Innovative Agricultural Practices to Mitigate Groundwater Nutrient Contamination

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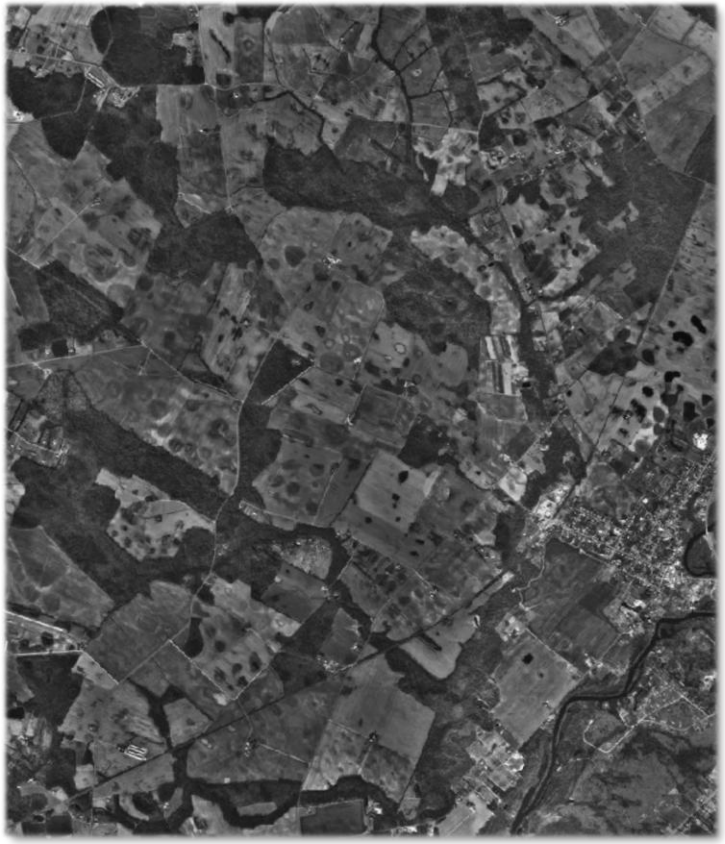
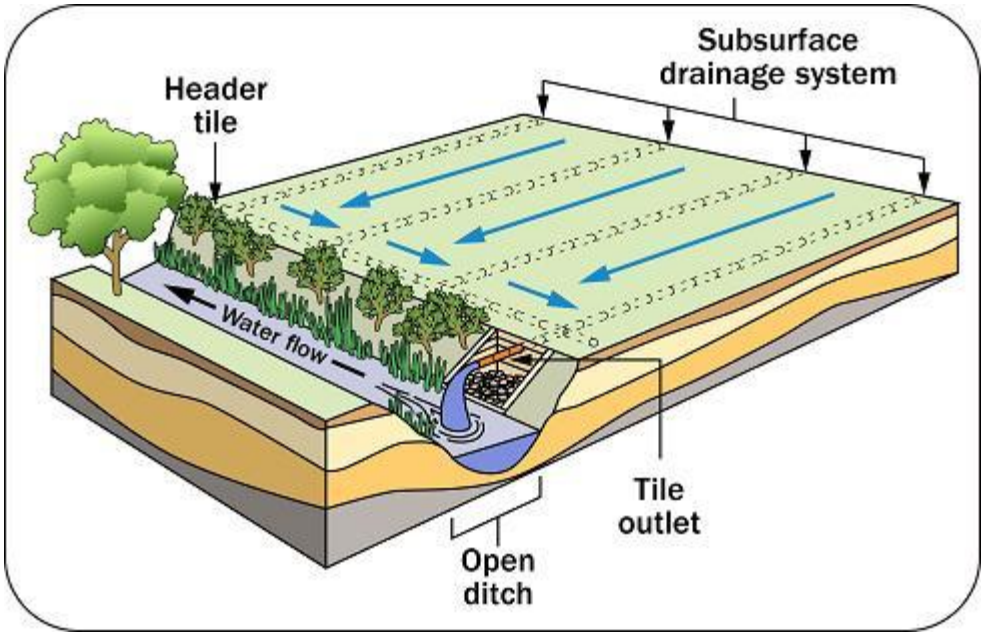
Ditch Drained Systems

- Flat, low-lying, poorly drained coastal plain soils
- Extensive ditching: In MD approximately 821 miles of ditches drain 183,000 acres of land
- Primarily corn, wheat and soybeans rotation
- High density poultry production has led to elevated soil P



Artificial drainage has modified hydrology

- Ditching
  - Placed 2-4 feet below surface
  - Lowered water tables
  - More efficient transport of water
- Tile drainage
  - Lowered water tables
  - Piped surface and groundwater



Ditching and tile drainage is effective, but….

