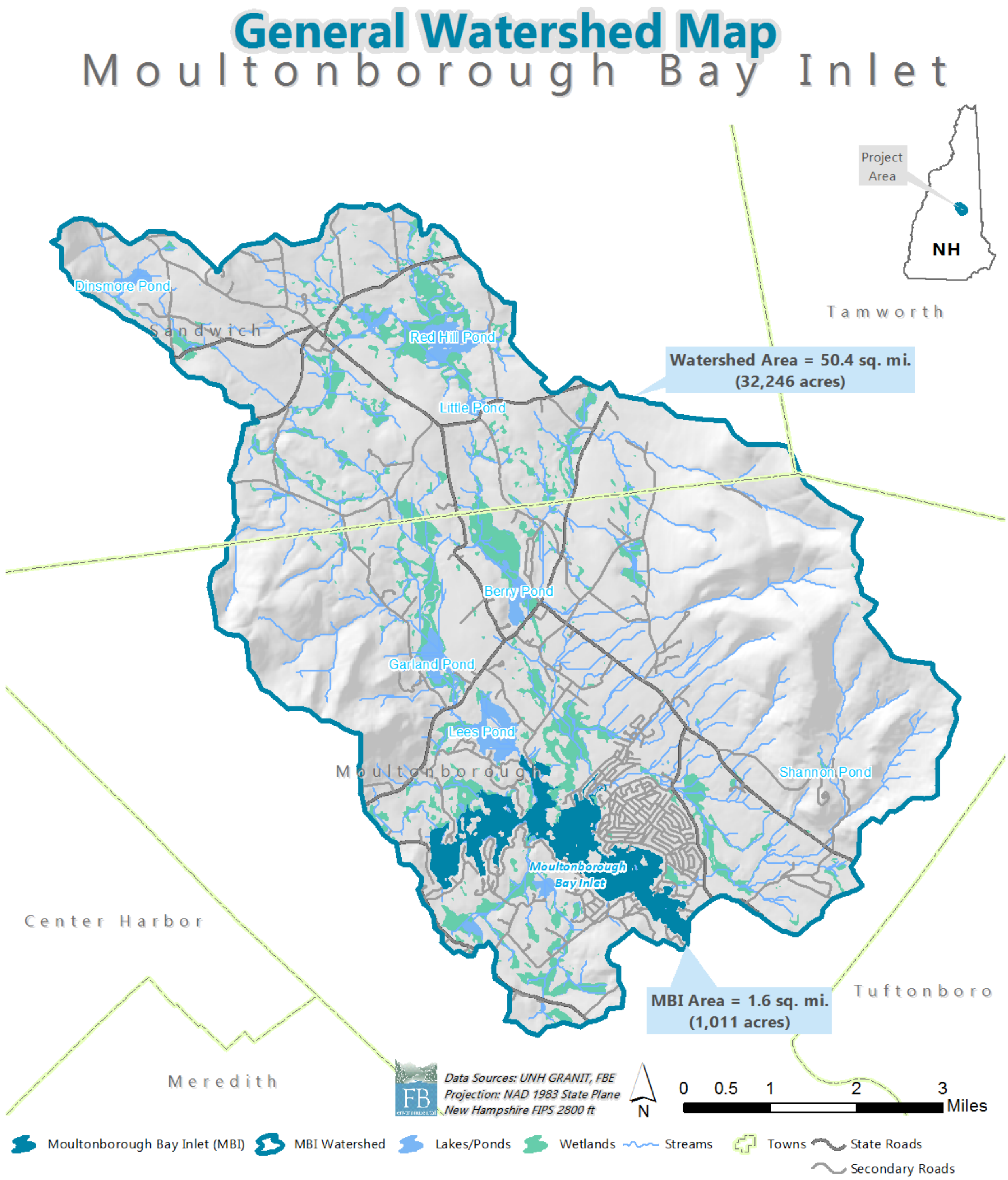
Moultonborough Bay Inlet

WATERSHED RESTORATION PLAN

Carroll County, New Hampshire

DECEMBER 2017


General Watershed Map
Moultonborough Bay Inlet
Project Area
NH
Tamworth
Sandwich
Dinsmore Pond
Red Hill Pond
Little Pond
Watershed Area = 50.4 sq. mi. (32,246 acres)
Berry Pond
Garland Pond
Lees Pond
Moultonborough
Shannon Pond
Moultonborough Bay Inlet
Center Harbor
Tuftonboro
MBI Area = 1.6 sq. mi. (1,011 acres)
Meredith
Data Sources: UNH GRANIT, FBE
Projection: NAD 1983 State Plane New Hampshire FIPS 2800 ft
N
0 0.5 1 2 3 Miles
Moultonborough Bay Inlet (MBI)
MBI Watershed
Lakes/Ponds
Wetlands
Streams
Towns
State Roads
Secondary Roads

Moultonborough Bay Inlet

WATERSHED RESTORATION PLAN

Carroll County, New Hampshire

Prepared by FB ENVIRONMENTAL ASSOCIATES
in cooperation with LAKE WINNIPESAUKEE ASSOCIATION
and NEW HAMPSHIRE DEPARTMENT OF ENVIRONMENTAL SERVICES

DECEMBER 2017

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Cover photo: View of mountains in Moultonborough Bay Inlet (credit: FBE)

EXECUTIVE SUMMARY

PROJECT OVERVIEW

The water quality of Moultonborough Bay Inlet (MBI) is threatened by harmful pollutants in nonpoint source (NPS) pollution from developed areas in the watershed. The desirability of MBI as a recreational destination, and increasingly as a permanent residence for newcomers, will likely stimulate continued population growth in the future. Thus, taking proactive steps to properly manage and treat NPS pollution in the MBI watershed is essential for continued ecosystem health and recreational enjoyment by future generations.

> The **Moultonborough Bay Inlet Watershed Restoration Plan** provides a roadmap for preserving the water quality of MBI, and provides a mechanism for procuring funding (e.g., Section 319 grants) to secure actions needed to achieve the water quality goal. USEPA requires that a watershed plan (or an acceptable alternative plan) be created so that communities become eligible for watershed assistance implementation grants.

QUICK FACTS

Town/State: Moultonborough, NH (68%)
Sandwich, NH (32%)
Tamworth, NH (<1%)

Total Watershed Area: 50 sq. mi. (32,246 ac.)

Lake Area: 1.6 sq. mi. (1,011 ac.)

Shore Length: 24.6 miles

Max Depth: 81 ft. (Basin 3)

Mean Depth: 15.4 ft. (Basin 3)

Lake Volume: 4.5 billion gallons

Flushing Rate: 5.8 times per year (Basin 3)

Lake Elevation: 500 ft.

Trophic Classification: Oligotrophic

Impairments: Cyanobacteria

Invasives: Variable milfoil was found in 1965 and has been proactively managed by the Milfoil Crisis Committee since 2009. Since 2010, the area from Green's Basin to Deepwood Ledges/Hemlock Point has reduced from 90% to 40% coverage.

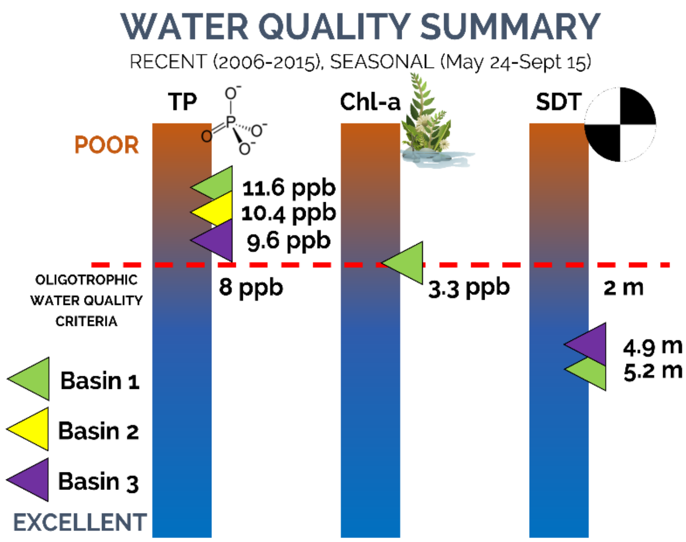
Tributaries: The area draining through Lees Pond to Basin 3 accounts for 55% of the water volume entering Basin 3. Other major inlets to Basin 3 include Shannon Brook, Halfway Brook, Middle Brook, Basins 1 & 2, and an unnamed tributary that flows north to Basin 3 from the southwest side of the Inlet.

Other Notes: The high flushing rate of 5.8 means that the entire volume of Basin 3 is replaced about six times every year, which limits time for pollutants to settle in lake bottom sediments and/or be taken up by biota.

As part of the development of this plan, a build-out analysis, water quality and assimilative capacity analysis, and volunteer shoreline and watershed stormwater surveys were conducted (Section 3). Results of these efforts were used to run a land-use model, or Lake Loading Response Model (LLRM), that estimated the historical, current, and projected amount of total phosphorus (TP) being delivered to the Inlet from the watershed (Section 3.3.2). An Action Plan (Section 5.2) with associated timeframes, responsible parties, and estimated costs was developed based on feedback from Advisory Committee members over the course of multiple meetings. Led by the Lake Winnipesaukee Association (LWA), the Advisory Committee represented a diverse range of interests: municipal staff and conservation commissions, state agency officials (e.g., NH Fish & Game, NHDES), residents and lake/pond/neighborhood associations (e.g., Milfoil Committee, Lees Pond Association, Suissevale, Balmoral), land trusts and non-profits (e.g., Lakes Region Conservation Trust, Granite State Rural Water Association), and technical experts (e.g., FB Environmental Associates, DK Water Resource Consulting). This plan was partially funded by a Watershed Assistance Grant for High Quality Waters from NHDES using Clean Water Act Section 319 funds from the USEPA, with additional financial and in-kind services provided by the Town of Moultonborough, Moultonborough Conservation Commission, residents, and stakeholders.

WATER QUALITY ASSESSMENT & MODELING

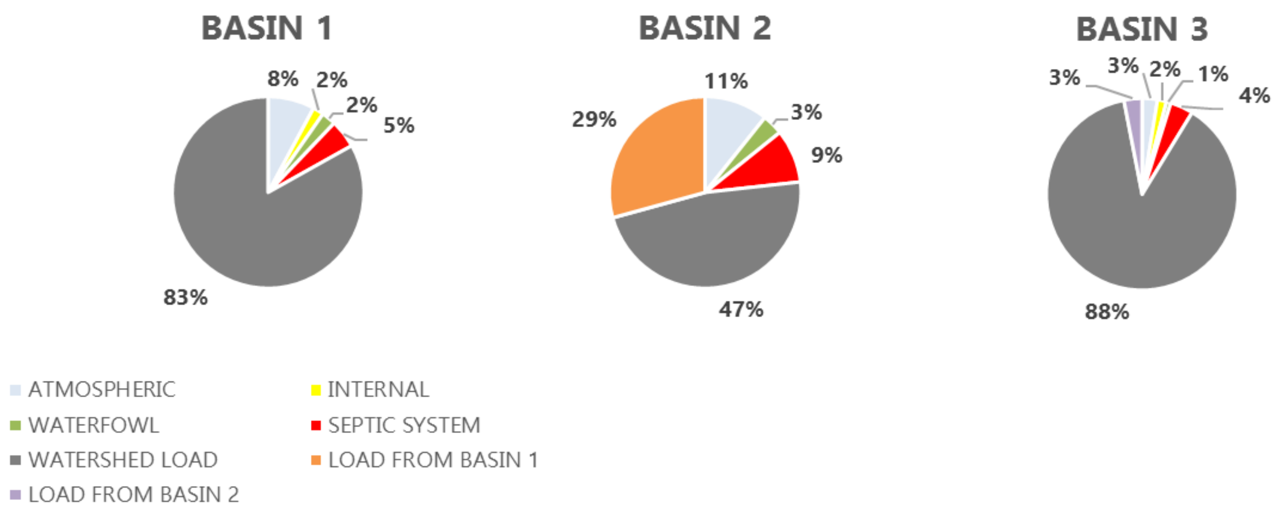
MBI is part of a larger lake system, Lake Winnipesaukee, and thus, the Inlet itself is not listed as a separate assessment unit by NHDES, but is integrated with and classified the same (oligotrophic) as Lake Winnipesaukee, which is listed on the 2014 NHDES 303(d) list as impaired for aquatic life based on the presence of cyanobacteria. Cyanobacteria are fed by excess nutrients in nonpoint source runoff from developed areas. Thus, this plan focuses on phosphorus as the overall driver of ecosystem health. Waterbodies with excess nutrients, particularly phosphorus, which is considered the limiting nutrient in freshwater systems, are overproductive and may experience symptoms of water quality decline, including algal or cyanobacteria blooms, fish kills, decreased water clarity, loss of aesthetic values, and beach closures. Decomposition of accumulated organic matter from dead algal or cyanobacteria blooms and plants, such as milfoil, can result in anoxia in bottom waters, which can release phosphorus back into the water column as food for algae and plants and can also be lethal to fish and other aquatic organisms.



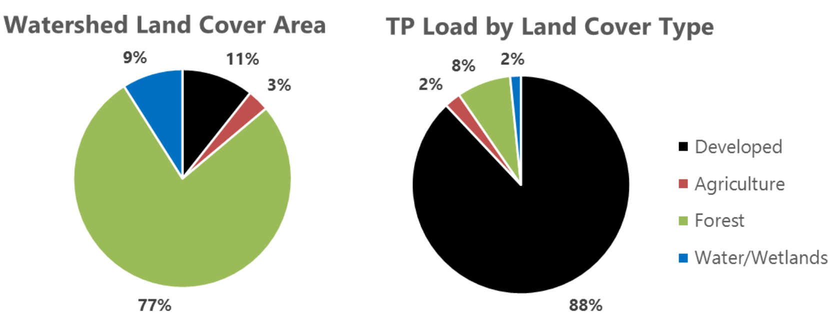
Visual summary of existing water quality in MBI. Data represent recent (2006-2015) and seasonal (May 24-Sept 15) median or average calculations. TP = total phosphorus; Chl-a = chlorophyll-a; SDT = Secchi Disk Transparency. No data are available for Chl-a and SDT at Basin 2 and Chl-a at Basin 3.

Because the morphology (shape) and bathymetry (depth) of MBI is irregular, causing the formation of individual basins, bays, or inlets within the study system that impact water and nutrient movement (flushing), and subsequently, system function and health, MBI was divided into three individual basins (Basin 1, 2, and 3) for modeling, data analysis, and goal setting purposes. Basin 1 is considered impaired for both TP and chlorophyll-a (Chl-a), while Basins 2 and 3 are potential non-supports due to insufficient, but likely lower than reserve capacity, Chl-a data (Section 3.2.2). The analysis revealed that Basin 1 requires the most reductions in TP and is at most risk for elevated nutrient input and algal blooms that can impact Basin 2 (and Basin 3 minimally), while Basins 2 and 3 may also have considerable reductions needed for TP if Chl-a levels are in fact a significant issue. However, data from multiple sites within Basin 3 show that Chl-a is better than the criterion (3.3 ppb) and reserve capacity threshold (3.0 ppb) for oligotrophic systems. Until more Chl-a data are collected for Basin 2 and 3 sites, the water quality goal will be based on the achievement of 7.2 ppb for TP with the understanding that this goal may change given the likely acceptable Chl-a levels in MBI.

The land use model results indicate that the greatest phosphorus load comes from watershed runoff, which accounts for 83%, 47%, and 88% of the total loading to Basins 1, 2, and 3, respectively. Atmospheric deposition accounts for <11%, septic systems <10%, waterfowl <3%, and internal loading <2% of the TP entering the three basins. While the load from Basin 1 to Basin 2 accounts for 29% of the total load to Basin 2, the load from Basin 2 and Basin 3 accounts for only 3% of the total load to Basin 3. This suggests that the higher TP concentrations observed at Green's Basin, while important locally, may not have a large impact further downstream.

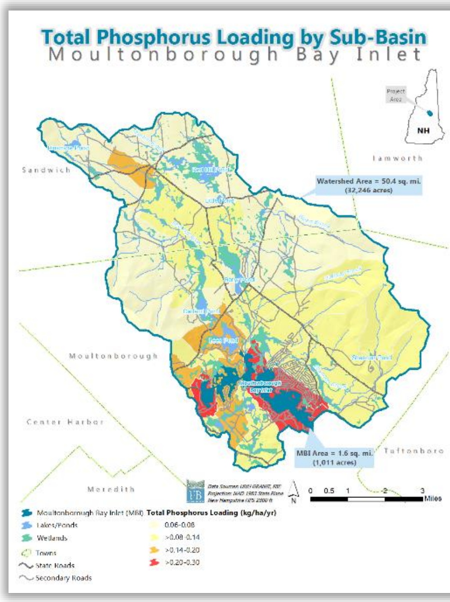


Percentage of total phosphorus (TP) loading (kg/yr) by source (atmospheric, internal loading, waterfowl, septic systems, watershed load).



Watershed land cover area by general category (developed, agriculture, forest, and water/wetlands) and total phosphorus (TP) load by general land cover type.

Although developed areas cover only 11% of the watershed (see Section 2.2.2), developed areas are contributing 88% of the phosphorus load to MBI. The direct drainage area of MBI contributes the highest phosphorus load per unit area to MBI (Appendix B). Direct shoreline areas are usually high phosphorus contributors because of their proximity to lakes and high-density development. Given this, the direct shoreline of a lake deserves special attention in any lake protection plan.



The direct drainage area of MBI contributes the most phosphorus per hectare per year compared to the other sub-basins (see Appendix B for larger map).

The build-out analysis identified an estimated 5,253 acres (26%) of the portion of the watershed in the Town of Moultonborough is developable (Appendix B; Section 3.2.4). Up to 2,184 new buildings (a 93% increase from current conditions) could be added at full build-out by the year 2058, using a conservative growth rate of 1.58%. This predicted increase in development was then input to the model; the future in-lake phosphorus concentration was estimated at 22.5, 14.5, and 16.6 ppb for Basins 1, 2, and 3, respectively. Shannon Brook is most at risk for increases in TP loading because of increased development. Results of the build-out analysis reinforce the concept of comprehensive planning at the watershed level to address future development and its effect on the water quality of MBI. Future development will increase the amount of polluted runoff that drains to MBI; therefore, it is recommended that town officials revisit zoning ordinances to ensure that existing laws encourage smart, low-impact development. Land-use and zoning ordinances are among the most powerful tools municipalities can use to protect their natural resources.

MBI may experience a 40-43% increase in phosphorus loading at full build-out by 2058. The direct drainage area and Shannon Brook sub-basins are most at risk for increases in phosphorus loading because of anticipated development.

WATER QUALITY GOALS

The over-arching goal for the watershed is to improve the water quality of MBI and to protect MBI from future, unaccounted-for inputs of phosphorus because of new development in the watershed over the next twenty years.

The Advisory Committee set a water quality goal of 7.2 ppb TP (for summer median epilimnion TP) for Basins 1, 2, and 3, along with adaptable interim goals and milestones that will help achieve this goal over the next twenty or more years. This will require a phosphorus loading reduction of 42% (26 kg/year) in Basin 1, 31% (27 kg/year) in Basin 2, and 20% (242 kg/year) in Basin 3 based on current conditions.

Over the next twenty years, new development using business-as-usual regulations will likely increase current phosphorus loading by 16, 22, and 294 kg/yr to Basins 1, 2, and 3, respectively. This will hinder progress toward achieving the water quality goals. Given this consideration, it will be just as important to focus on updating municipal regulations to incorporate more stringent water quality protections during new development as it will be to minimize TP loading from existing development. It is also important to note that there are several larger ponds within the Basin 3 drainage that should set their own water quality goals and TP reduction goals to help improve water quality in MBI.

POLLUTANT SOURCE IDENTIFICATION

During the 2015 watershed survey, 56 NPS sites were identified and rated for impact level based on location, slope, amount of soil eroded, and proximity to water. Recommendations ranged from installing buffer plantings and infiltration swales to replacing culverts and reconstructing concrete aprons. The following showcases select hotspot NPS sites in the MBI watershed.

SITE ID #1: a driveway and boat access ramp were identified as having moderate surface and road shoulder erosion that runs off directly into the lake. It is recommended that new surface material (e.g., recycled asphalt) be added, the road crown reshaped, and an open top culvert installed.

SITE ID #2: a commercial property was identified as having moderate surface and roof runoff erosion and lack of streambank vegetation that allows stormwater to enter the stream. It is recommended that an infiltration trench at the roof dripline be installed, and a buffer planted along the stream.

SITE ID #3: a town road was identified as having severe surface erosion with several large gullies that flow directly into the lake. It is recommended that runoff diverters are installed, a foot path is stabilized, and a buffer is planted with erosion control mulch.

SITE ID #4: a private road was identified as having moderate surface erosion, lack of adequate shoreline vegetation, and significant shoreline erosion that was depositing stormwater runoff into a stream. It is recommended that a buffer be planted along the stream for stabilization.

During the 2015 shoreline survey, 60% of the MBI shoreline (or 330 parcels) scored 10 or higher, indicating shoreline conditions that are likely detrimental to lake water quality. These shoreline properties tended to have inadequate buffers, evidence of bare soil, and structures within 75 ft. of the shoreline.

