Westtown Lake: Floating Wetland Islands

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Using Floating Wetland Islands to Limit Available Nutrients in Lakes

The Utilization of Nutrients by Algae and Aquatic Plants and the Application of Best Management Practices

As nutrients enter a waterbody, they are processed, cycled, and utilized through a variety of physical, chemical and biological mechanisms. While algae and aquatic plants, here collectively termed aquatic macrophytes, require a variety of nutrients to grow, the primary limiting nutrient for most freshwater systems, particularly in the northeast portion of the United States, is phosphorus. That is, it takes very little phosphorus to stimulate a lot of phytoplankton and macrophyte growth. For example, a one-pound bag of phosphorus has the potential to stimulate up to 1,100 pounds of wet algal biomass. Thus, keeping phosphorus concentrations as low as possible, or diverting this phosphorus into more desirable vegetation, are commonly employed long-term strategies in preserving and protecting freshwater ecosystems.

Unlike nitrogen, phosphorus does not have a gaseous phase, so the removal of phosphorus can focus primarily on processes such as settling, adsorption onto soil/sediment particles, and its assimilation by desirable organisms. Thus, many management measures to reduce phosphorus focus on watershed-based sources such as stormwater, on-site wastewater, goose control, or the use of non-phosphorus fertilizers. Depending on a number of factors, internal loading from the sediments can also be a substantial source of phosphorus fueling macrophyte growth; however, for most waterbodies, watershed-based sources of phosphorus tend to be the largest inputs.

Some of the most effective means to reduce the phosphorus load entering a waterbody is the creation and establishment of vegetation Best Management Practices (BMPs) such as stormwater wetlands, riparian lakeshore buffers, and biofilteration/rain garden structures. For example, based on Pennsylvania's stormwater manual, constructed wetlands are estimated to have phosphorus removal rates of 85 percent, while New Jersey's stormwater manual gives constructed wetlands an estimated removal rate of 50 percent. Obviously, site-specific conditions and the design of the constructed wetland will dictate its actual pollutant removal rate.

The vegetation associated with any stormwater BMP will filter out phosphorus that is adsorbed onto particulate material, as well as providing habitat for a variety of microbial organisms to assimilate phosphorus. While the vegetation in these systems will also assimilate phosphorus, the associated microbial communities dominant this uptake; it is estimated that 80 percent of the biological assimilation of phosphorus in wetland ecosystems is due to microbes.

Vegetation-based BMPs have been well documented to remove a substantial amount of the phosphorus load entering a waterbody. However, there are instances where the installation of such watershed-based BMPs is extremely difficult. Such cases are typically associated with the limitation of available spaces or inappropriate hydrologic conditions. Such situations commonly arise in urban or suburban impoundments.Thus, under such conditions, where the installation of large, vegetation-based BMPs either in the watershed or adjacent to the waterbody are not feasible some alternative measures need to be considered.

The Design and Installation of Floating Wetland Islands

An alternative to watershed-based constructed wetlands or similar BMPs is the installation of Floating Wetland Islands (FWIs), which are structures composed of woven, recycled, plastic material (Figure 1). Vegetation is planted directly in the plastic material of the FWI with some peat and mulch (Figure 2) and then launched into a waterbody (Figure 3). Once in position, the FWI is anchored with rope and cinder blocks. The vegetation grows on the FWI, with their roots growing through the plastic material, creating excellent habitat for a variety of micro-organisms. This is achieved primarily through the creation of a large amount of surface area that harbors a large amount of diverse microbial growth. It is estimated that one 250-square-foot FWI has the surface area equal to approximately one (1) acre of natural wetland.

Once installed and in position, the FWI serves as a sink for nutrients, in particular phosphorus.The diverse microbial communities in and underneath the FWI assimilate phosphorus where it is then sequestered into living biomass. Some of this biomass is the vegetation growing on the FWI; some is in other microbial organisms or larger organisms that may exist on the FWI (i.e., macroinvertebrates). In turn, a portion of this phosphorus may eventually be incorporated into larger organisms, such as fish or birds that can move away from the FWI.

Figure 1. Construction of the floating wetland islands at Westtown Lake.

Figure 2. Recently planted floating wetland islands.

Diverting some of the incoming phosphorus load into the FWI and associated biomass reduces the amount of phosphorus available for nuisance aquatic plant growth, particularly phytoplankton, filamentous mat algae, and free-floating plants such as duckweed. In addition to being a sink for nutrients, the FWIs also provide excellent refuge habitat for small invertebrates, which in turn attract desirable organisms such as forage fish and gamefish. Another value of the FWIs is that they can be planted with attractive, native vegetation, creating an aesthetic amenity for the lake. FWIs can provide other benefits such as habitat for desirable waterfowl and can contribute toward shoreline protection. However, while these ecosystem functions are certainly beneficial, nutrient assimilation tends to be one of the primary uses for FWIs.

