Bantam Lake

2023 Watershed Monitoring Report

Report to the Bantam Lake Protective Association,
Morris, CT

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TABLE OF CONTENT

Page

I. Introduction

Bantam Lake has been studied extensively over the past decade in an attempt to identify significant sources of nutrients that have led to increased eutrophication and cyanobacteria levels. These increases have led to public health concerns related to use of the lake for recreational swimming, wading, and boating. Restoration efforts in Bantam Lake greatly benefited from the development of a *Connecticut Statewide Lake Nutrient Total Maximum Daily Load Core Document* by the CT DEEP (2021a). That document listed the State's water quality standards, identified nutrient pollution sources to lakes, and established a planning process by which nutrient budgets for lakes could be established through *total maximum daily loading* (TMDL) analyses.

In 2021, CT DEEP initiated a TMDL study specifically for Bantam Lake, documented in Appendix 1 of the Core Document (CT DEEP 2021b). This TMDL assessment identified nutrient sources within the Bantam Lake watershed and the lake itself, offering preliminary recommendations for watershed-based restoration. The high-level recommendations for watershed-based restoration were expanded upon and are detailed in the Watershed-Based Plan for Bantam Lake (see below). The Bantam Lake TMDL Appendix also provided a framework for a water quality monitoring program designed to establish baseline data and evaluate the effectiveness of watershed restoration efforts.

In conjunction with a TMDL analysis, a *Watershed-Based Plan* to restore Bantam Lakes source waters and achieve compliance with the water quality goals established for the waterbody was developed (CEI 2021). Detailed recommendations in the Water-Based Plan were to implement structural *Best Management Practices* (e.g. culvert replacements and erosion controls) and to develop a monitoring program to assess changes in water quality resulting from project implementations.

In 2021, the Bantam Lake Protective Association (BLPA) sought the development of a Quality Assurance Project Plan (QAPP) to standardize and memorialize a lake and watershed monitoring program based on the framework established in the Bantam Lake TMDL Report. That work was initiated by Aquatic Ecosystem Research, LLC in 2022 and completed by Brawley Consulting Group (BCG) in October of 2023 following subsequent revisions based on reviews by the BLPA and CT DEEP. Prior to the completion of the QAPP, BCG was asked to begin collecting data from watershed sites in conjunction with the lake water quality monitoring that it was already performing. Watershed monitoring commenced in May of 2023. Many of the methods in the final QAPP were incorporated into on-going lake and watershed monitoring efforts in 2023 even though the QAPP had not been completed.

This report consolidates data collected from the 2023 watershed monitoring efforts and provides an assessment of phosphorus and nitrogen loading to Bantam Lake, including contributions from the lake's sub-watersheds (See Figure 1).

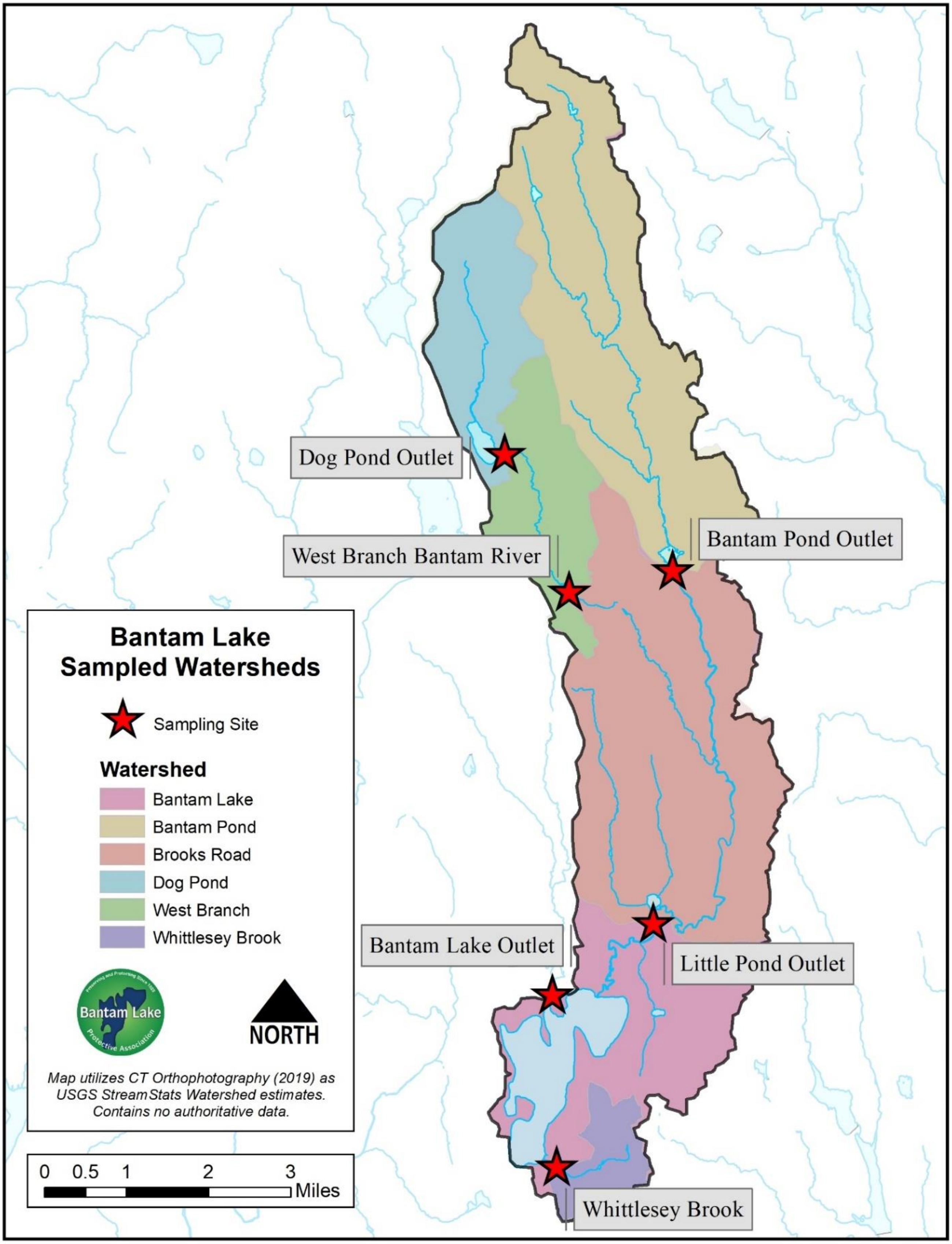

Figure 1. Map of the Bantam Lake watershed, subsheds and sampling sites

A. Site Description

Bantam Lake is a 966-acre waterbody located in the Towns of Litchfield and Morris, Connecticut and is the largest natural lake in the State. The lake has a maximum depth of 7.6 meters, a mean depth of 4.4 meters, and an estimated volume of 16,120,000 cubic meters (Canavan and Siver 1995). Geologically, the lake and watershed are situated in the Western Uplands of Connecticut (Bell 1985, Canavan & Siver 1995). That region has an erosion resistant, crystalline bedrock comprised of schists, gneiss, granite gneiss, and granofels (Healy & Kulp 1995). Surficial materials are glacial till to thick till with moderate to well drainage soils and with a fragipan (hard pan) present on uplands (CTECO 2010, Stone et.al. 1992).

The watershed of Bantam Lake is 20,218 acres, which equates to a large watershed to lake ratio of approximately 23 (Canavan & Siver 1995). In a 1995 survey, land use was characterized as mainly deciduous forest and agriculture lands with smaller areas of medium-density residential land use, wetlands, and coniferous forests (Healy & Kulp 1995). Analysis of watershed land cover conducted by AER utilized 2016 aerial photography and delineated a composition of approximately 53% forested, 16% agricultural fields, 15% developed, and 9% wetlands (AER 2018). Most of the southern shoreline is lined with homes, beaches, and several camps. Conversely, the northern shoreline and northeastern cove is dominated by open space, with a large portion of the shoreline owned by the White Memorial Foundation.

II. Methods

Six sites in the Bantam Lake watershed (Fig. 1) were visited monthly during 2023. Sampling occurred on the following dates: May 7th, June 1st, July 11th, August 9th, September 6th, and October 10th. A standardized approach was used, and samples were collected for laboratory analysis in addition to in-situ monitoring. Measurements of temperature (°C), dissolved oxygen (mg/L), % oxygen saturation (%), relative phycocyanin (µg/L), specific conductance (µS/cm), and pH (standard units) were performed from the shoreline using a Eureka Manta II Multiprobe meter.

Laboratory samples were collected during each visit as near to the middle of the watercourse as possible using a 500 mL sampling cup on the end of a 6-foot pole, transferred to lab-provided, sterile plastic sampling containers, and stored in an ice-filled cooler. Samples collected from May through July were transported in the cooler to York Environmental Laboratory in Newtown, CT on the same day they were collected. All *E. coli* samples collected in August through October were delivered in an iced cooler to York Environmental Laboratory on the same day as collected. All other samples collected in August through October were kept on ice until they were frozen at Brawley Consulting Group facilities and later taken to the laboratories of the University of Connecticut Center for Science and Engineering (UCONN CESE).

The discharge rates at each site were estimated using the Watershed Area Ratio Method (Gianfagna et.al. 2016) that is detailed in the *Bantam Lake and Watershed QAPP*. USGS gaging data was used as a surrogate for flow at each of the watershed sampling sites. The surrogate watershed used for the Bantam Pond Outlet, Dog Pond Outlet, West Branch Bantam River, and Whittlesey Brook subsheds was the Bunnel Brook Watershed (USGS 2024a), which is gaged for flow by USGS in Burlington, CT. The surrogate for the Bantam Lake Outlet and Little Pond Outlet subsheds was the Nepaug River Watershed (USGS 2024b) upstream of the Nepaug reservoir in Nepaug, CT. Estimated discharge rates were converted from cubic feet per second to liters per day for computation with laboratory values reported in mg/L.

Total phosphorus, ammonia, total Kjeldahl nitrogen (TKN), nitrate, nitrate were measured in collected samples by York Environmental in mg/L. The latter three analytes were used to determine total nitrogen for each sample. UCONN CESE analyzed and reported results for total phosphorus and ammonia in mg/L. Total nitrogen was determined by UCONN CESE without measuring TKN, nitrate, and nitrite, and therefore reported only as total nitrogen. All measurements were converted to kg/L, and then multiplied by the discharge rate to determine loading rates in kg/day. All analyses of *E. coli* were performed by York Environmental.