- Concentrates nitrate
- Reduces processing
  - Loss of ecosystem services
- Increases transport

Missouri Land Improvement Contractors Association, Ontario Ministry of Agriculture and Food

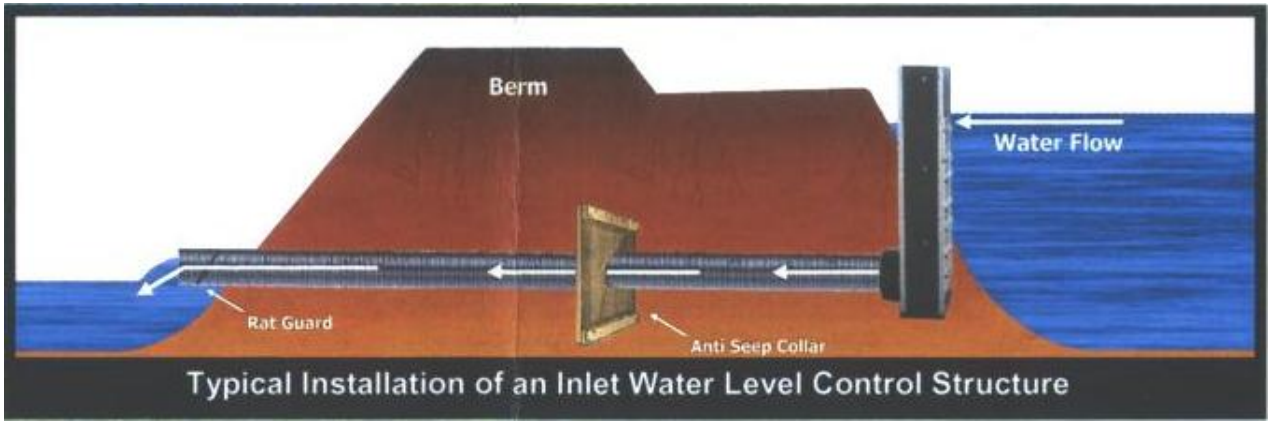
Practice Options

- Water Control Structures
- Bioreactors
- Passive Phosphorus Removal Systems

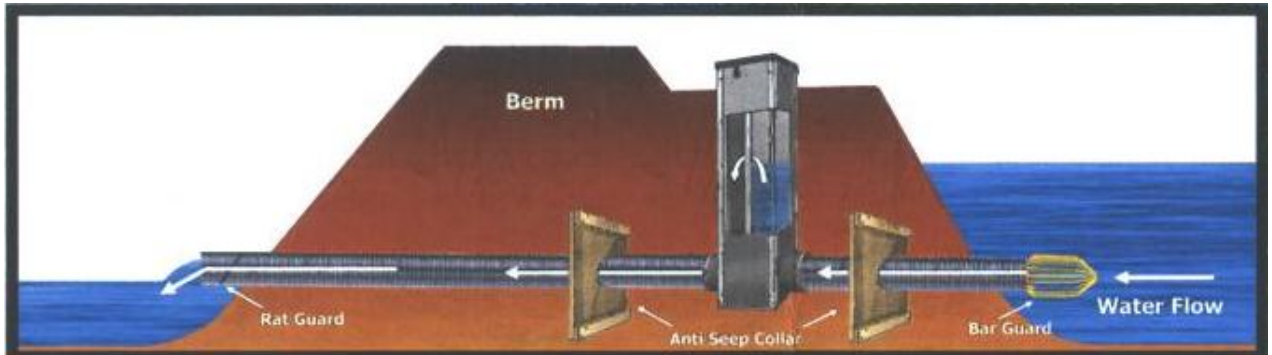
Water Control Structures

- USDA – Natural Resources Conservation Service Practice
- Regulates water in a drainage system to manage the outflow of drainage water
- Controls water surface elevations and discharge from surface and subsurface drainage