Lack of vegetative buffer (left) results in delivery of excess nutrients and sediments in the Inlet compared to vegetated shoreline areas (right). (Photo: FB Environmental)

PLAN IMPLEMENTATION STRATEGY & RECOMMENDATIONS

Management strategies for achieving the water quality goals involve using a combination of structural and non-structural BMPs, as well as an adaptive management approach (refer to Section 4). The recommendations of this plan should be carried out by an advisory committee like the one assembled for development of this plan. The following presents short-term recommendations for achieving the goal and objectives:

- WATERSHED & SHORELINE BMPS: Work with shorefront residents to encourage participation in shoreline residential BMP implementation efforts, with initial focus on the six high impact shoreline properties around Basins 2 and 3 and the 38 medium impact shoreline properties around Basin 1. A funding subcommittee should be created to help find and apply for funding that supports all aspects of the Action Plan. Begin implementing recommended BMPs at the 20 high priority sites identified in the watershed survey.
- SEPTIC SYSTEMS: Distribute educational information and lists of septic service providers to watershed residents. Host "septic socials" to start the conversation around septic system maintenance and replacement. Investigate grants and low-interest loans as a first step to upgrading identified problem systems in the watershed. Develop a septic system database.
- ROADS: Work with private road associations to begin a discussion about four season road maintenance and management. Coordinate with NHDOT to identify and replace priority culverts identified during the watershed survey.
- PLANNING & LAND CONSERVATION: Have towns formally adopt the plan. Provide information on LID and BMP descriptions to Selectmen, town staff, and Planning Board members. Encourage towns to consider making changes to ordinances to protect water quality. Suggestions include: increasing setbacks to 100 feet within the shoreland zone and wetlands, increase the amount of land set aside in conservation subdivisions to a minimum of 50% of the developed area, and include LID language. Given future development potential, it is critical for municipalities to develop and enforce stormwater management measures that prevent an increase in pollutant loadings from new and re-development projects, particularly as future development may offset reduced loads from other plan implementation actions.
- WATER QUALITY MONITORING: Take regular, annual DO and temperature profile readings, Secchi disk readings, and epilimnion and hypolimnion total phosphorus and epilimnion chlorophyll-a samples at a minimum of one station per basin. Recommend WMO00GL (Green's Basin), WMO01BL (Blanchard's Island), and WMO01LL (Little Ganzy). Aim for biweekly Secchi disk readings and monthly DO and temperature profile readings combined with chemical sampling. Assumes a sampling season from June-September.

ESTIMATED COSTS

The cost of successfully implementing this watershed plan is estimated at over $1,000,000 over the next twenty years (Section 5.4). However, many costs are still unknown and should be incorporated to the Action Plan as information becomes available. A sustainable funding plan should be developed within the first year of this plan and revisited on an annual basis to ensure that the major planning objectives can be achieved over the long-term.

This funding strategy would outline the financial responsibilities at all levels of the community (landowners, towns, community groups, and State and federal governments).

Estimated one-time or initial costs and 20-year total costs for watershed restoration.

Category	Estimated Costs	20-year Total
Watershed & Shorefront BMPs	$559,286	$613,536
Septic Systems*	$24,250	$27,500
Roads	$23,750	$23,750
Planning & Conservation	$22,500	$22,500
WQ Monitoring	$22,200	$406,000
Total Cost	**$651,986**	**$1,093,286**

**Septic system action items do not include design or replacement costs because these should be covered by private landowners. Action items cover assistance to secure grant funding for those individuals who cannot afford these costs.*

EVALUATING PLAN SUCCESS

The success of this plan is dependent on the continued effort of volunteers, and a strong and diverse advisory committee (like the one established for plan development) that meets regularly to coordinate resources for implementation, review progress, and make any necessary adjustments to the plan to maintain relevant action items and interim benchmarks. Measurable milestones (number of BMP sites, volunteers, funding received, etc.) should be tracked by an advisory committee and reported to NHDES on a regular basis.

A 20-42% reduction in phosphorus is no easy task, and because there are many diffuse sources of phosphorus reaching MBI from existing residential development, roads, septic systems, and other land uses in the watershed, it will require an integrated and adaptive approach across many different parts of the watershed community to be successful.

ACKNOWLEDGMENTS

MBI Watershed Restoration Plan Advisory Committee

Cristina Ashjian, Moultonborough Heritage Commission
Joshua Bartlett, Selectman, Town of Moultonborough
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Brain Sanford, Moultonborough Conservation Commission
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Shoreline Survey Volunteers

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Sara Steiner, Volunteer Lake Assessment Program, NHDES

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1. INTRODUCTION

1.1 BACKGROUND AND PURPOSE

Located in the Towns of Moultonborough and Sandwich in Carroll County, New Hampshire, Moultonborough Bay Inlet (MBI) serves as an attractive summer getaway for tourists who come to enjoy the scenic beauty and good water clarity of MBI and Lake Winnipesaukee. Lakes are highly valued natural resources that provide critical habitat for a diverse abundance of plants, wildlife, and aquatic life, and opportunities for recreation, scenic enjoyment, and drinking water. Because the water quality of lakes and streams can decline rapidly because of stormwater runoff from watershed development, taking proactive steps to properly manage and treat stormwater runoff to protect these important water resources is essential for continued ecosystem health, including resources valued by humans.

Seasonal and year-round residents and tourists alike enjoy the good water quality and clarity of MBI. (Photo: FB Environmental)

The MBI Watershed Restoration Plan is the culmination of a major effort by many individuals who not only care about the long-term protection of water quality in this waterbody, but also recognize that high water quality is directly connected to the economic well-being of the area. Lake Winnipesaukee Association (LWA) is the region's leader in protecting and managing water resources and hosted an initial meeting to generate interest in the plan with many stakeholders representing a diverse range of interests in attendance. From municipal staff and conservation commissions, to state agency officials (e.g., NH Fish & Game, NHDES), to local residents and lake/pond/neighborhood associations (e.g., Milfoil Committee, Lees Pond Association, Suissevale, Balmoral), to land trusts and non-profits (e.g., Lakes Region Conservation Trust, Granite State Rural Water Association), to technical experts – LWA guided the creation of an Advisory Committee to ensure that a strong watershed restoration plan was developed for this important New Hampshire waterbody.

This plan was partially funded by a Watershed Assistance Grant for High Quality Waters from NHDES using Clean Water Act Section 319 funds from the USEPA, with additional financial and in-kind services provided by the Town of Moultonborough, Moultonborough Conservation Commission, residents, and stakeholders. This comprehensive watershed plan will provide guidance for the next phase of actions needed to preserve the water quality of this picturesque waterbody. The water quality of MBI represents a core asset for the local economy as a premier tourist destination.

This plan provides a roadmap for improving the water quality of MBI, and provides a mechanism for procuring funding to secure actions needed to achieve water quality goals. In addition, this plan sets the stage for ongoing dialogue among key stakeholders in many facets of the community, and promotes coordinated municipal land use changes to address stormwater runoff. The success of this plan is dependent on the concerted effort of volunteers, and a strong and diverse Advisory Committee that meets regularly to review progress and make any necessary adjustments to the plan.

As part of the development of this plan, a build-out analysis, water quality and assimilative capacity analysis, and shoreline/watershed survey were conducted. Results of these efforts were used to run a land-use model, or Lake Loading Response Model (LLRM), that estimated the historical, current, and projected amount of phosphorus being delivered to the Inlet from the watershed.

The MBI Watershed Restoration Plan includes nine key planning elements to address NONPOINT SOURCE (NPS) POLLUTION in impaired waters. These guidelines, set forth by the USEPA, highlight important steps in protecting water quality for waterbodies impacted by human activities, including specific recommendations for guiding future development, and strategies for reducing the cumulative impacts of NPS pollution on lake water quality.

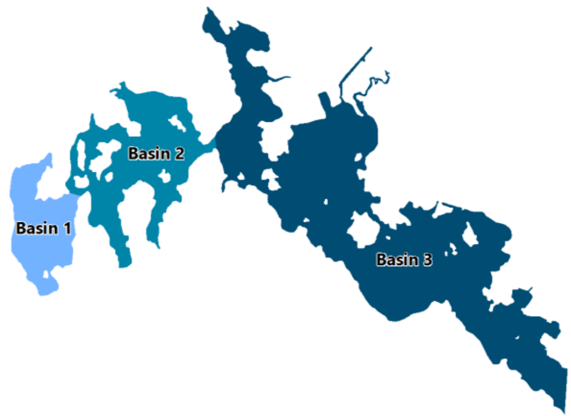
NONPOINT SOURCE (NPS) POLLUTION (a.k.a., stormwater runoff) cannot be traced back to a specific source, but comes from a number of diffuse sources throughout a watershed. One of the major constituents of NPS pollution is sediment, which contains a mixture of nutrients and inorganic and organic material that stimulate algal growth.

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

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

1.2 STATEMENT OF GOAL

MBI represents a unique system for study because it is not a true lake, but rather part of a larger lake system, Lake Winnipesaukee, and thus, the Inlet itself is not listed as a separate assessment unit by NHDES, but is integrated with and classified the same (oligotrophic) as Lake Winnipesaukee, which is listed on the 2014 DRAFT NHDES 303(d) list as impaired for cyanobacteria. The morphology (shape) and bathymetry (depth) of MBI is irregular, causing the formation of individual basins, bays, or inlets within the study system that impact water and nutrient movement (flushing), and subsequently, system function and health. Given these characteristics of MBI, the Inlet was divided into three individual basins (Basin 1, 2, and 3) for modeling, data analysis, and goal setting purposes. One of the challenges posed by this division is the lack of consistent, long-term data for each of the three basins. The number of sites and frequency of sampling in MBI has varied over the 20-year period with more consistent sampling occurring in the last 5 years.



Based on an oligotrophic classification, the assimilative capacity showed that Basin 1 is considered impaired for both total phosphorus (TP) and chlorophyll-a (Chl-a), requires the most reductions in TP compared to Basins 2 and 3, and is at risk for elevated nutrient input and algal blooms that could impact Basin 2 (and Basin 3 minimally). Basins 2 and 3 are potential non-supports due to insufficient, but likely lower than reserve capacity, Chl-a concentrations; minimal data from one site within Basin 2 and multiple sites within Basin 3 show that Chl-a is better than the criterion (3.3 ppb) and reserve capacity threshold (3.0 ppb) for oligotrophic systems. Until more Chl-a data are collected for Basin 2 and 3 sites, the water quality goal is based on the achievement of 7.2 ppb for TP with the understanding that this goal may change given the likely acceptable Chl-a levels in MBI.

WHY SHOULD WE BE CONCERNED WITH MANAGING PHOSPHORUS?

Phosphorus was used to set the water quality goals for MBI to improve current water quality conditions. Phosphorus is generally the limiting nutrient in freshwater systems, driving algal and plant growth, including non-native aquatic plants. Excess phosphorus can stimulate productivity (e.g., algal blooms and excessive plant growth). The algae and plants die and accumulate on the lake bottom where they are decomposed. Decomposition is a process that consumes oxygen, causing anoxia in bottom waters, particularly during stratification when oxygen-rich surface waters are thermally-separated from nutrient-rich bottom waters. Anoxia can release sediment-bound phosphorus back into the water column where it can re-stimulate algal blooms and plant growth, creating a positive feedback to eutrophication. Anoxia can also be lethal to fish and other aquatic organisms.

This plan provides short and long-term goals for improving the water quality of MBI over the next twenty years (2017-2036). **The Advisory Committee has set adaptable interim water quality goals and milestones that will reduce current median in-lake total phosphorus to 7.2 ppb for Basins 1, 2, and 3, which would require a phosphorus loading reduction of 42% (26 kg/year) in Basin 1, 31% (27 kg/year) in Basin 2, and 20% (242 kg/year) in Basin 3.** Refer to Sections 4 and 5 for more details on interim goals, milestones, and goal adaptation strategies for the three basins. Achieving these goals will help reduce current in-lake phosphorus (and subsequently reduce the potential for anoxia and algal blooms) over time and help safeguard against increased phosphorus loading from the landscape as a result of development (e.g., septic systems, paved surfaces, sediment, etc.).

This target reduction in phosphorus can be achieved through the following structural (engineered treatment options) and non-structural (planning) objectives:

- Implement BEST MANAGEMENT PRACTICES (BMPS) throughout the watershed to reduce sediment and phosphorus runoff from existing development (Sections 3.4 and 4.2).
- Educate landowners through the NHDES Soak Up the Rain program, BMP demonstration sites, workshops, and other communication strategies, targeting high priority septic systems (>25 years old, within 50 feet of a waterbody, and rarely pumped out).
- Institute greater controls on new and redevelopment, require LOW-IMPACT DEVELOPMENT (LID) in site plans, and encourage regular septic system maintenance.
- Continue and/or expand the water quality monitoring and aquatic invasive plant control programs (Section 5.2.5).

These objectives and more are discussed in greater detail in the Action Plan (Section 5.2).

1.3 INCORPORATING EPA'S NINE ELEMENTS

USEPA Guidance lists nine components that are required within a watershed restoration plan to restore waters impaired or likely to be impaired by NPS pollution. These guidelines highlight important steps in protecting water quality for any waterbody affected by human activities. The following locates and describes the nine required elements found within this plan:

A. Identify Causes and Sources: **Section 3.4** highlights known sources of NPS pollution in the MBI watershed and describes the results of the watershed and shoreline surveys. These sources of pollution must be controlled to achieve load reductions estimated in this plan, as discussed in item (B) below.

B. Estimate Phosphorus Load Reductions Expected from Planned Management Measures described under (C) below: **Section 4.3** describes how reductions in annual phosphorus loading to MBI may be realized over a twenty-year period, and describes the methods used to estimate phosphorus reductions. These reductions apply primarily to structural BMPs (e.g., installing vegetated buffers or rain gardens, mitigating runoff from roofs and driveways, improving and maintaining roads, and managing fertilizer) for existing development, but they will not be possible without the use of non-structural BMPs. Examples of non-structural practices include, but are not limited to, reviewing and improving zoning ordinances, promoting the use of LID designs for future development, and educating watershed citizens about activities to reduce phosphorus at home.

C. Description of Management Measures: **Section 5.2** identifies ways to achieve the estimated phosphorus load reduction and reach water quality targets. The Action Plan focuses on five major topic areas that address NPS pollution, including: septic systems, shoreline and watershed BMPs, roads, planning and land conservation, and water quality monitoring. Management options in the Action Plan focus on non-structural BMPs integral to the implementation of structural BMPs.

D. Estimate of Technical and Financial Assistance: **Sections 5.2 and 5.4** includes a description of the associated costs, sources of funding, and primary authorities responsible for implementation. Sources of funding need to be diverse, and should include state and federal granting agencies (USEPA and NHDES), local groups (watershed towns and lake associations), private donations, and landowner contributions for BMP implementation on private property. LWA and its core stakeholders, led by an Advisory committee, should oversee the planning effort by meeting regularly and efficiently coordinating resources to achieve the goals set forth in this plan.

E. Information & Education & Outreach: **Section 5.5** describes how the Education and Outreach component of the plan is already being or will be implemented to enhance public understanding of the project as a result of leadership from LWA and the Advisory Committee.

F. Schedule for Addressing Phosphorus Reductions: **Section 5.2** provides a list of strategies to reduce stormwater and phosphorus runoff to MBI. Each strategy, or "Action Item," has a set schedule that defines when the action should begin. The schedule should be adjusted by the Advisory Committee on an annual basis (see Section 4.4 on Adaptive Management).

G. Description of Interim Measureable Milestones: **Sections 5.3 and 5.6** outline indicators of implementation success that should be tracked annually. Using indicators to measure progress makes the plan relevant and helps sustain the action items. The indicators are broken down into three different categories: Environmental, Programmatic, and Social Indicators. Environmental indicators are a direct measure of environmental conditions, such as improvement in water clarity or reduction in median in-lake phosphorus concentration. Programmatic indicators are indirect measures of restoration activities in the watershed, such as how much funding has been secured or how many BMPs have been installed. Social indicators measure change in social behavior over time, such as the number of new stakeholders on the Advisory Committee or number of new lake monitoring volunteers.

H. Set of criteria: **Section 5.3** can be used to determine whether loading reductions are being achieved over time, substantial progress is being made towards water quality objectives, and if not, criteria for determining whether this plan needs to be revised.

I. Monitoring component: **Section 5.2.5** describes the long-term water quality monitoring strategy for MBI, the results of which can be used to evaluate the effectiveness of implementation efforts over time as measured against the criteria in (H) above. The ultimate objective of this plan is to achieve a stable or improving trophic state. The success of this plan cannot be evaluated without ongoing monitoring and assessment and careful tracking of load reductions following successful BMP implementation projects.

1.4 PLAN DEVELOPMENT AND COMMUNITY PARTICIPATION PROCESS

This plan was developed through the collaborative efforts of several Advisory Committee meetings and conference calls among FB Environmental and other technical staff, including LWA, DK Water Resource Consulting, and NHDES (see Acknowledgments). The Advisory Committee served to review water quality data and goals, identify priority BMP selections, and help tailor action plan items.

On May 29, 2014, Pat Tarpey of LWA participated in the filming of the cable program “Talk of the Town” with Carter Terenzini, Town Administrator, and Bruce Woodruff, Town Planner, to promote the plan.

On July 12, 2014, Bill Gassman of the Moultonborough Conservation Commission presented information on the plan to the Lees Pond Association; 25 people were in attendance.

On October 27, 2014, FB Environmental, DK Water Resource Consulting, and LWA held a kick-off meeting to provide an overview of the watershed restoration plan development process, give interested stakeholders an introduction to the main purpose of the plan, and explain how the watershed towns and residents can use the plan to protect MBI. Attendees included the Moultonborough Town Planner, members of the Planning Board, Conservation Commission, Zoning Board of Adjustment, Milfoil Committee, and Heritage Commission, lakefront property owners, staff and students from Plymouth State University, and NHDES.

On March 4, 2015, LWA hosted an initial Advisory Committee meeting with 15 stakeholders at the Moultonborough Town Library to generate interest in the plan. Stakeholders represented a diverse range of interests, including municipal staff and conservation commissions, state agency officials (e.g., NH Fish & Game, NHDES), residents and lake/pond/neighborhood associations (e.g., Milfoil Committee, Lees Pond Association, Suissevale, Balmoral), land trusts and non-profits (e.g., Lakes Region Conservation Trust, Granite State Rural Water Association), and technical experts.

On August 4, 2015, LWA hosted a second Advisory Committee meeting with 10 attendees at the Moultonborough Town Library. LWA provided a summary of the tasks involved in the watershed planning process and results from the assimilative capacity analysis. FB Environmental presented preliminary results of the watershed nonpoint source survey and the Lake Loading Response Model (LLRM) for MBI. The objective of the meeting was to familiarize the Advisory Committee with the model results and get any feedback from stakeholders that would improve model assumptions.

On April 12, 2016, LWA hosted a third Advisory Committee meeting with 15 attendees at the Moultonborough Fire Station. LWA and FB Environmental presented final results from the water quality analysis, assimilative capacity analysis, model results, shoreline and watershed surveys, and buildout analysis. Recommendations for the water quality goals were presented and discussed with stakeholders. Valuable concerns were mentioned and noted by technical staff for incorporation to the plan.

On June 14, 2016, LWA hosted a fourth meeting at the Moultonborough Public Library with a subset of four Advisory Committee members to discuss plan development progress and to solicit feedback from stakeholders on the final water quality goals and potential action items.

On August 13, 2016, LWA presented information on plan development and water quality of MBI at the Stanyon Pond Association Annual Meeting; 32 people in attendance.

The action plan was sent to the Advisory Committee at the beginning of November 2016 for thorough review and input along with the draft watershed restoration plan. No formal public forum was held, but public comment on the action plan and draft plan was solicited following initial review by the Advisory Committee. On December 7, 2016, a fifth meeting of the Advisory Committee (11 attendees) was held to review the action plan and draft plan, as well as solicit input for the final selection of sites for BMP design. Comments and final BMP designs were incorporated into the final plan in December 2017. The final plan was presented at a public meeting held on December 11, 2017 at the Moultonborough Public Safety Building (40 attendees).

2. WATERSHED CHARACTERIZATION

2.1 LOCATION & CLIMATE

Located in the Lakes Region of east central New Hampshire just south of the White Mountains, Moultonborough Bay Inlet (MBI) has been long treasured as a recreational haven for summer vacationers and year-round residents. The 50 square-mile (32,246-acre) watershed hosts some of the oldest summer vacation spots in New Hampshire and offers fishing, hiking, boating, sailing, canoeing, kayaking, and swimming in the summer, and ice fishing, cross-country skiing, and snowmobiling in the winter. The watershed is spread across three towns, with 68% (21,861 acres) in Moultonborough, 32% (10,380 acres) in Sandwich, and <1% (5 acres) in Tamworth.

MBI is situated within a temperate zone of converging weather patterns from the hot, wet southern regions and the cold, dry northern regions, which causes various natural phenomena such as severe thunder and lightning storms, hurricanes, and heavy snowfalls. The area experiences moderate to high rainfall and snowfall, averaging 51.7 inches of precipitation annually (data collected from 1981-2010 at the Tamworth, NH weather station; NOAA NCDC, 2016). Temperature generally ranges from 10 °F to 58 °F with an average of 21.5 °F in winter and 65.1 °F in summer (NCDC, 2016).

