Blanchard Pond Watershed Study

Evaluation of Blanchard Pond & Downstream System and associated Sub-watersheds for Removal of Phosphorus

Submitted to: Lake Auburn Watershed Protection Commission

February 18, 2021
Final Report

Tighe&Bond

100% Recyclable

Section 1
Introduction

The Lake Auburn Watershed Protection Commission ("LAWPC") hired Tighe & Bond to evaluate the impacts of Blanchard Pond's discharge of phosphorus to Lake Auburn[1] and to identify alternatives, including costs and benefits, for mitigation of the Pond's potential impact on public health and the environment. The study also includes the watershed area of Blanchard Pond, as well as the downstream waterbody and wetland system between the Pond and Lake Auburn and the watershed contributing to that system. The goal of this study is to help LAWPC understand the relative impact compared to other sources in the Lake Auburn watershed and arm LAWPC with additional strategies for managing nutrient loading from Blanchard Pond and the downstream system into Lake Auburn.

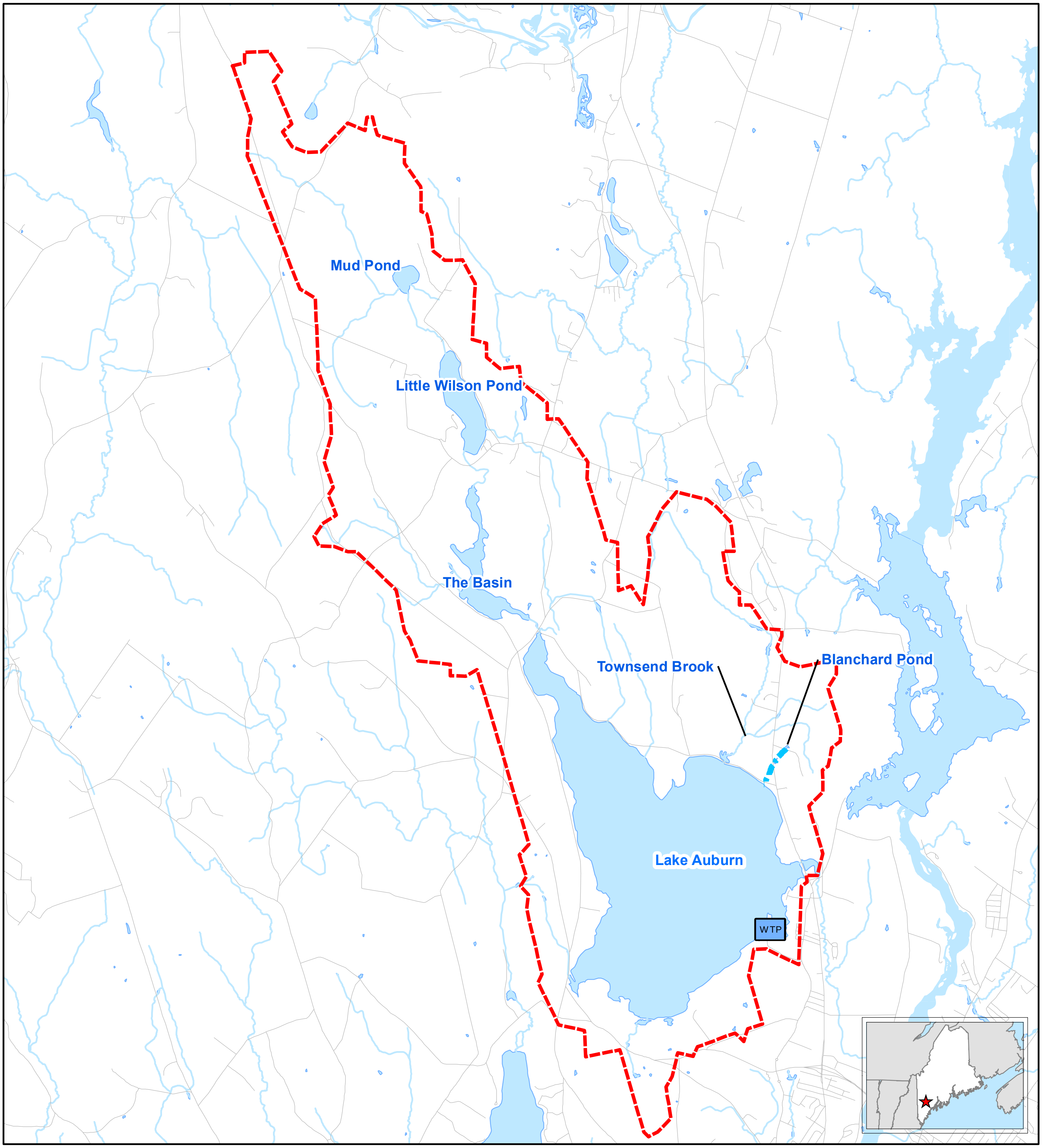
Previous studies on the Lake Auburn Watershed have quantified phosphorus loading to Lake Auburn by focusing on conditions within subwatersheds of larger tributaries to the lake and conditions in the lake.[2,3] Blanchard Pond and its associated drainage area was previously included as part of the Route 4 subwatershed, which is one of these larger subwatersheds entering Lake Auburn. Since the studies were completed, LAWPC has refined their phosphorus management approach to reflect:

1. Blanchard Pond is hydraulically connected to Lake Auburn via its own discrete stream system. Blanchard Pond is located on a private residential lot at 16 Blanchard Road where much of adjacent land use is farm pasture. The stream connecting Blanchard Pond to Lake Auburn runs just under 2,000 linear feet and passes through wetlands and beneath Blanchard Road, Turner Road (State Route 4), and Lake Shore Drive. Figure 1-1 shows the location of this waterbody with respect to the overall Lake Auburn watershed.
2. Blanchard Pond may be a potentially significant source of phosphorus to Lake Auburn. Recent watershed sampling by the Auburn Water District and Lewiston Water Division (AWD/LWD) has identified high total phosphorus concentrations in areas of the watershed that were not previously studied specifically. AWD/LWD first started sampling water quality in Blanchard Pond in August 2018 and have continued sampling through late 2020.

In addition, work by various consultants over the years and researchers at Bates College have continued to track and refine the phosphorus loading analysis and update conclusions and refine recommendations. Given these considerations, it is prudent to individually characterize the magnitude of the Blanchard Pond discharge on the overall Lake Auburn system. This report provides an overview of the potential sources of pollution in the watershed to Blanchard Pond and its downstream system based on visual observations, an estimate of phosphorus loading to Lake Auburn relative to previous evaluations, potential remediation strategies, and recommendations for next steps.

---

[1] Lake Auburn serves as the only public drinking water supply for the cities of Auburn and Lewiston and is currently exempt from filtration requirements under the Surface Water Treatment Rule due to historically high water quality and low raw water turbidity.
[2] Diagnostic Study of Lake Auburn and its Watershed: Phase 1 (2013) Prepared by CDM Smith in collaboration with Comprehensive Environmental, Inc. and Dr. Ken Wagner, Water Resources Services, Inc.
[3] Lake Auburn Watershed Management Plan: Final Report (2010) Prepared by Comprehensive Environmental, Inc.



LEGEND

- Blanchard Pond Stream
- Lake Auburn Watershed
- WTP Lake Auburn UV Plant
- Road
- Water Body

1:72,000 1 in = 6,000 ft

0 3,000 6,000

Feet

N

Tighe&Bond

FIGURE 1-1

LAKE AUBURN WATERSHED

Lake Auburn Watershed Protection Commission

Auburn, Maine

July 2020

Section 2
Characterization of Blanchard Pond, Downstream System, and Associated Watersheds

Tighe & Bond utilized a combination of publicly available data, water quality and quantity information collected by AWD/LWD, and physical investigation to characterize Blanchard Pond, the downstream stream and wetlands system, and the associated subwatersheds. It is important to note that this work is intended to further the previous studies completed (as noted in Section 1), and therefore does not modify or update the pollutant load analysis therein, including the model input data.

2.1 Watershed Overview

AWD/LWD conducts routine water quality sampling and stream flow measurements at three locations in the Blanchard Pond and downstream system:

- The outlet of Blanchard Pond (B-1);
- West of the Turner Road crossing (R-2); and
- South of Lake Shore Drive just upstream of the inlet to the Lake (Site 25).

Figure 2-1 shows these locations with respect to Blanchard Pond, and provides estimated subwatershed boundaries. Table 2-1 summarizes the watershed areas associated with this system and its segments. For context, Lake Auburn has a watershed area of 9,650 acres. This system comprises less than 1% of the Lake Auburn watershed.

TABLE 2-1
Blanchard Pond & Downstream System Watershed Areas

Subwatershed	Area (acres)
Sample Point B-1	1.2
Sample Point R-1	18.8
Sample Point Site 25	69.6

The previous studies developed a pollutant load analysis using information on each larger Lake Auburn subwatershed including land use and land cover (e.g., impervious areas), soils, and septic systems, coupled with atmospheric conditions (precipitation, temperature, evapotranspiration, etc.). Our intent was not to update these broad estimates but to further refine solutions through a combination of visual observation, targeted data collection, and overall comparative loading analysis.

2.1.1 Water Quality and Streamflow Measurements

Tighe & Bond recommended additional water quality sampling in a written sampling plan submitted to LAWPC in May 2020 (see Appendix A). This plan included a bi-weekly sampling with emphasis on corresponding water quality and quantity data gathering to aid in nutrient loading calculations. The water quality results are discussed in Section 3 of this report, as part of considering relative phosphorus loading to Lake Auburn.