Inlet vs Inline Water Control Structure



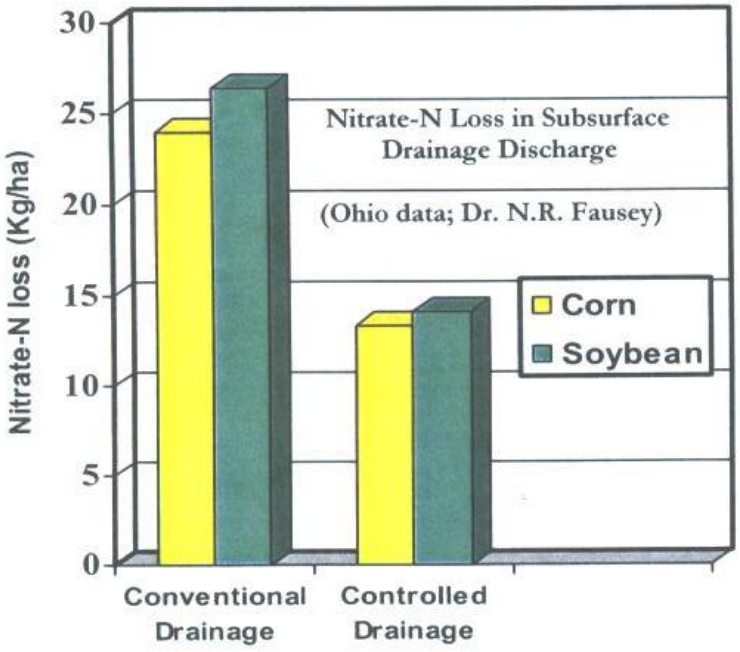
Typical Installation of an Inlet Water Level Control Structure



Typical Installation of an Inline Water Level Control Structure

Benefits of Implementation

- Improve water quality
  - Denitrification
  - Reduce soil erosion
  - Trap sediment
- Improve soil environment for vegetative growth
- Reduce the rate of oxidation of organic soils
- Reduces flashiness of drainage system
- Wildlife habitat – seasonal shallow flooding



