Lake Auburn Watershed Protection Commission

www.lakeauburnwater.org

Wednesday, March 13, 2024 at **3:00pm – 4:30pm** AVCOG, 125 Manley Road, Auburn, Maine

SPECIAL MEETING AGENDA

1. Presentation by Ken Wagner of Water Resource Services and Jennifer Jespersen of Ecological Instincts on the phosphorus reduction analysis of Lake Auburn

2. Public Comment

3. Adjournment

FUTURE REGULAR MEETING SCHEDULE:

April 10
June 12
September 11
November 13
December 4 (as needed)

Water Resource Services Inc.
144 Crane Hill Road
Wilbraham, MA 01095
kjwagner@charter.net
413-219-8071

January 12, 2024

To: Ms. Erica Kidd
Lake Auburn Watershed Protection Commission
Via email at ekidd@awsd.org

From: Ken Wagner, WRS, Inc.

Re: Evaluation of improvement potential for Lake Auburn

Dear Ms. Kidd and interested parties from the LAWPC:

WRS, Inc. with its partner Ecological Instincts, has completed a review of the potential to reduce phosphorus (P) loading to Lake Auburn and minimize the potential for harmful algal blooms. The actual field assessment and resulting estimation of loading reductions conducted by Ecological Instincts is described in an accompanying memorandum attached as an addendum. For purposes of assessing overall impact of non-point source (NPS) load reductions and other possible management actions (including dredging the Basin, installing a P inactivation dosing station, or treating the lake with aluminum a second time), we used the Lake Loading Response Model (LLRM). I will concisely describe its use here but have prepared a much larger document on how to apply this model in the past and can supply that to anyone with a more technical interest.

With the model set up and calibrated to pre-2019 conditions (before the lake aluminum treatment, using data from 2014-2018), LLRM was used it to predict the outcome of the aluminum treatment and compare that to actual data from 2020-2023. The result was accurate, suggesting the model was verified for use in testing further scenarios for managing P inputs to Lake Auburn. The results of those scenarios are expressed as a steady state average P concentration in the lake and the probability of observing chlorophyll-a (a common algal pigment indicative of algal biomass) in excess of 4, 6 or 8 ug/L. Results can be compared with each other and both the theoretical best possible condition attainable with current land use or the expected original condition of the lake without any human uses in the watershed. This analysis sheds light on what actions would be most effective for improving and protecting Lake Auburn.

LLRM Set Up

LLRM is a spreadsheet model with cells linked to provide calculations of contaminant load generation, attenuation on the way to a lake, and final concentration in the lake based on water and contaminant loading using a series of empirical models. It is a fairly simple model, requiring less data to use effectively, but it works best when water quality data are sufficient to test assumptions and adjust coefficients properly. LLRM is applied here to evaluate water and P loading to Lake Auburn.

The watershed of Lake Auburn was divided into 10 drainage areas, each with a land use breakdown and total area (Table 1, Figure 1).

Table 1. Drainage basins and land use in the Lake Auburn watershed

	1-Mud Pond	2-L Wilson Pond	3-The Basin	4-Townsend Bk	5-Rt 4	6-WAR-YC-GL	7-Spring Rd	8-N Auburn	9-Lake Shore Drive (W)	10-Lake Shore Drive (E)	TOTAL
LAND USE	AREA (HA)	AREA (HA)	AREA (HA)	AREA (HA)	AREA (HA)	AREA (HA)	AREA (HA)	AREA (HA)	AREA (HA)	AREA (HA)	AREA (HA)
Low-Density Mixed Urban	15.8	13.2	17.9	20.5	13.2	10.6	18.9	5.5	3.3	4.7	123.6
Medium-Density Mixed Urban	0.0	0.0	0.0	4.3	1.2	0.0	0.0	0.0	0.0	0.9	6.3
High-Density Mixed Urban	0.0	0.0	0.0	0.0	2.2	1.9	0.0	0.0	0.0	0.0	4.1
Low-Density Residential	30.7	37.6	21.8	17.0	10.2	12.1	28.1	10.3	2.3	14.5	184.5
Medium-Density Residential	0.0	0.0	0.0	3.6	1.5	0.0	0.0	0.0	0.0	0.0	5.1
High-Density Residential	0.0	0.0	0.0	0.0	3.1	0.0	0.0	0.0	0.0	0.0	3.1
Hay/Pasture	76.1	6.7	39.7	20.3	2.8	34.1	11.7	1.9	0.0	3.5	196.9
Cropland	16.1	0.0	2.0	7.0	0.2	12.7	4.8	0.0	0.0	1.1	44.0
Forest	689.1	320.5	506.4	435.5	86.0	207.9	221.6	121.1	91.2	130.9	2810.1
Water	44.5	52.9	49.6	14.2	4.4	10.8	0.2	4.0	1.8	2.2	184.7
Disturbed	2.2	0.5	2.5	24.7	0.0	3.1	0.0	0.0	0.0	0.0	33.0
Turf/Golf	0.0	0.0	0.0	14.7	0.0	0.9	0.0	0.0	0.0	0.0	15.6
Open Land	28.6	10.9	34.6	32.3	13.2	20.6	37.2	10.1	2.2	22.7	212.4
TOTAL	903.1	442.3	674.5	594.1	138.0	314.6	322.5	152.9	100.7	180.6	3823.3