LEGEND

- Sample Site
- Blanchard Pond Stream
- R-2 Sampling Point Watershed
- Blanchard Pond Stream Watershed
- Blanchard Pond Watershed
- Parcels

Tighe&Bond

1. 2018 Orthoimagery downloaded from MEGIS
2. Parcel data downloaded from Access Auburn

1:4,200 1 in = 350 ft

0 175 350

Feet

N

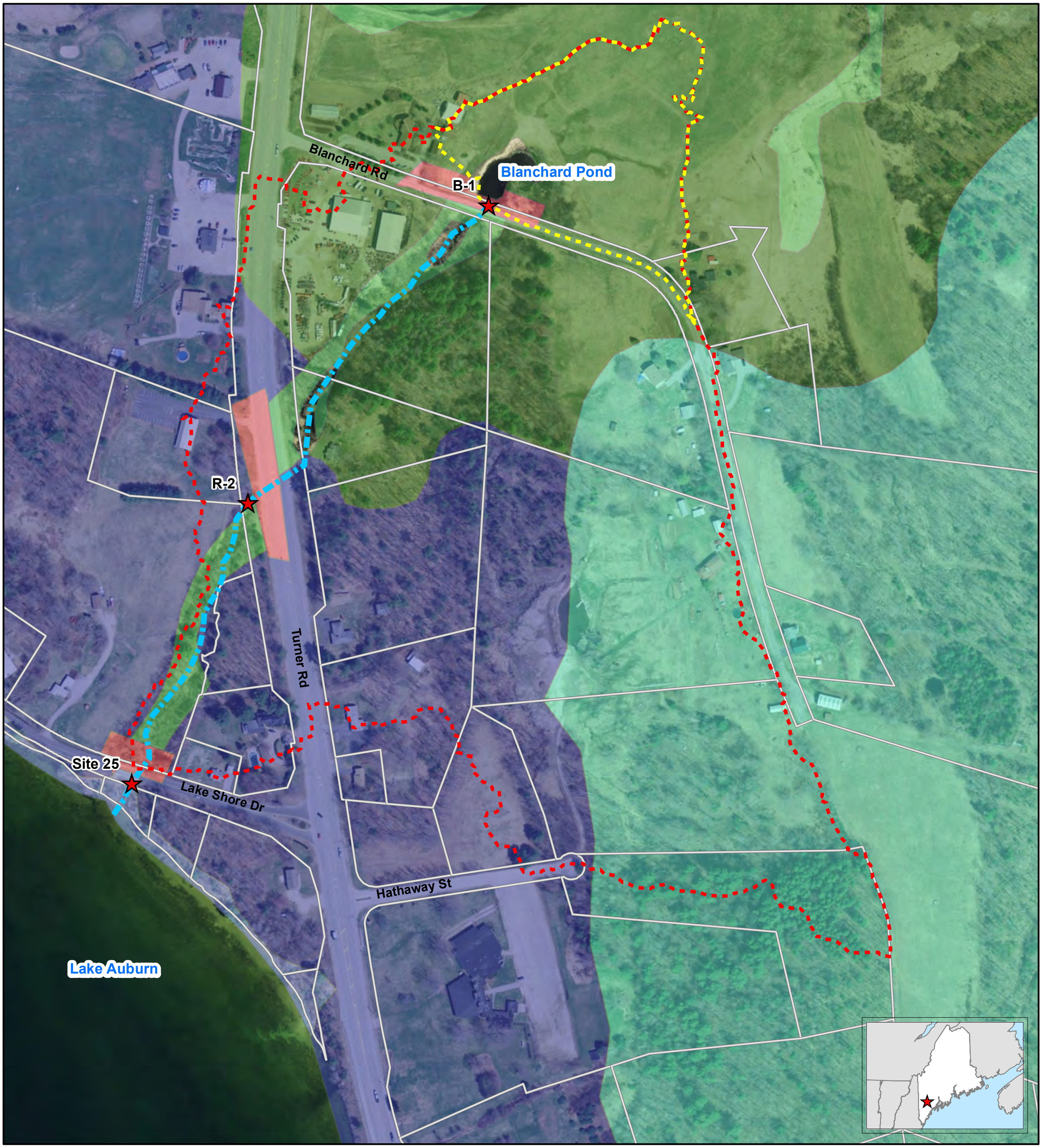
FIGURE 2-1
BLANCHARD POND WATER QUALITY AND STREAMFLOW MEASUREMENT SITES

Lake Auburn Watershed Protection Commission
Auburn, Maine

December 2020

J:\L\L5040 Lake Auburn Watershed\Figures\Fig2_Blanchard_Pond_SampleSite.mxd

L-5040



LEGEND

Sample Site

Blanchard Pond Stream

Parcels

BlanchardPondWatershed

Blanchard Pond Stream Watershed

Surficial Geology
Lake Auburn East 24k Quadrangle

Ha - Stream alluvium

Hls - Modern lakeshore deposit

Pm - Glaciomarine sediments, undifferentiated

Pp - Presumpscot Formation

Pt - Till

af - Artificial fill

1:4,200 1 in = 350 ft

0 175 350
Feet

N

Tighe&Bond

1. 2018 Orthoimagery downloaded from MEGIS
2. Parcel data downloaded from Access Auburn
3. Surficial Geology downloaded from MEGIS

FIGURE 2-2
BLANCHARD POND WATERSHED SURFICIAL GEOLOGY

Lake Auburn Watershed Protection Commission
Auburn, Maine

December 2020

J:\L\L5040 Lake Auburn Watershed\Data\Blanchard_Pond_SurficialGeology1.mxd

L-5040

2.1.2 Visual Observation of Watershed

On March 3, 2020, Tighe & Bond staff completed a visual non-point source pollution assessment of the watershed. As mentioned previously, the intent was not to use a desktop analysis to update watershed modeling but instead to visually identify potential sources of phosphorus inputs from the watershed to Blanchard Pond and the stream system, with considerations for consistency with the previous work completed.

As LAWPC is aware, one of the challenges with managing phosphorus is that it has many sources, including both naturally occurring and from human activity. To put it simply, naturally occurring sources of phosphorus include atmospheric deposition, animal waste, and even leaf litter decay. Anthropogenic sources of phosphorus include fertilizer, pet waste, detergents, lubricants, yard waste, and sewage. Phosphorus adsorbs to solids such as soil and sand and, when these materials are mobilized by stormwater runoff or snow melt, can transport directly to waterbodies. In addition, long-term over-application of fertilizer and failing septic systems contribute to phosphorus in groundwater, sometimes resulting in a significant source of phosphorus loading to waterbodies.[4]

- Land Use & Land Cover: Based on visual observation:
    - There is the potential for direct loading to Blanchard Pond from the private property on which it is located due to mowing and agricultural management practices.
    - Deicing roadways with sand mixtures has the potential to contribute phosphorus to the stream system at locations where roadways cross the waterbodies or the drainage system discharges.
    - There is an equipment company that abuts the stream system. A portion of this facility has an unpaved parking lot, which also has potential to contribute phosphorus due to sediment loading.
    - There has been anecdotal information about historical practices related to a private septic hauling company that abuts the stream system directly. The presence of this condition was not observed during our site visit.
    - There has been anecdotal information about a private property that may have had a drainage outfall or even a washer discharge in the backyard, but the presence of this condition was not observed during our site visit.
- Septic Systems: There are a number of septic systems with 300 feet of the stream system, but no observations of erosion, breakout flow, or indications of sewage were identified during our field effort.
- Soils (and Geology): Review of surficial geology maps published by the Maine Geological Survey show soils in this area are composed of primarily sand, gravel, and clay-silt deposits in the upstream portion of the watershed and regional marine clay known as the Presumpscot Formation in the lower portion of the watershed, west of Turner Rd (Figure 2-2).[5] As discussed in Section 2-3, the Presumpscot Formation was visible immediately downstream of sample site R-2. The

[4] Phosphorus and Groundwater: Establishing Links Between Agricultural Use and Transport to Streams (January 2012). Available online at https://pubs.usgs.gov/fs/2012/3004/

[5] Thompson, W.B (2001) Surficial Geology of the Lake Auburn East Quadrangle Androscoggin County, Maine: MGS, Open-File Map 08-72.

Presumpscot Formation is known to contain the phosphorus-bearing mineral apatite, which can potentially be released through chemical or physical weathering.

While there are sources of phosphorus throughout the subwatershed that have an opportunity to be managed as further noted in Table 4-1, these sources require private property and State participation and the cost per pound removed may be prohibitive. The geology and soils conditions may contribute to the historically elevated phosphorus concentrations in the downstream segment of this system and may be prudent to further investigate.

2.2 Blanchard Pond

Table 2-2 summarizes the physical characteristics of Blanchard Pond. For context, Lake Auburn has a surface area of 2,240 acres and has a maximum depth of 120 feet. Blanchard Pond is 7,000 times smaller than Lake Auburn.

