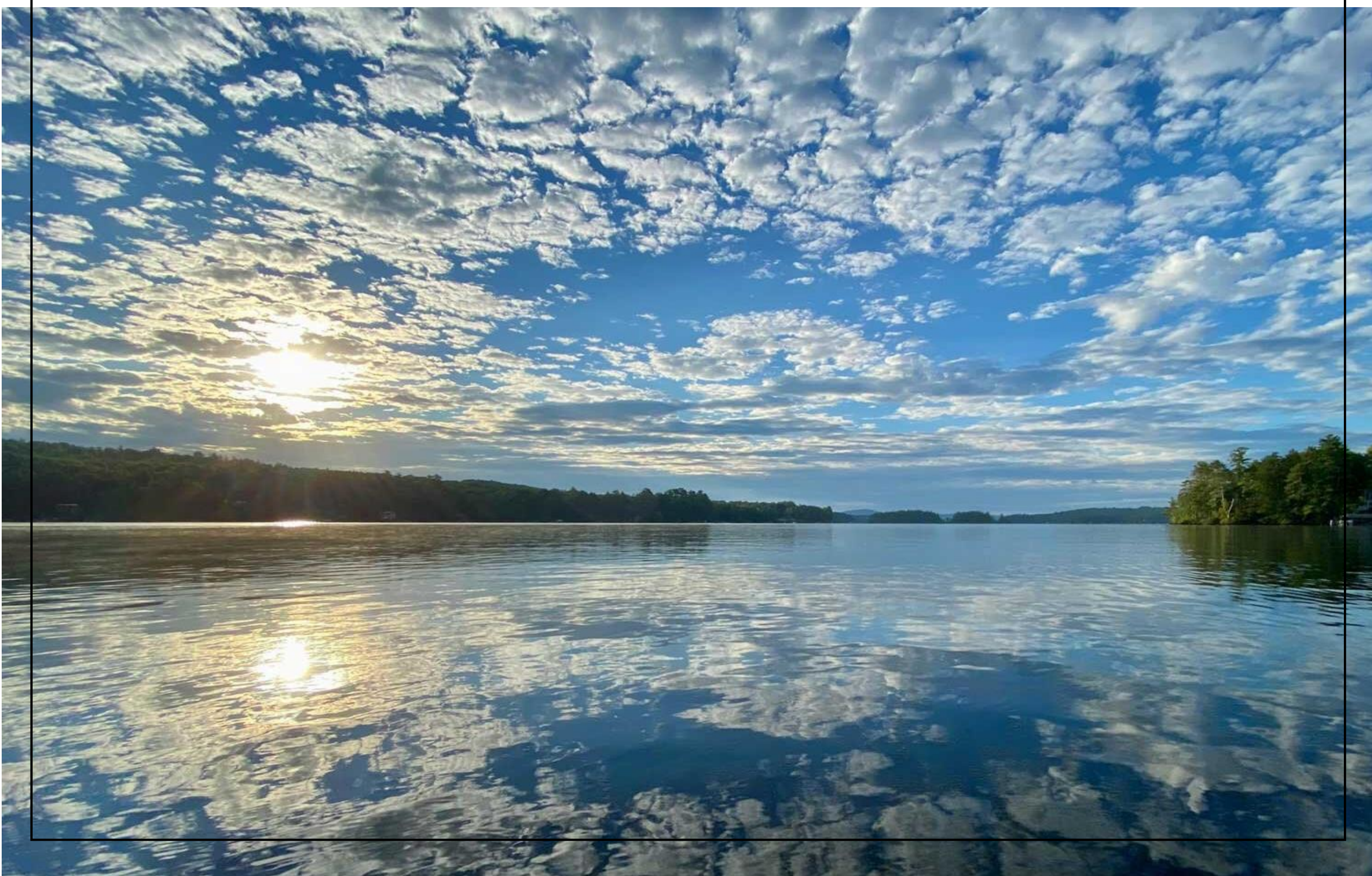
LAKE WINNISQUAM
WATERSHED-BASED PLAN

PREPARED BY FB ENVIRONMENTAL ASSOCIATES & HORSLEY WITTEN GROUP
in cooperation with the Winnisquam Watershed Network, the New Hampshire Department of Environmental Services, and the US Environmental Protection Agency

JULY 2022 | **FINAL**



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In Memory of Toby Stover, *TMDL and 303(d) Listing Coordinator for NH; Regional TMDL Alternative Restoration Plan Coordinator, US EPA Region 1*

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LIST OF ABBREVIATIONS

ACRONYM	DEFINITION
AC	Assimilative Capacity
AIPC	Aquatic Invasive Plant Control, Prevention and Research Grants
ACEP	Agricultural Conservation Easement Program
ALI	Aquatic Life Integrity
ARM	Aquatic Resource Mitigation Fund
ARP	Alternative Restoration Plan
BCCD	Belknap County Conservation District
BMP	Best Management Practice
CAGR	Compound Annual Growth Rate
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
DOS	Division of Security and Emergency Management
DPW	Department of Public Works
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
HW	Horsley Witten Group
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
LOPA	Lake Opechee Preservation Association
LRPC	Lakes Region Planning Commission
LWA	Lake Winnipesaukee Association
LWCF	Land and Water Conservation Fund
M	Meter
NAWCA	North American Wetlands Conservation Act
NERFG	New England Forest and River Grant
NCEI	National Centers for Environmental Information
NFWF	National Fish and Wildlife Foundation
NH GRANIT	New Hampshire Geographically Referenced Analysis and Information Transfer System
NHACC	New Hampshire Association of Conservation Commissions
NHD	National Hydrography Dataset
NHDES	New Hampshire Department of Environmental Services
NHDOT	New Hampshire Department of Transportation
NHFGD	New Hampshire Fish and Game Department

ACRONYM	DEFINITION
NHGS	New Hampshire Geological Survey
NHLCD	New Hampshire Land Cover Database
NOAA	National Oceanic and Atmospheric Administration
NPS	Nonpoint Source Pollution
NRCS	Natural Resources Conservation Service
NRI	Natural Resources Inventory
NWI	National Wetlands Inventory
PCR	Primary Contact Recreation
PCS	Potential Contamination Source
ppb, ppm	parts per billion, parts per million
PSU	Plymouth State University
QAPP	Quality Assurance Project Plan
RCCP	Regional Conservation Partnership Program
RCRA	Resource Conservation and Recovery Act
ROW	Right-of-Way
SADES	Statewide Asset Data Exchange System
SCC	State Conservation Committee
SCM	Stormwater Control Measure
SDT	Secchi Disk Transparency
TMDL	Total Maximum Daily Load
TP	Total Phosphorus
UNH	University of New Hampshire
USLE	Universal Soil Loss Equation
VLAP	Volunteer Lake Assessment Program
VRAP	Volunteer River Assessment Program
WBP	Watershed-Based Plan
WRBP	Winnipesaukee River Basin Program
WWN	Winnisquam Watershed Network
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.

Alternative Restoration Plan (ARP or 5-alt) is a voluntary plan for restoration developed in advance of a TMDL. These plans are created to speed up the planning and restoration process to meet water quality standards. A full TMDL planning process is not needed for Lake Winnisquam, so an ARP that demonstrates the practicality of meeting water quality standards in a reasonable timeframe can be developed instead. When the plan is accepted by EPA, the waterbody will remain at Category 5 (needing a TMDL) but can be assigned a lower priority for TMDL development. If water quality degrades or remains unchanged after 10 years (as set by this plan) or if implementation of the plan is not progressing during that time, then EPA may require a full TMDL process. Many of the required planning elements for the ARP overlap with the nine planning elements for WBPs.

Anoxia is a condition of low dissolved oxygen (Generally accepted as less than 2 ppm of dissolved oxygen).

Areal Water Load is the total annual flow volume reaching the waterbody divided by the surface area of the waterbody.

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 photosynthetic 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 concentration of algae in the lake.

Clean Water Act (CWA) is a federal law administered by the United States Environmental Protection Agency (EPA) that 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 toxins, in particular microcystin, a hepatoxin that is highly toxic to humans and other life forms.

Dimictic lakes mix twice per year, typically in spring and fall (see turnover).

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

Epilimnion is the top layer of lake water, the depth (or thickness) of which is directly affected by seasonal air temperature and wind. This layer is well-oxygenated by wind and wave action.

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

Flushing rate is the amount of time water spends in a waterbody. It is calculated by dividing the inputs of water to the lake (streams, groundwater, precipitation, etc.) by the volume of the waterbody. The flushing rate of a lake is the inverse of the time that water spends in the lake, known as the retention time.

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 commonly characterized by a lack 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 positive feedback to eutrophication with negative consequences.

Low Impact Development (LID) is an alternative approach to conventional site planning, design, and development that reduces the impacts of stormwater by working with natural hydrology and minimizing land disturbance by treating stormwater close to the source, and preserving natural drainage systems and open space, among other techniques.

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

Non-structural BMPs, which do not require extensive engineering or construction efforts, can help reduce stormwater runoff and associated pollutants through operational actions, such as land use planning strategies, municipal maintenance practices, and targeted education and training.

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

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

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). A reading of less than 2 meters is generally considered a nuisance algal bloom.

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 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 including algae. It is generally present in small amounts (measured in parts per billion (ppb)) and usually limits plant growth in lakes.

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

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.

EXECUTIVE SUMMARY

As the fourth largest lake in New Hampshire at 4,249 acres, Lake Winnisquam is situated within the economically vital Lakes Region of central New Hampshire and drains Lake Winnipesaukee through Paugus Bay and Lake Opechee via the Winnipesaukee River. The direct watershed area of Lake Winnisquam spans portions of the municipalities of Meredith, Laconia, Sanbornton, Belmont, Gilford, New Hampton, and Tilton and includes other important waterbodies such as Lake Wicwas and Lake Opechee, along with major tributaries such as Black Brook, Chapman Brook, Dolloff Brook, Durgin Brook, Durkee Brook, and Jewett Brook. From the outlet of Lake Winnisquam, water flows south to Silver Lake then west via the Winnipesaukee River until it joins with the Pemigewasset River to form the Merrimack River in Franklin.

The Problem

Lake Winnisquam is classified as an oligotrophic, Class B waterbody in New Hampshire but was placed on the New Hampshire Department of Environmental Services (NHDES) 303(d) List of Impaired Waters for the designated use of Aquatic Life Integrity (ALI) due to excessive turbidity coming from Hueber Brook, a small tributary to the southeast side of Lake Winnisquam off Route 3 and near Sun Lake Drive. Elevated turbidity indicates that Lake Winnisquam is experiencing enhanced sedimentation or infill of sediment and other materials from the landscape. Black Brook, a tributary to Lake Winnisquam, has been long impacted by excessive sediment loading from the gravel roads throughout the sub-watershed, most especially Huse Rd, Kaulback Rd, and Woodman Rd. This sediment load is transported out into Lake Winnisquam where a visible 300-ft radius sediment delta has formed over the years. Sediment often transports nutrients such as phosphorus to surface waters. Enhanced loading of phosphorus, a key limiting nutrient for growth in freshwater, to surface waters such as Lake Winnisquam can stimulate excessive plant and algae growth and degrade water quality. Lake Winnisquam has already experienced cyanobacteria bloom warnings, which were issued by NHDES in 2008 (28 days) and 2010 (43 days). NHDES issued a cyanobacteria bloom alert on 6/27/22 for the north end of Lake Winnisquam. Cyanobacteria concentrations were below the advisory level and dissipated within a couple days.

Potential sources of phosphorus in the watershed impacting the lake's water quality include stormwater runoff from urban areas, shoreline erosion, erosion from construction activities or other disturbed ground particularly along roads, excessive fertilizer application, illicit connections, failed or improperly functioning septic systems, leaky sewer lines, unmitigated agricultural activities, and pet, livestock, and wildlife waste. Over 100 problem sites were identified in the watershed during a field survey, and the main issues found were unpaved road and ditch erosion; waterfront park and beach erosion; buffer clearing; and untreated urban stormwater runoff. The model results revealed changes in phosphorus loading and in-lake phosphorus concentrations over time from pre-development through future conditions, showing that the water quality of Lake Winnisquam is threatened by current development activities in the watershed and will degrade further with continued development in the future, especially when compounded by the effects of ongoing climate change.

The Goal

The purpose and overarching goal of the Lake Winnisquam Watershed-Based Plan (WBP) is to guide implementation efforts over the next 10 years (2022-2031) to improve the water quality of Lake Winnisquam such that it meets state water quality standards for the protection of ALI. *Note: this plan covers only the direct Lake Winnisquam watershed area located in Laconia, Gilford, Belmont, Tilton, Sanbornton, Meredith, and New Hampton. Restoration efforts for the larger Lake Winnipesaukee watershed are being led by other local groups. In addition, two other lakes are located within the immediate drainage area to Lake Winnisquam: Lake Wicwas and Lake Opechee. While not the focus of the plan, their water quality status has a direct impact on the water quality of Lake Winnisquam, and thus secondary water quality objectives were set to improve their water quality both for their own benefit and for the benefit of Lake Winnisquam. Monitoring of these two waterbodies should continue and/or be expanded, and if water quality decline is evident, then development of individual plans may be warranted in the future.*

This goal will be achieved by accomplishing the following summarized objectives:

- OBJECTIVE 1: Reduce pollutant loading from Hueber Brook to remove Lake Winnisquam's impaired listing for ALI due to excessive turbidity.
- OBJECTIVE 2: Mitigate (prevent or offset) anticipated additional pollutant loading from future development in the watershed.

- OBJECTIVE 3: Reduce pollutant loading from existing development in the watershed, especially in the Black Brook sub-watershed.

The Solution

Through the efforts of many key watershed protection groups, including, but not limited to, the Winnisquam Watershed Network (WWN), Belknap County Conservation District (BCCD), Lake Wicwas Association, Lake Opechee Preservation Association (LOPA), Lake Winnipesaukee Association (LWA), Lakes Region Planning Commission (LRPC), NHDES, and municipalities and their conservation commissions, much planning and restoration work to protect and restore Lake Winnisquam's water quality has been accomplished in the watershed to date.

A watershed management plan for the Black Brook sub-watershed was completed in 2012. In 2017, WWN was formed in part to unify monitoring and assessment efforts around Lake Winnisquam. The monitoring program was significantly revamped and expanded to include more frequent sampling of the deep spot and key tributaries. In 2020, a shoreline survey of Lake Winnisquam was completed by WWN volunteers, 11 stream crossing culvert assessments were completed by Trout Unlimited in the Black Brook sub-watershed, septic system data in the shoreland zone were collected by WWN volunteers (and separated out from sewered parcels), and funding from the US Environmental Protection Agency (EPA) was secured to develop a WBP for Lake Winnisquam. As part of the development of the WBP, a build-out analysis, land-use model, water quality and assimilative capacity analysis, and watershed survey were conducted to better understand the sources of phosphorus and other pollutants to the lake. In addition, remaining stream crossing culverts in the watershed were assessed in 2021 by Trout Unlimited and the NHDES Wetlands Mitigation Program; BCCD hired an engineer in 2021 to review and assess sedimentation issues impacting Black Brook; BCCD teamed with Trout Unlimited to complete a large wood installation stream restoration project in 2021 for a one mile segment of Black Brook; and BCCD hired a consultant in 2022 to perform a quantitative evaluation and prioritization of 11 erosion sites in the Black Brook sub-watershed to serve as supporting documentation for future grant funding applications.

Results from these analyses were used to determine recommended management strategies for the identified pollutant sources in the watershed. An Action Plan was developed in collaboration with a plan development committee comprised of the key watershed protection groups noted above. The following actions were recommended to meet the established water quality goal and objectives for the Lake Winnisquam watershed:

WATERSHED STRUCTURAL BMPS: Sources of phosphorus from watershed development should be addressed through installation of stormwater controls, stabilization techniques, buffer plantings, etc. for stormwater infrastructure in the Hueber Brook sub-watershed, the top 24 high priority sites (and the remaining 84 medium and low priority sites as opportunities arise) identified during the watershed survey, including road erosion in the Black Brook sub-watershed, the 20 high impact shoreline properties (as well as the 282 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. WWN, in concert with University of New Hampshire (UNH) Lay Lakes Monitoring Program (LLMP) and NHDES Volunteer Lake Assessment Program (VLAP), has implemented the Lake Winnisquam Tiered Monitoring Plan since 2017 and should continue the annual monitoring protocol and consider incorporating additional monitoring recommendations laid out in this plan.

EDUCATION AND OUTREACH: WWN and other key watershed protection groups 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 connective habitat corridor parcels;

completing stream restoration projects; and improving agricultural practices. Future development should also be considered as a pollutant source and potential threat to water quality. Lake Winnisquam is at risk for greater water quality degradation because of new development in the watershed unless climate change resiliency and LID strategies are incorporated to existing zoning standards.

The recommendations of this plan will be carried out largely by WWN with assistance from a diverse stakeholder group, including representatives from the seven 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. The cost of successfully implementing the plan is estimated at $2.1-$3.2 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 eligible entities within the Lake Winnisquam watershed are 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.

Each municipality will likely have a unique response or implementation approach to the recommendations in the Action Plan, and thus, the execution of the actions may take a decentralized path. WWN and other local groups can work with each municipality to provide support in reviewing and tailoring the recommendations to fit the specific needs of each municipality. It should also be understood that the recommendations in this plan are idealized and, in some cases, may be difficult to achieve given the physical and political realities of each municipality dealing with old infrastructure, lack of access to key lakefront areas, and limited funding and staff capacity.

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. WWN and other key watershed protection groups 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 Lake Winnisquam long into the future.

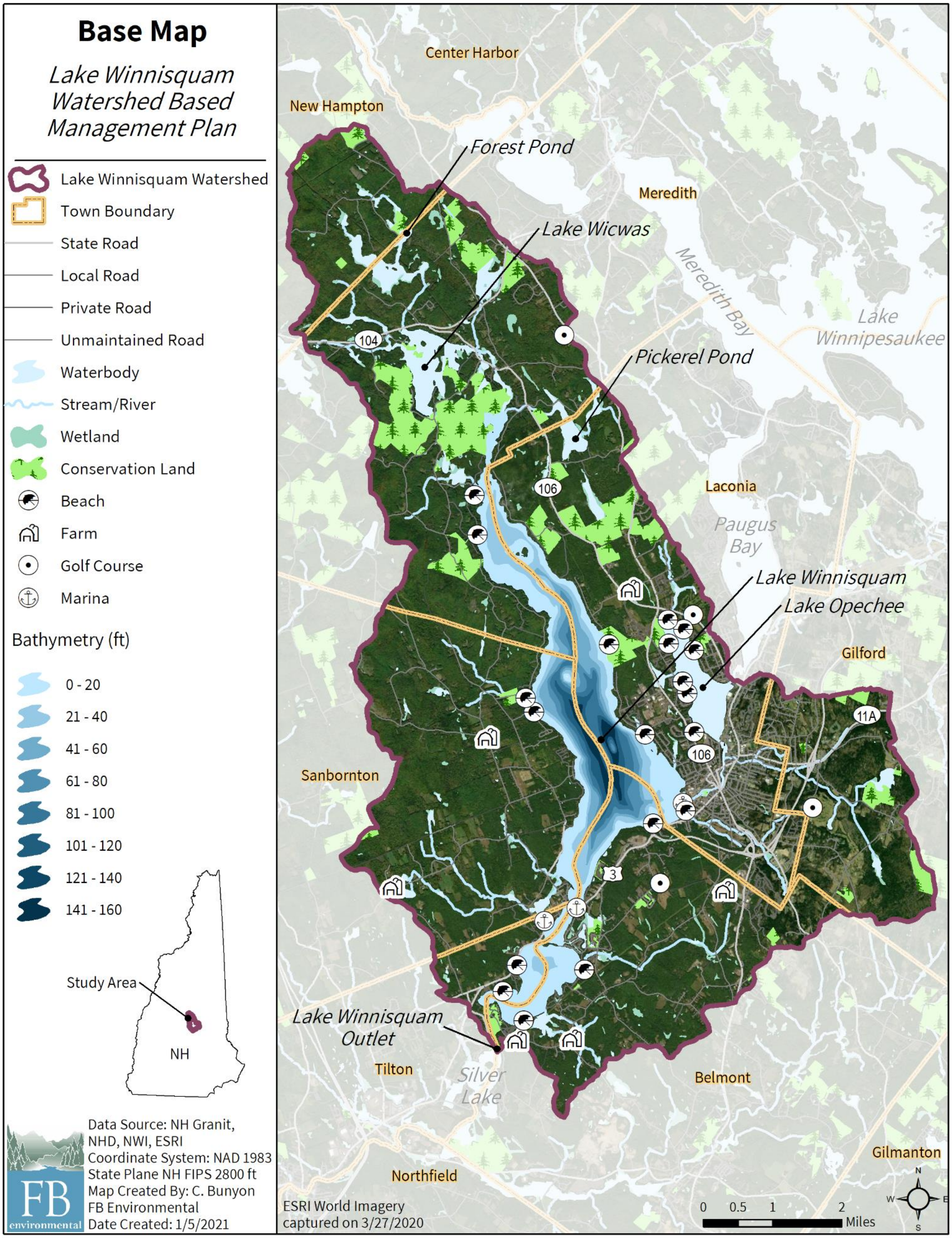
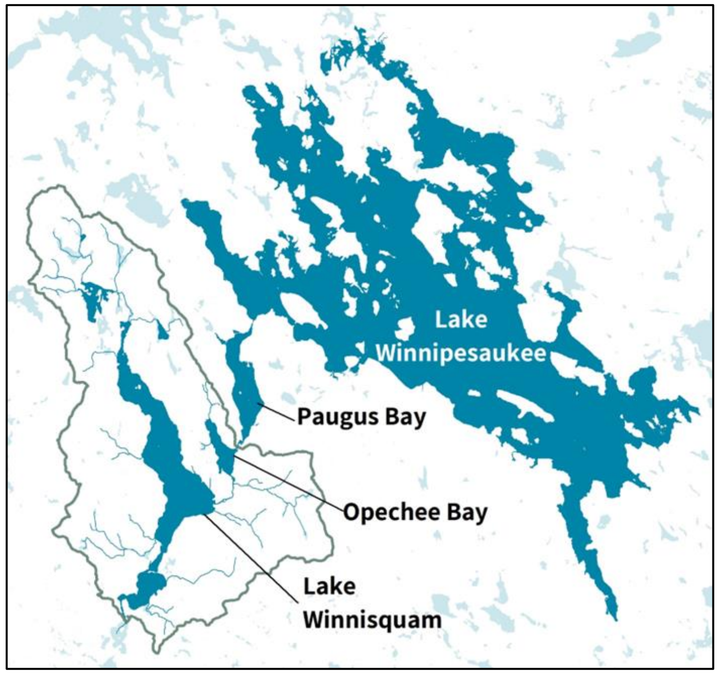


Figure 1. Lake Winnisquam watershed basemap.

1 INTRODUCTION

1.1 WATERBODY DESCRIPTION AND LOCATION

As the fourth largest lake in the State of New Hampshire, Lake Winnisquam is a 6.6-square-mile (4,249-acre) lake with a 64-square-mile (40,694-acre) direct watershed area (Figure 1) in the municipalities of Meredith (24%), Laconia (23%), Sanbornton (21%), Belmont (16%), Gilford (9%), New Hampton (5%), and Tilton (3%). The total watershed area to Lake Winnisquam includes Lake Winnipesaukee via Paugus Bay and the Winnipesaukee River (pictured right). Other major waterbodies in the direct Lake Winnisquam watershed include Lake Opechee (449 acres) and Lake Wicwas (350 acres), along with major tributaries such as Black Brook, Chapman Brook, Dolloff Brook, Durgin Brook, Durkee Brook, and Jewett Brook. From the outlet of Lake Winnisquam, water flows south to Silver Lake then west via the Winnipesaukee River until it joins with the Pemigewasset River to form the Merrimack River in Franklin, New Hampshire.



The Lake Winnisquam watershed is situated within a temperate zone of converging weather patterns from the hot, wet southern regions and the cold, dry northern regions, which causes various natural phenomena such as heavy snowfalls, severe thunder and lightning storms, and hurricanes. The area experiences moderate to high rainfall and snowfall, averaging 43 inches of precipitation annually (data collected for the period 1950-2020 from the Lakeport 2, NH US weather station (USC00274480), with gaps covered by the following weather stations: Lakeport, NH US (USC00274475), Franklin Falls Dam, NH US (USC00273182), and Plymouth, NH US (USC00276945) (Figure 2). Annual air temperature (from average monthly data) generally ranges from 20 °F to 70 °F with an average of 46 °F (NOAA NCEI, 2022).

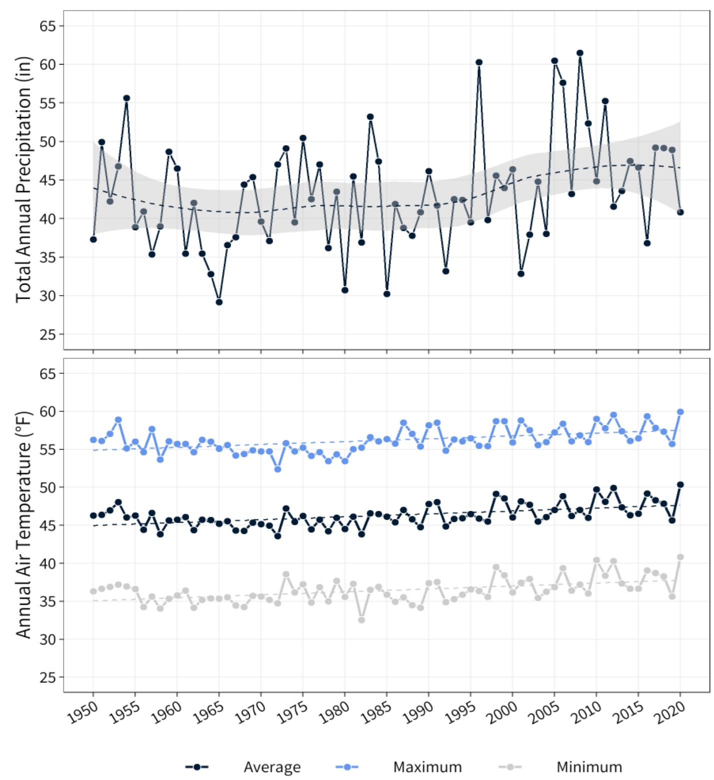


Figure 2. Total annual precipitation (TOP) and annual max, average, and min of monthly air temperature (BOTTOM) from 1950 - 2020 for the Lake Winnisquam watershed area. Data collected from NOAA NCEI.

The highest elevation in the watershed (about 1,480 feet above sea level) is located between the Bald Ledge Scenic Vista and the Sky Pond State Forest conservation areas in New Hampton. Lake Winnisquam and the direct shoreline area are situated at approximately 580 feet above sea level. These elevation measurements were derived from digital elevation models provided by NH GRANIT.

The watershed is characterized primarily by mixed forest that includes both conifers (e.g., white pine and eastern hemlock) and deciduous (e.g., beech, red oak, and maple) tree species. Fauna that enjoy these forested resources include land mammals (moose, deer, black bear, coyote, bobcats, fisher, fox, raccoon, weasel, porcupine, muskrat, mink, chipmunks, squirrels, snowshoe hares, and bats), water mammals (muskrat, otter, and beaver), land and water reptiles and amphibians (turtles, snakes, frogs, and salamanders), various insects, birds (herons, loons, gulls, geese, multiple species of ducks[1], wild turkeys, ruffed grouse, cormorants, bald eagles, and song birds), and fish. The only recorded invasive aquatic plant species present in Lake Winnisquam is variable milfoil (*Myriophyllum heterophyllum*) which became established in the lake in 1995. Invasive Chinese mystery snails have also been recorded in Lake Winnisquam. Vigilant Weed Watchers and Lake Hosts are helping to keep the lake free from additional invasive aquatic species.

1.2 WATERSHED PROTECTION GROUPS

The Winnisquam Watershed Network (WWN) serves as a non-profit lake association for Lake Winnisquam and its surrounding watershed with the mission to "*preserve and protect Lake Winnisquam and its watershed now and for future generations*." With focuses on water quality monitoring and invasive species prevention and control, the WWN helps educate members of the community and promote management initiatives.

Belknap County Conservation District (BCCD) is one 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 "*coordinate and implement programs for education and on the ground work regarding conservation, use, and development of soil, water, and related resources*." BCCD works 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. The BCCD is led by two paid staff and a volunteer Board of Supervisors with representation from each municipality.

The Lake Wicwas Association serves as a non-profit lake association for Lake Wicwas with the mission to "*maintain and promote what's best for the health and preservation of Lake Wicwas*." They perform water quality monitoring, watches for invasive species through the Lake Host and Weed Watcher programs and maintains effective communication with lake residents to promote education and awareness of lake protection initiatives. Their Conservation Committee actively pursues watershed parcels for conservation.

The Lake Opechee Preservation Association (LOPA) was created to combat the issue of invasive aquatic species in the lake, as well as to protect the overall health of the watershed and water quality of the lake. The group plans to expand their activities to include water quality monitoring in the future.

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

The New Hampshire Association of Conservation Commissions (NHACC) works to provide educational assistance to conservation commissions throughout New Hampshire (216 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 Lake Winnisquam

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

watershed include those from the municipalities of Tilton, Meredith, Laconia, Belmont, Gilford, Sanbornton, and New Hampton.

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

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 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 Lake Winnisquam Watershed-Based Plan (WBP) is to guide implementation efforts over the next 10 years (2022-2031) to improve the water quality of Lake Winnisquam such that it meets state water quality standards for the protection of Aquatic Life Integrity (ALI). *Note: this plan covers only the direct Lake Winnisquam watershed located in Laconia, Gilford, Belmont, Tilton, Sanbornton, Meredith, and New Hampton. Restoration efforts for the larger Lake Winnipesaukee watershed are being led by other local groups. In addition, two other lakes are located within the immediate drainage area to Lake Winnisquam: Lake Wicwas and Lake Opechee. While not the focus of the plan, their water quality status has a direct impact on the water quality of Lake Winnisquam, and thus secondary water quality objectives were set to improve their water quality both for their own benefit and for the benefit of Lake Winnisquam. Monitoring of these two waterbodies should continue and/or be expanded, and if water quality decline is evident, then development of individual plans may be warranted in the future.*

As part of the development of this plan, a **build-out analysis**, land-use model, water quality and **assimilative capacity** analysis, and shoreline and watershed surveys were conducted to better understand the sources of phosphorus and other pollutants to the lake (Sections 2 and 3). Results from these analyses were used to establish the water quality goal and objectives (Section 2.4), determine recommended management strategies for the identified pollutant sources (Section 4), and estimate pollutant load reductions and costs needed for remediation (Sections 5 and 6). Recommended management strategies involve using a combination of **structural and non-structural Best Management Practices** (BMPs), as well as an **adaptive management approach** that allows for regular updates to the plan (Section 4). An Action Plan (Section 5) with associated timeframes, responsible parties, and estimated costs was developed in collaboration with a plan development 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). This plan is also considered a Total Maximum Daily Load (TMDL) **Alternative Restoration Plan** (ARP or 5-alt), which is a voluntary plan for restoration developed in advance of a TMDL. These plans are created to speed up the planning and restoration process to meet water quality standards. A full TMDL planning process is not needed for Lake Winnisquam, so an ARP that demonstrates the practicality of meeting water quality standards in a reasonable timeframe can be developed instead. When the plan is accepted by EPA, the waterbody will remain at Category 5 (needing a TMDL) but can be assigned a lower priority for TMDL development. If water quality degrades or remains unchanged after 10 years (as set by this plan) or if implementation of the plan is not progressing during that time, then EPA may require a full TMDL process. Many of the required planning elements for the ARP overlap with the nine planning elements for WBPs.

1.4 COMMUNITY INVOLVEMENT AND PLANNING

This plan was developed over a period of nearly two years through active collaboration among FB Environmental Associates (FBE), Horsley Witten Group (HW), WWN, NHDES, EPA, BCCD, LWA, Lake Wicwas Association, LRPC, representatives from the municipalities of Meredith, Laconia, Gilford, Belmont, Tilton, Sanbornton, and New Hampton, and private landowners (see Acknowledgments).

1.4.1 Plan Development Meetings

Ten meetings were held over the duration of the plan's development. The following list does not include other smaller check-in meetings conducted among project partners.

1. **December 14, 2020:** EPA, NHDES, and the technical project staff (FBE, HW) held a logistics kickoff meeting to discuss project roles, communications, and timeline for tasks and deliverables.
2. **January 5, 2021:** Key project team members, including WWN, EPA, NHDES, FBE, and HW held a content kickoff meeting which walked through project tasks and the expected project timeline. Additional supporting organizations attending included LWA and BCCD.
3. **February 2, 2021:** WWN held a project kick-off meeting for local conservation commissions to attend and learn about the plan and the project's objectives, technical partners, timeline, and strategy.
4. **March 9, 2021:** The committee discussed the Quality Assurance Project Plan (QAPP) development and prepared for the virtual public workshop.
5. **April 6, 2021:** The committee discussed the outreach efforts for the upcoming public workshop and preparations for watershed assessments by FBE and HW.
6. **May 4, 2021:** The committee discussed the upcoming virtual public workshop, including WWN's advertisement, expected attendees, and break-out group facilitation. The committee also discussed the to-date work for the watershed assessment (FBE), culvert assessments (Trout Unlimited), and septic system database (WWN).
7. **June 1, 2021:** The committee discussed survey responses associated with the public workshop. FBE presented preliminary build-out results. HW and FBE provided an update on watershed assessments completed.
8. **August 3, 2021:** The committee walked through numerous task updates, including a summary of the public workshop, FBE's review of environmental monitoring data to-date, the updated draft of the build-out report with feedback from the watershed municipalities, and completed estimates of pollutant load reductions for the watershed assessment sites.
9. **December 7, 2021:** The committee discussed the completed land-use model by FBE and the recommended water quality goal and specific objectives identified for Lake Winnisquam. WWN submitted a full proposal for a Section 319 Watershed Assistance Grant that focuses on remediating several identified watershed assessment sites.
10. **March 1, 2022:** The committee discussed final rounds of edits made for reports that inform the plan, including the build-out analysis report, modeling report, water quality goal memorandum, public workshop summary, and watershed assessments and NPS management measures technical memorandum.

1.4.2 Public Workshop

A virtual public workshop was held on May 18, 2021 to introduce the project to the watershed community and solicit feedback on local interests, values, and concerns related to water quality and practical solutions. The workshop was attended by 44 people, including 12 team members and stakeholders who served as presenters and facilitators. Key topics discussed included land conservation and municipal planning, road erosion and maintenance, septic systems, stormwater management, and other water quality concerns. Refer to Appendix A for a full summary of solicited feedback.

1.4.3 Public Surveys

WWN posted a survey online to gather local feedback on water quality perceptions, values, and interests in the watershed. There were 133 respondents. Survey responses indicate that 50% of respondents live in the watershed year-round, most on Lake Winnisquam. Most respondents felt that water quality was about the same or getting somewhat worse and that maintaining excellent water quality was very important to them, valuing roughly equally recreational use, fishery health, wildlife health, drinking water, and property value. Respondents identified stormwater runoff, fertilizers, septic systems, and road salt as the largest perceived contributors to water quality degradation. About 57% of respondents were served by sewer; most septic systems were around 20 years old; 60% pumped their septic system in last 3-5 years. About 42% of respondents use fertilizer at least once per year on their lawn. About 92% of respondents supported land conservation to protect water quality. Other specific environmental concerns that respondents listed included: density of waterfront homes, lack of shoreline buffers, large tree removal, trash/litter, boat wakes generating shoreline erosion, boat and swimmer pollution at the sandbar, winter road maintenance, loss of wetland habitat, light pollution, and dirt road erosion, among others.

With a rise in the number of boaters entering Lake Winnisquam each year, WWN is concerned about boaters launching from private launches around the lake and bypassing the Lake Host Program inspection for invasives at the public launch. WWN created a survey targeting Winnisquam boaters to determine where boaters were coming from and where they were launching into the lake. There were 136 survey respondents, of which 48% were year-round and 52% were seasonal. Most of the boaters used motor boats (90%) compared to jet skis (31%), sail boats (11%), and wake boats (10%). About 41% of the boaters used the public launch, while 25% used private property, 19% used a marina, and 14% used a neighborhood/association launch. Of the public boat launches and neighborhood/association launches listed in the survey, most used the Laconia/Water Street launch with only a handful of respondents using Sunray Shore, Wildwood Shores, Mallards Landing, Winnisquam Marine, Black Brook Rd, and Waldron Bay Owner's Association. Most boaters keep their boats in the lake for the season (81%), while others launch their boats for day trips (12%) or short vacations (4%). While 84% of boaters do not bring their boat to other lakes, about 6% of boaters do, including such waterbodies as Lake Winnipesaukee, Rye Harbor, Lake George, Sarantac Lake, Beaver Lake, Merrimack River, Squam Lake, Arlington Pond, Lake Wicwas, Lake Champlain, and Sunapee Lake. Most boaters reported draining and drying their boats prior to launching them, though 5% were not familiar with the protocol.

1.4.4 Final Public Presentation

A final public presentation was held on June 7, 2022 to summarize the analyses and recommendations detailed in the plan. An opportunity for public feedback on the plan was offered. The presentation was attended by 26 people, including nine team members and stakeholders on the committee.

1.5 INCORPORATING EPA'S NINE ELEMENTS

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

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

2 ASSESSMENT OF WATER QUALITY

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

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 aquatic life, 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 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 Winnisquam is classified as a Class B waterbody**. Additionally, from 1974 to 2010, NHDES conducted surveys of lakes to determine **trophic state** (**oligotrophic**, **mesotrophic**, or **eutrophic**). The trophic surveys evaluated physical lake features, as well as chemical and biological indicators. **For Lake Winnisquam, the trophic state was determined to be oligotrophic** during all four completed surveys (1980, 1984, 1994, 2007) (NHDES, 2007). This means that in-lake water quality was consistent with the standards for oligotrophic lakes.

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 toxics) 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

According to New Hampshire's 2020-2022 303(d) List of Impaired Waters, **Lake Winnisquam is impaired for ALI due to excessive turbidity**, which was documented at one location: the outlet area of Hueber Brook, a small tributary to the southeast side of Lake Winnisquam off Route 3 and near Sun Lake Drive in Belmont. Excessive turbidity represents a threat to water quality and lake health. The original impairment was determined in 2007 during reconstruction of Route 3 and Route 11 when a plume of sediment with turbidity exceeding 10 NTU after rain events was documented in the lake and coming from Hueber Brook. Even with reconstruction of Route 3 and Route 11 complete, resampling of the area in 2015 revealed turbidity still exceeding 10 NTU after rain events. The water quality criteria for turbidity must be met everywhere in the lake to be considered attaining for ALI. Elevated turbidity indicates that Lake Winnisquam is experiencing enhanced sedimentation or infill of sediment and other materials from the landscape, in this case washed in from Hueber Brook. Sediment often transports nutrients such as phosphorus to surface waters. Enhanced loading of phosphorus to surface waters such as Lake Winnisquam can stimulate excessive plant and algae growth and degrade water quality. Lake Winnisquam has already experienced **cyanobacteria** bloom warnings, which were issued by NHDES in 2008 (28 days) and 2010 (43 days). NHDES issued a cyanobacteria bloom alert on 6/27/22 for the north end of Lake Winnisquam. Cyanobacteria concentrations were below the advisory level and dissipated within a couple days.

Lake Wicwas is currently listed on the NHDES 303(d) List of Impaired Waters for ALI due to low dissolved oxygen, which is often indicative of enhanced nutrient loading from external watershed sources and/or internal sediment sources. Low dissolved oxygen can release legacy phosphorus from bottom sediments and contribute to cyanobacteria blooms that capitalize on available light and nutrients in the water column. NHDES issued cyanobacteria (*Dolichospermum*) bloom warnings in August 2018 (14 days) and 2019 (6 days) for Lake Wicwas. **Lake Opechee is currently not listed as impaired for ALI** (but is listed as impaired for PCR due to elevated *E. coli*). There was evidence of low oxygen (at 13 m and deeper) and elevated hypolimnetic total phosphorus concentrations (at 15 m) in the 1979, 1986, and 1999 NHDES Trophic Survey Reports for Lake Opechee; thus, there is likely some internal loading occurring. Cyanobacteria bloom warnings were issued for Lake Opechee in 2008 (37 days) for *Anabaena* at Bond Beach, which represents localized blooms that should be tracked closely in the future; a lake-wide cyanobacteria advisory was issued by NHDES in June 2022 (5 days) for *Dolichospermum*. The high **flushing rate** of Lake Opechee due to the large incoming water volume from Lake Winnipesaukee through Paugus Bay helps to mix the lake with lower concentration water than that coming from the direct watershed area to Lake Opechee in Laconia. Much of the area in Laconia directly draining to Lake Opechee is already built-out but increasing the density of new or re-development will have consequences for the water quality of Lake Opechee in the future, especially when compounded by the effects of climate change.