To estimate the daily loading from the specific drainage area for each sampling site, the daily load determined at upstream sites were subtracted from the daily load of the downstream site. For example, the estimated daily load from the Dog Pond Outlet (DPO) site was subtracted from the corresponding daily load at the West Branch of the Bantam River (WBBR) site to assess nutrient export from the area of the watershed between the two sites (aka *corrected daily load*). Similarly, to determine the corrected daily loading at the Little Pond Outlet (LPO), the daily loads from WBBR and the Bantam Pond Outlet (BPO) site were subtracted out of the LPO load. The corrected daily loads estimated from the individual watersheds, i.e., areas between adjacent sampling sites, were also standardized by area, i.e., dividing the corrected daily loads by acres of the sub-watersheds.

Differences among site averages for the field variables and total phosphorus and total nitrogen concentrations, daily loading, corrected daily loading, corrected daily loading standardized to area were tested using Analysis of Variance (ANOVA) or the Kruskal Wallis Test depending upon normality of the data. Normality was checked with the Shapiro-Wilk Test. Datasets that were non-parametric were analyzed with the Kruskal Wallis Test.

III. Results

A. Watershed Analysis

The area of the entire drainage basin and subsheds therein were estimated using USGS StreamStats (USGS 2024c) and sampling points recommended in the Bantam TMDL document. The three larger subsheds were 2X to 3X the size of the three smaller subsheds (Fig. 2). The larger subsheds were identified as Bantam Pond Outlet, Little Pond Outlet, and Bantam Lake Outlet and were approximately 5.5, 6.7, and 4.3 thousand acres, respectively. The smaller subsheds were the Whittlesey Brook Inlet, West Branch Bantam River, and Dog Pond Outlet at 0.7, 1.8, and 2.0 thousand acres, respectively.

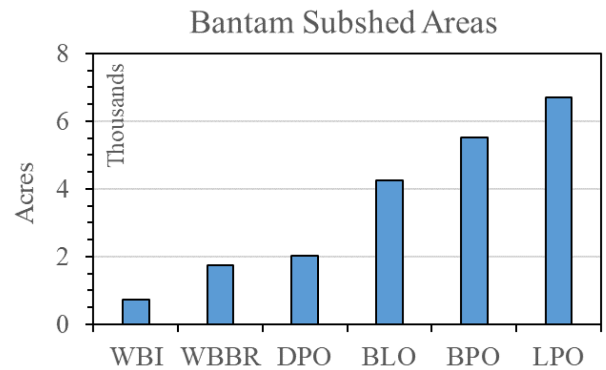

Figure 2. Estimated area of six subsheds within the Bantam Lake watershed based on USGS StreamStats and sampling points recommended in the Bantam TMDL. WBI = Whittlesey Brook Inlet; DPO = Dog Pond Outlet; WBBR = West Branch of Bantam River; BPO = Bantam Pond Outlet; LPO = Little Pond Outlet; and BLO = Bantam Lake Outlet.

B. In-Situ Measurements

1. Temperature

Statistically significant differences were not observed among the average season temperatures for the six sites. The highest average temperatures were observed at the Bantam Lake Outlet and Dog Pond Outlet sites at 20.0 and 20.4 °C, respectively. Site average temperatures at three sites – Bantam Pond Outlet, Little Pond Outlet, and West Branch Bantam River – were between 18 – 19 °C. The Whittlesey Brook average was 15.5 °C.

The lowest water temperatures were measured in May and October. Site temperatures in May were between 14 and 16 °C, except for the Whittlesey Brook Inlet which was 11.3 °C. In October, temperatures were between 11.8 and 14.7 °C. Most temperature measurements in June – September were between 20 and 24 °C, except at the Whittlesey Brook inlet site where the range for that period was 12.8 – 19.3 °C.

2. Specific Conductance

Specific conductance is a surrogate measurement for the ion concentration in water and indicative of dissolved salts, minerals, and metals concentrations. Site averages were lowest at the Whittlesey Brook Inlet and Bantam Pond Outlet sites at 150 and 153 µS/cm, respectively. Three sites – Bantam Lake Outlet, Little Pond Outlet, and Dog Pond Outlet – exhibited season averages between 191 and 210 µS/cm. The highest season average of 259 µS/cm was from the West Branch Bantam River site (Fig. 3).

Statistically significant differences did exist among the site averages. The West Branch Bantam River site average was significantly greater than the Bantam Pond Outlet and Whittlesey Brook Inlet sites ($p<0.005$), but not significantly greater than the other sites.

3. Dissolved Oxygen

The lowest dissolved oxygen concentration of 1.7 mg/L was recorded at the Bantam Lake Outlet in August and September while highs of 10+ mg/L were recorded at several sites in May and October. The low concentrations could be a result of late season oxygen depletion and subsequent downstream discharge. The Bantam Lake Outlet site also exhibited the widest range of concentrations with a high of 9.5 mg/L recorded in May. That site also exhibited the lowest season average at 5.1 mg/L. Highest season averages were observed at Bantam Pond Outlet and Whittlesey Brook Outlet at 8.6 and 9.2 mg/L, respectively. Averages at the other sites were between 5.7 and 7.9 mg/L (Fig. 3).

There was a significant difference ($p<0.05$) between the season averages of the Bantam Lake Outlet and Whittlesey Brook Inlet sites. The difference between the Bantam Lake Outlet and Bantam Pond Outlet sites was just below the threshold for being significant. No other significant differences were observed among the season averages at the other sites.

4. Percent Oxygen Saturation

Percent oxygen saturation is a measure of the amount of oxygen in the water relative to the amount it could contain at 100% saturation which varies with temperature of the water. In general, oxygen concentrations at 100% saturation decrease as water temperatures increase since warming decreases the solubility of oxygen in water.

Results from analyses of percent oxygen saturations were similar to dissolved oxygen concentrations. The lowest percent saturations were recorded at the Bantam Lake Outlet site in August and September at approximately 20%. Supersaturated conditions (% saturation >100%) were observed at the Bantam Pond Outlet, Dog Pond Outlet, and Whittlesey Brook Inlet sites in May, as well as at the Bantam Lake Outlet and Dog Pond Outlet sites in June. The Bantam Lake Outlet site exhibited the lowest season average at approximately 56%. The highest season averages were at the Bantam Pond Outlet and Whittlesey Brook Inlet sites, both at approximately 93%. The Dog Pond Outlet site was also relatively high at 88%. The season averages at the Little Pond Outlet and West Branch Bantam River sites were 61 and 66%, respectively.

Similar statistical differences were observed among site averages. The Bantam Lake Outlet average was significantly lower ($p<0.05$) than the Bantam Pond Outlet average and the Whittlesey Brook Inlet averages. The variability for the Bantam Lake Outlet was much greater than those for the Bantam Pond Outlet and Whittlesey Brook meaning that there was a wider range of measures at the Bantam Pond Outlet (20% – 103%) compared to the other two sites (collectively, 83% – 105%; see error bars in Fig 3).

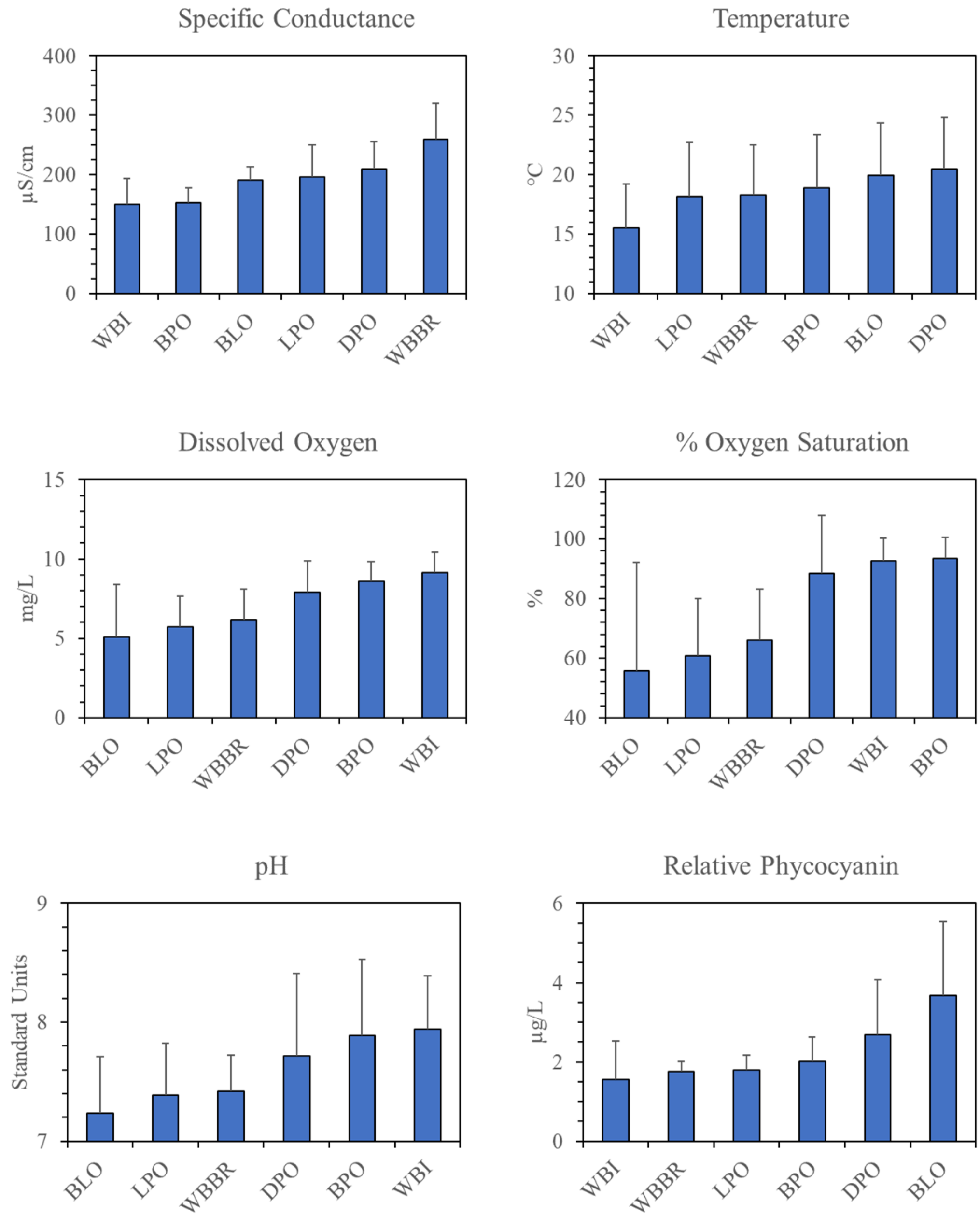

Figure 3. Site averages for in-situ measurements of specific conductance, water temperature, dissolved oxygen, percent oxygen saturation, pH and relative phycocyanin. Sites ordered from lowest to highest average for each parameter. Error bars are standard deviation. BLO = Bantam Lake Outlet, BPO = Ball Pond Outlet, DPO = Dog Pond Outlet, LPO = Little Pond Outlet, WBBR = West Branch of Bantam River, and WBI = Whittlesey Brook Inlet.

