Drainage Water Management as a BMP to Reduce Nitrate Loss from Cropland to Surface Waters in the Mississippi River Basin and the Hypoxic Zone in the Gulf.

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Background & Problem

It has been shown through research that outflow from subsurface drainage systems installed at a typical 1.0 meter depth can carry a significant load of Nitrate-N, thus Polluting receiving streams and water bodies. Discharges of Nitrate from the extensive subsurface drainage installations in the Midwestern U.S. have been identified as a major source contributing to the Hypoxic Zone in the Northern Gulf of Mexico.

Most Midwestern subsurface drainage systems are Conventional designs with un-controlled outlets, and thus permit full, or “free”, drainage of the soil profile to the depth of the drains.

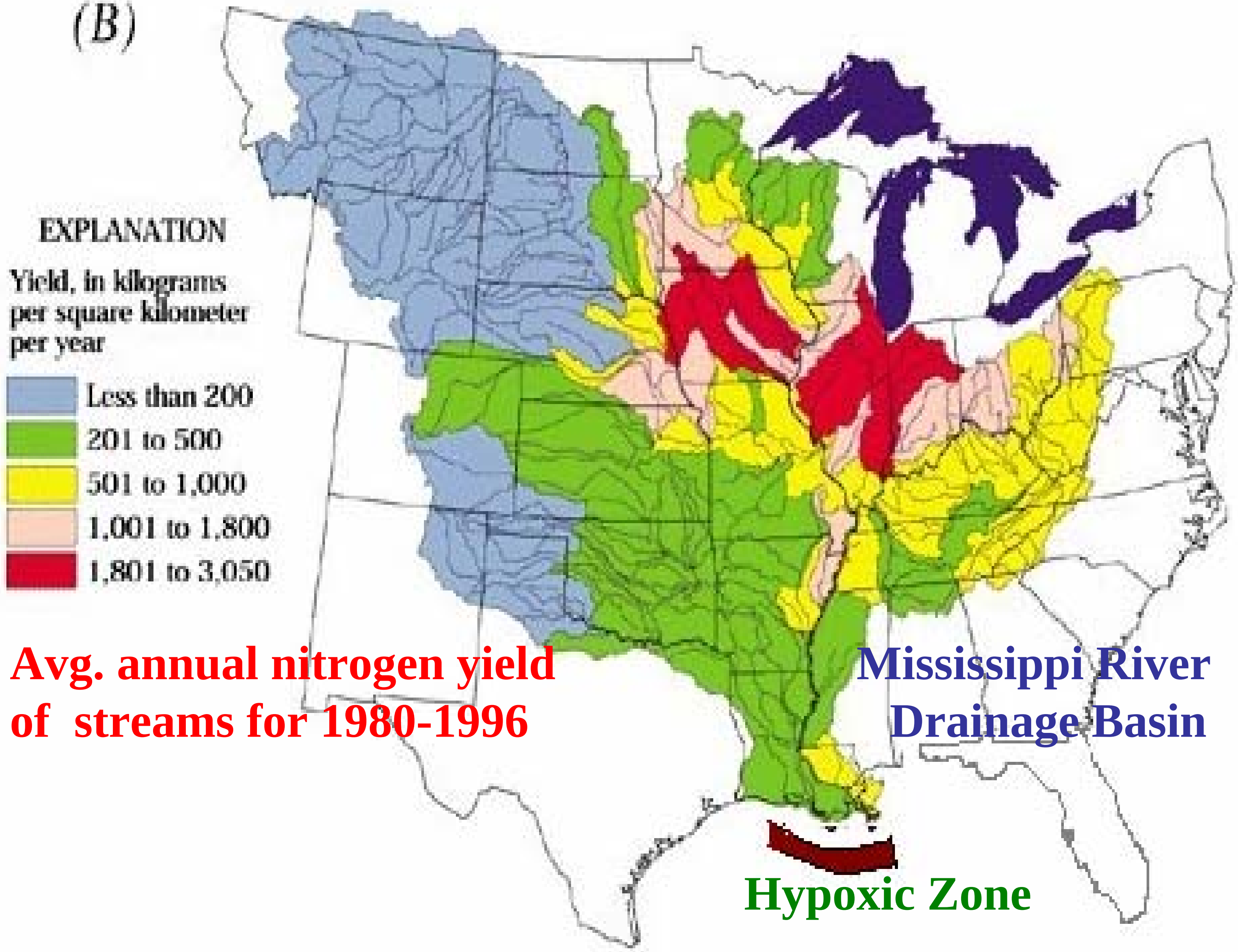
Un-Controlled Drainage Outlets can contribute to:

Nutrient Contaminated Surface Waters, Algal Blooms, Fish Kills, and Hypoxia in the Northern Gulf of Mexico

