SWANZEY LAKE

WATERSHED-BASED MANAGEMENT PLAN

PREPARED BY FB ENVIRONMENTAL ASSOCIATES

in cooperation with the Southwest Region Planning Commission, Swanzey Lake Protective Association, and Town of Swanzey

September 2024 | **FINAL**

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In Memory of Bill Stetson*, Lake Host, Swanzey Lake Protective Association*

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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
BMP	Best Management Practice
CAGR	Compound Annual Growth Rate
CCCD	Cheshire County Conservation District
CHL-A	Chlorophyll-a
CRC	Connecticut River Conservancy
CSP	Conservation Stewardship Program
CUM	Cubic Meters
CWA	Clean Water Act
CWP	Center for Watershed Protection
CWSRF	Clean Water State Revolving Fund
DO	Dissolved Oxygen
DPW	Department of Public Works
EMD	Environmental Monitoring Database
EPA	United States Environmental Protection Agency
EQIP	Environmental Quality Incentives Program
ESRI	Environmental Systems Research Institute
FBE	FB Environmental Associates
FT	Feet
HA	Hectare
HAB	Harmful Algal Bloom
ILF	In-Lieu Fee
KG	Kilogram
LCHIP	Land and Community Heritage Investment Program
LID	Low Impact Development
LLRM	Lake Loading Response Model
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
NHFG	New Hampshire Fish and Game Department
NHLCD	New Hampshire Land Cover Database
NOAA	National Oceanic and Atmospheric Administration
PCS	National Pollutant Discharge Elimination System
NPS	Nonpoint Source Pollution
NRCS	Natural Resources Conservation Service
NRI	Natural Resources Inventory
NWI	National Wetlands Inventory

ACRONYM	DEFINITION
PAS	Potentially Attaining Standards
PCR	Primary Contact Recreation
PCS	Potential Contamination Source
PFAS	Per- and polyfluoroalkyl substances
PNS	Potentially Not Supporting
ppb, ppm	parts per billion, parts per million
RCCP	Regional Conservation Partnership Program
RCRA	Resource Conservation and Recovery Act
ROW	Right-of-Way
SCC	State Conservation Committee
SDT	Secchi Disk Transparency
SWRPC	Southwest Region Planning Commission
TP	Total Phosphorus
UNH	University of New Hampshire
USLE	Universal Soil Loss Equation
VLAP	Volunteer Lake Assessment Program
WBMP	Watershed-Based Management Plan
YR	Year

DEFINITIONS

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

Anoxia is a condition of low dissolved oxygen.

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

Best Management Practices (BMPs) are conservation practices designed to minimize discharge of NPS pollution from developed land to lakes and streams. Management plans should include both non-structural (non-engineered) and structural (engineered) BMPs for existing and new development to ensure long-term restoration success.

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

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

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

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

Dissolved Oxygen (DO) is a measure of the amount of oxygen dissolved in water. Low oxygen can stress sensitive organisms like coldwater fish and can stimulate the release of phosphorus from bottom sediments.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

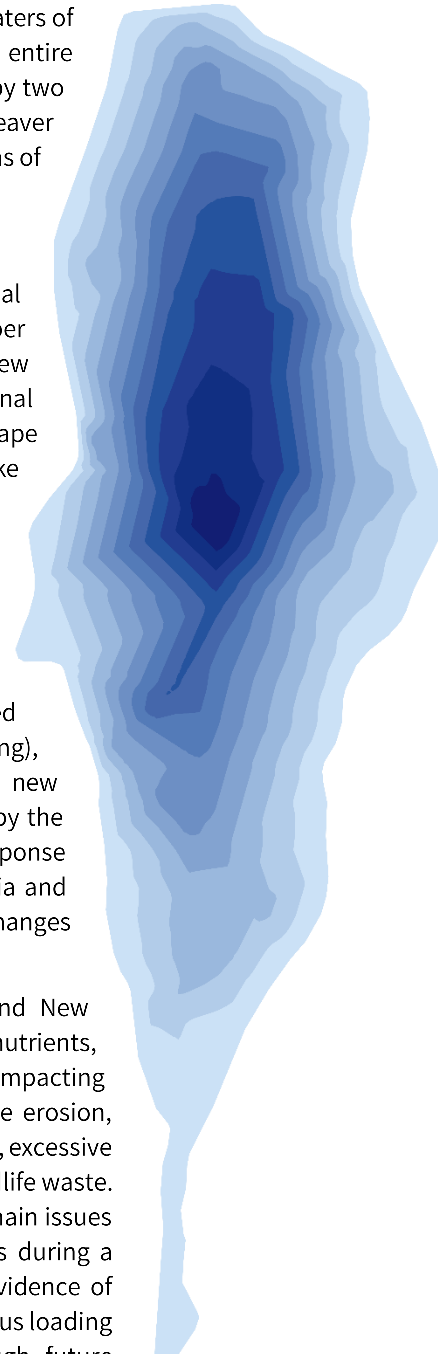
Thermal stratification is the process whereby warming surface temperatures in summer create a temperature and density differential that separates the water column into distinct, non-mixable layers.

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

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

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

EXECUTIVE SUMMARY



Swanzey Lake is a 111-acre lake with a 874-acre watershed situated within the headwaters of the Connecticut River basin, which ultimately feeds into the Long Island Sound. The entire watershed and lake reside within the Town of Swanzey. Swanzey Lake is fed mainly by two small tributaries, one of which is part of a wetland-pond complex dammed by beaver activity. There are also several intermittent or seasonal streams connecting uphill areas of the watershed to Swanzey Lake.

The Problem

Swanzey Lake has historically experienced generally good water quality, with minimal cyanobacteria bloom history but with cautionary low dissolved oxygen levels in deeper parts of the lake. Development in the lake's watershed is primarily residential, with a few summer campgrounds. In recent years, many residences have converted from seasonal cottages to year-round homes. Paired with the steepness of the surrounding landscape and the increasing frequency of extreme storms, the impact of the watershed on lake water quality has become a major concern. In 2021, a beaver dam breach and record rainfall caused a considerable decline in lake water quality and triggered a cyanobacteria bloom alert (no sample) by the NHDES Harmful Algal Bloom (HAB) Program in mid-August of that year. Similarly, an extreme storm event in July 2023 overwhelmed existing stormwater infrastructure, washed out roads, and flushed tons of eroded sediment into Swanzey Lake. The lake's water quality response to this storm event has not yet been fully assessed. Preliminary data collected in 2023 showed a worsening of anoxia in the lake (and thus possibly internal phosphorus loading), suggesting that the extreme weather may have set the lake's water quality on a new trajectory towards more rapid degradation. Due to the scale of destruction caused by the July 2023 storm and the model limitations, we strongly recommend that the lake's response to the 2023 extreme weather be carefully monitored (especially the extent of anoxia and internal phosphorus loading) and the water quality goal be re-assessed if dramatic changes in lake response occur over the next several years.

Cyanobacteria blooms, which are becoming more common in Swanzey Lake and New Hampshire at large, are spurred by a combination of warming waters and excessive nutrients, in particular phosphorus, to surface waters. Sources of phosphorus in the watershed impacting the lake's water quality include stormwater runoff from developed areas, shoreline erosion, erosion from construction activities or other disturbed ground particularly along roads, excessive fertilizer application, failed or improperly functioning septic systems, and pet and wildlife waste. Thirty-nine (39) sites were identified in the watershed during a field survey, and the main issues found were unpaved road and ditch erosion. Additionally, 21 shorefront properties during a shoreline survey were identified as having some impact to water quality due to evidence of erosion and lack of vegetated buffer. The model results revealed changes in phosphorus loading and in-lake phosphorus concentrations over time from pre-development through future conditions, showing that the water quality of Swanzey Lake 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 goal of the Swanzey Lake Watershed-Based Management Plan (WBMP) is to improve the water quality of Swanzey Lake such that it meets state water quality standards for the protection of aquatic life integrity and substantially reduces the likelihood of harmful cyanobacteria blooms in the lake. This goal will be achieved by accomplishing the following objectives:

OBJECTIVE 1: Reduce phosphorus loading from existing development in the watershed.

OBJECTIVE 2: Mitigate (prevent or offset) anticipated additional phosphorus loading from future development.

The Solution

As identified in the Town of Swanzey's 2022 Master Plan and due to concern over the threat of cyanobacteria blooms, the Swanzey Lake Protective Association (SLPA) initiated a campaign to better understand and protect the water quality of Swanzey Lake. SLPA partnered with the Southwest Region Planning Commission (SWRPC) to secure funding through the New Hampshire Department of Environmental Services (NHDES) to develop a WBMP for Swanzey Lake. As part of the development of the WBMP, FB Environmental Associates (FBE) completed a build-out analysis, land-use model, water quality and assimilative capacity analysis, septic system database development, shoreline survey, and watershed survey to identify and quantify the sources of phosphorus and other pollutants to the lake. Results from these analyses were used to determine recommended management strategies for the identified pollutant sources in the watershed. An Action Plan (Section 5) was developed in collaboration with the Swanzey Lake Work Group comprised of members of the SLPA and the Town of Swanzey (see Acknowledgements). The following actions were recommended to meet the established water quality goal and objectives for Swanzey Lake:

WATERSHED STRUCTURAL BMPS: Sources of phosphorus from watershed development should be addressed through installation of stormwater controls, stabilization techniques, buffer plantings, etc. for the following: stormwater infrastructure, the high priority sites (and the medium and low priority sites as opportunities arise) identified during the watershed survey, the medium impact shoreline properties identified during the shoreline survey, and any new or redevelopment projects in the watershed with high potential for soil erosion. Special focus by private landowners and the Town of Swanzey should be given to the highest ranked watershed survey sites, such as Talbot Hill Road, the Pilgrim Pines Campground, and the Richardson Town Beach, especially as efforts have already begun to pursue fully engineered designs for some of these locations. **We emphasize that the primary purpose of the WBMP is on water quality and not flood prevention or mitigation. The BMP recommendations are intended to help sites withstand moderate to large storm events but not necessarily extreme storm events, which can be so devastatingly intense that they typically overwhelm any infrastructure.**

MONITORING: A long-term water quality monitoring plan is critical to evaluate the effectiveness of implementation efforts over time. SLPA, in concert with the NHDES Volunteer Lake Assessment Program (VLAP), should continue the annual monitoring program and consider incorporating additional monitoring recommendations laid out in this plan. Additional data are also needed to better evaluate the contribution of internal phosphorus loading in the lake and the lake's response to the extreme weather events in July 2023.

EDUCATION AND OUTREACH: SLPA and other key watershed stakeholders should continue all aspects of their education and outreach strategies and consider developing new ones or improving existing ones to reach more watershed residents. Examples include creating a website to post information and 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; using best practices for road maintenance and other activities including municipal operations such as infrastructure cleaning; and conserving large or connective habitat corridor parcels. Future development should also be considered as a pollutant source and potential threat to water quality. Swanzey Lake is at risk for greater water quality degradation because of new development in the watershed unless climate change resiliency and LID strategies are incorporated into existing zoning standards.

The recommendations of this plan will be carried out largely by SLPA with assistance from a diverse stakeholder group, including representatives from the Town of Swanzey (e.g., board of selectman, planning boards), conservation commission, state and federal agencies or organizations, nonprofits, land trusts, schools and community groups, local business leaders, and private landowners. The cost of successfully implementing the plan is estimated at $1.3-$2.1 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 the Town of Swanzey or donations from private residents. Of significant note, this plan meets the nine planning elements required by the EPA, and Swanzey Lake is now eligible for federal watershed assistance grants.

Important Notes

The success of this plan is dependent on the continued effort of volunteers and a strong and diverse stakeholder group that meets regularly to coordinate resources for implementation, review progress, and make any necessary adjustments to the plan to maintain relevant action items and interim milestones. It will be important for private landowners to understand that the burden of plan implementation rests on the entire community and not a single stakeholder (such as SLPA or the Town of Swanzey), just as it will be important for the Town of Swanzey to understand that Swanzey Lake is a valuable public resource that contributes to the annual tax revenue and that plan implementation cannot be successful without their ongoing participation. A reduction in nutrient loading is no easy task, and because there are many diffuse sources of phosphorus reaching surface waters in the watershed, it will require an integrated and adaptive approach across many different parts of the watershed community to be successful. The recommendations in this plan are idealized and, in some cases, may be difficult to achieve given the physical and political realities of the community dealing with old infrastructure, lack of access to key lakefront areas, and limited funding and volunteer or staff capacity.

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. SLPA 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 Swanzey Lake long into the future.

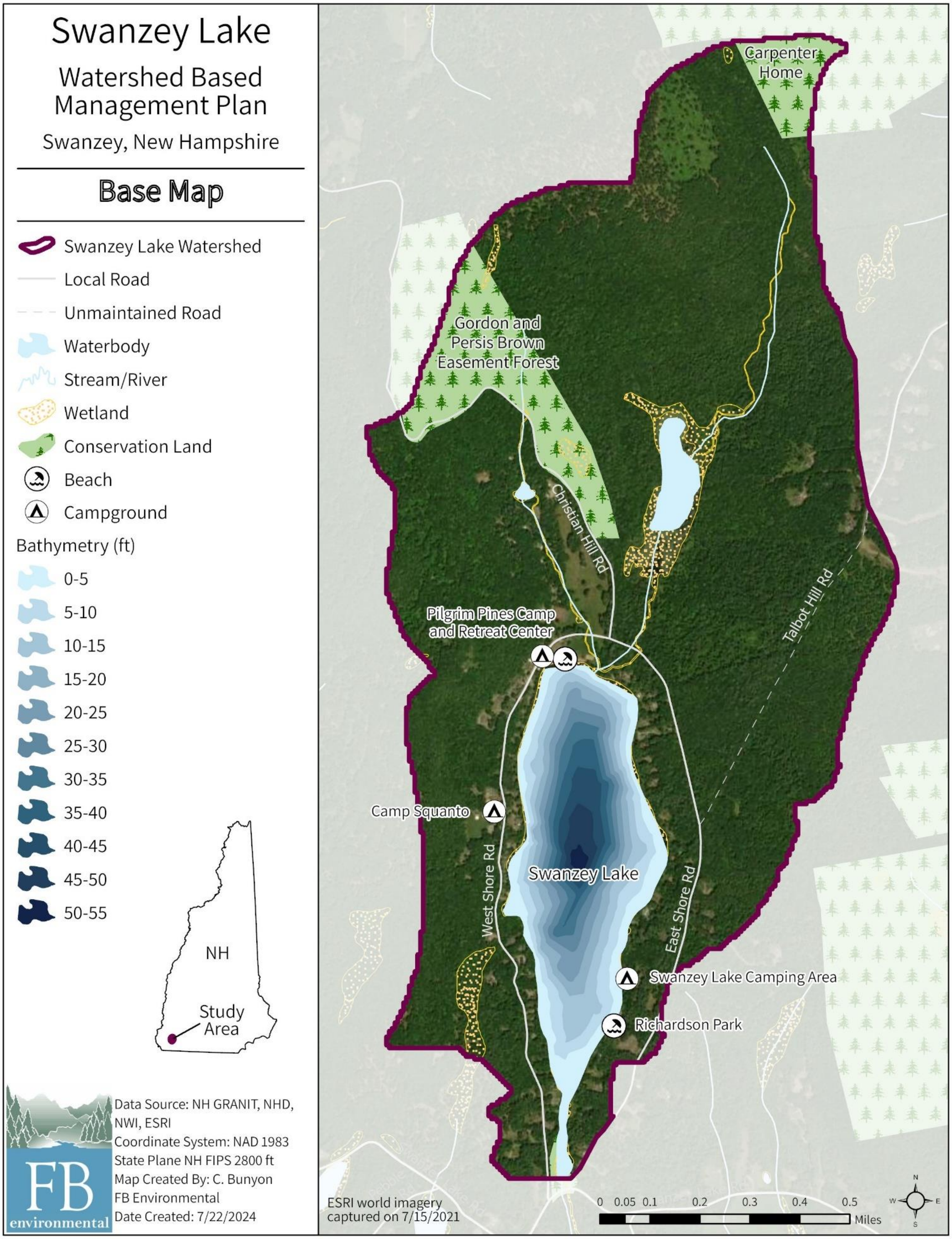


Figure 1. Swanzey Lake watershed.

1 INTRODUCTION

1.1 WATERBODY DESCRIPTION AND LOCATION

Swanzey Lake is a 111-acre (45-hectare) lake with a 874-acre (354-hectare) watershed located entirely within the Town of Swanzey, NH. Swanzey Lake is fed mainly by two small tributaries, one of which is part of a wetland-pond complex dammed by beaver activity. There are also several intermittent or seasonal streams connecting uphill areas of the watershed to Swanzey Lake. From the outlet of Swanzey Lake at the southern end of the waterbody, water flows to Perry Brook, a tributary to the Connecticut River (Figure 1).

The Swanzey Lake watershed is situated within a temperate zone, much like the rest of New England, and has a lower elevation than the northern areas of New Hampshire and is far from the Atlantic Ocean, which regulates the temperature in the eastern portion of the state. The area experiences high rainfall and snowfall, averaging 55 inches of precipitation per year in recent years. Data were collected for 1980-2022 from NASA's Daymet Daily Surface Weather and Climatological Summaries Single Pixel Extraction Tool (Daymet, 2024), which aggregates weather summaries for specific coordinates based spatially and temporally interpolating observed weather data from the nearest weather stations (Figure 2). Annual air temperature (from average daily data) generally ranges from 30°F to 60°F with an average of 47°F.

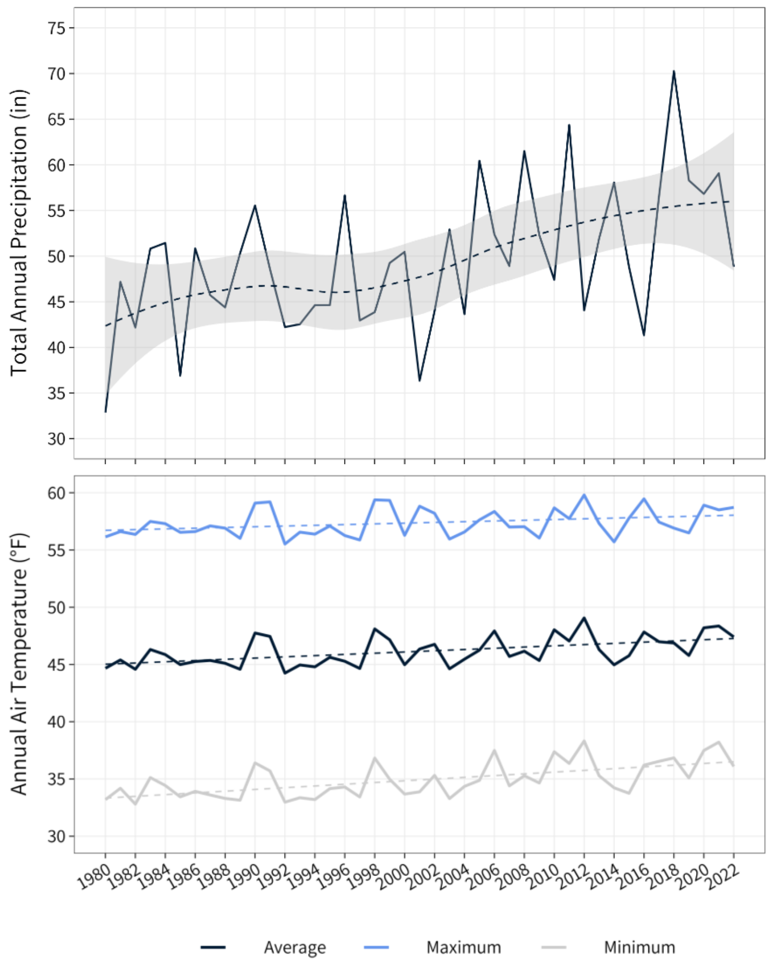


Figure 2. Total annual precipitation and annual max, average, and min monthly air temperature from 1980 – 2022 for the region. Data collected from NASA's Daymet service.

The highest elevation in the watershed (about 302 feet above sea level) is located slightly northwest of the chapel at the Pilgrim Pines Campground in the area where a landslide occurred after an extreme storm event in July 2023. Swanzey Lake and its direct shoreline area are approximately 159 feet above sea level. These elevation measurements were derived from digital elevation models provided by the USGS and NH GRANIT.

The watershed is characterized primarily by hemlock-hardwood-pine and Appalachian-oak-pine forests with both coniferous (white pine, eastern hemlock) and deciduous (oak, beech, sugar maple) tree species. There is also a wetland-pond complex located north of Swanzey Lake consisting of a deep impoundment area and wet meadow. Fauna that enjoy these forested resources include land mammals (moose, deer, black bear, bobcats, flying squirrel, fisher cats, porcupine, squirrel, and bats), water mammals (beavers), land and water reptiles and amphibians (turtles, toads, snakes, and salamanders), various insects and birds (woodcocks, owls, warblers, hawks, finches, grouse, turkeys, butterflies, and beetles), and fish (UNH Extension, 2015). The Town of Swanzey is home to various threatened and endangered species, including the eastern meadowlark, grasshopper sparrow, dwarf wedge mussel, long-headed windflower, and northeastern bulrush (Moosewood Ecological, LLC, 2018).

1.2 WATERSHED PROTECTION GROUPS

With 78 members, the Swanzey Lake Protective Association (SLPA) works to serve and promote the recreational interests that occur at Swanzey Lake. The SLPA is a partner in the Lake Advocates Network through NH Lakes, which is a statewide network of lake advocates working to support proactive and protective lake policy in New Hampshire to restore and preserve the health of lakes.

The Southwest Region Planning Commission (SWRPC) serves 34 communities in Cheshire, Hillsborough, and Sullivan counties with the goal to "*work in partnership with the communities of the Southwest Region to promote sound decision-making for the conservation and effective management of natural, cultural and economic resources.*" The organization works with local governments, lake associations, and landowners on projects related to natural resources, brownfield sites, watershed planning, climate resiliency, housing, and community development.

The Cheshire County Conservation District (CCCD) is a non-profit organization with the vision of "*encouraging stewardship for healthy soils, productive ecologically sound farms, diverse wildlife, productive sustainable forests, healthy watersheds and clean water to ensure those resources are available for future generations.*" It works with municipalities, foresters, farmers, and landowners within Cheshire County on soil, water, wildlife, and farm-related programs, including surface water improvement projects and rain garden technical assistance.

The Connecticut River Conservancy (CRC, formerly the CT River Watershed Council) is a nonprofit organization that works to protect the Connecticut River, whose efforts span four U.S states. Their efforts include climate resiliency, river cleanup, reconnecting fish habitat, flood preparation, tree plantings, and invasive species management. Their efforts include various projects in New Hampshire. Swanzey Lake is a headwater lake of the Connecticut River.

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

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

1.3 PURPOSE AND SCOPE

The purpose and overarching goal of the Swanzey Lake Watershed-Based Management Plan (WBMP) is to guide implementation efforts over the next 10 years (2024-2033) to improve the water quality of Swanzey Lake such that it meets state water quality standards for the protection of Aquatic Life Integrity (ALI) and substantially reduces the likelihood of harmful cyanobacteria blooms in the lake.

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

1.4 COMMUNITY INVOLVEMENT AND PLANNING

The plan was developed through the collaborative efforts of numerous meetings, public presentations, and conference calls among FB Environmental Associates (FBE), SLPA, SWRPC, NHDES, representatives from the Town of Swanzey, and private landowners (see Acknowledgments).

1.4.1 Plan Development Meetings

Several meetings of the Swanzey Lake Work Group were held over the duration of the plan development.

- **March 20, 2023:** Held a kick-off meeting and presentation to the Swanzey Lake Work Group.
- **June 14, 2024:** Reviewed results from the water quality analysis and discussed field survey logistics.
- **August 2, 2023:** Discussed the July 2023 major storm impact and rescheduling of field surveys.
- **August 30, 2023:** Discussed upcoming field surveys and community forum.
- **October 24, 2023:** Held a community forum to gather feedback on the action plan.
- **January 11, 2024:** Reviewed the shoreline and watershed survey results and site prioritization.
- **May 2, 2024:** Reviewed results from the water quality analysis and models and discussed setting a water quality goal.
- **July 10, 2024:** Discussed final public presentation logistics and content.

1.4.2 Residential Survey

SWRPC, with assistance from SLPA, carried out a residential survey of the Swanzey Lake watershed residents in summer 2023. In total, there were 42 responses (30 complete responses, 4 responses from individuals who do not own or live on property near Swanzey Lake). More than half of the respondents (62%) provided contact information to receive additional resources and technical assistance related to improving the water quality of the lake, indicating a strong interest by the community in the development and implementation of this WBMP. Most respondents indicated that they use Swanzey Lake for swimming, followed by boating, paddle boarding or kayaking, and fishing, and live year-round (53%) versus seasonally (47%). A few indicated that they also use the lake for water supply, bathing, or other uses. Most respondents perceived the water quality of Swanzey Lake as "good but could be improved" and indicated that they have noticed changes in water quality and wildlife activity in recent years.

1.4.3 Final Public Presentation

The final public presentation was held at Whitcomb Hall in Swanzey, NH on July 20, 2024 during SLPA's annual meeting. A couple dozen residents were in attendance, including members of the Work Group, as well as representatives from FBE and SWRPC.

1.5 INCORPORATING EPA'S NINE ELEMENTS

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

A. **IDENTIFY CAUSES AND SOURCES: Sections 2 and 3** highlight known sources of NPS pollution to Swanzey Lake 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 Swanzey Lake and the amount of reduction needed to meet the water quality goal, respectively.

- **C. DESCRIPTION OF MANAGEMENT MEASURES: Sections 4 and 5** identify ways to achieve the estimated phosphorus load reduction and reach water quality targets. The Action Plan focuses on several major topic areas that address NPS pollution. Management options in the Action Plan focus on non-structural BMPs integral to the implementation of structural BMPs.
- **D. ESTIMATE OF TECHNICAL AND FINANCIAL ASSISTANCE: Sections 5 and 6** 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 WBMP.
- **F. SCHEDULE FOR ADDRESSING PHOSPHORUS REDUCTIONS: Section 5** provides a list of action items and recommendations to reduce the phosphorus load to Swanzey Lake. 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 SLPA 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 Swanzey Lake, 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 water quality goal and objectives.