2.1.2 Water Quality Data Collection

Prior to 2017, volunteers conducted monitoring on Lake Winnisquam as part of both the UNH Lay Lakes Monitoring Program (LLMP) and NHDES Volunteer Lake Assessment Program (VLAP). LLMP monitoring was conducted almost every year from 1997-2016 during the summer months at four nearshore stations along the western shoreline of the lake in Sanbornton and Meredith. VLAP monitoring (going back to 1987) was conducted at three deep spot stations near Three Island, Pot Island, and Mohawk Island (Figure 3). NHDES also conducted monitoring of the three deep spot stations several times as part of their lake trophic surveys (1980, 1984, 1994, 2007). In 2017, the WWN met with the directors of both the LLMP and VLAP programs and put together a tiered monitoring plan for the lake that allowed for better coordination of volunteers, resources, and data.

Since 2017, the WWN, in collaboration with VLAP and LLMP, has been implementing the first tier of the monitoring plan, conducting sampling at two of the nearshore stations and the three deep spot stations. VLAP monitors three deep spot stations in Lake Winnisquam (Three Island, Pot Island, and Mohawk Island), and LLMP monitors two nearshore stations in Lake Winnisquam (10 Waldron and 30 Bartlett), three to five times each summer for total phosphorus (**epilimnion**, metalimnion, and **hypolimnion**), chlorophyll-a (composite or epilimnion), **Secchi disk transparency**, and dissolved oxygen-temperature profiles. Samples are analyzed by the NHDES laboratory in Concord. Volunteers also collect additional Secchi disk transparency readings at the three deep spot stations throughout the summer season. Dissolved oxygen-temperature profiles for 2017-2019 were not collected except for two profiles, one in 2017 and one in 2018, at the Three Island deep spot station.

In 2018, the WWN also added a tributary monitoring program using NHDES Volunteer River Assessment Program (VRAP) protocols to monitor nine stations for total phosphorus two to three times each summer (Figure 3). The City of Laconia has also monitored Jewett Brook under VRAP. Three stations (Jewett Brook, Black Brook, and Winnipesaukee River inlet to the lake) have been monitored consistently in the last 10 years. The other seven stations include Lake Wicwas outlet, Durkee Brook, Collins Brook, Chapman Brook (two branches), Durgin Brook, and the outlet of Lake Winnisquam.

Once each year, VLAP also monitors the deep spot, west cove, east cove, and the Route 104 inlet to Lake Wicwas in the headwaters of the Lake Winnisquam watershed for total phosphorus, chlorophyll-a, Secchi disk transparency, and/or dissolved oxygen-temperature profiles. VLAP collects up to six chlorophyll-a samples from Hunkins Pond. Dissolved oxygen and temperature are also monitored at several other sites throughout the watershed and at beaches.

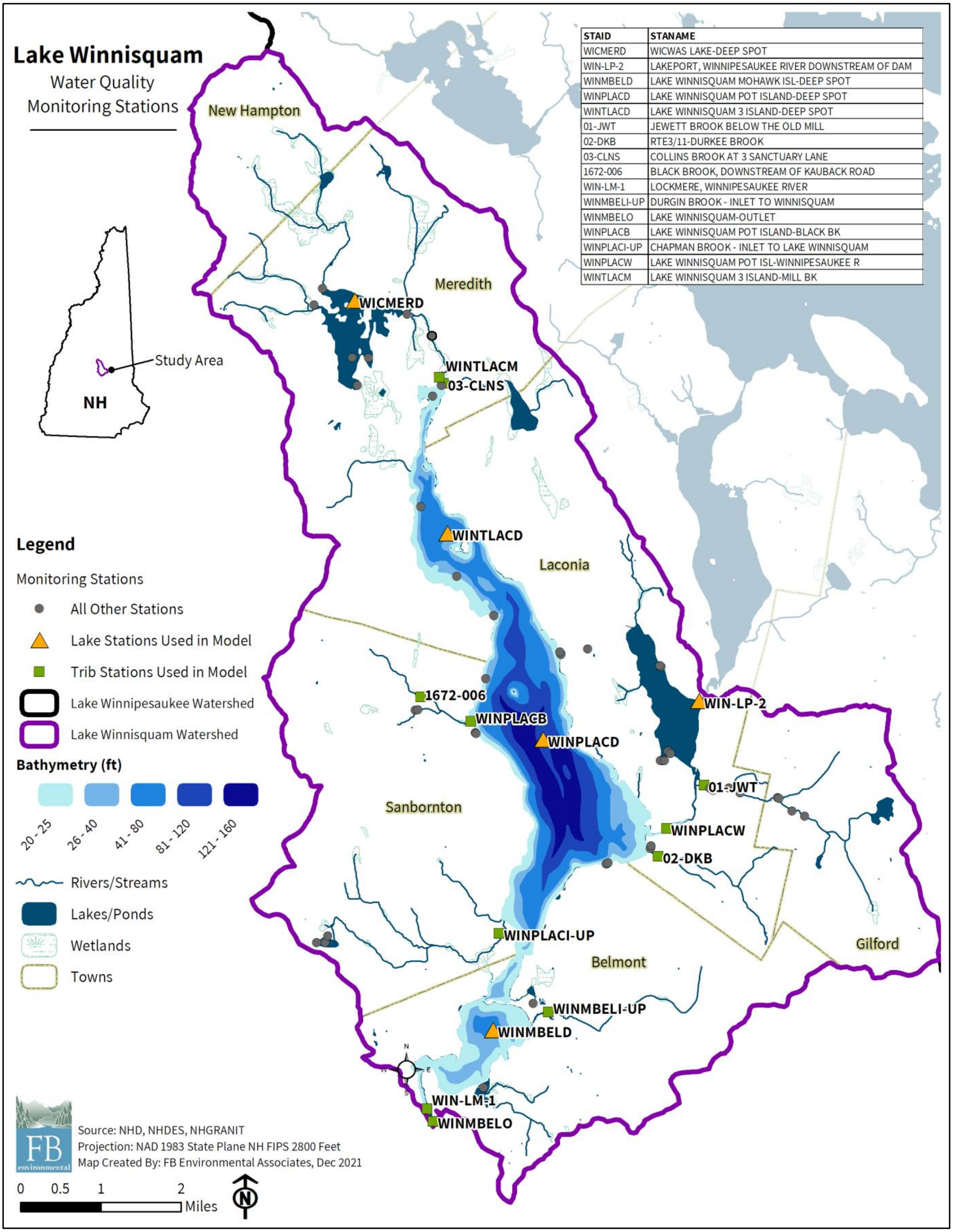


Figure 3. Bathymetric map with water quality monitoring stations in the Lake Winnisquam watershed.

2.1.3 Trophic State Indicator Parameters

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

Annual average water clarity at the three deep spot stations on Lake Winnisquam range from the shallowest of 5.6 m at Mohawk Island deep spot to the deepest of 8.6 m at Pot Island deep spot (Figure 4), with overall average water clarity from 2011-2021 ranging from 6.2 m to 7.7 m at the three stations. Annual average total phosphorus was highest at 13.0 ppb at Three Island deep spot in 2021 (possibly due to the extreme wet summer generating runoff that concentrated nutrient-laden sediment from the upper watershed); otherwise, the three stations range comparably similar from 6.7 ppb to 7.5 ppb for overall average total phosphorus concentration from 2011-2021. Mohawk Island deep spot generally had lower total phosphorus concentrations, likely due to the diluting effects of the large volume of incoming water from upstream waterbodies including Lake Winnipesaukee (though Pot Island is also influenced by Lake Winnipesaukee inflows). Annual average chlorophyll-a was consistently and comparably low, ranging from the lowest of 0.7 pb at Pot Island deep spot to the highest of 3.8 ppb at Three Island deep spot, with overall average chlorophyll-a from 2011-2021 ranging from 1.5 ppb to 1.9 ppb at the three deep spot stations.

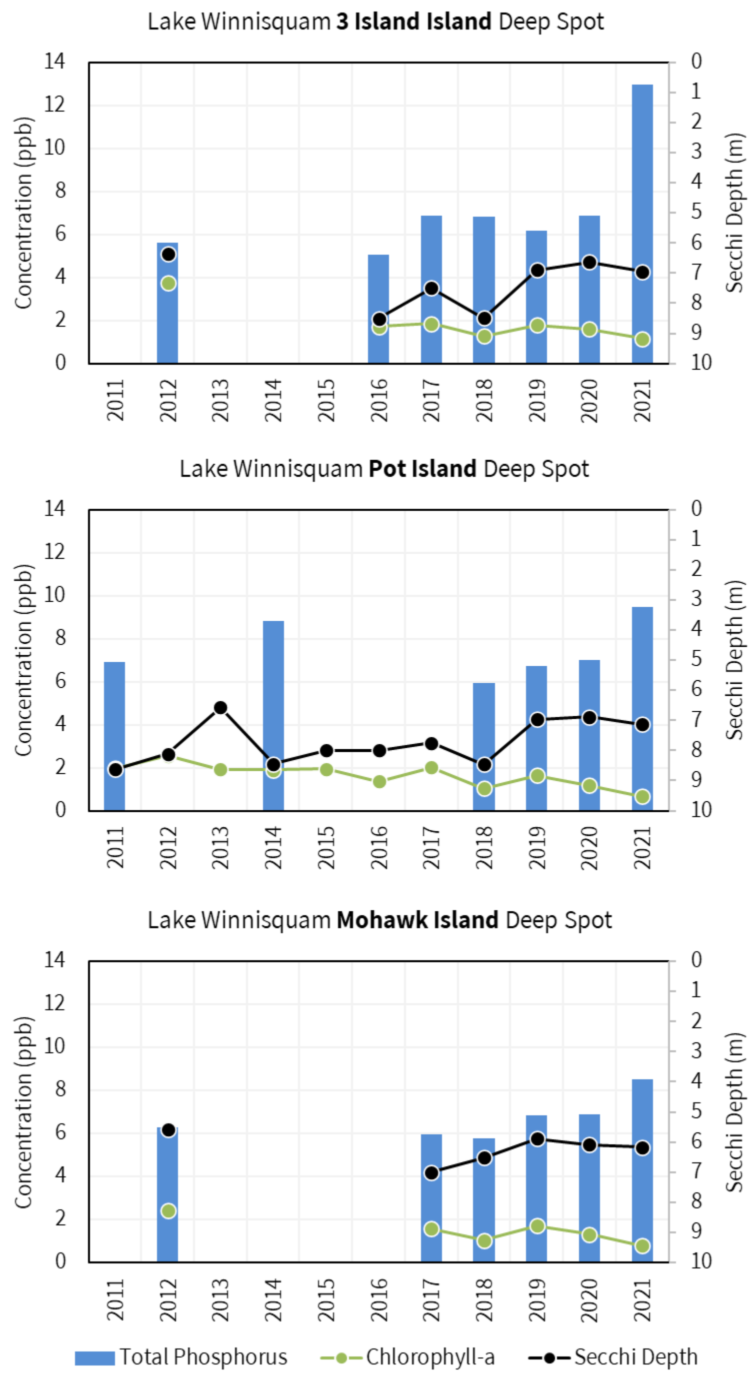


Figure 4. Annual average epilimnetic total phosphorus (blue), chlorophyll-a (green), and water clarity (Secchi depth, black) measured intermittently from 2011-2021 at three deep spot stations on Lake Winnisquam (from upstream to downstream): Three Island (TOP), Pot Island (MIDDLE), and Mohawk Island (BOTTOM).

2.1.4 Dissolved Oxygen & Water Temperature

A common occurrence in many New England lakes is the depletion of dissolved oxygen in the deepest part of lakes throughout the summer months, a natural phenomenon in some **dimictic** lakes that is made more severe by human disturbance. Chemical and biological processes occurring in bottom waters deplete the available oxygen throughout the summer, and because these waters are colder and denser, the oxygen cannot be replenished through mixing with surface waters. Dissolved oxygen levels below 5 ppm (and water temperature above 24 °C) can stress and reduce habitat for coldwater fish and other sensitive aquatic organisms. In addition, **anoxia** (dissolved oxygen < 2 ppm) at lake bottom can result in the release of sediment-bound phosphorus (otherwise known as **internal phosphorus loading**), which can become a readily available nutrient source for algae and cyanobacteria. It is important to keep tracking 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 5 shows temperature and dissolved oxygen profiles averaged across sampling dates (2012-2020) during **thermal stratification** in summer (between spring and fall **turnover**) for the three deep spot stations on Lake Winnisquam. The change in temperature, seen most dramatically between 6 and 12 m depth, indicates thermal stratification in the water column at all three sites. Dissolved oxygen levels did not fall below the 5 ppm threshold at the most upstream station, Three Island, indicating good oxygenation throughout the water column. Anoxia was measured at both Pot Island and Mohawk Island deep spots, though only near the very bottom at Pot Island. Mohawk Island deep spot showed dissolved oxygen depleting rapidly below the 5 ppm threshold at 9 m and below the 2 ppm threshold at 16 m.

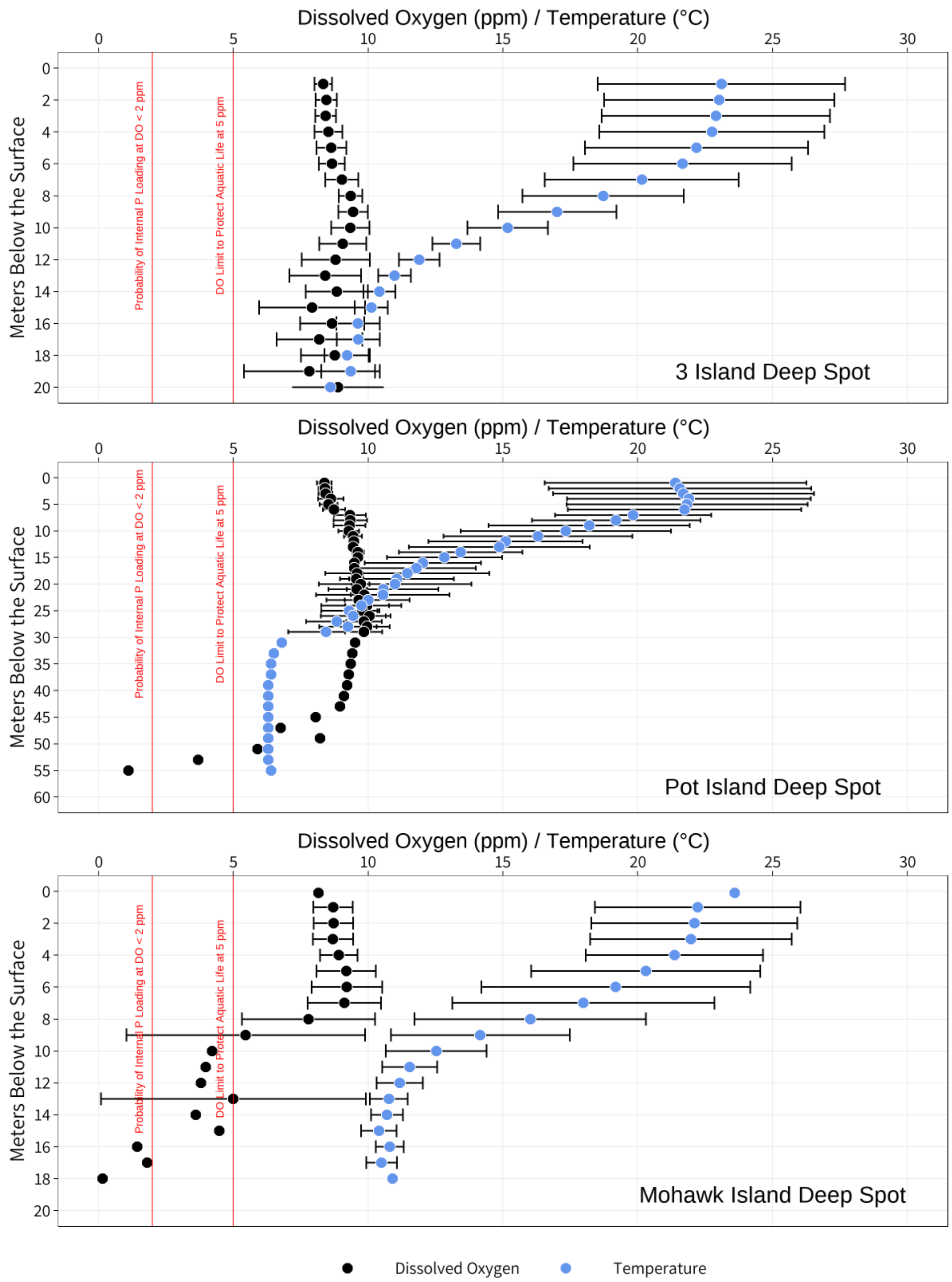


Figure 5. Dissolved oxygen (black) and temperature (blue) depth profiles for three deep spot stations on Lake Winnisquam (ordered from upstream to downstream): Three Island (TOP), Pot Island (MIDDLE), and Mohawk Island (BOTTOM). Profiles were measured once in 2012, 2013, 2016, 2017, and 2018, and twice in 2020 during thermal stratification in summer. Dots represent average values across sampling dates for each respective depth. Error bars represent standard deviation.

2.1.5 Cyanobacteria

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.

Cyanobacteria blooms and their associated toxins have been recorded in the Lake Winnisquam watershed, including Lake Winnisquam, Hunkins Pond, Lake Opechee, and Lake Wicwas (Table 1). Lake Winnisquam has experienced cyanobacteria bloom warnings, which were issued by NHDES in 2008 (28 days) and 2010 (43 days). NHDES issued a cyanobacteria bloom alert on 6/27/22 for the north end of Lake Winnisquam. The bloom appeared as diffuse green clouds or ribbons of material suspended in the water along the shoreline. Cyanobacteria concentrations contained *Dolichospermum* but were below the advisory level and dissipated within a couple days.

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. However, we can substantially minimize conditions favorable for blooms, such as reducing nutrient-rich runoff from the landscape during warm, sunny spells. Regulating water level and flow also helps to either flush out blooms or limit upstream nutrient sources to stymie growth.

Table 1. Cyanobacteria blooms occurring in the Lake Winnisquam watershed since 2006.

Location	Date of Advisory	Number of Advisory Days	Species	Illness Reported	Total Cell Concentration (cells/mL)
HUNKINS POND	7/20/2006	95	*Anabaena*	Unknown	>70,000 or >50%
LAKE WINNISQUAM	6/25/2008	28	Unidentified	Unknown	>70,000 or >50%
LAKE OPECHEE (BOND BEACH)	7/7/2008	37	*Anabaena*	Unknown	>70,000 or >50%
HUNKINS POND	8/21/2008	102	*Anabaena*	Unknown	>70,000 or >50%
LAKE WINNISQUAM (EPHRAIMS COVE)	9/19/2010	43	*Anabaena*	Unknown	58,459
HUNKINS POND	9/5/2014	25	*Anabaena*	Unknown	102,000
LAKE WICWAS	8/9/2018	14	*Anabaena/Dolichospermum*	Unknown	119,000
HUNKINS POND	6/26/2019	34	*Anabaena/Dolichospermum*	Unknown	611,000
HUNKINS POND	8/9/2019	19	*Anabaena/Dolichospermum*	Unknown	165,000
LAKE WICWAS	8/21/2019	6	*Anabaena/Dolichospermum*	Unknown	446,675
LAKE WINNISQUAM	6/27/2022	Alert Only	*Dolichospermum*	Unknown	<70,000
LAKE OPECHEE	6/27/2022	5	*Dolichospermum*	Unknown	73,133

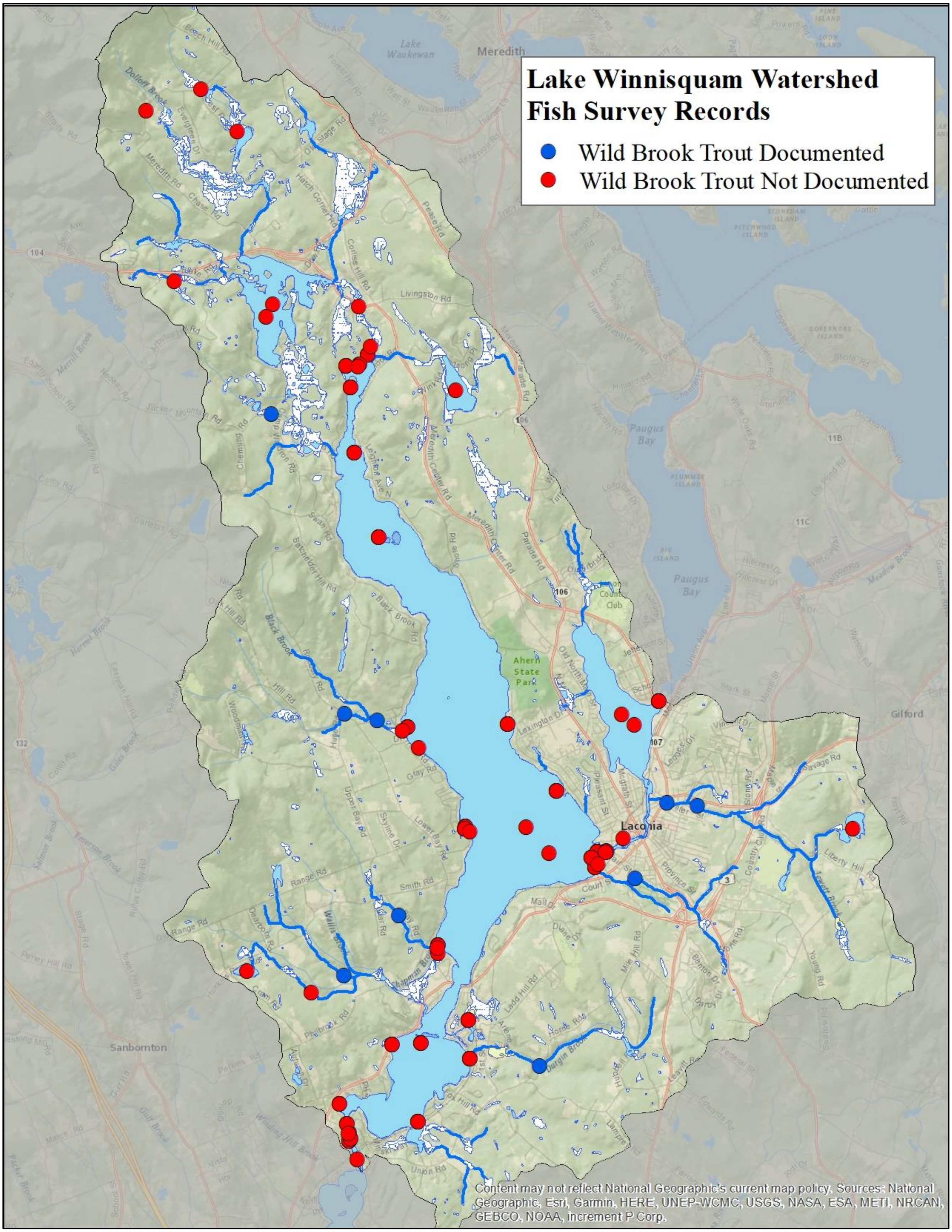


Figure 6. Map of documented wild brook trout occurrences. Courtesy of Trout Unlimited.

2.1.6 Fish

Fish are an important natural resource for sustainable ecosystem food webs and provide recreational opportunities. Lake Winnisquam supports a thriving population of both cold and warm water species including but not limited to rainbow trout, land locked salmon, lake trout, small and large mouth bass, eastern chain pickerel, brown bullhead, white perch, black crappie, bluegill, rock bass, burbot, and American eel. A map of documented wild brook trout occurrences is shown in Figure 6. Fish species of concern include river herring (whose population is stocked by the New Hampshire Fish and Game Department, NHFGD) in the Winnipesaukee River, as well as brown trout in Black Brook, Chapman Brook, Jewett Brook, and Durgin Brook. Historically, the Lake Winnisquam watershed hosted an abundant rainbow smelt population that spawned in the tributaries. Land use changes and sedimentation have since buried the cobble/gravel substrate needed to support egg incubation in fish spawning areas. Each year, about 20,000 migrating adult herring and alewives are trapped at dams in Massachusetts and transported to Lake Winnisquam where the adults spawn. At one time, Black Brook also supported a commercial alewife fishery.

2.1.7 Invasive Aquatic Species

The introduction of non-indigenous invasive aquatic plant species to New Hampshire's waterbodies has been on the rise. These invasive aquatic plants are responsible for habitat disruption, loss of native plant and animal communities, reduced property values, impaired fishing and degraded recreational experiences, and high removal costs. Once established, invasive species are difficult and costly to remove.

Variable milfoil (*Myriophyllum heterophyllum*) was first established in Lake Winnisquam around 1995 and was only managed sporadically in a few areas until 2018 when WWN began actively managing milfoil and other invasive aquatic species through several programs, including the NH Lakes' Lake Host Program, the NHDES Weed Watcher Program, and WWN's Milfoil Management Program. Through the Lake Host Program, which WWN operates in cooperation with NH Lakes, trained Lake Hosts inspect boats and trailers both entering and exiting Lake Winnisquam for invasive aquatic plants to prevent their spread. The Weed Watcher Program uses trained volunteers to survey the near-shore areas of the lake for any invasive aquatic plants. These survey efforts have identified previously unknown infestation areas that have since been eradicated. WWN established the Milfoil Control Program for Lake Winnisquam in 2018 with funding from NHDES, local matches from the municipalities of Meredith, Belmont, Tilton, Sanbornton, and Laconia, and donations from neighborhood associations and WWN members. Under the leadership of WWN, milfoil management, including diver-assisted harvesting and herbicide treatments, is done comprehensively lake-wide and according to a *Long-Term Variable Milfoil Management Plan* first created by NHDES in 2017 (with annual updates since) for Lake Winnisquam (NHDES, 2020). These survey efforts have identified previously unknown infestation areas that have since been eradicated, treated with herbicide, or removed by divers and monitored to detect any regrowth. At the end of the 2021 season, no milfoil was detected in Lake Winnisquam, which was declared milfoil-free. Although milfoil will likely return in future years, the eradication monitoring efforts (Weed Watcher, Lake Host) by WWN and volunteers followed by treatment of any infestation has proven to be effective and will continue each year.

Invasive Chinese mystery snails have also been recorded in Lake Winnisquam, but populations are low and are not actively managed by any group.

2.2 ASSIMILATIVE CAPACITY

The assimilative capacity of a waterbody describes the amount of pollutant that can be added to a waterbody without causing a violation of the water quality criteria. For oligotrophic waterbodies such as Lake Winnisquam and Lake Opechee, the water quality criteria are set at 8 ppb for total phosphorus and 3.3 ppb for chlorophyll-a (Table 2). Each trophic state has a certain phytoplankton biomass (chlorophyll-a) that represents a balanced, integrated, and adaptive community. Exceedances of the chlorophyll-a criterion suggests that the algal community is out of balance. Since phosphorus is the primary limiting nutrient for growth of freshwater algae (chlorophyll-a), phosphorus is included in this assessment process. 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. For mesotrophic waterbodies such as Lake Wicwas, the water quality criteria are set at 12 ppb for total phosphorus and 5 ppb for chlorophyll-a (Table 2). The 10% reserve assimilative capacity for mesotrophic lakes is set at 11.6 ppb for total phosphorus and 4.8 ppb for chlorophyll-a. Chlorophyll-a will dictate the final assessment if both chlorophyll-a and total phosphorus data are available and the assessments differ (Table 3).

Results of the assimilative capacity analysis showed that Lake Winnisquam, Lake Wicwas, and Lake Opechee are classified as Tier 2 high quality waters for their respective trophic class designations (Table 4). Tier 2 waters have one or more water quality parameters that are better than the water quality standard and that also exhibit a reserve capacity of at least 10% of the waterbody's total assimilative capacity.

Table 2. 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 3. 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 4. Assimilative capacity (AC) analysis results for Lake Winnisquam, Lake Wicwas, and Lake Opechee. Chlorophyll-a dictates the assessment results. Water quality data summarized from NHDES Environmental Monitoring Database (EMD) and applied to state water quality standards described in NHDES (2022).

Parameter	AC Threshold (ppb)	Existing Mean WQ (ppb)*	Remaining AC (ppb)	Assessment Results
Lake Winnisquam - Three Island Deep Spot [WINTLACD]				
Total Phosphorus	7.2	7.2	+0.0	Tier 2 (High Quality)
Chlorophyll-a	3.0	1.9	+1.1	
Lake Winnisquam – Pot Island Deep Spot [WINPLACD]				
Total Phosphorus	7.2	7.5	-0.3	Tier 2 (High Quality)
Chlorophyll-a	3.0	1.7	+1.3	
Lake Winnisquam – Mohawk Island Deep Spot [WINMBELD]				
Total Phosphorus	7.2	6.7	+0.5	Tier 2 (High Quality)
Chlorophyll-a	3.0	1.5	+1.5	
Lake Winnisquam - Aggregate Deep Spot Sites				
Total Phosphorus	7.2	7.1	+0.1	Tier 2 (High Quality)
Chlorophyll-a	3.0	1.7	+1.3	
Lake Wicwas – Deep Spot [WICMERD]				
Total Phosphorus	11.6	7.5	+4.1	Tier 2 (High Quality)
Chlorophyll-a	4.8	4.0	+0.8	
Lake Opechee – Lakeport, Winnipesaukee River Downstream of Dam [WIN-LP-2]				
Total Phosphorus	7.2	6.3	+0.9	Tier 2 (High Quality)
Chlorophyll-a	3.0	1.3	+1.7	

** Existing water quality data truncated to May 24-Sept 15 (though a few mid to late September samples were kept if thermal stratification was still evident) in the previous 10 years (2011-2020) for composite, epilimnion, or upper samples (in order of priority on a given day). Data were summarized by day, then month, then year using mean statistic.*

2.3 WATERSHED MODELING

2.3.1 Lake Loading Response Model (LLRM)

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

The LLRM is an Excel-based model that uses environmental data to develop a water and phosphorus loading budget for lakes and their tributaries (AECOM, 2009). Water and phosphorus loads (in the form of mass and concentration) are traced from various sources in the watershed through tributary basins and into the lake. The model incorporates data about watershed and sub-watershed boundaries, land cover, point sources (if applicable), septic systems, waterfowl, rainfall, volume and surface area, and internal phosphorus loading. These data are combined with coefficients, attenuation factors, and equations from scientific literature on lakes, rivers, and nutrient cycles to generate annual average predictions[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 Lake Winnisquam LLRM is provided in the *Lake Winnisquam Lake Loading Response Model Report* (FBE, 2021a).

2.3.1.1 Lake Morphometry & 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 Lake Winnisquam is 4,249 acres (28 miles of shoreline) with a maximum depth of 174 feet (53 m) and volume of 278,744,376 m^3. The **areal water load** is 111 ft/yr (33.7 m/yr), and the flushing rate is 2.1 times per year. The relatively high flushing rate of 2.1 means that the entire volume of Lake Winnisquam is replaced twice per year, allowing less time for pollutants to settle in lake bottom sediments or be taken up by biota.

There are multiple dams in the watershed controlling water flow, including: (1) Lake Wicwas Dam at the lake outlet on Mill Brook; (2) Winnipesaukee Lakeport Dam on the Winnipesaukee River between Paugus Bay and Lake Opechee; (3) Lake Opechee Avery Dam on the Winnipesaukee River between Lake Opechee and Lake Winnisquam; (4) Holding Pond Dam on Hunt Brook between Hunkins Pond and Lake Winnisquam (in the Chapman Brook drainage); and (5) Lochmere Dam at outlet from Lake Winnisquam.

2.3.1.2 Land Cover

Characterizing land cover within a watershed on a spatial scale can highlight potential sources of NPS pollution that would otherwise go unnoticed in a field survey of the watershed. For instance, a watershed with large areas of developed land 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 Lake Winnisquam watershed was determined by FBE and the LRPC, using a combination of the 2001 New Hampshire Landcover Database (NHLCD), ESRI World Imagery from March 27, 2020, and Google Earth satellite imagery from July 7, 2019. For more details on methodology, see the *Lake Winnisquam Lake Loading Response Model Report* (FBE, 2021a). Final land cover is shown in Appendix B, Map B-1.

The direct Lake Winnisquam watershed (not including the Lake Winnipesaukee and Paugus Bay watersheds) is 35,648 acres, not including the lake areas of Lake Wicwas, Lake Opechee, and Lake Winnisquam. Development accounts for 29% (10,392

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

acres) of the watershed, while forested and natural areas account for 67% (23,703 acres). Wetlands and open water represent 1% (361 acres) of the watershed (Figure 7). Agriculture represents 3% (1,191 acres). Figure 7 shows a breakdown of land cover by major category for the entire watershed (not including lake area), as well as total phosphorus load by major land cover category (refer to Section 2.3.1.4 or FBE, 2021a for details on methodology). Developed areas cover 29% of the watershed and contribute 84% of the total phosphorus watershed load to Lake Winnisquam.

Developed areas within the Lake Winnisquam watershed are characterized by **impervious surfaces**, including areas with asphalt, concrete, compacted 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.

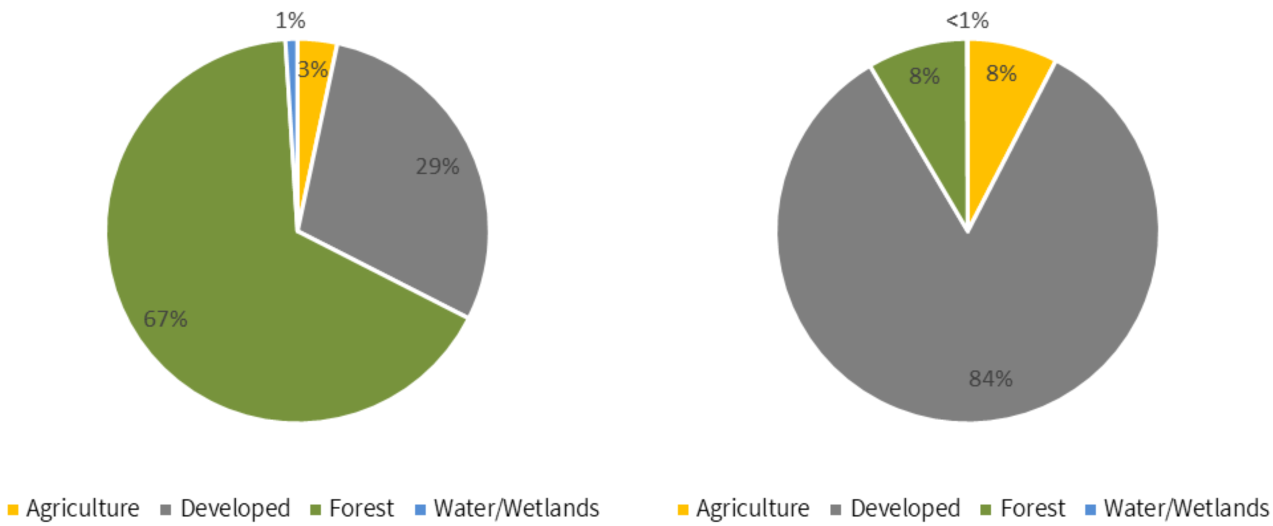


Figure 7. Lake Winnisquam watershed (including Lake Wicwas and Lake Opechee but not including Lake Winnipesaukee) land cover area by general category (agriculture, developed, forest, and water/wetlands) and total phosphorus (TP) watershed load by general land cover type. This shows that developed areas cover 29% of the watershed and contribute 84% of the TP watershed load to Lake Winnisquam. Water/wetlands category does not include the lake areas.

2.3.1.3 Internal Phosphorus Loading

Phosphorus that enters the lake and settles to the bottom can be re-released from sediment under anoxic conditions, providing a nutrient source for algae, cyanobacteria, and plants. Internal phosphorus loading can also result from wind-driven wave action or physical disturbance of the sediment (boat props, aquatic macrophyte management activities). Internal loading estimates were derived from dissolved oxygen and temperature profiles taken at the deep spots of Lake Winnisquam and Lake Wicwas from 2011-2020 (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 Lake Winnisquam and Lake Wicwas from 2011-2020 (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. There were insufficient data to determine whether there is a significant internal phosphorus load to Lake Opechee.

2.3.1.4 LLRM Results

Overall, model predictions were in good agreement with observed data for total phosphorus, chlorophyll-a, and Secchi disk transparency (Table 5). 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.

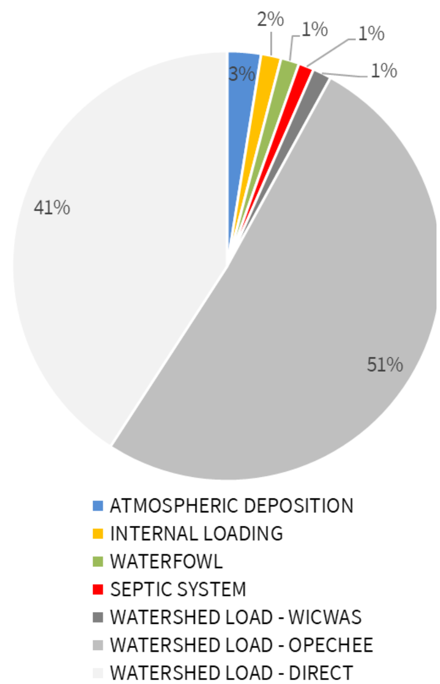


Figure 8. Summary of total phosphorus loading by major source for Lake Winnisquam. Refer to Table 6 for a breakdown.

Watershed runoff combined with baseflow (93%) was the largest phosphorus loading contribution across all sources to Lake Winnisquam. The watershed load (93%) includes the watershed loads from Lake Wicwas (1%), Lake Opechee and thus Lake Winnipesaukee via Paugus Bay (51%), and the direct land area to Lake Winnisquam (41%) (Figure 8, Table 6). Atmospheric deposition (3%), internal loading (2%), waterfowl (1%), and septic systems (1%) were relatively minor sources. Development in the watershed is most concentrated around the shoreline where septic systems or holding tanks are located within a short distance to the water, leaving little horizontal (and sometimes vertical) space for proper filtration of wastewater effluent. Improper maintenance or siting of these systems can cause failures, which leach untreated, nutrient-rich wastewater effluent to the lake. Nearly half of the shoreline area of Lake Winnisquam is serviced by sewer systems, which also represent a potential vulnerability if the sewer systems are old or damaged and leaking wastewater into groundwater near the lake. Note that septic systems are a relatively minor load to Lake Winnisquam because 1) the estimate is only for those systems directly along the shoreline and potentially short-circuiting minimally treated effluent to the lake and 2) much of the shoreline area is serviced by sewer which is not accounted for in the model since the assumption is that the sewer lines are not leaking. The load from septic systems throughout the rest of the watershed is inherent to the coefficients used to generate the watershed load.

Internal loading is currently a relatively minor source of phosphorus to Lake Winnisquam; however, locally significant internal phosphorus loading is occurring in the Mohawk Island basin area and should be monitored closely, especially given that cyanobacteria bloom warnings were issued for Lake Winnisquam in 2008 (28 days) and 2010 (43 days) with a brief alert issued in June 2022. Internal loading is currently a significant source of phosphorus (23%) to Lake Wicwas and may be driving recent cyanobacteria (*Dolichospermum*) bloom warnings issued by NHDES in August 2018 (14 days) and 2019 (6 days). (Note: The Lake Wicwas model estimated an average annual bloom probability of nine days at chlorophyll-a > 8 ppb and two days at chlorophyll-a > 10 ppb.) The 2009 NHDES Lake Trophic Survey Report for Lake Wicwas noted that zooplankton abundance was low which might otherwise help to keep phytoplankton at bay, depending on the palatability of dominant cyanobacteria species. Lake Wicwas is also highly colored (>30 CPU), which may help to block light at depth and limit phytoplankton growth. However, anecdotal information from the Lake Wicwas Association indicates that the lake may be becoming clearer in recent years and thus the 2009 color data may be outdated. The Lake Wicwas Association also noted that the lake is relatively shallow with legacy loading from an old sawmill that was decommissioned around 1950 and from log sinking to protect the logs from insects following the 1938 hurricane (5-10 logs continue to float to the surface each year). There were insufficient data to assess whether internal loading is occurring in Lake Opechee. There was evidence of low oxygen (at 13 m and deeper) and elevated hypolimnetic total phosphorus concentrations (at 15 m) in the 1979, 1986, and 1999 NHDES Trophic Survey Reports; thus, there is likely some internal loading occurring, but there were insufficient data to support an estimation for internal loading. Cyanobacteria bloom warnings were issued for Lake Opechee in 2008 (37 days) for *Anabaena* at Bond Beach and lake-wide in June 2022 (5 days) for *Dolichospermum*.

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., the southern portion of the watershed around Laconia; Figure 9). Drainage areas directly adjacent to waterbodies have direct connection to the lakes and are usually targeted for development, thus increasing the possibility for phosphorus export.

As part of the 2012 *Black Brook Watershed Management Plan* (AECOM, 2012), a portion of Lake Winnisquam was modeled (excluded most downstream Mohawk Island basin). The 2012 model outputs generally agreed well with 2020 model outputs when accounting for the differences in lake area modeled, annual precipitation, atmospheric deposition coefficient used, waterfowl estimates or lack thereof, and attenuation assumptions. The 2020 model assumed default water and phosphorus attenuation for longer stream networks such as Black Brook. The 2012 model assumed higher attenuation factors (more water and phosphorus passed through) due to relatively steep, shallow, moderate- to poorly-drained soils in the watershed, which accounted for the difference in total water and phosphorus load output from Black Brook between the two models.