5. pH

The pH measurements from all sites throughout the season ranged between 6.8 recorded from the Bantam Lake Outlet in July, to 9.1 recorded from the Bantam Pond Outlet site in October. Site averages, which were not significantly different ($p>0.05$), were lowest at the Bantam Lake Outlet site at 7.2, and highest at the Bantam Pond Outlet and Whittlesey Brook sites at 7.9.

6. Relative Phycocyanin Concentration

Phycocyanin is an auxiliary photosynthetic pigment unique to the cyanobacteria and relative concentrations were measured at the sites with a fluorimeter incorporated into the sensor array of the Eureka Manta II multiprobe. Fluorimeters work on the principle that a particular substance fluoresces at a specific wavelength when light of another wavelength is directed on that substance. The fluorimeter in our instrumentation emits a wavelength that interacts with phycocyanin. This sensor is not calibrated with known concentrations of phycocyanin, so measurements are not quantitative; instead, the measurements are relative to other measurements and to measurements on other dates.

Unlike field measurements discussed above, the number of relative phycocyanin measurements at each site were not equal (6). The nature of fluorimetry can result in outliers which were not used in ANOVA and calculation of means and standard deviations. The Bantam Lake Outlet, Bantam Pond Outlet, and Whittlesey Brook sites did have six measurements; because of outliers, the Little Pond Outlet had five measurements; and the Dog Pond Outlet and West Branch of the Bantam River site had four measurements.

The site with the greatest average was the Bantam Lake Outlet at 3.7 µg/L, followed by the Dog Pond Outlet at 2.7 µg/L. All other site averages were between 1.5 and 2.0 µg/L. The Bantam Lake Outlet average was significantly higher than the Whittlesey Brook Inlet average ($p<0.05$) but not greater than averages at the other sites.

The greatest season variability was observed at the Bantam Lake Outlet site where the season high and season low of 6.9 and 1.8 µg/L were measured in May and June, respectively. Measurements at the Dog Pond Outlet that were not outliers ranged between 1.8 and 4.7 µg/L, and measured in June and September, respectively. The site with the least variability was the West Branch Bantam River site where measurements ranged from 1.4 and 2.0 µg/L measured in August and September, respectively. The lowest measurement throughout the watershed was from the Whittlesey Brook Inlet site at 0.4 µg/L measured in June; that site's season high was 3.2 µg/L measured in July.

All field and laboratory data are provided in Appendix A

C. Discharge Rates

The discharge rates for the surrogate watersheds and the estimated discharge rates for the Bantam Lake subsheds are provided in Table 1. Surrogate discharge rates were used in combination with the surrogate watershed size / Bantam subshed size ratios to estimate discharge at the Bantam Lake watershed sites.

D. Total Phosphorus

All raw laboratory data is presented in Appendix B. Similar to the analyses of field data, total phosphorus and total nitrogen data were assessed by calculating site means and standard deviations. Calculations were made for the following: concentration, daily loading, corrected daily loading, and corrected daily loading standardized by area. In determining average corrected daily loading, the daily loading at upstream sites were subtracted from daily loading at downstream sites. Those were standardized by area by dividing average corrected loading at a site by corresponding area in acres. Site differences among the six sites for the four variables were assessed using Kruskal Wallis Test due to the lack of normal distribution for the datasets.

Table 1. Discharge rates on the 2023 Bantam Lake Watershed sampling dates for Bunnel Brook and Nepaug River USGS gaging stations and the estimated discharge rates at the Bantam Lake Watershed sites. The Bunnel Brook discharge rates were used to estimate the discharge rates at the Bantam Pond Outlet, Dog Pond Outlet, West Branch Bantam River, and Whittlesey Brook Inlet sites; the Nepaug River discharge rates were used to estimate the discharge rates at the Bantam Lake Outlet and Little Pond Outlet sites.

Date	Bunnel Brook (Surrogate)	Bantam Watershed Site Estimates			
		Bantam Pond Outlet	Dog Pond Outlet	West Branch Bantam River	Whittlesey Brook Inlet
	Cubic Feet per Second				
7-May-23	9.4	19.3	7.0	13.2	9.4
1-Jun-23	3.4	7.0	2.5	4.7	3.4
11-Jul-23	6.9	14.2	5.2	9.6	6.9
9-Aug-23	4.4	9.1	3.3	6.2	4.4
6-Sep-23	2.3	4.6	1.7	3.2	2.3
10-Oct-23	9.5	19.5	7.1	13.3	9.5

Date	Nepaug River (Surrogate)	Bantam Watershed Site Estimates	
		Bantam Lake Outlet	Little Pond Outlet
	Cubic Feet per Second		
7-May-23	46.7	65.5	49.9
1-Jun-23	13.3	18.6	14.2
11-Jul-23	139	194.8	148.5
9-Aug-23	28.1	39.4	30.0
6-Sep-23	9.25	13.0	9.9
10-Oct-23	54.4	76.3	58.1

1. *Concentrations*

Site average total phosphorus concentrations were lowest at the Dog Pond Outlet Site at 18.8 µg/L and highest at the Little Pond Outlet Site at 32.5 µg/L (Fig. 4). Averages at the other four sites were between 24.4 and 28.7 µg/L. Site variability was greatest at the West Branch Bantam River site where a season low of 10 µg/L was reported in May and July, and a season high of 60 µg/L was reported in June (Fig. 4). Season averages among sites were not significantly different ($p>0.05$).

2. *Daily Loading*

Average daily total phosphorus loading was highest at the Bantam Lake Outlet and Little Pond Outlet sites at 4.1 and 4.3 kg/day, respectively. The West Branch Bantam River and Bantam Pond Outlet sites exhibited the next highest daily averages at 0.5 and 0.8 kg/day, respectively. The Dog Pond Outlet and Whittlesey Brook Inlet sites exhibited the lowest daily averages at approximately 0.1 and 0.2 kg/day, respectively.

There were statistically significant differences among site averages. The Bantam Lake Outlet and Little Pond Outlet daily loading averages were significantly greater than the averages for the Dog Pond Outlet, West Branch Bantam River, and Whittlesey Brook Inlet sites ($p<0.05$). The Bantam Pond Outlet average was significantly higher than the Dog Pond Outlet and Whittlesey Brook Inlet averages ($p<0.05$). The Whittlesey Brook Inlet average was significantly lower than all other site averages except for the Dog Pond Outlet site.

Variability among average daily loading rates was notably higher at the Bantam Lake Outlet and Little Pond Outlet sites with both having season minimums of <1 kg/day and season maximums of 11.4 and 14.5 kg/day, respectively. Season maximums at the other sites were <1.5 kg/day.

3. Corrected Daily Loading

Average daily loading rates did not change at the Bantam Pond Outlet, Dog Pond Outlet, or Whittlesey Brook Inlet sites when corrected for subshed specific loading since there were no site loads above those to deduct. The Little Pond Outlet corrected loading average decreased by 1.3 kg/day after deducting average daily loading from the Bantam Pond Outlet and West Branch Bantam River sites but continued to have the greatest average and standard deviation among all sites. The West Branch Bantam River loading average decreased from 0.5 to 0.3 kg/day when loading rates at Dog Pond were subtracted out.

The corrected average daily loading at the Bantam Lake Outlet site exhibited the greatest change when loadings from the Little Pond Outlet and Whittlesey Brook sites were subtracted out. When corrected, the Bantam Lake Outlet average loading rate decreased from 4.1 to approximately -0.4 kg/day. Corrected loading at this site had a season high of 0.6 kg/day in October, and a season low of -3.3 kg/day in July.

Based on the Kruskal Wallis Test, the average corrected daily loading for Bantam Pond Outlet was significantly greater than the averages for all other sites other than the Little Pond Outlet site ($p<0.05$). The Little Pond Outlet site average was not significantly different from the average at the West Branch Bantam River, but significantly different from the from the Bantam Lake Outlet, Bantam Pond Outlet, Dog Pond Outlet, and Whittlesey Brook Inlet site averages.

