A Landscape View of Subsurface Tile, Nutrient Loss, and Conservation Drainage

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Transforming Drainage Project

TRANSFORMING DRAINAGE.ORG
Managing Water for Tomorrow's Agriculture

Crops, like people, need water to thrive

Not too much, not too little.

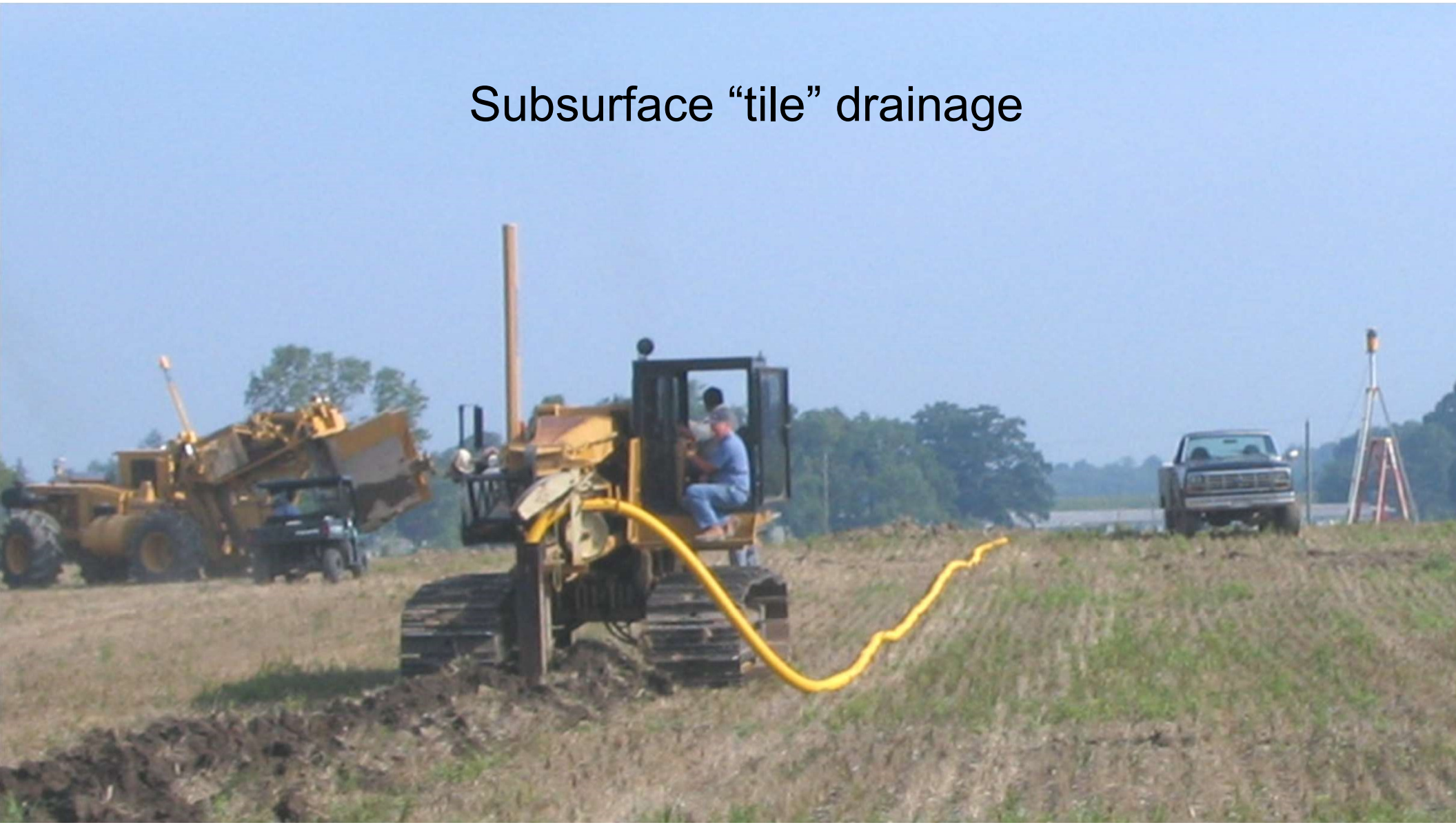
But in some years….

Too much (June)

Then too little (July)

Other years (2019) we just have too much.
But Midwest farmers are highly skilled at managing **excess** water.

Subsurface “tile” drainage




BUCKEYE
FINDLAY OHIO
USA

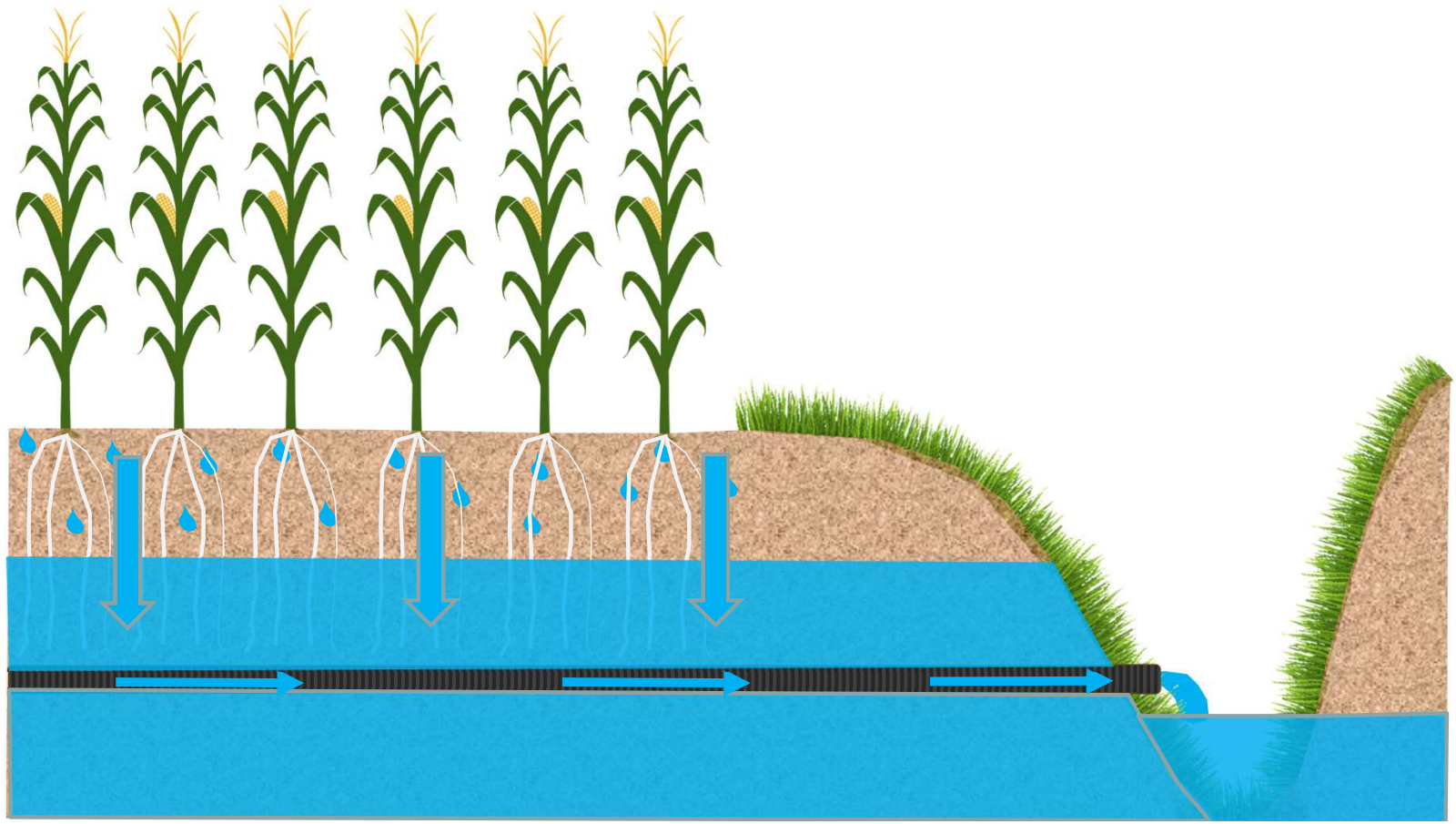
Tile drainage is increasing around the Midwest.

Drainage installation field day at Davis Purdue Ag Center


HYDRAMAXX
3300
PORT
INDUSTRIES

Impressive drainage infrastructure for getting rid of excess water

Tile drainage works year-round by lowering the water table



Side Effects of Drainage: Contaminants from drainage water…

Lead to poor water quality

Photo by Tom Bridgeman

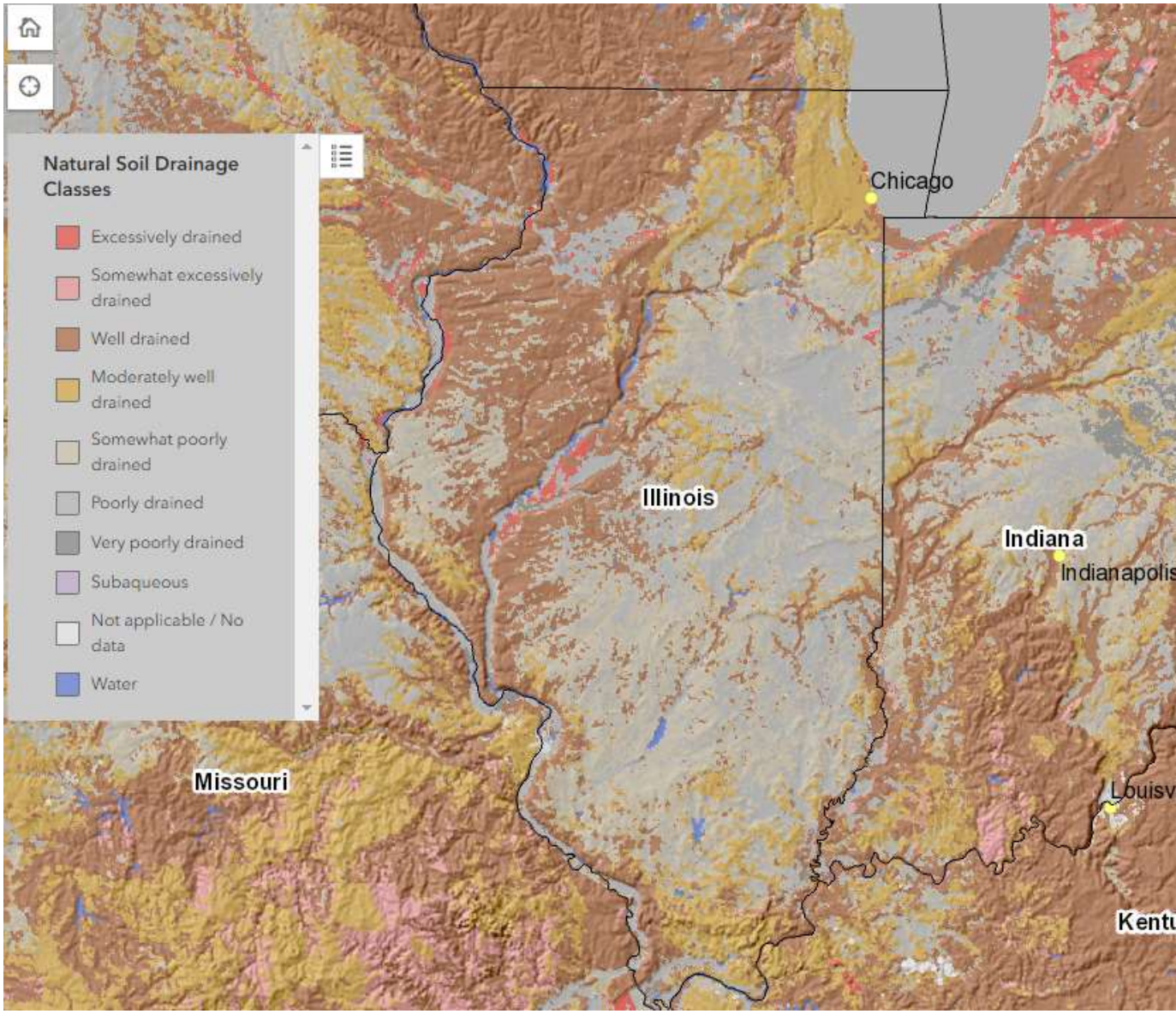
Surface runoff also carries pollution, but has greatly reduced thanks to soil conservation efforts since the 1930s.

Photo courtesy NRCS

Much of Illinois is poorly drained

Natural Soil Drainage Class

“Soil Explorer”
http://soilexplorer.net



Two problems

Sometimes too much → Sometimes too little

Crop yields are often reduced due to lack of water.


How will this situation
change in the future?

Sometimes too much; sometimes too little.

Both intensifying as **extreme weather increases**.

Spring: More runoff and nutrient loss

Summer: More drought and crop yield loss

In periods with too much water already, we expect more in the future

More water quality problems

Photo: Tom Bridgeman

More flooding

Photo: Reuters Media from Hurricane Florence, 2018

In periods with too little water already, we expect drier conditions in the future

More crop loss

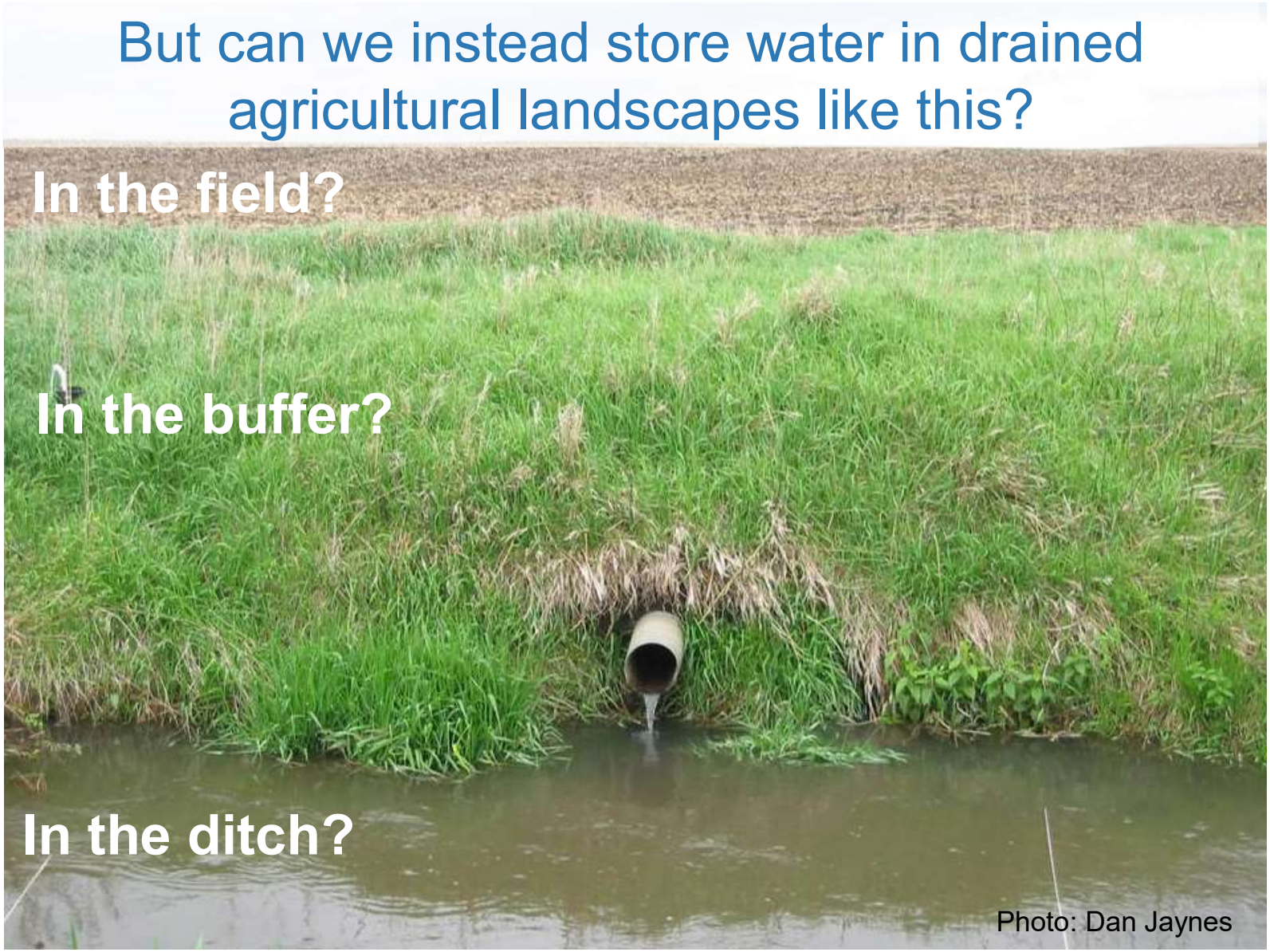
More need for irrigation using potentially scarce water supplies

A solution:
Storing more water in the landscape

The goal in agricultural drainage has been to get rid of excess water as quickly as possible.

We regularly install water storage as part of urban development

But can we instead store water in drained agricultural landscapes like this?



Storing water in the soil
Increasing soil health.

- Increasing soil organic matter can increase water holding capacity.