ARS

ARS

ARS



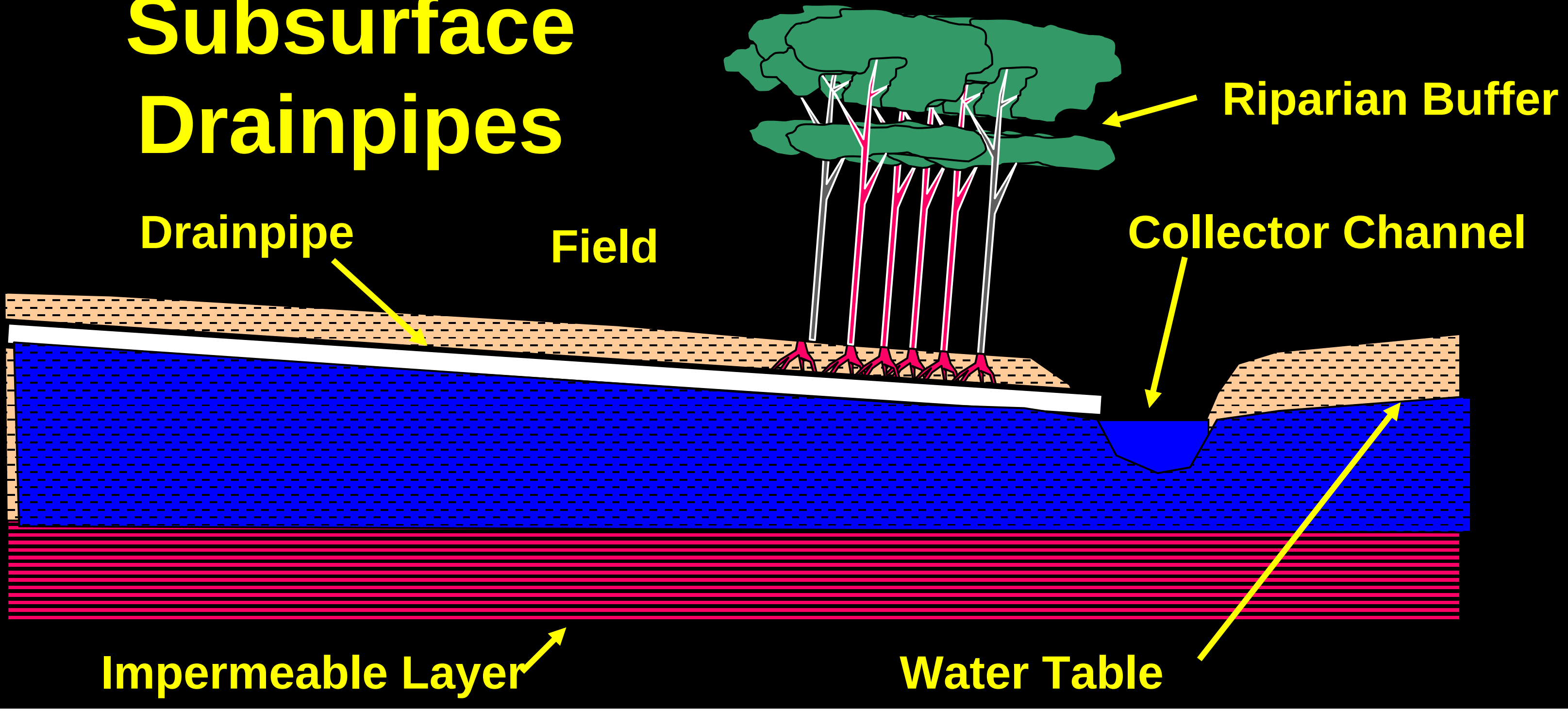
Avg. annual nitrogen yield of streams for 1980-1996

Mississippi River Drainage Basin

Hypoxic Zone

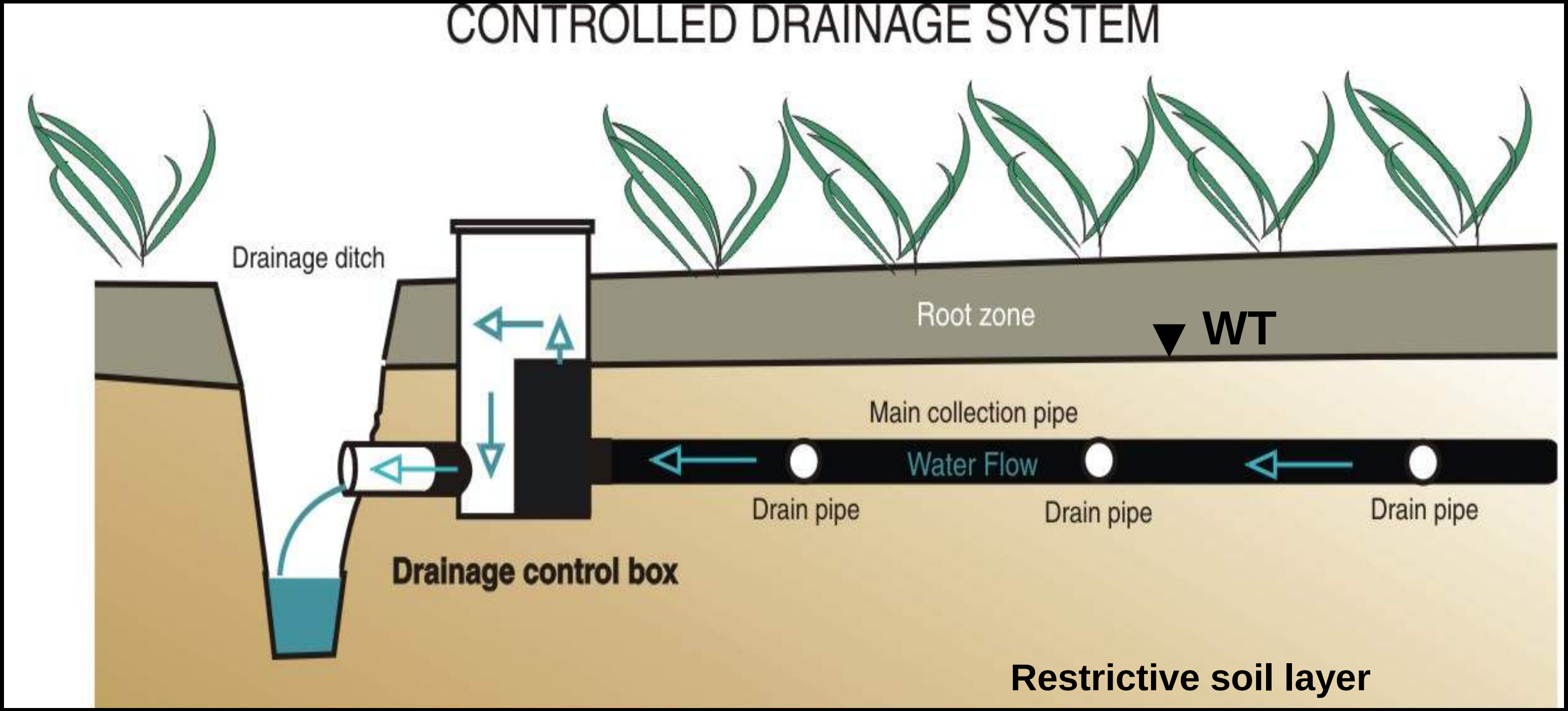
Riparian Buffers do not remove Nitrate-N carried in drainage flow through Uncontrolled Subsurface Drainpipes

(Lynn Betts, Iowa)

