WOLFEBORO BAY

WATERSHED-BASED MANAGEMENT PLAN

PREPARED BY FB ENVIRONMENTAL ASSOCIATES
in partnership with the Town of Wolfeboro
and the Lake Winnipesaukee Alliance

December 2024 | **FINAL**

Photo Credit: Jon Decker/The Laconia Daily Sun

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ACKNOWLEDGEMENTS

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For questions, comments, or additional information related to the Wolfeboro Bay Watershed-Based Management Plan, please contact the Lake Winnipesaukee Alliance at mail@winnipesaukee.org.

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LIST OF ABBREVIATIONS

ACRONYM	DEFINITION
AC	Assimilative Capacity
AIPC	Aquatic Invasive Plant Control, Prevention and Research Grants
ACEP	Agricultural Conservation Easement Program
ALI	Aquatic Life Integrity
ARM	Aquatic Resource Mitigation Fund
BCCD	Belknap County Conservation District
BMP	Best Management Practice
CAGR	Compound Annual Growth Rate
CCCD	Carroll County Conservation District
CHL-A	Chlorophyll-a
CNMP	Comprehensive Nutrient Management Plan
CSP	Conservation Stewardship Program
CUM	Cubic Meters
CWA	Clean Water Act
CWP	Center for Watershed Protection
CWSRF	Clean Water State Revolving Fund
DO	Dissolved Oxygen
DPW	Department of Public Works
EMD	Environmental Monitoring Database
EPA	United States Environmental Protection Agency
EQIP	Environmental Quality Incentives Program
ESRI	Environmental Systems Research Institute
FBE	FB Environmental Associates
FT	Feet
HA	Hectare
HAB	Harmful Algal Bloom
ILFP	In-Lieu Fee **Program**
KG	Kilogram
LCHIP	Land and Community Heritage Investment Program
LID	Low Impact Development
LLMP	Lakes Lay Monitoring Program
LLRM	Lake Loading Response Model
LRCT	Lakes Region Conservation Trust
LRPC	Lakes Region Planning Commission
LWA	Lake Winnipesaukee Alliance
LWCF	Land and Water Conservation Fund
M	Meter
NAIP	National Agriculture Imagery Program
NAWCA	North American Wetlands Conservation Act
NERFG	New England Forest and River Grant
NCEI	National Centers for Environmental Information
NFWF	National Fish and Wildlife Foundation
NH GRANIT	New Hampshire Geographically Referenced Analysis and Information Transfer System
NHACC	New Hampshire Association of Conservation Commissions
NHD	National Hydrography Dataset
NHDES	New Hampshire Department of Environmental Services
NHFG	New Hampshire Fish and Game Department
NOAA	National Oceanic and Atmospheric Administration

ACRONYM	DEFINITION
NPDES	National Pollutant Discharge Elimination System
NPS	Nonpoint Source Pollution
NRCS	Natural Resources Conservation Service
NRI	Natural Resources Inventory
NWI	National Wetlands Inventory
PCR	Primary Contact Recreation
PCS	Potential Contamination Source
PFAS	Per- and polyfluoroalkyl substances
ppb, ppm	parts per billion, parts per million
RCCP	Regional Conservation Partnership Program
RCRA	Resource Conservation and Recovery Act
ROW	Right-of-Way
SCC	State Conservation Committee
SCCD	Strafford County Conservation District
SDT	Secchi Disk Transparency
TP	Total Phosphorus
UNH	University of New Hampshire
USLE	Universal Soil Loss Equation
WBMP	Watershed-Based Management Plan
YR	Year

DEFINITIONS

Adaptive management approach recognizes that the entire watershed cannot be restored with a single restoration action or within a short time frame. The approach provides an iterative process to evaluate restoration successes and challenges to inform the next set of restoration actions.

Anoxia is a condition of low dissolved oxygen.

Assimilative Capacity is a lake's capacity to receive and process nutrients (phosphorus) without impairing water quality or harming aquatic life.

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) BMPs for existing and new development to ensure long-term restoration success.

Build-out analysis combines projected population estimates, current zoning restrictions, and a host of additional development constraints (conservation lands, steep slope and wetland regulations, existing buildings, soils with low development suitability, and unbuildable parcels) to determine the extent of buildable areas in the watershed.

Chlorophyll-a (Chl-a) is a measurement of the green pigment found in all plants, including microscopic plants such as algae. Measured in parts per billion or ppb, it is used as an estimate of algal biomass; the higher the Chl-a value, the higher the number of algae in the lake.

Clean Water Act (CWA) requires states to establish water quality standards and conduct assessments to ensure that surface waters are clean enough to support human and ecological needs.

Cyanobacteria are photosynthetic bacteria that can grow prolifically as blooms when enough nutrients are available. Some cyanobacteria can fix nitrogen and/or produce microcystin, which is highly toxic to humans and other life forms.

Dissolved Oxygen (DO) is a measure of the amount of oxygen dissolved in water. Low oxygen can directly kill or stress organisms and stimulate release of phosphorus from bottom sediments.

Epilimnion is the top layer of lake water directly affected by seasonal air temperature and wind. This layer is well-oxygenated by wind and wave action.

Eutrophication is the process by which lakes become more productive over time (oligotrophic to mesotrophic to eutrophic). Lakes naturally become more productive or "age" over thousands of years. In recent geologic time, however, humans have enhanced the rate of enrichment and lake productivity, speeding up this natural process to tens or hundreds of years.

Fall turnover is the process of complete lake mixing when cooling surface waters become denser and sink, especially during high winds, forcing warmer, less-dense water to the surface. This process is critical for the natural exchange of oxygen and nutrients between surface and bottom layers in the lake.

Flushing rate (also called retention time) is the amount of time water spends in a waterbody. It is calculated by dividing the flow in or out by the volume of the waterbody.

Full build-out refers to the time and circumstances in which, based on a set of restrictions (e.g., environmental constraints and current zoning), no more building growth can occur, or the point at which lots have been subdivided to the minimum size allowed.

Hypolimnion is the bottom-most layer of the lake that experiences periods of low oxygen during stratification and is devoid of sunlight for photosynthesis.

Impervious surfaces or cover refer to any surface that will not allow water to soak into the ground. Examples include paved roads, driveways, parking lots, and roofs.

Internal Phosphorus Loading is the process whereby phosphorus bound to lake bottom sediments is released back into the water column during periods of anoxia. The phosphorus can be used as fuel for plant and algae growth, creating a positive feedback to eutrophication.

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.

Nonpoint Source (NPS) Pollution comes from diffuse sources throughout a watershed, such as stormwater runoff, seepage from septic systems, and gravel road erosion. One of the major constituents of NPS pollution is sediment, which contains a mixture of nutrients (like phosphorus) and inorganic and organic material that stimulate plant and algae growth.

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, and targeted education and training.

Oligotrophic lakes are less productive or have fewer nutrients (i.e., low levels of phosphorus and chlorophyll-a), deep Secchi Disk Transparency readings (8.0 m or greater), and high dissolved oxygen levels throughout the water column. In contrast, **eutrophic** lakes have more nutrients and are therefore more productive and exhibit algal blooms more frequently than oligotrophic lakes. **Mesotrophic** lakes fall in-between with an intermediate level of productivity.

pH is the standard measure of the acidity or alkalinity of a solution on a scale of 0 (acidic) to 14 (basic).

Riparian refers to wildlife habitat found along the banks of a lake, river, or stream. Not only are these areas ecologically diverse, but they are also critical to protecting water quality by preventing erosion and filtering polluted stormwater runoff.

Secchi Disk Transparency (SDT) is a vertical measure of the transparency of water (ability of light to penetrate water) obtained by lowering a black and white disk into the water until it is no longer visible. Transparency is an indirect measure of algal productivity and is measured in meters (m).

Structural BMPs, or engineered Best Management Practices, are often at the forefront of most watershed restoration projects and help reduce stormwater runoff and associated pollutants.

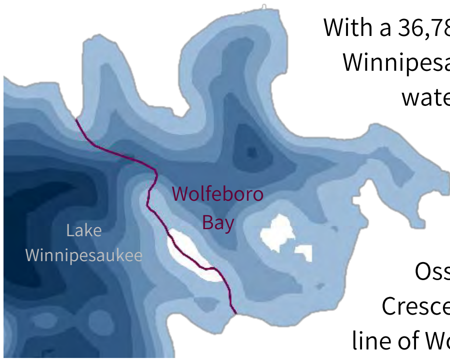
Thermal stratification is the process whereby warming surface temperatures in summer create a temperature and density differential that separates the water column into distinct, non-mixable layers.

Thermocline or **metalimnion** is the markedly cooler, dynamic middle layer of rapidly changing water temperature. The top of this layer is distinguished by at least a degree Celsius drop per meter of depth.

Total Phosphorus (TP) is one of the major nutrients needed for plant growth. It is generally present in small amounts (measured in parts per billion (ppb)) and limits plant growth in lakes. In general, as the amount of TP increases, the number of algae also increases.

Trophic State is the degree of eutrophication of a lake and is designated as oligotrophic, mesotrophic, or eutrophic.

EXECUTIVE SUMMARY



With a 36,784-acre watershed, Wolfeboro Bay is a 1,988-acre bay located within Lake Winnipesaukee in the economically vital Lakes Region of central New Hampshire. The watershed area to Wolfeboro Bay is divided into two primary watersheds – the Lake Wentworth/Crescent Lake watershed (22,649 acres), which is connected to Wolfeboro Bay via the Smith River, and the Wolfeboro Bay Direct watershed (14,135 acres). Wolfeboro Bay resides within the towns of Wolfeboro and Alton, while its watershed extends into Wolfeboro, Alton, New Durham, Brookfield, and Ossipee. Wolfeboro Bay is fed by upstream waterbodies including Lake Wentworth, Crescent Lake, Back Bay, Rust Pond, Shaws Pond, and Knights Pond. From the dividing line of Wolfeboro Bay, water mixes with the rest of Lake Winnipesaukee through the Broads.

The Problem

Wolfeboro Bay has experienced generally excellent water quality through the years and is not currently assessed as impaired according to the New Hampshire Department of Environmental Services (NHDES) 303(d) impaired surface waterbodies list. NHDES Lake Trophic Survey Reports (1979, 1984, 1990, 2001) classify Wolfeboro Bay as oligotrophic, with low phytoplankton abundance and few aquatic plants. The most recent report from August 2001 found that transparency reached as high as 10 meters, and the bottom depths were well oxygenated. However, recent cyanobacteria blooms in Lake Winnipesaukee, including Wolfeboro Bay, has resulted in NHDES posting warnings or alerts. In 2023, a warning was issued for Crescent Lake (7 days) and two alerts were issued, one for Lake Wentworth and another for Jockey Cove in Wolfeboro Bay. Jockey Cove has experienced blooms previously in 2021 (4 days) and 2022 (2 days). These blooms contained a diverse mix of potentially toxic types (taxa) including *Dolichospermum* and *Gloeotrichia*. Larger scale *Gloeotrichia* and/or *Dolichospermum* blooms were also observed in 2023 and 2024, with June 2024 *Dolichospermum* blooms pervasive in Wolfeboro Bay and August 2024 *Gloeotrichia* blooms apparent in most of Lake Winnipesaukee, including Wolfeboro Bay. These blooms largely occur despite low nutrient levels in the water and caution that anthropogenic inputs to Lake Winnipesaukee, such as impacts from stormwater runoff or shoreline erosion from increased wave action, can affect the health of the lake, especially as climate change increases the amount of large precipitation events and extends the ice-free period on lakes.

Other waterbodies in the Wolfeboro Bay watershed can impact the water quality of Wolfeboro Bay because they contribute water, and therefore nutrients, to the lake. Lake Wentworth and Crescent Lake have generally good water quality; the 2012 Lake Wentworth and Crescent Lake Watershed Management Plan notes that both lakes have exhibited worsening trends in major water quality parameters despite their generally low total phosphorus and chlorophyll-a concentrations. Rust Pond is an oligotrophic waterbody but has major sedimentation issues near some of its inlets, according to the 2012 Rust Pond North Inlet and Route 28 Boat Launch Subwatershed Assessment. Excess sediment loading can be detrimental to water quality because it can increase turbidity (a reflection of suspended solids in the water) and contribute sediment-bound phosphorus to the pond. Rust Pond is also known to occasionally have periods of anoxia, which can trigger the release of phosphorus from bottom sediments and be mixed up into the water column for use by cyanobacteria. Shaws Pond has also experienced a rapid degradation in water quality in recent years.

Cyanobacteria blooms are typically spurred by a combination of warming waters and excessive nutrients, in particular phosphorus, to surface waters. Sources of phosphorus in the watershed impacting the lake's water quality include stormwater runoff from developed areas largely from impervious cover, shoreline erosion, erosion from construction activities or other disturbed ground particularly along roads, excessive fertilizer application, failed or improperly functioning septic systems, leaky sewer lines, unmitigated agricultural activities, and pet, livestock, and wildlife waste. Ninety (90) problem sites were identified in the watershed during a field survey, and the main issues found were road shoulder and ditch erosion, buffer clearing, and untreated stormwater runoff from impervious surfaces. Additionally, 294 shorefront properties were identified as having some impact on water quality due to evidence of erosion and lack of vegetated buffer. The model results revealed changes in phosphorus loading and in-lake phosphorus concentrations over time from pre-development through future conditions, showing that the water quality of Wolfeboro Bay is threatened by current development activities in the watershed and will degrade further with continued development in the future, especially when compounded by the effects of ongoing climate change. In the Wolfeboro Bay watershed, the watershed load is the largest source of phosphorus, and runoff from residential/commercial development contributes to 61% of the watershed phosphorus load.

The Goal

The goal of the Wolfeboro Bay Watershed-Based Management Plan (WBMP) is to improve the water quality of Wolfeboro Bay such that it continues to meet the state water quality standards for Aquatic Life Integrity and Primary Contact Recreation, and substantially reduces the likelihood of harmful cyanobacteria blooms in the bay and Lake Winnipesaukee. This goal will be achieved by accomplishing the following objectives over the next 10 years and beyond:

OBJECTIVE 1: Reduce phosphorus loading from existing development by 9.4% (149 kg/yr) to Wolfeboro Bay to improve average summer in-lake total phosphorus concentration from 5.1 ppb to 4.6 ppb.

OBJECTIVE 2: Mitigate (prevent or offset) phosphorus loading from future development by 203 kg/yr to Wolfeboro Bay to maintain average summer in-lake total phosphorus concentration in the next 10 years (2033). *Note: excludes phosphorus loading from Crescent Lake and Lake Wentworth and mixing with the Broads, focusing only on future development within the direct watershed to Wolfeboro Bay.*

It is important to note that, while the focus of the objectives for this plan is on phosphorus, the treatment of stormwater and sediment erosion will result in the reduction of many other kinds of pollutants that may impact water quality. These pollutants would likely include other nutrients (e.g., nitrogen), petroleum products, bacteria, road salt/sand, excessive organic material (raking/blowing leaves and grass cuttings or erosion from boat wakes), and heavy metals (cadmium, nickel, zinc, etc.).

Measures of success for achieving the goal and objectives should be based on a reduction in phosphorus loading from the major tributaries to Wolfeboro Bay and/or from shorefront BMPs and septic system upgrades, as well as a reduction in the frequency and severity of cyanobacteria blooms in the bay and Lake Winnipesaukee. It is unlikely that reduction efforts in the watershed will result in a measurable improvement in the average summer in-lake total phosphorus concentration due to the large influence of mixing with the Broads, unless large-scale reductions are completed around Lake Winnipesaukee. While any amount of phosphorus load reduction to the lake will be helpful for controlling cyanobacteria blooms, it is important to understand that the dominant cyanobacteria taxa in the lake can uptake phosphorus from phosphorus-rich sediments and store phosphorus for later use under more optimal growth conditions. Thus, the management implications for minimizing the risk of cyanobacteria blooms is not straightforward and depends on a number of factors out of our direct control. The physiological characteristics of these cyanobacteria taxa also means that the typical application of the state's water quality standards for lakes in the form of the assimilative capacity analysis are less relevant for Lake Winnipesaukee.

The Solution

As part of a campaign to "Keep Winni Blue" and more recently to protect "Our Lake, Our Future", the Lake Winnipesaukee Alliance (LWA) has been coordinating the development of WBMPs for the entire Lake Winnipesaukee watershed, one sub-watershed at a time. To date, WBMPs have been completed for Meredith, Paugus, and Saunder's Bay (2010), Moultonborough Bay Inlet (2017), and Moultonborough Bay and Winter Harbor (2020). The remaining three major WBMPs are expected to be completed by 2026.

As part of the development of the Wolfeboro Bay WBMP, a build-out analysis, land-use model, water quality and assimilative capacity analysis, septic system database development, shoreline survey, and watershed survey were conducted to identify and quantify the sources of phosphorus and other pollutants to the lake. Results from these analyses were used to determine recommended management strategies for the identified pollutant sources in the watershed. An Action Plan (Section 5) was developed in collaboration with an Advisory Committee comprised of key watershed stakeholders (see Acknowledgements). The following actions were recommended to meet the established water quality goal and objectives for Wolfeboro Bay:

WATERSHED STRUCTURAL BMPS: Sources of phosphorus from existing watershed development should be addressed through installation of stormwater controls, stabilization techniques, buffer plantings, etc. for the following: stormwater infrastructure, the high priority sites (and the medium and low priority sites as opportunities arise) identified during the watershed survey, the high and medium impact shoreline properties (and low priority properties as opportunities arise) identified during the shoreline survey, and any new or redevelopment projects in the watershed with high potential for soil erosion.

MONITORING: A long-term water quality monitoring plan is critical to evaluate the effectiveness of implementation efforts over time. LWA, in concert with University of New Hampshire (UNH) Lakes Lay Monitoring Program (LLMP), should continue the annual monitoring program and consider incorporating additional monitoring recommendations laid out in this plan.

EDUCATION AND OUTREACH: LWA, Wolfeboro Waters, and other key watershed stakeholders should continue all aspects of their education and outreach strategies and consider developing new ones or improving existing ones to reach more watershed residents. Examples include providing educational materials to existing and new property owners, as well as renters, by distributing them at various locations and through a variety of means, such as websites, newsletters, social media, community events, or community gathering locations. Educational campaigns should include raising awareness of water quality concerns, septic system maintenance, fertilizer and pesticide use, pet waste disposal, waterfowl feeding, invasive aquatic species, boat pollution, shoreline buffer improvements, gravel road maintenance, and stormwater runoff controls.

OTHER ACTIONS: Additional strategies for reducing phosphorus loading to the lake include: revising local ordinances such as setting low impact development (LID) requirements on new development, including setting limits on impervious cover; identifying and replacing malfunctioning septic systems; inspecting and remediating leaky sewer lines; using best practices for road maintenance and other activities including municipal operations such as infrastructure cleaning; conserving large or connective habitat corridor parcels; and improving agricultural practices. Future development should also be considered as a pollutant source and potential threat to water quality. Wolfeboro Bay is at risk for greater water quality degradation because of new development in the watershed unless climate change resiliency and LID strategies are incorporated into existing zoning standards.

The recommendations of this plan will be carried out by a diverse stakeholder group in the form of a dedicated committee, including representatives from LWA, municipalities (e.g., select boards, planning boards), conservation commissions, Wolfeboro Waters, state and federal agencies or organizations, nonprofits, land trusts, schools and community groups, local business leaders, and landowners. The cost of successfully implementing the plan is estimated at $2.7-$3.9 million over the next 10 or more years in addition to the dedication and commitment of volunteer time and support to manage plan implementation. However, many costs are still unknown or were roughly estimated and should be updated as information becomes available. This financial investment can be accomplished through a variety of funding mechanisms via both state and federal grants, as well as commitments from municipalities or donations from private residents. Of significant note, this plan meets the nine planning elements required by the EPA, and Wolfeboro Bay is now eligible for federal watershed assistance grants.

Important Notes

The success of this plan is dependent on the continued effort of a dedicated committee that meets regularly to coordinate resources for implementation, review progress, and make any necessary adjustments to the plan to maintain relevant action items and interim milestones. A reduction in nutrient loading is no easy task, and because there are many diffuse sources of phosphorus reaching surface waters in the watershed, it will require an integrated and adaptive approach across many different parts of the watershed community to be successful. The recommendations in this plan are idealized and, in some cases, may be difficult to achieve given the physical and political realities of the community dealing with old infrastructure, lack of access to key lakefront areas, and limited funding and volunteer or staff capacity. The water quality goal and objectives are set to meet a desired future water quality condition, which may or may not be accomplished within the 10-year lifespan of this plan.

Finally, we all have a common responsibility to protect our lakes for future generations to enjoy. Private landowners arguably hold the most power in making significant impact to restoring and maintaining excellent water quality in our lakes; however, engaging private landowners as a single stakeholder group can be difficult and outreach efforts often have limited reach, especially to those individuals who may require the most education and awareness of important water quality protection actions. LWA, Wolfeboro Waters, and other relevant stakeholders will continue to engage the public as much as possible so that private individuals can help review and implement the recommendations of this plan and protect the water quality of Wolfeboro Bay long into the future.

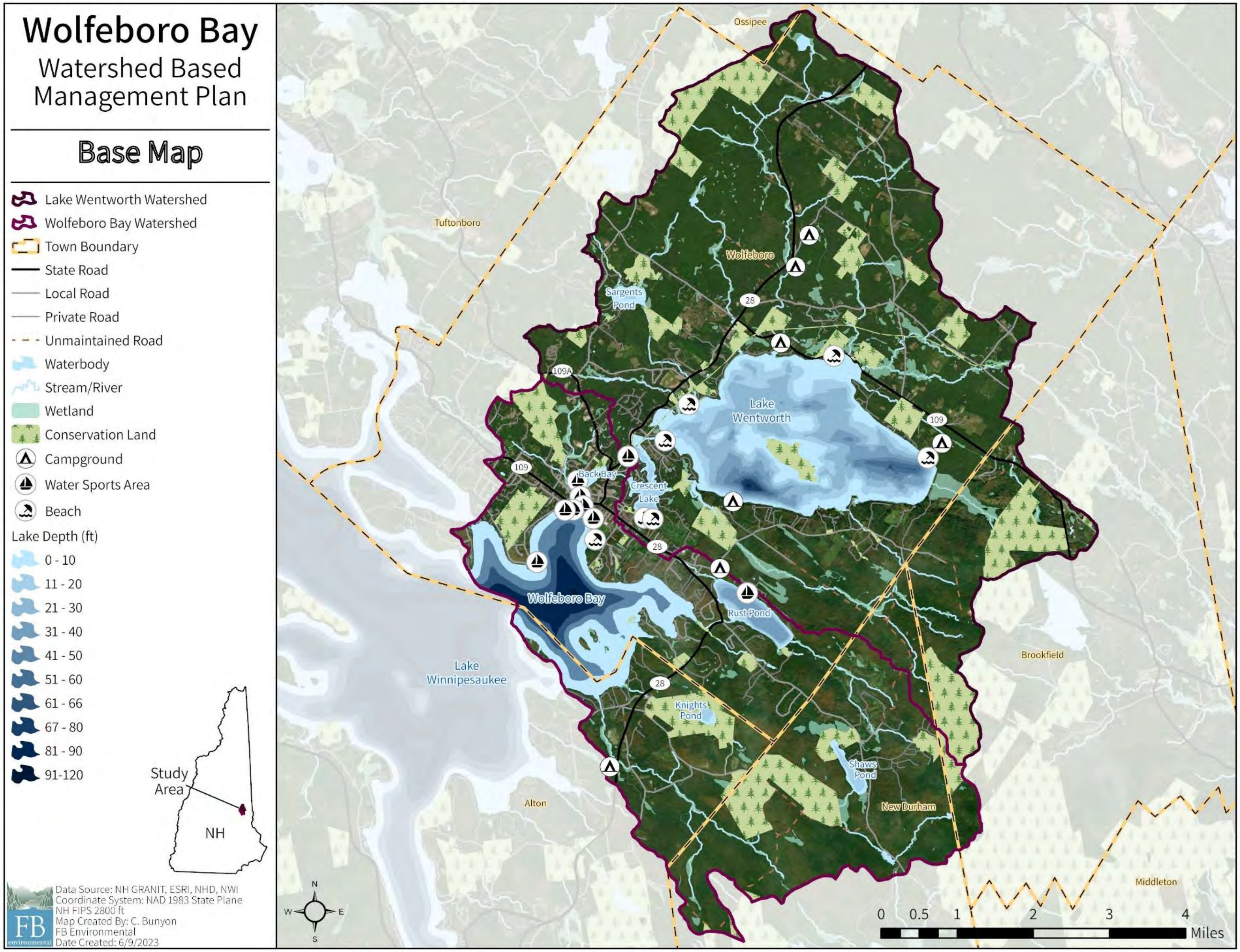


Figure 1. Wolfeboro Bay watershed.

1 INTRODUCTION

1.1 WATERBODY DESCRIPTION AND LOCATION

Wolfeboro Bay is a 1,988-acre (805-hectare) bay within Lake Winnipesaukee. Including the Lake Wentworth/Crescent Lake watershed, the Wolfeboro Bay watershed spans 36,784 acres (14,886 hectares) into the towns of Wolfeboro (70%), Alton (8%), New Durham (15%), Brookfield (8%), and Ossipee (0.2%). Wolfeboro Bay is fed by upstream waterbodies including Lake Wentworth, Crescent Lake, Back Bay, Rust Pond, Shaws Pond, and Knights Pond. Lake Wentworth is a 3,103-acre lake connected to Wolfeboro Bay via Crescent Lake (140 acres) and Back Bay (36 acres) via the Smith River. Other waterbodies within the watershed include Sargents Pond (58 acres), Rust Pond (245 acres), Shaws Pond (70 acres), and Knights Pond (31 acres) (Figure 1). There are many other named streams within the watershed including but not limited to Beaver Brook which flows into Wolfeboro Bay from the south, and Harvey Brook, Hersey Brook, Fernald Brook, Wiley Brook, Clay Pit Brook, Frost Brook, Ryefield Brook, Morrill Brook, Warren Brook, Townsend Brook, and Heath Brook which all flow into Lake Wentworth. From the dividing line of Wolfeboro Bay, water mixes with the rest of Lake Winnipesaukee before flowing out of the lake via the Winnipesaukee River to join the Pemigewasset River and eventually the Merrimack River.

The Wolfeboro Bay watershed is situated within a temperate zone of converging weather patterns from the hot, wet southern regions and the cold, dry northern regions, which causes various natural phenomena such as heavy snowfalls, severe thunder and lightning storms, and hurricanes. The area experiences moderate to high rainfall and snowfall, averaging 46.2 inches of precipitation annually. Data were collected for 1993-2022 from the Lakeport 2 weather station (USC00274480), with gaps covered by the following weather stations: New Durham weather station (USC00275783), North Conway (USC00275995), Meredith (US1NHBK0009), Center Harbor (US1NHBK0012), Laconia 2.8 S (US1NHBK0010), Laconia 7.9 E (US1NHBK0007), Tilton Northfield (US1NHBK0001), Tamworth 4 (USC00278614), and Tamworth 3 (USC00278612) (Figure 2). Annual air temperature (from average monthly data) generally ranges from 21 °F to 71 °F with an average of 47 °F (NCEI, 2024).

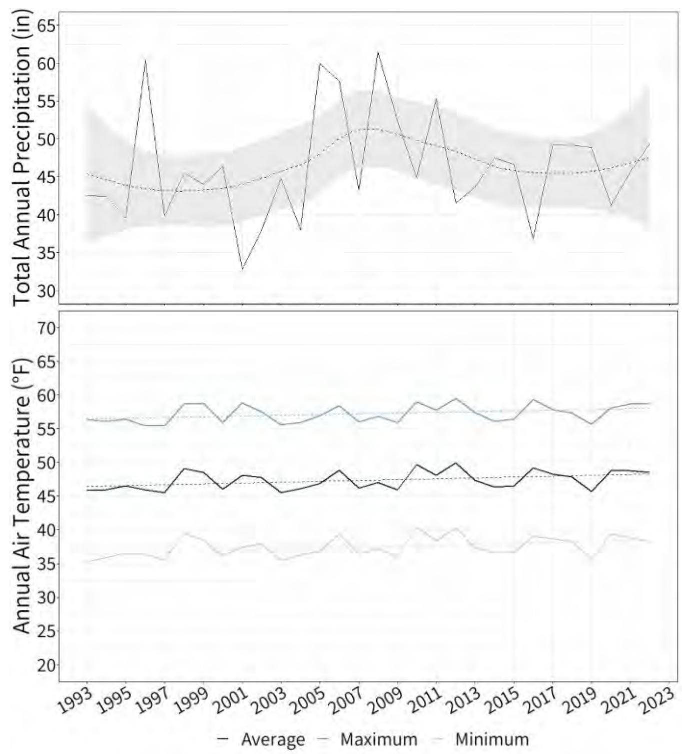


Figure 2. Total annual precipitation (top) and annual max, average, and min of monthly air temperature (bottom) from 1993 - 2022 for the region. Data collected from NOAA NCEI. The dashed line and grey shaded area for precipitation represents the Locally Estimated Scatterplot Smoothing (LOESS) regression and 95% confidence intervals, respectively. The dashed lines for air temperature indicate a statistically significant trend ($p < 0.05$).

The highest elevation in the watershed (about 565 meters or 1,853 feet above sea level) is located within the Copple Crown Conservation Area of Brookfield in the southeastern part of the watershed. Wolfeboro Bay and the direct shoreline drainage area are approximately 153 meters or 502 feet above sea level. These elevation measurements were derived from digital elevation models provided by NH GRANIT.

The watershed is characterized primarily by mixed forest that includes both conifers (e.g., white pine and eastern hemlock) and deciduous (e.g., beech, red oak, and maple) tree species. Fauna that enjoy these forested resources include land mammals (moose, deer, black bear, coyote, bobcats, fisher, fox, raccoon, weasel, porcupine, muskrat, mink, chipmunks, squirrels, snowshoe hares, and bats), water mammals (muskrat, otter, and beaver), land and water reptiles and amphibians (turtles, snakes, frogs, and salamanders), various insects, birds (herons, loons, gulls, geese, multiple species of ducks[1], wild turkeys, ruffed grouse, cormorants, bald eagles, and song birds), and fish. The Town of Wolfeboro is home to a variety of threatened and endangered species, including reproducing populations of common loons (Blue Moon Environmental, Inc., 2011).

1.2 WATERSHED PROTECTION GROUPS

The Lake Winnipesaukee Alliance (LWA) is a non-profit organization with the mission of "*protecting the water quality and natural resources of Lake Winnipesaukee and its watershed. Through monitoring, education, stewardship, and utilizing science-guided approaches for lake management, LWA works to ensure that Winnipesaukee's scenic beauty, wildlife habitat, water quality, and recreational potential continues to provide enjoyment today and for the future.*" LWA serves the 14 communities located in Belknap and Carroll counties. LWA is led by several paid staff and a volunteer Board of Directors.

Adapted from a letter to NHDES dated February 16, 2023, Wolfeboro Waters is a standing Town of Wolfeboro committee consisting of volunteers appointed by the Wolfeboro Board of Selectmen. The committee was established in response to a local cyanobacteria bloom in Lake Winnipesaukee that lasted for three weeks in August 2018. The committee complements the longer-term protection efforts of the Wentworth Watershed Association (WWA), Rust Pond Association, Mirror Lake Protective Association, and LWA. Wolfeboro Waters focuses on the risk and mitigation of cyanobacteria blooms in local waters.

The Carroll County Conservation District (CCCD), Belknap County Conservation District (BCCD), and Strafford County Conservation District (SCCD) are three of 10 county conservation districts in New Hampshire that operate as resource management agencies and a subdivision of local governments. CCCD focuses on "*water quality, erosion & sedimentation, wildlife habitats, health of forests & wetlands, non-point source pollution, and storm water & flooding.*" BCCD's mission is to "*coordinate and implement programs for education and on-the-ground work regarding conservation, use, and development of soil, water, and related resources.*" These organizations work with farmers, forest owners, landowners, schools, and municipalities to help protect and conserve the area's natural resources through projects such as stream bed restoration, invasive species management, and pollinator plantings. Wolfeboro and Brookfield are part of CCCD; Alton is part of the BCCD; and New Durham is part of the SCCD.

Lakes Region Conservation Trust (LRCT) is a non-profit organization "*dedicated to the permanent conservation, stewardship, and respectful use of lands that define the character of the Lakes Region and its quality of life.*" Their vision is a "*future where conserved lands support thriving biodiversity, healthy watersheds, and vibrant human communities.*" LRCT has conserved 174 properties totaling over 29,000 acres in the Lakes Region.

The New Hampshire Association of Conservation Commissions (NHACC) works to provide educational assistance to conservation commissions throughout New Hampshire (217 in total). As a non-profit organization, the NHACC's mission is to instill responsible use of the available natural resources by promoting conservation and serving as the communication link between conservation commissions, while providing technical support on the logistics of conservation commission meetings and document language. Conservation commissions in the Wolfeboro Bay watershed include those of Wolfeboro, Alton, New Durham, and Brookfield.

Covering 31 communities, the Lakes Region Planning Commission (LRPC) is a valuable resource to the region. The LRPC aids communities with their local planning services in a targeted approach to protect the environment, while supporting local economies and cultural values.

[1] American black duck, black scoter, canvasback, common goldeneye, hooded merganser, long tailed duck, wood duck, red breasted merganser, northern pintail, and mallard.

The New Hampshire Department of Environmental Services (NHDES) works with local organizations to improve water quality in New Hampshire at the watershed level. NHDES works with communities to identify water resource goals and to develop and implement watershed plans. This work is achieved by providing financial and technical assistance to local watershed management organizations and by investigating actual and potential water contamination problems, among other activities.

1.3 PURPOSE AND SCOPE

The purpose and overarching goal of the Wolfeboro Bay Watershed-Based Management Plan (WBMP) is to guide implementation efforts over the next 10 years (2024-2033) to improve the water quality of Wolfeboro Bay such that it continues to meet state water quality standards for Aquatic Life Integrity (ALI) and Primary Contact Recreation (PCR) and substantially reduces the likelihood of harmful cyanobacteria blooms in the bay and greater Lake Winnipesaukee. *Efforts to protect Wolfeboro Bay will also help protect other areas of Lake Winnipesaukee.*

As part of the development of this plan, a **build-out analysis**, land-use model, water quality and **assimilative capacity** analysis, and shoreline and watershed surveys were conducted to better understand the sources of phosphorus and other pollutants to the lake (Sections 2 and 3). Results from these analyses were used to establish the water quality goal and objectives (Section 2.4), determine recommended management strategies for the identified pollutant sources (Section 4), and estimate pollutant load reductions and costs needed for remediation (Sections 5 and 6). Recommended management strategies involve using a combination of **structural and non-structural Best Management Practices** (BMPs), as well as an **adaptive management approach** that allows for regular updates to the plan (Section 4). An Action Plan (Section 5) with associated timeframes, responsible parties, and estimated costs was developed in collaboration with the Advisory Committee (Section 1.4). This plan meets the nine elements required by the United States Environmental Protection Agency (EPA) so that communities become eligible for federal watershed assistance grants (Section 1.5).

1.4 COMMUNITY INVOLVEMENT AND PLANNING

The plan was developed through the collaborative efforts of numerous meetings, public presentations, and conference calls between FB Environmental Associates (FBE), LWA, UNH, NHDES, representatives from the towns of Wolfeboro, Alton, and New Durham, the Wolfeboro/Tuftonboro Land Bank, Inc., lake associations, business owners, and private landowners (see Acknowledgments).

1.4.1 Plan Development Meetings

Several meetings were held over the duration of the plan development. The following list does not include routine annual meetings conducted separately by LWA, except as they relate to watershed plan development.

- **February 2, 2023:** LWA and FBE call to kick-off the project and discuss the public kick-off meeting logistics.
- **February 28, 2023:** Kick-off virtual meeting with the public to introduce the watershed planning process. Over 70 participants were on the call.
- **March 6, 2023:** LWA and FBE call to discuss project data needs and progress.
- **March 17, 2023:** FBE and WWA call to discuss how Lake Wentworth/Crescent Lake will be addressed in the plan.
- **May 3, 2023:** Advisory Committee met to discuss concerns and issues to be addressed by the plan.
- **September 8, 2023:** LWA and FBE progress check-in meeting.
- **January 22, 2024:** Advisory Committee met to review the watershed and shoreline survey results.
- **June 27, 2024:** Advisory Committee met to review the water quality analysis and build-out analysis.
- **October 29, 2024:** Advisory Committee met to review the modeling results and set the water quality goal.

1.4.2 Final Public Presentation

A final virtual public presentation was held on December 18, 2024 to summarize the analyses and recommendations detailed in the plan. The presentation was attended by about 30 people. An opportunity for public feedback on the plan was offered. Several written comments were received and incorporated into the final plan.

1.5 INCORPORATING EPA'S NINE ELEMENTS

EPA guidance lists nine components that are required within a WBMP to restore waters impaired or likely to be impaired by **nonpoint source (NPS) pollution**. These guidelines highlight important steps in restoring and protecting water quality for any waterbody affected by human activities. The nine required elements found within this plan are as follows:

- **A. IDENTIFY CAUSES AND SOURCES: Sections 2 and 3** highlight known sources of NPS pollution to Wolfeboro Bay and describe the results of the watershed survey and other assessments conducted in the watershed. These sources of pollutants must be controlled to achieve load reductions estimated in this plan, as discussed in item (B) below.
- **B. ESTIMATE PHOSPHORUS LOAD REDUCTIONS EXPECTED FROM MANAGEMENT MEASURES: Sections 2 and 5** describe the calculation of pollutant load to Wolfeboro Bay and the amount of reduction needed to meet the water quality goal, respectively.
- **C. DESCRIPTION OF MANAGEMENT MEASURES: Sections 4 and 5** identify ways to achieve the estimated phosphorus load reduction and reach water quality targets. The Action Plan focuses on several major topic areas that address NPS pollution. Management options in the Action Plan focus on non-structural BMPs integral to the implementation of structural BMPs.
- **D. ESTIMATE OF TECHNICAL AND FINANCIAL ASSISTANCE: Sections 5 and 6** includes a description of the associated costs, sources of funding, and primary authorities responsible for implementation. Sources of funding need to be diverse and should include local, state, and federal granting agencies, local groups, private donations, and landowner contributions for implementation of the Action Plan.
- **E. EDUCATION & OUTREACH: Section 4** describes how the educational component of the plan is already being or will be implemented to enhance public understanding of the project.
- **F. SCHEDULE FOR ADDRESSING PHOSPHORUS REDUCTIONS: Section 5** provides a list of action items and recommendations to reduce the phosphorus load to Wolfeboro Bay. Each item has a set schedule that defines when the action should begin and/or end or run through (if an ongoing activity). The schedule should be adjusted by the committee on an annual basis (see Section 4 on Adaptive Management).
- **G. DESCRIPTION OF INTERIM MEASURABLE MILESTONES: Section 6** outlines indicators along with milestones of implementation success that should be tracked annually.
- **H. SET OF CRITERIA: Sections 2 and 6** can be used to determine whether loading reductions are being achieved over time, substantial progress is being made towards water quality objectives, and if not, criteria for determining whether this plan needs to be revised.
- **I. MONITORING COMPONENT: Section 6** describes the long-term water quality monitoring strategy for Wolfeboro Bay, the results of which can be used to evaluate the effectiveness of implementation efforts over time as measured against the criteria in (H) above. The success of this plan cannot be evaluated without ongoing monitoring and assessment and careful tracking of load reductions following successful BMP implementation projects.

2 ASSESSMENT OF WATER QUALITY

This section provides an overview of the past, current, and future state of water quality based on the water quality assessment and watershed modeling, which identified pollutants of concern and informed the established water quality goal and objectives for Wolfeboro Bay.

2.1 WATER QUALITY SUMMARY

2.1.1 Water Quality Standards & Impairment Status

2.1.1.1 Designated Uses & Water Quality Criteria

The **Clean Water Act** (CWA) requires states to determine designated uses for all surface waters within the state's jurisdiction. Designated uses are the desirable activities and services that surface waters should be able to support and include uses for ALI, fish consumption, shellfish consumption, drinking water supply, primary contact recreation (swimming), secondary contact recreation (boating and fishing), and wildlife. Surface waters can have multiple designated uses. **PCR and ALI are the two major uses for lakes – ALI being the focus of this plan.** In New Hampshire, all surface waters are also legislatively classified as Class A or Class B, most of which are Class B (Env-Wq 1700). **Lake Winnipesaukee is classified as Class B waters in the State of New Hampshire**. Additionally, from 1974 to 2010, NHDES conducted surveys of lakes to determine **trophic state** (**oligotrophic**, **mesotrophic**, or **eutrophic**). The trophic surveys evaluated physical lake features, as well as chemical and biological indicators. **For Wolfeboro Bay, the trophic state was determined to be oligotrophic across all assessments in 1979, 1984, 1990, and 2001** (NHDES, 1979, 1984, 1990, 2001). This means that in-lake water quality was consistent with the standards for oligotrophic lakes across the 1979-2001 timeframe.

Water quality criteria are then developed to protect designated uses, serving as a "yardstick" for identifying water quality exceedances and for determining the effectiveness of state regulatory pollution control and prevention programs. Depending on the designated use and type of waterbody, water quality criteria can become more or less strict if the waterbody is classified as either Class A or B or as oligotrophic, mesotrophic, or eutrophic. To determine if a waterbody is meeting its designated uses, water quality criteria for various parameters (e.g., **chlorophyll-a**, **total phosphorus**, **dissolved oxygen**, **pH**) are applied to the water quality data. If a waterbody meets or is better than the water quality criteria, the designated use is supported. The waterbody is considered impaired for the designated use if it does not meet water quality criteria. Water quality criteria for each classification and designated use in New Hampshire can be found in RSA 485 A:8, IV and in the state's surface water quality regulations.