Once the model is calibrated for current in-lake phosphorus concentration, we can then manipulate land cover and other factor loadings to estimate pre-development loading scenarios (e.g., what in-lake phosphorus concentration was prior to human development or the best possible water quality for the lake). Refer to FBE (2021a) for details on methodology. Pre-development loading estimation showed that total phosphorus loading to Lake Winnisquam increased by 438%, from 1,385 kg/yr prior to European settlement to 7,458 kg/yr under current conditions (Table 6). These additional phosphorus sources are coming from development in the watershed (especially from Lake Winnipesaukee, the direct shoreline of Lake Winnisquam, the direct shoreline of Lake Opechee, Durkee Brook, and Jewett Brook), septic systems, atmospheric dust, and internal loading (Table 6). Water quality prior to settlement was predicted to be excellent with extremely low phosphorus and chlorophyll-a concentrations and high water clarity (Table 5).

We can also manipulate land cover and other factors to estimate future loading scenarios (e.g., what in-lake phosphorus concentration might be at **full build-out** under current zoning constraints or the worst possible water quality for the lake). Refer to FBE (2021a) and the 2021 *Lake Winnisquam Direct Watershed Build-out Analysis Report* (FBE, 2021b) 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 Lake Winnisquam may increase by 54%, from 7,455 kg/yr under current conditions to 11,492 kg/yr at full build-out (2076) under current zoning for Lake Winnisquam (Table 6). Additional phosphorus will be generated from more development in the watershed (especially from Lake Winnipesaukee, the direct shoreline of Lake Winnisquam, Dolloff Brook[3], and Jewett Brook), greater atmospheric dust, more septic systems, and enhanced internal loading (Table 6). The total phosphorus load coming from the direct Winnipesaukee River sub-watershed (excluding input from Lake Winnipesaukee) showed minimal change because the small sub-watershed in Laconia is already largely built-out. The model predicted higher (worse) phosphorus (12.9 ppb), higher (worse) chlorophyll-a (3.6 ppb), and lower (worse) water clarity (3.3 m) compared to current conditions for Lake Winnisquam (Table 5). Predicted water quality was especially poor for Lake Wicwas, which would exhibit characteristics of a hypereutrophic lake that blooms throughout much of the year (267 days; Table 5). Even if the internal phosphorus load to Lake Wicwas were eliminated (either via an in-lake treatment or assuming the build-out assumptions are overestimating the predicted increase in total phosphorus load to the lake), Lake Wicwas would still experience severely degraded water quality and be classified as a eutrophic lake.

[3] Note that the predicted increase in total phosphorus load from Dolloff Brook may be overestimated due to build-out assumptions. The build-out analysis for the portion of the Lake Winnisquam watershed in the Town of New Hampton (which feeds into Dolloff Brook and ultimately Lake Wicwas) did not account for New Hampton's complex zoning standards that adjust the allowable lot size based on soil drainage class and slope, along with a more nuanced "adjustment factor" for other considerations such as water supply and sewage disposal. Some of these standards were accounted for in areas with hydric soils and steep slopes but not for the complex graduations of other soil and slope types. It is likely that accounting for this complex zoning would reduce the number of projected buildings in the New Hampton portion of the study area and thus reduce the estimated phosphorus load increase to Lake Wicwas; the significance of that reduction is unknown. Additionally, a 139-acre parcel along Dolloff Brook in New Hampton was recently put into conservation (and not accounted for in the build-out analysis), which would further reduce the number of projected buildings.

Table 5. In-lake water quality predictions for Lake Wicwas, Lake Opechee, and Lake Winnisquam. TP = total phosphorus. Chl-a = chlorophyll-a. SDT = Secchi disk transparency. Bloom Days represent average annual probability of chlorophyll-a exceeding 10 ppb. Refer to FBE (2021a).

Model Scenario	Median TP (ppb)	Predicted Median TP (ppb)	Mean Chl-a (ppb)	Predicted Mean Chl-a (ppb)	Mean SDT (m)	Predicted Mean SDT (m)	Bloom Days
Lake Wicwas							
Pre-Development	--	2.4	--	0.3	--	11.9**	0
Current -2020	9.6 (11.5)	12.1	4.0	3.3	4.2	3.4	2
Future (2076)	--	35.9	--	15.4	--	1.5	267
Lake Opechee							
Pre-Development	--	1.6	--	0.2	--	16.3**	0
Current -2020	6.3 (7.5)	7.8	1.3	1.6	--	4.8	0
Future (2076)	--	11.8	--	3.1	--	3.5	2
Lake Winnisquam							
Pre-Development	--	1.5	--	0.2	--	16.4	0
Current -2020	7.1 (8.5)	8.3	1.7	1.8	7.1	4.5	0
Future (2076)	--	12.9	--	3.6	--	3.3	4

**Mean TP concentration (first value) represents current in-lake epilimnion TP from observed data. Median TP concentration (second value in parentheses) represents 20% greater than the observed mean value as the value used to calibrate the model. Most lake data are collected in summer when TP concentrations are typically lower than annual average concentrations for which the model predicts. It was argued in the 2012 Black Brook Watershed Management Plan that the "average summer concentrations are likely representative of annual average or average at spring overturn values" given the large and continuous load of phosphorus and water from the Winnipesaukee River. April 2021 data collected at the three lake deep spots confirm minimal difference in average total water column phosphorus with average summer epilimnion phosphorus. However, for this model, our modeled lake area included the Mohawk Island basin and its contributing sources, slightly lessening the total load percent contribution from the Winnipesaukee River; in addition, the load contribution from the Winnipesaukee River flows through two large lakes (Paugus Bay and Lake Opechee) and may elevate phosphorus concentrations in winter. More winter data would be needed to confirm.*

***Hit Bottom*

Table 6. Total phosphorus (TP) and water loading summary by model and source for Lake Winnisquam. Italicized sources sum to the watershed load. Refer to FBE (2021a).

SOURCE	PRE-DEVELOPMENT			CURRENT (2020)			FUTURE (2076)		
	TP (KG/YR)	%	WATER (CU.M/YR)	TP (KG/YR)	%	WATER (CU.M/YR)	TP (KG/YR)	%	WATER (CU.M/YR)
LAKE WICWAS									
ATMOSPHERIC	9.9	15%	897,352	15.6	5%	897,352	35.3	3%	897,352
INTERNAL	0.0	0%	0	78.8	23%	0	228.6	23%	0
WATERFOWL	8.5	13%	0	8.5	2%	0	8.5	1%	0
SEPTIC SYSTEM	0.0	0%	0	6.2	2%	5,243	9.3	1%	7,865
WATERSHED LOAD	48.6	72%	10,435,330	232.2	68%	10,318,434	713.7	72%	9,995,418
TOTAL LOAD TO LAKE	**66.9**	**100%**	**11,332,682**	**341.2**	**100%**	**11,221,029**	**995.4**	**100%**	**10,900,635**
LAKE OPECHEE									
ATMOSPHERIC	12.1	1.4%	1,095,975	19.0	0.4%	1,095,975	43.2	0.7%	1,095,975
INTERNAL	0.0	0.0%	0	0.0	0.0%	0	0.0	0.0%	0
WATERFOWL	10.4	1.2%	0	10.4	0.2%	0	10.4	0.2%	0
SEPTIC SYSTEM	0.0	0.0%	0	9.7	0.2%	8,128	14.2	0.2%	11,910
WATERSHED LOAD	825.3	97.4%	488,213,857	4,216.3	99.2%	487,954,357	6,340.4	98.9%	487,855,167
Paugus Bay-Lake Winnipesaukee	*799.1*	*94.3%*	*482,712,903*	*3,817.9*	*89.8%*	*482,712,903*	*5,792.6*	*91.2%*	*482,712,903*
Direct Land Use Load	*26.2*	*3.1%*	*5,500,954*	*398.4*	*9.4%*	*5,241,454*	*547.8*	*7.8%*	*5,142,264*
TOTAL LOAD TO LAKE	**847.7**	**100%**	**489,309,833**	**4,255.4**	**100%**	**489,058,460**	**6,408.2**	**100%**	**488,963,052**
LAKE WINNISQUAM									
ATMOSPHERIC	120.4	9%	10,913,507	189.1	3%	10,913,507	429.9	3%	10,913,507
INTERNAL	0.0	0%	0	112.7	2%	0	173.6	2%	0
WATERFOWL	103.2	7%	0	103.2	1%	0	103.2	1%	0
SEPTIC SYSTEM	0.0	0%	0	86.3	1%	71,094	98.5	1%	81,089
WATERSHED LOAD	1,161.9	84%	570,577,547	6,963.8	93%	568,655,087	10,686.7	93%	567,266,589
Lake Wicwas	*20.4*	*1%*	*9,066,146*	*101.8*	*1%*	*8,976,823*	*293.5*	*3%*	*8,720,508*
Lake Opechee	*782.9*	*57%*	*489,309,833*	*3,814.7*	*51%*	*489,058,460*	*5,769.8*	*50%*	*488,963,052*
Direct Land Use Load	*358.6*	*26%*	*72,201,569*	*3,047.3*	*41%*	*70,619,804*	*4,623.4*	*40%*	*69,583,029*
TOTAL LOAD TO LAKE	**1,385.4**	**100%**	**581,491,054**	**7,455.2**	**100%**	**579,639,688**	**11,491.8**	**100%**	**578,261,186**

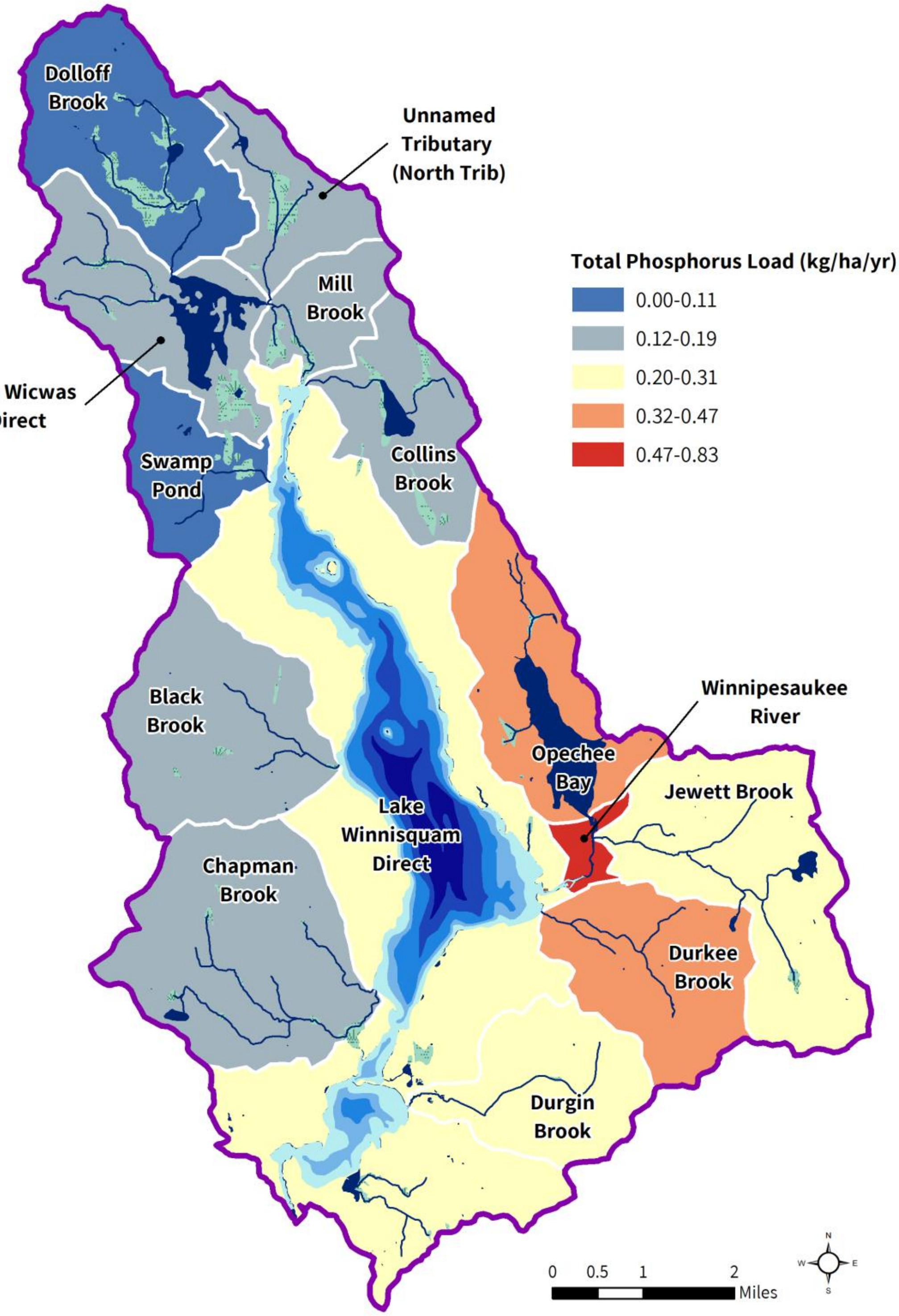


Figure 9. Map of current total phosphorus load per unit area (kg/ha/yr) for each sub-watershed in the Lake Winnisquam watershed. Higher phosphorus loads per unit area are concentrated in the more developed southern portion of the watershed. Refer to FBE (2021a).

2.3.2 Build-out Analysis

A full build-out analysis was completed for the direct Lake Winnisquam watershed for the municipalities of Belmont, Gilford, Laconia, Meredith, New Hampton, Sanbornton, and Tilton (FBE, 2021b). 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 extent permitted by local ordinances and zoning standards. Local ordinances and zoning standards are subject to change and the analysis requires simplifying assumptions and therefore the results of the build-out analysis should be viewed as planning-level estimates only for potential future outcomes from development trends. For example, current use (which lowers tax obligations on 10-acre or more parcels kept in a natural state) can be a deterrent to development because of the tax burden when parcels are removed from current use status.

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 extent permitted by local ordinances and 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 B, Map B-2). Existing buildings also reduce the capacity for new development.

Under current zoning regulations, 45% (15,027 acres) of the direct Lake Winnisquam watershed is buildable (Appendix B, Map B-3). The greatest acreages of land available for development include the Forestry and Rural District of Meredith (1,822 acres), the Forest Conservation Zone of Sanbornton (1,807 acres), and the Residential Rural Zone of Laconia (1,576 acres). New Hampton’s General Residential zone and Laconia’s Commercial zone are the most vulnerable to increased development potential with the highest percent increase from existing buildings to projected buildings at 2,461% and 1,500%, respectively (Table 7). FBE identified 8,456 existing buildings within the watershed, and the build-out analysis projected that an additional 6,734 buildings could be constructed in the future, resulting in a total of 15,190 buildings in the watershed (Appendix B, Map B-4). Currently, existing buildings are the densest along the shores of the lakes, as well as in Laconia. Major conservation lands in the watershed restrict existing and future development in rural areas of the watershed.

Table 7. Amount of buildable land and projected buildings by zone in the direct Lake Winnisquam watershed in Belmont, Gilford, Laconia, Meredith, New Hampton, Sanbornton, and Tilton, New Hampshire.

Zone	Total Area (Acres)	Buildable Area (Acres)	Percent Buildable Area	No. Existing Buildings	No. Projected Buildings	Total No. Buildings	Percent Increase
Belmont							
Commercial	653	248	38	136	88	224	65
Residential - Multi Family	113	22	19	53	10	63	19
Residential - Single Family	2,040	939	46	836	541	1,377	65
Rural	2,647	1,413	53	524	289	813	55
Gilford							
Industrial	119	42	35	15	20	35	133
Limited Residential	1,781	1,001	56	197	601	798	305
Natural Resource Residential	825	256	31	78	80	158	103
Professional Commercial	70	41	60	21	18	39	86
Single Family Residential	561	204	36	325	118	443	36
Laconia							
Commercial	164	113	69	5	75	80	1,500
Industrial	103	76	74	16	90	106	563
Industrial Park	129	86	67	19	20	39	105
Residential Apartment	157	136	87	70	117	187	167
Residential Rural	3,500	1,576	45	574	444	1,018	77
Residential Single-Family District	2,101	479	23	3,030	193	3,223	6
Urban Commercial District	428	257	60	651	738	1,389	113
Meredith							
Business Industrial District	14	5	37	7	3	10	43
Commercial District - Center	33	7	23	19	6	25	32
Forestry and Conservation	1,452	217	15	81	35	116	43
Forestry and Rural District	4,401	1,822	41	341	390	731	114
Residential District	1,133	605	53	186	337	523	181
Shoreline District	1,244	165	13	217	116	333	53
New Hampton							
General Residential	2,178	1,143	52	57	1,403*	1,460	2,461
Sanbornton							
Commercial (Lt. Manuf. Perm.)	123	45	36	60	57	117	95
Forest Conservation	3,563	1,807	51	121	204	325	169
General Agricultural	1,921	1,150	60	111	253	364	228
General Residence	1,141	720	63	180	246	426	137
Recreational	208	100	48	249	136	385	55
Tilton							
Medium Density Residential District	7	2	27	2	2	4	100
Mixed Use District	26	1	2	40	1	41	3
Resort Commercial	419	174	42	210	70	280	33
Rural Agricultural	303	173	57	25	33	58	132
Total	**33,555**	**15,027**	**45**	**8,456**	**6,734**	**15,190**	**80**

** Note on New Hampton's number of projected buildings: It is likely that accounting for New Hampton's complex zoning that adjusts allowable lot size based on soil drainage class and slope would reduce the number of projected buildings in the New Hampton portion of the study area; the significance of that reduction is unknown. Additionally, a 139-acre parcel along Dolloff Brook in New Hampton was recently put into conservation, which would further reduce the number of projected buildings.*

Three iterations of the TimeScope Analysis were run using compound annual growth rates (CAGR) for 20-, 30- and 50-year periods from 1990-2010 (1.09%), 1980-2010 (1.65%), and 1960-2010 (2.61%), respectively (Table 8). Full build-out is projected to occur in 2076 at the 20-year CAGR, 2057 at the 30-year CAGR, and 2044 for the 50-year CAGR (Figure 10). Note that the growth rates used in the TimeScope Analysis are based on town- or city-wide census statistics but have been applied here to a portion of the municipalities. Also note that the population growth rate in these municipalities is decreasing, so the 20-year estimate is likely more accurate than the 50-year estimate. Using census data to project population increase and/or development has inherent limitations. For instance, the building rate may increase at a different rate than population such as when considering commercial versus residential 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 8. Compound annual growth rates for the seven municipalities within the direct watershed of Lake Winnisquam, used for the TimeScope Analysis. 2020 data were not available for towns with populations less than 5,000 at the writing of this plan. Data from US Census Bureau.

	Compound Annual Growth Rate		
Municipality	**50 yr. Avg. 1960-2010**	**30 yr. Avg. 1980-2010**	**20 yr. Avg. 1990-2010**
Belmont	2.69%	2.03%	1.20%
Gilford	2.53%	1.30%	0.98%
Laconia	0.08%	0.08%	0.07%
Meredith	1.90%	0.99%	1.28%
New Hampton	1.86%	1.85%	1.50%
Sanbornton	2.51%	1.91%	1.65%
Tilton	1.03%	0.17%	0.48%
Combined	**2.61%**	**1.65%**	**1.09%**

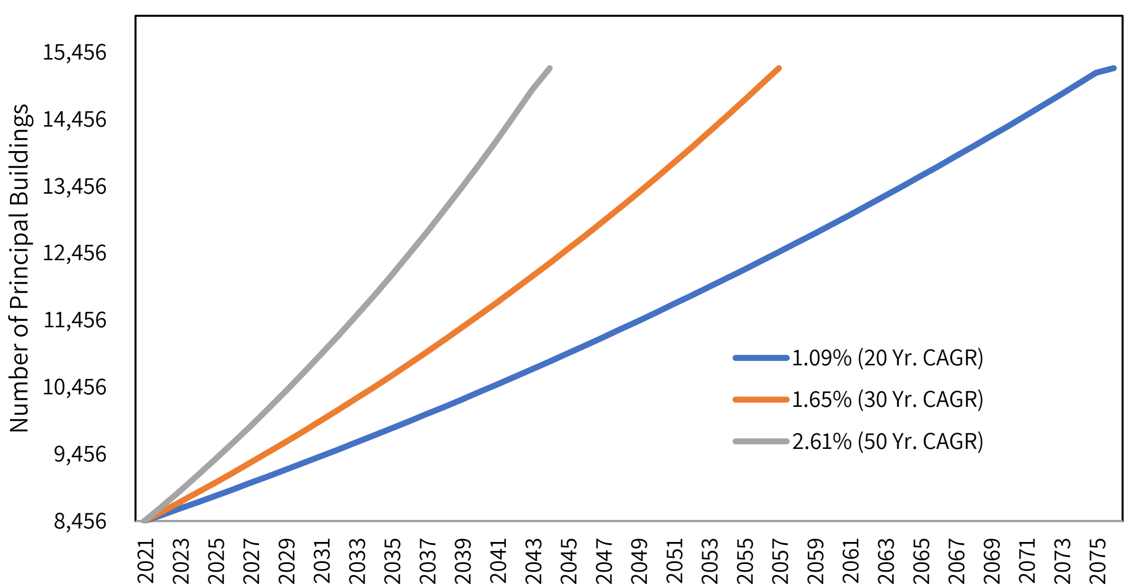


Figure 10. Full build-out time projections for the direct Lake Winnisquam watershed in Belmont, Gilford, Laconia, Meredith, New Hampton, Sanbornton, and Tilton, New Hampshire (based on compound annual growth rates reported in Table 8).

2.4 WATER QUALITY GOAL & OBJECTIVES

The model results revealed changes in total phosphorus loading and in-lake total phosphorus concentrations over time from pre-development through future conditions, showing that the water quality of Lake Winnisquam, Lake Wicwas, and Lake Opechee is threatened by current development activities in the watershed and will degrade further with continued development in the future. We can use these results to make informed management decisions and set an appropriate water quality goal for Lake Winnisquam, as well as Lake Wicwas and Lake Opechee. In-lake chlorophyll-a and total phosphorus concentrations are currently meeting state water quality criteria which would indicate that there is reserve capacity for the lakes to assimilate additional nutrients under a "business as usual" scenario. However, it is highly recommended that strong objectives be established to protect the water quality of these lakes over the long term, especially given that these lakes are not meeting other water quality criteria (e.g., turbidity, dissolved oxygen), are experiencing occasional cyanobacteria blooms, and are threatened by new development. The water quality goal and objectives were set by the Plan Development Committee with guidance from FBE.

The overarching goal of the Lake Winnisquam WBP is to improve the water quality of Lake Winnisquam such that it meets state water quality standards for the protection of ALI. This goal will be achieved by accomplishing the following objectives. Specific action items to achieve these objectives are provided in the Action Plan (Section 5). Refer to Section 5.2: Pollutant Load Reductions for more details on linking the established water quality objectives and needed pollutant load reductions with field-identified remediation opportunities.

- OBJECTIVE 1: Reduce pollutant loading from Hueber Brook to improve in-stream and in-lake turbidity concentration to <10 NTU. The drainage area of Hueber Brook is small and thus the possible pollutant sources from Hueber Brook are few. An investigation by FBE of the Hueber Brook sub-watershed was completed and identified sources of sedimentation to remediate. Meeting this objective will remove Lake Winnisquam's impaired listing for ALI due to excessive turbidity.

- OBJECTIVE 2: Mitigate (prevent or offset) phosphorus loading from future development in the direct watersheds to Lake Winnisquam, Lake Wicwas, and Lake Opechee to maintain in-lake total phosphorus concentration. The estimated total phosphorus direct watershed load increase from new development by 2076 was predicted at 1,576 kg/yr for Lake Winnisquam, 654 kg/yr for Lake Wicwas, and 149 kg/yr for Lake Opechee, equating to about 281 kg/yr, 117 kg/yr, and 27 kg/yr, respectively, in the next 10 years (by 2031). At a minimum, pollutant loading should be prevented or offset by 281 kg/yr, 117 kg/yr, and 27 kg/yr from the direct watershed areas to Lake Winnisquam, Lake Wicwas, and Lake Opechee, respectively, by 2031.

  Note: Objective 2 does not account for the additional load expected from Lake Winnipesaukee by 2031 given that the scope of management strategies for this plan is limited to the direct watershed of Lake Winnisquam. Other plans and management strategies are currently being implemented for the Lake Winnipesaukee watershed that will likely result in a lower-than-predicted increase in the total phosphorus load from Lake Winnipesaukee. Assuming an estimated increase of 314 kg/yr in the total phosphorus load from Lake Winnipesaukee via Lake Opechee to Lake Winnisquam in the next 10 years, the in-lake total phosphorus concentration for Lake Winnisquam may increase by 0.5 ppb, placing it within the 10% reserve assimilative capacity range. Because Lake Winnisquam is currently not impaired for ALI due to either of the trophic indicators, we recommend that this objective be re-evaluated after 5 and 10 years to determine the true increase in total phosphorus load from Lake Winnipesaukee and whether a more stringent objective should be set.

- OBJECTIVE 3: Reduce phosphorus loading from existing development by 4% (260 kg/yr) to Lake Winnisquam Pot Island Deep Spot [WINPLACD] to improve in-lake total phosphorus concentration to 7.2 ppb. Note: the target pollutant load reduction was calculated as 4% of the total phosphorus load to Lake Winnisquam (including Lake Winnipesaukee) minus the total phosphorus loads from the sub-watersheds of Chapman Brook, Durgin Brook, and roughly 50% of Lake Winnisquam Direct due to their downstream proximity to WINPLACD. Meeting this objective would be in addition to mitigation of the anticipated future phosphorus loading by 2031 (Objective 2) to achieve an in-lake total phosphorus concentration of 7.2 ppb at WINPLACD. Even though the response indicator (chlorophyll-a) meets ALI criteria, targeting additional pollutant load reductions to WINPLACD highlights the locally significant sedimentation and nutrient loading coming from the nearby Black Brook sub-watershed, which is estimated to contribute 151 kg/yr of phosphorus load to Lake Winnisquam.

The interim goals for each objective allow flexibility in re-assessing water quality objectives following more data collection and expected increases in phosphorus loading from new development in the watershed over the next 10 or more years (Table 9). Understanding where water quality will be following watershed improvements compared to where water quality should have been following no action will help guide adaptive changes to interim goals (e.g., goals are on track or goals are falling short). If the goals are not being met due to lack of funding or other resources for implementation projects versus due to increases in phosphorus loading from new development outpacing reductions in phosphorus loading from improvements to existing development, then this creates much different conditions from which to adjust interim goals. For each interim goal year, WWN should update the water quality data and model and assess why goals are or are not being met. WWN will then decide on how to adjust the next interim goals to better reflect water quality conditions and practical limitations to implementation.

Table 9. Summary of water quality objectives for Lake Winnisquam, Lake Wicwas, and Lake Opechee. Interim goals/benchmarks are cumulative.

Water Quality Objective	**Interim Goals/Benchmarks**		
	2024	**2026**	**2031**
1. Reduce pollutant loading from Hueber Brook to improve in-stream and in-lake turbidity concentration to <10 NTU.			
	Remediate sources of sediment to Hueber Brook	Remediate sources of sediment to Hueber Brook; re-evaluate water quality and track progress	Remediate sources of sediment to Hueber Brook; re-evaluate water quality and track progress
2. Mitigate (prevent or offset) pollutant loading from future development in the direct watersheds to Lake Winnisquam, Lake Wicwas, and Lake Opechee to maintain in-lake total phosphorus concentration			
	Prevent or offset 70 kg/yr in TP loading from new development to Lake Winnisquam	Prevent or offset 141 kg/yr in TP loading from new development to Lake Winnisquam; re-evaluate water quality and track progress	Prevent or offset 281 kg/yr in TP loading from new development to Lake Winnisquam; re-evaluate water quality and track progress
	Prevent or offset 29 kg/yr in TP loading from new development to Lake Wicwas	Prevent or offset 59 kg/yr in TP loading from new development to Lake Wicwas; re-evaluate water quality and track progress	Prevent or offset 117 kg/yr in TP loading from new development to Lake Wicwas; re-evaluate water quality and track progress
	Prevent or offset 8 kg/yr in TP loading from new development to Lake Opechee	Prevent or offset 16 kg/yr in TP loading from new development to Lake Opechee; re-evaluate water quality and track progress	Prevent or offset 27 kg/yr in TP loading from new development to Lake Opechee; re-evaluate water quality and track progress
3. Reduce pollutant loading from existing development by 4% (298 kg/yr) to Lake Winnisquam Pot Island Deep Spot [WINPLACD] to improve in-lake total phosphorus concentration to 7.2 ppb.			
	Achieve 0.25% (16 kg/yr) reduction in TP loading	Achieve 2% (130 kg/yr) reduction in TP loading; re-evaluate water quality and track progress	Achieve 4% (260 kg/yr) reduction in TP loading; re-evaluate water quality and track progress

3 POLLUTANT SOURCE IDENTIFICATION

This section describes sources of excess phosphorus to Lake Winnisquam. Sources of phosphorus to lakes can include stormwater runoff, shoreline erosion, construction activities, fertilizers, illicit connections, failed or improperly functioning septic systems, leaky sewer lines, fabric softeners and detergents in greywater, 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 nutrient 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 (lawns). Climate change is also not a direct source but can exacerbate the impact of the other phosphorus sources identified in this section and should be considered when striving to achieve the water quality objectives.

3.1 WATERSHED DEVELOPMENT

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

3.1.1 Development History of Lake Winnisquam

Lake Winnisquam, meaning “pleasant waters”, was once considered part of Lake Winnipesaukee until the late 1800s. Maps of Lake Winnisquam from the early 1800s label the waterbody as “Great Bay”, an extension of Lake Winnipesaukee. Many Native American tribes resided in the Lakes Region of New Hampshire until the mid-1700s when the European settlers arrived and established townships throughout the area, bringing in industries such as blacksmithing, tanneries, gristmills, and sawmills. By 1795, there were sawmills at Meredith Center, Meredith Bridge, and Lake Village. The Lakeport Dam was constructed on the Winnipesaukee River in 1851 to provide power to the mills in the area.

The most significant change that allowed the Lakes Region of New Hampshire to become the bustling recreation destination that it is today was the introduction of railways in the 1800s. In August 1848, the Boston, Concord, and Montreal Railroad opened its route between Concord and Meredith Bridge, right along Lake Winnisquam. This route allowed travelers from other areas to visit New Hampshire’s Lakes Region and establish the area as a vacation destination. The railway was extended over time to Montreal, and passengers could ride the train to Canada until the 1950s when passenger travel ceased, and the railroad was used only to transport freight until 1965.

One notable feature of Lake Winnisquam are its islands, including Pot Island, Three Islands, Loon Island, Hog Island, and Mohawk Island. Mohawk Island was once a peninsula known as Mohawk Point. In 1910, the Lochmere Dam was constructed, and the water level rose so that the island became permanently separated from the land. Mohawk Island was given its name because it was the site of a famous battle in 1685 between Mohawk warriors and an alliance of Pennacook and Pequaket warriors. In this battle, the Mohawk warriors hid behind part of the peninsula and then ambushed their enemy, eventually leading to their victory.

According to local legend, on the night of Halloween in 1931, a group of local youngsters got their hands on some dynamite that was being used to create new roads in the area. They rowed out to Pot Island and set the dynamite to blow up the island. The culprits made it out alive, but only one fourth of the original Pot Island remains because of this explosion.

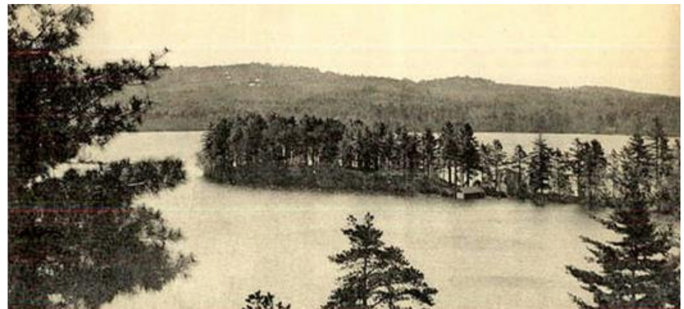
The Winnisquam Bridge, commonly known as Mosquito Bridge, was built between 1840 and 1844 and eventually replaced in 1916 and again in 1974. This bridge is known as Mosquito Bridge not because it was infested with mosquitos but because the old bridge’s humped shape resembled the back of a mosquito.

What is now known as Waldron Bay, a lakeside community in Meredith, was once Camp Waldron, a boy’s camp on the shore of the lake. The camp was run by the Boston Missionary School Society, which owned an extensive amount of land along Lake

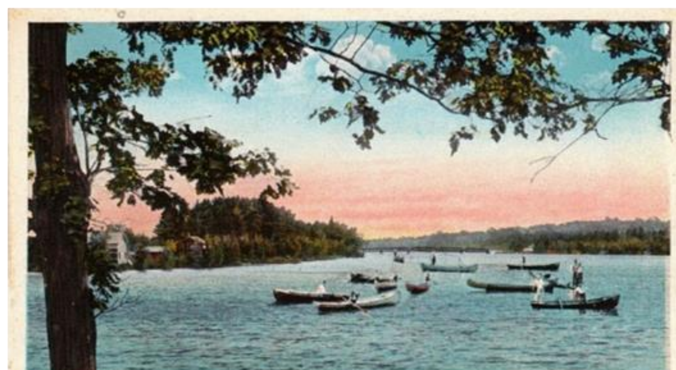
Winnisquam and also operated a girl's camp (Camp Andover) on the other side of the cove. These camps were created to provide outdoor opportunities to impoverished children from the Boston area. Camp Waldron was operational from the early 1900s until the 1970s.

Many of the residences along the shores of Lake Winnisquam were once primitive camps with no electricity or running water. In the 1950s and 1960s, many of these homes were converted to larger, year-round cottages with plumbing and running water. In the early 1980s, motorboats became increasingly popular, and lakefront properties were in high demand. Since then, development along the shoreline of the lake has continued to increase as people purchase their second homes in the area.


The Mills at Meredith Center in 1913.


Mohawk Island.

Pot Island, Lake Winnisquam, Laconia.


Winnisquam Bridge.


Mosquito Bridge, Laconia.


Development along Lake Opechee in 1963.

3.1.2 Watershed Assessments

Several watershed assessments to identify and document sources of NPS pollution have been completed in the Lake Winnisquam watershed. As part of the development of this plan, information was obtained through interviews with local partners, review of municipal documents and property records, desktop analysis of aerial imagery, record searches through online databases, review of publicly available GIS data, review of prior studies and reports, and field survey investigations.

3.1.2.1 Hueber Brook Investigation (2021)

In 2007, NHDES measured elevated turbidity in Hueber Brook, a small tributary that flows into Lake Winnisquam in Belmont. This turbidity was initially attributed to construction along Route 3/11. NHDES resampled Hueber Brook in 2015 after construction had been completed, yet turbidity remained elevated above acceptable water quality standards and the lake remains listed as impaired for ALI due to excessive turbidity. FBE performed a special investigation of the Hueber Brook watershed in 2021 to help prioritize next steps for remediation to remove the lake's ALI impairment listing. The investigation identified four potential sources of high turbidity to the brook. Problems identified included stormwater runoff, erosion, lack of filtration, degraded culverts, and lack of vegetated riparian buffer.

Stormwater runoff from within the Hueber Brook watershed in Belmont (Figure 11) is diverted into the brook through a series of roadside ditches, drains, and catch basins and appears to be the main source of flow for the brook. The flow path of Hueber Brook has been altered greatly by the installation of stormwater infrastructure such as culverts and catch basins. The brook also flows into a constructed wetland system along Sun Lake Drive in Belmont. Hueber Brook outlets into a retention pond, which discharges to Lake Winnisquam. The color of water flowing into and from Hueber Brook is orange. This may be due to naturally occurring iron and iron-oxidizing bacteria or due to degraded and rusting stormwater infrastructure, specifically metal culvert pipes, which were observed throughout the watershed. It should be noted that this rusty color was also observed in another small watercourse that flows parallel to Sun Lake Drive, into a catch basin, and then into the retention pond.

(TOP) Outflow from retention pond into Lake Winnisquam following a rain event. (BOTTOM LEFT) Rusty color and oil sheen flowing in Hueber Brook. (BOTTOM RIGHT) Rusty colored flow from small watercourse parallel to Sun Lake Drive.

(1) STORMWATER RUNOFF FROM LOTS ALONG ROUTE 3/11

Observations: Most of the land use in the portion of the Hueber Brook drainage area that is along Route 3/11 is industrial and/or commercial with impervious cover that carries stormwater runoff with any sediment and/or other particles (oils, etc.) directly into Hueber Brook.

Recommendations: Improve stormwater controls through the construction and implementation of stormwater runoff treatment measures, such as bioretention cells.

(2) SEDIMENT/GRAVEL DUMP SITE ON OLD STATE ROAD

Observations: There is a large sediment/gravel dump site along Old State Road. This site is situated atop a steep slope, with Old State Rd at the bottom of the slope. The bank of the elevated dump site is eroding into the road and is potentially washing down the road and into Hueber Brook during a storm event.

Recommendations: Remove sand and sediment from the site. Install erosion control measures along bank, such as an increased buffer and silt fences.

(3) OLD STATE ROAD

Observations: Old State Rd is a dirt road that runs parallel to Route 3/11 on the Lake Winnisquam side. This road is steeply sloped on both sides, with commercial and industrial land uses occurring atop both banks. Stormwater runs off impervious surfaces and down a ditch along Old State Road. Orange/rusty colored water was observed flowing down this ditch.

Recommendations: Enhance buffer and erosion controls on both sides of road. Improve stormwater runoff treatment.

(4) FAILING CULVERTS THROUGHOUT HUEBER BROOK DRAINAGE AREA

Observations: Multiple culverts within the drainage area were observed to be failing. Failures included rust, blockages, and algae build up.

Recommendations: Replace culverts.

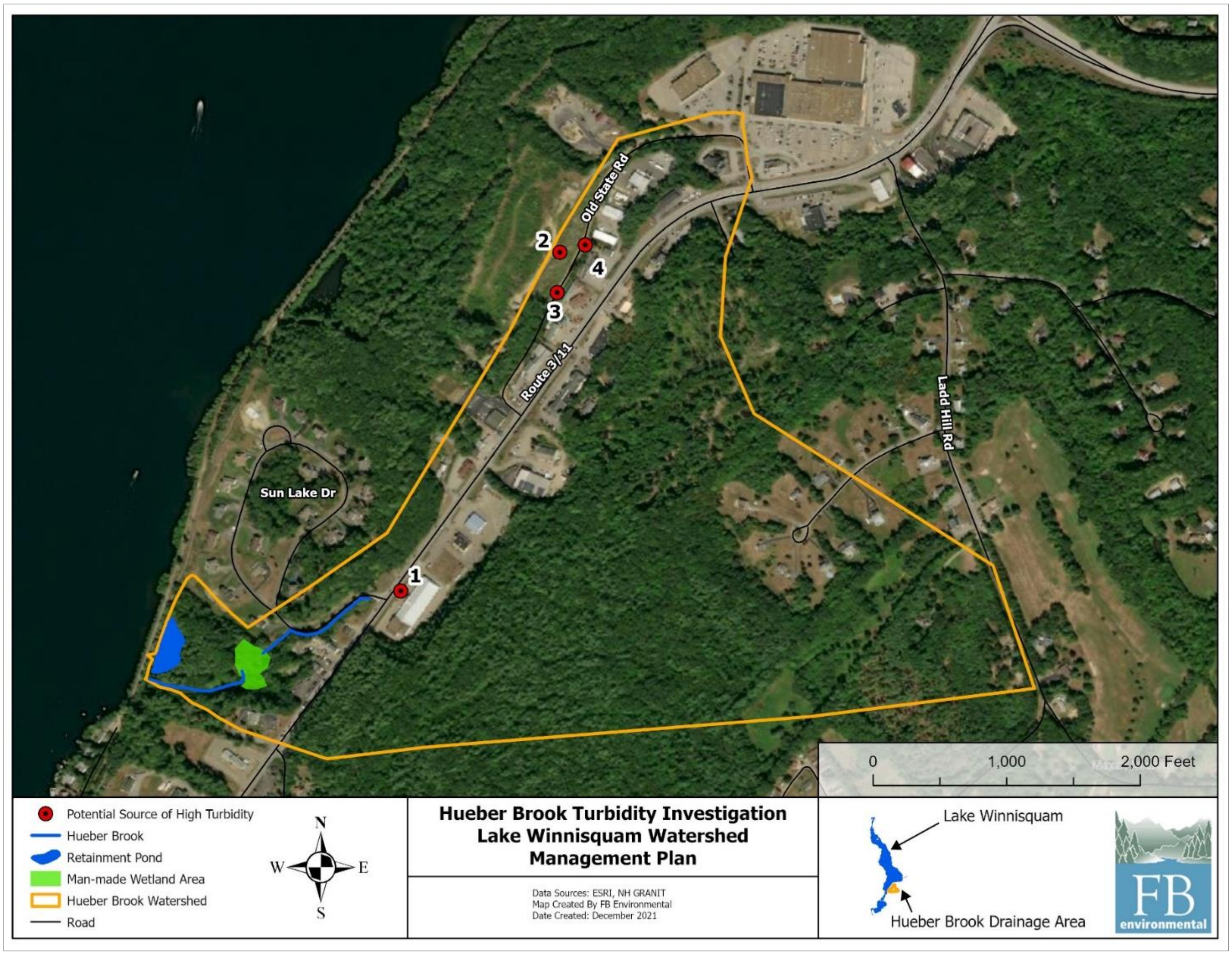


Figure 11. Map depicting identified sites and features of note during the 2021 investigation of Hueber Brook in Belmont.

