



# Do Constructed Flow-Through Wetlands Improve Water Quality in the San Joaquin River?

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*In the Central Valley, constructed wetlands can improve water quality of irrigation return flows by intercepting and/or transforming particulate organic carbon, nitrogen, phosphorous and sediment before it reaches the San Joaquin River.*

The primary goal of this study is to evaluate the efficacy of using constructed wetlands (CW) to improve water quality in irrigation return flows ultimately destined for the San Joaquin River. Two CWs were monitored during the 2005 irrigation season (April - Sept.), a new CW (W-1) and 12-year-old CW (W-2). No monitoring occurred in 2006 due to flood conditions that remained until August.

Sediment samples were analyzed for carbon, nitrogen, phosphorus and particle size; and intricate input/output flow monitoring systems were installed to calculate constituent loads. Input/output waters from CWs were collected on a weekly basis and analyzed for: total nitrogen (TN), total phosphorus (TP), dissolved organic carbon (DOC), particulate organic carbon (POC), total suspended solids (TSS), volatile suspended solids (VSS), and chlorophyll-a (a measure of algal biomass). High frequency sampling with autosamplers was also employed to better understand the temporal variability in water quality constituents. Carbon, nutrient and sediment retention efficiency was evaluated from input/output concentration data.

Particular emphasis was directed toward phosphorus cycling in 2005-2006. Suspended solids from input and output waters were processed through a sequential phosphorus extraction procedure in order to characterize the different P fractions.

## Results

The work has enabled us to compare the older CW with the newly constructed CW, but differences in size and irrigation water received may have complicated the results. Both CWs are clearly effective at capturing sediment and nutrients discharged from irrigated farmland.

Constructed wetlands have a potential to store carbon. After receiving tail water over the 2004 and 2005 irrigation seasons, the average soil organic carbon content of seasonally submerged soils increased almost five-fold at W-1 and approximately ten-fold at W-2.

In samples from 2004, chlorophyll-a tended to be higher in water at W-1 compared to W-2, especially at the input. In 2005, W-2 became a source of chlorophyll-a, while W-1 showed no differences between input and output. During spring 2005, CW-2 was not allowed to dry out. This prevented the germination of emergent vegetation, which allowed more light into the system over the irrigation season resulting in more algae.

While W-1 was generally a sink for DOC in 2004, W-2 was often a source, possibly due to leaching of DOC from vegetation and litter. In 2005, W-1 was a sink for DOC over 70% of the irrigation season; W-2 was a source roughly 50% of the season. A comparison of concentration and load data for DOC at input and output locations illustrates that although the concentration of DOC was greater at the outputs, the actual amount of DOC exiting the CW as a load

was much less than what entered. This was true at W-1 and to a lesser extent at W-2.

Both wetlands were effective in reducing bio-available phosphorus (BAP) throughout the season. Dissolved phosphorus (DP) removal was high in both wetlands although the average removal efficiency was higher in the older, larger CW than in the newer, smaller one. Removal efficiencies for particulate P were similar.

The retention of particle bound P is considered one of the primary retention mechanisms of constructed wetlands. Total suspended solids were significantly lower in both wetlands at the outputs relative to the inputs. This retention of suspended solids occurs primarily from the settling of particles due to decreased water velocities. As water flows through the wetlands and larger particles are deposited, the proportion of fine textured solids reaching the output increases.

### **Publications**

O'Geen, A.T., J.J. Maynard, and R.A. Dahlgren. Efficacy of constructed wetlands to mitigate non-point source pollution from irrigation tailwaters in the San Joaquin Valley California, *USA Water Science and Technology*, In press.

### **Professional Presentations**

Maynard, J.J., A.T. O'Geen and R.A. Dahlgren, Using Constructed Wetlands to Remove Water Quality Contaminants in Agricultural Return Flows. California Plant and Soil Science Conference, Modesto CA, Feb. 2005.

O'Geen Preliminary water quality monitoring in constructed wetlands. San Joaquin River Management Program Advisory Council, Modesto, Mar. 2005.

O'Geen, A.T., J.J. Maynard and R.A. Dahlgren, Strategies for Attenuating Hypoxia in the Lower San Joaquin River, California, World Water & Environmental Resources Congress, Anchorage AK, May 2005.

Maynard, J.J., A.T. O'Geen and R.A. Dahlgren, A Spatial Investigation of Bio-Available Phosphorus in Submerged Wetland Soils, Western Society of Soil Science Annual Meetings, Ashland OR, Jun. 2005.

Brauer, N, A.T. O'Geen, J.J. Maynard, and R.A. Dahlgren, Mineralogical Characterization of Seasonally Submerged Wetland Soils Western Society of Soil Science Annual Meetings, Ashland, OR, Jun. 2005.

O'Geen, A.T., Efficacy of constructed wetlands to mitigate non-point source pollution in the San Joaquin Valley California USA, Diffuse Pollution Specialist Conference, Johannesburg, South Africa, Aug. 2005.

O'Geen, A.T. and R.A. Dahlgren. Field tour for the Southwest States and Pacific Islands Regional Water Quality Program. Jun. 2006.

Maynard, J.J., A.T. O'Geen and R.A. Dahlgren, Transformations of Biologically-labile Particulate Phosphorus in Constructed Wetlands, Western Society of Soil Science Annual Meetings, Park City UT, Jun. 2006.

Maynard, J.J., A.T. O'Geen and R.A. Dahlgren, Effects of sedimentation on phosphorus retention in seasonally submerged wetland soils. World Congress of Soil Science, Philadelphia, PA. Jul. 2006.

### **Collaborative Efforts**

This project has fostered collaborations with the USDA-NRCS District Conservationist in Stanislaus County, Fish and Wildlife Service, Bureau of Reclamation, and the State Water Resource Control Board.

This project has also initiated a collaborative effort with the San Joaquin River Wild Life Refuge, one of the largest holdings of natural and constructed wetlands in the Central Valley.

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