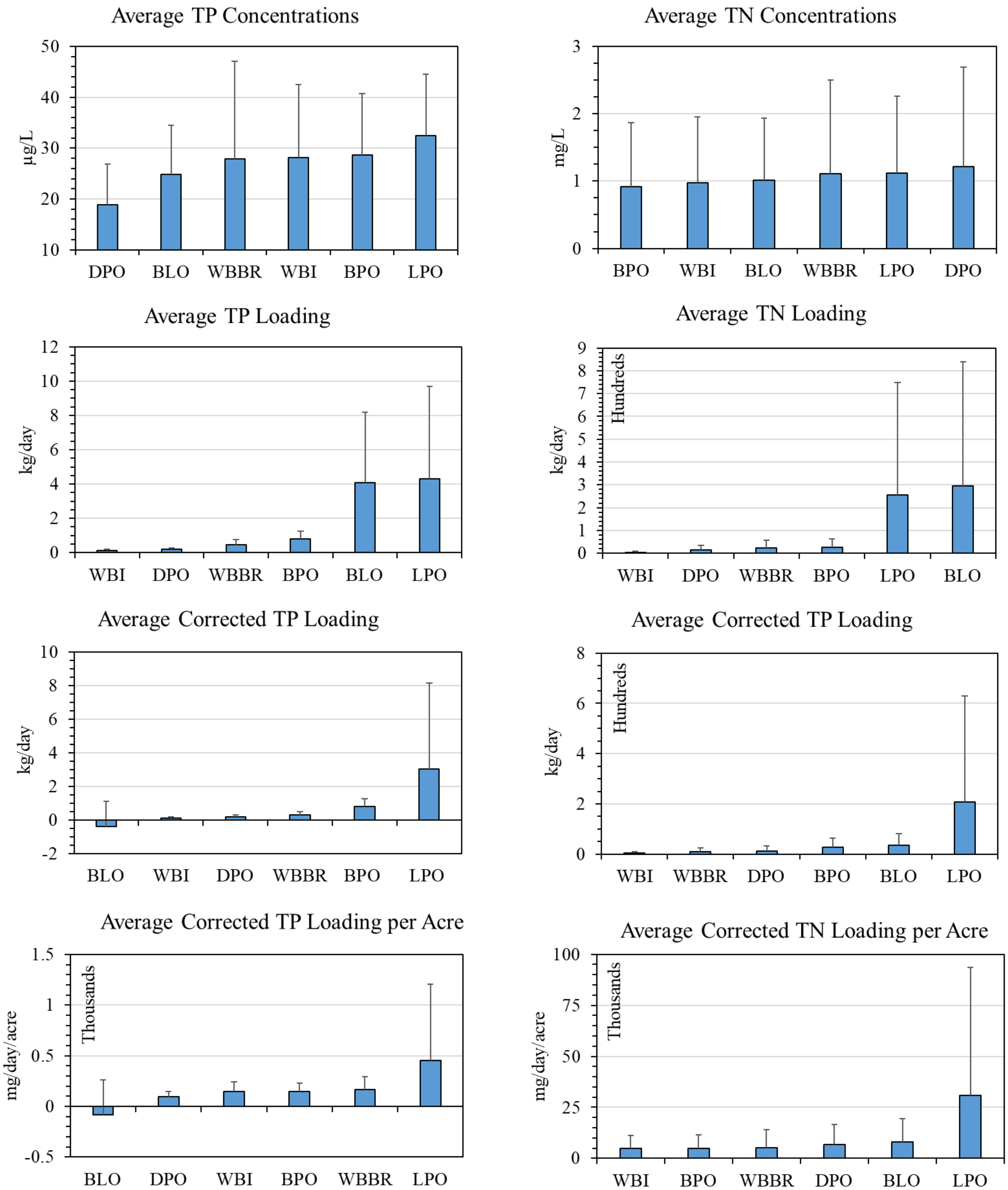

Figure 4. The 2023 average total phosphorus (TP, left) and average total nitrogen (TN, right) concentrations, daily loadings, corrected daily loadings, and corrected daily loadings standardized by acres at the six sites (see text). For each plot, sites are arranged in ascending order from left to right. BLO = Bantam Lake Outlet, BPO = Bantam Pond Outlet, DPO = Dog Pond Outlet, LPO = Little Pond Outlet, WBBR = West Branch Bantam River, and WBI = Whittlesey Brook Inlet. Error bars = standard deviation.

4. *Corrected Daily Loading Standardized by Acres*

When standardized for area in acres, the average corrected daily total phosphorus loading at Little Pond Outlet of 452 mg/day/acre was approximately 2.7 times greater than the next highest average from the West Branch Bantam River site. Averages for West Branch Bantam River, Bantam Pond Outlet, and Whittlesey Brook were similar at 168, 147, and 143 mg/day/acre, respectively. The Dog Pond Outlet average was slightly lower at 96 mg/day/area. The Bantam Lake Outlet average was -87 mg/day/acre.

The variability of standardized corrected loading rates was greatest at the Little Pond Outlet site that had a maximum of 1,968 mg/day/acre and minimum of 27 mg/day/acre. Bantam Lake Outlet also exhibited a wider range of standardized corrected loading rates with a maximum of 148 mg/day/acre and minimum of -765 mg/day/acre. Dog Pond Outlet and Bantam Pond Outlet exhibited the least variability (Fig. 4).

No statistically significant differences were determined among the site standardized, corrected loading averages based on the Kruskal Wallis Test.

E. Total Nitrogen

1. *Concentrations*

Results from total nitrogen analyses mirrored those from total phosphorus analyses (Fig. 4). Like total phosphorus concentrations, there were no significant differences among the total nitrogen concentration averages among the six sites. All average concentrations were within 0.3 mg/L of each other, and variability was high at all sites (Fig. 5). The Bantam Pond Outlet site had the lowest average concentration at 0.92 mg/L while Dog Pond Outlet site had the highest at 1.22 mg/L.

2. *Daily Loading*

The Bantam Lake Outlet and Little Pond Outlet total nitrogen daily loading averages of 294.3 and 256.2 kg/day, respectively, were significantly higher than the averages from the Dog Pond Outlet, West Branch Bantam River, and Whittlesey Brook Inlet sites of 13.4, 22.5, 3.8 kg/day, respectively based on Kruskal Wallis Test. Except for the Dog Pond Outlet average, the Whittlesey Brook Inlet average was significantly lower than the averages at all other sites including the Bantam Pond Outlet site with an average of 27.3 kg/day.

The lowest daily loading of total nitrogen at the Bantam Lake Outlet and Little Pond Outlet sites were 13.3 and 17.4 kg/day, respectively, while the maximum levels were 1,137 and 1,268 kg/day, respectively. The Whittlesey Brook Inlet site had the least variability with minimums and maximums of 0.8 and 12.6 kg/day, respectively. The range of concentrations at the Dog Pond Outlet site were modestly higher with a minimum and maximum of 2.3 and 48.6 kg/day. Like their site averages, the West Branch Bantam River and Bantam Pond Outlet site season minimums and maximums were similar. Minimums from those sites were 4.1 and 5.2 kg/day, respectively, while maximums were 84.5 and 90.4 kg/day, respectively.

3. *Corrected Daily Loading*

Corrected daily loading averages ranged from lows of 3.8 and 9.1 kg/day at the Whittlesey Brook Inlet and West Branch Bantam River sites, respectively, to 206 kg/day at the Little Pond Outlet site. Corrected daily loading averages at the Dog Pond Outlet, Bantam Pond Outlet, and Bantam Lake Outlet were 13.4, 27.2, and 34.3 kg/day, respectively. Significant differences among site averages were not detected and likely due to small sample size and the large variability at the Little Pond Outlet site that had a season minimum and maximum of 4.0 and 962 kg/day, respectively.

4. *Standardized Corrected Loading*

No statistically significant differences were found among site corrected daily loading averages standardized by area. Low sample size and high variability, particularly at the Little Pond Outlet, were likely contributors to that finding. The Little Pond Outlet site average, season minimum and maximum were 30,718, 589, and 143,203 kg/day/acre, respectively. Season averages at all other sites were between 4,931 and 8,005 mg/day/acre. Season minimums were similar at the Whittlesey Brook Inlet, Bantam Pond Outlet, West Branch Bantam River, Dog Pond Outlet sites and between 950 and 1,150 kg/day. Season maximums for those same sites were between 16,347 and 24,519 kg/day. The minimum and maximum at the Bantam Lake Outlet site were -240 and 27,569 kg/day, respectively.

IV. Discussion

A. General Considerations

The Bantam Lake watershed data collected in 2023 was the first of its kind since the development of the Bantam Appendix of the State's TMDL. As recommended in the Bantam Appendix and the Bantam Lake and Watershed QAPP, water samples were collected monthly. Since this data collection started in May of 2023 and ended with a sample collection in October of 2023, samples were collected on six different occasions. Data collections in 2024 started in April and will result in seven samples collected at each site.

A change in the laboratory analyzing water samples occurred in mid-season largely due to inconsistencies in data results and undesirable practices of the laboratory used in the first half of the season. Analytical resolution during that time was often low and the instrument minimum detection limits (MDLs) were often too high, particularly for nitrogen analyses. This resulted in no viable nitrogen data for samples collected in May. High resolution and appropriate MDLs characterized practices of the UCONN CESE laboratory used for samples collected in August through October. We do not anticipate changing from the UCONN CESE laboratory in the future.

B. Statistical Significance and Sample Size

Small sample sizes tend to work against good statistical analyses, and that should be considered throughout this report. Whether it was the six samples used for average total phosphorus loading or five samples used to determine average total nitrogen loading, sample sizes were generally low which compromised detecting significant differences among sites. While six replicates are generally a good baseline for statistical analysis, these samples were spread over a large temporal span, i.e. one discrete sample per month. As budgets allow and community interest continues, sample sizes for each site will increase over time. Although sampling could continue at monthly intervals, a greater span of conditions will be captured with additional years of consistent sampling.

C. General Observations

Statistically significant differences among site averages were not common within the total phosphorus or total nitrogen data. The two highest daily loading site averages for phosphorus – the averages for the Bantam Lake Outlet and Little Pond Outlet sites – were significantly higher than the lowest averages, e.g., the averages for the Whittlesey Brook Inlet and Dog Pond Outlet sites. In many ways, this was to be expected due to the disparity in the sizes of the associated watersheds. However, the magnitude of differences in the Bantam Lake and Little Pond values to the smallest averages was significant and notable. For daily loading of nitrogen, the averages for the Bantam Lake Outlet and Little Pond Outlet sites were significantly higher than the average for Whittlesey Brook Inlet. The Bantam Lake Outlet and Little Pond Outlet sites had the two largest watershed areas, were both modeled for discharge using the Nepaug River surrogate watershed, and regularly had higher estimated discharge rates than the other sites (Table 1).

By adjusting phosphorus and nitrogen loading rates to reflect specific portion of the watershed, individual watershed balances could be estimated. Little Pond Outlet was distinctive from all other sites for both average and standard deviation. The Bantam Lake Outlet site averages for corrected, and corrected and standardized phosphorus loading notably decreased from the average loading and were negative numbers. This implies that average loadings mainly from the Little Pond Outlet and to a much less degree Whittlesey Pond Inlet, accounted for more of the phosphorus mass than was exiting the lake at the Bantam Lake Outlet site. Internal loading, buffering of phosphorous and use of nutrients by primary production in Bantam Lake may be possible avenues of explanation for the differences in upstream versus downstream phosphorous values. In particular, waterbody buffering of phosphorus was not accounted for, i.e. the autochthonous loading of phosphorus from highly reduced and anoxic lake sediments, which is known to occur at Bantam Lake. Release of nutrients normally sequestered in the lake hydrosoil may be released seasonally, accounting for the high concentrations seen in the samples downstream of Bantam Lake. Furthermore, we further hypothesize that this phenomenon (i.e., differences in nutrient loads entering vs exiting) could also be explained by delayed watershed processes, i.e. samples were collected on the same day of each month & nutrient loading events might take a much longer time to make their way from upstream sources to the Bantam Lake outlet.

