Conservation Drainage and Water Management for Tomorrow's Agriculture

Dr. Jane Frankenberger,
Professor

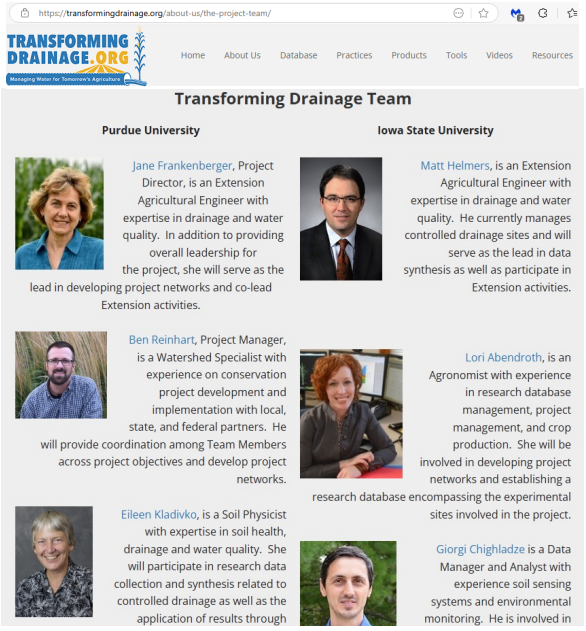
Agricultural & Biological Engineering

PURDUE UNIVERSITY

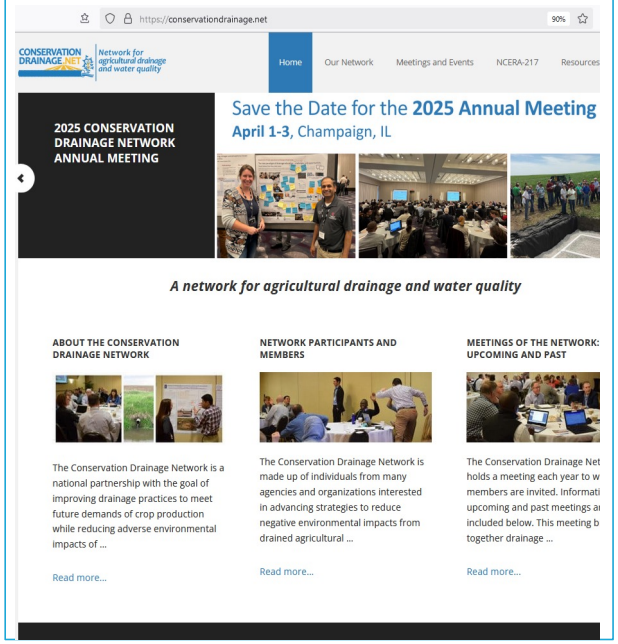
My work on Conservation Drainage and Agricultural Water Management

Professor and Extension Ag Engineer for 29 years at Purdue University

Project Director for **Transforming Drainage** Multistate Project



Led the formation of the **Conservation Drainage Network**




Managing water is key for successful agriculture.

Most years we have too much; sometimes too little.

Spring: Runoff and nutrient loss

Summer: Drought, crop yield loss

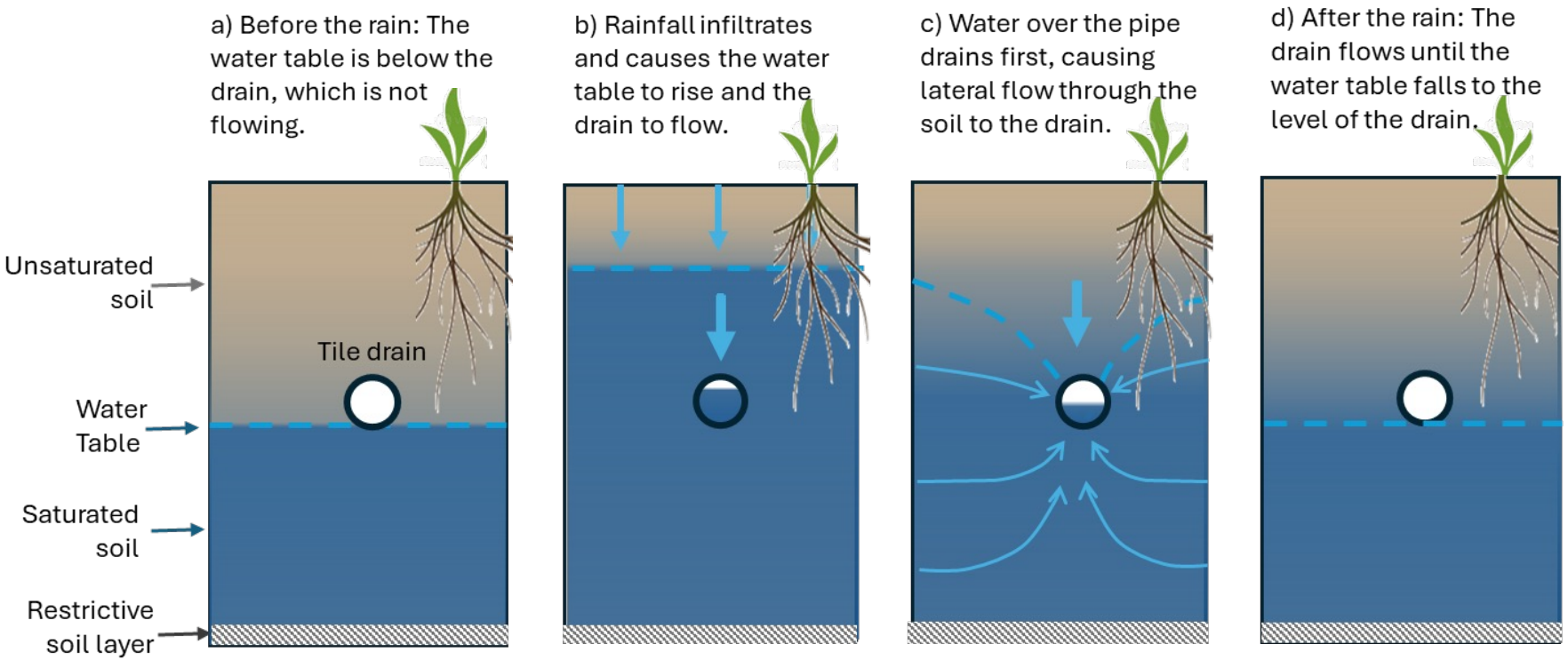
In the Midwest, we have an impressive drainage infrastructure designed to get rid of water as quickly as possible.

Subsurface tile drains

Surface drains (ditches)

Drainage lowers the water table to increase aeration.

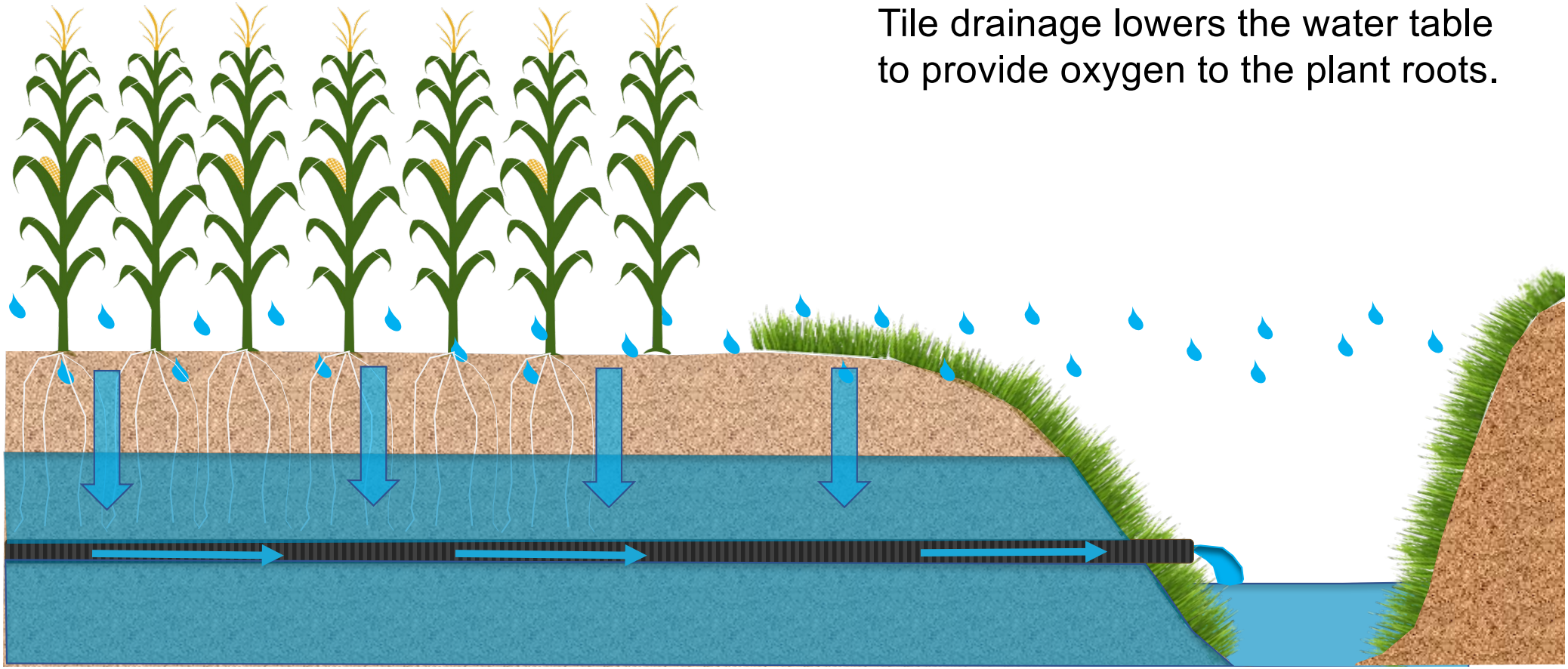
The **water table** divides the saturated zone (where all pore space is filled with water), from the unsaturated zone above (pore space includes air).



Drainage lowers the water table to increase aeration.

