Annual Report

2016 Annual Report on Performance of Iowa CREP Wetlands: Monitoring and Evaluation of Wetland Performance

William Crumpton
Professor

Greg Stenback
Associate Scientist

January 1, 2016 – December 31, 2016

Submitted to
Iowa Department of Agriculture and Land Stewardship

Submitted by
Department of Ecology, Evolution and Organismal Biology
Iowa State University, Ames

Monitoring and Evaluation

A unique aspect of the Iowa CREP is that nitrate reduction is not simply assumed based on wetland acres enrolled, but is calculated based on the measured performance of CREP wetlands. As an integral part of the Iowa CREP, a representative subset of wetlands is monitored and mass balance analyses performed to document nitrate reduction. By design, the wetlands selected for monitoring span the 0.5% to 2.0% wetland/watershed area ratio range approved for Iowa CREP wetlands. The wetlands also span a threefold range in average nitrate concentration. The wetlands thus provide a broad spectrum of those factors most affecting wetland performance: hydraulic loading rate, residence time, nitrate concentration, and nitrate loading rate. In addition to documenting wetland performance, ongoing monitoring and research programs will allow continued refinement of modeling and analytical tools used in site selection, design, and management of CREP wetlands.

Summary of 2016 Monitoring

Monitoring activities were conducted at 14 Iowa CREP wetlands and one mitigation wetland (DD15 north) during 2016 (Figure 1).

