Annual Report

2018 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 2018 Monitoring

Fourteen wetlands were monitored in 2018 (Figure 1), including 13 Iowa CREP wetlands and one mitigation wetland (DD15-N).

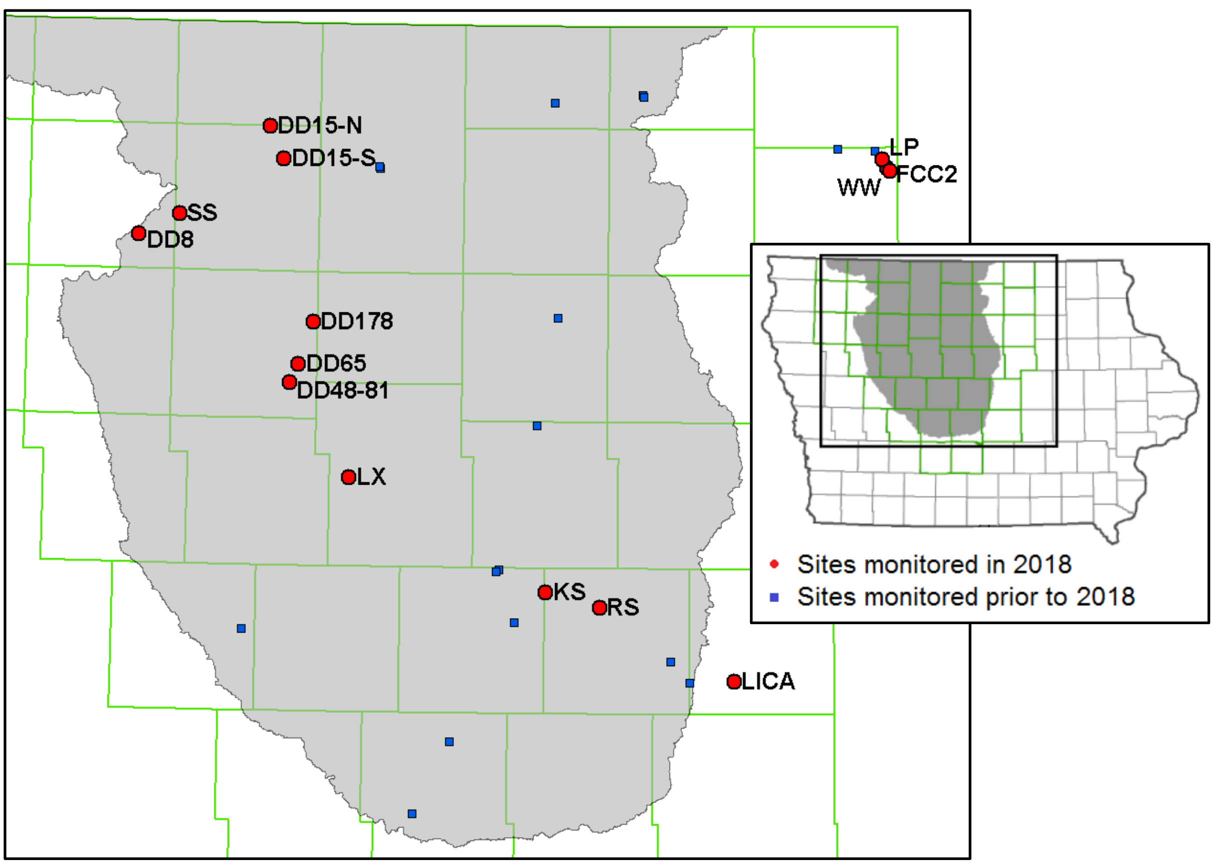

Figure 1. Wetlands monitored in 2018 (red circles, labeled) and additional wetlands monitored in prior years (blue squares). The shaded area represents the Des Moines Lobe in Iowa.

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 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. Due to occasional equipment failure, some daily values are missing. Wetland inflow during winter months may be estimated from nearby USGS river monitoring stations scaled to the wetland watershed area.

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 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. In total, 52 manual discharge measurements were collected during 2018, with at least one measurement at each wetland, to calibrate the SAV and V-notch weir discharge measurements.