Rainfall infiltrates and raises the water table.

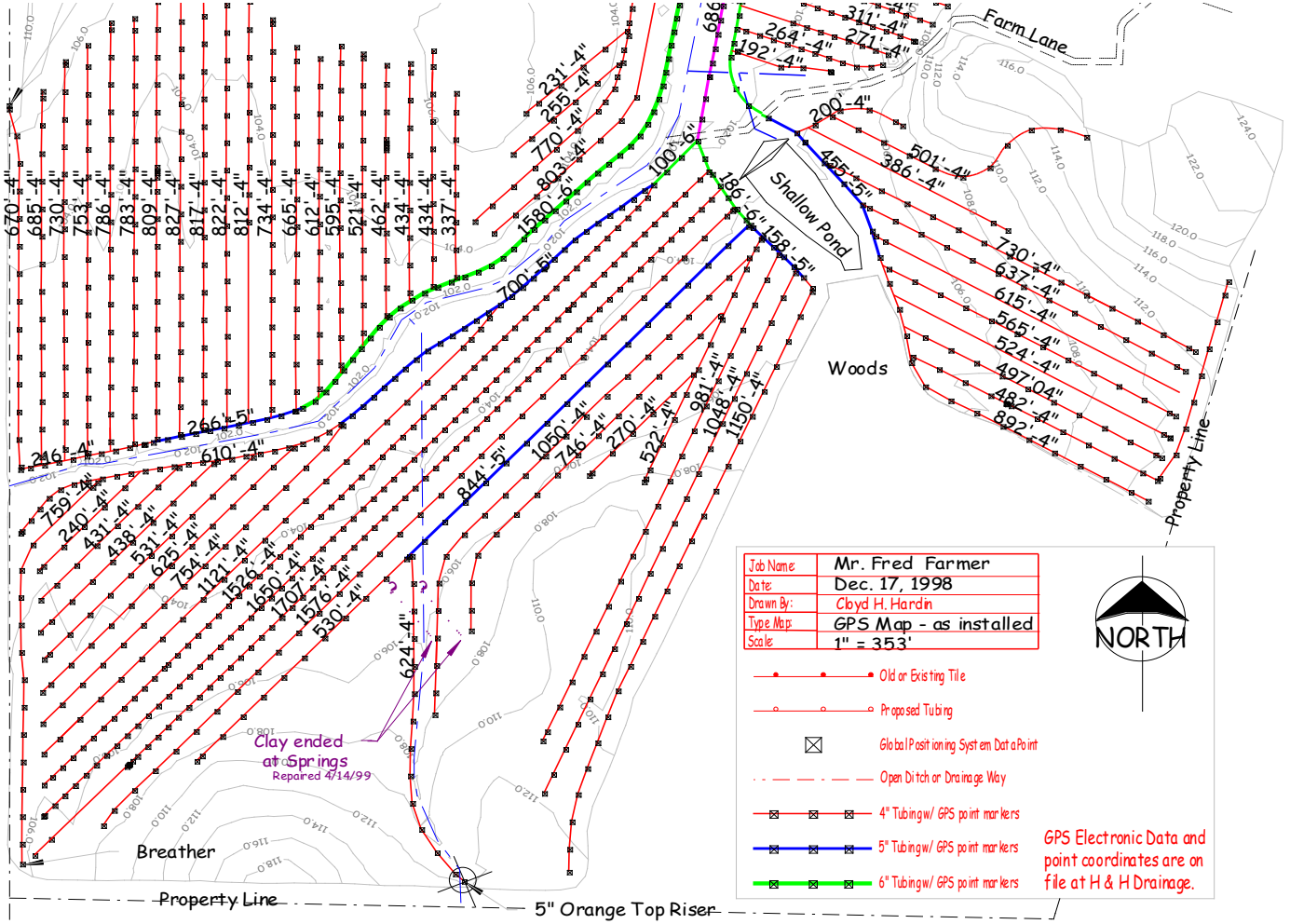
Tile drainage lowers the water table to provide oxygen to the plant roots.




Video clips from Davis Purdue Agricultural Center
Field Day, courtesy of Jeff Boyer, Superintendent

Tile Drainage Systems

The drains are spaced at a distance that allows drainage at a rate adequate to support crop growth, usually 20 to 100 feet apart.




Recently tiled field.
Photo from Gary Sands

Most years we have 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 the Midwest, we have an impressive drainage infrastructure designed to get rid of water as quickly as possible.

Subsurface tile drains

Surface drains (ditches)

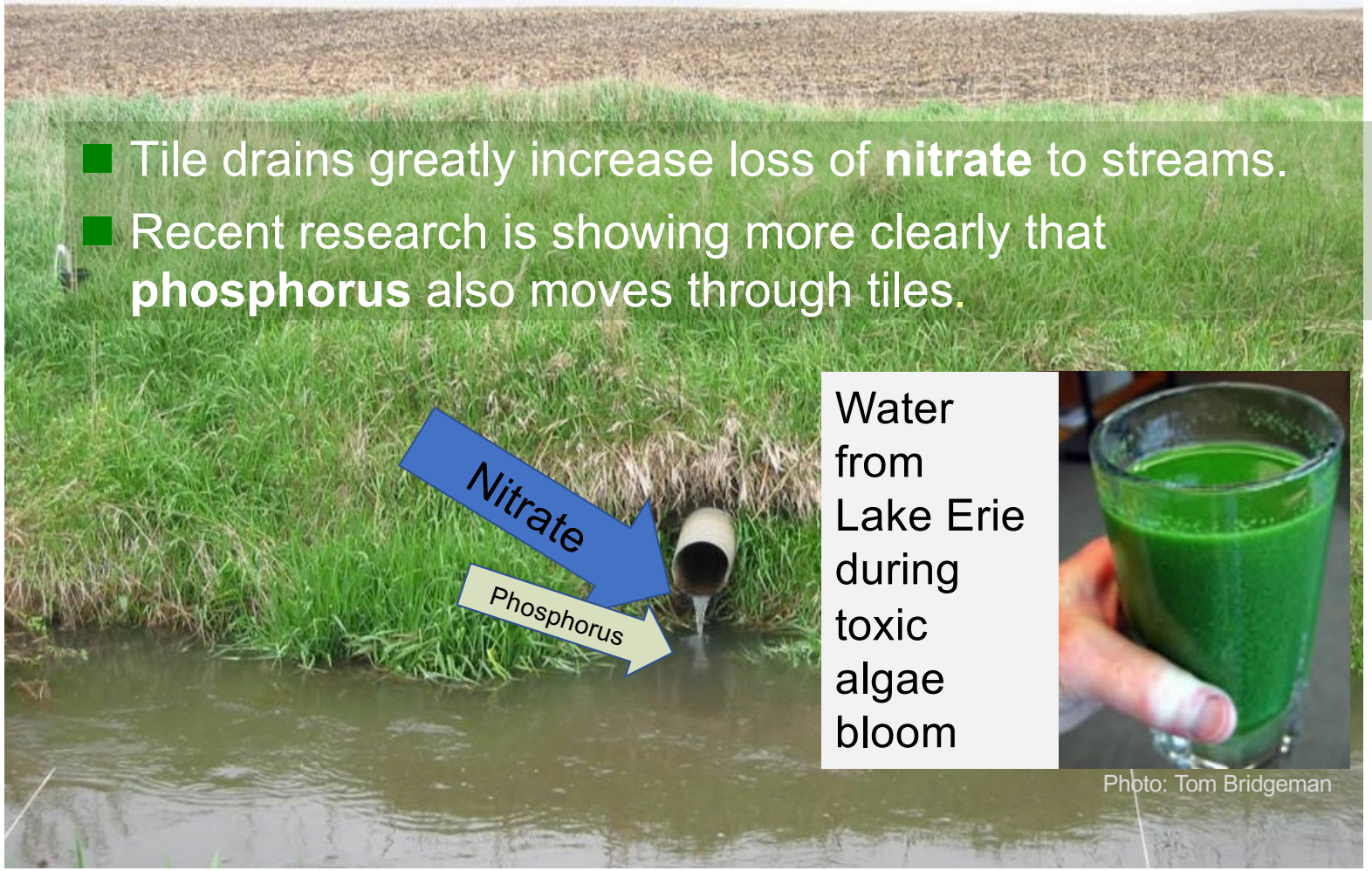
But is today's agricultural water management systems adequate to address tomorrow's needs?

Subsurface tile drains

Surface drains (ditches)

Issue 1: Nutrient loss from tile drainage is causing issues of national concern.

- Tile drains greatly increase loss of **nitrate** to streams.
- Recent research is showing more clearly that **phosphorus** also moves through tiles.



Water from Lake Erie during toxic algae bloom

Photo: Tom Bridgeman

Issue 2: Despite excess water in spring, yields are often limited by lack of water in late summer.

Some years we have excess water and water shortage in the same year.

Too much (June)

Then too little (July)

The LEAP district in Lebanon lacks water, so the Indiana Economic Development Commission has proposed a 40-mile pipeline from Tippecanoe County.

Proposed wells near Granville Bridge

Image from https://iedc.in.gov/leap-lebanon

Background map: https://maps.bing.com

This has caused great controversy, but no current state law addresses.

Pipeline location from https://www.clintoncountytoday.com/state-to-pump-water-through-clinton-county-to-boone-county/

Two issues; both are expected to be become more severe due to future extreme weather

- **Excess nutrients in spring will increase** as winter and spring becomes warmer and wetter

Photo: Tom Bridgeman

- **Water availability in late summer will decrease** with warmer summers and increased flashiness of precipitation


Storing drained water in the landscape addresses both these issues.
TRANSFORMING DRAINAGE.ORG
Managing Water for Tomorrow's Agriculture
CONSERVATION DRAINAGE.NET
Network for agricultural drainage and water quality

Feedback Form on Conservation Drainage

Typically, farmers’ goal is to get rid of excess water as quickly as possible.

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

Conservation Agriculture: Storing water in the soil
Increasing soil health.

- Increasing soil organic matter can increase water holding capacity.