TABLE 2-2
Blanchard Pond Statistics

	Value	Source
Watershed Land Area	0.002 mi^2, 1.2 ac	ArcGIS Watershed Delineation (2-ft elev. contours)
Perimeter	610 ft	2018 Orthoimagery
Surface Area	14,495 ft^2, 0.32 ac	2018 Orthoimagery
Max Depth	6.3 ft	Field Measurement (March 9, 2020)
Approximate Volume	60,900 ft^3	Assumes conical basin morphology
Hydraulic Residence Time	0.36 year	2019 Annual Precipitation (30 inches), Drainage Area, Volume

On March 9, 2020, Tighe & Bond staff, with support from AWD/LWD personnel, collected a sediment grab sample from Blanchard Pond. The sample was collected through the ice with a 2-inch diameter stainless steel hand corer. The top four (4) inches of sediment were preserved frozen for lab analysis. The Blanchard Pond sediment sample was analyzed by Northeast Laboratory in Berlin, CT for loosely bound phosphorus, reducible (iron bound) phosphorus, total phosphorus, and organic content. These analyses are designed to determine if the pond sediment is a potential source of phosphorus to the stream system. Dissolved oxygen (DO) measurements show that the pond frequently becomes anoxic (<2 mg/L DO) in the summer, which can result in internal phosphorus loading. Internal loading occurs when low oxygen concentration causes in a change in chemistry that can result in the release of iron-bound phosphorus in sediment back into the overlying water. The laboratory results are summarized in Table 2-3 and a copy of the laboratory's analytical report is included in Appendix B.

TABLE 2-3
Summary of Blanchard Pond Sediment Analysis

Parameter	Lab Result	Unit	Sediment Phosphorus Content	Unit
Iron Bound Phosphorus	64.4	mg/kg	28.1	µmol/g dry weight
Loosely Bound Phosphorus	9.0	mg/kg	3.9	µmol/g dry weight
Total Soluble Phosphorus	73.4	mg/kg	32.0	µmol/g dry weight
Total Phosphorus	3,220	mg/kg	1,406.9	µmol/g dry weight
Ash/Organic Matter	7.59	%		
Total Solids	7.39	%		

The sediment analysis found that the total soluble sediment phosphorus is 32 µmol/g dry weight, 28 µmol/g of which is potentially soluble when the pond becomes anoxic. By comparison, potential total soluble phosphorus in Lake Auburn, a lake known to release phosphorus during anoxic conditions, ranges 52−140 µmol/g dry weight.[6]

The sediment analysis requires extractions on different subsamples of the sediment. The laboratories conducting the extractions used drying methods to determine the non-water fraction of the sediment weight to be between 7-8%.

Based on the relatively low concentration of the iron bound and loosely bound phosphorus pools and comparison to other nutrient transport mechanisms in the watershed, we do not believe that internal loading from the sediment is a significant driver of high phosphorus concentrations in Blanchard Pond.

2.3 Downstream Stream and Wetlands System

On June 5, 2020, Tighe & Bond staff conducted a stream walk to trace the actual stream path and identify potential nutrient sources, such as evidence of additional surface water inputs, flooding, bank erosion, and/or impoundments. Photo documentation and a reference map summarizing our observations is included in Appendix C. Several observed locations have the potential to contribute phosphorus to the stream system:

- Historical land use around Blanchard Pond (Photo 1);
- Visible iron oxidation along the streambed (Photos 8 and 15);
- Erosion along Route 4 (Photo 9);
- A private dam visible just upstream of Turner Rd/Route 4 (Photo 10);
- Erosion at Sample Site R-2, evidence of an undersized culvert beneath Route 4 (Photos 11 and 12); and

[6] Heather A. Doolittle, Stephen A. Norton, Linda C. Bacon, Holly A. Ewing & Aria Amirbahman (2018): The internal and watershed controls on hypolimnetic sediment phosphorus release in Lake Auburn, Maine, USA, Lake and Reservoir Management.

- Beach erosion at the inlet to Lake Auburn (Photo 18).

While these all represent potential sources of phosphorus, no single location appeared to be significant enough to drive the historically elevated phosphorus concentrations in this system. The private dirt mounded dam with boards to stabilize the structure (Photo 10) creates an artificial impoundment that could be facilitating algae and nutrient development, which may be washed downstream by intense or significant precipitation events resulting in a potential concern, but further evaluation/remediation is dependent on landowner participation. Erica Kidd (Lake Auburn Watershed Manager) contacted the property owner during this evaluation. The property owner indicated that they are not currently interested in removing the impoundment but plan to make repairs to the structure and drainage in that area in the future.

Section 3
Relative Phosphorus Loading

The purpose of building a phosphorus loading model is to quantify the total mass of phosphorus that is being contributed to Lake Auburn from Blanchard Pond and the downstream system. The history of elevated total phosphorus in the pond has been identified by the LAWPC as a potentially significant contributor to nutrient transport in the watershed. Recent rising phosphorus concentrations in Lake Auburn, and subsequent declining water quality in the lake, have prompted further investigation of this part of the watershed. When considering the nutrient loading from this system, it is important to also understand the annual loading relative to other large Lake Auburn subwatersheds and the total Lake Auburn Watershed. Using this approach, investment in remediation strategies can be scaled to match anticipated benefits for greater watershed management economy and impact.

Daily precipitation records, streamflow measurements, and total phosphorus concentrations have been collected during 2018 through 2020, with 2019 being the first year that Blanchard Pond was formally included in watershed sampling efforts. The following sections discuss results of these data.

3.1 Water Quality Data

Table 3-1 summarizes the phosphorus concentration data collected since 2016. The discharge from Blanchard Pond (Site B-1) exhibits higher phosphorous concentrations than Sites R-2 and 25. Maximum, average, and median concentrations decrease from upstream to downstream in the overall system.

TABLE 3-1
Summary of Phosphorus Sampling Results[1]

	Total Phosphorus Concentration (ppb)			
Sample Location	Max Value	Min Value	Average Value	Median Value
B-1	350	31	129	110
R-2	160	17	71	70
Site 25	140	23	53	44

[1] Includes all reported samples collected between 3/29/2016 and 11/5/2020

Figure 3-1 shows total phosphorus concentrations at all three sample sites along the stream (sample locations are shown in Figure 2-1) over time between 2016 through 2020. Generally, concentrations sampling from Blanchard Pond have more variability than the downstream sampling locations. Figure 3-2 shows the comparative phosphorus concentrations and illustrate the magnitude of reduction from upstream to downstream sample location. However, to further evaluate the impact to Lake Auburn, these data must be considered in concert with streamflow.

FIGURE 3-1

Total phosphorus concentrations at each sample site between 2016 and 2020.

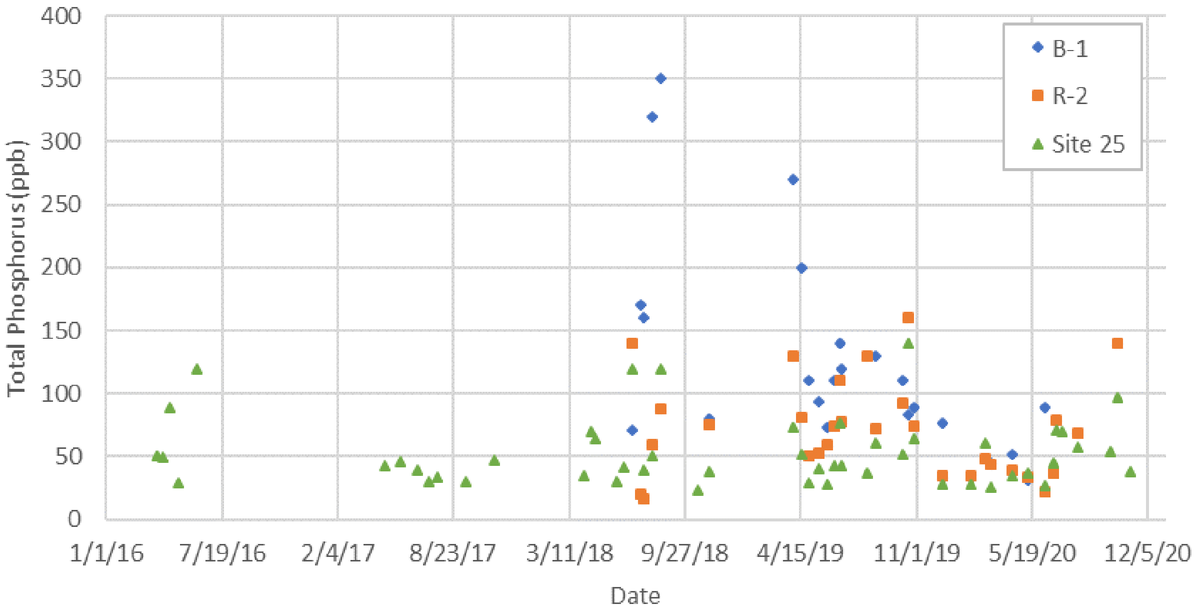
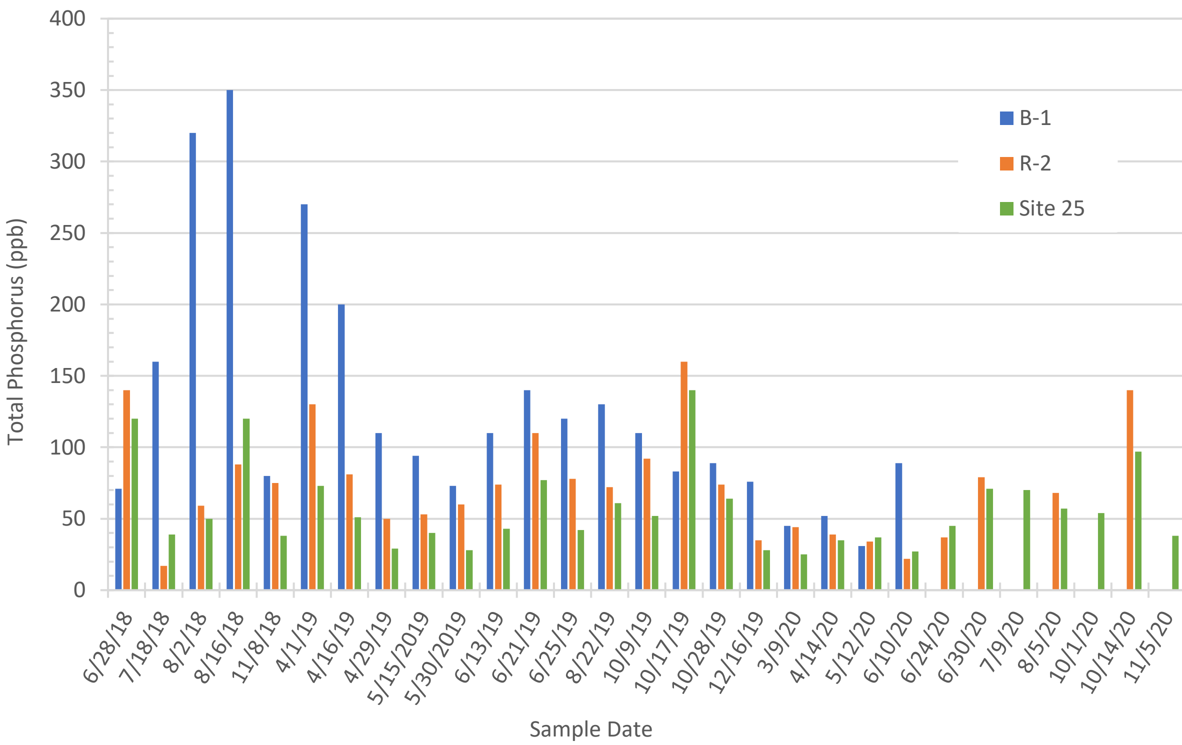


