Alton Bay

Watershed-Based Management Plan

December 2025 - **DRAFT**

Prepared by
FB Environmental Associates

ALTON BAY
WATERSHED-BASED MANAGEMENT PLAN

Prepared by **FB ENVIRONMENTAL ASSOCIATES**
in collaboration with the Lake Winnipesaukee Alliance

December 2025 | **DRAFT**

CONTACT
Pat Tarpey, Former President
Lake Winnipesaukee Alliance
PO Box 1624
Meredith, NH 03253

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ACKNOWLEDGEMENTS

STEERING COMMITTEE

Pat Tarpey, President, Lake Winnipesaukee Alliance
Kristin Bredbury
Tom Diveny
Seth Garland
Dana Huff, P.E., Former engineer for the Town of Alton
Russell Wilder

ADDITIONAL SUPPORT

Bree Rossiter, Conservation Program Manager, Lake Winnipesaukee Alliance
John Flaherty, Watershed Management and Restoration Specialist, Lake Winnipesaukee Alliance

TECHNICAL CONSULTANT STAFF

Forrest Bell, CEO/Owner, FB Environmental Associates
Margaret Mills, Senior Project Manager/Hydrologist, FB Environmental Associates
Laura Diemer, CLM, Senior Project Manager, FB Environmental Associates
Christine Bunyon, Project Manager/GIS Specialist, FB Environmental Associates
Magdalyn Kosalek, Project Manager, FB Environmental Associates
Evan Ma, Assistant Project Manager, FB Environmental Associates
Tim Kirsten, Project Scientist II, FB Environmental Associates
Amelia Wallis, Project Scientist I, FB Environmental Associates
Don Kretchmer, CLM, DK Water Resource Consulting

SPECIAL THANKS

Bob Craycraft, University of New Hampshire Lakes Monitoring Program Coordinator

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

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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
ILF	In-Lieu Fee
KG	Kilogram
LCHIP	Land and Community Heritage Investment Program
LID	Low Impact Development
LLMP	Lay Lakes Monitoring Program
LLRM	Lake Loading Response Model
LRCT	Lakes Region Conservation Trust
RPC	Lakes Region Planning Commission
LWCF	Land and Water Conservation Fund
M	Meter
NAWCA	North American Wetlands Conservation Act
NFRF	Northeast Forest and River Fund
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
NHLCD	New Hampshire Land Cover Database
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPS	Nonpoint Source Pollution

ACRONYM	DEFINITION
NRCS	Natural Resources Conservation Service
NRI	Natural Resources Inventory
NWI	National Wetlands Inventory
PAS	Potentially Attaining Standards
PCR	Primary Contact Recreation
PCS	Potential Contamination Source
PFAS	Per- and polyfluoroalkyl substances
PNS	Potentially Not Supporting
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
TKN	Total Kjeldahl Nitrogen
TP	Total Phosphorus
UNH	University of New Hampshire
USLE	Universal Soil Loss Equation
WMP	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.

Areal water load (m/yr) is the total annual volume of water (m^3) entering a waterbody from all sources (rain, runoff, groundwater, and streams) normalized to (or divided by) the lake's surface area (m^2). It represents the depth of water added to the lake surface annually if all inflow were evenly distributed over that surface.

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 sensitive aquatic organisms and stimulate the 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 times, 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 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.

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.

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.

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

Alton Bay is a 1,352-acre bay located within the southern portion of Lake Winnipesaukee, draining a 32,072-acre watershed within the economically vital Lakes Region of central New Hampshire. The watershed is divided into four primary sub-watersheds: the Merrymeeting River (16,562 acres), Merrymeeting Lake (7,107 acres), Alton Bay Direct Drainage (6,080 acres), and Watson Brook (2,323 acres) watersheds. Alton Bay is located within the town of Alton, while its watershed extends into New Durham, and to a lesser extent, into Brookfield, Middleton, and Gilmanton. Alton Bay is fed by upstream waterbodies including Merrymeeting Lake, Marsh Pond, Jones Dam Pond, Downing Pond, Merrymeeting River - Alton Power Dam Pond, and Meadow Dam Pond. From the dividing line of Alton Bay, water mixes with the rest of Lake Winnipesaukee through The Broads.

The Problem

Because of its size and complexity, maintaining the health of Lake Winnipesaukee depends on developing and implementing watershed-based management plans (WMPs) for all contributing watersheds, in collaboration with the many towns they span. Alton Bay is one of the last major watersheds still in need of a comprehensive WMP.

Historically, Alton Bay has experienced generally excellent water quality. Protecting this high water quality is critical given Lake Winnipesaukee's importance to New Hampshire's economy and natural heritage. However, Lake Winnipesaukee is formally listed as impaired for aquatic life integrity (ALI) on the 303(d) New Hampshire List of Impaired Waters for the 2024 cycle. The impairment (4A-M) is due to low pH and the presence of non-native aquatic plants. NHDES also assessed alkalinity and non-native fish, shellfish, or zooplankton as ALI parameters potentially not supporting (3-PNS). Although Lake Winnipesaukee is not listed as impaired for primary contact recreation (PCR), cyanobacteria hepatotoxic microcystins are potentially not supporting (3-PNS) state thresholds.

Recently, cyanobacteria blooms have emerged as a significant concern in Lake Winnipesaukee, including Alton Bay. Between July and September 2023, NHDES issued two cyanobacteria watches for Alton Bay, lasting seven (7) and 21 days. In August-September 2024, a 30-day watch was issued during a bloom event that affected much of the lake. Both the 21-day and 30-day advisories were associated with *Gloeotrichia*, a type of cyanobacteria that produces toxins harmful to humans, pets, and wildlife. These blooms are occurring despite generally low nutrient levels, highlighting the sensitivity of the lake to additional stressors. Anthropogenic inputs such as stormwater runoff, shoreline erosion from increased boat traffic and wave action, and other land use impacts can affect the health of the lake, especially as climate change drives more frequent extreme precipitation events and extends the ice-free period on lakes.

Waterbodies upstream of Alton Bay also influence its water quality by contributing nutrients to the lake. While Merrymeeting Lake remains one of the clearest lakes in New Hampshire, other upstream waterbodies—Marsh Pond, Jones Dam Pond, Downing Pond, and Mill Pond—are impaired for primary contact recreation (e.g., swimming, water skiing) due to elevated levels of cyanobacteria hepatotoxic microcystins. Toxic blooms are often indicative of enhanced nutrient loading, especially phosphorus, from both point source (PS) and nonpoint source (NPS) pollution such as stormwater runoff from developed and agricultural land uses. For example, the 2019 Merrymeeting River & Lake Watershed Management Plan estimated that discharges from the Powder Mill State Fish Hatchery contribute 342 kg of phosphorus annually (67% of the total load) to the Merrymeeting River, which flows into Marsh Pond. As a result, Marsh Pond is additionally listed as impaired for aquatic life integrity due to elevated chlorophyll-a and phosphorus concentrations.

Cyanobacteria blooms are typically spurred by a combination of warming waters and elevated nutrient inputs. In the Alton Bay watershed, key phosphorus sources include stormwater runoff from impervious surfaces, shoreline erosion, road and ditch erosion, disturbed soils from construction, excessive fertilizer application, failed or improperly functioning septic systems, unmitigated agricultural activities, and waste from pets, livestock, and wildlife. Thirty-six (36) problem sites were identified in the watershed during a field survey, and the main issues found were road shoulder and ditch erosion, clogged stormwater infrastructure, and untreated stormwater runoff from impervious surfaces. Additionally, 272 shorefront properties were identified as having some impact on water quality due to evidence of erosion and lack of vegetated buffer. These are in addition to the 78 problem sites and 285 prioritized shoreline properties identified in the *Merrymeeting River & Lake Watershed-Based Management Plan* (FBE, 2019), which also fall within Alton Bay's watershed. Lake modelling 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 Alton 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 environmental variability. In the Alton Bay watershed, watershed runoff combined with baseflow is the largest source of phosphorus (89% of the total load), including watershed loads from Merrymeeting Lake (53%), the direct land area around Alton Bay (18%), and mixing with other areas of Lake Winnipesaukee (18%).

The Goal

The goal of the Alton Bay WMP is to improve the water quality of Alton Bay such that it continues to meet state water quality standards for the protection of aquatic life integrity (ALI) and primary contact recreation (PCR) and substantially reduces the likelihood of harmful cyanobacteria blooms. This goal will be achieved by accomplishing the following objectives:

OBJECTIVE 1: Reduce phosphorus loading from **existing development** by 30% (492 kg/yr) to Alton Bay to improve average in-lake summer total phosphorus concentration of 4.5 ppb.

OBJECTIVE 2: Mitigate (prevent or offset) phosphorus loading from **future development** by 367 kg/yr to Alton Bay to maintain average summer in-lake total phosphorus concentration in the next 10 years (2035).

The Solution

In collaboration with the Lake Winnipesaukee Alliance (LWA), FB Environmental Associates (FBE) was contracted to develop a WMP to better understand and protect the water quality of Alton Bay in Lake Winnipesaukee. As part of the development of the WMP, a build-out analysis, land-use model, water quality and assimilative capacity analysis, septic system database, shoreline survey, and watershed survey were completed 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 the Steering Committee comprised of key watershed stakeholders (see Acknowledgements). The following actions were recommended to meet the established water quality goal and objectives for Alton Bay:

WATERSHED STRUCTURAL BMPS: Sources of phosphorus from watershed development should be addressed through installation of stormwater controls, stabilization techniques, buffer plantings, etc. as recommended for 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 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 the University of New Hampshire Extension's Lakes Lay Monitoring Program (LLMP), should continue the annual monitoring program and consider incorporating additional monitoring recommendations laid out in this plan, such as spiny water flea monitoring. The LLMP should remain the primary lab for processing water quality samples from Lake Winnipesaukee due to their lower method detection limits for total phosphorus.

EDUCATION AND OUTREACH: LWA 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 construction; 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 connected habitat corridor parcels; and improving agricultural practices. Future development should also be considered as a pollutant source and potential threat to water quality. Alton 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 largely by the Lake Winnipesaukee Alliance, with assistance from a diverse stakeholder group, including representatives from municipalities (e.g., select boards, planning boards), conservation commissions, state and federal agencies (e.g., NH State Parks) or organizations, nonprofits, land trusts, schools and community groups, local business leaders, and landowners. **The cost of successfully implementing the plan is estimated at $4-5.5 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 Alton Bay is now eligible for federal watershed assistance grants.

Important Notes

The success of this plan is dependent on the continued effort of volunteers and a strong and diverse stakeholder group 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. We encourage communities to review these priorities and be creative in their recommended approaches to addressing stormwater management and water quality issues. Many of the recommended actions in these plans can be scaled and adapted to meet the needs of individual participating communities.

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. The joint committee 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 Alton Bay long into the future.

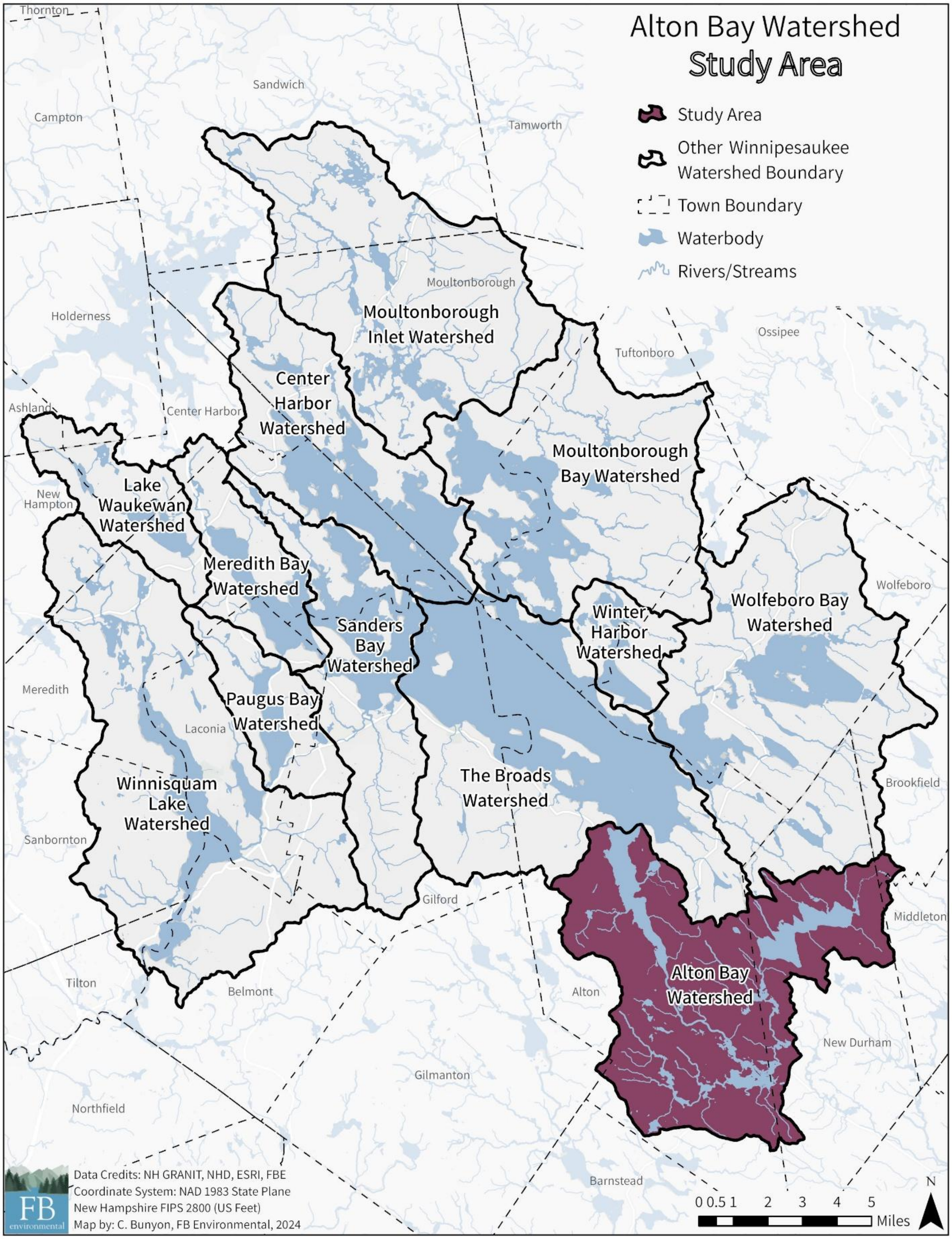


Figure 1. Location of the Alton Bay watershed in relation to the rest of Lake Winnipesaukee's watersheds.

1 INTRODUCTION

1.1 WATERBODY DESCRIPTION AND LOCATION

Alton Bay is a 1,352-acre (548-hectare) bay within the southern portion of Lake Winnipesaukee (Figure 1). Including the Merrymeeting Lake and River watershed, the Alton Bay watershed spans 32,072 acres (12,979 hectares) into the towns of Alton (71%), New Durham (28%), and Brookfield, Middleton and Gilmanton (<1% each). Alton Bay is primarily fed by upstream rivers and waterbodies, with most of the inflow coming from the Merrymeeting River, which drains the southern and eastern portions of the watershed, and Watson Brook, which drains the western side of the bay. Other named streams within the watershed include Coffin Brook and Jones Brook, both of which join the Merrymeeting River. Additional unnamed perennial and intermittent streams flow directly into the lake. From the dividing line of Alton Bay, water mixes with the Broads and 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 Alton Bay watershed lies in a temperate zone influenced by converging weather patterns—warm, moisture-laden air from the south and cooler, drier air from the north. These interactions give rise to a range of weather events, including heavy snowfall, nor'easters, severe thunderstorms, and the occasional hurricane. The area experiences moderate to high rainfall and snowfall, averaging 52 inches of precipitation annually between 1994 and 2023. (Data were collected for this period from Daymet which interpolates weather data at a specific location from nearby weather stations.) Annual precipitation has varied over the 30-year period, showing no significant increasing or decreasing trend (using the *rkt* package in R Studio). Average, minimum and maximum annual temperature values have significantly increased during the same time frame ($p < 0.05$) (Figure 2).

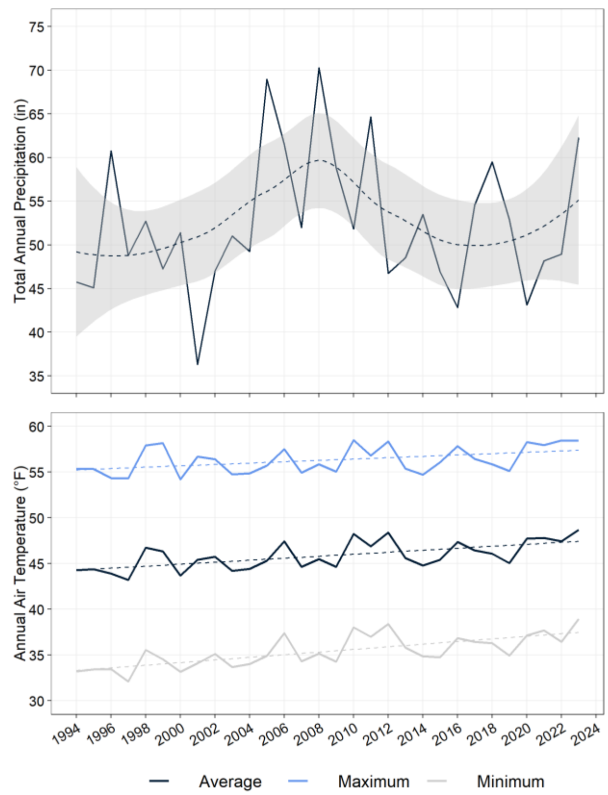


Figure 2. Total annual precipitation and average, maximum, and minimum air temperature for the Alton Bay watershed from 1994–2023. Data retrieved from Daymet (2024). The dashed line and grey shaded area for precipitation represents the Locally Estimated Scatterplot Smoothing (LOESS) regression and 95% confidence intervals, respectively. The dashed lines for air temperature indicate a statistically significant increasing trend ($p < 0.05$).

The highest elevation in the watershed, approximately 494 feet above sea level, is in its easternmost region near the intersection of New Durham, Brookfield and Middleton. Additional high terrain is found west of Alton Mountain Road. Lake Winnipesaukee's shoreline in Alton Bay is approximately 154 feet above sea level. These elevation measurements were derived from digital elevation models provided by NH GRANIT.

The watershed is primarily covered by mixed forest, consisting of both conifers (e.g., white pine, eastern hemlock) and deciduous trees (e.g., beech, oak, maple, ash, birch, and aspen). Peatlands and marshes also cover a large area within the vicinity of the Merrymeeting River system. This diverse habitat supports a variety of wildlife, including land mammals such as deer, moose, black bear, coyote, bobcat, fisher, fox, raccoon, weasel, porcupine, mink, chipmunks, squirrels, and bats. Water mammals include muskrat, otter, and beaver, while reptiles and amphibians (both terrestrial and aquatic) include turtles, snakes, frogs, and salamanders. The area is also home to numerous insect and fish species, as well as birds such as herons, loons, gulls, geese, multiple species of ducks[1], wild turkeys, ruffed grouse, cormorants, bald eagles, osprey and song birds. The Towns of Alton and New Durham are home to a variety of state-listed threatened (T) and endangered (E) wildlife species, including the common loon (T), purple martin (T), spotted turtle (T), Blanding's turtle (E), eastern box turtle (E), and bridle shiner (T) (NH NHB, 2020).

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

1.2 WATERSHED PROTECTION GROUPS

The Lake Winnipesaukee Alliance (LWA) is a non-profit organization with a mission "*dedicated to protecting the water quality and natural resources of Lake Winnipesaukee and its watershed now and for the future. Using education and science, we're relentless in our pursuit of the best policies and practices to ensure a healthy, vibrant Lake for residents, business owners, and visitors, today and for generations to come.*" LWA serves the 14 communities located in Belknap and Carroll counties. LWA is led by several paid staff and a volunteer Board of Directors.

The Belknap County Conservation District (BCCD), the Strafford County Conservation District (SCCD) and the Carroll County Conservation District (CCCD) are three of 10 county conservation districts in New Hampshire that operate as resource management agencies and a subdivision of local governments. BCCD's mission is to "*help landowners and communities conserve the natural resources of Belknap County.*" The mission of SCCD is "*to conserve and sustain the natural resources through management, landowner assistance and educational outreach*". CCCD focuses on "*water quality, erosion & sedimentation, wildlife habitats, health of forests & wetlands, non-point source pollution, and storm water & flooding.*" All three 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. Alton and Gilmanton are in the BCCD service area, New Durham and Middleton are in the SCCD service area, and Brookfield is in the CCCD service area.

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.

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 Alton Bay watershed include those of Alton, New Durham, Gilmanton, Middleton, and Brookfield.

NH LAKES has the mission to "*restore and preserve the health of New Hampshire's lakes. Our vision is a New Hampshire where all our lakes are clean and healthy, and caring for them is a way of living, doing business, and governing.*"

The University of New Hampshire Lakes Lay Monitoring Program engages volunteers and local groups in collecting and analyzing water quality data for lakes across New Hampshire, including Lake Winnipesaukee. The data collected support informed decision-making for lake management and protection strategies.

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-based management 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 Alton Bay Watershed-Based Management Plan (WMP) is to guide implementation efforts over the next 10 years (2026–2035) to improve the water quality of the Alton Bay section of Lake Winnipesaukee such that it meets state water quality standards for the protection of aquatic life integrity (ALI) and primary contact recreation (PCR) and substantially reduces the likelihood of harmful cyanobacteria blooms in the lake.

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 2.5), 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 Steering 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 FBE, LWA, representatives from the advisory committee and participating municipalities, 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 stakeholders, except as they relate to the watershed plan development.

- May 22, 2024: Kick-off meeting with the public to introduce the watershed planning process at the Alton Town Hall.
- October 20, 2025: FBE presented the water quality analysis, build-out analysis, modeling results and water quality goal to the Advisory Committee at the Alton Town Hall.
- November 20, 2025: FBE presented the draft action plan to the Advisory Committee via Zoom.

1.4.2 Final Public Presentation

A final public presentation was held virtually on December 17, 2025, to summarize the analyses and recommendations detailed in the plan. An opportunity for public feedback on the plan was offered.

1.5 INCORPORATING EPA'S NINE ELEMENTS

EPA guidance lists nine components that are required within a WMP 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: Section 3** highlights known sources of NPS pollution to Alton Bay and describes 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, 3, and 5** quantify the sources of phosphorus load to Alton Bay, calculate the pollutant load reductions that could be achieved by identified management measures, and determine 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** include descriptions 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: Sections 4 and 5** describe 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 Alton 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 4.4 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 Alton 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.

Alton Bay (left) at the Merrymeeting River inlet (right). Photo taken by Harrison Flagg, 2024. Used with permission.

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 Alton 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. **Primary contact recreation (PCR) and aquatic life integrity (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 in the State of New Hampshire**. Additionally, from 1976 to 2009, 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 Alton Bay, the NHDES Lake Trophic Survey Reports (1979, 1984, 1990, 2001) classify the lake as oligotrophic.

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**, and toxins) 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 Alton Bay watershed contains seven lake, pond, or impoundment assessment units: Lake Winnipesaukee, Merrymeeting Lake, Marsh Pond, Jones Dam Pond, Downing Pond, Merrymeeting River – Alton Power Dam Pond, and Mill Pond (Table 1). All seven are formally listed as impaired for either ALI or PCR on the 303(d) New Hampshire List of Impaired Waters for the 2024 cycle (NHDES, 2024). Two additional small waterbodies in the watershed, Bear Pond and Meadow Dam Pond, lack sufficient data for an assessment decision. In addition, the NH Statewide Mercury Advisory to limit consumption of fish applies to all assessment units (NHDES, 2021). Although Lake Winnipesaukee is not listed as impaired for PCR, cyanobacteria hepatotoxic microcystins are potentially not supporting state thresholds, and cyanobacteria blooms have recently emerged as a significant concern, as described in Section 0.

Table 1. NHDES assessment units covering lakes/ponds within the Alton Bay watershed and their associated water quality rating as reported on the NHDES 2024 303(d) list.

Assessment Unit Name	**AUID**	**Impaired Designated Use**	**Parameter***
LAKE WINNIPESAUKEE	NHLAK700020110-02-19	ALI	pH, non-native aquatic plants
MERRYMEETING LAKE	NHLAK700020102-03	ALI	pH
MARSH POND	NHIMP700020102-01-02	ALI and PCR	Chlorophyll-a, pH, total phosphorus, cyanobacteria hepatotoxic microcystins
JONES DAM POND	NHIMP700020102-01-01	ALI and PCR	Non-native aquatic plants, cyanobacteria hepatotoxic microcystins
DOWNING POND	NHLAK700020102-02	PCR	Cyanobacteria hepatotoxic microcystins
MERRYMEETING RIVER - ALTON POWER DAM POND	NHIMP700020102-02	ALI	pH
MILL POND	NHLAK700020102-04	PCR	Cyanobacteria hepatotoxic microcystins

**Lake Winnipesaukee potentially not supporting for alkalinity and non-native fish, shellfish, or zooplankton, as well as for cyanobacteria hepatotoxic microcystins for PCR. Merrymeeting Lake potentially not supporting for alkalinity. Marsh Pond potentially not supporting dissolved oxygen. Jones Dam Pond potentially not supporting for total phosphorus. Merrymeeting River – Alton Power Dam Pond potentially not supporting for cyanobacteria hepatotoxic microcystins (for PCR). Mill Pond potentially not supporting ALI parameters alkalinity, chlorophyll-a, and total phosphorus.*

2.1.2 Water Quality Data Collection

Data for this assessment were acquired from NHDES's Environmental Monitoring Database in February 2024. Additional data collected by the UNH Center for Freshwater Biology field team and Lakes Lay Monitoring Program (LLMP) volunteers in the Alton Bay watershed were provided by Bob Craycraft in April 2024. As such, this data analysis focuses on the period 2014–2023, the 10 most recent years at the time of assessment. Table 2 summarizes the available data for the Alton Bay Deep Spot, 25 Alton, and Pavillion stations for this period. The number of samples for most water quality parameters is relatively low compared to other lakes in New Hampshire, but sampling frequency has increased since 2022 and continued through 2024. A summary of 2024 water quality data is provided Section 2.4.

Table 2. Summary of 2014–2023 sampling data for total phosphorus (TP), chlorophyll-a (Chl-a), Secchi Disk transparency (SDT), dissolved oxygen (DO) and temperature (T) profiles, chloride, and specific conductivity at monitoring sites in Alton Bay with recent data collection. Sample size (*n*) refers to the number of unique sampling dates for each parameter.

Site Name	Lake Winnipesaukee, Alton Bay - Deep Spot	Lake Winnipesaukee, Alton Bay -Station 25	Lake Winnipesaukee, Alton Bay -Pavillion
Site ID	WINALTD	WAB25AL	WABPAPL
Years Sampled TP *(n)*	2015, 2022, 2023 (10)	2014, 2015, 2017, 2022, 2023 (32)	2014, 2015, 2018, 2022, 2023 (13)
Years Sampled Chl-a *(n)*	2022, 2023 (9)	2014, 2015, 2017, 2022, 2023 (32)	2014, 2015, 2018, 2022, 2023 (13)
Years Sampled SDT *(n)*	2016–2023 (16)	2014, 2015, 2017, 2022, 2023 (32)	2014, 2015, 2018, 2022, 2023 (13)
Years Sampled DO-T Profile *(n)*	2023 (2)	2014, 2015, 2023 (4)	2014, 2015, 2018, 2023 (5)
Years Sampled Chloride *(n)*	2021–2023 (12)	2022, 2023 (9)	2022, 2023 (9)
Years Sampled Specific Conductivity *(n)*	2021–2023 (12)	2015, 2022, 2023 (10)	2015, 2018, 2022, 2023 (12)

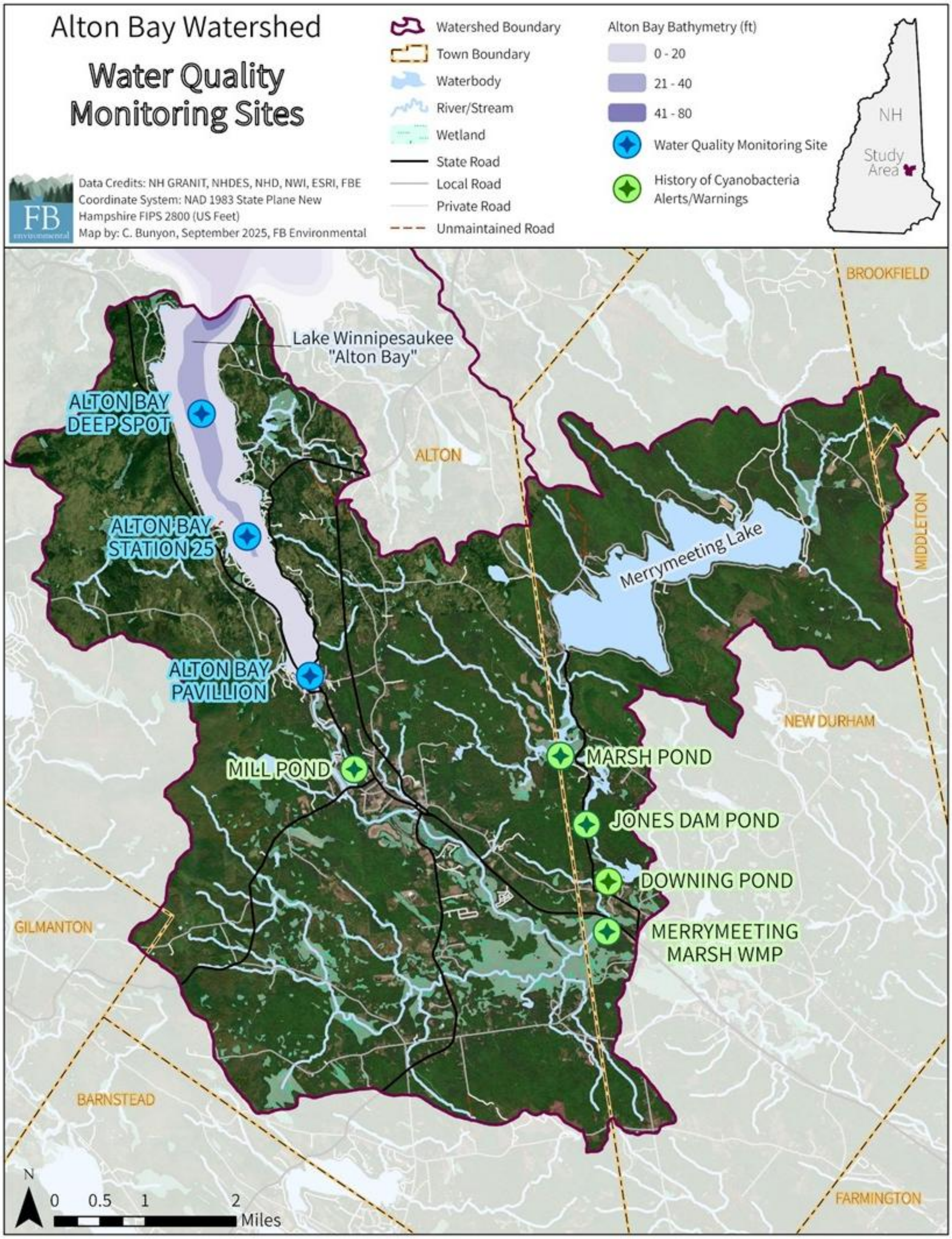


Figure 3. Map of the water quality monitoring sites analyzed in the Water Quality Analysis (blue) with the locations of cyanobacteria advisories/warnings (green).

