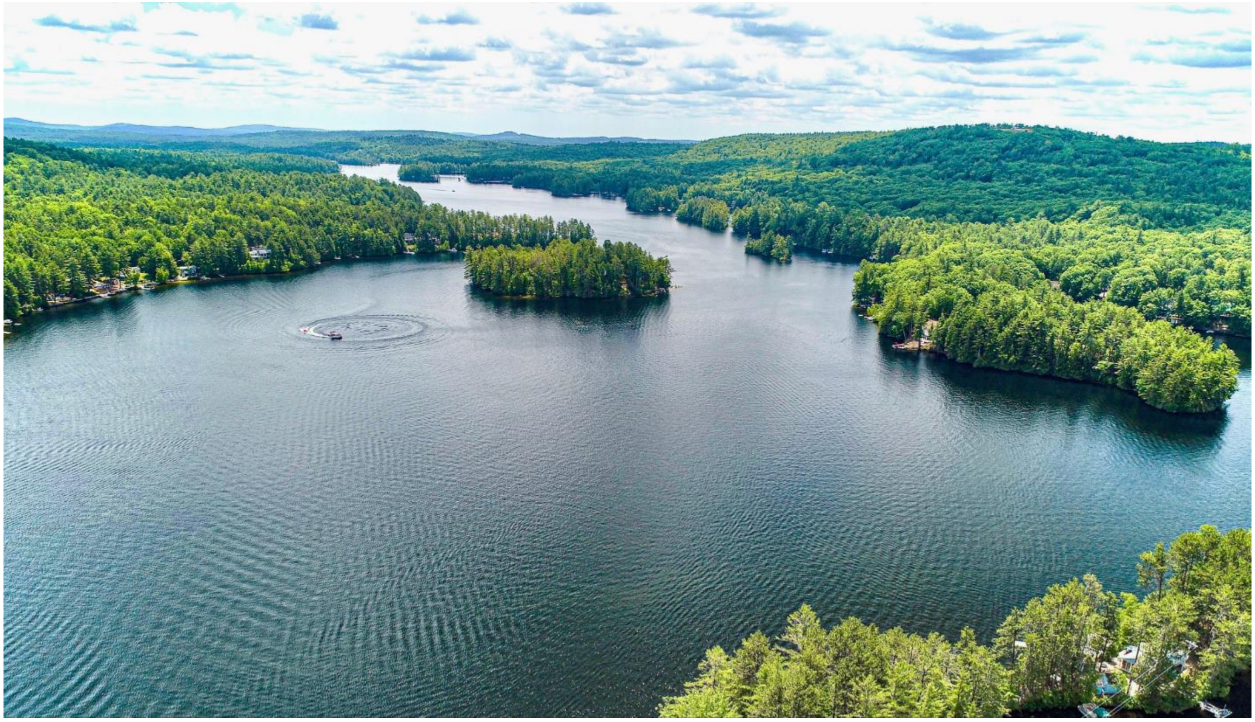

Pine River Pond Watershed Management Plan

PRP Association

Wakefield, NH

in coordination with

Acton Wakefield Watersheds Alliance

and the

New Hampshire Department of Environmental Services

This project was self-funded by the Pine River Pond Association.

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Credit Statement

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Acronyms

Acronym	Definition
AIS	Aquatic Invasive Species
ALI	Aquatic Life Integrity
AWWA	Acton Wakefield Watersheds Alliance
AUID	Assessment Unit Identification
BMPs	Best Management Practices
Chl-*a*	Chlorophyll-*a*
CWA	Clean Water Act
DKWRC	DK Water Resource Consulting
EPA	Environmental Protection Agency
FC	Fish consumption
ha	Hectare
kg	Kilogram
LLRM	Lake Loading Response Model
LLMP	UNH Lakes Lay Monitoring Program
m	Meter
Maine DEP	Maine Department of Environmental Protection
NHDES	New Hampshire Department of Environmental Services
NHFG	New Hampshire Fish and Game Department
NLCD	National Land Cover Database
NPS	Nonpoint Source
NWI	National Wetland Inventory
P	Phosphorus
PCR	Primary Contact Recreation
PRP	Pine River Pond
PRPA	Pine River Pond Association, Inc.
ppb	Parts per billion
QAPP	Quality Assurance Project Plan
SRPC	Strafford Regional Planning Commission
SDT	Secchi Disk transparency
SOAK	Soak Up the Rain
TMDL	Total Maximum Daily Load
TP	Total Phosphorus
USEPA	United States Environmental Protection Agency
UNH	University of New Hampshire
USGS	United States Geological Survey
VLAP	Volunteer Lake Assessment Program
WMP	Watershed Management Plan

Incorporating the EPAs Nine Watershed Planning Elements

The Pine River Pond Watershed Management Plan includes the US Environmental Protection Agency's nine-element criteria[1] that address developing and implementing watershed plans. These guidelines outline important strategies and steps to protect water quality for lakes impacted by human activities and reduce the cumulative impacts of nonpoint source pollution (NPS).

A. Identify causes and sources of pollution: An identification of the causes and sources or groups of similar sources that will need to be controlled to achieve the load reductions estimated in this watershed-based plan (and to achieve any other watershed goals identified in the watershed-based plan), as discussed in item (b) immediately below. Sources that need to be controlled should be identified at the significant subcategory level with estimates of the extent to which they are present in the watershed (e.g., X linear miles of eroded stream bank needing remediation).

B. Estimate pollutant loading into the watershed and the expected load reductions: An estimate of the load reductions expected for the management measures described under paragraph (c) below (recognizing the natural variability and the difficulty in precisely predicting the performance of management measures over time). Estimates should be provided at the same level as in item (a) above (e.g., eroded stream banks).

C. Describe management measures that will achieve load reductions and targeted critical areas: A description of the NPS management measures that will need to be implemented to achieve the load reductions estimated under paragraph (b) above (as well as to achieve other watershed goals identified in this watershed-based plan), and an identification (using a map or a description) of the critical areas in which those measures will be needed to implement this plan.

D. Estimate amounts of technical and financial assistance and the relevant authorities needed to implement the plan: An estimate of the amounts of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon, to implement this plan. As sources of funding, communities should consider the use of their Section 319 programs, State Revolving Funds, and other relevant federal, state, local and private funds that may be available to assist in implementing this plan.

E. Develop an information/education component: An information/education component that will be used to enhance public understanding of the project and encourage their early and continued participation in selecting, designing, and implementing the NPS management measures that will be implemented.

F. Develop a project schedule: A schedule for implementing the NPS management measures identified in this plan that is reasonably expeditious.

G. Describe the interim, measurable milestones: A description of interim, measurable milestones for determining whether NPS management measures or other control actions are being implemented.

H. Identify indicators to measure progress: A set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made towards attaining water quality standards and, if not, the criteria for determining whether this watershed-based plan needs to be

[1] https://www.epa.gov/nps/handbook-developing-watershed-plans-restore-and-protect-our-waters

revised or, if a NPS Total Maximum Daily Load (TMDL) has been established, whether the NPS TMDL needs to be revised.

I. Develop a monitoring component: A monitoring component to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under item (h) immediately above.

Element	Plan Section	Element Description
A	4	Identify causes and sources of pollution
B	5	Estimate pollution load reductions needed for restoration
C	6	Identify actions needed to reduce pollution
D	6	Estimate costs and authority to implement restoration actions
E	6	Implement outreach and education to support restoration
F	7	Restoration schedule
G	7	Milestones - interim measures to show implementation progress
H	8	Success indicators and evaluation - criteria to show restoration success
I	9	Monitoring plan

Table 1: Summary of EPA's Nine Watershed Planning Elements

1 Introduction

The Pine River Pond Watershed Management Plan describes watershed characteristics, water quality conditions, sources of phosphorus loading to the pond, and management actions that can be implemented to improve and protect the pond's water quality. The WMP establishes water quality goals and objectives, outlines nutrient management approaches, and outlines actions for meeting water quality goals.

Pine River Pond faces a number of concerns including nutrient loading from the watershed, the presence of benthic cyanobacteria mats in the littoral zone throughout the lake, low dissolved oxygen readings, and invasive species which all threaten water quality. Recent testing has identified readings in one part of the lake that differ significantly from the other testing sites suggesting further evaluation is needed. Deforestation in part of the watershed may also be compounding the issues in addition to the watershed and climate changes ongoing.

The WMP summarizes the factors affecting watershed health, with data from the watershed survey, water quality testing, septic system survey information, and phosphorus loading modeling output. This information is incorporated into actions and recommendations for reducing pollutant loading to the pond, and creates goals to maintain and improve watershed standards.

The management approach in this WMP enables property owners, road associations, and project partners to implement restoration activities in a responsive manner while recognizing that improvements to water quality cannot be achieved in any single activity or within an immediate time frame. It ensures that as management activities are conducted, water quality response is monitored, and success is documented.

1.1 Background

Located in the White Mountain region of north-central NH, Pine River Pond is in the Town of Wakefield within the villages of North Wakefield, East Wakefield, and Sanbornville. The major outlet at the northwestern end of the pond is controlled by the Arthur H. Fox Memorial Dam. The outflow becomes the Pine River which flows northwest to Ossipee Lake and is part of the Saco River watershed that flows through the White Mountains of NH and Maine, ultimately draining into the Atlantic Ocean at the Gulf of Maine.

Pine River Pond is about 3.6 miles long and 0.6 miles at its widest, within a watershed of about 7,808 acres. The 12.2 miles of shoreline are highly developed, and all precipitation that falls in the watershed drains into the pond through a network of streams, ditches, and overland flow. There are several association-owned community beaches and private boat launching sites. The State of New Hampshire owns two parcels on the pond but neither site is developed, access is difficult, and both are without parking or restroom facilities.

Pine River Pond's water quality sampling since 1987 shows the following:

- A trend of decreasing water clarity.
- Stable but oscillating Chlorophyll-a results over the years.
- A decreasing trend for total phosphorus.

Cumulatively this does not lend itself to an explanation as to why the benthic cyanobacteria mats are present.

Figure 1: Watershed Area Map

1.2 Goal Statement

This plan provides short- and long-term goals for improving the water quality of Pine River Pond over the next ten years (2022-2032). The long-term goal is to protect and maintain the lake's water quality to prevent occurrence of toxic cyanobacteria blooms. To achieve this goal would mean reducing the amount of phosphorus entering the pond by 10 percent. The water quality goal can be achieved by implementing various types of management approaches to reduce phosphorus input to the pond including:

- Structural
- Non-structural
- Septic system improvements
- Regulatory

These management approaches are discussed in greater detail in the Action Plan, Section 6.

1.3 Plan Development Process

This WMP is the culmination of a major effort led by the PRPA and AWWA in cooperation with local and state partner organizations and agencies; NH LAKES, NHDES, Maine DEP, Maine Conservation Corps, UNH, and UNH Cooperative Extension. Activities to develop the Plan included numerous project management team meetings and conference calls between the PRPA, AWWA, DK Water Resource Consulting LLC (DKWRC), and NHDES. Additional input was provided by watershed residents, road association members, town officials, students from UNH under Professor Allison Watts, Ph.D., and UNH Cooperative Extension's Bob Craycraft and Amanda Murby McQuaid, Ph.D. Funding for plan development was provided by the PRP Association. It should be noted that the Plan is a living document – modifications and updates are anticipated over time as implementation activities begin and as more is understood about the pond's ecology and its response to management efforts.

1.3.1 Public Engagement

The PRPA has engaged the public through discussions at its Annual Meeting and through their eNews emails. Given the COVID-19 pandemic, most of the public engagement has been electronic through the eNews to the lake association members which is about 82% of property owners with deeded rights to PRP.

1.3.2 Septic System Survey

An online septic system survey was developed by AWWA and made available to the lake association membership through the PRPA eNews from February through June 2021. A total of 131 property owners within 250 feet of the lake responded.

Approximately 25% or 1/4 of Pine River Pond residents responded to this survey and the vast majority perceive their lake as having average or above average water quality. Though not reflective of the entire lake community, these data imply that the majority of septic system owners on the lake follow responsible management practices, specifically pertaining to the nearly 80% of people who pump their system every 2-5 years. The fact that most systems were also reported to be less than 20 years old is promising, as anything older than this would face an increased likelihood of being outdated and in need of repair or replacement. As part of this survey, we also included questions pertaining to lawns and fertilizer use which can be another source of phosphorus for the lake. Fortunately, only 16 respondents (12%) had a lawn area within 100 feet of the lake, and only one of those people reported using fertilizer containing phosphorus.

Results of the survey indicate that:

- 92% of respondents perceive the water quality of PRP as average or above average
- Most septic systems were reported to be 1-20 years old
- 79% of respondents pump their system at least every 5 years
- 31% of respondents are 100 feet from the lake
- 12% of respondents have a grass lawn within 100 feet of the lake
- Of that number 56% of respondents fertilize and use phosphate-free fertilizer

Septic systems adjacent to the lake are another potential threat to water quality, as the wastewater they produce carries nutrients such as phosphorus that contribute to algae and bacterial growth in the lake. Though septic systems drain into groundwater, their proximity to the lake allows them to enter the water table and eventually into nearby surface waters. Well-functioning systems that are properly sized and maintained are highly effective at treating wastewater, while poorly functioning, undersized, and outdated systems do little to remove nutrients and bacteria before they reach the lake.

The overall results of the survey paint a promising picture of the state of septic systems on Pine River Pond. With that in mind, this survey does not include nearly 300 other residents on the lake, whose septic system conditions are not known. We can extrapolate our results out to the rest of the lake in order to make educated guesses about its conditions, but there are factors that could cause this to be misleading. For example, people who are unsure of their septic system's condition or know it to be in poor shape may be less inclined to answer the survey. Furthermore, even a small number of non-functioning systems could have an outsized impact on water quality, so it is important to address as many of these as possible, even if the percentage of nonfunctioning systems is relatively small. Many compounding factors can contribute to excess phosphorus loading in a lake. If the survey results do in fact reflect the larger state of septic systems on Pine River Pond that is good news and any additional upgrades that are done will have a compounding benefit to the lake.

1.3.3 Ongoing Watershed Efforts

The PRPA is the main entity that coordinates continual watershed efforts including:

- Water Quality Sampling and Testing with LLMP - Each summer, except for 2020 (due to the COVID-19 pandemic), volunteers assist Bob Craycraft from the UNH Cooperative Extension collect water samples as detailed in Section 3.
- Weed Watch - The shoreline is monitored by volunteer patrols of weed watchers trained by NHDES.
- Aquatic Invasive Species prevention - The PRPA participates in the NH LAKES Lake Host Program and staffs the most active boat ramp on weekends and holidays. Since this access point is not a public access point, the AIS risk is decreased, but watercraft do enter and exit the lake that have been at other waterbodies where AIS are present. The Town of Wakefield gives the PRPA $2,500 to assist with the Lake Host Program.
- Macrophyte Survey - Each fall, under contract with SOLitude Lake Management, the littoral zone is examined via video surveillance and a report is provided to the PRPA that is shared with the Weed Watch group.
- Cyanobacteria sampling and microscopic analysis conducted every 2 weeks from June through September in accordance with the water quality monitoring plan developed for PRPA by UNH LLMP and DK Consulting.

2 Characteristics of Pine River Pond

2.1 Arthur H. Fox Memorial Dam

Pine River Pond's water level is controlled by the Arthur H. Fox Dam. This wood and concrete dam was constructed at the current location at Pine River Pond's outlet for William Lord in 1923 to generate electric power. In 1971, the State of New Hampshire took over the dam, and rebuilt it to its current structure in 1977, with a reinforced concrete spillway to manage the level of Pine River Pond. The current dam spans the entire outlet of Pine River Pond, measuring approximately 150 feet long, with earthen embankment wings and dry-laid split stone block walls, as well as a concrete spillway and gate structure[2].

The dam is maintained and controlled by the NHDES Dam Bureau, and the yearly drawdown is 8 feet to Pine River Pond's natural high-water mark at 574.35 feet above sea level. The surface elevation of Pine River Pond at impeded height is 582.35 feet which serves as the NHDES regulated "Reference Line," as set forth in the NHDES Consolidated List of Water Bodies.

Figure 2: Arthur F. Fox Memorial Dam

2.2 Land Use

Wakefield was chartered in 1749 and industry began soon thereafter in 1767 with grist and sawmills. By 1789 there were seven (7) mills in Town, and all were positioned to harness waterpower from the many streams, rivers, and outlets of the lakes. Wakefield's conditions were conducive for agriculture, settlement, and industry, and local forests were harvested for lumber and wood products. With the arrival of the railroad in 1871, small village areas grew by the lakes and streams which played a large part in the town's economic growth. The natural resources and rural character attracted many summer visitors, and throughout the 20th century, waterfront development was Wakefield's primary industry with construction of summer homes and the services needed providing income for many of Wakefield's residents. As automobile use increased, Route 16 was built bisecting the town. In the 1950's, Route 16 was relocated to the western edge of Wakefield passing by the western tip of Pine River Pond.

By the end of the 1980's most of the waterfront property in town had been developed into seasonal or year-round homes. As this growth occurred, both formal and loosely-formed road associations came into being around the lake. The formal road associations are Crew Road Association, Windover Property Owners Association, Pickerel Cove Estates Association, Michawanic Village Condominium Association, Lord Road Association, Pine River Association (PRA), Virginia Lane Estates Property Owners Association, and Pinewood Shores Association. The less formal groups include the residents on the following roads: Clearwater, Windy Point, Chandler, Olde Pine,

[2] https://www.nh.gov/nhdhr/publications/documents/12435.pdf Wakefield Heritage Commission Survey of Water-Powered Mills Sites and Dams, 2011

Thornhill, Blackwood, Cese, Ridge, Highland, Fay Way, Lee's Way, Sleepy Hollow, Colosi Way, Anglin, Hunt, and Barend.

It is estimated that 452 properties on, or with access to, PRP are developed. Approximately a half dozen parcels serve as community beaches for associations or for back lots (e.g., Crew Road Railroad Lots), and another half dozen are private access points for launching boats. Very few buildable waterfront lots remain on the lake.

Approximately a third of the residences serve as full-time homes, and a large majority of camps have been improved to serve as year-round homes for seasonal residents. Wastewater for all homes is treated by individual septic systems or dry wells. As more properties in the watershed are converted from seasonal camps to more developed residences, the tendency is to convert more of the property from its native forested condition which will likely accelerate the rate at which NPS pollutants will reach the lake to impair water quality unless lake-friendly landscaping measures are installed.

The largest association not located directly on the lake is the PRA, a ±154-lot subdivision of non-waterfront lots with two (2) waterfront parcels that are used as a community beach lot for swimming, and a boat access point (known locally as the Lord Road boat ramp). Not all the roadways in the PRA were completely developed, hence some lots are undeveloped. Several other associations also have homes with deeded right to PRP that are not directly on the lake.

2.3 Population and Growth Trends

According to the US Census Bureau's 2019 Census, the population for Wakefield was 5,110 residents, which ranked 70th among New Hampshire's 234 incorporated cities and towns. The population density is 129.3 persons per square miles of land area. Wakefield has 39.5 square miles of land area and 5.3 square miles of inland water area.

2.3.1 Historic Population Trends

The population of Wakefield has increased nearly 240 percent since 1970. During the same period, Carroll County increased by 155 percent, Strafford County by 74 percent and the State experienced a population increase of 73 percent. The largest decennial percent change was an increase of 58 percent between 1970 and 1980, followed by increases of 37 percent and 40 percent, respectively over the next two decades.

A review of population data with other available information indicates the increase in population between 1990 and 2000 was due to seasonal residents becoming year-round residents. Across the state line, the growth of the population in Acton, ME has been more like Wakefield's with surges during the 1980's and 1990's, but since then the population growth has slowed. Between 2000 and 2010, Wakefield's population rose by 19.4 percent. Comparatively, neighboring lake towns of Ossipee and Wolfeboro had slow growth rates of 3.2 percent and 3.1 percent, respectively in that same span.

(Source: 2014 Wakefield Master Plan)

2.3.2 Projected Population Changes

Wakefield has been one of the fastest growing communities in the state and has consistently experienced a higher growth rate than neighboring towns, Carroll and Strafford Counties, and the State of New Hampshire. Wakefield's population is projected to increase but at a slower rate than experienced in previous decades.

The NH Office of Energy Planning in partnership with the state's Regional Planning Commissions project the following population increases through 2040.

