MANAGEMENT PLAN FOR THE LAKE SUNAPEE WATERSHED

March 2008
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Prepared by:

Sunapee Area Watershed Coalition
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With appreciation to NH DES and UVLSRPC

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Management Plan for the Lake Sunapee Watershed

Adopted by the Watershed Planning Subcommittee of the Sunapee Area Watershed Coalition

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Funding for this project was provided in part by a Watershed Assistance Grant from the NH Department of Environmental Services with Clean Water Act Section 319 funds from the U.S. Environmental Protection Agency.
The goal of this grant is to develop a watershed management plan to address phosphorus loading, which is considered to be one of the most critical water quality problems.

Watershed Planning Committee of the Sunapee Area Watershed Coalition

The Committee reviewed existing information about the watershed, completed two watershed tours to discuss potential threats to water resources, identified priority areas of concerns and developed recommendations to address these concerns. Members of the subcommittee:

> Aimee Ayers, Anita Blakeman, Peggy Chalmers, Terence Dancy, June Fichter, Deane Geddes, Cynthia Hayes, Charlie Hirshberg, Katherine Holmes, Suzanne Levine, Kenneth Lawson, Richard Wright

The following individuals provided technical assistance to the committee:

Jennifer Palmiotto, Source Protection Specialist – Granite State Rural Water Association
Robert Wood, Associate Executive Director and Watershed Steward - Lake Sunapee Protective Association
Andrew Chapman, Biologist, Water Division, NH Department of Environmental Services

Dear Reader;

Recognizing the value and importance of preserving the water quality of the Lake Sunapee Watershed, the Sunapee Area Watershed Coalition initiated the formation of the Sunapee Watershed Planning Committee in the winter of 2006. A committee of 12 volunteer members was established comprised of town board members and residents, representing each of the six towns within the watershed (Newbury, Springfield, Sunapee, New London, Sutton, and Goshen) with members having diverse skills, talents and perspectives. The Committee met on a regular basis over the course of 2007 and recently completed its initial work on a proposed management plan for the Lake Sunapee Watershed.

While the quality of water at Lake Sunapee is generally good, increasing levels of conductivity and occurrences of cyanobacteria should be considered warning signs of increasing impacts of human activity. In addition, the water quality at tributary monitoring stations is showing increasing levels of phosphorus, decreasing transparency and increasing turbidity and conductivity. All are likely results of direct human impacts from stormwater runoff, siltation from construction sites, and nutrients from fertilizers and septic systems. Lake Sunapee is a valued resource for drinking water as well as important recreational uses. It is critical that watershed residents understand their individual contributions to protecting the valued resources in the Lake Sunapee region for future generations.

The timing of this initiative is more than appropriate. We have learned that land use and the quality of our lakes and ponds are strongly linked, and that by making the *protection of drinking water our primary goal*, our recommendations will also result in the long term protection of plants, fish and other animals that are all part of the larger ecosystem. The committee recognizes that property owners and area visitors alike have historically used the water bodies within the watershed for recreational purposes. Our recommendations are also intended to balance the need for water recreation opportunities with important water quality objectives. This balance will benefit the long term potential for continued fishing, swimming, boating and other forms of recreational activities.

The Management Plan for the Lake Sunapee Watershed is the result of many hours spent working by consensus to identify the issues, prioritize the risks, and develop a list of activities that would substantially reduce the degradation of the water quality in the watershed. We have made recommendations that are both regulatory and non-regulatory in nature with the firm belief that much can be accomplished through increased public awareness. The Lake Sunapee Watershed Planning Committee believes that the implementation of this plan will go a long way to preserve the water quality throughout the Sunapee Watershed and looks forward to working with the six towns and all other interested parties to implement this plan.

Respectfully Submitted,

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Deane Geddes, Co-Chair

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Kenneth Lawson, Co-Chair

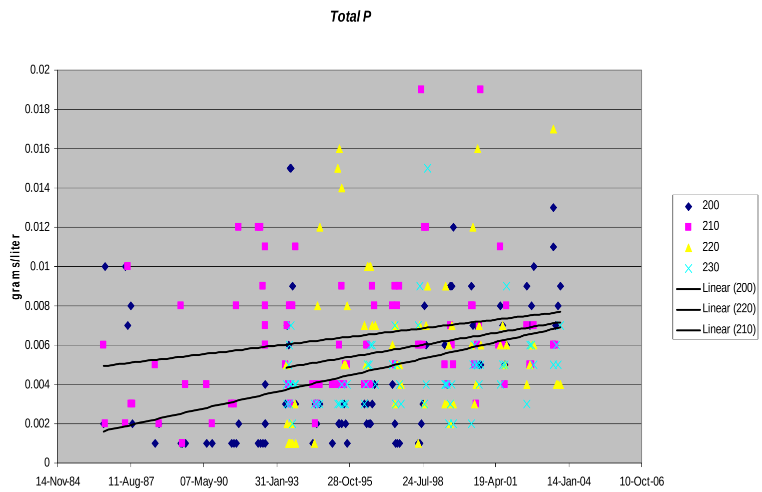
Watershed Planning Committee of the
Sunapee Area Watershed Coalition
March 2008

TABLE OF CONTENTS

Executive Summary

Water quality trends demonstrate that over the past 18 years, total phosphorus in-lake concentrations have increased more than 50%. Though the cycling of phosphorus (P) in water bodies is a natural process, changes in land use can significantly increase P loading into streams and lakes. A key element in controlling P levels in a lake is minimizing the amount of P entering that water body from the surrounding watershed - the streams and land surface that supply water to that lake. A major goal of the watershed management plan is to minimize excess nutrient (including P) and pollutant loading.

The influence of human activity within the watershed has caused this increase in phosphorus loading to Lake Sunapee. Impervious surfaces cover 28.2% of the 250' buffer zone around the lake, well above the 10% threshold at which water quality begins to decline. Over the last 20 years, building permit data shows that the level of development in the watershed increased by 24% (based on building permits).



Total Phosphorus Lake Sunapee Deep Spots 1981-2006

The presence of human activity increases phosphorus import to a watershed as it is found in our food, animal feed, landscaping materials, and road construction and maintenance materials (sand and gravel) to name a few. In other words, with less human activity there would be less phosphorus loading in the watershed. In addition, human activity increases the transport of phosphorus from the watershed to water bodies. With a transition from forested to non-forested landscapes, the runoff rate of phosphorus increases. While regulating the import of phosphorus within a watershed would mitigate the potential of phosphorus loading this is not feasible at this time. Instead, managing the transport or non-transport of phosphorus within the watershed is the preferred alternative.

SAWC anticipates managing the landscape through education, land use regulatory, and other improvements to reduce phosphorus runoff rates to maintain in-lake phosphorus concentrations (0.008 mg/L) in the short-term and in the long-term, given the expected increase in development, to maintain in-lake phosphorus concentrations at or below that level (.008 mg/L), which is considered to be indicative of an oligotrophic lake system.

Managing water resources at a watershed scale has been identified by the US EPA and the New Hampshire Department of Environmental Services as ecologically sound and practical, because watershed units are recognized as the most practical management units for the development of local plans. A watershed plan is a framework which enables the application of management tools so that water resource protection goals can be met.

This watershed management plan addresses the prevalent concerns of the Sunapee Watershed as identified by the Lake Sunapee Watershed Planning Committee. The twelve member committee represents a variety of skills and perspectives from the six watershed towns of Newbury, Springfield, Sunapee, New London, Sutton and Goshen. During the course of thirteen months, the Committee thoughtfully and methodically reviewed land uses in the watershed, identified potential threats and developed recommendations to address these concerns.

This management plan is divided into six chapters. *Chapter One* defines the term "watershed", describes the purpose of this watershed management plan and the watershed approach. Also in this chapter is a brief summary of how this project came about, and a description of the collaborative nature of this watershed project, and lastly identifies how this plan can be used.

Chapter Two provides a physical description of the watershed including its size, topography, characteristics of its ponds, streams and tributaries, wetlands, soils and geology. Land uses and water-based resources within the watershed are also described in this chapter. Water-based resources include lakes and ponds, fish habitat and fisheries, drinking water supplies, and significant natural communities and rare, threatened and endangered species.

Chapter Three provides a brief overview of Federal and State water quality regulations including the New Hampshire surface water quality standards which determine the baseline quality that all surface waters of the State must meet in order to protect their "intended uses". Available water quality information is collated and presented in this chapter. Water quality information was gathered from the NH DES Inventory and the Volunteer Lakes Assessment Program. These data sources indicate that water quality concerns in Lake Sunapee include:

- Increasing levels of conductivity
- Increasing phosphorus concentrations
- An increased occurrence of algae blooms and toxic algae
- Elevated sodium and chloride concentrations.

This section also contains a description of the water quality model for the Lake Sunapee watershed that was developed by Geosyntec Consultants, Inc. incorporating a Monte Carlo simulation to evaluate total phosphorus (TP) loading from the Watershed under two land use conditions: current land use and full build-out land use.

The New Hampshire Drinking Water Standards are presented and compared with water quality information from the Volunteer Lakes Assessment data collected by the Lake Sunapee Protective Association.

Chapter Four briefly summarizes existing protection measures in the watershed. Zoning ordinances in the watershed towns were reviewed and a composite map of aggregate zoning districts was produced (**Map 6**). This review is not a qualitative review which examined effectiveness of these regulations. Instead this zoning review looked for the presence or absence of water resource protection techniques that can be implemented through zoning. Development on steep slopes is largely controlled through zoning and site plan regulations for slopes greater than 25% across the watershed. Wetland protection buffers are established in Newbury and New London, however, there is no cohesive watershed protection overlay. Conservation land in the watershed is described and a map of conserved land presented in Chapter Four, **Map 4**. Currently 7,202 acres are set aside for conservation purposes. This represents approximately 23% of the entire 30,947.74 acre watershed. While the extent of protected areas is significant, it is important for local managers to determine those resource areas which are most important for future protection efforts and target conservation funding accordingly.

Chapter Five provides an inventory of potential sources of contamination in order to identify areas where remedial and preventative measures in the watershed are necessary. To develop this inventory, two types of pollution sources were reviewed: nonpoint and point pollution sources. Nonpoint sources of pollution contribute pollutants in an indirect pathway. Nonpoint source pollutants originate from rainwater or snowmelt washing over exposed pollutants on the land’s surface or in soils. In contrast, point source pollution can be traced to a specific point of discharge, such as a pipe, channel, or ditch connected to a wastewater treatment plant, sludge lagoon, or landfill.

Chapter Six follows with a summary of the top watershed protection priorities, based upon the inventory of potential sources of contamination presented in Chapter Five. From this process the Lake Sunapee Watershed Planning Committee identified 8 general areas of concern. These areas of concern include:

- Pollution from stormwater runoff;
- Erosion from land development activities;
- Impacts of impervious cover to water quality and stormwater runoff;
- Impacts from aging septic systems, and location of new systems;
- Enforcement of existing ordinances and regulations;
- Road salt use and storage;
- Using a watershed approach for protection of water resources;
- Education and implementation of the watershed plan.

This chapter presents the recommendations developed by the Lake Sunapee Watershed Planning Committee to address these water quality concerns. The recommendations are presented in a table form in Table 6.2. These recommendations can be addressed through programs and projects developed by the Sunapee Watershed partners including: watershed municipalities, New Hampshire Department of Environmental Services (NHDES), Upper Valley Lake Sunapee Regional Planning Commission (UVLSRPC), University of New Hampshire (UNH), New Hampshire Fish and Game (NHFG), the Sunapee Area Watershed Coalition (SAWC) and the Lake Sunapee Protective Association (LSPA), Granite State Rural Water Association (GSRWA), among others.

Chapter 1. Introduction

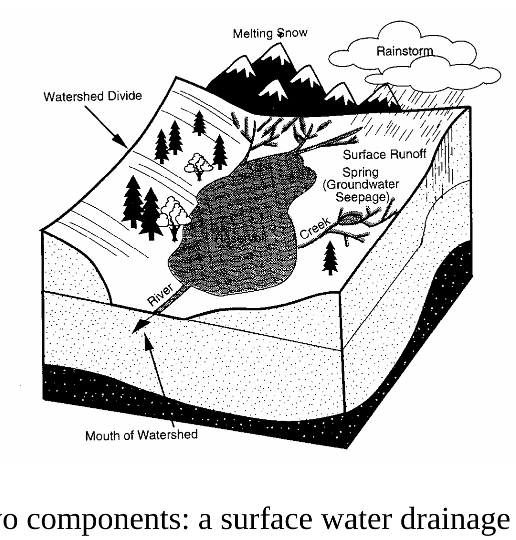
1.1 WATERSHEDS AND THE WATERSHED APPROACH

Although more than 70 percent of the Earth's surface is covered by oceans, lakes, rivers, and other bodies of water, only a small fraction (2.4 percent) is fresh water. And of this small percentage of fresh water, nearly 90 percent is tied up in glaciers, ice caps, and snowfields. This means that of the fraction which is fresh water, only approximately 0.24 percent of the Earth's water is in fresh liquid form and thus available for human use. Preserving the purity of these fresh water resources has long been recognized as a worthwhile goal. Fresh water is often vulnerable to both natural and anthropogenic contamination. It is therefore critical that these resources be managed wisely for the benefit of present and future generations.

Watersheds provide important goods and services that enrich our daily lives. They provide critical habitat for plants and animals, areas of scenic natural beauty, places to recreate and relax, they often facilitate transportation of goods and people, and provide fresh water necessary for human survival. So too, does the Lake Sunapee Watershed enrich the lives of the greater Sunapee Area and visitors alike. For example, residents enjoy boating, fishing and swimming in the Lake, and exploring the surrounding watershed. And lastly, the Lake serves as source water to the Town of Sunapee's public water system.

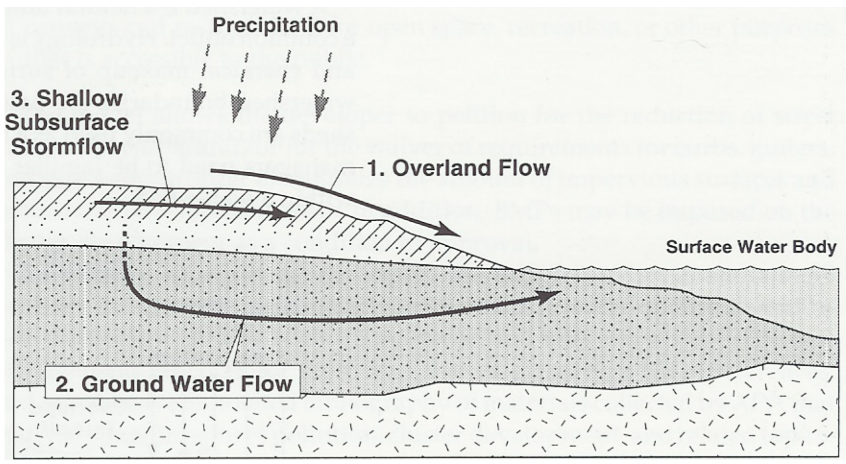
With this understanding of the limited nature of fresh water, this plan aims to increase the understanding of water resources in the Lake Sunapee Watershed, and to provide a meaningful foundation for decision-making. A watershed can be defined as a natural unit of land within which all water drains to a common outlet (Figure 1.1).

Figure 1.1 Depiction of a watershed. (Source: American Planning Association, NPS Pollution: A Handbook for Local Governments, Jeer et al, 1997)



A watershed includes two components: a surface water drainage basin and a groundwater drainage basin. The surface drainage basin is the land area from which all surface water flows drain toward a surface waterbody. The groundwater drainage basin is the land area and subsurface through which groundwater drains to a surface waterbody at a lower elevation (Figure 1.2). The surface drainage basin may be larger or smaller than the groundwater drainage basin, depending on factors such as soils, slope, and surface cover. ***One of the most important concepts is that surface water and groundwater are inextricably linked.*** For example, groundwater and surface water interact where groundwater discharges to lakes, rivers and in areas where ground conditions impede the drainage of water, such as in wetlands. This means that management of contamination and pollution sources throughout a watershed will benefit both groundwater and surface water.

Figure 1.2 Paths of surface and groundwater flow. (Source: American Planning Association, NPS Pollution: A Handbook for Local Governments, Jeer et al, 1997)



A watershed may occupy tens to hundreds of square miles and cover several jurisdictions. In this case, the Lake Sunapee Watershed covers approximately 48.36 square miles or 30,947.74 acres, spans Merrimack and Sullivan Counties, and covers portions of the towns of Newbury, Springfield, Sunapee, New London, Sutton and Goshen. The Lake Sunapee Watershed is defined as the area of land and complex of wetlands, ponds, and tributaries which drain to Lake Sunapee. This area includes 13 lakes and ponds and 35 tributary streams.

1.2 THE "WATERSHED APPROACH"

According to New Hampshire Department of Environmental Services, "The watershed approach for management and planning is a strategy that has as its premise that many water quality and ecosystem problems are best solved at the watershed level rather than at the individual waterbody level."

As early as the 1920's many federal agencies in the United States used watershed management for the purposes of controlling soil erosion and sedimentation. Increasingly, federal, state, and local agencies are focusing on non-point source pollution as a primary source of pollution to surface water and emphasizing the importance of planning at the watershed level. Watershed plans can work to improve water quality, manage recreational opportunities, maintain public health, and preserve the aesthetics of rivers and lakes. Community strategies for watershed planning have included the advent of partnerships and collaboration between the public, government agencies, and local organizations.

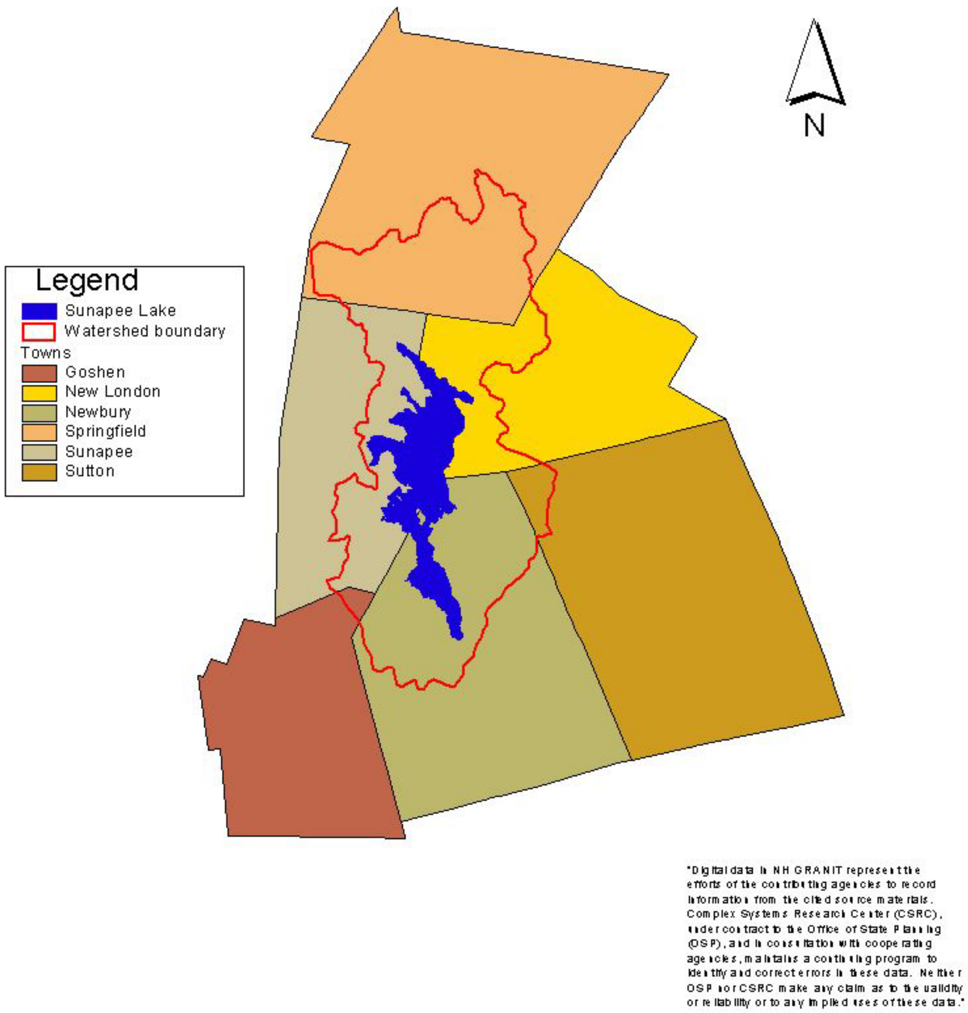


Figure 1.3 Sunapee Watershed Communities (Source: Institute for Community and Environment, Colby Sawyer College, Lake Sunapee Watershed Project, 2004)

Communities throughout the United States are increasingly coming to understand the importance of protecting watersheds in order to protect their water resources. As communities develop and the amount of watershed impervious cover increases in the form of parking lots, roads, and roof tops, the ability of a watershed to provide ecological services becomes impaired. For example, impervious cover significantly impacts the way stormwater runoff behaves. Impervious surfaces collect and accumulate pollutants and when storm events occur, pollutants are more rapidly delivered to aquatic systems through runoff. As the amount of impervious cover increases, the rate of runoff also increases, while the amount of water which infiltrates groundwater aquifers typically decreases, all of this having negative impacts on the hydrologic cycle.

Monitoring and modeling studies indicate that pollutant loads, such as phosphorus, are directly related to watershed imperviousness. Research has shown that when impervious cover exceeds 10 percent, pollutant loads increase having negative impacts on stream biodiversity and cause stream channels to become unstable and easily eroded (Schueler, 2002). When watershed imperviousness exceeds approximately 26 percent, streams become "non-supporting" meaning channel stability and biodiversity cannot be fully maintained even with the implementation of stormwater practices or retrofits (Schueler, 2002). For these reasons, managing activities in a watershed is critical to its future well-being.

Through use of a "watershed approach", watershed associations, volunteer groups, government agencies and others can work together to protect ecosystem structure and function in order to safeguard water quality. In 1991 the United States Environmental Protection Agency defined the "watershed approach" as a coordinating framework for environmental management that focuses public and private sector efforts to address the highest priority problems within hydrologically-defined geographic area, taking into consideration both ground and surface water flow.

The "watershed approach" used to develop this plan was guided by three overarching principles as identified by the Environmental Protection Agency: partnerships, geographic focus, and sound management recommendations based upon available science and data. In this case partnerships mean that the people most affected by management decisions are involved throughout the planning process and are an integral part of shaping key decisions. The geographic focus directs activities and resources within the specific management unit of the Lake Sunapee Watershed. And lastly watershed stakeholders, primarily through the Lake Sunapee Watershed Planning Committee, developed a series of recommendations based upon available scientific data and a ranking of threats. As the recommendations in this plan are implemented, the goals and objectives should be evaluated for effectiveness and revised as needed. This plan represents one of many steps needed to protect the quality of water resources in the Lake Sunapee Watershed.

1.3 THE LAKE SUNAPEE WATERSHED PLANNING PROCESS

In June 2005 the Lake Sunapee Protective Association invited Granite State Rural Water Association to a Sunapee Area Watershed Coalition meeting to discuss getting assistance in developing a watershed management plan. In September of 2005 Granite State made a commitment to Sunapee Area Watershed Coalition to provide assistance beginning in September 2006. In September 2006, Granite State helped to form a working group with representatives from the Lake Sunapee Protective Association, Sunapee Area Watershed Coalition, Upper Valley Lake Sunapee Regional Planning Commission, NH DES Watershed Management Bureau, and the Sunapee Water Department. This group organized a workshop entitled "Protecting Water Quality in the Sunapee Area" which was held on December 13, 2006 and attended by over thirty participants. Workshop presentations provided the audience with an overview of the Lake Sunapee Watershed, an introduction to water quality concerns, information about public drinking water systems in the watershed and their source water assessment reports, and how to go about developing a management plan for the watershed. The outgrowth of the workshop was the formation of the Watershed Planning Committee of the Sunapee Area Watershed Coalition.