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 often the result of human disturbance or other impacts to the lake's watershed.

At the Alton Bay deep spot, analysis of long-term and recent total phosphorus levels shows generally similar values in the epilimnion, metalimnion and hypolimnion (medians of 5.3–6.0 ppb; Figure 4). The limited collection of total phosphorus data in the metalimnion and hypolimnion in recent years constrains the ability to detect potential internal loading patterns over time. At Alton Bay Station 25, long-term median total phosphorus concentrations are similar between the epilimnion (5.7 ppb) and metalimnion (5.4 ppb), although the epilimnion shows a wider range, reaching a maximum of 70 ppb (Figure 5). In recent years, however, concentrations at this site have been more consistent, ranging from 4.2 to 9.8 ppb. The Pavillion station is not deep enough to stratify, but recent total phosphorus values there are marginally higher than at the other two stations (median of 8.5 ppb; Figure 5).

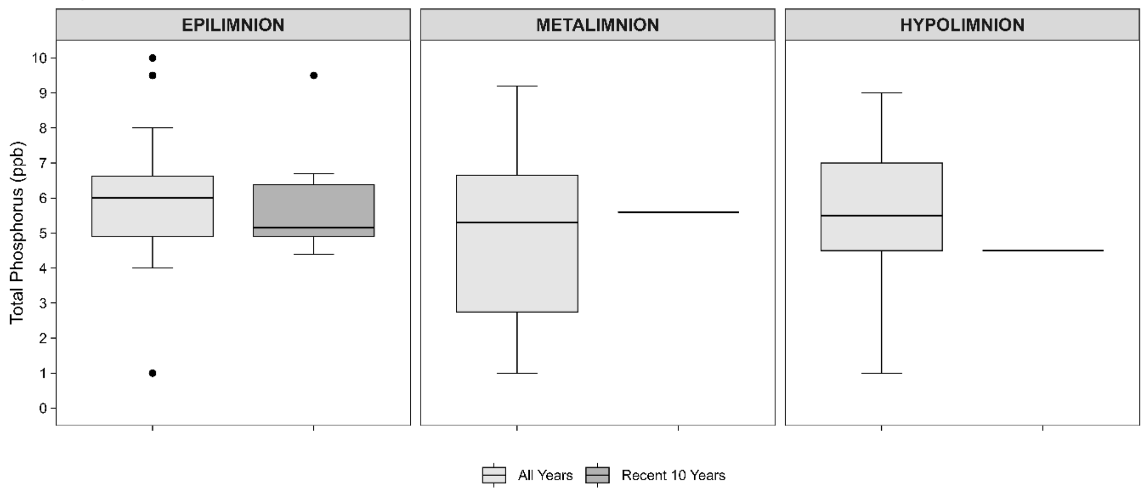


Figure 4. Boxplots showing median total phosphorus concentration in the epilimnion, metalimnion, and hypolimnion of the Alton Bay deep spot of Lake Winnipesaukee (WINALTD). Data are shown for all available years (1976–2023) as well as the most recent 10 years only (2014–2023).

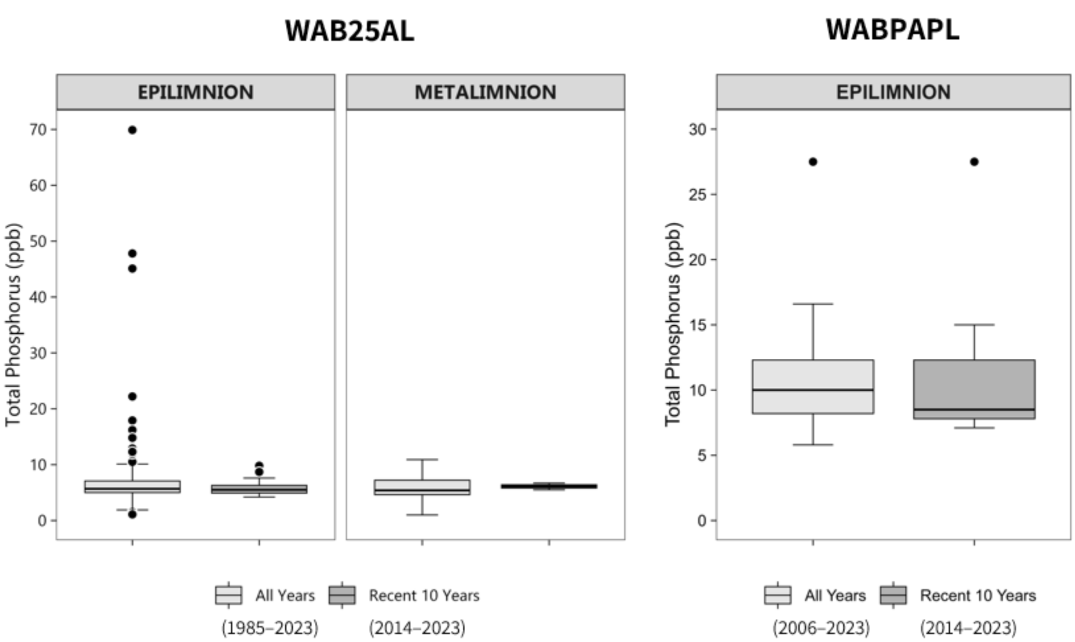


Figure 5. Boxplots showing median total phosphorus concentration in the epilimnion and metalimnion of Alton Bay Station 25 (WAB25AL; left) and in the epilimnion at the Pavillion station (WABPAPL; right), for both the recent period and all years of data.

No statistically significant trends were found for total phosphorus, chlorophyll-a, or Secchi Disk transparency at the Alton Bay deep spot of Lake Winnipesaukee for the available time period, 1976–2023 (Figure 6). No trend tests could be conducted for the most recent 10 years alone, because there were fewer than 10 data points. Caution should therefore be used when interpreting the trophic state indicator data, given that only one or two samples for total phosphorus and chlorophyll-a have been collected per decade at the Alton Bay Deep Spot.

Long-term trophic state indicator datasets are more complete at Alton Bay Station 25 and the Pavillion (Figure 7 and Figure 8). At Station 25, no significant trends were detected in epilimnetic phosphorus or chlorophyll-a from 1983–2023; however, Secchi Disk transparency increased significantly ($p = 0.02$, $n = 35$), indicating improved water clarity. At the Pavillion station, no significant trends were observed in any trophic state parameter.

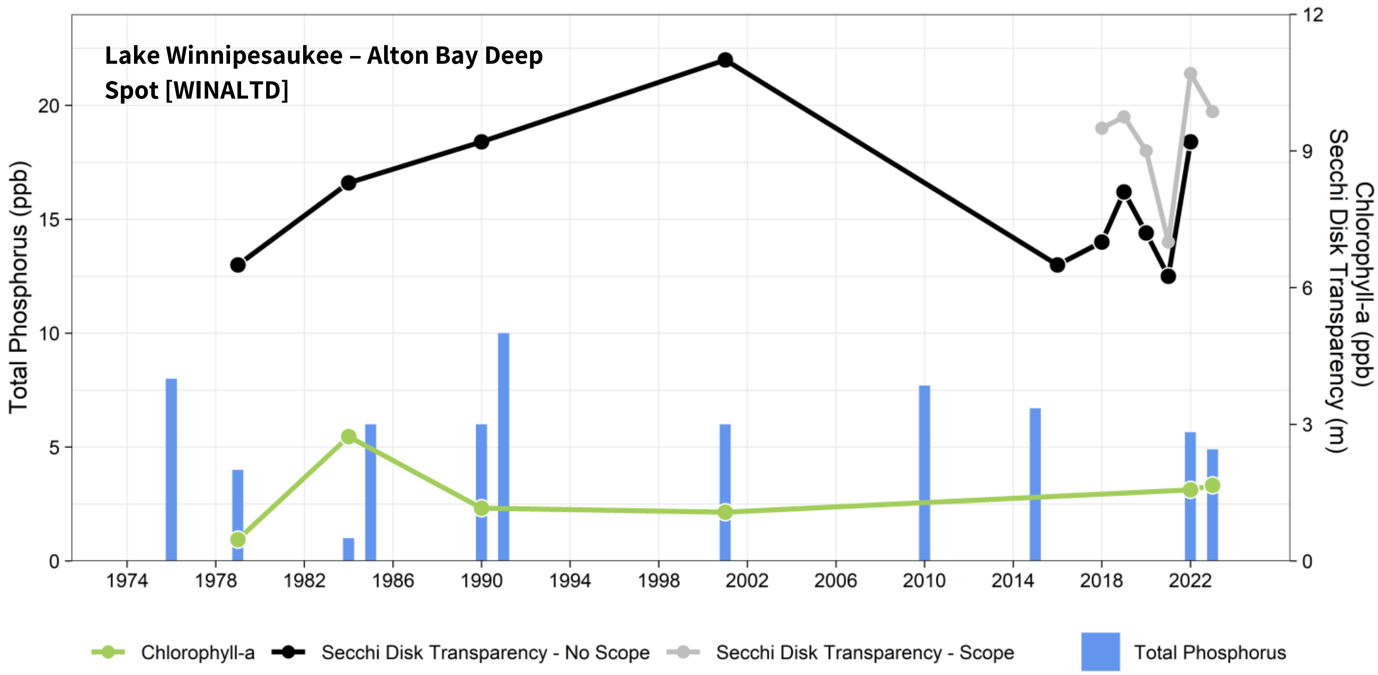


Figure 6. Median epilimnion (2 meters) total phosphorus, median composite epilimnion (0–6 meters) chlorophyll-a, and median water clarity (Secchi Disk transparency for scope and no scope methods) measured at Alton Bay between May 24th and September 15th from from 1976–2023 for the deep spot station (WINALTD). No statistically significant trends in epilimnion total phosphorus or no-scope Secchi Disk transparency (the only metrics with 10 or more data points) were detected from the Mann-Kendall nonparametric trend test using the *rkt* package in R Studio.

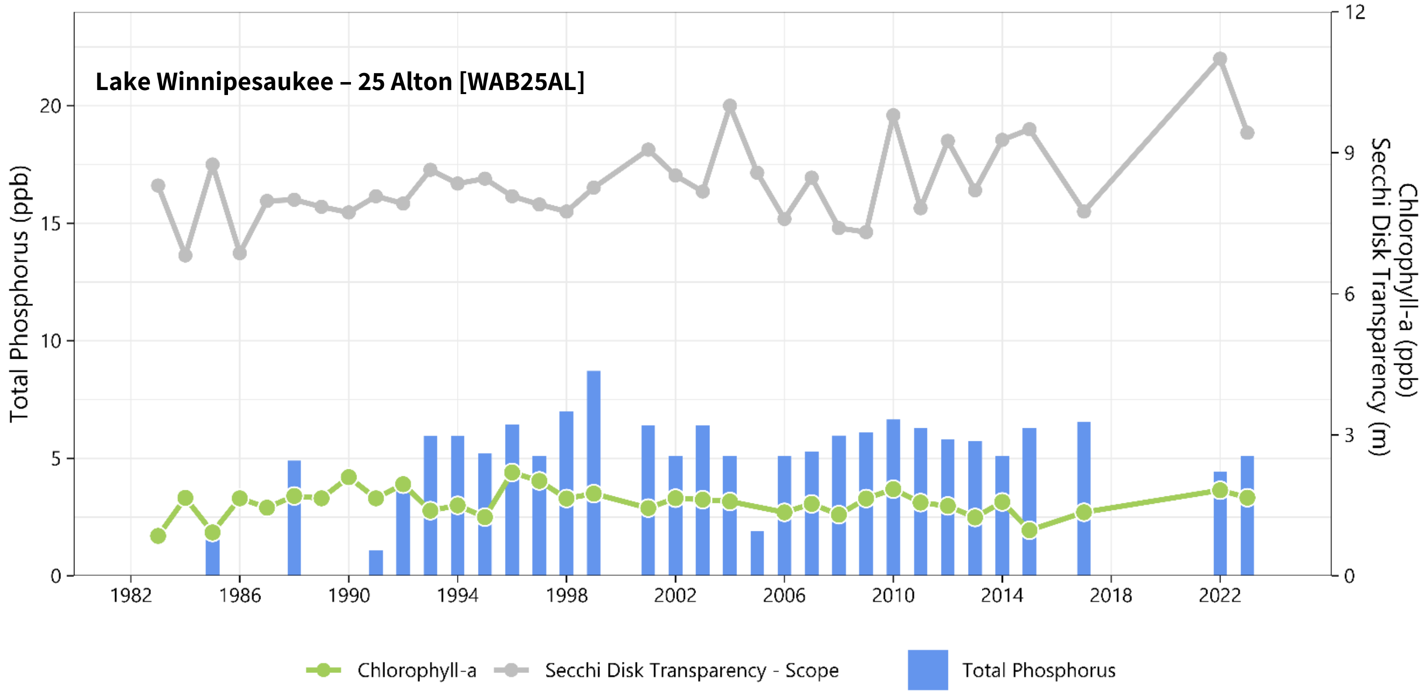


Figure 7. Median epilimnion (2 meters) total phosphorus, median composite epilimnion (0–8 meters) chlorophyll-a, and median water clarity (Secchi Disk transparency using a scope) measured at the 25 Alton station (WAB25AL) between May 24th and September 15th from 1983–2023. A statistically increasing trend in Secchi Disk transparency (p = 0.02, n = 35) was detected using the Mann-Kendall nonparametric trend test using the *rkt* package in R Studio.

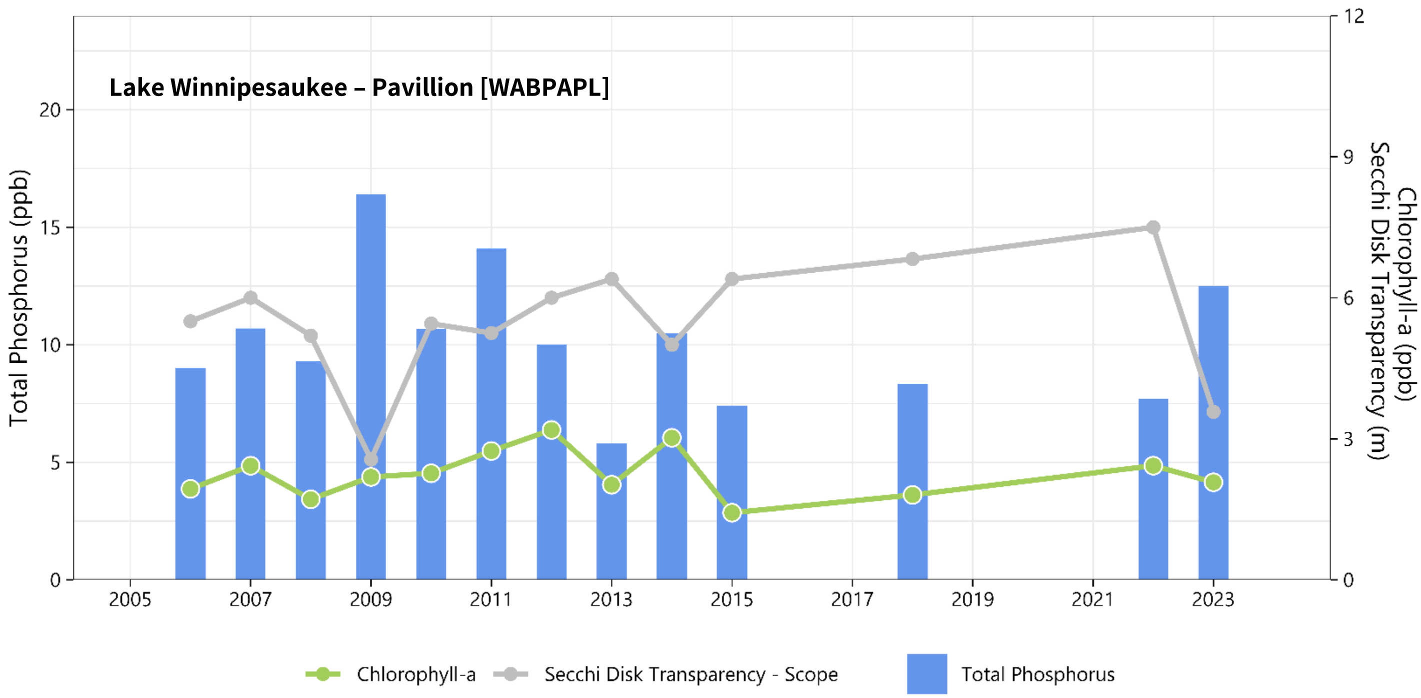


Figure 8. Median epilimnion (2 meters) total phosphorus, median composite epilimnion (0–9 meters) chlorophyll-a, and median water clarity (Secchi Disk transparency using a scope) measured at Alton Bay Pavillion station (WABPAPL) between May 24th and September 15th from 2006–2023. The Mann-Kendall nonparametric trend test (R *rkt* package) detected no statistically significant trends in any parameter.

2.1.4 Dissolved Oxygen & Water Temperature

Depletion of dissolved oxygen is a common occurrence in the deepest part of New Hampshire 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 more dense, 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 other sensitive aquatic organisms. In addition, **anoxia** (low dissolved oxygen) at lake bottom can result in the release of sediment-bound phosphorus (called **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 (lakes that mix twice per year) 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 9 shows temperature and dissolved oxygen profiles at the Alton Bay Deep Spot averaged across sampling dates (1990, 2001, and two profiles in 2023, with additional dissolved oxygen measurements taken in 1979 and 1984) during thermal stratification largely in summer (between spring and fall **turnover**). The median values from the 2023 profiles are highlighted in this figure and show a similar pattern to the medians calculated from the full sampling period. The change in temperature, seen most dramatically between 6 and 12 m, indicates thermal stratification in the water column. A very slight increase in dissolved oxygen between 7 and 14 m (near or at the top of the thermocline where microorganisms can be neutrally buoyant) indicates photosynthetic activity by phytoplankton. The average dissolved oxygen does not drop below the 2-ppm threshold, which indicates internal loading under anoxic conditions was unlikely to occur in the time period these measurements were collected. As with the trophic state indicator data, dissolved oxygen and temperature profile data in the Alton Bay Deep Spot are very limited, with no profiles collected in the 2010s.

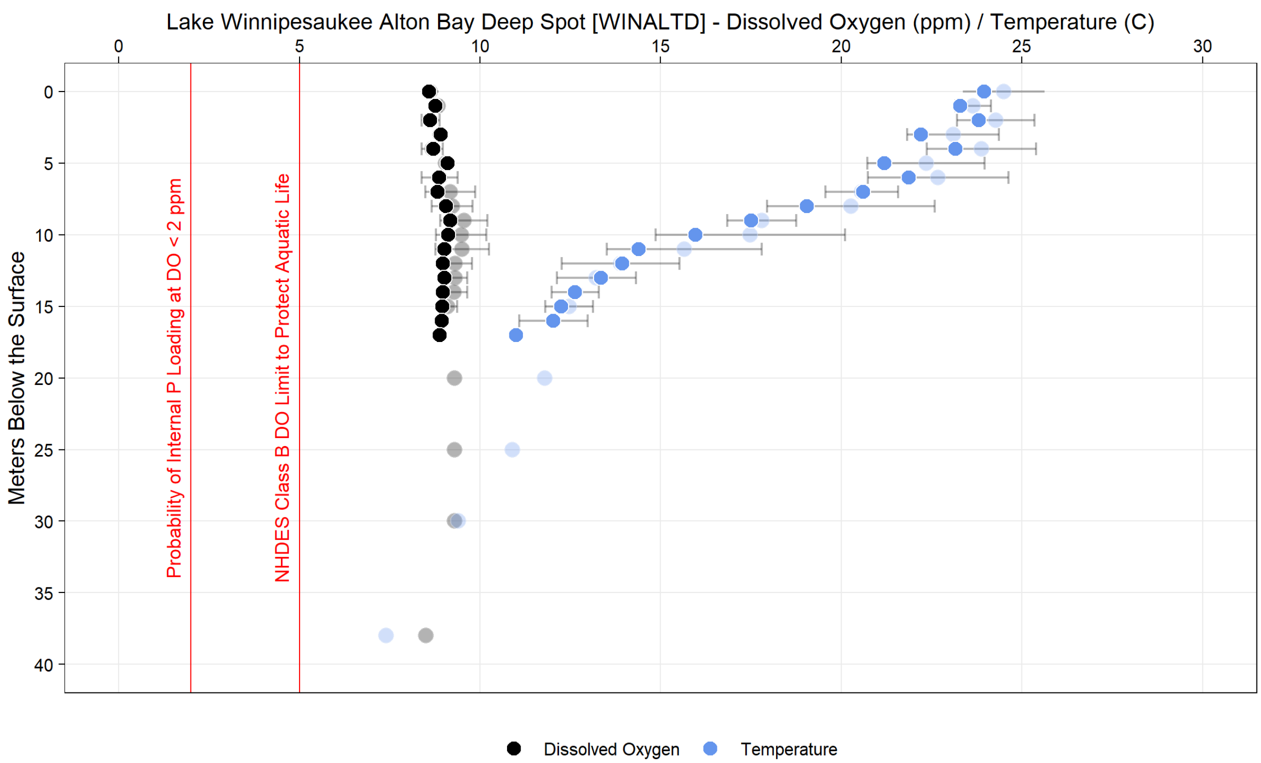


Figure 9. Dissolved oxygen (black) and water temperature (blue) depth profiles for the Alton Bay deep spot of Lake Winnipesaukee (WINALTD). Semitransparent dots are the medians from profile data collected between May and September in 1990, 2001 and 2023 (n=4; two profiles were collected in July 2023). Non-transparent dots represent 2023 profile values only (n=2). Error bars represent standard deviation.

Dissolved oxygen and temperature profiles from Alton Bay Station 25 and the Pavillion monitoring site also indicate healthy oxygen levels throughout the water column, averaging 5–10 ppm. Stratification is evident at Station 25 (Figure 10), while the Pavillion site is too shallow for a substantial temperature decline near the lake bottom (Figure 11).

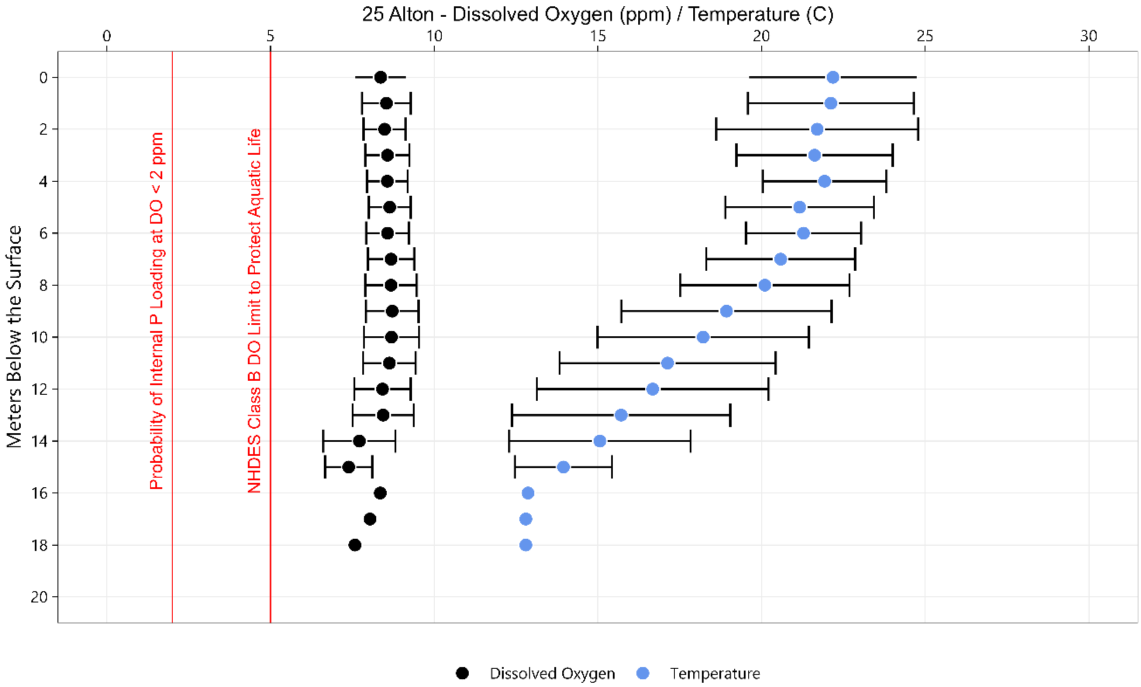


Figure 10. Dissolved oxygen (black) and water temperature (blue) depth profiles for Alton Bay Station 25 (WAB25AL). Profiles were taken over 22 sampling dates between 1991 and 2023, with one in 2014, one in 2015, and two in 2023 being the most recent events. Error bars represent standard deviation.

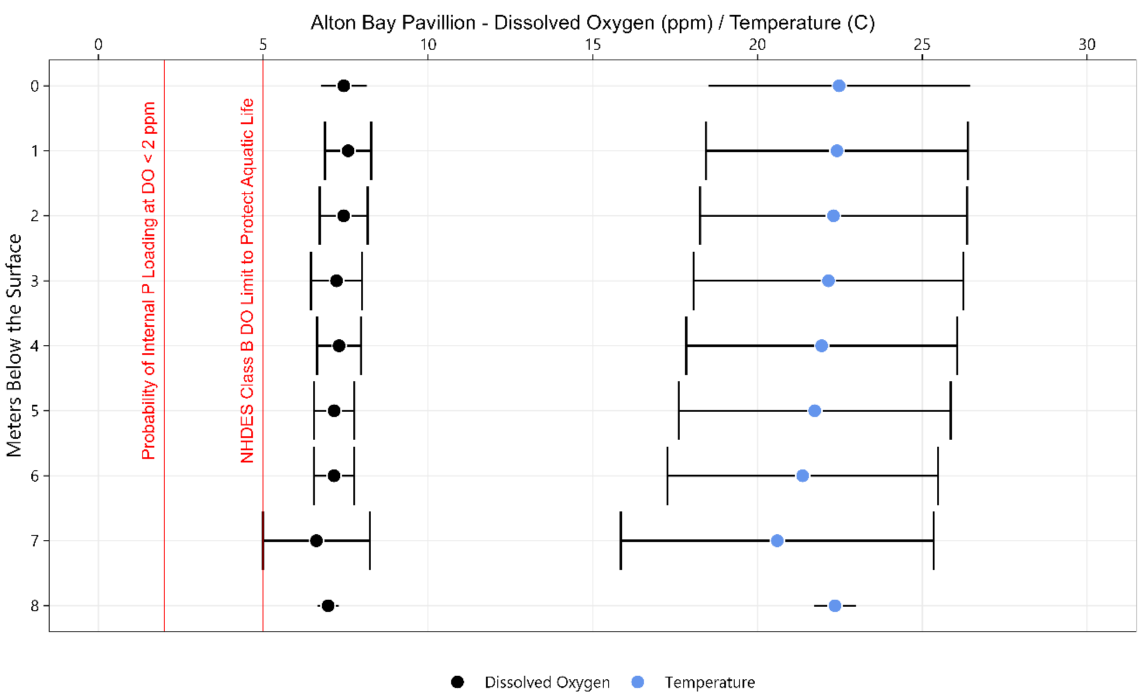


Figure 11. Dissolved oxygen (black) and water temperature (blue) depth profiles at the Alton Bay Pavillion monitoring site (WABPAPL). Profiles were taken over 12 sampling events between 2006 and 2023, with one taken each growing season in 2014, 2015, and 2018, and two in 2023. Error bars represent standard deviation.

2.1.5 Chloride & Specific Conductivity

Chloride pollution can cause harm to aquatic organisms and disrupt internal mixing processes when chloride concentrations reach toxic levels. Because chloride requires physical grab samples and analysis at a local laboratory, lake managers often use specific conductivity as a rough measure of potential chloride toxicity. Specific conductivity measures the water's ability to conduct an electrical current and gives lake managers a sense of the amount of dissolved material in the water. In the Northeast, chloride from winter salting practices often accounts for increased conductivity of waters. The State of New Hampshire sets a chronic threshold of 230 ppm for chloride (which roughly equates to 835 µS/cm for specific conductivity). Concentrations of chloride (epilimnetic mean of 19.2 ppm) and specific conductance (mean of 84.1 µS/cm in the epilimnion) at the Alton Bay Deep Spot between 2014-2023 are well below the chronic threshold, which is typical for a high-quality lake (most New Hampshire lakes are around 4 ppm or 40 µS/cm). While there does appear to be an increasing trend in both metrics between 1979 and 2023 (Figure 12), not enough years of data have been collected to run a Mann-Kendall trend analysis to determine if this trend is statistically significant (n=9). A significant increasing trend would indicate that chloride from winter salting practices for deicing roads and other surfaces in the watershed may be contaminating the lake. Such a trend has been observed for specific conductivity at Station 25 (Figure 13), and limited data collected at the Pavillion also suggest a possibly increasing trend (Figure 14). While not an immediate concern for the health of the lake, chronic chloride toxicity could likely become an issue in the future without a proactive reduction in salt use in the watershed.