FIGURE 3-2

Total phosphorus concentration in same-day samples from each sampling site



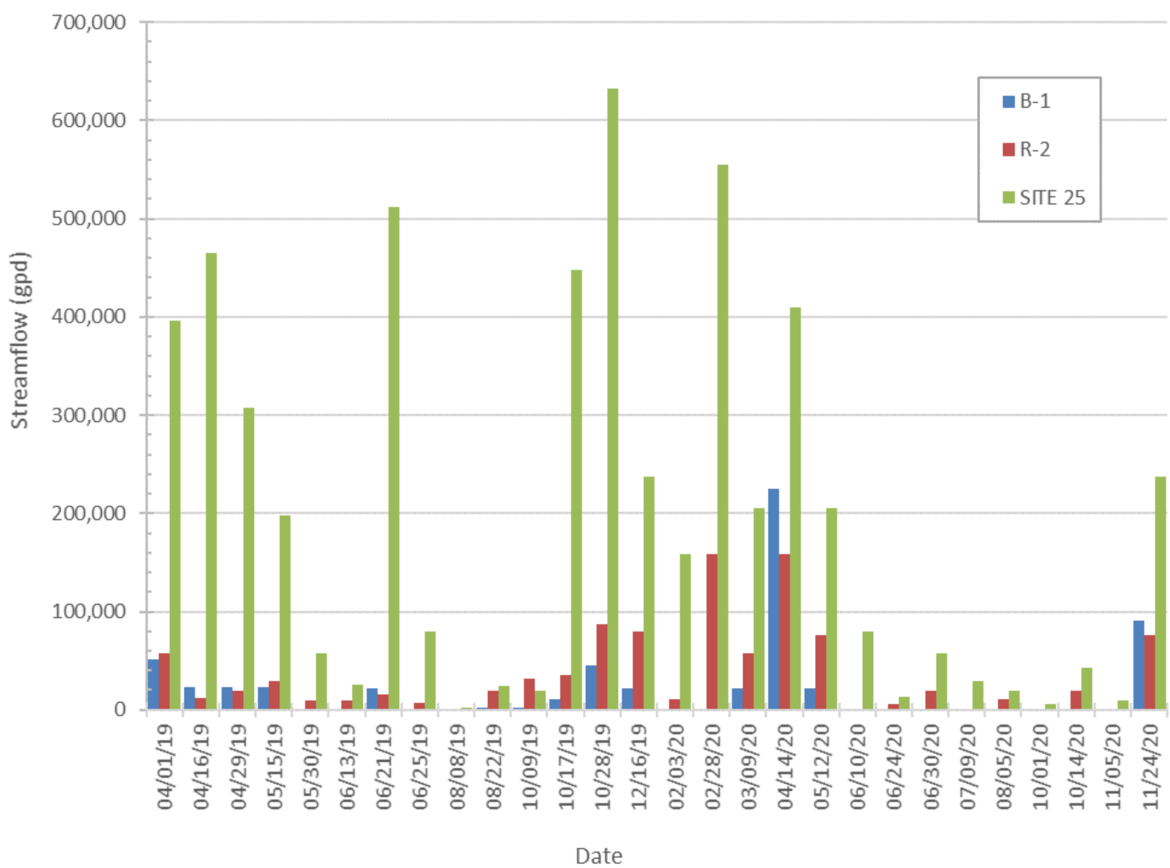
3.2 Streamflow and Precipitation

Streamflow measurements are collected at each location during sampling. Velocity is measured with a meter and water depth is measured in a location with a known diameter. Collecting streamflow data during water quality sampling allows for calculation of phosphorus mass loading (lbs/year). Figure 3-3 shows streamflow measurements from 2019 and 2020. Prior to 2020, flow was only measured at Site 25. Available records show that B-1 and R-2 typically have little to no flow during summer and fall, while Site 25 flows consistently has measurable flow. Figures 3-2 and 3-3 together show that the relative decrease in total phosphorus concentration through the system is less than the relative flow increase through the system.

Review of daily rainfall records for 2019 and 2020 available from the Auburn/Lewiston Municipal Airport (80 Airport Dr, Auburn, Maine) indicate that base streamflow in this system is controlled predominantly by seasonal weather patterns, not significant storm events. Because measured stream flows in this system are only available during the sampling events, peak discharges during storms are not known, and therefore true peak loads to Lake Auburn may be underrepresented.

FIGURE 3-3

Streamflow Measurements taken during 2019-2020

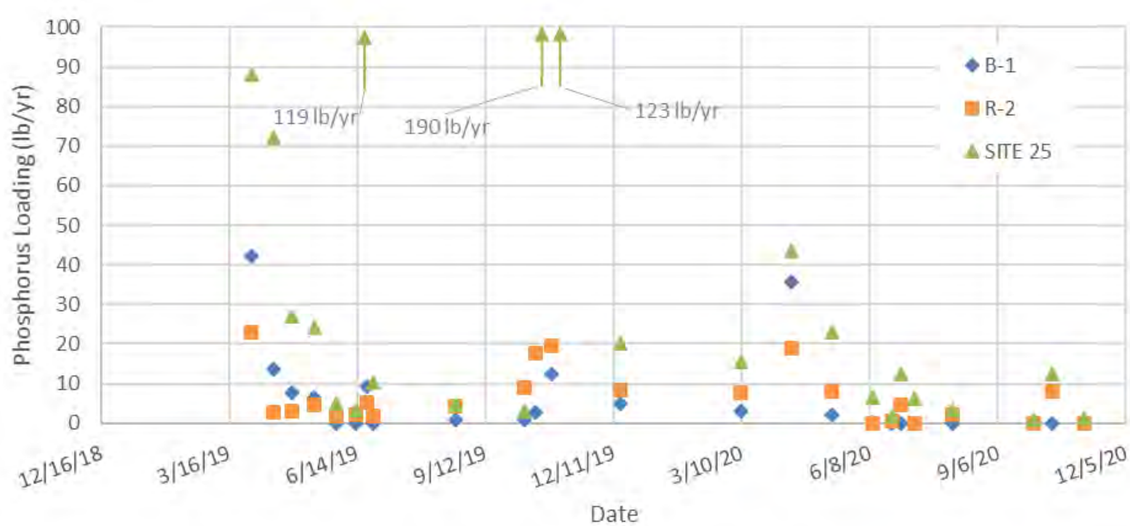


3.3 Phosphorus Loading in the Blanchard Pond Watershed

The total phosphorus concentration data from water quality samples were combined with the flow data by sample date calculate total phosphorus loading (lbs/day) at each location at the time of sampling. Evaluating streamflow and concentration together normalizes the impact on analysis due to effects of dilution. Figure 3-4 shows these results graphically and Table 3-2 provides a summary of the loading results. Generally, Site 25, the final sampling location and indication of load entering Lake Auburn, has the highest calculated phosphorus loading, which is driven by the higher streamflow in this part of the subwatershed as discussed previously in Section 3.2. The maximum phosphorus loading calculated from data collected since 2019 is 34 lb/day from Site 25, which occurred during late October 2019. Low precipitation in summer and fall 2020 resulted in limited loading during the second half of the year, however, a large rain event could overflow Blanchard Pond and/or the residential impoundment east of Route 4 and release a high concentration resulting in a large instantaneous load entering Lake Auburn. Total phosphorus samples for Blanchard Pond have not been collected since June 10, 2020.