On June 21, 2018 a beaver dam was observed on the KS wetland outflow structure causing elevated water depth in the wetland. The KS beaver dam was removed in late August. On May 16, 2018 a beaver dam was observed on the WW wetland outflow structure causing elevated water depth in the wetland. On July 25, 2018 a beaver dam was observed in the inflow stream to the LICA wetland causing elevated water depth and reduced water velocity in the inflow stream. The LICA beaver dam was removed on August 15, 2018 but the dam was back one week later on August 22, 2018. A beaver constructed a dam in the outflow channel downstream of the road culvert containing our flow monitoring equipment below the DD65 outflow spillway during 2017 causing water depth in the culvert to increase. That beaver dam near DD65 was apparently removed during a high flow event and has not returned during 2018.

Due to impending freezing conditions, the water velocity and water level probes and automated sampling equipment were removed from the field during early November 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 during late February or March but nitrate concentrations in the melt water and associated runoff are typically low. Spring flow is usually high and shows the highest nitrate concentrations. Nitrate concentration generally declines through July and August during dry years, but may remain elevated as long as there is sufficient flow during wet years. 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 concentrations often rebound 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 and modeling were used to calculate observed and predicted nitrate removal, respectively, for each monitored wetland. Wetland bathymetry data were used to characterize wetland volume and area as functions of wetland water 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 both 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 annual HLR, differences in wetland condition and in timing of loading can result in significant differences in performance. Hydraulic loading rates during 2018 were among the highest observed during the prior years of CREP wetland monitoring as a result of above average precipitation during 2018. As a result, the 2018 percent nitrate loss at most monitored wetlands was low relative to drier years (Figure 3). However, as a result of the elevated HLRs, observed nitrate loads for these same wetlands were higher during 2018 than during 2017. Excluding the LX wetland which had insufficient data in 2017 for this analysis, the higher 2018 loads resulted in greater measured average nitrate mass loss with about 2100 kg N ha^{-1} loss during 2018 versus 1500 kg N ha^{-1} loss during 2017. It is also true that the higher loading in 2018 coupled with lower percent removal compared with 2017 resulted in greater nitrate mass export during 2018 than was measured for 2017.