The Committee reviewed information about the watershed, including the results of the Water Quality Model, conducted two field trips to discuss potential threats to water resources, and met monthly from to January 2007 to March 2008. The field trips were to points of interest in the Sunapee Watershed: The New London Dump, the DOT highway facility, a managed forest, a commercial site with BMPs, the Sunapee and New London water supply facilities. This plan is the culmination of thirteen months of research, discussion, and decision-making by the Committee. The plan identifies potential contamination sources to water resources in the watershed and provides specific recommendations to manage these potential threats. Additionally, the plan aims to increase the understanding of the Lake Sunapee watershed, provide a meaningful foundation for decision-making, and to achieve control of phosphorus loading in the Sunapee Area waterbodies.

1.4 USE OF THE SUNAPEE WATERSHED PLAN

This watershed management plan may be used to:

- Serve as a guidance document to assist the SAWC in its planning efforts to protect water quality in the Lake Sunapee Watershed, including achieving limiting in-lake phosphorus to 8 µg/L.
- Guide New Hampshire Department of Environmental Services and other state, regional, and federal agencies in their efforts to protect and improve State surface waters.
- Outline the primary water quality and drinking water protection issues based upon existing data and local knowledge.
- Identify top watershed management concerns and recommendations to address these concerns.
- Provide background and context on the Lake Sunapee Watershed and its water-based resources.
- Develop project ideas related to water quality or water resources improvements.
- Help identify technical or financial resources.
- Identify the technical or financial need of potential projects and partners.
- Support grant proposals.
- Provide guidance to local and regional planning and zoning processes.

It should be noted that this watershed plan represents the first step of a multi-stage process to protect the water resources in the Lake Sunapee Watershed. As management activities are implemented and conditions change in the watershed, goals and objectives should be updated and the plan should be amended to reflect these changes. As watersheds are in a constant state of change, so too should management plans reflect their ever-changing nature.

Chapter 2. Description of the Lake Sunapee Watershed

2.1 PHYSICAL DESCRIPTION

General Description

The Lake Sunapee Watershed is a largely undeveloped watershed with good water quality and small amounts of development. This watershed is a medium-sized drainage basin in the Sugar River Watershed of the upper Connecticut Basin. Hydrological Unit (HUC 12 # 010801060402). NH DES has completed Assessments for each of the stream segments within the watershed. The Assessment data and water quality threats can be found in the Appendices. See **Map 1** for a Base Map of the Lake Sunapee Watershed

The Lake Sunapee Watershed spans approximately 30,947.74 acres or 48.36 square miles and includes portions of Merrimack and Sullivan Counties and portions of the six towns of Newbury, Springfield, Sunapee, New London, Sutton and Goshen (**Map 1**). For the purposes of this plan, the Lake Sunapee Watershed boundary was delineated using the National Hydrography Dataset (NHD) a vector geospatial theme for surface waters developed by the USGS and released through NH Granit. The hydrologic units representing the Upper Connecticut River Basin (HUC 6) are further defined as Connecticut – White River – Bellows Falls (HUC 8); Sugar River (HUC 10); and finally Sunapee Lake (HUC 12). The watershed can be further divided into sub-watersheds by using the NHD Flowline data. This step was not taken for the management plan for Lake Sunapee.

Table 2.1 Municipalities, associated acreage and percent of land cover in the Lake Sunapee Watershed, New Hampshire.

Municipality	Area (acres)	Percent of Watershed Area (%)
Newbury	9394.70	30.35
Springfield	7703.60	24.90
Sunapee	7446.35	24.06
New London	5309.62	17.16
Sutton	827.93	2.67
Goshen	265.54	0.86

Terrain within the watershed ranges from steep slopes (greater than 25%) to rolling terrain. Elevations range from over 2,760 feet at the summit of Mount Sunapee to 1092.5 feet at the Lake Sunapee outflow at the Sugar River in Sunapee.

Characteristics of Ponds and Streams

There are 13 lakes and ponds in the watershed. Statistical information about the water bodies is listed in Table 2.2. Lake Sunapee is the largest waterbody with Little Sunapee Lake to the northeast as the second largest.

Lake Sunapee is a 4088 acre waterbody with a mean depth of 37 feet and a maximum depth of approximately 105 feet. The lake is relatively long and narrow with a length to width ratio of about 4.1. Lake Sunapee has a total shoreline length of 32 miles (Source:

National Wetlands Inventory, US Fish and Wildlife Service, NH Granit Database). The shores are largely developed with both year-round and seasonal residential development.

See **Map 2** for Surface Water Resources.

Table 2.2. List of waterbodies and associated characteristics in the Lake Sunapee Watershed, New Hampshire.

Waterbody	Lake Area (acres)	Shore Length (miles)	Maximum Depth (feet)	Average Depth (feet)
Baptist Pond	98.9	2.1	24.6	7.9
Chalk Pond	20.1	1.1	11.8	6.56
Dutchman Pond	27.9	1.0	9.8	6.23
Goose Hole	15.2	0.85		
Lake Sunapee	4088.4	32.0	104.6	37.0
Little Lake Sunapee	472.0	6.7	43.0	14.43
McAlvin Pond	9.9	0.54		
Morgan Pond	55.1	1.84		
Mountainview Lake	104.8	2.6	22.0	10.1
Murray Pond	No Data			
Mud Pond	11.2	2.6		
Otter Pond	184.9	3.4	24.9	13.1
Star Lake	66.7	1.7		

Note: Source data varies by lake and includes NH DES VLAP, National Wetlands Inventory, US Fish and Wildlife Service, NH Granit Database and the National Hydrography Dataset (NHD).

See Appendices for a list and map of the DES Assessment Units of the Sunapee Watershed. Streams and tributaries not only serve as important sources of water for the lakes and ponds, but they can also serve as conduits for pollutants. The shorter the length of the stream or tributary, the greater the risk of pollutants reaching the receiving waters without adequate time for natural treatment. In addition, the amount of reaction time is reduced for shorter streams and tributaries in terms of spill response.

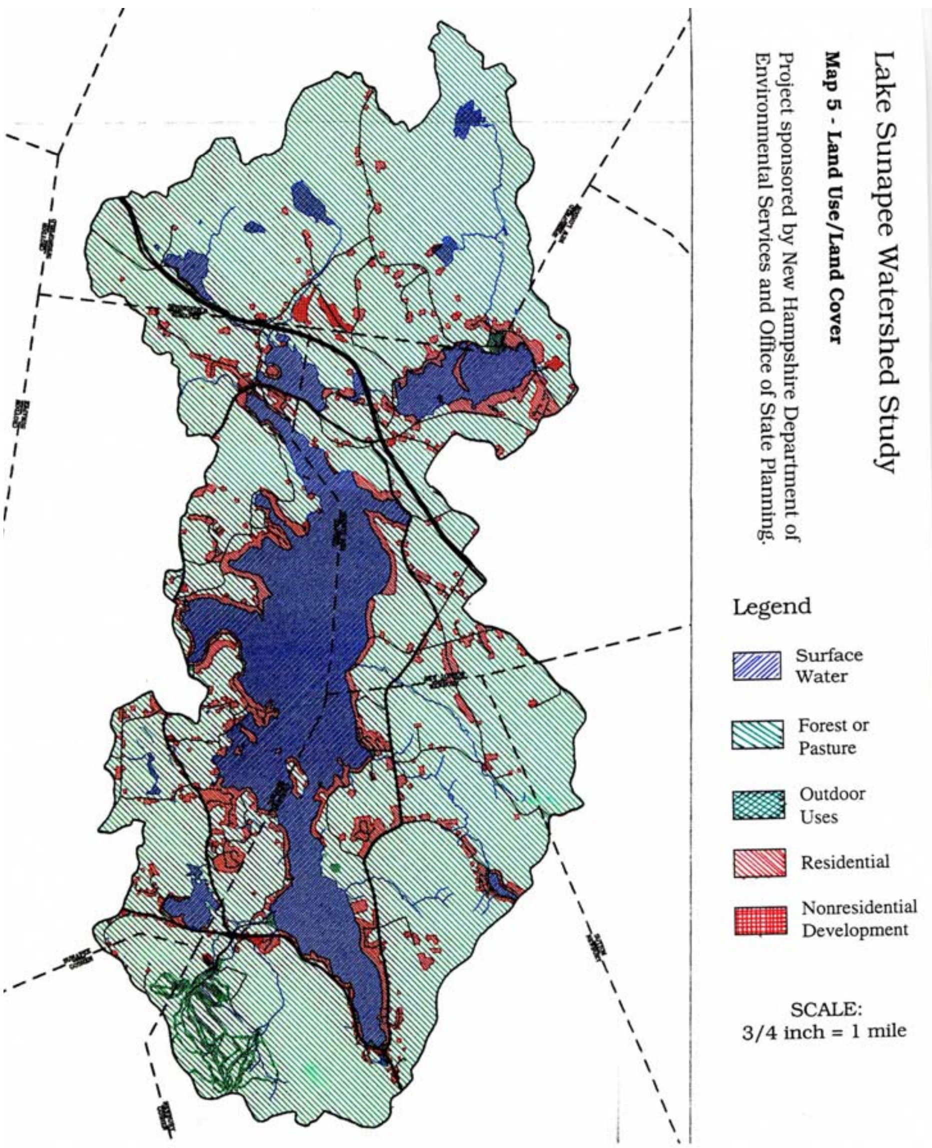
Wetlands, Soils and Conservation Lands

Wetlands represent a relatively small portion of the watershed. Excluding the lakes and ponds, only 1115.9 acres or 3.6% of the watershed is comprised of palustrine (freshwater) wetlands dispersed throughout the watershed. A total of 300 wetland units have been identified in the watershed using the National Wetlands Inventory. Steep slopes as determined through the soils surveys prepared by the Natural Resource and Conservation Service and cooperating agencies. *Data for Merrimack County are preliminary.* A total of 2,352 acres are considered steep soils – averaging 25% or greater in slope. This represents 7.6% of the watershed. While percentage of land in conservation in the watershed is higher than statewide averages at 23% (7,202 acres), very little of the shorelines of lakes, ponds and tributaries are currently permanently protected from development.

2.2 LAND USE

The Upper Valley Lake Sunapee Regional Planning Commission conducted two buildout studies of the Lake Sunapee Watershed. The first in 1995 showed residential development concentrated primarily along the shorelines of the major lakes and ponds, and also along existing road networks. Growth has continued in this pattern for the most part. It is worthy of note that the primary land uses are Forest and Outdoor Use (recreation). See Figure 2.1. Land use in 1995 was estimated as follows:

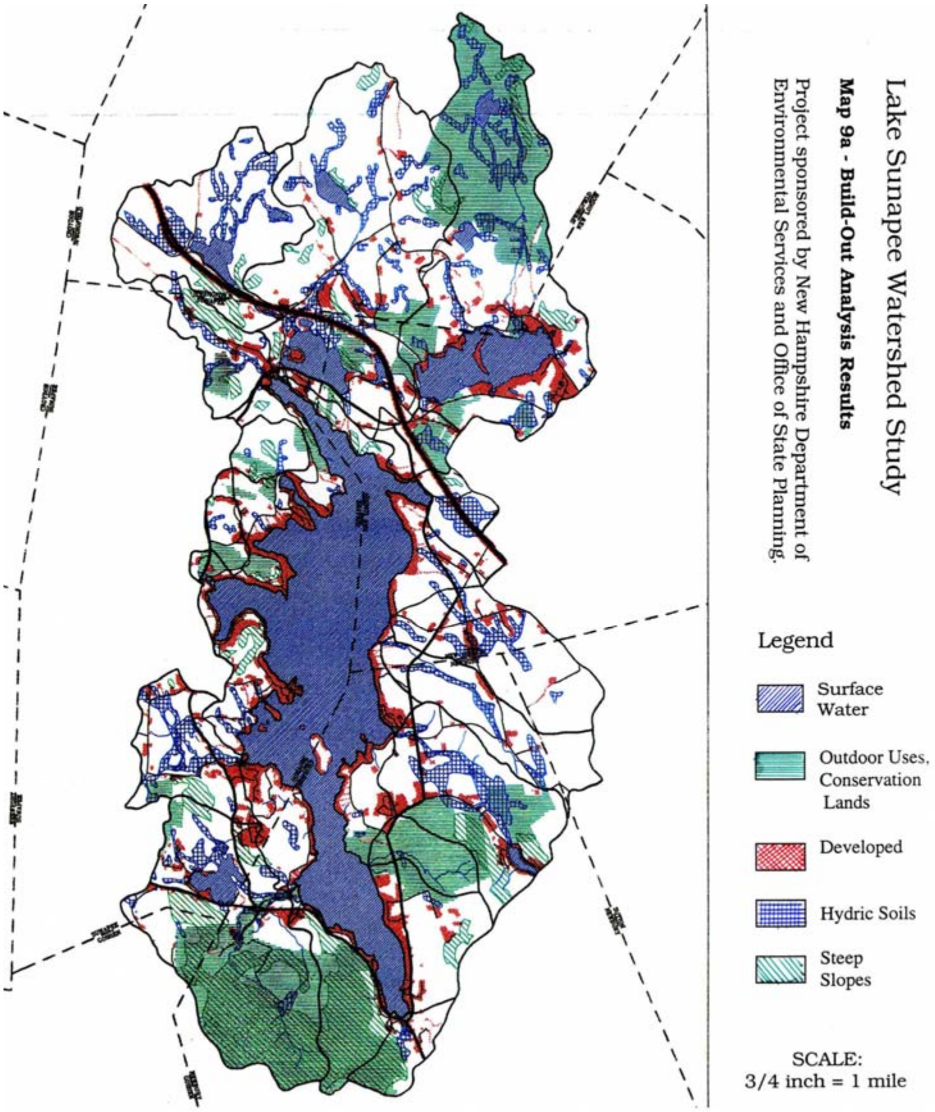
Figure 2.1 Lake Sunapee Watershed Land Uses, 1995 (Source: UVLSRPC Lake Sunapee Watershed Study Buildout Analysis,1995, update 2006)



Forest Use
59.7%
Outdoor Use
24.3%
Residential Use
8.5%
Transportation
5.4%
Agriculture
1.8%
Commercial/
Industrial
0.4%

The buildout analysis summarized developable land by town within the Lake Sunapee Watershed area and projected that if zoning remained the same an approximate number of 7,226 additional lots could be created within the watershed, and could increase the population by 18,564 people. This would represent a four fold increase in the current (1995) population. The 2006 update corrected the population numbers slightly downward to a buildout of 21,656 an increase of approximately 15,000 people. Still a significant increase from the 1995 estimated watershed population of 6344. Rather than try to establish more precise calculations of population increase, it is safe to assume that due to the desirability of the location with its nature resources, recreational opportunities and proximity to a major highway corridor, the Sunapee area will continue to grow.

Figure 2.2 Lake Sunapee Watershed Land Uses at Projected Buildout (Source: UVLSRPC Lake Sunapee Watershed Study Buildout Analysis,1995, update 2006)



While the 2006 Buildout Analysis does not project the type of development, typical growth patterns of primarily rural NH communities tends toward continued residential growth with loss of forest and agricultural land and a continued growth in the commercial sector – keeping pace with demands for services of the residential needs.

The UVLSRPC completed an assessment of current ordinances and regulations noting where these are in alignment with local Master Plans and resource protection interests. This table can be found in the appendices.

Figure 2.3 Lake Sunapee Watershed Land Uses - Current (Source: Lake Sunapee Protective Association).

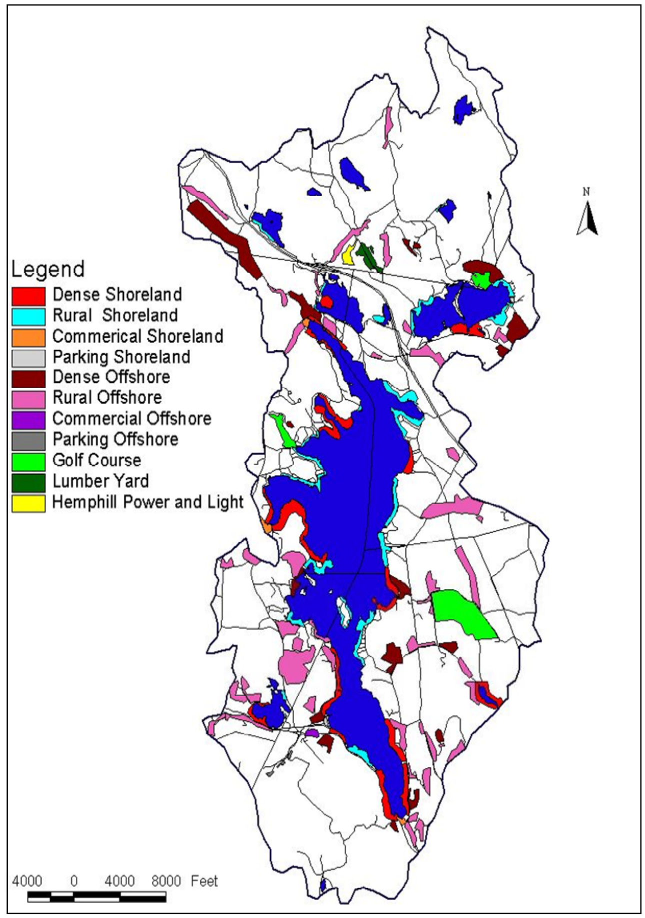
Watershed Impervious Surface

2004 Estimate:

Total Impervious Surface within the Lake Sunapee Watershed —5.8%

Total Impervious Surface within 250 ft of the shore—**28.2**%

Dense Development	50-100%
Parking	100%
Rural Area	2-10%



2.3 WATER-BASED RESOURCES

The Lake Sunapee Watershed provides many recreational opportunities. Recreation includes various types of boating activities and swimming during the summer months. During the winter skating, ice fishing, x-country skiing, snowmobiling, and dog sled racing are favored activities. For an excellent natural and cultural history of the Lake Sunapee Watershed see "Protecting the Lake Sunapee Watershed for Future Generations" by Aimee Bennett Ayers. The first significant development of permanent homes and summer camps along the shoreline of Lake Sunapee occurred in the late 1800's. Lake life centered on recreational activities, such as boating and swimming. Water resources in the watershed are also important for wildlife and fish habitat and fisheries, significant natural communities and rare, threatened, and endangered species, drinking water supplies, and aesthetics. The fundamental purpose for protecting water quality in New Hampshire is to protect these uses and values.

Drinking Water Supplies

The majority of residences in the watershed are served by individual wells. Most residences have bedrock wells, some have dug wells, and others may be supplied from untreated surface water. NH DES strongly cautions against use of untreated surface water from lakes, ponds and streams for drinking water regardless of the apparent safety

of this practice in the past. Even if past bacterial tests for a particular pond or stream may have shown good quality, quick shifts in wind direction coupled with poor sanitary practices of man or feces from passing animals can quickly contaminate any surface water source.
In addition to private residential sources, there are public water systems present in the watershed (Table 2.3). A public water system is defined as “a system for the provision to the public of piped water for human consumption if such system has at least 15 service connections or regularly serves an average of at least twenty-five individuals daily at least 60 days out of the year” (Chapter Env-ws 300 NH Drinking Water Rules).

Public water systems are further classified into three types: community water systems, non-transient non-community systems, and transient non-community systems. Community water systems serve at least 25 residents on a year round basis. Examples include municipal water systems, and systems at mobile home parks, condominiums, and single family housing developments. Non-transient non-community systems serve at least 25 people, for at least 6 months per year. These systems typically serve daycare facilities, schools, and commercial properties. Transient/non-community systems serve at least 25 people, for at least 60 days per year. These water systems serve restaurants, campgrounds, motels, recreational areas and services stations.

There are twenty public water systems and forty five public water wells in the watershed (See **Map 5**). These wells include the water supplies for The Town of Sunapee, Mount Sunapee Ski Area, New London/Springfield, Chalk Pond Water Company, Georges Mills Water Works, and Granliden on Sunapee are the largest systems. Only the Sunapee Water Works system is supplied by a surface waterbody: Lake Sunapee. All of the other systems get their water from groundwater.

Due to the connection between surface water and groundwater, protection of the watershed benefits all types of systems, whether they are public or private, or get their water from groundwater or surface water [1]. Source protection efforts, such as watershed planning, help to minimize the likelihood that contaminated water will enter a drinking water system. NH DES recommends that source protection plans be implemented for all public drinking water supplies. These plans should include management activities such as public education and land protection. One of the goals of the Lake Sunapee Watershed Management Plan is to reduce the risk of contamination from entering drinking water systems.

Table 2.3 Active public water systems in the Lake Sunapee Watershed.

EPA ID	Water System Name	Municipality	System Type	Population Served	Source Type
1721010	New London Springfield Water	New London	Community	2528	Groundwater
1652020	Chalk Pond Water Company	Newbury	Community	183	Groundwater
1658070	Davis Cabins on Lake Sunapee	Newbury	Transient Non-Community	45	Groundwater

[1] See Chapter One for brief description of groundwater and surface water interconnections.

1657020	Fells Gatehouse	Newbury	Transient Non-Community	50	Groundwater
1657010	Fells Mainhouse	Newbury	Transient Non-Community	50	Groundwater
1656010	Lake Sunapee Trading Post	Newbury	Transient Non-Community	25	Groundwater
1658010	Mountain Edge Resort	Newbury	Transient Non-Community	25	Groundwater
2277030	MT Sunapee Ski Area/Main Lodge	Newbury	Transient Non-Community	1000	Groundwater
2277040	MT Sunapee Ski Area/Summit	Newbury	Transient Non-Community	1000	Groundwater
2277020	MT Sunapee State Park Bath House	Newbury	Transient Non-Community	500	Groundwater
1658110	Digby's	Newbury	Transient Non-Community	200	Groundwater
1658180	Baker Hill Golf Club	Newbury	Transient Non-Community	25	Groundwater
2177010	Camp Sunapee / Ballfield	Springfield	Transient Non-Community	40	Groundwater
2278090	Dexter's Inn	Sunapee	Transient Non-Community	30	Groundwater
2278050	Edgemont House	Sunapee	Transient Non-Community	150	Groundwater
2271020	Georges Mills Water Works	Sunapee	Community	475	Groundwater
2272010	Granliden on Sunapee	Sunapee	Community	285	Groundwater
2272020	Meadowbrook at Sunapee	Sunapee	Community	33	Groundwater
2275020	Mount Royal Academy	Sunapee	Non-Transient Non-Community	78	Groundwater
2271010	Sunapee Water Works	Sunapee	Community	1510	Surface Water
2278020	The Inn at Sunapee	Sunapee	Transient Non-Community	50	Groundwater
2278050	One Mile West	Sunapee	Transient Non-Community	150	Groundwater

New London/Springfield Water[2]

The New London/Springfield Water Precinct community water system provides domestic water and fire protection to approximately 1,100 service connections serving an estimated 2, 750 people including Colby Sawyer College. The water system primarily serves the downtown area of New London. The water system also serves the Twin Lake Villa in Springfield. The reported average daily use for 2003 was 285,000 gallons per day.

The system is comprised of six gravel packed wells, pump house and a one million gallon water storage tank.

[2] System descriptions are taken from the DES Source Water Assessment Reports and Sanitary Surveys where available.

Chalk Pond

Chalk Pond community water system serves 200 individuals from two point wells, approximately 16 feet deep each and a bedrock well, of 600 foot depth. Water is pumped from each of the point wells via two suction pumps and from the bedrock well via submersible pump to the lower pumphouse where the three lines are combined and then routed to the upper pumphouse. Water is disinfected and treated for corrosion control and stored in a single 20,000 gallon tank.

Davis Cabins on Lake Sunapee

Davis Cabins system consists of a single bedrock well of 85'. The population served by the system is approximately 45 people and is considered a transient non-community water system.

Fells Gatehouse

The Fells Gatehouse obtains its water from a single bedrock well, with a reported depth of 180' and an unknown yield. Water is pumped via a submersible pump to a pressure tank located in the basement of the gatehouse. Water passes through a sediment filter and serves the Gatehouse. The system is classified as a transient non-community and serves approximately 50 people.

Fells Mainhouse

The Fells Mainhouse obtains its water from a single bedrock well with a reported depth of 525' and an unknown yield. Water is pumped via submersible pump to a 62 gallon pressure tank located in the basement. This water is distributed, untreated, for use in the buildings and small kitchen, bathrooms and outdoor faucets. The system is operational from May through October and drained for the winter. The system is classified as a transient non-community and serves approximately 50 people.

Lake Sunapee Trading Post

The Trading post has a 167' deep bedrock well, and serves approximately 25 people. It is a transient non-community system.