2.1.1.2 Antidegradation Provisions

The Antidegradation Provision (Env-Wq 1708) in New Hampshire's water quality regulations serves to protect or improve the quality of the state's waters. The provision outlines limitations or reductions for future pollutant loading. Certain development projects (e.g., projects that require Alteration of Terrain Permit or 401 Water Quality Certification) may be subject to an Antidegradation Review to ensure compliance with the state's water quality regulations. The Antidegradation Provision is often invoked during the permit review process for projects adjacent to waters that are designated impaired, high quality, or outstanding resource waters. While NHDES has not formally designated high-quality waters, unimpaired waters are treated as high quality with respect to issuance of water quality certificates. Antidegradation requires that a permitted activity cannot use more than 20% of the remaining assimilative capacity of a high-quality water. This is on a parameter-by-parameter basis. For impaired waters, antidegradation requires that permitted activities discharge no additional loading of the impaired parameter.

2.1.1.3 Waterbody Impairment Status

The Wolfeboro Bay watershed (including the Lake Wentworth/Crescent Lake watershed) contains 16 lake/pond assessment units split across the eight lakes and ponds: Batson Pond (1), Sargents Pond (1), Lake Wentworth (6), Crescent Lake (1), Back Bay (1), Shaws Pond (1), Knights Pond (1), Rust Pond (2), and Lake Winnipesaukee (2). While the Lake Winnipesaukee assessment unit covers much of the lake area, Wolfeboro Bay only makes up 1,974 acres of the 44,315-acre assessment unit. Five assessment units are formally listed as impaired for ALI on the 303(d) New Hampshire List of Impaired Waters for the

2020/2022 cycle (NHDES, 2022a) (Table 1). Three assessment units (beaches) are listed as impaired for PCR due to high levels of *E. coli*. All assessment units are listed as impaired for fish consumption due to the statewide mercury TMDL. According to New Hampshire's *Watershed Report Cards* built from the 2020/2022 305(b)/303(d) listing process (NHDES, 2022b), Lake Winnipesaukee is assessed as having poor water quality due to non-native aquatic plants and low pH, meaning the lake is marginally *"not meeting water quality standards/thresholds"*. Other factors in the assessment are rated as "likely good" due to limited current data, "marginal" for marginally meeting water quality standards, or "good" for meeting water quality standards. The Brewster Beach assessment unit is impaired for PCR due to *E. coli* contamination. The report card states that the beach is *"not meeting water quality standards/thresholds. The impairment is more severe and causes poor water quality."* Recently, cyanobacteria blooms have emerged as a serious concern for Lake Winnipesaukee, despite the current assessment, as described in Section 2.1.5 on cyanobacteria.

Table 1. NHDES assessment units covering lakes/ponds in the Wolfeboro Bay watershed and their associated water quality rating as reported on the NHDES 2020/2022 Watershed Report Cards.

Assessment Unit Name	AUID	Area (acres)	Water Quality
Batson Pond	NHLAK700020101-01	20.162	No Current Data
Sargents Pond	NHLAK700020101-02	62.225	Poor
Lake Wentworth	NHLAK700020101-05-01	3088.855	Severe
Lake Wentworth-Albee Beach	NHLAK700020101-05-02	0.145	Poor
Lake Wentworth-Wentworth State Park Beach	NHLAK700020101-05-03	2.206	Severe
Lake Wentworth-Public Beach	NHLAK700020101-05-04	0.533	No Current Data
Lake Wentworth-Camp Bernadette Beach	NHLAK700020101-05-05	1.380	Good
Lake Wentworth-Pierce Camp Birchmont Beach	NHLAK700020101-05-07	1.380	Good
Crescent Lake	NHLAK700020101-04	146.444	Poor
Back Bay	NHLAK700020101-08	34.927	Poor
Shaws Pond	NHLAK700020101-03	67.681	Likely Bad
Rust Pond	NHLAK700020101-07-01	238.476	Poor
Rust Pond-Wolfeboro Camp School Beach	NHLAK700020101-07-02	1.380	Good
Knights Pond	NHLAK700020101-06	31.989	No Current Data
Lake Winnipesaukee	NHLAK700020110-02-19	44,315.144	Poor
Lake Winnipesaukee-Brewster Beach	NHLAK700020110-02-09	0.897	Severe

2.1.2 Water Quality Data Collection

Wolfeboro Bay was monitored as part of the 1979, 1984, 1990, and 2001 Lake Trophic Surveys and was monitored periodically through the NHDES Volunteer Lake Assessment Program (VLAP). Beginning in recent years (2019-present) various sites on Wolfeboro Bay and Back Bay are monitored by the University of New Hampshire (UNH) Lakes Lay Monitoring Program (LLMP). The UNH LLMP has also been monitoring Shaws Pond since 2017 with the assistance of volunteers. Rust Pond has been monitored by the NHDES VLAP consistently since 1989. NHDES, the NH Department of Health and Human Services (DHHS), and staff or volunteers from LWA or Wolfeboro Waters have also monitored and assessed the lake over the years.

Water quality data were obtained for this plan from the NHDES Environmental Monitoring Database (EMD) and directly from Bob Craycraft of UNH LLMP. More than 60 water quality stations were identified in the watershed (not including Crescent Lake and Lake Wentworth sites). A descriptive overview of available water quality data in the Wolfeboro Bay watershed for a subset of sites is shown in Figures 3 and 4. Water quality monitoring sites for lakes with existing WBMPs (Crescent Lake, Lake Wentworth) are not included:

- **RUSWOLD (Rust Pond Deep Spot):** variable depth grab samples (from the **epilimnion**, **metalimnion**, and/or **hypolimnion**) were collected monthly from June-August from 1989-2022 for numerous parameters but largely for temperature, dissolved oxygen, total phosphorus, chlorophyll-a, chloride, specific conductivity, color, turbidity, alkalinity, and pH.

- **1 Deep (Shaws Pond Deep Spot):** epilimnion composite samples and variable depth grab samples (from the epilimnion and hypolimnion) were collected for total phosphorus, chlorophyll-a, color, total nitrogen, alkalinity, turbidity, chloride, specific conductivity, and pH from 2017-2022. Profiles were also collected using YSI EXO2 sonde in 2017 and 2018 for various parameters including temperature, dissolved oxygen, specific conductivity, pH, oxidation reduction potential, turbidity, chlorophyll-a fluorescence, phycocyanin fluorescence, and total dissolved solids.
- **SKI JUMP, Back Bay Buoy (Back Bay Sites):** epi-metalimnion composite samples or epilimnion grab samples were collected three to four times per year from 2019-2022 for total phosphorus, chlorophyll-a, and color.
- **WINWOJCD, WINWOCS, WAL01DL (Jockey Cove Deep and Shallow, Delings Cove):** epi-metalimnion composite samples were collected three to four times per year from 2019-2022 for total phosphorus, chlorophyll-a, and color.
- **WINBBAYL/WWBBAYL:** epi-metalimnion composite samples were collected three to four times per year from 2019-2022 for total phosphorus, chlorophyll-a, and color.
- **WINBWOLD (Wolfeboro Bay Deep Spot):** variable depth grab samples (from the epilimnion, metalimnion, and/or hypolimnion) were collected as part of the 1979, 1984, 1990, and 2001 Lake Trophic Surveys for numerous parameters but largely for temperature, dissolved oxygen, total phosphorus, nitrogen species, specific conductance, pH, chloride, color, and alkalinity. Current sampling began with composite samples for total phosphorus (2010, 2015, 2016, 2019-2022) and chlorophyll-a (2016, 2019-2022). Current sampling is conducted monthly between May and September, either four or five times per year.

Five Wolfeboro Bay sites (WINBBAYL, WINBWOLD, WINWOJCD, WINWOJCS, WAL01DL) are the most recently active sites with the most consistent dataset in the watershed, with most sites becoming active in 2019. These five sites are monitored three to five times per year by the UNH LLMP with LWA assistance. LWA staff took additional temperature/dissolved oxygen profiles in 2023 at the deep spot and in other sample locations to inform the WBMP.

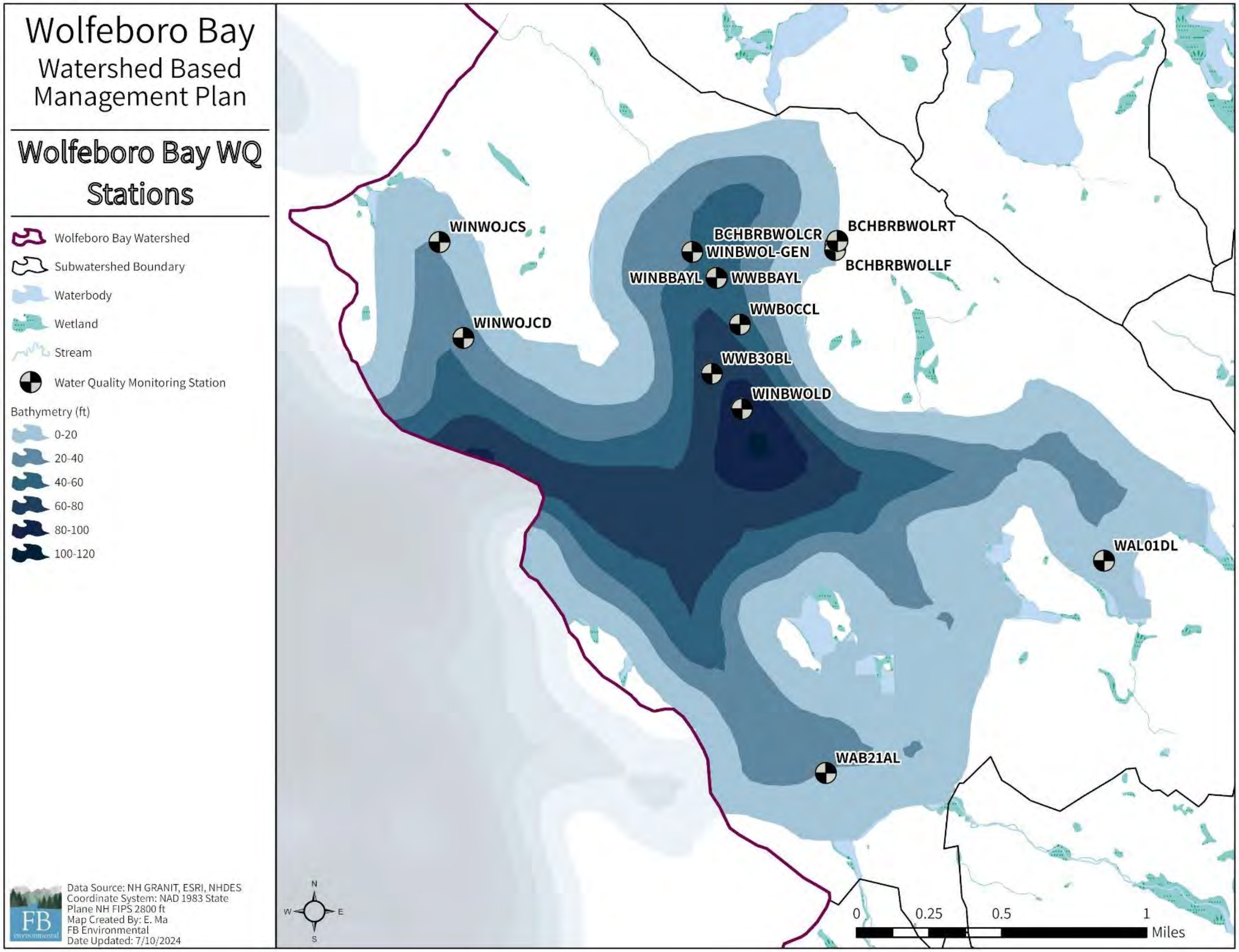


Figure 3. Water quality monitoring sites in Wolfeboro Bay. Sites on other waterbodies are not included. Refer to Table 2 for site descriptions.

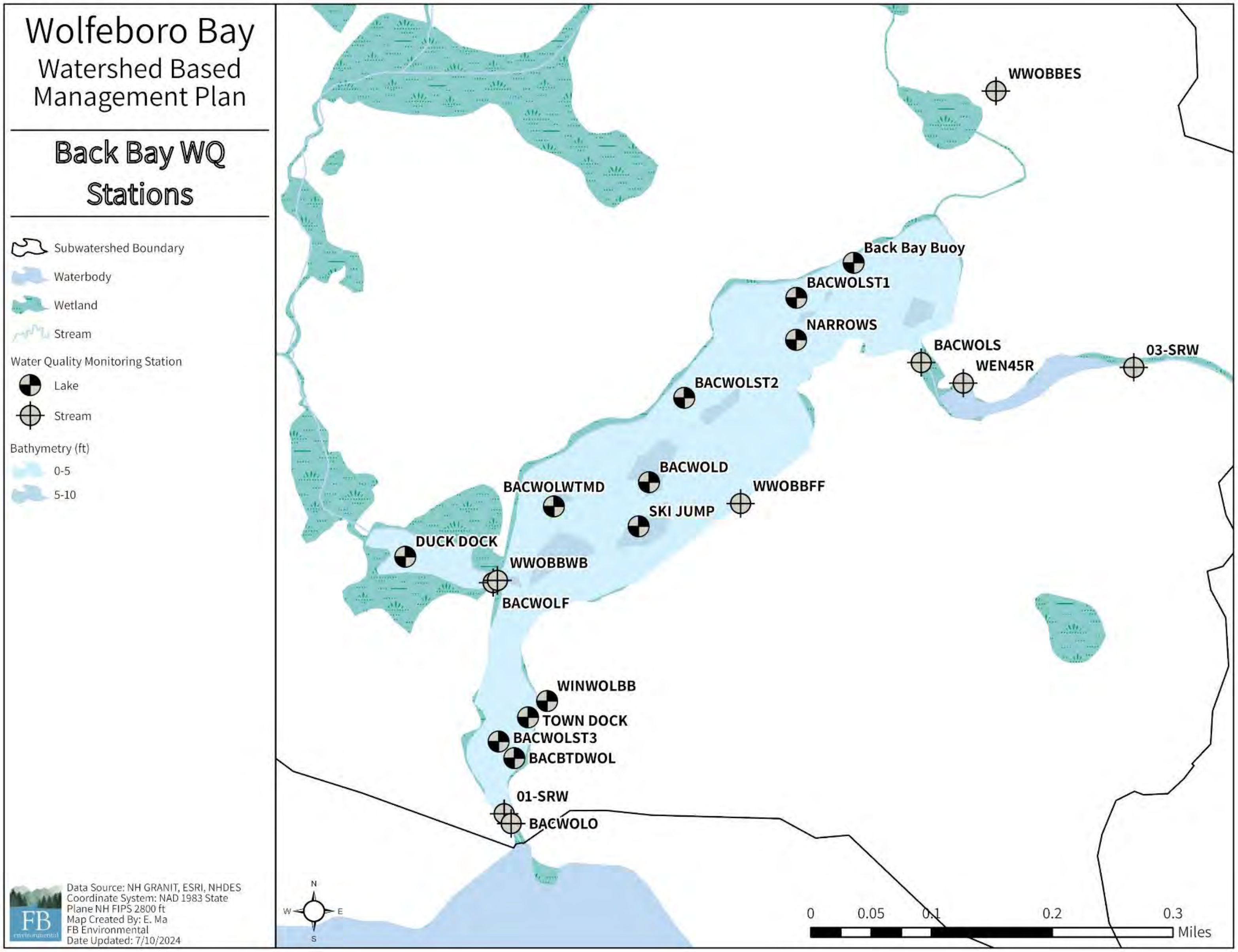


Figure 4. Water quality monitoring sites in Back Bay. Sites on other waterbodies are not included. Refer to Table 2 for site descriptions.

Table 2. Site ID and description. Refer to Figure 3Figure 4 for locations of all sites except Shaws Pond and Rust Pond.

Site ID	Site Description	Waterbody	Site Type
RUSWOLN	Rust Pond-North End Inlet	Rust Pond	Stream
RUSWOLNE	Rust Pond-North End at Cross Rd	Rust Pond	Stream
RUSWOLNE4	Rust Pond-North End Inlet #4	Rust Pond	Stream
RUSWOLNE3	Rust Pond-North End Inlet #3	Rust Pond	Stream
RUSWOLP	Rust Pond-Perry Brook	Rust Pond	Stream
RUSWOLPB3	Rust Pond-Perry Brook #3	Rust Pond	Stream
RUSWOLPB4	Rust Pond-Perry Brook #4	Rust Pond	Stream
RUSWOLPB2	Rust Pond-Perry Brook #2	Rust Pond	Stream
RUSWOLPB1	Rust Pond-Perry Brook #1	Rust Pond	Stream
RUSWOLGCO	Rust Pond-Golf Course Outlet	Rust Pond	Stream
RUSWOLO	Rust Pond-Outlet	Rust Pond	Stream
BACWOLF	Back Bay-Frog Hollow Inlet	Back Bay	Stream
WWOBBWB	Bay Street Inlet to Back Bay	Back Bay	Stream
WWOBBFF	Stormwater Outfall to Back Bay from Rec Fields	Back Bay	Stream
WWOBBES	Rt 109A Stream to Back Bay	Back Bay	Stream
BCHBRBWOLCR	Lk Winnipesaukee Brewster Beach-Center	Wolfeboro Bay	Beach
BCHBRBWOLLF	Lk Winnipesaukee Brewster Beach-Left	Wolfeboro Bay	Beach
BCHBRBWOLRT	Lk Winnipesaukee Brewster Beach-Right	Wolfeboro Bay	Beach
BCHWCSWOLLF	Wolfeboro Camp School-Left	Rust Pond	Beach
BCHWCSWOLRT	Wolfeboro Camp School-Right	Rust Pond	Beach
WINBWOLD	Lake Winnipesaukee, Wolfe. Bay-Deep Spot	Wolfeboro Bay	Lake
WWBBAYL	Lake Winnipesaukee-Wolfeboro Bay	Wolfeboro Bay	Lake
WINWOJCD	Jockey Cove Deep	Wolfeboro Bay	Lake
WINWOJCS	Jockey Cove Shallow	Wolfeboro Bay	Lake
WINBBAYL	Lake Winnipesaukee, Wolfe. Bay	Wolfeboro Bay	Lake
WAL01DL	Delings Cove	Wolfeboro Bay	Lake
WWB0CCL	Lake Winnipesaukee-Clarks Point	Wolfeboro Bay	Lake
WAB21AL	Lake Winnipesaukee-Alton Bay-Station 21	Wolfeboro Bay	Lake
WWB30BL	Lake Winnipesaukee-Wolfeboro Bay-30 Belknap	Wolfeboro Bay	Lake
BACWOLD	Back Bay-Deep Spot	Back Bay	Lake
Back Bay Buoy	Back Bay Skier Drop Buoy	Back Bay	Lake
SKI JUMP	Back Bay – Ski Jump	Back Bay	Lake
WINWOLBB	Lake Winnipesaukee-Back Bay	Back Bay	Lake
BACWOLST1	Back Bay-Station 1	Back Bay	Lake
BACWOLST2	Back Bay-Station 2	Back Bay	Lake
BACWOLST3	Back Bay-Station 3	Back Bay	Lake
TOWN DOCK	Back Bay Town Dock Area	Back Bay	Lake
RUSWOLD	Rust Pond-Deep Spot	Rust Pond	Lake
RUSWOL-GEN	Rust Pond-Generic	Rust Pond	Lake
RUSWOL1	Rust Pond-1	Rust Pond	Lake
RUSWOLWL	Rust Pond-Webb Launch	Rust Pond	Lake
RUSWOL28L	Rust Pond-28 Launch	Rust Pond	Lake
RUSWOLEOL	Rust Pond-End of Lake	Rust Pond	Lake
RUSWOLPE	Rust Pond-Peard	Rust Pond	Lake
RUSWOLSI	Rust Pond-Simpson	Rust Pond	Lake
RUSWOLWD	Rust Pond-Wasson Dock	Rust Pond	Lake
SHANWDD	Shaws Pond-Deep Spot	Shaws Pond	Lake
SHANWD-GEN	Shaws Pond-Generic	Shaws Pond	Lake
1C1-046	Shaws Pond	Shaws Pond	Lake
SHAUNHD	Shaws Pond-Deep	Shaws Pond	Lake
1 Deep	Shaws Pond-Deep Spot	Shaws Pond	Lake

2.1.3 Trophic State Indicator Parameters

Total phosphorus, chlorophyll-a, and Secchi disk transparency are trophic state indicators, or indicators of biological productivity in lake ecosystems. The combination of these parameters helps determine the extent and effect of **eutrophication** in lakes and helps signal changes in lake water quality over time. For example, changes in Secchi disk transparency may be due to a change in the amount and composition of algae communities (typically because of greater total phosphorus availability) or the amount of dissolved or particulate materials in a lake. Such changes are likely the result of human disturbance or other impacts on the lake's watershed.

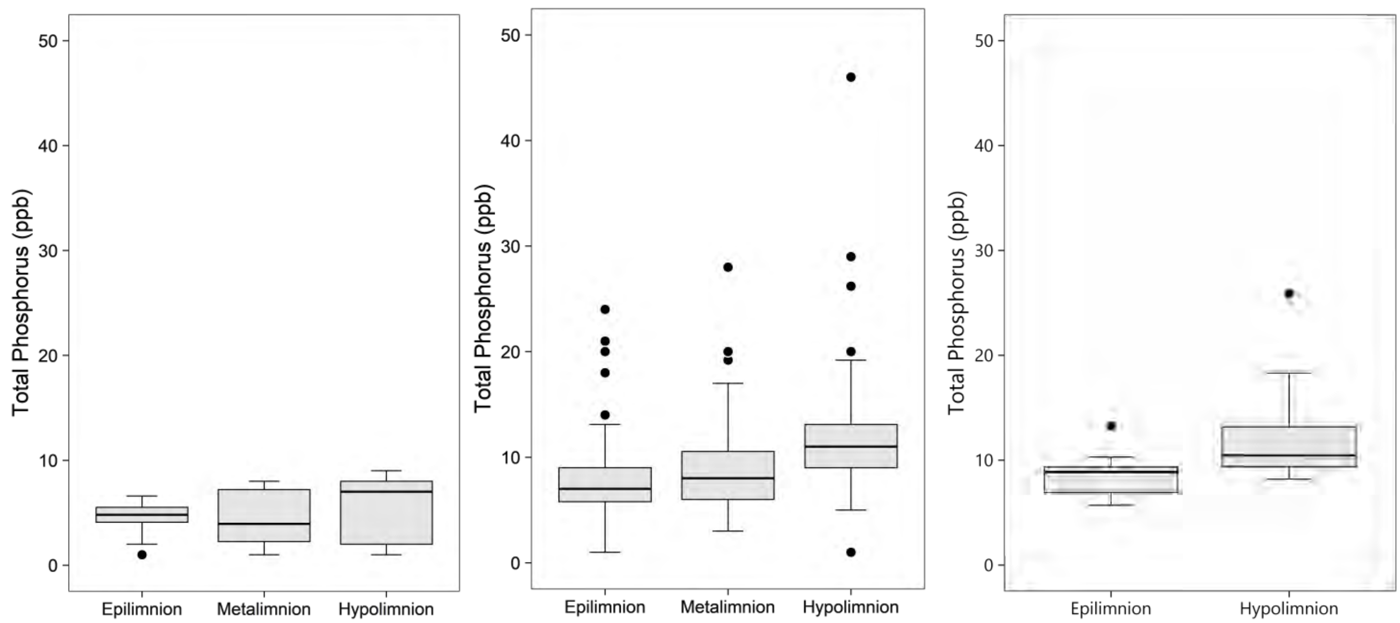


Figure 5. Boxplots showing median total phosphorus concentration in the epilimnion, metalimnion, and hypolimnion of the deep spots of Wolfeboro Bay [WINBWOLD] (left) and Rust Pond [RUSWOLD] (middle), and the epilimnion and hypolimnion of the Shaws Pond deep spot [1 Deep] (right).

Generally, higher total phosphorus concentrations in the hypolimnion compared to the epilimnion suggest that some amount of internal loading is occurring, because the internal phosphorus load originates from the bottom sediment-water interface. In Wolfeboro Bay, median total phosphorus concentrations are low across all existing data for all depth zones at about 5-8 ppb, with hypolimnion phosphorus being slightly higher than epilimnion phosphorus, though concentrations never exceeded 9 ppb (Figure 5, Figure 6). These slightly higher values in the hypolimnion could also result from small amounts of resuspended phosphorus that was loosely bound to lake sediments or additional organic phosphorus from sinking detritus. We recommend that deeper hypolimnion samples be collected at the deep spots to better inform and track internal phosphorus loading estimates in Wolfeboro Bay.

Rust Pond generally has higher median total phosphorus in the hypolimnion than the epilimnion, suggesting that some amount of internal loading is occurring. At its highest, hypolimnion total phosphorus has been measured at 46 ppb, which is higher than the median value for the epilimnion but amounts to an overall low internal phosphorus mass contribution. Because the extent of anoxia can vary across years, there may be variations in the amount of phosphorus released from lake sediments. The deep spot of Rust Pond [RUSWOLD] was found to have no trend for epilimnion total phosphorus and chlorophyll-a for the available time period of 1981, 1988-2022 (Figure 6).

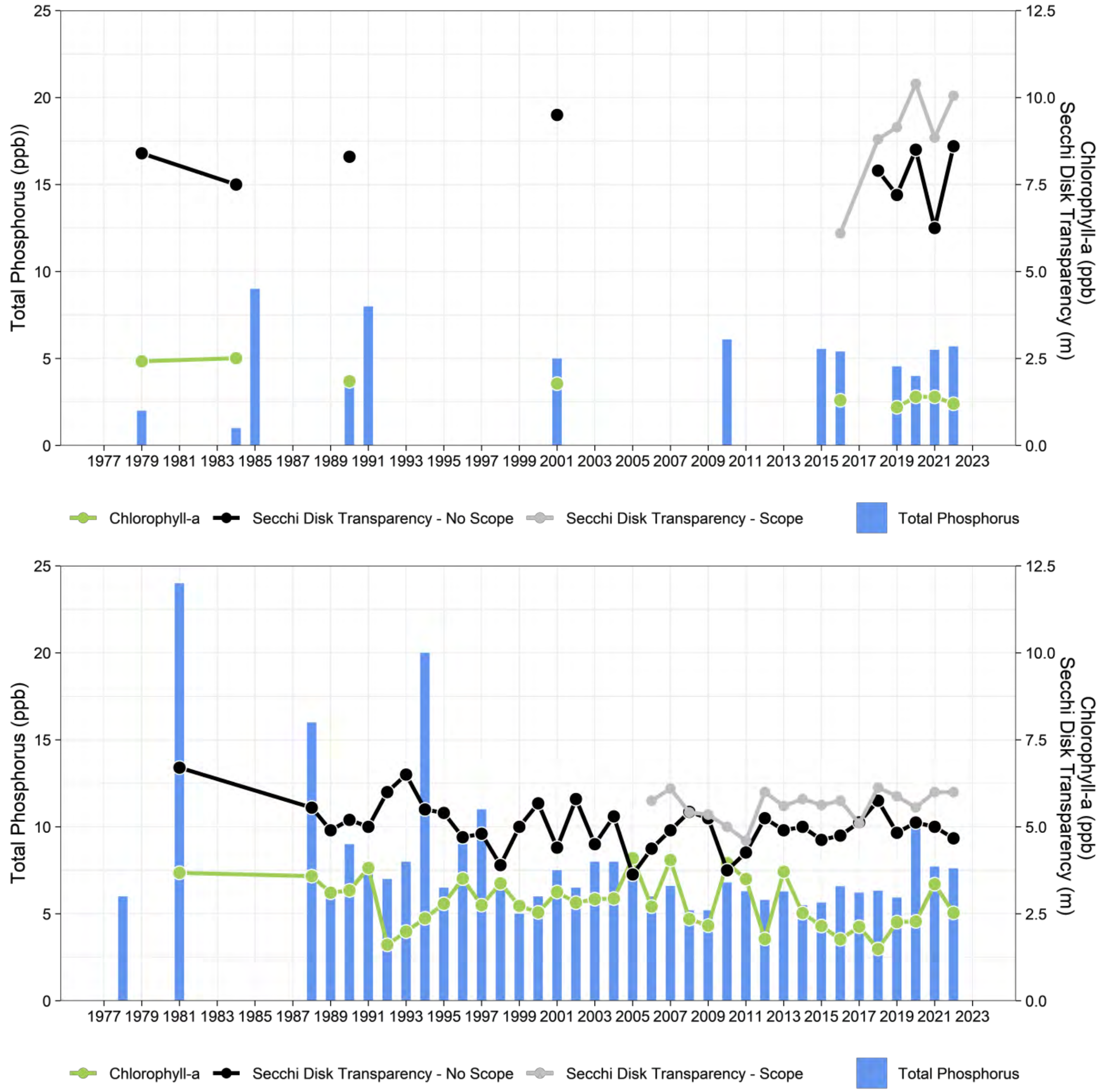


Figure 6. Median epilimnion (3-5 meters) or composite total phosphorus, median composite epilimnion (depth not recorded) chlorophyll-a, and median water clarity (Secchi Disk depth for scope and no scope methods) measured at the deep spot of Wolfeboro Bay [WINBWOLD] (top) largely in June-September occasionally from 1979 to 2022. For the deep spot of Rust Pond [RUSWOLD] (bottom), median epilimnion (1-3 meters) total phosphorus, median composite epilimnion (0-6 meters) chlorophyll-a, and median water clarity (Secchi Disk depth for scope and no scope methods) measured between 1981-2022. There were not enough data to perform a statistical trend analysis for the Wolfeboro Bay deep spot. No trends were detected from the Mann-Kendall nonparametric trend test using *rkt* package in R Studio for the Rust Pond deep spot.

Shaws Pond is shallow (maximum depth of 5 meters) and therefore does not stratify fully. It is likely that some amount of internal loading occurs in the pond due to the higher total phosphorus concentrations observed in the lower water column compared to surface or integrated core samples. In shallow lakes, internal loading may be caused by anoxia at the sediment-water interface, sediment resuspension from wind, and increased phosphorus release from organic matter decomposition associated with higher water temperatures. No statistically significant relationships were observed for Shaws Pond across the recent available time period of 2017-2023 (Figure 7). Future data collection consistent with the most recent years will allow for a better understanding of water quality trends in Shaws Pond.

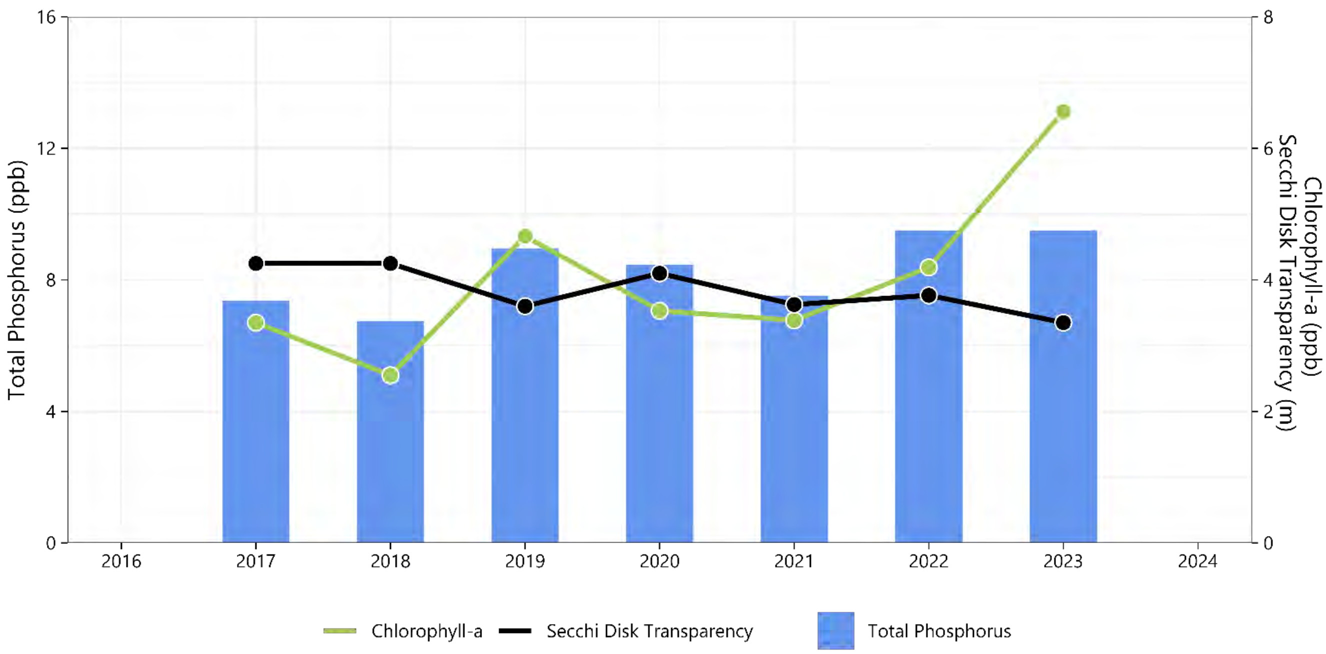


Figure 7. Median epilimnion (0-3 meters) or composite total phosphorus, median composite epilimnion (0-3 meters) chlorophyll-a, and median water clarity (Secchi Disk depth, methods not recorded) measured at the deep spot of Shaws Pond [1 Deep] largely in June-September from 2017 to 2023. No statistically significant trends for were detected from the Mann-Kendall nonparametric trend test using *rkt* package in R Studio.

2.1.4 Dissolved Oxygen & Water Temperature

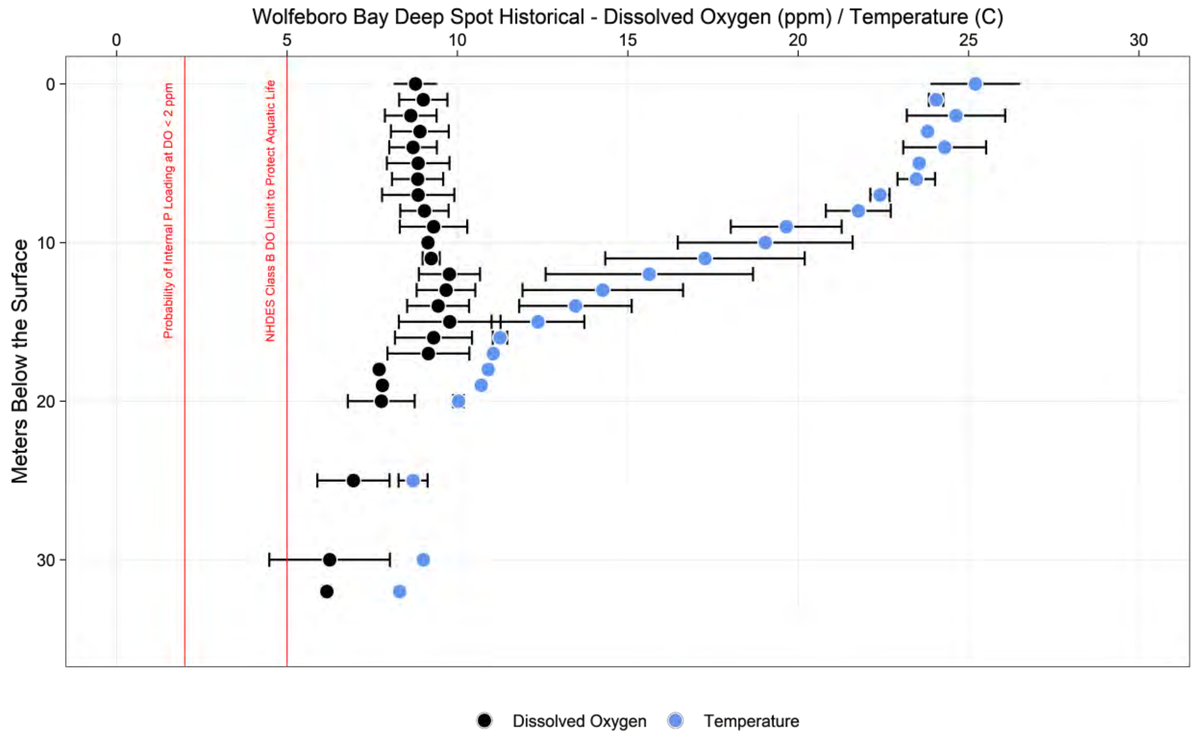
A common occurrence is the depletion of dissolved oxygen in the deepest part of lakes throughout the summer months. This occurs when thermal stratification prevents warmer (less dense), oxygenated surface waters from mixing with cooler (denser), oxygen-depleted bottom waters in the lake. Chemical and biological processes occurring in bottom waters deplete the available oxygen throughout the summer, and because these waters are colder and denser, the oxygen cannot be replenished through mixing with surface waters. Dissolved oxygen levels below 5 ppm (and water temperature above 24 °C) can stress and reduce habitat for coldwater fish and sensitive aquatic organisms. In addition, **anoxia** (low dissolved oxygen) at lake bottom can result in the release of sediment-bound phosphorus (otherwise known as **internal phosphorus loading**), which can become a readily available nutrient source for algae and cyanobacteria.

While **thermal stratification** and depletion of oxygen in bottom waters is a natural phenomenon in dimictic lakes such as Lake Winnipesaukee, it is important to track these parameters to make sure the extent and duration of low oxygen does not change drastically because of human disturbance in the watershed resulting in excess phosphorus loading.

Figure 8 shows temperature and dissolved oxygen profiles averaged across sampling dates during thermal stratification largely in summer (between spring and fall **turnover**) for historical and recent profiles at the deep spot of Wolfeboro Bay. Profiles for Wolfeboro Bay were recorded in 1990, 2001, and 2023. The change in temperature in Wolfeboro Bay, seen most dramatically between 6 and 16 m, indicates thermal stratification in the water column. The three historical profiles, taken in late July and August, suggest that the Wolfeboro Bay deep spot historically had sufficient oxygen to support coldwater fish and that there was minimal risk of internal loading. Preliminary data from 2023 show a sharp decline in dissolved oxygen with depth, falling below 5 ppm at 15 m and below 2 ppm at 25 m. Dissolved oxygen below 2 ppm suggests that there may be internal loading under anoxic conditions in Wolfeboro Bay. Continued monitoring of dissolved oxygen-temperature profiles in the deep spots will build on our understanding of anoxic extent in Wolfeboro Bay. Data from other sites in Wolfeboro Bay that were recently sampled by LWA show similarly low dissolved oxygen concentrations in bottom depths (Figure 10, next page). Sampling locations closer to other parts of the lake (near Little Barndoor Island) saw less extreme oxygen depletion than sites closer to Wolfeboro Bay (near Keniston Island).

Figure 9 shows temperature and dissolved oxygen profiles averaged across sampling dates (1988-2022) for Rust Pond. Rust Pond has the most obvious temperature changes between 5 and 8 meters, which is evidence of thermal stratification. The average dissolved oxygen at or less than 2 ppm at 10-13 meters depth indicates the possibility of internal loading under anoxic conditions. Data from temperature and dissolved oxygen profiles show that the pond typically has depleted oxygen from late July until fall turnover, indicating an elevated risk of internal loading.

Shaws Pond, with a maximum depth of 5 meters, does not fully stratify, as seen in temperature profiles taken from June-September where there is a defined transition from the epilimnion to the metalimnion towards the lake bottom. Despite this, dissolved oxygen has been observed to be depleted in the bottom waters, typically falling below 2 ppm below a depth of 4.5 meters (Figure 9) and occasionally as shallow as 3 meters. Anoxia in shallow, polymictic lakes can occur during calm, ephemerally stratified periods, especially in warmer periods which increases decomposition and oxygen demand near the sediment-water interface.