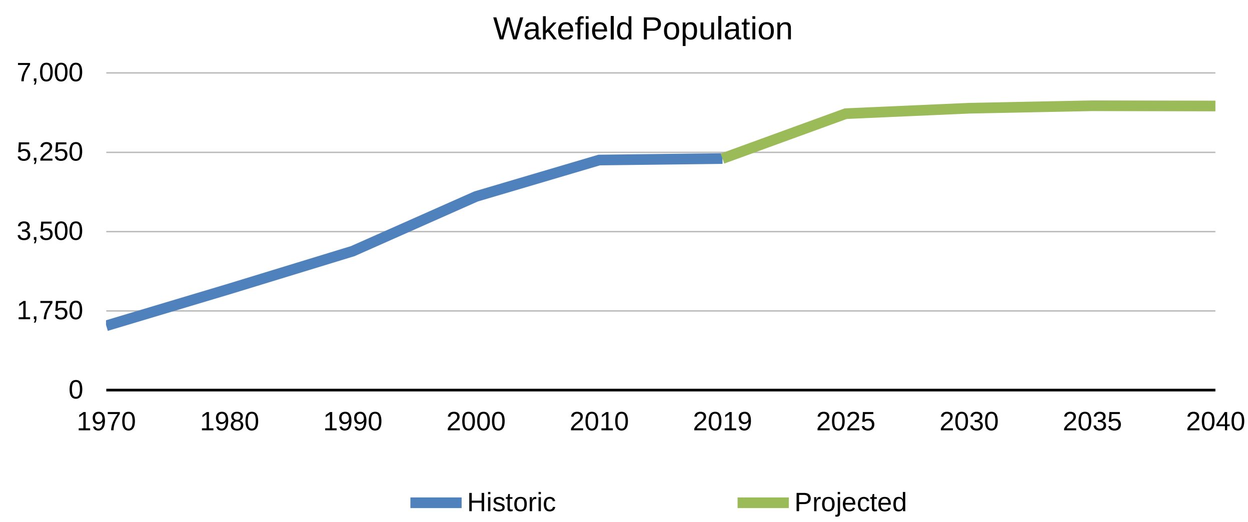


Figure 3: Wakefield Population

(Source: NH Employment Security, Economic and Labor Market Information Bureau)

2.4 Surficial Geology and Soils

A watershed's surficial geology plays an important role in the erosive potential of soils and soil infiltration capacity; both of which are important factors in phosphorus transport and attenuation potential. The surficial geology in the Pine River Pond watershed consists of alluvial material deposited 12,000 years ago at the end of the Great Ice Age. This material is characterized by unconsolidated materials, typically stony material, fine loams, and sand with moderate to high infiltration capacity. Soils of the Pine River Pond watershed consist of rocky, sandy, and fine loams dominated by soil types such as Champlain and Boscawen (USDA, 1977). These soils are well drained. Slopes in the watershed vary from zero percent to 60 percent with many slopes tending toward around eight percent. Steep slopes exist on either side of the pond including Cook's Hill to the southwest and Ballards Ridge to the northeast.

2.5 Watershed Habitat

The *New Hampshire Wildlife Action Plan* indicates that the Pine River Pond watershed contains lands considered to include habitat that is supportive of diverse species (NHFGD, 2020). Mammals, reptiles, birds, insects, and fish benefit from the watershed's rich natural habitats such as wetlands, forested lands, riverine areas at the pond's outlet, and open water.

Forest types in the Pine River Pond watershed include hemlock-hardwood-pine forest in the southwest, and Appalachian oak-pine in the northern and eastern sections. Tree species for these forest types include white pine, Eastern hemlock, maples, and oaks. The pond's shoreline contains a diversity of native shrubs typical for New Hampshire lakes including button bush, high bush blueberry, alders, and sweet pepperbush. Aquatic plants include scattered populations of vegetation such as grasses, lilies, pickerel weed, and several types of rushes (NHDES, 2005).

Endangered species in the watershed include the Common Loon and spotted turtle. Anecdotal reports from lakeshore residents indicate that Common Loons frequent the lake and have made nesting attempts for several years. The pond is classified as a warmwater fishery. Observed fish species in the pond include largemouth bass, smallmouth bass, brown bullhead, chain pickerel, and black crappie (NHFGD, ret. 2021).

2.6 Invasive Aquatic Vegetation

The PRPA has a Weed Watch committee that coordinates volunteer state trained weed watchers to monitor the shoreline from May through September. PRPA began contracting with SOLitude Lake Management out of Shrewsbury, MA in 2014 to conduct an annual macrophyte survey to identify, locate, monitor, and document the growth and spread of vegetation in the littoral zone. Since 2014, native whorled watermilfoil has been identified and is being monitored. In 2021, the whorled watermilfoil was documented in several locations with the densest growth in the quaking/floating bog area at the southeast end of the lake. Sparse to moderate growth was found in the cove southeast of Fay Way. Both these locations have benthic cyanobacteria mats with sections that have detached.

2.7 Algae and Cyanobacteria

There has been a noticeable increase in algae and cyanobacteria in Pine River Pond in recent years. In 2019, PRP had several observations of green filamentous algae, some stretching as long as 20 feet. The filamentous algae were observed floating in several areas of the lake. Increasingly, PRP has also observed the growth of benthic cyanobacteria mats. Many are found in coves surrounding the pond. The first benthic cyanobacteria mat was visually identified in Pine River Pond in 2019 by a kayaker at the mouth of Meadow Brook (Site 1, Figure 4). NHDES and AWWA visually confirmed the sighting, and UNH LLMP staff analyzed a sample; the result finding an abundance of *Oscillatoria*. NHDES issued an advisory on August 30, 2019, warning that the abundance of cyanobacteria benthic mats was especially concerning if they became dislodged from the bottom. Upon further inspection, the advisory was removed as the swimming/recreational season was ending and lake draw-down was approaching.

Over the next two years, PRPA examined its shoreline, and identified additional sites where benthic mats were discovered (blue numbered icons, Figure 4), and where cyanobacteria growth was found on rocks and logs along the shoreline (green location icons, Figure 4). Location 15 was tested by NHDES in 2020. Benthic mats of *Oscillatoria* were observed in abundance (too numerous to determine concentrations). Additionally, *Anabaena* and *Woronichinia* were detected, and the State issued a Cyanobacteria Alert in August 2020. Again, surface levels of cyanobacteria were not in exceedance of the state threshold of 70,000 cells/ml, however the abundance of benthic mats were also a concern as mats at icon locations 9, 10, and 15 shown in Figure 4 have detached and floated to the surface at times. These locations are relatively stagnant, slow-moving waters.

In November 2021, PRP had a surface cyanobacteria bloom near Loon Point off Camp Rd (see red icon, Figure 4). NHDES issued a local alert since the bloom dissipated within a few hours. This occurred late in the season (note PRP's annual 8 foot drawdown had begun on October 15th) and there was bloom residue along the shoreline, exposed by the drawdown.

Nationally, there has been an increase in the occurrence of benthic mats according to the literature; however, there are far fewer studies on mats than the planktonic types of cyanobacteria. The reports on environmental conditions and toxin production are quite variable[3]. Benthic mats of cyanobacteria can be extremely robust and can tolerate low light, low nutrients, and low oxygen. Mats can form in some extreme environments, including

[3] https://academic.oup.com/femsec/article/73/1/95/646354

high alpine and arctic lakes[4]. Mats can undergo freeze/thaw cycles, endure winter anoxia and exposure when Pine River Pond's water is drawn down, and have likely slowly grown for years. Benthic mats are like rugs, with interwoven filaments of a variety of cyanobacteria, (sometimes within the Oscillatoriales group but they are often diverse). These cyanobacteria can benefit from their overall structure together and from other microbial activity within the mats. These mats could also be benefiting from the protection of the coves, and the warmer water temperatures in these shallow areas. Runoff from the steep slopes and phosphorus transported through erosion could provide immediate nutrients that the benthic mats use. These mats may also benefit when there is a lower rate of algal competition and an increase in sunlight exposure since light can reach deeper.

Benthic mats have negative impacts on water quality, impacting recreation and other uses such as drinking water. However, the human health risks posed by these mats is poorly addressed in public recreational guidelines. The science to develop these guidelines needs further refinement as knowledge and monitoring tools for mats develop and improve. The PRPA will monitor the Interstate Technology and Regulatory Council for Harmful Cyanobacterial Blooms (ITRC HCB) technical and regulatory guidance document[5] for strategies in preventing and managing benthic cyanobacteria. This document reviews field screening and sampling, analytical toxin testing methods of mats, toxin thresholds, communication and response planning, and specific considerations for prevention and management control strategies. A goal of this watershed management plan is to provide management strategies and actions that will in theory help manage water quality conditions such that the occurrence of the mats is reduced.

[4] https://www.frontiersin.org/articles/10.3389/fmicb.2012.00140/full

[5] https://itrcweb.org/teams/active/hcb

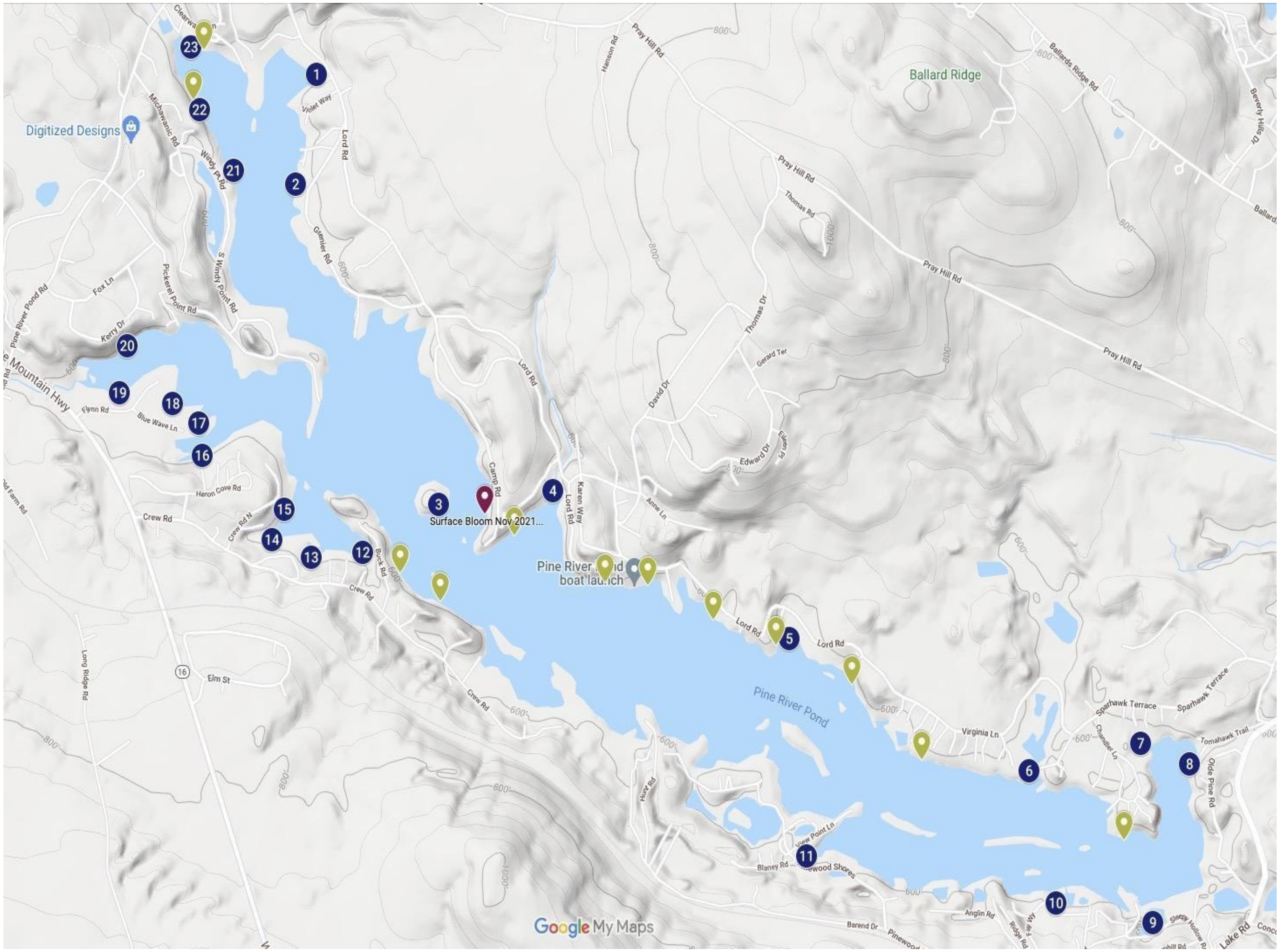


Figure 4: Cyanobacteria Map and Legend

Benthic Cyanobacteria Mats (blue numbered icons 1 to 23.)

1. Mouth of Meadow Brook
2. Small inlet near Grenier/Lord Road intersection
3. Newton's (Great) Island swim area
4. Mouth of Unnamed Brook/Wentworth Cove
5. End of Lord Road coves
6. Virginia Lane, inlet to White Pond Brook/Beaver Ponds
7. Sparhawk/Chandler junction cove
8. Olde Pine Rd near Sparhawk Trail
9. Quaking/floating bog area
10. Cove southeast of Fay Way
11. Junction of Pinewood Shores/Blaney Road
12. Mouth of Quimby Brook
13. Black's Cove
14. State Property near Sawdust Cove
15. Tiny Cove near 98 Crew Road north
16. Heron Cove shoreline
17. End of Blue Wave Lane shoreline
18. Blue Wave Lane shoreline
19. Flynn Road shoreline
20. Kerry Drive shoreline
21. Windy Point Rd shoreline
22. Michawanic Condominium docks
23. East side of Arthur Fox dam

Cyanobacteria on shoreline rocks and logs (green location icons)

Clearwater shoreline

Michawanic Condo. shoreline

Off Buck Rd shoreline

South side Loon Point

Crew Road shoreline

Lord Road shoreline

Lord Road shoreline #2

Lord Road shoreline #3

Lord Road shoreline #4

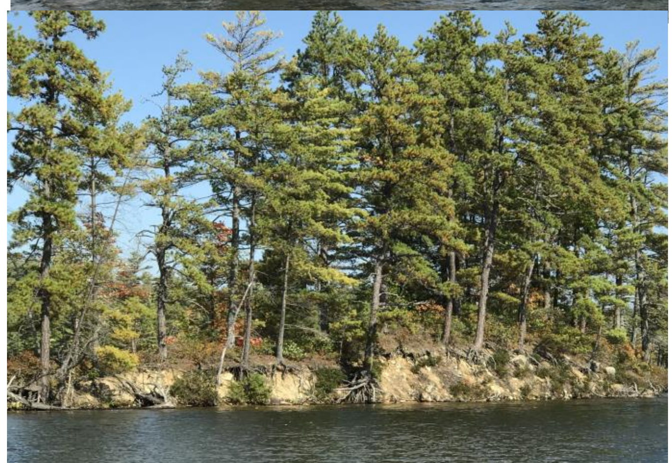
End of Virginia Lane

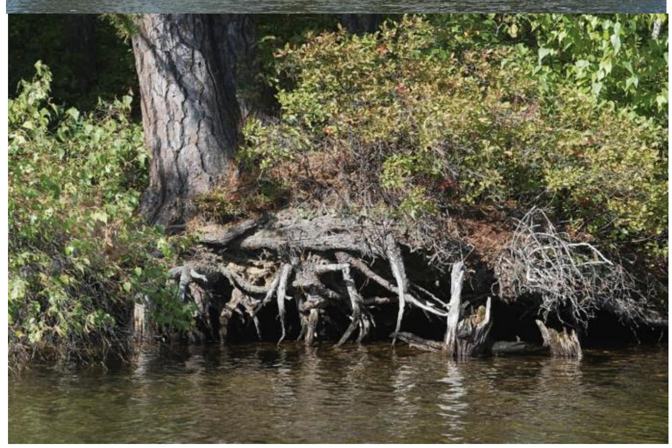
Virginia Lane shoreline

Chandler Lane Point

Surface Cyanobacteria Bloom (red icon) November 2021, Loon Point, south shoreline

2.8 Erosion





On September 10, 2004, the NHDES Wetlands Bureau issued a Field Inspection Report responding to concerns expressed by the PRPA over excessive rates of erosion on the shoreline of PRP. The report states that almost all the shoreline is subject to some form of erosion problem. The only frontages that have been spared are those that had been modified or armored at one time. The volume of material that had been removed was evident from photos included in the report. The likely causes were attributed to:

- The shoreline at the impeded high-water mark never evolved to be stable in the presence of water, and therefore is more susceptible to any erosive force.
- Increased wave forces from wake boat activity on the lake.
- Exposure of the shoreline by the deep drawdown of the lake.

The recommended action in the Report was to apply for grants to help develop a series of options for stabilizing the various types of frontages based on the differing conditions, and establish methods that the regulatory agencies would recognize as viable alternatives for property owners to stabilize their shoreline.

Almost 20 years later, increased wave action from wake boats and the recently popular wake surfing, along with increased numbers of people recreating, compounds an already bad situation. The erosive forces of wind and water have left behind deep scars in the form of undercutting (one property almost 30’) and has caused bankings to cave into the lake along PRP’s shoreline as shown in these photos. The worst banking cave-in is a concave area over 20’ high and wide.

PRP is a narrow lake with many choke points where speed should be reduced to prevent wake erosion. In many locations on the lake, watercraft operate above headway speed and are not 150’ from shore. In recent years the PRPA has requested that the NH Marine Patrol strictly enforce the 150’ rule to minimize wake erosion.

3 Assessment of Water Quality

This section provides an overview of New Hampshire's water quality standards and criteria that apply to Pine River Pond. Included are methodologies used by NHDES to assess water quality, and a summary of water quality conditions for parameters of concern - phosphorus, chlorophyll-a, and cyanobacteria. The State's assessment process, coupled with the water quality parameters of concern for Pine River Pond, provide a foundation for the Watershed Management Plan's water quality goals and success indicators which serve as targets for measuring water quality improvements as management actions are implemented.

3.1 Applicable Water Quality Standards and Criteria

To set the context for developing water quality goals and success indicators for this watershed management plan, a review of the State's water quality standards is presented below. This information has been applied to the water quality goal setting process for the pond.

The State of New Hampshire through NHDES is required to follow federal regulations to protect water quality under the US EPA's Clean Water Act (CWA) with some flexibility as to how those regulations are enacted. The Federal CWA, the NH RSA 485-A Water Pollution and Waste Control Statute, and the NH Surface Water Quality Regulations (Env-Wq 1700) form the regulatory basis for governing water quality protection in New Hampshire. These regulations also serve as the basis for New Hampshire's regulatory and permitting programs related to surface waters. Under the CWA, states are required to establish water quality standards and submit biennial water quality status reports to Congress via the US EPA. These reports provide an inventory of all waters assessed by the state and indicate which waterbodies exceed or meet the state's water quality standards. These reports are commonly referred to as the "Section 305 (b) Report" and the "Section 303(d) Surface Water Quality List" respectively.

The state's water quality standards are the "yardstick" for identifying water quality problems and for determining effectiveness of pollution control and prevention programs. New Hampshire's water quality standards are composed of three parts: designated uses, water quality criteria, and antidegradation. The CWA requires states to determine designated uses and antidegradation measures for all surface waters within the state's jurisdiction. Designated uses are the desirable activities and services that surface waters should be able to support, and include uses for aquatic life integrity, fish consumption, shellfish consumption, drinking water supply, primary contact recreation (swimming), secondary contact recreation (boating and fishing), and wildlife (Table 2). Surface waters, such as Pine River Pond, typically have multiple designated uses. Pine River Pond's designated uses include aquatic life integrity, fish consumption, potential drinking water supply, primary contact recreation, secondary contact recreation, and wildlife.

The state's water quality criteria provide a baseline measure of the quality surface waters must meet to support designated uses. If the existing water quality meets or is better than the water quality criteria, the waterbody supports its designated use(s). If the waterbody does not meet water quality criteria, it is considered impaired for its designated use(s). Water quality criteria for each designated use can be found in RSA 485 A:8, IV and in the state's surface water quality regulations (NHDES, 2018b).

Designated Use	NHDES Definition	Applicable Surface Waters
Aquatic Life	Waters that provide suitable chemical and physical conditions for supporting a balanced, integrated, and adaptive community of aquatic organisms.	All surface waters
Fish Consumption	Waters that support fish free from contamination at levels that pose a human health risk to consumers.	All surface waters
Shellfish Consumption	Waters that support a population of shellfish free from toxicants and pathogens that could pose a human health risk to consumers.	All tidal surface waters
Drinking Water Supply After Adequate Treatment	Waters that with adequate treatment will be suitable for human intake and meet state/federal drinking water regulations.	All surface waters
Primary Contact Recreation (i.e., swimming)	Waters suitable for recreational uses that require or are likely to result in full body contact and/or incidental ingestion of water.	All surface waters
Secondary Contact Recreation	Waters that support recreational uses that involve minor contact with the water.	All surface waters
Wildlife	Waters that provide suitable physical and chemical conditions in the water and the riparian corridor to support wildlife as well as aquatic life.	All surface waters

Table 2: Designated Uses

Source: Adapted from the 2018 New Hampshire Consolidated Assessment and Listing Methodology

An impaired waterbody is defined as a waterbody that does not meet the water quality criteria for its designated uses. The criteria might be numeric and specify concentration, duration, and recurrence intervals for various parameters, or they might be narrative and describe required conditions such as the presence or absence of scum, sludge, odors, or toxic substances. If the waterbody is impaired, the state will place it on the section 303(d) list (NHDES, 2019b).

