UNIVERSITY OF MINNESOTA

Conservation Strategies to Improve Water Quality in Artificially Drained Lands

2010 BWSR Academy

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Bioproducts & Biosystems Engineering

UNIVERSITY OF MINNESOTA

Minnesota Board of Water & Soil Resources

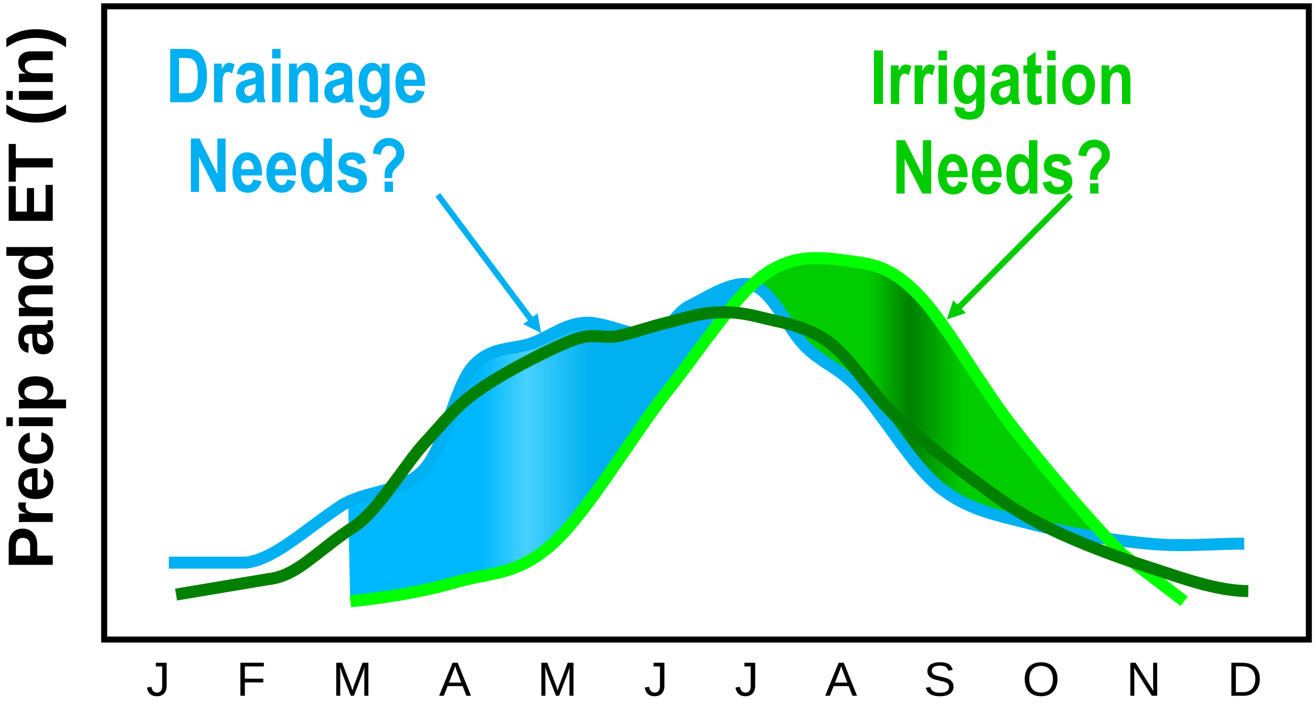
For Today:

- Background – Lite
- Issues and concerns
- Mitigation, practices & technologies, research and education programs

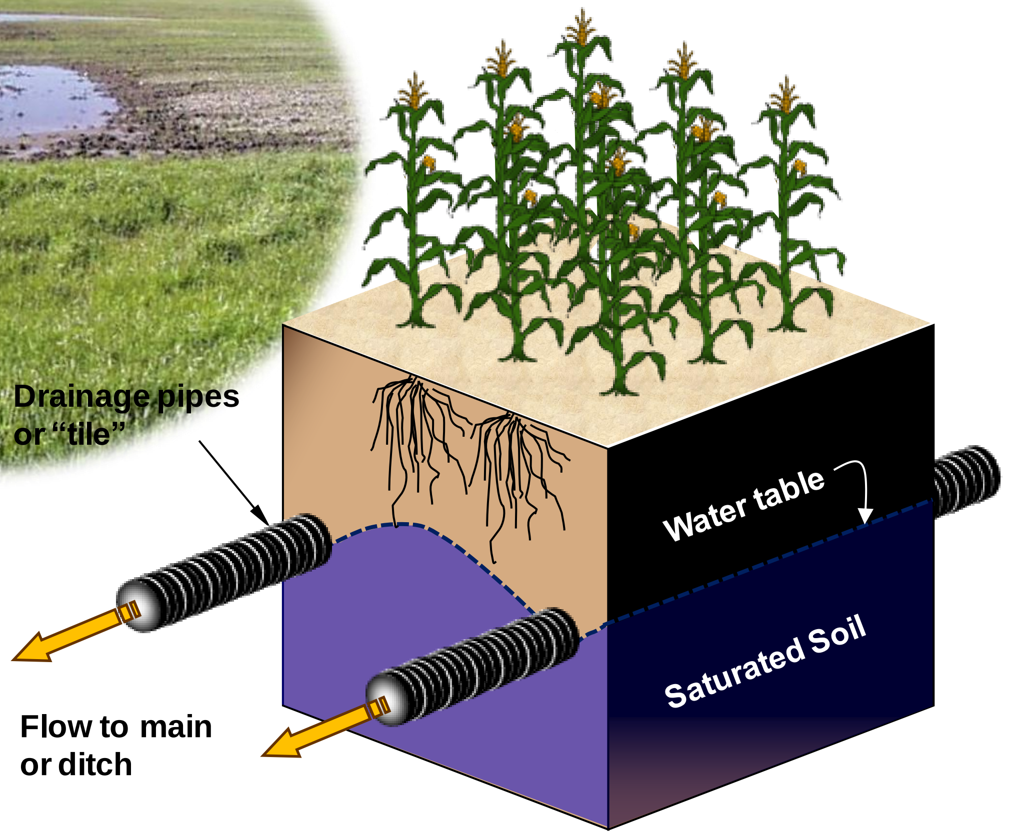
Background – Lite

Water Management in Agriculture

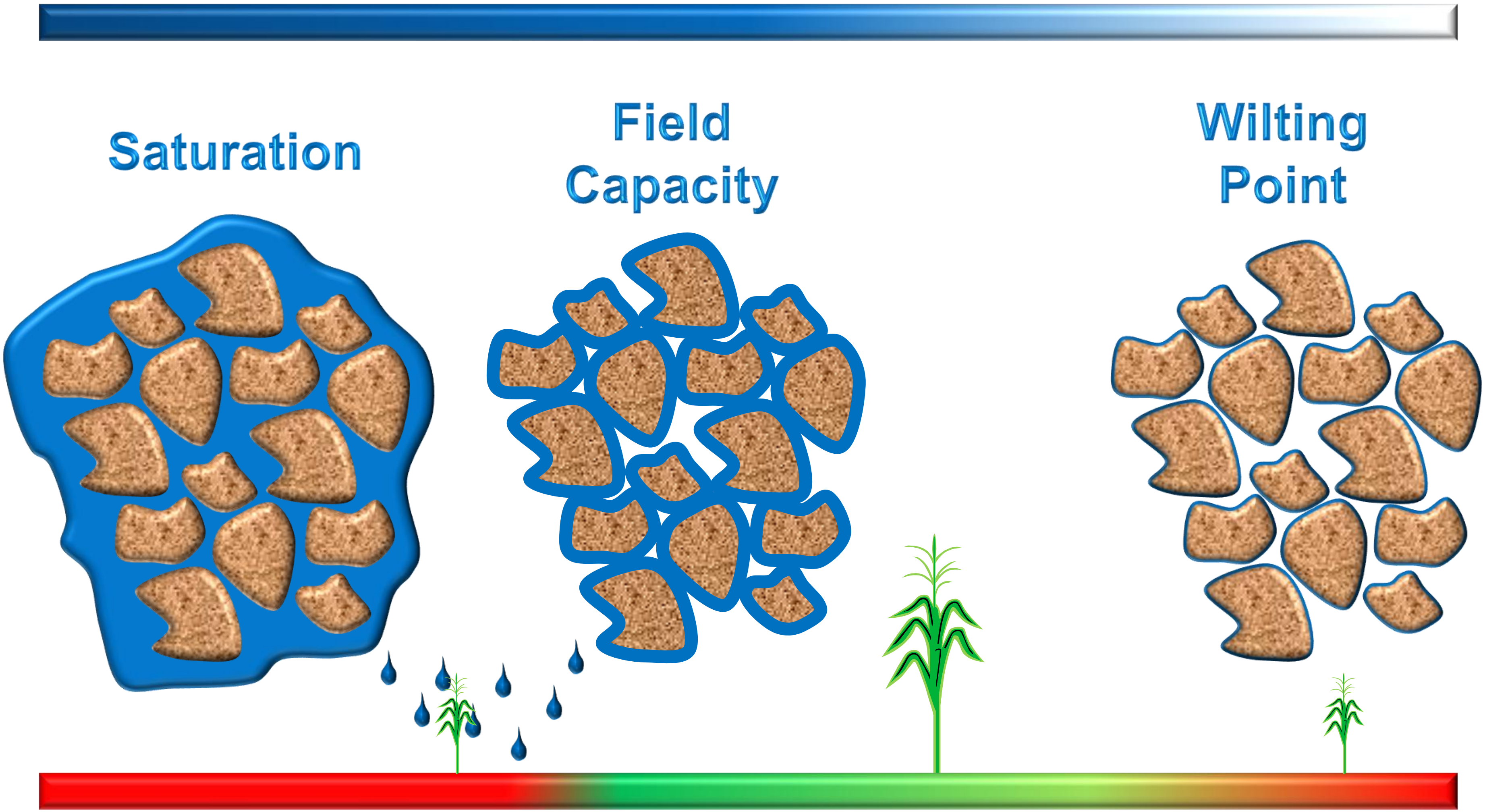
Challenges & Opportunities



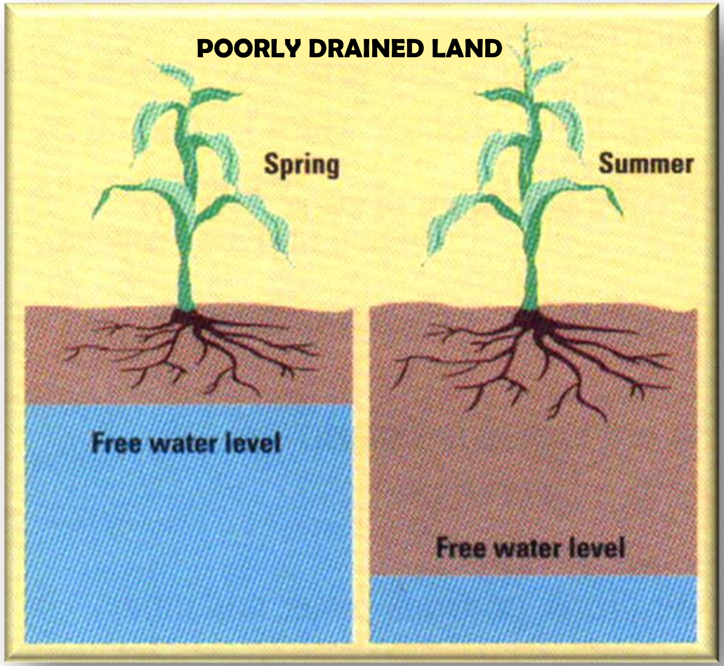
Artificial Drainage

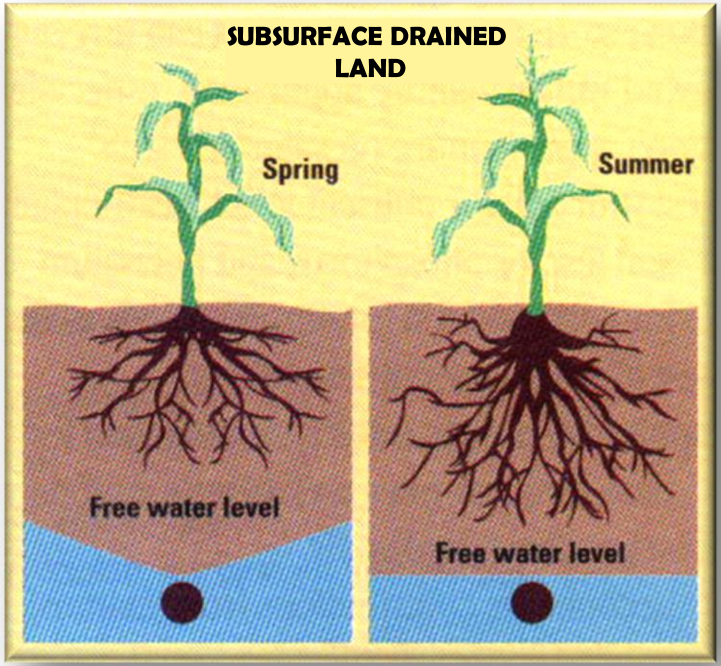


Soil Water and Drainage

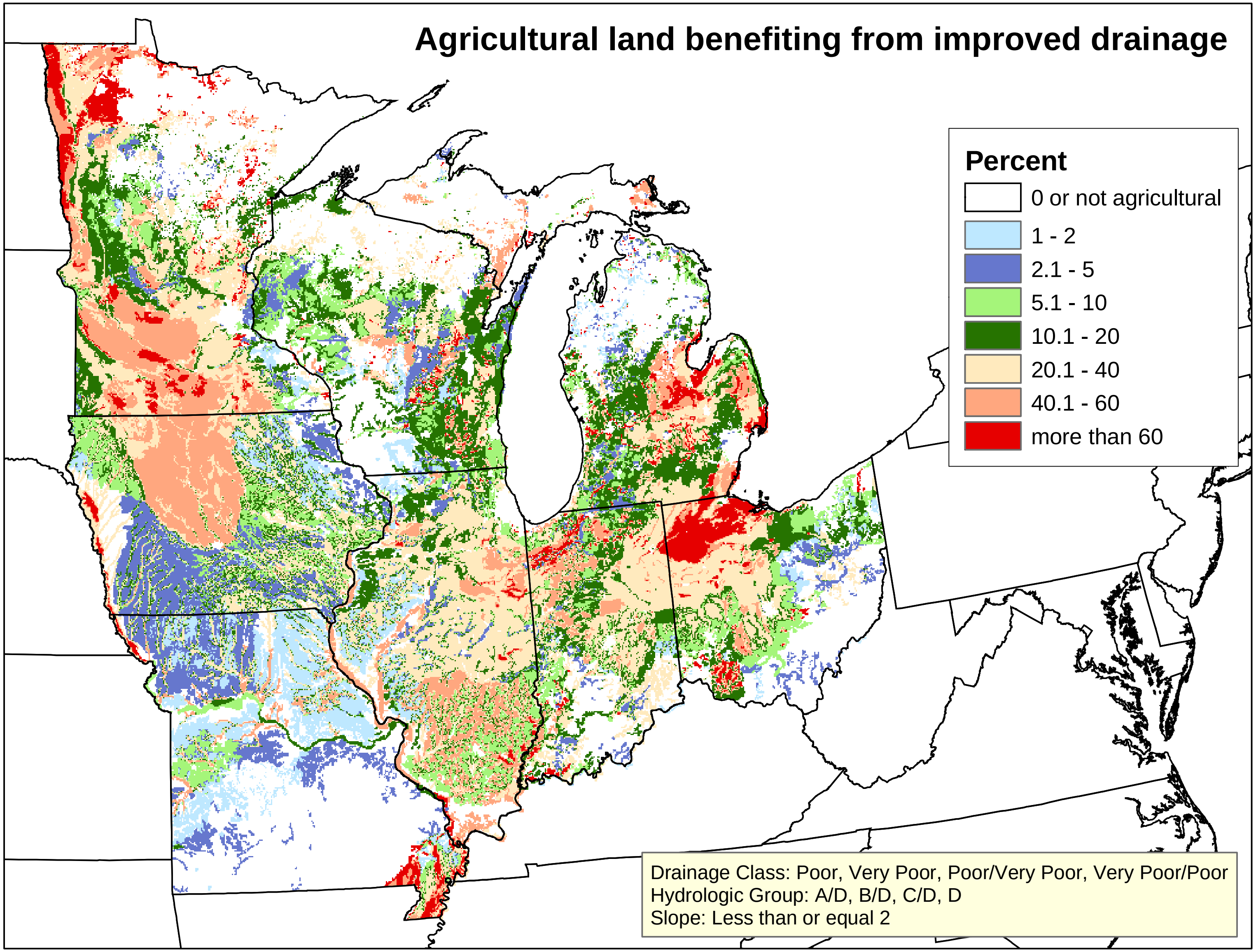


Farmers say, "drainage biggest bang for the buck"



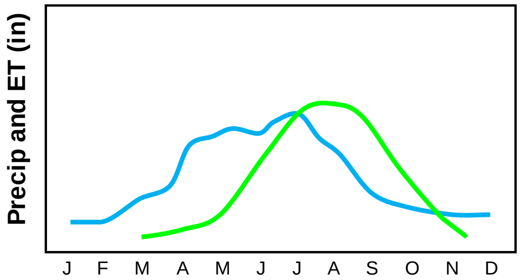


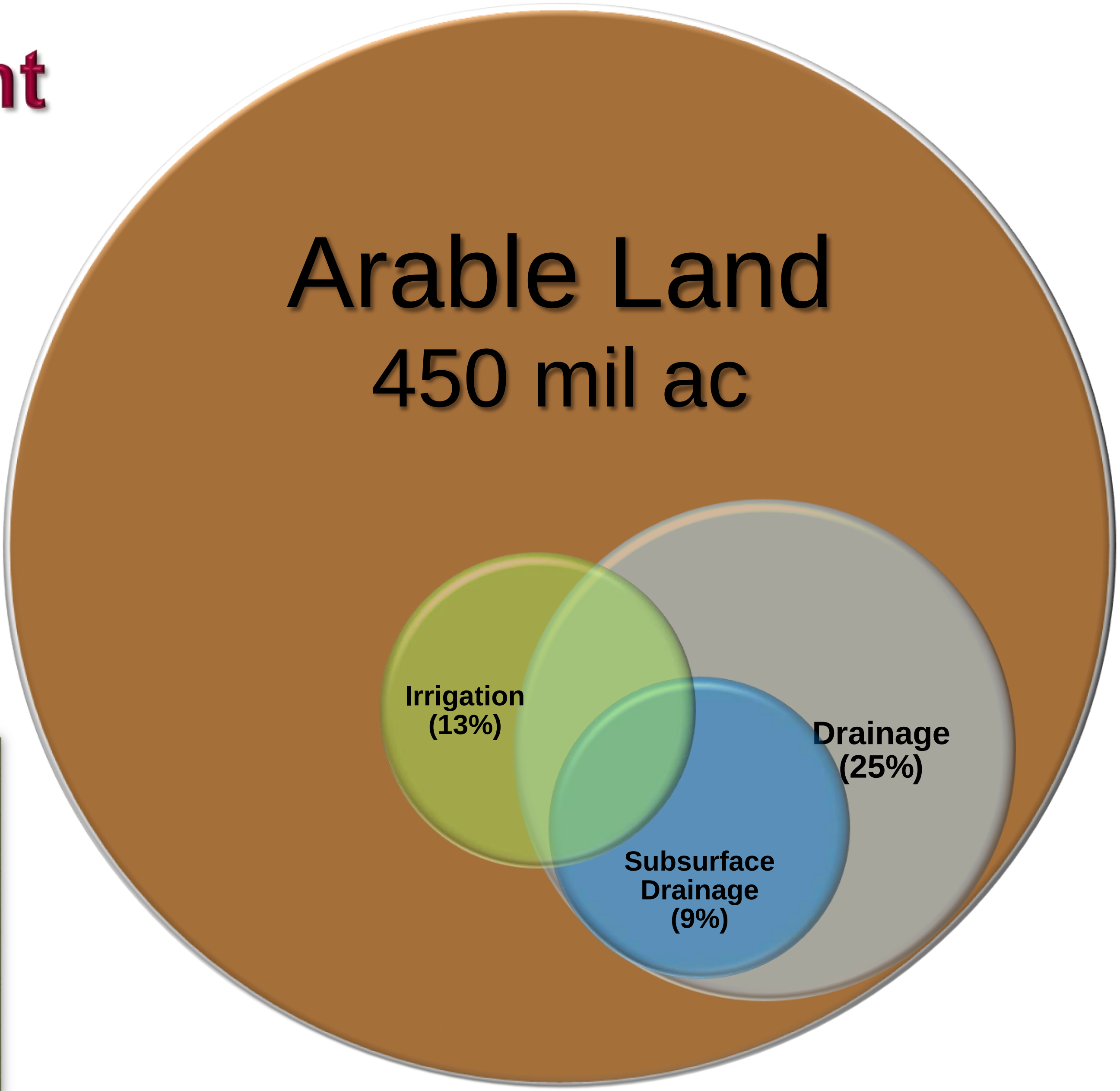
Poorly Drained Soils in the Upper Midwest