Figure 3. Positioning one of the floating wetland islands on Westtown Lake.

Westtown Lake, Chester County, Pennsylvania

In an effort to quantify the amount of phosphorus FWIs can assimilate, Princeton Hydro conducted a set of studies in 2011. In the first case, Princeton Hydro assisted Westtown School, a private Quaker school in Chester County, PA, to obtain a grant and implement a number of innovative, in-lake restoration techniques. Specifically, a grant was awarded to Westtown School by the Pennsylvania Lake Management Society; one of the grant tasks was to install three FWIs in Westtown Lake a 14-acre impoundment, located on the school's campus. The lake is used by both students and local residents for boating and fishing and provides for a number of educational opportunities.

The three FWIs installed in Westtown Lake had surface areas of 5, 60, and 250 square feet and as part of the grant, the five-square-foot FWI (Figure 4) was used to attempt to quantify the uptake of phosphorus over the course of the growing season.The FWIs were planted and installed in late May – early June 2011 with the assistance of some of the students of Westtown School (Figure 5). A variety of attractive, native vegetation was planted on the FWIs and included swamp milkweed, New England aster, rice cutgrass, pickerelweed, blue-flag iris, soft rush and others. Approximately one week after the FWIs were installed, an

Figure 4. An unplanted five-square-foot floating wetland island.

Figure 5. Westtown School students assisting in planting the floating wetland islands.

industrial scale was used to measure the weight of planted five-foot-square FWI and then in early October 2011 the FWI was re-weighed.

The FWIs were in the water for 113 days and the five-square-foot FWI gained approximately 10 lbs. Samples of the microbial mats underneath and the vegetation on the surface of the FWI were collected and sent to a laboratory for the analysis of total phosphorus (TP) and total nitrogen (TN). The results of these analyses were used to quantify how much TP and TN were removed from the lake through the FWIs. Based on this analysis, all three FWIs were estimated to remove approximately 1.6 lbs of TP per growing season and 8.4 lbs of TN per growing season. Thus, it is estimated that based on the amount of TP removed, total wet algal biomass in Westtown Lake was reduced by approximately 1,750 lbs.

It should be noted that this estimated removal rate is lower than what other studies have reported. For example, one study documented that a 250 square-foot FWI can remove approximately 10 lbs of phosphorus per growing year. The lower removal rate documented in the Westtown Lake study was more than likely due to a number of factors related to the experimental design. For example, the five-square-foot FWI was anchored close to the shoreline where it received a substantially lower amount of sunlight relative to the other FWIs, which were anchored in the middle of the lake. In addition, while samples of microbes underneath and plants on top of the FWI were collected, none of the microbial growth within the FWI was sampled, which underestimated the amount of nutrient uptake. Also, the study focused on measuring the TP concentration at the beginning and end of a portion of the growing season; it did not directly measure uptake rates over the entire growing season. Thus, it is more than likely the other study better represented actual uptake rates.

New Jersey, Somerset County Study

In another study conducted by Princeton Hydro to quantify the ability of FWIs to assimilate phosphorus, a series of FWIs, twelve (12) five square-foot units and thirteen (13) 64 square-foot units, were installed in a one-acre concert pool called Mermaid Pool (Figure 6) that

Figure 6. Floating wetland island approximately two months after it was planted.

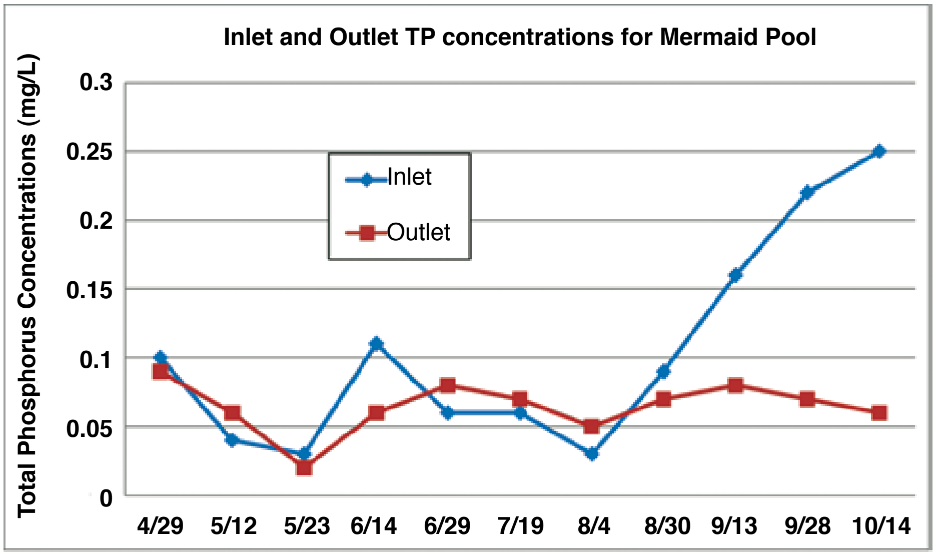


Figure 7. Inlet and outlet total phosphorus concentrations at Mermaid Pool over the 2011 growing season.