According to the 2020/2022 303(d) list of impaired or threatened waters, Pine River Pond is shown as potentially non-supporting for primary contact designated use due to cyanobacteria – this designation indicates that while the pond isn't fully listed as impaired for the cyanobacteria parameter, observational data suggests that there is enough history of blooms that impairment may be reached soon. Currently, NHDES does not have enough data to fully assess the pond for chlorophyll-*a* and phosphorus; however, this watershed plan will utilize existing data available to evaluate the levels of phosphorus and chlorophyll-*a* relative to cyanobacteria blooms and state water quality standards.

Assessment Unit ID: NHLAK600020703-03
Assessment Unit Name: Pine River Pond
Town(s) Primary Town is Listed First: Wakefield

Size: 568.8340 ACRES
Assessment Unit Category: 4A-P
Beach: N

2020/2022, 305(b)/303(d) - All Reviewed Parameters by Assessment Unit

Designated Use Description	Desig. Use Category	Parameter Name	Parameter Threatened (Y/N)	Last Sample	Last Exceed	Parameter Category	TMDL Priority
Aquatic Life Integrity	4A-P	ALKALINITY, CARBONATE AS CACO3	N	2007	2007	3-ND	
		CHLORIDE	N	2017	N/A	3-PAS	
		CHLOROPHYLL-A	N	2017	NLV	2-M	
		DISSOLVED OXYGEN SATURATION	N	2017	1991	3-PAS	
		OXYGEN, DISSOLVED	N	2017	N/A	3-PAS	
		PH	N	2017	2017	4A-P	
		PHOSPHORUS (TOTAL)	N	2015	NLV	2-M	
		TURBIDITY	N	2017	2002	3-PAS	
Fish Consumption	4A-M	MERCURY - FISH CONSUMPTION ADVISORY	N			4A-M	
Potential Drinking Water Supply	2-G	ESCHERICHIA COLI	N	2011	2011	3-PNS	
		SULFATES	N	2006	N/A	3-ND	
Primary Contact Recreation	3-PAS	CHLOROPHYLL-A	N	2017	N/A	2-G	
		Cyanobacteria hepatotoxic microcystins		2019	2019	3-PNS	
		ESCHERICHIA COLI	N	2011	N/A	3-PAS	
Secondary Contact Recreation	3-PAS	ESCHERICHIA COLI	N	2011	N/A	3-PAS	
Wildlife	3-ND						

Good	Marginal	Likely Good	No Current Data	Likely Bad	Poor	Severe
Meets water quality standards/thresholds by a relatively large margin.	Meets water quality standards/thresholds but only marginally.	Limited data available. The data that is available suggests that the parameter is Potentially Attaining Standards (PAS)	Insufficient information to make an assessment decision.	Limited data available The data that is available suggests that the parameter is Potentially Not Supporting (PNS) water quality standards.	Not meeting water quality standards/thresholds. The impairment is marginal.	Not meeting water quality standards/thresholds The impairment is more severe and causes poor water quality.

Figure 5: Pine River Pond Water Quality Assessment Summary

https://www4.des.state.nh.us/onestoppub/SWQA/010600020703_2020.pdf

The focus of this watershed planning project is to identify water quality goals and management actions that will reduce the frequency of cyanobacteria blooms in Pine River Pond. To reduce bloom frequency, the watershed management approaches outlined in the plan will address phosphorus, the key parameter that accelerates cyanobacteria blooms in the pond. Chlorophyll-*a*, a response parameter used to further evaluate phosphorus loading, will be used to evaluate watershed management success.

3.1.1 Antidegradation

The third and final component of the state's water quality assessment process is antidegradation. Antidegradation includes provisions designed to preserve and protect the existing beneficial uses of surface waters and to minimize degradation (Env-Wq 1700). Antidegradation provisions apply to activities conducted under permits issued by NHDES as follows.

- Proposed new or increased activity, including point and nonpoint source discharges of pollutants that would lower water quality or affect existing or designated uses.
- Proposed increases in pollutant loadings to a waterbody when the proposal is associated with existing activities.

- An increase in flow alteration over an existing alteration.
- Hydrologic modifications, such as dam construction and water withdrawals.

Under antidegradation assessments, waterbodies are evaluated and placed into tiers representing water quality conditions. Tier One waterbodies are within 10 percent of exceeding state water quality standards, while Tier 2 are considered high quality waters and have water that is better than 10 percent of the water quality standard (Figure 6).

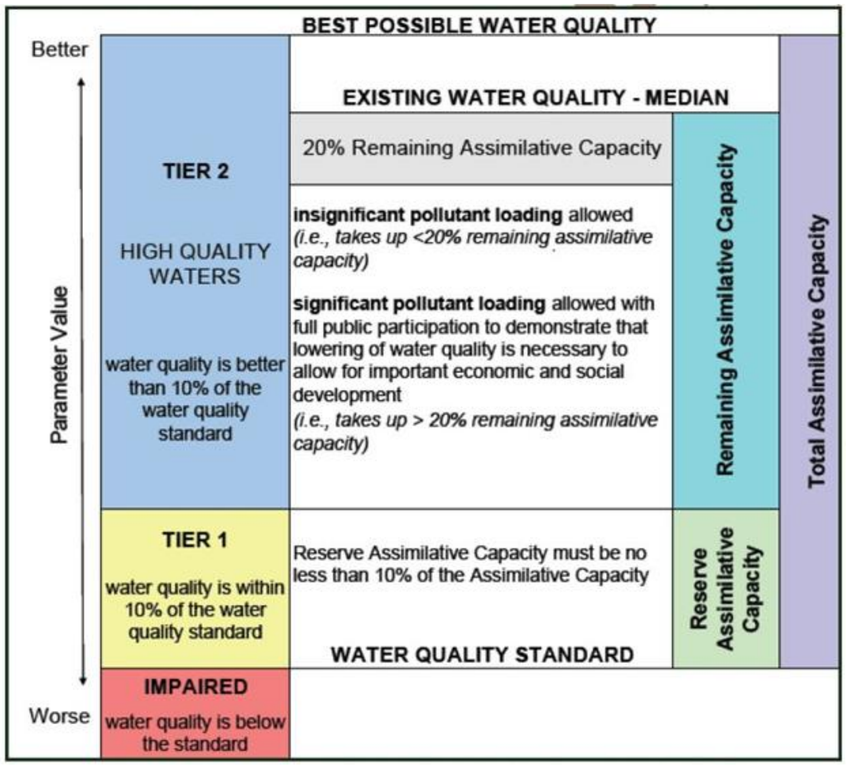


Figure 6: NHDES Antidegradation Tiers

Pine River Pond currently attains, and in fact, exceeds, the state's Tier 2 – High Quality Waters status for phosphorus and chlorophyll-*a*. To determine tier status, the assimilative capacity of the waterbody must be calculated. Assimilative capacity is the amount of pollutant that can be added to a waterbody without a violation of the water quality standard. To calculate assimilative capacity, NHDES requires that 10 percent of the difference between the best possible water quality and the appropriate trophic level water quality standard must be held in reserve as a buffer.

The 10 percent reserve assimilative capacity threshold for mesotrophic lakes is set at 11.6 micrograms per-liter for phosphorus and 4.8 micrograms per-liter for chlorophyll-*a*. The difference between the reserve assimilative capacity threshold and the current measured concentration represents the remaining assimilative capacity. For Pine River Pond, the remaining assimilative capacity exceeds the 10 percent reserve assimilative capacity, which puts both parameters in the Tier 2 High Quality Waters designation (Table 3).

Parameter	Assimilative capacity threshold (µg/L)	Current measured concentration (µg/L)	Remaining Assimilative Capacity (µg/L)
Phosphorus	11.6	6.7	+4.9
Chlorophyll-*a*	4.8	2.9	+1.9

Table 3: Assimilative Capacity Calculation Results

While the Tier 2 High Quality Waters designation reflects positively on the pond's water quality, nutrient loading has increasingly become a concern for Pine River Pond. The presence of algal mats and reported cyanobacteria blooms have compelled residents to take action to protect and improve the pond's water quality now before further degradation occurs. While in-lake phosphorus and chlorophyll-*a* concentrations do not currently exceed state water quality standards for lake nutrients, it is understood that nutrient limitation of algae and cyanobacteria growth in freshwater is primarily related to phosphorus. Therefore, management efforts to reduce nutrient loads to the pond are critical for preventing algal growth in the pond, which is a priority concern for watershed residents.

3.2 Role of Trophic Status in Water Quality Assessment

From 1974 to 2010, and from 2013 to 2019, NHDES conducted trophic surveys on waterbodies across the state to determine trophic status of the state's lakes and ponds. Trophic status is a classification system that categorizes the degree of eutrophication of a waterbody as either oligotrophic, mesotrophic, or eutrophic depending upon their varying levels of productivity, clarity, macrophyte densities, hypolimnetic oxygen concentrations, and other diagnostic parameters and indicators. Generally, oligotrophic waterbodies have less nutrients, and are known for clear water, few macrophytes, high dissolved oxygen levels, and low levels of phosphorus and chlorophyll-*a*. Eutrophic lakes are highly productive and have more nutrients, turbid water, low dissolved oxygen levels, and many macrophytes. Mesotrophic lakes are in-between or in transition between oligotrophic and eutrophic conditions. NHDES assesses waterbody trophic status by evaluating water transparency, chlorophyll-*a* levels, macrophyte density, and dissolved oxygen concentration.

Pine River Pond has been assessed twice under NHDES's trophic survey program, in 1977 and 1990. It was determined to be oligotrophic in 1977 but transitioned to mesotrophic in the 1990 survey due to the presence of additional rooted plants and algae and slightly less water clarity.

Water quality assessments in New Hampshire are based on the highest trophic status reported for a lake; therefore, when NHDES conducts assessments, Pine River Pond is considered an oligotrophic waterbody. For the parameters of concern for this project, phosphorus and chlorophyll-*a,* in-lake water quality concentrations and water quality goals should be consistent with the state's thresholds for oligotrophic waterbodies (Table 4).

P = phosphorus

Chl-*a* = chlorophyll-*a*, a surrogate measure for algal concentration

Trophic State	P (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 4: Nutrient Criteria by Trophic Class in New Hampshire

Source: Adapted from the 2018 New Hampshire Consolidated Assessment and Listing Methodology

3.3 Designated Use of Primary Concern

The definition of the primary contact recreation (PCR) designated use is "Waters suitable for recreational uses that require or are likely to result in full body contact and/or incidental ingestion of water." This use applies to all surface waters in the state. The narrative criteria for PCR can be found in Env-Wq 1703.03, 'General Water Quality Criteria' and reads, "All surface waters shall be free from substances in kind or quantity that: a)settle to form harmful benthic deposits; b) float as foam, debris, scum or other visible substances; c) produce odor, color, taste or turbidity that is not naturally occurring and would render the surface water unsuitable for its designated uses; d) result in the dominance of nuisance species; e) interfere with recreation activities."

Cyanobacteria scums interfere with aesthetic enjoyment, swimming, and may pose a health hazard to humans and animals. A summary of NHDES-issued cyanobacteria warnings is provided below.

Date Issued	Dominant Taxa	Total Cell Count (cells/ml)	Days	Issued by
5/27/2016	Anabaena	2,500,000	6	NHDES
8/8/2018	Oscillatoria / Planktothrix	>70,000	14	NHDES
8/30/2019	Oscillatoria / Planktothrix	Too numerous to count	6	NHDES
8/20/2020	Anabaena & Woronichinia	4,750	n/a	NHDES
11/8/2021	Dolichospermum, Woronichinia, & Aphanizomenon	500,000	n/a	NHDES

Table 5: Cyanobacteria Warnings Issued for Pine River Pond

4 Sources of Nutrients (Element A)

The USEPA's nine elements of watershed planning include steps to identify the causes and sources of pollution that will need to be controlled to achieve the load reductions estimated in the watershed plan. To assist with this step for Pine River Pond, DK Water Resource Consulting LLC was contracted to complete a water quality assessment and develop a linked watershed/lake model using the Lake Loading Response Model (LLRM) to identify and quantify sources of phosphorus loading to the pond. This modeling effort was based generally on historic water quality data and primarily on data collected in the past 10 years. The information in this section of the watershed plan was developed and written by DK Water Resources Consulting LLC and provides a review of data used to support the LLRM and a description of the model as it is applied to Pine River Pond. Complete documentation of the LLRM model can be found in AECOM (2009).

4.1 Characteristics of Pine River Pond

Pine River Pond and its watershed are in the Ossipee/Saco River Basin within the town of Wakefield, New Hampshire. The dammed, 231-hectare (571 acre) pond has a maximum depth of 16.8 m (55 ft) and a mean depth of 3.7 meters (12 feet) (Figure 7). The pond volume is 8,547,500 cubic meters with a flushing rate of approximately 2.2 times per year. The watershed is 13 times the pond's area making Pine River Pond moderately susceptible to excessive nutrient loading from activities in the watershed. Selected characteristics of Pine River Pond relevant to the LLRM modeling effort discussed in Section 4.0 are presented in Table 6.

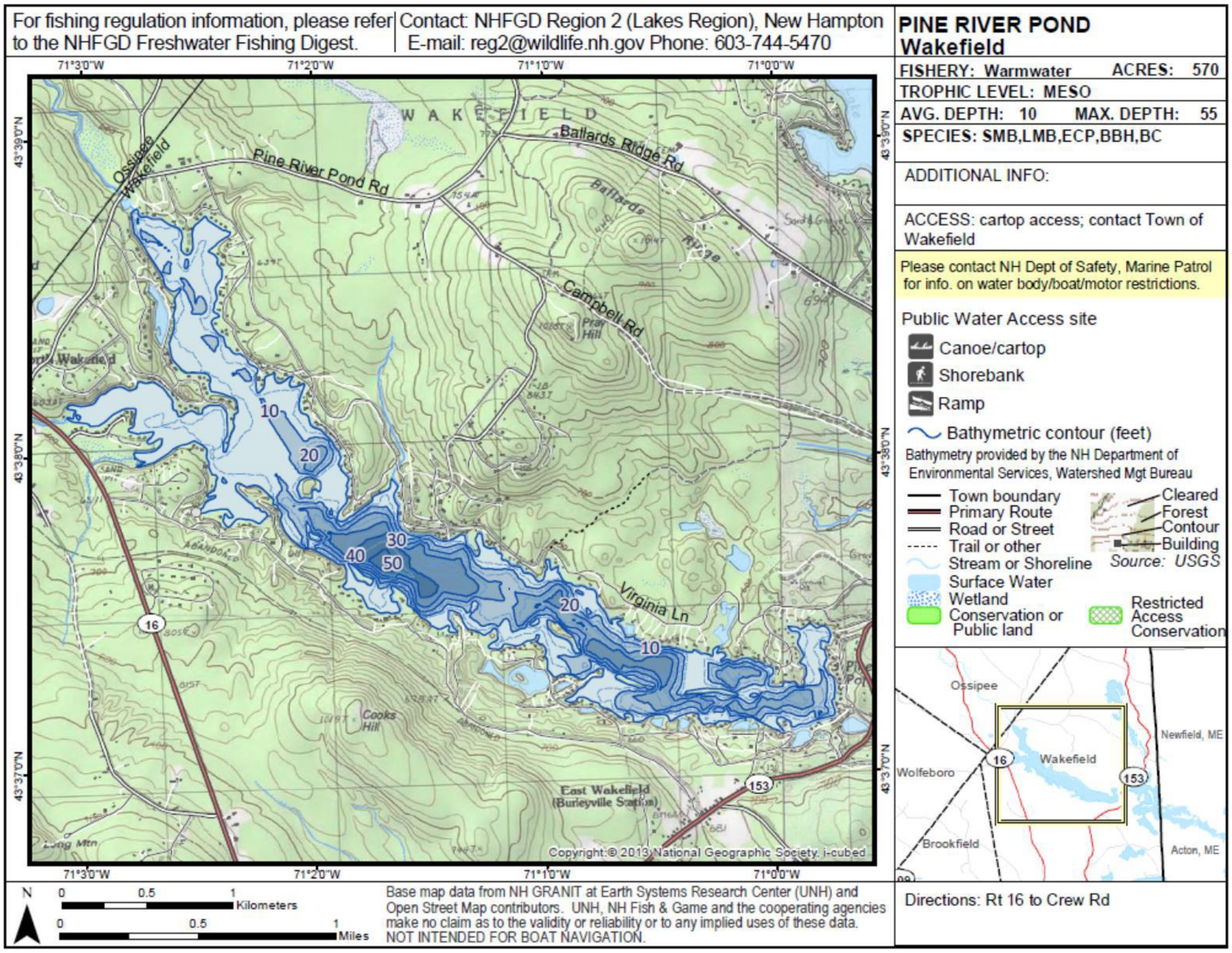


Figure 7: Pine River Pond Bathymetry (Source NHFGD 2021)

Parameter	Value
Lake Area (ha)	231
Lake Volume (m^3)	8.547,500
Watershed Area (ha)	3109
Watershed/Lake Area	13
Mean Depth (m)	3.7
Max Depth (m)	16.8
Flushing Rate (yr^{-1})	2.2
Hypolimnetic Anoxia	Yes

Table 6: Characteristics of Pine River Pond, Wakefield, NH (LLRM model output, NHF&G 2021)

4.2 Water Quality Summary

Water quality data has been collected regularly in Pine River Pond since 1977 primarily through the UNH LLMP (UNH 2019). Data relevant to this plan are summarized in Figure 8 and Figure 9. These data suggest that with respect to phosphorus and Secchi Disk transparency, Pine River Pond is consistently better than the nutrient poor (oligotrophic) threshold, particularly over the past ten years. With respect to chlorophyll-*a*, the pigment found in algae and cyanobacteria, the pond is occasionally above the low nutrient threshold. The most recent LLMP report supports current classification as oligotrophic with respect to these three parameters; however, observed dissolved oxygen depletion at depth during the summer is a cause for concern. These data suggest the need for reductions in phosphorus which will reduce chlorophyll-*a* by reducing algal and cyanobacterial growth. Reduction in algal and cyanobacteria growth may help improve dissolved oxygen conditions as well.

Anoxic conditions in proximity to lake sediments can lead to release of phosphorus (primarily iron-bound) from the sediments to the water column. This is generally referred to as internal loading and does not appear to be a large issue in Pine River Pond at present (DKWRC 2021).

The means of water quality parameters for the past ten years are summarized in Table 7. This period is considered representative of current conditions and is used as a target for calibration of the water quality model. Phosphorus concentrations are below the threshold for oligotrophic lakes in NH (0.008 mg/l). Similarly, both chlorophyll-*a* and Secchi Disk transparency meet the oligotrophic criteria.