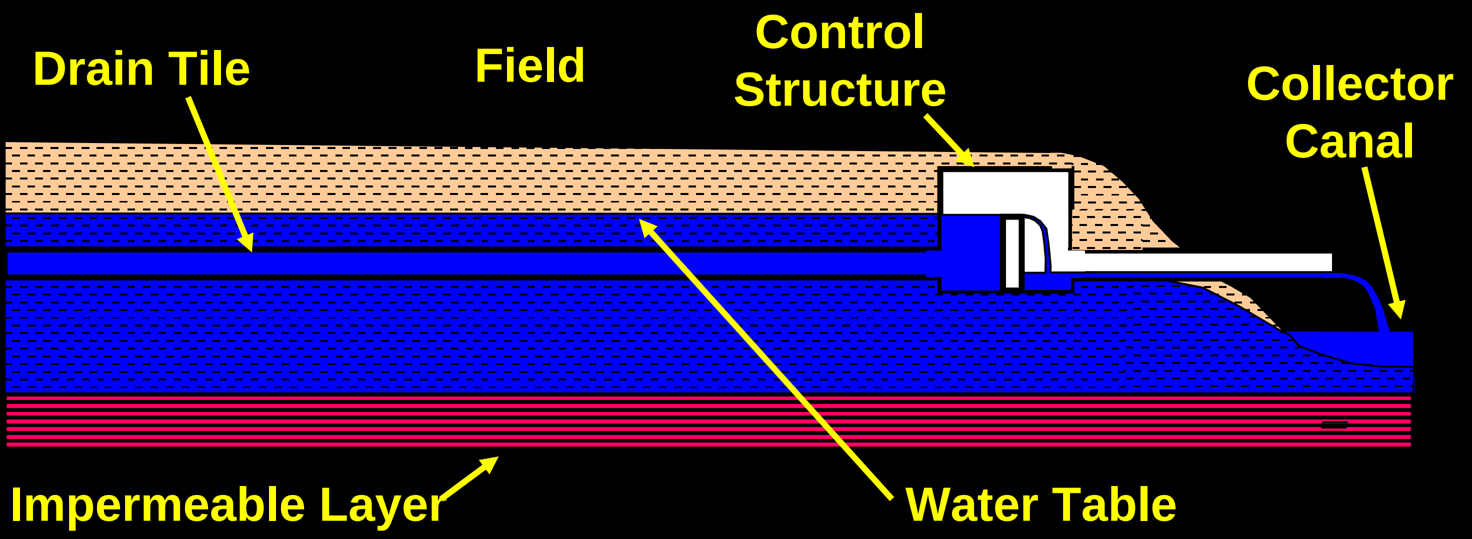


Best Management Practice (BMP) to apply:

Controlling Subsurface Drainage discharge (Drainage Water Management) to maintain a shallow water table (WT) during periods when deeper drainage is not needed for crop production (winter months & drought periods), can reduce Nitrate-N in drain outflow by 30% to 50%.



Controlled Subsurface Drainage



Drain Tile

Field

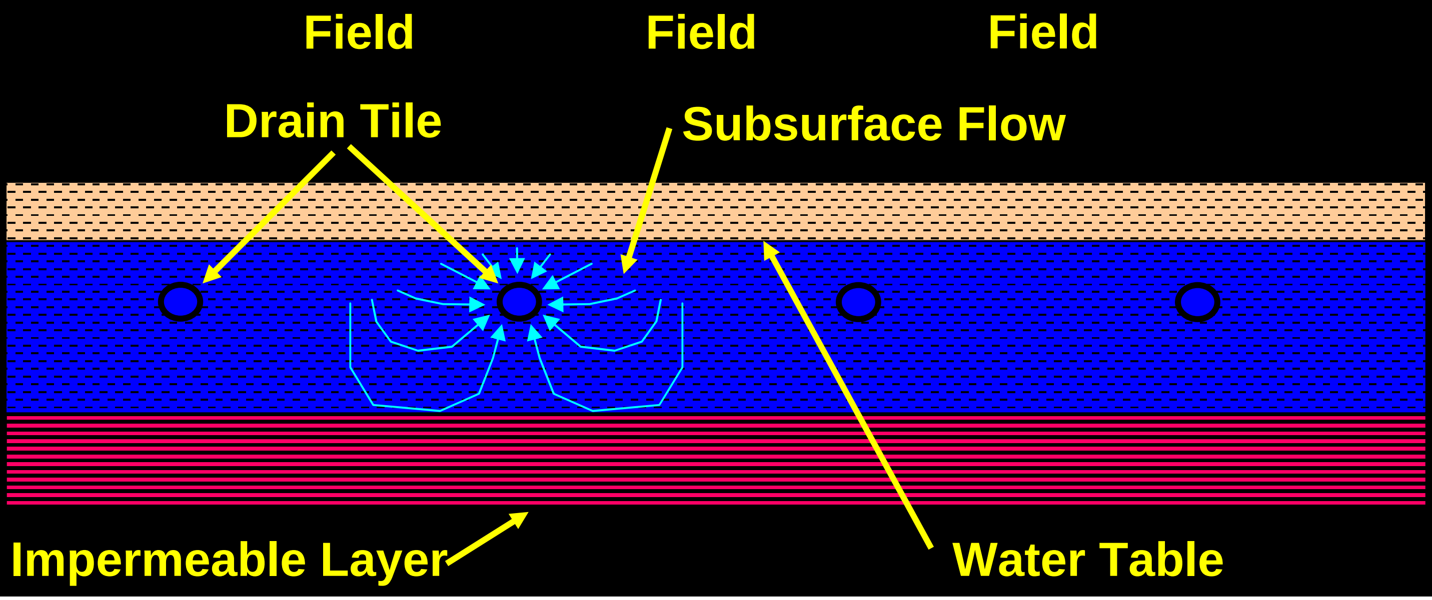
Control Structure

Collector Canal

Impermeable Layer

Water Table

Agri-Drain Corp.



Field

Field

Field

Drain Tile

Subsurface Flow

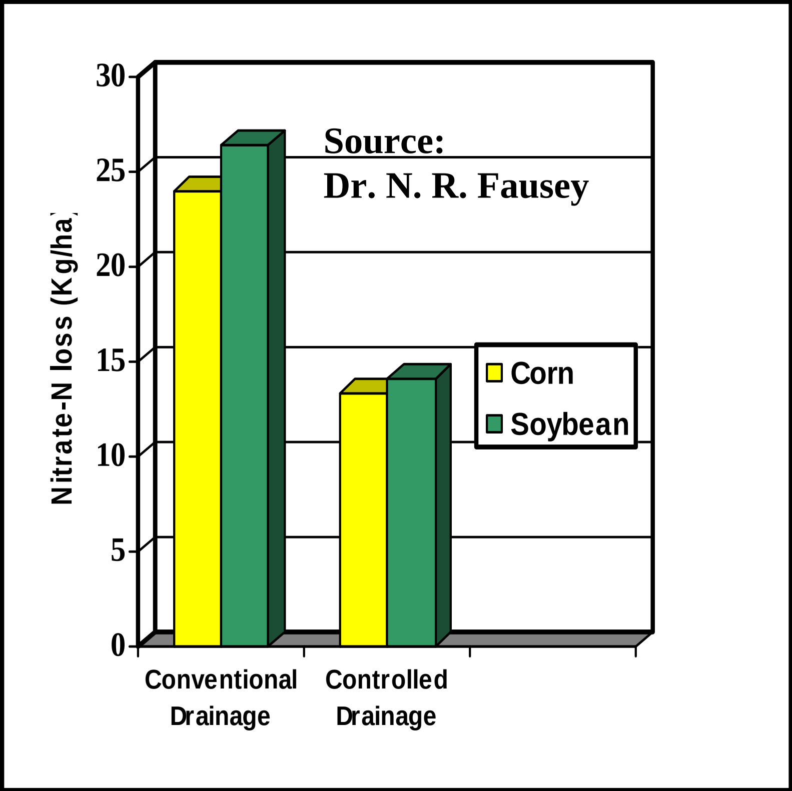
Impermeable Layer

Water Table

(Sheryl Kunickis, Illinois)