Courtesy of Dan Jaynes, ARS – Ames, IA

U.S. Water Management

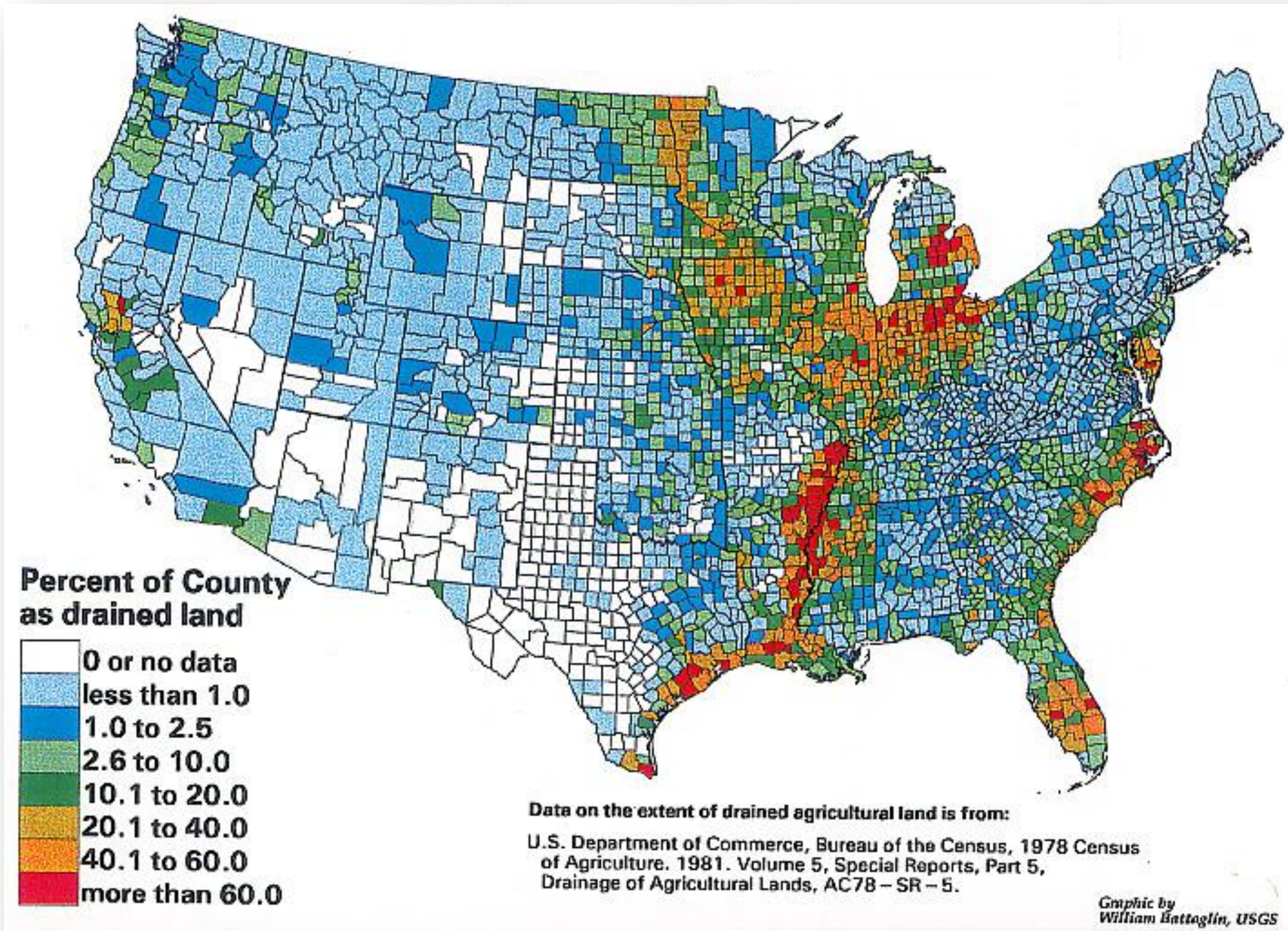




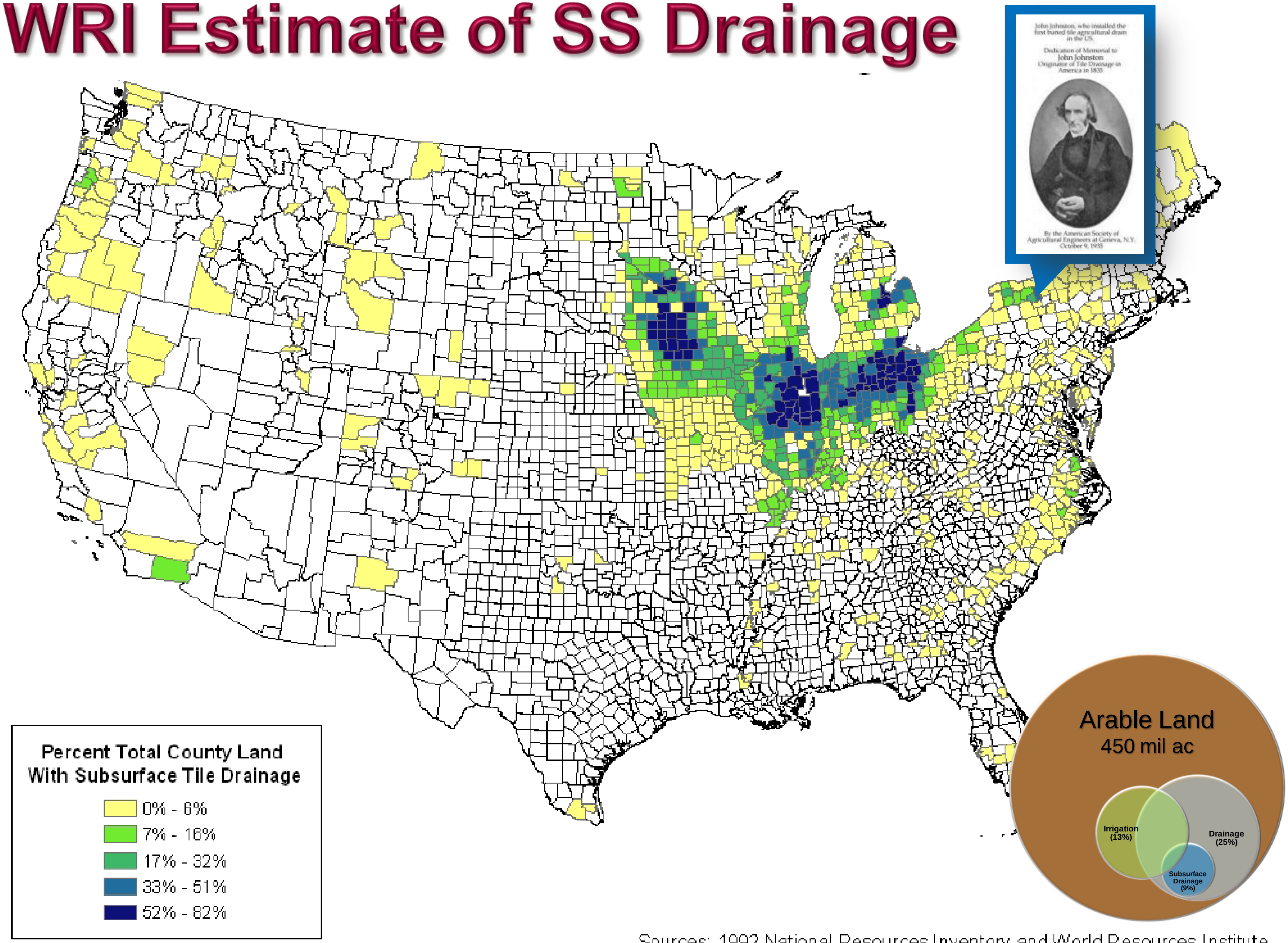
World (30% land)

- 11% arable
- 18% irrigated
- % drained ??

25% of Ag Soils Artificially Drained



WRI Estimate of SS Drainage



Sources: 1992 National Resources Inventory and World Resources Institute

John Johnston

“The Father of Tile Drainage in the U.S.”

John Johnston was born in Knockknolling, Dalrys, Dumfrieshire, Scotland, on April 11, 1791. He immigrated to the United States, landing at New York City in April of 1821. The following year he purchased 112 acres of farmland in Seneca County and built a house there, which he called "Viewfields." Later he added several more parcels to the farm, bringing the total size to 320 acres

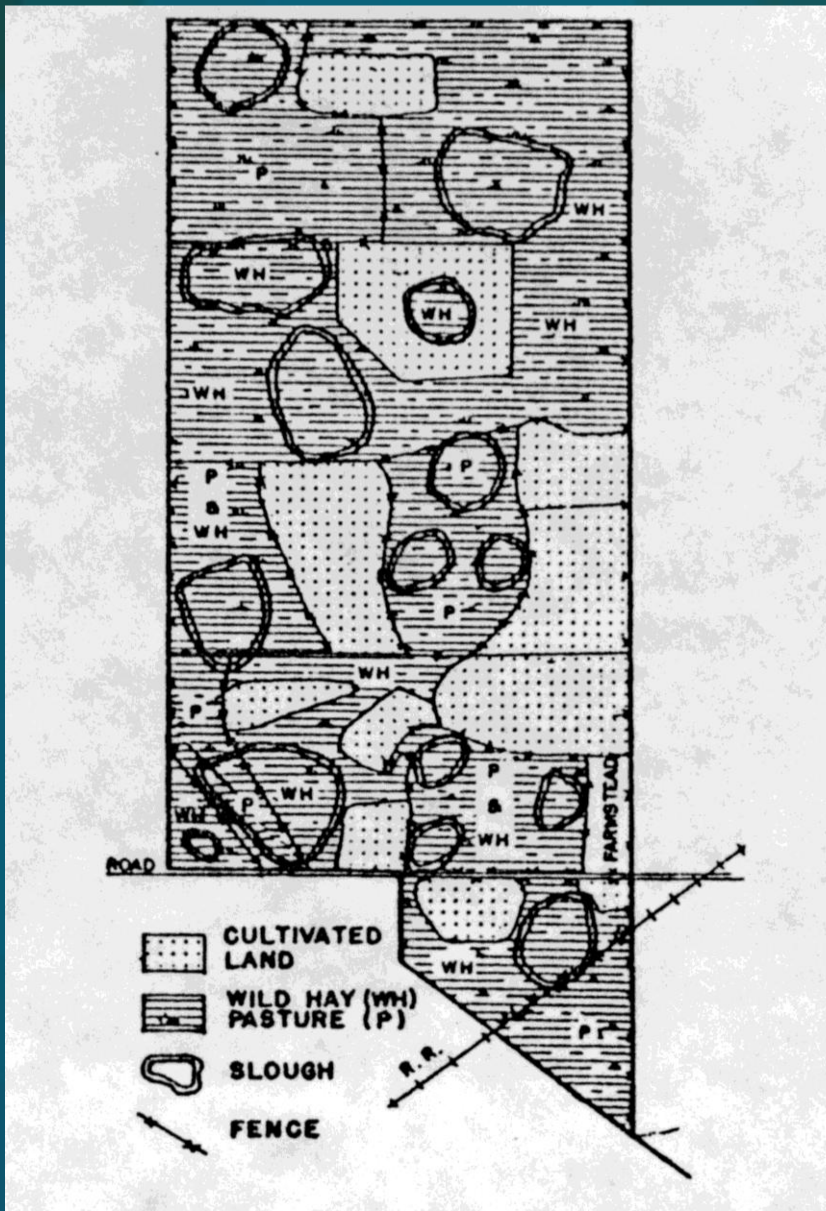
Due to abundant undergroun
imperceptible on the surface, the e
drainage in Scotland, Johnston kn
two pattern tiles in 1835, which he
made 3,000 tiles that Johnston laic
from farming he had 72 miles of til
1849, and Waterloo was home to t

A prolific writer for newspape
Johnston promoted tile drainage a
traveling to advise other farmers o
Because of his ceaseless advocac
“The Father of Tile Drainage” in the
Johnston’s son-in-law Robert Swa
technology for Rose Hill farm, help
farm in the state in 1858. Johnston
in his ninetieth year, having chang
agriculture in the United States.

Source: *www.genevahistoricalsoc*

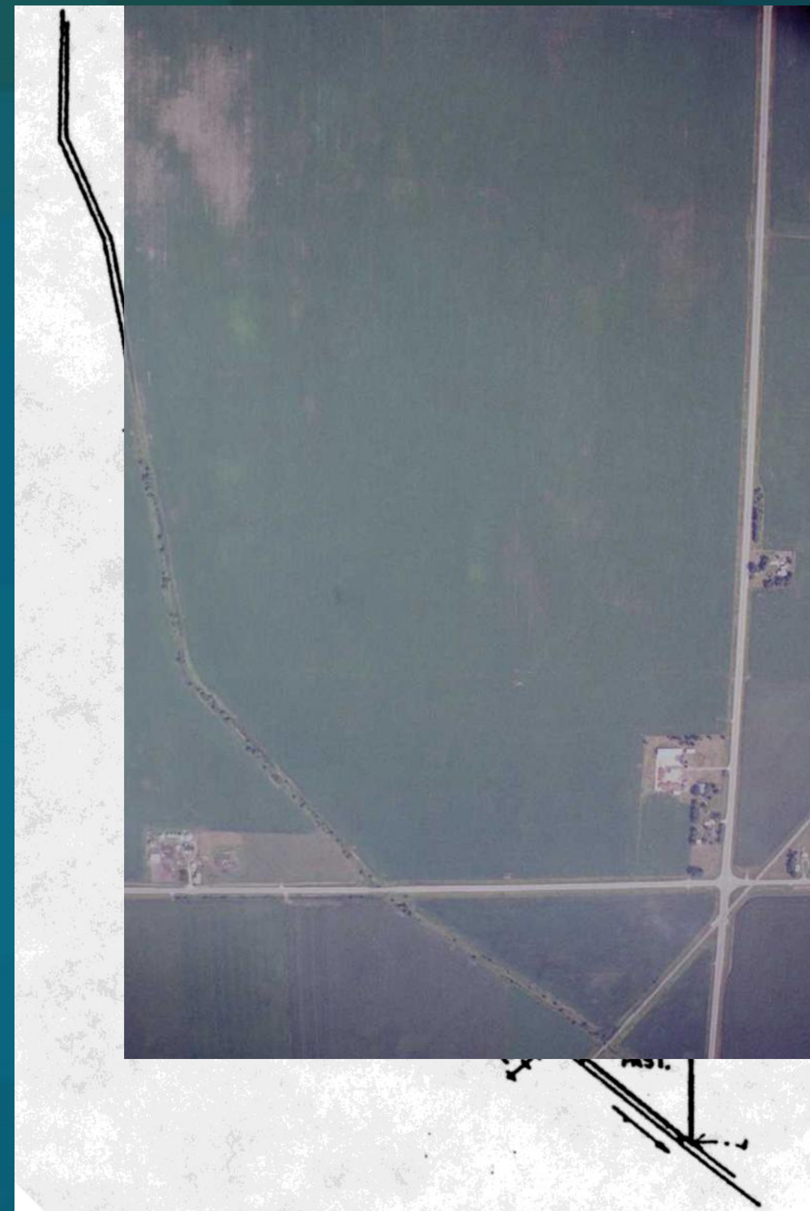

J. JOHNSTON.

Pre-drainage, 1900



Post-drainage, 1947

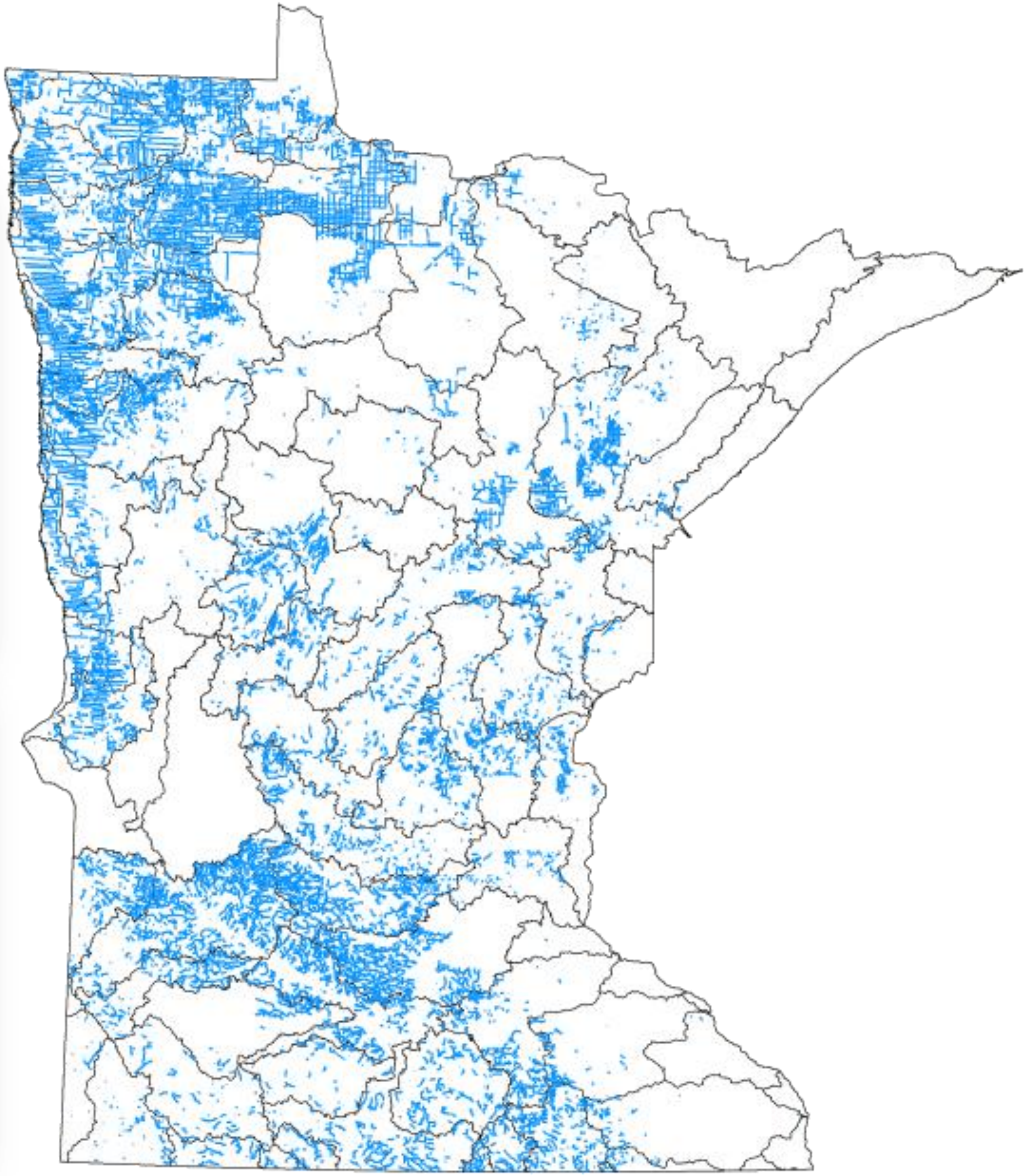
Frandson farm today



Frandson Farm, IA; Images Courtesy of Dan Jaynes, USDA-ARS

Drainage in Minnesota

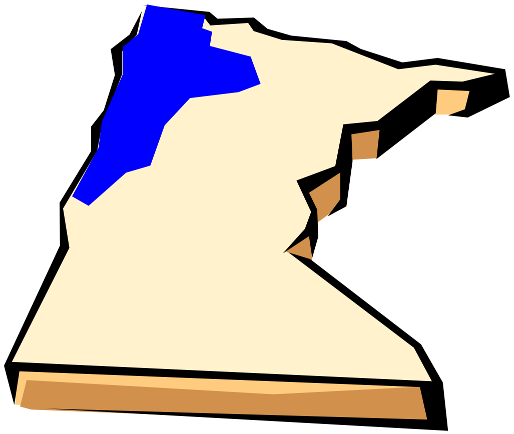
- > 21,000 mi of surface drainage works

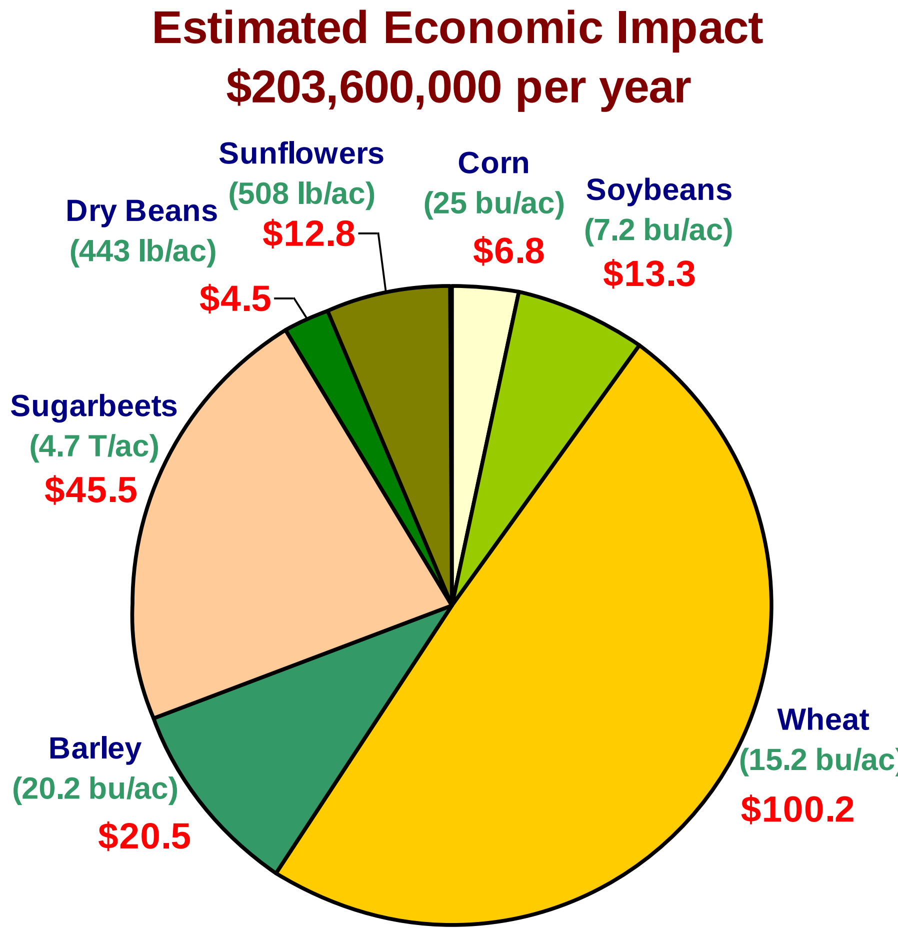


Drainage – Why Important?

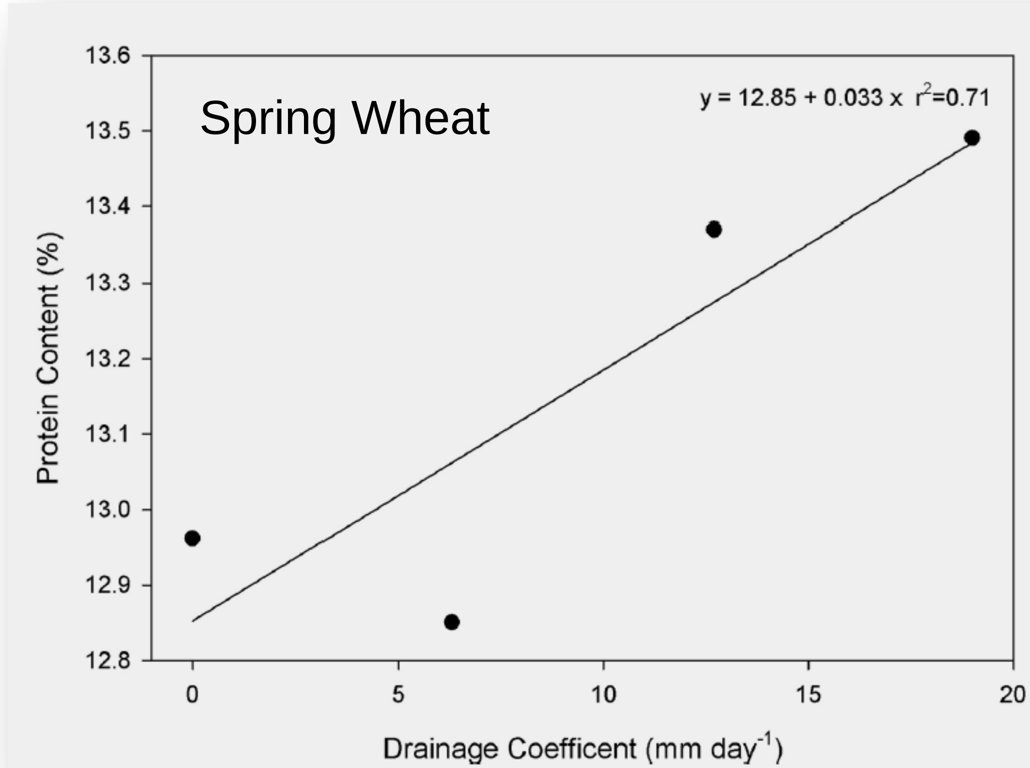
- Infrastructure
- Health
- Ag Production

Excess Water in the 1990's





Drainage & Production



Responses of Spring Wheat and Soybean to Subsurface Drainage in Northwest Minnesota