D. Temporal Differences and Precipitation

The total rainfall for 2023 was the third highest on record for Connecticut with July reported as the wettest month of the year (Weiss 2024). As recommended by members of the Bantam Watershed Advisory Committee, we examined monthly results from all sites (Fig. 5) with respect to rainfall. Daily rainfall data was collected from the weather station at the White Memorial Conservation Center (Weather Underground 2024). Cumulative totals were also determined for the 5 days preceding each sampling date. Both rainfall datasets were plotted and are displayed below (Fig. 6).

Data collected from July 11th samples exhibited the greatest differences from what otherwise might be considered baseline conditions on all other dates. This was particularly evident at the Bantam Lake Outlet and Little Pond Outlet sites (Fig. 5). A comparison of daily loading of both phosphorus and nitrogen to corrected and standardized daily loading lates is worth noting. The Bantam Lake Outlet site phosphorus loading shifted from concentrations which were approximately as high as the Little Pond Outlet loading, to a negative loading rate when corrected for upstream loading. The Bantam Lake Outlet nitrogen corrected loading was not negative on July 11th but was substantially lower than the nitrogen loading rate before correcting. Again, these phenomena may be explained by delayed impacts not elucidated by single monthly sampling, and delayed watershed processes.

July 11th estimated discharge rates at the Bantam Lake Outlet and Little Pond Outlet sites were one to two orders of magnitude greater than the estimated discharge rates at the other sites. For example, the July 11th estimated discharge rate was approximately 195 and 149 cubic feet per second at the Bantam Lake Outlet and Little Pond Outlet sites, respectively. The next highest estimated discharge rate was 14.2 cubic feet per second at the Bantam Pond Outlet site. It is important to remember the methods used for transformation of discharge are reliant on surrogate gaging sites, and therefore, values during high flow events may be less reliable than those at low or median flows. Despite this, it is without question that flow was very high at these sampling sites due to localized rainfall.

Figure 6 provides a comparison of corrected and corrected and standardized total phosphorus loading during the 2023 season in relation to daily rainfall and five days totals prior to sampling events. The season loading maximums on July 11th correspond with the highest 5-day total of 1.67 inches. Modestly elevated loading at the Little Pond Outlet site on October 10th occurred following the cumulative 1.18 inches falling prior to that sampling event.

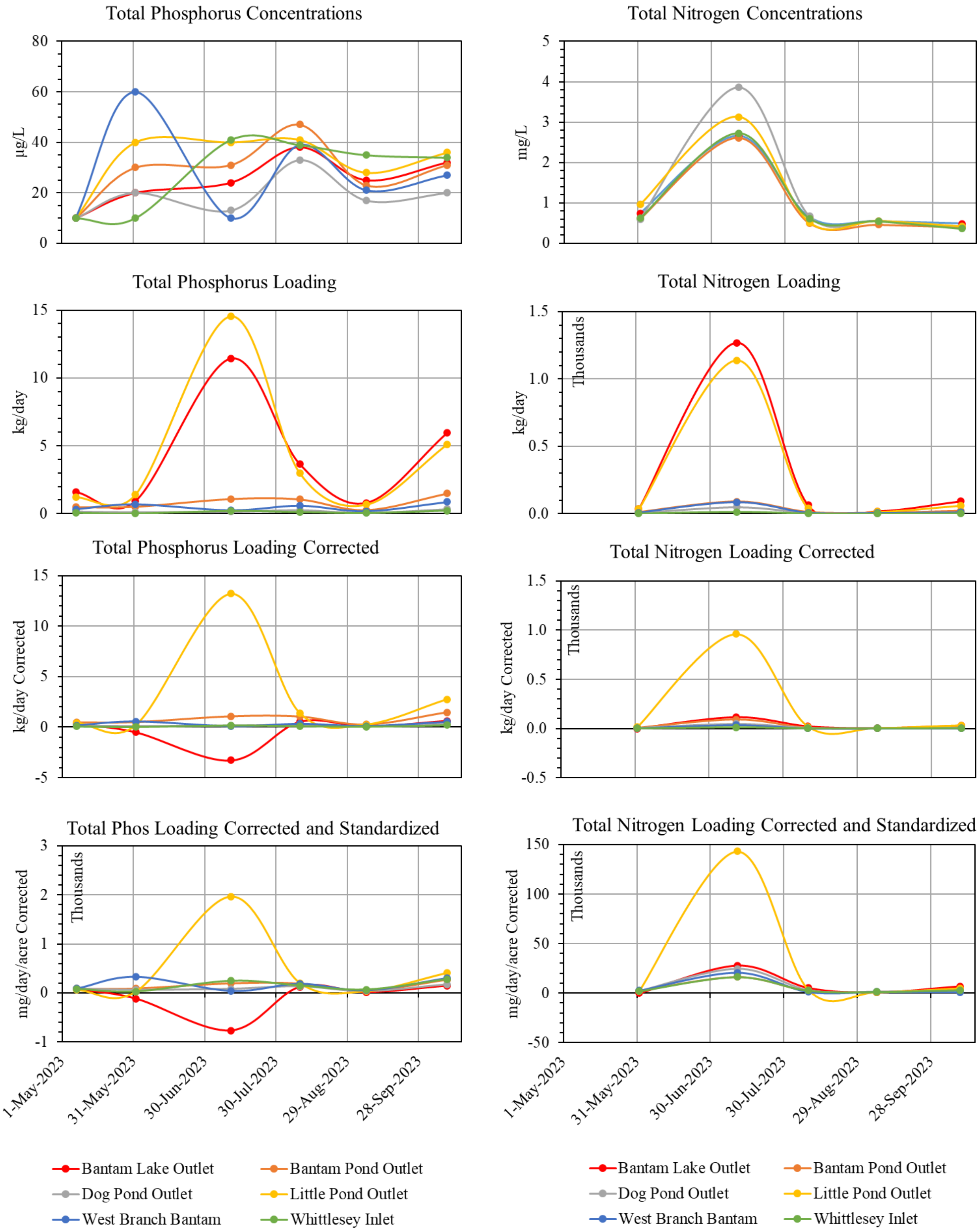

Figure 5. Total phosphorus (left) and total nitrogen (right) concentrations, daily loadings, corrected daily loadings, and corrected daily loadings standardized by area in acres during the 2023 sampling season. Specific sampling dates were May 7th, June 1st, July 11th, August 9th, September 6th, and October 10th. No total nitrogen data was available on May 7th.

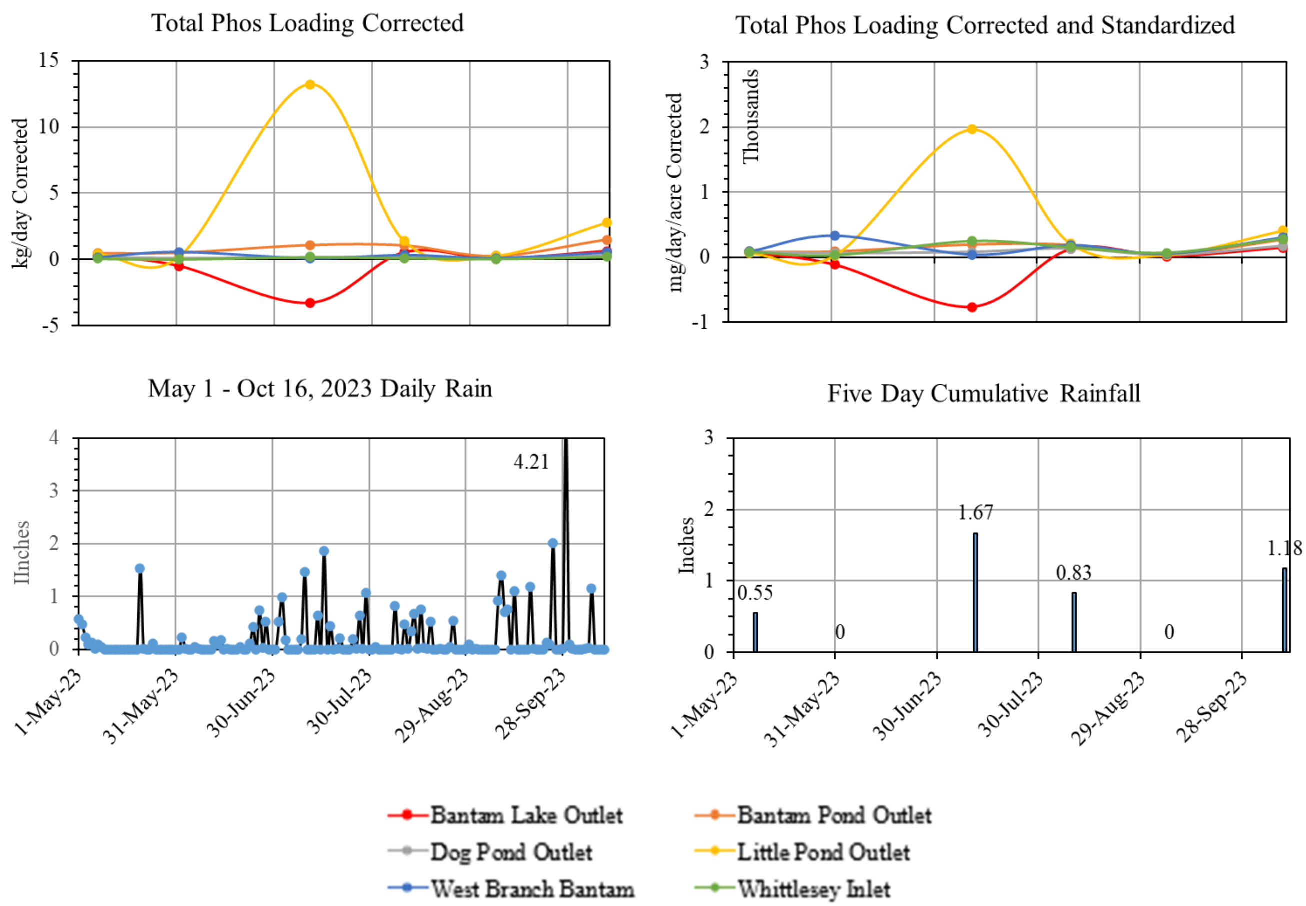

Figure 6. Total phosphorus loading and total phosphorus loading corrected in relation to daily rainfall from May through October of 2023 and five-day cumulative total rainfall prior to the sampling dates.