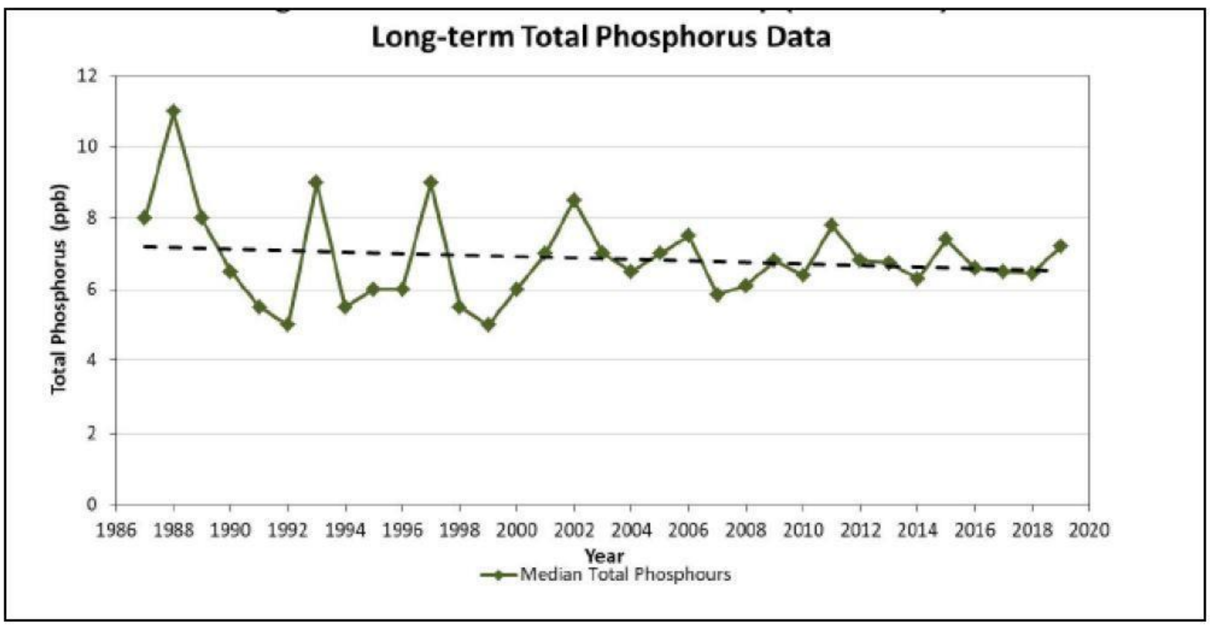


Figure 8: Phosphorus Data from the NH Lakes Lay Monitoring Program (UNH 2019)

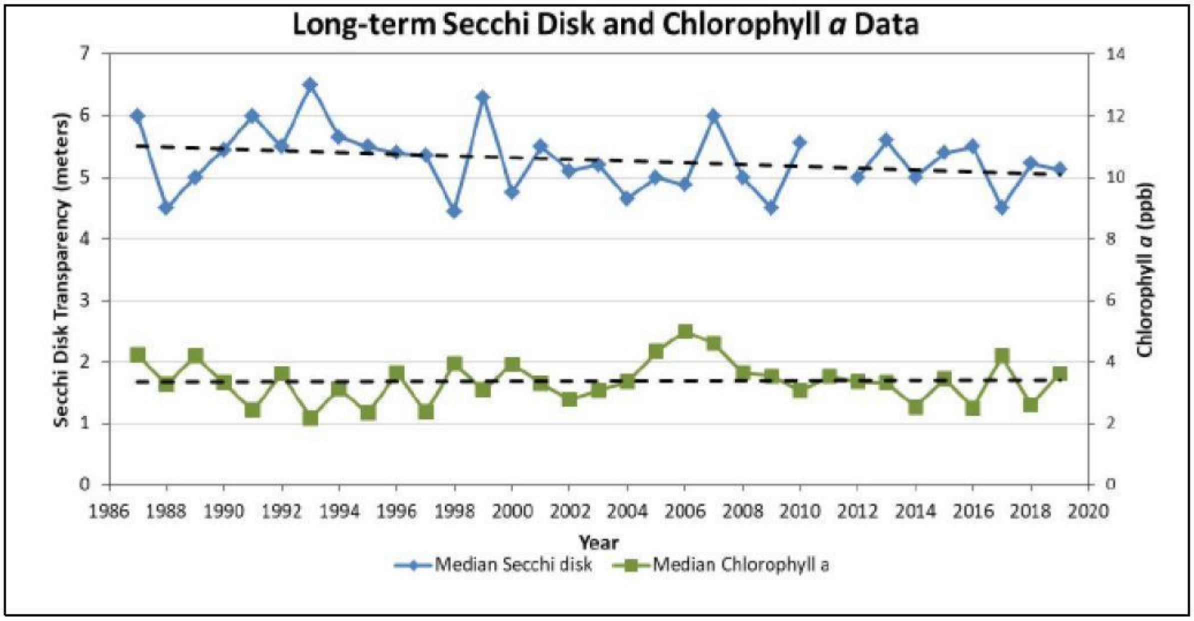


Figure 9: Secchi Disk and Chlorophyll-a Data from the NH Lakes Lay Monitoring Program (UNH 2019)

	Epilimnetic Total Phosphorus	Chlorophyll *a*	Secchi Transparency
	mg/l (N)	µg/l (N)	m (N)
Oligotrophic criteria	<0.008	<3.3	>4
Deep Spot Epilimnion	0.0067 (45)	2.9(44)	5.6(47)
Quimby Brook	0.0154 (37)		
Meadow Brook	0.0084 (21)		
Young Brook	0.0142 (36)		

Table 7: Pine River Pond Water Quality Summary 2012 - 2021 (mean values and observations)

Water quality samples have also been collected from the primary tributaries to Pine River Pond (Figure 10). A summary of water quality results from these samples are presented in Table 7. Phosphorus concentrations are moderate to low in the tributaries and slightly higher than in-lake concentrations. However, the samples were primarily collected during the summer season when flows are generally low and vegetation and wetlands throughout the watershed would be expected to absorb phosphorus. It is possible that substantial loading to the pond occurs during periods of vegetative die-back in the fall and runoff from snowmelt and spring rains. Additional seasonal data collection would help to fully understand the sources and timing of phosphorus loading to Pine River Pond.

4.3 Related Water Quality Concerns for Pine River Pond

In 2002, routine sampling detected an abnormally high bacteria (E. coli) concentration in Young (aka Young's) Brook that flows into Pine River Pond. By using the bracketing technique, the elevated E. coli levels were isolated to two small farms, and the NH Department of Agriculture was brought in to inspect the properties under RSA 431:33-35. Best Management Practices to achieve the beneficial use of animal waste and its nutrients while minimizing impact to land, water and humans were implemented to keep livestock away from the stream, conduct periodic cleaning and storage of manure away from the stream, and establish vegetative buffers along stream banks to minimize stormwater runoff. One landowner received a grant to fence the livestock out of the stream. Young Brook continues to be monitored under the PRPA's LLMP volunteer water quality monitoring efforts.

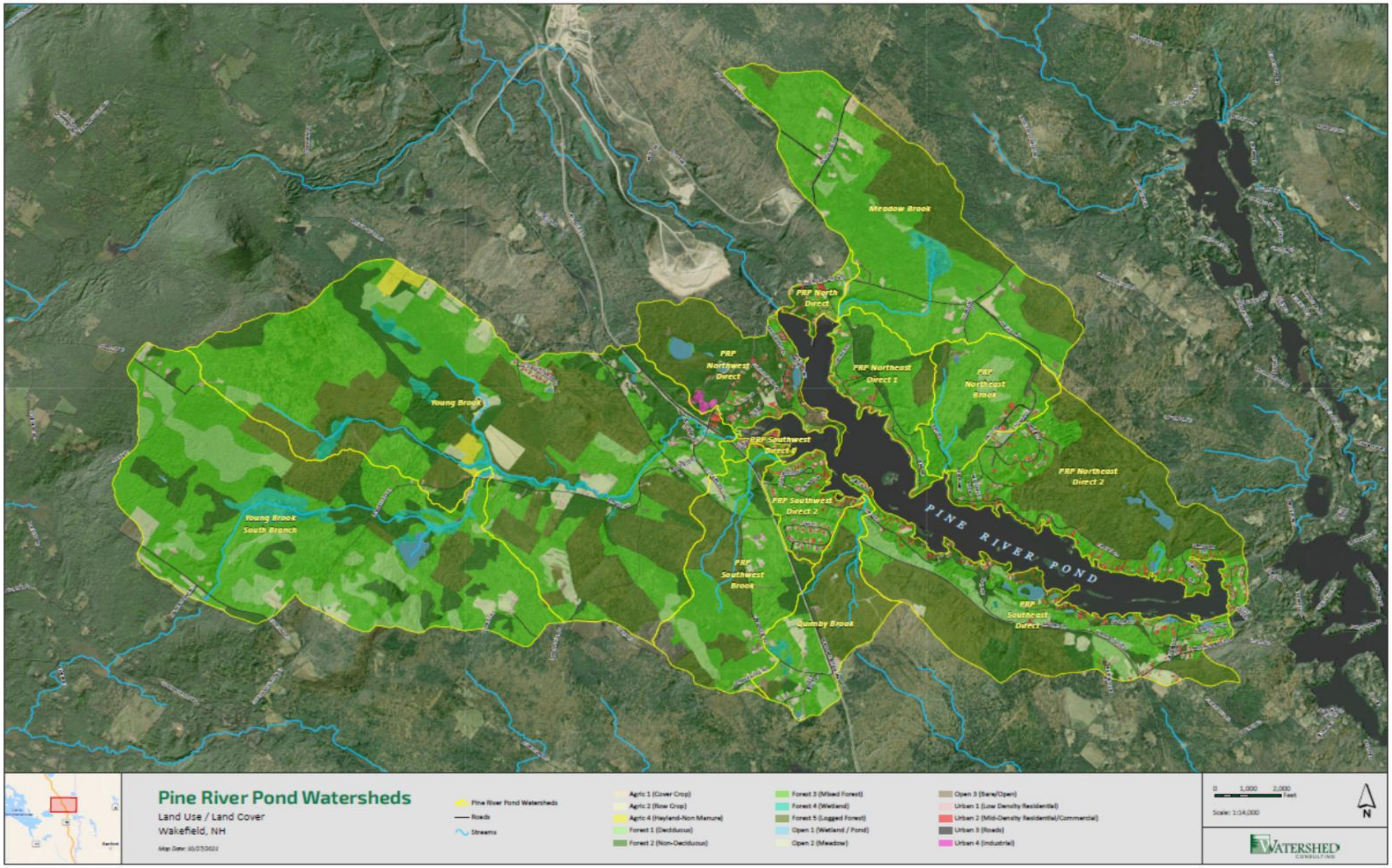


Figure 10: Subwatersheds and Land Cover of Pine River Pond (Compiled by Watershed Consulting Associates)

4.4 Pine River Pond Lake Loading Response Model

Current water and phosphorus loading to Pine River Pond was assessed using the Lakes Loading Response Model (LLRM) methodology (AECOM 2009), which is a land cover export/lake response model developed for use in New England and modified for New Hampshire lakes by incorporating New Hampshire land cover phosphorus export coefficients when available. The updated model was calibrated to current conditions using data from 2012 through 2021.

The direct and indirect nonpoint sources of water and phosphorus to Pine River Pond in this analysis include:

- Atmospheric deposition (direct precipitation to the pond)
- Surface water base flow (dry weather tributary flows, including groundwater seepage into streams)
- Stormwater runoff (runoff draining to tributaries or directly to the pond)
- Internal loading (from both anoxic release from deep sediments and erosion in drawdown zone)
- Waterfowl (direct input from resident and migrating birds)
- Direct groundwater seepage including septic system inputs from nearby residences

Hydrologic Inputs and Water Loading

Calculating phosphorus loads to Pine River Pond requires estimation of the sources of water to the pond. The three primary sources of water are: 1) atmospheric direct precipitation; 2) runoff, which includes all overland flow to the tributaries and direct drainage to the pond; and 3) baseflow, which includes all precipitation that infiltrates and is then subsequently released to surface water in the tributaries or directly to the pond (i.e., groundwater). Baseflow is roughly analogous to dry weather flows in streams and direct groundwater discharge to the pond. The annual water budget for the updated model is broken down into its components in Table 8.

- Precipitation - Mean annual precipitation was assumed to be representative of a typical hydrologic period for the watershed. For the Pine River Pond watershed, 1.25 m (≈49 in) of annual precipitation was used.
- Runoff - For each land cover category, annual runoff was calculated by multiplying mean annual precipitation by basin area and a land cover specific runoff fraction. The runoff fraction represents the portion of rainfall converted to overland flow.
- Baseflow - The baseflow calculation was calculated in a manner similar to runoff. However, a baseflow fraction was used in place of a runoff fraction for each land cover. The baseflow fraction represents the portion of rainfall converted to baseflow. Baseflow is infiltrated into the ground and returned to the pond via groundwater flow and discharge to tributary streams and direct discharge to the pond.

The hydrologic budget was calibrated to a representative standard water yield for New England (Sopper and Lull 1970; Higgins and Colonell 1971).

WATER BUDGET	Pine River Pond
	m^3/yr
Atmospheric	1,441,688
Septic Systems	53,927
Watershed Runoff and Baseflow	17,639,975
Total	19,135,590

Table 8: Pine River Pond Annual Water Budget Under Current Conditions as Estimated Using LLRM

4.5 Nutrient Inputs

4.5.1 Land Cover Export

The Pine River Pond subwatershed boundaries were determined using a geographic information system (GIS). Land covers within the watershed were determined using the most recent available GIS data (New Hampshire GRANIT 2019, accessed September 2021 by Watershed Consulting Associates), Google Earth imagery, and ground-truthing (when appropriate). Full land cover by subwatershed is presented in Appendix Table A.

The phosphorus load for the watershed was calculated using export coefficients for each land cover type. These coefficients were based on recent modeling efforts in New Hampshire. Watershed loading was adjusted based upon proximity to the pond, soil type, presence of wetlands, and attenuation provided by Best Management Practices (BMPs) for water or nutrient export mitigation. The watershed load (baseflow and runoff) was combined with direct loads (atmospheric, internal, septic system, and waterfowl) to calculate phosphorus loading. The generated load to the pond was then entered into a series of empirical models that provided predictions of in-lake phosphorus concentration, chlorophyll-*a* concentration, algal bloom frequency, and water clarity. Current watershed land cover and export coefficients are summarized in Table 9. It is recognized that some land cover categories are not explicitly represented in the data. For example, some roads and gravel roads are not included explicitly due to the coarse resolution of the spatial data; however, their contribution is included in the overlying land category (e.g., Low Density Residential or Institutional) export coefficient.

Land Cover	Total (ha)	Percentage of land cover	Phosphorus Export Coefficient (kg/ha/yr)	Source for Export Coefficient
Urban 1 (Low Density Residential)	12.6	0.4	0.34	USEPA 2017
Urban 2 (Mid-Density Residential/Commercial)	29.4	0.9	0.55	USEPA 2017
Urban 3 (Roads)	43.8	1.4	0.82	USEPA 2017
Urban 4 (Industrial)	2.2	0.1	1.27	USEPA 2017
Urban 5 (Parks, Recreation Fields, Institutional)	0.0	0.0	0.29	USEPA 2017
Agric 1 (Cover Crop)	2.9	0.1	0.29	Omernik 1976
Agric 2 (Row Crop)	8.5	0.3	0.37	Tarpey 2013
Agric 3 (Grazing)	10.8	0.3	1.5	Omernik 1976
Agric 4 (Hayland-Non Manure)	12.6	0.4	0.37	Tarpey 2013
Forest 1 (Deciduous)	183.4	5.9	0.03	USEPA 2017
Forest 2 (Non-Deciduous)	374.9	12.1	0.03	Tarpey 2013
Forest 3 (Mixed Forest)	1373.9	44.2	0.03	Tarpey 2013
Forest 4 (Wetland)	67.0	2.2	0.03	Tarpey 2013
Open 1 (Wetland / Pond)	21.9	0.7	0.01	Tarpey 2013
Open 2 (Meadow)	111.3	3.6	0.20	Schloss et al. 2000
Open 3 (Bare/Open)	20.6	0.7	0.80	USEPA 2017
Other 1 (Gravel Roads)	2.7	0.1	0.83	Hutchinson Environmental Sciences Ltd. 2014
Forest 5 (Logged Forest)	830.6	26.7	0.06	Logged values based on 2x forest P runoff export coefficient
Total	**3109.1**	**100.0**		

Table 9: Land Cover Categories and Phosphorus Export Coefficients for the Pine River Pond LLRM

The percentage of land cover by generalized type for the entire watershed is illustrated in Figure 11. The percentage of watershed phosphorus export by land cover type is illustrated in Figure 12. Watershed export does not include direct loads such as septic systems in proximity of the pond, waterfowl, internal load, or direct atmospheric deposition which are loaded directly to Pine River Pond. Although a small percentage of the land area has developed land cover (e.g., houses, roads, bare open land (recently logged), a large percentage of the phosphorus load to Pine River Pond comes from those land cover types. For Pine River Pond, a large portion of the recently logged forest cover is in the upper reaches of the Young Brook sub-watershed and the Northeast Direct sub-watershed.

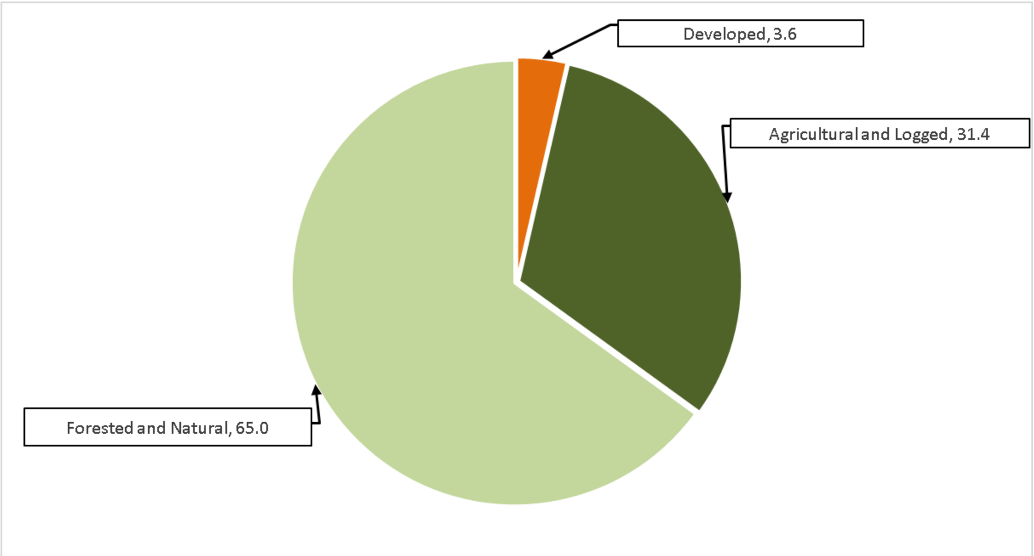


Figure 11: Percentage of Land Cover Type

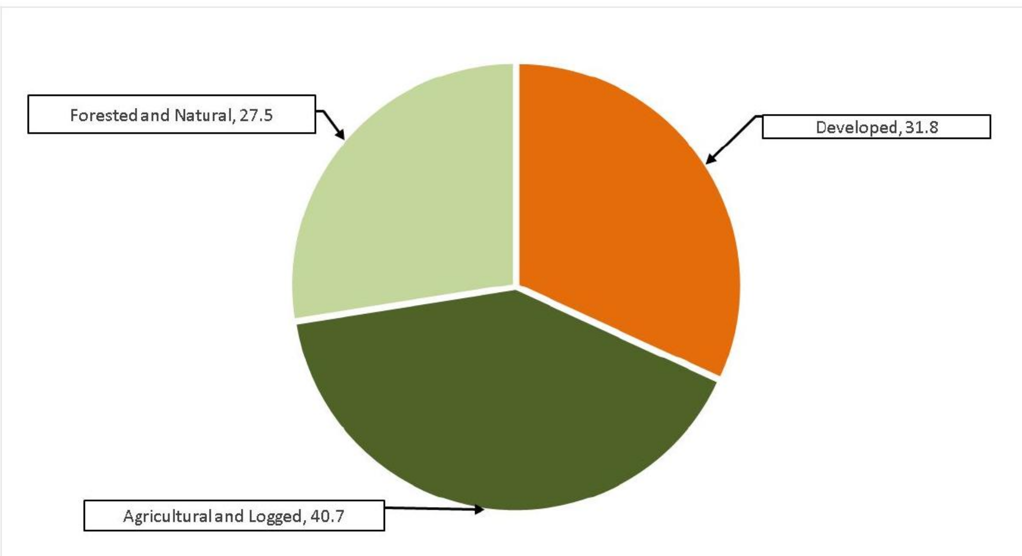


Figure 12: Percentage of Phosphorus Export by Land Cover Type

4.5.2 Atmospheric Deposition

Nutrient inputs from atmospheric deposition were estimated based on phosphorus coefficients for direct precipitation. The atmospheric load of 0.11 kg/ha/yr includes both the mass of phosphorus in rainfall and the mass in dryfall (Schloss and Craycraft 2013). The sum of these masses is carried by rainfall. The coefficient was then multiplied lake area (ha) to obtain an annual estimated atmospheric deposition phosphorus load.

4.5.3 Waterfowl

Phosphorus load from waterfowl was estimated using a phosphorus export coefficient and an estimate of annual mean waterfowl population of 54 provided by PRPA. The phosphorus export coefficient used for waterfowl was 0.2 kg/waterfowl/yr. Waterfowl loadings of nutrients are small relative to watershed loads but may be locally important to nearshore areas in the pond. Actual waterfowl counts would help improve this estimate. Waterfowl loading may be a component of the nutrient budget that can be beneficially addressed.

4.5.4 Septic Systems

Phosphorus export loading from residential septic systems was estimated within the 250-foot shoreline zone. These systems were split into new (<25 years) and old (>25 years) based on the 2021 septic survey conducted by PRPA and AWWA. Likewise, use was split into two categories, year-round and 4-month seasonal. It was assumed that there were the same proportion usage and age in the overall septic system population as in the survey respondent population. New systems were assumed to trap 90 percent of the phosphorus that entered them, while older systems were assumed to trap 80 percent.

4.5.5 Internal Loading

Internal loading generally refers to the release of phosphorus from sediments in the pond, typically under low oxygen conditions but also from resuspension of sediments. Anoxia has been observed in the deeper sections of the pond however only somewhat elevated phosphorus concentrations near the sediments have been observed in Pine River Pond, so this component is relatively small at this time (DKWRC 2021). Pine River Pond experiences an eight-foot drawdown every year. To quantify phosphorus contribution from eroding exposed sediments in the drawdown zone, the area was estimated from the difference in the pond’s area observed on Google Earth images from full pond to maximum drawdown. This difference represents 21.2 hectares that was assumed to be bare for six months of the year.

