Annual Report

2017 Annual Report on Performance of Iowa CREP Wetlands: Monitoring and Evaluation of Wetland Performance

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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 2017 Monitoring

Fourteen wetlands were monitored in 2017 (Figure 1), including 13 Iowa CREP wetlands and one mitigation wetland (DD15-N).

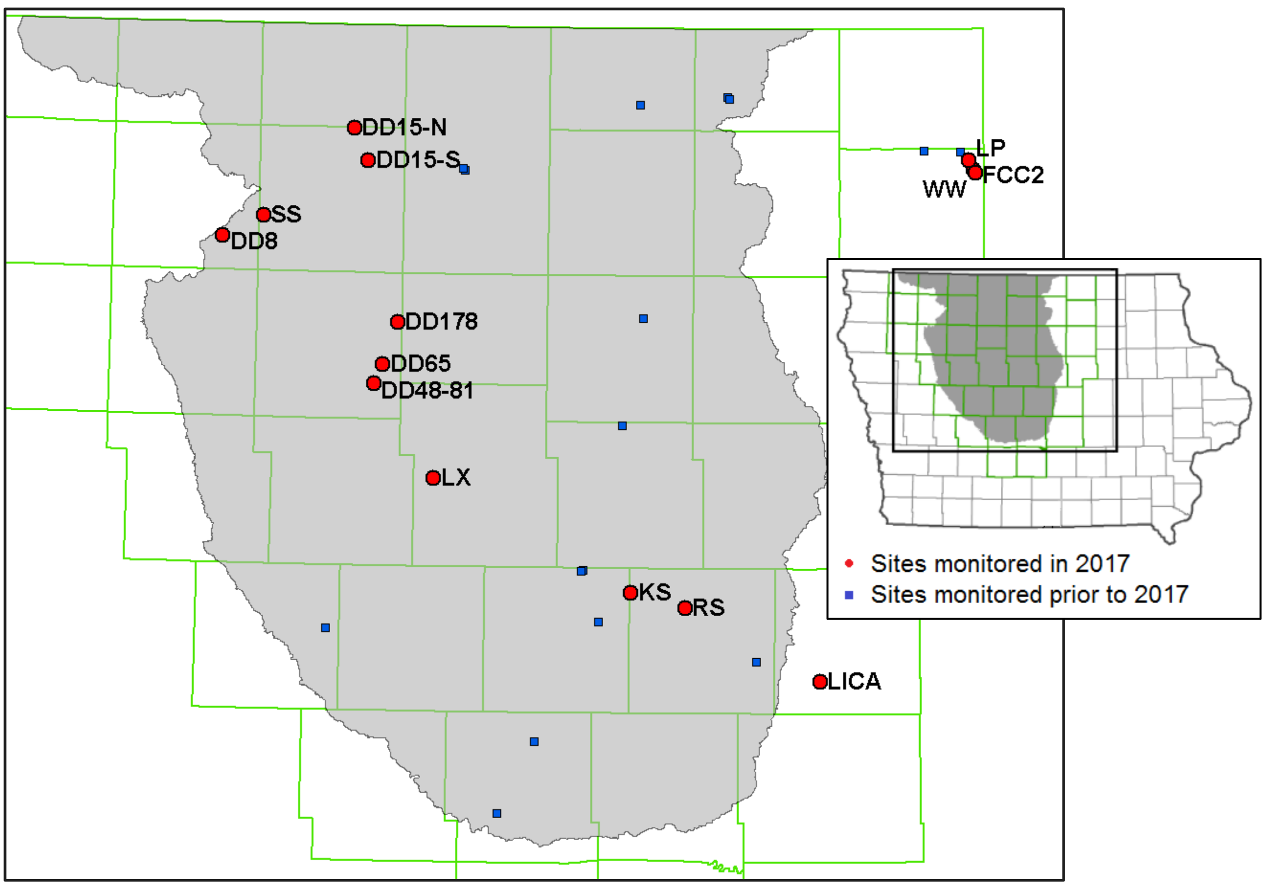

Figure 1. Wetlands monitored in 2017 (red circles, labeled) and additional wetlands monitored during prior years (blue squares). The shaded area represents the Des Moines Lobe in Iowa.

Monitoring strategy

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 automated samples. Daily samples were collected using automated samplers programmed to collect a daily sample at wetland inflows and outflows when temperatures were sufficiently above freezing to allow the equipment to function properly. All water samples are assayed for nitrate-N concentration. Due to occasional equipment failure, some daily values are missing. Wetland inflow during winter months is estimated from nearby USGS streamflow monitoring station data scaled to the wetland watershed area.