An example of research findings in terms of Controlled-Drainage benefits .….

- In a 4.5-year study in Northwest Ohio, controlled-drainage, compared to conventional subsurface drainage, reduced drainage outflows by about 60 % of conventional drainage flows and nitrate-nitrogen loadings by more than 45 % for corn and soybean crop production.



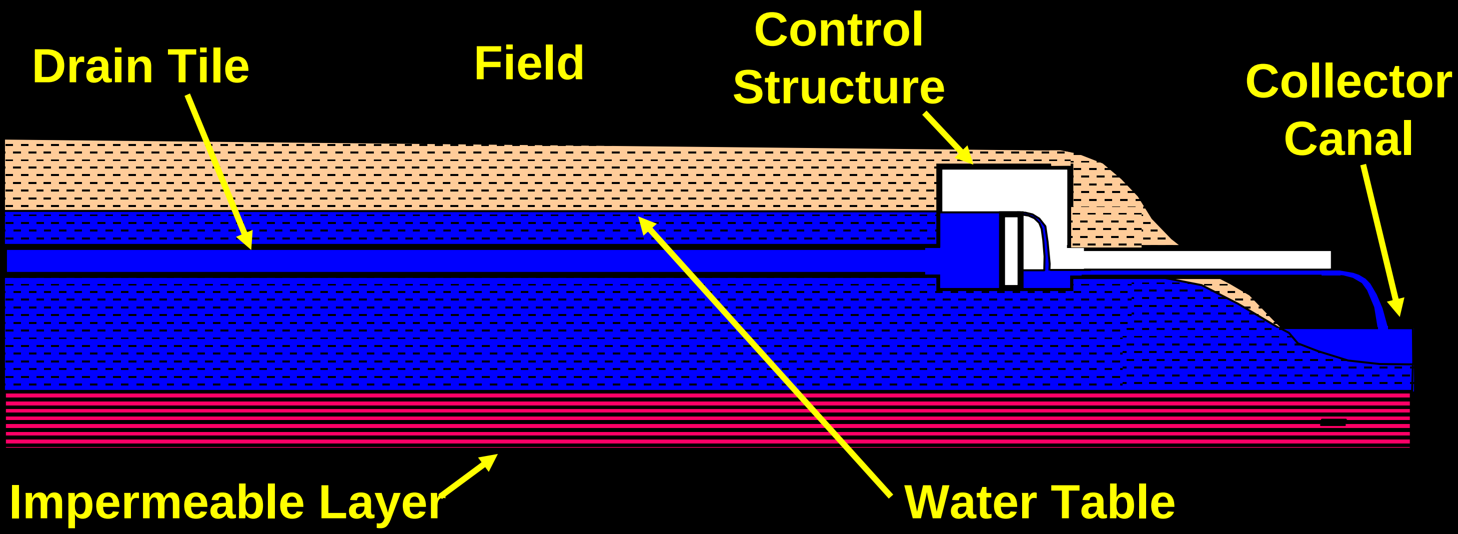
Source:
Dr. N. R. Fausey

Controlled Subsurface Drainage

Nitrate-N Reductions

- 50% in mass (Gilliam et al., 1979; Evans et al., 1989b; Skaggs and Cheschier, 1999; Fausey, 2004)
- 0%-20% in concentration (Gilliam et al., 1979; Evans et al., 1995)

Mostly by holding back nitrates with water that is not discharged through the outlet.



Priorities for Implementation of Controlled-Drainage Systems:

- **All new drainage systems (subsurface and surface) should be designed and installed for discharge management. NRCS Practice 554**

- **Existing subsurface and surface drainage systems should be retrofit for management of discharge, where ever feasible, *otherwise route discharge through a Wetland area.***

Drainage Water Management Implementation Cost Considerations:

The Innovative Practices provisions of the 2002 Farm Bill may provide Cost-Sharing to the Farmer on the <u>Control Components</u> for Drainage Management; *NRCS administers.*

Complementary WQ Management Practices…

- Install Bio-Filters or Reactors downstream from outlet pipes of controlled-drainage structures to further reduce Nitrate-N in sub-drainage flows.
- Establishment of Buffer Strips at the downslope edges of fields to filter runoff prior to flow into open ditches or streams.
- Diversion of cropland runoff or discharge from subsurface drainage systems through wetland areas to further reduce Nitrate carried in flows.
- Diversion of stream flow from agricultural cropland areas through wetland areas to remove excess Nitrate prior to returning flow to the mainstream channel.

Nitrate-N Reductions for Paired Controlled Subsurface Drainage and In-Line Bioreactor

Controlled-Drainage component

-50% in mass (Gilliam et al., 1979; Evans et al., 1989b; Skaggs and Cheschier, 1999; Fausey, 2004)