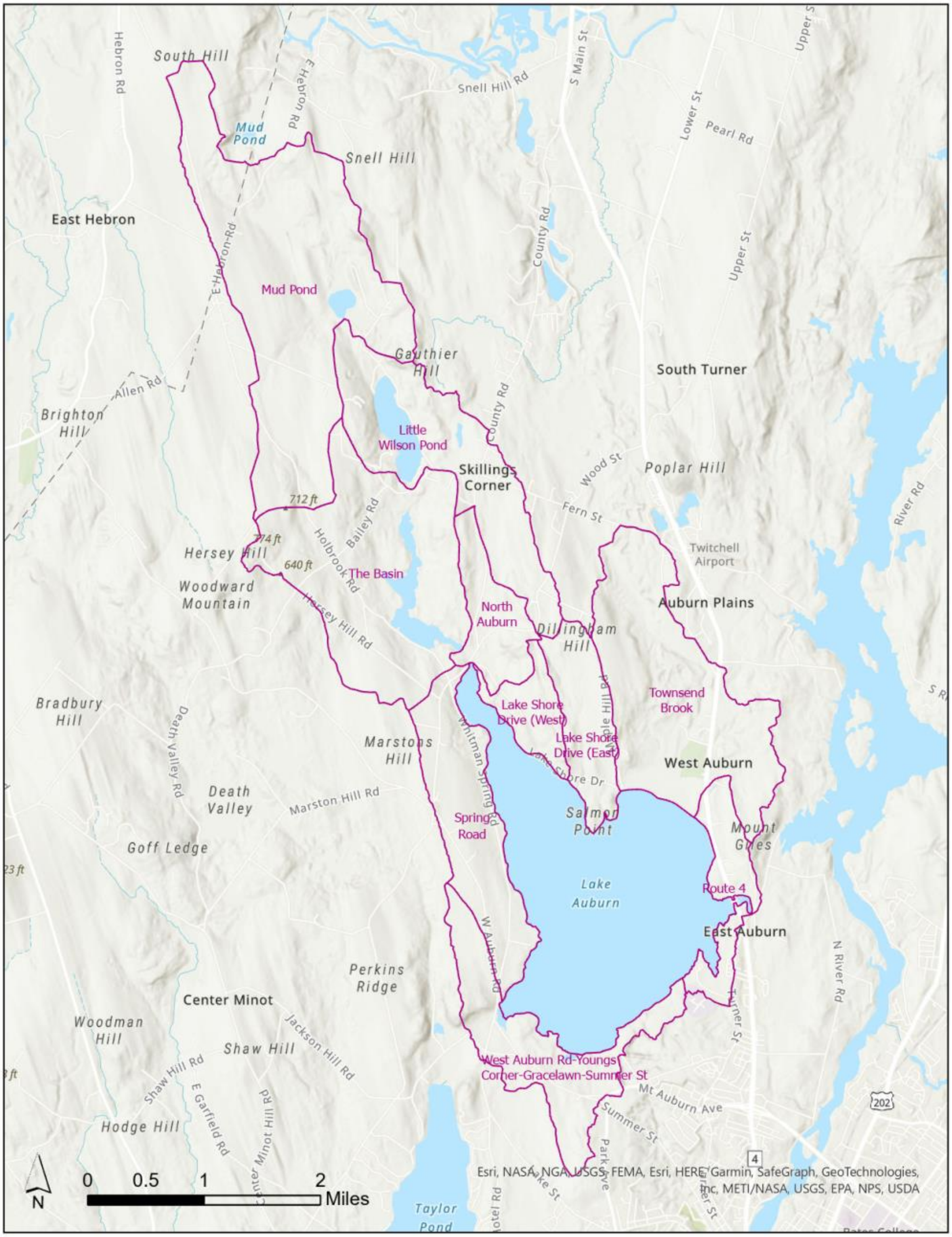
Water and P export coefficients are assigned based on a known range for the area, usually using the mean or median to start with and adjusting to get the model to match actual data. For example, the range of P export for forested land is 0.02 to 0.83 kg/ha/yr with a mean of 0.24 and median of 0.20 kg/ha/yr. Yet forested land in Maine falls near the low end of this scale from past experience and a value of 0.10 kg/ha/yr was applied based on that knowledge. Export coefficients apply to all land of a given type within the watershed; one cannot assign parcels in one drainage basin a different export coefficient than in the other basins.

Attenuation coefficients are also assigned, but on a basin by basin basis, depending on features or management actions that affect the transport of water and P to the lake. For example, a lake will typically remove at least half the P unless it is filled with sediment and evaporation will cause greater loss of water than for a stream. Again, there is a known range for attenuation for each drainage basin feature (e.g., lake, wetland, buffer zone, detention or infiltration basin, etc.) and values are applied based on knowledge of the specific basin. A basin with a stream passing through with steep slopes will provide minimal loss of water or attenuation of P, while a flat basin with extensive wetlands will cause greater loss of water and P on the way to the lake. This is where having data for flow and P at the downstream end of the drainage area is important to verify proper selection of attenuation coefficients.