2.1 WATER QUALITY SUMMARY

2.1.1 Water Quality Standards & Impairment Status

2.1.1.1 Designated Uses & Water Quality Criteria

The **Clean Water Act** (CWA) requires states to determine designated uses for all surface waters within the state's jurisdiction. Designated uses are the desirable activities and services that surface waters should be able to support and include uses for ALI, fish consumption, shellfish consumption, drinking water supply, primary contact recreation (swimming), secondary contact recreation (boating and fishing), and wildlife. Surface waters can have multiple designated uses. **Primary Contact Recreation (PCR) and 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). Class A waters are drinking water supplies or high-quality waters of the state. **Swanzey Lake is classified as a Class B water in the State of New Hampshire**. Additionally, from 1974 to 2010, NHDES conducted surveys of lakes to determine **trophic state** (**oligotrophic**, **mesotrophic**, or **eutrophic**). The trophic surveys evaluated physical lake features, as well as chemical and biological indicators. **For Swanzey Lake, the trophic state was determined to be oligotrophic in 1977 and mesotrophic in 1986 and 2005** (NHDES, 1977, 1986, and 2005). This means that in-lake water quality was consistent with the standards for mesotrophic lakes in 1986 and 2005; the mesotrophic designation was attributed primarily to increases in aquatic plant growth and decreases in water clarity and dissolved oxygen.

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 strict 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

Swanzey Lake is divided into three assessment units—two of which are beaches along the shore that are frequently used for recreation. The watershed includes two additional assessment units—unnamed inlets (given the names Pine Inlet A for the west inlet and Pine Inlet B for the east inlet). Only two assessment units—both inlet streams—are formally listed as impaired for at least one designated use on the 303(d) New Hampshire List of Impaired Waters for the 2020/2022 cycle (NHDES, 2022a).

These streams are assessed as impaired for ALI due to low pH. According to New Hampshire's *Watershed Report Cards* built from the 2020/2022 305(b)/303(d) listing process (NHDES, 2022b), Swanzey Lake is also not attaining standards (Category 4A-M) for ALI due to low pH and is only marginally attaining standards for critical parameters such as chlorophyll-a and total phosphorus (Table 1). The two beaches differ in their assessments. The Richardson Town Beach, located in the southeastern portion of the lake, is assessed as having a severe impairment for PCR for *E. coli* contamination. The Camp Squanto Beach, located on the northwestern side of the lake, is assessed as meeting water quality standards for PCR, reflecting lower *E. coli* concentrations. There is insufficient information to make an assessment on ALI at the two beaches. Additionally, the NH Statewide Mercury Advisory to limit consumption of fish applies to all assessment units (NHDES, 2021).

Table 1. NHDES assessment units covering Swanzey Lake and their associated water quality rating as reported on the NHDES 2020/2022 Watershed Report Cards.

Assessment Unit Name	AUID	Area (acres) / Length (miles)	Water Quality
Swanzey Lake	NHLAK802010302-01-01	107.8 acres	Poor
Swanzey Lake – Richardson Park Town Beach	NHLAK802010302-01-02	0.6 acres	Severe
Swanzey Lake – Camp Squanto Beach	NHLAK802010302-01-03	1.4 acres	Good
Pine Inlet A	NHRIV802010302-07	0.4 miles	Poor
Unnamed Brook – Pine Inlet B	NHRIV80210302-06	1.2 miles	Poor

2.1.2 Water Quality Data Collection

NH VLAP volunteers have been monitoring Swanzey Lake almost every year since 1990, with lake reports available through 2022. NHDES and the NH Fish and Game Department (NHFG) have also monitored and assessed the lake over the years under various other programs.

Water quality data were obtained for this plan from the NHDES Environmental Monitoring Database (EMD). A descriptive overview of available water quality data for Swanzey Lake is as follows at monitoring locations shown in Figure 3:

- **SWASWAD (Swanzey Lake Deep Spot):** variable depth grab or composite samples (from the **epilimnion**, **metalimnion** and/or **hypolimnion**) were collected from 1990 to 2022. Samples were collected for numerous parameters but largely for temperature, dissolved oxygen, total phosphorus, chlorophyll-a, Secchi disk transparency, specific conductance, chloride, pH, color, turbidity, and alkalinity.
- **SWASWAIA/SWASWAIB (Pine Hill Inlets A and B):** surface grab samples were collected from 1990 to 2022 for total phosphorus, specific conductivity, chloride, and turbidity.

Table 2. Matching site ID and site names by waterbody and site type. Refer to Figure 3 for the location of Swanzey Lake sites.

<table>
<tr><th>Waterbody Name</th><th>Site ID</th><th>Site Name</th><th>Site Type</th></tr>
<tr><td rowspan="14">Swanzey Lake</td><td>SWASWAD</td><td>Swanzey Lake Deep Spot</td><td rowspan="6">Lake/Pond</td></tr>
<tr><td>SWASWA-GEN</td><td>Swanzey Lake-Generic</td></tr>
<tr><td>SWASWAP</td><td>Swanzey Lake-Public Beach</td></tr>
<tr><td>SWASWAEC01</td><td>Swanzey Lake-Bacteria Sample #01</td></tr>
<tr><td>SWASWAEC02</td><td>Swanzey Lake-Bacteria Sample #02</td></tr>
<tr><td>SWASWAPPB</td><td>Swanzey Lake-Pilgrim Pines Beach</td></tr>
<tr><td>BCHRIPSWART</td><td>Swanzey Lk Richardson Pk Tb-Right</td><td rowspan="7">Beach</td></tr>
<tr><td>BCHRIPSWAFR</td><td>Swanzey Lake-Richardson Park – Far Right</td></tr>
<tr><td>BCHRIPSWACR</td><td>Swanzey Lk Richardson Pk Tb-Center</td></tr>
<tr><td>BCHRIPSWALF</td><td>Swanzey Lk Richardson Pk Tb-Left</td></tr>
<tr><td>BCHSQUSWACR</td><td>Camp Squanto-Center</td></tr>
<tr><td>BCHSQUSWART</td><td>Camp Squanto-Right</td></tr>
<tr><td>BCHSQUSWALF</td><td>Camp Squanto-Left</td></tr>
<tr><td>SWASWAO</td><td>Swanzey Lake-Outlet</td><td rowspan="3">River/Stream</td></tr>
<tr><td rowspan="2">Pine Inlet</td><td>SWASWAIA</td><td>Swanzey Lake-Pine Inlet A</td></tr>
<tr><td>SWASWAIB</td><td>Swanzey Lake-Pine Inlet B</td></tr>
</table>

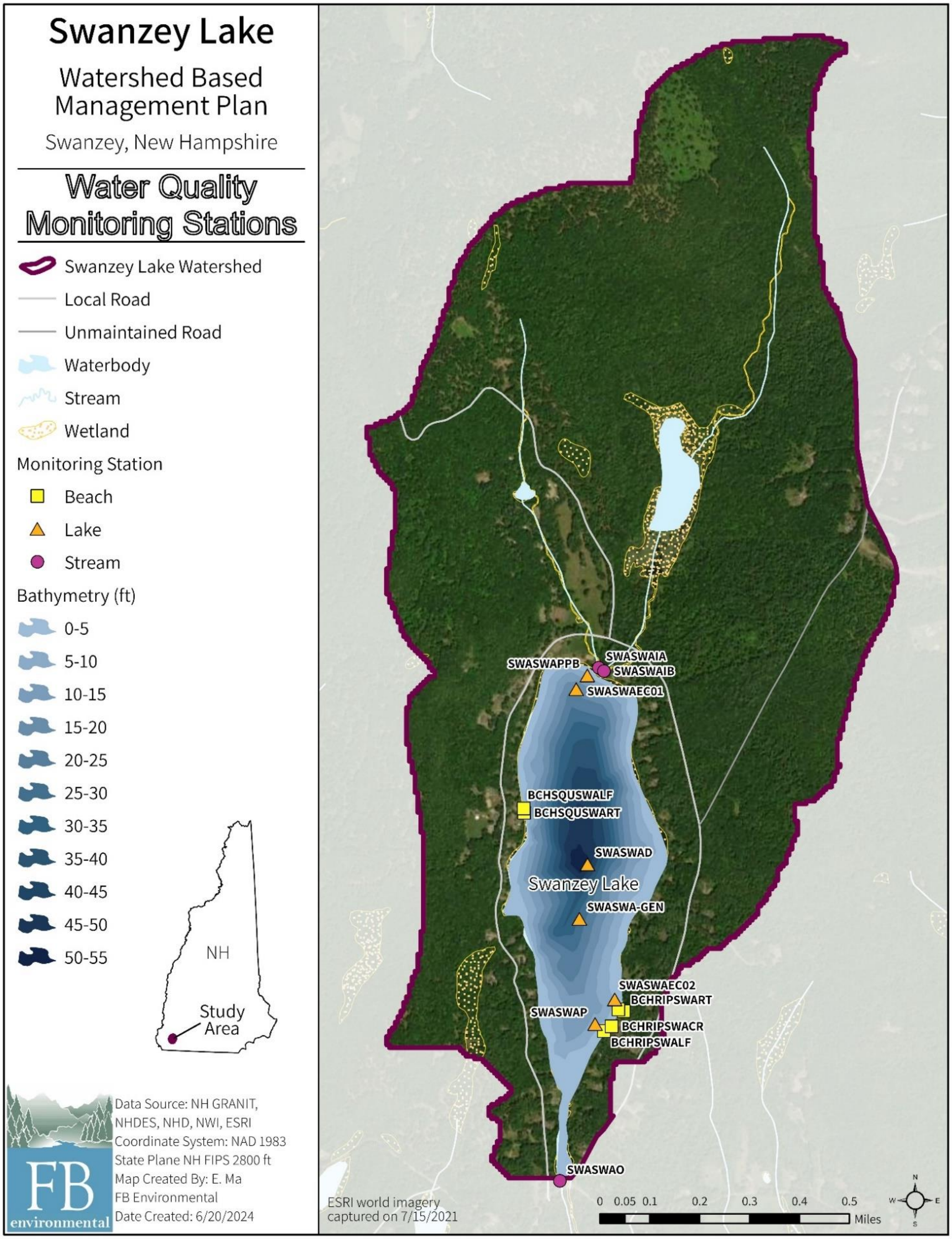


Figure 3. Water quality monitoring sites in the Swanzey Lake watershed. Not all sites are included in this map. Refer to Table 2 for site descriptions.

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.

Generally higher total phosphorus concentrations were measured in the hypolimnion compared to the epilimnion and metalimnion, indicating some amount of **internal phosphorus loading** is occurring in Swanzey Lake (Figure 4). No statistically significant trends were found for total phosphorus, chlorophyll-a, or Secchi disk transparency at the deep spot of Swanzey Lake (SWASWAD) for the available time period of 1977-2022 (Figure 5). The 2022 Data Summary of the NH VLAP Individual Lake Report for Swanzey Lake also indicates stable trends for these parameters. Caution should be used with these interpretations of the data given its limited availability (e.g., usually only one sample collected in June each year before peak internal loading occurs).

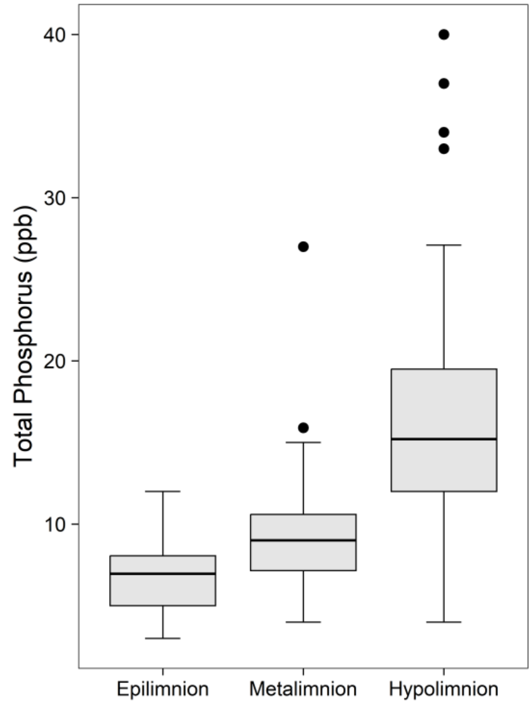


Figure 4. Boxplots showing the range of total phosphorus concentration in the epilimnion, metalimnion, and hypolimnion of the deep spot of Swanzey Lake (SWASWAD). Boxes represent the 25th to 75th percentiles (or Interquartile Range, IQR) with the median or 50th percentile as the solid middle line. Whiskers represent the minimum and maximum values within 1.5 times the IQR from the 25th and 75th percentiles, respectively. The dots represent the outliers.

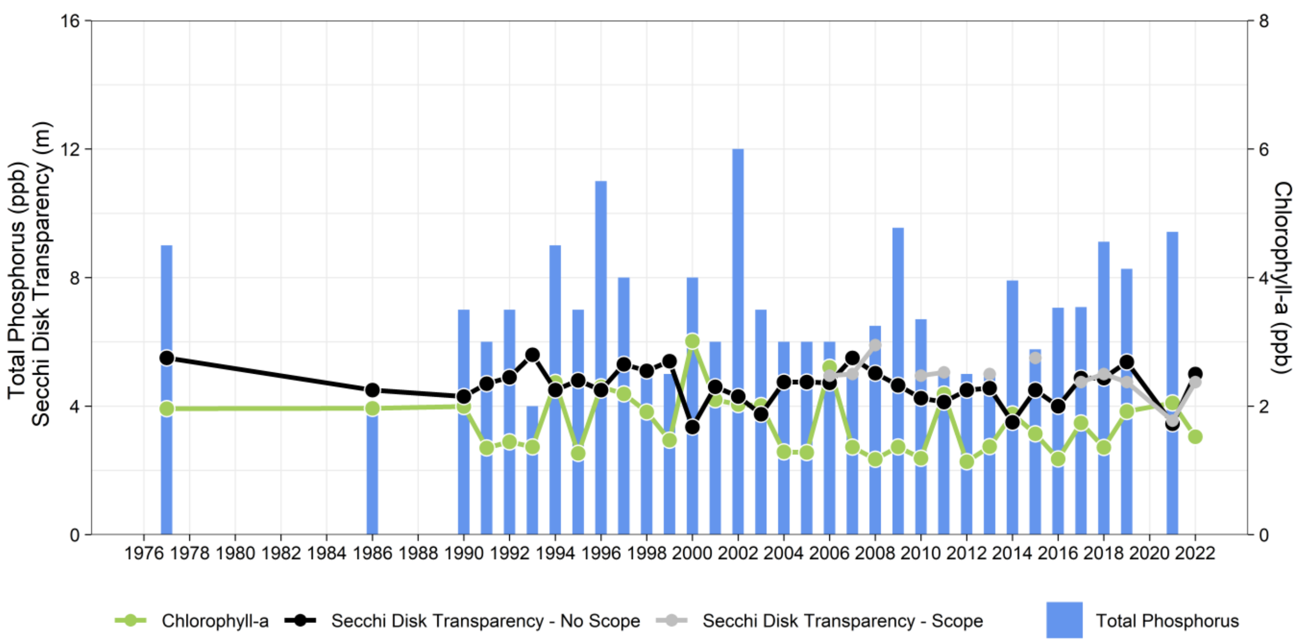


Figure 5. Median epilimnion (2 meters) total phosphorus, median composite epilimnion (0-7 meters) chlorophyll-a, and median water clarity (Secchi Disk depth for scope and no scope methods) measured at Swanzey Lake largely in June-September from 1977-2022 for the deep spot station (SWASWAD). No statistically significant trends were detected from the Mann-Kendall nonparametric trend test using rkt package in R Studio.

2.1.4 Dissolved Oxygen & Water Temperature

A common occurrence 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 6 shows temperature and dissolved oxygen profiles averaged across sampling dates (1986-2022) during **thermal stratification** largely in summer (between spring and **fall turnover**). The change in temperature, seen most dramatically between 5 and 9 m, indicates thermal stratification in the water column. An increase in dissolved oxygen between 5 and 7 m (near or at the top of the **thermocline** where microorganisms can be neutrally buoyant) indicates photosynthetic activity by phytoplankton. The average dissolved oxygen of <2 ppm at 12-17 m depth indicates the possibility of internal loading under anoxic conditions. Historic recording of temperature and dissolved oxygen profiles included only one water column profile per sampling season. While these data are useful in tracking major trends over time, collecting several profiles per sampling season can provide better insight to seasonal changes in the lake.

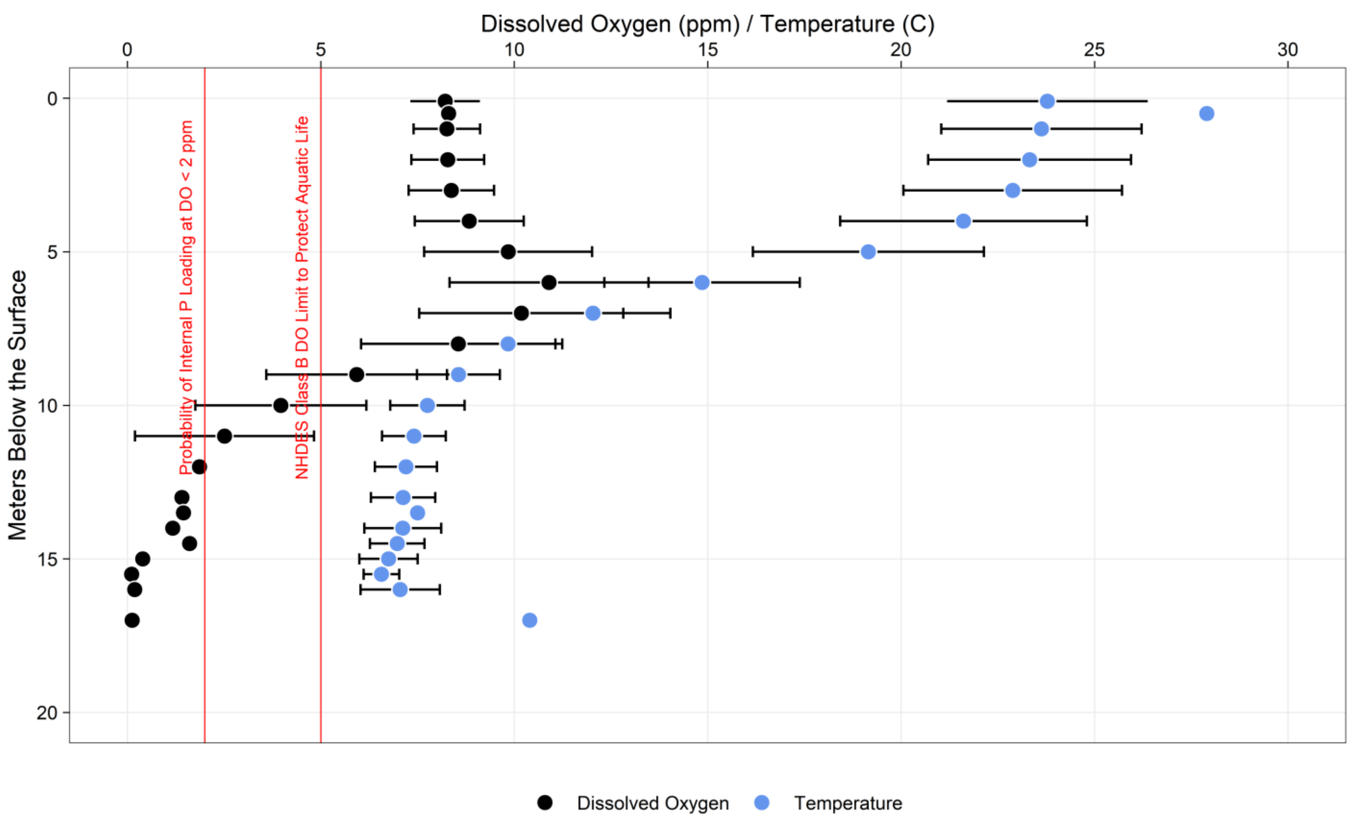


Figure 6. Dissolved oxygen (black) and water temperature (blue) depth profiles for the deep spot of Swanzey Lake (SWASWAD). Dots represent average values across sampling dates for each respective depth. Error bars represent standard deviation. Profiles were collected in 1986, 1990-2011, 2013, 2015, 2017, 2019, 2021, and 2022 (n=29).

2.1.5 Phytoplankton (Cyanobacteria) and Zooplankton

2.1.5.1 Phytoplankton/Zooplankton Surveys

Phytoplankton and zooplankton samples were collected and analyzed during the 1977, 1986, and 2005 NHDES Trophic Surveys of Swanzey Lake. The dominant phytoplankton species were *Asterionella* (diatom), *Tabellaria* (diatom), *Dinobryon* (golden-brown), and *Chrysosphaerella* (golden-brown). The dominant zooplankton species were *Vorticella* (rotifer), *Keratella* (rotifer), *Kellicotia* (rotifer), *Bosmina* (cladoceran), *Calanoid* (copepod), and *Nauplius* larvae (copepod) (Table 3). *Bosmina* are small and inefficient grazers. *Copepods* are small crustaceans that eat phytoplankton and provide an important food source to fish. *Daphnia* are among the most efficient grazers of phytoplankton but were not shown to be a dominant zooplankter in Swanzey Lake. Overall, zooplankton numbers were small and likely are inefficient at controlling phytoplankton/cyanobacteria growth. The 2022 Data Summary of the NH VLAP Individual Lake Report for Swanzey Lake shows phytoplankton population (relative percent cell count per taxa) for 2015, 2017, 2019, 2021, and 2022. In line with historic trophic surveys, diatoms and golden-browns dominate. Cyanobacteria overtook diatoms in 2021 during the cyanobacteria alert in August. Cyanobacteria were also found to have a higher percent abundance in 2022 than in previous years, with less golden-brown algae. Golden-brown algae typically prefer clean, low-nutrient lakes. Diatoms often dominate the spring and early summer before lakes fully stratify. Cyanobacteria can take advantage of nutrients released from internal sources to form nuisance blooms. Additional data collected across multiple months of the season can provide added insights to the long- and short-term phytoplankton dynamics in Swanzey Lake.

Table 3. Phytoplankton and zooplankton data summary for Swanzey Lake from Lake Trophic Survey Reports.

Date	Phytoplankton Species (% Total)	Total Phytoplankton Count (cells/mL)	Zooplankton Species (% Total)	Total Zooplankton Count (cells/L)
2/24/1977	*Dinobryon* (90%)		*Keratella* (50%) *Kellicottia* (30%)	
7/6/1977	*Chrysosphaerella* (30%) *Asterionella* (25%)		*Vorticella* (30%) *Keratella* (25%)	226
1/15/1987	*Asterionella* (67%) *Tabellaria* (22%)		*Kellicottia* (80%) *Nauplius* larvae (10%) *Keratella* (4%)	610
8/4/1986	*Chrysosphaerella* (45%) *Dinobryon* (30%) *Asterionrella* (15%)	965	*Nauplius* larvae (34%) *Keratella* (17%) *Bosmina* (14%)	198
6/30/2005	*Dinobryon* (40%) *Tabellaria* (40%) *Asterionella* (10%)		*Nauplius* larvae (37%) *Kellicottia* (16%) *Calanoid copepods* (11%)	19
2/8/2006	*Asterionella* (88%) *Mallomonas* (7%) *Tabellaria* (5%)		*Dinobryon* (40%) *Kellicottia* (16%) *Keratella* (8%)	122

2.1.5.2 Cyanobacteria Bloom History

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

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

- ***Anabaena/Dolichospermum***: typically observed as filaments, associated with microcystins, anatoxins, saxitoxins, and cylindrospermopsin
- ***Microcystis***: typically observed as variations of small-celled colonies, associated with microcystins and anatoxins
- ***Aphanizomenon*:** Typically forms rafts of filaments, associated with anatoxin-a, anatoxin-a (S), saxitoxins, and possibly microcystins
- ***Woronichinia*:** Typically forms dense colonies, associated with microcystins
- ***Planktothrix/Oscillatoria***: typically observed as filaments, associated with microcystins and cylindrospermopsin, can maintain high growth rate at relatively low light intensities when it forms metalimnetic blooms (NHDES, 2020)

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

Swanzey Lake has a limited cyanobacteria bloom history. There are no officially reported NHDES cyanobacteria bloom advisories for Swanzey Lake. A cyanobacteria bloom alert was issued by NHDES in August 2021 following a beaver dam breach and record rainfall that likely pushed a large pulse of nutrients to the lake. No samples were collected. According to VLAP phytoplankton data from 2017-2022, *Anabaena/Dolichospermum* are the most common cyanobacteria in Swanzey Lake, with *Woronichinia*, *Coelosphaerium*, and *Microcystis* also being present. *Anabaena/Dolichospermum* are nitrogen-fixers that can regulate their buoyancy in the water column. Other known cyanobacteria species in Swanzey Lake are not nitrogen-fixers but may still outcompete other phytoplankton by regulating their buoyancy in the water column to access phosphorus from the hypolimnion.

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

2.1.6 Chloride & Specific Conductivity

Chloride pollution can cause harm to aquatic organisms and disrupt internal mixing processes when chloride concentrations reach toxic levels. The State of New Hampshire sets a chronic threshold of 230 ppm for chloride (which roughly equates to 835 µS/cm for specific conductivity). Chloride concentrations in Swanzey Lake are well below the chronic threshold, with both chloride and specific conductivity low, which is typical for a high-quality lake (most New Hampshire lakes are around 4 ppm or 40 µS/cm). However, both chloride and specific conductivity show statistically significant increasing trends over the record from 1977-2022 (Figure 7. Yearly median of monthly medians for chloride and specific conductivity in the deep spot of Spofford Lake. Dashed lines indicate a statistically significant increasing (degrading) trend.

The increasing trends indicate that chloride from winter salting practices for deicing roads and other surfaces in the watershed may be contaminating the lake. While not an immediate concern for the health of the lake, chronic chloride toxicity will likely become an issue in the future without a proactive reduction in salt use in the watershed.