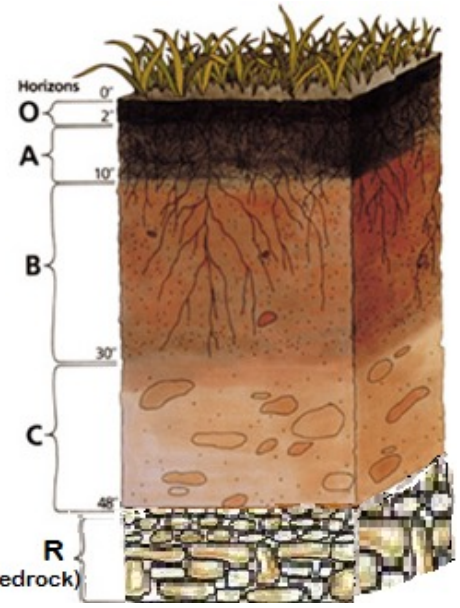
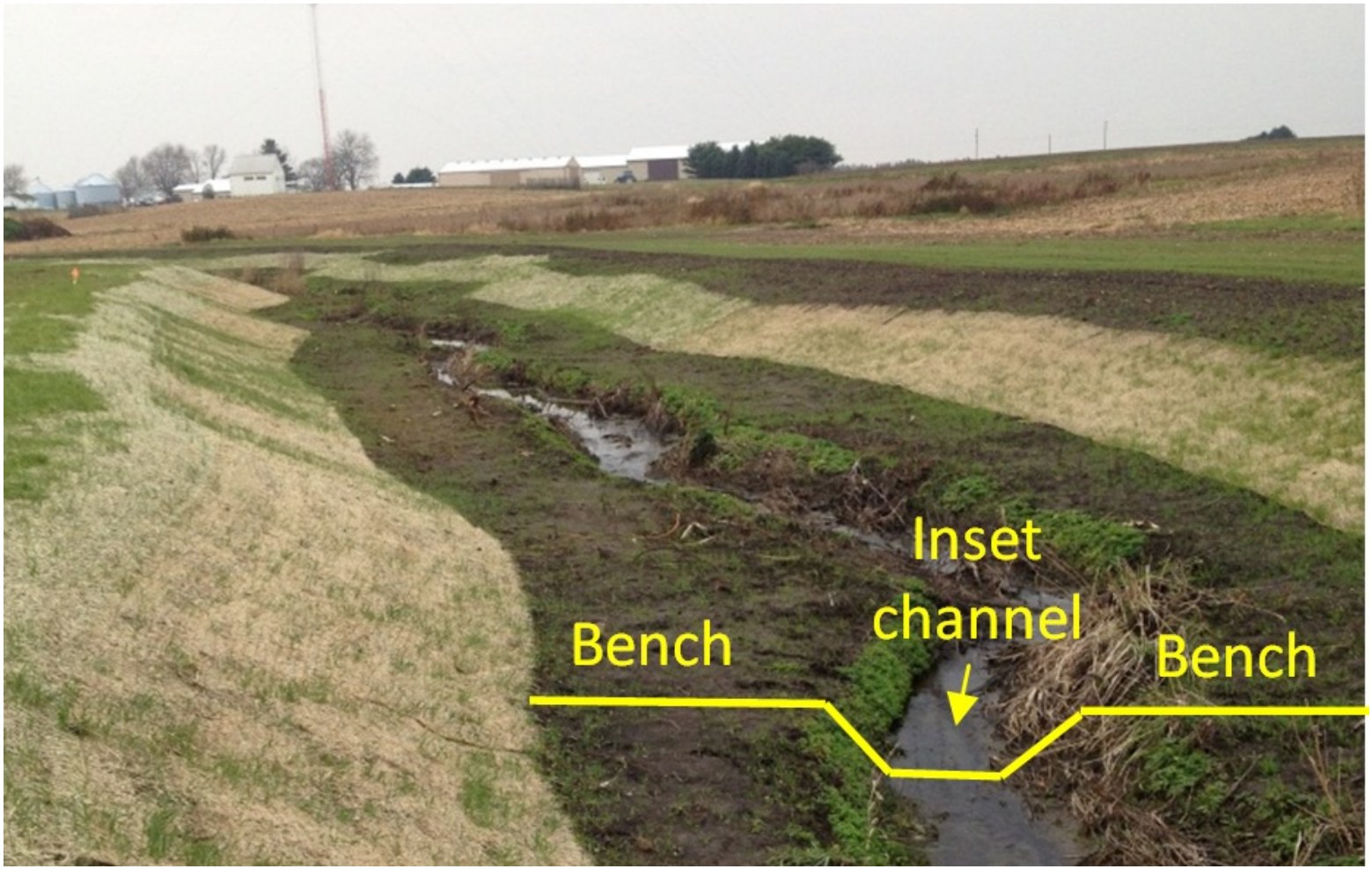


Image: Wikimedia Commons, Wilsonbriggs

- Bu ited in ou

Image: NRCS

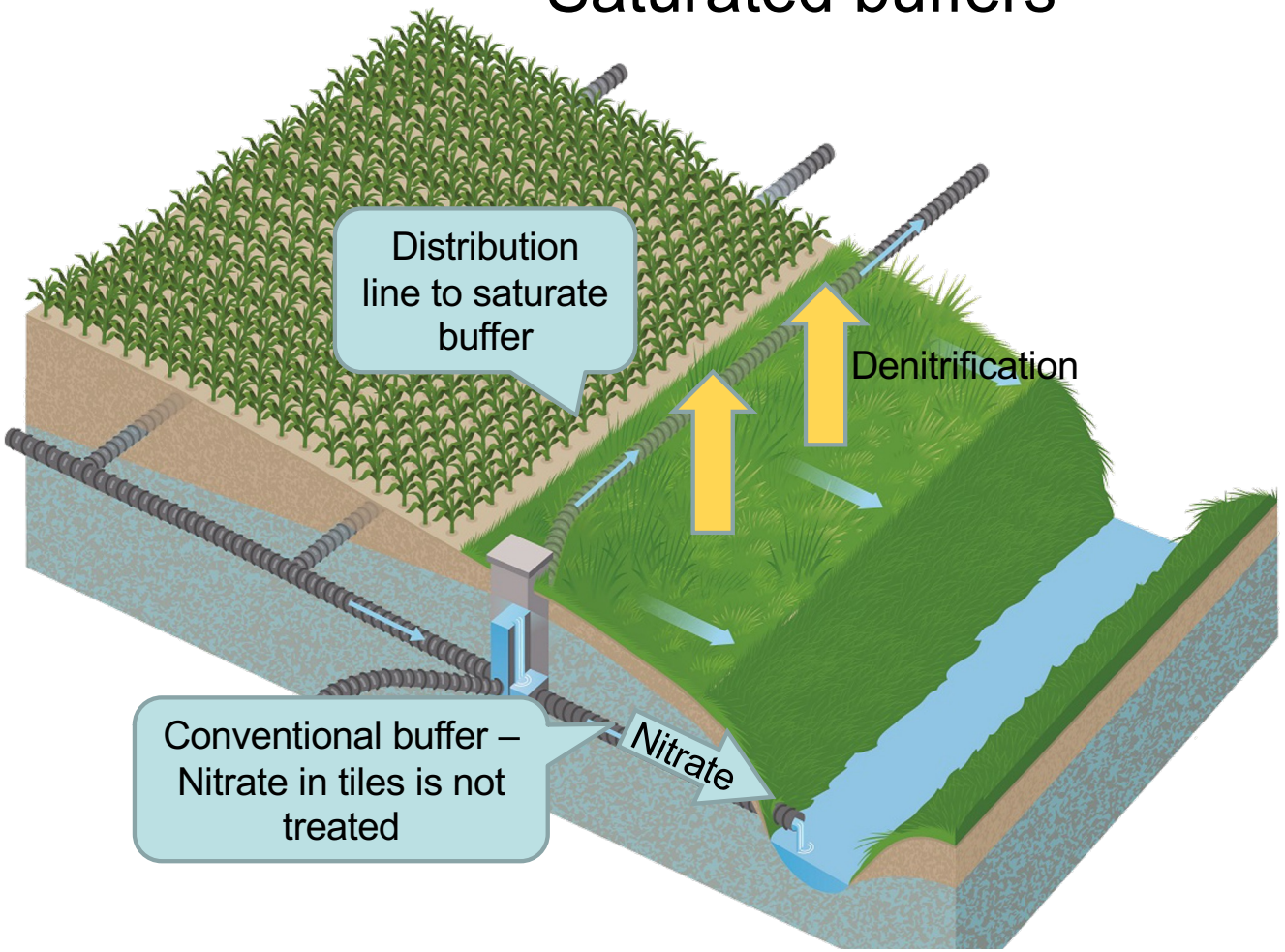
Conservation Drainage: Storing water in wider ditches:
Two-Stage Ditches



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

Conservation Drainage: ***Storing water in buffers:***

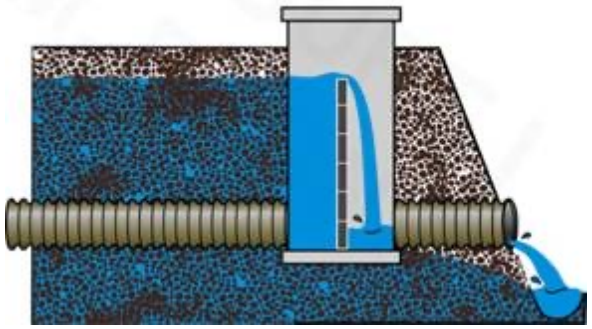
Saturated buffers



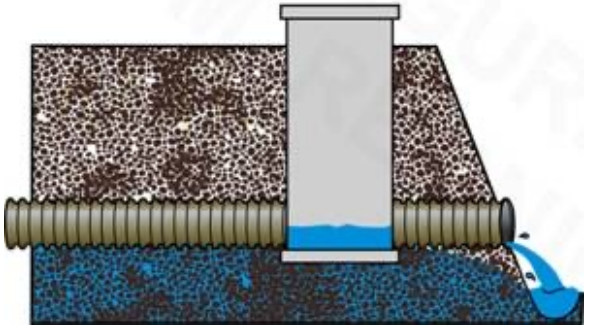
Conservation Drainage: Storing water in the field:
Drainage Water Management, also known as Controlled Drainage