There are also modules within LLRM for addressing direct atmospheric inputs (regional values from other studies are fairly reliable), point source inputs (none for Lake Auburn), on-site wastewater disposal (some but not a large influence in this system), wildlife inputs (less known for this system but estimates can be made), and internal loading (release from sediment, calculable from lake data).

The loads of water and P from different sources are summed up and act as inputs to the predictions part of the model, where the steady state average concentration of P in the lake is calculated and other water quality features such as clarity and the probability of chlorophyll-a occurring above chosen thresholds are estimated.

Figure 1. Drainage basins in the Lake Auburn watershed



Once the model is initially set up, data from the downstream end of any drainage area and from the lake itself can be used to evaluate the accuracy of the model results and coefficients can be adjusted to get better matches. While the ultimate goal is to match predicted in-lake P concentration to real data, having data to evaluate accuracy for each drainage basin is also important and is often a weak point of LLRM use. In the case of Lake Auburn, monitoring efforts by LAWPC staff has resulted in a valuable database of flows and water quality measures, typically with 50 to 100 values for each point of interest in the watershed over the last decade. Confidence in the model is greatly enhanced when the results for each basin match real data.

Pre-2019 Lake Condition

Very good agreement was obtained between actual data and either drainage basin or lake predictions in what is identified as scenario #1 (Table 2) with limited adjustment of model parameters. Data for Lake Auburn from 2014-2018 were used. The average volume weighted P concentration and average from epilimnetic cores provided a range of 10.8 to 11.2 ug/L while the prediction from LLRM was 10.9 ug/L. Tributary inputs were a reasonable match for actual flow data and P concentrations. Predicted and measured flows for drainage areas deviated by no more than 17% and averaged 6% difference. Predicted P concentrations for tributaries deviated from measured averages by <14%. A few drainage areas had limited data and larger deviations for understandable reasons (e.g., only one of several tributaries measured, data skewed by dominant wet weather values), but the overall agreement was acceptable. Chlorophyll-a is predicted to exceed 4 ug/L 27% of the time and did exceed that level 25% of the time. Thresholds of 6 and 8 ug/L had predicted occurrences of 7.7 and 2.3% with actual exceedances of 8 and 2%.

Current Lake Condition

LLRM was altered to represent current lake conditions by changing the internal loading in what is identified as scenario #2 (Table 2). The 2019 treatment of about half the lake area with aluminum stripped some P from the water column and inactivated surficial sediment P that could be released back into the water column. Based on the 2020-2023 data for the lake, a decrease in internal loading of 115 kg/yr was achieved. The treatment was expected to inactivate about half the available P in the contributing layer of sediment, but these data suggest that the reduction was closer to one third of the pre-treatment internal load. There will be year to year variation based on weather pattern (e.g., temperature and incoming organic load), but the model only considers a long-term steady state condition.

The predicted post-aluminum treatment TP was 9.7 ug/L while the range from actual data was 9.6 to 10.5 ug/L. Chlorophyll-a >4 ug/L was predicted at 17.6% vs actual data at 15.3%. Chlorophyll-a in excess of either 6 or 8 ug/L was predicted at 4.1 and 1.0% respectively, compared with 6.1 and 1.4% from actual data. The LLRM, as set up, appears to properly represent Lake Auburn and the result of P loading to it.

Potential Future Lake Condition with Management

LLRM was used to evaluate the likely results of various management options (Table 2). Changes were made to reflect the anticipated effect of chosen management actions, usually by altering the attenuation coefficient for any drainage area in which the action was planned. Choosing the new attenuation coefficient is the challenge, and being as rational and realistic as possible was the goal. The accompanying memorandum from Ecological Instincts provides the justification for the

Table 2. Results of LLRM for tested scenarios

Scenario #	1	2	3	4	5	6	7	8	9
SUMMARY TABLE FOR SCENARIO TESTING	2014-2018 pre-Al trtmnt	2020-2023 post-Al trtmnt	Pre-development Conditions	Maximum feasible P reduction	Identified NPS sites remediated (expected results)	Identiifed NPS sites maximum reduction	2nd Al trtmnt in lake	Basin dredged	Al dosing at Basin
Phosphorus (ppb)	10.9	9.7	4.6	6.8	9.4	9.2	8.5	9.1	8.7
Bloom Probability									
Probability of Chl >4 ug/L	27.0%	17.6%	0.0%	2.5%	15.6%	14.1%	9.6%	13.4%	10.6%
Probability of Chl >6 ug/L	7.7%	4.1%	0.0%	0.3%	3.4%	2.9%	1.7%	2.8%	2.0%
Probability of Chl >8 ug/L	2.3%	1.0%	0.0%	0.0%	0.8%	0.7%	0.4%	0.6%	0.4%