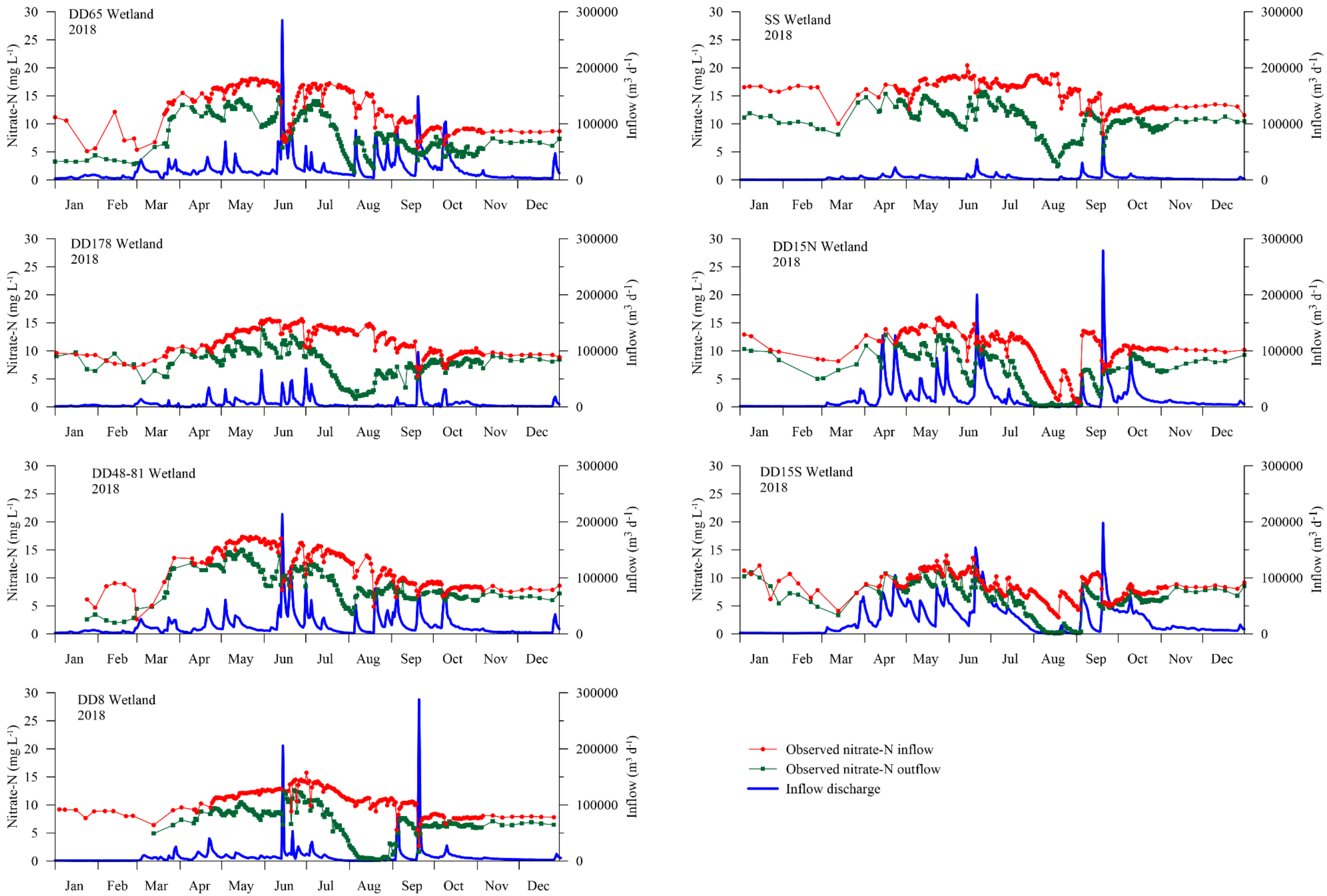

Figure 2. Measured nitrate concentrations and flows for northwest Iowa wetlands monitored during 2018.