J. J. Wiersma,* G. R. Sands, H. J. Kandel, A. K. Rendahl, C. X. Jin, and B. J. Hansen

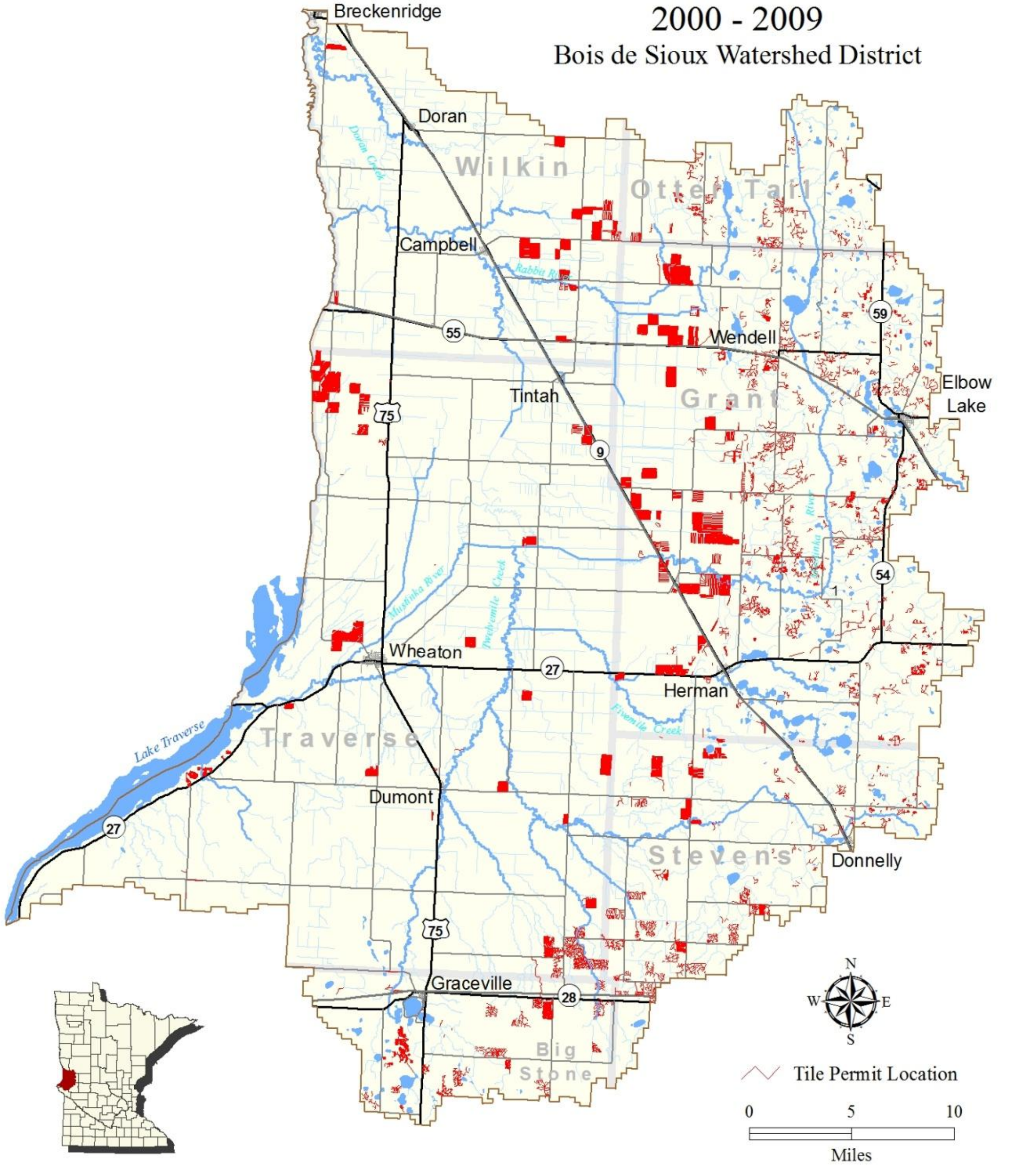
Agronomy Journal • Volume 102, Issue 5 • 2010 1399

Drainage Continues

TILE PERMIT LOCATIONS

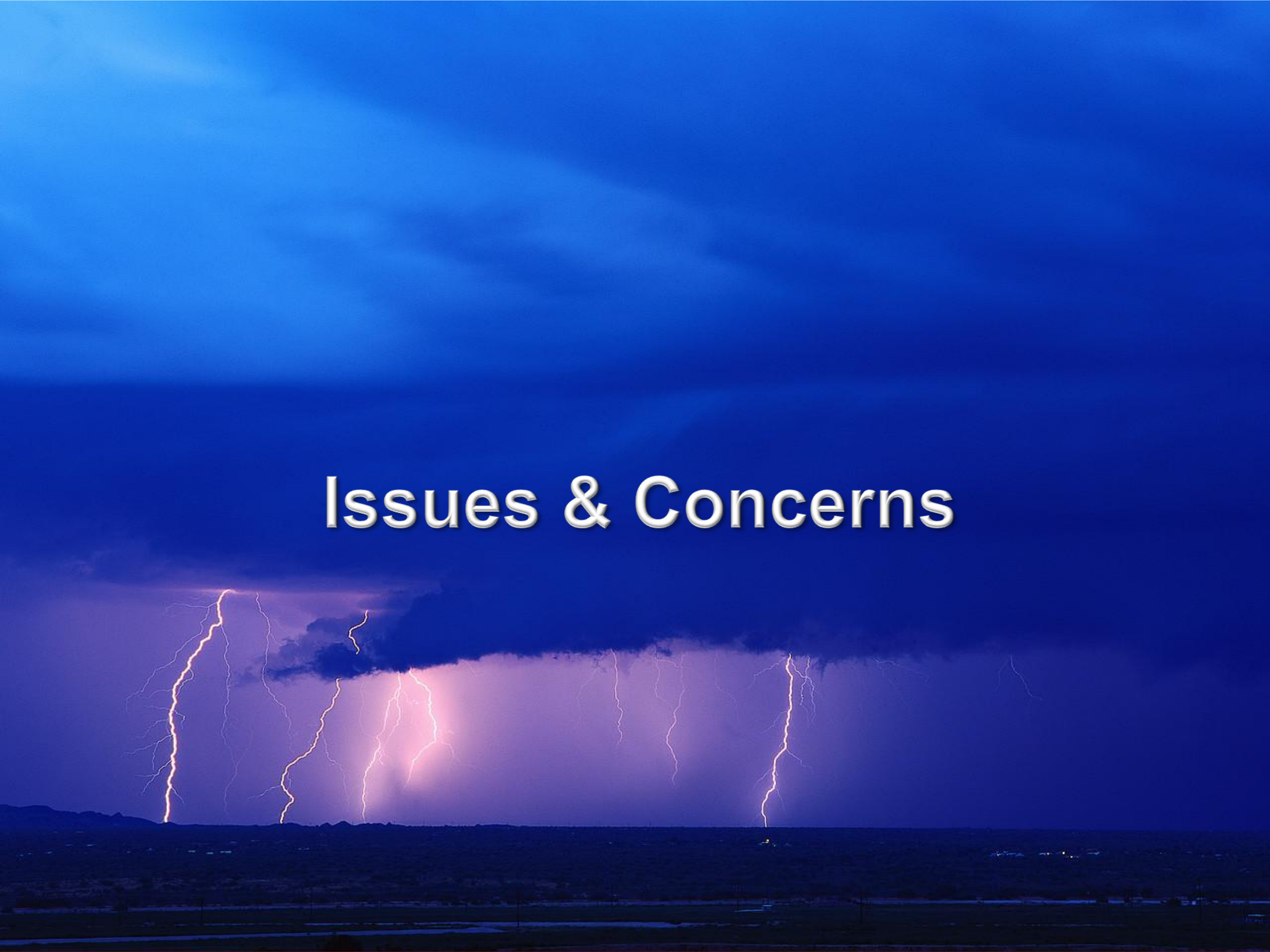
2000 - 2009

Bois de Sioux Watershed District

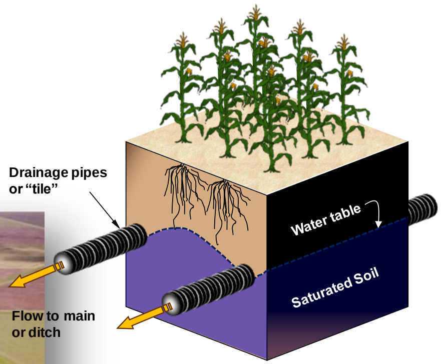


Source: JOR Engineering, Inc.

3/24/10



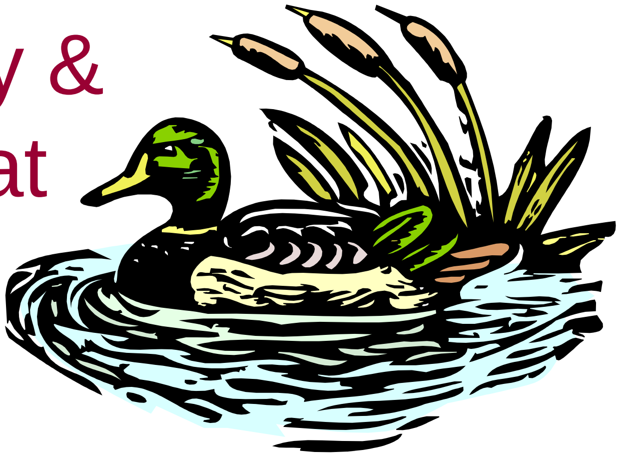
Issues & Concerns



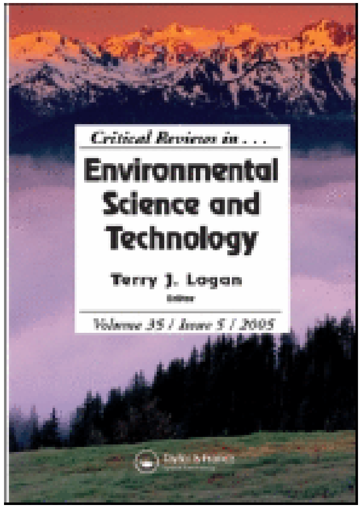
Water Quality

Hydrology

Ecology & Habitat



Unintended Effects



Critical Reviews in Environmental Science and Technology
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713606375

Effects of Agricultural Drainage on Aquatic Ecosystems: A Review

Kristen L. Blann [a]; James L. Anderson [b]; Gary R. Sands [c]; Bruce Vondracek [d]
[a] The Nature Conservancy, USA [b] Department of Soil, Water, and Climate, University of Minnesota, St. Paul, Minnesota, USA [c] Department of Bioproducts and Biosystems Engineering, University of Minnesota, St. Paul, Minnesota, USA [d] U.S. Geological Survey, Minnesota Cooperative Fish and Wildlife Research Unit, University of Minnesota, St. Paul, Minnesota, USA

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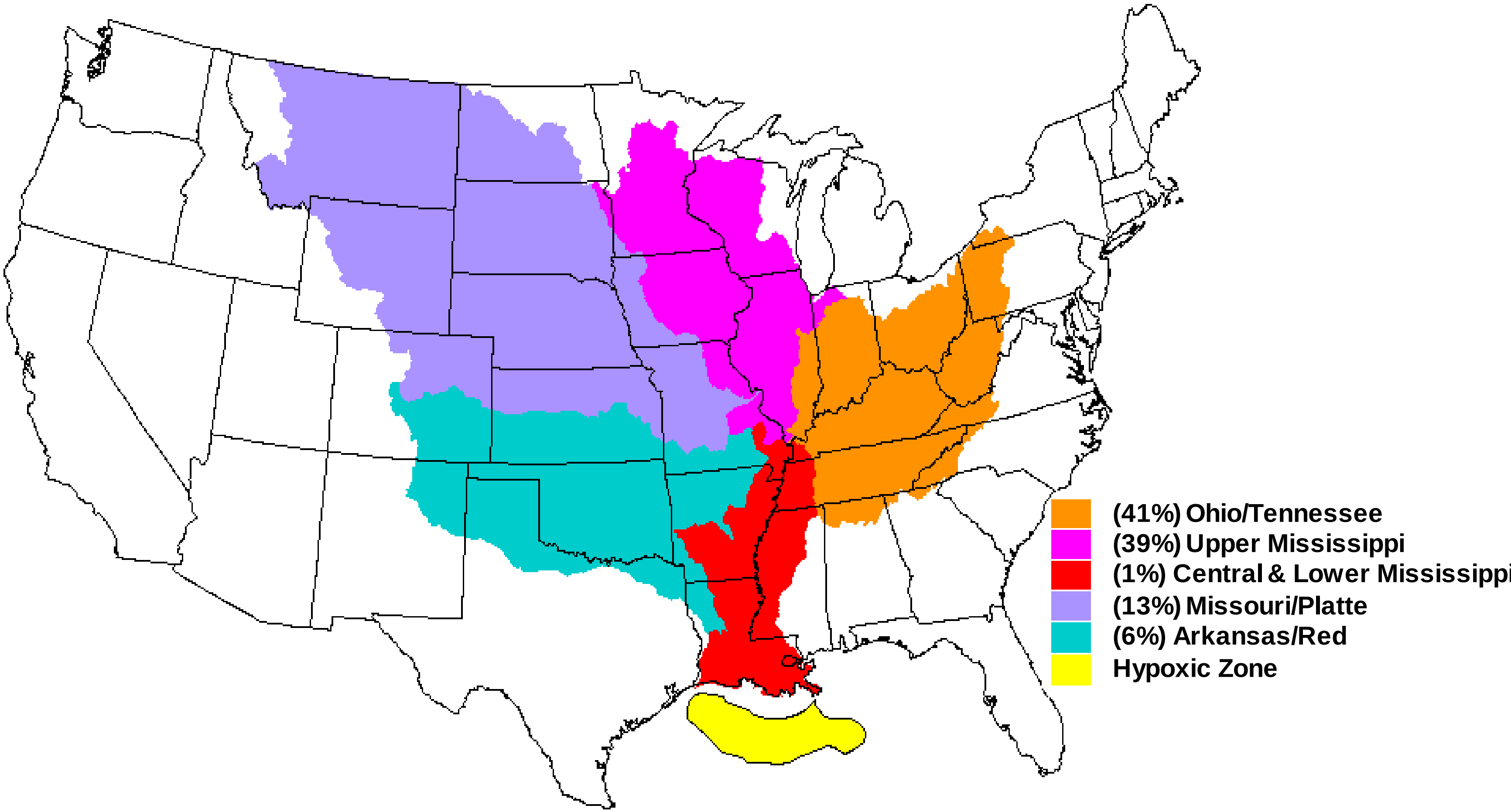
URL: http://dx.doi.org/10.1080/10643380801977966

Blann, K.L., J.L. Anderson, G.R. Sands, and B. Vondracek.

Effects of Agricultural Drainage on Aquatic Ecosystems: A Review, *Critical Reviews in Environmental Science and Technology, 39(11) 909-1001. 2009.*

Unintended Effects:

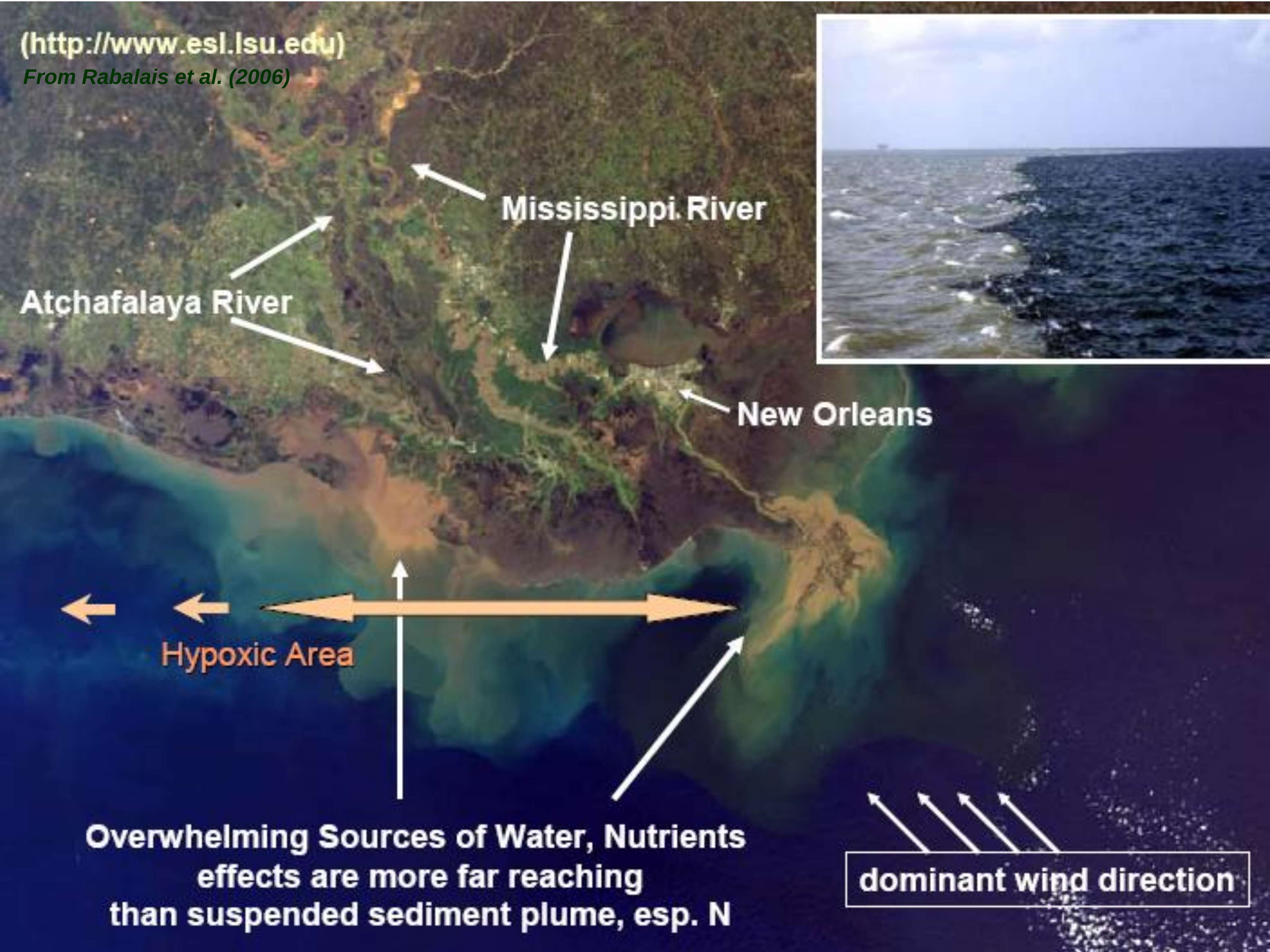
2001-2007 Nitrogen Loads by Drainage Basin



Source: USGS Open-File Report 2007-1080

Unintended Effects

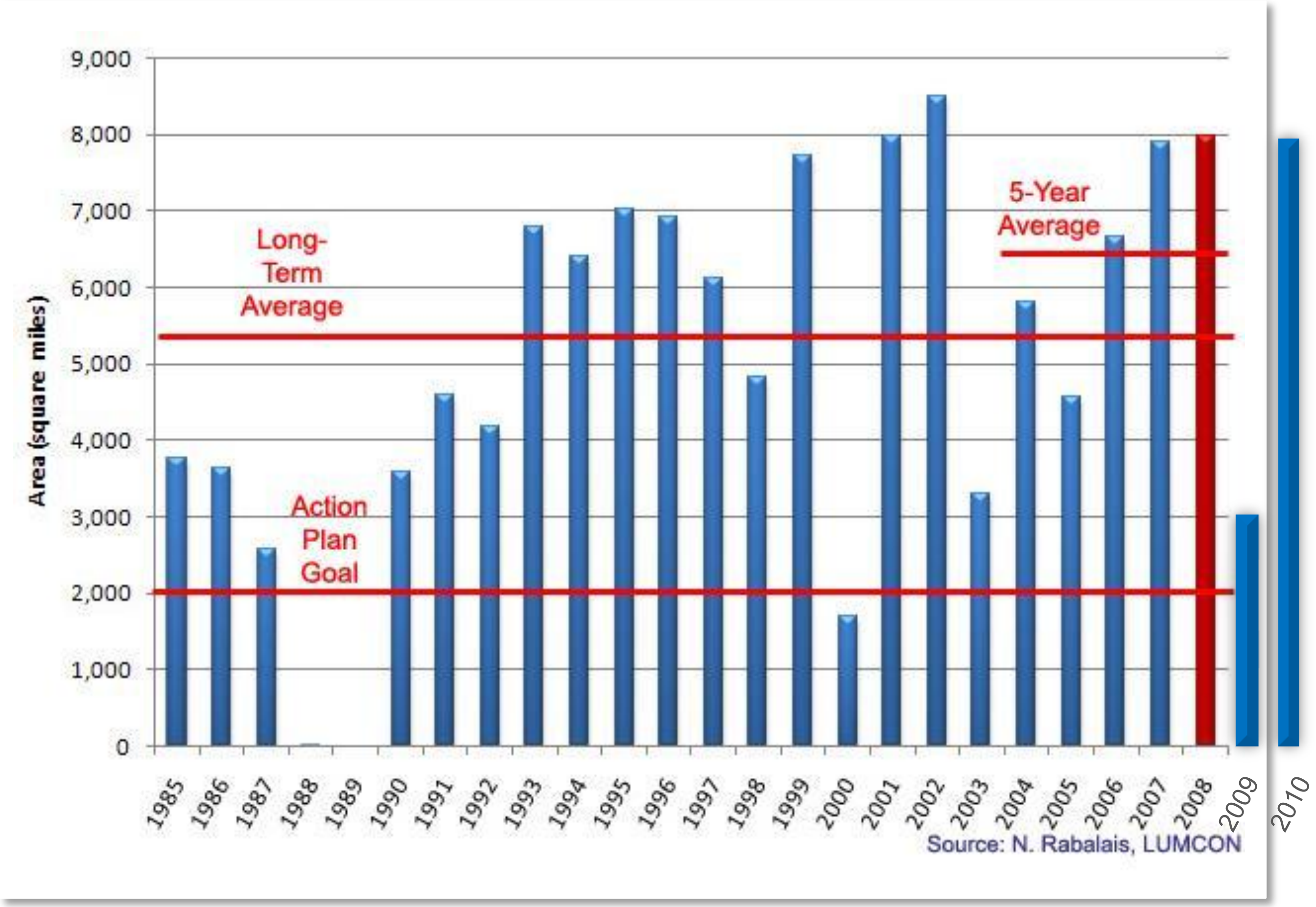
http://www.tpt.org/


(http://www.esl.lsu.edu)
From Rabalais et al. (2006)
Mississippi River
Atchafalaya River
New Orleans
Hypoxic Area
Overwhelming Sources of Water, Nutrients
effects are more far reaching
than suspended sediment plume, esp. N
dominant wind direction

Gulf Hypoxia

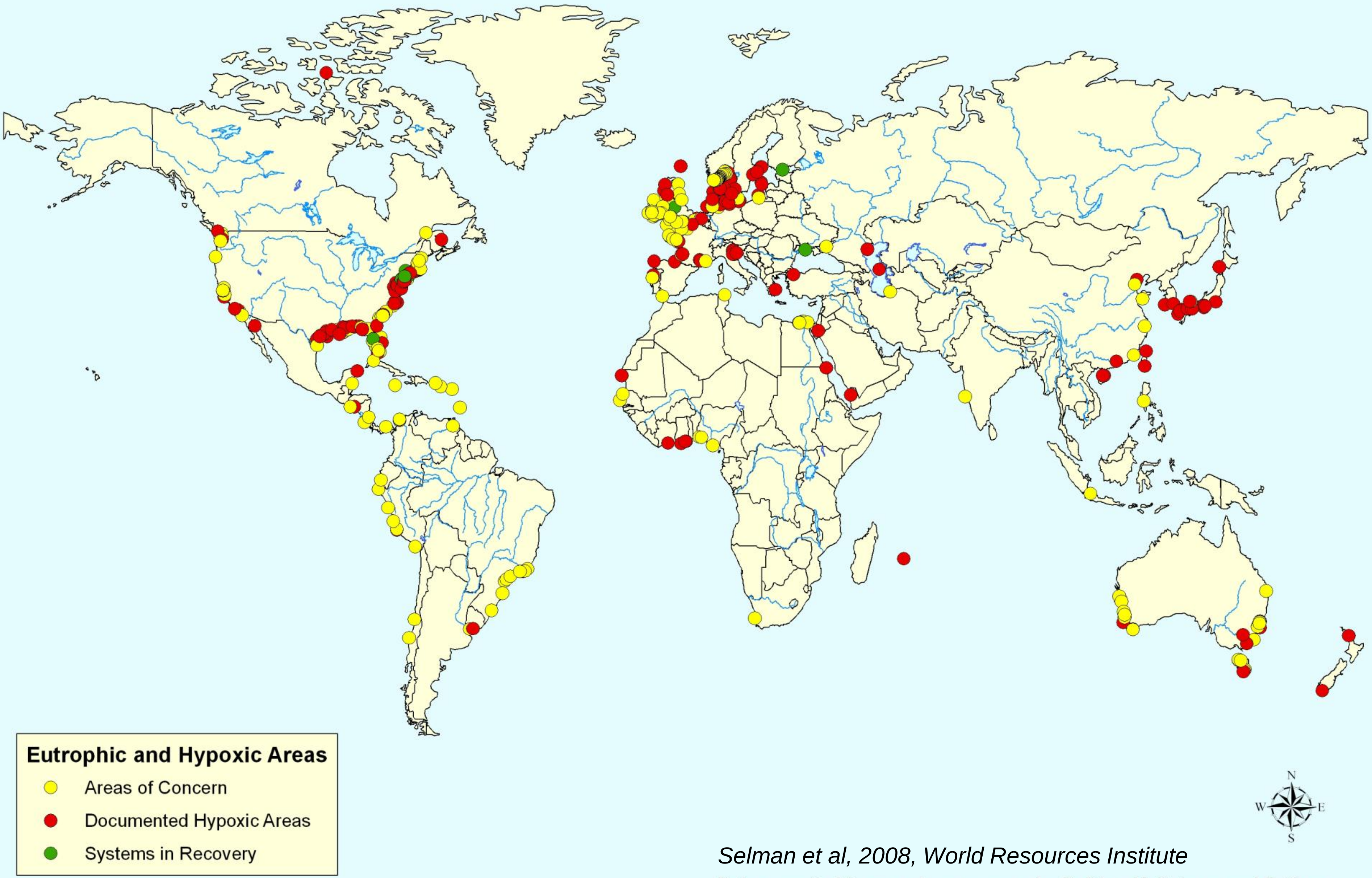
Area of Mid-Summer Hypoxia

(Dissolved Oxygen < 2 mg/L)