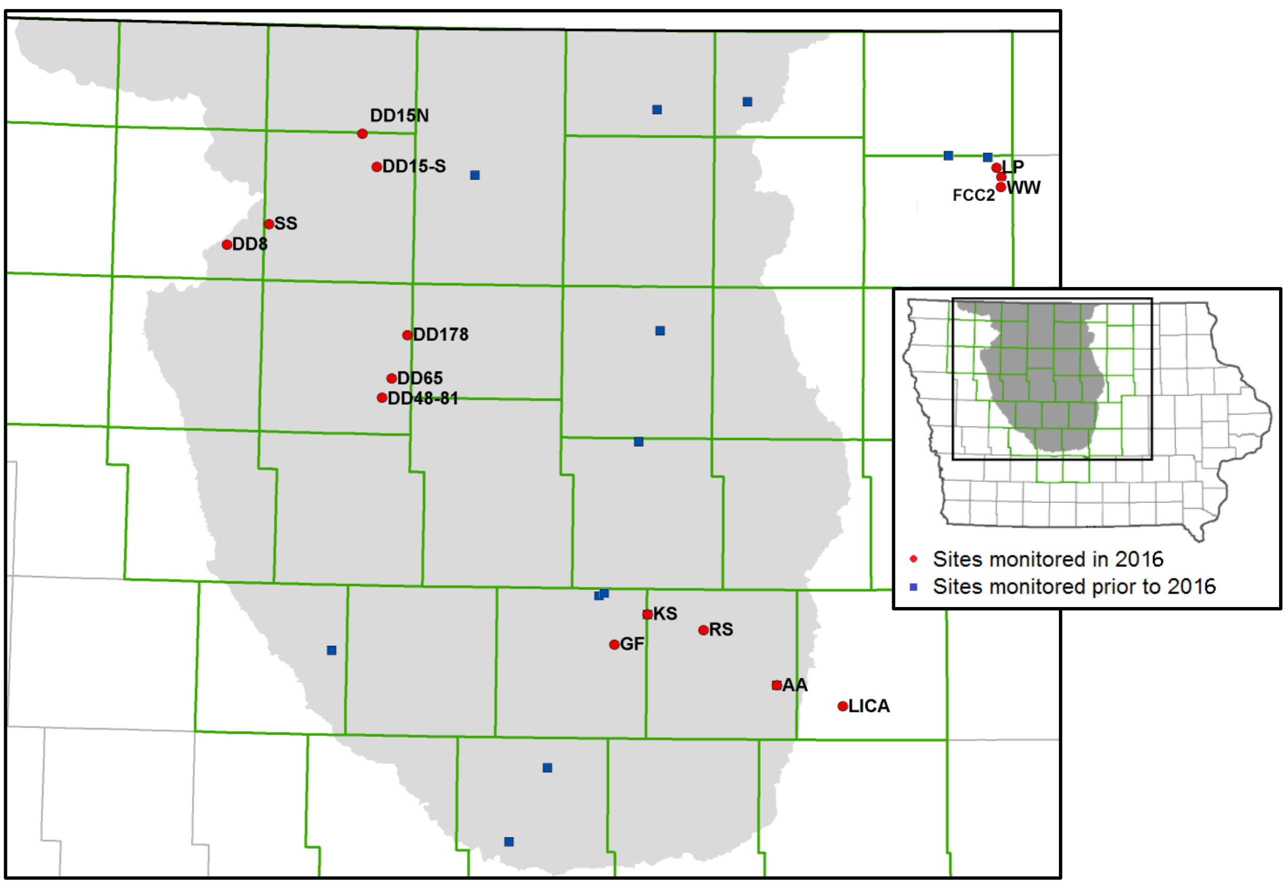

Figure 1. Wetlands monitored during 2016 (red circles, labeled) and wetlands monitored during prior years (blue squares). The shaded area represents the Des Moines Lobe in Iowa.

Wetland monitoring included measurements of wetland inflows, outflows, pool elevations and water temperature, and collection of weekly to biweekly water quality grab samples and daily samples. Automated samplers were used to collect daily samples at wetland inflows and outflows when temperatures were sufficiently above freezing to allow the equipment to function properly (mid to late March through mid-November during 2016). Due to occasional equipment failure, some daily samples were not collected. Wetland inflow during winter months was estimated from nearby USGS river monitoring stations scaled to the wetland watershed area.

The DD65 wetland was drawn down from April 4th to April 29th to assess the status of the submerged culverts underlying several submerged berms within the wetland and to attach cover plates to stop flow through the culverts if necessary. It was apparent that the culverts were open allowing undesirable, deep channelized flow through the wetland. However, the flow rate remained too high during April to allow safe installation of cover plates. To avoid losing the benefits of the wetland during the summer months, the pool was re-filled without installing cover plates to the submerged culverts.

Wetland inflow and/or outflow channels were instrumented with submerged area velocity (SAV) Doppler flow meters and stage recorders for continuous measurement of flow velocity and stream depth, respectively. The SAV measurements were combined with cross-sectional channel profiles and stream depth to calculate discharge as the product of water velocity and wetted cross-sectional area. Water depth upstream of V-notch weirs is monitored, but water velocity is generally not, and discharge is calculated using a weir equation. Wetland water levels were monitored continuously using stage recorders in order to calculate pool volume, wetland area, and discharge at outflow structures. The discharge equations and SAV based discharge measurements are calibrated using manual velocity-area based discharge measurements collected during 2016 and prior monitoring years. Manual velocity-area discharge measurements were determined using the mid-section method whereby the stream depth is determined at 10 cm intervals across the stream and the water velocity is measured at the midpoint of each interval. Velocity was measured with a hand held Sontek Doppler water velocity probe using the 0.6 depth method where the velocity at 60% of the depth from the surface is taken as the mean velocity for the interval. The product of the interval velocity and area is summed over intervals to give the total discharge.

Patterns in Nitrate Concentrations and Loads

Despite significant variation with respect to nitrate concentration and loading rates, the wetlands display similar seasonal patterns and general relationships to discharge (Figure 2). Historically, inflow nitrate concentrations are variable ranging from low to high during the winter. Spring snow-melt often results in increased flow during late February or March but nitrate concentrations in the melt water and associated surface runoff are typically depressed. Nitrate concentrations generally decline through July and August during dry periods, but may remain high as long as there is sufficient flow. Additionally, nitrate concentration during large summer flow events often declines abruptly with peak flows and is thought to be associated with surface runoff having low nitrate concentration; however, nitrate concentration often rebounds within a few days of these high flow events. These nitrate concentration and flow patterns are consistent with those of CREP wetlands monitored in prior years and represent the likely patterns for future wetlands restored as part of the Iowa CREP.

Wetland Performance (Nitrate mass loss and removal efficiency)
Wetland performance is a function of hydraulic loading rate, hydraulic efficiency, nitrate concentration, temperature, and wetland condition. Of these, hydraulic loading rate (HLR) and nitrate concentration are especially important for CREP wetlands. The range in HLR expected for CREP wetlands is significantly greater than would be expected based on just the four fold range in wetland/watershed area ratio approved for the Iowa CREP. In addition to spatial variation in precipitation (average precipitation declines from southeast to northwest across Iowa), there is large annual variation in both precipitation and water yield. The combined effect of these factors results in annual loading rates to CREP wetlands that vary by more than an order of magnitude, and will to a large extent determine nitrate loss rates for individual wetlands.