Some wetland inflows and/or outflows have weir structures designed to allow accurate gaging of discharge. Stage recorders positioned upstream of these weirs allow discharge to be calculated using a weir equation based on water depth and weir structure dimensions. Wetland inflow and/or outflow channels lacking adequate weir structures 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. 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 were calibrated using manual velocity-area based discharge measurements collected during 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 velocity and area summed over intervals gives the total discharge.

Monitoring Issues

The valve in the stoplog structure at DD65 was opened during the second week of March to allow the wetland pool to drain so that the open submerged culvert within the wetland could be plugged. An endcap was placed on the culvert on March 29 and the stoplogs were replaced and the valve was closed the following week. A beaver constructed a dam in the outflow channel downstream of the road culvert containing our flow monitoring equipment below the DD65 outflow spillway in early June. This caused the water depth in the culvert to increase. The beaver dam is still there but has not seriously affected our flow measurements as the water velocity remained high enough to for the velocity probe to give a reliable reading.

Monitoring at the LX wetland in Webster County was initiated on May 25 and the wetland did not receive significant flow after that. Accordingly, an accurate measure of nitrate reduction during 2017 at the LX wetland is not possible. There was a beaver dam on the LX wetland outflow structure and in the channel below during much of the monitoring period causing elevated water depth in the wetland.

A beaver dam constructed at the LICA wetland inflow channel in early June caused water to backup and slow to the point that our water velocity probe became unreliable. The beaver(s) and dam is still there. The LICA personnel pulled the stoplogs on August 5 nearly draining the LICA wetland before they replaced the stoplogs a few days later. The LICA wetland remained below full pool until October 22.

Multiple monitoring equipment batteries were stolen at the DD65, DD48-81 and DD178 wetlands. The County Sherriff was notified of these events. We plan to encase monitoring equipment batteries in heavy enclosures to avoid additional theft during 2018.

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 during the winter. However, because winter flows are typically low, the winter nitrate loading is also low during most years. Snow-melt often results in increased flow event during late January through March. Unfortunately, these snow melt events often occur prior to the deployment of automated daily samplers. However, the weekly grab sampling will occasionally capture these events and show that nitrate concentrations in the melt water and associated runoff are typically low. Spring flow is usually elevated and shows the highest nitrate concentrations. Nitrate concentration generally declines through July and August during dry years, but may remain high as long as there is sufficient flow. Nitrate concentrations during large summer flow events often decline abruptly with peak flows and is thought to be associated with surface runoff having low nitrate concentration; however, nitrate concentrations often rebound within a few days of these high flow events. In contrast, some summer rain events are accompanied by increasing nitrate concentrations. 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 and modeling were used to calculate observed and predicted nitrate removal, respectively, for each monitored wetland (except LX as previously noted). 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.