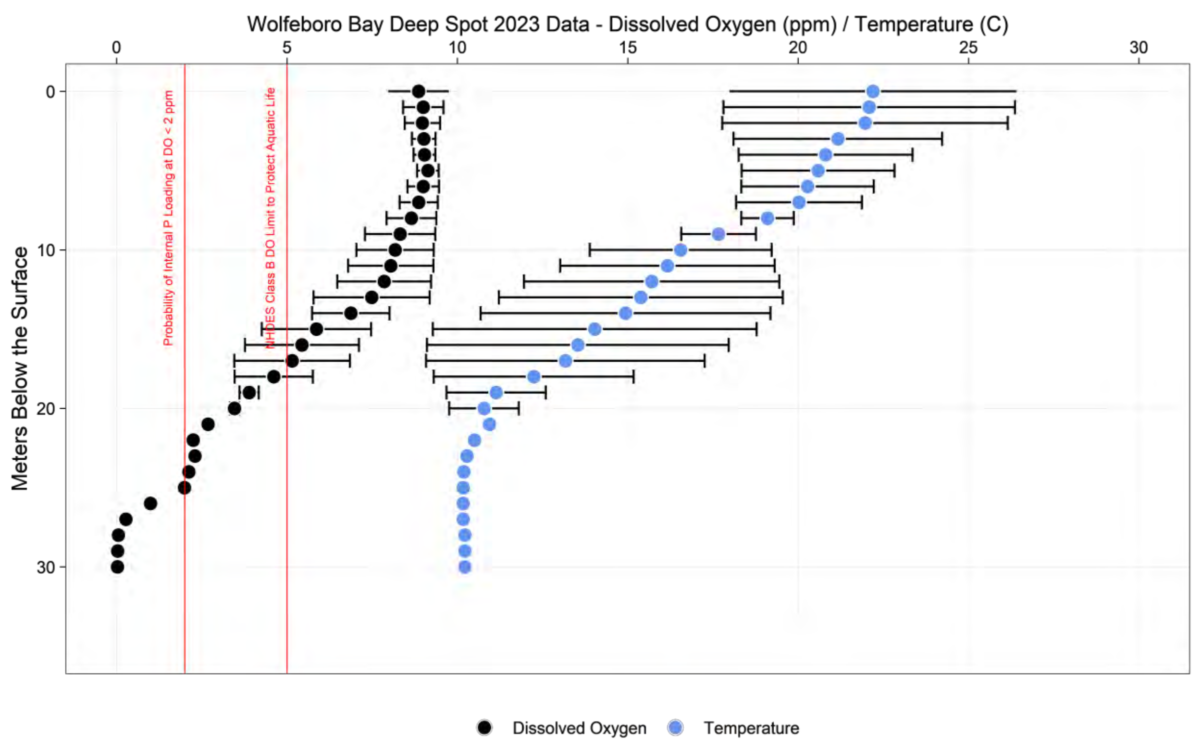
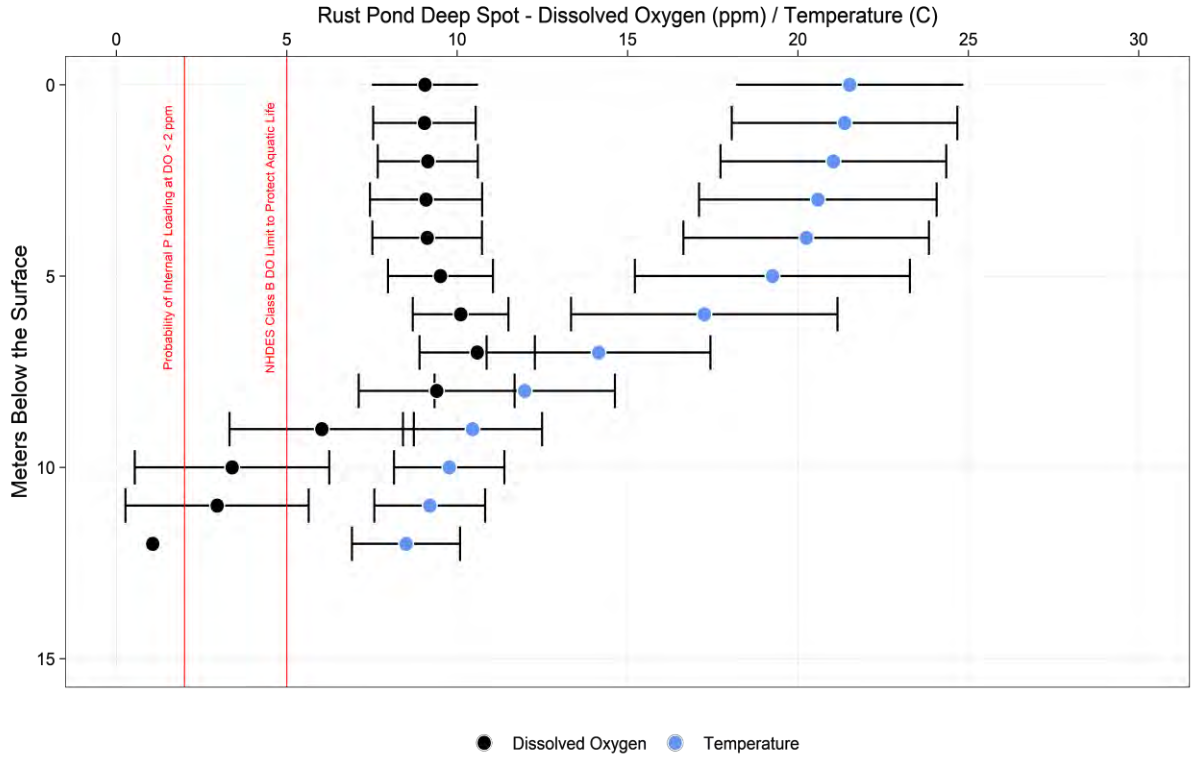


Figure 8. Dissolved oxygen (black) and water temperature (blue) depth profiles for the deep spot of Wolfeboro Bay [WINBWOLD] over ten years ago (top) and in 2023 (bottom). Dots represent average values across sampling dates for each respective depth. Error bars represent standard deviation. Historical profiles for Wolfeboro Bay were collected in 1990 and 2001 (n=3), with additional observations in 1977 and 1984; two profiles were taken in 2023.



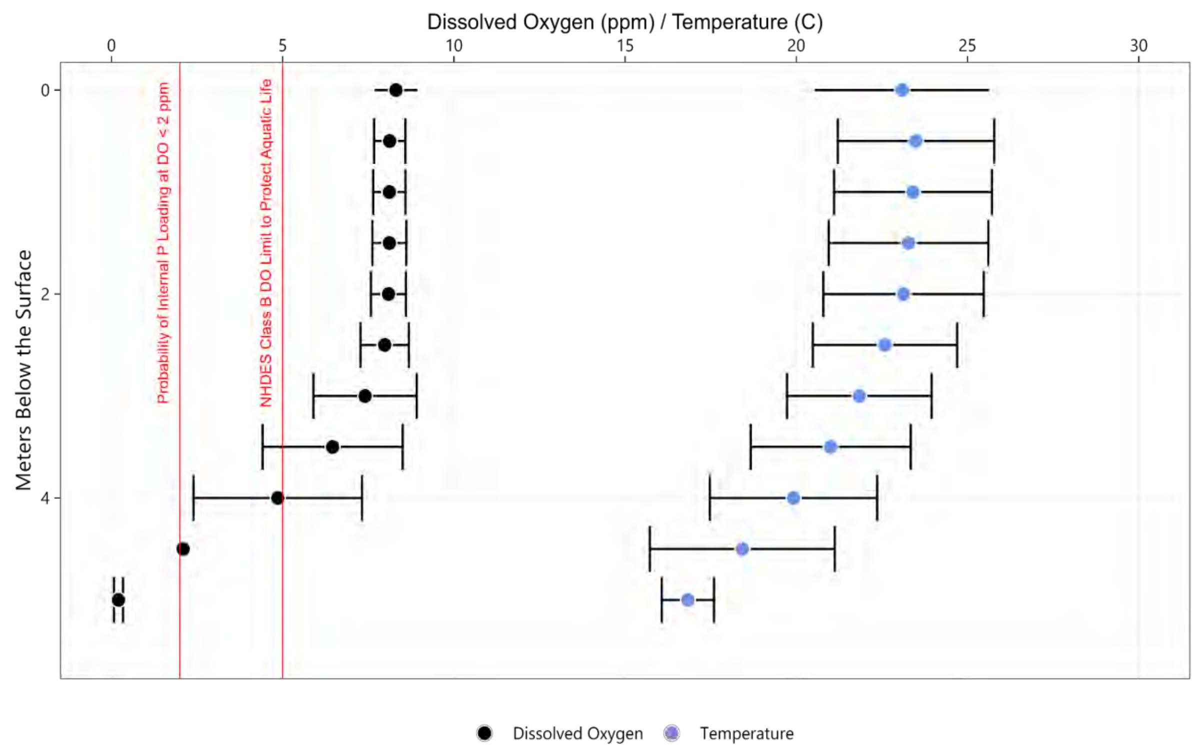
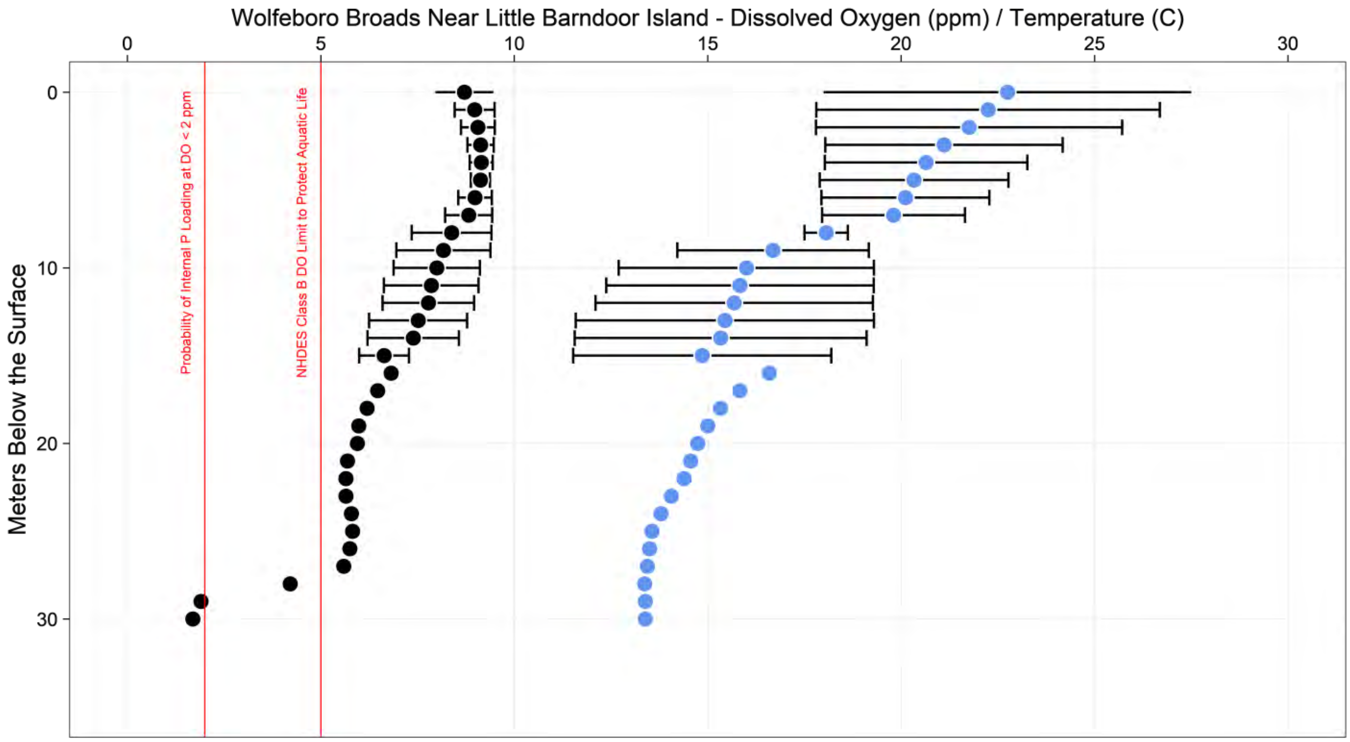


Figure 9. (Top) Dissolved oxygen (black) and water temperature (blue) depth profiles for the deep spot of Rust Pond [RUSWOLD] between 1988 and 2022 (n=35), with an additional bottom reading from 1981. Dots represent average values across sampling dates for each respective depth. Error bars represent standard deviation. (Bottom) Dissolved oxygen (black) and water temperature (blue) depth profiles for the deep spot of Shaws Pond [1 Deep] taken from June – September between 2017 and 2023 (n=18).



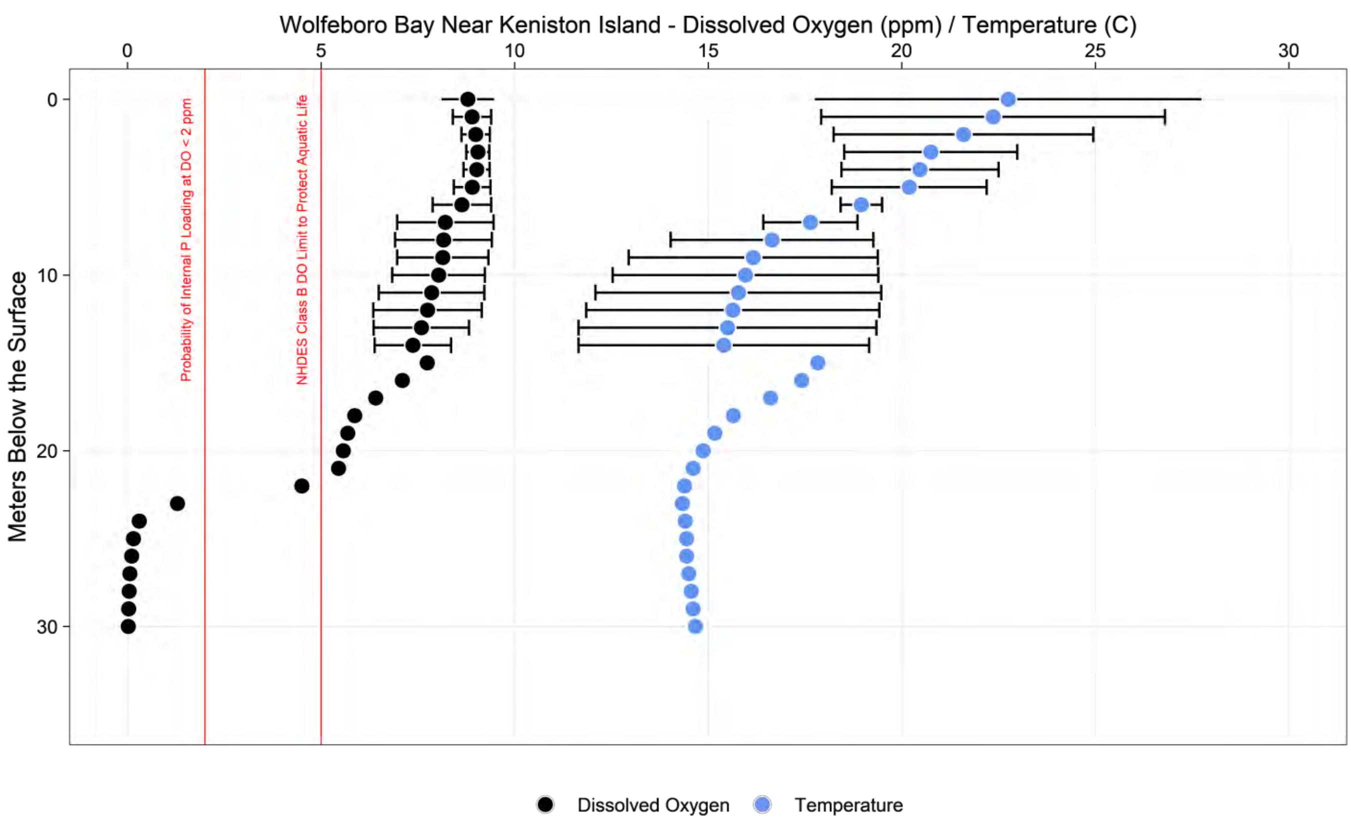


Figure 10. Dissolved oxygen (black) and water temperature (blue) depth profiles for additional sampling locations in Wolfeboro Bay (n=2) taken in 2023. Dots represent average values across sampling dates for each respective depth. Error bars represent standard deviation. 2023 profiles were taken in early September and October and reflect the conditions of late summer and early fall.

2.1.5 Phytoplankton (Cyanobacteria) and Zooplankton

2.1.5.1 Phytoplankton/Zooplankton Surveys

Phytoplankton and zooplankton samples were collected as part of the 1979, 1984, 1990, and 2001 NHDES Lake Trophic Survey Reports (NHDES 1979, 1984, 1990, 2001) and are included in Table 3. The dominant phytoplankton species were *Chrysosphaerella* (golden-brown), *Dinobryon* (golden-brown), *Asterionella* (diatom), and *Tabellaria* (diatom). The dominant zooplankton species were Nauplius larvae (copepod), *Keratella* (rotifer), *Calanoid* (copepod), and *Cyclopoid* (copepod). Copepods are small crustaceans that eat phytoplankton and provide an important food source to fish. Daphnia are among the most efficient grazers of phytoplankton but were not shown to be a dominant zooplankter in Wolfeboro Bay. Crustaceans are more dominant than rotifers in Wolfeboro Bay and are the more efficient grazers of the observed zooplankton. The dominance of golden-brown phytoplankton is common for oligotrophic lakes such as Lake Winnipesaukee.

Table 3. Phytoplankton and zooplankton data summary for Wolfeboro Bay.

Date	Phytoplankton Species (% Total)	Total Phytoplankton Count (cells/mL)	Zooplankton Species (% Total)	Total Zooplankton Count (cells/L)
2/1976	*Asterionella* (50%)	--	--	--
2/1976	*Dinobryon* (30%)	--	--	--
8/22/1979	*Chrysosphaerella* (30%)	--	*Vorticella* (25%)	144
8/22/1979	*Tabellaria* (35%)	--	*Nauplius* larva (20%)	--
8/1/1984	*Tabellaria* (45%)	--	*Nauplius* larva (35%)	60
8/1/1984	*Chrysosphaerella* (30%)	--	--	--
2/19/1985	*Tabellaria* (45%)	--	--	30
2/19/1985	*Rhizosolenia* (35%)	--	--	--
7/25/1990	*Dinobryon* (60%)	515	*Nauplius* larva (35%)	61
7/25/1990	*Tabellaria* (20%)	--	*Calanoid* copepod	--
7/25/1990	*Synura* (5%)	--	--	--
2/26/1991	*Asterionella* (65%)	--	*Cyclopoid copepods* (23%)	26
2/26/1991	Tabellaria (20%)	--	*Calanoid copepods* (19%)	--
8/14/2001	*Chrysosphaerella* (65%)	--	*Keratella* (49%)	104
8/14/2001	*Dinobryon* (20%)	--	*Nauplius* larva (8%)	--
8/14/2001	--	--	*Holopedium* (7%)	--

2.1.5.2 Cyanobacteria Bloom History

Nutrients such as phosphorus and nitrogen, as well as algae and cyanobacteria, naturally occur in the environment, including lakes and tributaries and their contributing watersheds, and are essential to lake health. Under natural conditions, algae and cyanobacteria concentrations are regulated by limited nutrient inputs and lake mixing processes that keep them from growing too rapidly. However, human related disturbances, such as erosion, overapplied fertilizers, polluted stormwater runoff, excessive domesticated animal waste, and inadequately treated wastewater, can dramatically increase the amount of nutrients entering lakes and their tributaries. Excess nutrient loading to human-disturbed lake systems, in combination with a warming climate, has fueled the increasing prevalence of Harmful Algal Blooms (HABs) or the rapid growth of algae and cyanobacteria in lakes across the United States.

Cyanobacteria are small photosynthesizing, sometimes nitrogen-fixing, single-celled bacteria that grow in colonies in freshwater systems. Cyanobacteria blooms can (but not always) produce microcystins and other toxins that pose a serious health risk to humans, pets, livestock, and wildlife, such as neurological, liver, kidney, and reproductive organ damage, gastrointestinal pain or illness, vomiting, eye, ear, and skin irritation, mouth blistering, tumor growth, seizure, or death. Blooms can form dense mats or surface scum that can occur within the water column or along the shoreline. Dried scum along the shoreline can harbor high concentrations of microcystins that can re-enter a waterbody months later. There are several different species of cyanobacteria, such as:

- ***Gloeotrichia*:** typically observed as large, round colonies of filaments, associated with microcystins, *documented in Wolfeboro Bay in 2018, 2023, and 2024.*
- ***Dolichospermum (formerly Anabaena)*:** typically observed as filaments, associated with microcystins, anatoxins, saxitoxins, and cylindrospermopsin, *documented in Wolfeboro Bay in 2022 and 2024.*
- ***Microcystis*:** typically observed as variations of small-celled colonies, associated with microcystins and anatoxins.
- ***Aphanizomenon*:** typically forms rafts of filaments, associated anatoxin-a, anatoxin-a (S), saxitoxins, and possibly microcystins.
- ***Woronichinia*:** typically forms dense colonies, associated with microcystins.
- ***Planktothrix (formerly Oscillatoria)*:** typically observed as filaments, associated with microcystins and cylindrospermopsin, can maintain high growth rate at relatively low light intensities when it forms metalimnetic blooms (NHDES, 2020).

Cyanobacteria are becoming more prevalent in low-nutrient lake systems likely due to climate change warming effects (e.g., warmer water temperatures, prolonged thermal stratification, increased stability, reduced mixing, and lower flushing rates at critical low-flow periods that allow for longer residence times) that allow cyanobacteria to thrive and outcompete other phytoplankton species (Przytulska, Bartosiewicz, & Vincent, 2017; Paerl, 2018; Favot, et al., 2019). Many cyanobacteria can regulate their buoyancy and travel vertically in the water column to maximize their capture of both sunlight and sediment phosphorus (even during stratification and/or under anoxic conditions) for growth. In addition, some cyanobacteria can also fix atmospheric nitrogen, if enough light, phosphorus, iron, and molybdenum are available for the energy-taxing process. Some taxa are also able to store excess nitrogen and phosphorus intra-cellularly for later use under more favorable conditions. Because of these traits and as climate warming increases the prevalence and dominance of cyanobacteria, cyanobacteria are one of the major factors driving positive feedbacks with lake eutrophication and may be both accelerating eutrophication in low-nutrient lakes and preventing complete recovery of lakes from eutrophic states (Dolman, et al., 2012; Cottingham, Ewing, Greer, Carey, & Weathers, 2015). A better understanding of cyanobacteria's role in nutrient feedbacks will be needed for better and more effective lake restoration strategies.

There have been four NHDES-issued cyanobacteria bloom warnings for Wolfeboro Bay, the first of which lasted for 22 days beginning on August 30, 2018 (Table 4). The bloom had greater than 70,000 cyanobacterial cells/mL and was primarily composed of *Gloeotrichia*. Another bloom warning lasted two days in June 2022 and was composed of *Dolichospermum*, with a cell count of 414,667 cells/mL. A recent recorded bloom of *Gloeotrichia* occurred in August 2023, though only an alert was issued for seven days because the cell counts were less than 70,000 cells/mL. The most recent blooms occurred in 2024, with advisories lasting for 14 days in June for *Dolichospermum* and 17 days in late August through early September for *Gloeotrichia*. The August 2024 bloom was concurrent with lake-wide *Gloeotrichia* blooms in Lake Winnipesaukee. Both *Gloeotrichia* and *Dolichospermum* are potentially toxin-producing, though accounts of toxic *Gloeotrichia* are rare. Both taxa are nitrogen-fixing species, meaning they can transform nitrogen into a useable form if it is not already available in the water column, and can regulate their buoyancy in the water column to outcompete less motile phytoplankton. Rust Pond has one cyanobacteria bloom on record. It was issued for nine days in August 2009, and the specific taxa were not identified.

Table 4. Cyanobacteria warnings issued by NHDES for Wolfeboro Bay (NHDES, 2022c).

Advisory Date	Duration (days)	Dominant Taxa	Illness Reported	Total Cell Conc. (cells/mL)
8/30/2018	22	*Gloeotrichia*	None	>70,000
6/29/2022	2	*Dolichospermum*	None	414,667
6/12/2024	14	*Dolichospermum*	None	160,000
8/19/2024	17	*Gloeotrichia*	None	1,562,500

It is impossible to fully eradicate cyanobacteria in Wolfeboro Bay as they are naturally occurring bacteria that have been on the planet for millennia and are resilient to environmental changes; some species of cyanobacteria can become dormant in sediment and then can jump-start cell reproduction once conditions are favorable (warm water temperatures and plenty of sunlight and nutrients). Given the long-term trend of increasing air and water temperatures due to climate change and increased phosphorus loading from development in the watershed, the likelihood of blooms will continue and possibly accelerate, though year-to-year variability in weather may determine the availability of phosphorus and/or the presence of other oxygen compounds such as nitrates and thus determine the timing, extent, and severity of blooms in any given year. Despite this, conditions favorable for blooms can be substantially minimized by reducing nutrient-rich runoff from the landscape during warm, sunny spells. Water level and flow also helps to either flush out blooms or limit upstream nutrient sources to stymie growth.

2.1.6 Fish

Fish are an important natural resource for sustainable ecosystem food webs and provide recreational opportunities. Lake Winnipesaukee is an oligotrophic lake that supports populations of warm and coldwater species including but not limited to lake trout, rainbow trout, landlocked Atlantic salmon, smallmouth bass, largemouth bass, chain pickerel (Eastern), black crappie, white and yellow perch, and pumpkinseed (common sunfish). The brindle shiner, American eel, burbot, lake trout, and lake whitefish are species of concern within the watershed, as identified in the 2015 Wildlife Action Plan (NHFG, 2015).

2.1.7 Invasive Species

The introduction of non-indigenous invasive aquatic plant and animal species to New Hampshire's waterbodies has been on the rise. These invasive aquatic plants are responsible for habitat disruption, loss of native plant and animal communities, reduced property values, impaired fishing and degraded recreational experiences, and high removal costs. Once established, invasive species are difficult and costly to remove. NHDES indicates in its Lake Information Mapper that variable leaf milfoil has been present in Lake Winnipesaukee since 1965. In particular, Back Bay suffers from milfoil infestation, which is managed largely by hand-pulling and suction harvesting with some consideration for chemical treatment. Wolfeboro Bay is not currently monitored by Weed Watchers. The spiny water flea, an invasive zooplankton, was found in Lake Winnipesaukee in 2023. The spiny water flea can alter the lake food web and shift algal communities due to its competition with native zooplankton species. The effect of the spiny water flea on Lake Winnipesaukee is still being assessed due to its relatively recent introduction to the lake.

2.2 ASSIMILATIVE CAPACITY

The assimilative capacity of a waterbody describes the amount of pollutant that can be added to a waterbody without causing a violation of the water quality criteria and is based on a lake's target trophic designation, which is typically based on early trophic surveys. Lake Winnipesaukee and Rust Pond are currently assessed as oligotrophic lakes. Back Bay does not have a trophic assessment of file; the oligotrophic designation will be used for the assimilative capacity analysis for enhanced protection. Shaws Pond was assessed as mesotrophic in 1984 and 1999 due to depleted dissolved oxygen and aquatic plant abundance, rather than elevated total phosphorus or chlorophyll-a, meaning oligotrophic standards may be applicable for this pond for enhanced protection. Based on this assessment, the oligotrophic designation was selected for running the assimilative capacity analysis for these waterbodies. For oligotrophic waterbodies, the water quality criteria are set at 8.0 ppb for total phosphorus and 3.3 ppb for chlorophyll-a, above which the waterbody is considered impaired (Table 5). NHDES requires 10% of the difference between the best possible water quality and the water quality standard be kept in reserve as described in the 2020/2022 Section 305(b) and 303(d) Consolidated Assessment and Listing Methodology (CALM); therefore, according to Table 3-17 of the CALM, total phosphorus and chlorophyll-a must be at or below 7.2 ppb and 3.0 ppb, respectively, to achieve Tier 2 High Quality Water status. Support determinations are based on the nutrient stressor (phosphorus) and response indicator (chlorophyll-a), with chlorophyll-a dictating the assessment if both chlorophyll-a and total phosphorus data are available and the assessments differ (Table 6).

Results of the assimilative capacity analysis show that Wolfeboro Bay and Rust Pond meet Tier 2 (High Water Quality) for the oligotrophic designation (Table 7). The existing median total phosphorus and chlorophyll-a concentrations meet the thresholds for all sample locations on both waterbodies. Rust Pond has less remaining assimilative capacity than Wolfeboro Bay. Back Bay may attain Tier 2 (High Water Quality) or Tier 1 (Within Reserve) for the oligotrophic designation, based on the sites sampled in the lake. Shaws Pond has total phosphorus and chlorophyll-a levels that exceed the thresholds for the oligotrophic standard, meaning it would be considered impaired based on an oligotrophic designation. However, use of the assimilative capacity for Wolfeboro Bay may be less relevant in terms of achieving a reduced risk of cyanobacteria blooms (refer to Section 2.4 Water Quality Goals & Objectives).

Table 5. Aquatic life integrity (ALI) nutrient criteria ranges by trophic class in New Hampshire. TP = total phosphorus. Chl-a = chlorophyll-a, a surrogate measure for algae.

Trophic State	TP (ppb)	Chl-a (ppb)
Oligotrophic	< 8.0	< 3.3
Mesotrophic	> 8.0 - 12.0	> 3.3 - 5.0
Eutrophic	> 12.0 - 28.0	> 5.0 - 11.0

Table 6. Decision matrix for aquatic life integrity (ALI) assessment in New Hampshire. TP = total phosphorus. Chl-a = chlorophyll-a, a surrogate measure for algae concentration.

Nutrient Assessments	TP Threshold Exceeded	TP Threshold *NOT* Exceeded	Insufficient Info for TP
Chl-a Threshold Exceeded	Impaired	Impaired	Impaired
Chl-a Threshold *NOT* Exceeded	Potential Non-support	Fully Supporting	Fully Supporting
Insufficient Info for Chl-a	Insufficient Info	Insufficient Info	Insufficient Info

Table 7. Assimilative capacity (AC) analysis results for Wolfeboro Bay, Back Bay, Rust Pond, and Shaws Pond. Chlorophyll-a dictates the assessment results. HQW = High Quality Water. WR = Within Reserve. TP = Total Phosphorus. Chl-a = Chlorophyll-a.

Station	Parameter	AC Threshold (ppb)	Existing Median (ppb)*	Remaining AC (ppb)	Assessment Results
LAKE WINNIPESAUKEE, WOLFE. BAY-DEEP SPOT [WINBWOLD]	TP	7.2	4.9	2.3	NA
LAKE WINNIPESAUKEE, WOLFE. BAY [WINBBAYL]	TP	7.2	6.2	1	NA
WOLFEBORO BAY - AGGREGATE	**TP**	**7.2**	**5.6**	**1.6**	**NA**
BACK BAY – SKI JUMP [Ski Jump]	TP	7.2	11.4	-4.2	NA
BACK BAY SKIER DROP BUOY [Back Bay Buoy]	TP	7.2	12.1	-4.9	NA
BACK BAY - AGGREGATE	**TP**	**7.2**	**11.8**	**-4.6**	**NA**
RUST POND – DEEP SPOT [RUSWOLD]	**TP**	**7.2**	**6.5**	**0.7**	**NA**
SHAWS POND – 1DEEP	**TP**	**7.2**	**8.5**	**-1.3**	**NA**
LAKE WINNIPESAUKEE, WOLFE. BAY-DEEP SPOT [WINBWOLD]	Chl-a	3	1.3	1.7	Tier 2 (HQW)
LAKE WINNIPESAUKEE, WOLFE. BAY [WINBBAYL]	Chl-a	3	1.3	1.7	Tier 2 (HQW)
WOLFEBORO BAY - AGGREGATE	**Chl-a**	**3**	**1.3**	**1.7**	**Tier 2 (HWQ)**
BACK BAY – SKI JUMP [Ski Jump]	Chl-a	3	2.4	0.7	Tier 2 (HQW)
BACK BAY SKIER DROP BUOY [Back Bay Buoy]	Chl-a	3	3.3	-0.3	Tier 1 (WR)
BACK BAY - AGGREGATE	**Chl-a**	**3**	**2.9**	**0.1**	**Tier 2 (HWQ)**
RUST POND – DEEP SPOT [RUSWOLD]	**Chl-a**	**3**	**2.5**	**0.5**	**Tier 2 (HWQ)**
SHAWS POND – 1DEEP	**Chl-a**	**3**	**3.5**	**-0.5**	**Impaired**

** Existing water quality data truncated to May 24-Sept 15 in the previous 10 years (2013-2022) for composite, epilimnion, or upper samples (in order of priority on a given day). Data were summarized by day, then month, then year using median statistic.*

2.3 WATERSHED MODELING

2.3.1 Lake Loading Response Model (LLRM)

Environmental modeling is the process of using mathematics to represent the natural world. Models are created to explain how a natural system works, to study cause and effect, or to make predictions under various scenarios. Environmental models range from very simple equations that can be solved with pen and paper, to highly complex computer software requiring teams of people to operate. Lake models, such as the Lake Loading Response Model (LLRM), can make predictions about phosphorus concentrations, chlorophyll-a concentrations, and water clarity under different pollutant loading scenarios. These types of models play a key role in the watershed planning process. EPA guidelines for watershed plans require that pollutant loads to a waterbody be estimated.

The LLRM is an Excel-based model that uses environmental data to develop a water and phosphorus loading budget for lakes and their tributaries (AECOM, 2009). 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 watershed and sub-watershed boundaries, land cover, point sources (if applicable), septic systems, waterfowl, rainfall, volume and surface area, and internal phosphorus loading. These data are combined with coefficients, attenuation factors, and equations from scientific literature on lakes, rivers, and nutrient cycles to generate annual average predictions of total phosphorus, chlorophyll-a, Secchi disk transparency, and algal bloom probability. The model can be used to identify current and future pollutant sources, estimate pollutant limits and water quality goals, and guide watershed improvement projects. A complete detailing of the methodology employed for the Wolfeboro Bay LLRM is provided in the *Wolfeboro Bay Lake Loading Response Model Report* (FBE, 2024a).

2.3.1.1 Lake Morphology & Flow Characteristics

The morphology (shape) and bathymetry (depth) of lakes and ponds are considered reliable predictors of water clarity and lake ecology. Large, deep lakes are typically clearer than small, shallow lakes as the differences in lake area, number and volume of upstream lakes, and **flushing rate** affect lake function and health.

The surface area of Wolfeboro Bay is 1,988 acres (17.4 miles of shoreline) with a maximum depth of 120 feet (36.6 meters) and volume of 75,053,046 m^3 (Appendix A, Map A-1). The **areal water load** is 21 ft/yr (6.4 m/yr), and the flushing rate is 2.3 times per year. The flushing rate of 2.3 means that the entire volume of Wolfeboro Bay is replaced 2.3 times per year. Wolfeboro Bay has a different flushing rate than Lake Winnipesaukee in aggregate due to the influence of the other bays and their watersheds; the flushing rate of Lake Winnipesaukee is about 0.2, meaning it takes 5 years for the entire volume of Lake Winnipesauke to be replaced.

2.3.1.2 Land Cover

Characterizing land cover within a watershed on a spatial scale can highlight potential sources of NPS pollution that would otherwise go unnoticed in a field survey of the watershed. For instance, a watershed with large areas of developed land (i.e., impervious cover) and minimal forestland will likely be more at risk for NPS pollution than a watershed with well-managed development and large tracts of undisturbed forest, particularly along headwater streams. Land cover is also the essential element in determining how much phosphorus is contributing to a surface water via stormwater runoff and baseflow.

Current land cover in the Wolfeboro Bay watershed was determined by FBE using a combination of wetlands from the National Wetlands Inventory (NWI), waterbodies from the National Hydrography Dataset (NHD), roads from the New Hampshire Department of Transportation (NHDOT), and building footprints from the publicly available Microsoft building footprints layer. All data was acquired from New Hampshire's data clearinghouse, NH GRANIT. FBE edited the land cover file to add in residential and commercial development, logging, excavation and other land uses using ESRI World Imagery and Google Earth satellite imagery. For more details on methodology, see the *Wolfeboro Bay Lake Loading Response Model Report* (FBE, 2024a). Refer also to Appendix A, Map A-2.

As of the 2021 NAIP imagery, development accounts for 8% (2,549 acres) of the watershed, while forested and natural areas account for 89% (27,306 acres). Wetlands and open water represent 1% (267 acres) of the watershed, not including the surface areas of Wolfeboro Bay, Lake Wentworth, Crescent Lake, Back Bay, Shaws Pond, and Rust Pond. Agriculture represents 2% (592 acres). Figure 11 shows a breakdown of land cover by major category for the entire watershed (not including waterbody areas), as well as total phosphorus load by major land cover category (refer to Section 2.3.1.4 or FBE, 2024a). Developed areas cover 8% of the entire watershed and contribute 61% of the entire total phosphorus watershed load to Wolfeboro Bay. Developed areas in the direct watershed cover 10% of the direct watershed and contribute 67% of the direct total phosphorus watershed load to Wolfeboro Bay. Development and associated impervious surfaces are concentrated along the shoreline to Wolfeboro Bay and in downtown Wolfeboro and represent a significant impact to water quality by contributing contaminated runoff with minimal treatment directly to Wolfeboro Bay. Development along the shorelines of Wolfeboro Bay and Back Bay is not regulated by the Comprehensive Shoreland Protection Act, RSA 483-B per the Urbanized Exemption that was requested by the Town of Wolfeboro and approved by NHDES on August 10, 2009.

Developed areas within the Wolfeboro Bay watershed are characterized by **impervious surfaces**, including areas with asphalt, concrete, compact gravel, and rooftops that force rain and snow that would otherwise soak into the ground to run off as stormwater. Stormwater runoff carries pollutants to waterbodies that may be harmful to aquatic life, including sediments, nutrients, pathogens, pesticides, hydrocarbons, and metals. There are documented correlations between the percentage of effective impervious cover in a drainage area and the water quality of the receiving waterbody, with higher percent impervious cover, often greater than 10% as per the NHDES "1065 Rule", causing degradation of water quality and aquatic habitat. While an impervious cover analysis was not completed for this plan, impervious cover in the direct watershed to Wolfeboro Bay is less than 10% since developed land cover (at 10%) reflects all human-impacted areas in addition to impervious surfaces and includes such non-impervious areas as lawns. However, development in downtown Wolfeboro and along the shoreline of Wolfeboro Bay contains dense impervious cover that would exceed the 10% threshold within the shoreland zone and contribute contaminated runoff in short, first-flush flow paths to Wolfeboro Bay, with the potential to severely impact the bay's water quality.

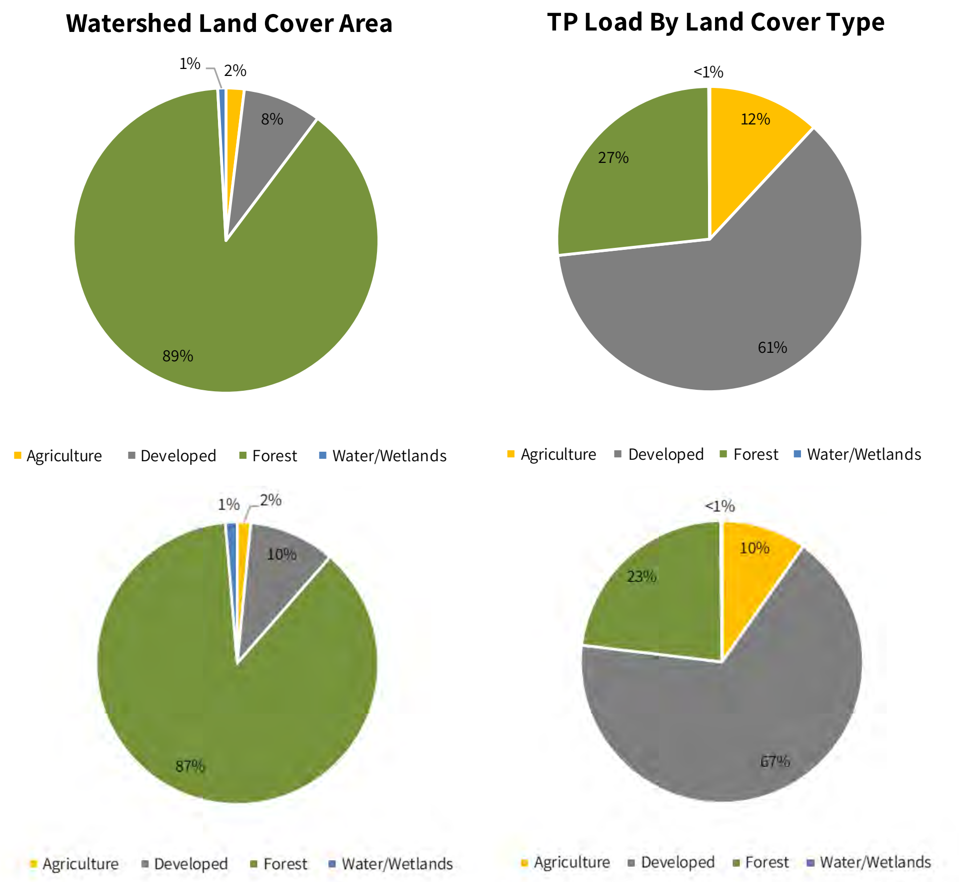


Figure 11. Wolfeboro Bay watershed (including Lake Wentworth, Crescent Lake, Back Bay, Rust Pond, and Shaws Pond watersheds) [TOP] and Wolfeboro Bay Direct watershed (including Back Bay, Rust Pond, and Shaws Pond watersheds) [BOTTOM] land cover area by general category (agriculture, developed, forest, and water/wetlands) [LEFT] and total phosphorus (TP) watershed load by general land cover type [RIGHT]. This shows that developed areas cover 8% of the entire watershed and contribute 61% of the entire TP watershed load to Wolfeboro Bay. Developed areas in the direct watershed cover 10% of the direct watershed and contribute 67% of the direct TP watershed load to Wolfeboro Bay. The water/wetlands category does not include the lake areas.

2.3.1.3 Internal Phosphorus Loading

Phosphorus that enters the lake and settles to the bottom can be re-released from sediment under anoxic conditions, providing a nutrient source for algae, cyanobacteria, and plants. Internal phosphorus loading can also result from wind-driven wave action or physical disturbance of the sediment (boat props, aquatic macrophyte management activities). Internal loading estimates were derived from dissolved oxygen and temperature profiles taken at the deep spots of each waterbody (to determine average annual duration and depth of anoxia defined as <2 ppm dissolved oxygen) and epilimnion/hypolimnion total phosphorus data taken at the deep spots of each waterbody (to determine average difference between surface and bottom phosphorus concentrations). These estimates, along with anoxic volume and surface area, helped determine rate of release and mass of annual internal phosphorus load. The internal load estimate in any given year was highly variable and warrants further investigation.

2.3.1.4 LLRM Results

Overall, model predictions for Wolfeboro Bay were in good agreement with observed data for total phosphorus (1%), chlorophyll-a (16%), and Secchi disk transparency (43%) (Table 8). It is important to note that the LLRM does not explicitly account for all the biogeochemical processes occurring within a waterbody that contribute to overall water quality and is less accurate at predicting chlorophyll-a and Secchi disk transparency. For example, chlorophyll-a is estimated strictly from nutrient loading, but other factors strongly affect algae growth, including transport of phosphorus from the sediment-water interface to the water column by cyanobacteria, low light from suspended sediment, grazing by zooplankton, presence of heterotrophic algae, and flushing effects from high flows. There were insufficient data available to evaluate the influence of these other factors on observed chlorophyll-a concentrations and Secchi disk transparency readings.

Watershed runoff combined with baseflow (88%) was the largest phosphorus loading contribution across all sources to Wolfeboro Bay. The watershed load (88%) includes the watershed loads from Back Bay, Crescent Lake, and Lake Wentworth (39%), Rust Pond (2%), Shaws Pond (2%), the direct land area to Wolfeboro Bay (21%), and mixing with other areas of Lake Winnipesaukee (24%) (Table 9; Figure 12). Atmospheric deposition (6%), internal loading (1%), waterfowl (3%), and septic systems (2%) were relatively minor sources. Development in the watershed is most concentrated in the urban downtown area around the Wolfeboro Bay shoreline, Back Bay, and Crescent Lake. Development is also dense around the shoreline where septic systems or holding tanks are located within a short distance to the water, leaving little horizontal (and sometimes vertical) space for proper filtration of wastewater effluent. Improper maintenance or siting of these systems can cause failures, which leach untreated, nutrient-rich wastewater effluent to the lake. The entirety of the Back Bay shoreline and much of the Wolfeboro Bay shoreline (particularly downtown) is serviced by sewer systems, which also represent a potential vulnerability if the sewer systems are old or damaged and leaking wastewater into groundwater near the lake. Note that septic systems are a relatively minor load to Wolfeboro Bay because 1) the estimate is only for those systems directly along the shoreline and potentially short-circuiting minimally treated effluent to the lake, 2) much of the shoreline area is serviced by sewer which is not accounted for in the model since the assumption is that the sewer lines are not leaking, and 3) shoreline septic systems for other lakes within the Wolfeboro Bay watershed are included in their respective watershed loads (see Table 9 for a breakdown). The load from septic systems throughout the rest of the watershed is inherent to the coefficients used to generate the watershed load.