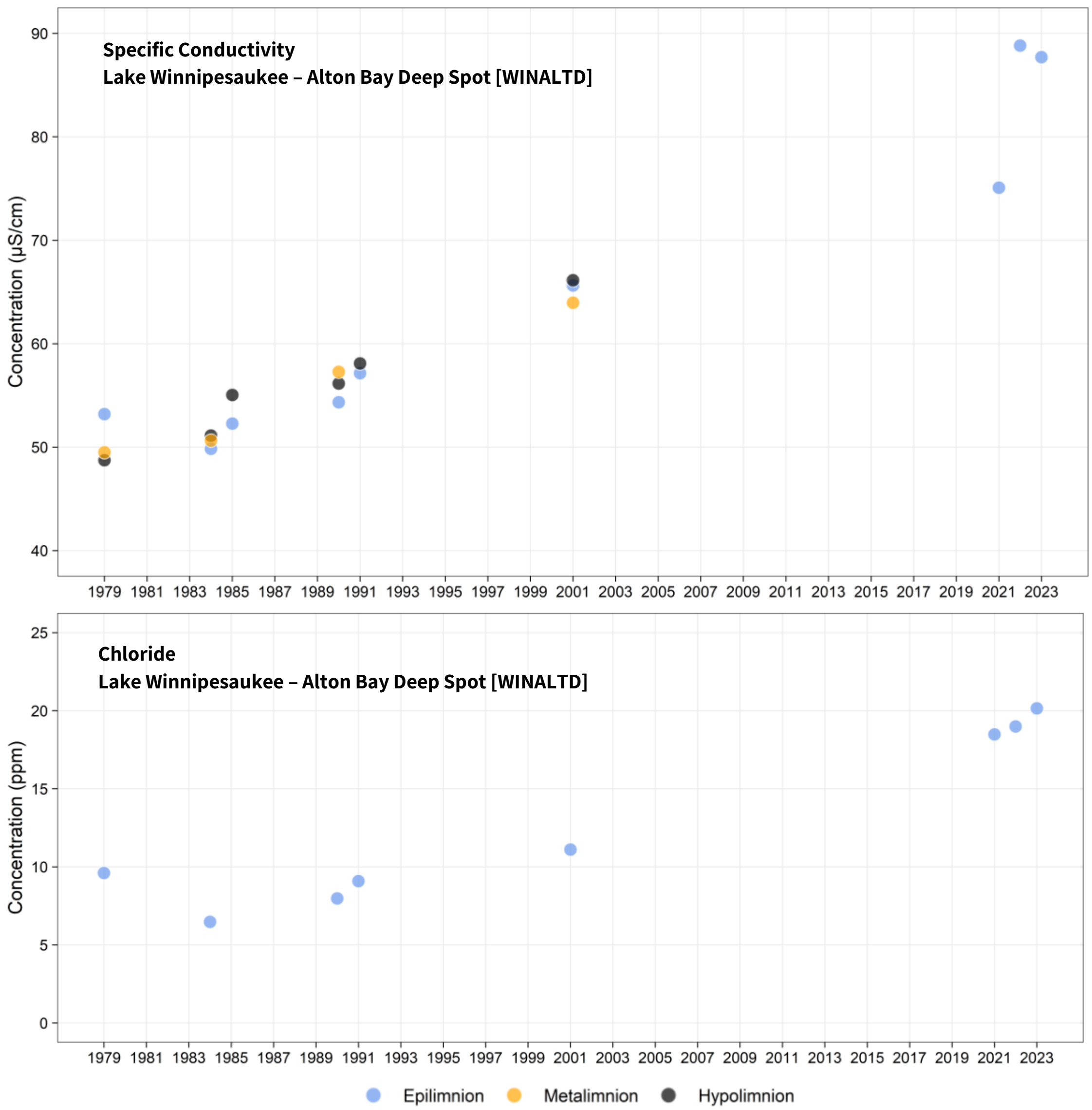


Figure 12. Yearly median of monthly medians for chloride and specific conductivity in the Alton Bay deep spot of Lake Winnipesaukee (WINALTD). Not enough data has been collected to run a trend analysis.

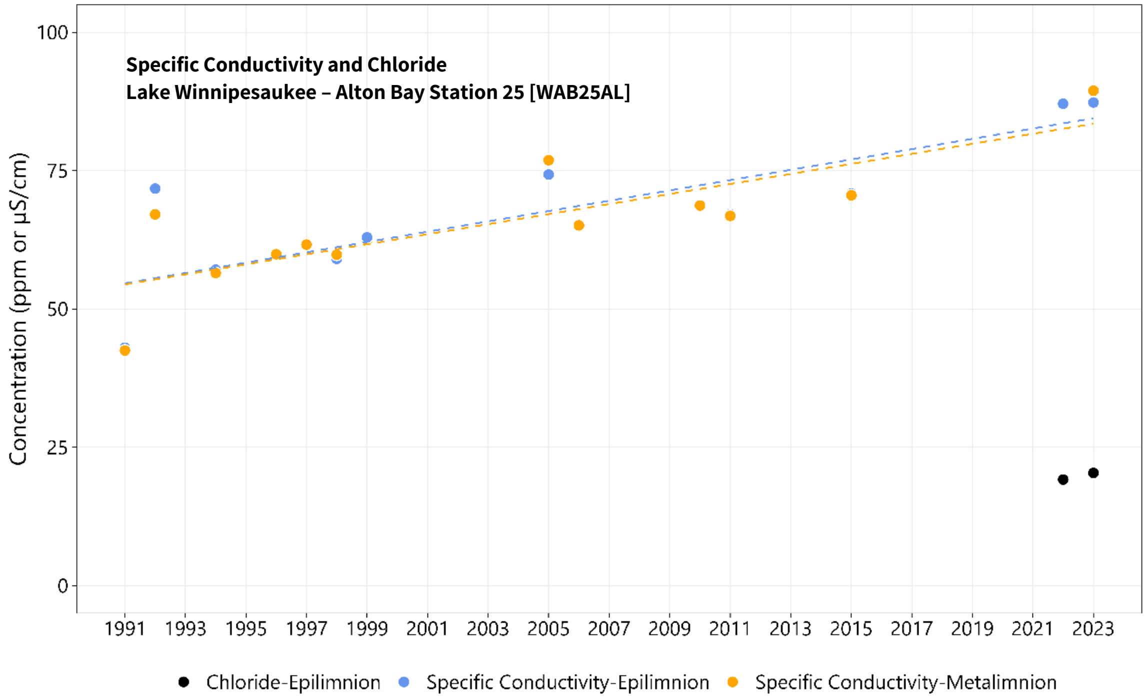


Figure 13. Yearly median of monthly medians for chloride and specific conductivity measurements taken at Alton Bay Station 25 (WAB25AL) between 1991 and 2023. Significant increases in specific conductivity in both the epilimnion and metalimnion have occurred (Mann-Kendall trend test, using R Studio package *rkt*).

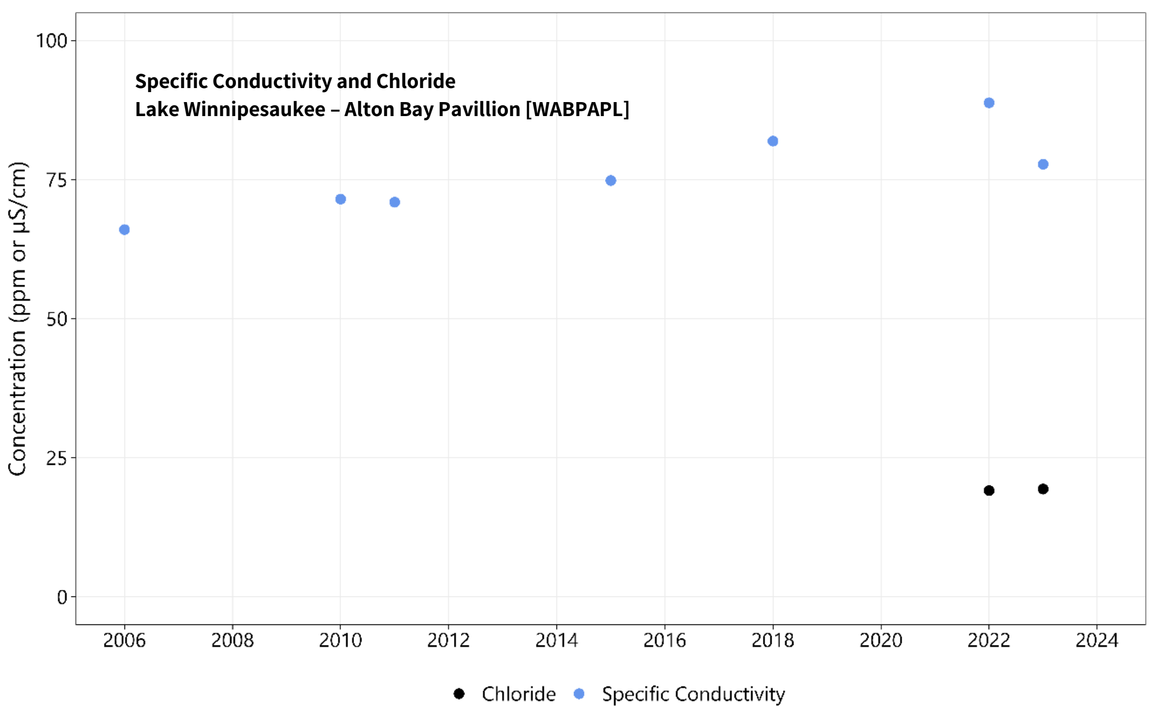


Figure 14. Yearly median of monthly medians for chloride and specific conductivity measurements taken at the Pavillion station (WABPAPL) between 2006 and 2023. Not enough data has been collected to run a Mann-Kendall trend analysis.

2.1.6 Phytoplankton (Cyanobacteria) and Zooplankton

2.1.6.1 Historical Phytoplankton/Zooplankton Surveys

Phytoplankton and zooplankton samples were collected and analyzed during the 1979, 1984, 1990, and 2001 NHDES Trophic Surveys of Alton Bay. The dominant phytoplankton species were *Chrysosphaerella* (golden-brown), *Asterionella* (diatom), *Dinobryon* (golden-brown), *Tabellaria* (diatom) and *Rhizosolenia* (diatom). The dominant zooplankton taxa were *Keratella* (rotifer), *Collotheca* (rotifer), *Nauplius* larvae (copepod) and cyclopoid copepods. 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 Alton Bay in the NHDES trophic surveys.

2.1.6.2 Recent Phytoplankton/Zooplankton Surveys

In recent years, NHDES has conducted annual phytoplankton and zooplankton surveys throughout Lake Winnipesaukee as part of efforts to monitor for the invasive spiny water flea (see Section 2.1.8). The relative densities of various phytoplankton and zooplankton groups recorded at the WINALTD monitoring station are summarized in Figure 15 below. Although it may be too early to identify clear trends in abundance over time, the introduction of the spiny water flea—first detected in the lake in September 2023—is expected to cause cascading impacts on plankton communities within Alton Bay. Both phytoplankton and zooplankton samples were filtered using an 80 μm mesh net. This small mesh size allows for a representative snapshot of the plankton community.

In most years from 2017 to 2024, cyanobacteria, diatoms and golden-brown algae dominated the phytoplankton community in Alton Bay. While the relative abundance of these groups varies from year to year, no consistent trend over time is evident. Among zooplankton, rotifers were the most abundant group from 2017 to 2024. Cladocerans were observed in relatively low proportions at the Alton Bay deep spot throughout this period, but notably, none were detected in 2023 or 2024—coinciding with the initial detection of the spiny water flea.

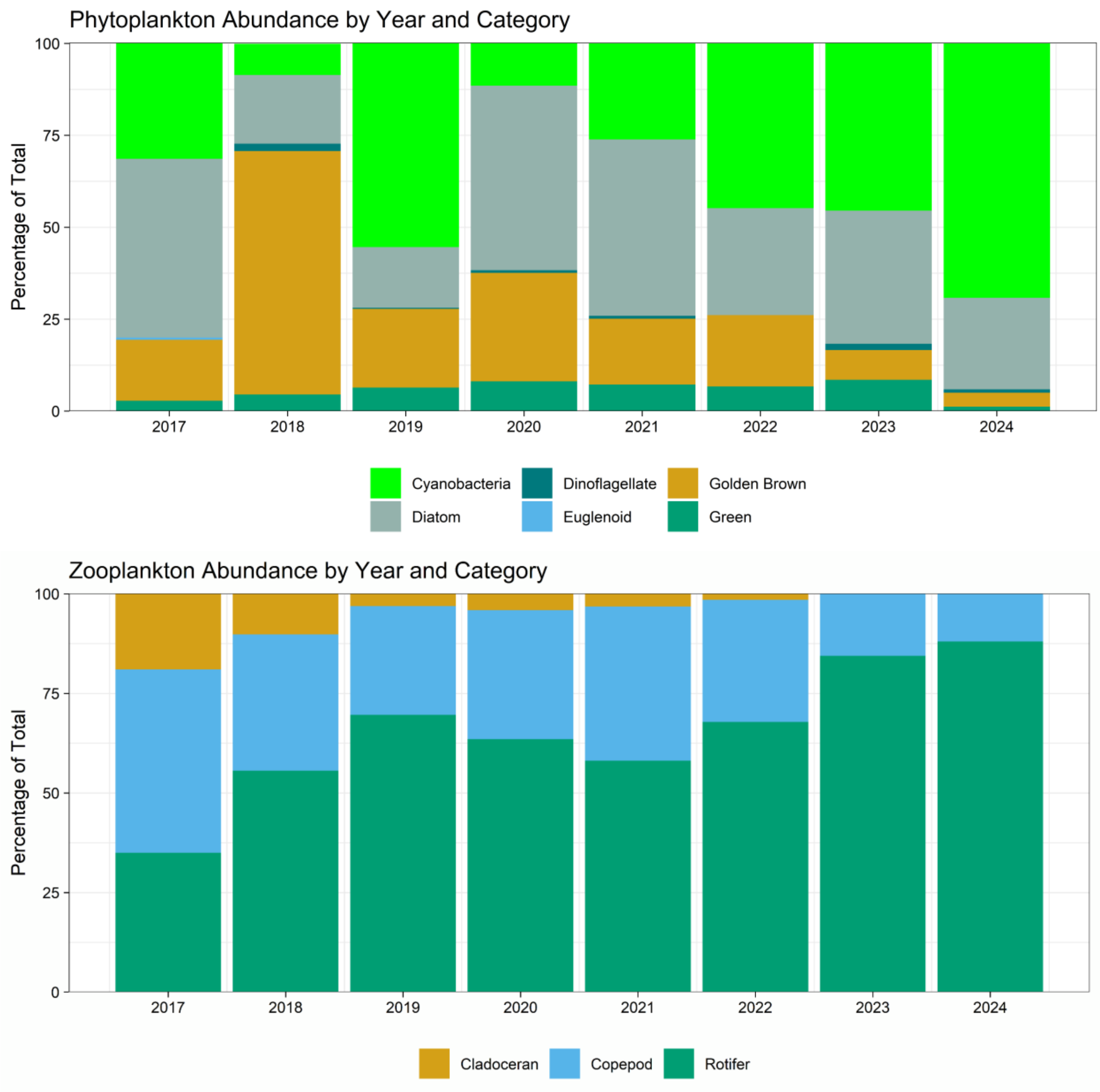


Figure 15. Relative abundance (% of total community) of plankton groups collected by NHDES using an 80 µm mesh net at the Alton Bay deep spot (WINALTD), 2017–2024. The top graph shows phytoplankton results; the bottom graph shows zooplankton results. Data provided by Kirsten Hugger, NHDES and collected by Kirsten Hugger and Amy Smagula, NHDES.

2.1.6.3 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 Alton Bay in 2023.
- *Dolichospermum* (formerly *Anabaena*): typically observed as filaments, associated with microcystins, anatoxins, saxitoxins, and cylindrospermopsin, documented in Downing Pond in 2015 and 2016 and in the Merrymeeting Marsh WMA in 2016.
- *Microcystis*: typically observed as variations of small-celled colonies, associated with microcystins and anatoxins, documented in Mill Pond in 2018.
- *Aphanizomenon*: typically forms rafts of filaments, associated with 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), documented in Jones Dam Pond and Marsh Pond several times between 2018 and 2023.
- *Pseudanabaena:* typically observed as filaments, documented in Alton Bay in 2019 and 2021–2024.

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.

As of October 2025, there have been three officially reported NHDES cyanobacteria bloom alerts for Lake Winnipesaukee in the Alton Bay watershed. Two occurred in 2023, one in late July/early August and the other in August–September. The first lasted for seven days and was not evaluated for dominant taxa or cell count. The August–September bloom lasted 21 days and was dominated by *Gloeotrichia*, though cells were not counted during this bloom either. A third bloom watch occurred in August and September 2024 and was in effect for 30 days, with 50,000 *Gloeotrichia* cells counted. Other waterbodies in the watershed have experienced numerous blooms since 2009 (Table 3). These waterbodies ultimately drain into Alton Bay and pose a risk to its water quality.

Table 3. Cyanobacteria blooms occurring in the Alton Bay watershed since 2009, including upstream waterbodies.

Date	Waterbody	Dominant taxa	Cells/mL	Number of advisory days
August 2009	Downing Pond	Unidentified	>70,000	53
August 2015	Downing Pond	*Anabaena*	4,100,000	20
2016	Merrymeeting Marsh Wildlife Management Area	*Anabaena*	Unknown	N/A
June 2016	Downing Pond	*Anabaena*	120,000	29
2018	Mill Pond	*Microcystis*		N/A
July 2018	Jones Dam Pond	*Planktothrix*	3,000,000	67
July 2018	Marsh Pond	*Planktothrix*	140,000	70
June 2019	Jones Dam Pond	*Planktothrix*	960,000	4
July 2019	Jones Dam Pond	*Planktothrix*	282,000	37
July 2019	Marsh Pond	*Planktothrix*	150,000	51
July 2020	Jones Dam Pond	*Planktothrix*	300,000	46
July 2020	Marsh Pond	*Planktothrix, Aphanocapsa, Pseudoanabaena*	351,050	66
July 2021	Marsh Pond	*Planktothrix*	85,000	61
July 2022	Jones Dam Pond	*Planktothrix*	177,500	7
August 2023	Marsh Pond	*Planktothrix*	100,000	13
July-August 2023	Lake Winnipesaukee	Unidentified	Unknown	7
Aug-Sept 2023	Lake Winnipesaukee	*Gloeotrichia*	Unknown	21
Jun-Jul 2024	Mill Pond	*Microcystis, Woronichinia*	334,000	25
Aug-Sept 2024	Lake Winnipesaukee	*Gloeotrichia*	50,000	30

Cyanobacteria taxa in Lake Winnipesaukee have also been identified and enumerated as part of the annual NHDES phytoplankton surveys discussed in Section 2.1.6.2. Figure 16 illustrates the diversity of cyanobacteria present at the Alton Bay deep spot (WINALTD). In 2023 and 2024, *Pseudanabaena* dominated the cyanobacteria community, while in 2021 and 2022 *Dolichospermum* were most abundant. Eleven other cyanobacteria species have been identified at this sample site since 2017.

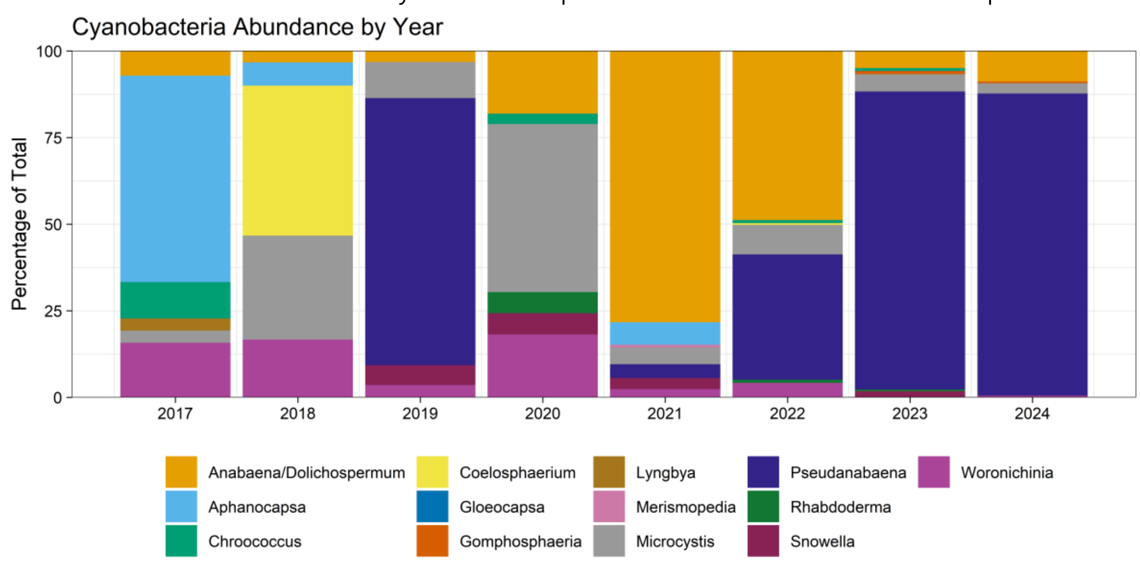


Figure 16. Relative abundance (% of total community) of cyanobacteria taxa sampled by NHDES using an 80 µm mesh net at the Alton Bay deep spot (WINALTD), 2017–2024. Data provided by Kirsten Hugger, NHDES and collected by Kirsten Hugger and Amy Smagula, NHDES.

2.1.7 Fish

Fish are an important natural resource for sustainable ecosystem food webs and provide recreational opportunities. Fish surveys conducted by NH Fish & Game in Robert's Cove in 2014 recorded smallmouth bass, while a 2010 stream survey in Watson Brook additionally recorded eastern brook trout, blacknose dace and common white sucker. The presence of brook trout is an indicator of high-quality coldwater stream habitat. The NH Fish and Game Wildlife Action Plan (NHFG, 2015) additionally identifies American eel, burbot and lake whitefish within Alton Bay, as well as eastern brook trout and bridle shiner in sections of the Merrymeeting River and burbot in Merrymeeting Lake (Appendix A, Map A-10).

2.1.8 Invasive Species

Variable milfoil (*Myriophyllum heterophyllum*) was first discovered in Lake Winnipesaukee in 1965, marking the state's earliest recorded infestation of an aquatic invasive species (NHDES, 2019). Since then, more than 90 waterbodies across New Hampshire have become infested with one or more types of aquatic invasive species (NHDES, 2022a). Although the rate of spread has slowed thanks to statewide prevention and early detection efforts, managing and removing established populations continues to pose significant challenges. disrupt natural habitats, displace native plant and animal communities, lower property values, impair fishing, degrade recreational experiences, and incur high removal costs. There are multiple programs that help prevent the introduction and spread of invasive species in lakes, including the Lake Host Program and the Weed Watcher Program. The Town of Alton has developed a Milfoil Committee to coordinate management activities, and NHDES published a *Long-Term Variable Milfoil Management Plan* for Alton Bay in 2022 (NHDES, 2022b).

Chinese mystery snail (*Cipangopaludina chinensis*), a non-native gastropod, was also observed in Alton Bay at the boat launch near the intersection of NH Routes 11 and 28A in 2017 (USGS, 2017). More than 50 snails were found in a 15-minute search, indicating a well-established population at this location. The Chinese mystery snail is federally categorized as a non-native aquatic species, though the USGS notes that its listing information is preliminary. This species exhibits characteristics typical of aquatic invasive species, including resistance to predation, rapid reproduction, and the ability to outcompete native mollusks for resources, ultimately disrupting food webs (Kingsbury et al., 2021). Introduced to the Niagara River basin in the 1930s or 1940s, it has since spread across northeastern freshwater systems, aided by the movement of water-related equipment and the release of aquarium pets (Minnesota DNR, 2025; USGS, 2025).

The ecological impacts of the Chinese mystery snail on lakes in the northeast can be significant. By consuming large amounts of algae and detritus, the snail excretes substantial quantities of nitrogen and phosphorus, promoting conditions favorable to harmful algal blooms (Bobeldyk, 2009; Olden et al., 2013). The snail can also outcompete native mollusks for food and habitat, potentially reducing native biodiversity and leading to cascading changes in ecosystem structure. Its thicker shell and larger body size compared to native gastropods also makes it more resistant to predation (Kingsbury et al., 2021).

The species' high fecundity further drives its exponential population growth once introduced to a waterbody. Female Chinese mystery snails produce an average of 30 embryos annually, primarily between June and October (Kingsbury et al., 2021). Despite this, the density threshold at which the species becomes ecologically problematic remains unclear, as monitoring efforts in North America are limited. Nevertheless, research indicates that even at low population densities the species can alter nutrient cycling because of its large biomass (Bobeldyk, 2009).

The Chinese mystery snail poses additional ecological and recreational challenges. It may harbor parasites that native mollusks do not typically host, threatening fish, freshwater mussels, and other aquatic organisms (Kingsbury et al., 2021). High-density populations of the snail also frequently experience large die-offs, leaving behind accumulations of shells and wrack along shorelines, which can diminish the recreational value of affected areas (USGS, 2025).

Unfortunately, no effective method for controlling established populations in North American waterbodies currently exists (Minnesota DNR, 2025). Manual removal and preventative measures, such as proper cleaning of watercraft and equipment and public education on aquatic pet disposal, are the most viable management strategies for this resilient species (Invasive Species Centre, 2025).

A more recent introduction to Lake Winnipesaukee is the spiny water flea (*Bythotrephes longimanus*), a large, predatory zooplankton first detected in Lake Winnipesaukee in 2023 and again in 2024. This invasive species can disrupt lake food webs by competing with native carnivorous and omnivorous zooplankton, such as large-bodied *Leptodora* and cyclopoid copepods, which feed on smaller zooplankton like rotifers. Additionally, the spiny water flea preys directly on native herbivorous, filter-feeding zooplankton, including *Daphnia* and bosminids (both types of cladocerans), and rotifers (Cutter et al., 2023). These groups are essential grazers in lake ecosystems. Declines in *Daphnia* populations resulting from spiny water flea invasion have been linked to increased diatom abundance in two Wisconsin lakes (Walsh et al., 2018). The spiny water flea has fewer predators than native zooplankton because small or juvenile fish are unable to consume their sharp, barbed spine (MAIRSC, 2025). They reproduce rapidly, reaching maturity and producing offspring within a week, and are capable of reproducing asexually. The lack of native predators and fast reproduction cycle enables the species to spread rapidly once introduced to a lake. See Figure 17 for a visual representation of these impacts.

The full impact of the spiny water flea on Lake Winnipesaukee is still being assessed (NHDES, 2023). However, preliminary data collected annually by NHDES suggest a decline in the density of cladoceran taxa (e.g., *Daphnia,* bosminids) across the lake between 2017 and 2024 (Hugger, 2025). Possible impacts could include an increase in diatom densities, a decrease in food sources for native fish (cladocerans), and the clogging of fishing rod eyelets. Continued annual monitoring of phytoplankton and zooplankton communities will help lake managers detect potential impacts, anticipate cascading effects, and implement strategies to prevent issues such as phytoplankton blooms or reduced water clarity.

Variable milfoil, NHDES

Chinese mystery snail. Peterwchen - Own work, CC BY-SA

Spiny water flea. MAISRC, 2025.

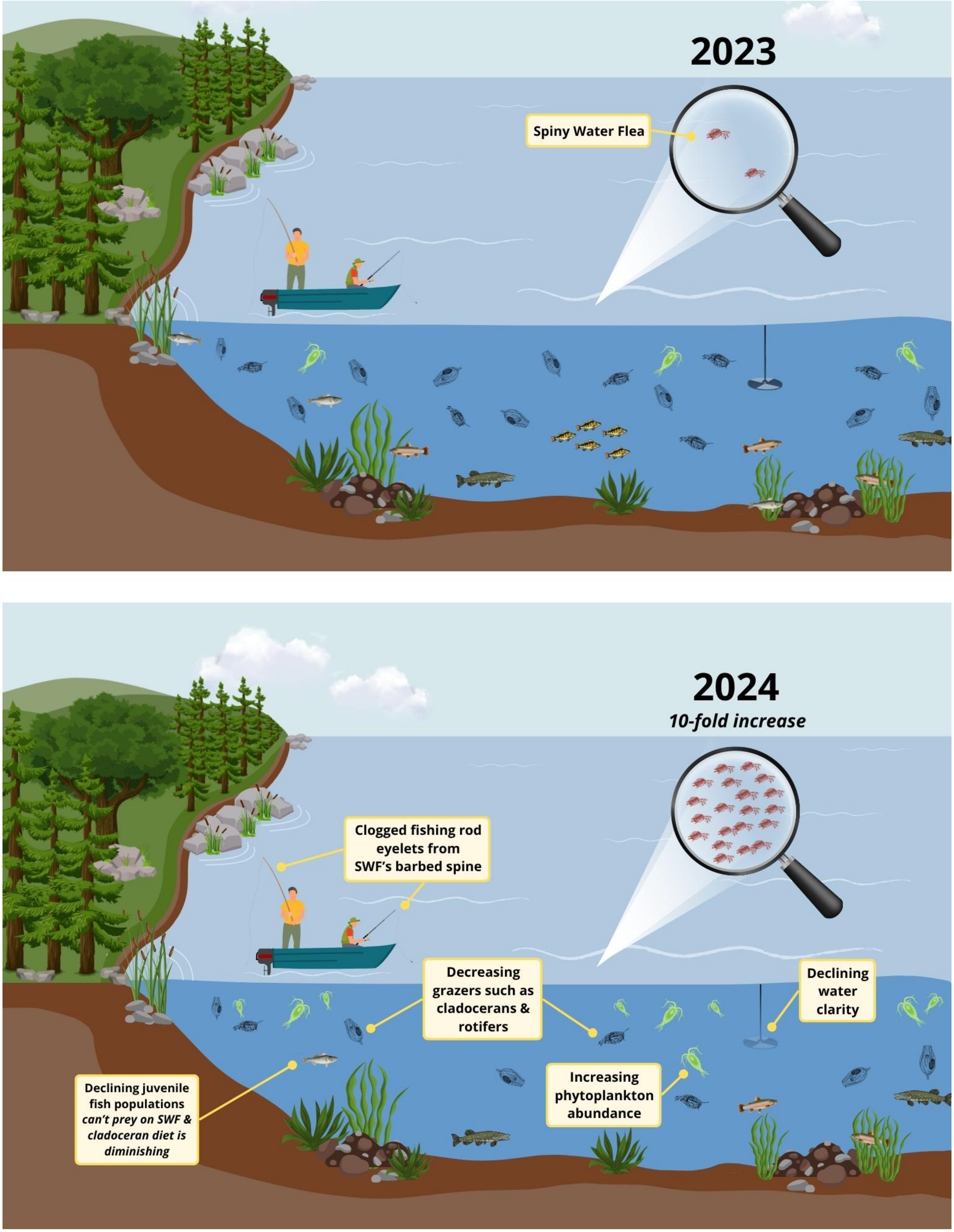


Figure 17. A representation of the impacts of increasing spiny water flea (*Bythotrephes longimanus*) populations in North American lakes.

2.2 ASSIMILATIVE CAPACITY

The assimilative capacity of a waterbody describes the amount of pollutant that can be added without causing a violation of the water quality criteria. The assimilative capacity is based on lake trophic designation. Lake Winnipesaukee is an oligotrophic waterbody, and this designation was selected for running the assimilative capacity analysis for Alton Bay. For oligotrophic waterbodies, the water quality criteria are set at 8 ppb for total phosphorus and 3.3 ppb for chlorophyll-a, above which the waterbody is considered impaired (Table 4). According to Table 3-17 in the 2024 Section 305(b) and 303(d) Consolidated Assessment and Listing Methodology (CALM), NHDES requires 10% of the difference between the best possible water quality and the water quality standard be kept in reserve. Therefore, 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 5).

Results of the assimilative capacity analysis of the Alton Bay deep spot show that Alton Bay meets Tier 2 (High Water Quality) for its trophic class designation (Table 6). The existing median total phosphorus and chlorophyll-a concentrations both meet the assimilative capacity threshold. This is true for the Alton Bay Station 25 monitoring site too. At the Pavillion, total epilimnetic phosphorus levels exceed the AC threshold by 1 ppb, but because chlorophyll-a is within the assimilative capacity the site still attains Tier 2 status.

Table 4. 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 5. 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 6. Assimilative capacity (AC) analysis results for Alton Bay in Lake Winnipesaukee using oligotrophic thresholds. Chlorophyll-a dictates the assessment results.

