Lake Waukewan and Lake Winona
Watershed Restoration Plan

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Watershed Restoration Plan for Lake Waukewan and Lake Winona

Report prepared by the Lake Winnipesaukee Association
and
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Executive Summary

PROJECT OVERVIEW

The Lake Waukewan and Lake Winona Watershed Restoration Plan (WRP) project is part of a long-term strategy to create a public, on-line Watershed Management Plan (WMP) for the entire Lake Winnipesaukee watershed that addresses nutrient loading.

Protecting the water quality of Lake Waukewan is a high priority for the town of Meredith, as not only is the lake a recreational and economic asset, it is also the primary drinking water supply serving over 3,000 residents and the Meredith Village Business community. Lake Winona is a beautiful lake located to the northwest of Lake Waukewan in a mostly undeveloped watershed, with year round and seasonal residential development located along its shores.

In 2005 a management plan for the Waukewan Watershed was developed that provides a detailed description and analysis of nonpoint sources of pollution in the watershed; however, the planning process at that time did not include quantifying pollutant loads and reductions. Both lakes are impaired for Aquatic Life Use due to low dissolved oxygen concentrations and in the case of Lake Waukewan, cyanobacteria blooms. The 2016 Lake Waukewan and Lake Winona Watershed Restoration Plan addresses the dissolved oxygen impairments by focusing on ways to reduce sediment and phosphorus input in the watershed. The plan is both a stand-alone plan for the Waukewan-Winona watershed and a supplement to the 2005 Waukewan Watershed Management Plan.

This watershed restoration plan is the culmination of a major effort by many individuals who not only care about the long-term protection of water quality in their lakes, but also recognize that high water quality is directly connected to the economic well-being of the area. Lake Winnipesaukee Association (LWA) hosted an initial meeting to generate interest in the plan with many stakeholders representing a diverse range of interests in attendance. From municipal staff and conservation commissions, to state agency officials (e.g., NH Fish & Game, NHDES), to local residents and lake/pond/neighborhood associations (e.g., Lake Waukewan Association, Lake Waukewan and Winona Watershed Protective

Association, Lake Winona Improvement Association, Waukewan Watershed Advisory Committee, Windy Waters Conservancy), to land trusts and non-profits (e.g., Lakes Region Conservation Trust, Belknap County Conservation District), to technical experts – LWA guided the creation of an Advisory Committee to ensure that a strong watershed restoration plan was developed for these special and important waterbodies.

This plan was partially funded by a Watershed Assistance Grant for High Quality Waters from NHDES using Clean Water Act Section 319 funds from the USEPA, with additional financial and in-kind services provided by the Waukewan Watershed Advisory Committee, the Windy Waters Conservancy, and the members of the Advisory Committee. This comprehensive watershed plan provides guidance for the next phase of actions needed to improve and preserve the water quality of these picturesque waterbodies.

The **WAUKEWAN-WINONA WATERSHED RESTORATION PLAN** is a scientifically-based plan that provides decision makers and local residents the tools needed to protect the water quality of these waterbodies for future generations.

THE WAUKEWAN-WINONA WATERSHED

The Waukewan-Winona watershed lies within five towns in the Lakes Region of NH; Meredith, New Hampton, Center Harbor, Holderness, and Ashland, NH. Developed land of 951 acres makes up 13% of the total 7,162 acres of land in the watershed, with over 6,000 acres of forest land accounting for 84% of the land area. Lake Winona, at 148 acres, and Lake Waukewan, 928 acres, are the largest waterbodies. Lake Winona outlets to the Snake River, which flows approximately 2 miles before emptying into Lake Waukewan. Development around the lake consists of a mix of seasonal and year round residential homes and cottages. Businesses in the watershed include some commercial and light industrial use, and several campgrounds. Potential threats to the water quality and public drinking water supply include development pressure, recreation, erosion, aging septic systems, and land use practices.

The Waukewan watershed includes three different sites impacted by nonpoint source pollutants which are listed on the State's current 303(d) list of impaired waters: Waukewan Lake, Waukewan Town Beach, and Winona Lake. Waukewan Lake fails to support designated uses due to a severe dissolved oxygen (DO) and DO saturation impairment (5-P) and a cyanobacteria (hepatotoxic microcystins) impairment (5-M), which is of concern and importance as Lake Waukewan is the public drinking water supply for the Town of Meredith. Waukewan Town Beach fails to support aquatic life use due to a DO impairment (5-M). Winona Lake also fails to support aquatic life use as a result of a severe dissolved oxygen (DO) and DO saturation impairment (5-P). The sources for all of these impairments are listed as "Source Unknown."

This plan focuses on phosphorus as the overall driver of ecosystem health. Phosphorus (P) is a naturally occurring element and a major nutrient required for biological productivity. It is found in all living plants, animals, and people (organic forms); as well as being present in soils and rock (inorganic forms). Although its existence is widespread in nature, it is not *naturally* abundant, and is the most limiting nutrient in freshwater ecosystems for aquatic plant productivity.

Increased levels of phosphorus in freshwater can cause decreased water clarity, increased chlorophyll-a levels, increased turbidity levels, accelerated lake eutrophication, etc. Higher concentrations of P in freshwater may also result in a decline in property values, economic loss from decline in tourism due to decline in water clarity, public health risk due to potential of increased occurrence of cyanobacteria blooms, decline in swimming, fishing and boating use, and an increase in public expenditures to address water quality impairments. Decomposition of accumulated organic matter from dead algal blooms and plants, can result in anoxia in bottom waters, which can release phosphorus back into the water column as food for algae and plants and can also be lethal to fish and other aquatic organisms.

The **fundamental goal** of this watershed restoration plan is to improve the low dissolved oxygen concentrations in the bottom depths of both lakes by reducing pollutant and nutrient inputs, primarily phosphorus. Although current in-lake phosphorus concentrations for each lake are below the NHDES state nutrient criteria established for oligotrophic (8.0 µg/L) and mesotrophic (<12 µg/L) waterbodies, representatives for both Lake Waukewan and Lake Winona opted to select target goals which decrease the in-lake phosphorus concentration from the predicted in-lake levels. **The target goal for Lake Waukewan was set to achieve an in-lake TP concentration of 5.3 µg/L in 10 years, requiring a reduction in phosphorus load to the lake of 31 kg/year. Although Lake Winona is well below the reserve assimilative capacity threshold of 10.8 µg/L for a mesotrophic waterbody, the WWLSAC chose to be aggressively proactive and selected a target goal to achieve a 5-10% decrease in in-lake TP concentration in 10 years.**

This plan provides a roadmap for improving the water quality of both lakes, and provides a mechanism for procuring funding to secure actions needed to achieve water quality goals. In addition, this plan sets the stage for ongoing dialogue among key stakeholders in many facets of the community, and promotes coordinated municipal land use changes to address stormwater runoff. The success of this plan is dependent on the concerted effort of volunteers, and a strong and diverse Advisory Committee that meets regularly to review progress and make any necessary adjustments to the plan.

As part of the development of this plan, a build-out analysis, water quality and assimilative capacity analysis, and watershed/shoreline survey were conducted. Results of these efforts were used to run a land-use model, or Lake Loading Response Model (LLRM), that estimated the historical, current, and projected amount of phosphorus being delivered to the lakes from their respective watersheds. To assist implementation of recommended strategies or best management practices (BMPs), an Action Plan (Section 7) with associated timeframes, responsible parties, and estimated costs was developed.

PLAN COMPONENTS

The Waukewan Winona Watershed Restoration Plan includes nine key planning elements to address nonpoint source (NPS) pollution (Section 1.1). These guidelines, set forth by the USEPA, highlight important steps in protecting water quality for waterbodies impacted by human activities, including specific recommendations for guiding future development and strategies for reducing the cumulative impacts of NPS pollution on lake water quality. Below is a summary of information presented by section:

SECTION 1 | INTRODUCTION

Section 1 introduces the plan by describing the purpose and scope, existing water quality impairments, the goals and objectives, and the community-based planning process.

SECTION 2 | LAKE HEALTH AND WATER QUALITY

Section 2 describes issues related to water quality and stormwater runoff, lake morphology and morphometry, provides a summary of current classification based on water chemistry assessment, and the assimilative capacity analysis for each lake.

SECTION 3 | WATERSHED CHARACTERIZATION

Section 3 describes the watershed, providing detailed information about climate, population and demographics, topography, soils and geology, subwatershed delineations, and breakdown of land use/cover areas.

SECTION 4 | LAKE SUSTAINABILITY

Section 4 provides the estimated nutrient loading to both lakes, as well as an estimation of the natural background condition, and the future loading based on results of the build out analysis. The process for selecting the local water quality goal or target for each lake is also included in this section.

SECTION 5 | IDENTIFICATION OF POLLUTION SOURCES IN THE WATERSHED

Section 5 presents the results of the watershed nonpoint source survey and shoreline survey, as well as the process for prioritization of mitigation strategies.

SECTION 6 | MANAGEMENT STRATEGIES

Section 6 outlines the necessary management strategies (both structural and non-structural best management practices (BMPs)) to reduce phosphorus inputs to the waterbody. Current and future sources of phosphorus are discussed and an adaptive management strategy is presented.

SECTION 7 | PLAN IMPLEMENTATION

Section 7 describes who will be carrying out this plan and how the action items will be tracked to ensure that necessary steps are being taken to improve the water quality of Lakes Waukewan and Winona over the next twenty years. This section also provides estimated costs and technical assistance needed to successfully implement the plan and a description of the evaluation plan to assess the effectiveness of restoration and monitoring activities.

FUNDING THE PLAN

Reducing phosphorus inputs from existing development in the Waukewan watershed is highly achievable. Addressing the **top six BMP** sites from the prioritized list of all identified survey sites for each of the Lake Waukewan and Lake Winona watersheds would remove **84.8 kg of phosphorus per year** from entering either Lake Waukewan or Winona, and would account for **75 % of the total estimated P load** per year contributed by all surveyed problem areas.

Implementation of this plan over the next 10 years is expected to cost $324,200 and will require the dedication and hard work of municipalities, conservation groups, and volunteers to ensure that the actions identified in this plan are carried out accordingly. Section 7 lists the costs associated with successfully implementing this ten-year watershed plan, including both structural and non-structural management measures. A sustainable funding plan should be developed within the first year of this plan and revisited on an annual basis to ensure that the major planning objectives can be achieved over the long-term. This funding strategy would outline the financial responsibilities at all levels of the community (landowners, towns, community groups, and state and federal governments).

ADMINISTERING THE PLAN

The recommendations of this plan should be carried out by a committee similar to the Advisory Committee assembled for development of this plan. Local participation is an integral part of the success of this plan, and should include the leadership of local municipalities (Meredith, Center Harbor, New Hampton, Holderness, and Ashland), as well as the support of other stakeholders, including conservation commissions, pond/road/neighborhood associations, NHDES, school/community groups, local businesses, and landowners. The committee will need to meet regularly and be diligent in coordinating resources to implement practices that will reduce NPS pollution in the Waukewan watershed. Periodic updates to the plan will need to be made to maintain the action items and keep the plan relevant to current watershed activities. Measurable milestones (number of BMP sites, volunteers, funding received, etc.) should be tracked by the Advisory Committee and reported to NHDES on a regular basis.

Acknowledgements

Development of a Watershed Restoration Plan requires the involvement and input of numerous interested parties; local lake associations, municipal officials, Planning Board and Conservation Commission members, residents, and state and federal agencies. More importantly, successful watershed restoration plans have a local advisory committee that guides and oversees the implementation of actions identified in the plan. A plan is just the first step; implementation is key to protecting lake quality.

In November 2013, the Lake Winnipesaukee Association (LWA) contracted with FB Environmental Associates (FBE) to assist with development of the Lake Waukewan and Lake Winona Watershed Restoration Plan. Helping FB Environmental with key aspects of the plan were DK Water Resources Consulting LLC and the UNH Stormwater Center.

Funding for the 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 following people and organizations were instrumental in the development of the Lake Waukewan and Lake Winona Watershed Restoration Plan:

Technical Staff:

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Emily DiFranco	FB Environmental Associates
Whitney Baker	FB Environmental Associates
Scott Reynolds	FB Environmental Associates
Logan Cline	FB Environmental Associates
Don Kretchmer	DK Water Resources Consulting
Patricia Tarpey	Lake Winnipesaukee Association

LWA would like to extend our sincere thanks to the following stakeholders who were involved in the development of this plan:

- Towns of Meredith, New Hampton, Center Harbor, Holderness and Ashland
- Waukewan Watershed Advisory Committee
- Windy Waters Conservancy
- Waukewan and Winona Watershed Protective Association
- Lake Waukewan Association
- Lake Winona Improvement Association
- Belknap County Conservation District
- NH Department of Environmental Services
- NH Fish & Game

The Waukewan & Winona Lake Study Advisory Committee was formed to review and comment on key *draft* deliverables and outputs for the project. These included:

1. Providing historical context for the project including documents, data and observations.
2. Reviewing and commenting on the lakes' water quality goal (in conjunction with NHDES).
3. Reviewing and commenting on the model outputs including the land use phosphorus load evaluation and the build out analysis.
4. Helping to prioritize the BMP sites identified in the summer of 2014.
5. Helping to identify and prioritize action items for the watershed that will act as the "roadmap" for future efforts in the watershed.
6. Reviewing the draft and final watershed plan.

Waukewan & Winona Lake Study Advisory Committee

Chuck Braxton, Windy Waters Conservancy

Deb Corr, Waukewan and Winona Watershed Protective Association

Maureen Criasia, Center Harbor representative

John Edgar, Community Development Director, Town of Meredith

Randy Eifert, Waukewan Watershed Advisory Committee

Janan Hayes, Waukewan and Winona Watershed Protective Association

John Hodsdon, Waukewan Watershed Advisory Committee

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Angela Labrecque, Town Planner, Town of Meredith

Steve Landry, Merrimack Watershed Supervisor, NHDES

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Duncan McNeish, Waukewan Watershed Advisory Committee

Don Miller, Large Lake Fisheries Biologist, NH Fish & Game

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Lisa Morin, Program Coordinator, Belknap County Conservation District

Frank Murphy, Lake Waukewan Association

Ben Nugent, Fisheries Biologist, NH Fish & Game

David Reilly, Waukewan and Winona Watershed Protective Association

Anthony Sabutis, Windy Waters Conservancy

Patricia Tarpey, Executive Director, Lake Winnipesaukee Association

Donald and Beatrice Thibeault, Lake Winona Improvement Association

Donna Van Ness, Lake Waukewan Association

Bob Vogler, Waukewan Watershed Advisory Committee, Center Harbor Representative

Paula Wanzer, Meredith resident

Robert Wenstrup, Lake Waukewan resident, Meredith

Tim Whiting, Waukewan Watershed Advisory Committee

Thank you all for your valuable input on this project!

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1. Introduction

Whether man made or natural, lakes serve a multitude of purposes which need to be protected. Lakes may be used for flood control, drinking water supplies, fisheries, wildlife, and/or recreational enjoyment such as swimming and boating, making management to protect those uses a complicated issue and task.

The Lake Waukewan and Winona Watershed Restoration Plan (WRP) is part of a long-term strategy to address current impairments in both lakes by focusing on ways to reduce sediment and nutrient loading inputs to the waterbodies. Current water quality impairments in the Waukewan watershed include elevated bacteria, cyanobacteria, low pH, low dissolved oxygen (DO) and DO saturation (*sources unknown*). Potential threats to water quality include development pressure, recreation, aging septic systems, erosion, and land use practices.

The WRP builds upon the previous Waukewan Management Plan completed in 2005 by quantifying nutrient loading by land use and source, sets local goals or thresholds for in-lake phosphorus levels, and presents an action plan to restore the impaired waterbodies to their designated uses. The Plan provides the communities with a tool to guide future development and redevelopment in the watershed in a manner that will have the least negative impact on water quality of the Waukewan subwatershed.

The Lake Winnipesaukee Association's (LWA) mission is to protect the water quality and natural resources of the lake and its watershed now and for future generations. The Lake Waukewan watershed drains to Meredith Bay in Lake Winnipesaukee and contributes the largest volume of water to the bay of all the watersheds that drain to this location. With partial funding provided through 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 LWA facilitated the development of a watershed-based restoration plan for the Waukewan-Winona watershed. Additional funding for the project has been generously provided by the Town of Meredith Waukewan Watershed Advisory Committee, the Windy Waters Conservancy, and through volunteer in kind match.

1.1 Purpose and Scope

In 2005 Granite State Rural Water Association (GSRWA) developed a management plan for the Waukewan Watershed which provided an extensive description and analysis of potential nonpoint sources of pollution in the watershed. However, the planning process at that time did not include quantifying pollutant loads to the lake, nor the reductions needed in order to maintain a high quality water. In 2010, the *"Plan 1: Meredith, Paugus and Sanders Bay Watershed Management Plan"* was the first plan completed to address nutrient loading to Lake Winnipesaukee. Although the Waukewan-Winona watershed is part of the greater Meredith Bay, Winnipesaukee watershed, the project scope of work for *Plan 1* did not allow for a comprehensive watershed assessment and nutrient modeling analysis to be performed for the Waukewan watershed.

In 2013, the Lake Winnipesaukee Association (LWA) was awarded a Section 319 Watershed Restoration Grant through the NHDES Watershed Assistance Section to develop a thorough Waukewan-Winona WRP that includes the EPA's "nine mandatory or key elements" for watershed-based plans. The EPA has identified the following 'a through i' elements as critical for achieving improvements in water quality:

a. *Identification of causes of impairment and pollutant sources that need to be controlled to achieve needed load reductions*
b. *An estimate of the load reductions expected from management measures*
c. *A description of the nonpoint source management measures that will need to be implemented to achieve load reductions estimated in element b*
d. *Estimate of the amounts of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon to implement this plan.*
e. *An information and education component used to enhance public understanding of the project and encourage their early and continued participation in selecting, designing, implementing the nonpoint source management measures.*
f. *Schedule for implementing the nonpoint source management measures identified in the plan*
g. *A description of the interim measurable milestones for determining progress in implementing the management measures or actions identified in the plan.*
h. *A set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made toward attaining water quality standards.*
i. *A monitoring component to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under element 'h'.*

The watershed restoration plan evaluates existing lake and tributary data, current and future watershed conditions, and in-lake nutrient concentrations to determine the sources and causes of lake quality impairment. A requirement of management plans funded through the Watershed Assistance Grant program is the establishment of local water quality goals for in-lake total phosphorus levels per assessment unit that either meet or exceed the nutrient threshold established by the State. The completed watershed restoration plan provides recommendations for non-structural and structural approaches for reducing current and future sources of nutrient and pollutant loading to the lake in order to achieve the local water quality goal.

Specifically, the plan:

a) quantifies primary sources of phosphorus loading using existing data and a watershed and lake response model;

b) uses a build-out analysis approach to predict future phosphorus sources and loading rates,

c) prioritizes sources and makes recommendations for actions to reduce phosphorus loading to both Lake Waukewan and Winona;

d) includes an outreach program for residents and lake users about the sources and consequences of non-point source pollution;

e) includes Best Management Practice (BMP) designs to address sources,

f) implements two small demonstration projects or BMPs.

This plan supplements both the *2005 Waukewan Watershed Management Plan* and *2010 Plan 1: Meredith, Paugus and Saunders Bay WMP*, which can be found on the Winnipesaukee Gateway site, www.winnipesaukeegateway.org.

1.2 Existing Water Quality Impairments in the Watershed

WATERSHED
All the land that surrounds a lake that drains (or sheds) its water into the lake through streams, ditches, over the land or through groundwater.

The Waukewan-Winona watershed includes five towns - Meredith, New Hampton, Center Harbor, Holderness, and Ashland, NH. Developed land of 951 acres makes up 13% of the total 7,162 acres of land in the Waukewan Watershed, with over 6,000 acres of forest land accounting for 84% of the land area. Lake Winona, at 148 acres, and Lake Waukewan, 928 acres, are the largest waterbodies. Lake Winona outlets to the Snake River, which flows approximately 2 miles before emptying into Lake Waukewan. Development around both lakes consists of a mix of seasonal and year round residential homes, and cottages. Some commercial and light industrial properties are located in the southern part of the watershed.

Protecting the water quality of Lake Waukewan is a major priority for the Town of Meredith, as not only is the lake a recreational asset, it is also a municipal drinking water supply serving approximately 3,000 residents and the business community.

Currently, the NH Department of Environmental Services (NHDES) categorizes Lake Waukewan as oligotrophic and Lake Winona as mesotrophic. Trophic status is a measure of a waterbody's productivity or the amount of organic matter that it produces. It is determined by a number of physical, biological and chemical parameters; mean depth, volume, flushing rate, phytoplankton and zooplankton abundance, aquatic vascular plant abundance, summer bottom dissolved oxygen, summer secchi disk transparency, total phosphorus and chlorophyll-*a* concentrations, and more. Oligotrophic waterbodies in general are low in nutrients, and therefore less prone to algal blooms, while mesotrophic waterbodies have moderate amounts of nutrients, more plant growth, and lower water clarity.

The Waukewan watershed includes three different sites impacted by nonpoint source pollutants which are listed on the State's current 303(d) list of impaired waters: Waukewan Lake, Waukewan Town Beach, and Winona Lake. Waukewan Lake fails to support designated uses due to a severe dissolved oxygen (DO) and DO saturation impairment (5-P) and a cyanobacteria (hepatotoxic microcystins) impairment (5-M), which is of concern and importance as Lake Waukewan is the public drinking water supply for the Town of Meredith. Waukewan Town Beach fails to support aquatic life use due to a DO impairment (5-M). Winona Lake also fails to support aquatic life use as a result of a severe dissolved oxygen (DO) and DO saturation impairment (5-P). The sources for all of these impairments are listed as "Source Unknown." Watershed Report Cards for each lake can be accessed at NHDES' website, http://des.nh.gov/organization/divisions/water/wmb/swqa/report_cards.htm.

1.3 Management Plan Goals

Potential threats to the water quality and public drinking water supply include development pressure, recreation, septic systems, erosion, and land use practices. The **overarching** goal of this project is to protect the water quality of the watershed from these threats by developing a WRP which will establish in-lake and watershed load reduction goals for phosphorus, the key limiting nutrient for this sub-watershed and Lake Winnipesaukee. The planning process focuses on local involvement and has resulted in recommendations and implementation strategies for public education, adoption of best management practices, site restoration projects, and reduction of pollution source materials.

Goals identified in the 2005 Waukewan Watershed Management Plan remain relevant to the overarching goal, and implementation of the strategies identified in this plan will help ensure achievement of the 2005 stated goals:

1. Reduce pollution from nonpoint sources in the watershed.
2. Reduce pollution from water contact activities.
3. Reduce pollution from point sources.
4. Increase understanding of the watershed through research and monitoring.
5. Continue watershed protection activities and continue to raise awareness about the watershed.

1.4 Who was involved in developing the Management Plan?

Local lake associations, residents, and community officials have worked with scientists and the NHDES to develop this plan. It has required understanding the lake's current water quality, setting local water quality goals regarding phosphorus loading, predicting future water quality trends based upon land use changes, identifying ways to reduce nutrient inputs, and establishing ongoing monitoring to evaluate how well those strategies are working.

LWA, FB Environmental Associates, and DK Water Resources Consulting held a public meeting on December 9, 2013 at the Meredith Community Center, Meredith, to kick off the project. More than 50 people came to learn about the project and steps involved in developing a watershed restoration plan. Attendees interested in learning more or becoming involved with the project were encouraged to join the Waukewan & Winona Lake Study Advisory Committee, which met four times during plan development to review project outputs. In addition, members of the Advisory Committee provided boats and volunteers in order to complete the shoreline surveys for Lakes Waukewan and Winona.

2. Lake Health and Water Quality

2.1 Why is Water Quality at Risk?

As with most New Hampshire lakes, the primary pollution source in the Lake Waukewan and Winona watershed is **polluted runoff** or nonpoint source (NPS) pollution. Stormwater runoff from rain and snowmelt picks up soil, nutrients and other pollutants as it flows across the land, and washes into the lake.

In an undeveloped forested watershed, stormwater runoff is slowed and filtered by tree and shrub roots, grasses, leaves, and other natural debris on the forest floor. It then soaks into the uneven forest floor and filters through the soil.

POLLUTED RUNOFF
Also called NPS or nonpoint source pollution. Soil, fertilizers, septic waste and other pollutants from diffuse sources across the landscape that are carried into a waterbody by rainfall.

In a developed watershed, however, stormwater does not always receive the filtering treatment the forest once provided. Rainwater picks up speed as it flows across impervious surfaces like rooftops, compacted soil, gravel camp roads and pavement, and it becomes a destructive erosive force.

2.2 Why is Runoff a Problem?

Nutrient over enrichment has consistently ranked as one of the top causes of water quality impairment in the U.S. (U.S. EPA, 2000a), with stormwater runoff from developed land areas as the major source for most lakes. Studies have shown that runoff from developed areas has five to ten times the amount of **phosphorus** compared to runoff from forested areas (NHDES, 2010). Other activities that contribute nutrients to lakes are lawn and garden fertilizers, faulty septic systems, washing with soap in or near the lake, soil erosion, dumping or burning leaves in or near a lake, and feeding ducks.

Phosphorus loading can lead to algal blooms, decreasing water quality and damaging the ecology and esthetics of a lake.

Retention basin along Waukewan Street, also known as Monkey Pond.

Although phosphorus (P) is not the only pollutant of concern affecting water quality, it is the most limiting nutrient in freshwater ecosystems for aquatic plant productivity. The nutrient phosphorus is food for algae and other plants and is found in soils, septic waste, pet waste and fertilizers. In natural conditions, the scarcity of phosphorus in a lake limits algae growth. However, when a lake receives additional phosphorus, algae growth increases dramatically. This growth may cause algal blooms, but more often results in small changes in water quality that, over time, damage the ecology, aesthetics and economy of lakes.

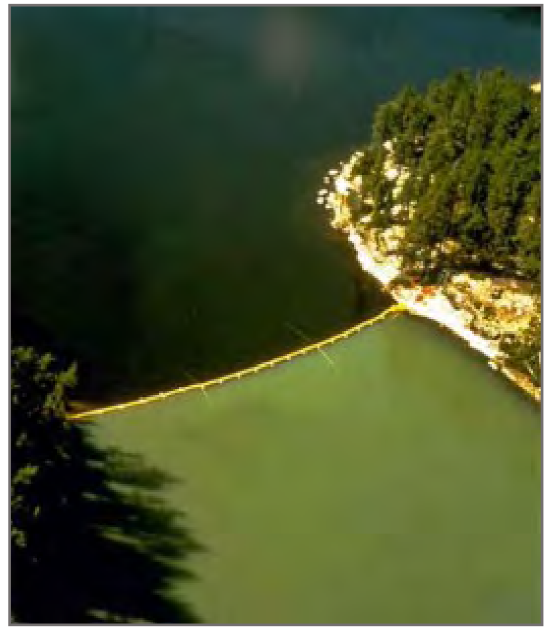
Soil erosion is the largest source of phosphorus in New Hampshire lakes. Phosphorus is bound in soil by adhering to the surface of soil particles. Erosion and sediment transport, including eroding stream banks, roadway runoff, and exposed soil on construction sites are all potential phosphorus sources. High intensity rain events result in untreated stormwater transported from the land and the road network to storm drains and catch basins which discharge directly and indirectly to surface waters.

2.3 Why Should We Protect Lake Waukewan and Winona from Polluted Runoff?

- Once a lake becomes polluted, it can be difficult or impossible to restore. Prevention is the key.
- The lake and stream systems within the watershed are valuable habitat for fish, birds and other wildlife.
- Lake Waukewan and Lake Winona support various warm and coldwater fisheries which include rainbow and brown trout, large and smallmouth bass, pickerel and horned pout among other species.
- Lake water quality affects property values. Studies in Maine and New Hampshire have stated that for every three-foot decline in water clarity, shorefront property values can decline as much as 5-10%. Declining property values affect individual landowners as well as the entire community.
- Sediment deposited into waterbodies from erosion creates the ideal environment for invasive aquatic plant species. These species can be transported via boats to other lakes and ponds.

2.4 Limnology and Ecology of Lakes Waukewan and Winona

The size and shape of a lake basin affect nearly all physical, chemical, and biological parameters of the lake. Other physical characteristics influencing a lake's productivity include geology, topography and land use, watershed area to lake area ratio, residence time, and flushing rate. As mentioned in Section 2.2, productivity in freshwater ecosystems is related to the nutrient load, particularly total phosphorus (TP) as demonstrated by Schindler in the early 1970's (Schindler, 1974).



Schindler, 1973. Ontario, CA
Experiment depicting results from adding Carbon(C), Nitrogen (N), and Phosphorus (P) to bottom half of lake, and only C and N to top half.

Lake Morphology and Bathymetry: Lake morphology (surface area, perimeter, volume) and bathymetry (depth contours) data are used to evaluate how the lake responds to nutrient inputs. Bathymetry data is also used to calculate internal loading; using the bathymetry data, the area of the lake bottom covered by anoxic waters may be calculated (Figure 1, Table 1).

Lake Waukewan is the largest waterbody within the watershed with an area of approximately 928 acres and a maximum depth of 21.4 meters. The lake is relatively long and narrow with a length to width ratio of 4:1. Lake Waukewan has a total shoreline length of 8.1 miles or 42,650 feet. The shores are largely developed with both year-round and seasonal residential development. There are 7 islands in the lake, 5 of which have structures on them. The lake is the primary drinking water supply for the town of Meredith serving over 3,000 residents and the Meredith Village Business community. It is fed by the outflow of the Snake River, which flows from Winona Lake to the north, and five other inflows. Waukewan's outlet is controlled by a dam which releases water to Meredith Bay in Lake Winnipesaukee.

Lake Winona is smaller with a surface area of 148 acres and a maximum depth of 14.6 meters. The lake is long and narrow with a length to width ratio of 10:1. Lake Winona has a total shoreline length of 3.1 miles or 16,513 feet. The shores are developed with both year-round and seasonal residential development. There are 6 inflows to the lake and the outflow leads to the Snake River. The lake has two islands; both of which have structures on them. Lake Winona is classified as a "natural lake" by NHDES.

Table 1. Watershed Characteristics and Lake Morphology

Watershed	Winona	Waukewan
Towns:	Center Harbor, Ashland, Holderness, New Hampton	Center Harbor, Meredith, Ashland, Holderness, New Hampton
HUC Number:	10700020109	10700020109
Shore Length (m):	6122.8	16,513
Mean Depth (m):	5.3	6.6
Max Depth (m):	14.6	21.4
Watershed Area (acres):	3369.8	8277.8
Watershed Area (m^2):	13,637,097	33,607,000
Lake Area (m^2):	599,000	3,754,000
Volume (m^3):	3,146,179	24,845,058
Watershed Area/Lake Area:	22.8	9
Areal Water Load (m/yr):	14.2	5.5
Residence Time (yr)	0.37	1.19
Flushing rate (yr^{-1}):	2.68	0.84
Downstream Waterbody:	Lake Waukewan	Meredith Bay

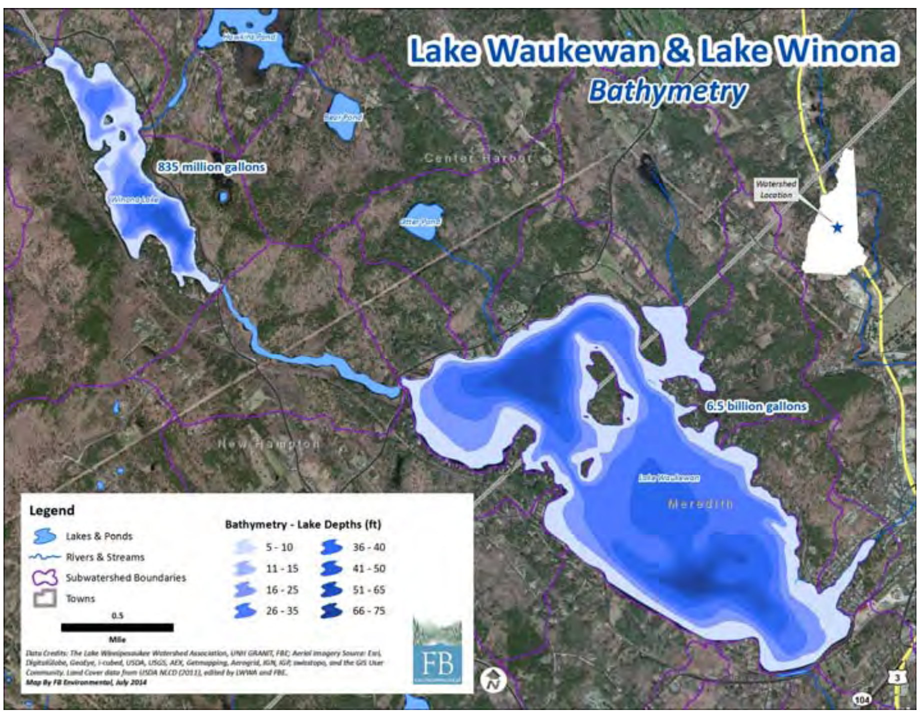


Figure 1. Bathymetry map for Lake Winona and Lake Waukewan

Lake Level Management

NHDES classifies Lake Waukewan as a "natural lake with a dam". A lake level investigation conducted by the NHDES Dam Bureau from 2008 to 2011, *"determined that a summer recreational level of 540.0 feet on Lake Waukewan is protective of the ecology of both Lake Waukewan and Lake Winona and strikes a proper balance among the many factors that NHDES must consider including balancing the interests of those whose use and enjoyment of the lakes are affected by high lake levels, and those whose use and enjoyment are affected by low lake levels"*. In addition, NHDES allows for the drawdown of the lake for flood control to an elevation of 538.5 feet. Drawdown begins Columbus Day of each year with the goal of refilling Lake Waukewan to its summer level of 540.0 feet by May 15th (NHDES, 2011: Lake Waukewan Notice of Decision – Final Operating Level). A copy of the complete Lake Waukewan Notice of Decision can be found in Appendix D.