World Hypoxic and Eutrophic Coastal Areas

Over 400 Zones Worldwide

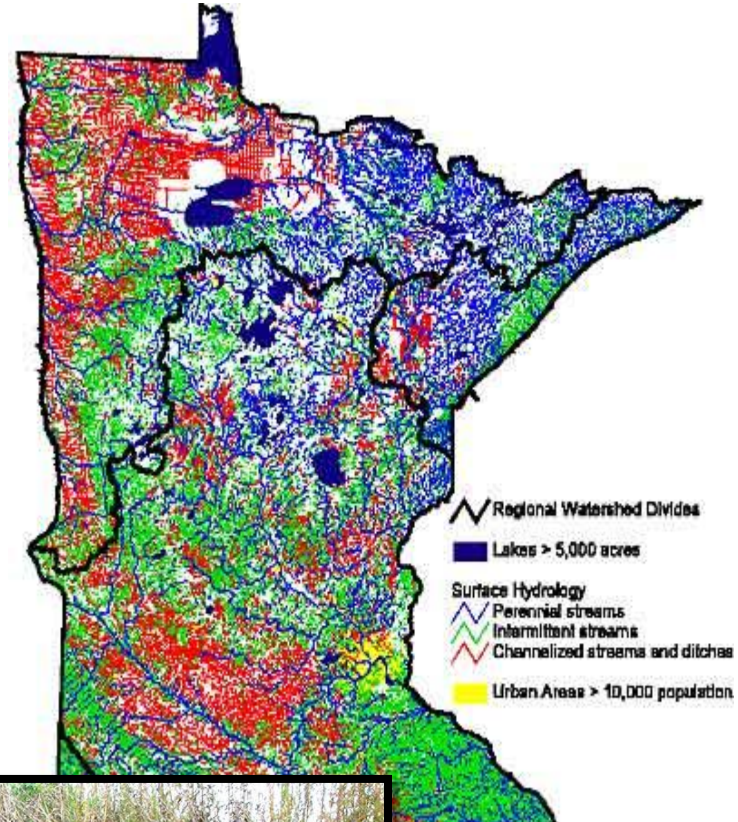


Selman et al, 2008, World Resources Institute

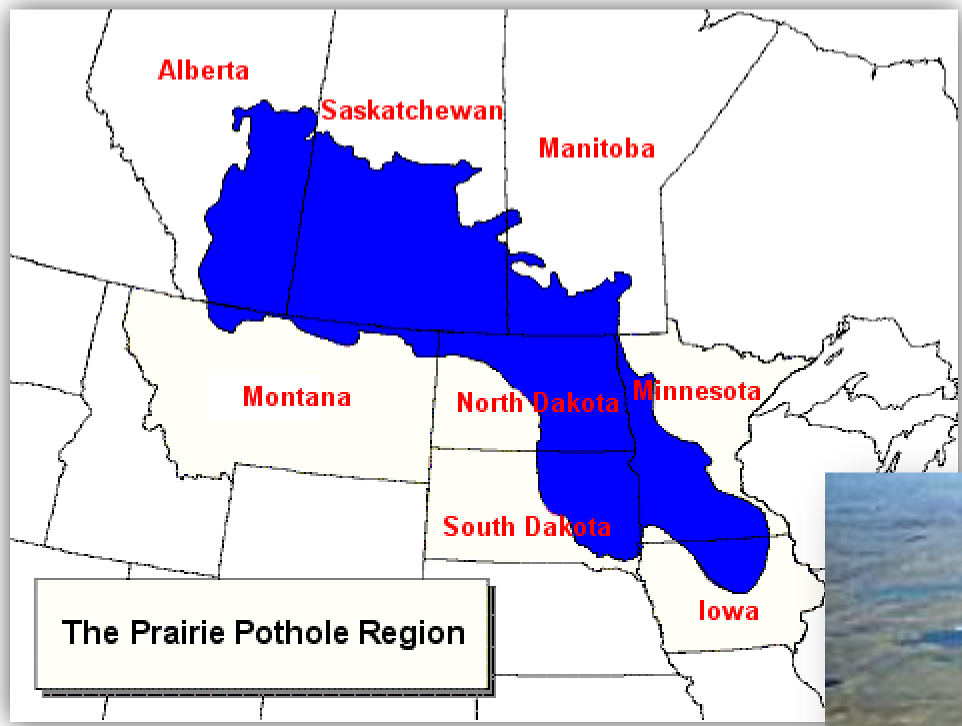
Data compiled from various sources by R. Diaz, M. Selman and Z. Sugg.

Drainage's Role in MN's TMDL's

Confluence of the Minnesota and Mississippi Rivers, St. Pa



Ecology & Loss of Habitat



Mitigation,

Practices & Technology,

Research & Education

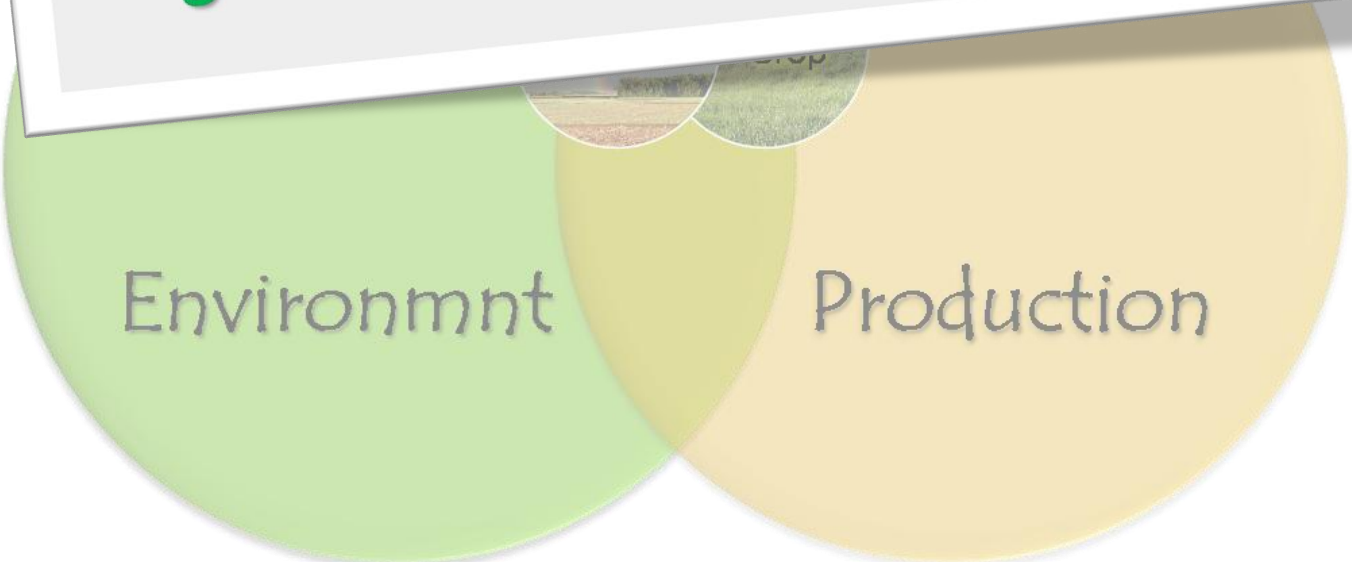
Research & Education Needs

Tiling Touted as a Partial Solution to Red River Valley Floods — Minnesota Congressman Collin Peterson says he's sick of going to flood meetings and is determined to fix the water issues within the Red River Valley. The answer may include many things, ranging from a diversion to a waffle plan. Farmers could also have a unique role. "I think that one of the things that can do us the most good, not only from a water control standpoint, but also improving the productivity of the (Red River) Valley, and that is tiling the land in the Valley. If we could tile all the land in the Valley, we would solve this problem if you did it right, and you would also, maybe, double production of the Valley by doing it, but what we'd be talking about is doing tiling that would be tied to control structures so that we could control this water if we needed to." Low-interest USDA loans were suggested as one way to pay for this tiling proposal.

Red River Farm Network

Golden Rule of Drainage

Drain only what is necessary for good trafficability and crop growth – and not a drop more!

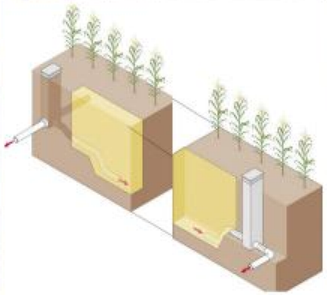











Sands' "A-B-C…T" Approach to Poorly Drained Acres

After agro/tillage considerations:

- **A**void - alternative use? Set-aside prog?
  - **B**i-objectional design

    Production & Environment
    - **C**ontrol/Management of water
      - **T**reatment of effluent

Conservation Drainage Toolkit

Nutrient & Crop Practices

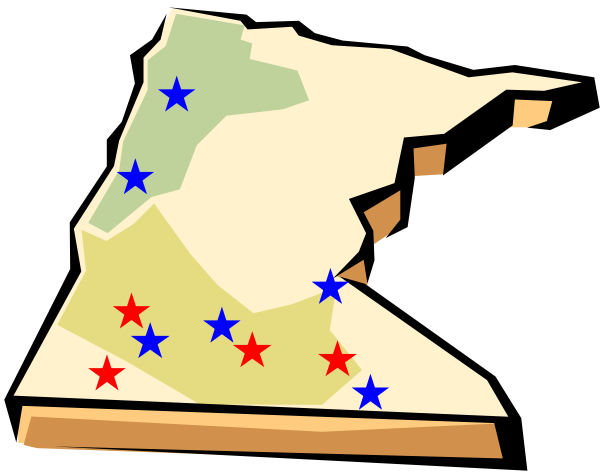
- Nutrient, crop, tillage management
- Alternative crops, cover crops, scavenger crops

Subsurface Drainage Practices

- Drainage water mgmt
- Better drainage design

Ditch, Impoundment & Treatment

- Culvert sizing
- Ditch modification/management
- Bioreactors & buffers
- Wetlands, impoundments
- Alternative surface inlets



Subsurface Drainage Practices

- Drainage water management
- Better drainage design

MN Drainage Guide: **Where's the Target?**

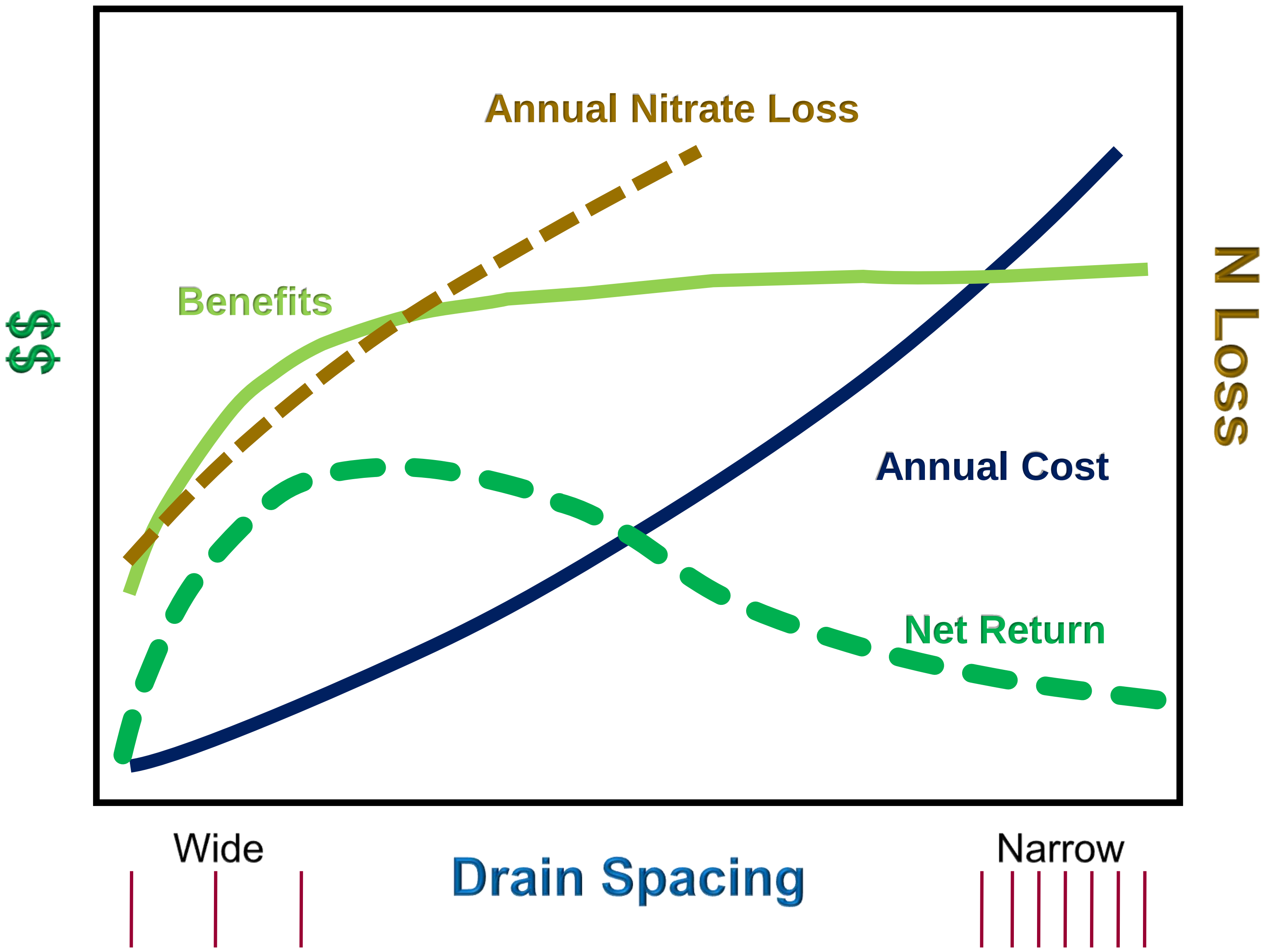
DRAINAGE GUIDE DATA FOR MINNESOTA

SOIL NAME UNIT KIND MODIFIER	ID NO.	DRAIN DESIGN RECOMMENDATIONS: COMMENTS	DSN GRP	DRAIN DEPTH In.	SPACINGS, Ft. DRAINAGE COEFF. In./24 Hrs. 1/4	3/8	1/2	3/4	HORIZ DEPTH In.	SOIL CHARACTERISTICS: UNIFIED SOIL CLASSIFICATION	PERMEABILITY In./Hr.	pH RANGE	DEPTH TO WATER TABLE Ft.	DEPTH TO BEDROCK In.
BLOMFORD SERIES	MN0239		1						0-9	SM	6.0-20	5.1-7.3	0.5-1.5	>60
			5	36	143	115	98	79	0-9	SM, SP-SM	6.0-20	5.1-7.3		
			5	48	179	144	124	100	9-25	SM, SP-SM	6.0-20	5.1-7.3		
									25-39	ML, CL, SC, SM	0.6-2.0	5.1-7.3		
									39-60	ML, CL, SC, SM	0.6-2.0	6.1-8.4		
BLOOMING SERIES	MN0150		7						0-8	ML, CL, CL-ML	0.6-2.0	5.6-6.5	>6.0	>60
									8-15	CL	0.6-2.0	5.6-6.5		
									15-48	CL, CL-ML, SC, SM-SC	0.6-2.0	5.1-7.3		
SLOPING			4	48	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
BLUE EARTH VARIANT	MN0177		1						0-16	OL	0.6-2.0	7.4-8.4	+1-1.0	>60
			1						16-25	ML	0.6-2.0	7.4-8.4		
			5	36	127	101	86	68	25-47	SM, SP-SM	2.0-6.0	7.4-7.8		
									47-60	CL	0.6-2.0	7.4-7.8		
BLUE EARTH VARIANT	MN0442		5	36	346	276	235	186	0-28	OL	2.0-6.0	7.4-8.4	+2-1.0	>60
			5	48	424	341	292	234	28-33	CL-ML, CL	0.6-2.0	7.4-8.4		
									33-60	SP-SM	6.0-20	6.1-8.4		
BLUFFTON SERIES	MN0184		1						0-19	CL	0.6-2.0	5.6-6.5	+2-2.0	>60
		L, SIL	5	36	58	46	39	30	0-19	SC, SM, SM-SC	0.6-6.0	5.6-6.5		
			5	48	76	60	51	40	19-22	SM, ML, CL, SC	0.6-6.0	5.6-7.3		
		SL, SCL	5	36	66	53	45	35	22-60	CL, ML, SC, SM	0.2-0.6	7.4-8.4		
			5	48	85	68	58	46						

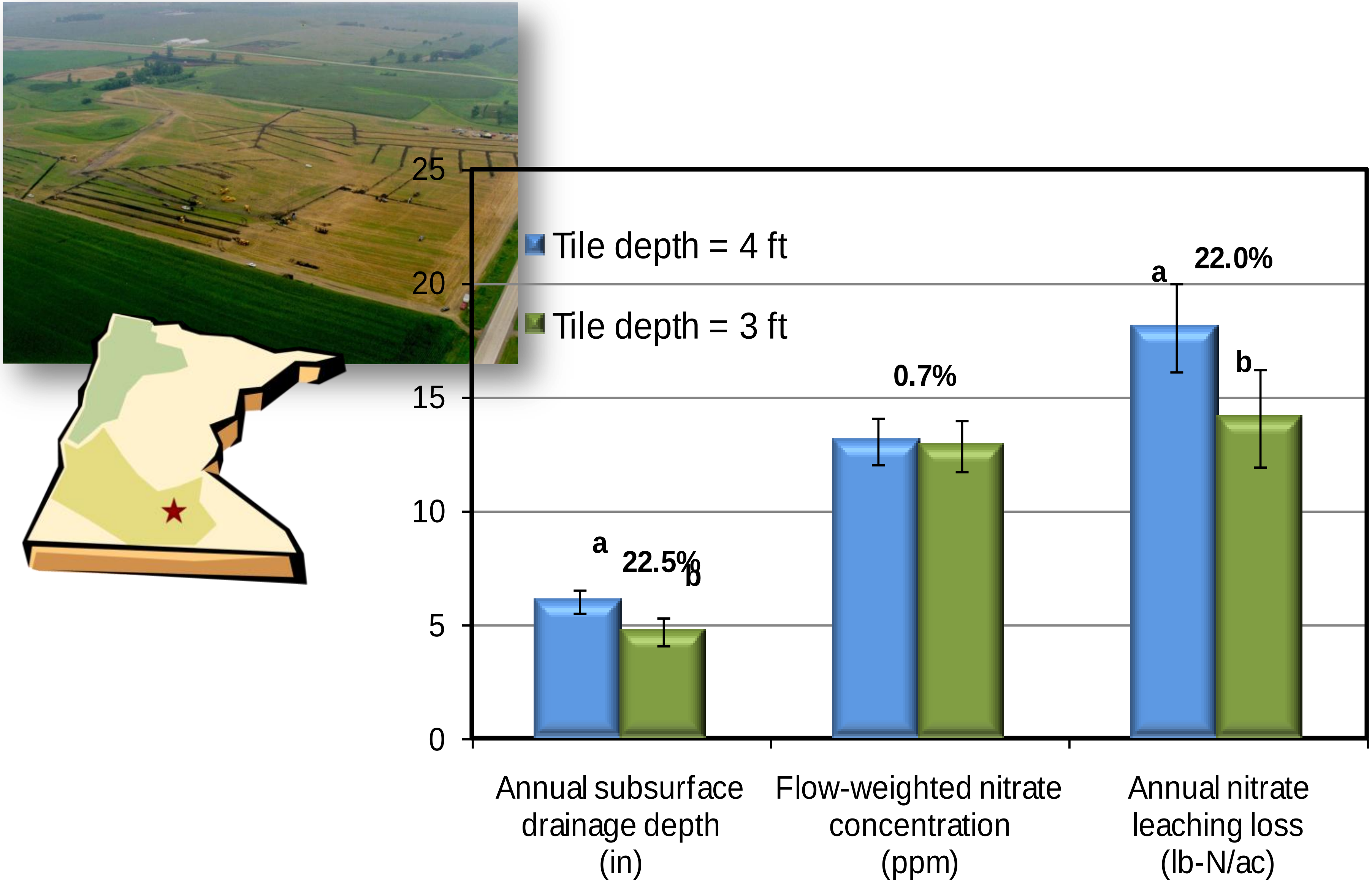
SOIL NAME UNIT KIND MODIFIER	ID NO.	DRAIN DESIGN RECOMMENDATIONS: COMMENTS	DSN GRP	DRAIN DEPTH In.	SPACINGS, Ft. DRAINAGE COEFF. In./24 Hrs. 1/4	3/8	1/2	3/4	HORIZ DEPTH In.	
BLUE EARTH SERIES	MN0064		1						0-10	PT
			5	36	95	74	62	49	0-10	OL, ML
			5	48	121	96	81	64	10-60	OL, ML
									60-70	CL, ML