Water control structure added in a main drain

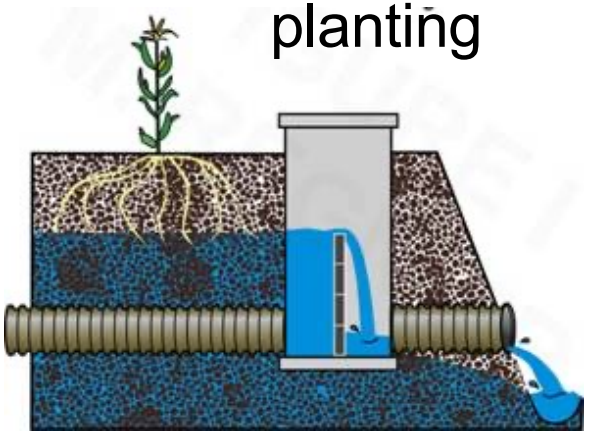
After harvest



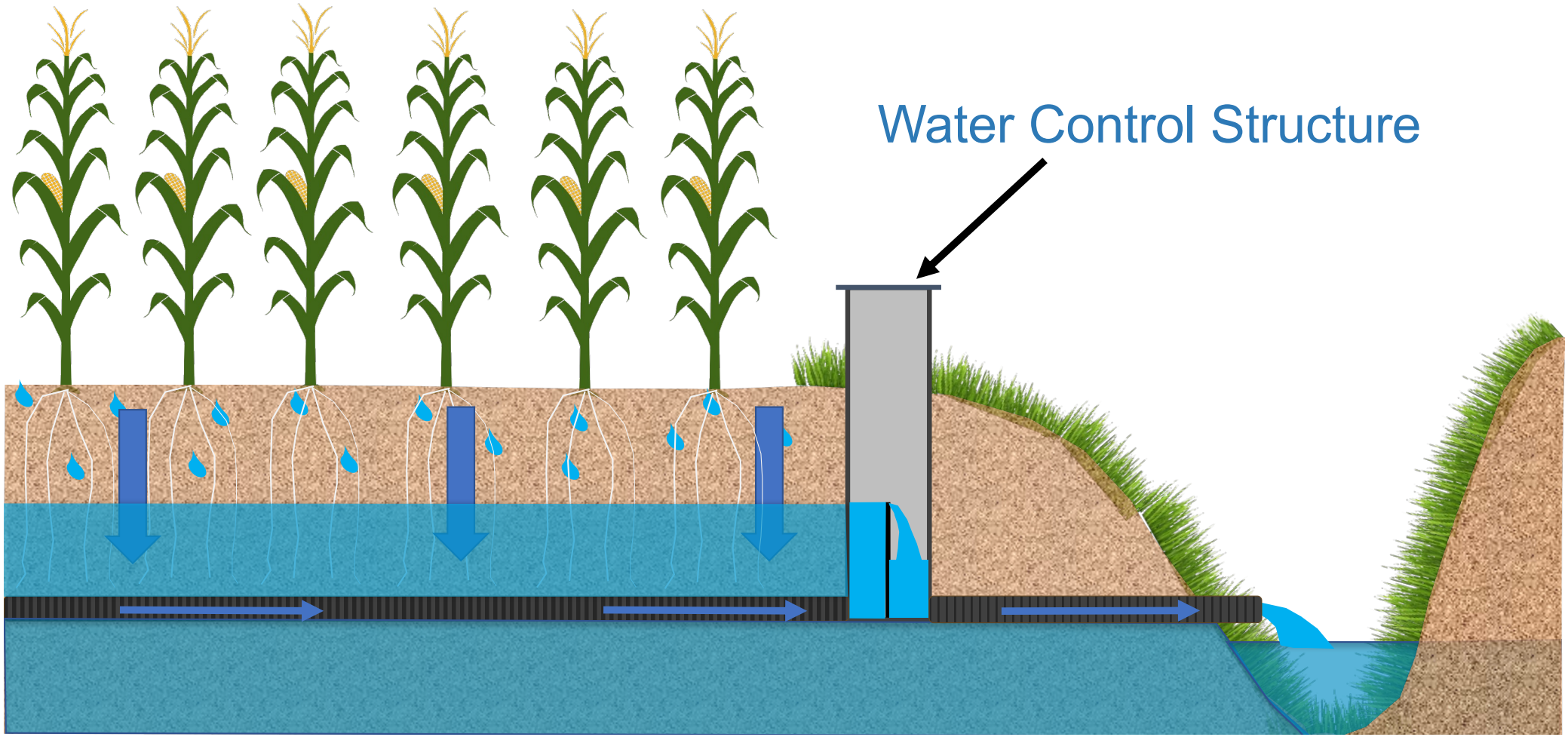
Before planting or harvest



After planting

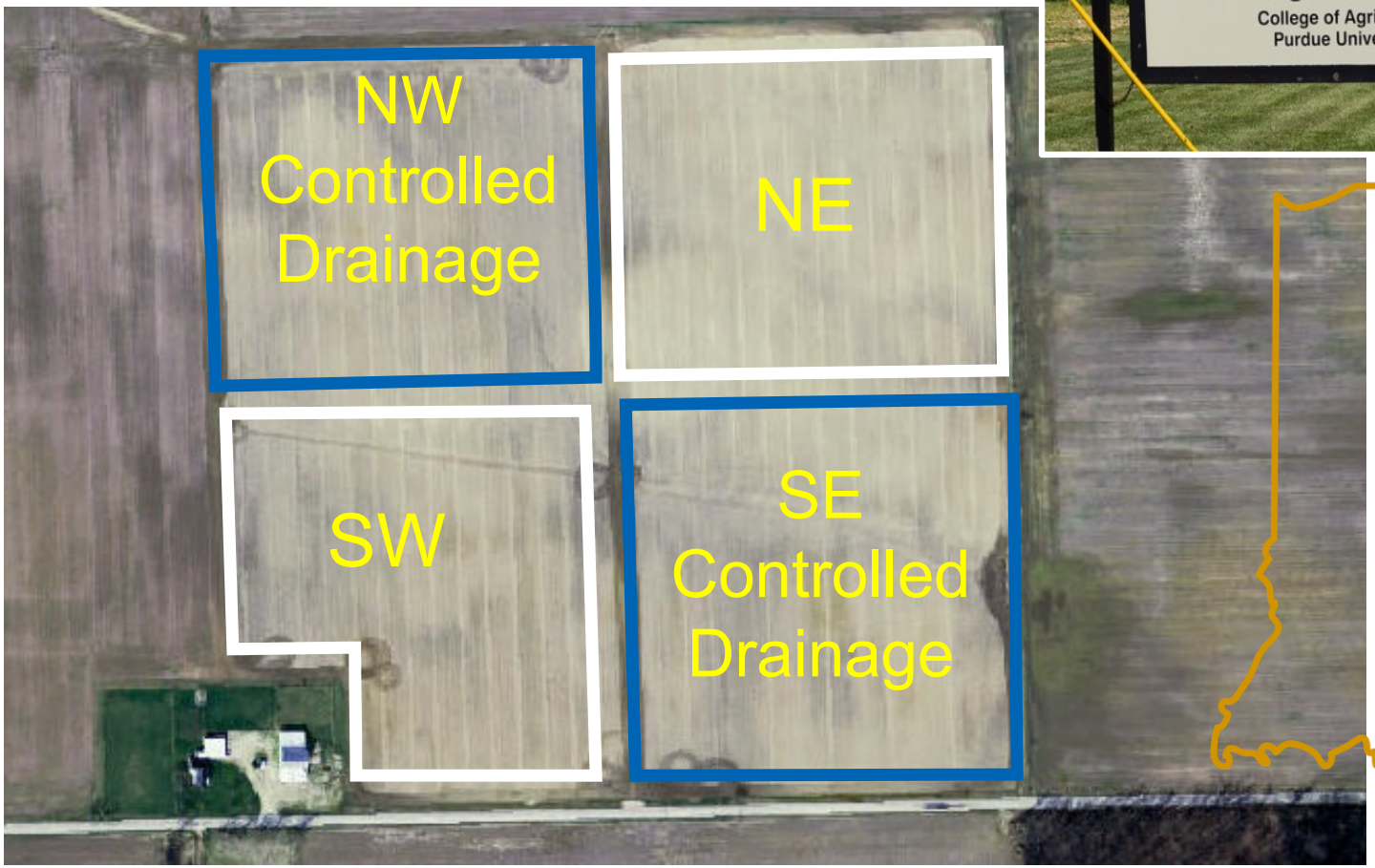


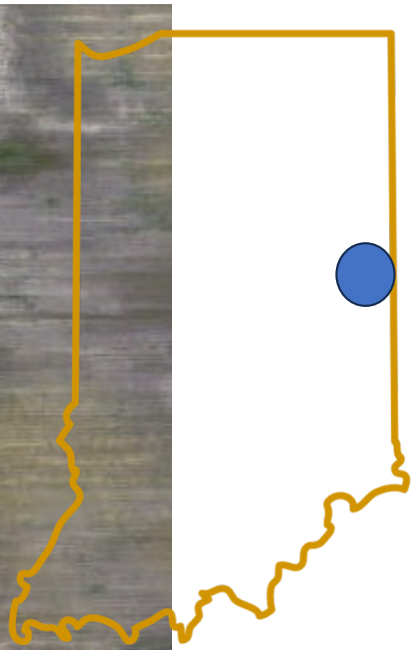
Storing water in the field: Controlled drainage