Surface Water Quality Criteria

In New Hampshire, designated uses and the water quality to protect those uses are regulated through the Water Quality Standards, which include RSA 485-A:8 - the Classification of Water, and Env-Wq 1700 - the Surface Water Quality Regulations. RSA 485-A:8 establishes that all New Hampshire surface waters are classified as either Class A or Class B waters, and specifies certain minimum surface water quality criteria for each classification. The Surface Water Quality Regulations further protect and maintain New Hampshire's waters through the identification of designated uses, anti-degradation provisions, and additional numeric and narrative water quality criteria. The designated uses for New Hampshire waters are:

1. Aquatic Life
2. Fish and shellfish consumption
3. Drinking water supply
4. Primary and secondary contact recreation (swimming and boating)
5. Wildlife

The State of New Hampshire has set water quality standards for nutrients based on the aquatic life designated use of the waterbody (Table 2).

Table 2. Total Phosphorus (TP) and Chlorophyll-*a* (Chl-*a)* Criteria for Aquatic Life Designated Use

Trophic State	TP (µg L^{-1})	Chl-*a*(µg L^{-1})
Oligotrophic	< 8.0	< 3.3
Mesotrophic	<= 12.0	<= 5.0
Eutrophic	<= 28	<= 11

Assessment Units (AU) are the basic unit of record for water quality assessments that use all available data to report whether or not a waterbody is meeting standards. Rivers and streams, lakes and ponds, wetlands, and segments or sections thereof, each have individual assessment unit IDs. Water quality is tracked by assessment unit for the purpose of reporting to the public.

Lake Waukewan and Lake Winona Water Quality Summary

An analysis of the existing water quality data available for the last ten years (2004-2013) for Lake Waukewan and Winona Lake was performed to determine the median total phosphorus (TP), median chlorophyll-*a* (Chl-*a*) values, and median water clarity (secchi disk depths) for each lake to determine if the waters of each lake meet the Tier 2 High Quality Water criteria set by the NH Department of Environmental Services (NHDES).

TROPHIC STATE

Currently, Lake Waukewan is classified as oligotrophic (low productivity) and Lake Winona as mesotrophic (moderate amount of nutrients)

The major source of the water quality data comes from measurements and samples collected by volunteers under the NHDES Volunteer Lake Assessment Program (VLAP). Lake Winona has one deep water site, WINNWHD; sampling frequency varies year to year, from a minimum of one to a maximum of three samples collected June through September. Two deep water sites are monitored on Lake Waukewan, WAUMERMD – Mayo Station N, WAUMERWD – Winona Station S; approximately three samples are collected each season, monthly from July through September. There is also a shallow site WAUMERP-Perkins Cove on Lake Waukewan that is sampled; however, data from shallow lake sites is not included in the assessment (Figure 2).

Phosphorus and chlorophyll-*a* data collected from the epilimnion (upper surface layer) between May 24 and September 15 are used to determine the summer median TP and Chl-*a* values for each waterbody. The median values for each water quality parameter (TP, Chl-*a*, Secchi depth) for Lake Waukewan (Table 3) were arrived at by first determining the median value of each water quality parameter for each site sampled during 2004 to 2013; the median of the two sites was then used to represent the overall lake value for the parameter.

As mentioned in Section 1.2, both Lake Waukewan and Lake Winona are impaired for low dissolved oxygen concentrations and saturation in the bottom depths. Both lakes are classified as Class A waters. NHDES water quality standard for DO for a Class A waterbody is 6 mg/L, or 75% minimum daily average saturation. The trophic point system for dissolved oxygen looks at the percentage of the hypolimnion that is anoxic and assigns points accordingly. In addition, for Class A waters, the point system looks at the dissolved oxygen values (DO) throughout the entire water column except for the bottom meter (Table 4).

Summaries of the annual water quality data for each lake can be accessed at the NHDES website http://des.nh.gov/organization/divisions/water/wmb/vlap/annual_reports/2015/lake-reports.htm. In addition, the NHDES Surface Water Quality Assessment Program produces Watershed Report Cards every two years which provide an analysis of the extent to which lakes and ponds provide for the protection and propagation of a balanced population of shellfish, fish, and wildlife, and allow recreational activities in and on the water (http://des.nh.gov/organization/divisions/water/wmb/swqa/report_cards.htm).

Table 3. Summary of water quality data for 10-year period (2004-2013) for Lakes Waukewan and Winona.

		Sampling Location		
Parameter	***Reading***	**Waukewan - Deep Spot N**	**Waukewan - Deep Spot S**	**Winona - Deep Spot**
Total Phosphorus (µg/L)	Min	3.0	3.0	4.0
	Max	9.0	10.0	8.3
	10-yr Median	**5.6**	**5.5**	**7.2**
Secchi Disk Transparency (m)	Min	4.2	4.5	3.0
	Max	10.0	8.9	7.2
	10-yr Median	**6.7**	**7.1**	**5.5**
Chlorophyll-*a* (µg/L)	Min	0.2	0.2	0.9
	Max	6.8	6.5	13.0
	10-yr Median	**2.6**	**2.2**	**4.0**

Table 4. Summary of Dissolved Oxygen data for 2004-2015 for Lakes Waukewan and Winona.

	Depth of DO Depletion (<2 mg/L DO)		
Year	**Wauk N**	**Wauk S**	**Winona**
2004	18	*Not Anoxic*	10
2005	17	*Not Anoxic*	10.5
2006	18	*No Data*	11
2007	19	*Not Anoxic*	10
2008	15	18	10
2009	*Not Anoxic*	17.5	12
2010	15	13	*Not Anoxic*
2011	*Not Anoxic*	*Not Anoxic*	11
2012	*No Data*	*No Data*	8
2013	19	*Not Anoxic*	10
2014			
2015	*Not Anoxic*	*Not Anoxic*	12
Max Depth Reading	**20**	**20**	**13**
Avg Depth Anoxic (m)	**17.3**	**16.2**	**10.3**
Avg Depth Anoxic (ft)	**56.7**	**53.0**	**33.7**

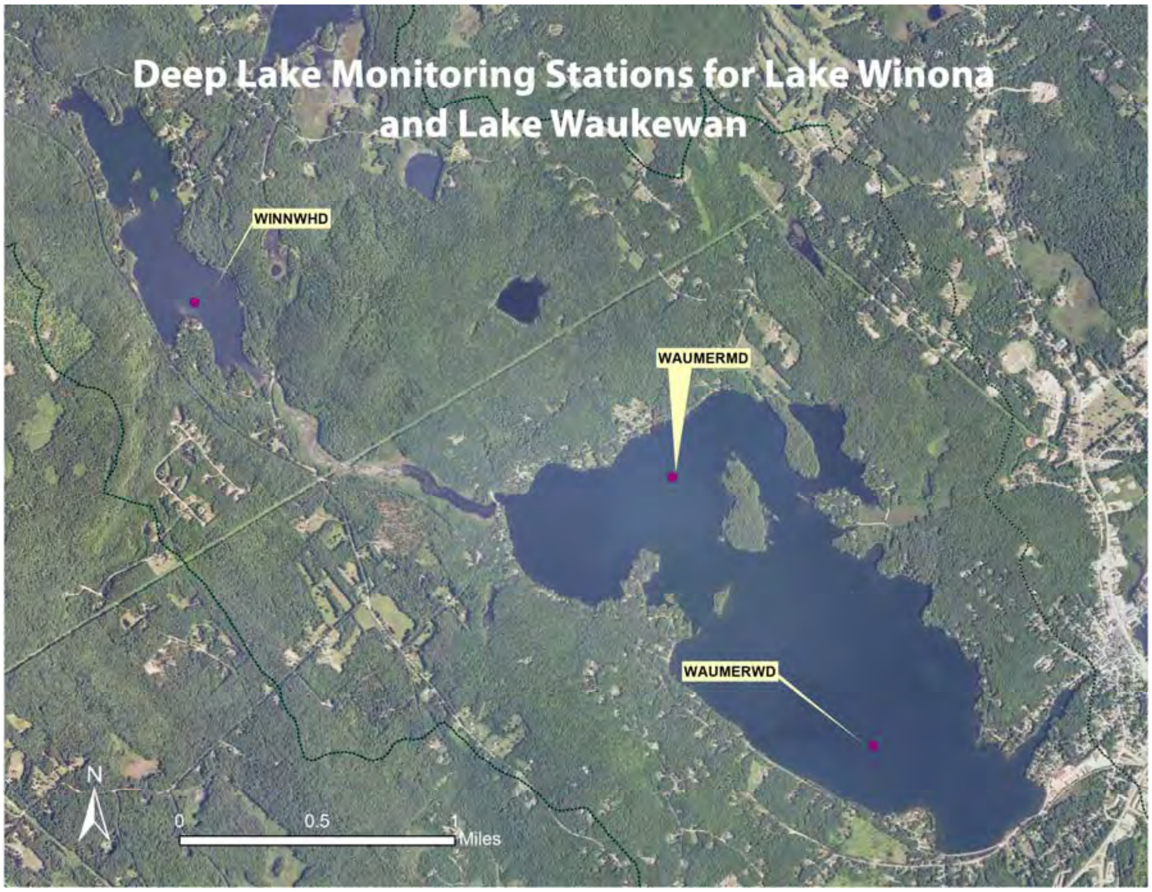
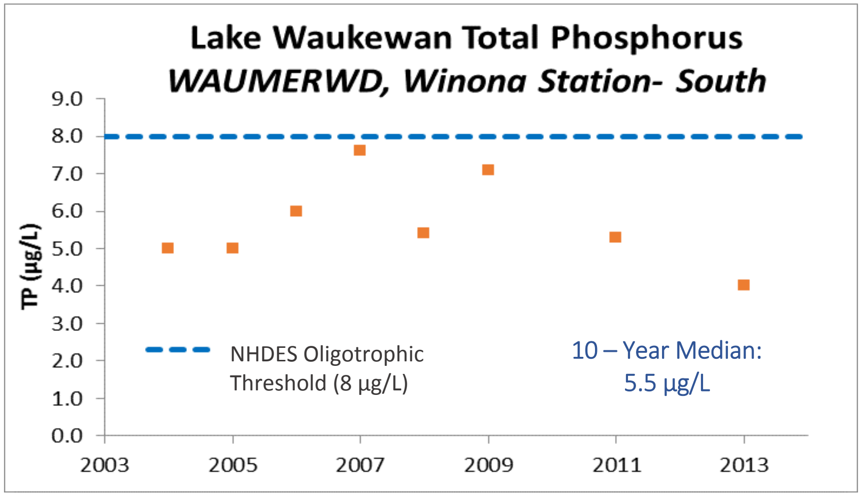
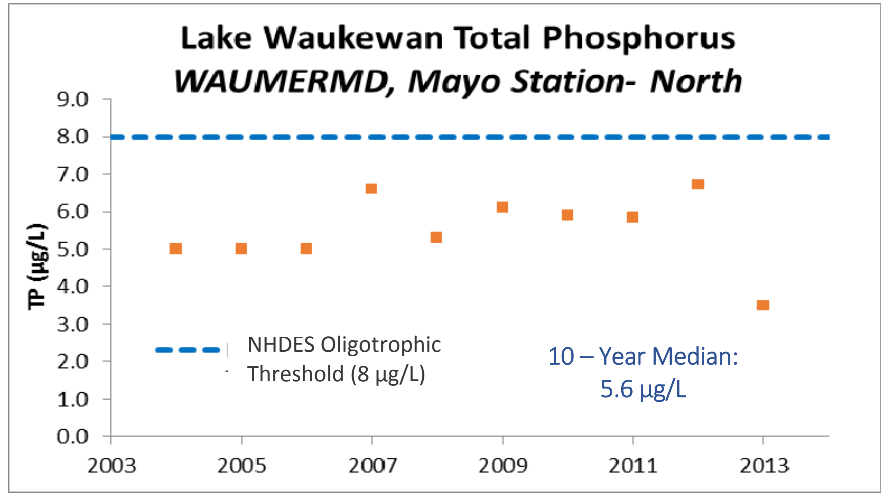


Figure 2: Map showing locations of deep sampling stations on Lake Winona and Lake Waukewan.

Figure 3. 10-Year Median Total Phosphorus Summer Epilimnion Concentrations, Deep Spots, Lake Waukewan and Winona





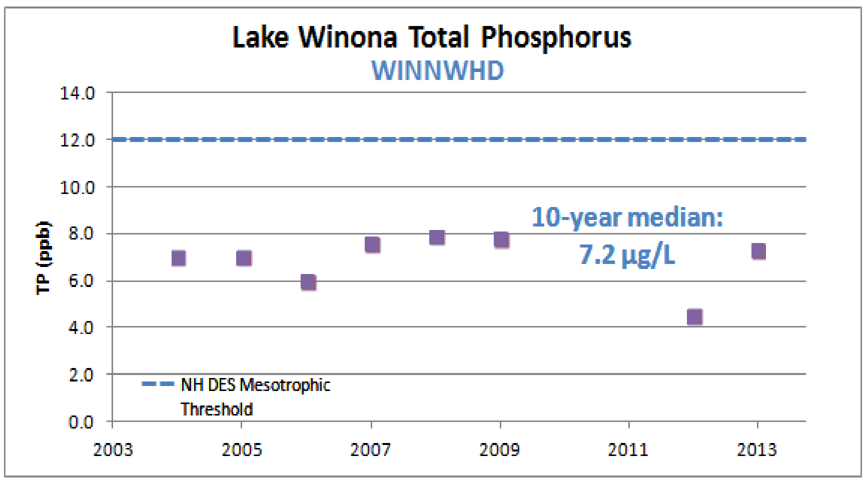
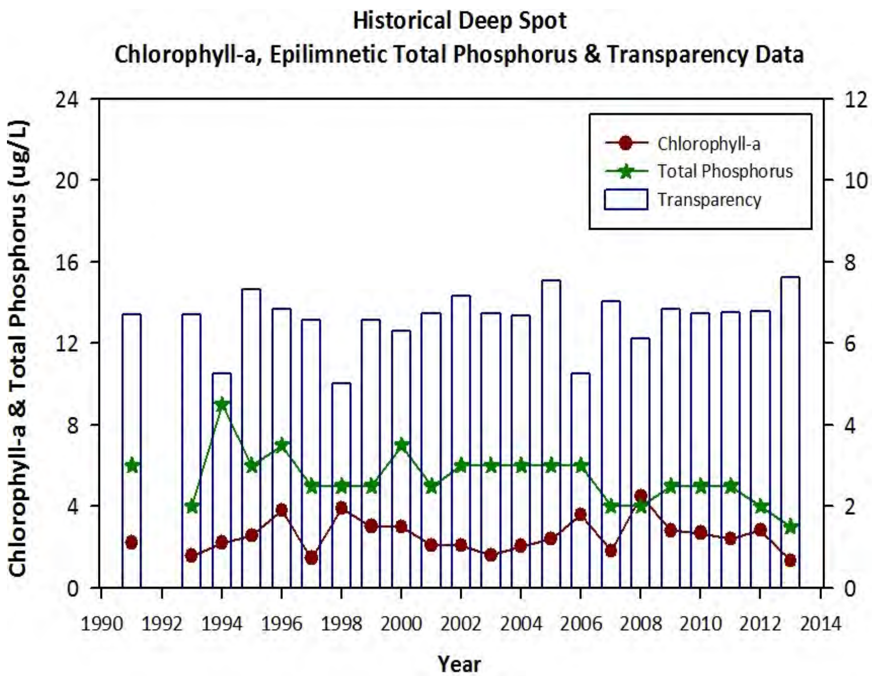
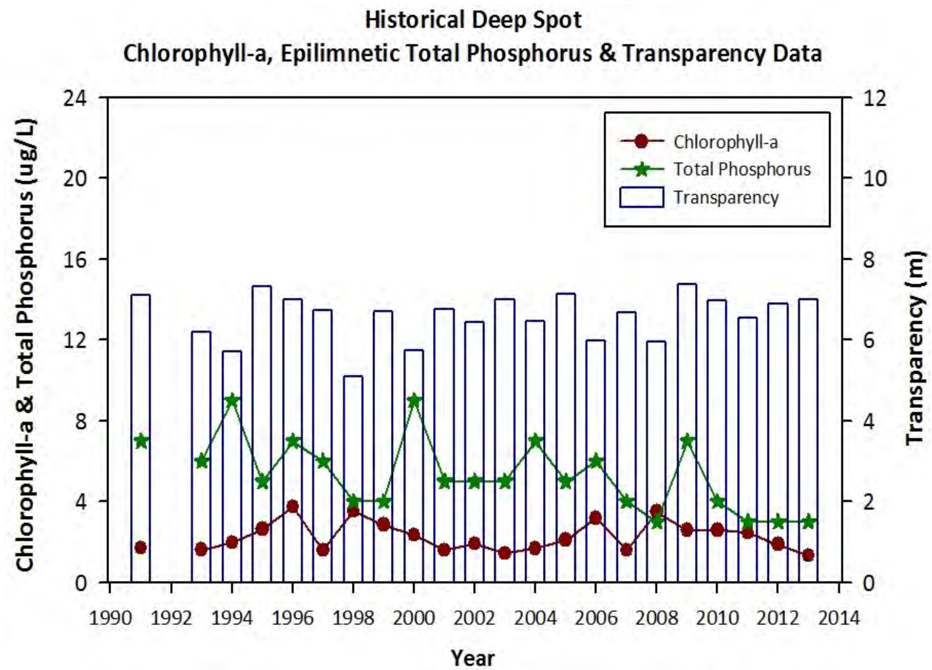


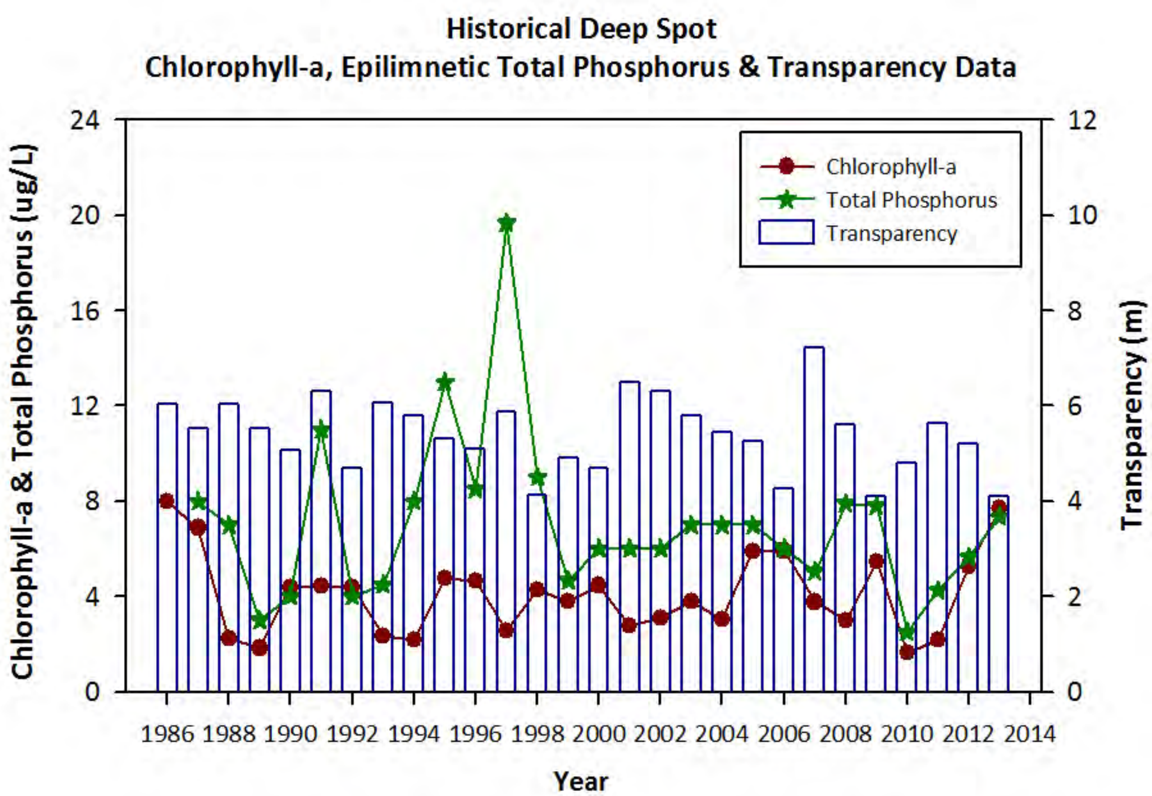
Figure 4. Historical Water Quality Data for Lake Waukewan and Lake Winona



Lake Waukewan – WAUMERMD, Mayo station (north)



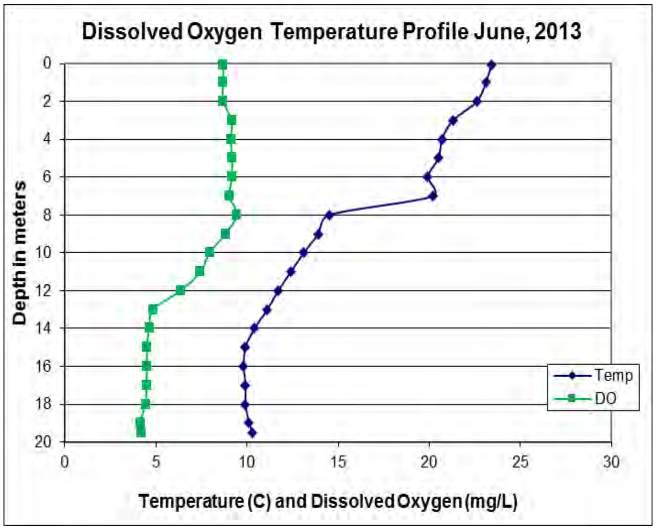
Lake Waukewan – WAUMERWD, Winona station (south)

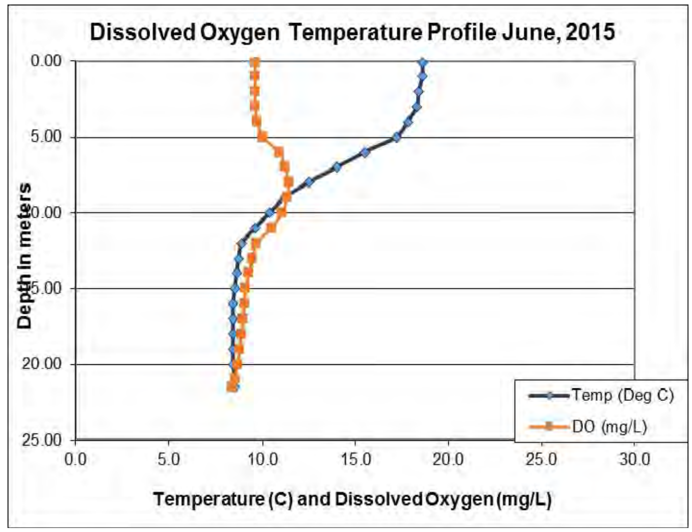


Lake Winona – WINNWHD

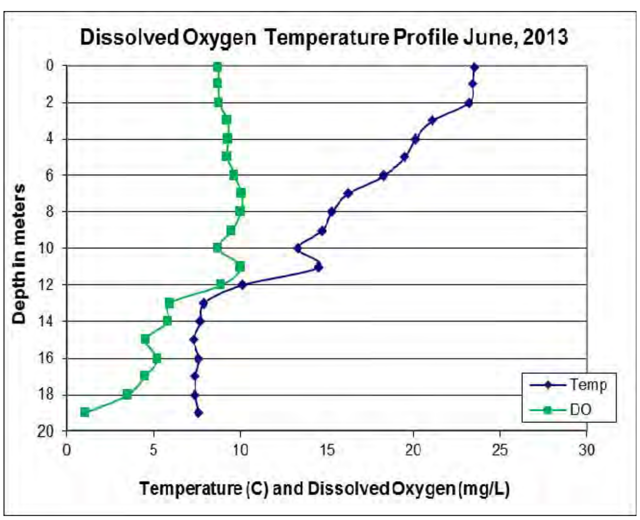
Figure 5a. Recent Dissolved Oxygen Profiles for Lake Waukewan

Lake Waukewan – WAUMERWD, Winona station (south)





Lake Waukewan – WAUMERMD, Mayo station (north)



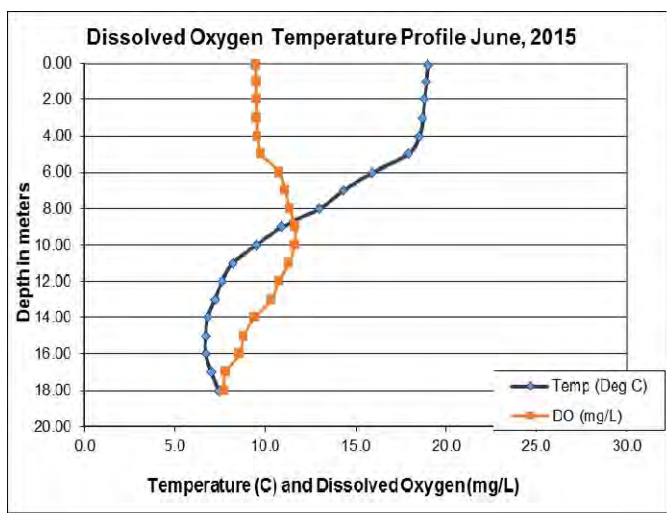
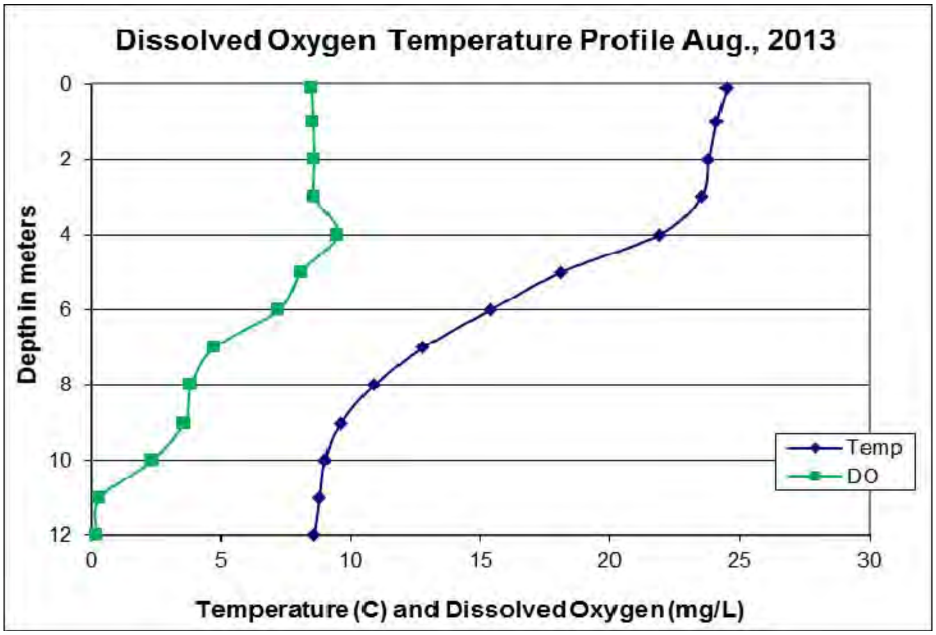
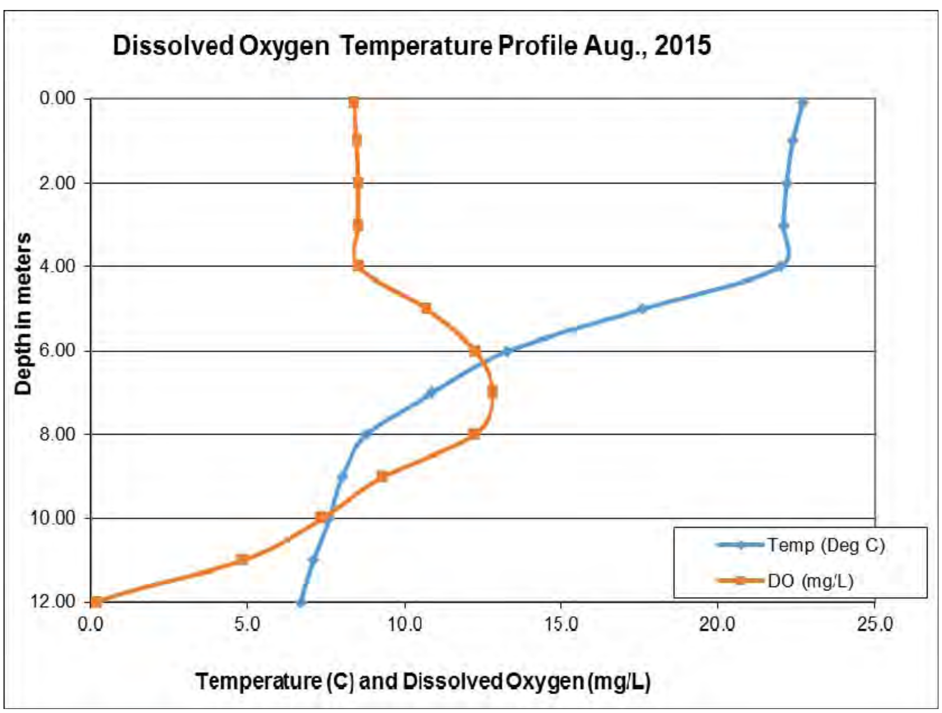


Figure 5b. Recent Dissolved Oxygen Profiles for Lake Winona

Lake Winona – WINNWHD





Tributary data were gathered from NHDES OneStop (Table 5). Mean and median total phosphorus values have been calculated for all monitoring sites within the study area watershed, assigned to their appropriate subwatersheds, and were used to evaluate the movement of phosphorus through the contributing watersheds of the study lakes.

Table 5. Statistics for lake tributaries in the study watershed (TP data in µg/L).