4.6 Phosphorus Loading Assessment Summary

Overall, the watershed of Pine River Pond is dominated by forest, previously logged forest, and residential land. The developed areas of the watershed tend to yield a larger portion of the nutrient load to the pond than their land area might suggest because of their relatively high nutrient export coefficients when compared to forest (Table 11 and Table 12). Phosphorus loads were estimated based on runoff and groundwater land cover export coefficients. Because much of the loading occurs in areas of the watershed close to the pond or tributary streams, attenuation of phosphorus loads was determined to be relatively low. Land based phosphorus load by sub-watershed is illustrated in Table 10. However, the phosphorus contribution on an areal (per unit area) basis provides additional information on which sub-watersheds have the most concentrated sources (Figure 14). So, while the Young Brook sub-watershed is the largest source of phosphorus overall, the direct drainage areas contribute substantially more phosphorus per unit area to Pine River Pond.

Note: Phosphorus loads presented in this table show gross runoff and baseflow. Net loads are somewhat lower due to attenuation through settling and absorption prior to entry into Pine River Pond.

	Land area (ha)	Load (kg/yr)
Young Brook S Branch	608.3	27.0
Young Brook	871.4	62.7
Meadow Brook	377.5	22.4
Quimby Brook	121.2	12.0
Northeast Brook	108.7	6.8
Southwest Brook	189.8	22.4
Northwest Direct	133.6	18.3
North Direct	20.8	2.5
Northeast Direct 1	87.5	6.7
Northeast Direct 2	262.7	24.7
Southwest Direct 1	9.4	1.4
Southwest Direct 2	53.9	7.7
Southeast Direct	261.2	24.1
Islands Direct	3.1	0.1
Total	3109.1	238.9

Table 10: Land Area Drained and Phosphorus Load by Sub-watershed for Pine River Pond

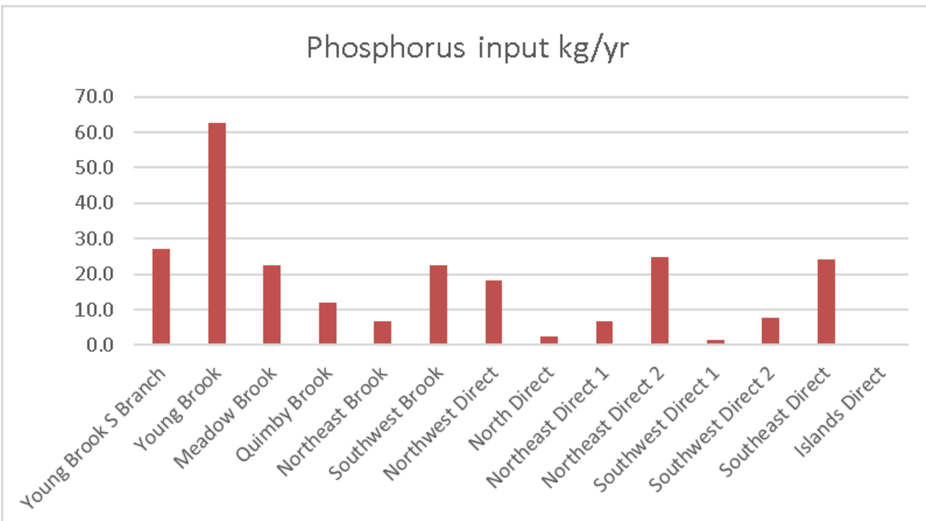


Figure 13: Current Watershed-based Phosphorus Loading by Sub-watershed for Pine River Pond

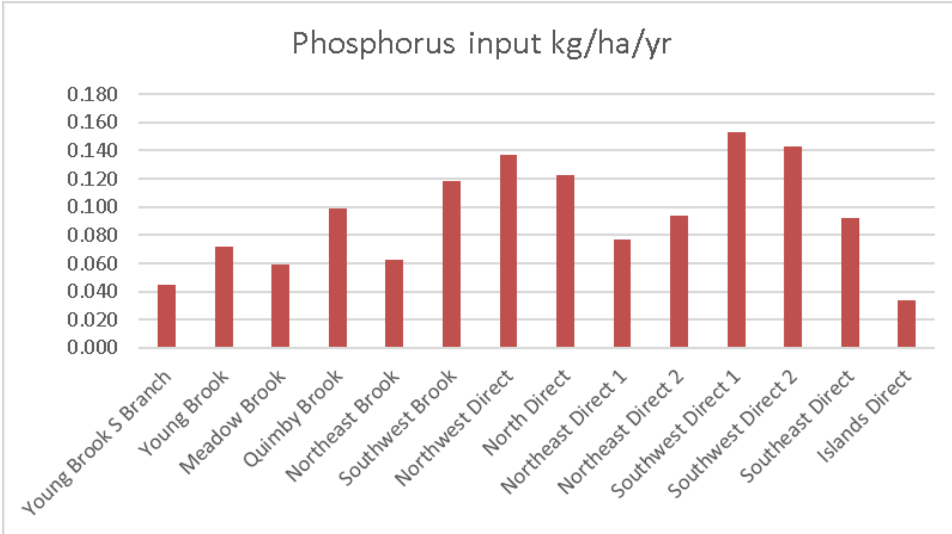


Figure 14: Current Areal Watershed-based Phosphorus Loading by Sub-watershed for Pine River Pond

The estimated existing phosphorus sources to Pine River Pond under current conditions by source are presented in Table 11. Loading from the watershed was overwhelmingly the largest source of phosphorus to the pond followed by septic systems. Both watershed management and septic inputs should be reduced to meet any future water quality goals.

WATERSHED AND DIRECT LOADS TO LAKE	Phosphorus (KG/YR)
ATMOSPHERIC	25.4
INTERNAL (Drawdown zone erosion)	8.5
INTERNAL (anoxic release)	3.6
WATERFOWL	7.2
SEPTIC SYSTEM	64.8
WATERSHED LOAD	180.9
TOTAL LOAD TO LAKE	290.4

Table 11: Pine River Pond Modeled Phosphorus Loading Summary Under Current Conditions

Estimated loads from the watershed as well as direct sources are used to predict in-lake concentrations of phosphorus, chlorophyll-*a*, Secchi Disk transparency, and algal bloom probability. The in-lake predictions were then compared to measured in-lake and tributary concentrations. A successful calibration shows a close agreement between predicted in-lake phosphorus and observed mean/median phosphorus. However, perfect agreement between modeled concentrations and monitoring data were not expected as monitoring data are generally limited to the ice-free season which may or may not be representative of long- term average conditions in the pond.

While the analysis presented above provides a reasonable accounting of sources of phosphorus loading to Pine River Pond, there are several limitations to the analysis:

- Precipitation varies among years and hence hydrologic loading will vary. This may greatly influence phosphorus loads in any given year, given the importance of runoff to loading.
- Spatial analysis has innate limitations related to the resolution and timeliness of the underlying data. In places, local knowledge was used to ensure the land cover distribution in the LLRM model was reasonably accurate, but data layers were not 100 percent verified on the ground. In addition, land covers were aggregated into classes which were then assigned export coefficients; variability in export within classes was not evaluated or expressed.
- Phosphorus export coefficients as well as runoff/baseflow exports were representative but also had limitations as they were not calculated for the study water body, but rather are typical regional estimates.
- The phosphorus loading estimate from septic systems was limited by assumptions associated with this calculation described above and in the "Septic Systems" subsection of AECOM (2009) and the extrapolation of septic survey results to the entire population of septic systems within 250 feet of the pond.
- Water quality data for the Pine River Pond tributaries are limited to concentration data, restricting calibration of the loading portion of the model. Collecting tributary flow data in conjunction with concentration data would allow calculation of loads which may improve the accuracy of the loading estimates generated by the model.

4.7 Response to Current Phosphorus Loads

Phosphorus load outputs from the LLRM methodology were used to predict in-lake phosphorus concentrations using empirical models. The models include: Kirchner-Dillon (1975), Reckhow (1977) and Nurnberg (1996). These empirical models estimate phosphorus from system features, such as depth and detention time of the waterbody. The load generated from the export portion of LLRM was used in these equations to predict in-lake phosphorus. The mean predicted phosphorus concentrations from these models were compared to measured (observed) values from the LLMP collected data. Input factors in the export portion of the model, such as export coefficients and attenuation, were adjusted to yield an acceptable agreement between measured and average predicted phosphorus. Because these empirical models account for a degree of phosphorus loss to the pond's sediments, the in-lake concentrations predicted by the empirical models are lower than those predicted by a straight mass-balance where the mass of phosphorus entering the pond is equal to the mass exiting the pond without any retention. Also, the empirical models are based on relationships derived from many other lakes. As such, they may not apply accurately to any one lake, but provide an approximation of predicted in-lake phosphorus concentrations and a reasonable estimate of the direction and magnitude of change that might be expected if loading is altered. These empirical modeling results and mean field data are presented in Table 12.

Because freshwater systems are most frequently limited by phosphorus, calibration of the model focused on matching predicted phosphorus with measured field data.

The model also predicts chlorophyll-*a*, Secchi Disk transparency and the probability of algal blooms. Chlorophyll-*a* was predicted by models from Vollenweider (1982) and NHDES (2009) while Secchi Disk transparency was predicted by Oglesby and Schaffner (1978). The probability of algal blooms was predicted by Walker (1984).

Water Quality Parameter	Pine River Pond
Annual TP Load (kg/yr)	290
Predicted TP (µg/l)	6.8
Epilimnetic Measured TP (2012-2021)(µg/l)	6.7
Predicted Chlorophyll-α (µg/l)	3.2
Measured Chlorophyll-α (2012-2021)(µg/l)	2.9
Predicted Secchi (m)	5.3
Measured Secchi transparency (2015-2019)(m)	5.6
Predicted Probability of Algal Bloom > 10 µg/l (% of time)	0.6

Table 12: Predicted and Measured Water Quality Parameters in Pine River Pond (2012-2021)

The phosphorus loads estimated using the LLRM methodology translates to predicted annual mean in-lake phosphorus concentration of 6.8 µg/l for Pine River Pond. This concentration is relatively low and would be expected to fuel little algal growth in the pond. Chlorophyll-*a* (a measure of the amount of algae) measurements are also low and slightly overpredicted by the model and the Secchi Disk transparency of Pine River Pond is also slightly lower than predicted. The model predicts that the pond will rarely experience pond-wide algal bloom conditions (chlorophyll-*a* > 10 µg/l) which is generally consistent with observations over the past several years.

The empirical lake models predict an annual average concentration of phosphorus. Comparison of modeled results to field data (summer epilimnetic concentrations) often results in modeled predictions that are slightly higher than observed concentrations. Collection of samples throughout the year (in particular, spring turnover samples) would give a better approximation of annual average phosphorus concentrations that may more closely match model results.

4.8 Natural Background Scenario

This scenario models a representation of the best possible water quality for Pine River Pond and was generated by converting all watershed land cover to forest and eliminating septic systems. While it is not realistic to expect the entire watershed to revert to forest, this scenario provides an estimate of the best possible water quality for the pond. Under this scenario, the pond would have been expected to have phosphorus concentrations approximately 2.5 µg/l and would support a trophic classification of oligotrophic or very low productivity (Table 13). Water quality would be excellent under this scenario.

Scenario	Total Phosphorus (µg/l)	Chlorophyll a (µg/l)	Secchi Transparency (m)	Probability of Algal Bloom > 10 µg/l (% of time)	Total Phosphorus Load (kg/yr)
Natural Background	2.5	1.3	11.2	0	110
Current Conditions	6.8	3.2	5.3	0.6	290

Table 13: Predicted Water Quality Parameters Under Natural Background as Compared to Current Conditions for Pine River Pond[6]

4.9 Load Reduction Scenarios

The LLRM model was used to evaluate the impact of potential structural and non-structural BMPs and associated reductions in phosphorus loading to Pine River Pond. Typically, phosphorus reductions come from several categories of loads to a lake: structural BMPs, non-structural BMPs, and septic system upgrades. Table 14 demonstrates the likely impact of a variety of future load reduction management activities. These simulations of load reductions that could be achieved through various management approaches demonstrate the value of phosphorus loading reductions and the influence of such reductions on in-lake conditions including a reduced probability of algal bloom occurrence.

Scenario	Phosphorus (µg/l)	Chlorophyll *a* (µg/l)	Secchi Transparency (m)	Probability of Algal Bloom > 10 µg/l (% of time)	Phosphorus Load (kg)
Current Conditions	6.8	3.2	5.3	0.6	290
10% increase in load	7.5	3.5	4.9	0.9	319
5% decrease in load	6.4	3.1	5.5	0.4	276
10% decrease in load	6.1	2.9	5.8	0.3	261
15% decrease in load	5.8	2.7	6.0	0.2	247
20% decrease in load	5.4	2.6	6.3	0.2	232
25% decrease in load	5.1	2.4	6.6	0.1	218

Table 14: Predicted Water Quality Parameters Under Various Loading Scenarios as Compared to Current Conditions for Pine River Pond

[6] DK Water Resource Consulting uses kg/yr for water quality reporting; AWWA and NHDES use lbs/yr for BMPs and water quality goals. The conversion is 1kg/2.2lbs.

5 Water Quality Goals for Pine River Pond (Element B)

Water quality goals are a critical component of watershed management plans. The plan's water quality goals are measures by which watershed management success is tracked. The water quality goals describe the pollutant load reductions needed to maintain or improve the pond's water quality. The establishment of water quality goals for Pine River Pond was guided by output from the LLRM methodology, an analysis of water quality data, and input from watershed residents on the attainment of desired uses for the pond.

The Pine River Pond watershed goal setting process determined that reducing phosphorus loading to meet an in-lake concentration of 6.0 micrograms per liter would reduce the probability of algal blooms occurring in the pond. Based on output from the LLRM modeling conducted for the watershed management plan, it is estimated that a 10 percent reduction of phosphorus from the current load to the pond is needed to meet the water quality goal (Figure 15).

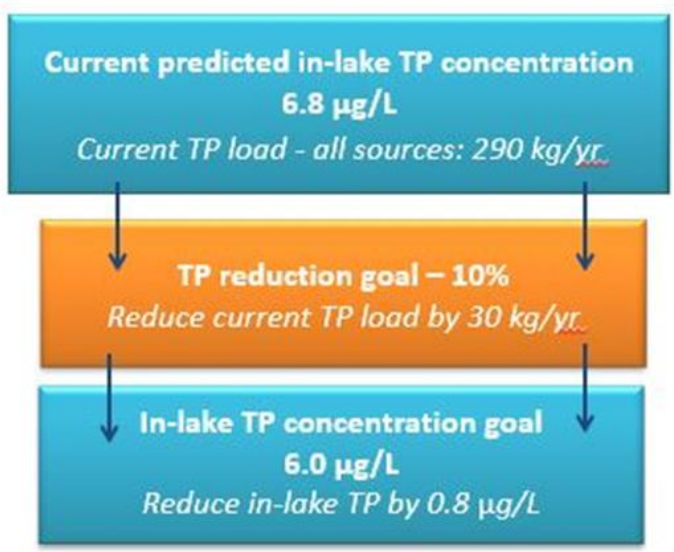


Figure 15: Pine River Pond Water Quality Goal - Prevent Cyanobacteria Blooms

In summary, to attain the water quality goals for Pine River Pond, phosphorus load reductions will be needed from multiple sources. The management actions proposed in the following sections of the Pine River Pond Watershed Management Plan will result in modest reductions in phosphorus concentrations, which in turn, may prevent algal blooms. Therefore, it is critical that the watershed management actions described in this plan are implemented over time to meet the water quality goals for the pond.

6 Action Plan for Implementation (Elements C, D, and E)

This section presents recommendations for management actions to control and reduce phosphorus loading to the pond in the direct drainage area. Recommendations for controlling phosphorus loading are presented in the following four categories:

Category 1: Structural Controls

Category 2: Non-structural Controls

Category 3: Septic Systems

Category 4: Regulations

Category 5: Watershed Outreach

Management measures to address sources of phosphorus are presented for each management action category, including a description of the approach, location, costs, partners, and pollution load reduction estimates (if known). Further, Table 27 of this plan offers a list of potential funding sources to implement the management actions.

The impact of load reductions from management actions implemented in upstream sub-watersheds is somewhat less than that of actions located in the pond's direct drainage area as attenuation along the watershed's flow path reduces the load to Pine River Pond as it travels downstream. Examples of upstream features that would attenuate the phosphorus load delivered to Pine River Pond include the presence of lakes or ponds, wetlands, well drained soils/groundwater recharge areas or existing controls. Due to this phenomenon, focusing on the pond's direct drainage area in early phases of watershed plan implementation should be a priority.

Water Quality Goal Attainment: If implemented, the BMPs proposed in this plan are estimated to reduce phosphorus loading to the pond by approximately 100 pounds per year. If all BMPs are implemented, the target load reduction of 66 pounds per year would be exceeded by over 60 percent.

6.1 Structural Controls (Category 1)

Structural BMPs are a critical management tool for reducing pollutant loads delivered to Pine River Pond from stormwater runoff. Typically, structural BMPs are stationary and permanent. Many structural BMPs rely on natural elements such as vegetation and soil processes to trap and remove pollutants. Additionally, structural BMPs designed to use infiltration mechanisms can also reduce the volume of stormwater runoff which can help to reduce the erosive force of runoff.

6.1.1 Private Road Stormwater Management

Examples of structural stormwater management BMPs on private roads include vegetated swales, check dams, grading, crowning, turnouts, catch basins, and culverts. To function properly, structural BMPs require on-going maintenance, and implementation efforts must take this into consideration when working with partners to build BMPs – all structural BMPs need an "owner" that is willing to follow the required operation and maintenance guidelines for the BMP.

To identify potential private road BMP projects on Pine River Pond, PRPA in collaboration with AWWA and NHDES, conducted a watershed survey in the Spring of 2021 to identify locations where structural approaches could be implemented to reduce phosphorus loading to Pine River Pond. The assessment focused on identifying erosion and stormwater runoff areas within the watershed that were reaching the pond, and prioritized these potential projects based on the scope of erosion and the presence of vegetation as well as potential cost. Survey crews developed recommendations for actions to address pollutant loading for identified problem areas. The BMPs were prioritized based on potential to reduce phosphorus loading to the pond, costs, and complexity of implementation (Table 15).

Site	**BMP Recommendations**	**P Loading lb/yr**	Cost Estimate	**Impact**
8-28	Crown, Add Road base material, Rubber Razor, Open Top Culvert, Ditch & Check Dams	10.0	$6,000	High
8-21	Pave, Crown, Ditch & Check Dams, Rubber Razor, Open Top Culvert limit size of driveway	12.0	$8,000	High
3-48	Crown, Turn outs, Ditch & Check Dams	17.0	$8,500	High
3-49	Add road base material, Crown, Install Detention Basin, Turn outs, Ditch & Check Dams	8.5	$12,000	High
2-13	Vegetate Shoulder, Install Catch Basin	0.4	$5,000	Medium
2-19	Install Catch Basin	0.4	$5,000	Medium
6-04	Vegetate Shoulder, Install Catch Basin	0.0	$5,000	Medium
2-02	Add road base material, Rubber Razor, Install Catch Basin	2.1	$7,000	Medium
8-09	Vegetate Shoulder, road shoulder and bank near culvert needs to be stabilized	0.3	$7,000	Medium
2-01	Vegetate Shoulder, retaining wall	2.5	$10,000	Medium
7-18	Remove Grader Plow Berms, turn outs, Install Detention Basin	2.6	$5,000	Medium

Table 15: Prioritization of Structural BMPs on Private Roads

6.1.2 Residential Stormwater Management

Many erosion sites identified in the Pine River Pond Watershed Survey were found on residential properties. A property was documented on the survey if there was evidence of stormwater getting directly into the pond from the property's shoreline. As such, shoreline stabilization projects are combined with residential stormwater management in this report. For each identified erosion site, surveyors identified which stormwater BMPs could be installed to correct the issue. The most common structural BMPs recommended for residential sites were vegetated buffer, infiltration paths, dripline trenches, erosion control mulch, water bars, and rubber razors.