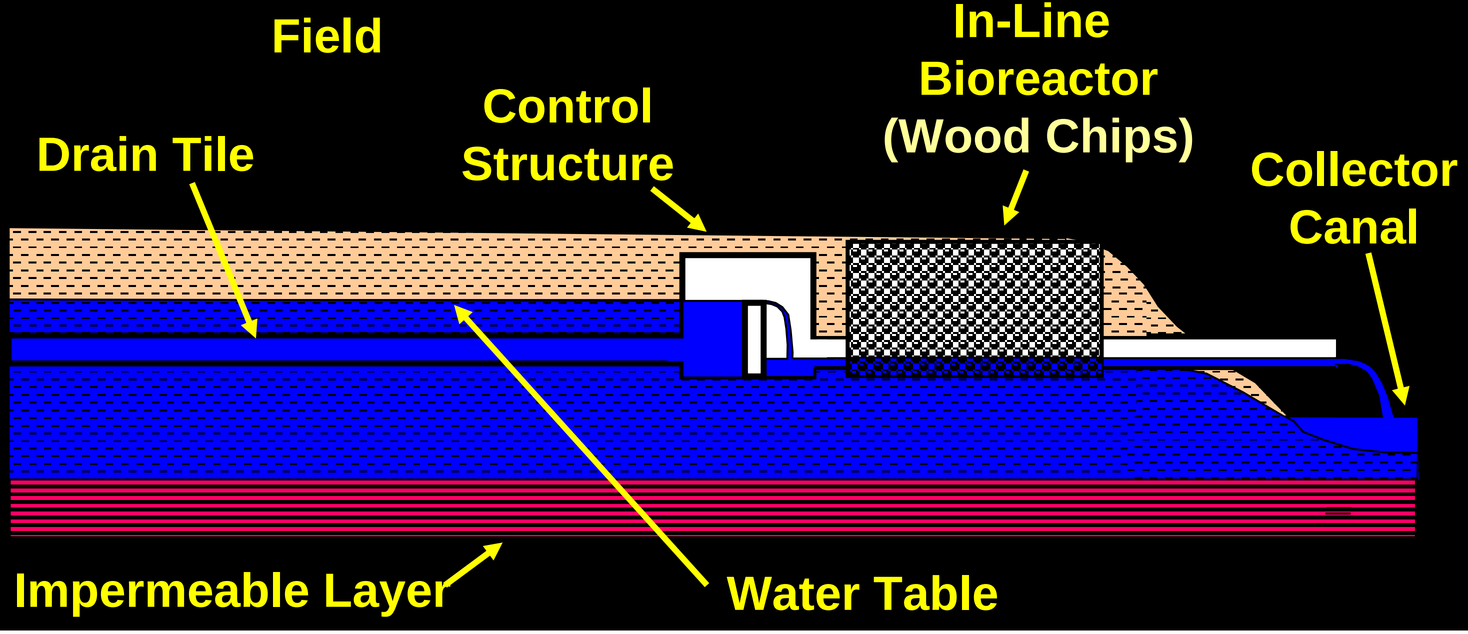
- 0%-20% in concentration (Gilliam et al.,1979; Evans et al., 1995)

In-Line Bioreactor component

- up to 50% in mass (Cooke, et al., 2006)

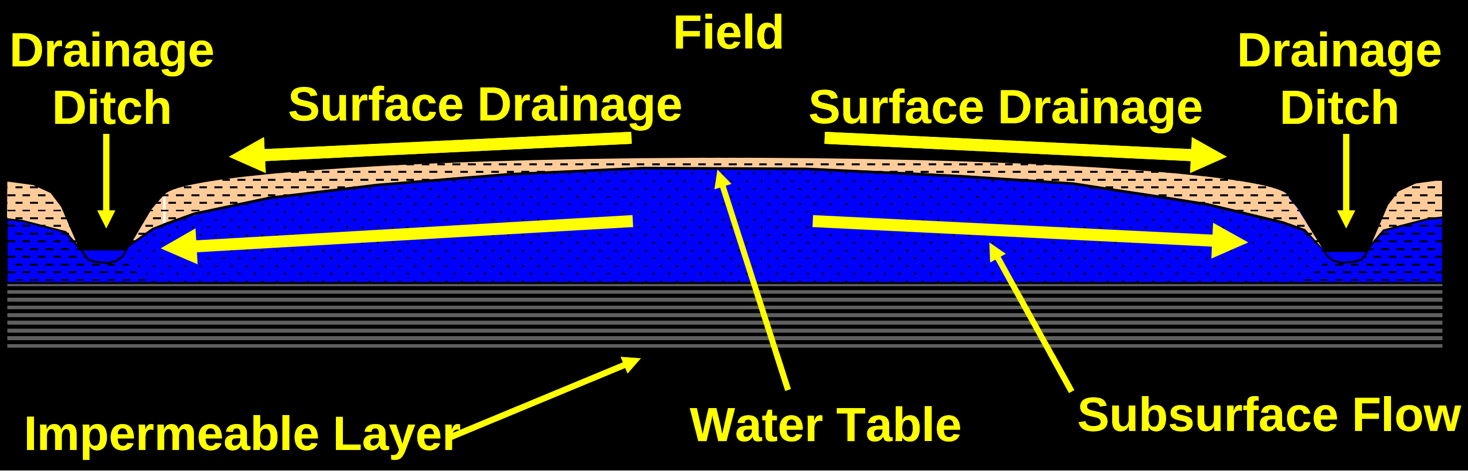
Total or combined Nitrate-N reduction:

- up to75% in mass

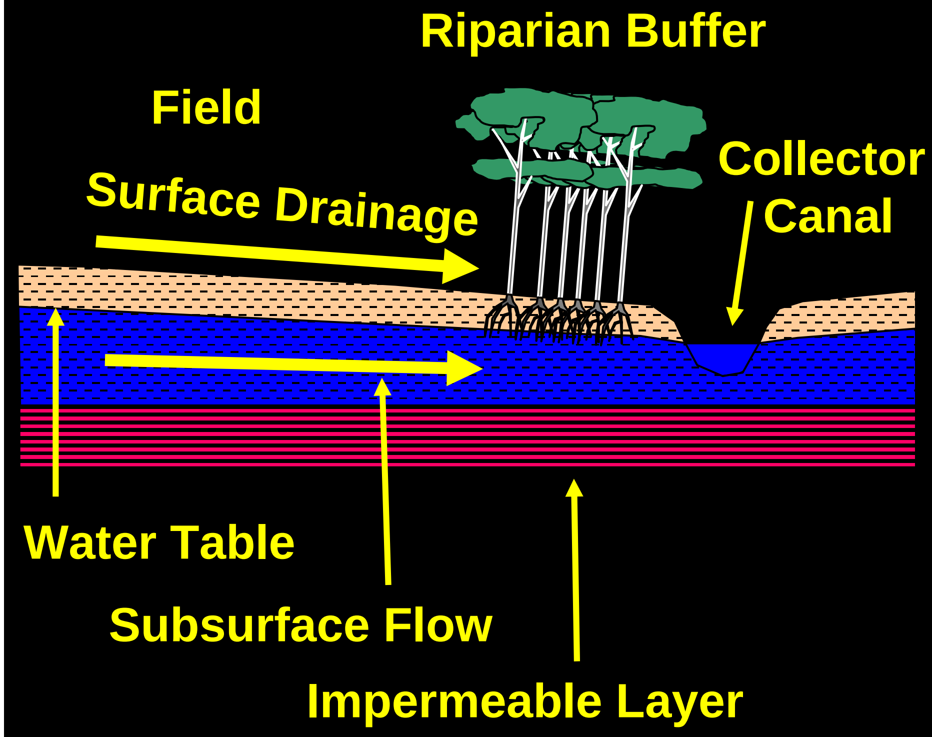


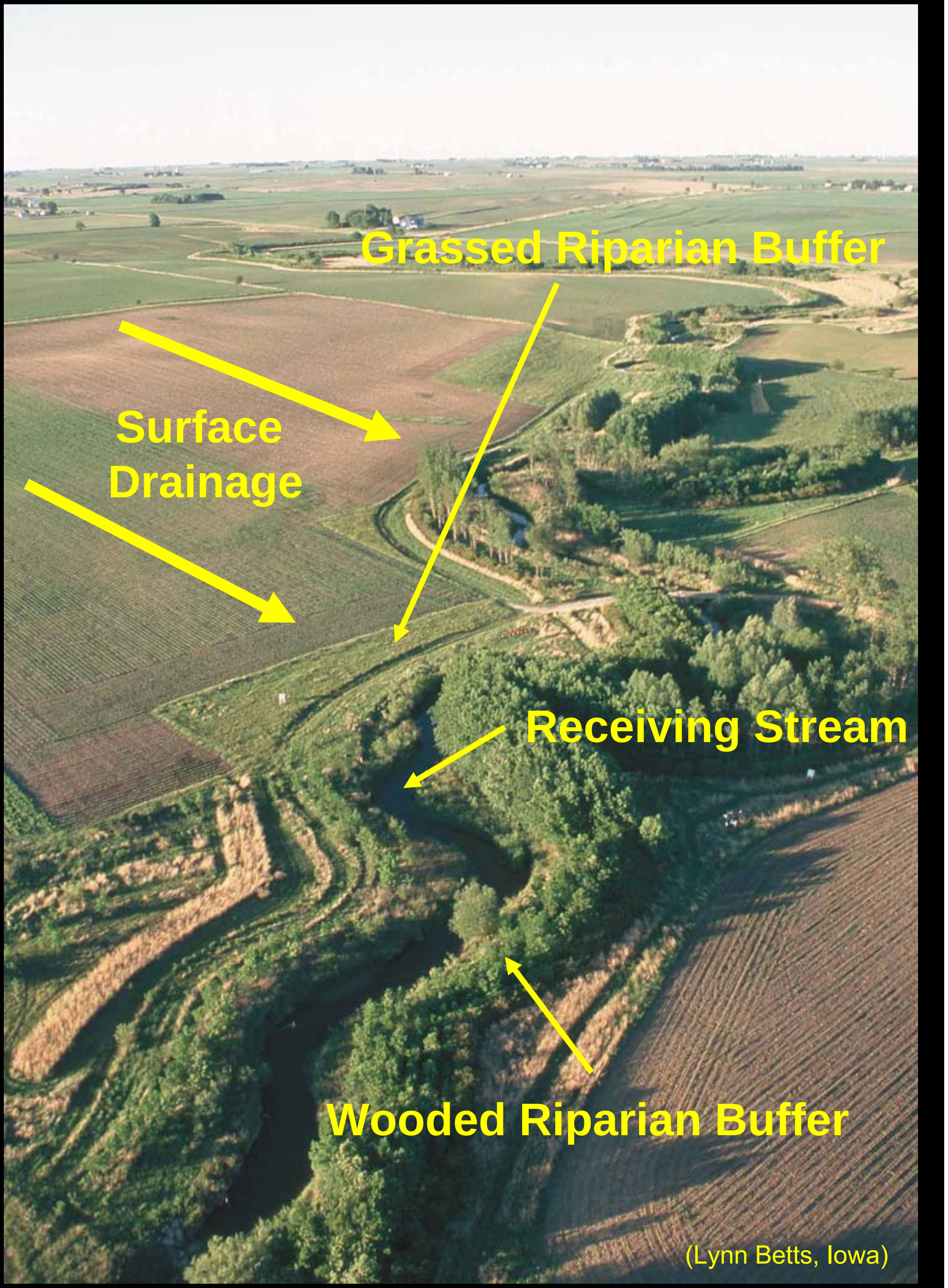
Deep Open Field Ditches Provide both Surface and Subsurface Drainage

(Lynn Betts, Iowa)



Riparian Buffers





(Lynn Betts, Iowa)