Mountain Edge Resort

The Mountain Edge Resort obtains its water from a single bedrock well, with a reported depth of 350' and yield of 15 gallons per minute. Water is pumped via submersible pump to two 6,000 gallon atmospheric storage tanks. Water is transferred from these tanks to two 119 gallon pressure tanks located in the report basement via dual booster pumps. Water is distributed for use in the resort, currently housing 24 rooms with 48 additional on completion (2005). A restaurant is planned. The water is untreated and serves approximately 25 people. The system is classified as a transient non community.

Mount Sunapee Ski Area/Main Lodge

The Main Lodge at Sunapee is served by a 244' deep bedrock well. The population served is 1000 and it is a transient non-community system.

Mount Sunapee Ski Area/Summit

The Mount Sunapee Summit lodge is served by a 760' deep bedrock well. The population served is 1000 and it is a transient non-community system.

Mount Sunapee State Park Bath House
The Mount Sunapee State Park Bath House is served by a 150' deep bedrock well. The population served is 500 and it is a transient non-community system.

Digby's
Digby's obtains its water from a single bedrock well, 380' deep and yielding 15 gallons per minute. Water is pumped from the well into the building where it enters a 120 gallon pressure tank. The untreated water is then distributed to the Grille, potentially serving 200 patrons. It is a transient non-community system.

Baker Hill Golf Club
The Golf Club is served by a 600' deep bedrock well. The population served is 25 and it is a transient non-community system.

Camp Sunapee / Ballfield
The Camp Sunapee/ Ballfield is served by a 500' deep bedrock well. The population served is 40 and it is a transient non-community system.

Dexter's Inn
Dexter's Inn is served by a 359' deep bedrock well. The population served is 30 and it is a transient non-community system.

1840 House Bed and Breakfast
There is no sanitary survey data available for this system.

Georges Mills Water Works
The Georges Mills Water Works community water system provides domestic water and fire protection to approximately 190 service connections serving an estimated population of 475 people. The reported average daily use for 2003 was 32,000 gallons per day. The system consists of two bedrock wells at 520' and 500' depth, and a 250,000 gallon atmospheric storage tank.

Granliden on Sunapee
The Granliden on Sunapee community water system obtains its water from one infiltration well. The Sunapee Lake intake is 12 feet deep with a 50 gallon per minute yield. Water is drawn from the lake by two centrifugal pumps located in the beach booster station. Water is then pumped through two sand filter beds and gathered in a 5,000 gallon concrete infiltration well. Sodium hypochlorite is injected directly into the infiltration well. Duplicate booster pumps force water to two atmospheric storage tanks totaling 40,000 gallons. Water is then transferred by two booster pumps to a 5,000 gallon hydropneumatic storage tank. Water is provided by gravity and pressure to 114 service connections within the distribution system, serving a population of approximately 285 people. This source is considered under the influence of surface water; therefore the assessment area includes the direct watershed for the cove.

Meadowbrook at Sunapee
Meadowbrook is served by a 510' deep bedrock well. The population served is 33 and it is a community system.

Mount Royal Academy
Mount Royal is served by two bedrock wells of unknown depth and yield. Water from BRW 1 is pumped to four 86 gallon pressure tanks located in the basement of the original building. BRW 2, located in the basement is tied into the system between the second and third pressure tanks. Water is metered and distributed, untreated to serve approximately 78 people. It is a non-transient non-community system

Sunapee Water Works
Sunapee Water Works is a community surface supply serving a population of 2,082 people with 833 service connections. This number also includes 86 summer residences. The average water usage reported for 2006 was 142,000 gallons per day. The system is comprised of a surface water intake, raw water pumping station, slow sand water treatment facility and storage tanks. The system serves the Sunapee Harbor area, west across Route 11along North Road to Hilltop Drive, north along Garnet Hill Road, and east along Lake Avenue to Rolling Rock Road.

The intake is located approximately 1,600 feet from the inner end of the harbor at a depth of 38 feet. Water is pumped into the slow sand filter and subsequently disinfected and treated for corrosion control prior to storage and distribution.

The Inn at Sunapee
The Inn is served by a 500' deep bedrock well. The population served is 50 and it is a transient non-community system.

One Mile West
One Mile West is served by a 112' deep bedrock well. The population served is 150 and it is a transient non-community system.

Significant Natural Communities and Rare, Threatened, and Endangered Species

A database review was conducted by the New Hampshire Natural Heritage Bureau for significant natural communities and rare, threatened and endangered species in the Lake Sunapee Watershed. The review identified two natural communities of "very high importance"; a palustrine Kettle Hole Bog System in New London, and a terrestrial Montane Circumneutral Cliff.

Several plant species are also of "very high interest" including Fragrant Fern (*Dryopteris fragrans*), Loesel's Twayblade (*Liparis loeselii*), and Peat Moss (*Sphagnum contortum*, & *Sphagnum subfulvum*). Vertebrates include birds: the Common Loon (*Gavia immer)* and the Pied Billed Grebe (*Podilymbus podiceps*). Other vertebrates include the Northern Leopard Frog (*Rana pipiens*) and the Wood Turtle (*Glyptemys insculpta*) These species, with the exception of the Leopard Frog are listed as "threatened" or "endangered" on the New Hampshire state list, none are on the federal list. Information from this database review was based upon information gathered by qualified biologists and reported to the NH Natural Heritage Bureau.

Many areas have never been surveyed or have only been surveyed for particular species. An on-site survey would provide better information on what species and communities are indeed present.

Chapter 3. Water Quality

3.1 INTRODUCTION

This chapter provides a brief overview of federal and state water quality regulations, summarizes available information on water quality for the lakes and ponds in the Lake Sunapee Watershed.

The data used to develop this water quality summary was collected from a number of different programs. The different programs often collected different parameters at different time periods. Analysis of this water quality data reveals several areas of concern. Potential pollution sources and management recommendations are discussed in Chapters Five and Six, respectively. It is critical to maintain good water quality in both raw and finished water for numerous reasons including: safeguarding of fisheries, protecting recreational water resources, minimizing drinking water treatment costs, and protection of public health.

3.2 REGULATORY BACKGROUND

The State of New Hampshire has numerous statutes and rules that are designed to protect lakes. Over the past two decades NH DES has made a major effort to remove point discharges of sewage and waste from lakes and from tributaries to lakes. A brief summary of some of the laws and regulations that help protect New Hampshire lakes is presented in Table 3.1

Table 3.1 List of pertinent statutes established to protect ground and surface water quality. Refer to statute as identified for specific land use criteria.

Provision	Regulatory Authority
1. All lakes are classified at least Class B. The goal is that these waterbodies are suitable for fishing, swimming, and other recreational activities, and violations of assigned classifications are not allowed.	RSA 485-A:11 RSA 485-A:8,II RSA 485-A:12
2. No discharge is allowed to a lake without a permit. It is prohibited to discharge marine toilets into a lake.	RSA 487:2
3. Graywater (sink and shower wastes) from boats cannot be discharged into a lake.	RSA 487:3
4. No new point sources of phosphorus to lakes are allowed, and no new discharges of phosphorus to tributaries of lakes are allowed that would encourage weed or algae growth.	Env-WS 1703.14
5. All surface waters shall be restored to meet the water quality criteria for their designated classification.	Env-WS 1703
6. Automobiles and other petroleum powered vehicles lost through the ice into a lake must be	RSA 485-A:14

Provision	Regulatory Authority
removed.	
7. No person shall excavate, remove, fill, dredge or construct any structures in or on any bank, flat, marsh, or swamp in and adjacent to any waters of the state without a permit from the department.	RSA 482-A:3 485-A:17
8. No construction or transportation of forest products (skidding etc.) can occur in or on the border of the surface waters of the state without a permit. Forestry activities are subject to the conditions of RSA 227-J:9 when in or near wetlands and surface waters.	RSA 485-A:17 RSA 227-J:9
9. No earth moving activities are allowed near a lake without a permit.	RSA 485-A:17
10. No subsurface disposal system may be installed near a lake without a permit and without meeting minimum standards.	RSA 485-A:29 RSA 483-B Env-WS 1008.04
11. It shall be unlawful for any person to dispose of, discard, or store any pesticides or pesticide containers in such a manner as to pollute any water supply or waterway.	RSA 430:41
12. Structures near lakes or tributaries to lakes cannot be converted from seasonal to year round use or expanded in size such that the load on the sewage disposal system is increased, unless an application for approval of the sewage disposal system is submitted.	RSA 485-A:38 Env-WS 1004.14
13. No property with a sewage disposal system located within 200 feet of a great pond can be offered for sale until a licensed sewage disposal designer has performed a site assessment to determine if the site meets current standards for sewage disposal systems.	RSA 485-A:39 Env-Ws 1025
14. The Lakes Management and Protection Program established a lakes coordinator and lakes management advisory committee to prepare: (1) statewide lake management criteria and (2) guidelines for the development of local lake management and shoreland protection plans.	RSA 483-A
15. The Shoreland Protection Act provides minimum protective standards for activities occurring within 250 feet of all fresh water bodies listed in the official list of public waters published by the department pursuant to RSA 271:20, II and rivers, meaning all year-round	RSA 483-B

Provision	Regulatory Authority
flowing waters of fourth order or higher.	
16. No household cleaning products except those used in dishwashers shall be distributed, sold, or offered for sale in New Hampshire which contains a phosphorus compound in excess of a trace quantity.	RSA 485-A:56
17. No exotic aquatic weeds shall be offered for sale, distributed, sold, or imported, purchased, propagated, transported, or introduced in the state.	RSA 487:16a
18. Permits are also required for the following activities, and permits will not be issued if lake quality is to be endangered: a. Groundwater discharges b. Underground storage tanks c. Solid waste landfills d. Sludge pits e. Hazardous waste sites	RSA 485-A:13 RSA 146-A RSA 149-M RSA 149-M RSA 147-A

Surface Water Quality Standards

Surface water quality in the United States is protected under the federal Clean Water Act. Federal standards promulgated under this act have been adopted by the State of New Hampshire in the form of surface water standards. The water quality standards establish the baseline quality that all surface waters of the State must meet in order to protect their intended uses. These standards are the yardstick for identifying where water quality violations exist and for determining the effectiveness of regulatory pollution control and prevention programs. The standards are composed of three parts: classifications, the criteria, and the anti-degradation regulations. All three are described below.

Waterbody Classification

All State surface waters (i.e. perennial and seasonal streams, lakes, ponds, and tidal waters) have either a Class A or Class B classification. The majority of waters fall under the Class B classification. Class A waters are intended to be and generally are waters of the highest quality and are considered potentially usable for water supply after adequate treatment. Discharge of sewage or wastes is prohibited to Class A waters. Class B waters are considered acceptable for Aquatic Life Use, Fish Consumption, Primary Contact Recreation (i.e. swimming), Secondary Contact Recreation (i.e. minor water contact through activities such as boating), Wildlife, and after adequate treatment for use as water supplies. Each surface waterbody regardless of class must meet the following water quality criteria:

- The presence of pollutants in the receiving waters is not the basis for further introduction of pollutants. The failure of waters to meet certain criteria due to natural causes does not necessitate the modification of the assigned water use classification.

- All waters shall be free from pollutants in concentrations or combinations that settle to form harmful deposits; float; produce odor, color, taste, or turbidity that is not naturally occurring; result in the dominance of nuisance species, or prevent recreational activities.

- The level of radioactive materials shall not be in concentrations or combinations that would be harmful to human, animal, or aquatic life; would result in radionuclides in aquatic life exceeding recommended limits for consumption by humans; or would exceed EPA's Drinking Water Regulations.

- Tainting substances shall not be present in combinations that individually or in combination produce undesirable flavors in aquatic organisms.

- Toxic pollutants, unless naturally occurring, shall be in concentrations that will not injure plants, animals, humans, or aquatic life; persist in the environment; or accumulate to harmful levels in aquatic organisms.

Table 3.2 Designated Uses for New Hampshire Surface Waters. (Source: NH DES 2004 New Hampshire Consolidated Assessment and Listing Methodology).

Designated Use	NH DES Definition	Applicable Surface Waters
Aquatic Life	Waters that provide suitable chemical and physical conditions for supporting a balanced, integrated and adaptive community of aquatic organisms.	All surface waters
Fish Consumption	Waters that support fish free from contamination at levels that pose a human health risk to consumers.	All surface waters
Shellfish Consumption	Waters that support a population of shellfish free from toxicants and pathogens that could pose a human health risk to consumers.	All tidal surface waters
Drinking Water Supply After Adequate Treatment	Waters that with adequate treatment will be suitable for human intake and meet state/federal drinking water regulations.	All fresh surface waters
Primary Contact Recreation (i.e. swimming)	Waters suitable for recreational uses that require or likely to result in full body contact and/or incidental ingestion of water.	All surface waters
Secondary Contact Recreation	Waters that support recreational uses that involve minor contact with the water.	All surface waters
Wildlife	Waters that provide suitable physical and chemical conditions in the water and the riparian corridor to support wildlife as well as aquatic life.	All surface waters

According to NH DES, all waterbodies in the watershed are classified as Class B waters except for Lake Sunapee which is classified as Class A.

> Law of 1969 178:1 On and after the effective date of this Act the surface waters of Lake Sunapee shall be classified in accordance with the provisions of RSA 149 as amended as Class A waters.

Water Quality Criteria

The second major component of the water quality standards is the criteria. These are numerical or narrative criteria which define the water quality requirements for Class A and Class B waters. A waterbody that meets the criteria for its assigned classification is considered to meet its intended use (State of New Hampshire 2006 Section 305(b) Water Quality Report). Water quality criteria for each classification are found in RSA 485-A:8, I-V and in the State of New Hampshire Surface Water Quality Regulations (Env-Ws 1700).

Antidegradation

The purpose of the antidegradation provisions in the water quality standards is to preserve and protect the existing beneficial uses of the State's surface waters and to limit the degradation allowed in receiving waters. Antidegradation regulations are included in Env-Ws 1708 of the New Hampshire Surface Water Quality Regulations. Pursuant to RSA 485-A:8, discharges containing "sewage" or "wastes" are not allowed in Class A waters. Consequently, degradation of Class A waters is prohibited.

NH DES 305(b) Water Quality Report

Biennially, NH DES is required by the Environmental Protection Agency to assess surface water quality. NH DES uses assessment units as the basic unit of record for conducting and reporting the results of water quality assessments. Assessment units are intended to be representative of homogenous units. Sometimes assessment units represent an entire waterbody. In other instances, an assessment unit may represent a town beach or portion of a waterbody. All surface waters were assessed by NH DES in 2006 to determine if they support their designated uses. During this reporting cycle, wildlife was not assessed because an assessment methodology for wildlife has yet to be developed.

There is a statewide fish consumption advisory or ban in effect for the general population for one or more fish species due to the atmospheric deposition of mercury. For this reason, all state waterbodies have been classified as "Not Supporting" the fish consumption designated use.

All of the lakes and ponds have been classified as "impaired" due to atmospheric deposition of mercury, and are required to complete a Total Maximum Daily Load study for mercury in the future.

Drinking Water Regulations

New Hampshire drinking water regulations are based on the Federal Safe Drinking Water Act (SDWA), enacted in 1974, and amended in 1986 and 1996. The Act requires that each state adopt standards that are no less stringent than the federal regulations. SDWA authorizes the Environmental Protection Agency to develop primary drinking water regulations that incorporate maximum contaminant levels (MCLs), maximum contaminant level goals (MCLGs), and treatment techniques for dozens of contaminants in order to protect public health.

Some of the contaminants have “chronic” effects which are the result of long term exposure. Consequently the MCLs for contaminants with chronic effects are established based on exposure over an average lifespan of seventy years. Contaminants which have more immediate or “acute” effects are based on short-term exposure. Examples of contaminants which cause acute effects are bacteria, pathogens, or viruses. These contaminants are also regulated to assure public health safety.

The New Hampshire Drinking Water Regulations mirror the SDWA regulations. They address the quality of finished water, before it is delivered to the consumer.

3.3 SUMMARY OF SURFACE WATER QUALITY DATA

Water quality in waterbodies throughout the watershed has been investigated at various times by the New Hampshire DES Lakes and Ponds Inventory Program and the Volunteer Lake Assessment Program (VLAP). For example, water quality data has been collected at Lake Sunapee since 1986. Every year VLAP volunteers collect data from four deep spot stations, nine near shore stations and numerous tributary stations. (Figure 3.2 & 3.3). In addition, VLAP monitors are active in six other lakes and ponds; Baptist Pond, Chalk Pond, Dutchman Pond, Ledge Pond, Little Sunapee Lake and Mountainview Lake. See Figures 3.4 – 3.8 for maps of the sampling stations. Maps are available as PDFs in the Appendices. The Observations and Recommendations Reports and Tables for the biennial reports for each of these lakes and ponds can be found in the digital appendices on the CD.

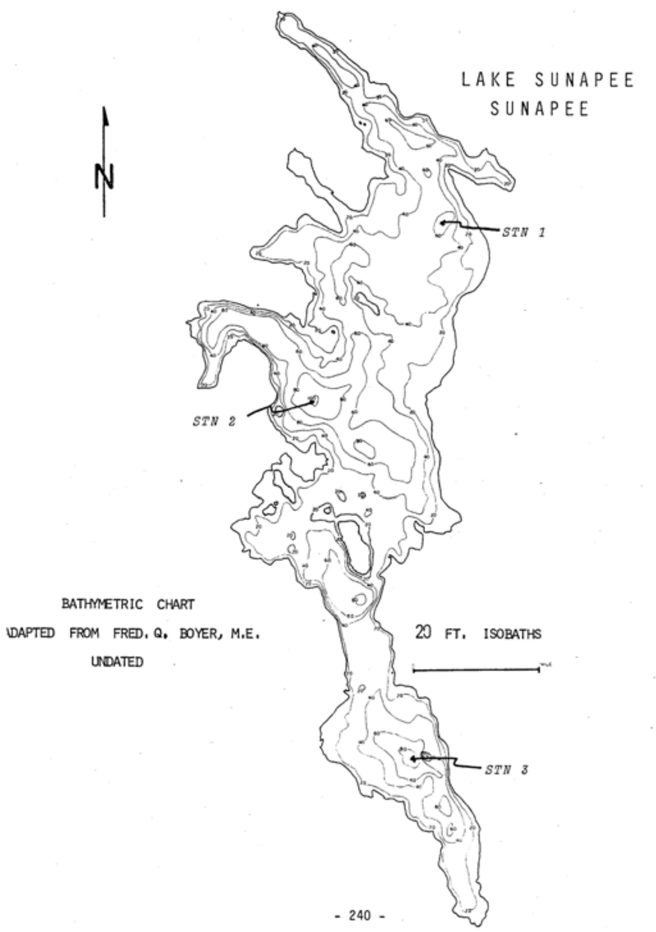
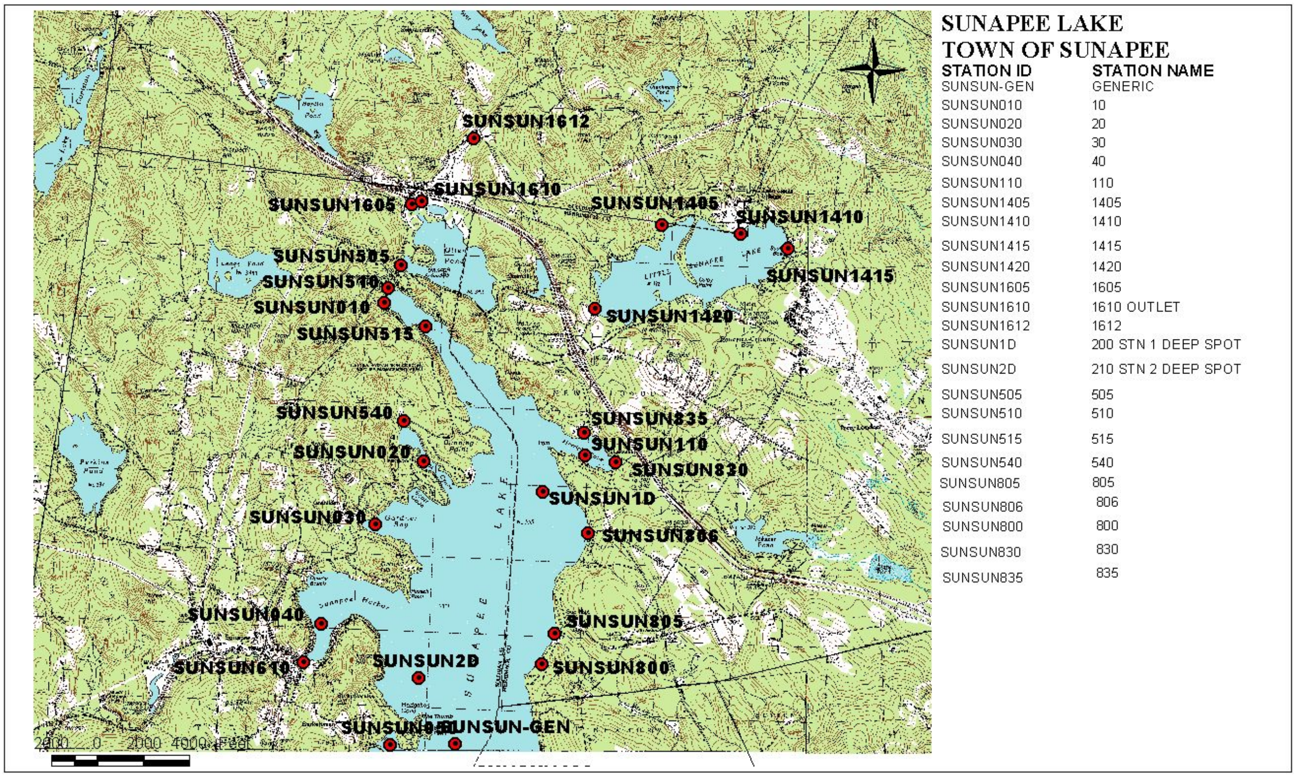


Figure 3.1 Bathymetry for Lake Sunapee.
(Source: NHDES Watershed Management Bureau, Volunteer Lakes Assessment Program)

Figure 3.2 Monitoring Stations where biological and chemical parameters are measured by Volunteer Lake Assessment Volunteers in Lake Sunapee. (Source: NH DES)



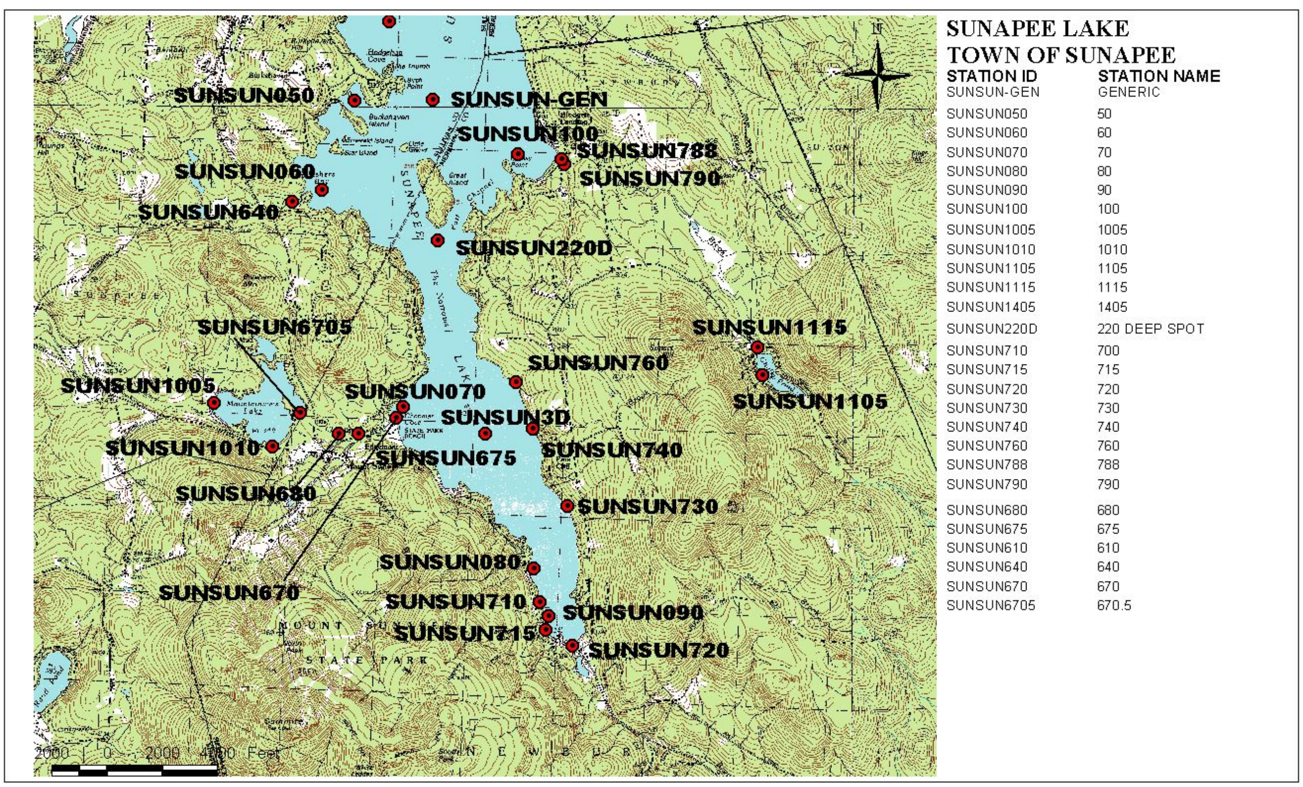


Figure 3.3 Tributary Monitoring Stations where biological and chemical parameters are measured by Volunteer Lake Assessment Volunteers. (Source: Lake Sunapee Protective Association, Volunteer Lake Monitoring Program)

