TECHNICAL MEMORANDUM | MILL POND

TO: Fred Quimby, Cyanobacteria Mitigation Steering Committee (CMSC)
FROM: Laura Diemer, FB Environmental Associates (FBE)
SUBJECT: Merrymeeting River & Lake WMP Implementation – Mill Pond LLRM Update
DATE: August 27, 2020
CC: Forrest Bell, FB Environmental Associates (FBE)

INTRODUCTION

Per the request of the Cyanobacteria Mitigation Steering Committee (CMSC), FB Environmental Associates (FBE) used the Lake Loading Response Model (LLRM) to quantify the major external and internal sources of phosphorus to Mill Pond, as an update to the larger LLRM created for the Merrymeeting River within which Mill Pond was treated as a sub-basin. FBE obtained water quality data from the CMSC and the NHDES Environmental Monitoring Database (EMD), as well as updated pond bathymetry completed by NHDES in 2019. FBE also used updated stormwater drainage areas mapped by Horsley Witten Group (HWG) as sub-basins to Mill Pond. The following brief memorandum describes the methods and results of the modeling effort for Mill Pond and includes recommendations for possible management measures to improve water quality in Mill Pond.

The LLRM is an Excel-based model that uses environmental data to develop a water and phosphorus loading budget for lakes/ponds and their tributaries[1]. Water and phosphorus loads (in the form of mass and concentration) are traced from various sources in the watershed, through tributary and lake/pond sub-basins, to the waterbody of interest. The model incorporates data about watershed and sub-basin boundaries, land cover, point sources, septic systems, waterfowl, rainfall, volume and surface area, and internal phosphorus loading. These data are combined with coefficients, attenuation factors, and equations from scientific literature on lakes, rivers, and nutrient cycles. The following describes the process by which critical inputs were determined and incorporated to the model using available resources and GIS modeling, and presents annual average predictions[2] of total phosphorus, chlorophyll-a, Secchi disk transparency, and algae bloom probability. The model can be used to identify pollutant sources, estimate pollutant limits and water quality goals, and guide watershed improvement projects.

DRAINAGE AREAS

Watershed and tributary drainage basin (sub-basin) boundaries are needed to determine both the amount of water flowing into a surface waterbody and the area of different land cover types contributing to nutrient loading. HWG completed field verification of the total drainage area to Mill Pond. Refer to the 2020 Mill Pond Outfall Assessment Memorandum from HWG. The field verified watershed area for Mill Pond is 64 acres smaller at 99.7 acres compared to the original estimated watershed area of 163.7 acres (Fig. 1). The watershed was divided into eight sub-basins for six outfall drainages, direct overland flow around the shoreline, and a managed drainage area where water is infiltrated directly to the ground and does not connect to Mill Pond from the surface (Fig. 1).

LAND COVER UPDATE

Land cover determines the movement of water and phosphorus from the watershed to surface waterbodies via surface runoff and baseflow (groundwater). FBE reviewed and refined the land cover data for the Mill Pond watershed, beginning with the updated land cover data created for the Merrymeeting River watershed. Refer to the 2019 Merrymeeting River & Lake LLRM Report for more details on how the updated land cover data file was created. ESRI World Imagery dated 10/17/2018 and Google Earth satellite images dated 5/4/2018 were reviewed. If discrepancies between the aerials and the updated land cover file were found, changes were made in ArcGIS.

Within the LLRM, export coefficients are assigned to each land cover to represent typical concentrations of phosphorus in runoff and baseflow from each land cover type (Attachment 1). Unmanaged forested land, for example, tends to deliver very little phosphorus downstream when it rains, while row crops and low to high density urban development export significantly more phosphorus due

[1] AECOM (2009). LLRM Lake Loading Response Model Users Guide and Quality Assurance Project Plan. AECOM, Willington, CT.
[2] The model cannot simulate short-term weather or loading events.

Figure 1. [LEFT] Comparison of the original and field verified watershed areas for Mill Pond. [RIGHT] Field verified sub-basins to Mill Pond.