2.2 POPULATION, GROWTH TRENDS, AND LAND COVER

2.2.1 POPULATION AND GROWTH TRENDS

Many lakeshore residents in the MBI watershed are seasonal and enjoy the natural beauty of the landscape from Independence Day to Labor Day. These seasonal residents and visitors utilize various property types around the lakeshore, including private camps, private rental camps, group rental cottages, family resorts, children's camps, and overnight cabins.

Development in the watershed changes the natural land cover that protects lake water quality. All new development should be managed carefully to mimic natural conditions by infiltrating stormwater runoff during storm events. (Photo: FB Environmental)

Understanding population growth and demographics, and ultimately development patterns, provides critical insight to watershed management, particularly as it pertains to lake water quality. According to the U.S. Census Bureau, the population of Carroll County in 2010 was 47,698, representing a 9.4% increase in population since the 2000 census (NHOEP, 2011). There is limited public transportation in the area, and most people use personal vehicles in their daily commute. Residents are attracted to the MBI watershed for its small-town character and easy commute by vacationers in northern and southern New England.

From 2000 to 2010, the population of Moultonborough decreased by 9.8% and the population of Sandwich increased by 3.1% (NHOEP, 2011; Table 2.1). Historically, Moultonborough experienced more rapid annual growth rate than the rest of the county up until 2000 when its annual growth rate slowed and declined, nearly equaling the positive growth rate experienced by the rest of the county. Sandwich has experienced slow, but steady growth in population compared to the rest of the county.

TABLE 2.1: Average annual population growth rates for watershed communities of MBI.

County/Town	1960	1970	1980	1990	2000	2010	50-Yr Annual Growth Rate (1960-2010)	20-Yr Annual Growth Rate (1990-2010)	10-Yr Annual Growth Rate (2000-2010)
Carroll	15,821	18,548	27,929	35,410	43,608	47,698	4.03%	1.74%	0.94%
Moultonborough	840	1,310	2,206	2,956	4,484	4,044	7.63%	1.84%	-0.98%
Sandwich	620	666	905	1,066	1,286	1,326	2.28%	1.22%	0.31%

Most the population for the watershed towns fall within the 20-64 age category. Residences in these watershed towns comprise a high percentage of seasonal (35-61%) and owner-occupied (86%) homes (Table 2.2). These statistics illustrate the well-known fact that the Lakes Region is an attractive tourist destination for those seeking a tranquil summer retreat, particularly along the shores of MBI. Interestingly, however, Moultonborough has a relatively low percentage of total occupied homes (35%) compared to the State and county, suggesting a significant portion of buildings in the town are vacant or non-livable structures.

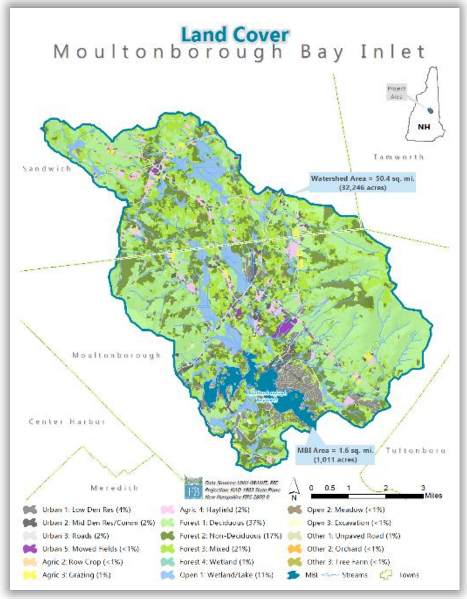
TABLE 2.2: 2010 population demographics for watershed communities of MBI.

State/County/Town	Total Pop	Aged 0-19	Aged 20-64	Aged 65+	Total Houses	% Total Occ Houses	% Owner Occ Houses	% Renter Occ Houses	% Total Seasonal Houses
New Hampshire	1,316,470	325,802	812,400	178,268	614,754	84%	71%	29%	10%
Carroll County	47,818	9,798	28,182	9,838	39,813	53%	79%	21%	42%
Moultonborough	4,044	828	2,311	905	4,940	35%	86%	14%	61%
Sandwich	1,326	235	784	307	1,057	58%	86%	14%	35%

The desirability of MBI as a recreational destination will likely stimulate a return of positive population growth in the future for the Town of Moultonborough. Therefore, communities within the watershed should consider the effects of current municipal land-use regulations on local water resources. As the region's watersheds are developed, erosion from disturbed areas increases the potential for water quality decline.

2.2.2 LAND COVER

Characterizing land cover within a watershed on a spatial scale can highlight potential sources of NPS pollution that would otherwise go unnoticed in a field survey of the watershed. For instance, a watershed with large areas of developed land and minimal forestland will likely be more at risk for NPS pollution than a watershed with well-managed development and large tracts of undisturbed forest, particularly along headwater streams.



Land cover within the MBI watershed is dominated by forest (see Appendix B for larger map).

Today, development accounts for 10% of the watershed, while forested areas dominate at 75% (Figure 2.1). Wetlands and open water (including the surface area of MBI) represent 2% and 10% of the watershed, respectively. Agriculture represents 3%, and includes row crops, grazing pastures, and hayfields. Development, while a relatively low percentage at the watershed-scale, is concentrated around waterbodies, particularly MBI, and consists of a mix of seasonal and year-round residential homes, including numerous old cottages and summer camps and two densely-built residential communities of approximately 400 homes located along the southeastern shore of the Inlet (e.g., Suissevale and Balmoral). Crystal Geiser Bottling Plant is located off Route 171 at Castle in the Clouds. There are also numerous livestock farms (e.g., Keyser Farm, Castle in the Clouds, Mt. Breeze Farm) that host a variety of animals, including horse, cattle, goat, and sheep.

Developed areas within the MBI watershed are characterized by impervious surfaces, including areas with asphalt, concrete, and rooftops that force rain and snow - that would otherwise soak into the ground - to runoff as stormwater. Stormwater runoff carries pollutants to waterbodies that may be harmful to aquatic life, including sediments, nutrients, pathogens, pesticides, hydrocarbons, and metals. Studies have shown a link between the amount of impervious area in a watershed and water quality conditions (CWP, 2003). In one study, researchers correlated the amount of pollutants in a waterbody to the percentage of land with impervious cover in a watershed (Mallin *et al.*, 2000). Therefore, the water quality of the Inlet is impacted by and reflective of the amount of developed area in the watershed. As population grows, it is imperative that watershed communities incorporate LID techniques into new development projects. More information on LID and BMP implementation can be found in the Action Plan in Section 5.2.

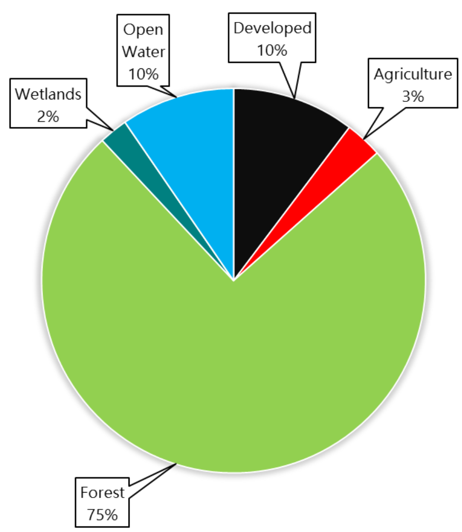
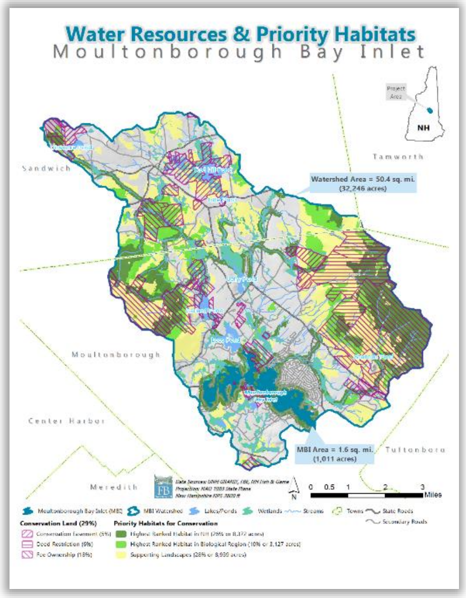


FIGURE 2.1: Land cover in the MBI watershed.

2.2.3 PROTECTED AND PUBLIC LANDS

Land conservation is essential to the health of a region, particularly for the protection of water resources, enhancement of recreation opportunities, vitality of local economies, and preservation of wildlife habitat. Considerable effort by watershed towns and private individuals has gone into the protection of land in the MBI watershed not only to protect critical wildlife habitat and other environmentally-sensitive land and water resources, but also to provide low-impact, public recreational access to these natural resources. Land conservation is one of many tools for protecting lake water quality for future generations. Conservation land in the MBI watershed covers 14.2 square miles (9,113 acres) or approximately 29% of the watershed, and includes a mix of conservation easements (5%), deed restrictions (6%), and fee ownerships (18%).



Conservation land covers 29% of the watershed of MBI (see Appendix B for larger map).

2.3 PHYSICAL FEATURES

2.3.1 TOPOGRAPHY

MBI exists at about 500 feet above sea level (fasl) and is encompassed by mountainous woodlands in all directions. The highest peaks in the watershed are located to the east in the Ossipee Mountains at 2,782 fasl (e.g., Faraway Mountain, Mt. Roberts, and Black Snout Mountain), to the north near Dinsmore Pond at 1,606 fasl, and to the west in the Red Hills at 2,030 fasl.

2.3.2 SOILS AND GEOLOGY

The composition of soils surrounding MBI reflects the dynamic geological processes that have shaped the landscape over millions of years. Over 380 million years ago, the region was under a shallow sea from a sinking continent; layers of mineral deposition compressed to form sedimentary layers of shale, sandstone, and limestone known as the Littleton Formation (Goldthwait, 1968). The Earth’s crust folded under high heat and pressure to form metamorphic rock comprising the parent material – schist, quartzite, and gneiss. This parent material has since been modified by bursts of igneous rock intrusions known as the New Hampshire Plutonic Series (300 million years ago) and the White Mountain Plutonic Series (120 million years ago) (Goldthwait, 1968).

The current landscape formed 12,000 years ago at the end of the Great Ice Age as the mile-thick glacier over half of North America melted and retreated, scouring bed rock and depositing glacial till to create the deeply scoured basin of lakes. The retreating action also eroded nearby mountains composed of granite, quartz, gneiss, and schist, leaving behind remnants of drumlins and eskers from ancient stream deposits. The glacier deposited more than three feet of glacial till (mix of coarse sand, silt, and clay), laying the foundation for invading vegetation and meandering streams as the depression basins throughout the region began to fill with water (Goldthwait, 1968).

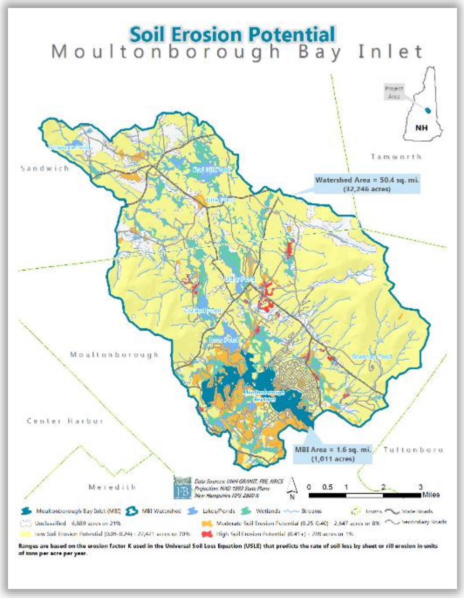
The MBI watershed is characterized by multiple soil series. Over 5,650 acres (18%) of the watershed is underlain by the Lyman-Berkshire rock outcrop complex; 4,651 acres (14%) is underlain by Becket fine sandy loam; 3,144 acres (10%) is underlain by Monadnock and Berkshire soils; and 3,070 acres (10%) is underlain by Lyman-Berkshire fine sandy loams (Table 2.3).

TABLE 2.3: Dominant soil series found in the watershed of MBI. Source: USDA, 1977.

Soil Series Name	Soil Erosion Potential	Parent Material
Lyman-Berkshire (Rock outcrop)	Low	Glacial till in hilly uplands and mountains
Becket (Fine sandy loam)	Low	Sandy glacial till on oval hills and mountainsides
Monadnock-Berkshire	Low	Sandy glacial till on upland hills and plains
Lyman-Berkshire (Fine sandy loam)	Low	Sandy glacial till on undulating foot slopes and ridgetops

Other soil series present in the watershed (<5%) include: Skerry fine sandy loam (1,605 acres), Marlow fine sandy loam (1,467 acres), Peru fine sandy loam (1,077 acres), Woodstock-Bice fine sandy loam (969 acres), Pillsbury fine sandy loam (881 acres), Ossipee mucky peat (765 acres), Chocorua mucky peat (750 acres), Leicester-Moosilauke fine sandy loam (688 acres), Henniker fine sandy loam (671 acres), Waumbek fine sandy loam (603 acres), Gloucester fine sandy loam (564 acres), Colton gravelly loamy fine sand (487 acres), Metacomet fine sandy loam (411 acres), Limerick silt loam (336 acres), Bucksport mucky peat (312 acres), Raynham silt loam (289 acres), Whitman loam (285 acres), Duane fine sandy loam (267 acres), Boscawen gravelly loamy sand (221 acres), Naumburg loamy sand (217 acres), Paxton fine sandy loam (175 acres), Woodstock-Bice-Rock outcrop complex (173 acres), Champlain loamy sand (163 acres), Croghan loamy fine sand (160 acres), Henniker-Gloucester fine sandy loams (158 acres), Berkshire fine sandy loam (106 acres), pits/gravel (51 acres), Adams loamy sand (40 acres), Woodbridge fine sandy loam (37 acres), Nicholville silt loam (36 acres), Salmon very fine sandy loam (33 acres), Podunk fine sandy loam (28 acres), Bice fine sandy loam (20 acres), Acton fine sandy loam (17 acres), and Ondawa fine sandy loam (9 acres). Water covers the remaining 1,662 acres in the MBI watershed.

Soil erosion potential is dependent on a combination of factors, including land contours, climate conditions, soil texture, soil composition, permeability, and soil structure (O'Geen et al. 2006). Soil erosion potential should be a primary factor in determining the rate and placement of development within a watershed. The soil erosion potential for the MBI watershed was determined from the erosion factor K (whole soil) used in the Universal Soil Loss Equation (USLE) that predicts the rate of soil loss to sheet or rill erosion by water in units of tons per acre per year. These estimates, which range from 0.02-0.69, are based on percentage of silt, sand, and organic matter, as well as soil structure and saturated hydraulic conductivity (Ksat).



Moderate to high soil erosion potential areas cover 9% of the watershed (see Appendix B for larger map).

Low soil erosion potential areas comprise most of the watershed at 70%. Moderate to high soil erosion potential areas account for 9% of the watershed and are concentrated around MBI in the southwestern portion of the watershed where development is prominent. Development should be restricted in areas with highly erodible soils due to their inherent tendency to erode at a greater rate than what is considered tolerable soil loss. Since a highly erodible soil can have greater negative impact on water quality, more effort and investment is required to maintain its stability and function within the landscape, particularly from BMPs that protect steep slopes from development and/or prevent stormwater runoff from reaching water resources. Due to the concentration of moderate soil erosion potential areas around the direct shoreline of MBI, even greater actions and/or precautions should be taken to address erosion on existing and future development in those areas.

2.3.3 WETLANDS, STREAMS, OPEN WATER, AND RIPARIAN HABITAT

MBI provides a plethora of critical water resources for the surrounding landscape, including 2,561 acres of wetlands, 1,595 acres of open water, and 174 miles of streams. The RIPARIAN HABITAT of these waterbodies is home to a diverse community of fish, birds, mammals, and plants that are dependent on clean water quality to flourish. Wetlands can maintain this necessary water quality by acting as a filter of nutrients and sediments from incoming stormwater runoff. Any decrease in the extent of wetlands because of development will limit this natural filtration and cause detrimental long-term effects on water quality and diversity of inhabiting species.

> RIPARIAN HABITAT refers to the type of wildlife habitat found along the banks of a lake, river or stream and associated waterbodies. Not only are these areas ecologically diverse, but they also help protect water quality by preventing erosion and filtering polluted stormwater runoff by trapping nutrients and sediments.

New Hampshire Fish & Game ranks habitat based on value to the state, biological region, and supporting landscape. According to this schema, a good portion (26%) of the MBI watershed is considered Tier 1 for highest ranked habitat in the State of New Hampshire. This area includes some of the major ponds, bays, and tributaries in the watershed, along with their contributing matrix forests, particularly in the higher elevation areas to the west and east. A smaller portion (10%) of the watershed, particularly hillslopes and wetlands, is considered Tier 2 for highest ranked habitat in the biological region. Tier 3 for supporting landscapes covers 28% of the watershed, particularly around Tier 1 and 2 habitats and around major wetland complexes. About 36% of the watershed is not classified as priority habitat. A map detailing priority habitats for conservation based on the NH Wildlife Action Plan can be found in Appendix B.

The MBI watershed is characterized primarily by mixed forest that includes both conifers (white pine, hemlock, larch, spruce, and juniper) and deciduous tree species (maple, birch, beech, ash, red oak, alder, and poplar). Fauna that enjoy these rich forested resources include land mammals (moose, deer, black bear, coyote, bobcats, fisher, fox, raccoon, weasel, porcupine, muskrat, mink, chipmunks, squirrels, and bats), water mammals (muskrat, otter, and beaver), land and water reptiles and amphibians (turtles, snakes, frogs, and salamanders), various insects, and birds (herons, loons, gulls, multiple species of ducks, wild turkeys, cormorants, bald eagles, and song birds).

Fish are an important natural resource for sustainable ecosystem food webs and provide recreational opportunities. New Hampshire Fish & Game report that most tributaries (e.g., Cook Brook, Trib 2 to Red Hill Brook, Weed Brook, Halfway Brook, and Shannon Brook) within the MBI watershed contain wild brook trout, an indicator of good stream health. In 2009, Cook Brook in the northwestern part of the watershed exhibited the highest density of wild brook trout at the Statewide level. Bridle Shiners have also been confirmed to exist in Garland and Lees Pond, as well as all upland ponds, including Berry, Red Hill, and Dinsmore Ponds.

2.3.4 LAKE MORPHOLOGY AND BATHYMETRY

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

The surface area of MBI is 1.6 square miles (1,011 acres) with mean depths of 9.8 ft. (3.0 m) for Basins 1 and 2 and 15.4 ft. (4.7 m) for Basin 3. A maximum depth of 81 ft. (24.7 m) was recorded in Basin 3 near the Little Ganzy monitoring station. There are 24.6 miles of shoreline and 17,048,456 cubic meters of water volume in MBI[1]. The AREAL WATER LOAD is 3.8 m/yr for Basin 1, 4.7 m/yr for Basin 2, and 27.2 m/yr for Basin 3. Basins 1, 2, and 3 flush on average 1.2, 1.5, and 5.8 times each year, respectively. A map detailing bathymetry and monitoring sites can be found in Appendix B.

> AREAL WATER LOAD is a term used to describe the amount of water entering a lake on an annual basis divided by the lake's surface area.

[1] Lake volume was calculated for the Inlet based on the most recent bathymetry data provided by NHDES; however, the data are very coarse. Obtaining more detailed bathymetry data would help improve the model. Using the hydrologic budget determined by the land use model, flushing rates were calculated for the basins.

2.3.5 DIRECT AND INDIRECT DRAINAGE AREAS

The most significant drainage to MBI is the area draining through Lees Pond to Basin 3. Covering 18,048 acres or 56% of the MBI watershed, this area accounts for 55% of the water volume and 46% of the total phosphorus (TP) loading entering Basin 3 and includes Cook Brook, Creamery Brook, Dinsmore Pond, Direct Red Hill Brook Drainage, Garland Pond, Lees Pond, Little Pond, Montgomery Brook, Red Hill Pond, Skinner Brook, Stanton Brook, Trib 2 to Red Hill Brook, Weed Brook/Berry Pond, and Weed Brook/Trib. Refer to Appendix B for a map of the sub-basins.

Other major inlets to Basin 3 include Shannon Brook (18% water volume, 18% TP loading), Basin 3 Direct (4% water volume, 13% TP loading), Halfway Brook (7% water volume, 7% TP loading), Middle Brook (6% water volume, 7% TP loading), Trib 2 to Basin 3 (5% water volume, 6% TP loading), and Basin 2 (5% water volume, 3% TP loading).

These tributaries and the contributing land cover of their watersheds are important to the water quality of MBI. Watershed load (runoff and tributary flow) accounts for 97% of the water entering MBI (Basin 3), including 5% water volume coming from Basin 2, which makes the condition of the tributaries and their associated land covers critical to water quality. Additional inputs to MBI (Basin 3) are from rainfall (2%). The large volume of water entering this waterbody directly or indirectly via tributary streams makes phosphorus loading from these subwatersheds of major importance for lake management. High phosphorus inputs can result in nuisance algal blooms that damage the ecology and aesthetics of a waterbody. As a result, reducing phosphorus inputs to MBI from tributaries should be a high management priority. A detailed summary of the nutrient loading analysis for MBI is provided in Section 3.2.3.