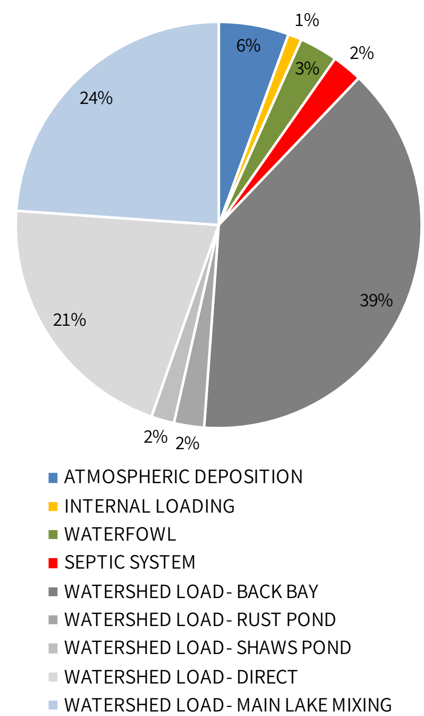


Figure 12. Summary of total phosphorus loading by major source for Wolfeboro Bay. The Back Bay watershed load includes inputs from Lake Wentworth and Crescent Lake. Refer to Table 9 for a breakdown.

Internal loading is currently a relatively minor source of phosphorus to Wolfeboro Bay and all other waterbodies in the watershed. Although the model predicts zero or few bloom days (Table 8) for all waterbodies, numerous bloom warnings and alerts were issued by NHDES in 2023 and 2024. In 2023, bloom warnings/alerts spanned 7 days on Wolfeboro Bay (*Gloeotrichia*), 30 days on Lake Wentworth (*Gloeotrichia*, *Dolichospermum*), and 6 days on Crescent Lake (*Dolichospermum*, *Woronichinia*).

Normalizing for the size of a sub-watershed (i.e., accounting for its annual discharge and direct drainage area) better highlights sub-watersheds with elevated pollutant exports relative to their drainage area. Sub-watersheds with moderate-to-high phosphorus mass exported by area (>0.20 kg/ha/yr) generally had more development (i.e., highly developed urban areas around Back Bay, Crescent Lake, and the Wolfeboro Bay shorelines; Figure 13). Drainage areas directly adjacent to waterbodies have direct connections to the lakes and are usually targeted for development, thus increasing the possibility for phosphorus export.

Once the model is calibrated for current in-lake phosphorus concentration, we can then manipulate land cover and other factor loadings to estimate pre-development loading scenarios (e.g., what in-lake phosphorus concentration was prior to human development or the best possible water quality for the lake). Refer to FBE (2024a) for details on methodology. Pre-development loading estimation showed that total phosphorus loading to Wolfeboro Bay increased by 142%, from 653 kg/yr prior to European settlement to 1,583 kg/yr under current conditions (Table 9). These additional phosphorus sources are coming from development in the watershed (especially from the direct shoreline of Wolfeboro Bay and the downtown area of Wolfeboro around Back Bay and Crescent Lake), septic systems, atmospheric dust, and internal loading (Table 9). Water quality prior to settlement was predicted to be excellent with extremely low phosphorus and chlorophyll-a concentrations and high water clarity (Table 8).

We can also manipulate land cover and other factors to estimate future loading scenarios (e.g., what in-lake phosphorus concentration might be at **full build-out** under current zoning constraints or the worst possible water quality for the lake). Refer to Attachment 3 and the 2024 Wolfeboro Bay Watershed Build-out Analysis Report (FBE, 2024b) for details on methodology. Note: the future scenario did not assume a 10% increase in precipitation over the next century (NOAA Technical Report NESDIS 142-1, 2013), which would have resulted in a lower predicted in-lake phosphorus concentration; this is because the model does not consider the rate and distribution of the projected increase in precipitation. Climate change models predict more intense and less frequent rain events that may exacerbate erosion of phosphorus-laden sediment to surface waters and therefore could increase in-lake phosphorus concentration (despite dilution and flushing impacts that the model assumes).

Future loading estimation showed that total phosphorus loading to Wolfeboro Bay may increase by 118%, from 1,583 kg/yr under current conditions to 3,455 kg/yr at full build-out (2075) under current zoning (Table 9). Additional phosphorus will be generated from more development in the watershed (especially near downtown Wolfeboro and undeveloped headwater areas), greater atmospheric dust, more septic systems, and enhanced internal loading (Table 9). The projected total phosphorus load for all other waterbodies showed substantial increases as well. The Wolfeboro Bay model predicted higher (worse) phosphorus (13.3 ppb), higher (worse) chlorophyll-a (4.5 ppb), and lower (worse) water clarity (3.2 m) compared to current conditions for Wolfeboro Bay (Table 8). Predicted future water quality was similarly poor for other waterbodies, with Shaws Pond predicted to have a total phosphorus concentration of 21.8 ppb and bloom concentrations for 159 days of the year (Table 8).

Table 8. In-lake water quality predictions for Lake Wentworth, Crescent Lake, Back Bay, Rust Pond, Shaws Pond, and Wolfeboro Bay. TP = total phosphorus. Chl-a = chlorophyll-a. SDT = Secchi disk transparency. Bloom Days represent average annual probability of chlorophyll-a exceeding 8 ppb.

Model Scenario	Median TP (ppb)	Predicted Median TP (ppb)	Mean Chl-a (ppb)	Predicted Mean Chl-a (ppb)	Mean SDT (m)	Predicted Mean SDT (m)	Bloom Days
Lake Wentworth							
Pre-Development	--	2.7	--	0.3	--	10.9	0
Current (2023)	5.8 (7.2)*	7.3	1.4	1.5	6.8	5.0	0
Future (2075)	--	13.9	--	4.0	--	3.1	19
Crescent Lake							
Pre-Development	--	2.4	--	0.3	--	11.8**	0
Current (2023)	7.7	7.9	2.0	2.3	5.0	4.7	1
Future (2075)	--	14.9	--	5.2	--	2.9	49
Back Bay							
Pre-Development	--	2.5	--	0.3	--	11.4**	0
Current (2023)	11.2	10.1	2.9	3.2	3.5	3.9**	7
Future (2075)	--	18.1	--	6.7	--	2.5**	99
Rust Pond							
Pre-Development	--	2.4	--	0.3	--	11.8	0
Current (2023)	6.8 (8.1)*	8.0	2.4	2.3	5.7	4.7	1
Future (2075)	--	19.1	--	7.1	--	2.4	115
Shaws Pond							
Pre-Development	--	3.4	--	0.7	--	8.9**	0
Current (2023)	8.0 (9.6)*	9.5	4.0	3.0	3.8	4.1	5
Future (2075)	--	21.8	--	8.4	--	2.2	159
Wolfeboro Bay							
Pre-Development	--	2.5	--	0.3	--	11.4	0
Current (2023)	5.1 (6.1)*	6.1	1.3	1.6	8.9	5.8	0
Future (2075)	--	13.3	--	4.5	--	3.2	30

**Mean TP concentration (first value) represents current in-lake epilimnion-metalimnion TP from observed data. Median TP concentration (second value in parentheses) represents 20% greater than the observed mean value as the value used to calibrate the model. Most lake data are collected in summer when TP concentrations are typically lower than annual average concentrations for which the model predicts.*

***Values exceed the maximum depth of the waterbody. Secchi depth would hit bottom of each respective lake: 5.5 m for Crescent Lake, 2 m for Back Bay, 5 m for Shaws Pond.*

Table 9. Total phosphorus (TP) and water loading summary by model (pre-development, current, and future) and source for modeled waterbodies in the Wolfeboro Bay watershed. Italicized sources sum to the watershed load.

MODEL/SOURCE	PRE-DEV			CURRENT (2023)			FUTURE (2075)		
	TP (KG/YR)	%	WATER (CU.M/YR)	TP (KG/YR)	%	WATER (CU.M/YR)	TP (KG/YR)	%	WATER (CU.M/YR)
LAKE WENTWORTH									
ATMOSPHERIC	87.9	23%	15,033,605	138.1	13%	15,033,605	313.9	16%	15,033,605
INTERNAL	0	0%	0	37.2	4%	0	71.7	3%	0
WATERFOWL	75.3	20%	0	75.3	7%	0	75.3	4%	0
SEPTIC SYSTEM	0	0%	0	79	8%	67,009	95.1	5%	87,175
WATERSHED LOAD	212.3	57%	46,859,661	704.2	68%	46,687,649	1,401.20	72%	46,390,611
TOTAL LOAD	**375.5**	**100%**	**61,893,266**	**1,033.90**	**100%**	**61,788,262**	**1,957.30**	**100%**	**61,511,391**
CRESCENT LAKE									
ATMOSPHERIC	1.5	1%	678,791	6.2	1%	678,791	14.2	1%	678,791
INTERNAL	0	0%	0	9.4	2%	0	17.7	2%	0
WATERFOWL	3.4	2%	0	3.4	1%	0	3.4	<1%	0
SEPTIC SYSTEM	0	0%	0	12.7	2%	11,185	15.9	2%	15,173
WATERSHED LOAD	155.2	97%	57,191,106	496.5	94%	57,027,400	941.3	95%	56,968,010
Lake Wentworth	*146.9*	*92%*	*55,434,573*	*403.9*	*76%*	*55,329,569*	*763.6*	*77%*	*55,052,698*
Direct Land Use Load	*8.4*	*5%*	*1,756,533*	*92.6*	*18%*	*1,697,831*	*177.8*	*18%*	*1,638,441*
TOTAL LOAD	**160.2**	**100%**	**57,869,897**	**528.2**	**100%**	**57,717,376**	**992.5**	**100%**	**57,385,103**
BACK BAY									
ATMOSPHERIC	1	1%	173,718	1.6	<1%	173,718	3.6	<1%	173,718
INTERNAL	0	0%	0	0.2	<1%	0	0.6	<1%	0
WATERFOWL	0.9	1%	0	0.9	<1%	0	0.9	<1%	0
SEPTIC SYSTEM	0	0%	0	0	0%	0	0	0%	0
WATERSHED LOAD	154	98%	61,262,979	631.4	>99%	61,046,432	1,124.90	>99%	60,641,824
Crescent Lake	*137*	*88%*	*57,578,277*	*453.7*	*72%*	*57,425,756*	*850.1*	*75%*	*57,093,483*
Direct Land Use Load	*16.9*	*10%*	*3,684,702*	*177.7*	*28%*	*3,620,676*	*274.8*	*24%*	*3,548,342*
TOTAL LOAD	**155.9**	**100%**	**61,436,697**	**634**	**100%**	**61,220,150**	**1,130.00**	**100%**	**60,815,542**
RUST POND									
ATMOSPHERIC	6.8	21%	1,158,182	10.6	10%	1,158,182	24.2	10%	1,158,182
INTERNAL	0	0%	0	3.1	3%	0	7.6	3%	0
WATERFOWL	5.8	18%	0	5.8	5%	0	5.8	2%	0
SEPTIC SYSTEM	0	0%	0	11.5	11%	9,356	17	7%	16,170
WATERSHED LOAD	19.3	61%	4,107,353	75.3	70%	4,074,321	198.6	78%	4,000,439
TOTAL LOAD	**31.9**	**100%**	**5,265,535**	**106.4**	**100%**	**5,241,859**	**253.2**	**100%**	**5,174,790**
SHAWS POND									
ATMOSPHERIC	2	11%	336,900	3.1	6%	336,900	7	6%	336,900
INTERNAL	0	0%	0	1.5	3%	0	3.4	3%	0
WATERFOWL	1.7	10%	0	1.7	4%	0	1.7	2%	0
SEPTIC SYSTEM	0	0%	0	4.5	9%	4,069	5.8	5%	5,772
WATERSHED LOAD	13.7	79%	2,857,712	37.3	78%	2,852,964	91.6	84%	2,840,994
TOTAL LOAD	**17.3**	**100%**	**3,194,613**	**48**	**100%**	**3,193,933**	**109.5**	**100%**	**3,183,666**
WOLFEBORO BAY									
ATMOSPHERIC	56.3	9%	9,625,721	88.4	6%	9,625,721	201	6%	9,625,721
INTERNAL	0	0%	0	17.3	1%	0	37.9	1%	0
WATERFOWL	48.2	7%	0	48.2	3%	0	48.2	1%	0
SEPTIC SYSTEM	0	0%	0	38	2%	27,656	49.5	2%	42,074
WATERSHED LOAD	548	84%	159,804,955	1,390.80	88%	159,492,424	3,118.50	90%	159,458,968
Back Bay	*294.5*	*45%*	*61,362,065*	*617.6*	*39%*	*61,145,518*	*1,102.40*	*32%*	*60,740,910*
Rust Pond	*11.3*	*2%*	*4,767,960*	*38*	*2%*	*4,744,284*	*89.4*	*3%*	*4,677,215*
Shaws Pond	*10.5*	*2%*	*3,049,874*	*29*	*2%*	*3,049,195*	*66.3*	*2%*	*3,038,928*
Exchange w/ Winni	*140*	*14%*	*70,000,000*	*378*	*24%*	*70,000,000*	*830.2*	*24%*	*70,000,000*
Direct Land Use Load	*91.6*	*21%*	*20,625,056*	*328.3*	*21%*	*20,553,427*	*1,030.10*	*30%*	*21,001,914*
TOTAL LOAD	**652.5**	**100%**	**169,430,676**	**1,582.70**	**100%**	**169,145,801**	**3,455.20**	**100%**	**169,126,763**

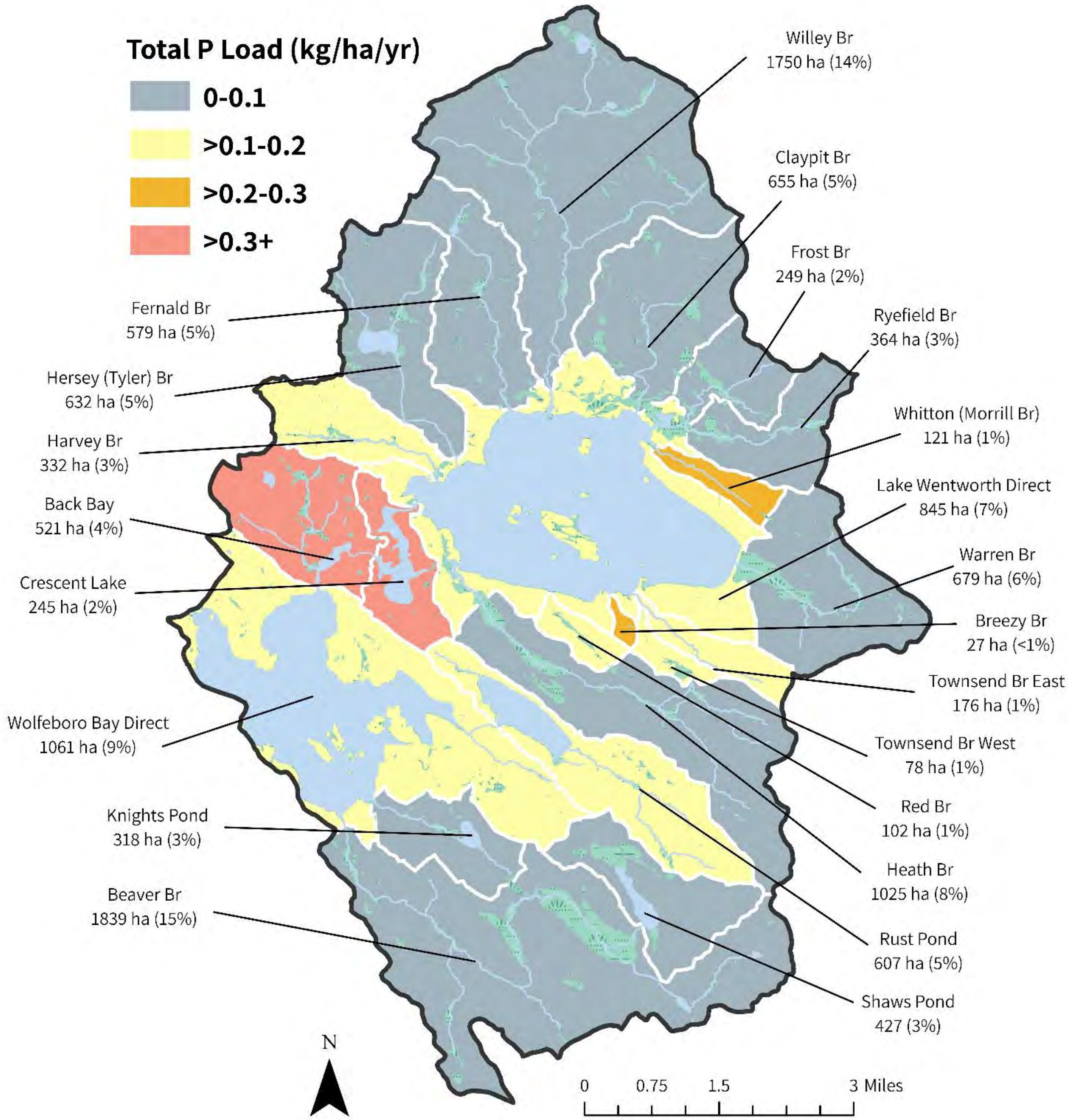


Figure 13. Map of current total phosphorus load per unit area (kg/ha/yr) for each sub-watershed in the Wolfeboro Bay watershed. Higher phosphorus loads per unit area are concentrated in the more developed southern portion of the watershed.

2.3.2 Build-out Analysis

A full build-out analysis was completed for the Wolfeboro Bay watershed for the municipalities of Wolfeboro, Alton, New Durham, Brookfield, and Ossipee (FBE, 2024b). A build-out analysis identifies areas with development potential and projects future development based on a set of conditions (e.g., zoning regulations, environmental constraints) and assumptions (e.g., population growth rate). A build-out analysis shows what land is available for development, how much development can occur, and at what densities. “Full Build-out” is a theoretical condition representing the moment in time when all available land suitable for residential, commercial, and industrial uses has been developed to the maximum capacity permitted by local ordinances and zoning standards. Local ordinances and zoning standards are subject to change, and the analysis requires simplifying assumptions; therefore, the results of the build-out analysis should be viewed as planning-level estimates only for potential future outcomes from development trends.

FULL BUILD-OUT is a theoretical condition representing the moment in time when all available land suitable for residential, commercial, and industrial uses has been developed to the maximum capacity permitted by current local ordinances and current zoning standards.

To determine where development may occur within the study area, the build-out analysis first subtracts land unavailable for development due to physical constraints, including environmental restrictions (e.g., wetlands, conserved lands, hydric soils), zoning restrictions (e.g., shoreland zoning, street Right-of-Ways (ROWs), and building setbacks), and practical design considerations (e.g., lot layout inefficiencies) (Appendix A, Map A-3). Existing buildings also reduce the capacity for new development.

The build-out analysis showed that 57% (17,333 acres) of the watershed is buildable under current zoning regulations (Appendix A, Map A-4). The Residential/Agricultural zone in Wolfeboro has the most acreage of buildable area at 5,425 acres (Table 10). FBE identified 3,314 existing buildings within the watershed, and the build-out analysis projected that an additional 5,418 buildings could be constructed in the future, resulting in a total of 8,732 buildings in the watershed at full build-out (Appendix A, Map A-5). A watershed-wide build-out analysis was completed for the Lake Wentworth and Crescent Lake portion of the watershed in 2012 (only included Wolfeboro and Brookfield) and was compared with the updated build-out analysis to evaluate how development patterns or pressures have changed since the 2012 build-out. Results of this build-out showed an increase in the number of existing buildings coupled with a decrease in buildable area (558 acres) and projected buildings (205 buildings) from 2012 to 2023, indicating development has occurred within this study area from 2012-2023. Brookfield also amended their town zoning to increase the lot size in the Rural residential/Agricultural zone from 1 acre to 5 acres which decreases the number of projected buildings in Brookfield when comparing these analyses.

It is recommended that Table 10 be amended to separate out values by the Wolfeboro Bay Direct and Lake Wentworth/Crescent Lake watersheds and include existing and proposed percent impervious cover and the water quality threshold severity level in each town’s zone, per Table 5.3 in NHDES (2008a).

Table 10. Amount of buildable land and projected buildings by each town's zone in the entire Wolfeboro Bay watershed, including the Lake Wentworth and Crescent Lake watersheds. MU = Mixed Use. Bus. = Business. Dis. = District. Ltd = Limited.

Zone	Total Area (Acres)	Buildable Area (Acres)	Percent Buildable Area	Total No. Existing Buildings	Total No. Projected Buildings	Total No. Buildings	Percent Increase
Wolfeboro							
Bay St Limited Business District (BSLBD)	353	68	19%	90	18	108	20%
Commercial Business District (C1- CBD)	69	34	50%	153	17	170	11%
General Residential District (GR)	1,566	993	63%	149	256	405	172%
Center St/Rt 28 MU Bus. Dis. (CSMUB)	92	42	45%	22	0	22	0%
Municipal Watershed (MW)	30	28	94%	3	5	8	167%
Pine Hill Road Dev District (PHRDD)	170	101	59%	23	115	138	500%
Residential District (R)	2,252	1,474	65%	665	1,261	1,926	190%
Residential/Agricultural District (RA)	8,956	5,425	61%	282	584	866	207%
Rural Residential District (RR)	4,081	2,211	54%	372	371	743	100%
Shore Front Residential District (SFR)	1,484	720	49%	735	290	1,025	39%
S Wolfeboro Ltd Bus. District (SWLBD)	15	12	78%	22	1	23	5%
Village Residential District (VR)	740	423	57%	374	292	666	78%
Wolfeboro Falls Ltd Bus. District (WFLBD)	43	31	72%	38	12	50	32%
Alton							
Rural Zone (RU)	2,041	1,463	72%	87	409	496	470%
Lakeshore Residential Zone (LR)	328	245	75%	83	176	259	212%
New Durham							
Residential/Agricultural	5,208	3,084	59%	174	1,471	1,645	845%
Brookfield							
Rural Residential/Agricultural	2,048	635	31%	6	74	80	1233%
Workforce Housing	744	288	39%	36	31	67	86%
Ossipee							
Rural	62	54	88%	0	35	35	NA
Total	**30,283**	**17,333**	**57%**	**3,314**	**5,418**	**8,732**	NA

Three iterations of the TimeScope Analysis were run using compound annual growth rates (CAGR) for 20-, 30- and 50-year periods from 2000-2020 (1.34%), 1990-2020 (1.87%), and 1970-2020 (2.10%) to project the rate of new development into the future (Table 11). Full build-out is projected to occur in 2096 at the 20-year CAGR, 2075 at the 30-year CAGR, and 2070 for the 50-year CAGR. This analysis showed that if the towns within the watershed continue to grow at recent rates identified in the 20- and 50-year period, and current zoning and other development constraints remain the same, full build-out could occur within 46 years (Figure 14).

Note that the growth rates used in the TimeScope Analysis are based on town-wide census statistics but have been applied here to a portion of the municipalities. If areas closer to the bay within each municipality develop faster than more inland areas, watershed full build-out conditions may occur sooner. Also note that the population growth rate in these municipalities is decreasing, so the 20-year estimate is likely more accurate than the 50-year estimate. Using census data to project population increase and/or development has inherent limitations. For instance, the building rate may increase at a different rate than population, due to factors such as commercial versus residential development and number of people per household. As such, the TimeScope Analysis might over or underestimate the time required for the study area to reach full build-out. Numerous social and economic factors influence population change and development rates, including policies adopted by federal, state, and local governments. The relationships among the various factors may be complex and therefore difficult to model.

Table 11. Compound annual growth rates for the municipalities in the Wolfeboro Bay watershed, used for the TimeScope Analysis. Data from U.S. Census Bureau.

Town	50 yr. Avg. 1970-2020	30 yr. Avg. 1990-2020	20 yr. Avg. 2000-2020
Wolfeboro	1.51%	1.21%	0.97%
Alton	2.58%	2.23%	1.97%
New Durham	3.11%	2.08%	1.04%
Brookfield	2.71%	1.70%	1.26%
Ossipee	1.97%	1.44%	0.93%
Combined	**2.10%**	**2.21%**	**1.87%**

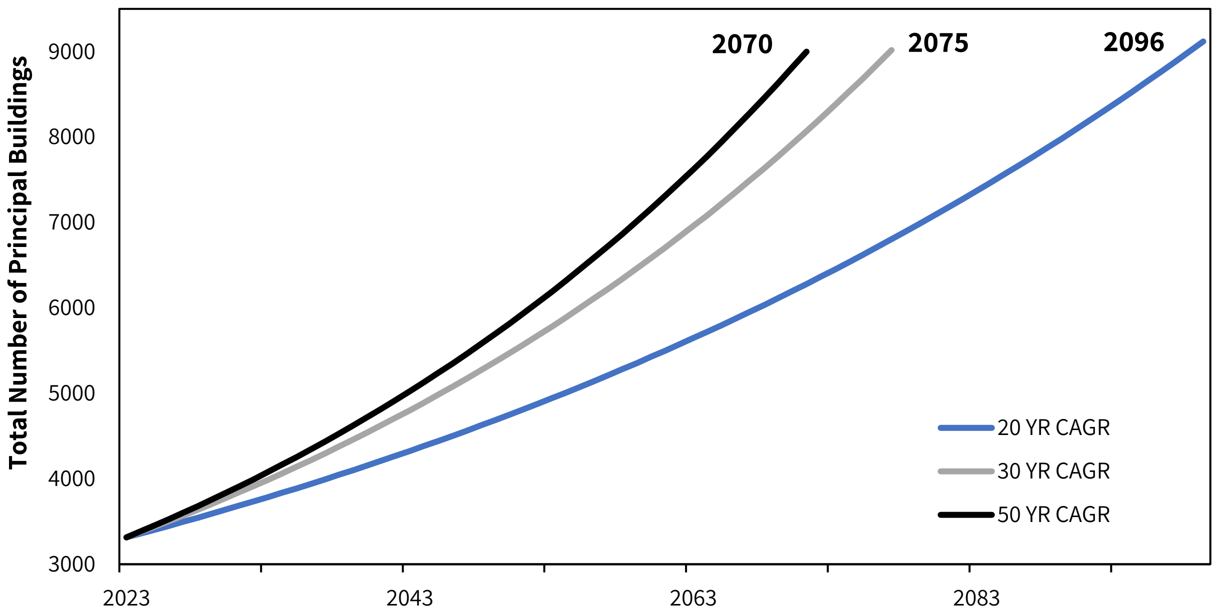


Figure 14. Full build-out projections of the Wolfeboro Bay watershed (based on compound annual growth rates).

2.4 WATER QUALITY GOAL & OBJECTIVES

The model results revealed changes in total phosphorus loading and in-lake total phosphorus concentrations over time from pre-development through future conditions, showing that the water quality of Wolfeboro Bay is threatened by current development activities in the watershed and will degrade further with continued development in the future. We can use these results to make informed management decisions and set an appropriate water quality goal for Wolfeboro Bay.

Although Wolfeboro Bay is currently meeting water quality standards for oligotrophic lakes and has ample reserve capacity, the increasing prevalence of cyanobacteria blooms indicates that there may not be reserve capacity for the lake to assimilate additional nutrients in the future under a "business as usual" scenario. Wolfeboro Bay has been experiencing recurring *Gloeotrichia* blooms resulting in multiple bloom warnings and alerts in recent years despite the low observed concentrations of total phosphorus and chlorophyll-a. Reducing watershed sources of phosphorus throughout the Wolfeboro Bay watershed will be necessary to protect water quality in the long-term by preventing the accumulation of phosphorus that can feed cyanobacteria blooms. Given that Wolfeboro Bay is experiencing cyanobacteria blooms and is threatened by new development, it is highly recommended that strong objectives be established to protect the water quality of Wolfeboro Bay and Lake Winnipesaukee over the long term.

The goal of the Wolfeboro Bay WBMP is to improve the water quality of Wolfeboro Bay such that it continues to meet state water quality standards for the protection of ALI and PCR and substantially reduces the likelihood of harmful cyanobacteria blooms in the lake. This goal will be achieved over the next 10 years and beyond by accomplishing the following objectives.

> **Objective 1:** Reduce phosphorus loading from existing development by 9.4% (149 kg/yr) to Wolfeboro Bay to improve average summer in-lake total phosphorus concentration from 5.1 ppb to 4.6 ppb.
>
> **Objective 2:** Mitigate (prevent or offset) phosphorus loading from future development by 203 kg/yr to Wolfeboro Bay to maintain average summer in-lake total phosphorus concentration in the next 10 years (2033). *Note: excludes phosphorus loading from Crescent Lake and Lake Wentworth and mixing with the Broads, focusing only on future development within the direct watershed to Wolfeboro Bay.*

Measures of success for achieving the goal and objectives should be based on a reduction in phosphorus loading from the major tributaries to Wolfeboro Bay and/or from shorefront BMPs and septic system upgrades, as well as a reduction in the frequency and severity of cyanobacteria blooms in the bay and Lake Winnipesaukee. It is unlikely that reduction efforts in the watershed will result in a measurable improvement in the average summer in-lake total phosphorus concentration due to the large influence of mixing with the Broads, unless large-scale reductions are completed around Lake Winnipesaukee. While any amount of phosphorus load reduction to the lake will be helpful for controlling cyanobacteria blooms, it is important to understand that the dominant cyanobacteria taxa in the lake can uptake phosphorus from phosphorus-rich sediments and store phosphorus for later use under more optimal growth conditions. Thus, the management implications for minimizing the risk of cyanobacteria blooms is not straightforward and depends on a number of factors out of our direct control. The physiological characteristics of these cyanobacteria taxa also means that the typical application of the state's water quality standards for lakes in the form of the assimilative capacity analysis are less relevant for Lake Winnipesaukee.

Reality Check for Meeting Objectives 1 and 2: The watershed survey identified 90 sites impacting the lake. Remediating these sites could prevent up to 62.5 kg/yr of phosphorus from entering Wolfeboro Bay. In addition, treating 294 shoreline survey sites could reduce the phosphorus load to Wolfeboro Bay by 11.6 kg/yr[2] for the 20 high impact sites (disturbance score 11+), 28.9 kg/yr[3] for the 100 medium impact sites (disturbance score between 9-10), and 25.2 kg/yr[4] for the 174 low impact sites (disturbance score 7-8). Finally, upgrading the 211 shorefront septic systems older than 25 years is estimated to reduce the phosphorus load to Wolfeboro Bay by 21 kg/yr. **In sum, treating existing pollutant sources identified as coming from the external watershed load (identified during the watershed survey, shoreline survey, and septic system survey) could reduce the phosphorus load to Wolfeboro Bay by 149.2 kg/yr, meeting 100% of Objective 1.** Objective 2 can be met through ordinance revisions that implement low impact development strategies, limit impervious cover, and encourage cluster development with open space protection and/or through conservation of key parcels of forested and/or open land.

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[2] Based on Region 5 model bank stabilization estimate for silt loams, using 200 ft (length) by 3 ft (height) and moderate lateral recession rate of 0.1 ft/yr.
[3] Based on Region 5 model bank stabilization estimate for silt loams, using 100 ft (length) by 3 ft (height) and moderate lateral recession rate of 0.1 ft/yr.
[4] Based on Region 5 model bank stabilization estimate for silt loams, using 50 ft (length) by 3 ft (height) and moderate lateral recession rate of 0.1 ft/yr.

It is important to note that the water quality goal does not include pollutant reduction efforts within the Crescent Lake and Lake Wentworth watersheds, which are anticipated to have an update to their existing WBMP in 2025. Pollutant reduction opportunities identified during the watershed survey focused on the direct Wolfeboro Bay watershed (which includes the drainages of Back Bay, Rust Pond, and Shaws Pond) and therefore achieving the water quality goal is possible without pollutant load reduction efforts in the upstream Crescent Lake and Lake Wentworth watersheds. Future efforts in these watersheds as part of the anticipated WBMP update will also improve water quality in Wolfeboro Bay. Shaws Pond also has an in-progress WBMP, and a water quality goal specific to Shaws Pond will be developed as part of that process.

The interim goals for each objective allow flexibility in re-assessing water quality objectives following more data collection and expected increases in phosphorus loading from new development in the watershed over the next 10 or more years (Table 12). Understanding where water quality will be following watershed improvements compared to where water quality should have been following no action will help guide adaptive changes to interim goals (e.g., goals are on track or goals are falling short). If the goals are not being met due to lack of funding or other resources for implementation projects versus due to increases in phosphorus loading from new development outpacing reductions in phosphorus loading from improvements to existing development, then this creates much different conditions from which to adjust interim goals. For each interim goal year, stakeholders should update the water quality data and model and assess why goals are or are not being met. Stakeholders can then decide on how to adjust the next interim goals to better reflect water quality conditions and practical limitations to implementation.

Table 12. Summary of water quality objectives for Wolfeboro Bay. Interim goals/benchmarks are cumulative.

Water Quality Objective	**Interim Goals/Benchmarks**		
	2026	**2028**	**2033**
1. Reduce phosphorus loading from existing development by 9.4% (149 kg/yr) to Wolfeboro Bay to improve average summer in-lake total phosphorus concentration from 5.1 to 4.6 ppb.	Achieve 2.4% (37 kg/yr) reduction in TP loading	Achieve 4.7% (74.5 kg/yr) reduction in TP loading; re-evaluate water quality and track progress	Achieve 9.4% (149 kg/yr) reduction in TP loading; re-evaluate water quality and track progress
2. Mitigate (prevent or offset) phosphorus loading from future development by 203 kg/yr to Wolfeboro Bay to maintain average summer in-lake total phosphorus concentration in the next 10 years (2033).	Prevent or offset 51 kg/yr in TP loading from new development to Wolfeboro Bay	Prevent or offset 102 kg/yr in TP loading from new development to Wolfeboro Bay; re-evaluate water quality and track progress	Prevent or offset 203 kg/yr in TP loading from new development to Wolfeboro Bay; re-evaluate water quality and track progress

3 POLLUTANT SOURCE IDENTIFICATION

This section describes sources of excess phosphorus to Wolfeboro Bay. Sources of phosphorus to lakes include stormwater runoff, shoreline erosion, construction activities, illicit connections, failed or improperly functioning septic systems, leaky sewer lines, boat discharges, fabric softeners and detergents in greywater, fertilizers, and pet, livestock, and wildlife waste. These external sources of phosphorus to lakes can then circulate within lakes and settle on lake bottoms, contributing to internal phosphorus loads over time. Additional phosphorus sources can enter the lake from atmospheric deposition but are not addressed here because of limited local management options. Wildlife is mentioned as a potential source but largely for nuisance waterfowl such as geese or ducks that may be congregating in large groups because of human-related actions such as feeding or having easy shoreline access (i.e., lawns). Climate change is also not a direct source but can exacerbate the impact of the other phosphorus sources identified in this section and should be considered when striving to achieve the water quality objectives.

3.1 WATERSHED DEVELOPMENT

NPS pollution comes from many diffuse sources on the landscape and is more difficult to identify and control than point source pollution. NPS pollution can result from contaminants transported by overland runoff (e.g., agricultural runoff or runoff from suburban and rural areas), groundwater flow, or direct deposition of pollutants to receiving waters. Examples of NPS pollution that can contribute nutrients to surface waters via runoff, groundwater, and direct deposition include erosion from disturbed ground or along roads, stormwater runoff from developed areas, malfunctioning septic systems, leaky sewer lines, boat discharges, excessive fertilizer application, pet waste, unmitigated agricultural activities, flooding, potential contamination sources, and wildlife waste.

3.1.1 Historical Development

Before the first settlers of Wolfeboro arrived in 1768, Indigenous people such as the Abenaki tribe lived around Lake Winnipesaukee, creating networks of hunting and fishing trails around the lake and through what is now considered Main Street in Wolfeboro. In the Abenaki language, “Lake Winnipesaukee” can be translated to “the lake between or around land or islands.” The Abenaki people primarily used Lake Winnipesaukee for fishing and benefitted from the abundance of fish in Wolfeboro Bay and Rust Pond. During this time, the area was mostly forested with minimal human impacts on the environment.

Early settlers of Wolfeboro began clearing land within Governor John Wentworth’s 3,600-acre estate along what is now known as Lake Wentworth. By 1771, settlers had built a saw and grist mill along the Smith River, which feeds what is currently known as Back Bay (Mark Lush, personal communication). The colonists of Wolfeboro originally farmed for sustenance, and large dairy and poultry farms became common as time progressed. Boating was an important aspect of Wolfeboro’s industry, particularly in the Wolfeboro Bay area. Animal-operated boats were common in the early 1800s, in the form of unorthodox horse-driven paddle boats in which horses walked on treadmills to move the paddles. In the winter, oxen were used to transport goods across the ice on Lake Winnipesaukee. When the use of steamboats began in 1838, transporting goods and merchandise became far easier; however, shipping across the lake using steamboats ceased a few decades after railroad service arrived in Wolfeboro (Denu, 2017).

Tourism was a large part of Wolfeboro’s identity and economy early in its history, beginning with Governor Wentworth’s seasonal estate and the construction of the first large hotel in 1795. In 1872, the tourist industry began to expand when the Eastern Railroad was extended into Wolfeboro (Denu, 2017). The rail line connected Wolfeboro to Boston and Maine and ran along the east side of the modern day Back Bay to end near the Lake Winnipesaukee shoreline (according to the Sanborn Fire Insurance Maps from 1917 (Library of Congress, n.d.)). The railroad service allowed Wolfeboro’s industries to flourish as it improved the transport of goods, allowed for the creation of summer camps and hotels, and encouraged tourists to purchase lakefront property to build summer cottages (Town of Wolfeboro, 2019). The end of the railroad near Lake Winnipesaukee was also home to a freight house, roundhouse for steam engine service, and other transportation infrastructure such as horse stables (Mark Lush, personal communication). Once cars became the dominant mode of transportation, the railroad was no longer used and was subsequently converted to a rail trail in the 1990s.

In the mid to late 1800s, downtown Wolfeboro saw an increase in industrial activity, such as mills and factories. The 1917 Sanborn Fire Insurance Maps show the exact location of these land uses, which primarily existed around the modern-day Back Bay and a smaller bay that has since been filled in. The former bay was once used for many industrial purposes and as the town dump until it was filled in 1967 and became Foss Field, the Wolfeboro Shopping Center, and the Clark Plaza (Mark Lush, personal communication). The Sanborn Fire Insurance Maps show a woodworking mill, grist mill, and the Berry Excelsior Factory (wood wool) located where the Smith River outlets into the modern-day Back Bay. Along the filled-in bay (formerly referred to as Back Bay), on what is currently Lehner Street, the Wolfeboro Electric Light Department had a coal shed and multiple underground oil tanks (Library of Congress, n.d.). Right next door was a four-story shoe factory. A smaller shoe factory in the same area later became an auto parts shop in the 1960s (Mark Lush, personal communication). Along the Back Bay shoreline near the railroad and large car garages - closer to where Back Bay meets Lake Winnipesaukee - were a few other mills fueled by underground gasoline tanks, such as the M.B. Blaisdell Grist Mill (Mark Lush, personal communication). The Lake Winnipesaukee shoreline in downtown Wolfeboro had numerous boat docks, shops, and garages.

Wolfeboro grew significantly after World War II. In the 1960's, tourism increased dramatically, leading to downtown commercial development. This coincides with the filling of the small bay that was once part of Back Bay. Year-round development grew in addition to tourism. The population grew from 3,036 to 3,968 (30.7%) between 1970 and 1980 (Wolfeboro Hazard Mitigation Update Committee, 2013). The rapid population growth was sustained though the turn of the century until it slowed in the 2010s.

Present-day Wolfeboro has changed dramatically since its settlement. Areas that were once served by outhouses with no electricity or running water now have septic systems and modern amenities. A large section of downtown Wolfeboro is served by a municipal sewer system with a wastewater treatment system (including an effluent storage pond and a rapid infiltration basin). While shoreline development began with the construction of summer cottages, contemporary summer homes have increasingly large footprints. As new summer homes are built, others are being converted to year-round use. Tourism is still a large industry for Wolfeboro, with various inns, golf courses, and private rentals. Boating remains a large part of vacationing in Wolfeboro, with numerous marinas and private docks dotting the shoreline. Tourists are attracted to Wolfeboro because of the downtown commercial area and recreation on Lake Winnipesaukee, causing the local population to swell in the summer and early fall.

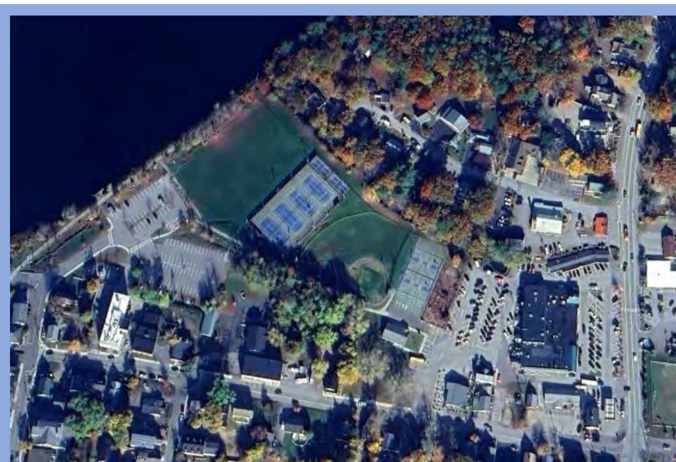
(Left) Dam associated with a grist mill on Back Bay (formerly known as Front Bay or Mill Pond). The railroad was located on the eastern shoreline of Back Bay and ended near the Lake Winnipesaukee shoreline. Credit: Wolfeboro Historical Society. (Middle) View of Back Bay after the Great Hurricane of 1938. The bay was filled with logs that would soon be processed at a sawmill. The bay to the left of the railroad was a former dumping ground that has since been filled. Credit: Wolfeboro Historical Society. (Right) Image of downtown Wolfeboro and Back Bay, circa 1960. The bay to the right of Back Bay has since been filled. The sawdust pile in the top left is from a large sawmill. Credit: Wolfeboro Historical Society.