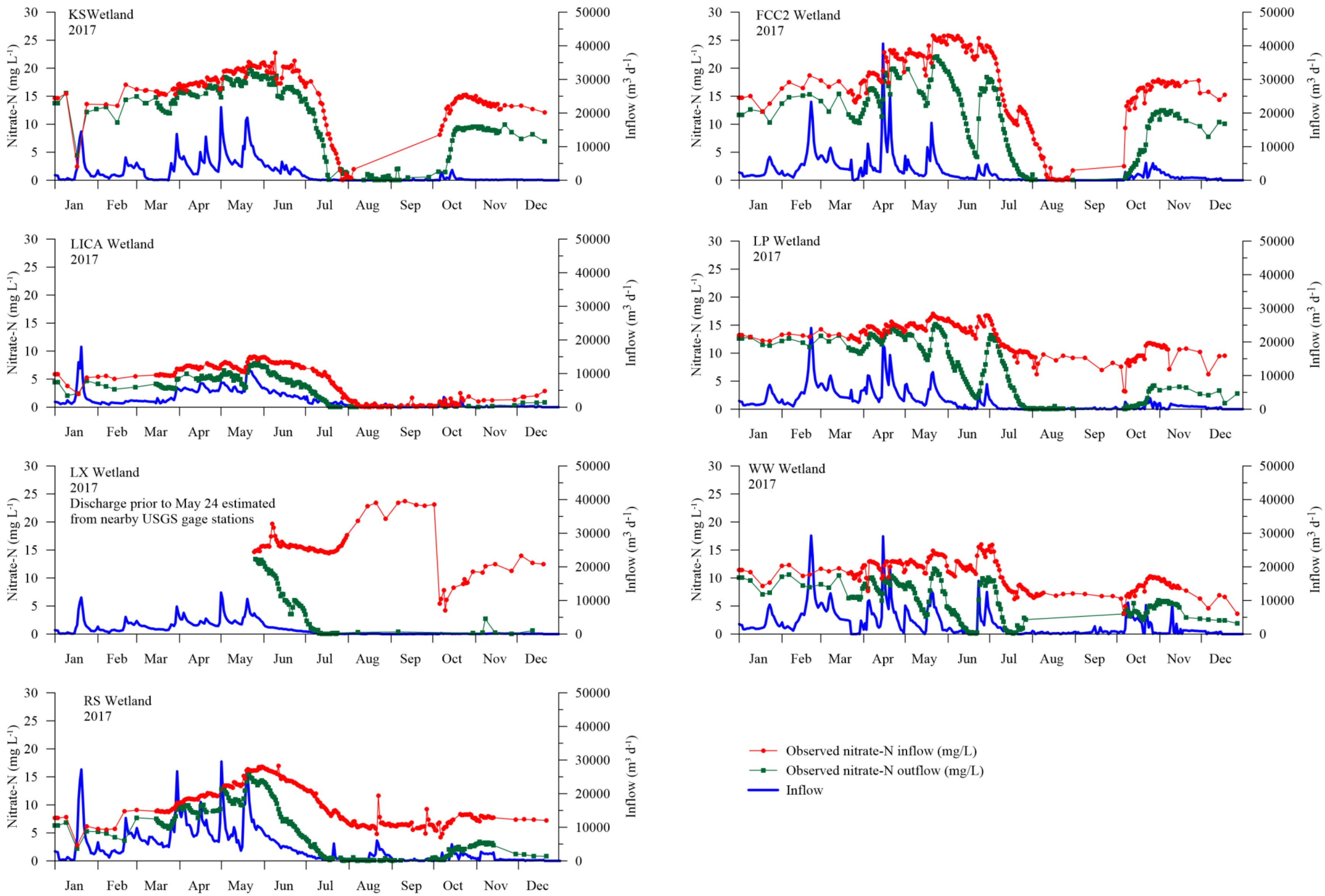

Figure 2. Measured and modeled nitrate concentrations and flows for northwest Iowa wetlands monitored during 2017.