Lake Waukewan		*Lake Winona*	
Perkins Cove TP Data 1991-2013		**Northern Inlet TP Data 1987-2013**	
min	2.0	*min*	5.0
max	15.0	*max*	50.0
median (all)	6.0	*median (all)*	14.0
Recent Median (2004-2013)	6.2	*Recent Median (2004-2013)*	7.0
Snake River TP Data 1991-2013		**Hawkins Pond Inlet TP Data 1987-2013**	
min	1.0	*min*	5.0
max	31.0	*max*	47.0
median (all)	8.3	*median (all)*	14.0
Recent Median (2004-2013)	7.0	*Recent Median (2004-2013)*	10.0
Sayward Brk TP Data 2006-2007		**Heights Brk TP Data 2000-2013**	
min	8.9	*min*	5.0
max	44.0	*max*	103.0
*median (all)**	21.6	*median (all)*	7.4
**very limited data*		*Recent Median (2004-2013)*	7.4
Reservoir Brk TP Data 2006-2007			
*median (all)**	1.1		
**very limited data*			

2.5 Assimilative Capacity Analysis

The assimilative capacity of a water body describes the amount of pollutant that can be added to that water body without causing a violation of the water quality criteria. The water quality nutrient criterion for phosphorus has been set at 8µg/L for an oligotrophic waterbody (high quality water) and <=12 µg/L for a mesotrophic waterbody. The criteria for chlorophyll-*a* is <3.3 µg/L for an oligotrophic waterbody, and <= 5.0 µg/L for a mesotrophic waterbody. The NHDES requires 10% of the state standard to be kept in reserve; therefore, with regards to phosphorus, levels must remain below 7.2 µg/L for oligotrophic and < 10.8 µg/L for mesotrophic waterbodies to be in the Tier 2 High Quality Water category. An example of the calculation for an oligotrophic classed waterbody is shown below.

Assimilative Capacity (AC) for Total Phosphorus (TP)

- Total AC = Water Quality Standard (8 µg/L TP) – Best Possible WQ (0 µg/L TP) = 8.0 µg/L TP
- Reserve assimilative capacity = 0.10 x Total AC = 0.8 µg/L TP
- Remaining assimilative capacity = 7.2 µg/L – Existing WQ

An analysis of a waterbody's assimilative capacity is used to determine the total assimilative capacity, the reserve assimilative capacity, and the remaining assimilative capacity of each water quality parameter being considered. This information is then used to determine water quality goals and actions necessary to achieve those goals. The assimilative capacity analysis is conducted in accordance with the Standard Operating Procedure for Assimilative Capacity Analysis for New Hampshire Waters.

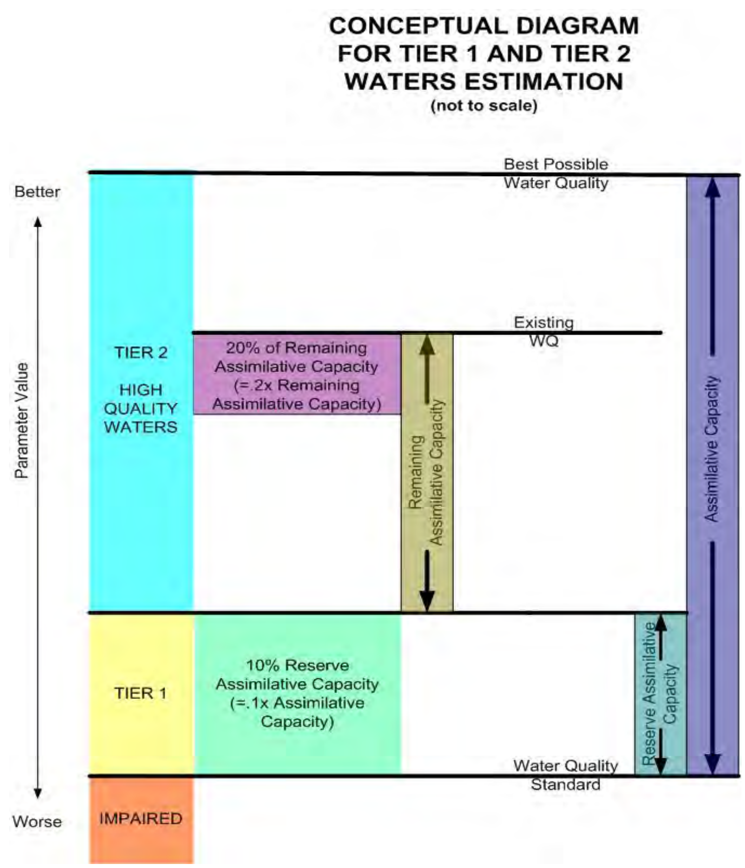


Figure 6. Conceptual diagram for the determination of Assimilative Capacity for a waterbody.

Results of Assimilative Capacity Analysis

The assimilative capacity analysis determined that both lakes are categorized as Tier 2 for both total phosphorus and chlorophyll-*a*, the highest water quality category designation possible. Tier 2 indicates that the lakes are not only below the threshold value of phosphorus and chlorophyll-*a* for their trophic class, but that they are also below the reserve assimilative capacity threshold for their assigned trophic class for these two parameters (Table 2). The other assimilative capacity designations are *Tier 1*, which indicates that a lake is below the water quality threshold but within the reserve assimilative capacity (buffer) for their trophic class; and *impaired*, meaning that the lake has exceeded the water quality standard.

Although Lake Waukewan and Lake Winona would not be considered impaired for total phosphorus or chlorophyll-*a*, it must be remembered that they are impaired for dissolved oxygen (DO) as the NHDES water quality standard for DO for a Class A waterbody is 6 mg/L, or 75% minimum daily average saturation. Both lakes have recorded low dissolved oxygen concentrations and saturation levels at the deeper depths (Table 4).

<u>Lake Winona</u>

The existing median TP value for Lake Winona of 7.2 µg/L results in a remaining assimilative capacity of 3.6 µg/L, which qualifies Lake Winona in Tier 2 for a mesotrophic waterbody. The ten-year Chl-*a* median value of 4.0 µg/L is also below the NH State Nutrient Criterion of <=5.0 µg/L for the aquatic life designated use set for a mesotrophic water body.

<u>Lake Waukewan</u>

The existing median TP value for Lake Waukewan of 5.6 µg/L results in a remaining assimilative capacity of 1.6 µg/L, which qualifies Lake Waukewan in Tier 2 for an oligotrophic waterbody. The existing Chl-*a* median value of 2.4 µg/L is also below the NH State Nutrient Criterion of <3.3 µg/L for the aquatic life designated use set for the oligotrophic classification.

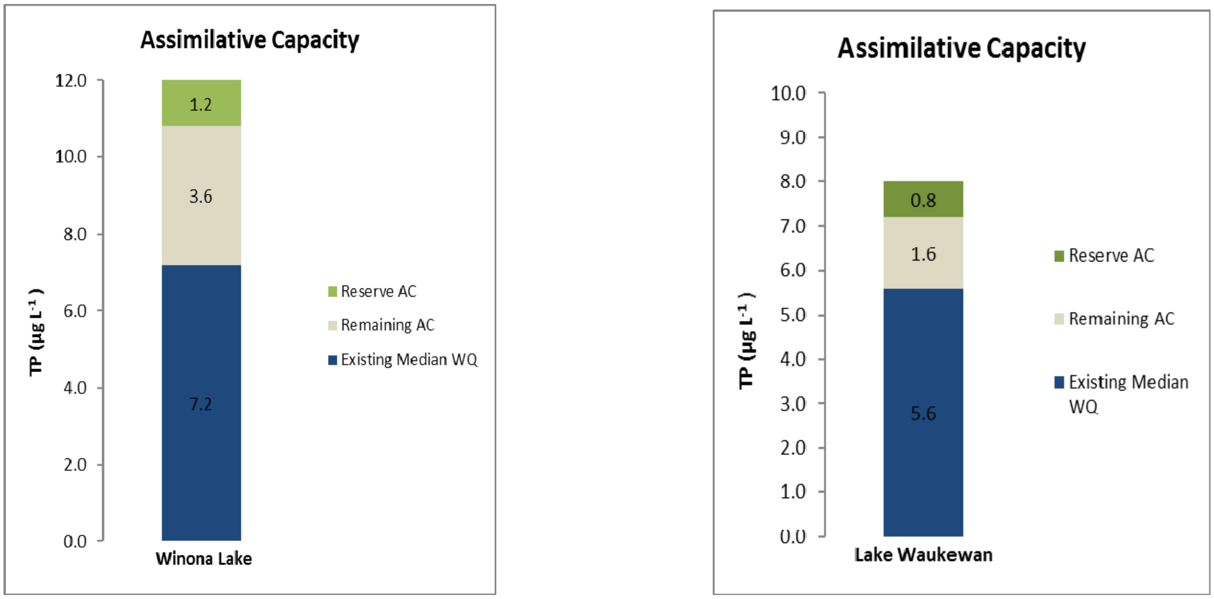


Figure 7. Graph depicting the results of the Assimilative Capacity analysis for total phosphorus for Winona Lake and Lake Waukewan

3.0 Watershed Assessment

3.1 Description of the Study Area

The Lake Waukewan and Winona watershed (Figure 8) encompasses approximately 8,300 acres or 13 square miles of forested and developed land in Belknap and Grafton Counties. The watershed is part of the larger Lake Winnipesaukee watershed and drains to Meredith Bay to its south. It includes portions of five towns: Meredith, New Hampton, Center Harbor, Holderness, and Ashland, New Hampshire. Watershed boundary data was obtained from GRANIT, the New Hampshire GIS clearinghouse maintained by the University of New Hampshire. The Watershed boundaries were edited to accommodate the goals of the Lake Loading Response Model (LLRM) and the watershed restoration plan.

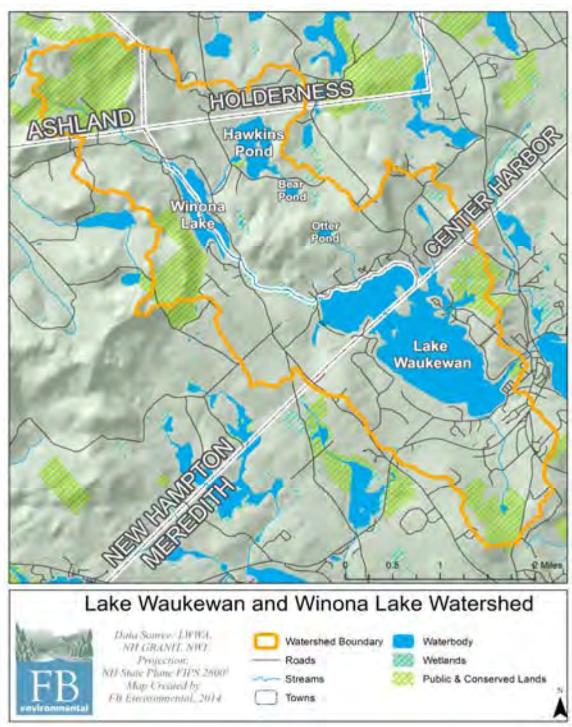


Figure 8. Lake Waukewan and Winona Watershed

Communities: Thirty-three percent (33%) of the watershed area lies within the town of Meredith, followed closely by Center Harbor and New Hampton at 29% and 24% respectively.

The small land area of Ashland and Holderness that lies within the watershed is characterized by forested and agricultural land. Seventy-nine percent (79%) of the land area that lies within Ashland's town boundary is in conservation, which is important as the headwaters to Lake Winona are located here (Table 6).

Municipality	Area (acres)	Percent of Watershed Area (%)
Ashland	699	8.4
Center Harbor	2,370	28.6
Holderness	527	6.4
Meredith	2,732	33
New Hampton	1,951	23.6

Table 6. Municipalities, associated acreage and percent of land cover in the Waukewan Watershed, New Hampshire.

Population and Growth Trends: The Lake Waukewan and Winona watershed is moderately developed with urban and concentrated residential development located mostly in the southern portion of the watershed in the Town of Meredith, NH (Figure 9). Population trends between 2000 and 2010 census data show an increase in population in all five watershed communities (Table 7) (NH Office of Energy & Planning, 2013). An increase in population often leads to increases in developed land which may lead to increased stormwater pollution if not properly planned and managed.

Table 7. Change in Population from 2000-2010 of the five Watershed Municipalities

Town	2000 Census	2010 Census	% Change
Meredith	5,943	6,241	5%
New Hampton	1,950	2,165	11%
Center Harbor	996	1,096	10%
Ashland	1,955	2,076	6%
Holderness	1,930	2,108	9%

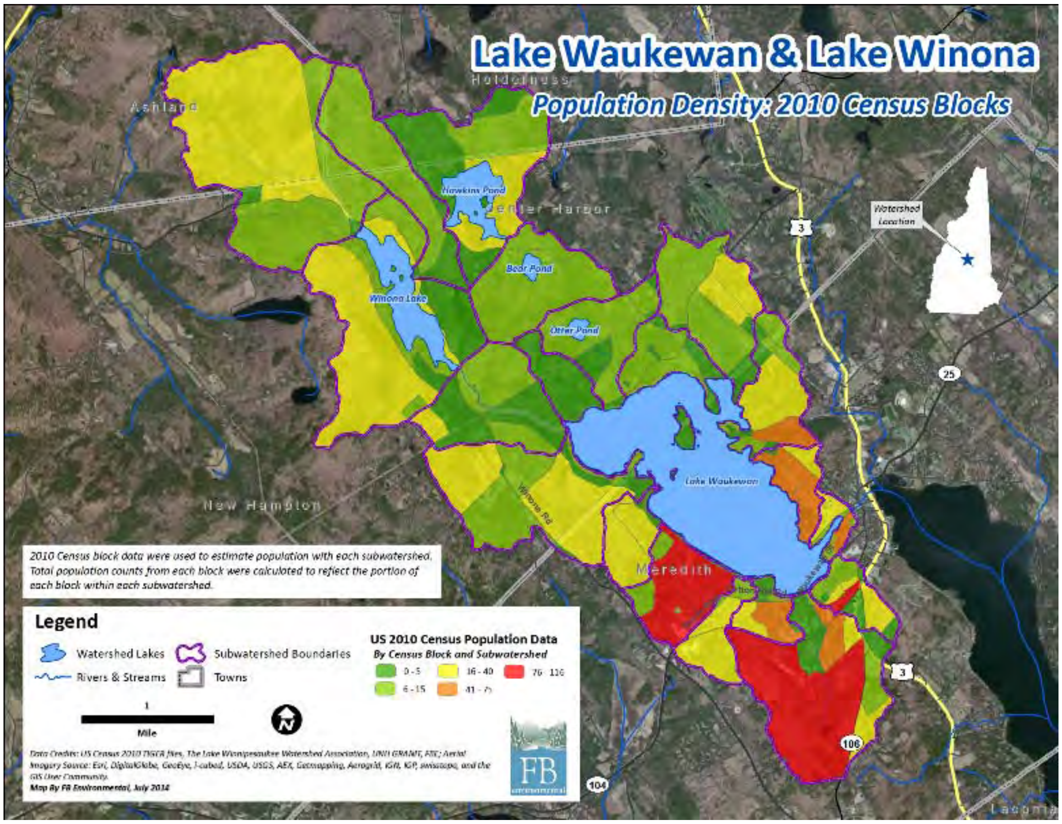


Figure 9. Population density in the study area, by US Census (2010) block, calculated for each sub-watershed.

Climate: Climate in the lakes region of New Hampshire is considered continental due to prevailing westerly winds, and highly variable due to the mid latitude location. Four distinct seasons are experienced with wide ranges in both daily and annual temperatures. Due to this factor the lakes are dimictic, turning over twice each year, once in the spring, and again in the fall, and will stratify during the summer months.

Precipitation for the area is calculated from long-term climate data from several weather stations near the watershed. A weighted yearly precipitation total, based on geographical positioning of the weather stations that compensates for local weather patterns, is calculated at 48.65 inches (1.24 m) for input in the current Lake Load Response Model (LLRM).

Topography: Terrain within the watershed ranges from steep slopes (47%) to rolling terrain. The average slope in the watershed is approximately 12%. Elevations range from 1,500 feet on Beech Hill near Sky Pond in New Hampton, to 540 feet at the Lake Waukewan outflow point in Meredith. *(excerpted from the Management Plan for the Waukewan Watershed)*

Soils: The mixture or composition of soil components (clay, loam, sand, silt) impacts the ability of the soil to infiltrate water, and thus reduce runoff. The USDA Natural Resource Conservation Service (NRCS) groups soils into four main hydrologic soil categories (A, B, C, D) based on estimates of runoff potential (U.S.D.A Natural Resource Conservation Service, 2007).

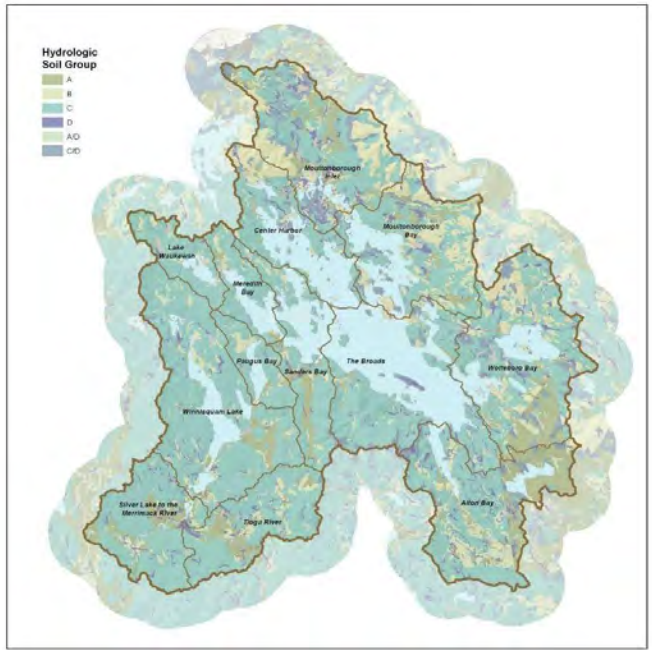


Figure 10. Map depicting Soil Hydrologic Groups for the Winnipesaukee River watershed.

The majority of soils in Belknap County fall within Hydrologic Soil Group C (Figure 10). Group C soils have a slow infiltration rate when thoroughly wet and therefore a moderately high runoff potential. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. Water transmission through the soil is somewhat restricted. Group C soils typically have between 20 to 40 percent clay and less than 50 percent sand and have loam, silt loam, sandy clay loam, clay loam, and silty clay loam textures (U.S.D.A Natural Resource Conservation Service, 2007).

Ponds and Streams: In addition to Lakes Waukewan and Winona, the watershed also includes eight tributaries, various wetlands, and three small ponds: Hawkins Pond, Bear Pond, and Otter Pond,. Otter Pond flows to a tributary that empties directly into Lake Waukewan. Bear Pond flows into Hawkins Pond which then flows into Winona Lake (Figure 11).

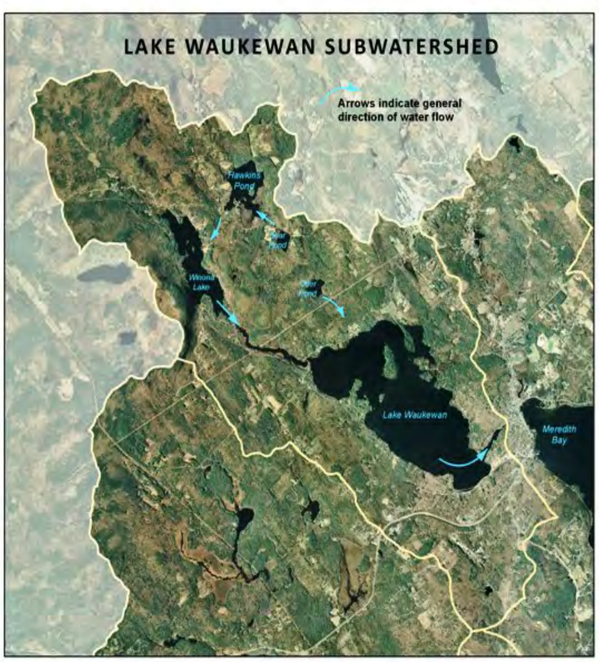


Figure 11. Direction of water flow of ponds and lakes within the Waukewan Watershed.

Fisheries: Lake Waukewan and Winona provide excellent habitat for a variety of cold and warm water fisheries. Lake Waukewan is classified as both a coldwater and warm water fishery by the NH Fish and Game Department and contains stocked rainbow trout, smallmouth bass, chain pickerel, horned pout and white perch among other species. Lake Winona is classified as a coldwater fishery and provides habitat for both rainbow trout and brook trout. However, Lake Winona also has a warm water fishery component and contains large and small mouth bass (NHF&G Dept., 2012). Both lakes and the various streams located within the watershed are valued for their beauty, recreational opportunities, ecological richness, and contribution to the local economy.

A summary of the fish surveys of the major tributaries to Lake Winona and Lake Waukewan (Figure 12) conducted in June 2010 by the NH Fish and Game Department can be found on the Winnipesaukee Gateway website at http://winnipesaukeegateway.org/lake-management/plan-2/appendices/.

For more information regarding the soils, wetlands, streams and tributaries in the Waukewan Watershed please refer to the 2005 *Management Plan for the Waukewan Watershed*.

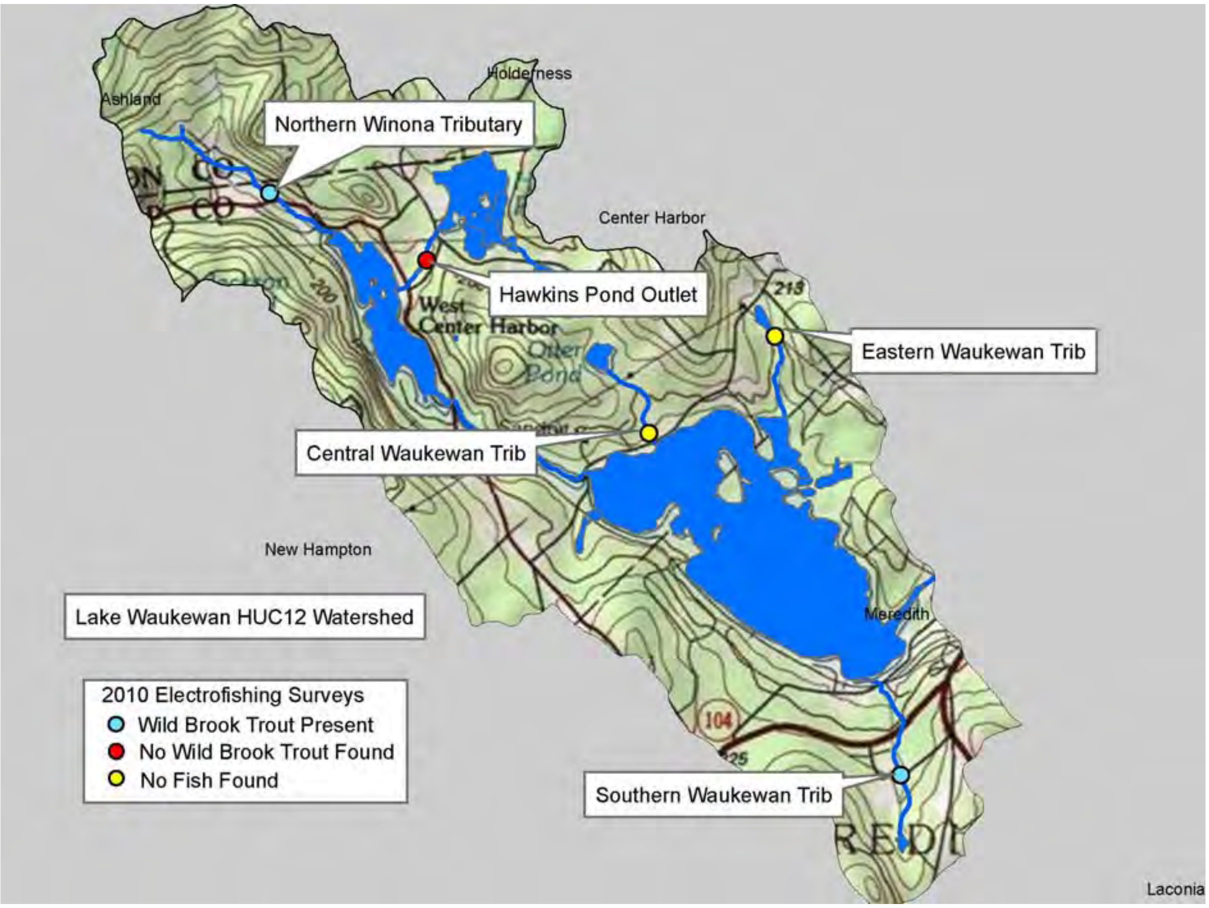


Figure 12. Map of 2010 fish stream survey locations in the Lake Waukewan watershed.

3.2 Subwatershed Delineations

In order to determine drainage flow and assess pollutant load, the Waukewan watershed was delineated into subwatersheds, including separated drainage areas for Lake Winona. Watershed boundary data obtained from the Lake Winnipesaukee Association (LWA) were edited to accommodate the goals of the LLRM and the watershed restoration plan. Further watershed delineations were made using digital topographic maps and the digital elevation model (DEM) obtained from GRANIT, the New Hampshire GIS clearinghouse maintained by the University of New Hampshire (Figure 13).

A total of twenty-one (21) subwatersheds were delineated; five (5) for the Lake Winona watershed and sixteen (16) subwatersheds which drain directly to Lake Waukewan. The Snake River subwatershed receives drainage from the five Lake Winona subwatersheds through the outlet of Lake Winona and therefore is the largest source of water inflow to Lake Waukewan.

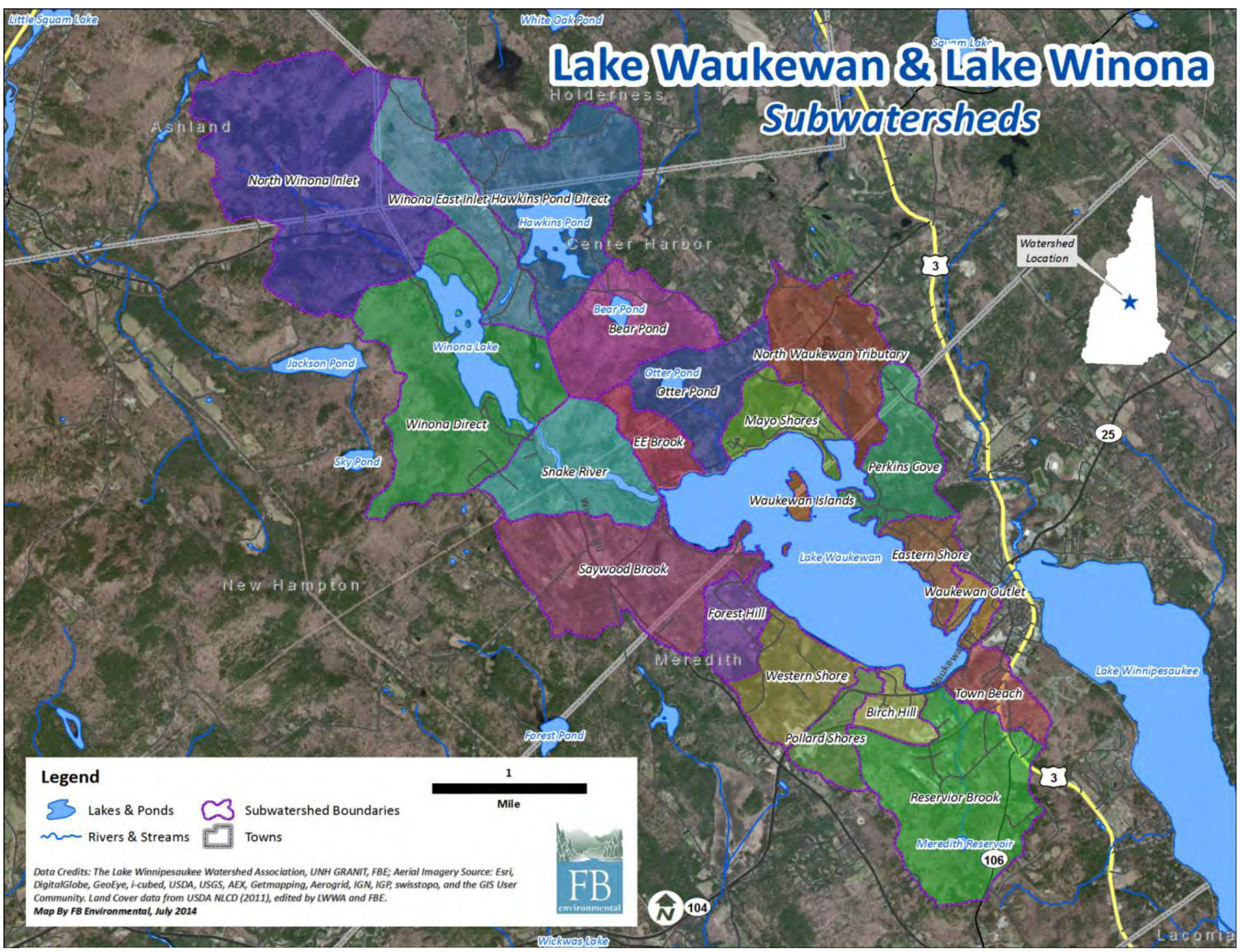


Figure 13. Subwatersheds in the study area.

3.3 Land Use/Land Cover

Land cover data is used to estimate the transport and retention patterns of phosphorus as it moves through a watershed. Land cover data (NLCD 2011) for the study area has been verified and edited as necessary using current aerial imagery (Figure 14). Forested land is the predominant land cover in both the Lake Waukewan and Winona Lake watersheds at 71% and 86% respectively. Lakes, ponds, and wetlands comprise the second largest land cover in both watersheds, with developed land area coming in third (Table 8, Figure 15). Land use data for the individual subwatersheds are listed in Table 9. Note that the land areas for the Waukewan watershed in Table 8 and Figure 15 include Winona's watershed area.

Table 8. Comparison of land area in each subwatershed (data are in hectares).

Land Use/Land Cover	Winona	Waukewan
Developed	62.3	329.9
Agriculture	23.5	56.6
Forest	1168.7	2429.0
Wetlands/Lakes	108.2	515.5
Disturbed Land	0.7	19.0

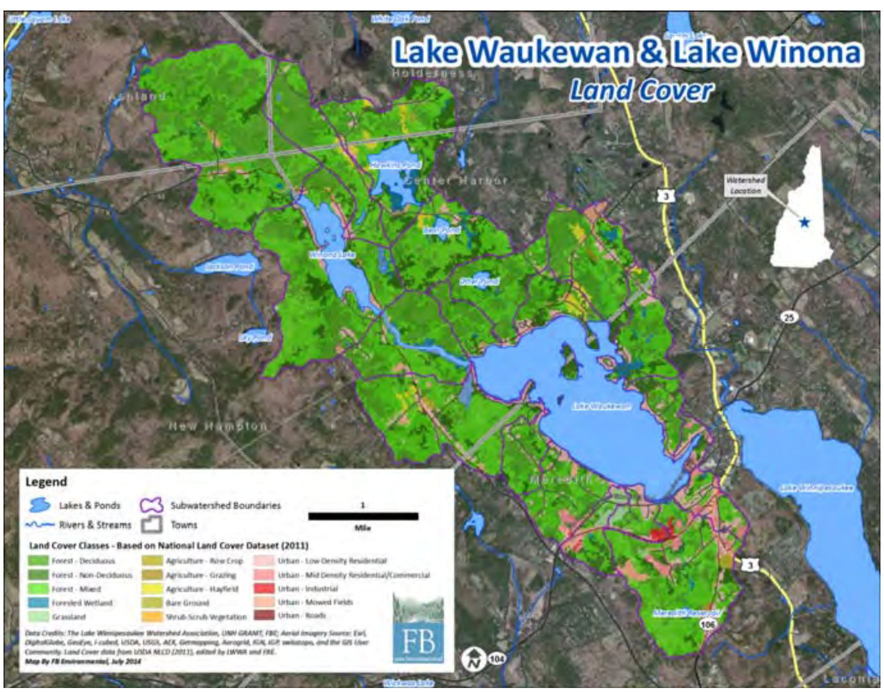
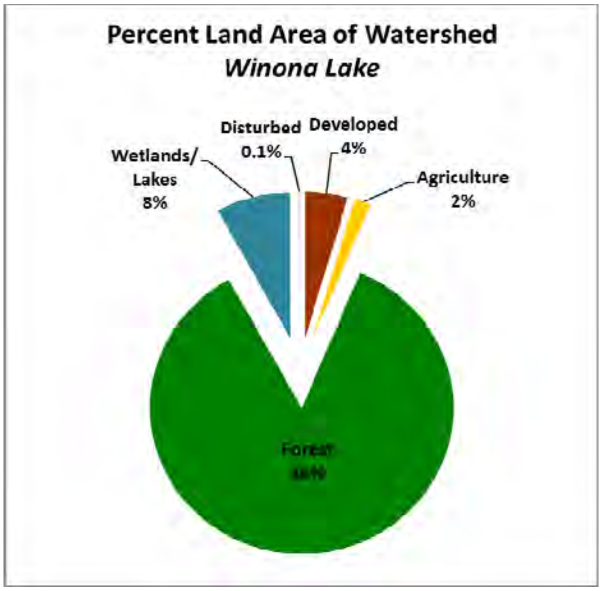


Figure 14. Land Cover in the study area (NLCD 2011, with edits by LWA and FBE).