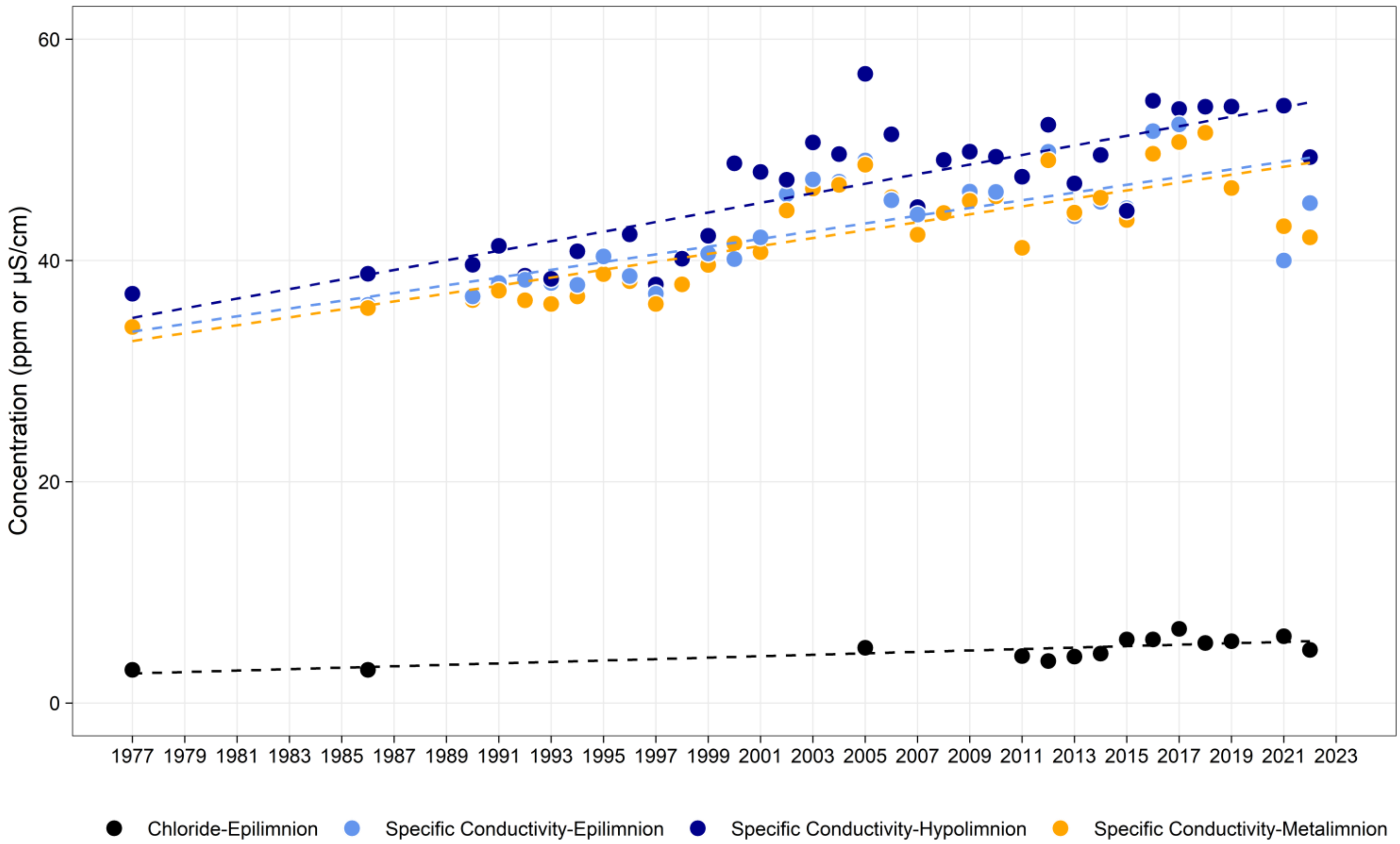


Figure 7. Yearly median of monthly medians for chloride and specific conductivity in the deep spot of Spofford Lake. Dashed lines indicate a statistically significant increasing (degrading) trend.

2.1.7 Fish

Fish are an important natural resource for sustainable ecosystem food webs and provide recreational opportunities. Swanzey Lake is a designated trout pond by the NHFG and is stocked yearly. According to the 2015 Wildlife Action Plan, Swanzey Lake supports both warm and coldwater fish species. The lake supports eastern brook trout, rainbow trout, smallmouth bass, chain pickerel, brown bullhead catfish, bluegill, American eel, common sunfish, and yellow perch (NHFG, 2023). The American eel is listed as a species of concern in the 2015 NH Wildlife Action Plan (NHFG, 2015).

2.1.8 Invasive 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. Since 2003, Swanzey Lake has been part of the Lake Host Program, which provides courtesy boat inspections aimed at preventing the transport of invasive aquatic species into or out of the lake. SLPA has also been part of the Weed Watchers Program in the past but no longer participates in a formal way. There are volunteers who continue to survey the lake for invasives. NHDES indicates in its Lake Information Mapper that there are no known invasive species in Swanzey Lake. The Lake Host Program at Swanzey Lake is currently led by Nancy Karlson, who is actively looking for more help from volunteers and from the town to hire additional paid Lake Hosts (refer to Section 2.3.1.5 Economic Impacts). Lake Hosts are currently posted from 9am to 5pm on Saturdays, Sundays, Tuesdays, and Thursdays and from 9am to 3pm on Mondays and Wednesdays in the summer.

2.2 ASSIMILATIVE CAPACITY

The assimilative capacity of a waterbody describes the amount of pollutant that can be added to a waterbody without causing a violation of the water quality criteria and is based on lake trophic designation. Swanzey Lake is a borderline oligotrophic/mesotrophic waterbody; however, the mesotrophic designation was largely attributed to an increase in aquatic plant growth, as well as degradation in dissolved oxygen and water clarity. For enhanced protection of water quality, the oligotrophic designation was selected for running the assimilative capacity analysis for Swanzey Lake. For oligotrophic waterbodies, the water quality criteria are set at 8 ppb for total phosphorus and 3.3 ppb for chlorophyll-a, above which the waterbody is considered impaired (Table 4). NHDES requires 10% of the difference between the best possible water quality and the water quality standard be kept in reserve; therefore, total phosphorus and chlorophyll-a must be at or below 7.2 ppb and 3.0 ppb, respectively, to achieve Tier 2 High Quality Water status. Support determinations are based on the nutrient stressor (phosphorus) and response indicator (chlorophyll-a), with chlorophyll-a dictating the assessment if both chlorophyll-a and total phosphorus data are available and the assessments differ (Table 5).

Results of the assimilative capacity analysis show that Swanzey Lake meets Tier 1 (within reserve) for its trophic class designation (

Table **6**). The existing median total phosphorus concentration meets the assimilative capacity threshold, but the existing median chlorophyll-a concentration falls within the 10% reserve, indicating that further reductions in total phosphorus load are likely needed to reduce the chlorophyll-a concentration to meet the 3.0 ppb threshold and reduce the risk of possible cyanobacteria blooms.

Table 4. Aquatic life integrity (ALI) nutrient criteria ranges by trophic class in New Hampshire. TP = total phosphorus. Chl-a = chlorophyll-a, a surrogate measure for algae.

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

Table 5. Decision matrix for aquatic life integrity (ALI) assessment in New Hampshire. TP = total phosphorus. Chl-a = chlorophyll-a, a surrogate measure for algae concentration.

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

Table 6. Assimilative capacity (AC) analysis results for Swanzey Lake. Chlorophyll-a dictates the assessment results.

Parameter	AC Threshold (ppb)	Existing Median WQ (ppb)*	Remaining AC (ppb)	Assessment Results
SWANZEY LAKE – DEEP SPOT [SWASWAD]				
Total Phosphorus	7.2	7.2	0.0	Tier 1 (Within Reserve)
Chlorophyll-a	3.0	3.3	-0.3	

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

2.3 WATERSHED MODELING

2.3.1 Lake Loading Response Model (LLRM)

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

The LLRM is an Excel-based model that uses environmental data to develop a water and phosphorus loading budget for lakes and their tributaries (AECOM, 2009). Water and phosphorus loads (in the form of mass and concentration) are traced from various sources in the watershed through tributary basins and into the lake. The model incorporates data about watershed and sub-watershed boundaries, land cover, point sources (if applicable), septic systems, waterfowl, rainfall, volume and surface area, and internal phosphorus loading. These data are combined with coefficients, attenuation factors, and equations from scientific literature on lakes, rivers, and nutrient cycles to generate annual average predictions[1] 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 Swanzey Lake LLRM is provided in the *Swanzey Lake Lake Loading Response Model Report* (FBE, 2024a).

2.3.1.1 Lake Morphology & Flow Characteristics

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

The surface area of Swanzey Lake is 111 acres (2.4 miles of shoreline) with a maximum depth of 53 feet (16 m) and volume of 2,502,491 m^3 (Appendix A, Map A-1). The **areal water load** is 20 ft/yr (6.1 m/yr), and the flushing rate is 1.1 times per year. The flushing rate of 1.1 means that the entire volume of Swanzey Lake is replaced 1.1 times per year.

There is a dam at the outlet of Swanzey Lake that controls water flow. The active dam (Swanzey Lake Dam) was damaged during an extreme weather event in July 2023 due to overtopping. The damage to the dam did not change the lake's flushing rate.

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 surface waters via stormwater runoff and baseflow.

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

Current land cover in the Swanzey Lake watershed was determined by FBE using a combination of the 2001 New Hampshire Landcover Database (NHLCD), ESRI World Imagery from July 15, 2021, and Google Earth satellite imagery from November 6, 2020. For more details on methodology, see the *Swanzey Lake Lake Loading Response Model Report* (FBE, 2024a). Refer also to Appendix A, Map A-2.

As of the 2020/2021 aerial imagery, development accounts for 11% (91 acres) of the watershed, while forested and natural areas account for 85% (745 acres). Wetlands and open water represent 4% (38 acres) of the watershed, not including the surface area of Swanzey Lake. There is no agriculture in the watershed. Figure 8 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, 2024a). Developed areas cover 11% of the watershed and contribute 70% of the total phosphorus watershed load to Swanzey Lake.

Developed areas within the Swanzey Lake watershed are characterized by **impervious surfaces**, including areas with asphalt, concrete, compact gravel, and rooftops that force rain and snow that would otherwise soak into the ground to run off as stormwater. Stormwater runoff carries pollutants to waterbodies that may be harmful to aquatic life, including sediments, nutrients, pathogens, pesticides, hydrocarbons, and metals.

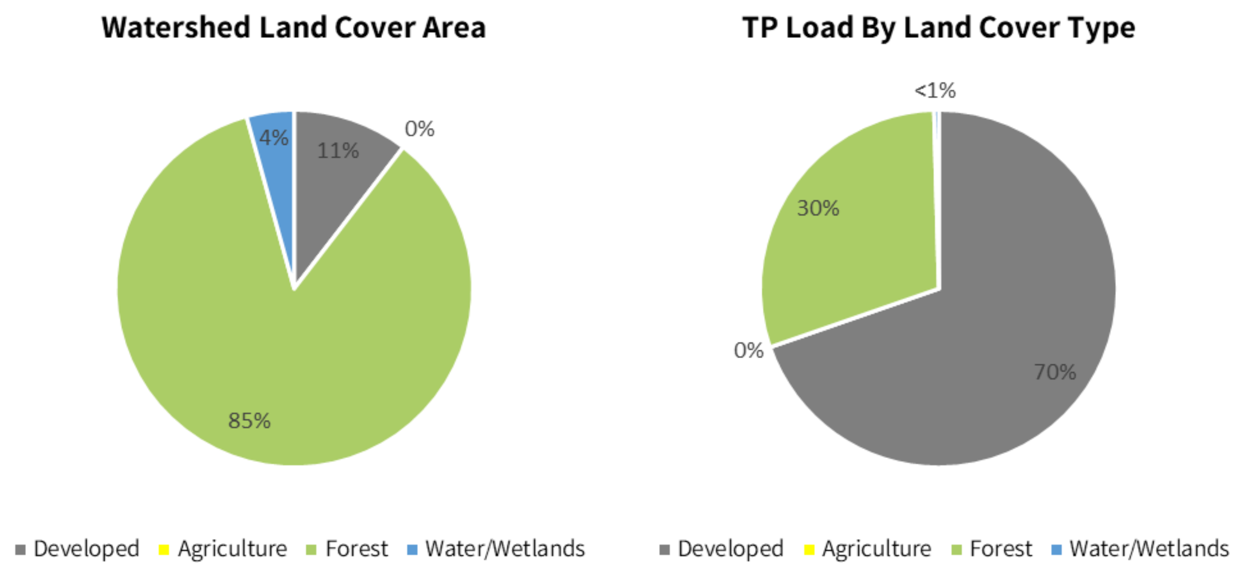


Figure 8. Swanzey Lake watershed land cover area by general category (agriculture, developed, forest, and water/wetlands) (LEFT) and total phosphorus (TP) watershed load by general land cover type (RIGHT). This shows that developed areas cover 11% of the watershed and contribute 70% of the TP watershed load to Swanzey Lake. Water/wetlands category does not include the lake area.

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 Swanzey Lake (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 spot of Swanzey Lake (to determine average difference between surface and bottom phosphorus concentrations). These estimates, along with anoxic volume and surface area, helped determine rate of release and mass of annual internal phosphorus load. The internal load estimate in any given year was highly variable and warrants further investigation.

2.3.1.4 LLRM Results

Overall, model predictions were in good agreement with observed data for total phosphorus (3%), chlorophyll-a (3%), and Secchi disk transparency (22%) (Table 7). 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.

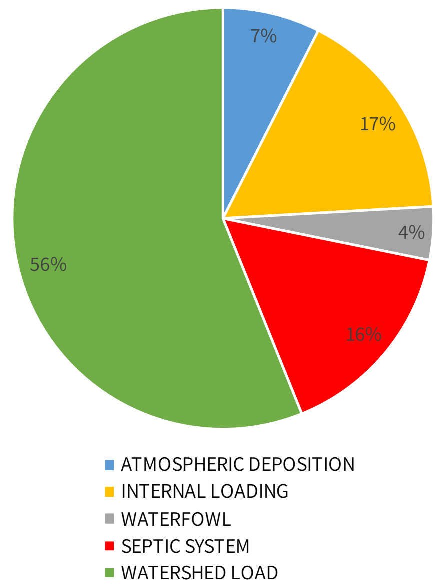


Figure 9. Summary of total phosphorus loading by major source for Swanzey Lake. Refer to Table 8 for a breakdown.

Watershed runoff combined with baseflow (56%) was the largest phosphorus loading contribution across all sources to Swanzey Lake, followed by internal loading at 17% and shorefront septic systems at 16% (Table 8; Figure 9). Atmospheric deposition (7%) and waterfowl (4%) 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. Note that 1) the estimate for the septic system load is only for those systems directly along the shoreline and potentially short-circuiting minimally treated effluent to the lake; and 2) the load from septic systems throughout the rest of the watershed is inherent to the coefficients used to generate the watershed load.

Internal loading, whereby low dissolved oxygen in bottom waters is causing a release of phosphorus from sediments, was estimated as a significant source of phosphorus to the lake; however, more data would be needed over at least 1-2 field seasons to determine whether the lake could be considered a candidate for an in-lake treatment of the internal load, if cyanobacteria blooms were to become a persistent issue in the future. In the meantime, watershed protection efforts should focus on reducing the watershed and septic system loads.

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 (Appendix A, Map A-6). Sub-watersheds with moderate-to-high phosphorus mass exported by area (> 0.20 kg/ha/yr) typically have more development (i.e., the direct shoreline area to Swanzey Lake) (Figure 10). Drainage areas directly adjacent to waterbodies have direct connection to lakes and are usually targeted for development, thus increasing the possibility for phosphorus export. Of note, the measured phosphorus concentration (mg/L) of the northwest tributary equals the calculated or modeled value of the northeast tributary and vice versa. Though unlikely, it is possible that water quality sample sites might have been mixed up, and we recommend that SLPA review site locations and names with VLAP to confirm.

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 Attachment 2 for details on methodology. Pre-development loading estimation showed that total phosphorus loading to Swanzey Lake increased by 304%, from 16.4 kg/yr prior to European settlement to 66.3 kg/yr under current conditions (Table 8). These additional phosphorus sources are coming from development in the watershed (especially from the direct shoreline of Swanzey Lake), internal loading, septic systems, and atmospheric dust (Table 8). Water quality prior to settlement was predicted to be excellent with extremely low phosphorus and chlorophyll-a concentrations and high water clarity (Table 7).

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 (2024a) and the 2024 *Swanzey Lake Watershed Build-out Analysis Report* for details on methodology and further discussion on the appropriate use of the build-out analysis as a planning tool only and not an actual prediction of future conditions. 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 Swanzey Lake may increase by 81%, from 66.3 kg/yr under current conditions to 120.0 kg/yr at full build-out (2097-2272) under current zoning for Swanzey Lake (Table 8). Additional phosphorus will be generated from more development in the watershed (especially from the direct shoreline of Swanzey Lake), enhanced internal loading, greater atmospheric dust, and more septic systems (Table 8). The model predicted higher (worse) phosphorus (19.1 ppb), higher (worse) chlorophyll-a (7.1 ppb), and lower (worse) water clarity (2.4 m) compared to current conditions for Swanzey Lake (Table 7). The number of bloom days may increase from an average of 9 days currently to an average of 114 days at full build-out for chlorophyll-a concentrations above 8 ppb (Table 7).

Table 7. In-lake water quality predictions for Swanzey Lake. TP = total phosphorus. Chl-a = chlorophyll-a. SDT = Secchi disk transparency. Bloom Days represent average annual probability of chlorophyll-a exceeding 8 ppb.

Model Scenario	Median TP (ppb)	Predicted Median TP (ppb)	Mean Chl-a (ppb)	Predicted Mean Chl-a (ppb)	Mean SDT (m)	Predicted Mean SDT (m)	Bloom Days
Pre-Develop.	--	2.6	--	0.7	--	11.1	0
Current (2021)	8.4 (10.2)	10.5	3.3	3.4	4.8	3.8	9
Future (2075)	--	19.1	--	7.1	--	2.4	114

**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.*

Table 8. Total phosphorus (TP) and water loading summary by source for Swanzey Lake .

SOURCE	PRE-DEVELOPMENT			CURRENT (2022)			FUTURE (2097)		
	TP (KG/YR)	%	WATER (CU.M/YR)	TP (KG/YR)	%	WATER (CU.M/YR)	TP (KG/YR)	%	WATER (CU.M/YR)
ATMOSPHERIC	3.2	19%	317,898	5.0	7%	317,898	11.3	10%	317,898
INTERNAL	0.0	0%	0	11.0	17%	0	24.3	20%	0
WATERFOWL	2.7	17%	0	2.7	4%	0	2.7	2%	0
SEPTIC SYSTEM	0.0	0%	0	10.4	16%	7,874	13.0	11%	9,847
WATERSHED LOAD	10.5	64%	2,430,973	37.2	56%	2,421,009	68.7	57%	2,408,844
TOTAL LOAD TO LAKE	**16.4**	**100%**	**2,748,871**	**66.3**	**100%**	**2,746,782**	**120.0**	**100%**	**2,736,590**

2.3.1.5 Economic Impacts

Lakes in New Hampshire have value both intrinsically as complex and diverse ecosystems and economically due to their impacts on recreation, property ownership, and tourism on local and regional scales. The water quality of lakes impacts the quality of lake recreation, fishing, and shorefront living. As water quality worsens, swimming, fishing, and other activities can become less enjoyable, especially if recurring cyanobacteria blooms become a persistent issue to those who frequent the lake. Along lake shorelines, declining water clarity and infestation by aquatic invasives have been linked to declining lakefront property values throughout states such as Maine and New Hampshire (Michael et al., 1996; Gibbs et al., 2002). In the area of New Hampshire near Swanzey Lake (Spofford/Greenfield area), a one-meter decline in water clarity is associated with an $11,094 decline in property values per property, or 6.64% of the property value on average (Gibbs et al., 2002). In Swanzey

Lake, model results predict that the Secchi disk transparency (one method of measuring water clarity) may decline by 1.4 m in a future buildout scenario. Given that the revenue from property taxes totaled $636,909 from lakefront properties and $96,069 from other homes near Swanzey Lake ($732,978 total), the predicted worsening water clarity at full buildout is estimated to result in a loss of between $59,208 and $68,138 in tax revenue each year for the Town of Swanzey. Halstead et al. (2003) estimated New Hampshire shoreline property value declines of 20-40% with infestation of the invasive variable milfoil, while Zhang and Boyle (2010) estimated Vermont shoreline property value declines of 1-16% with incremental infestation of the invasive Eurasian milfoil. Using a 20% decline in shoreline property value with infestation of invasives in Swanzey Lake, it is estimated that the town could lose an additional $127,382 in tax revenue each year.

Lake users also often spend money at local businesses when they visit or recreate on lakes. A 2001 study that included users of 15 lakes in Maine found that lake users typically spend $341 per year when visiting lakes, with $201 of those dollars (59%) being spent within 10 miles of their lake (Schuetz et al., 2001). The study finds that lake users of lower clarity lakes tend to enjoy the lakes less and spend less money at local businesses. Adjusting for inflation from 2001-2023, a 1.4-m decrease in water clarity as predicted by the water quality model would lead to a 4% decrease in expenditure by lake users, totaling $14 per lake user. In lakes such as Swanzey Lake that have a large seasonal population (campgrounds, public beaches, seasonal residents), a decrease in water clarity may lead to thousands of dollars in losses for local small businesses in the town.

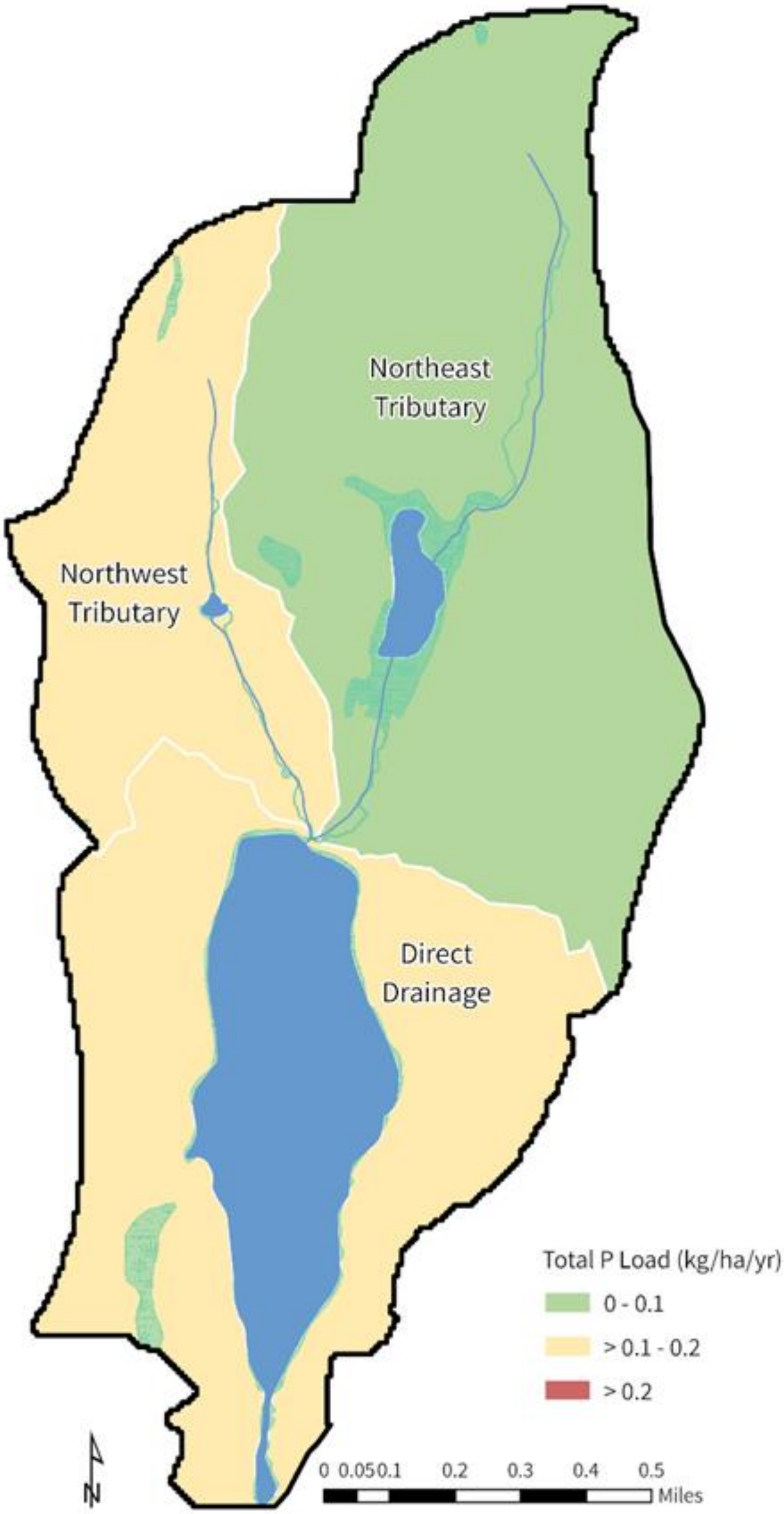


Figure 10. Map of current total phosphorus load per unit area (kg/ha/yr) for each sub-watershed in the Swanzey Lake watershed. Higher phosphorus loads per unit area are concentrated in the more developed areas. There were no areas with greater than 0.2 kg/ha/yr in comparison to other areas in New Hampshire.

2.3.2 Build-out Analysis

A full build-out analysis was completed for the Swanzey Lake watershed for the Town of Swanzey (FBE, 2022b). A build-out analysis identifies areas with development potential and projects future development based on a set of conditions (e.g., zoning regulations, environmental constraints) and assumptions (e.g., population growth rate). A build-out analysis shows what land is available for development, how much development can occur, and at what densities. "Full Build-out" is a theoretical condition representing the moment in time when all available land suitable for residential, commercial, and industrial uses has been developed to the maximum capacity permitted by local ordinances and zoning standards. Local ordinances and zoning standards are subject to change, and the analysis requires simplifying assumptions; therefore, the results of the build-out analysis should be viewed as planning-level estimates only for potential future outcomes from development trends.

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

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

The build-out analysis showed that 48% (472 acres) of the watershed is buildable under current zoning regulations (Appendix A, Map A-4); the entire Swanzey Lake watershed is in the Rural/Agricultural District (Table 9). FBE identified 86 existing buildings within the watershed, and the build-out analysis projected that an additional 105 buildings could be constructed in the future, resulting in a total of 191 buildings in the watershed at full build-out (Table 9; Appendix A, Map A-5). Because most of the shoreline parcels are already developed, most projected buildings fall outside the direct shoreline area between Swanzey Lake and West/East shore Roads.

The model did not project any additional buildings in the Pilgrim Pines Campground parcel – the largest parcel completely within the watershed area. After noticing this, the model was re-run with only one existing building on the Pilgrim Pines Campground parcel. The number of projected buildings in this version of the model was two less than the current number of buildings. Therefore, with this quality assurance check, the initial model did not project additional buildings on this parcel because of the current number of existing buildings on the parcel. It is important to note though that in the future, this parcel could be at risk for subdivision, and additional buildings could be built on the subdivided parcels if they meet current zoning regulations, setbacks, and lot sizes.