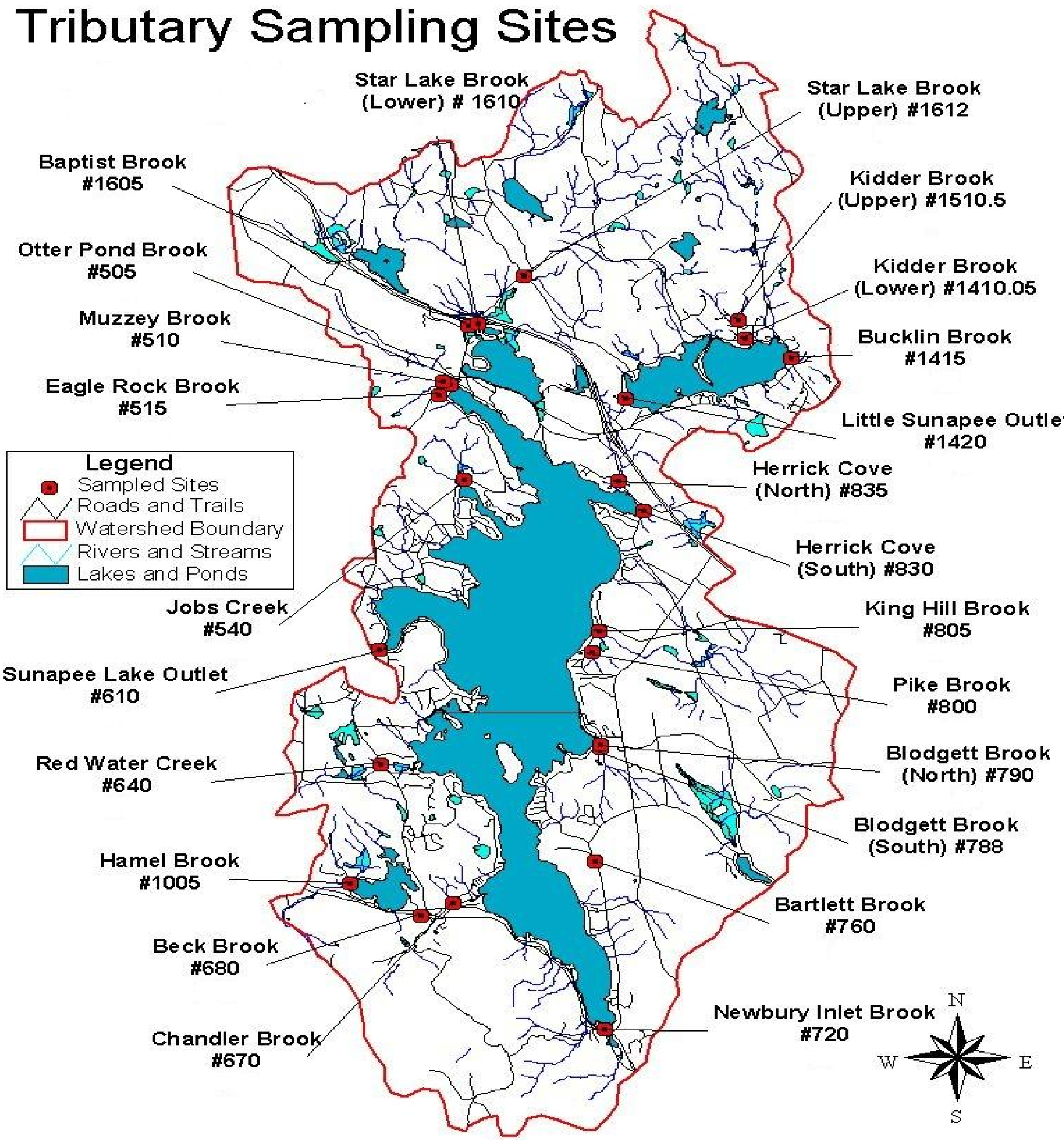


Figure 3.4 Monitoring Stations where biological and chemical parameters are measured by Volunteer Lake Assessment Volunteers in Lake Sunapee. (Source: NH DES)

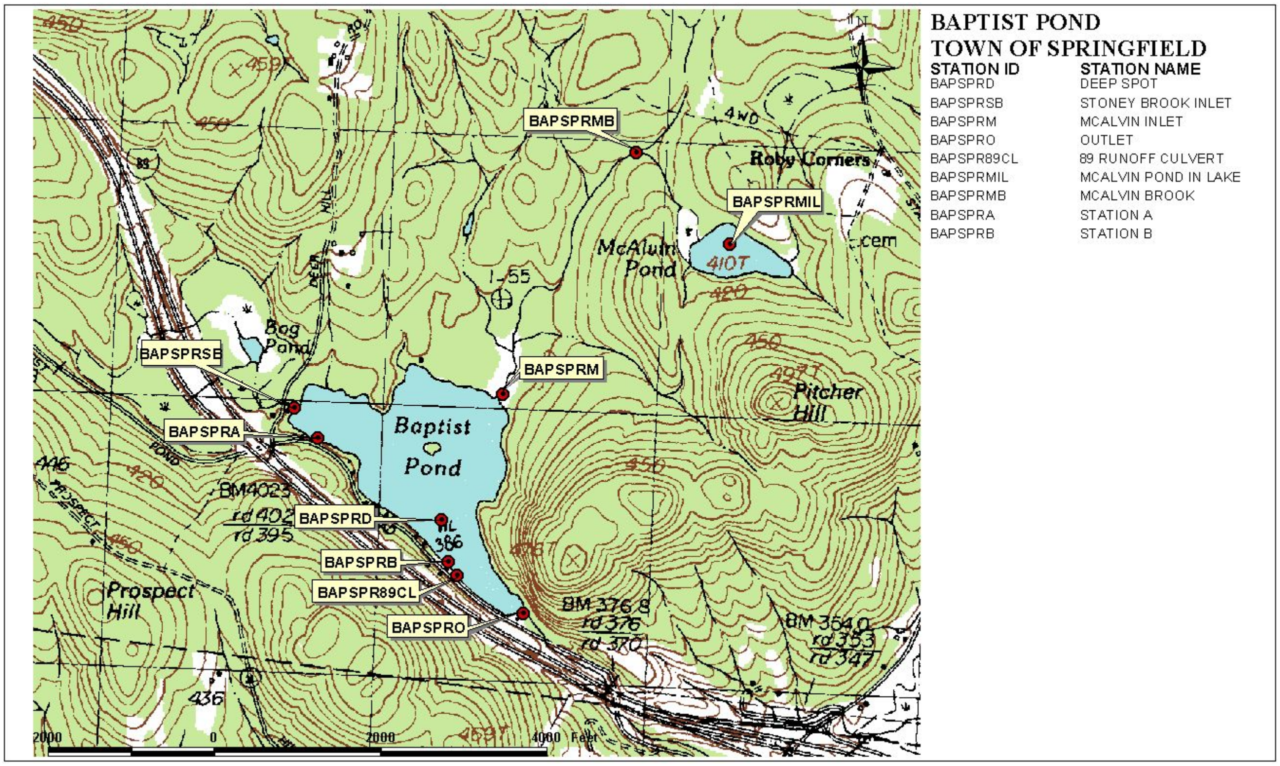


Figure 3.5 Monitoring Stations where biological and chemical parameters are measured by Volunteer Lake Assessment Volunteers in Lake Sunapee. (Source: NH DES)

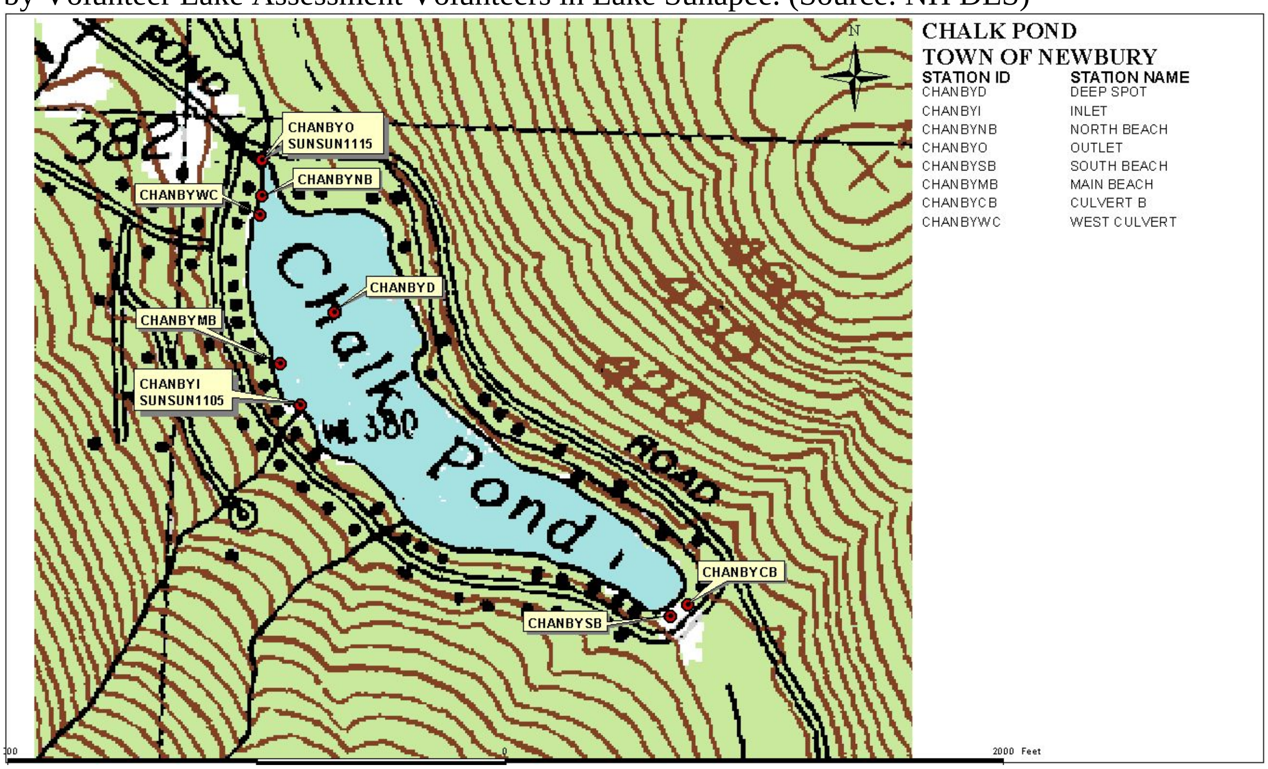


Figure 3.6 Monitoring Stations where biological and chemical parameters are measured by Volunteer Lake Assessment Volunteers in Lake Sunapee. (Source: NH DES)

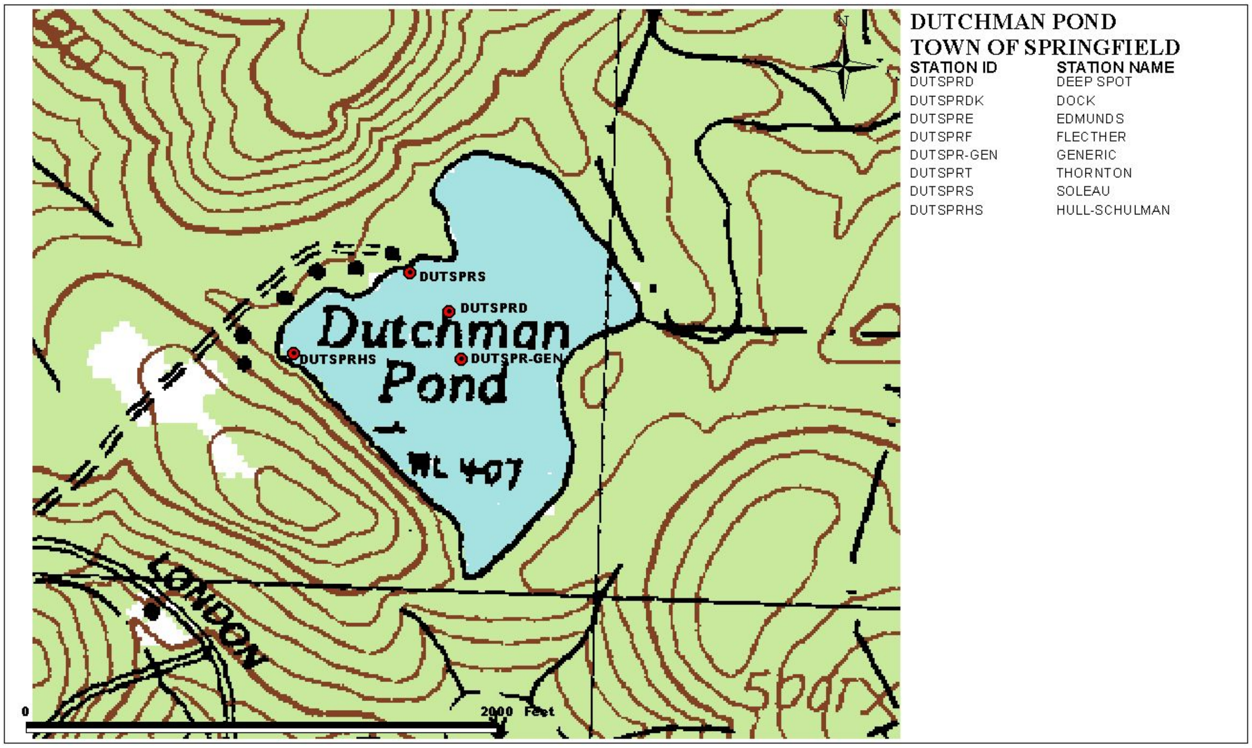


Figure 3.7 Monitoring Stations where biological and chemical parameters are measured by Volunteer Lake Assessment Volunteers in Lake Sunapee. (Source: NH DES)

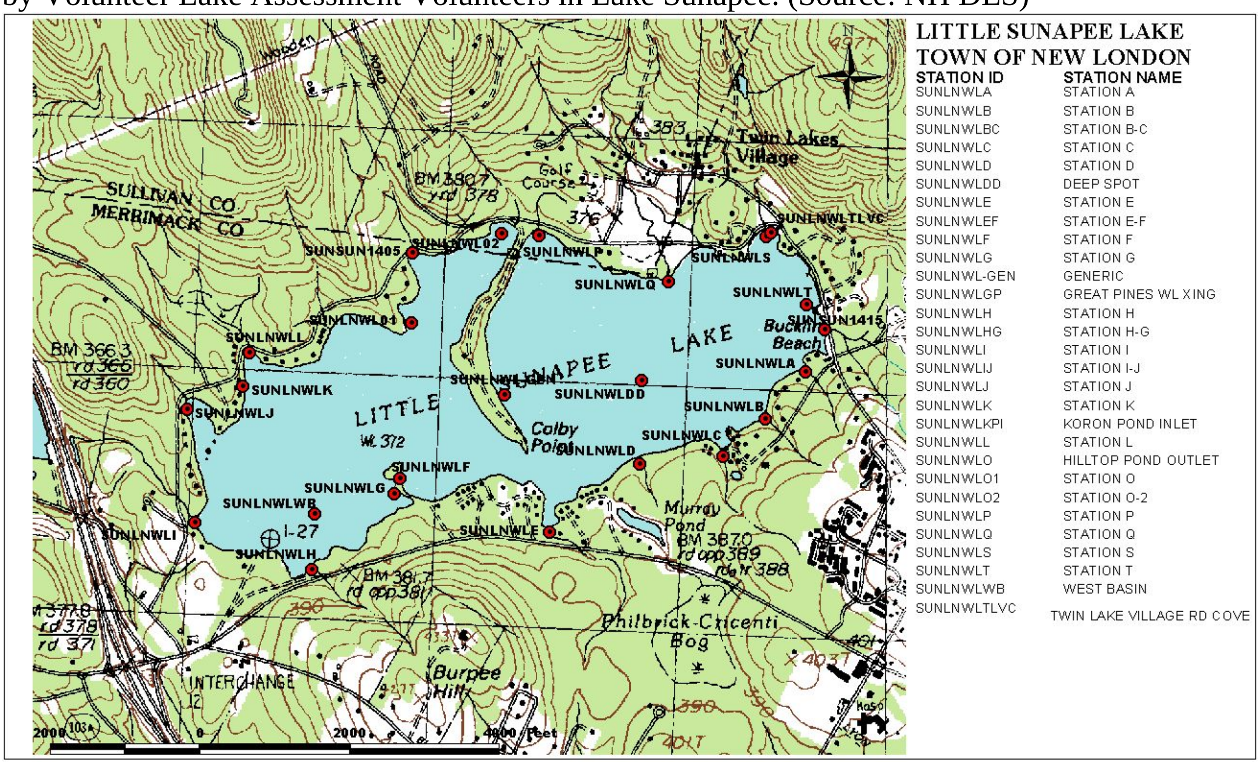


Figure 3.8 Monitoring Stations where biological and chemical parameters are measured by Volunteer Lake Assessment Volunteers in Lake Sunapee. (Source: NH DES)

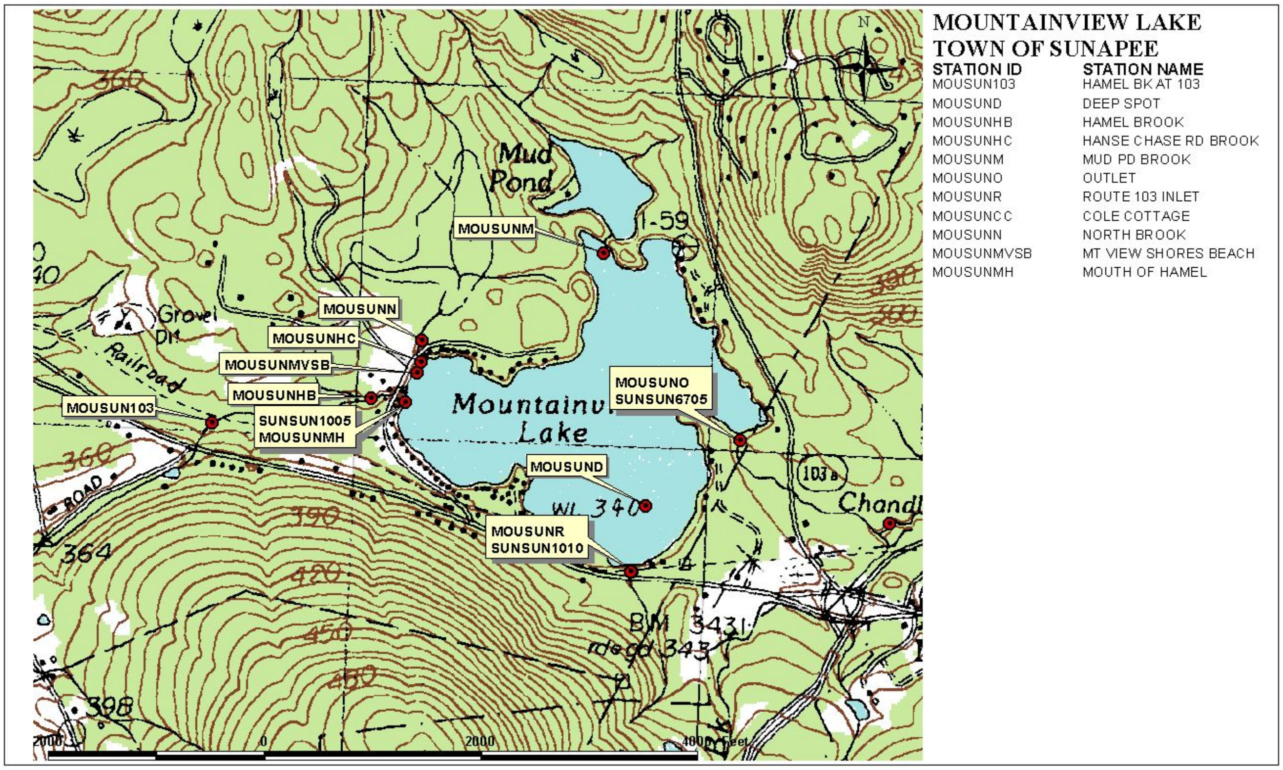

MOUNTAINVIEW LAKE
TOWN OF SUNAPEE
STATION ID STATION NAME
MOUSUN103 HAMEL BK AT 103
MOUSUND DEEP SPOT
MOUSUNHB HAMEL BROOK
MOUSUNHC HANSE CHASE RD BROOK
MOUSUNM MUD PD BROOK
MOUSUNO OUTLET
MOUSUNR ROUTE 103 INLET
MOUSUNCC COLE COTTAGE
MOUSUNN NORTH BROOK
MOUSUNMVSB MT VIEW SHORES BEACH
MOUSUNMH MOUTH OF HAMEL
MOUSUNM
MOUSUNN
MOUSUNHC
MOUSUNMVSB
MOUSUNHB
MOUSUN103
SUNSUN1005
MOUSUNMH
MOUSUNO
SUNSUN6705
MOUSUND
MOUSUNR
SUNSUN1010
Mud Pond
Mountainv
Lake
Gravel Pit
Railroad
ROAD
Chandl
2000
0
2000

Table 3.6 Summary of raw water sample results for selected biological and chemical parameters for waterbodies in the Lake Sunapee Watershed (Source: 2006 VLAP Reports).

Waterbody	pH	Acid Neutralizing Capacity	Phosphorus Historical Trends	Conductivity	Dissolved Oxygen - Hypolimnion	Chlorophyll-a	Cyanobacteria
Lake Sunapee Deep Spots	Satisfactory, note higher acidity in the hypolimnion	Moderately Vulnerable	Oligotrophic conditions Not significantly changed, at 6.5 µg/L average in lake. less than state median for P	Greater than the state median, increasing	High in the epilimnion, but depleted in the hypolimnion – potential internal phosphorus loading	Not significantly changed, historical data show the average is less than the state median	*Anabaena*, *Gleotrichia* and small amounts of *Microcystis* and/or *Oscillatoria*
Lake Sunapee Near Shore	Slightly Acidic	Moderately Vulnerable	Mesotrophic Conditions Generally increasing levels of P, greater than state median	Greater than the state median, increasing	High in the epilimnion, but depleted in the hypolimnion – potential internal phosphorus loading	Not significantly changed, some stations demonstrating improvement	*Gleotrichia*
Lake Sunapee Tributaries	Slightly Acidic	____________	Relatively high (>25ug/L) on some sampling events	Wide range of values, mean annual conductivity has increased	________________	________________	________________
Baptist Pond	Slightly Acidic	Moderately Vulnerable	Mesotrophic Conditions Increasing P (worsening)	Greater than state median	High	Increasing , greater than the State Median	Small amount of *Anabaena* and *Mycrocystis*
Chalk Pond	Slightly Acidic	Moderately Vulnerable	Oligotrophic Conditions Not significantly changed	Slightly lower than the state median, but increasing	High	Not significantly changed, historical data show the average is less than the state median	No data
Dutchman Pond	Slightly Acidic, note higher acidity in the hypolimnion	Extremely Vulnerable Much less than state median	Mesotrophic Conditions Highly variable P concentrations	Stable and low	High	Not significantly changed, historical data show the average is less than the state median	*Anabaena* and *Oscillatoria* were reported in the 2006 sample
Little Lake Sunapee	Slightly Acidic, note higher acidity in the hypolimnion	Moderately Vulnerable	Oligotrophic Conditions in the epilimnion and Mesotrophic Conditions in the hypolimnion, variable P	Greater than the state median, increasing	Lower in metalimnion and hypolimnion than the epilimnion – potential internal phosphorus loading	Variable, but overall increasing	*Coelosphaerium, Anabaena* and *Oscillatoria* were reported in the 2006 sample
Mountainview Lake	Slightly Acidic note higher acidity in the hypolimnion	Moderately Vulnerable Slightly greater than the state median	Mesotrophic conditions not significantly changed, P concentrations slightly greater than state median	Greater than the state median, increasing	Much lower in hypoliminion – potential internal phosphorus loading	Not significantly changed, historical data show the average is slightly greater than the state median	A small amount of *Anabaena* was detected in the 2006 sample

This section of the Plan summarizes water quality information from the Volunteer Lake Assessment program for each of the lakes and ponds as summarized in Table 3.6. Under phosphorus, it also contains a description and the results of the Water Quality Model.