Site	BMP Recommendations	P Loading lb/yr	Cost Estimate	Impact
8-24	Plant native vegetation, reseed bare soil, cover/remove bare sand	5.4	$500	High
9-02	Eliminate raking, reseed bare soil, erosion control mulch, dry wells	0.6	$400	High
3-13	Install water bars and rubber razors	0.3	$300	High
3-14	Erosion control mulch, native vegetation, terracing	4.3	$500	High
8-23	Install infiltration path, native vegetation, water bars, rubber razors	8.5	$600	High
7-14	native vegetation, reseed bare soil	0.5	$300	High
8-07	Native vegetation, reseed bare soil, erosion control mulch	1.2	$500	High
7-03	water bars, rubber razors, erosion control mulch	0.4	$1,000	High
2-15	Infiltration Path, Reseed bare soil, Erosion Control Mulch	5.3	$1,000	High
3-05	Erosion Control Mulch, Rubber Razors, Reseed bare soil, turnout	12.2	$1,000	High

Table 16: Prioritization of Residential Stormwater BMP Implementation Projects

6.1.3 Culverts

There are several culverts that convey small streams and brooks under private roads and into Pine River Pond. Many are old or undersized and need to be repaired or replaced. The most common issues found at culverts are erosion around wingwalls, crumbling wing and headwalls, scouring from increased water velocity due to undersized pipes, and pipes being crushed by the weight of vehicles. Culverts can be upgraded by armoring existing wingwalls and headwalls, vegetating adjacent slopes to improve soil stability. If replacement is necessary, pipes should extend beyond the road in either direction and the opening should extend beyond the natural width of the stream (target is 1.2 times the stream width). The Pine River Pond watershed survey identified three culvert sites that have failing infrastructure and are contributing erosion to the pond.

Site	Recommendations	P Loading lb/yr	Cost Estimate	Impact
6-14	Armor inlet & outlet	NA	$1,000	Medium
4-14	Stabilize headwall with erosion control mulch and vegetation	NA	$1,500	Medium
7-12	Armor inlet & outlet. build wing walls	NA	$5,000	Low

Table 17: Culvert Projects

6.2 Non-Structural Controls (Category 2)

Non-structural BMPs typically do not involve construction and are often more broadly applied throughout a watershed. Often these BMPs can result in significant pollutant load reductions. Examples include:

- Regulations

- Land conservation
- Fertilizer reduction
- Pet waste management
- Waterfowl management
- Vegetated buffers

BMP	Goal Description	Potential Partners	Result	Estimated Cost
Regulations	Consult with current Shoreland Officer and DPW to ensure enforcement of existing shoreland protection laws.	AWWA, PRPA, Town of Wakefield	Shoreland regulations are enforced	$5,000
Land Conservation	Work with local landowners, the town of Wakefield, and local land trusts to protect forested and agricultural lands in the pine river pond watershed.	PRPA, Town of Wakefield, MMRG	Land protection efforts are initiated and tracked	$500 and up
Fertilizer Reduction	Create digital and physical outreach to educate homeowners on the impact of fertilizer on water quality.	PRPA, AWWA	2-6 lbs/yr of phosphorus (P) reduction	$500
Waterfowl Management	• Implement shoreline modifications including vegetated buffers and no mow areas to manage waterfowl. • Conduct outreach to discourage homeowners from feeding waterfowl. • Conduct a waterfowl assessment to better understand impacts.	PRPA	1 - 4 lbs/yr of P reduction per project (for shoreline modification projects)	$500 - $1,000
Vegetated Buffers	Provide outreach and education about the many benefits of having a vegetated buffer on a lake front property.	PRPA, AWWA	Educational materials distributed annually	$500

Table 18: Prioritization of Non-structural BMPs

6.3 Septic Systems (Category 3)

This section provides an assessment and recommendations related to priority areas for potential subsurface wastewater management upgrades within the Pine River Pond watershed. In 2021, the PRPA and AWWA conducted a Residential Septic System Survey to acquire data about existing systems. The primary factors identified in the survey that could affect water quality include age of a system, proximity to the pond, number of people using the system, and how many months it was being used in a year. The watershed's population is served entirely by on-site septic systems, many of which are 80+ years old and very close to the pond and located in sandy soils having high transmissivity rates – meaning, there is not much opportunity for phosphorus to attenuate before reaching the pond. Septic systems represent approximately 22 percent of the contributing load of phosphorus load to Pine River Pond. Other than erosion, septic systems are one of the larger contributors of nutrients to the pond. Managing phosphorus loading from septic systems will be a critical strategy for improving water quality.

Septic systems function to treat wastewater to protect human health and water quality. However, systems that are poorly maintained, older, and those that are located without adequate separation to groundwater present a risk to water quality. When septic systems do not function properly it is likely that either they were installed before current standards were in effect (1967) or they were not adequately designed, sited, constructed, or maintained. NHDES estimates that between eight and ten percent of current septic system approvals address repair or replacement of existing systems (NHDES, 2020). As a result of a law (RSA 485-A:39) passed in 1993, evaluation of systems within 200 feet of a great pond or fourth order or higher river is required before the property changes hands; however, upgrading substandard systems is not required.

Modest reductions in phosphorus loading to the pond could be achieved if homeowners take responsibility to inspect their septic systems and conduct necessary maintenance or upgrades. Yearly pump outs and frequent inspection are essential. PRPA will conduct continuous outreach to the Pine River Pond community about septic maintenance, and also participate in septic cost-share replacement programs when funding allows to replace systems on the pond that have the greatest impact on water quality. Table 20 outlines questions that were asked in the PRP Septic Survey and sample data that was gathered.

Action Item	Description	Potential Partners	Estimated Cost	Results
Septic system outreach	Provide educational information about proper septic system operation and maintenance. Create list of local vendors who will do inspections and annual pumping.	PRPA, AWWA	$5,000	Fewer failed system, systems last longer, prevents future P sources
Septic system upgrades	Encourage upgrades and offer septic system cost-share program to offset cost of replacement. Prioritize based on greatest impact to water quality.	PRPA, AWWA	$200,000	1 - 3 lbs/yr of phosphorus reduction per upgraded system

Table 19: Management Actions to Reduce Phosphorus Loading from Septic Systems

Type of System	System Age (yrs)	Distance to Lake (ft)	Months Used	Occupancy	Pump Schedule	Last Pumped
Septic, Holding Tank	40+	0-50	0 - 3	3 - 4	Every 2-5	2020
Septic	40+	0-50	0 - 3	1 - 2	Never	na
Septic	40+	50-100	3 - 6	1 - 2	Every 5-10	2016
Cesspool	40+	50-100	0 - 3	3 - 4	More than 10	Do not recall
Septic, Holding Tank	40+	50-100	0 - 3	3 - 4	Every 1-2	2020
Septic	40+	50-100	0 - 3	1 - 2	Every 2-5	2020
Septic	40+	50-100	0 - 3	1 - 2	Every 2-5	2020
Holding Tank, Leaching field	40+	100-250	6 - 12	3 - 4	Every 2-5	2019
Holding Tank	40+	100-250	6 - 12	1 - 2	Every 2-5	2019
Septic	40+	100-250	6 - 12	1 - 2	Every 2-5	2020

Table 20: Prioritization of Septic System Upgrades on Pine River Pond Based on 2021 survey

6.4 Regulations (Category 4)

Municipal land-use regulations are a guiding force for where and what type of development can occur in a watershed, and therefore, how water quality is affected because of this development. Action items related to this element include the adoption of new or revisions to existing ordinances or incorporation of new standards that will directly protect water resources such as groundwater/aquifers, and surface waters and wetlands and their buffer areas. Regulatory options include zoning ordinances and land development regulations which are summarized in Table 21.

Each regulatory option described in Table 21 has its specific process for adoption and jurisdictional limitations. Zoning ordinances apply to all land and activities that take place on it whether a permit is required or not (e.g., Zoning Board, Planning Board or Building Permit). Land development regulations apply to development for which a permit is sought from the Planning Board including, subdivision of land or Site Plan Review, which covers all non-residential and multi-family development.

Zoning ordinance amendments are approved by voters by warrant article at town meeting. Typically, quite a lot of public outreach is implemented in advance of proposing a warrant article and the final vote. Site Plan Review Regulation and Subdivision Regulation amendments are administered and approved by the Planning Board through a public hearing process and the amendment process can occur at any point in the year.

Action Item	Description	Responsible Party	Funding	Schedule
Work with Town to provide the PRPA with notice when the Board of Assessors is presented an Intent to Cut Form for approval	Allow the PRPA to communicate to ensure proper forestry practices are employed to protect stream systems within the watershed. The State Forestry Service assists parties harvesting timber about how to properly protect water crossings, and their involvement is critical to protect the lake from nutrient runoff.	PRPA, Town Administrator, Board of Assessors, Assessor's Office	PRPA (volunteer time)	2023-2033
Work with Wakefield Planning Board to provide the PRPA with notice when applications involving the Shoreland Zone come before the Board for approval	Applications for Shoreline Zone work can involve a variety of topics that could prove harmful to the watershed. Being aware of pending applications so that the interests of the lake and the watershed are given the opportunity to be presented would go a long way in serving to protect water quality.	PRPA, Land Use Office (Code Enforcement Officer & Shoreland Protection Officer)	PRPA (volunteer time)	2023-2033
Work with Wakefield Zoning Board to provide the PRPA with notice when applications involving the Shoreland Zone come before the Zoning Board of Adjustment for approval	Applications for Shoreline Zone work can involve a variety of topics that could prove harmful to the watershed. Being aware of pending applications so that the interests of the lake and the watershed are given the opportunity to be presented would go a long way in serving to protect water quality.	PRPA, Land Use Office (Code Enforcement Officer & Shoreland Protection Officer)	PRPA (volunteer time)	2023-2033
Explore partnerships at the regional and statewide level to obtain funding for additional land conservation efforts around the lake	Regional and statewide land conservation organizations, such as SELT, MMRG, the Forest Society, TNC and the Lakes Region Conservation Trust, can help provide funding and stewardship for land protection activities.	PRPA, AWWA, Conservation Commission	NHDES, LCHIP, and other grants	As opportunities to preserve land present themselves

Table 21: Municipal Land Use Regulations, Policies, and Land Conservation

6.5 Watershed Outreach (Category 5)

The goal of outreach and education is to help change how people think and treat their property. Whether dealing with practices of past decades that many may have grown up with, or newcomers who have no understanding of what behaviors are harmful to water quality, outreach presents opportunities to:

- Promote activities that reduce or prevent pollutant loading such as:
    - fertilizer use reduction,
    - road salt use reduction,
    - scooping pet waste,
    - proper care of septic systems,
    - camp road maintenance best practices, and
    - lake-friendly landscaping workshops.
- Educate on local and state regulations through explaining them, what they serve to protect, the importance of compliance, and who to contact if you have questions.
- Present and provide updates on local warrant articles and state legislation that promotes clean water policies and responsible use and care of the pond.
- Promote and provide links to programs, webinars and talks about what people can do on their property and along and on the water to help keep the pond clean and healthy:
    - Planning and installing BMPs
    - Cyanobacteria
    - Wildlife
    - Climate impacts
    - Healthy forests
    - Lake-friendly living
    - Ecology and management of lakes
    - Aquatic invasive species (AIS)

As part of outreach, PRPA will use a four-prong approach to reach a vast audience through use of its website page, emails, annual newsletter, and Facebook Page.

- The website can be accessed by anyone, and a Watershed Management tab will be added to provide information about all the above activities.
- The eNews is PRPA's primary communication tool with its members, and is emailed weekly during the warmer months, and every other week off-season. A cycle of articles will provide information and links on the above outreach efforts for shorter-term and seasonal items like legislation updates, pet waste reminders, landscaping workshops, road salt use, and cyanobacteria status.
- The annual Newsletter is produced in hard copy and mailed to all members with membership renewal information. The Newsletter serves to inform on items like water quality reports and committee information. Articles in the Newsletter provide longer-term information that will be suitable for a BMP and AIS pamphlet, and articles on fertilizer use, septic system care, healthy forests, and lake-friendly living.

- The PRPA Facebook page reaches an audience beyond the members (non-members like renters, extended family, and friends). Posts would be topic-dependent since not all in this audience are property owners. However, appropriate information for this audience would include the importance of pet waste clean-up, and lake courtesy behavior that relate to water quality (no bathing with soap/shampoo in the pond, not letting pets use the islands as their bathroom, proper ways to observe wildlife (e.g., loons).

The PRPA will work with AWWA to host workshops to give property owners, road associations, and non-association camp roads an interactive experience and education on how to manage stormwater runoff issues, plan and build simple BMP projects, and what low-maintenance native plants are available for various conditions around the pond.

Action Item	Description	Responsible Party	Funding	Schedule
Update Pine River Pond Association website	Add tab for watershed management, and regulations accessible by the public	PRPA	N/A	Yearly
eNews Communication	Articles on education and outreach items above to members	PRPA	N/A	Seasonal - Weekly/Bi-monthly
Annual Newsletter	Hard copy articles on education and outreach items to members	PRPA	N/A	Annually
Facebook Page	Promote articles and links for outreach and education to audience beyond members	PRPA	N/A	Topic-dependent
Encourage road associations to use Green SnowPro and SALT certified contractors	Participation in this training to employ best management practices for snow and ice management on camp roads	PRPA, road associations	N/A	Yearly
Workshops	Hands-on, interactive education about stormwater management, BMPs, and native plants	AWWA, PRPA	To be determined	Yearly

Table 22: Outreach Action Matrix

7 Schedule and Milestones (Elements F and G)

The project schedule and milestones presented in this section will enable project partners to track remediation activities of watershed survey findings (pgs. 70 through 79) over time as part of the overall Watershed Management Plan.

The schedule is designed to ensure that nonpoint source management measures presented in the plan are implemented in a timeframe that is reasonably expeditious. The milestones are a set of success indicators for determining if management measures or other control measures are being implemented. Both elements are critical tools for tracking programmatic success over time.

7.1 Schedule

Major milestones for the implementation schedule for the survey related recommendations (pgs. 70 through 79) is presented in Table 23 (page56). Additionally, the Watershed Plan provides short- and long-term goals for improving the water quality of Pine River Pond over the next ten years (2022-2032). The schedule will be evaluated annually and revised as needed according to actual progress.

Implementation Task	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
1.0 Finalize Pine River Pond plan and distribute	▶										
2.0 Implement structural BMPS											
2.1 BMP implementation assessment and planning	▶				▶	▶	▷				▷
2.2 Round 1 BMP implementation	▶	▶	▶	▶	▶						
2.3 Continue planning and implementing BMPs						▶	▷	▷	▷	▷	▷
2.4 BMP operation and maintenance tracking			▶	▶	▶	▶	▷	▷	▷	▷	▷
4.0 Implement non-structural BMPs, septic system projects, and outreach	▶	▶	▶	▶	▶	▶	▷	▷	▷	▷	▷
5.0 Monitor water quality	▶	▶	▶	▶	▶	▶	▷	▷	▷	▷	▷
6.0 Review progress and report to project partners		▶		▶		▶		▷		▷	

Table 23: Implementation Schedule

7.2 Milestones

A description of interim, measurable milestones for determining if NPS management measures are being implemented is presented in Table 24.

Management Measure	Milestones
Watershed plan development	● The Pine River Pond Watershed Management Plan is complete and publicly available ● Efforts are underway to conduct outreach for the plan and build capacity for implementation
Structural BMP implementation	● Number of BMPs implemented and pollutant load reduction estimates are documented ● Operation and maintenance plans for BMPs are developed and BMP maintenance is tracked
Non-structural BMP implementation	● Annual metrics are tracked and documented ● Pounds per year pollutant load reduction is tracked and credited for non-structural practices
Septic systems	● Number of systems upgraded is tracked ● Pollutant load reduction estimates for upgrades are documented
Watershed outreach	● Number of outreach materials and events is tracked ● Number of participants in outreach events tracked
Water quality monitoring	● Monitoring is conducted annually, and reports/data evaluated to assess progress toward attaining water quality goals
Implementation tracking	● Plan implementation progress is tracked and reported to stakeholders every two years ● Adaptive management approaches are developed, if needed

Table 24: Pine River Pond Watershed Implementation Milestones

8 Success Indicators and Evaluation (Element H)

8.1 Water Quality Monitoring

Water quality goals established for the Pine River Pond Watershed Management Plan provide a framework for establishing numeric and narrative success indicators to 1) measure whether the in-lake phosphorus concentration becomes lower as management measures are implemented, and 2) track the frequency of cyanobacteria blooms to determine if bloom frequency is reduced as phosphorus loads decline.

As discussed in Section 4.7, page 42, the current predicted in-lake phosphorus concentration for Pine River Pond is 6.8 µg/L. The target epilimnetic in-lake phosphorus concentration target for Pine River Pond is 6.0 µg/L. To meet this goal, the annual phosphorus load to the pond needs to be reduced by approximately 30 kg/yr. To evaluate whether pond management measures are successful, targets shown in Table 25 will be measured and tracked as the management plan is implemented to determine if substantial progress is being made towards attaining the plan's water quality goals. Additionally, if regular progress reporting as shown in Table 23: Implementation Schedule shows that management targets are not being met, project partners will convene to evaluate and develop adaptive management approaches for meeting water quality goals.

8.2 Cyanobacteria Monitoring

The objective for monitoring cyanobacteria for Pine River Pond (PRP) is threefold with the third building upon the first two:

1. Track the development of cyanobacteria and dynamics within PRP;
2. Track trends that may be due to climate changes and current or emerging land use practices; and
3. Assess lake and human health vulnerability to cyanobacteria.

The monitoring component will focus on the relative concentrations of cyanobacteria found within the epilimnetic/photic zone by using fluorescence pigment measurements of chlorophyll-*a* and phycocyanin. Instruments used will have an established MDL of 1-2ppb for phycocyanin and 1ppb or less for chlorophyll-*a*, and a broad linear range from the 1-2ppb to 100,000ppb or greater for phycocyanin, and from 1ppb up to 2,500ppb for chlorophyll-*a* providing for adequate detective range values to track the seasonal progression of phytoplankton and the development of harmful cyanobacteria blooms. Data will be posted as required after quality control review.

Quality control measures ensure that the data collected is accurate, precise, and meets the needs of the end data users. All instruments will be calibrated annually prior to the state of the sampling season. Instrument group calibration will involve serial dilution series to check the instrument MDL at the start of the sampling season. The fluorometry instrument shall be checked prior to sampling utilizing solid state secondary standards to check primary calibration and ensure that any drift in the instrument is identified and corrected. Once each sampling season, triplicate samples will be collected. Triplicate readings of a sample will occur once for every 15 samples measured.

Ambient water sample for fluorometry will be collected at a 3-meter depth to fairly represent a depth to which sunlight penetrates the water surface sufficiently to support primary production and the development of bloom forming cyanobacteria. Samples may be collected in various locations and will be collected every other week from the beginning of June through September when algal blooms frequently occur. Additional baseline sampling may be added at the discretion of the monitoring group that may provide better insight to the unique dynamics and characteristics of PRP.

Open water samples will utilize an integrated tube sampler lowered into the water column 3 meters. One sample shall be collected every other week at minimum from the deep spot of PRP. Collection of shoreline samples will utilize the integrated tube sampler for data consistency and quality control. Samples shall be collected from the same locations throughout the sampling season, and additional samples may be collected at other locations such as coves or brook inlets where blooms are known to develop.

Sampling locations will be recorded using GPS coordinates. The first sampling location will be the deep spot. All locations coordinates will be recorded in decimal degrees and contain at least four decimal places to provide location accuracy of about 10 meters. Samples will be collected as close to the same time of day as is possible to provide consistency for the sample monitoring. In 2022, sample collection began to include mirroring the locations where water quality samples are collected to gather additional data for a more complete evaluation of PRP.

Sample bottles will be rinsed with the initial 3-meter sample, and then a second sample will fill the bottle, capped, labeled, and placed on ice in a darkened cooler. Labeling will include PRP, State, location ID (e.g., deep spot), date, time, and the sample type (e.g., IT for integrated tube), and sample depth (e.g., 3m). Samples should be tightly sealed and placed in a cooler until they can be frozen later that same day for future analysis. Ambient phycocyanin and chlorophyll-*a* fluorescence measurements may be taken prior to freezing. Samples will be placed on ice if ambient readings cannot be taken right away and rewarmed to 20-24 degrees C to avoid photodegradation of the pigments. Samples will be gently mixed for 30 seconds prior to pipetting out for the fluorometer. Samples shall be transferred and frozen as quickly as possible for phycocyanin, chlorophyll-*a*, and possible toxin analysis.

Water Quality Indicator	Current Conditions [2012-2020]	Target
Annual phosphorus load (modeled)[1]	290 kg	260 kg
Annual average phosphorus concentration (modeled)[1]	6.8 µg/l	6.0 µg/l
Epilimnetic phosphorus concentration (measured)	6.7 µg/l	≤6.0 µg/l
Annual average chlorophyll-*a* (measured)[2]	2.9 µg/l	<3.20 µg/l
Secchi disk transparency depth (measured)	5.6 m	>5.0 m
Predicted probability of algal bloom >10 µg/l [1,3]	2 days	1 Day

Evaluation methods: Targets shown above will be measured and tracked annually as the management plan is implemented to determine if substantial progress is being made towards attaining water quality goals. Additionally, if regular progress reporting as shown in Table 23: Implementation Schedule shows that restoration targets are not being met, project partners will convene to evaluate and develop adaptive management approaches for meeting water quality goals.