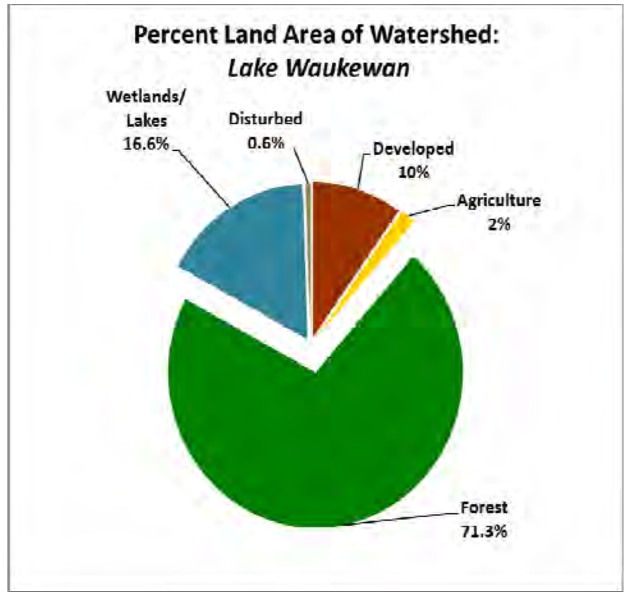


Figure 15. Percent land area for the Lake Winona and Lake Waukewan Watersheds

A breakdown of the 'Developed' portion of the land area indicates low density residential land use makes up the largest land use in each watershed at 56.8 % in Winona and 50.8% in the Waukewan watershed (Figure 16). Mowed fields is the second largest category (20.6%) in the Waukewan watershed followed by the road network; whereas, the road network makes up the second largest urban category in the Lake Winona watershed, followed closely by mowed fields. As mentioned previously, land areas for the Waukewan watershed include Lake Winona's watershed area. There is no industrial or mid-density residential/commercial land use in the Lake Winona watershed.

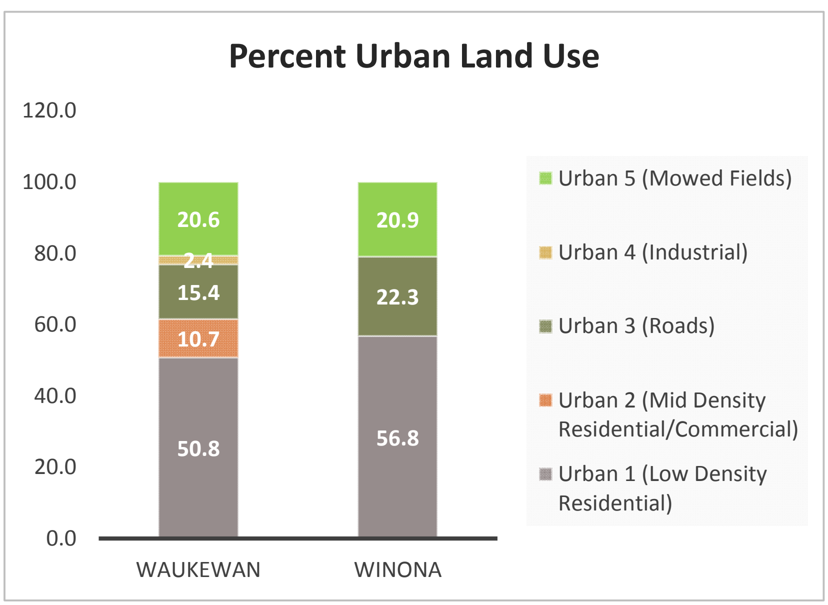


Figure 16. Breakdown of the Urban land use category by watershed.

Land Cover Type	Lake Waukewan										
	North Waukewan Tributary	Reservoir Brook	Snake River	Waukewan Direct - Birch Hill	Waukewan Direct - Eastern Shore	Waukewan Direct - EE Brook	Waukewan Direct - Forest Hill	Waukewan Direct - Mayo Shores	Waukewan Direct - Otter Pond	Waukewan Direct - Perkins Cove	Waukewan Direct - Pollard Shores
Urban - Low-Density Residential	5.5	18.5	3.2	10.9	9.3	1.1	5.7	6.2	2.3	10.2	3.9
Urban - Mid-Density Residential/commercial	0.6	12.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6
Urban - Roads	3.0	6.3	1.7	2.3	2.0	1.0	1.3	3.0	0.7	1.9	1.2
Urban - Industrial	0.0	2.8	0.0	3.8	0.0	0.0	0.0	0.0	0.0	0.0	0.7
Urban - Mowed Fields	11.1	17.5	2.3	1.8	1.1	0.9	1.1	2.3	0.5	1.3	5.3
Agriculture - Row Crop	2.8	4.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0
Agriculture - Grazing	0.0	3.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Agriculture - Hayfield	6.3	0.1	0.0	0.0	0.0	0.0	0.0	7.3	0.0	1.1	0.0
Forest - Deciduous	62.6	41.9	67.9	6.2	15.3	25.7	22.1	19.1	47.4	26.1	1.1
Forest - Non-Deciduous	17.2	22.9	3.7	0.1	7.0	3.4	4.0	13.4	11.2	10.5	14.3
Forest - Mixed	49.6	144.8	61.9	11.6	16.2	19.5	27.7	19.4	47.3	47.0	17.7
Forested Wetlands	2.8	1.0	8.1	0.0	0.0	0.5	0.0	0.0	0.5	8.1	0.5
Open Water	0.3	1.0	11.2	0.1	0.6	0.4	0.0	1.3	5.4	1.7	0.0
Disturbed Land	0.0	1.6	0.0	5.5	0.0	0.0	0.0	0.0	0.0	0.9	9.4
Grand Total (ha)	**161.7**	**278.4**	**159.9**	**42.3**	**51.5**	**52.5**	**62.0**	**72.1**	**115.2**	**108.8**	**55.9**

Land Cover Type	Lake Waukewan					Lake Winona				
	Waukewan Direct - Saywood Brook	Waukewan Direct - Town Beach	Waukewan Direct - Western Shore	Waukewan Islands	Waukewan Outlet	Bear Pond	Hawkins Pond Direct	North Winona Tributary	Winona Direct	Winona East Tributary
Urban - Low-Density Residential	19.3	17.1	9.7	0.2	9.2	3.2	2.9	3.1	21.8	4.3
Urban - Mid-Density Residential/commercial	0.0	10.9	6.2	0.0	4.1	0.0	0.0	0.0	0.0	0.0
Urban - Roads	5.0	3.7	2.3	0.0	1.2	1.0	3.2	3.0	4.6	2.2
Urban - Industrial	0.0	0.3	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Urban - Mowed Fields	3.7	0.8	5.3	0.0	0.0	1.0	5.2	2.4	2.8	1.6
Agriculture - Row Crop	3.0	0.0	0.0	0.0	0.0	0.0	1.5	4.6	0.0	0.0
Agriculture - Grazing	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Agriculture - Hayfield	4.6	0.0	0.0	0.0	0.0	3.0	11.5	0.0	0.0	2.9
Forest - Deciduous	41.5	3.5	23.3	0.0	7.2	13.7	36.2	186.4	97.8	68.8
Forest - Non-Deciduous	15.4	2.2	4.1	8.1	2.8	31.0	42.7	26.9	28.9	5.5
Forest - Mixed	150.6	16.6	55.3	0.8	0.6	82.9	97.2	213.1	151.3	63.5
Forested Wetlands	0.0	0.7	0.0	0.0	0.0	6.1	11.5	3.2	1.8	0.0
Open Water	7.2	0.2	0.1	1.7	0.7	5.3	37.0	0.3	5.0	0.7
Disturbed Land	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.7	0.0
Grand Total (ha)	**250.4**	**56.1**	**107.6**	**10.8**	**25.8**	**147.2**	**249.0**	**443.0**	**314.7**	**149.6**

Table 9. Land cover statistics for subwatersheds in the study watershed. See Figure 13 for location of subwatersheds. Data are in hectares (1 hectare = 2.47 acres). Note: Open Water category does not include area for Lake Waukewan or Lake Winona.

4.0 Lake Sustainability

Lakes age naturally as they become more enriched with nutrients over time. Over eons, deep crystal clear lakes become marshes and bogs. Without the visitation of another glacier, Minnesota will someday become the "Land of 10,000 bogs". However, landscape change and human activity have the potential to increase both the rate and quantity of nutrient loading to a waterbody. A process that would naturally take 10,000 years can occur in a lifetime. Land disturbing activities; cutting timber, farming, construction, have increased the rate of nutrient enrichment of lakes, and increased their rate of aging, a process referred to as *cultural eutrophication*.

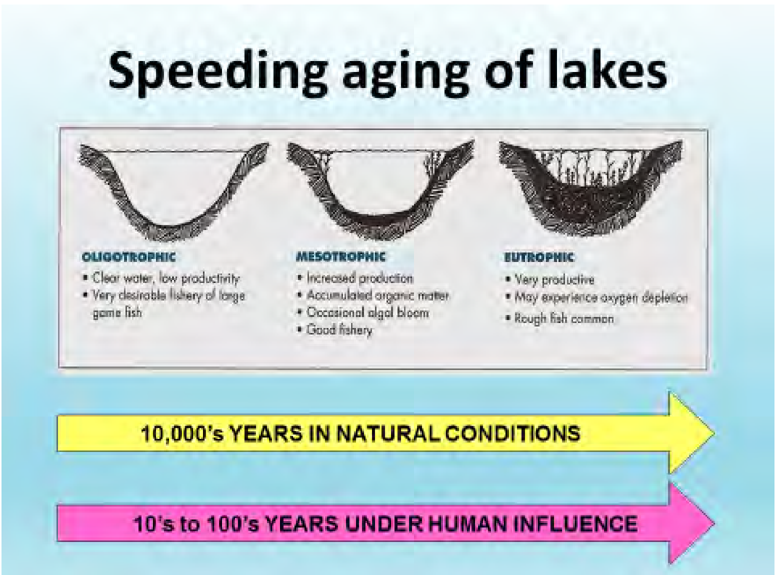


Figure 17. Graphic showing the productivity/trophic classification of lakes

Factors affecting watershed nutrient loading include climate (rainfall), watershed characteristics (slope, soil type), and land use. The ability of the receiving waterbody to assimilate the nutrient load is related to the morphometry and hydrology (volume, depth, flushing rate) of the waterbody and determines the in-lake nutrient concentrations, which in turn affect aquatic habitat and lake health (Figure 18).

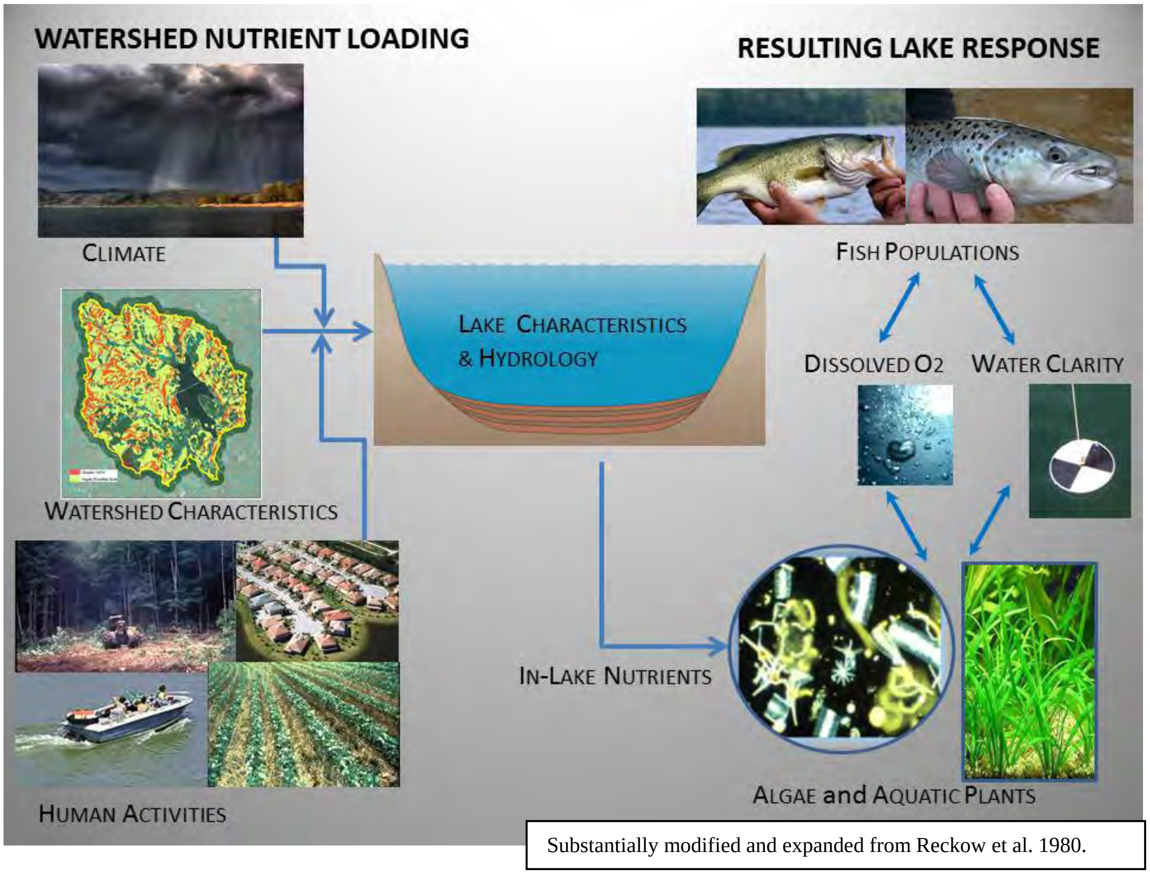


Figure 18. Generalized Watershed Nutrient Loading and Lake Response Model Schematic *(Diagram courtesy of J. Schloss, UNH Center for Freshwater Biology)*

4.1 Estimation of Current Nutrient Loading

Nutrient loading comes from several sources; atmospheric deposition, point sources, watershed loading from tributary and direct runoff, groundwater, septic systems, waterfowl, and internal loading. No point sources were identified in this study. As Lake Waukewan and Lake Winona are freshwater ecosystems, the nutrient of concern is total phosphorus (TP), which is the focus of discussion in the modeling results.

The total phosphorus budget for the Lake Waukewan and Winona sub-watersheds was determined from atmospheric, watershed, septic systems, waterfowl, internal loading and TP loadings from upstream/adjacent basins. Groundwater inputs are accounted for in the watershed loading and are not broken out separately.

Atmospheric Deposition:

Phosphorus inputs from the atmosphere were estimated using a P export coefficient of 0.11 kg/ha/year multiplied by the lake area; resulting in 41.3 kg/year TP to Lake Waukewan and 6.6 kg/year TP to Lake Winona.

Internal Phosphorus Loading:

The internal phosphorus load to both lakes was calculated using the difference in total phosphorus concentration between the epilimnion and hypolimnion in September, to reflect conditions during fall turnover (Table 10). This difference in concentration ("Accumulated TP" in Table 9) is then used to calculate "hypolimnetic TP mass accumulation" by multiplying accumulated TP by the volume of water in the hypolimnion, then converting the value to kilograms. This value is then adjusted by 50%, as it is assumed that half of the TP in the hypolimnion is particulate phosphorus from the epilimnion, and not released by lake sediment. Ideally, concentrations at spring turnover would be used to represent the initial concentration in the hypolimnion but those data are only available for one year. Additional sampling of both total and dissolved phosphorus in the hypolimnion, spring turnover phosphorus concentrations or actual sediment release of phosphorus may allow more accurate estimation of the internal load in the future.

Table 10. Internal loading calculations for Lakes Waukewan and Winona.

Parameter	*Units*	**Waukewan**	**Winona**
September epilimnetic TP concentration[1]	µg/L	6.45	7.10
September hypolimnetic TP concentration	µg/L	18.75	12.50
Accumulated TP	µg/L	12.30	5.40
Volume of hypolimnion[2]	liters	2,551,018,000	158,982,000
Hypolimnetic TP mass accumulation	kg	31.38	0.86
Adjustment for particulate vs. dissolved[3]	% fraction	0.50	0.50
Internal load	**kg**	**15.69**	**0.43**

Notes:
[1] *September epilimnetic TP concentration used because early season data were not available. Ideally, concentration at spring turnover would be used.*
[2] *volume of hypolimnion below 10 meters used*
[3] *adjustment factor assumes that 50% of TP in hypolimnion is particulate and came from epilimnion*

Waterfowl:

Presence of waterfowl is included in the model because of the potential of shore birds to directly introduce nutrients to the lake. Current estimates of waterfowl on the study lakes are based on the LLRM model recently completed on nearby Province Lake (re-calculated to account for differences in shoreline length of the present study lakes). The contribution of phosphorus to lakes by waterfowl is estimated in number of animal-years; 100 birds spending half a year on a lake = 50 bird-years. The estimate from the Province Lake model is 35 bird-years (Table 11).

Table 11. Density estimate of waterfowl along the shorelines of the study lakes, based on estimates of waterfowl on nearby Province Lake.

Lake	Shore Length (m)	# Waterfowl (bird-Years)
Province	*8,500*	*35.0*
Waukewan	16,513.0	**30**
Winona	6,122.8	**20**

Septic Systems:

Nutrient load from septic systems is calculated using mathematical models which calculate output of septic systems based on population data, estimated system age and degree of seasonal use. The septic model used in the Lake Loading Response Model (LLRM) was modified to account for distance to the waterbody as well.

In order to determine the pollutant load from septic systems a count of the number of septic systems within 250 feet of shoreline of Lake Waukewan and Winona Lake was made based on municipal tax parcel data. The majority of properties located along the southern portion of Lake Waukewan are served by municipal sewer, which is also the area of greatest residential density. A count of 181 properties with septic systems was made for Lake Waukewan, and 93 for Lake Winona. There are a number of factors to consider in calculating the potential loading from septic systems; age of the system, distance from the waterbody, number of people on the system, and the number of days it is in use. Although the majority of the properties are seasonal, due to the influx of visitors and residents, the number of people using a system during the summer months may actually be much greater than the annual average.

A review of the property tax lists for Meredith, Center Harbor, and New Hampton provided the following estimation of percent seasonal residents based on out of town or state mailing addresses. For Lake Winona 77 of the 93 properties are in seasonal use, or 83 percent. On Lake Waukewan the percent seasonal use is estimated at 71 %.

To the extent possible, distance to the lake, age of system, and seasonal use were determined from municipal and state records, but must be considered estimates. The average number of occupants for year round and seasonal use is an assumption based on data used in other models calculating nutrient load from septic systems.

The total estimated phosphorus load to Lake Waukewan from septic systems is 28.3 kg; 65% or 18 kg comes from septic systems over 25 years in age, which accounts for fifty percent (50%) of the total number of systems on the lake. The total septic load for Lake Winona is estimated at 13.6 kg; 73% or 10 kg attributed to systems over 25 years in age, which accounts for 61% of the septic systems on the lake.

Watershed Loading

An Excel-based model, known as the Lake Loading Response Model (LLRM), was used to develop a water and phosphorus loading budget for the lakes and their tributaries. The loading model also makes predictions about chlorophyll-*a* concentrations and secchi disk transparency. Water and phosphorus loads (in the form of mass and concentration) are traced from various sources in the watershed, through tributary basins, and into the lake.

The model incorporates data about land cover, watershed boundaries, point sources, septic systems, waterfowl, rainfall, and an estimate of internal lake loading, combined with nutrient export coefficients and equations from scientific literature on lakes and nutrient cycles. This information is used to determine phosphorus export by land use and therefore can be extrapolated to estimate the number of kilograms (or pounds) of phosphorus that needs to be prevented from entering the lake in order to improve water quality.

There are several limitations to the model; 1) it needs reliable data regarding land use, water quality data, septic systems, and seasonal and year round population estimates specific to the study watershed, 2) it assigns typical phosphorus loading rates for land uses; it does not distinguish between good or bad practices, 3) uses land use area sums only, it is not spatially aware, 4) calculates an average **annual** phosphorus concentration, whereas water quality data is often seasonal, thus the model and the data may not agree.

The modeling results indicate that the majority of the phosphorus contribution to both lakes is from the watershed load (Table 12 and Figure 19); i.e., phosphorus contained in overland runoff that is introduced to the lakes via streams, as well as sheet flow into the lake from the direct lakeshore drainage area. The contribution of phosphorus from septic systems may be underestimated, as results of the septic system inventory indicate that many of the properties on Lake Waukewan and Winona have septic systems over 40 years in age, which increases the risk of septic system failure and pollutant loading to the lake.

Table 12. Results of Lake Loading Response Model (LLRM) calculations for phosphorus inputs to Lake Winona and Lake Waukewan.

Phosphorus Sources	*Lake Waukewan*			*Lake Winona*		
	Phosphorus (kg/yr)	Percent TP Contribution	Water Load (m3/yr)	Phosphorus (kg/yr)	Percent Contribution	Water Load (m3/yr)
Direct Loads to Lake:						
Atmospheric	41.3	13%	2,707,948	6.6	6%	432,089
Internal Loading	15.7	5%	--	0.4	--	--
Waterfowl	6.0	2%	--	4.0	4%	--
Septic Systems & Wastewater	28.3	9%	22,756	13.6	13%	10,633
Watershed Load	215.3	70%	18,111,658	78.2	76%	7,973,387
Total Load to Lake	**306.6**	**100%**	**20,842,362**	**102.8**	**100%**	**8,416,108**

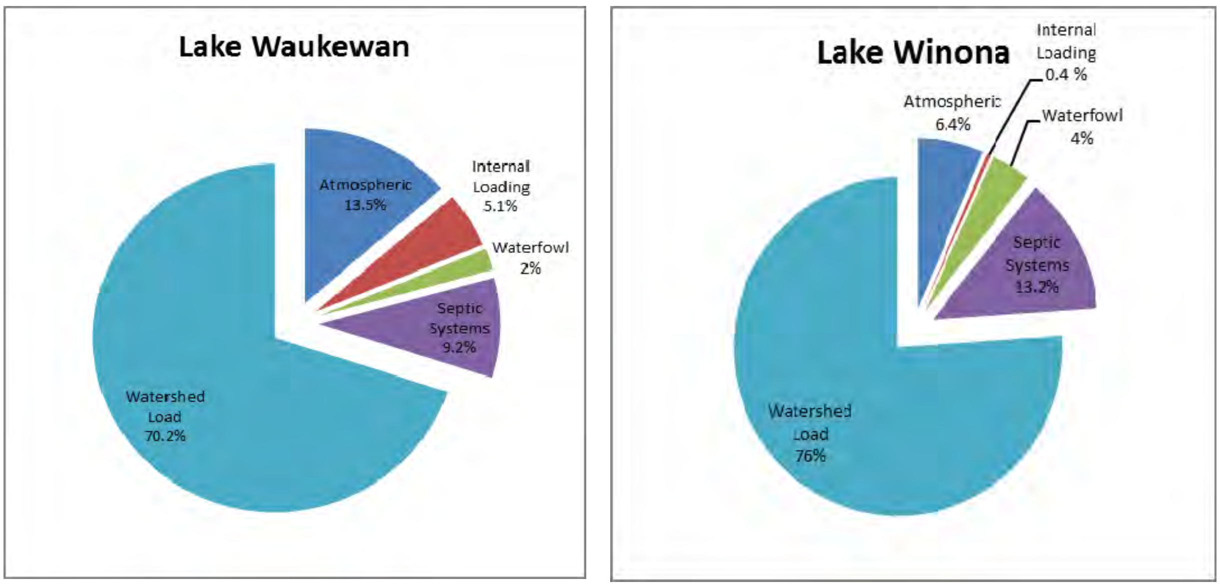
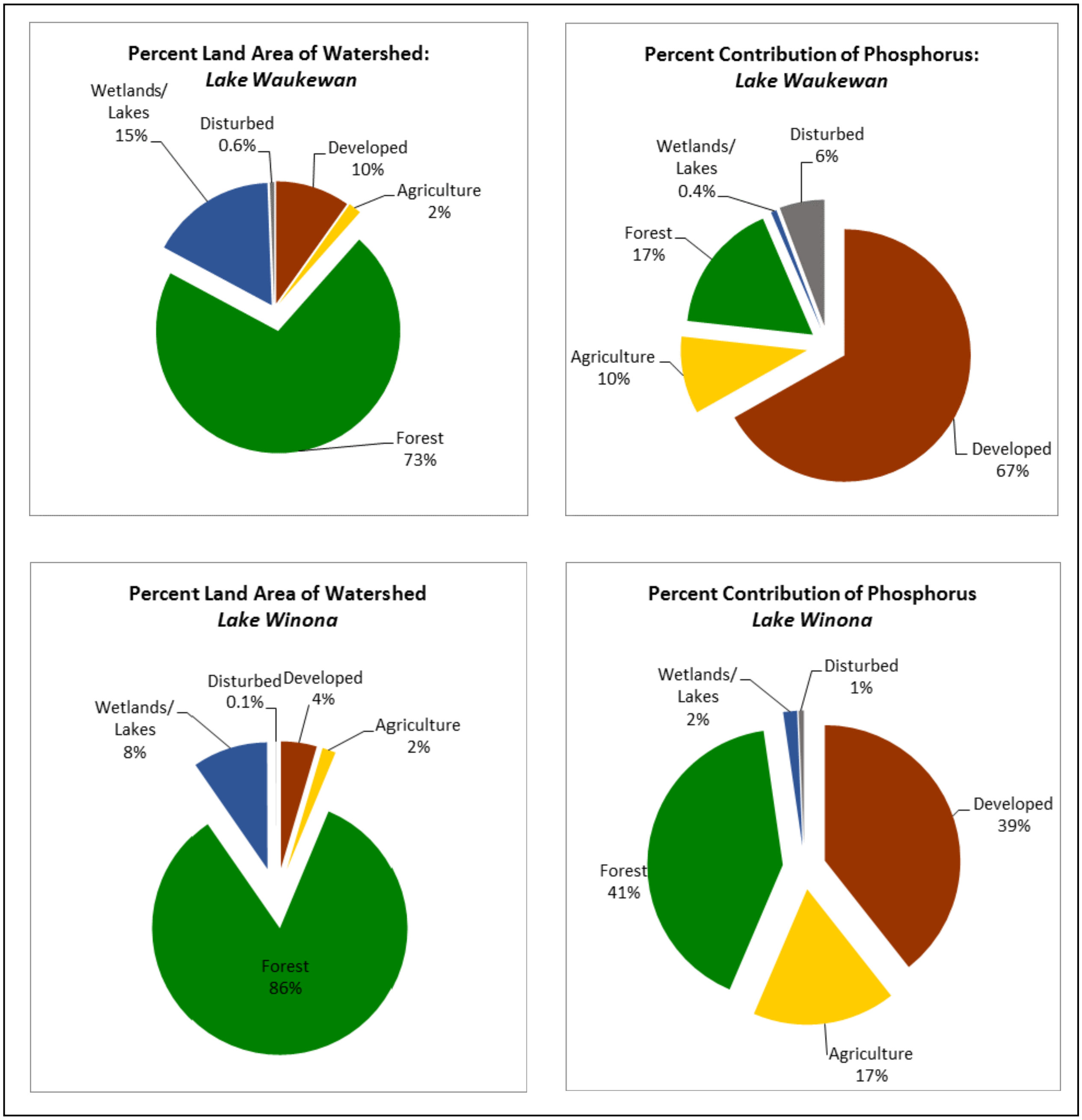


Figure 19. Percent phosphorus contribution by source in the Lake Waukewan and Winona watersheds.

A comparison of land area in the watershed to its corresponding contribution of phosphorus as a function of land use, shows that while the 'Developed' land area makes up a relatively small portion of both watersheds, it contributes the highest percentage of phosphorus. Four percent (4%) of the land area in the Lake Winona watershed contributes 39% of the phosphorus; whereas 10% of the land area in the Waukewan watershed contributes 67% of the phosphorus.

Figure 20. Comparison of percent land area to corresponding contribution of phosphorus in the Waukewan and Winona watersheds.



Watershed Loading – Subwatershed level

The model also calculates the contribution of phosphorus from each of the subwatersheds. In the Lake Waukewan model, the Reservoir Brook and Snake River subwatersheds show the largest contribution of phosphorus (Table 12). The Snake River subwatershed includes all of the Lake Winona watershed, therefore it has the largest contributing land area of the Waukewan LLRM.

Notably, the calculated concentration of phosphorus in the Snake River inlet to Waukewan is only 6.0 µg/L, which is quite low for a major tributary, but it is the volume of water in the Snake River times the nutrient concentration that equals the total nutrient load to Lake Waukewan. Birch Hill, Town Beach and Pollard Shores are the subwatersheds contributing the highest *concentrations* of phosphorus to Lake Waukewan. Many subwatersheds contribute relatively low amounts and concentrations of phosphorus to Lake Waukewan – namely, Otter Pond, Mayo Shores, Perkins Cove, Eastern Shore and Forest Hill. EE Brook, Waukewan Islands, and the Waukewan outlet subwatersheds likely contribute only negligible amounts of phosphorus to the lake (Table 13, Figure 21).

The Lake Winona LLRM suggests that the eastern tributary is contributing the greatest amount of phosphorus in that watershed, however, it includes the phosphorus loading from the Bear Pond and Hawkins Pond subwatersheds, and the load is only marginally higher than the North inlet and the direct shoreline drainage. The Bear Pond subwatershed contributes a very small amount of phosphorus to the system (Table 14, Figure 21).

Table 13. LLRM results of subwatershed phosphorus loading for Lake Waukewan.

Measurement (Lake Waukewan)	***Sub-Watersheds***							
	N.Wauk. Trib.	Reservoir Brook	Snake River[4]	Birch Hill	Eastern Shore	EE Brook	Forest Hill	Mayo Shores
Calculated Water Output (m^3/yr)[1]	1,003,611	1,749,664	9,086,493	259,911	319,732	329,707	388,450	439,033
Calculated Phosphorus Output (kg/yr)[2]	15.6	28.0	52.5	14.0	6.1	3.5	5.4	11.6
Calculated P Concentration of Tributaries (µg/L)[3]	16.0	16.0	6.0	54.0	19.0	10.0	14.0	26.0
Measurement (Lake Waukewan)	Otter Pond	Perkins Cove	Pollard Shores	Saywood Brook	Town Beach	Western Shore	Wauk. Islands	Wauk. Outlet
Calculated Water Output (m^3/yr)[1]	716,168	664,331	350,269	1,551,918	350,594	676,936	65,270	159,571
Calculated Phosphorus Output (kg/yr)[2]	3.8	9.3	13.8	23.4	11.4	15.5	0.4	0.9
Calculated P Concentration of Tributaries (µg/L)[3]	5.0	14.0	39.0	15.0	33.0	23.0	6.0	6.0

[1]Calculated volume of water from sub-basin
[2]Calculated phosphorus contribution from sub-basin
[3]LLRM Predicted - phosphorus concentration of tributary water
[4]Includes Lake Winona and its watershed

Table 14. LLRM results of subwatershed phosphorus loading for Lake Winona.

