University of Massachusetts Dartmouth
The School for Marine Science and Technology

TECHNICAL MEMORANDUM

Buttonwood Pond Baseline Assessment

Water Quality Assessment of Buttonwood Pond, City of New Bedford

Quantifying the Nutrient and Water Inputs/Outputs and Nutrient-Related Water Quality of Buttonwood Pond

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Overview: Buttonwood Pond in New Bedford, MA is degraded from excessive nutrient loading from human activities, localized watershed nutrient and stormwater inputs as determined by the *Diagnostic/Feasibility Study for the Management of Buttonwood Pond, New Bedford, Massachusetts* (1988)[1]. During the summer of 2018, scientists in the Coastal Systems Program (CSP), School for Marine Science and Technology University of Massachusetts Dartmouth were approached by the Director of AMT BioProducts, Jeff Young, about an approach to restore water quality in Buttonwood Pond. CSP UMass Dartmouth as a service focused institution agreed to provide unbiased scientific support for evaluation of AMT's restoration approach. This effort by CSP is part of its 20+ year technical assistance to freshwater and estuarine restoration efforts throughout the region. During late August through October of 2018, scientists began an initial baseline monitoring of Buttonwood Pond, mainly collecting water quality samples and measuring volumetric discharge from the Pond's outflowing stream. Additionally, based upon these initial data, in-pond water quality parameters: temperature and dissolved oxygen were added in June 2019 to assess stratification and potential oxygen depletion, as well as, transparency (Secchi depth) and total depth.

This Technical Memorandum summarizes the 2018 water sampling and volumetric outflow

[1] Baystate Environmental Consultants (BEC).

measurements. Stream velocities (volumetric discharge) were measured approximately weekly using a Marsh McBirney electromagnetic flow meter. Water quality samples were collected in conjunction with flow (volumetric discharge). Water quality samples were analyzed for temperature, conductivity, total nitrogen (nitrate + nitrite, ammonium, dissolved organic nitrogen, and particulate organic nitrogen), phytoplankton biomass (as chlorophyll-*a*, pheophytin-*a*), ortho-phosphate, total phosphorus, dissolved oxygen, transparency, and alkalinity. Data collection followed the protocols used in the Massachusetts Estuaries Project (MEP) for stream analysis, water quality monitoring and chemical analysis.

Description Findings from Water Quality and Stream Flow Monitoring 2018:

The nutrient (nitrogen and phosphorus) concentrations in the stream flowing out of Buttonwood Pond (to Apponagansett Bay) indicate that the Pond is showing signs of nutrient enrichment and eutrophication. The average total nitrogen (TN) concentration of Buttonwood Pond was 1.2 mg N L^{-1}, ranging from 0.89 to 1.74 (Figure 1). The concentrations of inorganic nitrogen, ammonia (NH_4^+) and nitrate+nitrite (NO_x^-), were generally low, with an average of 0.02 and 0.04 mg N L^{-1}, and never exceeded 0.07 and 0.15 mg N L^{-1}, respectively. Dissolved and particulate organic nitrogen (DON and PON) make up from 80 to 99% of the total nitrogen (N) flowing out of Buttonwood Pond. This is consistent with other freshwater ponds throughout the region where in-pond biological activity converts inorganic N to organic N forms. The average concentration of DON is 0.64 mg N L^{-1}, ranging from 0.43 to 0.87. Similarly, the average concentration of PON is 0.60 mg N L^{-1}, ranging from 0.37 to 0.94. The high organic versus inorganic nitrogen levels indicates that the Pond is not "saturated" with nitrogen, but that more inorganic inputs should result in more organic matter being produced by phytoplankton and aquatic plants. Total phosphorus (P) concentrations were also very high, ranging from 90 to 314 ug P L^{-1}, with an average of 171 ug P L^{-1} (Figure 2). Ortho-phosphate (PO_4^{3-}) concentration averaged 29 ug P L^{-1}, ranging from 10 to 56. Analysis of chlorophyll-*a* revealed high concentrations at an average of 67 ug L^{-1}, ranging from 48 to 105. The high chlorophylll-*a*, N and P levels are all consistent with a eutrophic pond, with almost certain habitat impairment and large export to downstream receiving waters. Although, concentrations described above are not in-pond measurements, they should be a very close approximation as Buttonwood Pond is relatively small and shallow and outflowing water should reflect pondwater concentrations.