2.4 INVASIVE PLANTS

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

In 2009, the Town of Moultonborough established the Milfoil Crisis Committee, charged with bringing the infestation of milfoil under control in the Inlet, ponds, and streams of the town. The Committee has encouraged a strong volunteer Weed Watcher program to inspect shorelines for and document evidence of invasive aquatic species. The Inlet is also supported by the Lake Host Program that provides courtesy boat inspections at public boat launches. The Milfoil Eradication Program is made possible through $200,000 in appropriated annual funds from the Town of Moultonborough and over 65 volunteers donating more than 3,000 hours each year to program activities. The program includes herbicidal treatment, mechanical suction harvesting (DASH units), and hand pulling techniques for milfoil treatment.

According to the 2015 Long Term Variable Milfoil Management Plan for Moultonborough, variable milfoil established in Moultonborough Bay in 1965 and has since established widespread, mature seed stocks of the invasive plant (NHDES, 2015a). Since 2010, the area from Green's Basin to Deepwood Ledges/Hemlock Point in Moultonborough Bay has greatly reduced from >90% coverage to 40% coverage of milfoil. The Committee is also testing new ideas for milfoil treatment, including benthic barriers, curtain barriers, and mature plan vacuuming.

3. ASSESSMENT OF WATER QUALITY

This section provides an overview of the water quality standards that apply to MBI, the methodology used to assess water quality, and recommendations for managing this waterbody to prevent future decline in water quality. MBI is part of a larger lake system, Lake Winnipesaukee, and thus, the Inlet itself is not listed as a separate assessment unit by NHDES, but is integrated with and classified the same (oligotrophic) as Lake Winnipesaukee, which is listed on the 2014 DRAFT NHDES 303(d) list as impaired for aquatic life based on the presence of cyanobacteria. Other waterbodies within the MBI watershed that are listed as impaired for aquatic life on the 2014 DRAFT NHDES 303(d) list include Garland Pond (based on elevated chlorophyll-a (Chl-a), low dissolved oxygen (DO), elevated total phosphorus (TP), and low pH) and Weed Brook (based on non-support for macroinvertebrates and low pH). Dinsmore Pond, Meadow Brook Pond, Lees Pond, Halfway Brook, and Shannon Brook are also listed as impaired for aquatic life based on low pH.

This plan focuses on phosphorus as the overall driver of ecosystem health. Waterbodies with excess nutrients, particularly phosphorus, which is considered the limiting nutrient in freshwater systems, are overproductive and may experience symptoms of water quality decline, including algal blooms, fish kills, decreased water clarity, loss of aesthetic values, and beach closures. Decomposition of accumulated organic matter from dead algal blooms and plants, such as milfoil, can result in anoxia in bottom waters, which can release phosphorus back into the water column as food for algae and plants and can also be lethal to fish and other aquatic organisms.

3.1 APPLICABLE WATER QUALITY STANDARDS AND CRITERIA

The State of New Hampshire is required to follow federal regulations under the CLEAN WATER ACT (CWA) with some flexibility as to how those regulations are enacted. The main components of water quality regulations include designated uses, water quality criteria, and antidegradation provisions. The Federal CWA, the NH *RSA 485-A Water Pollution and Waste Control*, and the NH Surface Water Quality Regulations (Env-Wq 1700) are the regulatory bases for governing water quality protection in New Hampshire. These regulations form the basis for New Hampshire's regulatory and permitting programs related to surface water. States are required to submit biennial water quality status reports to Congress via the USEPA. The reports provide an inventory of all waters assessed by the State and indicate which waterbodies exceed the State's water quality standards. These reports are commonly referred to as the "Section 303(d) list" and the "Section 305(b) report".

> The CLEAN WATER ACT (CWA) requires states to establish water quality standards and conduct assessments to ensure that surface waters are clean enough to support human and ecological needs.

3.1.1 DESIGNATED USES & WATER QUALITY CLASSIFICATION

The CWA requires states to determine designated uses for all surface waters within the state's jurisdiction. Designated uses are the desirable activities and services that surface waters should be able to support, and include uses for aquatic life, fish consumption, shellfish consumption, drinking water supply, primary contact recreation (swimming), secondary contact recreation (boating and fishing), and wildlife (Table 3-1). Surface waters can have multiple designated uses. In New Hampshire, all surface waters are also legislatively classified as Class A or Class B, most of which are Class B (Env-Wq 1700). A brief description of these classes is provided in Table 3-2 (NHDES, 2014a). **MBI, as part of Lake Winnipesaukee, is classified as Class B waters in the State of New Hampshire.** Water quality criteria are then developed to protect these designated uses. Depending on the designated use and type of waterbody, water quality criteria can become more or less strict if the waterbody is classified as either Class A or B. Water quality criteria for lakes are discussed in Section 3.1.3.

TABLE 3.1: Designated uses for New Hampshire surface waters (adapted from NHDES, 2015b).

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	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 3.2: New Hampshire surface water classifications (adapted from NHDES, 2015b).

Classification	Description (RSA 485-A:8)
Class A	Class A waters shall be of the highest quality. There shall be no discharge of any sewage or wastes into waters of this classification. The waters of this classification shall be considered as being potentially acceptable for water supply uses after adequate treatment.
Class B	Class B waters shall be of the second highest quality. The waters of this classification shall be considered as being acceptable for fishing, swimming and other recreational purposes and, after adequate treatment, for use as water supplies.

3.1.2 LAKE NUTRIENT CRITERIA

New Hampshire's water quality criteria provide a baseline measure of water quality that surface waters must meet to support their designated uses. These criteria are the "yardstick" for identifying water quality problems and for determining the effectiveness of state regulatory pollution control and prevention programs. 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, then it is considered impaired for its designated use(s).

Water quality criteria for each classification and designated use in New Hampshire can be found in RSA 485 A:8, IV and in the State's surface water quality regulations (NHDES, 2008). Aquatic Life Use (ALU) and Primary Contact Recreation (PCR) are the two major uses of concern for MBI.

AQUATIC LIFE USE

Criteria for ALU ensure that waters provide suitable habitat for the survival and reproduction of desirable fish, shellfish, and other aquatic organisms. For ALU assessment, the State has narrative nutrient criteria with a numeric translator or threshold, consisting of a "nutrient indicator" or TOTAL PHOSPHORUS (TP) and a "response indicator" or CHLOROPHYLL-A (CHL-A) (see also: Env-Wq 1703.03, Env-Wq

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

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

DISSOLVED OXYGEN (DO) is a measure of the amount of oxygen dissolved in water. Most living organisms need oxygen to survive. Low oxygen can directly kill or stress organisms and release phosphorus from bottom sediments.

1703.04, Env-Wq 1703.14, and Env-Wq 1703.19). The nutrient and response indicators are intricately linked since increased TP loading frequently results in increased algae, which can be estimated by measuring Chl-a levels in the lake. Increased algae may lead to decreased DISSOLVED OXYGEN (DO) at the bottom of the lake, decreased water clarity, and possibly changes in aquatic species composition.

TROPHIC STATE is the degree of eutrophication of a lake as assessed by the transparency, Chl-a levels, phosphorus concentrations, amount of macrophytes, and quantity of dissolved oxygen in the hypolimnion.

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

As shown in Table 3-3, ALU criteria vary by lake TROPHIC STATE, since each trophic state has a certain algal biomass (Chl-a) that represents a balanced, integrated, and adaptive community. Exceedances of the Chl-a criterion suggests that the algal community is out of balance. Since phosphorus is the primary limiting nutrient for growth of freshwater algae (Chl-a), phosphorus is included in this assessment process. For ALU assessment, TP and Chl-a are combined per the decision matrix presented in Table 3-4. The Chl-a concentration will dictate the assessment if both Chl-a and TP data are available and the assessments differ.

TABLE 3.3: Aquatic life nutrient criteria by trophic class in New Hampshire.

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

TABLE 3.4: Decision matrix for aquatic life use assessment determinations in New Hampshire.

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

From 1974 through 2010, NHDES conducted trophic surveys on lakes to determine TROPHIC STATE. The trophic surveys evaluated physical lake features, as well as chemical and biological indicators. Trophic state is designated as: oligotrophic, mesotrophic, or eutrophic. These are broad categories used to describe how productive a lake is. Generally, oligotrophic lakes are less productive or have less nutrients (i.e., low levels of TP and Chl-a), deep SECCHI DISK TRANSPARENCY (SDT) readings (8.0 m or greater), and high DO levels throughout the water column. In contrast, eutrophic lakes have more nutrients and are therefore more productive and exhibit algal blooms more frequently than oligotrophic lakes. Mesotrophic lakes fall in-between with an intermediate level of productivity. **MBI is designated as oligotrophic as part of the Lake Winnipesaukee assessment unit.**

PRIMARY CONTACT RECREATION

For PCR, New Hampshire has a narrative criterion with a numeric translator or threshold for the primary indicator E.coli. The narrative criteria for PCR (Env-Wq 1703.03) states that "All surface waters shall be free from substances in kind or quantity which float as foam, debris, scum or other visible substances, produce odor, color, taste or turbidity which is not naturally occurring and would render it unsuitable for its designated uses or would interfere with recreation activities." Nutrient response indicators, Chl-a and cyanobacteria scums, are used as secondary indicators. Elevated Chl-a levels or the presence of cyanobacteria scums interfere with the aesthetic enjoyment of swimming and/or may pose a health hazard. Chl-a levels greater than or equal to 15 ppb or the presence of cyanobacteria scums are considered "not supporting" for PCR. These secondary indicators can provide reasonable evidence to classify PCR as "not supporting," but cannot result in a "fully supporting" designation.

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

EPILIMNETIC CORE (EC) SAMPLES represent a vertical sample of the water column obtained within the lake's epilimnion using flexible plastic tubing, usually ½ inch in diameter. The tubing is lowered to a desired depth, clamped at the water's surface, raised, and decanted into a collection jug. This integrated sample is tested for multiple water quality parameters.

3.1.3 ANTIDEGRADATION PROVISIONS

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

3.2 WATERSHED MODELING

A lake receives natural inputs of phosphorus in the form of runoff from its watershed. This phosphorus will be taken up by aquatic life within the lake, settle in the bottom sediments, or flow out of the lake to downstream waterbodies. In this sense, there is a natural balance between the amount of phosphorus flowing in and out of a lake system, also known as the ability of a lake to "assimilate" phosphorus. The ASSIMILATIVE CAPACITY is based on factors such as lake volume, watershed area, and precipitation runoff coefficient. If a lake is receiving more phosphorus from the watershed than it can assimilate, then its water quality will decline over time as algal blooms become more frequent.

3.2.1 STUDY DESIGN AND DATA ACQUISITION

Historical water quality monitoring data was analyzed by LWA and FB Environmental to determine the median phosphorus value and the assimilative capacity for MBI. The New Hampshire Lake Survey Program and Volunteer Lake Assessment Program (VLAP) and the New Hampshire Lakes Lay Monitoring Program (LLMP) are the primary groups collecting water quality data from the Inlet, ponds, and streams in the MBI watershed. The LLMP is administered jointly by the UNH Center for Freshwater Biology (CFB) and UNH Cooperative Extension (UNHCE). All NHDES and UNH data are available through the NHDES Environmental Monitoring Database (EMD).

Data acquisition and analysis for MBI followed protocols set forth in the Site Specific Project Plan (SSPP; refer to Appendix A). Water quality data were combined into a common spreadsheet and then sorted by date and station for Quality Assurance/Quality Control (QA/QC) to avoid duplicating data sets. All duplicates were removed. Median in-lake TP was calculated for each station based only on EPILIMNETIC CORE (EC) and seasonal (May 24-September 15) samples. The seasonal (May 24-September 15) median EC TP value represents the 'Existing Median Water Quality' applied to the NHDES Assimilative Capacity Analysis for determining if a waterbody is Impaired, Tier 1, or Tier 2. See Figure 3-1 in the 2014 Consolidated Assessment and Listing Methodology for a conceptual diagram of Tier 1 and Tier 2 waters (NHDES, 2015b; NHDES, 2010). Due to the limited dataset (i.e., less than 10 years of data for all stations), Mann-Kendall trend tests[2] could not be performed to examine trends over time (improving, degrading, or stable) for TP in MBI.

The Moultonborough Bay Inlet (MBI) represents a unique system for study because it is not a true lake, but rather part of a larger lake system (Lake Winnipesaukee). The morphology (shape) and bathymetry (depth) of MBI is fairly irregular, causing the formation of individual basins, bays, or inlets within the study system that impact water and nutrient movement (flushing), and subsequently, system function and health. Given these characteristics of MBI, the Inlet was divided into three individual basins (Basin 1, 2, and 3) for modeling, data analysis, and goal setting purposes. One of the challenges posed by this division is the lack of consistent, long-term data for each of the three basins. The number of sites and frequency of sampling in MBI has varied over the 20-year period with more consistent sampling occurring in the last 5 years. A summary of sampling site data is provided in Table 3.5. Refer to Appendix B for a map of monitoring station locations.

[2] A non-parametric statistical test that determines if the central value (median) of a dataset has changed over time.

TABLE 3.5: Summary of sampling site data for MBI. No statistically-significant difference ($\alpha<0.05$) in TP data were found among sample sites.

Station ID	Depth (ft)	Station Name	MBI Basin	Median TP (ppb)*	n	Years Sampled	Statistical Diff (p<0.05)**
WMO00GL	25	Green's Basin	Basin 1	11.6	22	2010-15	A
WMO01BL	35	Blanchard's Island	Basin 2	10.4	2	2011	AB
WMOLEML	20	Lees Mills	Basin 3	12.8	4	2010, 2012	AB
WMOSTLL	30	State's Landing	Basin 3	9.5	15	2010-14	AB
WMO01LL	50	Little Ganzy	Basin 3	9.6	4	2010-11	AB
WMO0SSL	40	Suissevale	Basin 3	8.4	21	2010-15	B
WMO10AL	55	Black Point	Basin 3	7.1	22	2001-02, 2010-15	B

**Based on seasonal (5/24-9/15) and recent (2006-2015) data*

***Based on Welch's one-way analysis of variance and Games-Howell post-hoc test*

For Basin 1, WMO00GL (Green's Basin) has been sampled regularly since 2010 (n=22); therefore, the dataset was assumed to be a good representation of current water quality conditions. For Basin 2, WMO01BL (Blanchard's Island) was only sampled twice in 2011. More data will be needed to better inform the LLRM, assimilative capacity, and goals for Basin 2. The plan will include interim goals and milestones to reassess Basin 2 following several years (at least 5 years) of regular data collection. For Basin 3, there are multiple sites that have been monitored for total phosphorus (TP) at varying frequencies: WMOLEML (Lees Mills), WMOSTLL (State's Landing), WMO01LL (Little Ganzy), WMO0SSL (Suissevale), and WMO10AL (Black Point). These sites vary in depth (since there is no true deep spot) and spatial distribution across Basin 3, suggesting that these sites experience different flow patterns and inputs from the corresponding drainage area to each site. Despite this, no statistically-significant difference ($\alpha<0.05$) in TP data were found among Basin 3 sites, though accounting for the heteroscedasticity in the sample size data among sites using Welch's ANOVA ensures sensitivity to Type I (false positive) errors (Table 3.5).

Given the lower TP concentrations measured at WMO0SSL (Suissevale) and WMO10AL (Black Point) and the proximity of these sites to the southern outlet of MBI, it is very likely that these sites are influenced by mixing with the larger Lake Winnipesaukee system, and therefore, may not be representative of inputs from the MBI watershed. It is recommended that a single, representative station be established for Basin 3 at WMO01LL (Little Ganzy). This station is deep (50 ft) and centrally-situated within the basin, so that a good portion of watershed inputs is accounted for and the station is located above the two lower stations where mixing from Lake Winnipesaukee may be an issue. Despite WMO01LL (Little Ganzy) being only sampled four times from 2010-11, the median TP is in good agreement with nearby sites: WMOSTLL (State's Landing) upstream along the east shoreline of MBI and WMO0SSL (Suissevale) downstream in an area likely diluted by mixing with Lake Winnipesaukee. Therefore, WMO01LL (Little Ganzy) was used for the assimilative capacity analysis and goal with the intention that these values be updated and checked after more data are collected. The plan will include interim goals and milestones to reassess Basin 3 following several years (at least 5 years) of regular data collection.

3.2.2 ASSIMILATIVE CAPACITY ANALYSIS

As stated previously, the assimilative capacity of a lake is its ability to resist the effects of landscape disturbance without water quality impairment. For purposes of this plan, phosphorus was determined to have the greatest direct impact on water quality in MBI. The median TP concentration for each basin was used to calculate the total, reserve, and remaining assimilative capacity using procedures described in the 2014 Section 305(b) and 303(d) Consolidated Assessment and Listing Methodology for New Hampshire (Table 3.6; NHDES, 2015b). Tier 2 waters, or high quality waterbodies, have one or more water quality parameters that are better than the water quality standard and that also exhibit a reserve capacity of at least 10% of the waterbodies' total assimilative capacity. Tier 2 waters have some assimilative capacity remaining, whereas Tier 1 and Impaired Waters do not.

MBI shares Lake Winnipesaukee's oligotrophic classification, which forms the basis for MBI's assimilative capacity analysis and subsequent water quality goals. For oligotrophic waterbodies, the water quality criteria are set at 8 ppb TP and 3.3 ppb chlorophyll-a (Chl-a). NHDES requires 10% of the criteria be kept in reserve; therefore, median TP and Chl-a must be at or below 7.2 ppb TP and 3.0 ppb Chl-a, respectively, to achieve Tier 2 High Quality Water status. Support determinations are based on the nutrient stressor (TP) and response indicator (Chl-a), with Chl-a dictating the assessment if both Chl-a and TP data are available and the assessments differ.

For MBI, Basin 1 is considered impaired for both TP and Chl-a, while Basins 2 and 3 are potential non-supports due to insufficient, but likely lower than reserve capacity, Chl-a data (Table 3.6). The analysis revealed that Basin 1 requires the most reductions in TP and is at most risk for elevated nutrient input and algal blooms that can impact Basin 2 (and Basin 3 minimally), while Basins 2 and 3 may also have considerable reductions needed for TP if Chl-a levels are in fact a significant issue. However, data from multiple sites within Basin 3 show that Chl-a is better than the criterion (3.3 ppb) and reserve capacity threshold (3.0 ppb) for oligotrophic systems. Until more Chl-a data are collected for Basin 2 and 3 sites, the water quality goal will be based on the achievement of 7.2 ppb for TP with the understanding that this goal may change given the likely acceptable Chl-a levels in MBI.

TABLE 3.6: Assimilative capacity analysis results for MBI. Existing data reflects seasonal (5/24-9/15) and recent (2006-2015) data.

Station ID	Station Name	MBI Basin	Existing Median TP (ppb)*	Remaining TP Assim Capacity (ppb)	Existing Median Chl-a (ppb)	Remaining Chl-a Assim Capacity (ppb)	Assim Capacity Category
WMO00GL	Green's Basin	Basin 1	11.6	-4.4	3.3	-0.3	Impaired
WMO01BL	Blanchard's Island	Basin 2	10.4	-3.2	no data	no data	PNS/IF*
WMO01LL	Little Ganzy	Basin 3	9.6	-2.4	no data	no data	PNS/IF*

Assimilative Capacity Analysis Categories

Tier 2 = Better than Criterion and Reserve Capacity

Tier 1 = Better than Criterion, but within the Reserve Capacity (no remaining capacity)

Impaired = Worse than Criterion (no remaining capacity and not within the Reserve Capacity)

**PNS/IF = Potential Non-Support / Insufficient Info*

3.2.3 LAKE LOADING RESPONSE MODEL RESULTS

A second analysis was used to link watershed loading conditions with in-lake TP and Chl-a concentrations to predict past, current, and future water quality in MBI (FBE, 2016a). An Excel-based model, known as the Lake Loading Response Model (LLRM), was used to develop a water and phosphorus loading budget for the Inlet and its tributaries. Water and phosphorus loads (in the form of mass and concentration) are traced from various sources in the watershed, through tributary basins, and into the Inlet. The model incorporates data about land cover, watershed boundaries, point sources, septic systems, waterfowl, rainfall, and an estimate of internal lake loading, combined with many coefficients and equations from scientific literature on lakes and nutrient cycles.

Basin 1 model was calibrated to WMO00GL (Green's Basin) data; Basin 2 model was calibrated to WMO01BL (Blanchard's Island) data; and Basin 3 was calibrated to the median of WMO10AL (Black Point), WMO01LL (Little Ganzy), WMO0SSL (Suissevale), WMOLEML (Lees Mills), and WMOSTLL (State's Landing) data. Although we recommend the water quality goal be based on a single, representative station, an aggregate of station data was used for input to the model to ensure robustness of model calibration. The difference between methods is relatively small (summer median TP of 9.0 ppb for aggregated sites and summer median TP of 9.6 ppb for WMO01LL (Little Ganzy)). These data also reflect all existing data (regardless of season or year up to 2014) since the model takes into account year-round median TP, which is typically higher than summer median TP. Therefore, the existing median TP shown in Table 3.7 reflects all data median TP (2005-2014) available multiplied by a factor of 1.2 (assuming actual annual TP is 20% higher than summer TP).