Background

Trophic Levels and Flushing Rate

Lakes typically go through a natural aging process as the result of sedimentation processes and nutrient additions. Trophic level or lake "age" is determined by a number of factors including water transparency, nutrient enrichment, planktonic growth, presence of aquatic plants, types of fishery (cold or warm), and dissolved Oxygen content. As lakes age, the aforementioned characteristics change. For example, oligotrophic water bodies are considered to be in an early stage of development. Waterbodies in this trophic stage are characterized by clear water, low nutrient enrichment, low productivity, few aquatic plants, presence of a coldwater fishery and high dissolved oxygen content. Eutrophic waterbodies on the other hand, have high nutrient enrichment, high productivity as evidenced by much planktonic growth, extensive aquatic plant beds, sediment accumulation on the lake bottom, have warmwater fish species, and are susceptible to algae blooms and summer fish kills. Mesotrophic characteristics fall somewhere in between eutrophic and oligotrophic.

Another important parameter which relates to trophic level is the flushing rate. The flushing rate is the number of times a lake flushes (i.e., a volume of water equal to the lake's volume passes through the lake) in one year, expressed to the nearest 0.1 times/year. This rate incorporates the amount of inflow with the waterbody volume in order to produce a measure of lake water exchange (Jeer et Al., 1997). The flushing rate is important to consider when examining the effect of pollution loads, nutrient additions, or water diversions. In general, the lower a lake's flushing rate, the more susceptible the waterbody is to nutrient or pollutant additions. This is because nutrients or pollutants are less likely to be flushed from the waterbody.

NH DES has determined that the median flushing rates for New Hampshire lakes and ponds is 3.0 times/year.

pH

The parameter pH is a measure of hydrogen ions in the water, or in general terms, the acidity. pH is measured on a logarithmic scale of 0 to 14. The lower the pH, the more acidic the solution, due to the higher concentration of hydrogen ions. Lake pH is important for the survival and reproduction of fish and other aquatic species. There are several reasons and conditions which affect waterbody acidity. For example, many lakes exhibit lower pH values in deeper waters than nearer the surface. Decomposition carried out by bacteria in the lake bottom causes the pH to drop, while photosynthesis in the upper layers can cause pH to increase. A difference in pH from surface to bottom layers is greatest in a thermally stratified lake. Waterbody pH may be influenced by wetlands where tannic and humic acids are released to the water by decaying plants, thereby creating more acidic waters (VLAP, 2003). After the acidic spring-time snow melt or a significant rain event, surface water may have a lower pH than deeper waters and may take several weeks to recover.

New Hampshire lakes historically have had pH values in the mid to upper sixes, in most cases. A pH of between 6.5 and 7.0 is ideal (VLAP, 2003). As the pH decreases to between 5 and 6, many fish and aquatic organisms become stressed, and some species disappear because they are unable to tolerate acidic conditions. Fish typically are unable to tolerate acidic conditions below a pH of 5. The mean pH value for the epilimnion (upper layer) in New Hampshire lakes and ponds is 6.6, which indicates that the surface waters in the state tend to be slightly acidic.

Annual sampling data collected by the VLAP volunteers indicates that water in these waterbodies is "slightly acidic" but generally satisfactory for aquatic life purposes. The higher hypolimnion acidity in certain lakes may be attributable to the natural processes of decomposition and release of acidic by-products. It is noted that tributary sampling for pH is no longer conducted as pH is largely influenced by natural conditions rather than human activity, and the time spent is not justified. However, ongoing lake monitoring of pH is wise for tracking impacts of acid rain over the long term.

Acid NeutralizingCapacity (ANC)

Alkalinity is the measure of a lake's capacity to neutralize acid inputs. This value is often referred as "acid neutralizing capacity (ANC). New Hampshire has had historically low alkaline waters because of the State's granitic bedrock and there is some evidence that overall alkalinity has decreased in recent years. If the buffering capacity of a lake is lost, conditions for aquatic life will be adversely affected by acid rain inputs (NH DES, 2005). The mean ANC for New Hampshire lakes and ponds is 6.6 mg/L (VLAP 2004 Report).

Most waterbodies in the Sunapee watershed have been relatively stable in their ANC, and data indicate a "moderate vulnerability" to acidic inputs. However, Dutchman Pond and Ledge Pond sampling data indicate that these waterbodies are "extremely vulnerable" to acidic inputs with values less than 2mg/L and are much less than the state median for ANC.

Total Phosphorus, Goal and the Water Quality Model

Total phosphorus is a measure of all the forms of phosphorus (organic and inorganic) present. Phosphorus, along with nitrogen is a plant limiting nutrient, meaning that the amount of available phosphorus influences the amount of algae growth that can occur. Phosphorus concentration directly relates to trophic state. For example, values less than 8 ug/L are considered "ideal" and generally indicate oligotrophic conditions. Values greater than 20 ug/L are considered "more P than desirable" and indicate eutrophic conditions. Mesotrophic conditions exist between these two values and are considered "average." Values in excess of 40 ug/L are considered "excessive."

Phosphorus is an important indicator of pollution because this nutrient occurs naturally at very low levels in lakes and ponds in New Hampshire. The median summer total phosphorus concentration in the epilimnion of New Hampshire lakes and ponds is 12 ug/L. The median summer total phosphorus concentration in the hypolimnion of New Hampshire lakes and ponds is 14 ug/L.

Phosphorus levels across the watershed lakes, ponds and tributaries varies greatly. The Sunapee Deep Spots, Chalk Pond, Ledge Pond and Little Sunapee Lake appear to present oligotrophic conditions. Lake Sunapee Deep Spots average 6.5 µg/L. However, the near shore stations on Lake Sunapee and the tributaries are showing a substantial increase in concentrations of phosphorus, some samples showing greater than 25ug/L. This should concern water quality monitors and watershed residents as the implication is that non-point sources of phosphorus are increasing, and the subsequent effect on in-lake water quality and aesthetics will be significant. It is highly recommended that a non point source prevention program be implemented throughout the watershed as a first step in maintaining the high quality resources here. The goal of the Watershed Plan is to limit in-lake concentration to 8 µg/L through the watershed action plan.

Monitoring tributaries to a waterbody after snow-melt and during rain events can help to determine the source of phosphorus loading. Better quantification of the source and timing of addition of this nutrient can create a better understanding of the lake's functioning and help to identify tools for better lake management.

As part of the NH DES Pilot Grant Watershed Project, phosphorus is the focus of a conceptual model adopted for the management of the watershed. In 2007, Geosyntec Consultants, Inc. (Geosyntec) was contracted by the New Hampshire Department of Environmental Services (NH DES) to develop a water quality model for the Lake Sunapee Watershed. The water quality model that was developed by Geosyntec incorporates a Monte Carlo simulation to evaluate total phosphorus (TP) loading from the Watershed under two land use conditions: current land use and full build-out land use.

Water Quality Model for the Lake Sunapee Watershed Description & Methodology
Land Use Analysis

A land use analysis was conducted to evaluate land use conditions for the Watershed. Land use condition describes the type (e.g., residential, commercial, etc.) and/or cover (forested, wetland, etc.) of the land area within the Watershed and is used as an input to the model. For this modeling application, the Watershed's land use area, excluding the water surface area, was grouped by town. Land uses were grouped by town because of the following: (1) final build-out conditions and zoning requirements, where available, were provided at the town level; and (2) grouping by town facilitates land use development planning based on predicted water quality impacts.

Current Condition

The current land use condition was adapted from the 1995 Lake Sunapee Watershed Study prepared by the Upper Lake Sunapee Regional Planning Commission (ULSRPC). The 1995 Study used 1992 and 1993 aerial photography to determine land use characteristics for each town. The 1995 Study used the following land use categories: agriculture, forest, transportation, commercial/industrial, outdoor use areas, and residential. The 1995 study was used as the current condition based on the following assumptions: (1) Current land use distributions described in the study are comparable with those distributions described in the 1995 Study for full build-out; and (2) Current digital land use data that are readily available are based on aerial images between 1992 and 1995 (National Oceanic and Atmospheric

Administration (NOAA) Coastal Change Analysis Program (C-CAP) land use data) and between 1990 and 1995 (New Hampshire GRANITE data) and do not reflect more accurate information for the current land use condition when compared to the 1995 study.

Full Build-Out Condition

The full build-out condition was based on information provided by the UVLSRPC presented in a Technical Memorandum entitled *Update of 1995 Lake Sunapee Build-out Analysis* dated December 2006 (2006 Memo). The full build-out condition described in the 2006 Memo was reported as projected population at full build-out per town (i.e., population density). The projected population density at full build-out was
then converted to projected developed land area at full build-out as follows:
(1) The projected increase in population density was calculated by subtracting the projected population at full build-out (2006 Memo) from the current population described in the 1995 Study.
(2) The projected increase in population density for each town was converted into the projected number of homes per each town using standard values for the average household size descried in the 2006 Memo. This calculated value represents the number of new homes to be constructed to reach full build-out.
(3) This value was multiplied by the average lot sizes described in the 2006 Memo to estimate the projected increase in developed area in each town. The average lot sizes were different for each town and are based on the most recent zoning requirements.
(4) The projected increase in developed land area was then added to the developed area for the current condition. This value represents the total projected developed land area in each town at full build-out.
The projected increase in developed area was then incorporated into a full build-out land use condition that describes the land use of the entire Watershed at full build-out condition. Given the proportion of forested land use in the Lake Sunapee watershed, it was assumed that all development is likely to occur in areas which are currently forest. In addition, it was assumed that all build-out would occur as residential or mixed residential development. Furthermore, it was assumed that the current developed portions of the Watershed would not be redeveloped to a higher population density. Based on these assumptions, a projected forested land use area was calculated for each town by subtracting the area to be developed to reach full build-out from the current forested area in each town.

Water Quality Model with Monte Carlo Simulation Input Parameters

The Monte Carlo water quality assessment tool (M-CAT) model was developed to assess storm water quality impacts associated with land use. The model is an empirical, volume-based, pollutant loading model. The model was developed to assess the potential impact of development (e.g., changes in land use) on water quality of Lake Sunapee. Measured runoff volumes and water quality characteristics of storm water are highly variable. To account for this variability, a statistical modeling approach was used to estimate a distribution of storm water volume, concentration of pollutants in storm water runoff, and a statistical description of the overall pollutant load (total mass of pollutants) in storm water runoff associated with each development condition. A statistical description of storm water provides an indication of the average characteristics and also the variability of the water quality parameters of storm water, and the probability of compliance with regulatory criteria or water quality goals. The M-CAT does not forecast runoff characteristics or regulatory compliance for specific storms or monitoring periods. The M-CAT model is based on relatively simple expressions describing rainfall/runoff relationships and estimated pollutant concentrations in storm water runoff. The volume of storm water runoff was estimated using a modification to the Rational

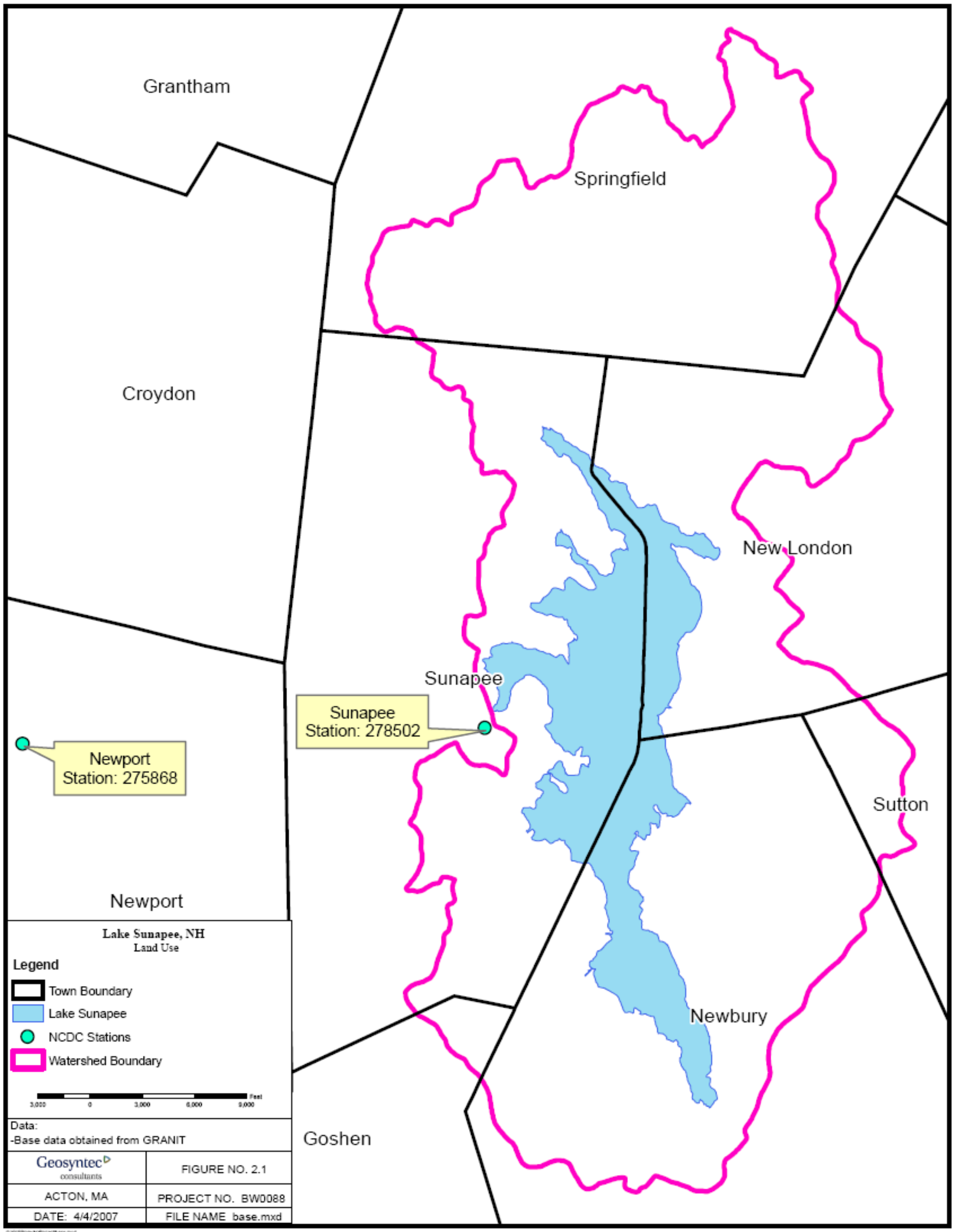
Formula, an empirical expression that relates runoff volume to the rainfall depth and the broad basin characteristics. The pollutant concentration in storm water runoff was represented by an expected average pollutant concentration, called the event mean concentration (EMC). EMC data were taken from published values presented in literature as described below, and are strongly dependent on land-use type and impervious surface area. As with all environmental modeling, the precision of results is heavily dependent on how well the hydrologic and water quality data describe the actual site characteristics. Local and regional data were used to the fullest extent possible to reduce variability in predictions. It is important to remember that, in addition to precision, the predictions of relative differences are also important. The input parameters for the water quality model fall into four main categories shown below. Each of the categories of input data is evaluated for accuracy reflecting the project site conditions: (1) rainfall data; (2) runoff coefficients; (3) land use data; and (4) storm water pollutant EMCs.

Rainfall Data:
Rainfall data for the model was taken from the NOAA National Climatic Data Center (NCDC). NCDC hourly precipitation data was downloaded from two stations: the Sunapee, NH Station No. 20018636, and the Newport, NH Station No. 275868. Information for each of the stations is presented in Table 3. The two stations are the closest in proximity to Lake Sunapee and have a combined historical period between 4/16/1954 and 6/30/2005. The Sunapee gauge included historical hourly precipitation data between 6/1/1948 through 11/20/1969. The Newport gauge included historical hourly precipitation data between 6/1/1948 through 6/30/2005 (last data point of published hourly precipitation data available through the NOAA NCDC data set at the time of this water quality evaluation). The data was combined to provide a longer period of record for the model input. These data did not overlap in time series so a side-by-side comparison of the data could not be performed. However, the gauge locations were plotted over the isohyetal maps for the northeast region (Cornell University, 1993). In general, the isohyets in the region New Hampshire region span in an east-west orientation and therefore the general deviation in annual precipitation is from north to south. The Sunapee and Newport gauges are both located at latitude 43.8333. Since the gauges are in an east west orientation, both gauges are likely to experience similar annual precipitation. In addition, the stations are located 5.01 miles apart and both gauges are located within a 7 mile radius of Lake Sunapee, immediately west of the Watershed. Figure 2.1 identifies the location of the two rainfall monitoring stations used in this study.

Table 2.1. Summary of NCDC Station Information

Name	SUNAPEE	NEWPORT
Station ID	20018636	20018637
Station	278502	275868
State	New Hampshire	New Hampshire
County	Sullivan	Sullivan
Latitude	43.383	43.383
Longitude	-72.083	-72.183
Elevation[1]	1030 FT	790 FT
Period of Data	01 Jun 1948 to 20 Nov 1969	01 Jun 1948 to 30 Jun 2005

1. Elevation data provided are in feet above sea level.



Runoff Coefficients:
Runoff coefficients used in the Lake Sunapee model framework were based on land use and are a function of impervious area. The Simple Method (Schueler 1987), a general runoff

coefficient equation, was considered most appropriate for this level of analysis. The Simple Method describes the runoff coefficient as a function of impervious area and is further described in the modeling procedure below.

Land Use Data:

Land use data is generally the most accurately quantified input parameter in water quality models.The land use input data for the current conditions and projected conditions at full build-out area were derived from the land use analysis described in Section 2.1. The percent impervious values used in the water quality model for developed portions of the Watershed were based upon the values reported by the National Storm Water Quality Database (NSQD) Version 1.1 (dated February 15, 2006), prepared by University of Alabama.

Storm Water Pollutant EMCs:

Storm water pollutant EMCs were taken from the best available published data and where possible taken from studies that were conducted in the northeastern United States. These sources included the following: (1) The NSQD Version 1.1; (2) American Water Works Association Research Foundation (AWWARF) Report, dated 2006; and (3) Dunne and Leopold, 1978. The AWWARF Report and the Dunne and Leopold report published EMC data specific to the northeast region. The NSWQ includes EMC data from over 200 municipalities located within the continental United States. Published EMC data typically includes only mean EMC values that are commonly used in simple land use based pollutant models. Published EMC studies do not typically report EMC statistical parameters including the standard deviation which characterizes the statistical distribution of the EMC data, which is necessary for a statistical water quality modeling approach. The NSQD Version 1.1 reports both mean and standard deviation values for the general land use categories used in this model and was therefore used for the majority of EMC data input to the model. To ensure that the NSWQ data closely represent storm water quality in the northeast, NSQD V1.1 EMC mean values were compared to EMC mean values from studies conducted in the northeast. A comparison of EMC data is presented in Table 4.

The residential land use EMC mean values reported in the NSQD are approximately equal to the EMC reported for the northeast region (Adamus, 1995). The commercial/industrial and transportation NSQD EMC values were slightly different than those published values for the northeast area. However, the model describes the water quality impacts associated with change in residential and forested areas and assumes that the change in commercial/industrial and transportation is negligible as further described in Section 3. Therefore, because statistical parameters are available for those EMCs in the NSQD V1.1, the NSQD V1.1 values for commercial/industrial and transportation were used in the model input. The majority of "Outdoor Recreation" lands within the Lake Sunapee watershed are forested and therefore were modeled using EMC data for forest land use.

Table 2.2. Comparison of Total Phosphorus EMC Data

Land Use Category	Total Phosphorus Event Mean Concentration (mg/L)			
	Modeled Mean Value	Reference	Local Mean Value	Reference
Residential	0.30	NSQD V1.1	0.3	Adamus, 1995
Agricultural	0.20	Dunne and Leopold, 1978	N/A	
Forest	0.04	AWWARF	N/A	
Outdoor Use	0.04	AWWARF	N/A	
Commercial/ Industrial	0.26	NSQD V1.1	0.20	Bannerman et al., 1992
Transportation	0.25	NSQD V1.1	0.40	Barrett and Malina, 1998

Water Quality Model with Monte Carlo Simulation Procedure

A Monte Carlo simulation method was used to develop the statistical description for storm water quality for Lake Sunapee. In this approach, the storm water characteristics from a single arbitrary rainfall event are first estimated. The rainfall depth of an arbitrary event was determined by randomly sampling from the historical rainfall information. Similarly, an arbitrary EMC was determined by randomly sampling from the distribution of EMCs in a manner that preserves the mean and standard deviation of the EMC input data. The randomly determined rainfall volume and EMC were used to determine runoff volume, pollutant concentration, and pollutant load of a single arbitrary storm event. This procedure was then repeated ten thousand (10,000) times, recording the volume, EMC, and load from each random storm event. The statistics of these recorded results provide a description of the average characteristics and variability of the volume and water quality of storm water runoff. The modeled pollutant was total phosphorus. The steps in the Monte Carlo Water Quality Model are as follows and are further described below:

1. Develop a statistical description of storm events & pollutant concentration in storm runoff.
2. Estimate the volume of storm runoff from a random storm event for each land use area.
3. Estimate a random pollutant concentration in storm runoff for each land-use area.
4. Calculate the total runoff volume, pollutant load, and concentration in runoff from the modeled portion of the project.
5. Estimate a random number of storms per year based on available historical records. To estimate a single random annual load, repeat steps 2 - 4 by random number of storms per year, summing the loads from each random storm event.
6. Repeat steps 2 - 5 a total of 10,000 times for each pollutant modeled, recording the estimated pollutant concentration, and annual load for each iteration.
7. Develop a statistical representation (mean annual value) of the recorded storm water pollutant loads and concentrations.

Each of the seven steps is described below.

Step 1 – Statistical Representation of Storm Events

The M-CAT model is set up to accept data files from the National Atmospheric and Oceanic Administration (NOAA) that have been processed through the SYNOP rainfall processing tool. The SYNOP tool processes hourly rain gauge data into storm event data using storm event criteria input by the user. Input criteria include an inter-event period and a minimum storm event depth. For the purpose of this model, a standard period of six hours was used for the inter-event period. A minimum storm depth of 0.10 inches was selected, because rain events smaller than this tend to produce little if any runoff (USEPA, 1989; Schueler, 1987). **Storm Depth** An arbitrary storm depth for each iteration was determined by randomly sampling from the population of 4,427 storms generated by the rainfall analysis. The historical record of storm depths was sampled such that each storm was pooled sequentially throughout the entire population of storms. This sequence was repeated until a total of 10,000 iterations were performed.

