Demonstrate and Evaluate Saturated Buffers at Field Scale to Reduce Nitrates and Phosphorus from Subsurface Field Drainage Systems

Mississippi River Basin - Water Management

PROJECT COLLABORATORS:

Agricultural Drainage Management Coalition Member Companies

Agricultural Drainage Management Systems Task Force

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This material is based upon work supported by the United States of Agriculture, Natural Resources Conservation Service(69-3A-75-11-205) and the Farm Service Agency (AG-3151-P-15-0168). Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the authors and do not necessarily reflect the views of the U.S. Department of Agriculture.

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Executive Summary

Nutrient loss through subsurface drainage systems is a major concern throughout the Midwest. This project sought to demonstrate and evaluate the effectiveness of a new conservation practice commonly referred to as a Saturated Buffer (SB). By hydrologically reconnecting a subsurface drainage outlet with an edge-of-field buffer this practice takes advantage of both the denitrification and plant nutrient uptake opportunities that are known to exist in buffers with perennial vegetation as a way to remove nutrients from the drainage water. The USDA-NRCS developed an interim practice standard (739 – Vegetated Subsurface Outlet) in conjunction with this project.

The objectives, or deliverables, of this project were 1) establish 15 saturated buffers (nine CIG-funded, six FSA-funded) in four states, 2) monitor drain flows, quantify nutrient reductions, and evaluate the impact of climate and operation timing at all 15 sites, 3) optimize management of and reduce nutrient transport from SB systems while maintaining agricultural productivity and enhancing wildlife benefit, 4) establish outreach material and distribute to producers and technical agencies.

Deliverable 1: This project installed a total of 15 SB's in Iowa, Illinois, Indiana, and Minnesota. These sites intentionally included a variety of soil types, buffer vegetation, surface topographies, and ditch/stream channel depths. This variety was included to evaluate the effectiveness of this practice if it were to be adopted on a regional scale. The original timeline included having all nine CIG-funded sites installed in 2012, of which seven were. The remaining two sites, as well as all six FSA-funded sites, were installed by June 2013. This delay in installation caused a delay in the start of full-scale monitoring at all sites.

Deliverable 2: Flow monitoring equipment was installed at all 15 sites. Extensive data logger and sensor malfunctions plagued the project in the initial stages. As a result, consistent flow measurements did not begin until Fall 2014. A one-year, no-cost extension was granted to compensate for this and allow for more data collection. Water sampling was irregular in 2013, but most sites had consistent samples collected during periods of tile flow in 2014 and 2015. The impacts of climate and operation timing were also observed in these years.

Deliverable 3: Data gathered as part of Deliverable 2 were used to calculate nutrient load reductions at the sites for 2014 and 2015. Field observations, with input from the producer, were used to maintain a balance between optimizing SB performance and maintaining agricultural productivity. As a result, the nutrient reduction capability at some SB sites was greatly reduced in order to prevent potential crop damage due to flooding. This was particularly a concern at sites where the buffer and cropped area were at similar ground elevations. While no direct measurements were taken, there was no observed conflict between the ability of the buffer systems to provide enhanced wildlife habitat and also provide water quality treatment.

Deliverable 4: There were 25+ field days and presentations given in association with this project. These events targeted producers, drainage contractors, government and technical agencies, as well as the general public. Magazine and news articles were also published that discussed this project and explained the potential benefits of a SB system. While some handout material was created for the field

days and presentations, a more comprehensive set of publications are planned to be distributed after the submission of this report.

Of the 15 SB sites that were installed and monitored, four of them (IA-1, IA-3, IL-3, and IL-5) showed substantial nitrate removal. IA-1 performed well over 2013-2015 and removed a total of 301 lbs of nitrate-N over 2 ½ years. In 2015, IA-3 removed 408 lbs, IL-3 removed 68 lbs and IL-5 removed 161 lbs of nitrate-N. These locations met our expected requirements for soil characteristics of successful saturated buffers. These project sites had an average installation cost of $3,700. Assuming a 50 year lifespan and 4% inflation rate, the cost of nitrate removal ranged from $0.50 - $4.64/lbs-N with an average cost of $2.13/lbs-N removed. This makes them competitive with other field-edge practices for nitrate load reduction.

Besides these four sites, IL-2, IL-4, and MN-3 showed promising results in at least one year. The site characteristics at IL-2 made tile monitoring difficult and treated flow was estimated using DRAINMOD. Making some simplifying assumptions we computed a sizeable (293 lbs N) nitrate removal at this site in 2014. IL-4 and MN-3 also had good nitrate removal in 2014 but limited removal in 2015. IL-4 also met all of our other criteria for a well-functioning SB and we feel that this site shows promise and may prove to be very effective in removing nitrate if more reliable flow data can be obtained.

Of the remaining sites, we had insufficient data for MN-1, IL-1, and IN-3 to determine their nitrate removal performance. However, given that IN-3 and MN-1 are susceptible to flooding at the control structure, their performance may be difficult to determine using the techniques used in this evaluation. The other five sites, IA-2, IN-1, IN-2, MN-2 and MN-4 did not show positive results for being used as saturated buffers for removing nitrate. Reasons for their failure vary, but could include coarse soil layers at depth which prevented the creation of an elevated water table, inadequate soil carbon levels at the depth of the raised water table, improper design or installation, and high water levels in the ditch that prevented the water from moving through the buffer. Even though these sites failed to demonstrate nitrate removal, they provided valuable information for improving the site selection process.

There were no consistent trends at the monitored buffers that indicated that dissolved phosphorus in the tile water was removed by the saturated buffers. Therefore, we conclude that the saturated buffer practice as implemented in this project cannot appropriately be assumed to treat phosphorus-related water quality concerns.

Soil samples were collected at all sites near the beginning and end of this project. There were no detected changes in soil organic matter or soil phosphorus that were attributable to the SB practice.

Two of the SB sites were selected for monitoring any change in streambank stability as a result of implementing a SB. The ditch channels, which had average depths of 6 and 10 ft, at these sites were intensively surveyed near the start and end of the project. Neither of these ditches, which had relatively stable banks prior to implementing the practice, showed any significant movement as a result of the SB practice. We conclude that on ditches/streams with stable banks the SB will not cause increased sloughing or other stability issues. Ditches/steams with highly unstable banks prior to implementation could still be considered but more thorough planning and design would be warranted.

The data from this study confirm that, when proper site conditions and design considerations are met, the SB practice can be an effective method for reducing nitrate transport from subsurface drainage systems. Phosphorus loads, however, appear to be generally unaffected by this practice. It is recommended that the guidelines in the NRCS Practice 739 be updated to include more refined site selection and design criteria that will lead to practice implementation at sites more likely to provide a water quality benefit. It is also recommended that additional monitoring of some select SB sites be conducted to better quantify nutrient removal effectiveness and refine management strategies. Testing of different SB design methods could also help overcome some of the site-specific hurdles and aid with effective widespread adoption of the practice.