Parameter	AC Threshold (ppb)	Existing Median WQ (ppb)*	Remaining AC (ppb)	Assessment Results
LAKE WINNIPESAUKEE – ALTON BAY DEEP SPOT [WINALTD]				
Total Phosphorus	7.2	4.9	2.3	Tier 2 (High Water Quality)
Chlorophyll-a	3.0	1.5	1.5	
LAKE WINNIPESAUKEE – ALTON BAY STATION 25 [WAB25AL]				
Total Phosphorus	7.2	5.3	1.9	Tier 2 (High Water Quality)
Chlorophyll-a	3.0	1.5	1.5	
LAKE WINNIPESAUKEE – ALTON BAY PAVILLION [WABPAPL]				
Total Phosphorus	7.2	8.2	-1.0	Tier 2 (High Water Quality)
Chlorophyll-a	3.0	2.0	1.0	

** Existing water quality data truncated to May 24–Sept 15 for 2014–2023 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 2024 WATER QUALITY SUMMARY

Water quality data for Alton Bay were collected between June 19th and September 24th, 2024 by UNH Extension LLMP volunteers at the WINALTD (deep spot) station. Their results are summarized in the 2024 sampling highlights (UNH LLMP, 2024). Mean epilimnion total phosphorus was 4.7 ppb and mean composite chlorophyll-a concentration was 1.8 ppb (n=6 for both parameters). While the phosphorus mean value is 0.2 ppb lower than the 2014–2023 median, chlorophyll-a is 0.3 ppb higher than the median for the same period. This level of interannual variation is natural and should not be interpreted as an indicator of worsening water quality. Secchi disk transparency was high, averaging 9.9 m. Similar results were recorded at the Alton Bay Station 25, while higher total phosphorus and chlorophyll-a levels were recorded at the Pavillion, the former parameter averaging 8.5 ppb, which is in the mesotrophic range (Table 7).

Table 7. Summary of trophic state indicator parameters collected by the UNH LLMP within Alton Bay in 2024.

Site Name and ID	Mean Total Phosphorus in ppb (*n*)	Mean Chlorophyll-a in ppb (*n*)	Mean Secchi Disk Transparency in m (*n*)
Alton Bay Deep Spot (WINALTD)	4.7 (n=6)	1.8 (n=6)	9.9 (n=7)
Alton Bay Station 25 (WAB25AL)	4.8 (n=6)	1.9 (n=6)	9.8 (n=7)
Alton Bay Pavillion (WABPAPL)	8.5 (n=6)	2.4 (n=6)	6.4 (n=8)

Dissolved oxygen levels recorded by the LLMP in a September 2024 profile at the deep spot averaged 7.7 ppm between 9.5 m and 14 m (metalimnion and hypolimnion waters), meeting oligotrophic standards.

NHDES additionally collected chloride and specific conductivity data at 1 m depth at WINALTD on September 4th, 2024, as part of its spiny water flea data collection. While the specific conductivity was similar to what NHDES measured in September 2022 and 2023 (89.8 µs/cm in 2024 compared to 92.4 µs/cm in 2022 and 91.9 µs/cm in 2023), the increase in chloride was more pronounced (27.6 mg/L in 2024 compared to 18.6 mg/L and 17.3 mg/L in 2022 and 2023, respectively). NHDES data was accessed in September 2025 via the Environmental Monitoring Database maintained by NHDES.

2.4 WATERSHED MODELING

2.4.1 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[2] 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 Alton Bay LLRM is provided in the *Alton Bay Lake Loading Response Model Report* (FBE, 2025a).

[2] The model cannot simulate short-term weather or loading events.

2.4.1.1 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 Alton Bay is 1,367 acres (13.4 miles of shoreline) with a maximum depth of approximately 100 feet (30.5 meters) and volume of 48,413,593 m^3 (Appendix A, Map A-1). The **areal water load** is 81 ft/yr (24.7 m/yr), and the flushing rate is 2.8 times per year. The flushing rate of 2.8 means that the entire volume of Alton Bay is replaced 2.8 times per year. Alton 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.

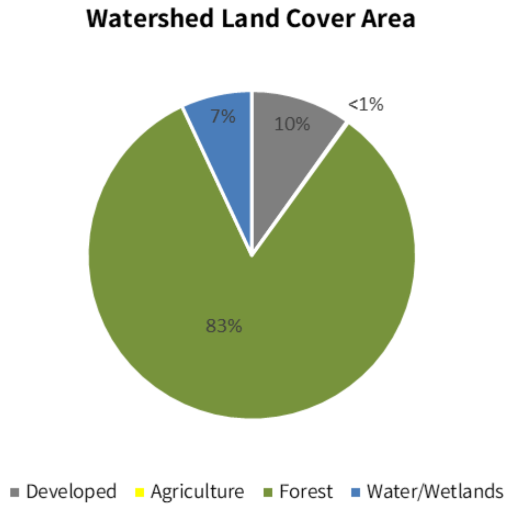
2.4.1.2 Land Cover

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 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 Alton Bay watershed was determined by FBE using a combination of published datasets on NH GRANIT and ESRI World Imagery from May 26, 2023, and Google Earth satellite imagery from October 10, 2020. For more details on methodology, see the *Alton Bay Lake Loading Response Model Report* (FBE, 2025a). Refer also to Appendix A, Map A-2.

As of the 2023/2020 aerial imagery, development accounts for 10% (689 acres) of the direct drainage area to Alton Bay, while forested and meadow areas account for 83% (5,805 acres; Figure 18). Wetlands and open water represent 7% (487 acres) of the watershed, not including the surface area of Lake Winnipesaukee. Agriculture represents <1% (8.9 acres). This area does not include the Merrymeeting River and Lake sub-watershed. These areas were previously assessed as part of the *Merrymeeting River and Lake Watershed Management Plan* (FBE, 2019).

Developed areas within the Alton 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 Alton Bay is less than 10% since developed land cover (at 10%) reflects all human-impacted areas and includes such non-impervious areas as lawns. However, development in downtown Alton and along the shoreline of Alton 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 Alton Bay, with the potential to severely impact the bay's water quality.



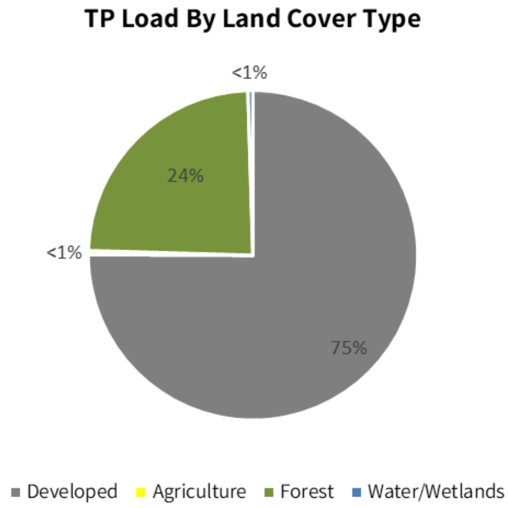


Figure 18. Direct drainage to Alton Bay land cover area by general category (agriculture, developed, forest, and water/wetlands) and total phosphorus (TP) watershed load by general land cover type. This shows that developed areas cover 10% of the watershed and contribute 75% of the TP watershed load to Alton Bay from the direct drainage area. The water/wetlands category does not include the lake areas. This area does not include the Merrymeeting River and subbasins included in that project. These areas were previously modeled as part of the *Merrymeeting River and Lake Watershed Management Plan* (FBE, 2019).

2.4.1.3 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 Lake Winnipesaukee within Alton Bay (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 Alton Bay (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. However, due to limited data, the extent of possible anoxia and internal phosphorus loading in Alton Bay is uncertain. Additional data, especially in September when internal loading peaks, may allow for a more refined internal loading estimate.

WHAT IS INTERNAL LOADING?

Over time, as phosphorus enters the lake from the landscape, this phosphorus either stays in the lake (i.e., settles to the bottom or is taken up by plants/algae for growth) or leaves the lake (i.e., get flushed out). The phosphorus that settles on the lake bottom will generally bind with one of two naturally occurring elements that also get flushed into the lake each year from the watershed: aluminum or iron. If phosphorus binds with aluminum, then the bond is permanent, and the phosphorus is sedimented in the lake bottom. If the phosphorus binds with iron, then the bond is non-permanent and in summer when the lake bottom is deprived of oxygen (anoxic), it triggers a chemical reaction that releases phosphorus from iron. This phosphorus is now free to be mixed up into the water column and serve as a nutrient source for plants and algae. Looking at the ratios between aluminum, iron, and phosphorus indicates whether the lake is vulnerable to internal loading or cycling of phosphorus.

2.4.1.4 LLRM Results

Overall, model predictions for Alton Bay were in good agreement with observed data for total phosphorus (0.8%), and in poor agreement for chlorophyll-a (44%), and Secchi disk transparency (52%) (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 (89%) was the largest phosphorus loading contribution across all sources to Alton Bay. The watershed load (89%) includes the watershed loads from Merrymeeting (53%), the direct land area Alton Bay (18%), and mixing with other areas of Lake Winnipesaukee (18%) (Table 9). Septic systems (5%), atmospheric deposition (4%), waterfowl (2%), and internal loading (<0.5%), were relatively minor sources. However, when considering only the direct drainage area of Alton Bay (excluding the Merrymeeting River watershed and exchange with the Broads), other phosphorus sources become more significant. For example, shoreline septic systems make up 16% of the total phosphorus load when only the direct watershed is considered. Development in the direct watershed is most concentrated in the urban downtown area in Alton, which is highly impervious. Development is also dense around the shoreline of Alton Bay and Merrymeeting Lake 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; none of the Alton Bay watershed is sewered. Note that septic systems are a relatively minor load to Alton 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) shoreline septic systems for other lakes within the Alton 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. Shoreline development also leads to high phosphorus loading when precipitation pushes pulses of fertilizer, grass clippings, organic matter, soil, and pet/animal waste directly into the lake with minimal opportunities for infiltration.

Internal loading is currently a relatively minor source of phosphorus to Alton Bay. Although the model predicts only one bloom day per year (Table 8) for Alton Bay, numerous bloom warnings and alerts were issued by NHDES in 2023 and 2024. In 2023, two bloom warnings were issued, one lasting 7 days and the other lasting 21 (*Gloeotrichia*). A 30-day watch was issued in 2024 (*Gloeotrichia*). No bloom warnings/alerts have been issued for Merrymeeting Lake.

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 Alton Bay shoreline; Figure 19). Drainage areas directly adjacent to Alton Bay have direct connection to the lake 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 loading factors 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 (2025a) for details on methodology. Pre-development loading estimation showed that total phosphorus loading to Alton Bay increased by 243%, from 474 kg/yr prior to European settlement to 1,624 kg/yr under current conditions (Table 9). These additional phosphorus sources are coming from development in the watershed (especially from the direct shoreline of Alton Bay, the downtown area of Alton Bay, and point-sources within the Merrymeeting River watershed), septic systems, and atmospheric dust (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 or the worst possible water quality for the lake). Refer to FBE (2025a) and the *Alton Bay Watershed Build-out Analysis Report* (FBE, 2025b) 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 Alton Bay may increase by 111%, from 1,624 kg/yr under current conditions to 3,421 kg/yr at full build-out (2073) under current zoning conditions (Table 9). Additional phosphorus will be generated from more development in the watershed (especially near downtown Alton and undeveloped headwater areas), greater atmospheric dust, and more septic systems (Table 9). It is likely that the internal load would increase beyond what was predicted in the future scenario; this is because the future projection is based on the current internal load, which was assumed to be minimal but was likely underapproximated due to a severe lack of data. The projected total phosphorus load for all upstream waterbodies (Merrymeeting River and Lake) showed substantial increases as well. The Alton Bay model predicted higher (worse) phosphorus (16.5 µg/L), higher (worse) chlorophyll-a (5.9 µg/L), and lower (worse) water clarity (2.7 m) compared to current conditions for Alton Bay (Table 8). This corresponded with a stark increase in predicted bloom days, increasing from one bloom day per year in 2025 to 73 bloom days per year by 2073.

Table 8. In-lake water quality predictions for Alton Bay. TP = total phosphorus. Chl-a = chlorophyll-a. SDT = Secchi disk transparency. Bloom Days represent average annual probability of chlorophyll-a exceeding 8 µg/L.

Model Scenario	Median TP (µg/L)	Predicted Median TP (µg/L)	Mean Chl-a (µg/L)	Predicted Mean Chl-a (µg/L)	Mean SDT (m)	Predicted Mean SDT (m)	Bloom Days
Alton Bay							
Pre-Development	--	2.3	--	0.2	--	12.2	0
Current (2024)	5.3 (7.7)*	7.8	1.6	2.3	10	5.5	1
Future (2073)	--	16.5	--	5.9	--	2.7	73

**Mean TP concentration (first value) represents current summer in-lake epilimnion TP from observed data. Median TP concentration (second value in parentheses) represents the annual median concentration from 2025 ice-out data 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.*

Table 9. Total phosphorus (TP) and water loading summary by model and source for modeled waterbodies in the Alton Bay watershed. Italicized sources sum to the watershed load.

SOURCE	PRE-DEVELOPMENT			CURRENT (2024)			FUTURE (2073)		
	TP (KG/YR)	%	WATER (CU.M/YR)	TP (KG/YR)	%	WATER (CU.M/YR)	TP (KG/YR)	%	WATER (CU.M/YR)
ALTON BAY									
ATMOSPHERIC	38.7	8%	7,204,980	60.8	4%	7,204,980	138.3	4%	7,204,980
INTERNAL	0.0	0%	0	1.0	<0.5%	0	2.2	<0.5%	0
WATERFOWL	33.2	7%	0	33.2	2%	0	33.2	1%	0
SEPTIC SYSTEM	0.0	0%	0	75.4	5%	58,744	88.8	3%	75,534
WATERSHED LOAD	402.1	85%	129,524,224	1,453.9	90%	129,254,054	3,162.6	92%	128,481,508
Direct Land Use Load	*78.3*	*17%*	*19,126,856*	*294.4*	*18%*	*18,985,264*	*647.7*	*19%*	*18,752,403*
Merrymeeting River	*221.8*	*47%*	*59,397,368*	*863.7*	*53%*	*59,268,790*	*1,883.2*	*55%*	*58,729,105*
Exchange with Main Lake	*102.0*	*22%*	*51,000,000*	*295.8*	*18%*	*51,000,000*	*631.6*	*18%*	*51,000,000*
TOTAL LOAD TO LAKE	**474.0**	**100%**	**136,729,204**	**1,624.4**	**100%**	**136,517,777**	**3,425.1**	**100%**	**135,762,022**

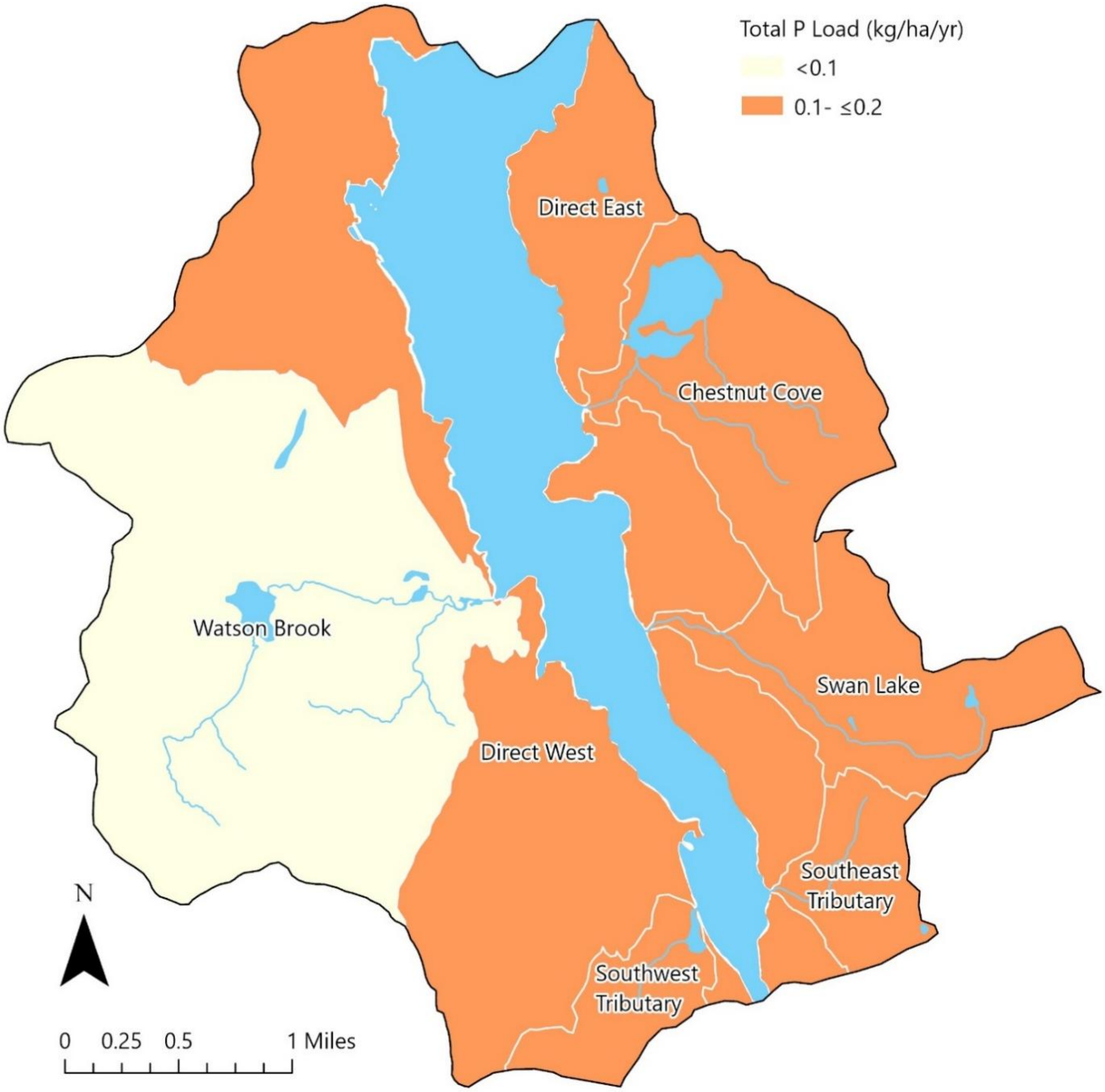


Figure 19. Map of current total phosphorus load per unit area (kg/ha/yr) for each sub-watershed in the direct drainage of the Alton Bay watershed. Higher phosphorus loads per unit area are concentrated in the more developed eastern shoreline of Alton Bay, followed by the western shoreline and the southeastern tributary.

2.4.2 Build-out Analysis

A full build-out analysis was completed for the Alton Bay watershed for the municipalities of Alton, Brookfield, Gilmanton, Middleton, and New Durham (FBE, 2025b). 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 60% (16,713 acres) of the study area is buildable under current zoning regulations (Appendix A, Map A-4). As most of the watershed lies within the Town of Alton, most of the buildable area can be found there as well, primarily in the Rural and Residential Rural zoning districts (Table 10). FBE identified 3,269 principal buildings within the watershed, and the build-out analysis projected that an additional 7,619 buildings could be constructed in the future resulting in a total of 10,888 buildings (Appendix A, Map A-5). In the Alton Bay watershed, many of the Lake Winnipesaukee shoreline parcels are already developed, so most of the projected buildings fall outside the direct shoreline area in expansive forested areas of Alton, Brookfield, Gilmanton, Middleton, and New Durham. With the majority of the watershed area in Alton and New Durham, more projected buildings can be found in the Alton and New Durham portions. Additional roadways would need to be built throughout the watershed for these projected buildings to be accessible.

Table 10. Amount of buildable land and projected buildings within the Alton Bay watershed, in Alton, Brookfield, Gilmanton, Middleton, and New Durham, NH.

Zone	Total Area (Acres)	Buildable Area (Acres)	Percent Buildable Area	No. Existing Buildings	No. Projected Buildings	Total No. Buildings	Percent Increase
Alton	*20,079*	*13,052*	*65%*	*2,430*	*5,905*	*8,335*	*243%*
Lakeshore Residential (LR)	1,624	836	52%	682	801	1,483	*117%*
Recreation Service (RS)	12	0	0%	17	0	17	*0%*
Residential (R) Single-family without Municipal Water	66	28	43%	48	24	72	*50%*
Residential (R) Single-family with Municipal Water	186	55	30%	275	62	337	*23%*
Residential Commercial (RC) Single-family or Commercial with Municipal Water	337	215	64%	294	329	623	*112%*
Residential Rural (RR)	4,766	3,530	74%	337	2,170	2,507	*644%*
Rural (RU)	13,088	8,387	64%	777	2,519	3,296	*324%*
Brookfield	*146*	*8*	*6%*	*0*	*2*	*2*	*NA*
Rural Residential/Agricultural (RA1)	146	8	6%	0	2	2	*NA*
Gilmanton	*70*	*64*	*91%*	*3*	*27*	*30*	*900%*
Rural (conventional lot)	70	64	91%	3	27	30	*900%*
Middleton	*219*	*8*	*3%*	*4*	*1*	*5*	*25%*
Rural Residential	219	8	3%	4	1	5	*25%*
New Durham	*7,368*	*3,582*	*49%*	*832*	*1,684*	*2,516*	*202%*
Rural Residential/Recreational/Agricultural	7,245	3,557	49%	779	1,672	2,451	*215%*
Town Center Mixed Use District (Village/Commercial)	124	25	20%	53	12	65	*23%*
Total	*27,881*	*16,713*	*60%*	*3,269*	*7,619*	*10,888*	*233%*

Three iterations of the TimeScope Analysis were run using compound annual growth rates (CAGR) for 10-, 20- and 50-year periods from 2010-2020 (0.94%), 2000-2020 (2.57%), and 1970-2020 (2.76%), respectively to project the rate of new development into the future (Table 11). Full build-out is projected to occur in 2209 at the 10-year CAGR, 2073 at the 20-year CAGR, and 2068 for the 50-year CAGR (Figure 20).

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 lake 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 10 or 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. Many projected buildings would also require the development of new roadways, which is a factor that would affect the rate of development. 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. US Census Bureau population growth rates for the towns of Alton, New Durham, Gilmanton, Brookfield, and Middleton, NH, 1970-2020. Population estimates obtained from the NH Office of Strategic Initiatives.

	Compound Annual Growth Rate (CAGR)		
Town	**50 Year Avg. (1970-2020)**	**20 Year Avg. (2000-2020)**	**10 Year Avg. (2010-2020)**
Alton	2.58%	1.36%	1.16%
New Durham	3.11%	0.97%	0.21%
Gilmanton	2.76%	1.28%	0.44%
Brookfield	2.71%	1.12%	0.59%
Middleton	2.93%	1.19%	0.22%
Combined	**2.76%**	**2.48%**	**0.65%**

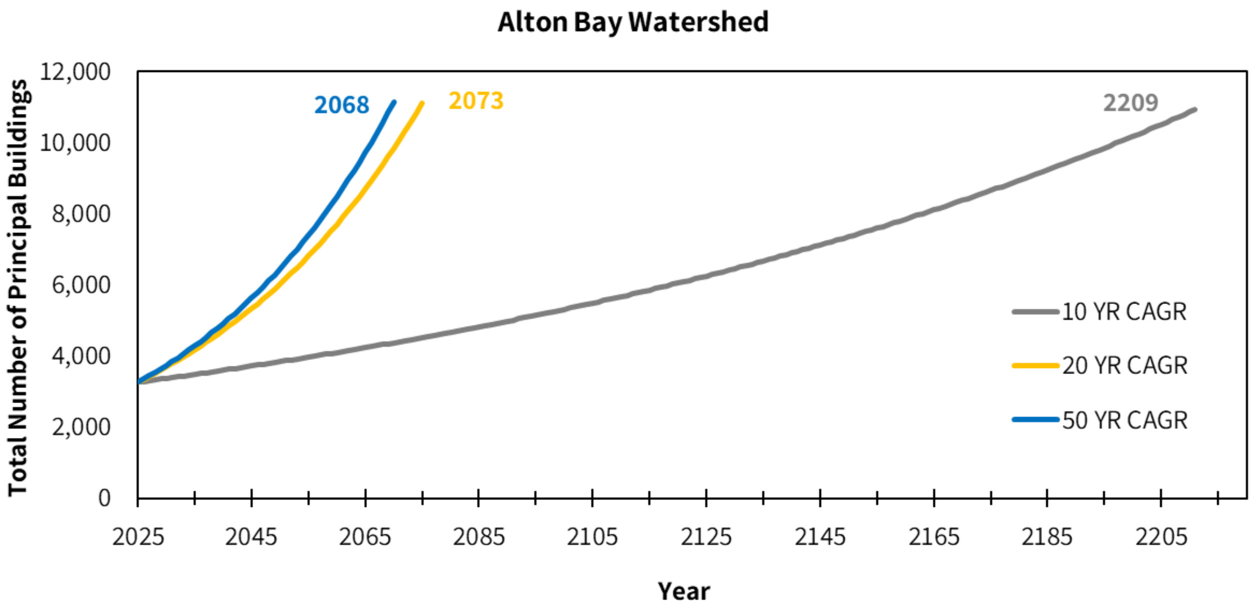


Figure 20. Full build-out time projections of the Alton Bay Watershed (based on compound annual growth rates reported in in the text).

2.5 WATER QUALITY GOAL & OBJECTIVES

The model estimated changes in total phosphorus loading and in-lake total phosphorus concentrations from pre-development through future conditions. Results show that in-lake concentrations have already more than doubled under current development and are projected to exceed the NHDES mesotrophic reserve capacity threshold if "business-as-usual" development continues, placing the long-term water quality of Alton Bay at risk.

Reducing watershed sources of phosphorus throughout the Alton 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 Alton 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 the bay and Lake Winnipesaukee into the future.

The goal of the Alton Bay WMP is to improve the water quality of Alton Bay such that it continues to meet state water quality standards for the protection of aquatic life integrity (ALI) and primary contact recreation (PCR) and substantially reduces the likelihood of harmful cyanobacteria blooms. This goal will be achieved by accomplishing the following objectives. More detailed action items to achieve these objectives are provided in the Action Plan (Section 5).

Objective 1: Reduce phosphorus loading from existing development by 30% (492 kg/yr) to Alton Bay to improve average in-lake summer total phosphorus concentration of 4.5 ppb.

Objective 2: Mitigate (prevent or offset) phosphorus loading from future development by 367 kg/yr to Alton Bay to maintain average summer in-lake total phosphorus concentration in the next 10 years (2035). *Note: excludes phosphorus loading from mixing with the Broads, focusing only on future development within the direct watershed to Alton Bay, Merrymeeting Lake, Downing, Jones and Marsh Ponds, and Merrymeeting River.*

Measures of success for achieving the goal and objectives should be based on a reduction in phosphorus loading from the major tributaries to Alton 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: The watershed survey identified 36 sites impacting the lake. Remediating these sites could prevent up to 17.3 kg/yr of phosphorus from entering Alton Bay. Treating prioritized shoreline sites (disturbance score between 7–12) could reduce the phosphorus load to Alton Bay by 56 kg/yr[3] identified from the shoreline survey. Upgrading the 447 known shorefront septic systems older than 25 years is estimated to reduce the phosphorus load to Alton Bay by 44.7 kg/yr. Additionally, remediating all non-point source pollution and point-source pollution sites in the Merrymeeting Lake, Marsh, Jones and Downing Pond, and Merrymeeting River sub-watersheds will reduce annual phosphorus loading by an additional 374 kg/yr (Table 12). **In sum, treating all existing pollutant sources identified as coming from the external watershed load could reduce the phosphorus load to Alton Bay by 492 kg/yr, which meets 100% of Objective 1 for Alton Bay.** Non-structural best management practices (BMPs) such as educating homeowners about septic system maintenance, fertilizer use, and residential stormwater management may also contribute to reducing phosphorus loading to Alton Bay beyond what has been identified in Table 12 to meet and exceed the water quality goals. Preventing septic system failures, reducing residential lawn fertilizer use, and improved stormwater management at the property scale were not included in the goal attainment calculations above. Because it is hydrologically connected to The Broads, reducing external watershed loads there would also decrease the load entering Alton Bay; however, these effects were not included in the above calculations.

Objective 2 can be met through ordinance revisions that implement low impact development strategies, reduce fertilizer use, and encourage cluster development with open space protection and/or through conservation of key parcels of forested and/or open land.

[3] Based on PLET model bank stabilization estimate for fine sandy loams, using 50–200 ft (length, depending on distance from the shoreline) by 3 ft (height) and moderate lateral recession rate of 0.1 ft/yr.

Table 12. Reality check of the water quality goal based on the identified external watershed loads.

	Alton Bay Watershed	**Merrymeeting River & Lake Watershed***
Remediating Watershed Assessment Sites Number of sites and total phosphorus load reduction.	36 sites, 17.3 kg/yr	78 sites, 25.5 kg/yr
Addressing Shoreline Properties Number of prioritized properties (Disturbance Scores 7–12) and total phosphorus load reduction.	272 properties, 56 kg/yr	285 properties, 51.6 kg/yr
Upgrading Shoreland Zone Septic Systems Number of septic systems > 25 years old and total phosphorus load reduction.	~447 systems, 44.7 kg/yr	~39 systems, 3.9 kg/yr
Addressing Point Source Pollution Reducing total phosphorus load at the Powder Mill Fish Hatchery	N/A	293 kg/yr
Total Phosphorus Load Reduction Per Individual Watershed Sum of remediating Non-Point Sources and Point Sources	118 kg/yr	374 kg/yr Total
Modeled Total Phosphorus Summer Concentration Goal, and Load Reduction Needed to Meet the Water Quality Goal	4.5 ppb 492 kg/yr	3.5 ppb, 16 kg/yr for Merrymeeting Lake 10 ppb, 307 kg/yr for Marsh, Jones, and Downing Ponds 10 ppb, 198 kg/yr for Merrymeeting River

* Values come from the 2019 Merrymeeting River & Lake Watershed-Based Management Plan (FBE, 2019). The values are likely an overestimate as some progress to reducing total phosphorus from the watershed has already been made.

The interim goals for each objective allow flexibility in reassessing 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 13). Understanding predicted water quality following watershed improvements compared to likely water quality 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 because of limited funding or other implementation resource constraints, rather than because phosphorus loading from new development is outpacing reductions from improvements to existing development, the conditions for adjusting interim goals are very different. 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 will then decide on how to adjust the next interim goals to better reflect water quality conditions and practical limitations to implementation.

Table 13. Summary of water quality objectives for Alton Bay. Interim goals/benchmarks are cumulative. TP refers to total phosphorus.

Water Quality Objective	Interim Goals/Benchmarks		
	2028	**2030**	**2035**
1. Reduce phosphorus loading from existing development to Alton Bay by 492 kg/yr to improve average in-lake summer or annual total phosphorus concentration to 4.5 ppb.			
	Achieve 7.5% (123 kg/yr) reduction in TP loading to Alton Bay.	Achieve 15% (246 kg/yr) reduction in TP loading to Alton Bay; re-evaluate water quality and track progress.	Achieve 30% (492 kg/yr) reduction in TP loading to Alton Bay; re-evaluate water quality and track progress.
2. Mitigate (prevent or offset) phosphorus loading from future development by 367 kg/yr to Alton Bay to maintain average summer in-lake total phosphorus concentration in the next 10 years (2035).			
	Prevent or offset 92 kg/yr in TP loading from new development to Alton Bay.	Prevent or offset 184 kg/yr in TP loading from new development to Alton Bay; re-evaluate water quality and track progress.	Prevent or offset 367 kg/yr in TP loading from new development to Alton Bay; re-evaluate water quality and track progress.