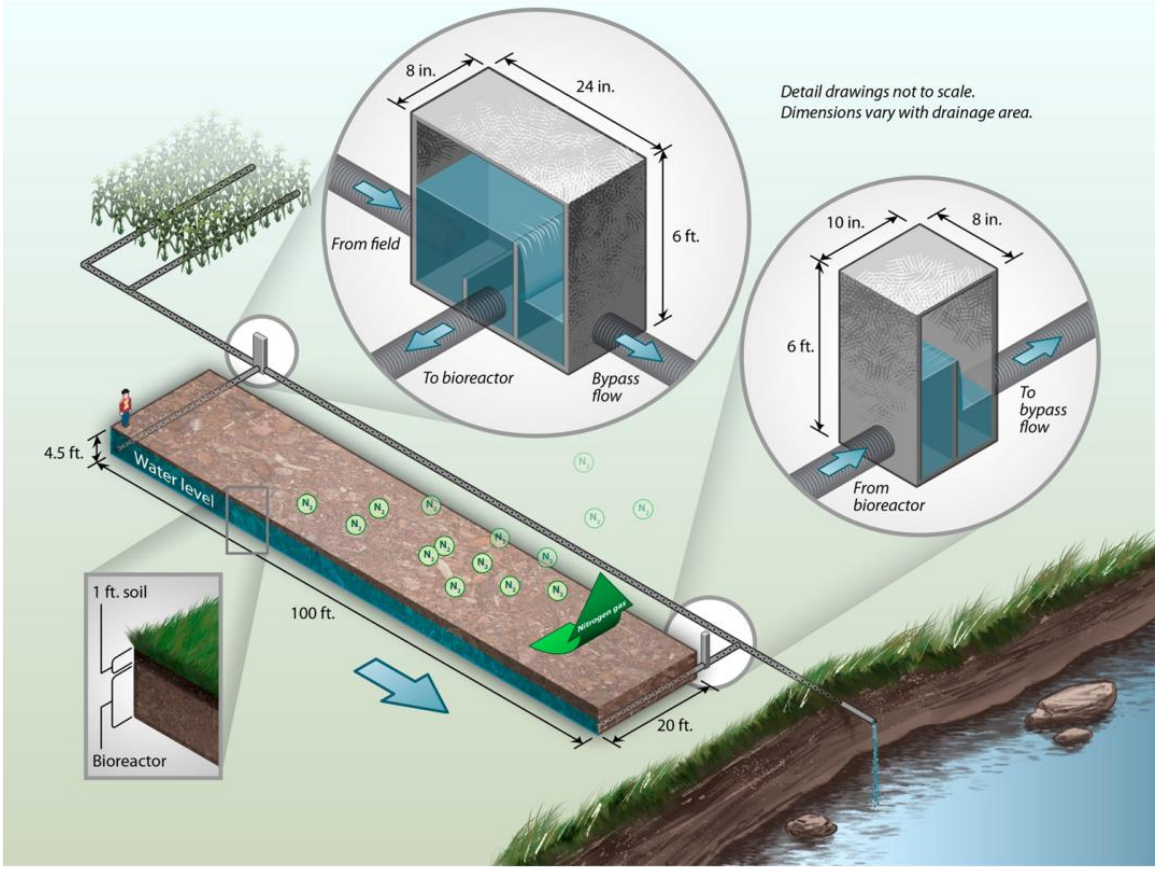
Research

- North Carolina – Robert Evans (1989)
  - Neuse River Watershed
  - 45% N reduction
  - 35% P reduction
  - Based on pounds/acre/year
- Delaware – DNREC (2004)
  - 33% N reduction
  - Did not assign P reduction efficiency
- Chesapeake Bay Program (2005)
  - Approved agricultural BMP for nutrient reduction credit
  - 30% N reduction

Cost-Share Assistance Available

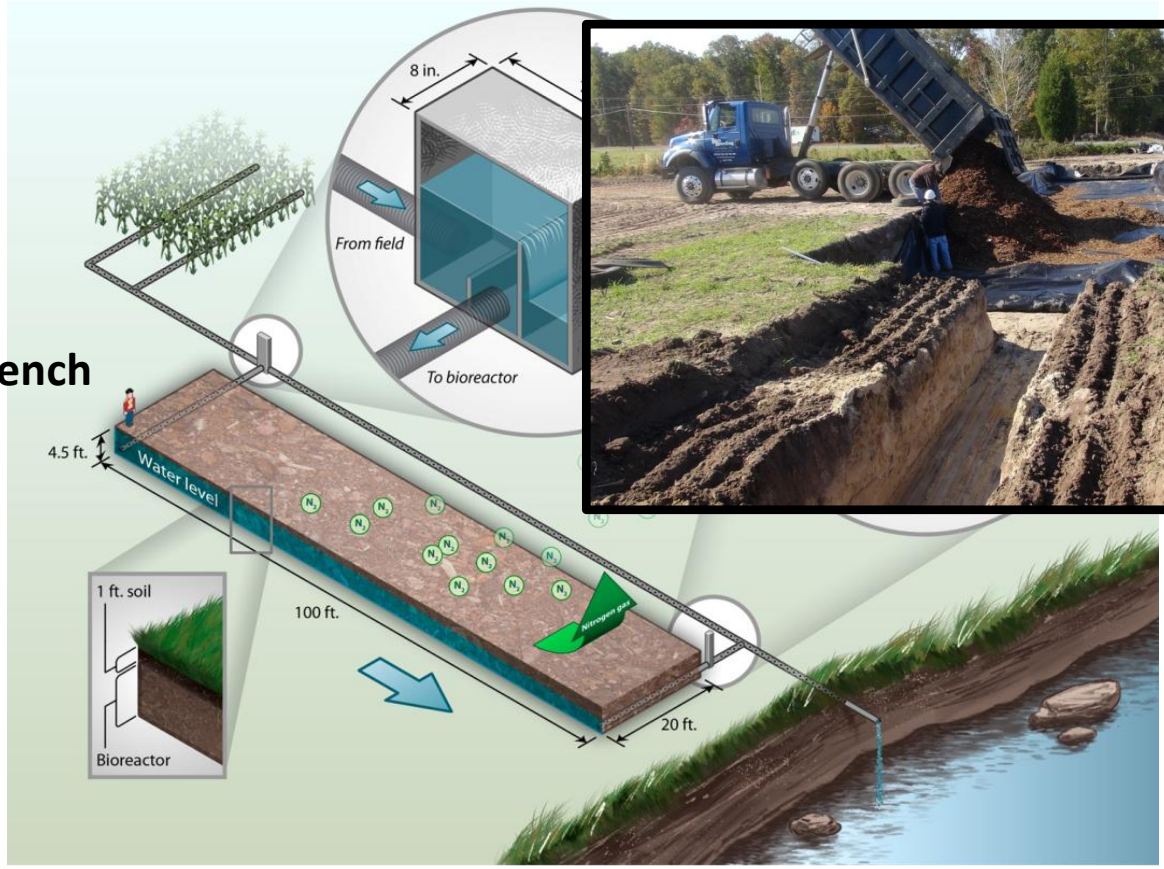
- 87.5% through MACS Program
- Up to $20,000
- 10 year maintenance life
- Maintenance agreement