FIGURE 3-4

Phosphorus Loading based on routine grab samples and streamflow measurements[1]



[1] The y-axis has been adjusted to highlight loading variations at sites B-1 and R-2. Three datapoints from Site 25 showed phosphorus loading >100 lb/yr and are shown as green arrows indicating sample/measurement date with calculated loading values labeled.

TABLE 3-2
Summary of Phosphorus Loading from each sample location in the Blanchard Pond Stream Watershed

Stream Sample Locations	Drainage Area (acre)[1]	Average Phosphorus Loading Rate		Median Phosphorus Loading Rate		Maximum Phosphorus Loading Rate	
		lb/yr	lb/acre-yr	lb/yr	lb/acre-yr	lb/yr	lb/acre-yr
Blanchard Pond (B-1)	1.2	5.87	4.77	0.77	0.63	42.15	34.24
Turner Rd Crossing (R-2)	18.8	6.35	0.34	4.38	0.23	22.81	1.21
Total (Site 25)	69.6	34.07	0.49	12.46	0.18	190.69	2.74

[1] Subwatershed boundaries are shown in Figure 2-2.

Normalizing the phosphorus loading to each sample site by total drainage area within the Site 25 stream system provides a comparison between subwatersheds to indicate where remediation solutions may be most beneficial. Table 3-2 shows that the Blanchard Pond watershed exports more phosphorus on a per-acre basis than other parts of the stream system. This is not surprising, as most of the drainage area is cleared former pastureland, which creates an environment conducive to overland flow and phosphorus transport. The reduction in loading at the next downstream site provides evidence that the existing system is removing phosphorus between B-1 and R-2. Based on these data and the field observations of both erosion and soils conditions between R-2 and Site 25, increase in both loading and normalized loading per acre is unsurprising, and indicates this is a second area in which to consider remediation alternatives.

3.4 Phosphorus Loading in the Lake Auburn Watershed

The 2010 Lake Auburn Watershed Management Plan calculated total watershed phosphorus loading to Lake Auburn as 1,802 lb/yr (excluding direct precipitation and internal loading). As shown in Table 3-3, average annual loading from the Blanchard Pond and downstream system directly into Lake Auburn (Site 25) is 34 lb/yr, or less than 2% of the total annual phosphorous load to Lake Auburn. When evaluating the median load, this system comprises <1% of the total phosphorus loading to Lake Auburn. Median values are less sensitive to outlier results than statistical means and provide a better representation of loading in typical conditions.

Considering only the average or median load may underestimate the actual load from this system, as it does not include high intensity events that could flush substantial amounts of phosphorus into the lake over relatively short periods of time, and winter rain-over-snow events that can be difficult to sample. These factors add complexity to comparing the loading determined from field measurements in this study to those determined from the loading models used in previous work. Despite the differences in methods it is still useful to use the 2010 model results as a reference for the total phosphorus budget.

This study uses the average loading from Site 25 (34 lb/yr) when comparing the loading calculations from grab sampling results in this study to the whole watershed for consistency (the 2010 Lake Auburn Watershed Study reports average phosphorus loading within the various subwatersheds). Table 3-3 and Figure 3-5 show these comparisons.

Table 3-3 also presents the normalized loads per acre for each watershed, which show a slightly different picture and facilitates understanding of comparative watershed conditions. Figure 3-6 makes this same comparison with subwatershed loading normalized by acre of watershed area.

The phosphorus loading model for the Blanchard Pond and downstream system watershed (based on Site 25 grab sample data) suggests that this system contributes a minor amount of the total phosphorus budget (<2%) but a significant amount when normalized based on contributing drainage area. This identifies potential for watershed improvements around Blanchard Pond and associated the stream but does not indicate that this system is a major driver of increasing phosphorus concentrations in Lake Auburn.

TABLE 3-3
Summary of Total Phosphorus Loading to Lake Auburn by subwatershed

Subwatershed	Land Area (ac)[1]	Phosphorus Load (lb/year)[1]	Percent of Total Load per year	Normalized Phosphorus Load (lb/ac-year)
Blanchard Pond & Downstream System[2]	70	34	1.9%	0.490
Summer Street	189	67	3.7%	0.354
Youngs Corner	229	73	4.1%	0.319
Route 4[3]	276	87	4.9%	0.315
Spring Road	803	218	12.1%	0.271
Little Wilson Pond	838	186	10.3%	0.222
Gracelawn	334	65	3.6%	0.195
Lake shore Drive, East	450	87	4.8%	0.193
North Auburn	537	103	5.7%	0.192
Mud Pond	2214	360	20.0%	0.163
Townsend Brook	1470	235	13.0%	0.160
The Basin	1587	242	13.4%	0.152
Lake Shore Drive, West	240	26	1.4%	0.108
West Auburn Road	176	19	1.1%	0.108
Total	9,413	1,802	100%	0.190

[1] Subwatershed area and loading from 2010 Watershed Study by CEI.

[2] Loading value shown is the average measured daily load at Site 25.

[3] Loading from the Route 4 subwatershed load was decreased proportionally by the load from the Blanchard Pond/downstream system subwatershed, as this subwatershed was included in Route 4 area in the 2010 study.

FIGURE 3-5

Subwatershed Phosphorus Loading in lb/acre

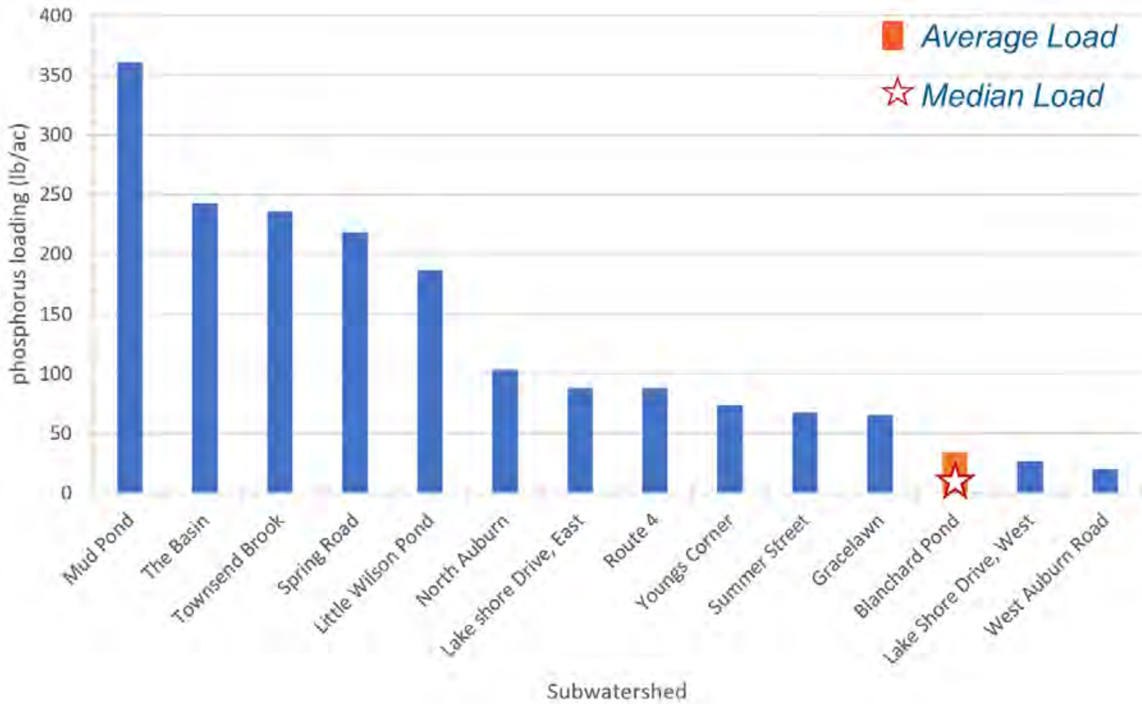
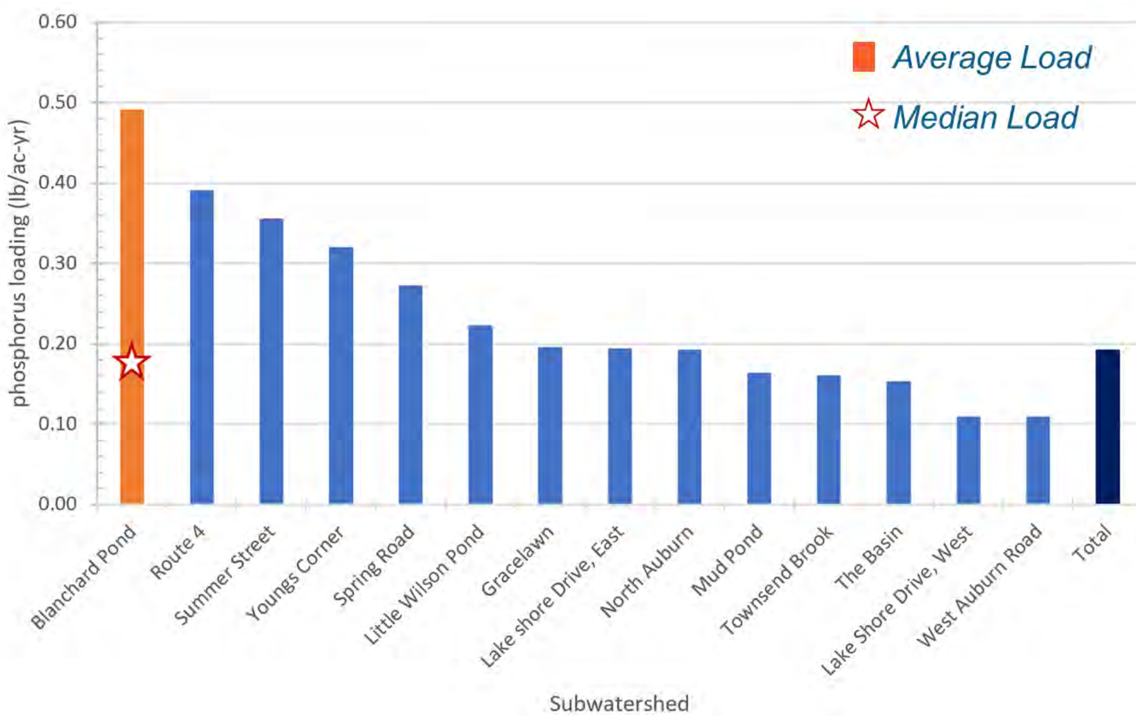


FIGURE 3-6

Subwatershed Phosphorus Loading in lb/acre-yr



Section 4
Phosphorus Remediation Strategies

This section summarizes alternative remediation strategies currently under consideration.