3.1.2.2 Black Brook Watershed Surveys (2012, 2020-2022)

Black Brook has been long impacted by excessive sediment loading from the gravel roads throughout the sub-watershed, largely in Sanbornton. This sediment load is transported out into Lake Winnisquam where a visible 300-ft radius sediment delta has formed over the years (pictured right). Local groups have prioritized investigation and remediation of road erosion in the watershed. Large-scale improvements in erosion and sedimentation in the Black Brook watershed are needed to improve the water quality of Black Brook and Lake Winnisquam.

Aerial view of a 300-ft radius sediment delta at the outlet of Black Brook as it enters Lake Winnisquam.

In 2012, the *Black Brook Watershed Management Plan* was created for the Town of Sanbornton by AECOM. The plan set a water quality goal for reducing the annual phosphorus load entering Lake Winnisquam from the Black Brook sub-watershed. A watershed survey was conducted to identify sites likely contributing disproportionate concentrations of sediment and phosphorus. BMPs were recommended for each site. The 38 identified sites were found in four general locations within the Black Brook sub-watershed: along Woodman Rd near Black Brook (south branch) (*n*=5), along Huse Rd (*n*=12), along Kaulback Rd (near the intersection of Roxbury Road) (*n*=16), and along Black Brook Rd (*n*=4). BMP recommendations for sites along these roadways included methods of runoff diversion, retention, and infiltration. It was recommended that the road shoulders and surfaces be re-graded to discourage the channelization of stormwater runoff where it gains velocity and discharges directly into Black Brook. Turnouts and rip rap lined retention areas were also recommended. Unpaved and steeply sloped roads typical for this area, particularly Huse Rd and Kaulback Road, are notorious for contributing to sediment and nutrient loads to tributaries and the lake. Routine maintenance was identified as being critical for the success of these proposed BMPs due to the highly erodible nature of the area's gravel roads.

The *Sanbornton Roadway Evaluation* (Underwood Engineers, Inc., 2020) created a detailed strategy for prioritizing road fixes in the Town of Sanbornton, which includes the Black Brook watershed. The strategy considered traffic flow, road widths, road conditions, among other parameters (but not including impact to water quality) for the 68 miles of the town's Class V roads, 50% of which are unpaved, gravel roads. Fixing all the roads was estimated to cost $26 million or $1.34 million per year over 20 years. Huse, Roxbury, and Woodman roads were among the highest priority roads targeted for immediate remediation.

Sedimentation evident at a new box culvert along Black Brook at the Black Brook Rd crossing. Photo courtesy of Lang (2021).

In 2021, BCCD hired an engineer (G. Lang, P.E.) to review and assess environmental issues affecting the water quality of Black Brook with emphasis on assessing the cause of sedimentation altering flow conditions at a newly installed box culvert at the Black Brook Rd crossing. Previous studies reviewed in preparation for the field assessment included the 2012 *Black Brook Watershed Management Plan* (AECOM, 2012) and the 2020 *Summary and Final Documentation, Sanbornton Roadway Evaluation* (Underwood Engineers, Inc., 2020). Lang (2021) found sediment loading issues coming from Huse Road, Kaulback Road, Woodman Road, and Black Brook Road. Lang (2021) also assessed sedimentation at the new box culvert on Black Brook Rd, as well as significant trash and organic material blocking a stop-log structure downstream of the box culvert, and recommended that the stream be surveyed for proper channel grade and backwater effects from the blockage. Lang (2021) recommended that the existing sediment at the box culvert be removed down to the design gravel bottom before opening up the stop-log dam to prevent the sediment from washing into Lake Winnisquam with normal flows restored. A bypass channel may need to be considered to prevent the situation from reoccuring in the future.

In 2022, FBE was hired by BCCD to perform a quantitative evaluation of 11 erosion and sedimentation sites in the Black Brook watershed, based on review of sites identified in the 2012 *Black Brook Watershed Management Plan* (AECOM, 2012) and the 2021 *Black Brook Watershed Assessment Update Report* (Lang, 2021). The evaluation results were used to prioritize the 11 sites for implementation and ultimately to serve as supporting documentation for future grant funding applications (site locations identified in Figure 12 and pictured on the next page). During the field visits, FBE evaluated the severity of erosion, collected measurements (length, width, depth) for screening-level erosion volume estimates, noted distance to the nearest surface water, flow condition, and sediment type (silt, sand, and/or gravel), and took representative photos of the sites. These observations were input to the Water Erosion Prediction Project (WEPP) model for estimating pollutant loading from each site. Site prioritization integrated WEPP model results and field observations through a quantitative ranking method (refer to FBE, 2022 for details). The three highest priority sites occurred along Huse Rd where runoff drains to Black Brook south branch, followed closely by Kaulback Rd where most runoff drains to Black Brook north branch. Both roads are unpaved gravel roads on steep slopes, transporting sediment to nearby surface waters.

Site 1a. Lower Huse Road

Site 1b. Huse Road crossing

Site 2. Upper Huse Road

Site 3. Kaulback-Roxbury Inter

Site 4. Kaulback Road West

Site 5. Kaulback Road East

Site 6. Kaulback Road Far N

Site 7. Black Bk Rd Crossing

Site 8. Woodman Rd Crossing

Site 9. Union Cemetery

Site 10. Roxbury Road

Photos of 11 evaluated and prioritized remediation sites in the Black Brook sub-watershed in Sanbornton. See FBE (2022) for more details. Refer to Figure 12 for site locations.

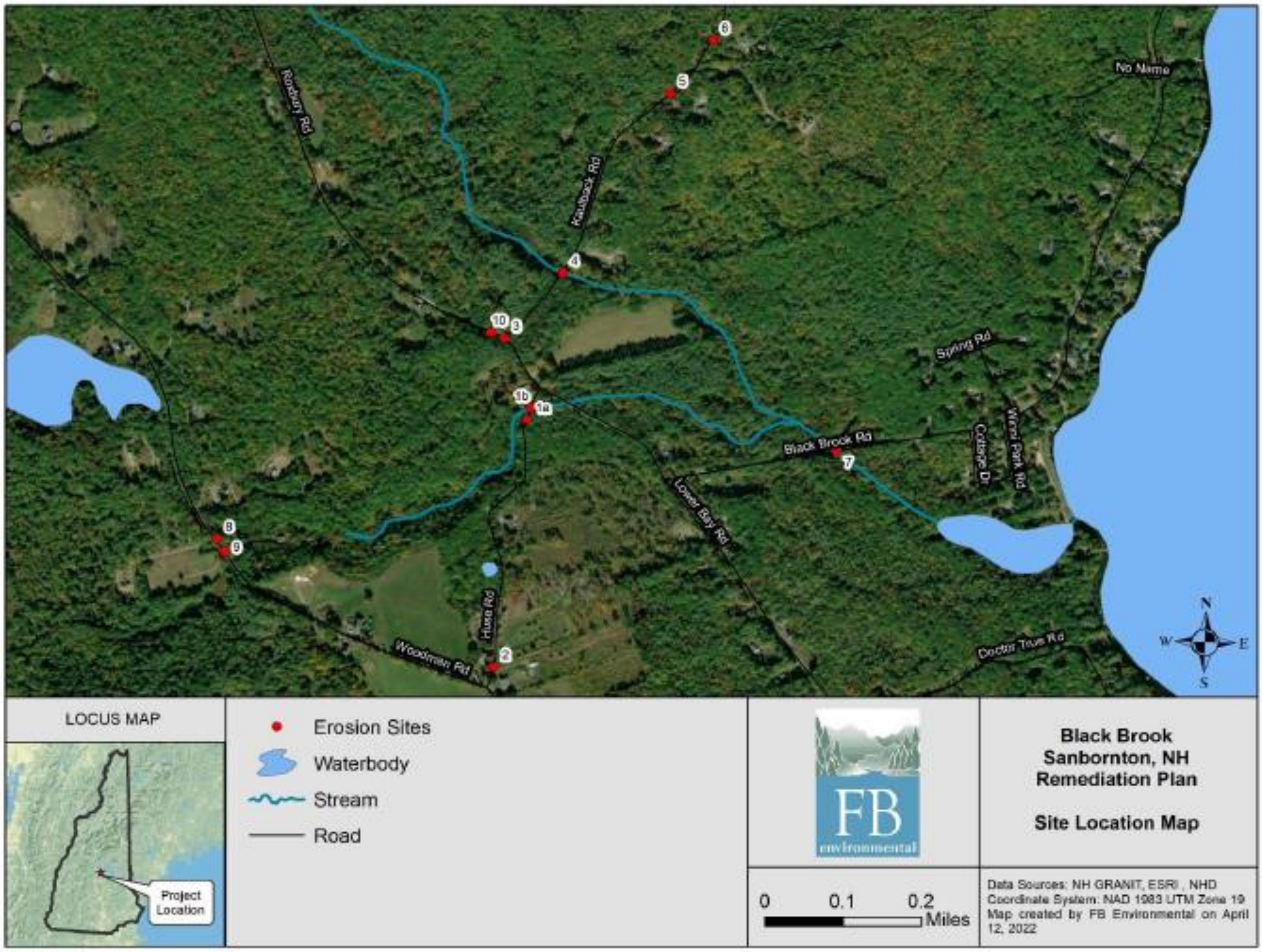


Figure 12. Map of documented and prioritized remediation sites in the Black Brook sub-watershed. Refer to site photos on the previous page as well as FBE (2022) for more details.

3.1.2.3 Lake Winnisquam Watershed Survey (2021)

A watershed survey of the Lake Winnisquam watershed was completed by technical staff from HW and FBE. 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 the field work, HW, FBE, and WWN solicited input from community members and municipal staff about locations with known NPS pollution. HW and FBE also analyzed aerial images and GIS data for land use/land cover, roads, municipal drainage system, public properties, waterbodies, and other features. This information enabled the team to better plan for the survey (e.g., to target known or likely high-polluting sites, such as unpaved roads, beaches, waterfront parks, highly impervious areas, and public works facilities) and to inform recommended solutions.

Plume of sediment washing into Lake Winnisquam from Batchelder Hill Rd in Meredith in the 1990s. The problem has since been remediated when the Town paved the road and installed a sediment forebay.

HW and FBE conducted the watershed survey in April and May 2021. For each location, field staff recorded site data and photographs on tablets. Information collected included location description and GPS coordinates; NPS problem description and measurements (e.g., gully dimensions); receiving waterbody; discharge type (direct or indirect/limited); and preliminary recommendations to mitigate the NPS problem. Field staff accessed sites throughout the watershed from public roads and waterfront access points.

Example of a road ditch with accumulated sediment and vegetation scraped out to maintain hydraulic capacity, as part of the town's maintenance practices.

HW and FBE identified over 100 problem sites in the watershed (Appendix B, Map B-5). The main issues found were unpaved road and ditch erosion; waterfront park and beach erosion; buffer clearing; and untreated urban stormwater runoff. For the sites with recommended stormwater treatment, erosion control, and/or buffer restoration practices, HW estimated the potential pollutant removal that could be achieved by implementing recommendations. Pollutant load reductions were calculated using the MS4 Permit methodology for stormwater treatment systems[4], Region 5 model for gully stabilization[5], and NH Green Buffer methodology for buffer restoration[6]. Table 10 summarizes the potential sediment and total phosphorus reduction by sub-watershed. A list of all identified sites is provided in Appendix C.

Table 10. Estimated pollutant reduction for structural BMPs by sub-watershed. Only those sites with a measurable reduction in pollutant loading from recommended remediation are included.

		Potential Pollutant Reduction	
Sub-watershed	**Number of Sites with Recommended Improvements**	**Average Annual Sediment Load (kg/yr)**	**Average Annual Total Phosphorus Load (kg/yr)**
Black Brook	7	15,948	7.3
Chapman Brook	4	10,741	4.8
Collins Brook	1	1,089	0.5
Dolloff Brook	3	239	0.1
Durgin Brook	8	2,559	1.2
Durkee Brook	9	5,764	2.8
Jewett Brook	7	5,293	2.6
Lake Wicwas Direct	6	4,356	1.9
Lake Winnisquam Direct	25	28,541	14.7
Mill Brook	4	1,872	0.9
Lake Opechee	3	1,051	1.0
Swamp Pond	16	26,593	11.5
Unnamed Tributary (North Trib)	5	6,653	2.8
Winnipesaukee River	3	575	1.0
Total	**101**	**111,274**	**52.9**

[4] Load reduction for stormwater treatment systems was estimated using the methodology presented in the NH MS4 General Permit Appendix F, Attachment 3

[5] For bank or gully stabilization, load reduction was estimated using EPA Region 5 Model for Estimating Pollutant Load Reductions.

[6] For restored or constructed buffers, load reduction was estimated using the methodology presented in UNH Stormwater Center "Pollutant Removal Credits for Restored or Constructed Buffers in MS4 Permits", 2019.

3.1.2.4 Culvert Assessments (2016, 2020, 2021)

The New Hampshire Geological Survey (NHGS), NHDES, New Hampshire Department of Transportation (DOT), NHFGD, and Division of Security and Emergency Management (DOS) have been working together to identify the most vulnerable stream crossings in the State of New Hampshire to allocate resources for replacement. Culvert assessment data collected in the field by trained personnel are stored on the Statewide Asset Data Exchange System (SADES) database and are used by NHGS, NHDES, NHDOT, NHFGD, and DOS to rank crossing structures for their risk of overtopping and failure, degree of aquatic organism passage, and impacts to stream geomorphology.

In 2016, the LRPC and Plymouth State University (PSU) interns conducted an inventory of 101 culverts on Class V roads not served by storm drains in Laconia. The inventory followed protocols for data collection according to the SADES Data Collection Specification Guide for Culverts. Most of the culverts inventoried were old, concrete features with evidence of degradation through spalling or corrosion (in the case of metal culverts), as well as deformation and joint separation (LRPC, 2016).

In October 2020, 11 stream crossings along Black Brook were assessed by Trout Unlimited, as funded through the BCCD. Using the NHDES Stream Crossing Initiative Protocol, culverts were assessed for their risk of failure due to an undersized passage, degree of aquatic organism passage, and the crossing's impacts to stream geomorphology. A table of Trout Unlimited's findings can be found in their 2020 *Black Brook Stream Crossing Assessment Summary* (Trout Unlimited, 2020). Four (4) of the 11 stream crossings intercepted Woodman Road, with two containing no passage, one with reduced passage, and the fourth with only adult trout passage. The Steele Hill Rd stream crossing also contained no passage, while Roxbury and Eagle Ledge Roads contained reduced passages. Four (4) of the 11 stream crossings contained full passage. Five (5) of the stream crossings received geomorphic compatibility scores of "partially compatible," while three were "mostly compatible" and two were "fully compatible". The Eagle Ledge Rd reduced passage stream crossing did not receive a geomorphic compatibility score.

In April 2021, Trout Unlimited conducted 32 stream crossing assessments in the Lake Winnisquam watershed. The NHDES Wetlands Mitigation Program also committed their seasonal employees to survey the remaining crossing structures in the watershed (namely the two urban streams in Laconia) in summer 2021. The assessments followed the NHDES Stream Crossing Initiative protocol. Scoring for hydraulic vulnerability, geomorphic compatibility, and aquatic organism passage were not yet available at the time of this publication.

3.1.2.5 Stream Geomorphic & Habitat Assessment (2010)

A stream geomorphic assessment of the Jewett Brook watershed was completed in 2010 by Bear Creek Environmental, LLC for the New England District of the US Army Corps of Engineers. The assessment was used to identify stressors on the stream's ecosystem health and recommend restoration projects for the stream. Six miles of stream channel divided into 14 reaches were assessed following the Vermont Agency of Natural Resources Protocols. The study found that the major issues along Jewett Brook included "*undersized stream crossings, corridor encroachments, increased stormwater runoff from impervious surfaces, channel straightening associated with the construction of roads and development, lack of riparian buffers, and degraded water quality*" (Bear Creek Environmental, LLC, 2011). Geomorphic conditions along the downstream portion of Jewett Brook were rated as "fair" due to evidence of adjustment processes, aggradation, widening, and planform migration. Jewett Brook has been and is currently "*undergoing a channel evolution process in response to large scale changes in its sediment, slope, and/or discharge associated with the human influences on the watershed*." Habitat condition throughout Jewett Brook was generally rated fair to poor, indicating major or severe departures from reference habitat conditions. Thirty (30) potential restoration projects were identified, including "*river corridor protection through conservation easements or adoption of fluvial erosion hazard zones, replacing undersized structures causing localized channel instability, improving riparian buffers and water quality through landowner education and outreach, and improved stormwater treatment*" (Bear Creek Environmental, LLC, 2011).

3.1.3 Shoreline Survey

With assistance from FBE, WWN volunteers conducted a shoreline survey of Lake Winnisquam in the summer of 2020. 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.

Eight volunteer teams were used for surveying parcels with lake frontage, documenting 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 ratings were evaluated and adjusted by technical staff at FBE to remove potential biases among the teams. These scores were summed to generate an overall "Shoreline Disturbance Score" and "Shoreline Vulnerability Score" for each parcel, with high scores indicating poor or vulnerable shoreline conditions. Photos were taken at each parcel and were cataloged by tax map-lot number. These photos will provide project 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 725 parcels were evaluated along the shoreline of Lake Winnisquam in Belmont, Laconia, Meredith, Sanbornton, and Tilton (Appendix B, Map B-6). The average Shoreline Disturbance Score (Buffer, Bare Soil, and Shoreline Erosion) for the entire lake was 6.2 (Table 11). About 42% of the shoreline (or 302 parcels) scored 7 or greater. A disturbance score of **7 or above** indicates shoreline conditions that may be detrimental to lake water quality. These shoreline properties tended to have inadequate buffers, evidence of bare soil, and shoreline erosion. The average Shoreline Vulnerability Score (Distance and Slope) was 3.9 (Table 11). About 82% (or 593 parcels) scored 4 or greater. A vulnerability score of **4 or greater** indicates that the parcel may have a home less than 150 ft. from the shoreline and a moderate or steep slope to the shoreline. Parcels with a vulnerability score of 4 or greater are more prone to erosion issues whether or not adequate buffers and soil coverage are present.

Table 11. Average scores for each evaluated condition criterion and the average Shoreline Disturbance Score and average Shoreline Vulnerability Score for Lake Winnisquam. Lower values indicate shoreline conditions that are effective at reducing erosion and keeping excess nutrients out of the lake.

Evaluated Condition	Average Score
Buffer (1-5)	3.1
Bare Soil (1-4)	1.8
Shoreline Erosion (1-3)	1.3
Shoreline Disturbance Score (3-12)	**6.2**
Distance (0-3)	2.5
Slope (1-3)	1.4
Shoreline Vulnerability Score (1-6)	**3.9**

The pollutant loading estimates are based on the shoreline survey disturbance scores. Twenty (20) parcels with a score of 11 or greater generate approximately 39 kg of phosphorus load to Lake Winnisquam annually[7]. If shoreline landowners were to create adequate buffers and install other shoreline BMPs on these properties (at a 50% BMP efficiency rate), the annual reduction would be 20 kg of phosphorus. The 282 parcels with scores 7-10, are contributing approximately 82 kg of phosphorus annually[8]. Remediation efforts on these properties using a 50% BMP efficiency rate could result in the annual reduction of 41 kg of phosphorus.

Certain site characteristics, such as slope, can cause shorelines to be naturally more vulnerable to erosion. For example, parcels along the Sanbornton shoreline scored higher for slope, indicating that the western shores of Lake Winnisquam are more steeply sloped, and thus, more vulnerable to stormwater runoff and erosion. Tilton in the southern portion of Lake Winnisquam contains Route 3, which diverts near the lake for a portion of the road's length resulting in more impacted shoreline buffer scores (less natural and more patchy buffers). Other site characteristics such as structure distance to the lake, are often a direct consequence of the historic development on that parcel and cannot be easily changed. Shoreline buffers and amount of exposed soil are more easily changed to strengthen the resiliency of the shoreline to disturbance in the watershed. In summary, the overall average shoreline condition of Lake Winnisquam is good (average disturbance score below 7) for erosion issues, with 302 properties (42%) needing to address erosion issues that are impacting the lake. Lake

[7] Based on Region 5 model bank stabilization estimate for silt loams, using 100 ft (length) by 5 ft (height) and moderate lateral recession rate of 0.2 ft/yr.

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

Winnisquam is also generally more prone to erosion issues because many homes are located close to shore and on moderate to steep slopes (average vulnerability score is 3.9).

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

3.1.4 Soil & Shoreline Erosion

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

3.1.4.1 Surficial Geology

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

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

The unique geological formation in this area formed the Winnipesaukee River Basin Stratified Drift Aquifer - one of the cleanest and most productive aquifers in the region. Seventeen (17) major aquifers comprise the Winnipesauke River Basin Stratified Drift Aquifer; one of which is within the Lake Winnisquam watershed (Durkee Brook Aquifer) (Ayotte, 1997). The aquifer’s saturated thickness measured between 20 to 40 ft and the aquifer’s transmissivity was recorded at less than 1,000 ft^2/day. By receiving groundwater from the Durkee Brook Aquifer (along with other smaller aquifers), Lake Winnisquam is a discharge point for the Winnipesaukee River Basin Stratified Drift Aquifer. Any contamination in the aquifer will move quickly to surface waters such as Lake Winnisquam due to the high transmissivity of the material. Therefore, protection of the aquifer is vital to the protection of the lake.

3.1.4.2 Soils and Erosion Hazard

The soils in the Lake Winnisquam watershed (Appendix B, Map B-7) are a direct result of geologic processes. Of the 42 different soil series present within the Lake Winnisquam watershed (excluding soils beneath waterbodies), the most prevalent soil group in the watershed is Tunbridge-Lymann Becket complex, very stony (7,190 acres, 20%), followed by Millsite-Woodstock-Henniker complex, very stony (5,978 acres, 17%), Canterbury Fine Sandy Loam, very stony (2,969 acres, 8%), Gilmanton Fine Sandy Loam, very stony (1,750 acres, 5%), and Pillsbury Sandy Loam, very stony (1,464 acres, 4%). These soils are all classified with having very stony material and are well drained (Tunbridge-Lymann, Millsite, and Canterbury). The remaining 45% of the watershed (excluding the lake area) is a combination of 37 additional soil series ranging from 4% to 0.01% of the watershed.

Soil erosion hazard is dependent on a combination of factors, including land contours, climate conditions, soil texture, soil composition, permeability, and soil structure (O'Geen et al., 2006). Soil erosion hazard should be a primary factor in determining the rate and placement of development within a watershed. Soils with negligible soil erosion hazard are primarily low-lying wetland areas near abutting streams. The soil erosion hazard for the Lake Winnisquam watershed was determined from the associated slope and soil erosion factor K_w[9] used in the Universal Soil Loss Equation (USLE). The USLE predicts the rate of soil loss by sheet or rill erosion in units of tons per acre per year. A rating of "slight" specifies erosion is unlikely to occur under standard conditions. A rating of "moderate" specifies some erosion is likely and erosion-control measures may be required. A rating of "severe" specifies erosion is very likely and erosion-control measures and revegetation efforts are crucial. A rating of "very severe" specifies significant erosion is likely and control measures may be costly. Excluding the lake area, "severe" and "very severe" erosion hazard areas account for 45% of the Lake Winnisquam watershed (15,897 acres) and are mostly concentrated in the Meredith and New Hampton portions of the watershed (Appendix B, Map B-8). Moderate erosion hazard areas account for 39% of the watershed land area (13,764 acres). Slight erosion hazard areas account for 16% (5,592 acres), and 118 acres or 1% are not rated. Development should be restricted in areas with severe and very severe erosion hazards due to their inherent tendency to erode at a greater rate than what is considered tolerable soil loss. Since a highly erodible soil can have greater negative impact on water quality, more effort and investment are required to maintain its stability and function within the landscape, particularly from BMPs that protect steep slopes from development and/or prevent stormwater runoff from reaching water resources.

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.

For about a week in early August 2021, WWN reported that lake water level was very high, about 8 inches above the normal high water level, causing docks and raised beaches to be flooded and shorelines to be eroded. The record-high rainfall in July in the Lake Winnisquam area (and across New England) caused severe dirt road erosion, which moved large amounts of sediment and organic material into the water, causing beach closures and reduced water clarity. Residents were particularly concerned about the enhanced shoreline erosion caused by boat wakes while the lake was experiencing abnormally high water level. Since the start of the pandemic, residents have also reported an increase in the number of boaters on the lake and a corresponding increase in shoreline erosion exposing tree roots.

3.1.5 Wastewater

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

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

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.

Lake Winnisquam was historically impacted by the dumping of untreated effluent from the City of Laconia's primary wastewater treatment plant, which was built in 1952 to collect wastewater from homes and businesses in the rapidly developing area. The excessive nutrients in the untreated effluent spurred severe blooms in the lake throughout the 1950s and 1960s. In 1959, the Lakes Region Clean Waters Association was formed and through many years of persistent grassroots efforts from community members, a $1 million dollar grant was secured from the EPA under the CWA Construction Grants Program to establish the Winnipesaukee River Basin Program (WRBP), a state-owned sewer system with a wastewater treatment plant in Franklin. The sewer system went online in 1976 and processed sewage from several municipalities in the area. The plant is located outside the watershed, but there are several pump-out stations and a maintenance facility in the watershed, along with the connecting sewer lines. The sewer system serves over 14,500 residential connections in 10 communities. WRBP owns and maintains the main sewer line and pump stations that convey the sewage from each community to the plant. The sewer infrastructure that connects homes and businesses to the main sewer line is owned and maintained by each respective municipality or by private owners. WRBP is funded by each municipality through the sewer tax bill collected. **Nearly half of the shoreline area of Lake Winnisquam is serviced by sewer systems, which represents a potential vulnerability if the sewer systems are old or damaged and leaking wastewater into groundwater near the lake.**

In 2021, WWN compiled septic system data for Lake Winnisquam shoreline properties (within 250 ft of Lake Winnisquam), including date house built, date of most recent septic installation or upgrade, number of bedrooms, and seasonal or year-round use, if available (otherwise assumed year-round). For the towns of Tilton, Belmont, Meredith, and Sanbornton, WWN visited town offices and reviewed tax record information to glean relevant septic system information not found through online records. The City of Laconia provided septic system data to WWN directly. Septic system survey findings are summarized in Table 12. WWN identified 1,027 parcels within 250 ft of Lake Winnisquam (includes all developed and vacant parcels), 365 of which were found to be using septic systems for wastewater treatment. **An estimated 39% of those septic systems were over 25 years old. The public survey conducted by WWN (see Section 1.4.3) also found that many systems were not up to code and were likely cesspools.** WWN's online survey noted cesspools on Mohawk Island as concerning for water quality.

Shoreline septic systems were estimated to contribute 86 kg/yr of total phosphorus loading to Lake Winnisquam, comprising 1% of the total load to the lake (refer to Section 2.3.1 and FBE, 2021a). Despite the relatively minor load estimated for septic systems around the lake, numerous septic systems, cesspools, or holding tanks are located within a short distance to the water, leaving little horizontal (and sometimes vertical) space for proper filtration of wastewater effluent. Improper maintenance or siting of these systems can cause failures, which leach untreated, nutrient-rich wastewater effluent directly to the lake. This effluent contains not only nutrients and bacteria but also microplastics, pharmaceuticals, and other pollutants harmful to public health.

Table 12. Summary of septic system data for properties along the shoreline of Lake Winnisquam. Note: The number of shoreline parcels within 250 ft of Lake Winnisquam (and subsequent percentages) include vacant lots.

Municipality	Shoreline Parcels (within 250 Ft of Lake Winnisquam)	Number Of Shoreline Properties on Septic	Percent Of Shoreline Properties on Septic	Number Of Septic Systems Older Than 25 Years	Percent Of Septic Systems Older Than 25 Years
TILTON	101	0	0%	0	0%
BELMONT	180	8	4%	Unknown	Unknown
MEREDITH	173	157	91%	36	23%
SANBORNTON	182	63	35%	38	60%
LACONIA	391	137	35%	69	50%
TOTAL	**1,027**	**365**	**36%**	**143**	**39%**

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.

WWN's online survey showed that about 42% of respondents used fertilizers on their lawns, with 33% applying 1-2 times per year, 7% applying 3-4 times per year, and 2% applying five or more times per year. Most respondents (53%) were not using different application practices near shoreland areas. Tardiff Park along Jewett Brook was identified as a potential source of nutrients due to observation of grass clippings in the channel and minimal buffer between the stream and park lawn (fertilizer use unknown), downstream of which was a significant algal bloom in the stream (Bear Creek Environmental, LLC, 2011). The municipalities of New Hampton, Meredith, Laconia, and Tilton indicated that no fertilizers are used on public land. Sanbornton hires Swain Landscaping, who likely does not use fertilizer, for maintaining public land in town. Gilford hired Boucher Landscape Company for mowing and clipping and Belknap Landscape for lawn and garden treatments at the town hall, fire department, Department of Public Works (DPW) facility, and cemeteries. Treatment at cemeteries is conducted in May/June and September/October with a broad leaf weed control and slow release fertilizer. Treatment at the town hall is conducted with Holganix 100% organic bionutritional fertilizer for turf.

There are also several golf courses within the Lake Winnisquam watershed that use fertilizer: (1) Oak Hill Golf Course uses Opti-45 fertilizer on the greens; (2) Laconia Country Club & Golf Course uses low or zero phosphorus products of blended organic and synthetics of historically granular but now liquid form (for direct feeding); and (3) Lakeview Golf Course was closed and sold in April 2021 to Stone Bluff Property Holdings LLC of Northfield, NH and reopened as a golf course again in late 2021; they currently use Nature Safe 8-35 Stress Guard fertilizer with 3% available phosphate.

3.1.7 Agriculture

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

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

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

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

Excessive or ill-timed application of fertilizer or poor storage which allows nutrients to wash away with precipitation not only endangers lakes and other waters, it also means those nutrients are not reaching the intended crop. The key to nutrient application is to apply the right amount of nutrients at the right time. When appropriately applied to soil, synthetic fertilizers or animal manure can fertilize crops and restore nutrients to the land. When improperly managed, pollutants in manure can enter surface waters through several pathways, including surface runoff and erosion, direct discharges to surface water, spills and other dry-weather discharges, and leaching into soil and groundwater. BCCD was unaware of any active issues with agricultural practices impacting water quality in the watershed and noted that farmers may not be working with Natural Resource Conservation Service (NRCS) to review agricultural practices unless they are receiving NRCS funding. A respondent through WWN's online survey noted that horse waste may be impacting a stream along Oak Hill Rd in Sanbornton. Hunkins Pond is also very likely impacted by agricultural runoff.

3.1.8 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 surface waters by direct deposition of fecal matter from pets standing or swimming in surface waters. Dog waste left along Collins Brook Rd in Meredith and along the fire access road between Weed Rd and Waldron Bay Association was noted in WWN's online survey as a problem area.

3.1.9 Future Development

Understanding population growth, and ultimately development patterns, provides critical insight to watershed management, particularly as it pertains to lake water quality. After a declining population trend from 1860 to 1900, the population of the seven watershed municipalities started growing, especially Laconia which grew rapidly from 1870 to 1950 and continued growing steadily over the last 50 years (US Census Bureau, 2022). The other six municipalities started growing significantly in population from 1970 to 2020 (Figure 13). The Lake Winnisquam watershed area has long been treasured as a recreational haven for both summer vacationers and year-round residents. The area is among the oldest summer vacation spots in New Hampshire and offers fishing, hiking, boating, sailing, canoeing, kayaking, and swimming in the summer, and ice fishing, cross-country skiing, snowshoeing, and snowmobiling in the winter. The desirability of Lake Winnisquam and the greater Lake Winnipesaukee area as a recreational destination will likely stimulate continued population growth in the future. Growth figures and estimates suggest that these seven municipalities 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.

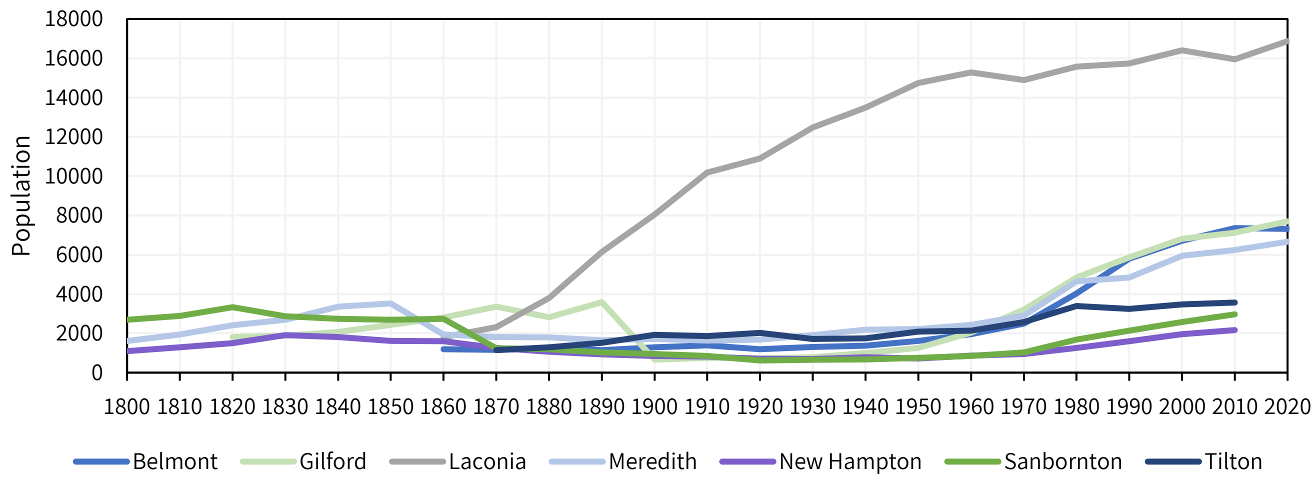


Figure 13. Historical demographic data for the municipalities of Belmont, Gilford, Laconia, Meredith, New Hampton, Sanbornton, and Tilton in the Lake Winnisquam watershed. The population of this community has grown dramatically over the last 50 years. **2020 official census data is only available for municipalities with populations greater than 5,000 people, as of the writing of this plan.*

3.2 POTENTIAL CONTAMINATION SOURCES

Point source 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 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. Downloaded and filtered for the Lake Winnisquam watershed, these data identify potential sources of pollution to the Lake Winnisquam (Figure 14). On 1/05/2020, 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.

3.2.1 Above and Underground Storage Tanks

Above and underground storage tanks include permitted containers with oil and hazardous substances such as motor fuels, heating oils, lubricating oils, and other petroleum and petroleum-contaminated liquids. There are 39 aboveground storage tanks within the Lake Winnisquam watershed. Two can be found in Belmont, one in Gilford, 30 in Laconia, five in Sanbornton, and one in Tilton. There are 139 underground storage tanks within the Lake Winnisquam watershed. Eight can be found in Belmont, eight in Gilford, 109 in Laconia, one in Meredith, five in Sanbornton, and five in Tilton. Ownership of these tanks range from auto salvage yards, auto dealerships, commercial industries, hospitals, industrial facilities, marinas, petroleum distributors, utilities, municipal, local, and state governments, and more.

3.2.2 Automobile Salvage Yards

There are two automobile salvage yards within the Lake Winnisquam watershed that either contain at least 12 “end-of-life” vehicles annually or at least 25 vehicles for more than 60 days at a time. The Reed’s Auto Wrecking Co. located in Laconia and Al’s Used Parts in Belmont are currently registered with the NHDES Greenyards Program as active.

3.2.3 Solid Waste Facilities

There are two solid waste facilities within the Lake Winnisquam watershed. One, the Frank Bean Rd Site, is a closed, unlined landfill no longer under operation, while the other is the Laconia Transfer Station which is currently under operation for collection, storage, and transfer of waste.

3.2.4 Hazardous Waste Sites

Hazardous waste generating facilities are identified through the EPA’s Resource Conservation and Recovery Act (RCRA) and either require federal or state regulation. Only 41 of the 135 hazardous waste generating facilities within the Lake Winnisquam watershed are listed as active; the remaining facilities are classified as either inactive (64), declassified (22), classified (7), or non-notifier (1). Of the 41 active hazardous waste sites, six can be found in Belmont, two in Gilford, 30 in Laconia, two in Sanbornton, and one in Tilton.

3.2.5 Local Potential Contamination Sources

Local potential contamination sources are sites that may represent a hazard to drinking water quality supplies due to the use, handling, or storage of hazardous substances. There may be overlap between local potential contamination sources and other PCS identified in this section. Of the 26 local potential contamination sources within the Lake Winnisquam watershed, nine can be found in Belmont, three in Gilford, 10 in Laconia, one in Meredith, and three in Tilton.

3.2.6 NPDES Outfalls

Of the nine NPDES outfalls that discharge pollutants directly to a surface water within the Lake Winnisquam watershed, only one is actively discharging (General Permit #NH0022730). Located along Durkee Brook, the Scotia Technology facility is characterized as a facility that processes wastewater, although the water discharging from the outfall is “Non-Contact Cooling Water” and “no toxic discharge, so no dilution factor” is needed (NHDES Outfalls Metadata).

3.2.7 Remediation Sites

The 295 remediation sites present within the Lake Winnisquam watershed consist of leaking storage facilities that contain fuel or oil, sites with chlorinated solvents and other non-petroleum products, non-hazardous and non-sanitary holding tanks, initial spill response sites, historical dump sites, leaking residential or commercial oil tanks for heating or motor oil tanks, underground injection control of wastewaters not requiring a groundwater discharge permit, unlined wastewater lagoons, or a flagged groundwater sample for contamination but with no direct connection to a source of contamination. Of the 295 remediation sites, 58 are identified in Belmont, 24 in Gilford, 170 in Laconia, 15 in Meredith, one in New Hampton, 16 in Sanbornton, and 11 in Tilton.

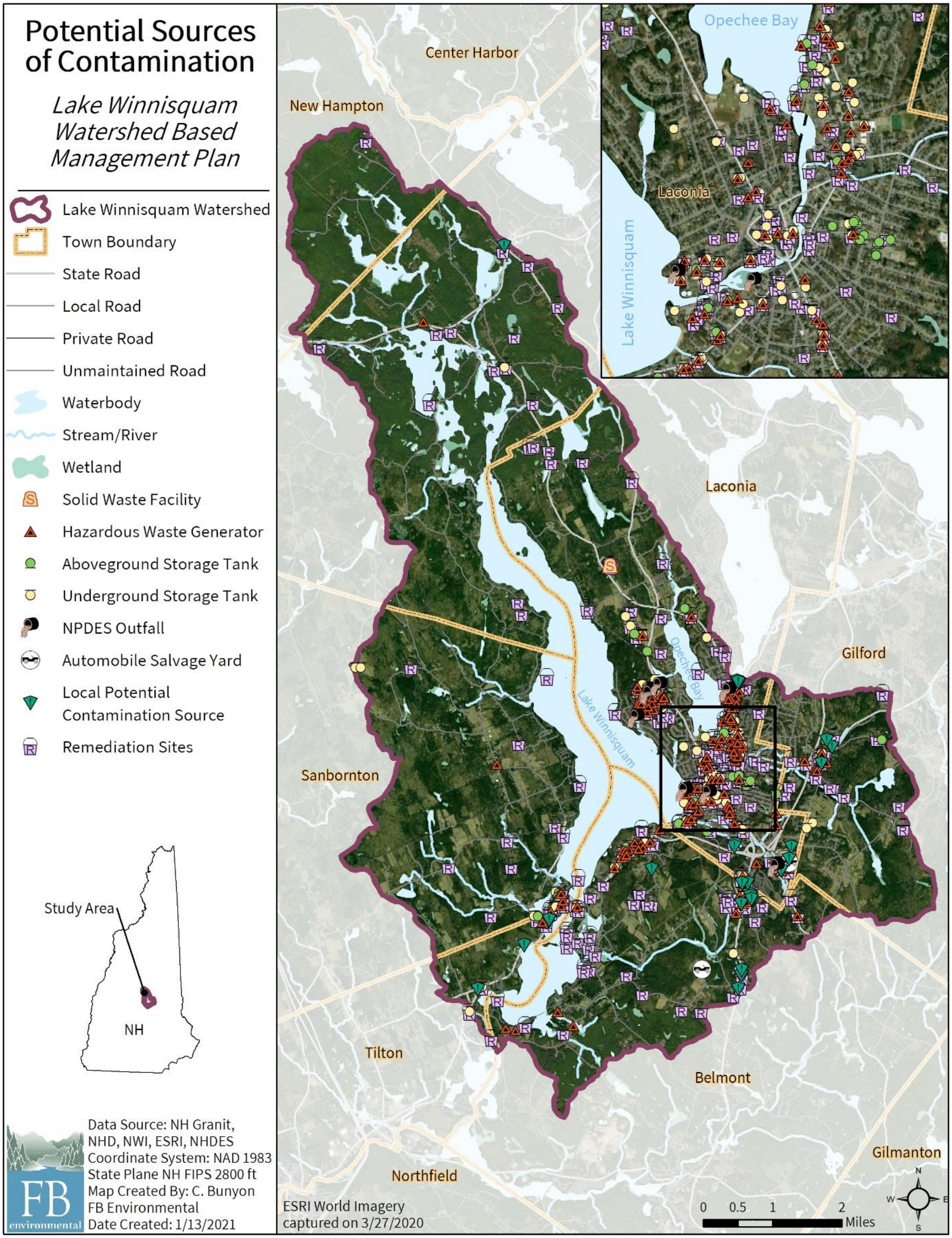


Figure 14. Potential sources of contamination in the Lake Winnisquam watershed.