3 POLLUTANT SOURCE IDENTIFICATION

This section describes sources of excess phosphorus to Alton Bay. Sources of phosphorus to lakes include stormwater runoff, shoreline erosion, construction activities, illicit connections, failed or improperly functioning septic systems, leaky sewer lines, 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

Nonpoint source pollution comes from many diffuse sources within the landscape and is more difficult to identify and control than point source pollution. Nonpoint source 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, excessive fertilizer application, unmitigated agricultural activities, pet waste, and wildlife waste.

3.1.1 Historical Development

Alton Bay has a long history of human use. The area has likely been occupied since around 8,000 BCE. Groups of the Indigenous Western Abenaki tribe, including the Winnipesaukee, occupied the Lakes region of New Hampshire when early English settlers arrived there in the mid-1600s. (Brames, Inc., n.d). Impacts of Indigenous people on the Alton Bay environment would have been minimal. Their livelihoods were based on a mix of hunting, fishing, gathering, and subsistence farming of corn, beans, squash, potato, and tobacco.

The Indigenous people developed an extensive network of trails around Lake Winnipesaukee, recently digitized in an online StoryMap (Indigenous New Hampshire Collaborative Collective, 2024a). Many of these paths, including the Ko-kchokook (Cocheco) Trail from the east, intersected near present-day Alton, in a Native American village known as Quannippi. The Abenaki Trail traveled from Alton to Wolfeboro, the Quanippi Trail connected Alton to Merrymeeting Lake, and the Aguadak'gan Trail connected to the Broads and Center Harbor Bay watersheds on the western side of Lake Winnipesaukee. New Durham also had one known Native American campsite located at Coldrain Pond. These trail systems formed the basis for road and rail networks that were to be established in the coming centuries (Indigenous New Hampshire Collaborative Collective, 2024b). The Ko-kchokook Trail is now Old Bay Road and Main Street in New Durham, and the Abenaki Trail is Kings Highway.

The first major shift in land use within the Alton Bay watershed came in the colonial era, during the decades following the establishment of the Province of New Hampshire in the 1620s. By 1721, the New Hampshire Colonial Assembly voted to cut a road from Dover to Lake Winnipesaukee to construct a fort at the lake. The road followed the trails used by the Native Americans traveling to Alton Bay and became known as Bay Road.

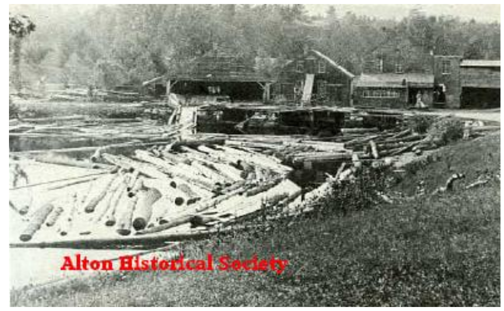
European settlers gradually displaced the Indigenous people in the region, establishing larger farms and logging operations. In its early years, the Alton Bay area developed primarily as a farming community (Lake Winnipesaukee Historical Society, 2024). The southern and eastern parts were the first to be settled, primarily for subsistence agriculture. New Durham was settled in 1750 and incorporated in 1762, though its rocky terrain made it more suitable for grazing than cultivation (New Durham Historical Society, 2022). People settled around the area's many waterbodies, including Merrymeeting Lake, Coldrain Pond, and the Merrymeeting, Mad, Isinglass, Ela, and Cocheco Rivers, relying on these waterways for power, moving goods, and food. As farming expanded into the higher elevations, merchants began settling in Alton Bay's lowlands. Colonists first arrived in Alton in the 1770s, and the town was officially incorporated in 1797.

Alton's agricultural land was greatly expanded for grazing of sheep during the "Great Sheep Boom" from 1810-40 (Alton Planning Board, 2023). Deforestation and the building of stone walls was particularly common in central New England during this time, including many parts of Alton Bay that are woodlands today. By 1840, there were an average of 65 sheep per square mile in New

England – more than two sheep for every person. The sheep boom collapsed rapidly after 1840 and many farms were quickly abandoned.

The clearing of forested land for farming increased the rates of sedimentation and nutrient runoff into Lake Winnipesaukee and other waterbodies. Another major human impact on the Lake during this period was the construction of the Lakeport dam in Paugus Bay in 1766. Prior to its construction, the water level was approximately 5–12 feet lower than it is today (Brames, Inc., n.d.).

Industrialization in the late 1700s and throughout the 1800s led to increased development and changing land use patterns around Lake Winnipesaukee. Lumber became the region's most important commodity. During this period, sawmills played a key role in the local economy, with Downing Pond forming as a result of a dam built in the late 1700s to support milling operations. Similarly, a sawmill and dam were established at the outlet of Merrymeeting Lake in the early 1800s, later transitioning to gunpowder production during the Civil War. For further details, see FBE (2019, pp. 9–10).



Wentworth Mills and dam in Alton, sometime before 1906. Credit: Alton Historical Society.

By 1859, New Durham had five sawmills, four shingle mills, two gristmills, and the gunpowder factory (New Durham Historical Society, 2022). Dams and canals associated with the mills were established along streams draining into Lake Winnipesaukee. These mills contributed to water pollution through the discharge of untreated waste, and their impervious surfaces increased precipitation runoff into the waterbodies they were built around. The combined impacts of damming and worsening water quality led to the extirpation of migratory shad in the Merrimack River, and thus Lake Winnipesaukee, by the end of the 19th century.

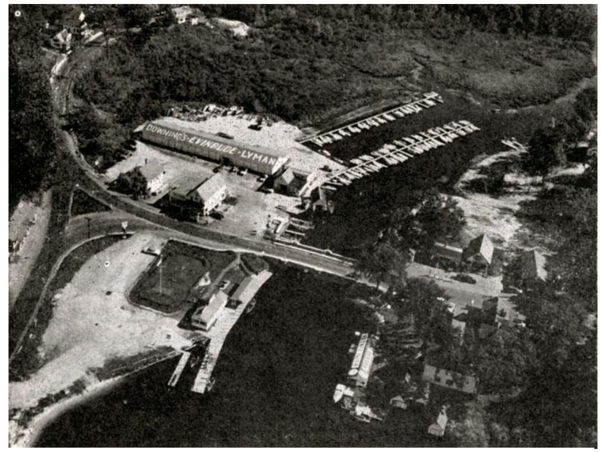
The establishment of industrialized mills and factories also led to increased urbanization in Alton Bay's towns, further contributing to logging and other land use changes in the watershed. Alton's 1797 population of 445 began to grow, swelling to 2,058 by 1820, and New Durham's population doubled between 1790 and 1820. This rapid urbanization in turn caused farms to expand further into the land surrounding Alton and New Durham, decreasing forest cover in the watershed.

During this time, agricultural productivity also increased as advances in farming techniques and machinery were introduced. Dairy farming became prominent in the late 19th century, facilitated by the extension of the Cocheco railroad to Alton in 1850 and the subsequent development of the Lakeshore Railroad to Lakeport in 1890. Steamboats also provided transport of goods and people to towns around the Lake, with Alton Bay being an important harbor. These transport networks allowed agricultural products to be shipped to outside markets. By the late 1800s, Alton had numerous types of stores and industries, including a corkscrew factory that by 1903 was producing 30 million corkscrews per year. A granite quarry was also operated for over a century, and ice was shipped out by railroad from Alton Bay in winter months. The Lakeshore Railroad remained in operation until 1935.

Tourism emerged as an important economic factor in the Alton Bay watershed during the late 19th century. The area became a popular vacation spot for visitors from all around the Northeast. Alton Bay is considered the birthplace of the Mount Washington Cruises, as they launched their first side-wheeler steamship there in 1872 (Lake Winnipesaukee Historical Society, 2024). For the first time, travelers could journey from Boston and New York City to Alton by rail, then take a steamboat from Alton Bay to Wolfeboro and other ports to continue their journey north to the White Mountains (Town of Alton, 2013). Increasing tourism led to the development of summer cottages, hotels, inns, and recreational facilities, especially concentrated around the shores of Lake Winnipesaukee and Merrymeeting Lake. It also contributed to further construction of roads, parking lots, and other impervious surfaces, in turn increasing stormwater runoff and pollution into waterbodies.

Dense development and clearing of natural vegetation along Alton Bay's shorelines increased in the 20th century as vacationing became more popular. Western shoreline of the Bay, looking south, in the 1930s. Credit: Lake Winnipesaukee Historical Society.

Residential, commercial, and recreational development continued to increase throughout the 20th century. Agriculture, especially dairy farming, became more commercialized as better transportation infrastructure allowed access to larger regional markets. This resulted in further conversion of forested lands to hayfields (to provide livestock feed for winter months) and pastures. Farms are still present in parts of the Alton Bay watershed, particularly further away from Lake Winnipesaukee's shorelines. For example, numerous hayfields and pastures are located along New Durham Road between New Durham and Alton, as well as in the south-east of the watershed along Halls Hill Road. In 2022, the town of Alton had 1,417 acres of farmland enrolled in the state's Current Use Program (Alton Planning Board, 2023). New Durham similarly has numerous active farms growing, among others, Christmas trees, peaches, berries, apples, and greenhouse plants (New Durham, 2024).



A 1956 aerial view of the Downings Landing marina near the Main Street bridge where the Merrymeeting River meets Lake Winnipesaukee in Alton. Credit: Weirs Beach.

Like the land within the watershed, use of the waterbodies within Alton Bay also continued evolving in the 20th century. New dams were constructed at Jones Pond and Merrymeeting Lake (FBE, 2019), and the New Hampshire Fish and Game Department (NHFG) built the state's largest fish hatchery, the Powder Mill Fish Hatchery, at the Merrymeeting Lake outlet in 1947. Today, the hatchery contains significant concrete damage. NHFG has recently commissioned a project to build a new wastewater treatment facility to address this issue (NHFG, 2024). In the 1960s, Marsh Pond, located just downstream of Merrymeeting Lake, was used as a disposal site for New Durham's town trash. The site was later closed by covering the waste with 21 truckloads of sand and compacting it with bulldozers (FBE, 2019).

The *Merrymeeting River and Lake Watershed Management Plan* (FBE, 2019) identified Mill Pond as a significant source of pollution into this river system, which eventually drains into Alton Bay. Mill Pond was created in the late 1800s, when a sawmill and grist mills were established. The pond has faced long-standing water quality issues, with concerns dating back to the 19th century when residents relied on an aqueduct system instead of the pond for drinking water. Over time, pollution from various sources, including a former landfill, septic failures, sawmill waste, and stormwater runoff, has further impacted water quality in this waterbody. For more details on Mill Pond's history, see FBE (2019, p. 34).

Today, the shoreline of Alton Bay serves several water-dependent establishments, including two marinas, a town boardwalk and public boat docks, the town beach and swimming areas (Alton Planning Board, 2023). Several lodging and restaurant establishments cater to the Lake's many visitors. Dense private ownership along the waterfront limits opportunities for public lake access. The present M/S Mount Washington cruise still transports tourists from Alton Bay to ports around Lake Winnipesaukee between May and October each year. Additionally, Alton Bay serves as New Hampshire's only public seaplane airport in the winter months, when the bay is used as an ice runway.

In 2022, the population census of Alton recorded 6,026 residents (NHES, 2024), and New Durham around 2,500 residents (New Durham, 2024). For the past half century, Alton's year-round population has consistently grown at a rate greater than the county or state. During the same period, the number of housing units in Alton more than doubled, and numerous new subdivision roads were constructed (Alton Planning Board, 2023). Alton Village is considered the primary center of the community, housing the Town Hall, Gilman Library, Gilman Museum, Alton Central School, Police Station, and Central Fire Station (Alton Planning Board, 2023). Several restaurants, shops, churches, and houses also dominate the land use in this part of Alton Bay, resulting in a high cover of impervious surfaces.

Most existing lots located along Lake Winnipesaukee in West Alton were created prior to zoning and are therefore often undersized and irregularly shaped (Alton Planning Board, 2023). Other than the dense development directly on the shoreline of the western part of Alton Bay, the area is generally more rural than Alton Village. Undeveloped land in this area is significant owing to steep slopes that restrict development potential. Much of this area, which includes parts of Mount Major, is considered high-value wildlife habitat, and is part of the 33,000 acres of unfragmented land in the Belknap Mountains (Alton Planning Board, 2023). This area is also popular for hiking and consists of a mix of private and public ownership.

Many of the houses on Alton Bay's eastern shorelines have been winterized and are now being used year-round, either as residences or as rental property. Many original cottages have been converted into larger houses, as evidenced by a large number of building permits for work on existing structures being processed in the last decade (Alton Planning Board, 2023). Several large land parcels on the eastern shore that were previously operated as youth summer camps have been subdivided for residential use, changing the character of this area from family summer getaways to high-income neighborhoods, and increasing the footprint of human impacts on the lakeshore (Alton Planning Board, 2023).

There are also several protected forested and wetland areas that lie partially or wholly within the Alton Bay watershed (see Section 4.2.3: Land Conservation). These contribute to the resiliency of the watershed, by increasing infiltration of rain and snowmelt, and reducing runoff and erosion. Land conservation is essential to the health of the region, particularly for the protection of water resources, enhancement of recreation opportunities, vitality of local economies, and preservation of wildlife habitat.

3.1.2 Watershed Survey

A survey of the Alton Bay watershed was completed by technical staff from FBE in Augst 2024. The objective of the watershed survey was to identify and characterize sites contributing NPS pollution and/or providing opportunities to mitigate NPS pollution in the watershed. Prior to fieldwork, FBE analyzed aerial images and GIS data for land use/land cover, roads, 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. The survey area excluded the Merrymeeting River and Lake watersheds, for which a watershed survey was conducted in 2018 as part of the *Merrymeeting River and Lake Watershed Management Plan* (FBE, 2019).

For each identified problem site, field staff recorded site data and photographs on mobile devices. 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.

FBE identified 36 problem sites in the watershed (Figure 21). The main issues found were water access point erosion and road and ditch erosion, and camp and beach runoff. FBE estimated the potential pollutant removal that could be achieved by implementing recommendations. Appendix B summarizes the impacts, load reduction estimates, and estimated costs for each site. The top five high priority sites (based on lowest impact-weighted cost per mass of phosphorus removed) 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 to for water quality protection.

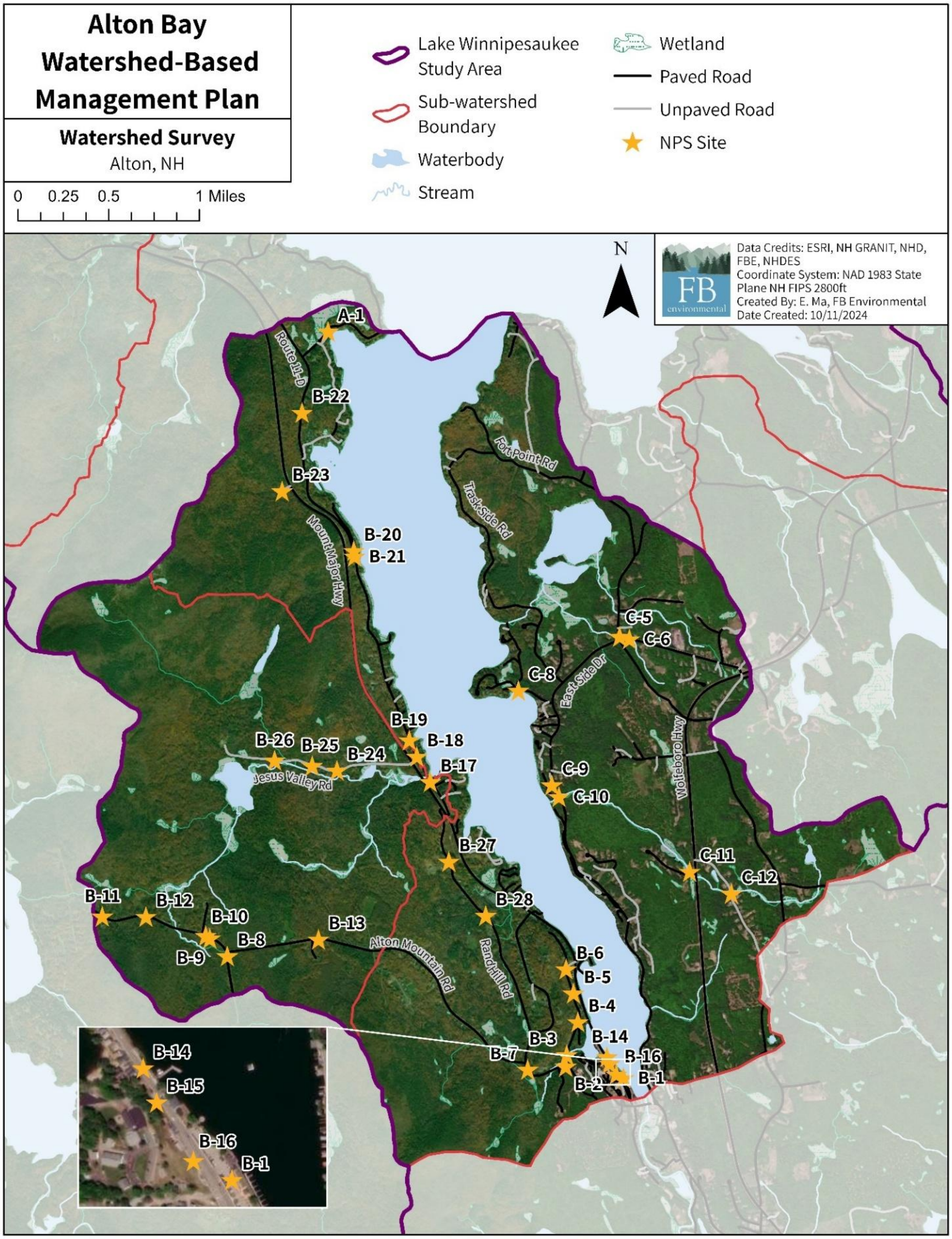


Figure 21. Location of identified nonpoint source sites in the Alton Bay watershed. The survey area excluded the Merrymeeting River and Lake watersheds, for which a watershed survey was conducted in 2018 as part of the *Merrymeeting River and Lake Watershed Management Plan* (FBE, 2019).

Site C-12: Lily Pond Road

Location (latitude, longitude): 43.48699, -71.22447

Impact: High

Observations: A large volume of sediment washes into the stream and wetland adjacent to Lily Pond Road from both sides of the road. This long stretch of erosion is upslope of the stream crossing on Lily Pond Road and begins near House 132. Lily Pond Road is unpaved.

Recommendations: We recommend constructing riprap-lined ditches with frequent check dams, and sediment plunge pools near the stream crossing on both sides of Lily Pond Road, from the stream crossing to House 132. Turnouts may be necessary to direct stormwater into the plunge pools.

(Top) Roadside ditch erosion on both sides of Lily Pond Road upslope of the stream crossing. (Bottom) Large volumes of sediment have been deposited in the wetlands adjacent to the road.

Site B-09: Alton Mountain Road Stream

Location (latitude, longitude): 43.48362, -71.28173

Impact: High

Observations: A massive gully runs along a steep section of Alton Mountain Road, which has deposited large amounts of sediment along the road shoulder and directly into a nearby headwater stream. The stream converges with Watson Brook and ultimately enters Alton Bay. The road ditch drains Alton Mountain Road, stretching from the intersection with Avery Hill Road to the site.

Recommendations: Armor the ditch with riprap and reshape the gully into a U-shape to disperse and slow stormwater movement. As the site is steeply sloped with evidence of high flow, install check dams intermittently along the ditch. Install a plunge pool at the bottom of the road ditch to capture and settle out sediment before it can enter the stream channel.

A, B, & C: The large gully on Alton Mountain Road leads directly to a stream. D & E: Sediment has accumulated at the intersection of the road ditch and the stream channel.

Site B-18: Route 11-D & Loon Cove Road Intersection

Location (latitude, longitude): 43.49808, -71.25891

Impact: High

Observations: There is a completely bare road shoulder and ditch on the northeastern side of Route 11-D, where it intersects with Loon Cove Road and Mount Major Highway. Several small gullies run through the ditch, and outwashed sand has accumulated in the ditch. Stormwater funnels through the ditch into a culvert, which likely outfalls to Alton Bay. Additionally, the intersection of Mount Major Highway and Route 11-D is wide with excessive impervious cover.

Recommendations: Vegetate the ditch with grass or riprap, if plantings are unable to establish. Replace excess impervious cover in the intersection with grass swales to treat stormwater from the adjacent roads.

(Left) The road ditch is on Route 11-D is completely bare. (Middle) Multiple small gullies run through the ditch. (Top right) Large impervious area at the intersection of Route 11-D and Mount Major Highway. (Bottom right) Stormwater exits the ditch through a culvert.

Site B-24: Jesus Valley Road #1

Location (latitude, longitude): 43.49600, -71.26768

Impact: Medium

Observations: Long stretches of erosion were observed in the road shoulder on both side of Jesus Valley Road, which is unpaved. On the southern side, the gully outlets into an intermittent stream/wetland in the forested area. The gully on the northern side of the road disappears as the road flattens out. The road is extremely narrow, and the ditch is V-shaped. Jesus Valley Road is located extremely close to Watson Brook.

Recommendations: Stabilize the soil with crushed gravel and install check dams or coir logs to slow down the water movement and filter out sediment. If possible with the narrow road shoulder, reshape the ditches to be U-shaped. Coir logs or a sediment plunge pool may be installed near the end of the gullies to settle out sediment and prevent it from entering the wetland.

(A, B) Road shoulder gullies lead toward a wetland. (C) View of a stormwater culvert on Jesus Valley Road. (D) Outwashed sediment on the road shoulder suggests that stormwater carries pollutants downslope. (E) Sediment from the road deposits into the forested area.

Site B-04: Spring Street Gravel Road

Location (latitude, longitude): 43.47681, -71.24138

Impact: Medium

Observations: An unarmored dug ditch runs along the unpaved portion of Spring Street, contributing sediment and therefore phosphorus to a stream leading to Alton Bay. Sediment has accumulated in the ditch from the dirt road, unpaved private driveways, and uphill properties with steep slopes. There are two clogged driveway culverts along this ditch, one of which is crushed and cracked. In flatter areas of the ditch, water has pooled. The furthest uphill gully has a puddle on a road that does not appear to be caused by runoff and is flowing into the ditch.

Recommendations: Reshape the ditch into a U-shape to slow and disperse stormwater along the channel. Armor the ditch with check dams and riprap in steep areas or vegetate in the wet, flat area. If it is still present, investigate the water source of the upstream puddle. Replace or clean out driveway culverts and provide outreach materials for homeowners to practice property level stormwater management.

(Left) Outwashed sand in the road ditch suggests that stormwater carries pollutants toward waterbodies. (Top) A crushed and cracked culvert is filled with sediment under a driveway on Spring Street. (Bottom Left) A driveway culvert is filled with sediment. (Bottom Right) The bare road ditch is eroding; vegetation may be a viable BMP option in flatter areas.

3.1.3 Shoreline Survey

LWA staff members Bree Rossiter and John Flaherty conducted a shoreline survey of Lake Winnipesaukee in Alton Bay in July and August 2024, with boating assistance for surveying lakefront parcels provided by Alton residents Dick Fleming and Dana Huff. 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.

Technical staff 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. The scores were summed to produce two metrics: the "Shoreline Disturbance Score" (ranging from 3 to 12) and the "Shoreline Vulnerability Score" (ranging from 1 to 6). Higher scores reflect poorer or more vulnerable shoreline conditions. Photos were taken at each parcel and were cataloged by tax map-lot number. These photos will provide stakeholders 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 472 parcels were evaluated along the shoreline of Alton Bay in Alton. The average Shoreline Disturbance Score, which evaluates buffer, bare soil, and shoreline erosion for Alton Bay, was 6.7 (Table 14). About 57% of the shoreline, or 272 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 tend to have inadequate buffers, evidence of bare soil or use of lawn fertilizer, and shoreline erosion.

The average Shoreline Vulnerability Score, which evaluates distance and slope, was 4.7 (Table 14). About 90%, or 424 parcels, scored 4 or greater. A vulnerability score of 4 or greater indicates that the parcel may have its residence within 150 feet of the shoreline with 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. The majority of shoreline parcels in Alton Bay (68%, or 323 parcels) are particularly prone to erosion for having homes within 75 feet of the shoreline, receiving the maximum score for distance to shore of 3.

Table 14. Average Shoreline Disturbance and Vulnerability Scores for Alton Bay. Higher values represent poorer or more vulnerable conditions.

Evaluated Condition	Average Condition Score	Average Score
Buffer (1-5)	3.4	Shoreline Disturbance Score (3-12) 6.7
Bare Soil (1-4)	1.9	
Shoreline Erosion (1-3)	1.4	
Distance (0-3)	2.4	Shoreline Vulnerability Score (1-6) 4.7
Slope (1-3)	2.2	

The pollutant loading estimates are based on the Shoreline Disturbance Scores. The 272 parcels with scores 7-11 are contributing approximately 112 kg of phosphorus annually[4]. If shoreline landowners were to create adequate buffers and install other shoreline Best Management Practices (BMPs) on these properties (at a 50% BMP efficiency rate), the annual reduction would be 56 kg of phosphorus.

Certain site characteristics, such as slope, can cause shorelines to be naturally more vulnerable to erosion. Other site characteristics such as the distance between the structure and 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 Alton Bay is moderate for erosion issues (average disturbance score of 6.7). Alton Bay is also generally more prone to erosion issues because many homes are located close to shore (average distance score is 2.4 out of 3).

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. In 2025, LWA sent postcard mailings to property owners of the 57% of parcels that received scores between 7 and 12 on the Shoreline Disturbance Score with a report of the results for their property and recommendations for getting technical assistance help. Property owners will be invited to participate in the free and voluntary Be Winni Blue/LakeSmart program.

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 reflects 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 for (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 have created the Winnipesaukee River Basin Stratified Drift Aquifers, comprising seventeen of the cleanest and most productive aquifers in the region. Several of these aquifers are located within the Alton Bay watershed, as mapped by the US Geological Survey (Ayotte, 1997). They consist of fine-grained, coarse-grained, and layered coarse-over-fine-grained drift deposits. The saturated thickness generally ranges from 0 to 20 feet but

[4] 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.

exceeds 100 feet in the southwestern portions of the Merrrymeeting River. Aquifer transmissivity varies widely, from less than 1,000 to greater than 4,000 ft^2/day.

Lake Winnipesaukee serves as a discharge point for these aquifers, receiving groundwater from the stratified drift deposits. Due to the high transmissivity of the material, contaminants can spread rapidly through the aquifer and into the lake and other surface waters. Therefore, safeguarding the aquifer is essential for protecting the water quality of Lake Winnipesaukee.

3.1.4.2 Soils and Erosion Hazard

The soils in the Alton Bay watershed (Appendix A, Map A-6) are a direct result of geologic processes. Of the 60 different soil series present within the Alton Bay watershed (excluding soils beneath waterbodies), the most prevalent soil group in the watershed is Tunbridge-Lyman-Becket complex (3,926 acres, 13% of the watershed land area; a well-drained soil type), followed by Gloucester extremely stony fine sandy loam (3,418 acres, 12%; somewhat excessively drained), Metacomet fine sandy loam (2,163 acres, 7%; moderately well drained), Pillsbury fine sandy loam (1,625 acres, 6%; poorly drained), and Millsite-Woodstock-Henniker complex (1,561 acres, 5%; well drained). The remaining 57% of the watershed (excluding areas identified with soil as “water”) is a combination of 55 additional soil series ranging from 5% 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 is determined from the associated slope and soil erosion factor K_w[5] 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. These ratings are derived as part of the Soil Erosion Hazard Off-Road/Off-Trail for each soil series. Excluding soils under waterbodies, “very severe” erosion hazard areas account for 4% (1,122 acres) of the Alton Bay watershed, and “severe” hazard areas account for 11% (3,083 acres). These areas are mostly concentrated in the northwestern, mountainous portion of the watershed (Appendix A, Map A-7). Moderate erosion hazard areas account for 60% of the watershed land area (17,381 acres) and slight erosion hazard areas account for 24% (7,117 acres). An additional 2% (500 acres) is not rated. Development should be restricted in areas with moderate to more severe 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.

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 Alton Bay have expressed concern about enhanced shoreline erosion caused by boat wakes. Water level management in Lake

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

Winnipesaukee is complex, requiring a balance between the various environmental and recreational needs of users of both the lake and the downstream Winnipesaukee River. The lake level is controlled at the Lakeport Dam in Laconia.

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 insufficient 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.

How Old is Your Septic System?

Unsure of the age or status of your septic system? Don't worry! You can investigate the age of your septic system by searching your street address on the NHDES Subsurface Application Status OneStop. We recommend entering the town and street name into the query to pull up your property. The approval date associated with your property should reflect the age of the system. Sometimes there is no data on the State's database. This might mean there was a clerical error, or your system is older than the database itself. In this case, call a licensed septic inspector, who can identify the location and status of your septic system. Inspections should be routinely performed every few years, to inform you of the status of your system and to ensure it is not failing or underperforming. Pumping the septic tank every 1-3 years can also ensure proper function.

Septic systems along the shoreline pose a great risk to water quality due to the proximity of the septic drainfield to the waterbody compared to others in the watershed. In a conventional septic system, household waste is held in a septic tank, which separates liquids, solids, and oils. Wastewater then flows to the drainfield, where it is dispersed into the soil for treatment through natural filtration. Although the primary public health concern in siting and designing septic systems is pathogen treatment, nutrients such as nitrogen and phosphorus are also present in wastewater and pose a risk to water quality if there is inadequate nutrient removal. Since septic systems rely on the soil to treat nutrients, the characteristics of the surrounding soil are incredibly important to the transport of nutrients from septic systems to waterbodies. For example, septic systems in coarse-textured soils, soils with shallow water table, or bedrock tend to have a lower capacity to treat nutrients. Septic systems can also fail as they age, which leads to wastewater ponding at the drainfield surface. This is largely a public health issue, due to the pathogens in the wastewater, but failing septic systems near the shore can also pose significant nutrient loading issues especially if there is a downslope path where the water can be easily transported to a waterbody.

The Lake Winnipesaukee shoreline in Alton is densely developed because of the desirability of the waterfront, limited areas where slopes allow for construction of houses, and the importance of the railroad in Alton Bay in the 19th century. The Alton Bay Christian Conference Center occupies a significant area of Alton Bay and has some of the watershed's densest development. Many of the houses in the shoreline area are also growing larger and their owners are increasingly becoming year-round residents (Alton Planning Board, 2023). Because of this density, there is a high volume of septic system effluent entering the ground in a small area. According to the Alton Master Plan (Alton Planning Board, 2023), known septic system failures have been rare despite many of these systems being undersized by modern standards. According to the Master Plan, collaboration between homeowners, NHDES and local officials has helped in the control of septic system failures. As of 2023, there were no plans to expand the municipal sewage system beyond Alton Village.

