Use of Constructed Wetlands for Protection of Water Quality in Water Supply Reservoirs
[Project #807]

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BACKGROUND
The Tarrant County Water Control and Improvement District Number One (TCWCID) supplies water to approximately 1.2 million residents of north central Texas. Additional water supplies from the Trinity River will help provide supplemental yield. At the point of diversion, the Trinity River water consists of highly treated wastewater flows from reservoir releases, groundwater, rain (constituents contained in runoff from watersheds), and stormwater runoff from both urban and rural areas. Treatment to control toxicant and nutrient input to the water supply reservoirs will be necessary to protect the water quality of the reservoirs.

OBJECTIVES
The objectives of the pilot-scale constructed wetland demonstration project were: (1) to determine design and operation requirements for use of constructed wetlands as effective best management practices (BMPs) of watershed management; (2) to determine the effectiveness of constructed wetlands to treat water diverted to water supply reservoirs; and (3) to determine performance and cost-effectiveness of constructed wetland systems as a BMP for nutrient loading reduction.

RESULTS AND DISCUSSION
Removal Efficiencies
The settling basins and wetland trains consistently achieved good removal efficiencies for both sediment and nutrients under extremely varied loading rates. The range of concentrations of solids, nitrogen, and phosphorus in the outflow demonstrate that the wetland system can generally maintain high quality outflow despite the variable input.

Both the settling basins and wetland trains very effectively removed suspended solids; generally, both maintained high-quality outflow, with 75 percent of the outflow concentrations less than 5 mg/L and the median outflow concentration 3.5 mg/L. Concentrations of total nitrogen (TN) exhibited a steady decrease through the wetland trains, with a very small range around median concentrations of about 0.5 mg/L for all three wetland trains. The settling basins exhibited greater removals for total phosphorus (TP) than for TN, with inflow median concentrations of 0.83 mg/L and median outflow concentrations of just over 0.5 mg/L for both basins. Concentrations of TP exhibited a steady decrease through the wetland trains, with a very small range around median concentrations of 0.19, 0.17, and 0.08 mg/L for wetland trains 1, 2, and 3, respectively. The median concentration of TP for the combined outflow was 0.14 mg/L.

Although the median fecal coliform levels in the inflow were only 26 cfu/100 mL, the pilot-scale wetland system exhibited an overall reduction in fecal coliform levels, with a median outflow concentration of 7 cfu/100 mL.
SUMMARY AND CONCLUSIONS

Evaluation of the data and mass balances developed from the pilot-scale wetland system for total suspended solids (TSS), TN, and TP indicate that a wetland system can generally maintain a high quality outflow despite significant variations in both the loading rate and inflow concentrations of pollutants. The pilot-scale system settling basins averaged 87, 20, and 30 percent mass removal for TSS, TN, and TP, respectively. The wetland trains averaged 86, 82, and 64 percent mass removal for TSS, TN, and TP, respectively, based on the loadings to the wetland trains from the settling basins. Calculated water quality improvement for the pilot-scale settling basin/wetland system based on mass loading to the system was 99, 82, and 12 percent mass removed for TSS, TN, and TP, respectively. The removals achieved in full-scale systems will be related to the operation and management of an individual system. The routine operation of the pilot-scale system was based on a hydraulic retention time of approximately 3 days within the settling basins, with both settling basins on line, and approximately 7-10.5 days within the three wetland trains operated at an average depth of 12 in. Variations in operations that significantly shorten the hydraulic retention time may significantly impact the removal of pollutants, especially nitrogen and phosphorus.

The longevity of constructed wetland systems is poorly documented because no successful operating-scale system has been in operation for more than 20 years. Design should incorporate factors to allow for some accumulation of sediments and litter or detritus accumulation based on the projected loading rate for solids and projected accumulation rate of the litter layer to minimize the frequency of disturbance to the system. Accumulation of toxic substances, such as heavy metals, salts, or toxic organics, in the sediments needs to be monitored periodically to identify any potential solids handling limitations.

Based on the evaluation of data from TCWCID’s pilot-scale constructed wetland demonstration project and current available literature, a constructed wetland BMP system consisting of a settling pond and a constructed wetland arrangement can be an effective watershed management tool to retain some nutrients and sediments from nonpoint source (NPS) pollution and thereby protect receiving waters, including lakes and reservoirs. However, constructed wetlands should be utilized in the context of an overall watershed management plan and should not be expected to control all of the influx of sediments and nutrients from a watershed, nor should the construction of one small wetland be expected to result in significant improvements in downstream water quality. Site-specific conditions (including soil types, types and concentrations of pollutant loads, topography, and hydrology) must be evaluated to determine the suitability and cost-effectiveness of constructed wetlands as a BMP option to meet defined objectives within a watershed management plan.