Article 74

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Performance of Stormwater Ponds in Central Texas

Is any more data on stormwater ponds really necessary? After all, the performance of nearly 40 storm water ponds has been investigated over the last two decades. However, there are a few good reasons to acquire still more monitoring data on these stormwater workhorses. First, most of the stormwater ponds monitored in the past were relatively small in size and simple in design. Moreover, these ponds seldom possessed the forebays, aquatic benches, greater volumes, extended detention, pondscaping and other design features now routinely prescribed by many local stormwater agencies. It is thus of more than passing interest whether these new and often expensive features can actually improve the pollutant removal performance of ponds and by how much.

Second, most prior pond research has occurred on the coasts, and mostly within humid climates. Because of this, performance monitoring data has been lacking for stormwater ponds built in semi-arid climates that have very hot and dry summers and the accompanying high evaporation rates. Stormwater managers have frequently wondered whether it is possible to maintain a permanent pool and prevent stagnation in ponds within these regions, and how these factors might influence the pollutant removal capability and maintenance requirements of wet ponds.

Two recent monitoring studies conducted near Austin, Texas shed some light on both of these issues (COA, 1997, and LCRA, 1997). While the Central Texas region typically gets about 30 to 35 inches of rainfall each year, it is not unusual for the area to go many weeks without rain during the summer, when evaporation rates are as high as 10 inches per month. As a consequence, significant pond draw downs must be factored into the design of stormwater ponds, or else they must be supported with supplemental water.

The first stormwater pond, known as St. Elmo's, had a permanent pool of 4.1 acre-feet. The pond served a 27.1 acre catchment that had more than 66% impervious cover, most of which was either street or parking lot. The surface area of the pond was 1.65 acres, with about 40% devoted to shallow wetlands, and 60% allocated for deeper pools. The layout and pondscaping plan for St. Elmo's are depicted in Figure 1. Forebays were located at the primary stormwater inlets, and berms were used to extend the flow path and prevent runoff from short-circuiting through the pond. The pond also provided extended detention storage above the pool, with a one to three day draw down time after a storm. Combined, the permanent pool and extended detention storage provided about 1.8 watershed-inches of storage quality treatment. Overall, the hydraulic retention time in the pond ranged from two to 70 days, with an average of about a month. Clearly, St. Elmo's was not an undersized pond.

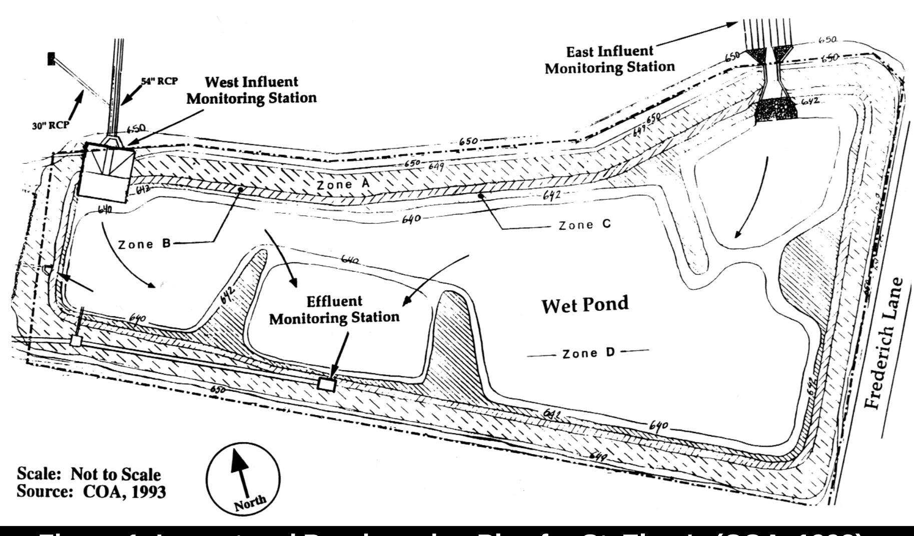

Figure 1: Layout and Pondscaping Plan for St. Elmo's (COA, 1993)