Step 2 – Estimate the Volume of Storm Runoff from a Random Storm Event.
The runoff volume from each storm event was estimated with the following modification to the Rational Formula: $Q=R_vPA$ (1) where:
Q = the storm water runoff volume (ft^3/year);
P = the rainfall depth of the storm event (ft);
A = the drainage area (ft^2); and
R_v = the mean volumetric runoff coefficient, a unit-less value that is a function of the imperviousness of the drainage: Runoff Coefficient = 0.009 × (% Impervious) + 0.05. (2)
Total storm water runoff volume was determined as the sum of runoff from each land-use type:

$$Q_{total} = \sum_{lu} Q_{lu} = R_{v\,lu} P A_{lu} \quad (3)$$

where lu designates the land-use type. It was assumed that rain falls uniformly over all land-uses within a town during each storm event.

The steps used to calculate the volume of runoff from a random storm event were:
Step 2a - Obtain a rainfall depth by randomly sampling from the 4,427 storm events as described in step 1.
Step 2b - For each land-use area calculate a runoff volume using equation (1). The same rainfall depth is applied to each land-use area.
Step 2c - Sum the runoff volumes from each land-use area to obtain the total runoff from the town for a particular storm event with equation (3).

Pollutant Load and Concentrations

Step 3 - Estimate a Pollutant Concentration in Storm Water Runoff from Each Land Use Area.
TP was modeled as the pollutant of concern for the purpose of the Lake Sunapee analysis. The distribution of land use-based TP concentrations in storm runoff was modeled using published TP EMC data as described above. The distribution of TP EMC data for all land-use categories were assumed to be log-normally distributed (NSQD V1.1). It is also assumed that runoff concentration is independent of rainfall depth, and is also independent of runoff concentration in neighboring land-use areas. The TP pollutant concentration in storm water runoff from each land-use area was estimated by randomly sampling from the associated EMC distribution (log-normal) estimated from the NSQD. The runoff concentration from each land-use area was evaluated with the expression:

$$C_{land-use} = \exp\left(\mu_{\ln x} + \sigma_{\ln x} R_N\right) \quad (4)$$

where:

$\mu_{\ln x}$ = the log-normal mean;

$\sigma_{\ln x}$ = the log-normal standard deviation; and

R_N = a standard normal random variable.

Step 4 – Calculate the Total Runoff Volume, Pollutant Load, and Pollutant Concentration in a Random Storm Event

Step 4A - The total runoff volume in the watershed was calculated by summing the runoff from each land use area calculated using equation (3) as discussed in Step 2:

$$Q_{total} = Q_{land-use1} + Q_{land-use2} + \ldots + Q_{land-usei} \quad (5)$$

where the same random rainfall event was used to calculate runoff volume in each of the land-use areas.

Step 4B - The total pollutant load was calculated by:

$$L_{total} = Q_{land-use1} C_{land-use1} + \ldots + Q_{land-usei} C_{land-usei} \quad (6)$$

where the runoff from each individual land-use area was calculated with equation (3) discussed in step 2, and the concentration in each individual land-use area was calculated with equation (4) discussed in step 3.

Step 4C - The average pollutant concentration in runoff from the entire watershed from a single storm event was calculated by dividing the total watershed load by the total watershed runoff volume:

$$C_{total} = L_{total} / Q_{total} \quad (7)$$

where the runoff from individual land-uses is calculated from step 2 and the concentration in individual land-uses in calculated by step 3.

Pollutant Loads and Concentrations Leaving the Project Site (Step 5):

The annual pollutant load is simply the sum of pollutant loads generated from all storms in a given year. Thus, to compute an annual pollutant load, the number of storms in a random year must first be determined. This was accomplished by randomly sampling from the distribution using the expression:

$$\mathrm{N}_{\mathrm{storms}} = 15.4 + 6.2 R_N \quad (8)$$

where RN = a standard normal variant with a mean of 0 and a standard deviation of 1. The number of storms was rounded to the nearest whole number, and in cases where zero or a negative number of storms was obtained, the distribution was re-sampled until a positive number was obtained (years without any storms did not occur in the available period of record so this situation was not simulated in the water quality model).

Next, steps 2-4 were repeated Nstorms times, recording the total pollutant load from each random storm event. Finally, the individual storm loads were summed to obtain the total annual pollutant load.

Determine Distribution of Storm Concentration and Annual Loads (Steps 6 and 7):

Steps 2-5 were repeated a total of 10,000 times, recording the pollutant concentration and annual load from each iteration. The resultant distributions can be used to present frequency distribution for pollutant concentrations or loads using statistics calculated from the 10,000 Monte-Carlo iterations.

RESULTS

Land Use Analysis

Two land use conditions were analyzed for this model application; current land use and a full build-out condition land use. The results of the land use analysis are described below.

3.1.1 Current Condition

Current land uses were adapted from the 1995 Study prepared by the ULSRPC and are summarized in Table 3.1on the following page.

Table 3.1. Current Condition Land Use Analysis Summary (areas are reported in acres)

	Land Area (acres)						
Town	Agriculture	Forest	Transportation	Commercial/ Industrial	Outdoor Use Areas	Residential	Town Total
Goshen	9	156	4	0	137	1	307
New London	130	2,380	410	8	458	560	3,946
Newbury	115	3,495	285	23	3,172	608	7,698
Springfield	114	4,741	241	57	1,796	142	7,091
Sunapee	69	3,246	350	15	454	799	4,933
Sutton	6	742	8	0	0	0	756
Watershed Total	443	14,760	1,299	103	6,016	2,111	24,731

3.1.2 Full Build-Out Condition

The full build-out condition was based the projected population density and the projected number of homes provided by the UVLSRPC as summarized in column 1 and 2, respectively, of Table 3.2. The number of new homes required to achieve full-build-out was estimated by subtracting the number of existing homes in 1994 (1995 Study) from the number of homes at build-out (column 2). The number of new homes was then multiplied by the average lot area for each town (column 4) to estimate the area to be developed to achieve build-out. The lot areas were derived from the current zoning criteria for residential development described in the 2006 Memo.

Table 3.2. Estimated Build-Out Population and Development Summary

Town	Estimated # of Homes in 1994	Estimated Population at Build-out	Estimated # of Homes at Build-out	# of New Homes to Achieve Build-Out	Average Lot Size	Estimated Area to be Developed to Achieve Build-Out	Total Developed Area at Build-Out
Goshen	5	143	54	49	3.00	147	151.91
New London	545	2,324	993	448	4.14	1,855	2833.61
Newbury	981	5,679	2,311	1,330	2.00	2,660	3576.38
Springfield	166	6,225	2,541	2,375	1.59	3,785	4224.90
Sunapee	865	6,467	2,690	1,825	1.44	2,634	3797.67
Sutton	1	819	332	331	2.00	662	670.32
Watershed Total	2563	21,656	8,921	6,358	NA	11,742	15254.79

The estimated total area of development at full build-out condition was then used to develop full buildout land use conditions. As described in Section 2.1, Geosyntec assumed that future development would occur in areas that are currently forested. A summary of anticipated land use conditions at full build-out is summarized in Table 3.3 on the following page.

Table 3.3. Estimated Full Build-Out Land Use Condition Summary

	Land Area (acres)						
Town	Agriculture	Forest	Transportation	Commercial/ Industrial	Outdoor Use Areas	Residential	**Town Total**
Goshen	9	9	4	0	137	148	307
New London	130	525	410	8	458	2,415	3,946
Newbury	115	835	285	23	3,172	3,268	7,698
Springfield	114	956	241	57	1,796	3,927	7,091
Sunapee	69	612	350	15	454	3,433	4,933
Sutton	6	80	8	0	0	662	756
Watershed Total	443	3,017	1,299	103	6,016	13,853	**24,731**

The net changes in land use to achieve full build-out are predicted to occur in forested and residential areas. These changes consist of a reduction in forested land cover areas, not including those with the land use category of open space, and a corresponding increase in residential land use area. Goshen is predicted to have a 94.3% reduction in forested area (from 156 acres to 9 acres), resulting in a with a 99.4% increase in residential area (from 1 acre to 148 acres). New London is expected to experience a 77.9% reduction in forested area with a 76.8% increase in residential area. Newbury is expected to experience a 76.1% reduction in forested area with a 81.4% increase in residential area. Springfield is expected to experience a 79.8% reduction in forested area with a 96.4% increase in residential area. Sunapee is expected to experience a 81.1% reduction in forested area with a 76.7% increase in residential area. Sutton is expected to experience a 89.3% reduction in forested area with a 100% increase in residential area. This represents an anticipated 79.6% net reduction of forested area in the Watershed and an anticipated 84.8% increase in residential area in the Watershed.

Water Quality Model with Monte Carlo Simulation Input Parameters

The input parameters for the M-CAT model fall into the following four main categories, which are described below: (1) rainfall data; (2) runoff coefficients; (3) land use data; and (4) storm water pollutant EMCs.

Rainfall Data:

Hourly precipitation data for the model was taken from two NOAA NCDC stations (Sunapee, NH Station No. 20018636, and Newport, NH Station No. 275868). The combined rainfall data set for Sunapee and Newport stations included hourly precipitation data between 4/16/1954 and 6/30/2005 and includes 4,427 individual storm events with an accumulation of 0.10 inches or more. A summary of the rainfall data used in the model is included in Table 3.4. A complete record of rainfall data input to the M-CAT is provided in Appendix A.

Table 3.4 M-CAT Rainfall Data Summary

Start Date of Rain Event Data:	4/16/1954
End Date of Rain Event Data:	6/30/2005
Total Number of Storm Events:	4,427
Average Storm Event Volume (in):	0.4
Average Storm Duration (hrs):	6.38
Average Storm Intensity (in/hr):	0.064

Runoff Coefficients/Land Use Data

Runoff coefficients used in the Lake Sunapee model framework were based on land use and are a function of impervious area. The percent impervious values used in the water quality model for developed portions of the Watershed were based upon the values reported by NSQD V1.1. Percent impervious values used the model are summarized in column 2 of Table 3.5. The corresponding runoff coefficients using the Simple Method are summarized in column 3 of Table 3.5.

Table 3.5. Summary of Percent Impervious Values for Land Use Category

Land Use Category	Percent Impervious	Runoff Coefficient
Agricultural	0.10	0.050
Forest	0.02	0.050
Transportation	0.95	0.051
Commercial	0.90	0.050
Outdoor Use	0.02	0.059
Residential	0.65	0.058

Storm Water Pollutant EMCs:

Storm water pollutant EMCs were taken from the best available published data as described in Section 2.1. A summary of EMC data used in the Watershed model is included in Table 3.6. TP EMCs ranged from 0.04 mg/L for both forest and outdoor use to 0.30 mg/L for residential land uses. Outdoor Use land use was modeled as forested land cover as the majority of outdoor recreation areas in the Lake Sunapee region is forested and as such is conservatively modeled as such.

Table 3.6. Summary of Total Phosphorus EMC Data for each Land Use Category

Land Use Category	Total Phosphorus Event Mean Concentration (mg/L)		
	Mean Value	Std. Dev.	Reference
Residential	0.30	0.333	NSQD V1.1
Agricultural	0.20	0.465	Dunne and Leopold, 1978
Forest	0.04	0.1	AWWARF
Outdoor Use	0.04	0.1	AWWARF
Commercial/Industrial	0.26	0.364	NSQD V1.1
Transportation	0.25	0.450	NSQD V1.1

Water Quality Model with Monte Carlo Simulation Procedure

The M-CAT was run using the input data described above a total of 10,000 iterations recording the polled TP EMC, runoff volume and TP load in tons of TP per year (tons/yr) for each town. The statistics of these recorded results for the current condition and full build-out condition is provided in Table 3.7 and 3.8, respectively. These data provide a description of the average characteristics and variability of the volume and water quality of storm water runoff. A comparison of the data is discussed in Section 4.0.

Table 3.7. Current Condition Total Phosphorus M-CAT Summary

	Polled EMC Data (mg/L)		Runoff Volumes (Acre-Ft)		Total Phosphorus Loads (pounds/year)		
Town	EMC (Mean)	EMC Std Dev	Volume (Mean)	Volume Std. Dev.	Estimated Load (Mean)	Std. Dev. Of Estimated Load	Estimated TP Load per acre (lbs/acre/year)
Goshen	0.19491	0.14533	40.78	11.28	**6**	**2**	**0.0195**
New London	0.19686	0.14750	541.17	149.64	**172**	**60**	**0.0436**
Newbury	0.19556	0.14731	1036.83	286.69	**220**	**70**	**0.0286**
Springfield	0.19616	0.14700	948.83	262.36	**156**	**46**	**0.0220**
Sunapee	0.19638	0.14700	674.16	186.41	**204**	**70**	**0.0414**
Sutton	0.19555	0.14600	100.43	27.77	**12**	**4**	**0.0159**

Table 3.8. Full Build-Out Condition Total Phosphorus M-CAT Summary

	Polled EMC Data (mg/L)		Runoff Volumes (Acre-Ft)		Total Phosphorus Loads (pounds/year)		
Town	EMC (Mean)	EMC Std Dev	Volume (Mean)	Volume Std. Dev.	Estimated Load (Mean)	Std. Dev. Of Estimated Load	Estimated TP Load per acre (lbs/acre/year)
Goshen	0.1954	0.1468	42.98	11.89	**22**	**10**	**0.0717**
New London	0.1961	0.1473	568.95	157.32	**382**	**156**	**0.0968**
Newbury	0.1958	0.1472	1076.68	297.71	**522**	**208**	**0.0678**
Springfield	0.1952	0.1465	1005.53	278.03	**578**	**240**	**0.0815**
Sunapee	0.1956	0.1469	713.61	197.32	**502**	**214**	**0.1018**
Sutton	0.1961	0.1468	110.34	30.51	**88**	**38**	**0.1164**

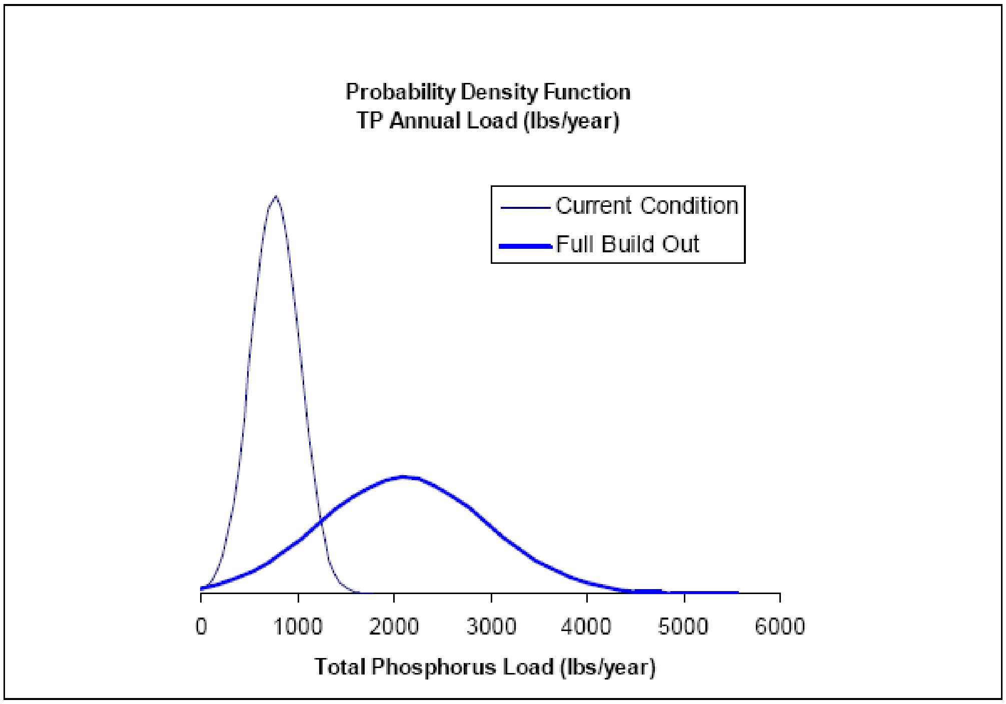
A summary of estimated total phosphorus loads for each town and for the Watershed is presented below in Table 3.9. A comparison of the data to water quality criteria and eutrophication benchmarks is discussed in Section 4.0.

Table 3.9. Comparison of TP Load for each town for Current and Full Build-Out Conditions

Town	Acres in watershed (per town)	Current TP Load (lbs/yr)	Current TP Load (lbs/ac/yr)	Build-out TP Load (lbs/yr)	Build-out TP Load (lbs/ac/yr)	Predicted TP Load Increase (lbs/yr)	Predicted TP Load Increase (lbs/ac/yr)
Goshen	307	6	0.0195	22	0.0717	16	0.0522
New London	3,946	172	0.0436	382	0.0968	210	0.0532
Newbury	7,698	220	0.0286	522	0.0678	302	0.0392
Springfield	7,091	156	0.0220	578	0.0815	422	0.0595
Sunapee	4,933	204	0.0414	502	0.1018	298	0.0604
Sutton	756	12	0.0159	88	0.1164	76	0.1005
Watershed Total	24,731	770	0.0311	2,094	0.0847	1,324	0.0535

• The largest relative increase in mean annual TP load in the Watershed is anticipated to take place in Sutton. The estimated annual TP load from Sutton at full build-out (88 lbs. per year) is predicted to shift from having the Watershed's lowest current TP load per acre (0.0159 lbs/ac/yr) to having the Watershed's highest TP load per acre (0.1164 lbs/ac/yr). The estimated TP load from the town of Sutton at full build-out has one of the lowest standard deviations and therefore one of the highest confidence intervals for the predicted loads.
• Newbury has both the largest land area in the Watershed and the largest predicted current phosphorus load (220 lbs/yr). However, among all towns in the watershed, Newbury has the lowest predicted per-acre increase in loading rate at full build-out (0.0392 lbs/ac/yr).
• At full build-out, Springfield is predicted to have 3.7 times its current phosphorus load and become the Watershed's top contributor of phosphorus.
• The smallest relative increase in mean annual TP load in the Watershed is predicted to take place in New London. At full build-out, the estimated TP load from New London is expected to increase 2.2 times the current load. As shown above, the standard deviations for predicted phosphorus loads in the current condition range between ±2 lbs/yr and ±70 lbs/yr. Standard deviations for phosphorus loads in the build-out condition range between ±10 lbs/yr and ±208 lbs/yr. The build-out condition data has a higher standard deviation because the EMC data for residential land has a higher standard deviation than the EMC data for forested land use. Since forest land is converted to residential land in the full buildout scenario, the standard deviation increases accordingly. A probability density function was graphed for TP load (lbs/year) from the entire Watershed for both conditions and is shown on Figure 3.1. The estimated distribution of TP load for the current condition has a higher confidence interval with a mean TP load of 770 lbs/year and a standard deviation of ±252 lbs/yr. Specifically, approximately 68% of the 10,000 TP loads predicted by the model for the current condition were between 518 lbs/year and 1,022 lbs/year. The predicted distribution of TP loads for the full build-out condition has a lower confidence interval with a mean TP load of 2,094 lbs/year and a standard deviation of ±866 lbs/year. Approximately 68% of the of the 10,000 TP loads predicted by the model were between 1,228 lbs/year and 2,958 lbs/year. The coefficient of variation (CV) represents a measure of dispersion of the probability distribution and is defined as the standard deviation divided by the mean. The CV associated with the current condition is 33% while the CV associated with the full build-out condition is 41%.

Figure 3.1 TP Load Probability Density Function



DISCUSSION

The predicted TP load for the Watershed's full build-out condition is 2,094 ± 866 lbs/year. This represents an approximate increase of 2.7 times the mean TP load estimated for the current land use condition (770 ±252 lbs/yr). To understand the potential implications of this phosphorus load increase, Geosyntec evaluated Lake Sunapee's current trophic status and its sensitivity to changes in phosphorus load. Standard eutrophication benchmark values were evaluated and a literature review was conducted to determine the relationship between Lake Sunapee's external phosphorus loads and in-lake trophic status. Eutrophication is the gradual process of nutrient enrichment in aquatic ecosystems, such as lakes. Eutrophication occurs naturally as lakes become more biologically productive over geological time, but this process may be accelerated by human activities that occur in the watershed. Nutrients that contribute to eutrophication can come from many natural and anthropogenic sources, such as fertilizers applied to agricultural fields, golf courses, and suburban lawns; deposition of nitrogen from the atmosphere; erosion of soil containing nutrients; and sewage treatment plant discharges. Land development not only increases the sources of nutrients, but also decreases opportunities for natural attenuation (e.g. uptake by vegetation) of such nutrients before they can reach a water body. Nutrients such as phosphorus and nitrogen can stimulate abundant growth of algae and rooted plants. Over time, this enhanced plant growth leads to reduced dissolved oxygen in the water, as dead plant material decomposes consumes oxygen. Phosphorus is typically the "limiting nutrient" for freshwater lakes, which means that plant productivity is most often controlled by the supply of this nutrient. As such, increases in phosphorus load in a lake watershed are closely correlated with increases in plant productivity and accelerated eutrophication. Surface water bodies are categorized according to trophic state as follows:

Oligotrophic: Low biological productivity. Oligotrophic lakes are very low in nutrients and algae, and typical have high water clarity and a nutrient-poor inorganic substrate. Oligotrophic water bodies are capable of producing and supporting relatively small populations of living organisms (plants, fish, and wildlife). If stratified, hypolimnetic oxygen is abundant.

Mesotrophic: Moderate biological productivity and moderate water clarity. A mesotrophic water body is capable of producing and supporting moderate populations of living organisms (plant, fish, and wildlife).

Eutrophic: High biologically productivity due to relatively high rates of nutrient input and nutrient rich organic sediments. Eutrophic lakes typically exhibit periods of oxygen deficiency and reduced water clarity. Nuisance levels of macrophytes and algae may result in recreational impairments.

Hypereutrophic: Dense growth of algae throughout the summer. Dense macrophyte beds, but extent of growth is light-limited due to dense algae and associated low water clarity. Summer fish kills are possible.

The Carlson Trophic State Index (TSI) is one of the most commonly used means of characterizing a lake's trophic state. As illustrated in the figure below, the TSI assigns values based upon formulas which describe the relationship between three parameters (total phosphorus, chlorophyll-a, and Secchi disk clarity) and the lake's overall biological productivity. As shown in the figure below, TSI scores below 40 are considered oligotrophic, scores between 40 and 50 are mesotrophic, scores between 50 and 70 are eutrophic, and scores from 70 to 100 are hypereutrophic.

Carlson Trophic State Index

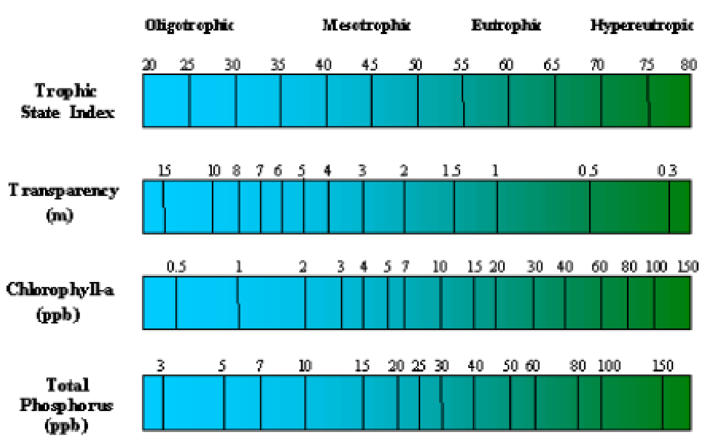


Figure from 1988 Lake and Reservoir Restoration Guidance Manual. USEPA. EPA 440/5-88-002.

NH DES categorizes lakes into trophic state according to total phosphorus concentration:

Total Phosphorus (ug/L)	Trophic Status
<10	Oligotrophic
10-20	Mesotrophic
>20	Eutrophic

Based on data for Lake Sunapee from 7 September 1995 and 28 February 1996, NH DES classified Lake Sunapee as an oligotrophic lake (NH DES Water Supply and Pollution Control Division-Biology Bureau, Lake Trophic Data). (*Note: Lake trophic data from this time period was assessed by Geosyntec to represent the current condition of the lake because of its relative proximity to the 1994 land use data which was used in the model to represent the current condition.)* In-lake total phosphorus concentrations from the above dates ranged from 1 ug/L to 9 ug/L, with a mean concentration of 5.3 ug/L.