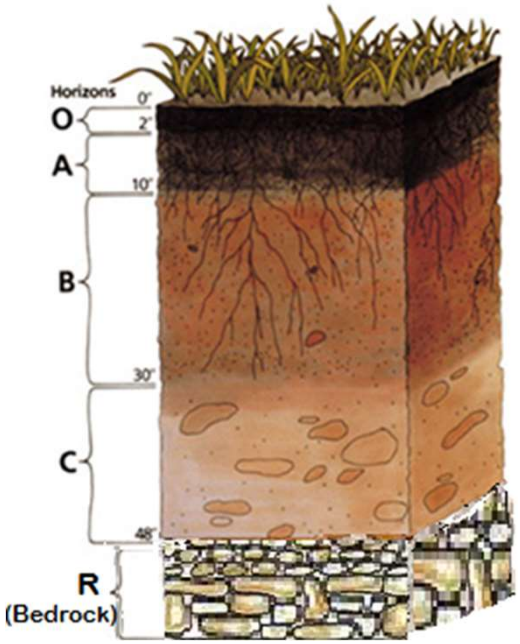
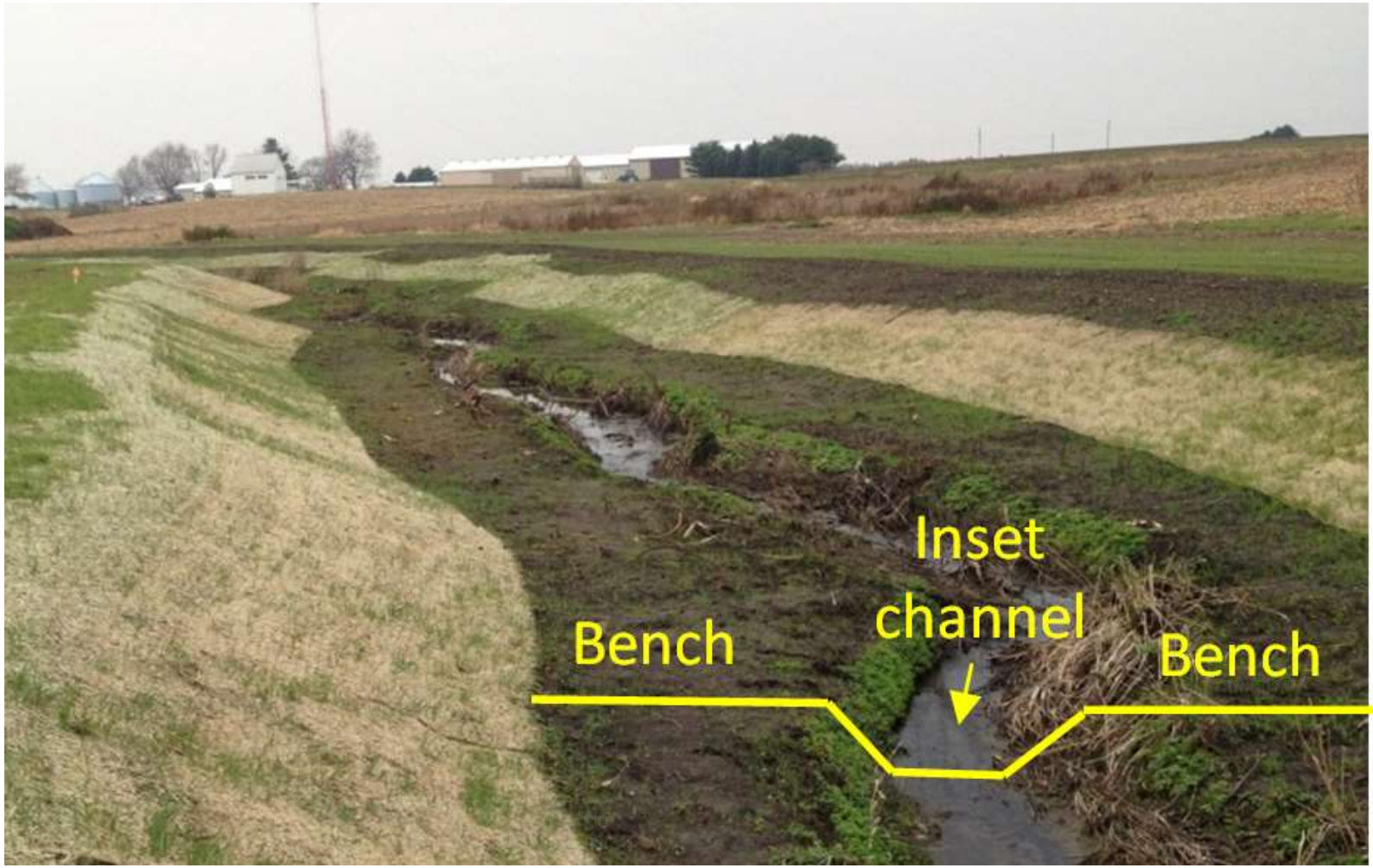


Image: Wikimedia Commons, Wilsonbriggs

Image: NRCS

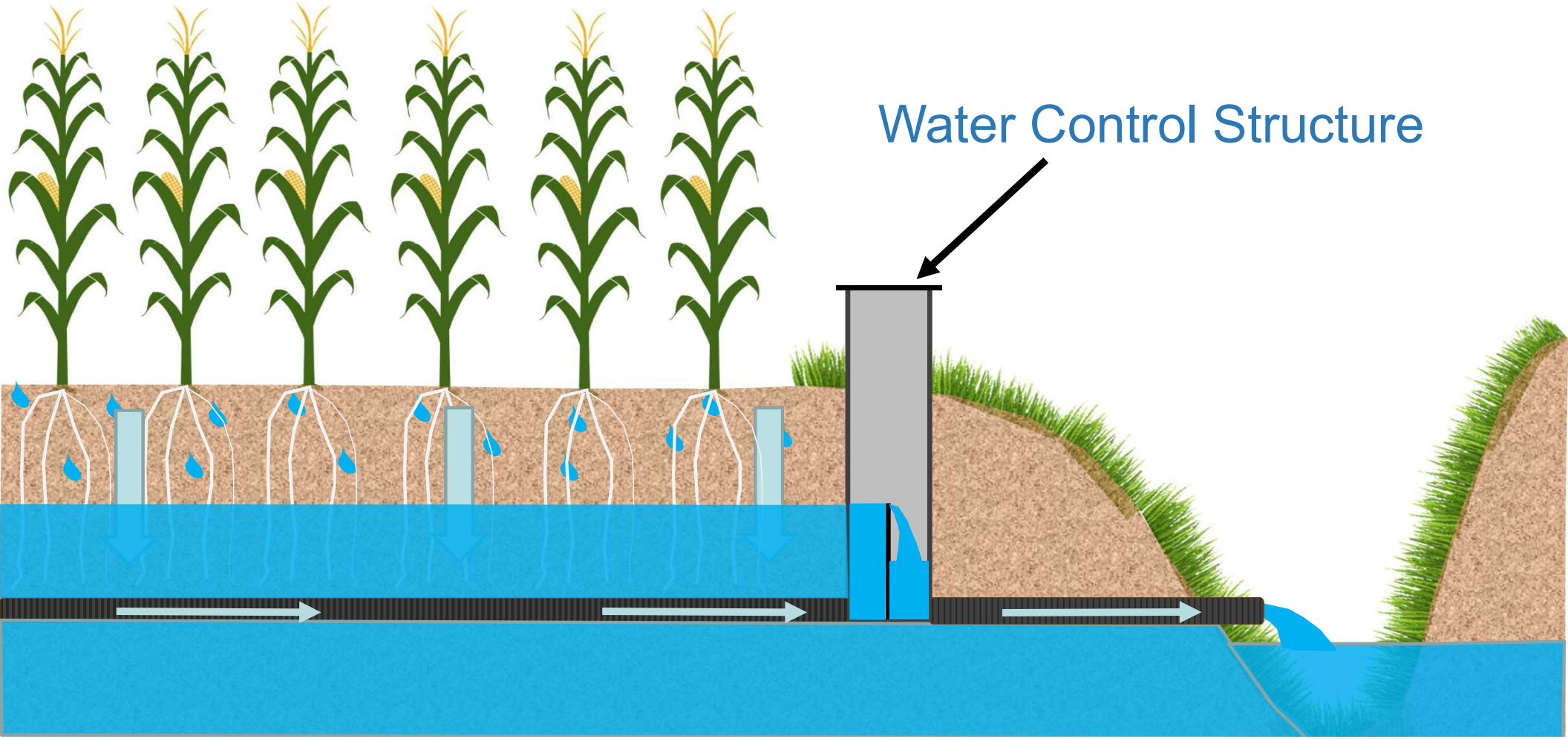
Storing water in wider ditches:
Two-Stage Ditches

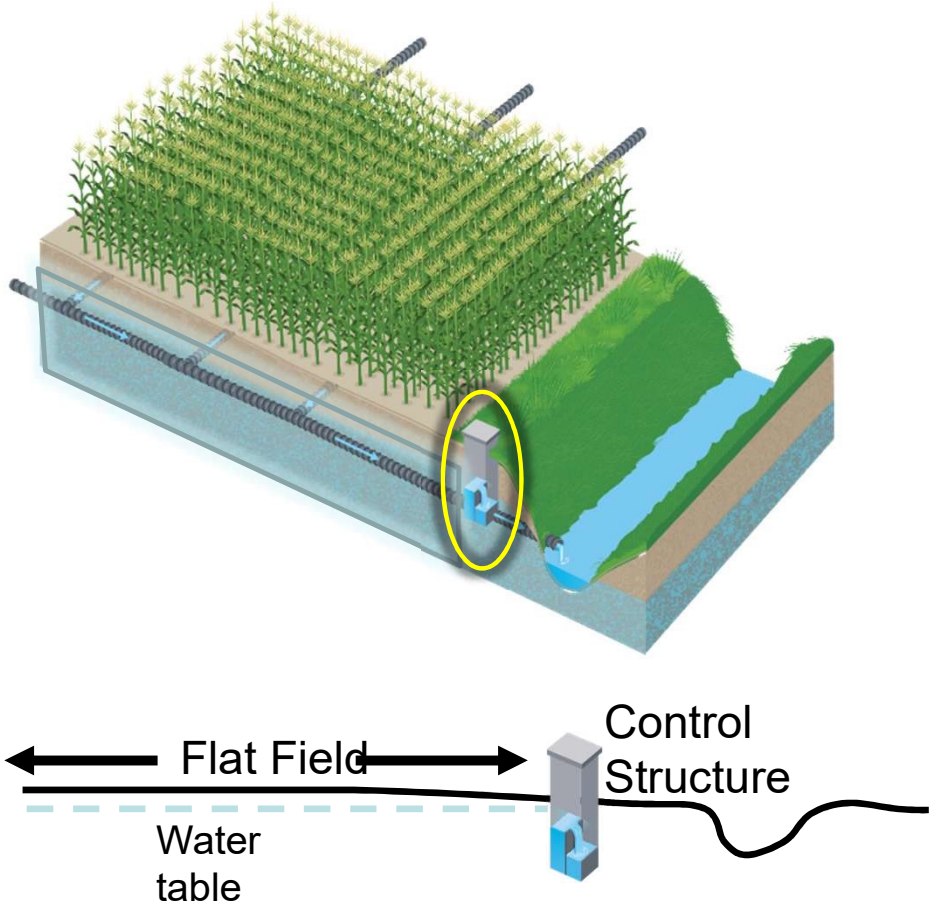


Trapezoidal ditches were once the only standard, but they can be modified to store water and support aquatic ecosystems.

Storing water in the field:
Controlled drainage

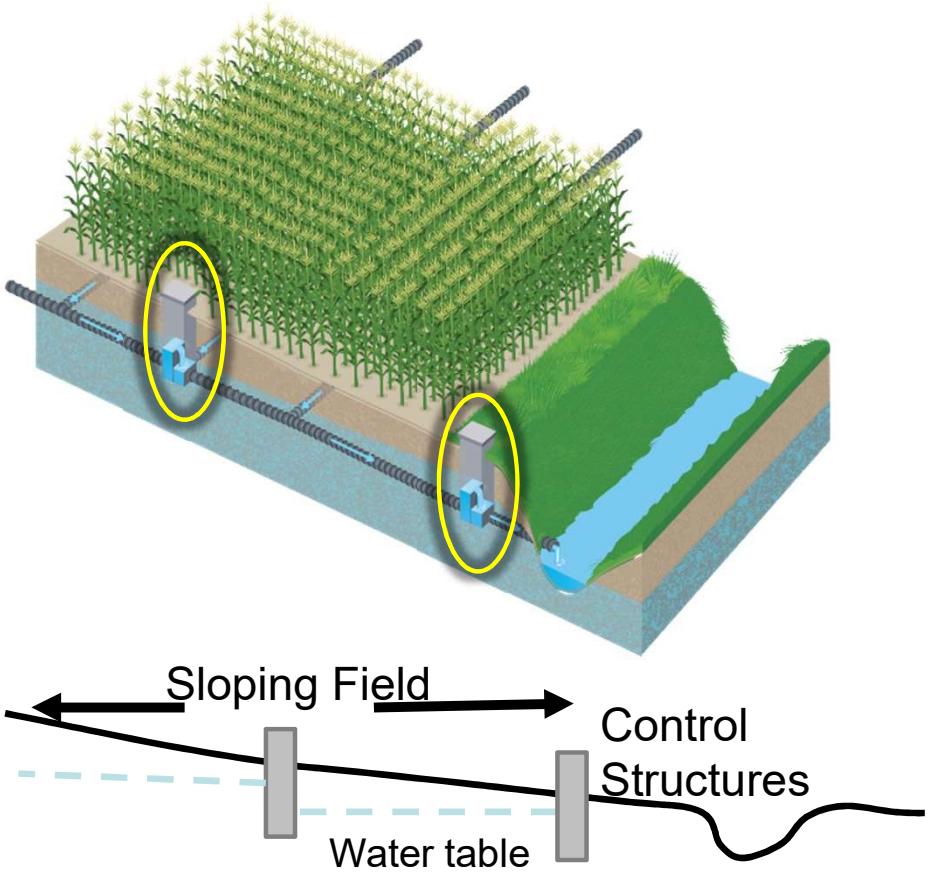
Storing water in the field: Controlled drainage





Suitability for Controlled Drainage

1. Poorly drained soils
2. Slope is < 1%



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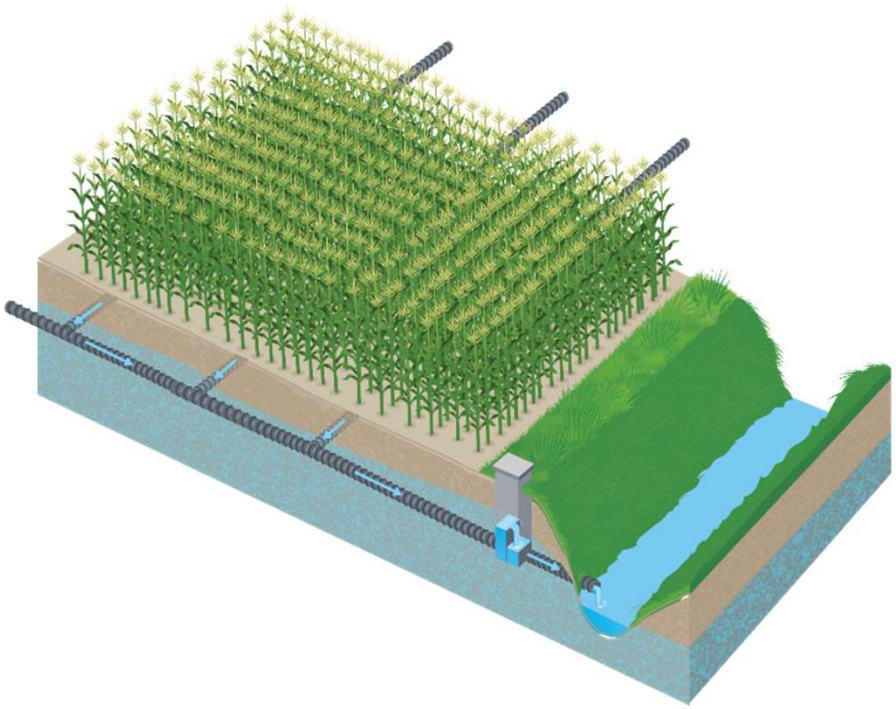
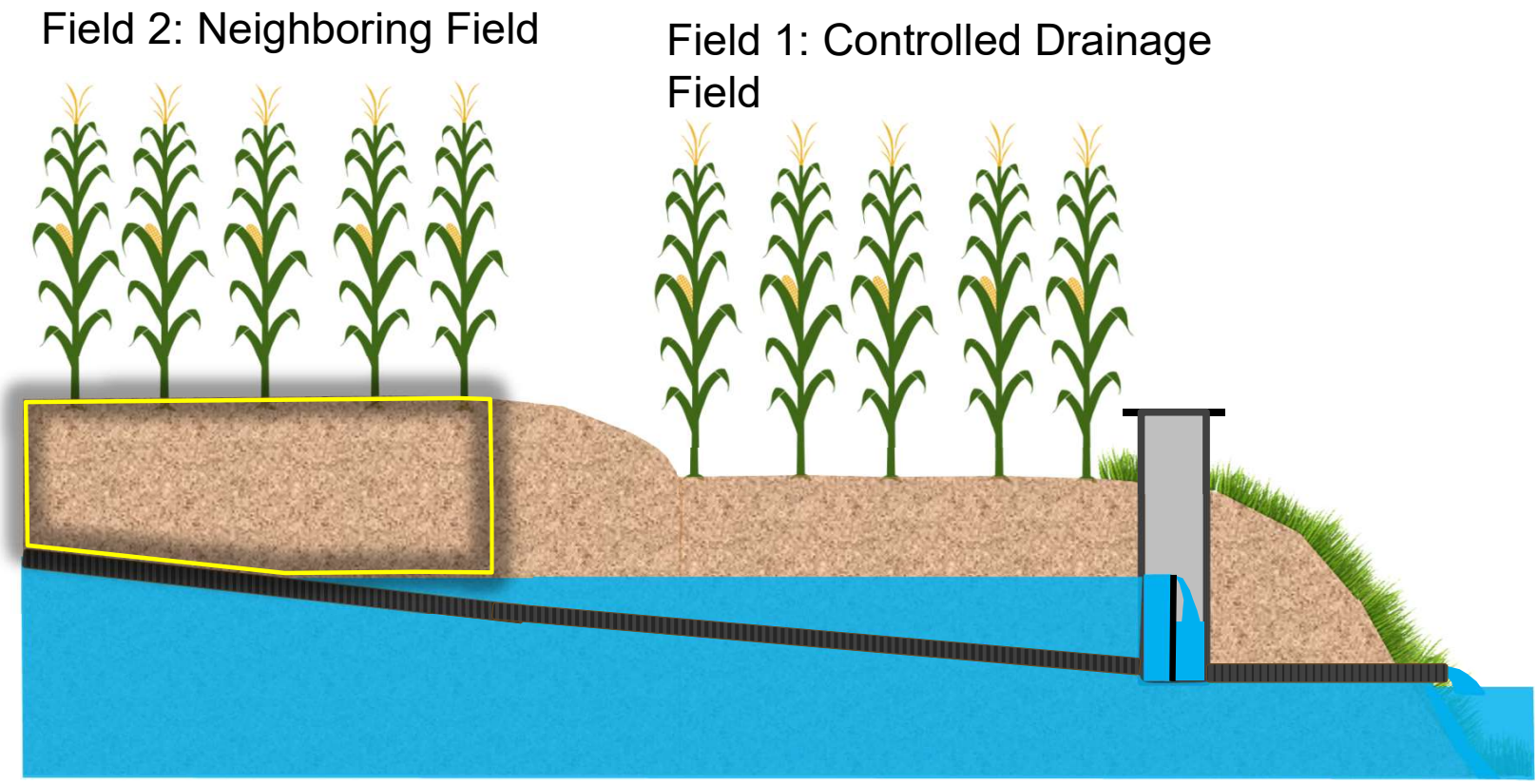