Table 9. Amount of buildable land and projected buildings in the Swanzey Lake watershed.

Zone	Total Area (Acres)	Buildable Area (Acres)	Percent Buildable Area	No. Existing Buildings	No. Projected Buildings	Total No. Buildings	Percent Increase
Swanzey							
Residential/Agricultural Zone	985	472	48%	86	105	191	122%

A TimeScope analysis was used to determine the year at which full build-out will occur by using compound annual growth rates (CAGR) for 20-, 30- and 50-year periods from 2000-2020 (0.32%), 1990-2020 (0.72%), and 1970-2020 (1.08%) to project the rate of new development into the future (Table 10; Figure 11). Full build-out is projected to occur in 2272 at the 20-year CAGR, 2134 at the 30-year CAGR, and 2097 for the 50-year CAGR (Figure 11). Note that the growth rates used in the TimeScope

Analysis are based on town-wide census statistics but have been applied here to a portion of the town. Also note that the population growth rate in this town 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 10. Compound annual growth rates for Swanzey and the State of New Hampshire used for the TimeScope Analysis. Data from US Census Bureau.

	Compound Annual Growth Rate		
Town	**50 yr. Avg. 1970-2020**	**30 yr. Avg. 1990-2020**	**20 yr. Avg. 2000-2020**
Swanzey	1.08%	0.72%	0.32%
New Hampshire	*1.26%*	*0.72%*	*0.54%*

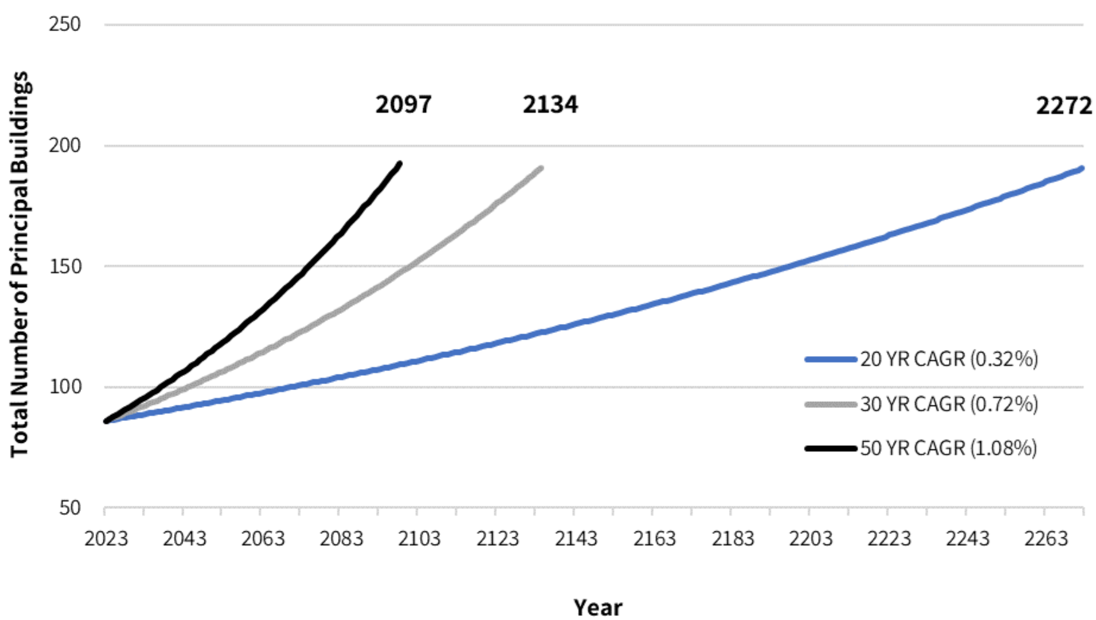


Figure 11. Full build-out projections of the Swanzey Lake watershed (based on compound annual growth rates).

2.4 WATER QUALITY GOAL & OBJECTIVES

The model results revealed changes in total phosphorus loading and in-lake total phosphorus concentrations over time from pre-development through future conditions, showing that the water quality of Swanzey Lake 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 Swanzey Lake. In-lake chlorophyll-a and total phosphorus concentrations indicate that there is limited reserve capacity for the lake to assimilate additional nutrients under a "business as usual" scenario. Thus, it is highly recommended that strong objectives be established to protect the water quality of Swanzey Lake over the long term, especially given that the lake is within reserve and close to not meeting water quality criteria, experiences cyanobacteria blooms, and is threatened by new development. The water quality goal and objectives were set by the Swanzey Lake Work Group with guidance from FBE.

The goal of the Swanzey Lake WBMP is to improve the water quality of Swanzey Lake such that it meets state water quality standards for the protection of ALI and substantially reduces the likelihood of harmful cyanobacteria blooms in the lake. 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).

> **Objective 1:** Reduce phosphorus loading from existing development by 18% (12 kg/yr) to Swanzey Lake to improve average summer in-lake total phosphorus concentration from 8.5 ppb to 7.2 ppb.
>
> **Objective 2:** Mitigate (prevent or offset) phosphorus loading from future development by 7.0 kg/yr to Swanzey Lake to maintain average summer in-lake total phosphorus concentration in the next 10 years (2033).

It should be noted that the pollutant load reduction opportunities were identified after an extreme weather event in July 2023 that washed out roads, eroded beaches, and overwhelmed local stormwater control measures, sending large quantities of sediment and phosphorus into Swanzey Lake. Modeling efforts using the LLRM were based on in-lake data collected before this event took place and were unable to consider nonpoint source pollution from specific problem sites or event-scale loading. **<u>Due to the scale of destruction caused by the July 2023 storm and the model limitations, we recommend that the lake's response to the 2023 extreme weather be carefully monitored (especially the extent of anoxia and internal loading) and the water quality goal be re-assessed if dramatic changes in lake response occur over the next several years.</u>** Data collected in 2023 showed a worsening of anoxia in the lake (and thus possibly internal loading), suggesting that the extreme weather may have set the lake's water quality on a new trajectory towards more rapid degradation. After external pollutant load reduction efforts have been exhausted, lakes with high internal load (>20%) may need an in-lake management strategy to reduce the internal load if the lake response is slow (low flushing) and nuisance cyanobacteria blooms become a persistent issue.

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

Table 11. Summary of water quality objectives for Swanzey Lake . Interim goals/benchmarks are cumulative.

Water Quality Objective	Interim Goals/Benchmarks		
	2026	**2029**	**2033**
1. Reduce phosphorus loading from existing development by 18% (12 kg/yr) to Swanzey Lake to improve average summer in-lake total phosphorus concentration from 8.5 ppb to 7.2 ppb.			
	Achieve **4.5% (3 kg/yr)** reduction in TP loading	Achieve **9% (6 kg/yr)** reduction in TP loading; re-evaluate water quality and track progress	Achieve **18% (12 kg/yr)** reduction in TP loading; re-evaluate water quality and track progress
2. Mitigate (prevent or offset) phosphorus loading from future development by 7.0 kg/yr to Swanzey Lake to maintain average summer in-lake total phosphorus concentration in the next 10 years (2033).			
	Prevent or offset **2 kg/yr** in TP loading from new development to Swanzey Lake	Prevent or offset **4 kg/yr** in TP loading from new development to Swanzey Lake; re-evaluate water quality and track progress	Prevent or offset **7 kg/yr** in TP loading from new development to Swanzey Lake; re-evaluate water quality and track progress

3 POLLUTANT SOURCE IDENTIFICATION

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

3.1 WATERSHED DEVELOPMENT

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

3.1.1 Watershed Survey

A watershed survey of the Swanzey Lake watershed was completed by technical staff from 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, FBE solicited input from SWRPC and SLPA about locations with known NPS pollution. FBE also analyzed aerial images and GIS data for land use/land cover, roads, culverts, public properties, waterbodies, and other features. This information enabled FBE to better plan for the survey (e.g., to target known or likely high-polluting sites, such as unpaved roads, beaches, steeply sloping areas, etc.) and to inform recommended solutions.

FBE conducted the watershed survey in September 2023, two months after a large and devastating storm impacted the Swanzey Lake watershed in July. This storm caused massive amounts of flooding and road washouts. Storms like these exacerbate smaller issues and draw attention to areas at risk. Identifying and addressing these areas so they better withstand such storms will help the watershed community become more resilient in the face of climate change. For each location, field staff recorded site data and photographs on tablets. Information collected included location description and GPS coordinates; NPS problem description and measurements (e.g., gully dimensions); receiving waterbody; discharge type (direct or indirect/limited); and preliminary recommendations to mitigate the NPS problem. Field staff accessed sites from public roads and waterfront access points.

Road ditch erosion on Christian Hill Road. September 2023.

FBE identified 39 problem sites in the watershed and one point of interest (Figure 12). The main issues found were unpaved roads, road surface erosion of unmaintained/camp roads, ditch erosion, blocked culverts, buffer clearing, and camp and beach runoff. FBE estimated the potential pollutant removal that could be achieved by implementing recommendations. Appendix B summarizes the recommendations, load reduction estimates, and estimated costs for each site grouped by privately-owned and town-owned sites. The top five high priority sites (based on lowest impact-weighted cost per mass of phosphorus removed) are shown below. In addition to these specific sites, managers of both private and public roads should use best practices for road installation and maintenance to for water quality protection. **It is important to note that the recommendations provided are intended to help sites withstand moderate to large storm events but not necessarily extreme storm events, which can be so devastatingly intense that they typically overwhelm any infrastructure.**

PRIVATELY-OWNED SITES

Site 1-03a: Pilgrim Pines – Upper Campground / Beach Area
Location (latitude, longitude): 42.83659, -72.30358
Impact: **High**

Observations: The entire Pilgrim Pines property experienced severe damage from the July 2023 storm, particularly the upper campground and beach area. Stormwater came down the main road of the campground and crossed West Shore Rd to wash onto the beach area, eroding beach sand into Swanzey Lake. The camp reclaimed the eroded sand from the lake back to the beach and cleaned out all sediment and debris from the area, regraded washed out roads with hard pack, and regraded and seeded the lawn area (resolving the bare lawn issue once vegetation grows back next season). The disc golf course with a frog pond was also washed out during the storm. The pond has since been repaired so that it connects to the stream for better flushing. The upper campground sustained the most damage. As of the day of survey, only one road through the campground had been regraded for drivable use. The rest of the campground will be repaired following an engineering study in the next couple of years. There were no sewage line breaks in the campground. Sewage is pumped to a leach field under the disc golf course.

Recommendations: Complete a high-level engineering design for stormwater drainage reconfiguration and repair in the campground area. The owner is currently in the process of remediating the campground and much work has already begun.

A, C, & D: *Erosion channels and road destruction from the July 2023 storm at Pilgrim Pines.* ***B:*** *Erosion near a stream channel on the campground.* ***E:*** *The beach at Pilgrim Pines was washed into Swanzey Lake during the July 2023 storm and has since been reclaimed.* ***F:*** *Damage from the storm destroyed some areas of the camp. This bare soil has been seeded.* ***G:*** *Destruction at the upper campground.*

Site 3-02: East Shore Rd Near Houses 111 and 113
Location (latitude, longitude): 42.84389, -72.29899
Impact: **High**

Observations: Stormwater flows down one side of the driveway of house 127 and turns south into the road shoulder, creating long erosion gullies leading down the road. Stormwater flows through under-driveway culverts and spills out into a forested area near house 111. The path of sediment accumulation demonstrates that stormwater continues to snake through the forested area before reaching another culvert that goes underneath the road and into an area that is possibly a wetland.

Recommendations: We recommend installing water bars or other runoff diverters periodically along the driveway to divert water before it reaches the road. The road shoulder may be formed into a ditch and armored with rip rap and check dams. A small bioretention swale may be formed in the forested area with a meandering flow path to prevent sediment from flowing through the next culvert. The Town of Swanzey may need to coordinate with the landowner on fully remediating this site.

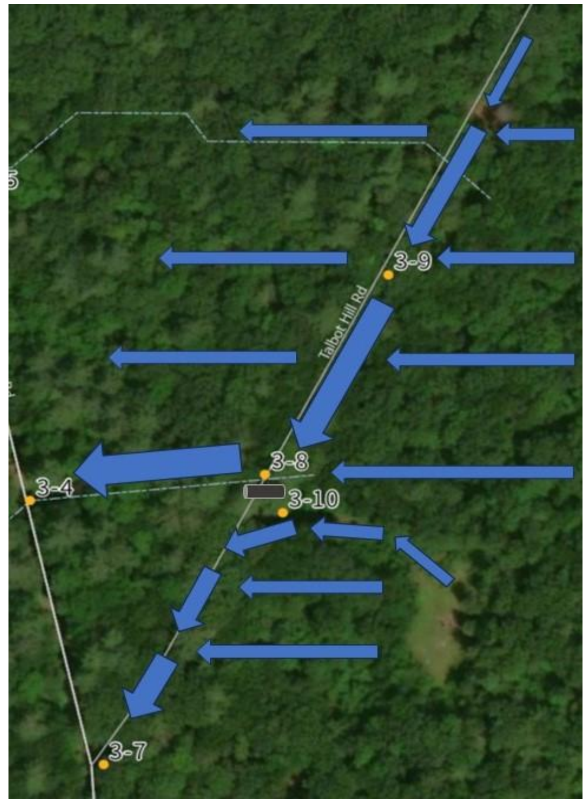
(Left, Middle Left) Erosion gully follows down the eastern road shoulder of East Shore Rd, under a driveway, spills into the forested area, loops back around, and through a culvert under the road. (Middle Right) Erosion begins coming down a sloped driveway. (Right) Sediment has accumulated in the forested area.

TOWN-OWNED SITES

Sites 3-07, 3-08, and 3-09: Talbot Hill Rd
Location (latitude, longitude): 42.84774, -72.29775
Impact: **High**

Observations: Although these sites were evaluated separately, they have been combined into one site based on the evaluation results. The site was severely affected by storms in July 2023. The road surface of Talbot Hill Rd is completely washed out and eroded up to a depth of approximately 6 feet. Multiple culverts have been uncovered and serve as concentrated flow paths for stormwater. The site outlets at a culvert that carries water from an ephemeral stream down the forested hill. The culvert is intended to carry stormwater from an ephemeral stream underneath the road surface and downslope. However, stormwater eroded Talbot Hill Rd beyond the culvert depth, which caused the culvert to function as a water bar that diverts water into the ephemeral stream channel, thus forming a small ravine (Site 3-04). There was little documented erosion upstream of the culvert, where the ephemeral stream flows, indicating that the erosion of the site is the result of stormwater runoff traveling down from Talbot Hill Rd. Field staff noted that the path of water flow at the site differs from the presumed flow path from GIS analysis, suggesting that human alteration of the landscape has changed the flow path of water. The northern section of the road has been severely eroded by stormwater, forming one massive gully that runs along at least 450 ft of Talbot Hill Rd. The erosion has removed all soil down to parent material in some locations, and a small stream of daylighted groundwater is present in the deepest location.

On the lowest (most downhill) area of Talbot Hill Rd, stretching up from the intersection of Talbot Hill Rd and East Shore Rd to where the class 6 road intersects a trail, large erosion gullies run down Talbot Hill Rd, making it impassable except by foot. Runoff comes down from the trail on the eastern fork in the road (site 3-10) and carves multiple gullies down the surface of Talbot Hill Road toward site 3-7. Runoff from this area travels north toward site 3-4, south to site 3-3, and spills onto the road during large storm events.



Sketch of the Talbot Hill Rd sites and drainage. Blue arrows represent water moving across the landscape. Dashed lines are intermittent streams. The gray cylinder is the culvert. Water is intercepted by the road before reaching the culvert at Site 3-08, where it is directed west to create a ravine in the stream channel that was documented in Site 3-04.

(Left) Erosion gullies down the bottom of Talbot Hill Rd at Site 3-07. (Right) Multiple gullies were observed over the entire length of Site 3-07.

Recommendations: It is likely that Talbot Hill Rd cannot be fully re-naturalized so there are two options recommended: 1) convert from a Class VI to a Class V road, or 2) convert to a walking trail. For either option, the substantial erosion will require the filling and recontouring of the former road surface to restore the area's natural hydrology and minimize the risk of further erosion. Research suggests that recontouring tends to lead to less surface runoff and sediment loss (Kolka & Smidt, 2004), more robust recovery of plant communities in the long term (Larson & Rew, 2022), and more favorable soil properties that reflect undisturbed forested areas (Lloyd et al., 2013). Given the extensive work needed at this site, additional task planning in coordination with local stakeholders may be merited. A full guidance document on road decommissioning techniques (if converted to a walking trail) is available through the United States Department of Agriculture and United States Forest Service (2018). Restoration of the lowest (most downhill) portion of Talbot Hill Road should be completed last so improvements are not damaged by restoration teams accessing the upper sites. Interim stormwater and sediment control measures are necessary to prevent additional erosion during restoration. Gullies should be stabilized, and water bars or other runoff diverters should be installed to divert runoff toward the forested area and away from flow paths connecting to other NPS sites and away from East Shore Rd. The road may be reconstructed as a Class V road, complete with paving, culverts large enough to accommodate moderate to high stormflows, and a fully engineered closed drainage system to facilitate easier public and emergency access to the lake. Open-bottom culverts preserve **riparian** and streambed habitat and can handle larger stormflows. Consider incorporating green stormwater infrastructure to the maximum extent practicable. **The town indicates that either option will be an extensive and drawn-out process that will require lengthy procedures at the town level to make any engineering option feasible.**

A & F: *A culvert at the fork in Talbot Hill Rd has been uncovered due to July 2023 storm erosion and serves as a barrier, sending stormwater down a stream channel that carved a ravine.* ***B, D, E & G:*** *Damage from the storm destroyed Talbot Hill Rd.* ***C & H:*** *The July 2023 storm caused erosion up to six feet deep. The entire soil profile is visible at the second culvert.*

Site 1-01: Richardson Town Beach
Location (latitude, longitude): 42.84036, -72.30138
Impact: **High**

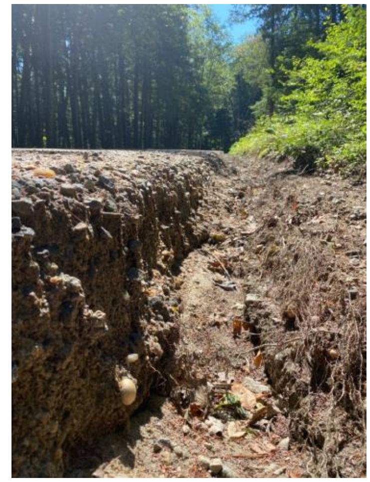
Observations: A large sloped paved parking lot leads to a sloped beach area with a recreational building and new restroom facilities. Water from the parking lot diverts to multiple channels: the woods at the downslope end of the lot, a paved swale near the large building to the woods, and under the recreational building to a catch basin at the beach. From the forested area, the multiple channels converge to a long, paved swale that empties directly into the lake. Partial drainage from the parking lot and surrounding area flows to a rain garden swale with a catch basin installed by the new restroom facilities. The overflow from the rain garden enters the lake via a plastic corrugated pipe. About 300 ft of shoreline has minimal buffer, exposed tree roots, and bare soil. Significant amounts of soil and sand were lost during the extreme July 2023 storm. A couple large trees were also lost in 2023 during a microburst. About 70 camp kids utilize the northern shoreline and grassy area each year. Granite steps to the water have large gullies and erosion.

Recommendations: Regrade the parking lot to divert runoff to the northern downslope area of the lot and install an infiltration/bioretention unit to capture the water before and/or as it enters the woods. Remove all paved swales and replace them with bioretention swales or a similar treatment option to capture water and treat pollutants instead of funneling it to a single discharge point. Define and stabilize access points to the water, such as the granite steps, and reestablish a prominent buffer in all other areas along the 300+ ft shoreline length. Staff from the Town of Swanzey are aware of the issues presented at Richardson Town Beach and are hoping to address them as part of a larger 3-to-5-year planning process.

A: *Erosion channel leading under the building towards a drain inlet.* ***B and C:*** *Paved swales funnel stormwater to a single discharge point.* ***D:*** *Overflow from a rain garden discharges to the lake via a plastic pipe.* ***E:*** *Granite steps leading to the water's edge.* ***F:*** *Highly impervious parking lot ultimately drains to the lake.* ***G:*** *Shoreline erosion from an area of bare soil combined with an inadequate shoreline buffer.*

Site 2-05: West Shore Rd – North of House 103 at Culvert
Location (latitude, longitude): 42.84322, -72.30624
Impact: **High**

Observations: A deep gully was observed along the shoulder of West Shore Rd spanning about 150 feet, leading to a culvert that carries stormwater toward Swanzey Lake. Downstream of the culvert, large sediment deposits were observed along the flow path in the forested area, possibly the byproduct of road washout from the July 2023 storm.



(Left) Sediment accumulation in the forested area. (Middle and Right) Deep gully on road shoulder.

Recommendations: We recommend cleaning out the culvert and installing a plunge pool to retain sediment that travels through the culvert. Sediment piles may be removed to restore the original stream channel. In addition, the road shoulder may be reshaped into a ditch and armored with stone or grass. Check dams may also be installed within the ditch to slow stormwater/filter out sediment.

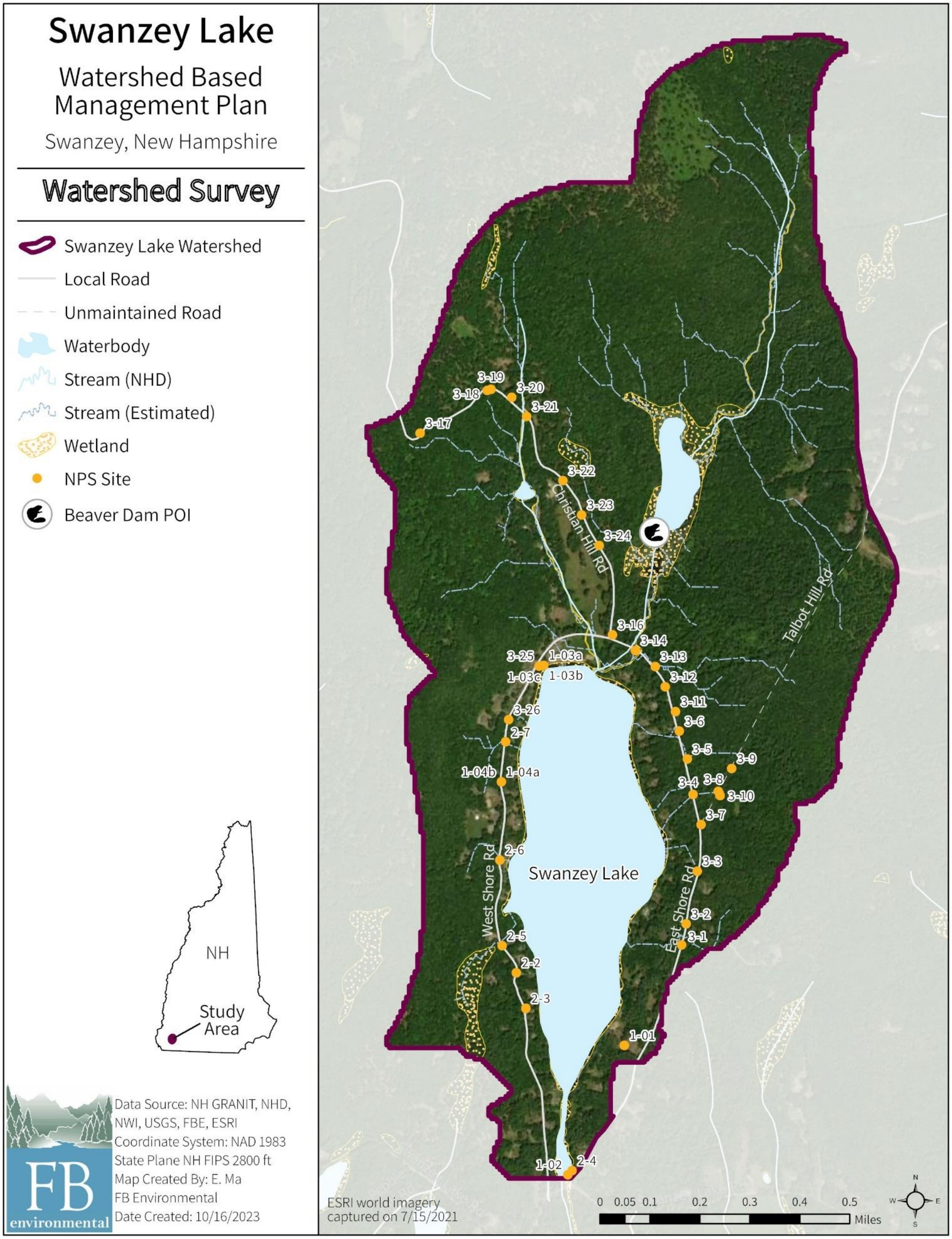


Figure 12. Location of identified nonpoint source sites in the Swanzey Lake watershed.

3.1.2 Shoreline Survey

FBE technical staff conducted a shoreline survey of Swanzey Lake on August 11, 2023. The shoreline survey uses a simple scoring method to highlight shoreline properties around the lake that exhibit significant erosion. This method of shoreline survey is a rapid technique to assess the overall condition of properties within the shoreland zone and prioritize properties for technical assistance or outreach. One boat was used for surveying parcels with lake frontage, with boating assistance provided by two residents. Technical staff documented the condition of the shoreline for each parcel using a scoring system that evaluates vegetated buffer, presence of bare soil, extent of shoreline erosion, distance of structures to the lake, and slope. 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 SLPA and SWRPC 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 63 parcels were evaluated along the shoreline of Swanzey Lake in Swanzey, NH. The average Shoreline Disturbance Score (Buffer, Bare Soil, and Shoreline Erosion) for the entire lake was 6.0 (Table 12). About 33% of the shoreline (or 21 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[2]. The average Shoreline Vulnerability Score (Distance and Slope) was 3.8 (Table 12). About 78% (or 49 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 12. Average scores for each evaluated condition criterion and the average Shoreline Disturbance Score and average Shoreline Vulnerability Score for Swanzey Lake. 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)	2.6	**Shoreline Disturbance Score (3-12)** 6.0
Bare Soil (1-4)	1.8	
Shoreline Erosion (1-3)	1.6	
Distance (0-3)	2.4	**Shoreline Vulnerability Score (1-6)** 3.8
Slope (1-3)	1.4	

The pollutant loading estimates are based on the Shoreline Disturbance Scores. The 21 parcels with scores 7-9, are contributing approximately **8.1 kg of phosphorus annually**[3]. If shoreline landowners were to create adequate buffers and install other shoreline Best Management Practices (BMPs) on these properties (at a 50% BMP efficiency rate), the annual reduction would be 4.0 kg of phosphorus.