LWA completed an initial review of available data on septic systems within 250 feet of the Alton Bay shoreline in 2024. The objective of this survey was to determine the number of septic systems along the shoreline of Alton Bay and the proportion of older septic systems. Using GIS and parcel data from the Town of Alton, it was determined that 724 parcels of land fall within the 250-foot boundary of the lake. Deductions were made for vacant land, commercial lots, conservation land, and sub-parcels, resulting in 576 parcels with buildings. Further analysis of the 576 parcels indicated that 447 parcels contain buildings built before 1999; the date used to determine the number of systems older than 25 years (the average life span of a septic system). Alton tax records were reviewed to gather information on property ownership and the NHDES Subsurface OneStop online database was searched to provide information on the construction or operational approval dates of the septic system. A review of the 364 parcels with lot sizes equal to or under 0.5 acres determined that 292 parcels had buildings built before 1999. The NHDES Subsurface OneStop database indicated that only 17 systems had been replaced. Refer to the *Septic System Risk Analysis Alton Bay Watershed* Technical Memorandum (LWA, 2024) for further details on assessment methodology.

Nutrient loading was estimated using the Excel-based LLRM Septic System Nutrient Model, with default literature values for daily water usage, phosphorus concentration output per person, and system phosphorus attenuation factors, to estimate phosphorus loading. Due to the high seasonal use of properties on Lake Winnipesaukee, the number of people per dwelling has been increased to 3.5, rather than the 2.5 value normally used in the LLRM. Septic system data for Merrymeeting Lake and River were kept the same as those from the *Merrymeeting River and Lake Watershed Management Plan* (FBE, 2019), with the assumptions that there were no major increases in development over the five-year period since the modeling, and the relative proportion of “old” to “new” septic systems would remain nearly constant as old systems are replaced and formerly new systems have aged.

As detailed in the *Alton Bay Lake Loading Response Model Report* (FBE, 2025a), shoreline septic systems contribute **95.3 kg/yr** of total phosphorus loading to Alton Bay, comprising **6%** of the total phosphorus load from all sources to the lake. Some septic systems, cesspools, or holding tanks are located within a short distance to the water, leaving little horizontal (and sometimes vertical) distance through soil for proper filtration of wastewater effluent. Improper siting, installation, or maintenance 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.

3.1.6 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. The New Hampshire Shoreland Water Quality Protection Act (SWQPA) prohibits all fertilizer use within 25 feet of the reference line of public waters, as well as quick-release fertilizers (those containing more than 2% phosphorus and a nitrogen component that is less than 50% slow-release) within 25 to 250 feet of the reference line.

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 Alton Bay watershed is minimal (<1% of the total area) and includes some cropland, orchards, grazing areas, and hayfields. Agricultural activities, including dairy farming, raising livestock and poultry, growing crops, and keeping horses and other animals for pleasure or profit, involve managing nutrients, although Alton has a history of more intensive agriculture than is visible today (see Section 3.1.1).

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 poorly timed fertilizer application, as well as improper storage that allows nutrients to wash away with precipitation, not only threatens lakes and other water bodies but also prevents nutrients from reaching the intended crops. 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

Parts of Alton have experienced significant inland flooding caused by major storms, notably in May 2006, December 2022 and in May, July and December 2023 (Alton Hazard Mitigation Planning Team, 2024). The most severe floods recorded in the watershed occurred across New Hampshire in the late 1930s, one triggered by the Great New England Hurricane and another resulting from heavy rainfall coinciding with spring snowmelt.

Areas of concern for flooding include hilly areas, areas with large amounts of impervious cover, or areas located within a floodplain. The west side of Alton Bay, particularly along NH Route 11, contains a large amount of impervious surface cover and managed lawns, and relatively steep topography. Additionally, the Alton Power Dam, owned by New Hampshire Fish & Game, is rated as 'high hazard' in the 2024 Alton Hazard Mitigation Plan Update for inland flooding and dam failure. 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, provides critical insight to watershed management, particularly as it pertains to lake water quality. According to the US Census Bureau, Alton, New Durham, Middleton, Brookfield, and Gilmanton have experienced steady population growth over the last 50 years (see Section 2.4.2). The watershed has experienced consistently higher population growth rates than the statewide average. The Alton Bay area has long been treasured as a recreational haven for both summer vacationers, young campers, and year-round residents. The area 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 Alton Bay and the greater New Hampshire Lakes Region as recreational destinations and full-time residence 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 on local water resources. As the region's watersheds are developed, erosion from disturbed areas 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 2.4 identified internal phosphorus load as a minimal source of phosphorus to Alton Bay (<0.5% of the total phosphorus load) though more data are needed to accurately determine its contribution.

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 January 28, 2025, FBE downloaded datasets for aboveground storage tanks, underground storage tanks, automobile salvage yards, solid waste facilities, hazardous waste sites, local potential contamination sources, NPDES outfalls, and remediation sites in the Alton Bay watershed. Out of the eight possible categories, seven occur in the watershed: all but automobile salvage yards (Appendix A, Map A-9).

3.3.1 Hazardous Waste Sites

Hazardous waste generating facilities are identified through the EPA's Resource Conservation and Recovery Act (RCRA) and require either federal or state regulation. Of the 12 hazardous waste generating facilities within the Alton Bay watershed, four are listed as active – Huggins Hospital, NH Electric Co-Op Inc, Hannaford, and the Alton Auto Center. Seven are inactive and one is declassified.

3.3.2 Solid Waste Facilities

There are two solid waste facilities within the Alton Bay watershed. One of these, the Alton Municipal Landfill, is no longer operating. The Hurd Hill Road Municipal Transfer Station remains in operation for the collection, storage, and transfer of waste.

3.3.3 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 eight aboveground storage tanks within the Alton Bay watershed. Three are at the Alton Irving Bulk Terminal, two are at the New Durham General Store, one is at the Alton Highway Garage along the Letter S Road, and one is at Downings Landing marina near the Merrymeeting River inlet to Alton Bay. There are an additional 43 underground storage tanks within the watershed. They are concentrated around downtown Alton, with additional concentrations in downtown New Durham and at the southwestern end of Merrymeeting Lake. Ownership of these tanks can range from commercial industries, gas stations, hospitals, marinas, schools, local government, residential or farms, and utilities.

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. Within the Alton Bay watershed, nine potential local contamination sources have been identified: three near the inlet of the Merrymeeting River into the bay, three in the Main Street area of downtown Alton, two near the Merrymeeting River wetland complex, and one in downtown New Durham.

3.3.5 NPDES Outfalls

Three NPDES outfalls associated with the Powder Mill State Fish Hatchery (Permit #NH0000710) discharge pollutants into the Merrymeeting River. The permit is held by the New Hampshire Fish and Game Department.

3.3.6 Remediation sites

There are 104 remediation sites present within the Alton Bay watershed including underground injection control sites, leaking storage facilities that contain fuel or oil, initial spill response sites, historical dump sites, and submerged vehicles, among others.

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 33.2 kg/yr (2%) of the total phosphorus load to Alton Bay.

3.5 ENVIRONMENTAL VARIABILITY

Environmental variability has important implications for water quality that should be incorporated into WMPs. In the last century, New England has already experienced significant changes in stream flow and air temperature. Out of 28 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). 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 are occurring 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 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. 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 up to 7,619 new buildings could be added to the watershed at full build-out based on current zoning standards. Alton Bay is at serious risk for sustained water quality degradation with the possibility for new development in the watershed unless environmental 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.

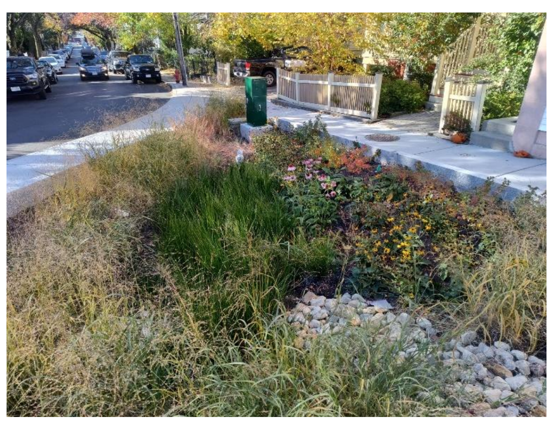
4.1.1 Watershed & Shoreline BMPs

Thirty-six (36) NPS sites identified during the 2024 watershed survey and two hundred and seventy-two (272) prioritized shoreline properties from the 2024 shoreline survey were documented to have some impact to water quality through the delivery of phosphorus-laden sediment (refer to Section 3.1.2 and 3.1.3). 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 (and the remaining 31 sites as opportunities arise) identified during the 2024 watershed survey. The sites were ranked based on phosphorus load reduction, waterbody proximity, and estimated cost. The full prioritization matrix with recommended improvements is provided in Appendix B.
- Provide technical assistance and/or implementation cost sharing to the 272 prioritized shoreline properties identified during the 2024 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, the committee 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.



An example of an urban stormwater BMP in Boston, MA.

Engineered Best Management Practices for Stormwater Runoff & Pollution Prevention

To protect water quality by reducing stormwater runoff and nutrients from entering Alton Bay, a suite of engineered Best Management Practices (BMPs) may be considered with routine maintenance. These may include but are not limited to the following:

- **Stormwater Detention Basins** – Temporarily store runoff during storm events to prevent downstream flooding and allow pollutants to settle.
- **Curb Cuts to Detention Areas** – Strategic gaps in curbing direct surface runoff from impervious areas into vegetated or engineered detention zones, promoting infiltration and reducing pollutant loads.
- **Vegetated Swales** – Direct and slow down runoff while promoting natural infiltration and pollutant uptake through vegetation.
- **Rain Gardens & Bioretention Areas** – Designed to capture and treat stormwater onsite using vegetation and soil media to filter pollutants before reaching surface waters.
- **Permeable Pavement** – Reduces runoff volume by allowing stormwater to infiltrate through or between surfaces or pavers in parking areas and walkways.
- **Catch Basins** – Capture and settle out sediments and coarse materials from stormwater before it enters downstream infrastructure or waterbodies.

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, 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* (UNH Stormwater Center, CEI & NHDES, 2025) 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 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 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. LWA completed a preliminary ordinance review of natural resource protections for the towns surrounding Lake Winnipesaukee, including Alton and New Durham (Table 15). These towns have already incorporated several important regulations into their ordinances. A more robust review of these ordinances is encouraged for more specific recommendations on improving ordinances and regulations related to natural resource protection. The towns should also consider their staffing capacity to enforce existing and proposed regulations.

Local land use planning and zoning ordinances should consider incorporating environmental 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 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 freshwater. 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.

- **Encouraging Riparian Buffers and Maintaining Floodplains:** Municipal ordinances should forbid construction in floodplains, and in some instances, floodplain protections should be expanded. Riparian (vegetated) buffers and filter strips along waterways should be preserved and/or created to slow runoff and filter pollutants.
- **Protecting and Re-establishing Wetlands:** Wetlands are increasingly important for preservation because wetlands hold water, recharge groundwater, and mitigate water pollution.
- **Encouraging Tree Planting and Conservation:** 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.

Table 15. Ordinance review summary of regulatory and non-regulatory tools for natural resource protection in Alton and New Durham, which comprises 98.6% of the Alton Bay watershed and the entire lake shoreline. (Table produced by staff at LWA.)

Strategy	Alton	New Durham
Aquifer Protection Overlay District	Yes. Adequate areas of pervious surfaces and open areas are needed for groundwater infiltration methods. On-site disposal of solid wastes other than brush and stumps is prohibited.	Yes, follows normally permitted underlying zoning uses, except that no more than 20% of a lot shall be covered by impervious surfaces.
Comprehensive Shoreland Protection	Shoreland Protection overlay district was Rescinded on 12 March 2024. Follows NH state regulations.	Follows NHDES regulations.
Conservation Focus Area Overlay District	None were mentioned so it must follow state regulations.	Yes, has a 100 ft naturally vegetated buffer zone.
Erosion and Sedimentation Control Ordinance	No ordinances but regulations for sedimentation and erosion control during site planning and incorporated in the stormwater management plan.	Coupled with stormwater management and is called the stormwater management and erosion control ordinance.
LID Reference	Yes, are preferred and will be used to the maximum extent possible.	Parking area designs should incorporate low-impact development designs.
Groundwater Protection Ordinance	No, considered part of the aquifer protection overlay district.	None were mentioned so it must follow state regulations.
Phosphorus Ordinance	None were mentioned so it must follow state regulations.	None were mentioned so it must follow state regulations.
Shorefront Conservation Overlay District	None were mentioned so it must follow state regulations.	Yes - 300 ft boundary/reference line, 75 ft building setback, 150 ft leach field setback.

Strategy	Alton	New Durham
Site Plan Review Regulations	Yes, last revised in December 2012.	Yes, plans are needed for multi-family dwellings, non-residential sites or structures, or mixed-use development. Last revised May 2014.
Steep Slope Watershed Overlay	None mentioned so it must follow state regulations.	Yes, a steep slope conservation overlay district is anything with a slope of 15% or greater. Has a conditional use permit and a no conditional use permit which depends on the gradient and activity.
Sewer Ordinance	None, but is talked about in the floodplain development ordinance in which if the sewer is placed in a special flood hazard area assurance has to be given to the codes enforcement officer that the design will limit or eliminate infiltration of flood water from the system.	Yes, follows the NHDES regulations. In situations where there is no valid subsurface design approved on file with NHDES, they will certify with the Health Officer in the town.
Stormwater Management	The purpose of Alton's stormwater management ordinance is to protect public health, safety, and welfare by reducing pollution, enhancing groundwater recharge, managing runoff velocity, and preserving water quality and infrastructure. The ordinance applies to developments with slopes of 15% or more or areas near steep slopes, requiring landowners to implement temporary erosion controls and permanent stormwater measures, while obtaining necessary permits and maintaining systems. Applicants must submit detailed site plans, erosion control strategies, and inspection schedules, ensuring compliance with design standards that control runoff and preserve natural drainage. The Code Official and Board of Selectmen oversee administration, including plan reviews, inspections, bonding requirements, and consultation with the Conservation Commission.	The Stormwater Management and Erosion Control Ordinance applies to new subdivisions and land disturbances exceeding specific thresholds based on slope and size. Disturbances include exposing soil or altering topography through activities like clearing, grading, or excavation, while exemptions cover minor repairs, utility trenching, and certain agricultural or forestry operations if Best Management Practices are followed. Incidental disturbances are defined as smaller-scale projects (e.g., up to 12,000 square feet on gentler slopes) with limited impervious surface impacts, while non-incidental disturbances involve larger-scale or steeper slope alterations. The ordinance establishes clear thresholds and requirements to manage runoff and erosion, depending on the scope and nature of the disturbance.
Subdivision Regulations	Yes, last amended April 2017.	Yes.
Washing/Public Waters	None were mentioned so it must follow state regulations.	Unlawful to use or deposit any soaps, detergents, cleaning agents, or petroleum products in any public waters.
Water Quality Protection Overlay District	Follows NHDES regulations	New Durham shall require conservation and land management practices that minimize environmental degradation and alteration of scenic and rural character.

Strategy	Alton	New Durham
Water Resources Conservation Overlay District	None.	None were mentioned so it must follow state regulations.
Conservation Subdivision Design Ordinance	None were mentioned so it must follow state regulations.	Yes, a minimum of 100 feet wide naturally vegetated and/or landscaped buffer area shall be provided along the perimeter of the lot with few exceptions. The planning board may issue conditional use permits for areas greater than 1,000 feet but less than 1,500 feet if it meets certain conditions.
Watershed Overlay District	None were mentioned so it must follow state regulations.	Yes, for Merrymeeting Lake. Regulations on protecting skyline as a natural vegetative growth area and outdoor lights to maintain dark sky.
Wastewater/Septics	None were mentioned so it must follow state regulations.	Adopted March 2023. In cases where no valid septic system design is on file with DES, the owner shall certify to the health officer that the existing system is not in failure.
Wetland Resources Conservation Overlay District	25-ft wetland buffer otherwise follows NHDES regulations.	Yes, incorporated in the water quality protection overlay district. 25 ft buffer, 75 ft buildings and structures setback, 75 ft septic systems setback, 50 ft impervious surfaces setback.

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 Alton Bay, 17% (4,970 acres) of the watershed's land area has been classified as conservation land** (refer to Appendix A, Map A-10). Major conserved areas include the Mount Major State Forest, Birch Ridge Community Forest, Collins Family Forest, Alton Bay State Forest, Alton Town Forest, New Durham Town Forest, Merrymeeting Marsh Wildlife Management Area (WMA), Marks WMA, Ellis R. Hatch Jr. WMA, Marks Memorial Forest, and the Evelyn H. & Albert D. Morse, Sr. Preserve. Many of these conservation areas border parts of the Merrymeeting Lake and riverways in the watershed, though there is limited conserved land directly on Lake Winnipesaukee's shores. In July 2025, the Society for the Protection of New Hampshire Forests (SPNHF) was awarded $397,189 through the NHDES Drinking Water and Groundwater Trust Fund to protect the 385-acre Meinelt parcel in Alton (Map 7, Lot 15). The property contains 350 acres of forest, eight acres of open water, 19 acres of talus-cliff habitat, and eight acres of forested wetlands. The project expands upon the Morse Preserve, and with adjacent conserved land (Alton Bay State Forest and Alton Town Forest), creates a contiguous block of 1,630 acres of protected forest at the southern end of the Belknap Range. Ninety acres of the property is within a wellhead protection area for Alton Water Works. The property is managed by SPNHF for drinking water quality, sustainable forestry and outdoor recreation. A portion of this parcel extends into the Alton Bay watershed.

Land conservation is especially important in Alton Bay given its large watershed area, and the high density of development along the western shores of the bay. Local groups should continue to pursue opportunities for land conservation in the 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 Alton Bay watershed is predominantly part of the Sebago-Ossipee Hills and Plains ecoregion, with a small area in the southwest extending into the Worcester/Monadnock Plateau (NHFG, 2015). Approximately 25,559 acres (80%) of the watershed (including the lake area) is considered Highest Ranked Habitat in New Hampshire. A large percentage of the land area in the Alton Bay watershed is highest ranked habitat in the State or bioregion, or a supporting landscape. Most of the conservation areas therefore overlap with at least one of these three categories. A map of priority habitats for conservation based on the NH Wildlife Action Plan can be found in Appendix A, Map A-10.

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 to remove pathogens from wastewater and not specifically 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, though available systems remove nitrogen and not phosphorus. 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 is dependent on the use and total volume entering the system. A typical 3-bedroom, 1,000 gallon tank should be pumped every 3 years or more frequently if within the shoreland zone.
- 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. New Hampshire state law requires buyers to obtain a state-licensed septic system evaluator for any part of a septic system within 250 feet of the shoreline (see Statutes § 485-A:39).

4.2.5 Boats & Marinas

Alton Bay provides several boat access points and marinas that serve recreational boaters in the watershed. Public access is available at Downing's Landing, the Alton Public Dock and Ramp, and the Merrymeeting Public Boat Ramp, while Merrymeeting Marina offers additional services for boaters. These facilities play an important role in maintaining safe and responsible boating activity in both lakes. The following best practices apply to marinas and boat access points:

- Target outreach to marina owners, boat dealers, and their consumers regarding State and EPA requirements;
- 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.

4.2.6 Fertilizer Use

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 ft of a surface water. Outside of 25 ft, 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, 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 as nearly all shoreline properties are privately owned.

The Town of New Durham does not use any phosphorus-based fertilizer (Merrymeeting River WMP, 2019). The ballfields on Smitty Way, for example, are treated with either Dimension Fertilizer which contains 18% nitrogen derived from urea and 2% chlorine, or Allectus Turf Fertilizer, which contains 17% nitrogen, 6% soluble potash, 2% iron, and 4.5% chlorine. New Durham does not use a commercial applicator of fertilizer in the spring or the fall. Alton does not fertilize the Jones Fields due to the proximity to the Merrymeeting River. The Diamond B farm in New Durham uses a combination of fertilizer methods, including hatchery manure, cattle manure, and chemical fertilizer depending on what the soil tests show.

4.2.7 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.

4.2.8 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.

4.2.9 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. Homeowners can discourage Canada goose activity on their properties by replacing lawns with herbs, shrubs, and trees.

Beaver dam management may also be necessary in the watershed. Beavers repair their dams if they detect the noise or sensation of flowing water through the dam. If the beaver senses the water level is too low upstream of the dam after constructing a dam, they will abandon the dam and find another suitable site to build a dam. In the context of beaver dam management, this could pose additional issues if beavers relocate to another site along the same stream to build a new dam thus creating additional impoundments and greater flooding potential. Investigating the status of beaver dams in the watershed may be useful in determining if beaver dam management is needed. Options for dam management include installing culverts with beaver exclusion fencing (i.e., the Beaver Deceiver design) and/or other beaver deterrents to maintain a lower water level in the lower dam's pooling area. If the dam is present and active, a more advanced design such as the Clemson Pond Leveler may be necessary to regulate the water level above and below the dam to prevent washouts. The Clemson Pond leveler deceives beavers by releasing water inconspicuously such that beavers are not triggered to repair the dam (thus impounding more water). Physically maintaining the dams to ensure they are not built too high is also a viable option.

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 is the primary entity for education and outreach campaigns in the watershed and for development and implementation of the plan. LWA should continue all aspects of their education and outreach strategies and consider developing new ones or improving existing ones and/or forming new collaborations with other organizations (conservation commissions, neighboring watershed associations, etc.) 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 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.

Throughout the development of this WMP (2024–2025), LWA has conducted multiple outreach events to the Lake Winnipesaukee community (Table 16). These include presentations on water quality issues to communities and organizations, and the promotion of the Winni Blue Initiative to businesses and individuals in the lake watershed. LWA conducted and produced reports for 52 LakeSmart visits in 2024–2025. Weekly articles on lake issues are written by LWA and published in the local paper beginning in May and running through Columbus/Indigenous Peoples Day in October—43 articles were published in 2024–2025. A sign campaign promoting support and awareness of the Lake Winnipesaukee Alliance was run through the summer into the fall of 2025, radio spots were run on LAKES 101.5, and public service announcements were run throughout the summer 2025. Additionally, LWA produced printed newsletters, annual reports, social media posts, and electronic newsletters and distributed these to donors and residents throughout the watershed detailing the work of the organization, including updates on the watershed-based management plans.

Table 16. Outreach events hosted by the Lake Winnipesaukee Alliance in 2024 and 2025.

Date	Outreach activity
Presentations on Water Quality Issues	
1/17/24	Fire & Ice at Lake Life Realty
3/7/24	GSRWA Presentation
3/9/24	GIA Presentation
4/12/24	Delta Gamma Kappa Presentation

4/20/24	Water Dance in Meredith
4/25/24	Meredith Democrats Presentation
5/16/24	Source Water Protection Conference
6/1/24	Open House at Cyr Lumber
6/8/24	Water Summit
6/21/24	Radio Spot at Shep Browns with The Pulse of NH
6/29/24	Black Cat Island Presentation
7/6/24	Woodlands Association Meeting
7/13/24	Krainewood Association Meeting
7/17/24	Governor's Island Presentation
7/31/24	Moultonborough Cyano Presentation
8/1/24	Meredith Cyano Presentation
8/2/24	LRCT Paddle and Talk
8/10/24	Twin Barns Release Party
8/11/24	Lake Winni Day
8/25/24	Bald Peak Event
8/28/24	Meredith Rotary Presentation
9/12/24	Alton Bay Business Association Meeting
10/12/24	Winni Clean Up Days
10/24/24	Cyano Talk at LPC
11/7/24	Tuftonboro Womens Service Organization
12/12/24	Lakes Region Conservation Trust Board of Directors
12/18/24	Presentation of the Wolfeboro Bay Watershed Management Plan
1/6/25	Taylor Community Presentation
1/22/25	Lakes Region Community College meeting with the President
1/30/25	Meredith Community Center tabling event
2/25/25	Meeting with Moultonborough Town Administrator and Town Planner to discuss septic system regulations
2/26/25	Meredith Rotary Club to solicit assistance with ice-out sampling
3/6/25	Belknap County Natural Resource Assessment Workgroup
3/15/25	Gilford Island Association's meeting
3/26/25	Meeting with UNH and NH Department of Environmental Services to discuss issues on Lake Winnipesaukee and monitoring needs
4/3/25	Cherry Valley Road site walk on proposed development project
4/10/25	Radio interview with Lakes 101.5 on ice out story
4/22/25	Meeting with Gilford DPW director to discuss road projects in Gilford
5/8/25	Presentation to the Lakes Region Sail & Power Squadron
Promotion of the Lake Winni Blue Initiative	
5/10/25	Table event at Love Our Earth Day, Laconia
5/15/25	Presentation to the Meredith Garden Club
5/29/25	Presentation on updates to the NH Stormwater Manual, Moultonborough Town Library
6/14/25	Septic System talk held at Moultonborough Public Library
6/18/25	Septic Regulations webinar held for Realtors
6/18/25	Meredith Local Lakes Associations meeting and presentation
6/19/25	Tabling event at Four Your Eyes Only, Moultonborough
6/21/25	Presentation to the Black Point Assn, Alton
6/23/25	Presentation at the annual meeting of Lakes Region Planning Commission
7/12/25	Presentation to Krainewood Association's Annual meeting, Moultonborough
7/12/25	Lake Kanasatka Watershed Assn annual meeting, Moultonborough
7/17/25	Presentation to the members of the Winnipesaukee Golf Club
7/19/25	Varney Point Assn annual meeting, Gilford
7/19/25	Barber Pole Assn. annual meeting, Tuftonboro
7/20/25	Twin Barns public promotion of Keep Winni Blue beer

7/22/25	Podcast with Andy Opel on water quality
7/24/25	Presentation on cyanobacteria at the Loon Preservation Committee, Moultonborough
8/8/25	Tabling event at Lake Winnipesaukee Day, Wolfeboro
8/9/25	Party with a Purpose, Governors Island, Gilford – 100+ in attendance
8/13/25	Landscaping by the Waters Edge Presentation, Moultonborough
8/15/25	Presentation to the Wolfeboro Corinthian Yacht Club
8/30/25	Presentation to the Langdon Cove Assn., Moultonborough
9/10/25	Geology webinar
9/11/25	Presentation to NEPA, Laconia
9/23/25	Laconia High School talk
9/23/25	Gathering at Olcott's home in Wolfeboro to discuss water quality issues – 50 in attendance
10/6/25	Moultonborough's Womens Club

4.4 ADAPTIVE MANAGEMENT APPROACH

An adaptive management approach, to be employed by the Steering Committee, is highly recommended for protecting Alton 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 through LWA should be assembled to coordinate watershed management actions. This group can include representatives from state and federal agencies or organizations, municipalities, local businesses, 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 implementing this plan. Continued public awareness and outreach campaigns will aid in securing this engagement. Refer to Section 4.3: Outreach & Education.
- **Continuing and/or Establish Long-Term Monitoring Programs.** A water quality monitoring program is necessary to track the health of surface waters in the watershed. Information from the monitoring programs 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 2.5: Establishment of Water Quality Goal for interim milestones.

An aerial view of Alton Bay. © FBE.

5 ACTION PLAN

5.1 ACTION PLAN

The Action Plan (Table 17) outlines responsible parties, approximate costs[6], 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 2026–2035 and is flexible to allow for new priorities throughout the 10-year implementation period as additional data are acquired.

Table 17. Action plan for the Alton Bay watershed. LWA: Lake Winnipesaukee Alliance; BCCD: Belknap County Conservation District; CCCD: Caroll County Conservation District; LRPC: Lakes Region Planning Commission; LKWA: Lake Kanasatka Watershed Association; CWSRF: Clean Water State Revolving Fund; NH ARM: NH Aquatic Resource Mitigation Fund; NFWF: National Fish & Wildlife Foundation; NFRF: Northeast Forests and Rivers Fund; NAWCA: North American Wetlands Conservation Act; LCHIP: Land and Community Heritage Investment Program; RCCP: Regional Conservation Partnership Program; LWCF: Land and Water Conservation Fund; ACEP: Agricultural Conservation Easement Program; CSP: Conservation Stewardship Program; EQIP: Environmental Quality Incentives Program.

