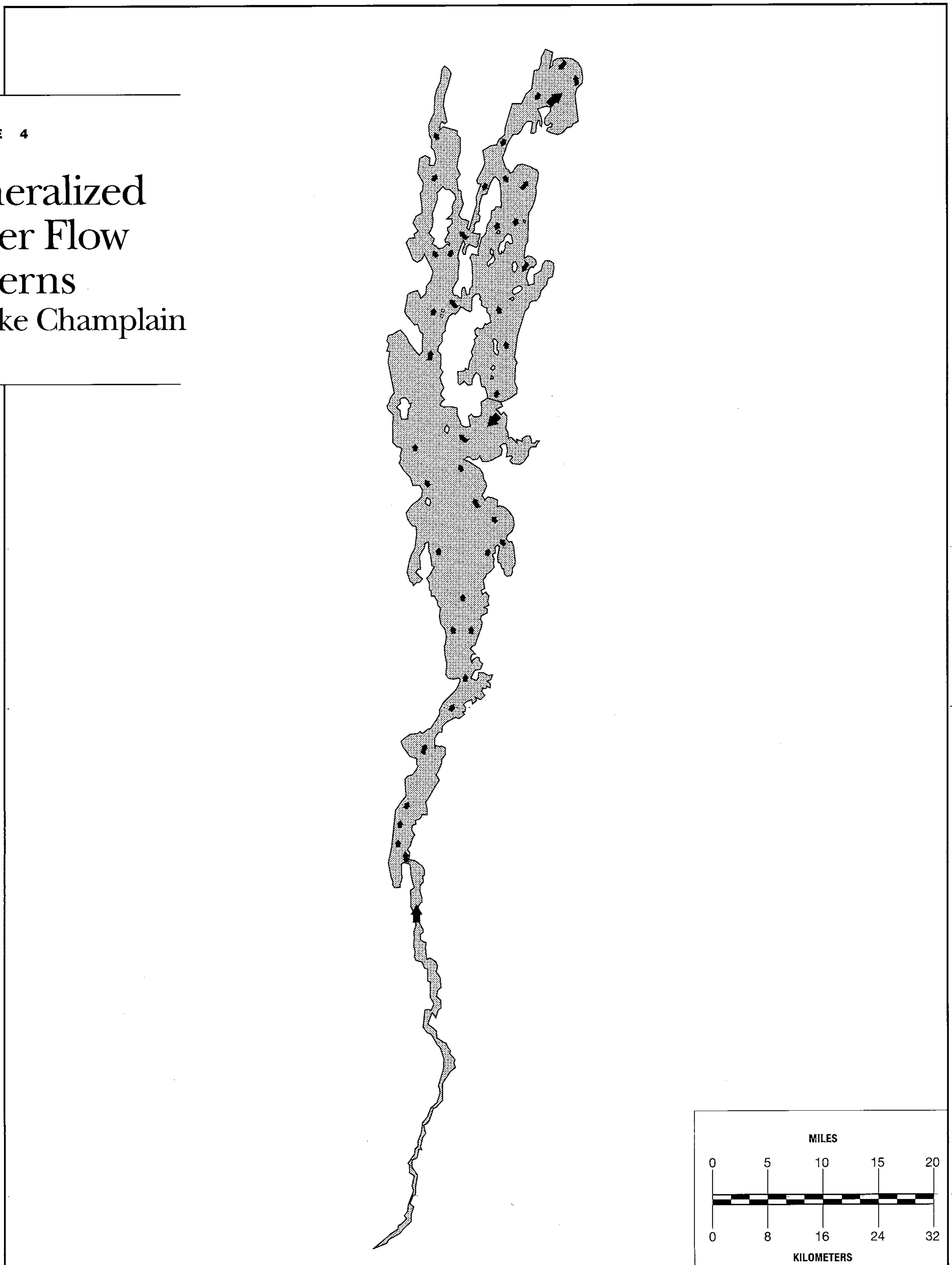
Flow Patterns and Hydrodynamics
The water in Lake Champlain is constantly moved by complex processes that change seasonally, and over longer periods of time. "Hydrodynamics" refers to water movements or flow patterns, which control the transport of sediment, nutrients and toxic substances in the Lake. Scientists are just beginning to measure and understand water movement and pollutant transport processes in the Lake.

The long-term flow of water is from the South Lake north to where the water drains into the Richelieu River. This movement is different in Malletts Bay, the Inland Sea, and Missisquoi Bay, where water moves south and west to reach the Main Lake through the narrow openings between the Islands and causeways (Figure 4). There are many variations in these patterns, with the flow at times reversing, and drifting across the Lake (Watzin, 1992). Water retention times are longest in the Main Lake, about three years, and shortest in the South Lake -- less than 2 months (Myer and Gruendling, 1979).

Water currents are primarily driven by wind and temperature differences within the Lake. Once temperature stratification is established in the Lake, changing wind directions and speeds set up an internal wave called the "seiche" (pronounced "saysh"). These large internal waves which occur at the surface as well as in deeper water in the Lake, cause the generally sluggish northward flow of water to reverse direction. A few days of consistent winds from the south gradually pile up the warm surface waters at the north end of the Lake, pushing the colder, deep water to the south. When the wind slows or reverses its direction, surface water flows back to the south, causing the metalimnion to lower in the south and rise up in the north. This process sets up the back and forth sloshing motion of the internal seiche. This very long internal wave (about 124 miles or 200 km) creates currents of up to a knot in the Main Lake and a maximum vertical displacement of the metalimnion of well over 200 feet (61 meters). The internal seiche can also cause turbulent mixing and resuspension of sediments. The internal seiche is continually active from early spring to late fall (when stratification exists in the Lake). As the surface waters cool in late fall, they become more dense, causing the water layers to mix or "turnover." In winter, the temperature of the entire Lake approaches 39 degrees Fahrenheit (4 degrees Celsius),

FIGURE 4

Generalized Water Flow Patterns
in Lake Champlain



Source: Myer and Greundling, 1979

while the surface waters are cooled to the freezing point and ice forms.

The Inland Sea is much shallower and smaller than the Main Lake, resulting in different summer patterns of thermal stratification and water movement. This area also has an internal seiche and variable currents, but they are not as strong as those observed in the central Lake (Watzin, 1992). Malletts Bay, Missisquoi Bay, Cumberland Bay, Shelburne Bay, and Burlington Harbor do not show as dramatic a thermal layering as the Main Lake because they are shallower and the water mixes more readily with strong winds. Flow patterns of Cumberland Bay and Burlington Harbor have been studied to determine the mixing and dilution potential of the wastewater discharges located there. Circular flow patterns that follow the shape of the shoreline are common, and in Burlington Harbor, there are strong currents away from the shoreline (Watzin, 1992).

A more complete understanding of the hydrodynamics of the entire Lake is absolutely essential to predicting how and where pollutants such as nutrients, toxic substances and sediment are transported, and where they will end up in the Lake. The LCBP is currently developing a simplified 3-dimensional hydrodynamic transport model to estimate the movement of water and substances within and between the different segments of Lake Champlain. It is hoped that within the next several years (after improvements are made based on data collected from the Lake) this model can be used as a management tool to determine potential effects of pollution inputs and other changes to the Lake.

Lake Level and Flooding

One of the important characteristics of Lake Champlain is its naturally fluctuating water level. Because the Lake's level is not controlled by any dams or weirs, it depends on seasonal precipitation, temperatures, and runoff. The Lake is at its lowest levels in the winter, when ice and snow hold the Basin's precipitation on the land. The Lake reaches high levels in the spring and early summer, after snowmelt and peak runoff. Normal annual variation between high and low average water levels is about 6 feet in Lake Champlain, but since the early 1870s, when daily records began, the maximum range between the high and low average water levels was measured at 9.4 feet. The record low water level was 92.4 feet mean sea level (m.s.l.) in 1908, and the record high was 101.89 m.s.l. at Rouses Point in 1993.

These changing water levels have a variety of beneficial and negative effects. Survival of various life stages of many important food and game fishes is intimately linked to natural water level fluctuations. Annual flooding supports fish spawning habitat, replenishes and nourishes wetlands, and has many other beneficial functions. However, when combined with strong winds from storms, flooding can also cause severe shoreline erosion, resulting in property damage and environmental impacts. Much of this is attributable to intensive shoreline development which removes protective sediment deposits, alters wetlands, removes stabilizing vegetation, and reduces the ability of the shoreline to withstand the damaging effects of wind and waves. Along the Lake, flooding commonly affects low-lying areas in Clinton, Grand Isle, and Addison Counties. St. Jean and Missisquoi Counties in Quebec are also commonly affected by high water events.

In 1981, a flood forecasting and warning system was established to help reduce flood damages on the recommendation of the International Joint Commission (IJC), and is now maintained by the National Oceanographic and Atmospheric Administration (NOAA), with support from state agencies. The IJC also recommended that both States and Quebec implement state and local floodplain management laws consistent with the National Flood Insurance Program administered by the Federal Emergency Management Agency. New York and Vermont have since done so. Proposals have also been made, as far back as 1900, for damming and/or large scale water diversion for industrial, commercial or public use, including a proposal to use Lake Champlain as a drinking water supply for New York City. As New York City developed its own system of reservoirs, the need for water from Lake Champlain decreased. New York State has recently enacted water withdrawal registration regulations for the Great Lakes Basin and Lake Champlain, which require approval for such diversions.

Watershed Processes and the Hydrologic Cycle

The continual cycling of water from the atmosphere to the watershed to the Lake and back to the atmosphere is known as the "hydrologic cycle." This movement can be divided into the processes of precipitation, surface runoff, infiltration, groundwater recharge, and evaporation, and is ultimately fueled by energy from the sun. These processes also govern the fate and transport of pollution in the air, land or water, and are therefore essential to understand in order to prevent pollution more effectively.

When water comes in contact with dry air, it evaporates from the lakes, plants and other surfaces of the earth, forming water vapor. This vapor can remain as gas, contributing to the humidity of the atmosphere, or it can condense and form water droplets, forming fog and clouds. Moisture, along with other substances, is also carried into the Basin in air masses from other regions. This moisture can be deposited as rain, snow, or even fog. Precipitation that falls on the land returns to the Lake as surface runoff. It can also infiltrate the soil and be taken up by vegetation or become groundwater.

Whether rain and snowmelt flow over the surface of the land into streams ("surface runoff") or move into the ground ("groundwater") depends on several factors. Sandy soils, gravel and some rock types encourage movement to groundwater, while clays and impermeable surfaces contribute to surface runoff. Water falling on sloped land tends to run off rapidly, while infiltration or surface pooling is common on more level areas. Vegetation slows surface runoff by taking up and storing water in roots and leaves.

Surface runoff is an important process affecting the environmental quality of the Lake Champlain Basin. Before human settlement, streams typically ran much clearer because natural vegetation prevented soil loss. Clearing of forests for agriculture, logging, and development has resulted in erosion, and more runoff into the streams and lakes. Rain falling on exposed soil tilled for agriculture or cleared for construction can carry soil particles and pollutants into tributaries. Suspended soil particles in water are deposited as sediment in the Lake, and often collect near the mouths of tributaries. Much of the sediment deposited in the near-shore areas is resuspended and carried farther into the Lake during storms. The finest particles (silts and clays) may remain in suspension long enough to reach the Main Lake.

Surface runoff, along with wastewater discharges, is the principal mechanism for nutrient loading to the Lake. Other minor sources of nutrient loading to the Lake include direct precipitation and groundwater. Studies of nutrient loading require an understanding of how nutrients move through soil and into streams, as well as how they are exchanged between the stream sediment and the overlying water column, and then transported to the Lake. Many of the watershed processes that influence nutrient delivery to the Lake also influence the movement of toxic substances through the environment. Surface runoff can pick up many types of pollutants, including pesticides applied to our lawns and agricultural crops, leachate from hazardous waste sites and landfills, and pollutants like motor oil and grease washed off paved surfaces.

Knowledge of hydrologic processes is necessary to determine amounts of pollutants delivered from the atmosphere with rain and snow, or delivered directly as particles. It is also important to determine how the pollutants are transformed as they are stored or carried through the watershed to the Lake. Since hydrologic processes move water through the Basin, they are intimately linked to processes of exchange and transport of materials and energy that comprise the ecosystem processes in the Basin.

Ecosystems and Food Webs

Ecosystems are groups or communities of organisms interacting with their non-living environment. The Lake Champlain Basin ecosystem includes freshwater aquatic and land components in an interconnected web of plants and animals of which humans are a part. Ecosystems are fueled by the sun, which provides energy in the forms of light and heat. This energy warms the earth, water and air, causing wind, currents, evaporation and precipitation. The light energy from the sun also fuels photosynthesis, the process whereby green plants turn inorganic nutrients into plant material. This is the base of the food chain.

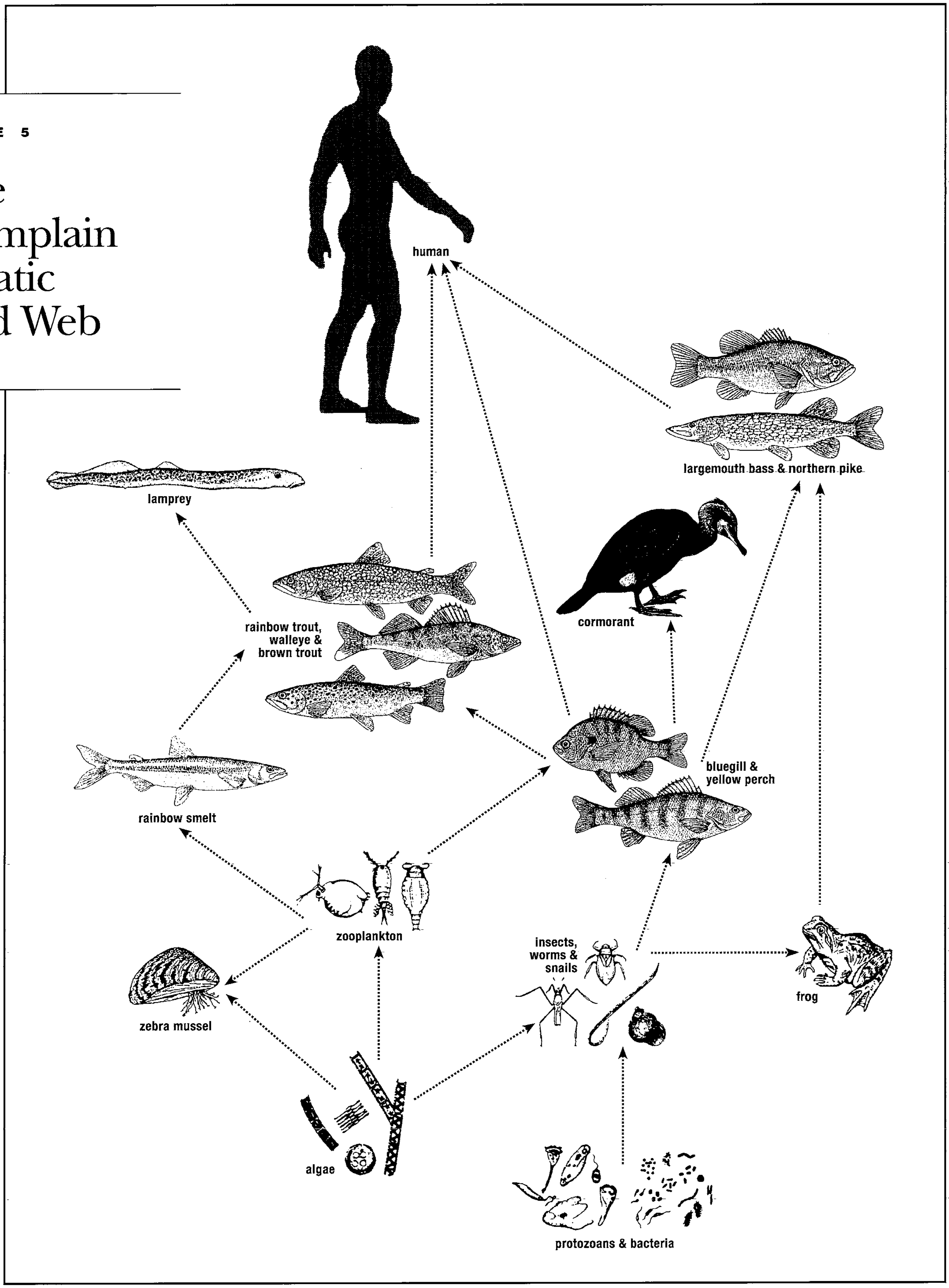
In the waters of the Basin, plants form the base of the food chain, growing when nutrients such as phosphorus and nitrogen are available. These plants, including algae and other types of "phytoplankton" are consumed by tiny floating animals, or "zooplankton," including mysids, water fleas, and copepods. Next in the food chain are the larger organisms that feed on these animals, including small crustaceans, and forage fish. Larger fish and other animals in turn eat these organisms, and then are eaten by birds and mammals, including humans. The step that closes the cycle of energy flow is decomposition, where plants and animals die and break down into the basic materials and nutrients from which they came. This process is helped by essential microorganisms that recycle this material back to the earth so it can be used again.

Each link in the food chain represents the transfer of energy through the ecosystem. Since each species is usually part of more than one food chain, the food chains in an ecosystem are interconnected. These connected food chains make up the complex system called the "food web" (see Figure 5). Food chains and food webs are simplified ways of understanding the process by which energy for life is transferred as one organism consumes another organism as food. This concept also explains how some harmful contaminants can accumulate and magnify through the chain up to humans.

An understanding of the food web is also critical to an assessment of ecosystem health. Those species that might be the best indicators of the health of the ecosystem are species that are critical or pivotal links in the food web, or species that are natural integrators -- those whose survival depends on several other important links lower in the food web.

FIGURE 5

Lake Champlain Aquatic Food Web



Food (energy) moves in the direction of the arrows

The ecosystem concept provides the framework for exploring the relationships between a system's seemingly independent parts, e.g. the people, the wetlands, the fish and the quality of the water. It is possible to describe the roles of each part in the larger ecosystem, to compare their status with respect to undisturbed or baseline conditions, and to define some of the stresses which may compromise the healthy functioning of each component.

Rather than managing individual species (through means such as regulating harvests), ecosystem management focuses on the environmental conditions and habitats necessary to support a diversity of plants and animals and maintain their functional roles in that system. Managers now know that simply regulating the concentrations of chemicals entering a body of water from discharge pipes is not sufficient to restore and maintain a healthy and diverse ecosystem. It is important to look at the assemblages of organisms living in the system, and use information about their health and community structure as a measure of larger ecosystem function.

The Social and Economic Setting

An ecosystem approach to studying and managing Lake Champlain must recognize the relationships between humans and their environment. Economic and demographic data collected along ecosystem boundaries is especially important in efforts to plan for a watershed as large as the Lake Champlain Basin, where there are many differences in population characteristics and human activities. Recognizing and understanding these differences will lead to a management plan that is responsive to environmental concerns as well as to contemporary social and economic conditions in the Basin. An ecosystem approach to management in the Lake Champlain Basin encourages a cooperative effort among people regardless of their county, state, or national place of residence.

In 1993, the LCBP funded the development of an economic database for the Lake Champlain Basin to examine economic and demographic patterns and the relationships between the Lake and its residents and visitors. This study provided detailed social and economic data for towns within the watershed, but also examined data along watershed and sub-basin lines. The statistics in the following section were taken from this economic database completed by Holmes and Associates (1993).

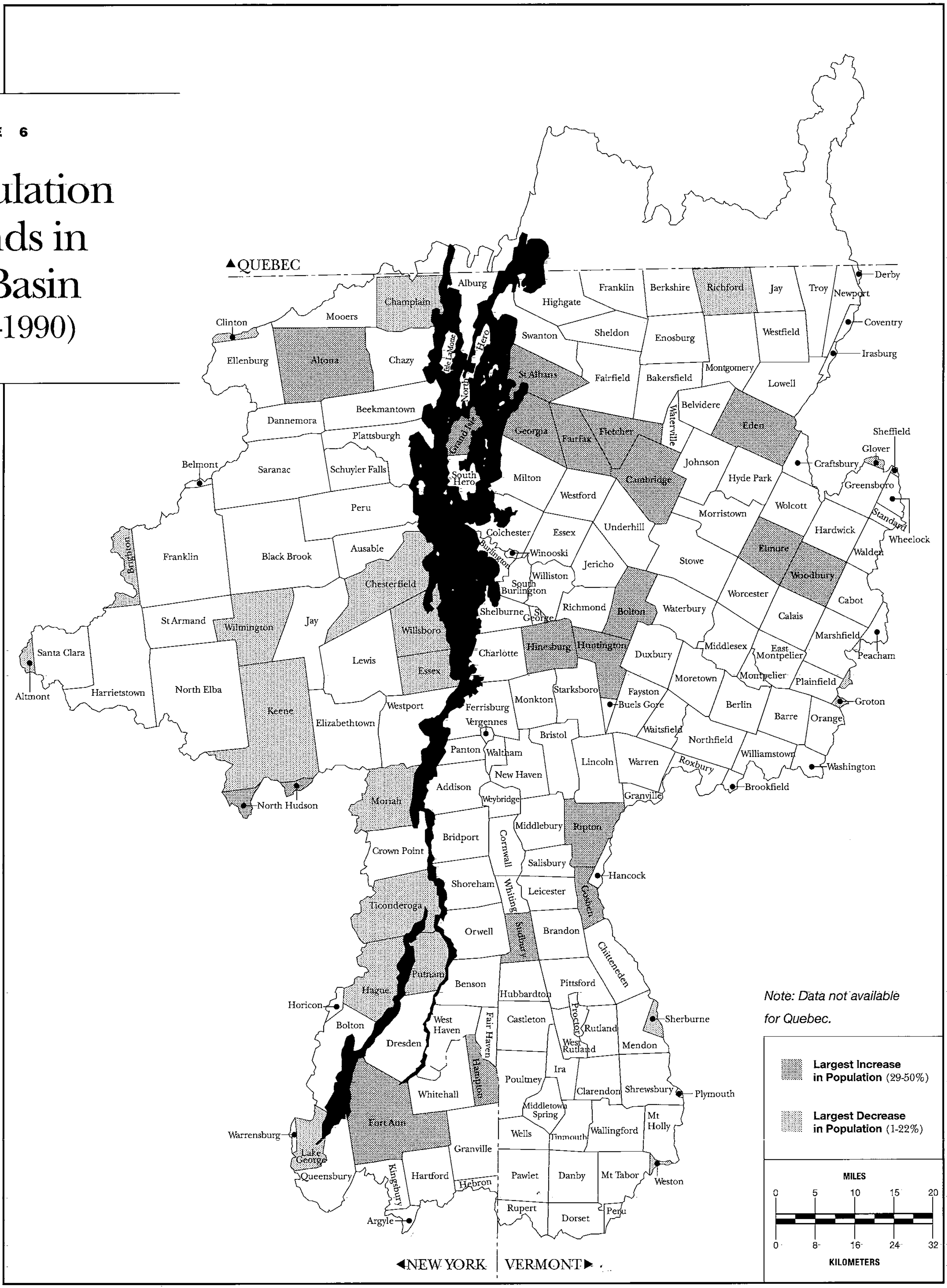
Trends in Basin Population

In 1990, approximately 608,000 people lived in the Lake Champlain Basin (61% in Vermont, 35% in New York, and 4% in Quebec). The Basin population increased 56.2% since 1950, 25% since 1970, and 9% since 1980, the smallest increase over a decade since 1950-60, when the population also increased by 9%. Annually, the Basin population has been increasing an average of 1.2% over the past 40 years, so by the end of 1995 it is likely that at least 653,000 people will be residing in the Basin.

The population density of the Basin as a whole is 61 persons per square mile, but New York shoreland towns have a population density twice that of the Basin overall, and Vermont's shoreland town population density is three times that of the Basin. Almost two-thirds of the Basin's U.S population was classified as rural in 1990, but a large percentage of Basin residents live in Plattsburgh, New York (38,486 people) or Burlington and South Burlington, Vermont (combined population of 51,936), the only metropolitan area recognized by the U.S. Census.

FIGURE 6

Population Trends in the Basin
(1980-1990)



Source: Holmes and Assoc., 1993

Other population centers in the Vermont portion of the Basin, all located inland from the Lake, include Rutland (18,230), Barre (9,482), Montpelier (8,247), and Middlebury (8,034). Population centers in New York include Queensbury (22,630) and Kingsbury (11,851).

While the Basin's population has grown steadily over the past 40 years, growth rates vary in different areas of the Basin (See Figure 6). Population for the entire Vermont portion of the Basin increased by 11.3% from 1980-1990, while that of New York increased by 7.0%. The total population residing in Vermont shoreland towns increased by 12.4% in the 1980s, as compared to 4.6% for New York shoreland towns. The Quebec population decreased slightly (-1%) from 1980-1990.

Individual towns in the vicinity of Burlington, especially those lying 20 to 30 miles from the city, were among the fastest growing towns in the Basin between 1980 and 1990. Population growth in the Malletts Bay region has far out-paced other areas in the Basin, growing 139% between 1950 and 1990, compared to 58% for the U.S. Basin area as a whole. Two towns on the Lake shore to the north of the Burlington, Georgia and St. Albans, experienced a population increase of 33.2% and 29.6%, respectively. Other Burlington area towns grew by 40% to 50% during the decade. New York towns experiencing a greater than average population increase in the 1980s include the Town of Fort Ann at the south end of the Lake and Altona to the northwest of Plattsburgh.

Although shoreland towns grew at a faster rate than the rest of the Basin between 1950 and 1970, that trend has reversed over the past two decades in New York. Seven of the 17 shoreland towns on the New York side of the Lake experienced a net decrease in population between 1980 and 1990. The towns of Chesterfield, Ticonderoga, and Moriah all experienced 5% to 6% decreases in population. One of the largest decreases in population in the Basin during the decade occurred in the town of Essex, New York, which recorded a 21.9% loss. Only five of the 144 Vermont towns in the Basin experienced a decline in population. Generally, these towns were located in the highland areas along the Basin's eastern boundary.

One of the major components of the Lake Champlain Basin economy is the large influx of seasonal residents. An average of 6,496,752 non-U.S. citizens per year (541,396 per month) cross into the Basin through the 14 points of entry. The number of border crossings per month is almost equal to the entire population of the Lake Champlain Basin. Over the past five years, annual boat border crossings into Lake Champlain at Rouses Point have averaged 26,343 people travelling in 7,318 boats.

While about 40% of the year-round population resides in shoreland towns, seasonal residents are more evenly distributed throughout the Basin. According to 1990 Census data, there were 38,530 seasonal homes in the Basin, which is 14.6% of all Basin housing units, and approximately 9,120 of the seasonal homes are in Lake Champlain shoreland areas. According to data from the Quebec Ministry of the Environment for the Missisquoi Bay area, the year-round population of 19,000 residents more than doubles during the summer with the influx of 21,274 summer residents. If all of the seasonal homes were occupied at the same time by at least three people, seasonal homes could potentially represent a part-time population increase of about 20% for some communities. Potential impacts to shoreland towns include increased revenues from tourism, more local recreational use of Lake Champlain, and increased traffic on local roads.

Population increases and decreases in the Basin are relevant to many issues addressed in this document. For example, population growth is likely to increase the amount of nutrients and other pollutants delivered to the Lake. More households in the Basin rely on septic tanks (55%) than on public sewer systems (43%). The percent of shoreland households connected to public systems is somewhat higher than the Basin as a whole, with 17,760 households in New York and 19,196 households in Vermont relying on septic systems.

The Basin's Economy

The economy of the Lake Champlain Basin was traditionally a rural resource-based economy. In addition to agriculture, both renewable natural resources (such as timber, tannin, fish, game, ice, maple syrup) and non-renewable natural resources (such as iron ore, marble, gravel, slate, wollastonite) have played a central role in the economic history of the Basin. Settlement in the Lake Champlain area by non-Natives began in earnest in the early 1800s with the cutting of timber and the mining of iron ore. The economic well-being of Lake Champlain shoreland residents quickly became dependent on the development of these natural resource industries. The lumber camps and mining towns that supported these industries fueled additional economic activities such as farms to supply food, and railroad and canal boats to move timber and iron to market. The boat building industry was one of many economic links to the natural resource base during these times.

The region's economy soon diversified beyond timber, iron, and other mining activities, but continued to depend on natural resources. For instance, the non-consumptive resource use of "vacationing" around Lake Champlain that began in the early 1800s quickly had a positive impact on local economies. More recently, the growth of the tourism industry in the region has included development of activities such as Nordic and Alpine skiing, marinas, sports fishing, white-water rafting, and outdoor guiding.

In the 1990s, natural resources still play a significant role in the Lake Champlain Basin economy. Log homes, paper products, milk, ice cream, apples, fish, fowl, venison, slate, and granite are a few of the natural resource commodities produced in the Basin today. In 1994, maple syrup production contributed over $10 million to the Basin's economy (Miller, 1994). The only mine for wollastonite (a mineral that replaces asbestos in floor tile, plastic, paint, and brake linings) in the United States is found in Essex County, New York, and is world renowned for its quality. Natural resource activities such as farming, forestry, mining, and guiding also provide employment in rural areas where opportunities are otherwise limited. The 1990 census data indicate that more than 25% of all employment in the Vermont towns of Bridport, Shoreham and Addison is in agriculture, forestry and fisheries. Agriculture-related activities and the processing and packaging of commodities harvested or extracted in the Basin result in significant additional natural resource-based employment. Besides their importance to local economies, natural resources industries in the Basin also have social and cultural importance to local areas, representing "traditional" ways of life that help to distinguish the unique character of the region.

While agriculture and other natural resource based activities continue to make significant contributions to local economies, the Basin economy has diversified into such areas as education, health care, tourism services, prisons, and manufacturing. Vermont and New York are very similar in employment by sector, except that twice the percentage of people in New York are employed in state, county, and local government. Census data from 1990 show that one third (33.2%) of all people in the Lake Champlain Basin are employed in service occupations, including personal business, health, legal, professional, and educational services. Service occupations also include tourism facilities in the Basin such as hotels, motels, museums and amusement attractions, as well as all hospitals, health care facilities and schools. The economy of the Lake Champlain Basin can thus be classified as a service economy, in line with national trends. Median family income in the Basin in 1989 was highest in Vermont shoreland towns, at $38,709, compared to $31,605 in New York shoreland towns.

Wholesale and retail trade is the next largest sector of the economy, at 22.3%. Retail trade sales in the Lake Champlain Basin during 1991 totaled $4.5 billion, with 65% occurring in Vermont and 35% in New York. Shoreland towns accounted for 38% of all retail trade. Manufacturing is the third highest employment sector, accounting for 14.9% of all employment within the Basin. Manufacturing value-added (final sales less the cost of materials) in the Lake Champlain Basin during 1987 totaled $2.8 billion, with 69% occurring in Vermont, and 31% in New York. Shoreland towns accounted for 41% of all manufacturing value-added.

The economies of the New York portion of the Basin rely on manufacturing to a slightly greater degree than the Vermont Basin economies. For example, manufacturing provides the highest percentage of employment in the South Lake area of the Basin, a trend which is intensified by statistics from the Glens Falls and Ft. Edward areas within the Basin. It should be noted that the South Lake area, both in New York and Vermont, also exhibits a greater than average reliance on agriculture than is found in other areas of the Basin.

During the 1980s, manufacturing declined from 22% to 15% as a percentage of total employment in the Basin, a region-wide phenomenon that reflects national trends during the decade. However, the variety of employment found within the Basin is more diverse than that found in the rest of New York and Vermont, with agriculture, forestry, mining and construction comprising a larger relative portion of the workforce in the Basin than they do in either of the States as a whole. This diversity is one of the main features of the Basin's economy, and should contribute to its future economic health.

The role of Lake Champlain in the economic well being of the region is not yet fully understood. Many regional and local economies clearly depend heavily on the natural resources and aesthetics of the Lake. Recreation-related activities are probably the best example of this relationship, generating sales revenues to local businesses, employment to residents and tax revenues to local governments. A case study of the Town of Champlain funded by the Lake Champlain Basin Program showed that 10% of the Town's total assessed value, or $22.5 million dollars, came from residential land, seasonal and year round dwellings in Lake and river neighborhoods. An estimated 15% of sales tax revenues for the community were generated by consumers using the Lake. A similar case study of the City of Vergennes and surrounding towns estimated that Lake-related business generates an annual average revenue of $14.7 million for the firms in the area, and additional Lake-related income when multiplier effects are taken into consideration. Up to 43% of business owners surveyed felt that there was a direct relationship between the health of their business and maintenance of the existing level of water quality in the Vergennes area. Approximately 33% of Vergennes business owners felt that their businesses would be enhanced if water quality was improved.

Tourism connected directly to the Lake is a significant economic factor for the region. It has been estimated that total tourist expenditures within the Lake Champlain Basin were $2.2 billion in 1990, with roughly 71% in the Vermont portion of the Basin ($1.6 billion) and 29% in the New York portion ($638 million). Fishing related expenditures are estimated at $61.6 million for the Basin, and $24.8 million for shoreland towns (1988 statistics, Holmes and Associates, 1993). Roughly 40%, or $880 million, of the total Basin tourism expenditures occurred in shoreland towns. People living within the Region account for almost 44% ($968 million) of total tourist expenditures.

In shoreline towns, 16,400 people were directly dependent on Lake Champlain-related tourism jobs in New York and Vermont. Marinas, one of the tourism-related industries on Lake Champlain, employed approximately 344 people in 1990, with a total annual payroll of $5.4 million. However, although tourism does have excellent potential for economic development, it is not a panacea for all economic ills. Much of tourism-related employment is part time, whereas only about 10% of manufacturing jobs are part time and seasonal. Other disadvantages include low wages, as well as inadequate medical coverage and lack of long term advancement for workers. While tourism does provide both skilled and unskilled employment opportunities, helps stimulate local commerce, and provides recreational facilities for local residents as well as tourists, it needs to be seen within the context of a healthy and diversified regional economy.
The Lake Champlain Basin's natural and cultural resources provide a foundation to support important aspects of the area economy. Abundant and diverse natural resources are a major reason many Basin residents choose to live where they do. Sport fishing and hunting, along with the tourism and local business generated by these activities, are extremely important. Non-consumptive uses such as boating, hiking and cross-country skiing are all made more attractive by virtue of excellent water quality, abundant wildlife and wildlife habitat. Commercial fishing, logging and maple syrup production are classic examples of direct economic returns from a healthy, diverse natural resource base. Conserving healthy ecosystems and the organisms they support also conserves options for future direct economic return. For example, maintaining Lake Champlain's productivity and water quality will provide future entrepreneurs with opportunities for initiating aquaculture and other businesses for the long-term economic vitality of the Basin.

Conservation of natural resources also entails economic costs to communities. Environmental restoration and conservation programs sometimes involve restrictions that increase the cost of previously unrestricted business practices. Development can be constrained by the presence of regulated wetlands, or by the lack of available infrastructure for wastewater treatment and water supply. Development can also be limited by polluted water and disappearing natural habitats. There are a wide range of economic futures for the Lake Champlain Basin. Developing strategies which guide the region to a sustainable future (both economically and environmentally) is in the interest of all residents.

Resource Management Setting

The need for state and international communication and cooperation regarding the management of Lake Champlain has been apparent since the 1940s. There have been numerous efforts to bring the two states and countries together since that time, including the International Joint Commission (IJC), the Interstate Commission on the Champlain Basin (INCOCHAMP), the Lake Champlain Fish and Wildlife Management Cooperative, the New England River Basin Commission (NERBC) Level B Study, and the Memorandum of Understanding signed by the governors of New York and Vermont, and by the Premier of the Province of Quebec (see Table 1). Each of these organizations took important steps toward cooperative management of the Lake, but none were able to provide permanent institutions for holistic Lake management.

Table 1. Review of Past and Present Institutional Arrangements for Management of Lake Champlain

Institutional Arrangement	Years in Existence	Purpose
International Joint Commission (IJC)	1909-present	coordinates activities concerning U.S.-Canadian boundary waters; specifically examined regulation of water level in Lake Champlain during the 1970s
Interstate Commission on Lake Champlain (INCOCHAMP)	1949-1990 in Vermont; 1949-present in New York[1]	coordinated and fostered cooperation for environmentally-sound development in the Basin; attempted to pass a Champlain Basin Compact to manage Lake Champlain
New England River Basin Commission (NERBC)	1969-1981	developed Level B study and management plan for Lake Champlain in 1979; examined the possibilities for its implementation; federal funding was discontinued in 1980
Lake Champlain Fish and Wildlife Management Cooperative	1973-present	Federal-State cooperative that manages the fish and wildlife resources of Lake Champlain
Memorandum of Understanding on Environmental Cooperation on Lake Champlain	1988-present	developed joint work plans between New York, Vermont, and the province of Quebec; established a Steering Committee and Citizens Advisory Committees; has no powers of enforcement
Lake Champlain Basin Program and Lake Champlain Management Conference	1990-present	developed comprehensive pollution prevention, control, and restoration plan for Lake Champlain (*Opportunities for Action*); oversees and provides funding for numerous research, demonstration and education projects in the Basin

[1]Pro forma organization since 1968, providing no substantial decisions regarding the Lake.

The Lake Champlain Basin Program was established in 1991 and has built upon past and present institutional efforts to produce a coordinated, comprehensive approach to planning for the future of the abundant resources of the Lake Champlain Basin. Once the Lake Champlain Basin Program concludes its planning phase, numerous agencies, organizations, and individuals will be responsible for implementing the Plan, *Opportunities for Action*.

Managing the suite of resources in the Lake Champlain Basin is a challenging task that involves many responsible public agencies and diverse interests. The existing resource management programs have made significant progress in controlling point source discharges of pollution, upgrading sewage treatment plants, and improving the sports fishery and fish populations. The Federal Water Pollution Control Act of 1972 (and later amendments) is responsible for many improvements in water quality, however, much remains to be done by citizens and government to protect and restore the Lake's health and productivity. For example, current environmental programs often promote species- and issue-specific resource protection (e.g., deer management, Endangered Species Act) rather than protecting whole ecosystems and biodiversity. Agencies also may lack adequate financial and human resources to comply fully with existing mandates to implement programs.

A complex array of agencies, plans, regulations, and laws govern activities that affect the resources of the Lake Champlain Basin. This is sometimes confusing to the general public, as well as to other resource managers and decision-makers. Areas of control often overlap, requiring inter-governmental communication and coordination. For example, several government agencies and entities are involved with managing and protecting the Basin's wetlands. Communication among these agencies and a coordinated framework of management goals are essential to protect these invaluable areas. In some cases, agency mandates for resources conflict, making implementation difficult. In many cases, there is a lack of coordination among local government planning efforts to protect resources. Lack of sound scientific information can hinder effective decision making related to natural resource protection.

Research is being conducted on many resource management topics, but its value to policy development is sometimes limited. For example, maps and technical information about critical resources often exist, but towns and other interested parties may not know about or have easy access to them. Regional Planning Commissions in Vermont and County Planning Departments in New York exist to consider issues affecting more than one municipality, and to make decisions and policies concerning these issues; however, towns often do not take advantage of the technical expertise provided by these regional and county entities, and there is no guarantee that resource issues will be addressed. Also, there are times when towns seek technical assistance, but their needs are not addressed due to financial or temporal constraints. There is also a need for information sharing and communication between agency staffs and the private sector.

Some problems may require a completely new approach. For instance, using watershed boundaries to define management units so that cumulative impacts can be better addressed, and so that resources can be allocated to areas with the biggest problems, would require the realignment of several existing programs. Many management actions recommended in Opportunities for Action will be best implemented at the local level, requiring unprecedented coordination between different levels of government and the public. Public and private partnerships may be an efficient and promising approach to resource management. Many citizen groups and other private entities are becoming directly involved in habitat restoration projects, monitoring, and pollution prevention. A more detailed discussion of opportunities for citizens groups is included in the watershed planning and education & outreach sections of Chapter 4.

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Chapter 2. Water Quality and the Health of the Lake

As recently as 20 years ago, the Basin experienced serious water pollution and public health problems from the discharge of untreated sewage and wastes. Since then, water quality has improved as a result of required industrial waste treatment, and a large investment of state, federal, municipal and private funds for sewage treatment facilities. But these successes represent the easiest solutions. Additional clean-up must also address nonpoint source pollutants from urban and agricultural areas, such as nutrients, low levels of persistent toxic substances, and pathogens. Significant opportunities exist for further reductions of pollutant discharges (especially nutrients) from sewage treatment plants as well.

Lake Champlain serves as a catch basin for pollutants delivered directly to it and those washed from the land or air into tributary rivers. Several indicators of the health of the Lake show its tendency to accumulate pollutants. The most obvious indicators are excessive weed and algae growth due to nutrient enrichment, fish consumption advisories due to PCBs and mercury in some lake fish, elevated levels of toxic substances in lake bottom sediments, and periodic beach closings because of pathogens.

The source, extent, and effects of the contamination responsible for these problems vary by pollutant type. Pollutants of concern can be separated into three categories: nutrients, toxic substances, and pathogens. Nutrient loading to the Lake is a critical problem because excess nutrients accelerate eutrophication, the aging process that increases plant productivity and decreases dissolved oxygen levels. In Lake Champlain, phosphorus is the limiting nutrient for most plant growth, and is, therefore, the focus of nutrient management efforts. Toxic substances of greatest concern include trace metals such as mercury, arsenic, cadmium, chromium, lead, nickel, silver and zinc, and synthetic organic chemicals such as PCBs, PAHs, and pesticides. Pathogens are bacteria and viruses, as well as other disease-causing organisms from human and animal wastes that cause beach closings and make it unsafe to drink untreated water. An additional pollutant of less widespread concern is sediment, which can damage fish spawning habitat, interfere with navigation, and increase flood damages, among other problems.

Background information and management issues for these pollutant categories have been organized into the following sections: Reducing Phosphorus Pollution, Preventing Pollution from Toxic Substances, and Protecting Human Health. Information on the control of sediment is included in the phosphorus section, as most phosphorus is associated with sediment.

Reducing Phosphorus Pollution

Background

The Need for Phosphorus Reduction

Phosphorus is the nutrient that poses the greatest threat to clear and nuisance free water in Lake Champlain. Nutrients act as fertilizers, promoting rapid growth of algae and plants. Human activities can greatly increase nutrient inputs to the Lake. These "cultural" nutrient sources accelerate eutrophication, the natural aging process of lakes where biological and chemical material accumulates, causing lakes to become more productive.

Nutrients are necessary to the growth and survival of plants in aquatic environments. If a key nutrient is absent, growth will stop. The missing nutrient is said to "limit" the growth of plant material. Phosphorus is normally the limiting nutrient in Lake Champlain, and the focus of nutrient management efforts. When the amount of phosphorus entering the Lake increases and remains high over time, the Lake becomes over-fertilized and produces excessive amounts of algae and other aquatic plants. Algal blooms turn water green, reduce water transparency, deplete the oxygen supply, and create odor problems. Ultimately, these blooms alter fish and wildlife habitat, impair scenic views, reduce recreational appeal, impair water supplies, and lower property values.

Several of the reasons why phosphorus levels in Lake Champlain are too high and should be reduced are explained by Smeltzer (1992b) and summarized below.

Algal Nuisances

Use and enjoyment of the Lake are frequently impaired by algal nuisances. The algal blooms and reduced water clarity that result from high phosphorus levels have led to reduced uses of Lake Champlain, particularly recreational uses. A user survey conducted as part of the Vermont Lay Monitoring Program indicated that, with the exception of Malletts Bay, the open-water areas of the Main Lake and the Northeast Arm experience nuisance algal conditions about one day per week on average during the summer. In Missisquoi and St. Albans Bays and in the South Lake, nuisance conditions exist nearly half the time.

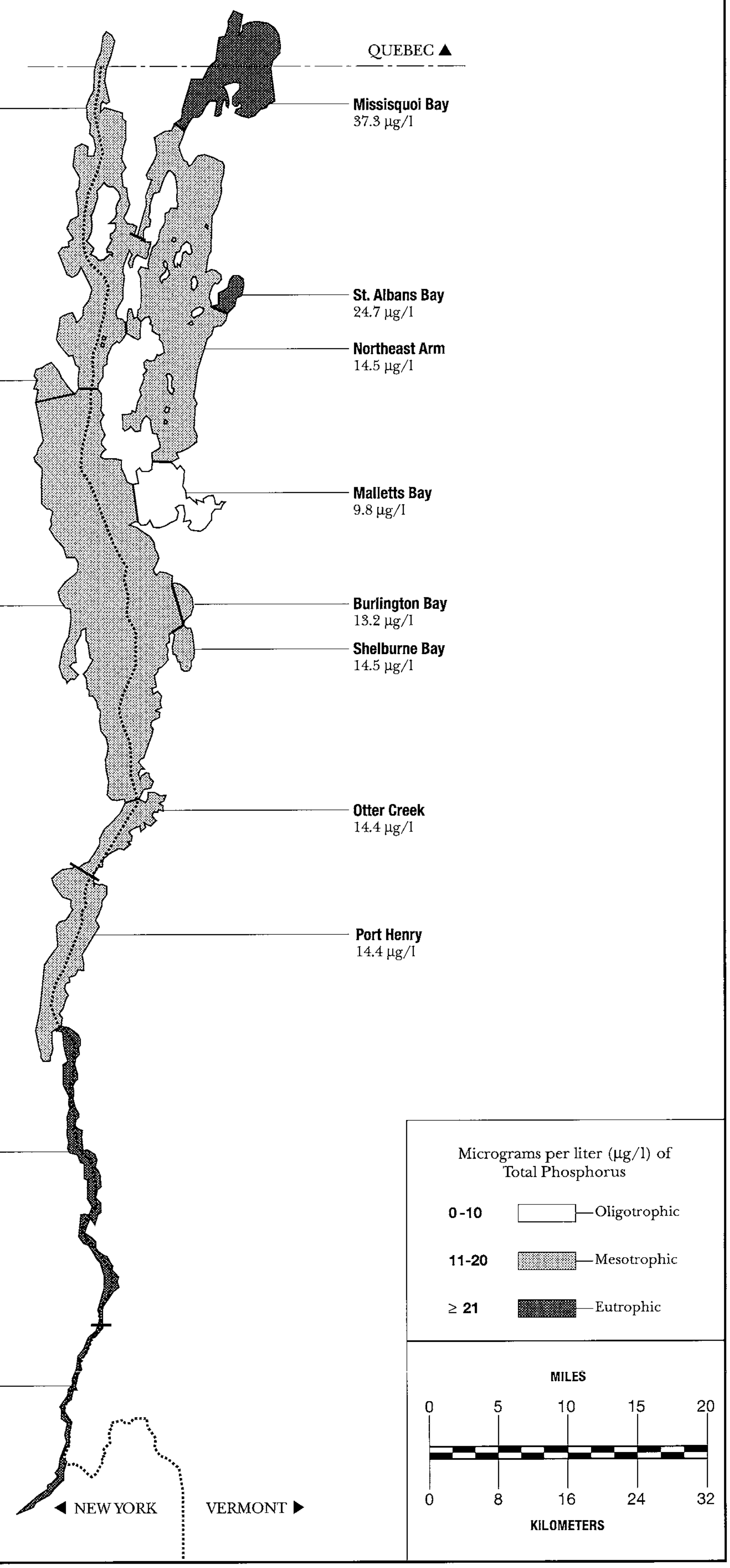
High Phosphorus Concentrations

Currently, Lake Champlain is mesotrophic (having a moderate amount of plant growth) to eutrophic (having excessive plant growth and low water clarity). The lowest phosphorus levels in the Lake occur in Malletts Bay, where the average annual value is just below 10 μg/l, the conventional oligotrophic (clear and nuisance free) criterion. All other segments of the Lake are either in the mesotrophic (10-20 μg/l) or eutrophic ($>$20 μg/l) range. Areas such as the South Lake, Missisquoi Bay, and St. Albans Bay regularly have annual phosphorus concentrations in the 25-50 μg/l range. Figure 7 shows the average annual phosphorus concentrations recorded by the joint New York and Vermont Long-term Monitoring Program from 1990-1994 for twelve segments of the Lake. Phosphorus levels are substantially higher than pre-development levels, and in portions of the Lake, are as high as levels in the most eutrophic parts of the Great Lakes (such as Saginaw Bay and the western end of Lake Erie) during the 1970s (Smeltzer, 1992b; Vighi and Chiaudani, 1985). Eutrophication problems in these areas of the Great Lakes

FIGURE 7

Lake Segment Boundaries

& Current Phosphorus Concentrations



Source: New York State DEC, et al., 1995 prompted large-scale international phosphorus reduction efforts beginning in the early 1970s.

The Lake Champlain Basin Study of 1979 identified phosphorus as a problem and recommended reductions through the continuation of phosphorus-detergent bans, improvements at municipal treatment plants, and implementation of agricultural best management practices (New England River Basins Commission 1979). Partial implementation of these recommendations has held phosphorus concentrations level during the 1980s and early 1990s (Watzin, 1992; NYSDEC et. al., 1995). But phosphorus levels have not decreased, and with continued population growth and development in the Basin, levels may gradually increase unless control efforts are accelerated.

Sources of Phosphorus

Eutrophication of the open water areas of the Lake is the result of the cumulative impact of many individually small phosphorus sources, both point and nonpoint. Nonpoint sources are estimated to account for about 70% of the total phosphorus load to Lake Champlain, with point sources contributing the remaining 30% (VT DEC and NYSDEC, 1994). Natural background sources are estimated to account for only 24% of the present day total load, indicating that human activities in the Basin have increased phosphorus loading to Lake Champlain four-fold over the original pre-development levels.

Point Sources

The primary point source of phosphorus in the Basin is municipal wastewater treatment plants. There are 76 municipal wastewater treatment plants in the Lake Champlain Basin, and each of these discharges some phosphorus to receiving waters, although amounts vary considerably from plant to plant. There are also a number of industries and state facilities (such as fish hatcheries) that discharge phosphorus directly to Lake Champlain or its tributaries. All municipal treatment plants and major industrial sources permitted to discharge more than 200,000 gallons per day are listed in Table 4, p. 37.

Nonpoint Sources

Nonpoint sources of phosphorus include lawn and garden fertilizers, dairy manure and agricultural wastes, and exposed or disturbed soil. At the local scale, nonpoint sources may include malfunctioning septic systems and streambank erosion. The quantity of nonpoint source phosphorus delivered through the tributaries depends partly on how the land is used within a watershed. The major categories of land use within the Lake Champlain Basin are urban and other developed land, agricultural land, and forested land. The major phosphorus sources associated which each of these land use categories are described below.

Urban and Other Developed Land

Urbanization within a watershed can have a variety of negative effects, including pollution from urban activities, increases in stormwater runoff, and physical changes to river systems.
Development increases the amount of impervious area in a watershed, which directly affects water quality. Parking lots, buildings and other "hardened" surfaces cover the ground, interfering with the natural pollution filtering ability of soils. The quantity of runoff also increases because the soils can no longer absorb and store rain and snowmelt. Suburban and rural residential areas, construction sites, commercial developments, industries, and roads each contribute phosphorus to the Basin's waterbodies.

In order of significance (as determined by USDA NRCS inventories), the major sources of phosphorus are manure and commercial fertilizer runoff from fields, soil erosion from fields, runoff from livestock concentration areas, milkhouse effluent, runoff from stacked manure, livestock access to streams, and induced streambank erosion.

Studies in Vermont have estimated that phosphorus loading by animal unit ranges from 0.9 to 9.6 pounds of total phosphorus per year (USDA-SCS, 1983, 1985a and 1985b). Loadings near the higher end of this range occur in areas with significant soil erosion problems. Voluntary use of appropriate nutrient management systems such as manure pits and barnyard runoff systems in USDA project areas (see Table 5, p.41) have reduced these loadings by an estimated 25 to 60 percent.

Table 2. Lake Champlain Basin Farm Data, New York and Vermont (Numbers and Types)

Farm Type	Number in New York[1]	Number in Vermont[2]	TOTAL
Dairy	367	1726	2080
Beef	66	176	232
Horse	29	166	198
Other Livestock	75	122	189
Apples (over 25 acres)	27	27	54
Other fruits, berries, vegetables (>25 acres)	94	9	97
Cash Crops	419	-	415
Other	9	-	15
TOTALS	**1086**	**2226**	**3314**

(Source: USDA-NRCS, 1993)

[1] **Definition of Farm in New York:** An enterprise having 10 or more animal units (animal unit = 1000 pounds of animal body weight), or 25 acres or more of cultivated cropland.

[2] **Definition of Farm in Vermont:** An enterprise having at least one of the following characteristics: 40 or more animal units of dairy cattle, 10 or more animal units of non-dairy animals, 25 acres or more of cultivated cropland. Over 95 percent of the total number of Vermont farms indicated sell more than $10,000 of farm produce annually.

Forested Land

Forested land is the dominant land use in the Basin. Undisturbed forested land is an ideal land cover to protect water quality values because forests typically contribute the least amount of nonpoint source pollutants per acre of any land cover. Forests cover about 62% of the Basin's surface area but are estimated to contribute only 16% of the average annual nonpoint source phosphorus load to Lake Champlain (Budd and Meals, 1994). Additionally, less of the phosphorus from forestland is bioavailable than is the case for agricultural and urban sources of phosphorus.

About 1% of commercial forestland in New York and Vermont is subject to harvest operations in any given year (NYSDEC, 1993; VT DEC, 1993). In addition, much of the forestland in the New York portion of the Basin is owned by the state as the Adirondack Forest Preserve and cannot be harvested. This means that the "manageable" component of nonpoint source pollution from forestland represents a very small percentage of total pollutant loadings from forestland in the Basin.

This manageable portion of pollutants from forestland is mostly associated with road construction and timber harvesting activities. Badly planned and carelessly performed logging operations may expose and disturb soils in ways that increase erosion, and thus increase sediment and nutrient loads to surface waters. The layout of haul roads and skid trails, the size and location of landings, and the timing of harvest operations all affect sediment and nutrient export. Forestry activities within the riparian zone often pose the greatest threat to water quality. Stream crossings, road construction, landing construction, and tree harvesting within the riparian zone, all can contribute to direct sedimentation of the waterbody. A recent Vermont study (Brynn et al., 1990) found that the primary source of sediment from harvesting activity was improper stream crossings. Timber harvesting can be planned and conducted in a manner that minimizes erosion and sedimentation. However, if management practices are not followed, local water quality impacts can be significant (VT ANR, 1987).

Current Phosphorus Reduction Strategy

The States of New York and Vermont and the Province of Quebec signed the Water Quality Agreement of 1993 in accordance with the **Memorandum of Understanding on Environmental Management of Lake Champlain**. The agreement commits the three entities to a consistent approach to phosphorus management in the Lake that includes the following: 1) endorsing the numeric, in-lake phosphorus criteria given in Table 3 as interim management goals (until a consistent set of state water quality criteria can be formalized by rule in New York); 2) using the interim criteria in Table 3 to jointly develop Basin-wide phosphorus load allocations between point and nonpoint sources in New York, Quebec, and Vermont using the data and modeling capability developed by the Lake Champlain Phosphorus Diagnostic-Feasibility Study and other related research; 3) conducting rule-making for lake water quality criteria in New York and Vermont, with participation from Quebec, to promote consistency in the numeric criteria established for Lake Champlain; and 4) having the Lake Champlain Steering Committee (described in Chapter 1) reconsider the issue of consistent point and nonpoint source management policies between the three jurisdictions when modeling results and phosphorus load allocation recommendations become available.

The water quality agreement laid out a three part management strategy: 1) establishment of in-lake criteria; 2) assessment of phosphorus reductions needed to attain the criteria; and 3) targeting of point and nonpoint source phosphorus reductions throughout the Basin. Background information and the current status of each of these steps is provided below.

Establishment of the Numeric Phosphorus Criteria

The establishment of the in-lake criteria was a key step in the phosphorus reduction strategy. The criteria provide a clear goal for phosphorus reduction activities and a means of measuring the success of future phosphorus reduction efforts.

Table 3. Lake Champlain Interim Total Phosphorus Criteria and Existing Phosphorus Concentrations

Lake Segment[1]	Phosphorus Criterion (μg/l)	Existing Phosphorus Concentration[2]	Trophic Status[3]
Main Lake	10	11.4	M
Malletts Bay	10	9.8	O
Shelburne Bay	14	14.5	M
Burlington Bay	14	13.2	M
Cumberland Bay	14	13.5	M
Northeast Arm	14	14.5	M
Isle LaMotte	14	13.3	M
Otter Creek	14	14.4	M
Port Henry	14	14.4	M
St. Albans Bay	17	24.7	E
Missisquoi Bay	25	37.3	E
South Lake A	25	33.3	E
South Lake B	25	56.9	E

[1]Segment boundaries used by the Diagnostic-Feasibility Study are shown in Figure 7.
[2]1990-1994 mean total phosphorus concentrations recorded by the New York and Vermont Long-term Monitoring Program for Lake Champlain (NYSDEC et al., 1995).
[3]O = Oligotrophic = less than 10 μg/l (low plant growth and high water clarity)
M = Mesotrophic = 10 - 20 μg/l (moderate plant growth, moderate water clarity)
E = Eutrophic = more than 20 μg/l (excessive plant growth, low water clarity)

Basis for Development of the Criteria

The goal in selecting interim phosphorus criteria for Lake Champlain was to provide numbers that fully protect the beneficial values and uses of the Lake, and that were also realistically attainable through management efforts. The basis for the selection of total phosphorus criteria for each Lake segment (shown in Table 3) is described by VT DEC (1990) and summarized below.