4.1 Remediation Strategy Alternatives and Opinions of Probable Cost

The following table presents alternative remediation strategies for Blanchard Pond and the downstream wetlands and stream system for consideration. Given the specialized nature of the work, estimating true costs may be significantly impacted by contractor availability. The estimated costs (Opinion of Probable Cost or "OPC" in table) are accurate +40% to -25%. All alternatives may require also an Auburn Shoreland permit, which can be determined following refinement of scope of the alternative.

TABLE 4-1
Summary of Alternative Remediation Strategies

Strategy	OPC [1]	Notes
Pond Remediation Alternatives		
Riparian buffer: Installing a riparian buffer around Blanchard Pond is a natural and aesthetic method of controlling nutrient runoff. Native plantings around the pond will serve to slow runoff and take up nutrient loads from the surrounding pasture. The buffer zone will work to decrease the movement of soil, which is a significant form of nutrient transport as phosphorus tends to stick soil particles. In addition to acting as a filter for runoff, the plantings will also take-up nutrients and convert into biomass. Additional advantages include low maintenance cost and potential to discourage Canada Geese.	$10,000 to $20,000	Assumes minimum of 15-foot (Ideally 25-foot) radius of plantings around approximately 2/3 of pond (~10,000 to 20,000 square feet). The planting plan needs to consider existing vegetation and the appropriate integration of new plantings to minimize disturbance and maximize phosphorus uptake. Recommend adding native species and seed (6 to 12 species). One to two weeks of labor. Cost depends on plants selected and final arrangement and spacing. Permitting required including wetlands delineation and report, Army Corps Self Verification, and Maine NRPA Permit by Rule. This work may qualify for NRCS financial support.
Dredging: If pond sediment is a source of phosphorus, dredging the pond is a method of removing the phosphorus-rich upper sediments. Dredging will stir up sediment and proper environmental controls should be in place to prevent downstream release. In addition, access for heavy machinery will likely disrupt the land surround the pond. This alternative should be paired with creating a riparian buffer to repair damaged banks, and prevent continued nutrient accumulation, which could result in needing to routinely re-dredge the pond.	$60,000 to $75,000	Assumes hydroraking method including onsite dewatering, hauling, and 10K allowance for permitting. Potential unknowns/risks are disposal (potential contamination?) and those associated with permitting. Permitting required including wetlands delineation and report, Army Corps PCN, and Maine NRPA Tier 2.

Strategy	OPC [1]	Notes
Alum Addition: As an alternative to dredging, treating the sediment with alum (aluminum sulfate) is another method to control sediment phosphorus loading. As with dredging, this alternative should also be combined with constructing a riparian buffer to prevent continued nutrient loading and prolong the effectiveness of the application.	$5,000	Annual Cost. Cost includes 2-3 applications per year. This is necessary likely for at least 3-5 years because size of pond limits dosing during each application. Unknowns with sedimentation rate and runoff from pasture could require annual dosing indefinitely. The OPC excludes permitting costs, assumes Water District Staff can complete this process given previous work in Lake Auburn.
Aeration: Aeration, either through mixing, bubblers, or fountains, maintains an oxygen saturated water column and prevents the release of phosphorus during anoxia. Aeration systems are common in ponds and can be aesthetically pleasing, however costs associated with operation and maintenance of the system needs to be considered.	$4,000	Consider low cost alternative: solar powered aeration, such as: https://outdoorwatersolutions.com/products/ solar-pond-aerators/ No permits needed. If a permanent solution was desired depending on performance, costs would be greater and require permitting.
Stream Remediation Alternatives		
Removal of Impoundment on 2481 Turner Road: During the site walk, we observed a small wood "dam" that creates an artificial impoundment at this address. There is potential for significant nutrient development in this part of the system and a heavy rainstorm could flush loads downstream.	$5,000 to $7,500	Assumes dam could be removed by hand or with small equipment. Permitting required including wetlands delineation and report, Army Corps Self Verification, Maine NRPA Permit by Rule. Area should be restored, costs associated with that work are included with next item.
Rt. 4 (Turner Rd) Erosion Control & Stream Stabilization: During the site walk, erosion along the northbound shoulder of Rt. 4 (east) was observed. Repair, stabilization, and improved drainage at this location could reduce sediment and nutrient inputs to the Blanchard Pond Stream. In addition, erosion of the stream channel and artificial armoring was observed in the vicinity of Route 4.	$64,000 to $115,000	Assumes 400 linear feet upstream and 400 linear feet downstream stabilized (total of 1600 feet of bank), includes stream restoration for 2481 Turner Road as well. Costs depend on actual extent restored, contractor methods, materials use, etc. Permitting required including wetlands delineation, Army Corps PCN, and Maine NRPA Tier 2.
Rt. 4 (Turner Road) Culvert upsizing: Visible in Photos 11 and 12 (attached), erosion at the culvert outlet west of Rt. 4 provides evidence that the culvert is undersized. Increasing the 24" diameter culvert size and repairing/stabilizing the stream bank at the outlet would help prevent erosion and sediment transport in this part of the stream system. This location has the advantage of being accessible, relative to other parts of the stream, however, Rt. 4 is a state road which could present project challenges, but grants may also be available to perform this work.	Costs are not provided.	Culvert appears to be in satisfactory condition. Due to limited reduction in phosphorus, high cost, and coordination with Maine DOT, alternative not recommended at this time. This could be reexamined if work is proposed in this roadway.

Strategy	OPC [1]	Notes
In-place treatment: In situ stormwater treatment units are available. Typical system design includes filters installed in a manhole. Solids are removed are the water flows through the filter. In the Blanchard Pond stream, Lake Shore Drive has been identified as the ideal location, filtering the water immediately before entering the lake. In our experience, these units can be very effective, but require significant maintenance (cleaning, inspection, filter replacement, etc.). In some applications these units can have issues such as filter blowout if not properly maintained or during high flow events, which can result in significant downstream nutrient releases.	\$150,000 to \$400,000	StormFilter 8 x 14' vault using 24 cartridges containing PhosphoSorb media. The StormFilter with PhosphoSorb media is able to remove over 50% total phosphorus and can achieve over 80% reduction. Costs include unit, media cartridges, installation and road resurfacing. Does not include annual maintenance (including cartridge replacement) costs of approximately \$7,500 to \$10,000. https://www.conteches.com/stormwater-management/treatment/stormwater-management-stormfilter Permitting required including wetlands delineation and report, Army Corps Self Verification, Maine NRPA Permit by Rule.
Other Watershed Management Options		
Additional Non-point sources: As noted in Section 2.1.2, there are of commercial, agricultural, and transportation land uses in the watershed on privately-owned parcels or State-owned land. Structural (infiltration practices, etc.)[2] or non-structural stormwater (sweeping, drainage system cleaning, leaf litter pickup, etc.) management improvements may reduce quantity of runoff, improve quality of runoff, and limit phosphorus loading. Potential improvements would require additional assessments of site-specific conditions and necessitate property owner participation.	Cost will vary considerably based on site and solutions proposed and must consider cost per lbs/year removed.	Treating single sites or smaller drainage areas throughout the subwatersheds can be politically and logistically challenging and therefore specific solutions were not defined in this report. However, opportunities may arise through new or redevelopment and retrofit solutions could be identified through further study and collaboration with private parties.

[1] This is an engineer's Opinion of Probable Cost (OPC). Tighe & Bond has no control over the cost or availability of labor, equipment or materials, or over market conditions or the Contractor's method of pricing. The OPC is made on the basis of Tighe & Bond's professional judgment and experience. Tighe & Bond makes no guarantee nor warranty, expressed or implied, that the bids or the negotiated cost of the Work will not vary from this OPC.
[2] Reference Maine Stormwater Best Management Practices Manual https://www.maine.gov/dep/land/stormwater/stormwaterbmps/

Section 5
Conclusions and Recommendations

While this study has not identified Blanchard Pond as a significant driver of increasing phosphorus concentrations in Lake Auburn, it is unlikely that a single location in the Lake Auburn Watershed is driving water quality changes in the Lake. By framing Blanchard Pond, its subwatershed, and the downstream system and associated subwatersheds in the context of the greater Lake Auburn watershed conditions, remediation efforts can be scaled to match the impact. Based on the evaluation and findings documented in this report, we recommend LAWPC consider following remediation strategies previously presented in Section 4:

1. Install riparian buffer around Blanchard Pond: This is one of the lower cost alternatives and will likely have a beneficial impact on water quality in Blanchard Pond. Improving upstream water quality typically carries downstream to improve water quality and may facilitate reduction in overall annual phosphorus loading to Lake Auburn.

