The Pioneer Grant Program

The 2016 Pioneer Grant Program aims to reduce nutrient and/or sediment contaminant loads to the Maryland portion of the Chesapeake Bay and Maryland Coastal Bays from any nonpoint source: agriculture, urban or suburban stormwater, air, and septic by seeking proposals that focus on new techniques, information, or programs that increase the rate at which load reductions can occur.

Baltimore County Department of Environmental Protection & Sustainability

Self-Converted Detention Ponds

2012-2016

Project Track: New Information

Research Question: This project will provide new information on the pollutant removal efficiency of dry detention ponds that have converted to shallow marsh systems. Previous studies have indicated that dry detention ponds provide greater removal efficiencies than are currently credited through the CBP Watershed Model 5.3.2, possibly due to self conversion of dry ponds to shallow marsh. Results will enhance the ability to more effectively prioritize restoration activities for pollutant load reductions.

Research Results: Statistical testing of load removals between groups did not support our hypothesis, but a small sample size (n = 3 ponds) of each limited the power of detecting a statistically significant difference in load reductions.

Notable Information: Results from this study may also help the County demonstrate progress towards addressing the stormwater wasteload allocations for water quality pollutants under its NPDES MS4 permit, and enhance the County's ability to more effectively prioritize restoration activities for pollutant load reductions across the County.

PROJECT PARTNERS

UEBL — Urban Environmental Biogeochemistry Laboratory

KCI

CEM — Applying Practical Science to Improve Communities

Baltimore County Department of Environmental Protection & Sustainability

Self-Converted Detention Ponds

2012-2016

Summary of Project

Three (3) self-converted (study) ponds and three (3) control ponds that met the needs of the study were selected following the guidance of the Urban Stormwater BMP Performance Monitoring Manual (USEPA, 2009) to ensure that the sites are optimally suited for the projects goals. Monitoring protocols for the study were implemented to evaluate the effectiveness of each type of facility at reducing pollutants, namely nutrients (total phosphorus and total nitrogen) and suspended solids. A Quality Assurance Project Plan (QAPP) (KCI, 2014) was developed for the study to ensure the data collected are consistent and of the highest quality. The study design consists of water quality monitoring, both storm flow and base flow (when present) sampling of influent and effluent at six facilities located throughout the County over the course of a year. The study began in the summer of 2014 and continued through the fall of 2015. Sampling was generally conducted to provide a range of small and large storm events representing all four seasons, with a total of 8 storm events spread throughout the year at each site. Precipitation samples were also collected in each season to document wet deposition of pollutants directly into the facilities. The study employed automated rain gauges at each facility to collect continuous precipitation data (10-minute intervals), as well as pressure transducer level loggers and flow gauging devices for continuous discharge gauging (5-minute intervals) at all inflow and outflow structures. Discrete water quality samples representing the rise, peak, and falling limb of each storm hydrograph were collected at each inlet/outlet and were laboratory analyzed for Total Suspended Solids (TSS), Total Kjehdahl Nitrogen (TKN), Nitrate/Nitrite Nitrogen, Total Nitrogen (TN), Total Phosphorus (TP), Orthophosphorus, and Total Dissolved Solids (TDS). Precipitation samples were analyzed for nutrients only.

Event Mean Concentration (EMC) values were calculated for each storm event, which were used to compare influent and effluent concentrations and evaluate BMP efficiency. Paired samples were compared using the non-parametric Wilcoxon signed-rank test (Wilcoxon, 1945). Cumulative distributions between influent and effluent EMCs were compared using a two-sample Kolmogorov-Smirnov test. EMCs were also used to evaluate BMP performance using the Effluent Probability Method (Burton and Pitt, 2001), which involves examining the influent and effluent quality on a standard probability plot.