	10	11	12	13	14	15	16	17
SUMMARY TABLE FOR SCENARIO TESTING	Al dosing and dredging at Basin	Al dosing and dredging at Basin + 2nd lake Al trtmt	NPS sites remediated + 2nd lake Al trtmnt	NPS sites remediated + dredging at Basin	NPS sites remediated + dredging at Basin + 2nd lake Al trtmnt	NPS sites remediated + Al dosing and dredging at Basin	NPS sites remediated + Al dosing and dredging at Basin + 2nd lake Al trtmnt	NPS sites remediated to max + Al dosing and dredging at Basin + 2nd lake Al trtmnt
Phosphorus (ppb)	8.3	7.2	8.3	9.0	7.8	8.3	7.1	7.0
Bloom Probability								
Probability of Chl >4 ug/L	8.6%	3.5%	8.1%	12.5%	6.0%	8.5%	3.4%	2.9%
Probability of Chl >6 ug/L	1.5%	0.4%	1.4%	2.5%	0.9%	1.5%	0.4%	0.3%
Probability of Chl >8 ug/L	0.3%	0.1%	0.3%	0.6%	0.2%	0.3%	0.1%	0.1%

amount of P load that could be reduced by work on NPS sites, including developed and agricultural sites listed by CDM Smith in its evaluation as adjusted by Ecological Instincts through its 2023 assessment. For management of NPS sources, attenuation coefficients that resulted in the expected P load reductions were chosen. In some cases, actions also affect water load, as with dredging the Basin, which would provide more detention time and evaporation as well as greater P retention. Adjustments were made on a drainage area by drainage area basis. Once individual actions like dredging or NPS control were evaluated, combinations of management actions were modeled.

Management Options

Considered management options included remediating identified NPS sites at two levels of success, a second in-lake aluminum treatment, dredging the Basin, and installing an aluminum dosing station in the Basin or near its outlet. To provide comparison of results beyond the pre-aluminum treatment period (2014-2018) and the current condition (2020-2023, post-aluminum treatment), LLRM was run to simulate pre-development conditions (all land altered by human use restored to forest) and maximum feasible P reduction conditions (watershed loading decreased by 20% or to an attenuation minimum of 50%, Basin dredged, internal load reduced by 75%). Combinations of management options were also simulated by LLRM for comparison.

LLRM Results from Management

The model suggests that prior to human development (including agriculture) in the Lake Auburn watershed, average P concentration in the lake was slightly less than 5 ug/L, consistent with values for the more pristine lakes in Maine (scenario #3, Table 2). Chlorophyll-a >4 ug/L would not be expected. With current land use but every practical management method applied throughout the watershed and in the lake, the average P concentration would be expected to be slightly less than 7 ug/L, chlorophyll-a would exceed 4 ug/L 2.5% of the time and very rarely go above 6 ug/L (scenario #4, Table 2). Scenario 4 sets the maximum expectation for improvement through management. While doing better is not impossible, it is very unlikely based on considerable experience elsewhere. An increase of about 2 ug/L from pre-development to current land use conditions is therefore suggested as unavoidable. Fortunately, P at 7 ug/L would minimize algae issues and provide conditions that support the filtration waiver. The central question is how close to this expected maximum improvement can various management actions move the lake?

Scenarios 5 through 9 examine the individual management methods listed above, each applied independently and singly. These result in average P concentrations between 8.5 and 9.4 ug/L, slight decreases from the current average P concentration of 9.7 ug/L (scenario #2). Chlorophyll-a concentration would exceed 4 ug/L between 9.6 and 15.6% of the time, compared to 17.6% now by LLRM prediction. Chlorophyll-a concentration would exceed 6 ug/L between 1.7 and 3.4% of the time, compared to 4.1% now by LLRM prediction. Chlorophyll-a >8 ug/L would still be rare, <1%, compared to about 1% now. These are significant improvements, but do not approach the maximum feasible improvement (scenario #4).

The best improvement from an individual management action comes from a second lake treatment with aluminum (scenario #7), but that improvement would diminish over 4-8 years. Remediating NPS sites (scenarios #5 and 6) provides the least improvement, either at a management level expected to be achievable by normal effort or a higher level that will require more effort than is typical. Benefits might be provided for a longer duration, however, with watershed management. Dredging the Basin to provide enhanced detention of water and retention of P and installation of a dosing station to inactivate P leaving the Basin provide improvement intermediate to NPS site remediation and lake treatment to inactivate P. All may be worthwhile and will improve conditions over the current situation, but none is sufficient by itself to eliminate algae issues. One additional important benefit of dredging the Basin is that it would reduce organic loading to Lake Auburn, likely a major factor in oxygen loss during summer. NPS site remediation will also provide benefits in organic input control, but the Basin serves the largest drainage area by far and covers some of the NPS sites.

The second part of Table 2 includes scenarios involving combinations of the individual management actions assessed in the first part of Table 2. Dredging the Basin to improve its performance in sequestering P from this largest of drainage areas and installing a dosing station to inactivate P passing through that waterbody (scenario #10) would decrease average P concentration to 8.3 ug/L, reducing the probability of chlorophyll-a >4 ug/L to 8.6%, >6 ug/L to 1.5%, and >8 ug/L to 0.3%. This combination action would greatly reduce P entering Lake Auburn from 53% of the watershed but has no effect on other inputs. Adding a second lake treatment to inactivate P to the Basin dredging and a P inactivation dosing station (scenario #11) decreases the average P concentration to 7.2 ug/L and moves the probabilities for exceeding chlorophyll-a thresholds much closer to the expected maximum feasible improvement level. How long the in-lake treatment will last depends on continued loading from the watershed, but the dredging of the Basin and inactivation of P passing through it could extend the duration of benefits from in-lake treatment considerably.