Bioreactor


8 in.
24 in.
6 ft.
From field
To bioreactor
Bypass flow
Detail drawings not to scale.
Dimensions vary with drainage area.
10 in.
8 in.
6 ft.
To bypass flow
From bioreactor
4.5 ft.
Water level
1 ft. soil
Bioreactor
100 ft.
20 ft.
Nitrogen gas

Components

Woodchip Trench



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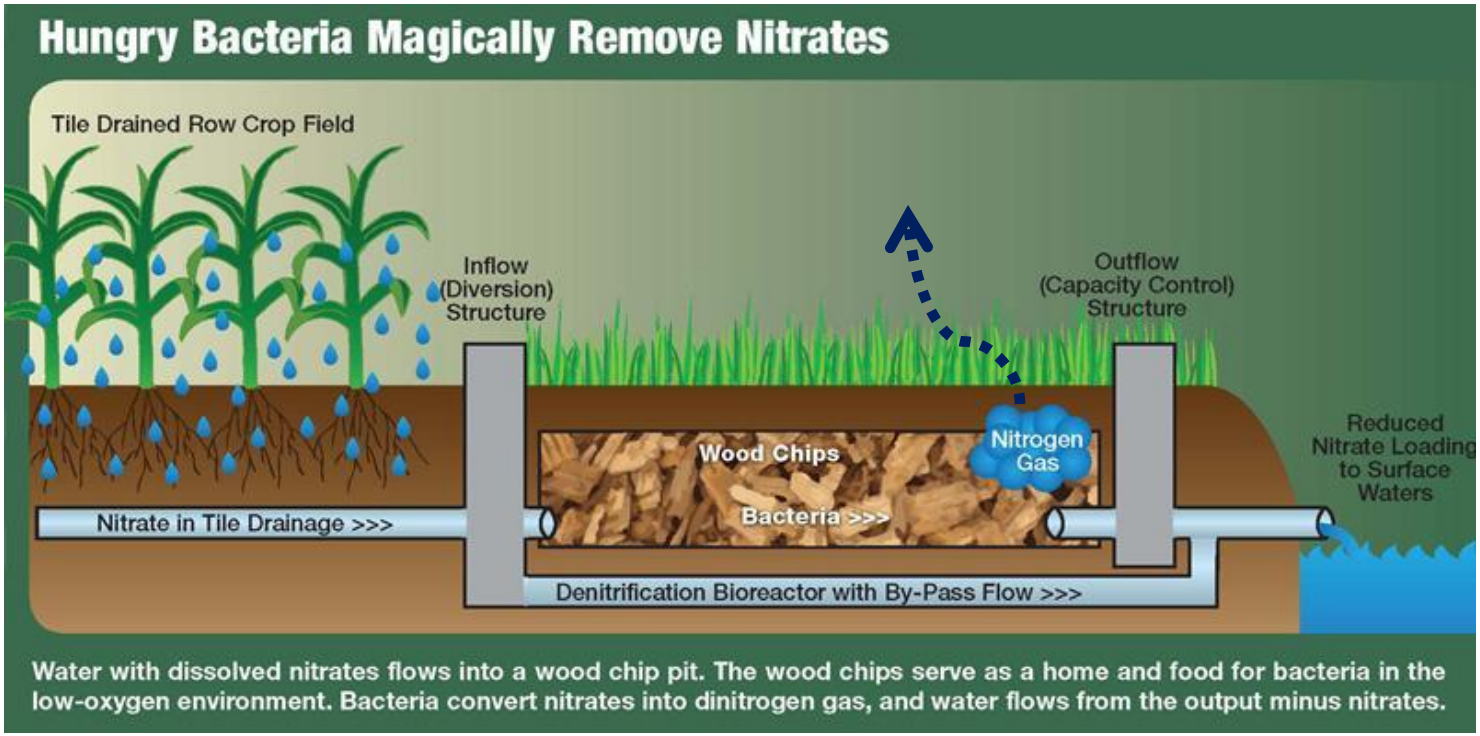
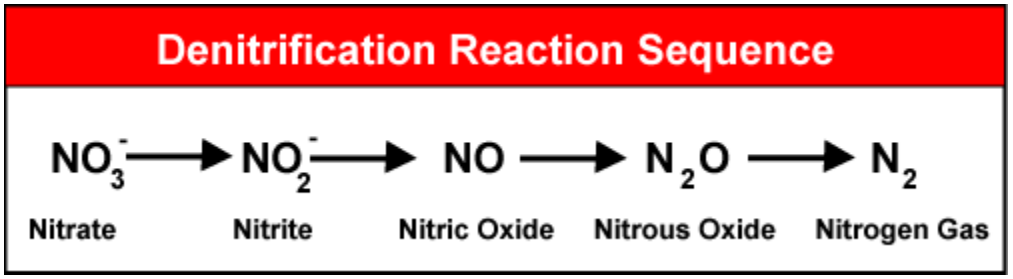
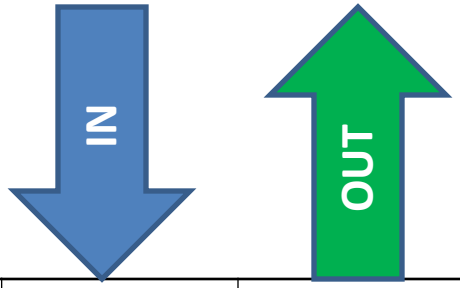
Nitrate Removal





