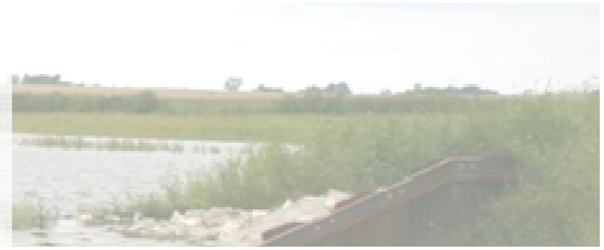
# Targeting Sites for Constructed Wetlands to Remove Nitrate in an Agricultural Watershed

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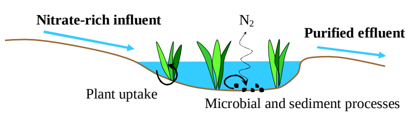
## Problem Statement

Intensification of agricultural practices in the Midwest has led to increased nutrient (nitrogen and phosphorus) losses, potentially impacting the downstream water quality and hypoxia problem in the Gulf of Mexico. Nitrate losses are especially significant in heavily tile drained land, characteristic of parts of Indiana. The 2008 EPA action plan calls for a reduction of the hypoxic zone to about thirty percent of its five-year running average by 2015 (Gulf Hypoxia Action Plan, 2008). Such a reduction will require significant nitrate load reductions from agricultural areas throughout the Midwest.

## Constructed Wetlands: A Potential Solution

Constructed wetlands have been shown to be an effective practice to reduce nitrate loads leaving Midwestern crop land. Strategically targeting sites that intercept high nitrate loads and sizing the wetlands according to the characteristics of their watersheds can maximize wetland efficiency while minimizing costs and maintaining productive agriculture (Crumpton, 2001).

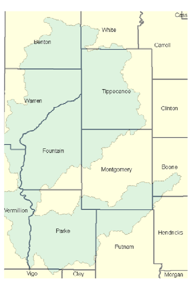



Nitrate removal in a wetland takes place by plant uptake, denitrification and microbial processes. A number of factors affect the rate of nitrate removal, including hydraulic loading rate/hydraulic retention time, concentration of nitrate in the inflow water, temperature of the water, soil conditions, vegetation processes, and flow characteristics in the wetland.

## Project Goals

1. Determine suitable wetland sites in an 8-digit watershed in Indiana using GIS analysis
2. Create preliminary designs of wetlands
3. Estimate nitrate removal by each wetland

An innovative aspect of this GIS analysis is **calculating the watershed area draining to each location**, which ensures that these wetlands intercept large flows and maximize nitrate reduction in the landscape.

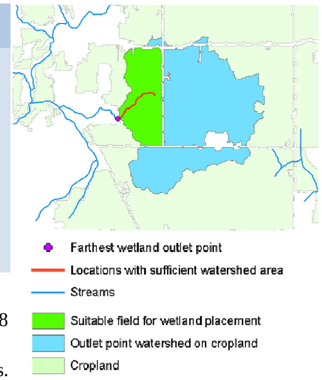



Middle Wabash—Little Vermillion (8-digit) Watershed

## Locating Suitable Sites

### Wetland Siting Criteria

1. Wetland has **sufficient watershed area** from tile-drained land (500-2000 acres of tile-drained land; excludes streams)
2. Located at the interface **between closed and open drains**
3. Wetland is on **cropland**
4. **Topography** lends itself to wetland placement

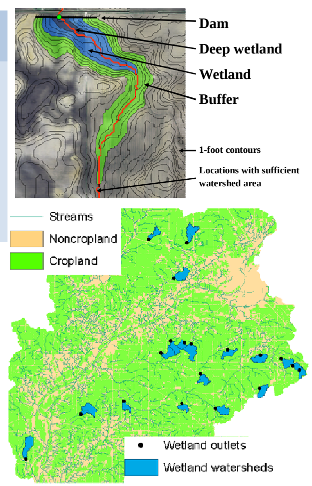



Using publicly available data and GIS analysis, we found **31 locations** in the 8-digit watershed where wetlands may be placed to intercept high nitrate loads.

## Preliminary Wetland Designs

### Wetland Design Criteria

5. Desired **wetland size** is 0.5-2% of its watershed area
6. No more than 25% of the wetland is more than 3 feet **deep**
7. Surrounding **buffer** must extend 4 feet above wetland surface, and not exceed 4 times the size of the wetland




**19 locations** have at least one reasonable wetland design based on the wetland placement criteria. We **designed 34 wetlands** at these 19 sites. The total watershed of these 19 sites is 21,650 acres, with 16,081 acres estimated to be tile drained land. Creating wetlands at all 19 locations would necessitate conversion of 1320 acres of cropland.

## Nitrate Removal Estimates

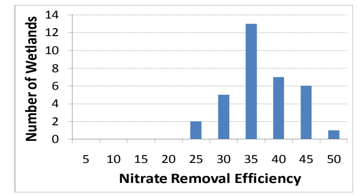
We estimated average percent nitrate removal for each wetland using a simple model developed from similar constructed wetlands existing in Iowa (Crumpton et al. 2006).

$$\textit{Nitrate Removed} = 103 * HLR^{-0.33}$$

*Nitrate Removed* = annual percent of nitrate removed from wetland (%)
*HLR* = annual hydraulic loading rate to the wetland (m/yr)

We used flow data from a local tile main and wetland surface area to estimate annual hydraulic loading rate.

**The average nitrate removal rate was 35% for 34 wetlands designed at 19 sites.**




## Conclusions

All suitable sites are located in the northern part of the watershed, which is relatively flat and extensively tile drained. The best locations for wetlands are in the headwaters of streams, often near the edges of the watershed. Topography greatly limits wetland placement, because the four-foot elevation drop in the buffer is difficult to find in the relatively flat landscapes.

If wetlands are placed at all of these 19 locations, they will **intercept three percent of the nitrate** from the entire tile drained portion of the 8-digit watershed, and therefore **remove approximately one percent of all nitrate** exported. This is achieved by **converting less than 0.2%** of tile-drained farmland to wetland. Because we have targeted nitrate by intercepting large nitrate loads, this one percent reduction results from an efficient conversion of a small amount of land. But this work has shown that a small number of these suitable locations can be found. In order to reach the EPA's goals for nitrate reduction it is clear that a suite of best management practices must be implemented at the watershed scale.

The most critical step in this analysis is to **target locations with a large watershed area** draining into the wetland, to maximize nitrate reduction. Any GIS analysis must consider wetland placement from a **watershed-scale perspective**, and the use of GIS in the placement of these wetlands is an important part of a strategy to reduce nitrate loads in the agricultural Midwest.


1. Mississippi River/Gulf of Mexico Watershed Nutrient Task Force (2008). *Gulf Hypoxia Action Plan 2008 for Reducing, Mitigating, and Controlling Hypoxia in the Northern Gulf of Mexico and Improving Water Quality in the Mississippi River Basin.* Washington, DC.

2. Crumpton, W.G. (2001). *Using wetlands for water quality improvement in agricultural watersheds: The importance of a watershed scale approach.* Water Science and Technology, 44:559-564.

3. Crumpton, W.G., Stenback, G.A., Miller, B.A., Helmers, M.J. (2006). *Potential benefits of wetland filters for tile drainage systems: Impacts on nitrate loads to Mississippi River subbasins.* Report to USDA.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