Measurement (Lake Winona)	***Sub-Watershed***				
	Winona Direct	Bear Pond	Hawkins Pond Direct	North Winona Tributary	Winona East Tributary
Calculated Water Output (m^3/yr)[1]	1,847,744	850,788	2,068,711	3,114,279	3,011,364
Calculated Phosphorus Output (kg/yr)[2]	24.8	5.6	21.6	23.7	29.7
Calculated P Concentration of Tributaries (μg/L)[3]	13.0	7.0	10.0	8.0	10.0

[1]*Calculated volume of water from sub-basin*

[2]*Calculated phosphorus contribution from sub-basin*

[3]*LLRM Predicted - phosphorus concentration of tributary water*

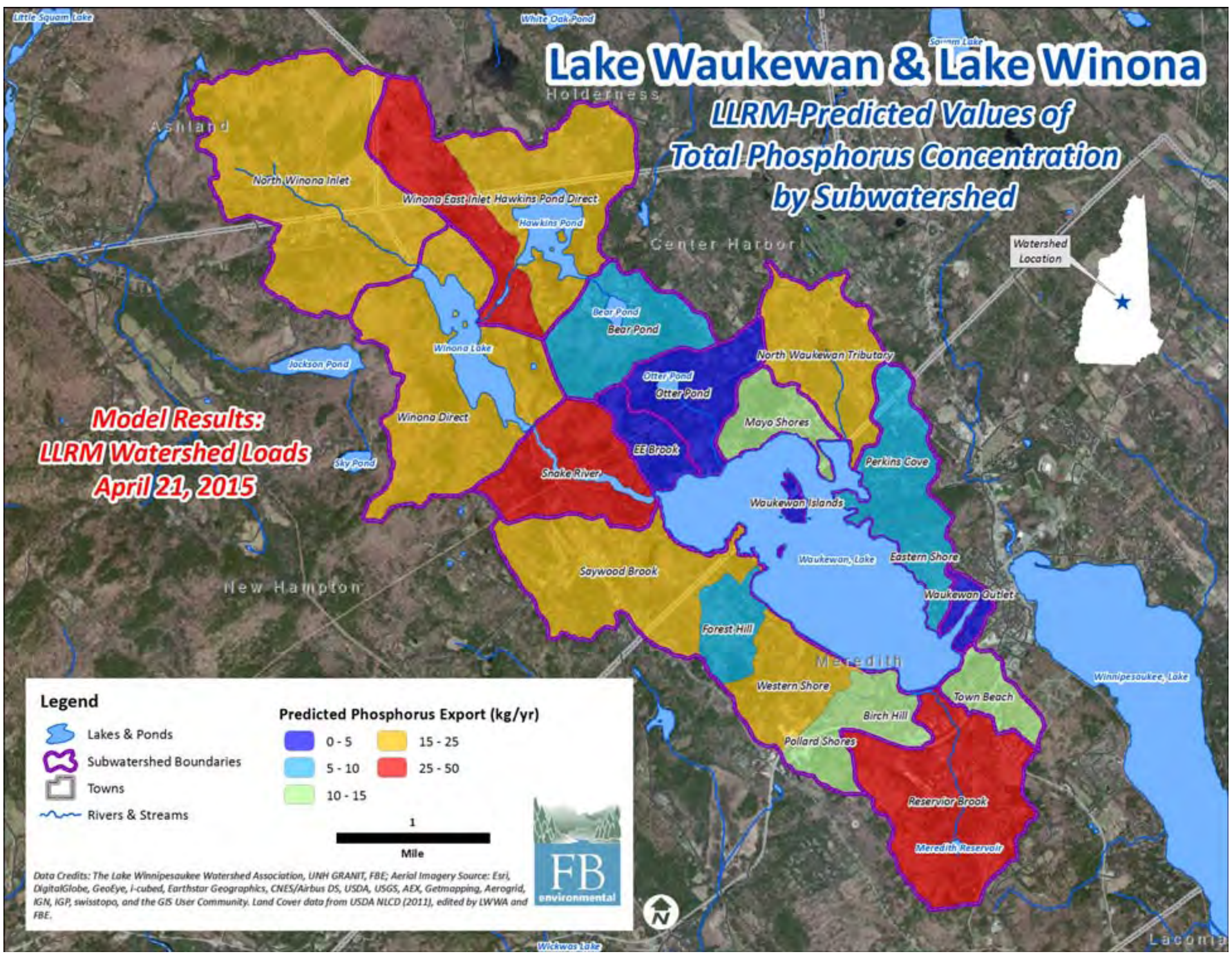


Figure 21. LLRM estimated Phosphorus loading by subwatershed. Note that due to water routing, the phosphorus load from the Snake River represents the entire Lake Winona watershed, and not the Snake River subwatershed itself.

In-lake Response

With the total phosphorus loads to Lake Waukewan and Winona estimated, the LLRM is able to predict the in-lake response; in other words, how will the lake respond to X amount of phosphorus? A total estimated TP load of 306.6 kg/year to Lake Waukewan results in a predicted in-lake phosphorus concentration of 5.88 µg/L; while an estimated load of 102.8 kg/year TP to Lake Winona results in a predicted in-lake concentration of 7.17 µg/L TP.

The predicted values from the LLRM for total phosphorus concentrations are close (within 5%) to the empirical values observed in sampling data for Lake Waukewan and Lake Winona (Table 15), which indicates that the LLRM is performing well for these watersheds.

Table 15. Comparisons between LLRM-predicted phosphorus concentrations and median data from field samples.

Measure of Total Phosphorus (µg/L)	Lake Waukewan	Lake Winona
Predicted TP	5.88	7.17
Empirical TP*	5.60	7.20
Relative percent difference	*4.9%*	*0.3%*

**Empirical values were determined from the Assimilative Capacity Analysis by LWA (Oct 2014)*

The results of the models indicate that in order to prevent increasing phosphorus levels in the lake, measures and actions should focus on limiting the phosphorus load coming from developed areas. Land use categories included within the ‘developed’ or urban land use are: commercial, industrial, roads, multi and single family residential, and mowed fields. Within the urban land use, single family residential and roads were the main sources of phosphorus. Roads are a large source of P due to the fact that they represent impervious areas which carry untreated stormwater from land surfaces to storm drains and catch basins that empty directly into associated waterbodies.

4.2 Natural Background Conditions

In order for residents, municipal officials, and other stakeholders to make informed decisions regarding protecting lake quality and to understand how development has impacted current water quality, the natural background condition, i.e. what the in-lake concentration of TP might have been before European settlement or pre-development, needs to be determined. To estimate in-lake P concentrations for both Lake Waukewan and Lake Winona, all land cover in the model was set to 100% forested land.

The estimated watershed TP load for Lake Waukewan decreased from 215.3 kg/year to 83.8 kg/year, a 61% decrease, resulting in a predicted in-lake TP concentration of 2.82 µg/L in Lake Waukewan. For Lake Winona, the watershed portion of the total load decreased from 78.2 kg/year to 36.0 kg/year, resulting in a predicted in-lake TP concentration of 3.28 µg/L. The other estimated direct sources of loading to the lakes (atmospheric, internal, waterfowl) were not changed, except for the septic system loading, which was eliminated.

4.3 Future Land Use Projections: Build-out Analysis

"Build-out" is a theoretical condition that represents the period when all available land suitable for residential, commercial, and industrial construction has been developed to the maximum conditions permitted by local ordinances. A build-out analysis is a planning tool which identifies areas with development potential and projects future development based on a set of conditions (e.g., zoning regulations) and assumptions (e.g., population growth rate). A build-out analysis was conducted by FB Environmental for the Lake Waukewan watershed, which consists of portions of the towns of Ashland, Center Harbor, Holderness, Meredith, and New Hampton. However, the study area for the build-out includes only Center Harbor, Meredith, and New Hampton, as data required to extend the analysis within Holderness were not obtained and the vast majority of Ashland within the Waukewan watershed is conserved and/or unbuildable. The analysis was conducted using CommunityViz version 4.3, an extension program for ArcMap Geographic Information System (GIS) software.

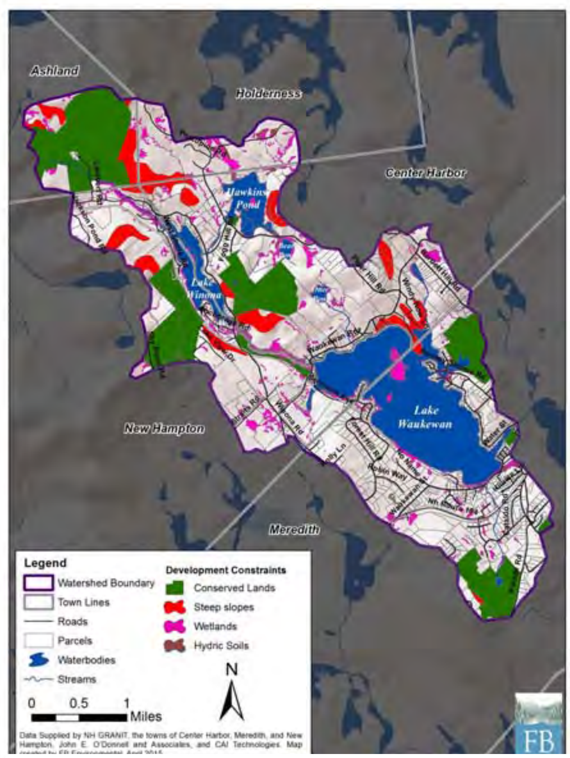


Figure 22: Development constraints in the Waukewan watershed.

To determine where development could potentially occur in the study area, build-out calculations deduct land with physical constraints to development including environmental restrictions (e.g. hydric soils, steep slopes, wetlands) (Figure 22), zoning restrictions (e.g. minimum lot size and building setbacks), and practical design considerations (e.g. lot layout inefficiencies). Existing buildings also reduce the available capacity for new development.

The build-out analysis classified 2,729/5,540 acres (49 %) of the land within the watershed as buildable (Figure 23, Table 16), with the majority of the land located in rural and agricultural zones in Center Harbor and New Hampton. Of the 2,729 acres, 1,556 acres (57%) are on vacant land (i.e., parcels with no currently existing structures). An additional 769 buildings could be constructed in the future, resulting in a total of 1,693 buildings within the study area. Of the total 769 projected buildings, 548 (71%) were placed on land that is currently vacant (Figure 24, Table 17).

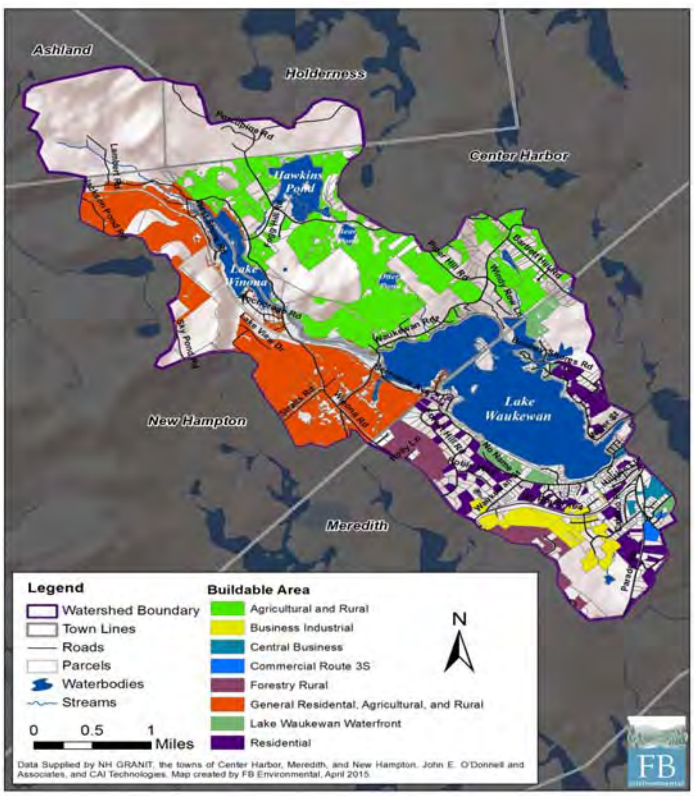


Figure 23. Buildable area by zone for portions of Center Harbor, Meredith, and New Hampton, New Hampshire within the Lake Waukewan watershed.

Table 16. Buildable area by zone for portions of Center Harbor, Meredith, and New Hampton, New Hampshire within the Lake Waukewan watershed.

Zone	Total Area (Acres)	Total Buildable Area (Acres)	Percent Buildable Area
Center Harbor			
Agricultural and Rural	2,087	1,020	49
New Hampton			
General Residential, Agricultural, and Rural	1,608	934	58
Meredith			
Business Industrial	227	162	71
Central Business	81	32	39
Commercial Route 3S	23	16	71
Forestry Rural	563	178	32
Lake Waukewan Waterfront	247	104	42
Residential	704	283	40
Total	**5,540**	**2,729**	**49**

Table 17. Existing and projected buildings for portions of Center Harbor, Meredith, and New Hampton, New Hampshire within the Lake Waukewan watershed.

Zone	No. Existing Buildings	No. Projected Buildings	No. Buildings at Full Build-Out
Center Harbor			
Agricultural and Rural	189	183	372
New Hampton			
General Residential, Agricultural, and Rural	149	314	463
Meredith			
Business Industrial	28	59	87
Central Business	34	15	49
Commercial Route 3S	6	8	14
Forestry Rural	27	46	73
Lake Waukewan Waterfront	169	39	208
Residential	322	105	427
Total	**924**	**769**	**1,693**

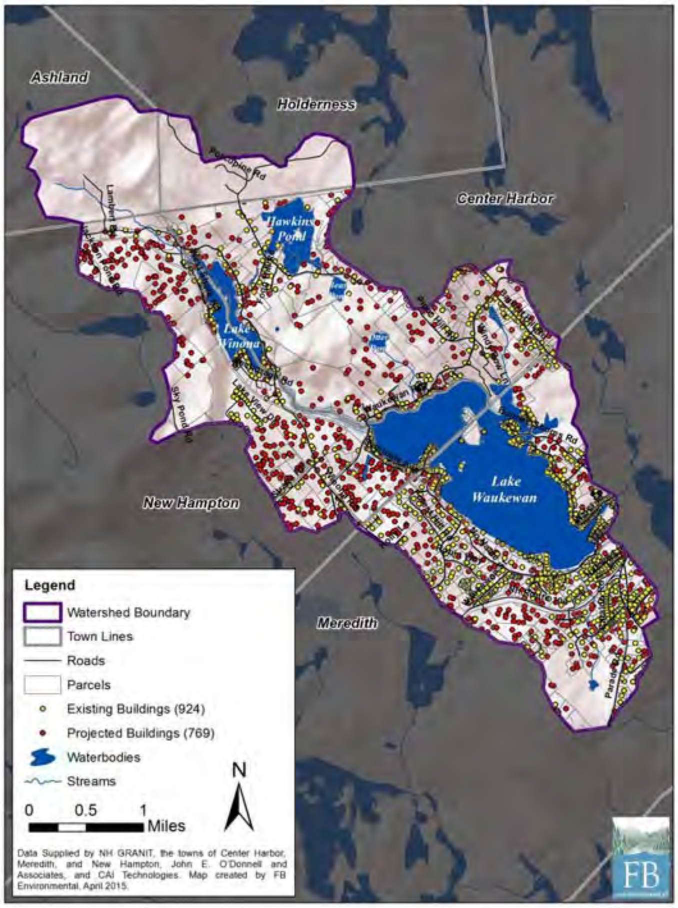


Figure 24. Existing and projected buildings for portions of Center Harbor, Meredith, and New Hampton, New Hampshire within the Lake Waukewan watershed.

CommunityViz's TimeScope tool is used to look at changes in the amount of development within a given area over time. The tool assigns a "build date" to features within a layer based on a specific set of rules including (most importantly) population growth rate and building sequence type (e.g., random or near roads).

Examination of data obtained from the US Census Bureau shows that the towns within the study area have experienced steady population growth since the middle of the last century. Since 1960, the populations of Center Harbor, Meredith, and New Hampton have increased 114%, 156%, and 151%, respectively. The 10-year (2000-2010) compound annual growth rate (CAGR) for the three towns is 0.67%, the 20-year (1990-2010) CAGR is 1.23%, and the 30-year (1980-2010) CAGR is 1.17%. These figures were used for three iterations of the TimeScope analysis. Full build-out is achieved in 2111, 2066, and 2069 for the 10-, 20-, and 30-year CAGR's, respectively (Figure 25).

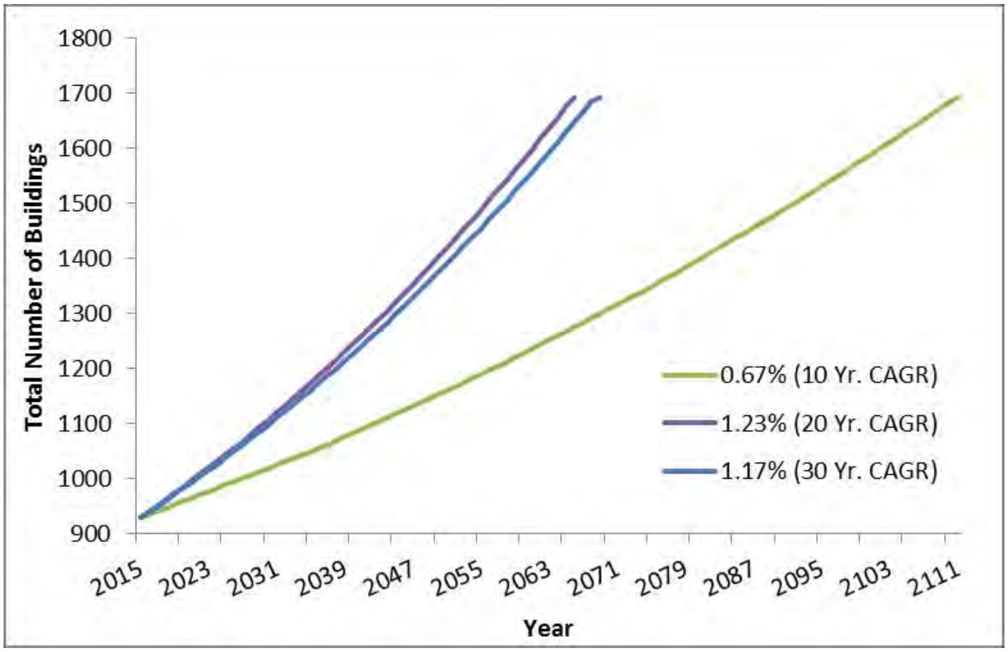


Figure 25. Full build-out projections of the study area using 10-, 20-, and 30-year compound annual growth rates.

Note that the dates provided here are estimates only; numerous factors including the amount of land in current use designation and the status of the economy may affect the rate of development.

An increase in watershed development could lead to more phosphorus (P) entering Lakes Winona and Waukewan from the surrounding watershed each year. The Lake Loading Response Model (LLRM) was used to estimate the additional annual phosphorus load that could result from full build-out in the watershed.

For current conditions in Lake Waukewan, the LLRM predicted 5.9 µg/L total phosphorus concentration, which is close to the empirical value (mid-summer epilimnetic median at both north and south deep spots) of 5.6 µg/L. The modeled phosphorus mass load was 306.5 kg/year, with 215.3 kg/year coming from the watershed (including Lake Winona), 28.3 kg/year coming from septic systems, and the remainder from atmospheric deposition, internal loading, and waterfowl.

Under the full build-out scenario for the Lake Waukewan watershed (including Lake Winona), the in-lake phosphorus concentration under build-out conditions would increase 36% to 8.0 µg/L. The P load from runoff would increase 42% to 304.8 kg/year, and loading from septic systems would increase 71% to 48.4 kg/year.

Lake Winona was modeled as a distinct subwatershed. For current conditions, the LLRM predicted an in-lake total phosphorus concentration of 7.2 µg/L, close to the composite empirical data point (10-year summer median concentration at Snake River and Winona Outlet/Waukewan Inlet) of 7.3 µg/L. The phosphorus mass load modeled by LLRM was 103 kg/year. Of this P load, 78 kg/year came from runoff, 13.6 kg/year came from septic systems, and the remainder from atmospheric deposition and waterfowl.

Viewed as a separate watershed, Lake Winona would see an increase in P concentration of 48% to 10.6 µg/L. P loading from watershed sources would rise 35% to 105.9 kg/year, and septic systems would contribute 156% more at 34.9 kg/year.

Although the build-out analysis would indicate that both Lake Winona and Lake Waukewan would still meet the water quality criterion for P for their trophic classification at full build-out (Table 18), both lakes are currently impaired for dissolved oxygen, as well as a cyanobacteria impairment for Lake Waukewan, indicating that future loading would likely lead to greater impairment.

Table 18. Comparison of phosphorus loading and in-lake response under various development scenarios.

Watershed	***Natural Background***		***Current Conditions***		***Full Build-out***	
	In-Lake TP (µg/L)	Phosphorus Load (kg/yr)	In-Lake TP (µg/L)	Phosphorus Load (kg/yr)	In-Lake TP (µg/L)	Phosphorus Load (kg/yr)
Winona	3.28	47.1	7.17	102.8	10.6	151.8
Waukewan	2.82	146.8	5.88	306.6	8.0	416.1

4.4 Selecting a Water Quality Goal

Lake quality is impacted by the amount of pollutants that enter the waterbody. Pollutants are delivered in several ways; through atmospheric deposition (rainfall), groundwater, point sources, watershed loading (land use), streambank and lakeshore erosion, septic systems, and internal loading. Because many of the pollutants contribute oxygen-demanding organic matter, and nutrients that stimulate the growth of organic matter, pollutants cause a decrease in average dissolved oxygen (DO) concentrations. If the organic matter is formed in the lake, for example by algal growth, at least some of the oxygen produced during growth will offset the eventual loss of oxygen during decomposition. However, in lakes where a large portion of the organic matter is brought in from outside the lake, oxygen production and oxygen consumption are not balanced and low DO may become even more of a problem.

Dissolved Oxygen and Lakes: *excerpted from the Michigan Inland Lakes Partnership*

> The amount of dissolved oxygen in the water is an important indicator of overall lake health. In the summer most lakes with sufficient depth (greater than 30 feet) are stratified into three distinct layers of different temperatures. These layers are referred to as the epilimnion (warm surface waters) and hypolimnion (cold bottom waters) which are separated by the metalimnion, or thermocline layer, a stratum of rapidly changing temperature. The physical and chemical changes within these layers influence the cycling of nutrients and other elements within the lake.
>
> During summer stratification the thermocline prevents dissolved oxygen produced by plant photosynthesis in the warm waters of the well-lit epilimnion from reaching the cold dark hypolimnion waters. The hypolimnion only has the dissolved oxygen it acquired during the short two-week spring overturn. This finite oxygen supply is gradually used by the bacteria in the water to decompose the dead plant and animal organic matter that rains down into the hypolimnion from the epilimnion, where it is produced. With no opportunity for re-supply the dissolved oxygen in the hypolimnion waters is gradually exhausted. The greater the supply of organic matter from the epilimnion and the smaller the volume of water in the hypolimnion the more rapid the oxygen depletion in the hypolimnion. Highly productive eutrophic lakes with small hypolimnetic volumes can lose their dissolved oxygen in a matter of a few weeks after spring overturn ends and summer stratification begins. Conversely, low productive oligotrophic lakes with large hypolimnetic volumes can retain high oxygen levels all summer.
>
> When a lake's hypolimnion dissolved oxygen supply is depleted, significant changes occur in the lake. Fish species that require cold water and high dissolved oxygen levels are not able to survive. With no dissolved oxygen in the water the chemistry of the bottom sediments is changed resulting in the release of the nutrient phosphorus into the water from the sediments. As a result, the phosphorus concentrations in the hypolimnion of productive lakes can reach extremely high levels. During major summer storms or at fall overturn, this phosphorus can be mixed into the surface waters to produce nuisance algae blooms.
>
> ***http://michiganlakes.msue.msu.edu/lake_ecology/dissolved_oxygen_and_temperature***

As phosphorus is the limiting nutrient of concern for NH's freshwater lakes, preventing or limiting increases in phosphorus loading to both Lake Waukewan and Lake Winona is critical for addressing the dissolved oxygen impairment and for protecting lake health.

Setting a water quality goal for total phosphorus is of central importance to the Plan because it will dictate the level and scope of watershed restoration efforts necessary to reduce phosphorus loads by the determined amount.

A local water quality goal for phosphorus for Lake Waukewan and Lake Winona should either meet or exceed the State Standard in order to protect the health of the waterbody and Lake Winnipesaukee for the long term. In general, local water quality goals may be set to:

- result in no increase in in-lake TP concentration,
- no increase that would violate state water quality criteria,
- attain a decrease in existing in-lake TP levels.

To guide the Waukewan Winona Lake Study Advisory Committee in choosing water quality targets for Lakes Waukewan and Winona, staff from LWA, FB Environmental Associates, DK Water Resource Consulting and NHDES reviewed the water quality data, assimilative capacity and pollutant loading analyses.

NH lakes have a greater Chl-*a* response to TP loadings than many other lakes due to their excellent water clarity. As the in-lake TP concentration nears 8-10 µg/L, an increased response in cyanobacteria is often seen. Because of this low tipping point for many NH lakes (8-10 µg/L threshold), it is important to prevent increases in in-lake TP concentrations as it may not be possible to return to lower levels (J. Schloss, personal communication, August 8, 2013).

Evaluation of options for selection of a WQ goal

The ability to run various scenarios that will predict in-lake response to nutrient load is important to the setting of the local water quality goal. FB Environmental Associates used the Lake Loading Response Model (LLRM) to predict in-lake phosphorus and chlorophyll-*a* for each lake based on estimates of current nutrient loading. Predictions of in-lake phosphorus and chlorophyll-*a* are important to the loading model because they allow for calibration of model inputs. Values predicted in the LLRM are compared to actual field data to ensure the accuracy of data used to build the model, and the validity of the results that the model provides (Table 19).

Table 19. In-lake concentrations of Phosphorus and Chlorophyll-*a*, compared to actual observed field data (median values for previous 10 years)

Parameter		**Waukewan**	**Winona**
Total Phosphorus (µg/L)	Actual (10-year Median)	5.6	7.2
	Predicted (LLRM)	5.88	7.17
Chlorophyll-*a* (µg/L)	Actual (10-year Median)	2.4	4.0
	Predicted (NH Chl-*a* Model)	2.5	3.0

Three possible water quality goals are presented below (Table 20). The first goal is set to attain the in-lake phosphorus value that is the threshold for each lake's trophic class, as designated by NHDES. Lake Waukewan is currently designated as Oligotrophic, and Lake Winona as Mesotrophic. The corresponding TP concentrations for these designations (8.0 and 12.0 µg/L, respectively) are used in the calculations below. Although Lake Winona's TP is within the Oligotrophic threshold for NH lakes, several parameters are considered to determine trophic class, including summer bottom Dissolved Oxygen, Secchi disk transparency, aquatic vascular plant abundance, and summer epilimnetic Chl-*a*.

The second scenario uses a goal of the NHDES threshold minus 10% of that value, in order to provide the lake with reserve assimilative capacity that will keep it below the threshold, accounting for year to year variation. The third goal uses a target value of predicted in-lake phosphorus concentrations minus 10% of that value, in order to set water quality goals that will quantify reductions in phosphorus loading to the lakes.

Since both lakes have current phosphorus concentrations below the NHDES thresholds, the "Change in P loading" values for these goals are expressed as a positive percentage value. These values represent an allowable increase in phosphorus loading before the threshold target is reached. In the third scenario (Predicted concentration – 10%), the percent change is expressed as a negative number, indicating the amount of decreased phosphorus load necessary to meet the target concentrations.

Table 20. Lake data and possible water quality goals, with phosphorus reduction estimates.

Current Values

Lake	Current NHDES Trophic Class Phosphorus Threshold (µg/L)	Current TP Concentration (µg/L)	Predicted TP Concentration (µg/L)	Current Phosphorus Load (kg/yr)
Waukewan	8.0	5.6	5.88	307
Winona	12.0	7.2	7.17	103

Option 1. Water Quality Goal: Meet Current NHDES Thresholds for Trophic Class

Lake	Predicted TP Concentration (µg/L)	Target TP (µg/L)	Current Phosphorus Load (kg/yr)	Phosphorus Load to meet target TP (kg/yr)	Change in P loading (kg/yr) to achieve target concentration
Waukewan	5.9	8.0	307	421	37.1%
Winona	7.2	12.0	103	172	67%

Option 2. Water Quality Goal: Meet Current NHDES Thresholds for Trophic Class, with 10% reserve assimilative capacity

Waukewan	5.9	7.2	307	375	22.1%
Winona	7.2	10.8	103	155	50.5%

Option 3. Water Quality Goal: 10% Decrease from predicted in-lake phosphorus concentrations

Waukewan	5.9	5.3	307	276	-10.1%
Winona	7.2	6.5	103	93	-9.7%

The above information was presented to the Waukewan Winona Lake Study Advisory Committee (WWLSAC) on October 27, 2014. Representatives for both Lake Waukewan and Lake Winona opted to select target goals which decrease the in-lake phosphorus concentration from the predicted in-lake levels. **The target goal for Lake Waukewan was set to achieve an in-lake TP concentration of 5.3 μg/L in 10 years, requiring a reduction in phosphorus load to the lake of 31 kg/year. Although Lake Winona is well below the reserve assimilative capacity threshold of 10.8 μg/L for a mesotrophic waterbody, the WWLSAC chose to be aggressively proactive and selected a target goal to achieve a 5-10% decrease in in-lake TP concentration in 10 years.**

5.0 Identification of Pollution Sources in the Watershed

To assist the WWLSAC achieve the respective target goals, watershed and shoreline surveys were conducted to identify potential sources of pollution and sediment loading throughout the watershed. The information gathered from the surveys was used to estimate the pollutant loading from each source and to determine priority areas for implementing best management practices (BMPs).

5.1 Watershed Nonpoint Source Survey

In April, 2014 trained technical staff from FB Environmental Associates and DK Water Resources Consulting spent two days documenting erosion on the roads, municipal properties, driveways, and stream crossings in the Waukewan and Winona watershed. Problems were identified and documented, solutions were recommended, and the costs of improvements were estimated. In addition to documenting erosion sites, staff obtained information on shoreline and stream bank erosion as well as gully dimensions at each site.

The primary purpose of the 2014 Lake Waukewan and Winona Lake Watershed NPS Survey was to:

- Identify and prioritize existing sources of polluted runoff, particularly soil erosion sites, within the watershed. The survey focused on investigating potential sources of erosion and runoff to all waterbodies in the Waukewan-Winona watershed.
- Raise public awareness (through this plan and other outreach conducted by LWA) about the connection between land use and water quality, and the impact of soil in the watershed.
- Provide the basis to obtain additional funds to assist in fixing identified erosion sites throughout the watershed.
- Use the information gathered as one component of a long-term lake protection strategy.
- Collect site information to model estimated pollutant load reductions for each source of NPS pollution to Lake Waukewan and Winona Lake.

The purpose of the survey was NOT to point fingers at landowners with documented problems, nor was it to seek enforcement action against landowners not in compliance with ordinances. It is the hope that through future projects, local lake associations and communities can work together with landowners to solve erosion problems on their property, or help them learn how best to accomplish solutions on their own.

Volunteers and technical staff identified **64 sites** in the Lake Waukewan and Winona Lake watershed that are currently impacting or have the potential to impact water quality in the lake (Figure 26). Some key conclusions include:

- 34 of the identified sites were documented on town roads (Figure 27). In total, there were 51 road-based sites (78%), including private roads, state roads and driveways; these sites generally have more severe problems, which in turn have a greater impact on the lake, as shown in Table 21).
- Problems on residential land account for about 10% of all documented erosion sites. Residential sites are often less severe and less costly to fix. Additionally, landowner support and assistance can be instrumental in fixing these problems. Please note that additional residential sites were identified in the shoreline survey.
- The cost of fixing the sites was roughly estimated for all sites (Figure 29). 24(38%) of these sites are expected to incur a high cost (over $2,500). These high cost sites are commonly road and stream crossing sites. 29 sites (45%) are expected to have an associated cost ranging from $500-$2,500. These sites are mainly located on roadways, driveway sites and public areas. 11 sites (17%) will incur a low cost (under $500), and are primarily associated with slight surface erosion found at a variety of sites.
- Erosion sites were identified throughout the watersheds on a variety of different land uses. As such, everyone has a role to play in lake protection. The Towns of Meredith, New Hampton and Center Harbor, shorefront property owners, business owners, road

associations, lakefront landowners and even people living farther from the lake can all take measures to reduce lake pollution.