Stauffer (1985) identified that approximately 8% of external phosphorus loads are retained within a lake annually. Stauffer (1985) also showed that, for oligotrophic lakes in the northeastern United States, there is a linear relationship between in-lake eutrophication level and external loading by the following:

$$TP_y = 8.5 + 0.081(L_{TP})(q_s^{-1}) \qquad (10)$$

Where:

TP_y = In-lake Total Phosphorus concentration (mg/L)

L_{TP}= external TP loading to the lake in mg P/m^{2*}yr

q_s=lake overflow rate in m/yr.

The equation above was used to calculate the annual phosphorus loading rate that would be predicted to result in an in-lake total phosphorus concentration of 10 ug/L, the threshold value required to tip Lake Sunapee from oligotrophic to mesotrophic according to the NH DES trophic status classification. Assuming that (1) the annual storm water volume represents the lake overflow rate, and (2) a Lake surface area of 4,090 acres, the resulting L_{TP} value was calculated to be 1,060 lbs/yr. This means that an annual phosphorus load of 1,060 lbs/yr is predicted to be Lake Sunapee's "tipping point" between oligotrophic status and mesotrophic status.

According to the M-CAT model developed by Geosyntec, the full build-out condition for the Lake Sunapee watershed will yield a predicted TP load of 2,094 tons/year with a standard deviation of ±866 lbs/yr. The "tipping point" TP loading rate loading rate described above (1,060 lbs/yr) is within the 84% confidence interval for the build-out condition predicted by the M-CAT model. This means that 84% of the 10,000 TP loads calculated by the model for the build-out condition were predicted to be greater than or equal to 1,060 lbs/yr. As such, the model predicts with a high degree of confidence that the full build-out scenario for the Lake Sunapee watershed will result in a phosphorus load that will shift Lake Sunapee from oligotrophic status to mesotrophic status.

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Conductivity

Conductivity is the numerical expression of the ability of water to carry an electrical current. It is determined primarily by the number of ionic particles present. The soft waters of New Hampshire have traditionally had low conductivity values, generally less than 50 uMhos/cm. However, specific categories of good and bad levels cannot be constructed for conductivity because variations in watershed geology can result in natural fluctuations in conductivity. Generally, values in New Hampshire lakes exceeding 100 uMhos/cm indicate cultural, meaning human, disturbances. An increasing conductivity trend typically indicates point sources and/or non-point sources of pollution are occurring within the watershed. The median conductivity for New Hampshire lakes is 40uMhos/cm while the mean conductivity is 59.4 uMhos/cm. (VLAP 2006).

For the most part, conductivity values are increasing across the watershed, and in some cases is already higher than the state median. In particular, the Lake Sunapee nearshore, deep spots and tributary stations have been showing increases on the 2-3% per year range. There is an anomaly in the 2006 data in that the values decreased for these samples. This has been attributed to the higher than usual rainfalls and spring runoff which likely diluted the conductivity concentrations for this sampling period.

The increasing conductivity concentrations indicate impacts from human activities such as land development, road runoff, agricultural runoff and failing septic systems. Shoreline surveys of the lake shore and contributing tributaries would help identify sources of conductivity, human and naturally occurring.

Dissolved Oxygen

The presence of dissolved oxygen is vital to bottom-dwelling organisms as well as fish and amphibians. If the concentration of dissolved oxygen is low, typically less than 5 mg/L, species intolerant, meaning sensitive, to this situation, such as trout, will be forced to move up closer to the surface where there is more dissolved oxygen but the water column is generally warmer, and the species may not survive.

Temperature is also a factor in the dissolved oxygen concentration. Water can hold more oxygen at colder temperatures than at warmer temperatures. Therefore, a lake will typically have a higher concentration of dissolved oxygen during the winter, spring, and fall than during the summer. (VLAP 2006)

Dissolved oxygen concentrations in all of the lakes and ponds in the watershed appears to be very good. It should be noted that in aging lakes which may be stratified, the hypolimnion layer will tend to show oxygen depletion as a result of natural processes of decomposition. In some cases the oxygen depletion at the lake bottom may reach a critical low and cause phosphorus which is bound up in the sediment to be released back into the water column. This is known as *internal phosphorus loading.* Careful monitoring and control of additional phosphorus inputs to these lakes is critical to maintaining the dissolved oxygen balance.

Chlorophyll –a

Algae, formally referred to as phytoplankton are photosynthetic plants that contain chlorophyll but do not have true roots, stems, or leaves. They do, however, grow in many forms such as aggregates of cells (colonies), in strands (filaments), or as microscopic single cells. They may also be found growing on objects, such as rocks or vascular plants, on the lake bottom or free-floating in the water column.

VLAP uses the measure of chlorophyll-a as an indicator of the algae abundance. Because algae is a plant and contains the green pigment chlorophyll, the concentration of chlorophyll measured in the water gives an estimation of the concentration of algae. If the chlorophyll-a concentration increases, this indicates an increase in the algal population. Generally, a chlorophyll-a concentration of less than 5 mg/m^3typically indicates water quality conditions that are representative of oligotrophic lakes, while a chlorophyll-a concentration greater than 15mg/m^3 indicates eutrophic lakes. A chlorophyll concentration greater than 10 mg/m^3 generally indicates an algae bloom, an undesirable
reproduction of algae, is occurring. The median chlorophyll concentration for New Hampshire lakes is 4.58 mg/m^3 and the mean is 7.16 mg/m^3 (VLAP 2006).

Chlorophyll-a concentrations throughout the watershed tend to be low, which indicates good water quality and implies a low abundance of algae. In order to maintain this condition of low chlorophyll-a concentrations and subsequent minimal appearance of algae, it is important to monitor in-lake and tributary contributions of phosphorus which is the nutrient which promotes algal growth.

Cyanobacteria

Cyanobacteria are bacterial microorganisms that photosynthesize and may produce chemicals toxic to other organisms, including humans. Many species of cyanobacteria may accumulate to form surface water blooms. They produce a blue-green pigment but may impart a green, blue, or pink color to the water. Cyanobacteria occur in all lakes, everywhere. There are many types of cyanobacteria in New Hampshire lakes. Most cyanobacteria do not have the ability to produce toxins. In New Hampshire, there are several common cyanobacteria that include: *Gleotrichia*, *Merismopedia*, *Anabaena*, *Oscillatoria*, *Coelosparium*, *Lyngbya*, and *Mycrocystis*. *Anabaena* produces neurotoxins that interfere with the nerve function and have almost immediate effects when ingested. *Mycrocystis* and *Oscillatoria* are known for producing hepatotoxins (liver toxins) known as microcystins. *Oscillatoria* and *Lyngbya* produce dermatotoxins which cause skin rashes. (VLAP 2006).

Cyanobacteria are present in very limited amounts across the watershed. It is important for water quality monitors to continue tracking this phytoplankton. As in-lake phosphorus levels increase, and conditions become favorable, such as August warm sunny days, cyanobacteria can bloom and present a serious health threat for humans and their pets.

3.4 CONCLUSIONS

There are multiple signs that Lake Sunapee and the other watershed lakes and ponds are threatened. While on the surface, these lakes and ponds appear to be high quality and healthy, they remain in a very delicate balance. Each of the water quality indicators summarized above demonstrate that the systems may be on the edge of a downward track.

This trend is shown in the decreasing dissolved oxygen concentrations in the hypolimnion coupled with increasing phosphorus concentrations from the near shore and tributary stations as well as in-lake. Increasing conductivity and the potential for algal blooms and cyanobacterial growth are all indicators of land use activities resulting in non-point source pollution.

In addition to the concerns raised by these results, there is a demonstrated need for more information about these waterbodies. For example, more in-depth investigations of the largest contributors of stream flow to Lake Sunapee is recommended. These include Otter Brook, Chandler Brook, Johnson Brook, Blodgett Brook, Pike Brook, King Hill Brook, and Herrick Cove. Stormwater sampling should be conducted wherever feasible as well.

All is not so bleak though, the Lake Sunapee Watershed benefits from several very active, committed organizations and citizen volunteers. Chapter Six presents the recommendations of the Lake Sunapee Watershed Planning Committee to address many of the water quality concerns raised in this chapter.

Chapter 4. Existing Protection Measures

4.1 INTRODUCTION

In addition to the regulations discussed in Chapter 3 on water quality, protective measures have been adopted by various watershed towns (see the UVLSRPC Buildout Study in the Appendices). This chapter provides information on protective measures including local regulatory controls, land use controls, and information on protected land.

4.2 REGULATORY PROTECTION

Local regulations can help protect water quality by directing development away from ecologically sensitive areas, by guiding the location of construction and development projects, and by prohibiting high risk land uses in specific areas. Local regulations include zoning bylaws and ordinances, subdivision regulations, local health ordinances, and site plan review regulations.

Zoning

Zoning regulates land use, including the size, shape, and permitted uses of lots and structures. Zoning controls where people live and where they work. The purpose of this land use control mechanism is to separate incompatible land uses in order to protect the public from health risks and to guide development to appropriate districts.

Ideally, zoning regulates land use in order to meet the goals set forth in a municipality's master plan. In a master plan, a community describes how it wants to look in the future. It is the zoning regulations that help implement this vision.

In 1995, the Upper Valley Lake Sunapee Regional Planning Commission completed a two phase study estimating development buildout and then evaluating the effects of phosphorus on water quality in Lake Sunapee as a result of full buildout. This study and the 2006 update include a detailed town by town analysis of resource protection zoning codes. This summary is included in the appendices.

The zoning categories include: Village (0.5 acre), Residential (1 acre) Rural residential 1.5 acres – 3.0 acres) Agricultural (4.0 acres) and Conservation (10 – 25 acres). All communities have either Shoreland Overlay, Water Resources or Wetland Conservation District ordinances.

See **Map 6** Generalized Zoning in the Lake Sunapee Watershed

Zoning District Type and Lot Size

While most of the watershed land area is zoned for residential use, 23% is protected as conservation lands. In addition, steep slope and wetland protections also limit potential development near resource areas. Most of the shoreline is zoned for residential lot sizes between 1.5 and 3.0 acres. New London has the most conservation zoning with the Agricultural and Conservation Districts ranging from 4.0 acres to as much as 25 acres. Commercial development within the watershed Is limited to the Route 103 corridor in Newbury and limited Village and Mixed Uses in Sunapee.

Lower density residential zoning (three acre minimum), provides better protection of water resources than high density residential zoning because larger lot sizes can help to limit impervious area associated with residential development. Imperviousness, as mentioned in Chapter One, hinders the natural rate of the hydrological cycle. As residential development becomes more dense, negative impacts on water resources tend to increase from the addition of more cars, roads, residential heating fuel storage, pets, and other sources of waste material. Commercial and industrial land uses typically have the greatest impacts on water quality because these zones tend to create large amounts of impervious cover and they tend to create the greatest amounts of unfiltered stormwater.

Soils Based Lot Sizing

New London, Springfield and Sutton have provisions in their zoning ordinances or subdivision regulations to determine lot size based upon soils and slope characteristics. The purpose of soil based lot sizing is to determine appropriate lot size that safeguards public health. This determination is based upon soil texture, slope, and the ability of a site to process nitrogen in leachate from septic systems.

Wetland and Stream Buffers

Buffers are the single most effective protection for water resources (Connecticut River Joint Commissions, 1998). Buffers consist of strips of vegetated land along wetlands, streams, lakes, and ponds. These transition zones filter polluted runoff and are often complex ecosystems that provide important habitat. Buffers catch and filter out pollutants such as sediments, nutrients, and debris from surface runoff. Depending upon the width and species composition in a buffer zone, 50-100% of the sediments and nutrients will settle out and be absorbed by plants. Wider forested buffers are more effective than narrow grassy buffers. Buffers also help to regulate surface water flow by slowing the velocity of runoff. By slowing the rate of surface flow, water can infiltrate and recharge groundwater resources. Buffers also help to stabilize banks which, in turn, helps to limit erosion. Plant roots in the buffer zone help to hold soil together.

All of the watershed communities have some provisions for wetlands and/or shoreland setbacks and buffers.

Steep Slope Protection

Steep slopes are highly vulnerable to erosion. When erosion occurs, sediment is transported to nearby water bodies. Increased sediment loading can lead to increased turbidity in water bodies. Turbidity has numerous negative effects on fisheries, water supplies, wetlands, and recreation (Jeer et al. 1997). For example, sediment additions can lead to increased surface water temperatures. High temperatures result in decreased dissolved oxygen concentrations in the water and have negative impacts on fisheries. Increased sediment loads may also negatively impact water supplies by damaging water treatment equipment, thereby driving up the cost of operation. In addition, sediments can require increased drinking water disinfection treatment which in turn can lead to unhealthful disinfection byproducts.

All of the watershed communities regulate development on steep slopes through zoning ordinances.

Erosion Control

Erosion control is another important factor to consider when protecting water quality. Erosion control measures help to prevent increased sediments loads and the negative effects described above. Erosion control measures can require the implementation of best management practices on construction sites.

All of the watershed communities have some level of erosion and sedimentation control requirements for land clearing and development. However, improvements can be made in greater uniformity and clarity with respect to water quality goals, performance standards and guidance criteria.

Shoreline Protection Regulations

Shoreline protection regulations are intended to protect the shoreline of surface waterbodies. Municipalities can enact regulations which are more stringent than RSA 483-B, NH Shoreland Protection Act.

Newbury, New London, Sunapee and Sutton have zoning ordinances which provide shoreland protection. Here again, there is opportunity for creating language which is more uniform in protecting the shores of Lake Sunapee and associated lakes and ponds within the watershed. It might be worthwhile for the SAWC and the LSPA to work toward a regional shoreline protection overlay with clear water quality goals, performance standards and guidance criteria.

Septic setbacks

Septic setbacks protect water quality by requiring a specified distance from waterbodies. State regulations exist which determine these distances.

Lake Sunapee Watershed community zoning does not restrict septic system location more than state requirements, with the exception of Springfield and Sutton. More work can be done here by the SAWC and LSPA to educate local officials on the importance of separation of waste disposal systems from important surface water resources.

Protection Overlay Districts

Protection overlay districts can be created to provide specialized protection for wetlands, floodplains, water supplies or watersheds. These districts isolate and protect specific resources that are not adequately covered in existing zoning regulations. As the name implies, overlay districts are laid on top of existing zoning for the purpose of protecting critical areas. The underlying zoning remains, however, the overlay district adds supplemental requirements and provides additional protection to the resource of interest.

The Town of Sunapee has codified all water resource protection ordinances into a Water Resources Overlay District. This is a practical approach. All of the watershed towns do have overlay districts for either wetlands, shorelines and/or steep slopes. However, there is no overlay district which provides for consistent and continuous protection for the Lake Sunapee Watershed across all six towns. A watershed protection overlay district would provide for coordinated and effective protection.

Subdivision Regulations

Subdivision regulations can play a significant role in protecting water resources. Subdivision regulations set forth design and engineering standards and construction practices for proposed projects. Project plans must meet these standards in order to gain subdivision plan approval. When subdivision regulations are developed with water resources in mind, these regulations can promote better stormwater drainage and runoff control, environmentally sensitive sewage disposal, and promote designs which implement erosion and sedimentation controls.

Site Plan Review

The purpose of the site plan review process is to promote commercial and multifamily development which is compatible with a community's character and infrastructure. The site plan review process focuses on ensuring that environmental factors such as pollution, noise, and odor are addressed, that natural features are protected, solid waste and waste water disposal are well-managed, and sediment and erosion control is incorporated into development projects. The site plan review process can serve as a vehicle for better protecting water quality if it encourages designs which maintain the hydrological cycle and/or promote techniques to better manage stormwater. Site Plan Review regulations were not reviewed as part of this plan.

Health Ordinances

RSA 147:1, I authorizes local health officers to make regulations that in their judgement are required for the health and safety of the people. Protection of public drinking water supplies clearly falls within this broad grant of power. A health ordinance is typically relatively easy to adopt. It takes effect after it is approved by a municipality's Board of Selectmen, recorded by the town clerk, and published in a newspaper of general circulation in the town, or when copies have been posted in two or more public places in town. Health ordinances were not reviewed as part of this plan.

4.3 LAND PROTECTION

Land ownership for the purpose of conservation is one of the most effective ways to protect water resources. Land ownership through fee simple ownership or conservation easements provides the most control over land use activities. Fee simple ownership refers to complete ownership of all the "bundle of rights" associated with a property. A conservation easement is a permanent legal agreement between a land-owner and a public agency or private nonprofit conservation organization. Conservation easements can limit or restrict how land can be used. By placing a conservation easement on a property, the landowner retains ownership, but transfers some of the development rights to a responsible third party, such as a land trust. The land trust is then responsible for ensuring that the easement restrictions are met.

Approximately 7,202 acres, 23% of the watershed, is protected as either public or private conservation land (Map 4). Conservation land fairly well distributed across the watershed. The largest blocks are the Sunapee State Park, the Gile State Forest and the Hay Reservation.

Many water departments throughout the state own or purchase land in order to protect water supplies. Water systems and associated customers who have had the foresight to purchase land to protect their sources are likely to benefit from reduced public health risks and lower treatment costs. NH DES promotes this practice through the land protection grants program. To better protect water resources into the future, key properties for conservation should be identified and conserved by a variety of partners.

4.4 OTHER PROTECTIVE MEASURES

Nearly all water supply watersheds extend beyond the municipalities that they serve, making protecting of these resources challenging. In the 1890's the Water Purity Act was passed in NH which provided rules to better protect the Lake Sunapee watershed. Env-Ws 386.64 "Protection of the Purity of Lake Sunapee and its Watershed" codifies a set of restrictions for protecting the water quality of the lake. For example:

> *A person shall not build, continue, or maintain any privy, pig-pen, stable, or other building or structures in which horses, cattle, swine or other livestock or fowls are kept, within 75 feet of Lake Sunapee's, high water mark, or within 75 feet of any bay, cove, or inlet thereto, or within 75 feet of any stream tributary to said lake, bays, coves or inlets;*

4.5 CONCLUSIONS

It is important to note that while the purpose of protective measures such as local regulatory controls, land use controls, and administrative rules may be valid, without adequate enforcement, protective measures are ineffective. Implementation of existing protective measures is necessary to safeguard water quality within the watershed.

Chapter 5. Inventory of Potential Pollution Sources

5.1 INTRODUCTION

An inventory of potential sources of contamination was created in order to identify areas where remedial and preventative measures in the watershed are necessary. The inventory was developed from a variety of sources. These sources include NH DES source water assessment reports for public drinking water supplies, a database search using the NH DES on-line OneStop Database, review of information provided by GRANIT GIS data layers and two watershed tours.

The PCS reports for Sunapee Water Works, Lake Sunapee, Chalk Pond, Georges Mills, Granliden, Lake Sunapee Trading Post, Meadowbrook at Sunapee, Mount Royal Academy and New London/Springfield are available in the appendices.

Three types of pollution sources were reviewed as part of this inventory: nonpoint sources of pollution, point sources, and lake contact sources. Nonpoint sources of pollution contribute pollutants in an indirect pathway. As rainwater or snowmelt wash past exposed pollutants on the land's surface or in soils, water transports these pollutants into surface water or groundwater, later emerging in streams, lakes, and coastal waters. This type of pollution is the accumulated result of many small actions whose origins are difficult to trace. Nonpoint source pollution may come from many places and many different types of land use including agricultural land uses, residential development, and transportation corridors.

In contrast, point source pollution can be traced to a specific point of discharge, such as a pipe, channel, or ditch connected to a wastewater treatment plant, sludge lagoon, or landfill. Point sources are usually directly piped and often require permits. For the purposes of this plan, commercial, industrial, and municipal activities which require a state permit are considered to be a point source due to their known location. In comparison to nonpoint sources, point sources are often more readily managed by direct regulatory management.

Lake contact sources of pollution include recreational activities such as swimming, boating activities, snowmobiling, and use of the lake by float planes. Recreational use of source waters and the supporting land-based infrastructure necessary to support recreational activities increase the potential for microbial, physical, and chemical contaminants to enter the drinking water supply.

5.2 REVIEW OF NONPOINT POLLUTION SOURCES

Seven general categories of nonpoint source pollution were identified in the watershed. These sources include:

- Site Development and Lot Conversion
- Agricultural Land Use
- Recreation Activities
- Residential Land Use
- Transportation Corridors

- Stormwater Management
- Utility Right-of Ways

Site Development and Lot Conversion

Site development and lot conversion occur or have the potential to occur throughout the watershed. During site development and lot conversion the ground is typically disturbed altering vegetation and hydrological processes. Site development and lot conversion can be sources of sediment if drainage, grading, and re-vegetation are not well-planned and controlled. The sediment that is washed into surface waters from construction sites is considered to be the greatest single nonpoint source pollutant. Impacts of sedimentation on fisheries include reduction in water clarity, increases in water temperature which decrease dissolved oxygen levels, and filling in of spawning habitat. Impacts of sedimentation on wetlands include reduction in flood storage capacity. Sedimentation can also have negative impacts on drinking water supplies by damaging water treatment pumps, increasing treatment costs, and increasing the production of unhealthful disinfection byproducts.

Agricultural Land Use

According to the NH DES Source Water Assessment, agricultural land use in the watershed was assessed as a “medium” threat. This classification was based upon computer-interpreted satellite imagery. For the purposes of this inventory, golf courses and timbering are included under agricultural land use.

Recreation Activities

Recreation activities occur on the waterbodies and surrounding land base. Water contact activities include motor-boating, use of private watercraft, use of seaplanes, swimming, fishing, sailing, kayaking, canoeing and other non-motorized boating. During the winter snowmobiling, and ice fishing occur. Recreational activities on the land base include hunting, use of all terrain vehicles, horseback riding, alpine skiing and mountain biking.

Residential Land Use

Residential land use poses threats to water resources from several sources. For example, potential contamination sources include residential fuel storage, septic systems, landscape care, and household hazardous waste.

Pesticides and Pharmaceuticals

A new generation of toxic contaminants includes compounds such as endocrine disruptors (EDCs), pharmaceutically active compounds (PhACs) and personal care products (PCPs). Endocrine disruptors interfere with the natural hormonal balance of an animal. The compounds include some natural products such as soy or alfalfa or man made products such as detergents and pesticides. These enter the waste stream through a variety of non-point source means, such as residential septic systems and agricultural runoff. The American Water Works Association (AWWA) Research Foundation has identified these compounds as a priority research area for potential human health impacts through drinking water supplies (see web links page for further information).

Because of reported cases of fish and amphibian developmental and reproductive anomalies, the US EPA has also funded several research grants examining the potential health effects of these compounds in drinking water.

It would be worthwhile for the watershed community to be attentive to occurrences of malformations, and developmental and reproductive abnormalities in fish, amphibians and water fowl.

Residential Heating Fuel Storage

Residential heating fuel tanks are potential sources of contamination because they are prone to leaks due to line breakage, corrosion, and fitting and filter leaks. Over-filling of tanks is also a concern. The primary pollutants associated with residential heating fuel are volatile organic chemicals which can have negative impacts on fisheries and human health.

The location of residential heating fuel tanks is significant. For example, residential heating fuel tanks consist of aboveground storage tanks which are located outside and inside tank installations which are usually located in a basement. There are two common concerns associated with outside tanks. Above ground storage tanks should be located on an impermeable surface to prevent leaching of fuel spills into the groundwater and the tank themselves should be protected from harsh weather conditions. Tanks may tip over or become damaged due to ice and snow. Often tanks are not located on an impermeable surface and do not have weather protective structures. Inside tanks are typically located in finished or unfinished basements. Finished basements provide some spill or leak containment. In contrast, unfinished basements do not have a physical barrier which helps to contain spills. Finished basements may also have sump pumps to alleviate wet conditions. Although useful for removing water, sump pumps can accidentally pump fuel or fuel-contaminated water into groundwater resources or directly into surface water.

Wastewater Disposal

Everything that goes down the drain, into the toilet, dishwasher, and clothes washing machine goes to some type of waste water disposal system. In the watershed there are two general categories of wastewater disposal systems: a system associated with an individual home and a municipal sewer system. The majority of households in the watershed dispose of their waste water using individual systems which include septic systems, cesspools, and holding tanks. Of these three types of disposal systems, septic systems are the most common. Much of the land area near the center of the town of Sunapee and along the lake shore is sewered.