E. Little Pond Outlet Site

Based on the 2023 data, the Little Pond Outlet subshed appeared to contribute, on average, a high proportion of phosphorus and nitrogen load to Bantam Lake. However, much of that was due to the July 11th loading event. As mentioned previously, the small temporal distri.bution of the datasets also masks meaningful differences. Interestingly, but also likely influenced by small dataset size, the sum of Bantam Pond Outlet and West Branch Bantam River corrected phosphorus loading averages were not significantly different from the Little Pond Outlet average

V. Recommendations

Our primary recommendation is to continue with the current sampling program to develop a long-term data set of sampling parameters. Additional years of data will not only provide for some trending of annual conditions but will also capture a greater span of conditions. For example, monthly sampling may only capture high flow events on some months or some years, collecting multiple years (2-5) of data is much more likely to highlight different phenomenon. Utilizing consistent monitoring protocols will be necessary for an accurate comparison of monthly and annual data collected.

Additional recommendations are focused on the most obvious outliers in the dataset, specifically high nutrient concentrations and loading which was detected at the outlet of Little Pond. The large disparity between upstream and downstream sampling seems to indicate significant nutrient input in the watershed areas between these sampling sites. Heuristic analysis of the Little Pond watershed highlighted the expansive golf course property which is directly upstream of the Little Pond proper. This property directly abuts the watercourse, and few riparian buffers are visible in aerial photography. It is recommended that additional sampling is considered upstream of Little Pond to further delineate watershed sources of nutrient loading. Specifically, upstream of the golf course, and downstream of RT 202, to highlight if either of these urbanized areas may be disproportionally contributing to loading.

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Appendix A - Bantam Lake Watershed Field Data

Date	Site	Temperature (°C)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% Saturation)	Rel. Phyco (µg/L)	Specific Cond. (µS/cm)	pH (Standard Units)
7-May-23	Bantam Lake Outlet	13.96	9.54	96.4	6.92	199.0	7.58
	Bantam Pond Outlet	14.57	10.17	104.2	1.48	140.4	7.84
	Dog Pond Outlet	15.44	10.36	108.2	-94.34	242.5	7.86
	Little Pond Outlet	13.18	8.45	83.9	1.44	192.3	7.89
	West Branch Bantam	14.35	8.48	86.4	16.92	247.9	7.58
	Whittlesey Inlet	11.34	11.04	105.2	2.06	125.8	7.71

Date	Site	Temperature (°C)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% Saturation)	Rel. Phyco (µg/L)	Specific Cond. (µS/cm)	pH (Standard Units)
1-Jun-23	Bantam Lake Outlet	22.66	8.49	102.6	1.78	215.0	7.61
	Bantam Pond Outlet	21.05	8.34	97.6	1.35	171.2	7.92
	Dog Pond Outlet	23.11	8.57	104.4	1.82	261.3	8.36
	Little Pond Outlet	20.37	7.3	84.4	2.39	239.2	7.42
	West Branch Bantam	20.18	7.26	83.6	1.84	337.6	7.78
	Whittlesey Inlet	12.78	9.04	89	0.36	182.6	8.17

Date	Site	Temperature (°C)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% Saturation)	Rel. Phyco (µg/L)	Specific Cond. (µS/cm)	pH (Standard Units)
11-Jul-23	Bantam Lake Outlet	22.93	3.91	45.8	2.19	189.1	6.8
	Bantam Pond Outlet	20.13	7.55	83.8	3.03	128.0	7.22
	Dog Pond Outlet	22.64	4.56	53.1	2.05	215.6	7.06
	Little Pond Outlet	20.31	4.83	53.7	1.93	117.0	6.99
	West Branch Bantam	21.62	4.65	53.1	132.99	223.9	7.11
	Whittlesey Inlet	19.33	8.56	93.4	3.16	105.0	7.81

Date	Site	Temperature (°C)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% Saturation)	Rel. Phyco (µg/L)	Specific Cond. (µS/cm)	pH (Standard Units)
9-Aug-23	Bantam Lake Outlet	21.9	1.7	19.5	3.03	190.6	6.86
	Bantam Pond Outlet	20.8	7.92	89	2.22	158.1	7.56
	Dog Pond Outlet	21.46	7.62	86.7	-56.84	179.4	7.72
	Little Pond Outlet	20.46	3.62	40.4	1.73	207.4	7.02
	West Branch Bantam	19.43	4.74	51.8	1.44	247.2	7.23
	Whittlesey Inlet	18.41	8.42	90.2	1.49	157.4	7.67
Date	Site	Temperature (°C)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% Saturation)	Rel. Phyco (µg/L)	Specific Cond. (µS/cm)	pH (Standard Units)
6-Sep-23	Bantam Lake Outlet	23.6	1.68	19.9	3.89	203.2	6.76
	Bantam Pond Outlet	24.62	7.54	91.1	1.77	188.9	7.71
	Dog Pond Outlet	25.34	7.3	89.4	4.74	216.5	7.69
	Little Pond Outlet	22.89	3.73	43.6	23.43	264.2	7.06
	West Branch Bantam	22.3	4.12	47.7	2.04	322.7	7.14
	Whittlesey Inlet	18.87	7.64	82.7	1.13	216.4	7.53
Date	Site	Temperature (°C)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% Saturation)	Rel. Phyco (µg/L)	Specific Cond. (µS/cm)	pH (Standard Units)
10-Oct-23	Bantam Lake Outlet	14.67	5.12	50.7	4.27	147.6	7.79
	Bantam Pond Outlet	12.29	10.1	94.9	2.19	132.9	9.09
	Dog Pond Outlet	14.63	8.99	88.9	2.17	142	7.62
	Little Pond Outlet	11.84	6.3	58.5	1.53	154.5	7.94
	West Branch Bantam	11.85	7.88	73.3	1.72	174.2	7.7
	Whittlesey Inlet	12.24	10.21	95.8	1.19	113.5	8.75

Appendix B. Bantam Lake Watershed Total Phosphorus and Total Nitrogen Data

Date	Site	Total Phosphorus				Total Nitrogen			
		mg/L	kg/day	kg/day corrected	mg/day/ acre	mg/L	kg/day	kg/day corrected	mg/day/ acre
7-May-23	Bantam Lake Outlet	0.010	1.602	0.318	74.132	---	---	---	---
	Bantam Pond Outlet	0.010	0.473	0.473	85.856	---	---	---	---
	Dog Pond Outlet	0.010	0.172	0.172	86.661	---	---	---	---
	Little Pond Outlet	0.010	1.221	0.426	63.416	---	---	---	---
	West Branch Bantam River	0.010	0.322	0.150	86.825	---	---	---	---
	Whittlesey Inlet	0.010	0.063	0.063	81.992	---	---	---	---
1-Jun-23	Bantam Lake Outlet	0.020	0.912	-0.501	-116.853	0.740	33.752	-1.030	-240.147
	Bantam Pond Outlet	0.030	0.511	0.511	92.889	0.610	10.396	10.396	1888.736
	Dog Pond Outlet	0.020	0.124	0.124	62.507	0.600	3.720	3.720	1875.203
	Little Pond Outlet	0.040	1.391	0.183	27.177	0.960	33.374	15.082	2244.407
	West Branch Bantam River	0.060	0.697	0.573	331.408	0.680	7.896	4.175	2416.309
	Whittlesey Inlet	0.010	0.023	0.023	29.570	0.620	1.408	1.408	1833.316
11-Jul-23	Bantam Lake Outlet	0.024	11.440	-3.282	-765.363	2.660	1267.982	118.214	27568.621
	Bantam Pond Outlet	0.031	1.074	1.074	195.084	2.610	90.402	90.402	16424.851
	Dog Pond Outlet	0.013	0.164	0.164	82.577	3.860	48.646	48.646	24519.062
	Little Pond Outlet	0.040	14.533	13.223	1967.758	3.130	1137.213	962.324	143202.990
	West Branch Bantam River	0.010	0.236	0.072	41.761	3.580	84.487	35.841	20741.315
	Whittlesey Inlet	0.041	0.189	0.189	246.405	2.720	12.554	12.554	16346.851
9-Aug-23	Bantam Lake Outlet	0.038	3.662	0.535	124.704	0.640	61.674	22.020	5135.152
	Bantam Pond Outlet	0.047	1.047	1.047	190.171	0.498	11.091	11.091	2014.999
	Dog Pond Outlet	0.033	0.267	0.267	134.777	0.666	5.397	5.397	2720.040
	Little Pond Outlet	0.041	3.011	1.373	204.309	0.515	37.827	19.392	2885.701
	West Branch Bantam River	0.039	0.592	0.324	187.717	0.484	7.344	1.947	1127.021
	Whittlesey Inlet	0.039	0.116	0.116	150.700	0.616	1.828	1.828	2380.293

Date	Site	Total Phosphorus				Total Nitrogen			
		mg/L	kg/day	kg/day corrected	mg/day/ acre	mg/L	kg/day	kg/day corrected	mg/day/ acre
6-Sep-23	Bantam Lake Outlet	0.025	0.793	0.063	14.708	0.547	17.352	3.200	746.266
	Bantam Pond Outlet	0.023	0.261	0.261	47.476	0.461	5.238	5.238	951.593
	Dog Pond Outlet	0.017	0.070	0.070	35.420	0.552	2.282	2.282	1150.124
	Little Pond Outlet	0.028	0.677	0.253	37.667	0.551	13.322	3.959	589.093
	West Branch Bantam River	0.021	0.163	0.092	53.406	0.533	4.126	1.844	1067.180
	Whittlesey Inlet	0.035	0.053	0.053	68.996	0.548	0.830	0.830	1080.277
10-Oct-23	Bantam Lake Outlet	0.032	5.970	0.635	148.080	0.487	90.854	29.241	6819.301
	Bantam Pond Outlet	0.031	1.477	1.477	268.418	0.401	19.111	19.111	3472.118
	Dog Pond Outlet	0.020	0.347	0.347	174.798	0.410	7.109	7.109	3583.352
	Little Pond Outlet	0.036	5.119	2.765	411.443	0.417	59.295	31.352	4665.524
	West Branch Bantam River	0.027	0.877	0.530	306.665	0.272	8.832	1.723	996.949
	Whittlesey Inlet	0.034	0.216	0.216	281.147	0.365	2.318	2.318	3018.194