The remainder of the scenarios in the second part of Table 2 include NPS site remediation with various combinations of the other management options. Where NPS remediation is coupled with dredging the Basin or inactivating P at the Basin outlet or a second in-lake P inactivation treatment (scenarios #12 through #15), predicted average P is no greater than 9 ug/L, but does not approach the level achieved by scenario #11. Combining the lower level of NPS site remediation with Basin dredging and P inactivation at the Basin and in the lake (scenario #16) reduces the average P concentration to 7.1 ug/L, while combining the higher level of NPS site remediation with the other actions (scenario #17) decreases P concentration to 7.0 ug/L. These combination management scenarios achieve the greatest P load reduction and maximum improvement of in-lake conditions.

However, remediation of identified NPS sites, while beneficial, does not provide a large enough P load reduction in scenarios #16 and #17 to be very different from scenario #11 (dredging, P inactivation in Basin and Lake Auburn). Much greater watershed NPS load control is needed and is very challenging in this (and many other) watersheds. The identified sites are mostly small and diffuse, necessitating a lot of separate efforts and considerable expense. Going beyond the identified problem sites will require more assessment and work on private property, much of it not under any jurisdiction that provides a means to force action. The higher level of NPS management applied in scenarios #6 and #17 assumes a level of cooperation that may not be achievable and only reduces P in Lake Auburn by 0.1 ug/L over the lower level of NPS management.

Conclusions

The current condition of Lake Auburn is acceptable for most uses, but the risk of algae problems is higher than desirable for a water supply, especially one with a filtration waiver. The expected condition of the lake prior to settlement and increased human uses would be characterized as pristine, while the feasibly achievable condition with current land uses includes P that is higher by 2 ug/L (26% increase from background). The pre-in-lake P inactivation concentration was more than 6 ug/L (137%) higher than the predicted background level, while the current post-in-lake P inactivation concentration is about twice the predicted background level. Reducing the current P concentration and probability of algae issues to the best feasible condition for existing land use requires a reduction of about 3 ug/L. This will require multiple management measures over an extended period of time, but some approaches yield faster improvement than others.

A much larger watershed management program, involving legislation to gain jurisdiction, particularly outside the Auburn city limits, and a high level of funding to bring it to fruition, would be needed to achieve desired in-lake conditions by that approach. Such an effort, if possible, would take several decades to achieve appropriate goals. Watershed management is needed and should be pursued in the Lake Auburn watershed, but if improved conditions are desired within the next few years, management will have to include options other than remediation of NPS sites and protection from additional land use changes that induce greater P and organic loading. This will undoubtedly be disappointing to people or organizations devoted to controlling pollution at the source, but it is a reality of historic land use change and regulatory and funding limitations.

Dredging the Basin to improve its retention capacity for a range of contaminants, including both P and organic matter, and installing a P inactivation dosing station in or just downstream of the Basin would address the largest delineated drainage area to Lake Auburn (53% of watershed area) and reduce average P concentration in Lake Auburn to 8.3 ug/L. Combined with a second in-lake P inactivation treatment, the P concentration could be reduced to 7.2 ug/L, only 6% higher than the expected maximum improvement achievable.

Any decision on how to approach the improvement of Lake Auburn will involve more than just estimation of achievable reductions. Cost, permitting, implementation timeframe, and jurisdiction must all be considered. Yet this analysis suggests that relatively rapid improvement could be achieved through P inactivation, especially if coupled with dredging the Basin to restore its retention capacity.

TECHNICAL MEMORANDUM

TO: Ken Wagner, Water Resource Services

FROM: Jen Jespersen, Ecological Instincts

SUBJECT: **Pollutant Reduction Estimates- Lake Auburn Watershed**

DATE: January 4, 2024

INTRODUCTION

In October 2023, Ecological Instincts assessed NPS pollution sources in the Lake Auburn watershed. The assessment took place over the course of four days between October 4-16, and involved revisiting 64 sites identified by CDM Smith in 2022. The purpose of the assessment was to document the current state of each site and to collect field measurements for estimating pollutant load reductions. The goal of the assessment was to provide estimates of potential phosphorus reductions that could be achieved across the watershed as part of a larger modeling effort by Water Resource Services for the Auburn Water District.

FIELD ASSESSMENTS

Methods

Detailed measurements of erosion were recorded at each site including the length and width of eroding streambanks, road shoulders, and shorelines, and the dimensions of any gullies. Survey123 was used to collect GPS coordinates, photographs, and other site-specific information including site sketches for more complex sites. Any new sources of NPS pollution observed by the Ecological Instincts survey team that were not previously documented by CDM in 2022 were recorded. NPS sites located on agricultural land were observed from the road to confirm the land use type and to document any NPS issues.

