Ten Ways to Reduce Nitrogen Loads from Drained Agricultural Land

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Tile drainage is the largest pathway for nutrient loss in Midwestern rivers.

- Tile drains greatly increase loss of nitrate to streams.
- Recent research is showing more clearly that phosphorus also moves through tiles.
Tile drainage: An unseen “plumbing system” critical to crop production in poorly-drained land.
Estimated percentage of land with subsurface drainage

Source: Zachary Sugg, World Resources Institute
How is the impact of drained land changing?
More of our precipitation is falling in very heavy events

Observed change in percent of precipitation falling in “very heavy events” (i.e., this is what has already occurred)

(very heavy events defined as the heaviest 1% of all daily events; time period is from 1958 to 2012)

From National Climate Assessment - http://nca2014.globalchange.gov/
How will farmers respond to more heavy precipitation events?
New publication: 10 Ways to Reduce Nitrogen Loads from Drained Cropland in the Midwest
10 Ways to reduce nitrogen loads

1. Improved Nitrogen Management
2. Cover Crops
3. Perennials in the Cropping System
4. Drainage Water Management
5. Reduced Drainage Intensity
6. Recycling Drainage Water
7. Bioreactors
8. Wetlands
9. Alternative Ditches
10. Saturated Buffers
4 ways practices can improve water quality

1. Nitrogen Fixation
2. Fertilizer or Manure Application
3. Mineralization
4. Nitrification
5. Plant Uptake
6. Denitrification
7. Seepage
8. Drainage

- reducing the nitrogen source
- increasing plant uptake
- increasing denitrification
4 ways the practices improve water quality

- reducing the nitrogen source
- increasing plant uptake
- increasing denitrification
- reducing the amount of drainage or flow entering the stream
Overview of practices – page 4

- Are you interested in practices that...
  - are cropping or management strategies?
  - are in the field and that...
  - modify the drainage system?

- Are you at the edge of the field or offsite?

- Improved Nitrogen Management
- Winter Cover Crops
- Perennials in the Cropping System
- Drainage Water Management (Controlled Drainage)
- Reduced Drainage Intensity
- Recycling Drainage Water
- Bioreactors
- Wetlands
- Alternative Open-Ditch Design
- Saturated Buffers

This practice improves water quality by...
- reducing the nitrogen source
- increasing plant uptake
- reducing the amount of drainage or flow entering the stream
- increasing denitrification
In-field management practice:

1. Improved N management (4Rs)

What is it? Applying “the right source of nutrient, at the right rate, at the right time, and in the right place.”
- Rate: Decreasing nitrogen fertilizer rate generally reduces nitrate concentration and load.
- Time of application: Application in spring is better than fall, and sidedress (after planting) is best.

How does it reduce N loss in drainage?
- Reduces the source of N
- May increase plant uptake (timing)
In-field management practice:

2. Winter cover crops

**What is it?** A crop planted in late fall to cover the soil over the winter.

Load reduction: 13% to 94%

From Christianson et al. (2013) Int’l J. Ag. Sust.

Photo: http://www.covercrops.msu.edu/general/general.html
In-field management practice:

2. Winter cover crops

**How does it reduce N loss in drainage?**
Cover crops take up water and nitrate from the soil after the main crop is harvested and before the next crop starts growing.

Lots of additional benefits! Slows erosion, improves soil health, smothers weeds, increases biodiversity...

- Increasing plant uptake
- Reducing the amount of drainage or flow entering the stream

From Christianson et al. (2013) Int’l J. Ag. Sust.
In-field management practice:
3. Perennials in the rotation

**What is it?** Inclusion of perennials within an extended rotation or at critical locations within a field

From Christianson et al. (2013) Int. J. Ag. Sust.
In-field management practice:

3. Perennials in the rotation

Source: Christianson and Harmel, 2015 (Ag. Water Management)
In-field management practice:

3. Perennials in the rotation

How does it reduce N loss in drainage? Takes up water and nitrate from the soil during periods when annual crops are not growing.
In-field Drainage system practice:

4. Drainage water management

From Christianson et al. (In preparation)
In-field Drainage system practice:

Drainage water management

**What is it?** Adjustable structures to manage the level of the drainage outlet

![Diagram of controlled drainage system with adjustable gates to raise or lower the outlet elevation by adding or subtracting gates.](image-url)
In-field Drainage system practice:

Drainage water management

**What is it?** Adjustable structures

**How does it reduce N loss in drainage?** Holds back water and nitrate in the water

Reducing the amount of drainage or flow entering the stream.

**Controlled Drainage**

Control Structure

You can raise or lower the outlet elevation by adding or subtracting gates.
In-field Drainage system practice:

5. Reduced drainage intensity

**What is it?** Installation of subsurface drains either closer to the surface or with wider spacing than conventional

**How does it reduce N loss in drainage?** Less water leaves the field as drainage, thus less N leaves the field.

Source: Luo et al., 2010

From Christianson et al. (In preparation)
6. Recycling drainage water

**What is it?** Drainage water is stored in a pond or reservoir and then returned it to the soil through irrigation during dry periods.

**How does it reduce N loss in drainage?**
Recycling the drainage water can reduce or even eliminate nitrate loss by reducing or eliminating the water that leaves the site and increasing plant uptake.

From Christianson et al. (In preparation)
In-field Drainage system practice:

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Transforming Drainage: A multi-State project advancing research and extension of this practice

From Christianson et al. (In preparation)
Edge-of-field or off-site practice:

7. Woodchip bioreactors

What is it?
Woodchip-filled trench where good microbes “eat” the carbon in the woodchips to fuel their work removing nitrate from the drainage water

From Christianson et al. (2013) Int'l J. Ag. Sust.
Edge-of-field or off-site practice: Woodchip bioreactors

How does it reduce N loss in drainage? Additional carbon “super-powers” the natural process of denitrification.
Edge-of-field or off-site practice:

8. Wetlands

**What is it?** Constructed wetlands are dynamic ecosystems of plants, soil, bacteria, and water.

**How does it reduce N loss in drainage?** Wetlands primarily enhance the natural process of denitrification, but also provide some plant uptake of N and reduced downstream flow.
Edge-of-field or off-site practice:

9. Alternative ditch design (Two-stage)

What is it? Retrofit an existing ditch to contain a small “main” channel and low, grassed floodplains.

How does it reduce N loss in drainage?
Denitrification, plant uptake, and reduced flow via infiltration to the mini-floodplains.

From Christianson et al. (In preparation)
Edge-of-field or off-site practice:

10. Saturated buffers

**What is it?** A modification of the edge-of-field drainage system that allows drainage water to flow as shallow groundwater through the buffer’s soil.

From Christenson et al. (In preparation)
Edge-of-field or off-site practice:

Saturated buffers

**What is it?** A modification of the edge-of-field drainage system that allows drainage water to flow as shallow groundwater through the buffer’s soil.

**How does it reduce N loss in drainage?** As water moves through the buffer’s soil, nitrate is denitrified, plants uptake water and N, and flow is reduced.

From Christianson et al. (In preparation)
10 ways to reduce nitrogen loads

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Annual crops like corn and soybeans are “leaky systems”. Practices exist to reduce nitrogen loads -- varying in cost, effectiveness, suitability, and additional benefits.
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A reasonable goal: No one practice will be suitable on every acre, but every acre needs at least one practice.

For more information or to obtain the publication:

http://go.aces.illinois.edu/TenWays