Suitability for
Controlled Drainage

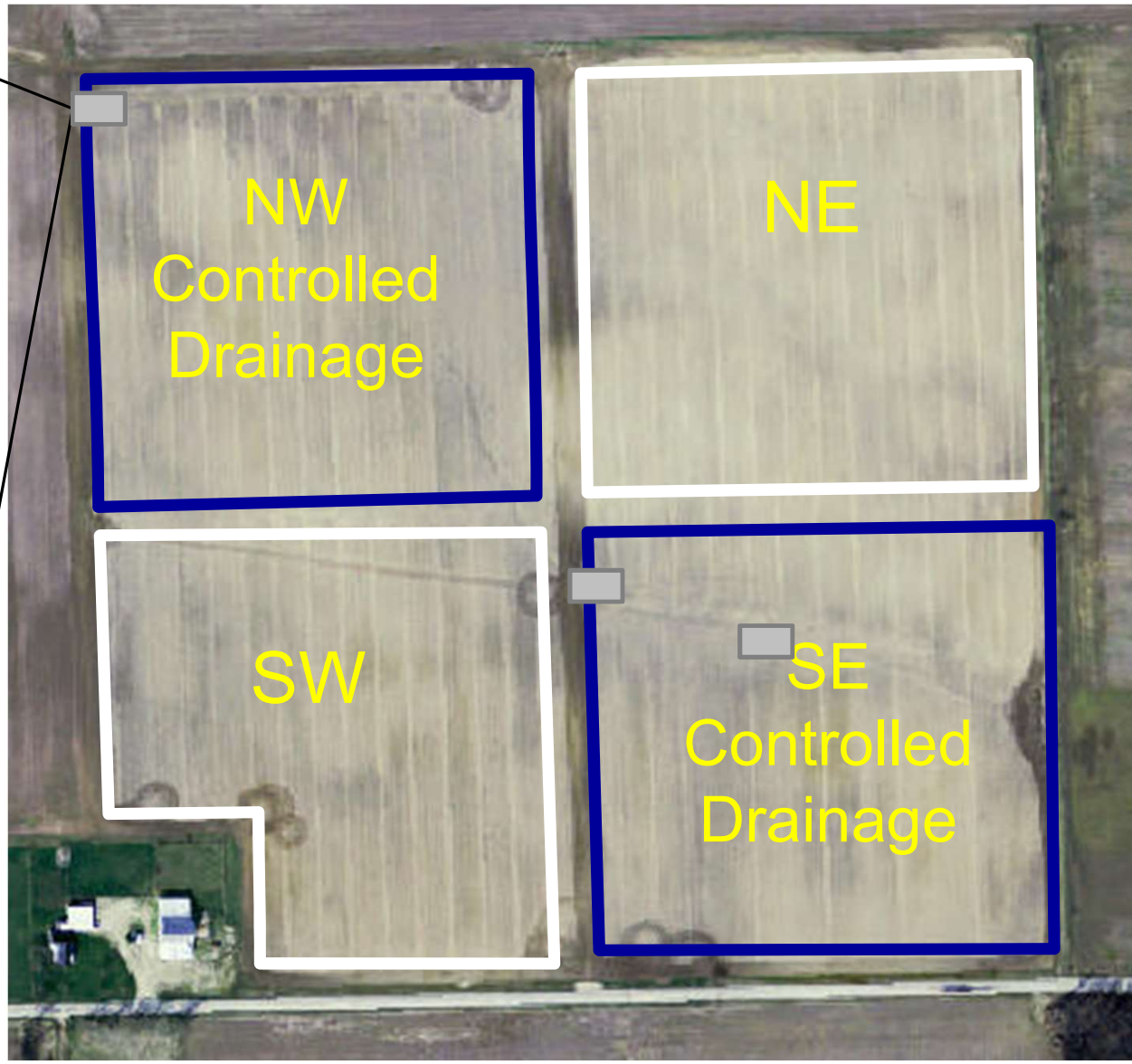
1. Poorly drained soils

2. Slope is < 1%

3. Drainage can be
   managed without
   affecting neighbors


Field 2: Neighboring Field
Field 1: Controlled Drainage Field


Controlled Drainage
at the
Davis Purdue Agriculture Center


NW
Controlled
Drainage
NE
SW
SE
Controlled
Drainage

Raw Yield Data

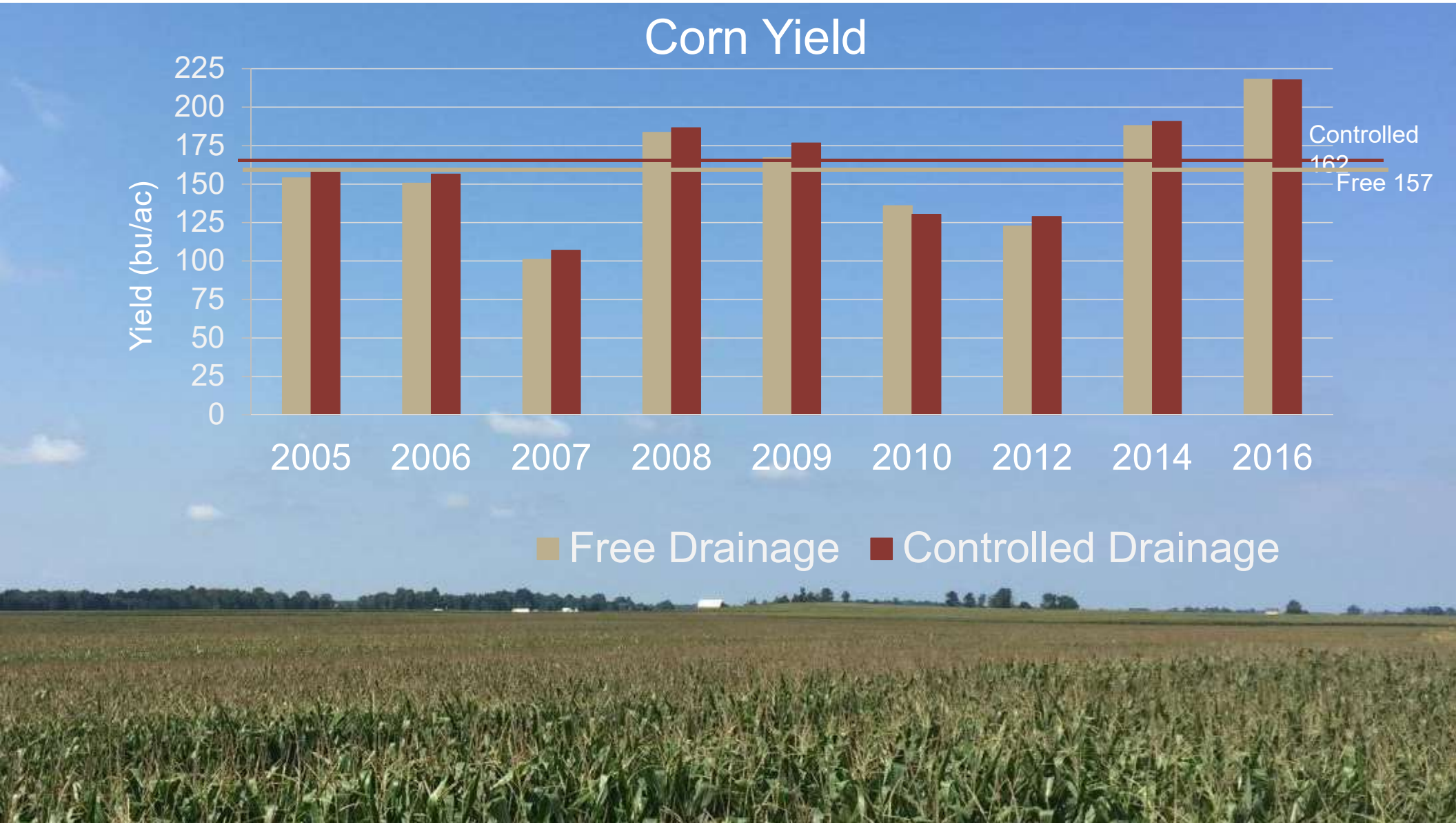
Yield (bu/ac)

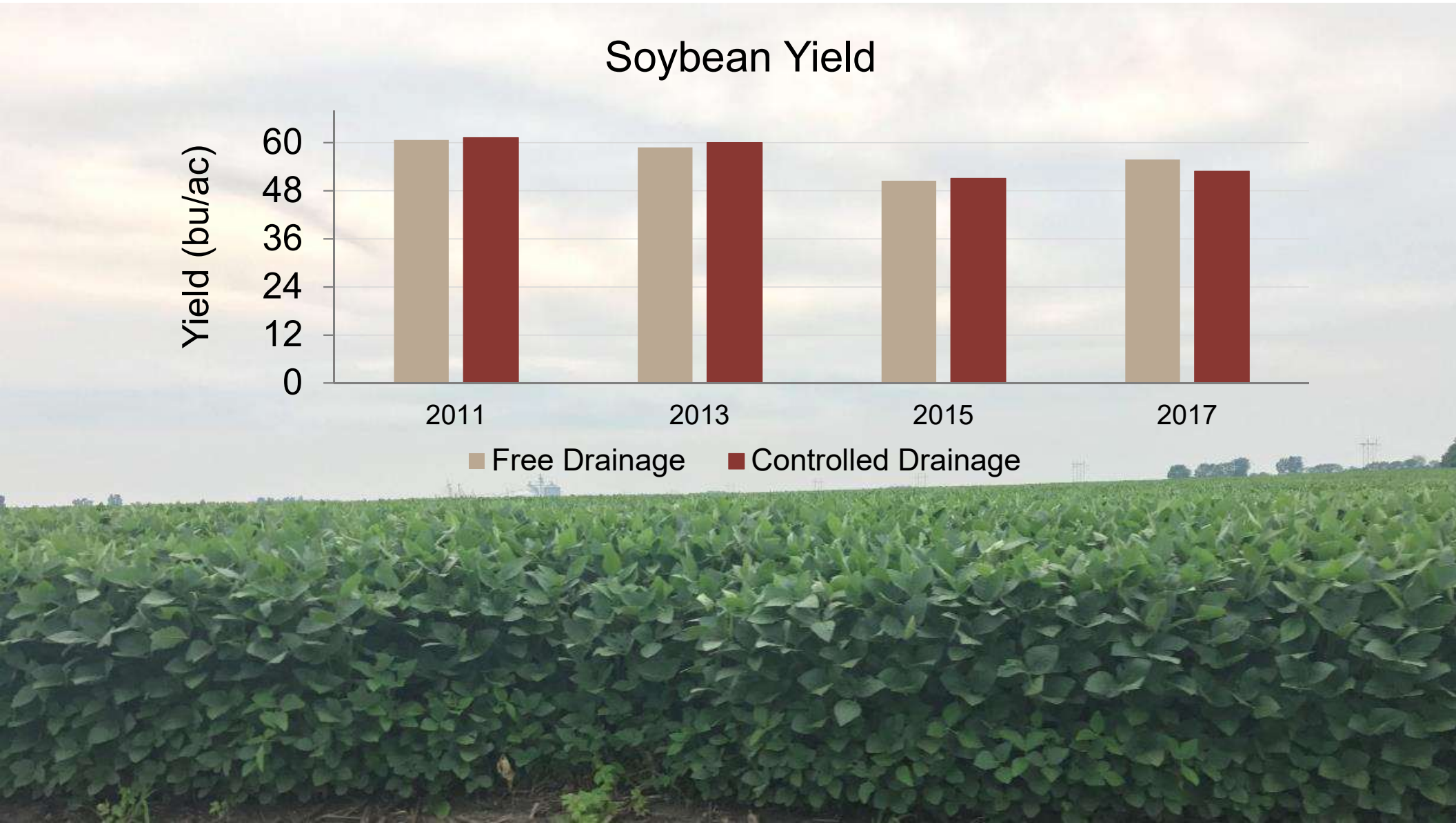
- ≤80
- ≤100
- ≤120
- ≤140
- ≤180
- ≤200
- >200

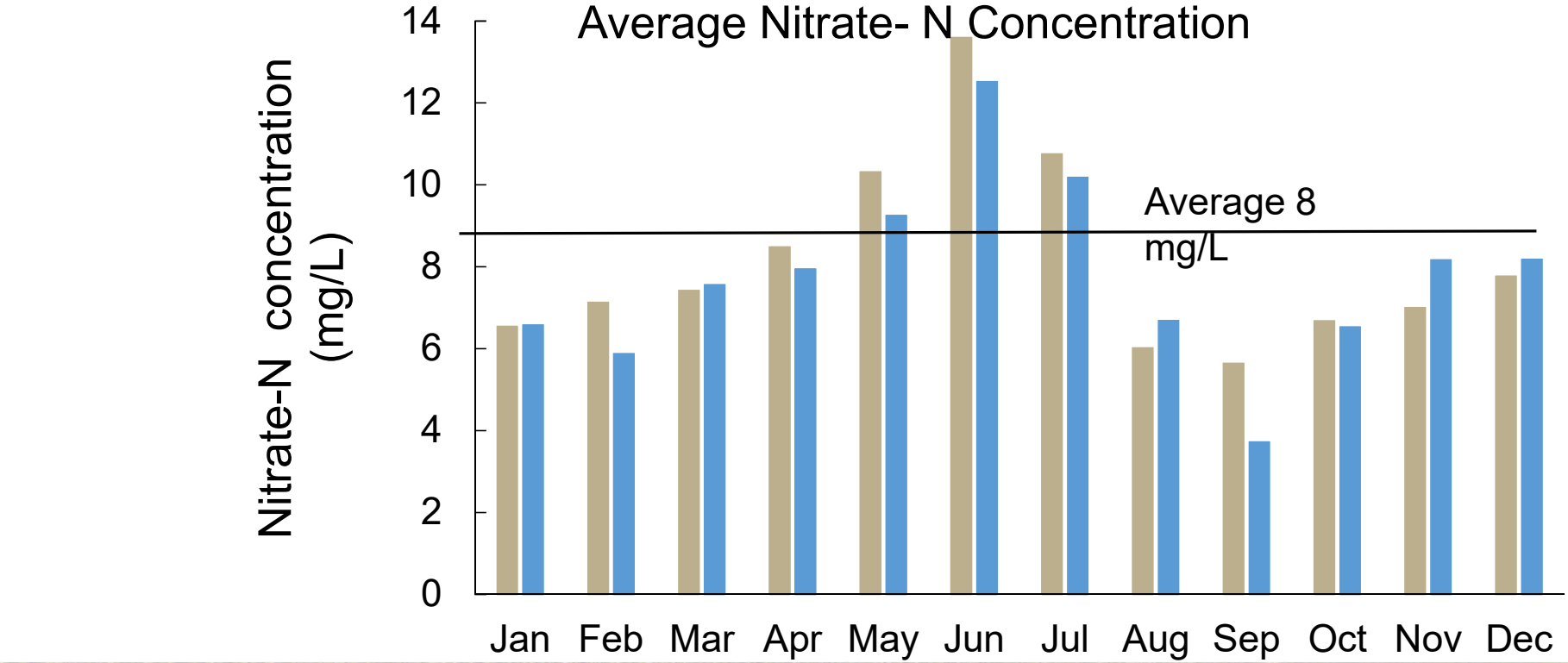
Processed Yield Data

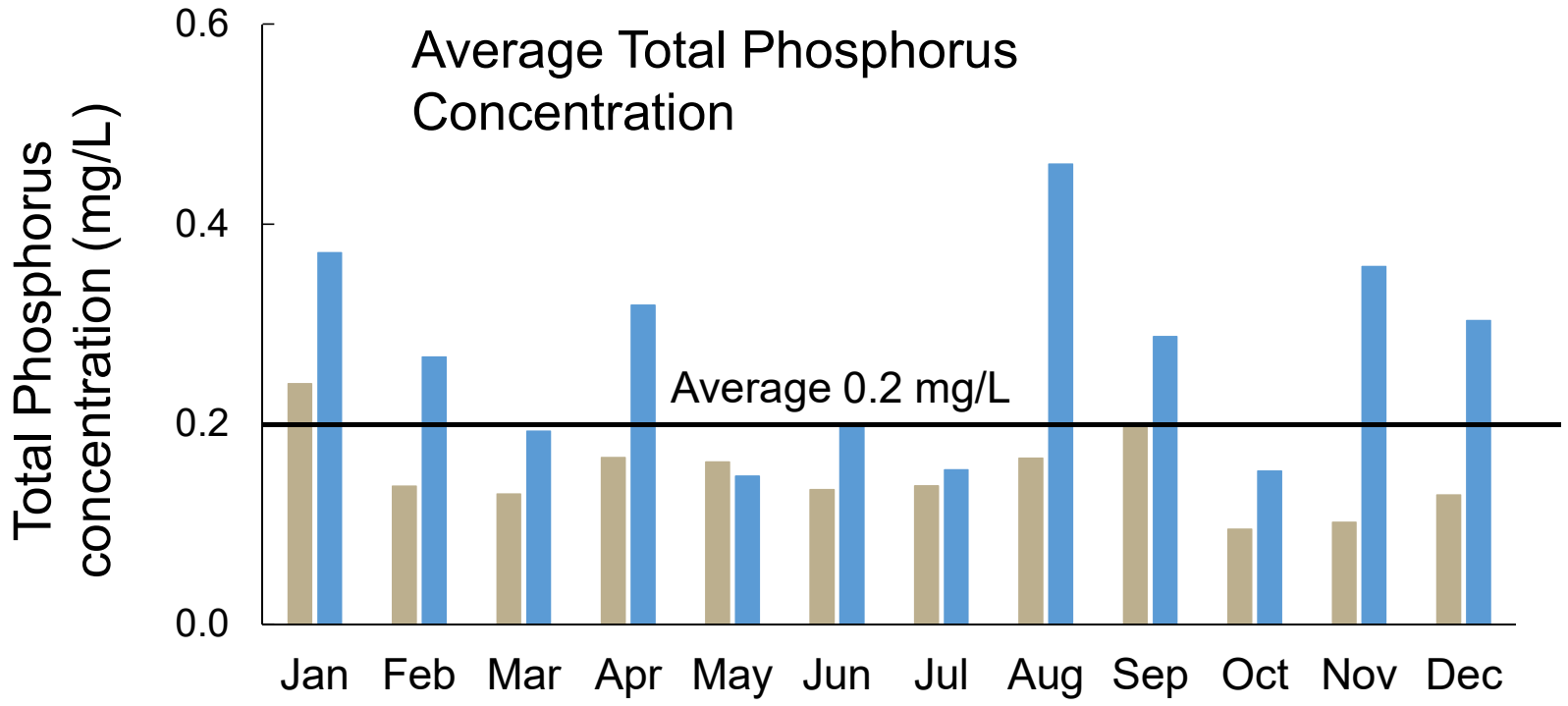
Controlled Drainage (CD)