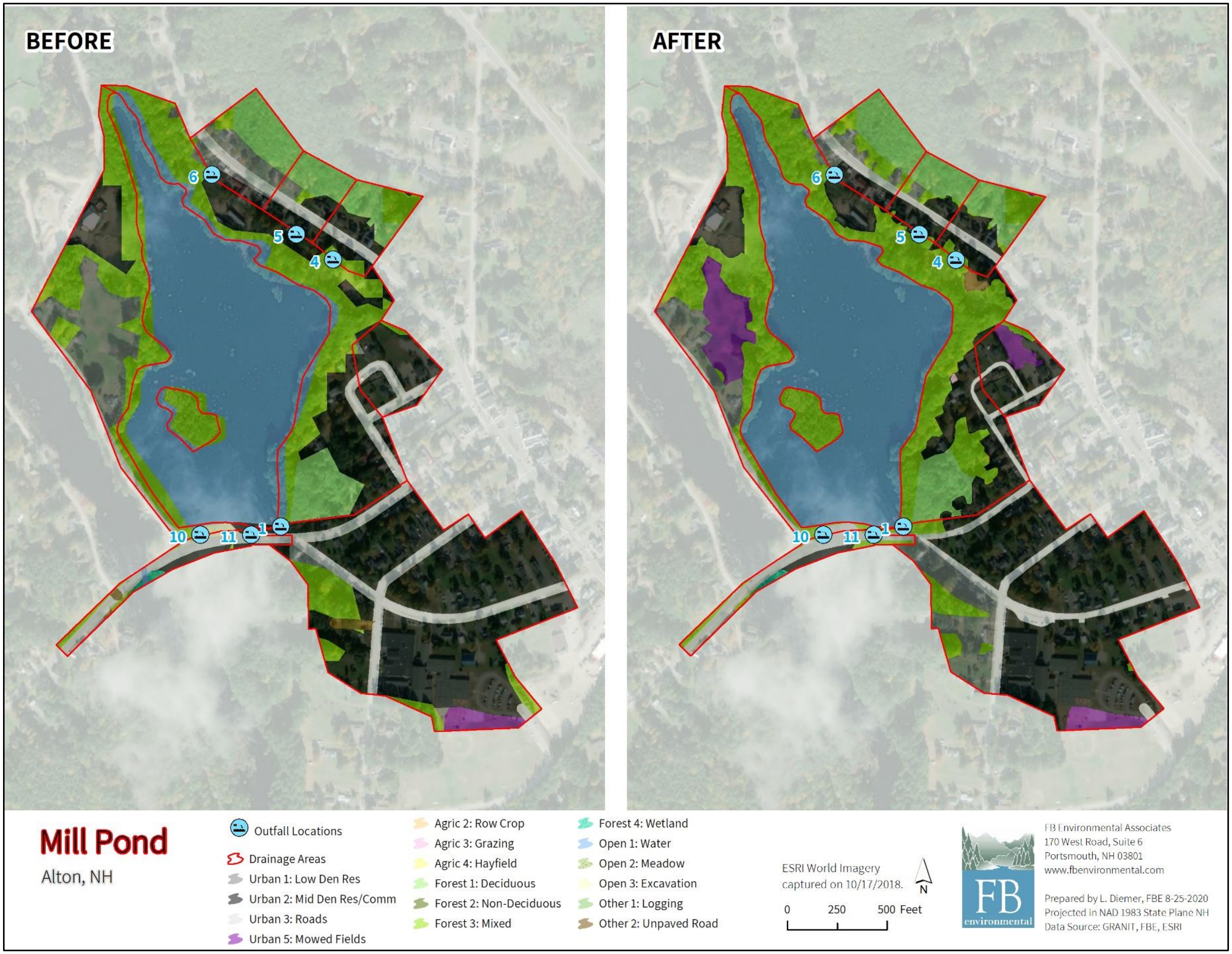

Figure 2. Comparison of land cover before [LEFT] and after [RIGHT] a more refined review by FBE.

to fertilizer use, soil erosion, car and factory exhaust, pet waste, and many other sources. Smaller amounts of phosphorus are also exported to lakes and streams via groundwater under baseflow conditions. This nutrient load is delivered with groundwater directly to the lake/pond or indirectly to tributary streams; however, much of the phosphorus is adsorbed onto soil particles as water infiltrates to the ground. Attachment 1 presents the runoff and baseflow phosphorus export coefficients for each land cover type used in the model, along with the total land cover area by land cover type and sub-basin. These coefficients were based on values from Tarpey (2013), East Pond TMDL Report (2001), Hutchinson Environmental Sciences Ltd (2014), and Schloss and Connor (2000), among others. High phosphorus export areas in the watershed are highlighted in Fig. 3 and represent concentrations or clusters of dense development. Fig. 4 shows a breakdown of land cover by major category for the watershed (not including the surface area of Mill Pond), as well as the total phosphorus load by major land cover category. Developed areas cover 64% of the watershed and contribute 97% of the total phosphorus watershed load (land cover-derived only) to Mill Pond.