The lowest phosphorus concentrations in Lake Champlain exist in the Main Lake and Malletts Bay segments. Here, the 10 μg/l phosphorus criterion was considered to be realistically attainable and desirable. The 10 μg/l value represents the upper end of the phosphorus range for the conventional definition of an oligotrophic lake. An oligotrophic standard was considered appropriate for the large, central broad area of the Lake.

In the remainder of the Lake, the existing phosphorus concentrations (Table 3) are substantially higher than 10 μg/l, and the attainability of this oligotrophic criterion is doubtful. For the rest of the Lake (except for St. Albans Bay, Missisquoi Bay, and the South Lake), an alternative phosphorus criterion of 14 μg/l was selected because it protects values and uses associated with oligotrophy (such as good aesthetics and absence of high algae levels), and is more realistically attainable. The 14 μg/l value was derived from the analysis of Lake Champlain user survey and water quality data (Smeltzer and Heiskary, 1990; Smeltzer, 1992a). It represents an average summer phosphorus concentration below which essentially no Lake users would perceive "high algae levels" or find their enjoyment of the Lake "substantially reduced" more than 1% of the time during the summer.

For the highly eutrophic segments of St. Albans Bay, Missisquoi Bay, and the South Lake, the 14 μg/l criterion would not be realistically attainable. St. Albans Bay has a long history of phosphorus management efforts, including treatment plant upgrades and nonpoint source controls. The Vermont Department of Environmental Conservation's goal for restoring water quality in St. Albans Bay has been phosphorus reduction in the center bay area to a concentration of about 3 μg/l above the level outside the bay in the Northeast Arm. Consequently, a phosphorus criterion of 17 μg/l was selected for St. Albans Bay.

Missisquoi Bay and the South Lake segments are, to some extent, naturally eutrophic areas as a result of their shallow depth and wetland-like characteristics. Many beneficial values and uses of these waters, such as productive warmwater fisheries and wildlife habitat, in fact depend on a moderate degree of eutrophication. Therefore, a phosphorus criterion of 25 μg/l reflecting a moderate level of eutrophication was selected for these segments. A more complete discussion of criteria development for Lake Champlain is provided by the Vermont Department of Environmental Conservation (1990) and Smeltzer (1992a).

Revising the Criteria

The criteria were established with the understanding they would be continually evaluated and revised over time as new information becomes available. Federal law provides for state water quality criteria to be reviewed and revised as necessary at least every three years. Revisions could take into consideration results of current research on bioenergetics modeling and food web interactions in the Lake. The Lake Champlain Phosphorus Management Task Force (1993) recommended that research results on the ecological effects of specific phosphorus values in Lake Champlain should be used to derive criteria that provide for both a healthy ecosystem and sustainable human use and enjoyment of the Lake. The Task Force also recommended that the criteria be modified if modeling results indicate that certain values are not practically attainable through reasonable phosphorus management efforts.

Assessment of Phosphorus Reductions Needed to Attain the Criteria

In 1989 the States of Vermont and New York jointly began a large phosphorus study of Lake Champlain, funded by the U.S. Environmental Protection Agency Clean Lakes Program as a diagnostic-feasibility study (Vermont DEC and New York State DEC, 1994). The purpose of this bi-state effort was to measure phosphorus loadings to Lake Champlain from all tributaries, wastewater discharges, and other major sources, and to develop a whole-lake phosphorus mass balance model for Lake Champlain. The model is being used in a targeting procedure (described below) to recommend phosphorus load reductions in a manner that most efficiently attains the in-lake phosphorus criteria specified in the 1993 New York, Quebec, and Vermont Water Quality Agreement.

Phosphorus loadings to Lake Champlain were measured over a two year period by frequent sampling of sources, including tributary inflows, direct wastewater discharges, and precipitation to the Lake's surface. A network of new and pre-existing stream flow gages was maintained by the U.S. Geological Survey to support the tributary loading measurements. An extensive lake sampling program was conducted concurrently with the load measurements to provide a basis for developing a whole-lake phosphorus model for Lake Champlain. Loadings and in-lake concentrations of chloride were also determined during the study to quantify in-lake mixing and transport of materials between Lake segments.

The study included measurements of both total and dissolved phosphorus loadings and Lake concentrations. However, the modeling analysis was based on total phosphorus results because total phosphorus is a good predictor of algae levels, water clarity, and Lake user impacts.

The data were used to establish a phosphorus budget for Lake Champlain which identifies and ranks all the major phosphorus sources to the Lake. A steady-state phosphorus mass balance model was then developed for 13 interconnected segments of Lake Champlain to analyze the Lake's response to its phosphorus loadings.

The model was applied to identify the point and nonpoint source phosphorus loading reductions necessary to attain the in-lake phosphorus concentration criteria endorsed by New York, Quebec, and Vermont in the 1993 Lake Champlain Water Quality Agreement. The load allocation procedure treated point and nonpoint sources separately because of their different regulatory and management programs. Three alternative point source reduction policies were considered which involved various levels of Basin-wide effluent phosphorus limits in Vermont, New York, and Quebec. The remaining reductions necessary to attain the in-lake criteria were targeted to nonpoint sources within watersheds feeding the 13 Lake segments (Lake segment watersheds are shown in Figure 8). The overall approach of seeking cost effective reductions in phosphorus loading from point sources Basin-wide first, and then reducing nonpoint sources to the extent necessary to meet in-lake water quality objectives, is comparable to the approach employed for phosphorus management in the Great Lakes system. The targeting procedure (described below) being incorporated into the LCBP June 1996 Draft Plan builds upon this basic approach.

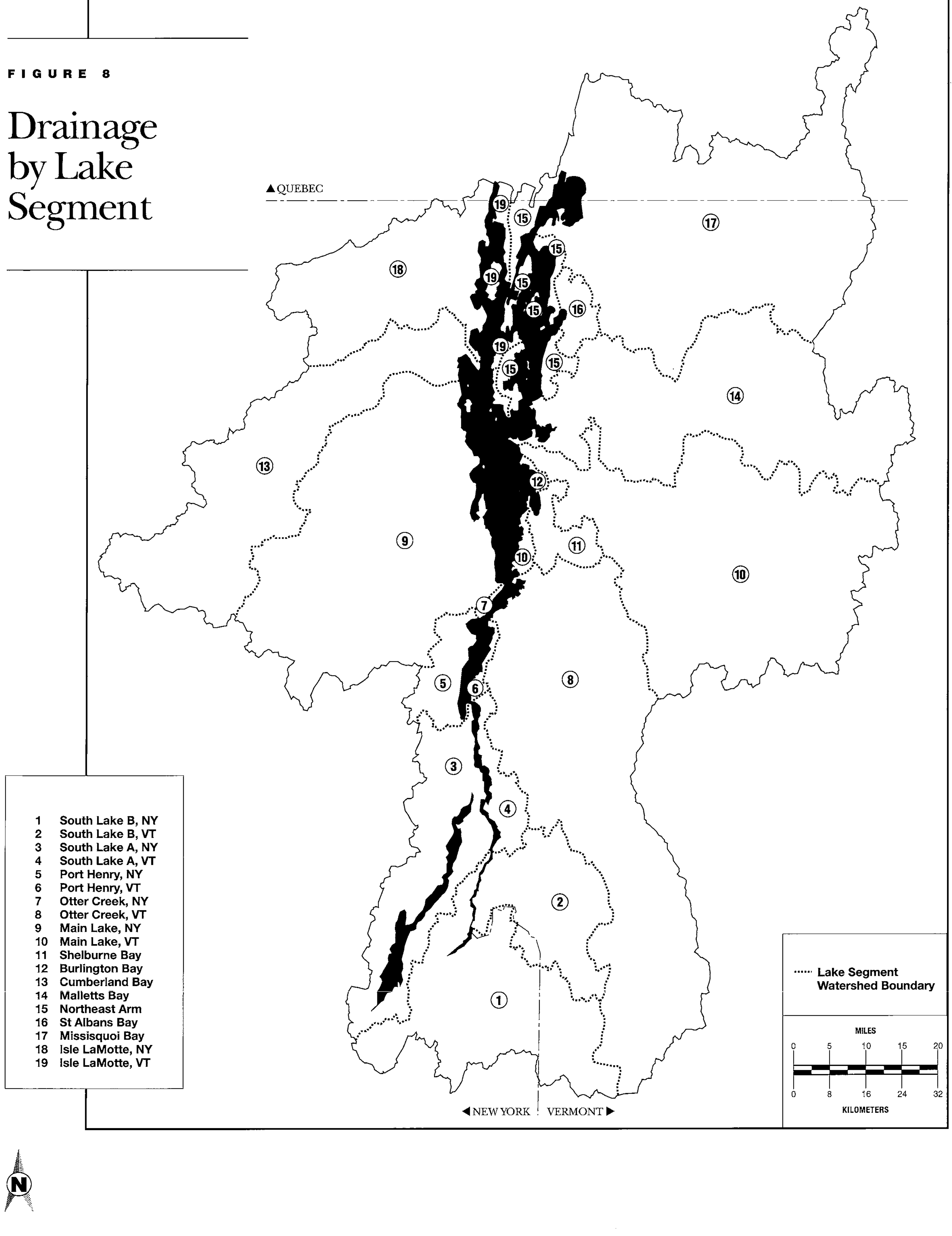
A summary of point and nonpoint sources of phosphorus to Lake Champlain measured in the Diagnostic-Feasibility Study is presented in Figure 9. Nonpoint sources of phosphorus in Figure 9 are separated into natural sources (based on phosphorus exported per unit of forested land in the Basin) and sources resulting from human activities. Several general observations are apparent from these data: 1) most of the phosphorus load (74%) comes from the Vermont and Quebec side of the Lake; 2) nonpoint sources contribute the majority (about 70%) of the total loading of 647 metric tons per year (mt/yr); 3) the rivers contributing the greatest phosphorus loads are those draining the largest river basins, including the Otter, Winooski, Missisquoi, Pike, Lamoille, Rock and Mettawee; and 4) tributaries with the highest percentage of nonpoint source phosphorus from human activities include the Missisquoi, Rock, Pike, Mettawee, Little Otter, Stevens, LaPlatte, Lewis, Mill Rivers, Great Chazy, and Boquet Rivers.

Targeting of Phosphorus Reductions

While the Phosphorus Diagnostic-Feasibility Study indicates the amount of phosphorus loading reduction needed, it does not include an analysis of the cost effectiveness of point versus

FIGURE 8

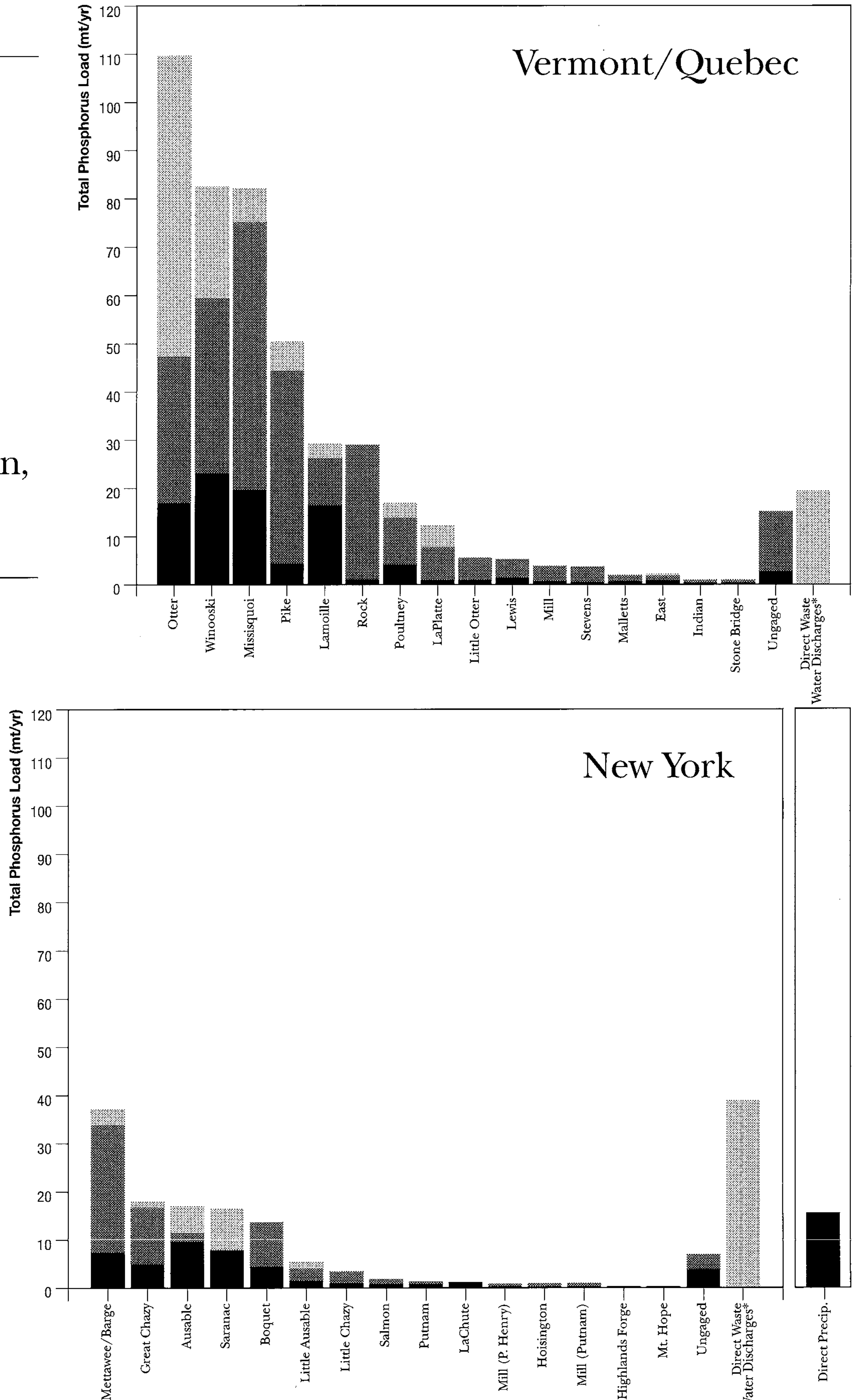
Drainage by Lake Segment



1 South Lake B, NY
2 South Lake B, VT
3 South Lake A, NY
4 South Lake A, VT
5 Port Henry, NY
6 Port Henry, VT
7 Otter Creek, NY
8 Otter Creek, VT
9 Main Lake, NY
10 Main Lake, VT
11 Shelburne Bay
12 Burlington Bay
13 Cumberland Bay
14 Malletts Bay
15 Northeast Arm
16 St Albans Bay
17 Missisquoi Bay
18 Isle LaMotte, NY
19 Isle LaMotte, VT

FIGURE 9

Summary of Point & Nonpoint Source Phosphorus Loadings
to Lake Champlain, 1991



** Direct waste water discharges include loadings from municipal and industrial treatment plants that discharge to Lake Champlain*

- Natural Nonpoint Source Load
- Nonpoint Source Load from Human Activities
- Point Source Load

Source: VT Department of Environmental Conservation and NY State Department of Environmental Conservation, 1994 nonpoint source reductions or any assessment of the opportunity for nonpoint source reductions in different parts of the Basin. Similarly, the Vermont State Clean Water Strategy, which prioritizes watersheds in the Vermont portion of the Basin for point and nonpoint source reductions based on water quality impairment status, does not take into consideration the amount of phosphorus (or other pollutant) reduction potentially achievable in the various watersheds or the cost-effectiveness of these reductions.

In early 1995, Holmes and Artuso developed an optimization procedure for point and nonpoint source phosphorus reduction as part of the LCBP economic analysis of the draft plan (Holmes and Artuso, 1995). Incorporating potential reduction estimates and costs initially supplied by the USDA, this procedure used a computer spreadsheet to identify the cost-effectiveness of various reduction strategies. LCBP's Eutrophication and Nonpoint Source Subcommittees subsequently modified this procedure and provided much more comprehensive data on costs and potential phosphorus reductions from agricultural land. A more complete description of the procedure and its assumptions is provided in Holmes and Artuso (1995) and Holmes and Associates and Artuso (1996). This procedure is being used to develop phosphorus load reduction targets for each of the lake segment watersheds shown in Figure 8.

On-going Pollution Control Programs

A number of federal, state, regional and local agencies are involved in phosphorus reduction efforts. Point source control programs occur mostly at the state or provincial level, and are described briefly below. Nonpoint source programs exist at many levels; only major programs are described here.

Controlling Point Sources

State NPDES Programs

Since the early 1970s Vermont and New York have administered regulatory programs under the National Pollutant Discharge Elimination System (NPDES), which is authorized by the federal Clean Water Act. Each state has developed EPA approved plans which must be at least as stringent as the federal statute requirements. NPDES permits (called SPDES permits in New York) regulate point source discharges from municipal waste water treatment facilities and from industrial facilities. Regulated discharge constituents include (but are not limited to) phosphorus, nitrogen and suspended solids. In 1993 the NPDES program was amended to cover stormwater discharges associated with industrial activities, including certain industrial sites. The State of New York has developed a general permit for these activities; Vermont is developing a similar general permit.

Other State/Provincial Laws and Policies

In Vermont, a phosphorus reduction statute (10 V.S.A Sec.1266a) enacted in 1992 established a Basin-wide phosphorus effluent concentration limit of 0.8 mg/l applicable to all discharges greater than 200,000 gal/day, and exempted facilities using aerated lagoon treatment processes. Compliance with this section is required only to the extent that 100% state funding is provided to municipalities for the construction cost of phosphorus removal facilities. The statutory 0.8 mg/l limit applies to about 26 of the 55 currently operating discharges in Vermont (see Table 4), some of which are already complying with a previous statute requiring phosphorus removal

Table 4. Phosphorus loads and concentrations from point sources permitted to discharge more than 0.2 mgd (million gallons per day) in the Lake Champlain Basin

Facility	Flow (mgd)			Concentration (mg/l)		Load (kg/yr)	
	1990-1991	1995	Permitted (1995)	1990-1991	1995	1990-1991	1995
VERMONT							
Barre City	2.938	2.282	3.800	1.36	2.00	5518	6300
Brandon	0.327	0.226	0.700	1.40		632	436
Burlington East	0.805	0.714	1.000	0.68	0.28	756	277
Burlington Main	3.841	4.102	5.300	2.12	0.35	11245	2186
Burlington North	1.303	0.906	2.000	1.91	0.57	3437	707
Castleton	0.263	0.273	0.360	2.15		781	811
Enosburg Falls	0.364	0.316	0.450	2.65	6.94	1332	3030
Essex Junction	1.487	1.517	2.750	0.78	0.67	1602	1405
Fair Haven	0.289	0.296	0.500	3.02	3.14	1205	1284
Hardwick	0.216	0.148	0.371	2.75		820	563
Hinesburg	0.177	0.203	0.250	17.09	0.66	4177	185
Middlebury	1.103	0.735	2.200	28.69	4.82	43702	4889
Montpelier	2.044	1.550	3.970	2.52		7113	5394
Morrisville	0.335	0.277	0.425	2.70		1249	1033
Northfield	1.096	0.438	1.630	2.35		3557	1422
Poultney	0.318	0.286	0.350	2.14		940	845
Proctor	0.248	0.229	0.325	2.18		747	688
Richford	0.347	0.276	0.380	1.04		498	396
Rutland City	5.047	4.165	6.800	2.03	0.29	15158	1668
Shelbrne F.D. #1	0.306	0.268	0.310	0.67	0.37	283	137

Facility	Flow (mgd)			Concentration (mg/l)		Load (kg/yr)	
	1990-1991	1995	Permitted (1995)	1990-1991	1995	1990-1991	1995
Shelburne F.D.#2	0.278	0.302	0.450	0.70	0.50	269	210
South Burlington Airport Park	1.313	1.132	2.300	0.76	0.57	1378	1029
South Burlington Bart. Bay	0.727	0.607	0.800	0.58	0.22	582	188
St. Albans City	2.114	2.383	4.000	0.27	0.49	788	1613
Swanton	0.742	0.675	0.900	2.38	0.24	2439	220
Vergennes	0.467	0.330	0.660	0.70		451	157
Waterbury	0.239	0.244	0.510	4.95		1634	1667
West Rutland	0.236	0.219	0.325	2.00[1]		652	606
Winooski	0.837	0.716	1.200	0.52	0.59	601	515
IBM	1.957	3.062	3.500	0.26	0.17	703	736
Pittsford Fish Hatchery		5.000	5.000	0.10		691	691
Rock Tenn	2.515	0.181	3.500	0.40		1389	355
Vermont Whey	0.333	0.414	0.425	0.36	0.42	166	238
Weed Fish Culture Station		5.921	11.500	0		0	528
QUEBEC							
Bedford	0.729		0.729[2]	4.00[1]		4027	
Sutton	0.268		0.268[2]	4.00[1]		1480	
NEW YORK							
Champlain	0.323	0.380	0.400	2.05	1.20	914	630
Dannemora	0.699	0.611	1.500	3.08	3.20	2973	2700

Facility	Flow (mgd)			Concentration (mg/yr)		Load (kg/yr)	
	1990-1991	1995	Permitted (1995)	1990-1991	1995	1990-1991	1995
Granville	0.793	0.700	0.650	1.50	2.00[1]	1643	
Keeseville	0.264	0.234	0.300	3.25	2.98	1185	963
Lake Placid	1.341	1.300	2.500	2.27	2.30	4204	4129
Peru	0.254	0.200	0.500	4.00	2.30	1403	635
Plattsburgh City	8.402	7.300	16.000	1.74	0.76	20190	7662
Port Henry	0.588	0.600	0.440	1.92	2.10	1559	1740
Rouses Point	0.814	0.850	2.000	1.62	1.90	1821	2230
Saranac Lake	1.884	1.884	1.200	2.06	0.80	5360	5360
Ticonderoga	0.902	0.800	1.500	1.12	1.20	1395	1326
Whitehall	0.539	0.600	0.600	0.96	0.96	715	795
Adirondack Fish Culture Station	2.623	2.600	3.600	0.05	0.03	181	108
Great Meadows Correctional	0.371	0.280	0.400	2.00[1]	2.00[1]	1025	773
International Paper Company	17.464	17.000	17.000	0.34	0.30	8200	7043
Wyeth-Ayerst Laboratories	0.039		0.026	83.80		4513	
Vermont Total	12.064		20.38			11335	42409
Quebec Total	.997		.997			5507	
New York Total	36.507	34.639	47.966			55638	36094

[1] Estimated value; no data available.
[2] Existing flows used for permitted flows.

Source: VT DEC and NYSDEC, 1994; 1995 data compiled by Fred Dunlap, NYSDEC, and Eric Smeltzer, VT DEC. The 1995 data are preliminary; more final 1995 estimates will be included in the 1996 Draft Plan.

to 1.0 mg/l at certain designated facilities. The Edgar Weed Fish Culture Station and the Vermont Whey Co. have effluent phosphorus loading limits in their discharge permits that were derived from site-specific water quality considerations. Most of the other smaller Vermont facilities in the Lake Champlain Basin are exempt from any specific phosphorus effluent limits under current policy. However, Vermont Water Quality Standards require "no significant increase over currently permitted loadings" to Lake Champlain, and wastewater treatment facilities undergoing expansion have been required to maintain current loadings under this rule.

In New York, a Department of Environmental Conservation, Division of Water, Technical and Operational Guidance Series document (1.3.6) recommends that new discharges in lake watersheds: 1) employ sub-surface disposal at facilities where the permitted flow is less than 10,000 gal/day; 2) limit the permitted effluent phosphorus concentration to 1.0 mg/l at facilities with 10,000-50,000 gal/day permitted flow; and 3) limit phosphorus to 0.5 mg/l at facilities with greater than 50,000 gal/day permitted flow. Under these guidelines, existing permitted discharges undergoing flow expansion cannot increase phosphorus loading, and other existing discharges must employ phosphorus removal treatment if the need is demonstrated through a special study or "detailed analysis." Two existing New York discharges (International Paper Co. and Wyeth-Ayerst, Chazy facility) have phosphorus loading limits specified in their discharge permits. No other existing New York facilities have phosphorus concentrations or loading limits specified in their discharge permits under current policy.

In Quebec, there is an active sewer and wastewater treatment facility construction program in the Missisquoi Bay watershed that will result in the construction of treatment plants for all municipal and industrial discharges in the Basin. All Quebec facilities in the Basin will be required to meet a 1.0 mg/l effluent limit.

Controlling Nonpoint Sources

There are a wide variety of programs at various levels of government that are responsible for some aspect of nonpoint source pollution control. Brief descriptions of some of the more important programs (in terms of phosphorus reduction) are included below.

Federal Programs

United States Department of Agriculture (USDA)

Voluntary USDA programs in Vermont and New York for controlling agricultural nonpoint source pollution have been in operation since the 1940s. Technical assistance is provided by the USDA Natural Resources Conservation Service (NRCS) for planning and implementing improvements such as manure storage structures, waste utilization, stream bank protection, and critical area plantings to protect erosion. Farmers who meet certain eligibility requirements may apply for up to 75% cost share funding for these improvements through the USDA Farm Services Agency (FSA). The FSA County Committees, composed of farmers elected from each County, prioritize projects and make decisions on funding. Additional USDA cost share funding has been available for farms within a number of watershed project areas in the Basin (see Table 5). While funding for USDA programs in the Basin has been declining since 1994, recent passage of the 1996 Farm Bill is expected to reverse this trend.

Table 5. USDA Agricultural Nonpoint Source Pollution Management Projects in the Lake Champlain Basin (1972 through 1992)

Program/Project	Number of Farms Contracted	Funding (by source)	
USDA, FSA and NRCS (NY)		**USDA**	**Landowner**
Empire Basin Special Project	45	$1,400,000	$470,000
Water Quality Incentive Program	40	212,500	70,800
Ongoing Program		1,999,000	666,000
USDA, FSA and NRCS (VT)			
Lower Lake Champlain Special Project	46	1,600,900	470,000
Lower Lamoille River Special Project	36	1,844,000	615,000
Grand Isle Special Project	46	985,200	328,400
Lower Missisquoi R. Hydrologic Unit Area	122	3,700,000	1,233,000
St. Albans Bay Rural Clean Water Program	61	1,686,300	615,200
Lake Carmi RC&D Measure	11	377,100	273,900
Lower Winooski River PL566	9	285,800	262,000
LaPlatte River PL566	27	709,900	286,300
Lemon Fair River PL566	18	452,200	396,800
Lower Otter-Dead Creek PL566	60	1,800,000	1,272,400
Ongoing Program		8,400,000	8,600,000
Totals in Projects		15,053,900	6,293,800
Totals in Ongoing Program		10,399,000	9,266,000
TOTAL		25,452,900	15,559,800

(Source: Data compiled by Dick Croft, USDA, 1993)

Since the 1970s, many farmers have been actively installing recommended management practices to reduce or prevent agricultural nonpoint source pollution. Table 5 shows past investment in the Basin by the USDA and farmers who have voluntarily participated in cost-share programs and projects. This represents an investment on the farmers' part of more than 15 million dollars, and a total investment of more than 41 million dollars in the Basin.

A great deal of progress has been made in the Basin through implementation of management practices on farms. The USDA estimates that its programs and the voluntary efforts of farmers have provided a fairly high level of treatment (barnyard runoff and manure management) for about one-third of the animal units in the Basin to date, mostly in the Vermont portion of the Basin. Common management practices implemented on these farms include manure and fertilizer management, milkhouse waste treatment, and barnyard runoff management. USDA-NRCS models estimate that the projects listed in Table 5 have reduced the amount of phosphorus exported from farms by more than 45 metric tons/yr.

During the 1980s and early 1990s, much of the cost share funding in Vermont was allocated to priority watersheds identified initially by the Vermont Section 208 Areawide Planning Committee. The original list of priority watersheds was subsequently amended based on further study (USDA-SCS, 1983) and incorporated into the Vermont State Clean Water Strategy. Major USDA water quality improvement projects have now been completed in about 12 of these 20 priority watersheds (see Table 5), and many smaller projects have occurred elsewhere in the Basin. The availability of new information on in-lake phosphorus reduction needs, phosphorus sources, and phosphorus reduction costs will allow for additional (and more refined) targeting of future agricultural cost share dollars in the Basin (see description of targeting procedure, above).

United States Environmental Protection Agency (USEPA) Section 319 Program
Congress enacted Section 319 of the Clean Water Act in 1987, establishing a national program to control and abate nonpoint sources of water pollution. Section 319 provides funds for states to implement projects resulting from USEPA approved state Nonpoint Source Management Programs (VT and NY NPS Programs are described under state programs, below). The USEPA oversees all grants awarded under Section 319. Section 319 funds have been available since 1990, and have been used for a wide variety of projects in the Basin ranging from erosion control to milkhouse waste best management practice demonstration. All Section 319 funds require a 40% non-federal match.

An important agricultural project recently funded through Section 319 is the "Lake Champlain Agricultural Watersheds BMP Implementation and Effectiveness Monitoring Project" being conducted by the University of Vermont and Vermont DEC in cooperation with watershed landowners. The objective of this 6-year study is to provide a quantitative assessment of the effectiveness (in terms of NPS nutrient reduction) of: 1) streambank stabilization and livestock exclusion, and 2) grazing management. This study is one of ten projects in the U.S. approved by EPA under the National Monitoring Program. The project will help document the effectiveness of some additional (less widely used) tools to reduce NPS phosphorus loads in the Lake Champlain Basin.

United States Fish & Wildlife Service (USFWS) Partners for Wildlife Program
The USFWS Partners for Wildlife Habitat Restoration program provides cost-share funds to willing landowners to restore and protect streamside habitat, particularly in agricultural areas. The program helps landowners construct streamside fencing and plant or maintain streambank vegetation. The benefits include both the establishment of wildlife corridors and the reduction of nonpoint source nutrient loading from agricultural sources and streambank erosion. The program requires a 35% non-USFWS contribution, but the landowner does not necessarily have to pay this full amount (in 1995, for example, the Lake Champlain Basin Program provided a 25% match, reducing the landowner's share to 10% of total project costs).

<u>State Programs</u>

Vermont Nonpoint Source Management Program
The Vermont Nonpoint Source Management Program was prepared in response to the federal Clean Water Act Amendments of 1987. The program is administered by VT DEC as part of the State Clean Water Strategy. The program addresses four priority areas for surface waters:

siltation and turbidity, nutrients, flow alteration, and noxious aquatic plants. The program uses six strategies for implementation: education, financial assistance, technical assistance, monitoring and evaluation, regulatory enforcement and oversight, and continued planning. The state has adopted ten sets of management practices which apply directly to the Nonpoint Source Program, including the Accepted Agricultural Practices and the Acceptable Management Practices (silviculture) which are discussed separately below.

Vermont Agricultural NPS Pollution Reduction Program
In 1993, the Vermont Department of Agriculture, Food and Markets (VT DAFM) and the Vermont Department of Environmental Conservation (VT DEC) signed a memorandum of agreement transferring authority for managing agricultural nonpoint source pollution to the Department of Agriculture. Subsequently, the state developed a two tiered program that combines voluntary implementation of specific land treatment practices at a reasonable public cost with mandatory implementation of basic practices at no public cost. The first component of the program is a list of Accepted Agricultural Practices (AAPs) designed to encourage farm owners and operators to follow six basic management techniques. The AAPs define minimum farm management standards which are presumed to protect water quality. The AAPs address issues such as the storage and application of manure and fertilizer, and vegetative buffer zones. Following an extensive public review process, the AAPs became effective in June, 1995. Adopted as rules, the AAPs must now be followed by all farm operators in Vermont as part of their normal operations, and are enforceable under state law.

The second major component of Vermont's Agricultural Nonpoint Source Program provides state cost-sharing for voluntary implementation of Best Management Practices (BMPs) in targeted watersheds. Best Management Practices in this context are specific practices that have water quality benefits beyond those of the AAPs. The VT DAFM adopted BMP rules in 1996, and the state legislature appropriated $350,000 in cost-share funding for this part of the program in both 1995 and 1996. These cost-share funds are being targeted to the Lake Champlain and Lake Memphremagog basins.

Vermont's Acceptable Management Practices - Erosion Control on Forestland
Vermont adopted performance standards known as Acceptable Management Practices (AMPs) to maintain water quality on logging operations in 1987. These practices are based on guidelines in existence and applied for more than ten years prior to adoption of the AMPs. They describe the proper method for the control and dispersal of water collecting on logging roads, skid trails and log landings to minimize erosion and reduce sediment and temperature changes in streams. The AMPs have the force of law, but have been implemented primarily through education and training programs. Technical assistance on the AMPs is provided by the Vermont Department of Forests, Parks and Recreation, and implementation has been improved through a working agreement with the Vermont Forest Products Association.

Vermont's Stormwater Program
The State of Vermont enacted legislation in 1981 (10 V.S.A. §1264) to address runoff "from large scale developments to sensitive water quality areas". In 1987 the Vermont DEC adopted draft Stormwater Procedures that provide the administrative process for issuing stormwater permits and contain details on control requirements and procedures. Stormwater is also addressed for some projects through issuance of an Act 250 permit (see below). Additionally, the state has

requested delegation from USEPA for the NPDES stormwater permits process in Vermont (described under point source programs, above).

Vermont Act 250

Vermont's Act 250 directs the state to review large or commercial development proposals for consistency with ten performance criteria pertaining to issues such as water pollution, soil erosion and wetlands. Under criteria 4, the state Department of Environmental Conservation reviews development proposals to ensure that there are adequate erosion control measures, adequate buffers to surface water and wetlands, and minimal disruption of existing drainage patterns. Act 250 is administered by District Commissions and the State Environmental Board.

Pasture Management Outreach Program, University of Vermont

This program was started in 1992, and now provides assistance to farmers in eight Vermont counties on all aspects of feedings cows on pasture. The goals of the program are to minimize soil erosion, reduce pollutant loadings from manure, fertilizers and pesticides, and to create a farm landscape that is aesthetically pleasing and will support the farm family for generations. Program personnel advise farmers on all aspects of pasture management including nutrition and health, soil fertility, paddock design and layout, and farm business management. Program advocates believe that intensive grazing management provides economic as well as environmental benefits to the farmer (for farms with suitable space) and the program received a grant through the Lake Champlain Partnership Program in 1995 to help document the economic impacts of these practices.

The New York State Nonpoint Source Management Program

New York's Nonpoint Source Management Program (NYSDEC, 1990) aims to control nonpoint source pollution through proper land management. It relies on the use of financial incentives, voluntary compliance, and regulation to bring about improvements. The program includes: 1) watershed planning process and guidelines for setting priorities in and among watersheds; 2) recommended control measures for identified categories of nonpoint source pollution; and 3) potential funding for implementation, including federal and state grants and low interest loans from the state water pollution control revolving fund.

In 1989, the New York State Legislature passed a nonpoint source pollution control law which authorized two matching grants programs for planning and implementation of nonpoint source pollution control and abatement projects. One of the programs is to be administered by the New York State Soil and Water Conservation Committee and is for agricultural nonpoint source abatement and control projects. Soil and Water Conservation Districts can apply for matching grants to implement management practices in priority watersheds. The other program is to be administered by NYSDEC and is for non-agricultural nonpoint source abatement and control projects. For this program, municipalities can seek matching grants to implement management practices that address non-agricultural sources in priority watersheds. The two programs received a combined total of $1 million in the NYS 94-95 budget.

New York State Stormwater Management Program

New York State has developed two State Pollutant Discharge Elimination System (SPDES) general permits for stormwater discharges; one for industrial activities except construction, and the other for construction activities involving the disturbance of 5 acres or more of land. Both permits require that a stormwater pollution prevention plan be developed, implemented, and maintained for a site in accordance with conditions specified in the permit. Pollution prevention plans may incorporate a combination of good housekeeping practices, best management practices, and structural measures to achieve the desired controls. The NYSDEC, which administers the program, has published a Technical and Operational Guidance Series (TOGS) on stormwater management (TOGS 5.1.8) and erosion and sediment control (TOGS 5.1.10) which provide much of the framework for the two SPDES general permits and contain guidance on the preparation of pollution prevention plans.

The New York State Environmental Quality Review Act
This statute requires the preparation of an Environmental Impact Statement (EIS) for any action that is undertaken, approved or financed by a state or local agency that may have a significant effect on the environment. Similar to the National Environmental Policy Act, it is designed to ensure that social, economic and environmental impacts are considered when there is agency action.

The New York State Adirondack Park Act
This Act provides for the Adirondack Park Agency to issue permits for certain development projects within the Adirondack Park. Permits are only issued if it is determined that a project will not have an undue adverse impact on the environmental resources of the Park. Consideration of potential impacts to water quality from nonpoint sources is included in this review process.

The New York State Cooperating Timber Harvester Program
The Cooperating Timber Harvester Program is sponsored by NYSDEC and is designed to improve relations between landowners and timber harvesters and to promote the use of New York Timber Harvesting Guidelines to protect water quality. Under this program the NYSDEC provides forest management and business management assistance to cooperating timber harvesters, distributes a list of cooperating timber harvesters to interested landowners, and requires cooperating timber harvesters to follow the Timber Harvesting Guidelines. The Timber Harvesting Guidelines include all the silvicultural best management practices in New York State's Silviculture Management Practices Catalogue (NYSDEC, 1993), and address activities such as stream crossings, felling near streams, and erosion control at landings, roads and skid trails.

Cooperative Extension Services
The Cooperative Extensions of the University of Vermont and Cornell University provide valuable technical assistance to farmers on topics such as soil testing and overall nutrient management. The Cooperative Extensions coordinate their work with other organizations such as the USDA Natural Resource Conservation Service, and provide nutrient management training to private consultants, farmers, and government agencies.

<u>Quebec Programs</u>
The primary regulatory agency for nonpoint source pollution in Quebec is the Ministry of Environment and Fauna (MEF). A number of agricultural practices are required by the MEF, including the use of buffer strips, limits on land application of manure, controls on the expansion of livestock operation, and a drainage permit process. The application of manure to frozen or snow covered land has been prohibited for more than 20 years. The Quebec Ministry of

Agriculture provides technical and financial assistance to farmers on management practices. Cost-share rates range from 30% to 70%, but funding (which is partly supported by Agriculture Canada) has been declining in recent years (Garvey and Usher, 1994).

As a result of the 1993 Water Quality Agreement for Lake Champlain, the MEF along with the Ministry of Agriculture and other agencies have formed a Missisquoi Bay Phosphorus Reduction Committee. The committee is preparing a phosphorus reduction plan for the Riviere-aux-Brochets (Pike River) watershed, which feeds into Missisquoi Bay.

Municipal, County or Regional Programs

New York County Coordinating Committees
To facilitate local implementation efforts, the NYSDEC, in conjunction with the NYS Soil and Water Conservation Committee, set up County Water Quality Coordinating Committees to prepare county water quality strategies. Committee membership is voluntary, and made up of representatives from local organizations involved in preventing nonpoint source pollution. Each committee identifies and sets local priorities for nonpoint source pollution prevention. Committee strategies have helped to organize and focus diverse constituencies, and achieve consensus on priorities within counties. The strategies have also facilitated communication among various agencies, thus avoiding duplication of effort and making the most of scarce resources. Minimum requirements for county strategies established by the NYS Soil and Water Conservation Committee and the NYSDEC include the following: 1) watershed-specific list of water quality problems in order of importance; 2) a list of goals and objectives for public participation; 3) a list of work tasks for achieving each objective; and 4) an indication of who is responsible for each task, estimated time of completion, potential funding sources and estimated costs. Counties that developed strategies meeting these minimum requirements were eligible to receive a one-time payment of $4,750 to implement a component of their strategy.

Other Regional and Municipal Programs
County Soil and Water Conservation Districts (NY) and Natural Resource Conservation Districts (VT) are funded by the states and/or USDA and work directly with farmers to help implement the USDA cost-share and technical assistance programs. The Districts also provide demonstrations and assistance on innovative pollution prevention techniques. For example, a coalition of three Districts in Vermont and New York recently received funding from the Lake Champlain Basin Program to demonstrate and document the environmental and economic benefits of on-farm composting of manure.

Municipalities, through their local ordinances, can adopt important phosphorus reduction measures. Many local ordinances include vegetative cover and buffer requirements, erosion control provisions, or wetland protection measures. Only a few municipalities in the Basin have adopted local stormwater regulations, an effective means of reducing nutrient loads from new development. Regional planning commissions in Vermont and County Planning Offices in New York provide technical assistance to local governments on a variety of pollution control issues.

Watershed Associations
Watershed Associations can play a key role in local water quality improvement projects, as described in the Action Plan for Building Local Capabilities for Watershed Planning. An

excellent example is the Boquet River Association (BRASS) in New York, which has been actively involved in phosphorus and other nonpoint source reduction efforts since 1984. BRASS, a largely volunteer organization, maintains an aggressive stream bank willow planting program to control erosion (approximately 200,000 willows have been planted to date), monitors long term water quality trends, and conducts a variety of education and water quality improvement programs in the Boquet River Watershed. There are relatively few watershed associations in the Basin, but their numbers have been growing in recent years, particularly in the Vermont portion of the Basin.

Issues

Targeting phosphorus reductions at the Basin-wide scale
Recent Basin-wide targeting efforts are described above, and have greatly enhanced the LCBP's ability to recommend the most cost-effective scenarios for phosphorus reduction in the Basin. The targeting procedure is intended to evaluate the efficiencies of various point and nonpoint source phosphorus reduction options at the Basin-wide scale. Current targeting scenarios being developed for the LCBP Plan identify phosphorus reduction goals for the groups of sub-basins draining into each of the 13 Lake segments (see Figure 8). While there are opportunities for further refinement, this targeting procedure is a strong tool for establishing load reduction targets at the Lake segment watershed scale. However, more detailed analyses of point and nonpoint sources within each targeted watershed will be required to verify that reduction goals can be achieved and to identify specific reduction options (see below).

Reducing phosphorus at the local level
While information on phosphorus loadings and potential reductions has been compiled at the Basin-wide scale, more work is needed at the sub-basin level to identify cost-effective reduction strategies, particularly for urban and developed areas. This process needs to include a much more detailed assessment of urban phosphorus reduction opportunities than has been accomplished through the Basin-wide targeting effort. Regularly up-dated land use data are also needed for the entire Basin to facilitate the sub-basin planning and implementation process. While new Basin-wide land use data are scheduled for release in 1996, these data will need to be up-dated on a regular basis to keep up with land use changes in the Basin.

The sub-basin planning process currently underway in the LaPlatte River watershed in Vermont and the Little Ausable watershed in New York appears to be effectively accomplishing the above goals, and should be considered for use elsewhere in the Basin as well. This process includes the following steps: 1) determine phosphorus loadings from all sources in the watershed; 2) determine the amount and cost of reduction achievable from each source; and 3) select an economically and politically feasible method to attain the phosphorus reduction target. Since implementation is likely to require significant funding, the development of funding strategies is an important final step in the sub-basin planning process.

The term "sub-basin" as used in this document refers to one of the 34 major drainage areas (larger than 26 km^2) to Lake Champlain (see Table 6, p. 53). The Basin-wide targeting procedure referred to above is establishing phosphorus reduction targets for each Lake segment watershed. Because a Lake segment watershed includes all of the sub-basins that drain to a given Lake segment, several sub-basin plans may need to be completed for each Lake segment watershed. Lake segment watersheds that cross the state border are divided into Vermont and New York portions for management purposes.

The Timing of In-Lake Response to Phosphorus Reductions on the Land

Steady-state phosphorus models used for lake load allocation analyses generally predict the long-term, ultimate response of the system to changes in loading. Experience in Lake Champlain and elsewhere has shown that water quality improvements in rivers and lakes can be delayed for many years following implementation of phosphorus controls. These delays can be caused by the accumulation and storage of phosphorus in sediments and other components of the watershed-lake system after many years of excessive loadings. In St. Albans Bay, for example, where high levels of phosphorus have persisted despite years of phosphorus reduction efforts, a series of recently completed studies funded by the LCBP (Hyde et al., 1994; Martin et al., 1994; Smeltzer et al., 1994) indicates that Lake sediments are an important source of continuing phosphorus release to the Bay. The studies also indicate that phosphorus inputs from the sediments are decreasing with time as this source is depleted. The LCBP is currently studying phosphorus exchange rates with the sediment throughout the Lake to determine the importance of this source in other parts of the Lake (see "current studies and additional research needs", below).

Delays in lake response can also result from a lag time between the implementation of phosphorus reduction measures on the land and water quality improvements in the downstream tributary. Studies in the LaPlatte River and St Albans Bay watersheds between 1979 and 1990 found that significant reductions in phosphorus resulting from management measures implemented on farms were not clearly detected in the stream within the ten year time-span of these studies (Meals, 1990; Vermont Rural Clean Water Program Coordinating Committee, 1991). However, both studies found a clear decline in indicator bacteria (fecal coliform and fecal strep bacteria) counts in all monitored watersheds. The lack of watershed response for phosphorus may be the result of large reservoirs of phosphorus stored in soils or aquatic sediments, an inadequate level of participation in voluntary programs, a failure to address all nonpoint sources, or a combination of these factors. The fact that there was a clear reduction of pollutants that are not stored in the environment (the indicator bacteria) suggests that the management practices did have an effect, and supports the conclusion that the lack of response with respect to phosphorus is primarily due to phosphorus storage in the sediments and biota. This means that steps taken to reduce phosphorus on land should eventually be seen in streams and in the Lake, when the intervening phosphorus storage areas are depleted. There are, however, a number of unanswered questions regarding the length of this lag time, and the Lake Champlain Basin Program is conducting several studies to better understand phosphorus movement between the land and the Lake (see descriptions under "current studies" below).

Measuring Success of Phosphorus Reduction Efforts

Continued monitoring of phosphorus levels in the Lake and tributary mouths is critical to evaluating the ultimate success of phosphorus reduction efforts. A lake-wide water quality monitoring program has been conducted by New York and Vermont DECs since 1991, with funding from the Lake Champlain Basin Program. While other monitoring programs such as the Vermont Lay Monitoring program have provided a valuable record of in-lake phosphorus measurements dating back to the 1970s, continuation of the comprehensive NYS/VT DECs lake-wide monitoring program is needed to best assess future phosphorus reductions in the tributaries as well as in-lake environments. Specific monitoring recommendations are included in Chapter 5 of the Draft Final Plan. As should be clear from the discussion of timing, above, in-lake phosphorus reductions will probably not be apparent for a number of years, even with significant implementation of phosphorus management practices on the land.

Preventing Increases in Phosphorus Loads to the Lake

Phosphorus levels in a number of the Lake segments are at or near the phosphorus criteria (refer to Table 3, p. 31). For sub-basins where the Lake Champlain phosphorus targeting procedure indicates no reduction is necessary to attain the criteria (refer to the June 1996 Draft Plan), management efforts should focus on preventing phosphorus increases in phosphorus levels. For sub-basins where reduction is necessary, management efforts should focus on reduction and the prevention of increases from new sources. One way to minimize loading increases is to ensure that new development complies with appropriate management practices to minimize phosphorus export. It is much less expensive to prevent phosphorus discharges at the initial stage of development than to attempt to reduce phosphorus runoff after project completion. Both New York and Vermont have programs in place to control erosion, sedimentation and stormwater runoff from new development. Opportunities for strengthening these programs are discussed below.

New York issued two general permits in 1993 (under the National Pollutant Discharge Elimination System, or NPDES program) for stormwater discharges. One permit covers regular operational activities for ten industrial categories. The other is for stormwater discharges associated with construction activity that disturbs five or more acres, and requires the development of a stormwater pollution prevention plan, a copy of which must be sent to the local governing body. While NYSDEC has the authority (pursuant to Article 17 of Environmental Control Law) to enforce the terms of the permits, including pollution prevention plan review and approval, the Agency has decided to rely on local governments (usually municipalities) to perform these tasks due to state staffing limitations. However, if municipalities do not adopt the local ordinances necessary to give them authority to approve plans (which is usually the case), then these plans will not be reviewed at all. With additional funding, NYSDEC could provide staff to review these plans and conduct limited site visits within the Lake Champlain Basin.

Vermont issues state stormwater discharge permits, and has requested delegation from EPA for the issuance of federal NPDES general stormwater permits. Stormwater issues may also be addressed through the Act 250 permit process, although the Act does not have specific stormwater management requirements. While Vermont's permitting program has been underway for several years, there are opportunities for improvement. Draft Stormwater Procedures issued in 1987, which contain details on control requirements and procedures, should be updated and strengthened to reflect current knowledge on controlling runoff from urban, residential and commercial land. These procedures should be finalized to include greater emphasis on water quality protection by requiring best management practices (BMPs) such as wet ponds and constructed wetlands. Notwithstanding these recommendations, the existing program needs more funding to provide adequate staffing for critical activities such as plan review and site inspection.

Focusing Agricultural Efforts on Improved Nutrient Management
While it is important to continue with structural improvements to farms (such as the construction of manure pits and barnyard runoff systems) additional emphasis needs to be placed on nutrient management. Nutrient management is an integrated approach to maximizing the efficient use of plant nutrients. The LCBP sponsored a variety of recent research and demonstration projects to enhance nutrient management capabilities. For example, studies have assessed the effectiveness of different methods of manure application (Jokela et al., 1995) and demonstrated the advantages of using perennial forage grasses to improve phosphorus management (Cherney et al., 1993). Studies in progress are determining optimum phosphorus concentrations for various soil types in the Basin (the Soil Phosphorus Concentration Study) and identifying ways to reduce the net accumulation of phosphorus on the farm (the On-farm Phosphorus Budgeting Project). Additionally, an on-farm composting project is demonstrating that properly designed and operated compost operations can be both an economically and environmentally viable alternative to spreading raw manure on fields.

The knowledge derived from these studies and others, combined with basic nutrient management skills, can save farmers money as well as protect water quality. This information now needs to be made more available to farmers for daily application. There is also a large un-met demand for technical support services for tasks such as record keeping, computer analysis, and soil/manure sampling. Over the last few years, the State of Vermont has used portions of its Clean Water Act Section 319 funds to establish nutrient management training and assistance programs through the Natural Resource Conservation Districts and non-profit organizations. The Section 319 funds were used as start-up funds to support these programs for the first three years, and at least one of these programs (the Champlain Valley Crop Management Association) has already become self-sustaining: the fees paid by farmers for nutrient management assistance fully support the association's staff. The economic benefits of improved nutrient management are becoming better known in the agricultural community and there is now more demand for nutrient management assistance than can be provided by existing trained consultants. Some nutrient management services are available from commercial fertilizer enterprises, and Vermont's Section 319 program has continued to support the development of a handful of crop management services, but additional start-up funds are needed.

The Potential Impact of Zebra Mussels on Phosphorus and Algae Levels
Zebra mussels are capable of filtering large amounts of algae and other particles from lake water, and zebra mussel infestations have been associated with increases in water clarity in some lakes. The question has been raised as to whether the zebra mussel invasion of Lake Champlain will result in attainment of the water quality goals without the need for expensive point and nonpoint source control programs.

One of the most thorough and transferrable analyses to date of the potential impact of zebra mussels on phosphorus cycling and algae in lakes is that of Mellina et al. (1995). Mellina et al. examined data from three lakes where water clarity changes resulting from zebra mussel have been extensively reported and documented. The authors supplemented their analysis with laboratory measurements of zebra mussel filtration and phosphorus excretion rates. They also analyzed a data set from 27 European lakes with a much longer history of zebra mussel infestation.

The study's findings suggest that phosphorus reductions resulting from the zebra mussel invasion in Lake Champlain are likely to be transient, persist only during the biomass expansion phase of the infestation, and occur only in shallow areas of the Lake. Once zebra mussel densities reach an approximate equilibrium in a lake, their phosphorus uptake should be balanced by losses and the excreted phosphorus will be mostly recycled back into the water column. Some initial reduction of algal growth is also likely due to direct zebra mussel grazing of algal cells, but the analyses of both the North American and European lakes suggest that lake ecosystems gradually compensate for the mussel filtration effects. Algae populations in some North American lakes, for example, shifted to large, ungrazable blue-green species.

In another study, Meisner et al. (1993) conducted a phosphorus mass balance modeling analysis of the Bay of Quaint, Lake Ontario to predict the effects of the anticipated zebra mussel infestation on phosphorus reduction remedial action plans. The model predicted that there will be significant phosphorus reductions during the initial years of the infestation, but that concentrations will later return to levels that would have been present in the absence of zebra mussels. Phosphorus initially deposited in the sediments in zebra mussel feces is predicted to slowly return to the water column, restoring concentrations to previous levels.

The results from both studies suggest that it would be unwise to delay implementation of point and nonpoint source phosphorus controls in the hope that zebra mussels will produce water quality improvements in Lake Champlain. If such improvements occur, they are likely to be limited in area, temporary, and unstable.

Current Studies and Additional Research Needs

The LCBP has sponsored many studies that will provide useful information for attaining the phosphorus reduction goal, and a number of these are still in progress. A study of phosphorus movement between farms and streams ("Determination and Quantification of Factors Controlling Pollutant Delivery from Agricultural Lands to Streams") will identify which factors, and therefore which management practices, most effectively reduce phosphorus transport in this zone. This project should also provide some insight into how long it should take for the benefits of agricultural management practices to be visible in the stream. A somewhat related project investigating phosphorus storage and movement in streams (The "Instream Phosphorus Transport, Transformation, Storage and Release Processes" study) will allow modeling efforts to more accurately account for phosphorus taken up and released from sediments and plants. Because this study is focusing on phosphorus dynamics within several small river reaches, more work will be required in order to estimate phosphorus transport rates (i.e. the lag time discussed above) for an entire river system.

A bioenergetics modeling study (the so-called "Bottom-up" study) investigating relationships between nutrients, phytoplankton, bacteria, protozoa and zooplankton will provide a better understanding of the impact of changing phosphorus levels on the food web and vice versa.
The combination of this and a second bioenergetics study (the so-called "Top-down" study) that is focusing on predator-prey relationships among various fish species, will provide information necessary to help determine ecologically optimum in-lake phosphorus concentrations. Both studies are scheduled for completion in 1996, and results should be available for the next review of the in-lake phosphorus criteria.

Another important in-lake study that is still in progress is the "Internal Phosphorus Dynamics" project that is quantifying the exchange of phosphorus between the sediments and the water column at selected sites in the Lake. The results of this study will enhance in-lake phosphorus modeling efforts and will improve our ability to predict the in-lake response to changes in phosphorus loading.

An important additional research need is to improve our understanding of the effectiveness of agricultural and urban nonpoint source management practices. The long term monitoring studies in the LaPlatte and St. Albans Watersheds (Meals, 1990; Vermont Rural Clean Water Program Coordinating Committee, 1991) found that management practices on the farm can effectively reduce phosphorus export at the edge of a field or farmstead. For example, nearly 90 percent of phosphorus in milkhouse effluent can be removed from surface runoff by employing a properly sized buffer strip, and alternatives to winter manure spreading can prevent the release of 15 percent of the phosphorus contained in manure. However, more work is needed to demonstrate the effectiveness of such practices in terms of phosphorus reductions in the stream. Through a series of carefully controlled long term demonstration projects with both implementation and monitoring components, we could document response times, build a record of successes, and increase the confidence and participation of farmers and other nonpoint source contributors.

Additional investigation of the water quality of the river-like South Lake (below the Crown Point Bridge) is also needed. Recent research in the South Lake indicates that both algal and non-algal particles contribute to the turbid nature of this segment. Also, the sources and sinks of turbidity and phosphorus to this segment of Lake Champlain are not well understood. Sources and sinks that need to be investigated include tributary and point source loadings of both phosphorus and particles, resuspension of particles from the bottom muds under windy conditions, and the settling of particles out of the water column. The hydrodynamics of the South Lake also need further study; this work should culminate in a revised water quality model for the South Lake. This research will improve our understanding of the impact of the South Lake on phosphorus levels in the remainder of Lake Champlain. Data collection to support this effort should be included in the ongoing long-term monitoring program.

Table 6. Lake Champlain Sub-basins listed by Lake Segment

Lake Segment/ Tributary	Drainage Area (km^2)	Lake Segment/ Tributary	Drainage Area (km^2)
Cumberland Bay, NY		**Port Henry, NY**	
Saranac	1575	Hoisington	28
Scomotion	104	Mill (Port Henry)	73
Isle La Motte, NY		**Shelburne Bay, VT**	
Great Chazy	769	LaPlatte	137
Little Chazy	139		
Riley	28		
Main Lake, NY		**South Lake A, NY**	
Ausable	1323	LaChute	702
Boquet	712	Mill (Putnam Sta.)	27
Highlands Forge	30	Putnam	160
Little Ausable	189		
Salmon	175		
Main Lake, VT		**South Lake A, VT**	
Winooski	2828	East	81
Malletts Bay, VT		**South Lake B, NY**	
Indian	31	Mettawee/Barge Canal	736
Lamoille	1909	Mt. Hope	30
Malletts	76	Poultney	62
Missisquoi, VT and Quebec		**South Lake B, VT**	
Missisquoi	2223	Mettawee/Barge Canal	362
Pike	517	Poultney	630
Rock	152		
Northeast Arm, VT		**St. Albans Bay, VT**	
Mud	30	Mill	59
Stone Bridge	32	Stevens	59
Otter Creek, VT			
Lewis	209		
Little Otter	185		
New Haven	298		
Otter	2462		

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Preventing Pollution from Toxic Substances

Background

Why are Toxic Substances a Problem?