Free Drainage (FD)


Corn Yield
Yield (bu/ac)
225
200
175
150
125
100
75
50
25
0
2005
2006
2007
2008
2009
2010
2012
2014
2016
Controlled 162
Free 157
Free Drainage
Controlled Drainage


Soybean Yield
Yield (bu/ac)
60
48
36
24
12
0
2011
2013
2015
2017
Free Drainage
Controlled Drainage

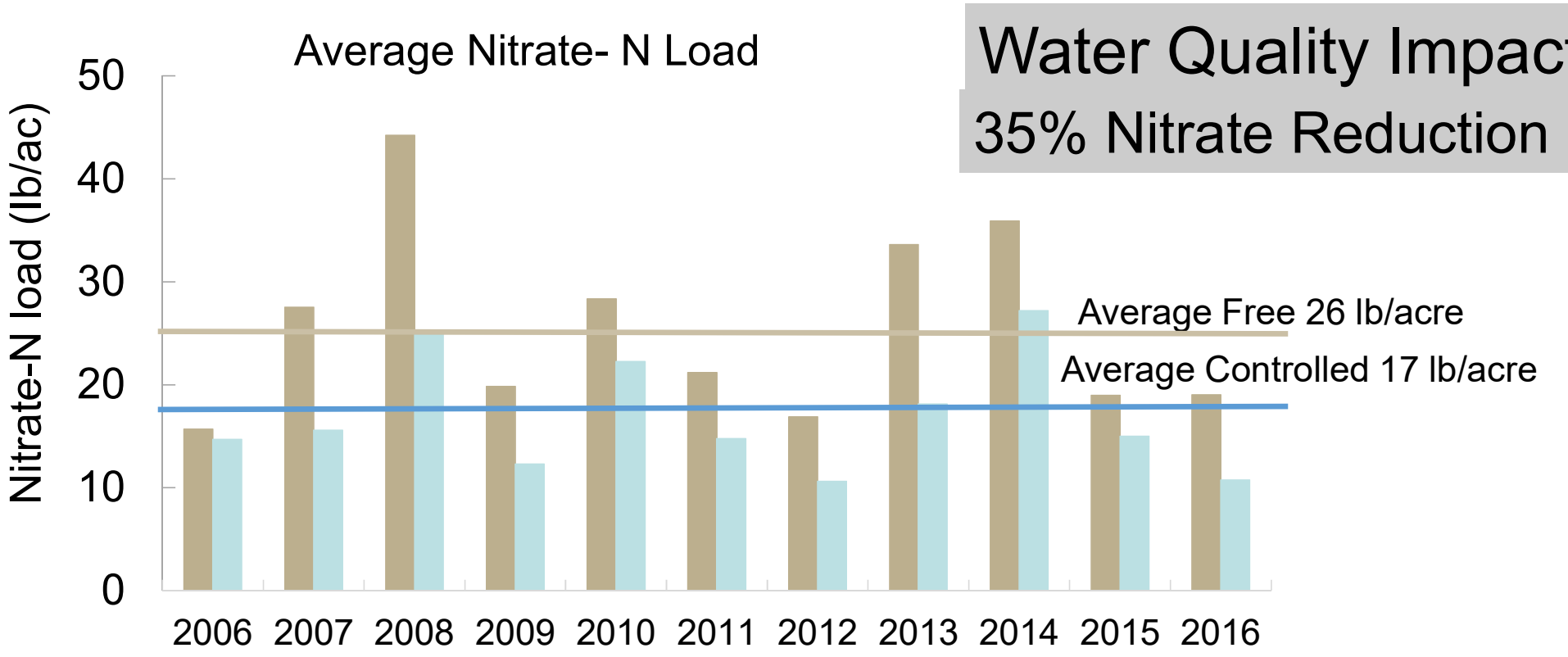

Average Nitrate- N Concentration
Nitrate-N concentration (mg/L)
14
12
10
8
6
4
2
0
Average 8 mg/L
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

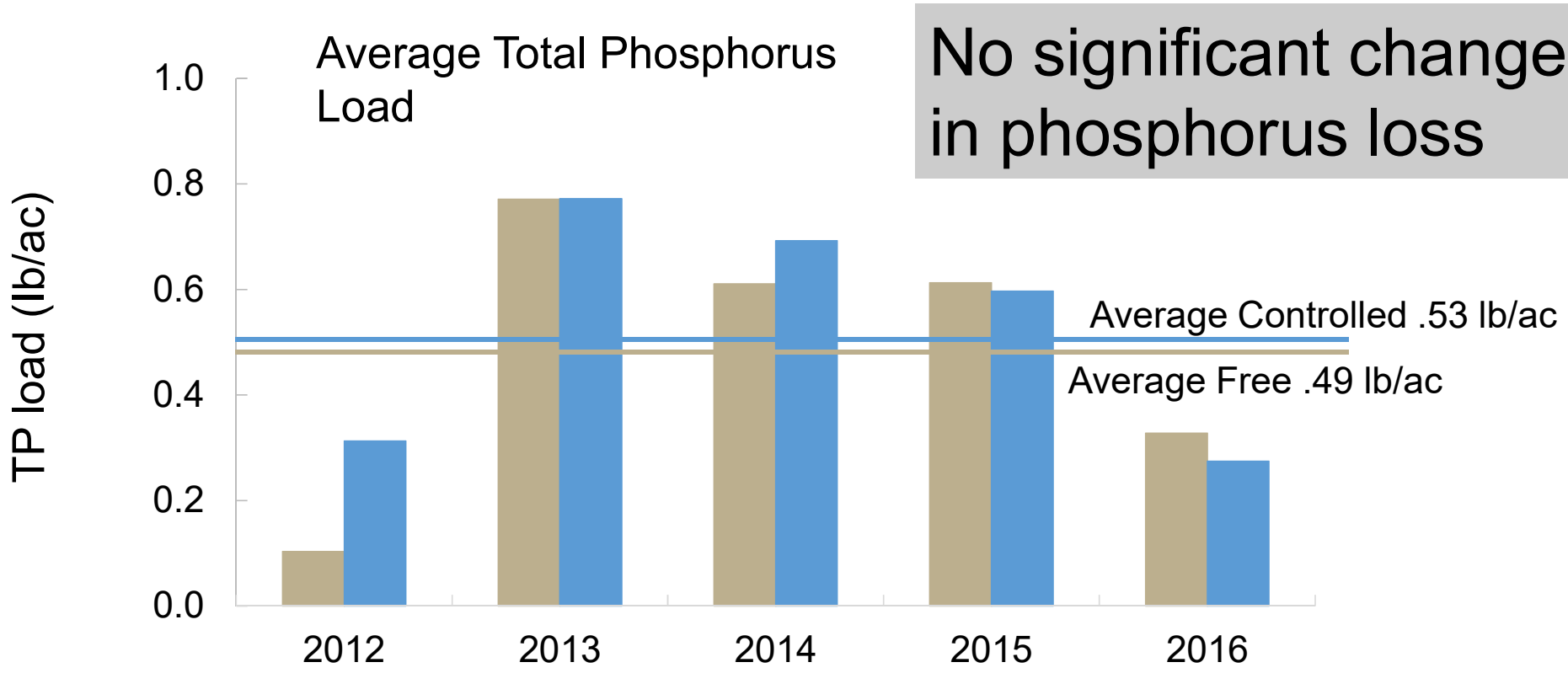

Average Total Phosphorus Concentration
Total Phosphorus concentration (mg/L)
0.6
0.4
0.2
0.0
Average 0.2 mg/L
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec