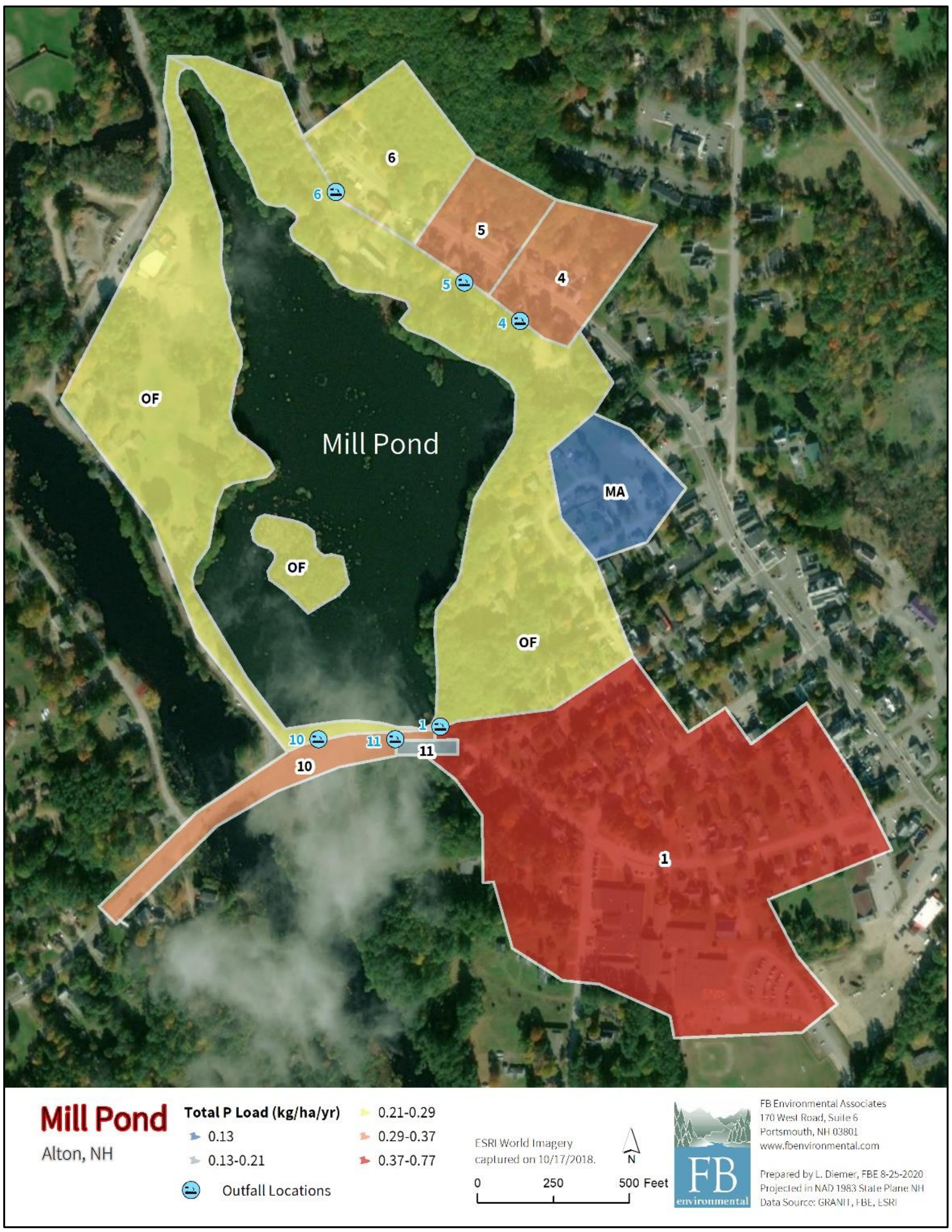

Figure 3. Total phosphorus (TP) watershed load per unit area (kg/ha/yr) for the eight sub-basins.