[1] Pine River Pond Watershed/Lake Model (DKWRC, 2021)
[2] Incorporates a measure of safety of 10 percent over annual average of 2.9 µg/l
[3] Current probability of algal bloom >10 µg/l is 0.6 percent; predicted future probability is 0.3 percent

Table 25: Success Indicators and Evaluation Measures

9 Monitoring Plan (Element I)

Water quality monitoring is a critical activity for evaluating success of management actions and for measuring progress toward attainment of water quality goals. Water quality data has been collected regularly in Pine River Pond since 1977 (currently, as part of the UNH LLMP, and formerly, through the NHDES Volunteer Lake Assessment Program). The PRPA will continue this effort as the watershed plan is implemented, and results will be used to evaluate attainment of the plan's water quality goals. The PRPA recognizes and understands the importance of a robust and continued monitoring effort for Pine River Pond.

Currently PRPA tests water quality at five locations across the lake including the deepest point, as well as Young Brook, Meadow Brook, and Quimby Brook on a monthly basis. They test for water clarity, chlorophyll a, Total Phosphorus, dissolved oxygen, color, alkalinity, pH, and conductivity.

The following water quality monitoring recommendations were proposed for inclusion in Pine River Pond's current water quality monitoring program based on testing and results from the lakebed sediment sampling. These recommendations have been incorporated for the 2022 sampling season (expanded sampling components in red and proposed Internal Nutrient loading evaluation in Blue):

1. Standard monthly deep site sampling.
2. Standard monthly Stream sampling @ Quimby, Meadow and Young Brooks.
3. Expanded evaluation/sampling of small stream (unnamed brook/Wentworth Cove) during monthly visits. Collect samples if stream is flowing.
4. On standby for bracketing of Young Brook which, if needed, would include supplemental upstream and downstream sampling locations.
5. Expanded monthly epilimnetic total phosphorus sampling at extreme ends of the lake; supplemental temperature/oxygen/conductivity profiles will also be collected.
6. Accessory monthly epilimnetic total phosphorus sampling in Sawdust Cove.

Pine River Pond Internal Nutrient Loading Evaluation (Proposed)

General Sampling approach:

- A multi-basin sampling effort will be employed that emphasizes the collection of dissolved oxygen profiles and the collection of total phosphorus samples near the lake bottom.
- Supplemental sampling will be conducted during the months of August and September, when the dissolved oxygen concentrations are likely to be reduced near the lake bottom. At a minimum, a YSI ProSolo meter will be used to collect a Temperature/Oxygen/Conductivity profile through the water column @ 0.5-meter increments. If a YSI EXO2 is available, additional parameters will be measured at finer increments (e.g., 0.1 meter) to characterize physical, chemical and biological variations.
- Total phosphorus concentrations will be collected when the dissolved oxygen concentrations (at the respective sampling location) are below 2.0 mg/l. Total phosphorus samples will be collected as close to the lake bottom (e.g., 0.5 to 1.0 meter) as possible without disturbing the bottom sediments.
- Sampling locations will typically be near the Pine River Pond sediment sampling locations; should sampling locations be adjusted, corresponding GPS coordinates will be collected, and the alternative locations will be visited during both the August and September sampling events. A deeper sampling location will be selected, near site 2, that better reflects the deepest location for that basin.

Site	Approximate Depth *(feet)*	Latitude (dd mm ss.ss)	Longitude (dd mm ss.ss)
PRP2 (deep)	20	43° 37’ 59.2”	71° 00’ 58.9”
PRP4	55	43° 37’ 40.2”	71° 00’ 41.0”
PRP6	30	43° 37’ 20.95”	71° 00’ 41.51”
PRP7	20	43° 37’ 12.13”	71° 00’ 03.06”

Table 26: Proposed Sampling Locations

Note: there are a couple other basins, based on bathymetry, which are approximately 30 feet deep and that could be added to the sampling regiment.

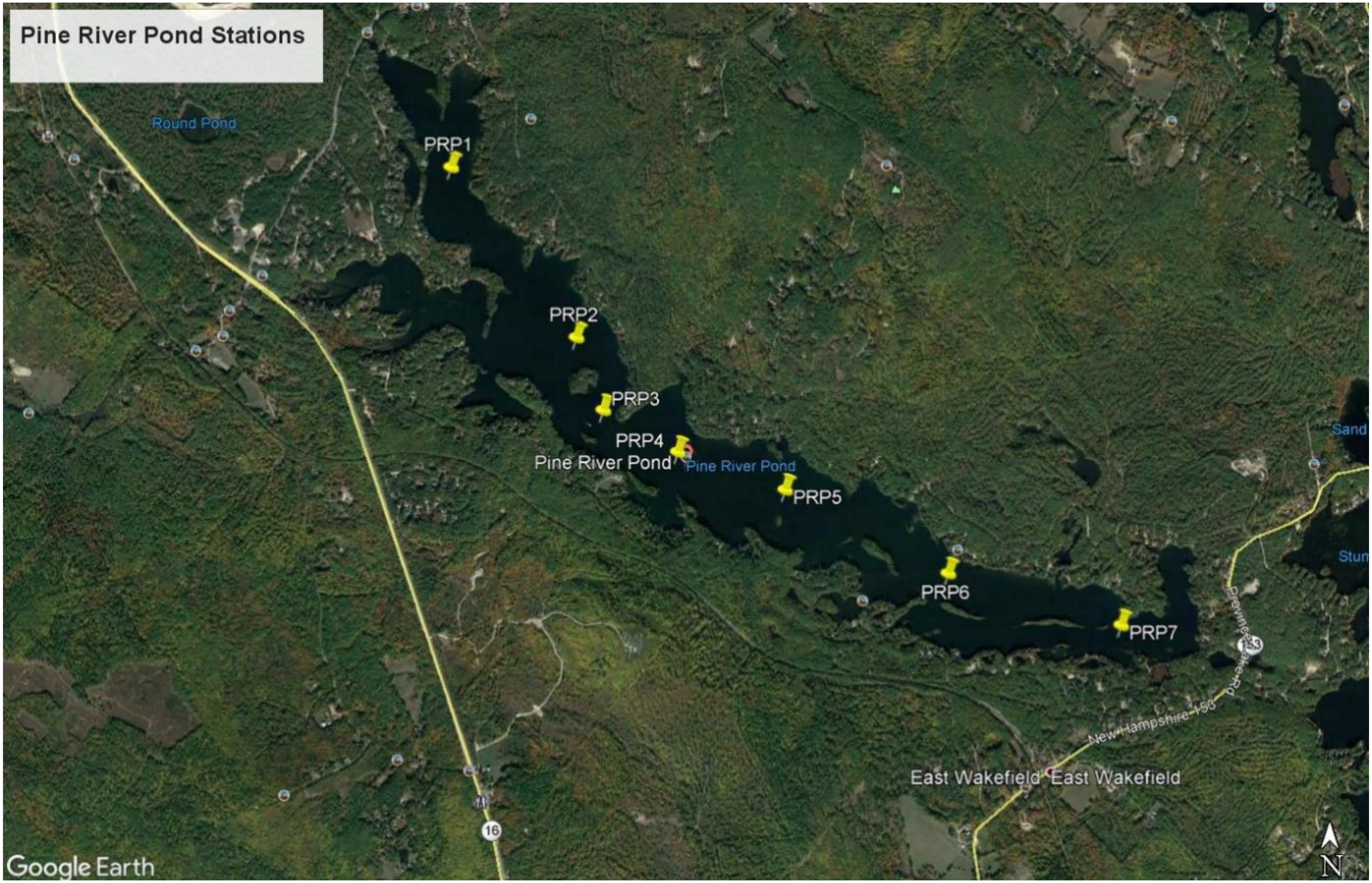


Figure 16: Sampling Locations by Number Assigned

10 Funding for Future Watershed Planning Phases and Implementation

Implementation of management recommendations for Pine River Pond will require significant financial support from diverse sources. State and federal grants, local contributions, private funding, and grants from other sources such as foundations will be required to implement watershed management and protection activities.

As the plan evolves, formation of a funding subcommittee would be a critical step for building local ownership and capacity for fundraising and project management. Table 27 summarizes potential sources of funding; however, this list is not exhaustive, and efforts should be made at the local level to continue to identify potential sources of support for watershed management and protection activities.

Funding Opportunity	Description	For more information
Aquatic Resource Mitigation Fund (ARM) - NHDES	Annual funding for conservation and water resources projects	Aquatic Resource Mitigation Fund | NH Department of Environmental Services
Clean Water State Revolving Fund - NHDES	Loans and funding for water quality projects (planning and implementation)	Clean Water State Revolving Fund | NH Department of Environmental Services
Land Transaction Grant Program - Great Bay Resource Protection Partnership	Funding for land conservation transaction costs	Great Bay Resource Protection Partnership (greatbaypartnership.org)
Milfoil and Other Exotic Plant Prevention Grants - NHDES	Annual funding for projects that prevent infestations of exotic plants	Rivers and Lakes | NH Department of Environmental Services
Moose Plate Grants - New Hampshire State Conservation Committee Grant Program	Annual funding for water quality, conservation, and habitat projects	Conservation Grant Program | State Conservation Committee | NH Department of Agriculture, Markets and Food
New England Grassroots Environmental Fund	Grants for sustaining environmentally sustainable communities	New England Grassroots Environment Fund (grassrootsfund.org)
New Hampshire Charitable Foundation	Multiple grant categories awarded annually including funding for environmental projects	Home - NH Charitable Foundation (nhcf.org)
Land & Community Heritage Investment Program	Grants for land and cultural protection activities	LCHIP - Protecting New Hampshire's Natural, Historic, and Cultural Resources
Water Quality Planning Grants - NHDES	Annual funding to assist regional planning commissions and their partners – for water quality projects	Watershed Assistance Grants | NH Department of Environmental Services
Watershed Assistance Grants - NHDES	Annual grant program with funding to implement projects described in watershed plans	Watershed Assistance Grants | NH Department of Environmental Services

Table 27: Funding Opportunities for Watershed Management and Protection

11 Conclusion

Pine River Pond is a thriving ecosystem with a tight-knit community that is experiencing significant environmental stressors resulting from development and climate change. These stressors are manifesting as increasingly frequent benthic and floating cyanobacteria blooms which indicate a tipping point in the ecosystem, but one that there is still time to address. This Watershed Based Plan clearly outlines the sources of environmental stress the lake is experiencing, both internally and externally, and provides recommendations on how these sources can be addressed through best management practices, outreach, and monitoring. Extensive modeling and data analysis indicates that while Pine River Pond has pockets of high Total Phosphorus levels, average in-lake Phosphorus remains low. The water quality goal of the pond is to maintain this low average TP rather than drastically reduce it. To do this, new and existing sources of external Phosphorus must be prevented from entering the lake, primarily via soil erosion and outdated individual sewage disposal systems.

The Pine River Pond Association, affiliated road associations, and the community at large rallied to protect this resource when the need arose. In the span of two years, they recruited volunteers, local organizations, students, and state agencies to self-fund and produce the components necessary to produce a watershed-based plan. With this momentum they have also worked with the same groups to apply for and receive an EPA Clean Water Act Section 319 Grant to begin addressing the most pressing issues facing the health of the lake. With continued action from the community, and buy-in from state and local municipalities, there is little doubt that Pine River Pond can transform this tipping point into an opportunity to maintain and preserve this invaluable resource and build both ecological and community resilience to withstand the known and unknown challenges that lie ahead.

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13 Appendix Table A: Land Cover by Subwatershed

Land Cover Area (HA)

Land Use	Young Brook South Branch	Young Brook	Meadow Brook	Quimby Brook	PRP NE Brook	PRP SW Brook	PRP NW Direct	PRP North Direct	PRP NE Direct 1	PRP NE Direct 2	PRP SW Direct 1	PRP SW Direct 2	Southeast Direct	Islands Direct	**Total**
Urban 1 (Low Density)	2.38	4.03	2.05	1.53	0.09	1.91	0.00	0.24	0.00	0.00	0.00	0.00	0.33	0.00	**12.56**
Urban 2 (Mid-Density Residential/Commercial)	0.00	1.54	0.03	0.29	0.88	0.20	3.54	1.43	1.56	6.51	1.33	4.70	7.43	0.00	**29.44**
Urban 3 (Roads)	2.05	7.91	4.52	3.01	1.68	3.32	2.91	0.70	2.02	5.80	0.34	2.87	6.68	0.00	**43.82**
Urban 4 (Industrial)	0.00	0.13	0.00	0.00	0.00	0.00	2.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**2.22**
Urban 5 (Parks, Recreation Fields, Institutional)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Agric 1 (Cover Crop)	0.00	0.00	2.88	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**2.88**
Agric 2 (Row Crop)	0.00	8.37	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**8.50**
Agric 3 (Grazing)	0.00	3.21	0.00	0.30	0.00	7.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**10.79**
Agric 4 (Hayland-Non-Manure)	0.16	12.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**12.59**
Forest 1 (Deciduous)	93.83	26.75	8.57	3.67	9.62	11.16	0.00	0.00	0.00	0.00	0.00	0.00	29.77	0.00	**183.37**
Forest 2 (Non-Deciduous)	86.36	136.94	0.29	7.76	9.67	15.23	48.73	6.72	14.60	2.27	0.24	1.61	44.53	0.00	**374.93**
Forest 3 (Mixed Forest)	319.56	318.62	244.95	37.90	75.17	93.77	13.59	9.90	60.15	88.05	6.83	38.00	64.38	3.10	**1373.97**
Forest 4 (Wetland)	27.77	26.70	9.38	2.72	0.00	0.00	0.22	0.00	0.00	0.00	0.00	0.00	0.19	0.00	**66.98**
Open 1 (Wetland / Pond)	5.71	0.79	0.00	0.41	0.32	0.31	5.62	0.00	0.03	4.13	0.01	0.13	4.45	0.00	**21.91**
Open 2 (Meadow)	21.30	36.01	7.97	6.65	0.73	5.39	5.41	1.55	1.00	4.63	0.58	4.17	15.88	0.00	**111.27**
Open 3 (Bare/Open)	0.35	2.99	1.91	1.15	1.56	0.77	5.88	0.24	1.24	3.18	0.07	0.46	0.82	0.00	**20.61**
Other 1 (Gravel Roads)	0.09	0.44	0.00	1.70	0.00	0.00	0.33	0.00	0.00	0.17	0.00	0.00	0.00	0.00	**2.74**
Forest 5 (Logged Forest)	48.75	284.56	94.98	53.93	9.02	50.52	45.29	0.00	6.94	147.93	0.00	1.93	86.74	0.00	**830.60**
Total	**608.31**	**871.42**	**377.53**	**121.16**	**108.74**	**189.85**	**133.60**	**20.78**	**87.55**	**262.66**	**9.40**	**53.88**	**261.19**	**3.10**	**3109.16**

14Appendix Table B: Pine River Pond Watershed Survey Findings

Site	Impact	Cost	Technical Level	Land Use	Issue	Recommendations	P Loading lb/yr	Soil Loss tons/yr
8-24	High	Low	Low	Residential	Gully, Bare Soil	Native Vegetation, reseed bare soil, cover/remove bare sand	NA	NA
8-08	High	Low	Low	Shoreline	Inadequate Shoreline Vegetation	Establish Vegetated Buffer, cover bare sand, add to buffer	10.6	6.3
3-50	High	Low	Low	Shoreline	Undercutting	Establish Vegetated Buffer, Shoreline Stabilization	21.5	12.5
8-02	High	Low	Low	Residential	Gully	Eliminate Raking, leaf blowing, Reseed bare soil, Erosion Control Mulch, dry well	0.6	0.4
3-13	High	Low	Low	Residential	Gully	Water Bars, Rubber Razors	0.3	0.2
3-14	High	Low	Low	Residential	Sheet, Bare Soil	Erosion Control Mulch, Native Vegetation, Terracing	4.3	2.5
8-23	High	Low	Low	Residential	Rill	Infiltration Path, Native Vegetation, Water Bars, Rubber Razors, Reseed bare soil	8.5	5.0
7-14	High	Low	Low	Residential	Sheet	Native Vegetation, Reseed bare soil	0.5	0.3
8-07	High	Low	Low	Residential	Sheet, Bare Soil	Native Vegetation, Reseed bare soil, Erosion Control Mulch	NA	NA
7-03	High	Low	Medium	Residential	Rill	Water Bars, Rubber Razors, Erosion Control Mulch	0.4	0.3
2-15	High	Low	Medium	Residential	Sheet, Bare Soil	Infiltration Path, Reseed bare soil, Erosion Control Mulch	5.3	3.1
3-05	High	Low	Medium	Residential	Sheet, Gully	Erosion Control Mulch, Rubber Razors, reseed bare soil, Direct Road runoff to nearby veg areas	13.3	7.8
3-08	High	Low	Medium	Residential	Sheet	Erosion Control Mulch, Rubber Razors	1.3	0.8
3-10	High	Low	Medium	Residential	Sheet, Bare Soil	Erosion Control Mulch, Water Bars	17.0	10.0
3-11	High	Low	Medium	Residential	Sheet, Bare Soil	Infiltration Path, Erosion Control Mulch, Reseed bare soil	1.3	0.8
7-05	High	Low	Medium	Residential	Gully	Water Bars	3.4	2.0
7-05	High	Low	Medium	Residential	Gully	Native Vegetation, Rubber Razors, Erosion Control Mulch, Reseed bare soil	2.6	1.5
7-10	High	Low	Medium	Residential	Gully	Rubber Razors	4.3	2.5
7-15	High	Low	Medium	Residential	Sheet	Erosion Control Mulch, Native Vegetation, Rubber Razors	0.9	0.5

Site	Impact	Cost	Technical Level	Land Use	Issue	Recommendations	P Loading lb/yr	Soil Loss tons/yr
7-17	High	Low	Medium	Residential	Sheet, Bare Soil	Native Vegetation, Dripline Trench, Water Bars, Reseed bare soil	0.4	0.3
1-50	High	Low	Medium	Residential	Sheet, Gully	Erosion Control Mulch, Native Vegetation, Dripline Trench, Infiltration trench	17.0	10.0
3-09	High	Low	Medium	Shoreline	Excessive Clearing	Box out picnic area to separate from large beach access; add check dams to gully; rake out gullies	NA	NA
1-09	High	Low	Medium		No vegetation, sand	Native Vegetation, Erosion Control Mulch	NA	NA
3-17	High	Medium	Low	Residential	Sheet, Bare Soil	Erosion Control Mulch, Infiltration Path, Native Vegetation	2.6	1.5
4-11	High	Medium	Low	Residential	Bare Soil	Erosion Control Mulch, reseed bare soil, Native Vegetation, Eliminate Raking, leaf blowing	NA	NA
8-12	High	Medium	Medium	Residential	Rill	Erosion Control Mulch, Eliminate Raking leaf blowing, reseed bare soil, stabilize footpaths- lots of bare soil	NA	NA
5-01	High	Medium	Medium	Residential	Sheet	Erosion Control Mulch, Water Bars	20.4	12.0
5-23	High	Medium	Medium	Residential	Sheet	Erosion Control Mulch, Native Vegetation, Rubber Razors, Water Bars	15.9	9.4
7-20	High	Medium	Medium	Shoreline	Large beach with sediment transport to lake		NA	NA
7-50	High	Medium	Medium	Shoreline	Erosion, Inadequate Shoreline Vegetation, Unstable Access	Establish Vegetated Buffer, Shoreline Stabilization	21.3	12.5
7-49	High	Medium	Medium	Shoreline	Undercutting, Erosion	Establish Vegetated Buffer, Shoreline Stabilization	NA	NA
2-21	High	Medium	Medium	Residential	Sheet, Bare Soil	Water Bars, Rubber Razors, Reseed bare soil	NA	NA
5-15	High	Medium	Medium	Residential	Sheet, Gully	Erosion Control Mulch, Native Vegetation, Rubber Razors, Drywells	2.8	1.6
4-03	High	Medium	Medium	Residential	Rill, Sheet	Erosion Control Mulch, Eliminate Raking leaf blowing	0.1	0.1
4-09	High	Medium	Medium	Residential	Dripline, Sheet	Native Vegetation, roof drips directly into the lake, driveway has erosion over steep slope into lake	2.1	1.3
4-09	High	Medium	Medium	Residential	Dripline, Sheet	Native Vegetation, roof drips directly into the lake, driveway has erosion over steep slope into lake	NA	NA