Appendix C. Bantam Lake Watershed Additional Laboratory Data

Date	Site	Ammonia mg/L	Nitrate mg/L	Nitrite mg/L	E. coli MPN/100mL
7-May-23	Bantam Lake Outlet	0.220	<0.500	<0.100	3
	Bantam Pond Outlet	0.280	<0.500	<0.100	2
	Dog Pond Outlet	0.190	<0.500	<0.100	3
	Little Pond Outlet	0.210	<0.500	<0.100	12
	West Branch Bantam River	0.070	<0.500	<0.100	19
	Whittlesey Inlet	0.290	<0.500	<0.100	10
1-Jun-23	Bantam Lake Outlet	0.350	<0.500	<0.100	2
	Bantam Pond Outlet	0.330	<0.500	<0.100	8
	Dog Pond Outlet	0.280	<0.500	<0.100	65
	Little Pond Outlet	0.280	<0.500	<0.100	138
	West Branch Bantam River	0.490	<0.500	<0.100	48
	Whittlesey Inlet	0.330	<0.500	<0.100	142
11-Jul-23	Bantam Lake Outlet	0.545	<0.500	<0.100	291
	Bantam Pond Outlet	0.505	<0.500	<0.100	770
	Dog Pond Outlet	<0.050	<0.500	<0.100	345
	Little Pond Outlet	0.495	<0.500	<0.100	770
	West Branch Bantam River	0.355	<0.500	<0.100	124
	Whittlesey Inlet	0.545	<0.500	<0.100	517
9-Aug-23	Bantam Lake Outlet	NA	<0.500	<0.100	43
	Bantam Pond Outlet	NA	<0.500	<0.100	32
	Dog Pond Outlet	NA	<0.500	<0.100	461
	Little Pond Outlet	NA	<0.500	<0.100	173
	West Branch Bantam River	NA	<0.500	<0.100	74
	Whittlesey Inlet	NA	<0.500	<0.100	276
6-Sep-23	Bantam Lake Outlet	0.028	NA	NA	20
	Bantam Pond Outlet	0.029	NA	NA	2
	Dog Pond Outlet	0.024	NA	NA	17
	Little Pond Outlet	0.037	NA	NA	104
	West Branch Bantam River	0.038	NA	NA	64
	Whittlesey Inlet	0.032	NA	NA	308
10-Oct-23	Bantam Lake Outlet	0.035	NA	NA	
	Bantam Pond Outlet	0.020	NA	NA	
	Dog Pond Outlet	0.017	NA	NA	
	Little Pond Outlet	0.019	NA	NA	
	West Branch Bantam River	0.018	NA	NA	
	Whittlesey Inlet	0.010	NA	NA	

Appendix D - Preparer's Qualification

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RELEVANT EXPERIENCE

- Thirty years as a lake ecologist, manager, advocate, educator, and leader in Connecticut. Successful in the academic, public, and private sectors.
- Advanced the mission of the Candlewood Lake Authority from 1998 through 2017 with the last 14 of those as Executive Director. The board and staff of that agency served the five municipalities surrounding Candlewood Lake, the largest lake in the State and one of Connecticut's most important inland water resources.
- Developed meaningful relationships and worked with the general CT lake community, local and state environmental agency staff, academic researchers, elected leaders at all levels of government, and educators from middle school through college/university levels.
- Co-directed an interdistrict grant program that utilized Candlewood Lake as a living, learning laboratory. The program ran for 10+ years and engaged ~150 high school students and teachers each year.
- Have trained and supervised employees and/or students in Limnological and Paleolimnological field and laboratory methods.
- Founding member of the Connecticut Federation of Lakes, have, and served as a volunteer and an officer of Connecticut's lake advocacy, nonprofit organization until 2022.

PROFESSIONAL EXPERIENCE

- **Principal Limnologist – Brawley Consulting Group, LLC.** 2023 to present
- **Principal Partner – Aquatic Ecosystem Research, LLC.** July 2017 to 2022
- **Adjunct Faculty** – Western Connecticut State University, Biol. and Enviro. Science Dept. August 2011 to present.
- **Executive Director –** Candlewood Lake Authority, Sherman, CT 06784. April 2003 to July 2017
- **Lake Preservation Director –** Candlewood Lake Authority, Sherman, CT 06784. April 1998 to Oct. 2002
- **Academic Research Associate –** Connecticut College, New London, CT 06320. Sept. 1989 to Jan. 1998
- **Visiting Lecturer –** Connecticut College, New London, CT 06320. August 1997 to January 1998
- **Research Assistant** – Western Connecticut State University, Danbury, CT 06810. 1987 to 1989

CERTIFICATION, EDUCATION, AND TRAINING

- **Certified Lake Manager**, North American Lake Management Society, 2017
- **Professional Certification** in GIS, Pace University, 2014
- **Graduate Certification** in GIS Technology, University of New Haven 2001
- **M.A. in Botany**, Connecticut College 1993
- **B.A. in Biology**, Western Connecticut State University 1988

AWARDS

- **Excellence in Environmental Stewardship** from the **Connecticut Outdoor and Environmental Education Association** in 2018
- **Recognition of Service** in the **Congressional Record** by **US Rep. Elizabeth Esty** on June 14, 2017
- **Watershed Conservationist Award** from the **Housatonic Valley Association** in 2011
- **Conservation Professional of the Year** from the **Litchfield County Conservation District** in 2002
- **Honor Award**, **Southern New England Chapter of the Soil and Water Conservation Society** in 2000.
- **Green Circle Award** from the **Connecticut Department of Environmental Protection** in 1999.
- **Conservation Award** from **Housatonic Valley Association** for publication entitled *Candlewood Lake: Watershed Awareness and Lake Preservation* in 1998.

ORGANIZATIONS

- **Connecticut Federation of Lakes** – Founding member 1995; Treasurer from 1995 – 2001; Vice President from 2009 – 2011, 2018 - present; President from 2011 - 2015
- **Connecticut Forest and Park Association** – Board member from 1994 – 2002
- **North American Lakes Management Society** – Member since 1990

SELECTED PUBLICATIONS

PEER-REVIEWED SCIENTIFIC PAPERS

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Lott, A.M., Siver, P.A., **Marsicano**, L.J., Kodama, K.P. and R.E. Moeller. 1994. The paleolimnology of a small waterbody in the Pocono Mountains of Pennsylvania, USA: reconstructing 19th-20th century specific conductivity trends in relation to changing land use. Journal of Paleolimnology 12: 75-86.

Marsicano, L.J. and P.A. Siver. 1993. A paleolimnological assessment of lake acidification in five Connecticut lakes. Journal of Paleolimnology 9:202-221.

Siver, P.A. and L.J. **Marsicano**. 1993. *Mallomonas connensis* sp. nov., a new species of Synurophyceae from a small New England lake. Nordic Journal Botany. 13: 337-342

Siver, P.A. and L.J. **Marsicano**. 1991. Assessing acidification trends in Connecticut lakes using a paleolimnological approach. CT. Department of Environmental Protection Bulletin, 44 pp. + appendices

POLICY PAPERS AND SUBMITTALS

Marsicano, LJ. 2009. An Examination of Recreational Pressures on Candlewood Lake, CT. Candlewood Lake Authority. Sherman, CT. 68 pp.

Marsicano, L.J., et al. 2000 – 2017. Submittals of the Candlewood Lake Authority to the Federal Energy Regulatory Commission during license renewal and management plan processes for Housatonic Hydro, FERC Docket No. P-2576.

A. Hunter Brawley
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PROFESSIONAL EXPERIENCE

Owner/Manager, Brawley Consulting Group LLC, Windsor, CT
(January 2008 to present).
Provides land conservation and management services to local land trusts and conservation organizations, including designing and implementing habitat restoration projects, grant writing, trail design and construction, crafting and monitoring conservation easement, boundary posting, Baseline Documentation Reports and developing property management plans. www.brawleycg.com

Land Manager, Naromi Land Trust, Sherman, CT
(March 2004 to present).
Manage all land trust properties and help acquire, monitor and enforce conservation easements. Responsibilities also include designing and building trails, securing funding for habitat restoration projects, and assisting with organizational and administrative tasks. Work cooperatively with the town and other conservation organizations to identify and prioritize lands for future acquisition. www.naromi.org

Land Manager, Kent Land Trust, Kent, CT
(September 2008 to August 2014).
Manage all land trust properties and help acquire, monitor and enforce conservation easements. Responsibilities also include securing funding for habitat restoration projects and preparing Baseline Documentation Reports (BDRs) and property management plans. Addressed backlog of stewardship items required for Kent Land Trust to become the second land trust in Connecticut accredited by the Land Trust Alliance.

Project Manager, Northeast Instream Habitat Program, Amherst MA.
(January 2004 to March 2005).
Coordinated all facets of two fisheries habitat assessment projects working with researcher at the University of Massachusetts, including project planning, data collection, hiring and overseeing seasonal staff, data analysis and report preparation. http://www.neihp.org/index.htm

Executive Director, Pomperaug River Watershed Coalition, Southbury, CT
(July 2001 to May 2003).
Managed all activities of non-profit watershed management organization dedicated to conserving regional water resources, including research, outreach, budgets, grant writing, website development, fundraising, and volunteer relations. www.pomperaug.org

Senior Project Manager, LabLite, LLC, New Milford, CT
(January 2000 to June 2001).
Product development, testing, sales, and customer service for a software company that provides Laboratory Information Management Software (LIMS) to environmental and other laboratories. www.lablite.com

Research Coordinator, The National Audubon Society, Southbury, CT
(March 1998 to January 2000).
Designed and implemented all research on birds and other wildlife at the 625-acre wildlife sanctuary. Conducted natural resources inventory, created checklists of wildlife and plants, established environmental education programs, and coordinated cooperative research projects with state agencies and regional conservation organizations.
http://ct.audubon.org/IBA_BOR.html

Environmental Analyst, Land-Tech Consultants, Inc., Southbury, CT
(November 1996 to February1998).

As Project Manager conducted environmental impact statements, wetland assessments, and wildlife surveys; prepared federal, state and local permit applications; designed pond and tidal wetland restoration projects; and conducted lake diagnostic studies. Worked with state agencies and local land use agencies to mitigate impacts of residential and commercial development projects. www.landtechconsult.com

Wetland Ecologist, The Deep River Land Trust, Deep River, CT.

(July to October 1995).

Worked in association with The Nature Conservancy Connecticut Chapter on a conservation project at two freshwater tidal marshes in the lower Connecticut River. Position entailed mapping dominant vegetation communities, identifying potential environmental impacts, researching information on appropriate buffer zones and recommending methods for long-term monitoring of the system.