3.3 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 (such as at Opechee Park, Laconia Country Club, or Oak Hill Golf Course) 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 8.5 kg/yr (4%) of the total phosphorus load to Lake Winnisquam (FBE, 2021a).

3.4 CLIMATE CHANGE

Climate change will have important implications for water quality that should be considered and incorporated into WBPs. In the last century, New England has already experienced significant changes in stream flow and air temperature. Out of 28 rural stream flow stations throughout New England, 25 showed increased flows over the record likely due to the increase in frequency of extreme precipitation and total annual precipitation in the region. In 79 years of recorded flooding in the Oyster River in Durham, NH, three of the four highest floods occurred in the past 10 years (Ballestero et al., 2017). 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 will flush more nutrients to surface waters for algae to feed on and flourish under warmer air temperatures.

These trends will likely continue to impact both water quality and quantity. Climate change models predict a 10-40% increase in stormwater runoff by 2050, particularly in winter and spring and an increase in both flood and drought periods as seasonal precipitation patterns shift. Adding to this stress is population growth and corresponding development in New Hampshire. The build-out analysis for the watershed showed that about 15,027 acres is still developable and up to 6,734 new buildings could be added to the watershed at full build-out based on current zoning standards. Lake Winnisquam is at risk for water quality degradation because of new development in the watershed unless climate change resiliency and **low impact development** (LID) strategies are incorporated into 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

Over 100 NPS sites identified during the 2021 watershed survey and 302 high/medium impact rated shoreline properties from the 2020 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.

Example of structural BMPs installed at the Sanbornton Town Beach.

The following series of BMP implementation action items are recommended for achieving Objectives 1 and 3 (see Action Plan in Section 5 for more details):

- Remediate stormwater runoff through infrastructure rehabilitation in the Hueber Brook sub-watershed to Lake Winnisquam to remove Lake Winnisquam's ALI impairment listing.
- Address the top 24 high priority sites (and the remaining 84 medium and low priority sites as opportunities arise) identified during the 2021 watershed survey. The 108 sites were ranked based on phosphorus load reduction and waterbody proximity. Table 13 presents the recommended improvements and corresponding pollutant load reductions for the top 24 high priority sites. The full prioritization matrix is provided in Appendix C. Conceptual designs for three of the top 24 high priority sites are provided below. Design and implementation for these three sites are currently underway through a NHDES 319 Watershed Assistance Grant (2022-23) awarded to WWN. These sites will be used as models for other similar sites in the watershed.
- Address road erosion control measures identified in Lang (2021) and FBE (2022). BCCD and WWN plan to pursue grant funding for the design and remediation of erosion sites in the Black Brook sub-watershed.
- Provide technical assistance and/or implementation cost sharing to 20 high impact shoreline properties identified during the 2020 shoreline survey. Encourage landowners to implement stormwater and erosion controls on the 282 medium impact shoreline properties identified during the 2020 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. WWN will be working with NH Lakes through the LakeSmart Program to educate homeowners on lake-friendly landscaping and stormwater control practices.

For the proper installation of structural BMPs in the watershed, WWN and other stakeholders 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 (including public outreach) are included in Section 5. For helpful tips on implementing BMPs, see Additional Resources.

Table 13. Top 24 high priority structural BMP sites in the Lake Winnisquam watershed.

				Potential Pollutant Reduction	
Site ID	**Site Description**	**Municipality**	**Recommendations**	**Average Annual Sediment Load (kg/yr)**	**Average Annual TP Load (kg/yr)**
1-12	Gale Ave - small pocket park with access to lake	Laconia	Install a bioretention basin within the park to treat runoff from Gale Ave. Stabilize eroded areas, improve buffer.	2,282	1.6
2-05	Swain Rd at Jewett Brook crossing	Gilford	Armor ditch with stone or grass, Install turnout, Reshape ditch, Stabilize banks, Install runoff diverter, Plant/improve buffer	1,361	0.8
3-10	Chemung Rd	Meredith	Armor ditch with stone or grass, Reshape ditch, Reshape or crown road, Reshape/vegetate shoulder	1,633	0.7
3-11	Roxbury Rd	Meredith	Armor ditch with stone or grass, Reshape ditch, Reshape or crown road, Reshape/vegetate shoulder	2,195	0.9
3-12	Stoney Brook Rd	Meredith	Reshape or crown road, Reshape/vegetate shoulder, Clean out and stabilize plow pile area	3,024	1.3
3-13	Stoney Brook Rd, crossing with river	Meredith	Armor ditch with stone or grass, Reshape ditch, Reshape or crown road, Reshape/vegetate shoulder, Investigate geomorphic stability of river	1,597	0.7
3-14	Deer Park Association beach on Weed Rd	Meredith	Reshape or crown road, Reshape/vegetate shoulder, Restore sediment forebay, Install rain garden, tiered landscaping, infiltration steps; Improve buffer, Install turnouts on south access road to lake	1,597	0.7
3-16	Weed Rd	Meredith	Armor ditch with stone or grass, Reshape ditch, Reshape or crown road, Reshape/vegetate shoulder, Improve buffer	1,814	0.8
3-20	New road construction off Batchelder Hill Rd	Meredith	Armor ditch with stone or grass, Reshape ditch, Reshape or crown road, Reshape/vegetate shoulder	1,996	0.8
3-21	Eagle Ledge Rd intersection with Batchelder Hill Rd	Meredith	Armor ditch with stone or grass, Reshape ditch, Reshape or crown road, Reshape/vegetate shoulder	3,592	1.5
3-22	Eagle Ledge Rd, Black Brook crossing	Sanbornton	Stabilize inlet and/or outlet, Armor ditch with stone or grass, Reshape ditch, Reshape or crown road, Reshape/vegetate shoulder	2,395	1.0
3-23	Kaulback Rd and Roxbury Rd	Sanbornton	Stabilize inlet and/or outlet, Replace/enlarge culvert, Armor ditch with stone or grass, Reshape ditch, Reshape or crown road, Reshape/vegetate shoulder	3,393	1.4
3-24	Lower Bay Rd and Huse Rd	Sanbornton	Armor ditch with stone or grass, Reshape ditch, Reshape or crown road, Reshape/vegetate shoulder	2,776	1.4
3-25	Woodman Rd	Sanbornton	Stabilize inlet and/or outlet, Armor ditch with stone or grass, Reshape ditch, Reshape/vegetate shoulder	2,159	1.1
3-26	Woodman Rd	Sanbornton	Armor ditch with stone or grass, Reshape ditch, Reshape/vegetate shoulder, Divert driveway runoff, Enhance and stabilize buffer between road and stream	1,597	0.7

Site ID	Site Description	Municipality	Recommendations	Potential Pollutant Reduction: Average Annual Sediment Load (kg/yr)	Potential Pollutant Reduction: Average Annual TP Load (kg/yr)
3-28	Woodman Rd intersection with Steele Hill Rd	Sanbornton	Stabilize inlet and/or outlet, Armor ditch/turnouts with stone or grass with check dams, Reshape ditch, Reshape or crown road, Reshape/vegetate shoulder	3,629	1.5
3-30	Chapman Rd	Sanbornton	Stabilize inlet and/or outlet, Armor ditch with stone or grass, Reshape ditch, Reshape or crown road, Reshape/vegetate shoulder	1,996	0.8
3-31	Philbrook Rd	Sanbornton	Stabilize inlet and/or outlet, Armor ditch with stone or grass, Reshape ditch/turnouts, Reshape or crown road, Reshape/vegetate shoulder	2,395	1.0
3-32	Philbrook Rd	Sanbornton	Stabilize inlet and/or outlet, Armor ditch with stone or grass, Reshape ditch/turnouts, Reshape or crown road, Reshape/vegetate shoulder	1,361	0.8
3-34	Bay Rd	Sanbornton	Stabilize parking area, pull-off area, and access ramps	4,990	2.1
3-36	Doctor True Rd and Maple Circle	Sanbornton	The Town is considering paving Dr True Rd and Maple Circle to address erosion and travel issues. If paving moves forward, evaluate BMPs to manage sand and salt from newly paved roads.	9,273	4.6
4-06	Old Stage Rd culvert	Meredith	Install turnout, Reshape ditch, Reshape/vegetate shoulder, Reshape or crown road, Install runoff diverter	1,814	0.8
4-08	Intersection of Rt 104 and Hatch Corner Rd	Meredith	Remove winter sand, Install erosion controls (e.g., silt fence), Armor ditch with stone or grass	1,814	0.8
4-09	Dow Rd, near intersection with Rt 104	Meredith	Armor ditch with stone or grass, Install erosion controls (e.g., silt fence)	1,814	0.8

4.1.2 Conceptual Designs for Select Priority Structural BMP Sites (2021)

For sites ranked as high priority for structural BMPs, WWN consulted with landowners and municipalities to assess their willingness to implement the recommended stormwater improvements. The team then selected three high priority sites to carry forward for conceptual design. In addition to water quality performance and municipal/landowner support, these sites were selected based on their potential to demonstrate replicable solutions for the key NPS issues observed in the watershed: urban stormwater runoff, unpaved road and ditch erosion, and private waterfront erosion. The conceptual designs presented herein represent planning level recommendations for stormwater management improvements at each site, along with planning level estimates of costs[10] and potential phosphorus load reduction[11]. The overarching goal of proposed improvements is to reduce phosphorus loading into Lake Winnisquam. These designs seek to accomplish phosphorus reduction by reducing erosion and by treating stormwater runoff using structural stormwater control measures (SCMs). Secondarily, these designs aim to demonstrate replicable NPS management practices, maintain existing site uses, preserve and enhance ecological resources, minimize long-term maintenance requirements, and educate the public about water quality and stormwater management. Construction-ready design and implementation for these three sites are currently underway through a NHDES 319 Watershed Assistance Grant (2022-23) awarded to WWN. WWN plans to work with local partners to complete the designs at each site.

[10] Planning-level costs were estimated using EPA Region 1 (2016) *Methodology for Developing Cost Estimates for Opti-Tool*, NHDOT and MassDOT unit prices, and best professional judgement. Costs include 25% contingency and are expressed in 2021 dollars.

[11] Phosphorus reduction was estimated using NH MS4 Permit Appendix F, EPA Region 5 Erosion Control Model, and UNH Stormwater Center (2019) *Pollutant Removal Credits for Restored or Constructed Buffers in MS4 Permits*.

Gale Ave Park, Laconia, NH


Shoreline of Gale Ave Park.

Existing Site Description: Gale Ave Park is a small public park on Lake Winnisquam at the end of Gale Ave in Laconia. The park is accessed from Gale Ave by sidewalks that extend into the park to the south and north. The park features two stone benches and a lawn area. Along the 80-ft shoreline, there is a concrete block remaining from a former wharf, a small, vegetated area, and a small beach-like section that slopes down to the water. The Laconia Department of Parks and Recreation is developing plans for a shoreline retaining wall, an accessible paved path, and a kayak launch. Stormwater runoff from Gale Ave and adjacent residential properties appears to bypass storm drains along Gale Ave and flow into shallow swales along the north and south edges of the park. Further investigations are needed to determine the cause(s) and amount of bypass. The swales are significantly eroded, particularly at the end of the swale to the south. A drainage outfall is located to the north of the park. A sanitary sewer extends from Gale Ave into the park, where there are two sewer manholes. Soils at the site are categorized as hydrologic soil group (HSG) C, indicating moderate infiltration capacity.

Proposed Improvements:

- Collect stormwater runoff entering the park with a paved inlet flume and route flow into a sediment forebay and bioretention basin to manage low-flow storm events. The bioretention basin will include an overflow spillway to route excess flows into a vegetated swale to the north. Plantings for the bioretention basin will include generally low-growing and low-maintenance species.
- Convert the eroded swale to the north into a vegetated swale to carry flow from the bioretention basin to the lake. Plantings for the swale will include low maintenance grasses, sedges, and rushes such as Common Rush (*Juncus effuses*), Prairie Dropseed (*Sporobolus heterolepis*), and Northern Sea Oats (*Chasmanthium latifolium*).
- Transition the swale to meet a level spreader and stone apron for energy dissipation. Between the stone apron and the shoreline, plant dense groundcover vegetation.
- Restore the eroded swale to the south with loam and seed to match surrounding lawn.
- Install educational signage about water quality and stormwater management.
- Integrate the bioretention and swale design with park improvements planned by Laconia Parks and Recreation.

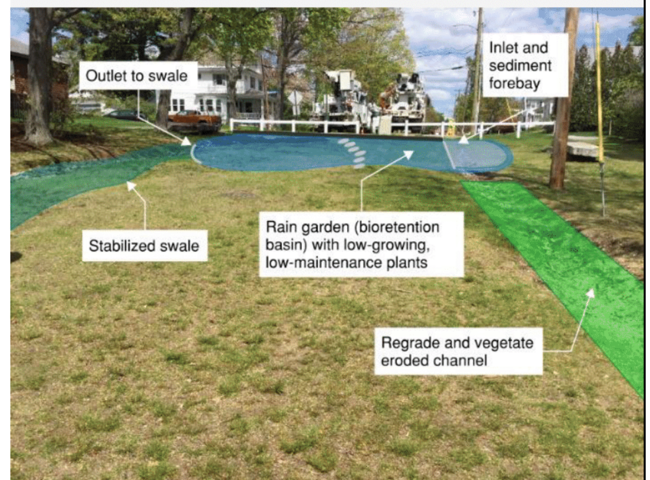
Operation and Maintenance: Operation and maintenance (O&M) for the proposed bioretention basin and swale is anticipated to incur 20 hours annually. Typical O&M includes routine inspections, preventative maintenance, and corrective actions, such as the following:

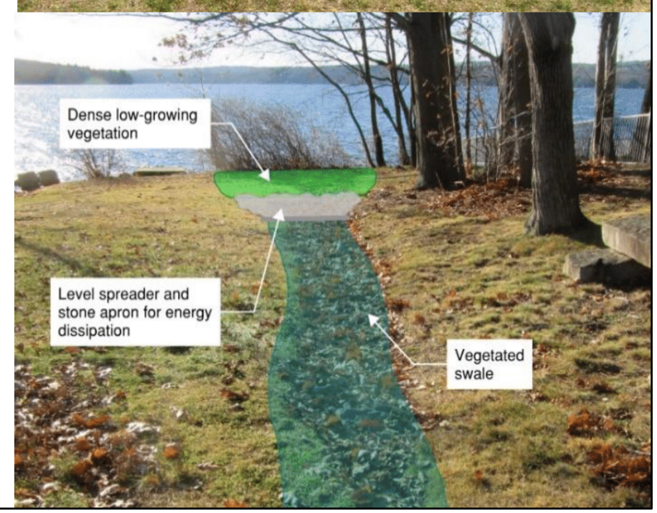
1) Clean out trash, debris, and accumulated sediment from inlet, forebay, bioretention basin, spillway, and swale.
2) Maintain vegetation (weeding, replanting, etc.) and water plants during establishment period.
3) Check for erosion within and downstream of facility; stabilize areas of erosion, if found.
4) Check for standing water (lack of drainage) in the bioretention basin. Investigate and correct clogging if the basin does not drain within 48 hours following a rain event.

Operation and maintenance for bioretention systems, as provided in EPA Region 1 (2016) *Methodology for Developing Cost Estimates for Opti-Tool*

SITE SUMMARY

Owner: City of Laconia
Receiving Water: Lake Winnisquam
Estimated Phosphorus Load Reduction: 1.6 kg/year
Estimated Costs: Capital costs: $39,000-$47,000
Annual operation and maintenance costs: $2,000
20-year life cycle cost: $83,000





Deer Park Beach, Meredith, NH

Existing Site Description: Deer Park Beach is a private beach and boat launch on Lake Winnisquam in Meredith. The beach is accessed via granite steps off Weed Rd, opposite Heritage Rd, and an unpaved driveway to the south. The beach is owned by Deer Park Association, which consists of 28 member households. The beach is used primarily for boat launching. The driveway is gated and only members have the lock combination. Daily use rarely exceeds 10 people on any given day. Some members use golf carts to access the beach, a few use cars, and many walk to the site. The beach features an unpaved parking area, a permanent canoe/kayak rack, a sandy beach, and a paved boat ramp. The parking area is located to the north of the driveway. Cars typically park nose-in toward the post and beam fence. The parking area is not heavily used, and neither the driveway nor parking area are maintained during the winter. It appears that sediment-laden runoff from Heritage Rd, an unpaved private way, bypasses catch basins at the intersection with Weed Rd and continues downhill toward the granite steps into Deer Park Beach. Erosion is evident alongside the steps, likely caused both by runoff and pedestrian traffic. Runoff from Weed Rd collects in a shallow swale on the east side of Weed Rd and flows south. This runoff was formerly diverted into a sediment forebay at the top of the slope just north of the access driveway. Due to sediment buildup at the diversion point on Weed Rd, the runoff now continues along Weed Rd to the beach driveway, where it turns the corner and flows down the drive. The driveway frequently erodes. Two deep gullies formed along the driveway during heavy rains in July 2021. Erosion is also evident on the north side of the paved boat ramp and along the sandy beach. Soils at the site are categorized as HSG A, indicating good infiltration capacity.

Proposed Improvements:

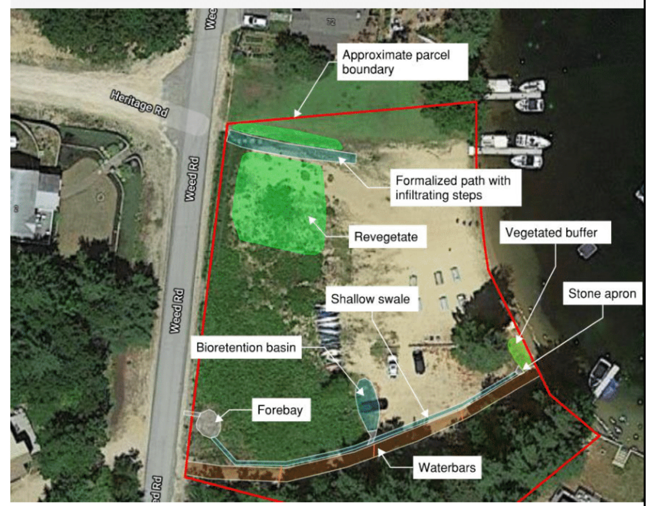
- Improve and formalize the existing footpath opposite Heritage Rd with the addition of infiltrating steps and vegetation. Revegetate the eroded slope using low-maintenance native plants.
- Create terraced landscaping above eroded beach areas to slow and infiltrate runoff from Weed Rd and the steep slope above the beach.
- Improve the existing forebay at the top of slope by removing sediment and stone and installing a concrete paver mat underlain with crushed stone. The concrete paver mat will allow stormwater to pond and infiltrate through the crushed stone, prevent scour erosion, and will make it easier to remove accumulated sediment.
- On the driveway, install waterbars to divert runoff into a swale to the north. The swale will have a turnout at the base of the vegetated slope to divert runoff into an infiltrating forebay and bioretention basin. The basin will include a level-spreader emergency spillway for large storm events.
- At the end of the swale, install a level spreader and stone apron to slow and spread out flows into a restored vegetated buffer. The vegetated buffer will be located downhill from the parking area, between the boat ramp and the tree. It will be planted densely with low-growing plants.

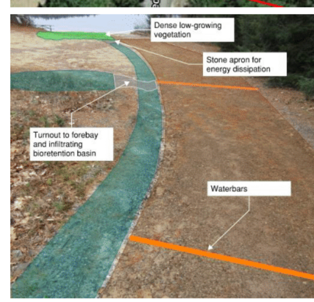
Operation and Maintenance: O&M for the proposed stormwater improvements is anticipated to incur 30 hours annually. O&M includes routine inspections, preventative maintenance, and corrective actions, such as the following:

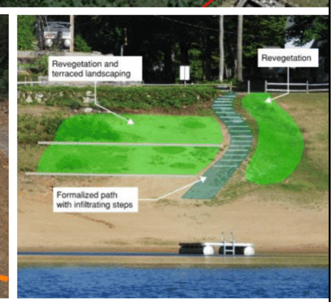
1) Clean out trash, debris, and accumulated sediment from inlets, forebays, bioretention basin, spillway, swale, and infiltrating steps.
2) Maintain vegetation (weeding, replanting, etc.) and water plants during establishment period.
3) Check for erosion within and downstream of stormwater facilities; stabilize areas of erosion, if found.

SITE SUMMARY

Owner: Deer Park Association
Receiving Water: Lake Winnisquam
Estimated Phosphorus Load Reduction: 0.7 kg/year
Estimated Costs: Capital costs: $65,000-$79,000
Annual operation and maintenance costs: $3,000
20-year life cycle cost: $132,000







4) Check for standing water (lack of drainage) in the bioretention basin and infiltrating steps. Investigate and correct clogging if ponded water does not drain within 48 hours following a rain event. If the crushed stone in the infiltration steps become filled with sediment over time, remove the stone, clean out the sediment, and replace.

Operation and maintenance for bioretention systems, as provided in EPA Region 1 (2016) *Methodology for Developing Cost Estimates for Opti-Tool*

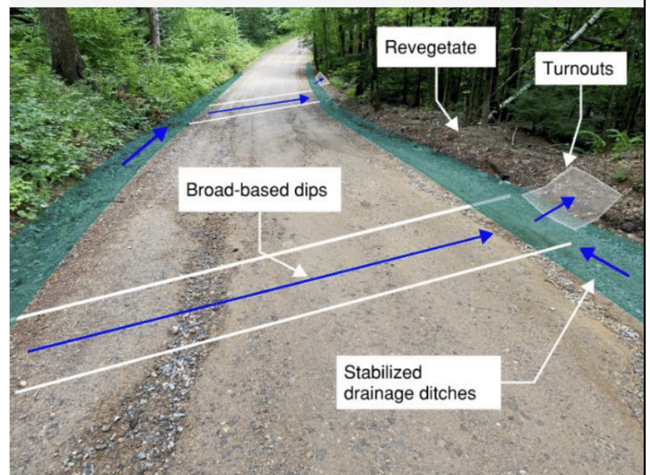
Kaulback Rd, Sanbornton, NH

Erosion along Kaulback Road.

Existing Site Description: The focus area is a 1,100 ft segment of Kaulback Road from the intersection with Roxbury Rd to approximately 500 ft north of the Black Brook crossing. The road is unpaved and has eroding shoulders and ditches on both sides, rills, sediment buildup, and small berms at the road edge caused by road maintenance with graders (aka grader berms). Soils at the site are categorized as HSG A (to the south of Black Brook) and HSG C (to the north).

SITE SUMMARY

Owner: Town of Sanbornton
Receiving Water: Black Brook, tributary to Lake Winnisquam
Estimated Phosphorus Load Reduction: 1.5 kg/year
Estimated Costs: Capital costs: $32,000-$40,000
Annual operation and maintenance costs: $1,500
20-year life cycle cost: $66,000



Proposed Improvements:

- Regrade the road with broad-based dips to break up the drainage area and divert runoff to stabilized ditches and turnouts into the downgradient forest.
- Create shallow drainage ditches/swales on both sides of the road, with stabilized turnouts. Along the steeper section to the north (> 5% slope), install stone check dams in the ditches to reduce flow velocity. Remove grader berms and revegetate shoulders where needed.
- Divert runoff into the forest via turnouts before it reaches the Black Brook crossing. Restore eroded areas at the stream crossing. Where runoff cannot be diverted before reaching the crossing, install sediment forebay(s) to settle out sediment and to slow and spread out flows.

Operation and Maintenance:

In addition to typical maintenance for unpaved roads (which typically includes annual or more frequent grading, removal of sediment from turnouts and periodic correction of eroded areas), O&M for the proposed stormwater improvements is anticipated to incur 15 hours annually. O&M includes routine inspections, preventative maintenance, and corrective actions, such as the following:

1) Clean out trash, debris, and accumulated sediment from check dams, ditches, and sediment forebays.
2) Inspection and backfilling of edges of broad-based dips where erosion has occurred. Broad-based dips made of concrete are most effective and long lasting; other materials typically require more frequent maintenance.
3) In restoration areas, water plants during establishment period.

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, stream restoration, zoning and ordinance updates, land conservation, septic system regulation, fertilizer use prohibition, proper agricultural practices, pet waste management, 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 “Kaulback Rd, Sanbornton, NH” conceptual design (Section 4.1.2) and the *New Hampshire Stormwater Manual* (NHDES, 2008) for standard road design and maintenance best practices.

Even though none of the seven watershed municipalities are required to comply with the six minimum control measures under the New Hampshire Small MS4 General Permit, each municipality could consider instituting the permit’s key measures, such as street sweeping, catch basin cleaning, and road/ditch maintenance. 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.

Each municipality employs the following best practices:

- In New Hampton, the DPW inspects (and cleans, as needed) stormwater outfalls and culverts regularly mostly in the spring and summer. Street sweeping is conducted once in the spring. No landscaping material is disposed of from municipal lands except leaves at the transfer station. The Town uses both sand and salt for winter road maintenance (salt is kept in an enclosed facility). LRPC assisted the Town with a culvert inventory that the Town uses to prioritize work. The Town maintains, monitors, and regrades as needed 26 miles of gravel roads.
- In Meredith, street sweeping occurs every spring. Catchbasins are inspected and cleaned once per year. The Town uses an ice control protocol to determine whether sand and/or salt is needed for winter road maintenance. Culverts are inspected regularly. The Town maintains 36 miles of gravel roads.
- In Laconia, cleaning and inspecting of stormwater infrastructure is completed on an as-needed basis. Street sweeping is conducted about three times in the summer. Any landscaping material/leaves are brought to Gilford for composting. The City typically uses sand with some salt on gravel roads and largely salt on paved roads for winter road maintenance practices, depending on the storm type and severity. There is no City-wide culvert inventory for prioritized replacement. The City maintains about 5 miles of gravel roads, which are regraded multiple times per year, especially following heavy rain events. For road maintenance, the City digs out ditches and applies a seed mix.
- In Sanbornton, catchbasins are inspected once per year and cleaned as needed. There is no street sweeping. Sand is used on gravel roads and salt/sand is used on paved roads in the winter. The Town maintains 40 miles of gravel roads, which are regraded twice per year. Huse Rd is their most problematic gravel road because it washes out frequently.
- In Tilton, catch basins and culverts are cleaned 4-5 times per year and inspected twice per year. Street sweeping occurs once in the spring. Landscaping/leaf/grass clippings are composted at the dump. Salt and sand are both used for winter road maintenance, and the salt is stored in a covered garage. There is no formal culvert inventory for the Town. The Town does not maintain any gravel roads.
- In Belmont, an outside engineering firm assists the Town with prioritizing and replacing culverts. The Town uses both salt and sand on roads for winter road maintenance. Gravel roads are maintained as needed and are usually regraded in spring each year.
- In Gilford, catch basin cleaning occurs once each year, and culverts are inspected as needed or as part of road projects. Street sweeping is conducted every spring. Landscaping material is brought to Gilford for composting. Salt is mainly used for winter maintenance on paved roads. The Town uses a magnesium chloride solution sprayed on the salt to work faster and better at lower temperatures. DPW drivers have indicated that they are using half the salt they usually do with this new system. Sand is used for winter maintenance on unpaved roads. Salt is stored inside a

building. The Town does not currently have a culvert inventory but plans to complete one in the future. Culverts were last inspected in 2016. The Town maintains three gravel roads and plans to pave them all within the next five years.

4.2.2 Stream Restoration

Ecosystem restoration, such as buffer and wetland enhancement, stream restoration, and floodplain reconnection are also management practices that can provide nutrient and sediment reduction benefits. Large wood in streams is important for natural function of the stream and reduces water velocity, traps sediment, and creates habitat for Eastern brook trout and other aquatic species. BCCD with Trout Unlimited completed a one mile stream restoration project (felling large woody material) in Black Brook in August 2021. This work was funded by a National Fish and Wildlife Foundation grant and Demonstration Project funding through the NHACC.

The felling of large woody material was completed in a one mile segment of Black Brook as part of a stream habitat restoration project in 2021 by the BCCD and Trout Unlimited.

4.2.3 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, in most lake watersheds, local land use planning and zoning ordinances can be the most critical components of watershed protection strategies.

WWN completed a preliminary ordinance review of natural resource protections for the seven municipalities in the Lake Winnisquam watershed (Table 14). Many of these municipalities have already incorporated into their ordinances important regulations for shoreland protection, cluster and open space development, LID standards, erosion control, and steep slopes. A more robust review of these ordinances is encouraged for municipal-specific recommendations for improving ordinances and regulations related to natural resource protection. Each municipality should also consider its staffing capacity to enforce existing and proposed regulations.

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

- **Installing Green Infrastructure and Nature-Based Solutions:** Planning for greener infrastructure requires that we think about creating a network of interconnected natural areas and open spaces needed for groundwater recharge, pollution mitigation, reduced runoff and erosion, and improved air quality. Examples of green infrastructure include forest, wetlands, natural areas, riparian (banks of a water course) buffers, and floodplains; all of which already exist to various extents in the watershed and have minimized the damage created by intense storms. As future development occurs, these natural barriers must be maintained or even increased to reduce runoff of pollutants into freshwaters. See also Section 4.2.4: 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 of 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, floodplains should be expanded to increase the land area to accommodate larger rainfall events. Riparian (vegetated) buffers and filter strips along waterways should be preserved and/or created to slow runoff and filter pollutants.
- **Protecting and Re-establishing Wetlands:** Wetlands are increasingly important for preservation because wetlands hold water, reduce flooding, recharge groundwater, and mitigate water pollution.
- **Encouraging Tree Planting:** Trees help manage stormwater by reducing runoff and mitigating erosion along surface waters. Trees also provide critical shading and cooling to streams and land surfaces.
- **Promoting Landscaping Using Native Vegetation:** Landowners should promote the use of native vegetation in landscaping, and landscapers should become familiar with techniques which minimize runoff and the discharge of nutrients into waterbodies (Chase-Rowell et al., 2012).
- **Slowing Down the Flow of Stormwater:** To slow and infiltrate stormwater runoff, roadside ditches can be armored or vegetated and equipped with turnouts, settling basins, check dams, or infiltration catch basins. Rain gardens can retain stormwater, while waterbars can divert water into vegetated areas for infiltration. Water running off roofs can be channeled into infiltration fields and drainage trenches.
- **Coordinating Infrastructure, Housing, and Transportation Planning**: Coordinate planning for infrastructure, housing, and transportation to minimize impacts on natural resources. Critical resources including groundwater must be conserved and remain free of pollutants especially as future droughts may deplete groundwater supplies.

Table 14. Ordinance review summary of regulatory and non-regulatory tools for natural resource protection for the seven watershed municipalities of the Lake Winnisquam watershed.

	STRATEGY	MEREDITH	LACONIA	GILFORD	BELMONT	TILTON	SANBORNTON	NEW HAMPTON
Regulatory Tools	**Shoreland Zoning**	Zoning Ord. Art.V,D.4, Shoreline District - setbacks from high water mark on shorefront properties	Zoning Ord. Art. IV, Sec. 235-19, Shoreland Protection District	Zoning Ord. Art. 2, 2.4, Island and Shore Frontage Dist.	Zoning Ord. Art.8.D, Shorefront Development	Zoning Regs. Art. VII, App. C, Dimensional Regs., ref. NH Shoreland Protection Act	Zoning Ord. Art. 14, Shorefront District	
	Cluster development and/or open space provisions for subdivisions	Zoning Ord. Art. XXI, Conservation Subdivision Design - requires 50% of tract to remain as Open Space	Zoning Ord. Art. VII, Sec. 235-40.B, Cluster Development - 50% of buildable area required as Open Space	Zoning Ord. Art. 11, 4.4.3, Cluster Development, 4.4, Planned Unit Development	Zoning Ord. Art.6, Open Space Residential Development	Subdivision Regs. Amendment, Cluster Residential Development (pg. 61)	Zoning Ord. Art.4.T, Cluster Development Zoning, 50% of tract req. as Open Space	Subd. Regs. Section VII.C, Cluster Dev., tracts >20 AC
	Septic Regulations	Zoning Ord. Art. V, D.9, Water Resources Conservation Overlay District, D.10, Lake Waukewan Watershed Overlay District - leach field setbacks	Zoning Ord. Art.IV, Sec. 235-17.J., Sec. 235-19.E	Zoning Ord. Art. 6.9, Sanitary Regs.		Zoning Regs. Art. XIV.14.4.1	Zoning Ord. Art. 4.H, Art. 14.C.3, Art. 15	Zoning Ord. Art.V.C, Sewage Disposal
	Zoning Districts that address environmental protection	Zoning Ord. Art. V, D.1, D.2, D.4, D.9, D.10, Art. XIV	Zoning Ord. Art. IV, Sec. 235-17, Sec. 235-19, Sec. 235-44, Site Plan Review Regs.	Zoning Ord. Art. 2, 2.2, 2.4, Art. 19, Aquifer Protection District, Subd. Regs., Site Plan Regs.	Zoning Ord. Art.7, Aquifer Protection, Wetlands Ordinance, Earth Excavation Regs, Site Plan Regs., Subd. Regs	Zoning Regs., Art.XIV, Wetlands Conservation Dist., Art. XV, Groundwater Protection Dis.	Zoning Ord. Art.7, Forest Conservation Dist., Art. 12, Aquifer Conservation Dist., Art. 13, Floodplain Conservation Dist., Art. 14, Shorefront Dist., Art. 15, Wetlands Conservation Dist.	Zoning Ord. Art.IV.G., Flood Hazard Dist., IV.H. Pemigewasset Overlay Dist., IV.I. Lake Waukewan Overlay Dist.
	Zoning Districts that address wetland conservation	Zoning Ord. Art. V, D.9, Water Resources Conservation Overlay District	Zoning Ord. Art. IV, Sec. 235-17, Wetlands Conservation and Water Quality Overlay District	Zoning Ord. Art. 11, Wetlands District	Wetlands Ordinance	Zoning Regs. Art. XIV, Wetlands Conservation Dist.	Zoning Ord. Art. 15 Wetlands Cons. Dist.	
	Erosion Control Regulations	Zoning Ord., Art.XIV, Erosion and Sediment Control Ordinance	Zoning Ord. Art. I, Sec. 235-44, Erosion and Sediment Control, Subdivision Regs.	Subd. Regs. Sec. VII.A, Sedimentation and Erosion Control	Site Plan Regs., Subdiv. Regs. Earth Excavation Regs.	Subd. Regs. Sec.6.E	Zoning Ord. Art.4.M, Site Plan Regs. Sec.V.E.	
	Zoning Districts that protect groundwater	Zoning Ord., Art. V, D.9, Water Resources Conservation Overlay District	Zoning Ord. Art.IV, Sec. 235-17.J, Wetlands Conservation and Water Quality Overlay District, Sec. 235-22, Water Supply Protection Overlay District	Zoning Ord. Art. 19, Aquifer Protection District	Zoning Ord. Art.7, Aquifer Protection, Wetlands Ord., Earth Excavation Regs., Site Plan Regs., Subd. Regs.	Zoning Regs. Art.XV, Groundwater Protection Dist.	Zoning Ord. Art.4.H, Art. 12, Art. 15.C.3(c),	Zoning Ord. Art. IV.I, Lake Waukewan Overlay Dist.

	STRATEGY	MEREDITH	LACONIA	GILFORD	BELMONT	TILTON	SANBORNTON	NEW HAMPTON
	Protection of steep slopes	Zoning Ord. Art. XXI, Conservation Subdivision Design - slopes>25% considered not buildable	Zoning Ord.Art. VII, Sec. 235-44.2, Steep Slope Protection, Site Plan Review 7.12	Zoning Ord. Art. 5.1.1(e), Sub. Regs Sec. IX.B.9.d.10	Zoning Ord. Art. 6, Site Plan Regs.,Sec. 9.B	Subd. Regs. Sec.6.C	Zoning Ord. Art. 16	
	Nutrient loading analysis required for fresh waterbodies						Site Plan Regs. Sec.V.J.	
	Low impact development requirements and standards	Zoning Ord. Art. XXI	Zoning Ord. Art. VII, Sec. 235-40.B, Cluster Development, Sec. 235-44.2 Steep Slope Protection	Zoning Ord. Art. 11, 4.3, 4.4	Zoning Ord. Art. 6		Zoning Ord. Art. 4.T	Subd. Regs. Sec. VII.C
	Fertilizer and pesticides ordinances		Zoning Ord. Art.IV, Sec. 235-19.D.2	Zoning Ord. Art. 15.5.1			Zoning Ord. Art.12.D	
	Stormwater Management Plan implementation and enforcement	Zoning Ord. Art. XIV, Site Plan Review Regs., Subdivision Regs.	Zoning Ord. Art. VII, Sec. 235-40.B, Cluster Development, Sec. 235-44.2 Steep Slope Protection, Major Site Plan Review, Subdivision Regs.	Zoning Art. 19, Sub. Regs. Sec. VII.A, Sec. IX	Site Plan Regs. Sec.9.E.d, 9.Q, Subd. Regs. Sec.9.D	Zoning Regs. Art. XV.I.8 Groundwater Protection performance standards	Zoning Ord. Art. 4.M, Art. 12.E.2.c, Art. 16	Site Plan Regs. Sec. X.J, Subd. Regs. Sec. VI.C.1, VII.C.G
Non-Regulatory Tools	**Open Space Plan**	Included in Community Plan, 2002	2007 Master Plans mentions Open Space	2016 Master Plan mentions Open Space	2002 Master Plan, Ch. 7	2013 Master Plan mentions Open Space		Completed 2019
	Master Plan addresses natural resources and environmental protection	Yes	Yes	Master Plan 2016 Ch. 5	2002 Master Plan, Ch. 7	2013 Master Plan Sec. 3	2012 Master Plan Sec. III.E	2021 Master Plan references Open Space Plan
	Municipality-wide natural resources inventory	Completed 2005	Completed 2009	Completed 2021	Completed 2007	Completed 2007		
	Incentive-based programs for voluntary low impact development implementation	Zoning Ord. Art. XXI	Zoning Ord. Art.IV, Sec. 235-40.B(6)(e)					

4.2.4 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 management tools for protecting water quality for future generations. About 2,718 acres (7%) of the Lake Winnisquam watershed is currently conserved, and major conserved areas (greater than 100 acres) include the Chemung State Forest, multiple Meredith town forests, the Huston-Morgan State Forest, Ahern State Park, and Prescott State Park (refer to Appendix B, Map B-9). Local groups should continue to pursue opportunities for land conservation in the Lake Winnisquam watershed.

Areas for land conservation can be prioritized based on the highest valued habitat identified by the NHFGD, which often includes riparian areas and wetlands critical to water quality protection. NHFGD 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 Lake Winnisquam watershed is part of the Sebago-Ossipee Hills and Plains ecoregional subsection of the biological region (NHFG, 2015). Over 8,031 acres (39%) of the Lake Winnisquam watershed are considered Highest Ranked Habitat in New Hampshire. This habitat includes Lake Winnisquam and a 200-meter buffer surrounding the lake. A map of priority habitats for conservation based on the Wildlife Action Plan can be found in Appendix B, Map B-10.

4.2.5 Septic System Regulation

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

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

4.2.6 Sanitary Sewer System Inspections

Because a portion of the watershed also relies on a municipal sewer system, it is important for municipalities with sewer to develop a program (if not already in place) to inspect and evaluate their sanitary sewer system and reduce identified leaks and overflows, especially in areas near waterbodies.

4.2.7 Fertilizer Use Prohibition

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

- In Meredith, NH Rule 502.04 requires a permit to apply pesticides or fertilizers (including manure or compost) within 250 feet of surface waters in the Lake Waukewan watershed, unless in strict conformance with the *Manual of Best Management Practices for Agriculture in New Hampshire* (New Hampshire Department of Agriculture, Markets, and Food, 2017).
- In Laconia, no phosphorus-based fertilizers or herbicides/pesticides can be applied within 250 feet of any waterbody in the City.
- In Sanbornton, in the Aquifer Conservation District (areas delineated as having medium-high potential to yield groundwater by the USGS), spraying or spreading of chemical fertilizers or pesticides may be permitted subject to approval of the Zoning Board of Adjustment.
- In Tilton, fertilizers (except for lime and wood ash) cannot be applied within the Wetlands Conservation Overlay District. Fertilizers must be stored within a structure designed to prevent generation and escape of contaminated runoff or leachate in conformance with the *Manual of Best Management Practices for Agriculture in New Hampshire* (New Hampshire Department of Agriculture, Markets, and Food, 2017).
- In Belmont, fertilizers cannot be applied within the Aquifer and Groundwater Protection District. Fertilizers must be stored within a structure designed to prevent generation and escape of contaminated runoff or leachate in conformance with the *Manual of Best Management Practices for Agriculture in New Hampshire* (New Hampshire Department of Agriculture, Markets, and Food, 2017).
- In Gilford, fertilizers cannot be applied within the Aquifer Protection District. Fertilizers must be stored within a structure designed to prevent generation and escape of contaminated runoff or leachate in conformance with the *Manual of Best Management Practices for Agriculture in New Hampshire* (New Hampshire Department of Agriculture, Markets, and Food, 2017). Fertilizer is listed as a household hazardous waste and must be disposed of properly.