2. Route 4 Erosion Control and Stream Stabilization: Erosion of the roadside and streambank near the Turner Rd (Route 4) culvert would limit sediment transport. This would likely decrease phosphorus mobilization and improve the natural stream systems ability to sequester phosphorus. This recommendation has a variable opinion of probable cost, with a number of unknowns such as permitting, methods, access, and participation of the property owner at 2481 Turner Road. However, LAWPC may be eligible for grants to offset project costs.

In addition to the above remediation alternatives, we recommend:

1. LAWPC Continue Collecting Concentration and Streamflow Data: Sampling and streamflow measurements along the stream system continue so that a consistent and long-term record of water quality can be constructed. It is especially important to gather water quality samples from in Blanchard Pond even if there is no measurable flow as this can help identify potential slug loading when flow resumes. Even during and after completing remediation projects sample should continue as this can help provide insights into project impacts and help guide remediation projects elsewhere in the watershed.
2. Further Investigation into Soils and Sediment Impacts in Final Segment between Route 4 and Lake Shore Drive: Additional sampling of stream sediment between sampling Site R-2 and Site 25 may be helpful to improve understanding and help refine strategies to mitigate loading to the Lake.

Finally, as this study shows, there are other parts of the watershed that export greater amounts of phosphorus to Lake Auburn than the Blanchard Pond system. We recommend that LAWPC continue to study, identify, and remediate other sources of phosphorus to Lake Auburn.

APPENDIX A

Proposed 2020 Blanchard Pond Watershed Sampling Plan

TO: Erica Kidd and Chris Curtis, Auburn Water District

FROM: Heather Doolittle, Jennie Moonan, and Dan Bisson, Tighe & Bond

DATE: May 14, 2020

As part of our ongoing evaluation of the Blanchard Pond Watershed, Tighe & Bond is proposing the following sampling plan for 2020 (Table 1). This plan was designed using on available water quality and streamflow data collected since 2016 by the Auburn Water District and builds on the existing routine sampling performed by Water Treatment Plant personnel at approximately bi-weekly intervals throughout the ice-out season.

TABLE 1

Proposed 2020 Blanchard Pond Sampling Plan

Frequency	Location	Data to be Collected [1]	Comments
Bi-weekly	• B-1 • R-2 • 25	• Streamflow Measurement • Existing Water Quality Parameters: o pH o Temp o Turbidity o Color o Conductivity o Total Dissolved Solids o Total Phosphorus* o Orthophosphate* • *Additional Water Quality Parameters:* o *Total Suspended Solids (TSS)*	Streamflow measurements coinciding with water quality sampling is critical in determining total P transport and loading. The addition of TSS will provide further insight into potential P transport through bank erosion. Correlation of NTU and TSS may provide estimates of TSS where only NTU data is available (historical and post-2020 sampling). We have assumed that the laboratory at the UV Plant is able to run TSS.
Late June, Late August, & Mid-October	• B-1 • R-2 • 25	*In addition to bi-weekly parameters:* • *Alkalinity* • *Total Organic Carbon** • *Dissolved Organic Carbon** • *TKN* • *Nitrate/Nitrite*	Sample frequency for these additional parameters are based on historical data and are designed to capture seasonal shifts in water quality.

[1] Italicized water quality parameters are in addition to those already collected as part of routine watershed sampling.

We assume Water Treatment Plant personnel will submit items marked with an asterisk to the Maine Health and Environmental Testing Laboratory (HETL).

APPENDIX B

Tighe & Bond
Attn: Heather Doolittle
2 Monument Sq – Suite # 302
Portland ME 04101

Email to: **hadoolittle@tighebond.com**

Date Received @ NELabs: **10/09/2020**
(delivered to Lab via client)

Report #: **N2082262**

Report Date: **11/05/2020**

Sample Site:	**BLANCHARD POND**
Sample Description:	**Lake Sediment (0-4")**
Date / Time Sample Collected:	**3/09/2020 10:00** *(as noted on client's chain of custody)*

Client ID#:	Laboratory ID #	Iron Bound Phosphorus	Loosely Bound Phosphorous	Ash / Organic Matter (Solids, Non-Volatile)	Total Solids ♦	Total Phosphorous ♦
Blanchard Pond	2082262 - 01	64.4 mg/kg	9.0 mg/kg	7.59 %	7.39 %	3,220 mg/kg
	Method:	SM4500P	SM4500P	SM2540G	SM2540B-11	SM4500PE-11

♦ = Analysis for Phosphorous and Total Solids was outsourced to & tested by Phoenix Lab#PH0618 / Rpt#: CH03452

Comments:
Results are based on sample, as submitted to Northeast Laboratories, Inc. on: 10/09/2020

Approved by: [signature]
Laboratory Director

APPENDIX C

LEGEND

- Blanchard Pond Stream
- Photo Location
- Inaccessible Area
- Parcels

Tighe&Bond

1. Data shown were collected during June 5, 2020 stream survey.
2. Photographs taken at at the indicated location are presented in the accompanying photo log.
3. 2018 Orthoimagery downloaded from MEGIS
4. Parcel data downloaded from Access Auburn

1:4,200 1 in = 350 ft

0 175 350

Feet

N

BLANCHARD POND
STREAM INVESTIGATION
PHOTO LOCATION MAP

Lake Auburn Watershed Protection Commission
Auburn, Maine

August 2020

J:\L\L5040 Lake Auburn Watershed\Data\Blanchard_Pond.mxd

L-5040

Blanchard Pond Photo Log – 6/5/20 Stream Survey

Photo 1: Northwest-facing view of Blanchard Pond.

Photo 2: Northwest facing view of Bank erosion along Blanchard Rd upstream of the pond. The stone-lined swale directs flow directly into the pond.

Photo 3: South-facing view of the flooded wetland downstream of Blanchard Pond. The 20″ culvert connecting the pond to this wetland was dry at the time of this photo. Green tint on waterbody is pollen cover, not algae, based on site observations.

Photo 4: North-facing view from downstream of the flooded wetland. Thick reed growth and detritus heavily obscured the stream bed although no flow was observed.

Photo 5: Downstream of the reeds, brownish-red standing water was observed in various pools, no flow was observed.

Photo 6: Upstream-facing view of the bridge crossing the stream behind Wallingford Equipment Co. A gravel access road leading to the bridge was observed to the east. Discarded tires and building materials were visible. Standing water did not appear to be flowing.

Photo 7: The stream channel immediately downstream of the bridge showed characteristics of high-flow, evidence by a relatively straight channel with dual bank erosion. This stream morphology was visible for approximately 70 ft before establishing a meandering channel.

Photo 8: The stream again becomes a flooded wetland before crossing Route 4.

Photo 9: An east-facing view from Route 4 showing the flooded wetland prior crossing under the road. Erosion along the side of Route 4 is visible in the foreground and an underground structure of unknown purpose is visible in the center of the photo.

Photo 10: A second east-facing view from Route 4 showing what appears to be a wooden structure damming the stream.

Photo 11: A north-facing view west of Route 4 approximately 10 ft downstream of sample site R-2. An existing rock wall provides bank stabilization directs streamflow south. An eroded slope is visible in the top center of the photo. Standing water was observed in the streambed and culvert.

Photo 12: A south-facing view west of Route 4 approximately overlooking sample site R-2. An existing rock wall provides bank stabilization directs streamflow south. The loose soil visible on the right is on the same eroded slope shown in Figure 11. Photo taken 3/9/2020.

Photo 13: South-facing (downstream) view of the stream approximately 20 ft. The transition from sand to clay is visible in the foreground (refer to Figure 14). This was the first portion of the stream that appeared to be flowing.

Photo 14: Comparison of streambed deposits upstream (left) and downstream (right) where flow was first observed. Sediment changed from red-brown sand to blue clay. This boundary matches closely with the mapped Presumpscot Formation boundary on the Lake Auburn East Quadrangle Surficial Geology map (Open-File No. 08-72, Maine Geological Survey).

Photo 15: Red deposits, potentially indicating iron oxidation, and stream bed erosion downstream of R-2 with observed stream flow.

Photo 16: Upstream-facing view of the stream between Route 4 and Lake Shore Drive. Erosion above the water line provides evidence of past flooding.

Photo 17: A north-facing (upstream) view from Lake Shore Dr shows a flooded wetland as the stream continues to flow towards the lake.

Photo 18: A north-facing view of the stream as it enters Lake Auburn showing visible erosion of the coarse sand channel.