Minnesota Drainage Guide, NRCS, 1984

“Optimized” Drainage Design

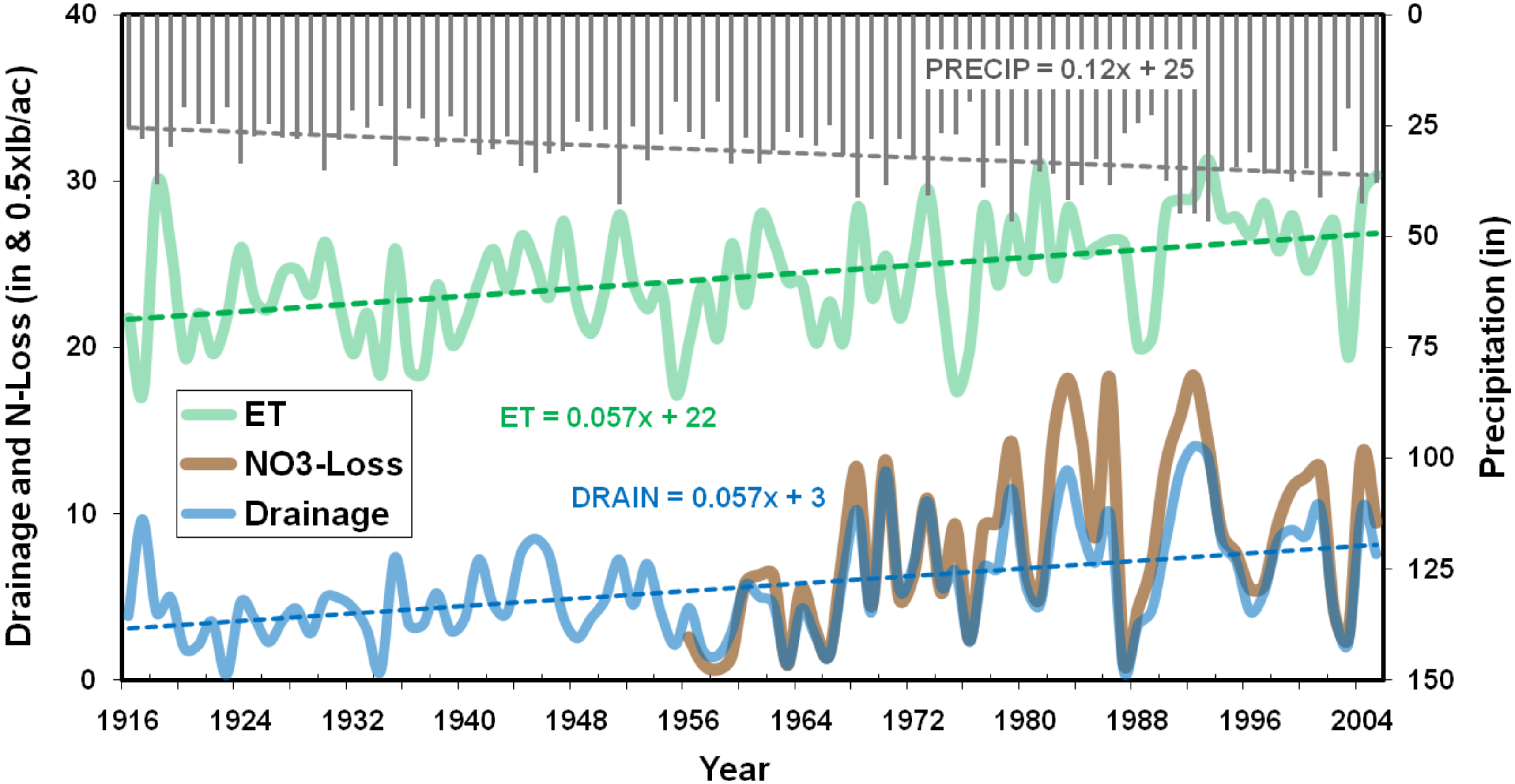


Field Research – Waseca, MN

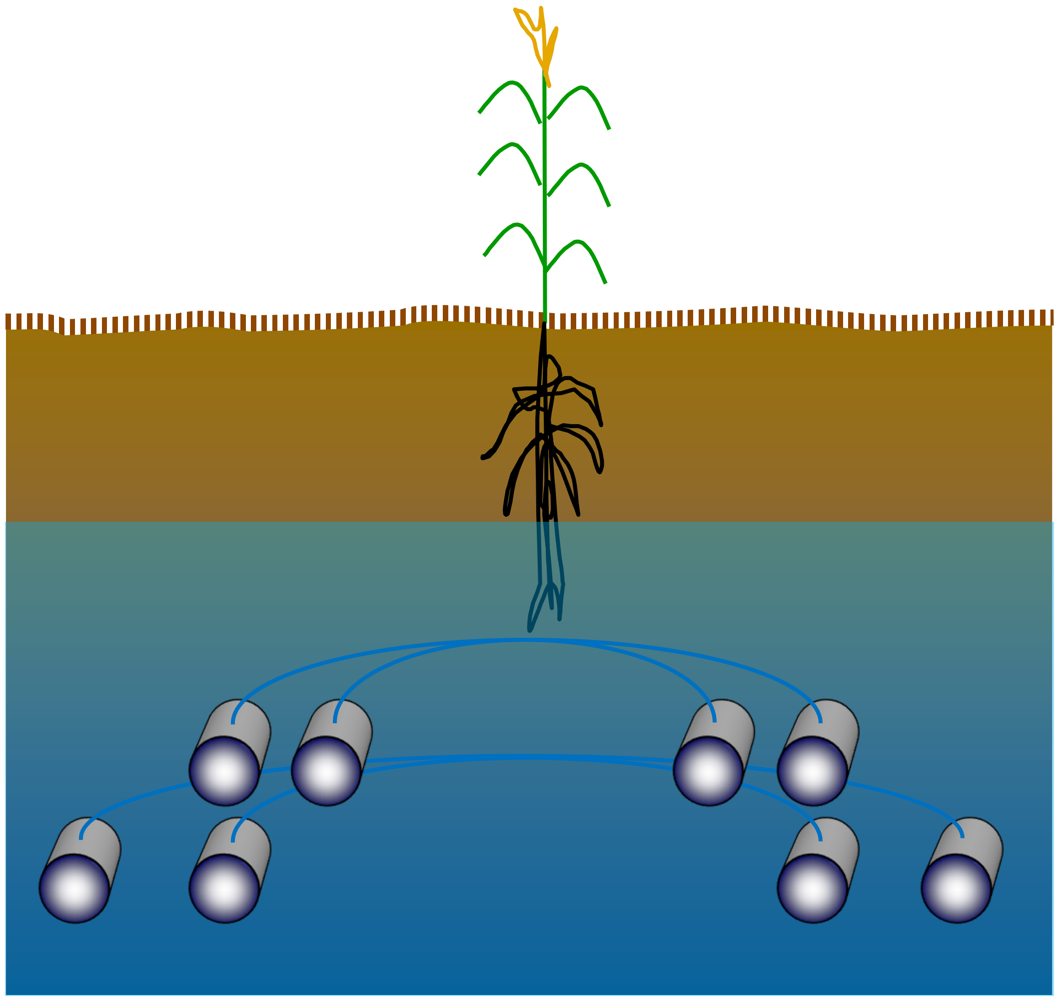


Computer Modeling

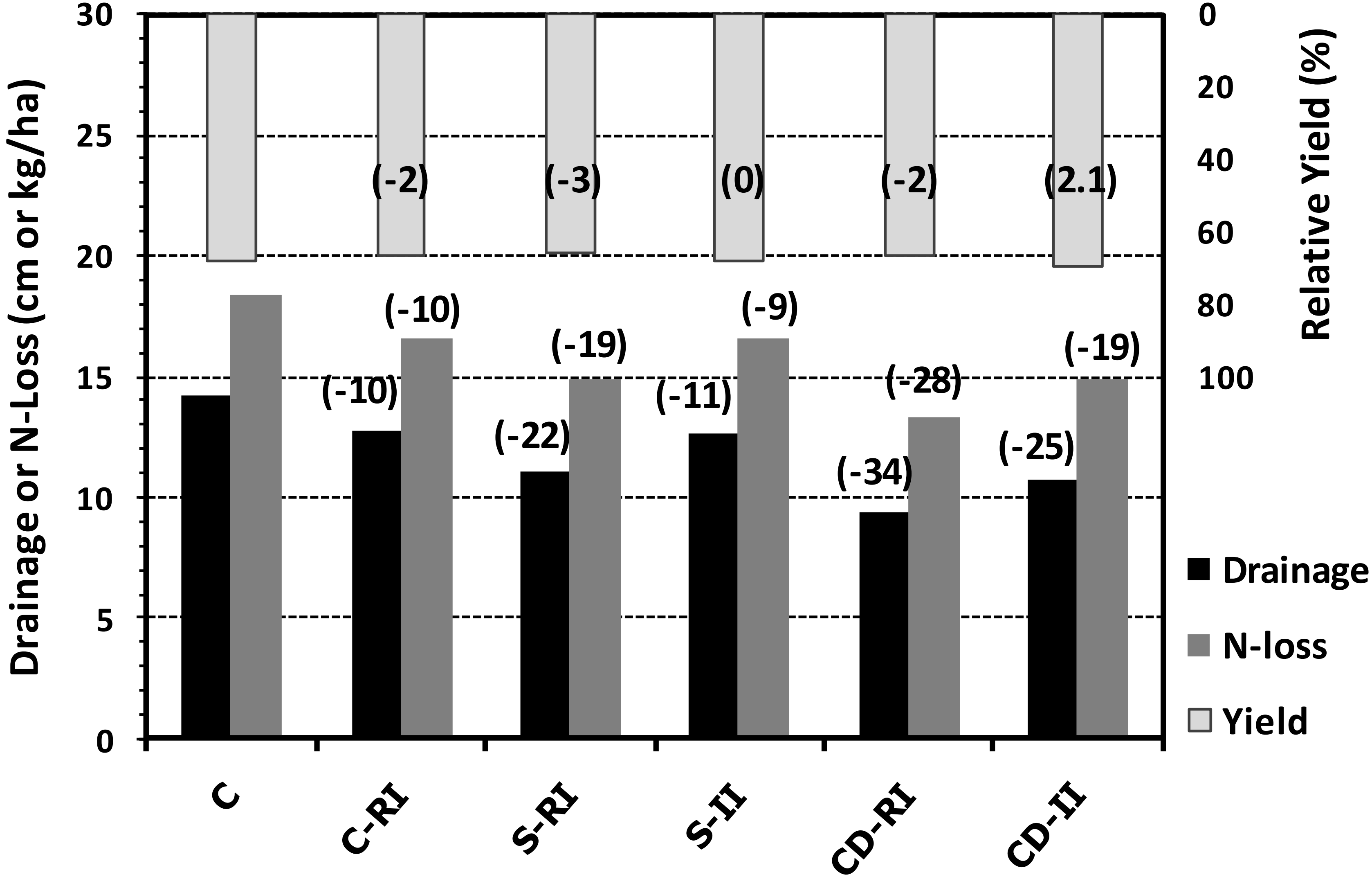
Conventional Drainage:90-yr Simulation



Conservation Drainage Scenarios



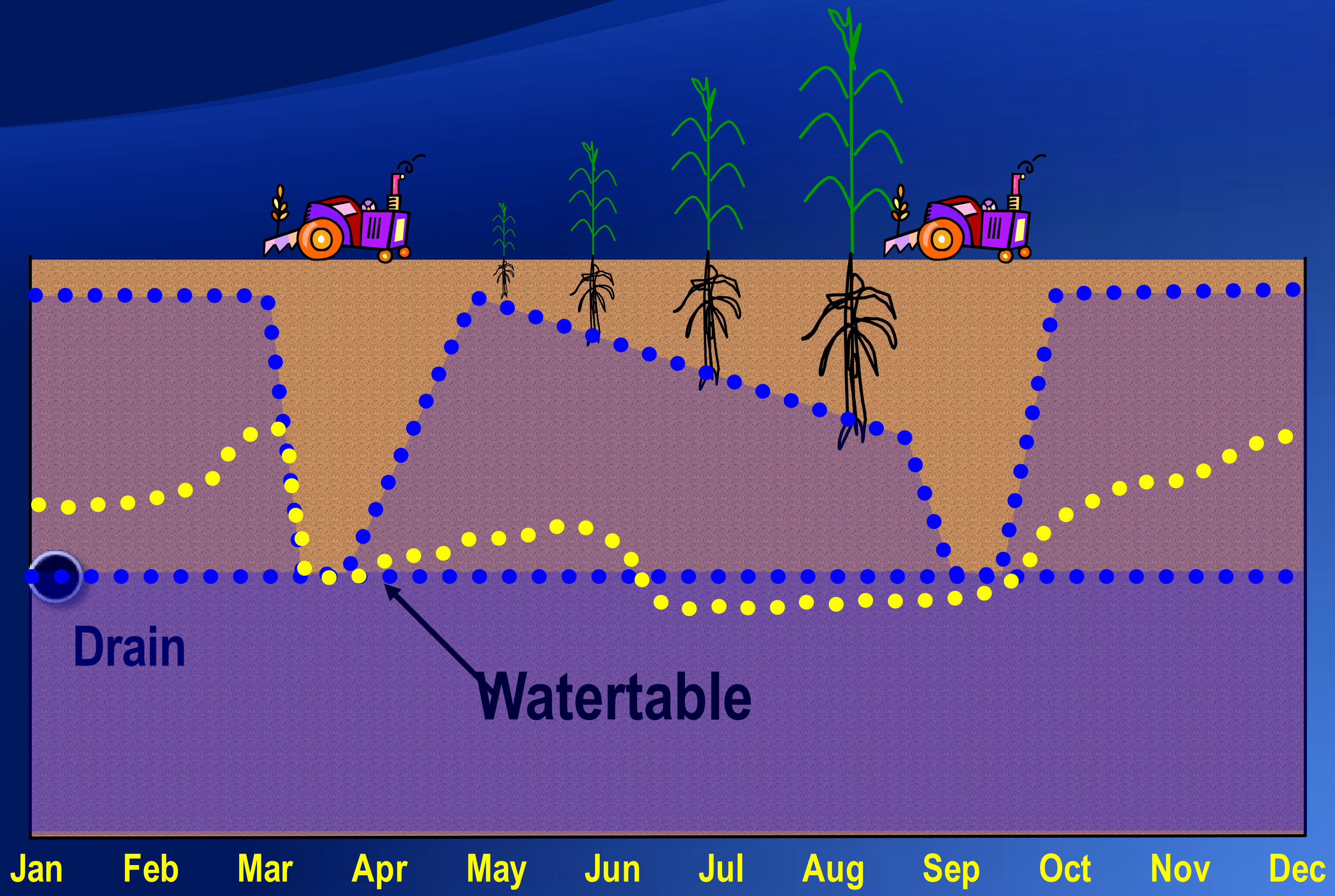
Modeling Alternative Drainage Scenarios



Subsurface Drainage Practices

- Drainage water management
- Better drainage design

Drainage Water Management



Drainage Water Management

Conventional Drainage Mode

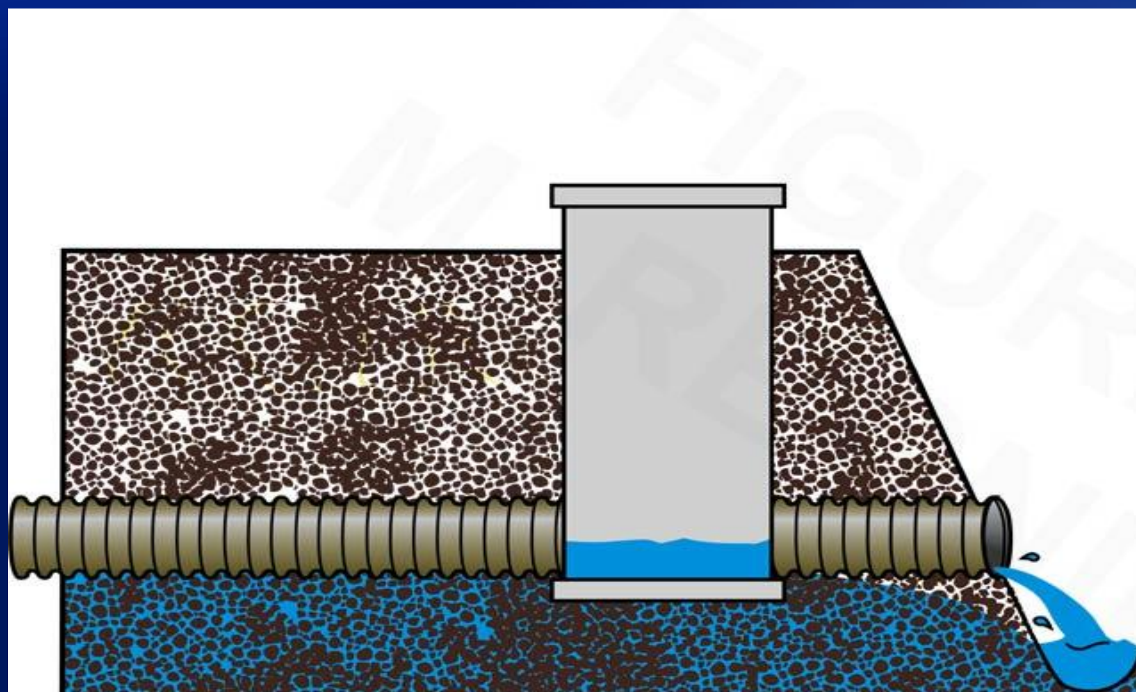


Illustration Courtesy of Dr. Jane Frankenberger
Purdue Extension

Drainage Water Management

Summer Conservation Mode

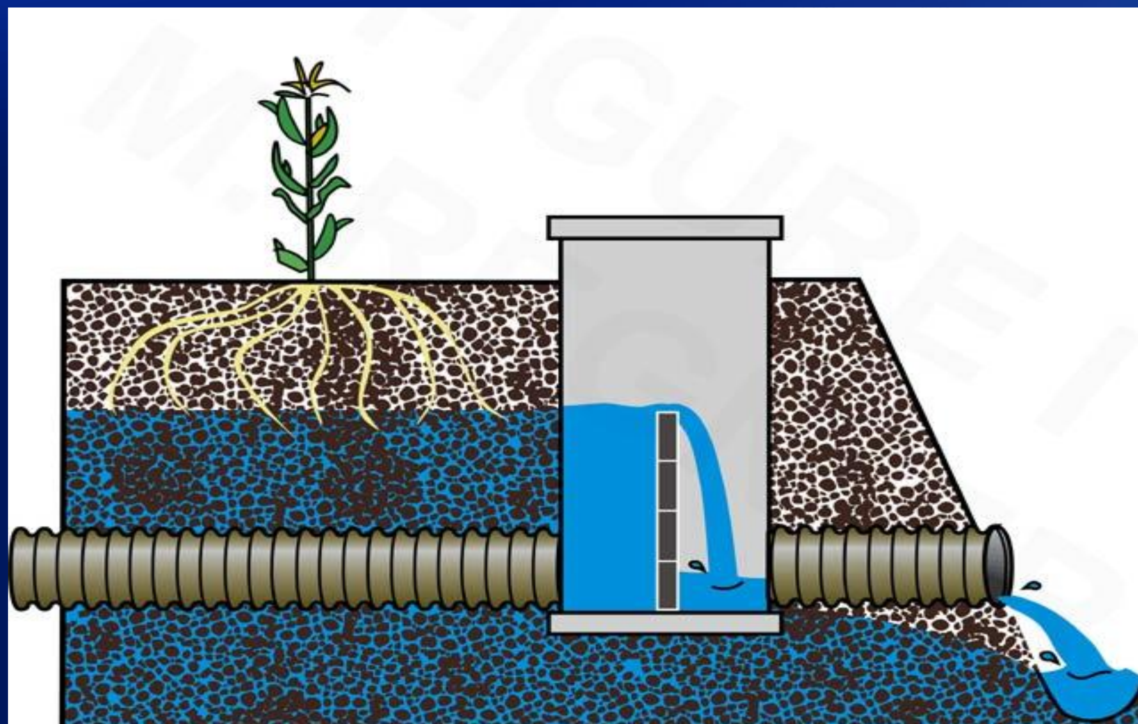


Illustration Courtesy of Dr. Jane Frankenberger
Purdue Extension

Drainage Water Management

Winter Conservation Mode

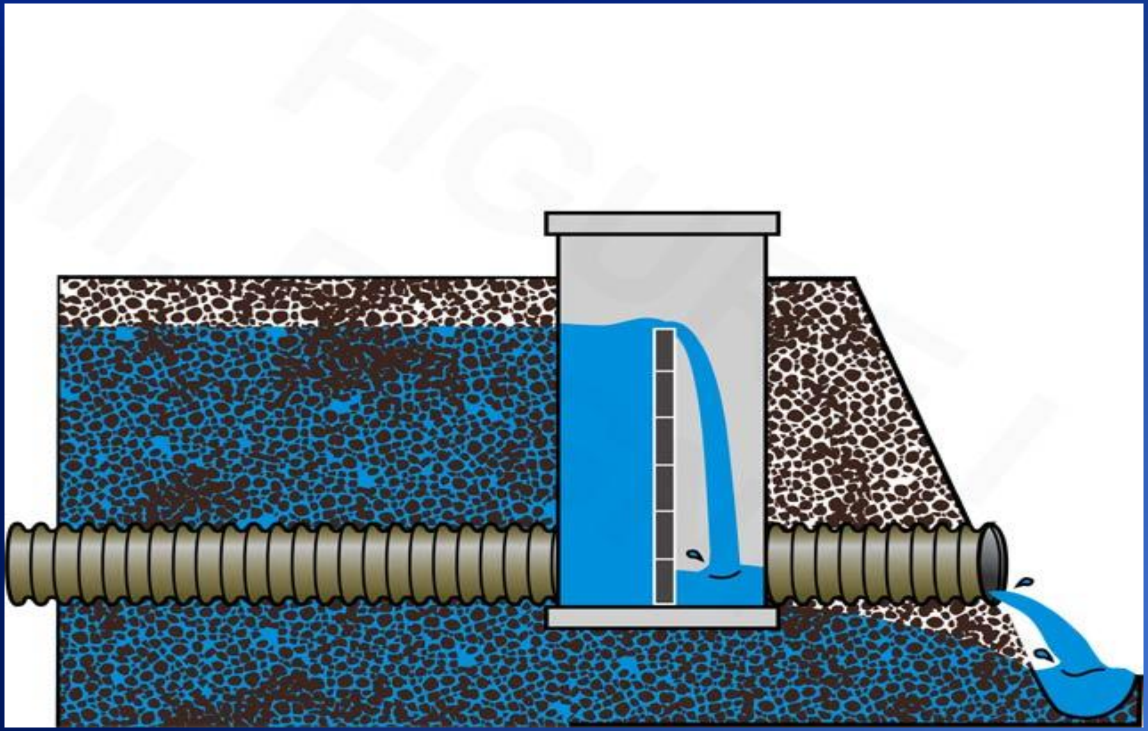


Illustration Courtesy of Dr. Jane Frankenberger
Purdue Extension

DWM Designs are the Key

Part of complete coverage on
Gulf Coast Oil Disaster

GULF COAST
OIL DISASTER

Minnesota farmer battles Gulf 'dead zone'

By **John D. Sutter**, CNN
August 30, 2010 9:37 a.m. EDT | Filed under: Innovation

In cooperation with the University of Minnesota, Thompson has installed an intricate system that lets him control the height of the groundwater table beneath his fields. By raising and lowering these levels at the right time, he can stop fertilizer from leaving.