Toxic substances are elements, chemicals or chemical compounds that can poison living plants and animals, including humans. While some toxic substances may come from natural sources, the increasing use of chemicals in manufacturing processes, for agriculture and in our daily lives may be threatening the high quality of our Lake environment.

Toxic substances are an issue of wide public concern in the Lake Champlain Basin, due in large part to health advisories in both New York and Vermont regarding the consumption of certain fish species with elevated levels of mercury and polychlorinated biphenyls (PCBs) in their flesh. Now that scientists have confirmed elevated levels of lead, mercury, zinc, PCBs and polycyclic aromatic hydrocarbons (PAHs) in sediments of selected bays (McIntosh, ed., 1994), people are concerned about the impact of toxic substances on the Lake ecosystem, as well as on their drinking water and the Lake's other uses.

This section summarizes what we know about toxic substances in the Lake Champlain ecosystem and describes major management issues. It also looks upstream into the Lake's tributaries and into the atmosphere to locate sources of toxic substances found in the Lake. Further work is needed to assess problems caused by toxic substances within the tributaries and other waterbodies within the Basin, and to reduce risks from airborne sources. This section does not address the presence of toxic substances in groundwater, nor potential risks from that medium. It also does not address the potential risks to human health resulting from direct human exposure to airborne toxics. The problem of toxic pollution in the Lake Champlain Basin is linked to several other issues discussed in this document (see sections on Protecting Human Health, Managing Fish and Wildlife Resources, and Reducing Phosphorus Pollution).

What is the Status of Toxic Substances in Lake Champlain?

In 1979, the Level B Study reported that Lake Champlain's water was safe to drink and its fish were safe to eat. Based upon the data available at the time, it was concluded that levels of toxic substances posed no immediate threat to human health nor to fish and wildlife (New England River Basin Commission, 1979). While these results were reassuring, the Study's recommendations stressed the importance of improving monitoring efforts and strengthening programs to protect the relatively high quality of Lake Champlain waters, particularly given the unknown effects of toxic substances.

Recent efforts to improve our understanding of toxic pollution in the Lake suggest that, while levels are low compared to more industrialized areas such as the Great Lakes, there is still cause for concern. Two toxic substances found in some Lake Champlain fish now exceed levels set to protect human health. Lake bottom sediments tested near the most developed and urbanized areas along the Lake shore contain higher levels and greater numbers of trace metals and organic compounds than elsewhere in the Lake; and, in a few instances, levels indicate potential risks to aquatic life. Early results of research measuring the direct effects of toxic organic substances on aquatic life confirm earlier suspicions that, even at relatively low levels, persistent toxic substances can harm the environment.

The following section summarizes these and other results of research and monitoring efforts on toxic pollution in Lake Champlain. It presents a brief overview of efforts to measure levels of trace metals and toxic organic substances, understand their effects, focus management on the substances posing the greatest risks and identify sources of these pollutants. A summary of the existing programs designed to manage these issues is also provided.

Levels of Toxic Trace Metals

Recent studies on the levels of trace metals found in Lake Champlain's biota, water, sediments, and air are summarized below.

<u>Biota</u>

Mercury has been measured in Lake Champlain's fish since the early 1970s. In 1970, levels of mercury found in several species, particularly large predators, were equal to or greater than the Federal Food and Drug Administration's (FDA) tolerance level of 0.5 parts per million (ppm) in food items. However, when the FDA revised this guideline upward to 1.0 ppm in the 1980s, fish from Lake Champlain were deemed safe for consumption. Vermont and New York State fish tissue monitoring data from 1988-1994 indicate that, while mercury levels for most species met this health standard, levels in large walleye taken from the Missisquoi, Great Chazy, Lamoille and Poultney Rivers were at, or above, 1.0 ppm (Gates, personal communication). This discovery led both states to issue health advisories regarding the consumption of walleye from Lake Champlain.

<u>Water</u>

Data from State monitoring programs indicate that levels of toxic trace metals in the Lake Champlain water column are generally below standard analytical detection levels. Highly sensitive analytical procedures have detected quantifiable concentrations of mercury in the water in certain areas of the Lake and arsenic in Malletts Bay (Fuller, personal communication). The New York State Department of Environmental Conservation (NYSDEC) has included four tributaries to Lake Champlain, the Boquet, Saranac, Lachute, and Richelieu Rivers, in its Rotating Intensive Basin Studies (RIBS). The 1987-1988 survey showed measurable levels of cadmium and copper in water samples, but overall water quality at all the sites but the Richelieu was considered good (NYSDEC, 1990). The RIBS program sampled the same sites in the New York portion of the Basin again in 1993-1994, with results to be published toward the end of 1995.

<u>Sediments</u>

In the early 1970s, Dr. Allen Hunt of the University of Vermont sampled bottom sediments at over 200 locations in Lake Champlain to determine lake-wide levels of trace elements, and found that lead and zinc were above background levels throughout most of the Lake. Nickel exceeded average lake-wide values at Ticonderoga, and nickel and chromium showed enrichment in Malletts Bay sediments. High levels of copper were measured in St. Albans Bay. Cadmium and cobalt levels were low or non-detectable throughout the Lake (Hunt, 1976). RIBS 1987-1988 survey also showed measurable levels of lead in sediments (NYSDEC, 1990).

The Sediment Toxics Assessment Program, initiated in 1991 with funding from the LCBP, represents the first effort to track trends in the accumulation of toxic substances in the Lake over time. Sediments were sampled at 30 sites throughout Lake Champlain to measure levels of contaminants. Results from Phase I of the study showed the following (McIntosh, ed., 1994):

Table 7. Results of Sediment Toxics Assessment Program: Phase I

Location	Relative Level of Toxic Substance Found
Lake-wide	• cadmium, chromium and copper levels are low at most sites
Northern half of the Lake	• lead and zinc levels are high at several sites • mercury levels are modestly elevated at several sites
Inner St. Albans Bay	• chromium levels are high
Outer Malletts Bay	• arsenic, nickel and manganese levels are high • elevated levels of nickel and arsenic measured in sediments of lower main-stem Lamoille River by VT DEC, 1992
Inner Burlington Harbor	• silver is elevated • lead levels are particularly high
Cumberland Bay	• lead levels are particularly high

In another study designed to evaluate toxic substance inputs from Lake Champlain's tributary rivers and streams, the U.S. Geological Survey (USGS) sampled stream bed sediments from 34 major and 39 minor tributaries during 1992 for trace metals and organic substances. Results of this work have not yet been analyzed.

In 1993-1994, the NYSDEC and VT DEC screened 12 predominantly urban watersheds in the Basin for toxic pollutants. Urban stream sediments sampled by VT DEC in 1993 showed elevated levels of some metals, particularly zinc, nickel, lead, copper and chromium; however, concentrations were generally low when measured in the whole sediment. Concentrations were highest in the more highly developed watersheds such as Englesby and Potash Brooks in Chittenden County, Stevens Brook in St. Albans, and the Boynton Street drainage in Plattsburgh. Silver was elevated at one site, Englesby Brook, and cadmium was below detection at all sites sampled (Quackenbush, 1995).

<u>Air</u>

Sampling for airborne toxic metals at four sites in the Lake Champlain Basin (Whiteface Mountain, New York; Willsboro Bay, New York; Burlington, Vermont; and Underhill, Vermont) reveals comparatively elevated levels of zinc in Burlington's air. Possible sources include refuse incineration, tire wear and industries (LCBP, 1993). Assessment of arsenic levels at these and other sites across the Northeast shows periodic episodes of high regional concentrations, with peak levels measured at Whiteface Mountain, grading to lower levels eastward through the Basin and network. The suspected source of these anomalous levels of arsenic is a smelter in Quebec (LCBP, 1993).

Measurements of toxic metals in air samples from Underhill show that arsenic, chromium, lead, nickel, vanadium and zinc are present in the air at concentrations ranging from one to three times above natural background levels (VT ANR, 1993). Other evidence suggests that some of these air-deposited toxic substances are accumulating in aquatic sediments and forest soils. Hunt's data on uniformly elevated lead and zinc levels in Lake Champlain sediments also suggest an atmospheric source for some of these substances (Hunt, 1975).

Levels of Toxic Organic Substances

The following section summarizes recent studies on the levels of toxic organic compounds found in Lake Champlain's biota, water, sediments, and air.

Biota

Comprehensive testing for toxic organic substances in fish tissue did not begin until 1987-88. Of the 17 contaminants analyzed by Vermont and New York State personnel, elevated levels of PCBs were found in large lake trout from throughout the Lake, and in American eel and brown bullhead from Cumberland Bay (Gates, personal communication). At that time, a health advisory against eating lake trout over 25 inches long was issued jointly by New York and Vermont. This testing also revealed the presence of other organic substances, including DDT, dieldrin, alpha BHC, chlordane, and hexachlorobenzene. Quebec's Ministere de l'Environnement found pesticides and PCBs in mollusks and fish taken from the Richelieu and Pike Rivers in 1978, and at sites in the Richelieu in 1983 (Watzin, 1992).

Mussels and other organisms have the ability to concentrate toxic substances in their tissues from the water and sediment. Taking advantage of this physical process, called "bioaccumulation," the Vermont Agency of Natural Resources deployed caged mussels at the mouths of several Lake Champlain tributaries to identify specific watersheds that are "sources" of toxic materials to the Lake. This work, with funding by the LCBP, has identified chlordane in mussel tissue in the Poultney River and PAHs in mussels placed in the Saranac River (Langdon, 1993). Additional placement of caged mussels in 12 predominantly urban watersheds revealed trace amounts of PAHs in samples from all the watersheds except Malletts Creek, and no PCBs or pesticides in any of the samples (Quackenbush, 1995).

Water

Data from state monitoring programs indicate that levels of organic contaminants in the Lake Champlain water column are generally below standard analytical detection levels. Highly sensitive analytical procedures have detected quantifiable concentrations of some organics (PCBs) in the water in certain areas of the Lake (NYSDEC and NYSDOH, 1994).

Sediments

Results of the Sediment Toxics Assessment Program reveal little evidence of widespread high-level contamination by PCBs, pesticides, or PAHs. In general, levels are below acceptable guidelines (McIntosh, ed., 1994). However, PCB and PAH-bearing sediments were discovered near Wilcox Dock in Cumberland Bay, and lesser, but elevated, levels were measured in Inner Burlington Harbor (McIntosh, ed., 1994). The NYSDEC collected sludge and sediment samples near Wilcox Dock and sediment samples in other parts of Cumberland Bay in 1993 and 1994. The sampling results show that PCBs are present at higher levels in the sludge and at lower levels in the Bay outside of the sludge bed. The levels of PCBs in the sludge north of Wilcox Dock range between nondetectable and 1,850 parts per million (ppm). The levels of PCBs exceed 50 ppm at many locations and depths within the sludge bed. PCBs found at levels above

50 ppm in the environment are considered to be hazardous waste by legal definition in New York State. The levels of PCBs found in most samples collected outside of the sludge bed area were lower, ranging between nondetectable and 2.6 ppm. In one area just southeast of the Saranac River outlet, levels of PCBs were found at approximately 40 ppm (Callinan, 1995).

In 1992, the USGS sampled and tested bottom sediments at the mouths of 16 tributaries, and bed sediments within the streams, for PCBs. An analysis of patterns of the different types of PCBs (called "congeners") from different tributaries to distinguish sources of these toxic substances is underway. In 1994-1995, VT DEC detected PAHs in sediments from urbanized tributaries; no PCBs were detected.

Air

New York State's Toxics Air Monitoring Network has measured volatile organic compounds (VOCs) in air samples from across New York State since 1990. This network operates a monitoring station at Willsboro Bay on Lake Champlain. For all compounds monitored at this station except benzene, annual average levels fall within state guidelines. Benzene levels are above state guidelines at all stations in New York State, indicating a widespread source of this pollutant (most likely from automobile emissions) (NYSDEC, 1993).

Fate and Effects of Toxic Substances

The fate and effects of contaminants in Lake Champlain depend on several factors, including the biochemical characteristics of persistence and ability to bioaccumulate and biomagnify, and the physical processes of the Lake and its watershed. Most persistent toxic substances (such as metals and PCBs) are attached to suspended particles which settle to the bottom and accumulate in sediments, often near their source. While hydrodynamic processes in Lake Champlain may transport these pollutants to other areas, the greatest concentrations are often found in near-shore areas where human activity and recreation are common.

Human Health Effects

Although contaminant levels in the water column are generally very low, they can be much higher in fish because of biomagnification through the food web. High concentrations of toxic substances in fish can make them unsuitable for humans and other organisms to eat because of the threat of adverse health effects (see Human Health Section). As detailed above, samples of fish from Lake Champlain are analyzed for a variety of trace metals and organic compounds.

The New York State Department of Health advises that people should eat no more than one meal per week of freshwater fish, and no more than one meal per month of lake trout (over 25 inches) and walleye (over 19 inches) caught in Lake Champlain. Women of child-bearing age and children under 15 should not eat any fish from Lake Champlain. New York State's advisory also recommends eating no more than one meal per month of American eel, brown bullhead, and yellow perch caught in Cumberland Bay (NYSDOH, 1995).

The Vermont Department of Health advises that people should eat not more than one meal per month of walleye, three meals per month of lake trout (over 25 inches), and six meals per month of all other fish caught in Vermont state waters. Women of child-bearing age and children under 6 should not eat any walleye, limit consumption of lake trout to one meal per month, and limit consumption of all other fish caught in Vermont state waters to two meals per month. The

Vermont advisory for lake trout in Lake Champlain is more restrictive. Adults should limit their consumption of lake trout (over 25 inches) caught in Lake Champlain to one meal per month, and women of childbearing age and children under 15 should not eat any lake trout from Lake Champlain.

Ecosystem Effects

Toxic effects on living organisms and communities are just beginning to be studied in Lake Champlain. In the Great Lakes, chemical contamination is linked to increased wildlife and fish mortality, and numerous physical and physiological abnormalities. Wildlife species that live on fish and water from the Great Lakes are known to experience reproductive and other problems from exposure to toxic chemicals (Environment Canada, 1991). While we have yet to see such severe effects in Lake Champlain, the possibility of effects resulting from exposure to low levels of toxic substances on other similar systems helps underscore the importance of protecting this ecosystem by reducing or eliminating sources of pollution wherever possible. Toxicity tests using water extracted from Lake bottom sediments show toxicity of sediment pore water from Inner and Outer Malletts Bay to the zooplankton *Ceriodaphnia*; limited chronic effects of sediment pore water from Cumberland Bay; and toxicity of sediment pore water from a site near the Burlington wastewater treatment plant to *Ceriodaphnia* (McIntosh, ed., 1994).

Results from a lab experiment to test whether PCBs in contaminated sediments can enter the Lake's food web indicate that Lake bottom sediments may be a significant source of this pollutant. *Mysis*, a small freshwater shrimp and a key food source for forage fish, ingested and bioaccumulated PCBs to higher levels than specimens not allowed contact with the same sediments (McIntosh, ed., 1994).

In another study of effects, changes in the cell structure of organs and tissues were evaluated in fish taken from areas in the Lake with contaminated sediments, and from uncontaminated or "reference" sites. Differences between fishes from contaminated and reference sites include external lesions around the fishes' mouths and barbels, altered immune systems, enlarged livers, and cellular changes caused by physiological stresses potentially associated with exposure to contaminants, or other factors (Blazer et. al., 1994).

Toxics of Concern and Where they are Located in Lake Champlain

List of Toxic Substances of Concern

The Lake Champlain Basin Program has reviewed the substances found to date in Lake Champlain and proposes to rank them based on the extent and levels at which they are found and the risk that they may pose to human health and that of the ecosystem. This set of priorities will be used to: 1) direct further research on presence and effects; 2) serve as a focus for source identification efforts; and 3) direct management efforts, including source reduction, treatment and remediation.

Table 8 below lists these toxic substances in order of priority based on their occurrence (found lake-wide or in localized areas), concentration compared to standards or guidelines, toxicity, persistence, ability to bioaccumulate, and presence in regulated waste discharges within Lake Champlain's watershed.

Table 8. Toxic Substances of Concern Found in the Lake's Biota, Sediment and Water

Priority	Toxic Substance	Criteria for Selection
Group 1	PCBs, mercury[1]	Persistent contaminants found Lake-wide (in either sediment, water or fish) at levels above standards indicating potential risk to human health, wildlife, or aquatic biota. These are highest priority for management action.
Group 2	Arsenic, cadmium, chromium, dioxins/furans, lead, nickel, PAHs, silver, zinc[2]	Persistent contaminants found in localized areas (in either sediment, water or fish) at levels above standards or guidelines indicating potential risk to human health, wildlife, or aquatic biota. These are next highest priority for management action.
Group 3	Ammonia, persistent chlorinated pesticides, phthalates, chlorinated phenols, chlorine, copper	Contaminants that are found above background levels in localized areas of the Lake, but below appropriate standards or guidelines.
Group 4	e.g., VOCs such as benzene, acetone, pesticides such as atrazine and alachlor, strong acids and bases, other potential pollutants such as fluoride	Contaminants known to be used or known to occur in the Lake Champlain Basin environment.

[1]Based on FDA standards

[2]Based on a variety of guidelines (NOAA, Ontario, EPA) regarding toxics in sediments

Groups 1 and 2 toxic substances merit highest priority for management action because they are found in Lake Champlain sediment, water or biota at levels above appropriate standards or guidelines, indicating potential human health or ecosystem risks. Appropriate standards and guidelines include: VT and NY Water Quality Standards, Federal and State drinking water standards, Federal and state health guidelines regarding the consumption of water and aquatic organisms, Federal (USEPA, NOAA) and Provincial (Ontario) guidelines regarding toxics in sediments. Group 1 substances (PCBs and mercury) rank higher because they are found lake-wide, and are known to biomagnify in the food web, while Group 2 substances are presently known to occur in relatively localized areas such as bays, or at the mouths of tributaries to the Lake. Toxic substances in Groups 3 and 4 are considered "of potential concern" because, at current levels, they do not pose a known risk to human health or the environment based upon existing standards, but they are known to have detrimental effects in other systems where chemical concentrations are greater. These substances should be monitored more extensively and their effects studied further.

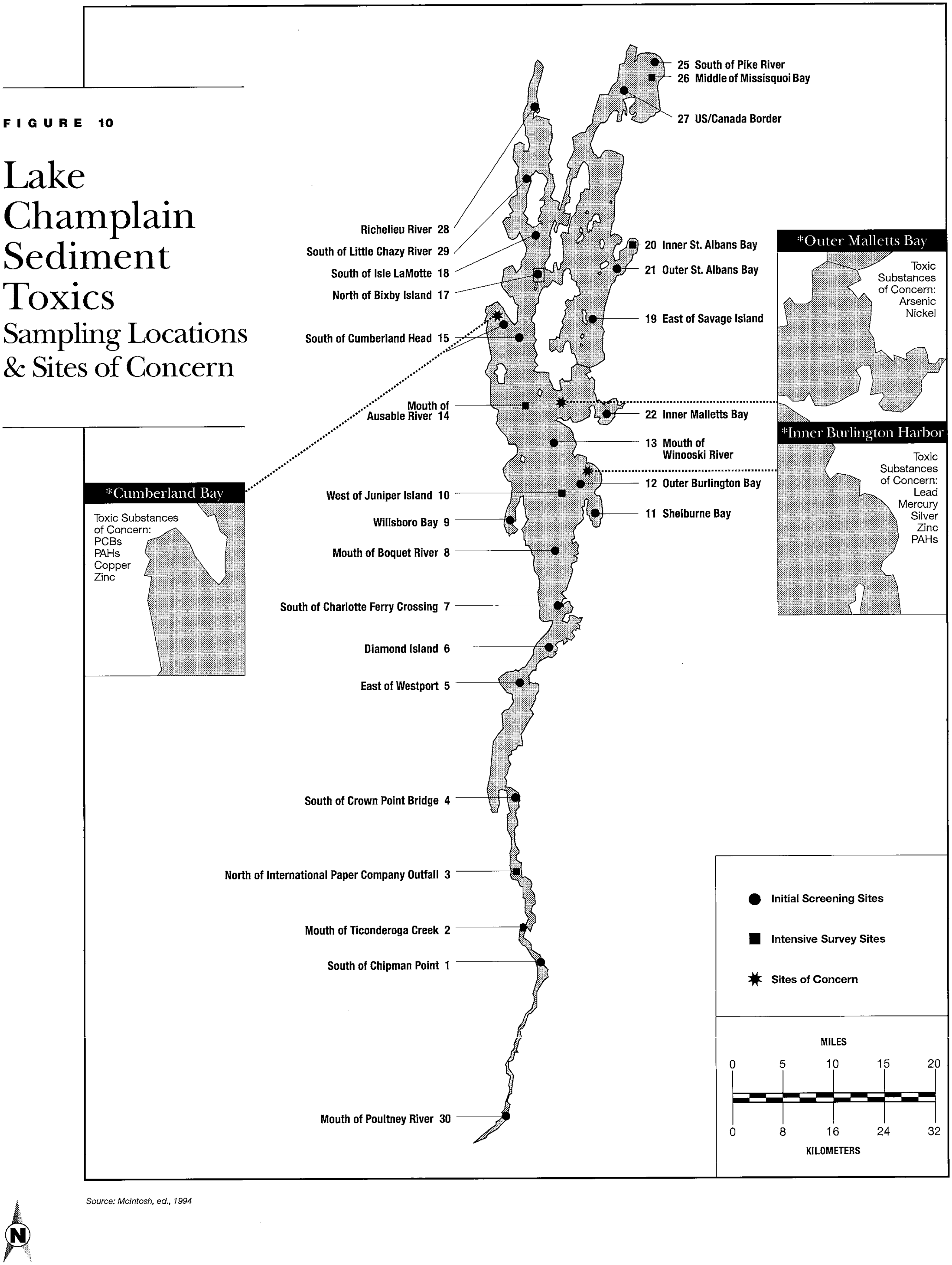
Sites of Concern in Lake Champlain

Fortunately, most toxic substances found to date in the Lake occur at levels that do not pose a known threat to human health. However, there are a few areas in the Lake where toxic substances are found in higher concentrations, or where several toxic substances are found together. The Sediment Toxics Assessment Program has identified three "sites of concern" with respect to toxic substances in Lake Champlain: Inner Burlington Harbor, Cumberland Bay, and Outer Malletts Bay (McIntosh, ed., 1994). Figure 10 illustrates all of the sediment sampling locations, sites targeted for more intensive study, and these three sites of special concern regarding toxic substances in Lake Champlain sediment. The toxic substances of concern at each

FIGURE 10

Lake Champlain Sediment Toxics

Sampling Locations & Sites of Concern



Source: McIntosh, ed., 1994

location are also listed in Figure 10. More intensive study of these sites is underway.

Results of these and other studies allow managers to geographically target toxic reduction and prevention actions to those areas where there are known problems, or to where future problems can be prevented. While it is understood that the three sites identified above may not be the only "sites of concern" because of contamination by toxic substances, they represent three areas where accelerated action to reduce and prevent contamination by toxic substances should begin.

Where are these Toxic Substances Coming From?

Both New York and Vermont have recently accelerated efforts to locate and control sources of toxic pollution within the Lake Champlain Basin, particularly for substances of concern or potential concern. A preliminary summary of the results of these efforts for both point and nonpoint sources of toxic pollution in the U.S. portion of the Basin is presented below.

Potential Point Sources of Toxics

Point sources are most often industries and municipalities that discharge wastewater to streams or other surface waters through pipes or "conveyances." Over the past 20 years, most state and federal pollution control efforts have focused on ensuring that these wastes are treated to remove both conventional and toxic pollution.

Municipal Sewage Treatment Plants

There are 75 publicly-owned treatment works (POTWs), or sewage treatment plants, permitted to discharge a total of approximately 78 million gallons per day of treated municipal wastes within the Lake Champlain Basin. Thirty industries discharge industrial wastes into these POTWs. In some cases, these wastes include toxic substances or other pollutants requiring "pre-treatment" prior to discharge into public sewers. Sampling of sludge from New York's POTWs as well as sediment from selected sites was completed to further locate sources of toxic substances (Callinan et al., 1995). Vermont screened 21 POTWs for priority pollutant metals and organics, and conducted more intensive sampling, including Whole Effluent Toxicity and ammonia tests, at the 12 POTWs most likely to discharge toxic substances. The limited toxicity effects measured appear to be more related to elevated ammonia concentrations than metals or organics. Metals and volatile organic compounds were detected in some discharges, but generally at concentrations below those expected to cause or contribute to violations of water quality standards (Quackenbush, 1993). In 1993, VT DEC investigated the influence of Significant Industrial Dischargers on the effluent characteristics of the POTW to which they discharged. Results suggest the these industrial inputs of POTWs have negligible effects on the toxic characteristics of the final POTW effluent. In 1995, VT DEC analyzed sludge samples from 32 POTWs in the Lake Champlain Basin for all priority pollutants. Data are currently being analyzed, but preliminary analysis indicates that no PCBs were detected in any sludges (Burnham, personal communication).

Industries

Fifteen industrial facilities in the Basin are permitted to discharge a total of approximately 47 million gallons per day of treated process wastes. An additional 13 industrial facilities discharge untreated non-process wastes, such as non-contact cooling water. Major industrial facilities in Vermont with toxic limitations in their National Pollutant Discharge Elimination System

(NPDES) discharge permits are IBM and Rock-Tenn Corp. Twelve facilities in New York have some toxics limits or toxicity testing requirements in their permits. These are: Atlantic Fuels, Altona Correctional Facility, Plattsburgh Terminal Tank Farm, Champlain Sewage Treatment Plant, 11-87 Truck Maintenance Facility, D&N Grocery Site, Gonyo's Store Site, 3-J Fuels Inc., Plattsburgh Water Pollution Control Plant, NYSEG Plattsburgh Coal Tar Site, Cadyville Gulf Station remediation, and International Paper Co. (Callinan et. al., 1995). Discharge and material use data provided by these industries in Vermont and New York suggest that they do not contribute large amounts of Group 1 or 2 toxic substances of concern to Lake Champlain (Burnham, personal communication; Callinan, et. al., 1995).

Potential Nonpoint Sources of Toxics

There are a variety of nonpoint, or diffuse, sources of toxic substances within the Lake Champlain Basin. In most cases, few data concerning their relative magnitude or location are available, making these sources much more difficult to evaluate.

Stormwater/Urban Runoff

Stormwater runoff from urbanized areas can carry significant amounts of contaminants to surface waters. Typical toxic pollutants include used motor oil, pesticides, fertilizers, road de-icing chemicals, and trace metals. There are more than 500 permitted stormwater discharges in the Vermont portion of the Basin, concentrated primarily in the urban centers of western Chittenden County, Rutland, St. Albans and Barre/Montpelier. There are known environmental impacts in the small tributary streams in the Burlington area that carry many of these stormwater discharges to the Lake, but the role of toxic substances in these effects is not well understood (Burnham, personal communication).

To understand the magnitude and impacts of urban runoff, Vermont and New York are currently undertaking a cooperative study with the Cities of Burlington, South Burlington, and Plattsburgh to screen urban watersheds for sources of persistent toxic substances to Lake Champlain. Initial results of this work are presented above (under the sub-section: Levels of Toxic Trace Metals); final results should be available in 1996.

Combined Sewer Overflows

In 1990, there were 57 combined sewer overflow (CSO) structures in 14 communities in the Vermont portion of the Lake Champlain Basin, and as of 1995, 16 such structures in the New York portion of the Basin, mostly in Plattsburgh. Elevated levels of toxic contaminants of concern have been measured in CSO discharges in Vermont, although whole effluent toxicity testing showed no acutely toxic effects associated with those elevated levels. Vermont DEC's 1990 Combined Sewer Overflow Policy is being implemented, and to date, thirty-two (56%) of the 57 discharges have been eliminated, eighteen (32%) other eliminations are currently under construction, and the remaining discharges are in the planning stages of elimination. Plattsburgh has inventoried and assessed its CSOs in compliance with the NYS Combined Sewer Overflow Control Strategy, and all are operating in accordance with special conditions specified by SPDES (State Pollutant Discharge Elimination System) permit.

Agriculture/Forestry

Agriculture relies more heavily on pesticides for crop production than does forestry within the Basin. By far the largest use of pesticides in agriculture is for the production of silage corn. In the Vermont portion of the Basin in 1991, a little more than 182,000 pounds of pesticide- active ingredient were applied by commercial applicators to crop land. Most of this was herbicide. This is much higher than the amount of pesticides used on small fruits and vegetables, Christmas trees or apples (Benedict, personal communication). Still, while it is believed that these herbicides may affect local populations of organisms within individual stream segments, they are likely having little impact on the aquatic biota of the Lake itself. Prior to the mid 1970s, agriculture and forestry managers relied on chlorinated pesticides and several inorganic substances for pest management. Some of these persistent materials such as mercury and arsenic-bearing compounds and PCBs may still be released from soils where these compounds were used, and find their way to Lake Champlain in quantities of potential significance (Benedict, personal communication).

<u>Hazardous Waste Sites</u>

Since 1985, over 400 sites in Vermont have been identified, investigated, and managed by VT DEC or USEPA as hazardous waste sites. The identified sites range in contamination severity from a single seep located adjacent to a surface water body to the multi-media/contaminant Pine Street Barge Canal Superfund site in Burlington. The majority of sites are associated with underground petroleum storage tanks; fifteen sites are associated with inactive landfills; the remainder are associated primarily with inactive industrial waste disposal activities. Monitoring data for all actively managed hazardous waste sites in Vermont suggest that they are not significant contributors of toxic substances of concern to Lake Champlain (VT ANR, 1993).

There are 13 hazardous waste sites in the New York portion of the Basin, including the Cumberland Bay-Wilcox Dock site in Plattsburgh. Two of these sites have been fully remediated, with the remaining sites in various stages of investigation and/or remediation (Callinan, et. al., 1995).

Two Basin sites are on USEPA's National Priorities List for hazardous waste clean-up: Pine Street Barge Canal in Burlington, and the Plattsburgh Air Force Base. The Pine Street Barge Canal site is undergoing study to determine clean-up options with funding from the USEPA Superfund program. Forty individual sites have been identified at the Plattsburgh Air Force Base to date. So far only five of the sites are considered "significant," and three have already been cleaned up, with funding from the Department of Defense's Defense Environmental Restoration Account.

<u>Landfills</u>

There are a total of 63 operating or closed landfills in the Vermont portion of the Basin. Of the total, 6 or about 9%, are active. Two of those active landfills are lined and collect and treat leachate. Of the 57 landfills that have ceased activity and have completed closure, 14 or about 20% of the total sites, are being managed as hazardous waste sites. Monitoring data to date suggest that these landfills are not significant contributors of toxic substances of concern to Lake Champlain (VT ANR, 1993). There are currently six operating landfills in the New York portion of the Basin. Two accept only construction and demolition debris, and another two are primarily for sludge from paper mills. One of the sludge landfills is being relocated to an area outside of the Basin. There are two municipally operated landfills within the Basin, one in Clinton County, NY and one in Essex County, NY. Town landfills in Essex County, NY were closed in 1992 and replaced by the County landfill. An upgraded landfill with liners and leachate collection is being constructed in Clinton County.

Spills

Spills from petroleum storage facilities, oil barges and fueling stations are other potential sources of toxic substances to Lake Champlain.

In-place Contaminants

The role of in-place contaminants (toxic substances found in lake bottom sediments) in areas like Cumberland Bay and Inner Burlington Harbor (see previous discussion on toxic metals and organics in sediments) as sources of toxics to the aquatic environment and risks they pose are poorly understood, although current research and monitoring activities are aimed at clarifying potential risks. An LCBP sponsored study of the effects of toxic substances in Inner Burlington Harbor is scheduled for completion in 1997. Results of LCBP research on the transport of PCBs in Cumberland Bay should be available by late 1996.

Atmospheric Sources

There has been little data collection on atmospheric sources of toxic pollutants, or the movement of pollutants such as PCBs and arsenic from the atmosphere directly to the Lake or through the watershed. In the Great Lakes, recent studies have shown that a large percentage of certain chemical contaminants have an atmospheric source; for instance, as much as 90% of the direct inputs of PCB and lead into Lake Superior may come from the atmosphere (IJC, 1988). Airborne toxics in the Champlain Basin exhibit influence from local, regional and distant sources. While emissions of toxic air pollutants within the Basin are considered low relative to other areas because of the low number of industries and utilities, the Basin is subjected to relatively high levels of air pollutants carried from regions to the south, west and north. Car and truck emissions, and other residential energy consumption activities such as wood burning, are local sources of air pollution (VT ANR, 1993).

Data from Vermont reveal elevated levels of toxic substances of concern, including arsenic, cadmium, chromium, and nickel, in air samples. Elevated levels of some organics, including PAHs, dioxin, and others associated with fossil fuel burning, have been detected at some sites in Vermont.

Canadian smelters (most notably the Noranda smelter on the Quebec/Ontario border) appear to be a dominant historical and continuing source of arsenic in the air and deposited in the Basin. Midwestern utilities are also significant arsenic sources, though less prominent than the smelters. Although both source types are well beyond local jurisdictional control, there may be potential for future reductions, given the relatively small number of large sources, and current (acid rain) regulatory programs in both countries.

While mercury sources are much less certain than arsenic, similar source regions (Canadian smelters and midwestern coal burning) appear to be associated with both arsenic and mercury found in the Champlain Basin. Local sources of arsenic appear to be relatively insignificant, but data on mercury is insufficient to rule out the possibility of significant local atmospheric mercury sources in the Basin.

Airborne nickel and vanadium appear to be associated with residual oil combustion sources, including a significant contribution from multiple local sources within or near to the Champlain Basin. The source of zinc in the Burlington urban area is significant, but unknown at this time.

Transportation-related emissions (including automotive exhaust, evaporative engine running losses, evaporative emissions from gasoline refueling and spillage, and re-suspension of contaminated roadside soils) represent the largest local source of toxic air emissions and concentrations in the Champlain Basin. Ambient air concentrations of toxic organic compounds from transportation sources exhibit substantially higher ambient concentrations in high-traffic lake shore urban areas like Burlington than in lower traffic, rural sites elsewhere in the Basin.

Hazardous, municipal and medical waste incinerators are another likely source of toxic substances of concern to the atmosphere, particularly of dioxin/furans and mercury. Only one medical waste incinerator, in Colchester, VT, operates within the Basin. No hazardous or municipal waste incinerators are located within the Basin, although there is a municipal waste incinerator in Hudson Falls, NY, just outside the Basin boundaries.

Other Sources

In the summer of 1995, the U.S. Coast Guard disclosed that it had discarded lead-acid batteries in eleven locations in Lake Champlain over a period of several decades. The agency has since removed the batteries and eliminated this potential source of toxic contaminants.

Current Approach for Managing Toxic Substances

There are many federal, state, regional and local agencies responsible for managing toxic substances and protecting the public and other living resources from adverse effects of these pollutants in the Lake Champlain Basin. These efforts are briefly outlined below.

Federal Level

The U.S. Environmental Protection Agency (USEPA) administers six federal laws to control toxic substances: the Resource Conservation and Recovery Act (RCRA), the Toxic Substances Control Act (TSCA), the Clean Water Act (CWA), the Clean Air Act (CAA), the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or "Superfund"). New York and Vermont have been delegated authority to oversee implementation of RCRA, CAA, and CWA. TSCA regulates the generation, use and disposal of toxic chemicals through a reporting and recordkeeping system and through evaluation of environmental and human health hazards posed by the toxicants. FIFRA requires registration and labelling of pesticides. CERCLA established the Superfund program, which requires reporting and clean-up of hazardous waste sites, allows USEPA to pursue compensation for environmental damage, and authorizes USEPA to clean up hazardous waste spills. There is one Superfund site in the Basin - the Pine Street Barge Canal in Burlington (sites at the Plattsburgh Air Force Base are not called "Superfund sites" because they are under jurisdiction of the Department of Defense). USEPA has appointed a task force to recommend a course of action for the clean-up of this site.

State Level

The States of New York and Vermont regulate point and nonpoint sources of water-borne pollution primarily under the Clean Water Act and its amendments. Each State conducts planning, permitting and enforcement activities with regard to environmental discharges of pollutants. Programs administered by the states include the National Pollutant Discharge Elimination System (NPDES) program (called "State Pollutant Discharge Elimination System" or "SPDES" in New York), which regulates municipal and industrial wastewater and stormwater discharges, and the Nonpoint Source Program (319 Program), which develops strategies to eliminate pollution from diffuse sources. The states also establish water quality standards and objectives for toxic pollutants for which USEPA has published water quality criteria.

Beginning in the early 1970s, the NYSDEC instituted the Water Quality Surveillance Network (WQSN) and the Toxics Surveillance Network (TSN) sampling programs. The WQSN sampled New York waters for conventional pollutants (low dissolved oxygen, suspended solids, etc.) until 1986. The TSN sampled waters for toxic substances, including several tributaries to Lake Champlain (Saranac, Boquet, Lachute and Richelieu Rivers). This program is still underway, although it has been scaled back to include routine sampling at only the Richelieu location, as the Rotating Intensive Basin Studies (RIBS) program has taken over most of these screening activities. Sampling for toxic substances in wastewater discharges was initiated in 1984 under the SPDES Enhancement Program. New York has recently initiated a new program for reducing toxics, the Multimedia Program for Pollution Prevention. This program, when fully implemented, will integrate environmental protection programs across all "media" - air, water, and land - to correct the problem with single media programs where pollution removed from water is transferred to the air or land, or vice versa.

In addition to their point source pollution control program, Vermont has initiated several efforts to control toxic water pollution. The Toxic Discharge Control Strategy was designed to identify, assess and control point source discharges of toxic pollutants through aggressive monitoring for priority pollutants and whole effluent toxicity. These data are used to support Vermont's water quality-based NPDES permitting and enforcement efforts. In 1990, Vermont committed to a combined sewer overflow (CSO) control policy to eliminate or treat waste from overflowing combined sanitary and storm sewers. At this time, over half the municipalities with combined sewers have eliminated CSO structures or otherwise corrected the environmental risks related to CSO discharge event, and the remaining communities have established schedules for CSO elimination.

Vermont directly monitors the health of aquatic organisms in streams and lakes through the Ambient Biological Monitoring Program. This program collects biological data using standardized protocols, from a total of 383 sites on 151 rivers and streams within the Lake Champlain Basin. Vermont also provides on-site technical assistance on proper waste treatment to plant operators, and promotes education about the importance of wastewater treatment to middle school students. Vermont has recently reorganized staff in the Department of Environmental Conservation to create the Environmental Assistance Division, responsible for promoting conservation, recycling and waste reduction, providing technical assistance to the regulated community, and training other state staff on pollution prevention.

Both Vermont and New York have authority to implement the RCRA program, which governs the generation, transport and disposal of hazardous solid wastes on land or water. Hazardous wastes must be disposed of at RCRA-certified facilities. Vermont and New York also have authority to implement the Clean Air Act through State Implementation Plans (SIP). National Ambient Air Quality Standards are mandated at the federal level, but states may determine the best way to achieve those standards.

The State of Vermont conducts a regulatory program for sources of some 288 Hazardous Air Contaminants (carcinogens, long-term chronic systemic toxicants, or short-term irritants). This program establishes Hazard Ambient Air Standards (HAAS) for each of these contaminants, and imposes the following requirements on new and existing sources (excluding fossil fuel combustion) emitting any hazardous air contaminant in excess of a pre-determined "action level" for each pollutant: 1) quantify and report annual emissions of all Hazardous Air Pollutant Emissions to VT DEC; 2) apply controls sufficient to achieve the Hazardous Most Stringent Emission Rate; 3) conduct an Air Quality Impact Evaluation to assure that combined emissions from the source (in combination with "background" emissions from all existing sources) will not exceed Vermont's HAAS standards.

As part of the 1988 Memorandum of Understanding on Environmental Management of Lake Champlain between New York, Vermont and Quebec, an emergency spill response procedure was established for spills affecting Lake Champlain and its tributaries. This procedure was designed to provide immediate notification and coordinated response to oil and/or hazardous spills or discharges in the Lake.

The States of New York and Vermont have established a Permit Exchange Agreement in accordance with the 1988 Memorandum of Understanding. This agreement keeps both States informed of permitted projects in the Champlain Basin and provides opportunities for each of the States and its citizens to participate in the permit comment and review process for projects that may affect the other State. Potential toxics sources subject to this agreement include: 1) wastewater treatment plants discharging directly to the Lake or below the first dam on tributaries which discharge 100,000 gpd and/or priority pollutants subject to effluent limits; 2) construction or expansion of commercial marinas involving 20 or more berthing slips or moorings; 3) disturbance of jurisdictional wetlands contiguous to the Lake (including all chemical weed control and fish management projects); 4) solid or hazardous waste disposal facilities within 1 mile of the shoreline; and 5) air pollution sources within 50 miles of each state border that should annually emit 50 tons of sulfur dioxide, nitrogen oxides, carbon monoxide, particulate matter or volatile organic compounds, 5 tons of lead, and/or are subject to Title V of the 1990 Clean Air Act Amendments.

Vermont also has a Household Hazardous Product Shelf Labeling Program, begun in retail stores in 1991. The primary goal of the program is to promote toxics use reduction, whereby consumers will choose to purchase products with fewer and less hazardous ingredients. Following toxicity reduction, the program emphasizes toxicity diversion, where household hazardous wastes are diverted from the municipal solid waste stream and collected for safer disposal.

The New York and Vermont Legislatures enacted prohibitions on the sale of certain dry cell batteries that contain mercury and reductions of mercury levels in other battery types. New York requires that nickel cadmium and small lead acid batteries be labelled regarding their chemical content and be packaged so that they are easily removed from the product (NYSDEC 1992). Vermont requires that manufacturers of nickel-cadmium batteries provide collection systems for commercial use of these batteries. Vermont also has a law that limits the amount of lead, cadmium, mercury and chromium allowed in packaging sold in the state.

NYSDEC has initiated efforts to remediate PCB contamination in Cumberland Bay, one of three Sites of Concern in Lake Champlain. As of May, 1995, approximately 185.5 tons of contaminated wood chips had been removed from the Cumberland Bay beaches and disposed of in a chemical waste disposal facility. The beaches were inspected weekly throughout the summer and fall to remove any additional wood chips that washed ashore. Several remedial actions are currently being considered for the site, and buoy markers have been installed in the Bay to indicate the edges of the sludge bed. A remediation alternative that will most likely remove the sludge bed will be selected in 1996 (NYSDEC, 1995).

Municipal, Local Level and Other Efforts
The City of Burlington operates an Environmental Depot to collect and appropriately dispose of household hazardous waste. In its first year of operation, 16 percent of households in the city used this facility. Most solid waste districts in the Vermont portion of the Basin sponsor hazardous waste collections. Clinton County, NY also periodically sponsors household hazardous waste collection. Other toxic reduction efforts are underway in local areas, some spearheaded by not-for-profit, citizen-based environmental groups. The Lake Champlain Committee (LCC) is working with the City of Burlington and UVM to develop a comprehensive program to reduce and eventually eliminate discharges of toxic substances to Lake Champlain and the Winooski River from Burlington. The Toxic Substance Reduction and Elimination Plan includes steps to identify toxic substances entering the Lake and tributaries from Burlington, identify their sources, and an aggressive plan to reduce them through public education. The LCC is also helping other communities in the Basin reduce their discharges of toxic substances by identifying sources of metals found in sewage sludge, and has strong, on-going public education efforts to teach people about alternatives to using toxic household and lawn care products.

Issues

The following section is a summary of some of the major technical and policy issues involved with selecting the best and most cost-effective actions to reduce toxic substances in the Lake Champlain Basin.

Defining the Scope of this Toxics Reduction Effort
While it is the intent of the Lake Champlain Basin Program to address toxic substance pollution in a comprehensive manner by applying the principles of watershed management, resource limitations require that the first round of research focus on understanding how toxic substances are affecting the Lake itself. Further work is needed to define the extent of problems related to toxic pollution in tributary rivers and streams, other waterbodies within the Basin, and in the air. This effort also does not address the presence of toxic substances in groundwater, nor potential risks from that source.

There is concern that this "lake first" approach may compromise our ability to understand and reduce diffuse sources throughout the watershed, particularly upstream sources whose impacts may be localized (e.g. impacts to stream biota from runoff carrying sediments and pesticides). Given that source identification research has turned up few clear links between levels of toxic substances in the Lake and active or more easily "controllable" point sources, it will be necessary to improve upon existing efforts to track down sources and develop strategies for reducing nonpoint source pollution, while more aggressively reducing point sources and remediating in-place sources of contaminants throughout the Basin.

Focusing Efforts on Sites of Concern and Substances of Concern

Early research results reveal that, while several toxic substances are found in the Lake Champlain ecosystem, most levels in sediment and water that may pose a threat are limited to certain areas, including Cumberland Bay, Inner Burlington Harbor, and Outer Malletts Bay. Locating these Sites of Concern allows managers to focus management efforts on selected "source" watersheds and limited areas. Because there are limited resources to study and monitor toxic substances, some assessments have focused on areas where contamination is most likely to be found, i.e., near-shore sediments near urban or industrial areas. It is possible that some Sites of Concern were missed in early screening surveys. Therefore, it may be premature to limit management or clean-up actions to these areas. The major issue is how to divide resources between restoration of areas already identified as having problems, source identification, and continued screening for additional areas and effects.

There are also questions about limiting reduction efforts to the list of Toxic Substances of Concern. For instance, which substances should be included on this list, given uncertainties about the efficacy of existing standards and our poor understanding of environmental effects? Another issue is how to resolve problems with the current chemical-by-chemical approach to managing pollution. This approach fails to account for cumulative or combined impacts from several substances present at levels below existing standards, and does not protect the Lake's ecosystem from the introduction of new -- and possibly more toxic -- unregulated substances. These issues argue for expanding the overall reduction strategy to include toxic substances even if they are not currently exceeding human health standards or causing measurable impacts within the Basin, in addition to moving towards a monitoring and assessment approach that strives to measure real effects through biological indicators.

Historical Sources, In-place Toxics

Even if all sources of toxic substances were eliminated tomorrow, it would take a very long time to rid the ecosystem of these pollutants. Toxic substances accumulate in lake bottom sediments, where they remain for long periods if undisturbed. They may be resuspended, consumed, or directly absorbed into organisms, and enter the food web. Scientists do not know much about these interactions, or risks to humans, wildlife or aquatic organisms from these in-place sources. At some locations, very high concentrations of pollutants are present at deeper layers, raising a concern about disturbing upper sediments and possibly resuspending more polluted materials. Is it better to leave these pockets of highly contaminated sediments in place? What about dredging activities or other activities that could disturb sediments in areas like Cumberland Bay, the mouth of the Lachute River, and Inner Burlington Harbor?

Another issue with contaminated sediments is that there presently are no federal standards against which to compare the contamination of Lake Champlain sediments. There is an on-going effort by USEPA to develop technically sound sediment quality criteria, with five criteria currently proposed for toxic organic substances. At this time, guidelines set by NOAA and others are used to evaluate levels. Some states (including New York) and provinces are taking the lead in developing their own sediment quality criteria.

What Do We Know About PCBs and Mercury?

While there are localized concerns about a number of toxic substances, two specific contaminants, mercury and polychlorinated biphenyls (PCBs), are viewed as highest priority because of their relative toxicity and ability to bioaccumulate. Several questions remain concerning the sources of mercury to the Basin, and the contribution of each source to the levels found in the air, water, and sediment. For example, how important is atmospheric deposition of mercury in the Basin? What processes govern the conversion of inorganic mercury to the more biologically available and toxic form of methylmercury? These information gaps on sources and transport of mercury pose significant questions with respect to future management efforts.

Similar questions remain with respect to PCBs. These include identification of sources and their relative significance, active versus historic sources, how these substances are processed and transported through the environment, evaluation of remedial actions and ramifications, and questions about risks. For example, while Cumberland Bay has been identified as having high levels of PCBs, researchers do not know if this is a primary source for the PCBs found in Lake fish outside of Cumberland Bay. Decisions must be made concerning how best to fill these information gaps, how to coordinate this work, and what level of effort is justifiable and affordable.

Adopting a Strategy to Prevent Pollution Rather Than Manage It

The numerous pathways by which toxic substances enter, accumulate, and move in aquatic ecosystems make these substances difficult to regulate. In general, it is easier to regulate point source discharges than nonpoint sources because they are usually visible, discrete discharges from pipes that can be tested easily, and they are generated by known industrial processes. Historically, efforts to reduce the input of pollutants to the Lake have focused on "end-of-pipe" treatment of these point source discharges, often simply removing toxic substances from the water and transferring them to the air or landfills. Given the environmental problems and great expense associated with pollution treatment, storage, transportation and disposal, efforts to prevent the creation of pollution are gaining increasing attention. Pollution prevention techniques (also called "source reduction") represent a promising alternative for achieving reductions at the source of the problem, and eventually eliminating toxic substances from Lake Champlain. Both Vermont and New York have initiated new programs that embrace this concept; however, these programs are not yet fully integrated into the existing pollution control programs.

There is also a need to provide better information to the public and decision-makers at all levels of government on toxic substances, where the health risks are greatest, and how we can change our individual activities to prevent toxic pollution.

Setting Appropriate Goals and Standards

Despite the successes of current programs to reduce toxic substances in the environment, some problems, such as consumption advisories because of PCBs and mercury in fish, continue to defy solution. These and other substances that are persistent and tend to bioaccumulate to some degree exceed the capacity of the existing regulatory structure because: 1) existing programs were designed to deal primarily with "simpler" contaminants; 2) certain sources of these contaminants are unregulated; and 3) significant quantities of these substances have built up in the environment (in sediment, biota, etc.) and continue to cycle through the ecosystem.

Many of these issues are gaining attention in other areas of the country, including the Great Lakes, Chesapeake Bay, etc. Managers charged with solving pollution problems in the Great Lakes have adopted a general, long-term goal to "virtually eliminate" sources of certain high priority toxic substances in the Basin. They are currently considering options, ranging from removing sediments from highly contaminated areas to establishing battery collection programs, to deal with contamination from mercury. What can we learn from the Great Lakes approach to dealing with toxic substances? What are the challenges inherent in implementing a program to reduce or "virtually eliminate" sources of certain toxics in the Lake Champlain Basin? Are there non-regulatory, low-cost options for toxics reduction that would solve most of the problem? Solving these problems for the Lake Champlain Basin will require establishing firm and defensible toxic reduction goals, and implementation of mechanisms capable of attaining these goals. This will likely require an evolution of the existing regulatory structure to enable it to confront the challenges posed by persistent and bioaccumulating contaminants. The control of air emissions of mercury, for example, will require binational agreements which specify goals for reducing mercury emissions. Enforcement mechanisms would need to be put in place to assure compliance with the agreement.

The Need for Public Education

Most Basin residents use products that contain toxic substances that may be harmful to aquatic life, or otherwise damaging to the environment. Other human activities, such as driving automobiles, using lawn mowers, and applying pesticides to lawns and gardens, are sources of toxic substances to the Basin's air, water and land. While each person's contribution to the overall loading of toxic substances to the Lake may seem small, the cumulative amount may have substantial effects. Because it is not feasible to ban or remove all toxic substances from these products and activities, people need information about using "cleaner" alternatives. Residents and visitors to the Basin also have the right to the facts concerning the quality of water in the Lake, and any threats posed by toxic substances present in fish. For all these reasons, a strong commitment and coordinated efforts to educate the public about toxic substances in the Lake Champlain Basin are needed.

Limitations of Current Information on Sources and Effects

A number of critical unknowns about human and ecosystem health effects from toxic substances present in the Basin environment, including the risk to humans from eating contaminated fish, complicate decisions regarding the appropriate public policy response. Public awareness and understanding of fish consumption advisories must be improved, along with coordination of state and federal fish tissue monitoring programs. There is also a need to evaluate impacts of toxics on the Lake-wide ecosystem, and on Inner Burlington Harbor, Cumberland Bay, and Outer Malletts Bay. We also do not fully understand the potential health risks from agri-chemicals used in the Basin.

Major questions also remain concerning the sources of toxic substances within - and outside - the Basin. Current information suggests that regulated point source wastewater discharges are not the primary sources of PCBs and mercury in the Basin, the former having been virtually banned from discharges, and the latter limited to very low levels. Questions such as what percentage of a given substance comes from outside the Basin and what role in-place contaminated sediments play must also be answered. Development of some level of mass balance is a critical step in the management of toxic substances within the Basin. To regulate existing discharges further without first understanding the sources would likely prove both ineffective and inefficient.

Important information can be gained from other ecosystems, including the Great Lakes and the Chesapeake Bay, that have had the benefit of longer term monitoring and research efforts. The findings of other regional and national programs can help to identify emerging issues as well as potential solutions.

Study the Problem More, or Act on What We Know Now?

While significant work has been initiated to identify toxic substances in the water, sediments and living organisms in Lake Champlain, determine the sources of these contaminants, and study their effects on the viability of Lake-dependent populations, there are still many unknowns. Because these issues are so complex, and causes and effects are so difficult to define, managers often must make decisions about possible solutions to environmental problems before they have the complete picture. In some cases, in order to prevent human health risks in a responsible manner, they must use "best professional judgement" based on problems and experiences observed in other, similar environments. In the case of reducing risks from toxic substances, we need to balance the need for additional research with the imperative to act to reduce existing risks and prevent future ones.

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Protecting Human Health

Background

Daily, we are faced with a variety of voluntary risks (e.g., cigarette smoking or driving a car) and involuntary risks (e.g., breathing air of poor quality or being struck by lightning). Determining what is an acceptable level of voluntary risk is an individual decision based on knowledge of the risks. Many environmental regulatory actions are directed towards reducing involuntary risk from exposures to substances in air, water and food. Such actions involve determining what is an acceptable level of risk and limiting exposure below the level thought to be acceptable.

Acceptable levels of risk are difficult to determine and vary depending on the individual and the nature of the risk. In many cases, an excess lifetime risk of one-in-one million is considered the maximum level of acceptable risk, but levels as high as one-in-ten-thousand may be acceptable under certain conditions. Once a level of acceptable risk has been determined, then it may be one of the factors used to establish permits for industrial or municipal discharges into air or water, or to determine whether or not fish should be eaten or drinking water filtered.

This section focuses on potential health threats associated with poor water quality in Lake Champlain and is limited to assessing risks from drinking water, eating fish and wildlife, and swimming in the Lake. These threats come largely from exposure to toxic substances and/or pathogens in the environment. Known pathways of exposure include drinking tainted water, breathing air of poor quality, eating fish and wildlife which have accumulated toxic substances, or coming into direct bodily contact with contaminants, particularly pathogens. This section does not address ground water quality, or other surface water bodies in the Basin, air quality issues in the Basin, and it does not cover the numerous other threats that are common to many people within and outside of the Basin. A more complete examination of human health issues throughout the Basin will be completed over time, as resources permit.

Potential Threats to Human Health from Drinking Water

Approximately 188,000 people, or 32% of the Basin population, depend on the Lake for their drinking water. Almost all (about 98%) of these people obtain their water from public water supplies regulated by the states (Holmes and Associates, 1993).

The New York State Department of Health and the Vermont Department of Environmental Conservation (Water Supply Division) have primary responsibility for implementing the Safe Drinking Water Act (SDWA) within their states. Under SDWA programs, public water systems (those serving at least 25 people, or 15 connections, for at least 60 days per year) must monitor routinely for a wide array of contaminants, including microorganisms. Based on the 1986 amendments to the SDWA, additional monitoring requirements for inorganics, synthetic organics, volatile organics, radionuclides and disinfection-byproducts are being phased in. The states review this monitoring data and respond when the water's contaminant level is greater than the drinking water standard. These standards, called maximum contaminant levels (MCLs), are set by EPA at a level which minimizes public health risks. Of the eighty-three drinking water standards established at this time, Table 9 presents MCLs for toxic substances of concern in Lake Champlain. Ninety-nine public water systems withdraw water from the Lake: 73 in Vermont and 26 in New York. Since 1986, there have been 9 reported violations of these standards, all of these for coliform contamination in Vermont. All violations have either been corrected or are being managed with a boil water notice.

There is virtually no information available from either state regarding the quality of drinking water for the remaining approximately 4000 people that withdraw water directly from Lake Champlain. It is likely that this water has minimal or no treatment. Because public water systems drawing from the same source have had coliform contamination, it is possible that these individual water withdrawals are similarly contaminated.

The Vermont Agency of Natural Resources report *Environment 1991: Risks to Vermont and Vermonters* (known as the "Third Century Report") ranks drinking water at the tap as a moderate risk to Vermonters' quality of life. Although exposure to contaminants through drinking water poses a relatively low risk to human health, it is ranked higher in the report because of the very high value placed on having safe, clean water in Vermont. This ranking includes public and private water supplies from surface or ground water sources. The report recognizes that individuals obtaining water from a surface water supply are more likely to be exposed to pathogens and the chemical by-products of chlorination. To remove pathogens from any public drinking water supply, the "Surface Water Treatment Rule" of the SDWA will require filtration of surface water supplies unless the water source is well protected.