The Cape Cod Ponds Atlas derived standards for freshponds, with water quality target concentrations to maintain high quality habitat of 310, 10, and 1.7 ug L^{-1} for TN, TP, and chlorophyll-*a*, respectively. Based upon comparisons to 100's of Cape Cod ponds, for concentrations of TP, TN, and chlorophyll-*a,* all constituents are currently many times higher than the standards, again supporting the designation of Buttonwood Pond as eutrophic and in need of nutrient management.

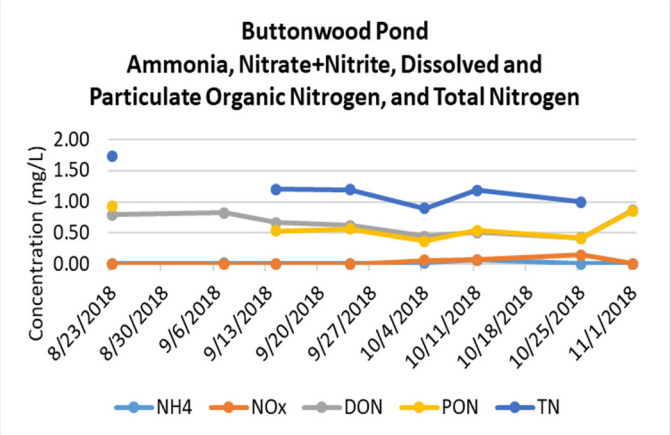

Figure 1. Total nitrogen, ammonia, nitrate + nitrite, dissolved organic nitrogen, particulate organic nitrogen concentrations (mg N L^{-1}) throughout the 2018 sampling period.

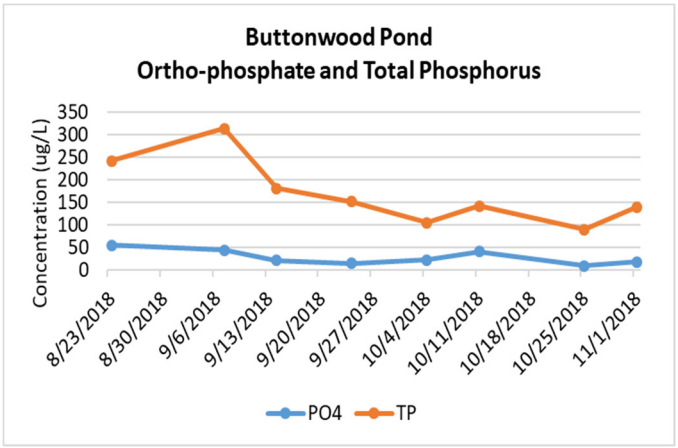

Figure 2. Total phosphorus and ortho-phosphate levels (ug P L^{-1}) through the 2018 sampling period.

Stream volumetric flow (discharge rate) was determined from cross-sectional flow velocities. Results showed a generally low flow of water coming from Buttonwood Pond to downgradient Buttonwood Brook. Measurements conducted on eight sampling dates had a low discharge of 138 m^3 day^{-1} and a high of 1,902 m^3 day^{-1}, the latter being measured within 24 hours of a rain event (Figure 3). Using the detention volume of 21,600 m^3 (pond volume) determined by BEC in 1988, and the 2018 stream flow data, the water residence time is estimated to vary between 11 and 156 days, averaging 65 days (Figure 3).