connects water pumped from the Raritan River, Somerset County, New Jersey, to an approximately 19-acre lake on an estate that is open to tours for the public. The FWIs were installed in Mermaid Pool in 2010 and thrived. A monitoring program was conducted in 2011 to determine if the installed FWIs had a measurable impact on the incoming TP concentrations.

Over the course of the 2011 growing season, water samples were collected from the inlet, originating from water pumped from the Raritan River, and outlet, directly discharging into Vista Lake, of Mermaid Pool 11 times and analyzed for TP. Outlet TP concentrations were lower than the inlet TP concentrations during seven of the 11 monitoring events. In addition, as shown in Figure 7, a decline in the outlet TP concentration was typically identified when inlet TP concentrations were equal to or greater than 0.1 mg/L. Other studies have documented this result; that is, a measurable reduction in TP concentrations as a result of FWIs was common when TP concentrations were at or greater than 0.1 mg/L. In contrast, once inlet TP concentrations fell below 0.1 mg/L, there was generally little or no net uptake of TP (Figure 7). Thus, this and other studies have provided data that support the idea that FWIs tend to be most effective as a sink for phosphorus when TP concentrations are excessive.

For the 11 monitoring events, the mean inlet and outlet TP concentrations for Mermaid Pool were 0.105 and 0.065 mg/L, respectively, representing a growing season-wide reduction of 38 percent. During a similar monitoring program in 2003, prior to the installation of the FWIs, the growing-season wide reduction through Mermaid Pool was 29 percent. Thus, the FWIs did contribute toward a measurable reduction in TP concentration, beyond standard settling and assimilation activities within the pool.

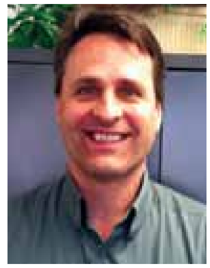
Using hydrologic data collected over the 2011 growing season, the monthly or bi-monthly loads of TP entering and leaving Mermaid Pool were calculated. Based on this analysis, the FWIs within Mermaid Pool resulted in a net reduction of TP over the 2011 growing season of approximately 60 lbs. Translating this to potential wet algal biomass, 60 lbs of TP could generate up to 66,000 of wet algal biomass.

Once installed, the overall maintenance of the FWIs tends to be relatively low. After the vegetation is planted, it should be allowed to grow, with no harvesting of biomass for at least two or three growing seasons.This allows the vegetation to become well integrated into the island material and to grow high enough to dissuade Canada geese from feeding on the plants and/or using the FWI for nesting. In addition, goose netting should be installed over the vegetation during the first one or two growing seasons to prevent geese from feeding on the plants. Eventually, after a few years, vegetation should be harvested to stimulate additional growth and to remove sequestered nutrients; however, harvesting should only focus on plant biomass above the island material. The root complex should remain intact in order to preserve the microbial habitat (Figure 8). Thus, only biomass above the root system should be periodically

Figure 8. Close-up of the high amount of surface area within the floating wetland islands.

harvested. Additional goose netting may be required after the vegetation has been harvested to protect the secondary growth.

In conclusion, FWIs are an alternative to watershed-based BMPs that may not be feasible due to limitations in space or other environmental factors. FWIs can function as net sinks of nutrients, particularly phosphorus, but tend to be more effective when water column TP concentrations are greater than 0.1 mg/L. In addition to nutrient uptake FWIs can also create habitat for desirable organisms such as forage and gamefish, as well as increase both biodiversity and the general aesthetics of a lake ecosystem.



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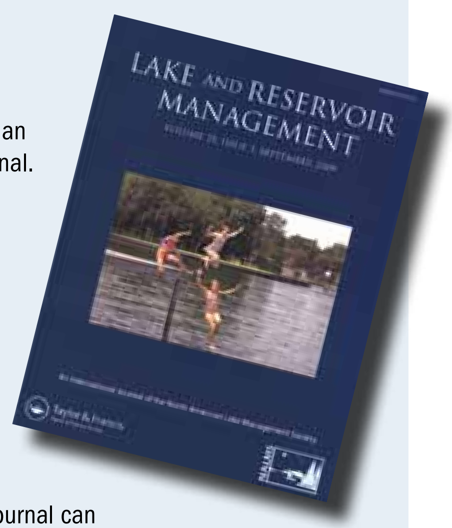

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