Potential Threats to Human Health from Toxic Substances

Research findings identify numerous toxic substances present in the Lake and bottom sediments (see section on Toxic Substances). Toxic substances found in the sediments of the Lake may be taken up by bottom feeding microorganisms and then accumulate within the fish that eat them. Because these persistent substances do not break down, they tend to "biomagnify" to higher levels at each step in the food chain. Mercury and polychlorinated biphenyls (PCBs), found lakewide in the sediment and biota, are the substances of primary concern because they have bioaccumulated to relatively high levels in some fish. The levels of these contaminants in certain species of large fish are above federal guidelines which indicate a potential risk to humans who eat them, and to wildlife or aquatic biota.

Mercury and PCBs pose different risks to human health. PCBs, which are difficult to eliminate and are stored in body fat, may not cause an immediate health problem. However, long-term exposure to PCBs is suspected of increasing the risk of cancer, and may cause developmental and growth problems in infants whose mothers ate contaminated fish. Mercury may affect the health of those consuming contaminated fish much sooner, damaging the nervous system and altering the ability to see, feel, taste and move. However, it is eliminated from the body over time and does not accumulate in body fat (Wisconsin Department of Natural Resources, 1991).

Arsenic, cadmium, chromium, lead, nickel, polycyclic aromatic hydrocarbons (PAHs), silver, and zinc, identified and discussed in the Toxic Substances section, comprise a second group of compounds found in Lake bottom sediment in localized areas. All of these substances occur at levels above the guidelines indicating a potential risk to human health, wildlife, or aquatic biota in Lake Champlain. Nickel, arsenic, chromium and cadmium are also present in the air at levels above protective guidelines.

Each of these "group 2" substances may pose a threat to human health. The toxicity of metals is generally a function of their chemical form and the route of exposure. While some metals are essential for life, others have no known biological function. Cadmium, chromium, nickel, silver and zinc are classified by the EPA as Class D substances, which means that there is inadequate evidence that they cause cancer in humans or animals. However, cadmium may damage the kidneys, and chromium may damage the liver and kidneys. Nickel has not been shown to be carcinogenic through oral exposure, but nickel compounds may cause nose and lung cancer when inhaled. Excessive absorption of silver causes a condition known as argyria, a skin discoloration. Zinc, an essential element in human nutrition, is toxic at levels only ten times above the Recommended Daily Allowance.

Arsenic is classified by USEPA as a human carcinogen (a Class A substance), which means there is sufficient evidence from epidemiological studies that it is a human carcinogen. Ingestion of high levels of arsenic causes an increased risk of skin cancer. Lead is classified by USEPA as a probable human carcinogen (Class B), which means that there is sufficient evidence from animal studies, but inadequate data on humans, to show carcinogenicity. Small children are particularly susceptible to lead poisoning because it may affect learning ability, hearing and growth. In adults, lead may cause high blood pressure and interfere with hearing.

PAHs are a class of diverse compounds formed during the incomplete combustion of organic matter (eg. fuel burning). They are found throughout the environment, and come from many sources. Animal studies have found that they are stored in the kidneys, liver and fat with some accumulation in the spleen, adrenals and ovaries. There is a great deal of variation in the carcinogenic potential of different types of PAHs.

Drinking water standards for these substances of concern (summarized in Table 9 below) are determined by the USEPA and must be met by all public water supplies serving the same population for more than six months of the year in order to protect public health. States can, and in some cases have, set standards that are more stringent than these federal standards. None of these standards for toxic substances have been violated.

Potential Threats from Fish Consumption

The FDA, under the authority of the Federal Food, Drug and Cosmetics Act (FFDCA), has the primary responsibility for ensuring the safety of the food sold in interstate commerce. The FDA also sets nationwide "action levels" or tolerances for contaminants found in a particular fish species. If fish tissue analysis indicates that levels of contaminants exceed these action levels in a significant number of fish, a fish advisory for that body of water is established, generally by a state agency.

Pollutant levels in the waters of Lake Champlain are generally low, and many fish species do not have specific advisories. However, some contaminants have been found to be higher in certain fish and wildlife because of the processes of bioaccumulation and biomagnification. Advisories have been issued against consumption of lake trout and walleye because levels of PCBs and mercury, respectively, exceed Food and Drug Administration (FDA) criteria.

Table 9. Drinking Water Standards for Toxic Substances of Concern

Mercury (inorganic)	0.002 mg/L
PCBs	0.0005 mg/L
PAHs - Polycyclic Aromatic Hydrocarbons	No drinking water standard.
Nickel	No drinking water standard. Lifetime health advisory[1] = 0.1 mg/L
Arsenic	0.05 mg/L
Silver	No drinking water standard. Lifetime health advisory = 0.1 mg/L
Cadmium	0.005 mg/L
Chromium	0.1 mg/L
Lead	To be measured at the tap using a treatment technique. Action level = 0.015 mg/L
Zinc	No drinking water standard. Lifetime health advisory = 2 mg/L

[1]Lifetime Health Advisory = The concentration of a chemical in drinking water that is not expected to cause any adverse non-carcinogenic effects over a lifetime of exposure, with a margin of safety.
(Source: USEPA. Drinking Water Regulations and Health Advisories, 1995)

Based on an FDA tolerance of 2 parts per million for PCBs and an action level of 1 part per million for mercury, the New York State Department of Health advises that an individual eat no more than one meal per week of freshwater fish, no more than one meal per month of large walleye (over 19 inches) or lake trout (over 25 inches) caught in Lake Champlain. Women of childbearing age and children under 15 are advised to not eat any fish from Lake Champlain. Additionally, the New York advisory recommends that consumption of American eel, brown bullhead and yellow perch from Cumberland Bay should be limited to no more than one meal per month (New York State Department of Health, 1995).

The Vermont Department of Health advises that people should eat not more than one meal per month of walleye, three meals per month of lake trout (over 25 inches), and six meals per month of all other fish caught in Vermont state waters. Women of child-bearing age and children under 6 are advised to not eat any walleye, limit consumption of lake trout to one meal per month, and limit consumption of all other fish caught in Vermont state waters to two meals per month. The Vermont advisory for lake trout in Lake Champlain is more restrictive. Adults should limit their consumption of lake trout (over 25 inches) caught in Lake Champlain to one meal per month, and women of childbearing age and children under 15 should not eat any lake trout from Lake Champlain.

FDA action levels use national average consumption rates to determine action levels or tolerances. However, in other parts of the country it has been demonstrated that actual consumption rates may vary regionally and within particular groups of people. The Lake Champlain Basin Program recently completed a fish consumption survey to study what species of fish are eaten, by whom and in what quantities. This study (Connelly and Knuth, 1995) found that 71% of the respondents to a mail survey were aware of the fish consumption advisories, 70% of respondents did not harvest or eat fish with advisories, and that 18% harvested these fish but ate them within the limits stated in the advisory. Fish consumption rates for Lake Champlain were found to be slightly to greatly above consumption rates for the U.S. population as a whole. The survey was distributed to licensed anglers only.

Both Vermont and New York have limited fish tissue sampling programs for Lake Champlain. Fish are also tested by the Province of Quebec, but these data are not well integrated into Vermont's and New York's analyses due, in part, to differences in nomenclature and difficulties in interpreting the results.

The New York Statewide Toxic Substances Monitoring Program tested for PCBs, organochlorine pesticides and mercury on a periodic basis from 1977 to 1982. Since that time, the New York State Department of Environmental Conservation (NYSDEC) has conducted special studies of fish on an as needed basis. Results of these studies, which indicated that 43% of the lake trout over 25 inches long had PCB concentrations over 2 part per million and 68% of walleye over 19 inches had mercury concentrations over 1 part per million, helped to establish the fish advisory. These New York programs also sampled other species, including Atlantic salmon, cisco, lake whitefish, largemouth bass, northern pike, rainbow smelt, redhorse suckers, smallmouth bass and yellow perch. None of these species contained contaminants at levels that pose a threat to human health. Further sampling of lake trout and whitefish was done by NYSDEC in 1992, although results are not yet available.

Vermont has also undertaken various fish tissue sampling efforts since 1970. Many of these studies have focused on particular contaminants of concern, and have limited sampling to a particular geographic location where a problem is already suspected. Examples include: sampling for mercury throughout Lake Champlain (1970); for PCBs at three river mouths (1976); for pesticides, PCBs and mercury in Burlington Harbor (1980); for mercury at Pine Street Canal (1983); for PCBs in American Eel in Burlington Harbor (1985); for PCBs in Lake Trout at Juniper Island (1987); and for mercury in walleye at two river mouths (1990). Since 1987, Vermont has had a more systematic Fish Contaminant Monitoring Program based on a revolving 5 year sampling of several species at set locations. The program is designed to provide a screening mechanism to identify areas that may require more intensive investigation. Data generated from these intensive efforts are used to help develop consumption advisories.

In 1987 the Vermont Departments of Environmental Conservation, Fish and Wildlife, and Health, in conjunction with New York Department of Environmental Conservation, undertook a comprehensive examination of the threat of PCBs and other types of contamination in fish commonly consumed by the public. Biologists tested eight species of fish from 11 locations. Utilizing a method developed by NYSDOH which allows the health effect of multiple contaminants to be assessed, the study concluded that no additional advisories for fish consumption on Lake Champlain were needed at that time. Vermont repeated this study in 1993. Results indicated a continued need for the lakewide PCB advisory on lake trout, but no need for additional PCB advisories at this time.

The National Bioaccumulation Study, conducted in 1987-88 by EPA in cooperation with the states and the U.S. Fish and Wildlife Service, tested for dioxins, dibenzofurans, PCB, organochlorine pesticides, and several metals. One important result of this study was the suggestion that dioxin levels in fish are not a significant concern to human health in Lake Champlain. Carp, which are used as indicators of local dioxin problems, were sampled from the Ticonderoga area. Dioxin levels in the fish were low and similar to background levels found in the rest of the Lake.

Limited fish tissue data from Quebec are also available. Although fish tissue sampling is done each year, the location is rotated and focuses on popular fishing areas (Gouan, personal communication). Data for Lake Champlain were published in 1982. At that time, white suckers, walleye and mussels were sampled for the presence of organochlorine pesticides including DDT, DDE, DDD, dieldrin and hexachlorobenzene. Separate studies sampled for PCBs and for metals. Two sampling sites, at the mouth of the Pike River (the "Brochet" in French) in Missisquoi Bay, and on the Richelieu River at Lacolle, are of interest because they are within the Basin. At the mouth of the Pike River, total DDT and hexachorobenzene were found at levels above reference or "clean" sites.

Fish from the Lake are often sold in local area restaurants and grocery stores. Informal reports are that perch is popular, and interviews with anglers conducted as part of a study on the winter perch fishery in the northeast arm of the Lake, indicate that perch is sold to markets in Montreal, New York, Boston and perhaps farther west (LaBar, 1988).

Potential Threats to Human Health from Pathogens

Pathogens are disease-causing agents such as bacteria, viruses and parasites. Water-related pathogens include giardia and cryptosporidium, which cause gastrointestinal illness when ingested. These microorganisms are present in human and animal fecal matter, and enter the Lake through point and nonpoint sources. Combined sewer overflows may, during times of high rainfall, be the primary source of pathogens entering the Lake. Runoff from the ground spreading of septage, sludge and manure, as well as discharges from malfunctioning septic systems, may also be sources of pathogens found in the Lake.

Giardia is a common parasite which causes gastrointestinal illness. The Vermont Department of Health receives statewide reports of approximately 415 cases of giardia per year (Vermont, Agency of Natural Resources, 1993). Cases of giardia have also been reported to local or state health departments in New York. For example, Clinton County received reports of 10 cases of giardia during 1993 (Snizek, personal communication). These estimates are considered low because such illnesses are not always reported. While it can be difficult to identify the pathway of contamination, some Lake-related possibilities include drinking water and accidental ingestion while swimming. The greatest concern is contamination of private water supplies which do not filter their water.

There are occasional and isolated incidents throughout the Lake of swimmer's itch, a skin irritation caused by a free swimming stage of a fluke (a flatworm). The fluke lives part of its life cycle in snails and completes its life cycle in water birds. When water birds are not present, the fluke may mistakenly attempt to burrow into a human's skin, causing itching. There is public concern that these outbreaks will occur more frequently.

People may be exposed to pathogens via their drinking water and/or through contact and subsequent ingestion of the water. For these reasons, all public drinking water supplies are filtered and treated, generally with chlorine, to remove pathogens. Individuals withdrawing drinking water directly from the Lake do not benefit from this safeguard. Water at public beaches is tested for the presence of pathogens periodically, particularly after storm events, to ensure that swimmers are not exposed to unsafe levels. Chlorine, used as a disinfectant for drinking water, produces by-products, including trihalomethanes (THMs), which may be carcinogenic to humans. Public water supplies must monitor for THMs and other by-products in drinking water.

Beach Closings

Local health departments in New York and Vermont sample the water at public beaches to determine if there is any threat to human health from pathogens. Generally, local health officials test for elevated levels of fecal coliform in the water, which is a common indicator of the presence of pathogens. When found, preventing the transmission of disease to humans usually means closing beaches. The number and frequency of beach closings is one indication of how serious the threat of water-borne disease is to Basin residents and visitors; available information indicates that pathogens cause occasional problems along the Lake's shoreline (see Table 10).

The City of Burlington has four municipal beaches. Over the past six years, three of these beaches have been closed for a total of 29 days due to the presence of coliform bacteria. The fourth beach, Blanchard Beach, has been closed indefinitely due to continued water quality problems. Improvements recently completed at the wastewater treatment plant in Burlington, which include the separation of stormwater from sewage flows to minimize raw sewage discharges during storm events, should reduce a major source of pathogens at City beaches, particularly North Beach.

The Towns of Colchester, Shelburne and South Burlington have also had beach closings. South Burlington operates one public beach, Red Rocks Beach on Shelburne Bay. It was closed 12 times in 1989, but closures were reduced significantly during the early 1990s due to remedial actions taken by the City. The recent increase in pathogen levels that closed Red Rocks for 8 days in 1995 appears to be due to beaver inhabiting ponds in the watershed above the beach. Officials from the City said that the beach had not been closed due to swimmer's itch, but that the parasite was an annoyance for about one week each year. The Town of Colchester operates the Bayside Beach. This beach was closed for 12 days in 1988, but only five times during the past seven years. The Town of Shelburne had no record of beach closings until 1994, when its beach was closed for 14 days. In 1995, Shelburne Beach was closed for most of the summer. The town is actively investigating possible sources of pathogens, and currently suspects malfunctioning septic systems along a nearby tributary.

In New York, there have been four events causing municipal beach closings since 1990. At least one closing was a precautionary measure after a heavy rainfall, and another was due to the presence of the parasite that causes swimmer's itch. In addition to these municipal beaches on Lake Champlain, there are numerous state park beaches as well as private beaches associated with camps, motels and campgrounds, but since information on pathogen problems and associated beach closings is not readily available at those beaches, it is not presented here.

Table 10. Total Days of Municipal Beach Closings on Lake Champlain, 1989 - 1995

BEACHES	1989	1990	1991	1992	1993	1994	1995
Burlington, VT North Beach	n/a	4 days	1 day	0	0	2 days	7 days
Burlington, VT Blanchard Beach	n/a	n/a	closed	closed	closed	closed	closed
Burlington, VT Cove Beach	n/a	2 days	1 day	0	0	0	0
Burlington, VT Leddy Beach	n/a	0	1 day	2 days	2 days	2 days	5 days
Colchester, VT Bayside Beach	2 days	0	0	3 days	0	0	0
Shelburne, VT	n/a	n/a	n/a	n/a	0	14 days	most of summer
So. Burlington Red Rocks Beach, VT	12 days	5 days	2 days	1 day	2 days	1 day	8 days
Port Douglas, NY	n/a	n/a	n/a	n/a	7 days	0	0
Essex Beach, NY	n/a	1 day	closed[1]	closed	closed	closed	closed
Cliff Haven Beach, NY	n/a	n/a	n/a	0	0	0	0
Plattsburgh Beach, NY	n/a	n/a	n/a	7 days	1 day	0	0

[1]The Essex Beach closure is due to "swimmer's itch" rather than bacterial contamination.
(Source: Koons, personal communication; Kapur, personal communication; Lougar, personal communication; Holmes and Artuso, 1995)

The Third Century Report (VT ANR, 1993) states that, in Vermont, the level of health risk to swimmers from pathogens is unknown. Because testing for these substances is limited to public beaches, the risk to people swimming at locations away from these areas is unknown. This Report recommends that swimmers continue to avoid swimming downstream from wastewater treatment plant discharges or areas where animal wastes obviously drain from agricultural areas.

Pathogens from Failing Septic Systems

When operating properly, on-site septic systems are an effective method of treating human waste. However, failing septic systems, particularly those close to the Lake, may threaten human health by delivering pathogens to the Lake. This section summarizes information available on the quantity and failure rates of these systems within the Lake Champlain Basin as a first step to understanding the extent of this source of pollution.

Holmes and Associates (1993) estimated that there are approximately 150,000 septic systems within the Lake Champlain Basin. Distribution of septic systems throughout the Basin is presented in Table 11 below.

Table 11. Septic Systems in the Lake Champlain Basin

State	Household Units	%	# Septic System
New York	95,925	60.1	57,651
Vermont	167,841	53.0	88,956
Quebec	11,964	50.0	5,982
TOTAL	275,730	55.0	152,589

(Source: Budd and Meals, 1994, from Holmes and Assoc., 1993)

Budd and Meals (1994) estimated the failure rate of septic systems within the Basin as part their study of nonpoint source pollution. Compiling available data from both states, they estimated that roughly 5-10% of all septic systems, or between 7,629 and 15,259 systems, may be failing within the Basin. While failing systems are clearly a problem throughout the Basin, and may result in ground water pollution or localized nutrient problems, the extent to which these systems are a source of pathogens to surface waters is unknown.

The State of Vermont has performed inspections of septic systems through the Clean Water Act, Section 319 program, and has provided limited funds for remediation when problems are detected. These inspections are targeted to watersheds with known surface water quality problems.

A recent water quality inventory of Malletts Bay indicates that 40% of lakeshore septic systems do not have current permits because they were installed before the early 1970s. Although there are few documented cases of failure, the age of the systems and proximity to the Lake indicate a potential threat, and several particular problem areas have been identified (Skenderian, 1993; Williams, 1994).

A pollution study of the St. Albans Bay area was undertaken in 1991. A survey was distributed to 460 residences to determine the type of waste disposal system, age of the system and frequency of use. There was a 37% response rate (170 responses), of which approximately 51% were vacation homes. Results indicate that 74% of the respondents used an on-site septic system. Twenty-three percent of these systems were over 21 years old and 21% were of an unknown age. Soil samples were taken to determine the potential for movement of septage through different soil types, and estimate leaching of pathogens and nutrients to surface water. Further analysis indicated that potentially 97% of the bacteria in St. Albans Bay is directly discharged by residences from the area addressed in this study (TWM Northeast, 1991). Another bacteria sampling study around St. Albans Bay was undertaken by Vermont's Department of Environmental Conservation in 1989, including sampling at 11 stations along tributaries to the Bay. Coliform violations were observed at most stations, although only one indicated contamination from human wastes. Other sites indicated contamination from animal wastes.

The New York State Department of Health does not have an active survey program for septic systems in Essex County, and Clinton County does not have a proactive program. The New York Department of Environmental Conservation receives calls from citizens expressing concerns about failing septic systems. Over the past three years the regional office in Ray Brook has received an average of 21 calls per year. Approximately one third were referred to the state or local health departments because of a potential threat to human health (Venne, personal communication). The State Department of Health does have a set of guidelines for septic system renovations. The Lake George Park Commission has an active septic system testing program around Lake George, and uses dye tests to identify leaking systems.

In Vermont, a task force organized by the Secretary of the Agency of Natural Resources recently released a report (Vermont On-Site Sewage Committee, 1995) that concludes that many septic systems are legally or illegally installed without appropriate consideration of the protection of health or water quality. The report indicates that Vermont state standards currently lack the flexibility to permit the use of alternative systems, and includes a number of recommendations for overall regulatory reform. In 1995, the Lake Champlain Basin Program funded the construction of four alternative individual on-site septic systems to demonstrate their potential effectiveness, particularly in areas that are not suitable for conventional septic systems. These four include a recirculating filter system, an intermittent filter system, a single trench mound system and a constructed wetland system. It is hoped that this project will result in increased use (and greater acceptance within the regulatory community) of alternative systems.

Pathogens from Ground Spreading of Septage and Sewage Sludge
Ground spreading of septage and sewage sludge is regulated by both New York and Vermont in accordance with federal laws. The Clean Water Act establishes standards for land disposal including monitoring for pollutants (including pathogens and toxic metals). It also prohibits application of sewage to frozen or flooded lands or to sites less than ten meters (32.8 feet) from a body of water, to prevent runoff from polluting surface waters. In Vermont, setback requirements for spreading are more stringent than this federal requirement, prohibiting spreading within 100 feet of an intermittent stream and within 300 feet of a drinking water source, such as Lake Champlain. In New York the setback distance is 200 feet from any surface water body or drinking water supply.

Each of these requirements helps to minimize the threat to human health from this source. EPA has stated in a letter to Vermont that "EPA is not aware of any human, domestic animal or wildlife disease outbreaks associated with the land application of treated sewage sludge or domestic septage" (Correspondence dated 1/26/94). There is concern regarding the presence of metals found in sewage sludge which can accumulate in any crops grown on the land where it is applied. Federal standards also set maximum concentrations and loading rates for metals levels in sludge, which each of the state programs must enforce.

Issues

Protecting the Health of Swimmers at Private Beaches and Other Recreation Areas

Precautionary testing of the Lake's water for pathogens is only done at public beaches. However, many individuals swim elsewhere - perhaps from the beach front of their own home, or from a boat. Since pathogen contamination may not be apparent from the water's appearance, there is no warning of the potential risks to these swimmers. The same is true of exposure to the parasite causing swimmer's itch. In Vermont, individuals may collect water samples from their local area for analysis at the state laboratory for a cost of $12. However, this service is not widely publicized, and in particular may be unknown to seasonal residents.

Controlling the Sources of Pathogens Entering the Lake

Sources of pathogens include discharges from combined sewer overflows (CSOs), runoff from agricultural fields, ground spreading of septage, sludge or manure, and improperly functioning septic systems. Burlington is addressing the problems associated with CSOs in the City by separating storm water and sewer lines in some places, and treating the entire stormwater flow elsewhere. CSOs may also contain other contaminants from storm water runoff including oil, deicers and sand. It is possible that CSOs pose a significant threat in other areas as well; however, all CSOs in the Basin are now, or will soon be, in compliance with respective state CSO policies (see Toxic Substances section). Although there is no evidence that failed septic systems are a threat to human health lake-wide, water supplies may be contaminated with pathogens in localized areas with high failure rates. Even though ground spreading of septage and sludge is regulated by the states, no assessment has been made to determine whether this practice is a source of pathogens or metals to Lake Champlain, or otherwise a threat to human health. Agricultural activities are another important source of pathogens; management of agricultural wastes is addressed in the phosphorus section.

Protecting the Health of People Withdrawing Drinking Water from the Lake

The Safe Drinking Water Act (SDWA) provides the means to protect the health of those drinking from public water supplies. However, it does not regulate individuals, or any water supply which serves less than 25 people or 15 connections, and there are no testing or monitoring requirements for these water users. Additionally, the ambient water quality monitoring activities, which could possibly provide some of this information to an individual, do not monitor for all the same contaminants using protocols specified in the Safe Drinking Water Act.

It may seem reasonable from a human health standpoint to encourage individual water users to consolidate into small systems and thereby come under the auspices of the SDWA and the protection it affords. However, the costs of implementing the SDWA, particularly the monitoring of 84 potential contaminants, can be an enormous burden on a small system. These costs need to be considered and balanced with the human health benefits.

Difficulties Facing Small Public Water Systems Attempting to Meet the Requirements of the Safe Water Drinking Act

Of the 99 water systems withdrawing from the Lake, 64 are motels, trailer parks, businesses, schools, restaurants etc., and 35 are community supplies. Twenty-five of these community supplies serve less than one thousand people. The SDWA presently requires all public water systems serving the same population for more than six months to monitor for 84 contaminants in drinking water. Public water systems serving a transient population are required to monitor for acute contaminants including bacteria, nitrate and nitrite. Additional requirements are to be phased in (25 new contaminants every three years, begun in 1993) until 200 contaminants are to be monitored by the year 2000. Of particular concern is the "surface water treatment rule", which will require filtration of all surface water sources unless the water supplier can meet certain strict criteria related to the protection of the supply from sources of contamination. Although these requirements may be amended as part of the upcoming reauthorization of the

Act, it is clear that there will be an increasing burden placed on public water supply systems in the near future. It is widely agreed that this burden will fall most heavily on small water systems, many of which are privately owned. Costs imposed by these requirements will be difficult for small systems to bear, and technical expertise often will not be readily available.

Availability of Comprehensive, Statistically Valid Fish Tissue Data

The fish sampling programs of the two states and Quebec are not well coordinated, and do not provide a comprehensive data base over time. One reason the state programs are limited is the high cost associated with sampling fish for the types of contaminants of concern. However, it is difficult to discover trends or provide statistically valid conclusions without a more extensive data base. This is particularly important given the interest within the Basin in pursuing a toxics reduction program that makes it possible to trace reductions of toxic substances in fish over time.

Communication of Potential Human Health Risks to the Public

Risk communication is an important part of any effort to protect human health. Both state health departments work to provide understandable information to the public on any potential human health threat so that the public may make informed decisions to protect their health. At the same time, the information is placed in context in order to minimize undue fear. In Lake Champlain there are two lakewide fish advisories. Communication of the risk posed by consuming these species should be done in a responsible and responsive tone that does not create unnecessary fear or leave the impression that consumption of all fish species is dangerous.

New York and Vermont have worked together to the extent that they inform each other of any press releases or health advisories before they are released. The States are beginning to use similar methods of informing the public about risks. New York hands out information on all fish advisories with every fishing license issued and Vermont has just initiated a similar practice in 1994. Neither state coordinates closely with Quebec on these issues. A coordinated risk communication strategy would provide the same information to individuals from all three jurisdictions surrounding Lake Champlain.

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Chapter 3. Living Natural Resources

The Lake Champlain Basin is a complex ecosystem made up of interconnected habitats in the Lake and its immediate environs, as well as in the more remote upstream areas of the watershed. The aquatic community in the Lake itself is a diverse assemblage of organisms, including phytoplankton, zooplankton, benthic organisms, forage fish and top predators.

The Lake is known for its important recreational fishing. Of the 81 species of fish in the Lake, about 20 are actively sought by anglers. There has been an aggressive stocking program to improve recreational fishing, with fisheries management plans focusing primarily on game fish and game fish population conditions.

Wetlands are an important component of the Basin's ecosystem. In spite of the tremendous values of wetlands both to the ecosystem and to humans, considerable areas have been and continue to be lost, despoiled or impaired by growth and development.

Changes in the plant and wildlife populations have occurred over time. Several species of non-native plants and animals within the Lake Champlain Basin disturb the ecological balance of the system or cause problems for human uses. Nuisance aquatic species that are not native to the area have invaded the Basin and Lake, sometimes posing a threat to fish and wildlife, as well as to recreational enjoyment of the Lake, resulting in economic impacts.

This chapter is organized around the following topics: Managing Fish and Wildlife; Protecting Wetlands; and Managing Nuisance Nonnative Aquatic Species.

Managing Fish and Wildlife

Background

The Importance of the Basin's Living Resources

The fish and wildlife[1] resources in the Lake Champlain Basin are part of a complex ecosystem. They occupy a mosaic of interconnected aquatic and terrestrial habitats that include the open waters of the Lake, rivers and streams that drain into it, wetlands, shallow water flats around the Lake's perimeter, islands, forests, agricultural lands and other areas. Although fish may be one of Lake Champlain's most obvious resources, many other animals (vertebrates and invertebrates) and plants depend on the Lake and its associated habitats in the Basin. Wildlife species, such as snow geese, great blue herons, double-crested cormorants, ring-billed gulls and common terns, depend on the islands and wetlands in and around the Lake for breeding, wintering, and migration habitat.

Humans are also part of the ecosystem and are a dominant force of change throughout the biosphere. In many places, the effects of human activities and development have had severe adverse consequences on local ecosystems. Fortunately, the Lake Champlain Basin is a premier example of a place where human communities continue to conserve and benefit from relatively unspoiled communities of living natural resources. The Lake Champlain Special Designation Act "envisions that all aspects of human and ecological life within the Basin be maintained in harmony with one another."

The Basin's fish and wildlife resources presently provide indispensable social and environmental benefits. For example, the abundance of some fish and wildlife species attracts recreational hunters, bird watchers and anglers who spend money in local communities. Many Basin residents find satisfaction in knowing that a complex, varied, interdependent and often incompletely understood array of plant and animal species find habitats in their watershed. This complex array of plants and animals provides innumerable environmental benefits, too, such as pollution and sediment filtration by some wetland communities, and aquatic food web support by Lake Champlain's plankton and forage fish populations. Although the role of many species in the Lake Champlain ecosystem is poorly understood, their presence is highly valued as part of the region's natural heritage.

A significant number of threatened and endangered plant and animal species also depend on the wetlands and other habitats in the Lake Champlain Basin. Federal and state mandates require protection of these species, because of both their intrinsic and societal values.

It is important to understand fish and wildlife resources and issues throughout the entire watershed, from the lakes to the more remote landscapes and headwater areas. However, this section focuses on those resources that live in Lake Champlain and its immediate environs, and addresses plants and animals considered unique to the Basin, as well as those that are threatened or endangered. Wetlands, one of the many habitats vital to these fish and wildlife resources, are addressed in the section on Protecting Wetlands. Management of invading species that are not

[1] For purposes of this report, the term "wildlife" includes any non-domesticated mammal, fish, bird amphibian, reptile, mollusk, crustacean, arthropod, and other invertebrate or plant.

native to the region and which threaten the balance of living natural resources is detailed in the section on Managing Nuisance Nonnative Aquatic Plants and Animals.

Description of Resources and Threats

Many different fish and wildlife species make up the living natural resources of the Lake Champlain Basin. These can be divided into six major groups: **fish, invertebrates, amphibians and reptiles, birds, mammals and plants.** The status of each group within the Basin, and known threats to their health, are summarized below.

Fish

The fish of Lake Champlain are part of an aquatic community that also includes diverse assemblages of plants, phytoplankton, zooplankton, and benthic organisms. Eighty-one species of fish have been identified in Lake Champlain (Table 12, p.105). About twenty of these species are actively sought by anglers, including large and smallmouth bass, walleye, northern pike, chain pickerel, brown bullhead, channel catfish, yellow perch, lake trout, landlocked Atlantic salmon, steelhead trout, brown trout, and rainbow smelt. The distributions of several nongame species of minnows, darters and sculpins are not clearly defined. Understanding the distribution of these nongame species is important because the Lake Champlain Basin represents the eastern boundary of the distributional range for many species.

At present, four species found in the Basin are classified by Vermont or New York as endangered: lake sturgeon (VT), northern brook lamprey (VT), stonecat (VT) and eastern sand darter (NY). Four species are listed as threatened: eastern sand darter (VT), American brook lamprey (VT), mooneye (NY), and lake sturgeon (NY). A history of changes to popular game species of fish and efforts to manage them are summarized below.

Fish populations in Lake Champlain have changed dramatically over the last century. Based on historical records, Lake Champlain once supported populations of landlocked and/or sea run Atlantic salmon and lake trout. At one time, salmon weighing up to 20 pounds were caught in the Lake. Sampling by the New York State Conservation Department in 1929 did not yield a single lake trout. These declines are attributed to rapid development in the watershed and "encroachment by civilization" (Lake Champlain Fish and Wildlife Cooperative, 1977).

By 1977, ice fishing for rainbow smelt provided the only major cold water sport fishing in the Lake. Limited commercial fishing for lake whitefish existed then in Quebec waters, and the yellow perch was the most important warm water species year-round. During the 1970s, 1980s and early 1990s, the Lake Champlain Fish and Wildlife Management Cooperative conducted an aggressive stocking program to develop and maintain a diverse salmonid fishery on Lake Champlain. Specific objectives outlined in *A Strategic Plan for Development of Salmonid Fisheries in Lake Champlain* were: 1) re-establish a lake trout fishery by 1985 that would annually provide at least 45,000 additional angler-days with an approximate yield of 18,000 lake trout averaging 5 pounds each; 2) re-establish a landlocked Atlantic salmon fishery by 1985 that would annually provide at least 41,000 additional angler-days with an approximate yield of 12,200 Atlantic salmon averaging 4 pounds each; 3) establish a "steelhead" rainbow trout fishery by 1985 that would annually provide at least 31,000 additional angler-days with an approximate yield of 6,100 steelhead averaging 4 pounds each; and, 4) maintain the rainbow smelt fishery at a level that will annually average at least 25,000 angler-days with an approximate annual yield of 100,000 pounds (Lake Champlain Fish and Wildlife Cooperative, 1977).

Significant open-water fisheries for lake trout and salmonids were established through this program. Objectives of the Strategic Plan were not met by 1985, primarily because of the proliferation of the sea lamprey, a nuisance aquatic species (see also the section on Managing Non-native Nuisance Aquatic Plants and Animals). The stocking program only achieved the following percentages of the goals: lake trout-56%, landlocked Atlantic salmon-26%, and steelhead-21%.

Sea lampreys are parasitic on salmonids and other species of fish and cause significant mortality. In 1990, an experimental program to control this species in Lake Champlain was approved (NYSDEC, VT FWD, and USFWS, 1990), and will last eight years. The objectives of the program are: 1) reduce the abundance of parasitic stage sea lampreys by applying chemical lampricides to lamprey infested streams and deltas; 2) evaluate effects of this reduction on certain fish populations, the sport fishery and the region's growth and economy; and 3) formulate a long-range management strategy for sea lamprey in Lake Champlain. Preliminary results of this program are beginning to show indications of enhanced salmonid survival.

Lake sturgeon populations have dropped dramatically during the past 100 years throughout the United States and Canada. The population of lake sturgeon in Lake Champlain has also declined and therefore, this fish is classified as an endangered species in Vermont and threatened in New York. The LCBP recently completed a study to determine the feasibility of restoring sturgeon populations in the Lake. The authors of the study concluded that reestablishing a self-sustaining population will require a program of stocking (Moreau and Parrish, 1994).

The perceived decline in the Lake Champlain walleye population is another major concern to anglers and fisheries biologists. Since 1986, more than 12 million walleye fry have been stocked in the Lake, but angler catch rates in the northern part of the Lake are consistently low. A recent LCBP study evaluated the status of walleye using existing state monitoring data. Results suggest that we do not yet know enough about juvenile walleye survival to effectively manage this species in Lake Champlain. The study recommends increased monitoring and assessment of all walleye life stages, and increased research efforts to assess spawning habitat, juvenile survival, and interactions with other species, such as rainbow smelt and white suckers (Newbrough et al., 1994). The LCBP subsequently funded a study (currently underway) conducted by the Lake Champlain Walleye Association to help improve sampling techniques for walleye. A variety of sampling methods using seines, traps, light traps, nets, and electrofishing are being tested to determine the best ways to sample and study walleye life stages from egg through adult. The results of this study will help resource managers effectively monitor and manage Lake Champlain walleye populations.

The primary focus of most of Lake Champlain's fisheries management efforts to date has been to understand and improve conditions that affect species that support the Lake's important recreational fishery. Commercial fishing and the population status of nongame fish have received less emphasis. While some small-scale commercial fishing for yellow perch, smelt, bullhead and bait fish, augments the income of some Lake Champlain area residents, its impact on the overall fishery is unclear.

Invertebrates

Invertebrates, including organisms such as mussels, aquatic snails, and insects are a very important and poorly understood part of the Lake Champlain ecosystem. Surveys and studies of invertebrates in the Lake Champlain Basin have focused on freshwater mussels, dragonflies and damselflies, butterflies and moths, and beetles (particularly ground beetles and tiger beetles). The Basin supports eight freshwater mussel species, which are at the edges of their ranges in Vermont. A rare dragonfly, the clubtail, is known from historic records to have inhabited the southern Lake Champlain Basin.

Other small shrimp-like invertebrates, called "zooplankton," float in the Lake and its tributaries. All of these invertebrates are food for a huge variety of larger animals, such as small fish, frogs and turtles and, along with tiny plants called "phytoplankton," form the base of Lake Champlain's food web. Greater knowledge of this broad group of animals will help us to better understand this important food web linkage and to preserve the Basin's biological diversity.

Two studies, funded by the LCBP to investigate the predator-prey relationships that make up Lake Champlain's food web, will help fisheries managers predict the impacts of stocking programs, lamprey control, fishing regulations and habitat restoration projects. One study is examining the species supporting the base of the food web to understand interactions between these microscopic organisms and the larger organisms that feed on them. Another is concentrating on how top predators, such as trout and walleye, affect populations of the species they consume. Results of this work should be available in 1996.

The LCBP has also funded two studies of native mussels: an Assessment of Mussel Populations on Select Delta Areas of Lake Champlain Following Application of Bayer 73, and a Survey of Shale and Cobble Zone Macroinvertebrate Community and Survey of Mussel-Beds in Lake Champlain. Preliminary information from these studies, conducted by the USFWS and VT DEC, suggests that the most severe threat to native mussels in Lake Champlain may be infestation by the zebra mussels. Native mussels are an ideal surface to which zebra mussels can attach. Zebra mussels impact native mussels by competing with them for food and by making it difficult for the native mussels to open and close which they must do to feed and reproduce. More than 200 individual zebra mussels have been observed attached to a single native mussel in Lake Champlain. If zebra mussels in Lake Champlain follow the same infestation rates as in the Great Lakes, native mussel populations could be decimated in Lake Champlain.

Some water quality and aquatic ecosystem monitoring programs use invertebrates as indicators of habitat or ecosystem health. Examples include the use of freshwater mussels to assess the presence of toxic substance contamination in the lower portions of Lake Champlain's tributary rivers; the use of mayflies for water quality monitoring; and the use of amphipods (scuds or freshwater shrimp) as indicators of toxic contamination (see also the section for Preventing Pollution from Toxic Substances).

Threats to invertebrates include low oxygen conditions in the water (called "hypoxia") related to eutrophication caused by nutrient pollution, siltation that covers habitat and fouls some of these organisms' filtering or feeding processes and the accumulation of toxic substances, as well as imbalances in predator/prey population relationships, and the introduction of nonnative or "exotic" species. Vermont lists two freshwater mussels--the black sandshell and eastern pearlshell--in addition to the rough-necked tiger beetle as threatened species. Vermont considers several other invertebrate species in the Basin to be "of special concern," including a deep water amphipod found in Lake Champlain.

Amphibians and Reptiles
Twenty-one species of amphibians have been identified in the Lake Champlain area (Table 13, p. 106). Only one species, the striped chorus frog, is listed as endangered in Vermont. This species has no special status in New York. Little is known about the population status and distribution of amphibians in the Lake Champlain area.

Twenty species of reptiles are found in the vicinity of the Lake (Table 13). Species listed by either Vermont or New York as threatened or endangered include the five-lined skink (VT), spotted turtle (VT), timber rattlesnake (VT and NY), spiny softshell turtle (VT), and the bog turtle (NY). In Vermont, the five-lined skink is presently known from only one locality. Vermont timber rattlesnake populations were decimated out of fear, for bounties, and by destruction of habitat. Only two known populations remain in the Vermont portion of the Basin. Spiny softshell turtles in Lake Champlain are disjunct from Great Lakes populations, and have been found only on the Vermont side of the Lake and in some Vermont tributaries. In Vermont, map turtles are restricted to Lake Champlain and the lower portions of its tributaries. Little is known about the distribution and population status of reptiles in the Lake Champlain area. New York and Vermont are developing statewide atlases of amphibians and reptiles, which should be completed by 1999.

Birds
Three hundred and eighteen species of birds breed, or have once lived, in the vicinity of Lake Champlain (Table 14, p. 107). A very visible part of the ecosystem, waterfowl and shore birds use the Lake Champlain Basin as breeding grounds, and for critical stopovers during spring and fall migrations along the Atlantic Flyway. Waterfowl use of the Basin's productive habitats is well documented, particularly at Missisquoi National Wildlife Refuge and other wildlife management areas. The Atlantic Flyway Council, a coalition of states and provinces working in concert with the U.S. Fish and Wildlife Service and Canadian Wildlife Service, coordinates waterfowl management in the Lake Champlain Basin. This partnership has established research, restoration, and management goals for key species, including Canada geese, snow geese, black ducks, mallards, wood ducks, canvasbacks, and sea ducks. Several important waterfowl habitat areas have been acquired and are currently managed by the state and federal agencies.

Twelve species in the Basin are listed by New York, Vermont and/or the federal government as endangered or threatened: bald eagle (NY, VT, USFWS), peregrine falcon (NY, VT, USFWS), golden eagle (NY), loggerhead shrike (NY, VT), common loon (VT), osprey (NY, VT), common tern (NY, VT), Henslow's sparrow (VT), northern harrier (NY), red-shouldered hawk (NY), upland sandpiper (VT), and sedge wren (VT). Common threats to these species are destruction of habitat and declining water quality, particularly from persistent toxic pollutants.

In recent years, the numbers of bald eagle, peregrine falcon, osprey and wild turkey have increased in the Basin. New York has developed a statewide management plan for the bald eagle. Breeding bird atlases have been prepared for both states. State management emphasis is placed upon a number of birds of management concern as indicated in Table 14. Colonial nesting waterbirds, American woodcock, mourning doves and neotropical migrants receive extra attention through annual federal or state surveys, and emphasis through national programs such as Partners in Flight. Other surveys, such as the National Audubon Society's Christmas Bird Count, hawk migration watches and the National Biological Service's Breeding Bird Survey also contribute to the data on bird populations in the Lake Champlain Basin.

Mammals
Fifty-six species of mammals find their homes in the Lake Champlain area (Table 15, p. 110). Two species are listed as endangered: the Indiana bat (USFWS, VT, NY) and the marten (VT). The small-footed bat is listed as threatened in Vermont. There is a state recovery plan for the marten and a federal recovery plan for the Indiana bat. State management plans have been completed for the white-tailed deer (NY, VT), moose (NY, VT), black bear (VT), and beaver (NY).

Plant Communities and Rare Plants
The Lake Champlain Basin, including the shorelines of the Lake and associated wetlands, river shores, cliffs and bluffs, supports a diverse array of natural plant communities and many rare plant species. Cobble shores, sand beaches and dunes, low-gradient rivers, emergent marshes, bogs and fens, floodplain forests, maple-ash swamps, hardwood-cedar swamps, pine-oak-heath sandplain forests, oak-hickory forests, calcareous cliffs, alpine tundra, and cedar-pine lake bluffs are some important natural communities found in the watershed. The mineral-rich bedrock and soils of this region support natural communities high in plant diversity, including several plant species rarely encountered outside the area. Two publications, *Ecological Communities of New York State* (Resche, 1990) and *Natural Communities of Vermont* (Thompson, 1995), provide valuable descriptions of the Basin's plant communities.

In the Vermont portion of the Basin, 56 plant species are listed as endangered or threatened under Vermont law. New York State published a list of protected native plants that includes endangered, threatened, vulnerable and rare species. One hundred and twenty species on this list are associated with Lake Champlain and its wetlands, tributaries, shorelines, and bluffs. Common threats to these rare plants and plant communities are land development, land clearing and trampling.

Expanding Nuisance Wildlife Populations
A number of native wildlife species are considered to be, or have the potential to be, nuisances. They include beaver, ring-billed gull, Canada goose, double-crested cormorant, Canadian waterweed and muskrat. Some of these species, such as the beaver, ring-billed gull, and cormorant, are considered nuisances because of their direct conflict with humans and other species of fish and wildlife. For instance, beavers sometimes flood roads, driveways and forests, and compete directly with humans for the use of a given land area. Likewise, the beaver and ring-billed gull can have tremendous impacts on the aesthetics of the area as beaver cut down picturesque trees, or gulls congregate on beaches, lawns and picnic tables, degrading the use of these areas for humans. Some wildlife species can threaten populations of other native species by aggressively out competing them for food, nesting or breeding areas. The ring-billed gull and double-crested cormorant compete for island nesting sites with the common tern. Some people allege that cormorants also consume significant quantities of important game fish such as salmon and lake trout. Preliminary data from studies in progress suggest that they consume mostly yellow perch.

Current Programs to Manage and Protect Fish and Wildlife

Federal and State Programs
Several government agencies are involved in managing and conserving fish and wildlife resources in the Lake Champlain Basin. The primary U.S federal agency responsible for managing fish and wildlife is the U.S. Fish and Wildlife Service (USFWS), which operates a

fish hatchery at Pittsford, Vermont and the Missisquoi National Wildlife Refuge in Swanton, Vermont. The USFWS also provides fish and wildlife management assistance and mitigation/conservation recommendations focusing on migratory species and federally-listed threatened or endangered species from offices in Essex Junction, Vermont, Concord, New Hampshire and Cortland, New York. The Canadian counterparts to the USFWS are the Canadian Wildlife Service, and the Department of Fisheries and Oceans, Canada, which are respectively involved in wildlife and fisheries conservation.

The New York State Department of Environmental Conservation (NYSDEC), with regional headquarters in Ray Brook, New York, operates several fish hatcheries and wildlife management areas on a statewide basis, manages state-listed threatened and endangered species conservation efforts, is involved in setting harvest regulations for game species, and carries out a wide variety of fish and wildlife management activities in the Lake Champlain Basin. The Vermont Fish and Wildlife Department (VT FWD), with offices in Waterbury, Essex Junction and Pittsford, Vermont, oversees management activities in Vermont similar to those listed above.

In an effort to develop a unified, coordinated approach to fish and wildlife management, the above federal and state agencies established the Lake Champlain Fish and Wildlife Management Cooperative. At its inception in 1973, the primary goal of this group was to develop and maintain a diverse salmonid fishery in Lake Champlain. In communication with Quebec, the Cooperative is a successful model of bi-state, state/federal partnership for managing a shared resource.

The Cooperative initiated the experimental sea lamprey control program now underway, and continues to deal with fishery regulations, forage management, fish passage and other management strategies. In fact, the inclusion of a management objective for the rainbow smelt fishery in the 1977 Strategic Plan was an explicit recognition of the importance of monitoring predator/prey relations as a component of ecosystem management in the aquatic community. The Cooperative has recently recreated a wildlife management technical committee as part of ongoing efforts to enhance interjurisdictional management of wildlife resources including threatened and endangered species.

Vermont's Nongame and Natural Heritage Program and New York's Natural Heritage Program are responsible for completing inventories of rare plants, rare animals, and natural communities of ecological significance. These programs also survey and protect endangered species, and teach people about the states' significant natural areas. In addition, the Natural Heritage Programs maintain a computerized biological inventory, have conducted surveys in Franklin and Addison Counties in Vermont and Clinton County in New York, and are currently conducting surveys in Washington County and Essex County in New York, with funding from the Lake Champlain Basin Program. This information is used in the environmental review and local, regional, and state planning processes in New York and Vermont.

Other agencies involved in land use planning and/or regulation activities in the Basin include the Adirondack Park Agency and local governments. The government agencies with jurisdictional responsibility for protecting and managing Lake Champlain have made significant progress over the last 25 years in abating pollution, restoring habitats and fish and wildlife populations, and providing for public access, use, enjoyment and understanding of fish and wildlife resources. Involved agencies have been working steadily and effectively toward an integrated, ecosystem approach to managing an important system shared by two states, two countries and countless individuals.

Private Programs
A number of nonprofit organizations are also actively involved with natural resource conservation in the Lake Champlain Basin. For example, Ducks Unlimited, Trout Unlimited, the Lake Champlain Walleye Association and The Nature Conservancy have provided critical support for habitat conservation and restoration efforts within the Basin through private funding sources.

Issues

The following section outlines some of the major technical and policy issues involved with managing fish and wildlife resources in the Lake Champlain Basin. They are not listed in order of priority.

The Need for Comprehensive, Ecosystem-based Management

Lake Champlain supports an abundance of fish and wildlife species, and current management efforts have achieved a measure of success. These management activities should be expanded and integrated to incorporate additional components of the Lake Champlain ecosystem. Recreational use and enjoyment of fish and wildlife resources is an important feature to be considered.

A number of ongoing and proposed management actions for Lake Champlain may have significant effects on other natural communities. For example, the lamprey control program and salmonid stocking efforts are increasing the numbers of predators feeding on forage fish in the Lake. Also, Basin-wide management of phosphorus inputs, by decreasing the nutrient concentrations in the Lake, will alter the phytoplankton food base available to zooplankton and smaller fish. We cannot yet predict how the Lake Champlain aquatic community will respond to these changes.

Food web or "bioenergetics" models can be used to predict how changes in salmonid populations can effect smelt populations. They can also address questions about optimum stocking levels of all salmonids, the balance of the salmonids with other fish species, and the impacts of the zebra mussel. The focus can be on the relationships among species and how those relationships can be managed to produce desired results for individual species. Nutrient management that reduces point and nonpoint inputs of phosphorus from the Basin seems necessary to improve water quality in Lake Champlain. However, food web models can also be used to explore whether nutrient transfer rates could be manipulated in such a way that more excess phosphorus is transferred from the phytoplankton to higher trophic levels. If so, nutrient loadings to the Lake may not need to be reduced as much as expected to control nuisance algae blooms.

Resource managers need more information to support sound decision-making and an ecosystem-based approach to managing Lake Champlain's fish and wildlife resources. Researchers are currently working to fill existing knowledge gaps and are modeling food web dynamics, but the accuracy of the results of any model depends on the amount and quality of data available. Results from two food web studies funded by the LCBP and scheduled for release in 1996, will help provide data to better understand these relationships.

Enhancing the Management of Top Aquatic Predators

A policy to manage top aquatic predators (game fish) must ensure a sustainable yield while maintaining and enhancing ecosystem integrity and stability. One of the major factors affecting the management of top predators is the presence of sea lampreys, the subject of an experimental ongoing control and assessment program scheduled for completion in 1998. Because of the highly popular sport fishery on the Lake, continued coordination of harvest regulations between New York and Vermont is also a high priority.

Protecting and Restoring Threatened and Endangered Species

Populations of some plant and animal species in the Lake Champlain Basin are declining as a result of habitat degradation, invasions of exotic species, collecting, and other factors. Plant and invertebrate species attract less public attention, and are therefore lower priorities for conservation efforts by public agencies, than more visible or "popular" fish and wildlife species. More information on the status of and threats to species and natural communities, in addition to more public education, is necessary to achieve their protection and restoration.

Another issue is inconsistency in the endangered and threatened classification of some species across state borders. For example, the lake sturgeon is listed by Vermont as an "endangered" species, while New York considers it "threatened." This difference may result in different priorities and different levels of protection by the two states. Because a number of agencies are involved in the protection and management of threatened and endangered species, close coordination on all aspects of protection and restoration efforts is critical.

Developing and implementing protection strategies is required to protect federal and state-listed endangered and threatened species. To facilitate this effort, intergovernmental and public/private partnerships could be established to assure coordinated planning and maximum efficiency. These partnerships could also be used to enhance the conservation of important endangered species habitats.

The many gaps in our knowledge of species numbers, locations, and most pressing threats underscores the importance of completing a comprehensive inventory of these species and their critical habitats for the entire Lake Champlain Basin. As mentioned above, both New York's Natural Heritage Program and Vermont's Nongame and Natural Heritage Program are working on these inventories, and have recently undertaken studies to identify and catalogue plant and animal species and significant natural communities. This information will be used to help developers and land planners choose appropriate project sites, and to enable good stewardship of these resources.

Loss of Significant Natural Communities and Habitat

The Lake Champlain Basin provides a rich and varied habitat for its aquatic and terrestrial species. However, much habitat has been lost due to residential and commercial development. In addition, other activities such as forestry, hydroelectric generation and some agricultural practices have impacted fish and wildlife habitats throughout the Basin. Some habitat changes produce complicated results. For example, allowing agricultural lands to revert to forested land in some New York counties has resulted in significant improvement in habitat availability for woodland species while habitat for grass species is declining. In conjunction with the work described above, further study is needed to document land use practices which can cause adverse direct and indirect impacts to important habitats. For migratory species, important habitats away from the Lake but within the Basin need to be surveyed, and included in programs for habitat protection, enhancement and restoration. For example, tributary habitats related to natural reproduction of Atlantic salmon and lake sturgeon must be considered if those species are to be managed effectively. Protection policies need to be formulated for the most important habitats identified. Close coordination and data sharing among agencies are of prime importance. Strategies should also be developed to address areas needing restoration.

Some tributaries and certain areas in the Lake support a high degree of human use that may, in some cases, affect fish and wildlife populations and plant communities. For example, colonial waterbird rookeries, osprey nest sites, and tern and shorebird nesting areas on islands in Lake Champlain and sand dunes sometimes experience disruption or even trampling from sunbathers, explorers and beach combers. Such disturbance can result in significant losses of eggs and juvenile birds or damage to rare plants.

Current research throughout the world suggests that isolating some species that formerly enjoyed large, contiguous habitats into smaller habitat fragments may have serious consequences to the viability of those species. Fragmentation can diminish a species gene pool and increase its susceptibility to random, catastrophic natural events, such as storms.

Coordination with other Resource Management Efforts

Many of Lake Champlain's important living resources depend on healthy water quality in the Lake. Increasing our knowledge and ability to manage water quality is a major concern to the resource managers. There should be close coordination of management goals for fisheries, wildlife, nutrients, and toxics because of their interdependence. In particular, the relationships between water quality, phosphorus content and fishery productivity warrants careful examination. Excess phosphorus clearly degrades water quality, but since phosphorus is also directly related to biological productivity, aquatic resources may be affected if threshold levels of phosphorus are too low. As phosphorus reduction targets are established, the level of phosphorus necessary for a healthy aquatic community should be considered.

The Need for Public Education and Outreach

Public awareness of fish and wildlife resources in the Lake Champlain Basin is critically important to the success of management programs and protection efforts. A strong understanding of the variety of species, their life histories, habitat requirements and threats they face from human activities enables their human neighbors to better appreciate them and participate in their protection. Recognizing this fact, biologists and managers from state and federal agencies frequently conduct educational programs at schools and for interested organizations such as sporting clubs. While these efforts are a primary way to inform the public, they stretch already understaffed programs, and do not meet the demand nor address the larger need for public education and participation.

Funding Needs

Although fish and wildlife management agencies in the Lake Champlain Basin have accomplished a great deal, developing and implementing comprehensive fish and wildlife management programs will require new sources of funding. Agency budgets are currently inadequate for either conducting studies and surveys to provide critical information, or implementing a comprehensive policy. State fish and wildlife agencies, which are funded largely by hunters and anglers, are finding it increasingly difficult to carry out habitat management, and fish and wildlife resource conservation activities not directly linked to game species.

Table 12. Fish Species Present in the Lake Champlain Basin

Bass
- Largemouth (*Micropterus salmoides*)
- Rock (*Ambloplites rupestris*)
- Smallmouth (*Micropterus dolomieu*)

Bluegill (*Lepomis macrochirus*)
Bowfin (*Amia calva*)
Bullhead
- Brown (*Ameiurus nebulosus*)
- Yellow (*Ameiurus natalis*)

Burbot (*Lota lota*)
Carp (*Cyprinus carpio*)
Catfish, Channel (*Ictalurus punctatus*)
Chub, Creek (*Semotilus atromaculatus*)
Cisco (*Coregonus artedi*)
Crappie
- Black (*Pomoxis nigromaculatus*)
- White (*Pomoxis annularis*)

Dace
- Blacknose (*Rhinichthys atratulus*)
- Finescale (*Phoxinus neogaeus*)
- Longnose (*Rhinichthys cataractae*)
- Northern Redbelly (*Phoxinus eos*)
- Pearl (*Margariscus margarita*)

Darter
- Channel (*Percina copelandi*)
- Eastern Sand (1,4) (*Ammocrypta pellucida*)
- Fantail (*Etheostoma flabellare*)
- Johnny (*Etheostoma nigrum*)
- Tessellated (*Etheostoma olmstedi*)

Drum, Freshwater (*Aplodinotus grunniens*)
Eel, American (*Anguilla rostrata*)
Fallfish (*Semotilus corporalis*)
Gar, Longnose (*Lepisosteus osseus*)
Herring, Blueback (*Alosa aestivalis*)
Killifish, Banded (*Fundulus diaphanus*)
Lamprey
- American Brook (4) (*Lampetra appendix*)
- Northern Brook (2) (*Ichthyomyzon fossor*)
- Sea (*Petromyzon marinus*)
- Silver (*Ichthyomyzon unicuspis*)

Logperch (*Percina caprodes*)
Minnow
- Bluntnose (*Pimephales notatus*)
- Cutlips (*Exoglossum maxillingua*)
- Fathead (*Pimephales promelas*)
- Silvery (*Hybognathus regius*)

Mooneye (3) (*Hiodon tergisus*)
Mudminnow, Central (*Umbra limi*)
Muskellunge (*Esox masquinongy*)
Perch
- White (*Morone americana*)
- Yellow (*Perca flavescens*)

Pickerel
- Chain (*Esox niger*)
- Grass (*Esox americanus vermiculatus*)
- Redfin (*Esox americanus americanus*)

Pike, Northern (*Esox lucius*)
Pumpkinseed (*Lepomis gibbosus*)
Quillback (*Carpiodes cyprinus*)
Redhorse
- Greater (*Moxostoma valenciennesi*)
- Shorthead (*Moxostoma macrolepidotum*)
- Silver (*Moxostoma anisurum*)

Rudd (*Scardinius erythrophthalmus*)
Salmon, Landlocked Atlantic (*Salmo salar*)
Sauger (*Stizosledion canadense*)
Sculpin
- Mottled (*Cottus bairdi*)
- Slimy (*Cottus cognatus*)

Shad, Gizzard (*Dorosoma cepedianum*)
Shiner
- Blackchin (*Notropis heterodon*)
- Blacknose (*Notropis heterolepis*)
- Bridle (*Notropis bifrenatus*)
- Common (*Luxilus cornutus*)
- Emerald (*Notropis atherinoides*)
- Golden (*Notemigonus crysoleucas*)
- Mimic (*Notropis volucellus*)
- Rosyface (*Notropis rubellis*)
- Sand (*Notropis stramineus*)
- Spotfin (*Cyprinella spiloptera*)
- Spottail (*Notropis hudsonius*)

Smelt, Rainbow (*Osmerus mordax*)
Stickleback, Brook (*Culaea inconstans*)
Stonecat (2) (*Noturus flavus*)
Sturgeon, Lake (2,3) (*Acipenser fulvescens*)
Sucker
- Longnose (*Catosomus catosomus*)
- Northern Hog (*Hypentelium nigricans*)
- White (*Catosomus commersoni*)

Trout
- Brook (*Salvelinus fontinalis*)
- Brown (*Salmo trutta*)
- Lake (*Salvelinus namaycush*)
- Rainbow (*Oncorhynchus mykiss*)

Trout-Perch (*Percopsis omiscomaycus*)
Walleye (*Stizostedion vitreum*)
Whitefish
- Lake (*Coregonus clupeaformis*)
- Round (*Prosopium cylindraceium*)

(1)=Endangered Species NY
(2)=Endangered Species VT
(3)=Threatened Species NY
(4)=Threatened Species VT
(5)=Endangered Species Federal
(6)=Threatened Species Federal
(7)= Federal Management Concern

Source: NYSDEC, VT FWD, USFWS, 1990.