Certain site characteristics, such as slope, can cause shorelines to be naturally more vulnerable to erosion. Other site characteristics such as structure distance to the lake, are often a direct consequence of the historic development on that parcel and cannot be easily changed. Shoreline buffers and amount of exposed soil are more easily changed to strengthen the resiliency of the shoreline to disturbance in the watershed. In summary, the overall average shoreline condition of Swanzey Lake is good for erosion issues (average disturbance score below 7), with 21 properties (33%) needing to address

[2] Shoreline erosion can be from or exacerbated by natural phenomena or human-related activities. Natural phenomena typically include the orientation of the parcel to prevailing winds and subsequent greater wave action, composition of the shoreline bank (whether highly erodible soil material or hardened rocky or bedrock outcroppings), and winter ice damage. Human-related activities typically include motorboating (which generate wakes whose wave energy is dissipated by the shoreline) and shoreline development (which includes retaining walls, beaches, access points, etc.).

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

erosion issues that are impacting the lake. Swanzey Lake 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 3.8).

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.

3.1.3 Stream Crossing & Culvert Assessments

With assistance from Underwood Engineers and SWRPC, the Town of Swanzey is in the process of completing a stormwater asset management plan to inventory stream crossings, culverts, and closed drainage systems, including those around Swanzey Lake. Current assessment data and rankings can be found on the NH Aquatic Restoration Mapper and the SADES CCDS Collection Mapper.

3.1.4 Soil & Shoreline Erosion

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

3.1.4.1 Surficial Geology

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

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

The surficial geology of the Swanzey Lake watershed is uniformly composed of intrusive igneous rock such as granite, granodiorite, and trondhjemite, which was formed by bursts of molten magma. Granite is coarse grained and is high in quartz and feldspar, giving it its light color. The minerals present in the geologic parent material are critical because they influence which plant nutrients become available in the soil after sufficient weathering occurs (soil formation). Aside from the parent material, soil formation is influenced by the climate, organisms, topography, and time. Quartz is a resilient mineral composed of silicon and oxygen. Feldspar contains aluminum, silicon, potassium, sodium, and calcium. Potassium and calcium are essential nutrients for plant growth. No stratified drift aquifers are present in the watershed, unlike other areas of Swanzey (Medalie & Moore, 1995).

3.1.4.2 Soils and Erosion Hazard

The soils in the Swanzey Lake watershed (Appendix A, Map A-7) are a direct result of geologic processes. Of the 18 different soil series present within the Swanzey Lake watershed (excluding soils beneath waterbodies), the most prevalent soil group in the watershed is Lyman-Tunbridge-Rock outcrop complex, very stony (167.4 acres, 19%), followed by Tunbridge-Lyman-

Rock outcrop complex, very stony (150.6 acres, 17%), Berkshire fine sandy loam, very stony (126.4 acres, 14%), Marlow fine sandy loam, very stony (101.8 acres, 12%), and Monadnock fine sandy loam, very stony (77.9 acres, 9%). Lyman-Tunbridge-Rock soils are classified as somewhat excessively well drained, and Tunbridge-Lyman-Rock, Berkshire, Marlow, and Monadnock soils are well drained. The remaining 29% of the watershed (excluding the lake area) is a combination of 13 additional soil series ranging from 5.3% to 0.26% of the watershed.

Soil erosion hazard is dependent on a combination of factors, including land contours, climate conditions, soil texture, soil composition, permeability, and soil structure (O'Geen et al., 2006). Soil erosion hazard should be a primary factor in determining the rate and placement of development within a watershed. Soils with negligible soil erosion hazard are primarily low-lying wetland areas near abutting streams. The soil erosion hazard is determined from the associated slope and soil erosion factor K_w[4] used in the Universal Soil Loss Equation (USLE). The USLE predicts the rate of soil loss by sheet or rill erosion in units of tons per acre per year. A rating of "slight" specifies erosion is unlikely to occur under standard conditions. A rating of "moderate" specifies some erosion is likely and erosion-control measures may be required. A rating of "severe" specifies erosion is very likely and erosion-control measures and revegetation efforts are crucial. A rating of "very severe" specifies significant erosion is likely and control measures may be costly. These ratings are derived as part of the Soil Erosion Hazard Off-Road/Off-Trail for each soil series. Excluding the lake area, "severe" erosion hazard areas account for 76% of the Swanzey Lake watershed, covering most of the area except for the majority of West Shore Rd, the southeastern shoreline, and wetland areas throughout the watershed (Appendix A, Map A-8). Moderate erosion hazard areas account for 18% of the watershed, while slight erosion hazard areas account for 6% of the watershed. The remaining watershed area (<0.5%) has soils not rated for the soil erosion hazard. Development should be restricted in areas with severe erosion hazards due to their inherent tendency to erode at a greater rate than what is considered tolerable soil loss. Since a highly erodible soil can have greater negative impact on water quality, more effort and investment are required to maintain its stability and function within the landscape, particularly from BMPs that protect steep slopes from development and/or prevent stormwater runoff from reaching water resources.

Soil erosion is often exacerbated when the landscape is steeply sloped (>20%). Steeply sloped areas generally produce more runoff than low-lying areas because there is less time for the water to infiltrate into the soil before it continues moving downhill. Steep slopes also provide stormwater with more energy, as the force of gravity allows stormwater to move quickly, giving it more power to dislodge soil particles and carry them downslope toward waterbodies. The Swanzey Lake watershed is extremely steep, with much of the watershed having slopes greater than 30%, and most of the area having between 10% and 20% slopes (Appendix A, Map A-9). Steep slopes throughout the watershed are a factor in the soil erosion hazard rating and provide an added emphasis on stormwater management for the Swanzey Lake watershed.

3.1.4.3 Shoreline Erosion

Water level fluctuations in lakes and ponds can occur on long- and short-term timescales due to naturally changing environmental conditions or as a response to human activity. The effect of lake level fluctuation on physical and environmental conditions depends on several factors including the degree of change in water level, the rate of change, seasonality, and the size and depth of the waterbody (Leira & Cantonati, 2008; Zohary & Ostrovsky, 2011). Changes in lake level can impact flora and fauna mainly by altering available habitat, impacting nesting locations, and altering available food sources. In addition to impacts to the biological communities, lakes can experience physical impacts on water quality from changes in lake level. Frequent lake level fluctuations can impact the shoreline, leading to erosion and increased sedimentation in near-shore habitats, inhibiting light penetration and altering water clarity. Exposed shoreline sediment that is inundated at high water levels can release phosphorus, leading to alterations in nutrient accumulation and algae populations. High and low water levels can have detrimental effects on water systems, so finding a balance in managing water level at appropriate times throughout the year is critical to maintaining a healthy waterbody for both recreational enjoyment and aquatic life use. Management strategies become even more challenging when considering the impact of increased wake boating and extreme weather events (droughts and storms) on water level. Residents of Swanzey Lake have expressed concern about enhanced shoreline erosion caused by boat wakes, particularly in the southern area near the outlet channel. The dam at the outlet of Swanzey Lake was damaged in the July 2023 storm and is responsible for regulating lake levels. Ongoing efforts to support the reconstruction/repair of the dam should be continued to ensure proper control of lake levels.

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

3.1.5 Wastewater

3.1.5.1 Septic Systems

Untreated discharges of sewage (domestic wastewater) are prohibited regardless of source. An example of an NPS discharge of untreated wastewater is from insufficient or malfunctioning subsurface sewage treatment and disposal systems, commonly referred to as septic systems, but which also include holding tanks and cesspools. When properly designed, installed, operated, and maintained, septic systems can reduce phosphorus concentrations in sewage within a zone close to the system (depending on the development and maintenance of an effective biomat, the sorption 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 failing or underperforming septic systems can enter surface waters through surface overflow or breakout, stormwater runoff, or groundwater. Cesspools are buried concrete structures that allow solid sludge to sink to the bottom and surface scum to rise to the top and eventually leak out into surrounding soils through holes at the top of the structure. Cesspools used to be a primary method of wastewater disposal before they were subsequently prohibited due to their impact on water bodies and drinking water wells. Because they are dug deeply into the ground, there is less vertical separation between the cesspool and a restrictive layer or water table, leading to incomplete wastewater treatment. Holding tanks are completely enclosed structures that must be pumped regularly to prevent effluent back-up into the home. These systems are often used when development constraints make it impossible to install a septic system a safe distance away from a waterbody, or when soils are unsuitable for a septic system and other design options are unfeasible.

The soils within the watershed provide some insight into the phosphorus removal capabilities of watershed septic systems. Generally, coarse-textured soils such as sands or soils with shallow distances to bedrock or groundwater have lower phosphorus retention capacities. The mineralogy of the soil is also important to phosphorus retention because of the various reactions phosphorus may have with iron and aluminum oxides and base cations such as calcium and magnesium; iron and aluminum rich soils often have greater phosphorus retention capacities than calcium rich soils (Robertson, 2003; Robertson et al., 2021). According to soil survey data from the USDA-NRCS, the soils in the Swanzey Lake watershed have textures with reasonable capacity to retain phosphorus, typically sandy loam or fine sandy loam with between 65-75% sand throughout the soil profile. Sandy loams and fine sandy loams tend to have a higher capacity than sands to retain phosphorus from septic systems (McCray et al., 2005). Most soils in the watershed (76%) are classified as spodosols, which are weathered soils that often have accumulations of iron and aluminum oxides and organic matter, indicating potentially high phosphorus retention capacity. Inceptisols, which make up 22% of the watershed area, lack these characteristics and may have less phosphorus retention capacity if a septic system is installed. Soil survey data suggests that the soils in the area are well drained and the water table is deep. Septic system siting that considers these factors may reduce phosphorus loading to Swanzey Lake over time. Locating a septic system on well drained soils (large vertical separation distance to groundwater, bedrock, or a restrictive layer) with reasonable phosphorus retention capacity (medium texture, potentially high in iron and aluminum) and far from the lake shoreline is ideal for lake protection. If inadequate vertical separation distance is present, a raised (or mound) system may be used to achieve greater soil depth.

SLPA completed an initial review of available data on septic systems along the Swanzey Lake shoreline in October 2023, which SWRPC supplemented with a survey provided to shoreline residents to collect occupancy data and other information. One of the objectives of the data collection effort was to determine the number of septic systems along the shoreline of Swanzey Lake and the proportion of older septic systems to newer systems. FBE queried the NHDES OneStop online database for subsurface permits and SLPA reviewed Swanzey tax parcel records. There were 63 shoreline properties identified (within 250 feet of the shoreline), 59 of which had structures built on them. The 2023 residential survey indicated that 90% (28) of respondents use a septic system and 10% (3) use a holding tank. Septic system permits within OneStop were found for 36% of the built properties. Of these, 62% were found to have septic systems newer than 25 years, and 5% had septic systems installed prior to 1996. Shoreline systems older than 25 years are more likely to fail and send nutrient-rich wastewater directly to Swanzey Lake. Older systems are also more likely to have substandard designs or be installed close to the waterbody. Most respondents (85%) pump their septic system every 5 years or less.

FBE estimated the pollutant loading from shoreline septic systems using default literature values for daily water usage, phosphorus concentration output per person, and system phosphorus attenuation factors. The number of people using shoreline septic systems was calculated by multiplying the number of “old” (>25 years) and “young” (<25 years) shoreline septic systems used seasonally or year-round by the number of bedrooms (as a surrogate for the average number of persons using the septic systems). Data for the loading estimation were supplied by a survey conducted by SLPA in which residents responded with their typical occupancy, number of residents, and age of their septic system, if known. SLPA supplemented this with a property records search to confirm system age. As detailed in the *Swanzey Lake Lake Loading Response Model Report* (FBE, 2024), shoreline septic systems contribute 10.4 kg/yr of total phosphorus loading to Swanzey Lake, comprising 16% of the total phosphorus load from all sources to the lake. Septic systems, cesspools, or holding tanks are located within a short distance to the water, leaving little horizontal (and sometimes vertical) space for proper filtration of wastewater effluent. Improper maintenance or siting of these systems can cause failures, which leach untreated, nutrient-rich wastewater effluent directly to the lake.

3.1.6 Fertilizers

When lawn and garden fertilizers are applied in excessive amounts, in the wrong season, or just before heavy precipitation, they can be transported by rain or snowmelt runoff to lakes and other surface waters where they can promote cultural eutrophication and impair the recreational and aquatic life uses of the waterbody. Many states and local communities are beginning to set restrictions on the use of fertilizers by prohibiting their use altogether or requiring soil tests to demonstrate a need for any phosphate application to lawns. The 2023 residential survey indicated that more than half of respondents use some kind of chemical on their property, such as insect/pest control (37%), weed/nuisance plant control (10%), road/walkway salt (3%), and lawn/plant fertilizer (13%). It is important for residents to understand that even organic fertilizer is still fertilizer and adds nutrients to the lake. It is better to avoid the use of fertilizers within the shoreland zone (250 feet of the lake) unless they are contained such as within raised garden beds.

3.1.7 Pets

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

3.1.8 Future Development

Understanding population growth, and ultimately development patterns, provides critical insight to watershed management, particularly as it pertains to lake water quality. According to the US Census Bureau, the Town of Swanzey has experienced slow-to-moderate population growth over the last 50 years, increasing from a total of 4,254 people in 1970 to 7,270 people in 2020 (see Section 2.3.2). The Swanzey Lake watershed area has long been treasured as a recreational haven for both summer vacationers and year-round residents, complete with many seasonal shorefront homes and summer campgrounds. The lake is used for swimming, canoeing, kayaking, boating, and fishing in the summer, and the surrounding watershed area is used for various activities such as hiking, ATV riding, and snowmobiling. Development pressures in southwestern New Hampshire and the lake's desirability as a recreational space will likely lead to population growth in the future. Growth figures and estimates suggest that towns should continue to consider the effects of current municipal land-use regulations on local water resources. As the region's watersheds are developed, erosion from disturbed areas increases the potential for water quality decline. Residents have indicated that in the last decade many former seasonal camps and cottages have been redeveloped into year-round homes, some with larger building footprints. A few new houses have also been built along West Shore Rd.

3.2 INTERNAL PHOSPHORUS LOAD

Phosphorus that enters the lake and settles to the bottom can be re-released from sediment under anoxic conditions, providing a nutrient source for algae, cyanobacteria, and plants, otherwise known as internal phosphorus loading. The watershed modeling in Section 2.3 identified internal phosphorus loading as the second largest source of phosphorus to Swanzey Lake, making up 17% of the total phosphorus load. The modeled phosphorus loading into Swanzey Lake was calibrated to in-lake data collected before a destructive storm in July 2023 washed out beaches, roads, and sent large quantities of sediment-bound phosphorus to Swanzey Lake. The model is unable to consider phosphorus loading from single storm events such as the July 2023 storm. Due to the storm's impacts and model limitations, the extent of anoxia and internal load in Swanzey Lake should be carefully monitored over the next several years. Data from 2023 showed worsening anoxia in Swanzey Lake; enhanced monitoring of the internal load may reveal whether the extreme weather and erosion set the lake on a new trajectory towards more rapid water quality degradation. In the meantime, watershed protection efforts should focus on reducing the watershed and septic system loads. After exhausting external load reduction opportunities, lakes where the internal load comprises over 20% of the total phosphorus load may be candidates for an in-lake treatment if lake response is slow and cyanobacteria blooms become a persistent issue.

3.3 POTENTIAL CONTAMINATION SOURCES

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

NHDES operates and maintains the OneStop database and data mapper, which houses data on Potential Contamination Sources (PCS) within the State of New Hampshire. Identifying the types and locations of PCS within the watershed may help identify sources of pollution and areas to target for restoration efforts.

On June 12, 2023, FBE downloaded datasets for above ground storage tanks, underground storage tanks, automobile salvage yards, solid waste facilities, hazardous waste sites, local potential contamination sources, NPDES outfalls, and remediation sites in the Swanzey Lake watershed. Out of the eight possible categories, only one category was present in the watershed: remediation sites (Appendix A, Map A-10).

3.3.1 Remediation sites

There is one remediation site in the Swanzey Lake watershed located at 88 East Shore Road. The remediation site is a former camping area on the lakeshore.

3.4 WILDLIFE

Fecal matter from wildlife such as geese, gulls, other birds, and beavers may be a significant source of nutrients in some watersheds. This is particularly true when human activities, including the direct and indirect feeding of wildlife and habitat modification, result in the congregation of wildlife (CWP, 1999). Congregations of geese, gulls, and ducks are of concern because they often deposit their fecal matter next to or directly into surface waters. Examples include large mowed fields adjacent to lakes and streams where geese and other waterfowl gather, as well as the underside of bridges with pipes or joists directly over the water that attract large numbers of pigeons or other birds. Studies show that geese inhabiting riparian areas increase soil nitrogen availability (Choi et al., 2020) and gulls along shorelines increase phosphorus concentration in beach sand pore water that then enters surface waters through groundwater transport and wave action (Staley et al. 2018). When submerged in water, the droppings from geese and gulls quickly release nitrogen and phosphorus into the water column, contributing to eutrophication in freshwater ecosystems (Mariash et al., 2019). On a global scale, fluxes of nitrogen and phosphorus from seabird populations have been estimated at 591 Gg N per year and 99 Gg P per year, respectively (with the highest values derived from arctic and southern shorelines) (Otero et al., 2018). Additionally, other studies show greater concentrations of nitrogen, ammonia, and dissolved organic carbon downstream of beaver impoundments when compared to similar streams with no beaver activity in New England (Bledzki et al., 2010). The model estimated that waterfowl are likely contributing 2.7 kg/yr (4%) of the total phosphorus load to Swanzey Lake.

The upper beaver dam located in the northeastern drainage to Swanzey Lake.

Watershed residents also identified beaver dams as an indirect cause of pollution to Swanzey Lake, as beaver dam breaches in the past have led to localized flooding that flushed pulses of sediment and nutrients to Swanzey Lake. Increased flows from dam breaches can lead to streambank erosion and erosion of flooded areas. In 2021, a beaver dam breach sent a pulse of nutrients into Swanzey Lake which led to a cyanobacteria bloom alert. There are currently two known beaver dams in the Swanzey Lake watershed, including an upper and lower beaver dam on the pond north of Swanzey Lake. The upper beaver dam is located off of Christian Hill Road and currently separates the pond from a wetland area, spanning approximately 50 feet. Long-time residents have noted that the area around the beaver dams has changed. According to residents, there used to be a second, lower (downgradient) beaver dam that held water back such that the pond level rose to cover the location of the upper beaver dam (photographed below), preventing vegetation from growing. The presence of vegetation implies that the lower beaver dam impounds less water after the lower dam breach or the lower dam was not reconstructed by the beaver(s). There appears to be minimal risk of a beaver dam breach impacting water quality as observed during the 2023 watershed survey, though reconstruction of the lower dam may increase the risk of water quality impacts from a breach if additional water is impounded.

3.5 CLIMATE CHANGE

Climate change will have important implications for water quality that should be considered and incorporated into WBMPs. In the last century, New England has already experienced significant changes in stream flow and air temperature. Out of 28 rural stream flow stations throughout New England, 25 showed increased flows over the record likely due to the increase in frequency of extreme precipitation and total annual precipitation in the region. In 79 years of recorded flooding in the Oyster River in Durham, NH, three of the four highest floods occurred in the past 10 years (Ballestero et al., 2017). 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). In New Hampshire, mean annual maximum temperatures have increased 2.0 °F since 1971. Mean annual minimum temperature in New Hampshire has increased 3.1 °F since 1971. There is also significantly more warming occurring in the fall and winter seasons (Lemcke-Stampone, Wake, & Burakowski, 2022).

Photos of the aftermath from the devastating extreme storm event in July 2023 that washed out roads and beaches, collapsed hillsides, and sent tons of sediment, organic material, and other debris into Swanzey Lake.

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. 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. Adding to this stress is population growth and corresponding development in New Hampshire. The build-out analysis for the watershed showed that about 985 acres are still developable and up to 105 new buildings could be added to the watershed at full build-out based on current zoning standards. Swanzey Lake is at risk for sustained water quality degradation because of new development in the watershed, especially considering the steep slopes and high erosion risk soils throughout the watershed unless climate change resiliency and **low impact development** (LID) strategies are incorporated to existing zoning standards.

4 MANAGEMENT STRATEGIES

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

4.1 STRUCTURAL NONPOINT SOURCE (NPS) RESTORATION

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

4.1.1 Watershed & Shoreline BMPs

Thirty-nine (39) NPS sites identified during the September 2023 watershed survey and 21 medium impact rated shoreline properties from the 2023 shoreline survey were documented to have some impact to water quality through the delivery of phosphorus-laden sediment (refer to Section 3.1.1-3.1.2). As such, structural BMPs to reduce the external watershed phosphorus load are a necessary and important component for the protection of water quality in the watershed.

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

- Address the top five high priority areas (seven sites, and the remaining 5 high, 7 medium, and 20 low priority sites as opportunities arise) identified during the 2021 watershed survey. The three highest priority sites on Talbot Hill Road were combined into a singular site for implementation purposes. The sites were ranked based on phosphorus load reduction and waterbody proximity. The full prioritization matrix with recommended improvements is provided in Appendix B and was separated into privately-owned and town-owned sites.
- Provide technical assistance and/or implementation cost sharing to shoreline properties identified during the 2023 shoreline survey. Encourage landowners to implement stormwater and erosion controls on the 21 medium impact shoreline properties identified during the 2023 shoreline survey. Workshops and tours of demonstration sites can help encourage landowners to utilize BMPs on their own property. Conduct regular shoreline surveys to continue prioritizing properties for technical follow-up.

For the proper installation of structural BMPs in the watershed, SLPA 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 are included in Section 5. For helpful tips on implementing BMPs, see Additional Resources.

4.2 NON-STRUCTURAL NONPOINT SOURCE (NPS) RESTORATION

Non-structural NPS restoration techniques refer to a broad range of behavioral practices, activities, and operational measures that contribute to pollutant prevention and reduction. The following section highlights important restoration techniques for several key areas, including pollutant reduction best practices, zoning and ordinance updates, land conservation, septic system regulation, fertilizer use prohibition, pet waste management, and nuisance wildlife controls. Agricultural practices were not discussed since there is no current agriculture in the watershed. In-lake treatments were also not included because we are not recommending in-lake treatments for Swanzey Lake at this time.

4.2.1 Pollutant Reduction Best Practices

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

Even though only a small portion of Swanzey is required to comply with the six minimum control measures under the New Hampshire Small MS4 General Permit, the town could consider instituting the permit's key measures, such as road/ditch and culvert maintenance, if not already in place. The MS4 permit also covers illicit discharge detection and elimination plans (and ordinance inclusion), source control and pollution/spill prevention protocols, and education/outreach and/or training for residents, municipal staff, and stormwater operators, all of which are aimed at minimizing polluted runoff to surface waters.

Additionally, SLPA is petitioning the state to make the southern area of the lake a "no wake" zone to minimize shoreline erosion by boat wakes. The "no wake" zone is being proposed as approximately 150 ft from the mouth of the outlet channel and 150 ft from both shores.

4.2.2 Zoning and Ordinance Updates

Regulations through municipal zoning and ordinances such as LID strategies that prevent polluted runoff from new and re-development projects in the watershed are equally important as implementing structural BMPs on existing development. In fact, local land use planning and zoning ordinances can be the most critical components of watershed protection. FBE completed a preliminary ordinance review of natural resource protections for the Town of Swanzey (Table 13). A more robust review of these ordinances is encouraged for more specific recommendations for improving ordinances and regulations related to natural resource protection. The town should also consider its staffing capacity to enforce existing and proposed regulations. Special attention should be focused on the Rural/Agricultural District as it is the only zoning district present in the Swanzey Lake watershed.

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

- **Installing Green Infrastructure and Nature-Based Solutions:** Planning for greener infrastructure requires that we think about creating a network of interconnected natural areas and open spaces needed for groundwater recharge, pollution mitigation, reduced runoff and erosion, and improved air quality. Examples of green infrastructure include forest, wetlands, natural areas, riparian (banks of a water course) buffers, and floodplains; all of which already exist to various extents in the watershed and have minimized the damage created by intense storms. As future development occurs, these natural barriers must be maintained or even increased to reduce runoff of pollutants into freshwaters. See also Section 4.2.3: Land Conservation.
- **Using LID Strategies:** Use of LID strategies requires replacing traditional approaches to stormwater management using curbs, pipes, storm drains, gutters, and retention ponds with innovative approaches such as bioretention, vegetated swales, and permeable paving.
- **Minimizing Impervious Surfaces:** Impervious surfaces such as roads, buildings, and parking lots should be minimized by creating new ordinances and building construction design requirements which reduce the imperviousness of new development. Property owners can increase the permeability for their lots by incorporating permeable driveways and walkways.
- **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, recharge groundwater, and mitigate water pollution.
- **Encouraging Tree Planting:** Trees help manage stormwater by reducing runoff and mitigating erosion along surface waters. Trees also provide critical shading and cooling to streams and land surfaces.
- **Promoting Landscaping Using Native Vegetation:** Landowners should promote the use of native vegetation in landscaping, and landscapers should become familiar with techniques which minimize runoff and the discharge of nutrients into waterbodies (Chase-Rowell et al., 2012).

- **Slowing Down the Flow of Stormwater:** To slow and infiltrate stormwater runoff, roadside ditches can be armored or vegetated and equipped with turnouts, settling basins, check dams, or infiltration catch basins. Rain gardens can retain stormwater, while waterbars can divert water into vegetated areas for infiltration. Water running off roofs can be channeled into infiltration fields and drainage trenches.
- **Coordinating Infrastructure, Housing, and Transportation Planning**: Coordinate planning for infrastructure, housing, and transportation to minimize impacts on natural resources. Critical resources including groundwater must be conserved and remain free of pollutants especially as future droughts may deplete groundwater supplies.