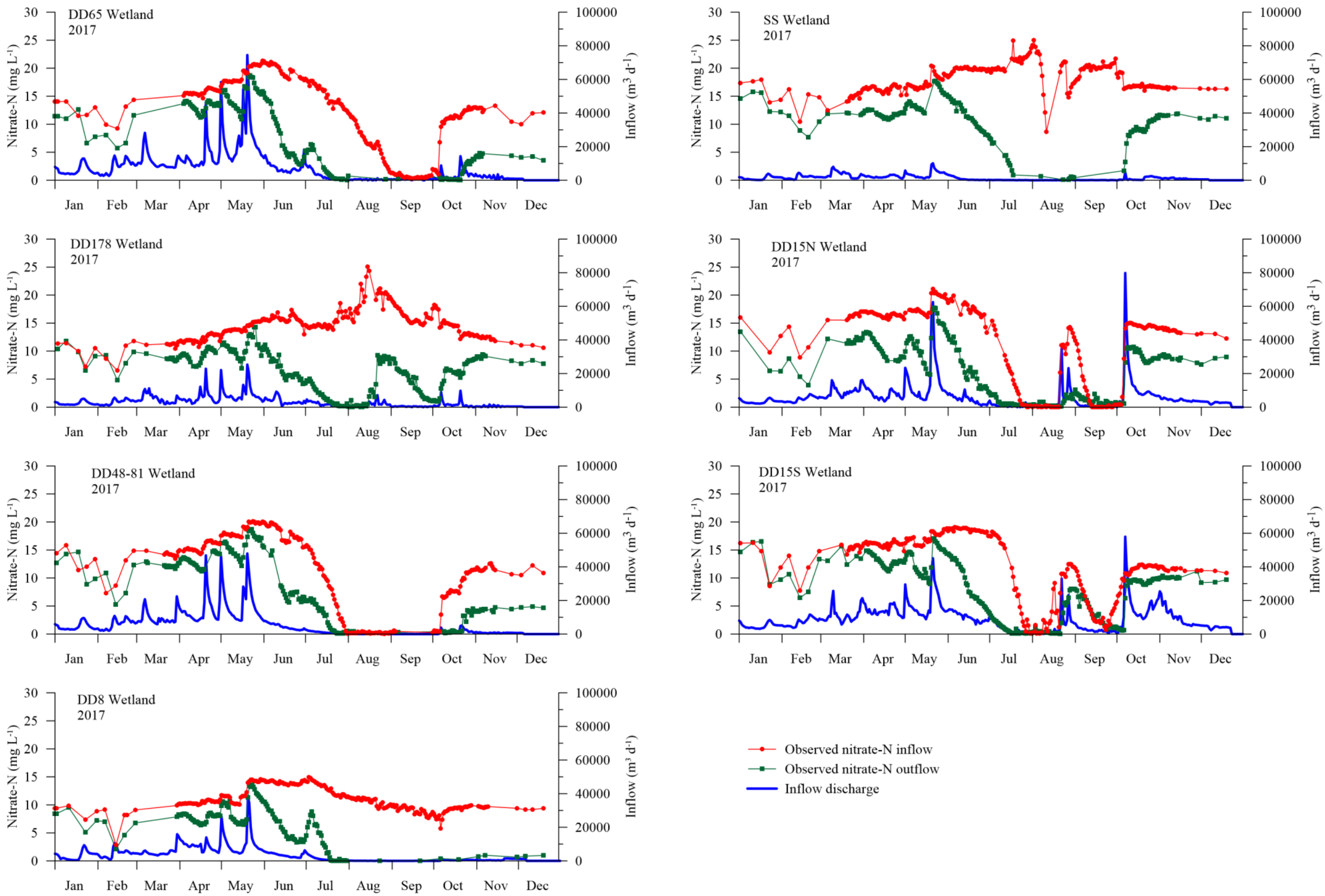

Figure 2. (Continued) Measured and modeled nitrate concentrations and flows for central and northeast Iowa wetlands monitored during 2017.

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 2017, 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).

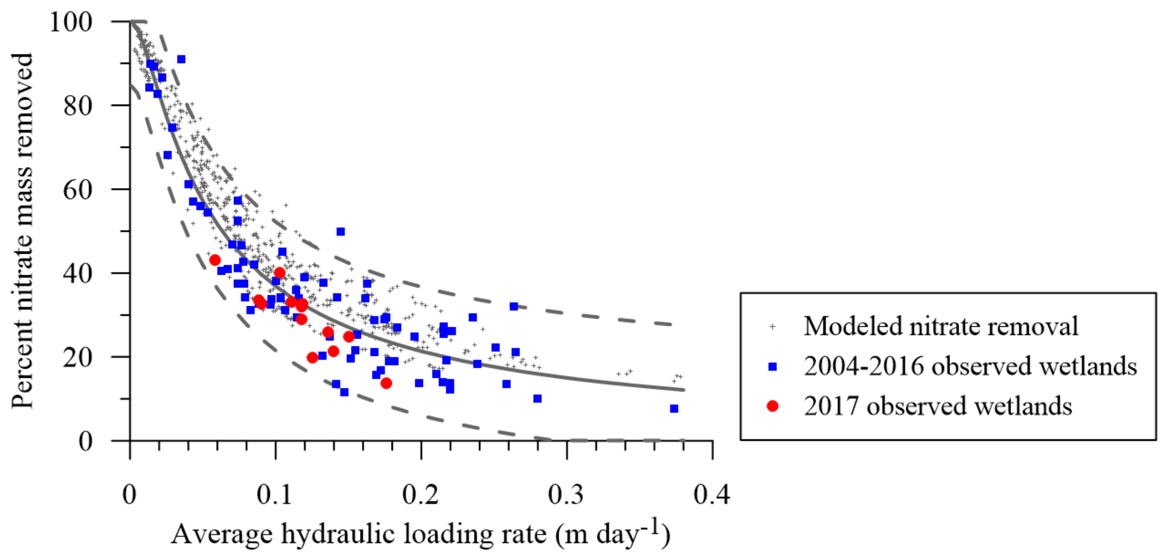

Figure 3. Percent nitrate removal performance for 2017 (red circles) and wetlands monitored during prior years (2004-2016, blue squares). The dashed lines indicate the range expected to contain 95% of similar wetlands in Iowa on the basis of the 2004 to 2015 wetlands monitored.