Conservation DRAINAGE
Subsurface drainage, also known as tile drainage, has been crucial for improving agricultural production throughout the Midwest. An estimated 51,000,000 acres in the Midwest have a form of artificial subsurface drainage. Tile drainage creates an environment for consistent crop yields by reducing the risk of excessive water stress, promoting root development, increasing infiltration and reducing soil compaction. Along with yield gains, tile drainage is known to decrease surface runoff and associated sediment and phosphorus (P) losses. Surface runoff is reduced by increasing the amount of available soil pore space, which increases infiltration.

The drawback to tile drainage is that it increases the delivery of water soluble nutrients such as nitrate-N and water-soluble phosphorus. Subsurface drainage has been linked to hypoxia outbreaks in the Gulf of Mexico, as well as increasing nitrate-N concentrations in surface water used for municipal drinking supplies. Nitrate-N concentrations can exceed the 10 ppm drinking water standard, requiring treatment to meet the standard. In the 31-state Mississippi River Basin, nine states — Illinois, Iowa, Indiana, Missouri, Arkansas, Kentucky, Tennessee, Ohio and Mississippi — contribute nearly 75 percent of the nitrogen (N) and P to the Gulf.

**Subsurface Drainage**

**PURPOSE**
To intercept tile drainage prior to discharging to surface waters and redistribute the water laterally in the soil profile of the streamside buffer.

**N REDUCTION**
Limited data is available, but there was a 55 percent nitrate-N reduction over a two-year period on the saturated buffer on Bear Creek in Story County, Iowa.

**LOCATION**
Currently the practice is being installed on streams and ditches that are not deeply incised — less than 8 foot streambanks — in order to prevent potential bank collapse. A dewatering zone may be used with incised streambanks. The buffer needs to be at least 45 feet wide with 500 lateral feet available, but vary based on soil types. Ideal sites would have relief entering the filter strip from the crop field as to not back water into the cropped area. Finally, saturated buffers are not recommended in areas with gravel or sandy soils.

**COST**
Costs are relatively low if the buffer already exists and range from $2,000-$4,000.

**BARRIERS**
There is no potential yield increase so there are no current economic benefits to the farmer. Saturated buffers also have more specific site requirements than a bioreactor.
Denitrifying Bioreactors

**PURPOSE**
The purpose for this practice is to redirect a portion of tile flow through an underground pit of woodchips to remove nitrate-N prior to discharging to surface waters. Bioreactors also have shown the ability to remove phosphorus, chemical constituents and bacteria from subsurface drainage water.

**N REDUCTION**
Nitrate reduction varies with annual precipitation patterns, but current bioreactor N load reduction efficiency ranges from 15-60 percent. Nitrate reduction rates increase as subsurface drainage water temperatures rise in the summer months. Years in which subsurface drainage flow volumes are dominated in the cooler winter and spring months, nitrate reductions are on the lower end of the range. Bioreactor efficiency is maximized in years with sustained tile flow in the warmer months of June, July and August.

**LOCATION**
Bioreactors are adaptable to many landscape positions, but are typically located at the field edge near the tile outlets to a stream or other surface water body. Tiles treated by bioreactors are generally 6-10 inch diameter mains that drain 30-100 acres. Smaller drainage areas usually are not worth the expense of a bioreactor.

**COST**
A typical bioreactor installation will cost $8,000-$12,000 but will vary with size.

**BARRIERS**
There is no direct benefit to the farmer as bioreactors do not influence yield, and they require seasonal management.

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**Table: Practice Options**

<table>
<thead>
<tr>
<th>PRACTICE</th>
<th>LOCATION PRACTICE APPLIES</th>
<th>NITROGEN REMOVAL %*</th>
<th>BARRIERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drainage Water Management</td>
<td>Flat fields with 0.5%-1% grades. Can be installed on new tile or retrofitted to existing systems.</td>
<td>33 (32)</td>
<td>Difficult to retrofit unless previous tile was installed along field contours.</td>
</tr>
<tr>
<td>Shallow Drainage</td>
<td>New tile installations, or when splitting lateral spacing.</td>
<td>32 (15)</td>
<td>Requires closer lateral spacing, increasing the cost compared to conventional.</td>
</tr>
<tr>
<td>Bioreactor</td>
<td>30-100 acre drainage areas with 6”-10” tiles. Frequently recommended for smaller drainages.</td>
<td>43 (21)</td>
<td>No economic benefit and requires periodic management.</td>
</tr>
<tr>
<td>Saturated Buffer</td>
<td>Non-incised channel and 45 ft. buffer minimum.</td>
<td>55</td>
<td>Site specific and minimal performance data.</td>
</tr>
<tr>
<td>Constructed Wetlands</td>
<td>0.5%-2% wetland to drainage area and minimum 500 acre drainage area.</td>
<td>52</td>
<td>Large footprint and design time.</td>
</tr>
</tbody>
</table>

*Reduction percentages based upon the Iowa Nutrient Reduction Strategy.*
**Drainage Water Management (DWM)**

**PURPOSE**
To manage the water table with control structures to reduce drainage during periods when it is not needed. Water may be stored in the soil profile and made available to the crop during portions of the year when water is scarce.