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 both small hobby farms and larger-scale operations in the watershed. The 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 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.

4.2.10 Nuisance Wildlife Controls

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

The Oak Hill Golf Course does not employ any large bird deterrents but will have employees drive down to where the geese are congregating and scare them off. The Laconia Country Club & Golf Course had a geese problem in the past and used a herding dog to chase them off. Geese congregation has not been an issue in recent years at the Laconia Country Club & Golf Course, but the Superintendent indicated that they would use a herding dog again if geese became an issue again.

4.3 OUTREACH & EDUCATION

Awareness through education and outreach is a critical tool for 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. WWN is the primary entity for education and outreach campaigns in the watershed and for development and implementation of the plan. WWN and other key watershed protection groups should continue all aspects of their education and outreach strategies and consider developing new ones or improving existing ones to reach more watershed residents. Refer to Section 5: Action Plan. Examples include providing educational materials to existing and new property owners, as well as renters, by distributing them at various locations and through a variety of means, such as websites, newsletters, social media, community events, or community gathering locations. Additionally, WWN should continue to engage with local stakeholders such as BCCD, conservation commissions, land trusts, municipalities, businesses, and landowners. Educational campaigns should include raising awareness of water quality, septic system maintenance, fertilizer and pesticide use, pet waste disposal, waterfowl feeding, invasive aquatic species, boat pollution, shoreline buffer improvements, gravel road maintenance, and stormwater runoff controls.

4.4 ADAPTIVE MANAGEMENT APPROACH

An adaptive management approach, to be employed by a committee, is highly recommended for protecting Lake Winnisquam. 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 the WWN 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 implement this plan. Continued public awareness and outreach campaigns will aid in securing this engagement. Refer to Section 4.3: Outreach & Education.
- **Continuing the Long-Term Monitoring Program.** A water quality monitoring program is necessary to track the health of surface waters in the watershed. Information from the monitoring program will provide feedback on the effectiveness of management practices. Refer to Section 6.4: Monitoring Plan.
- **Establishing Measurable Milestones.** A restoration schedule that includes milestones for measuring restoration actions and monitoring activities in the watershed is critical to the success of the plan. In addition to monitoring, several environmental, social, and programmatic indicators have been identified to measure plan progress. Refer to Section 6.5: Indicators to Measure Progress and Section 2.4: Water Quality Goal & Objectives for interim milestones.

5 ACTION PLAN

5.1 ACTION PLAN

The Action Plan (Table 15) outlines responsible parties, approximate costs[12], 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 2022-2031 and is flexible to allow for new priorities throughout the 10-year implementation period as additional data are acquired.

Table 15. Action Plan for the Lake Winnisquam watershed.

Action Item	Responsible Party	Estimated Cost / Schedule	Potential Funding Sources
Watershed & Shoreline BMPs			
Further investigate sources of turbidity in Hueber Brook. Recommend and implement mitigation measures. Cost assumes stormwater retrofit inventory and stormwater mitigation designs completed along Route 3/11 (no construction costs). **Achieves Objective 1.**	WWN, Belmont	$75K 2022-25	Belmont, CWSRF, Grants (319)
Complete design and construction of mitigation measures at the top 24 high priority sites identified in the watershed survey. Three sites will be remediated through a NHDES 319 Watershed Assistance Grant (2022-23) awarded to WWN. **Achieves 11% (29 kg/yr P of 260 kg/yr P) of Objective 3.**	WWN, BCCD, Municipalities, private landowners	$400K-$800K 2022-27	CWSRF, Grants (319, Moose Plate, NFWF 5-Star, ILFP), Municipalities, private landowners
Complete design and construction of mitigation measures at 84 medium and low priority sites identified in the watershed survey as opportunities arise (refer to Appendix C for complete list). **Achieves 9% (24 kg/yr P of 260 kg/yr P) of Objective 3.**	WWN, BCCD, Municipalities, private landowners	$100K-$200K 2022-31	CWSRF, Grants (319, Moose Plate, NFWF 5-Star, ILFP), Municipalities, private landowners
Within the Black Brook sub-watershed, implement unpaved road erosion control measures recommended in Lang (2021) and FBE (2022).	WWN, BCCD, Municipalities	TBD 2022-27	CWSRF, Municipalities, Grants (Moose Plate, NFWF 5-Star)
Promote the LakeSmart program evaluations and certifications through NH Lakes to educate property owners about lake-friendly practices such as revegetating shoreline buffers with native plants, avoiding large grassy areas, and increasing mower blade heights to 4 inches. Coordinate with NHDES Soak Up the Rain NH program for workshops and trainings. Cost assumes coordination of and materials for up to 10 workshops.	WWN, BCCD, NH Lakes, NHDES Soak Up the Rain NH, Municipalities	$10K 2022-31	NH Lakes, NHDES Soak Up the Rain NH, Grants (319, Moose plate), CWSRF, Municipalities

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

Action Item	Responsible Party	Estimated Cost / Schedule	Potential Funding Sources
Provide technical assistance and/or implementation cost sharing to watershed/shoreline property owners to install stormwater and/or erosion controls such as rain gardens and buffer plantings. Prioritize high impact properties identified during the shoreline survey. Cost assumes technical assistance and implementation cost sharing provided to the 20 high impact shoreline properties. **Achieves 8% (20 kg/yr P of 260 kg/yr P) of Objective 3.**	WWN, BCCD, Municipalities	$200K 2022-25	Grants (319, Moose plate), CWSRF
Implement stormwater and erosion controls on watershed/shoreline properties. Prioritize medium impact properties identified during the shoreline survey. Cost assumes landowner implementation costs (budget: $3K each) for 282 medium impact shoreline properties. **Achieves 16% (41 kg/yr P of 260 kg/yr P) of Objective 3.**	Landowners	$850K 2022-31	Landowners
Conduct a shoreline survey for Lake Wicwas and Lake Opechee. Use the results to target education and technical assistance for high impact sites. Cost assumes hired technical review and summation of shoreline survey results. Surveys to be performed by volunteers.	WWN, LWA, LOPA, Municipalities	$5K 2025	Municipalities, Grants (Moose plate), CWSRF
Repeat the shoreline surveys in 5-10 years when updating the WBP. Use the results to target education and technical assistance for high impact sites. Cost assumes hired technical review and summation of shoreline survey results. Surveys to be performed by volunteers.	WWN, Municipalities	$8K 2025, 2030	Municipalities, Grants (Moose plate), CWSRF
Road Management			
Review practices for road and drainage maintenance currently used for each municipality and road association and determine areas for improvement.	Municipalities, WWN, BCCD	$10K 2023	CWSRF, Municipalities, Grants (Moose Plate, NFWF 5-Star)
Develop and/or update a written protocol for road maintenance best practices.	Municipalities, WWN, BCCD	$20K 2023	CWSRF, Municipalities, Grants (Moose Plate, NFWF 5-Star)
Provide education and training to contractors and municipal staff on protocols for road maintenance best practices. Cost assumes one workshop for all seven municipalities.	Municipalities, WWN, BCCD	$15K 2024	CWSRF, Municipalities, Grants (Moose Plate, NFWF 5-Star)
Incorporate water quality considerations and strategies into roadway evaluations and action plans (e.g., Sanbornton Roadway Evaluation[13]).	Municipalities, WWN, BCCD	N/A 2022-31	Municipalities
Establish inspection and maintenance agreements for private unpaved roads. Cost does not include the implementation of proper road maintenance by private landowners and assumes that municipalities can accommodate this additional effort in current budgets.	Municipalities, private landowners	N/A 2022-31	Municipalities, private landowners

[13] https://www.sanborntonnh.org/sites/g/files/vyhlif3776/f/uploads/sanbornton_roadway_evaluation_-_summary_report_and_final_documentation_0.pdf

Action Item	Responsible Party	Estimated Cost / Schedule	Potential Funding Sources
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.	WWN, BCCD, Municipalities, private landowners	$10K 2022-31	CWSRF, Municipalities, Grants (Moose Plate, NFWF 5-Star), private landowners
Municipal Operations			
Review and optimize MS4 compliance for all municipalities (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 2022-31	Municipalities
Participate in Green SnowPro training. Become Green SnowPro Certified once program rules for municipalities have been adopted by the Joint Legislative Committee on Administrative Rules.	Municipalities (Public Works/Highway)	Est. $150-$250/person 2022-31	Municipalities
Review and update winter operations procedures to be consistent with Green SnowPro best management practices for winter road, parking lot, and sidewalk maintenance.	Municipalities (Public Works/Highway)	N/A 2023	Municipalities
In Sanbornton, Belmont, and Gilford, 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 2022-25	Municipalities
For Sanbornton, Belmont, and Tilton, adopt a program to accept residential yard waste at respective transfer stations for composting. (Other municipalities currently accept yard waste for no fee.)	Municipalities (Public Works/Highway)	TBD 2022-25	Municipalities
Develop best practice design standards for stormwater control measures, including deep sump catch basins.	Municipalities (Public Works/Highway)	N/A 2023	Municipalities
Municipal Land Use Planning & Zoning			
Present WBP recommendations to Select Boards/City Council and Planning Boards in Meredith, Laconia, Gilford, Belmont, Tilton, Sanbornton, and New Hampton.	WWN	$3K 2022	Grants (319), CWSRF
Meet with municipal staff to review recommendations to improve or develop ordinances addressing setbacks, buffers, lot coverage, low impact development, and open space.	WWN, Municipalities	$7K 2022-25	Municipalities, Grants (319), CWSRF
Incorporate WBP recommendations into municipal master plans and encourage regular review of the WBP action plan.	Municipalities	N/A 2022-25	Municipalities

Action Item	Responsible Party	Estimated Cost / Schedule	Potential Funding Sources
Adopt/strengthen zoning ordinance provisions and enforcement mechanisms: 1) to promote low impact development practices; 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 2022-31	Municipalities
Increase municipal staff capacity for inspections and enforcement of stormwater regulations on public and private lands.	Municipalities	TBD 2022-31	Municipalities
Update the New Hampton portion of the watershed in the build-out analysis to better reflect current zoning standards. New Hampton's zoning standards adjust allowable lot size by slope and drainage conditions that were not fully reflected in the 2021 build-out analysis.	WWN, New Hampton	$3K 2022-25	Grants, CWSRF, New Hampton
Land Conservation			
Conduct a Natural Resources Inventory (NRI) in Sanbornton. Update the NRIs from 2007 in Belmont and Tilton. (Meredith, Laconia, Gilford, and New Hampton have recent NRIs).	Municipalities, Conservation Commissions	$8-16K per municipality 2022-25	Municipalities, Grants (NFWF NEFRG), CWSRF
Create a priority list of watershed areas that need protection based on NRIs. Refer to Section 4.2.4 to understand current conservation lands and valuable habitats and wildlife in the watershed that can be used to help identify potential areas to target for conservation.	WWN, Municipalities, Conservation Commissions, Lakes Region Conservation Trust or other local land trusts	$4-8K 2022-25	Grants (NFWF NEFRG, NAWCA), CWSRF, Municipalities
Identify potential conservation buyers and property owners interested in easements within the watershed. Use available funding mechanisms, such as the Regional Conservation Partnership Program (RCPP) and the Land and Community Heritage Investment Program (LCHIP), to provide conservation assistance to landowners.	WWN, Municipalities, Conservation Commissions, Lakes Region Conservation Trust or other local land trusts	N/A 2022-25	Grants (Moose Plate, LCHIP, RCCP, NAWCA, LWCF, ACEP, CSP, EQIP)

Action Item	Responsible Party	Estimated Cost / Schedule	Potential Funding Sources
Maximize conservation of intact forest and other ecologically important properties though education, zoning, and public or private conservation.	WWN, Municipalities, Conservation Commissions, Lakes Region Conservation Trust or other local land trusts, private landowners	TBD 2022-31	Grants (Moose Plate, LCHIP, RCCP, NAWCA, LWCF, ACEP, CSP, EQIP, NFWF NEFRG), Municipalities, private landowners
Septic System Management			
Distribute educational materials to property owners about septic system function and maintenance.	Municipalities, WWN	$7K 2022, 2027, 2031	Municipalities, Grant (319), CWSRF
Look into whether any septic pumping companies would give a quantity discount or a discount to members to incentivize septic system pumping.	WWN	N/A 2022-25	Grants
Evaluate locations of older and/or noncompliant septic systems to identify clusters where conversion to community septic systems might be desirable.	WWN, Municipalities	TBD 2022-25	Grants, CWSRF, Municipalities
Require 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. Consider modeling an ordinance on Meredith's septic system regulations pertaining to the Lake Waukewan watershed.	Municipalities	N/A 2022-31	Municipalities
Develop and maintain a septic system database for the watershed to facilitate code enforcement of any septic system ordinances.	Municipalities	$5-10K per municipality 2022-25	Municipalities, Grants, CWSRF
Institute a minimum pump-out/inspection interval for shorefront septic systems (e.g., once every 3-5 years). Require cesspools to be pumped every 1-2 years. Pump-outs (~$250 per system) are the responsibility of the owner.	Municipalities	N/A 2022-25	Municipalities
If not already in place, develop a program to evaluate the sanitary sewer system and reduce leaks and overflows, especially in the areas near waterbodies. Include periodic inspections of the sewer line.	Municipalities	N/A 2022-31	Municipalities
Agricultural Practices			
Work with NRCS to implement soil conservation practices such as cover crops, no-till methods, and others which reduce erosion and nutrient pollution to surface waters from agricultural fields.	NRCS, farm owners	TBD 2022-31	Grants, NRCS
Education & Outreach			
Share additional/dynamic information on the WWN website, such as water quality data, weather conditions, and webcam, to generate more traffic to the website.	WWN	TBD 2022-25	Grants

Action Item	Responsible Party	Estimated Cost / Schedule	Potential Funding Sources
Educate managers of private boat launches about invasive species management, in addition to the existing lake host program that operates at public boat launches.	WWN	$10K 2022-25	Grants (NHDES AIPC)
Offer workshops for landowners with 10 acres or more for NRCS assistance with land conservation. Cost assumes up to two workshops.	WWN	$5K 2022-25	Grants (RCCP, ACEP, CSP, EQIP)
Encourage private property owners to hire Green SnowPro certified commercial salt applicators.	WWN, BCCD, Municipalities	N/A 2022-31	Grants, Municipalities
Educate contractors and municipal staff about erosion and sediment control practices required on plans. Work with municipalities to ensure that there are sufficient resources to enforce permitting conditions.	Municipalities, WWN, BCCD	$10K 2022-25	Municipalities, Grants (319), CWSRF
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, WWN, BCCD	$50K-$100K 2022-31	Municipalities, Grants (319), CWSRF
Collaborate with NH Lakes on legislative or advocacy issues such as cyanobacteria, septic systems, and wake boat impacts.	WWN, NH Lakes	N/A, 2022-31	Grants

5.2 POLLUTANT LOAD REDUCTIONS

To meet the water quality goal and state water quality standards for oligotrophic waterbodies, Objective 3 set a target phosphorus load reduction of 260 kg/yr to achieve an in-lake total phosphorus concentration of 7.2 ppb at Lake Winnisquam Pot Island Deep Spot [WINPLACD]. The following opportunities for phosphorus load reductions to achieve Objective 3 were identified in the watershed based on field and desktop analyses:

- Remediating the over 100 watershed survey sites could prevent up to **53 kg/yr** of phosphorus load from entering Lake Winnisquam.
- Treating shoreline sites could reduce the phosphorus load to Lake Winnisquam by **20 kg/yr** for the 20 high impact sites (disturbance score 11+) and by **41 kg/yr** for the 282 medium impact sites (disturbance score between 7-10) identified from the shoreline survey.
- Upgrading the 198 shorefront septic systems older than 25 years is estimated to reduce the phosphorus load to Lake Winnisquam by **29 kg/yr**.

Addressing these field-identified phosphorus load reduction opportunities (i.e., watershed and shoreline sites and shorefront septic systems) could reduce the phosphorus load to Lake Winnisquam by 143 kg/yr, meeting about half of the estimated 260 kg/yr phosphorus load reductions needed to achieve Objective 3 (Table 16). Because Lake Winnisquam is considered a Tier 2 High Quality Water, additional phosphorus load reductions to fully achieve Objective 3 may not be necessary and should be re-evaluated after 5-10 years of plan implementation.

Objective 2 (preventing or offsetting additional phosphorus loading from anticipated new development) can be met through ordinance revisions that implement LID strategies 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, and heavy metals (cadmium, nickel, zinc, etc.). Without a monitoring program in place to measure these other pollutants, it will be difficult to track the success of efforts that reduce these other pollutants. However, there are various spreadsheet models available that can estimate reductions in these pollutants depending on the types of BMPs installed. These reductions can be tracked to help assess long-term response.

Table 16. Breakdown of phosphorus load sources to Lake Winnisquam and modeled water quality for current and target conditions that meet the water quality goal (Objective 3) for Lake Winnisquam and that reflect all field identified reduction opportunities in the watershed. Reduction percentages are based out of the current condition value for each parameter.

			WQ Goal & Estimated Reduction Needed		Field Identified Reduction Opportunities	
Parameter	**Unit**	**Current Condition**	**Target Condition**	**Reduction (Unit, %)**	**Target Condition**	**Reduction (Unit, %)**
Total P Load (All Sources)[3]	kg/yr	7,455	7,195	-260 (4%)	7,312	-143 (2%)
(A) Background P Load[1]	kg/yr	1,385	1,385	0 (0%)	1,385	0 (0%)
(B) Disturbed (Human) P Load[2]	kg/yr	6,070	5,810	-260 (4%)	5,927	-143 (2%)
(C) Developed Land Use P Load	kg/yr	5,871	5,640	-231 (4%)	5,757	-114 (2%)
(D) Septic System P Load	kg/yr	86	57	-29 (34%)	57	-29 (34%)
(E) Internal P Load	kg/yr	113	113	0 (0%)	113	0 (0%)
In-Lake TP*	ppb	7.5	7.2	-0.3 (4%)	7.4	-0.1 (1%)
In-Lake Chl-a*	ppb	1.7	1.6	-0.1 (6%)	1.6	-0.1 (6%)
In-Lake SDT*	meters	7.7	8.0	+0.3 (NA)	7.9	+0.2 (NA)
In-Lake Bloom Probability*	days	0	0	0 (0%)	0	0 (0%)

[1] Sum of forested/water/natural land use load, waterfowl load, and atmospheric load (i.e., pre-development load)
[2] Sum of developed land use load (including additional atmospheric load), shorefront septic system load, and internal load (B = C+D+E)
[3] Total P Load (All Sources) = A + B
** Water quality parameters were sourced from the model, but total phosphorus and chlorophyll-a were adjusted to match the Assimilative Capacity analysis (which uses a slightly different time period for averaging data).*

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 WWN with assistance from a diverse stakeholder group, including representatives from the municipalities (e.g., select boards, planning boards, and conservation commissions), state and federal agencies or organizations, nonprofits, land trusts, schools and community groups, local business leaders, and landowners. WWN 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 WWN.

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

- **WWN** will be responsible for plan oversight and implementation. WWN will conduct 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 (Section 5). Each municipality will likely have a unique response or implementation approach to the recommendations in the Action Plan (Section 5), and thus, the execution of the actions may take a decentralized path. WWN and other local groups can work with each municipality to provide support in reviewing and tailoring the recommendations to fit the specific needs of each community.
- **Conservation Commissions** will work with municipal staff and boards to facilitate the implementation of the recommended actions specified in the Action Plan (Section 5).
- **BCCD** will provide administrative capacity and help acquire grant funding for BMP implementation projects and education/outreach to watershed residents and municipalities.
- **NHDES** will 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 Lake Winnisquam to meet the water quality goal and objectives set in Section 2.4 will be dependent on available funding and labor resources but will include approaches that address sources of phosphorus loading, as well as water quality monitoring and education and outreach. Additional significant but difficult to quantify strategies for reducing phosphorus loading to the lake are revising local ordinances such as setting LID requirements on new construction, identifying and replacing malfunctioning septic systems, performing proper road maintenance, and improving agricultural practices (refer to Section 5: Action Plan for more details). With a dedicated stakeholder group in place and with the help of grant or local funding, it is possible to achieve the target phosphorus reductions and meet the established water quality goal for Lake Winnisquam in the next 10 years. **The cost of successfully implementing the plan is estimated**

at $2.1-$3.2 million over the next 10 or more years (Table 17). However, many costs are still unknown or were roughly estimated and should be updated as information becomes available. In addition, costs to private landowners (e.g., septic system upgrades, private road maintenance, etc.) are not reflected in the estimate.

Table 17. Estimated pollutant reduction (TP) in kg/year and estimated total and annual 10-year costs for implementation of the Action Plan (Section 5) to meet the water quality goal and objectives for Lake Winnisquam. 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	**114**	$1,648,000-$2,148,000	$164,800-$214,800
Road Management	TBD	$55,000	$5,500
Municipal Operations	TBD	TBD	TBD
Municipal Land Use Planning & Zoning	**281***	$13,000	$1,300
Land Conservation		$12,000-$24,000	$1,200-$2,400
Septic System Management	**29**	$42,000-$77,000	$4,200-$7,700
Agricultural Practices	TBD	TBD	TBD
Education & Outreach	TBD	$75,000-$125,000	$7,500-$12,500
Monitoring	NA	$250,0000-$750,000	$25,000-$75,000
Total	**424**	**$2,095,000-$3,192,000**	**$209,500-$319,200**

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

6.3 FUNDING STRATEGIES

It is important that WWN 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 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 WWN with future water quality and watershed work on Lake Winnisquam.

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 2014) 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. https://www.des.nh.gov/business-and-community/loans-and-grants/watershed-assistance
- **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 $24,000. https://www.mooseplate.com/grants/
- **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. https://www.lchip.org/index.php/for-applicants/general-overview-schedule-eligibility-and-application-process
- **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. https://www.des.nh.gov/climate-and-sustainability/conservation-mitigation-and-restoration/wetlands-mitigation

- **New England Forest and River Grant (NFWF NEFRG)**– This grant awards $50,000 to $200,000 to projects that restore and sustain healthy forests and rivers through habitat restoration, fish barrier removal, and stream connectivity such as culvert upgrades. https://www.nfwf.org/newengland/Pages/home.aspx
- **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. https://www.des.nh.gov/business-and-community/loans-and-grants/rivers-and-lakes
- **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. https://www.des.nh.gov/business-and-community/loans-and-grants/clean-water-state-revolving-fund
- **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. https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/rcpp/
- **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. https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/easements/acep/
- **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. https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/csp/
- **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. https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/eqip/
- **National Fish and Wildlife Federation (NFWF) Five Star and Urban Waters Restoration Grants (NFWF 5-Star) -** Grants seek to address water quality issues in priority watersheds, such as erosion due to unstable streambanks, pollution from stormwater runoff, and degraded shorelines caused by development. Eligible projects include wetland, riparian, in-stream and/or coastal habitat restoration; design and construction of green infrastructure BMPs; water quality monitoring/assessment; outreach and education. https://www.nfwf.org/programs/five-star-and-urban-waters-restoration-grant-program
- **North American Wetlands Conservation Act (NAWCA) Grants -** The U.S. Standard Grants Program is a competitive, matching grants program that supports public-private partnerships carrying out projects in the United States that further the goals of the North American Wetlands Conservation Act (NAWCA). These projects must involve long-term protection, restoration, and/or enhancement of wetlands and associated uplands habitats for the benefit of all wetlands-associated migratory birds. https://www.fws.gov/service/north-american-wetlands-conservation-act-nawca-grants-us-standard
- **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. https://www.nhstateparks.org/about-us/community-recreation/land-water-conservation-fund-grant

6.4 MONITORING PLAN

A long-term water quality monitoring plan is critical to evaluate the effectiveness of implementation efforts over time. WWN, in concert with VLAP and LLMP, has implemented the Lake Winnisquam Tiered Monitoring Plan since 2017 and should continue the following annual monitoring protocol:

- VLAP monitors three deep spot stations in Lake Winnisquam (Three Island, Pot Island, and Mohawk Island) and LLMP monitors two nearshore stations in Lake Winnisquam (10 Waldron and 30 Bartlett), three to five times each summer for total phosphorus (epilimnion, metalimnion, and hypolimnion), chlorophyll-a (composite or epilimnion), Secchi disk transparency, and dissolved oxygen-temperature-conductivity profiles.
    - Ensure that dissolved oxygen-temperature profiles are being collected concurrently with sampling of lake deep spot stations.
    - Work with LOPA to consider monitoring the same parameters at the same frequency at the Lake Opechee deep spot.
- VLAP also monitors the deep spot, west cove, east cove, and the Route 104 inlet to Lake Wicwas once each year for total phosphorus, chlorophyll-a, Secchi disk transparency, and/or dissolved oxygen-temperature-conductivity profiles.
    - Work with Lake Wicwas Association to consider increasing the sampling frequency to at least three times per summer.
- Volunteers collect additional Secchi disk transparency readings at the three deep spot stations in Lake Winnisquam throughout the summer season (ideally every other week).
    - Consider collecting Secchi disk transparency readings every other week in summer at the deep spot stations for Lake Wicwas and Lake Opechee.
- WWN through VRAP monitors total phosphorus and chloride in nine tributary or outlet stations in the watershed, two to five times per year each summer. Stations include Black Brook, Winnipesaukee River inlet to the lake, Lake Wicwas outlet, Durkee Brook, Collins Brook, two branches of Chapman Brook, Durgin Brook, and the outlet of Lake Winnisquam.
    - Consider adding Mill Brook (WINTLACM), Hueber Brook, and Jewett Brook. Measure turbidity at Hueber Brook and total phosphorus at all three streams. Mill Brook (WINTLACM) is located at its outlet to Lake Winnisquam and would be helpful for calibration during future model updates.
    - Consider monitoring the same parameters at the same frequency at major inflows to Lake Opechee, especially the inflow from the Winnipesaukee River to Lake Opechee.
    - Consider collecting flow measurements or estimates concurrently with grab samples at all tributary stations for better calculation of nutrient loading.

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 Lake Winnisquam watershed (Table 18). These benchmarks represent short-term (2023), mid-term (2026), and long-term (2031) 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. WWN 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 18. Environmental, programmatic, and social indicators for the Lake Winnisquam Watershed-Based Plan. Environmental indicator milestones determined from Assimilative Capacity Analysis in Section 2.2 and FBE (2021a). Programmatic and social indicator milestones estimated from best professional judgement.

Indicators	Milestones*		
	2023	2026	2031
ENVIRONMENTAL INDICATORS			
Achieve an in-stream (Hueber Brook) and in-lake (Lake Winnisquam) turbidity concentration < 10 NTU	10 NTU+	< 10 NTU	<10 NTU
Maintain or achieve an average summer deep spot epilimnion total phosphorus concentration of 7.2 ppb at the deep spot stations in Lake Winnisquam and Lake Opechee (as well as Lake Wicwas despite being beholden to only the mesotrophic threshold of 11.6 ppb for total phosphorus)	<7.2 ppb	<7.2 ppb	<7.2 ppb
Maintain an average summer deep spot epilimnion chlorophyll-a concentration of less than 3.0 ppb at the deep spot stations in Lake Winnisquam and Lake Opechee	<3.0 ppb	<3.0 ppb	<3.0 ppb
Maintain an average summer deep spot epilimnion chlorophyll-a concentration of less than 4.8 ppb at the deep spot station in Lake Wicwas	<4.8 ppb	<4.8 ppb	<4.8 ppb
Eliminate the occurrence of cyanobacteria or algal blooms in Lake Winnisquam, Lake Opechee, and Lake Wicwas (milestones based on model results)	0-2 day/yr	0-2 day/yr	0 days/yr
Maintain an average summer water clarity of 7 m or deeper at the deep spot stations in Lake Winnisquam and Lake Opechee	7 m+	7 m+	7 m+
Achieve an average summer water clarity of 5 m or deeper at the deep spot station in Lake Wicwas	4.2 m	4.5 m	5.0 m
Prevent and/or control the introduction and/or proliferation of invasive aquatic species all waterbodies	Absence of invasives	Absence of invasives	Absence of invasives
PROGRAMMATIC INDICATORS			
Amount of funding secured from municipal/private work, fundraisers, donations, and grants	$500,000	$1,500,000	$3,000,000
Number of NPS sites remediated (108 identified)	10	25	75
Linear feet of buffers improved in the shoreland zone	500	1,000	2,000
Percentage of shorefront properties with LakeSmart certification	25%	50%	75%
Number of watershed/shoreline properties receiving technical assistance for implementation cost sharing	5	25	50
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	5	10
Number of new municipal staff for inspections and enforcement of regulations	1	3	5
Number of voluntary or required septic system inspections (seasonal conversion and property transfer)	5	25	50
Number of septic system upgrades	5	25	50
Number of informational workshops and/or trainings for landowners, municipal staff, and/or developers/landscapers on local ordinances, watershed goals, and/or best practices for road management and winter maintenance	2	10	20
Number of parcels with new conservation easements or number of parcels put into permanent conservation	2	5	15

Indicators	**Milestones***		
	2023	**2026**	**2031**
Number of copies of watershed-based educational materials distributed or articles published	500	750	1,000
Number of new best practices for road management and winter maintenance implemented on public and private roads by the municipalities	5	20	50
Number of best practice design standards for stormwater control measures created and implemented by the watershed municipalities	5	20	50
Number of municipalities accepting residential yard waste at transfer stations	4	5	7
Number of municipalities fully implementing key aspects of the MS4 program	2	5	7
Number of meetings and/or presentations to municipal staff and/or boards related to the WBP	10	50	100
Number of CNMPs completed or NRCS technical assistance provided for farms in the watershed	1	2	5
SOCIAL INDICATORS			
Number of new association members	5	20	50
Number of volunteers participating in educational campaigns	15	25	50
Number of people participating in informational meetings, workshops, trainings, BMP demonstrations, or group septic system pumping	50	200	500
Number of watershed residents installing conservation practices on their property and/or participating in LakeSmart	10	100	200
Number of municipal DPW staff receiving Green SnowPro training	5	10	20
Number of groups or individuals contributing funds for plan implementation	50	100	200
Number of newly trained water quality and invasive species monitors	3	5	10
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 or BCCD	1	2	5
Number of daily visitors to the WWN website	20	250	500

**Milestones are cumulative starting at year 1.*

ADDITIONAL RESOURCES

Buffers for wetlands and surface waters: a guidebook for New Hampshire municipalities. Chase, et al. 1997. NH Audubon Society. Online: https://www.nh.gov/oep/planning/resources/documents/buffers.pdf

Conserving your land: options for NH landowners. Lind, B. 2005. Center for Land Conservation Assistance / Society for the Protection of N.H. Forests. Online: https://forestsociety.org/sites/default/files/ConservingYourLand_color.pdf

Environmental Fact Sheet: Erosion Control for Construction within the Protected Shoreland. New Hampshire Department of Environmental Services, SP-1, 2020. https://www.des.nh.gov/sites/g/files/ehbemt341/files/documents/2020-01/sp-1.pdf

Gravel road maintenance manual: a guide for landowners on camp and other gravel roads. Maine Department of Environmental Protection, Bureau of Land and Water Quality. April 2010. Online: http://www.maine.gov/dep/land/watershed/camp/road/gravel_road_manual.pdf

Gravel roads: maintenance and design manual. U.S. Department of Transportation, Federal Highway Program. November 2000. South Dakota Local Transportation Assistance Program (SD LTAP). Online: https://www.epa.gov/sites/production/files/2015-10/documents/2003_07_24_nps_gravelroads_gravelroads.pdf

Innovative land use techniques handbook. New Hampshire Department of Environmental Services. 2008. Online: https://www.nh.gov/osi/planning/resources/innovative-land-use-guide.htm

Landscaping at the water's edge: an ecological approach. University of New Hampshire, Cooperative Extension. 2007. Online: https://extension.unh.edu/resources/files/resource004159_rep5940.pdf

New Hampshire Homeowner's Guide to Stormwater Management: Do-It-Yourself Stormwater Solutions for Your Home. New Hampshire Department of Environmental Services, Soak Up the Rain NH. Revised November 2019. Online: https://www.des.nh.gov/sites/g/files/ehbemt341/files/documents/2020-01/homeowner-guide-stormwater.pdf

Protecting water resources and managing stormwater. University of New Hampshire, Cooperative Extension & Stormwater Center. March 2010. Online: https://extension.unh.edu/resources/files/Resource002615_Rep3886.pdf

Stormwater Manual, Volumes 1-3. New Hampshire Department of Environmental Services. 2008. Online: https://www.des.nh.gov/water/stormwater

University of New Hampshire Stormwater Center 2009 Biannual Report. University of New Hampshire, Stormwater Center. 2009. Online: https://www.unh.edu/unhsc/sites/unh.edu.unhsc/files/pubs_specs_info/2009_unhsc_report.pdf

REFERENCES

AECOM (2009). LLRM Lake Loading Response Model Users Guide and Quality Assurance Project Plan, AECOM, Willington CT.

AECOM (2012). Black Brook Watershed Management Plan. Prepared by AECOM for the Town of Sanbornton, September 2012.

Ayotte, J. (1997). Geohydrology and water quality of stratified-drift aquifers in the Winnipesaukee River basin, central New Hampshire. U.S. Geology Survey Water-Resources Investigations Report 94-4150. Prepared in cooperation with the New Hampshire Department of Environmental Services.

Ballestero,T.P., Houle, J.H., Puls, T.A., & Barbu, I.A. (2017). Stormwater Management in a Changing Climate. Presented at NH Lakes Assoc. Annual Meeting, Meredith, NH.

Bear Creek Environmental, LLC. (2011). Jewett Brook Watershed Stream Geomorphic Assessment, Laconia and Gilford, New Hampshire, May 30, 2011.

Bledzki, L. A., Bubier, J. L., Moulton, L. A., & Kyker-Snowman, T. D. (2010). Downstream effects of beaver ponds on the water quality of New England first- and second-order streams. Ecohydrology, 698-707. Retrieved from https://onlinelibrary.wiley.com/doi/abs/10.1002/eco.163

Chase-Rowell, C., Davis, M.T., Hartnett, K., & Wyzga, M. (2012). Integrated Landscaping: Following Nature's Lead. University of New Hampshire Press, pp. 167.

Choi, R. T., Beard, K. H., Kelsey, K. C., Leffler, A. J., Schmutz, J. A., & Welker, J. M. (2020). Early Goose Arrival Increases Soil Nitrogen Availability More Than an Advancing Spring in Coastal Western Alaska. Ecosystems, 23, 1309-1324. Retrieved from https://link.springer.com/article/10.1007/s10021-019-00472-9

Cottingham, K. L., Ewing, H. A., Greer, M. L., Carey, C. C., & Weathers, K. C. (2015). Cyanobcateria as biological drivers of lake nitrogen and phosphorus cycling. *Ecosphere, 6*(1), 1-19. doi:https://doi.org/10.1890/ES14-00174.1

CWP (1999). Watershed Protection Techniques. Center for Watershed Protection, Vol. 3, No. 1.

Dolman, A. M., Rucker, J., Pick, F. R., Fastner, J., Rohrlack, T., Mischke, U., & Wiedner, C. (2012). Cyanobacteria and cyanotoxins: the influence of nitrogen versus phosphorus. *PLoS ONE, 7*(6). doi:10.1371/journal.pone.0038757

EPA. (2005). National Management Measures to Control Nonpoint Source Pollution from Urban Areas. United States Environmental Protection Agency. November 2005. EPA 841-B-05-004. Available online at: https://www.epa.gov/sites/production/files/2015-09/documents/urban_guidance_0.pdf

EPA. (2016). Wastewater Technology Fact Sheets. Retrieved from EPA Septic Systems: https://www.epa.gov/septic/wastewater-technology-fact-sheets

Favot, E. J., Rühland, K. M., DeSellas, A. M., Ingram, R., Paterson, A. M., & Smol, J. P. (2019). Climate variability promotes unprecedented cyanobacterial blooms in a remote, oligotrophic Ontario lake: evidence from paleolimnology. *Journal of Paleolimnology*, *62*(1), 31-52. doi: https://doi.org/10.1007/s10933-019-00074-4

FBE. (2021a). Lake Winnisquam: Lake Loading Response Model. Prepared by FB Environmental Associates (FBE) for the US EPA, NHDES, and Winnisquam Watershed Network, December 2021.

FBE. (2021b). Lake Winnisquam: Build-out Analysis. Prepared by FB Environmental Associates (FBE) for the US EPA Region 1, NHDES, and Winnisquam Watershed Network, December 2021.

FBE. (2022). Memorandum: Black Brook Remediation Plan. FB Environmental Associates, April 21, 2022.

Goldthwait, J.W., Goldthwait, L., & Goldthwait, R.P. (1951). The Geology of New Hampshire. Part I: Surficial Geology. Concord, NH: State of New Hampshire State Planning and Development Commission.

Intergovernmental Panel on Climate Change (IPCC). (2013). Chapter 12: Long-term Climate Change: Projections, Commitments, and Irreversibility. In: Climate Change 2013: The Physical Science Basis. Cambridge University Press, UK and New York, USA. Retrieved online at: https://www.ipcc.ch/site/assets/uploads/2018/02/WG1AR5_Chapter12_FINAL.pdf

Lang, G. J. (2021). Black Brook Watershed Assessment Update Report. Belknap County Conservation District, December 2021.

Leira, M., & Cantonati, M. (2008). Effects of water-level fluctuations on lakes: an annotated bibliography. *Hydrobiologia, 613*(1), 171-184. doi:https://doi.org/10.1890ES14-00174.1

LRPC. (2016). Culvert Assessment Report: Laconia, NH. Lakes Region Planning Commission, 2016.

Mariash, H. L., Rautio, M., Mallory, M., & Smith, P. (2019). Experimental tests of water chemistry response to ornithological eutrophication: biological implications in Arctic freshwaters. Biogeosciences, 4719-4730. Retrieved from https://search.proquest.com/openview/4f008318d39b55648830d53e4a366062/1?pq-origsite=gscholar&cbl=105740

McCormick, R., & Dorworth, L. (2019). Climate Change: How will you manage stormwater runoff? Purdue Extension. FNR-426-W; IISG-10-14. Retrieved online at: https://www.extension.purdue.edu/extmedia/FNR/FNR-426-W.pdf

National Centers for Environmental Information (NCEI). (2022). National Oceanic and Atmospheric Association. Retrieved from: https://www.ncdc.noaa.gov/data-access/land-based-station-data

New Hampshire Code of Administrative Rules. Chapter Env-Wq 1700, Surface Water Quality Regulations. Retrieved from: https://www.des.nh.gov/organization/commissioner/legal/rules/documents/env-wq1700.pdf

New Hampshire Department of Agriculture, Markets, and Food. (2017). *Manual of Best Management Practices for Agriculture in New Hampshire: Best Management Practices for the Handling of Agricultural Compost, Fertilizer, and Manure.* Prepared by the Agricultural Best Management Practices Task Force, Revised July 2017. Available online at: https://www.agriculture.nh.gov/publications-forms/documents/bmp-manual.pdf

New Hampshire Fish and Game Department (NHFGD). (2015). New Hampshire Wildlife Action Plan. 2015 Revised Edition. Retrieved from: https://www.wildlife.state.nh.us/wildlife/wap.html

NHDES. (2008). *Stormwater Manual, Volumes 1-3.* New Hampshire Department of Environmental Services. 2008. Online: https://www.des.nh.gov/water/stormwater

NHDES. (2007). NHDES Lake Trophic Data. Department of Environmental Services Water Division – Watershed Management Bureau. 2007. Available online at: https://www4.des.state.nh.us/onestoppub/TrophicSurveys/Winnisquam%2C%20Pot%20Isl%2C%20Laconia%2C%20NH%2C%20Belmont%20NH%2C%20Belknap%20County%202007.pdf

NHDES. (2020). Long-Term Variable Milfoil Management Plan. Lake Winnisquam, Meredith, Sanbornton, Laconia, Belmont, & Tilton, New Hampshire. New Hampshire Department of Environmental Services, February 2020.

NHDES. (2022). State of New Hampshire 2020/22 Section 305(b) and 303(d) Consolidated Assessment and Listing Methodology (CALM). NHDES-R-WD-19-04. Retrieved from: https://www.des.nh.gov/sites/g/files/ehbemt341/files/documents/r-wd-20-20.pdf

O'Geen, A., Elkins, R., & Lewis, D. (2006). Erodibility of Agricultural Soils, With Examples in Lake and Mendocino Counties. Oakland, CA: Division of Agriculture and Natural Resources, University of California.