Nitrate (mg/l)



	Box 1	Box 2	Box 1	Box 2		
Date	NO3-N (mg/l)	NO3-N (mg/l)	NO3 Load (lbs/d)	NO3 Load (lbs/d)	Load Reduction	Concentration Reduction
11/20	9.14	0.07				99.28%
11/26	9.13	0.07				99.28%
11/27	0.97	0.32				67.18%
12/3	0.01	0.03	0.000	0.000	-97.86%	-97.86%
2/7	13.41	0.68	3.307	0.033	15.60%	94.92%
2/12	20.60	0.03	14.977	0.003	10.73%	99.85%
2/17	13.64	0.91	5.973	0.080	15.55%	93.33%
3/11	17.50	0.10	12.723	0.005	6.01%	99.43%
4/28	2.41	0.10	0.114	0.009	62.29%	95.85%
AVERAGE	**9.65**	**0.26**	**6.18**	**0.02**	**22.0%**	**94.0%**

How well are they working?

- Highly efficient at reducing nitrate
  - 94%-98% efficiency (concentration)
- Load reduction low
  - Amount of water diverted into bioreactor
  - 22% load reduction
- Ammonium treatment variable
  - Depends on influent concentration
  - Source during periods of low influent concentration
- Bioreactor is leaching phosphorus
  - High at onset as bound phosphorus is freed (anaerobic conditions)
  - Will continue at some level