Tighe&Bond

APPENDIX D

TABLE D-1

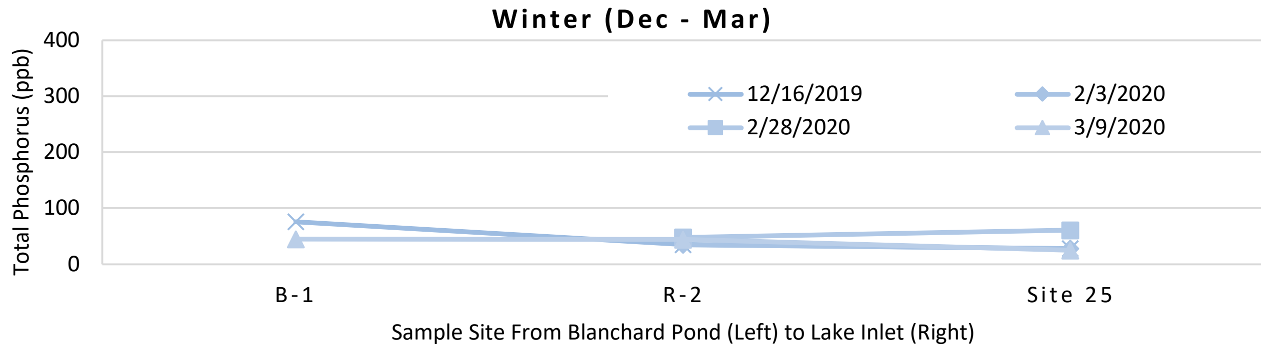
Blanchard Pond Data Summary

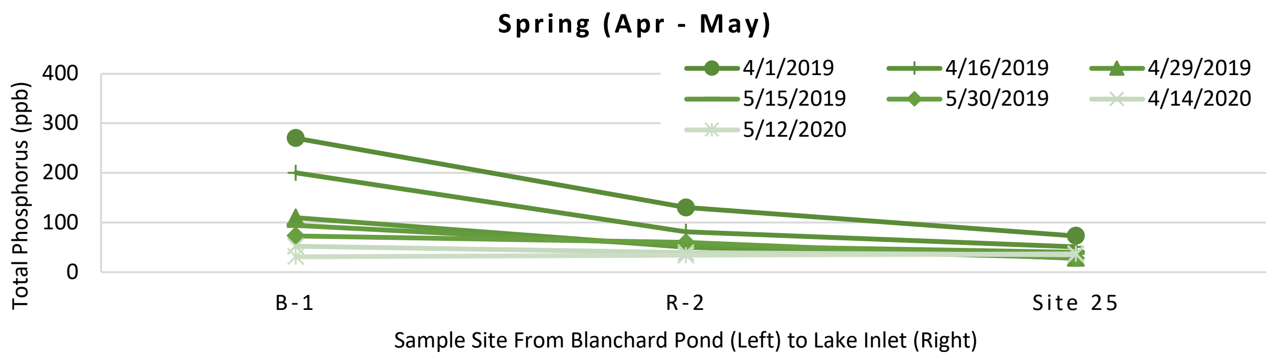
	Precipitation (in)			Streamflow (gpd)			Total Phosphorus (ppb)			Phosphorus Loading (lb/yr)		
Sample Date	7-Day Total	2-Day Total	Sample Day Total	B-1	R-2	SITE 25	B-1	R-2	Site 25	B-1	R-2	Site 25
4/1/2019	0.21	0.21	0.20	51,362	57,738	396,369	270	130	73	42.15	22.81	87.94
4/16/2019	0.70	0.50	0.22	22,554	11,388	464,797	200	81	51	13.71	2.80	72.05
4/29/2019	2.15	1.71	0.00	22,554	19,083	307,076	110	50	29	7.54	2.90	27.07
5/15/2019	1.11	0.41	0.02	22,554	28,869	198,184	94	53	40	6.44	4.65	24.09
5/30/2019	0.92	0.59	0.00	0	9,541	57,738	73	60	28	0.00	1.74	4.91
6/13/2019	0.42	0.27	0.06	0	9,541	25,590	110	74	43	0.00	2.15	3.34
6/21/2019	0.06	0.01	0.00	21,545	15,493	511,794	140	110	77	9.17	5.18	119.78
6/25/2019	0.03	0.01	0.01	0	7,592	79,274	120	78	42	0.00	1.80	10.12
8/8/2019	0.45	0.45	0.45	0	178	1,908	--	130	37	--	--	--
8/22/2019	1.49	0.91	0.50	2,118	19,083	24,815	130	72	61	0.84	4.18	4.60
10/9/2019	1.63	1.05	0.00	2,118	31,684	19,083	110	92	52	0.71	8.86	3.02
10/17/2019	1.43	1.42	1.41	10,187	35,950	448,137	83	160	140	2.57	17.48	190.69
10/28/2019	0.71	0.11	0.00	45,108	86,607	632,641	89	74	64	12.20	19.48	123.06
12/16/2019	3.60	2.86	0.00	21,545	79,274	237,821	76	35	28	4.98	8.43	20.24
2/3/2020	0.00	0.00	0.00	0	10,561	158,548	--	35	28	--	--	--
2/28/2020	1.28	1.27	1.09	0	158,548	554,916	--	48	61	--	--	--
3/9/2020	0.21	0.00	0.00	21,545	57,738	204,717	45	44	25	2.95	7.72	15.56
4/14/2020	2.32	1.11	0.99	225,540	158,548	409,435	52	39	35	35.65	18.79	43.55
5/12/2020	0.39	0.25	0.24	21,545	76,330	204,717	31	34	37	2.03	7.89	23.02
6/10/2020	0.61	0.00	0.00	262	168	79,274	89	22	27	0.07	0.01	6.51
6/24/2020	0.00	0.00	0.00	0	5,281	13,415	--	37	45	0.00	0.59	1.83
6/30/2020	4.35	4.34	1.63	0	19,083	57,738	--	79	71	0.00	4.58	12.46
7/9/2020	1.84	1.41	1.41	0	0	28,869	--	--	70	0.00	0.00	6.14
8/5/2020	0.85	0.61	0.61	0	10,561	19,083	--	68	57	0.00	2.18	3.31
10/1/2020	1.18	1.09	0.22	0	0	5,281	--	--	54	0.00	0.00	0.87
10/14/2020	1.95	1.63	1.63	0	19,083	42,245	--	140	97	0.00	8.12	12.45
11/5/2020	0.02	0.00	0.00	0	0	9,541	--	--	38	0.00	0.00	1.10
11/24/2020	1.19	1.19	0.96	90,216	76,330	237,821	--	--	--	0.00	0.00	0.00

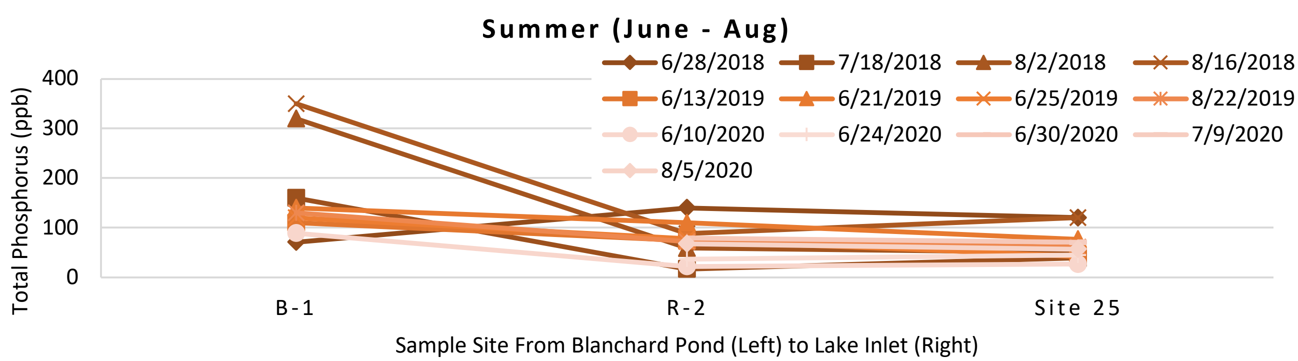
J:\L\L5040 Lake Auburn Watershed\Data\WaterQuality_Dec2020.xlsx
2/17/2021

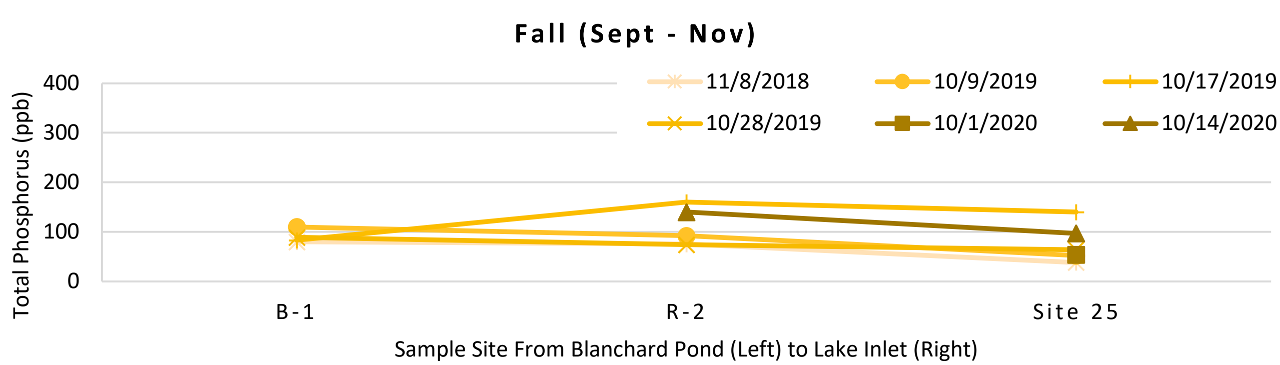
FIGURE D-1

Seasonal Total Phosphorus Concentration in Blanchard Pond Stream









www.tighebond.com

100% Recyclable