The data collected for the field assessment was reviewed for quality control, GPS points were uploaded to an existing GIS project, and all photographs were downloaded and properly labeled to match the site #. A copy of field photos are located in the following shared drive: https://drive.google.com/drive/folders/107lDnxeibBQrPRQK2TxQpJGz6-9RsWw6

Results

A total of 61 CDM sites were resurveyed by Ecological Instincts, 48 of which were determined to be a current source of NPS pollution to Lake Auburn. Thirteen of the CDM sites were determined not to be current sources of NPS pollution to the lake, either because they had been remediated or because there was no evidence of runoff reaching the lake from the site. Three of the CDM sites were not revisited because they were located on private property, including posted property. Two of the three sites were assumed to be active sources of NPS pollution based on observations made by CDM Smith in 2022.[1]

Ecological Instincts documented an additional nine sites that were not on CDMs 2022 list of sites, for a total of 59 active NPS sites (Figure 1, next page). Five of these sites are located on agricultural land. Agricultural land not referenced in the 2022 CDM survey was observed from the road to document the type of agriculture (e.g.,

[1] The third site not visited in 2023 was assumed to no longer be an active source of pollution because it was a construction site that appeared to have been stabilized since the original survey. Local groups should conduct outreach to the landowner to ensure that there are no current erosion problems at the property.

hay, pasture, row crops, etc.), to aid in developing potential phosphorus reduction estimates from agriculture in the watershed.

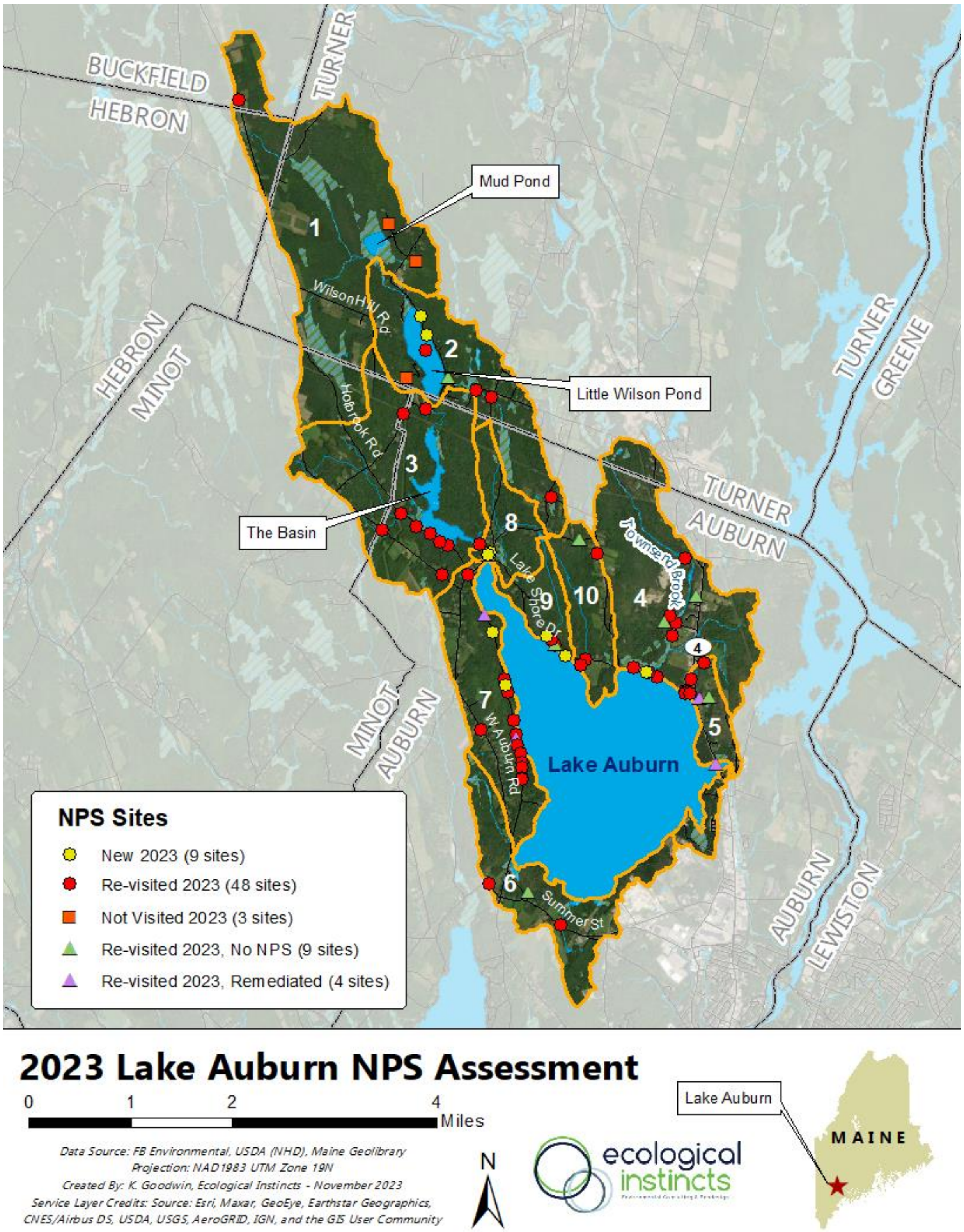


Figure 1. Map of documented NPS Sites for the 2023 NPS Assessment for Lake Auburn, ME.
(Numbers on the map represent the 10 LLRM basins delineated by FB Environmental Associates.)

Spring Road (Basin 7) contains the greatest number of documented NPS sites followed by The Basin (Basin 3) and Townsend Brook (Basin 4) (Table 1). Only six sites had at least one bank or gully that ranked severe (UB-5, UB-10, LS-9, SR-3, L-3, TB-8), 21 sites had at least one bank or gully that ranked moderate, and the remainder of sites ranked slight for the lateral recession rate. Multiple sites had several eroding banks or gullies.