Table 13. Amphibians and Reptiles that are Known to Occur in the Lake Champlain Basin

AMPHIBIANS	REPTILES
Frog	Skink, Five-lined (2) *(Eumeces fasciatus)*
*Bull *(Rana catesbeiana)*	Snake
Gray Tree *(Hyla versicolor)*	Black Rat *(Elaphe o. obsoleta)*
*Green *(Rana clamitans melanota)*	Brown *(Storeria d. dekayi)*
*Mink *(Rana septentrionalis)*	Common Garter *(Thamnophis s. sirtalis)*
*Northern Leopard *(Rana pipiens)*	*Eastern Ribbon *(Thamnophis s. sauritus)*
*Pickerel *(Rana palustris)*	Milk *(Lampropeltis t. triangulum)*
Striped Chorus (2) *(Pseudacris triseriata)*	Northern Black Racer *(Coluber c. constrictor)*
Wood *(Rana sylvatica)*	*Northern Water *(Nerodia s. sipedon)*
*Mudpuppy *(Necturus m. maculosus)*	Redbelly *(Storeria o. occipitomaculata)*
*Newt, Eastern *(Notophthalmus viridescens)*	Ringneck *(Diadophis punctatus edwardsi)*
Peeper, Spring *(Hyla c. crucifer)*	Smooth Green *(Opheodrys v. vernalis)*
Salamander	Timber Rattlesnake (2,3) *(Crotalus horridus)*
Blue-spotted *(Ambystoma laterale)*	Turtle
Four-Toed *(Hemidactylium scutatum)*	Bog *(Clemmys muhlenbergii)*
Jefferson *(Ambystoma jeffersonianum)*	*Map *(Graptemys geographica)*
Mountain Dusky *(Desmognathus ochrophaeus)*	*Painted *(Chrysemys picta marginata)*
Red-backed *(Plethodon cinereus)*	*Snapping *(Chelydra s. serpentina)*
Spotted *(Ambystoma maculatum)*	*Spiny Softshell (4) *(Trionyx s. spiniferus)*
*Spring *(Gyrinopilus p. porphyriticus)*	Spotted *(Clemmys guttata)*
*Two-Lined *(Eurycea b. bislineata)*	*Stinkpot *(Sternotherus odoratus)*
Toad, American *(Bufo a. americanus)*	*Wood *(Clemmys insculpta)*

* = Species that make use of lake or stream habitat for breeding, feeding or seasonal movements

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Source: NYSDEC, VT FWD, USFWS, 1990.

Table 14. Birds That are Known to Occur in the Vicinity of Lake Champlain

American Avocet*	Eagle(s)	Gull, cont.
Bittern(s)	Bald (1,2,4)	Herring
American (7)	Golden (1)	Iceland
Least (7)	Egret	Ivory *
Blackbird(s)	Cattle	Laughing *
Brewer's *	Great	Lesser Black-backed
Red-winged	Snowy	Little
Rusty	Eider (Duck)	Ring-billed
Yellow-headed *	Common *	Sabine's *
Bluebird, Eastern	King *	Thayer's
Bobolink (7)	Falcon, Peregrine (1,2)	Gyrfalcon
Bobwhite, Northern	Finch(es)	Harrier, Northern (3,7)
Brant	House	Hawk(s)
Bufflehead (Duck)	Purple	Broad-winged
Bunting(s)	Flicker, Northern (7)	Cooper's
Indigo	Flycatcher(s)	Northern Goshawk (7)
Snow	Acadian	Red-shouldered (3,7)
Canvasback (Duck)	Alder	Red-tailed
Cardinal, Northern	Great Crested	Rough-legged
Catbird, Gray	Least	Sharp-shinned
Chat, Yellow-breasted	Olive-sided (7)	Heron(s)
Chickadee	Willow	Black-crowned Night
Black-capped	Yellow-bellied	Great Blue
Boreal	Gadwall (Duck)	Green-backed
Coot, American	Gnatcatcher, Blue-gray	Little Blue
Cormorant(s)	Godwit, Hudsonian	Tricolored *
Double-crested	Goldeneye (Duck)	Yellow-crowned Night
Great	Barrow's*	Hummingbird, Ruby-throated
Cowbird, Brown-headed	Common	Ibis, Glossy *
Crane, Sandhill	Goldfinch, American	Jaeger(s)
Crossbill	Goose (Geese)	Long-tailed *
Red	Canada	Parasitic
White-winged	Greater White-fronted	Jay(s)
Crow, American	Snow	Blue
Cuckoo(s)	Grackle, Common	Gray
Black-billed	Grebe(s)	Junco, Dark-eyed
Yellow-billed	Eared*	Kestrel, American
Curlew, Long-billed *	Horned	Killdeer
Dickcissel (7) *	Pied-billed	Kingbird, Eastern
Dove(s)	Red-necked	Kingfisher, Belted
Rock	Western*	Kinglet(s)
Mourning	Grosbeak(s)	Golden-crowned
Dowitcher	Blue *	Ruby-crowned
Long-billed	Evening	Kittiwake, Black-legged *
Short-billed	Pine	Knot, Red
Duck(s)	Rose-breasted	Lark, Horned
American Black	Grouse, Ruffed	Longspur, Lapland
Harlequin	Guillemot, Black *	Loon(s)
Ring-necked	Gull(s)	Common (2,7)
Ruddy	Bonaparte's	Red-throated
Wood	Glaucous	Mallard (Duck)
Dunlin	Great Black-backed	Martin, Purple

Meadowlark, Eastern (7)
Merganser (Duck)
  Common
  Hooded
  Red-breasted
Merlin
Mockingbird, Northern
Moorhen, Common
Murre, Thick-billed *
Nighthawk, Common
Oldsquaw (Duck)
Oriole(s)
  Northern
  Orchard
Osprey (2,3)
Ovenbird
Owl(s)
  Barred
  Boreal
  Common Barn
  Eastern Screech
  Great Gray *
  Great Horned
  Long-eared
  Northern Hawk
  Northern Saw-whet
  Short-eared (7)
  Snowy
Partridge, Gray
Pelican, American White*
Pewee, Eastern Wood
Phalarope(s)
  Red-winged
  Wilson's
Pheasant, Ring-necked
Phoebe
  Eastern
  Say's *
Pintail, Northern
Pipit, Water
Plover(s)
  Black-bellied
  Lesser Golden
  Semipalmated
Rail(s)
  Clapper *
  King
  Virginia
  Yellow *
Raven, Common
Redhead (Duck)
Redpoll
  Common
  Hoary
Robin, American
Ruff *
Sanderling
Sandpiper(s)
  Baird's
  Buff-breasted
  Least
  Pectoral
  Purple
  Semipalmated
  Solitary
  Spotted
  Stilt
  Upland (4,7)
  Western
  White-rumped
Sapsucker, Yellow-bellied
Scaup (Duck)
  Greater
  Lesser
Scoter (Duck)
  Black
  Surf
  White-winged
Shearwater, Greater*
Shoveler, Northern (Duck)
Shrike(s)
  Loggerhead (1,2,7) *
  Northern
Siskin, Pine
Snipe, Common
Sora
Sparrow(s)
  American Tree
  Chipping
  Clay-colored *
  Field
  Fox
  Grasshopper (7)
  Harris' *
  Henslow's (2,7)
  House
  Lincoln's
  Savannah
  Sharp-tailed *
  Song
  Swamp
  Vesper
  White-crowned
  White-throated
Starling, European
Stork, Wood *
Swallow(s)
  Bank
  Barn
  Cliff
Swallow, cont.
  Northern Rough-winged
  Tree
Swan(s)
  Mute
  Tundra
Swift, Chimney
Tanager, Scarlet
Teal (Duck)
  Blue-winged
  Green-winged
Tern(s)
  Black (7)
  Caspian
  Common (2,3,7)
  Forster's
  Least (1) *
  Sooty *
Thrasher, Brown
Thrush(es)
  Gray-cheeked
  Hermit
  Swainson's
  Varied *
  Wood (7)
Titmouse, Tufted
Towhee, Rufous-sided
Turkey, Wild
Turnstone, Ruddy
Veery (7)
Vireo(s)
  Philadelphia
  Red-eyed *
  Solitary
  Warbling
  White-eyed
  Yellow-throated
Vulture, Turkey
Warbler(s)
  Bay-breasted
  Black-throated Blue
  Black-throated Green
  Blackburnian
  Blackpoll
  Blue-winged (7)
  Canada
  Cape May
  Chestnut-sided (7)
  Connecticut
  Golden-winged (7)
  Hooded *
  Magnolia
  Mourning
  Nashville
  Northern Parula

Warbler, cont. Orange-crowned Palm Pine Prairie (7) Prothonotary * Tennessee Wilson's Worm-eating (7) Yellow Yellow-rumped Yellow-throated * Waterthrush Louisiana (7) Northern	Waxwing(s) Bohemian Cedar Wheatear, Northern * Whimbrel Whip-poor-will Wigeon (Duck) American * Eurasian * Willet * Woodcock, American Woodpecker(s) Black-backed Downy Hairy	Woodpecker, cont. Pileated Red-bellied Red-headed (7) Northern Three-toed Wren(s) Carolina House Marsh Sedge (4,7) Winter Yellowthroat, Common Yellowlegs Greater Lesser

(1)=Endangered Species NY
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(3)=Threatened Species NY
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(5)=Endangered Species Federal
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(7)=Federal Management Concern
* = Casual and Occasional
Source: NYSDEC, VT FWD, USFWS, 1990.

Table 15. Mammals That are Known to Occur in the Lake Champlain Basin

- Bat
  - Big Brown *(Eptesicus fuscus)*
  - Hoary *(Lasiurus cinereus)*
  - Indiana (1,2) *(Myotis sodalis)*
  - Little Brown *(Myotis lucifugus)*
  - Northern Long-eared *(Myotis keenii)*
  - Red *(Lasiurus borealis)*
  - Silver-haired *(Lasionycteris noctivagans)*
  - Small-footed (4) *(Myotis leibii)*
- Bear, Black *(Ursus americanus)*
- Beaver *(Castor canadensis)*
- Bobcat *(Felis rufus)*
- Chipmunk, Eastern *(Tamias striatus)*
- Cottontail
  - Eastern *(Sylvilagus floridanus)*
  - New England *(Sylvilagus transitionalis)*
- Coyote *(Canis latrans)*
- Deer, Whitetail *(Odocoileus virginianus)*
- Fisher *(Martes pennanti)*
- Fox
  - Gray *(Urocyon cinereoargenteus)*
  - Red *(Vulpes vulpes)*
- Hare, Snowshoe *(Lepus americanus)*
- Lemming, Southern Bog *(Synaptomys cooperi)*
- Marten (2) *(Martes americana)*
- Mink *(Mustela vison)*
- Mole
  - Hairytail *(Parascalops breweri)*
  - Starnose *(Condylura cristata)*
- Moose *(Alces alces)*
- Mouse
  - Deer *(Peromyscus maniculatus)*
  - House *(Mus musculus)*
  - Meadow Jumping *(Zapus hudsonius)*
  - White-footed *(Peromyscus leucopus)*
  - Woodland Jumping *(Napaeozapus insignis)*
- Muskrat *(Ondatra zibethicus)*
- Opossum, Virginia *(Didelphis virginiana)*
- Otter, River *(Lutra canadensis)*
- Pipistrelle, Eastern *(Pipistrellus subflavus)*
- Porcupine *(Erethizon dorsatum)*
- Raccoon *(Procyon lotor)*
- Rat, Norway *(Rattus norvegicus)*
- Shrew
  - Longtail *(Sorex dispar)*
  - Masked *(Sorex cinereus)*
  - Pigmy *(Sorex hoyi)*
  - Shorttail *(Blarina brevicauda)*
  - Smoky *(Sorex fumeus)*
  - Water *(Sorex palustris)*
- Squirrel
  - Eastern Gray *(Sciurus carolinensis)*
  - Northern Flying *(Glaucomys sabrinus)*
  - Red *(Tamiasciurus hudsonicus)*
  - Southern Flying *(Glaucomys volans)*
- Skunk, Striped *(Mephitis mephitis)*
- Vole
  - Meadow *(Microtus pennsylvanicus)*
  - Pine *(Pitymys pinetorum)*
  - Rock *(Microtus chrotorrhinus)*
  - Southern Red-backed *(Clethrionomys gapperi)*
- Weasel
  - Longtail *(Mustela frenata)*
  - Shorttail *(Mustela erminea)*
- Woodchuck *(Marmota monax)*

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(4)=Threatened Species VT
(5)=Endangered Species Federal
(6)=Threatened Species Federal
(7)=Federal Management Concern
Source: NYSDEC, VT FWD, USFWS, 1990.

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Protecting Wetlands

Background

Why are Wetlands Important?

The more than 300,000 acres[2] of wetlands in the Lake Champlain Basin provide a variety of important functions and values, and contribute to the overall biological diversity in the Lake Champlain Basin. Wetlands improve water quality by filtering sediments, pollutants and nutrients; provide habitat and nourishment for fish and wildlife; protect groundwater and drinking water supplies; and provide habitat for rare, threatened and endangered species and natural communities; they also stabilize shorelines and prevent erosion; provide recreational opportunities; control flooding; contribute to the aesthetic quality of the landscape; and provide educational opportunities.

During the 1970s, the Lake Champlain Basin Study, conducted by the New England River Basins Commission, identified 42 major wetlands, at least 50 acres or larger, contiguous to Lake Champlain. These wetlands support extensive wildlife and fisheries resources. In addition, the International Joint Commission's Champlain-Richelieu Board has recognized the values of shoreline wetlands and the importance of yearly fluctuations in water levels in supporting the early life stages of many organisms, such as northern pike.

Located along the Atlantic flyway, a migratory corridor for waterfowl and other wetland birds, Lake Champlain wetlands provide critical resting and feeding sites during the fall and spring migrations. Between 20,000 and 40,000 ducks and geese have been counted on flights during early October. Over 30 species of waterfowl use Lake Champlain annually, including black ducks, wood ducks, mallards, blue winged teal, common goldeneye, hooded mergansers and Canada geese.

What are the Threats to Wetlands?

Despite federal, state and local wetland protection regulations, threats to wetlands in the Lake Champlain Basin remain. Once considered wastelands, wetlands were drained and filled for agricultural, residential and commercial development. Nationally, over 50 percent of the wetlands resource base has been lost. In addition to being drained or filled for development, wetlands can be degraded from sedimentation and development of adjacent uplands, which leads to habitat fragmentation. The introduction and invasion of nuisance nonnative aquatic species such as purple loosestrife, water chestnut and Eurasian watermilfoil have also degraded wildlife habitat and native plant communities in Lake Champlain Basin wetlands. While no wetland loss

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[2]Previous estimates indicate 50,000 acres of wetlands in the Lake Champlain Basin, however, these estimates were based on inventories prior to the availability of National Wetland Inventory (NWI) maps. Based on NWI data for Vermont, over 128,000 acres of wetlands have been identified in the Vermont portion of the basin alone. Although NWI maps are not available for the entire NY portion of the Basin, wetland acreage estimated from NY wetland inventory maps indicate that there may be over 200,000 acres of wetlands in the NY portion of the Basin. The Lake Champlain Basin Program has a study underway to complete the wetland inventory maps in New York to NWI standards.

estimates exist specifically for the Lake Champlain Basin, regional trends mirror those at the national level.

Approximately 35 percent of Vermont's wetlands have been lost since European settlement. Based on project tracking information collected between 1990 and 1993, the Vermont Agency of Natural Resources estimates that between 200 and 400 acres of wetlands continue to be lost each year. A recent USEPA study concluded that wetland loss was concentrated in the Lake Champlain region, and especially in rapid growth areas such as Chittenden County, one of the most rapidly developing areas in the nation during the 1980s. The study also concluded that the loss of wetlands was incremental, with hundreds of projects involving one acre or less of alteration.

Estimates of wetland loss in the New York portion of the Basin are the same as national trends. Approximately 50 percent of wetlands in Clinton and Washington Counties have been lost or degraded. Within the Adirondack Park, less than 10 percent of the wetlands have been lost. This figure is much lower than national trends because public lands owned by the State of New York were set aside as a forest preserve over a hundred years ago.

Current Framework for Managing Wetlands

With jurisdiction ranging from the international to the local level, numerous regulatory and non-regulatory programs exist for protecting and managing wetlands in the Lake Champlain Basin. The national policy for protecting wetlands is to achieve "no net loss" of wetlands, with a long-term goal of increasing the quantity and quality of the wetlands resource base. Both Vermont and New York state programs apply similar "no net loss" policies.

International

The International Joint Commission's Champlain-Richelieu Board actively studied ways to address lake flooding during the 1970s. The Board found that significant wetland losses would occur as a result of a proposed structure to regulate water levels on the Richelieu River. Although the Board has not been active since that time, Lake Champlain experienced flooding problems as recently as the spring of 1993. Additional flooding problems may resurrect discussions about structural controls and the resulting ecological and economic consequences of regulating water levels.

Federal

A number of federal agencies protect and manage wetlands. The primary regulatory program for wetlands is jointly administered by the U.S. Army Corps of Engineers and the U.S. Environmental Protection Agency (USEPA) under Section 404 of the Clean Water Act. Although Section 404 is not a wetlands protection program per se, it regulates the discharge of dredged or fill material into waters of the U.S., including wetlands. The Section 404 program is administered in close coordination with the U.S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS). The Corps also administers Section 10 of the Rivers and Harbors Act, which prohibits unauthorized obstruction or alteration of any navigable water, including wetlands.

USEPA establishes the standards for permit applications under Section 404. These standards prohibit the issuance of a permit for projects which would cause, or contribute to, significant adverse impacts to the aquatic environment; projects where feasible, less environmentally damaging alternatives are available; and projects which would violate any applicable state water quality standard. With veto authority over Corps permit decisions, USEPA plays an important role in reviewing permits and enforcing Section 404.

In addition to participating in the regulatory programs that protect wetlands, the USFWS also maintains and enhances wetlands on lands in the National Wildlife Refuge system, including the 5,800 acre Missisquoi National Wildlife Refuge near Swanton, Vermont. The USFWS also acquires high priority wetlands using the Migratory Bird Conservation Fund and the Land and Water Conservation Fund. In addition, The USFWS Partners for Wildlife Program and the Challenge Grant Program provide funding and technical assistance for restoring wetlands on private land. The National Wetlands Inventory Program produces maps of wetlands in the United States, and is also one of the functions of the USFWS.

Two U.S. Department of Agriculture agencies are responsible for wetland management. The Farm Services Agency (FSA) administers and enforces the Swampbuster provision of the Food and Security Act of 1985. The Swampbuster provision denies federal farm program benefits to producers who convert a wetland to plant an agricultural commodity. The Swampbuster provision does not apply to wetland conversions for agricultural purposes prior to December 1985. The Natural Resources Conservation Service (NRCS) is responsible for identifying wetlands subject to the Swampbuster provision, and for granting certain exemptions. The NRCS conducts wetland delineations, notifies producers of the presence of wetlands and processes producers' appeals of NRCS delineations.

The Corps, USEPA, USFWS and NRCS, federal agencies involved in wetland determinations, developed a Federal Manual for Identifying and Delineating Jurisdictional Wetlands. The federal manual applies a three-parameter approach to delineating wetland boundaries using soils, vegetation and hydrology. The manual has undergone various revisions and has not been adopted by all of the agencies. Presently, a wetland manual developed in 1987 by the Corps of Engineers is in effect for all Federal Clean Water Act wetland determinations for Vermont and New York.

State Wetland Programs

The State of New York has been regulating wetlands under the Freshwater Wetlands Act (Article 24 of the Environmental Conservation Law) since 1975. The purpose of the Act is to "preserve, protect and conserve" freshwater wetlands consistent with the beneficial economic, social and agricultural development of the state. With the exception of the Adirondack Park, only wetlands larger than 12.4 acres, or certain wetlands of unusual local significance, are regulated. In the Adirondack Park, all wetlands larger than one acre, or adjacent to a water body, are protected. The New York Freshwater Wetlands Act also regulates activities within a 100 foot wide "buffer zone" adjacent to wetlands. In addition to Article 24, additional protection is given in New York to those wetlands annually inundated by mean high water and adjacent to navigable bodies of water under Article 15 (Protection of Waters) of the New York State Environmental Conservation Law. Wetlands in New York are delineated using New York's "Freshwater Wetlands Delineation Manual" (Final, July 1995). This manual is modeled after the 1987 and 1989 *Federal Manual for Identifying and Delineating Jurisdictional Wetlands*.

Both the New York State Department of Environmental Conservation (NYSDEC) and the Adirondack Park Agency (APA) have prepared maps of wetlands subject to their individual jurisdiction under the Freshwater Wetlands Act and the Adirondack Park Agency Act. The Freshwater Wetlands Act also requires the NYSDEC and APA to classify wetlands into four different classes according to the functions and benefits they provide, and their various characteristics and values.

Under New York's classification system, Class I wetlands provide the most critical of the State's wetland benefits, reduction of which is acceptable only in the most unusual circumstances. A permit shall be issued for work in these wetlands only if it is determined that the proposed activity satisfies a compelling economic or social need that clearly and substantially outweighs the loss of, or detriment to, the benefits of the Class I wetland. Class IV wetlands provide some wildlife and open space benefits, and may provide other benefits cited in the act. Therefore, wanton or uncontrolled degradation or loss of Class IV wetlands is unacceptable. A permit shall be issued for a proposed activity in a Class IV wetland only if it is determined that the activity would be the only practicable alternative which could accomplish the applicant's objectives (NYCRR 663.5(e)).

In New York, applicants for a freshwater wetlands permit have the option of proposing mitigation projects to enhance existing benefits provided by a wetland, or to create and maintain new wetland benefits, in order to increase the likelihood that a proposed activity will meet the applicable standards for permit issuance. New York also participates in the Federal Permit program by preparing Section 401 Water Quality Certifications where activities subject to Federal Permits influence the quality of the water in wetlands and adjacent surface waters of the State.

The Vermont Wetlands Act was enacted in 1986 (10 V.S.A. Chapter 37 §905(a)(7-9), establishing the statutory framework for identifying and protecting Vermont's wetlands. The Act authorized Vermont's Water Resources Board to adopt rules which apply to those wetlands which are "so significant that they merit protection." The Board has subsequently adopted the Vermont Wetland Rules which became effective in February, 1990. The Vermont Wetland Rules establish a three-tier classification system for wetlands. Classification is based on the significance of wetland functions, and reflects the level of protection a wetland receives under the rules. Class one wetlands are those determined by the Board to be "exceptional and irreplaceable" based on a functional assessment. They are protected by a minimum 100 foot buffer zone, and criteria for mitigating impacts are stringent. All palustrine wetlands and contiguous wetland areas identified on National Wetland Inventory maps (other than Class one wetlands) are designated Class two. These are protected by a 50 foot buffer zone. Class three are not protected under the rules, either because they are not on NWI maps, or the Board has determined they are not significant.

Wetland boundaries are determined in the field using the 1989 version of the *Federal Manual for Identifying and Delineating Jurisdictional Wetlands*. The Board may act on petitions to change the classification of a wetland or to change the width of a buffer zone, based on an evaluation of the wetland's functions. The Vermont Wetland Rules contain a list of allowed uses which do not require further review providing there is no draining, dredging, filling, grading or alteration of water flow. All other uses are conditional uses, and are prohibited in significant wetlands and their adjacent buffer zones unless the Secretary of the Agency of Natural Resources approves a conditional use determination. Wetlands also receive protection under Act 250, Vermont's development control law. Major developments and subdivisions must meet requirements for water quality, shoreline protection, wetlands and rare or irreplaceable natural areas. The Vermont Agency of Natural Resources also participates in the federal permit program by preparing Section 401 water quality certifications where activities subject to federal permits influence the quality of water in wetlands.

In 1992, the Agency of Natural Resources began work on a Vermont Wetlands Conservation Strategy. A draft strategy, released in April, 1994, reviewed wetland conservation programs in the state, assessed strengths and weaknesses of wetland programs, and identified actions for public and private organizations. Ninety-five individuals, businesses and organizations are participating in the project.

Through acquisitions in the Champlain Valley since the 1940s, the State of Vermont has established 12 Waterfowl and Wildlife Management Areas. Mud Creek, Black Creek (St. Albans), Fairfield Swamp, Sandbar Refuge, Intervale Marsh, Half Moon Cove-Derway Island, Little Otter Creek, Lower Otter Creek, Dead Creek, Whitney-Hospital Creek, and East Creek are all Waterfowl and Wildlife Management Areas. New York State has had a similar acquisition program in the Champlain Valley. Since the late 1940s, New York has established waterfowl and wildlife management areas at Kings Bay, Monty's Bay, Lake Alice, R. Lewis Preserve, Ausable Marsh, Wickham Marsh, Putts Creek, the East Bay on the Poultney River, and Dunham's Bay on Lake George.

Regional and Local

Regional organizations are also involved in wetland protection programs. For example, the Winooski Valley Park District is involved with management, ownership and protection of wetlands along the Winooski River. The Park District is also involved in wetland education programs. They developed an interpretive trail through wetlands in Burlington's Intervale Marsh, and recently received a grant from the Lake Champlain Basin Program to develop a mobile exhibit to educate the public about the importance of wetlands.

With a grant from the USEPA, the Chittenden County Regional Planning Commission in cooperation with the Agency of Natural Resources, developed a guidance document to assist Vermont communities in planning and protecting wetlands. Recognizing the value of local wetlands protection, the document includes a step-by-step approach for communities to plan for and protect wetlands. A pilot project was conducted in five Chittenden County communities which were in the process of updating town plans. These communities received technical assistance in developing detailed wetland inventories, evaluating wetland functions and values, and drafting wetland protection provisions in their plans and zoning by-laws. Specific examples of planning and zoning language from these projects is provided in the guidance document.

Private

Many private organizations protect and manage wetlands in the Basin. The Nature Conservancy's Vermont, Adirondack and Eastern New York Chapters, as well as the Vermont Land Trust, Adirondack Land Trust, Lake Champlain Islands Trust, and Ducks Unlimited protect shorelines, wetlands and wetland buffers by acquisition of lands in fee title, and by acquisition of permanent conservation easements.

Lake Champlain Wetland Protection Programs

Wetland Inventories

With funding from the Lake Champlain Basin Program, the New York State Department of Environmental Conservation, in cooperation with the National Wetlands Inventory, undertook a project in 1994 to complete wetland inventory maps for the New York portion of the Lake Champlain Basin. Prior to this effort, freshwater wetland inventories in the State of Vermont and within portions of the Adirondack Park have been mapped to National Wetlands Inventory

(NWI) specifications and standards. NWI maps are accurate at identifying wetlands within a three to five acre threshold, and can identify certain wetland types down to a one acre threshold. Outside of the Adirondack Park in New York, the Department of Environmental Conservation has prepared wetland inventory maps for regulatory purposes. The New York regulatory maps include only those wetlands which are 12.4 acres and larger. For fifteen USGS quadrangles (approximately 540 square miles) in the Lake Champlain Basin, no wetland inventory maps exist. The project currently underway will fill in these data gaps and digitize maps into GIS.

Advance Planning

Based on the results of a study which indicated a rapid rate of wetland loss in the Vermont portion of the Lake Champlain Basin, EPA Region 1 Wetlands Section, in cooperation with the Vermont Agency of Natural Resources, undertook an advance planning project in a 26 town area. The project involves a mapping component using satellite imagery and GIS, and a field evaluation component, to identify valuable wetlands in need of further protection. The Natural Heritage Program in the Agency of Natural Resources received a grant from EPA to identify wetlands which support rare species, and rare and outstanding wetlands in Chittenden County. The Heritage Program's work will enhance the advance planning project. The mapping and field evaluation components of the project are now complete. During the next phase of the project, actions will be taken using existing authorities at the federal, state and local level to provide more effective wetlands decisions in the study area.

Lake Champlain Wetland Acquisition Strategy

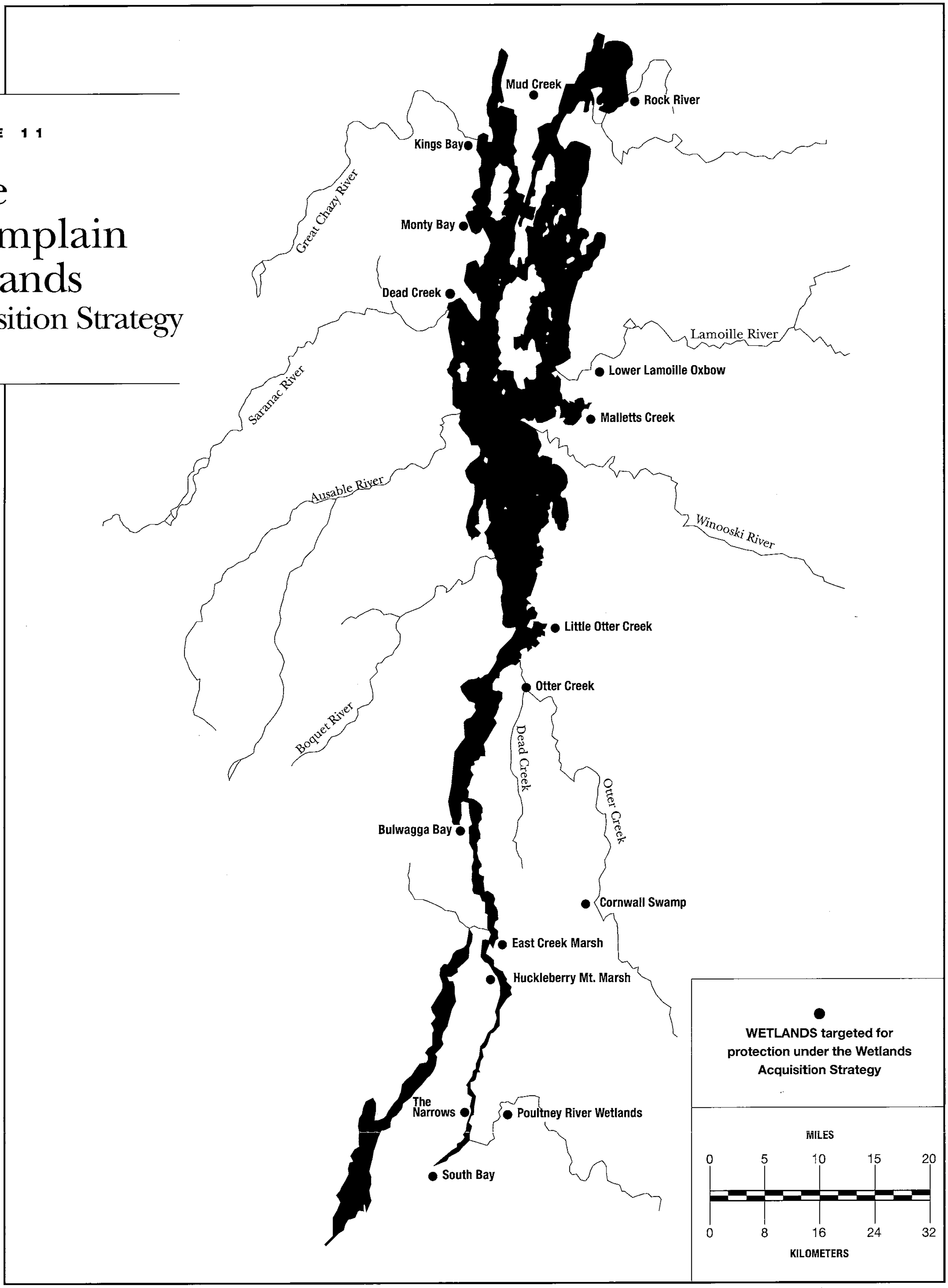
The Lake Champlain Basin Program sponsored a project to develop a wetlands acquisition strategy for important Lake Champlain Basin wetlands. After several years of working to acquire wetlands in the Basin considered to be ecologically significant based on fish and wildlife habitat values, the Vermont Agency of Natural Resources, New York State Department of Environmental Conservation, The Nature Conservancy and Adirondack Park Agency came together to pursue a cooperative approach to wetland protection, and formed a Lake Champlain Wetlands Acquisition Study Committee. In 1991, the Vermont Chapter of The Nature Conservancy, working with the study committee, began the process of identifying the highest quality wetland sites in the Champlain Valley (Figure 11). A four phase, multi-year strategy to permanently protect almost 9,000 acres of wetlands in the Champlain Valley was developed. The strategy will be used to apply for funding from the North American Wetland Conservation Act. The USFWS administers this funding program, which supports implementation of the North American Waterfowl Management Plan. Over $600,000 of funding has been approved for the first phase of the strategy, which will protect 1,500 acres of wetland at 10 sites in New York and Vermont. The Adirondack, Eastern New York and Vermont Chapters of The Nature Conservancy will take the lead in coordinating the acquisition project, and in applying for future funding.

Lake Champlain Wetlands Restoration Project

A pilot project to restore previously drained wetlands in the Lake Champlain Basin began in 1993. The project, modeled after the USFWS Partners for Wildlife program, is a joint effort between New York State Department of Environmental Conservation, Vermont Agency of Natural Resources, USDA Soil Conservation Service and U.S. Fish and Wildlife Service. The project provided funding and technical assistance to willing landowners for wetland restoration. The current project is expected to restore between 100 and 525 acres of wetlands, depending upon individual site conditions.

FIGURE 11

Lake Champlain Wetlands
Acquisition Strategy



Source: Binhammer, 1994

Issues

Updating Wetland Inventories

The air photos used to create National Wetland Inventory maps in portions of the Lake Champlain Basin are nearly 20 years out of date. No program exists to update maps and monitor changes in the distribution of wetlands over time. Such a program could be implemented using existing land cover data, satellite imagery and other technologies along with an appropriate ground-truthing effort.

Consistent and Coordinated Approach to Wetlands Regulation

Wetlands regulation under section 404 has been one of the most controversial aspects of the debate regarding the Clean Water Act reauthorization. The debate has focused on several issues: 1) use of the *Federal Manual for Identifying and Delineating Jurisdictional Wetlands*, 2) multiple wetland definitions, 3) use of wetland ranking and classification, 4) wetland mitigation, and 5) consistent permit review.

In the Lake Champlain Basin, wetlands are managed by multiple agencies and multiple divisions within agencies. For example, the Basin falls within two districts or regions of the Corps, USEPA, NRCS and FSA. In New York, the Adirondack Park Agency and the Department of Environmental Conservation regulate wetlands. In New York and Vermont, federal and state agencies have regulatory jurisdiction over freshwater wetlands. The need for establishing a more uniform approach to wetlands management has been raised as an issue in the Lake Champlain Basin. A range of options could be considered for improving coordination and consistency, ranging from the simple exchange of information to a more dramatic reform of the regulatory process. This topic alone may have the greatest potential for elevating the discussions in the Lake Champlain Basin to the national debate over reauthorization of the Clean Water Act. The Lake Champlain Basin has the opportunity to serve as a national model for managing of wetlands within a watershed boundary. Some issues that would need to be addressed in considering the feasibility of a consistent and coordinated approach to regulating wetlands in the Lake Champlain Basin are: 1) consistent use of the three-parameter approach in the Federal Manual to delineating wetlands in the Basin; 2) individual federal agencies, New York and Vermont all use different wetland definitions; 3) in ranking wetlands, New York uses a four-tier classification system, Vermont uses a three-tier classification system, federal agencies do not classify wetlands for regulatory purposes, and techniques used to evaluate wetland functions are different for each agency; 4) both federal and state agencies allow for wetland mitigation, but apply different policies in their regulatory review processes; and 5) permit review among federal agencies is coordinated but is a separate process from the states. Interstate coordination of regulatory programs is also difficult because of differences in state wetland protection laws. For example, the level of wetlands protection between the Vermont program and the Adirondack Park Agency is only similar relative to the New York regulatory program outside of the Adirondack Park, where only wetlands over 12.4 acres in size are regulated.

Mitigation Banking

Mitigation banking is a form of compensatory mitigation completed in anticipation of offsetting unavoidable impacts from future projects. If carefully controlled, it can offer positive opportunities for market-based wetland regulation. Mitigation banking consists of treating wetland impacts as debits, and wetland creation, restoration and enhancement as credits. Any mitigation banks should be established in advance of wetland impact activities, and should be located in the watershed where permitted activities would occur. Careful monitoring, record-keeping and standardization of mitigation measures are all important considerations for a viable mitigation banking program. Although mitigation banking is being explored as an option in both New York and Vermont, it is not consistent with current state policy in other states. The Natural Resources Conservation Service has an active mitigation banking program in Vermont for agricultural lands which are exempt from the Vermont Wetland Rules.

Acquisition and Restoration Programs

The acquisition and restoration programs currently underway in the Basin are an important non-regulatory approach to wetlands protection and conservation. The acquisition project provides an opportunity to systematically acquire some of the Champlain Valley's most valuable wetlands, based on habitat considerations, and their adjacent buffer zones. The restoration project is an incentive program which has been very well received in other parts of the country. Securing funds will be critical to the success of these non-regulatory programs.

Local Watershed Approaches

Wetlands protection can be enhanced and the permitting process improved by promoting local watershed approaches to wetlands protection. Watershed approaches also provide an opportunity to address cumulative impacts of wetland loss. Effective planning at the sub-watershed level can help protect wetlands in advance of permit applications. Watershed approaches also can increase public awareness about wetland values, and improve wetlands protection, while providing more certainty and direction to the development community in the permitting process.

An advance planning project is currently underway in the Vermont portion of the Basin. The pilot project will produce wetland inventory information which can be used by state and local agencies to improve wetlands conservation and predictability for landowners. The effectiveness of this approach should be assessed for applicability to other parts of the Basin.

Funding

Funds for wetland protection and restoration are scattered in several places in federal and state budgets. Both federal and state funding for wetlands programs are very limited and need to be enhanced.

Research Needs

The Lake Champlain Research and Monitoring Workshop in 1991 identified the following research priorities: 1) compile existing data on wetlands and critical habitats; 2) conduct surveys of biota found within the Lake Champlain Basin wetlands; 3) investigate best stewardship methods to protect priority habitats from future degradation; 4) study the role wetlands play in providing important functions; 5) identify economic value of Lake Champlain wetlands; 6) assess the effects of nuisance nonnative aquatic species on wetlands functions and values; 7) determine the role of natural water level fluctuations in the maintenance and health of Lake Champlain wetlands; and 8) assess the potential impacts of zebra mussels on the functions of Lake Champlain wetlands. Other research needs identified at the workshop include: 1) assess cumulative losses of wetlands in the Lake Champlain Basin; 2) assess successes and failures of mitigation projects; 3) investigate the use of created wetlands for tertiary treatment of wastewater and water quality improvement; and 4) investigate potential financial incentives and tax structure changes to protect wetlands.

Public Education

Wetland education programs are needed to improve the public understanding of the importance of wetlands and the programs designed to protect wetlands. The public also needs information about how to take individual action and participate in the stewardship of this important resource.

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Managing Nuisance Nonnative Aquatic Species

Background

What are Nuisance Nonnative Aquatic Species?

Nonnative aquatic plants and animals that become established in the Lake Champlain Basin can pose serious threats to native fish and wildlife and impede recreational activities. In some cases, they can have substantial negative ecological and economic impacts. These species, labeled "nuisances," enter the Lake Champlain Basin through the Champlain Canal, the Richelieu River, and over land through boat and bait transport.

The majority of nonnative species introductions into the Lake Champlain Basin are associated with introductions that occur in the St. Lawrence-Great Lakes ecosystem. Many nonnative species have been inadvertently introduced to the Great Lakes region through transatlantic shipping practices. Interconnected waterways then enable the nonnative aquatic species to disperse into other ecosystems including Lake Champlain. This process is often facilitated by human activities, particularly boat and barge traffic. Plants and animals in various stages, can be transported while attached to boat engines, hulls or equipment, or while trapped in the water of boat bilges, engine cooling systems or live wells. Once nuisance species are introduced to the Basin, such activities can facilitate dispersal to other locations throughout the Basin. The intentional use of nonnative aquatic animals for bait may also help their spread to and within the Basin.

Some of the most commonly encountered nuisance nonnative aquatic species in and around Lake Champlain include Eurasian watermilfoil, water chestnut, purple loosestrife, flowering rush, common reed, and sea lamprey. White perch, European rudd, and gizzard shad are recent nonnative fish introductions that could become nuisances. Great water cress, slender-leaved naiad, yellow floating heart, and curlyleaf pondweed are potential nuisance plant species. Zebra mussels, a very recent invader to the Lake Champlain aquatic ecosystem, have already had dramatic effects in other parts of the United States, particularly the Great Lakes.

Strategies for controlling, eliminating or preventing nuisance nonnative aquatic species in the Lake Champlain Basin currently exist only for sea lamprey, Eurasian watermilfoil, water chestnut, and zebra mussels. Actions that prevent the introduction of nonnative plants and animals that are not yet established in the Basin but are found in nearby areas such as the Great Lakes, may be appropriate. However, management is complicated by a general lack of knowledge about ecosystem characteristics and about how introduced species might affect the ecosystem. Is the nonnative species displacing native species by taking over their habitats? If it excludes or eliminates a native species, what will the effects be on the rest of the food web? Because of these unanswered questions, managers are forced to use a "species-by-species" approach to remediation and control of nuisance nonnative aquatic species.

This section addresses nonnative species that pose, or potentially pose, a threat to the ecological makeup of aquatic communities of the Lake Champlain Basin. Descriptions of these species follow, and will be continually updated as new information becomes available. Nuisance aquatic species considered native to the Basin are addressed in the section on **Managing Fish and Wildlife.**

Nuisance Nonnative Aquatic Animals and Control Programs in the Lake Champlain Basin

Sea Lamprey

Sea lamprey are parasitic marine invaders that are believed to have entered Lake Champlain via the Champlain Canal. They first became a noticeable problem in Lake Champlain in the 1970s when Vermont and New York state biologists attempted to reintroduce landlocked salmon and lake trout to the Lake. Adult sea lamprey spawn in several of the Lake's tributaries, leaving nonparasitic larvae (ammocoetes) to remain in stream sediments for several years until they transform into the adult form, at which point they migrate to the Lake to prey on fish. Attacks by adult sea lamprey on salmon, lake trout, and other fish species have limited the full development of a Lake Champlain fishery, and restricted recreational and associated economic opportunities.

Efforts are underway to reduce sea lamprey populations in the Lake as part of an experimental control program initiated in 1990. Control strategies currently include the use of the lampricides 3-trifluoromethyl-4-nitrophenol (TFM) in 13 streams, and Bayer 73 on five tributary deltas. Survey and monitoring efforts currently underway include U.S. Fish and Wildlife Service (USFWS) sea lamprey larval surveys and adult nest counts, and salmonid lamprey wounding analysis by New York State Department of Environmental Conservation (NYSDEC) and Vermont Department of Fish and Wildlife (VT FWD) fisheries personnel in conjunction with Lake Champlain salmonid assessments. The Lake Champlain Basin Program has also provided funding to repair an old barrier dam to reduce sea lamprey colonization in Lewis Creek, Vermont, and to make the existing Waterworks Dam on the Great Chazy River in New York impenetrable to sea lamprey. Installation of this physical control on the Great Chazy River will alleviate the need for chemical sea lamprey treatment on 14 of the 21 miles now treated on this river.

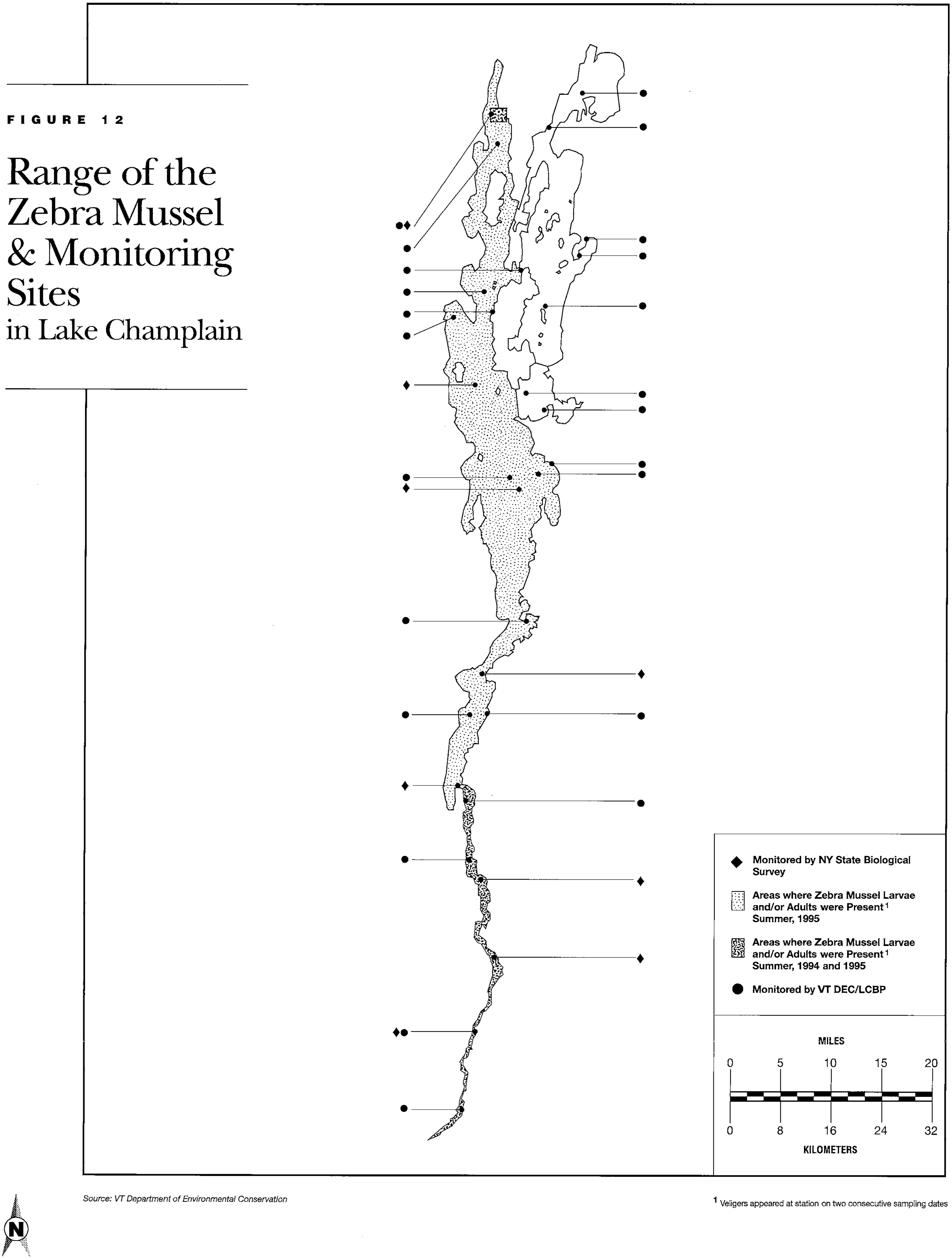
Zebra Mussel

The zebra mussel is a small freshwater mollusk native to the Caspian and Black sea regions of Eurasia. They are thought to have been transported to North America in the ballast tanks of ships, and were first discovered in the Great Lakes in 1988. Since then, the mussels have spread to other waters throughout much of the eastern half of North America. In 1993, adult zebra mussels were found in the southern portion of Lake Champlain. By the end of 1994, they had spread approximately eighty miles beyond their 1993 range, and adult colonies were found as far north as Alburg, Vermont. In 1995, zebra mussel reproduction was extremely high in the south portion of the Lake with mussel larvae densities reaching as high as 110,000 per cubic meter of water. Adult and larvae densities increased substantially in other portions of the Lake in 1995 as well (See Figure 12).

Planktonic zebra mussel larvae can be transported in bait buckets, bilge water, and engine cooling systems. Once settled on a hard surface, the mussels grow rapidly, with adult colonies reaching densities of up to 750,000 mussels per square meter. One year after their arrival, zebra mussels clogged the intake pipes and shut down a municipal water facility on Lake Erie in Michigan. Zebra mussels also foul boat hulls and engines, cover recreational beaches and the Lake bottom, and obscure underwater archeological artifacts. These combined impacts have

FIGURE 12

Range of the Zebra Mussel & Monitoring Sites
in Lake Champlain



Source: VT Department of Environmental Conservation

[1] Veligers appeared at station on two consecutive sampling dates

resulted in millions of dollars of damage and lost revenues. Zebra mussels may also have long-term effects on the aquatic food chain by disrupting the food base of fish and fish-eating birds and mammals. Since water intake pipes are an ideal habitat for the zebra mussel, commercial, industrial, and private lake water users are likely to be adversely affected in the near future by the invasion of the zebra mussel in Lake Champlain.

Zebra mussel studies have yet to yield effective strategies for controlling zebra mussel populations within waterbodies. Consequently, management actions have focused on controlling the mussels' attachment to surfaces and water intake pipes and preventing further spread. Ecosystem impacts from zebra mussel infestations are also not well understood, but information from the Great Lakes and Europe may offer some understanding of possible effects.

In 1993, the Vermont Department of Environmental Conservation (VT DEC), with support from the Lake Champlain Basin Program (LCBP), initiated efforts to monitor the extent and distribution of zebra mussel infestation, and to study zebra mussel impacts on native mussels and other macroinvertebrates in Lake Champlain (See Figure 12). A multi-disciplinary study (Vermont Zebra Mussel Study Committee), conducted by the Vermont Agency of Natural Resources (VT ANR) to study threats from zebra mussels and develop strategies to minimize potential problems, presented its findings and recommendations in January 1994. The study recommended that VT DEC continue to monitor the spread of zebra mussels within Lake Champlain by expanding its existing zebra mussel programs. It also recommended that the VT ANR coordinate and implement a comprehensive education and outreach program for zebra mussels (VT ANR, 1994). The LCBP began a zebra mussel education and outreach effort in 1992 by posting zebra mussel informational signs at all Lake Champlain boat accesses, preparing public service announcements, distributing mussel identification cards and fact sheets, and giving presentations to many schools and groups. In 1994, education and outreach for zebra mussels was assumed by the VT DEC. An Education and Outreach specialist coordinates this effort for the entire Basin with support from the LCBP. Finally, the Safe Drinking Water Act was recently amended to include a provision for federal funding to local communities for the installation of zebra mussel controls.

Potential Nuisance Nonnative Aquatic Animals

Several nonnative aquatic animal species have become established in the Basin which are not yet perceived as nuisances. White perch, a marine invader, has been present in the Lake for several years, and may displace yellow perch populations. Gizzard shad, a plankton-eating fish, has recently been identified in Lake Champlain, and is known to have displaced important forage species in other areas. European rudd, a species often sold as bait fish, is also present in the Lake. Little is known about the potential impacts of these new invaders in the Lake Champlain Basin.

In addition to the nuisance nonnative animal species already present, there are very real threats of invasion by several species that are causing problems in other areas, including the ruffe, alewife, quagga mussel, rusty crayfish, round goby, and spiny water flea.

Nuisance Nonnative Aquatic Plants and Control Programs in the Lake Champlain Basin

Eurasian Watermilfoil

Eurasian watermilfoil was first discovered in Lake Champlain in 1962 and now exists in many areas throughout the Lake and Basin. Eurasian watermilfoil displaces other aquatic plants, is of little food value to wildlife, and, if conditions are suitable, can form dense mats which change habitat and interfere with recreational activities. Infestations are severe in some areas. Detailed watermilfoil surveys have been conducted for many of Lake Champlain's bays, and for 34 other lakes within the Basin. Infestations in some lakes within the Basin are well documented, but many other waters have had little or no study regarding the presence and extent of infestation.

Eurasian watermilfoil is spread primarily by plant fragments transported by waves, wind, currents, people, and, to some extent, animals. If milfoil problems are identified, periodic surveys are necessary to track the spread of this nuisance species and develop effective control programs. Currently, annual monitoring of changes in milfoil populations is limited to lakes with ongoing control programs.

Although there is no easy method of controlling Eurasian watermilfoil, control mechanisms that have been employed in the Basin include mechanical harvesting, diver-operated suction harvesting, hydro-raking, installation of bottom barriers, lake level draw-down, fragment barriers, and hand-pulling. The VT DEC currently oversees management programs for Eurasian watermilfoil on several lakes within the Basin. The programs are funded by a grant from the Army Corps of Engineers, and from state and local funds. The VT DEC is also assessing the effectiveness of biological milfoil control by aquatic weevils in two lakes within the Basin. Within Lake Champlain itself, hand-pulling and installation of bottom barriers are presently the most common control techniques used.

Water Chestnut

Water chestnut was first documented in Lake Champlain in the 1940s. Like Eurasian watermilfoil, water chestnut displaces other aquatic plant species, is of little food value to wildlife, and forms dense mats which change habitat and interfere with recreational activities. Water chestnut is spread primarily through seed dispersal. While there has been no detailed survey of the extent of water chestnut in the Lake Champlain Basin, populations are established as far north in the Lake as Ferrisburgh, Vermont, and have spread to a few other lakes in the Basin. Extensive populations are limited to southern lake Champlain where growth severely restricts boat traffic and other recreational uses.

Although there is no easy method of controlling this nuisance aquatic plant, mechanical harvesting and hand-pulling of the water chestnut has been conducted since 1982. The goal of this effort is to reduce the infestation in Basin waters and limit the spread of the plant to other areas in and outside of Lake Champlain. The LCBP has recently contributed funding to this effort which was originally funded through the U.S. Army Corps of Engineers. New efforts by the VT ANR have been initiated in Lake Champlain and other infested waterbodies; however, budget constraints in recent years have prevented adequate control of existing growth, and water chestnut has continued to spread.

Purple Loosestrife
Purple loosestrife has been present in New England for almost 100 years. Loosestrife displaces native wetland species and provides few benefits for wildlife. Because the colorful flower is aesthetically pleasing, people have sometimes intentionally spread this plant to new sites. The extent of the purple loosestrife invasion has not been well documented in the Basin. Experimental releases of insects that destroy the roots or eat the leaves of purple loosestrife, currently underway at Cornell University, might prove useful as a control mechanism in the Lake Champlain Basin. Organized efforts to control purple loosestrife in the Lake Champlain Basin have been limited to chemical herbicide use in the Missisquoi National Wildlife Refuge Area.

Flowering Rush
There is currently no effort to control this nuisance aquatic plant, which has been present in Vermont since at least 1929. This species, native to Eurasia, is commonly found in marshes, and along the shores of Lake Champlain. In southern Lake Champlain, dense stands appear to be crowding out native species in localized areas.

Common Reed
Another Eurasian native, common reed is a very competitive plant and is able to drive out native wetland species. It is also of little value to wildlife. Although widely scattered throughout New York and Vermont, the extent of the common reed invasion has not been well documented. There is currently no effort to control this species.

Potential Nuisance Plants
Yellow floating heart has been identified in southern Lake Champlain, and can infest shallow areas. Curlyleaf pondweed, present in Lake Champlain and a number of other lakes in the Basin, has the potential to become more problematic in dense concentrations. Slender-leaved naiad and great water cress are both in Lake Champlain, and have the potential to become problematic. Other species that have not yet been found in the Basin, but that could become nuisances if introduced include but are not limited to: fanwort, hydrilla, variable-leaved watermilfoil, parrot's feather, Brazilian elodea, and frog's bit.