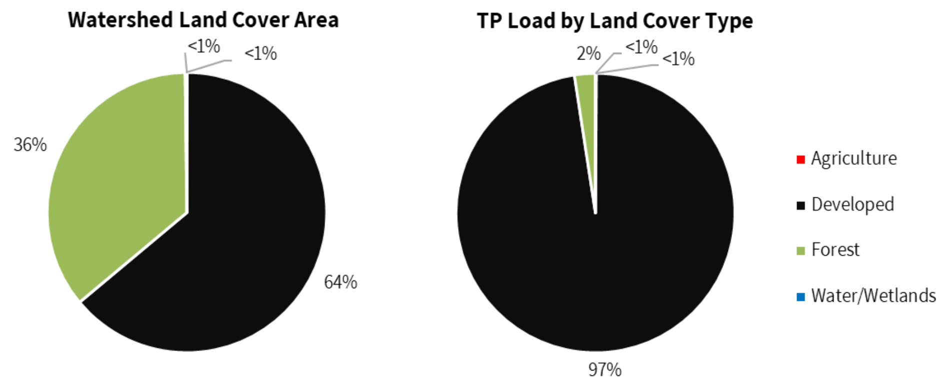

Figure 4. Watershed land cover area by general category (agriculture, developed, forest, and water/wetlands, not including the surface area of the pond) and total phosphorus (TP) watershed load by general land cover category. This shows that developed areas cover 64% of the watershed and contribute 97% of the TP watershed load to Mill Pond.

OTHER MAJOR LLRM INPUTS

The following presents a brief outline of other variable sources and assumptions input to the model. Refer to Limitations to the Model for further discussion.

Monthly precipitation data were obtained from NOAA NCEI for the Laconia, NH weather station (Station ID: US1NHBK0007). The average annual precipitation for 2019 was input to the model (53.2 in or 1.35 m). Data for the deep spot of Mill Pond were only available for 2019 and 2020 and thus the model was calibrated to those data, using 2019 precipitation since 2020 was not yet complete at the writing of this report.

Pond volume and area estimates were obtained from the NHDES bathymetry shapefile. NHDES completed a bathymetric survey of Mill Pond in 2019.

Data for septic systems within 250 feet of Mill Pond were obtained from state and local records compiled by the Town of Alton and the CMSC. Data included information on the age, distance to surface water, and use (seasonal or year-round and occupancy) of septic systems, if present. There were no seasonally used septic systems.

Waterfowl counts were based on bird census data collected by volunteers through eBird (online) and the CMSC, who made observations four times from 8/23/18 to 11/14/18 at Mill Pond. Volunteers logged large bird sightings, including ducks, herons, geese, and cormorants. Best professional judgement was used when interpreting the counts and inputting a value to the model. We assumed 10 birds regularly occupy Mill Pond for 8 months per year. Waterfowl can be a direct source of nutrients to lakes/ponds; however, if they are eating from the lake/pond and their waste returns to the lake/pond, the net change may be less than might otherwise be assumed; even so, the phosphorus excreted may be in a form that can be readily used by algae and plants.

Water quality data were obtained from the NHDES EMD and the CMSC. Recent total phosphorus, chlorophyll-a, and Secchi Disk Transparency data from 2019-2020 were summarized by day, then month, then year for Mill Pond. Recent outfall discharge data (2018-2019) were summarized by day, then month, then year, if applicable, to obtain median annual water quality summaries for total phosphorus. These data were used as general guidelines for setting attenuation factors and confirming overall model calibration. For waterbodies without large point source or internal phosphorus loads, average summer total phosphorus concentrations in the epilimnion are generally (14-40%, median 20%) lower than average annual concentrations (Nurnberg, 1996; Nurnberg, 1998) because low baseflow periods in summer restrict phosphorus mobilization from the landscape to surface waters. In the case of Mill Pond, we used 30.7 ppb (20% higher than the observed median of 25.6 ppb for summer total phosphorus concentration in the epilimnion) to calibrate the model.

Internal loading estimates can be derived from dissolved oxygen and temperature profiles (to determine average annual duration and depth of anoxia defined as <1 ppm dissolved oxygen) and epilimnion/hypolimnion total phosphorus data (to determine average difference between surface and bottom phosphorus concentrations) collected at the deep spot of Mill Pond. These estimates, along with anoxic volume and surface area, can help determine rate of release and mass of internal phosphorus loading per year.

There was minimal evidence of significant internal loading or an extended anoxic period in Mill Pond. Only a single bottom grab sample for total phosphorus was available to compare to a composite sample. The results showed no difference between surface and bottom phosphorus concentrations; however, the sample was collected early in the growing season on 5/27/2019. Additional sampling should be conducted in August and September to characterize the possible prevalence of internal loading more accurately in Mill Pond. Dissolved oxygen profiles showed good oxygenation throughout the water column.

We assumed that some amount of internal loading is likely occurring at Mill Pond. Additional investigation will be needed to quantify internal loading at Mill Pond. We used the background rate of release at 0.5 mg/m^2/day over 60 days for the portion of Mill Pond greater than 6 ft deep to estimate a modest internal load. These assumptions and resulting values should be viewed as placeholders until more data can be collected.