When wastewater disposal systems fail they can be sources of bacteria, viruses, and protozoa which can cause gastrointestinal illness. They can also be sources of pollutants from improper disposal of household hazardous waste. Both types of systems, sewers and individual wastewater disposal systems are capable of failure. Municipal sewer systems are typically managed by professional staff. Individual systems, on the other hand, often receive less attention after they have been installed. Typically the homeowner is responsible for ensuring proper system operation and maintenance. Septic systems should be maintained by pumping out wastes approximately every 3-5 years.

When septic systems function properly they can process household organic waste and destroy disease-producing bacteria. The most commonly approved system consists of a septic tank connected to a leach field. Wastewater first flows to the septic tank where heavy solids sink to the bottom. Grease, oils, and lighter solids rise to the top where they form a layer of scum. Beneficial bacteria which are naturally present in materials that are flushed into the system, decompose the biodegradable waste. Liquids flow from the tank to the leach field where unhealthful bacteria, viruses, and some phosphorus are removed. Eventually the filtered water flows to the water table (CRJC, 1994). A failed system jeopardizes public health, is a neighborhood nuisance, and negatively impacts water quality in the watershed.

According to the NH DES Source Water Assessment Reports, septic systems in proximity of water supply wells were assessed as having a “High” risk for the Lake Sunapee Watershed.

It is difficult to assess current levels of septic system maintenance in the watershed. It does not appear that any of the watershed communities collect information on septic system maintenance. There are no septic system maintenance ordinances, tracking programs, or municipal septic system programs present in the watershed. The purpose of septic system ordinances is to promote inspection and periodic pump-outs to prevent system failure. A tracking program is a non-regulatory way to ensure that septic systems are functioning. The program typically requires registration of all systems and encourages routine system inspections and pumpings. Under a municipal system, the municipality assumes responsibility for maintenance and repair of septic systems. Homeowners are charged an annual fee for this service.

Prior to executing a purchase and sale agreement for any "developed waterfront property" using a septic disposal system, an owner is required to engage a permitted subsurface sewer or waste disposal system designer to perform an on-site assessment study (RSA 485-A:39). "Developed waterfront property" means any parcel of land which is contiguous to or within 200 feet of a great pond as defined in RSA 4:40-a and upon which stands a structure suitable for either seasonal or year-round human occupancy. A “great pond” is defined in RSA 4:40 as "... a public water body of more than 10 acres." The site assessment study is required whenever any part of the property is within 200 feet of the great pond, not merely when the structure or the septic disposal system is within 200 feet of the water. Relevant Law includes RSA 4:40-a, 485-A:2, 485-A:39 and Administrative Rule Env-Ws 1025.

Lawn care

Nutrients and pesticides are common pollutants associated with lawn care and gardening activities. Pesticides are sources of synthetic organic chemicals. These chemicals can be washed from lawns during a rain event, transported to surface water where they can bioaccumulate in fish tissue. Once these chemicals enter the drinking water supply they can pose potential health risks. Fertilizers are a source of nutrients such as Nitrogen and Phosphorus. Excess additions of these nutrients to waterbodies can result in increased frequency and mass of algal blooms. Algal blooms tend to increase water treatment costs, cause odors and poor taste and in some cases the blooms can be toxic.

Transportation Corridors

Transportation corridors include roads, highways, and railroad right-of ways. Roadways serve as potential sources of contamination because these impervious surfaces accumulate de-icing materials and chemicals from automobiles. Stormwater runoff carries these pollutants to nearby waterways and groundwater.

The NH DES Source Water Assessment report ranked transportation corridors as having a "medium" risk in the watershed. Water quality data collected by the Volunteer Lake Assessment Program for Lake Sunapee and the other lakes and ponds found specific conductivity levels to be at levels indicative of "human impact". Conductivity is a measure of water's ability to conduct electricity, and therefore a measure of the water's ionic activity and content. The higher the concentration of ionic (dissolved) constituents, the higher the conductivity level is of the water.

Conductivity is generally found to be a good measure of the concentration of total dissolved solids (TDS) and salinity in a waterbody. Road salt, non-point source pollution (for example, agricultural run-off) and industrial inputs tend to increase conductivity levels as their intensity and frequency increase. Because of the elevated conductivity levels present in the Sunapee Watershed, and the number of road and stream crossings, contaminants from roadways is one of the primary suspected sources.

Stormwater Management

Stormwater runoff occurs when the capacity of soils and vegetation to absorb water from precipitation is exceeded and water flows across the land's surface. In developed areas, natural vegetation and permeable soils are replaced by tracts of impervious surfaces such as roads, parking lots, rooftops, driveways, sidewalks, and compacted fill. Because water cannot penetrate the impervious surfaces, it runs off into gutters and storm drains picking up toxins and suspended solids along the way. In undeveloped areas, water infiltrates the soil where some pollutants can be treated by natural processes. In contrast, in developed areas, the rate of stormwater runoff increases allowing for less time for natural pollutant treatment and increasing the volume of water flow.

According to the Environmental Protection Agency, contaminated stormwater discharges are responsible for the impairment of one-third of all assessed waters in the United States. Common stormwater pollutants include sediments, toxic chemicals (e.g. cyanide, phenolics, and trichloroethylene), metals, oxygen depleting chemicals, fecal coliform, oil, grease, pesticides, fertilizers, and trash.

Little is known about the quality and location of stormwater runoff in the watershed. No water quality monitoring of stormwater has occurred and the identification and location of stormwater inflows is in the very early stages. Also important for determining the potential volume of stormwater runoff is the percent impervious cover present in the watershed. Research has shown that percent of imperviousness cover in a watershed can be used to estimate current and future water quality of subwatersheds.

Utilities

There are two potential sources of contamination associated with utilities in the watershed: power-line right-of-ways and a sewer system. Pesticides are commonly sprayed to manage vegetation growth on the right-of-ways. Pesticides are sources of synthetic organic chemicals. Prior to spraying, utilities are required to give notice to municipalities.

The Sunapee Sewer System is another potential source of contamination. When sewer systems malfunction or sewer lines rupture, they can be sources of bacteria, viruses, and nutrients. Through proper monitoring and maintenance of the sewer system, potential sources of pollution can be minimized.

5.3 REVIEW OF POINT POLLUTION SOURCES

As mentioned previously commercial, industrial, and municipal activities which require a state permit were considered to be point sources as part of this plan because they are potential sources of contamination and they have a known location. This inventory of point sources in the watershed was created by conducting a state database review using the NH DES OneStop on-line database, a Best Management Practices Survey of Commercial and Industrial entities, a windshield survey, and reviewing available GRANIT GIS data layers.

The full PCS reports for the watershed point source and non-point source threats are available in the appendices.

5.4 LAKE CONTACT SOURCES OF POLLUTION

Motor-boating

According to the NH DES Source Water Assessment Report for Lake Sunapee Water Works, “motorboats, particularly those using two-stroke outboard motors, present a potential threat of contamination of water supplies by gasoline. While gasoline contains many compounds, of particular concern is MtBE, a highly soluble chemical which is a possible human carcinogen and has been shown to produce cancer in laboratory animals”. MtBE can cause kidney and liver damage and creates an increased risk of cancer (NH DES Analytical Requirements for Community Public Water Supplies, 2004). Although EPA has placed MtBE on the Drinking Water Contaminant Candidate List, the Agency has not yet set a maximum contaminant level for this compound. In 2000, NH DES adopted a drinking water standard of 13 ug/L for MtBE.

The American Water Works Association recommends that utilities and other responsible parties monitor water quality to assess the impacts of recreation activities such as motor-boating. In addition, AWWA advises that the water utility should work with other stakeholders to develop an integrated plan to evaluate and, if necessary, mitigate water quality impacts (AWWA, 2004). The American Water Works Association discourages body contact recreation and use of polluting two-cycle gasoline engines in sources that supply public drinking water (AWWA, 2004).

Swimming

Use of lakes for water-based recreational sports, such as swimming, may be considered an asset by many communities. However, in many cases lakes which are used for swimming are also used as the primary source for drinking water supplies. These dual objectives can lead to resource use conflicts. Swimming poses a risk for drinking water supplies which use surface water as a primary source. Swimming is a known source of fecal contaminants in lakes and reservoirs that permit this activity (Stewart et al., 2002). During swimming activities, swimmers may accidentally introduce pathogens, such as *cryptosporidium,* that are resistant to treatment. A recent study on the public health consequences of body-contact recreation found that the placement of recreational activities is an important factor in safeguarding public health. For example by locating swimming activities at a distance from water intake structures, the level of pathogens that enter a drinking water treatment plant can be attenuated (Stewart et al.).

Seaplanes

Lake Sunapee is used for seaplane access and transportation to homes along the shore. Seaplane operations on Lake Sunapee represent less of an environmental risk than carbureted two-cycle engines because seaplane engine exhaust is discharged to the air. In addition, aviation fuel is not mixed with oil so there is less oil present in seaplane exhaust. Furthermore, aviation fuel does not contain MtBE like gasoline powered engines (Seaplane Pilots Association, 2000). Unlike motorboats, seaplanes are required to have annual inspections, pilots are trained and certified, and there is limited contact time with the waterbody.

Env-Ws 386.64 (g)(7) prohibits seaplane use within the contributing area to the Sunapee Water works.

> *A person shall not use a seaplane in Sunapee Harbor north and west of a line from Russell Point bearing south 45 degrees west to the opposite shore.*

Chapter 6. Recommendations

6.1 INTRODUCTION

This chapter summarizes the risks and priorities used to identify watershed concerns and the recommendations developed by the Lake Sunapee Watershed Planning Committee. Specific recommendations have been identified and are listed as “objectives” below. In order to help implement these objectives, the committee developed concrete tasks or “strategies”. These objectives will be shared with watershed municipalities and others with the goal that the recommendations from this plan will be implemented.

6.2 RECOMMENDATIONS FOR IMPROVING WATER QUALITY

The Lake Sunapee Watershed Planning Committee identified 8 general areas of concern:

- Pollution from stormwater runoff; (A benchmark is the phosphorus loading limitation of 8 µg/L)
- Erosion from land development activities;
- Impacts of impervious cover to water quality and stormwater runoff;
- Impacts from aging septic systems, and location of new systems;
- Enforcement of existing ordinances and regulations;
- Road salt use and storage;
- Using a watershed approach for protection of water resources;
- Education and Implementation of the watershed plan.

Each area of concern or Goal is divided into several Objectives, and each objective is followed by a number of “strategies”. Strategies are specific actions which can be implemented in order to meet the objective. The overall emphasis is on improving water quality by addressing specific issues and identifying particular tasks. The strategies are being developed from the ground up, and some may evolve as they are implemented.

The objectives and strategies can be listed in a “report card” format which specifies potential lead agencies, partners, funding sources, timeline and benchmarks. When it comes time to review the efficacy of watershed protection activities, this format can aid in the evaluation process. Goals, objectives and strategies are summarized in Table 6.2.

Figure 6.1 Proposed Report Card format of goals, objectives, and strategies.

GOAL: (to improve water quality)

- Objective (To implement effective practices that will improve water quality)

  Strategy (The specific practice that can be implemented to achieve the objective)

  - Potential Lead Agency and Partners: Describes a likely candidate for implementing the strategy and highlights potential partners.
  - Potential Funding Sources: Identifies potential sources for financial support
  - Time frame: The anticipated time it will take for either implementation of the strategy or to bring about the desired outcome of implementation.
  - Benchmark: The desired outcome of the strategy. The overarching goal is to preserve water quality, and use phosphorus loading of 8 µg/L as a benchmark.

Table 6.2 List of Recommended Watershed Management Activities for the Lake Sunapee Watershed, New Hampshire. Recommendations developed by the SAWC Watershed Planning Committee.

Concern	***Objective***	Strategy	Potential Lead Agencies and Partners	Potential Funding Sources	Timeframe
I. Pollution from Stormwater Runoff	A. Reduce stormwater volumes and impacts. B. Specifically limit phosphorus loading so as to not exceed an in-lake concentration of to 8 µg/L. C. A major amount of phosphorus loading occurs via sediment transport, therefore an objective is to limit sediment loading to surface waters.	1. Incorporate Low Impact Development design measures in local regulations including subdivision regulations, site plan review, and individual home sites.	Planning Boards SAWC		
		2. Reduce erosive forces by decreasing velocities of stormwater and runoff through installation of stormwater management structures such as check dams and stone filters.	Watershed Municipalities, Highway Departments		
		3. Adopt local regulations which limit the amount of impervious cover permitted.	Planning Boards SAWC		
		4. Establish maximum disturbance limits for various zoning districts in municipal zoning ordinances.	Planning Boards SAWC		
		5. Adopt buffer requirements for streams in the watershed. Width, clearing limitations, soil type and slope must be considered.	Planning Boards SAWC		
		6. Include conservation design and compact development concepts into municipal regulations.	Planning Boards SAWC		
		7. Eliminate illicit cross connections between stormwater structures and sanitary sewer systems.	Sewer Authority	Sec 319, SRF, USDA Rural Development Funds	
		8. Adopt standards for new developments which require that stormwater be controlled through use of best management practices.	Planning Boards		
		9. Use covenants and deed restrictions to ensure long-term implementation of Low Impact Development measures and maintenance of stormwater structures.	Planning Boards		
		10. Conduct an e-coli speciation study to determine the source (human or animal) of this bacteria at selected sites of concern.	LSPA UNH	NH DES Source Protection Grant	
		11. Encourage members of town boards to take a field trip to UNH's Stormwater Center to learn about the latest technologies used to manage stormwater.	SAWC LSPA		

Concern	*Objective*	Strategy	Potential Lead Agencies and Partners	Potential Funding Sources	Timeframe
	D. Gather information about stormwater in the watershed. Knowledge of where streams have been modified or where sediment is transported will help with the goal of holding in-waterbody nutrient concentrations.	1. Conduct a study on the effect of Climate Change on stormwater flows in the watershed.	LSPA Antioch New England Graduate School		
		2. Identify and map all stormwater structures and stream crossings in the watershed. Use this inventory to develop a stormwater management plan and program.	Watershed Municipalities, HWY Departments LSPA GSRWA	NH DES Source Protection Grant	
	E. Reduce the quantity of contaminants from stormwater. Specifically limit phosphorus loading to 8 µg/L.	1. Continue to improve road design and maintenance in the watershed (e.g. road drainage, road-side design)	NHDOT Road Agents LSPA		
		2. Hold a stormwater management workshop for town officials and road agents.	LSPA		
		3. Continue to educate watershed residents about the use of lawn care chemicals. Prohibit chemical applications in riparian areas.	LSPA		
II. Erosion	A. Keep sediment out of surface waterbodies.	1. Provide education about the causes and effects of erosion by educating residents, developers, builders, building inspectors, road agents, and town managers about ways to prevent and manage erosion.	SAWC LSPA Watershed Municipalities		
	B. Monitor and enforce regulations and best management practices related to erosion prevention and control.	1. Watershed municipalities should look into coordinating zoning administrators whose responsibilities would include monitoring and enforcing implementation of erosion best management practices.	SAWC LSPA Watershed Municipalities Selectmen	Use building permits fees for staff salaries.	
	C. Establish permanent erosion controls.	1. Encourage planning boards to require permanent erosion control programs as part of the site plan process.	SAWC LSPA Planning Boards		
	D. Prevent disturbance of soils on slopes greater than 15%.	1. Adopt regulations which control development on slopes greater than 15% throughout the watershed. Soil criteria should be included. Sediment should be retained within the development area. Require USGS topo or soils data on building permits.	Planning Boards SAWC		

Concern	Objective	Strategy	Potential Lead Agencies and Partners	Potential Funding Sources	Timeframe
III.Development and Impervious Surfaces	A. Minimize impacts from development and impervious surfaces, such as in-lake phosphorus concentrations. The ideal result would be a return to pre-development conditions.	1. Adopt a watershed overlay district which limits the amount of impervious surface which can be developed per lot.	SAWC Planning Boards UVRPC		
	B. Limit the amount of impervious surface in the watershed, so as to reduce stormwater discharges, limit nutrient and pollutants into water resources.	1. Identify and conserve key properties to protect drinking water quality and sensitive ecological features. Use fee simple acquisition, conservation easements, tax incentives, transfer of development rights, and other tools to fund these conservation projects.	LSPA ASLPT Conservation Commissions		
	C. Provide education about the effects of impervious cover on stormwater discharge, and hydrologic impacts.	1. Educate landowners, contractors, architects, general contractors builders and others about preferred driveway surfacing techniques. Place an article in the local press. Develop a flyer for circulation for use when a building permit is requested.	Watershed Municipalities SAWC		
IV. Septic Systems	A. Ensure that septic systems do not pollute groundwater or surfacewater	1. Educate watershed residents and businesses about septic system maintenance and use. Develop an education and outreach program about the proper use and maintenance of septic systems.	SAWC LSPA Watershed Municipalities		
	B. Gather information about septic systems located within 250 ft of Lake Sunapee.	1. Conduct a septic system survey to collect information about system age, type, location, size, maintenance etc.	SAWC LSPA GSRWA	Watershed Municipalities NH DES Source Protection Program	
	C. Develop stronger controls for installation of new systems or replacement of systems.	1. Improve siting and technology where possible.	Planning Boards		
		2. Tie system replacement to building permits and require post-construction inspections and certification.	Planning Boards Selectmen		
		3. Create minimum setbacks from surface water (125 ft).	Planning Boards SAWC, LSPA		
	D. Ensure that adequate resources are available to repair/replace systems in cases of economic hardship.	1. Develop a finance program for cases of economic hardship which enable residents to fix or replace failing systems.	Watershed Municipalities Private Sector NHDES, SAWC		

Concern	***Objective***	Strategy	Potential Lead Agencies and Partners	Potential Funding Sources	Timeframe
V. Inadequate Enforcement of current laws and regulations	A. Education and Outreach Including the effects of increased contaminants, including the tipping point of in-waterbody concentrations of phosphorus.	1. Raise watershed awareness through signage, storm drain stenciling, stream walks, and maps. Have information about watershed protection and associated regulations available at town websites, town offices, and local libraries.	SAWC LSPA	NH DES Watershed Assistance Grant Program	
		2. Promote personal stewardship by educating residents about the role they play in the watershed and communicating specific messages about positive and negative behaviors.	SAWC LSPA	NH DES Watershed Assistance Grant Program	
		3. Provide professional training for the land development and real estate community about tools for watershed protection.	SAWC LSPA		
		4. Provide opportunities for the public to actively engage in watershed protection and restoration (i.e. monitoring).	SAWC LSPA		
	B. Improve enforcement of Existing Laws and Regulations to prevent groundwater and surface water pollution. A metric for surface water improvement will be tracking in-waterbbody phosphorus concentration which should not exceed 8µg/L.	1. Determine the official jurisdiction and enforcement responsibilities of existing laws and regulations.	SAWC Municipalities		
		2. Develop a local plan for carrying out these laws and regulations.	SAWC Municipalities		
		3. Identify and appoint the appropriate enforcement agents.	SAWC Municipalities		
		4. Develop and implement a formal procedure for addressing complaints and violations.	SAWC Municipalities		
		5. Ensure that adequate resources both financial and technical are available to carryout these ordinances and regulations through adoption of permit fees and use of training and educational outreach materials.	SAWC Municipalities		
		6. Examine and evaluate the effectiveness of Administrative Rule Env-ws 386.64 "Protection of the Purity of Lake Sunapee and Its Watershed"	SAWC Sunapee Water Dept LSPA		
		7. Compare building permits and associated process of the watershed municipalities. Use building permits as a tool to make property owners more accountable.	SAWC		
VI. Road Salt	A. Reduce the negative impacts on	1. Follow best management practices for use of road	SAWC		

Concern	Objective	Strategy	Potential Lead Agencies and Partners	Potential Funding Sources	Timeframe
Use and Storage	water resources from road salt use. The ideal goal would be to reduce the impact from road salt to pre-development levels.	salt.	Road Agents Municipalities NH DOT Public Works Departments		
		2. Identify salt-free or low-salt zones. Post signs to inform motorists of these areas. Work to implement lower speed limits in these areas.	SAWC Road Agents Municipalities		
		3. Large parking lots should have adequate snow storage areas identified and be sited for no run-off.	Planning Boards		
		4. Identify what de-icing materials are currently being used in the watershed by municipalities and NH DOT. Research case studies of model salt application and storage.	SAWC through DOT and DPWs		
		5. Ensure that all salt storage areas within the watershed use best management practices, have an impervious surface beneath de-icing materials and that these materials are covered, preventing run-off.	SAWC Road Agents Watershed Municipalities		
		6. Hold a workshop to discuss current salt application in the watershed, model and effects of salt in the watershed. Facilitate location of alternative snow dumping sites.	SAWC, LSPA Municipalities Road Agents NH DOT/DES		
	B. Work with NH DOT to identify methods for reducing road salt on state roads.	1. Encourage NH DOT to utilize spreader-mounted friction sensors and on-board pavement temperature measurement equipment to automatically control the application rate of salt.	SAWC LSPA NH DOT Municipalities		
		2. Encourage NH DOT to utilize other mechanical devices including the types of spreaders and plows which may aid in decreasing the amount of salt used.	SAWC LSPA NH DOT Municipalities		
		3. Encourage NH DOT to recognize that residual road salt may play an important anti-icing role and cause reduction in salt applications for subsequent storms.	SAWC LSPA NH DOT Municipalities		
		4. Explore the use of various spread patterns such as applying salt in a windrow onto the crown of the road rather than by spreading it uniformly across	SAWC LSPA NH DOT		

Concern	*Objective*	Strategy	Potential Lead Agencies and Partners	Potential Funding Sources	Timeframe
		the surface.	Municipalities		
		5. Encourage continuing education for Public Works Departments in an effort to stay current with the latest de-icing techniques and technologies. (e.g. Roads Scholar Program)	SAWC LSPA NH DOT Municipalities		
VII. Inadequate Protection of Water Resources.	A. Adopt regulations which promote protection of water resources. These will minimize pollutants in those water resources.	1. Towns should be encouraged to draft water resources management and protection plans, and adopt them as part of their master plans. These plans review and evaluate existing regulations as they pertain to protection of water resources. These plans may serve as the justification for the adoption of water protection regulations.	SAWC Watershed Municipalities GSRWA UVLSRPC Planning Boards		
		2. Adopt a watershed overlay district which directs development away from ecologically sensitive areas, guides construction and development, and prohibits high risk land uses. The overlay should include environmental protections such as soil based lot sizing, limits the amount of impervious cover, and control development on slopes greater than 15%.	SAWC Watershed Municipalities UVLSRPC		
	B. Preserve high quality domestic water supply.	1. Collect and analyze existing information (e.g. location, type, depth, yield) of private residential wells. Use this to identify water quality trends and promote protection.	LSPA SAWC Watershed Municipalities UVRPC Dartmouth College NH DES US EPA		
	C. Preserve quality of public drinking water supplies.	1. Work with public water systems to help them protect their watersheds and wellhead protection areas.	LSPA SAWC Watershed Municipalities GSRWA NH DES UVLSRPC		

Concern	***Objective***	Strategy	Potential Lead Agencies and Partners	Potential Funding Sources	Timeframe
		2. Develop a water quality and quantity database of private well monitoring data. Facilitate local monitoring program.	SAWC		
	D. Protect ecological systems which support hydrological functions. For example, minimizing stream modifications and reduce sediment transport.	1. Identify and conserve key properties to protect water resources including riparian buffers, wetlands, and land over aquifers.	LSPA ASLPT Land Trusts Conservation Commissions Colby Sawyer Hubbard Brook Dartmouth UNH UVM Antioch NE US Forest Service	NH DES Drinking Water Supply Land Grant Program, local funding mechanisms such as general fund appropriations and legislatively approved tax increases, federal Land and Water Conservation	
VIII. Continue watershed protection activities and continue to raise awareness about the watershed.	A. Implement the Watershed Management Plan for the Lake Sunapee Watershed. Monitor in lake phosphorus and use the resulting measurement values as a tool for progress. The goal is 8µg/L inlake concentration.	1. Encourage watershed municipalities to formally adopt the management plan and to work toward achieving the goals.	SAWC LSPA Municipalities SAWC		
		2. Continue the Sunapee Area Watershed Coalition in order to help shepherd the implementation of the management plan.	Municipalities SAWC LSPA		
	B. NH DES Demonstration Project	1. Define and carry out a demonstration project, as an educational tool for stormwater management.	SAWC LSPA	NH DES Watershed Pilot Grant	In Progress