NO3
-

Water Quality Impact

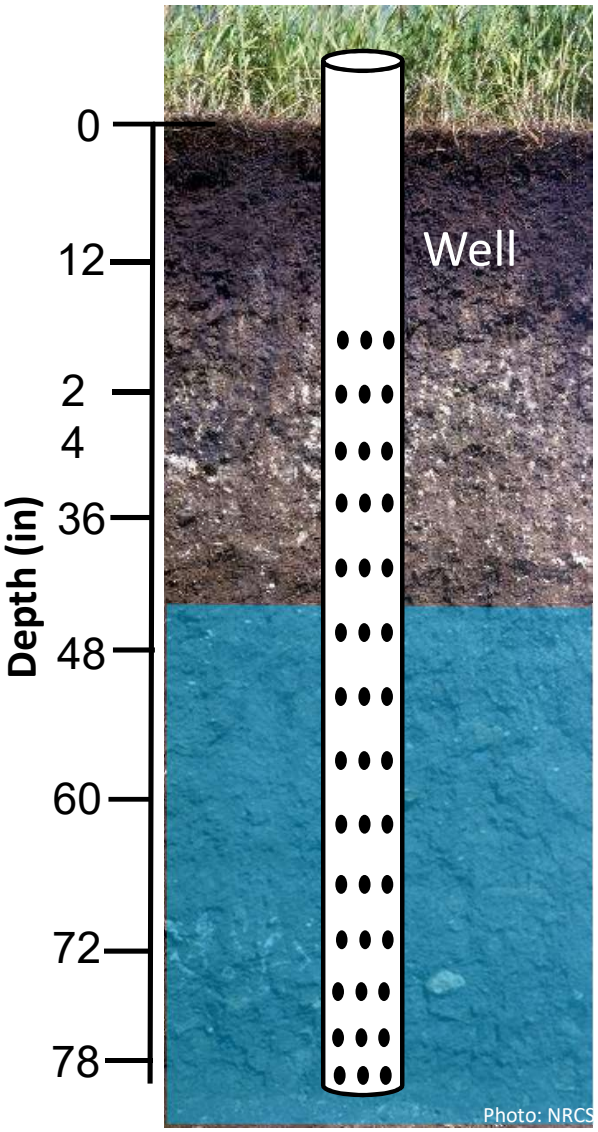
35% Nitrate Reduction

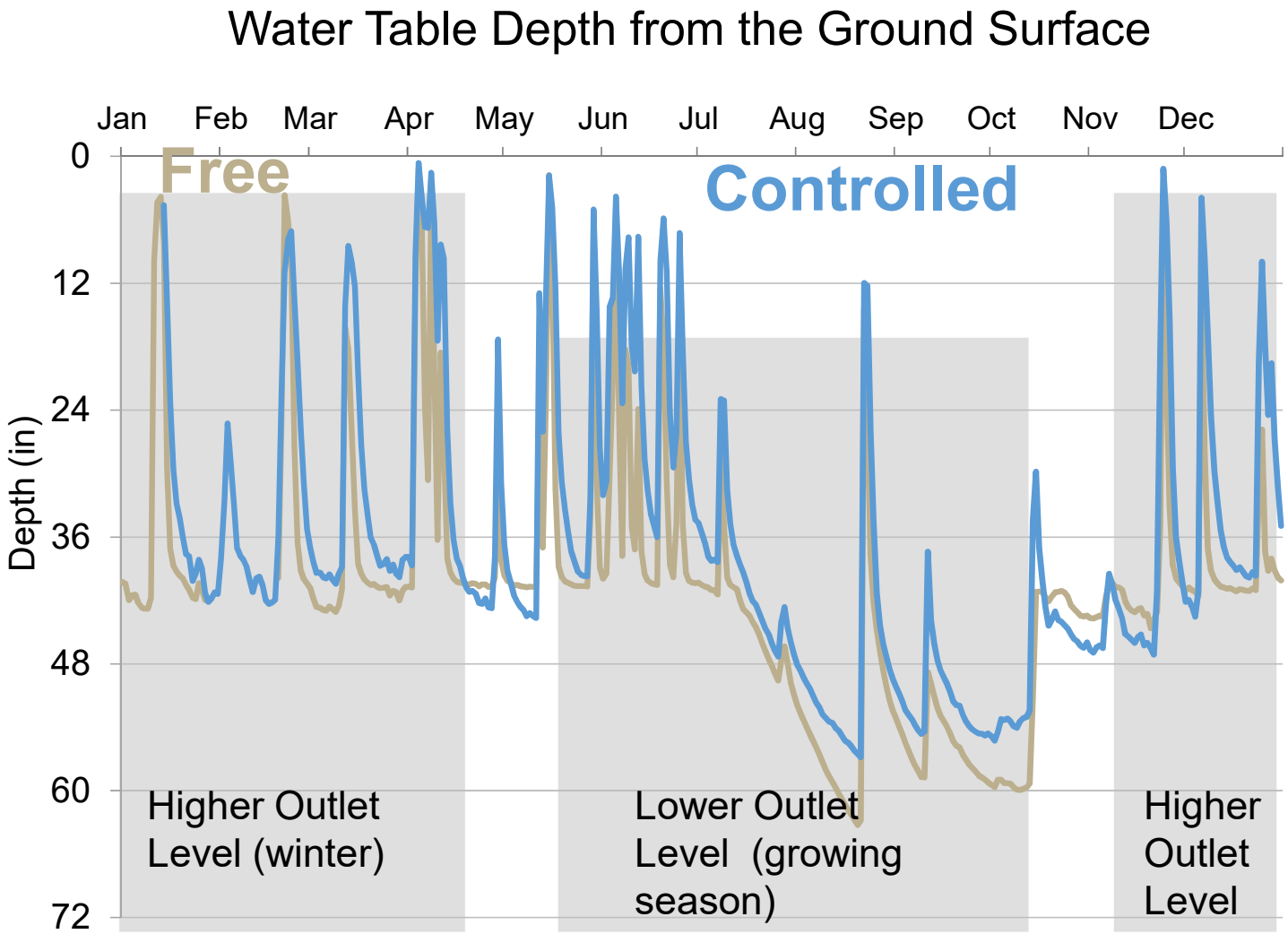


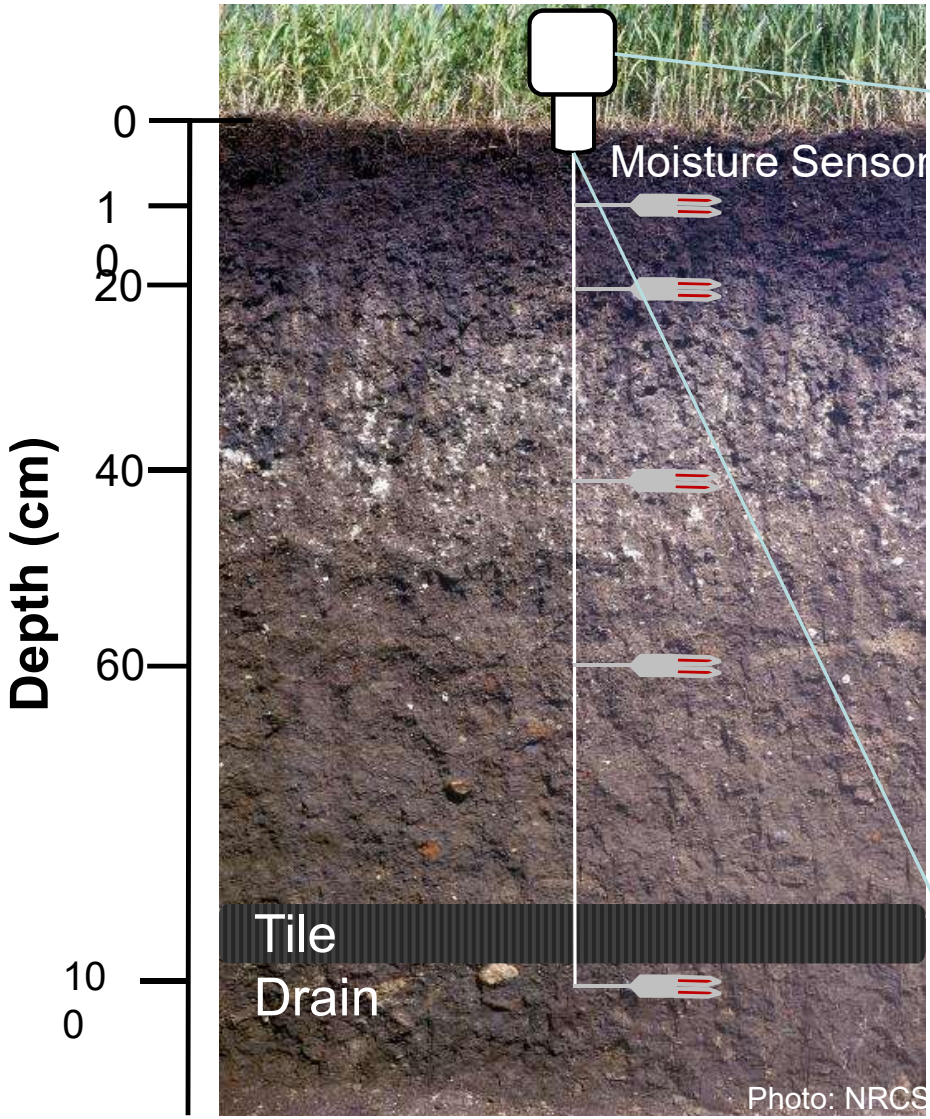


No significant change in phosphorus loss


Depth (in)
0
12
2
4
36
48
60
72
78
Well
Photo: NRCS

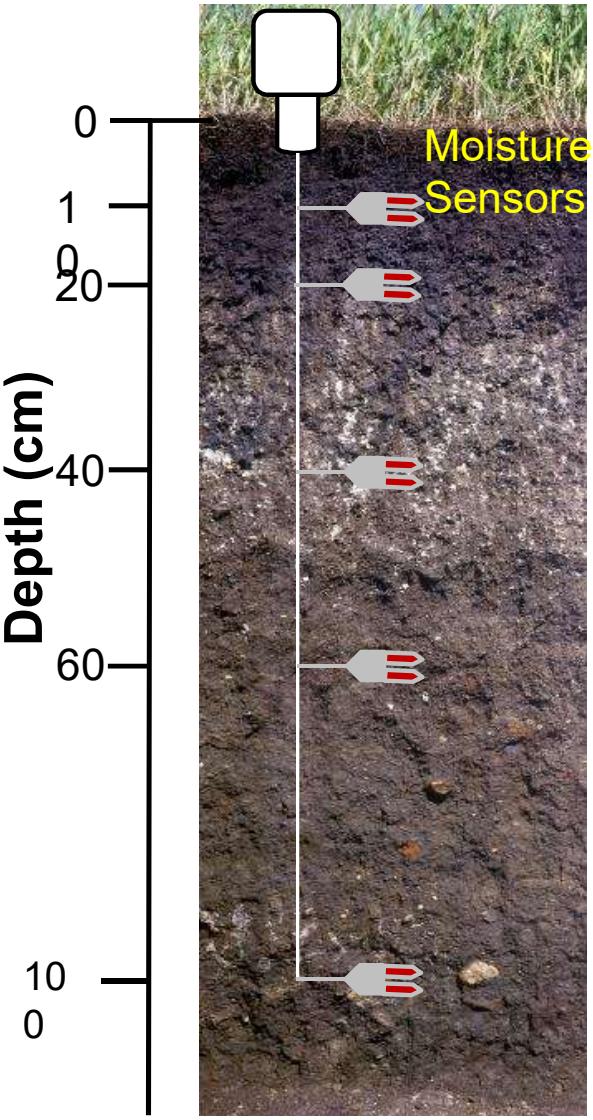

0
12
2
4
36
48
60
72
78
Depth (in)
Well
Photo: NRCS

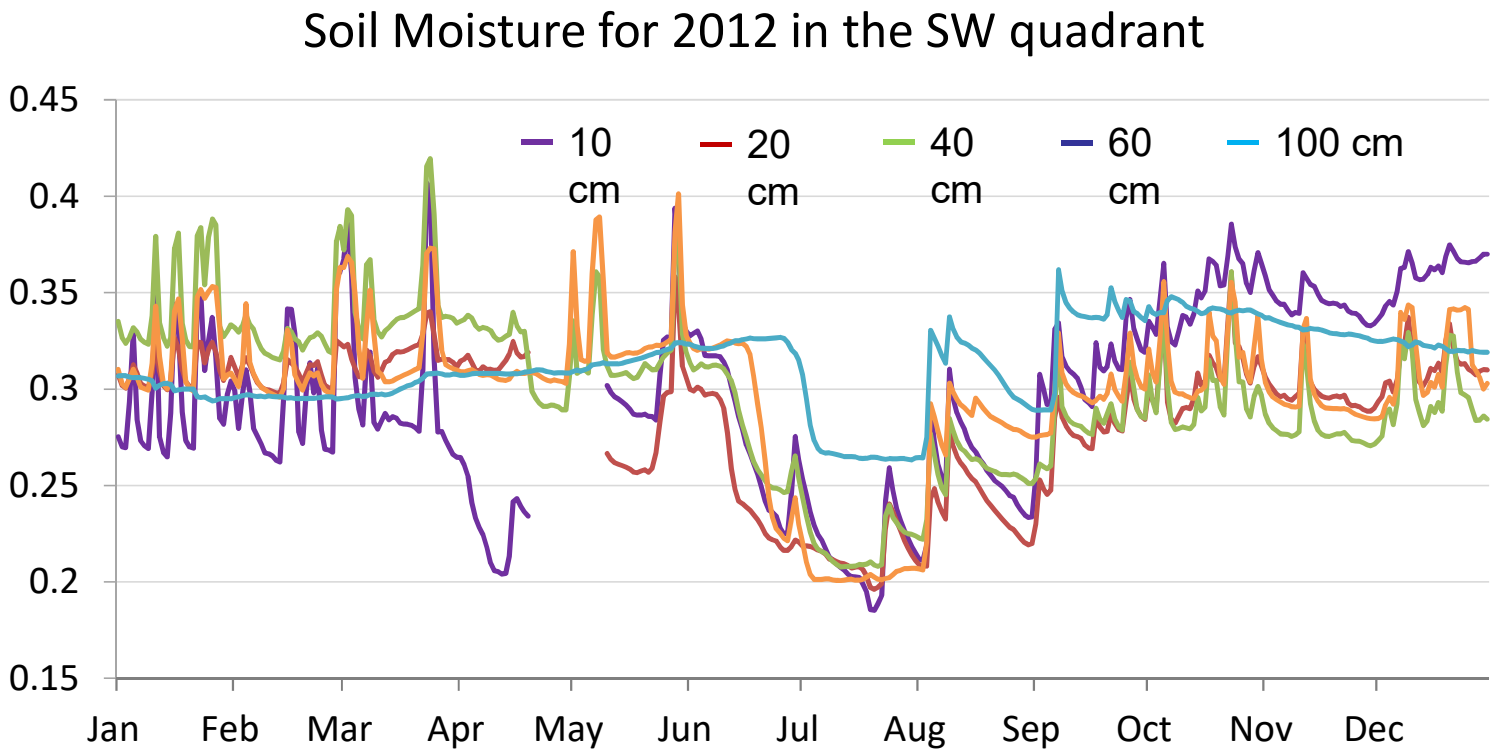

Water Table Depth from the Ground Surface
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
0
12
24
36
48
60
72
Depth (in)
Free
Controlled
Higher Outlet Level (winter)
Lower Outlet Level (growing season)
Higher Outlet Level


Depth (cm)
0
10
20
40
60
100
Moisture Sensor
Tile
Drain
Photo: NRCS

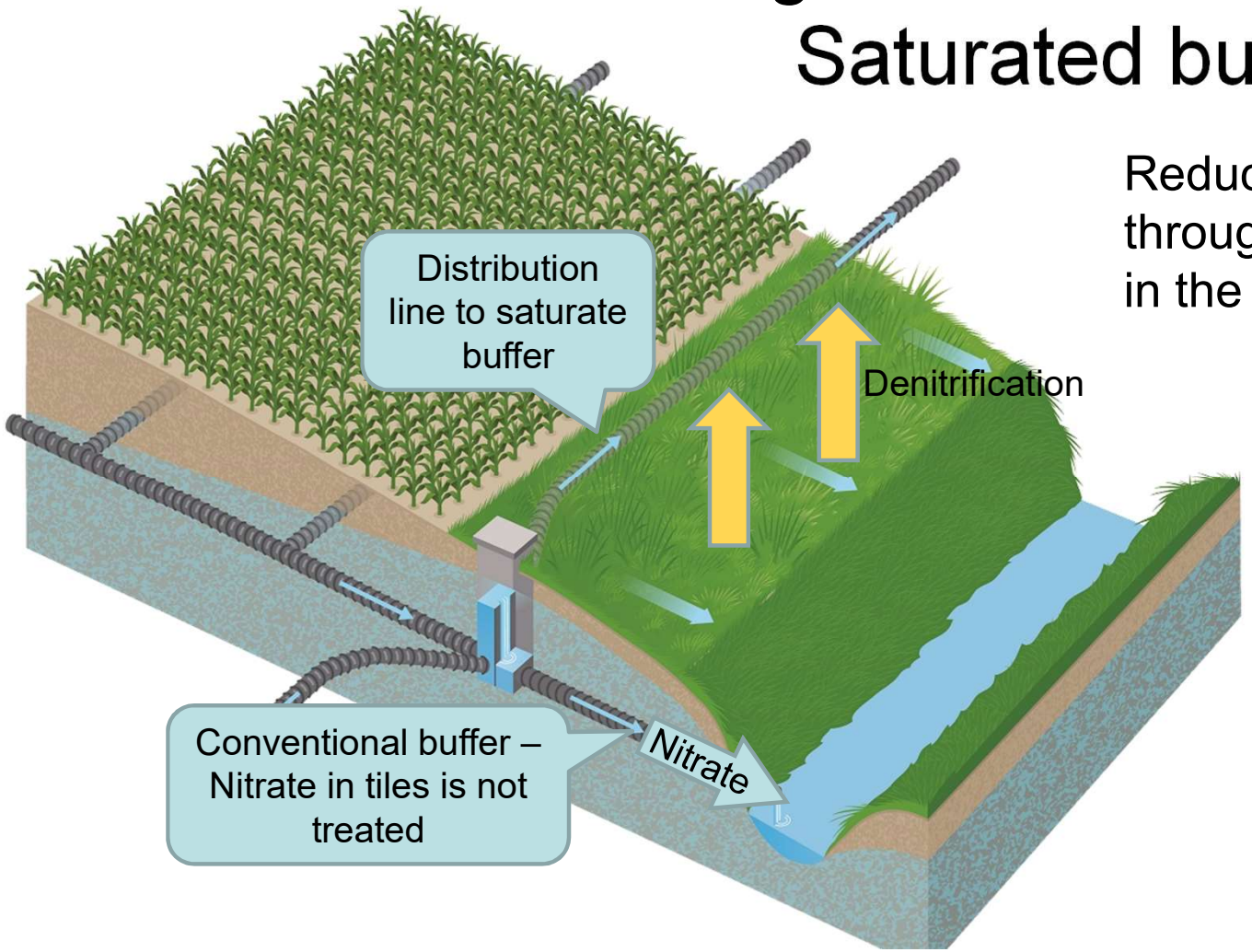
Data Logger


5
Em50
DECAGON


Moisture
Sensors
0
10
20
40
60
100
Depth (cm)

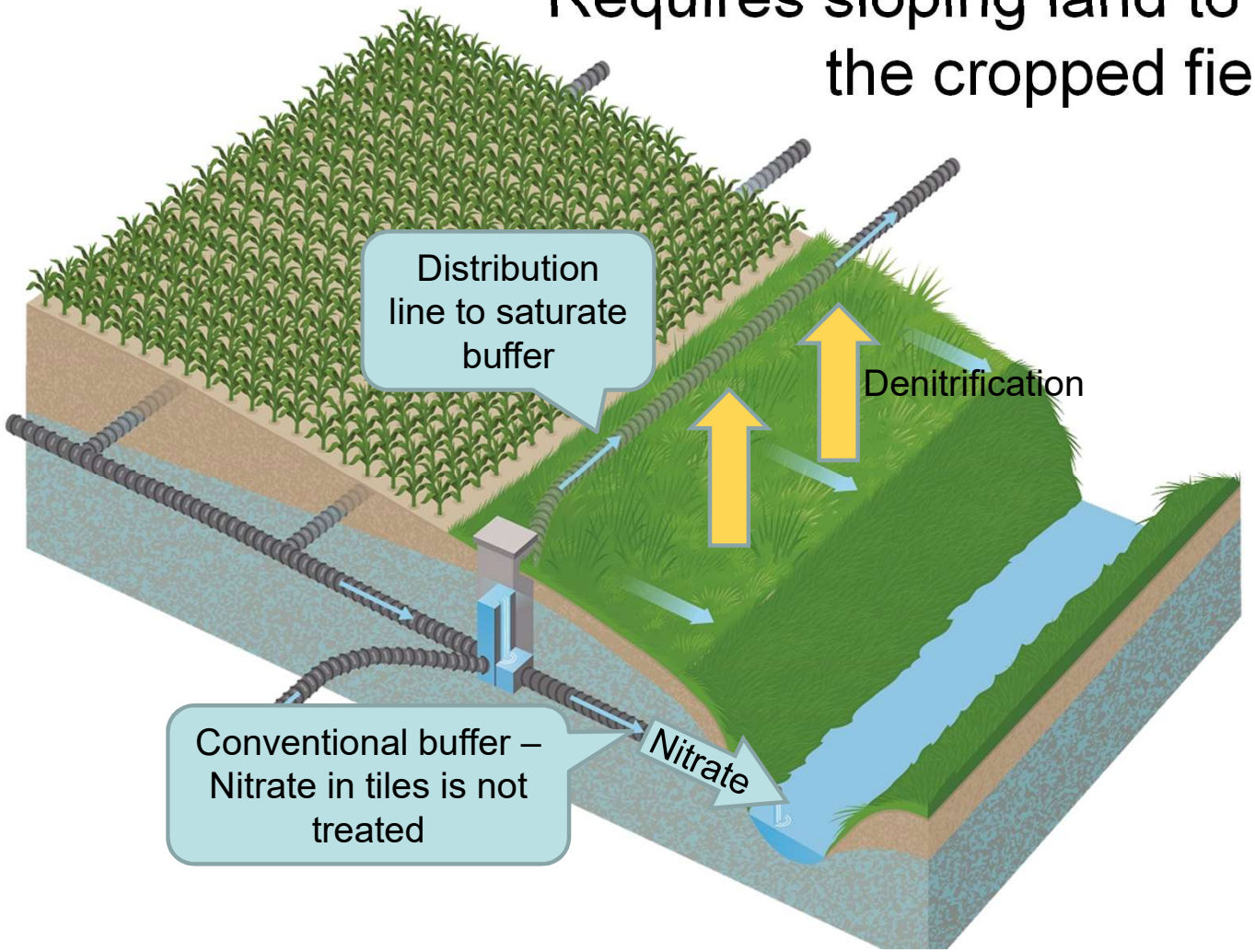

Soil Moisture for 2012 in the SW quadrant
0.45
0.4
0.35
0.3
0.25
0.2
0.15
10 cm
20 cm
40 cm
60 cm
100 cm
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

Storing water in buffers: Saturated buffers



Reduces nitrate loss through denitrification in the buffer.

Where can we put saturated buffers? Requires sloping land to not saturate the cropped field.



Where can we put saturated buffers?

Sites where the water table can be raised in the buffer **without raising it in the cropped field**.