Research Assistant, The Nature Conservancy CT Chapter, Weston, CT.

(May to July 1995).

Assisted with research on the productivity and survivorship of Worm-eating Warblers at the 1700-acre Devil's Den Preserve in Weston, CT. Responsibilities included mist-netting, bird banding, and locating and monitoring approximately 25 nest sites throughout the breeding season.
http://www.nature.org/wherewework/northamerica/states/connecticut/

Master's Thesis Research, Connecticut College, New London, CT.

(September 1993 to May 1995).

Conducted two-year study investigating relationships between bird populations and environmental conditions in tidal wetlands of Connecticut. Quantified bird use, vegetation, and selected environmental parameters in eight tidal marsh systems on the Long Island Sound to assess the use of birds as indicators of environmental quality.
http://www.conncoll.edu/departments/botany/index.htm

Research Associate, Connecticut College Arboretum, New London, CT.

(Sept. 1992 to January 1994).

Conducted a natural resources inventory of The Harriet C. Moore Foundation property in Westerly, RI, including producing lists of all plants and animals (flora and fauna), conducting a breeding bird census, and identifying and tagging over 100 ornamental trees. Developed a five-year plan for the management and use of this 35-acre public land preserve.
http://arboretum.conncoll.edu/

Principal Investigator, The Nature Conservancy CT Chapter, Middletown, CT

(Summer 1994).

Studied five marshes in the tidelands of the lower Connecticut River to assess the impacts of the spread of common reed (*Phragmites australis*) on bird populations. Designed project that included the systematic collection of data on bird use, vegetation sampling and an analysis of physical site characteristics.
http://www.nature.org/wherewework/northamerica/states/connecticut/

EDUCATION

Connecticut College, New London, CT. Master of Arts in Botany, 1995.

Connecticut College, New London, CT. Bachelor of Arts in American History, 1982.

The Loomis Chaffee School, Windsor, CT. Graduated 1978.

PUBLICATIONS

Brawley, A. H., Zitter, R. and L. Marsicano, Editors. 2005. Candlewood Lake Buffer Guidelines. Candlewood Lake News *Special Edition*, Vol 1:21.

Warren, R.S., P. E. Fell, R. Rozsa, A. H. Brawley, A. C. Orsted, E. T. Olson, V. Swamy and W. A. Niering. 2002. Salt Marsh Restoration in Connecticut: 20 years of Science and Management. *Restoration Ecology* 10 (3) 497-513.

Markow, J. and H. Brawley. 2001. Herpetofaunal and Avifaunal Surveys of Vaughn's Neck Peninsula, Candlewood Lake, Connecticut. Report to the Town of New Fairfield, CT. 32 p.

Brawley, A. H. 1998. A Vegetation Survey and Conservation Analysis of Vaughn's Neck Peninsula. Report to The Candlewood Lake Authority. The National Audubon Society. 11 p.

Brawley, A. H., R. S. Warren and R. A. Askins. 1998. Bird Use of Restoration and Reference Marshes Within the Barn Island Wildlife Management Area, Stonington, Connecticut, USA. *Environmental Management* 22(4): 625-633.

Marsicano, L. J. and A. H. Brawley. 1997. Land Use, Watersheds, and Aquatic Resources. *Connecticut Woodlands* 62(3): p. 21.

Niering, W. A., and A. H. Brawley. 1996. Functions and Values Assessment of Area A Downstream Wetlands and Watercourses. Naval Submarine Base New London, Groton, CT. Report to Brown & Root Environmental, The Environmental Protection Agency, and The United States Navy. 36 p.

Brawley, A.H. 1995. Pratt and Post Coves: A Vegetation Survey and Conservation Analysis. Report to the Deep River Land Trust, Deep River, CT. 62 p.

Brawley, A.H. 1995. Birds of Connecticut's Tidal Wetlands: Relating Patterns of Use to Environmental Conditions. Master's Thesis, Connecticut College, New London, CT. 87 p.

Brawley, A.H. 1994. Birds of the Connecticut River Estuary: Relating Patterns of Use to Environmental Conditions. Report to the Nature Conservancy Connecticut Chapter Conservation Biology Research Program, Middletown, CT. 23 p.

Brawley, A.H., G.D. Dreyer. 1994. Master Plan for the Future Management and Use of Moore Woods. Connecticut College Arboretum Publication. New London, CT. 65 p.

Brawley, A.H., G.D. Dreyer and W.A. Niering. 1993. Connecticut College Arboretum Phase One Report to the Harriet Chappell Moore Foundation. Connecticut College Arboretum Publication. New London, CT. 100 p.

ACTIVITIES

Forest and Trails Conservation Committee, Connecticut Forest & Park Association (CFPA)

Coverts Project Cooperator, UConn Cooperative Extension System

WILLIAM HENLEY
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EXPERIENCE

Sr. Aquatic Resource Scientist **May 2018 – Present**
South Central Connecticut Regional Water Authority, New Haven, CT

- Supervise source water quality monitoring at a regional water company serving 400,000+ customers in 15 towns
- Coordinate field work on 11 active reservoirs totaling over 2,000 acres as well as watershed lands (26,000 acres)
- Manage environmental programs and initiatives as they relate to source waters (streams, reservoirs, aquifers)
- Administer program budgets as well as plan and manage special projects
- Collect in situ profile data and water samples at reservoirs to monitor reservoir ecosystem health
- Process samples at the Authority's laboratory; analyze, interpret, and report the results
- Conduct aquatic macrophyte surveys and manage downstream release compliance
- Attend public events and participate in environmental outreach and education
- Contribute to ecological restoration by collaborating with various departments and external stakeholders
- Operate/maintain water quality sampling equipment as well as company boat and vehicle

Core accomplishments:

- Played a focal role in the realization of a new stream water quality monitoring initiative
- Worked on the discovery and management of an invasive species in one of the Authorities waterbodies
- Provided management and oversight of downstream release from reservoirs, and determined needs to meet new regulations.

Fisheries Durational Resource Technician **Apr – Nov 2016, July 2017 – Mar 2018**
DEEP Inland Fisheries Division, Marlborough, CT

- Provided support to fisheries biologists by collecting biological data as it relates to fish and aquatic ecosystems at over 65 stream sites and 25 lakes and ponds
- Conducted monitoring of stream and lake fish species utilizing electrofishing boats, backpacks, and trap nets
- Performed surveys of freshwater anglers on statewide lakes 2-3 days weekly in open water and ice conditions
- Collected and cataloged freshwater mussels for identification in conjunction with the CT DEEP Wildlife Division
- As a lead observer, facilitated stream crossing and culvert assessments for the North Atlantic Aquatic Connectivity Collaborative (NAACC)
- Collected dissolved oxygen profiles on lakes intended for stocking as part of a long-term dataset
- Provided direction to new technicians and oversaw volunteers

Core accomplishments:

- Served as a leader for sampling crews as well as managed several critical projects
- Participated in the discovery/confirmation of an invasive plant now found in the Connecticut River
- Contributed to a study of winter road sand impact presented at the Connecticut Natural Resource Conference
- Certified as North Atlantic Aquatic Connectivity Collaborative (NAACC) Lead Observer
- Participated in wild Brook Trout PIT tagging initiative

Adjunct Limnologist **July 2015 – January 2023**
Aquatic Ecosystem Research, Branford, CT

- Worked as a technician under the companies' principal limnologist executing field work on over a dozen freshwater bodies of water totaling over 2,500 acres
- Performed water quality monitoring and algal sampling using YSI Water Quality Sondes and Van Dorn samplers

- Conducted aquatic plant community surveys, including invasive species monitoring
- Collected various geospatial data, aquatic plant data, bathymetric data, and infrastructure data to conduct research, analyze trends, and create geospatial products and maps
- Compiled and managed large data sets and generated accurate reports on a regular basis
- Closely collaborated with freshwater and coastal stakeholders on the creation and planning of conservation and management projects

Core accomplishments:
- Developed various geospatial methodologies for assessment of ecological systems
- Implemented new techniques for monitoring aquatic plant communities
- Created standardized templates for company map products
- Integrated new technologies for bathymetric and plant mapping
- Participated in research initiatives for various projects, including authorship on a research paper

Wildlife, Geospatial & Field Technician **May 2016 – May 2018**
Davison Environmental, Chester, CT

- Worked independently on a variety of projects performing various assorted environmental work as a subcontracted environmental technician
- Accountable for geospatial data collection and analysis
- Participated in wetland and plant surveys as well as mapping initiatives
- Conducted wildlife surveys for amphibians, herps, birds, and bats
- Solely developed geospatial techniques and maps

Environmental & Aquatic Field Technician **Summer 2013 – 2015**
All Habitat Services, Branford, CT

- Identified and removed invasive wetland, upland, and aquatic vegetation by applying pesticides
- Conducted aquatic vegetation surveys and water quality sampling as well as produced professional map products
- Implemented new geospatial methodologies to survey sediments and bathymetry

EDUCATION

B.A. in Geography with minor in Wildlife Conservation • *University of Delaware* **Spring 2015**
Graduate Certificate Geographic Information Science • *University of Delaware* **Spring 2015**

VOLUNTEER & COMMUNITY SERVICE

White-tailed Deer Capture & Tracking • University of Delaware, Milton, Delaware **Jan – Apr 2015**
Marsh Bird Surveys • St. Jones Reserve, Dover, Delaware **June – July 2014**
President of National Meteorological Society Student Chapter, University of Delaware
Boy Scouts of America • Rank of Life Scout

PUBLICATIONS

June-Wells M, Simpkins T, Coleman AM, **Henley W**, Jacobs R, Aarrestad P, Buck G, Stevens C, Benson G. (2017) Seventeen years of grass carp: an examination of vegetation management and collateral impacts in Ball Pond, New Fairfield, Connecticut. Lake and Reservoir Management 33:84–100

SKILLS & QUALIFICATIONS

Proficient with Microsoft Word, Excel, and PowerPoint
Proficient with ArcMap, ENVI, and GIS Data Procurement
Basic knowledge of NCL, Python, R, and Unix
Proficient in use of GPS hand and backpack units (Garmin, Trimble)
Proficient in a variety of water quality sampling techniques/equipment
North Atlantic Aquatic Connectivity Collaborative (NAACC) Lead Observer
National Weather Service Skywarn storm spotter training
North American Lake Management Society Certifield Lake Manager