**N REDUCTION**
There has been a reported 18-75 percent total flow and nitrate-N reduction — depending on system design, location, soil and site conditions (Skaggs et al. 2012). DWM nitrate-N load reductions are a result of reduced flow volumes and not concentration reductions. Reduced drainage flow volumes result from an increase in evapotranspiration, horizontal seepage and surface runoff.

**LOCATION**
Fields suited for DWM generally have areas with slopes of 0.5-1 percent or less. Fields with slopes up to 2 percent can feasibly use DWM but costs increase with slope. New tile systems can be installed with laterals following the elevation contours in order to make them more cost effective to retrofit if drainage water management structures are to be installed in the future.

**COST**
Cooke et al. (2008) estimated the cost differential between conventional and controlled drainage at $49/acre. Controlled drainage ranged from $20-$89/acre. Annualized cost for nitrate-N removal with DWM ranges from $3.20-$4.52 per pound of N removed for retrofitted systems on flat fields and as high as $13.89-$20.28 per pound of N removed for new systems with complex, undulating fields.

**BARRIERS**
There is a limited amount of land that matches the slope requirements and has not had tile previously installed. Existing tile systems may be difficult to retrofit for DWM purposes and all DWM requires seasonal management.

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**Shallow Subsurface Drainage**

**PURPOSE**
Shallow drainage is intended to reduce flow volume by reducing tile depth. Typical subsurface drainage depth in the Midwest is 4 feet, but shallow drainage depth is 3 feet, thereby reducing the drainable soil volume by 25 percent.

**N REDUCTION**
Literature shows an average nitrate-N reduction of 32 percent. Similar to drainage water management, shallow drainage does not reduce nitrate-N concentration in tile water but reduces the amount of tile flow, which reduces nitrate load.

**LOCATION**
Shallow tile drainage can be applied anywhere a new tile system is being installed, or when “splitting” existing tile spacing, such as transitioning from 100 foot spacing down to 50 foot spacing. Shallow drainage does not require any annual management. Less distance is required between shallow tile depths and wetlands, and therefore shallow drainage can better manage the water table closer to wetlands.

**COST**
To obtain the same drainage coefficient and yield benefits as conventional drainage, narrower tile spacing is needed. For example, in a southwest Minnesota field study with silty clay loam/clay loam soils, tile spacing needed to be reduced from 80 feet to 60 feet in order to obtain the same half-inch drainage coefficient. The reduction in lateral spacing can increase the costs of tile installation by 25 percent or more.

**BARRIERS**
Shallow subsurface drainage is more expensive than conventional drainage as 25-33 percent more material is needed to install the narrowly spaced laterals compared to conventional drainage.
**Constructed Wetlands**

**PURPOSE**

Wetlands are capable of performing multiple ecosystem services such as wildlife habitat, nutrient removal and flood storage. Constructed wetlands, or water treatment wetlands, are designed to enhance nutrient removal, specifically N processing. The Natural Resources Conservation Service designed water treatment wetlands to treat effluent from agricultural drainage systems in a shallow vegetated pool.

**N REDUCTION**

Performance varies based upon the size of wetland relative to its drainage or watershed area, but wetlands have been shown to remove 40-90 percent of incoming nitrate-N. The Iowa Nutrient Reduction Strategy reports a 52 percent reduction in wetlands in the Conservation Reserve Enhancement Program.

**LOCATION**

A minimum of 25 percent of the contributing watershed must consist of drained row crop agriculture. The typical wetland size is 2-5 percent of the contributing area. The maximum size of the constructed wetland is 40 acres. A buffer is required around the wetland to prevent sedimentation. The buffer to wetland area must be a minimum of 2:1 and a maximum of 4:1.

**COST**

Constructed wetlands can be enrolled in the continuous CRP program. Producers may receive an annual rental payment for a 10-15 year period, plus one time payments for 50 percent of the costs of the vegetation establishment and 40 percent of practice installation. Also, the area enrolled in the wetland is eligible for an additional incentive payment of 20 percent of the soil rental rate.

**BARRIERS**

Land may be required to be taken out of production.