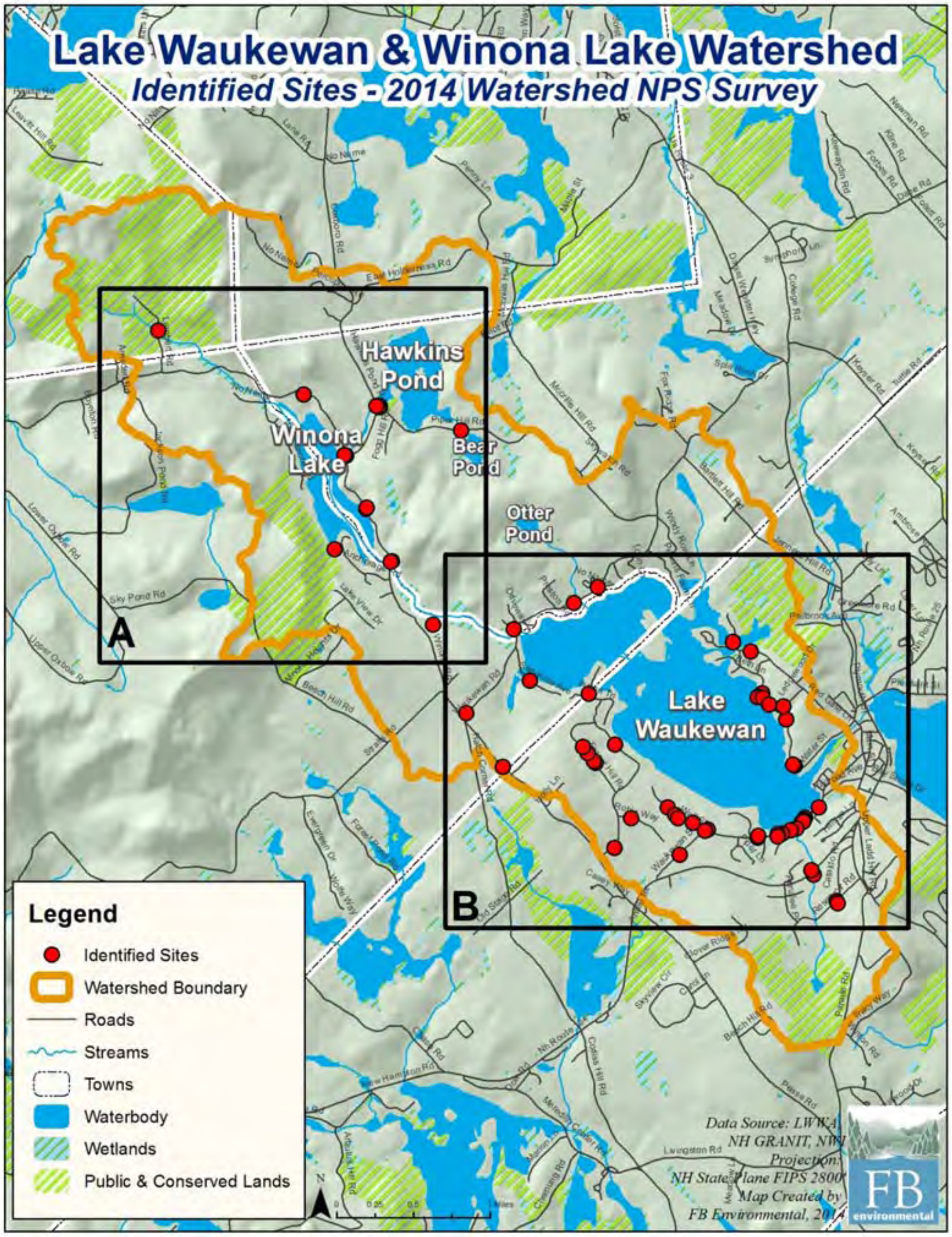


Figure 26. Map of Nonpoint Source Sites identified in the Waukewan watershed survey. Maps A and B can be found in the Appendices.

FIGURE 27. NUMBER OF NPS SITES BY LAND USE

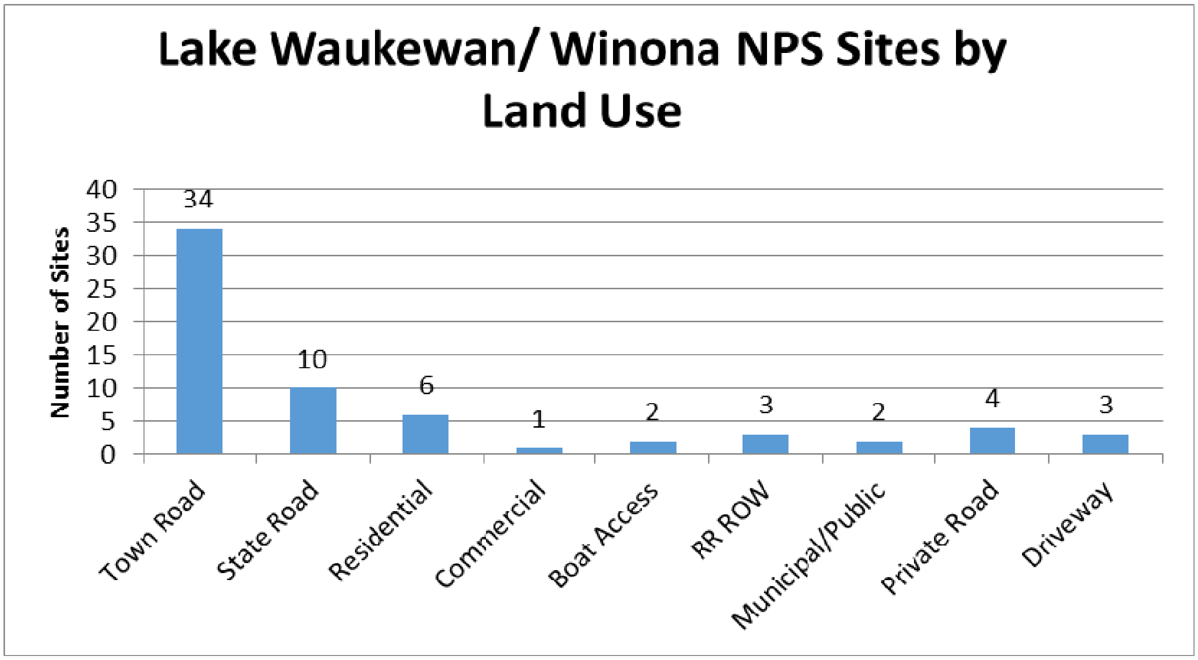


Table 21. NPS Sites Land Use and Impact

Land Use	High Impact	Medium Impact	Low Impact	Total
State Road	4	3	3	10
Driveway	0	1	2	3
Town Road	11	12	11	34
Private Road	2	2	0	4
Residential	0	4	2	6
Boat Access	0	2	0	2
RR ROW	0	2	1	3
Commercial	1	0	0	1
Municipal/Public	0	2	0	2
Total	17	28	19	65

Each site was rated for its potential impact to waterbodies (Figure 28). Just under half of the surveyed sites were determined to have a medium impact on water quality. **Impact** is based on slope, soil type, amount of eroding soil, buffer size and proximity to water.

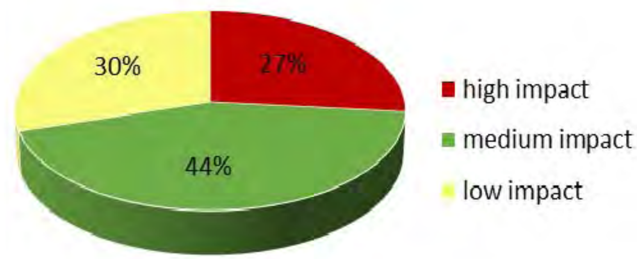


FIGURE 28. EROSION SITE IMPACT RATINGS

"Low" impact sites are those with limited transport of soil off-site with 30% of sites were rated low impact. "Medium" impact sites exhibit sediment transportation off-site, but the erosion does not reach high magnitude. 44% of sites were rated medium impact. "High" impact sites are those with large areas of significant erosion and direct flow to water. 27% of sites were rated high impact.

Recommendations were made for fixing each site, and the associated cost of labor and materials was estimated (Figure 29). **Cost** is an important factor in planning for restoration and the associated costs of BMP application.

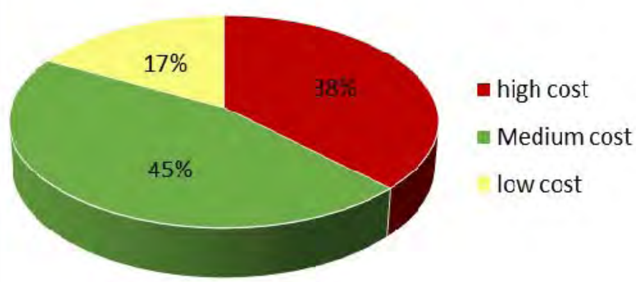


Figure 29. Site Cost Ratings

"Low" costs sites were estimated to cost less than $500. 17% of sites were rated low cost. An estimated cost between $500 and $2,500 was rated as "Medium." 45% of sites were rated medium cost. If the estimated cost was greater than $2,500, a "High" rating was assigned. 38% of sites were rated high cost.

Each evaluated site may be an isolated area of erosion, or connected to other sites as a cause or a result of stormwater runoff in adjacent areas. For example, runoff from a roadway may be eroding a nearby driveway. Runoff issues on one residential lot may affect a driveway nearby. The following section discusses the issues associated with NPS pollution identified for the three main land uses.

NPS Sites - Residential Areas

Residential areas accounted for about 10% of identified sources of polluted runoff. Four of the six total residential sites were determined to be medium impact. The remaining two sites were estimated to be low impact to the lake. Four of the sites were estimated as "medium" cost, and the remaining sites were assigned a "low" cost rating. The residential sites documented during the survey were often observed from road related sites and stream crossings. All of these sites were characterized as having buffer problems with an inadequate or non-existant buffer area between adjacent impervious surfaces and the streambank or shorefront. Below are examples of the most common problems seen at these sites, and recommended conservation practices to prevent soil erosion from affecting water quality in the lake.

Problem: Lack of Buffer or Inadequate Buffer

Solution: Control runoff from impervious surfaces from eroding the lake shore or adjacent streambank by establishing a vegetaive buffer or no-mowing zone.

Buffer Zone along lake shore slows runoff from adjacent areas and prevents erosion.

NPS Sites - Roads

34 town road sites, 10 state road sites, and 4 private road sites were identified during the survey. These account for 73% of all surveyed sites. There were 17 high-impact sites, 17 medium-impact sites, and 14 low-impact sites. 19 of these sites were rated as medium cost, and 23 sites were determined to be high cost. The remaining 6 road sites were given a low cost rating. Road sites documented during the survey were often related to unstable or eroding culverts, road shoulder erosion, and ditch erosion. The following problems are examples of the most common road sites documented during the survey.

Problem: Severe road shoulder erosion resulting in sediment delta into stream

Solution: Remove road berms. Resurface road with new material and reshape. Install a plunge pool and direct runoff into forested buffer.

Plunge Pool Collecting runoff

Re-grade Road & add new surface material

Problem: Severe ditch erosion

Solution: Line ditch with rock and vegetate for stability. Install turnouts directing water into forested buffer.

Ditch armored with stone and vegetation

Turnouts direct water into vegetated areas

NPS Sites - Driveways

Three driveway sites were documented and represent 5% of all sites. None of the sites were determined to be high impact. Two sites were assessed as low impact and one site was determined to be medium impact. No driveway sites were estimated to have high cost fixes. One site was estimated to cost between $500 and $2,500 (medium cost rating), and the other two sites were considered low cost (less than $500). The following example represents the most common driveway problem observed during the survey.

Problem: Surface erosion

Solution: Re-grade driveway. Install rubber razors or water bars.

Rubber razors direct water off driveway and into vegetation

Resurface driveway with hard-packing, cohesive surface material.

Fixing the NPS sites identified in this survey will require efforts by individuals, local lake and homeowner associations, road associations and municipal officials.

One approach to prioritizing erosion sites is to focus first on identifying sites rated high impact. Addressing problems at any of these sites would likely improve water quality at a moderate cost. To further prioritize this list, sites with the highest likelihood of available funding, landowner participation, and/or community interest should also be identified.

It should also be noted that, although addressing high-impact sites is important, multiple low-impact erosion sites in one area can also have a negative impact on water quality and should be addressed.

5.2 Shoreline Survey

The Lake Waukewan and Lake Winona Shoreline Survey was conducted on Wednesday, July 11, 2014 by FB Environmental Associates (FBE) and several local watershed association volunteers. Two boats were utilized for surveying Lake Waukewan and one boat was used for Lake Winona. Staff and volunteers documented conditions of the lake shorelines by parcel using a scoring system that FBE has used previously for several lakes in ME and NH that evaluated vegetated buffer condition, appearance of bare soil, areas of shoreline erosion, the distance of structures to the lake, and the slope of the shoreline. Overall scores were given to each site based on these criteria. Photos were taken of each parcel evaluated; these photos have been cataloged by lake and site number and are stored on file at FBE and LWA. The photos will provide the project stakeholders with a valuable tool for assessing the lake shoreline conditions over time. It is recommended that a shoreline survey be conducted every 5 to 10 years to evaluate changing conditions. Ideally a re-survey should be conducted in mid-summer.

A total of 303 parcels were evaluated, of which 215 were located on Lake Waukewan and 88 on Lake Winona. Each parcel was given a score for different shoreline conditions that varied from one to five depending on the category (Buffer, Bare Soil, Shoreline Erosion, Distance, Slope). Scores of 12 or more tend to indicate conditions that may be detrimental to lake water quality. Total scores could range from zero to eighteen (Figure 30, Figure 31). Shoreline conditions and overall scores were higher (slightly worse) on Lake Waukewan than Lake Winona (Table 22).

Figure 30. Lake Winona parcel receiving a final score of 7

Figure 31. Lake Waukewan parcel receiving a final score of 12

Table 22. Average shoreline disturbance scores for each category evaluated, and the total average score for each lake. Lower values indicate shoreline conditions that are effective at reducing erosion and keeping excess nutrients out of the lake.

Lake	# Parcels Evaluated	*Average Scores Per Parcel*					Total Shoreline Disturbance Score (0 - 18)
		Buffer (1 - 5)	Bare Soil (1 - 4)	Shoreline Erosion (1 - 3)	Distance (1 - 3)	Slope (1 - 3)	
Lake Waukewan	215	3.6	1.6	1.2	2.5	1.5	**9.6**
Lake Winona	88	2.2	1.2	1.1	2.5	1.8	**8.6**
Total	*303*	*2.9*	*1.4*	*1.1*	*2.5*	*1.7*	***9.1***

The overall average combined shoreline disturbance score of both lakes was 9.1. High scoring parcels on both lakes are those scoring a 10 or higher (Figure 32, Figure 33). These sites tended to have inadequate buffers, some evidence of bare soil, and structures within 75 feet of the shoreline. This trend tells us where the greatest improvements can be made around the lake shorelines, such as through planting stronger buffers and installing erosion controls. Although sites with good buffers, lack of shoreline erosion, and gradual slope conditions tended to score lower they should still be monitored for future changes and, if necessary, improvement.

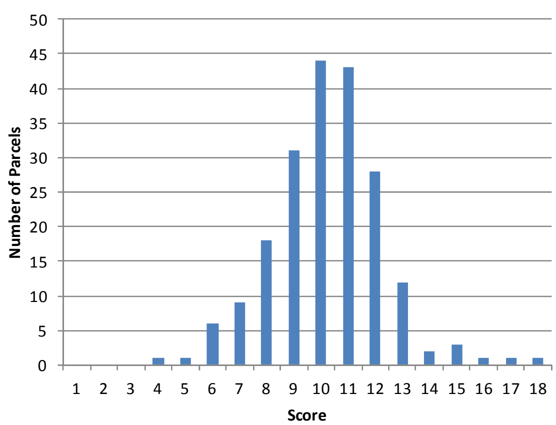


Figure 32. Lake Waukewan Parcel Scores

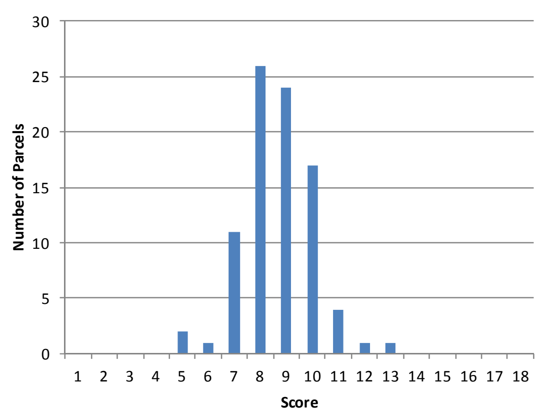


Figure 33. Lake Winona Parcel Scores

The shoreline survey can be used to target future implementation efforts on residential shoreline properties. A recommended next step for the local lake associations is to locate property owners willing to "demonstrate" what an ideal shoreline buffer looks like and how it functions.

Data from both surveys will be used to inform the watershed plan and steps for improving the shoreline of these lakes. This includes highlighting areas contributing to non-point source pollution, determining actions needed to reduce NPS pollution and maintain water quality goals, as well as prioritizing areas for shoreline restoration using stormwater Best Management Practices (BMPs).

5.3 Prioritization of Mitigation Projects

Malfunctioning septic systems, beach erosion, inadequate shoreline buffers, poorly maintained roads, winter sand inputs, and boat traffic all contribute to the current state of the water quality in Lake Waukewan and Lake Winona. The watershed survey conducted in April 2014 documented more than 60 issues persisting today within the watershed contributing sediment and other pollutants to various waterbodies throughout the watershed. The Lake Winnipesaukee Association and the Waukewan and Winona Lake Study Advisory Committee have begun the task of educating residents about the potential adverse effects of soil erosion and phosphorus as part of the watershed planning process and through recent projects.

By modeling results of pollutant reductions expected from addressing the 64 identified sites, we can estimate the total P load currently contributed by these selected locations throughout the watershed. Currently, 249.9 pounds of P enter Lake Waukewan and Winona Lake annually from these areas. Ideally, if all 64 problem sites identified in the 2014 watershed survey were treated with Best Management Practices (BMPs), and all new development contained proper phosphorus controls, these annual TP loadings would be significantly reduced, even in the face of growing development.

The EPA Region 5 Model was used to calculate the reduction in pollutant load in response to the implementation of BMPs in the Lake Waukewan and Winona watershed. The Region 5 Model provides a gross estimate of sediment and nutrient load reductions from the implementation of agricultural and urban BMPs. While it is recognized that this system has limitations, it does provide a uniform system of estimating relative pollutant loads.

During the watershed survey, measurements were collected at each identified site. The measurements document the area of any observed surface erosion or exposed/bare soil, the average dimensions of any gully erosion observed at each site (depth, width and length), and the height and lengths of eroded streambanks observed during the survey. These measurements are used as inputs in the Region 5 Model to calculate the reduction in pollutant load expected if these eroded areas were addressed by installing the recommended BMP.

Technical staff conducting the watershed survey also made in-field recommendations for each identified site in the watershed. Based on these recommendations, FBE was able to provide estimates of cost for each recommended BMP. Cost estimates were based roughly on the table below:

Table 23. Cost Estimates of common Best Management Practices (BMPs).

BMP Type	*Materials*	*Labor*	*Total*	*Reference*
Vegetated Buffer (20')	$ 400	$ 80	$ 480	*CCSWCD (2008). Table of Estimated Costs for Conservation Practices*
New Culvert (20' X18")	$ 500	$ 1,000	$ 1,500	*CCSWCD (2008). Table of Estimated Costs for Conservation Practices*
Gravel and grading (200' x 16')	$ 500	$ 860	$ 1,360	*CCSWCD (2008). Table of Estimated Costs for Conservation Practices*
Dripline/infiltration trench (18''x20'x8'')	$ 150	$ 110	$ 260	*CCSWCD (2008). Table of Estimated Costs for Conservation Practices*
Rubber waterbar (16')	$ 320	$ 60	$ 380	*CCSWCD (2008). Table of Estimated Costs for Conservation Practices*
Grass-lined ditch (100')	$ 175	$ 400	$ 575	*CCSWCD (2008). Table of Estimated Costs for Conservation Practices*
Rock-lined ditch (100')	$ 350	$ 400	$ 750	*CCSWCD (2008). Table of Estimated Costs for Conservation Practices*
Ersion control mulch (30' x 30' x 4'')	$ 350	$ 120	$ 470	*CCSWCD (2008). Table of Estimated Costs for Conservation Practices*
Plunge Pool	$1.25/sq. ft.	$75/hr	-	*Corespondence with J. Houle - University of NH Stormwater Center*
Guard Rail	$20/ Linear ft.	$75/hr	-	*Corespondence with J. Houle - University of NH Stormwater Center*
Retention Swales	$1.35/sq. ft.	$75/hr	-	*Corespondence with J. Houle - University of NH Stormwater Center*
Recycled Asphalt	$3.80/sq. ft.	$75/hr	-	*Corespondence with J. Houle - University of NH Stormwater Center*
Check dams & turnouts	$500-600 ea.	$75/hr	-	*Corespondence with J. Houle - University of NH Stormwater Center*
Paving (driveway)	$3.80/sq. ft.	$75/hr	-	*Corespondence with J. Houle - University of NH Stormwater Center*
Open-top Culvert	$ 100	$ 50	$ 150	*Estimate based on current lumber prices*
Retaining Walls	$40/sq. ft.	$75/hr	-	*Estimates from two landscaping companies for block/concrete walls: http://www.landscapingnetwork.com/walls/retaining-cost.html http://www.bahlerbrothers.com/blog/bid/111056/How-much-do-Retaining-Walls-Cost*
Concrete curbing	$15/linear foot	*Included in material*	-	

Estimates were also provided for annual maintenance cost for each BMP. The initial cost of the BMP was combined with the annual cost of each BMP over a ten-year period (initial cost + (annual maintenance cost x 10 yrs)) to calculate a 10-year BMP cost for each site. This 10-year cost estimate was then used to determine the 10-year cost per lb and per kg of phosphorus removed by each BMP per year.

All surveyed sites were prioritized by two factors. First, priority was given to sites assessed as having a higher environmental impact to water quality. Second, sites were then sorted by cost per lb. of phosphorus removed by the recommended BMP each year. The resulting prioritized list for each lake's watershed can be found in Appendix E.

The **top six BMP** sites from the prioritized list of all identified survey sites for each of the Lake Waukewan and Lake Winona watersheds would remove **84.8 kg of phosphorus per year** from entering either Lake Waukewan or Winona (Table 24, Figure 34). This would account for **75 % of the total estimated P load** per year contributed by all surveyed problem areas. On average, the top 12 BMPs will have an estimated 10-year cost of $874 per kilogram of phosphorus removed.

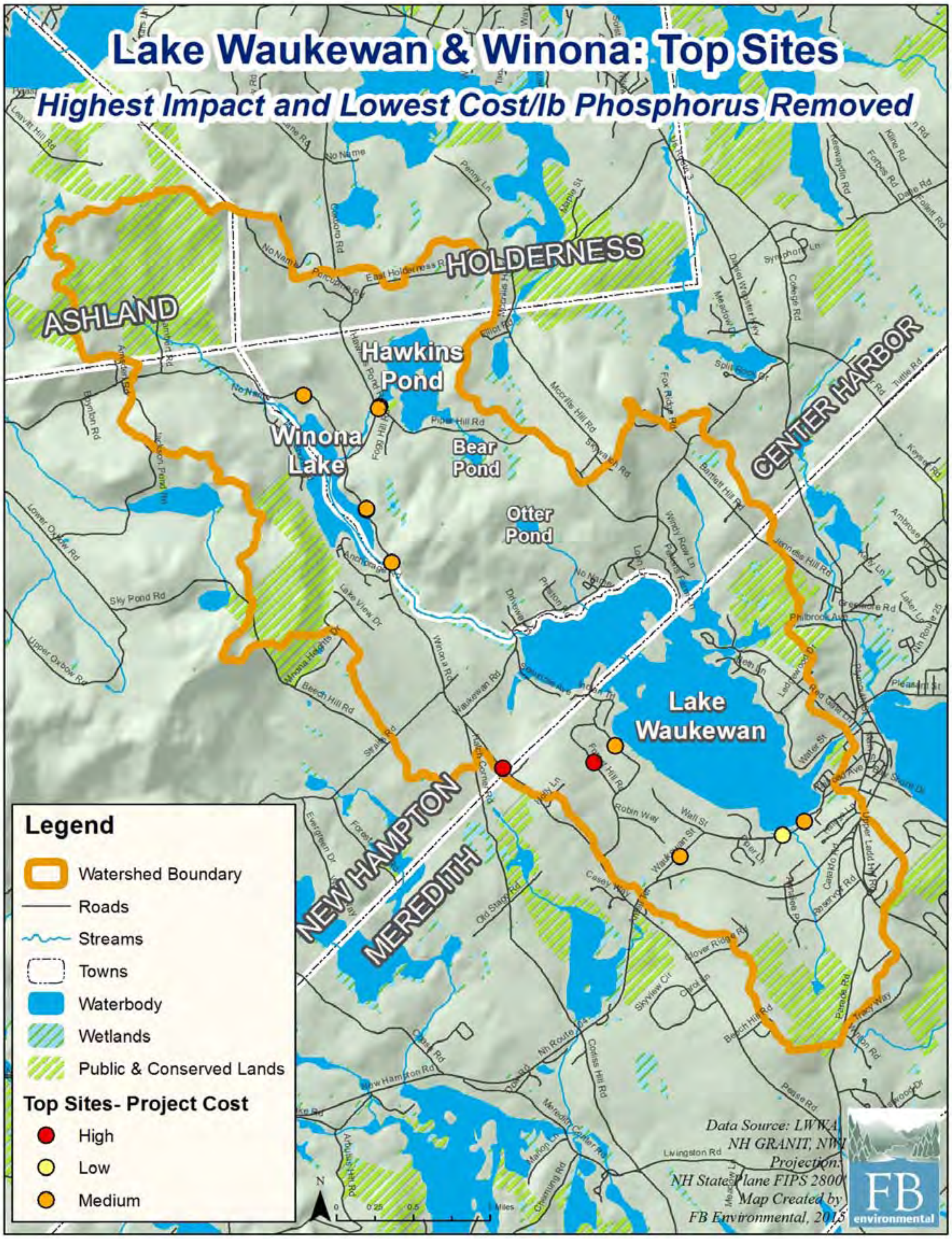


Figure 34. Map of top 12 BMP sites identified as having highest impact and lowest cost per pound of phosphorus removed.

Table 24. Top 6 BMP sites in the Lake Winona and Waukewan subwatersheds.

Site	Land Use	Recommendations	Impact rating	Sediment (t/yr)	Phosphorus (kg/yr)	BMP Cost Estimate	BMP Annual Maintenance Cost Estimate	10-yr Cost	10-yr Cost for TP Removed ($/kg)	Technical Level
Lake Waukewan										
1-09 C	Town Road	Remove winter sand early spring, reseed bare soil and thinning grass on adjacent property	Low	15.8	6.1	$575	$75	$1,325	$218	Low
2-07	Private paved road	Vegetate ditch or armor with stone, vegetate shoulder	Low	13.8	6.3	$1,150	$50	$1,650	$264	Low
1-21	Town Road	Vegetate ditch, reshape ditch, install sediment pools, vegetation mats or riprap	High	12.6	4.9	$2,000	$250	$4,500	$927	Medium
2-08	State and Private Road Intersection	Change ditch cross-section & remove plug and/or stabilize new ditch, install detention pond?	Medium	17.9	8.1	$3,625	$250	$6,125	$754	High
1-08 A	Municipal/Public	Add new surface material to parking area (crushed stone?) to prevent movement of sand, vegetate shoulder, Re-seed grassed areas, armor catch basin outlet at beach and create plunge pool.	Medium	10.5	4.0	$1,260	$300	$4,260	$1,055	Medium
2-03 B	Private Rd	Armor ditch with stone, install check dams, vegetate shoulder	Medium	8.9	4.0	$2,400	$500	$7,400	$1,833	High
				TOTAL	**33.4**			**$25,260**	**$842**	
Lake Winona										
2-13 A	State Road	Need to armor and stabilize shoreline where Rd is closest to lake	High	78.8	30.3	$25,000	$200	$27,000	$890	High
2-13 B	State Road	Vegetate ditch and armor with stone	Medium	11.3	4.6	$1,500	$200	$3,500	$764	Medium
2-19	Town Road	Create ditch to sediment retention area to collect runoff before entering CB, remove winter sand in early spring to reduce sediment inputs, or redirect outlet of CB away from lake	Medium	6.3	2.4	$1,275	$100	$2,275	$929	High
2-12 A	Municipal/Public, State Rd	Create swales to direct water from Road into woods, add new surface material (pea stone?) to parking areas, water retention swales	Medium	17.1	6.6	$4,380	$250	$6,880	$1,046	
2-14	State Road	Armor ditch with stone, vegetate ditch	Medium	8.4	3.2	$2,000	$150	$3,500	$1,087	Medium
2-16 A	Boat access	Add new surface material (crushed stone to prevent sediment movement off site, install runoff diverter (waterbar), rain garden near launch/slope, infiltration trench to collect runoff before it enters parking area	Medium	11.0	4.3	$3,684	$200	$5,684	$1,333	Medium
				TOTAL	**51.4**			**$48,839**	**$1,008**	

6.0 Management Strategies

6.1 Goals for Long-term Protection

The ultimate vision of the Lake Waukewan and Lake Winona Watershed Restoration Plan is to protect and enhance existing water quality in the lakes. This effort is supported by the idea that existing and new development can be conducted in a manner that sustains environmental values, and citizens, businesses, government, and other stakeholder groups can be responsible stewards of the Lake Waukewan/Lake Winona watershed. The long-term goal is to protect the watershed and water quality of Lake Waukewan and Lake Winona through a 10% (31 kg/year) and 5-10% (5-10 kg/year) reduction in median in-lake total phosphorus (TP), respectively[1]. Since TP comes from diffuse (i.e. nonpoint) sources in the watershed, such as residential development, roads, septic systems, and other land uses, achieving this goal will require an integrated and adaptive management approach that uses a variety of tools and methods for implementing **Best Management Practices (BMPs)**. This target reduction in TP can be achieved through the following **structural** and **non-structural BMP** objectives:

Best Management Practices (BMPs) are conservation practices designed to minimize discharge of NPS pollution from developed land to lakes and streams. Management plans should include both non-structural (non-engineered) and structural (engineered/permanent) BMPs for existing and new development to ensure long-term restoration success.
Structural BMPs, or engineered Best Management Practices are often on the forefront of most watershed restoration projects. However, **non-structural BMPs,** which do not require extensive engineering or construction efforts, can help reduce stormwater runoff and associated pollutants through operational actions such as land use planning strategies, municipal maintenance practices such as street sweeping and road sand/salt management, and targeted education and training.
Low Impact Development (LID) is an alternative approach to conventional site planning, design, and development that reduces the impacts of stormwater by working with natural hydrology and minimizing land disturbance by treating stormwater close to the source, and preserving natural drainage systems and open space, among other techniques.

1) Use the BMP matrix to identify, prioritize, and implement BMPs throughout the watershed to reduce sediment and phosphorus runoff from existing shoreland development and roads.

2) Educate landowners through BMP demonstration sites, workshops, and other communication strategies, targeting high priority septic systems (>20 years old, within 50 feet of a waterbody, and rarely pumped out).

[1] Although both lakes are currently below NHDES thresholds for median in-lake total phosphorus (TP) concentrations in oligotrophic (Lake Waukewan) and mesotrophic (Lake Winona) lakes, these target TP reductions will help safeguard these lakes against impacts from future development and land use change in the watershed.

3) Institute greater controls on new and re-development, require **low-impact development (LID)** in site plans, and encourage regular septic system maintenance.
4) Continue to protect and conserve high value plant and animal habitat, wetlands, and riparian areas through preservation, conservation, and restoration efforts.
5) Continue and/or expand the water quality monitoring and aquatic invasive plant control programs.

These objectives and more are discussed in greater detail in the Action Plan. Achieving the goals and objectives for future implementation work in the Lake Waukewan/Winona watershed will require a comprehensive and integrated set of activities as identified below.

6.2 Addressing Nonpoint Source Pollution (NPS)

Structural NPS Restoration

The Lake Waukewan/Winona watershed survey identified 64 sites that impact water quality through the delivery of phosphorus-laden sediment (Appendix E). Consequently, structural BMPs are a necessary and important component for the improvement and protection of water quality in Lake Waukewan and Lake Winona. The best methods for treating these sites are to:

- Address the top priority sites for both Lake Waukewan and Lake Winona, with an emphasis on cost-efficient fixes that have the lowest cost per kg of phosphorus treated, weighted by impact score (Table 24).
  - Priority rankings were based on field observations and model estimates. Local stakeholders reviewed the prioritized sites to determine the most appropriate sites for BMP implementation. Many other factors not considered in these rankings may change the order of prioritized sites, including landowner cooperation, funding availability, visibility, etc.
  - Conceptual designs and cost estimates were generated for two sites; one each in the list of top six sites identified in the Lake Waukewan and Lake Winona watersheds; Site 1-08A at the Waukewan Bath house, Meredith, and Site 2-12A/B site at the Lake Winona boat launch.
- Work with landowners to get commitments for treating and maintaining sites. Workshops and tours of demonstration sites can help encourage landowners to use BMPs on their own property.
- Measure the pollutant load reduction for each BMP installed.