The Status of Current Management Programs
As stated above, current efforts to manage specific nuisance nonnative aquatic species are underway by the USFWS. VT FWD, VT DEC, and NYSDEC. Additionally, the LCBP has funded several demonstration projects, including an electric field barrier feasibility study on the Champlain Canal. The barrier would potentially exclude nonnative aquatic organisms (primarily fish) although the effectiveness and safety is unproven at this point, and costs would be high. The NYSDEC's Division of Fish and Wildlife has also developed a nonnative aquatic species management plan in response to a directive of the New York Legislature (Chapter 456 of the laws of 1991) and in keeping with the Federal Nonnative Aquatic Nuisance Prevention and Control Act of 1990 (Public Law 101-646). NYSDEC was recently awarded a grant to implement a portion of the plan.

Issues

The following section outlines some of the major technical and policy issues involved with managing and preventing nuisance nonnative aquatic species in the Lake Champlain Basin.

Limitations of Current Information

There is a lack of knowledge concerning the presence and extent of several nuisance nonnative aquatic species found in the Basin, and little is known about their impact on indigenous species and habitats. Adequate information is essential to formulating management strategies, and must be based on surveys and monitoring programs. Technical information, such as basic research on the population biology of nonnative aquatic species, studies of effects, and demonstrations of technologies for their exclusion, reduction or elimination, are all necessary but lacking the components of an effective management strategy. Coordination with research and management efforts in other areas outside the Basin is also limited. Technology and information are necessary to prevent the unwanted invasion or spread of these species.

Challenges Facing Management Efforts

Comprehensive management plans do not currently exist for the control, elimination or exclusion of species other than sea lamprey, Eurasian watermilfoil and water chestnut. A cooperative approach among agencies, states and Quebec is needed. Upgrading and enforcing existing regulations, and creating new regulations to control the spread of nuisance nonnative aquatic species should also be considered. Coordination between management agencies is necessary for the success of any comprehensive plan to manage and prevent nuisance nonnative aquatic species in the Lake Champlain Basin.

Educational Needs

Education is paramount for public understanding of Basin species biology, for employment of coping strategies, and for enlisting the public in possible control and spread prevention programs. Effective long-term education and outreach programs about nuisance nonnative aquatic species must be developed and implemented.

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Chapter 4. The Human Component

The human history of Lake Champlain and its Basin is long and varied. Spanning more than 10,000 years, it includes Native American settlements, early Euro-American settlement, French and British exploration and occupation, numerous and pivotal military conflicts, and a dynamic period of commercial development in the 19th century. Today's Basin residents continue to enjoy the natural beauty of the Lake and depend on the Basin's rich resources for their livelihoods. Only through planning for this watershed can we ensure that the Lake will be preserved for future generations to use as our ancestors did.

Residents of the Basin have left behind rich cultural heritage resources, including historic structures and settlements, cultural landscape resources such as agricultural landscapes, archeological resources both on land and underwater, and Native American cultural properties. Many cultural sites are concentrated along the lakeshore and tributary waterways, where historic and prehistoric archeological resources include ancient and historic Native American villages, campsites and cemeteries. There is also rich evidence of early Euro-American settlements, and industrial, commercial, and military sites, including the recently discovered historical remains of a stone wall at Crown Point built by the French during the French & Indian War. Lake Champlain has perhaps the best preserved and intact collection of historic shipwrecks and submerged artifacts in the United States. Remnants from these times provide a context and sense of place to people enjoying the Lake today.

The Lake also provides a multitude of recreational opportunities to individuals and families in the area, and to tourists who come to take advantage of the Lake's natural beauty and recreational opportunities, including swimming, biking, skiing and hiking. Many types of boating, particularly motorboating, sailing, canoeing, jetskiing and kayaking, are also popular on the Lake and in some areas the increasing number of boats in the past decade is creating congestion, conflicts between users, and possible safety concerns. The Lake supports a large sport fishing community as well. Many Basin residents fish year-round, and many others travel to the Lake and its tributaries in summer months to fish and participate in events such as the Lake Champlain International Fishing Derby.

The lives of those who live within the Basin, and particularly along the shoreline, are inextricably connected to the Lake. Tourists attracted to the Lake and the services they need are also important to the area's economy. The lowlands of the Champlain Valley support many dairy farms, contributing to the rural character of the Basin, and farmers are being encouraged to implement sometimes costly management practices to minimize runoff and maintain water quality. Watershed planning efforts funded by the Lake Champlain Basin Program, especially those spearheaded by local entities such as Friends of the Mad River and the Boquet River Association, are working to maintain this diversity of land uses and protect water quality. Supporting human uses of the Lake and its watershed while also protecting the resource for future generations is often a challenge. In this Chapter, these issues are organized into the following topics: Managing Recreation; Protecting Cultural Heritage Resources; Building Capabilities for Cooperative Watershed Planning and Protection; and Educating and Involving the Public.

Managing Recreation

Background

The Importance of Recreation on Lake Champlain

Lake Champlain is a significant natural resource offering a diversity of four-season recreational opportunities for Basin residents and visitors each year. Fishing, swimming, boating, kayaking, sail boarding, scuba diving, skating, ice sailing, snowmobiling, hunting, trapping and cross-country skiing are just a few of the activities enjoyed on the Lake. In addition, the Lake is enjoyed through shoreline activities such as biking, hiking, camping, picnicking, sight-seeing, bird watching and photographing, among others. Lake Champlain is an invaluable recreational resource, rich in cultural heritage and scenic beauty.

Recreation is also an important part of the local economy. Total tourism-related expenditures in the Basin were estimated at **$2.2 billion** in 1990. Seventy-one percent of this total came from activities in Vermont ($1.6 billion), with 29% from activities in New York ($638 million). In comparison, the Basin produced roughly **$2.8 billion** in manufacturing, **$4.5 billion** in total retail sales, and **$1.8 billion** in the service industry during 1991 (Holmes and Associates, 1993). These figures show the important effect tourism and recreation have on the Basin's local economy.

Recreational Problems on Lake Champlain

Although recreation in Lake Champlain and its Basin is considered highly desirable, both the quality of recreational experiences and the Basin's natural, cultural and historic resources are being threatened by increasing recreational use in specific areas of the Lake. A number of important issues need to be addressed to provide and maintain high quality recreational experiences into the future. These issues include: inadequate public access; increases in the number and types of recreational conflicting uses; safety and enforcement concerns; the degradation of resources; and lack of planning for tourism.

Many of the Lake's recreational issues do not apply to the Lake as a whole. Because Lake Champlain is such a large lake, with various concentrations of settlement along its shoreline, different issues exist in different areas, and at different levels. This section considers ways to alleviate problems in areas of concern while preserving, protecting and enhancing those areas and uses considered optimum or desirable.

Research to date on public access and water-based recreation issues has generally been confined to Lake Champlain and its shorelines. Therefore, for these issues, the focus of this section is on the Lake itself (and adjacent land) and not on the Basin as a whole. However, for other issues, such as exploring the advantages and implications of tourism promotion and the stewardship of natural, cultural and historic resources, the focus is on the entire watershed.

Much of the information in this section is based on an extensive planning and public involvement process resulting in five technical reports described below:

Lake Champlain Boat Study (Bulmer, 1993), Technical Report No. 1. This study used aerial photographs to assess the number, types, and patterns of boats on Lake Champlain on a sunny weekend day in July 1992. Although it is only a snap-shot of boating use, it provides evidence that boat numbers have indeed increased when compared to a similar study performed in 1980.

Lake Champlain Recreation - Public Involvement (Smith, 1994), Technical Report No. 2. This is a comprehensive overview of the public involvement process and its findings pertaining to recreation on Lake Champlain to date. The report includes a summary of issues and concerns obtained from three workshops and over 50 meetings held with a diversity of recreation user groups, shoreline towns and the general public mainly on the Vermont side of the Lake.

Lake Champlain Recreation - User Surveys (Dziekan, 1995), Technical Report No. 3. This is an assessment of the needs and perceptions of Lake users, current types and levels of use, the economic impacts of recreational use, and user characteristics. A total of nine surveys were conducted with a variety of Lake users during the winters and summers, 1991-1993. Over 12,000 copies of these surveys were distributed to various types of recreationists on and around Lake Champlain.

Lake Champlain Recreation - Resources Inventory (Farnum, 1995), Technical Report No. 4. This is a comprehensive inventory of recreational facilities, opportunities and resources within a three mile buffer of the Lake Champlain shoreline.

Lake Champlain Recreation Assessment Report (Dziekan and Smith, 1995), Technical Report No. 5. This document synthesizes recreation research results and provides recommendations for action.

Past management efforts confirm that the issues as now defined fit a pattern of increasing concern. As far back as 1973, people recognized that increased use of the Lake *in some areas* was creating problems with overcrowding at access sites, conflicts among different user groups, shoreline protection and boating safety. Background on each of these problems is presented below.

Need for Expanding and Enhancing Public Access

Lake Champlain and its surrounding natural, cultural and historic resources provide an abundance of recreational opportunities. Public access to the Lake, however, is often restricted by the lack of available access facilities, as well as the inadequacy of many existing facilities.

Public access needs are very diverse. In addition to boating access sites, public access areas include beaches, marinas, parks, fishing piers, trails, campgrounds and scenic overlooks. All of these resources accommodate various recreational uses of the Lake and should not be overlooked when considering access needs. As shoreline access to the Lake is often restricted by private settlement patterns, results of the public involvement process and user surveys indicate that non-boating public access facilities such as beaches, shoreline parks, biking and hiking trails, campgrounds and fishing piers are all needed in various areas surrounding the Lake to provide both visual and physical access to the Lake. Many communities have indicated a particular need for new beaches and other types of recreational access to the Lake.

Planning studies also indicate that more boating access sites are needed in selected areas on the Lake. In some cases this need is due to overuse at some existing sites, while in other cases there simply are no public boating access sites available. In New York, research indicates that additional boating access sites are needed in the towns of Essex and Rouses Point and the city of Plattsburgh. In Vermont, the towns of West Haven, Georgia, Highgate and towns surrounding the Burlington area have all expressed a need for additional boating access sites (Smith, 1994; Dziekan, 1995).

Many existing boating access sites on Lake Champlain are in a state of disrepair and need to be upgraded and/or expanded. The Recreation User Surveys and the Public Involvement effort (Smith, 1994; Dziekan, 1995) identified many state and town-owned boat launch sites in need of site improvements such as dredging, dock repair and expansion, parking, and support facilities such as restrooms, pumpouts, and accommodations for persons with disabilities. Specific boat launch site improvement needs and priorities for improvements are summarized in Table 16.

Incorporating multiple use capabilities at boating access sites is important to diversify access opportunities and to enhance these sites for seasonal and year-round use. Non-boating activities such as picnicking, ice fishing and visual access to the Lake also need to be considered when improving access sites. Boating access is also needed by small non-motorized boat users such as canoeists, kayakers and sailboarders.

Winter use of the Lake is also important when considering access needs. Many people do not realize the diversity of winter activities that occur on the Lake. In addition to ice fishing—which is extremely popular, especially around the islands and in the South Lake — ice boating, skating, snowmobiling and cross-country skiing are all enjoyed on and around the Lake during the winter months. Depending on snow and ice conditions, Lake Champlain can be a wonderful resource for winter activities, but very few access areas provide facilities or services on a year-round basis (Farnum, 1995). According to the 1993 Winter User Surveys conducted in the Basin (Dziekan, 1995), the plowing of parking lots and year-round restroom facilities were desired by ice anglers and snowmobilers.

Table 16. Priority needs at Vermont Fish and Wildlife Access Sites, New York State DEC Fishing Access Sites and New York State Office of Parks Recreation and Historic Preservation Boat Launching Sites Identified by Public Access Site User Survey Respondents, Public Involvement Efforts and New York and Vermont Boating Access Improvement Plans.

New York State DEC Boating Access Sites/NYSOPRHP Boat Launch Sites	Identified Need	Estimated Improvement Costs	Agency Priority Rank for Improvements*
Chazy Landing (OPRHP) Chazy, NY	restrooms (installed toilet 1991)	NA	Recently Improved in 1991
Crown Point Reservation (DEC) Crown Point, NY	launch ramp & dock improvements, restrooms, parking capacity	$650,000	8
Ticonderoga (DEC) Ticonderoga, NY	dock improvement, launch ramp improvement & parking capacity	$400,000	2
Westport(DEC) Westport, NY	launch ramp; parking and dock improvements; site prone to flooding-raise parking area	$600,000	1
Peru Dock (DEC) Peru, NY	Site supervision, security lighting, restroom improvement	$150,000	6
Point Au Roche Boat Launch (OPRHP) Plattsburgh, NY	restrooms, dock improvements	NA	Recently Improved Site
Point Au Roche State Park (OPRHP) Plattsburgh, NY	access site recently reconstructed in 1991	NA	Recently Improved Site
Port Douglas (DEC) Keeseville, NY	restroom, launch ramp & dock improvements	$150,000	5
Port Henry (DEC) Port Henry, NY	restroom improvements, expand parking capacity	$400,000	4
South Bay (DEC) Dresden, NY	restroom improvements, site maintenance, fishing pier (handicapped accessible)	$335,000	3
Willsboro (DEC) Willsboro, NY	restroom & dock improvements	$100,000	7
Vermont F&WD Access Sites	**Identified Need**	**Estimated Improve-ment Costs**	**Agency Priority Rank for Improvements****
Shelburne Bay Shelburne, VT	launch ramp & dock improvement, dredging	$95,000	5
Malletts Bay Colchester, VT	restroom	$25,000	7
Hathaway (St. Albans Bay) St. Albans, VT	restroom, increased parking, acquisition	$75,000	8
Fort Cassin Ferrisburgh, VT	dock improvement, increased parking, universal shore fishing platform	$40,000	21
Dillenbeck Bay Alburg, VT	docks & dredging, breakwater	To be determined	To be determined

Vantines Grand Isle, VT	launch ramp reconstruction, breakwater, increased parking, docks	$140,000	16
Holcomb Bay Isle La Motte, VT	parking expansion	$15,000	10
Rock River Highgate, VT	ramp reconstruction, dredging, parking improvement	$45,000	11
Larabees Point Shoreham, VT	port-o-let, north ramp reconstruction, docks	$55,000	13
Laphams Bay Shoreham, VT	port-o-lets	n/a	4
Bensons Landing Benson, VT	port-o-lets, dock improvement, universal shore fishing platform	$45,000	15
Stoney Point Isle La Motte, VT	breakwater, ramp reconstruction	$110,000	22
South Slang Ferrisburgh, VT	parking improvements, ramp reconstruction	$55,000	25
Tabor Point Swanton, VT	ramp reconstruction, breakwater, docks	$165,000	23
Van Everest Georgia, VT	ramp reconstruction, dock improvements, parking	$165,000	19
West Swanton Swanton, VT	parking and dock improvements, port-o-let	$50,000	12
Winooski River (Rte 127) Colchester, VT	universal shore fishing platform, parking improvements	$100,000	3
Converse Bay Charlotte, VT	parking improvement, universal shore fishing platform	$45,000	28
Chimney Point Addison, VT	breakwater, new ramp construction, parking improvements, universal shore fishing platform	$110,000	6
Stephenson Point North Hero, VT	future improvements as needed	to be determined	29
Keeler Bay South Hero, VT	ramp reconstruction, dredging	$75,000	17
Lamoille River Milton, VT	dock improvements, port-o-let, shoreline stabilization	$25,000	14
Burlington Waterfront Park Boat Access (Joint project with City of Burlington) Burlington, VT	new concrete ramp, parking, docks, landscaping	$150,000	2
Grand Isle Shore Fishing Access Grand Isle, VT	fishing pier and parking	$12,000	1
Pelot's Point North Hero, VT	construct boat ramp, new parking, universal shore fishing area	$95,000	9
Lewis Creek Charlotte, VT	land acquisition	$45,000	18
Missisquoi River (site to be determined)	land acquisition	$35,000	20

Lewis Creek Ferrisburgh, VT	land acquisition, parking	$55,000	24
McCuen's Slang Addison, VT	ramp reconstruction, dock, channel improvement	$85,000	27
Shelburne Bay Shelburne, VT	universal shore fishing	$30,000	26

*Priorities for improvement identified by NYSDEC for the next five years (1996-2001)
**Priorities for improvement identified by VT ANR for the next seven years (1996-2003)
Note: Some of the needs identified in Table 16 may have been addressed since data were collected.

Congestion and Conflicting Uses

Lake Champlain is used by many diverse recreationists, many with different needs, concerns and limitations. Conflicts occur in varying degrees throughout the Lake but are most prevalent in high use areas. According to research results (Bulmer, 1993; Smith, 1994; Dziekan, 1995), Plattsburgh, Point Au Roche, Burlington, Malletts Bay, Shelburne and Charlotte are consistently the heaviest used areas for recreation and experience the most conflict among different types of users, and congestion problems (see Figure 13). In many protected bays and coves, the congestion is largely due to the steady proliferation of free-swinging moorings.

Major problems associated with congestion and user conflicts include: congestion problems in localized areas due to high boat concentrations, unsafe boating conditions and adverse environmental impacts; lack of awareness of other users sharing the Lake and its facilities; competition for limited and/or inadequate public access sites by a number of recreationists with different needs and expectations; inconsistencies in boating laws and enforcement measures between New York, Vermont and Quebec, making compliance with the rules difficult and sometimes confusing; conflicts between recreationists' use of natural, cultural and historic resources and the protection of those resources; and noise pollution from fast power boats or personal watercraft affecting both recreationists and residents along the Lake.

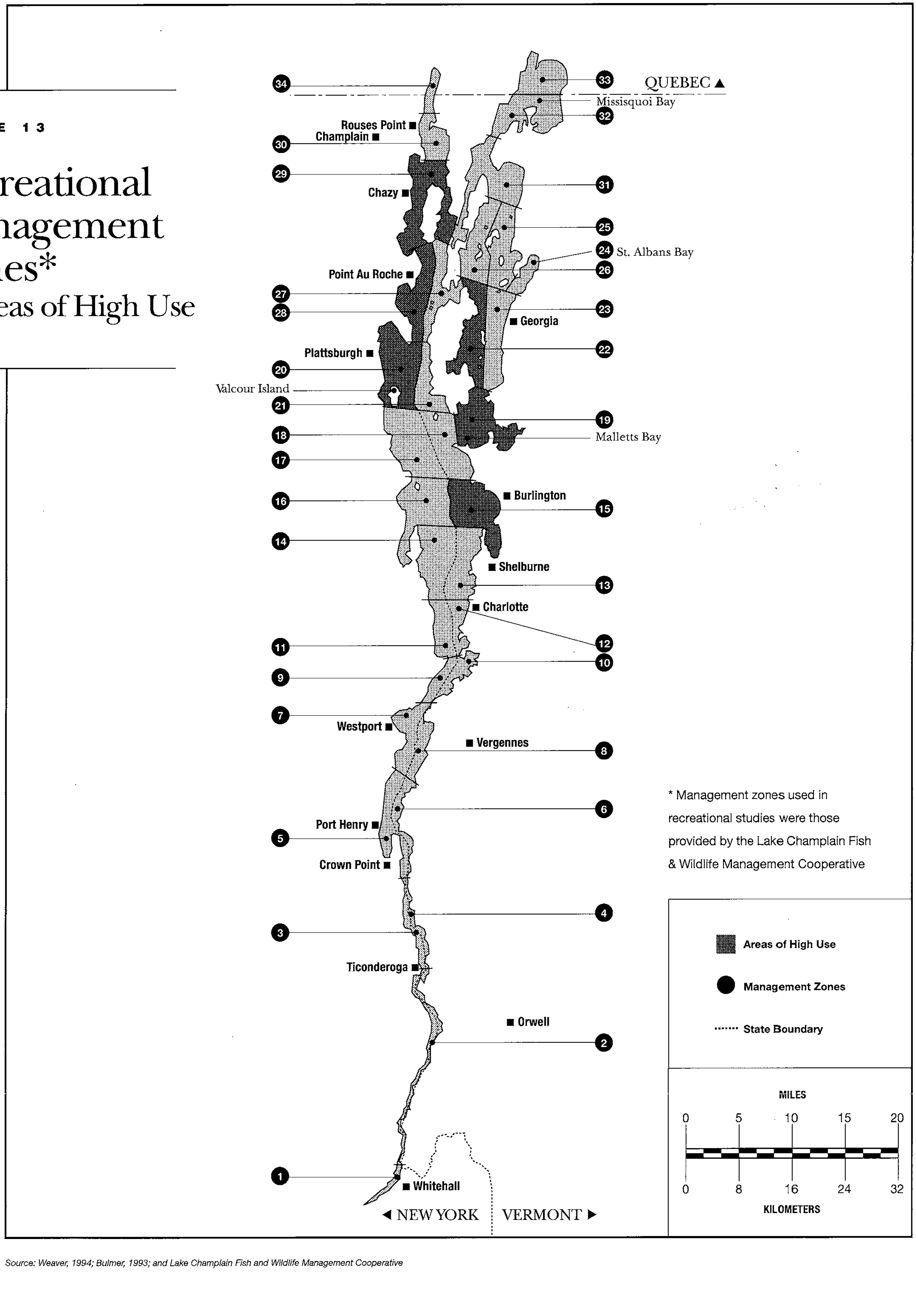
The 1993 Lake Champlain Boat Study (Bulmer, 1993) found a tremendous increase since 1980 in the number of boats in high use, populated areas such as Malletts Bay (a 47% increase), Shelburne Bay (an 80% increase), and Burlington Harbor. The study suggests that boating activity will continue to increase with population growth in the Basin.

The Lake Champlain Basin Program recently funded a demonstration project (completed in 1995) that identified solutions to boating congestion and other recreational problems in Malletts Bay. The Malletts Bay Recreation Resource Management Plan addresses ways to manage the public waters in Malletts Bay; the density of moorings and marinas; the allocation of recreational uses to reduce conflicting uses, eliminate water quality concerns and protect environmentally and culturally sensitive areas; and planning for future access areas. This demonstration project should serve as a model to address similar management concerns for other areas and bays in the Lake.

The concept of "carrying capacity" is sometimes used to estimate how much use a lake can withstand. However, it is extremely difficult to determine an area's recreational carrying capacity because of the complexity and diversity of personal values and perceptions involved. Virtually all relevant recent research indicates that a fixed and absolute formula for determining carrying capacities for recreational activities cannot be established. However, a range of values can be achieved through specific management objectives. For example, if the management objective for a given area of concern is to control the amount of use, measures such as

FIGURE 13

Recreational Management Zones* & Areas of High Use



* Management zones used in recreational studies were those provided by the Lake Champlain Fish & Wildlife Management Cooperative

Source: Weaver, 1994; Bulmer, 1993; and Lake Champlain Fish and Wildlife Management Cooperative regulating boat use, limiting launch sites, controlling boat size, or imposing speed limits can be implemented to achieve management objectives.

Safety and Enforcement Concerns
Reckless and unsafe boating has resulted in dissatisfaction and sometimes hazardous situations for recreationists using Lake Champlain. Many recreationists have expressed a need for more boating safety education to make Lake Champlain a safer place. New York statistics indicate that the lack of a personal flotation device (e.g., life jackets) is the single greatest contributor to fatal accidents in New York waters (NYSOPRHP, 1993). Since 1990, 10 out of the 11 victims that died in Vermont waters of Lake Champlain were not wearing personal flotation devices. More often than not, these accidents occurred because of overloaded vessels and a general disrespect for the importance of boating safety measures. Boating while intoxicated is also a serious safety problem as alcohol and drugs impair one's ability to make wise decisions and often induce reckless behavior. According to the United States Coast Guard, sixty percent of all boating accidents are alcohol related.

Educating users about the hazards of boating, the rules of the road, safe boat handling and navigation skills, as well as increasing an awareness of the needs and limitations of others sharing the Lake, is crucial for safe boating. Comments obtained through public involvement meetings have shown a strong need for increased safety education. Many have witnessed dangerous boating situations on the Lake, as well as a general negligence of boating laws.

The 1992-93 Recreation User Surveys (Dziekan, 1995) found that five out of the seven recreation user groups surveyed generally felt that a boating safety course should be a requirement to operate a power boat on Lake Champlain. Many also indicated that they had not taken a boating safety course in the past five years. Vermont currently has a mandatory boating safety program in effect which applies to those born on or after January 1, 1974; eventually this will cover all boaters in Vermont. New York's mandatory program only applies to persons 18 years or younger, while Quebec's program is completely voluntary.

Current Management: Roles and Responsibilities
There are a wide variety of agencies and jurisdictions involved in managing recreation on Lake Champlain. Two countries, two states and many towns are all responsible for imposing regulations and enforcement on the Lake. Table 17, displays the specific players and their roles and responsibilities.

The Vermont Department of Forests, Parks and Recreation, the New York Office of Parks, Recreation and Historic Preservation and the New York Department of Environmental Conservation are responsible for developing and implementing recreation management plans in their respective states. Together, these agencies take the lead role in recreation planning for Lake Champlain. The many other agencies listed in Table 17 (including appropriate Canadian agencies) are involved in various specific management tasks as indicated.

Table 17. Management Agencies and their Responsibilities

Organization	Roles and Responsibilities
VT Department of Fish and Wildlife	Enforcement and management of fishing and hunting laws. Management of fishing access areas and state wildlife management areas. Protection and management of fisheries and wildlife habitat.
VT Department of Forests, Parks, and Recreation	Management of State forests and parks. Planning, development, and management of state recreation programs and facilities.
VT Department of Environmental Conservation	Protection and management of lake water quality and air quality; advisory to VT Water Resources Board on surface use issues.
VT Water Resources Board	Management and regulation of surface use of public waters in Vermont.
VT Department of Tourism	Promotion and management of tourist activities.
VT Public Safety Marine Division VT State Police	Enforcement of Vermont boating laws and education.
VT, NY, and Province of Quebec Department of Motor Vehicles	Administers, records, and tracks motorized vessels through registration. VT Department of Motor Vehicles (only) - Development and updating of boating rules and regulations.
VT Department of Historic Preservation	Management of State Historic Sites.
U.S. Fish and Wildlife Service	Monitoring of threatened and endangered species. Advisory to other agencies for fish and wildlife management.
U.S. Coast Guard	Enforcement of federal boating laws. Responsible for marking hazardous waters and search and rescue.
U.S. Army Corps of Engineers	Jurisdiction of navigable waters as ascribed by section 10 of the Rivers and Harbors Act and Section 404 of the Clean Waters Act. Provide permits for encroachments and fill of lands.
NY Department of Environmental Conservation	Protection of NY State's land, water, and air; protection and management of fish & wildlife habitats and forest preserves in the Adirondacks and Catskills parks and wetlands; development and maintenance of water access sites; and implementation of the Environmental Conservation Law.
NYS Office of Parks, Recreation, and Historic Preservation	Planning, development, and management of NYS parks and historic sites; maintenance of State and National register of historic places; administration of boating laws and safety education; implementation of Parks, Recreation, and Historic Preservation Law of 1972.
NY State Police	Enforcement of New York State boating laws.
NYS Division of Tourism	Promotion and management of tourism activities in NY State.
Adirondack Park Agency	Management, planning, and regulation within park boundary.
U.S. and Canadian Power Squadrons	Education of boat operation and safety.
Canadian Coast Guard	Responsible for marking hazardous waters and search and rescue.
Canadian Provincial Police	Enforcement of Canadian boating laws.

Regional and Local	
VT Regional Planning Commissions and NY County Planning Depts.	Coordination, Program Initiatives, Project Review, Tourism Promotion, Education, Environmental Analysis, and Shoreland Protection/Planning.
NY County Sheriff Depts.	Enforcement of NYS Navigation Laws within County Jurisdiction.
NY Regional Tourism Committees	
Quebec Tourism Committees	
Town Planning and Recreation Commissions	Administration and Management of Local Park and Recreation Areas.
Chambers of Commerce	
Local Power Squadron	Boating Education and Search and Rescue Operations.
Conservation Associations and Land Trusts	Shoreland Protection/Planning.

Exploring the Advantages and Implications of Tourism Promotion in the Basin

The Lake Champlain Basin provides tremendous recreational, natural, cultural and historic resources that could be better promoted. Research has shown that very little has been done to specifically promote Lake Champlain as a tourist destination. Instead, tourist destinations such as Quebec, the Adirondacks and Vermont in general have been individually promoted. Many Basin residents and recreationists alike have indicated a strong desire to expand efforts to promote Lake Champlain as a tourist destination. However, it has also been emphasized that a sustainable approach is needed to maintain an appropriate balance between tourism promotion and the protection of the region's valuable resources.

Promotion of the area as a major destination should include providing tourist information that specifically outlines recreational opportunities along the Lake and in the Basin. It is evident that there is a lack of tourism planning and coordination between tourism organizations within the Lake Champlain region. The Lake Champlain Bikeways Project (an ongoing project to develop interconnected bicycle routes on existing roads around the Lake) is one of the few cases where there has been coordination between New York, Vermont and Quebec concerning tourism marketing, research or planning.

Recreational facilities and attractions need to be identified, mapped, linked and made available at centralized locations around the Lake. Many recreational user groups have also indicated that certain types of activities such as scuba diving, kayaking, bicycling and sail boarding have not been fully recognized and enhanced on the Lake (Smith, 1994). In addition, results from the 1992-93 Recreation User Surveys (Dziekan, 1995) indicate the need to enhance the supporting tourism infrastructure within the Basin, including facilities and services such as lodging, equipment rentals, restaurants, clubs and marinas.

Linkages with Natural, Cultural and Historic Resources Stewardship

Lake Champlain recreationists affect, and are affected by, the state of the natural, cultural and historic resources in the Lake Champlain Basin. Protection and enhancement of the environment and cultural and historic resources is clearly important to recreationists as these resources are often the main focus of the recreational experience. Overuse or misuse of the resources should be carefully evaluated and monitored to avoid resource degradation.

There are many linkages between recreation planning and the management of natural, cultural and historic resources. For example, the siting of a new recreational facility can affect fish and wildlife habitat or the protection of historic shipwrecks. More extensive background information on these topics can be found in other sections of this report, but brief descriptions of linkages with water quality, nuisance aquatic species, cultural and historic resources, and fish and wildlife are included below.

Water Quality

Recreationists clearly have a vested interest in the water quality of the Lake, as clear and nuisance free water is an important part of the recreational experience. While most pollution in the Lake results from activities on the land, water-based recreational activities may also pose some threats to water quality.

Older two stroke outboard engines pass as much as 18% of their fuel and lubricating oil directly out of the tailpipe and into the environment, either as combusted gases or as a raw petroleum product (USEPA, 1984). Once expelled, about two-thirds of the discharge is evaporated into the atmosphere while the remaining portion stays in or on the water (Hare and Springer, 1986). While there is no evidence of large scale contamination from oil and gas discharges in Lake Champlain, further research on the effects of these discharges in marina settings may be warranted.

The marine industry has been working with the USEPA to develop lower emission engines for a number of years. The EPA is currently finalizing new rules that will require a 75% reduction of hydrocarbon emissions from outboard motors. These rules will apply to all new boats starting in 1998, but it may take up to twenty years for the older engines to all be replaced (Henschen, 1993).

Discharge of sewage from boats has been a concern and questions about the problem are often asked by the public. New York, Vermont and Quebec all have laws prohibiting any wastewater discharge into the Lake and marine toilets must be equipped with a holding tank. If holding tanks are illegally discharged, they can contribute pathogens and other pollutants such as phosphorus to the Lake.

Many boaters have expressed a need for more pumpout facilities around the Lake (Smith, 1994; Dziekan, 1995). Twenty-seven of the 64 public and private enterprises that provide marina facilities do not have pumpout facilities (Farnum, 1995) and a preliminary survey of a group of Vermont marina's found that 8 out of 15 indicated a need for pumpout improvements or expansions (Dziekan and Smith, 1995). A more complete analysis of boating patterns and pumpout facility locations may be necessary to verify pumpout needs, but the above data suggest that additional and/or improved facilities are probably needed in some areas. Many recreationists also feel that more education is needed to inform boaters about the effects of high pathogen levels and where they can properly discharge their wastes.

Recreation is also linked with public health concerns about water quality. Swimming constitutes a primary recreational use at beaches throughout the Lake, attracting thousands of people each summer. Unfortunately, problems with water quality and threats to public health often exist near public beaches. This is particularly a problem in Malletts Bay and Burlington Harbor in Vermont, and in Plattsburgh, New York, where beaches have occasionally been closed due to high bacteria levels. More information on beach closings and human health issues is included in the section on Protecting Human Health (Chapter 2).

Nuisance Aquatic Species
Recreationists are affected by a number of nuisance aquatic species found in Lake Champlain, including Eurasian watermilfoil, water chestnuts, sea lamprey, and most recently zebra mussels. Many swimmers, anglers, boaters and residents complain that the presence of Eurasian watermilfoil and water chestnuts significantly affects their recreational experiences, and anglers are concerned about the impacts of sea lamprey and zebra mussels on the fisheries (Smith, 1994).

At the same time, recreationists, especially boaters, need to realize that they may be a part of the problem. Boaters may unknowingly spread nuisance aquatic species as they transport their boats from one body of water to another. Education is therefore critical to reducing the spread of these unwanted species. Refer to the section on Managing Nuisance Nonnative Aquatic Plants and Animals (Chapter 3) for a more complete discussion of this topic.

Cultural and Historic Resources
Cultural and historic resources are an important part of the recreational experience in the Basin. But the need to enhance access to these resources has to be carefully balanced with the need to protect them from overuse and degradation (see the section on Protecting Cultural Heritage Resources in this chapter). The historic significance and social value of a site should also be recognized when considering recreational enhancements.

The management of the historic shipwrecks in the Lake is a particularly important issue for recreationists. Many Lake Champlain divers are concerned that not enough is being done to protect underwater historic shipwrecks from potential vandalism and the illegal salvage of artifacts (Dziekan, 1995). Divers have expressed the need to protect these important historic resources by designating them in Vermont's Underwater Historic Preserves Program to ensure respectful use. More than 90% of respondents to the divers survey indicated that underwater historic preserves on Lake Champlain should be expanded, and 67% indicated that they would be willing to pay a user fee for underwater historic preserves. Many divers also recommended that a program be established to preserve historic wrecks throughout the Lake. By designating historic resources lakewide, divers believe that underwater wrecks will be better protected while Lake Champlain receives the publicity it deserves as a culturally rich body of water and a desirable place to dive (Smith, 1994; Dziekan, 1995).

Fisheries
Lake Champlain is a unique fishing resource offering an abundance of opportunity for residents and visitors alike. Open water and ice fishing is pervasive throughout the Lake; in many communities, recreational fishing is a way of life. Lake Champlain also hosts a number of fishing derbies year round, including the Lake Champlain International which attracts over 6000 participants, generating at least $1-1.5 million annually. In addition, the Sea Lamprey Control Program, initiated in 1990, is beginning to benefit salmonid fisheries in Lake Champlain. Many anglers are reporting improved fishing for lake trout, landlocked salmon, steelhead and brown trout. Lake Champlain also offers excellent fishing for smallmouth and largemouth bass and several other species. However, despite being a desirable resource for fishing, public involvement meetings have indicated that people perceive problems on the Lake. These perceptions include: decline of certain types of fish species, lack of adequate access, and the proliferation of nuisance aquatic species.

One of the more pressing issues identified by anglers on Lake Champlain is the need for a reciprocal fishing license agreement between New York and Vermont that would provide anglers with the opportunity to fish New York and Vermont waters while in possession of either state's basic fishing license (Smith, 1994; Dziekan, 1995). Many anglers are advocating for this type of license to allow more widespread fishing opportunities, and fishing charter captains indicate that a reciprocal license would increase their business. The Vermont Fish & Wildlife Department is concerned about the impacts of a reciprocal license agreement due to the potential for a significant reduction in license revenues and resultant program cuts. In addition, the Department feels that increases in fishing opportunity for Vermont and New York should be equitable. New York strongly supports a reciprocal fishing license agreement for its border waters, including Lake Champlain.

Wildlife
Hunting for waterfowl and trapping along Lake Champlain are popular recreational activities. Recreational use of wildlife fosters first-hand enjoyment and appreciation of the Lake Champlain ecosystem. Wildlife observation, photography and nature observation are also valued by many recreationists on the Lake (Smith, 1994; Dziekan, 1995). As people enjoy the Lake from a boat or along the shoreline, wildlife viewing is an important aspect of experiencing the natural environment of the Lake and its surroundings. Birdwatching in Vermont generated an estimated $52 million in 1991 from feeding, watching and photographing wildlife. Wildlife management issues are described more fully in Chapter 3 under Managing Fish and Wildlife.

Shoreland Resources
Just as boating and other water-related activities are popular on Lake Champlain, experiencing the Lake's tremendous shoreland resources is an extremely important way for many to enjoy the Lake. Recreationists value shoreland resources highly, and survey results and public involvement efforts (Smith, 1994; Dziekan, 1995) illustrate that recreationists are generally concerned with the accelerated rates of growth and shoreland development. Some common concerns of recreationists with shoreline development include: overdevelopment which limits public access opportunities and hinders scenic vistas and visual enjoyment of the Lake; potential impacts of development on the natural environment; and the loss of open space and agricultural land. The protection of shoreland resources is also addressed elsewhere in this document, especially in the fish & wildlife and wetlands sections (Chapter 3).

Issues

The following section is a summary of some of the major policy issues involved with managing recreation in the Basin.

Expanding or Enhancing Public Access
The overall management issue surrounding public access on Lake Champlain is how to expand and enhance access opportunities in a manner that allows for a diversity of experiences while minimizing congestion, user conflicts and impacts to the natural environment. In identifying specific access needs for future improvements or developments, a step-wise process, based on the willing-seller principle and an emphasis on conservation easements, is critical to analyzing and setting priorities for these needs. Secondly, identifying or developing funding mechanisms to obtain public access is also a major policy issue.

In providing more and better access, the challenge is to accommodate a diversity of users. This includes users of both motorized and non-motorized watercraft as well as non-boaters, such as swimmers, hikers and other users. Many of the problems associated with public access are caused by conflicts between the various user types. For example, there are growing conflicts between paddling craft and motorized craft at boat access areas. Conflicts also occur between swimmers and boaters where designated uses are not clear. One option for addressing conflicts at access areas is to design and organize the site to meet the variety of needs. Another option is to separate different uses by establishing designated use areas. Establishing specific management objectives for each access site on the Lake would help alleviate conflicts among users.

Another challenge is to accommodate people with low incomes and those with disabilities at public access facilities. Lake Champlain is a resource for all to enjoy and must be made available for those with special needs or limitations. People with low incomes in the Basin usually live inland from the Lake and need more information about recreational opportunities on the Lake. People with disabilities may have better access to the Lake as facilities which accommodate their needs are developed. Specific areas such as beaches, fishing piers, boating access sites and parks need to be identified to provide both affordable access and accommodations for persons with disabilities. The Lake Champlain Basin Program is currently funding a Handicapped Access Development Project, a demonstration project to upgrade an existing public access area at the mouth of the Saranac River in Plattsburgh, New York. Managed by a partnership of the City of Plattsburgh and the New York State Department of Environmental Conservation, the project involves the construction of a fishing pier accessible to persons with disabilities. The New York State DEC is also considering handicapped access projects in Rouses Point, Port Henry and South Bay. The Vermont Fish and Wildlife Department has completed "universal" access projects on the Lamoille River, Kelly Bay and in North Hero and is planning similiar types of access in various other locations.

Alleviating Congestion and Conflicting Uses

Increased management efforts are needed in certain areas of Lake Champlain experiencing high levels of congestion and conflicting uses. Congestion and conflicting uses can be addressed through regulation, education or a combination of the two. The decision to pursue a regulatory, educational or combined approach can be made on a site by site basis depending on the severity of problems and the nature of conflicts.

As the number of free-swinging moorings in the Lake increases, the States of Vermont and New York may need to address mooring management. Towns may need to develop mooring management plans in high use areas, and there may be a need for increased regulation on the placement of moorings in certain parts of the Lake. The management strategies defined by the Malletts Bay Recreation Resources Management Plan may serve as a model for other localities in addressing similar mooring management, user conflict and congestion issues.

The Visitor Impact Management (VIM) Process is a new process for assessing the impacts of recreational use on a resource. This process consists of the following steps: 1) a review of previous research and policies concerning visitor impact on a resource; 2) the identification of management objectives for the resource and for the visitor experience; 3) the selection of social and ecological indicators that will measure the success/failure of management objectives; 4) the development of management strategies to lessen negative visitor impact on a resource if it is determined that objectives are not being met; and 5) implementation of a management strategy(s) and continued monitoring of its success against the identified objectives. The VIM process provides managers with information about making rational decisions to manage for unacceptable user impacts (Zwick Associates, et al., 1990).

Rather than attempting to establish a carrying capacity for the Lake, which research has shown to be ineffective, one option is to concentrate on developing overall management objectives for areas of concern through a process like the VIM process. This is likely to be more effective in reducing the adverse impacts of congestion and user conflicts, while providing better management of an area.

Improving Safety and Enforcement

In addressing the need for improved boating safety and better compliance with boating laws, the overall management issue is whether increased regulation and/or enforcement is needed in addition to education measures. At what level these actions should be pursued, and in what combination, also needs to be considered.

Increased enforcement is critical in certain areas of the Lake to address safety concerns. In particular, increased enforcement is needed to combat boating while under the influence of drugs and/or alcohol. According to law enforcement officials in New York, Vermont and Quebec, there is a distinct need for more patrols on Lake Champlain including Canadian waters. In addition, marine patrols generally need to be more visible, and better distributed lakewide, especially during high use times.

Coordination between the various enforcement entities on Lake Champlain is key to addressing safety issues and improving law enforcement. The Vermont and New York State Police, the County Sheriff Departments, New York State Park Police, U.S. and Canadian Coast Guard, the Quebec Provincial Police and the New York Department of Environmental Conservation all have enforcement capabilities on the Lake. Improved coordination between these entities will make it easier for boaters to comply with laws that vary by jurisdiction. For example, in Vermont, it is illegal for boaters to be within 200 feet of "diver down" flags but in New York the distance is 100 feet and in Canadian waters boaters need only to proceed with caution.

Exploring the Advantages and Implications of Tourism Promotion

The overall management issue in addressing tourism in the Lake Champlain Basin is the need to explore the advantages of the Basin as a tourist destination, and determine the possible implications that promotion might create. In promoting resources, care should be taken to avoid spoiling or degrading them. An appropriate balance can be achieved by promoting tourism, and protecting the array of resources that make the Basin so attractive. It is also important to fully utilize existing tourism infrastructure before developing additional facilities.

Considering the richness of the natural, cultural and historic resources in the Basin, a specific emphasis on sustainable tourism or eco-tourism, and heritage or rural tourism, could strive to preserve the region's natural, cultural and historic character while also serving as a stimulus to the area's economy. Sustainable tourism or eco-tourism is low impact tourism which does not exploit nature, but rather instills a sense of appreciation and responsibility in using the resources. A definition of ecotourism currently accepted by the Ecotourism Society is "responsible travel that conserves the natural environment and sustains the well-being of local people." Rural and heritage tourism follows the same principles, with an emphasis on appreciation for the heritage and working landscape of an area, as well as promoting an ethic of maintaining the rural or historic character.

A strategy is needed to develop a sustainable approach to tourism promotion and development. The strategy should: promote relatively undiscovered and under-utilized recreational activities and opportunities; coordinate special projects and promotional efforts across state and political boundaries; enhance and support existing tourism infrastructure; develop comprehensive information describing the rich diversity of recreation opportunities; and identify specific recreational opportunities which promote appreciation for the resources and avoid adverse impacts. While one goal is to strengthen the regional economy, it may not be wise to promote tourism to the point where the Lake and its resources are degraded or compromised. One option is to stress a stewardship ethic and appropriate use of the resources to both residents and visitors of the Basin, and encourage communities to take a more active role in defining and guiding tourism development. For example, coordinated projects such as Lake Champlain Bikeways could be pursued to emphasize and promote the international appeal of the Lake Champlain region.

Lake Champlain is an important recreational resource which contributes significantly to the local economy of the region. Choosing to ignore tourism issues may result in a no-win situation with local communities missing economic opportunities while resources are potentially threatened by unwise use.

Promoting Natural, Cultural and Historic Resources Stewardship

An important issue in promoting natural, cultural and historic resources stewardship is the need to enhance access to these resources while protecting them from irreplaceable losses and deterioration. Critical to this is the need for comprehensive inventories of the resources, and an appropriate and reliable method of evaluating and monitoring visitor impacts. Education and continued funding mechanisms for protecting these resources is also paramount. Cultural and historic resources stewardship issues are discussed more fully in the cultural resources section.

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Protecting Cultural Heritage Resources

Background

What are Our Cultural Heritage Resources?

Cultural heritage resources can be defined as those places, buildings, structures or objects that link us to our past. While cultural heritage resources of local, regional and national importance are threatened throughout the Basin and merit protection, the primary focus of this section is on lake- and water-related heritage resources.

Lake Champlain is considered by many to be the most historic body of fresh water in the northern hemisphere. The extraordinary array of historic and archeological resources around the Lake's shores, underwater, and throughout the Champlain Basin are the physical evidence of a long and varied history spanning more than 10,000 years. There are remains of Native American settlements, camps and other sites, and of early Euro-American settlements; sites relating to French and British exploration and occupation, and numerous military conflicts; and a vast array of buildings, structures and sites resulting from a dynamic era of industrial, commercial and agricultural development in the 19th century. Of singular importance are Lake Champlain's historic shipwrecks, believed to be the largest and most intact collection in North America.

The cultural heritage resources that embody the Basin's broad cultural diversity allow us to understand our past and where we came from as a people. The Abenaki and Iroquois who live here today have long called the Basin "home." Some of the most significant sites to the Basin's Native Americans are neither historic nor archeological, but are places of traditional or sacred importance that have been celebrated and revered by many generations of Native people. These historic and archeological resources, and sacred, traditional sites have historical, cultural, educational and recreational importance for all citizens of New York, Vermont and Quebec.

What Types of Cultural Heritage Resources are in the Basin?

The major categories of cultural heritage resources in the Lake Champlain Basin are described below.

Historic Structures and Settlements

Historic buildings, structures, complexes, districts, and communities constitute the most widely recognized and documented heritage resources in the Basin. Many of us live, work, play, learn and worship in historic buildings, which are the resources most accessible to preservation (being visible, often appreciated, and recyclable) and, perhaps, the most quickly lost (to deterioration, demolition, fire, redevelopment or other pressures).

Cultural Landscape Resources

Industrial activities, agriculture, military encounters, transportation, conservation, and other activities have created landscapes in the Champlain Basin imbued with historic and cultural significance. The most common examples are agricultural landscapes, which significantly contribute to the character of the Basin. Yet, these are landscapes which are disappearing at an alarming rate, in part due to the economic challenges associated with farming, and in part due to suburban sprawl as more and more people choose to live outside of traditional population centers.

Archeological Resources on Land

The Lake Champlain Basin contains a rich and ancient archeological heritage. Historic and prehistoric archeological resources include Native American villages, campsites and burial grounds, as well as early Euro-American settlements, and industrial, commercial, and military sites. Fluctuating Lake levels during the last 4000-6000 years have submerged, or buried, many lakeshore archeological sites, some of which remain undiscovered. These are especially fragile and vulnerable resources. Other archeological sites are submerged and just along the shore, such as wharves and jetties, store houses, and remains of bridges, long decayed, representing a very different, but linked, aspect of the stories told by the archeological sites on land.

Archeological Resources Underwater

Lake Champlain and nearby Lake George have perhaps the best preserved collection of submerged cultural heritage resources in North America. Shipwrecks already found reflect every era of past human activity in the Champlain Basin, from prehistoric periods, through the repeated military conflicts, and the dynamic commercial period of the 19th century. Management issues, degradation of water quality, zebra mussels and other nuisance aquatics, improved search technologies, and increased accessibility pose difficult challenges in protecting these resources.

Traditional Cultural Properties

Native American people in the Basin, such as the Abenaki and the Iroquois, have a long tradition of using the land very differently from Euro-Americans. Some places throughout the Basin that were used by Native Americans for thousands of years for spiritual and secular purposes contain no artifacts or even evidence of having been used, but are still revered and used today by Native Americans. These places are given some levels of protection in a variety of federal and state laws.

Archival Resources

Numerous publications, historic records, journals, maps, photographs, and artifacts are contained in the Basin's museums, historical societies and libraries and serve as an important foundation to the information contained in this section. These resources are crucial for interpreting history, and enhancing a public appreciation of local heritage resources. In addition, interpretive centers and museums provide many economic benefits and opportunities.

What are Major Themes of Our Cultural Heritage Resources?

The cultural heritage resources of the Basin encompass several themes which help to identify and interpret the past, and provide a useful framework for a variety of recreational and educational opportunities. Time periods in parentheses provide a range of dates that characterize each theme; generally a property must be 50 years of age or more to be considered an historic place.

Native American resources (10,000 years ago - present) constitute a significant and under-documented part of the Basin's cultural heritage, from prehistoric archeological sites to traditional sacred sites still in use today by native people.

Exploration & Early Settlement (1609 - c.1800) concerns French & British exploration and settlement which have left their mark on archeological and historic sites and on language and culture in the Basin.

Transportation (1609-1945) defined new patterns of settlement and commerce as European settlers used the Richelieu River - Lake Champlain - Lake George link between the St. Lawrence and Hudson Rivers for military, industrial and commercial interests. This water-based transportation corridor remained viable with the opening of the

Champlain and Chambly Canals in 1823 and 1843, respectively. In 1850, railroad construction across the Basin altered patterns of transportation on the Lake, and in the 1920s, America's love affair with the automobile brought dramatic changes to the landscape as well.

Commerce (1609-c.1945) flourished early on Lake Champlain and influenced early settlement patterns as well as political conflicts.

Military & maritime history (1690-1945) Lake Champlain was a crucial battleground in the French & Indian Wars, the Revolutionary War and the War of 1812. Military historic resources in the Basin include Fort William Henry, Fort Ticonderoga, Mount Independence, Crown Point, Fort Montgomery, Fort Ethan Allen, and Plattsburgh Air Force Base.

Agriculture (c.1760-1945), beginning with European settlement, has been one of the strongest forces shaping the pattern of towns and rural landscapes of the region.

Industries (c.1790-1945) that have relied on the Basin's natural resources (including logging, mining, quarrying, manufacturing and shipbuilding) have produced a rich legacy of historic structures and industrial archeological sites.

Community development & culture (c.1760-1945) encompass a wealth of historic settlements and structures associated with community development, architecture, the arts, education, ethnic heritage, health, religion and social history.

Government (c. 1760-1945), from the period and the Vermont Republic to the New Deal, has contributed governmental structures and institutions to the architectural and community heritage of the Basin.

Tourism & recreation (1781-1945), linked to the Basin's natural resources, beauty, and climate, led to the early development of hotels, spas, seasonal residences and camps, and public parks, historic sites, and recreational facilities in the late 19th and the 20th centuries.

How are Cultural Heritage Resources at Risk and Why Protect Them?

The Lake Champlain Basin's historic and archeological resources, both on land and underwater, provide a tangible link to an extraordinarily rich and diverse past. Inseparably linked with their surrounding geographical and natural features, these resources provide us with a familiar sense of place and with the palpable memory of the past, without which we cannot remember who we are and where we came from. To our contemporary life, these resources contribute enormous spiritual, economic, recreational, educational and aesthetic value. They make our communities viable, attractive, and memorable places in which to live, work, and play, and they draw thousands of visitors to the region. But both natural and human factors seriously threaten these irreplaceable historic and prehistoric resources. Effective management of these resources requires that we know where they are, why they are important, and what threatens their survival.

Threats to historic places include: a tax structure that encourages demolition and discourages protection; functional obsolescence; changing building code requirements; planning and zoning laws which ignore resources or historic patterns; and economic conditions. Threats to archeological resources on land include natural physical processes/erosion; hydroelectric projects; looting and vandalism; some farming practices such as construction of drainage systems; activities that enhance natural resources such as wetland restoration; and activities that improve water quality such as treatment plants, septic systems, etc.. Underwater archeological resources are threatened by recent technological advances that make it easier to locate and identify sites so that anyone can access shipwrecks. Additional threats include vandalism, looting, over-use, unsystematic and low-level management, recreational conflicts, degraded water quality, zebra mussels, and other nuisance aquatic species. Traditional Cultural Properties are threatened as well because they are difficult to recognize and delineate by non-Native Americans and are subject to competing modern uses by Euro-Americans.

Cultural heritage resources are interwoven with the Basin's natural resources, both contained within natural environments or areas at the bottom of the Lake, and are affected by the forces that alter those environments. For this reason, protection of cultural heritage resources should go hand-in-hand with protection of the natural resources of the Basin. Developments that threaten wetlands and wildlife habitat also threaten archeological sites and historic landscapes. Streambank and lakeshore erosion that harms our waters and fisheries (and reduces agricultural lands) also destroys ancient Native American camps, burial grounds and important 18th century early Euro-American settlements. Shipwrecks are directly affected by deterioration in water quality. Loss of historic farms and agricultural landscapes not only threatens our economy, but also an historic way of life and a settlement pattern that defines our sense of place. Ironically, heritage resources are sometimes threatened by actions taken to improve water quality, such as construction of lake-side water treatment facilities which may threaten archeological sites both on land and underwater.

Cultural heritage resources are not renewable or replaceable. Once demolished or destroyed, they are lost forever - historic neighborhoods representing 19th century slate workers' housing will never again develop in the Basin; Revolutionary War archeological sites represent one small time in our history that will never again occur; a shipwreck like the *General Butler* will never again occur; the Indian villages along the big rivers of the Basin will never again thrive with the activities of ancient people.

Current Management and Protection of Cultural Heritage Resources

The vast majority of cultural heritage resources in the Basin are privately owned, and most are not protected by federal or state laws. These resources are thus managed and protected only to the extent that owners have knowledge of them and have a sense of stewardship (or, perhaps, perceive an economic benefit). Some privately owned resources are held and managed by private museums, historical societies, clubs, schools, and other institutions which may abide by non-regulatory protective covenants and make the resources available to the public for educational and recreational purposes.

One major management dilemma is resource management and protection programs that are not comprehensive, or coordinated with other programs. Each agency has its own methods, policies, data repository, and jurisdiction; what one agency attempts to protect can be threatened or lost through the actions of another agency. But recent initiatives such as the New York State Canals project, and the submerged resources projects, indicate considerable advocacy and energy for protecting cultural heritage resources in both the public and private sectors. Further progress towards reaching cultural resource protection goals of the nature and scale envisioned for the Basin will require a cooperative and coordinated working relationship between all key organizations, public and private, in New York, Vermont, and Quebec, as well as strong and integrated working relationships among key state and federal agencies.

Federal Programs

Of the federal programs, review under Section 106 of the National Historic Preservation Act is the primary protection mechanism for cultural heritage resources. Under Section 106, all federally funded projects, and projects that require federal permits, licenses or any other federal involvement, must consider project effects on cultural heritage resources. Only heritage resources listed on, or eligible for inclusion in, the National Register of Historic Places are protected under this law. Under the Section 106 review process, efforts to identify, evaluate, protect (if possible) or otherwise mitigate adverse impacts to heritage resources are routinely carried out by most federal agencies (or recipients of federal money, permits or licenses). Adequate compliance with Section 106 remains an outstanding issue for some federal agencies and some state agencies that receive "pass-through" federal funding. The federal government also funds tax credits for Certified Rehabilitation of Historic Structures, and funnels funding to local communities to preserve cultural resources through such programs as Department of Housing and Urban Development (HUD) Community Development grants, and the Federal Highway Administration's Intermodal Surface Transportation Efficiency Act (ISTEA) program.

In Canada, the primary federal legislation protecting cultural resources includes: the Historic Sites and Monuments Act, the Federal Heritage Buildings Program, and the Heritage Railway and Heritage Rivers Programs. Administered by Parks Canada, federal protection programs have an active cultural resource management policy which mandates identification, inventory, evaluation, designation and protection of federal buildings (over 40 years old). Canadian legislation in more directly protective of designated resources (prohibiting unauthorized demolition, sale, or alteration) than American legislation.

State and Provincial Programs

In New York, the State Environmental Quality Review Act (SEQRA) mandates consideration of impacts to the environment, including archeological, historic, and cultural resources, resulting from the actions of state and local governments. New York State agencies are also required, under the State Historic Preservation Act, to protect archeological, historic and cultural resources from impacts caused by state-permitted and funded activities. Formally created State Historic Sites are acquired and managed by the Office of Parks, Recreation and Historic Preservation. For those areas of New York State lying within the Adirondack Park, this responsibility lies with the Department of Environmental Conservation.

Vermont's Act 250 and state preservation legislation provide similar review functions for proposed development and protection to some categories of development and to state-owned resources. The Vermont Division for Historic Preservation also owns and manages several historic properties in the Basin.

Similar to the states, provinces can pass and enforce legislation extending legal protection to designated properties. Quebec's primary legislation, which offers a level of protection to designated properties, is Loi Sur Les Biens Culturels.