4.2.3 Land Conservation

Land conservation is essential to the health of a region, particularly for the protection of water resources, enhancement of recreation opportunities, vitality of local economies, and preservation of wildlife habitat. Land conservation is one of many tools for protecting water quality for future generations. For Swanzey Lake, 7% (68 acres) of the watershed has been classified as conservation land (refer to Appendix A, Map A-11). Conserved areas include the Gordon & Persis Brown Easement Forest, the Carpenter Home Forest, and the boat launch to Swanzey Lake. These conserved areas cover a forested area west of Christian Hill Road and a small portion of the northern tip of the watershed.

Local groups should continue to pursue opportunities for land conservation in the Swanzey Lake watershed based on the highest valued habitat identified by the New Hampshire Fish & Game (NHFG). NHFG ranks habitat based on value to the State, biological region (areas with similar climate, geology, and other factors that influence biology), and supporting landscape. These habitat rankings are published in the State's 2015 Wildlife Action Plan (with updated statistics and data layers released in January 2020), which serves as a blueprint for prioritizing conservation actions to protect Species of Greatest Conservation Need in New Hampshire. The Swanzey Lake watershed is part of the Hillsboro Inland Hills and Plains ecoregional subsection of the biological region (NHFG, 2015). None of the Swanzey Lake watershed is considered the Highest Ranked Habitat in New Hampshire, and only a small portion (3.5 acres or 0.4%) is considered the Highest Ranked Habitat in the Ecoregion, which includes the large wetland complex to the north of the lake. A larger percentage of the area is considered Supporting Landscapes, which are critical edge habitat areas that facilitate healthier core habitat. About 433 acres (44%) of the Swanzey Lake watershed is classified as Supporting Landscapes, which includes the upper watershed, the area west of West Shore Road, the wetland, and the southern section of Talbot Hill Road. Existing conservation land only overlaps a small portion of the Supporting Landscapes in the watershed. Future conservation efforts should focus on areas that are ranked as highly valued habitat in the state, such as Supporting Landscapes that provide critical edge habitat and habitat connectivity. Conservation efforts may also focus on steeply sloping forested areas or areas that would pose a severe erosion risk if they were to be developed. A map of priority habitats for conservation based on the NH Wildlife Action Plan can be found in Appendix A, Map A-12.

Table 13. Ordinance review summary of regulatory and non-regulatory tools for natural resource protection in Swanzey, the only town in the Swanzey Lake watershed.

	STRATEGY	SWANZEY
REGULATORY TOOLS	Shoreland zoning.	"Shoreland Protection District" [Section VIII, effective 1995] establishes an overlay district that encompasses the shoreline of certain waterbodies in Swanzey and references the state's guidelines (RSA 483-B).
	Cluster development and/or open space provisions for subdivisions.	"Conservation Residential Subdivision Regulations" [effective 2008], with the goal of preserving open space, protecting environmentally sensitive areas, encouraging a creative approach to land development that considers conservation, and creating a continuous network of greenways.
	Septic pump-out ordinance or regulation of septic and sewer systems.	None identified. Septic systems must not be closer than 125 feet from a wetland.
	Zoning districts address environmental protection.	Zoning districts addressing environmental protection: "Shoreland Protection District," "Floodplain District," and "Wetlands Conservation District."
	Zoning overlay districts that address wetland conservation.	"Wetlands Conservation District" [Section VII, effective 2005], regulates uses in and around saturated soils that support wetland vegetation, with the goal of protecting wetlands from development which would contribute pollutants to ground and surface waters.
	Zoning overlay districts that protect groundwater.	None identified. The "Wetlands Conservation District" aims to protect groundwater resources. Pursuing a Groundwater Protection Ordinance is identified as a goal in the 2022 Master Plan.
	Protection of steep slopes.	Section III "General Provisions Applicable to All Districts" excludes steep slopes (>25%) from the total buildable area for a lot.
	Nutrient loading analysis required for fresh waterbodies.	None identified.
	Low impact development requirements and standards.	None identified.
	Fertilizer and/or pesticide ordinances.	None identified.
	Implement and enforce a Stormwater Management Plan.	None identified.

	STRATEGY	**SWANZEY**
CONSERVATION FUNDING STRATEGIES	Development transfer overlay district.	None identified.
	Conservation impact fees.	None identified.
	Wetland mitigation funds.	Participate in state wetland mitigation program.
	Fee in lieu of land dedication.	None identified.
	Stormwater utility district.	None identified.
	Open space or non-lapsing conservation fund.	None identified.
	Has a Land Use Change Tax per RSA 79-A:25.	None identified.
	Participate or collaborate with a local watershed association.	Swanzey Lake Protective Association.
	Participate or collaborate with a local land trust.	Monadnock Conservancy.
NON-REGULATORY TOOLS	Open space plan.	Yes [2004], "A Plan for the Protection of Open Space." An update to the Open Space Plan is a goal of the 2022 Master Plan.
	Master plan addresses natural resources and environmental protection.	Yes [2022]. Sub-chapters relevant to environmental protection include "Natural Resources." Natural resources are noted as a priority for protection in chapters such as "Transportation," "Historic and Recreational Resources," and "Economic Development."
	Conduct a town-wide natural resources inventory.	Yes, Phase I completed in 2018.
	Incentive-based programs for voluntary low impact development implementation.	None identified.
	Incentive-based programs for stormwater reduction efforts.	None identified.
	Have established conservation commission.	Yes.
	Incentivize and/or encourage property owners to implement low impact development stormwater practices.	None identified.
	Encourage property owners to put land into farmland/tree growth programs.	None identified.

4.2.4 Septic System Regulation

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

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

4.2.5 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 surface water. Outside of 25 feet, property owners can get their soil tested before considering the application of fertilizers to their lawns and gardens to determine whether nutrients are needed and if so in what quantity or ratio. A soil test kit can be obtained through the UNH Cooperative Extension. Many New England communities are starting to adopt local regulations prohibiting the use of both fertilizers and pesticides, especially near critical waterbodies. The watershed towns could consider a similar prohibition, at the very least for a watershed zoning overlay of major lakes and ponds.

4.2.6 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.

4.2.7 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, improving buffers, 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.

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

4.3 OUTREACH & EDUCATION

Awareness through education and outreach is a critical tool to protecting and restoring water quality. Most people want to be responsible watershed stewards and not cause harm to water quality, but many are unaware of best practices to reduce or eliminate contaminants from entering surface waters. SLPA is the primary entity for education and outreach campaigns in the watershed and for development and implementation of the plan. SLPA 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, SLPA should continue to engage with local stakeholders such as conservation commissions, land trusts, the Town of Swanzey, 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 stakeholders, is highly recommended for protecting Swanzey Lake. 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 SLPA should be assembled to coordinate watershed management actions. This group can include representatives from state and federal agencies or organizations, the Town of Swanzey, 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: Establishment of Water Quality Goal for interim milestones.

5 ACTION PLAN

5.1 ACTION PLAN

The Action Plan (Table 14) outlines responsible parties, approximate costs[5], 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; and (7) Education and Outreach. The plan is designed to be implemented from 2024-2033 and is flexible to allow for new priorities throughout the 10-year implementation period as additional data are acquired.

Table 14. Action plan for the Swanzey Lake watershed.

Action Item	Responsible Party	Estimated Cost / Schedule	Potential Funding Sources
Watershed & Shoreline BMPs			
Complete design and construction of mitigation measures at the top five high priority areas (seven sites) identified in the watershed survey for privately-owned sites. **Achieves 40% (4.8 kg/yr P of 12 kg/yr P) of Objective 1.**	SLPA, SWRPC, CCCD, private landowners	$215K 2025-30	CWSRF, Grants (319, Moose Plate, NFWF 5-Star, ILF), private landowners
Complete design and construction of mitigation measures at the top five high priority areas (seven sites) identified in the watershed survey for town-owned sites. **Achieves 92% (11.0 kg/yr P of 12 kg/yr P) of Objective 1.**	SLPA, SWRPC, CCCD, Town of Swanzey	$660K-$1.160M 2025-30	CWSRF, Grants (319, Moose Plate, NFWF 5-Star, ILF), Town of Swanzey
Complete design and construction of mitigation measures at 32 high, medium, and low priority sites identified in the watershed survey as opportunities arise (refer to Appendix B for complete list). **Achieves 146% (17.5 kg/yr P of 12 kg/yr P) of Objective 1.**	SLPA, SWRPC, CCCD, Town of Swanzey, private landowners	$315K-$460K 2025-33	CWSRF, Grants (319, Moose Plate, NFWF 5-Star, ILF), Town of Swanzey, private landowners
Promote the LakeSmart program evaluations and certifications through NH Lakes to educate property owners about lake-friendly practices such as revegetating shoreline buffers with native plants, avoiding large grassy areas, and increasing mower blade heights to 4 inches. Coordinate with NHDES Soak Up the Rain NH program for workshops and trainings. Direct landowners to UNH Extension's *Landscaping at the Water's Edge*. Cost assumes coordination of and materials for up to five workshops.	SLPA, CCCD, NH Lakes, NHDES Soak Up the Rain NH, Municipalities	$5K 2024-33	NH Lakes, NHDES Soak Up the Rain NH, Grants (319, Moose plate), CWSRF, Town of Swanzey

[5] 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
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 21 medium impact shoreline properties. **Achieves 25% (3 kg/yr P of 12 kg/yr P) of Objective 1.**	SLPA, CCCD, Landowners, Town of Swanzey	$63K 2024-33	Grants (319, Moose plate), CWSRF, Landowners
Repeat the shoreline survey in 5 and 10 years. Use the results to target education and technical assistance for high impact sites. Cost assumes hired consultant for survey and summation of shoreline survey results.	SLPA, Town of Swanzey	$10K 2028, 2033	Town of Swanzey, Grants (Moose plate), CWSRF, 604(b)
Hire an engineer to assess sedimentation of the southern outlet channel and options for remediation and prevention.	SLPA, Town of Swanzey	TBD 2024-28	CWSRF, Grants (319, Moose Plate, NFWF 5-Star, ILF), Town of Swanzey
Road Management			
Review practices for road and drainage maintenance currently used by public and private entities/groups and determine areas for improvement.	Town of Swanzey, SLPA, Landowners (private roads), CCCD	$3K 2025	CWSRF, Town of Swanzey, Grants (Moose Plate, NFWF 5-Star)
Develop and/or update a written protocol for road maintenance best practices. Consider coordinated effort with nearby stakeholders (other lake associations) for cost sharing savings.	Town of Swanzey, SLPA, CCCD	$4K 2025	CWSRF, Town of Swanzey, Grants (Moose Plate, NFWF 5-Star)
Provide education and training to contractors and municipal staff on protocols for road maintenance best practices. Assumes one workshop. Consider holding joint workshop with other municipalities in the region (or other wider service area) for cost sharing savings.	Town of Swanzey, SLPA, CCCD	$15K 2025	CWSRF, Town of Swanzey, Grants (Moose Plate, NFWF 5-Star)
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.	SLPA, CCCD, Town of Swanzey, private landowners	$10K 2024-33	CWSRF, Town of Swanzey, Grants (Moose Plate, NFWF 5-Star), private landowners
Municipal Operations			
Review and optimize MS4 compliance for the Town of Swanzey (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).	Town of Swanzey (Public Works/Highway)	TBD 2024-33	Town of Swanzey
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.	Town of Swanzey (Public Works/Highway)	Est. $150-$250/person 2024-33	Town of Swanzey

Action Item	Responsible Party	Estimated Cost / Schedule	Potential Funding Sources
Review and update winter operations procedures to be consistent with Green SnowPro best management practices for winter road, parking lot, and sidewalk maintenance.	Town of Swanzey (Public Works/Highway)	N/A 2025	Town of Swanzey
In Swanzey (though likely not relevant to the watershed at this time), 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.	Town of Swanzey (Public Works/Highway)	N/A 2025-27	Town of Swanzey
Municipal Land Use Planning & Zoning			
Present WBMP recommendations to Board of Selectmen and Planning Board in Swanzey.	SLPA	N/A 2024	SLPA
Meet with municipal staff to review recommendations to improve or develop ordinances addressing setbacks, buffers, lot coverage, low impact development, and open space.	SLPA, Town of Swanzey, SWRPC	$3K 2024-27	Town of Swanzey, Grants (319), CWSRF
Encourage the Town of Swanzey to adopt the WBMP as part of the Town's Master Plan or include it in the "Town Plans and Reports" page of the town website. Incorporate recommendations from the WBMP in future updates of the Town's Master Plan.	Town of Swanzey	N/A 2024	Town of Swanzey
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 with specific development regulations (phosphorus control plans, stormwater control plans, installation of vegetative buffers, greater setbacks/minimum lot sizes; and 7) to enhance performance standards for unpaved roads to prevent erosion and protect lake water quality.	Town of Swanzey	N/A 2024-33	Town of Swanzey
Increase municipal staff capacity for inspections and enforcement of stormwater regulations on public and private lands.	Town of Swanzey	TBD 2024-33	Town of Swanzey

Action Item	Responsible Party	Estimated Cost / Schedule	Potential Funding Sources
Land Conservation			
Update the Natural Resource Inventory (NRI) for Swanzey when needed.	Town of Swanzey, Conservation Commissions	$20K 2033	Town of Swanzey, Grants (NFWF NEFRG), CWSRF
Identify additional watershed areas that need protection based on NRIs. Refer to Section 4.2.3 to understand current conservation lands and valuable habitats and wildlife in the watershed that can be used to help identify potential areas to target for conservation.	SLPA, Town of Swanzey, Conservation Commission, Monadnock Conservancy	$5-10K 2024-33	Grants (NFWF NEFRG, NAWCA), CWSRF, Town of Swanzey
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.	SLPA, Town of Swanzey, Conservation Commission, Monadnock Conservancy	N/A 2024-33	Grants (Moose Plate, LCHIP, RCCP, NAWCA, LWCF, ACEP, CSP, EQIP)
Septic System Management			
Distribute educational materials to property owners about septic system function and maintenance.	Town of Swanzey, SLPA	$3K 2024, 2028, 2032	Town of Swanzey, 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.	SLPA	N/A 2024-25	CWSRF
Evaluate locations of older and/or noncompliant septic systems (including cesspools or holding tanks) to identify clusters where conversion to community septic systems might be desirable.	SLPA, Town of Swanzey	TBD 2024-2027	CWSRF, Town of Swanzey
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.	Town of Swanzey	N/A 2024-2033	Town of Swanzey
Develop and maintain a septic system database for the watershed to facilitate code enforcement of any septic system ordinances.	Town of Swanzey	$5-10K 2024-2033	Town of Swanzey, CWSRF
Institute a minimum pump-out/inspection interval for shorefront septic systems (e.g., once every 3-5 years). Pump-outs (~$250 per system) are the responsibility of the owner.	Town of Swanzey	N/A 2024-2027	Town of Swanzey, Landowners
Education & Outreach			
Create a website for the SLPA and use it to share additional/dynamic information, such as water quality data, weather conditions, and workshops, to generate traffic to the website.	SLPA	TBD 2024-2027	Grants, SLPA Membership Dues, Donations
Offer workshops for landowners with 10 acres or more for NRCS assistance with land conservation. Cost assumes up to two workshops.	SLPA	$5K 2024-2027	Grants (RCCP, ACEP, CSP, EQIP)

Action Item	Responsible Party	Estimated Cost / Schedule	Potential Funding Sources
Encourage private property owners to hire Green SnowPro certified commercial salt applicators.	SLPA, CCCD, Town of Swanzey	TBD 2024-2033	Grants, Town of Swanzey
Educate contractors and municipal staff about erosion and sediment control (ESC) practices required on plans. Work with municipal staff to ensure that there are sufficient resources to enforce permitting conditions.	Town of Swanzey, CCCD	$6K 2024-27	Town of Swanzey, 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.	Town of Swanzey, SLPA, CCCD	$20K-$60K 2024-33	Town of Swanzey, Grants (319), CWSRF
Hire additional paid Lake Hosts to monitor the public boat launch throughout the summer.	SLPA, Town of Swanzey	TBD 2024-33	Town of Swanzey, Grants
Petition the state to make the southern area of the lake a “no wake” zone to minimize shoreline erosion.	SLPA	NA 2024-25	NA

5.2 POLLUTANT LOAD REDUCTIONS

To meet the water quality goal, Objective 1 set a target phosphorus load reduction of 12 kg/yr to achieve a summer in-lake total phosphorus concentration of 7.2 ppb, which meets state water quality standards for oligotrophic waterbodies and is anticipated to substantially reduce the likelihood of cyanobacteria blooms in Swanzey Lake. The following opportunities for phosphorus load reductions to achieve Objective 1 were identified in the watershed based on field and desktop analyses:

- Remediating the 39 watershed survey sites could prevent up to **33.3 kg/yr** of phosphorus load from entering Swanzey Lake.
- Treating shoreline sites could reduce the phosphorus load to Swanzey Lake by **3 kg/yr** for the 21 medium impact sites (disturbance score between 7-9) identified from the shoreline survey.
- Upgrading the 36 shorefront septic systems older than 25 years is estimated to reduce the phosphorus load to Swanzey Lake by **3.6 kg/yr**.

Addressing these field-identified phosphorus load reduction opportunities coming from the external watershed load (i.e., watershed and shoreline sites and shorefront septic systems) could reduce the phosphorus load to Swanzey Lake by 39.9 kg/yr, meeting 333% of the needed reductions to achieve Objective 1 (Table 15). Given the large instances of erosion observed throughout the Swanzey Lake watershed, remediating identified watershed survey sites should be prioritized to achieve the water quality goal. However, non-structural best management practices (BMPs) such as educating homeowners about fertilizer use and residential stormwater management may also be an effective strategy to reduce phosphorus loading to Swanzey Lake and meet the water quality goal by reducing the amount of fertilizer used on residential lawns and encouraging stormwater management at the property-scale.

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. Although flooding is not the focus on the watershed management plan, implementing BMPs throughout the watershed that seek to divert stormwater into forested areas, infiltrate runoff, and disconnect impervious cover have the co-benefit of reducing the severity of localized flooding due to extreme storm events.

Table 15. Breakdown of phosphorus load sources and modeled water quality for current and target conditions that meet the water quality goal (Objective 1) 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	66.3	54.3	-12 (18%)	36.7	-29.6 (45%)
(A) Background P Load[1]	kg/yr	18.9	18.9	0 (0%)	18.9	0 (0%)
(B) Disturbed (Human) P Load[2]	kg/yr	47.4	35.4	-12 (25%)	17.8	-29.6 (62%)
(C) Developed Land Use P Load	kg/yr	26.0	17.6	-8.4 (32%)	0**	-36.3** (100%)
(D) Septic System P Load	kg/yr	10.4	6.8	-3.6 (35%)	6.8	-3.6 (35%)
(E) Internal P Load	kg/yr	11.0	11.0	0 (0%)	11.0	0 (0%)
Summer In-Lake TP*	ppb	8.4	6.9	-1.5 (18%)	4.6	-3.8 (45%)
In-Lake Chl-a*	ppb	3.4	2.6	-0.8 (24%)	1.5	-1.9 (56%)
In-Lake SDT*	meters	3.8	4.4	+0.6 (16%)	6.0	+2.2 (58%)
In-Lake Bloom Probability*	days	9	2	-7 (78%)	0	-9 (100%)

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

[2] Sum of developed land use 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. A 20% correction is applied to the in-lake TP concentration from the model to account for differences between summer epilimnion TP and annual average TP.*

*** Due to the severe erosion from the July 2023 storm that took place before the watershed survey, the phosphorus reduction opportunities are greater than the developed land use load calculated from the LLRM, which was based on 2022 in-lake data. The pollutant load reduction opportunities represent extraordinary circumstances which left much of the watershed highly vulnerable to erosion.*

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 SLPA and private landowners with assistance from a diverse stakeholder group, including representatives from the Town of Swanzey (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 other residents. SLPA 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 SLPA.

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

- **SLPA** will be responsible for plan oversight and implementation with support from other stakeholder groups. SLPA will conduct water quality monitoring, facilitate outreach activities and watershed stewardship, and raise funds for stewardship work.
- **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. Landowners will also seek opportunities to improve shoreline buffers, enhance stormwater management on their properties, and install BMPs on properties or private roadways.
- **The Town of Swanzey** will work to address NPS problems identified in the watershed, including conducting regular best practices maintenance on municipal roads, adopting ordinances for water quality protection, and addressing other recommended actions specified in the Action Plan. SLPA and other local groups can work with the town to provide support in reviewing and tailoring the recommendations to fit the specific needs of the community.
- **The Swanzey Conservation Commission** will work with municipal staff and boards to facilitate the implementation of the recommended actions specified in the Action Plan.
- **CCCD or SWRPC** can provide administrative capacity and can help acquire grant funding for BMP implementation projects and education/outreach to watershed residents and municipalities.
- **NHDES** can provide technical assistance, permit approval, and the opportunity for financial assistance through the 319 Watershed Assistance Grant Program and other funding programs.

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 Swanzey Lake 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, and performing proper road maintenance (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 Swanzey Lake in the next 10 years. **The cost of successfully implementing the plan is estimated to be at least $1.4-$2.1 million**

over the next 10 or more years (Table 16). 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 16. Estimated pollutant reduction (TP) in kg/year and estimated total and annual 10-year costs for implementation of the Action Plan to meet the water quality goal and objectives for Swanzey Lake. 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	**36.3**	$1,268,000 - $1,913,000	$126,800 - $191,300
Road Management	TBD	$32,000	$3,200
Municipal Operations	TBD	TBD	TBD
Municipal Land Use Planning & Zoning	**7.0***	$3,000	$300
Land Conservation		$25,000 - $30,000	$2,500 - $3,000
Septic System Management	**3.6**	$8,000 - $13,000	$800 - $1,300
Education & Outreach	TBD	$31,000 - $71,000	$3,100-$7,100
Monitoring (includes equipment)	*NA*	$30,000-$100,000	$3,000-$10,000
Total	**46.9**	**$1,397,000-$2,162,000**	**$139,700-$216,200**

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

6.3 FUNDING STRATEGY

It is important that SLPA 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 the town through tax collection (as approved by majority vote by town residents). Monitoring and assessment funding could come from a variety of sources, including state and federal grants, town funds, 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 SLPA with future water quality and watershed work on Swanzey Lake.

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. SLPA, in concert with NHDES VLAP, should continue the following annual monitoring protocol with a few adjustments and additions that provide essential information about the lake:

- SLPA VLAP currently monitors the Swanzey Lake deep spot station three times each summer (June-August) for total phosphorus (epilimnion, metalimnion, and hypolimnion), chlorophyll-a (composite), Secchi disk transparency, and dissolved oxygen-temperature profiles.
    - Ensure that dissolved oxygen-temperature profiles are being collected concurrently with sampling of lake deep spot stations; consider collecting profiles at a higher frequency (e.g., every two weeks from May-October). Ensure profiles are collected between the hours of 10am and 2pm.
    - Increase the number of sampling events to 3-5 times per year, including at least one sampling event in the late summer or early fall (September or October).
    - To better understand and characterize the contribution of phosphorus from internal loading, collect discrete grab samples for total phosphorus every 2 meters from the surface (1 meter) to the bottom (15 meters) at the deep spot of Swanzey Lake, for a total of 2-3 times in late July through September each year OR collect total phosphorus samples from the epilimnion, metalimnion, and hypolimnion immediately after fall turnover.
- SLPA VLAP currently collects one sample per year for speciation and phytoplankton via a water column net tow.
    - Increase sampling frequency to monthly sampling for speciation and enumeration of phytoplankton, concurrent with regular VLAP sampling, via a grab sampler or core and zooplankton by tows in the water column. These additional plankton samples will likely need to be analyzed by an different organization other than NHDES.
- SLPA VLAP monitors two tributary sites (Pine Inlets A and B) twice per year for total phosphorus, chloride, specific conductivity, and turbidity.
    - Increase sampling frequency to 3-5 months per year, concurrent with lake sampling.
    - Supplement stream sampling with flow monitoring or continuous data loggers collecting water level.
- Continue to monitor the lake for cyanobacteria blooms and alert NHDES immediately. Coordinate with NHDES to collect samples for analysis.
- Consider collecting sediment samples (top 4 inches) once from the deep spot of Swanzey Lake to analyze elemental ratios of phosphorus, aluminum, and iron and characterize biologically labile fractions of phosphorus.

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 Swanzey Lake watershed (Table 17). These benchmarks represent short-term (202), mid-term (2028), and long-term (2033) targets derived directly from actions identified in the Action Plan (Section 5). Setting milestones allows for periodic updates to the plan, maintains and sustains the action items, and makes the plan relevant to ongoing activities. SLPA 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 17. Environmental, programmatic, and social indicators for the Swanzey Lake Watershed-Based Management Plan.