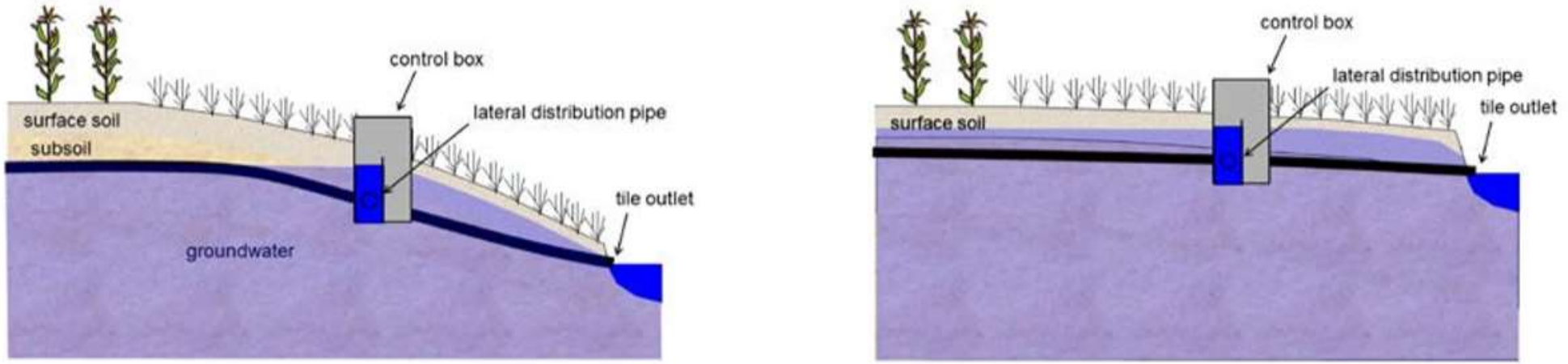
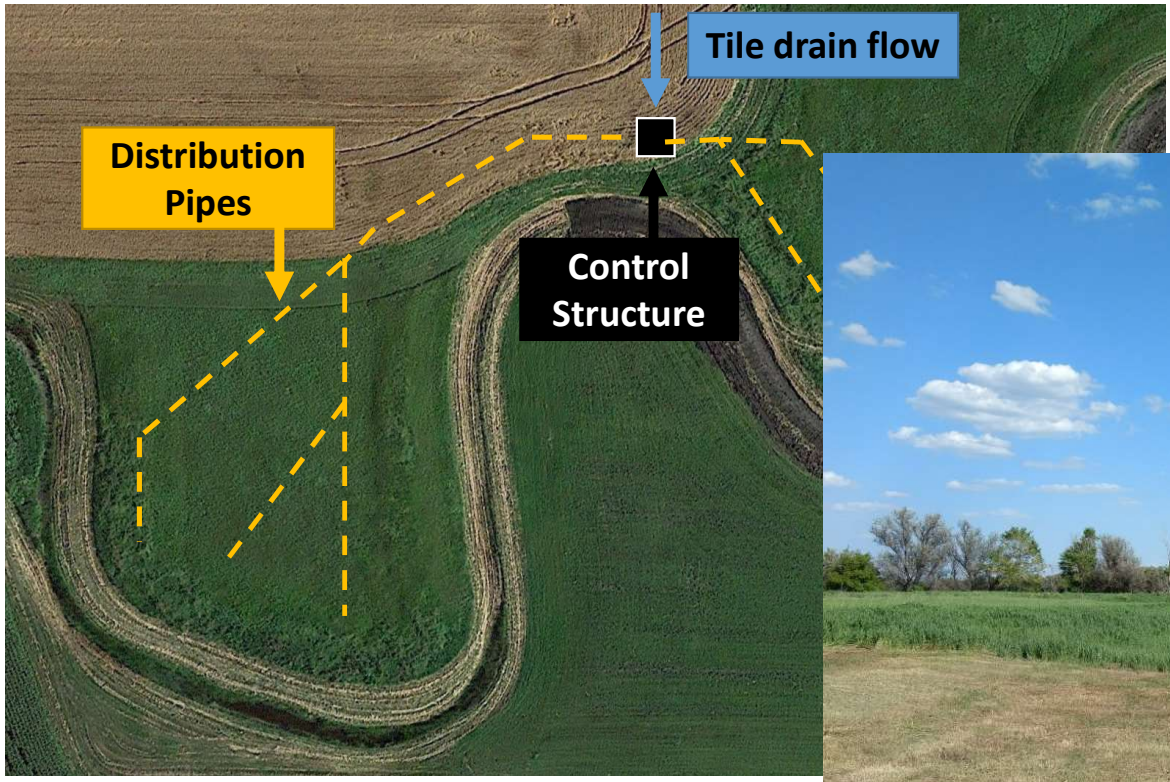
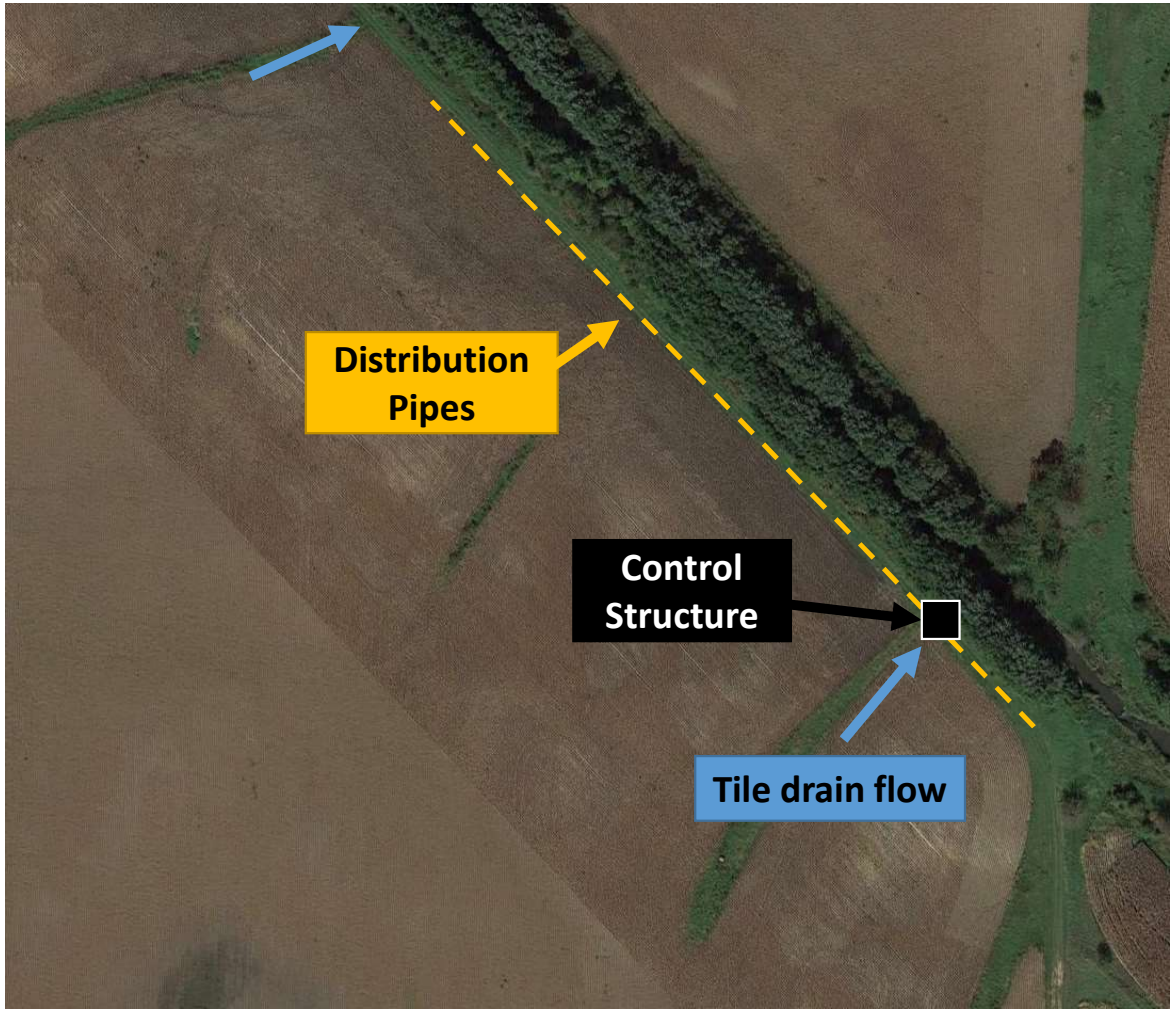


Figure 2: Left: Suitable locations allow the water table to be raised within the buffer without raising the water table within the cropped field. Right: Less desirable locations, where the field and buffer are nearly level, require the water table at the control box to be manually adjusted at least twice a year so as to not adversely affect the cropped field.

Saturated buffer in a stream meander

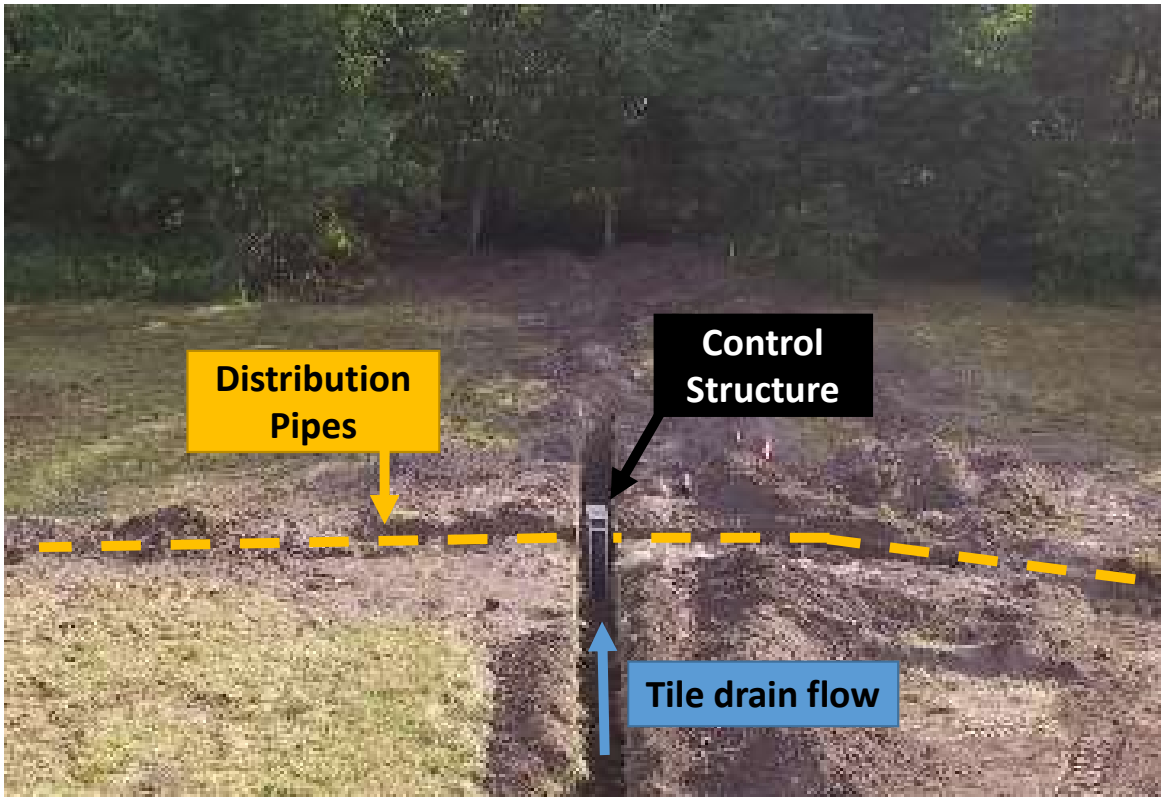


Agricultural Drainage Management Systems Task Force visit to North Dakota saturated buffer

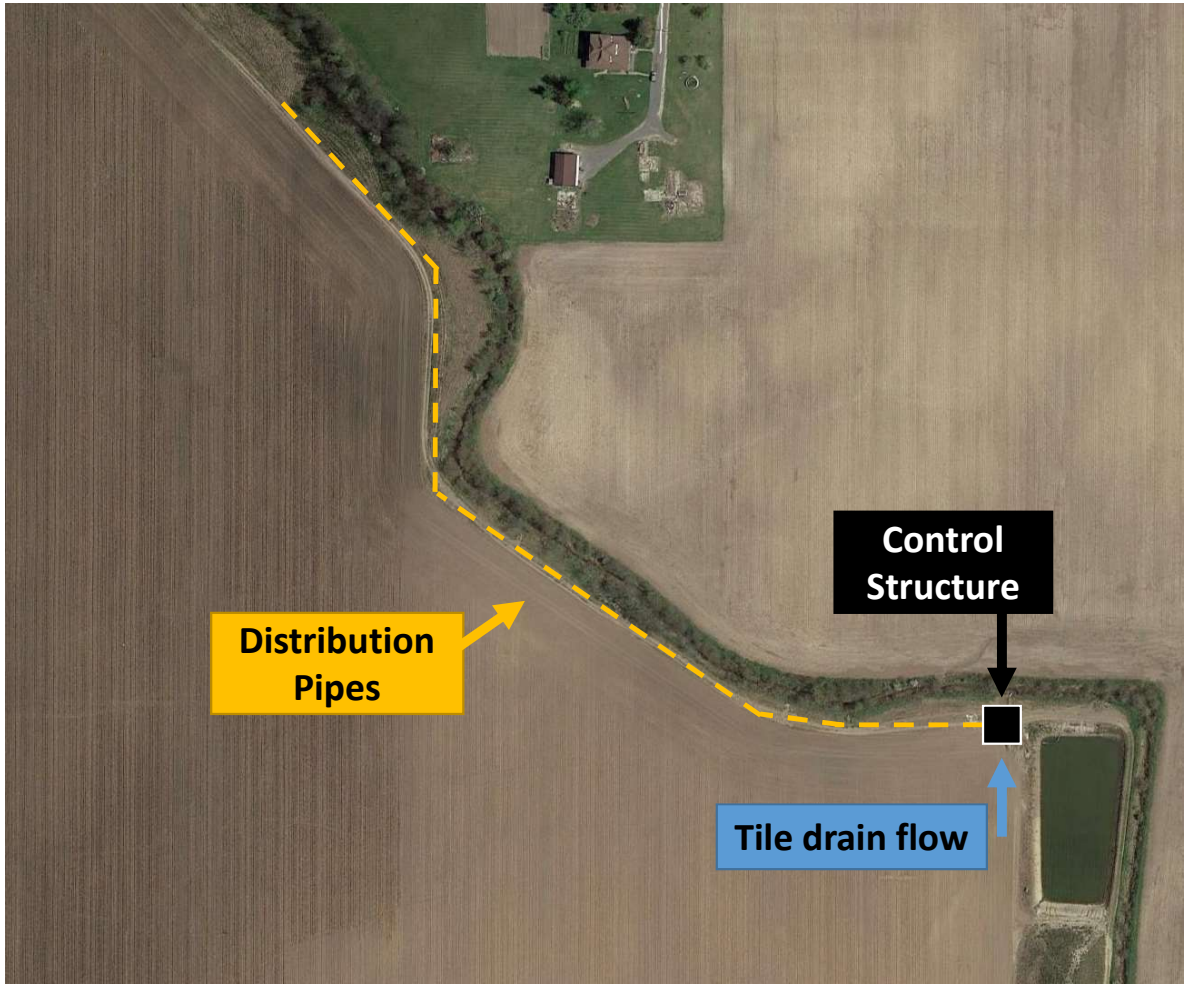


SATURATED BUFFER ALONG WOODED RIPARIAN BUFFER

SATURATED BUFFER ALONG WOODED RIPARIAN BUFFER AND HAYED



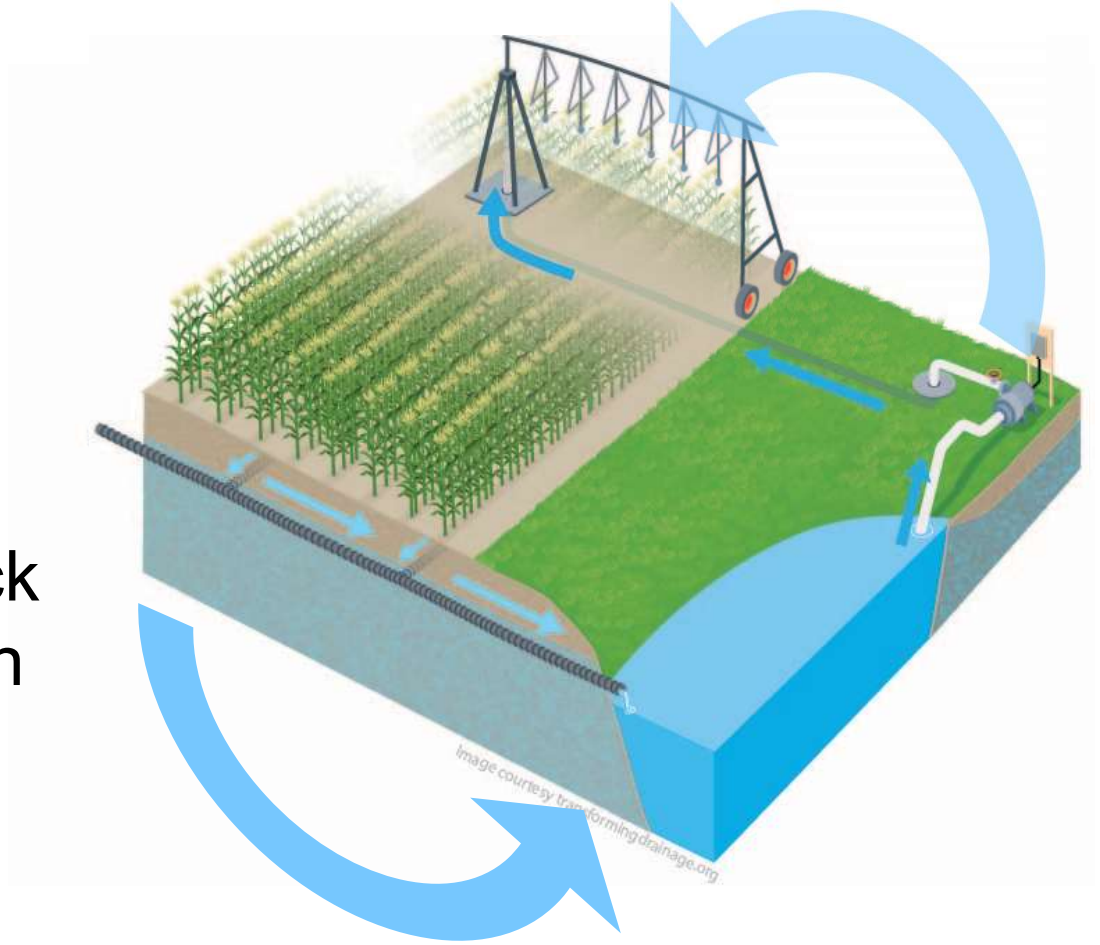
SATURATED BUFFER ALONG OPEN DITCH



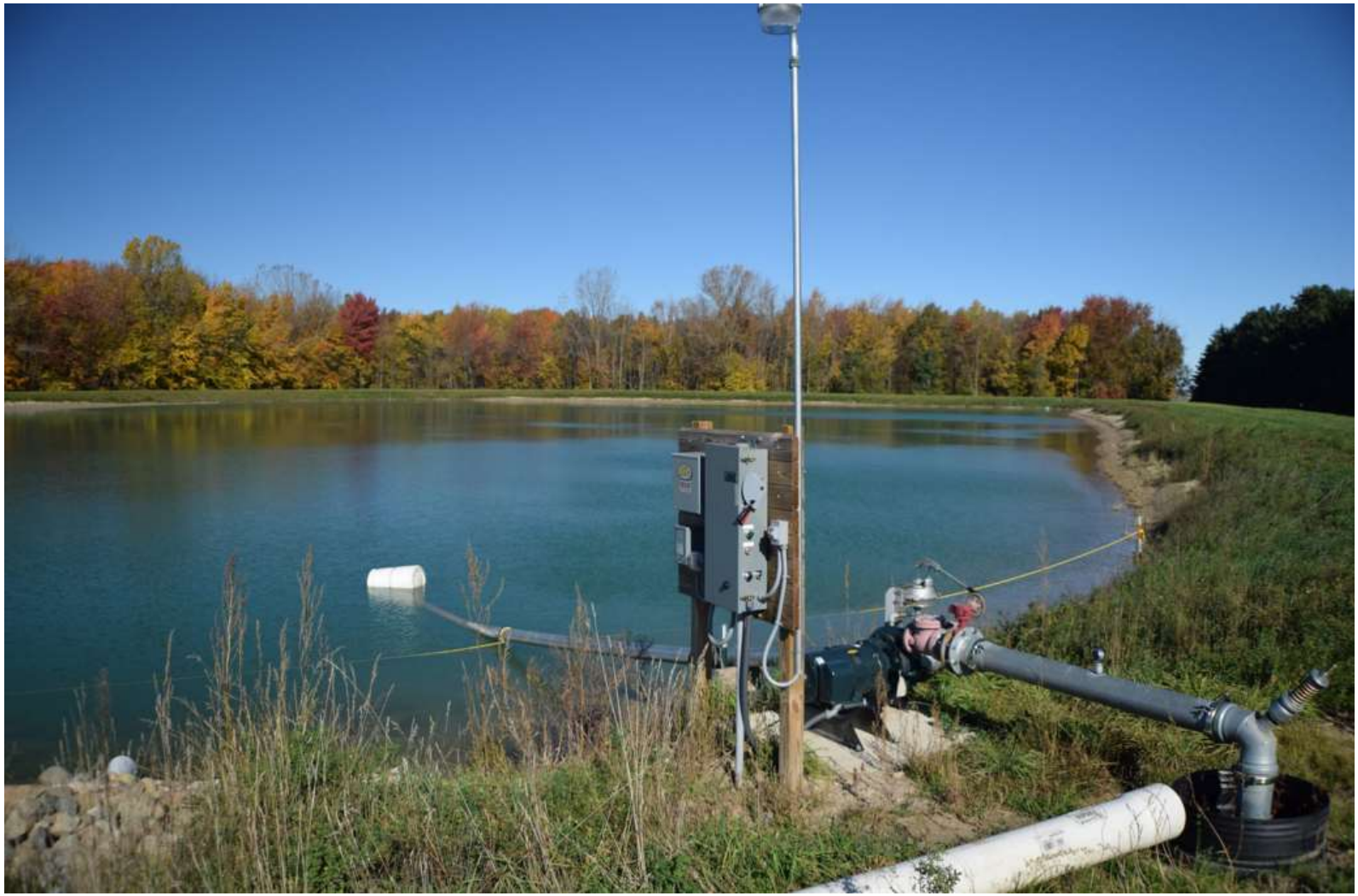
Storing water in ponds or reservoirs:
Drainage Water Recycling