Underwater archeological resources, such as shipwrecks, are <u>all</u> publicly-owned resources in Vermont and New York. The two states have conducted extensive underwater surveys in cooperation with the former Champlain Maritime Society, the Lake Champlain Maritime Museum and, on Lake George, with Bateaux Below, Inc. The Federal Abandoned Shipwreck Act of 1988 stresses increased management responsibility by the states, following Vermont's model, and reinforces the need to continue underwater surveys. Since 1985, Vermont has designated five historic shipwrecks in Lake Champlain, and New York has designated three in Lake George, as Underwater Historic Preserves. The preserves are meant to encourage awareness and stewardship, and to enhance their recreational opportunities as safe and interesting dive sites. Management of underwater heritage resources is hampered by lack of funding and available state staff. Sustained and immediate efforts to improve the management of these public resources, and reliable sources of funding, are needed. In the Province of Quebec, the Ministry of Tourism and Culture is responsible for publicly owned cultural heritage resources. There is currently no linkage between Canadian and United States federal, provincial, or state laws and management programs.

Local Programs

Pro-active, consensus-driven local planning efforts provide one of the most effective mechanisms for protecting cultural resources. A good example is the Mad River Planning District in Fayston, Waitsfield and Warren, Vermont, where local residents recognized the value of what they have, and put together a means to protect it. More and more local governments are integrating cultural resources into local and regional plans. Within the Basin there are five Certified Local Governments, ten Local Historic District/Preservation Commissions, and eight Design Control Districts. These local planning efforts not only work to preserve the local fabric of communities, but also catalyze economic incentives through federal, state and private grants and through increased heritage tourism-related opportunities.

Voluntary and Other Programs

Voluntary means of protection are the mechanisms of first choice. The vast majority of cultural resources throughout history have been preserved through the stewardship of their owners. Education is critical to good stewardship, and economic incentives and legal designation can greatly enhance resource protection. Voluntary preservation activities under such programs as the Certified Rehabilitation Tax Credit Program, and New York State's Environmental Quality Bond Act (EQBA) program, have declined or, in the case of the EQBA, recently expired. Non-regulatory protection of resources, such as voluntary stewardship programs, must be strengthened since this is the sole source of protection for most of the Basin's resources. Easements, land trusts, and other voluntary protection and stewardship programs are successful in so far as the private organizations directing such efforts have the ability and the resources to pursue them. Increasing initiatives for voluntary protection are necessary steps to protect the future of the Basin's resources.

Recent Accomplishments in Managing and Protecting Cultural Heritage Resources

Lack of easily accessible information about heritage resources in the Basin has impeded their management and interpretation. The Lake Champlain Basin Program, through the National Park Service, and the States of Vermont and New York, funded a "Cultural Heritage Planning Needs Assessment" (Argus Architecture and Preservation, et. al., 1996). This document contains detailed information about what we know, and don't know, about the Basin's heritage resources, the extent, quality, locations and uses of existing inventories, how the resources are now being managed, and recommendations to better protect irreplaceable resources.

Underwater resources pose additional challenges and opportunities. With improvements in the technology for surveying underwater cultural heritage resources, we can expect to identify and inventory previously undocumented shipwrecks in Lake Champlain and the Basin waterways. Given the recent introduction and proliferation of zebra mussels in Lake Champlain which threaten to destroy, or at least obscure, many underwater resources there is an added urgency in gathering as much information as soon as possible. As a result, the Management Conference has funded two studies: 1) a study of the potential impact of zebra mussels on Lake Champlain's shipwrecks and recommendations for mitigating those impacts (Cohn et. al., 1995); and 2) an underwater cultural resource survey that will focus on areas of probable zebra mussel impact, to be completed by late 1996.

In 1992, the Lake Champlain Basin Program also funded an inventory and evaluation of the underwater archeological resources located between Mount Independence, Vermont and Fort Ticonderoga, New York (Cohn et. al., 1995). A focal area of Revolutionary War conflicts, this area is also favored by looters who pilfer artifacts for private gain. Spurred by a 1991 looting episode, the Lake Champlain Management Conference funded the study as a demonstration and characterization project to better understand the extent and importance of these resources, and to develop a bi-state management and protection strategy for them. The interdisciplinary research team discovered an incredible array of Revolutionary War artifacts of national importance that will add to our knowledge about this episode of Basin and American history. This important discovery led the State of Vermont to fund an intensive program to document these sites in 1993, and conserve these fragile and unique artifacts in a laboratory open to the public. This provided an invaluable opportunity for visitors to learn first hand about the challenges and complexities of conserving underwater historic artifacts and other resources. The State of Vermont is currently building a visitor center at Mount Independence for displaying recovered artifacts and interpreting the historic site to the public.

The Lake Champlain Basin Program sponsored a preliminary inventory and assessment of industrial and commercial activities in the Lake that may have contributed toxic and other pollutants over the past 200 years (Neudorfer, 1993). This study begins to describe the complex and varied sources of historic contamination in Lake Champlain and illustrates how our "out of sight, out of mind" attitude about waste disposal continues to haunt us as we strive for a cleaner environment. Cleaning up toxic sites that are also historically significant to the industrial history of the Basin will pose special challenges.

An "Archeology on the Farm Project", funded by the Lake Champlain Basin Program in 1991, investigated whether privately owned archeological sites on farms might be faced with increased risks as water quality improvement projects in the Basin accelerated. This demonstration project, developed in cooperation with the USDA Natural Resources Conservation Service (NRCS), the Vermont Division for Historic Preservation and others, made it apparent that farmers were the most effective stewards of the resources on their own lands (Rossen, 1994). Virtually all of the participating farmers were interested in learning about sites on their land, and many were enthusiastic about protecting them. It was also found that nearly all projects with the potential for affecting archeological sites could be successfully redesigned to avoid site areas. The presence of a professional archeologist on the NRCS staff provided intensive training opportunities to other NRCS staff, and free technical assistance and outreach to farmers and interested organizations, such as town planning commissions and local non-profits involved in land preservation. The efforts of the "Archeology on the Farm" project were invaluable in increasing public awareness of archeological resources, and an important result was a full-time archeologist hired by the NRCS in April, 1994.

Issues

Lack of Recognition and Appreciation

Public awareness, appreciation and understanding of the Basin's cultural resources is limited. This is due partly to incomplete or cursory documentation of resources, and partly to varying perceptions of what constitutes cultural heritage resources. The consequences of this lack of recognition are especially important since the majority of heritage resources in the Basin are privately owned, and their preservation is directly related to an owner's understanding and appreciation of a property's significance in combination with the availability of technical and financial means necessary to maintain those resources. Lack of recognition and appreciation results in missed opportunities for stewardship, economic development, recreation and education. Other consequences include: resources that are often at risk and under-valued by owners, communities, and regulatory authorities; resources that are subject to accidental destruction and vandalism; opportunities for revitalization and adaptive reuse are not recognized; resources are lost to degradation by natural processes (e.g. deterioration, erosion and exposure of archeological sites); lack of public education about cultural heritage resources, and inaccessible information, such as site inventories, to users (owners, researchers, and planners).

Challenges Facing Protection of Heritage Resources in Private Ownership

Private property owners are the primary custodians of the Basin's cultural heritage resources. It is critical that the stewardship role and concerns of private landowners be fully acknowledged in heritage resource discussions, and that communication and active relationships with landowners be increased and strengthened if heritage resource protection is to be effective.

There is often a perception by landowners that recognition, including designation, of their property invariably means restrictions on its use. Most federal and state laws regulating heritage resources have little or no impact on private landowners. For example, the owner of an historic house (even if it is listed on the National or State Register of Historic Places) is free to demolish the house as long as he/she is not tearing it down with state or federal dollars or under a state or federal permit. And although property owners in Vermont and New York are prohibited from disturbing or destroying burial sites and burial grounds anywhere, a farmer can freely bulldoze other important Indian sites in the Basin as long as he/she is not receiving federal or state money or technical assistance (for example, from the NRCS or the Farm Services Agency [FSA]). In cases where there is federal or state funding, permitting or licensing, the goal is to protect the cultural heritage resource, or, if protection is not feasible, document it before it is destroyed.

Use of NRCS technical assistance and FSA funding on a farm illustrates the regulatory process associated with building a manure pit. In planning the storage pit, the NRCS looks to see if heritage resources, such as prehistoric Indian sites, may be harmed by the proposed construction. If a site is discovered, plans are made to build the pit away from the archeological site - a simple solution that often works in regulatory situations. But simple solutions cannot always be found, and preserving resources sometimes cost money. For example, rehabilitating historic barns that are still functional requires money, and data recovery of an archeological site prior to its destruction is costly, as is avoiding a site by reducing the number of lots in a subdivision. Issues such as who pays to preserve resources on private lands, and how private landowners should be compensated merit vigorous discussion with all involved groups. Regulations may be necessary to complement stewardship efforts, and landowners' frustration with the regulatory process must be kept in mind throughout discussions. Improved communication with landowners about the regulatory process, preservation alternatives and mutual goals, and frank exchange of issues, concerns and heritage information with private landowners is necessary.

Increasing voluntary stewardship programs will be a critical effort. An important example is the voluntary sale, or donation, of development rights on lands that contain important cultural heritage resources. In exchange for conservation or preservation easements on some of the land, the rest can be used for development, agriculture or timber harvesting. A variety of incentives, such as tax rebates or credits, could encourage heritage protection on private lands, especially in difficult economic times. Programs such as Vermont's Historic Barn Grants for privately-owned historic barns still in agricultural use need to be continued and expanded. The National Trust for Historic Preservation's "Barn Again!" program has provided assistance that would benefit private landowners in the Basin.

Challenges Facing Current Management and Protection: Government Issues

To date, the Basin has not been considered as a whole with regard to inventory, management, interpretation, and preservation of heritage resources. Therefore, management of cultural heritage resources is not coordinated, and protection of resources, even on public lands and under public waters, is far from cohesive. Management and protection efforts face several challenges. For instance, each agency or entity involved with the management or preservation of cultural resources has its own policy, agenda, and methods, and they are only now beginning to actively work together, in part, as a result of the Lake Champlain Basin Program. Common themes and linkages among heritage resources in the Basin are beginning to be defined regionally, with promise of greater coordination and communication. Existing legislation is not integrated between the states, which is a barrier for protecting historic shipwrecks and other underwater historic resources, and existing federal and state historic preservation legislation is not followed or enforced by some federal and state agencies. Insufficient capacity in staff and technical support at national, state, regional and local levels is a major impediment to resource management and preservation.

Limitations with Current Information

Inventories of cultural heritage resources in the Basin are incomplete and, in some areas, are non-existent. We cannot protect, interpret, and promote resources that we do not know about. Existing inventories focus on small discrete areas (e.g., a town), but not the region. They also under-represent (or ignore) many types of resources, and employ varying methodologies and levels of documentation. Appropriate contexts, boundaries, linkages, and groupings of resources have not been adequately identified throughout the Basin. Priorities for inventory and evaluation projects have also not been identified. The Cultural Heritage Needs Assessment project, discussed in an earlier section, provides a baseline of current information. On a positive note, architectural historical surveys of three entire counties in the Basin have been completed, and two, Addison and Rutland Counties, Vermont, have been published. Washington County, New York has been surveyed. These surveys provide invaluable educational information and lead to locally driven, pro-active planning and stewardship efforts.

Issues with Data Management

More and more data on the Basin's cultural heritage resources will be generated as inventory work continues. Current data exists in many different formats and repositories with no common index or data base. Access to data for planning, education, and/or management purposes is difficult, and computerization of data is just beginning. The Cultural Heritage Needs Assessment project provides a baseline of information about how inventory and other cultural heritage resource data are managed across the Basin. One goal identified in the Needs Assessment is to make that data readily accessible to potential users.

Unrealized Economic Opportunities of Cultural Heritage Resources

The opportunity exists for cultural heritage resources to play a significantly larger role in the Basin's economy. The success of two of the major historical attractions in the Basin is clear: the Shelburne Museum attracts 175,000 visitors each year, and Fort Ticonderoga attracts over 100,000. These attendance figures translate into millions of dollars spent on entrance fees, food, gifts, transportation, and lodging. Yet these figures only indicate the current demand at these relatively large sites. Many of these visitors would also visit some of the smaller, related sites scattered around the Basin if they were aware of their existence and location.

Much of the demand for cultural and historic tourism is for smaller sites, featuring knowledgeable guides and interpreters, and for programs providing hands-on experiences. A few of these types of activities and programs are currently underway in the Basin, and the potential exists for many more. One recent example being explored in Essex County, New York is the establishment of working farm tours. There is also a great potential for linking historic sites within the Basin through interpretive maps, educational pamphlets, and an historic driving and bicycling trail system. For example, students from the University of Vermont Historic Preservation Program are developing a guide to Champlain valley maritime-related historic sites. This effort will feature the international aspect of the Basin and encourage people to visit related sites in Vermont, New York, and Quebec. The result of heritage tourism efforts would be increased visitation and increased tourism-related expenditures, as well as an enhanced appreciation of the Lake Champlain Basin.

While promotion is a necessary step in increasing visitation at historic and cultural sites, planners also need to remain aware of the potential for overuse of some sites. Fortunately, much can be learned from other parts of the country that are further along in addressing the promotion and protection of their cultural and historic resources. The on-going efforts to preserve and protect underwater shipwrecks in Lake Champlain, while at the same time making it easier for divers to locate and access the sites, is an example of how promotion and protection can work together.

To promote economic development related to history and culture, and to ensure the enjoyment of these resources by future generations, three additional factors need to be addressed: research must be compiled that shows the economic value of historic and cultural resources; a comprehensive marketing and promotion plan for the Basin's cultural heritage resources must be developed; and the property tax structure in each state must be examined, and model codes must be developed, that will encourage the preservation rather than the demolition of historic structures.

Developing New Sources of Support to Implement Action

There are significant costs involved in addressing the issues discussed in this section. Some costs, such as those related to planning, survey and inventory, and public education and outreach, are eligible for support from the federal Historic Preservation Fund (HPF) through the New York and Vermont State Historic Preservation Offices, but reduced federal and state dollars have greatly decreased the availability of HPF dollars. Other state and federal agencies may be sources for project support in specific geographical or program areas. The Lake Champlain Basin Program, with funding from the National Park Service and the Environmental Protection Agency, has provided significant annual support. In some cases, an integrated project addressing, for example, a combined recreation and historic preservation need, may qualify for funding under one program, or both.

Locally, municipalities may have funds to further options regarding cultural resources; some of these funds may come from state or federal sources into the jurisdiction of the local government. Conservation organizations like the Vermont Housing and Conservation Board must be encouraged to support projects that protect multiple resources, such as combinations of agricultural lands/prehistoric Native American sites. Regional trusts and charitable funds are another potential source, especially if the action can be shaped to address their project guidelines. Local philanthropy and fund-raising, including enlisting volunteer support, has long been a funding source for historic preservation projects. Developing an organized and systematic approach to the identification, recording and protection in the region should enhance the definition of need for such projects. From the millions of dollars dedicated to the region through federal and state programs, to the yard sale which raises funds for a historic plaque program in a small hamlet — all sources and levels of participation can contribute to the long-term management and protection of the Basin's significant cultural heritage.

The greatest support for heritage resources comes from the thousand of private landowners who are the best stewards of the resources on their land. Landowners need more and better information about their resources, their opportunities, and options for incentives. It is critical to direct, or redirect, funds and technical assistance towards these local efforts.

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Building Capabilities for Cooperative Watershed Planning and Protection

Background

Residents of the Lake Champlain Basin value the abundant water resources of the Lake and its tributaries, and the diverse recreational, economic, cultural, and environmental benefits they provide. Increasingly, Basin residents are recognizing the vulnerability of these resources, and the importance of taking action to protect water quality. This section focuses on ways to bring together diverse interests and watershed groups to enhance cooperative local and regional approaches to watershed protection.

Linking Land Use and Water Quality

The intensity and pattern of development on land surrounding Lake Champlain can have important consequences for the human use and enjoyment of the Lake and Basin, and for the lake water quality as rains wash soil and pollutants into streams and ponds, which eventually drain to Lake Champlain. Some types of land can have a greater impact on water quality than others, depending on how much soil is disturbed and the nature of activities on the land. For example, forested land generally has less impact on water quality than urban or agricultural land, where runoff from development (especially areas such as construction sites, gravel roads, ditches and failing septic systems) carries nutrients, sediments, pathogens, and sometimes toxic substances to surface waters.

Other chapters address management issues pertaining to specific pollutants and natural and cultural and resources. This section focuses on the process at the state, regional, municipal, and grass roots levels that is necessary to achieve these management goals. It focuses on watershed planning at the local scale, as this is the level at which most planning occurs in the Basin.

What is a Watershed Plan?

A watershed plan is an integrative plan that focuses on the water resources of a watershed but does not exclude the other resources of the area. It is based on a compatible set of social, economic, cultural and environmental goals and addresses all activities in the watershed that affect or are affected by water. A watershed plan differs from a community plan because the geographic scope of a community plan is defined by the political boundary of a governing body, such as a town. In contrast, the geographic scope of a watershed plan is defined by a ridge line that determines the direction that streams and surface runoff will flow. Watershed boundaries rarely coincide with political boundaries and may include all or part of more than one political subdivision. A watershed planning effort, therefore, needs to be organized to include all the affected political units.

The Mad River Management and Protection Plan is one example of a watershed plan recently completed within the Basin. A cooperative effort between the Mad River Valley Planning District (comprised of five towns) and the Friends of the Mad River, this project was funded through the Lake Champlain Basin Program as a watershed planning demonstration project. The main objectives of the Mad River Project were to 1) identify the assets of the river (its uses and values), 2) identify problems and threats to these river assets, and 3) develop solutions to existing and potential problems, and use conflicts. The project included local officials, businesses, organizations, schools, and citizens in the planning process. An important component of the project was an intra-basin advisory committee made up primarily of representatives of other watershed groups throughout the Basin that helped guide the project and, very importantly, communicated the experiences of the project to other areas of the Basin. Implementation of priority recommendations in the plan is now underway, including erosion control and habitat improvement work at selected sites along the Mad River.

Common water quality concerns in upland watersheds include sedimentation (and its effect on fish habitat), bacterial contamination, and nutrient enrichment. The watershed planning process is an opportunity to identify the full range of local water quality concerns along with recommended solutions. Additionally, local watershed plans can contribute to the attainment of water quality goals in downstream waters such as Lake Champlain. The phosphorus section in Chapter 2, for example, discusses the development of watershed plans to reduce phosphorus within targeted sub-basins. Local and regional scale watershed protection efforts should be an important part of these larger sub-basin plans.

The Need to Include all Interested Parties

An effective watershed planning process must include all interested parties within the watershed. Examples include landowners (including farmers and forestland owners), businesses, lake users, citizens who do not own land, visitors, and government. All of these interests should be taken into consideration and incorporated into watershed plans. The Lake Champlain Basin Program has funded two community case studies of Vergennes, Vermont and Champlain, New York (EFCA, 1993; Yellow Wood Associates, 1993) which provide good examples of how to integrate many of these interests into the water resources planning process. These studies evaluate each community's economic base, and a variety of social and economic factors such as property values, sales revenues, vitality of agriculture, sewer and water expenditures, and local business concerns, and the relationship of those factors to local water resources.

Existing Framework for Watershed Planning

Planning in the Basin is shared by government and citizens. Local and regional watershed planning and protection efforts occur within a variety of institutional arrangements and administrative structures. Brief descriptions of some of the types of organizations and government programs commonly involved in watershed planning are included below. A few examples of state and federal legislation affecting watershed planning and protection are described as well.

Citizen-based River and Lake Associations

River and Lake Associations play a key role in organizing watershed protection efforts. These associations can accomplish a great deal through education and outreach programs, democratic participation in the development review process, participation in citizen monitoring activities, etc. Over the past year, the LCBP has provided financial assistance to several watershed associations for a variety of activities. A sampling of activities commonly pursued by watershed associations in the Lake Champlain Basin is included in Table 18.

Watershed associations may also act as catalysts for developing non-regulatory protection programs, and can effectively advocate for improved conservation-oriented land use practices. River and Lake associations can also be regional in scope and encompass several local jurisdictions. Examples of river and watershed associations include the Boquet River Association in New York, and the Lewis Creek Association, the Mt. Mansfield Association, and the Friends

Table 18. Common Watershed Association Activities in the Lake Champlain Basin.

WATERSHED ASSOCIATION ACTIVITIES
River watch activities, including monitoring water quality, inventorying resources (fish habitat, wetlands, etc.)
Streambank stabilization to prevent erosion and sedimentation; the establishment and operation of nurseries to propagate willows for streambank plantings
Provision of support and assistance to municipalities and Municipal Conservation Commissions
Publication of informational newsletters
Development and distribution of educational materials to schools
Publication of informational materials for landowners
Participation in development review decisions
Development and submittal of wetland and stream reclassification petitions to the state
River cleanups
Fish habitat restoration
Watershed planning and public participation and involvement
Development of educational programs dealing with the history of a river or waterbody
Cooperative work with landowners to improve water quality (for example, repair of stream fencing on farms)
Collaborative work with state agencies to assist in guiding the management of the water resource

(Source: Mad River Valley Planning District and Friends of the Mad River, 1995)

of the Mad River in Vermont. All of these organizations work closely with local government, and respect a wide variety of interests including property rights, environmental protection, and economic development.

Municipal Planning

Most land use planning in the Basin occurs at the municipal level, where watershed planning can be very effective to the extent that watershed boundaries are contained within municipal boundaries. Municipalities may develop watershed districts that have special review criteria for new development based on a long term water quality protection strategy. Additionally, municipal measures such as the designation of riparian "buffer" zones along streams, lakes, and wetlands can be important water resources protection tools. In Vermont, much water quality protection occurs at the municipal level. Local capabilities for watershed planning vary greatly throughout the Basin in both New York and Vermont. In some areas (often near urban centers) municipalities have already developed watershed plans and instituted aggressive water quality protection measures. Municipalities in these areas typically benefit from on-going technical support from local staff, watershed associations, regional planning commissions, county planning offices, or conservation districts. In other parts of the Basin, municipalities have very limited local capacity for any type of planning or land use regulation.

In Vermont, municipal planning and zoning is guided by the State Municipal and Regional Planning and Development Act. As amended through 1990, this legislation includes guidelines for the development of regional and municipal comprehensive plans, and enables municipalities to enact zoning, subdivision and site plan review regulations once comprehensive plans are in place. The Act requires that comprehensive plans be developed at the regional level, and gives municipalities the option of developing local plans. Similar legislation in New York enables municipalities to adopt zoning, subdivision and site plan review regulations based on comprehensive plans as defined by New York statutes.

The enabling legislation in both Vermont and New York does not specifically address the watershed planning concept. However, municipalities may incorporate a watershed focus into local comprehensive plans and develop special watershed districts (as noted above) for watersheds within their jurisdiction. While state law in both New York and Vermont also allows for the development of inter-municipal agreements or the formation of regional districts to manage larger watersheds, there are only a few places in the Basin where such districts have been formed. The Mad River Valley Planning District in Vermont is an example of a regional district comprised of five towns sharing the Mad River watershed.

County and Regional Programs

In New York, the Department of Environmental Conservation uses county water quality coordinating committees to establish local priorities, and develop strategies for addressing nonpoint source problems at the local level. To the extent that watershed boundaries fall within county lines, these coordinating committees can adopt a watershed planning approach. Both Essex and Clinton Counties have developed detailed water quality strategies that serve as blueprints for local action.

In Vermont, regional planning commissions provide technical assistance to municipalities on all planning issues, facilitate the development of regional plans, and are responsible for approving local comprehensive plans. County planning offices provide comparable technical assistance in New York. New York also provides for the establishment of Environmental Management Councils, which can serve as vehicles for citizens and agencies to share ideas and interests on environmental protection.

State Watershed Protection Programs

In Vermont, DEC's Water Quality Division provides on-going technical assistance to watershed associations and municipalities. Vermont DEC assists municipalities with portions of town master plans or ordinances dealing with the protection of surface water or wetlands, and helps towns conduct lake watershed surveys. The Department supports an aggressive education program on watershed planning, and has prepared a number of educational guides for land owners and municipalities including: "Planning for Lake Water Quality Protection: A Manual for Vermont Communities" and "Native Plants for Lakeshores, Streamsides and Wetland Buffers: What You Need to Know to Re-establish or Enhance a Buffer Strip Along Water & Wetlands in Vermont". Descriptions of additional Vermont water quality programs are included in the Chapter 2.

New York State's DEC provides similar technical assistance to municipalities and watershed associations, but with more limited staffing. The DEC has also published a variety of education materials on watershed protection, and recently released a guide titled: "Watershed Planning Handbook for the Control of Nonpoint Source Pollution".

There are also a variety of state laws in Vermont and New York that affect land use. For example, Vermont's "Act 250" directs the state to review large or commercial development proposals for consistency with ten performance criteria pertaining to issues such as water pollution, soil erosion and wetlands. Criteria ten stipulates that Act 250 reviews must also consider a proposal's conformance with existing regional and municipal comprehensive plans. Another example of an influential state law affecting a large portion of the Basin is New York's Adirondack Park legislation. The Adirondack Park Agency (APA) was created by state legislation in 1971 to develop long range land use plans for both private and public lands within the Park boundaries. The APA has partitioned the Park's private land into six land use classifications which determine allowable maximum building densities and other stipulations.

Other state laws that affect land use and development include Vermont's Management of Lakes and Ponds, 29 V.S.A. section 401 et. seq., and New York's Protection of Water Act. Both of these laws, broadly defined, require permits from the VT DEC or NYSDEC for any alteration of a stream bed including encroachments on the water such as dams, large docks, or other obstructions. Wetlands are also regulated by the states. The Vermont Wetland Rules, 10 V.S.A. section 905(7-9), classify wetlands in Vermont into three categories and establish allowed and conditional uses for those wetlands and their buffers. The New York Freshwater Wetlands Act, N.Y. ECL Art. 24, 6 NYCRR Parts 662-664, protects wetlands above 12.4 acres and smaller wetlands of "unusual local importance" outside the Adirondack Park. Developments proposed in or within 100 feet of these wetlands require a permit from NYSDEC. Inside the Adirondack Park, wetlands of 1 acre size or greater or those adjacent to open water are protected. Any land use that will affect the functions and benefits of these wetlands must be permitted by the APA. New York also has regulations concerning the dredging and filling of wetlands in addition to the requirements of Section 404 of the Clean Water Act, as administered by the federal government.

Federal Programs

The federal government provides funding through the U.S. Department of Agriculture, Natural Resource Conservation Service (USDA-NRCS) and other agencies on an ongoing basis to develop watershed plans in selected areas within the Basin. Many of these projects (such as the PL566 projects) are administered by the NRCS, but are developed and implemented by a local sponsor. Such projects typically assess nonpoint source pollution problems in a watershed (with a particular emphasis on agricultural sources), and recommend solutions. A list of all USDA watershed projects completed or in progress in the Lake Champlain Basin is included in the section on Reducing Phosphorus Pollution.

The federal government has also adopted a number of laws that affect land use and development. Local or regional watershed plans need to recognize these laws and should take into account their potential influence on development activities. For example, the dredging and filling of wetlands is governed by a permitting process administered by the Army Corps of Engineers and approved by the EPA under section 404 of the Clean Water Act. (For more information on wetlands programs and laws, refer to the wetlands section.)

Issues

Following is a summary list, not arranged in priority order, of some of the major issues involved with building capabilities for watershed planning and protection.

The Need for Better Communication Between Communities on Watershed Planning

There is often insufficient communication among communities and regions within the Basin on watershed planning. An effective process for disseminating information on successful watershed planning approaches is needed. Likewise, the difficulties and problems encountered in less successful watershed planning efforts need to be documented and communicated to help others avoid these problems.

The Need for More Public Participation

A critical component of successful watershed planning efforts is strong public awareness of, and involvement with, the issues. Residents must be aware of the relationship between water quality and activities that occur in the watershed, along the shoreline, and in rivers and lakes. Local and citizen groups should also be more involved in the development of state guidelines, policies and regulations that affect local watershed issues. For example, local communities and local watershed organizations can provide the impetus for state stream classifications in their regions. State agencies need this kind of local input to develop locally relevant guidelines and policies. Additionally, local involvement in implementing state programs is critical to program success.

Addressing Cumulative Impacts

Local communities and agencies have traditionally made land use decisions over time without assessing the cumulative impacts of their decisions. Watershed planning is based largely on considerations of these cumulative impacts. It is very difficult to determine how many land use changes may occur before a problem develops. It is also difficult to make the first determination to turn down a request for a land use change based on cumulative impacts. A quantitative method for assessing cumulative impacts is needed to aid in making these decisions. In some parts of the country, cumulative impacts are assessed in terms of estimated contributions per acre of a particular contaminant, such as phosphorus or nitrogen. While this approach may or may not be desirable in the Champlain Basin, some system for recording basic project characteristics related to cumulative impact is needed.

Insufficient Technical and Financial Assistance

One of the major impediments to the development and implementation of watershed protection plans at the local and regional level is insufficient financial and technical support. Watershed groups may develop the necessary awareness and enthusiasm for a project, but may flounder without technical and organizational assistance from appropriate professionals. Some assistance is currently provided to watershed associations in VT through the State Agency of Natural Resources, and in NY through the Department of Environmental Conservation, the Cornell Cooperative Extension, and county and regional planning commissions. However, there is a need for additional technical and financial assistance to municipalities and to help watershed associations hire their own paid staff. Developing a local capacity grant program for watershed associations may be one effective way to help address this shortage.

The Need for Innovative Partnerships

Experience in a number of communities/regions has pointed to the value of innovative partnerships in developing and implementing of effective watershed plans. For example, the Mad River Valley Planning District in Vermont has developed a strong watershed planning capability through the formation of a three-way partnership among district towns, a private nonprofit environmental organization, and the State of Vermont. This arrangement provides for a funding base, extensive grass roots involvement, strong local political support though the district board membership, and technical assistance from the state. There often may be an important role for state and federal governments, as well and county and regional planning commissions, in this process (e.g. funding, technical assistance).

The Need for Land Use Forecasts within the Basin

An understanding of likely future development trends is critical to the watershed planning process. Existing trends and assumptions about future conditions provide the basis for developing future scenarios for the Basin. Impact models can evaluate the effect of various scenarios on the Basin's economic, social, cultural and environmental resources. The design and implementation of a process to forecast and evaluate alternative futures for land use in the Basin is needed. This effort should begin with the projection of present land use trends, and evaluation of the impact of these trends on water quality.

Need for an Integrated Approach to Watershed Planning

Just as watershed planning considers the watershed as a whole rather than as segmented streams, watershed planning should be undertaken in coordination with a comprehensive range of concerns. Care must be taken to ensure that watershed protection strategies operate in concert with other planning goals and are consistent with the development of a strong regional economy, the protection of cultural resources, and the continued existence of the working landscape.

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Educating and Involving the Public

Background

Why is an Informed and Involved Public Important?

The future of the Lake Champlain Basin rests in the hands of its citizens and leaders. Public education and involvement efforts must be continued and expanded to actively involve people in protecting and truly appreciating the Lake's resources. Ultimately, a public that understands the Basin's water quality and related resource management issues as well as possible solutions can make informed choices about its long-term protection and restoration.

Over 600,000 people live, work and play in the Lake Champlain Basin, which they share with over six million visitors annually. These people depend upon the Lake for drinking water, for water in agriculture and industry, for recreation, and for the Lake's aesthetic beauty. A healthy Lake Champlain Basin is crucial to a healthy regional economy. To **become better stewards of the Basin's resources**, citizens must become actively involved in the Plan, and have access to the tools necessary to bring about awareness and involvement in Basin issues.

It is the cumulative results of many individual actions that make a difference in the complex issues facing the Lake Champlain Basin. People need to become aware of how they may be contributing to pollution before they can **take responsible actions** to reduce and prevent it. Education about individual responsibility in protecting a shared resource is very important. When people are given the opportunity to develop awareness, knowledge, skills and commitment towards a Basin issue, they can make informed decisions and take constructive actions. When people know how they can make a difference, they will.

Current Programs to Involve and Educate the Public

A wide range of opportunities exist at the federal, state and local level to learn about the Lake's resources through written materials, educational workshops and programs, on-the-water activities and public forums. Several of these programs have been successful in educating and involving the public. For example, both Vermont and New York's water quality protection programs have education programs, such as NYSDEC's "Water Week," and VT DEC's Lay Monitoring and Lake Protection programs. The Lake Champlain Basin Program has sponsored several non-profit organizations such as the Lake Champlain Committee to run education and involvement programs, such as the "Clean Streets, Clean Streams" project.) This project in Plattsburgh, NY and Burlington, VT was aimed at improving Lake Champlain water quality by educating citizens about the sources and impacts of urban runoff, and implementing hands-on local solutions.

Many tributaries are being protected and monitored by local river associations, such as the Boquet River Association in Elizabethtown, New York, the Lewis Creek Association in Huntington, Vermont, and a growing network of local River Watch groups. Each of these organizations strives to develop an awareness of these tributaries, and provide water quality monitoring and restoration through localized education programs. The Lake Champlain Basin Program has created education consortiums, such as the Champlain Basin Education Initiative between Shelburne Farms in Vermont, the Adirondack Park Visitors Interpretive Centers in New York, and McGill University in Quebec. These groups have joined forces to provide teachers with innovative and creative tools to teach their students about Basin issues, and what can be done to solve Basin problems. Education programs through the Lake Champlain Maritime Museum, Crown Point Historic Site and Fort Ticonderoga provide extensive resources for those interested in learning about the history and other cultural resources of the region. Conservation Districts, Commissions and Extension Systems in both New York and Vermont provide invaluable education and outreach resources.

These are just a few examples of existing education and outreach programs within the Basin. An Education & Outreach Field Guide produced by the LCBP summarizes these efforts, and is a useful resource for teachers, local officials and interested citizens who would like to become involved (see List of Resources at end of this section). The LCBP has sought to strengthen and coordinate these existing governmental and non-governmental educational efforts to maximize the use of scarce resources.

Lake Champlain Basin Program Education & Outreach

In June 1991, the Education & Outreach Advisory Committee (E&O Committee) was formed by the LCMC to develop a comprehensive education & outreach program for the Lake Champlain Basin. The Committee consists of members of the LCMC, CACs and the education community. In November 1991, an Education & Outreach Coordinator was hired to develop a five-year work plan, and create a comprehensive public education and involvement program with the advice of the E&O Committee.

Many educational materials have now been developed and widely distributed, such as "Casin' the Basin," LCBP's quarterly newsletter, a slide show, video, and fact sheets on several Basin issues, bi-lingual zebra mussel identification cards, a LCBP brochure, a field guide to existing education & outreach organizations in the Basin, and annual progress reports. A comprehensive teacher education program, including a series of one day workshops and a week long Summer Institute, has reached over 230 teachers from all parts of the Basin. Sixteen grants totalling $75,000 have also been made to help support existing education and outreach programs within the Lake Champlain Basin, and 14 Participation and Demonstration grants totalling $145,000 have helped citizens and organizations become more involved in Lake issues and protecting the resource.

An extensive program was started in 1993 to actively involve the public in the LCBP planning process. The first phase concentrated on finding out what Basin citizens think about Lake Champlain: what people value most, what they are most concerned about, and how these problems should be solved. The information gathered during this series of public meetings was used by the Plan Formulation Team to develop the draft Plan. The second phase began in early 1994, when a preliminary summary of *Opportunities for Action* was developed. It described eleven priority issues based on prior public input and current research knowledge and possible actions under consideration by the Lake Champlain Management Conference (LCMC), and provided an opportunity for the public to voice their opinions and concerns about the evolving Plan. Over 120,000 copies of *Opportunities for Action* were distributed in Basin newspapers by the LCBP, and 12 public input meetings were held throughout the Basin in the Spring of 1994 to receive public input on this document. Focus group meetings were also held with different groups of constituents, including representatives from the agriculture community, business and economic interests, recreation interests, and sports fishing groups, to obtain feedback on these possible actions. Responses from this process were compiled and presented to the LCMC for consideration in the initial decision-making process.

The LCBP continues to do presentations for educational, civic and business organizations. The program has also held multi-day celebrations of Lake Champlain, bringing people together to celebrate the Lake's unique qualities. In addition, the Citizens Advisory Committees (with their diverse user and interest group representation), have been, and will continue to be, an important communication channel for the public in New York, Vermont and Quebec. They serve as the public liaisons to the Lake Champlain Basin Program through continued public forums, monthly meetings, field trips, annual action plans and education programs. All of these activities, and more, have been targeted at four major audiences: school children and educators; constituent groups (such as shoreland property owners, business, civic organizations, commercial fishing, environmental organizations, etc.); local, state and federal decision makers; and the general public.

Issues

The following section outlines some of the major issues involved with educating people about Lake Champlain and its Basin, and involving citizens in planning for its future.

The Need for Increased Public Awareness and Understanding of Basin Issues

Public awareness and understanding of Lake Champlain Basin issues and the priority actions needed to address them are limited. This is especially true of communities located further from the Lake, who may be unaware that they are within the Lake Champlain drainage basin and therefore connected to the quality of Lakes resources. As stated at several public meetings, people need to become aware of an issue before they can understand how they contribute to the problem and assume responsibility for solving it.

The Need for Local Community Involvement

Many participants at public input meetings stressed that the real power in public involvement comes from a local or community level. Programs such as the "State of the Bay Project" in Colchester, Vermont, which brings together students, professionals and community members, are a powerful and cost-effective tool for getting people involved. Unfortunately, programs such as these are limited in the Basin. Community involvement is important for addressing local issues that occur in only specific areas of the Basin. People most affected by an issue will be best able to address that issue; if this is done at a community or watershed level, partnerships can be created and local action taken (for more information see "Building Capabilities for Cooperative Watershed Planning and Protection" earlier in this chapter).

The Need for More Individual Action

Public awareness of the Basin's problems is growing, but there is a definite lack of information about how each of us can help to solve these issues. People must understand their responsibility as stewards of the Basin, and must speak out for its protection. During times of budget constraints in both the government and in the private sector, it is important to use the public's skills, energy and enthusiasm to solve many Basin issues. There is currently a lack of programs and opportunities that allow individuals to become involved and take individual action. Programs that emphasize how each person can make a difference need to be developed.

The Need for a Long-Term, Coordinated Education & Outreach Structure

Although there are many successful organizations throughout the Basin involved in education and outreach for Lake Champlain and water-related issues, there is a need for a continued comprehensive program (similar to the LCBP) that can distribute and coordinate resources, literature and research results. There is also a need for a comprehensive program that can link existing organizations together to form a successful Basin-wide network of education & public involvement programs that coordinates existing activities for Lake Champlain, and creates partnerships to reduce duplication and maximize the use of funds.

List Of Educational Resources

LCBP Education and Outreach Materials:

Education and Outreach Field Guide - a comprehensive guide of educational programs, workshops and publications relevant to the Lake Champlain Basin. (see for a listing of available programs, publications, etc... by other organizations and agencies throughout the Basin).

Casin' the Basin - LCBP's newsletter published four times a year to inform the public about events and issues which affect the Lake Champlain Basin.

Lake Champlain Basin Slide Show and Presentation - this 30 minute slide show provides a comprehensive overview of the Lake Champlain Basin, the issues surrounding it and the role of the LCBP in Basin planning. This show can be adapted to any audience and can be presented by LCBP staff or available in VHS format.

LCBP Annual Reports - these documents contain information on how the Basin Program was formed, summarizes projects funded by the LCBP and profiles each of the LCBP committees (1991-1992, 1993 and 1994).

LCBP Informational Brochure - this brochure contains background information on the LCBP, who we are, what we are planning for and how you can get involved. It also includes a map of the Lake Champlain Basin and accompanying "Lake Facts."

Zebra Mussel Fact Sheet - a four page informational fact sheet which defines the problems which zebra mussels pose to Lake Champlain, describes the life history, outlines actions we can take to slow the spread of zebra mussels and additional resource information.

Zebra Mussel Identification Cards - a pocket-size informational card which outlines how to identify the species and who to contact.

Nonpoint Source Pollution Fact Sheet - a four page informational fact sheet that defines nonpoint source pollution, describes where it comes from, the sources and types, and how you can help to reduce nonpoint source pollution in the Basin.

Lake Champlain: Its Future Depends on Us - Conference proceedings; September 8-9, 1992, South Burlington, VT. NH/VT and Empire Chapters of the Soil and Water Conservation Society. July, 1993

Lake Champlain Drainage Basin Maps - These maps (24"X 32") highlight town, county, state and international boundaries. They also illustrate the principal surface waters, and the boundaries of major river basins which lie within the Lake Champlain Basin.

Public Input in the Lake Champlain Basin - results of a series of public input meetings, April - May, 1993.

Discovering the History and Heritage of the Champlain Basin - a resource guide for educators who want to plan classroom instruction which focuses on the history and cultural heritage of the Champlain Basin. Compiled by Gregory Sharrow and Amy Demerest, Spring, 1993.

Opportunities for Action - "An Evolving Plan for the Future of the Lake Champlain Basin." A summary of the draft Plan for solving the problems that currently face Lake Champlain. February, 1994.

Lake Champlain's Future: A Community Based Strategy for Environmental Policy Development. SUNY Plattsburgh. February, 1994.

Lake Champlain Citizens Advisory Committees' Publications:

Public Information Forum Report: Water Quality Problems in St. Albans Bay. Produced by the VT Citizens Advisory Committee, February, 1992.

Lake Champlain.... for our Children's Children - a 22 minute video that reflects a citizens based perspective on the issues and solutions to Basin problems. Produced by the NY and VT Citizens Advisory Committees. March, 1994.

Vermonters' Views on Lake Champlain - perceptions of its environmental health and recommendations for its future protection. Prepared by Middlebury College, for the Vermont Citizen's Advisory Committee on Lake Champlain's Future.

North Country Public Opinion About Lake Champlain - a survey of North Country opinions about public policy and environmental management in the Lake Champlain Basin. Prepared by SUNY Plattsburgh, for the New York Citizens Advisory Committee on Lake Champlain Management.

Lake Champlain Action Plan - an annual report produced by the Vermont Citizens Advisory Committee on Lake Champlain's Future. This report is a summary of recommendations on the condition and management of Lake Champlain (91'- 94').

Chapter 5. Economic Considerations

The Lake Champlain Basin Program has funded a variety of studies designed to improve our understanding of the Basin's economy and economic aspects of the resource issues discussed in this document and LCBP's Draft Plan (Holmes and Associates, 1993; Holmes and Artuso, 1995a, 1995b and 1996). A general description of the Basin's economy is included in Chapter 1. This chapter focuses on economic considerations associated with the specific management issues identified in this document. The material is drawn largely from Holmes and Artuso (1995a and 1995b) and includes three sections: water quality; living natural resources; and tourism, recreation, and cultural resources.

Water Quality and the Health of the Lake

Phosphorus Reduction
Substantial work has been done in quantifying the costs of point and nonpoint source phosphorus controls and of determining what facilities and watersheds should be targeted for implementation of treatment upgrades as well as agricultural and urban best management practices (BMPs). This work has been undertaken by the LCBP's technical subcommittees using a cost optimization model developed as part of the preliminary economic analysis of the Draft Plan (Holmes and Artuso 1995a).

This model can be used to identify individual treatment plants, watersheds and urban/suburban areas where additional controls would be most cost-effective in achieving in-lake phosphorus concentration targets established for the Lake. Much of the information in the model on the costs of point source controls and urban BMPs and the effectiveness of agricultural BMPs requires further refinement. The model also does not include the nonpoint source contribution that will result from new development. However, the model is very useful for establishing general targets for phosphorus reduction for point and nonpoint sources at the scale of lake segment watersheds.

An important aspect of nutrient and nonpoint source pollution control is the effect of new development. To the degree that forested land (or other land uses that generate low levels of phosphorus) is converted to residential subdivisions or other urban/suburban uses, there will be an increase in nonpoint source phosphorus loadings. This is a situation where no action would significantly increase costs. Incorporating nonpoint source phosphorus control measures into new developments as they are built is considerably less expensive than trying to do so after streets have been constructed, homes have been built, and stormwater drainage facilities have been constructed.

Several unresolved issues have been raised in relation to the benefits of phosphorus controls. First, there is continued uncertainty over the time lag between the implementation of farm controls and the detection of reductions in phosphorus concentrations in the Lake. It is likely that there will be some delay in seeing positive effects of agricultural BMPs on water quality due to phosphorus attenuation on land and in streams after it is off the farm. There may also be some delay in achieving in-lake phosphorus reductions due to significant levels of phosphorus stored in lake bottom sediments. Further study is warranted on both the effectiveness of on-farm phosphorus controls in reducing in-stream phosphorus loadings and on the time it will take for lake segments to respond to reductions in external phosphorus loads. Some research on this topic is underway and is described in the phosphorus section of Chapter 2 ("research needs").

To ensure efficient use of phosphorus control funds there is a need for continued monitoring of phosphorus levels and for continued research on the effects of phosphorus levels on recreational uses including swimming, boating and fishing. In order to distinguish short term fluctuations from long term trends, identify the causes of both short and long term phosphorus fluctuations, and revise control programs in light of this information, an integrated monitoring and evaluation program will be needed that includes all major sources and sinks of phosphorus in the Lake watershed. The costs of an ongoing monitoring and evaluation effort can be kept to a minimum through the use of volunteers and collaboration among public agencies, environmental education and research programs in the Basin. The benefits of continued monitoring and evaluation programs include improved targeting of phosphorus controls, an early warning system for increases in phosphorus levels, and increased public awareness of environmental conditions in the Lake.

Dairy Farming and Manure Management in the Lake Champlain Basin

Profit margins in dairying, as in most agricultural enterprises, are very slim. It will get increasingly difficult for dairy farms with less than 100 cows to remain economically viable in the Northeast. It is reasonable to expect the recent acceleration in dairy farms leaving the industry to continue. While farm size will undoubtedly get larger, off setting some of this decline, the industry as a whole will likely get smaller in the Northeast.

The reduction of nonpoint pollution from agriculture will require many more farms to change their manure management practices. Ecologically sound manure management practices include diversion of barnyard runoff, maintenance of grass cover between water ways and cultivated fields, and elimination of manure spreading on frozen ground. Each of these practices are designed to eliminate or reduce the amount of manure runoff into adjoining waterways.

The optimal management regime (environmental and economic) will vary from farm to farm depending upon its unique circumstances. To accurately assess the cost and benefits of implementing a particular manure management option on a farm, the unique circumstances of that farm must be considered. The cost and benefits of adopting an alternative manure management regime will vary widely from one farm to another. Site location and soil types will dictate the types and construction costs of feasible manure storage structure units.

Because manure management systems are generally more cost effective on larger dairy farms, the reliance on government cost share for reducing phosphorus loading in the Basin sharply increases with decreases in farm size. While the number of large farms in the Basin has been increasing in recent years, the majority of dairy farms in the Lake Champlain Basin are in the smaller farm category (i.e., less than 90 cows). It is on these small farms where the economic cost of moving from daily spreading often outweighs the benefits. A conclusion is that a significant infusion of cost sharing will be necessary to incorporate phosphorus control measures on all agricultural land in the Basin.

While cost share funding through the USDA Agriculture Conservation Program (ACP) decreased from $200 million in 1994 to $100 million in 1995, the 1996 Farm Bill has brought funding levels back up to $200 million a year through a new comprehensive program called EQIP (Environmental Quality Insentive Program). Additionally, cost share funds availalbe through a new Vermont state program (funded at $350,000 in both 1995 and 1996) can be used to augment USDA funds up to 85% of total project costs. Thus a farmer participating in both federal and state programs may only need to contribute 15% of total project costs.

Preventing Pollution from Toxic Substances
The most well publicized indicator of toxic pollution in the Lake Champlain ecosystem is the presence of elevated levels of mercury and PCBs in certain species of lake fish. This contamination can cause direct economic costs in a number of ways. First, detrimental human health effects can occur from excessive consumption of these fish species. The obvious intent of the fish consumption advisories issued by the states of New York and Vermont is to alter fish consumption patterns in ways that would minimize these public health risks. Evidence indicates that the advisories have been reasonably successful in achieving this objective (Connelly and Knuth 1994). But even if the consumption advisories were completely effective in preventing public health risks this would not eliminate the costs imposed by toxic contamination of lake fish species. Another cost of toxic contamination of fish is the adverse impact on recreational use of the Lake. For example, the perception of a toxics problem can reduce the number of fishing trips anglers make to Lake Champlain and reduce the net benefits they receive from each trip. There may also be secondary effects on other recreational activities (e.g. swimming, boating) and expenditures due to the public perceptions about toxic contamination.

In a recent study, Montgomery and Needelman (1994) used a discrete choice, travel cost model to estimate the recreational fishing benefits that would result from elimination of toxic pollutants that are responsible for fish consumption advisories in New York State lakes. They estimate that the combination of increases in fishing participation rates and increases in net benefits per fishing trip would result in total net benefits of $28 per adult state resident per year. To understand the implications of these findings for Lake Champlain, it is important to realize that there is no guarantee that implementation of toxics reduction strategies will permit the lifting of all fish consumption advisories. In addition, the Montgomery and Needelman study estimated the benefits that the average New York State resident would receive from the opportunity to fish in any lake in the state without worrying about toxic contamination of fish. Basin residents would presumably receive a somewhat lower level of benefit from elimination of toxic contamination just in Lake Champlain. The annual benefit of $28 per person should be viewed as an estimate of the upper limit of the direct recreational benefits to Basin residents from implementation of toxics reduction strategies.

Another principal means by which toxic pollution in Lake Champlain can result in economic costs is through public and ecosystem health risks posed by contaminated sites. Economic analysis of the benefits of remediation of contaminated sites requires information generated from risk assessment studies and engineering analyses of remediation costs and effectiveness. Risk assessments of contaminated sites are normally summarized in the form of increased probabilities that members of the affected population will develop various illnesses or health impairments as a result of direct contact with or movement of toxics from the site via physical or biological processes. Economic analysis of remediation efforts also must consider to what degree potential remediation alternatives will reduce the probability of negative health effects from the site. The estimated reduction in the probabilities of harm are then multiplied by the economic cost of the potential health effects to derive an estimate of the expected benefits (avoided costs) that would result from remediation. These avoided costs can include lost wages, reduced profits, medical expenses and the costs of pain and suffering. The expected benefits of each remediation option can then be compared with its costs.

Risk assessments have not yet been completed for any of the three priority sites of concern identified in Chapter 2. Cumberland Bay sludge beds have been added to New York's Inactive Hazardous Waste Site list and cost estimates for various remedial alternatives are under development.

In addition to the direct public health risks and recreational costs of contamination fish species, toxic pollution may create indirect economic costs as a result of more widespread ecosystem effects. Preliminary tests of microorganisms, freshwater shrimp, and fish species in Lake Champlain indicate that elevated levels of toxic pollutants at certain sites may already be having some detrimental ecological effects. While, these findings are cause for concern, further research is needed on trends in levels of contamination as well as fate and effects of contaminants of concern before any estimates can be made of the potential economic costs of indirect ecological effects of toxic pollution in the Lake.

Given the current uncertainty over sources, fate, effects and remediation options for toxic substances in the Lake Champlain Basin, expenditures on toxic pollution prevention and control should be made in a sequential fashion contingent on the results of continued research, risk assessments and source identification efforts.

Beach Closings

There are about 35 public beaches and 33 private beaches on the shore of Lake Champlain (Farnum 1994). Chapter 2 provides beach closing data for 11 municipal beaches for the period 1989-1995. There does not appear to be an overall trend in beach closings, although in 1995 there were more closed days than average for 4 of the 11 beaches.

Beach closings in 1995 appear to be primarily related to coliform bacteria counts, and the problems appear to be very site specific, with the source of coliform being in the vicinity of the beach, or up-stream in the watershed area above the beach. While the source of the contaminants have been identified for some beaches, for others it is still unknown. In one case, Red Rocks Beach, the source may be a population of beaver inhabiting ponds in the watershed above the beach.

Since beach closings are site specific, and apparently not symptomatic of a lake-wide coliform bacteria problem, beach users have a number of options when arriving at a beach and seeing a "CLOSED" sign. Visitors can look for another beach on Lake Champlain, travel to another lake entirely, or cancel their beach trip for the day. In terms of economic impacts, in the first case, the economic benefit of the beach trip-related expenditures is transferred to the other beach location.

In the other two scenarios, the economic impact is lost to Lake Champlain area businesses. The best figures for estimated expenditures by beach users for Lake Champlain were provided by Tommy Brown (personal communication, Cornell Human Dimensions Research Unit, 9/19/95). In his 1984 research involving Cumberland Bay Park, NY on Lake Champlain, Brown found that most users were primarily interested in swimming. They spent on average $12.18 per person. By subtracting out the entrance fee, and converting the expenditure to 1995 dollars, the average Lake Champlain beach user expenditure is approximately $16.60 per person per day.

Without a detailed analysis of beach attendance and beach closings by date, it is difficult to estimate the economic impact of beach closings. But as an example, if a beach with an average use of 500 people on a weekend day were closed on a Saturday, using the $16.60 figure, the direct economic value foregone would be $8,300 per closed day, not including the entrance fee.

The economic impact of beach closings would appear to go far beyond the one day impact in the example given above. For some, when a beach is closed once, they chose not to return to that beach for the rest of the year. Similarly, when a "Beach Closed" sign appears repeatedly, another percentage of the user group will choose to travel to a beach that is open more consistently. On a broader, public perception level, beach closing notices give the impression that the Lake is somehow polluted, regardless of the localized nature of the problem. For that segment of the population, use of any beach on the Lake, and lake use in general, may be curtailed.

According to recent surveys of users on Lake Champlain, beaches and swimming areas were among the top priority areas for needing improved facilities (Dzeikan 1995). Public beaches often lack user fees, so are provided as a community amenity that enhances quality of life in the area. For some small communities, the difficulty and cost of solving the water quality problem at the local beach has been determined as not cost effective, and the beach has been closed. In the community of Westport, New York, the traditional public beach was finally closed for good because of reoccurring coliform bacteria problems, and a new, safer beach developed in 1995 by a partnership of private and public interests.

Living Natural Resources

Managing Fish & Wildlife

Many values associated with fish and wildlife are difficult to quantify. The existence value of many species, for example, is very significant, but very hard to attach a monetary value to. Because this chapter focuses on dollar amounts of costs and benefits, most of following discussion is limited to the costs and benefits associated with recreation values of fish and wildlife -- values that are more easily quantified.

Fish and wildlife recreation activities are popular both to local residents and to tourists who visit the Lake Champlain Basin. In 1990-91, anglers purchased nearly 108,000 fishing licenses in the Vermont area of the Basin, and 60,000 licenses in the New York area of the Basin. About 35% of licenses were purchased by nonresidents of the Basin. Approximately 41,000 anglers licensed in New York fished Lake Champlain approximately 482,000 angler days in 1988 and spent approximately $9.5 million ($19.61 per person per day) in the area of Lake Champlain (Connelly and Brown 1988).

Sea lamprey control will almost certainly generate additional angler days fishing. Gilbert (1991) found that 80% of 1991 lake trout anglers and 91% of salmon anglers indicated they would fish more if sea lamprey control meets its objective. Furthermore, 50% of non-lake trout anglers and 61% of non-salmon anglers indicated they would start fishing for these species if sea lamprey control meets its objective. Approximately 80% of respondents indicated that catching fish without lamprey scars was an essential or important factor in a really satisfying fishing trip.

Using a willingness to pay question, Gilbert (1991) found that anglers were willing to pay a median annual value of $11.64 for sea lamprey control related to lake trout, and $11.47 related to salmon. This translates into total willingness to pay values which Gilbert estimated at approximately $1.1 million per year each for lake trout and salmon-based lamprey control. Gilbert assumes anglers were willing to pay one and not both values and thus places an aggregate value of sea lamprey control to anglers at $1.1 million.

A total of 35,788 hunting licenses were sold in the New York area of the Basin in 1993. Statewide, Vermont had an estimated 107,162 hunting license holders in fiscal 1992.

Nonconsumptive wildlife activities such as observing, feeding, and photographing wildlife are also very popular in the Lake Champlain Basin. Approximately 62% of Vermont residents participated in these activities away from their residence in 1991 (U.S. Fish and Wildlife Service 1992). Bird and other wildlife viewing activities generate over $50 million a year in Vermont (Vermont Agency of Natural Resources, 1996).

Residents of the region have long held an interest in protecting the natural environment. Studies elsewhere have shown that threatened and endangered species have significant values among the general public (Stevens et al. 1990, Bowaker and Stoll 1988). For example, the general public in New England was willing to pay an average of $18 per person to protect bald eagles (Steven et al. 1990). Other studies have shown that the public is willing to pay more to preserve endangered species if it has information on the status of those species (Samples et al. 1986). Thus, educational programs are valuable in attempts to protect these species.

Protecting Wetlands

There are over 300,000 acres of wetlands in the Lake Champlain Basin. These wetlands provide a wide variety of ecological functions that include improving water quality by filtering sediments, pollutants and nutrients; protecting groundwater and drinking water; contributing to overall biological diversity; providing habitat for fish and wildlife; and providing habitat for some rare and endangered species and natural communities. Wetlands also help stabilize shorelines and prevent erosion, provide recreational and educational opportunities, and contribute to the aesthetics of the region.