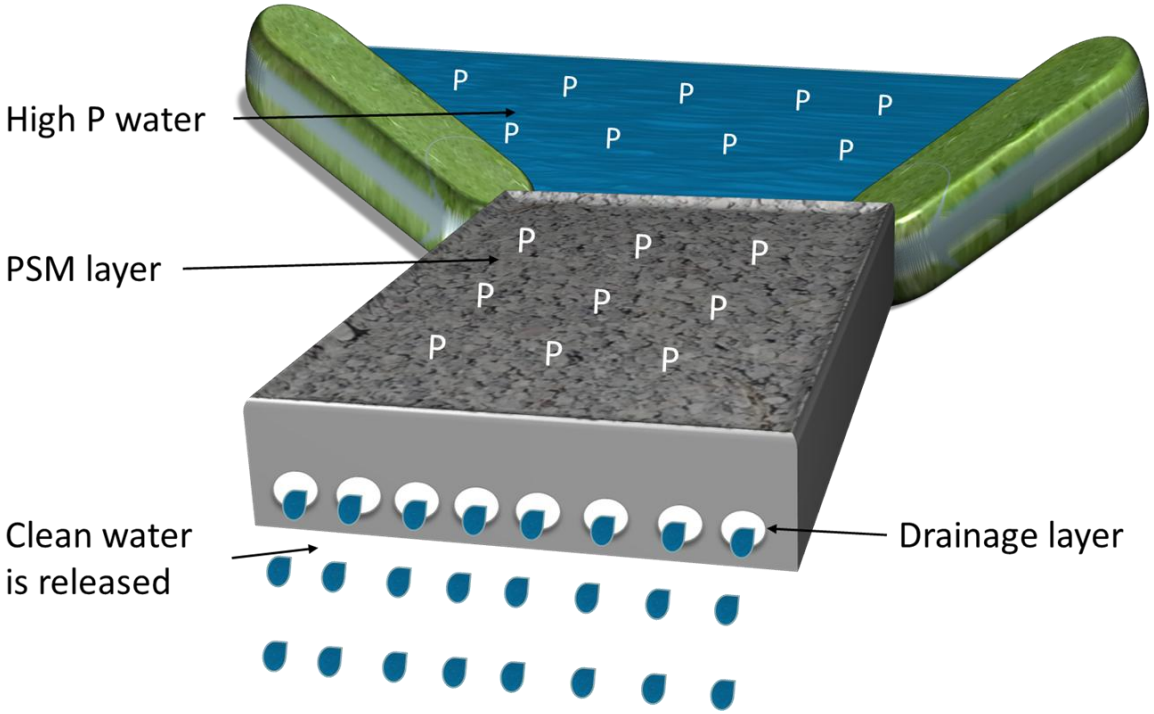
Effectiveness

- 23% to 98% reduction in nitrate load
  - Temperature
  - Retention Time
- Lifespan of greater than 15 years
- Low Maintenance
- Cost Effective
  - Less than $3.50 per kg N removed
- Edge of field

Drawbacks

- Some N2O production
  - Negligible to 4 %
  - Higher during cold conditions
- May cause methylation of mercury
  - Rare
  - Occurs if sulfate reducing conditions present

Passive Phosphorus Removal Systems



Ditch P Transport

- Legacy P releases dissolved P over many years
- There are no BMP's designed to control dissolved P transport
  - dissolved P is most dangerous to aquatic ecosystems
- Ditches provide direct transport path for dissolved P
- Majority of the P in ditches gets there through shallow subsurface flow
- Ditches provide ideal collection point for treatment

Basic Ditch Filter

- Structure filled with P sorbing materials (PSMs)
  - Any material that chemically sorbs P through precipitation or fixation reactions
  - Fe, Mg, Al, or Ca containing materials, or combination of these elements
  - Typically focused on industrial residuals
- Alter hydraulic head in ditch to force flow through filter material
- Confine material in some sort of structure

Confined Bed

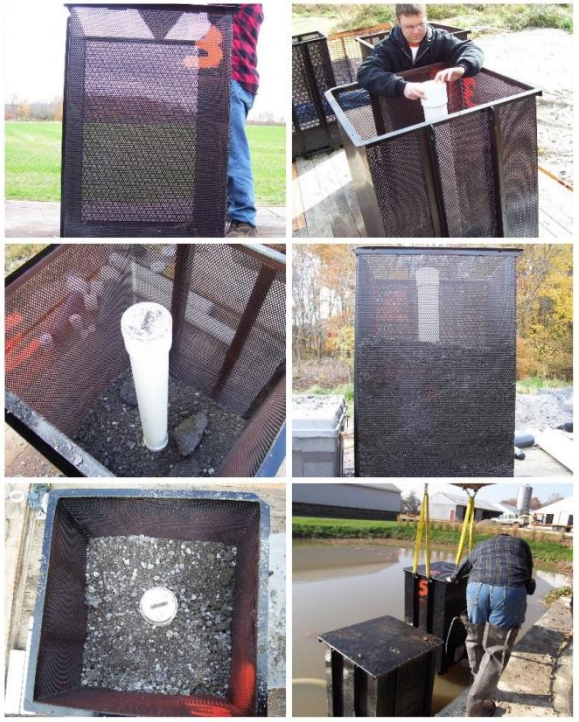
- Good for large filter
- Ideal for drainage swales that require high peak flow and little water backing
  - Achieved through shallow PSM with large surface area

Tile Drain

- Similar to bed, but without confinement
- Allows large amount of material to be used
- Use flow control to build head
- Low cost
- Probably best option, but there seems to bias with landowners

Box Filter

- Easily switch out material
- Modular design – integrates with flow control
  - Agri-Drain
- Small ditches or pond overflow
- Drawback: Small amount of material