Controlled drainage research at
Davis Purdue Agriculture Center in Indiana

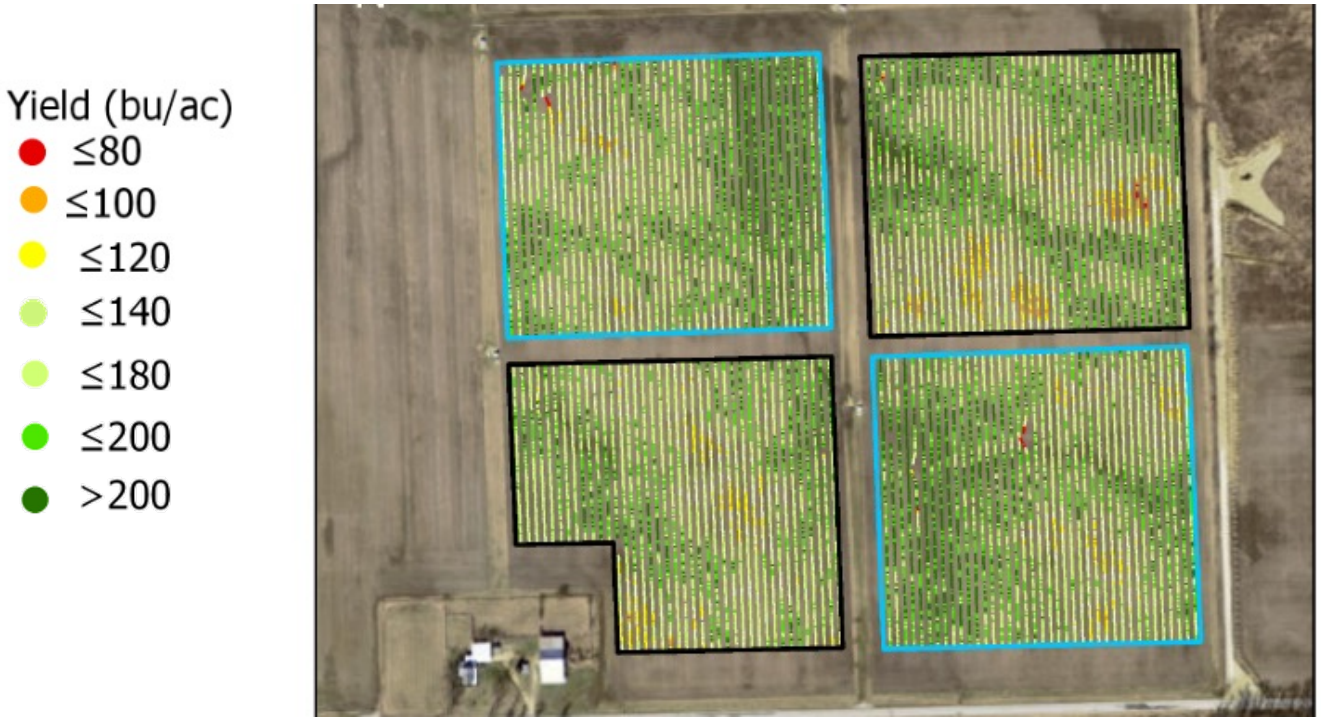
40 acre field divided into
2 controlled and 2 free draining quadrants

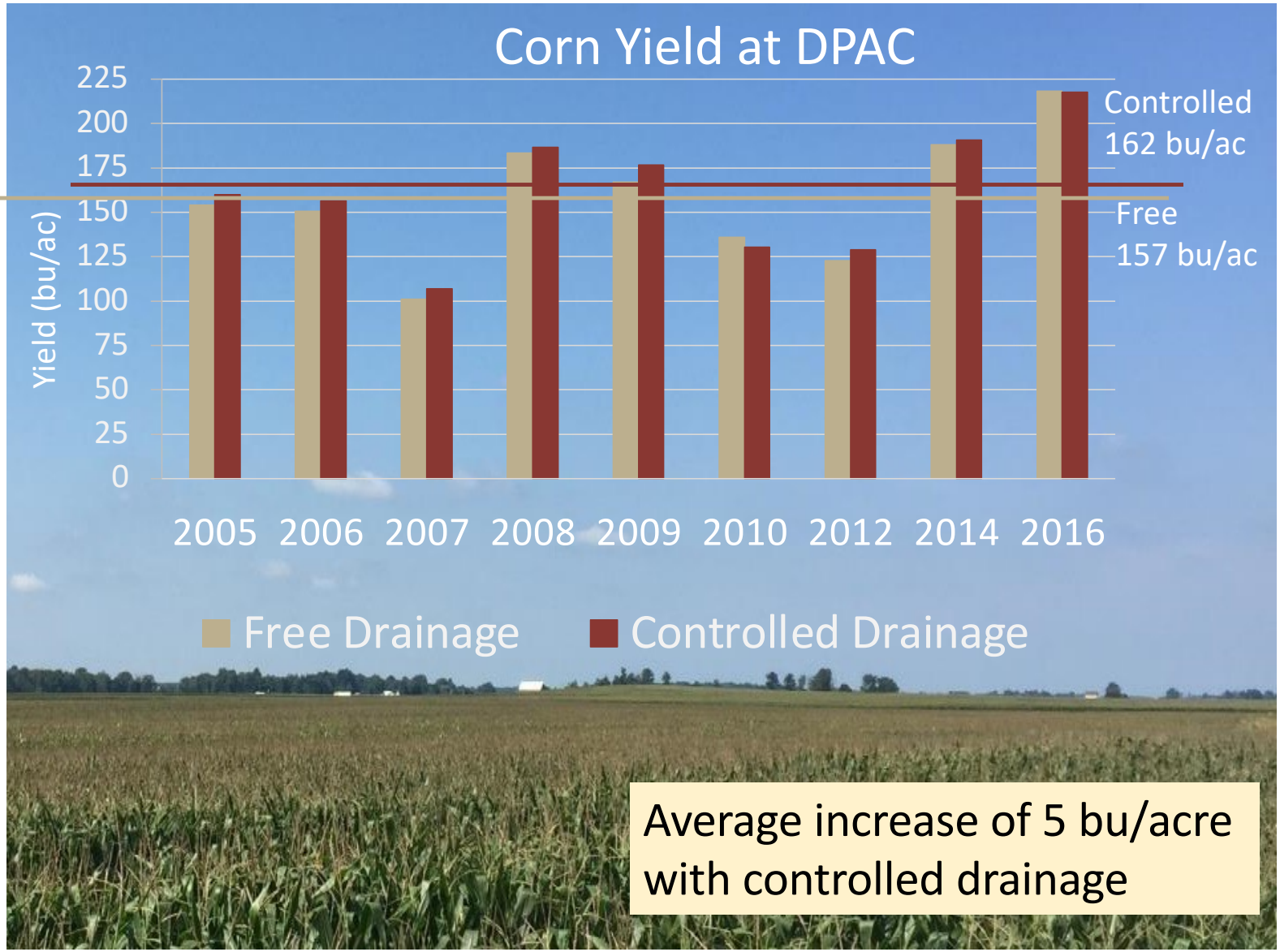




Corn yield over 9 years increased slightly with controlled drainage

- Yield measured with yield monitor each year, cleaned and processed. Example for 2009:




Corn Yield at DPAC
Yield (bu/ac)
225
200
175
150
125
100
75
50
25
0
2005
2006
2007
2008
2009
2010
2012
2014
2016
Controlled
162 bu/ac
Free
157 bu/ac
Free Drainage
Controlled Drainage
Average increase of 5 bu/acre
with controlled drainage

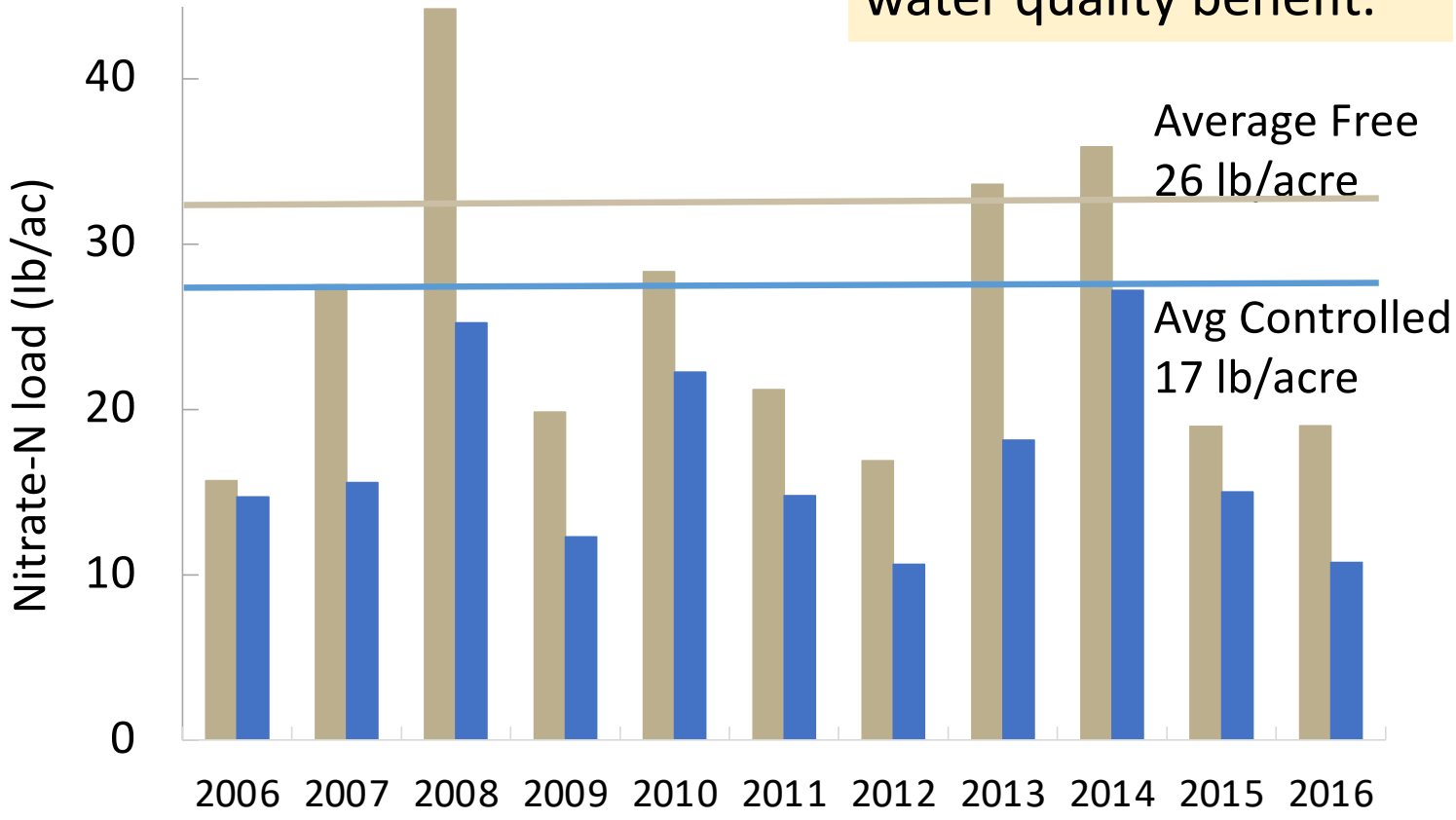
Drain flow, nitrate, and phosphorus concentrations were monitored in each quadrant.