Indicators	Milestones*		
	2025	2028	2033
ENVIRONMENTAL INDICATORS			
Achieve an average summer deep spot epilimnion total phosphorus concentration of 7.2 ppb at the deep spot station in Swanzey Lake	<8.4 ppb	<7.8ppb	<7.2 ppb
Achieve an average summer deep spot epilimnion chlorophyll-a concentration of less than 3.0 ppb at the deep spot station in Swanzey Lake	<3.4 ppb	<3.0 ppb	<3.0 ppb
Eliminate the occurrence of cyanobacteria or algal blooms in Swanzey Lake (milestones based on model results)	9 days/yr	2 days/yr	0 days/yr
Achieve an average summer water clarity of 6 m or deeper at the deep spot station in Swanzey Lake	4 m+	5 m+	6 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	$130,000	$650,000	$1,300,000
Number of NPS sites remediated (39 identified)	8	20	39
Linear feet of buffers improved in the shoreland zone	250	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	2	10	22
Number of workshops and trainings for stormwater improvements to residential properties (e.g., NHDES Soak Up the Rain NH program)	1	2	5
Number of updated or new ordinances that target water quality protection	1	2	3
Number of new municipal staff for inspections and enforcement of regulations	1	1	2
Number of voluntary or required septic system inspections (seasonal conversion and property transfer)	2	10	25
Number of septic system upgrades	1	5	10
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	1	5	10
Number of parcels with new conservation easements or number of parcels put into permanent conservation	1	2	3
Number of copies of watershed-based educational materials distributed or articles published	200	500	1,000
Number of new best practices for road management and winter maintenance implemented on public and private roads by the municipalities	2	5	10
Number of key aspects of the MS4 program implemented	1	2	5
Number of meetings and/or presentations to municipal staff and/or boards related to the WBMP	5	10	20
SOCIAL INDICATORS			
Number of new association members	5	10	15
Number of volunteers participating in educational campaigns	6	12	25
Number of people participating in informational meetings, workshops, trainings, BMP demonstrations, or group septic system pumping	25	50	75
Number of watershed residents installing conservation practices on their property and/or participating in LakeSmart	5	15	25
Number of municipal DPW staff receiving Green SnowPro training	1	3	5

Indicators	**Milestones***		
	2025	**2028**	**2033**
Number of groups or individuals contributing funds for plan implementation	25	50	100
Number of newly trained water quality and invasive species monitors	1	3	5
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 daily visitors to a proposed SLPA website	5	10	25

**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

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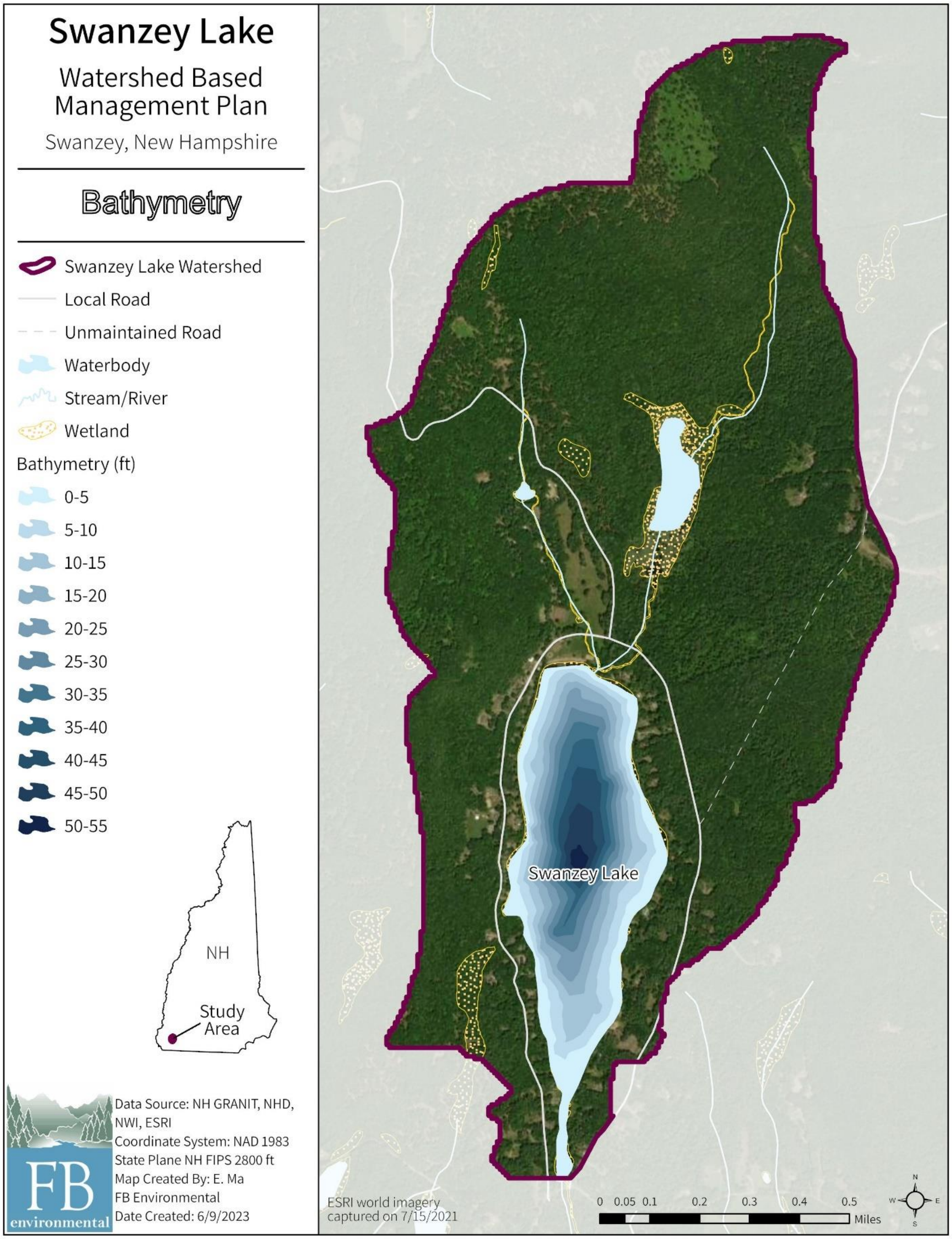
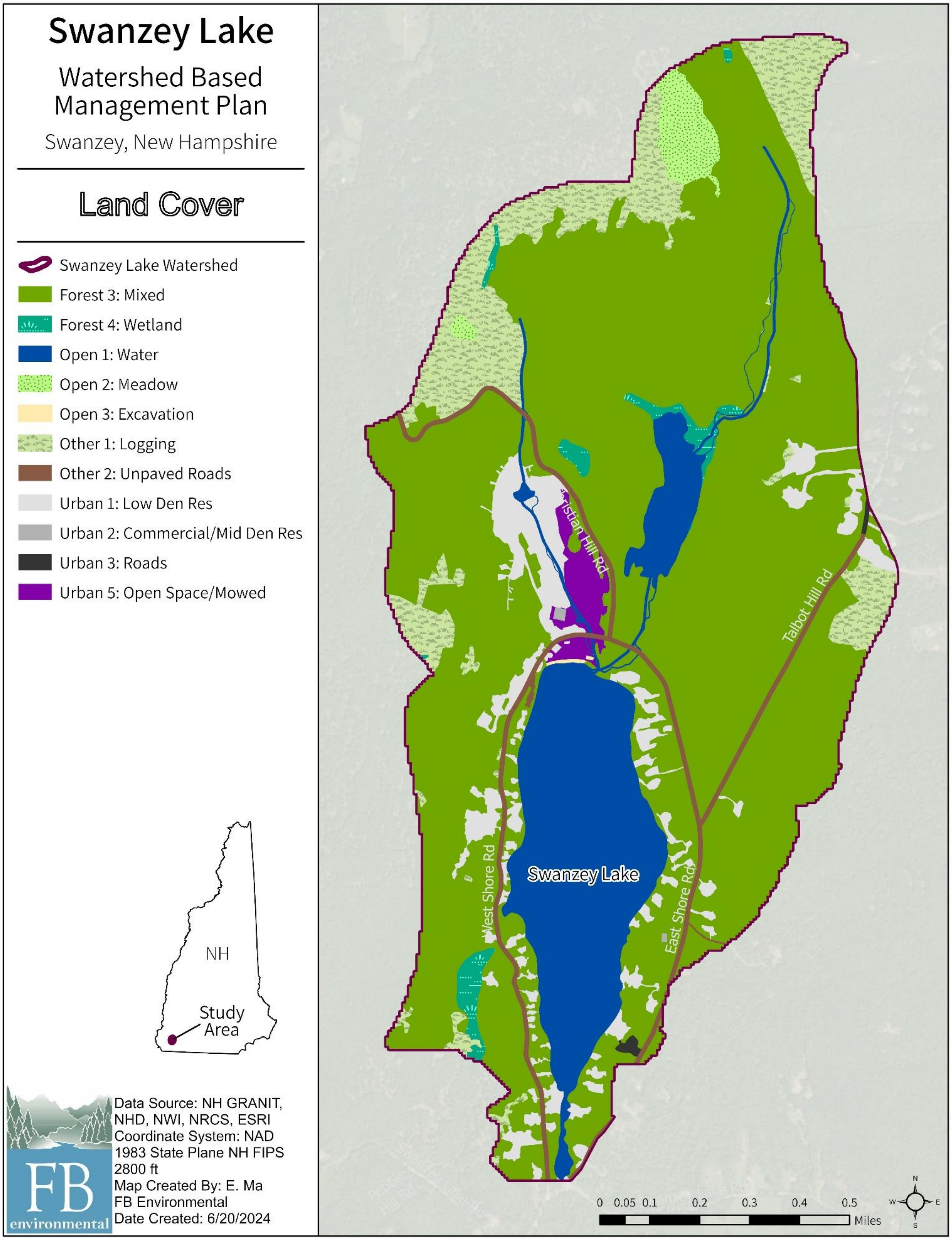
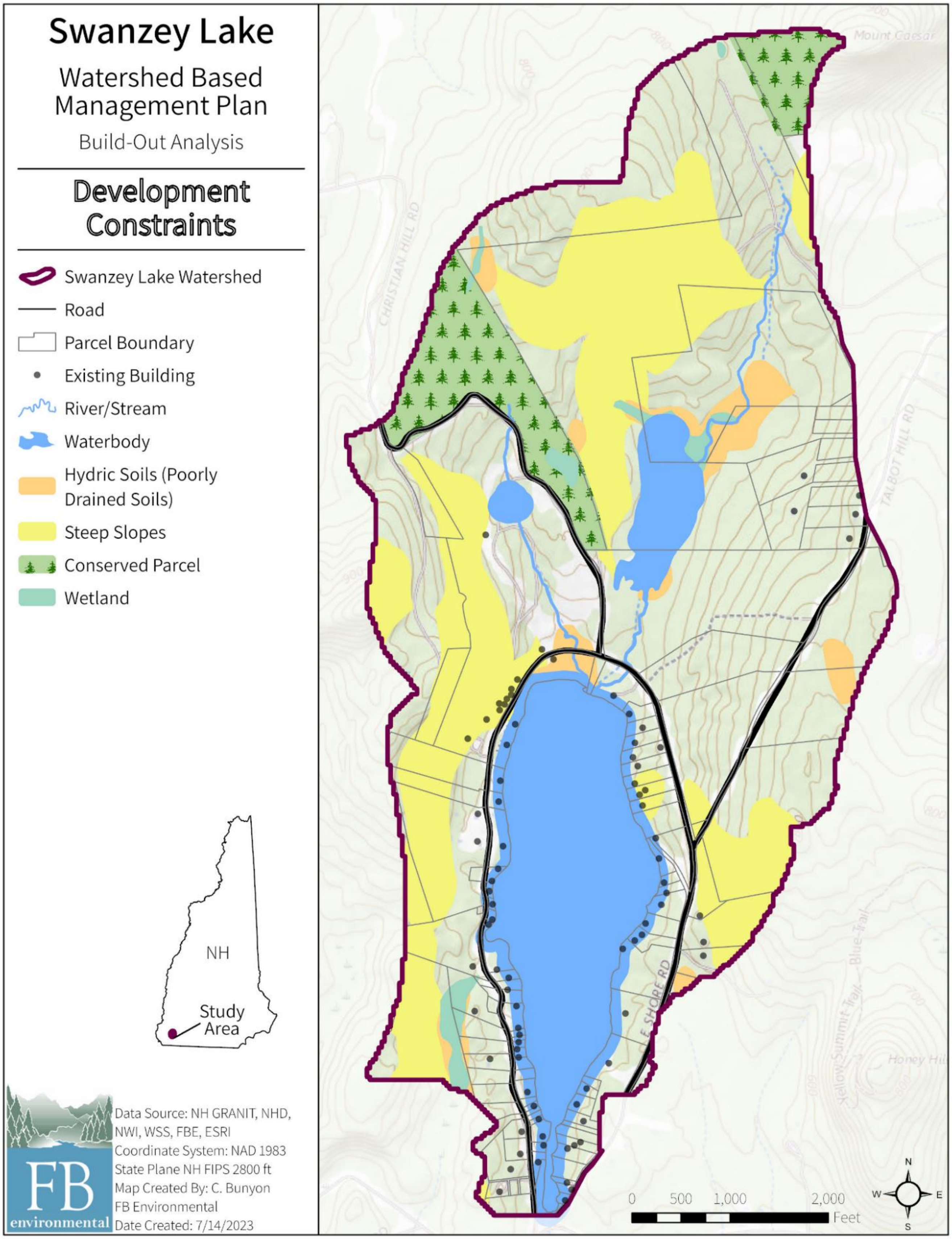
APPENDIX A: SUPPORTING MAPS



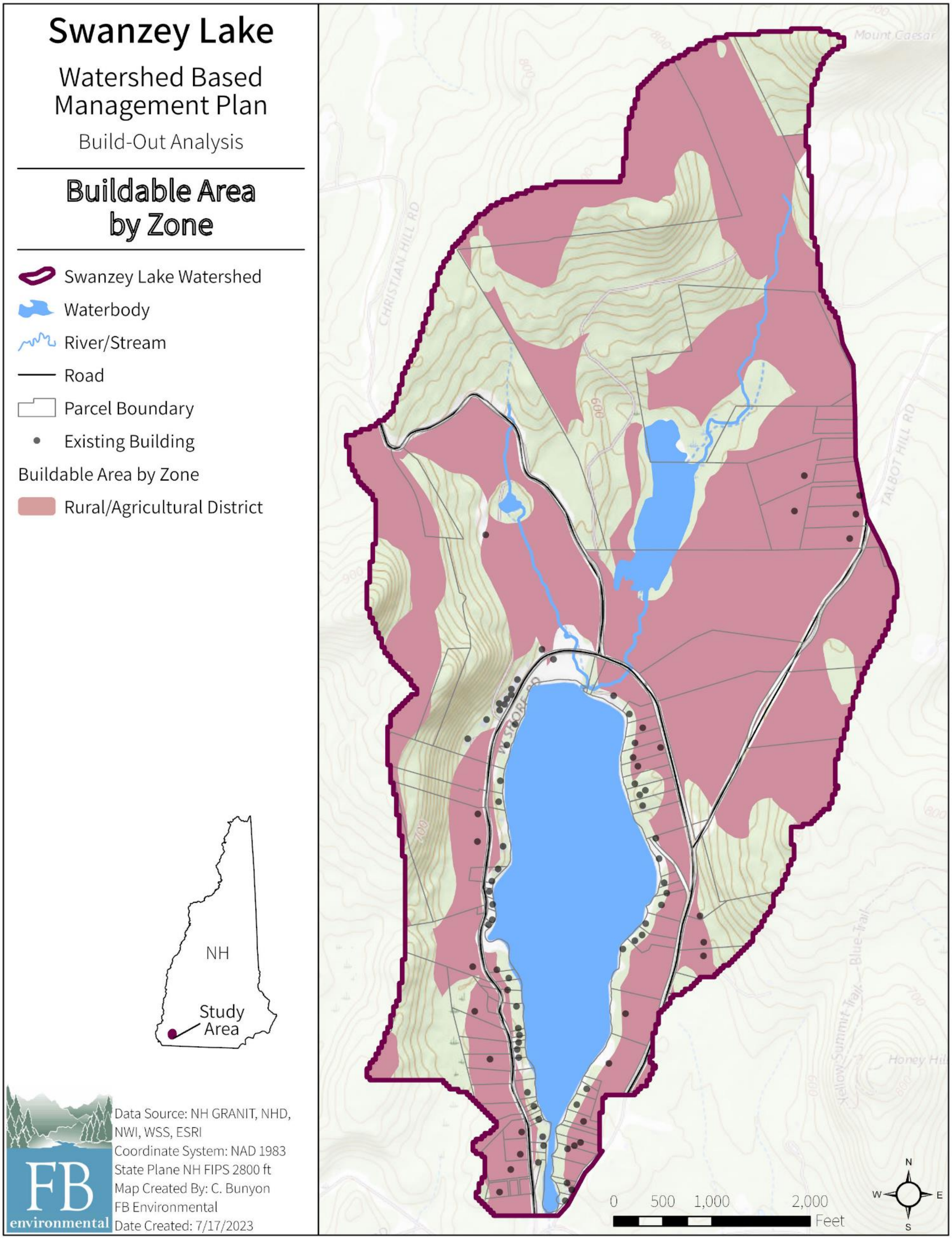
Map A-1. Bathymetry as 5-foot depth contours for Swanzey Lake. Surveyed by NHDES in 2005.



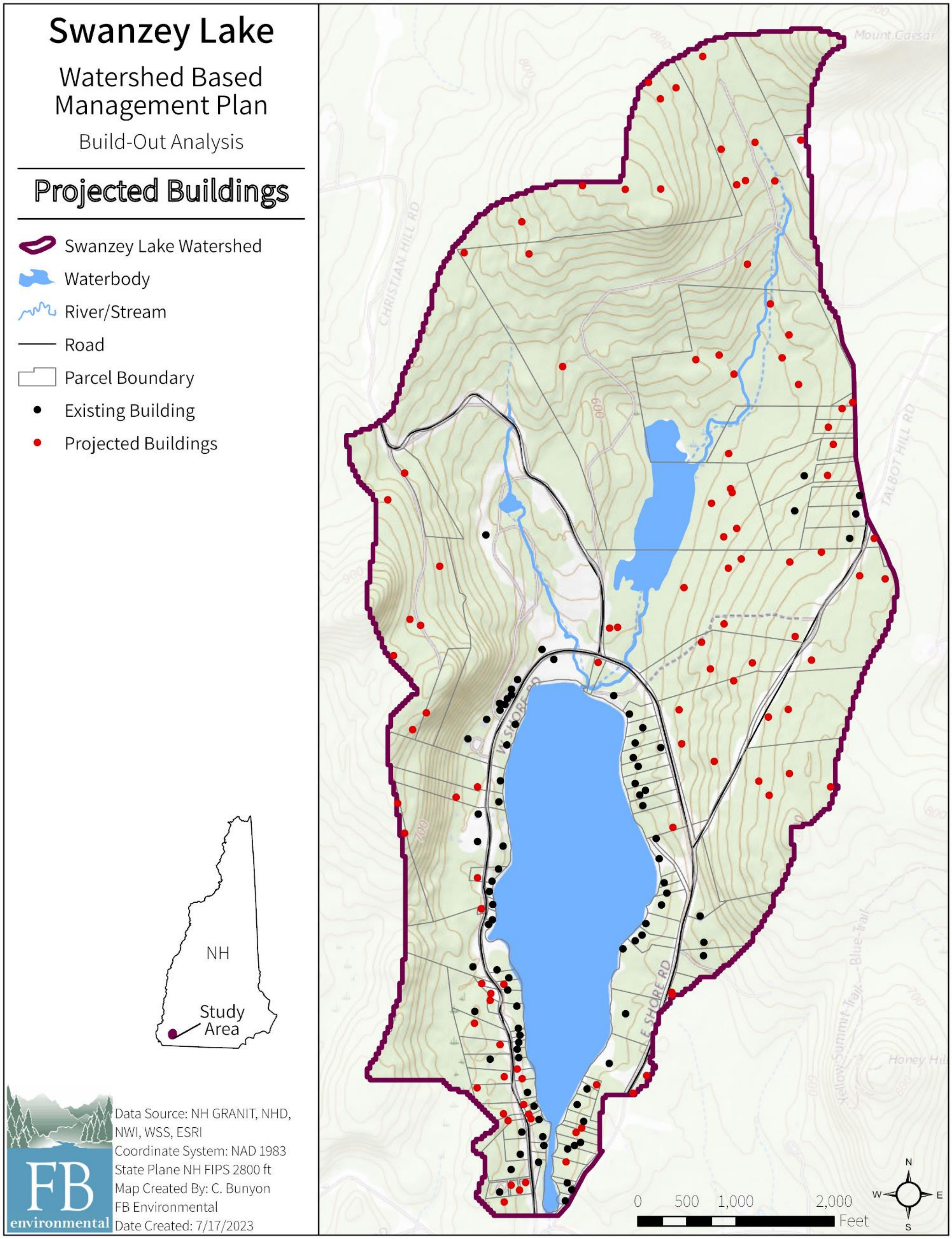
Map A-2. Land cover for the Swanzey Lake watershed.



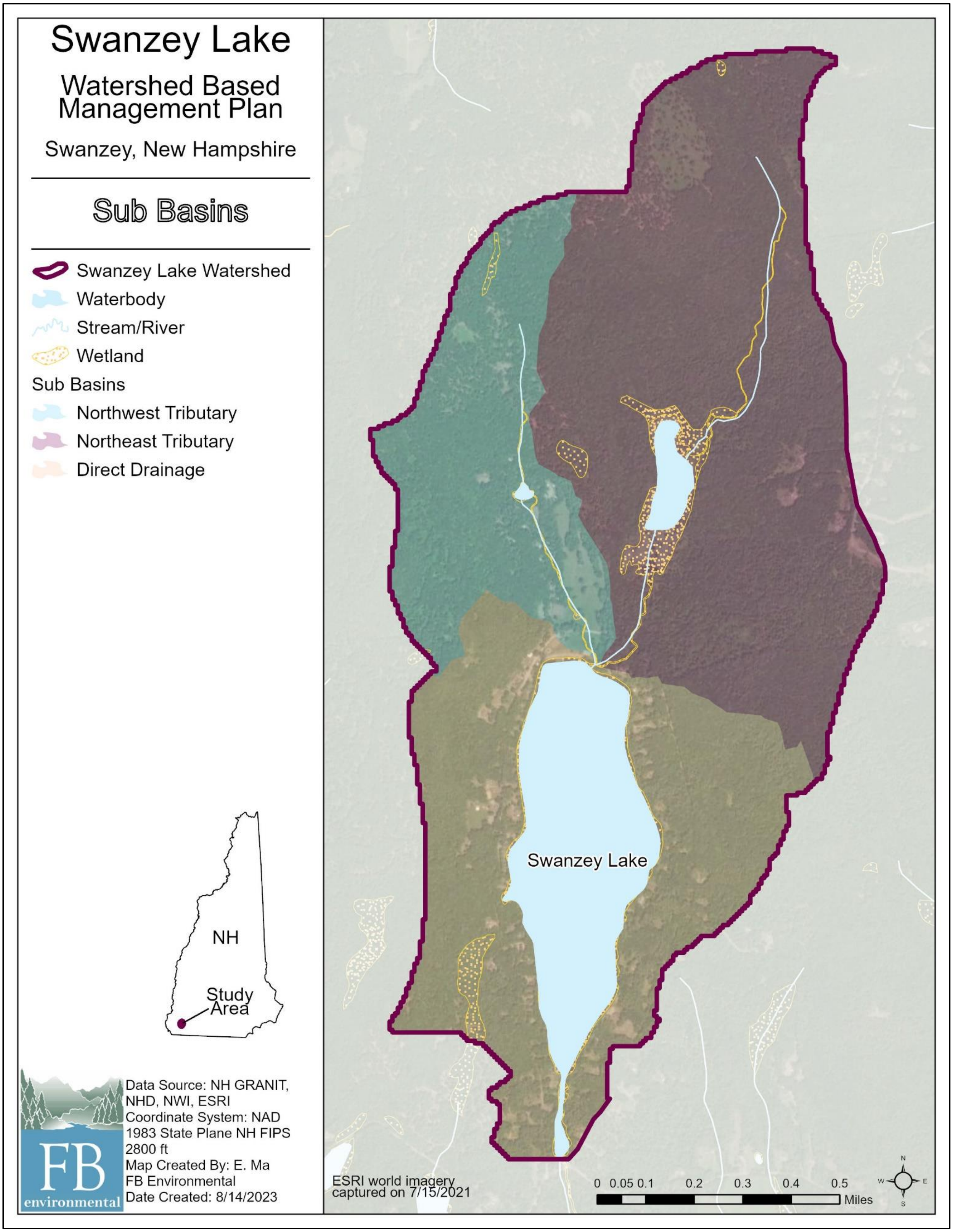
Map A-3. Development constraints (including existing buildings) in the Swanzey Lake watershed in Swanzey, NH.



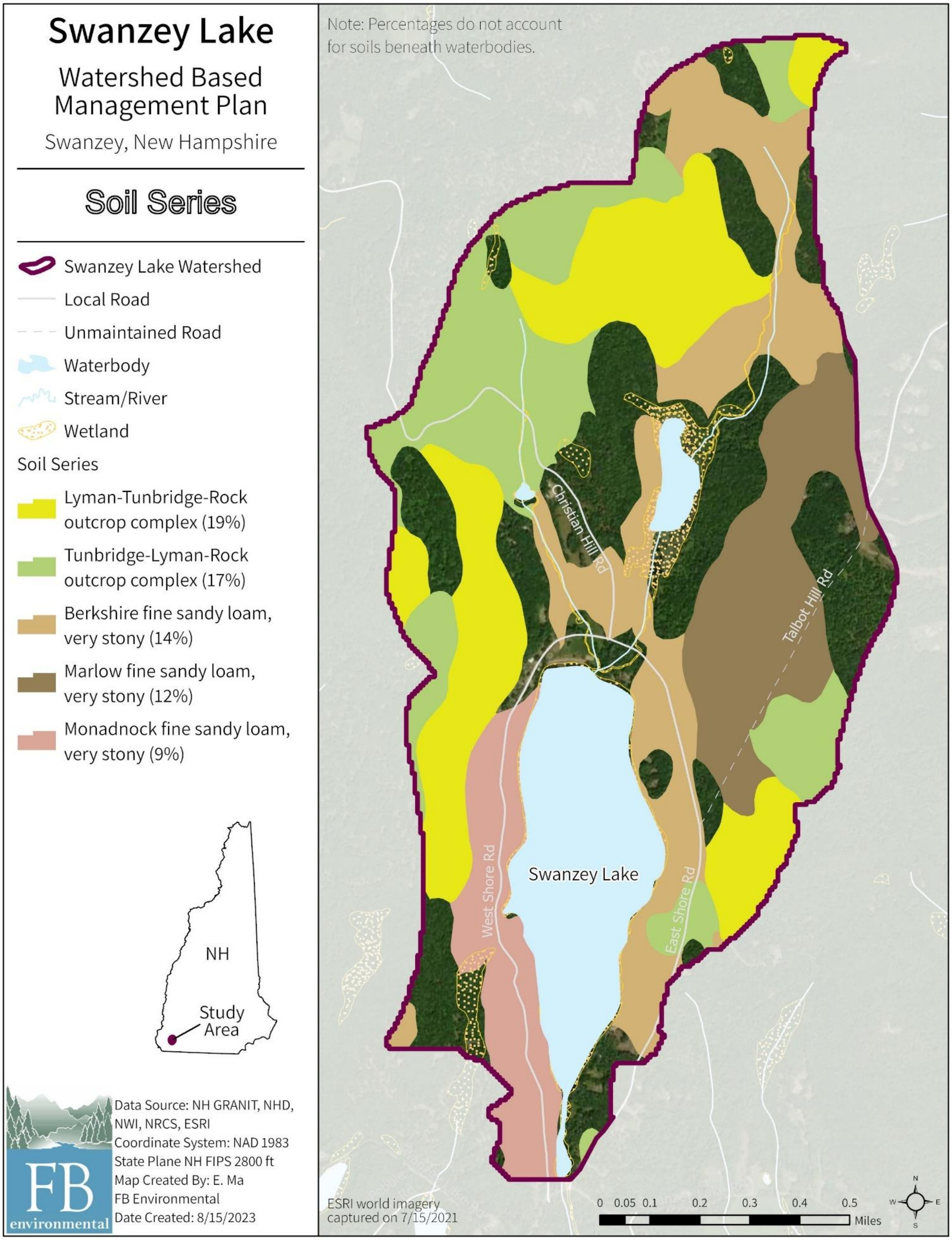
Map A-4. Buildable area by municipal zone in the Swanzey Lake watershed in Swanzey, NH.