Performance

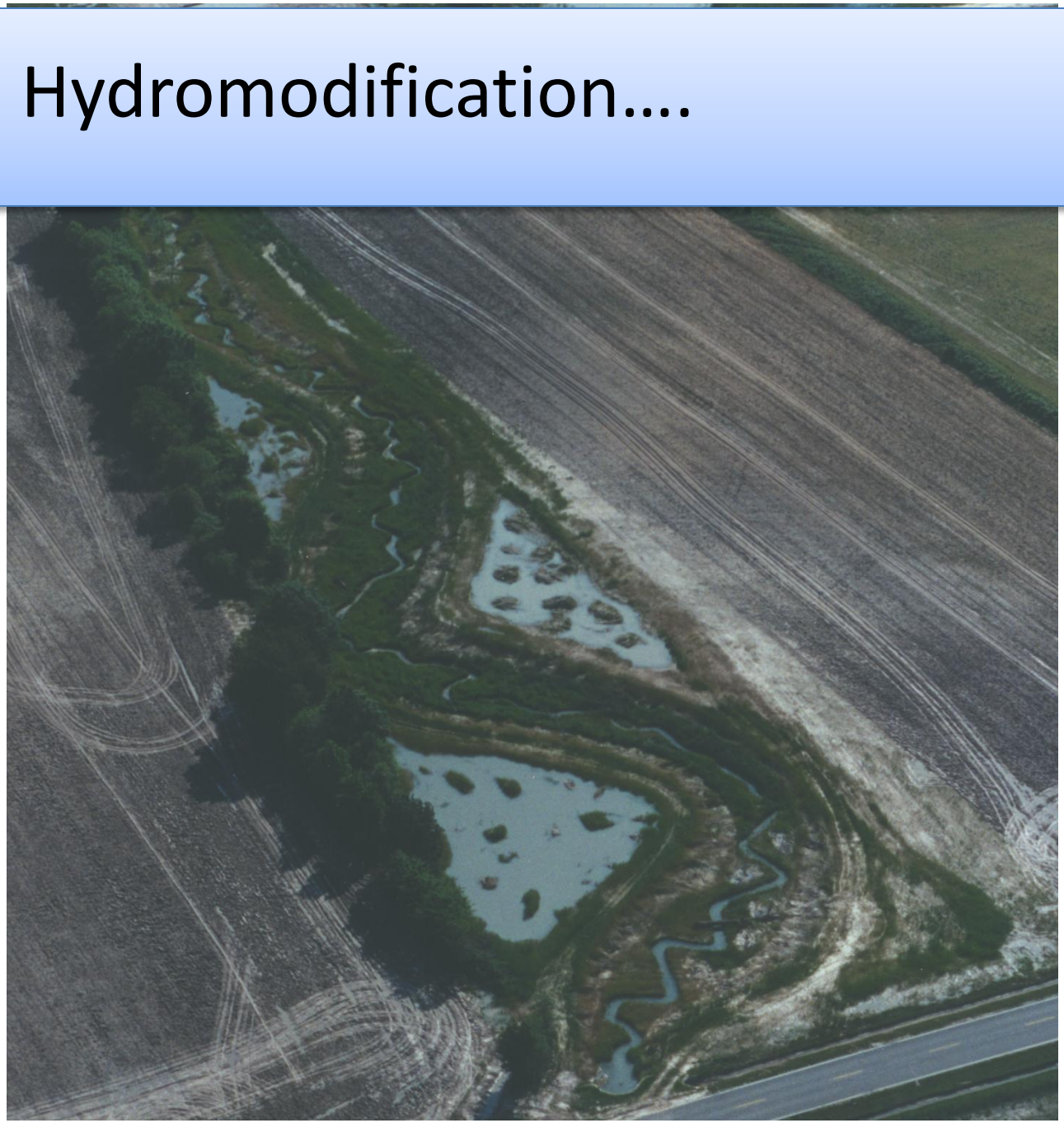
- Slag confined bed: 43% removal
- Gypsum tile drain: initial (limited) data indicates 67% removal
- Box style filter approximately 20% load reduction
  - Approximately 50% when flow is good
  - Reduced FWMC of TP 25%
  - Reduced FWMC of DRP 29%

- To date model predicts P removal accurately
- Need robust field data to validate model and to predict overflow versus flow through
  - 4 ditches with tile filters
  - 3 ditches with cartridge filters
  - 2 ditches (1 ag and 1 golf course) with confined bed filters
  - 1 retention pond with box filter
- Developing complete guidance for government and private stakeholders

Weed Wiper

- Selectively targets tall woody vegetation and brush without harming the low growing vegetation
- Used to stabilize and protect the ditch slopes
- Allows for increased wildlife habitat

Hydromodification….



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