The results of this study suggest that mature (i.e., decades-old) dry detention ponds provide greater removal efficiencies than the crediting currently provides, whether they are considered self-converted or unconverted. Our study population of self-converted dry ponds showed average reductions of 23.3% for TN, 47.9% for TP, and 60.0% for TSS. Similar performance was observed unconverted dry detention ponds, with average reductions of 18.5% for TN, 28.8% for TP, and 53.2% for TSS. Comparison between the study results and the current approved CBP rates suggests that the self-converted group was quite similar to that of the wet pond/wetland category. The control group of un-converted ponds performed much better than the CBP dry detention pond rates and performed overall more closely to the dry extended detention pond rates.

Project Evaluation

The primary goal of this study was to test the hypothesis that self-converted dry detention ponds provide greater removal efficiencies than unconverted dry detention ponds. Statistical testing of load removals between groups did not support our hypothesis, but a small sample size (n = 3 ponds) of each limited the power of detecting a statistically significant difference in load reductions. Furthermore, one of the 'Control' ponds performed much better than expected, which resulted in considerable overlap between the sample groups. Although the results from our study do not support the notion that self-converted ponds perform statistically better than unconverted dry ponds in our sample population, they do suggest that some unconverted dry ponds perform as well as, or better than, some self-converted facilities. In effect, this raises many questions regarding the mechanisms behind the pollutant removal within these different types of dry ponds, which could be the focus of future research. It also highlights the difficulties in attempting to group 'mature' detention ponds into generic categories given the many unique characteristics observed at each site with regard to vegetation, micro-topography within the facility, water retention and/or infiltration, and hydrologic functionality.

It is also important to consider how these ponds function in their present state 30 or more years after construction, as opposed to how they were designed to function when newly constructed. For example, of the dozens of ponds visited as part of the site selection process, many showed signs of decades' worth of sediment accumulation within the pond bottom that influenced the hydrology and occasionally resulted in areas of storage and attenuation. A common occurrence was the formation of 'deltas' immediately below the inlet structures where the energy had dissipated and the stormwater dropped sediment and/or organic matter loads. Over time these deposits became vegetated and stabilized often acting as berms, ultimately changing the flow path and rendering the pilot channels less effective at passing small events through with minimal retention time. Many ponds no longer showed evidence of rip-rap pilot channels, which were shown on the design plans, because they had become filled with sediments and subsequently vegetated. Many potential sites had to be excluded because the inlets were submerged and/or backwatered, which would have hindered our ability to accurately gauge discharge into the facilities.

What is not surprising in this study is the demonstrated ability of self-converted dry detention ponds to provide greater removal efficiencies (Avg TN = 23.3%, Avg TP = 47.9%, Avg TSS = 60.0%) than the CBP and MDE crediting currently provides. However, we also observed a broad range of pollutant removal performance across the unconverted dry detention ponds (Avg TN = 18.5%, Avg TP = 28.8%, Avg TSS = 53.2%) that suggests comparable performance but within a broader range than the self-converted facilities. Load reductions tended to be influenced by storage and infiltration of base flow in addition to small amounts of storm flow, therefore, facilities with base flow input generally performed better.

Because we selected an array of ponds with different drainage area characteristics within each class (control vs. study) in an effort to be more representative of the County's larger population of dry detention ponds, it becomes more difficult to determine why some ponds perform much better than others. After studying theses ponds for a year or more and observing how they perform under a broad range of storm events of differing durations and intensities, we feel that it is more appropriate to discuss and evaluate the ponds individually, as opposed to being grouped into one category, and to provide some insight to explain the complexities that were not apparent during our site selection, but nonetheless have influenced our results. We have identified a number of additional factors that may affect the performance of pollutant removal for these facilities, as well as the expected direction of response, which are displayed in Table 28. Each pond was evaluated for the following characteristics:

- Direct Flow Path – Does the facility have at least one inlet with a direct flow path, either as a constructed pilot channel or defined channel, leading from the inlet to the outlet?
- Diffuse Flow – Does the influent spread out over the pond bottom, rather than remain concentrated in a defined flow path?
- Base flow Input – Does the facility have seasonal or year-round base flow inputs?
- Base flow Retained – If base flow is present, is it primarily retained within the facility?
- Mowed Vegetation – Is the vegetation in the facility mowed regularly, or at least annually?
- Herbaceous Vegetation – Does the facility contain herbaceous vegetation?
- Woody Vegetation – Does the facility contain woody vegetation (i.e., shrubs and trees)?
- Detritus Present – Does the facility contain noticeable quantities of detritus (i.e., leaf litter, sticks, seed pods, etc.) in the pond bottom?