FEATURE: BACK BAY

The former Back Bay was once used for many industrial purposes, including a woodworking mill, grist mill, wood wool factory, and shoe factory. It was also used as a town dump until it was filled in 1967 and became Foss Field, the Wolfeboro Shopping Center, and Clarke Plaza. According to NHDES OneStop Database, hazardous waste associated with former and active industrial/commercial operations around Back Bay include paint, propane, oil, gas, aerosols, PFOS, arsenic, anti-freeze, silver, bleach, batteries, acetone, lead soil debris, barium, chloroform, pharmaceuticals, mercury, ammonia, selenium, to name a few. Because of the area's former use as a dump, substances of general concern include heavy metals from batteries, industrial waste, paints, and coatings; organic contaminants from volatile organic compounds (VOCs), polychlorinated biphenyls (PCBs), and polycyclic aromatic hydrocarbons (PAHs); nutrients from food waste and fertilizers; dioxins and other organic pollutants from pesticides and herbicides; petroleum hydrocarbons from gas and oil; asbestos from construction waste; pharmaceuticals; and plastics and microplastics. Much of the current Back Bay had been filled with sawdust from the former mills and may contribute to a higher oxygen demand in sediments that could release phosphorus into the water. The former Back Bay area is marked as a flood hazard and has flooded in the past.

Other concerns for the current Back Bay are the 58 acres of effluent spray fields maintained by the Town of Wolfeboro in the Back Bay drainage area; milfoil infestation managed by suction harvesting; sewer lines and pump stations, particularly in the former Back Bay floodplain; and stormwater discharges from the former to current Back Bay. The Town of Wolfeboro maintains a large stormwater retention swale that receives runoff from Route 28, Lehner Street, and Grove Street, including Foss Field, the Wolfeboro Shopping Center, and Clarke Plaza (the former Back Bay) and discharges through an outfall to the current Back Bay along the Cotton Valley Rail Trail. In early November 2024, an unknown discharge of turbid water not associated with a rain event was observed at the outfall. Steve Randall, Wolfeboro DPW Director, scouted the drainage area, including catch basins, and was unable to find the sediment source.

Back Bay suffers from numerous water quality issues and pollutant sources that should be investigated further for remediation opportunities. We included several recommendations for follow-up monitoring and assessment of Back Bay to better assess and prioritize those pollutant sources, which ultimately impact Wolfeboro Bay and Lake Winnipesaukee.



[Top] Aerial photo of the former Back Bay, since filled for the creation of Foss Field, the Wolfeboro Shopping Center, and Clarke Plaza. [Middle] Stormwater retention swale off Foss Field that discharges runoff to the current Back Bay via an outfall. [Bottom] Turbid water of unknown source observed at the outfall in early November 2024.

3.1.2 Watershed Survey

A watershed survey of the Wolfeboro Bay direct watershed was completed by technical staff from FBE, Horsley Witten Group, and LWA. The objective of the watershed survey was to identify and characterize sites contributing to NPS pollution and/or providing opportunities to mitigate NPS pollution in the watershed. Prior to the field work, FBE solicited input from LWA about locations with known NPS pollution. FBE also analyzed aerial images and GIS data for land use/land cover, roads, municipal drainage system, public properties, waterbodies, and other features. This information enabled FBE to better plan for the survey (e.g., to target known or likely high-polluting sites, such as unpaved roads, beaches, highly impervious areas, etc.) and to inform recommended solutions.

FBE conducted the watershed survey on July 12 and 13, 2023. LWA joined FBE on July 13, 2023. HW and Steve Randall, the Town of Wolfeboro Department of Public Works Director, surveyed the downtown area of Wolfeboro on September 19, 2023. For each location, field staff recorded site data and photographs on tablets. Information collected included location description and GPS coordinates; NPS problem description and measurements (e.g., gully dimensions); receiving waterbody; discharge type (direct or indirect/limited); and preliminary recommendations to mitigate the NPS problem. Field staff accessed sites from public and private roads and waterfront access points.

In total, 90 problem sites were identified in the watershed (Figure 15). The main issues found were road shoulder ditch erosion, unstable water access points, and buffer clearings. FBE estimated the potential pollutant removal that could be achieved by implementing recommendations, including 62.5 kg of phosphorus per year. Appendix B summarizes the recommendations, load reduction estimates, and estimated costs for each site. The top six high priority sites (based on lowest impact-weighted cost per mass of phosphorus removed and project engineer/local stakeholder input) are shown below. In addition to these specific sites, managers of both private and public roads should use best practices for road installation and maintenance for water quality protection. The Town of Wolfeboro is also undertaking a water main (followed by sewer, then stormwater, then roadway) replacement project (over the next 4-5 years) along Main Street in Wolfeboro from Pickering Corner to the Smith Bridge. This project represents a great opportunity for the Town to incorporate green street or similar green stormwater control designs that are more protective of water quality.



Examples of road shoulder erosion near Winnipesaukee Drive, July 2023. Photo Credit: FBE.

Site 2-23-1: South Main St

Location (latitude, longitude): 43.56638329, -71.17804115

Impact: High

Observations: Gullies spanning 238 feet long and up to 3 feet wide follow the west side of South Main St in Wolfeboro heading toward Alton. Stormwater runoff has overwhelmed the existing stormwater management measures currently in place. The gully begins as a small, concentrated pathway through a vegetated ditch and expands as the volume/speed of stormwater increases downslope. Sediment has washed through the gully and ultimately collects in a catch basin near the bottom of the hill at the intersection with Abenaukee Drive. This catch basin is a drain inlet that outfalls directly into Rust Pond. The extreme erosion has exposed bare soil all throughout the road shoulder and has begun to expose the metal culverts. The existence of bare soil along the road shoulder is highly susceptible to erosion as there are no plant roots to stabilize it. Nutrients such as phosphorus are bound to soil minerals, meaning that sediment transport into waterbodies can be a source of excess nutrient loading. The Town of Wolfeboro notes "the drainage swales along this section of Rt. 28 were cleaned [in spring 2023] by NH DOT." Unfortunately, the drainage swales could not withstand the summer 2023 storms.

A, B, C, and D: *Stormwater has eroded an existing road ditch, exposing bare soil and the tops of metal culverts. Sediment from the erosion ultimately accumulates in the catch basin near the bottom of the hill or continues moving downgradient.*

Recommendations: The road ditch should be reshaped to eliminate a concentrated flow pathway and to create a uniform channel for water to flow through. The ditch should be armored with either large stones (rip rap) or grass on the bottom and sidewalls. Larger stones are a better candidate than smaller stones for this site because of the moderate slope and the volume of stormwater that flows through the site. Larger stones are less susceptible to being carried downstream by fast moving water. The road shoulder should also be vegetated with grass or shrubs to stabilize the soil and prevent additional erosion from occurring. Replace the drain inlet at the bottom of the hill with a deep sump catch basin to collect sediment before water discharges to Rust Pond. Investigate the outfall at Rust Pond and determine if additional BMPs are needed to stabilize the outlet.

Site HW-3: Lake Street

Location (latitude, longitude): 43.58323669, -71.2151947

Impact: Medium

Observations: There is shoreline erosion of the grassy area at the end of Lake St, likely the result of the site's use as a boat launch. Runoff from Lake St and the adjacent parking lot drain through the site. This site is mapped at the end of a public right of way but may be used by various community members.

Recommendations: If water access is to be restricted at this site, revegetate the area with shrubs to stabilize the bare soil. If the area is to be kept as a boat launch, stabilize the area with a permeable paver mat that will allow water access but prevent erosion.

(Left) Erosion and bare soil at the water access point at the end of Lake St. (Right) Formerly grassy area is used as a boat launch.

Site HW-8: Parking at Back Bay Docks

Location (latitude, longitude): 43.58571625, -71.21305847

Impact: Medium

Observations: The parking area at the Back Bay docks is impervious and generates stormwater runoff with no infiltration. The parking lot only has drain inlets with no sumps and no stormwater treatment.

Recommendations: A linear bioswale/planter should be installed between the parking lot and docks. Removing the curb would allow runoff to sheet flow into the bioswale. The trees here do not appear to be healthy, and may be removed and replaced with more suitable, hardier trees. Drain inlets should be replaced with deep sump catch basins.

The location of the proposed bioswale/planter between the parking lot and docks.

Site HW-7: Back Bay Boat Ramp

Location (latitude, longitude): 43.5859642, -71.21299744

Impact: High

Observations: The parking area near the Back Bay boat ramp is impervious and has no stormwater treatment. The storm drains in the parking lot are drain inlets with no sumps. In the adjacent Bean Park, there is a rain garden meant to treat some stormwater runoff from the area, and there is a diversion hump across the boat ramp meant to direct water into the rain garden. However, the hump is shallow and is unlikely to divert water into the rain garden. It appears that the water diverted by the hump flows downhill next to the boat ramp, rather than into the rain garden.

Recommendations: We recommend the drain inlets be replaced with catch basins with deep sumps (4-foot diameter and 3 feet deep). Raise the diversion hump on the boat ramp to divert more runoff and install a paver mat forebay for the rain garden.

(Left) Runoff tends to move downhill rather than into the rain garden. A forebay would increase the amount of stormwater reaching the rain garden. (Right) Rain garden in Bean Park that could receive and treat runoff from the parking lot.

Site HW-1: Town Dock and Boat Ramp

Location (latitude, longitude): 43.58405685, -71.21264648

Impact: High

Observations: The town docks and boat ramp are an impervious, highly trafficked area that is used year-round. The parking lot runoff drains to two drain inlets that connect to an outfall under the dock. There is no stormwater treatment in the area and there are no sumps to collect sediment under the drain inlets. The outfall pipe is half-collapsed. The grading of the boat ramp directs most of the runoff toward the storm drains, but the area above the ramp sheet flows directly into the lake. Roof drainage in this area is directed into dripline gravel trenches.

Recommendations: The drain inlets should be replaced with deep sump catch basins. The outfall pipe should also be replaced. Stormwater at the site should be diverted away from the lake. Install a trench drain or speed bumps above the boat ramp to divert runoff toward the catch basins. Wolfeboro Waters notes that "the dockside parking lot and drainage system are included in the fourth phase of the Town's project to upgrade the Wolfeboro Bay docks and dockside parking lot."

(Left) Large paved area between commercial buildings and the boat ramp. (Right) One of the drain inlets within the parking lot.

Site HW-9: Municipal Lot at Back Bay

Location (latitude, longitude): 43.58766174, -71.2106781

Impact: Medium

Observations: The municipal parking lot generates stormwater runoff which sheet flows into a lawn strip between the lot and the rail trail. There's a yard drain in the lawn strip, but there is also standing water, indicating that the area does not drain. Parts of the shoreline buffer along the rail trail are inadequate.

Recommendations: We recommend the ponded area be converted into a wet swale, similar to other areas to the north and south along the rail trail. The shoreline buffer should also be improved with native plantings and trees to provide multiple stories of vegetation.

(Left) The lawn strip between the lot and rail trail. (Right) Lack of vegetated buffer along the shoreline.

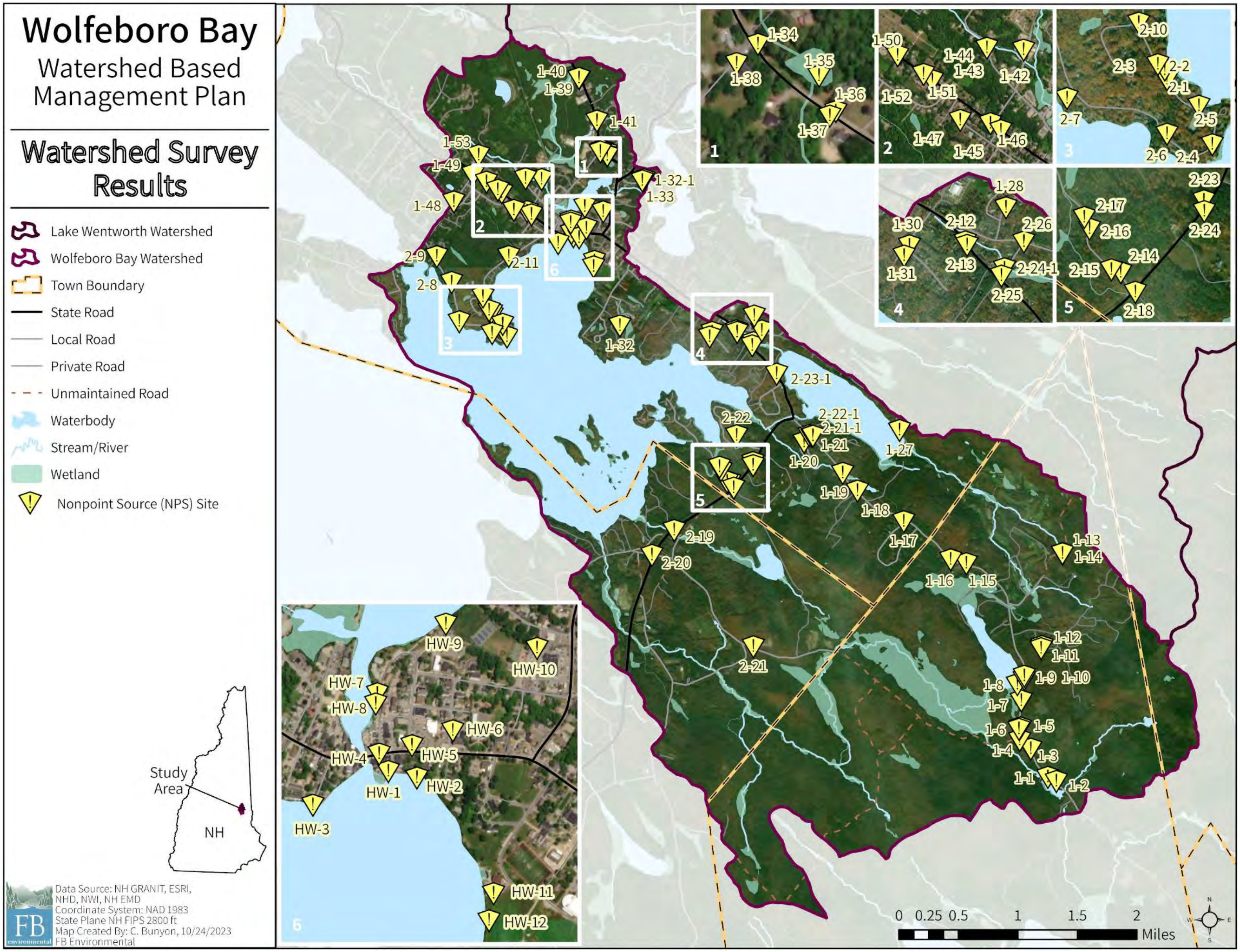


Figure 15. Location of identified nonpoint source sites in the Wolfeboro Bay direct watershed.

3.1.3 Shoreline Survey

FBE technical staff, assisted by LWA staff and volunteers, conducted a shoreline survey of Wolfeboro Bay on August 10, 2023. Bree Rossiter of LWA conducted the shoreline survey of Back Bay on September 8, 2023. The shoreline survey uses a simple scoring method to highlight shoreline properties around the lake that exhibit significant erosion. This method of shoreline survey is a rapid technique to assess the overall condition of properties within the shoreland zone and prioritize properties for technical assistance or outreach. Five boats were used for surveying parcels with lake frontage. Technical staff and volunteers documented the condition of the shoreline for each parcel using a scoring system that evaluates vegetated buffer, presence of bare soil, extent of shoreline erosion, distance of structures to the lake, and slope. These scores were summed to generate an overall "Shoreline Disturbance Score" and "Shoreline Vulnerability Score" for each parcel, with high scores indicating poor or vulnerable shoreline conditions. Photos were taken at each parcel and were cataloged by tax map-lot number. These photos will provide the towns with a valuable tool for assessing shoreline conditions over time. It is recommended that a shoreline survey be conducted in mid-summer every five years to evaluate changing conditions.

A total of 497 parcels were evaluated along the shoreline of Wolfeboro Bay in Wolfeboro and Alton. The average Shoreline Disturbance Score (Buffer, Bare Soil, and Shoreline Erosion) for the entire lake was 6.9 (Table 13). About 60% of the shoreline (or 294 parcels) scored 7 or greater. A disturbance score of 7 or above indicates shoreline conditions that may be detrimental to lake water quality. These shoreline properties tended to have inadequate buffers, evidence of bare soil, and shoreline erosion. The average Shoreline Vulnerability Score (Distance and Slope) was 3.8 (Table 13). About 74% (or 367 parcels) scored 4 or greater. A vulnerability score of 4 or greater indicates that the parcel may have a home less than 150 feet from the shoreline and a moderate or steep slope to the shoreline. Parcels with a vulnerability score of 4 or greater are more prone to erosion issues whether or not adequate buffers and soil coverage are present. Many parcels are particularly prone to erosion for having homes within 75 feet of the shoreline, as 307 parcels (62%) received the maximum score of 3 for a distance less than 75 feet from the waterbody. Parcels receive a higher distance score if the structure is close to the waterbody.

Table 13. Average scores for each evaluated condition criterion and the average Shoreline Disturbance Score and average Shoreline Vulnerability Score for Wolfeboro Bay and Back Bay. Lower values indicate shoreline conditions that are effective at reducing erosion and keeping excess nutrients out of the lake. Note: the numbers in parentheses are the range of possible scores for that variable.

Evaluated Condition	Average Score	Total Score
Buffer (1-5)	2.95	Average Shoreline Disturbance Score (3-12) **6.9**
Bare Soil (1-4)	2.09	
Shoreline Erosion (1-3)	1.82	
Distance (0-3)	2.31	Average Shoreline Vulnerability Score (1-6) **3.8**
Slope (1-3)	1.47	

The pollutant loading estimates are based on the Shoreline Disturbance Scores. The 294 parcels with scores 7-11, are contributing approximately **131 kg of phosphorus annually**[5]. Remediation efforts on all properties using a 50% Best Management Practices (BMP) efficiency rate could result in an **annual reduction of 66 kg of phosphorus**.

Certain site characteristics, such as slope, can cause shorelines to be naturally more vulnerable to erosion. Other site characteristics such as structure distance to the lake, are often a direct consequence of the historic development on that parcel and cannot be easily changed. Shoreline buffers and amount of exposed soil are more easily changed to strengthen the resiliency of the shoreline to disturbance in the watershed. In summary, the overall average shoreline condition of Wolfeboro Bay and Back Bay is low to moderate for erosion issues (average disturbance score just below 7), with 294 properties (60%) needing to address erosion or runoff issues that are impacting the lake. Wolfeboro Bay is also generally more prone to erosion issues because many homes are located close to shore (average distance score is 2.3 out of 3).

[5] Based on Region 5 model bank stabilization estimate for fine sandy loams, using 50 ft or 100 ft or 200 ft (length) by 3 ft (height) and moderate lateral recession rate of 0.1 ft/yr.

Scores should be used to prioritize areas of the shoreline for remediation. Recommendations largely include improving shoreline vegetated buffers. Encouraging landowners to plant and/or maintain vegetated buffers as a BMP along their shoreline, particularly in areas of bare soil, will help mitigate erosion and reduce sediment and nutrient loading to the lake.

3.1.4 Soil & Shoreline Erosion

Erosion can occur when ground is disturbed by digging, construction, plowing, foot or vehicle traffic, or wildlife. Rain and associated runoff are the primary pathways by which eroded soil reaches lakes and streams. Once in surface waters, nutrients are released from the soil particles into the water column, causing excess nutrient loading to surface waters or cultural eutrophication. Since development demand near lakes is high, construction activities in lake watersheds can be a large source of nutrients. Unpaved roads and trails used by motorized vehicles near lakes and streams are especially vulnerable to erosion. Stream bank erosion can also have a rapid and severe effect on lake water quality and can be triggered or worsened by upstream impervious surfaces like buildings, parking lots, and roads which send large amounts of high velocity runoff to surface waters. Maintaining natural vegetative buffers around lakes and streams and employing strict erosion and sedimentation controls for construction can minimize these effects.

3.1.4.1 Surficial Geology

The composition of soils in the area reflect the dynamic geological processes that have shaped the landscape of New Hampshire over millions of years. Some 300 to 400 million years ago, much of the northeastern United States was covered by a shallow sea; layers of mineral deposition compressed to form sedimentary layers of shale, sandstone, and limestone (Goldthwait, 1951). Over time, the Earth's crust then folded under high heat and pressure to change the sedimentary rocks into metamorphic rocks (quartzite, schist, and gneiss parent material). This metamorphic parent material has since been modified by bursts of molten material intrusions to form igneous rock, including granite for which New Hampshire is famous (Goldthwait, 1951). Erosion has further modified and shaped this parent material over the last 200 million years.

The current landscape formed 12,000 years ago at the end of the Great Ice Age, as the mile-thick glacier over half of North America melted and retreated, scouring bedrock and depositing glacial till to create the deeply scoured basin of the region's lakes. The retreating action also eroded mountains and left behind remnants of drumlins and eskers from ancient stream deposits. The glacier deposited a layer of glacial till more than three feet deep. Glacial till is composed of unsorted material, with particle sizes ranging from loose and sandy to compact and silty to gravely. This material laid the foundation for vegetation and streams as the depression basins throughout the region began to fill with water (Goldthwait, 1951).

The unique geological formation in this area formed the Winnipesaukee River Basin Stratified Drift Aquifers, comprising seventeen of the cleanest and most productive aquifers in the region. Several of these aquifers can be found within the study area to the southeast of Wolfeboro Bay and surrounding many streams flowing into Lake Wentworth as shown by the NH GRANIT statewide aquifer transmissivity data layer. Most of these aquifers have a maximum transmissivity of 1,000 ft^2/day, while two sections, near Warren and Harvey Brooks, reach a maximum transmissivity of up to 200 ft^2/day. By receiving groundwater from stratified drift aquifers, Lake Wentworth and Wolfeboro Bay are discharge points for the Winnipesaukee River Basin Stratified Drift Aquifer. Any contamination in these aquifers will move quickly due to the high transmissivity of the material and enter Wolfeboro Bay and other surface waters. Therefore, protection of the aquifer is vital to the protection of the bay.

3.1.4.2 Soils and Erosion Hazard

The soils in the Wolfeboro Bay watershed (Appendix A, Map A-6) are a direct result of geologic processes. Of the 57 different soil series present within the Wolfeboro Bay watershed (excluding soils beneath waterbodies), the most prevalent soil group in the watershed is Paxton fine sandy loam (3,404 acres, 11%), followed by Woodstock-Bice fine sandy loam (2,522 acres, 8%), Henniker-Gloucester fine sandy loams (2,296 acres, 7%), and Metacomet fine sandy loam (2,135 acres, 7%). Paxton fine sandy loam, Woodstock-Bice fine sandy loam, and Henniker-Gloucester fine sandy loams are all well to excessively drained, while Metacomet is classified as moderate to well drained. The remaining 67% of the watershed (soils under waterbodies) is a combination of 53 additional soil series ranging from 6% to 0.01% of the watershed.

Soil erosion hazard is dependent on a combination of factors, including land contours, climate conditions, soil texture, soil composition, permeability, and soil structure (O'Geen et al., 2006). Soil erosion hazard should be a primary factor in determining the rate and placement of development within a watershed. Soils with negligible soil erosion hazard are primarily low-lying wetland areas near abutting streams. The soil erosion hazard for the Wolfeboro Bay watershed was determined from the associated slope and soil erosion factor K_w[6] used in the Universal Soil Loss Equation (USLE). The USLE predicts the rate of soil loss by sheet or rill erosion in units of tons per acre per year. A rating of “slight” specifies erosion is unlikely to occur under standard conditions. A rating of “moderate” specifies some erosion is likely and erosion-control measures may be required. A rating of “severe” specifies erosion is very likely and erosion-control measures and revegetation efforts are crucial. A rating of “very severe” specifies significant erosion is likely and control measures may be costly. Excluding soils under waterbodies, “severe” erosion hazard areas account for 53% of the Wolfeboro Bay watershed (16,473 acres) and are mostly concentrated near the edges of the watershed in New Durham and northwestern Wolfeboro (Appendix A, Map A-7). Moderate erosion hazard areas account for 34% of the watershed land area (31,003 acres). Slight erosion hazard areas account for 12% (3,839 acres), and 47 acres or 0.2% are not rated. Development should be restricted in areas with severe erosion hazards due to their inherent tendency to erode at a greater rate than what is considered tolerable soil loss. Since a highly erodible soil can have greater negative impact on water quality, more effort and investment are required to maintain its stability and function within the landscape, particularly from BMPs that protect steep slopes from development and/or prevent stormwater runoff from reaching water resources. Other areas prone to erosion include steeply sloped areas and areas with roadways within 50 feet of the waterbody (Appendix A; Map A-8).

3.1.4.3 Shoreline Erosion

Water level fluctuations in lakes and ponds can occur on long- and short-term timescales due to naturally changing environmental conditions or as a response to human activity. The effect of lake level fluctuation on physical and environmental conditions depends on several factors including the degree of change in water level, the rate of change, seasonality, and the size and depth of the waterbody (Leira & Cantonati, 2008; Zohary & Ostrovsky, 2011). Changes in lake level can impact flora and fauna mainly by altering available habitat, impacting nesting locations, and altering available food sources. In addition to impacts to the biological communities, lakes can experience physical impacts on water quality from changes in lake level. Frequent lake level fluctuations can impact the shoreline, leading to erosion and increased sedimentation in near-shore habitats, inhibiting light penetration and altering water clarity. Exposed shoreline sediment that is inundated at high water levels can release phosphorus, leading to alterations in nutrient accumulation and algae populations. High and low water levels can have detrimental effects on water systems, so finding a balance in managing water level at appropriate times throughout the year is critical to maintaining a healthy waterbody for both recreational enjoyment and aquatic life use. Management strategies become even more challenging when considering the impact of increased wake boating and extreme weather events (droughts and storms) on water level. Residents of Wolfeboro Bay have expressed concern about enhanced shoreline erosion caused by boat wakes. In addition, flow in the Smith River, which connects Crescent Lake with Back Bay and ultimately Wolfeboro Bay, is subject to operations at the Crescent Lake dam and dries up for portions of most summers, thereby limiting the influence of the upstream Lake Wentworth and Crescent Lake on the bays during these periods and negatively impacting aquatic life in the river. The Town of Wolfeboro is not required to maintain a minimum discharge in the Smith River as part of Crescent Lake dam operations, a decision that was made in the 1990s and should be reassessed.

3.1.5 Wastewater

3.1.5.1 Septic Systems

Untreated discharges of sewage (domestic wastewater) are prohibited regardless of source. An example of an NPS discharge of untreated wastewater is from insufficient or malfunctioning subsurface sewage treatment and disposal systems, commonly referred to as septic systems, but which also include holding tanks and cesspools. When properly designed, installed, operated, and maintained, septic systems can reduce phosphorus concentrations in sewage within a zone close to the system (depending on the development and maintenance of an effective biomat, the adsorption capacity of the underlying native soils, and proximity to a restrictive layer or groundwater). Age, overloading, or poor maintenance can result in system failure and the release of nutrients and other pollutants into surface waters (EPA, 2016). Nutrients from underperforming septic systems can enter surface waters through surface overflow or breakout, stormwater runoff, or groundwater. Cesspools are buried concrete structures that allow solid sludge to sink to the bottom and surface scum to rise to the top and eventually leak out into surrounding soils through holes at the top of the structure. Holding tanks are completely enclosed structures that must be pumped regularly to prevent effluent back-up into the home.

[6] K_w = the whole soil k factor. This factor includes both fine-earth soil fraction and large rock fragments.

LWA completed an initial review of available data on septic systems within 250 feet of the Wolfeboro Bay shoreline in 2023. The objective of this data survey was to determine the number of septic systems along the shoreline of Wolfeboro Bay and the proportion of older septic systems. LWA queried the NHDES OneStop online database for subsurface permits and reviewed Wolfeboro and Alton tax parcel records. There were 284 shoreline properties with buildings identified (within 250 feet of the shoreline). 211 of the 284 properties (74%) had septic systems older than 25 years. There are concerns about failed septic systems around Jockey Cove in Wolfeboro Bay.

LWA estimated the pollutant loading from shoreline septic systems using default literature values for daily water usage, phosphorus concentration output per person, and system phosphorus attenuation factors. The number of people using shoreline septic systems was determined by reviewing individual tax records per parcel. Properties with mailing addresses outside of Wolfeboro and Alton, depending on parcel location, were assumed to be seasonal. As detailed in the *Wolfeboro Bay Lake Loading Response Model Report* (FBE, 2024a), shoreline septic systems contribute 27.7 kg/yr of total phosphorus loading to Wolfeboro Bay, comprising 2% of the total phosphorus load from all sources to the lake. Septic systems, cesspools, or holding tanks are located within a short distance to the water, leaving little horizontal (and sometimes vertical) space for proper filtration of wastewater effluent. Improper maintenance or siting of these systems can cause failures, which leach untreated, nutrient-rich wastewater effluent directly to the lake. This effluent contains not only nutrients and bacteria but also microplastics, pharmaceuticals, and other pollutants harmful to public health.

3.1.5.2 Sewer Systems

Much of downtown Wolfeboro, particularly around Back Bay, is serviced by municipal sewer. In Wolfeboro, treated wastewater is stored in an Effluent Storage Reservoir (ESR) before either being pumped to a Rapid Infiltration Basin outside of the Wolfeboro Bay watershed or dispersed onto large effluent spray fields covering roughly 58 acres of land within the Back Bay watershed. Generally, these spray fields operate between May and October of each year. The Town of Wolfeboro has optimized spray field application to the maximum extent possible to prevent contamination of downstream water resources by rotating spray areas, avoiding spraying during wet weather, and reducing spray field footprints by abandoning areas with slow infiltration rates. The spray fields are operated under a NHDES groundwater discharge permit and are regularly monitored for the volume of effluent and concentration of total phosphorus in the effluent. Considering the Town of Wolfeboro's operation practices, it is likely that most of the effluent does not enter Back Bay as direct overland runoff and instead is retained onsite through plant uptake and precipitation/adsorption within the underlying soils. The model treated the effluent spray fields as grazing pasture for phosphorus export coefficients. In addition, a significant limitation of the model is the assumption that sewered shoreline areas do not contribute additional phosphorus through groundwater to Wolfeboro Bay or Back Bay, when it is likely that some portion of the sewer system is leaking nutrient-rich effluent into surrounding soils.

3.1.5.3 Boat Discharges

Boats have the potential to discharge nutrients in sewage from installed toilets and greywater (such as drainage from sinks, showers, and laundry). The impact of dumping even a small amount of raw sewage into surface waters can significantly impact the local ecosystem, causing algal blooms and a degradation in water quality.

3.1.6 Fertilizers

When lawn and garden fertilizers are applied in excessive amounts, in the wrong season, or just before heavy precipitation, they can be transported by rain or snowmelt runoff to lakes and other surface waters where they can promote cultural eutrophication and impair the recreational and aquatic life uses of the waterbody. Many states and local communities are beginning to set restrictions on the use of fertilizers by prohibiting their use altogether or requiring soil tests to demonstrate a need for any phosphate application to lawns. During the shoreline survey, properties with lush green grass were common, and it is presumed that fertilizer is used on many shoreline properties. Municipal properties, which are often used for recreation, can be fertilized. In Wolfeboro and Brookfield, a phosphorus-free fertilizer is used (ratio of 24-0-5 of K-P-N) during the spring, summer, and fall. Managed properties include Foss Field, the Clark House Complex, and Cate Park. The Kingswood Golf Course and Lake Winnipesaukee Golf Club did not respond to LWA's inquiries. Brewster Academy should also be contacted in the future to discuss any fertilizer use on their athletic fields.

3.1.7 Pets

In residential areas, fecal matter from pets can be a significant contributor of nutrients to surface waters. Each dog is estimated to produce 200 grams of feces per day, which contain concentrated amounts of phosphorus (CWP, 1999). If pet feces are not properly disposed, these nutrients can be washed off the land and transported to surface waters by stormwater runoff. Pet feces can also enter by direct deposition of fecal matter from pets standing or swimming in surface waters.

3.1.8 Agriculture

Agriculture in the Wolfeboro Bay watershed includes cropland and grazing areas. Agricultural activities, including dairy farming, raising livestock and poultry, growing crops, and keeping horses and other animals for pleasure or profit, involve managing nutrients.

Agricultural activities and facilities with the potential to contribute to nutrient impairment include:

- Plowing and earth moving;
- Fertilizer and manure storage and application;
- Livestock grazing;
- Animal feeding operations and barnyards;
- Paddock and exercise areas for horses and other animals; and
- Leachate from haylage/silage storage bunkers.

Diffuse runoff of farm animal waste from land surfaces (whether from manure stockpiles or cropland where manure is spread), as well as direct deposition of fecal matter from farm animals standing or swimming in surface waters, are significant sources of agricultural nutrient pollution in surface waters. Farm activities like plowing, livestock grazing, vegetation clearing, and vehicle traffic can also result in soil erosion which can contribute to nutrient pollution.

Excessive or ill-timed application of fertilizer or poor storage which allows nutrients to wash away with precipitation not only endangers lakes and other waters, but it also means those nutrients are not reaching the intended crop. The key to nutrient application is to apply the right amount of nutrients at the right time. When appropriately applied to soil, synthetic fertilizers or animal manure can fertilize crops and restore nutrients to the land. When improperly managed, pollutants in manure can enter surface waters through several pathways, including surface runoff and erosion, direct discharges to surface water, spills and other dry-weather discharges, and leaching into soil and groundwater.

3.1.9 Flooding

Various areas of Wolfeboro are susceptible to flooding. The most destructive flooding events in the town's history occurred in the late 1930s and were part of a series of statewide floods. One flood in 1936 was the result of heavy precipitation coinciding with spring snow melt. The most significant flooding was during the Great New England Hurricane of 1938, which inspired the construction of flood control dams in the following decades. Severe storms in the summer of 1986 and 1990 resulted in statewide flooding that impacted Wolfeboro once again. Hurricane Bob mostly affected southwestern New Hampshire, but it may also have led to flooding in Wolfeboro (Wolfeboro Hazard Mitigation Update Committee, 2013). The town also reported flooding in October of 2005, May of 2006, and April of 2007, the most recent of which led to the acquisition of FEMA funds to help repair the damage.

Areas of concern for flooding include hilly areas, areas with large amounts of impervious cover, or areas located within a floodplain. The Hazard Mitigation Plan Update for the Town of Wolfeboro (2013) specifically mentions a high probability of flooding at North Main Street, Clarke Plaza, the sewer pumps, the downtown area, and NH Route 28/109. The area of the filled-in bay, east of Back Bay, is denoted as a floodplain. This area has a history of flooding since the bay was filled and includes Clarke Plaza and the sewer pumps. The risk of shoreline flooding from Lake Winnipesaukee, Back Bay, and Lake Wentworth is reduced by dams that control water levels. The Hazard Mitigation Plan notes that most of the floodplain is undeveloped apart from the Back Bay area.

Though the probability of dam failure is low in Wolfeboro, the possible failure of numerous dams could have adverse effects on water quality, infrastructure, and/or people. Specifically, the Crescent Lake dam, the Rust Pond dam, and the Sewage Lagoon Dam on Filter Bed Road all have a Class B or higher rating from the NHDES Dams Bureau, meaning they have the highest potential for damage if the dam were to fail (Wolfeboro Hazard Mitigation Update Committee, 2013). The Crescent

Lake dam controls the flow of water from Crescent Lake to Back Bay. The Sewage Lagoon dam controls water levels of the effluent storage pond before the treated wastewater is transported to the rapid infiltration basin. The Rust Pond dam is of the highest concern for the town because it would wash onto Route 28 upon failure, which could pose public safety concerns. Dam breaks could have negative impacts on water quality because they can rapidly transport sediment-bound nutrients, untreated sewage, and other pollutants to the lake through erosion and stormwater flow.

3.1.10 Future Development

Understanding population growth, and ultimately development patterns, provide critical insight to watershed management, particularly as it pertains to lake water quality. According to the US Census Bureau, Wolfeboro, Alton, New Durham, Brookfield, and Ossipee have experienced moderate population growth over the last 50 years, increasing from a total of 7,111 people in 1970 to 20,130 people in 2020 (see Section 2.3.2). The Wolfeboro Bay watershed area has long been treasured as a recreational haven for both summer vacationers and year-round residents. The Winnipesaukee Region is among the oldest summer vacation spots in New Hampshire and offers fishing, hiking, boating, sailing, canoeing, kayaking, and swimming in the summer, and ice fishing, cross-country skiing, snowshoeing, and snowmobiling in the winter. The desirability of downtown Wolfeboro and the greater Lake Winnipesaukee area as a recreational destination will likely stimulate continued population growth in the future. Growth figures and estimates suggest that towns should continue to consider the effects of current municipal land-use regulations, particularly impervious cover limits, on local water resources. As the region’s watersheds are developed, erosion from disturbed areas and runoff from impervious surfaces increases the potential for water quality decline.

3.2 INTERNAL PHOSPHORUS LOAD

Phosphorus that enters the lake and settles to the bottom can be re-released from sediment under anoxic conditions, providing a nutrient source for algae, cyanobacteria, and plants, otherwise known as internal phosphorus loading. The watershed modeling in Section 2.3 identified internal phosphorus load as a minor portion of the total phosphorus load for Wolfeboro Bay, likely 17.3 kg-P/yr (1%). However, additional monitoring may be conducted to refine the internal loading estimate, which was based on a limited amount of data that did not include samples from September and October, when internal loading is typically at its peak.

3.3 POTENTIAL CONTAMINATION SOURCES

Point source (PS) pollution can be traced back to a specific source such as a discharge pipe from an industrial facility, municipal treatment plant, permitted stormwater outfall, or a regulated animal feeding operation, making this type of pollution relatively easy to identify. Section 402 of the CWA requires all such discharges to be regulated under the National Pollutant Discharge Elimination System (NPDES) program to control the type and quantity of pollutants discharged. NPDES is the national program for regulating point sources through issuance of permit limitations specifying monitoring, reporting, and other requirements under Sections 307, 318, 402, and 405 of the CWA.

NHDES operates and maintains the OneStop database and data mapper, which houses data on Potential Contamination Sources (PCS) within the State of New Hampshire. Identifying the types and locations of PCS within the watershed may help identify sources of pollution and areas to target for restoration efforts. On June 10, 2023, FBE downloaded datasets for above and underground storage tanks, soil waste facilities, hazardous waste generators, local potential contamination sources, NPDES outfalls, and remediation sites in the Wolfeboro Bay watershed. Twelve (12) aboveground storage tanks, 64 underground storage tanks, 29 hazardous waste generators, 5 local potential contamination sources, two NPDES outfalls, and 143 remediation sites were identified in the study area (Appendix A, Map A-9).

3.3.1 Above and Underground Storage Tanks

Above and underground storage tanks include permitted containers with oil and hazardous substances such as motor fuels, heating oils, lubricating oils, and other petroleum and petroleum-contaminated liquids. There are 12 aboveground storage tanks within the Wolfeboro Bay watershed. Most are near the headwaters of Back Bay, and within downtown Wolfeboro. There are 64 underground storage tanks within the Wolfeboro Bay watershed. Similar to the aboveground storage tanks, most can be found near downtown Wolfeboro though some are scattered near streams draining to Lake Wentworth. Ownership of these tanks can range from commercial industries, gas stations, hospitals, marinas, schools, local government, residential or farms, and utilities.

3.3.2 Solid Waste Facilities

There are five solid waste facilities within the Wolfeboro Bay watershed. Four of these five are no longer operating. The only operating solid waste facility in the study area is the Wolfeboro Transfer Station on Beech Pond Rd which is currently under operation for collection, storage, and transfer of waste.

3.3.3 Hazardous Waste Sites

Hazardous waste generating facilities are identified through the EPA's Resource Conservation and Recovery Act (RCRA) and require federal or state regulation. Only 12 of the 29 hazardous waste generating facilities within the Wolfeboro Bay watershed are listed as active; the remaining facilities are classified as either inactive (11), declassified (3), non-notifier (1), or no data (2).

3.3.4 Local Potential Contamination Sources

Local potential contamination sources are sites that may represent a hazard to drinking water quality supplies due to the use, handling, or storage of hazardous substances. There may be overlap between local potential contamination sources and other PCS identified in this section. Of the five local potential contamination sources within the Wolfeboro Bay watershed, four can be found along Center Street and one along Pine Hill Road.

3.3.5 NPDES Outfalls

The two NPDES outfalls within the Wolfeboro Bay watershed discharge pollutants directly to Back Bay (General Permit #NH0022926). The facility holding the permit is the Town of Wolfeboro, and the category of the outfalls are "process wastewater" (NHDES Outfalls Metadata).

3.3.6 Remediation Sites

The 143 remediation sites present within the Wolfeboro Bay watershed include leaking storage facilities that contain fuel or oil, sites with chlorinated solvents and other non-petroleum products, non-hazardous and non-sanitary holding tanks, initial spill response sites, historical dump sites, leaking residential or commercial oil tanks for heating or motor oil tanks, underground injection control of wastewaters not requiring a groundwater discharge permit, unlined wastewater lagoons, or a flagged groundwater sample for contamination but with no direct connection to a source of contamination.

3.4 WILDLIFE

Fecal matter from wildlife such as geese, gulls, other birds, and beaver may be a significant source of nutrients in some watersheds. This is particularly true when human activities, including the direct and indirect feeding of wildlife and habitat modification, result in the congregation of wildlife (CWP, 1999). Congregations of geese, gulls, and ducks are of concern because they often deposit their fecal matter next to or directly into surface waters. Examples include large mowed fields adjacent to lakes and streams where geese and other waterfowl gather, as well as the underside of bridges with pipes or joists directly over the water that attract large numbers of pigeons or other birds. Studies show that geese inhabiting **riparian** areas increase soil nitrogen availability (Choi et al., 2020) and gulls along shorelines increase phosphorus concentration in beach sand pore water that then enters surface waters through groundwater transport and wave action (Staley et al. 2018). When submerged in water, the droppings from geese and gulls quickly release nitrogen and phosphorus into the water column, contributing to eutrophication in freshwater ecosystems (Mariash et al., 2019). On a global scale, fluxes of nitrogen and phosphorus from seabird populations have been estimated at 591 Gg N per year and 99 Gg P per year, respectively (with the highest values derived from arctic and southern shorelines) (Otero et al., 2018). Additionally, other studies show greater concentrations of nitrogen, ammonia, and dissolved organic carbon downstream of beaver impoundments when compared to similar streams with no beaver activity in New England (Bledzki et al., 2010). The model estimated that waterfowl are likely contributing 48.2 kg/yr (3%) of the total phosphorus load to Wolfeboro Bay.