Mass balance analysis was used to calculate the observed nitrate removal for each monitored wetland. Wetland bathymetry data were used to characterize wetland volume and area as functions of wetland depth. Wetland bathymetry has been determined by ISU on the basis of wetland construction plans and/or bathymetric surveys. These bathymetric relationships were used in numeric modeling of water budgets and nitrate mass balances to calculate nitrate loss, hydraulic loading, and hydraulic residence time. Wetland water depth and temperatures were recorded at five minute intervals for numerical modeling of nitrate loss.

The monitored wetlands generally performed as expected with respect to nitrate removal efficiency (percent removal) and mass nitrate removal (expressed as kg N ha^{-1} $year^{-1}$). Variability in wetland performance is in part due to differences in wetland characteristics and condition and partly due to differences in loading rates and patterns. At a given HLR, differences in wetland condition and in timing of loading can result in significant differences in performance (Figure 3). Mass balance analysis and modeling was also used to examine the long term variability in performance of CREP wetlands including the effects of spatial and temporal variability in temperature and loading patterns. In addition to calculating the percent mass removal observed for wetlands monitored from 2004 through 2016, the percent nitrate removal expected for CREP wetlands was estimated based on hindcast modeling over the period from 1980 through 2005. The results illustrate reasonably good correspondence between observed and modeled performance and demonstrate that HLR is clearly a major determinant of wetland nitrate removal performance (Figure 3).