These basic methods help guide the process and prioritization of BMP implementation in the watershed. Refer to the Action Plan and conservation practice fact sheets provided by the

Cumberland County Soil & Water District (http://www.cumberlandswcd.org/ta/index.htm) for a continued discussion of BMP implementation strategies.

The top 6 priority sites for Lake Waukewan will reduce the watershed TP load by an estimated 33.4 kg TP/year, or 108% of the total needed to reach the goal of 276 kg TP/year. Approximately $25,000 would need to be raised to successfully implement and maintain these BMPs over the next 10 years (Table 23). The top 6 priority BMP sites identified around Lake Winona will reduce the watershed TP load by an estimated 51 kg TP/year, or more than 500% of the total needed to reach the goal of 93-98 kg TP/year. This would cost roughly $49,000 over the course of 10 years. These estimates are based on the Region 5 model for estimating pollutant load reductions.

Using a simple scoring method, the shoreline survey served as an excellent tool for highlighting shoreline properties around each lake that exhibited significant erosion. This method of shoreline survey is a rapid technique to assess the overall condition of properties within the shoreland zone; but it does not allow for making specific recommendations for BMP implementation. Therefore, these properties should be resurveyed in person for more accurate estimations of TP reductions and BMP implementation costs by site. However, given some broad assumptions:

- Properties with no buffer (scored 5) have 100 ft shorelines contributing 2 kg TP/yr each and would each cost about $3,000 to revegetate and mulch with volunteer labor.

Revegetating impacted shoreline along Lake Waukewan would cost about $60,000 to implement and reduce TP by 80 kg/year (Table 25). Only one property along Lake Winona was observed to have no buffer, so buffer plantings would cost about $3,000 to implement and reduce TP by 2 kg/year.

Table 25. Summary of cost estimates and total phosphorus (TP) reductions for sites identified by the shoreline survey as needing buffer plantings.

Waterbody	# Sites with No Buffer (Score 5)	Total Cost to Revegetate ($)	TP Reduction (kg/yr)
Lake Waukewan	40	$60,000	80
Lake Winona	1	$3,000	2
	TOTAL	**$63,000**	**82**

All together, these BMPs would greatly reduce TP loading to Lake Waukewan and Lake Winona, well beyond the TP reduction goals set by the Waukewan/Winona Lake Study Advisory Committee (Table 26). The TP reductions for Lake Waukewan may be even greater if BMPs are implemented at Lake Winona, since this waterbody feeds into Lake Waukewan. Implementing these suggested BMPs at Lake Waukewan and Lake Winona would cost roughly $137,000 and would address more than 100% of the 5 or 10% (31 and 5-10 kg TP/year) needed in TP reduction for both Lake Waukewan and Lake Winona, respectively.

Table 26. Summary of total phosphorus (TP) reductions and estimated costs of priority BMP implementations at Lake Waukewan and Lake Winona.

Waterbody	Shoreline Survey - Buffer Score 5		Watershed Survey Top Priority		Grand Total	
	Cost ($)	TP Reduction (kg/yr)	Cost ($)	TP Reduction (kg/yr)	**Total Cost ($)**	**Total TP Reduction (kg/yr)**
Lake Waukewan	$60,000	80	$25,000	33	**$85,000**	**113**
Lake Winona	$3,000	2	$49,000	51	**$52,000**	**53**
					$137,000	**166**

It is important to note that, while the focus of this plan is on phosphorus, the treatment of stormwater will result in the reduction of many other kinds of harmful pollutants that could have a negative impact on these waters. These pollutants would likely include:

- Nutrients (e.g. nitrogen)
- Bacteria and viruses
- Heavy metals (cadmium, nickel, zinc)
- Petroleum products
- Road sand/salt

Without a monitoring program in place to determine these pollutant levels, it will be difficult to track successful reduction efforts. However, there are various spreadsheet models available that can estimate reductions in these pollutants, depending on the types of BMPs installed. These reductions can be input to the LLRM model developed for this project to estimate the response of the lakes to the reductions.

Non-Structural NPS Restoration

Non-structural watershed restoration practices prevent or reduce stormwater related runoff problems by reducing the exposure and generation of pollutants and providing a regulatory framework that minimizes impervious cover. Non-structural approaches to watershed restoration can be the most cost-effective and holistic practices within a watershed management framework. The non-structural approaches recommended in this plan can not only improve water quality, but can also enhance watershed aesthetics (e.g. through shade tree planting, landscaping, and trash reduction), streamline the permitting process (e.g. by removing conflicting design or stormwater codes), and reduce development costs (e.g. by minimizing impervious area development).

There are two primary components of non-structural BMPs:

1) Planning and design that minimizes or eliminates adverse stormwater impacts; and
2) Good housekeeping measures and education/training to promote awareness regarding the first component.

In watersheds with future development potential, such as the Lake Waukewan and Lake Winona watershed with buildable land extending across 65% of the watershed, it is critical for municipal staff and planning boards to develop and enforce stormwater management criteria to prevent any increase in pollutant loadings that may offset reduced loads as a result of plan implementation. Zoning in the watershed presents considerable opportunity for continued development (see Buildout Analysis) and, by extension, increased threats to aquatic habitat and recreational use of the lakes. In watersheds with significant development potential, the Center for Watershed Protection (CWP) identifies BMP/LID implementation requirements for development projects as the best mechanism for enhanced long-term stormwater management. It can be argued that local land use planning and zoning ordinances are the most critical components of watershed protection despite federal Clean Water Act requirements. The guidelines for local water policy innovation are as follows:

- Review current zoning ordinances for regulatory barriers and improvements.
- Set performance based standards.
- Take additional measures to reduce impervious cover.
- Promote the use of specific LID designs.
- Use overlay districts to add new requirements to existing zoning districts.
- Establish standards or incentives to improve stormwater management in developed areas.
- Address storage/use of pollutants that contact stormwater.

6.3 Adaptive Management Approach

An **adaptive management approach** is highly recommended for protecting lake watersheds because it enables stakeholders to conduct restoration activities in an iterative manner. For example, the advisory committee should review and update the BMP matrix annually to re-establish priorities as the plan progresses. This provides opportunities for utilizing available resources efficiently through BMP performance testing and watershed monitoring activities. Stakeholders can evaluate the effectiveness of one set of restoration actions and either adopt or modify them before implementing effective measures in the next round of restoration activities. The adaptive management approach recognizes that the entire watershed cannot be restored with a single restoration action or within a short-time frame. Instead, adaptive management features establishing an ongoing program that provides adequate funding, stakeholder guidance, and an efficient coordination of restoration activities. Implementation of this approach would ensure that restoration actions are implemented and that surface waters are monitored to document restoration over an extended time period. The adaptive management components for future implementation efforts should include:

> The **Adaptive Management Approach** recognizes that the entire watershed cannot be restored with a single restoration action or within a short time frame.

- **Maintaining an Organizational Structure for Implementation.** Since the watershed spans multiple municipalities, a cooperating group, representing the towns, association, and other local watershed groups, should be established for the implementation of future efforts in the watershed. This will help coordinate the implementation of restoration activities. In addition to state and municipal officials and watershed groups, this collaborative approach should involve the various commercial business interests in the watershed to allow for a full consideration of all issues relevant to an effective, efficient, and cost-effective restoration program.
- **Establishing a Funding Mechanism.** A long-term funding mechanism should be established to provide financial resources for restoration actions. In addition to construction and organizational management costs, consideration should also be given to the type and extent of technical assistance needed to design, inspect, and maintain stormwater BMPs. Technical assistance costs for the annual field monitoring program should also be considered. Funding is a critical element of sustaining the restoration process, and, once it is established, the management plan can be fully vetted and restoration activities can move forward.
- **Synthesizing Restoration Actions.** This watershed management plan provides prioritized recommendations to support restoration (e.g., structural/nonstructural recommendations for priority areas). These recommendations, or action items, need to be revisited and synthesized to create a unified watershed restoration strategy. Once a funding mechanism is established, the lake watershed restoration program should begin in earnest by developing detailed designs for priority restoration activities on a project-area basis and scheduling their implementation accordingly.
- **Continuing the Community Participation Process.** The development of the Lake Waukewan and Lake Winona Watershed Restoration Plan has greatly benefited from the active involvement of an engaged group of watershed stakeholders with a diversity of skills and interests. Plan implementation will require their continued and ongoing participation as well as additional community outreach efforts to involve even more stakeholders throughout the watershed. A sustained public awareness and outreach campaign is essential to secure the long-term community support that will be necessary to successfully implement this project.
- **Developing a Long-Term Monitoring Program.** Although current monitoring efforts are strong, a detailed monitoring program (including ongoing monitoring of watershed tributaries) is necessary to track the health of the lakes. Indeed, the overall goal of the watershed management planning process is the improvement of water quality and long-term health of these lakes. Refer to Monitoring section of the Action Plan.
- **Establishing Measurable Milestones.** A restoration schedule that includes milestones for measuring the restoration actions and monitoring activities in the watershed is critically important to the success of the plan. In addition to monitoring, several environmental, social, and programmatic indicators have been identified to measure the progress of the

Lake Waukewan and Lake Winona Watershed Management Plan. These indicators are listed in Section 7.2 and are intricately tied to the action items identified in the Action Plan.

7.0 Plan Implementation

Plan implementation will be led by the Waukewan Winona Lake Study Advisory Committee. Local participation is an integral part of the success of this plan, and should include the leadership of NHDES, local municipalities (including Meredith, New Hampton, Center Harbor, Holderness, and Ashland), local lake associations, local schools, community groups, local businesses, road associations, and individual landowners. The advisory committee will need to meet regularly and be diligent in coordinating resources to implement practices that will reduce NPS pollution in the Lake Waukewan and Lake Winona watershed.

7.1 Action Plan

The Action Plan was developed through the combined efforts of the LWA and FB Environmental, as well as the advisory committee. The Action Plan is a critical component of the plan because it provides a list of specific strategies for improving water quality and the means to make the water quality goals a reality. The Action Plan consists of action items to help address threats identified within five major categories in no particular order of priority:

- Best Management Practices (BMPs)
- Wastewater Systems
- Municipal Ordinances, Planning, & Land Conservation
- Education & Outreach
- Water Quality Monitoring

In addition to the goal of nutrient (phosphorus) reduction, the Action Plan was also developed to foster thinking about long-term strategies for improving the water quality and related natural resources within the watershed, and to promote communication between citizens, municipalities, and state agencies. The Action Plan outlines responsible parties, potential funding sources, approximate costs, and an implementation schedule for each task within each category. Current cost estimates for each action item will need to be adjusted based on further research and site design considerations.

Best Management Practices (BMPs)

Best Management Practices (BMPs) are restoration tools that property owners can use to minimize impacts from stormwater runoff and restore degraded areas, particularly along shorelines that feed directly to the lakes. This could be as simple as planting vegetated buffers, installing gravel driplines along roof edges, and ensuring that runoff from paths and driveways is filtered into the ground rather than running overland and into the lake. Coordination with landowners is crucial for successful implementation of BMPs identified in this Action Plan because mitigation measures will need to be implemented on private land. The 2014 watershed and shoreline surveys identified and prioritized several areas within the watershed that should be treated for erosion and/or stormwater runoff issues.

Table 27. Lake Waukewan/Winona Action Plan – Best Management Practices

WATERSHED BEST MANAGEMENT PRACTICES (BMPs)

ACTION ITEM	DESCRIPTION	RESPONSIBLE PARTY	FUNDING SOURCE	SCHEDULE	ESTIMATED COST
Priority BMPs	1) Conduct stakeholder review of the BMP matrix and top prioritized sites to ensure that targeted sites are appropriate for the watershed and local interests.	Lake Associations, WWLSAC, Towns	N/A	2015-2025	N/A
	2) Implement BMPs at top priority sites identified from the 2014 watershed survey for both lakes.	Lake & Homeowner Associations, BCCD, Towns	NHDES, Towns, Private, Other Grants	2015-2025	$74,000*
	3) Work with landowners to stabilize shorelines identified in the 2014 shoreline survey.	Lake Associations, NHLAKES, BCCD, Towns	NHDES, Towns, Private, Other Grants	2015-2025	$63,000*
NPS Tracker & BMP Monitoring	1) Track pollutant reductions as sites are identified and BMPs are implemented. Recommend using NPS Tracker template.	LWA, BCCD, Volunteers, Towns	NHDES, Towns, Volunteers	2015-2025	$100/yr
	2) Re-survey implemented BMP sites every five years and develop a tracking system to document long-term functionality. Obtain digitized parcel data before re-surveying.	Lake Assns, BCCD, Volunteers, Towns	NHDES, Towns	2015-2025	$1,000
Shoreline Surveys	1) Conduct a shoreline survey every 5-10 years to track changes in shoreline development over time.	WWLSAC, WWAC, Lake & Homeowner Assns., Towns	Volunteers	2015-2025	$2,000
NH Lakes Conservation Corps (NH LAKES CC)	1) Enlist the NH LAKES Conservation Corps for implementation and outreach activities throughout the watershed.	Lake Associations, NH LAKES, BCCD, Towns	N/A	2015-2025	N/A
Plant Sale	1) Organize and host an annual spring plant sale. Locally-sourced, native plants can be used for shoreline buffer plantings by landowners.	BCCD, Volunteers	LWA, BCCD, Grants, Donations	2015-2025	$500/yr

*Cost estimates include initial cost of BMP plus associated annual costs over a 10-year period.

Wastewater Systems

Septic system effluent typically stores a thousand times the concentration of phosphorus in lake waters, which means that a small amount of effluent could have a major impact on the lake. An old or improperly-maintained septic system can also result in the delivery of chemicals and hormones used in pharmaceutical and personal care products, as well as the delivery of disease-causing bacteria or viruses that cause gastro-intestinal illness in swimmers. Inundation of systems by groundwater greatly enhances the transport of phosphorus and pathogens to the lake. Therefore, it is critical to ensure adequate setbacks and good vertical separation from the seasonally-high groundwater table.

Based on the watershed modeling that has been completed, septic systems are the third and second largest source of phosphorus to Lake Waukewan and Lake Winona, respectively. The contribution of septic systems was estimated to provide 9% (28.3 kg TP/yr) and 13% (13.6 kg TP/yr) of the total phosphorus load to Lake Waukewan and Lake Winona, respectively. A wastewater inspection and maintenance program will help reduce phosphorus and bacteria loading to these lakes. Significant reductions in phosphorus loading to the lakes will be achieved if landowners take responsibility to evaluate and maintain their systems, and make necessary upgrades, especially to old systems, cesspools, and outhouses.

Table 28. Lake Waukewan/Winona Action Plan- Wastewater Systems

WASTEWATER SYSTEMS						
ACTION ITEM	**DESCRIPTION**	**RESPONSIBLE PARTY**	**FUNDING SOURCE**	**SCHEDULE**	**ESTIMATED COST**	**STATUS (As of June 2016)**
SEPTIC SYSTEMS						
Initial Septic System Inventory	Conduct a comprehensive septic system survey of all properties within 250 ft. of a critical waterbody.	LWA, Towns, Consultants	Towns, NHDES, Other Grants	Completed	$5,000	Completed in 2014 by LWA.
Septic Database	Encourage town officials to track septic system pumping and upgrades; maintain database based on recent comprehensive septic system survey completed by LWA.	Lake Associations, WWLSAC, WWAC, Towns	Towns	2015-2025	$1,000	Initial database exists for properties located within 250 ft of Lakes Waukewan and Winona
Mandatory Inspections & Pumping	1) Continue progress toward development and implementation of an ongoing septic system inspection program to identify failed systems in the 250 ft. shoreline zone around Lake Waukewan and Lake Winona.	Towns	NHDES, Towns	Ongoing	$1,000/yr	Meredith adopted Health Regulation in 2013 requiring evaluation of certain properties within 250 ft. of Lake Waukewan. Requires re-evaluation every 5 yrs.
	2) Require inspections and maintenance of septic systems and repair at time of property transfer. $250-$500/system	Towns, State, Landowners	Landowners	2015-2025	N/A	
	3) Require inspections and maintenance of septic systems for all new permit requests. $250/system	Towns, State, Landowners	Landowners	2015-2025	N/A	
Dye Testing	Encourage and help fund voluntary dye testing for homeowners to evaluate septic system performance. Goal: 20 systems.	WWLSAC, WWAC, Towns	NHDES, Towns	2015-2017	$75/system	
Community Septic Systems	Install community septic systems for cluster developments (campgrounds & small camps with outhouses). Goal: 2 communities at $30,000 each.	Towns, Landowners	NHDES, Other Grants, Low- Interest Loans	2016-2018	N/A	

ACTION ITEM	DESCRIPTION	RESPONSIBLE PARTY	FUNDING SOURCE	SCHEDULE	ESTIMATED COST	STATUS (As of June 2016)
Landowner Assistance	1) Offer landowner assistance (technical, permitting, and grants) for septic system maintenance and upgrades.	LWA, NHDES, Towns	NHDES	2015-2025	$1,000/yr	LWA provided 9 Cost Share Grants in 2014/2015 to property owners to replace failing septic systems. A total of 15 systems were upgraded, resulting in a reduction of 5.3 kg TP/year to Lake Waukewan.
	2) Coordinate group septic system pumping discounts.	Lake & Homeowner Associations, Towns	Towns, Private	2015-2025	N/A	
	3) Investigate grants and low-interest loans to provide cost-share opportunities for septic system upgrades.	Lake Associations, Towns, Landowners	NHDES, USDA Towns, Private	Completed	N/A	List of potential funding sources available for wastewater improvement projects drafted in 2012 and updated Feb. 2015
	4) Establish a finance program for septic system upgrades in cases of economic hardship	Towns	Towns	2015-2025	N/A	Meredith has a finance program in place.
	5) Develop a long-term funding source for septic system upgrades in the watershed.	LRPC, Towns	Grants, Donations	2015-2025	N/A	
SEWER SYSTEM						
Sewer Expansion Mitigation	**1) Make appropriations for a feasibility study to examine expansion of the Meredith sewer system around the southwest end of Lake Waukewan.**	**Town of Meredith**	**Town of Meredith**	**Completed**	**$10,000**	**Completed in May 2009. Report can be found on the Town's website at: http://www.meredithnh.org/Joomla/pdfdocs/ws/Sewer%20Extension%20Study.pdf**
	2) Ensure that prioritized sewer replacement projects in Meredith are completed in a timely manner.	Town of Meredith	Town of Meredith	Ongoing	N/A	
Sewer Database	Encourage town officials to update sewer system connection map; develop database.	LRPC, Town of Meredith	Town of Meredith, NHDES	2015-2025	$1,000	

Note: Blue highlighted areas indicate action item has been completed or is in process.

Municipal Ordinances, Planning, & Land Conservation

Municipal land-use regulations are a guiding force for where and what type of development can occur in a watershed, and therefore, how water quality is affected because of this development. The buildout analysis conducted by FB Environmental indicates that there is considerable need for improvement in protecting water quality through non-structural BMPs, such as municipal ordinance adoption or revisions for new or re-development. Action items related to this element have been divided into those relating to wastewater systems, development planning, other regulations, good housekeeping, and land conservation. These action items will help guide municipalities in making effective ordinance or regulation changes that protect water quality within the Lake Waukewan/Winona watershed.

Refer to Table 29. Lake Waukewan/Winona Action Plan- Municipal Ordinance Review

Education & Outreach

Education and outreach activities can be used to enhance public understanding of the water quality and encourage community participation in watershed restoration and protection activities. Much effort has already been done by various groups (e.g. Towns of Meredith, New Hampton, Center Harbor, WWAC, local lake associations, LWA, Lakes Region Planning Commission (LRPC), Belknap County Conservation District (BCCD), New Hampshire Lakes Association (NH LAKES), etc.) in the watershed to educate, communicate, and coordinate with the community for the protection, preservation, and improvement of the quality of Lake Waukewan and Lake Winona. Local lake associations and the Waukewan Watershed Advisory Committee are the primary entities for education and outreach campaigns in the watershed and for implementation of this plan. The various local lake associations and the WWAC should continue all aspects of their education and outreach programs and consider developing new ones or improving existing ones to reach more watershed residents.

Refer to Table 30. Lake Waukewan/Winona Action Plan - Education and Outreach

Water Quality Monitoring

Monitoring programs are crucial for evaluating the effectiveness of watershed planning activities and determining if water quality goals are being achieved over the long-term. This Action Plan includes recommendations for enhancing current water quality monitoring efforts, including sample collection from lakes and tributaries, and continuation of the Weed Watch and Lake Host programs. Since volunteers typically conduct many different monitoring activities, it will be critical to continue building on the success of the local lake associations' ongoing education, outreach, and water quality monitoring programs.

Lake Monitoring – It is recommended that monitoring continue at all existing lake sampling locations. Alterations to the monitoring plan may include:

- ***Increase sampling frequency*** to examine how nutrients are distributed in the water column and processed throughout and outside of the growing season.
- ***Sampling at pre-determined times of year to maintain a consistent dataset***. Such times could include spring turnover, peak of summer algal growth, and fall turnover.
- ***Promoting advanced research collaborations with other groups*** active in the lake system to collect data with more frequency and for additional parameters. Consider working with universities to develop a cyanobacteria monitoring program, conduct a sediment core study for the lakes, or conduct a boat traffic study.
- ***Conducting a dissolved oxygen study at the lakes***. Both lakes have issues with DO depletion in the deeper waters through the summer. Collecting temperature and DO profiles with greater frequency (and year-round) could help determine the extent of DO depletion and how it relates to sediment phosphorus release.

Tributary Monitoring – It is recommended that monitoring continue at all existing tributary sampling locations. Alterations to the monitoring plan may include:

- ***Capturing water samples at new sites and year-round*** to better quantify pollutant loading from tributaries in the watershed.
- ***Capturing water samples during storm events*** to examine peak discharges and measure inputs of sediment and nutrients during heavy rains. These samples may be collected either by manual or automated grab sampling during storm events; these automated sampling devices are deployed at collection sites and triggered to fill when water rises to a pre-determined level (e.g., the samplers may be positioned so that they fill when the water rises 6 inches).
- ***Deploying data loggers to capture continuous water quality information***. Data sondes and loggers may be deployed at strategic locations in rivers, streams, and lakes to capture continuous (e.g., every 30 minutes) data on a number of parameters, including water temperature, dissolved oxygen, specific conductivity, turbidity, and chlorophyll-a or algae abundance. Data such as these could be valuable for understanding water quality processes in the watershed.
- ***Using water level loggers***. These are a specific type of logger that measure continuous water level in a river, stream, or lake. In flowing waters, water level can be converted to stream discharge. Coupled with water chemistry data, loading rates of nutrients may also be calculated with continuous flow data.

Refer to Table 31. Lake Waukewan/Winona Action Plan - Water Quality Monitoring

Table 29. Lake Waukewan/Winona Action Plan- Municipal Ordinance Review

MUNICIPAL ORDINANCES, PLANNING, & LAND CONSERVATION						
ACTION ITEM	**DESCRIPTION**	**RESPONSIBLE PARTY**	**FUNDING SOURCE**	**SCHEDULE**	**ESTIMATED COST**	**STATUS (As of June 2016)**
WASTEWATER SYSTEMS REGULATIONS						
Septic System Regulations Assessment	1) Review septic system rules for all watershed towns.	LWA, Towns	Towns, Grants	Completed	$1,500	2009 - Review of Town regulations by Meredith and in 2013 by LWA as part of Septic System Improvement Initiative
Septic System Permitting	1) Require a permit for the replacement or repair of septic systems to ensure proper installation.	Towns	Towns, Fees	2015-2017	N/A	The Town of Meredith adopted a Health Regulation in 2013 that addresses septic permitting. New Hampton and Center Harbor should consider adopting a similar regulation.
	2) Require upgrade, repair, or replacement of septic systems with building permits.	Towns	Towns, Fees	2015-2025	N/A	
	3) Improve septic system regulations/ordinances to consider more than just number of bedrooms when doing expansions.	LRPC, Towns	Towns, Fees	2015-2025	N/A	
Enforcement	1) Communicate with town departments to enforce occupancy loads and have septic system inventories in Master Plans.	LRPC, Towns, Planning Boards	Towns	2015-2025	N/A	
DEVELOPMENT PLANNING						
Plan Adoption	1) Incorporate watershed plan recommendations into town master plans.	Towns	Towns	2015-2020	N/A	
Conservation Subdivisions	1) Increase incentives for conservation subdivisions in town ordinances.	LRPC, Towns	Towns	2015-2020	$1,500	Meredith has a Conservation Subdivision Ordinance. Center Harbor has a Cluster Subdivision Ordinance, New Hampton encourages Cluster Development design.
	2) Adopt open space guidelines for conservation subdivisions.	LRPC, Towns	Towns	2015-2020	N/A	
Low Impact Development (LID)	1) Develop new policy to encourage LID for all future development.	LRPC, Towns, BCCD	Towns, Grants	2015-2020	$1,500	
Note: Blue highlighted areas indicate action item has been completed or is in process.						

ACTION ITEM	DESCRIPTION	RESPONSIBLE PARTY	FUNDING SOURCE	SCHEDULE	ESTIMATED COST	STATUS (As of June 2016)
Setbacks, Buffers & Lot Coverage	1) Improve ordinances to include mandatory setbacks, riparian buffers between development and waterbodies, and maximum lot coverage restrictions.	LRPC, Towns	Towns, Grants	2015-2020	$1,500	
	2) Base zoning on "maximum % impervious cover allowed" rather than "% green space required."	LRPC, Towns	Towns	2015-2020	N/A	
	3) Determine current and future impervious cover for watershed towns so that communities can make better informed planning decisions.	LRPC, Towns, Consultant	LWA, Towns	2015-2020	$5,000	
	4) Review and lower limits of impervious cover by zone to less than 10-20% imperviousness.	Towns, Consultant	LWA, Towns	2015-2020	$1,500	
	5) Limit amount of tree removal and/or expand ordinance to include logging.	State, LRPC, Land Trusts, Towns, Lake Assns, Landowners	Federal Grants (NRCS, EPA), Private	2015-2020	$1,500	
Overlay Districts	Adopt a watershed overlay district that directs development away from ecologically-sensitive areas, guides construction and development, and prohibits high risk land uses.	Towns	NHDES, Towns	Completed		Meredith (2006) and New Hampton (2008) adopted a Lake Waukewan Watershed Overlay District. Center Harbor has a 5 ac minimum for rural and agriculture zones. In March 2016, Center Harbor adopted a Water Resources Conservation Overlay District Ordinance, http://www.centerharbornh.org/sites/centerharbornh/files/pages/zoning-chapter-10.pdf
Erosion Control BMPs	1) Require erosion control BMPs through the development review process, including construction inspection and site stabilization. Distinguish between temporary and permanent erosion control methods.	Town Planning Boards, Code Enforcement Officers	Towns, Fees	2015	N/A	This has been completed for Meredith, but should also be completed for the other watershed towns.
	2) Require formal construction agreements that specify sequencing, inspections, and reports, for both temporary and permanent controls.	Town Planning Boards, Code Enforcement Officers	Towns, Fees	2015	N/A	
	3) Integrate Erosion and Sediment Control Regulations with Stormwater Regulations.	Towns	Towns	2015	N/A	

	4) Strengthen Erosion and Sediment Control Regulations by moving it from Site Plan Review and Subdivision Regulations to an Ordinance.	Towns	Towns	2015	N/A	
	5) Review procedures and regulations for maintenance of BMPs and existing vegetation.	LRPC, BCCD, Towns	Towns	Ongoing	N/A	
Stormwater Regulations	1) Implement a comprehensive stormwater management plan in the watershed that prevents potential harmful and destructive effects of stormwater runoff.	Towns, NHDES, NHDOT	NHDES, Other Grants	2015	N/A	Current update to the Waukewan Watershed Management Plan will quantify pollutant loads and assist the municipalities in identifying measures to reduce loading.
	2) Review effectiveness of existing stormwater regulations and practices in the watershed communities, and update the regulations as necessary.	LRPC, Towns, NHDES, NHDOT	NHDES, Other Grants	Completed	N/A	2013 - LRPC completed a study for Meredith, Laconia, and Gilford. Review should be done for other watershed towns.
	3) Ensure that stormwater BMPs are incorporated in land use planning, zoning, and subdivision/site plan reviews.	Towns, Planning Boards, NHDES	Towns	2015	N/A	
	4) Map all watershed catch basins, culverts, and stormwater discharge points in the watershed.	LRPC, Towns, Consultant	LWA, Towns	2015-2025	$5,000	
	5) Clearly define imperviousness or impervious surfaces in documents.	LRPC, Towns	LWA, Towns	2015-2025	N/A	
	6) Consider the use of different stormwater standards for treatment (e.g. more frequent storms vs. retention during 25-50 yr. size storms).	Town Planning Boards	Towns	2015-2017	N/A	
Enforcement	Employ a single code enforcement officer for purposes of permitting, inspection, and compliance for watershed towns. Ensure consistent application of the provisions of the Shoreland WQ Protection Act.	Towns	Towns	Ongoing	N/A	Meredith Code Enforcement Officer coordinates with the other towns in the watershed.
OTHER REGULATIONS						

Heating Fuel Tank Regulations	1) Adopt an ordinance that requires new or replacement installations for residential heating fuel storage have either double-walled tanks or secondary containment, be weather protected if located outdoors, and have encapsulated lines.	Towns, Code Enforcement Officers, Fire Departments, NHDES	Towns	2015-2020	N/A	
	2) Ensure local enforcement of state code requirements for oil burning equipment installations and tank replacements (e.g. fill alarms with audible whistle, use of UL-approved tanks, protected lines, etc.).	Code Enforcement Officers, Fire Departments	Towns	2015-2020	N/A	Meredith Fire Chief states this is N/A for residential and cites NFPA 211 as code.
	3) Encourage, or where necessary require, inspection and testing of residential heating fuel tanks.	Oil Industry	Private	2015-2020	N/A	
Heating Fuel Tank Regulations	4) With the assistance of local home heating fuel distribution companies, create a database of existing residential fuel tanks which include an inventory of tank age, type, volume, etc.	Town Planning Departments, Oil Industry	NHDES	2015-2020	N/A	
Recreational Regulations	1) Encourage enforcement of RSA 270-D:2 "General Rules for Vessels Operating on Water."	NH Marine Patrol, NHDES, LWA, Towns	N/A	Ongoing	N/A	
	2) Post prohibitions outlined by NHDES Administrative Rule Env-Ws 386.49 at public access points to the lakes.	Town Water Departments	Towns	Ongoing	N/A	
	3) Write a letter to entities that provide aviation training in the watershed and request that they discontinue use of Lake Waukewan as a flight training area. A copy of this letter should be sent to the Seaplane Pilots Association.	Town Board of Selectmen	N/A	Completed	N/A	Letter sent requesting aviation training entities not use Lake Waukewan. Result?
	4) Prohibit fueling of airplanes and establishment of commercial seaplane bases in the watershed.	Towns	N/A	Ongoing	N/A	
	5) Adopt an ordinance to restrict or prohibit use of fireworks under NH RSA 160-B:10.	Towns	N/A			

Hazardous Waste Regulations	1) Review progress of facilities classified as "hazardous waste handlers" or Resource Conservation and Recovery Act sites (RCRA) in the watershed.	Town Water Departments, NH DES	N/A	Ongoing	N/A	Searchable database on NHDES website should be reviewed every 2 years. http://des.nh.gov/onestop/index.htm
	2) Determine discharge location of floor drains at two businesses in the watershed and develop a spill prevention plan for each.	Meredith Water Department	Meredith Water Department	Completed	N/A	
	3) Send letter to the NHDOT Railroad Bureau and owners of the railroad requesting that all stockpiles of abandoned railroad ties along the railroad right-of-way around Lake Waukewan be removed.	Town of Meredith, NHDOT, Railroad owners	N/A	Completed	N/A	Letter sent in 2006. Reportedly railroad ties have been removed.
GOOD HOUSEKEEPING						
Road Management	1) Implement a comprehensive and collaborative road maintenance management program in the watershed that safeguards public safety, identifies ecologically-sensitive areas, identifies corresponding low salt zones, and uses techniques for minimizing the use of deicing materials.	Towns, NHDES, NHDOT, WWAC, Lake and Homeowner Assns	NHDES, Other Grants	Ongoing	N/A	WWAC requested Meredith DPW treat Water St. and Waukewan St. as a low salt area for snow removal/treatment. Practice has been implemented and appropriate signage installed.
Road Management	2) Encourage new road designs that limit imperviousness and minimize negative environmental effects.	Boards of Selectmen, Planning Boards, NHDES, NHDOT	N/A	Ongoing	N/A	In Meredith this is done via road waiver standards with all new road construction projects.
Materials Management	1) Dispose material from street sweeping, catch-basin sump cleaning, and snow collection in an environmentally-sound manner.	Town Department of Public Works	N/A	Ongoing	N/A	In Meredith the snow dump is only for snow. Street sweeping material is not considered hazardous and is disposed of as solid waste. Catch basin material in deposited in a DES approved retention basin.
	2) Recommend that the state prohibit transport of hazardous material cargoes and petroleum transport trucks through the watershed, except on major State roads. Local residential delivery is not included.	Towns, LRPC, NHDOT	N/A	Completed	N/A	This action has been tabled by the WWAC. Roads of concern were monitored in 2013 to determine the actual threat. No hazardous material carrying vehicles were observed traveling the road.