Otero, X. L., De La Peña-Lastra, S., Pérez-Alberti, A., Osorio Ferreira, T., & Huerta-Diaz, M. A. (2018). Seabird colonies as important global drivers in the nitrogen and phosphorus cycles. Nature Communications. Retrieved from https://www.nature.com/articles/s41467-017-02446-8

Paerl, H. W. (2018). Mitigating toxic planktonic cyanobacterial blooms in aquatic ecosystems facing increasing anthropogenic and climatic pressures. *Toxins*, *10*(2), 76. doi: https://doi.org/10.3390/toxins10020076

Przytulska, A., Bartosiewicz, M., & Vincent, W. F. (2017). Increased risk of cyanobacterial blooms in northern high-latitude lakes through climate warming and phosphorus enrichment. *Freshwater biology*, *62*(12), 1986-1996. doi: https://doi.org/10.1111/fwb.13043

Staley, Z. R., He, D. D., Shum, P., Vender, R., & Edge, T. A. (2018). Foreshore beach sand as a reservoir and source of total phosphorus in Lake Ontario. Aquatic Ecosystem Health & Management, 268-275. Retrieved from https://www.tandfonline.com/doi/abs/10.1080/14634988.2018.1505353

Trout Unlimited. (2020). Black Brook Stream Crossing Assessment Summary, December 2020.

Underwood Engineers, Inc. (2020). Summary Report and Final Documentation: Sanbornton Roadway Evaluation, Town of Sanbornton, New Hampshire, March 2020.

US Census Bureau (2022). Belknap County, New Hampshire. United States Census Bureau. Available at: https://www.census.gov/quickfacts/belknapcountynewhampshire

Zohary, T., & Ostrovsky, I. (2011). Ecological impacts of excessive water level fluctuations in stratified freshwater lakes. *Inland Waters, 1*(1), 47-59. doi:https://doi.org/10.5268/IW-1.1.406

APPENDIX A: PUBLIC WORKSHOP

The following tables (A-1, A-2, A-3) summarize feedback received from participants in break-out sessions during a virtual public workshop held on May 18, 2021. Each break-out session focused on a specific topic related to known or potential NPS sources to Lake Winnisquam.

Table A-1. Public Workshop: Issues and Challenges

Discussion Topic	Challenges and Issues Identified
Land Conservation and Municipal Planning	• Lack of information and knowledge about how landowners can conserve land • Inconsistent policies/regulations across municipalities in the watershed • Lack of economic opportunity, need for grant funding for municipalities with smaller budgets • Issue with land clearing to improve views

Road Erosion	• Lack of established vegetation in ditches leads to erosion
	• Small streams contributing contaminants from roads and other NPS sources
	• Need for funding to fix roads and other sites
	• Specific locations with known erosion:
	  ○ Tucker Mountain Rd at/upgradient of Hamlin-Eames conservation land
	  ○ Deer Park Association Beach
	  ○ Culvert under Collins Brook Rd (at the north end) right where it turns to dirt

Stormwater Management	• Erosion and sediment control during construction • Controls are not well maintained and are different from what was on approved plans • Enforcement is difficult for small communities with limited staff capacity • Lack of state follow up on approved timber cutting plans • Clearing within 25' natural buffer on shoreline properties • Need for homeowner education and support for addressing stormwater runoff • Trash and sediment contributions from Winnipesaukee River
Septic Systems	• Need for upgrades to older and failing septic systems • How to get cooperation of property owners? Need for public outreach and education • Cost and water quality tradeoffs for septic upgrades versus sewer • Unknown age of systems, inventories in each municipality • Question of whether you can put in a viable system on very small lots around Winnisquam
Other water quality concerns	• Need for better coordination between the state, Planning Commissions, Public Works, and others • Many roads dead-end at the lake, conveying stormwater directly into the lake, e.g., Fenton Ave • DPW grading of road and ditches continues to be source of sediment to lake • Shoreline erosion issues due to wake from boats and other recreational watercraft • Messages about "don't do this, don't do that" do not resonate or translate into interest and action.

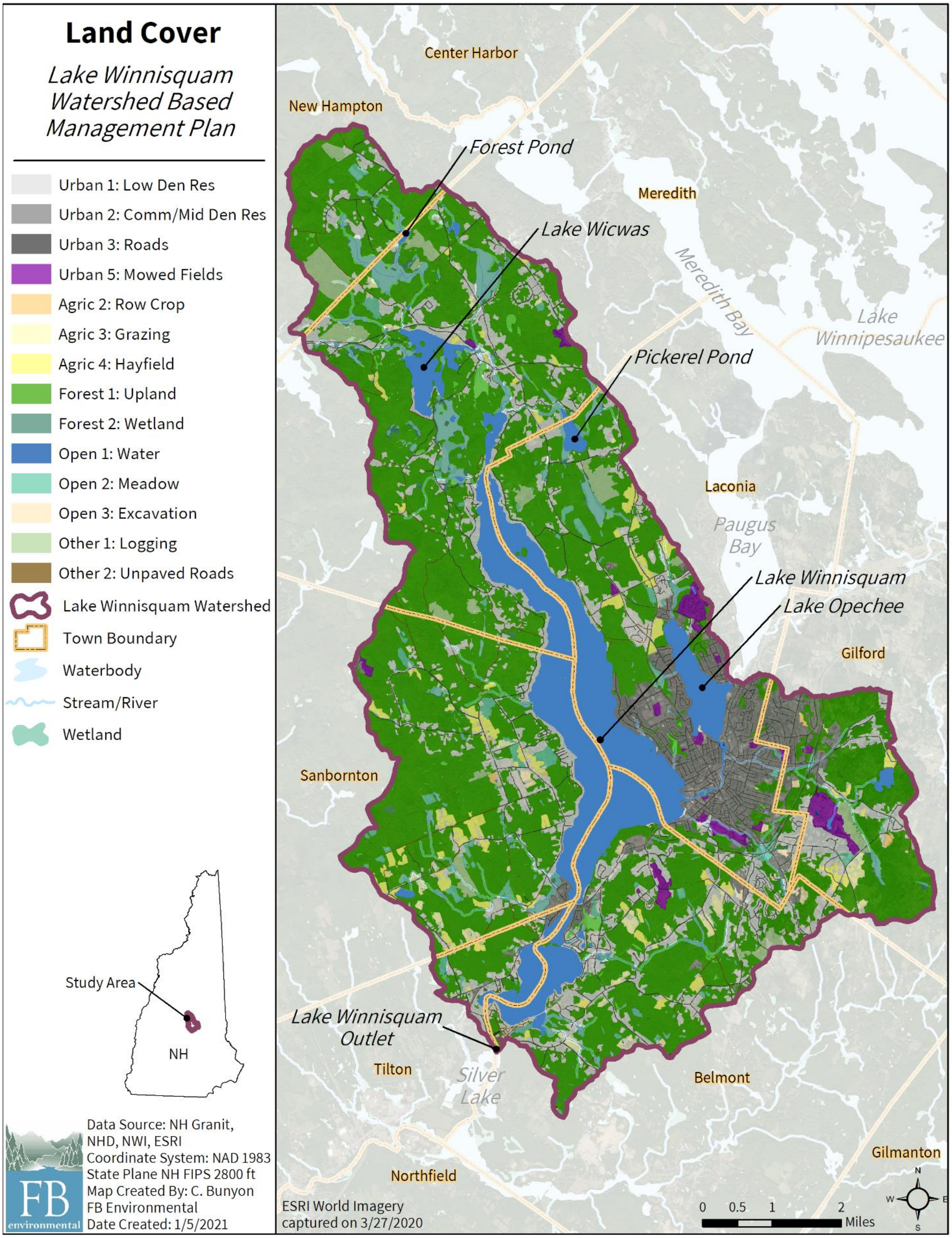
Table A-2. Public Workshop: Potential Solutions

Discussion Topic	Potential Solutions Suggested by Participants
Land Conservation and Municipal Planning	• Improve enforcement of regulations at the state and municipal level • Collaborate with local conservation partners on land conservation initiatives within the watershed. Assign a liaison to communicate with conservation groups.
Road Erosion and Maintenance	• Demonstration projects – present DPWs with options and ideas for trial or demonstration site • Help DPWs pursue grant funding
Stormwater Management	• Work with waterfront property owners to install rain gardens and restore vegetated buffers. • Access resources through NH Soak up the Rain, NH Lakes - Lake Smart Lake Friendly Living program, and Belknap County Conservation District. • Educate homeowners about low-growing plants for shoreline restoration without blocking view • Encourage soil tests to ensure that fertilizer applications are appropriate and proportional to site needs. • Manage trash in Winnipesaukee River – in the past, done by volunteers and BCCD • Promote/implement BMPs; increase use of permeable pavements, rain gardens • Engage school kids to do cleanups, learn about runoff going into streams • Improve inspections and enforcement; focus on increasing staff capacity • Increase setback requirements for shoreline buffer – e.g., Meredith requires 65' setback to structure
Septic Systems	• Enforce occupancy limits and have septic system inventories in Master Plans. • Consider septic system ordinances that require regular pump-outs and inspections to ensure proper functioning. E.g., Meredith's Health Ordinance and Moultonborough Draft Health Ordinance Pertaining to Evaluation and Replacement of Certain Subsurface Wastewater Disposal Systems in Moultonborough • Work with real estate agents to distribute pamphlet on how to maintain a septic system • In Mass, septic systems need to be functioning before property sale. Consider a similar requirement.
Other water quality concerns	• Install stormwater BMPs, restore shoreline buffers on roads that dead-end at the lake. • Educate DPW staff about invasive species. • Share additional/dynamic info on WWN website; e.g., water quality, weather, webcam. See Kezar Lake Watershed Association website for example. North end of Winnisquam could be potential location for a webcam.

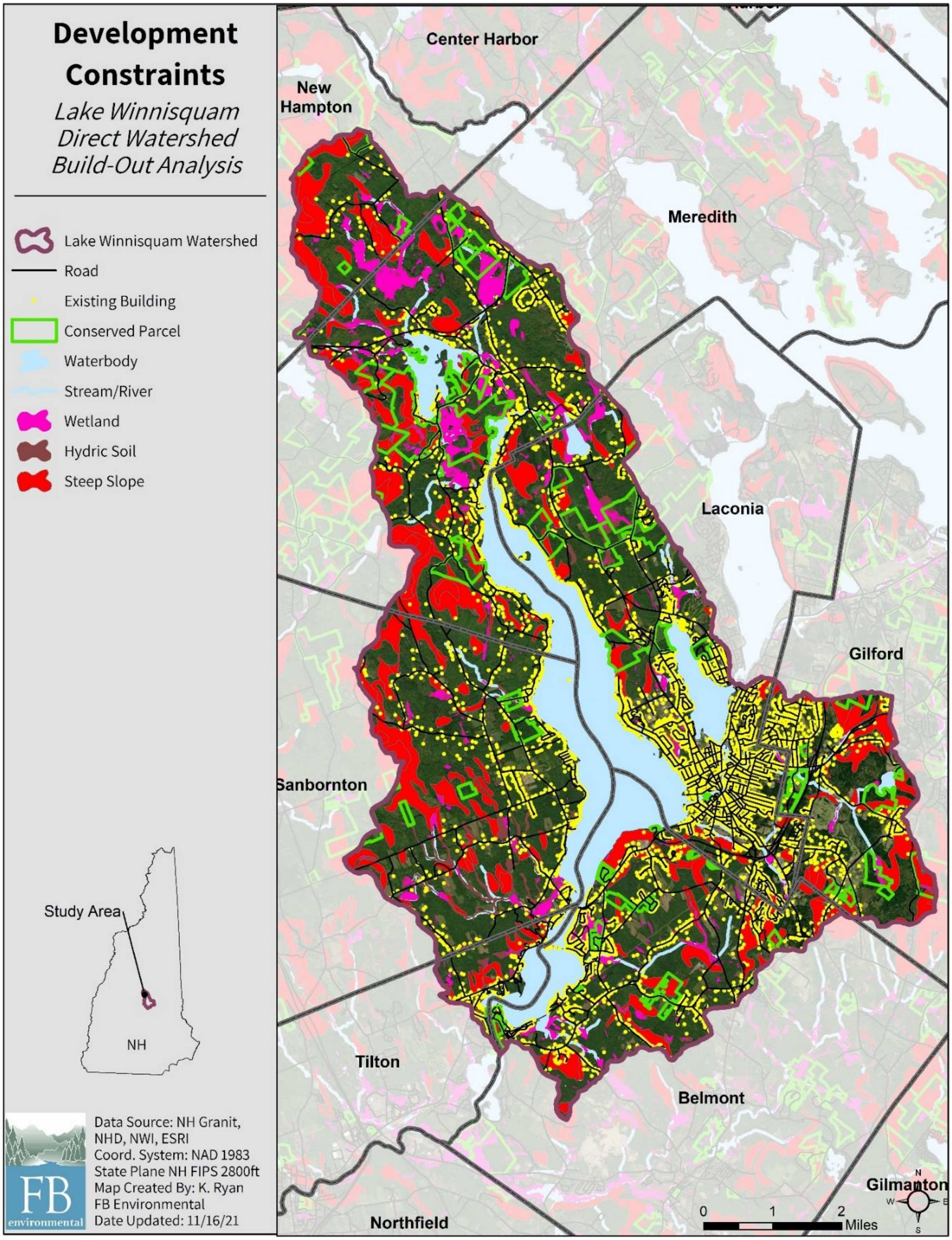
Table A-3. Public Workshop: Priority Actions

Discussion Topic	Priority Actions
Land Conservation and Municipal Planning	• Create a priority list of watershed areas that need protection based on natural resource inventories and identify potential conservation buyers and property owners interested in easements within the watershed. • Zoning and enforcement
Road Erosion & Maintenance	• Education and outreach to DPWs. • Provide guide/written protocol for road installation and maintenance best practices to DPW. Train public works staff on best practices for unpaved road maintenance. • Go to DPW with options and ideas for demonstration sites to show them the type of work that will create win/win to improve water quality and help them save time and money in the long run. Help to obtain grant funding. • Review road installation and maintenance practices currently used for each municipality and determine areas for improvement. • Establish inspection and maintenance agreements for private unpaved roads.
Stormwater Management	• Educate contractors and municipal staff about erosion and sediment control practices • Increase municipal staff capacity for inspections and enforcement • Educate and provide technical support to waterfront property owners to install rain gardens and restore vegetated buffers.
Septic systems	• Distribute educational materials about septic system function and maintenance. • Require inspection for all home conversions (from seasonal to permanent residences), property sales – make sure systems are sized and designed properly, require upgrades if needed. • Develop and maintain a septic system database for the watershed to facilitate code enforcement.
Other water quality concerns in the watershed	• Close the gap, improve coordination between planning commissions, public works, and water quality stakeholders. • Install stormwater BMPs, restore shoreline buffers on roads that dead-end at the lake. • Share additional/dynamic info on WWN website; e.g., water quality, weather, webcam. • Change messaging from "don't do this" to "here's what you can do" and "get involved".

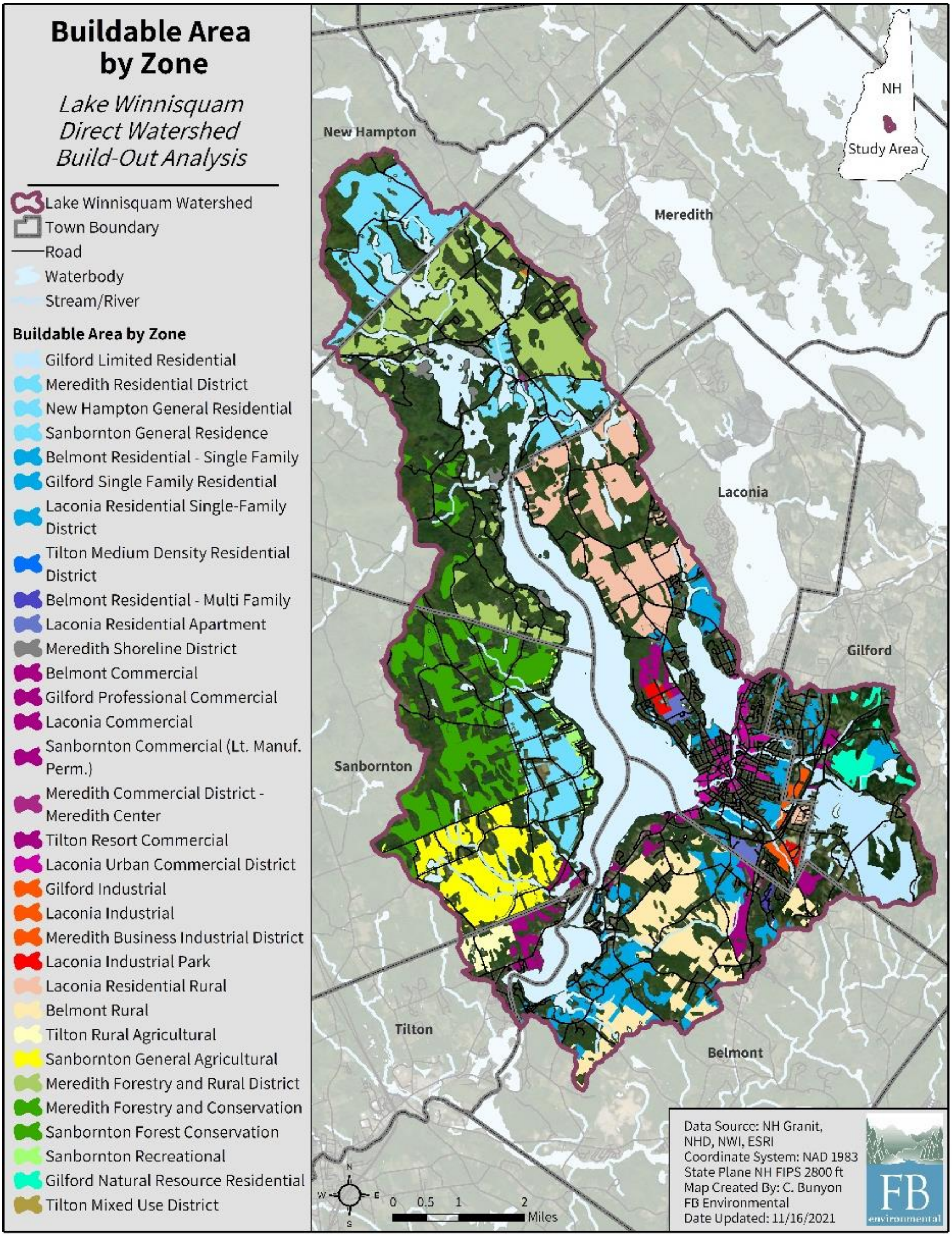
APPENDIX B: SUPPORTING MAPS



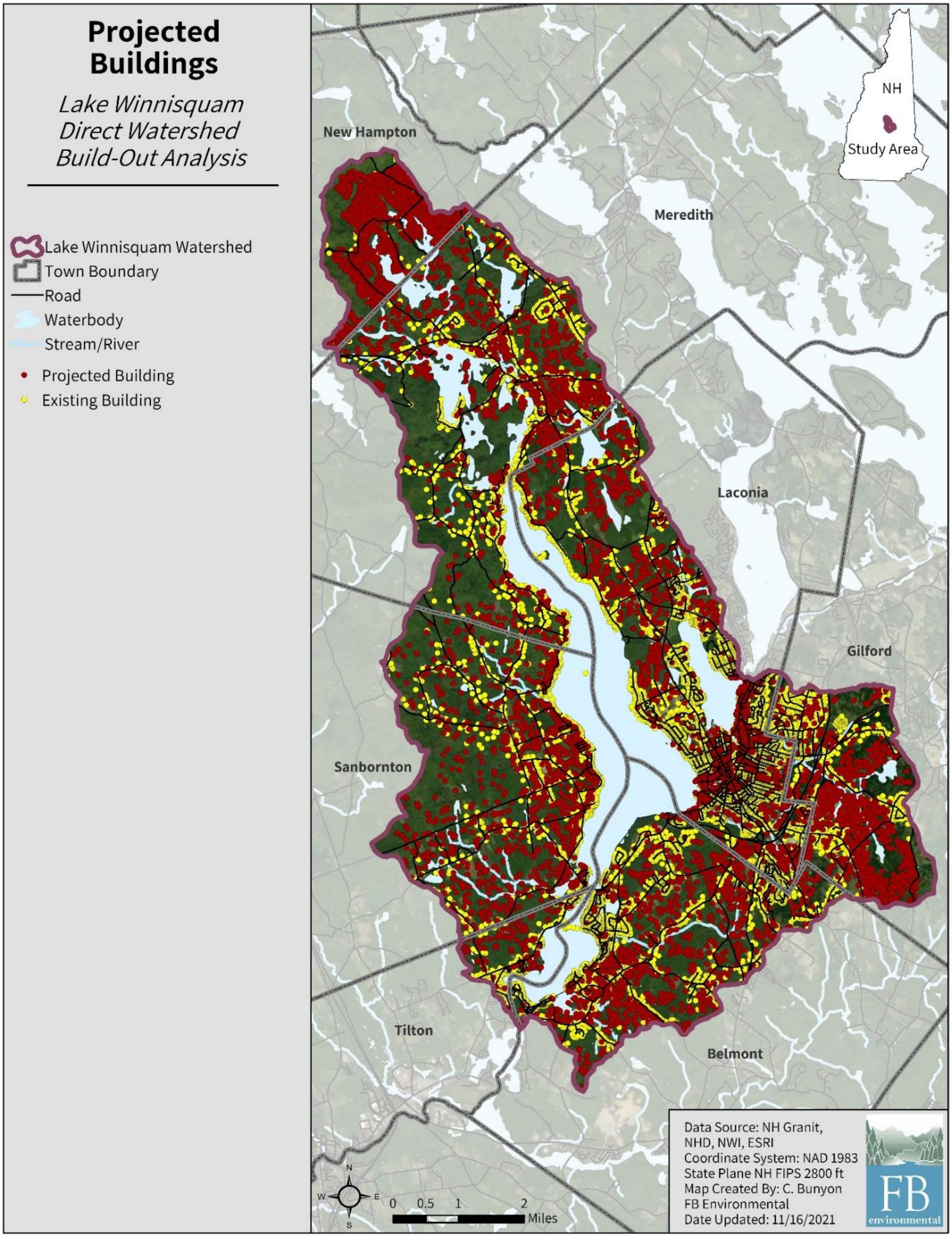
Map B-1. Land cover in the direct Lake Winnisquam watershed.



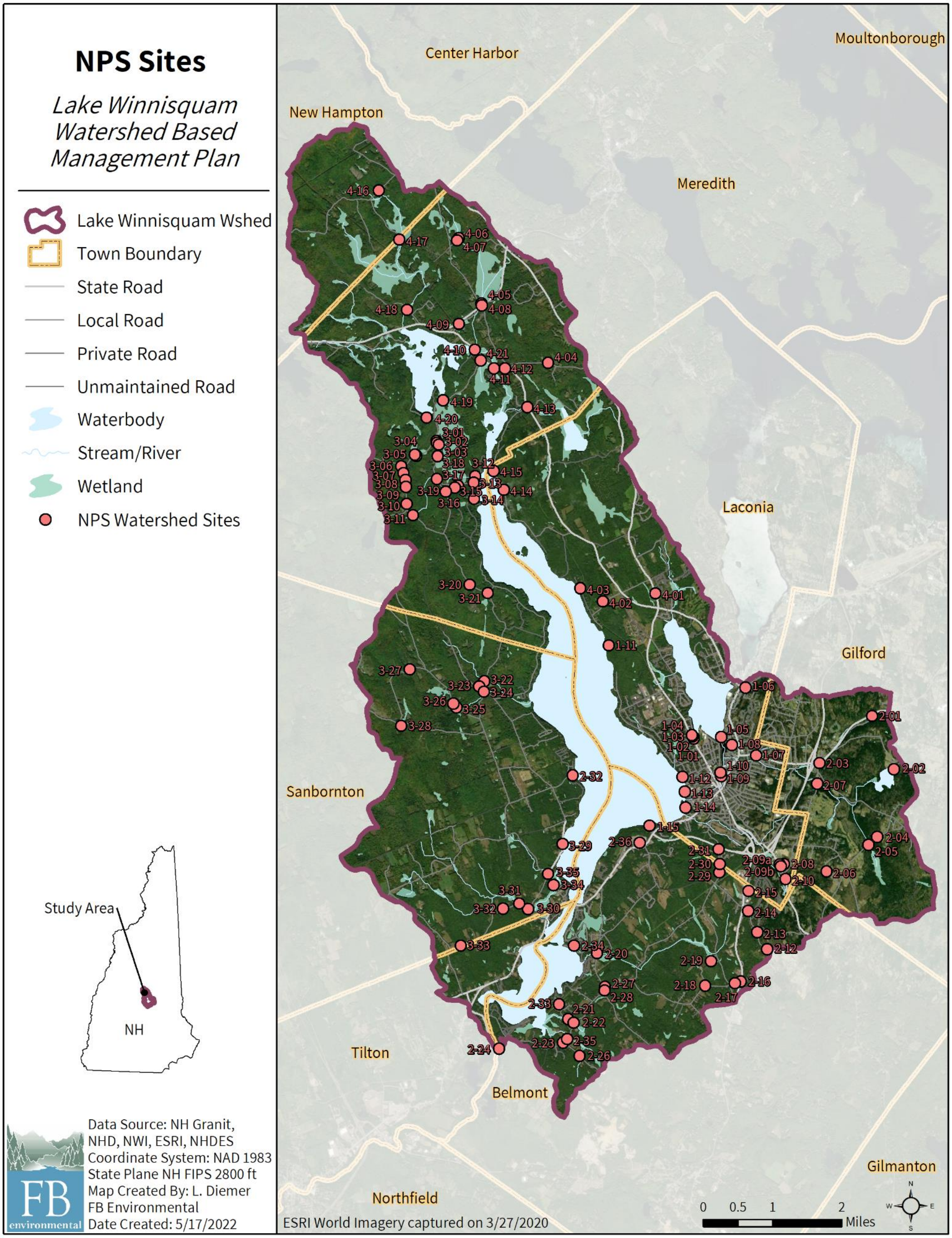
Map B-2. Development constraints (including existing buildings) in the direct watershed of Lake Winnisquam in Belmont, Gilford, Laconia, Meredith, New Hampton, Sanbornton, and Tilton, New Hampshire.



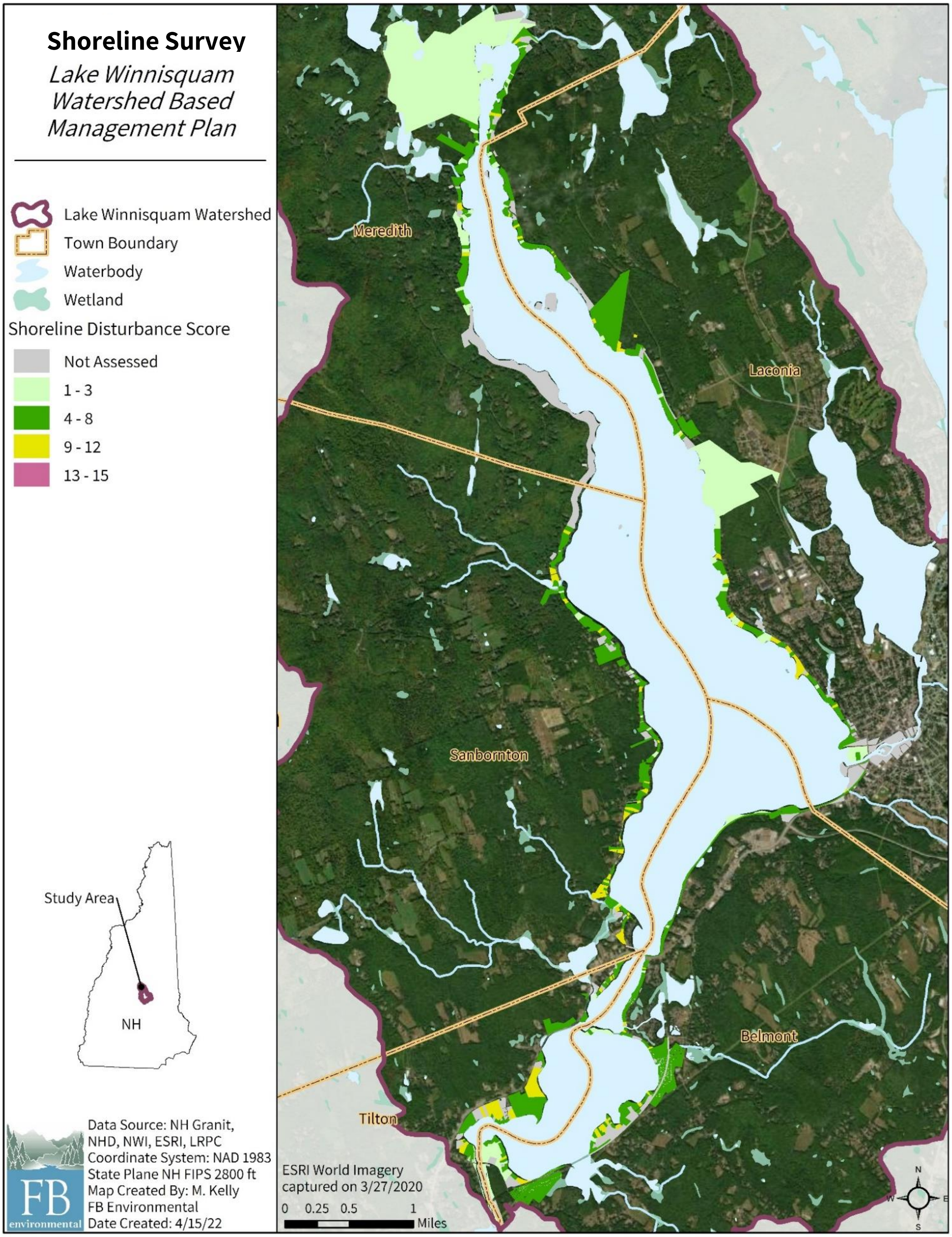
Map B-3. Buildable area by municipal zone in the direct Lake Winnisquam watershed in Belmont, Gilford, Laconia, Meredith, New Hampton, Sanbornton, and Tilton, New Hampshire.



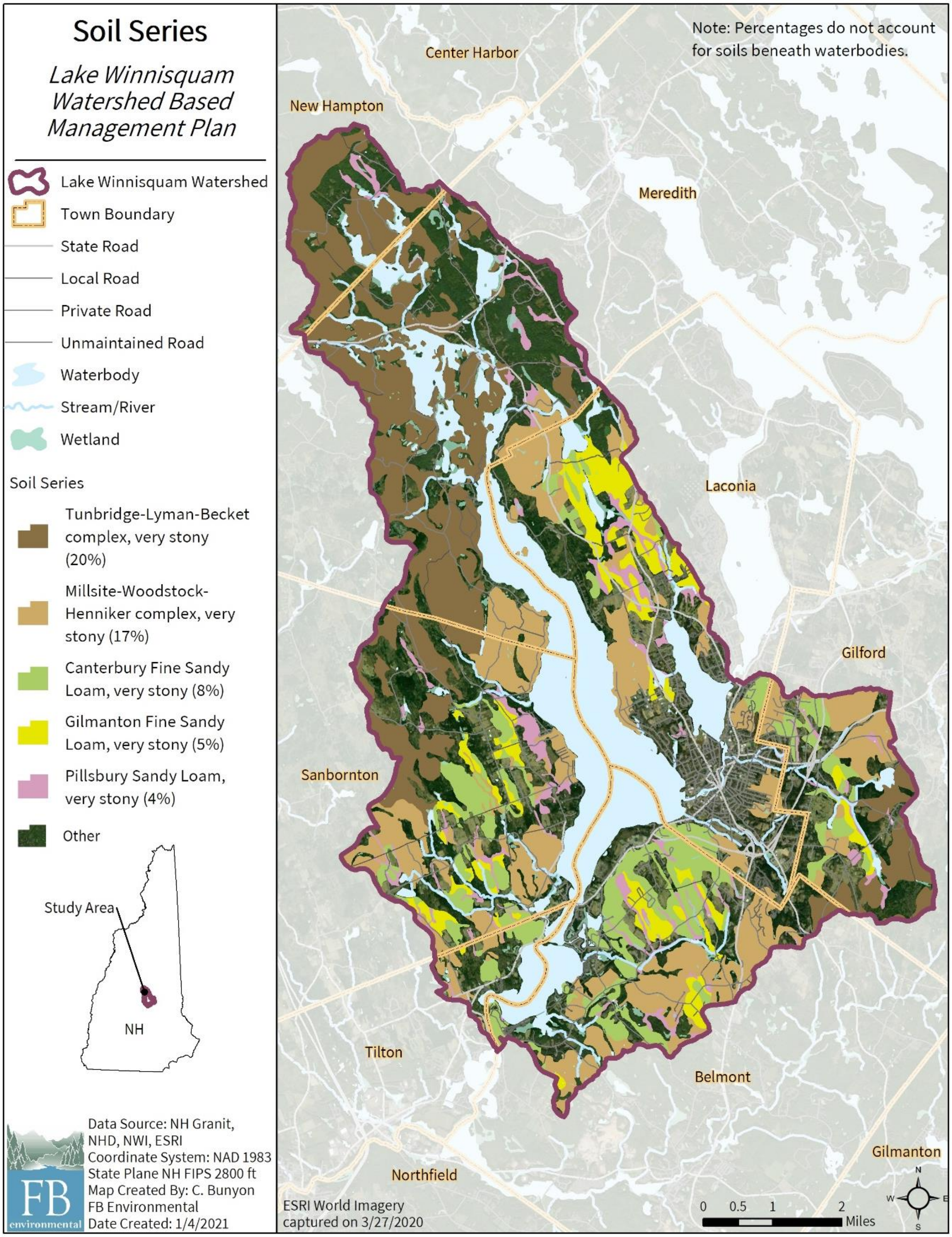
Map B-4. Projected and existing buildings in the direct Lake Winnisquam watershed in Belmont, Gilford, Laconia, Meredith, New Hampton, Sanbornton, and Tilton, New Hampshire.



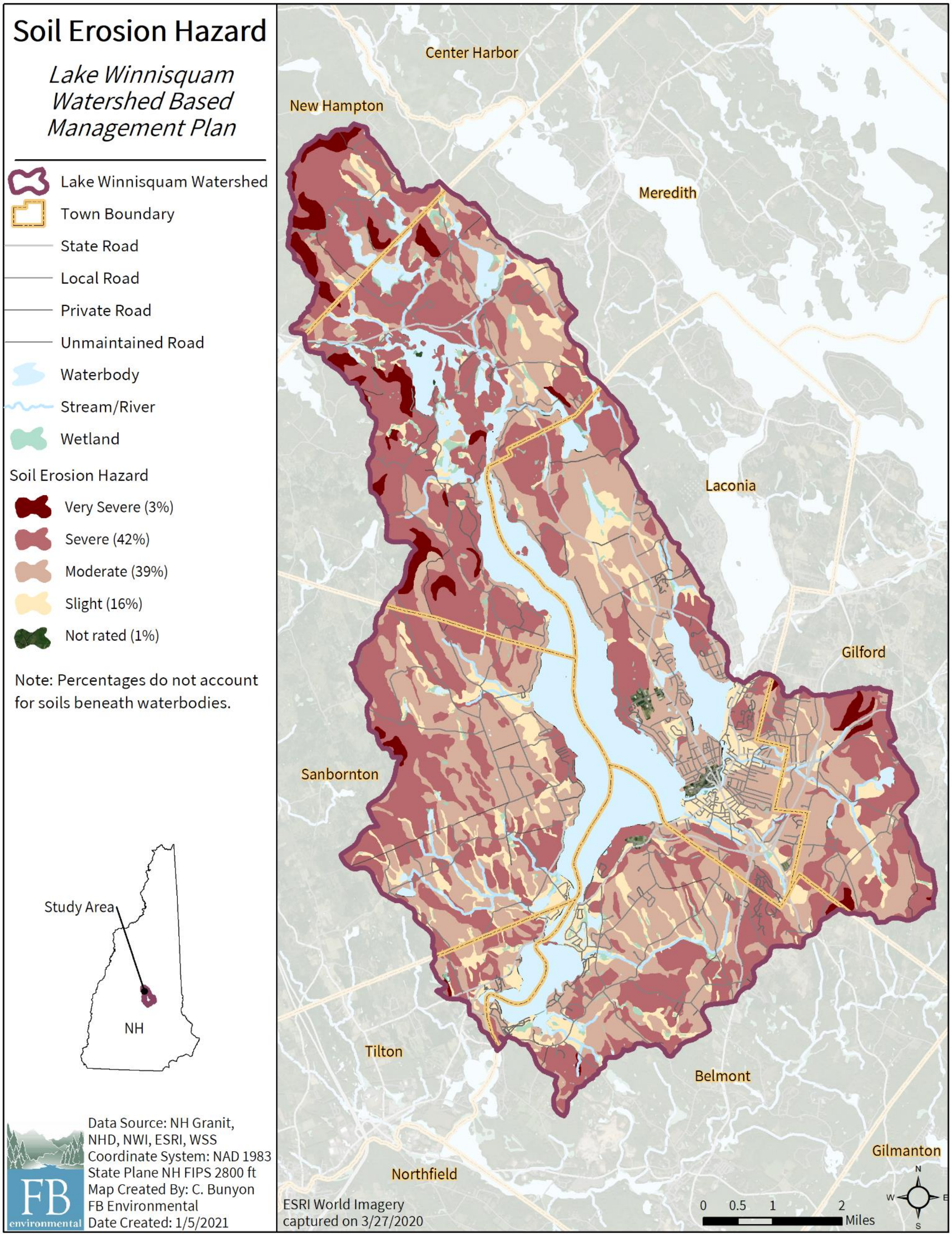
Map B-5. NPS sites identified during the 2021 watershed survey in the direct Lake Winnisquam watershed.



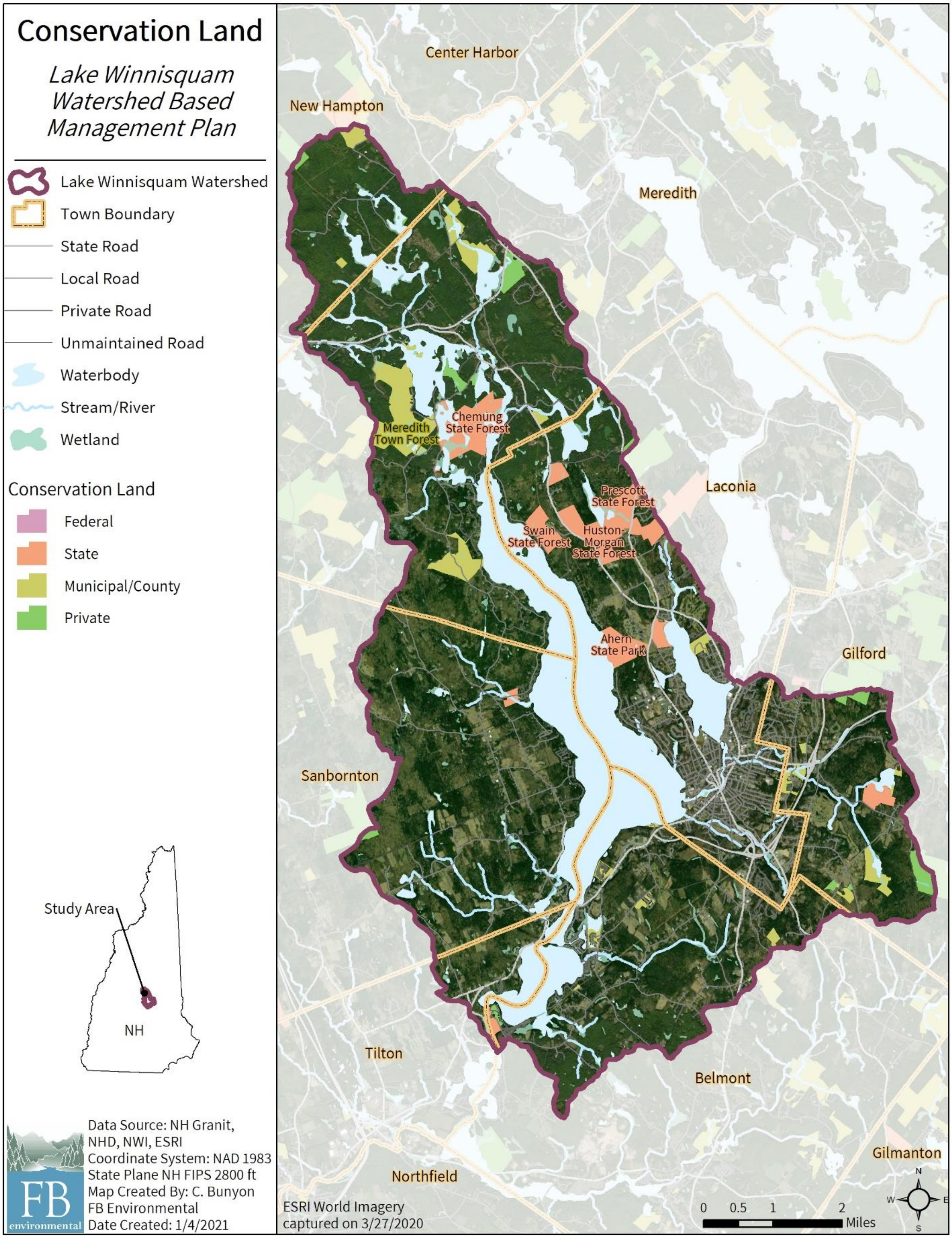
Map B-6. Shoreline Disturbance Score for parcels with frontage on Lake Winnisquam, as rated during the 2020 shoreline survey by WWN volunteers.