3.5 CLIMATE CHANGE

Climate change will have important implications for water quality that should be considered and incorporated into WBMPs. In the last century, New England has already experienced significant changes in stream flow and air temperature. Out of 28 rural stream flow stations throughout New England, 25 showed increased flows over the record likely due to the increase in frequency of extreme precipitation and total annual precipitation in the region. In 79 years of recorded flooding in the Oyster River in Durham, NH, three of the four highest floods occurred in the past 10 years (Ballestero et al., 2017). The average annual air temperature in New England has risen by 1°C to 2.3 °C since 1895 with greater increases in winter air temperature (IPCC, 2013). Lake ice-out dates occur earlier as warmer winter air temperature melts the snowpack and lake ice; earlier ice-out allows a longer growing season and increases the duration of anoxia in bottom waters. Increasing storm frequencies will flush more nutrients to surface waters for algae to feed on and flourish under warmer air temperatures.

These trends will likely continue to impact both water quality and quantity. Climate change models predict a 10-40% increase in stormwater runoff by 2050, particularly in winter and spring and an increase in both flood and drought periods as seasonal precipitation patterns shift. Adding to this stress is population growth and corresponding development in New Hampshire. The build-out analysis for the watershed showed that about 17,333 acres is still developable and up to 5,418 new buildings could be added to the watershed at full build-out based on current zoning standards. In the direct Wolfeboro Bay watershed (not including Lake Wentworth), there are 7,691 acres of developable land and 3,175 projected buildings. Wolfeboro Bay is at serious risk of water quality degradation because of new development in the watershed unless climate change resiliency and **low impact development** (LID) strategies are incorporated to existing zoning standards.

4 MANAGEMENT STRATEGIES

The following section details management strategies for achieving the water quality goal and objectives using a combination of structural and non-structural restoration techniques, as well as outreach and education and an adaptive management approach. A key component of these strategies is the idea that existing and future development can be remediated or conducted in a manner that sustains environmental values. All stakeholder groups have the capacity to be responsible watershed stewards, including citizens, businesses, the government, and others. Specific action items are provided in the Action Plan (Section 5).

4.1 STRUCTURAL NONPOINT SOURCE (NPS) RESTORATION

Structural NPS restoration techniques are engineered infrastructure designed to intercept stormwater runoff, often allowing it to soak into the ground, be taken up by plants, harvested for reuse, or released slowly over time to minimize flooding and downstream erosion. These BMPs often incorporate some mechanism for pollutant removal, such as sediment settling basins, oil separators, filtration, or microbial breakdown. They can also consist of removing or disconnecting impervious surfaces, which in turn reduces the volume of polluted runoff generated, minimizing adverse impacts to receiving waters.

4.1.1 Watershed & Shoreline BMPs

Ninety (90) NPS sites identified during the 2023 watershed survey and 294 high/medium/low impact rated shoreline properties from the 2023 shoreline survey were documented to have some impact on water quality through the delivery of phosphorus-laden sediment (refer to Section 3.1.1-3.1.2). As such, structural BMPs to reduce the external watershed phosphorus load are a necessary and important component for the protection of water quality in the watershed.

The following series of BMP implementation action items are recommended for achieving Objective 1:

- Address the top five high priority sites (as well as the remaining 23 high and medium impact sites and the 62 low impact sites as opportunities arise) identified during the 2023 watershed survey. The sites were ranked based on phosphorus load reduction and waterbody proximity. The full prioritization matrix with recommended improvements is provided in Appendix B.
- Provide technical assistance and/or implementation cost sharing to 20 high impact shoreline properties identified during the 2023 shoreline survey. Workshops and tours of demonstration sites can help encourage landowners to utilize BMPs on their own property. Conduct regular shoreline surveys to continue prioritizing properties for technical follow-up.

For the proper installation of structural BMPs in the watershed, landowners should work with experienced professionals on sites that require a high level of technical knowledge (engineering). Whenever possible, pollutant load reductions should be estimated for each BMP installed. More specific and additional recommendations are included in Section 5. For helpful tips on implementing BMPs, see Additional Resources.

In addition, in a letter to LWA dated February 21, 2024, Wolfeboro Waters indicated that HW-5 Parking Lot will include an “upgrade to the drainage system, which will include a filter system at the bottom of the parking lot before going into the Town’s drainage system. The Town’s Public Works Department will address the cleaning of the road and the catch basin at 297 Sewell Rd. Shoulder and ditch repair are part of the summer maintenance program. 2-10 Pointe Sewall Road is part of the Town’s Road upgrade projects and will be addressed in the next few years. The road shoulders and ditches will be addressed as part of the Town’s general maintenance. Due to the heavy storm in 2023, the Town addressed road washouts instead of shoulder ditch maintenance.” The Town of Wolfeboro is also in the beginning stages of developing engineering designs for a drainage system from Sewall Road down the Jockey Cove side of Forest Road to Hopewell Point Road.

4.2 NON-STRUCTURAL NONPOINT SOURCE (NPS) RESTORATION

Non-structural NPS restoration techniques refer to a broad range of behavioral practices, activities, and operational measures that contribute to pollutant prevention and reduction. The following section highlights important restoration techniques for several key areas, including pollutant reduction best practices, zoning and ordinance updates, land conservation, septic system regulation, sanitary sewer system inspections, boats and marinas, fertilizer use prohibition, pet waste management, agricultural practices, and nuisance wildlife controls.

4.2.1 Pollutant Reduction Best Practices

Pollutant reduction best practices include recommendations and strategies for improving road management and municipal operations for the protection of water quality. Following standard best practices for road maintenance and drainage management protects both infrastructure and water quality through the reduction of sediment and other pollutant transport. Refer to the *New Hampshire Stormwater Manual* (NHDES, 2008a) for standard road design and maintenance best practices.

Even though none of the watershed towns are required to comply with the six minimum control measures under the New Hampshire Small MS4 General Permit, each town could consider instituting the permit's key measures, such as street sweeping, catch basin cleaning, and road/ditch maintenance, if not already in place. The MS4 permit also covers illicit discharge detection and elimination plans (and ordinance inclusion), source control and pollution/spill prevention protocols, and education/outreach and/or training for residents, municipal staff, and stormwater operators, all of which are aimed at minimizing polluted runoff to surface waters. New Durham completes street sweeping and catch basin cleaning once per year. Homeowners maintain catch basins at the end of their driveways. New Durham also has no municipally maintained gravel roads within 500 feet of waterbodies. Alton completes street sweeping once per year in the spring and again in the fall if necessary. Alton contracts with a company that cleans catch basins. Alton maintains municipal gravel roads, none of which are within 500 feet of Lake Winnipesaukee.

4.2.2 Zoning and Ordinance Updates

Regulations through municipal zoning and ordinances such as LID strategies that prevent polluted runoff from impervious surfaces associated with new and re-development projects in the watershed are equally important as implementing structural BMPs on existing development. In fact, local land use planning and zoning ordinances can be the most critical components of watershed protection. FBE completed a preliminary ordinance review of natural resource protections for the towns of Wolfeboro, Alton, New Durham, and Brookfield (Table 14). These towns have already incorporated several important regulations into their ordinances. A more robust review of these ordinances is encouraged for more specific recommendations for improving ordinances and regulations related to natural resource protection (refer to NHDES, 2008b). The towns should also consider its staffing capacity to enforce existing and proposed regulations.

Local land use planning and zoning ordinances should consider incorporating climate change resiliency strategies for protecting water quality and improving infrastructure based on temperature, precipitation, water levels, wind loads, storm surges, wave heights, soil moisture, and groundwater levels (Ballestero et al., 2017). There are nine strategies which can aid in minimizing the adverse effects associated with climate change and include the following (McCormick and Dorworth, 2019).

- **Installing Green Infrastructure and Nature-Based Solutions:** Planning for greener infrastructure requires that we think about creating a network of interconnected natural areas and open spaces needed for groundwater recharge, pollution mitigation, reduced runoff and erosion, and improved air quality. Examples of green infrastructure include forest, wetlands, natural areas, riparian (banks of a water course) buffers, and floodplains; all of which already exist to various extents in the watershed and have minimized the damage created by intense storms. As future development occurs, these natural barriers must be maintained or even increased to reduce runoff of pollutants into freshwaters. See also Section 4.2.3: Land Conservation.
- **Using LID Strategies:** Use of LID strategies requires replacing traditional approaches to stormwater management using curbs, pipes, storm drains, gutters, and retention ponds with innovative approaches such as bioretention, vegetated swales, and permeable paving.
- **Minimizing Impervious Surfaces:** Impervious surfaces such as roads, buildings, and parking lots should be minimized by creating new ordinances and building construction design requirements which reduce the imperviousness of new development. Property owners can increase the permeability for their lots by incorporating permeable driveways and walkways. It is highly recommended that existing impervious surfaces are reduced by incorporating Effective Impervious Cover regulations in zoning codes per NHDES (2008a). Currently, Wolfeboro zoning ordinance regulations on lot coverage exceeds the recommended threshold of 10% or less impervious cover for all zoning districts. Refer to NHDES (2008b) for additional recommendations.

- **Encouraging Riparian Buffers and Maintaining Floodplains:** Municipal ordinances should forbid construction in floodplains, and in some instances, floodplains should be expanded to increase the land area to accommodate larger rainfall events. Riparian (vegetated) buffers and filter strips along waterways should be preserved and/or created to slow runoff and filter pollutants. Refer to NHDES (2008b) for additional recommendations.
- **Protecting and Re-establishing Wetlands:** Wetlands are increasingly important for preservation because wetlands hold water, recharge groundwater, and mitigate water pollution.
- **Encouraging Tree Planting:** Trees help manage stormwater by reducing runoff and mitigating erosion along surface waters. Trees also provide critical shading and cooling to streams and land surfaces.
- **Promoting Landscaping Using Native Vegetation:** Landowners should promote the use of native vegetation in landscaping, and landscapers should become familiar with techniques which minimize runoff and the discharge of nutrients into waterbodies (Chase-Rowell et al., 2012).
- **Slowing Down the Flow of Stormwater:** To slow and infiltrate stormwater runoff, roadside ditches can be armored or vegetated and equipped with turnouts, settling basins, check dams, or infiltration catch basins. Rain gardens can retain stormwater, while waterbars can divert water into vegetated areas for infiltration. Water running off roofs can be channeled into infiltration fields and drainage trenches.
- **Coordinating Infrastructure, Housing, and Transportation Planning:** Coordinate planning for infrastructure, housing, and transportation to minimize impacts on natural resources. Critical resources including groundwater must be conserved and remain free of pollutants especially as future droughts may deplete groundwater supplies.

4.2.3 Land Conservation

Land conservation is essential to the health of a region, particularly for the protection of water resources, enhancement of recreation opportunities, vitality of local economies, and preservation of wildlife habitat. Land conservation is one of many tools for protecting water quality for future generations. For Wolfeboro Bay, 13% (4,170 acres) of the watershed's land area (not including Wolfeboro Bay or Lake Wentworth) has been classified as conservation land (refer to Appendix A, Map A-10). Major conserved areas include the Copple Crown Conservation Area, Beaver Brook Wildlife Management Area, Knights Pond Conservation Area, and the Seawall Woods Conservation Area. Many of the conservation areas border parts of waterbodies or riverways in the watershed

Local groups should continue to pursue opportunities for land conservation in the Wolfeboro Bay watershed based on the highest valued habitat identified by the New Hampshire Fish & Game (NHFG). NHFG ranks habitat based on value to the State, biological region (areas with similar climate, geology, and other factors that influence biology), and supporting landscape. These habitat rankings are published in the State's 2015 Wildlife Action Plan (with updated statistics and data layers released in January 2020), which serves as a blueprint for prioritizing conservation actions to protect Species of Greatest Conservation Need in New Hampshire. The Wolfeboro Bay watershed is part of the Sebago-Ossipee Hills and Plains ecoregional subsection of the biological region (NHFG, 2015). Approximately 9,241 acres (25%) of the Wolfeboro Bay watershed are considered Highest Ranked Habitat in New Hampshire (including the waterbody of Wolfeboro Bay). Many of the conserved areas overlap with the Highest Ranked Habitat in New Hampshire and the Highest Ranked Habitat in the Biological Region. A map of priority habitats for conservation based on the NH Wildlife Action Plan can be found in Appendix A, Map A-10.

Table 14. Ordinance review summary of regulatory and non-regulatory tools for natural resource protection in Wolfeboro, Alton, New Durham, and Brookfield, which comprises 99.8% of the Wolfeboro Bay watershed and the entire lake shoreline.

STRATEGY	WOLFEBORO	ALTON	NEW DURHAM	BROOKFIELD
Shoreland zoning.	"Shorefront Residential District" [Chapter 175 Article IX, effective 2010] regulates building dimensions and setbacks within the 250ft protected shoreland. There is a minimum setback from the shore of 50ft. It addresses impervious surfaces, stormwater management, and natural woodland buffers within 250ft of water bodies in order to "maintain the integrity and exceptional quality of the waters."	"Shoreland Protection Overlay District" defers to the Shoreland Water Quality Protection Act [RSA 483:B] "Lakeshore Residential Zone" [Zoning Ordinance Article 400, Section 410, effective 1983] allows for single-family residential and recreational land uses while regulating lot sizes, shoreline and street frontage. Other measures to protect the shoreline include the "Commonly Used Water Front Parcels or Lots" provision [Article 300, Section 326, effective 2009], which regulates shorefront parcels "which are intended for common access by the non-shoreland property owners." It provides standards for swimming areas, shoreline frontage, and restroom facilities and limits impervious cover to 10% of the parcel area. "Setback Requirements" [Article 300, Section 327, amended 2021], requires a 30ft setback from the reference line of any water body per the NHDES under the Shoreland Water Quality Protection Act.	"Shorefront Conservation Overlay District" [Article XIV] applies to a 300ft buffer from each lake or pond greater than 10 acres and a few rivers. It requires a 75ft setback from all structures and the shoreline, except for water related structures, and 125ft setback for septic systems. Permitted uses include shorefront common areas and single-family detached dwellings. Conditional uses must have a stormwater management plan.	No shoreland zoning. Article II establishes a minimum setback of 75ft from any pond, lake, stream, marsh, or seasonally wet area; setback may be larger for different zoning districts.
Cluster development and/or open space provisions for subdivisions.	"Conservation Subdivision" [Chapter 175 Article XXIV, effective 2001] encourages environmentally sound development of land and preservation of open space. Seeks to conserve both forested land and agricultural land. Requires buffer areas where 50% of land area shall be permanently dedicated as limited use open space. A minimum of 50% of the total area (excluding roads or easements) is required to be open space.	None identified. Planning Board may require special features such as open space as part of a subdivision.	"Open Space Conservation Subdivision" [Article XV] provides an alternative to a typical subdivision with the goal of protecting water quality, agriculture and forestry, wildlife habitat areas, and other natural features. Street designs are regulated to follow natural topography. At least 50% of the buildable area must be permanently designated as open space, recorded at the Registry of Deeds.	Subdivision Regulations Article XI requires at least 5% open space for all subdivisions where four or more lots are created in a five-year period and 50% of those lots are less than five acres.

STRATEGY	WOLFEBORO	ALTON	NEW DURHAM	BROOKFIELD
Septic pump-out ordinance or regulation of septic and sewer systems.	Septic systems must be inspected after installation [Chapter 126]. Within 250ft of shorelines, site assessment must occur when a property is sold [Chapter 175 Article IX]. Septic systems must have a 100ft setback from prime wetlands [Chapter 175 Article II, effective 2001]. Septic system setbacks from waterbodies are regulated based on the soil type beneath the leach field [Chapter 175 Article VI, Section 175-50]. Where soil types downgradient of leach field is sand and gravel with fast percolation rate, there must be a setback of 125ft. Where a restrictive layer is within 18 inches of the soil surface, the required setback is 100ft. For all other soil characteristics, the minimum setback is 75 feet.	None identified. Septic systems must be sited to limit the possibility of impairment if located in the Floodplain Development Overlay District [Zoning Ordinance Article 600, Section 660].	Septic systems may not be located within 125ft of any wetland or water body [Article XIII, Section H]. As of 2023, "Regulations Pertaining to Certain subsurface Wastewater Disposal Systems in the Lake Merrymeeting Area and Surrounding Water Bodies in New Durham" apply to all systems within 250 ft of the shorelines of Lake Merrymeeting or any other pond. New regulations require inspections for all systems that do not have a design approval on file with NHDES. For expanding a septic system, it prevents the acquisition of a building permit without valid NHDES construction and operation approvals. If there is no ISDS permit on-file and the homeowner seeks to expand the structure, they must provide an NHDES construction approval alongside their building permit application.	None identified.
Zoning districts address environmental protection.	"Wetlands Conservation Overlay District," "Shorefront Residential District," "Groundwater Protection Overlay District," "Steep Slope Protection Conservation District," "Municipal Watershed District,' "Conservation Subdivision" [Chapter 175].	"Shoreland Protection Overlay District," "Aquifer Protection Overlay District," "Floodplain Development Overlay District."	"Aquifer Protection Overlay District," "Water Quality Protection Overlay District," "Shorefront Conservation Overlay District," "Open Space Conservation Subdivision," "Merrymeeting Lake Watershed Overlay District"	None identified. But there is a "Floodplain Development and Management Ordinance" "The regulations in this ordinance shall overlay and supplement the regulations in the Town of Brookfield Zoning Ordinance and shall be considered part of the zoning ordinance for purposes of administration and appeals under state law. If any provision of this ordinance differs from or appears to conflict with any provision of the zoning ordinance or other ordinance or regulation, the provision imposing the greater restriction or more stringent standard shall be controlling."

STRATEGY	WOLFEBORO	ALTON	NEW DURHAM	BROOKFIELD
Zoning overlay districts that address wetland conservation.	"Wetlands Conservation Overlay District" [Chapter 175 Article II] applicable to all wetlands, with increased diligence around "prime wetlands," which are identified in the ordinance. Requires a 100ft buffer around prime wetland and a 25ft buffer around other wetlands or poorly drained soils. Permitted uses include natural resource management, passive recreation, and scientific research. Single family homes and other types of dwellings are only allowed through special use permits. Conditional uses are only allowed if the use is consistent with best management practices.	None identified. The Setback Requirements [Zoning Ordinance Article 300, Section 327] require a 25ft natural vegetative buffer around all wetlands greater than 10,000 sq. ft (excludes septic systems) for lots created after 2006. Exceptions may be granted by the Planning Board.	"Water Quality Protection Overlay District" [Article XIII] restricts development adjacent to surface waters and wetlands. Regulates buffer/setback distances for buildings, septic systems, and impervious surfaces. Buffers increase in width if the site is also located on slopes of over 10%.	No wetland overlay district or ordinance. Article II establishes 75 ft minimum setback from all marshes and seasonally wet areas; setback may be larger for different zoning districts. Wetlands are excluded from buildable area.
Zoning overlay districts that protect groundwater.	"Groundwater Protection Overlay District" [Chapter 175 Article IV, effective 2008] establishes a groundwater protection overlay district with the goal of preventing the contamination of groundwater and protecting surface waters that are fed by the groundwater. It requires a stormwater management plan if impervious cove exceeds 15% of any lot and regulates land use to ensure proper groundwater recharge. Provides standards for animal manure, fertilizer, waste disposal, and other contaminants.	"Aquifer Protection Overlay district" [Zoning Ordinance Article 600, Section 602, effective 1995]. Requires pervious surfaces and open areas in order to infiltrate the maximum amount of stormwater as determined by a stormwater management plan. It prevents the construction of septic systems designed for discharges greater than that of a single-family home, and it regulates the disposal of other hazardous materials.	"Aquifer Protection Overlay District" [Article XII] includes performance standards for contaminant storage and prohibits multi-family dwellings and the disposal of certain waste products. Prohibits having greater than 205 impervious cover.	No groundwater protection ordinance. RA-1 and REC-1 zoning districts are designed to protect the aquifer [Appendix C].
Protection of steep slopes.	"Steep Slope Protection" [Chapter 175 Article IVB, effective 2012] applies to areas where the proposed site disturbance of slopes 15% or greater is greater than 20,000 square feet. Requires an engineering plan that shows how soil erosion, soil loss, and stormwater runoff will be controlled during and after construction. Also requires hydrology, drainage, and flooding analysis. Encourages preserving natural features such as vegetation.	Stormwater Management [Zoning Ordinance Article 300, Section 359] requires erosion and sedimentation control measures, BMPs, LID techniques, and natural vegetation to reduce stormwater runoff on new development on land with a slope of 15% or greater or within 20ft of 15% or greater slope.	"Steep Slope Conservation Overlay District" [Article XI] applicable to all areas of 15% slope or greater. Residential development is permitted if less than 10,000 sq. ft. or 25% of lot area is disturbed. Discusses limiting soil erosion and stormwater runoff while maintaining the natural topography of the region. Slopes over 25% may not have more than 500 sq. ft. of disturbance or 12,000 sq. ft. with a conditional use permit.	No steep slope overlay. Article II excludes slopes of over 25% from buildable area, and requires differing amounts of buildable area depending upon the slope.

STRATEGY	WOLFEBORO	ALTON	NEW DURHAM	BROOKFIELD
Nutrient loading analysis required for fresh waterbodies.	None identified.	None identified.	None identified.	None identified.
Low impact development requirements and standards.	Site Plan Review stormwater regulations [Chapter 173 Article IX, Section 173-21, effective 2022] apply to any new or redevelopment project that disturbs more than 10,000 sq. ft., or when a new road is created. Low impact development "must be used to the maximum extent practicable to reduce stormwater runoff volumes, protect water quality, and maintain predevelopment site hydrology". Requires on-site treatment of stormwater, plantings of native vegetation, the use of BMPs to treat suspended solids, nitrogen, and phosphorus in stormwater. Requires that measures are taken to ensure that post-development peak runoff does not exceed predevelopment runoff via drainage analysis. Other erosion and sediment control measures are required.	None identified. The "preferred design" of a Stormwater Management Plan includes the use of LID standards and BMPs [Subdivision Regulations Section VII.C.10].	"Stormwater Management and Erosion Control" [Article XVI] requires the use of BMPs and stormwater management practices for all development activity. Measures to prevent soil erosion during construction are discussed.	None identified.
Fertilizer and/or pesticide ordinances.	None identified. Fertilizer storage is regulated in the Zoning Ordinance [Chapter 175], and fertilizer is prohibited in the Wetlands Conservation Overlay District [Chapter 175 Article II].	None identified.	None identified.	None identified.
Implement and enforce a Stormwater Management Plan.	Site Plan review stormwater regulations [Chapter 173 Article IX, Section 173-21D] require a stormwater management plan with all applications where the proposed disturbance is greater than 10,000 sq. ft. Requires BMPs, infiltration practices, and other measures of managing stormwater. Applies only to commercial development and residential subdivisions.	Site Plan Review may be required for minor site plan, at discretion of the Planning Board [Section 3.01G]. For a major site plan, Stormwater Management, Sediment and Erosion Control and Drainage Plan is required for developments that disturb greater than 20,000 sq. ft., construction of a road is involved, or critical areas may be disturbed [Section 4.01.G.4]. A Stormwater Management Plan and an Erosion and Sedimentation Control Plan are required for major subdivisions [Subdivision Regulations Section VII].	"All developments subject to the incidental and non-incidental disturbance requirements of this ordinance shall submit a permanent (post construction) Stormwater Management Erosion and Sedimentation Control Plan" [Article XVI]. An incidental disturbance is greater than 2,000 sq. ft. A non-incidental disturbance is greater than 12,000 sq. ft. or will result in more tan 5,000 sq. ft. of impervious area. The parameters vary depending on the slope of the site.	Subdivision Regulations Article VII.A requires a Storm Water Drainage and Erosion and Sediment Control Plan for all developments where the disturbed area is greater than 20,000 sq. ft., it involves the construction of a road is a major subdivision, or disturbs steep slopes, wetlands, or floodplains.

STRATEGY	WOLFEBORO	ALTON	NEW DURHAM	BROOKFIELD
Development transfer overlay district.	None identified.	None identified.	None identified.	None identified.
Conservation impact fees.	No conservation impact fee. "Impact Fees" [Chapter 175 Article XXVIA] allows the town to assess impact fees for new development due to the increased demand on the school district. The Master Plan [2022] discusses possible impact fees for water and sewer service.	None identified.	No conservation impact fee, but "Impact Fee Ordinance" [Zoning and Land Use Ordinance Article XVIII] states that the Planning Board is authorized to assess impact fees for the additional demand that new development creates on public facilities.	None identified.
Wetland mitigation funds.	None identified.	None identified.	None identified.	None identified.
Fee in lieu of land dedication.	None identified.	None identified.	None identified.	None identified.
Stormwater utility district.	None identified.	None identified.	None identified.	None identified.
Open space or non-lapsing conservation fund.	None identified.	Yes. Conservation fund through the Conservation Commission.	None identified.	None identified.
Has a Land Use Change Tax per RSA 79-A:25.	Master Plan (2019) discusses encouraging landowners to keep large tracts of land unfragmented through the state's "Current Use" program.	Yes. Mentioned in Chapter 3 of Master Plan. Most of the Town's undeveloped land is enrolled in the state's "Current Use" program.	Yes. Landowners are specifically encouraged to participate in state current use program in the Merrymeeting Lake Watershed Overlay District [Article XVII]. The minimum lot size is 12 acres specifically to allot 2 acres for a dwelling and 10 acres to be placed in Current Use according to RSA79-A.	None identified. Current Use forms are accessible on town website.
Participate or collaborate with a local watershed association.	Lake Winnipesaukee Alliance, Wolfeboro Waters, Wentworth Watershed Association, Lakes Region Planning Commission, possibly Mirror Lake Protective Association.	Lake Winnipesaukee Alliance	Merrymeeting Lake Association.	None identified.
Participate or collaborate with a local land trust.	Lakes Region Conservation Trust, Moose Mountains Regional Greenways	Lakes Region Conservation, The Forest Society, Society for the Protection on New Hampshire Forests.	Moose Mountain Regional Greenways.	Moose Mountain Regional Greenways, Society for the Protection of New Hampshire Forests
Open space plan.	No open space plan identified. Within Chapter 6 (Land Use) of the 2019 Master Plan, there are Open Space Protection recommendations.	No open space plan. Section 3.6 of the Master Plan (Conservation Lands) may be relevant.	None identified.	None identified.

STRATEGY	WOLFEBORO	ALTON	NEW DURHAM	BROOKFIELD
Master plan addresses natural resources and environmental protection.	Yes [2019]. Chapter 7 (Natural Resources) discusses salt use on roads, BMPs for agricultural and timber harvests, protecting the watershed to the drinking water supply through land conservation, and protecting the aquifer. Chapter 6 (Land Use) also involves many recommendations centered on water resources, watershed protection, septic systems, and stormwater management.	Yes [2022]. Chapter 3 (Natural Resources) has sections on water quality and how the zoning ordinance can be amended to be more protective. Chapter 5 (Land Use) discuses shoreline land use, septic systems, new development and maintaining forested areas.	Yes [2017]. Chapters on Natural Resources and Land Use are relevant to environmental protection. Topics include preserving water quality, low-impact development, identifying wetlands, and maintaining scenic resources.	Yes [2006, new master plan in development]. Natural Resources/Conservation and Preservation [Section 2.02] discusses protecting wetlands, bedrock aquifer, water resources. Land Use [Section 2.05] mentions water quality protection and supports the preservation of forests, trail networks, and native wildlife.
Conduct a town-wide natural resources inventory.	Yes, completed in 2011.	Yes, completed in 2022.	Yes, completed in 2011.	Yes, completed in 2008.
Incentive-based programs for voluntary low impact development implementation.	None identified.	None identified.	None identified.	None identified.
Incentive-based programs for stormwater reduction efforts.	None identified.	None identified.	None identified.	None identified.
Have established conservation commission.	Yes. Wolfeboro Conservation Commission.	Yes. Town of Alton, NH Conservation Commission.	Yes.	Yes.
Incentivize and/or encourage property owners to implement low impact development stormwater practices.	None identified.	None identified.	None identified.	None identified.
Encourage property owners to put land into farmland/tree growth programs.	None identified.	None identified.	In the Merrymeeting Lake watershed Overlay District [Article XVII], landowners are encouraged to take advantage of state agricultural and forestry programs.	None identified.

4.2.4 Septic System Regulation

When properly designed, installed, operated, and maintained, septic systems can treat residential wastewater and reduce the impact of excess pollutants in ground and surface waters. It is important to note, however, that traditional septic systems are designed for pathogen removal from wastewater and not specifically for other pollutants such as nutrients. The phosphorus in wastewater is “removed” only by binding with soil particles or recycled in plant growth but is not removed entirely from the watershed system. Nutrient removal can only be achieved through more expensive, alternative septic systems. Proper design, installation, operation, maintenance, and replacement considerations include the following:

- Proper design includes adequate evaluation of soil conditions, seasonal high groundwater or impermeable materials, proximity of sensitive resources (e.g., drinking water wells, surface waters, wetlands, etc.);
- Proper siting and installation mean that the system is installed in conformance with the approved design and siting requirements (e.g., setbacks from waterways);
- Proper operation includes how the property owner uses the system. While most systems excel at treating normal domestic sewage, disposing of some materials, such as toxic chemicals, paints, personal hygiene products, oils and grease in large volumes, and garbage, can adversely affect the function and design life of the system, resulting in treatment failure and potential health threats; proper operation also includes how the property owner protects the system; allowing vegetation with extensive roots to grow above the system will clog the system; driving large vehicles over the system may crush or compact piping or leaching structures;
- Proper maintenance means having the septic tank pumped at regular intervals to eliminate accumulations of solids and grease in the tank; it may also mean regular cleaning of effluent filters, if installed. The frequency of septic pumping depends on the use and total volume entering the system. A typical 3-bedroom, 1,000 gallon tank should be pumped every 3-4 years;
- Proper replacement of failed systems, which may include programs or regulations to encourage upgrades of conventional systems (or cesspools and holding tanks) to more innovative alternative technologies.

Management strategies for reducing water quality impacts from septic systems (as well as cesspools and holding tanks) start with education and outreach to property owners so that they are better informed to properly operate and maintain their systems. Other management strategies include setting local regulations for enforcing proper maintenance and inspection of septic systems and establishing funding mechanisms to support replacement of failing systems (with priority for cesspools and holding tanks). For instance, the Town of New Durham adopted a subsurface ordinance that regulates septic systems within 250 feet of the shoreline of Merrymeeting Lake and ponds within the Town. Regulations include the requirement of homeowners without a valid subsurface system design approval on file and/or who seek a proposed building expansion to submit proof of proper system functioning by a certified septic system inspector within one year of notification. The Town of Wolfeboro also requires a septic system assessment at the time of sale.

4.2.5 Sanitary Sewer System Inspections

Because a portion of the watershed also relies on or includes infrastructure for a municipal sewer system, it is important for municipalities with sewer to develop a program (if not already in place) to inspect and evaluate their sanitary sewer system and reduce identified leaks and overflows, especially in areas near waterbodies. The Town of Wolfeboro is installing a force main sewer line around Jockey Cove where there are suspected failing septic systems.

4.2.6 Boats & Marinas

NHDES provides an interactive map of boat pump-out locations, including both public and private boat pump-outs, dump stations for portable toilets, and mobile pump-out vessels. There is an active pump-out facility in Wolfeboro Bay at the Wolfeboro Corinthian Yacht Club off Nancy’s Way. There was a now out-of-order pump-out facility at the Goodhouse & Hawkins Navy Yard off Sewall Road. The following are best practices for boats and marinas:

- Target outreach to marina owners, boat dealers, and their consumers regarding State and EPA requirements; and
- Encourage marina owners to provide clean and safe onshore restrooms and pump-out facilities;
- Provide an appropriate location for boat washing;
- Do not allow waste from the pump-out stations to drain directly into receiving waters;
- Consider alternatives to asphalt for parking lots and vessel storage areas such as permeable pavement;

- Install infiltration trenches at the leading edge of a boat ramp to catch pollutants in an oil absorbent barrier or crushed stone before discharge;
- Install vegetated buffers between surface waters and upland areas; and
- Protect storm drains with filters or oil-grit separators. Stencil words (such as “Drains to the Lake”) on storm drains to alert customers and visitors that storm drains lead directly to waterbodies without treatment. Contact the appropriate municipal public works department before stenciling any drain.

4.2.7 Fertilizer Use Prohibition

Management strategies for reducing water quality impacts from residential, commercial, and municipal fertilizer application start with education and outreach to property owners. New Hampshire law prohibits the use of fertilizers within 25 feet of a surface water. Outside of 25 feet, property owners can get their soil tested before considering application of fertilizers to their lawns and gardens to determine whether nutrients are needed and if so in what quantity or ratio. A soil test kit can be obtained through the UNH Cooperative Extension. Many New England communities are starting to adopt local regulations prohibiting the use of both fertilizers and pesticides, most especially near critical waterbodies. The watershed towns could consider a similar prohibition, at the very least for a watershed zoning overlay of major lakes and ponds. In 2024, HB1293 was passed by the legislature to prohibit the sale of fertilizer with a phosphate content level greater than 0.67 percent.

4.2.8 Pet Waste Management

Pet waste collection as a pollutant source control involves a combination of educational outreach and enforcement to encourage residents to clean up after their pets. Public education programs for pet waste management are often incorporated into a larger message of reducing pollutants to improve water quality. Signs, posters, brochures, and newsletters describing the proper techniques to dispose of pet waste can be used to educate the public and create a cause-and-effect link between pet waste and water quality (EPA, 2005). Adopting simple habits, such as carrying a plastic bag on walks and properly disposing of pet waste in dumpsters or other refuse containers, can make a difference. It is recommended that pet owners do not put dog and cat feces in a compost pile because it may contain parasites, bacteria, pathogens, and viruses that are harmful to humans and may or may not be destroyed by composting. “Pooper-scooper” ordinances are often used to regulate pet waste disposal. These ordinances generally require the removal of pet waste from public areas, other people’s properties, and occasionally from personal property, before leaving the area. Fines are typically the enforcement method used to encourage compliance with these ordinances.

4.2.9 Agricultural Practices

Manure and fertilizer management and planning are the primary tools for controlling nutrient runoff from agricultural areas. Direct outreach and education should be conducted for small hobby farms and any larger-scale operations in the watershed. NRCS is a great resource for such outreach and education to farmers. Larger-scale agricultural operations can work with the NRCS to complete a Comprehensive Nutrient Management Plan (CNMP). These plans address soil erosion and water quality concerns of agricultural operations through setting proper nutrient budgets, identifying the types and amount of nutrients necessary for crop production (by conducting soil tests and determining proper calibration of nutrient application equipment), and ensuring the proper storage and handling of manure. Manure should be stored or applied to fields properly to limit runoff of solids containing high concentrations of nutrients. Manure and fertilizer management involve managing the source, rate, form, timing, and placement of nutrients. Writing a plan is an ongoing process because it is a working document that changes over time.

4.2.10 Nuisance Wildlife Controls

Human development has altered the natural habitat of many wildlife species, restricting wildlife access to surface waters in some areas and promoting access in others. Minimizing the impact of wildlife on water quality generally requires either reducing the concentration of wildlife in an area or reducing their proximity to a waterbody. In areas where wildlife is observed to be a large source of nutrient contamination, such as large and regular congregations of waterfowl, a program of repelling wildlife from surface waters (also called harassment programs) may be implemented. These programs often involve the use of scarecrows, kites, a daily human presence, or modification of habitat to reduce attractiveness of an at-risk area. Providing closed trash cans near waterbodies, as well as discouraging wildlife from entering surface waters by installing fences, pruning trees, or making other changes to landscaping, can reduce impacts to water quality. Public education and outreach on prohibiting waterfowl or other wildlife feeding is an important step to reducing the impact of nuisance wildlife on the lake.

4.3 OUTREACH & EDUCATION

Awareness through education and outreach is a critical tool to protecting and restoring water quality. Most people want to be responsible watershed stewards and not cause harm to water quality, but many are unaware of best practices to reduce or eliminate contaminants from entering surface waters. LWA and Wolfeboro Waters are the primary local entities for education and outreach campaigns in the watershed and for development and implementation of the plan. LWA and Wolfeboro Waters should continue all aspects of their education and outreach strategies and consider developing new ones or improving existing ones to reach more watershed residents. Refer to Section 5: Action Plan. Examples include providing educational materials to existing and new property owners, as well as renters, by distributing them at various locations and through a variety of means, such as websites, newsletters, social media, community events, or community gathering locations. Additionally, LWA and Wolfeboro Waters should continue to engage with local stakeholders such as conservation commissions, land trusts, municipalities, businesses, and landowners. Educational campaigns should include raising awareness of water quality, septic system maintenance, fertilizer and pesticide use, pet waste disposal, waterfowl feeding, invasive aquatic species, boat pollution, shoreline buffer improvements, gravel road maintenance, and stormwater runoff controls.

4.4 ADAPTIVE MANAGEMENT APPROACH

An adaptive management approach, to be employed by a dedicated committee, is highly recommended for protecting Wolfeboro Bay. Adaptive management enables stakeholders to conduct restoration actions in an iterative manner. Through this management process, restoration actions are taken based on the best available information. Assessment of the outcomes following restoration action, through continued watershed and water quality monitoring, allows stakeholders to 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 actions. This process enables efficient utilization of available resources through the combination of BMP performance testing and watershed monitoring activities. Adaptive management features establishing an ongoing program that provides adequate funding, stakeholder guidance, and an efficient coordination of restoration actions. Implementation of this approach ensures that restoration actions are implemented and that surface waters are monitored to document restoration over an extended time. The adaptive management components for implementation efforts should include:

- **Maintaining an Organizational Structure for Implementation.** Communication and a centralized organizational structure are imperative to successfully implementing the actions outlined in this plan. A diverse group of stakeholders should be assembled to coordinate watershed management actions. This group can include representatives from state and federal agencies or organizations, municipalities, local businesses, non-profits, and other interested groups or private landowners. Refer to Section 6.1: Plan Oversight.
- **Establishing a Funding Mechanism.** A long-term funding mechanism should be established to provide financial resources for management actions. In addition to initial implementation costs, consideration should also be given to the type and extent of technical assistance needed to inspect and maintain structural BMPs. Funding is a key element of sustaining the management process, and once it is established, the plan can be fully vetted and restoration actions can move forward. A combination of grant funding, private donations, and municipal funding should be used to ensure implementation of the plan. Refer to Section 6.3 for a list of potential funding sources.
- **Determining Management Actions.** This plan provides a unified watershed management strategy with prioritized recommendations for restoration using a variety of methods. The proposed actions in this plan should be used as a starting point for grant proposals. Once a funding mechanism is established, designs for priority restoration actions on a project-area basis can be completed and their implementation scheduled. Refer to Section 5: Action Plan.
- **Continuing and Expanding the Community Participation Process.** Plan development has included active involvement of a diversity of watershed stakeholders. Plan implementation will require continued and ongoing participation of stakeholders, as well as additional outreach efforts to expand the circle of participation. Long-term community support and engagement is vital to successfully implement this plan. Continued public awareness and outreach campaigns will aid in securing this engagement. Refer to Section 4.3: Outreach & Education.

- **Continuing the Long-Term Monitoring Program.** A water quality monitoring program is necessary to track the health of surface waters in the watershed. Information from the monitoring program will provide feedback on the effectiveness of management practices. Refer to Section 6.4: Monitoring Plan.
- **Establishing Measurable Milestones.** A restoration schedule that includes milestones for measuring restoration actions and monitoring activities in the watershed is critical to the success of the plan. In addition to monitoring, several environmental, social, and programmatic indicators have been identified to measure plan progress. Refer to Section 6.5: Indicators to Measure Progress and Section 2.4: Establishment of Water Quality Goal for interim milestones.

5 ACTION PLAN

5.1 ACTION PLAN

The Action Plan (Table 15) outlines responsible parties, approximate costs[7], an implementation schedule, and potential funding sources for each recommendation within the following major categories: (1) Watershed & Shoreline BMPs; (2) Road Management; (3) Municipal Operations; (4) Municipal Land Use Planning & Zoning; (5) Land Conservation; (6) Septic System Management; (7) Agricultural Practices; and (8) Education and Outreach. The plan is designed to be implemented from 2024-2033 and is flexible to allow for new priorities throughout the 10-year implementation period as additional data are acquired.

Table 15. Action plan for the Wolfeboro Bay watershed.

Action Item	Responsible Party	Estimated Cost / Schedule	Potential Funding Sources
Watershed & Shoreline BMPs			
Complete design and construction of mitigation measures at the top 13 high priority sites identified in the watershed survey. Three sites will be remediated through a NHDES 319 Watershed Assistance Grant (2025-26) awarded to LWA. **Achieves 22% (32.9 kg/yr P of 149 kg/yr P) of Objective 3.**	LWA, CCCD, BCCD, Municipalities, private landowners	$700K-$1.1M 2024-33	CWSRF, Grants (319, Moose Plate, NFWF 5-Star, ILFP), Municipalities, private landowners
Complete design and construction of mitigation measures at 15 medium priority sites identified in the watershed survey as opportunities arise (refer to Appendix B for complete list). **Achieves 4% (6.4 kg/yr P of 149 kg/yr P) of Objective 3.**	LWA, CCCD, BCCD, Municipalities, private landowners	$200K-300K 2024-33	CWSRF, Grants (319, Moose Plate, NFWF 5-Star, ILFP), Municipalities, private landowners
Complete design and construction of mitigation measures at 62 low priority sites identified in the watershed survey as opportunities arise (refer to Appendix B for complete list). **Achieves 16% (23.3 kg/yr P of 149 kg/yr P) of Objective 3.**	LWA, CCCD, BCCD, Municipalities, private landowners	$500K-700K 2024-33	CWSRF, Grants (319, Moose Plate, NFWF 5-Star, ILFP), Municipalities, private landowners
Promote the LakeSmart program evaluations and certifications through NH Lakes to educate property owners about lake-friendly practices such as revegetating shoreline buffers with native plants, avoiding large grassy areas, and increasing mower blade heights to 4 inches. Coordinate with NHDES Soak Up the Rain NH program for workshops and trainings. Cost assumes coordination and materials for up to 10 workshops.	LWA, CCCD, BCCD, NH Lakes, NHDES Soak Up the Rain NH, Municipalities	$70K 2024-33	NH Lakes, NHDES Soak Up the Rain NH, Grants (319, Moose plate), CWSRF, Municipalities

[7] Cost estimates for each recommendation will need to be adjusted based on further research and site design considerations.