Two farmers' efforts to reduce pollution

» HIDE CAPTION

‹ 1 2 3 4 5 6 7 8 9 **10** 11 ›

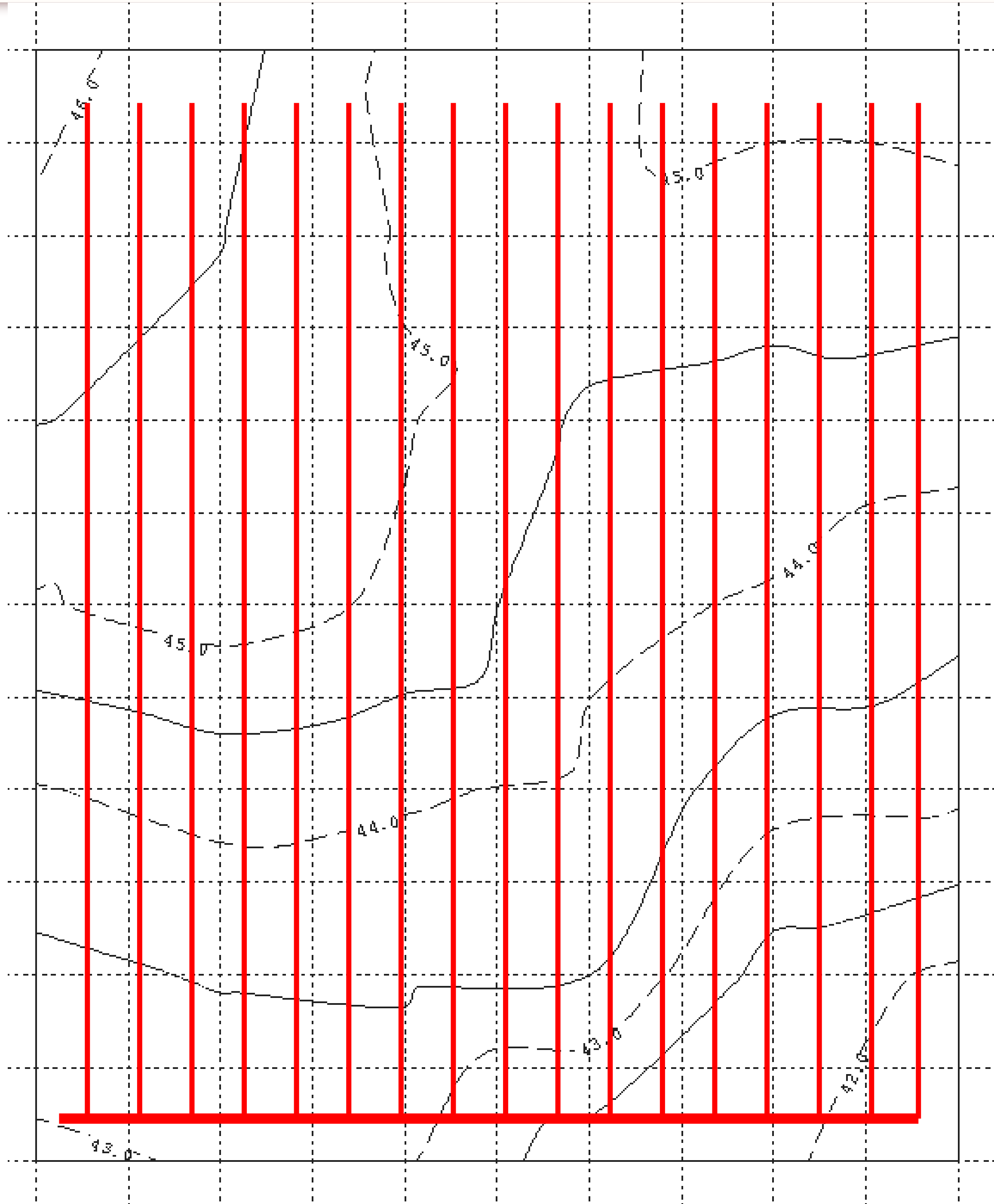
STORY HIGHLIGHTS

- A 'dead zone' forms in the Gulf of Mexico each summer
- The zone is void of oxygen and kills marine life; it's the size of New Jersey

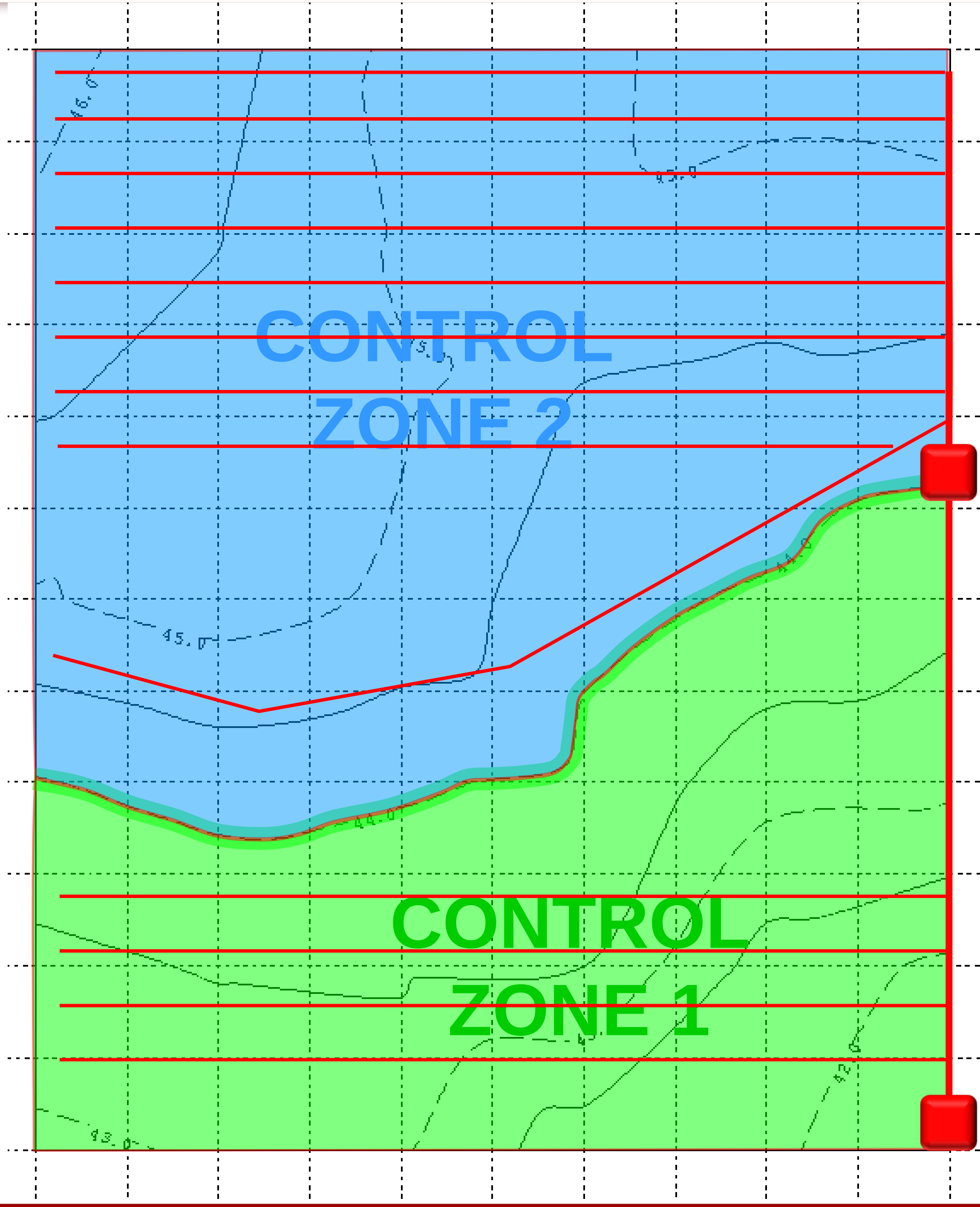
Windom, Minnesota (CNN) -- Within moments of meeting Tony Thompson, you can tell he sees the world from a different tilt.

His frayed shirt pocket is stuffed so full of notes that it's ripping at the seams. Hairy eyebrows spring off his face like grasshopper antennae. There's a purple prairie clover stuck in the dash of his van, a bird book

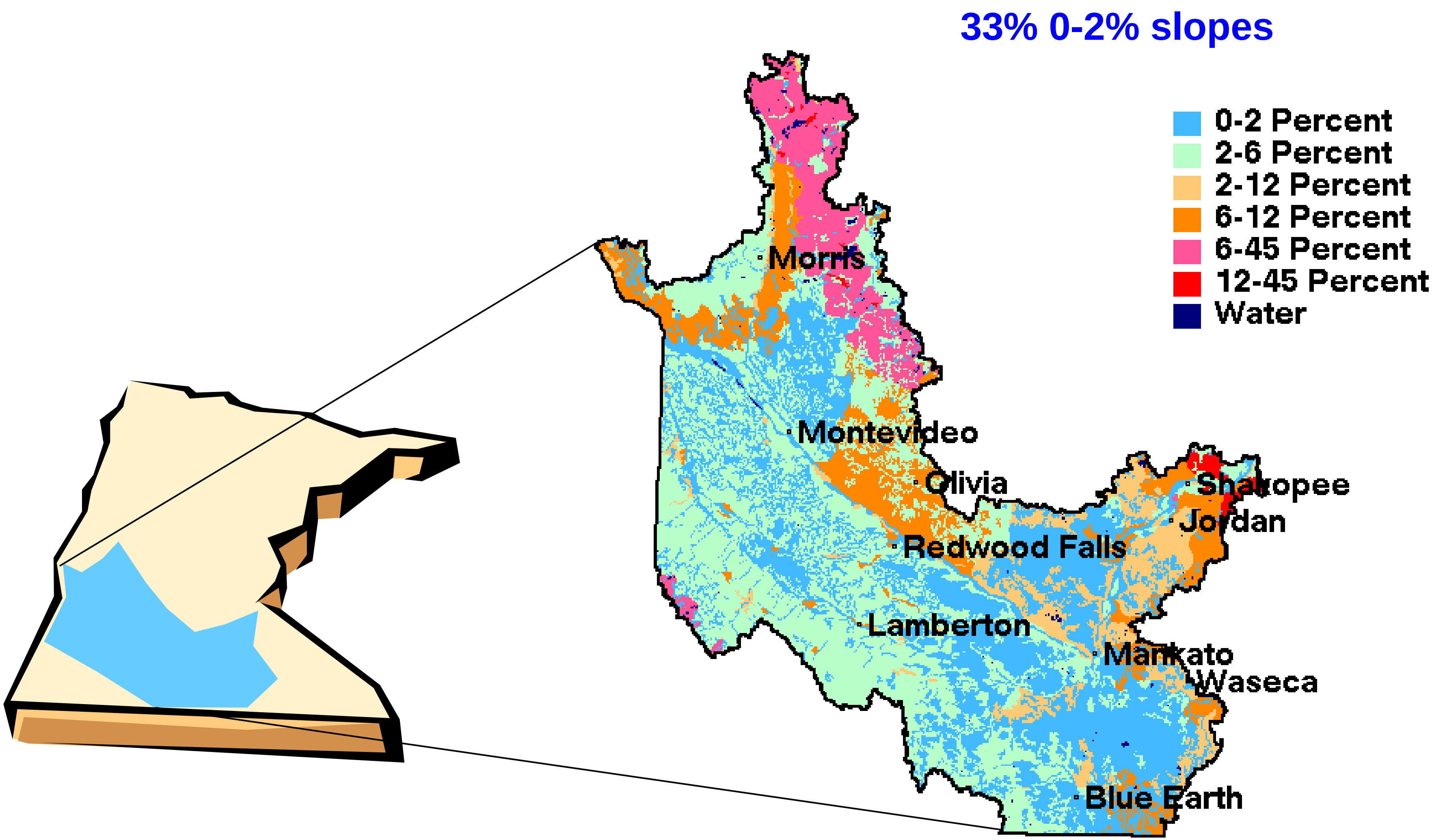
Designing For DWM Zones



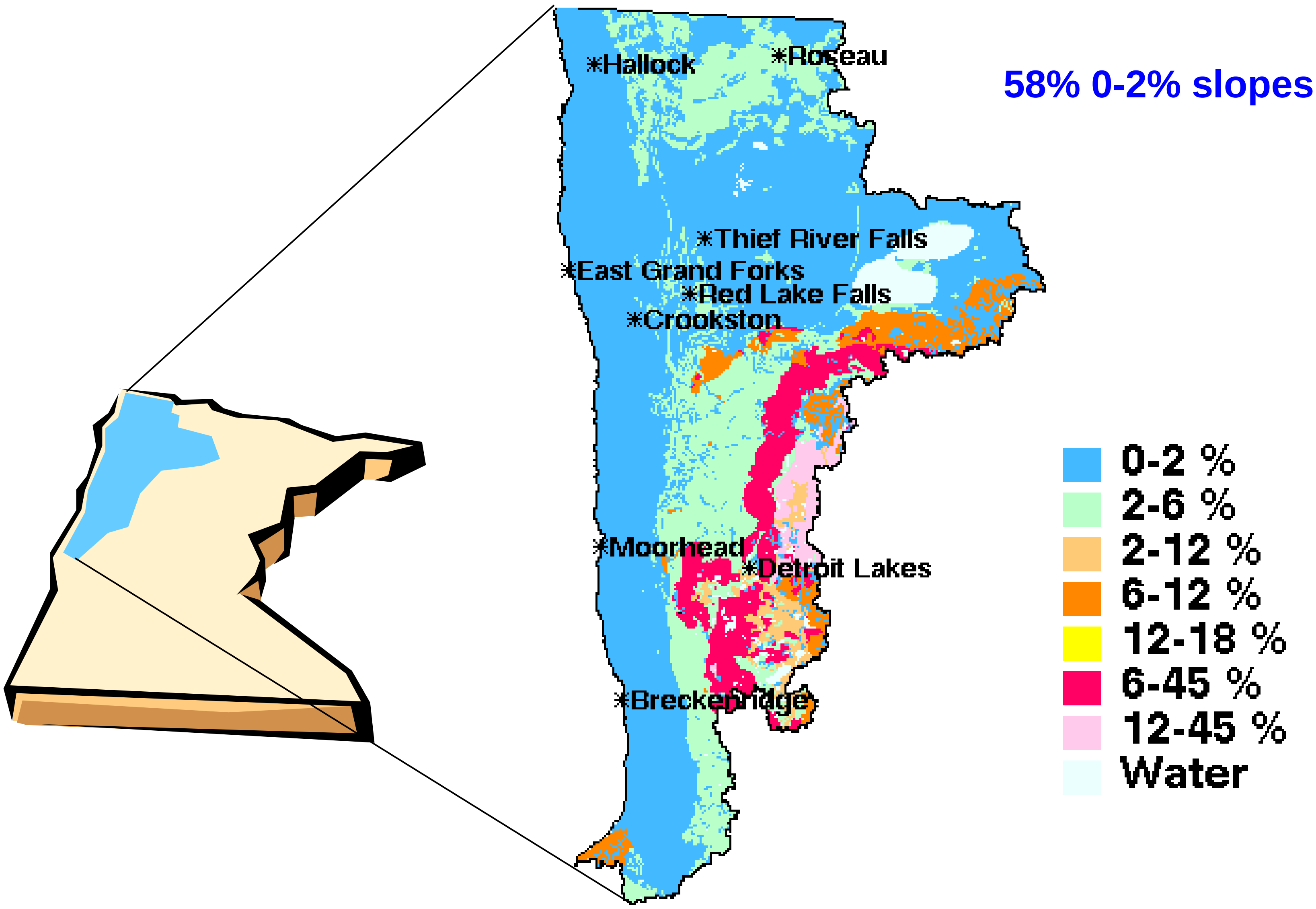
Designing For DWM Zones



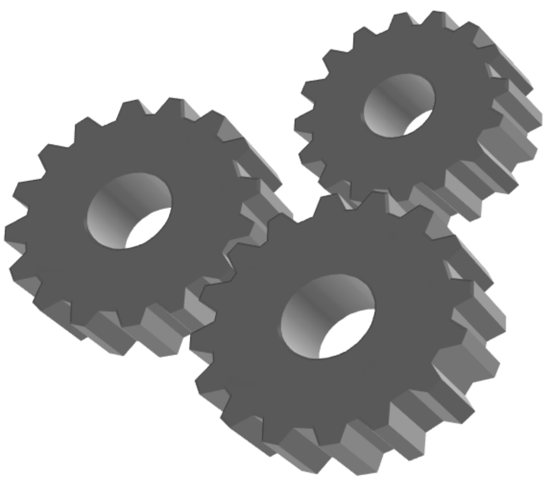
Where Can DWM Be Used?



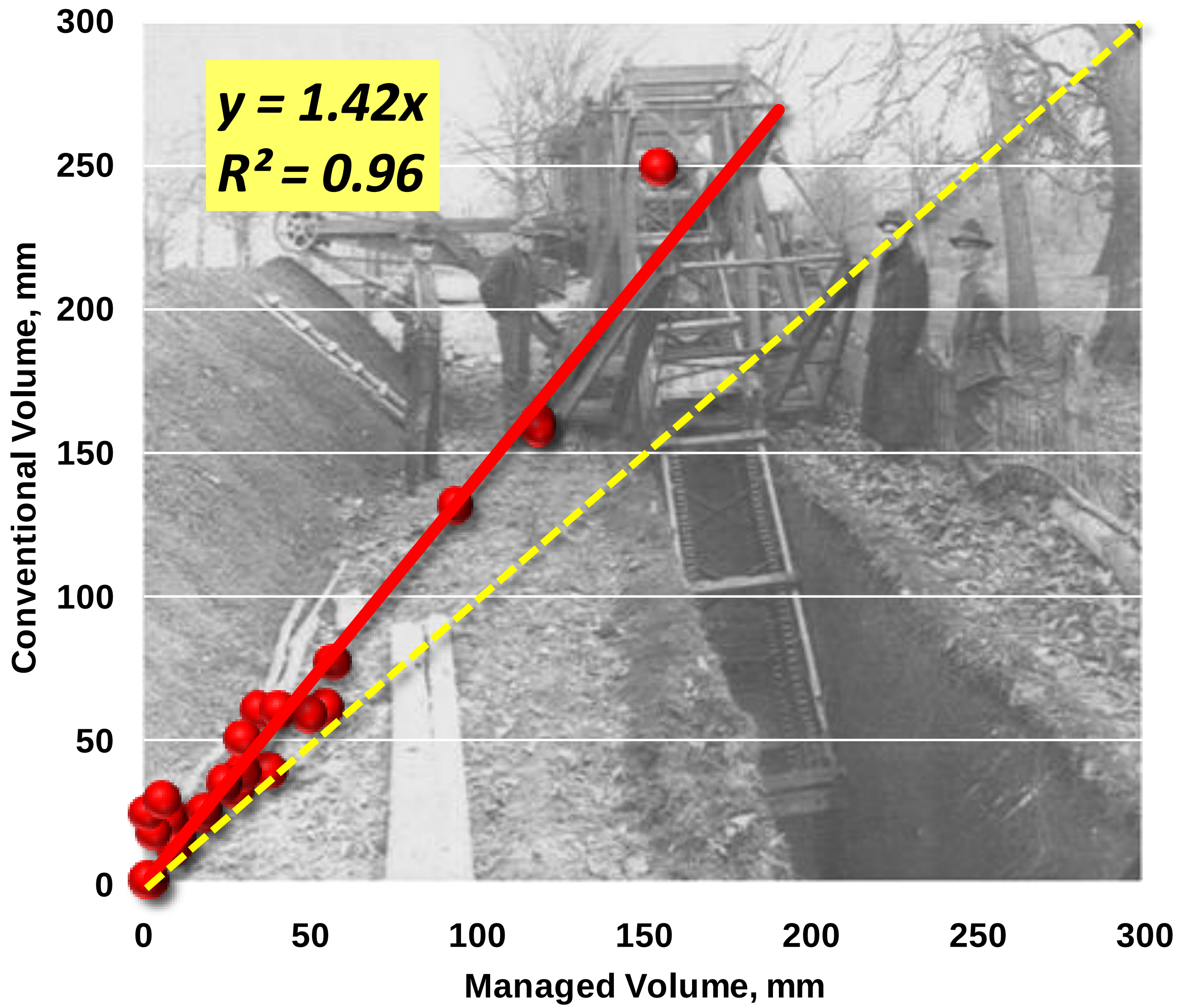
DWM in the Valley?



