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Performance of a Stormwater Pond/Wetland System in Colorado

Urbonas and his colleagues recently investigated the pollutant removal performance of a large stormwater pond/wetland system located in Aurora, Colorado. The unique runoff treatment system is illustrated in Figure 1. Runoff enters a large wet pond that provided a total of 0.3 watershed-inches of runoff treatment (0.1 inches of permanent pool, plus 0.2 inches of extended detention — approximately 20 hours for most storm events). Runoff then exits the pond over a soil/cement spillway and enters a series of six cascading wetlands cells.

Wetland cells were located in a flat and broad channel, and were formed by a soil/cement drop structure installed across the channel. Water velocity was designed to be less than three feet per second (fps) during major floods, and less than 0.3 fps during smaller storm events. The wetland consisted primarily of cattail and bulrush species. Average contact time in the 3.8 acre wetland area was about two hours during smaller storms. The wetland cells comprised about 0.7 %of total watershed area.

The Shop Creek watershed draining to the system was 550 acres in size and almost exclusively composed of detached single family homes. Watershed imperviousness averaged 40%, although only 75% of the impervious surfaces were hydraulically connected. Shop Creek is located in the high plains and foothills of the Rockies mountains east of Denver.

Thirty-six storm events were sampled over a three year period in a cooperative effort of the Cherry Basin Water Quality Authority and the Denver Urban Drainage and Flood Control District. Monitoring was confined to the growing season (May to September) in the semi-arid area. In addition, a limited number of baseflow samples were taken along the wet pond and wetland system to characterize water quality dynamics during dry weather periods.

The monitoring revealed that the pond/wetland system was reasonably effective at removing many pollutants during storm events (Table 1). For example, about half of the total and dissolved phosphorus load was removed as it passed through the pond, with the majority occurring in the pond rather than the wetland. Likewise, about 72% of suspended sediment was removed by the system, even with a slight export from the wetland component. Removal of total zinc and copper approached 60% for the system. Chemical oxygen demand (COD) was reduced by 56%.

The performance of the pond/wetland system in removing nitrogen, however, was mediocre, due in

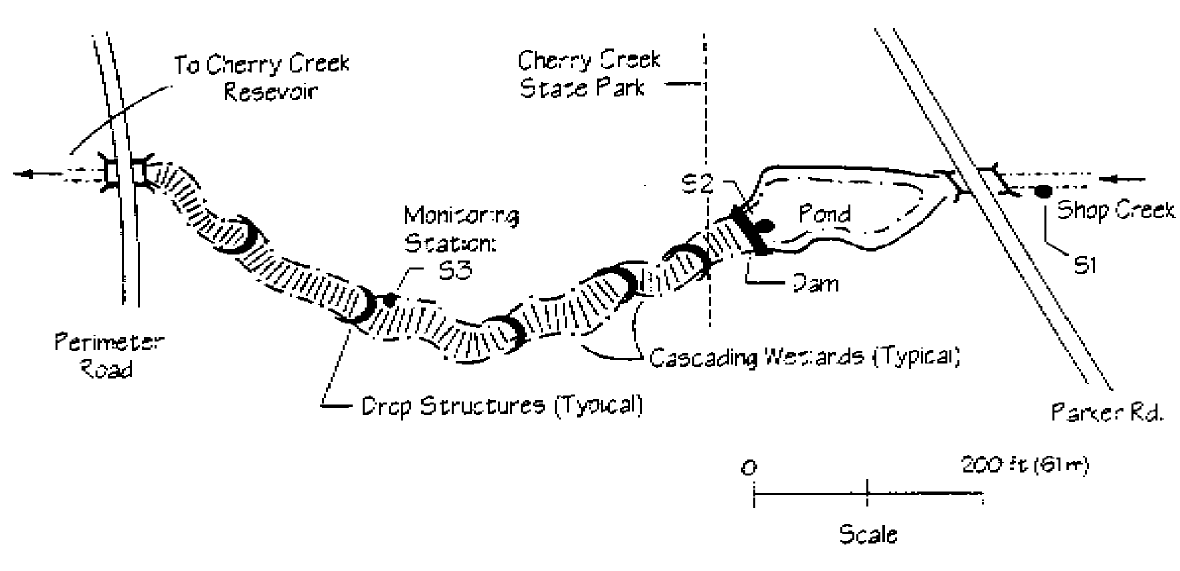

Figure 1: Arrangement of the Pond-Wetland System on Shop Creek (Urbonas *et al.*, 1994)

most part to a large export of nitrate (76%) and to a lesser degree, nitrite. The modest removal of organic forms of nitrogen (30%) could not offset this export of nitrate, which may be in fact due to a large resident waterfowl population. In general, the combined system worked effectively, with the extended detention wet pond providing the bulk of the storm removal. The cascading wetlands helping to polish the quality of runoff during baseflow periods.

The importance of the wetland component was most evident during baseflow periods (Table 2). During these dry weather periods, the pond tended to export some pollutants due to biological activity and other processes (e.g., total copper, total iron, total phosphorus, organic nitrogen, and suspended solids).

The slight export of pollutants from the pond was generally compensated by further pollutant removal within the wetland component during dry weather periods. The only exception to this pattern was total copper, which increased by 110% as it passed through both portions of the system.

In summary, the long-term monitoring of the Shop Creek pond/wetland system indicates the importance of assessing pollutant removal during both storm and dry weather periods. The common practice of neglecting baseflow when pollutant removal efficiencies are computed is not a wise idea on pond systems that serve large drainage areas.

The study also supports the trend toward design of multiple and redundant stormwater treatment systems to provide more reliable pollutant removal over a range of runoff conditions.

—TRS

Table 1: Average Removal Rates for the Pond/Wetland System During Storms, 1990-1992 (Urbonas *et al.*, 1994)

Parameter	% Removed by Pond	% Removed by Wetland	% Removed by System
Total Phosphorus	49	3	51
Dissolved Phosphorus	32	12	40
Nitrate-Nitrogen	-85	5	-76
Organic-Nitrogen	32	-1	31
Total Nitrogen	-12	1	19
Total Copper	57	2	57
Dissolved Copper	53	-1	58
Total Zinc	51	31	66
Dissolved Zinc	34	-5	30
Total Suspended Solids	78	-29	72
Chemical Oxygen Demand	44	21	56

Reference

Urbonas, B., J. Carlson, and B. Vang. 1994. *Joint Pond-Wetland System in Colorado, USA.* An Internal Report of the Denver Urban Drainage and Flood Control District.

Table 2: Baseflow Water Chemistry Through the Shop Creek Pond/Wetland System (N=5)

Parameter	Baseflow to Pond	Baseflow from Pond	Baseflow from Wetland	Storm Outflow *
Total Phosphorus (mg/l)	0.11	0.19	0.09	0.20
Dissolved Phosphorus (mg/l)	0.095	0.047	0.07	0.13
Nitrate-N (mg/l)	0.71	0.32	0.22	2.2
Total Copper (µg/l)	15	28	32	15
Dissolved Zinc (µg/l)	15	8	6	32
TSS (mg/l)	7	26	6	33
COD (mg/l)	19	56	24	36

* Average concentration of storm outflow from pond-wetland system