Action Item	Responsible Party	Estimated Cost & Schedule	Potential Funding Sources
1. Watershed & Shoreline BMPs			
1.a. Complete design and construction of mitigation measures at the seven high priority sites identified in the watershed survey. **Achieves a total reduction of 9.4 kg/yr P.**	LWA, BCCD, SCCD, LRPC, Municipalities, private landowners	$300K-$475K 2026–35	CWSRF, Grants (319, Moose Plate, NFWF 5-Star, ILFP), Municipalities, private landowners
1.b. 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 a total reduction of 5.5 kg/yr P.**	LWA, BCCD, SCCD, LRPC, Municipalities, private landowners	$250K-$400K 2026–35	CWSRF, Grants (319, Moose Plate, NFWF 5-Star, ILFP), Municipalities, private landowners
1.c. Complete design and construction of mitigation measures at 14 low priority sites identified in the watershed survey as opportunities arise (refer to Appendix B for complete list). **Achieves a total reduction of 2.4 kg/yr P of 492 kg/yr P.**	LWA, BCCD, SCCD, LRPC, Municipalities, private landowners	$250K-$400K 2026–35	CWSRF, Grants (319, Moose Plate, NFWF 5-Star, ILFP), Municipalities, private landowners

[6] 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
1.d. Continue promoting the Be Winni Blue/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, BCCD, SCCD, LRPC, NH Lakes, NHDES Soak Up the Rain NH, Municipalities	$15K 2026–35	NH Lakes, NHDES Soak Up the Rain NH, Grants (319, Moose plate), CWSRF, Municipalities
1.e. 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 272 prioritized shoreline properties. With a 50% BMP removal efficiency rate this would amount to **an annual reduction of 56 kg/yr P (Achieves 11% of Objective 1).**	LWA, BCCD, SCCD, LRPC, Municipalities, private landowners	$1M 2026–35	Grants (319, Moose plate), CWSRF, private landowners
1.f. Repeat the shoreline survey in 5–10 years when updating the WMP. 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	$25K 2030, 2035	Municipalities, Grants (Moose plate), CWSRF
1.g. Provide technical support to local marinas like the Downing's Landing to ensure proper pump-out facilities and washing stations are preventing contamination of the lake.	LWA	TBD 2026–35	CWSRF, Grants (Moose Plate), Municipalities
1.h. Continue addressing the Action Plan items identified in the 2019 Merrymeeting Lake and River Watershed-Based Management Plan and update the plan in 2029. Addressing recommendations from the watershed survey, shoreline survey, and septic system assessment and upgrading the Powder Mill State Fish Hatchery would **achieve 76% (374 kg/yr P) of Objective 1**.	LWA, Cyanobacteria Mitigation Steering Committee of New Durham/Alton, Municipalities, NHDES (Fish Hatchery)	$2M-$3M 2026-2029	Grants (319, Moose Plate), CWSRF, Municipalities
1.i. Complete implementation of the BMP project at the parking lot and along the road shoulder on Letter S Road.	Town of Alton	ASAP	N/A

Action Item	Responsible Party	Estimated Cost & Schedule	Potential Funding Sources
1.j. Clear out debris and sediment from culverts identified as needing maintenance due to blockages in Appendix G of the Alton Stormwater Asset Management Program (Tighe and Bond, 2024).	Town of Alton	TBD 2026	Municipalities
2. Road Management			
2.a. Review practices for road and drainage maintenance currently used by public and private entities/groups and determine areas for improvement.	Municipalities, LWA, BCCD, SCCD, LRPC	$10K 2026	CWSRF, Municipalities, Grants (Moose Plate, NFWF 5-Star)
2.b. 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, BCCD, SCCD, LRPC	$15K 2026	CWSRF, Municipalities, Grants (Moose Plate, NFWF 5-Star)
2.c. Continue to update the written protocol for road maintenance best practices.	Municipalities, LWA, BCCD, SCCD, LRPC	$20K 2026	CWSRF, Municipalities, Grants (Moose Plate, NFWF 5-Star)
2.d. Incorporate water quality considerations and strategies into roadway evaluations and action plans.	Municipalities, LWA, BCCD, SCCD, LRPC	N/A 2026–35	Municipalities
2.e. 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 2026–35	Municipalities, private landowners
2.f. 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, BCCD, SCCD, LRPC, Municipalities, private landowners	$10K 2026–35	CWSRF, Municipalities, Grants (Moose Plate, NFWF 5-Star), private landowners
3. Municipal Operations			
3.a. 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 2026–35	Municipalities
3.b. Continue to participate in the Municipal Green SnowPro Program and to certify new staff.	Municipalities (Public Works/Highway)	Est. $150-$250/person 2026–35	Municipalities

Action Item	Responsible Party	Estimated Cost & Schedule	Potential Funding Sources
3.c. Continue to employ practices recommended by the Green SnowPro Program (Alton Public Works already participates in the Green SnowPro Program and uses Magnesium Chloride as a pre-wetter for salt, certifies all employees, and calibrates trucks annually.)	Municipalities (Public Works/Highway)	N/A 2026	Municipalities
3.d. Share Green Snow Pro practices with neighboring communities that are not using this program.	Alton Public Works	Annually, beginning in 2026	Municipalities
3.e. In both Alton and New Durham, 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 2026-35	Municipalities
3.f. Develop best practice design standards for stormwater control measures, including deep sump catch basins. Refer to the Stormwater Asset Management Program for Alton (Tighe & Bond, 2024).	Municipalities (Public Works/Highway)	N/A 2026	Municipalities
4. Municipal Land Use Planning & Zoning			
4.a. Present WMP recommendations to Select Boards/City Council and Planning Boards in Alton and New Durham. Cost assumes presentations conducted by LWA or volunteers.	LWA	N/A 2026	LWA
4.b. Meet with municipal staff to review recommendations to improve or develop ordinances addressing setbacks, buffers, lot coverage, low impact development, and open space. Cost assumes meetings conducted by LWA.	LWA, Municipalities	N/A 2026-29	LWA, Municipalities
4.c. Incorporate WMP recommendations into municipal master plans and encourage regular review of the WMP action plan.	Municipalities	N/A 2026–35	Municipalities
4.d. Support the Town of Alton's 2023 Master Plan goal to protect and improve water quality throughout the town. Encourage the Town to incorporate water quality considerations into decision-making, including land use regulations, programs and policies, and capital budgeting. Formally adopt this Watershed Plan into the 2023 Master Plan.	Town of Alton	2026	N/A

Action Item	Responsible Party	Estimated Cost & Schedule	Potential Funding Sources
4.e. Adopt/strengthen zoning ordinance provisions and enforcement mechanisms (refer to NHDES, 2008): 1) to promote low impact development practices, particularly impervious cover limits that incorporate Effective Impervious Cover regulations per UNH Stormwater Center, CEI & NHDES (2025); 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 2026–35	Municipalities
4.f. Increase municipal staff capacity for inspections and enforcement of stormwater regulations on public and private lands.	Municipalities	TBD 2026–35	Municipalities
5. Land Conservation			
5.a. Update the New Durham's NRI from 2011 (Alton has a recent NRI - 2022).	Municipalities, Conservation Commissions	$20K-$30K per municipality 2026-28	Municipalities, Grants (NFWF NFRF), CWSRF
5.b. Create a priority list of watershed areas that need protection based on NRIs. Refer to Section 4.2.3 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. Ensure that protection efforts in Alton are linked to the Master Plan goal to *"Consider protection of the town's water resources, important habitats and natural areas, scenic views, and linkages between natural areas when prioritizing land for conservation."*	LWA, Municipalities, Conservation Commissions, Lakes Region Conservation Trust or other local land trusts	$4K-$8K 2026-28	Grants (NFWF NFRF, NAWCA), CWSRF, Municipalities

Action Item	Responsible Party	Estimated Cost & Schedule	Potential Funding Sources
5.c. 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 2026-28	Grants (Moose Plate, LCHIP, RCCP, NAWCA, LWCF, ACEP, CSP, EQIP)
5.d. 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 2026–35	Grants (Moose Plate, LCHIP, RCCP, NAWCA, LWCF, ACEP, CSP, EQIP, NFWF NFRF), Municipalities, private landowners
5.e. Complete a co-occurrence analysis in each community to prioritize land for conservation. Consider pairing this with a build-out alternatives analysis.	LWA, Regional Planning Organizations	$25K-$30K 2026-28	Grants (Moose Plate)
6. Septic System Management			
6.a. Distribute educational materials to property owners about septic system function and maintenance. Ensure wide distribution while targeting the 447 Alton Bay shoreline parcels with septic systems older than 25 years. Reducing external load from old septic systems would achieve **44.7 kg/yr P reduction (9% of Objective 1).**	Municipalities, LWA	$10K 2026, 2029, 2034	Municipalities, Grant (319), CWSRF
6.b. Look into whether any septic pumping companies would give a quantity discount or a members discount to incentivize septic system pumping.	LWA	N/A 2026–35	LWA
6.c. 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 2026	CWSRF, Municipalities
6.d. 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 Alton Bay.	Municipalities	N/A 2026-35	Municipalities

Action Item	Responsible Party	Estimated Cost & Schedule	Potential Funding Sources
6.e. Develop and maintain a septic system database for the watershed to facilitate code enforcement of any septic system ordinances.	Municipalities	$5K-$10K 2026-35	Municipalities, CWSRF
6.f. 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 2026-28	Municipalities, private landowners
7. Agricultural Practices			
7.a. 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 2026–35	Grants, NRCS
8. Education & Outreach			
8.a. Share additional/dynamic information on the Lake Winnipesaukee Alliance website, such as water quality data, loon activity, weather conditions, and webcam, to generate more traffic to the website.	LWA	TBD 2026-27	Grants
8.b. 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 2026, 2030, 2035	Grants (NHDES AIPC)
8.c. Offer workshops for landowners with 10 acres or more for NRCS assistance with land conservation. Cost assumes up to two workshops.	LWA	$5K 2026-30	Grants (RCCP, ACEP, CSP, EQIP)
8.d. Encourage private property owners to hire Green SnowPro certified commercial salt applicators.	LWA, BCCD, SCCD, LRPC, Municipalities	N/A 2026–35	LWA, CCCD, Municipalities
8.e. 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, BCCD, SCCD, LRPC	$6K 2026-28	Municipalities, Grants (319), CWSRF
8.f. 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, BCCD, SCCD, LRPC	$20K-$60K 2026-35	Municipalities, Grants (319), CWSRF

Action Item	Responsible Party	Estimated Cost & Schedule	Potential Funding Sources
8.g. Collaborate with NH Lakes on legislative or advocacy issues such as boat speed limits.	LWA, NH Lakes	N/A 2026–35	LWA
8.h. Establish a Weed Watchers team for Lake Winnipesaukee.	LWA, NH Lakes, Municipalities	N/A 2026–35	LWA, NH Lakes, Municipalities
8.i. Secure Lake Host participation at the Alton Town Docks and Downing's Landing. Lake Host volunteers can provide boat inspections and education on invasive plant species.	LWA, Private Landowners, Volunteers	N/A 2026-35	LWA, Municipalities, Private Landowners

5.2 POLLUTANT LOAD REDUCTIONS

To meet the water quality goal, Objective 1 set a target phosphorus (P) load reduction of **492 kg/yr** to achieve a summertime in-lake total phosphorus concentration of 4.5 ppb, which meets state water quality standards for oligotrophic waterbodies and is anticipated to reduce the likelihood of cyanobacteria blooms in Alton Bay. The following opportunities for P load reductions to achieve Objective 1 were identified in the watershed based on field and desktop analyses:

- Remediating the 36 watershed survey sites could prevent up to **17.3 kg/yr** of P load from entering Alton Bay.
- Treating the 272 prioritized shoreline survey sites could reduce the P load to Alton Bay by **56.0 kg/yr**.
- Upgrading the 447 (approximate) shorefront septic systems older than 25 years is estimated to reduce the P load to Alton Bay by **44.7 kg/yr**.

Addressing these field-identified phosphorus load reduction opportunities coming from the external watershed load could reduce the phosphorus load to Alton Bay by **118 kg/yr**, meeting 24% of the needed reductions to achieve Objective 1 (Table 18). Addressing the external load sources identified in the *Merrymeeting River and Lake WMP* (FBE, 2019) will result in a reduction of an **additional 374 kg/yr** phosphorus to Alton Bay. Together, implementing both sets of recommendations will achieve **100%** of Alton Bay's Objective 1.

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 18. Breakdown of phosphorus load sources and modeled water quality for current and target conditions that meet the water quality goal (Objective 1) for Alton 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** (Amount, % change)
Total P Load (All Sources)[1]	kg/yr	1,624	1,132	-492 (30%)
(A) Background P Load[2]	kg/yr	496	496	0 (0%)
(B) Disturbed (Human) P Load[3]	kg/yr	1,128	636	-492 (44%)
(C) Developed Land Use P Load[4]	kg/yr	1,052	600	-452 (43%)
(D) Septic System P Load	kg/yr	75	36	-40 (53%)
(E) Internal P Load	kg/yr	1	1	0 (0%)
In-Lake TP (summer)*	ppb	6.5	4.5	-2 (31%)
In-Lake Chl-a*	ppb	1.6	1.4	-0.2 (13%)
In-Lake SDT*	meters	10	10	0 (0%)
In-Lake Bloom Probability*	days	1	0	-1 (100%)

[1] Total P Load (All Sources) = A + B.

[2] Sum of forested/water/natural land use load, waterfowl load, and atmospheric load.

[3] Sum of developed land use load, shorefront septic system load, and internal load (B = C + D + E).

[4] Sum of developed land use P load from Alton Bay's direct drainage, Merrymeeting River and Lake, and exchange with Lake Winnipesaukee.

* Water quality parameters were sourced from the model except for SDT, which has a higher observed value than predicted value.

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 largely by LWA with assistance from a diverse stakeholder group, including representatives from the municipalities (e.g., select boards, planning boards), conservation commissions, state and federal agencies or organizations, nonprofits, land trusts, schools and community groups, local business leaders, and landowners. LWA and an established 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 be responsible for plan oversight and implementation. LWA will assist with water quality monitoring, facilitate outreach activities and watershed stewardship, and raise funds for stewardship work.
- **Municipalities** 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. LWA 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.
- **BCCD and SCCD** can provide administrative capacity and 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 Alton Bay to meet the water quality goal and objectives set in Section 2.5 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 Alton Bay in the next 10 years. **The cost of successfully implementing the plan is estimated to be at least $4–$5.5 million over the next 10 or more years,** including for certain actions identified in the Merrymeeting River and Lake watershed in 2019 (Table 19). 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 19. Estimated total phosphorus (TP) reductions and costs for implementation of the Action Plan. 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	447.3	$3,840,000–$5,315,000	$384,000–$531,500
Road Management	TBD	$55,000	$5,500
Municipal Operations[1]	TBD	$1,250–$2,500 +	$125–$250 +
Municipal Land Use Planning & Zoning	(367)*	TBD	TBD
Land Conservation	Included in Land Use Planning & Zoning row	$49,000–$68,000	$4,900–$6,800
Septic System Management[2]	44.7	$15,000–$20,000	$1,500–$2,000
Agricultural Practices	TBD	TBD	TBD
Education & Outreach	TBD	$41,000–$81,000	$4,100–$8,100
Total	**492**	**$4,001,250–$5,541,500**	**$400,125–$554,150**

** Estimated increase in phosphorus load from new development in the next 10 years. Not included in the total load reduction.*

[1] The cost of municipal operations as a planning action only reflects the cost of the Green SnowPro Program course for employees, not other items shown in the Action Plan.

[2] Septic system management only reflects shoreline septic systems, and does not include the cost of inspecting, repairing, or replacing, private septic systems.

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 property owners. 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 in Alton Bay.

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. The 2025 acquisition of conservation land at the Meinelt property (next to the Morse Preserve) was partially funded by a LCHIP grant.

- **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 (ILF) 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.
- **Northeast Forests and Rivers Fund (NFWF NFRF)** – This National Fish and Wildlife Foundation grant awards $75,000 to $300,000 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.
- **Drinking Water & Groundwater Trust Fund Source Water Protection Program (NHDES DWGTF SWP)** – The SWP program provides grants to permanently protect drinking water supply lands in New Hampshire, including land that falls within wellhead protection areas, hydrologic areas of concern, high-yield stratified drift aquifers classified as GA2, and/or land that the Advisory Commission has determined will likely benefit a future public or community public water system. The 2025 acquisition of conservation land at the Meinelt property (next to the Morse Preserve) was partially funded by an SWP grant.
- **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 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) U.S. Standard 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 must 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 Lakes Region's waterbodies for decades, providing valuable water quality data to communities that would otherwise not exist. LWA, in concert with the LLMP, should continue and consider expanding upon the following annual monitoring:

> NHDES requires **dissolved oxygen** samples to meet stringent requirements to be included in State assessment. These requirements are intended to ensure that dissolved oxygen data is consistent and represents the highest stress periods of the year and time of day (June 1 to September 30 and between 10am and 2pm). Samples also must be collected from the epilimnion (defined as the surface to the first 1 or more °C change in temperature). To meet Class B standards, no more than two or 10% of samples (whichever is greater) that meet these requirements can have a dissolved oxygen concentration less than 5 mg/L.

- Continue to monitor the active sites within Alton Bay, including the deep spot (WINALTD), Station 25 (WAB25AL), and the Pavillion (WABPAPL), 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 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.
- Continue to monitor the Merrymeeting River and Lake subwatersheds as laid out in that WMP (FBE, 2019; Table 5-1, Items #9-10):
    - Conduct at least three annual sampling events at the deep spot of Merrymeeting Lake, Marsh Pond, Jones Pond, Downing Pond, and Mill Pond in July, August, and September (prior to Sept 15) to include dissolved oxygen and temperature profile readings, Secchi Disk Transparency readings, hypolimnion and metalimnion grab samples for total phosphorus (if applicable), and epilimnion core samples for total phosphorus, cyanobacteria, total nitrogen, total carbon, chlorophyll-a, pH, alkalinity, and color. Aim for biweekly Secchi Disk Transparency readings and monthly DO and temperature profile readings from May 24-Sept 15.
    - Sample major tributary and mainstem river sites for at least total phosphorus, and also consider turbidity, pH, total nitrogen, total carbon, and chloride 3-4 times per year from June-September. Consider adding stream gages to monitor flow.
- 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 Alton Bay (Watson Brook, Merrymeeting River, and Coffin Brook), at least two to five times per year each summer, specifically targeting wet and dry weather conditions.
- Continue monthly samples for speciation and enumeration of phytoplankton and zooplankton in the water column at WINALTD.
- Continue collaboration with NHDES to monitor spiny water flea populations.
- Consider expanding cyanotoxin testing, fluorometry, and picocyanobacteria analysis via e-DNA (through the Bigelow Laboratory for Ocean Sciences) to Alton 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 Alton Bay watershed (Table 20). These benchmarks represent short-term (2026), mid-term (2030), and long-term (2035) 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 the improvement of 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 20. Environmental, programmatic, and social indicators for the Alton Bay Watershed-Based Management Plan. Milestones are cumulative, starting in Year 1 (2026). ** indicators particularly relevant to assessing progress toward achieving the water quality goal and objectives.

Indicators	Milestones		
	2026	2030	2035
ENVIRONMENTAL INDICATORS			
Achieve an average summer deep spot epilimnion total phosphorus concentration of 4.5 ppb at the deep spot station in Alton Bay	<5.3 ppb	<4.9 ppb	<4.5 ppb
Achieve an average summer deep spot epilimnion chlorophyll-a concentration of less than 1.4 ppb at the deep spot station in Alton Bay	<1.6 ppb	<1.5 ppb	<1.4 ppb
Eliminate the occurrence of cyanobacteria or algal blooms in Alton Bay (milestones based on observed data from 2024)**	<7 days/yr	<5 days/yr	0 days/yr
Maintain an average summer water clarity of 10 m or deeper at the deep spot station in Alton Bay	10 m+	10.5 m+	11 m+
Control the proliferation of spiny water flea and variable milfoil in Alton Bay and upstream waterbodies	Invasives Controlled	Invasives Controlled	Invasives Controlled
Prevent the introduction of new invasive aquatic species in all waterbodies in the Alton Bay watershed	No New Invasives	No New Invasives	No New Invasives
PROGRAMMATIC INDICATORS			
Amount of funding secured from municipal/private work, fundraisers, donations, and grants	$300,000	$2,000,000	$4,000,000
Number of NPS sites remediated (36 identified in this WMP)**	7	18	36
Linear feet of buffers improved in the shoreland zone of Alton Bay**	3,000	15,000	30,000
Percentage of shorefront properties with LakeSmart certification**	20%	50%	75%
Number of watershed/shoreline properties receiving technical assistance for implementation cost sharing	25	50	100
Number of workshops and trainings for stormwater improvements to residential properties (e.g., NHDES Soak Up the Rain NH program)	2	5	10
Number of updated or new ordinances that target water quality protection	1	2	5
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	50	100

Indicators	Milestones		
	2026	2030	2035
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	3	5	8
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	5
Number of meetings and/or presentations to municipal staff and/or boards related to the WMP	2	10	20
Number of CNMPs completed or NRCS technical assistance provided for farms in the watershed	1	5	10
SOCIAL INDICATORS			
Number of new association members joining LWA from the Towns of Alton and New Durham (principal towns in the Alton Bay watershed)	5	10	15
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	10	15
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, BCCD, SCCD, or CCCD	1	3	5
Number of daily visitors to the LWA website	10	25	50

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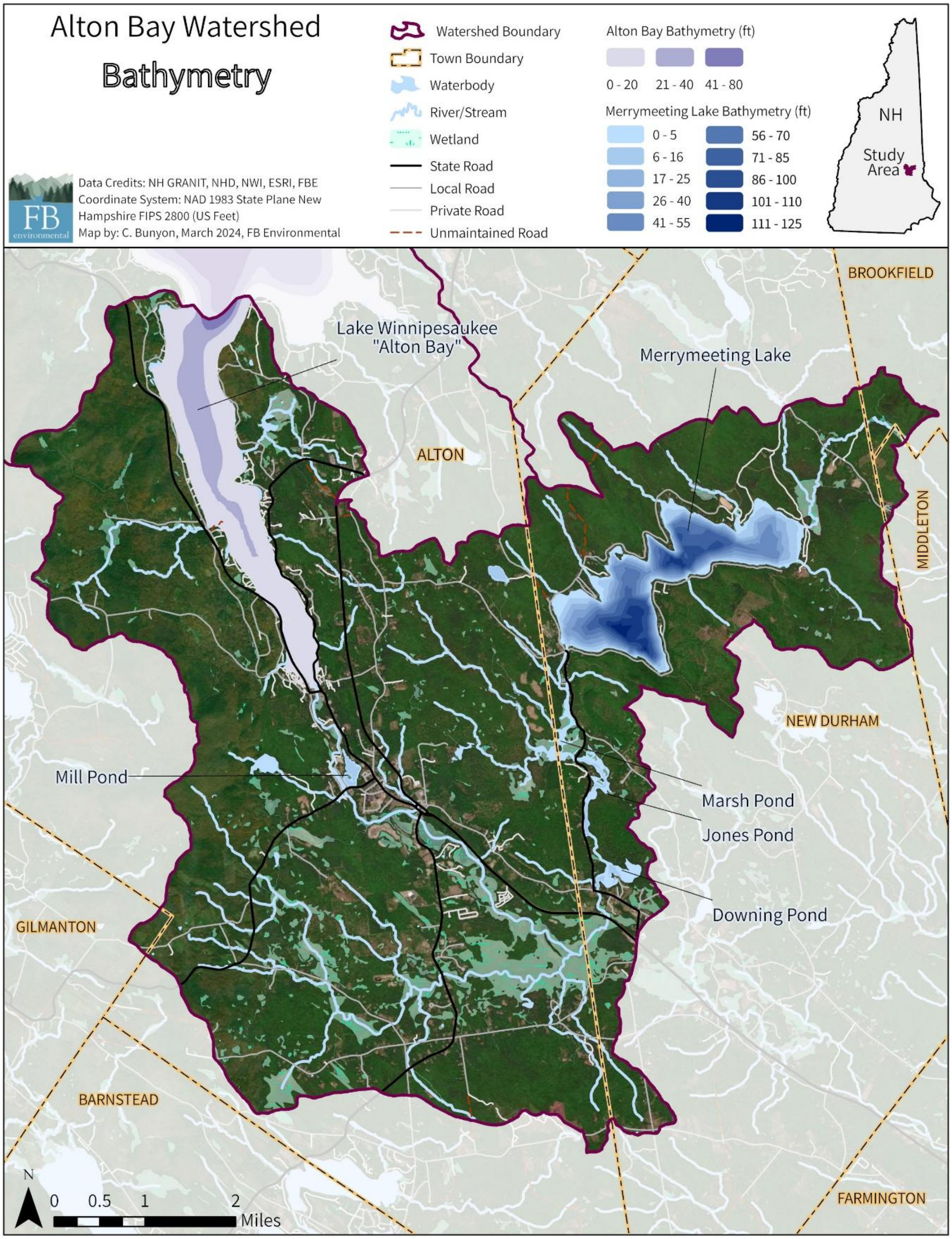
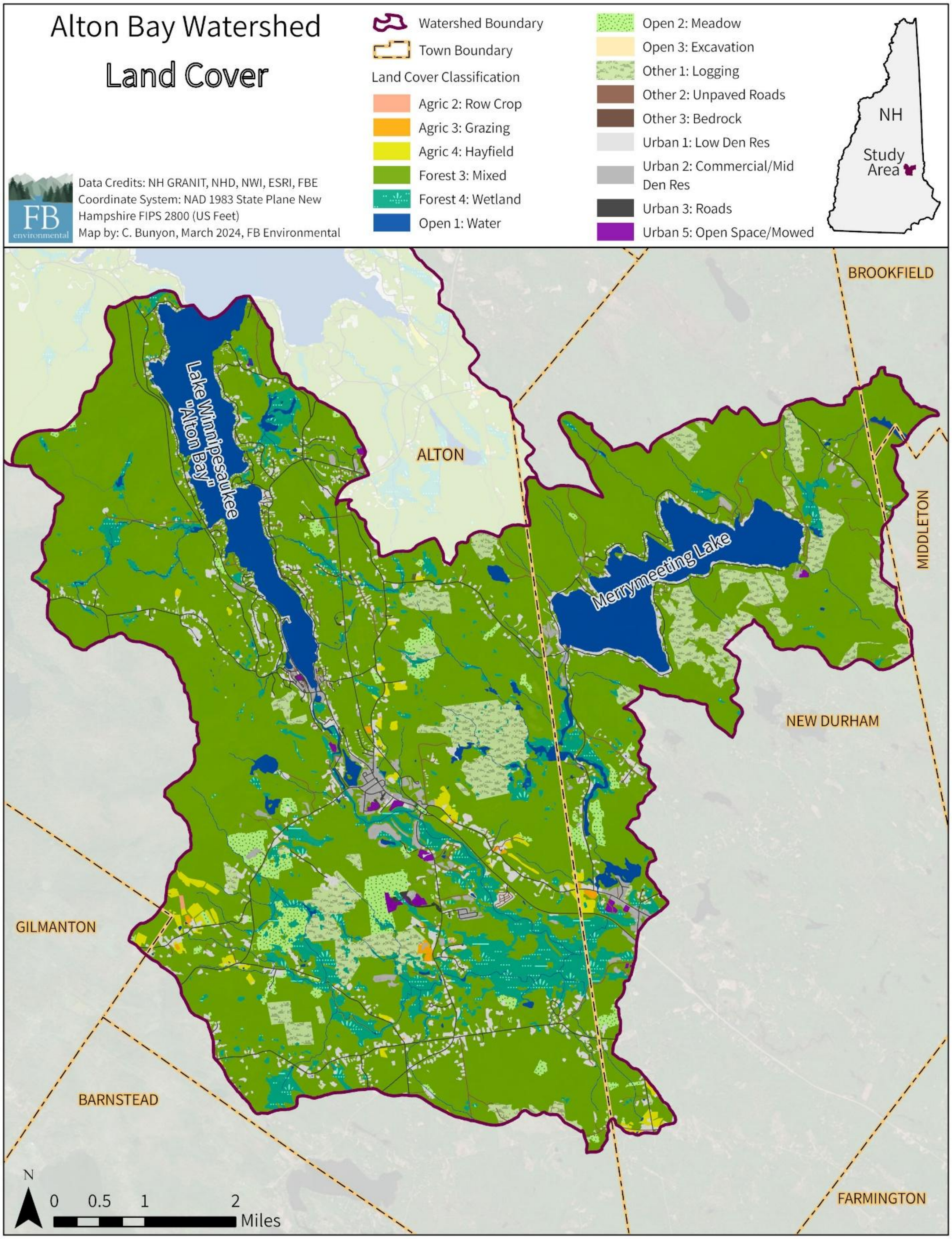
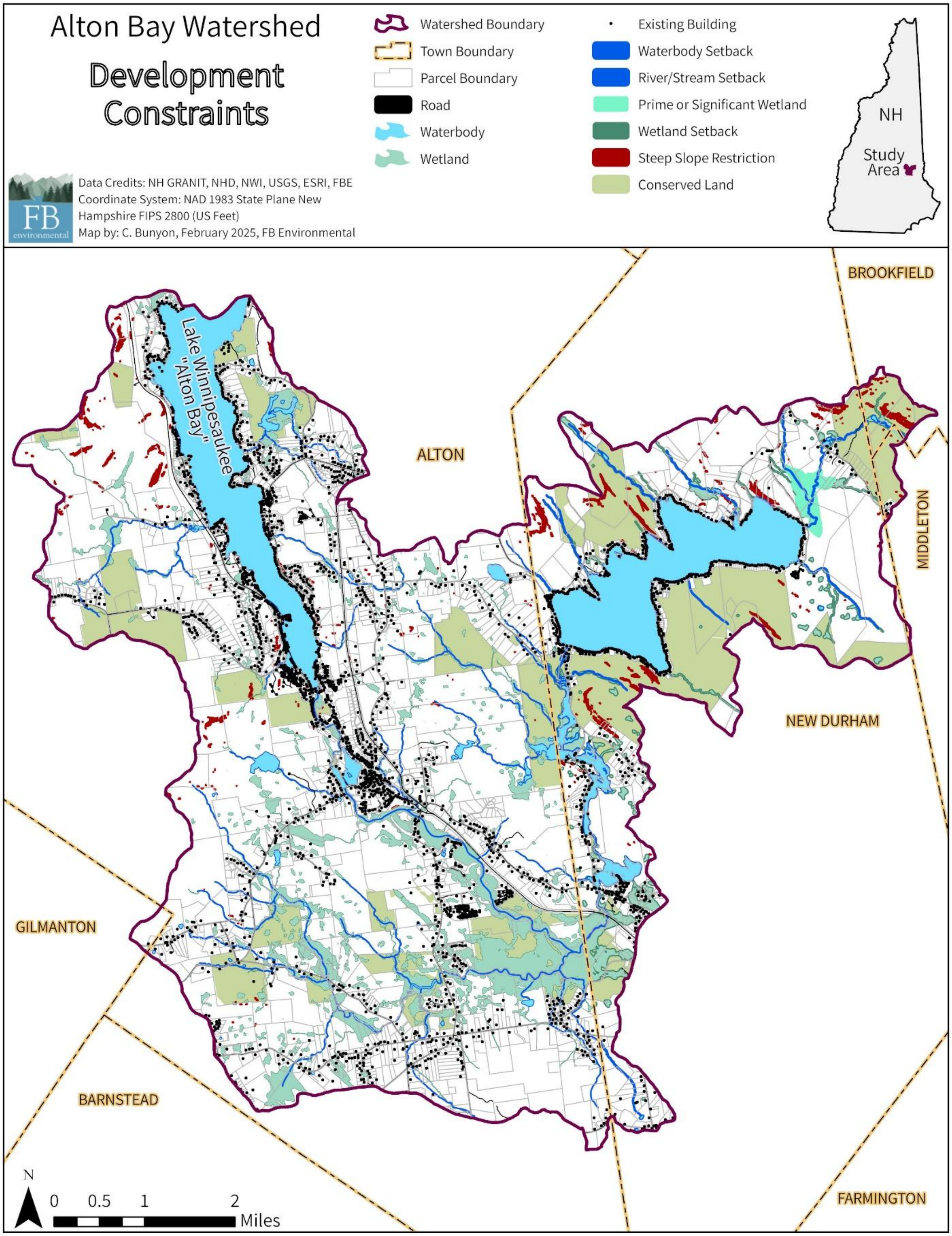
APPENDIX A: SUPPORTING MAPS



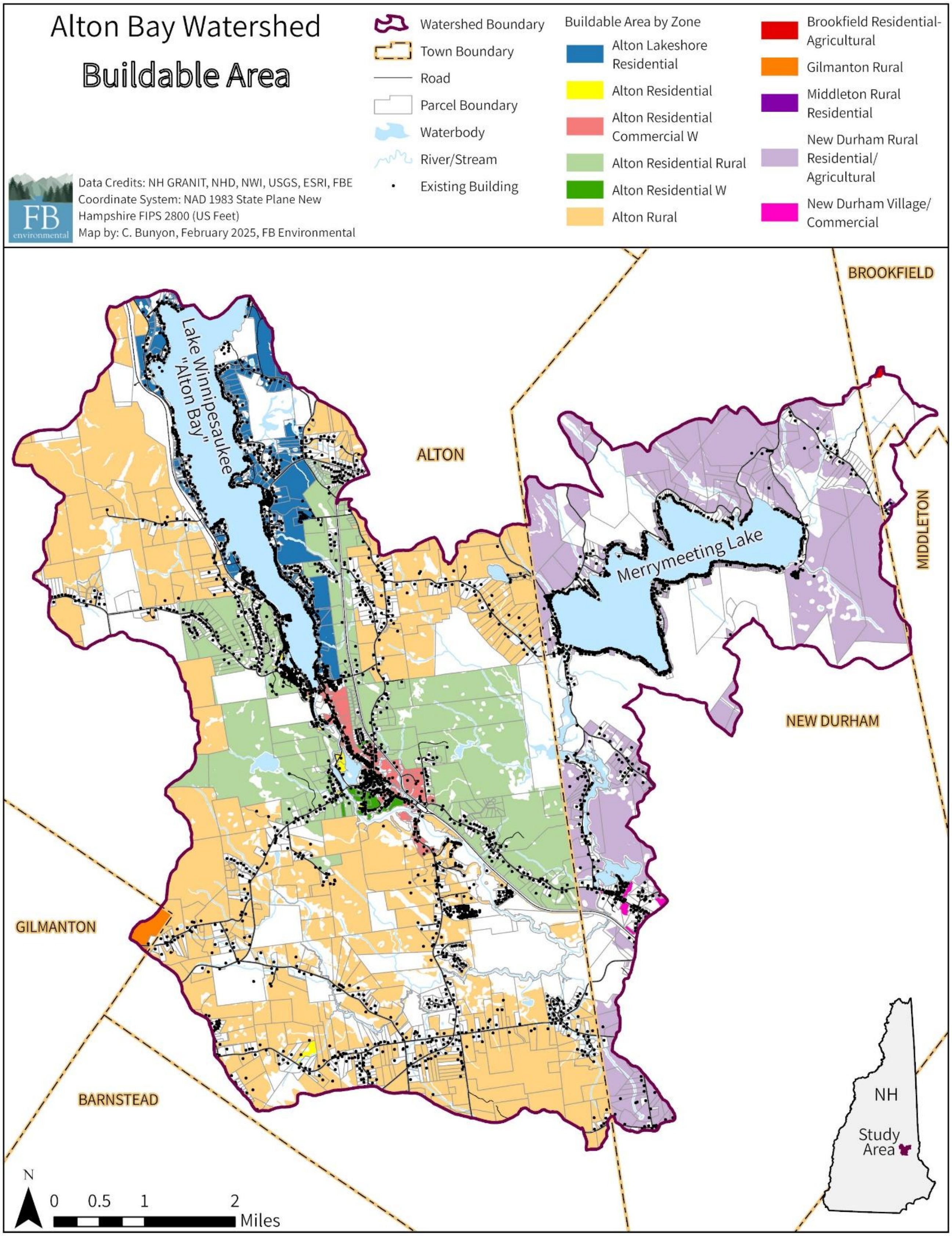
Map A-1. Bathymetry as 20-foot depth contours for Alton Bay (Lake Winnipesaukee) and as 5-foot depth contours for Merrymeeting Lake.