Transferability and Sustainability

The results of this study suggest that mature (i.e., decades-old) dry detention ponds provide greater removal efficiencies than the crediting currently provides, whether they are considered self-converted or unconverted. Our study population of self-converted dry ponds showed estimated reductions of 9-36% for TN, 24-75% for TP, and 24-82% for TSS. A broad range of pollutant removal performance was also observed in our population of unconverted dry detention ponds, with estimated reductions of 2-29% for TN, 15-42% for TP, and 19-73% for TSS. Comparison between the study results using average rates for each pollutant and the current approved CBP rates is included in Table 29. The control group of unconverted ponds performed much better than the CBP dry detention pond rates and performed overall more closely to the dry extended detention pond rates. Performance of the self-converted group was quite similar to that of the wet pond/wetland category.

With the broad range in performance for both self-converted and unconverted facilities, it may become a challenge to extrapolate the results to the County's other facilities since the factors driving pollutant removal success involve more than just the presence or absence of wetland soils and vegetation. While there appear to be numerous factors responsible for increasing the potential for pollutant removal, the primary characteristics observed among the best performing facilities are 1) diffuse flow through the facility without a pilot channel; 2) base flow retention, and 3) presence of vegetation (other than turf grass). What is perhaps less clear, is the contribution each of these factors play in the overall reduction of TN, TP, and TSS. Future studies could investigate how much the diffuse flow and vegetation contribute to removal, since these are the only two characteristics that can be modified for retrofit/enhancement purposes. It is possible that relatively inexpensive and disruptive retrofits using flow splitters or plugging pilot channels could direct flow through the facility to results in better interaction with vegetation and soils to promote enhanced treatment. Furthermore, it remains unknown whether attempting to recreate some of these conditions artificially would provide the same levels of performance as those that have developed over decades through natural ecological processes such as sediment deposition, vegetative colonization, and nutrient cycling.

Since conducting this study to evaluate the performance of self-converted and unconverted dry detention ponds, a number of additional questions have been raised that follow-up studies may help to address. Additional water quality parameters were tested for that were outside of the direct focus of this investigation and therefore not reported on here, but can be investigated in the future. Questions to investigate include: Are these types of ponds as effective at removing sodium and chloride, given the pervasiveness of salt use in treating roadways in the winter? What is the performance of these ponds for the removal of the different forms of nitrogen and phosphorus? Does storm intensity and/or duration of storms affect the removal rates, and if so, to what degree? Does influent concentration impact performance or reduction efficiency?

Lastly, it is recommended that the data be presented to MDE and the Chesapeake Bay Program for a review, given that the pollutant removal rates observed in this study far surpassed those currently recommended by MDE and the Chesapeake Bay Program. Accurate crediting is increasingly important in today's regulatory environment, especially with the current Chesapeake Bay TMDL goals for reducing nutrients and sediments throughout the entire watershed.

As conditions of the Pioneer Grant supporting the study, KCI, Towson UEBL and Baltimore County will present the results to the Bay Program's Urban Stormwater Workgroup and will submit the resulting data to the International Stormwater BMP Database.

Partnerships

The County partnered with KCI Technologies, Inc. (KCI) and their project team including Towson University's Urban Environmental Biogeochemistry Laboratory (UEBL) and Chesapeake Environmental Management (CEM) to implement this study. The focus was the evaluation of dry detention ponds that have self-converted to ponds with soils and vegetation species that are characteristic of wetlands, which have not been well studied and may provide enhanced pollutant removal when compared to maintained (i.e., unconverted) dry detention ponds.

Accounting of Expenditures

CBT Funds: $100,000
Bonds: $196, 389
Total Funds: $296,389