Store drained water in a pond

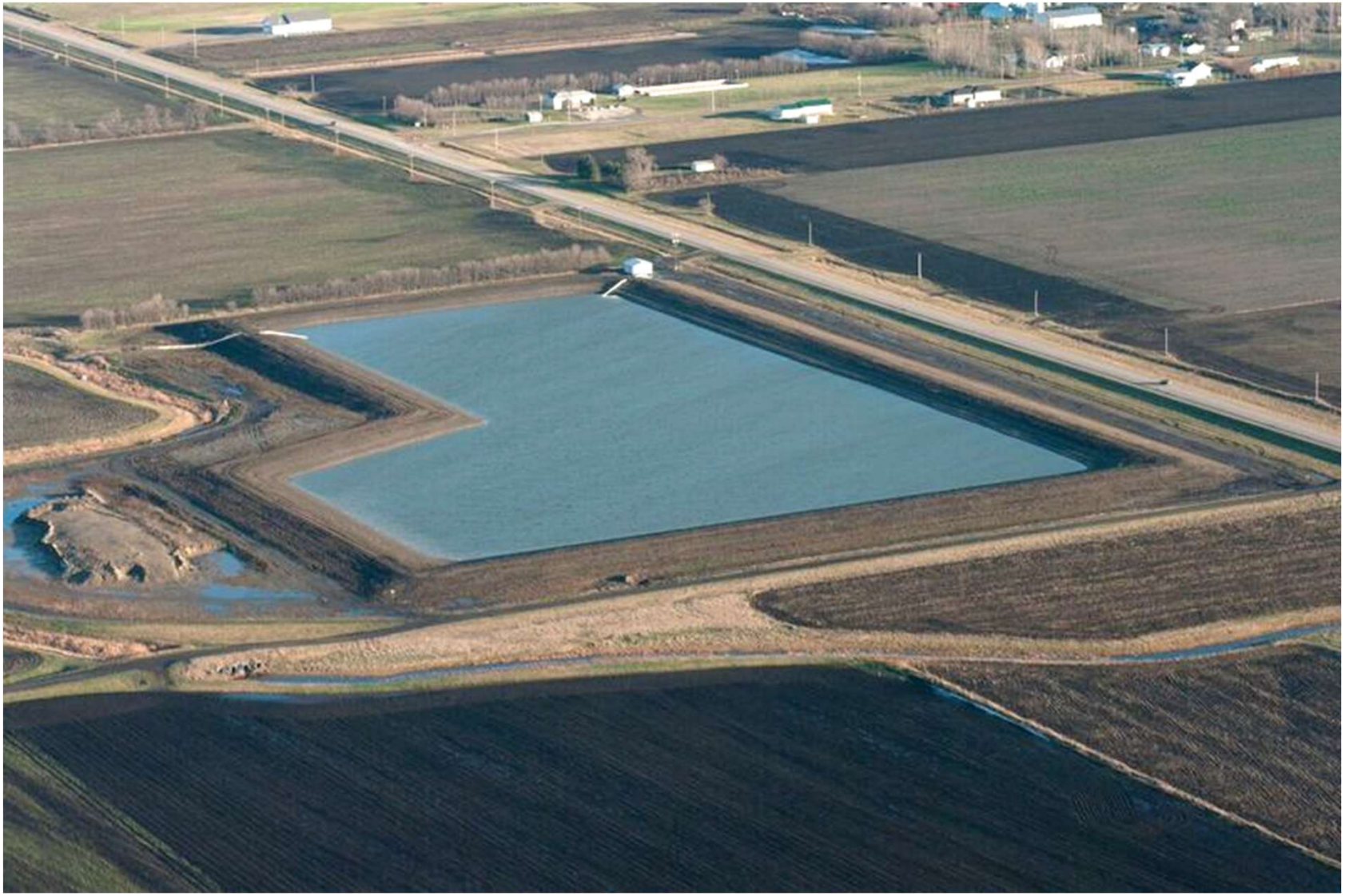
and irrigate it back onto crops later in the season



An old idea being revived and made part of the conversation



Reservoirs will need to be **large.**

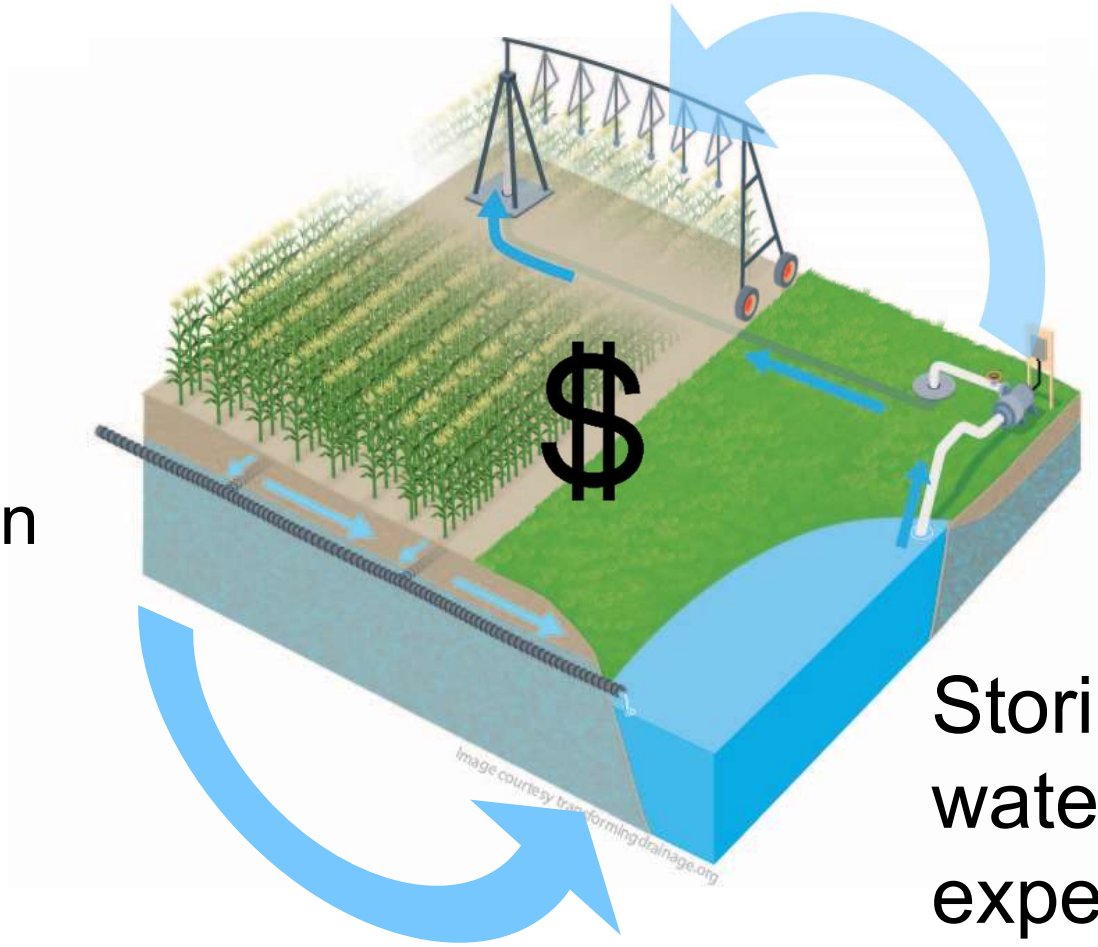


Drainage water recycling

stores drained water in a pond

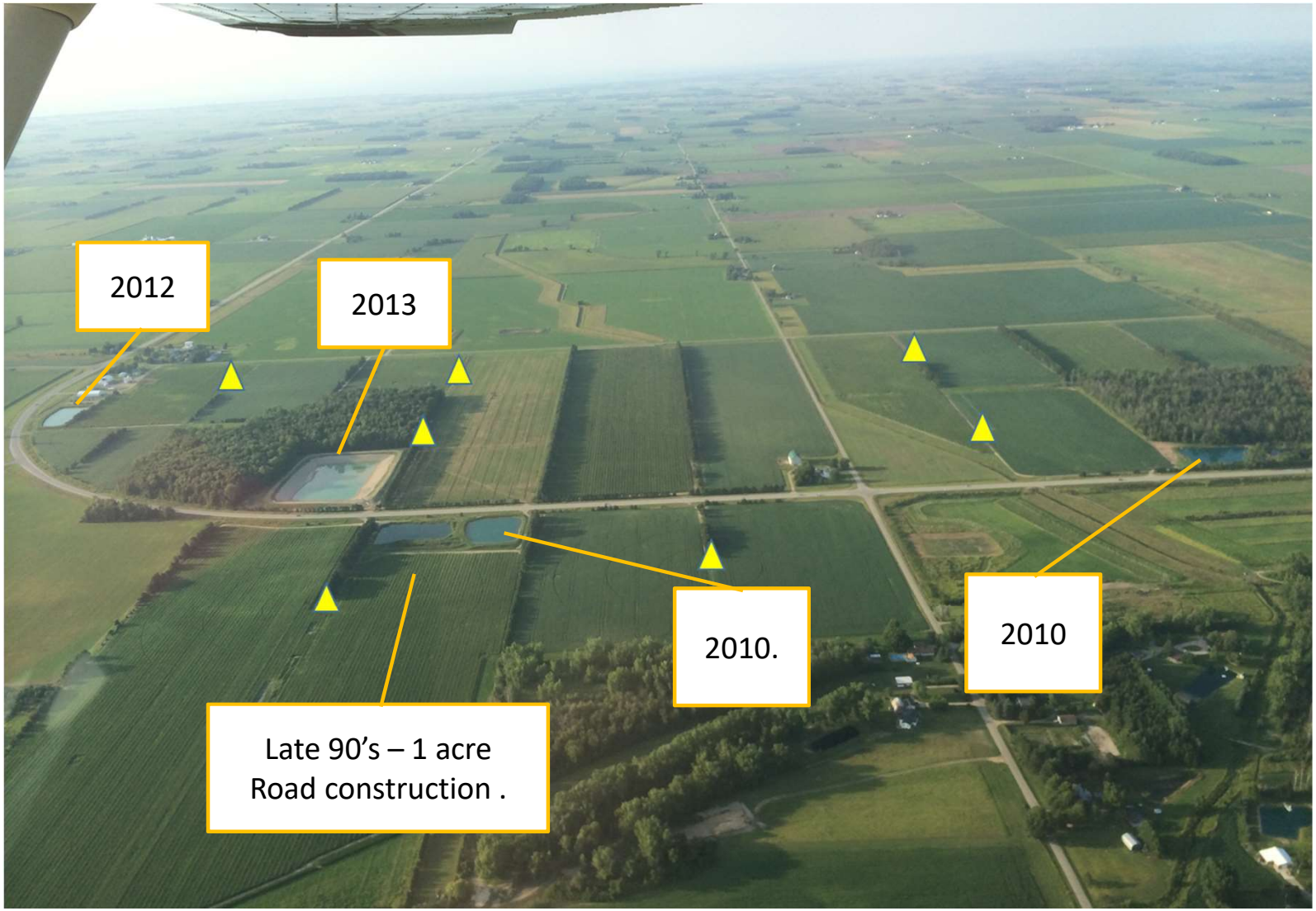
and irrigates it back onto crops later in the season

But there is a major challenge.



Storing water is expensive!

Drainage water recycling ponds in Michigan

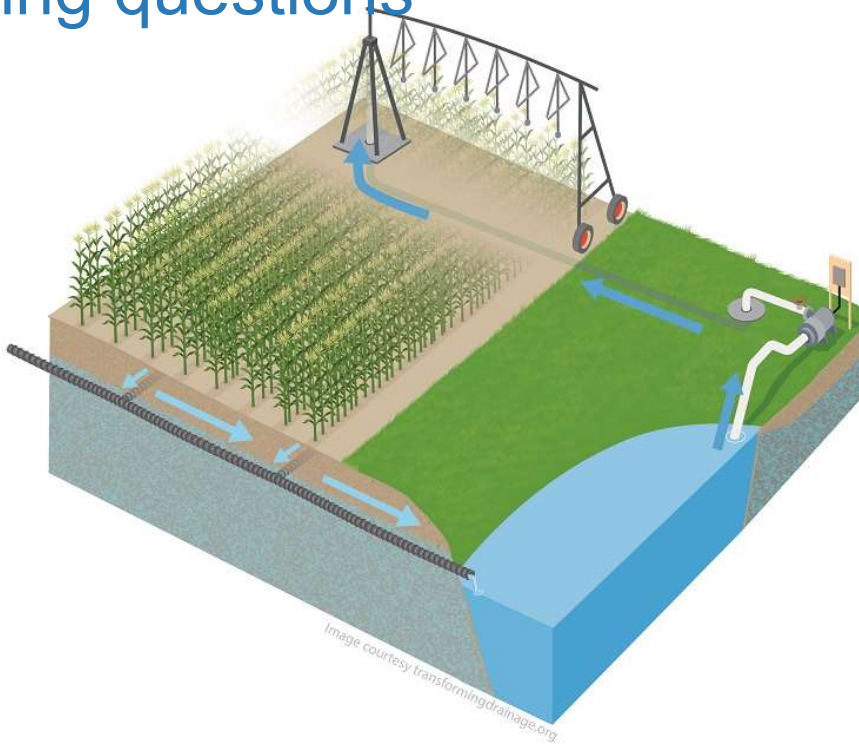


Questions to address: Where and how can water be stored, and how much benefit can we expect?

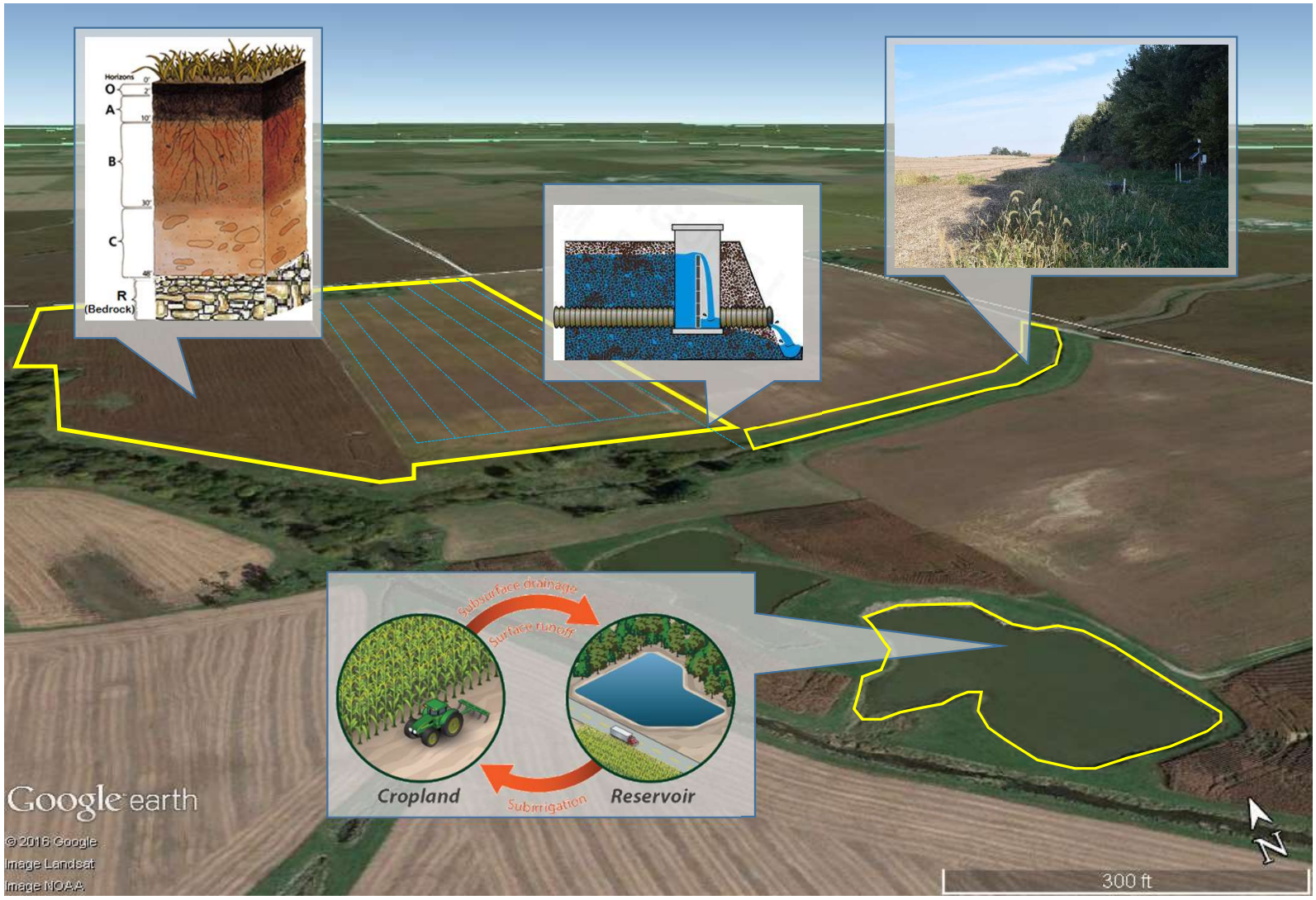
Tool for estimating these values throughout the region available at http://transformingdrainage.org/tools/EDWRD

Drainage Water Recycling – a new practice with great potential but many remaining questions

- Water storage reservoirs must be **large**, ranging from 2% to more than 10% of the field area. 6% provides many benefits.
- http://transformingdrainage.org/tools/EDWRD provides a new tool to help estimate benefits for various sizes.
- Optimal size must balance benefits with costs, and depends on climate, topography, soils, and crops.