Table 1. Number of active NPS sites and percentage of watershed area by basin in the Lake Auburn Watershed.

Basin	# of NPS Sites	% of Watershed Area
1- Mud Pond (UB)	3	24%
2- L Wilson Pond (UB)	8	12%
3- The Basin (UB)	10	18%
4- Townsend Bk (TB)	10	16%
5- Rt 4 (R)	9	4%
6- West Auburn Rd-Young's Corner - Gracelawn-Summer St (L)	3	8%
7- Spring Rd (SR)	16	8%
8- N Auburn (LS)	3	4%
9- Lake Shore Drive W (LS)	6	3%
10- Lake Shore Drive E (LS)	5	5%

POLLUTANT REDUCTION ESTIMATES

Methods

Results of the NPS assessment were used to estimate the potential pollutant load reductions that could be achieved by installing BMPs throughout the watershed. Two sets of load reduction estimates were calculated to develop a range of load reductions, presented as low and high. Low-end estimates reflect the most realistic values for each site based on field observations while high estimates utilized slightly higher lateral recession rates. Three different methods were used depending on the land use type and the recommended BMP(s) for each site.

PLET

For the majority of sites, the US EPA Pollutant Load Estimation Tool (PLET)[2] was used (51 of the 59 active erosion sites). Two of the three CDM sites that were not visited during the 2023 assessment due to lack of access were included in the PLET, with dimensions of the eroding areas estimated based on photos provided by CDM. Lateral recession rate (ft/yr) for each site was estimated in the field, where applicable, as either slight, moderate, or severe. Soil type for each site was entered into the PLET based on data from the USDA/NRCS Web Soil Survey.[3] Number of years that gullies have been eroding were based on best professional judgement. BMP efficiencies used in the PLET are based on values for sediment and phosphorus reduction efficiencies provided by the US EPA's guidance for the Region 5 model.[4]

For the low-end load reduction scenario, the lateral recession rates for streambanks were adjusted from the default values within the model for each category (slight, moderate, severe) based on field

[2] https://www.epa.gov/nps/plet
[3] USDA/NRCS Web Soil Survey: https://websoilsurvey.nrcs.usda.gov/app/
[4] https://19january2021snapshot.epa.gov/nps/region-5-model-estimating-pollutant-load-reductions_.html

observations for each site. For the high-end estimates, default values for each category were used (0.03 ft/yr for slight, 0.13 ft/yr for moderate, and 0.4 ft/yr for severe).

Agriculture

Because access to agricultural properties was not available during the surveys, and limited information was provided beyond the 2022 CDM survey related to agriculture in the watershed, the PLET model was not the best fit for estimating P reductions from agricultural land. Therefore, the Maine DEP's Relational Method[5] was used to estimate phosphorus loading reductions by addressing NPS pollution on agricultural land in the watershed. This model has been used recently in other Maine lake watersheds to estimate load reductions for various land cover types. In this application, the Total P reduced was calculated for cropland and hay/pasture by calculating the fraction of the total watershed P load these land use types represent, the fraction of the load addressed, and the expected BMP efficiency for each land cover type. BMP efficiencies of 0.43 and 0.31 (for phosphorus) were applied to cropland and hay/pasture, respectively, based on the average efficiencies for cropland and pastureland BMPs from the US EPA Region 5 model.

A breakdown of agricultural land by basin indicates that the Mud Pond basin (Basin 1) contains the largest area of agriculture followed by West Auburn Rd (Basin 6) and The Basin (Basin 3) (Table 2).

Table 2. Area of agricultural land by basin in the Lake Auburn Watershed.

Town	Basin	Cropland Area (ha)	Pasture Area (ha)	Total Area (ha)
Turner, Buckfield, Hebron & Minot	1- Mud Pond	16.1	76.1	**92**
Turner, Minot, Auburn	2- L Wilson Pond	0.0	6.7	**7**
Auburn	3- The Basin	2.0	39.7	**42**
Auburn	4- Townsend Bk	7.0	20.3	**27**
Auburn	5- Rt 4	0.2	2.8	**3**
Auburn	6- West Auburn Rd-Young's Corner-Gracelawn-Summer St	12.7	34.1	**47**
Auburn	7- Spring Rd	4.8	11.7	**17**
Auburn	8- N Auburn	0.0	1.9	**2**
Auburn	9- Lake Shore Drive (W)	0.0	0.0	**0**
Auburn	10- Lake Shore Drive (E)	1.1	3.5	**5**

To get low-end phosphorus reduction estimates, the fraction of the load addressed was set at 72% for cropland and 68% for hay/pasture. It was assumed that BMPs would be installed on all farms in the City of Auburn because of local ordinances that require all active agricultural operations to complete a farm plan. The fraction of the P load addressed was set at 25% for all farms in towns outside of the City of Auburn. For high-end agriculture estimates, farms outside of Auburn installing BMPs was increased from 25% to 75%, for a total fraction addressed for all agriculture in the watershed of 91% for cropland and 89% for hay/pasture.

[5] Jeff Dennis, Division of Watershed Management, Maine DEP, n.d.