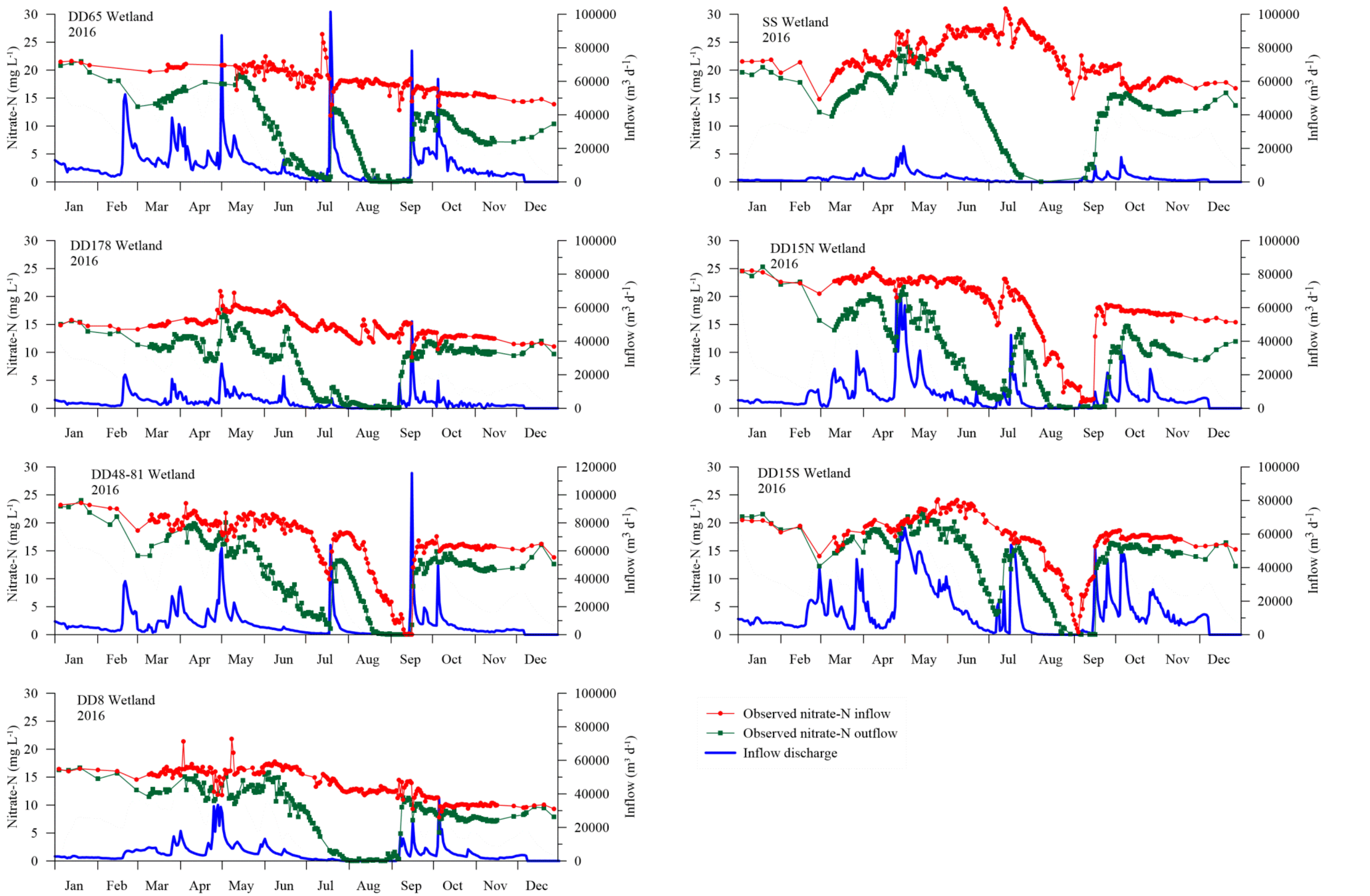

Figure 2. Measured nitrate concentrations and flows for northwest Iowa wetlands monitored during 2016.