To prevent evaporation in the summer, the bottom of the pond was sealed by a liner. Still, evaporation made it difficult to maintain the pool at a constant level. To conceal changes in water levels, shallow areas in the pond were planted with spike rush (*Eleoarchis spp.*), Bulrush (*Scirpus*), Duck Potato *(Saggitaria)* and other aquatic plants. The pond was less than two years old when monitoring began in 1994, and more than 20 paired stormwater samples were collected at the inlets and outlet over the next two years. As usual, the monitoring effort and subsequent data analysis followed the exacting standards of the City of Austin Drainage Utility (COA, 1997a). The computed pollutant rates for the St. Elmo's wet pond are provided in Table 1.

It is evident that the St. Elmo wet pond provided a very high rate of pollutant removal, with more than 90% removal of total suspended solids and bacteria. Nutrient removal was also quite strong, with exceptional removal of total phosphorus (87%) and dissolved phosphorus (66%). Removal of various forms of nitrogen ranged from 40 to 90%, as well. However, the removal of metals was not as promising, ranging from 30 to 60%. Overall, the St. Elmo pond consistently achieved removal rates approximately 20% above the national median removal rates for wet ponds. A close inspection of the outflow from the pond revealed very low concentrations of most stormwater pollutants, which is another indicator of a high level of treatment (see Table 1).

A third indicator of the high level of stormwater treatment achieved by the St. Elmo pond was the high pollutant concentrations found in the sediments (Table 2). Despite the fact that the pond was only a few years old, its sediments had trace metal and hydrocarbon levels similar to those found in the sediments of Austin area oil/grit separators. The high level of stormwater treatment achieved at St. Elmo was attributed to its enhanced pond design features and large permanent pool. These resulted in unusually long hydraulic residence times that allowed settling, algal uptake and other pollutant removal processes to operate.

The second pond was a micropool extended detention pond monitored by Bruce Melton and Tom Curran of LCRA (1997). The pond drained roughly 12 acres of office park and roadway, and utilized a much different design concept than St. Elmo's. Most of the water quality storage provided in the pond (about one watershed-inch) was devoted to extended detention (ED), with only a small permanent pool located near the outlet (about 0.29 acre-feet). During dry weather, the pool was maintained by draining excess condensation water from the air-conditioning systems of the buildings in the office park. This supplied about 2.6 acre-feet per year of supplemental water needed to sustain the micropool, which had a fringe of wetland plants. The pond had two inlets, each of which had a forebay formed by a rock or gabion berm to provide pretreatment. Some of the upland drainage was treated with other innovative peat sand filters.

The pond was extensively landscaped with a variety of drought and/or inundation tolerant plant species planted, depending on their elevation within the pond.

Table 1: Performance of the St. Elmo Wet Pond System

Water Quality Parameter	Outflow Concentration	Removal Efficiency
Total Suspended Solids TSS	9 mg/l	93%
BOD, five day	2.4	61%
COD	23	50%
Nitrate-Nitrogen	0.45	40%
Total Kjeldahl Nitrogen	0.47	57%
Ammonia-Nitrogen	0.03	91%
Total Nitrogen	0.92	50%
Total Phosphorus	0.04	87%
Dissolved Phosphorus	0.03	66%
Copper*	4.2 ug/l	58%
Lead*	3.9 ug/l	39%
Zinc*	59.6 ug/l	27%
Fecal Coliform	1324	98%
Fecal Strep	1265	96%

For comparison purposes, the median removal rates for wet ponds was 77% (TSS), 47% (TP), 30% TN and 45% (Cu), according to CWP National BMP Database (see article 69). Pollutant removal rates for trace metals were computed based on means of instantaneous individual inflow and outflow concentrations.