The model predicted within 3% difference of observed median TP for Basins 1 and 3 (Table 3.7). We left a 28% difference between modeled and observed in-lake TP concentrations for Basin 2 due to the lack of data (n=2) for the Blanchard's Island station. The median in-lake TP concentration of 12.5 ppb may not be representative of the basin. Without a more robust dataset, it is difficult to calibrate the model. Attenuation factors that were appropriate for other similar tributaries with data were used consistently and no further calibration was done for Basin 2. Interestingly, despite the model predicting variable (low or high) median TP concentrations compared to observation data, the model consistently predicted higher-than-observed Chl-a concentrations and lower-than-observed mean water clarity (Table 3.7). This suggests that other factors aside from phosphorus may be controlling observed water quality (i.e., the general empirical equations used in the LLRM do not fully account for all the biogeochemical processes occurring within the Inlet that contribute to the overall water quality condition).

TABLE 3.7: In-lake water quality predictions for Basins 1, 2, and 3. Note: median TP concentrations represent 20% greater than actual median values to account for year-round variation. This is because most data are collected in the summer when TP concentrations are typically lower than the annual average concentrations.

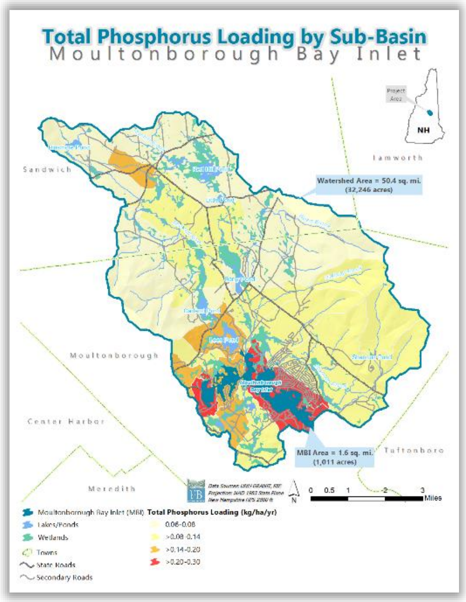
Basin	Median TP (ppb)	Predicted Median TP (ppb)	Mean Chl-a (ppb)	Predicted Mean Chl-a (ppb)	Mean SDT (m)	Predicted Mean SDT (m)
Basin 1	14.9	14.8	4.0	5.2	4.6	2.9
Basin 2	12.5	9.4	2.0	2.9	--	4.1
Basin 3	10.8	11.1	2.3	3.6	5.3	3.6

As shown in Table 3.8, the results of this model indicate that the greatest phosphorus load comes from watershed runoff, which accounts for 83%, 47%, and 88% of the total loading to Basins 1, 2, and 3, respectively. Atmospheric deposition accounts for <11%, septic systems <10%, waterfowl <3%, and internal loading <2% of the TP entering the three basins. While the load from Basin 1 to Basin 2 accounts for 29% of the total load to Basin 2, the load from Basin 2 and Basin 3 accounts for only 3% of the total load to Basin 3. This suggests that the higher TP concentrations observed at Green's Basin, while important locally, may not have a large impact further downstream.

TABLE 3.8: MBI total phosphorus (TP) and water loading summary for Basins 1, 2, and 3.

INPUT CATEGORY	BASIN 1			BASIN 2			BASIN 3		
	P (KG/YR)	%	WATER (CU.M/YR)	P (KG/YR)	%	WATER (CU.M/YR)	P (KG/YR)	%	WATER (CU.M/YR)
ATMOSPHERIC	5	8%	295,995	9	11%	558,205	31	3%	1,868,572
INTERNAL	1	2%	0	0	0%	0	18	2%	0
WATERFOWL	2	2%	0	3	3%	0	9	1%	0
SEPTIC SYSTEM	3	5%	2,505	8	9%	6,545	47	4%	39,441
WATERSHED LOAD	52	83%	1,374,623	41	47%	1,698,773	1,060	88%	70,375,053
LOAD FROM BASIN 1				25	29%	1,673,123			
LOAD FROM BASIN 2							37	3%	3,936,647
TOTAL LOAD TO LAKE	**62**	**100%**	**1,673,123**	**86**	**100%**	**3,936,647**	**1,202**	**100%**	**76,219,714**

Examining the phosphorus concentration and attenuation factors for each contributing sub-basin to MBI is important for nutrient management. Based on high phosphorus concentrations and low attenuation, the model determined that the direct drainage area of MBI contributes the most phosphorus per hectare per year of any of the other sub-basins. The phosphorus load to MBI is much lower for sub-basins in forested headwater areas and higher for sub-basins in developed areas. Although developed areas cover only 11% of the watershed, these areas are contributing 88% of the phosphorus load to MBI (Figure 3.1).



The direct drainage area of MBI contributes the most phosphorus per hectare per year compared to the other sub-basins (see Appendix B for larger map).

A brief sensitivity analysis was performed per the request of the Advisory Committee. Three scenarios were selected and analyzed for percentage change in total phosphorus load to Basin 3 of MBI. If all septic systems were older systems (>25 years) and used year-round (assuming we are underestimating the septic system load), the TP load would increase by 5.3%. If the direct drainage area was unbuffered with no infiltration capacity (keeping current development coverage and assuming we are underestimating direct drainage load), the TP load would increase by 3.8%. If the TP load from Basin 2 to Basin 3 increased to the predicted full build-out concentration of 14.5 ppb (assuming we are underestimating current Basin 2 load), the TP load would increase by 1.7% A more detailed discussion of watershed modeling results with a breakdown of loading by subwatershed can be found in Appendix C or FBE (2016a).

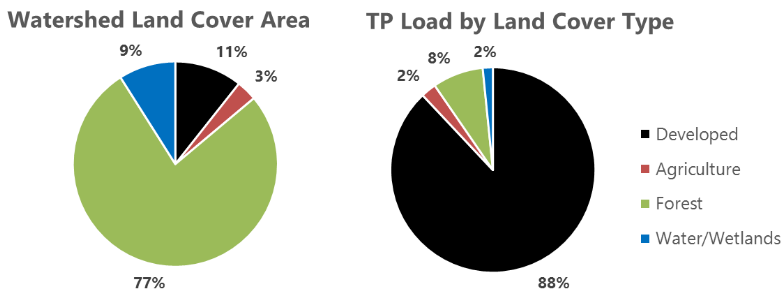
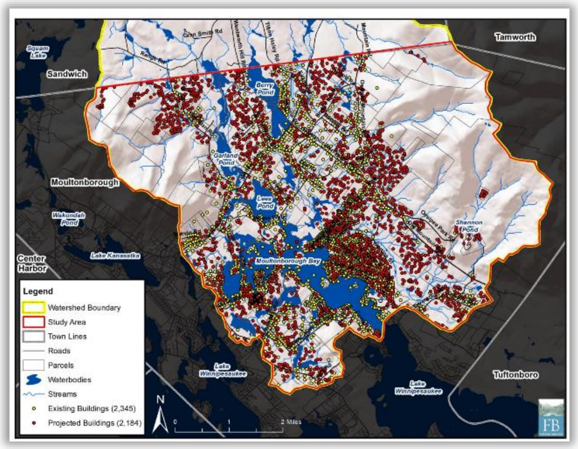


FIGURE 3.1: Watershed land cover area by general category (developed, agriculture, forest, and water/wetlands) and total phosphorus (TP) load by general land cover type. This shows that although developed areas cover only 11% of the watershed, these areas are contributing 88% of the TP load to Moultonborough Bay Inlet.

3.2.4 HISTORICAL AND FUTURE LAND COVER PROJECTIONS: BUILD-OUT ANALYSIS

With support from the Town of Moultonborough, a build-out analysis was conducted by FB Environmental for the entire Town of Moultonborough, as well as for a portion of the Town within the MBI watershed (FBE, 2016b). The analysis combined projected population estimates, current zoning restrictions, and a host of additional development constraints (conservation lands, steep slope and wetland regulations, existing buildings, soils with low development suitability, and unbuildable parcels) to determine the extent of buildable areas in the town and watershed. The analysis determined that 26% (5,253 acres) of the portion of the watershed in the Town of Moultonborough is buildable and can house up to 2,184 more buildings (a 93% increase from current conditions); most of the new development would be contained in the residential/agricultural zones.



Map of existing and projected buildings in MBI watershed in Moultonborough (see Appendix B for larger map).

At the compounded annual rate of population growth that the Town of Moultonborough experienced from 2000-2010 (-1.03%), 1990-2010 (1.58%), 1980-2010 (2.04%), and 1970-2010 (2.86%), full build-out for the portion of the watershed in the Town of Moultonborough could occur as early as 2058, 2049, or 2039 for the 20-, 30-, and 40-year compound annual growth rates (CAGRs), respectively. Full build-out refers to the time and circumstances in which, based on a set of restrictions (e.g., environmental constraints and current zoning), no more building growth can occur, or the point at which lots have been subdivided to the minimum size allowed.

Results of this analysis reinforce the concept of comprehensive planning at the watershed level to address future development and its effect on the water quality of the region. A phosphorus load analysis using the LLRM was conducted for historical and full build-out scenarios for the MBI watershed (e.g., what in-lake TP concentration was prior to human development and what in-lake TP concentration will be following full buildout of the watershed under current zoning restrictions and conservative growth rates). A comparison of historical, current, and future in-lake TP concentrations for the three basins is shown in Figure 3.2.

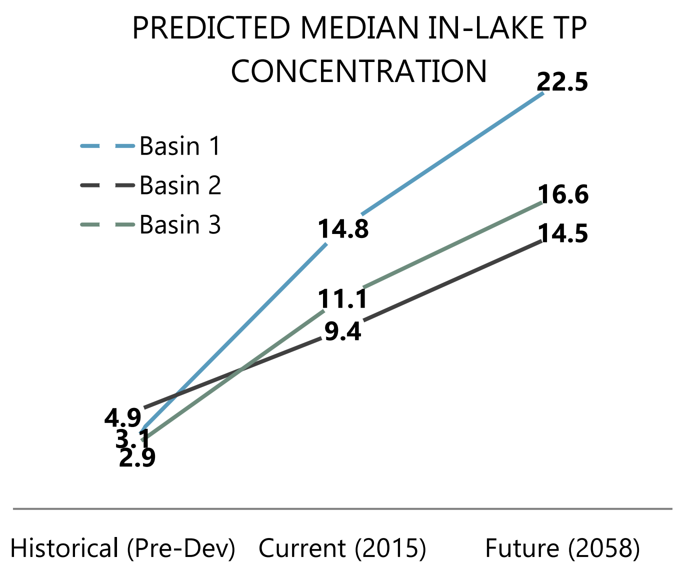


FIGURE 3.2: Historical, current, and future in-lake total phosphorus concentrations for Basins 1, 2, and 3.

Historical median in-lake TP concentration ranged from 2.9-4.9 ppb compared to 9.4-14.8 ppb for the three basins under current conditions (Figure 3.2). This represents an increase of 64-130% compared to current conditions. Basin 3 Direct and Shannon Brook subdrainages changed the most from historical to current conditions, likely a result of concentrated development in these drainages. The historic assessment is useful to provide an estimate of the best possible water quality for the Inlet. In this case, historical in-lake TP concentrations are well within oligotrophic criteria, suggesting that an oligotrophic classification and goal may be at least theoretically realistic for MBI.

The model predicted an in-lake TP concentration of 22.5, 14.5, and 16.6 ppb in Basins 1, 2, and 3, respectively, at full buildout in 2058 (based on conservative 20-year average annual growth rate of 1.58% and current zoning). This represents an increase of 40-43% compared to current conditions. Any new increases in phosphorus to a lake can disrupt the ecological balance in favor of increased algal growth, resulting in degraded water clarity. Shannon Brook is most at risk for increases in TP loading as a result of increased development. A more detailed discussion of watershed modeling results with a breakdown of loading by subwatershed can be found in Appendix C or FBE (2016a).

3.3 ESTABLISHMENT OF WATER QUALITY GOALS

The purpose of setting a water quality goal in a phosphorus-focused watershed restoration plan is to quantify the amount of reductions in phosphorus loading needed to achieve the desired water quality conditions. The process of establishing water quality goals for MBI was guided by the water quality and assimilative capacity analysis and watershed modeling conducted by LWA, FB Environmental, and DK Water Resource Consulting, as well as input and approval from the Advisory Committee.

The over-arching goal for the watershed is to improve water quality conditions at MBI and to protect the waterbody from future, unaccounted-for inputs of phosphorus because of new development in the watershed over the next twenty years. The Advisory Committee set a water quality goal of 7.2 ppb TP (for summer median epilimnion TP) for Basins 1, 2, and 3, along with adaptable interim goals and milestones that will help achieve this goal over the next twenty or more years. **This will require a phosphorus loading reduction of 42% (26 kg/year) in Basin 1, 31% (27 kg/year) in Basin 2, and 20% (242 kg/year) in Basin 3.**

The following describes interim goals, milestones, and goal adaptation strategies for the three basins:

- BASIN 1 requires a 42% (26 kg/yr) reduction in TP loading to achieve the oligotrophic classification goal of 7.2 ppb for in-lake summer median epilimnion TP (Table 3.9). Current in-lake Chl-a concentrations require a 10% reduction to achieve the oligotrophic classification goal of 3.0 ppb for in-lake summer median epilimnion Chl-a; this Chl-a goal could be achieved with only a 9% (6 kg/yr) reduction in TP loading. Basin 1 has experienced the greatest increase in in-lake TP concentration since pre-development and will continue on a more aggressive upward trajectory than the other two basins. Any improvement or degradation in Basin 1 water quality will decrease or increase in-lake TP concentrations by 14% for Basin 2 and 1% for Basin 3. Since Basin 1 is at most risk for elevated nutrient inputs and algal blooms, has the lowest total TP load reduction needed (26 kg/yr), and drains a relatively small, manageable watershed, Basin 1 may be ideal for priority project implementation to achieve the water quality goal on a faster timescale. Successful projects in the Basin 1 drainage can serve as examples to be replicated in the other basin drainages. This prioritization hinges on local resident engagement throughout the process.

- BASIN 2 requires a 31% (27 kg/yr) reduction in TP loading to achieve the oligotrophic classification goal of 7.2 ppb for in-lake summer median epilimnion TP (Table 3.9). These reduction estimates are based on minimal data; therefore, we recommend collecting several years of data (epilimnion and hypolimnion TP, Chl-a, and SDT) for WMO01BL (Blanchard's Island), updating the LLRM for Basin 2, and revisiting the water quality goal in 5 years. One important consideration for the Basin 2 water quality goal is Chl-a, which dictates support determinations. Preliminary data show that Chl-a may be better than the reserve capacity threshold (3.0 ppb) for oligotrophic systems, but until more data are collected for Basin 2, the water quality goal will be based on the achievement of 7.2 ppb TP with the understanding that this goal may change given the likely acceptable Chl-a levels in Basin 2.

- BASIN 3 requires a 20% (242 kg/yr) reduction in TP loading to achieve the oligotrophic classification goal of 7.2 ppb for in-lake summer median epilimnion TP (Table 3.9). These reduction estimates are based on an aggregate of multiple sites within Basin 3, but future monitoring and modeling should focus on a single, sentinel station for Basin 3; therefore, we recommend collecting several years of data (epilimnion and hypolimnion TP, Chl-a, and SDT) for WMO01LL (Little Ganzy), updating the LLRM for Basin 3, and revisiting the water quality goal in 5 years. Implementation projects should begin right away in the Basin 3 drainage, particularly in the direct shoreline and Shannon Brook drainages where development is concentrated (Suissevale and Balmoral) or in areas at most risk for new development. Development in the direct shoreline and Shannon Brook drainages account for 107 kg/yr and 96 kg/yr, respectively, of TP loading to Basin 3, both of which account for a significant portion of the total TP load reduction needed (242 kg/yr). One important consideration for the Basin 3 water quality goal is Chl-a, which dictates support determinations. Preliminary data show that Chl-a may be better than the reserve capacity threshold (3.0 ppb) for oligotrophic systems, but until more data are collected for WMO01LL (Little Ganzy), the water quality goal will be based on the achievement of 7.2 ppb TP with the understanding that this goal may change given the likely acceptable Chl-a levels in Basin 3.

An important consideration for adjusting interim goals during the adaptive management process is how the expected increase in TP loading following new development in the watershed will impact ultimate and interim water quality goals. Over the next twenty years, new development using business-as-usual regulations will likely increase current TP loading by 16, 22, and 294 kg/yr to Basins 1, 2, and 3, respectively (Table 3.9). This will hinder progress toward achieving ultimate and interim goals. Given this consideration, it will be just as important to focus on updating municipal regulations to incorporate more stringent water quality protections during new development as it will be to minimize TP loading from existing development.

TABLE 3.9. Summary of TP load reductions based on water quality goals for each basin.

Basin	% TP Reduction Needed to Achieve Oligo Criterion	TP Load Reduction Needed to Achieve Oligo Criterion (kg/yr)	% Chl-a Reduction Needed to Achieve Oligo Criterion	% TP Reduction Needed to Achieve % Chl-a Reduction	TP Load Reduction Needed to Achieve % Chl-a Reduction (kg/yr)	Estimated TP Load Increase from New Development from 2017-2036 (kg/yr)	Estimated Total TP Load Reduction Needed if Stay on Development Trajectory from 2017-2036 (kg/yr)
Basin 1	42%	26	10%	9%	6	16	42
Basin 2	31%	27	Likely 0%	Likely 0%	Likely 0	22	49
Basin 3	20%	242	Likely 0%	Likely 0%	Likely 0	294	536

Ultimate and interim water quality goals for each basin are outlined in Section 5.3. The interim goals allow flexibility in re-assessing water quality goals following more data collection and incorporation of expected increases in TP loading with new development in the watershed over the next twenty years. Understanding where we will be following watershed improvements compared to where we should have been following no action will help guide adaptive changes to the goals (e.g., goals are on track or goals are falling short). If the goals are not being met due to lack of funding for implementation projects versus new development TP loading outpacing improvements to existing development TP loading, this creates much different conditions from which to adjust goals. For each interim goal year, the committee should meet to update water quality data and model and assess why goals are or are not being met. The committee will then decide on how to adjust the next interim goals to better reflect water quality conditions and practical limitations to implementation.

It is also important to note that there are several larger ponds within the Basin 3 drainage that should set their own water quality goals and TP reduction goals to help improve water quality in MBI.

3.4 WATERSHED & SHORELINE SURVEY ASSESSMENTS

During large precipitation events in forested areas, it is natural for approximately 10% of rain or snowmelt to flow as runoff. In developed areas, however, runoff volumes (a.k.a., stormwater runoff or NPS pollution) increase five-fold due to impervious surfaces, including packed dirt or paved roads, parking lots, and rooftops. Stormwater pollutants can have negative consequences for fish and wildlife, native vegetation, public drinking water sites, and public recreational water usage. Stormwater retrofits (i.e., BMPs) can be utilized for existing development where stormwater issues are prevalent. Landowners, municipal officials, and developers should also consider alternatives such as LID for mitigating impacts from any new development.

Watershed and shoreline surveys are designed to locate potential sources of NPS pollution in an area that drains to a waterbody. These surveys are an excellent education and outreach tool, as they raise public awareness by documenting types of problems, engaging volunteers, and providing specific information to landowners on how to reduce NPS pollution on their property. Results of these surveys are essential to the watershed planning process because they identify individual NPS sites and prioritize BMP implementation projects throughout the watershed (refer to the Action Plan in Section 5.2).

The 2015 watershed survey identified 56 sites where stormwater improvements are needed. (Photo: FB Environmental)

A watershed stormwater survey was conducted on May 18 and 19, 2015 by FB Environmental. Teams documented erosion on roads, residential and commercial properties, driveways, stream crossings, and municipal areas using cameras and standardized forms. Problems were identified and documented, solutions were recommended, and costs of improvements (labor and materials) were estimated. Impact levels were assigned to each site based on location, area, slope, amount of soil eroded, and proximity to water.

Fifty-six sites were documented during the stormwater survey. Twenty-three sites were located on town roads (Table 3.10). These sites were often a result of eroding road shoulders and unstable culverts. Ten sites were located on private roads, primarily on the northeast side of the Inlet. Half of the identified sites were considered low impact (Table 3.10); however, fixing multiple low impact sites can have an overall greater impact on erosion control. Just over half (55%) of the identified sites were of medium cost to repair ($500-$2,500). Refer to the MBI Watershed Nonpoint Source Survey Report for more details (FBE, 2015).

TABLE 3.10: Impact rating for each identified polluted runoff problem by type.