Above: Water samples from the automated sampler

Right: Analyzing samples in the lab; Inline flow meter

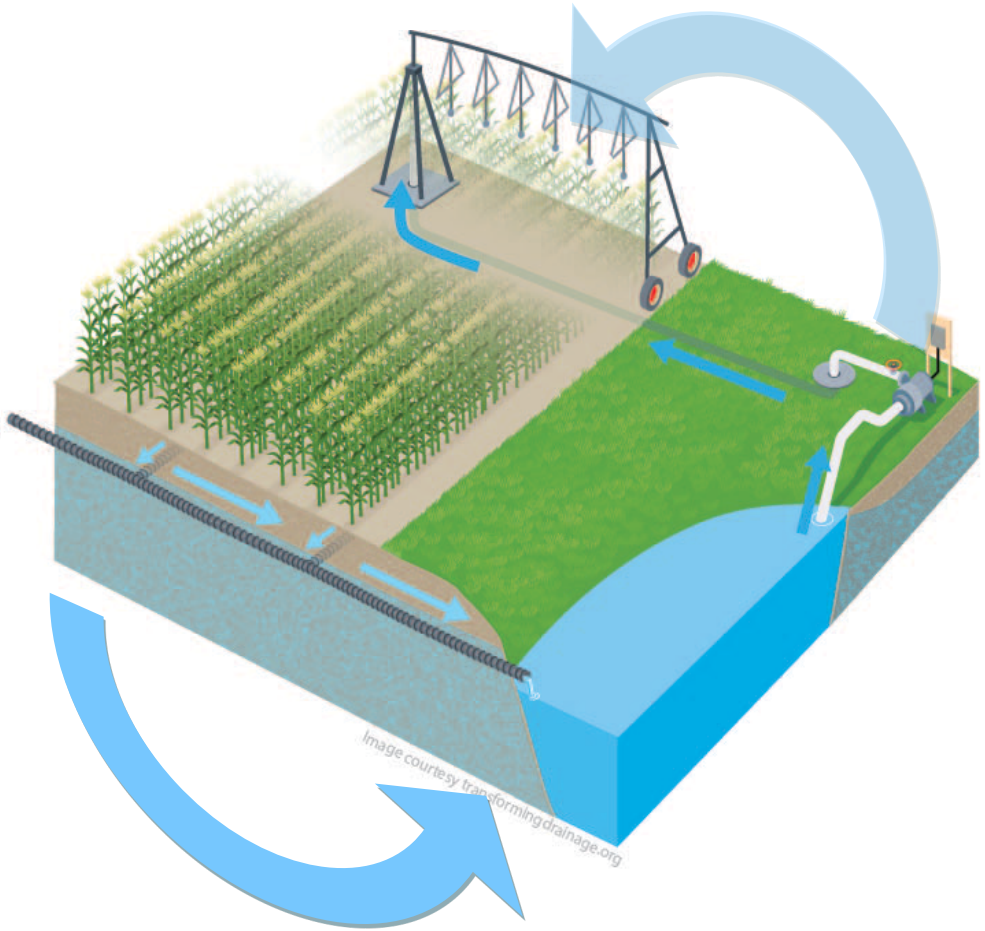
Nitrate load (lb/acre) was reduced by 9 lb/acre on average

35% nitrate load reduction – a significant water quality benefit.

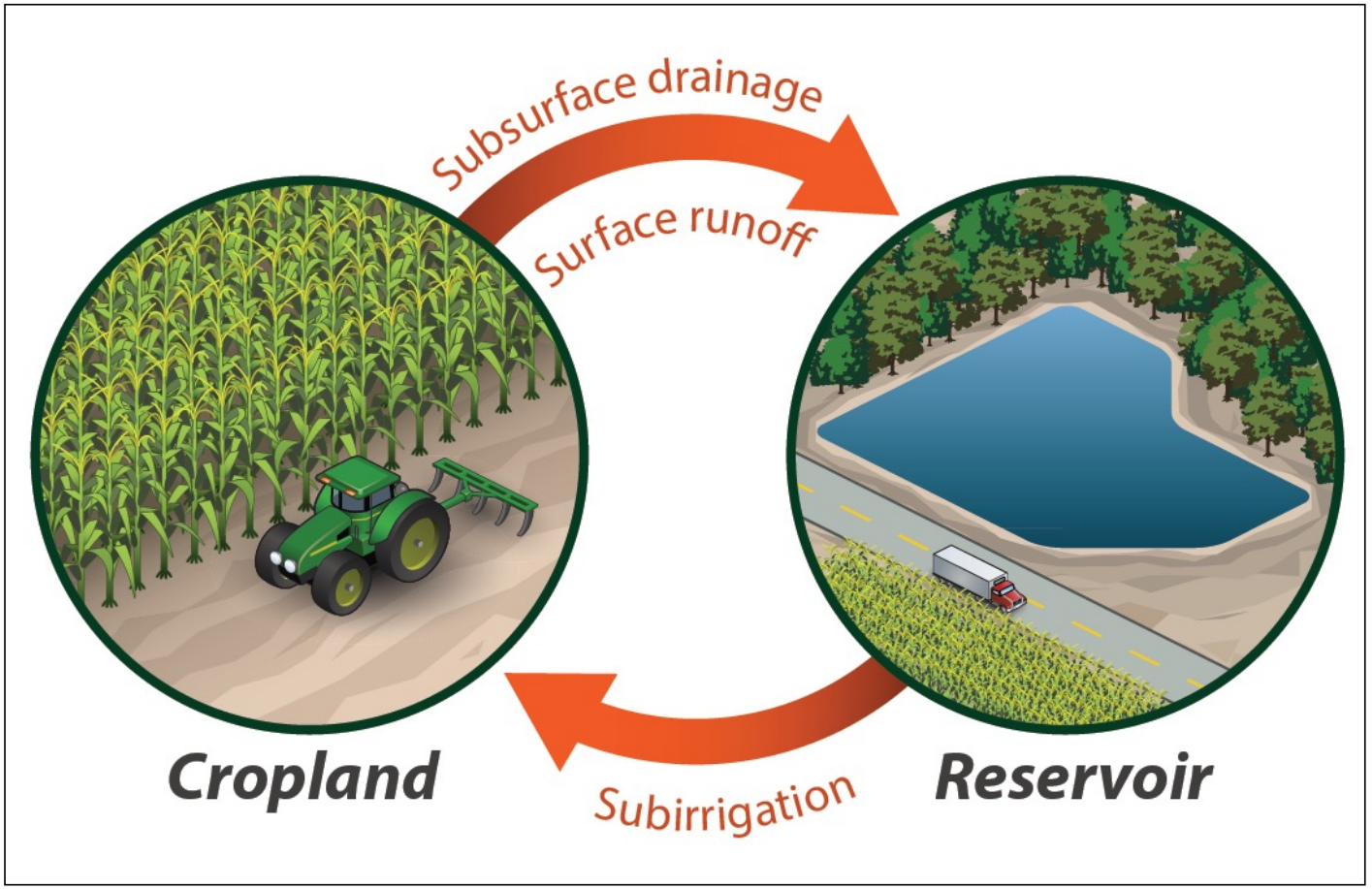


Conservation Drainage: Storing drained water, and irrigating nutrient-rich drainage water back onto crops