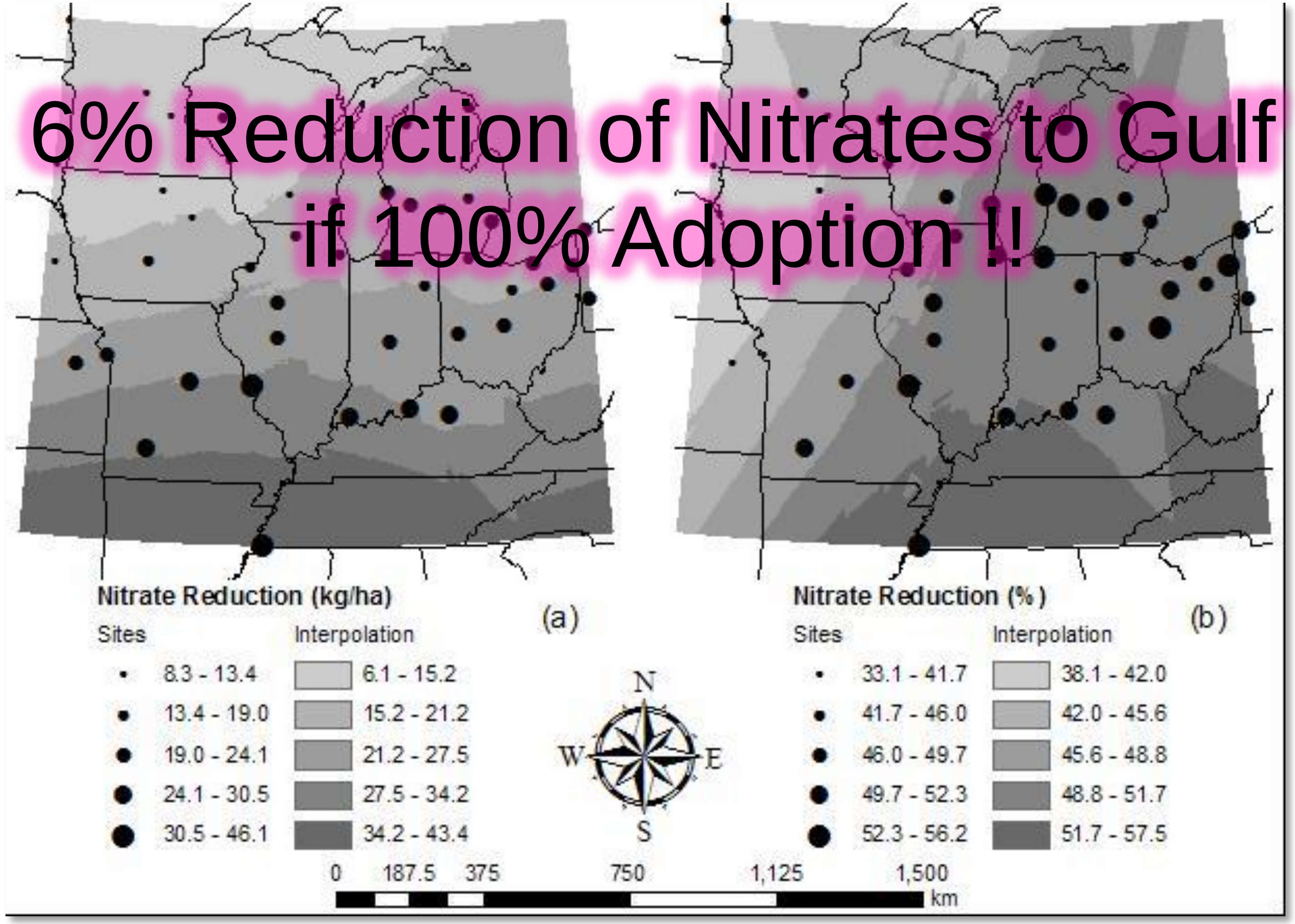
Efficacy



Drainage Volume – All Studies

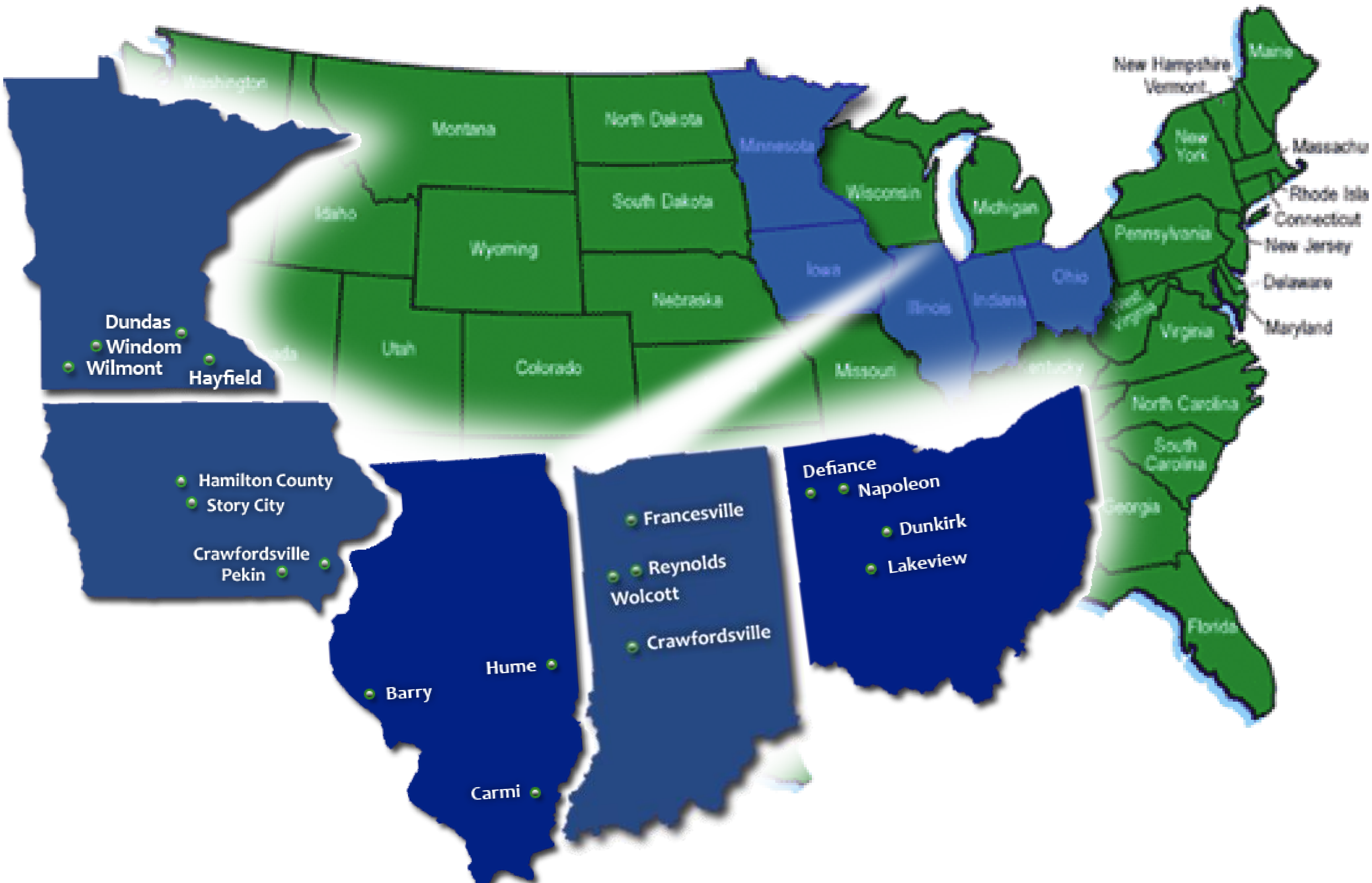


Regional DWM Effectiveness

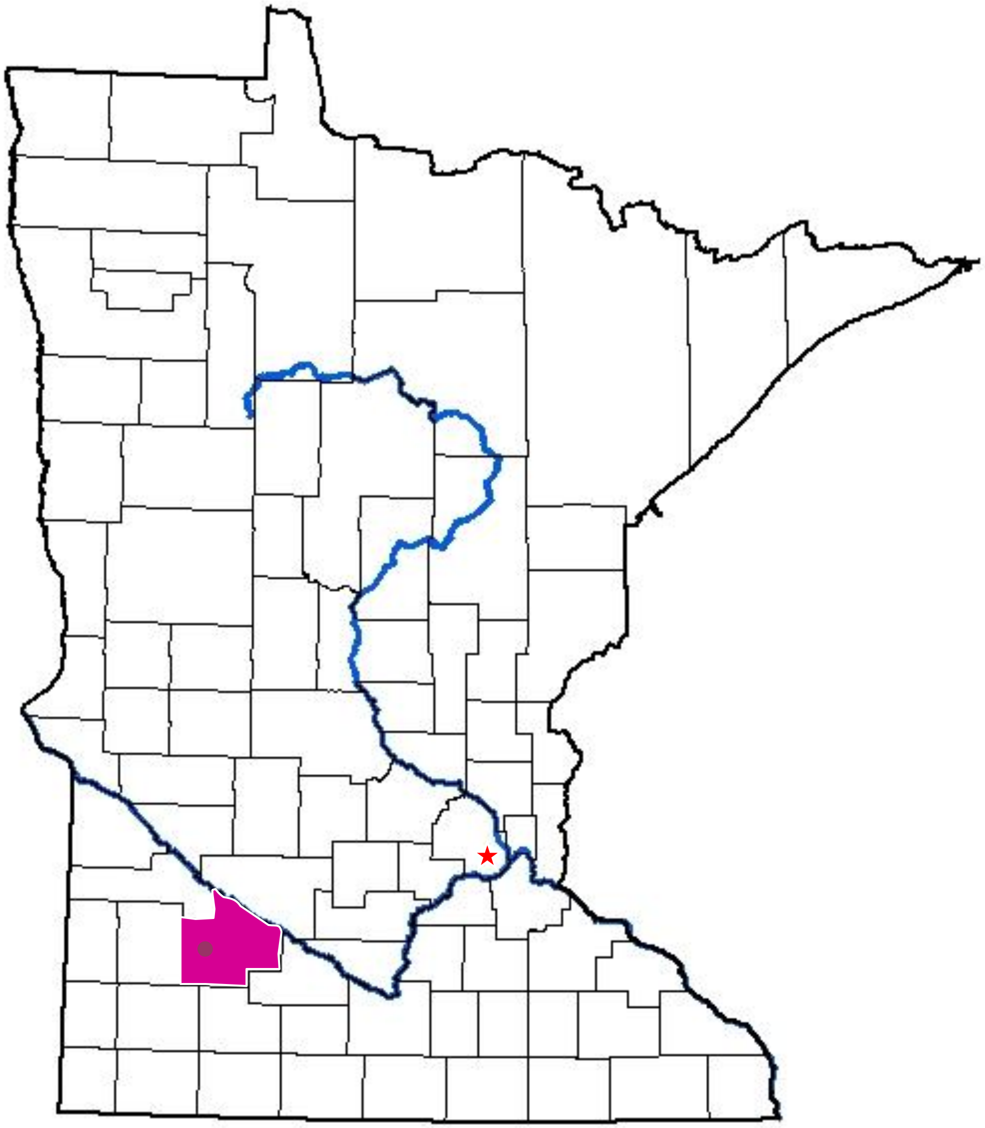


Thorp et al., 2008

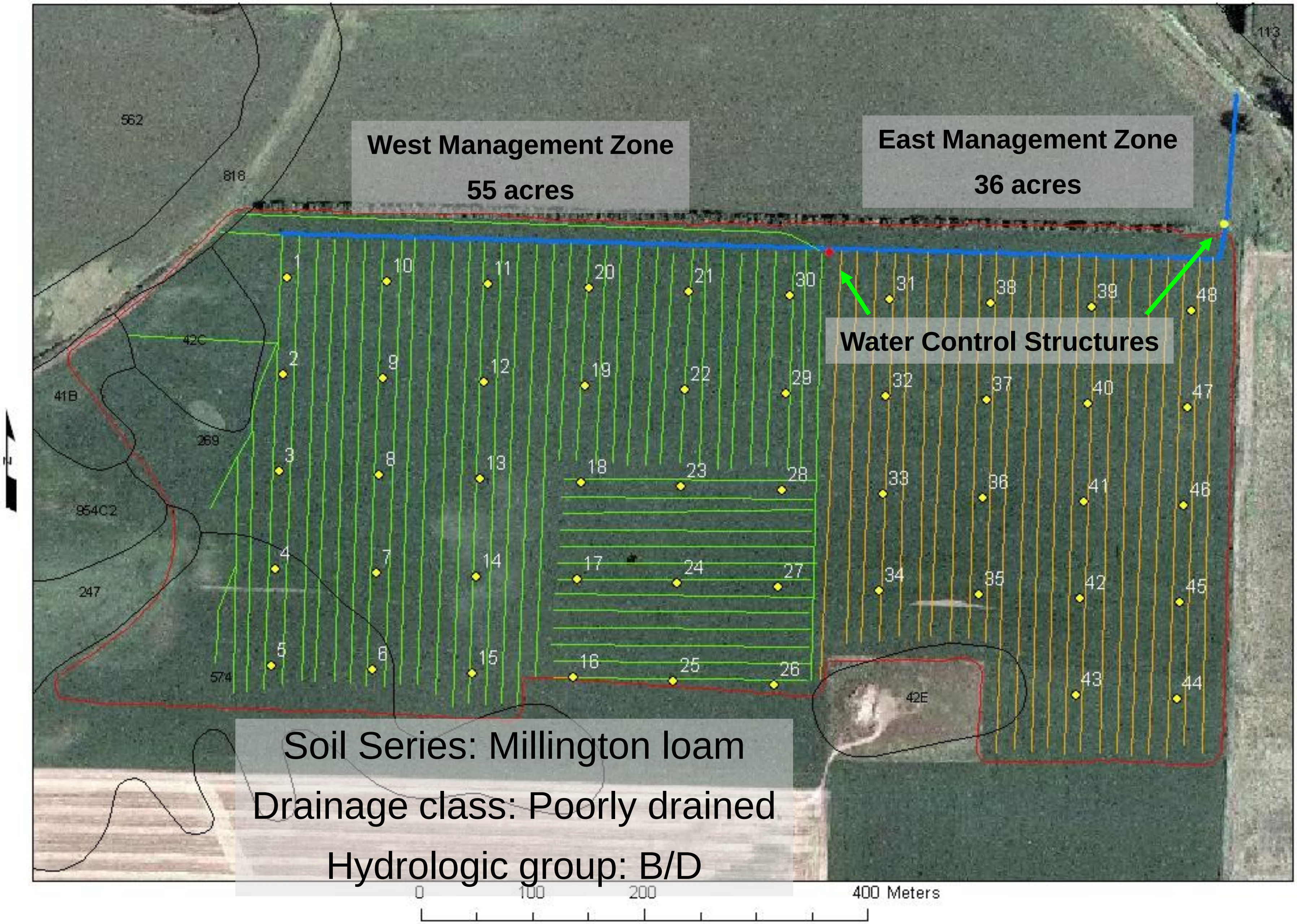
5-State Demo Project (USDA-NRCS)



Redwood Co. Farm



Hicks Family Farm - Controlled Drainage Site



Annual loads

	2006	2007	2008-W (controlled)	2008-E (conv)
Precipitation (inches)	24	24	20	
Drainage (inches)	5.8	2.0	1.5	4.5
TN (lbs/A)	41	3.8	4.4	16.9
NO_3-N (lbs/A)	43	3.6	4.3	16.7
NO_3-N FWMC (mg/L)	10.6	9.96	12.7	10.8

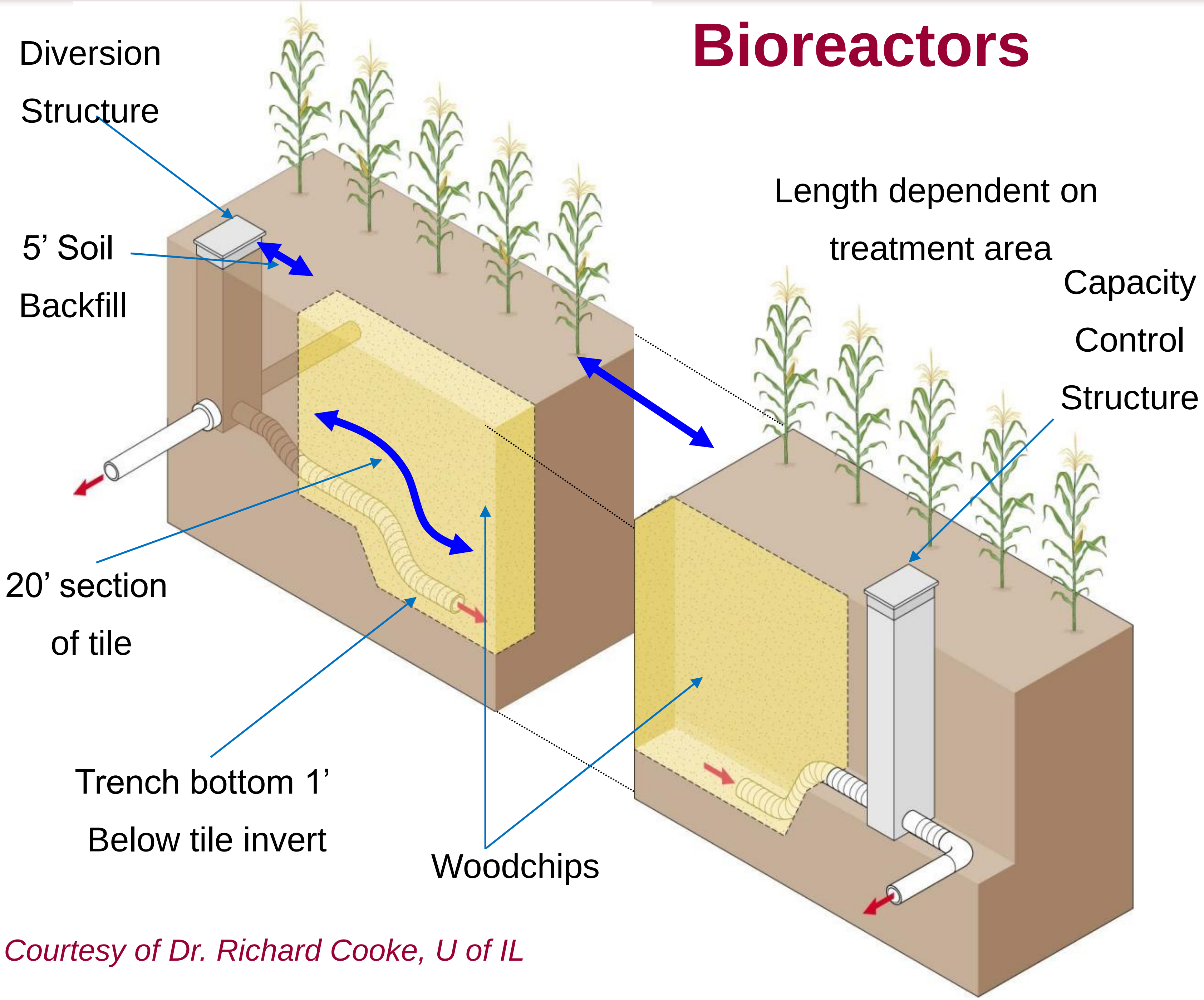
DWM Workshops


Drainage Water Management
Demonstration Site
The Innovative Future of Agriculture
www.admcoalition.com

Ditch, Impoundment & Treatment

- Culvert sizing
- Ditch modification/management
- Bioreactors & buffers
- Wetlands, impoundments
- Alternative Surface Inlets

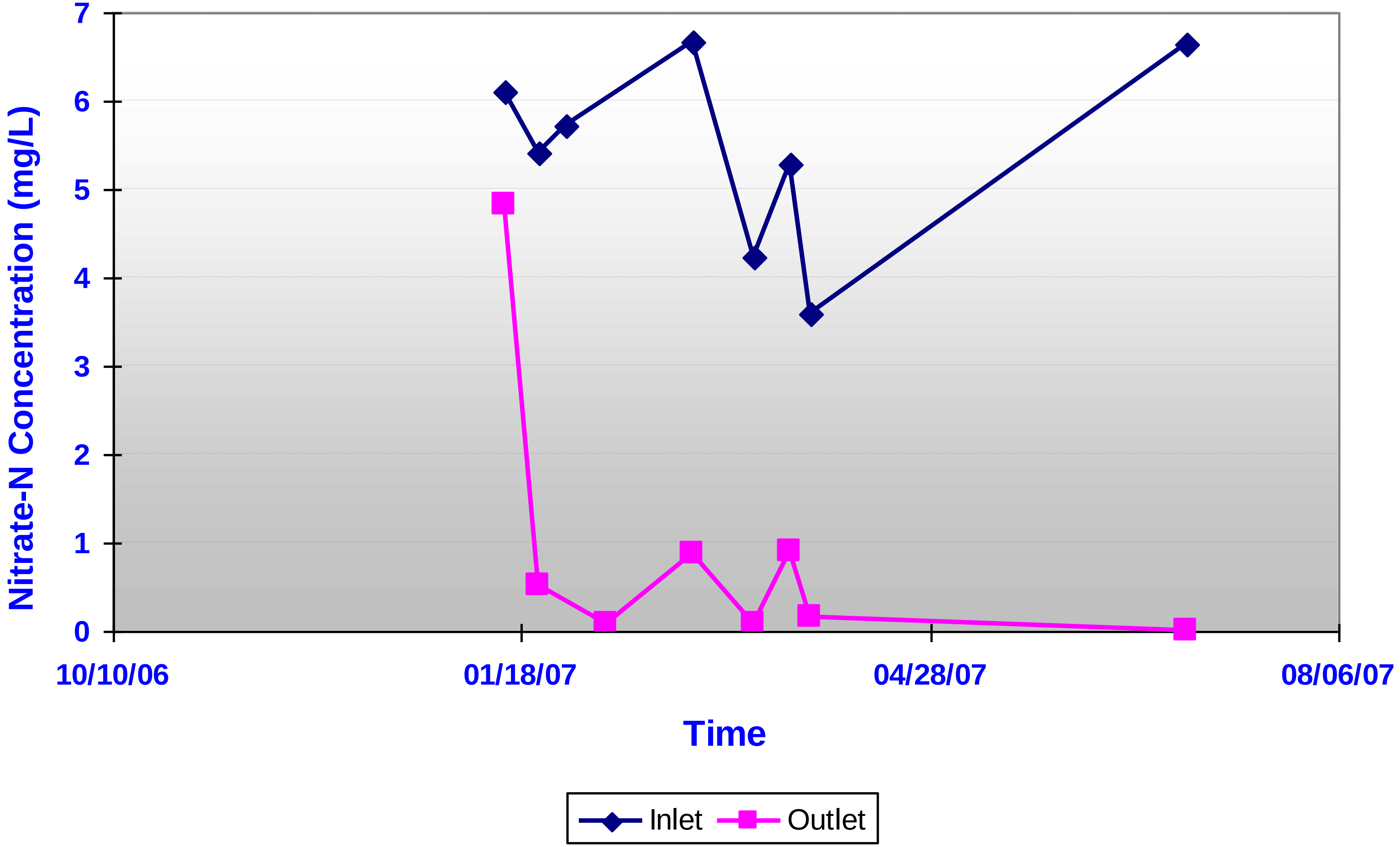
Bioreactors



Courtesy of Dr. Richard Cooke, U of IL

Courtesy of Dr. Richard Cooke, University of Illinois

Bioreactor Data Example - IL



Courtesy of Dr. Richard Cooke, University of Illinois

Bioreactor Workshops & Demos

Ditch, Impoundment & Treatment

- Culverts sizing
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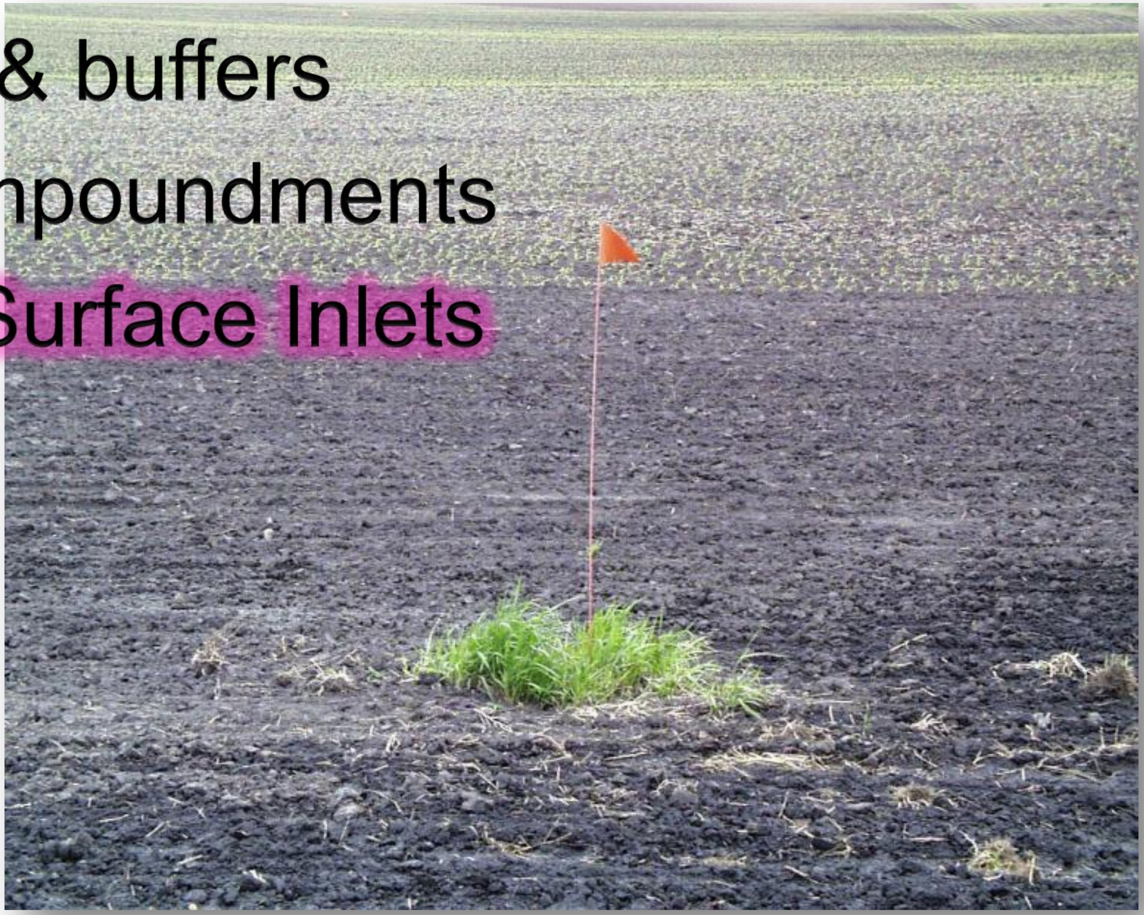
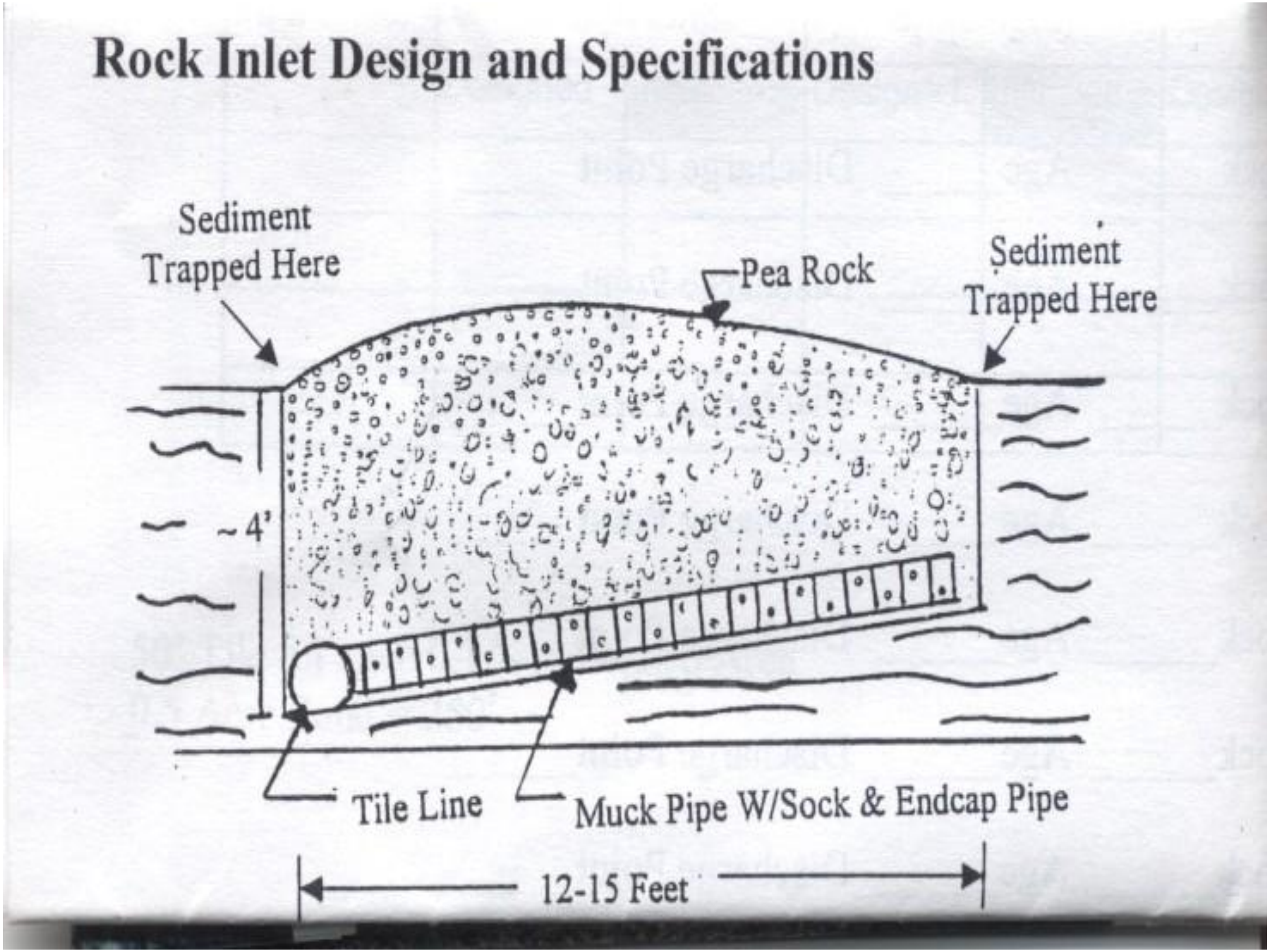
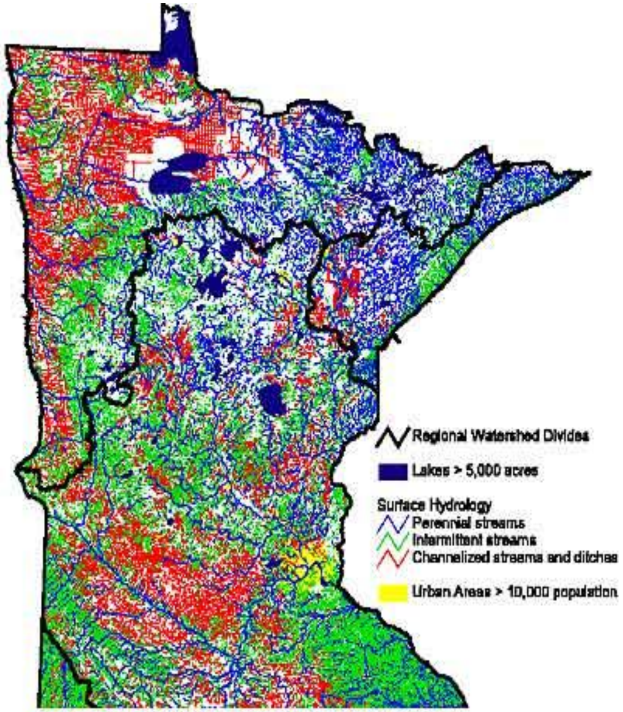