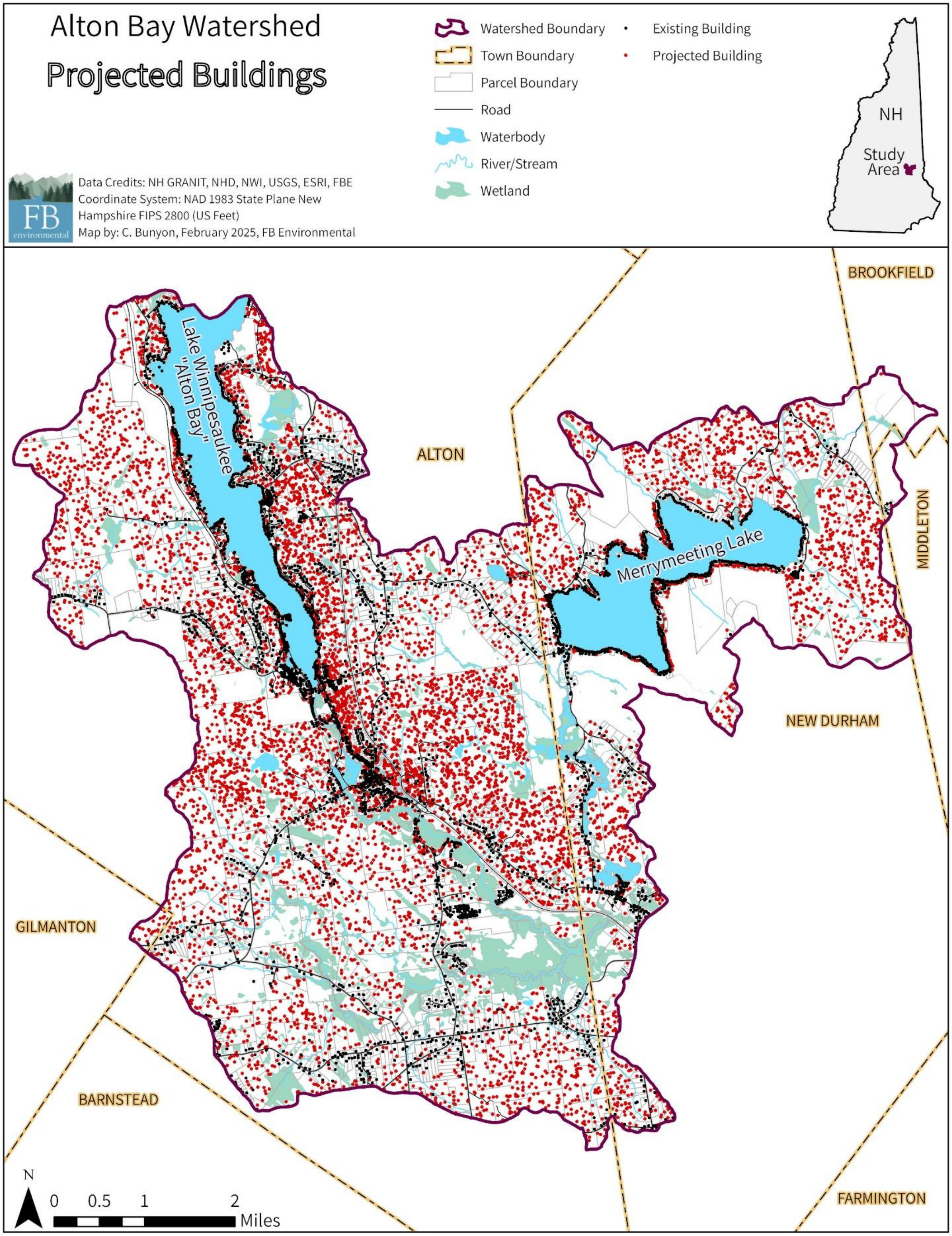
Map A-2. **Land cover for the Alton Bay watershed.**



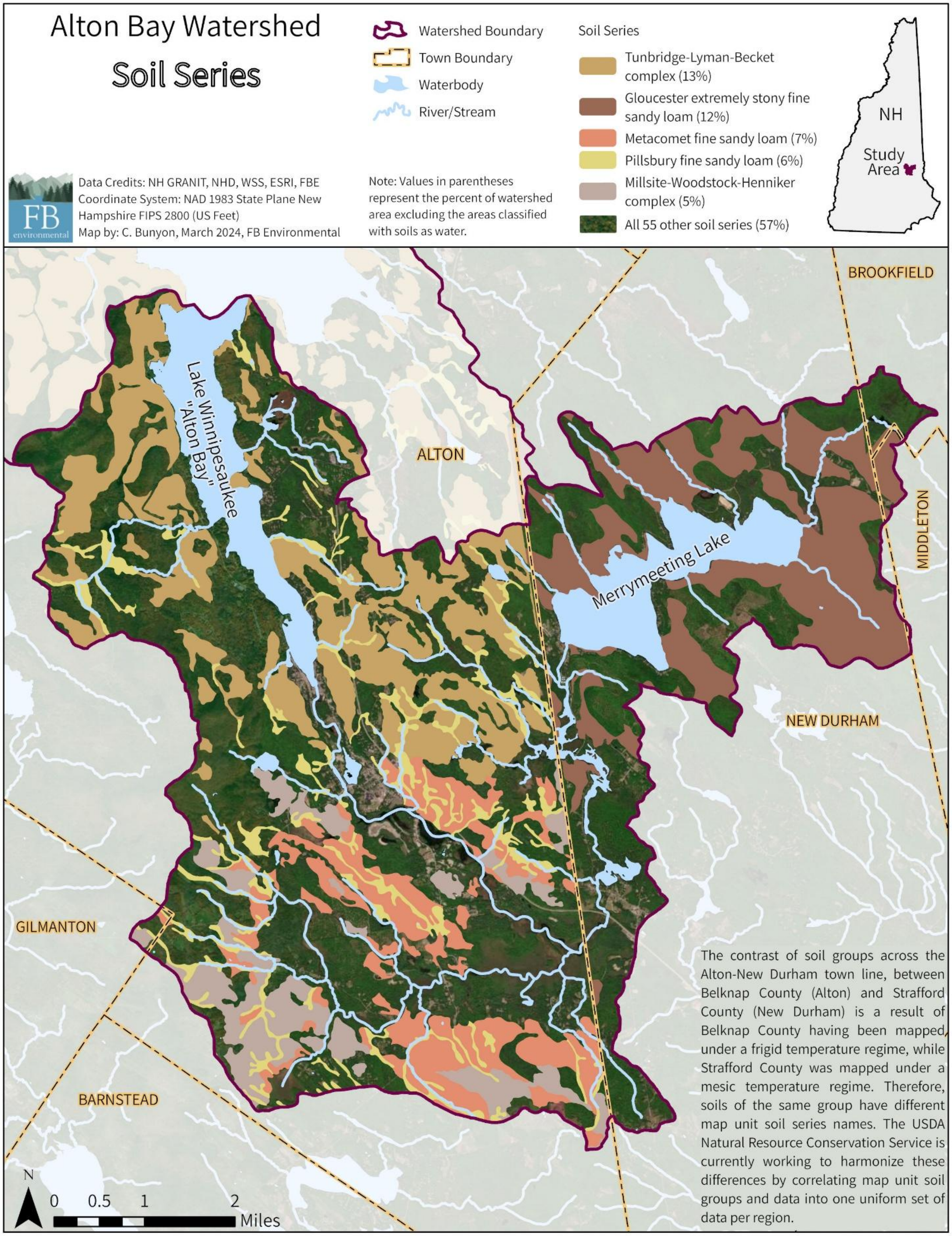
Map A-3. Development constraints (including existing buildings) in the Alton Bay watershed in Alton, New Durham, Gilmanton, Brookfield and Middleton, New Hampshire.



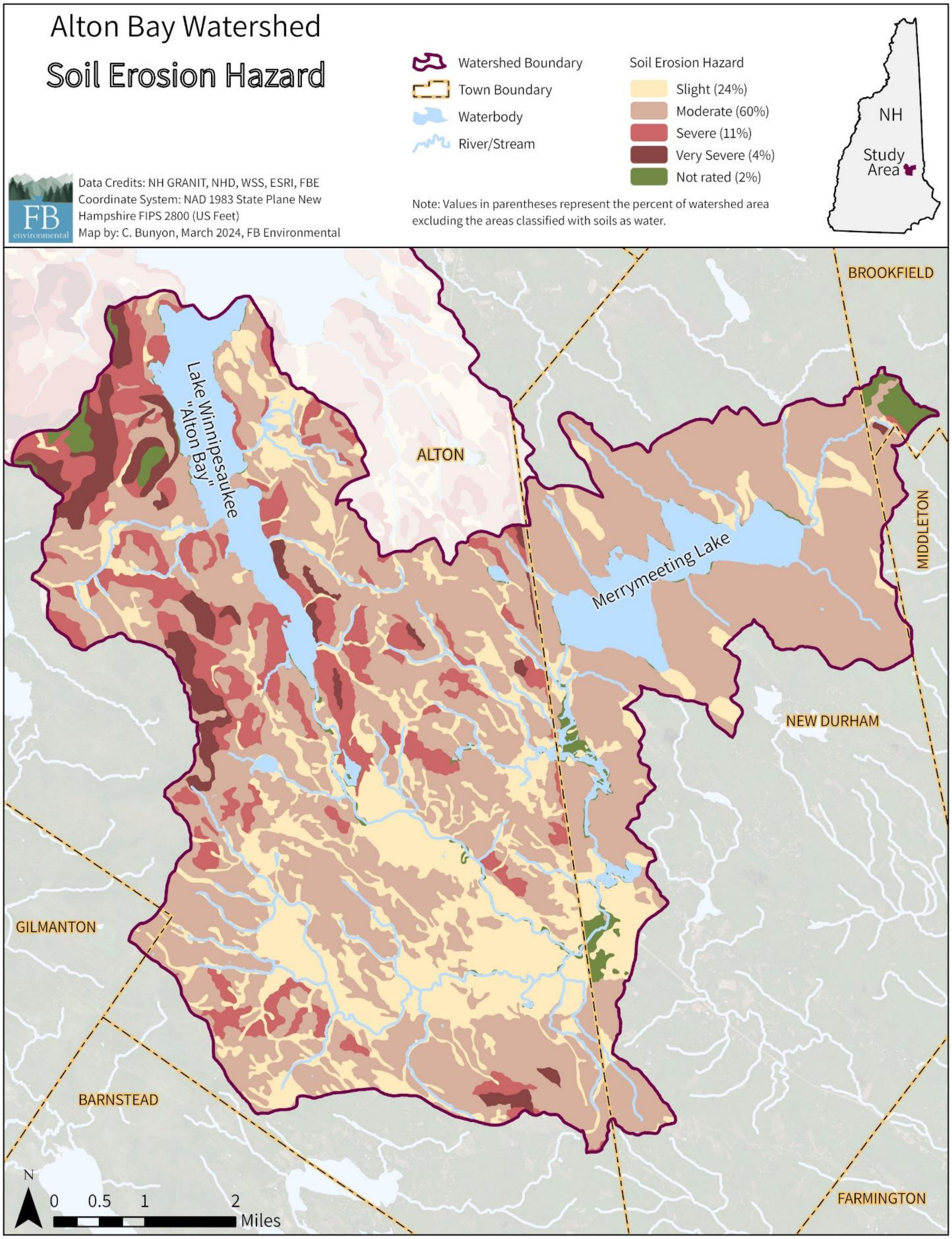
Map A-4. Buildable area by municipal zone in the Alton Bay watershed in Alton, New Durham, Gilmanton, Brookfield and Middleton, New Hampshire.



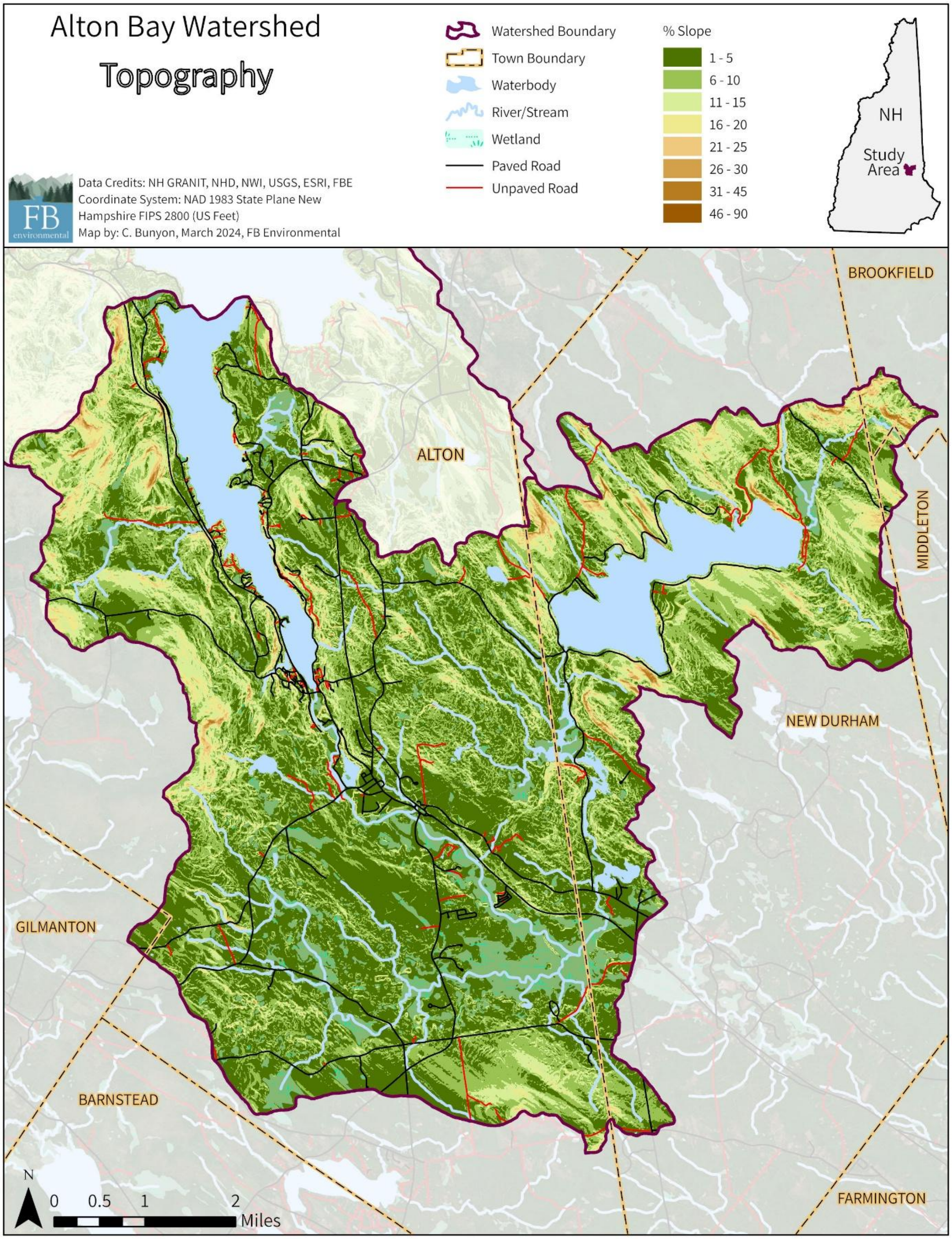
Map A-5. Projected buildings in the Alton Bay watershed in Alton, New Durham, Gilmanton, Brookfield and Middleton, New Hampshire.



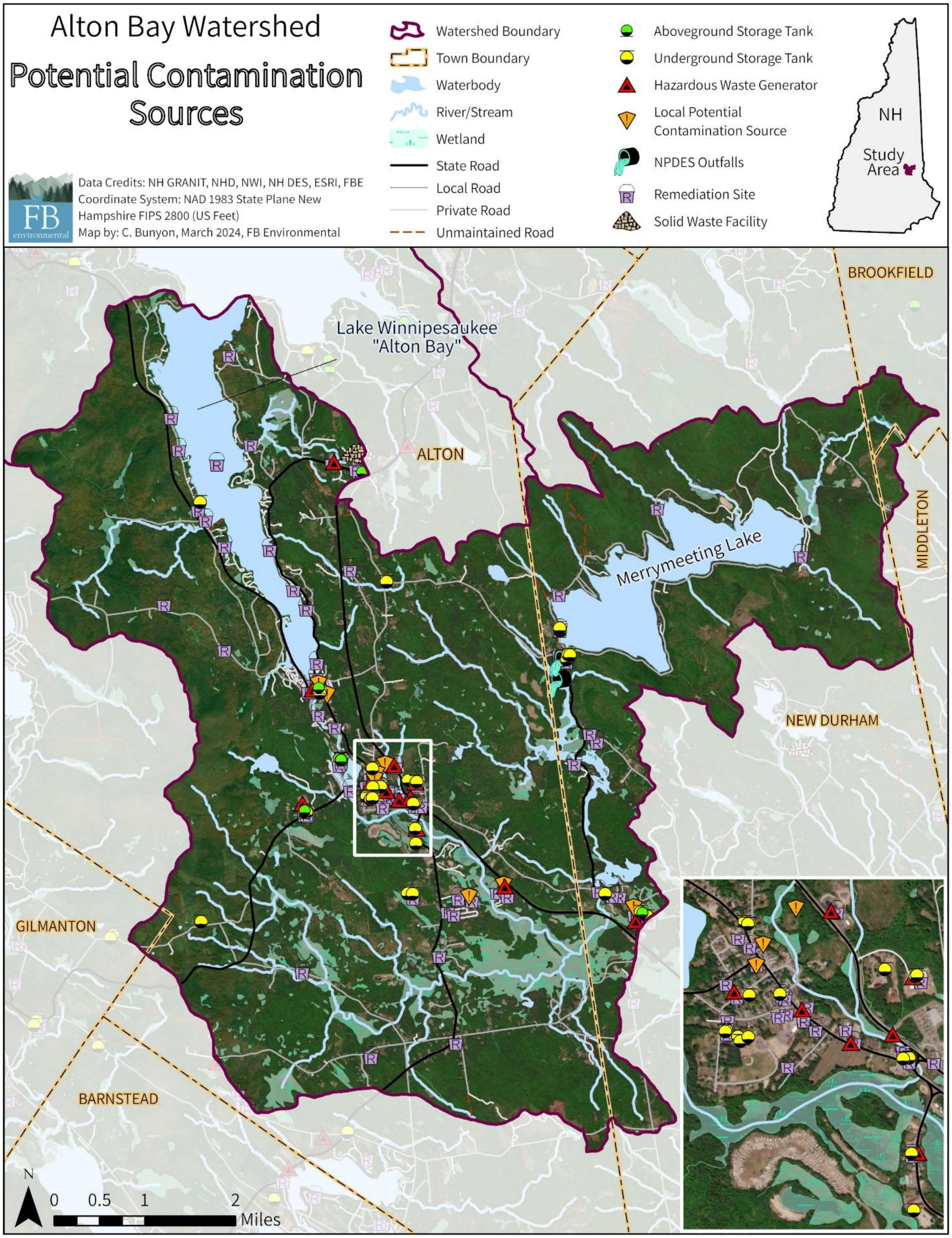
Map A-6. Soil series in the Alton Bay watershed.



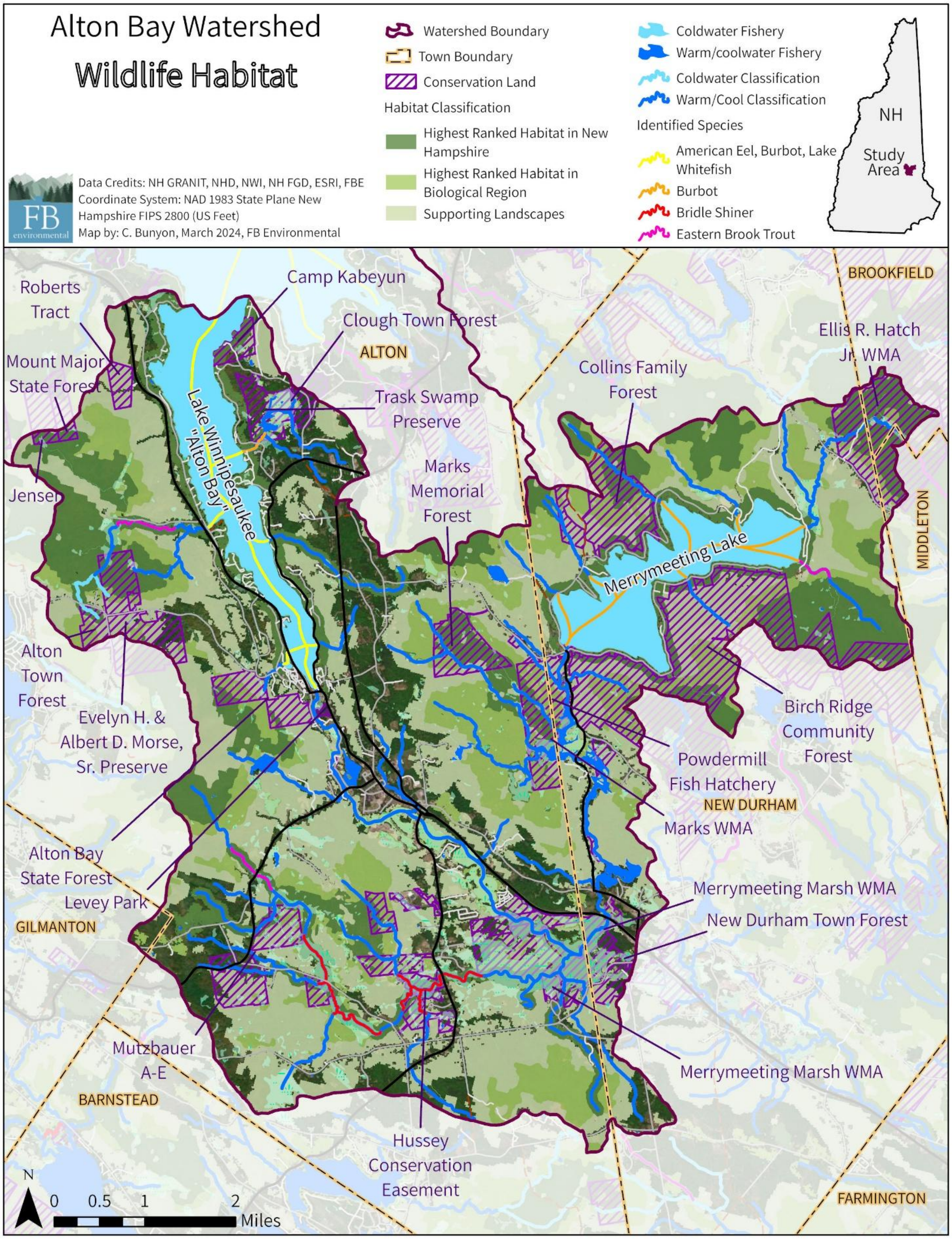
Map A-7. Soil Erosion Hazard in the Alton Bay watershed.



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



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



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

APPENDIX B: BMP MATRIX

Table B-1. Site ID, location description, water quality impact, estimated load reduction, and implementation costs for the 36 nonpoint source sites identified in the Alton Bay watershed. **Pollutant load reduction and cost estimates are preliminary and are for planning purposes only**. Some cost estimates are based on pre-COVID19 ranges (adjusted for 2024 inflation), and thus actual construction costs could be highly variable at this time. Sites are priority ranked from 1-36 for lowest to highest cost per kilogram of phosphorus load reduced with remediation.

SITE	LOCATION	IMPACT	LOAD REDUCTION			ESTIMATED COST			RANK
			TSS (kg/yr)	TP (kg/yr)	TN (kg/yr)	Est. Low Cost	Est. High Cost	Est. Avg. Cost	
C-12	Lily Pond Road	High	10.6	3.4	7.0	$35,000	$45,000	$40,000	1
B-09	Alton Mountain Road Stream	High	6.1	1.6	4.1	$20,000	$30,000	$25,000	2
B-18	Route 11-D & Loon Cove Road Intersection	High	5.1	1.3	3.5	$25,000	$50,000	$37,500	3
B-24	Jesus Valley Road #1	Medium	6.8	1.8	4.6	$20,000	$50,000	$35,000	4
B-04	Spring Street Gravel Road	Medium	2.4	0.6	1.6	$15,000	$25,000	$20,000	5
C-10	Cascade Terrace Bridge	Medium	0.1	0.2	0.0	$5,000	$10,000	$7,500	6
B-08	Avery Hill Road Shoulder	Medium	1.3	0.3	0.9	$10,000	$15,000	$12,500	7
B-11	Alton Mountain Road Near House 585	High	2.1	0.5	1.4	$30,000	$50,000	$40,000	8
B-01	Shibley's & Public Parking Lot	High	0.4	0.9	6.7	$50,000	$80,000	$65,000	9
B-16	Downtown Alton Bay	High	0.0	0.9	3.0	$60,000	$100,000	$80,000	10
B-26	Jesus Valley Road Stream Crossing	Low	1.9	0.5	1.3	$10,000	$20,000	$15,000	11
B-07	Rand Hill & Alton Mountain Road Intersection	Medium	1.0	0.3	0.7	$10,000	$20,000	$15,000	12
B-17	Loon Cove Road Bridge	Medium	1.6	0.4	1.1	$20,000	$30,000	$25,000	13
C-08	Echo Point Road Boat Ramp	High	0.7	0.8	5.4	$70,000	$120,000	$95,000	14
B-13	Alton Mountain Road Near House 286	Medium	2.1	0.5	1.4	$30,000	$40,000	$35,000	15
B-12	Alton Mountain Road Near House 522	Medium	1.8	0.5	1.2	$30,000	$35,000	$32,500	16
C-09	East Side Drive Crossing Near House 431	Medium	0.1	0.1	0.2	$5,000	$10,000	$7,500	17
B-28	Rand Hill Road #2	Medium	0.3	0.1	0.2	$5,000	$10,000	$7,500	18
B-02	Rand Hill Road Near Camp Advenchur	Low	1.4	0.4	1.0	$20,000	$30,000	$25,000	19
B-14	Mount Major Highway	Medium	1.2	0.3	0.8	$20,000	$40,000	$30,000	20
B-03	Spring Street Culvert	Low	0.3	0.1	0.2	$4,000	$10,000	$7,000	22
B-21	Route 11-D Road Shoulder	Medium	1.0	0.3	0.7	$25,000	$35,000	$30,000	21
B-27	Rand Hill Road #1	Low	1.0	0.3	0.7	$15,000	$25,000	$20,000	23
B-25	Jesus Valley Road #2	Low	0.5	0.1	0.4	$8,000	$16,000	$12,000	24
B-20	Temple Drive Entrance	Low	0.9	0.2	0.6	$10,000	$30,000	$20,000	25
A-01	Woodlands Road - South	Low	0.7	0.2	0.5	$12,000	$20,000	$16,000	26
B-10	Alton Mountain Road & Solari Rd Intersection	Low	0.3	0.1	0.2	$5,000	$10,000	$7,500	27
B-05	Spring Street Gully	Low	0.2	0.1	0.1	$4,000	$8,000	$6,000	28
B-19	Route 11-D Culvert	Low	0.3	0.1	0.2	$5,000	$10,000	$7,500	29

SITE	LOCATION	IMPACT	LOAD REDUCTION			ESTIMATED COST			RANK
			TSS (kg/yr)	TP (kg/yr)	TN (kg/yr)	Est. Low Cost	Est. High Cost	Est. Avg. Cost	
B-22	Route 11-D Stream	Medium	0.1	0.0	0.1	$5,000	$10,000	$7,500	30
B-06	Spring Street & Widerstrom Lane	Medium	0.5	0.1	0.3	$30,000	$40,000	$35,000	31
C-06	East Side Drive Crossing	Low	0.3	0.1	0.2	$15,000	$25,000	$20,000	32
B-23	Mount Major Parking Lot & Road Shoulder Erosion	Low	0.1	0.3	1.6	$80,000	$120,000	$100,000	33
B-15	Driveway Near Pop's Clam Shell	Low	0.2	0.0	0.1	$20,000	$30,000	$25,000	34
C-05	Chestnut Cove Road Crossing	Medium	0.0	0.0	0.0	$20,000	$30,000	$25,000	35
C-11	Swan Lake Trail Crossing	Low	0.0	0.0	0.0	$25,000	$50,000	$37,500	36
		TOTAL	**53.3**	**17.3**	**52.0**	**$773,000**	**$1,279,000**	**$1,026,000**	