LAND USE	HIGH IMPACT	MEDIUM IMPACT	LOW IMPACT	TOTAL
AGRICULTURE	1	0	0	1
BEACH ACCESS	2	1	2	5
BOAT ACCESS	1	2	0	3

COMMERCIAL	0	1	0	1
MUNICIPAL/PUBLIC	0	1	1	2
PRIVATE ROAD	0	3	7	10
RESIDENTIAL	0	1	4	5
STATE ROAD	1	2	3	6
TOWN ROAD	2	10	11	23
TOTAL	7	21	28	56

Implementing erosion control and stormwater runoff control improvements at these sites to limit phosphorus loading to MBI will require efforts by individual property owners, road associations, and municipal officials. The top twenty sites for remediation were selected based on the impact-weighted cost per mass of phosphorus reduced (refer to Appendix D). From these twenty high-priority sites, the Advisory Committee selected four sites for completion of engineered designs by the UNH Stormwater Center (UNHSC). The four high impact sites are summarized below and UNHSC designs are included in Appendix E).

SITE ID #1: a driveway and boat access ramp were identified as having moderate surface and road shoulder erosion that runs off directly into the lake. It is recommended that new surface material (e.g., recycled asphalt) be added, the road crown reshaped, and an open top culvert installed.

SITE ID #2: a commercial property was identified as having moderate surface and roof runoff erosion and lack of streambank vegetation that allows stormwater to enter the stream. It is recommended that an infiltration trench at the roof dripline be installed, and a buffer planted along the stream.

SITE ID #3: a town road was identified as having severe surface erosion with several large gullies that flow directly into the lake. It is recommended that runoff diverters are installed, a foot path is stabilized, and a buffer is planted with erosion control mulch.

SITE ID #4: a private road was identified as having moderate surface erosion, lack of adequate shoreline vegetation, and significant shoreline erosion that was depositing stormwater runoff into a stream. It is recommended that a buffer be planted along the stream for stabilization.

A shoreline survey of MBI, Garland Pond, and Lees Pond was conducted in August and September of 2015 by FB Environmental staff and local volunteers. Teams documented the condition of the shoreline for each parcel using a scoring system that evaluates buffer condition (1-5), bare soil extent (1-4), shoreline erosion extent (1-3), building setback distance (1-3), and slope (1-3) (Table 3.11). The score for each category was summed for each site as a total "shoreline disturbance score" used to help with BMP prioritization and highlighting areas along shorelines where mitigation efforts should be focused. Lower scores equate to better shoreline conditions, while higher scores correspond to inadequate shoreline conditions with extensive erosion. A disturbance score of 10 or above indicates shoreline conditions that may be detrimental to water quality.

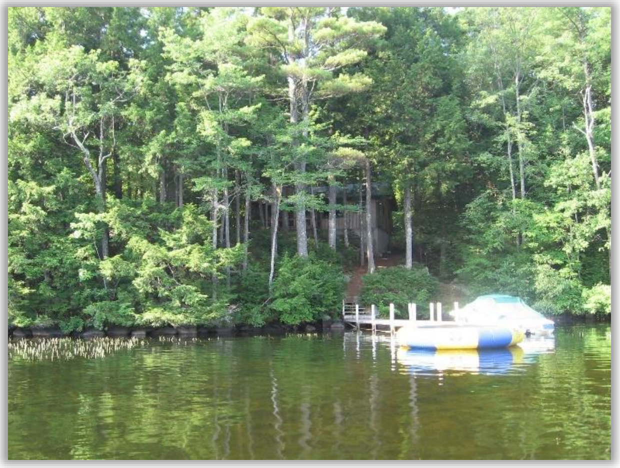
Of the 549 parcels evaluated, the average shoreline disturbance score for MBI was 9.8 (Table 3.12). A total of 6 parcels scored 15 or greater (out of a maximum of 18) and may contribute 13 kg of phosphorus load to MBI annually[3]. If shoreline property owners were to create adequate buffers and install other shoreline BMPs (at a 50% BMP efficiency rate), the annual reduction would be 6 kg of phosphorus. A total of 330 parcels scored 10-14 and may contribute 105 kg of phosphorus annually[4]. Remediation efforts on these properties using a 50% BMP efficiency rate could result in an annual reduction of 52 kg of phosphorus.

Of the 11 parcels evaluated, the average shoreline disturbance score for Garland Pond was 5.1 (Table 3.12). Garland Pond had the lowest scores because a large parcel of land is owned and conserved by The Nature Conservancy. Development around the pond is minimal with only one developed parcel containing a home visible from the shoreline. Pollutant load estimates were not generated for Garland Pond due to the low scores and the likelihood that the majority of nutrients entering Garland Pond are not the result of shoreline development.

Of the 56 parcels evaluated, the average disturbance score for Lees Pond was 8.1, ranging from 5-14 (Table 3.12). Parcels around Lees Pond were smaller compared to Garland Pond and had more shoreline residential development. A total of 17 parcels scored 10-14 and may contribute 5 kg of phosphorus load to Lees Pond annually. Remediation efforts on these properties using a 50% BMP efficiency rate could result in an annual reduction of 3 kg of phosphorus.

[3] Based on Region 5 model bank stabilization estimate for sandy soils, using 100 ft (length) by 5 ft (height) and moderate lateral recession rate of 0.2 ft/yr.
[4] Based on Region 5 model bank stabilization estimate for sandy soils, using 50 ft (length) by 3 ft (height) and moderate lateral recession rate of 0.1 ft/yr.

The shoreline survey data and the maps generated (refer to Appendix B, F and FBE, 2016c) highlight areas contributing NPS pollution to these waterbodies, help determine actions needed to reduce NPS pollution and achieve the water quality goal for MBI, and help prioritize areas for shoreline restoration using stormwater BMPs.



Lack of vegetative buffer (left) results in delivery of excess nutrients and sediments in the Inlet compared to vegetated shoreline areas (right). (Photo: FB Environmental)

TABLE 3.11: Scoring criteria for the shoreline survey.

Category	Scoring Criteria
Buffer	1 = Excellent Buffer (all natural vegetation - trees of mixed sizes and shrubs) 2 = Good (some trees and shrubs, some bare areas) 3= Moderate (a few small trees/shrubs, some lawn) 4= Minimal (mostly lawn, some shrubs) 5= No Buffer (all lawn/bare)
Bare Soil	1=No exposed Soil 2= minimal exposed Soil 3= Fair amount of exposed soil 4=Large amounts of exposed soil
Shoreline Erosion	1=No Erosion Visible 2=Some Erosion Visible 3=Moderate to Severe shoreline erosion
Setback Distance	1 = homes more than 150' from shore 2 = home between 75 - 150' from shore 3 = house/camp less than 75' from shore
Slope	1=Little to no slope (3 - 8%) 2=Moderate Slope (8 - 20%) 3=Steeply sloped (>20%)

TABLE 3.12: Average shoreline disturbance score values for each waterbody.

Waterbody	**Number of parcels evaluated**	**Buffer**	**Bare Soil**	**Shoreline Erosion**	**Setback Distance**	**Slope**	**Average Shoreline Disturbance Score**
MBI	549	3.0	2.0	1.1	2.4	1.5	9.8
Garland Pond	11	1.1	1.0	1.0	1.0	1.9	5.1
Lees Pond	56	1.8	1.6	1.2	2.1	1.4	8.1

4. MANAGEMENT STRATEGIES

4.1 GOALS FOR LONG-TERM PROTECTION

The ultimate vision of the MBI Watershed Restoration Plan is to protect critical watershed characteristics for the improvement of current water quality status. This ambitious effort is supported by the idea that existing and new development can be remediated or conducted in a manner that sustains environmental values, and that citizens, businesses, government, and other stakeholder groups can be responsible stewards of the watershed. The long-term goal is to protect the watershed and water quality of MBI through a 42% (26 kg P/yr), 31% (27 kg P/yr), and 20% (242 kg P/yr) reduction in annual phosphorus loading to Basins 1, 2, and 3, respectively. This target reduction in phosphorus can be achieved through the following STRUCTURAL AND NON-STRUCTURAL BMP objectives:

> STRUCTURAL BMPS, or engineered Best Management Practices (BMPs) are often on the forefront of most watershed restoration projects. However, NON-STRUCTURAL BMPS, which do not require extensive engineering or construction efforts, can help reduce stormwater runoff and associated pollutants through operational actions such as land use planning strategies, municipal maintenance practices such as street sweeping and road sand/salt management, and targeted education and training.

- Implement structural BMPs throughout the watershed to reduce sediment and phosphorus runoff from existing development.
- Educate landowners through the NHDES Soak Up the Rain program, BMP demonstration sites, workshops, and other communication strategies, targeting high priority properties with inadequate buffers and/or potentially-malfunctioning septic systems (>25 years old, within 50 feet of a waterbody, and rarely pumped out).
- Institute greater controls on new and re-development, require LID in site plans, and encourage regular septic system maintenance.
- Continue and/or expand the water quality monitoring and aquatic invasive plant control programs.

These objectives and more are discussed in greater detail in the Action Plan (Section 5.2). Achieving the goals and objectives for future implementation work in the MBI watershed will require a comprehensive and integrated set of activities as identified below.

4.2 ADDRESSING NONPOINT SOURCE (NPS) POLLUTION

4.2.1 STRUCTURAL NPS RESTORATION

FB Environmental and LWA documented 56 watershed NPS sites and 336 shoreline properties that impact water quality in MBI through the delivery of phosphorus-laden sediment. Consequently, structural BMPs are a necessary and important component for the improvement and protection of water quality of MBI. The best approach for treating these sites is to:

Lack of a protective buffer results in excess sediment and nutrient load to MBI. (Photo: FB Environmental)

1) Address high priority sites with an emphasis on cost-efficient fixes that have a high impact to low cost per kg of phosphorus treated.
2) Work with landowners to get commitments for treating and maintaining sites. Workshops and tours of demonstration sites can help encourage landowners to utilize BMPs on their own property.
    - **LWA and the town of Moultonborough hosted a 'Landscaping for Water Quality' workshop on March 30, 31, 2017, which was attended by 30 landscaping professionals. The workshop utilized the Balmoral Clubhouse as a field exercise for generating landscaping recommendations to improve stormwater runoff. The Balmoral community implemented two of the recommendations, stabilizing an eroding slope and defining a foot path with infiltration steps.**
3) Work with experienced professionals on sites that require a high level of technical knowledge (engineering) to install, and ensure proper functioning of the BMP. UNH Stormwater Center generated BMP designs and cost estimates for two sites, both in the direct shoreline drainage area of Basin 3 (Appendix E).
    a. **Site 1-23: Glen Forest Drive, Balmoral. Eroding ditch near inlet to lake.**
    b. **Site 2-05: Balmoral Beach, shoreline is eroding along several hundred feet. Valuable habitat lost.**
4) Measure the pollutant load reduction for each BMP installed (see below).

These basic criteria will help guide the proper installation of BMPs in the watershed. Refer to the Action Plan in Section 5.2 and conservation practice fact sheets provided by the Cumberland County Soil & Water District for a continued discussion of BMP implementation strategies (CCSWD, 2014).

In total, the top 20 sites identified in the watershed survey will reduce 21 kg P/yr and cost $52,536 to implement and maintain over the next ten years (Table 4.1; refer to Section 5.4 and Appendix D). These estimates are based on the Region 5 model for estimating pollutant load reductions. Only one site (1-13) was identified within the drainage to Basin 1; the remaining 55 NPS sites were identified within the drainage to Basin 3. It is recommended that another survey be conducted to target the Basin 1 drainage area, if the Advisory Committee decides to pursue Basin 1 for priority implementation projects.

Using a simple scoring method, the shoreline survey served as an excellent tool for highlighting shoreline properties around MBI that exhibited significant erosion (refer to Section 3.4). This method of shoreline survey is a rapid technique to assess the overall condition of properties within the shoreland zone; but it does not allow for making specific recommendations for BMP implementation. Therefore, high priority properties (6 parcels), plus medium priority properties (330 parcels), around MBI should be resurveyed in person for specific BMP recommendations and more accurate estimated phosphorus reductions and implementation costs by site. However, given some broad assumptions (100 ft shoreline contributing 4.7 kg P/yr), the high priority properties around the shorelines of Basins 1, 2, and 3 likely contribute 0, 14, and 14 kg P/yr and would cost $0, $9,000, and $9,000 to revegetate and mulch with volunteer labor, respectively (Table 4.2; refer to Appendix F). The medium priority properties around the shorelines of Basins 1, 2, and 3 likely contribute 27, 51, and 153 kg P/yr and would cost $57,000, $109,500, and $328,500 to revegetate and mulch with volunteer labor, respectively (Table 4.2; refer to Appendix F).

TABLE 4.1: Summary of estimated cost and total phosphorus (TP) loading removal rates for top 20 priority BMP sites. Estimates are based on CCSWD estimates and UNHSC (2012). The 10-year cost is the sum of the estimated BMP cost plus 10 times the estimated annual cost to maintain the BMP.

Site ID	Basin Drainage	Location	TP (kg/yr)*	BMP Cost Estimate**	Annual Cost	10-yr Cost
1-18	3	Ossipee Mtn Rd. #446	4.4	$600	$25	$850
1-19	3	Wool Wakefield #23	0.6	$150	$25	$400
1-58	3	Blake Road by School	2.0	$1,500	$100	$2,500
1-26	3	Blueberry Lane (end of Road)	0.5	$370	$25	$620
1-08	3	Sheridan Road near House #65	4.4	$1,863	$250	$4,363
1-12	3	Sheridan Road near Town Line	1.2	$3,600	$50	$4,100
1-14	3	Whittier Highway across from Moultonborough Self storage	0.5	$661	$25	$911
1-13	1	House #75	1.5	$1,540	$100	$2,540
2-02	3	Paradise Drive	0.3	$1,200	$50	$1,700
1-16	3	Evans Road	0.5	$800	$25	$1,050
2-07	3	Severance Road	0.5	$2,632	$50	$3,132
1-03	3	Holland Road at Weed Brook Crossing	0.5	$720	$50	$1,220
2-04	3	Balmoral Beach	0.2	$150	$50	$650
1-60	3	Lee Road	0.1	$400	$25	$650
1-06	3	Parking lot West of Town Hall	0.5	$1,500	$100	$2,500
1-20	3	Ossipee Mtn Rd. near Interstate Governor Wentworth	0.5	$1,500	$25	$1,750
1-02	3	Holland Road - Weed Brook Crossing	1.5	$3,830	$500	$8,830
1-30	3	Suissevale Beach and Marina	0.5	$5,350	$50	$5,850
1-59	3	Lee Road	1.2	$7,200	$50	$7,700
1-24	3	Blackbird Lane #14	0.2	$720	$50	$1,220
		TOTAL	21.1	$36,286	$1,625	$52,536

** TP reduction estimates based on Region 5 model for bank stabilization or urban runoff*

*** BMP cost estimates based on CCSWCD (2008) and assumes volunteer labor*

TABLE 4.2: Summary of properties with high (15-16) and medium (10-14) shoreline disturbance scores for each basin. Refer to Appendix F for full results.

Basin	# High Priority Parcels (Score 15-16)	# Medium Priority Parcels (Score 10-14)	TP Load for High Priority Parcels (kg/yr)	TP Load for Medium Priority Parcels (kg/yr)	Total TP Load (kg/yr)
1	0	38	0	27	27
2	3	73	14	51	65
3	3	219	14	153	167

All together assuming 50% BMP efficiency for shoreline sites, these priority BMPs would reduce 15, 33, and 103 kg P/yr to Basins 1, 2, and 3, respectively (Table 4.3). Implementing these BMPs would cost about $565,536. These reduction estimates more than meet the goal for Basin 2, which requires a 31% (27 kg/yr) phosphorus load reduction. For the other basins, these reduction estimates only meet roughly half the goals for Basins 1 and 3, which require a 42% (26 kg/yr) and 20% (242 kg/yr) phosphorus load reduction, respectively. To meet these goals, an additional 11 kg P/yr and 139 kg P/yr would need to be reduced to Basins 1 and 3, respectively. These reductions could be achieved as new sites are identified and added to the BMP matrix, as site-specific BMPs are implemented along shorelines, enabling more accurate, and likely higher, phosphorus load reduction estimates, and as shoreline BMPs are implemented along Lees Pond or other waterbodies within the watershed. In addition, non-structural BMPs implemented throughout the watershed will help to further reduce the phosphorus loading to MBI.

TABLE 4.3: Summary of total phosphorus (TP) reductions and estimated costs of high or medium priority BMP implementations for Basins 1, 2, and 3.

Basin	**Watershed Survey**		**Shoreline Survey**		**Total**	
	TP Reduction (kg/yr)	Estimated Cost	TP Reduction (kg/yr)	Estimated Cost	TP Reduction (kg/yr)	Estimated Cost
1	1.5	$2,540	13.3	$57,000	14.8	$59,540
2	0	$0	32.6	$118,500	32.6	$118,500
3	19.6	$49,996	83.7	$337,500	103.3	$387,496

4.2.2 NON-STRUCTURAL NPS RESTORATION

Non-structural watershed restoration practices prevent or reduce stormwater related runoff problems by reducing the exposure and generation of pollutants and providing a regulatory framework that minimizes impervious surfaces. Non-structural approaches to watershed restoration can be the most cost-effective and holistic practices within a watershed management framework. The non-structural approaches recommended in this plan can not only improve water quality, but can also enhance watershed aesthetics (e.g., through shade tree planting and landscaping), streamline the permitting process (e.g., by removing conflicting design or stormwater codes), and reduce development costs (e.g., by minimizing impervious area development).

There are two primary components of non-structural BMPs:

1) Planning, design, and construction that minimizes or eliminates adverse stormwater impacts; and
2) Good housekeeping measures and education/training to promote awareness.

In watersheds with future development potential, it is critical for municipalities to develop and enforce stormwater management criteria to prevent any increase in pollutant loadings that may offset reduced loads as a result of plan implementation. Zoning in the MBI watershed presents considerable opportunity for continued development (see the build-out analysis in Section 3.2) and, by extension, increased threats to aquatic habitat and recreational use of the Inlet. In watersheds with significant development potential, the Center for Watershed Protection identifies BMP/LID implementation requirements for development projects as the best mechanism for enhanced long-term stormwater management. It can be argued that local land use planning and zoning ordinances are the most critical components of watershed protection despite federal Clean Water Act requirements. The guidelines for local water policy innovation are as follows:

1) Review current zoning ordinances for regulatory barriers and improvements.
2) Set performance-based standards.
3) Take additional measures to reduce impervious surfaces.
4) Promote the use of specific LID designs.
5) Use overlay districts to add new requirements to existing zoning districts.
6) Establish standards or incentives to improve stormwater management in developed areas.
7) Address storage/use of pollutants that contact stormwater.
8) Consider approving a septic system ordinance that requires regular maintenance and inspections.

4.3 CURRENT AND FUTURE POLLUTANT SOURCES

LWA and other project stakeholders have taken great measures in educating residents about the potential adverse effects of phosphorus-based detergents. In 2009, New Hampshire revised its Prohibited Products Statutes to prohibit the distribution, sale, or offering for sale any household cleansing products containing phosphorus (485-A:56). In 2010, sixteen other states followed suit and enacted a phosphate ban for dishwasher detergent, while many other states have banned the use of high-phosphate laundry detergents.

The 2015 watershed stormwater survey and shoreline survey indicate that a significant amount of phosphorus is delivered to the Inlet as a result of soil erosion. By combining the land-use modeling results with estimated future loading increases from the build-out analysis, we can estimate the phosphorus load at full build-out. Currently, 62 kg of phosphorus enters Basin 1 annually; 86 kg of phosphorus enters Basin 2 annually, 25 kg/yr of which comes from Basin 1; and 1,202 kg of phosphorus enters Basin 3 annually, 37 kg/yr of which comes from Basin 2. According to the build-out analysis, Basins 1, 2, and 3 will experience a 53% increase (to 95 kg/yr), 55% increase (to 133 kg/yr), and 51% increase (to 1,819 kg/yr) in phosphorus loading at full build-out (2058), respectively. Watershed load contributed the greatest increase in phosphorus loading to the three basins. At full build-out, in-lake phosphorus concentration could be as high as 22.5, 16.6, and 14.5 ppb in Basins 1, 2, and 3, respectively.

Ideally, if all NPS pollution sites identified in the 2015 watershed and shoreline surveys were treated with BMPs, and all new development contained proper phosphorus controls, these annual phosphorus loadings would be greatly reduced.

It is important to note that, while the focus of this plan is on phosphorus (through the direct treatment of sediment), the treatment of stormwater will result in the reduction of many other types of harmful pollutants that could have a negative impact on these waters. These pollutants would likely include:

1) Other Nutrients (e.g., nitrogen)
2) Bacteria
3) Heavy metals (cadmium, nickel, zinc)
4) Petroleum products
5) Road salt/sand

Without a monitoring program in place to determine these pollutant levels, it will be difficult to track successful reduction efforts. However, there are various spreadsheet models available that can estimate reductions in these pollutants depending on the types of BMPs installed. Phosphorus and nitrogen reductions can be input to the LLRM model developed for this project to estimate the response of the Inlet to the reductions.