Phil Morriem Rock Inlet Design



Ditch, Impoundment & Treatment

- Culvert sizing
- Ditch modification/management
- Bioreactors & buffers
- Wetlands, impoundments
- Rock Inlets, side inlets



Additional Filters Next To Fields
Low Grassed Bench
Main Channel
Elevation (ft)
108
106
104
102
100
98
96
-25
-20
-15
-10
-5
0
5
10
15
20
25.0
Width Left to Right (ft)

Ditch, Impoundment & Treatment

- Culvert sizing
- Ditch modification/management
- Bioreactors & buffers
- Wetlands, impoundments
- Rock Inlets, side inlets

Wetland Restoration: Nicollet County

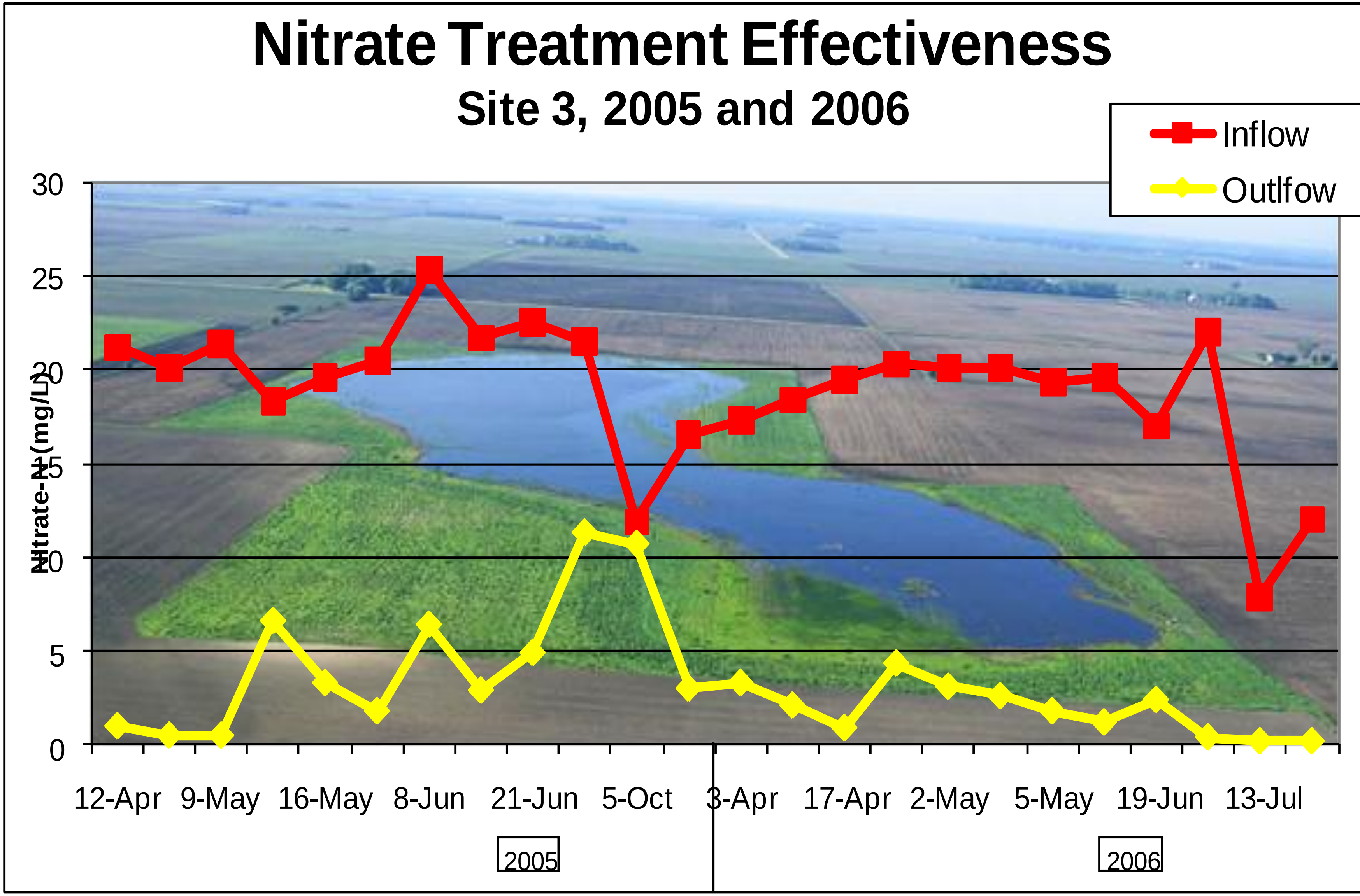
- In drained wetlands
- Used tile breaks/plugs for hydrology

BEFORE

AFTER

Seven Mile Creek Watershed Project

Brown Nicollet Cottonwood Water Quality Board



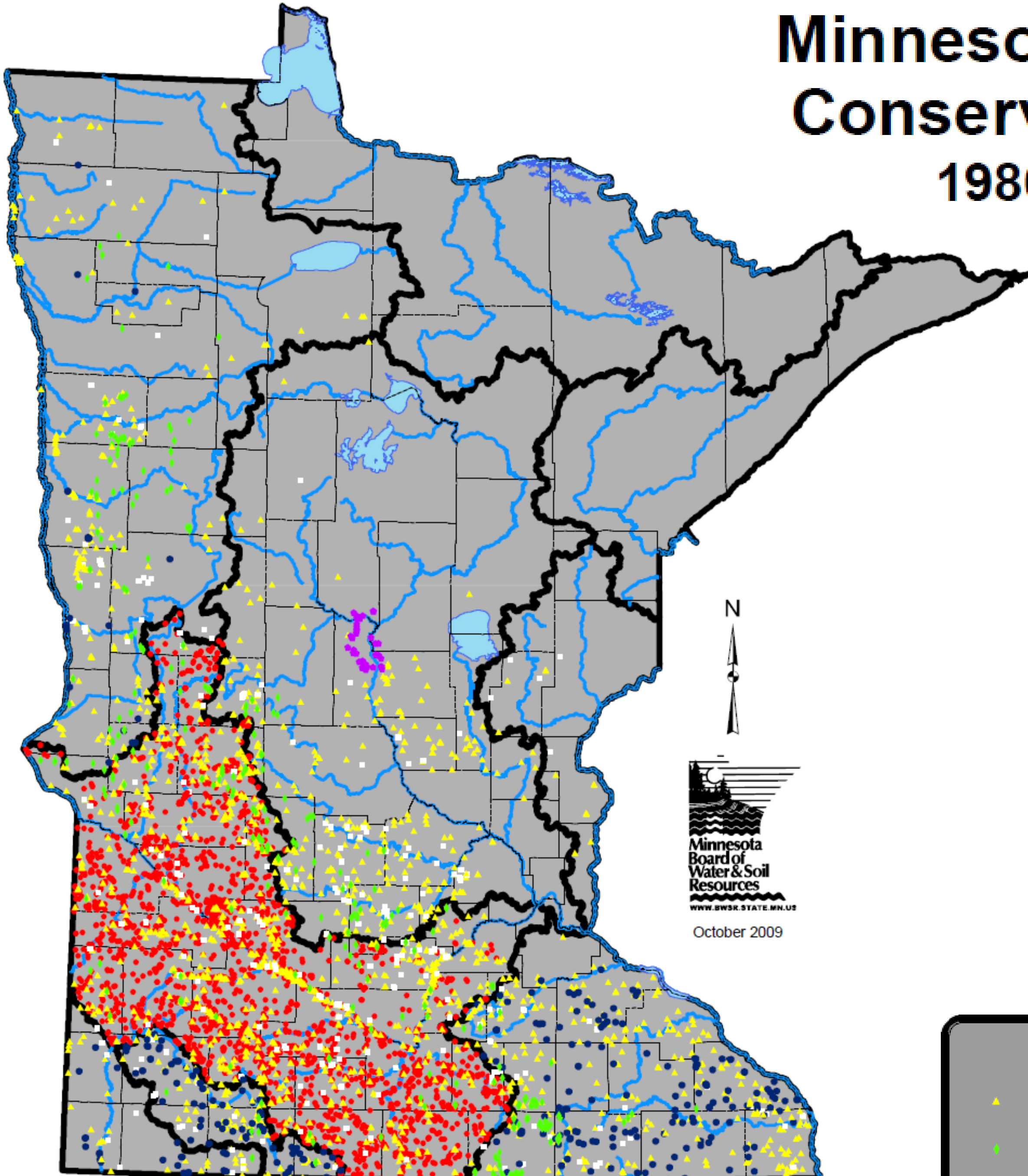
Seven Mile Creek Watershed Project

Brown Nicollet Cottonwood Water Quality Board

82% Average Reduction

Minnesota's State-Funded Conservation Easements

1986 - October 2009



RECORDED EASEMENTS

PROGRAM	NUMBER	ACRES
RIM Reserve	1,859	57,636
RIM-WRP	147	11,509
CREP I	2,479	100,292
CREP II	275	7,058
PWP	299	11,413
ACUB	35	5,417
TOTAL	**5,094**	**193,325**

EASEMENTS IN PROCESS

PROGRAM	NUMBER	ACRES
RIM Reserve	57	2,371
RIM-WRP	219	21,170
CREP II	8	265
ACUB	11	2,309
TOTAL	**295**	**26,115**

State Easement Programs

RIM Reserve
CREP II
River Basins
RIM-WRP
PWP
Major Rivers
CREP I
ACUB

Courtesy of Dr. Joel Peterson, 2009

Ditch, Impoundment & Treatment

– Culverts sizing
– Ditch modification/management
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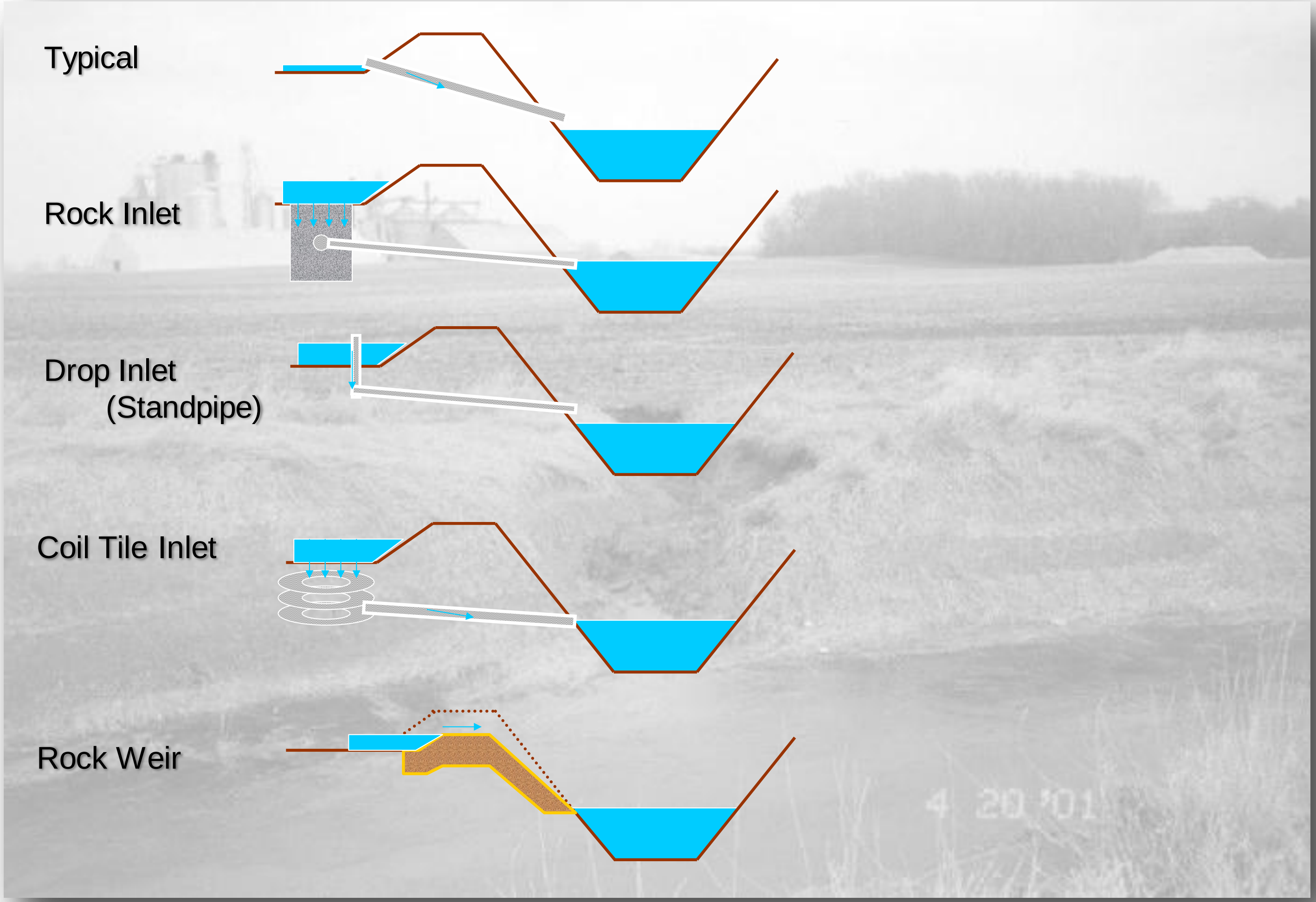
– Wetlands, impoundments
– Rock Inlets, side inlets

Side Inlets Contribute Water, Sediment, and Nutrients to Ditches



Courtesy of Dr. Joel Peterson, 2009

Summary

- Artificial drainage is needed and continues on many soils
- Many environmental concerns
- Merging production and environmental goals
- Golden Rule of Drainage
- Much ongoing education and research and much to do
- Many practices need greater traction
- Minnesota well connected

Drainage Publications

University of Minnesota Extension
www.extension.umn.edu

AGRICULTURAL DRAINAGE publication series

Soil Water Concep

The **Agricultural Drainage** series covers topics includin economics; environmental impacts; wetlands; and legal

The growing use of artificial subsurface or "tile" drainage in Minnesota has sparked much debate about its impact on local hydrology and water quantity and quality. Discussions are typically focused on the following questions that have important policy implications for local and state decision makers.

- Does subsurface drainage lessen or worsen localized flooding?
- Are catastrophic floods more frequent because of subsurface drainage?

This publication presents concepts that are fundament soil water and the water balance. It provides informatic crop/soil system and their relationship to drainage. In a drainage, soil water, and hydrology are addressed. Un broad issues and policy questions related to drainage

SUBSURFACE DRAINAGE

Artificial subsurface drainage continues to be a common practice in Minnesota, as well as in other states and countries around the world. Subsurface drainage is the practice of placing perforated pipe at a specified grade (slope) at some depth below the soil surface. Excess water from the crop root zone can enter the pipe through the perforations and flow away from the field to a ditch or other outlet. Subsurface drainage improves the productivity of poorly drained soils by lowering the water table, providing greater soil aeration, and enabling faster soil drying and warming in the spring. This may allow fields to be planted earlier and other field operations to take place in a timely fashion. It also provides a better environment for crop emergence and early growth, and can reduce soil compaction. Once a

AGRICULTURAL DRAINAGE publication series

Issues and Answ

The **Agricultural Drainage** series covers such topics economics; environmental impacts; wetlands; and le

WHAT IS AGRICULTURAL DRAINAGE?

Agricultural drainage is the use of surface ditches, subsurface permeable pipes, or both, to remove standing or excess water from poorly drained lands. During the late 1800s, European settlers in the Upp Midwest began making drainage ditches and channelizing (straightening and reshaping) streams to carry water from the wet areas of their farms to nearby streams and rivers. Later, farmers increased drainage by installing subsurface drainage pipes generally at a depth of three to six feet. Until the 1970s, most subsurface drainage pipes were made from short, cylindrical sections of concrete or clay called "tile." That is why terms like tile, tile drainage, and tiling are still used, even though most drainage pipe today is perforated polyethylene tubing. When installing a subsurface drainage system, pipes are either strategically placed in a field to remove water from isolated wet areas or installed in a pattern to drain an entire field. In some areas, surface inlets or intakes (risers extended from underground pipes to the surface) remove excess surface water from low spots in fields.

Poorly drained agricultural land

AGRICULTURAL DRAINAGE publication series

Planning an Agricul Subsurface Drainage S

The **Agricultural Drainage** series covers such topics as economics; environmental impacts; wetlands; and legal

GENERAL CONSIDERATIONS

Many soils in Minnesota and throughout the world would remain wet for several days after a rain without adequate drainage, preventing timely fieldwork, and causing stress on growing crops. Saturated soils do not provide sufficient aeration for crop root development, and can be an important source of plant stress. That's why artificial drainage of poorly draining soils has become integral to maintaining a profitable crop production system. Some of the world's most productive soils are drained, including 25 percent of the farmland in the United States and Canada.

Planning an effective drainage system takes time and requires consideration of a number of factors, including:

- Local, state, and federal regulations
- Soil information
- Wetland impact
- Adequacy of system outlet
- Field elevation, slope (grade), and topography assessment
- Economic feasibility
- Present and future cropping strategies
- Environmental impacts associated with drainage discharge
- Easements and right-of-ways
- Quality of the installation

The U.S. Department of Agriculture (USDA) Food Security Act and the farm bills of 1985, 1990, and 1996 created many special wetlands restrictions and mandates that all drainage projects, including upgrades, must follow. It's also very important that the landowner, system designer, and contractor understand other applicable federal laws, as well as the local watershed and state laws dealing with

WQ-44

DRAINAGE WATER MANAGEMENT for the Midwest

Questions and Answers About Drainage Water Management for the Midwest

Jane Frankenberger, Eileen Kladivko, Gary Sands, Dan Jaynes, Norm Fausey, Matt Helmers, Richard Cooke, Jeff Strock, Kelly Nelson, Larry Brown

Purdue University
University of Minnesota
Iowa State University
University of Missouri
University of Illinois
The Ohio State University
USDA-Agricultural Research Service

Purdue Extension Knowledge to Go 1-888-EXT-INFO

Introduction

Subsurface tile drainage is an essential water management practice on many highly productive fields in the Midwest. However, nitrate carried in drainage water can lead to local water quality problems and contribute to hypoxia in the Gulf of Mexico, so strategies are needed to reduce the nitrate loads while maintaining adequate drainage for crop production. Practices that can reduce nitrate loads on tile-drained soils include growing winter forage or cover crops, fine-tuning fertilizer application rates and timing, bioreactors, treatment wetlands, and modifying drainage system design and operation. Drainage water management is one of these practices and is described in this fact sheet. Answers given here apply specifically to Midwest corn and soybean cropping systems, and not to perennial or winter annual crops.

1. What is drainage water management?

Drainage water management is the practice of using a water control structure in a main, submain, or lateral drain to vary the depth of the drainage outlet. The water table must rise above the outlet depth for drainage to occur, as illustrated at right. The outlet depth, as determined by the control structure, is:

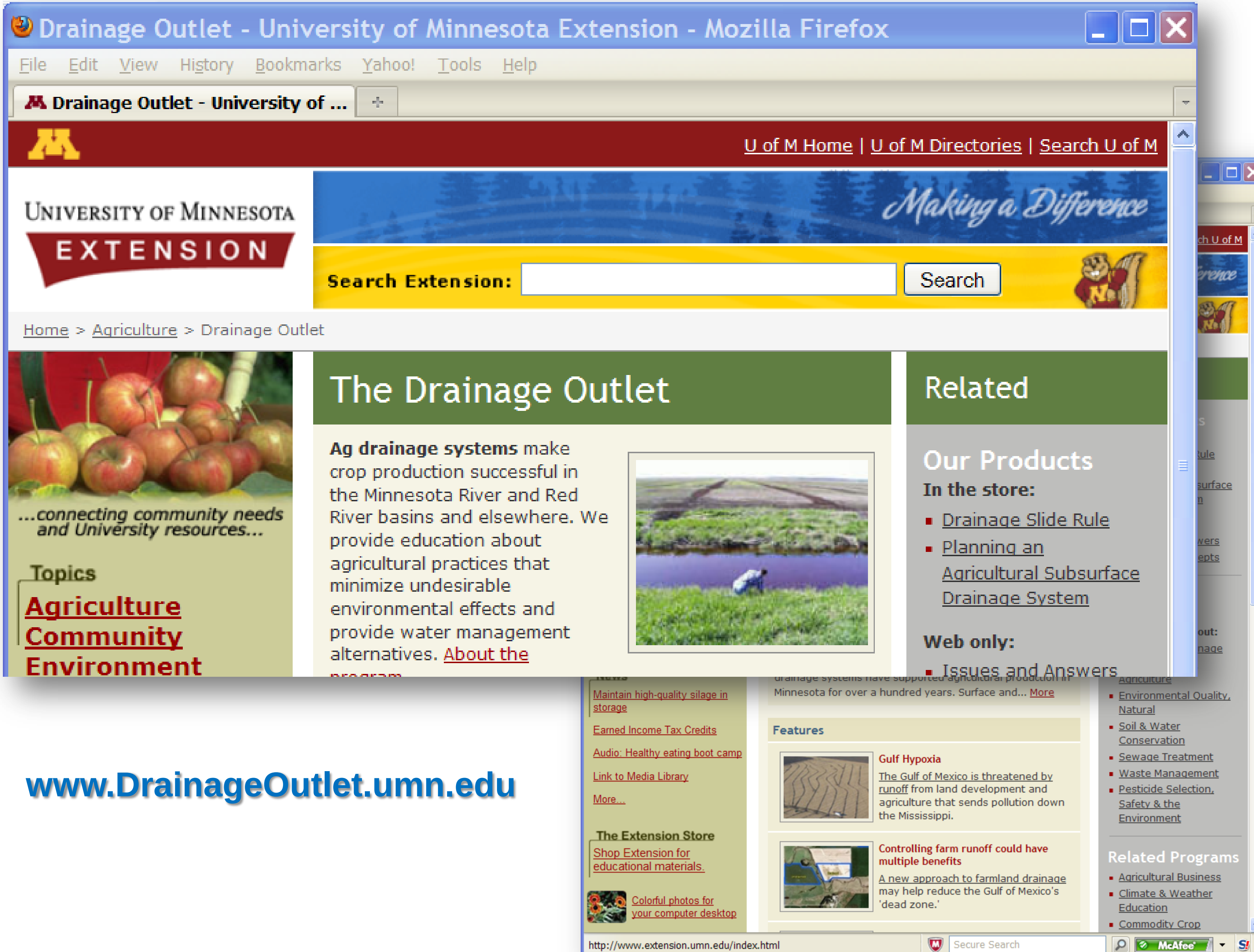
- Raised after harvest to limit drainage outflow and reduce the delivery of nitrate to ditches and streams during the off-season. (Figure 1)
- Lowered in early spring and again in the fall so the drain can flow freely before field operations such as planting or harvest. (Figure 2)
- Raised again after planting and spring field operations to create a potential to store water for the crop to use in midsummer. (Figure 3)

Outlet

Figure 1. The outlet is raised after harvest to reduce nitrate delivery.

Figure 2. The outlet is lowered a few weeks before planting and harvest to allow the field to drain more fully.

Figure 3. The outlet is raised after planting to potentially store water for crops.



www.DrainageOutlet.umn.edu

Minnesota

11th Annual

Drainage Research Forum

Iowa

November 23rd, 2010

Cabela's

Owatonna, Minnesota

9:00am – 4:30pm


Thank You!
Questions?
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