Drainage
Water
Recycling



Storing water, and applying it when needed = **Recycling**

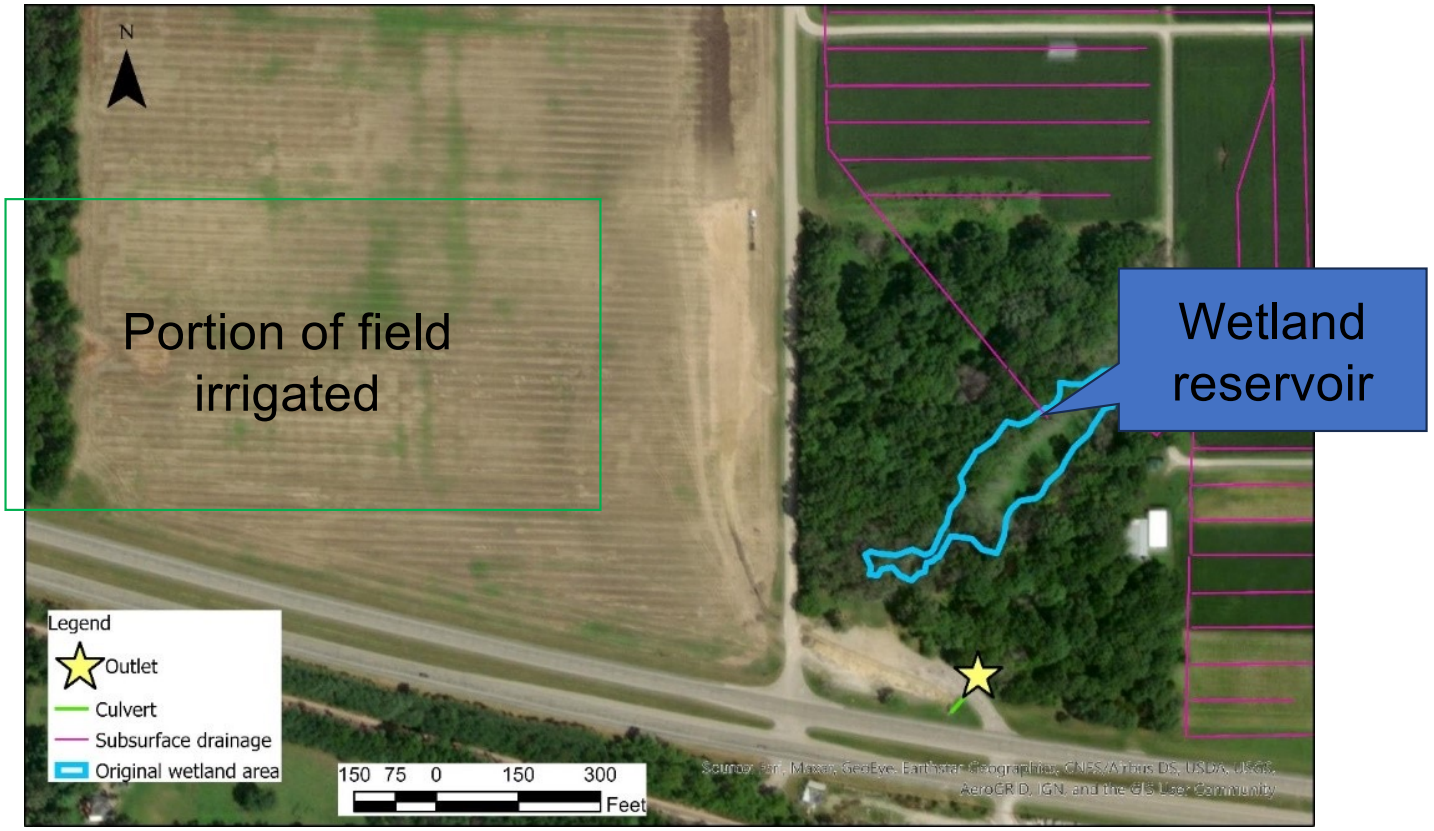


Benefits of Storing Drainage Water

Feedback Form on Conservation Drainage

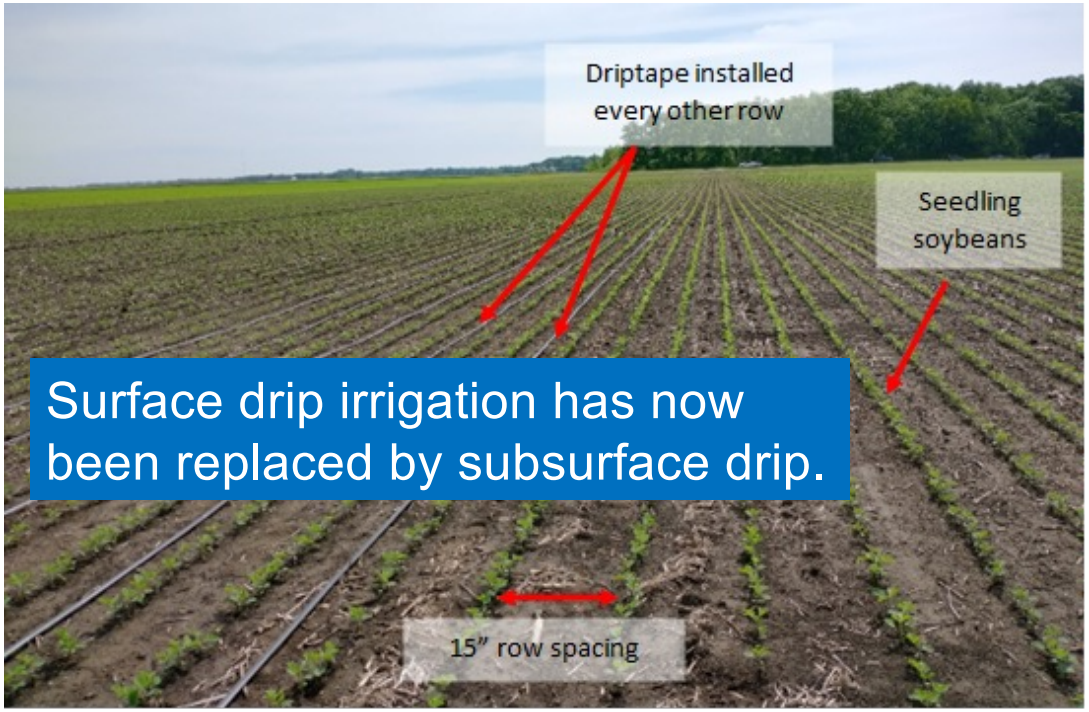
Drainage Water Recycling study at Purdue Agronomy Center for Research and Education (ACRE)

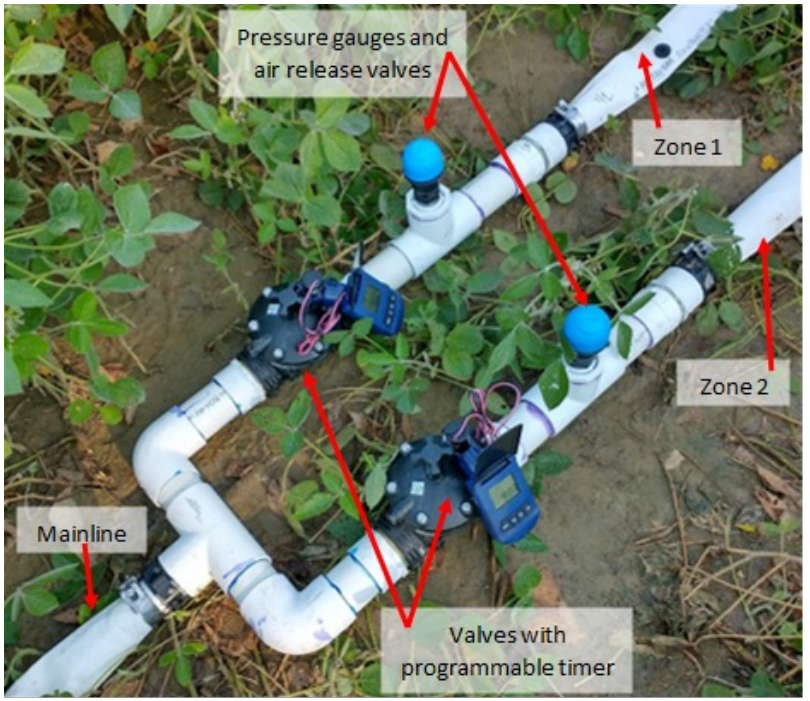
led by Laura Bowling, Keith Cherkauer, Shawn Casteel, Dan Quinn, Juan Sesmero



Drip irrigation in corn & soybeans, including fertigation

Will provide information on crop yield, leaching, and water use impacts of drainage water recyling.

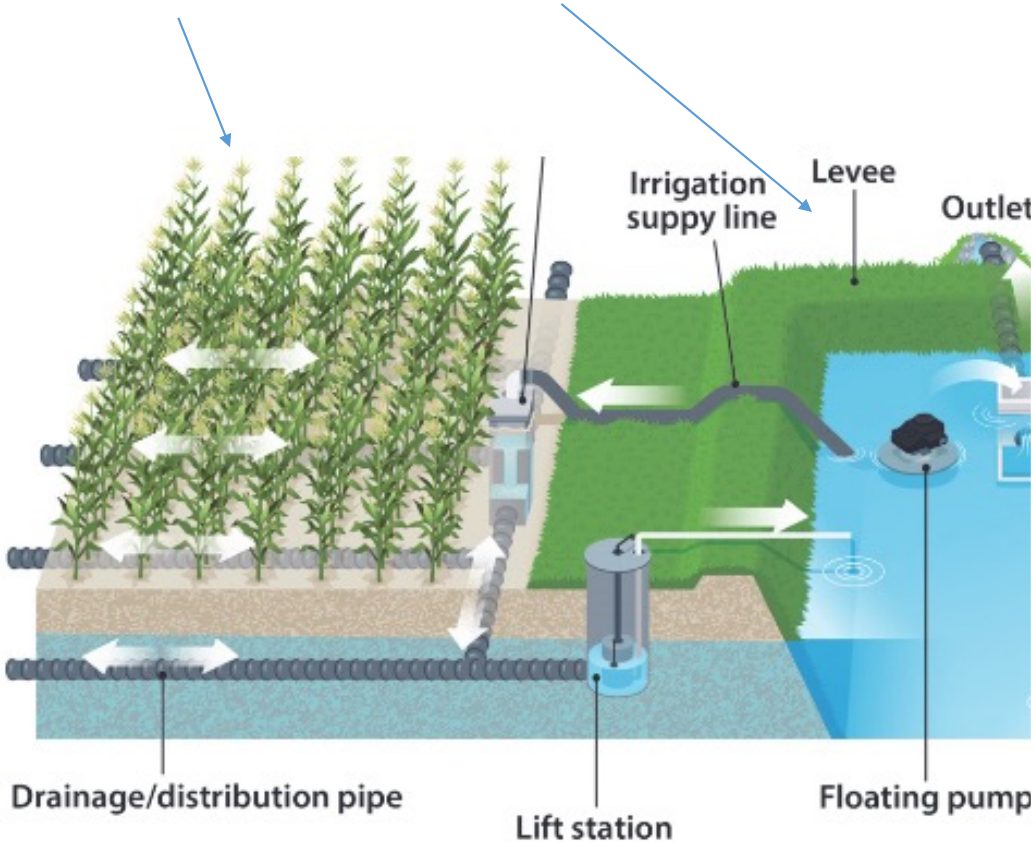




(Talk with Shawn Casteel or Dan Quinn for more info.)