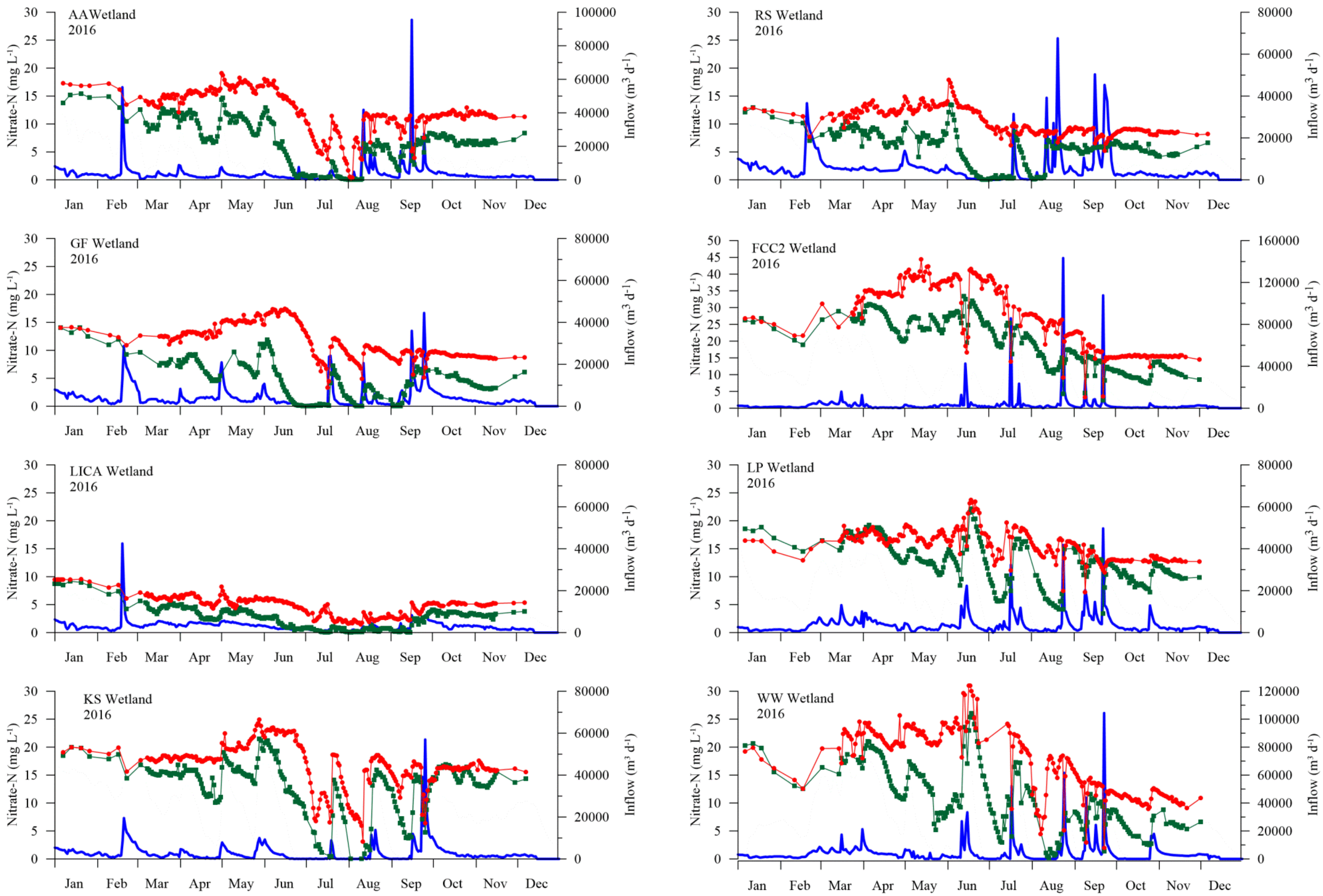

Figure 2 (continued). Measured nitrate concentrations and flows for central and northeast Iowa wetlands monitored during 2016.

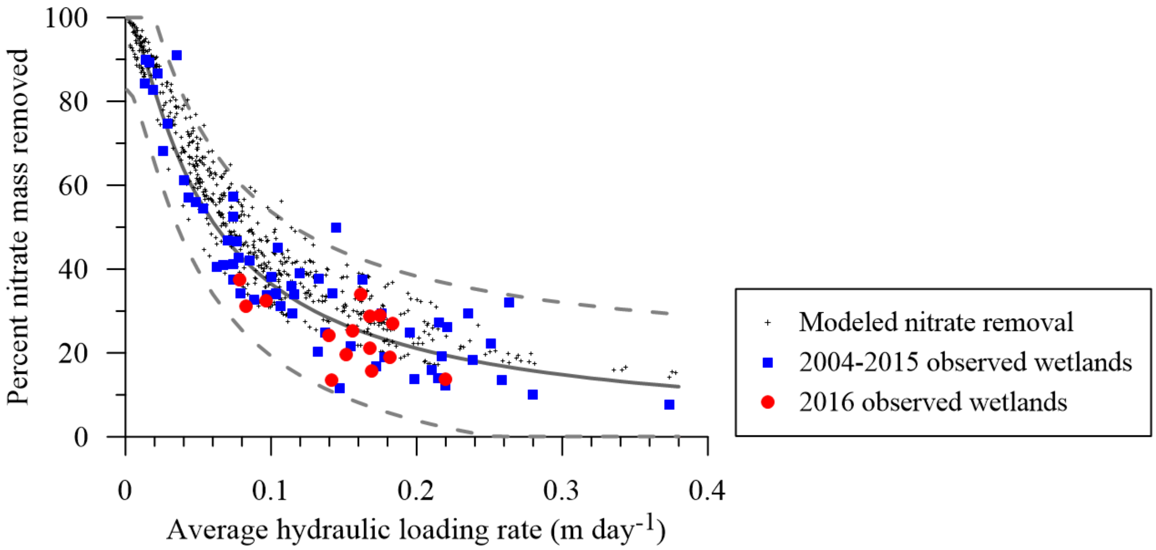

Figure 3. The percent nitrate removal performance for 2016 (red circles) and wetlands monitored during prior years (2004-2015, blue squares). The dashed lines indicate the range expected to contain 95% of similar wetlands in Iowa on the basis of the 2004 to 2015 wetlands monitored.

Wetland Vegetation Patterns

From 2011-2014 thirty-seven CREP wetlands were seeded with an emergent seed mix consisting of 19 species, six of which are deep water species (30-100 cm), and 13 of which are shallow water species (0-30 cm). To evaluate the success of this seeding effort, vegetation surveys were conducted on 47 CREP wetlands during the 2014 and 2015 field seasons. Among the wetland sites in this survey, 12 had been seeded at construction completion, and 12 had been seeded between 3 and 8 years after construction. The 12 older sites had been flooded after construction, but water was temporarily drawn down for seeding/establishment. The remaining 23 surveyed sites had not been seeded and ranged in age from 3 to 12 years.

Results of these vegetation surveys revealed that the seeding effort had no significant effect on total vegetation coverage, with mean coverage for seeded and non-seeded sites at about 10% each. Species included in the seeding mix were found at somewhat greater abundance at seeded sites than at non-seeded sites primarily due to greater abundance of the shallow water species at the seeded wetlands. Species in the shallow water mix had greater abundance at seeded sites, whereas species included in the deep water mix were found in relatively the same abundance for both seeded and non-seeded sites. Reed canary grass was found at every site, and represented at least half of the vegetation found in 24 of the 47 surveyed sites.