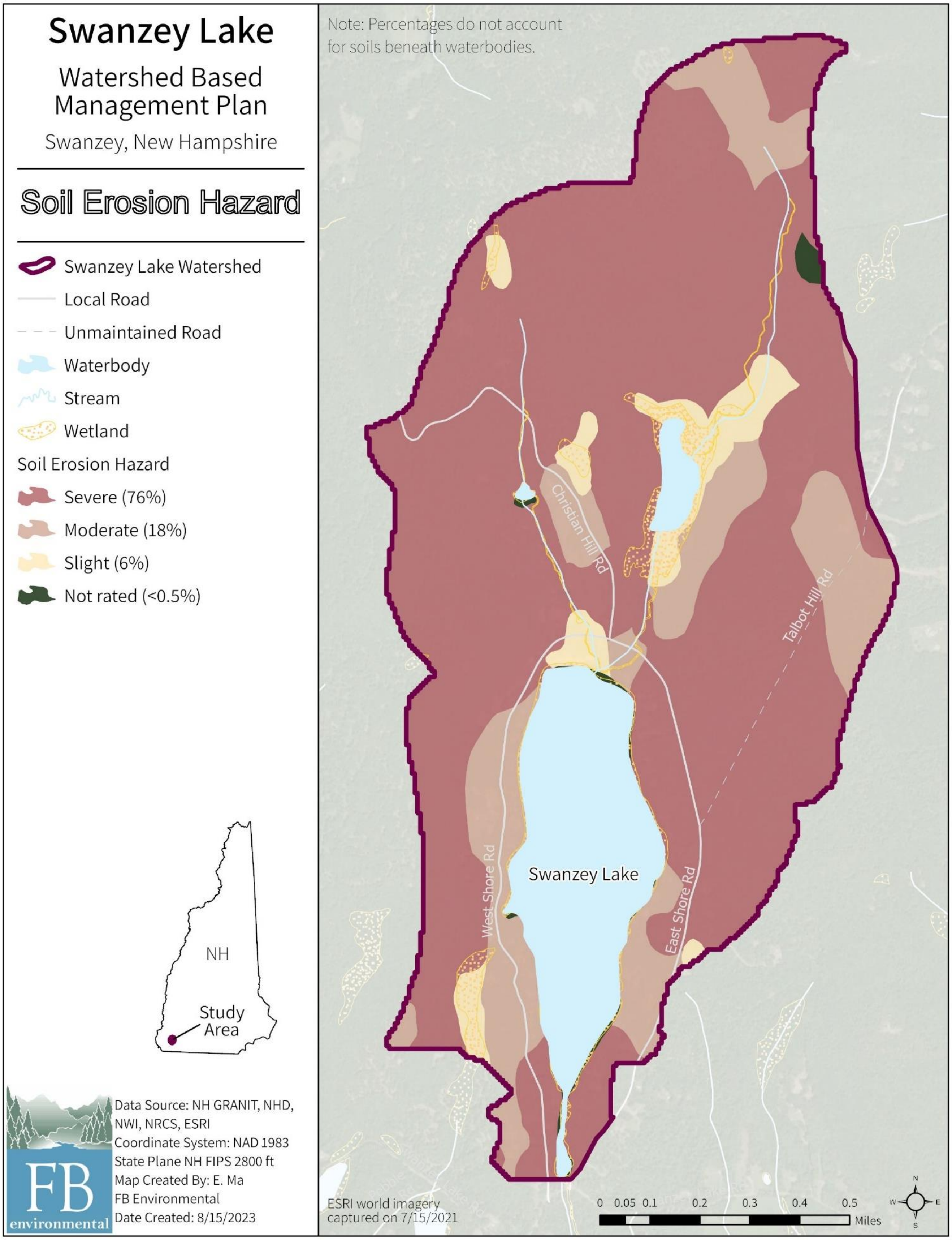
Map A-5. Projected buildings in the Swanzey Lake watershed in Swanzey, NH.



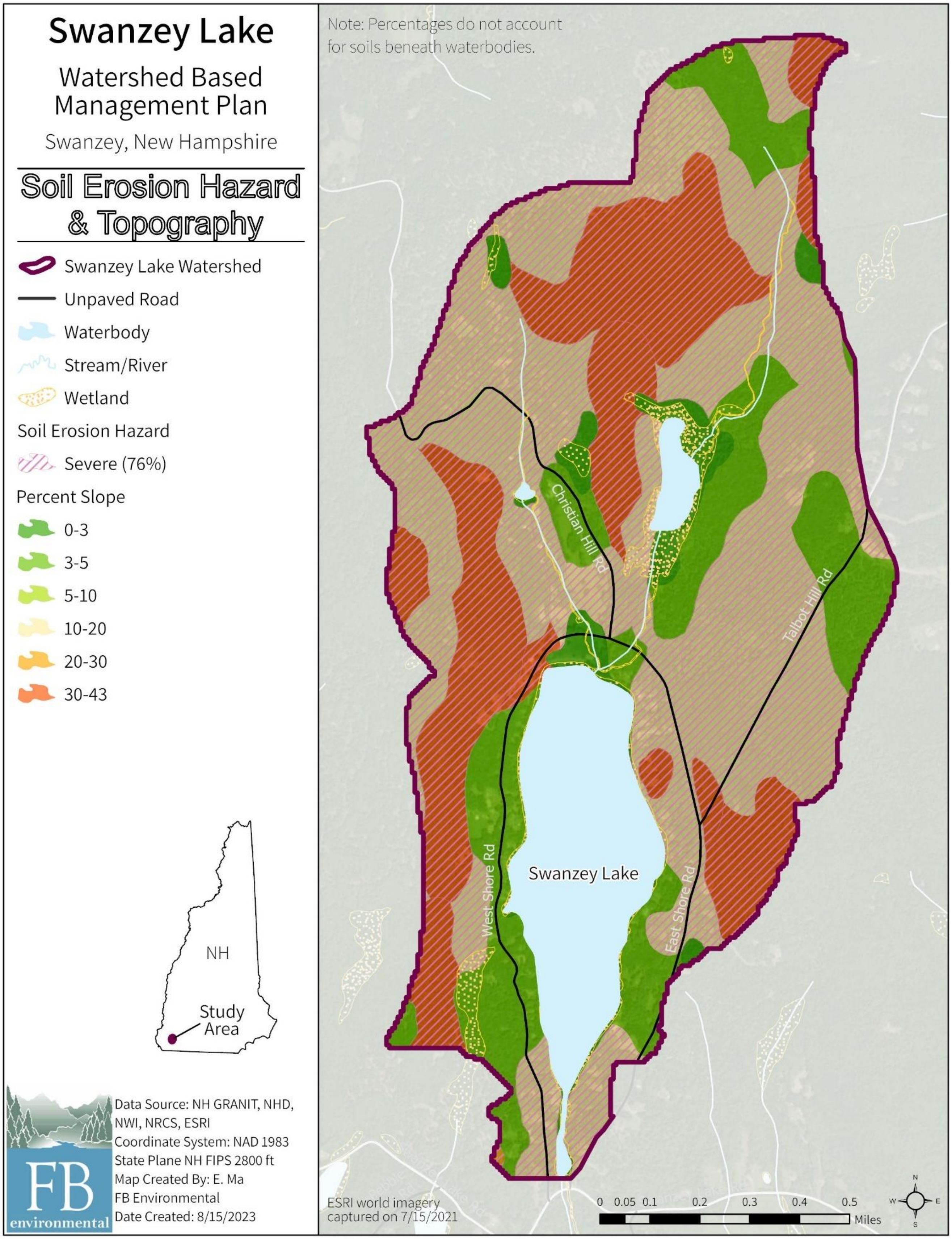
Map A-6. Sub-watersheds in the Swanzey Lake watershed.



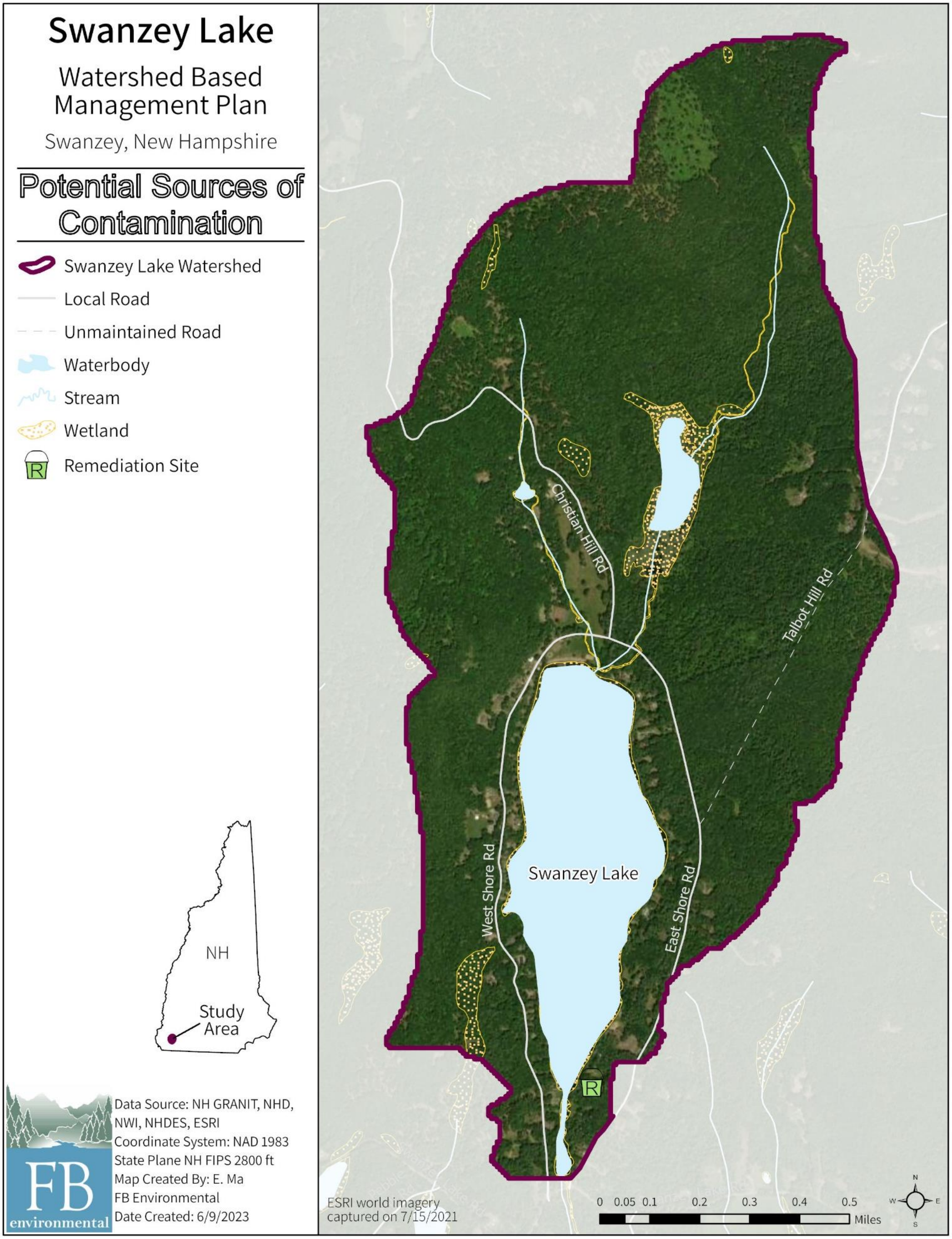
Map A-7. Soil series in the Swanzey Lake watershed.



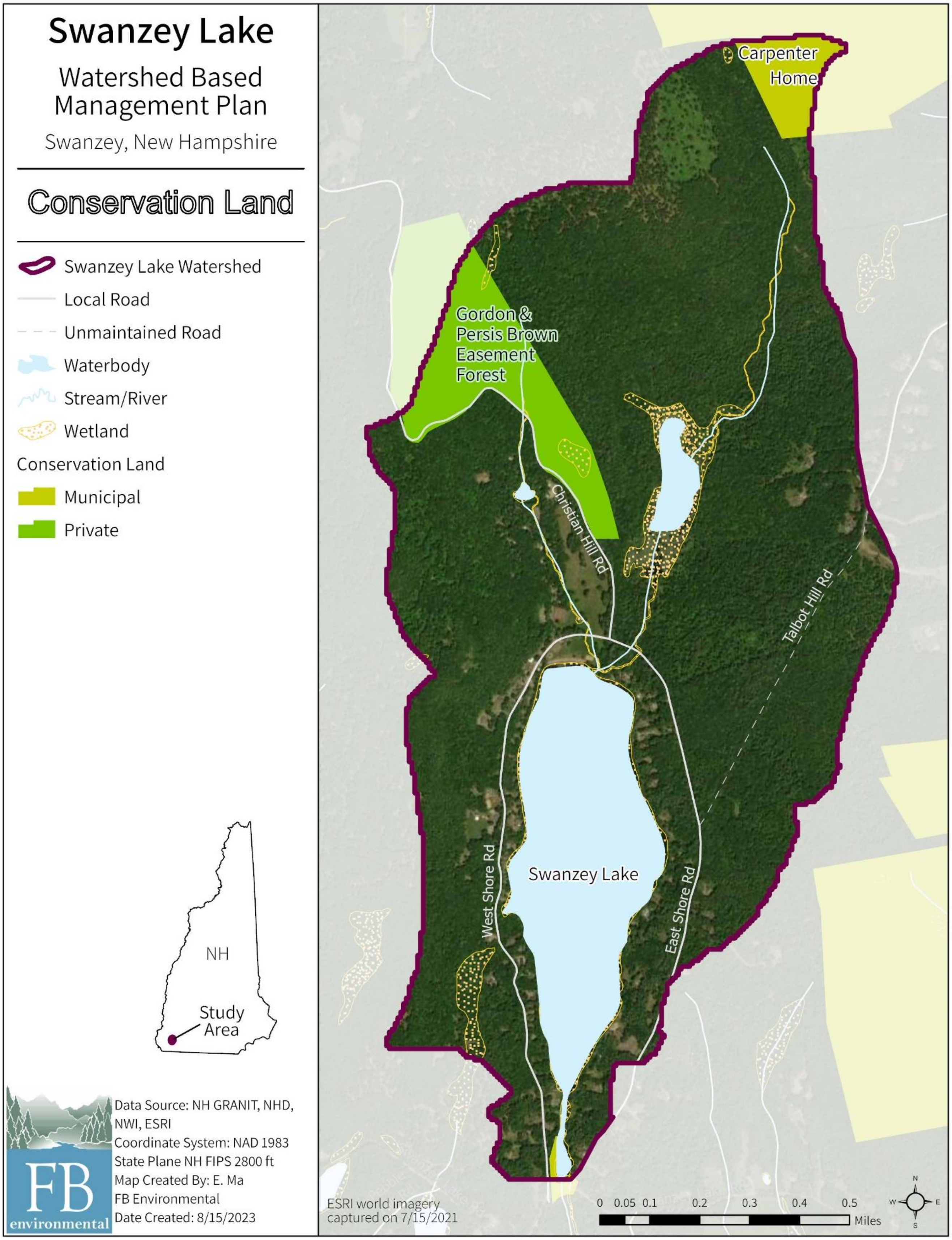
Map A-8. Soil Erosion Hazard in the Swanzey Lake watershed.



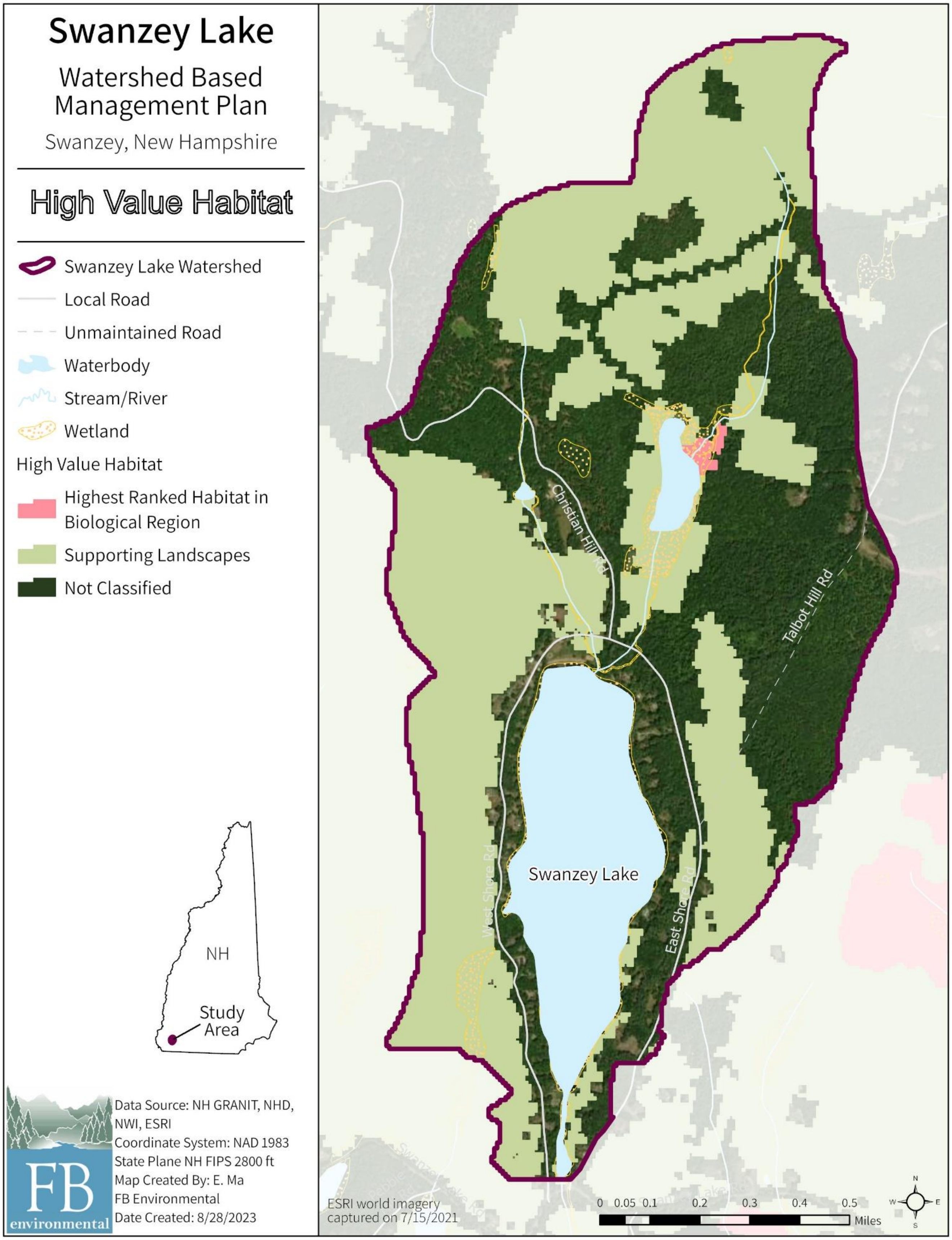
Map A-9. Soil Erosion Hazard and slope in the Swanzey Lake watershed.



Map A-10. Potential sources of contamination in the Swanzey Lake watershed.



Map A-11. Conservation land within the Swanzey Lake watershed.



Map A-12. High value habitat in the Swanzey Lake watershed according to the 2020 New Hampshire Wildlife Action Plan.

APPENDIX B: BMP MATRIX

Table B-1. Site ID, location description, water quality impact, estimated load reduction, and implementation costs for the 39 privately-owned and town-owned nonpoint source (NPS) sites identified in the Swanzey Lake watershed. Sites 3-07, 3-08, and 3-09 are listed together. Pollutant load reduction and cost estimates are preliminary and are for planning purposes only. Cost estimates are based on pre-COVID19 ranges (adjusted for 2023 inflation), and thus actual construction costs could be highly variable at this time. Sites are priority ranked from lowest to highest cost per pound of phosphorus load (using average cost reduced with remediation). **Note that these load reductions are based on extraordinary circumstances following the severe July 2023 storm and do not reflect long-term average load reduction potential from these areas as they were functioning prior to the storm. We assessed the sites in their current state as of the September 2023 survey and estimated load reductions assuming normal precipitation conditions impacting these sites (many of which still have exposed bare soil and are highly vulnerable to further erosion). Thus, the load reductions are not meant to reflect the load reduction potential from the total load that was transported from these sites to the lake during that one severe storm event.**

SITE	LOCATION	IMPACT	LOAD REDUCTION			ESTIMATED COST			RANK
			TSS (metric tons/yr)	TP (kg/yr)	TN (kg/yr)	Est. Low Cost	Est. High Cost	Est. Avg. Cost	
PRIVATELY-OWNED									
1-03a	Pilgrim Pines - Upper Campground/Beach	High	1.9	3.4	26.0	$200,000	$200,000	$200,000	2
3-02	East Shore Rd Near Houses 111 & 113	High	3.3	1.4	2.8	$15,000	$15,000	$15,000	5
3-13	Unnamed ATV Trail	High	3.1	1.3	2.6	$30,000	$60,000	$45,000	8
1-04a	Squanto Youth Camp - Shoreline	High	0.4	1.0	4.5	$30,000	$30,000	$30,000	11
1-04b	Squanto Youth Camp - Girls Cabins	Low	0.1	0.3	0.3	$5,000	$5,000	$5,000	22
2-08	West Shore Rd - Driveway Near House 28	Low	0.3	0.7	3.9	$10,000	$15,000	$12,500	23
1-03b	Pilgrim Pines - Shoreline Buffer	Medium	0.7	0.3	0.6	$10,000	$10,000	$10,000	26
2-07	Stream Crossing Within Camping Area	Low	0.5	0.2	0.4	$5,000	$5,000	$5,000	27
3-25	Pilgrim Pines Footpath	Low	0.1	0.2	1.0	$5,000	$10,000	$7,500	32
1-03c	Pilgrim Pines - Chapel	Low	0.0	0.1	0.6	$5,000	$5,000	$5,000	35
TOWN-OWNED									
3-07, 3-08, & 3-09	Talbot Hill Rd	High	12.8	5.4	10.8	$500,000	$1,000,000	$750,000	1
1-01	Richardson Town Beach	High	10.3	4.4	8.7	$150,000	$150,000	$150,000	3
2-05	West Shore Rd - North of House 103	High	2.7	1.2	2.3	$10,000	$10,000	$10,000	4
3-14	East Shore Rd Northern Stream	High	2.3	1.0	1.9	$10,000	$15,000	$12,500	6
3-12	East Shore Rd Near House 212	Medium	3.5	1.5	3.0	$10,000	$15,000	$12,500	7
3-10	Talbot Hill Rd - Trail	Medium	1.8	0.8	1.5	$10,000	$10,000	$10,000	9
3-04	East Shore Rd - North of Talbot Hill Rd	High	3.6	1.5	3.1	$30,000	$60,000	$45,000	10

SITE	**LOCATION**	**IMPACT**	**LOAD REDUCTION**			**ESTIMATED COST**			**RANK**
			TSS (metric tons/yr)	TP (kg/yr)	TN (kg/yr)	Est. Low Cost	Est. High Cost	Est. Avg. Cost	
3-05	East Shore Rd Near House 182	Medium	1.0	0.5	0.9	$5,000	$10,000	$7,500	12
3-11	East Shore Rd Near House 208	Low	1.1	0.4	0.9	$5,000	$5,000	$5,000	13
3-01	East Shore Rd Near Town Beach	Medium	1.4	0.6	1.1	$10,000	$10,000	$10,000	14
3-03	East Shore Rd Near Brown Ln	Medium	3.2	1.3	2.6	$20,000	$25,000	$22,500	15
2-06	West Shore Rd - Across from House 143	Medium	2.3	1.0	1.9	$10,000	$15,000	$12,500	16
3-19	Christian Hill Rd #1	Low	1.4	0.6	1.2	$5,000	$10,000	$7,500	17
2-02	West Shore Rd - South of House 95	Low	1.4	0.6	1.2	$5,000	$10,000	$7,500	18
3-21	Christian Hill Rd #3	Low	1.2	0.5	1.0	$5,000	$10,000	$7,500	19
2-03*	West Shore Rd - South of House 86	Low	1.1	0.5	1.0	$5,000	$10,000	$7,500	20
3-16	Christian Hill & East Shore Intersection	Low	0.7	0.3	0.6	$5,000	$5,000	$5,000	21
3-26	Culvert Near Pilgrim Pines	Low	0.2	0.6	3.3	$5,000	$20,000	$12,500	24
3-24	Christian Hill Rd Near Disc Golf	Low	0.5	0.2	0.4	$5,000	$5,000	$5,000	25
3-22	Christian Hill Rd Near Top of Pilgrim Pines	Low	0.5	0.2	0.4	$5,000	$5,000	$5,000	28
3-23	Christian Hill Rd #4	Low	0.5	0.2	0.4	$5,000	$5,000	$5,000	29
3-06	Near 196 East Shore Rd	Low	0.7	0.3	0.6	$5,000	$10,000	$7,500	30
3-20	Christian Hill Rd #2	Low	0.7	0.3	0.6	$5,000	$10,000	$7,500	31
3-18	Christian Hill Rd - Across from Sand Piles	Low	0.1	0.1	0.8	$5,000	$5,000	$5,000	33
2-04	Town Boat Launch	Low	0.5	0.2	0.5	$10,000	$10,000	$10,000	34
3-17	Top of Christian Hill Rd	Low	0.8	0.4	0.7	$15,000	$20,000	$17,500	36
1-02	Dam Outlet Area	High	0.0	0.0	0.0	$20,000	$20,000	$20,000	37
		TOTAL	**66.6**	**33.3**	**94.4**	**$1,190,000**	**$1,835,000**	**$1,512,500**	

**Note: Site 2-03 culvert on West Shore Rd was unearthed and replaced by the Town of Swanzey in 2024. The site should continue to be monitored for any remaining or new runoff issues.*

Also note that sites along Christian Hill Rd and East Shore Rd have been at least partially addressed by the Town of Swanzey following the extreme July 2023 storm event. The Town is also addressing the dam outlet damage per NHDES recommendations.