CALIBRATION

Calibration is the process by which model results are brought into agreement with observed data and is an essential part of environmental modeling. Usually, calibration focuses on the input data with the greatest uncertainty. Changes are made within a plausible range of values, and an effort is made to find a realistic explanation among environmental conditions for these changes. In-pond and outfall discharge phosphorus concentrations were used as guideposts, but attenuation values were generally defaulted to reflect little attenuation because of the watershed's small area and short pathways to the pond (Table 1). Observed in-pond phosphorus concentrations were given primacy during the calibration process, such that the ability of the model to accurately simulate annual average in-pond phosphorus concentrations was used as a leading indicator of acceptable model performance. Continued water quality sampling (to include all seasons) in the watershed can be designed to reduce the uncertainty encountered in modeling and help assess changes made during calibration.

The following key calibration input parameter values and modeling assumptions were made:

- The **standard water yield** coefficient was input as 2.1 cubic ft/sq. m, which is the high end of the range for New England but reflects the watershed's high runoff potential. Much of the surface runoff to Mill Pond is diverted artificially through stormwater networks.
- **Direct atmospheric deposition** phosphorus export coefficient was assumed to be 0.11 kg/ha/yr from Schloss et al. (2013) and represents a largely undeveloped watershed.
- Default **water and phosphorus attenuation factors** were used, with exceptions noted in Table 1. Water can be lost through evapotranspiration, deep groundwater, and wetlands, while phosphorus can be removed by infiltration or uptake processes. We generally expect at least a 5% loss (95% passed through, default) in water and a 10% loss (90% passed through, default) in phosphorus for each sub-basin. Larger water losses (<95% passed through) can be expected with lower gradient or wetland-dominated sub-basins. Additional infiltration, filtration, detention, and uptake of phosphorus will lower the phosphorus attenuation value, such as for sub-basins dominated by moderate/small ponds or wetlands (75%-85% passed through) or channel processes that favor uptake (85% passed through), depending on the grade. Outfalls with significant impervious cover were given water and phosphorus attenuation values of 1.00 because there is minimal capacity for uptake due to the stormwater conveyance through pipes and short pathway to Mill Pond.
- The average of multiple **empirical formulas** for predicting annual in-pond phosphorus concentration excluded the Vollenweider (1975) empirical formula because the formula was predicting phosphorus concentrations that were higher than observed data or the other formulas.

Table 1. Reasoning for water and phosphorus (P) attenuation factors used by sub-basin (not including default values).

Model-Sub-Basin	Water Atten. Factor	Phos. Atten. Factor	Reasoning
Outfall #1	1.00	1.00	Drainage area with significant impervious cover, a stormwater conveyance system, and a short distance to the pond
Outfall #4	0.95	0.90	Default attenuation values with a small amount of water and P loss
Outfall #5	0.95	0.90	Default attenuation values with a small amount of water and P loss
Outfall #6	0.95	0.90	Default attenuation values with a small amount of water and P loss
Outfall #10	1.00	1.00	Drainage area with significant impervious cover, a stormwater conveyance system, and a short distance to the pond

Model-Sub-Basin	Water Atten. Factor	Phos. Atten. Factor	Reasoning
Outfall #11	1.00	1.00	Drainage area with significant impervious cover, a stormwater conveyance system, and a short distance to the pond
MA = Managed Drainage Area	0.14	0.18	Based on removal efficiencies for a retention pond (UNHSC 2009 Biennial Report)
OF = Overland Flow	0.95	0.90	Default attenuation values with a small amount of water and P loss

LIMITATIONS TO THE MODEL

There were several limitations to the model; literature values and best professional judgement were used in place of measured data, wherever appropriate. Acknowledging and understanding model limitations is critical to interpreting model results and applying any derived conclusions to management decisions. The model should be viewed as one of many tools available for pond management. Because the LLRM incorporates specific waterbody information and is flexible in applying new data inputs, it is a powerful tool that predicts annual average in-pond total phosphorus concentrations with a high degree of confidence; however, model confidence can be increased with more data. The following lists specific limitations to the model:

- **<u>The model represents a static snapshot in time based on the best information available at the time of model execution.</u>** Factors that influence water quality are dynamic and constantly evolving; thus, the model should be regularly updated when significant changes occur within the watershed and as new water quality and physical data are collected. In this respect, the model should only be considered up-to-date on the date of its release. Model results represent annual averages best used for planning level purposes and should only be used (such as to set regulatory limits) with full recognition of the model limitations and assumptions.
- **<u>Water quality data were limited to recent years (2018-2020) and the growing season (May-August)</u>** for the Mill Pond deep spot and outfall discharges. The model generates an average annual prediction of water quality that accounts for interannual variation in water quality over many years; 1-2 years with only 1-2 samples may not represent long-term system dynamics in Mill Pond. Because of the limitations to data availability, observed data were used as general guidelines for setting attenuation factors and performing overall model calibration. Collecting samples under a variety of flow conditions (and measuring flow) in all seasons and across several years can help reduce model uncertainty and help inform assumptions on export coefficients and attenuation factors used.
- **<u>Internal loading estimates were based on limited data.</u>** Phosphorus that enters the pond and settles to the bottom can be re-released from sediment under anoxic conditions, providing a nutrient source for algae and other plants. Internal phosphorus loading can also result from wind-driven wave action, physical disturbance of the sediment (boat props, aquatic macrophyte management activities), or anoxic sediment release under oxic conditions if anoxic sediment releases phosphorus to overlying oxygenated water via water flow along the sediment surface. It was unclear whether and to what extent internal loading was occurring under anoxic or oxic conditions at any time in Mill Pond. More investigation is warranted to quantify internal loading in Mill Pond.
- **<u>Land cover export coefficients were estimates.</u>** Literature values and best professional judgement were used in evaluating and selecting appropriate land cover export coefficients for the watershed. While these coefficients may be accurate on a larger scale, they are likely not representative on a site-by-site basis. Refer to documentation within the LLRM spreadsheet for specific citations.
- **<u>Septic system loading was estimated based on record surveys and default literature values.</u>** We assumed that the number of bedrooms represented the number of people using the septic system; some commercial businesses may be underestimated depending on the presence and use of public restrooms. Default literature values for daily water usage per person, phosphorus concentration output per person, and system phosphorus attenuation factors were used and may not reflect local watershed conditions. The true functioning of individual septic systems in the watershed is unknown.
- **<u>Waterfowl counts were based on limited data.</u>** Continued collection of bird counts would help improve the model loading estimates, which were largely limited to only one season of data in 2018.

RESULTS

CURRENT LOAD ESTIMATION

Overall, model predictions were in good agreement with observed data and were within 3% (relative percent difference) of observed median annual total phosphorus and 6% of observed mean annual Secchi disk transparency (Table 2). Differences in predicted and observed values for chlorophyll-a were more variable. It is important to note that the LLRM does not explicitly account for all the biogeochemical processes occurring within a waterbody that contribute to overall water quality and is less accurate at predicting chlorophyll-a. For example, chlorophyll-a is estimated strictly from nutrient loading, but other factors strongly affect algae growth, including low light from suspended sediment, grazing by zooplankton, presence of heterotrophic algae, and flushing effects from high flows. There were insufficient data available to evaluate the influence of these other factors on observed chlorophyll-a concentrations.

Watershed runoff and baseflow (55%) were the largest loading contribution across all sources, followed by septic systems (34%), waterfowl (5%), atmospheric deposition (5%), and internal loading (<1%) (Table 3; Fig. 5). Development in the watershed is densely clustered with high amounts of impervious cover located a short distance to Mill Pond. Septic systems or holding tanks are mostly located within a short distance to the water, leaving little horizontal (and sometimes vertical) space for proper filtration of wastewater effluent. Improper maintenance or siting of these systems can cause failures, which leach untreated, nutrient-rich wastewater effluent to surface waters.

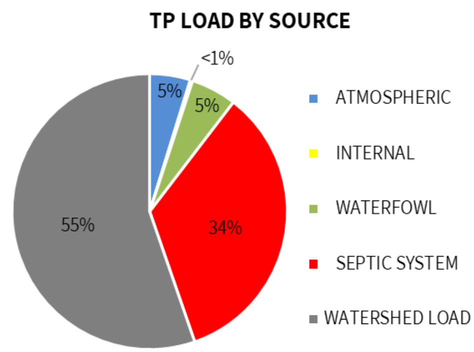

Figure 5. Total phosphorus (TP) load (kg/yr) by source (atmospheric, internal loading, waterfowl, septic systems, watershed load) for Mill Pond.

The sub-basins for Outfall #1 and the direct shoreline or overland flow (OF) area to Mill Pond had the highest watershed phosphorus load export by total mass (Table 4). Drainage from areas directly adjacent to waterbodies or with extensive stormwater conveyance systems do not have adequate treatment time or area, thus increasing the possibility for phosphorus export. Normalizing for the size of a sub-basin (i.e., accounting for its annual discharge and direct drainage area) better highlights sub-basins with elevated pollutant exports relative to their drainage area. The sub-basin for Outfall #1 had the highest watershed phosphorus mass exported by area because of concentrated mid-to-high density development within its relatively small drainage area (Table 4, Fig. 3). Sub-basins with moderate-to-high phosphorus mass exported by area included Outfalls #4, 5, and 10.