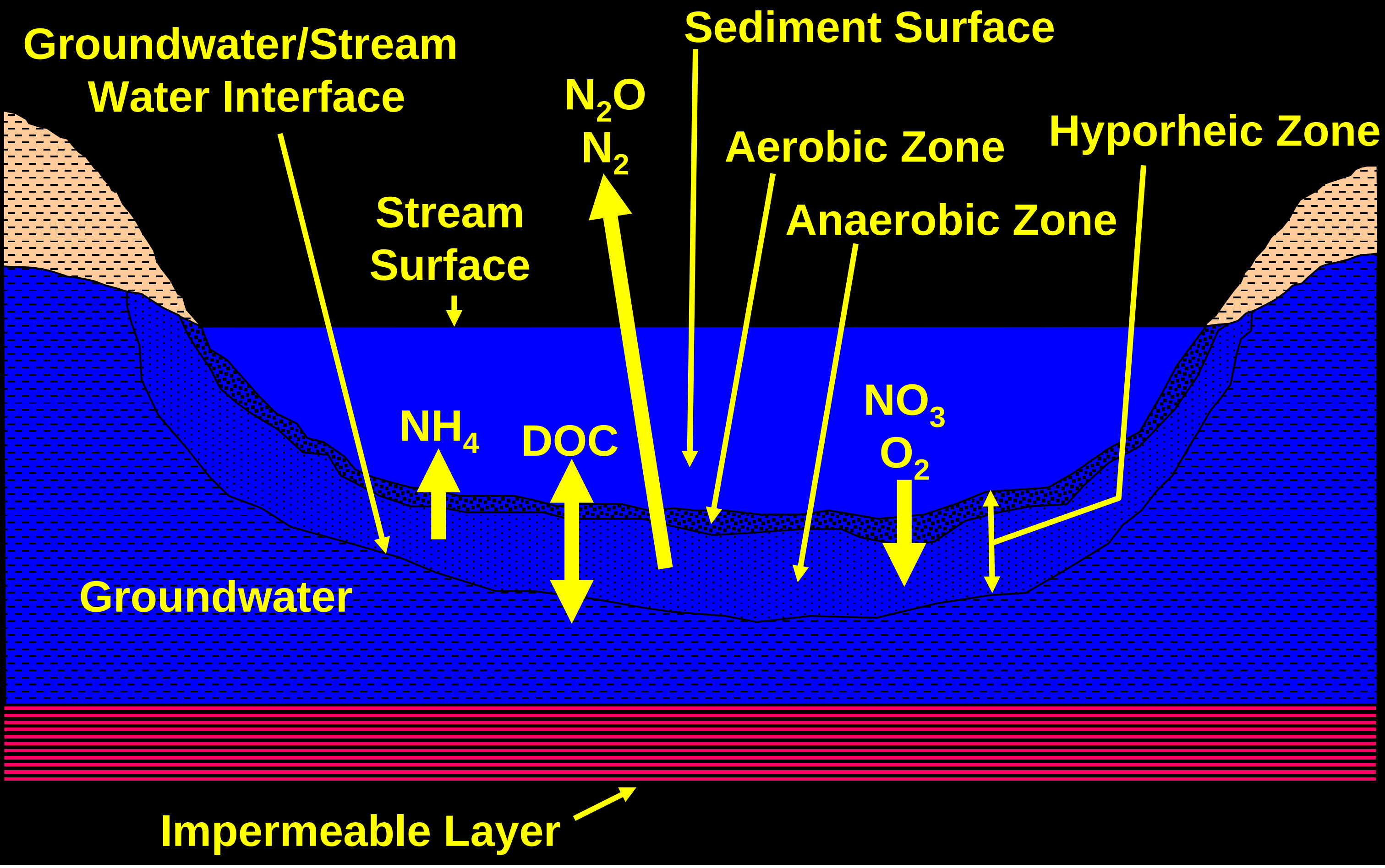
Ditch Drainage Management Needs to be Evaluated

In-Stream Denitrification

Nitrate Reductions

- 1% to 66% in mass (Birgand Lit Review, 20004)

(5% to 68% nitrate reduction in mass (Birgand Lit Review, 20004))