Action Item	Responsible Party	Estimated Cost / Schedule	Potential Funding Sources
Provide technical assistance and/or implementation cost sharing to watershed/shoreline property owners to install stormwater and/or erosion controls such as rain gardens and buffer plantings. Prioritize high impact properties identified during the shoreline survey. Cost assumes technical assistance and implementation cost sharing provided to the 294 medium to high impact shoreline properties. With a 50% BMP removal efficiency rate this would amount to **an annual reduction of 66 kg/yr P (Achieves 44% of Objective 3).**	LWA, CCCD, BCCD, Municipalities, private landowners	$1M 2024-33	Grants (319, Moose plate), CWSRF, private landowners
Repeat the shoreline survey in 5-10 years when updating the WBMP. Use the results to target education and technical assistance for high impact sites. Cost assumes hired consultant for survey and summation of shoreline survey results.	LWA, Municipalities	$20K 2028, 2033	Municipalities, Grants (Moose plate), CWSRF
Within the Wolfeboro Bay Direct, Knights Pond, and Beaver Brook sub-watersheds, implement unpaved road erosion control measures recommended in Lang (2021) and FBE (2022).	LWA, CCCD, BCCD, SCCD, Municipalities	TBD 2024-33	CWSRF, Municipalities, Grants (Moose Plate, NFWF 5-Star)
Evaluate the proper functioning of the stormwater swale and outfall discharge off Foss Field, including the unknown source of turbid water observed in early November 2024.	LWA, Municipalities	TBD 2024-26	CWSRF, Grants (319, Moose Plate, NFWF 5-Star, ILFP), Municipalities
Re-model sources of phosphorus to Back Bay possibly using a more sophisticated model and with more robust data collection to refine load estimates coming from the Smith River, the spray fields, and the stormwater outfall discharge off Foss Field.	LWA, Municipalities	TBD 2028-33	CWSRF, Grants (Moose Plate), Municipalities
Provide technical support to local marinas like the Wolfeboro Corinthian Yacht Club to ensure proper pump-out facilities and washing stations are preventing contamination of the lake.	LWA	TBD 2024-33	CWSRF, Grants (Moose Plate), Municipalities
Complete a stormwater evaluation of the Wolfeboro Corinthian Yacht Club property by a qualified stormwater engineer and implement recommended stormwater BMPs.	Wolfeboro Corinthian Yacht Club, LWA	TBD 2025-27	Grants (319, Moose Plate), Wolfeboro Corinthian Yacht Club
Road Management			
Review practices for road and drainage maintenance currently used by public and private entities/groups and determine areas for improvement.	Municipalities, LWA, CCCD, BCCD, SCCD	$10K 2025	CWSRF, Municipalities, Grants (Moose Plate, NFWF 5-Star)
Provide education and training to contractors and municipal staff on protocols for road maintenance best practices. Assumes one workshop. Consider holding joint workshop with other Lake Winnipesaukee region municipalities (or other wider service area) for cost sharing savings.	Municipalities, LWA, CCCD, BCCD, SCCD	$15K 2025	CWSRF, Municipalities, Grants (Moose Plate, NFWF 5-Star)

Action Item	Responsible Party	Estimated Cost / Schedule	Potential Funding Sources
Develop and/or update a written protocol for road maintenance best practices.	Municipalities, LWA, CCCD, BCCD, SCCD	$20K 2025	CWSRF, Municipalities, Grants (Moose Plate, NFWF 5-Star)
Incorporate water quality considerations and strategies into roadway evaluations and action plans.	Municipalities, LWA, CCCD, BCCD, SCCD	N/A 2024-33	Municipalities
Establish inspection and maintenance agreements for private unpaved roads. Cost does not include the implementation of proper road maintenance by private landowners and assumes that municipalities can accommodate this additional effort in current budgets.	Municipalities, private landowners	N/A 2024-33	Municipalities, private landowners
Hold informational workshops on proper road management and winter maintenance and provide educational materials for homeowners about winter maintenance and sand/salt application for driveways and walkways. Cost assumes up to five workshops.	LWA, CCCD, BCCD, SCCD, Municipalities, private landowners	$10K 2024-33	CWSRF, Municipalities, Grants (Moose Plate, NFWF 5-Star), private landowners
Municipal Operations			
Review and optimize MS4 compliance for towns (regardless of MS4 designation), including infrastructure mapping, erosion and sediment controls, illicit discharge programs, and good housekeeping practices. Sweep municipal paved roads and parking lots two times per year (spring and fall).	Municipalities (Public Works/Highway)	TBD 2024-33	Municipalities
Participate in the Municipal Green SnowPro Program. Complete training to become Green SnowPro Certified.	Municipalities (Public Works/Highway)	Est. $150-$250/person 2024-33	Municipalities
Review and update winter operations procedures to be consistent with Green SnowPro best management practices for winter road, parking lot, and sidewalk maintenance.	Municipalities (Public Works/Highway)	N/A 2025	Municipalities
In Wolfeboro (and Alton, New Durham, and Brookfield if applicable), adopt policies to either eliminate fertilizer applications on town properties or implement best practices for fertilizer management (to minimize application and transport of phosphorus). Consider extending these regulations to private properties as well.	Municipalities (Public Works/Highway)	N/A 2024-27	Municipalities
Develop best practice design standards for stormwater control measures, including deep sump catch basins.	Municipalities (Public Works/Highway)	N/A 2025	Municipalities
Reassess the Crescent Lake dam operations to determine whether it is feasible to have the dam open year-round to maintain a minimum discharge in the Smith River, particularly in the summer months when it currently dries up and impacts aquatic life.	Town of Wolfeboro	TBD 2025	Municipalities

Action Item	Responsible Party	Estimated Cost / Schedule	Potential Funding Sources
Municipal Land Use Planning & Zoning			
Present WBMP recommendations to Select Boards/City Council and Planning Boards in Wolfeboro, Alton, New Durham, and Brookfield. Cost assumes presentations conducted by LWA or volunteers.	LWA	N/A 2025	LWA
Meet with municipal staff to review recommendations to improve or develop ordinances addressing setbacks, buffers, lot coverage, low impact development, and open space.	LWA, Municipalities	N/A 2024-27	LWA, Municipalities
Incorporate WBMP recommendations into municipal master plans and encourage regular review of the WBMP action plan.	Municipalities	N/A 2024-33	Municipalities
Adopt/strengthen zoning ordinance provisions and enforcement mechanisms (refer to NHDES, 2008b): 1) to promote low impact development practices, particularly impervious cover limits that incorporate Effective Impervious Cover regulations per NHDES (2008a); 2) to require stormwater regulations that align with MS4 Permit requirements; 3) to promote or require vegetative buffers around lake shore and tributary streams; 4) to require shorefront "tear down and replace" home construction to be no more non-conforming than existing structures; 5) to require shorefront seasonal to year-round conversions of homes to demonstrate no additional negative impacts to lake water quality; 6) to establish a lake protection overlay zoning ordinance that prohibits erosion from sites in sensitive areas (e.g., lake shorefront, along lake tributaries, steep slopes); and 7) to enhance performance standards for unpaved roads to prevent erosion and protect lake water quality.	Municipalities	N/A 2024-33	Municipalities
Increase municipal staff capacity for inspections and enforcement of stormwater regulations on public and private lands.	Municipalities	TBD 2024-33	Municipalities
Land Conservation			
Update the NRIs from 2011 in Wolfeboro and New Durham and 2008 in Brookfield. (Alton has a recent NRI - 2022).	Municipalities, Conservation Commissions	$20-30K per municipality 2025-27	Municipalities, Grants (NFWF NEFRG), CWSRF

Action Item	Responsible Party	Estimated Cost / Schedule	Potential Funding Sources
Create a priority list of watershed areas that need protection based on NRIs. Refer to Section 4.2.4 to understand current conservation lands and valuable habitats and wildlife in the watershed that can be used to help identify potential areas to target for conservation.	LWA, Municipalities, Conservation Commissions, Lakes Region Conservation Trust or other local land trusts	$4-8K 2025-27	Grants (NFWF NEFRG, NAWCA), CWSRF, Municipalities
Identify potential conservation buyers and property owners interested in easements within the watershed. Use available funding mechanisms, such as the Regional Conservation Partnership Program (RCPP) and the Land and Community Heritage Investment Program (LCHIP), to provide conservation assistance to landowners.	LWA, Municipalities, Conservation Commissions, Lakes Region Conservation Trust or other local land trusts	N/A 2024-27	Grants (Moose Plate, LCHIP, RCCP, NAWCA, LWCF, ACEP, CSP, EQIP)
Maximize conservation of intact forest and other ecologically important properties through education, zoning, and public or private conservation.	LWA, Municipalities, Conservation Commissions, Lakes Region Conservation Trust or other local land trusts, private landowners	TBD 2024-33	Grants (Moose Plate, LCHIP, RCCP, NAWCA, LWCF, ACEP, CSP, EQIP, NFWF NEFRG), Municipalities, private landowners
Septic System Management			
Distribute educational materials to property owners about septic system function and maintenance. Ensure wide distribution while targeting the 211 Wolfeboro Bay shoreline parcels with septic systems older than 25 years.	Municipalities, LWA	$5K 2025, 2028, 2033	Municipalities, Grant (319), CWSRF
Look into whether any septic pumping companies would give a quantity discount or a discount to members to incentivize septic system pumping.	LWA	N/A 2025-27	LWA
Evaluate locations of older and/or noncompliant septic systems (including cesspools or holding tanks) to identify clusters where conversion to community septic systems might be desirable.	LWA, Municipalities	TBD 2024-25	CWSRF, Municipalities
Require and/or enforce inspection for all home conversions (from seasonal to permanent residences) and property sales to ensure systems are sized and designed properly. Require upgrades if needed. Prioritize shorefront properties around Jockey Cove.	Municipalities	N/A 2025-33	Municipalities
Develop and maintain a septic system database for the watershed to facilitate code enforcement of any septic system ordinances.	Municipalities	$5-10K 2025-27	Municipalities, CWSRF
Institute a minimum pump-out/inspection interval for shorefront septic systems (e.g., once every 3-5 years). Pump-outs (~$250 per system) are the responsibility of the owner.	Municipalities	N/A 2025-27	Municipalities, private landowners

Action Item	Responsible Party	Estimated Cost / Schedule	Potential Funding Sources
If not already in place, develop a program to evaluate the sanitary sewer system and reduce leaks and overflows, especially in the areas near waterbodies. Include periodic inspections of the sewer line.	Municipalities	N/A 2024-33	Municipalities
Agricultural Practices			
Work with NRCS to implement soil conservation practices such as cover crops, no-till methods, and others which reduce erosion and nutrient pollution to surface waters from agricultural fields.	NRCS, farm owners	TBD 2024-33	Grants, NRCS
Education & Outreach			
Share additional/dynamic information on the LWA website, such as water quality data, weather conditions, and webcam, to generate more traffic to the website.	LWA	TBD 2025-26	Grants
Educate managers of private boat launches about invasive species management, in addition to the existing lake host program that operates at public boat launches.	LWA	$10K 2025-27	Grants (NHDES AIPC)
Offer workshops for landowners with 10 acres or more for NRCS assistance with land conservation. Cost assumes up to two workshops.	LWA	$5K 2025-27	Grants (RCCP, ACEP, CSP, EQIP)
Encourage private property owners to hire Green SnowPro certified commercial salt applicators.	LWA, CCCD, Municipalities	N/A 2024-33	LWA, CCCD, Municipalities
Educate contractors and municipal staff about erosion and sediment control (ESC) practices required on plans. Work with municipalities to ensure that there are sufficient resources to enforce permitting conditions.	Municipalities, LWA, CCCD, BCCD, SCCD	$6K 2025-27	Municipalities, Grants (319), CWSRF
Partner or collaborate with watershed associations within the Wolfeboro Bay watershed (Wentworth Watershed Association, Rust Pond Association, Shaws Pond) on Action Items related to municipal planning, training for municipal staff, advocacy issues, or relevant outreach to leverage greater collective power and cost share, if applicable.	LWA	N/A 2024-2033	LWA, other lake associations
Create flyers/brochures or other educational materials through printed or online mediums, regarding topics such as stormwater controls, road maintenance, buffer improvements, fertilizer and pesticide use, pet waste disposal, boat pollution, invasive aquatic species, waterfowl feeding, and septic system maintenance. Consider creating a "watershed homeowner" packet that covers these topics and is distributed (mailed separately or in tax bills or posted at community gathering locations or events) to existing and new property owners, as well as renters. Hold 1-2 informational workshops per year to update the public on restoration progress and ways that individuals can help. Cost is highly variable.	Municipalities, LWA, CCCD, BCCD, SCCD	$20K-$60K 2024-33	Municipalities, Grants (319), CWSRF

Action Item	**Responsible Party**	**Estimated Cost / Schedule**	**Potential Funding Sources**
Collaborate with NH Lakes on legislative or advocacy issues such as boat speed limits.	LWA, NH Lakes	N/A 2024-33	Grants
Establish a Weed Watchers team for Wolfeboro Bay.	LWA, NH Lakes, Municipalities	N/A 2025-33	LWA, NH Lakes, Municipalities
Connect with the Kingswood Golf Course to review their maintenance practices for water quality protection. Encourage them to become Audubon certified.	LWA, NH Lakes	N/A 2025-33	LWA, NH Lakes, Golf Course

5.2 POLLUTANT LOAD REDUCTIONS

To meet the water quality goal, Objective 1 set a target phosphorus load reduction of 149 kg/yr to achieve an in-lake total phosphorus concentration of 4.6 ppb, which meets state water quality standards for oligotrophic waterbodies and is anticipated to reduce the likelihood of cyanobacteria blooms in Wolfeboro Bay. The following opportunities for phosphorus load reductions to achieve Objective 1 were identified in the watershed based on field and desktop analyses:

- Remediating the 90 watershed survey sites could prevent up to 62.5 kg/yr of phosphorus load from entering Wolfeboro Bay.
- Treating the 294 low to high impact shoreline survey sites could reduce the phosphorus load to Wolfeboro Bay by 66 kg/yr.
- Upgrading the 211 shorefront septic systems older than 25 years is estimated to reduce the phosphorus load to Wolfeboro Bay by 21 kg/yr.

Addressing these field-identified phosphorus load reduction opportunities coming from the external watershed load (i.e., watershed and shoreline sites and shorefront septic systems) could reduce the phosphorus load to Wolfeboro Bay by 149 kg/yr, meeting 100% of the needed reductions to achieve Objective 1 (Table 16).

Objective 2 (preventing or offsetting additional phosphorus loading from anticipated new development) can be met through ordinance revisions that implement LID strategies, limit impervious cover, and encourage cluster development with open space protection and/or through conservation of key parcels of forested and/or open land.

It is important to note that, while the focus of the objectives for this plan is on phosphorus, the treatment of stormwater and sediment erosion will result in the reduction of many other kinds of pollutants that may impact water quality. These pollutants would likely include other nutrients (e.g., nitrogen), petroleum products, bacteria, road salt/sand, , excessive organic material (raking/blowing leaves and grass cuttings or erosion from boat wakes), and heavy metals (cadmium, nickel, zinc, etc.). Without a monitoring program in place to measure these other pollutants, it will be difficult to track the success of efforts that reduce these other pollutants. 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 tracked to help assess long-term response.

Table 16. Breakdown of phosphorus load sources and modeled water quality for current and target conditions that meet the water quality goal (Objective 1) for Wolfeboro Bay and that reflect all field identified reduction opportunities in the watershed. Reduction percentages are based out of the current condition value for each parameter.

Parameter	Unit	Current Condition	Target Condition	Reduction (Unit, %)
Total P Load (All Sources)	kg/yr	1,583	1,434	-149 (9.4%)
(A) Background P Load[1]	kg/yr	685	685	0 (0%)
(B) Disturbed (Human) P Load[2]	kg/yr	898	749	-149 (17%)
(C) Developed Land Use P Load	kg/yr	282	154	-128 (45%)
(D) Septic System P Load	kg/yr	38	17	-21 (55%)
(E) Internal P Load	kg/yr	17	17	0 (0%)
(F) Back Bay Developed P Load	kg/yr	323	323	0 (0%)
(G) The Broads Developed P Load	kg/yr	238	238	0 (0%)
In-Lake TP*	ppb	6.1	5.5	-0.6 (10%)
In-Lake Chl-a*	ppb	1.6	1.4	-0.2 (13%)
In-Lake SDT*	meters	5.8	6.2	+0.4 (7%)
In-Lake Bloom Probability*	days	0	0	0 (0%)

[1] Sum of forested/water/natural land use load (pre-development watershed load), current waterfowl load, and current atmospheric load
[2] Sum of developed land use P load for direct Wolfeboro Bay watershed (including Rust and Shaws ponds), developed P load for Back Bay (including Crescent Lake and Lake Wentworth), and developed P load for the Broads; Wolfeboro Bay shorefront septic system load; and Wolfeboro Bay internal load (B = C+D+E+F+G)
** Water quality parameters were sourced from the model and reflect annual average conditions*

6 PLAN IMPLEMENTATION & EVALUATION

The following section details the oversight and estimated costs (with funding strategy) needed to implement the action items recommended in the Action Plan (Section 5), as well as the monitoring plan and indicators to measure progress of plan implementation over time.

6.1 PLAN OVERSIGHT

The recommendations of this plan will be carried out by a diverse stakeholder group in the form of a dedicated committee, including representatives from LWA, municipalities (e.g., select boards, planning boards), conservation commissions, Wolfeboro Waters, state and federal agencies or organizations, nonprofits, land trusts, schools and community groups, local business leaders, and landowners. The committee will need to meet regularly and work hard to coordinate resources across stakeholder groups to fund and implement the management actions. The Action Plan (Section 5) will need to be updated periodically (typically every 2, 5, and 10 years) to ensure progress and to incorporate any changes in watershed activities. Measurable milestones (e.g., number of BMP sites, volunteers, funding received, etc.) should be tracked by the committee.

The Action Plan (Section 5) identifies the stakeholder groups responsible for each action item. Generally, the following responsibilities are noted for each key stakeholder:

- LWA will conduct water quality monitoring, facilitate outreach activities and watershed stewardship, and raise funds for stewardship work.
- Municipalities will be responsible for establishing a dedicated committee and will work to address NPS problems identified in the watershed, including conducting regular best practices maintenance on roads, adopting ordinances for water quality protection, and addressing other recommended actions specified in the Action Plan. Other stakeholder groups can work with each municipality to provide support in reviewing and tailoring the recommendations to fit the specific needs of each community.
- Conservation Commissions will work with municipal staff and boards to facilitate the implementation of the recommended actions specified in the Action Plan.
- Wolfeboro Waters will continue to monitor and report on cyanobacteria blooms and other water quality issues and provide critical outreach and education on water quality protection needs.
- CCCD and BCCD can provide administrative capacity and can help acquire grant funding for BMP implementation projects and education/outreach to watershed residents and municipalities.
- NHDES can provide technical assistance, permit approval, and the opportunity for financial assistance through the 319 Watershed Assistance Grant Program and other funding programs.
- Private landowners will seek opportunities for increased awareness of water quality protection issues and initiatives and conduct activities in a manner that minimizes pollutant impact to surface waters.

The success of this plan is dependent on the continued effort of volunteers and a strong and diverse committee that meets regularly to coordinate resources for implementation, review progress, and make any necessary adjustments to the plan to maintain relevant action items and interim milestones. A reduction in nutrient loading is no easy task, and because there are many diffuse sources of phosphorus reaching the rivers, lakes, and ponds from existing development, roads, septic systems, and other land uses in the watershed, it will require an integrated and adaptive approach across many different parts of the watershed community to be successful.

6.2 ESTIMATED COSTS

The strategy for reducing pollutant loading to Wolfeboro Bay to meet the water quality goal and objectives set in Section 2.4 will be dependent on available funding and labor resources but will include approaches that address sources of phosphorus loading, as well as water quality monitoring and education and outreach. Additional significant but difficult to quantify strategies for reducing phosphorus loading to the lake are revising local ordinances such as setting LID requirements on new construction, identifying and replacing malfunctioning septic systems, performing proper road maintenance, and improving agricultural practices (refer to Section 5: Action Plan for more details). With a dedicated stakeholder group in place and with the help of grant or local funding, it is possible to achieve the target phosphorus reductions and meet the established water quality goal for Wolfeboro Bay in the next 10 years. **The cost of successfully implementing the plan is**

estimated to be at least $2.7-$3.9 million over the next 10 or more years (Table 17). However, many costs are still unknown or were roughly estimated and should be updated as information becomes available. In addition, costs to private landowners (e.g., septic system upgrades, private road maintenance, etc.) are not reflected in the estimate.

Table 17. Estimated pollutant reduction (TP) in kg/year and estimated total and annual 10-year costs for implementation of the Action Plan to meet the water quality goal and objectives for Wolfeboro Bay. The light gray shaded planning actions are necessary to achieve the water quality goal. Other planning actions are important but difficult to quantify for TP reduction and costs, the latter of which were roughly estimated here as general placeholders.

Planning Action	TP Reduction (kg/yr)	Estimated Total Cost	Estimated Annual Cost
Watershed & Shoreline BMPs	**128**	$2,490,000 - $3,190,000	$249,000 - $319,000
Road Management	TBD	$55,000	$5,500
Municipal Operations	TBD	TBD	TBD
Municipal Land Use Planning & Zoning	**203***	TBD	TBD
Land Conservation		$64,000 - $98,000	$6,400 - $9,800
Septic System Management	**21**	$10,000 - $15,000	$1,000 - $1,500
Agricultural Practices	TBD	TBD	TBD
Education & Outreach	TBD	$36,000 - $76,000	$3,600-$7,600
Monitoring	*NA*	$100,000-$500,000	$10,000-$50,000
Total	**352**	**$2,756,000-$3,935,000**	**$275,600-$393,500**

** Estimated increase in phosphorus load from new development in the next 10 years.*

6.3 FUNDING STRATEGY

It is important that the committee develop a strategy to collect the funds necessary to implement the recommendations listed in the Action Plan (Section 5). Funding to cover ordinance revisions and third-party review could be supported by municipalities through tax collection (as approved by majority vote by town residents). Monitoring and assessment funding could come from a variety of sources, including state and federal grants, municipalities, or donations. Funding to improve septic systems, roads, and shoreland zone buffers would likely come from private landowners. As the plan evolves into the future, the establishment of a funding subcommittee will be a key part in how funds are raised, tracked, and spent to implement and support the plan. Listed below are state and federal funding sources that could assist the committee with future water quality and watershed work on Wolfeboro Bay. Links to each funding source are embedded in the title.

Funding Options:

- **EPA/NHDES 319 Grants (Watershed Assistance Grants)** – This NPS grant is designed to support local initiatives to restore impaired waters (priorities identified in the NPS Management Program Plan, updated 2024) and protect high quality waters. 319 grants are available for the implementation of watershed-based plans and typically fund $50,000 to $150,000 projects over the course of two years.
- **NH State Conservation Committee (SCC) Grant Program (Moose Plate Grants)** – County Conservation Districts, municipalities (including commissions engaged in conservation programs), and qualified nonprofit organizations are eligible to apply for the SCC grant program. Projects must qualify in one of the following categories: Water Quality and Quantity; Wildlife Habitat; Soil Conservation and Flooding; Best Management Practices; Conservation Planning; and Land Conservation. The total SCC grant request per application cannot exceed $40,000.
- **Land and Community Heritage Investment Program (LCHIP)** – This grant provides matching funds to help municipalities and nonprofits protect the state's natural, historical, and cultural resources.
- **Aquatic Resource Mitigation Fund (ARM)** – This grant provides funds for projects that protect, restore, or enhance wetlands and streams to compensate for impacted aquatic resources. The fund is managed by the NHDES Wetlands Bureau that oversees the state In-Lieu Fee Program (ILFP) compensatory mitigation program. A

permittee can make a payment to NHDES to mitigate or offset losses to natural resources because of a project's impact to the environment.

- **New England Forest and River Grant (NFWF NEFRG)** – This grant awards $50,000 to $200,000 to projects that restore and sustain healthy forests and rivers through habitat restoration, fish barrier removal, and stream connectivity such as culvert upgrades.
- **Aquatic Invasive Plant Control, Prevention and Research Grants (NHDES AIPC)** – Funds are available each year for projects that prevent new infestations of exotic plants, including outreach, education, Lake Host Programs, and other activities.
- **Clean Water State Revolving Fund (NHDES CWSRF)** – This fund provides low-interest loans to communities, nonprofits, and other local government entities to improve and replace wastewater collection systems with the goal of protecting public health and improving water quality. A portion of the CWSRF program is used to fund NPS pollution prevention, watershed protection and restoration, and estuary management projects that help improve and protect water quality in NH.
- **Regional Conservation Partnership Program (RCCP) -** This NRCS grant provides conservation assistance to producers and landowners for projects carried out on agricultural land or non-industrial private forest land to achieve conservation benefits and address natural resource challenges. Eligible activities include land management restoration practices, entity-held easements, and public works/watershed conservation activities.
- **Agricultural Conservation Easement Program (ACEP)** - This NRCS grant protects the agricultural viability and related conservation values of eligible land by limiting nonagricultural uses which negatively affect agricultural uses and conservation values, protect grazing uses and related conservation values by restoring or conserving eligible grazing land, and protecting, restoring, and enhancing wetlands on eligible land. Eligible applicants include private landowners of agricultural land, cropland, rangeland, grassland, pastureland, and non-industrial private forestland.
- **Conservation Stewardship Program (CSP) -** This NRCS grant helps agricultural producers maintain and improve their existing conservation systems and adopt additional conservation activities to address priority resource concerns. Eligible lands include private agricultural lands, non-industrial private forestland, farmstead, and associated agricultural lands, and public land that is under control of the applicant.
- **Environmental Quality Incentives Program (EQIP)** - This NRCS grant provides financial and technical assistance to agricultural producers and non-industrial forest managers to address natural resource concerns and deliver environmental benefits. Eligible applicants include agricultural producers, owners of non-industrial private forestland, water management entities, etc.
- **National Fish and Wildlife Federation (NFWF) Five Star and Urban Waters Restoration Grants (NFWF 5-Star) -** Grants seek to address water quality issues in priority watersheds, such as erosion due to unstable streambanks, pollution from stormwater runoff, and degraded shorelines caused by development. Eligible projects include wetland, riparian, in-stream and/or coastal habitat restoration; design and construction of green infrastructure BMPs; water quality monitoring/assessment; outreach and education.
- **North American Wetlands Conservation Act (NAWCA) Grants** - The U.S. Standard Grants Program is a competitive, matching grants program that supports public-private partnerships carrying out projects in the United States that further the goals of the North American Wetlands Conservation Act (NAWCA). These projects involve long-term protection, restoration, and/or enhancement of wetlands and associated uplands habitats for the benefit of all wetlands-associated migratory birds.
- **National Park Service - Land and Water Conservation Fund Grant Program (LWCF)** - Eligible projects include acquisition of parkland or conservation land; creation of new parks; renovations to existing parks; and development of trails. Municipalities must have an up-to-date Open Space and Recreation Plan. Trails constructed using grant funds must be ADA-compliant.

6.4 MONITORING PLAN

A long-term water quality monitoring plan is critical to evaluate the effectiveness of implementation efforts over time. The UNH LLMP has been monitoring the region's waterbodies for decades, providing valuable water quality data to communities that would otherwise not exist. LWA and Wolfeboro Waters, in concert with the UNH LLMP, should continue and consider expanding on the following annual monitoring:

- Continue to monitor the five active sites on Wolfeboro Bay, including the deep spots (WINBWOLD, WWBBAYL, WINWOJCD, WINWOJCS, WAL01DL) for all parameters included in the UNH LLMP protocol. This includes sampling three to five times each summer (June-September or October) for at least total phosphorus (epilimnion, metalimnion, and hypolimnion), chlorophyll-a (composite or epilimnion), Secchi disk transparency, and dissolved oxygen-temperature profiles to the lake bottom.
  - Ensure that dissolved oxygen-temperature profiles are being collected concurrently with sampling of lake deep spot stations and consider collecting profiles at a higher frequency (e.g., every two weeks from May-October).
  - Consider purchasing a ~70-meter cord handheld meter for the LWA to reach the bottom of the deepest area of Lake Winnipesaukee.
  - Consider adding total nitrogen and the nitrogen species (total dissolved nitrogen, nitrate-nitrite, and ammonium) to routine lake sampling.
  - Consider monitoring Back Bay in the winter season when the dam is open to better estimate the annual average phosphorus concentration for model calibration.
- Continue to monitor the lake for cyanobacteria blooms and alert NHDES immediately. Coordinate with NHDES to collect samples for analysis.
- Monitor total phosphorus and flow (as well as specific conductance, chloride, temperature, and/or turbidity, if able) at major tributary inflows to Wolfeboro Bay, at least two to five times per year each summer, specifically targeting wet and dry weather conditions.
  - Establish long-term stream monitoring stations at the Filter Bed Road and Bay Street stream crossing for total phosphorus and flow to determine a site-specific export coefficient for the spray fields.
  - Regularly monitor the stormwater outfall off Foss Field for a variety of contaminants of concern, not just phosphorus.
- Consider collecting monthly samples for speciation and enumeration of phytoplankton and zooplankton in the water column.
- Consider expanding cyanotoxin testing, fluorometry, and picocyanobacteria analysis via e-DNA (through the Bigelow Laboratory for Ocean Sciences) to Wolfeboro Bay.

6.5 INDICATORS TO MEASURE PROGRESS

The following environmental, programmatic, and social indicators and associated numeric targets (milestones) will help to quantitatively measure the progress of this plan in meeting the established goal and objectives for the Wolfeboro Bay watershed (Table 18). These benchmarks represent short-term (2025), mid-term (2028), and long-term (2033) targets derived directly from actions identified in the Action Plan (Section 5). Setting milestones allows for periodic updates to the plan, maintains and sustains the action items, and makes the plan relevant to ongoing activities. The committee should review the milestones for each indicator on an ongoing basis to determine if progress is being made, and then determine if the 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 recommendations outlined in the Action Plan (Section 5) will be implemented accordingly and will result in an improvement in water quality. 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. Social Indicators measure changes in social or cultural practices and behavior that lead to implementation of management measures and water quality improvement.

Table 18. Environmental, programmatic, and social indicators for the Wolfeboro Bay Watershed-Based Management Plan. ** indicators particularly relevant to assessing progress toward achieving the water quality goal and objectives.

Indicators	Milestones*		
	2025	**2028**	**2033**
ENVIRONMENTAL INDICATORS			
Achieve an average summer deep spot epilimnion total phosphorus concentration of 4.6 ppb at the deep spot station in Wolfeboro Bay (included but likely not a meaningful measure of success in this case)	<5.1 ppb	<4.9 ppb	<4.6 ppb
Achieve an average summer deep spot epilimnion chlorophyll-a concentration of less than 1.4 ppb at the deep spot station in Wolfeboro Bay (included but likely not a meaningful measure of success in this case)	<1.6 ppb	<1.5 ppb	<1.4 ppb
Eliminate the occurrence of cyanobacteria or algal blooms in Wolfeboro Bay (milestones based on observed data from 2024) **	12 days/yr	6 days/yr	0 days/yr
Achieve an average summer water clarity of 9 m or deeper at the deep spot stations in Wolfeboro Bay	9 m+	9.5 m+	10 m+
Achieve a reduction in total phosphorus load from the major tributaries to Wolfeboro Bay. More data are needed to establish a baseline from which to track change over time. **	TBD	TBD	TBD
Prevent and/or control the introduction and/or proliferation of invasive aquatic species all waterbodies	Invasives Controlled	Invasives Controlled	Invasives Controlled
PROGRAMMATIC INDICATORS			
Amount of funding secured from municipal/private work, fundraisers, donations, and grants	$270,000	$1,300,000	$2,700,000
Number of NPS sites remediated (90 identified) **	10	45	90
Linear feet of buffers improved in the shoreland zone **	1,500	6,000	15,000
Percentage of shorefront properties with LakeSmart certification **	25%	50%	75%
Number of watershed/shoreline properties receiving technical assistance visits	25	50	100
Number of workshops and trainings for stormwater improvements to residential properties (e.g., NHDES Soak Up the Rain NH program)	1	2	5
Number of updated or new ordinances that target water quality protection	1	2	3
Number of new municipal staff for inspections and enforcement of regulations	1	1	2
Number of voluntary or required septic system inspections (seasonal conversion and property transfer)	5	10	25
Number of septic system upgrades **	10	25	50
Number of informational workshops and/or trainings for landowners, municipal staff, and/or developers/landscapers on local ordinances, watershed goals, and/or best practices for road management and winter maintenance	2	5	10
Number of parcels with new conservation easements or number of parcels put into permanent conservation	1	2	5
Number of copies of watershed-based educational materials distributed or articles published	200	500	1,000
Number of new best practices for road management and winter maintenance implemented on public and private roads by the municipalities	2	5	10
Number of municipalities fully implementing key aspects of the MS4 program	1	2	3
Number of meetings and/or presentations to municipal staff and/or boards related to the WBMP	4	12	30
Number of CNMPs completed or NRCS technical assistance provided for farms in the watershed	1	2	3

Indicators	Milestones*		
	2025	**2028**	**2033**
SOCIAL INDICATORS			
Number of new association members	20	50	75
Number of volunteers participating in educational campaigns	5	10	25
Number of people participating in informational meetings, workshops, trainings, BMP demonstrations, or group septic system pumping	25	50	100
Number of watershed residents installing conservation practices on their property and/or participating in LakeSmart	25	50	100
Number of municipal DPW staff receiving Green SnowPro training	1	3	5
Number of groups or individuals contributing funds for plan implementation	25	50	100
Number of newly trained water quality and invasive species monitors	2	4	6
Percentage of residents making voluntary upgrades or maintenance to their septic systems (with or without free technical assistance), particularly those identified as needing upgrades or maintenance	10%	25%	50%
Number of farmers working with NRCS, CCCD, SCCD, or BCCD	1	2	3
Number of daily visitors to the LWA website	10	25	50

**Milestones are cumulative starting at year 1.*

ADDITIONAL RESOURCES

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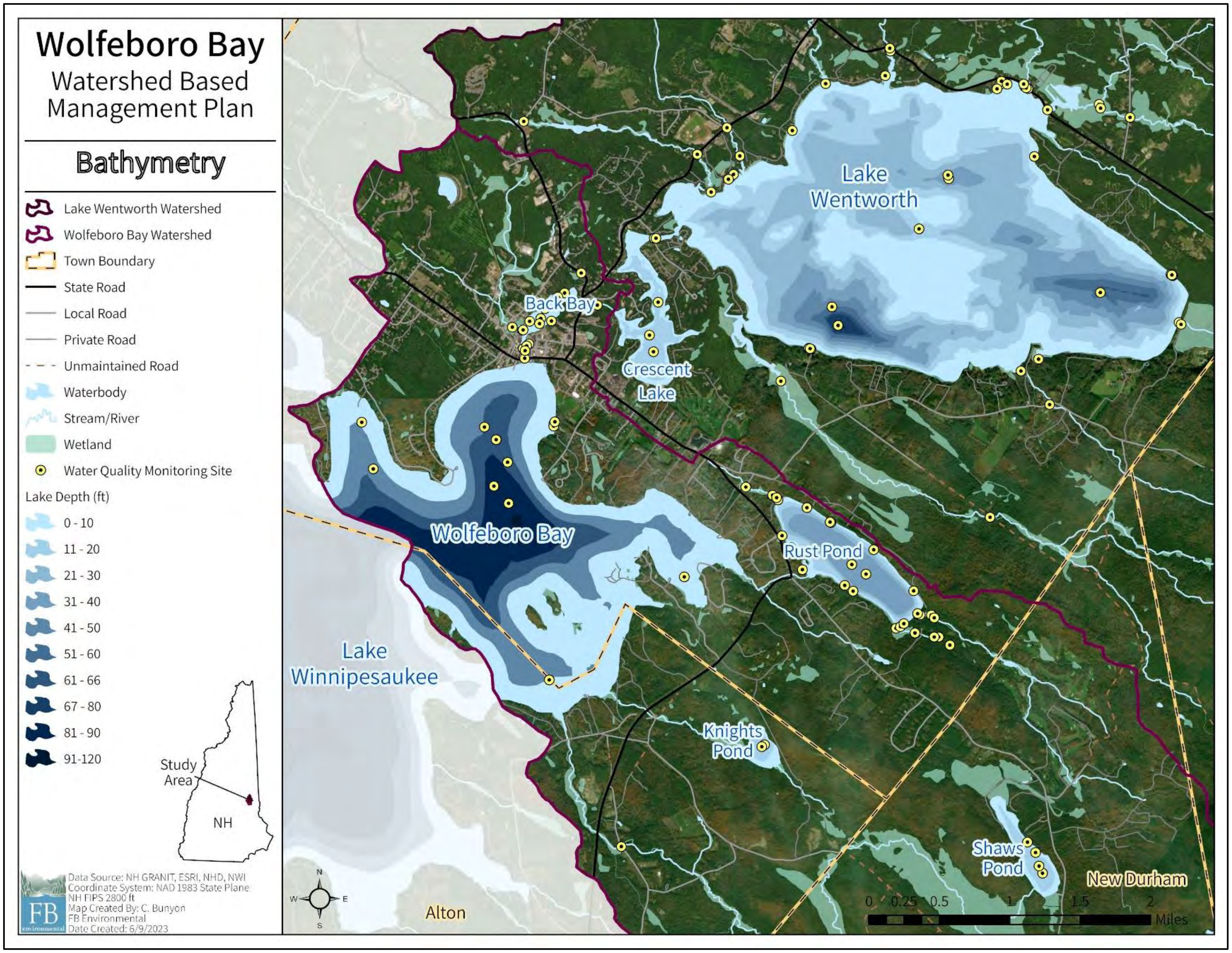
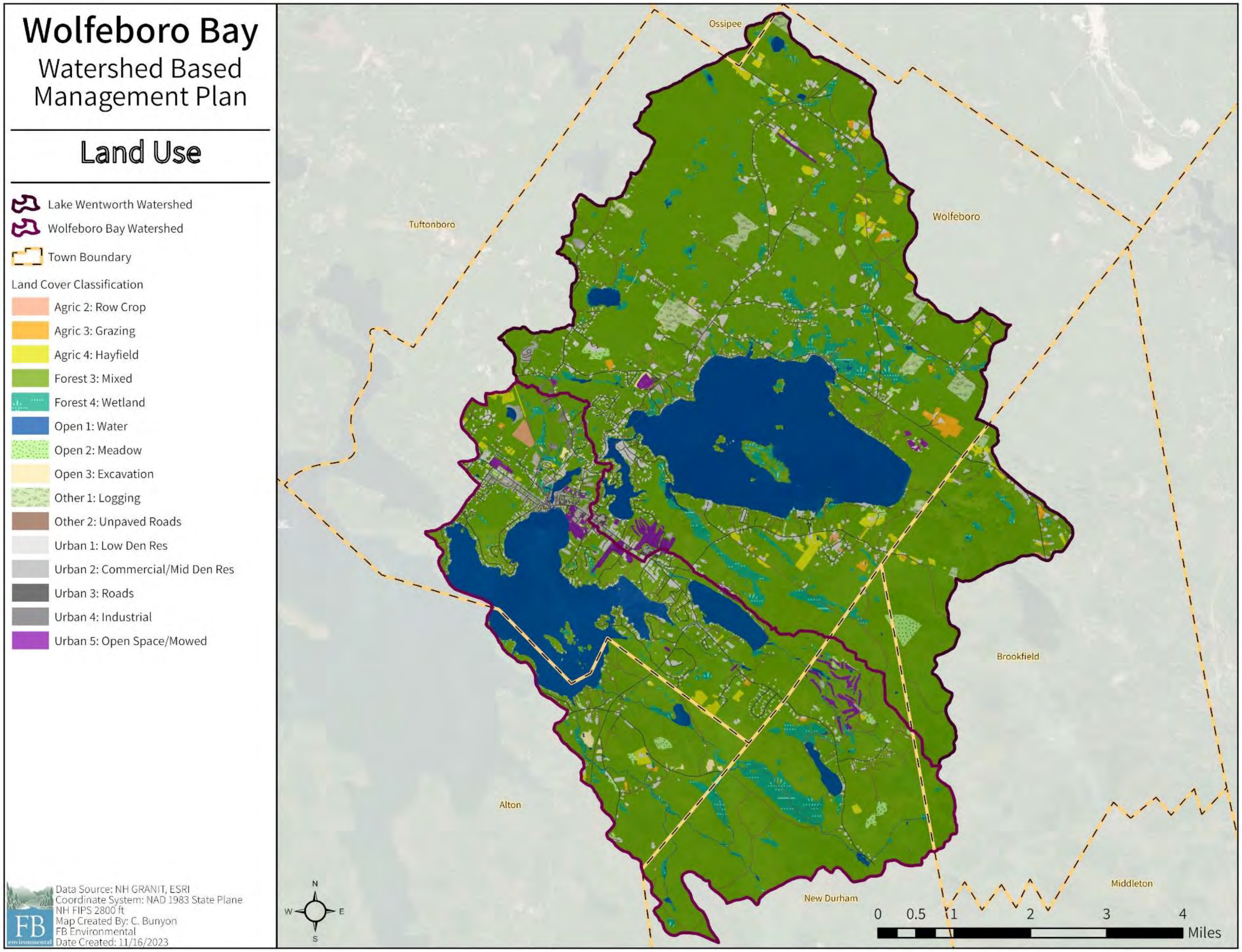
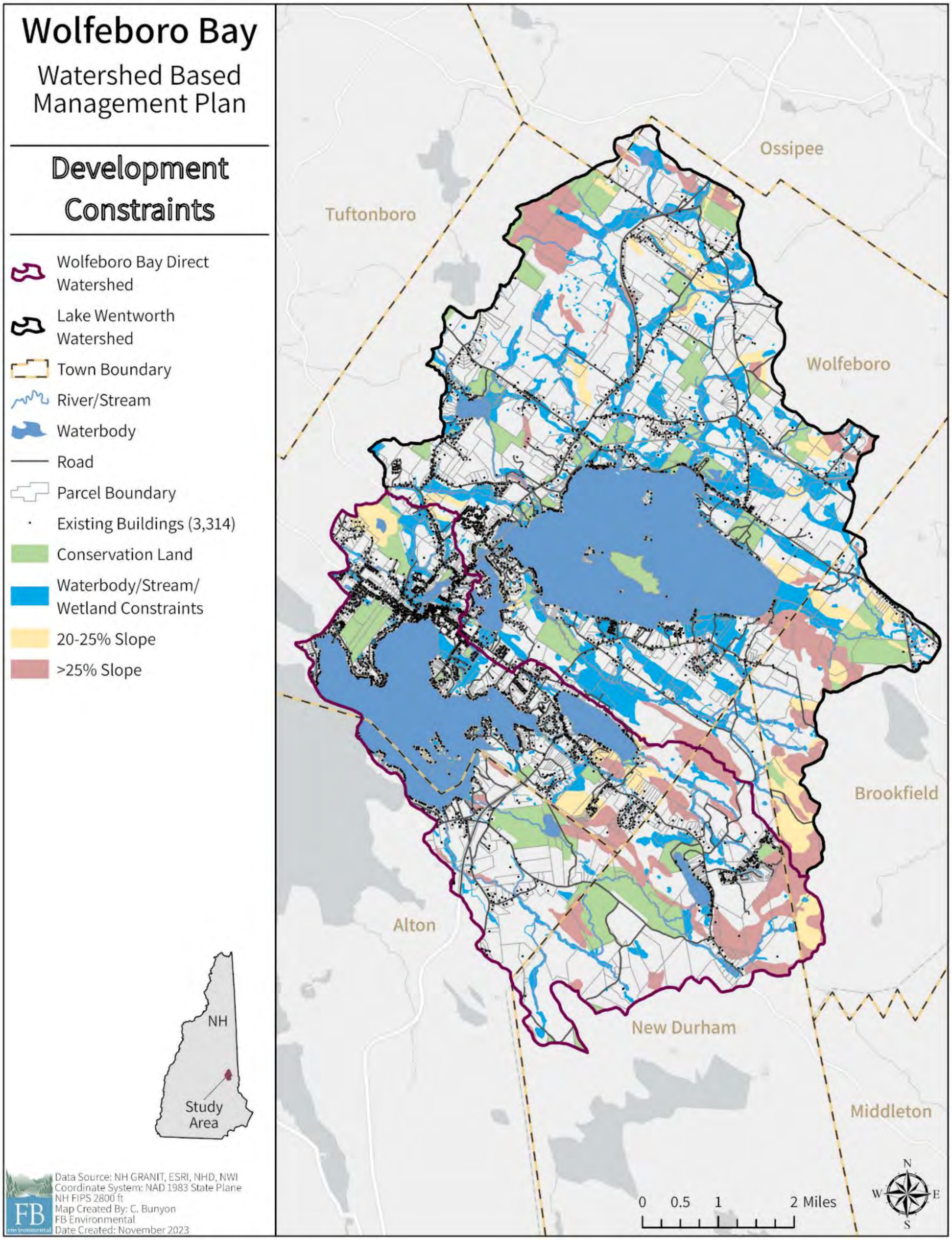
APPENDIX A: SUPPORTING MAPS