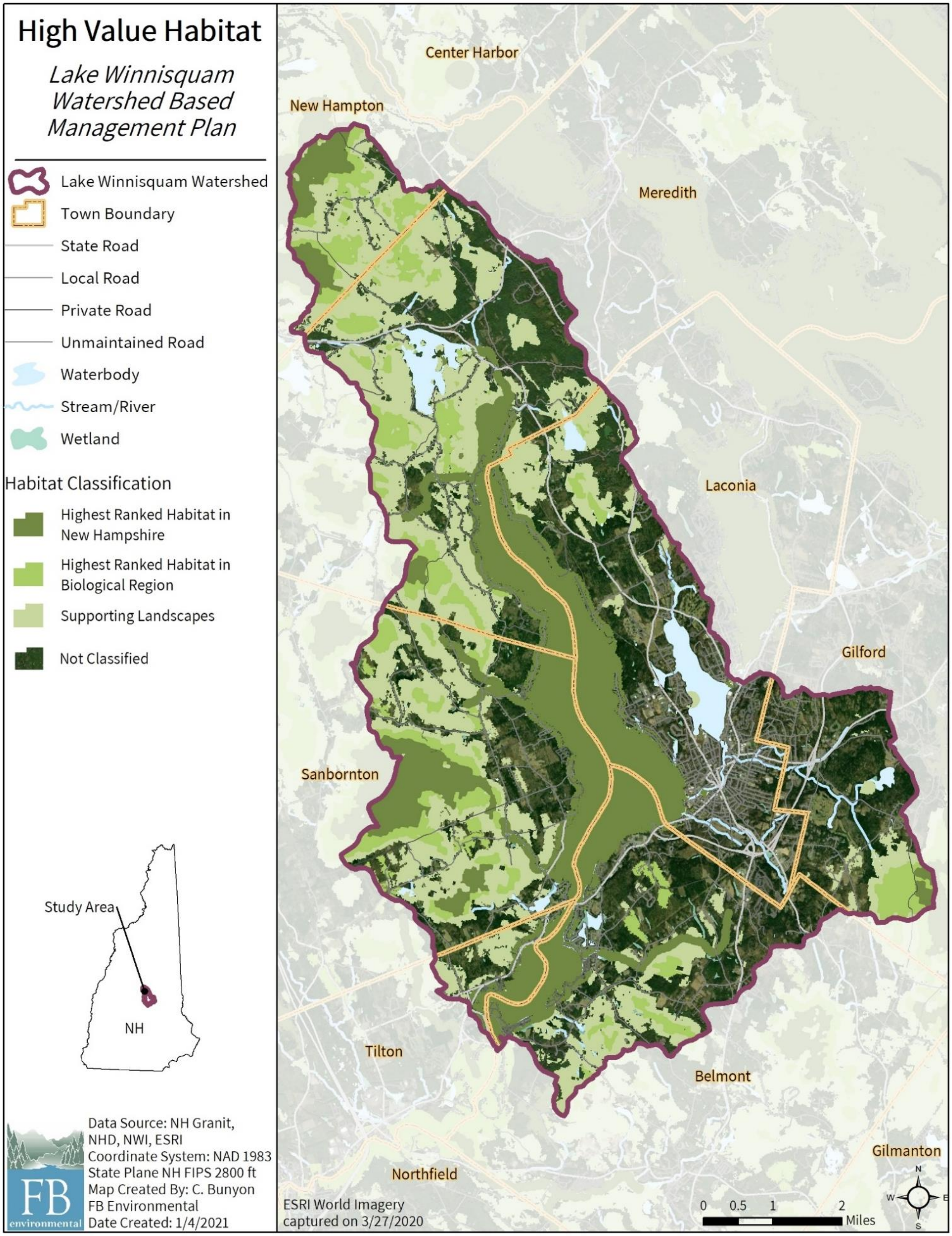
Map B-7. Soil series in the direct Lake Winnisquam watershed.



Map B-8. Soil Erosion Hazard in the direct Lake Winnisquam watershed.



Map B-9. Conservation land within the direct Lake Winnisquam watershed.



Map B-10. High value habitat according to the 2015 New Hampshire Wildlife Action Plan in the direct Lake Winnisquam watershed.

APPENDIX C: BMP MATRIX

Site ID	Site Descr.	Municipality	Subbasin	Description of Problem	Recommendations	Primary Recommended Actions	Total Average Annual Sediment Load Removed (kg/yr)	Total Average Annual TP Load Removed (kg/yr)	Direct or Indirect/Limited Discharge to Waterbody	Priority
3-36	Doctor True Rd and Maple Circle, Sanbornton	Sanbornton	Lake Winnisquam Direct	Identified by Sanbornton Selectman. Dr. True Rd and Maple Circle are impassable during mud season, with ruts up to a foot deep and large sections of unpassable mud. Sediment flows to lake.	Town is considering paving Dr True Rd and Maple Circle to address erosion and travel issues. BMPs will be needed to manage runoff and pollutants (including sand, salt) from newly paved roads.	Stabilization	9,273	4.6	Direct	High
3-34	Bay Rd	Sanbornton	Chapman Brook	Loose sediment and erosion observed along unpaved parking area, access ramp, and pull-off area at stream crossing (downstream side), private property sign posted	Stabilize parking area, pull-off area, and access ramps	Stabilization	4,990	2.1	Direct	High
1-12	Gale Ave - small pocket park with access to lake	Laconia	Lake Winnisquam Direct	Two gullies directly to water, reports of trash. Sheet flow from crowned road goes into gullies.	Route flow into bio use existing ditch to north because it is more stable	Treatment, Stabilization	2,282	1.6	Direct	High
3-28	Woodman Rd intersection with Steele Hill Rd	Sanbornton	Black Brook	Road shoulder/ditch erosion, Unstable culvert inlet/outlet, Concentrated stormwater flow paths evident, Winter sand, Steep slope from road to stream (large boulders and riprap in place for stabilization)	Stabilize inlet and/or outlet, Armor ditch/turnouts with stone or grass with check dams, Reshape ditch, Reshape or crown road, Reshape/vegetate shoulder	Stabilization	3,629	1.5	Direct	High
3-21	Eagle Ledge Rd intersection with Batchelder Hill Rd	Meredith	Lake Winnisquam Direct	Road shoulder/ditch erosion, Unstable culvert inlet/outlet, Concentrated stormwater flow paths evident, Construction site uphill on Eagle Ledge Rd without controls in place	Armor ditch with stone or grass, Reshape ditch, Reshape or crown road, Reshape/vegetate shoulder	Stabilization	3,592	1.5	Direct	High

Site ID	Site Descr.	Municipality	Subbasin	Description of Problem	Recommendations	Primary Recommended Actions	Total Average Annual Sediment Load Removed (kg/yr)	Total Average Annual TP Load Removed (kg/yr)	Direct or Indirect/Limited Discharge to Waterbody	Priority
3-23	Kaulback Rd and Roxbury Rd, trib to Black Brook crossing	Sanbornton	Black Brook	Road shoulder/ditch erosion, Unstable culvert inlet/outlet, Concentrated stormwater flow paths evident, Plow pile area, Loose sediment, Grader berms	Stabilize inlet and/or outlet, Replace/enlarge culvert, Armor ditch with stone or grass, Reshape ditch, Reshape or crown road, Reshape/vegetate shoulder	Stabilization	3,393	1.4	Direct	High
3-24	Lower Bay Rd and Huse Rd, trib to Black Brook crossing	Sanbornton	Black Brook	Road shoulder/ditch erosion, Concentrated stormwater flow paths evident, Loose sediment	Armor ditch with stone or grass, Reshape ditch, Reshape or crown road, Reshape/vegetate shoulder	Stabilization	2,776	1.4	Direct	High
3-12	Stoney Brook Rd	Meredith	Swamp Pond	Unpaved road with poor crown and minimal road shoulder to ditch with direct contact with water, plow pile area with loose sediment adjacent to wetland	Reshape or crown road, Reshape/vegetate shoulder, Clean out and stabilize plow pile area	Stabilization	3,024	1.3	Direct	High
3-25	Woodman Rd	Sanbornton	Black Brook	Road shoulder/ditch erosion, Unstable culvert inlet/outlet, rill formation from road shoulder to culvert inlet/outlet	Stabilize inlet and/or outlet, Armor ditch with stone or grass, Reshape ditch, Reshape/vegetate shoulder	Stabilization	2,159	1.1	Direct	High
3-22	Eagle Ledge Rd, Black Brook crossing	Sanbornton	Black Brook	Road shoulder/ditch erosion, Unstable culvert inlet/outlet, Concentrated stormwater flow paths evident, Minimal road shoulder at culvert crossing, Plow pile area, Loose sediment, Grader berms	Stabilize inlet and/or outlet, Armor ditch with stone or grass, Reshape ditch, Reshape or crown road, Reshape/vegetate shoulder	Stabilization	2,395	1.0	Direct	High
3-31	Philbrook Rd	Sanbornton	Chapman Brook	Road shoulder/ditch erosion, Unstable culvert inlet/outlet, Concentrated stormwater flow paths evident, Loose sediment, Turnouts lead directly to stream	Stabilize inlet and/or outlet, Armor ditch with stone or grass, Reshape ditch/turnouts, Reshape or crown road, Reshape/vegetate shoulder	Stabilization	2,395	1.0	Direct	High
3-11	Roxbury Rd	Meredith	Swamp Pond	Road shoulder/ditch erosion along both sides of road leading to culvert stream crossing	Armor ditch with stone or grass, Reshape ditch, Reshape or crown road, Reshape/vegetate shoulder	Stabilization	2,195	0.9	Direct	High

Site ID	Site Descr.	Municipality	Subbasin	Description of Problem	Recommendations	Primary Recommended Actions	Total Average Annual Sediment Load Removed (kg/yr)	Total Average Annual TP Load Removed (kg/yr)	Direct or Indirect/Limited Discharge to Waterbody	Priority
3-20	New road construction off Batchelder Hill Rd	Meredith	Lake Winnisquam Direct	New road construction up steep grade, minimal controls in place to prevent loose gravel and sediment from eroding, ponding water on south side, runoff directed to stream on north side that flows under Batchelder Hill Rd and to the lake	Armor ditch with stone or grass, Reshape ditch, Reshape or crown road, Reshape/vegetate shoulder	Stabilization	1,996	0.8	Direct	High
3-30	Chapman Rd	Sanbornton	Chapman Brook	Road shoulder/ditch erosion, Unstable culvert inlet/outlet, Concentrated stormwater flow paths evident, Loose sediment	Stabilize inlet and/or outlet, Armor ditch with stone or grass, Reshape ditch, Reshape or crown road, Reshape/vegetate shoulder	Stabilization	1,996	0.8	Direct	High
2-05	Stream crossing	Gilford	Jewett Brook	Road shoulder/ditch erosion, Unstable culvert inlet/outlet, Excessive trash, Severe streambank erosion/failure	Armor ditch with stone or grass, Install turnout, Reshape ditch, Stabilize banks, Install runoff diverter, Plant/improve buffer	Stabilization	1,361	0.8	Direct	High
3-32	Philbrook Rd	Sanbornton	Chapman Brook	Road shoulder/ditch erosion, Unstable culvert inlet/outlet, Concentrated stormwater flow paths evident, Loose sediment, Turnouts lead directly to stream	Stabilize inlet and/or outlet, Armor ditch with stone or grass, Reshape ditch/turnouts, Reshape or crown road, Reshape/vegetate shoulder	Stabilization	1,361	0.8	Direct	High
3-16	Weed Rd	Meredith	Swamp Pond	Road shoulder/ditch erosion along both sides of Weed Rd leading to wetland, road shoulder material eroding into woodline/wetland	Armor ditch with stone or grass, Reshape ditch, Reshape or crown road, Reshape/vegetate shoulder, Improve buffer	Stabilization	1,814	0.8	Direct	High
4-06	Old stage rd. culvert	Meredith	Unnamed Tributary (North Trib)	Road surface erosion, Road shoulder/ditch erosion	Install turnout, Reshape ditch, Reshape/vegetate shoulder, Reshape or crown road, Install runoff diverter	Stabilization	1,814	0.8	Direct	High

Site ID	Site Descr.	Municipality	Subbasin	Description of Problem	Recommendations	Primary Recommended Actions	Total Average Annual Sediment Load Removed (kg/yr)	Total Average Annual TP Load Removed (kg/yr)	Direct or Indirect/Limited Discharge to Waterbody	Priority
4-08	Intersection of route 104 and Hatch Corner Road	Meredith	Unnamed Tributary (North Trib)	Road shoulder/ditch erosion with erosion channels leading to stream.	Remove winter sand, Install erosion controls (e.g. silt fence), Armor ditch with stone or grass	Stabilization	1,814	0.8	Direct	High
4-09	Dow Road, near intersection with Rte.104	Meredith	Unnamed Tributary (North Trib)	Road shoulder/ditch erosion directly to stream/pond	Armor ditch with stone or grass, Install erosion controls (e.g. silt fence)	Stabilization	1,814	0.8	Direct	High
3-10	Chemung Rd	Meredith	Swamp Pond	Road shoulder/ditch erosion along both sides of road leading to culvert stream crossing, groundwater spring at culvert inlet, multiple turnouts were noted on the east ditch up road slope with significant sediment deposits	Armor ditch with stone or grass, Reshape ditch, Reshape or crown road, Reshape/vegetate shoulder	Stabilization	1,633	0.7	Direct	High
3-13	Stoney Brook Rd, crossing with river	Meredith	Swamp Pond	Geomorphic instability of river downstream of road crossing, large trees uprooted from bank with fresh soil exposed, multiple concentrated stormwater flow paths from Stoney Brook Rd entering river	Armor ditch with stone or grass, Reshape ditch, Reshape or crown road, Reshape/vegetate shoulder, Investigate geomorphic stability of river	Stabilization	1,597	0.7	Direct	High
3-14	Deer Park Association beach on Weed Rd	Meredith	Lake Winnisquam Direct	Road surface erosion, Road shoulder/ditch erosion from Heritage Rd and Weed Rd causing rill formation on road surface and gully formation on the beach, beach is positioned on a steep grade leading to the lake	Armor ditch with stone or grass, Reshape ditch, Reshape or crown road, Reshape/vegetate shoulder, Improve buffer, Consider tiered landscaping for infiltration practices, Install turnouts on south access road to lake	Stabilization	1,597	0.7	Direct	High
3-26	Woodman Rd	Sanbornton	Black Brook	Road shoulder/ditch erosion, Concentrated stormwater flow paths evident from ditch and residential driveway, Minimal buffer between road and stream	Armor ditch with stone or grass, Reshape ditch, Reshape/vegetate shoulder, Divert driveway runoff, Enhance and stabilize buffer between road and stream	Stabilization	1,597	0.7	Direct	High

Site ID	Site Descr.	Municipality	Subbasin	Description of Problem	Recommendations	Primary Recommended Actions	Total Average Annual Sediment Load Removed (kg/yr)	Total Average Annual TP Load Removed (kg/yr)	Direct or Indirect/Limited Discharge to Waterbody	Priority
3-05a	Hamlin Rec and Cons area parking lot	Meredith	Swamp Pond	Parking area surface erosion leads to road shoulder/ditch erosion, runoff from Chemung Rd evident and causing the rill formation	Build up road/ add surface material, Install runoff diverter, Armor ditch with stone or grass, Reshape road crown	Stabilization	3,402	1.4	Limited	Medium
4-03	Dirt road with pot holes on Eastman Shore Rd N	Laconia	Lake Winnisquam Direct	Road surface erosion, Road shoulder/ditch erosion, Unstable culvert inlet/outlet, Unstable construction site, Excessive build-up of sediment, Buried culvert, Surface sheet erosion from a new construction lot and unpaved dirt driveway to an unpaved road. Culvert under driveway apron is buried in sediment from an unpaved steep driveway with construction at the top. No sediment control practices are visible and sediment is spilling out all over the private roadway and into the drainage ditch.	Clean out culvert, Armor ditch with stone or grass, Install erosion controls (e.g. silt fence), Reshape/vegetate shoulder, Reshape or crown road	Stabilization	2,468	1.2	Limited	Medium
2-33	Jefferson Rd	Belmont	Lake Winnisquam Direct	Road shoulder/ditch erosion, Road surface erosion, The full road is a soft unpaved sandy material	Build up road/ add surface material, Reshape or crown road	Stabilization	1,996	0.8	Limited	Medium
3-07	Chemung Rd	Meredith	Swamp Pond	Road shoulder/ditch erosion along both sides of road leading to culvert crossing, runoff from east side ditch overtops culvert, gully formation evident, flowing water through culvert	Armor ditch with stone or grass, Reshape ditch, Reshape or crown road, Reshape/vegetate shoulder	Stabilization	1,814	0.8	Limited	Medium
3-19	Camp Waldron Rd	Meredith	Swamp Pond	Road shoulder/ditch erosion, Unstable culvert inlet/outlet, rill formation from road shoulder to culvert inlet/outlet	Stabilize inlet and/or outlet, Armor ditch with stone or grass, Reshape ditch, Reshape or crown road, Reshape/vegetate shoulder	Stabilization	1,814	0.8	Limited	Medium

Site ID	Site Descr.	Municipality	Subbasin	Description of Problem	Recommendations	Primary Recommended Actions	Total Average Annual Sediment Load Removed (kg/yr)	Total Average Annual TP Load Removed (kg/yr)	Direct or Indirect/Limited Discharge to Waterbody	Priority
2-04	Swain Rd	Gilford	Jewett Brook	Road shoulder/ditch erosion	Reshape/vegetate shoulder, Armor ditch with stone or grass	Stabilization	1,542	0.8	Limited	Medium
2-06	Garden Hill Drive	Gilford	Durkee Brook	Road shoulder/ditch erosion	Install erosion controls (e.g. silt fence), Reshape/vegetate shoulder, Armor ditch with stone or grass, The ditch is armored with riprap but is getting filled in from the smaller stone lining the roadway.	Stabilization	1,542	0.8	Limited	Medium
3-08	Chemung Rd	Meredith	Swamp Pond	Road shoulder/ditch erosion along both sides of road leading to culvert crossing, runoff from east side ditch overtops culvert, gully formation evident, flowing water through culvert, grader berms evident	Armor ditch with stone or grass, Reshape ditch, Reshape or crown road, Reshape/vegetate shoulder	Stabilization	1,542	0.8	Limited	Medium
2-01	Savage Rd	Gilford	Jewett Brook	Road shoulder/ditch erosion	Armor ditch with stone or grass, Install ditch, Reshape ditch, Remove winter sand, Reshape/vegetate shoulder, Plant/improve buffer	Stabilization	1,597	0.7	Limited	Medium
3-15	Weed Rd	Meredith	Swamp Pond	Road shoulder/ditch erosion along both sides of Weed Rd leading to wetland, road adjacent to wetland with minimal buffer, ditch scraping maintenance evident	Armor ditch with stone or grass, Reshape ditch, Reshape or crown road, Reshape/vegetate shoulder, Improve buffer	Stabilization	1,451	0.6	Direct	Medium
3-09	Chemung Rd	Meredith	Swamp Pond	Road shoulder/ditch erosion along both sides of road leading to culvert stream crossing, green PVC pipes under road may be directing water from west to east side ditch	Armor ditch with stone or grass, Reshape ditch, Reshape or crown road, Reshape/vegetate shoulder	Stabilization	1,080	0.5	Direct	Medium

Site ID	Site Descr.	Municipality	Subbasin	Description of Problem	Recommendations	Primary Recommended Actions	Total Average Annual Sediment Load Removed (kg/yr)	Total Average Annual TP Load Removed (kg/yr)	Direct or Indirect/Limited Discharge to Waterbody	Priority
3-05b	Chemung Rd to Hamlin Rec and Cons area trail head	Meredith	Swamp Pond	Road surface runoff down steep grade concentrates in turnout at bend in road, turnout leads down steep slope through the woods to the trail head and crossing with a stream, significant material movement and soil erosion, severe gully formation, erosion impacting trail stability, sediment/soil depositing directly into stream	Reshape/vegetate shoulder, Reshape or crown road, Install runoff diverter, Armor ditch and turnout with stone or grass, Stabilize trail	Stabilization	1,270	0.5	Direct	Medium
2-35	Union Rd stream crossing	Belmont	Lake Winnisquam Direct	Lack of buffer flowing through agricultural fields. Horses do not have access to stream itself	Plant/improve buffer	Buffer	0	0.5	Direct	Medium
3-02	Camp Waldron Rd near intersection with Chemung Rd	Meredith	Lake Wicwas Direct	Significant road shoulder/ditch erosion along south side of Chemung Rd and both sides of Camp Walton Rd; significant gully formation in west side ditch leading to culvert	Stabilize inlet and/or outlet, Armor ditch with stone or grass, Reshape ditch, Stabilize banks, Reshape/vegetate shoulder	Stabilization	1,197	0.5	Direct	Medium
3-06	Tucker Mtn Rd	Meredith	Swamp Pond	Road surface erosion, Road shoulder/ditch erosion to culvert crossing under Tucker Mtn Rd, culvert conveys small flowing stream	Armor ditch with stone or grass, Reshape ditch, Reshape or crown road, Reshape/vegetate shoulder	Stabilization	1,179	0.5	Direct	Medium
2-24	Across from drinking water protection area	Belmont	Lake Winnisquam Direct	Road shoulder/ditch erosion, Trash	Armor ditch with stone or grass, Install check dams	Stabilization	925	0.5	Direct	Medium
2-10	Province Rd	Laconia	Durkee Brook	Stockpiled soil, Road surface erosion, Source of sand is a private driveway	Install erosion controls (e.g. silt fence),Install runoff diverter, The sand that spills out onto the state road shoulder isn't leading to anywhere just piling up on itself. This could be a residential fix if it becomes connected to a waterbody or catch basin	Maintenance	1,331	0.6	Limited	Low

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4-07	Hatch Corner Rd north of Old Stage Rd	Meredith	Unnamed Tributary (North Trib)	Road surface erosion, Road shoulder/ditch erosion	Armor ditch with stone or grass	Stabilization	1,210	0.5	Limited	Low
4-04	Livingston Rd	Meredith	Mill Brook	Road surface erosion, Road shoulder/ditch erosion, Unstable culvert inlet/outlet. Road shoulder eroding down to the drainage ditch with gullies.	Clean out culvert, Armor ditch with stone or grass, Stabilize inlet and/or outlet, Reshape ditch, Reshape/vegetate shoulder	Stabilization	1,028	0.5	Limited	Low
3-04	Chemung Rd, across from Hamlin Rec and Cons parking area	Meredith	Swamp Pond	Road shoulder/ditch erosion down steep grade with flowing water along south side of Chemung Rd, driveway culvert small	Reshape/vegetate shoulder, Reshape ditch, Armor ditch with stone or grass, Replace culvert	Stabilization	1,179	0.5	Limited	Low
2-30	Mile Hill Rd	Belmont	Durkee Brook	Road shoulder/ditch erosion, Unstable culvert inlet/outlet	Clean out culvert, Install plunge pool, Stabilize inlet and/or outlet, Armor ditch with stone or grass, Install ditch, Reshape ditch	Stabilization	925	0.5	Limited	Low
4-13	Corner of Collins Brook Rd and Meredith Center Rd	Meredith	Collins Brook	Road shoulder/ditch erosion	Armor ditch with stone or grass, Reshape ditch	Stabilization	1,089	0.5	Limited	Low
4-20	Wicwas Shores Rd culvert	Meredith	Lake Wicwas Direct	Road surface erosion, Road shoulder/ditch erosion	Armor ditch with stone or grass, Install erosion controls (e.g. silt fence), Check dams	Stabilization	1,089	0.5	Limited	Low
1-10	City hall parking lot - north	Laconia	Winnipesaukee River	Depression filled with sediment	Retrofit basin into attractive bio with Forebay. Check property lines. Only upper basin is city owned. Might be able to include private. Do not remove parking.	Treatment	0	0.4	Direct	Low
2-23	Near Hurricane Rd, Union Rd intersection	Belmont	Lake Winnisquam Direct	Road shoulder/ditch erosion, Buried culvert partially	Reshape ditch, Armor ditch with stone or grass	Stabilization	998	0.4	Direct	Low

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1-01	Opechee Park parking lot, picnic/play area, and beach	Laconia	Lake Opechee	Goose habitat, parking lot runoff erosion. Existing vegetated swale.	Buffer planting, enhance veg swale along beach, swale along parking edge conveying to terrace with infiltration under picnic tables with timber ties. Slide tables away from oak.	Treatment, Stabilization	0	0.4	Direct	Low
3-17	Camp Waldron Rd	Meredith	Swamp Pond	Road shoulder/ditch erosion, Unstable culvert inlet/outlet, gully and rill formation from road shoulder to culvert inlet/outlet, Stormwater flow path noted entering stream at inlet end	Stabilize inlet and/or outlet, Armor ditch with stone or grass, Reshape ditch, Reshape or crown road, Reshape/vegetate shoulder	Stabilization	798	0.3	Direct	Low
3-18	Camp Waldron Rd	Meredith	Swamp Pond	Road shoulder/ditch erosion, Unstable culvert inlet/outlet, rill formation from road shoulder to culvert inlet/outlet	Stabilize inlet and/or outlet, Armor ditch with stone or grass, Reshape ditch, Reshape or crown road, Reshape/vegetate shoulder	Stabilization	798	0.3	Direct	Low
4-10	Meredith Center Rd by house 27 (Lake Wicwas outflow?)	Meredith	Lake Wicwas Direct	Road shoulder/ditch erosion, Severe streambank erosion/failure, lack of stable buffer, no buffer.	Stabilize banks, Plant/improve buffer, Reshape/vegetate shoulder	Stabilization	798	0.3	Direct	Low
1-04	Opechee Park and N Main St/Rt 106- Overland flow and outfall from road	Laconia	Lake Opechee	Large outfall. Road runoff (N. Main St) overtops at CB, flows overland through park toward Opechee, causing erosion.	To treat road runoff: Cap CB, curb cut and divert runoff into vegetated infiltration swale. For outfall, evaluate if it would be possible to add DMH with perforated laterals to divert first flush into subsurface sand filters. Would likely encounter issues with high groundwater.	Treatment, Stabilization	370	0.3	Direct	Low

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1-08	Highway garage, equipment storage, salt sheds	Laconia	Winnipesaukee River	Sand buildup. Degraded stream. Snow storage next to stream. Erosion and dead grass where runoff flows overland from north parking lot entrance into stream. Erosion and sediment-laden runoff from parking area along stream.	Sediment forebay and level spreader at north entrance where runoff flows overland into stream. Cap CB.	Treatment, Stabilization	575	0.3	Direct	Low
3-03	Camp Waldron Rd	Meredith	Lake Wicwas Direct	Road shoulder/ditch erosion, gully formation on sloping road shoulder; road shoulder material slumping evident; lack of proper road crown	Reshape/vegetate shoulder, Reshape or crown road	Stabilization	748	0.3	Direct	Low
1-11	Ahern State Park beach	Laconia	Lake Winnisquam Direct	Eroding road and parking lot	Swale/stabilized channel of drivable grass across fire road to redirect run-on from above lot, into bio. Bio in area of standing water to south of lot. Water bar across lot to direct flow to it.	Stabilization	679	0.3	Direct	Low
1-09	City Hall parking lot - south	Laconia	Winnipesaukee River	Existing small biobasin for large parking lot, not well maintained	Enlarge bio, add grasspave forebay, plants that are easier to maintain	Treatment	0	0.3	Direct	Low
2-02	Salt marsh pond NHFGD boat ramp	Gilford	Jewett Brook	Road surface erosion, lack of vegetated buffer	Reshape or crown road, Install erosion controls (e.g. silt fence), Install runoff diverter, Install water bars over driveway, and before boat ramp, Plant/improve buffer	Stabilization	514	0.3	Direct	Low
2-21	Jefferson Rd	Belmont	Lake Winnisquam Direct	Road shoulder/ditch erosion, Excessive build-up of sediment, Severe streambank erosion/failure, Buffer not wide enough, Poor/degraded buffer	Plant/improve buffer, Reshape/vegetate shoulder	Stabilization	599	0.3	Direct	Low
3-29	Lower Bay Rd	Sanbornton	Lake Winnisquam Direct	Minimal buffer between road and lake, Unstable bank in some areas	Stabilize bank with living shoreline techniques	Buffer	0	0.2	Direct	Low

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3-01	Chemung Rd at intersection with Camp Waldron Rd, across from white house with blue roof #157	Meredith	Lake Wicwas Direct	Significant road shoulder/ditch erosion along Chemung Rd; drainage from Chemung Rd feeds into collapsed undersized culvert; significant rill and gully formation off road shoulder around culvert outlet	Replace and enlarge culvert, Stabilize inlet and/or outlet, Armor ditch with stone or grass, Reshape ditch, Stabilize banks, Reshape/vegetate shoulder	Stabilization	499	0.2	Direct	Low
2-22	Jefferson Rd at Union Rd stream crossing	Belmont	Lake Winnisquam Direct	very slight road shoulder erosion. Culvert looks great.	Regrade and stabilize road shoulder	Stabilization	366	0.2	Direct	Low
3-27	Woodman Rd, open field	Sanbornton	Black Brook	Minimal stream buffer through open field, landowners mow grass right to stream bank edges.	Enhance buffer with shrubs, Establish a minimum 50 ft no-mow zone around stream	Buffer	0	0.1	Direct	Low
4-18	Chase Rd stream crossing	Meredith	Dolloff Brook	Road shoulder/ditch erosion, Lack of stream shading, Buffer not wide enough, unstable road shoulder.	Stabilize inlet and/or outlet, Stabilize banks, Reshape/vegetate shoulder, Bank stabilization	Stabilization	239	0.1	Direct	Low
2-26	Hurricane Rd stream crossing	Belmont	Lake Winnisquam Direct	Lack of stream buffer. Buffer not wide enough/or present. Culvert itself and stabilization rip rap look great.	Improve stream buffer near the slope to the roadway and downstream on private property with the large lawn.	Buffer	0	0.1	Direct	Low
2-20	Union Rd stream crossing	Belmont	Durgin Brook	Bank/channel downcutting/incision, Severe streambank erosion/failure	Bank stabilization	Stabilization	160	0.1	Direct	Low
2-07	Country Club Rd stream crossing	Gilford	Jewett Brook	Road shoulder/ditch erosion, Only slight road shoulder erosion leading to stream crossing, Excessive trash, Buffer not wide enough, Poor/degraded buffer	Reshape/vegetate shoulder, Plant/improve buffer	Stabilization	120	0.1	Direct	Low
4-19	Chemung Rd near a wetland crossing	Meredith	Lake Wicwas Direct	Road shoulder/ditch erosion, Buffer not wide enough	Armor ditch with stone or grass, Plant/improve buffer	Stabilization	24	0.0	Direct	Low

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1-13	End of Water St, town land and outfall	Laconia	Lake Winnisquam Direct	Tons of trash, partially buried outfall. Some trash blows in and some from homeless camps.	Trash cans and regular cleanups. Remove pavement and restore buffer, with plantings to discourage water access and keep trash from blowing/washing into water. Evaluate feasibility of constructed wetland; potential soil contamination.	Buffer, Maintenance	0	0.0	Direct	Low
2-19	Hubble Rd	Belmont	Durgin Brook	Road shoulder/ditch erosion, Excessive build-up of sediment	Armor ditch with stone or grass, Install turnout, Reshape ditch, Reshape/vegetate shoulder, Install runoff diverter, Install erosion controls (e.g. silt fence)	Stabilization	907	0.4	Limited	Low
2-15	Logan Dr	Belmont	Durkee Brook	Road shoulder/ditch erosion	Armor ditch with stone or grass, Install check dams	Stabilization	771	0.4	Limited	Low
2-31	Mile Hill Rd	Laconia	Durkee Brook	Road surface erosion, Road shoulder/ditch erosion, Unstable culvert inlet/outlet, Bare soil/fields, 2 catch basins are like this	Clean out culvert, Install plunge pool, Remove winter sand, Build up road/ add surface material, Clean out ditch	Stabilization	771	0.4	Limited	Low
4-01	On State Route 106 just north of the Meredith Center Rd intersection	Laconia	Lake Opechee	Road shoulder/ditch erosion leading to a catch basin	Armor ditch with stone or grass, Reshape ditch	Stabilization	681	0.3	Limited	Low
2-13	Plummer Hill Rd	Belmont	Durgin Brook	Road shoulder/ditch erosion, Stockpiled soil, This entire road has really sandy shoulders which may be from winter sand not being swept up	Armor ditch with stone or grass, Reshape ditch, Remove berms created by road grader, Remove winter sand	Stabilization	463	0.2	Limited	Low
2-27	Union Rd	Belmont	Lake Winnisquam Direct	Road shoulder/ditch erosion, About 2’ deep, Poor/degraded buffer	Armor ditch with stone or grass, Plant/improve buffer	Stabilization	463	0.2	Limited	Low

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4-14	Leighton Ave N	Laconia	Lake Winnisquam Direct	Road shoulder/ditch erosion, Stream ditch channel has check dams. Leaves need to be cleaned out	Armor ditch with stone or grass, Stabilize banks	Stabilization	544	0.2	Limited	Low
4-02	Eastman Rd	Laconia	Lake Winnisquam Direct	Road surface erosion, Road shoulder/ditch erosion leading to an unpaved driveway toward the lake	Install ditch, Install turnout, Reshape ditch, Remove winter sand, Reshape/vegetate shoulder, Install runoff diverter, Plant/improve buffer	Stabilization	411	0.2	Limited	Low
4-21	Intersection of Chemung and Meredith Center Road	Meredith	Mill Brook	Road shoulder/ditch erosion	Armor ditch with stone or grass	Stabilization	435	0.2	Limited	Low
2-17	Dutile Rd	Belmont	Durgin Brook	Road shoulder/ditch erosion	Armor ditch with stone or grass, Install check dams	Stabilization	399	0.2	Limited	Low
4-11	Meredith Center Rd between Meredith Center Coop MHP and Baywoods Rd	Meredith	Mill Brook	Road shoulder/ditch erosion	Reshape/vegetate shoulder, Reshape ditch, Armor ditch with stone or grass	Stabilization	363	0.2	Limited	Low
2-08	Frank Bean Rd	Laconia	Durkee Brook	Road shoulder/ditch erosion, Bare soil/fields	Armor ditch with stone or grass, Install turnout	Stabilization	308	0.2	Limited	Low
2-12	Plummer Hill Rd	Belmont	Durgin Brook	Road shoulder/ditch erosion, Unstable culvert inlet/outlet, To house 141	Armor ditch with stone or grass, Clean out culvert, Reshape/vegetate shoulder, Reshape ditch	Stabilization	308	0.2	Limited	Low
2-18	Hubble Rd	Belmont	Durgin Brook	Road shoulder/ditch erosion, Until house 39	Remove berms created by road grader, Install ditch, Reshape ditch, Armor ditch with stone or grass	Stabilization	154	0.1	Limited	Low
2-28	Hurricane Rd	Belmont	Lake Winnisquam Direct	Road shoulder/ditch erosion	Reshape ditch, Armor ditch with stone or grass	Stabilization	154	0.1	Limited	Low

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2-03	Sawmill Rd and Country Club Rd intersection on Bank of NH corner	Gilford	Jewett Brook	Road shoulder/ditch erosion	Reshape ditch, Armor ditch with stone or grass	Stabilization	160	0.1	Limited	Low
2-29	Mile Hill Rd	Belmont	Durkee Brook	Road shoulder/ditch erosion	Install ditch, Armor ditch with stone or grass, Install turnout, Reshape ditch, Install plunge pool	Stabilization	116	0.1	Limited	Low
4-15	Leighton Ave N and Collins Brook Rd	Laconia	Lake Winnisquam Direct	Road surface erosion, Road shoulder/ditch erosion	Install ditch, Armor ditch with stone or grass, Reshape ditch, Reshape/vegetate shoulder, Reshape or crown road, Check dams	Stabilization	121	0.1	Limited	Low
2-14	Plummer Hill Rd	Belmont	Durgin Brook	Road shoulder/ditch erosion, Road shoulder sediment sliding down hill perpendicular to road with flow channels	Install erosion controls (e.g. silt fence), Armor ditch with stone or grass, Reshape/vegetate shoulder	Stabilization	91	0.0	Limited	Low
2-16	Dutile Rd	Belmont	Durgin Brook	Road shoulder/ditch erosion	Armor ditch with stone or grass, Reshape/vegetate shoulder	Stabilization	77	0.0	Limited	Low
2-32	Lakeside of Lakeshore Drive	Sanbornton	Lake Winnisquam Direct	Road shoulder/ditch erosion, Road surface erosion. The road is a soft unpaved sandy material.	Build up road, add surface material, reshape or recrown road.	Stabilization	77	0.0	Limited	Low
4-12	Near Meredith town park playground on Meredith Center Rd	Meredith	Mill Brook	Road surface erosion, Road shoulder/ditch erosion	Remove winter sand, Reshape ditch, Armor ditch with stone or grass	Stabilization	45	0.0	Limited	Low

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1-02	Opechee Park- Point where parking lot runoff could be diverted to infiltration under picnic area	Laconia	Lake Opechee	Goose habitat, parking lot runoff erosion. Existing vegetated swale.	Propose swale to infiltration under picnic table terrace	NA	0	0.0	Direct	Low
1-03	Opechee Park - Swale along beach	Laconia	Lake Opechee	Goose habitat, parking lot runoff erosion. Existing vegetated swale.	Swale could be expanded/enhanced to provide additional treatment	NA	0	0.0	Direct	Low
1-05	Messer St boat ramp	Laconia	Lake Opechee	Contaminated site, capped. Gravel drive, two paved spaces near ramp. Owned by Eversource.	Buffer plantings but probably not a feasible site due to ownership and contamination.	NA	0	0.0	Direct	Low
1-14	Bartlett Beach	Laconia	Lake Winnisquam Direct	Gravel/sand parking lot. Graded away from lake into what looks like was meant to be a swale. Wetland at back of lot.	No recommendations except perhaps to ensure maintenance of swale along back of lot.	Maintenance	0	0.0	Direct	Low
1-15	Leslie Beach, Belmont	Belmont	Lake Winnisquam Direct	No issues - stormwater and erosion appear well managed		NA	0	0.0	Direct	Low
2-09b	Province Rd	Laconia	Durkee Brook	Road shoulder/ditch erosion, Unstable culvert inlet/outlet, Bare soil/fields	Stabilize inlet and/or outlet, Install plunge pool, Clean out culvert, Reshape/vegetate shoulder, Armor ditch with stone or grass	Stabilization	0	0.0	Direct	Low
2-34	Linda Drive	Belmont	Lake Winnisquam Direct	Lots of private large and very green lawns with little to no buffers.	Target this neighborhood for sustainable lawn maintenance and buffer practices.	Buffer, Education	0	0.0	Direct	Low

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3-33	Philbrook Rd	Sanbornton	Lake Winnisquam Direct	Green algae observed in ponded water area, water is conveyed through a culvert under the road, small stream flowing into ponded area, drains residential and agricultural land, residential home nearby, may be lawn fertilizer, faulty septic, or manured fields	Investigate source of nutrients in drainage area	Other	0	0.0	Direct	Low
3-35	Lower Bay Rd Bay Rd intersection	Sanbornton	Chapman Brook	No noticeable channelization from the roadway. There is a rip rapped drainage/slope stabilization perpendicular to the stream but the stream banks themselves are natural. Did not walk on private property.	No major problems observed so no recommendations.	NA	0	0.0	Direct	Low
4-05	Stream crossing from an unnamed pond under Hatch Corner Rd	Meredith	Unnamed Tributary (North Trib)	Downstream of a beaver wetland, Hanging culvert (no fish passage), Icky smell, undetermined if its sewage or just a high organic content. Trash around stream. Pedestrian said it sometimes has a strong sulfur smell.	Re-align, repair, or upgrade culvert	Other	0	0.0	Direct	Low
1-06	Sanborn Park	Laconia	Lake Opechee	Urban runoff to closed drainage	Green space. Potential to divert from drainage structure on Clinton St but at top of catchment area, not great opportunity.	NA	0	0.0	Limited	Low
1-07	Tributary to Jewett Brook at Gilford Ave	Laconia	Jewett Brook	Mowed to edge of stream on one side, stockpile on other side. Minor erosion.	Generally, encourage stream buffers	Buffer, Education	0	0.0	Limited	Low
2-09a	Province Rd	Laconia	Durkee Brook	Road shoulder/ditch erosion, Unstable culvert inlet/outlet, Bare soil/fields	Stabilize inlet and/or outlet, Install plunge pool, Clean out culvert, Reshape/vegetate shoulder, Armor ditch with stone or grass	Stabilization	0	0.0	Limited	Low

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2-36	Belmont Mall	Belmont	Lake Winnisquam Direct	Large paved parking area with stores. Increases stormwater runoff temperature	Install parking lot stormwater controls and infiltration areas (need more investigation, info on existing BMPs)	NA	0	0.0	Limited	Low
4-16	Straits Rd	New Hampton	Dolloff Brook	Winter sand lining the road	Remove winter sand	Maintenance	0	0.0	Limited	Low
4-17	Forest Pond Rd	New Hampton	Dolloff Brook	So much winter sand still on the road	Remove winter sand	Maintenance	0	0.0	Limited	Low