Many of the benefits of wetlands are not reflected in market transactions. Nevertheless, it is well understood among economists, and there is a growing understanding across wider segments of the public, that wetlands are valuable economic resources when maintained in their natural or semi-natural state. Components of wetland systems - water, some plants, and fish and wildlife are of direct benefit to humans. In some cases wetland aesthetics make a region more attractive to tourists and thus contribute to local economies. Undeveloped wetlands have a variety of possible future option values, some of which we may have little awareness of today; those options become lost for wetlands that are developed. Wetlands also have non-use values or existence values in that people are willing to pay something to keep them in their natural state even when they have no intention of using these areas.

Wetlands provide critical temporary habitat for many migratory bird species and migratory bird hunting generates significant levels of expenditures that benefit local economies. These hunting expenditures are not known for all of the Champlain Basin, but in Vermont, about half of which lies within the Basin, approximately 7,300 migratory bird hunters spent $383 each in 1991, for a total of $2.8 million (US Fish and Wildlife Service 1993). Better data is needed to determine expenditures made within the basin, what portion of those expenditures represent new dollars coming into the Basin, and the secondary economic impacts of that spending. In addition, it is important to determine how migratory bird species are affected by incremental changes in the quantity and quality of wetlands.

As increasing amounts of wetlands are permanently protected through acquisition or other means the marginal benefits of protecting or acquiring additional wetlands would be expected to decline and the economic costs of doing so would be expected to increase. Consequently, as protection and acquisition programs proceed, it is important to periodically reevaluate the costs and benefits of additional acquisition as well as the costs and benefits of changes in regulatory programs.

There is currently significant debate about wetlands policy, at least at the federal level. The debate includes how to define wetlands for regulatory purposes, and what regulatory purposes and protection programs are appropriate given this definition. More fundamentally, the debate is about property values. Are wetlands and the ecosystem services they provide a public resource which private landowners should be obligated to protect, or are they private property for which the public should compensate the landowner if development options are limited through regulation? In the midst of this controversy there are at least a few points of general agreement. First, the sometimes duplicative mix of current wetlands regulatory programs and responsibilities can sometimes increase costs and create unnecessary uncertainty for landowners and developers. Second, there is broad agreement that certain types of wetlands provide very substantial public benefits and should be protected. Building upon these areas of agreement and public/private and intergovernmental cooperation already underway within the Basin, there is an opportunity to fashion an integrated set of economic incentives, acquisition programs, and regulations that strike an appropriate balance between public benefits and private costs.

Nuisance Non-native Aquatic Plants and Animals

This section discusses some of the economic considerations associated with the management of three nuisance species in the Lake Champlain Basin: sea lamprey, water chestnut, and the zebra mussel. Most of the analysis relates to the zebra mussel, as this is a very recent invader that is causing especially costly problems.

Nuisance aquatics cause recreational use problems that can be clearly linked to economic impacts. As pointed out in Chapter 3, attacks by adult sea lamprey on salmon, lake trout, and other fish species have limited full development of a Lake Champlain fishery, and restricted recreational and associated economic opportunities. The sea lamprey control program has cost approximately $320,000 per year for the past five years, and appears to be effective in addressing the problem. The final economic impact analysis for the program, expected in 1996, will evaluate the program's overall cost effectiveness.

Monitoring and control of water chestnut has also been an ongoing activity. Between 1982 and 1990, a total of $1.7 million has been spent by Vermont, the State of New York, and the Army Corps of Engineers on water chestnut control. The average annual expenditure during that period was approximately $177,000. However, since 1991, the average annual expenditure has dropped to $74,000 (Bove 1995). According to a recent report on the water chestnut control program, a mid-season survey in 1994 by VT DEC biologists revealed that "the water chestnut infestation has grown considerably since the last Vermont harvest year of 1991." (Bove 1995). In addition, three new infestation sites were discovered during the survey, including one large site north of Ticonderoga, NY.

When the Lake Champlain Management Conference began its work in 1990, zebra mussels were just becoming a problem in the Great Lakes, and had not yet made their way into Lake Champlain. By the time the draft Plan went to press in 1994, zebra mussels were spreading out from the south end of the Lake, and were found as far north as Crown Point. Now, only a year later in the fall of 1995, zebra mussels or their microscopic immature form (i.e., veligers) have been found in virtually every part of the Lake.

Since zebra mussels have been in the Great Lakes for almost eight years, it is instructive to study the impacts on communities in that region. One researcher estimates that the 10 year cost of the zebra mussel invasion in the Great Lakes will be in the range of $2 to $3 billion (personal communication: Chuck O'Neil, NY Sea Grant Zebra Mussel Clearing House at SUNY Brockport, November 1995). Ealier cost estimates were much higher, but these higher costs appear to have been avoided through effective education and outreach efforts. According to a group of leading researchers on the socio-economic impacts of zebra mussels, the costs imposed by the zebra mussel were greatly reduced because a variety of research organizations (e.g., Sea Grant, Fish and Wildlife Service, Great Lakes Environmental Research Laboratory, the Great Lakes Commission) collaborated in a research and outreach effort around core issues.

A survey of water users in 18 states is now in progress concerning their experience with the zebra mussel. Preliminary findings are that there have been $68 million worth of impacts to date, including impacts to water treatment plants, nuclear power plants, and locks and dams (personal communication: Chuck O'Neil).

It is difficult, if not meaningless, at this point to estimate an average cost per water treatment plant. The survey data includes treatment plants as varied in size as New York City, Chicago, and North Hero, Vermont. Cost depends greatly on the capacity of the pipes, but also relates to the capacity of the plant, and the average amount of water treated per day. The physical structure of the plant and pipes are also major factors, with distance to the water source and the amount of bends in the pipe affecting the cost of zebra mussel control. One plant that serves about 30,000 people spent approximately $25,000 for a retro-fit, but that was using in-house labor, and does not include annual maintenance costs (personal communication: Chuck O'Neil)

By comparison, the Town of Willsboro, NY has been studying the possible impacts of zebra mussels on their community water system for two years. They serve about 1,600 people and have an intake pipe that extends 2,500 feet into the Lake. They recently budgeted $60,000 to address the problem using a chlorine infuser. The necessary work has an estimated cost of $120,000, however they anticipate cost savings by doing some of the work themselves (personal communication, Teresa Sayward, Town of Willsboro, October 1955).

The Vermont Coalition of Water Suppliers has been intently studying the economic impacts of zebra mussels on their eleven water suppliers. Presently, they are estimating a total of $1.6 million dollars in capital costs for those eleven facilities. Cost estimates per facility range from $60,000 to $334,000. At least three systems now have chlorination control in operation (personal communication: John Coate, Champlain Water District, October 1995).

Water users other than the water treatment plants will be affected around Lake Champlain. For example, private homeowners who draw water from the Lake will also have to address the possibility of zebra mussels in their pipes. Lake Champlain is the source of drinking water for approximately 60,000 households, with 55,015 households receiving their water through community drinking water systems, and an estimated 4,149 households drawing drinking water directly from the Lake. Zebra mussels will affect each of these households directly or indirectly. For those households on community systems, they will likely see an increase in their bill reflecting the costs of deterring or removing zebra mussels from in-take pipes. Households that draw drinking water from the Lake through personal systems will have direct costs related to keeping their water pipe clear of zebra mussels.

In addition to drinking water users, other users who withdraw Lake Champlain water will incur costs. For example, there are marinas, beaches, campgrounds and other commercial establishments on the Lake that may draw Lake Champlain water for washing, toilets, etc., and they will incur costs to keep those pipes clear of zebra mussels. Other water users impacted by zebra mussels will include fire departments that either draw water directly from the Lake in the case of an emergency, or who rely at times on "dry" fire hydrants that are essentially a conduit for drawing water from an adjacent surface water source. There is at least one report from Lake Erie of a building being lost to fire because zebra mussels clogged the dry hydrant pipe (personal communication: Chuck O'Neil). Lower costs are associated with zebra mussel control for all those types of small diameter water withdrawal pipes.

One of the larger, institutional users of Lake Champlain water is the Vermont fish hatchery on Grand Isle. Costs to prevent zebra mussels from affecting that operation could reportedly reach $2 million or more.

Another major impact category related to zebra mussels is the area of recreational impacts. Results from initial studies on the recreational impacts of zebra mussels became available in 1994, and additional study is underway. A 1991 survey of individuals living in the vicinity of Lake Erie concluded that the zebra mussel was negatively perceived by a large number of respondents, but that few visitors changed their visits to the Lake or incurred significantly increased recreational costs due to the presence of zebra mussels. Thirteen percent of 109 responding boat owners reported expenditures for protective paints, with an average cost of $94. Four percent reported additional boat maintenance at an average cost of $171, 3% reported increased insurance costs averaging $207, and one respondent reported $50 in boat motor damages directly attributable to the zebra mussel (Vilaplana and Hushak 1994).

In addition to some increased costs related to boating, the impacts of zebra mussels on recreational boaters require behavioral changes, such as storing their boat out of the water, painting or aggressively cleaning the bottom, and flushing the motor. Other costs of zebra mussels relate to beach clean-up when large quantities of zebra mussels wash up on shore. The mussels have to be dumped in a landfill, so tipping fees and hauling costs, as well as labor, are all economic concerns.

There are mixed blessings related to zebra mussels and underwater historic resources. On one hand, the zebra mussel has contributed (at least temporarily) to a significant increase in water clarity in some lakes. Parts of Lake Erie went from four foot visibility to 40 feet. This can be a boon to the dive industry in terms of increased visibility and enjoyment of ship wrecks on the bottom of the lake. Unfortunately, zebra mussels are attracted to any hard surface, and will readily attach themselves to the wrecks. Some of the historic resources at the bottom of Lake Champlain are already being covered by zebra mussels. In addition, there is a danger that the weight of accumulating mussels will collapse the wooden vessels on the bottom of the lake. A recent LCBP report on the impacts of zebra mussels on historic shipwrecks (Lake Champlain Maritime Museum, 1996) predicts that all shipwrecks in 80 feet of water or less will be covered by zebra mussels.

Tourism, Recreation, and Cultural Heritage Resources

The value of Lake-related tourism is difficult to pinpoint, but research funded by the Lake Champlain Basin Program has produced some estimates. The Economic Database Project determined that Lake Champlain-related tourism expenditures could be as high as $880 million in 1990, comprising 40% of all tourism expenditures in the Basin. As many as 16,400 jobs were estimated to be dependent on Lake Champlain-related tourism in New York and Vermont

(Holmes & Associates 1993). The figures were derived from estimated tourism expenditures in the Lake shore towns in New York and Vermont, and could be viewed as overestimating purely Lake-related tourism. For example, while the figures do not include expenditures at winter ski resorts and for similar upland recreation activities, they do include expenditures by visitors to Plattsburgh and Burlington who may not be directly involved in Lake-related activities during their stay. Yet the question remains, if Lake Champlain were not there, would Plattsburgh and Burlington be the tourist destinations that they are today?

The economic contribution of travel related expenditures varies significantly depending on type of accommodation used, and types of preferred recreational activities. A survey of visitors to the Adirondacks found that trip costs averaged $82 per day (Ambrosino Research, Inc. 1993). A series of Lake Champlain user surveys found that trip expenditures while at Lake Champlain varied from $37.19 for park users to $464 for Chambly Canal users (Dziekan 1994).

Although tourism does have excellent potential for economic development, it is not a panacea for all economic ills. Much of the tourism-related employment is part time, whereas only about 10% of manufacturing jobs are part time and seasonal. Other disadvantages include low wages, as well as inadequate medical coverage and lack of long term advancement for workers. While tourism does provide both skilled and unskilled employment opportunities, helps stimulate local commerce, and provides recreational facilities for local residents as well as tourists, its economic impact needs to be evaluated within the context of a healthy and diversified regional economy.

Vermont's travel and tourism industry is not keeping pace with the nation-wide growth in the travel industry, according to a recent study of tourism in the state (Ramaswamy and Kuentzel 1994). Major travel indicators (e.g., travel expenditures, tourism generated employment) have been steadily increasing across the United States, while in Vermont the travel indicators peaked in 1978 and have been in decline ever since. This finding is mirrored in the attendance figures at Vermont State Parks along Lake Champlain for the five year period 1990 through 1994. Total attendance data for the nine parks indicate a general decline in attendance during the five year period.

In New York, attendance appears to be trending upward at the five parks, boat launches, and historic sites on Lake Champlain operated by the NYS Office of Parks, Recreation, and Historic Preservation. Attendance at the 44 NYS Department of Environmental Conservation campgrounds in the Adirondack Park was down slightly in 1992 and 1993, but has remained fairly steady, fluctuating between 105,000 and 122,000 annually from 1987 to 1993 (Dawson et al. 1994). So in general, participation in recreation and tourism around Lake Champlain has been decreasing somewhat on the Vermont side, and increasing slightly on the New York side.

Specific business beneficiaries of Lake Champlain-related tourism and recreation include marinas, sporting goods stores, restaurants, campgrounds, hotels and other related tourism businesses. There are currently a number of lake-related promotion activities in the Basin that will serve to increase the tourism impact in the Basin. For example, the Lake Champlain Bikeways effort, canoe trail activities, lamprey eel control measures, salmon stocking, and recommended boat launch improvements are a few of the lake-related tourism activities that will contribute to increased use of the Lake.

Vermont's "mature" tourism industry is suffering from increased competition from other state's aggressive promotion and marketing organizations. By not keeping pace with the new tourism businesses that are capturing an expanding tourism market, Vermont is thus less able to compete with the many new tourism destinations that did not even exist ten years ago (Ramaswamy and Kuentzel 1994). The New York portion of the Basin could be suffering from a similar state of "maturity".

New York and Vermont are only beginning to effectively promote the Lake resource. For example, last year the cover of Vermont's statewide tourism brochure reportedly featured Lake Champlain for the first time. Given that many of the benefits related to improved Lake water quality will accrue in relation to increased recreational opportunity, capitalizing on that opportunity will be difficult without Lake Champlain tourism promotion and development that appeals to new tourism markets.

The Quebec portion of the Lake Champlain Basin has yet to fully capitalize on its strategic position between New York, Vermont, New England, and the greater Montreal area. Tourism related activities have tremendous potential, especially up the Richelieu River and into the St-Jean-sur-Richelieu region, however the regional transborder economic potential has yet to be exploited. More and more, economic experts believe that the regions that will be successful in improving their overall economic benefits will be the ones understanding and advocating regional interdependencies.

The international flavor of Lake Champlain, and the cooperative tourism efforts already underway, especially within the US\Canadian corridor along Missisquoi Bay and the Richelieu River, makes the Basin one of the more appealing tourist destinations in the Northeastern U.S. These are the reasons why the Richelieu Valley finds that it is important to stimulate tourism inter-regionally by emphasizing outdoor opportunities, visitor oriented resources such as museums, and the similar coutryside tourism opportunities provided by the Lake Champlain and Richelieu River basins.

The geographic link and shared water bodies are disrupted only by the border line, which roughly follows the 45th parallel. The concept of an international bikepath around Lake Champlain and the Richelieu river; the military heritage circuits; the establishment of an countryside tourism development plan for the Lake Champlain Basin, and other cooperative projects demonstrate that international cooperation can provide great opportunities. Furthermore, this type of cooperation can bring back the original geographical link that our respective regions share, with Lake Champlain and Richelieu River being an integral part of one of the major north-south river corridors in North America, linking New York city (via the Hudson River) to Montreal (via the St. Lawrence River).

As is true of the rest of the U.S., the Lake Champlain region has rapidly evolved into a service-oriented economy, with one-third of total employment in the service industries in 1990. Outdoor recreation and tourism constitutes a major portion of the service economy of the region, and a significant portion of the total economy. Total tourism-related expenditures in the Basin were estimated at $2.2 billion in 1990 (Holmes & Associates 1993). A maximum of 880 million, or about 40% of the Basin-wide total expenditures, were Lake Champlain-related. Furthermore, as many as 16,400 jobs were directly dependent on Lake Champlain-related tourism in New York and Vermont.

A substantial portion of outdoor recreation and tourism within the Basin is directly associated with the Lake. Sailing, motorboating, kayaking, canoeing, and fishing are among the popular lake activities. A number of other recreation activities are important to the region, including camping, hiking and climbing, bicycling and mountain biking, horseback riding, and several newer forms of adventure recreation. The winter activities of skiing (downhill and cross country), bobsledding and luge are also important within the Basin.

Projections for recreational participation in New York State point to steady growth in water-based recreation participation between 1990 and 2010. Swimming is projected to have a 5.4% growth in the number of participants, boating a 3.4% growth, and fishing a 5.8% growth during the 20 year period. Of the 19 recreational activities analyzed, golfing is projected to experience the greatest growth in participation, at 6.9% (NYSOPRHP 1992a). These projections indicate that demand for water-based recreational opportunities will continue to grow, and that economic opportunities will result from an increase in Lake Champlain water quality.

Much of the recreation management challenge concerns providing additional recreation opportunities in ways that do not significantly worsen environmental quality. Few studies anywhere in the world have established definitive quantitative relationships between recreation activities, tourism visitation, and water quality. Certainly at some levels or ranges these relationships exist. However, the relationships typically are not linear, and the findings concerning one water body are not necessarily exportable to another water body. Effects of improving water quality on increased recreational fishing are theoretically measurable, but much more work is needed to arrive at estimates that can be generalized or incorporated into policy models.

Cultural and historical sites and facilities are an integral part of the Basin's tourism resources. Vermont Department of Travel and Tourism data indicate that visiting historic sites ranked as the leading interest of visitor inquiries in 1994 and 1995. The major historic sites in the Basin generate millions of dollars annually in the Basin economy. Those sites are listed among the major employers in the areas where they are located. In addition, numerous small homesteads and museums scattered throughout the Basin help stimulate small, local economies by providing an enjoyable activity to both visitors and residents. With a growing national and international focus on cultural heritage tourism, there is an opportunity for cultural heritage sites to play a significantly larger role in the Basin's tourism-based economy. According to the Spring 1996 *Travelometer*, a quarterly forecast report prepared by the U.S. Travel Data Center, 45% of Americans planning a pleasure trip that quarter intended to include a visit to an historic site on their itinerary, and 41% indicated inclusion of a cultural event on their tour itinerary. Additional evidence of the economic value of cultural heritage sites is the significant effort being invested in developing new museums and interpretive efforts around the Basin. Community leaders are recognizing that historic districts, interpretive walking tours, museums, and many other approaches for displaying an area's history and culture have a direct economic impact on their communities.

The protection of cultural heritage resources is economically linked directly and indirectly to the pollution prevention and restoration efforts discussed in Chapter 2. Lake Champlain and its shoreland area was the major focus of development in the Basin, strongly influencing early settlement patterns, military activities, transportation, commerce, agriculture, and industry. Yet, as is repeatedly the case, communities have "turned their backs" to the water resources that gave them their existence. Many communities started out facing out over the Lake; the Lake was their transportation link and the source of their commerce. Common now are lakeshore areas where backs of buildings face the Lake and where visitors are discouraged from walking and exploring.

As specific areas are targeted for clean-up, and as others benefit indirectly from a cleaner Lake, lakeshore communities will begin to see economic opportunities in once again looking out over Lake Champlain, capitalizing on what the Lake and shoreline have to offer, both as recreation and transportation resources, and as heritage tourism resources. The City of Burlington's considerable investment and effort to improve its waterfront, including protection of historic buildings, is a case in point and represents the economic link between the Lake, cultural heritage, and local economies.

The costs of protecting, maintaining, and operating cultural heritage sites seldom fall entirely within the public sector. Many of the efforts are partnerships between the public and private sectors, where foundation grants and private donations traditionally provide a significant portion of the necessary funding. Significantly, user fees (i.e., cost of admission) are more common and accepted with visits to cultural heritage sites, than perhaps with any other type of recreational activity. People expect to pay a few dollars to visit a museum, historic site, or interpretive center, and in addition will often make a donation and buy a gift or souvenir to help support the site. This type of expectation and expenditure is not often associated with a visit to the beach, launching a boat, or taking a hike on a trail. In that sense, cultural heritage sites tend to "pay their own way" to a greater extent than other recreation areas, and will undoubtedly continue to do so.

The costs associated with not protecting and maintaining cultural heritage resources should be factored in to the economic considerations. Ships from the Revolutionary War period will never again sail -- or sink -- in Lake Champlain. Historic homesteads, villages, field patterns and industrial sites are irreplaceable tangible evidence of how our ancestors lived and worked in the Basin. Likewise, archeological artifacts are the only record of the Basin's 10,000 year history before European settlement. These are only a few of the valuable, some would say priceless, economic resources embodied by the phrase "cultural heritage resources." The costs of protecting these resources is an investment, and should be considered in light of the cost of replacement.

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Glossary

A

Acceptable management practices (AMPs) - a phrase used in Vermont to indicate a forestry practice or pollution control mechanism that is effective in reducing nonpoint source pollution to surface water and ground water.

Accepted agricultural practices (AAPs) - minimum farm practices which are required in Vermont to reduce nonpoint source pollution to surface water and ground water, while maintaining the economic vitality of the agriculture industry. One example is avoiding the storage of manure on floodplains.

Acquisition - in the context of wetlands, to obtain through direct purchase, easement, donation, or other means, in order to protect, enhance, or restore habitat functions and values.

Action levels - levels of pesticide residues in food and most feed products that are permitted by the EPA and enforced by the FDA and the USDA. In Lake Champlain, if the concentration of a toxic contaminant like PCBs in a fish species is higher than the action level, an advisory on eating that fish is issued because it increases the risk of harmful effects on human health.

Acute toxicity - the ability of a substance to cause poisonous effects resulting in severe biological harm or death soon after a single exposure or dose; Any severe poisonous effect resulting from a single short-term exposure to a toxic substance.

Advanced planning - in the context of wetlands, a proactive process by which wetlands are mapped and evaluated to determine which areas need to be protected. By conducting advanced planning, future needs and problems can be anticipated before they become a permit issue in development.

Aerobic - a process or form of life that occurs only in the presence of oxygen.

Algae - small aquatic plants which occur as single cells, colonies, or strands. Algae use carbon dioxide and nutrients such as nitrogen and phosphorus to make their own food through photosynthesis. Algae form the base of the aquatic food chain.

Algae bloom or **algal bloom** - a situation often caused by excess nutrients whereby algae grow and reproduce rapidly, often forming dense mats on the surface of the water. Algae blooms can cause unpleasant conditions for swimmers or boaters.

Anaerobic - a process or form of life that occurs in the absence of oxygen.

Angler-days - The equivalent of one angler spending one day fishing on a waterbody. For example, 10 angler days might be achieved by 10 anglers spending a day each fishing, or one angler spending 10 days fishing.

Anoxic - without oxygen. Most organisms in the Basin require oxygen to survive.

Aquatic - growing in, living in, or dependent upon water.

Aquatic biota - plants or animals which grow in, live in or are dependent upon water.

B

Barnyard runoff system - an installed system for the interception, collection and safe disposal of runoff water from a barnyard or concentrated feedlot.

Basin - the surrounding land that drains into a waterbody. For Lake Champlain, the land that drains through the many rivers and their tributaries into the Lake itself.

Benthic community or **Benthic organisms (benthos)** - collectively, all organisms living in, or on the bottom of a body of water. In this document, these terms are used interchangeably.

Benzene - a clear, aromatic, flammable, poisonous, aromatic liquid, formed during the processing of coal. It is used to dissolve fats and to make lacquers, varnishes, dyes, and other synthetic materials. Benzene is also released into the air through automobile emissions.

Best management practices (BMPs) - a practice or activity that reduces the amount of pollution entering a body of water.

Bioaccumulation - the ability of a contaminant to be retained and build up in the tissues of an organism from breathing contaminated air, drinking contaminated water, or eating contaminated food.

Biocriteria (biological criteria) - numerical or descriptive measures of the characteristics of a biological community. Biocriteria are used as an index of the health of the community.

Bioenergetics - the study of energy flow through the food web.

Bioenergetics models - mathematical or conceptual illustrations of an ecosystem that account for all or some of a food web's known characteristics. By using bioenergetics models, one can predict how changing one part of the food web will affect the rest of the food web.

Biological indicators (bioindicators) - biological characteristics at the cellular, organismal, population, or community level that are representative of a given habitat or its ecological condition.

Biomagnification - process whereby harmful substances become increasingly concentrated in tissues or internal organs of organisms with each step up the food chain. For example, pesticides and mercury may enter a river or lake and be eaten by aquatic organisms such as fish, which, in turn, are eaten by large birds, animals or humans. The highest concentrations of the contaminants are found in the large birds, animals or humans at the top of the food chain.

Biota - the animal or plant life of a region.

Buffer zones (strips) - protective land borders that reduce runoff and nonpoint source pollution loading to critical habitats or water bodies; areas created or sustained to lessen the negative effects of land development on animals and plants and their habitats. See vegetative buffer zone.

C

Carcinogen - any substance that can cause or contribute to the development of cancer.

Carrying capacity - in recreation management, the amount of use a recreation area can sustain without deterioration of its quality. In wildlife management, the maximum number of animals an area can support. Carrying capacity depends upon the conditions of the habitat.

Chlorination - the application of chlorine to drinking water, sewage, or industrial waste to disinfect it or to oxidize undesirable compounds.

Chronic toxicity - any toxic effect on an organism that results from long-term exposure to a substance. The end result can be death, although the usual effects are not lethal. These sublethal effects may be reflected by changes in behavior, reproduction, or other characteristics.

Combined sewers - a sewer system that carries both sewage and storm-water runoff. Normally, its entire flow goes to a waste treatment plant, but during a heavy storm, the stormwater volume may be so great that untreated mixtures of storm water and sewage overflow into receiving waters.

Combined sewer overflow (CSO) - an event after a large storm when untreated wastewater that carries both sewage and stormwater is discharged from a sewer system. The overflow occurs because the system does not have the capacity to transport, store, or treat the increased water volume caused by stormwater runoff.

Comprehensive agricultural monitoring and evaluation network (CAMEN) - a framework of research, monitoring and evaluation activities created under the Lake Champlain Special Designation Act as a step toward a comprehensive agricultural nonpoint source pollution control program for the Basin. It is a set of objectives, goals and action items designed to ensure long-term success of the efforts of resource management agencies and the agricultural community to improve water quality.

Concentration - the amount of a material dissolved in a solution.

Congeners - when in reference to PCBs, different molecular forms of this chemical group.

Conservation easement - an agreement between a property owner and a holder of the easement, such as a state agency or land trust, that restricts the right of the property owner to develop the land. Conservation easements are often donated or sold by property owners to preserve the land for wildlife habitat and corridor protection.

Contaminant - a substance that is not naturally present in the environment or is present in amounts that can adversely affect the environment.

Contamination - in water resources, the impairment of water quality by waste to a degree that creates a hazard to public health or living resources through poisoning or the spread of disease. Air and soil can also be contaminated in a similar way.

Conventional pollutants - total suspended solids, fecal coliform bacteria, depleted oxygen conditions, low pH, and oil and grease. These pollutants are listed as conventional pollutants in the Clean Water Act.

Cost-share - a method for sharing installation costs for conservation practices, including BMPs, between a governmental body (federal, state, local) and a farmer or landowner/land user.

Criteria - a standard, rule, or test by which something can be judged; a measure of value.

Critical habitat - any area which has unique or fragile natural, historical, geological, archeological or wildlife value; areas which are essential to the conservation of an officially-listed endangered or threatened species and which may require special management considerations or protection are also considered critical habitats.

Cryptosporidium - a disease-causing microorganism that is found in water contaminated by fecal matter and that can cause stomach and intestinal illness when ingested.

Cultural eutrophication - eutrophication that is caused by additions of extra nutrients from human activities. See **eutrophication.**

Cultural heritage - historical and archeological past.

Cultural heritage resources - the physical record and memory of the past.

Cumulative impacts - environmental impacts that add up over time and space from a series of similar or related individual actions, contaminants, or projects. Although each action may seem to have a negligible impact, the combined effect can be severe.

D

Database - a collection of data arranged for ease and speed of retrieval.

Dioxin - any of a family of compounds known chemically as dibenzo-p-dioxins. Dioxins are sometimes generated by industrial processes, and can contaminate water and soil. Tests on laboratory animals indicate that it is one of the most toxic man-made chemicals known.

Drainage basin - land area from which water flows into a river or lake, either from streams, groundwater, or surface runoff. (See Watershed)

E

Easement - an agreement by which a landowner gives up or sells one of the rights on his/her property. For example, a landowner may donate a right of way across his/her property to allow community members access to the Lake.

Eco-tourism - responsible travel that conserves the natural environment and sustains the well-being of local people.

Ecological communities - a group of interacting plants and animals inhabiting a given area.

Ecological integrity - a structurally sound and fully functional ecosystem is one that is said to have "ecological integrity." Such an ecosystem is self-maintaining and resilient when disturbed.

Ecosystem - a group of plants and animals occurring together, and the physical environment with which they interact.

Ecosystem approach - a way of looking at socio-economic and environmental information based on the boundaries of ecosystems such as the Lake Champlain Basin, rather than based on town, city, and county boundaries.

Ecosystem-based management - an approach to making decisions based on the characteristics of the ecosystem in which a person or thing belongs. This concept takes into consideration interactions between the plants, animals, and physical characteristics of the environment when making decisions about land use or living resource issues.

Effluent - the liquid, treated or untreated, that flows out of a facility or household into a water body or sewer system; Liquid wastes from sewage treatment, septic systems, or industrial sources that are released to a surface water.

Elevated levels - levels that are higher than natural, background levels for an area.

Endangered species - a species in immediate danger of becoming extinct.

End-of-pipe - at the point of discharge to the environment.

Energy flow - the transformation of energy by organisms within the food web. For example, phytoplankton transform the sun's energy into complex sugars which they store and use to fuel body functions. Zooplankton eat phytoplankton and transform the stored sugars into energy needed for their body functions.

Erosion - the loosening and subsequent transport of soil away from its native site. Erosion often results from wind or the removal of vegetation. OR the wearing away of the land surfaces by running water, wind, ice or gravity.

Eutrophic - from Greek for "well-nourished," it describes a lake with low water clarity and excessive plant growth due to high concentrations of nutrients.

Eutrophication - the slow, natural process of aging of a lake, estuary, or bay. Dissolved nutrients enter the water body, often leading to excess plant growth and decreased water quality. As the plants die, they decompose by benthic organisms and microorganisms which use up dissolved oxygen vital to fish species. Over very long periods of time, the decaying plant matter builds up and causes the lake to fill in to form a bog or marsh. **Cultural eutrophication** speeds up this natural process.

Exotic species - a species which is not native or is introduced from another location.

F

Failed, failing, or faulty septic system - a septic system that releases untreated or inadequately treated wastewater to surface or groundwater by surfacing and overland flow of effluent or by subsurface percolation.

Fecal coliform - bacteria from the intestines of warm blooded animals. High numbers of fecal coliform bacteria in a water body may indicate a recent release of untreated wastewater and/or the presence of animal feces which may contain disease-causing bacteria.

Fishery - the act, process, occupation, or season for taking fish.

Food chain - a sequence of organisms, each of which uses the next, lower member of the sequence as a food source. For example a human eats a large fish that eats minnows that eat zooplankton that eat phytoplankton.

Food web - the pattern of food consumption in a natural ecosystem. A food web is composed of many interconnecting food chains.

Furan - a colorless liquid, prepared from wood tar and used as a solvent for resins and plastics or as a tanning agent.

G

Giardia - a protozoan which causes stomach and intestinal illness.

Geographic Information System (GIS) - a computer system that is used to compile, store, analyze, and display geographic and associated data tables. This system can be used to produce maps which overlay information layers of locations of various environmental and physical features.

Guidelines - standards or principles by which to make a judgement or determine a policy or course of action.

H

Habitat - the place where a particular type of plant or animal lives. An organism's habitat must provide all of the basic requirements for life and should be free of harmful contaminants.

Habitat restoration - the artificial manipulation of a habitat to restore it to its former condition.

Habitat conservation - the protection of an animal or plant's habitat to ensure that the use of that habitat by the animal or plant is not altered or reduced.

Habitat degradation - reduction of the quality of the environment in which an organism or biological population usually lives or grows.

Habitat corridors - segments of land or water that are used by animals to travel from one point to another, for example, from winter range to summer range. These habitats are critical to the survival of the animals and must be preserved by developers to prevent harm or death to the animals.

Habitat fragmentation - breaking up of a specific habitat into smaller unconnected areas. A habitat area that is too small may not provide enough space to maintain a breeding population of the species in question.

Hazardous waste - any solid, liquid or gaseous substance that is a by-product of society and classified under state or federal law as potentially harmful to human health or the environment. Hazardous wastes are subject to special handling, shipping, storage, and disposal requirements and possess at least one of the following four characteristics: ignitability, corrosivity, reactivity, or toxicity.

Health risks - anything which may reduce human health. These may be ranked according to high, moderate, and low risk.

Household hazardous waste - substances found in the home which contain hazardous materials (which should be disposed of properly to prevent pollution to the air, groundwater and surface water).

Hydrologic cycle - the continual cycling of water between the land, the sea, other waterbodies, and the atmosphere through evaporation, condensation, absorption into the soil, and stream runoff.

Hydrologic unit area - a US Department of Agriculture project to provide technical, financial, and educational assistance to implement a program within a hydrologic unit (major drainage basin) or aquifer recharge area to solve an agricultural non-point source pollution problem.

I

Impaired waterbodies - waters which do not meet their designated use, as identified by state water quality standards.

Impervious areas - land surfaces such as pavement, buildings and other hard surfaces that prevent water from flowing into the soil.

In-place contaminants - toxic substances which have accumulated in lake bottom sediments. They can stay in the sediments for long periods if undisturbed, or they can be stirred up and enter the water column or food web.

Indigenous - originating or living naturally in an area, generally the same as "native."

Inorganic chemicals - chemical substances of mineral origin that do not usually contain carbon.

Invertebrate - small organisms like worms and clams that do not have a backbone.

L

Land trusts - organizations dedicated to conserving land by purchasing land, receiving donations of land, or accepting conservation easements from landowners.

Limiting nutrient - a nutrient which first becomes scarce in the environment and therefore controls how much the organisms can grow and reproduce.

Load (also loading) - the amount of a material entering a system from all sources over a given time interval.

Load allocation - the maximum desirable pollutant load from one or more sources needed to meet desired load reduction.

Local watershed - in this document, any watershed within a sub-basin of Lake Champlain.

M

Macroinvertebrates - aquatic insects, worms, clams, snails, and other animals without backbones that can be seen without the aid of a microscope and that may be associated with or live on sediments.

Manage - to control the movement or behavior of; to manipulate.

Management (natural resources management) - to make a conscious, deliberate decision on a course of action to conserve, protect, restore, enhance, or control living natural resources, or to take no action.

Management zones - any area or region considered as separate or distinct from others because of its particular use, crops, plant or animal life, etc, which is controlled in the same manner.

Maximum contaminant levels (MCL) - the maximum permissible level of a contaminant in water delivered through a public water system. MCLs are enforceable standards.

Mesotrophic - a moderately nutrient enriched lake, between oligotrophic and eutrophic.

Microorganisms - living organisms so small that individually, they can usually only be seen through a microscope.

Mitigation - actions taken to compensate for the negative effects of a particular project. Wetland mitigation usually takes the form of restoration or enhancement of a previously damaged wetland or creation of a new wetland.

Mitigation bank - a system of credits and debits used to account for habitat restoration, creation or enhancement undertaken as mitigation prior to future development actions that will incur unavoidable habitat losses.

Mutagen - any substance that can cause a change in genetic material, the building blocks of life.

N

No net loss of wetlands - the goal in the Lake Champlain Basin and the nation that wetlands will reach equilibrium between gains and losses in acreage and function in the short run, and will increase in the long term. This goal does not imply that individual wetlands will be protected in every instance or that the no net loss standard should be applied on an individual permit or decision basis.

Nongame species - wildlife species, such as songbirds and raptors, which are not commonly hunted, killed or consumed by humans.

Nonnative - not originating naturally in the Lake Champlain Basin.

Nonpoint source pollution - nutrients or toxic substances that enter water from dispersed and uncontrolled sites, rather than through pipes. Sources of non-point source pollution include runoff from agricultural practices, urban and forest land, and on-site sewage disposal.

Nuisance species - species causing annoyance or having adverse ecological impacts.

Nutrient - a substance or ingredient which nourishes life. These are essential chemicals needed by plants or animals for growth. If other physical and chemical conditions are appropriate, excessive amounts of nutrients can lead to degradation of water quality by promoting excessive growth, accumulation, and subsequent decay of plants, especially algae. Some nutrients can be toxic to plants and animals at high concentrations.

Nutrient management - an integrated approach designed to maximize the efficient use of nutrients, particularly phosphorus which is found in animal manure and fertilizer.

O

Oligotrophic - from the Greek for "poorly nourished"; Describes a lake, with low plant growth and high clarity. Oligotrophic lakes contain little organic matter and have a high dissolved oxygen level.

Optimum sustainable yield - the amount harvested which is best economically for humans but that also ensures that the resource is not depleted.

Organic compound - chemical compound containing carbon as the base element. Some kinds of organic compounds can be toxic to plant and animal life.

Organochlorine pesticides - a class of organic pesticides, such as DDT, that contain chlorine atoms. Organochlorine pesticides affect numerous organisms and are long-lived in the environment.

P

PAH - polycyclic or polynuclear aromatic hydrocarbons. A class of complex organic compounds, some of which do not easily break down and may cause cancer. PAH compounds are formed from the combustion, or burning, of organic material and are widespread in the environment. PAHs are commonly formed by forest fires and by the combustion of gasoline and other petroleum products. They often reach the environment through atmospheric fallout and highway runoff.

Palustrine wetlands - includes all non-tidal wetlands dominated by trees, shrubs, plants, mosses, or lichens. This group of vegetated wetlands includes marsh, swamp, bog, fen and prairie and small shallow water bodies called ponds.

Pathogens - organisms, usually viruses, bacteria or fungi, capable of causing disease.

PCBs - polychlorinated biphenyls. A group of manufactured chemicals, including about seventy different but closely related compounds made up of carbon, hydrogen and chlorine, used in transformers and capacitors for insulating purposes. If released to the environment, PCBs do not break down for long periods and can biomagnify in food chains. PCBs are suspected of causing cancer in humans and other animals. PCBs are an example of an organic toxic chemical.

Persistence - the length of time a compound remains in the environment once it has been introduced. A compound may persist for less than a second or indefinitely.

Persistent contaminants - harmful compounds that do not readily degrade in the environment.

Phosphorus coefficient - an average value for the amount of phosphorus that runs off from a unit area per year. This number is used to estimate phosphorus loading from nonpoint pollution sources to waterbodies.

Phytoplankton - very small plants found in water bodies.

Point source pollution - nutrients or toxic substances that enter a water body from a specific entry point, such as a pipe. For example, the discharge from a sewage treatment plant is point source pollution.

Pollutant - something that pollutes.

Pollution - impairment of land, air, or water quality caused by agricultural, domestic, or industrial waste that negatively impacts beneficial uses of the land, air, or water, or the facilities that serve such beneficial uses.

Pollution prevention - any action such as the efficient use of raw materials, energy, and water, that reduces or eliminates the creation of pollutants. In the Pollution Prevention Act, pollution prevention is defined as source reduction. See **Source reduction.**

Polycyclic aromatic hydrocarbons - see **PAHs**.

Population - the number of inhabitants in a country or region; in ecology, a population is a group of organisms of the same species living in a specified area and interbreeding.

Pretreatment - the treatment of industrial wastewater to remove contaminants prior to discharge into municipal sewage systems.

Priority pollutants - substances listed by EPA under the federal Clean Water Act as toxic and urgent for regulatory controls.

R

Radionuclides - a radioactive atom that has a measurable average time of existence and is characterized by its nuclear properties, such as the number of neutrons and protons and the energy state of its nucleus. Radionuclides can be manmade or naturally occurring. They can persist as soil or water pollutants, and are believed to have potentially mutagenic effects on the human body.

Rare species - a species not presently in danger, but of concern because of low numbers.

Restoration - any action taken to repair, maintain, protect, and enhance the ecological integrity of the Basin.

Retrofitted stormwater management - the installation of best management practices (BMPs) in existing developed areas to improve water quality and lessen other negative impacts associated with urbanization.

Riparian (habitat or zone) - habitat occurring along rivers, streams, and creeks that provides for a high density, diversity and productivity of plant and animal species.

Riparian "buffer" zones - the transitional areas between aquatic and terrestrial (land) environments that protect the waterway from harmful activities on the upland areas by filtering runoff.

Risk assessment - the evaluation of the danger that a given activity or presence of specific pollutants might pose to human health and/or the environment.

Risk communication - the exchange of information about health or environmental risks between those who evaluate risk, those who manage situations of risk, the general public, news media, interest groups, etc.

Runoff - water from rain, melted snow, or agricultural or landscape irrigation that flows over the land surface into a water body.

S

Salmonids - a member of the family *Salmonidae*, which includes salmon, trout and whitefishes.

Sedimentation - the deposition or accumulation of sediment, such as sand, silt or clay.

Septage - the sludge and scum material that is pumped out of a septic tank.

Sites of concern - areas where toxic substances are found in concentrations greater than acceptable levels, or where several toxic substances are found together.

Social and environmental benefits - anything which improves the welfare of both humans and the plants and animals of the Lake Champlain ecosystem.

Socio-economic vitality - the vigor and endurance of the welfare of the residents of the Basin and of the financial status of the Basin.

Source reduction - any practice which reduces the amount of any hazardous substance, pollutant, or contaminant entering wastewater. Source reduction decreases the hazards to public health and the environment associated with the release of such substances, pollutants, or contaminants. Technology modifications, process or procedure modifications, reformulation or redesign of products, substitution of raw materials, and improvements in housekeeping, maintenance, training or inventory control are examples of source reduction.

Stewardship - the concepts of responsible caretaking; based on the premise that we do not own resources, but are managers of resources and are responsible to future generations for their condition.

Stormwater runoff - precipitation running off from an impervious surface such as a paved parking lot, street or roof.

Sub-basin - a smaller portion of a large drainage basin, such as the Lake Champlain Basin.

Surface water treatment rule - a section of the Safe Drinking Water Act that requires that all water drawn from lakes, streams, ponds, etc. for drinking must be filtered before drinking, unless the water source is well protected.

Sustainable yield - the amount of harvest of a natural resource able to maintained over a long period of time with no destruction of the resource's productivity.

Sustainable (human) use - use of resources in an efficient way without destroying the basis of their productivity, such that they may be used in the present and by future generations.

Sustainable tourism - see **Carrying capacity**.

Synthetic organics - organic compounds that are manmade, not naturally occurring in the environment.

T

Terrestrial habitats - upland or dry land environments.

Toxic substance contamination - contact with or addition of substances which could cause a toxic or harmful effect.

Toxic substances - any substance which upon exposure, ingestion, inhalation, or assimilation into any organism, causes death, disease, genetic mutations, physiological malfunctions or physical deformation. Examples of toxic substances are cyanides, phenols, pesticides, and heavy metals.

Toxic substance of concern - see **Priority pollutants**.

Toxic - poisonous, carcinogenic, or otherwise directly harmful to life.

Toxicity tests - scientific experiments which evaluate whether a substance in water, air, soil, plant and animal tissue, or other material is poisonous to a test organism.

Trace elements - members of the set of ninety-two naturally occurring elements (such as selenium and silver) found in low concentration in rocks, soil, and water, usually less than one part per million.

Tributary - a stream or river that flows into a larger stream or river or lake.

Trihalomethanes (THMs) - carcinogenic materials that are formed as by-products when organic compounds found in water come into contact with chlorine used for disinfection during water treatment.

Trophic level - the level of nourishment. A plant that obtains its energy directly from the sun occupies the first trophic level and is called an autotroph. An organism that consumes the tissue of an autotroph occupies the second trophic level, and an organism that eats the organism that had eaten autotrophs occupies the third trophic level.

Trophic state - the extent or condition of eutrophication in a body of water.

Turbidity - a measure of the amount of material like fine silts and clay suspended in the water column. If turbidity is high, the water will appear cloudy.

U

Urban runoff - stormwater from city streets and adjacent domestic or commercial properties that may carry pollutants of various kinds into the sewer systems and/or receiving waters.

V

Vegetative buffer zones (strips) - planted zones created or sustained to minimize the negative effects of land development on animals and plants and their habitats. Vegetated buffer zones filter sediment and other pollutants from runoff, stabilize banks, regulate water temperature, and provide cover and habitat for animal life.

Volatile organics - any organic compound which participates in atmospheric chemical reactions driven by light, excluding those designated by the EPA as having negligible chemical reactivity in the presence of light.

Volatile organic compounds (VOCs) - see **Volatile organics.**

W

Water column - All the water in a lake from the sediments that form the bottom of the lake to the surface of the lake.

Water quality criteria - definitions of the conditions necessary to maintain and protect designated water uses. The criteria are descriptive factors taken into account by EPA in setting standards for various pollutants in water bodies. When issued by EPA, the criteria provide guidance to the states on how to establish their standards.

Watershed - the geographic reach within which water drains into a particular river, stream or body of water. A watershed includes both the land and the body of water into which the land drains.

Watershed planning - cooperative local and regional land use planning that recognizes watershed boundaries rather than political boundaries and considers water resources management is the central planning objective.

Wet pond - a basin with a permanent pool of water.

Wetland mitigation - usually takes the form of restoration or enhancement of a previously damaged wetland or creation of a new wetland. (See also mitigation.)

Wetland protection and restoration - any action that aids in preserving, repairing, maintaining, or enhancing wetlands.

See **Wetlands**.

Wetlands - lands that are transitional between land and water where the water table is usually at or near the surface of the land. Wetlands are characterized by unique hydric soils and contain plant and animal communities adapted to aquatic or intermittently wet conditions. Swamps, bogs, wet meadows, and marshes are examples of wetlands. The boundary of Lake Champlain wetlands has been defined at 105 feet (31.1 meters) above mean sea level.

Working landscape - the rural landscape created and used by traditional laborers in New England. Agriculture, forestry, and fishing all contribute to the working landscape of the Lake Champlain Basin. For instance, farmers keep land open when they mow fields or graze cattle.

Z

Zooplankton - microscopic aquatic animals that drift with the current or swim weakly.

Appendix A

Lake Champlain Basin Program Technical Committees

Technical Advisory Committee (TAC)

Mary Watzin (chair)	University of Vermont, Natural Resources
John Banta	Adirondack Park Agency
Mark Barie	Champlain Development Corporation
Gerald Barnhart	NYSDEC
James Beil	NYSDEC
Phil Benedict	VT Dept of Agriculture, Food and Markets
Ken Bogdan	NYS Health Dept
Bill Bress	VT Health Dept
Susan Bulmer	VT Dept of FPR
Thomas Bushey	Addison County Natural Resource Conservation District, farmer
David Clough	VT DEC, Water Quality
Richard J. Croft	USDA-NRCS
Robert Fuller	SUNY, Center for Earth and Environmental Science
Robert Genter	LCRC
Bob Gagliuso	VCGI
Angelo Incerpi	VT Dept. of Fish & Wildlife
Ivan James	USGS, Water Resources Division
William Johnston	Essex County Planning
Thomas Manley	Middlebury College
Alan McIntosh	University of Vermont, Natural Resources
Grady Moore	USGS
Brian Mrazik	USGS
Giovanna Peebles	VT Div. for Historic Preservation
David Tilton	US Fish & Wildlife
Everett Thomas	William H. Miner Ag. Research Institute
Scott Quinn	NYSDEC
Arthur Woolf	UVM, Economics

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Plan Formulation Team

James C. Dawson (chair)	SUNY Plattsburgh
Carl Baren	USFWS
Eleanor Berger	NY CAC
Gregory Campbell	APA
Italo Carcich	NYSDEC
Garry Douglas	Plattsburgh - North Country Chamber of Commerce
Monty Fischer (vice chair)	National Wildlife Federation, VT CAC

Lori Fisher	Lake Champlain Committee
Fran Keeler	USDA - NRCS
Sandra LeBarron	NYSDEC
Ron Manfredonia	USEPA, Region 1
Don McIntyre	Town of Westport
Rose Paul	VT ANR
Mike Sullivan	Vergennes/Panton Water District
John Titchner	USDA - NRCS
Mary Watzin	UVM School of Natural Resources

Staff Contact: Stephanie Clement, LCBP

TAC Subcommittees

Data Management Subcommittee

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Yvonne Baevsky	USGS
John Barge	Adirondack Park Agency
Jim Beil	NYSDEC
Marcy Berbeck	USEPA
Greg Charest	USEPA
Andy Cohen	USGS
Dave Franzi	SUNY
Art Hogan	Chittenden County Planning Commission
Kathy Kramer	NYSOPRHP
Kathy Manwaring	USEPA
Grady Moore	USGS
Jim Olmstead	SUNY
Ron Pote	International Paper
Robert Reinhardt	NYSOPRHP
Bruce Westcott	VT OGIS
Ed Woo	USEPA
Mary Watzin	UVM Natural Resources

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Economics Subcommittee

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Art Hogan	Chittenden Cty RPC
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Eutrophication Subcommittee

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Jay Bloomfield	NYSDEC
Robert Bonham	NYSDEC
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Jack Drake	UVM
Lori Fisher	Lake Champlain Committee
Ginny Garrison	VT DEC
Lynn McIlroy	SUNY
Scott Quinn	NYSDEC
Karen Roy	Adirondack Park Agency
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Human Health Subcommittee

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William Bress (co-chair)	VT Dept of Health
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Linden Witherell	
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Living Natural Resources Subcommittee

See also the following workgroups: Fisheries, Wildlife, Wetlands, Nuisance Aquatics

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Brian Chipman	VT Fish & Wildlife
William Crenshaw	VT Fish & Wildlife
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John Gersmehl	US Fish & Wildlife
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Robert Inslerman	NYSDEC
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Thomas Myers	VT Fish & Wildlife

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Cathy O'Brien	VT DEC
Donna Parrish	Coop FW Research Unit
Jerry Rasmussen	NYSDEC Habitat Inventory
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Appendix B

Lake Champlain Basin Program Demonstration Reports

1. *Case Study of the Town of Champlain.* Yellow Wood Associates. October 1993.

2. *(A) Demonstration of Local Economic/Other Community Impacts.* Community Case Studies for Economic Plan Elements. The City of Vergennes, Vermont. Economic and Financial Consulting Associates, Inc. October 1993.

   (B) Demonstration of Local Economic/Other Community Impacts. Community Case Studies for Economic Plan Elements. Appendix. The City of Vergennes, Vermont. Economic and Financial Consulting Associates, Inc. October 1993.

3. *The Archeology on the Farm Project.* Improving Cultural Resource Protection on Agricultural Lands: A Vermont Example. Jack Rossen. May 1994.

4. (A) *The 1992 Fort Ticonderoga-Mount Independence Submerged Cultural Resource Survey. Executive Summary.* Arthur Cohn. May 1995.

   (B) *The 1992 Fort Ticonderoga-Mount Independence Submerged Cultural Resource Survey.* Arthur Cohn. May 1995.

5. *Implementation, Demonstration, and Evaluation of BMPs for Water Quality: Application Methods ("Manure Injections") for Improved Management of Manure Nutrients.* Bill Jokela, Sid Bosworth and Don Meals. September 1995.

6. (A) *Malletts Bay Recreation Resource Management Plan.* T.J. Boyle and Associates, Resource Systems Group, Associates in Rural Development and Engineering Ventures. October 1995.

   (B) *Malletts Bay Recreation Resource Management Plan. Executive Summary.* T.J. Boyle and Associates. October 1995.

   (C) *Review and Relevant Studies. Malletts Bay Recreation Resource Management Plan.* T.J. Boyle and Associates. October 1995.

   (D) *Natural and Built Resources Inventory: Data Documentation. Malletts Bay Recreation Resource Management Plan.* Associates in Rural Development. October 1995.

   (E) *Survey Implementation and Analysis. Malletts Bay Recreation Resource Management Plan.* Resource Systems Group. October 1995.

   (F) *Institutional Review and Analysis. Malletts Bay Recreation Resource Management Plan.* Engineering Ventures. October 1995.

Lake Champlain Basin Program Education Reports

1. *Lake Champlain: Its Future Depends on Us.* Conference Proceedings; September 8-9, 1992, South Burlington, VT. NH/VT and Empire Chapters of the Soil and Water Conservation Society. July 1993.

2. *Public Input in the Lake Champlain Basin.* Results of a series of Public Input Meetings. April - May, 1993. Education & Outreach Committee. October 1993.

3. *Lake Champlain's Future: A Community Based Strategy for Environmental Policy Development.* Dr. Bryan Higgins, SUNY Plattsburgh, Dr. Richard Kujawa, St. Michael's College, Dr. Thomas Dietz, George Mason University, Dr. Linda Kalof, SUNY Plattsburgh, and Timothy P. Holmes, Holmes & Associates. June 1994.

4. *Alternative Waste Water Treatment: Conference Proceedings.* Judy Bond, AWWT Conference Coordinator. January 1995.

5. *Summary of Public Input on Opportunities for Action - A Summary of the Draft Plan for the Future of the Lake Champlain Basin. Results of a Series of Public Input Meetings, March - April 1994.* Education & Outreach Committee. February 1995.

Other LCBP Publications

1. *The Lake Champlain Basin Program, 1991-1992 Annual Report.*

2. *The Lake Champlain Basin Program, 1993 Annual Report.*

3. *The Lake Champlain Basin Program, 1994 Annual Report.*

4. *Casin' the Basin.* Lake Champlain Basin Program Quarterly Newsletter, Spring 1992 - Fall, 1995.

4. *Lake Champlain Boat Study Report.* Vermont Department of Forest, Parks and Recreation. March 1993.

5. *Lake Champlain Basin Program Directory.* December, 1993.

6. *Education and Outreach Field Guide.* Lake Champlain Basin Program.

Lake Champlain Basin Program Technical Reports (see list at the front of this report)

List of Abbreviations

AAC	Agricultural Advisory Council
AAPs	Accepted Agricultural Practices
AMPs	Acceptable Management Practices
APA	Adirondack Park Agency
ARS	Agricultural Research Service
ASCS	Agricultural Stabilization and Conservation Service
BMPs	Best Management Practices
CACs	Citizens Advisory Committees
CAMEN	Comprehensive Agricultural Monitoring and Evaluation Network
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CSOs	Combined sewer overflows
CWA	Clean Water Act
DDD	Dichlorodiphenyldichloroethane
DDE	Dichlorodiphenyldichloroethylene
DDT	Dichlorodiphenyltrichloroethane
DWEL	Drinking Water Equivalent Level
E&O	Education and Outreach
EPA	U.S. Environmental Protection Agency
FDA	U.S. Food and Drug Administration
FFDCA	Federal Food, Drug and Cosmetics Act
FSA	Farm Services Agency
GIS	Geographic Information Systems
HPF	Historic Preservation Fund
HUA	Hydrologic Unit Area Projects
ICM	Integrated Crop Management
IJC	International Joint Commission
INCOCHAMP	Interstate Commission on the Champlain Basin
IPM	Integrated Pest Management
ISTEA	Intermodal Surface Transportation Efficiency Act
LCBP	Lake Champlain Basin Program
LCC	Lake Champlain Committee
LCFWMC	Lake Champlain Fish and Wildlife Management Cooperative
LCMC	Lake Champlain Management Conference
LCRC	Lake Champlain Research Consortium
MCLs	Maximum Contaminant Levels
NASBLA	National Association of Boating Law Administrators
NBS	National Biological Service
NEA	National Endowment for the Arts
NERBC	New England River Basin Commission
NMFS	National Marine Fisheries Service
NOAA	National Oceanographic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NRCD	National Resource Conservation District

NRCS	Natural Resources Conservation Service
NURP	Nationwide Urban Runoff Program
NWI	National Wetland Inventory
NYSDAM	New York State Department of Agriculture and Markets
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
NYSDOT	New York State Department of Transportation
NYSOPRHP	New York State Office of Parks, Recreation and Historic Preservation
O&M	Operating and Maintenance
PAH	Polycyclic aromatic hydrocarbon
PCB	Polychlorinated biphenyl
POTWs	Publicly-owned treatment works
RC&D	Resource Conservation and Development Program
RCRA	Resource Conservation and Recovery Act
RCWP	Rural Clean Water Program
RIBS	Rotating Intensive Basin Studies
RPC	Regional Planning Commission
SCS	Soil Conservation Service
SDA	Special Designation Act
SDWA	Safe Drinking Water Act
SEQRA	State Environmental Quality Review Act
SPDES	State Pollutant Discharge Elimination System (New York)
STP	Sewage Treatment Plant
SWCD	Soil and Water Conservation District
THMs	Trihalomethanes
TSN	Toxics Surveillance Network
USACOE	U.S. Army Corps of Engineers
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
UVM	University of Vermont
VCGI	Vermont Center for Geographic Information
VIM	Visitor Impact Management
VOCs	Volatile organic compounds
VT ANR	Vermont Agency of Natural Resources
VT AOT	Vermont Agency of Transportation
VT DAFM	Vermont Department of Agriculture, Food and Markets
VT DEC	Vermont Department of Environmental Conservation
VT DFPR	Vermont Department of Forests, Parks and Recreation
VT DOH	Vermont Department of Health
VT FWD	Vermont Fish and Wildlife Department
WQSN	Water Quality Surveillance Network