4.4 ADAPTIVE MANAGEMENT APPROACH

An adaptive management approach, to be employed by the Advisory committee, is highly recommended for protecting watersheds. Adaptive management enables stakeholders to conduct restoration activities in an iterative manner. This provides opportunities for utilizing available resources efficiently through BMP performance testing and watershed monitoring activities. Stakeholders can evaluate the effectiveness of one set of restoration actions and either adopt or modify them before implementing effective measures in the next round of restoration activities. The adaptive management approach recognizes that the entire watershed cannot be restored with a single restoration action or within a short-time frame. Instead, adaptive management features establishing an ongoing program that provides adequate funding, stakeholder guidance, and an efficient coordination of restoration activities. Implementation of this approach would ensure that restoration actions are implemented and that surface waters are monitored to document restoration over an extended time period. The adaptive management components for future implementation efforts should include:

- Maintaining an Organizational Structure for Implementation. Since the watershed spans multiple municipalities, a cooperating group representing the watershed towns and associations should be established for the implementation of future efforts in the watershed and to help coordinate the implementation of restoration activities. Fortunately, LWA has already stepped up to take on this role, but other prominent groups, including Moultonborough Conservation Commission, Lees Pond Association and the Suissevale/Balmoral neighborhood associations, should also be involved. These groups should try to involve the various business interests in the watershed to allow for a full consideration of all issues relevant to an effective, efficient, and cost-effective restoration program.

- Establishing a Funding Mechanism. A long-term funding mechanism should be established to provide financial resources for restoration actions, and should be guided by an advisory committee that would include representatives from watershed towns, lake residents, LWA, businesses, associations,

> The ADAPTIVE MANAGEMENT APPROACH recognizes that the entire watershed cannot be restored with a single restoration action or within a short time frame.

land trusts, and more. In addition to construction and organizational management costs, consideration should also be given to the type and extent of technical assistance needed to design, inspect, and maintain stormwater BMPs. Technical assistance costs for the annual field monitoring program should also be considered. Funding is a critical element of sustaining the restoration process, and once it is established, the restoration plan can be fully vetted and restoration activities can move forward.

- Synthesizing Restoration Actions. This watershed restoration plan provides prioritized recommendations to support restoration (e.g., structural/nonstructural recommendations for priority areas). These recommendations, or action items, need to be revisited and synthesized to create a unified watershed restoration strategy. Once a funding mechanism is established, the lake watershed restoration program should begin in earnest by developing detailed designs for priority restoration activities on a project-area basis and scheduling their implementation accordingly.

- Continuing the Community Participation Process. The development of the plan has greatly benefited from the active involvement of an engaged group of watershed stakeholders with a diversity of skills and interests. Plan implementation will require their continued and ongoing participation, as well as additional community outreach efforts to involve even more stakeholders throughout the watershed. A sustained public awareness and outreach campaign is essential to secure the long-term community support that will be necessary to successfully implement this project.

- Developing a Long-Term Monitoring Program. Although current monitoring efforts are strong, a detailed monitoring program (including ongoing monitoring of watershed tributaries and other surface waters, such as Lees and Garland Ponds) is necessary to track the health of the Inlet, particularly when the overall goal of the watershed restoration planning process is the protection of the long-term health of this waterbody (refer to Section 5.2).

- Establishing Measurable Milestones. A restoration schedule that includes milestones for measuring restoration actions and monitoring activities in the watershed is critically important to the success of the plan. In addition to monitoring, several environmental, social, and programmatic indicators have been identified to measure the progress of the plan. These indicators are listed in Section 5.3, and are intricately tied to the action items identified in the Action Plan in Section 5.2.

5. PLAN IMPLEMENTATION

5.1 PLAN OVERSIGHT

With the help of LWA, this watershed restoration plan should be carried out by an advisory committee similar to the one established during the development of this plan. Local participation is an integral part of the success of this plan, and should include the leadership of local municipalities, such as the Towns of Moultonborough and Sandwich. This task will also require the support of other stakeholders, including conservation commissions, NHDES, schools and community groups, lake/road/neighborhood associations, local businesses, and individual landowners. The primary stakeholder group will need to meet regularly and be diligent in coordinating resources to implement practices that will reduce NPS pollution in the MBI watershed.

The formation of subcommittees would result in more efficient implementation of the Action Plan. Suggested action committees include:

1) Funding: form a new subcommittee to focus on obtaining funding for the other subcommittees.
2) Education and Outreach: form a new subcommittee to focus on education-related action items that incorporate elements already being implemented and targets communities within the MBI watershed.
3) Septic Systems: form a new subcommittee to focus on improving septic system maintenance in the watershed.
4) Planning and Land Conservation: form a new subcommittee to focus on improving municipal ordinances and increase the amount of conserved land (work with local land trusts and conservation commissions).
5) BMP Implementation: redirect existing subcommittee to focus on BMP action items and coordinate with the funding subcommittee on applying for the next phase of 319 implementation funds.
6) Water Quality Monitoring and Assessment: continue existing subcommittee to focus on monitoring action items, including a revision of the long-term monitoring program.

These subcommittees will be charged with implementing projects and actions within the Action Plan with the support and assistance of state and local natural resource agencies and groups. It is important to note that these subcommittees are merely recommendations under ideal circumstances where membership numbers allow for proper staffing of each subcommittee. It may not be practical to have subcommittees if committee membership is low. LWA should work to encourage more participation, if this is the case.

5.2 ACTION PLAN

The Action Plan was developed through the combined efforts of LWA, FB Environmental, and the Advisory Committee, as well as the public by way of feedback provided during public review of the draft plan. The Action Plan is a critical component of the plan because it provides a list of specific strategies for improving water quality and the means to make the water quality goals a reality (Section 1.2; 3.3). The Advisory Committee should work toward implementing the Action Plan and identifying improvements, as needed.

The Action Plan consists of action items that help address threats identified within five major categories: (1) Septic Systems; (2) Watershed and Shoreline BMPs; (3) Roads; (4) Planning and Land Conservation; and (5) Water Quality Monitoring. The Action Plan outlines responsible parties, potential funding sources, approximate costs, and an implementation schedule for each task within each category. Current cost estimates for each action item will need to be adjusted based on further research and site design considerations. Refer to Table 5.1 at the end of this section for a complete list of action items.

5.2.1 WATERSHED & SHORELINE BEST MANAGEMENT PRACTICES (BMPS)

Watershed and shorefront residential development was also identified as a significant threat to the water quality of MBI. Direct shoreline areas are typically among the highest for pollutant loading given their proximity to lakes and desirability for development. The Advisory Committee and technical staff conducted a comprehensive shoreline survey in 2015 for MBI, Garland Pond, and Lees Pond, and found that 58% of the shoreline area surveyed received high disturbance scores and are likely impacting water quality. It was also estimated by the LLRM that the direct drainage areas to MBI provide the greatest phosphorus load per unit area compared to the other subwatersheds. As such, the shoreline deserves special attention in any lake protection plan, and MBI is no exception.

The BMPs recommended in this plan are restoration tools that property owners can use to minimize impacts from stormwater runoff and restore degraded shoreline areas. This could be as simple as planting vegetated buffers, installing gravel driplines along roof edges, and ensuring that path and driveway runoff is filtered into the ground rather than forced overland to surface waters. Coordination with landowners is crucial for successful implementation of BMPs identified in this plan because many of these mitigation measures will need to be implemented on private land.

- → **LWA hosted a “Landscaping at the Water’s Edge” talk at the Moultonborough Public Safety building. The talk was given by Cathy Neal of the UNH Cooperative Extension.**
- → **LWA gave a presentation on DIY stormwater management tips for homeowners on May 28, 2016 at the Loon Center in Moultonborough; 30 people were in attendance.**
- → **A “SOAK Up the Rain” display was put up at the Moultonborough Public Library from June 8 to August 9, 2016.**

5.2.2 SEPTIC SYSTEMS

Septic systems were identified as a significant threat to the water quality of MBI. This includes septic systems built in saturated areas, used beyond design capacity, or maintained improperly. Septic system effluent typically stores a thousand times the concentration of phosphorus found in lake waters, which means that a small amount of effluent could have a major impact on surface waters. An old or improperly-maintained septic system can also result in the delivery of disease-causing bacteria or viruses that can result in gastro-intestinal illness in swimmers. Untreated septic waste may contain chemicals and hormones used in pharmaceutical and personal care products, which can reach lake water if a system is not working properly. Inundation of systems by groundwater greatly enhances the transport of phosphorus and pathogens to the lake. Therefore, it is critical to ensure adequate setbacks and good vertical separation from the seasonally-high groundwater table.

Based on the watershed modelling that has been completed, wastewater systems, including septic systems, outhouses, and cesspools, are the third largest source of phosphorus to the watershed. The contribution of septic systems was estimated to provide 5% (3 kg), 9% (8 kg), and 4% (47 kg) of the phosphorus load to Basins 1, 2, and 3, respectively. A wastewater inspection and maintenance program would help to reduce phosphorus and bacteria loading to MBI. Meaningful reductions in phosphorus loading to the Inlet will be achieved if landowners take responsibility to check their systems, and make necessary upgrades, especially to old systems, cesspools, and outhouses.

- → **LWA hosted a Septic Sense Seminar on August 5, 2014 at the Balmoral Improvement Association's Clubhouse. The seminar was presented by Gary Spaulding, a member of Granite State Designers and Installers Association; 19 people were in attendance.**

5.2.3 ROADS

Threats to water quality as a result of roads include undersized culverts, excess road salt and sand, lack of stormwater control, lack of resources to improve and maintain road infrastructure, and erosion from gravel or logging roads in the watershed. The 2015 watershed survey conducted by LWA and FB Environmental identified 56 sites that are resulting in the delivery of nutrients and other pollutants to the lake. Of these sites, 40 are associated with state, town, or private roads or municipal parking lots. Several of these road sites are a significant threat to water quality due to their proximity to the lake and its tributaries and their ability to deposit sand and gravel directly into the water. Refer to Appendix G for a separate list of recommended culvert replacements identified during the watershed survey. Refer to Appendix D for the top 20 priority BMP sites that include a mix of road fixes.

- → **LWA hosted a Gravel Roads Workshop for road associations and other interested stakeholders from around the State on July 11, 2015. The 2.5-hr workshop presented by Russ Lanoie was attended by 28 people, 16 of which were from Moultonborough.**
- → **NH Lakes teamed up with Lees Pond Association and Moultonborough Academy in July 2014 to identify and implement BMP projects at the Lees Pond access road and boat ramp.**

5.2.4 PLANNING AND LAND CONSERVATION

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. The build-out analysis indicates that there is room for improvement in protecting water quality through non-structural BMPs such as municipal ordinance adoption or revisions, especially as it relates to new development. Action items were based on improvements identified by technical staff during a review of water quality-related ordinances for the Towns of Moultonborough and Sandwich. It is anticipated that Basins 1, 2, and 3 will experience a 53% increase (to 95 kg/yr), 55% increase (to 133 kg/yr), and 51% increase (to 1,819 kg/yr) in phosphorus loading at full build-out (2058), respectively. Improving municipal ordinances that help protect water quality in the watershed will help mitigate the estimated 16, 22, and 294 kg/yr of additional phosphorus loading that Basins 1, 2, and 3 will receive in the next 20 years, respectively.

5.2.5 WATER QUALITY MONITORING

Monitoring programs are crucial to evaluating the effectiveness of watershed planning activities and to determining if water quality goals are being achieved over the long-term. The Action Plan includes recommendations for enhancing current water quality monitoring efforts, including sample collection from various tributaries and ponds, and continuation of the invasive species monitoring program. Since volunteers typically conduct many different monitoring activities, it will be critical to continue building on the success of the area's ongoing education, outreach, and volunteer monitoring programs. Refer to Appendix B for a map showing current lake monitoring sites in the Inlet.

LAKE MONITORING

Recommendations for lake water quality monitoring include:

- Take regular, annual DO and temperature profile readings, Secchi disk readings, and epilimnion and hypolimnion total phosphorus and epilimnion chlorophyll-a samples at a minimum of one station per basin. Recommend WMO00GL (Green's Basin), WMO01BL (Blanchard's Island), and WMO01LL (Little Ganzy). Aim for biweekly Secchi disk readings and monthly DO and temperature profile readings combined with chemical sampling. Assumes a sampling season from June-September.
- Add additional parameters to collect from the epilimnion, including pH, alkalinity, color, total dissolved nitrogen, and total dissolved organic carbon.
- Add additional sampling sites in Basin 3 for the full sampling program addressed above. This will depend on available funding and/or desires of project partners.
- Expand sampling outside normal season (June-September) to include spring and fall turnover. This will provide information on how the Inlet responds to environmental changes during critical turnover periods and help to better estimate internal loading contributions.
- Team up with university consultant to take sediment cores at the three basins or other critical areas around the Inlet. This will provide valuable historical information regarding changes in water quality over time.
- Install 3-season buoy system in the three basins to monitor DO and temperature throughout the water column using continuous data loggers. This would provide a finer-scale resolution of changes in DO and temperature throughout the season, so that we could pinpoint critical turnover times, determine the extent and duration of anoxia, and track changes over time.

TRIBUTARY/POND MONITORING

Recommendations for tributary and pond water quality monitoring include:

- Encourage continued regular sampling of Lees Pond. Take regular, annual DO and temperature profile readings, Secchi disk readings, and epilimnion and hypolimnion total phosphorus and epilimnion chlorophyll-a samples at the deep spot. Consider including pH, alkalinity, color, total dissolved nitrogen, and total dissolved organic carbon. Aim for biweekly Secchi disk readings and monthly DO and temperature profile readings combined with chemical sampling. Assumes a sampling season from June-September.
- Expand pond sampling to include other major waterbodies in the watershed, including Garland Pond, Shannon Pond, Berry Pond, Red Hill Pond, Little Pond, Dinsmore Pond, and Meadow Pond (in order of priority). This will provide critical information for better predictive ability of the land

use model. This need only be done 1-3 times per year for epilimnion total phosphorus and chlorophyll-a.

- Sample major tributaries flowing directly to MBI, including Lees Pond outflow, Halfway Brook, Middle Brook, Shannon Brook, Tributary 2 to Basin 3, Basin 1 Tributary, and Basin 2 Tributary. Sample for total phosphorus at a minimum. Sampling should occur at least 3 times per year and cover both baseflow and stormflow conditions. This will provide critical information for better predictive ability of the land use model.
- Add additional parameters to collect from the major tributaries flowing directly to MBI, including pH, *E. coli*, total dissolved nitrogen, chloride, and turbidity.
- Add additional tributary sampling sites for the full tributary sampling program described above. Recommended sites are the outflows of Stanton Brook, Creamery Brook, Montgomery Brook, Cook Brook, Skinner Brook, Tributary 2 to Red Hill Brook, and Weed Brook.
- Consider installing continuous data loggers measuring flow, DO, conductivity, and temperature at key tributary locations. These data would be useful in understanding water quality processes in the watershed. Coupled with water chemistry data, loading rates of nutrients may be calculated using the continuous flow data and used to update the land use model. The Town of Moultonborough is currently joining the NH LoVoTECS program run by Plymouth State University. Temperature, conductivity, and flow will be measured continuously in four tributaries flowing into Lake Winnipesaukee within the Town.

TABLE 5.1: Action Plan.

ACTION ITEM	DESCRIPTION	LWA	Lake Associations	Towns	Conservation Commissions	NH DOT	SOAK NH	Local Conservation Partners	Residents/Businesses/ Neighborhood	Consultant	University Partners	SCHEDULE	ESTIMATED COST
Watershed & Shorefront BMPs													
Garner funding for action items	1) Develop a subcommittee that develops a fundraising strategy and determines how funding is spent.	✓	✓	✓	✓				✓			2017-19	N/A
	2) Establish a capital reserve fund for watershed towns to spend on lake protection initiatives. Cost covers labor to setup and maintain fund.			✓	✓							2017-36	$1,000/yr
	3) Solicit residents for individual donations.	✓	✓						✓			2017-36	N/A
	4) Develop a "Friends of the Watershed" program for donations from local businesses.	✓	✓						✓			2017-36	N/A
Address priority BMPs identified in surveys	1) Implement BMPs at the 20 high priority sites identified in the watershed survey. Cost estimate includes implementation and annual maintenance for all BMPs in a ten-year period. Expected to reduce pollutant load by 21 kg P/year.	✓	✓	✓	✓	✓	✓		✓			2017-26	$52,536
	2) Resurvey drainage areas to Basins 1 and 2 for NPS sites.	✓	✓		✓					✓		2017-20	$3,000
	3) BASIN 1: Implement shoreline BMPs at the 38 medium impact sites identified in the shoreline survey with disturbance scores of 10 or greater. Assumes cost of $1,500 per site to revegetate and mulch with volunteer labor. Expected to reduce pollutant load by 13 kg P/year.	✓	✓		✓		✓		✓			2017-26	$57,000
	4) BASIN 2: Implement shoreline BMPs at the 3 high impact and 73 medium impact sites identified in the shoreline survey with disturbance scores of 10 or greater. Assumes cost of $3,000 for high impact sites and $1,500 for medium impact sites to revegetate	✓	✓		✓		✓		✓			2017-26	$118,500

ACTION ITEM	DESCRIPTION	LWA	Lake Associations	Towns	Conservation Commissions	NH DOT	SOAK NH	Local Conservation Partners	Residents/Businesses/ Neighborhood	Consultant	University Partners	SCHEDULE	ESTIMATED COST
	and mulch with volunteer labor. Expected to reduce pollutant load by 33 kg P/year.												
	5) BASIN 3: Implement shoreline BMPs at the 3 high impact and 219 medium impact sites identified in the shoreline survey with disturbance scores of 10 or greater. Assumes cost of $3,000 for high impact sites and $1,500 for medium impact sites to revegetate and mulch with volunteer labor. Expected to reduce pollutant load by 84 kg P/year.	✓	✓		✓		✓		✓			2017-26	$337,500
	6) OTHER WATERBODIES: Implement shoreline BMPs around other waterbodies impacted by development within the watershed, particularly Lees Pond.	✓	✓		✓		✓		✓			2017-26	TBD
	7) Develop a method of tracking and monitoring BMP implementation progress (e.g., NPS Site Tracker).	✓	✓							✓		2017-26	$500/yr
	8) Host LID/BMP training workshops for Town Public Works.	✓		✓	✓							2017-26	$5,000
	9) Host tours of BMP demonstration sites for interested residents to enhance awareness of link between land use and water quality and provide easy erosion-control solutions to homeowners.	✓	✓		✓		✓			✓		2017-26	$500/yr
	Septic Systems												
Enhance awareness of proper septic system maintenance	1) Distribute educational pamphlets on septic system function and maintenance in tax bills.	✓		✓	✓					✓		2017-18	$2,000
	2) Create and distribute a list of septic service providers (create magnets, etc.).	✓			✓							2017-18	$500
	3) Host multiple "septic socials" in key neighborhoods near the lake to address link between septic system maintenance and water	✓	✓		✓				✓			2017-36	$150/yr

ACTION ITEM	DESCRIPTION	LWA	Lake Associations	Towns	Conservation Commissions	NH DOT	SOAK NH	Local Conservation Partners	Residents/Businesses/ Neighborhood	Consultant	University Partners	SCHEDULE	ESTIMATED COST
	quality. Target educational campaign in areas with minimally-maintained or aging septic systems.												
Inventory status of septic systems in watershed	1) Conduct a comprehensive septic system survey of all properties within 250 ft of a critical waterbody in the watershed.	✓	✓	✓	✓					✓		2017-20	$10,000
	2) Conduct voluntary dye testing of high impact septic systems. Goal: 5 systems.	✓		✓					✓			2020-22	$100/system
	3) Develop and maintain a septic system database for the watershed. Code Enforcement Office for each town to maintain database. Cost estimate based on initial setup by LWA or consultants.	✓		✓	✓					✓		2017-36	$5,000
Enforce town septic system regulations	1) Communicate with town departments to enforce occupancy loads and have septic system inventories in Master Plans.			✓	✓							2017-36	TBD
	2) Inspect all home conversions from seasonal to permanent residences and property transfers for proper septic system size and design.			✓					✓			2017-36	$250/system
Garner funding or discounts that support and encourage septic system maintenance	1) Coordinate group septic system pumping discounts. Assumes volunteer labor to coordinate. Pump-out costs on landowners.	✓	✓						✓			2017-36	N/A
	2) Investigate grants and low-interest loans (e.g., NHDES Clean Water State Revolving Fund) to provide cost-share opportunities for septic system upgrades. Cost estimate based on resources to apply for grant.	✓	✓	✓								2017-18	$1,500
	3) Encourage towns and/or conservation commissions to reserve a portion of conservation dollars for the watershed that can be used for septic system upgrades.	✓	✓	✓	✓							2017-36	N/A

ACTION ITEM	DESCRIPTION	LWA	Lake Associations	Towns	Conservation Commissions	NH DOT	SOAK NH	Local Conservation Partners	Residents/Businesses/ Neighborhood	Consultant	University Partners	SCHEDULE	ESTIMATED COST
Canine Detection	1) Hire canine detection team to investigate shoreline septic systems.	✓	✓	✓	✓					✓		2017-20	$5,000
	Roads												
Create and manage drainage easements on roads	1) Work with road agents and landowners to create and manage drainage easements on private properties. This will help control salt/sand and stormwater runoff from roads.		✓	✓	✓	✓			✓			2017-36	TBD
Address culvert replacements identified during watershed survey	1) Work with towns, NH DOT, and residents or neighborhood associations to replace undersized or poorly-designed culverts. Cost assumes materials only, but likely underestimated until more detailed designs are completed.	✓	✓	✓	✓	✓			✓			2017-20	$16,750
Require training of road agents	1) Require regular training for road agents on proper salt, sand, and equipment use (e.g., UNH Technology Transfer Center Green SnowPro trainings for snow plot operators).			✓								2017-36	$5,000
Host road maintenance workshops	1) Hold workshops on proper road management, particularly for gravel roads.	✓	✓	✓	✓							2017-36	$2,000
Encourage private road associations	1) Be sure there are road associations in key neighborhoods or heavily-used roads for better management by local stakeholders. Encourage these road associations to communicate with each other on best road management practices.		✓		✓				✓			2017-36	TBD
	Municipal Planning & Land Conservation												
Adopt plan recommendations	1) Incorporate watershed plan recommendations into town master plans.			✓								2017-26	N/A