PRE-DEVELOPMENT LOAD ESTIMATION

Once the model is calibrated for current in-pond phosphorus concentration, we can then manipulate land cover and other factor loadings to estimate pre-development loading scenarios (e.g., what in-pond phosphorus concentration was prior to human development or the best possible water quality for the pond). Refer to Attachment 2 for details on methodology.

Pre-development loading estimation showed that total phosphorus loading increased by 730%, from 3.0 kg/yr prior to European settlement to 24.9 kg/yr under current conditions, for Mill Pond (Table 3). These additional phosphorus sources are coming from development in the watershed, septic systems, atmospheric dust, and internal loading (Table 3). Water quality prior to settlement was likely excellent with extremely low phosphorus and chlorophyll-a concentrations and high water clarity (Table 2).

Table 2. Model predictions for Mill Pond. TP = total phosphorus. Chl-a = chlorophyll-a. SDT = Secchi disk transparency.

Model	Annual TP (ppb)*	Predicted Annual TP (ppb)	Observed Mean Chl-a (ppb)	Predicted Mean Chl-a (ppb)	Observed Mean SDT (m)	Predicted Mean SDT (m)
Current (2019)	25.6 (30.7)	31.6	9.8	13.2	1.7	1.6
Pre-Dev	--	3.8	--	0.8	--	HIT BOTTOM

**Observed annual TP of 25.6 ppb and 30.7 ppb for Mill Pond represents median in-pond epilimnion TP and 20% adjusted increase from median in-pond epilimnion TP, respectively. Most pond data are collected in summer when TP concentrations are typically lower than annual average concentrations for which the model predicts.*

Table 3. Total phosphorus (TP) and water loading summary by source for Mill Pond.

SOURCE LOAD	PRE-DEV			CURRENT (2019)		
	P (kg/yr)	%	Water (m^3/yr)	P (kg/yr)	%	Water (m^3/yr)
ATMOSPHERIC	0.8	25%	90,489	1.2	5%	90,489
INTERNAL	0.0	0%	0	0.1	<1%	0
WATERFOWL	1.3	44%	0	1.3	5%	0
SEPTIC SYSTEM	0.0	0%	0	8.5	34%	10,585
WATERSHED LOAD	0.9	31%	226,676	13.8	55%	218,936
TOTAL LOAD TO POND	**3.0**	**100%**	**317,164**	**24.9**	**100%**	**320,010**

Table 4. Summary of land area, water flow, and total phosphorus (TP) loading by sub-basin for Mill Pond. Note: the measured TP concentrations for the outfalls were based on 1-2 samples in 2018-2019 and were not used for calibration.

Sub-Basin	Current (2019) Watershed Load					
	Land Area (ha)	Water Flow (m^3/yr)	Calculated TP Concentration (mg/L)	Measured TP Concentration (mg/L)	TP mass (kg/yr)	TP mass by area (kg/ha/yr)
Outfall #1	10.7	81,925	0.101	0.019	8.3	0.77
Outfall #4	1.3	9,967	0.044	0.288	0.4	0.33
Outfall #5	1.0	7,781	0.049	0.100	0.4	0.37
Outfall #6	1.7	13,184	0.037	0.291	0.5	0.28
Outfall #10	1.1	9,086	0.041	0.073	0.4	0.34
Outfall #11	0.1	878	0.024		0.0	0.21
MA = Managed Drainage Area	1.3	1,405	0.124		0.2	0.13
OF = Overland Flow	12.6	96,115	0.040		3.8	0.30

CONCLUSION & RECOMMENDATIONS

Based on model analysis of current and historic water quality conditions, Mill Pond has severely degraded water quality as a result of its highly developed watershed. NHDES has placed Mill Pond on the 303(d) list of impaired surface waters as impaired for aquatic life use due to elevated levels of cyanobacteria microcystins.