	3) Develop an Emergency Response Spill Plan for the watershed that protects Lake Waukewan as a source of public drinking water.	Town Water Departments, Fire Departments	N/A	Updated every 5 yrs.	N/A	Local Emergency Operations Plan addresses this action item.
BMP Maintenance	1) Integrate maintenance agreements into structural BMPs to ensure continued maintenance and proper functioning.	Town Department of Public Works, Landowners	Towns, Private, Grants	2015-2025	N/A	
LAND CONSERVATION						
Natural Resource Protection	1) Identify and conserve key properties that protect drinking water supplies and sensitive ecological features in the watershed. Use tools such as buildout analyses, GIS, and natural resource inventories to target critical land for protection.	Conservation Commissions, LRCT, SPNHF, BCCD	NHDES, LRCT, Private, Donations	Ongoing		Individual Conservation Commissions, land trusts continue to work to conserve important parcels of land. In 2014, LRCT acquired 192 acre parcel on Fogg Hill, Center Harbor and in 2015 acquired another 43 acre parcel for a total of 235 conserved acres. The Fogg Hill Conservation Area forms part of a 900+ acre unfragmented woodland and wetland habitat in the Waukewan watershed, and is located within one of the highest priority areas for conservation in the town. It has significant ecological, wildlife habitat, scenic, water quality, and recreational values.
	2) Protect natural areas that are essential for the control of stormwater runoff.	Conservation Commissions, LRCT, BCCD	NHDES, LRCT, Private, Donations	Ongoing	TBD	Center Harbor and Meredith have Wetlands Overlay Districts. New Hampton, Ashland, and Holderness do not have Wetland Ordinances
Funding	1) Add extra tax to town property bills that goes into a lake protection fund. Develop a subcommittee that determines how the funding is spent.	Towns	Towns, Fees	2015-2025	N/A	
	2) Solicit residents for individual donations.	Lake & Homeowner Assns, LRCT, Conservation Commissions	Private, Donations	2015-2025	N/A	

Table 30. Lake Waukewan/Winona Action Plan - Education and Outreach

EDUCATION & OUTREACH						
ACTION ITEM	**DESCRIPTION**	**RESPONSIBLE PARTY**	**FUNDING SOURCE**	**SCHEDULE**	**ESTIMATED COST**	**STATUS (As of June 2016)**
BMPs						
Plan Promotion	1) Promote the plan throughout the watershed.	WWAC, Lake and Homeowner Assns, LWA, LRPC, BCCD, Towns, Landowners	Towns, Private, Volunteer	Ongoing	N/A	
BMP Demonstrations	1) Setup demonstration projects at high-visibility residential BMPs throughout the watershed.	Lake & Homeowner Assns, BCCD, Towns, Landowners	NHDES, Other Grants	2015-2025	$10,000	
	2) Locate willing volunteers to "demonstrate" what an ideal shoreline buffer looks like and how it functions.	Lake & Homeowner Assns, BCCD, Towns, Landowners	NHDES, Other Grants, Private, Volunteers	2015-2025	N/A	
	3) Continue to host workshops on vegetative buffers and landscaping by the water's edge for local residents.	Lake & Homeowner Assns, BCCD, Towns, Landowners	NHDES, Other Grants, Donations	Ongoing	$2,000	2011- UNH Cooperative Extension held Healthy Waterfront Property Workshop for the Lakes Region Board of Realtors. BCCD held 'Landscaping by Water's Edge' in Moultonborough in 2012, Meredith hosted a Shoreland Protection Workshop in 2014
BMP Educational Materials	1) Develop and send letters to residents in the spring showing before/after photos of implemented BMPs.	Lake & Homeowner Assns	Donations, Fundraisers	2015-2025	$1,000	
	2) Continue to distribute educational packets to businesses and industries in the watershed about safeguarding water quality through BMP implementation.	Town Water Departments	Town Water Departments	2015-2025	N/A	
Self-Assessment Tool - Stormwater Footprint calculator - 'What's Your P?'	Encourage homeowners to calculate their stormwater footprint and determine the positive impact from BMP implementation	LWA, BCCD, Towns, WWAC, NHDES	N/A	Ongoing		Online Stormwater Footprint Calculator available on the Winnipesaukee Gateway at http://winnipesaukeegateway.org/resources/phosphorus-calculator/

ACTION ITEM	DESCRIPTION	RESPONSIBLE PARTY	FUNDING SOURCE	SCHEDULE	ESTIMATED COST	STATUS (As of June 2016)
Door-to-Door BMP Education	Enlist volunteers to go door-to-door to inform neighbors about erosion, BMPs, and programs that can help.	Lake & Homeowner Assns	Volunteers	2015-2017	N/A	
			NPS Pollution			
Educational Signage	1) Install educational signs at select locations in the watershed, such as "Scoop the Poop!"	Towns, Lake & Homeowner Assns	Grants, Fundraisers	2015-2017	$250	
P-Based Products	1) Educate residents that urine and some household products contain phosphorus that can be harmful in excessive amounts to the lake's ecology.	Lake & Homeowner Assns, WWAC, BCCD, Towns	Volunteers	Ongoing	N/A	
Spill Prevention & Awareness	1) Educate homeowners about spill liability, methods of secure storage and spill prevention, how to get tanks inspected, changes in consumption rates, how sump pumps can contaminate water resources, what to do if a leak is found, and permit and code requirements.	Towns, NHDES	NH Small Outreach and Education Grants for Nonpoint Source Pollution	2015-2025	N/A	Home Heating Oil Tanks - A Hidden Threat?' document created and published in the June 2007 Waukewan ShoreOwners Association newsletter. Article also submitted to other local newspapers.
	2) Educate local residential heating fuel distributors about the locations of public water supplies in the watershed and inform them about their susceptibility to spills. Remind companies about spill reporting requirements.	Town Planning Departments	Towns	Ongoing	N/A	
			Community Involvement			
Winnipesaukee Gateway	Keep the Winnipesaukee Gateway website current, and include up-to-date information about watershed efforts, ongoing activities, and interactive water quality data.	LWA, LRPC	Donations, Fundraisers	Ongoing	$5,000	**Map Atlas, 'What's Your P?' stormwater footprint calculator, water quality data map feature are new tools, resources added to the Gateway since 2010.**
Publicity	Publicize events and lake quality updates through local newspapers and newsletters.	WWAC, Towns, Lake and Homeowner Assns	Donations, Fundraisers	2015-2025	$500	
Educational Kiosk	Maintain kiosk at Waukewan boat ramp with educational posters/signs conveying issues related to the boat launch, no wake zone, cyanobacteria, etc.	WWAC, Towns, Lake and Homeowner Assns	Donations, Fundraisers	2015-2016	$1,500	
Donations	Build a donation box, and encourage landowners to donate to watershed restoration efforts.	WWAC, Lake and Homeowner Assns	Donations, Fundraisers	2015	$100	

ACTION ITEM	DESCRIPTION	RESPONSIBLE PARTY	FUNDING SOURCE	SCHEDULE	ESTIMATED COST	STATUS (As of June 2016)
Community Involvement						
Discovery Cruises	Organize an annual discovery cruise/paddle on the lake.	Lake & Homeowner Assns	Volunteers, Grants	2015-2025	$250	
Roads						
Road Maintenance BMPs	1) Educate town officials, road maintenance personnel, and contractors through roadway BMP outreach workshops.	BCCD, Towns	Grants, Towns	2015-2025	$1,000	
	2) Salt Reduction: Require Green SnoPro certification for DPWs, and commercial snow removal contractors	Towns, Homeowner & Lake Assns	NHDES, UNH, Contractors	2015-2025	N/A	
Road Associations	1) Consider forming private road associations in key neighborhoods or heavily-used roads for better management by local stakeholders.	Lake and Homeowner Assns	Volunteers	2015-2025	N/A	
	2) Host a Gravel Roads workshop for road associations every two years.	BCCD, Towns	Grants	2015-2025	$1,000	
Aquatic Invasives						
Lake Host/Boat Launch Brochure	Continue the Lake Host program and distribute information about inspection of boats before and after launching.	NH LAKES, Windy Waters Conservancy, WWAC, Lake & Homeowner Assns	Grants, Donations	Ongoing	$500	Lake Waukewan has an active lake host program
Weed Watchers Program	Continue the Weed Watchers Program on Lake Waukewan to prevent milfoil and other invasive species from becoming established. Hold annual trainings for identification of native vs. invasive plants.	Lake Associations, NHDES	Volunteers	Ongoing	N/A	
Recreational Activities						
Recreational Boating	1) Continue to educate boaters who have inboard motors to use oil absorbing pillows or "bilge socks" to prevent pollutants from entering the lake.	WWAC, Towns, Lake & Homeowner Assns	In-kind, Grants	Ongoing	N/A	In 2007, the Waukewan Watershed Advisory Committee gave out free bilge pillows to every I/O boat on Lake Waukewan and Winona with a note on how to use and where to purchase replacements. Consider doing this every few years.

ACTION ITEM	DESCRIPTION	RESPONSIBLE PARTY	FUNDING SOURCE	SCHEDULE	ESTIMATED COST	STATUS (As of June 2016)
Recreational Activities						
Recreational Boating	2) Continue to educate boaters (residents and visitors) that Lake Waukewan is a public drinking water source, about safe fueling practices, the availability of MtBE-free gasoline, servicing and cleaning of boats, and invasive species prevention.	Towns, NH LAKES, WWAC, Lake Host Program, Lake and Homeowner Assns	NHDES, Other Grants	Ongoing	N/A	
	3) Educate swimmers about the importance of Lake Waukewan as a public water supply and about healthy swimming etiquette (e.g. use of restrooms, no diapers allowed in lake).	Towns	NHDES, Other Grants	Ongoing	N/A	In 2014 WWAC commissioned a mural on retaining wall at town beach to raise awareness of protecting lake quality
	4) Provide permanent restroom facilities at the Meredith Town Beach on Lake Waukewan.	Meredith	Town of Meredith	Complete	N/A	Permanent rest rooms completed in 2008
	5) Continue to provide temporary restrooms in appropriate access sites for boating enthusiasts. Consider developing a long-term funding source for this action item.	Towns	General Appropriations	Ongoing	N/A	Port A Potty placed at Lake Waukewan boat ramp. Funding provided by Town of Meredith for 2010 and 2011.
Fireworks Research & Education	1) Investigate the effects of fireworks on lake water quality, and distribute information via website, or develop an informational brochure on results.	Lake Associations, NHDES, UNH	Grants	2015-2016	$500	
Septic Systems						
Septic System Maintenance Awareness	1) Distribute educational pamphlets on septic system function and maintenance in tax bills.	WWAC, Homeowner Assns, Lake Assns, Towns	NHDES, Towns, Private, Volunteer	2015-2025	$1,000	In 2008 Meredith created and distributed a one page "Caring for Lake Waukewan: It Starts at Home" document. Septic System Reference material can be found http://www.winnipesaukee.org/category/programs-2/lakeside-learning/
	2) Continue to host Septic Sense Seminars to address link between septic system maintenance and water quality.	LWA, WWAC, Homeowner Assns, Lake Assns, Towns	Granite State Designers & Installers Assn (GSDIA), Towns, Volunteer	2015-2025	$250/yr	

ACTION ITEM	DESCRIPTION	RESPONSIBLE PARTY	FUNDING SOURCE	SCHEDULE	ESTIMATED COST	STATUS (As of June 2016)
Septic Systems						
Targeted Septic Outreach	1) Continue to focus outreach on neighborhoods with properties that have no septic systems on town record.	WWAC, Homeowner Assns, Lake Assns, Towns	Grants, Volunteers	2015-2017	$1,000	Meredith's Health Regulation adopted in 2013 targets properties located within 250' of Lake Waukewan, which have no record of operational approval on file.
	2) Focus septic system maintenance education at campgrounds.	WWAC, Homeowner Assns, Lake Assns, Towns	Volunteers	2015-2017	$500	
	3) Conduct door-to-door septic education to follow-up on septic survey.	WWAC, Homeowner Assns, Lake Assns, Towns, Landowners	Volunteers	2015-2017	N/A	
Septic Provider List	1) Create and distribute a list of septic service providers (create magnets, etc.).	WWAC, Homeowner Assns, Lake Assns, Towns, Landowners	Volunteers, Fundraisers	2015-2017	$500	
Development/Landscaping						
Landscaping	1) Continue to educate homeowners and businesses about lawn care and landscaping techniques that minimize impacts on water resources (e.g. water conservation, native plant species, low maintenance grasses, and low-phosphorus lawn and garden fertilizers).	Towns, Local lake Assns, BCCD, WWAC, NHDES	NH DES Small Outreach and education Grants for Nonpoint Source Pollution	2015-2020	$500	2011- UNH CE held Healthy Waterfront Property Workshop for the Lakes Region Board of Realtors in Meredith. 2012 - BCCD held 'Landscaping by Water's Edge' 2014- Meredith hosted a Shoreland Protection Workshop
Fertilizer Use	1) Continue to promote use of phosphorus-free fertilizers or no fertilizers, such as "Don't P in the Lake" campaign	LWA, NH LAKES, WWAC, Lake & Homeowner Assns, BCCD, Towns, Landowners	Private, Volunteer	Ongoing	$500	The WWAC developed the 'Don't P in the Lake' campaign in 2009/2010. Meredith town fields and lawns converted to low/no phosphorus and no pesticides. Education/outreach was performed by BOS, Meredith Rotary, Kiwanis
Workshops	1) Hold informational workshops for new landowners and developers on local ordinances and watershed goals.	Conservation Commissions, NHDES, Towns, LWA, LRPC, BCCD	NHDES, Towns, Fundraisers	2015-2025	$250/yr	

ACTION ITEM	DESCRIPTION	RESPONSIBLE PARTY	FUNDING SOURCE	SCHEDULE	ESTIMATED COST	STATUS (As of June 2016)
Development/Landscaping						
Workshops	2) Hold educational workshops on conservation easements in the region. Reach out to large landowners to discuss conservation options.	Conservation Commisions, Lakes Region Conservation Trust, SPNHF	NHDES, Towns, Fundraisers, Grants	2015-2025	$250/yr	
Training	1) Require State-sponsored training for code enforcement officers and ZBAs in watershed towns.	Towns	Towns	2015-2025	$5,000	
	2) Require contractors to have adequate training in the installation and maintenance of Low Impact Development (LID) and BMPs for all permit work.	Towns	Contractors	2015-2025	N/A	
	3) Require Green SnoPro certification for DPWs, and commercial snow removal contractors	Towns, Homeowner & Lake Assns	NHDES, UNH, Contractors	2015-2025	N/A	http://t2.unh.edu/green-snowpro-training-and-certification

Table 31. Lake Waukewan/Winona Action Plan - Water Quality Monitoring

ACTION ITEM	DESCRIPTION	RESPONSIBLE PARTY	FUNDING SOURCE	SCHEDULE	ESTIMATED COST	STATUS (As of June 2016)
WATER QUALITY MONITORING						
LAKES						
Expand Lake Monitoring Program	1) Extend lake monitoring season April through November (or year-round) to capture spring and fall turnover and timing of potential algal blooms.	Lake Associations, Volunteers, NHDES VLAP	Lake Associations, NHDES	2015-2025	$250	Current monitoring season generally runs July through September, with one sample collected at each site per month.
	2) Recruit and train additional VLAP volunteers.	Lake Associations, Volunteers, NHDES VLAP	Lake and Homeowner Associations, Volunteers, NHDES VLAP	2015-2025	N/A	
	3) Increase frequency of Secchi Disk Transparency and DO/temperature profile readings. More data on DO profiles could help determine the extent of DO depletion and how it relates to sediment phosphorus release.	Lake Associations, Volunteers, NHDES VLAP	Lake and Homeowner Associations, Volunteers, NHDES VLAP	2015-2025	N/A	
Weed Watch & Lake Host Programs	1) Continue Weed Watcher program; recruit new volunteers, conduct routine surveys of dam, tributaries, and shallows during summer months.	Lake Associations, Homeowner Associations, Volunteers, NHDES	Lake and Homeowner Assns., NHDES, Volunteers	Ongoing	N/A	
	2) Support State legislation that increases funds for aquatic invasive plant (e.g. milfoil) eradication.	Lake Associations, Volunteers, NHDES, NH LAKES	Lake Assns., Homeowner Assns., Residents, Towns	2015-2025	N/A	
	3) Increase the number of volunteer inspectors for the Lake Host program at Lake Waukewan. Consider adding Lake Winona to program.	Lake Associations, Volunteers, NH LAKES	Lake Associations, Towns, Volunteers	2015-2025	N/A	
Cyanobacteria Monitoring	1) Work with UNH and NHDES to implement a formal cyanobacteria monitoring program for the lakes.	Lake Associations, UNH, NHDES	Lake Assns, Towns, NHDES, UNH	2015-2025	TBD	

ACTION ITEM	DESCRIPTION	RESPONSIBLE PARTY	FUNDING SOURCE	SCHEDULE	ESTIMATED COST	STATUS (As of June 2016)
LAKES						
Cyanobacteria Monitoring	2) Host a cyanobacteria talk in coordination with UNH every few years.	Lake Assns, Towns, UNH, NHDES	UNH, NHDES, Donations	2015-2016	$250	Last one held in Meredith in 2011.
Sediment Cores	Work with PSU to examine sediment cores for phosphorus, copper and other parameters; use students to assist with studies.	Lake Assns, Towns, NHDES, PSU	NHDES, PSU	2015-2020	N/A	
Boat Traffic Study	1) Consider collecting data (TP, Chl-a, Color, Turbidity, and SDT) before, during, and after busy holiday weekends to examine effects of boat traffic. Consider adding boat counts, time lapse photography, and the use of a submerged sonde to quantify the effects of boat traffic.	Lake Assns, NHDES, Consultant	Lake Assns, Donations	2015-2020	$5,000	
	2) Implement a monitoring program to assess concentrations of gasoline constituents including MtBE in Lake Waukewan from May to September	Meredith Water Dept., UNH, NHDES	Meredith Water Dept.	Completed		Monitoring program began in 2005. 2007 - Monthly reports from June through Oct.; no issues found, 2008- no issues found. No VOC testing has been done since 2008. MtBE fuel no longer sold in NH
	3) Further research is needed to assess whether or not the drinking water intake in Lake Waukewan should have an isolation zone, demarcated by buoys, in which motorized activity should not occur.	Lake Assns, Meredith, NHDES, NH Marine Patrol	LWA	Ongoing	TBD	
Shoreline Septic Systems	Develop a water quality monitoring program that identifies failing septic systems along the shorelines.	Town Water & Sewer Department, Meredith	NHDES, Other Grants, Donations	Completed		Town of Meredith did a one-time water testing at 9 locations on Lake Waukewan in order to detect failing septic systems. The results were inconclusive
Data Access	Continue to provide water quality data on the Winnipesaukee Gateway website.	LWA, NHDES	Donations, Grants	Ongoing	N/A	LWA uploads water quality data on an annual basis to the Winnipesaukee Gateway

ACTION ITEM	DESCRIPTION	RESPONSIBLE PARTY	FUNDING SOURCE	SCHEDULE	ESTIMATED COST	STATUS (As of June 2016)
			TRIBUTARIES			
Expand Tributary Monitoring Program	1) Conduct intensive tributary monitoring at new and existing stations in the watershed to better understand the effects of nutrient and sediment loading to the lake. Include both wet and dry weather sampling events and collect flow data to help further quantify nutrient loading from individual tributaries.	Lake Assns, WWLSAC, PSU, Towns	NHDES, Other Grants, Donations, Volunteers	Ongoing	$1,000/yr	
Year-Round Sampling	Consider collecting year-round and/or continuous monitoring data in several of the streams to further characterize loading and flow during different times of the year.	Lake Assns, WWLSAC, NHDES, PSU, Towns	NHDES, Other Grants, Donations, Volunteers	2015-2025	$500/yr	
Bracket Sampling	Conduct bracket sampling upstream of sampling locations to identify potential sources of increased loading, particularly for subwatersheds with the highest TP loading (e.g. Winona East Inlet, Snake River, and Reservoir Brook).	Lake Assns, WWLSAC, NHDES, PSU, Towns	NHDES, Other Grants, Donations, Volunteers	2015-2025	$500	
Storm Events	Train volunteers to monitor during storm events at road crossings and culverts near the shorelines. Use information to identify problem areas and recommend solutions.	Lake Assns, WWLSAC, NHDES, PSU, Towns	NHDES, Other Grants, Donations, Volunteers	2015-2025	$500	
Mapping Update	Develop a detailed drainage network map of persistent and intermittent streams and tributaries that can be used to guide water quality monitoring, road maintenance, stormwater management, development, review, and emergency response planning.	LRPC, Towns, NHDES, PSU	NHDES, Other Grants, Donations, Volunteers	Ongoing	N/A	
Continuous Loggers	Add continuous loggers for stage/flow, temperature, dissolved oxygen, conductivity, turbidity, etc. at key sampling locations throughout the watershed.	Lake Assns, PSU, NHDES, Towns	NHDES, Other Grants, Donations, Volunteers	2015-2025	$3,000/yr	

7.2 Indicators and Benchmarks to Measure Progress

Establishing indicators and numeric targets (benchmarks) to quantitatively measure the progress of this plan will provide both short and long-term input about how successful the plan has been in meeting the established goals and objectives for the watershed.

Indicators are derived directly from tasks identified in the Action Plan. While the Action Plan provides a description of tasks, responsible parties, a schedule, and estimated annual costs associated with each task, the indicators are developed to reflect how well implementation activities are working, and provides a means by which to track progress toward established goals and objectives.

The following environmental, programmatic, and social indicators and associated benchmarks will help measure the progress of this plan. These benchmarks represent short-term (2017), mid-term (2020), and long-term (2025) targets for improving water quality in these waterbodies. Setting benchmarks allows for periodic updates to the plan, maintains and sustains the action items, and makes the plan relevant to ongoing activities. The advisory committee will review the benchmarks for each indicator on an ongoing basis to determine if progress is being made, and then determine if the watershed plan needs to be revised because the targets are not being met.

Environmental Indicators are a direct measure of environmental conditions. They are measurable quantities used to evaluate the relationship between pollutant sources and environmental conditions. They assume that BMP recommendations outlined in the Action Plan will be implemented accordingly and will indirectly result in water quality improvement, including reductions in median in-lake TP concentrations, the duration and extent of anoxic conditions at deep holes, and the frequency of peak flows to tributaries from unbuffered impervious or bare soil surfaces that carry phosphorus-laden sediment.

Table 32. Environmental Indicators to measure progress in plan implementation and toward established goals.

Environmental Indicators			
Indicators	**Benchmarks**		
	2017	2020	2025
Improvement in mean annual water clarity	+ 0.1 m	+ 0.25 m	+ 0.4 m
Reduction in median in-lake phosphorus concentration. Goal: 4.95 ppb for Lake Waukewan; 6.30-6.65 ppb for Lake Winona	10% of goal	30% of goal	75% of goal
Reduction in frequency and number of algal blooms			
Reduction in number of beach postings/closures due to elevated *E.coli* (bacteria) levels			
Reduction in erosion and sedimentation issues throughout the watershed			
Increase in fish and wildlife species populations			

Programmatic Indicators are indirect measures of watershed protection and restoration activities. Rather than indicating that water quality reductions are being met, these programmatic measurements list actions intended to meet the water quality goal.

Table 33. Programmatic Indicators to measure progress in plan implementation and toward established goals.

Programmatic Indicators			
Indicators	**Benchmarks**		
	2017	2020	2025
Amount of funding secured for plan implementation through fundraisers, donations, and grants	$50,000	$150,000	$300,000
Successful completion of annual review and update of the plan			
Number of priority sites remediated with recommended BMPs			
Number of high-visibility residential BMP demonstration projects completed			
Linear feet of roadway addressed by BMPs			
Number of shoreline properties showing improved survey scores			
Linear miles of stabilized streambanks or shorelines			
Number of culverts stabilized or retrofitted			
Number of retrofitted stormdrains/catch basins			
Number of voluntary septic system inspections			
Number of sewer or septic system upgrades			
Number of acres of new land in conservation			
Number of new conservation subdivisions			
Number of new or re-developments using LID techniques			
Number of watershed-based educational materials distributed			
Number of educational signage posted throughout the watershed			
Number of new water quality monitoring sites added			
Number of sites monitored during storm events and year-round			
Number of sites with continuous data loggers			

Social Indicators measure changes in social or cultural practices and behavior that lead to implementation of management measures and water quality improvement.

Table 34. Social Indicators used to measure progress in plan implementation and toward established goals.

Social Indicators			
Indicators	**Benchmarks**		
	2017	2020	2025
Number of new lake association members			
Number of new stakeholders on the advisory committee			
Number of homeowners who participate in "septic socials"			
Number of landowners receiving free landowner assistance for septic system maintenance and upgrades			
Number of homeowners who participate in residential demonstration projects/workshops			
Number of volunteers who sign up for BMP implementation projects			
Number of volunteers participating in door-to-door education campaigns			
Number of people participating in educational workshops			
Number of people attending annual spring plant sale			
Number of people participating in online Self-Assessment Quiz			
Number of new road associations			
Number of contractors completing a BMP or LID training			
Number of new regulations or new/amended ordinances passed by citizen support			
Number of landowners with >10 acre lots participating in land conservation programs			
Number of new and active "Lake Hosts"			
Number of new and active "Weed Watchers"			
Number of newly-trained NHDES VLAP volunteers			
Number of new volunteers and sponsors for water quality monitoring			

7.3 Estimated Costs and Technical Assistance Needed

The cost of successfully implementing this watershed plan for Lake Waukewan and Lake Winona is estimated at $324,200 over the next 10 years (Table 35). However, many costs are still unknown and should be incorporated into the Action Plan as information becomes available. This includes both structural BMPs, such as fixing eroding roads and planting shoreline buffers, and non-structural BMPs, such as improving ordinances. Annual BMP costs were estimated based on a 10-year total for the initial BMP installation plus 10 years of maintenance. Therefore, the annual BMP costs are not truly representative of how funds will likely be allocated during implementation since the annual costs may be higher earlier in the 10-year plan and less toward the end.

Table 35. Estimated annual and 10-year costs for watershed restoration.

Category	Estimated Annual Costs	10-year Total
Wastewater Systems	$3,850	$38,500
Best Management Practices (BMPs)	$14,600	$146,000
Municipal Ordinance, Planning, & Land Conservation	$4,500	$45,000
Education & Outreach	$3,270	$32,700
Water Quality Monitoring	$6,200	$62,000
Total Cost	**$32,420**	**$324,200**

A diverse source of funding and a funding strategy will be needed to match these implementation activities. Funding to cover ordinance revisions and third-party review could be supported by municipalities through tax collection, permit fees, or violation fees. Monitoring and assessment funding could come from a variety of sources, including state and federal grants (Section 319, ARM, Moose Plate, etc.), private foundations, and municipalities. Funding for education and outreach might also be expected to come from these sources as well as the local lake associations. Funding to improve septic systems, public and private roads, and shoreland buffers could be expected from property owners most affected by the improvements. As the plan evolves into the future, the Advisory Committee will play a key role in how the funds are raised, tracked and spent to implement and support the plan.

7.4 Evaluation of the Plan

Annual advisory committee meetings should be organized to review the status of goals and objectives presented in this watershed management plan. It is recommended that an adaptive management approach be used to assess annual progress, determine key projects for the following year, and provide a venue for sharing information with watershed stakeholders. Adaptive management is the process by which new information about the health of the watershed is incorporated into the plan. This process allows stakeholders the opportunity to evaluate the effectiveness of restoration and monitoring activities before implementing future actions. Tasks listed in the Action Plan should be tracked and recorded as they occur, and new tasks should be added to the plan as determined through the adaptive management process. All achievements, such as press releases, outreach activities, number of sites repaired, number of volunteers, amount of funding received, and number of sites documented, should be tracked. Stakeholders can then use the established indicators to determine the effectiveness of the plan.

7.5 Conclusion

Watershed residents, landowners, business owners, and recreationalists alike have a vested interest in protecting the long-term water quality of Lake Waukewan and Lake Winona for future generations. The goal of this plan is to improve the dissolved oxygen concentrations in the bottom depths by reducing the amount of pollutants, sediments, and nutrients that enter the lakes. The lake study advisory committee has chosen to reduce the median in-lake phosphorus concentrations by 10% and 5-10% in Lake Waukewan and Lake Winona, respectively, over the next 10 years. This goal can be reached if management actions discussed in this plan are implemented accordingly. Implementation of this plan over the next 10 years is expected to cost $324,200, and will require the dedication and hard work of municipalities, conservation groups, and volunteers to ensure that the actions identified in this plan are carried out accordingly. The Action Plan will need to be updated as the plan is implemented and new action items are added, in accordance with the adaptive management approach.

Additional Resources

Where Do I Get More Information?

Contacts

Lake Winnipesaukee Association
Patricia Tarpey, Executive Director
PO Box 1624
Meredith, NH 03253
ptarpey@winnipesaukee.org
(603) 581-6632

Belknap County Conservation District
64 Court Street, Laconia, NH 03246
(603) 527-5880
Offers assistance with watershed planning and surveys, environmental education, engineering support, seminars and training sessions, and education on the use of conservation practices.

Lakes Region Planning Commission
103 Main Street, Suite 3
Meredith, NH 03253
(603) 279-8171

New Hampshire Lakes Association
14 Horseshoe Pond Lane, Concord, NH 03301
(603) 226-0299
http://www.nhlakes.org/

New Hampshire Department of Environmental Services
29 Hazen Drive, Concord, NH 03301
(603) 271-3503
Provides permit applications and assistance, numerous reference materials, environmental education, funding opportunities, and stewardship activities for lakes.

Publications

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http://des.nh.gov/organization/commissioner/pip/publications/wd/documents/vrap_native_plantings.pdf

New Hampshire Homeowner's Guide to Stormwater Management: Do-it-Yourself Stormwater Solutions for Your Home. NHDES. 2016. http://des.nh.gov/organization/commissioner/pip/publications/wd/documents/wd-11-11.pdf

Rain Garden App for iPhones - leads homeowners & contractors through the proper siting, sizing, construction, planting and maintenance of rain gardens. http://nemo.uconn.edu/tools/app/raingarden.htm

Shoreland Protection Fact Sheets. NHDES.
http://des.nh.gov/organization/commissioner/pip/factsheets/sp/index.htm

Soak up the Rain New Hampshire. NHDES.
http://soaknh.org/

Winnipesaukee Gateway Website http://winnipesaukeegateway.org/: Residents can access watershed information and maps, management plans, learn how to get involved in watershed stewardship, and run the Stormwater Footprint Calculator – "What's Your P?" This calculator is based on the NH DES Residential Loading Model: http://winnipesaukeegateway.org/resources/phosphorus-calculator/

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