Little Wilson Pond

The third pollutant load reduction modeling method focused on P reductions for shoreline residential development on Little Wilson Pond. The 2023 field assessment documented lack of adequate shoreline buffers and areas of eroding shoreline at lake access points. Load reductions were estimated by averaging pollutant reduction estimates calculated using the PLET for two of the 2023 NPS sites on the shoreline of Little Wilson Pond (UB-20 & UB-21) and previously used load reduction estimates for low-impact residential NPS sites from a recent Ecological Instincts project at North Pond in Smithfield, ME to calculate an average pollutant load reduction for a single site.[6]

The number of developed shoreline properties on the pond was estimated using parcel data and aerial imagery. Low-end pollutant load reductions assume that BMPs will be installed on 50% of all shoreline properties on Little Wilson Pond, while high-end estimates assume BMPs will be installed on 75% of shoreline properties.

Other

Two NPS sites visited during the 2023 assessment (TB-5 & TB-7) are smaller ponds and known sources of nutrient loading to Lake Auburn. Nutrient load reductions were not estimated for these smaller ponds as part of this analysis.

Results

Results of the pollutant reduction estimates provide two potential scenarios for load reductions in the Lake Auburn watershed. The more realistic scenario estimates a total of 40 kg/yr of phosphorus could be prevented from entering Lake Auburn if all current NPS sites were addressed (14 kg P/yr), if BMPs are applied on active agricultural land across all towns in the watershed (23 kg P/yr), and if vegetated buffers are installed on shorefront properties on Little Wilson Pond (3 kg P/yr). In addition, 47 kg/yr of nitrogen and 74 tons/yr of sediment would be prevented from entering the lake, not including nitrogen and sediment reductions from installing BMPs on agricultural lands.

The more optimistic high-end reduction scenario indicates a total load reduction of 59 kg/yr of phosphorus if all current NPS sites were addressed (25 kg P/yr), if BMPs are applied on active agricultural land across all towns in the watershed (29 kg P/yr), and if vegetated buffers are installed on shorefront properties on Little Wilson Pond (5 kg P/yr), along with an estimated reduction of 80 kg/yr of nitrogen and 125 tons/yr of sediment just by addressing NPS sites and installing shoreline buffers on Little Wilson Pond (Table 3).

Pollutant load reduction estimates calculated for the Lake Auburn watershed suggest that **between 40 and 59 kg/yr of phosphorus could be removed from the total phosphorus load to Lake Auburn if watershed NPS sites are fully addressed.** The largest load reductions are estimated for the Mud Pond sub-basin (Basin 1), which accounts for close to a quarter of the watershed area (24%),[7] followed by Townsend Brook (Basin 4) which represents 16% of the watershed area and is tied for the second greatest number of documented NPS sites. The Basin (Basin 3) is the second largest sub-basin at 18% of the watershed area and tied with Townsend

[6] Average reductions of 0.16 kg P/yr, 0.49 kg N/yr and 0.63 tons sediment/yr were used to estimate pollutant loading reductions for low-impact residential shoreline properties on Little Wilson Pond.

[7] The majority of the estimated P reduction for Mud Brook is related to agricultural BMPs.

Brook for the second greatest number of NPS sites (10 sites). This information suggests that Mud Pond, Townsend Brook and The Basin should be the highest priorities for P reduction.

Table 3. Pollutant load reduction estimates by basin in the Lake Auburn Watershed.

Basin	P Load Reduction Scenarios (kg/yr)	
	Low	**High**
1- Mud Pond	9.0	11.5
2- L Wilson Pond	4.8	6.8
3- The Basin	5.7	8.5
4- Townsend Bk	6.6	10.9
5- Rt 4	1.6	1.7
6- WAR-YC-GL	5.5	6.9
7- Spring Rd	2.7	4.7
8- N Auburn	0.8	3.0
9- Lake Shore Drive (W)	2.3	3.9
10- Lake Shore Drive (E)	1.3	1.6
Total	**40.2**	**59.3**

However, other sub-basins should be considered a high priority despite not covering as large an area or having the highest P reduction estimates include Spring Road with the greatest number of NPS sites of all the sub-basins (16 sites), and Lake Shore Drive (Basins 9 & 10 and portions of Basins 4 & 8) due to the close proximity of the sites to the lake, evidence of ongoing erosion, and public visibility. Seven of the top 10 NPS sites with the greatest P reduction potential are located on Lake Shore Drive including TB-13 and TB-14 along with five LS sites (Table 4).

Table 4. Top ten NPS sites with greatest P reduction (high-end) estimates in the Lake Auburn watershed.

Site ID	P Reduction (kg/yr)
TB-13	3.9
LS-11	2.3
LS-1b	1.6
TB-14	1.4
LS-9	1.3
TB-8	1.3
UB-7	1.3
LS-1a	1.3
SR-16	1.0
LS-6	0.7
Total	**16.1**

Combined, the 10 NPS sites with highest potential P reductions account for approximately 16 of the 56 kg/yr of potential P reduction, or close to one-third of the total P reduction from the watershed. Targeting NPS sites with the greatest P load reductions could be another approach to prioritizing remediation in the watershed. This includes seven sites on Lake Shore Drive.