Drainage water storage can be stored:



Transforming Drainage Project –

Advancing drainage water storage across the Midwest

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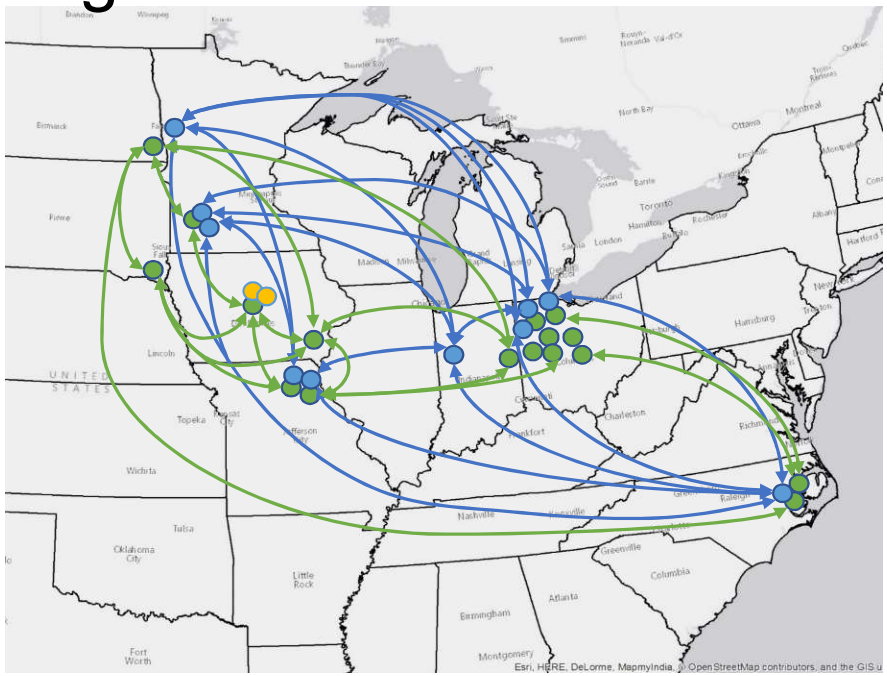

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USDA United States Department of Agriculture

SOUTH DAKOTA STATE UNIVERSITY

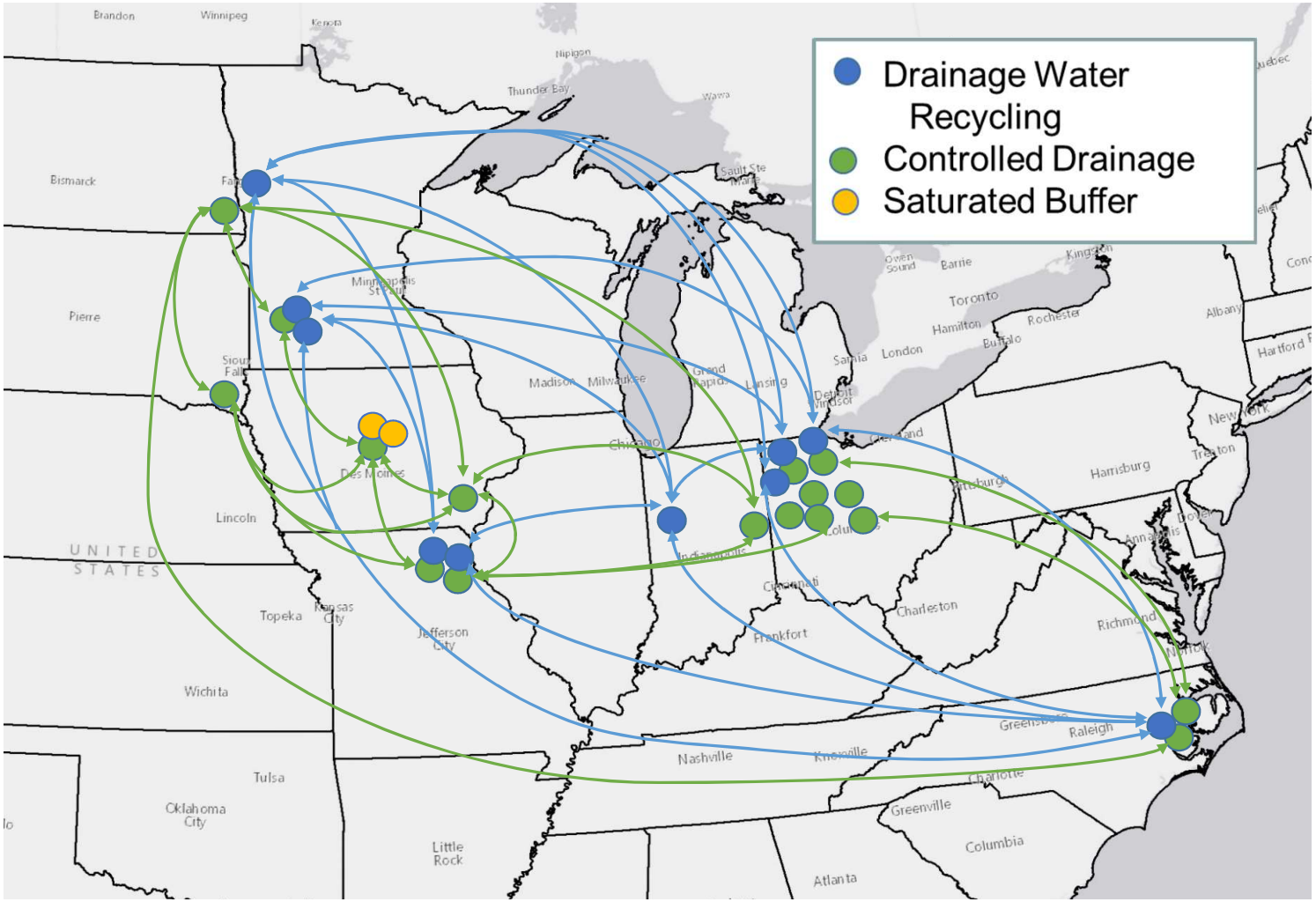
University of Missouri

IOWA SOYBEAN Association

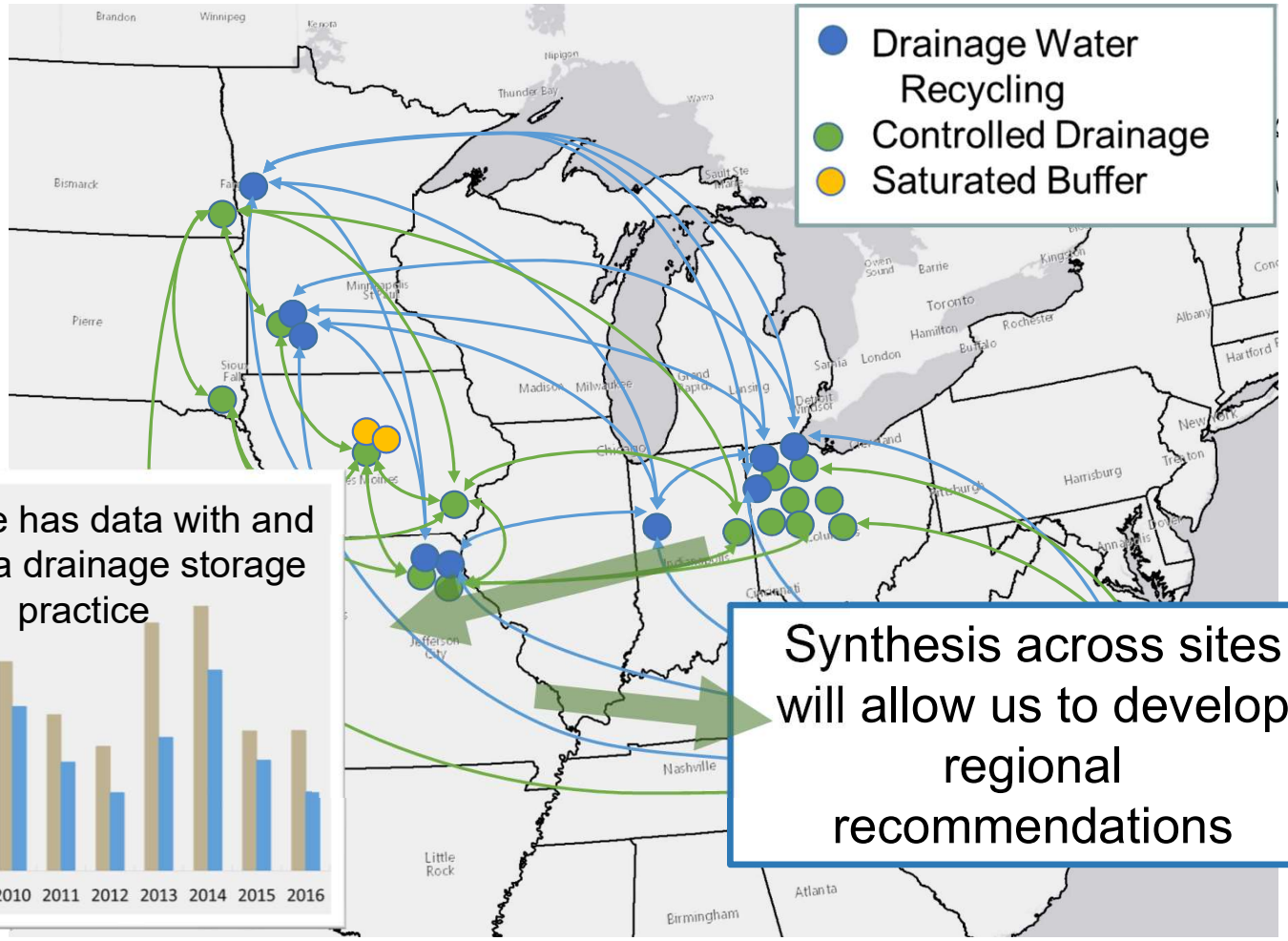
This material is based upon work that is supported by the National Institute of Food and Agriculture, U.S. Department of Agriculture, under award number 2015-68007-23193, "Managing Water for Increased Resiliency of Drained Agricultural Landscapes.

Transforming Drainage Team

Field Research – Existing, New, Historical Sites



Our database includes 186 site years of data on drainage practices



Each site has data with and without a drainage storage practice

Synthesis across sites will allow us to develop regional recommendations

Transforming Drainage Project

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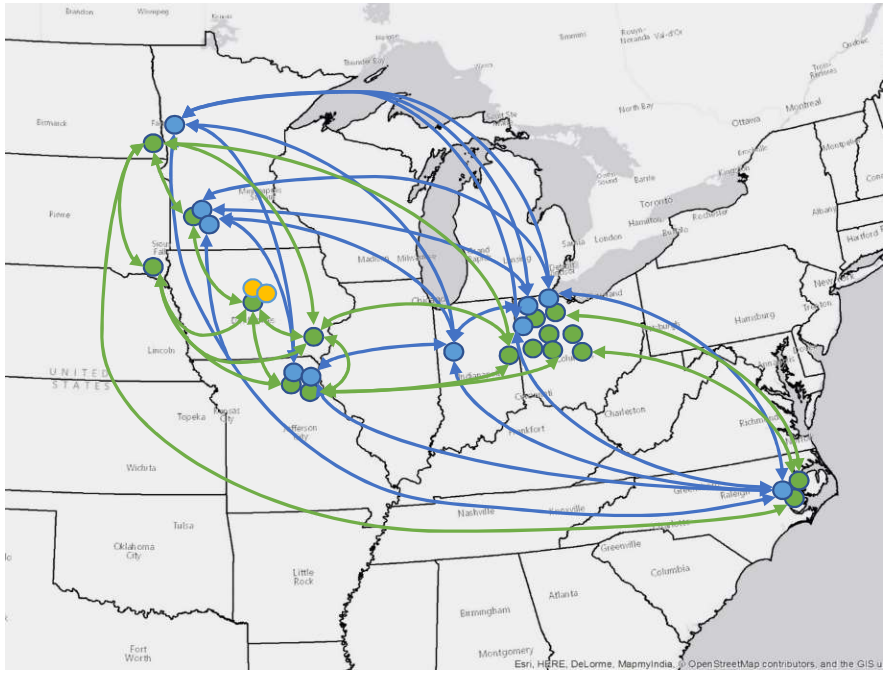

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Reducing nutrient loss | Attracting millennials

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Creating a project toolkit

An update on the Transforming Drainage project

by Bob Clark

It was a busy and productive first year for the Transforming Drainage research study, according to project manager Ben Reinhart.

Funded by the United States Department of Agriculture and led by Jane Frankenberger of Purdue University in Indiana, the project team brings together a wide network of drainage stakeholders to discuss, among other things,

part of the toolkit that is a focal point of the project – and this is the kind of thing that, in my opinion, will really help new conservation practices take off. I am excited to accompany the development of these tools and communicate their evolution to the contractor community as the project develops.

As we continue through spring, the plows and trenchers that many of us spend our days operating

GUEST COLUMN

Water recycling feasibility

The latest on the Transforming Drainage project.

by Ben Reinhart

The Transforming Drainage project is capitalizing on the network established during our first year with new research to advance our understanding of drainage water storage systems (e.g. controlled drainage, saturated buffers, and drainage water recycling), foundations for innovative tools, and continued outreach to stakeholders across the Midwest.

Research in Iowa, led by Chris Hay of the Iowa Soybean Association and Matt Helmers of

In other efforts, Mohamed Youssef, agricultural engineer at North Carolina State University, led the development of an approach to estimate the impact of controlled drainage systems on reducing annual drainage volume and nitrogen loss. Using the field-scale modeling program, DRAINMOD, the team at North Carolina State conducted thousands of simulations across various climates, soil types, drainage designs, and cropping scenarios in the

- Leadership by the drainage industry in saturated buffer research and outreach.

The Agricultural Drainage Management Coalition (ADMC), Agricultural Drainage Management Systems Task Force and Dr. Dan Jaynes with the National Laboratory for Agricultural & The Environment collaborated to demonstrate and evaluate saturated buffers at field scale to reduce nitrates and phosphorus from subsurface field drainage systems.

- Iowa Soybean Association and other commodity groups

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Managing Water for Tomorrow's Agriculture

The Vision: Transforming Drainage

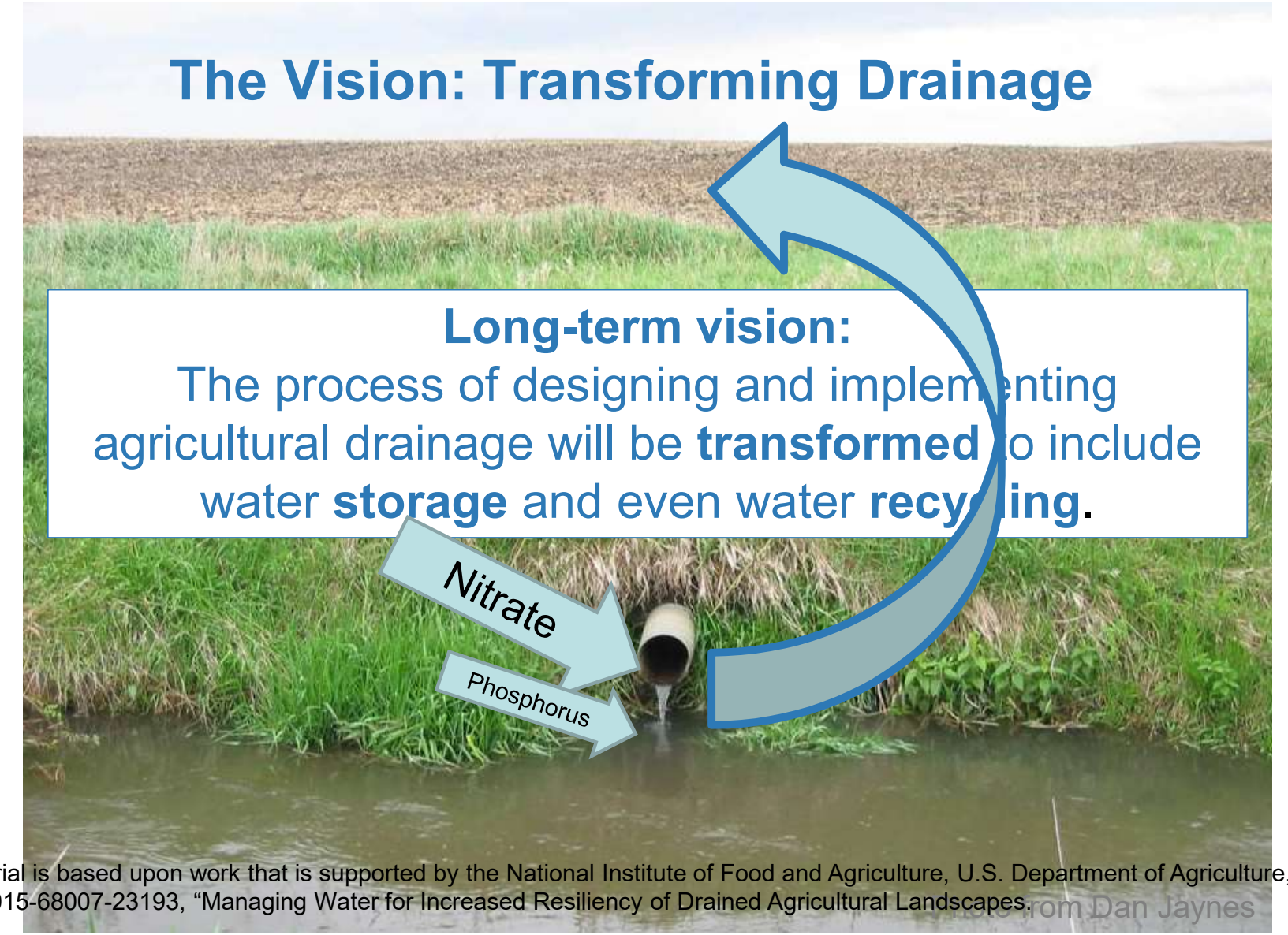

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Photo from Dan Jaynes