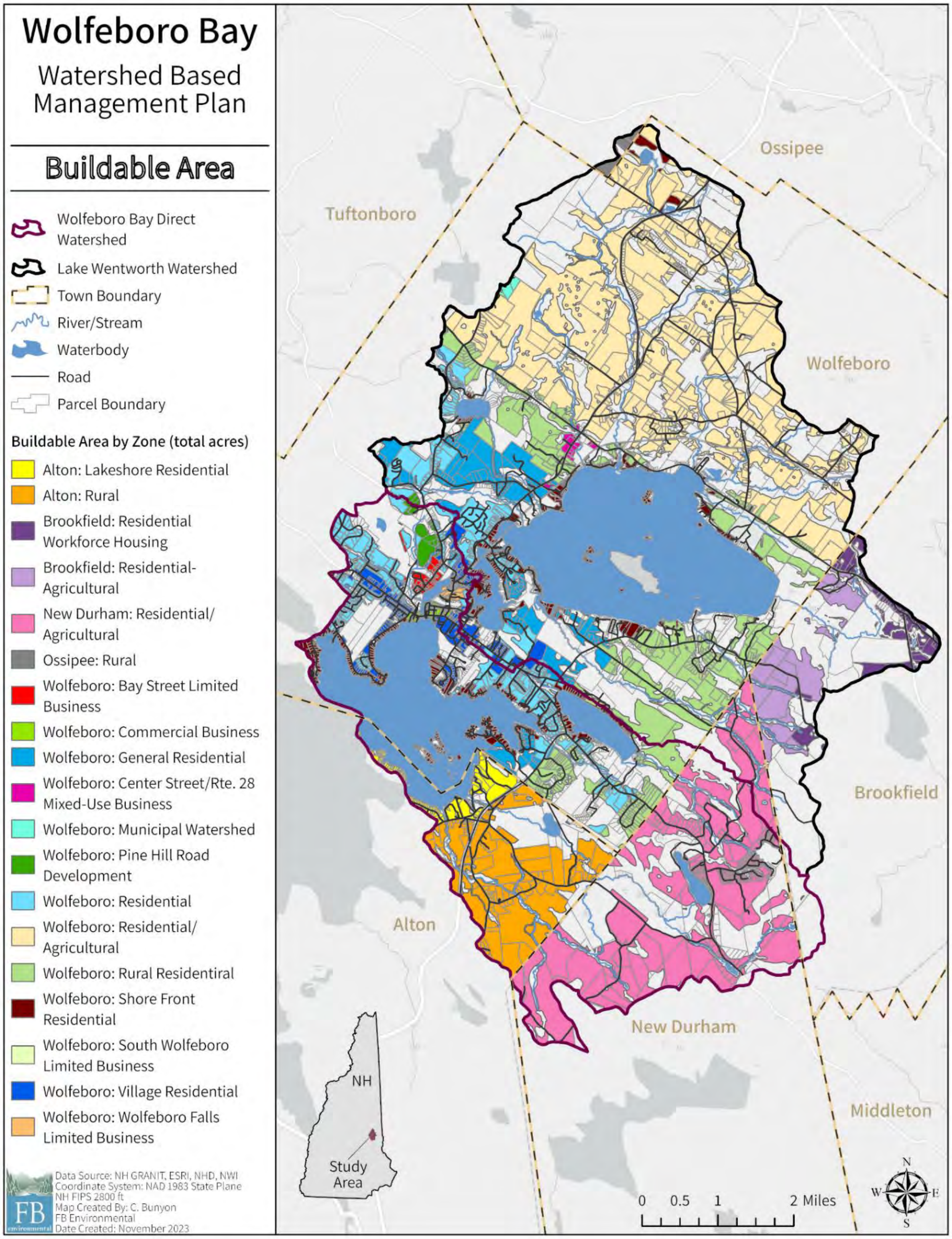
Map A-1. Bathymetry as 20-foot depth contours for Wolfeboro Bay and 10-foot depth contours in Lake Wentworth.



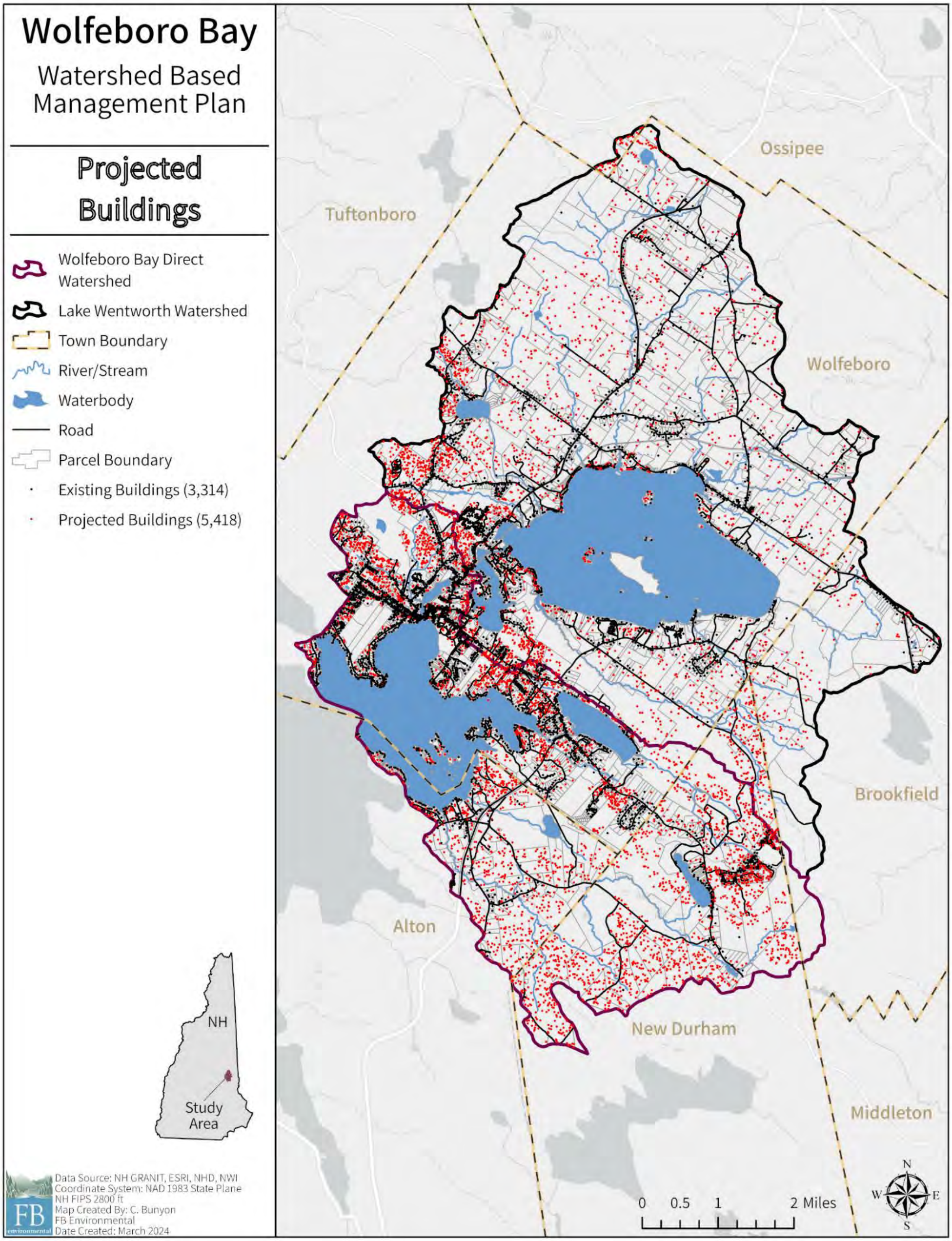
Map A-2. Land cover for the Wolfeboro Bay watershed.



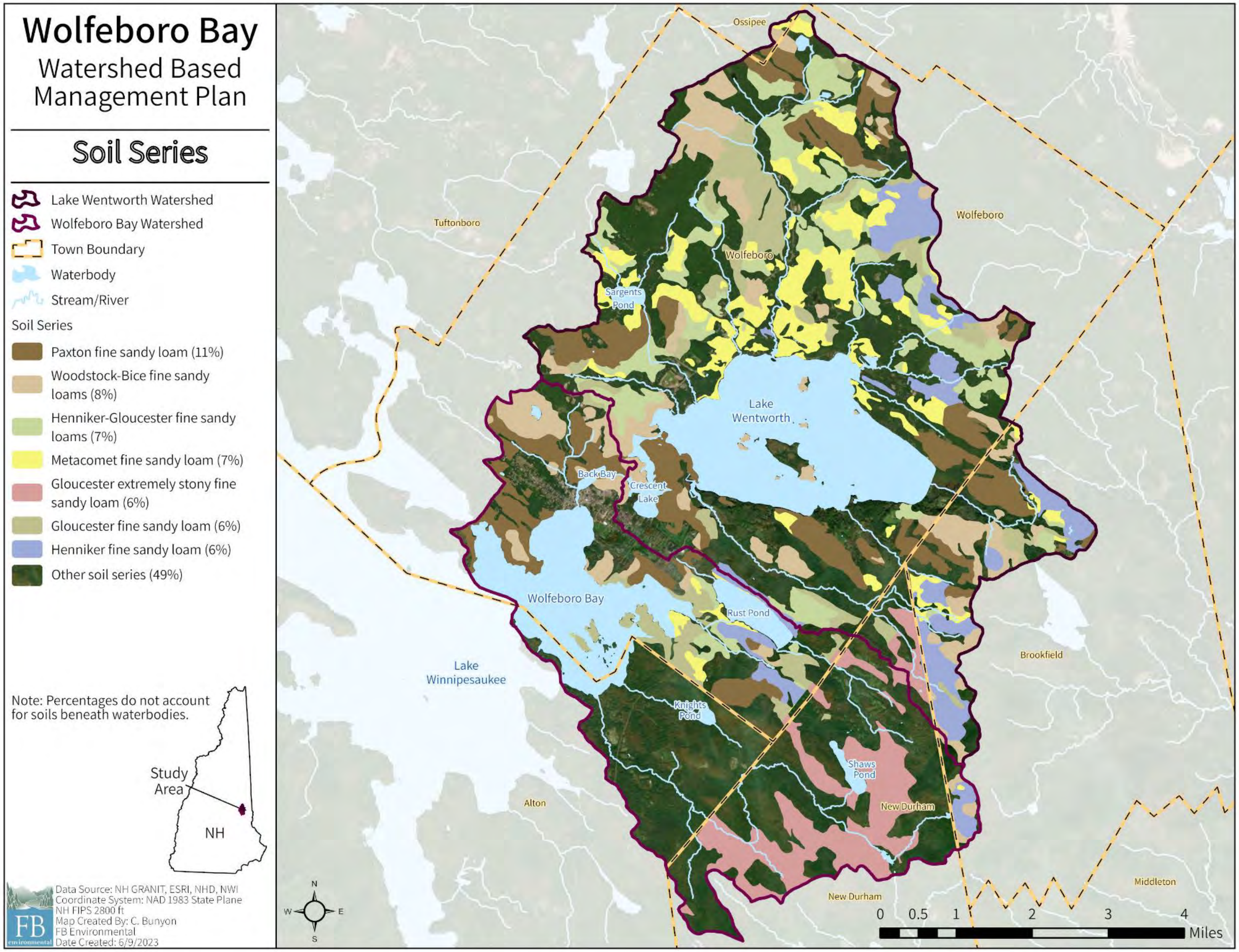
Map A-3. Development constraints in the Wolfeboro Bay watershed in Wolfeboro, Alton, New Durham, Brookfield, and Ossipee, NH.



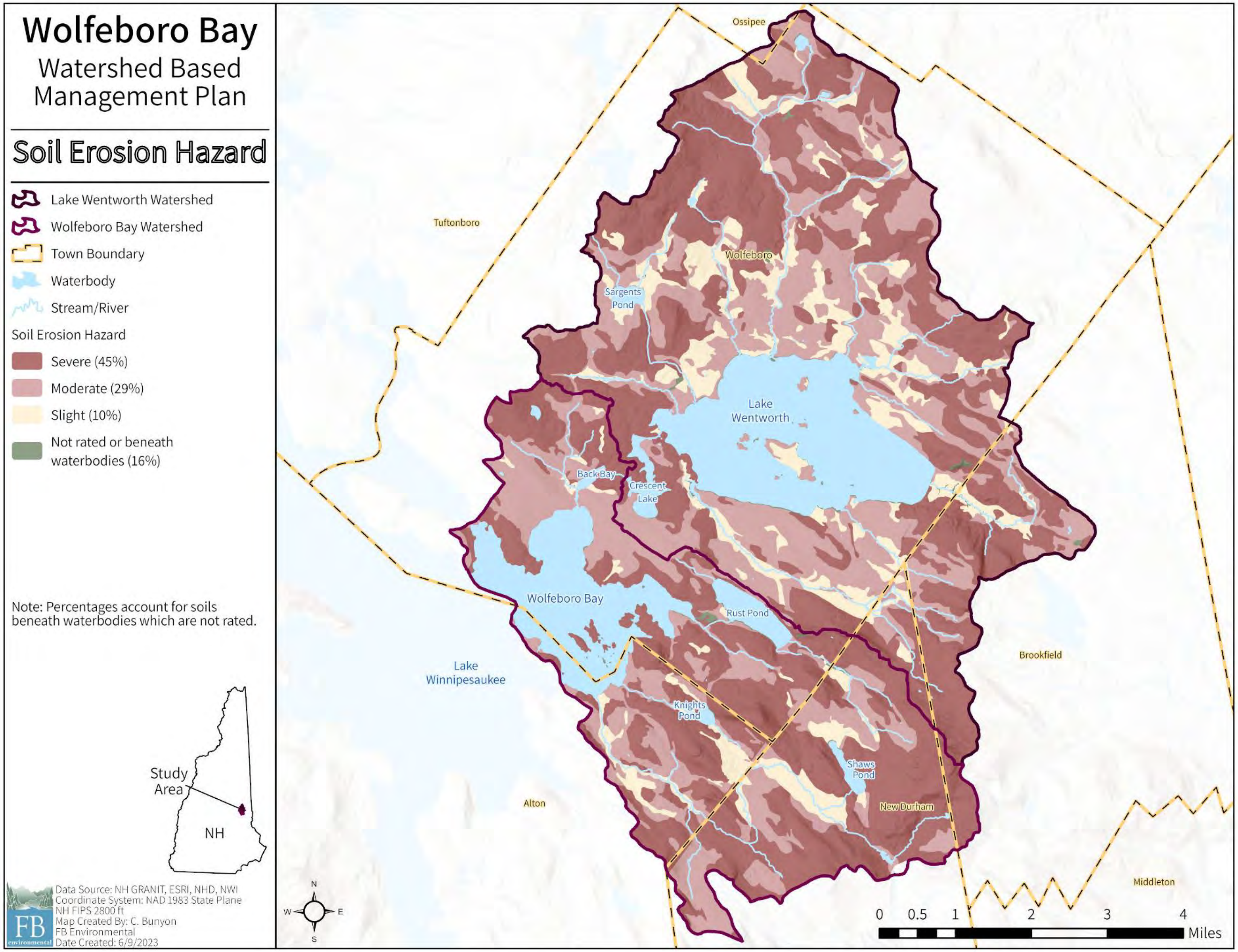
Map A-4. Buildable area by municipal zone in the Wolfeboro Bay watershed in Wolfeboro, Alton, New Durham, Brookfield, and Ossipee, NH.



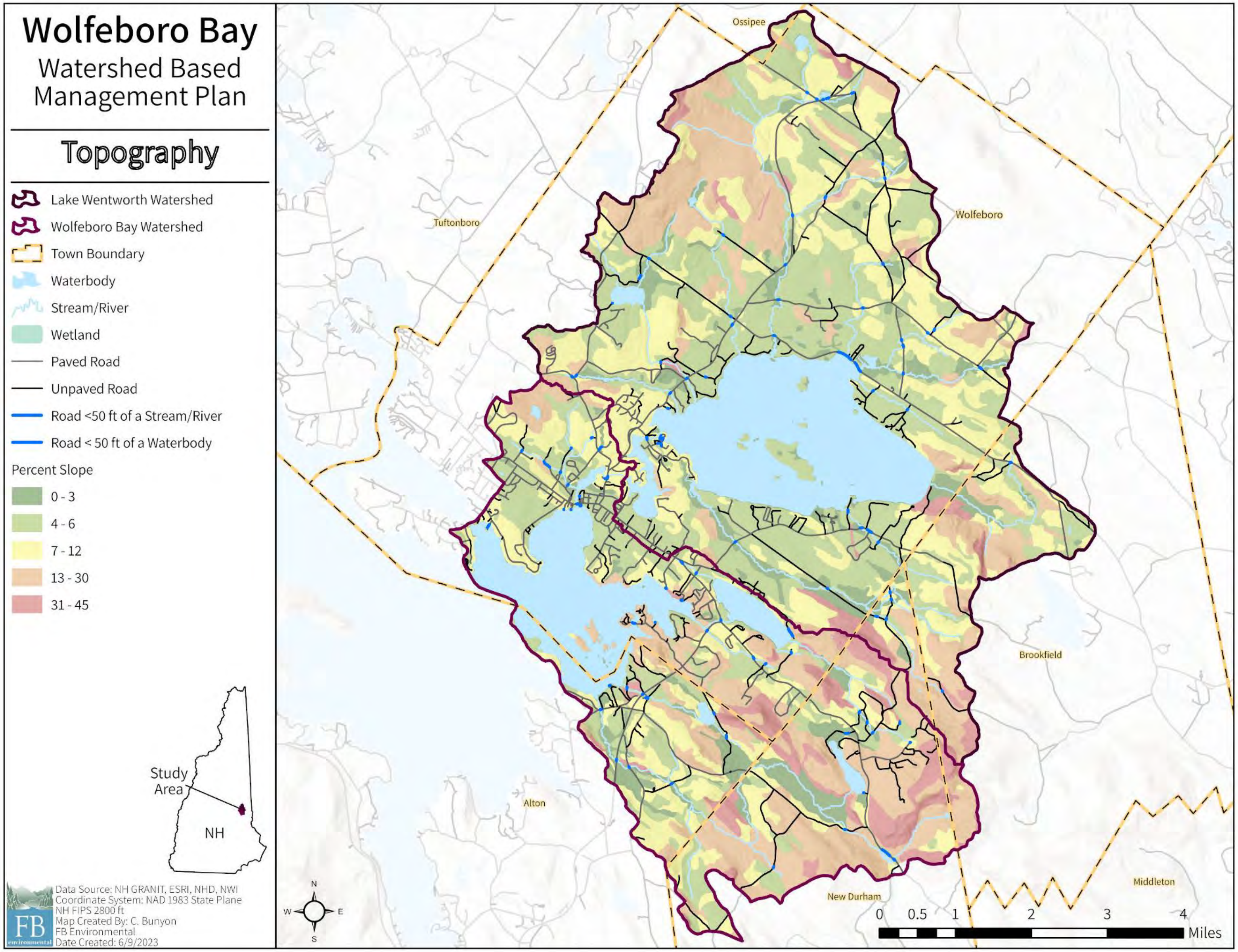
Map A-5. Projected buildings in the Wolfeboro Bay watershed in watershed in Wolfeboro, Alton, New Durham, Brookfield, and Ossipee, NH.



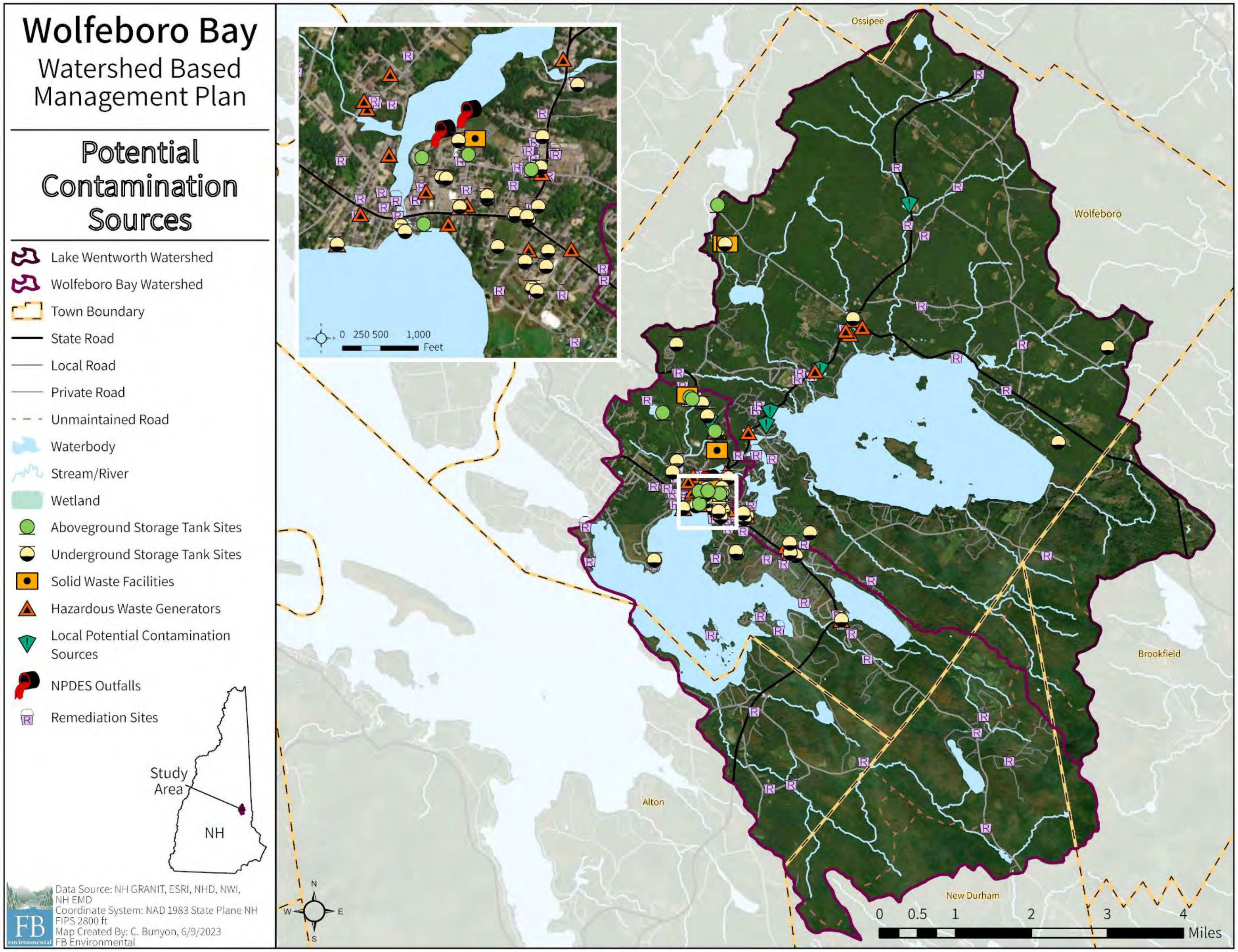
Map A-6. Soil series in the Wolfeboro Bay watershed.



Map A-7. Soil Erosion Hazard in the Wolfeboro Bay watershed.



Map A-8. Topography of the Wolfeboro Bay watershed.



Map A-9. Potential sources of contamination in the Wolfeboro Bay watershed.

Map A-10. Conservation land and High value habitat according to the 2020 New Hampshire Wildlife Action Plan within the Wolfeboro Bay watershed.

APPENDIX B: BMP MATRIX

Table B-1. Site ID, location description, town, primary recommended actions, estimated pollutant load reductions, and estimated implementation costs for the 90 sites identified in the direct Wolfeboro Bay watershed (excluding the Lake Wentworth and Crescent Lake watersheds). Pollutant load reductions and cost estimates are preliminary and are for planning purposes only. Cost estimates are based on pre-COVID19 ranges (adjusted for 2023 inflation), and thus actual construction costs could be highly variable at this time. Sites are priority ranked from 1-90 for lowest to highest cost per pound of phosphorus load reduced with remediation. Sediment loads are calculated only for stabilization sites using the Region 5 model. Sites highlighted in grey were indicated by project engineers, consultants, and/or local stakeholders as having high priority for remediation and/or conceptual BMP designs. Four sites listed at the end of this table were given zero load reductions because the recommended actions were maintenance related.

Site ID	Location	Town	Recommended Actions	TP (kg/yr)	TN (kg/yr)	Sediment (tons/yr)	Est. Low Cost	Est. High Cost	Est. Avg. Cost	Rank
2-23-1	South Main St	Wolfeboro	Stabilization	3.67	7.34	9.52	$15,000	$30,000	$22,500	1
HW-3	Lake Street	Wolfeboro	Stabilization	0.29	0.58	0.75	$8,000	$12,000	$10,000	2
HW-8	Parking at Back Bay docks	Wolfeboro	Treatment	0.09	0.45	--	$38,000	$56,000	$47,000	3
HW-7	Back Bay boat ramp	Wolfeboro	Treatment	0.01	0.06	--	$6,000	$10,000	$8,000	4
HW-1	Town Dock and Boat Ramp	Wolfeboro	Pretreatment	0.05	0.00	--	$32,000	$48,000	$40,000	5
HW-9	Municipal Lot at Back Bay	Wolfeboro	Treatment	0.18	0.92	--	$33,000	$49,000	$41,000	6
*2-21	Rines Rd	Alton	Stabilization	19.86	39.72	51.52	$30,000	$100,000	$65,000	7
1-9	Mountain Hwy Near House 274	New Durham	Treatment, Stabilization	0.22	0.59	0.53	$5,000	$10,000	$7,500	8
*2-18	Winnipesaukee Drive Intersection	Wolfeboro	Stabilization	2.17	4.35	5.64	$25,000	$30,000	$27,500	9
HW-11	Brewster Academy	Wolfeboro	Stabilization	2.31	4.63	6.00	$24,000	$36,000	$30,000	10
1-2	Pond Shoreline Along Kings Hwy Culvert	New Durham	Buffer, Stabilization	1.00	1.98	2.56	$50,000	$75,000	$62,500	11
HW-2	Cate Park	Wolfeboro	Bank Stabilization	0.12	0.23	0.30	$8,000	$12,000	$10,000	12
1-8	Shaws Pond Access	New Durham	Treatment, Buffer	0.21	2.28		$15,000	$20,000	$17,500	13
1-50	North Main St Near House 234	Wolfeboro	Stabilization	0.90	1.80	2.34	$10,000	$20,000	$15,000	14
HW-10	Retention pond at Foss Field and Wolfeboro Shopping Center	Wolfeboro	Treatment	2.96	15.80	--	$432,000	$648,000	$540,000	15
2-12	Main St Near House 460	Wolfeboro	Stabilization	0.63	1.26	1.64	$5,000	$10,000	$7,500	16
1-31	Canopache Rd - Across from Site 1-30	Wolfeboro	Stabilization	1.26	2.52	3.26	$8,000	$15,000	$11,500	17
*1-5	Kings Hwy Near House 227	New Durham	Stabilization	1.64	3.28	4.25	$10,000	$20,000	$15,000	18
1-35	Elm St #2	Wolfeboro	Stabilization, Maintenance	0.12	0.25	0.32	$5,000	$5,000	$5,000	19
1-47	Pleasant Rd Near House 66	Wolfeboro	Stabilization	0.62	1.25	1.62	$5,000	$8,000	$6,500	20

Site ID	Location	Town	Recommended Actions	TP (kg/yr)	TN (kg/yr)	Sediment (tons/yr)	Est. Low Cost	Est. High Cost	Est. Avg. Cost	Rank
2-11	Sewall Rd Near House 95	Wolfeboro	Bank Stabilization	0.94	1.89	2.45	$15,000	$20,000	$17,500	21
1-51	North Main St Near House 209	Wolfeboro	Stabilization	0.56	1.12	1.45	$25,000	$35,000	$30,000	22
1-32	Eagle Trace Rd	Wolfeboro	Stabilization	0.79	1.58	2.05	$15,000	$25,000	$20,000	23
1-20	Sleepy Hollow Rd	Wolfeboro	Stabilization	0.82	1.64	2.13	$20,000	$30,000	$25,000	24
1-14	Copple Crown Rd #2	New Durham	Stabilization	4.51	9.02	11.70	$10,000	$15,000	$12,500	25
1-13	Copple Crown Rd #1	New Durham	Stabilization	1.58	3.16	4.10	$5,000	$10,000	$7,500	26
1-15	Kings Hwy Near Horses	New Durham	Stabilization	0.74	1.48	1.92	$10,000	$15,000	$12,500	27
1-10	Mountain Hwy North of Site 1-09	New Durham	Stabilization	2.89	5.78	7.50	$12,000	$16,000	$14,000	28
HW-4	Main St/Downtown	Wolfeboro	Treatment	0.28	1.51		$76,000	$114,000	$95,000	29
2-14	Near Top of Springfield Pt Rd	Wolfeboro	Stabilization	0.60	1.20	1.55	$5,000	$10,000	$7,500	30
2-20	Route 28 Toward Wolfeboro	Alton	Stabilization	1.07	2.13	2.77	$10,000	$20,000	$15,000	31
2-23	Route 28 Toward Alton #1	Wolfeboro	Stabilization	1.16	2.31	3.00	$12,000	$25,000	$18,500	32
2-15	Springfield Pt Rd - Across from Site 2-14	Wolfeboro	Stabilization	0.77	1.54	2.00	$10,000	$15,000	$12,500	33
1-53	Lakeview Rd	Wolfeboro	Stabilization	0.39	0.77	1.00	$5,000	$8,000	$6,500	34
1-27	Camp Rd	Wolfeboro	Stabilization	0.39	0.77	1.00	$8,000	$12,000	$10,000	35
2-24	Route 28 toward Alton #2	Wolfeboro	Stabilization	0.65	1.30	1.69	$8,000	$15,000	$11,500	36
2-25	Croner of Cross Rd	Wolfeboro	Stabilization	0.07	0.13	0.18	$5,000	$5,000	$5,000	37
1-3	Kings Hwy Near Caverly Rd	New Durham	Stabilization	0.63	1.26	1.63	$10,000	$15,000	$12,500	38
2-22-1	Opposite Sleepy Hollow Rd	Wolfeboro	Treatment	0.36	3.91	--	$5,000	$10,000	$7,500	39
2-24-1	Cross Rd	Wolfeboro	Disconnection, Maintenance	0.05	0.00	--	$5,000	$10,000	$7,500	40
HW-12	Brewster Academy Field	Wolfeboro	Buffer	0.06	0.66	--	$6,000	$10,000	$8,000	41
1-44	Varney Rd Near House 71	Wolfeboro	Stabilization, Maintenance	0.19	0.39	0.50	$5,000	$5,000	$5,000	42
2-9	Sewall Rd	Wolfeboro	Stabilization	0.05	0.09	0.12	$5,000	$5,000	$5,000	43
1-36	Elm St #1	Wolfeboro	Stabilization	0.18	0.36	0.47	$5,000	$5,000	$5,000	44
1-52	North Main St Near House 214	Wolfeboro	Stabilization, Treatment	0.52	4.64	0.31	$12,000	$18,000	$15,000	45
2-22	Oakwood Rd	Wolfeboro	Stabilization	0.17	0.34	0.45	$5,000	$5,000	$5,000	46
1-28	Brewster Heights	Wolfeboro	Stabilization	0.39	0.77	1.00	$20,000	$25,000	$22,500	47
2-8	Sewall Rd Near House 428	Wolfeboro	Stabilization, Maintenance	0.15	0.30	0.39	$5,000	$5,000	$5,000	48
1-32-1	River St #1	Wolfeboro	Stabilization	0.30	0.59	0.77	$10,000	$10,000	$10,000	49

Site ID	Location	Town	Recommended Actions	TP (kg/yr)	TN (kg/yr)	Sediment (tons/yr)	Est. Low Cost	Est. High Cost	Est. Avg. Cost	Rank
1-42	Filter Rd	Wolfeboro	Treatment, Maintenance	0.03	0.20		$5,000	$5,000	$5,000	50
2-16	Springfield Pt Rd - Down the Road from Site 2-15	Wolfeboro	Stabilization	0.20	0.39	0.51	$5,000	$10,000	$7,500	51
1-49	Forest Rd	Wolfeboro	Stabilization	0.34	0.68	0.88	$10,000	$18,000	$14,000	52
1-16	Kings Hwy Near House 410	New Durham	Stabilization	0.11	0.22	0.29	$5,000	$5,000	$5,000	53
1-17	Friar Tuck Way	Wolfeboro	Stabilization	0.11	0.22	0.28	$5,000	$5,000	$5,000	54
2-13	Main St	Wolfeboro	Stabilization	0.42	0.83	1.08	$15,000	$25,000	$20,000	55
1-4	Caverly Road Surface	New Durham	Treatment	0.26	2.61	--	$10,000	$15,000	$12,500	56
1-39	Pine Hill Rd #1	Wolfeboro	Stabilization	0.20	0.41	0.53	$10,000	$10,000	$10,000	57
1-11	St. Moritz Dr - North	New Durham	Stabilization	0.33	0.65	0.85	$10,000	$25,000	$17,500	58
1-48	Intersection of Cricket Hill Rd	Wolfeboro	Disconnection	0.02	0.00	--	$5,000	$5,000	$5,000	59
1-33	River St Across from Site 1-32-1	Wolfeboro	Stabilization	0.08	0.16	0.21	$5,000	$5,000	$5,000	60
1-1	Pond Shoreline Along Kings Hwy	New Durham	Buffer	0.01	0.01	--	$5,000	$5,000	$5,000	61
1-41	Pine Hill Rd Across from Public Works	Wolfeboro	Treatment	0.08	0.46	--	$5,000	$5,000	$5,000	62
1-34	Corner of Ray St	Wolfeboro	Stabilization	0.08	0.16	0.21	$5,000	$5,000	$5,000	63
HW-6	Town Hall	Wolfeboro	Treatment	0.08	0.44		$9,000	$13,000	$11,000	64
2-17	Springfield Pt Rd - Across from Site 2-16	Wolfeboro	Stabilization	0.06	0.12	0.16	$5,000	$5,000	$5,000	65
2-21-1	Corner of Sleepy Hollow Rd #2	Wolfeboro	Treatment, Maintenance	0.01	0.16	--	$5,000	$5,000	$5,000	66
1-19	Kings Hwy Near Electric Department	Wolfeboro	Disconnection	0.01	0.00	--	$5,000	$5,000	$5,000	67
1-6	Kings Hwy Across from Site 1-5	New Durham	Stabilization	0.05	0.11	0.14	$5,000	$5,000	$5,000	68
1-12	St. Moritz Dr - South	New Durham	Stabilization	0.04	0.08	0.11	$5,000	$5,000	$5,000	69
1-46	Oak St Near Sewall Rd	Wolfeboro	Disconnection, Maintenance	0.04	0.00	--	$5,000	$5,000	$5,000	70
1-30	Canopache Rd	Wolfeboro	Stabilization	0.06	0.11	0.15	$5,000	$10,000	$7,500	71
1-18	Kings Hwy Near House 174	Wolfeboro	Stabilization	0.15	0.30	0.39	$15,000	$25,000	$20,000	72
1-37	Across from Site 1-36	Wolfeboro	Stabilization	0.03	0.07	0.09	$5,000	$5,000	$5,000	73
2-7	Sewall Rd Near House 354	Wolfeboro	Disconnection	0.03	0.00	--	$5,000	$5,000	$5,000	74
1-7	Kings Hwy Near House 250	New Durham	Treatment	0.05	0.49	--	$10,000	$10,000	$10,000	75
2-1	Sewall Rd Near House 216	Wolfeboro	Treatment	0.02	0.10	--	$5,000	$5,000	$5,000	76
1-40	Pine Hill Rd #2	Wolfeboro	Treatment	0.03	0.17	--	$10,000	$15,000	$12,500	77

Site ID	Location	Town	Recommended Actions	TP (kg/yr)	TN (kg/yr)	Sediment (tons/yr)	Est. Low Cost	Est. High Cost	Est. Avg. Cost	Rank
1-38	Bay St	Wolfeboro	Disconnection, Maintenance	0.01	0.00	--	$5,000	$5,000	$5,000	78
2-4	Sewall d Near House 268	Wolfeboro	Disconnection, Maintenance	0.002	0.00	--	$5,000	$5,000	$5,000	79
1-21	Corner of Sleepy Hollow Rd #1	Wolfeboro	Disconnection	0.002	0.00	--	$5,000	$5,000	$5,000	80
2-3	Swall Rd Across from Site 2-2	Wolfeboro	Treatment	0.002	0.01	--	$5,000	$5,000	$5,000	81
2-19	Stage Coach Rd	Alton	Disconnection	0.01	0.00	--	$55,000	$65,000	$60,000	82
2-26	Cross Rd and Pleasant Valley Rd	Wolfeboro	Disconnection	0.001	0.00	--	$5,000	$5,000	$5,000	83
1-43	Varney Rd	Wolfeboro	Culvert Repair	0.00	0.00	--	$10,000	$10,000	$10,000	84
1-45	North Main St Near Oak St	Wolfeboro	Maintenance	0.00	0.00	--	$5,000	$5,000	$5,000	85
2-2	Sewall Rd Near House 206	Wolfeboro	Maintenance	0.00	0.00	--	$5,000	$5,000	$5,000	86
2-5	Across from Navy Yard Marina	Wolfeboro	Maintenance	0.00	0.00	--	$5,000	$5,000	$5,000	87
According to the Town of Wolfeboro, the following sites have already been addressed or will be addressed as part of the Town's regular maintenance program.										
HW-5	Walgreens parking lot	Wolfeboro	Treatment	0.12	0.63	--	--	--	--	--
2-10	Pointe Sewall Rd Intersection	Wolfeboro	Stabilization	0.75	1.51	1.96	--	--	--	--
2-6	Sewall Rd Near House 297	Wolfeboro	Treatment, Maintenance	0.005	0.03	--	--	--	--	--
TOTAL:				**62.54**	**149.14**	**150.18[1]**	**$1,407,000**	**$2,103,000**	**$1,755,000**	--

** Indicates sites that were in active construction during the time of the watershed survey.*

[1] Indicates the value is only a summation of sediment loads from stabilization sites. This is an underestimation of the total sediment load reduction potential from these sites within the Wolfeboro Bay watershed.