Site	Impact	Cost	Technical Level	Land Use	Issue	Recommendations	P Loading lb/yr	Soil Loss tons/yr
3-21	High	Medium	Medium	Residential	Dripline, Sheet	Erosion Control Mulch, Infiltration Path, Dripline Trench, Reseed bare soil	NA	NA
1-48	High	Medium	Medium	Residential	Sheet, Rill	Erosion Control Mulch, Native Vegetation, Rubber Razors, Dripline Trench, buffer	2.6	1.5
2-07	High	Medium	Medium	Shoreline	Inadequate Shoreline Vegetation	Establish Vegetated Buffer	NA	NA
3-18	High	Medium	Medium	Residential	Sheet, Bare Soil	Erosion Control Mulch, Infiltration Path, reseed bare soil, Improve/add terracing	1.6	0.9
8-28	High	Medium	Medium	Road	Gully	Crown, add road base material, Rubber Razor, Open Top Culvert, Ditch & Check Dams,	NA	NA
2-14	High	Medium	High	Residential	Sheet, Rill, Gully, Bare Soil	Native Vegetation, Reseed bare soil	NA	NA
8-21	High	High	Medium	Road	Rill, Sheet	Pave, Crown, Ditch & Check Dams, Rubber Razor, Open Top Culvert limit size of driveway	NA	NA
3-48	High	High	Medium	Road	Sheet, Rill, Gully	Crown, Turn outs, Ditch & Check Dams	17.0	10.0
3-49	High	High	Medium	Road	Sheet, Rill, Gully	Add road base material, Crown, Install Detention Basin, Turn outs, Ditch & Check Dams	8.5	5.0
8-06	High	High	High	Shoreline	Erosion, Undercutting	Shoreline Stabilization is going to need a creative solution here. very steep and severe. could try live staking or adding gabions? needs engineering	1.4	0.9
1-02	High	High	High	Residential	Gully	Engineered Site Visit	8.5	5.0
6-06	High	High	High	Road	Rill		0.0	0.0
2-10	High	High	High	Shoreline	Undercutting, Erosion, Inadequate Shoreline Vegetation	Establish Vegetated Buffer, Shoreline Stabilization	NA	NA
3-16	Medium	Low	Low	Residential	Gully	Water Bars, Improve terraced beach	0.2	0.1
8-13	Medium	Low	Low	Residential	Sheet, Bare Soil	Erosion Control Mulch, Reseed bare soil, Native Vegetation	0.4	0.3
5-16	Medium	Low	Low	Residential	Rill	Erosion Control Mulch, Native Vegetation, Dripline Trench, Infiltration trench	0.1	0.0
4-06	Medium	Low	Low	Residential	Sheet	Erosion Control Mulch, Infiltration Path	NA	NA
2-20	Medium	Low	Low	Residential	Sheet	Erosion Control Mulch, Native Vegetation	NA	NA

Site	Impact	Cost	Technical Level	Land Use	Issue	Recommendations	P Loading lb/yr	Soil Loss tons/yr
8-26	Medium	Low	Low	Residential	Rill	Infiltration Path, reseed bare soil, Eliminate Raking leaf blowing, Native Vegetation	0.4	0.2
6-12	Medium	Low	Low	Residential		Erosion Control Mulch	0.3	0.2
6-13	Medium	Low	Low	Residential	Sheet	Erosion Control Mulch	0.2	0.1
7-11	Medium	Low	Low	Residential	Rill	Erosion Control Mulch, Native Vegetation, Reseed bare soil	0.5	0.3
7-19	Medium	Low	Low	Residential	Sheet	Native Vegetation	1.7	1.0
1-06	Medium	Low	Low	Residential	Sheet, Rill	Erosion Control Mulch, Infiltration Path, Native Vegetation, Infiltration steps leading to beach	0.2	0.1
5-03	Medium	Low	Low	Residential	Sheet	Dripline Trench, Erosion Control Mulch	3.2	1.9
5-11	Medium	Low	Low	Residential	Sheet	Erosion Control Mulch, Native Vegetation	6.8	4.0
5-17	Medium	Low	Low	Residential	Sheet, Rill	Erosion Control Mulch, Native Vegetation, Water Bars, Reseed bare soil	6.8	4.0
5-29	Medium	Low	Low	Residential	Sheet	Erosion Control Mulch, Native Vegetation	1.0	0.6
4-07	Medium	Low	Low	Shoreline	Inadequate Shoreline Vegetation	Establish Vegetated Buffer, adjust fertilizer use	NA	NA
2-05	Medium	Low	Low	Shoreline	Inadequate Shoreline Vegetation	Establish Vegetated Buffer	6.8	4.0
2-06	Medium	Low	Low	Shoreline	Inadequate Shoreline Vegetation	Establish Vegetated Buffer	1.0	0.5
1-05	Medium	Low	Low	Shoreline	Erosion, Inadequate Shoreline Vegetation	Establish Vegetated Buffer	0.4	0.3
6-49	Medium	Low	Low	Shoreline	Undercutting, Erosion	Establish Vegetated Buffer, Shoreline Stabilization	1.7	1.0
7-02	Medium	Low	Low	Residential	Gully	Water Bars, Reseed bare soil, Erosion Control Mulch	0.2	0.1
3-06	Medium	Low	Low	Residential	Gully	Infiltration Path, Great spot to retrofit existing steps with infil steps	0.5	0.3
8-17	Medium	Low	Low	Residential	Rill, Dripline	Dry well	0.0	0.0
6-03	Medium	Low	Low	Residential	Sheet	Infiltration Path	0.5	0.3
6-09	Medium	Low	Low	Residential	Rill, Sheet	Infiltration Path	0.0	0.0
6-10	Medium	Low	Low	Residential	Sheet, Rill	Erosion Control Mulch, Infiltration Path	0.1	0.0
7-16	Medium	Low	Low	Residential	Sheet	Native Vegetation, Erosion Control Mulch	NA	NA
1-07	Medium	Low	Low	Residential	Sheet	Erosion Control Mulch, Native Vegetation	1.7	1.0

Site	Impact	Cost	Technical Level	Land Use	Issue	Recommendations	P Loading lb/yr	Soil Loss tons/yr
1-08	Medium	Low	Low	Residential	Sheet	Infiltration berm	0.4	0.2
1-23	Medium	Low	Low	Residential	Sheet	Erosion Control Mulch, Native Vegetation	1.3	0.8
8-10	Medium	Low	Low	Residential	Gully	Water Bars, Reseed bare soil	0.1	0.0
8-18	Medium	Low	Low	Residential	Sheet, Dripline, Bare Soil	Erosion Control Mulch, Dripline Trench, Eliminate Raking leaf blowing, Reseed bare soil, Native Vegetation	NA	NA
8-19	Medium	Low	Low	Residential	Sheet, Bare Soil	Eliminate Raking leaf blowing, Erosion Control Mulch	NA	NA
8-22	Medium	Low	Low	Residential	Sheet, Bare Soil	Erosion Control Mulch, Native Vegetation, Reseed bare soil, Eliminate Raking leaf blowing	NA	NA
8-24	Medium	Low	Low	Residential	Sheet, Bare Soil	Erosion Control Mulch, Eliminate Raking leaf blowing, Reseed bare soil	NA	NA
8-25	Medium	Low	Low	Residential	Rill	Infiltration Path	1.9	1.1
6-12	Medium	Low	Low	Residential	Sheet, Rill	Erosion Control Mulch	NA	NA
1-11	Medium	Low	Low	Residential	Sheet, Bare Soil	Erosion Control Mulch, Native Vegetation, Infiltration Path, Rubber Razors	1.3	0.8
5-14	Medium	Low	Low	Residential	Sheet, Rill	Erosion Control Mulch, Rubber Razors, trench	1.3	0.8
5-18	Medium	Low	Low	Residential	Sheet	Erosion Control Mulch, Infiltration Path, Native Vegetation	3.4	2.0
1-46	Medium	Low	Low	Residential	Sheet	Erosion Control Mulch, Native Vegetation	1.7	1.0
5-02	Medium	Low	Low	Residential	Sheet	Erosion Control Mulch, Dripline Trench,, Native Vegetation Drywell	6.8	4.0
1-49	Medium	Low	Low	Residential	Sheet	Erosion Control Mulch, Infiltration Path	1.0	0.6
2-08	Medium	Low	Low	Shoreline	Inadequate Shoreline Vegetation	Establish Vegetated Buffer	6.4	3.8
3-01	Medium	Low	Low	Shoreline		Shoreline Stabilization	1.1	0.6
3-07	Medium	Low	Low	Shoreline	Erosion, Inadequate Shoreline Vegetation	Establish Vegetated Buffer	0.1	0.0
8-05	Medium	Low	Low	Shoreline	Erosion, Unstable Access	Establish Vegetated Buffer, cover roots ans bare soil	0.0	0.0
6-14	Medium	Low	Low	Culvert		Armor Inlet Outlet	NA	NA
6-50	Medium	Low	Low	Shoreline	Undercutting	Shoreline Stabilization	17.0	10.0
2-03	Medium	Low	Low	Residential	Rill	Erosion Control Mulch, Native Vegetation	0.1	0.1

Site	Impact	Cost	Technical Level	Land Use	Issue	Recommendations	P Loading lb/yr	Soil Loss tons/yr
1-03	Medium	Low	Low	Residential	Rill	Infiltration Path, Native Vegetation, Reseed bare soil Infiltration steps, vegetative buffer in and stone trough along house	1.0	0.6
1-26	Medium	Low	Low	Residential	Sheet	Native Vegetation, Infiltration step	0.2	0.1
5-10	Medium	Low	Low	Residential	Sheet	Erosion Control Mulch, Native Vegetation	1.7	1.0
5-13	Medium	Low	Low	Residential	Sheet	Erosion Control Mulch, Infiltration Path, Native Vegetation, Dripline Trench	6.4	3.8
1-10	Medium	Low	Low	Residential	Sheet	Erosion Control Mulch, Native Vegetation Push path farther inland,	0.1	0.1
5-07	Medium	Low	Low	Residential	Rill	Erosion Control Mulch, Infiltration Path, Native Vegetation, Dripline Trench, Fieldstones	0.3	0.2
5-24	Medium	Low	Low	Residential	Sheet	Erosion Control Mulch, Native Vegetation	7.4	4.4
3-04	Medium	Low	Low	Shoreline	Undercutting, Erosion, Inadequate Shoreline Vegetation	Establish Vegetated Buffer, Shoreline Stabilization	0.2	0.1
3-19	Medium	Low	Low	Shoreline	Erosion	Establish Vegetated Buffer	0.8	0.5
5-19	Medium	Low	Low	Residential	Sheet	Erosion Control Mulch, Native Vegetation	0.2	0.1
3-03	Medium	Low	Medium	Residential	Sheet, Bare Soil	Erosion Control Mulch, Native Vegetation, Reseed bare soil, Add timber atop existing, retrofit existing steps with infil steps	0.3	0.2
8-11	Medium	Low	Medium	Residential	Rill	Water Bars, Rubber Razors	4.3	2.5
6-02	Medium	Low	Medium	Residential	Sheet	Infiltration Path, infiltration steps	1.5	0.9
6-08	Medium	Low	Medium	Residential	Sheet, Rill	Erosion Control Mulch, Infiltration Path, Native Vegetation, Water Bars	0.3	0.2
7-06	Medium	Low	Medium	Residential	Sheet	Native Vegetation, Erosion Control Mulch	NA	NA
7-07	Medium	Low	Medium	Residential	Gully	Erosion Control Mulch, Native Vegetation, Dripline Trench, Reseed bare soil	0.4	0.3
5-09	Medium	Low	Medium	Residential	Sheet, Rill	Erosion Control Mulch, Infiltration Path, Native Vegetation, Dripline Trench, Rubber Razors	6.8	4.0
5-21	Medium	Low	Medium	Residential	Sheet	Erosion Control Mulch, Infiltration Path, Native Vegetation	NA	NA
3-11	Medium	Low	Medium	Shoreline	Erosion, Inadequate Shoreline Vegetation, Excessive Clearing	Establish Vegetated Buffer, Shoreline Stabilization	21.3	12.5

Site	Impact	Cost	Technical Level	Land Use	Issue	Recommendations	P Loading lb/yr	Soil Loss tons/yr
1-04	Medium	Low	Medium	Shoreline	Erosion	Shoreline Stabilization, Establish Vegetated Buffer	1.5	0.9
7-08	Medium	Low	Medium	Residential	Sheet	Erosion Control Mulch	1.3	0.8
7-09	Medium	Low	Medium	Residential	Sheet	Dripline Trench, Erosion Control Mulch, Reseed bare soil	1.0	0.6
7-13	Medium	Low	Medium	Residential	Sheet	Rubber Razors	NA	NA
1-20	Medium	Low	Medium	Residential	Gully	Infiltration steps in replacement of old steps	0.1	0.0
5-25	Medium	Low	Medium	Residential	Rill	Erosion Control Mulch, Rubber Razors, Drywell	NA	NA
4-08	Medium	Low	Medium	Residential	Dripline, Bare Soil	Erosion Control Mulch, Infiltration Path, Dripline Trench	0.3	0.2
3-15	Medium	Low	Medium	Residential	Sheet, Bare Soil	Erosion Control Mulch, Native Vegetation, Reseed bare soil, Terracing or vegetate top of wall	8.0	4.7
8-16	Medium	Low	Medium	Residential	Sheet	Infiltration Path,, Eliminate Raking leaf blowing, Native Vegetation, Erosion Control Mulch retrofit existing steps.	NA	NA
1-48	Medium	Low	Medium	Residential	Sheet	Erosion Control Mulch, Infiltration Path, Native Vegetation, Dripline Trench	1.3	0.8
2-13	Medium	Low	Medium	Road	Rill	Vegetate Shoulder, Install Catch Basin	0.4	0.3
2-19	Medium	Low	Medium	Road	Gully	Install Catch Basin	0.4	0.3
3-02	Medium	Low	Medium	Shoreline	Erosion	Establish Vegetated Buffer, Shoreline Stabilization	0.3	0.2
5-05	Medium	Low	Medium		Boat launch		0.7	0.4
7-01	Medium	Low	Medium	Residential	Gully	Rubber Razors, Erosion Control Mulch	0.8	0.5
1-12	Medium	Low	Medium	Residential	Sheet	Infiltration steps, Rubber Razors	NA	NA
1-14	Medium	Low	Medium	Residential	Sheet, Rill	Native Vegetation, Rubber Razors Vegetated buffer and edge, infiltration step and diversion	1.7	1.0
1-16	Medium	Low	Medium	Residential	Sheet	Native Vegetation, Rubber Razors Vegetated barrier on retaining wall, infiltration berm	4.3	2.5
1-17	Medium	Low	Medium	Residential	Rill, Sheet	Rubber Razors Drip edge; razors and divert for rill and infiltration steps and trench for sheet	1.2	0.8
1-19	Medium	Low	Medium	Residential	Gully, Sheet	Rubber Razors Infiltrate high, using razor to direct into infiltrate area	0.2	0.1

Site	Impact	Cost	Technical Level	Land Use	Issue	Recommendations	P Loading lb/yr	Soil Loss tons/yr
1-24	Medium	Low	Medium	Residential	Gully	Native Vegetation, Infiltration berm	0.2	0.1
1-25	Medium	Low	Medium	Residential	Sheet, Rill	Rubber Razors Infiltration, crown the road	4.8	2.8
1-27	Medium	Low	Medium	Residential	Sheet	Native Vegetation, Rubber Razors Infiltrate before fire pit	0.4	0.3
5-22	Medium	Low	Medium	Residential	Rill	Infiltration Path, Erosion Control Mulch, Native Vegetation, Fieldstones	0.4	0.3
6-04	Medium	Low	Medium	Road	Gully	Vegetate Shoulder, Install Catch Basin	0.0	0.0
1-01	Medium	Low	High	Residential		Rubber Razors	1.3	0.8
4-12	Medium	Medium	Low	Residential	Bare Soil	Erosion Control Mulch, Native Vegetation, Eliminate Raking/leaf blowing, Reseed bare soil	1.7	1.0
2-11	Medium	Medium	Medium	Residential	Sheet, Bare Soil	Erosion Control Mulch, Native Vegetation	NA	NA
2-12	Medium	Medium	Medium	Residential	Sheet, Bare Soil	Erosion Control Mulch, Native Vegetation, Infiltration Path	NA	NA
4-10	Medium	Medium	Medium	Residential	Sheet, Bare Soil, Dripline	Erosion Control Mulch, Infiltration Path, Dripline Trench	0.9	0.5
5-06	Medium	Medium	Medium	Residential	Rill	Erosion Control Mulch, Native Vegetation, Rubber Razors, Drywell	0.3	0.2
2-02	Medium	Medium	Medium	Road	Gully	Add road base material, Rubber Razor, Install Catch Basin	2.1	1.3
2-04	Medium	Medium	Medium	Shoreline	Undercutting, Inadequate Shoreline Vegetation	Establish Vegetated Buffer, Shoreline Stabilization	3.4	2.0
8-03	Medium	Medium	Medium		ditch		0.4	0.3
8-09	Medium	Medium	Medium	Road	Gully	Vegetate Shoulder, road shoulder and bank near culvert needs to be stabilized	0.3	0.2
8-20	Medium	Medium	Medium	Shoreline	Unstable Access, Erosion	Shoreline Stabilization, driveway low point drains down boat launch and washes out sand	1.4	0.8
6-05	Medium	Medium	Medium	Road	Sheet		0.3	0.2
6-16	Medium	Medium	Medium	Residential	Gully	Water Bars, Rubber Razors	NA	NA
6-18	Medium	Medium	Medium	Residential	Sheet	Erosion Control Mulch	1.4	0.8
1-21	Medium	Medium	Medium	Residential	Sheet	Erosion Control Mulch, Native Vegetation	1.0	0.6
4-02	Medium	Medium	Medium	Residential	Sheet, Dripline	Erosion Control Mulch, Dripline Trench	0.1	0.1

Site	Impact	Cost	Technical Level	Land Use	Issue	Recommendations	P Loading lb/yr	Soil Loss tons/yr
8-01	Medium	Medium	Medium	Residential	Rill	Eliminate Raking/leaf blowing, Rubber Razors, Dripline Trench, improve driveway turnouts	0.2	0.1
1-28	Medium	Medium	Medium	Residential	Rill, Gully	Native Vegetation Infiltration steps, vegetation berm to slow flow,	NA	NA
2-01	Medium	Medium	Medium	Road	Rill	Vegetate Shoulder, retaining wall	NA	NA
7-18	Medium	Medium	High	Road	Sheet	Remove Grader Plow Berms, Turn outs, Install Detention Basin	NA	NA
5-04	Medium	Medium	High	Residential	Rill	Remediate outlet pipe	0.1	0.1
2-16	Medium	Medium	High	Shoreline	Undercutting	Shoreline Stabilization	NA	NA
4-14	Medium	Medium	High	Culvert			0.2	0.1
1-13	Medium	Medium	High	Residential	Gully	Native Vegetation Retaining wall, wrap thatching to build vegetation in hill so plants can grow over bank	NA	NA
2-09	Medium	Medium	High	Road	Sheet	Vegetate Shoulder, Install Catch Basin	0.2	0.1
4-13	Medium	Medium	High	Road	Rill	Install Catch Basin, Turn outs	NA	NA
6-07	Medium	Medium	High	Residential	Rill	enhance veg buffer, install catch basin with rip rap outlet	NA	NA
8-04	Medium	High	Medium	Residential	Gully	Erosion Control Mulch, Native Vegetation	NA	NA
5-12	Medium	High	High	Residential	Sheet	Erosion Control Mulch, Infiltration Path, Native Vegetation, Water Bars, Dripline Trench, Rebuid retaining wall	NA	NA
4-05	Medium	High	High	Road	Gully	Ditch & Check Dams, Open Top Culvert	1.1	0.6
6-11	Medium	High	High	Residential	sheet	remove sand or fix retaining wall	NA	NA
6-01	Medium	High	High	Residential	Gully	permeable pavement	0.2	0.1
8-14	Low	Low	Low	Residential	Rill, Bare Soil	Erosion Control Mulch, reseed bare soil, remove or cover sand pile	0.0	0.0
5-28	Low	Low	Low	Residential	Sheet	Infiltration Path, Erosion Control Mulch, Native Vegetation	0.5	0.3
6-17	Low	Low	Low	Residential	Sheet	Native Vegetation, Erosion Control Mulch	0.2	0.1
2-18	Low	Low	Medium	Residential	Sheet	repair wall	0.4	0.3
1-15	Low	Low	Medium	Residential	Rill	Retention wall, infiltration trench, vegetated border at the perched beach	0.8	0.5
1-18	Low	Low	Medium	Residential	Sheet	Infiltrate high to take down velocity, vegetation buffer	3.4	2.0

Site	Impact	Cost	Technical Level	Land Use	Issue	Recommendations	P Loading lb/yr	Soil Loss tons/yr
1-22	Low	Low	Medium	Residential	Sheet	Rubber Razors, Native Vegetation Razor above razor present, reposition razor to prevent erosion under deck	2.1	1.3
5-20	Low	Low	Medium	Residential	Sheet	Erosion Control Mulch, Infiltration Path, Native Vegetation	0.3	0.2
4-01	Low	Medium	Medium		bank undercutting		NA	NA
7-12	Low	High	High	Culvert	eroding sides	Armor Inlet Outlet, wing walls	NA	NA