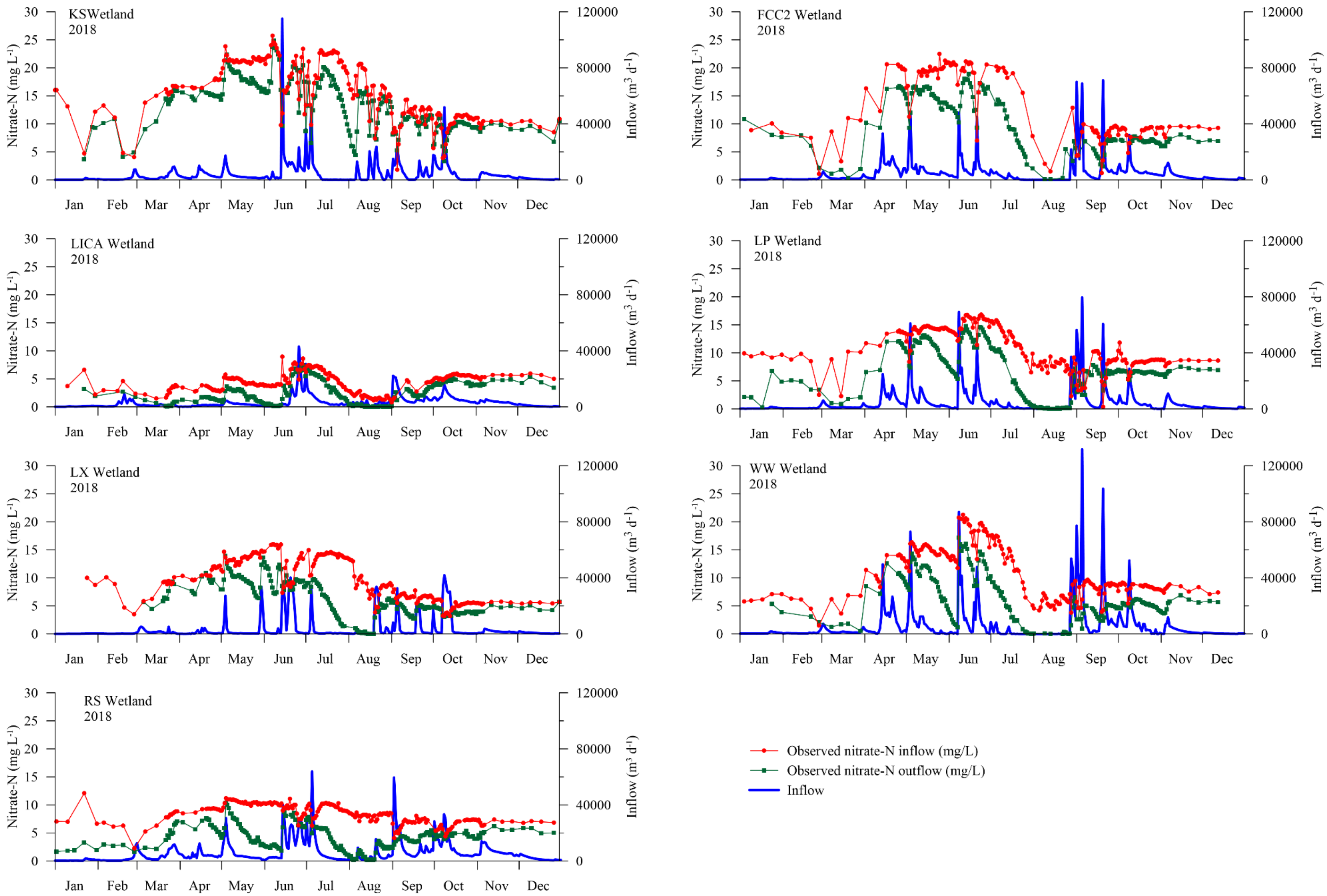

Figure 2. (Continued) Measured nitrate concentrations and flows for central and northeast Iowa wetlands monitored during 2018.

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 2018, 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).

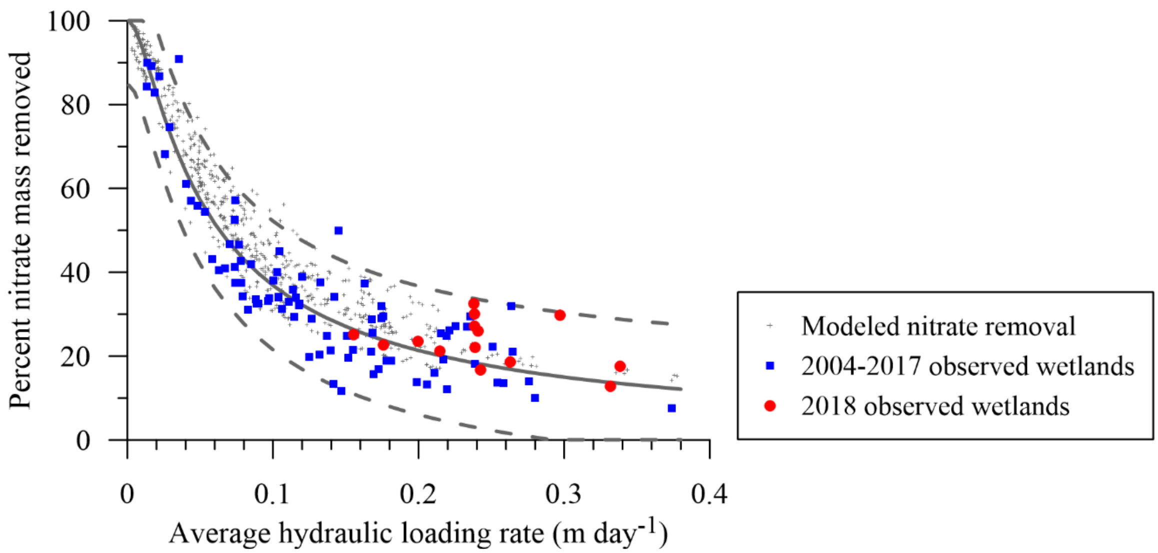

Figure 3. Percent nitrate removal performance for 2018 (January to early November, red circles) and wetlands monitored during prior years (2004-2017, blue squares). The dashed lines indicate the range expected to contain 95% of similar wetlands in Iowa on the basis of the 2004 to 2015 monitored wetlands.