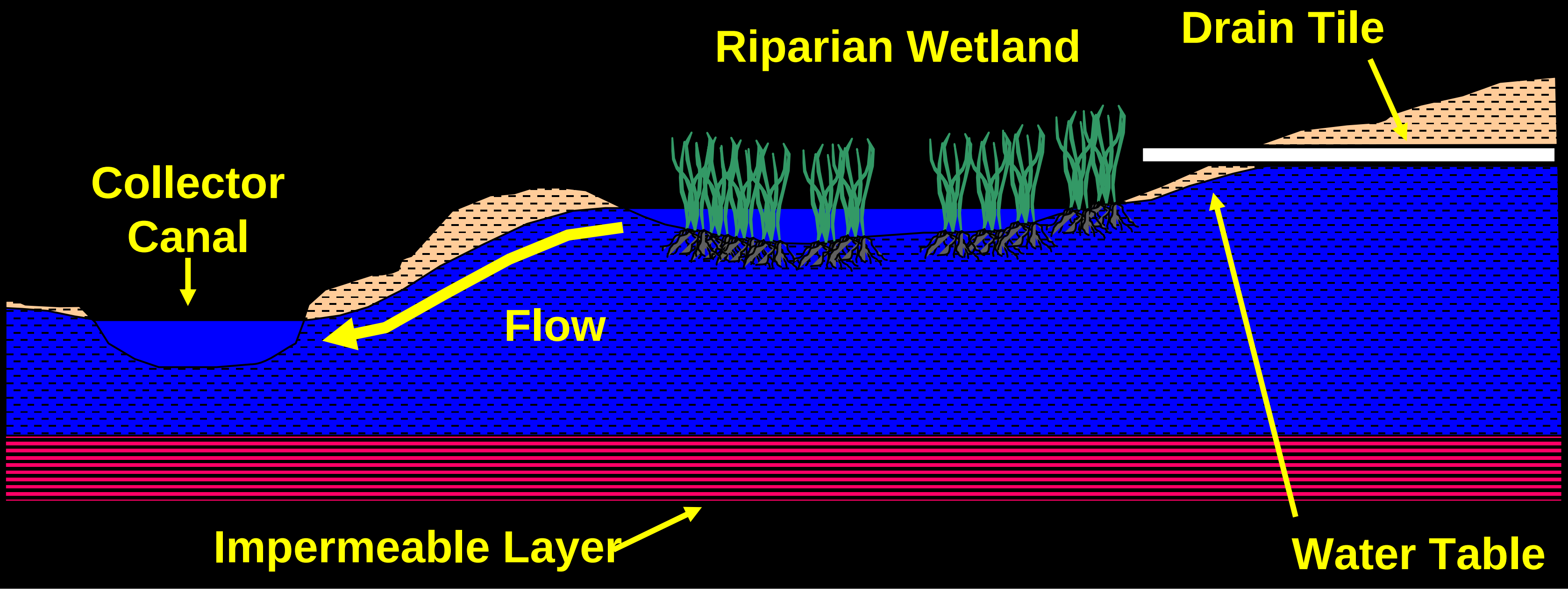
Wetlands

Total Nitrogen Reductions

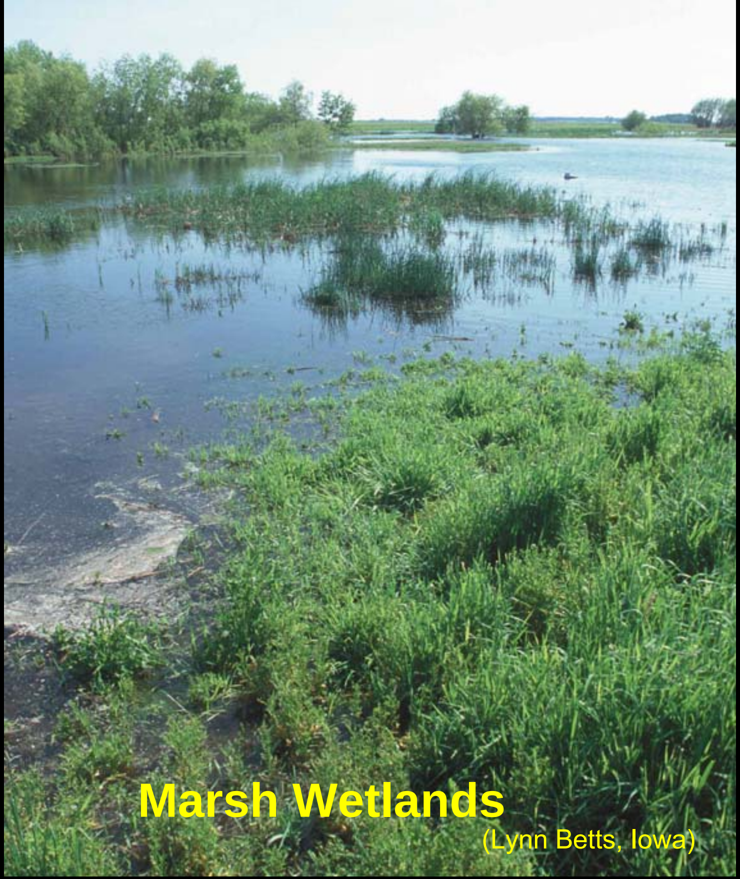
- 2% to 10% in mass due to plant uptake (Day et al., 2004; Borin et al., 2001)
- 16% in mass due to burial (Day, 2004)
- 11% to 47% in mass due to denitrification (Hunt et al., 1999; Day et al., 2004)
- 37% to 65% in mass total nitrogen removal (Hunt et al., 1999; Day et al., 2004)

(of which 70% to 81% nitrogen removed being nitrate (Hunt et al., 1999; Day et al., 2004))

- 18% additional in mass due to berm (Kovacic et al., 2000)



Diverting Stream Flow from Cropland Drainage through Wetlands to reduce Nitrate-N Load



Marsh Wetlands

(Lynn Betts, Iowa)

Woodland Wetlands

(Lynn Betts, Mississippi)

Grassland Wetlands

(Lynn Betts, California)

Don’t Forget !

Fertilizer

Nutrient Management Compliments Improved Water Management


(Lynn Betts, Iowa)


(NRCS)


(Lynn Betts, Iowa)

Summary

Controlled Drainage - 50% nitrate reduction in mass (Gilliam et al., 1979; Evans et al., 1989b; Skaggs and Cheschier, 1999; Fausey, 2004)

Wetlands - 26% to 53% nitrate reduction in mass (Hunt et al., 1999; Day et al., 2004)

(Additional 18% in mass reduction if berm used (Kovacic et al., 2000))

Bioreactors - 65% nitrate reduction in mass (Jaynes et al., 2004)

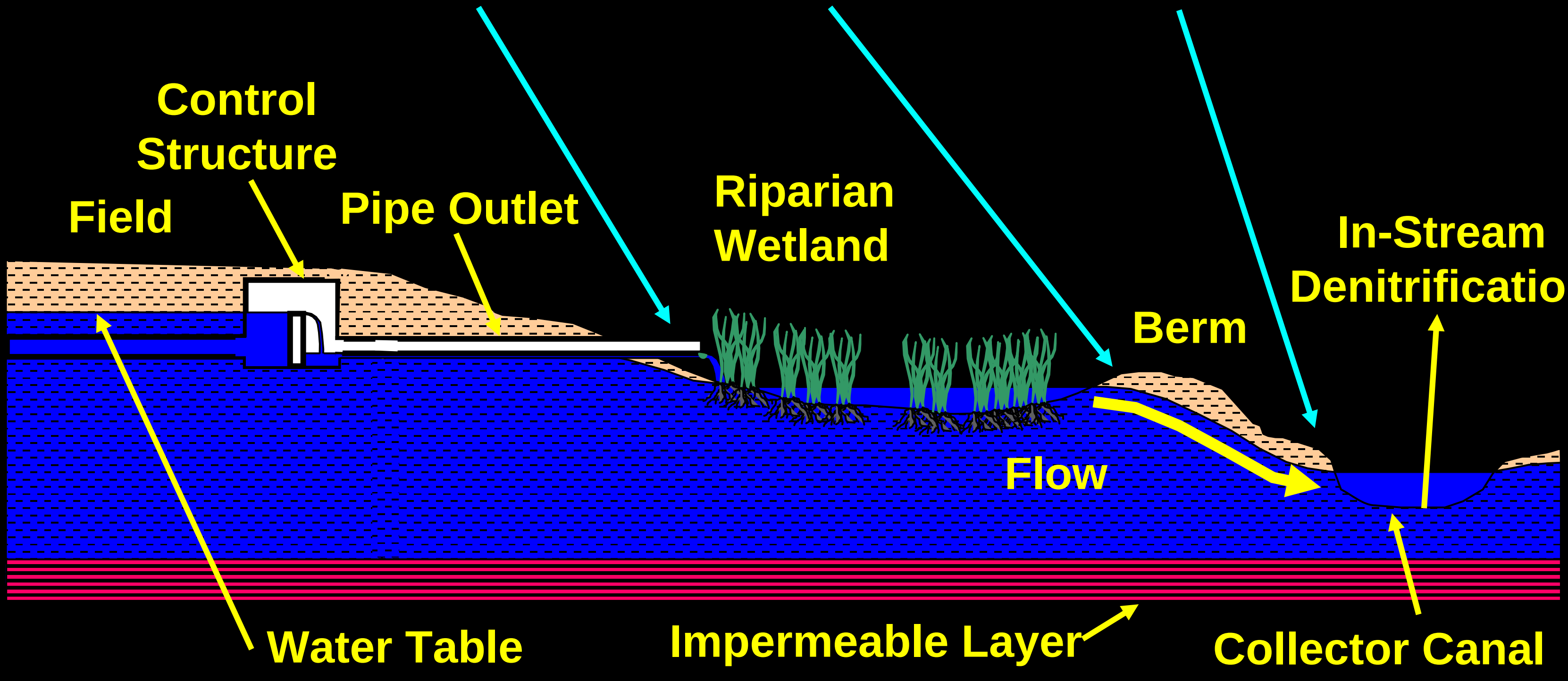
In-Stream Denitrification – 5% to 68% nitrate reduction in mass

(Birgand Lit Review, 20004)

But by combining practices

Example

5 acres				
½ inch/day	50% flow red.	40% mass red.	18% mass red.	5% mass red.
266 m³/day	133 m³/day	133 m³/day	133 m³/day	133 m³/day
10 mg/L	10 mg/L	6 mg/L	4.9 mg/L	4.7 mg/L
2.66 kg/day	1.33 kg/day	0.79 kg/day	0.65 kg/day	0.63 kg/day



Overall ⇨ 76% reduction in mass
53% reduction in concentration