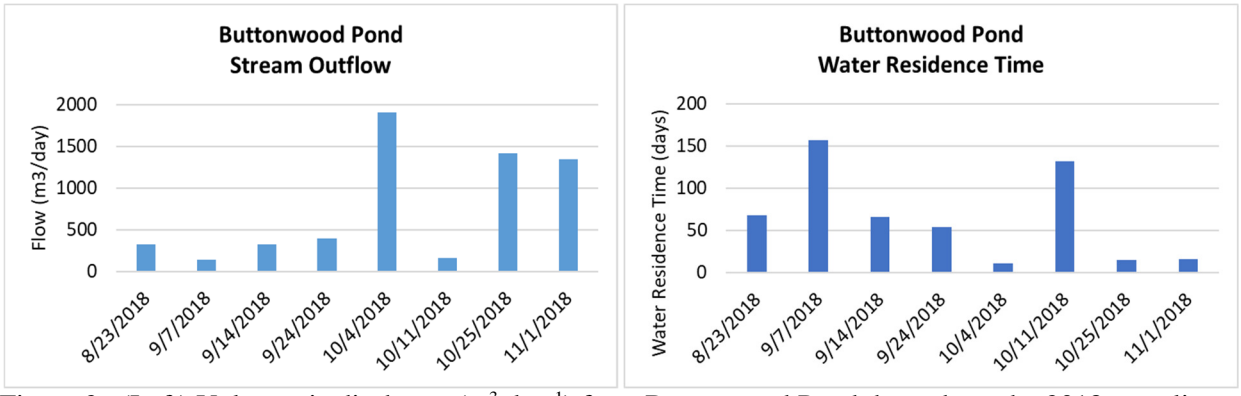

Figure 3. (Left) Volumetric discharge (m^3 day^{-1}) from Buttonwood Pond throughout the 2018 sampling. (Right) Water residence time (days) of a parcel of water in Buttonwood Pond.

Stream flow and nutrient concentration are integrated to determine the nutrient (phosphorus and nitrogen) load leaving Buttonwood Pond in the outflowing water. Nutrient loading from impaired systems is relevant to nutrient loading to down-gradient systems, such as estuaries. The outflowing water from Buttonwood Pond is a contributor to the nitrogen enriched and impaired Apponagansett Estuary. Restoration of Buttonwood Pond would have benefits to the aquatic life and condition of the pond, but also potentially have ecosystem benefits to Apponagansett Estuary by reducing its incoming nitrogen load.

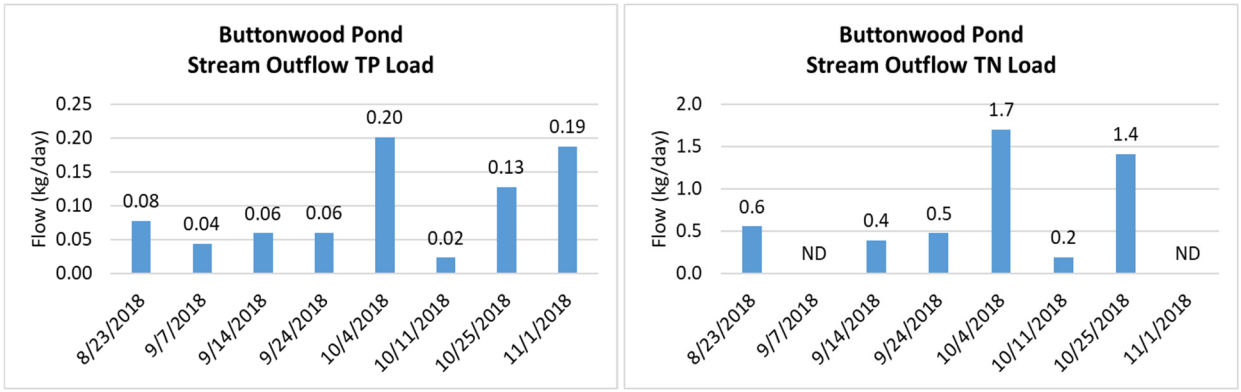

Figure 4. Total phosphorus (left) and total nitrogen (right) load (kg day^{-1}) from Buttonwood Pond throughout the 2018 sampling.

Description Findings from in-pond Water Quality Monitoring 2019:

A sampling effort was conducted on June 13, 2019, in order to gain insight on the in-pond water quality conditions. Sampling measurements were made at five locations in Buttonwood Pond (Figure 5), starting at the edge of the emergent wetland in the northern area of the pond and moving toward the outlet, collecting sufficient data on areas near and far from the pond's aeration system, located near the outlet. At each station, profiles of temperature and dissolved oxygen were taken to assess the level of mixing in the pond. Additionally, secchi depth measurements were made to assess the level of turbidity.

Water quality conditions seen throughout the pond indicated that the pond is currently well mixed, with no temperature stratification or variable dissolved oxygen conditions, likely due in part to the actions of the aeration system. The temperature of the pond on this day was 20.4 to 20.6 ˚C, with dissolved oxygen averaging 7.41 mg L^{-1}, ranging from 7.10 to 7.63 mg L^{-1}. Secchi depth was consistently between 0.3 and 0.4 m, and unable to see the bottom at all five stations. Based on the sites sampled, the pond is deepest in the southern half of the pond. The deepest depth measured was 1.2 m at BTW4, east of the small island. It appears that while oxygen levels were generally moderate to high, that the high nutrients were resulting in organic enrichment that would likely render the pond hypoxic if aeration stopped, i.e. one of the consequences of eutrophication is being managed, but not others (e.g. turbidity, blooms) which will require reduction in nutrient levels.

Figure 5. Station map of Buttonwood Pond.