ACTION ITEM	DESCRIPTION	LWA	Lake Associations	Towns	Conservation Commissions	NH DOT	SOAK NH	Local Conservation Partners	Residents/Businesses/ Neighborhood	Consultant	University Partners	SCHEDULE	ESTIMATED COST
Host workshops for watershed resident education of local land ordinances	1) Hold informational workshops for new landowners, towns, and developers on relevant town ordinances, permitting procedures, conservation easements, and watershed goals. Goal: 1-2.	✓	✓	✓	✓			✓	✓	✓		2017-36	$5,000
Host training of code enforcement officers and ZBAs	1) Host training for code enforcement officers and ZBAs in watershed towns, where applicable.			✓								2017-36	$5,000
Identify opportunities for land protection and conservation within the watershed	1) Fund tools, such as natural resource inventories, to help target critical land for protection.			✓	✓			✓		✓		2017-36	$10,000
	2) Collaborate with local conservation partners on land conservation initiatives within the watershed. Assign a liaison to communicate with conservation groups.		✓		✓			✓				2017-36	N/A
Enhance enforcement of proper land management practices	1) Create better enforcement of forestry rules and regulations.			✓	✓				✓			2017-36	TBD
	2) Encourage easement holders to be notified and present at closings.			✓	✓				✓			2017-36	N/A
Improve municipal permitting process	1) Create list of BMP and LID descriptions for Town Selectman, ZBA, Planning Boards, and landowners.	✓	✓	✓	✓					✓		2017-19	$1,500
Improve municipal ordinances (to help mitigate the anticipated 15, 22, and 287 kg P/yr loading increase to Basins 1, 2, and 3, respectively, due to	1) Lot Coverage: adopt uniform requirements between both towns on Stormwater Management Plans for subdivisions, commercial, and multi-family development, and redevelopment disturbing 20,000 sq. feet or more.			✓	✓							2017-36	TBD
	2) Setbacks (Shoreland Zoning): increase the setback distance to 100 feet within the shoreland zone of Moultonborough.			✓	✓							2017-36	TBD

ACTION ITEM	DESCRIPTION	LWA	Lake Associations	Towns	Conservation Commissions	NH DOT	SOAK NH	Local Conservation Partners	Residents/Businesses/ Neighborhood	Consultant	University Partners	SCHEDULE	ESTIMATED COST
predicated future development)	3) Wetland Buffers: increase the setback distance from all wetlands (not just prime or larger wetlands) to 100 feet in both towns.			✓	✓							2017-36	TBD
	4) Conservation/Cluster Subdivisions: increase the amount of land set aside in conservation subdivisions to min. 50% of the development area (Sandwich only requires 25%).			✓	✓			✓				2017-36	TBD
	5) LID: Amend Stormwater Management ordinances to state that the use of LID techniques is preferred and shall be implemented to the maximum extent possible.			✓	✓							2017-36	TBD
	6) Generate a new storm event schedule that dictates better infrastructure development.			✓	✓					✓		2016-26	TBD
	7) Meet with town staff to review recommendations to improve or develop ordinances addressing setbacks, buffers, lot coverage, LID, and open space.			✓	✓					✓		2017-19	$1,000
	Water Quality Monitoring												
Modify current lake monitoring program	1) Take regular, annual DO and temperature profile readings, secchi disk readings, and epilimnion and hypolimnion total phosphorus and chlorophyll-a samples at a minimum of one station per basin. Aim for biweekly secchi disk readings and monthly DO and temperature profile readings combined with chemical sampling. Assumes season from June-September. Cost assumes volunteer labor.		✓		✓						✓	2017-36	$18,000
	2) Add additional parameters to collect from the epilimnion, including pH, alkalinity, color, total dissolved nitrogen, and total dissolved organic carbon.		✓		✓						✓	2017-36	$27,000

ACTION ITEM	DESCRIPTION	LWA	Lake Associations	Towns	Conservation Commissions	NH DOT	SOAK NH	Local Conservation Partners	Residents/Businesses/ Neighborhood	Consultant	University Partners	SCHEDULE	ESTIMATED COST
	3) Add additional sampling sites in Basin 3 for the full sampling program addressed in #1 and #2 above. Cost assumes 3 additional sample sites.		✓		✓						✓	2017-36	$45,000
	4) Re-evaluate water quality at regular intervals based on interim goals, update model, and revisit water quality goals.	✓	✓		✓					✓	✓	2021, 2026, 2036	$10,000
Expand current lake monitoring program	1) Expand sampling outside normal season (June-September) to include spring and fall turnover. Cost assumes two extra sample events at 3 sites for base program (hypo/epi TP, epi Chl-a).		✓		✓							2017-36	$9,000
	2) Team up with university or consultant to take sediment cores at the three basins or other critical areas around the Inlet.		✓		✓					✓	✓	2017-36	TBD
	3) Install 3-season buoy system in the three basins to monitor DO and temperature throughout the water column using continuous data loggers. Cost includes initial setup and 5 years of maintenance by consultant.		✓		✓					✓	✓	TBD	$50,000
Continue and/or expand tributary and pond monitoring program	1) Encourage continued regular sampling of Lees Pond. Take regular, annual DO and temperature profile readings, Secchi disk readings, and epilimnion and hypolimnion total phosphorus and epilimnion chlorophyll-a samples at the deep spot. Consider including pH, alkalinity, color, total dissolved nitrogen, and total dissolved organic carbon. Aim for biweekly Secchi disk readings and monthly DO and temperature profile readings combined with chemical sampling. Assumes a sampling season from June-September. Cost assumes volunteer labor.		✓		✓						✓	2017-36	$15,000

ACTION ITEM	DESCRIPTION	LWA	Lake Associations	Towns	Conservation Commissions	NH DOT	SOAK NH	Local Conservation Partners	Residents/Businesses/ Neighborhood	Consultant	University Partners	SCHEDULE	ESTIMATED COST
	2) Expand pond sampling to include other major waterbodies in the watershed, including Garland Pond, Shannon Pond, Berry Pond, Red Hill Pond, Little Pond, Dinsmore Pond, and Meadow Pond (in order of priority). This need only be done 1-3 times per year for epilimnion total phosphorus and chlorophyll-a. Cost assumes volunteer labor.		✓		✓						✓	2017-36	$21,000
	3) Sample major tributaries flowing directly to MBI, including Lees Pond outflow, Halfway Brook, Middle Brook, Shannon Brook, Tributary 2 to Basin 3, Basin 1 Tributary, and Basin 2 Tributary. Sample for total phosphorus at a minimum. Sampling should occur at least 3 times per year and cover both baseflow and stormflow conditions.		✓		✓						✓	2017-36	$11,000
	4) Add additional parameters to collect from the major tributaries flowing directly to MBI, including pH, E. coli, total dissolved nitrogen, chloride, and turbidity.		✓		✓						✓	2017-36	$50,000
	5) Add additional tributary sampling sites for the full tributary sampling program described above. Recommended sites are the outflows of Stanton Brook, Creamery Brook, Montgomery Brook, Cook Brook, Skinner Brook, Tributary 2 to Red Hill Brook, and Weed Brook.		✓		✓						✓	2017-36	$68,000
	6) Consider installing continuous data loggers measuring flow, DO, conductivity, and temperature at key tributary locations. These data would be useful in understanding water quality processes in the watershed. Coupled with water chemistry data, loading rates of nutrients may be calculated using the continuous flow data and used to update the		✓		✓					✓	✓	TBD	$70,000

ACTION ITEM	DESCRIPTION	LWA	Lake Associations	Towns	Conservation Commissions	NH DOT	SOAK NH	Local Conservation Partners	Residents/Businesses/ Neighborhood	Consultant	University Partners	SCHEDULE	ESTIMATED COST
	land use model. Cost assumes initial setup at 3 sites and 5 years of maintenance by consultant.												
Obtain more funding for water quality monitoring	1) Obtain funding from sources such as municipal contributions, NHDES grants, lake associations, targeted fundraising, and other grants related to climate change or invasive species studies.	✓	✓	✓	✓							2017-36	N/A
Maintain and/or improve current invasives management program	1) Continue to work with NHDES and the Town of Moultonborough Milfoil Committee to monitor and treat milfoil infestation areas.		✓	✓	✓				✓			2017-36	TBD
	2) Increase the number of volunteer inspectors for the Lake Host and Weed Watchers programs		✓	✓	✓				✓			2017-36	N/A
	3) Support State legislation that increases funds for aquatic invasive plant (e.g., milfoil) eradication.	✓	✓	✓	✓				✓			2017-36	N/A
Enhance awareness of water quality issues in the watershed	1) Contact local representatives and attend selectman meetings to voice concerns and stay informed.								✓			2017-36	N/A
	2) Create flyers/brochures for shorefront homes regarding BMPs and septic systems.	✓	✓		✓					✓		2017-20	$2,000
	3) Contribute interesting articles about water quality and watershed protection efforts to various media sources. Assumes volunteer labor.	✓	✓		✓							2017-36	N/A
	4) Work with SOAK Up the Rain NH to implement small scale BMPs and host concurrent residential stormwater workshops. Cost estimate does not include actual BMP implementation. Cost assumes printing, mailing to advertise events.	✓	✓		✓		✓					2017-36	$500/yr

5.3 INDICATORS TO MEASURE PROGRESS

Establishing indicators and numeric targets (benchmarks) to quantitatively measure the progress of this plan will provide both short-term and long-term input on how successful the plan has been in meeting the established goals and objectives for the watershed. Understanding where we will be following watershed improvements compared to where we should have been following no action will help guide adaptive changes to these benchmarks (e.g., goals are on track or goals are falling short). If the benchmarks are not being met due to lack of funding for implementation projects versus new development TP loading outpacing improvements to existing development TP loading, this creates much different conditions from which to adjust benchmarks. For each benchmark year, the committee should meet to update water quality data and the model and assess why goals are or are not being met. The committee will then decide on how to adjust the next benchmark goals to better reflect water quality conditions and practical limitations to implementation. It is also important to note that there are several larger ponds within the Basin 3 drainage that should set their own water quality goals and TP reduction goals to help improve water quality in MBI.

The following environmental, programmatic, and social indicators and associated benchmarks will help measure the progress of this plan. These benchmarks represent short-term (2021), mid-term (2026), and long-term (2036) targets for improving water quality in MBI. Setting benchmarks allows for periodic updates to the plan, maintains and sustains the action items, and makes the plan relevant to ongoing activities.

ENVIRONMENTAL INDICATORS are a direct measure of environmental conditions. They are measurable quantities used to evaluate the relationship between pollutant sources and environmental conditions. They assume that BMP recommendations outlined in the Action Plan will be implemented accordingly and will indirectly result in water quality improvements. Note that the benchmarks for environmental indicators can also reflect mitigation of anticipated water quality degradation as a result of new development.

Environmental Indicators

Indicators	Benchmarks		
	2021	2026	2036
Reduce median in-lake TP for Basins 1, 2, and 3	25% of goal	50% of goal	100% of goal
Reduce the duration and extent of low DO occurrence in the basins	5%	10%	50%
Improve and/or maintain water clarity in the basins	0.2 m	0.5 m	1.0 m
Reduce magnitude of peak flows during storm events using BMP/LID techniques	2%	5%	10%

PROGRAMMATIC INDICATORS are indirect measures of watershed protection and restoration activities. Rather than indicating that water quality reductions are being met, these programmatic measurements list actions intended to meet the water quality goal.

Programmatic Indicators

Indicators	Benchmarks		
	2021	2026	2036
Amount of funding secured for plan implementation (include contributions from fundraisers, donations, and grants)	$250,000	$500,000	$1,000,000
Amount of reduced phosphorus loading to Basin 1 (GOAL: 42% or 26 kg/yr)	9% (6 kg/yr)	25% (16 kg/yr)	42% (26 kg/yr)
Amount of reduced phosphorus loading to Basin 2 (GOAL: 31% or 27 kg/yr)	NA	15% (13 kg/yr)	31% (27 kg/yr)
Amount of reduced phosphorus loading to Basin 3 (GOAL: 20% or 242 kg/yr)	5% (61 kg/yr)	10% (121 kg/yr)	20% (242 kg/yr)
Number of water quality data re-evaluations and goal revisions	1	2	3
Number of years collecting water quality data for reformed lake monitoring program	5	10	20
Number of years collecting water quality data for reformed pond/tributary monitoring program	5	10	20
Number of high priority watershed sites remediated (20 identified)	5	10	20
Number of undersized or poorly-designed culverts replaced (6 identified)	2	4	6
Number of high priority MBI shoreline BMP projects completed (6 identified)	2	4	6
Number of medium priority MBI shoreline BMP projects completed (330 identified)	80	165	330
Number of new NPS and shoreline sites identified and remediated throughout the watershed	5	10	20
Number of shoreline BMP demonstration tours	2	5	10
Linear feet of buffers installed in the shoreland zone	1,000	5,000	10,000
Linear feet of roadway addressed by BMPs (~2,200 feet identified)	500	1,000	2,200
Number of voluntary septic system inspections and dye testing	10	25	100
Number of septic system upgrades	2	5	10
Number of "septic socials" held	2	5	10
Number of properties with septic systems surveyed for database within 250 ft around MBI	100	250	500
Number of properties enforced for occupancy loads	As Required	As Required	As Required
Number of properties inspected for proper septic system design during home conversions or property transfers	As Required	As Required	As Required
Number of parcels with conservation and/or drainage easements	2	5	10
Number of copies of watershed-based educational materials distributed	500	1,000	5,000
Number of active road associations	75	76	77
Number of workshops or trainings held or attended by watershed stakeholders (LID/BMP for Public Works, Gravel Roads, Green SnowPro, Septic Systems, Conservation Easements, Permitting, Ordinances, etc.)	10	20	30
Number of town ordinances updated or added to improve water quality	1	3	5
Percentage of shoreline area monitored and treated for milfoil infestation	50%	75%	100%

SOCIAL INDICATORS measure changes in social or cultural practices and behavior that lead to implementation of management measures and water quality improvement.

Social Indicators

Indicators	Benchmarks		
	2021	2026	2036
Number of new LWA, conservation commission, or other local association members	25	50	75
Number of people participating in group septic system pump-outs	5	10	20
Number of volunteers participating in surveys or educational campaigns	100	250	500
Number of people participating in workshops, trainings, or demonstrations	20	50	75
Number of easement holders present at closings	2	5	10
Number of new lake hosts (partner with conservation commission)	2	3	5
Number of newly-trained VLAP volunteers (partner with conservation commission)	2	3	5
Number of active weed watchers (partner with conservation commission)	65	70	75
Percentage of residents making voluntary upgrades or maintenance to their septic systems (with or without free technical assistance), particularly those identified as needing upgrades or maintenance	5%	10%	20%
Number of businesses participating in the "Friends of the Watershed" program	2	5	10

5.4 ESTIMATED COSTS AND TECHNICAL ASSISTANCE NEEDED

The cost of successfully implementing this watershed restoration plan for MBI is estimated at over $1,000,000 over the next twenty years (Table 5.2). **However, many costs are still unknown and should be incorporated into the Action Plan as information becomes available.** These costs will come from a variety of stakeholders, grants, or other funding sources identified in the Action Plan. This includes both structural BMPs, such as fixing eroding roads and planting shoreline buffers, and non-structural BMPs, such as improving ordinances. Annual BMP costs were estimated based on a ten-year total for the initial BMP installation plus ten years of maintenance (refer to Table 4.1).

Table 5.2: Estimated one-time or initial costs and 20-year total costs for watershed restoration.

Category	Estimated Costs	20-year Total
Watershed & Shorefront BMPs	$559,286	$613,536
Septic Systems*	$24,250	$27,500
Roads	$23,750	$23,750
Planning & Conservation	$22,500	$22,500
WQ Monitoring	$22,200	$406,000
Total Cost	**$651,986**	**$1,093,286**

**Septic system action items do not include design or replacement costs because these should be covered by private landowners. Action items cover assistance to secure grant funding for those individuals who cannot afford these costs.*

A diverse source of funding and a funding strategy will be needed to match these implementation activities. Funding to cover ordinance revisions and third-party review could be supported by municipalities through tax collection (as approved by majority vote by town residents). Monitoring and assessment funding could come from a variety of sources, including state and federal grants (Section 319, ARM, Moose Plate, etc.), municipalities, conservation commissions, LWA, and lake associations. Funding to improve septic systems, roads, and shoreland zone buffers could be expected from property owners. As the plan evolves into the future, the Advisory Committee will be a key part of how funds are raised, tracked, and spent to implement and support the plan.

5.5 EDUCATIONAL COMPONENT

Much effort is already being done by various groups (e.g., LWA, Moultonborough Conservation Commission, Milfoil Committee, etc.) in the watershed to enhance public understanding of the project and encourage community participation in watershed restoration and protection activities. LWA is the primary entity for education and outreach campaigns in the watershed and for development of this plan. LWA should continue all aspects of their education and outreach programs and consider developing new ones or improving existing ones to reach more watershed residents. Educational campaigns specific to the five Action Plan categories are detailed in their respective tables (Section 5.2).

5.6 EVALUATION PLAN

Annual Advisory Committee meetings should be organized to review the status of goals and objectives presented in this watershed restoration plan. It is recommended that an adaptive management approach be used to assess annual progress, determine key projects for the following year, and provide a venue for sharing information with watershed stakeholders. Adaptive management is the process by which new information about the health of the watershed is incorporated into the plan. This process allows stakeholders the opportunity to evaluate the effectiveness of restoration and monitoring activities before implementing future actions. Tasks listed in the Action Plan should be tracked and recorded as they occur, and new tasks should be added to the plan as determined through the adaptive management process. All achievements, such as press releases, outreach activities, number of sites repaired, number of volunteers, amount of funding received, number of sites documented, should be tracked. Stakeholders can then use the established indicators (Section 5.3) to determine the effectiveness of the plan.

5.7 CONCLUSION

Watershed residents, landowners, business owners, and recreationalists alike should have a vested interest in protecting the long-term water quality of MBI for future generations. With a goal of reducing in-lake phosphorus concentrations to acceptable oligotrophic thresholds in the three basins, implementation of the plan to achieve this over the next twenty years is projected to cost over $1,000,000, and will require the dedication and hard work of municipalities, conservation groups, and volunteers to ensure that the actions identified in this plan are carried out accordingly. The Action Plan will need to be updated as the plan is implemented and new action items are added, in accordance with the adaptive management approach detailed in Section 4.4. Please refer to the Executive Summary for a summary of the plan.

ADDITIONAL RESOURCES

A Shoreland Homeowner's Guide to Stormwater Management. New Hampshire Department of Environmental Services. NHDES-WD-10-8. Online: http://des.nh.gov/organization/commissioner/pip/publications/wd/documents/nhdes-wd-10-8.pdf

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

Conserving your land: options for NH landowners. Lind, B. 2005. Center for Land Conservation Assistance / Society for the Protection of N.H. Forests. Online: http://extension.unh.edu/resources/resource/1557/Conserving_Your_Land:_Options_for_NH_Landowners

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

Gravel roads: maintenance and design manual. U.S. Department of Transportation, Federal Highway Program. November 2000. South Dakota Local Transportation Assistance Program (SD LTAP). Online: http://www.gravelroadsacademy.com/media/filer_private/2012/02/14/sd_gravel_roads_brochure_1.pdf

Innovative land use techniques handbook. New Hampshire Department of Environmental Services. 2008. Online: https://www.nh.gov/oep/resource-library/planning/documents/innovative-land-use-planning-techniques-2008.pdf

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

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University of New Hampshire Stormwater Center 2012 Biannual Report. University of New Hampshire, Stormwater Center. 2012. Online: https://www.unh.edu/unhsc/sites/unh.edu.unhsc/files/docs/UNHSC.2012Report.10.10.12.pdf

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FB Environmental Associates (FBE). (2015). *Moultonborough Bay Inlet Watershed Nonpoint Source Survey Report*. See LWA for copy.

FB Environmental Associates (FBE). (2016a). *LLRM Update – Moultonborough Bay Inlet Watershed.* Technical Memorandum, May 10, 2016. See LWA for copy.

FB Environmental Associates (FBE). (2016b). *Moultonborough Bay Inlet Watershed Build-out Analysis.* Technical Memorandum, March 11, 2015 (Updated July 22, 2016). See LWA for copy.

FB Environmental Associates (FBE). (2016c). *2015 Moultonborough Bay Inlet and Two Ponds: Shoreline Survey Results.* Shoreline Survey Memorandum, March 7, 2016 (Updated July 22, 2016). See LWA for copy.

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