Mill Pond was created in the late 1800's when Mill Road (currently known as Letter S Road) was extended south to connect the Wentworth Mills, which included a grist mill, saw mill, and box shop at the dam to Wentworth Pond, to the present Route 140 (Griffin, 1965). The water quality of Mill Pond has since suffered from both legacy and current sources of pollution. A landfill along the banks of Mill Pond was in operation from the early 1900's to about 1950. Following 2018 rain events, CMSC observed seepage from the banks of Mill Pond at the capped landfill, indicating a possible break in the lining. A commercial laundromat along Route 11 experienced a complete septic system failure that resulted in raw sewage discharge to Mill Pond for nearly a year in 1979 before it was identified and shut down. About 50 years ago, a large sawdust pile remnant from the sawmill at the former Wentworth Mills was bulldozed into Mill Pond. About 25 years ago, the stormwater system for Route 11 was reconfigured to direct untreated stormwater runoff to Mill Pond. Because of these current and legacy issues, Mill Pond has been prioritized for monitoring of phosphorus and cyanobacteria, as well as pollutant source investigations of potential nonpoint source pollution issues.

The following provides our recommendations for continued investigation and remediation of Mill Pond:

- **Quantify the prevalence of internal loading in Mill Pond.** *Note: Based on the limited data available for estimating the contribution of internal loading to Mill Pond, we suspect that Mill Pond would not be a good candidate for an in-pond treatment option. Most of the nutrient load is likely sourced from the watershed.*
    - ➢ Conduct at least three sampling events at the deep spot of Mill Pond in August-September to include dissolved oxygen and temperature profile and Secchi disk transparency readings, hypolimnion (or bottom) grab samples for total phosphorus, and epilimnion composite samples for total phosphorus and chlorophyll-a.

- ➢ Collect a sediment core sample (aggregate of at least three samples collected around the deep spot) and analyze at least two depths (within 2 inches and 10 or more inches deep) for phosphorus, aluminum, and iron. The ratios of these elements will help determine Mill Pond's vulnerability to internal loading and how that vulnerability has changed over time. Consider expanding the analysis to include a more robust and historic analysis for sediment particle size, organic matter content, and phytoplankton communities.

- **Inspect the condition of the capped landfill located along the banks of Mill Pond.** Determine the type and amount of buried materials and how it was capped. Devise and conduct a monitoring strategy using surface and groundwater samples to determine the extent of possible seepage coming from the landfill.
- **Design and install stormwater improvements to the conveyance network in the drainage areas to Outfalls #1, 4, 5, and 10.** These four outfalls were identified as contributing the most phosphorus on a per area basis, with Outfall #1 being the highest priority for follow-up assessments and design work.
  - ➢ Hire stormwater engineers to design and install stormwater improvements to the identified drainage areas.
  - ➢ Design and conduct an outfall monitoring strategy that will help assess and track water quality improvements before and after implementation work.

ATTACHMENT 1: Land Cover by Sub-Basin

Land cover phosphorus (P) export coefficients and land cover areas for sub-basins in the Mill Pond watershed. Summed areas of sub-basins equal total watershed area minus the surface area of Mill Pond.

Land Cover	Runoff P export coefficient used	Baseflow P export coefficient used	Area (hectares)							
			1	4	5	6	10	11	MA	OF
Urban 1 (Low Den Res)	0.79	0.010	1.2		0.0	0.3	0.0			0.8
Urban 2 (Mid Den Res/Comm)	0.90	0.010	7.3	0.5	0.4	0.3	0.1		0.8	2.6
Urban 3 (Roads)	0.30	0.010	1.4	0.1	0.1	0.2	0.7	0.1	0.2	0.5
Urban 5 (Mowed Fields)	0.60	0.010	0.3	0.0					0.2	0.9
Agric 3 (Grazing)	1.50	0.010								0.0
Forest 1 (Deciduous)	0.03	0.004		0.4	0.4	0.7				0.7
Forest 3 (Mixed)	0.03	0.004	0.5	0.3	0.1	0.3	0.2	0.0	0.0	7.0
Forest 4 (Wetland)	0.03	0.004					0.1			
Open 1 (Water)	0.01	0.004								0.0
Other 2 (Unpaved Road)	0.83	0.010	0.0	0.0			0.0			0.1
		TOTAL	**10.7**	**1.3**	**1.0**	**1.7**	**1.1**	**0.1**	**1.3**	**12.6**

ATTACHMENT 2: Estimating Pre-Development Phosphorus Load

1. Converted all human land cover to mixed forest (Forest 3) and updated model.
2. Removed all septic inputs (set population to zero).
3. Removed internal loading, assuming internal loading was the result of excess nutrient loading from human activities in the watershed.
4. Reduced atmospheric loading coefficient to 0.07 kg/ha/yr.
5. Roughly matched outflow TP to predicted in-pond TP.
6. Kept all else the same, assuming waterfowl counts and precipitation input did not change (though they likely did).