Table 2: Sediment Chemistry of St. Elmo Pond Sediment (mean of five sediment samples)

Sediment Parameter	Units	Level
Lead	mg/kg	21.5
Zinc	mg/kg	471
Copper	mg/kg	46.7
Petroleum Hydrocarbons	mg/kg	5202
Total Organic Carbon	mg/kg	4,414
PAHs (max)	ug/kg	10,210

A clay liner was installed to prevent infiltration losses, which failed initially and was subsequently repaired. Water levels in the pool were fairly stable, but did draw down during extended dry periods (which coincided, naturally, with the onset of the stormwater monitoring program). With some persistence, the research team was able to collect 17 paired storm samples at the inlet and outlet over a two-year period. Their estimates of the pollutant removal capability for the pond are provided in Table 3.

In general, the micropool extended detention pond performed quite well in removing most pollutants found in urban stormwater. Overall, the removal rates are generally higher than the national median removal rates for all stormwater ponds, and are the highest yet recorded for a pond that devoted most of its treatment volume to extended detention. The micropool ED pond removed roughly half of the total nitrogen and phosphorus in incoming runoff, and produced very low concentrations of all forms of nutrients in its outflows (see Table 3). Removal of sediment and trace metals was greater than 80% in the pond.

Implications for Stormwater Design

The strong nutrient removal performance in both ponds was promoted by the long growing season and bright sunshine for which Central Texas is noted. Both ponds were rapidly overgrown with surface and benthic algae, emergent plants and submerged aquatics. As much as 70 to 80% of the surface area of each pond was covered by these aquatic plants, which undoubtedly led to the high removal. At the same time, the high rate of plant growth added to the annual maintenance burden, as some form of aquatic plant management or harvesting was needed to keep each pond looking attractive. The role of evaporation, while not directly studied, was thought to be very important in the pollutant removal performance of the ponds.

Glick *et al.* (1998) noted that the monitoring studies clearly demonstrated that wet ponds exhibit greater pollutant removal than other stormwater practices in Austin, Texas, at a lower cost per volume treated than other practices, such as sand filtration. Consequently, the City has developed new specifications for wet ponds and actively promote their use (COA, 1997b).

In many instances, wet ponds can require supplemental water to maintain a stable pool elevation during dry periods in Central Texas. Consequently, designers need to explore innovative means of recycling other sources of water to maintain pools. Otherwise, designers working in semi-arid watersheds should design for a variable pool level that can have as much as a three-foot draw down during the dry season. The use of wetland plants along the pond's shoreline margin can help conceal these drops in water level, but managers will need to reconcile themselves to chronic algal blooms, high densities of aquatic plants and the occasional episode of odor problems. Thus, the price for attaining higher pollutant removal in ponds in Central Texas is often supplementary source of water and certainly a greater effort to maintain aquatic vegetation. ***–TRS***

Table 3: Performance of the LCRA Office Wet Extended Detention Pond (LCRA, 1997)

Water Quality Parameter	Outflow Concentration (mg/l)	Removal Efficiency (%) [a]
Total Suspended Solids	12.0	83
Total Organic Carbon	8.7	45
Total Phosphorus	0.11	52
Ortho-phosphorus	0.034	76
Nitrate-nitrogen	0.06	85
Total Kjeldahl Nitrogen (TKN)	0.69	52
Total Nitrogen	0.77	55
Lead	0.003	90
Zinc	0.030	86

(a) removal computed based on average event mean concentration (EMC) from 17 storms at inlet and outlet of basin. (b) removal for Cadmium and Chromium could not be computed because most samples were below detection limits.

References

City of Austin (COA). 1997a. *Evaluation of Nonpoint Source Controls— An EPA/TNRCC Section 319 Grant Report.* Drainage Utility Department. Report No. COA-ERM-97-04. Austin, TX.130 pp.

City of Austin, (COA) 1997b. "Wet Pond Design Supplement." Section 1.6.6.C of *Environmental Criteria Manual.* City of Austin, TX Drainage Utility.

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Profile of the St. Elmo Wet Pond Showing Landscaping Zones (COA, 1993)