Drainage water recycling: Multiple options for implementation

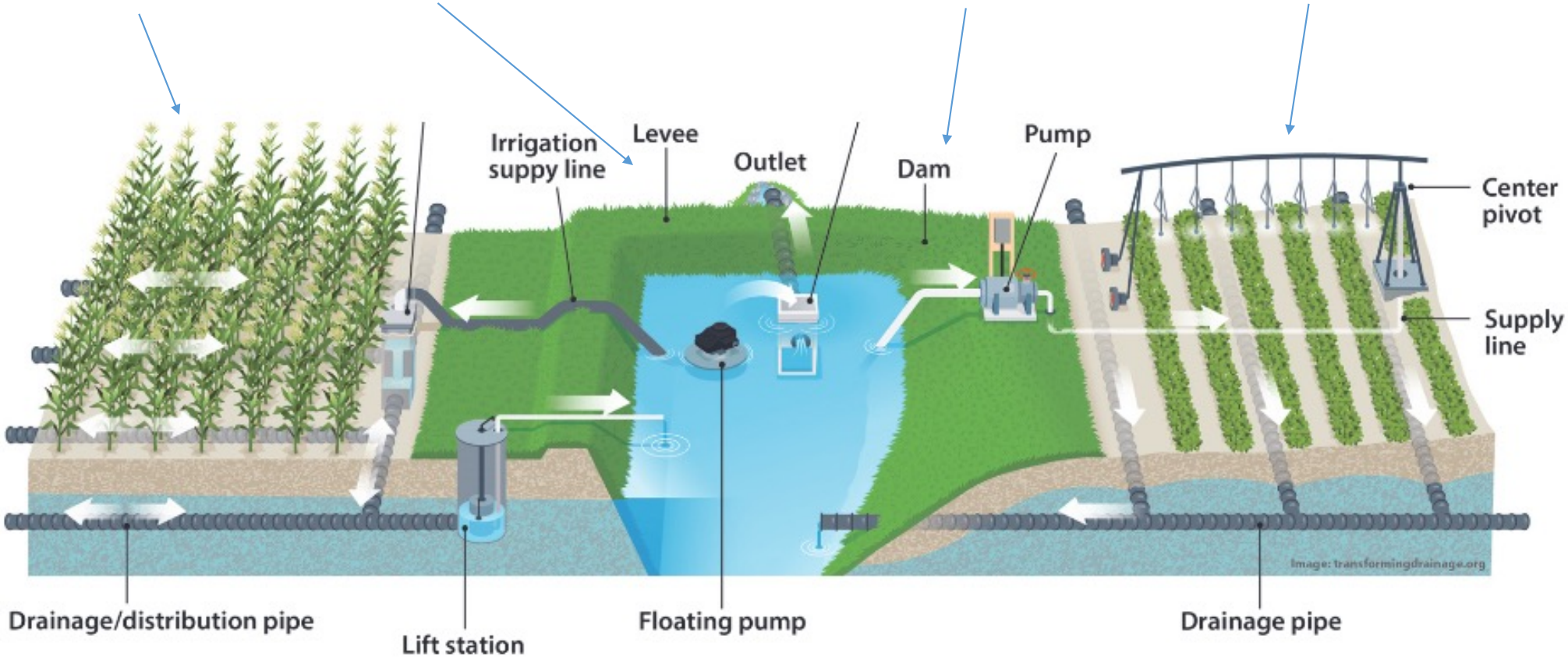
Subirrigation, Excavated pond



Drainage water recycling: Multiple options for implementation

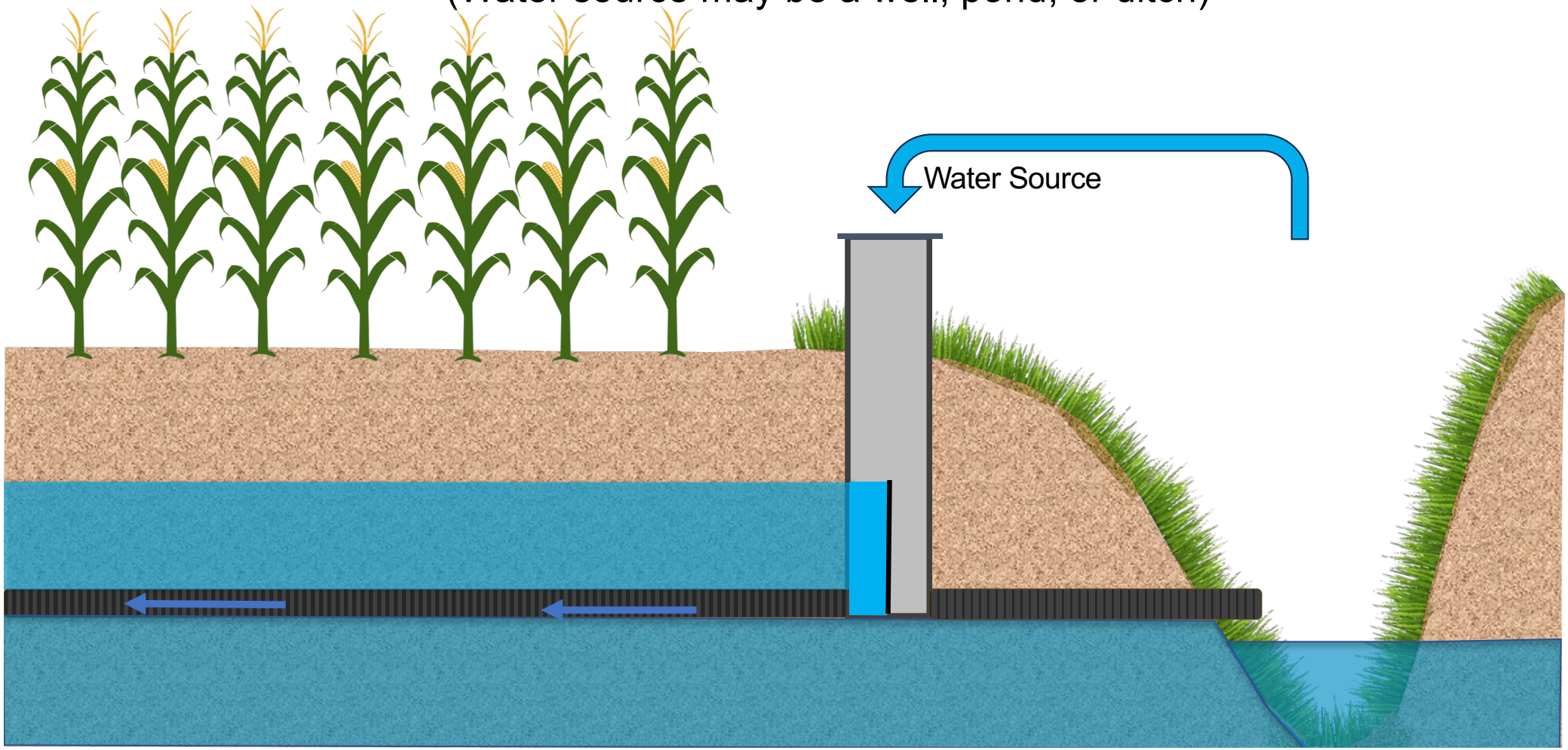
Subirrigation, Excavated pond

Embankment pond, **Sprinkler irrigation**



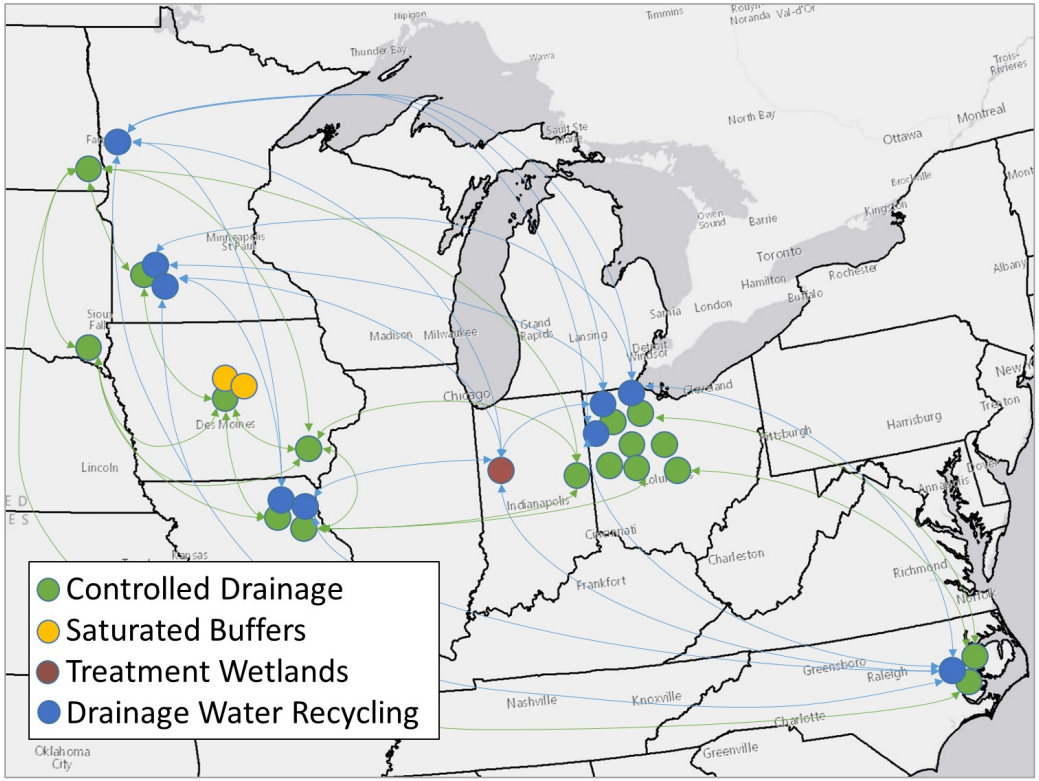
Subirrigation: Adding water to the soil through the tile line.

(Water source may be a well, pond, or ditch)



Transforming Drainage Project

Multistate drainage research, extension, and education (project now completed)



TRANSFORMING DRAINAGE.ORG

Managing Water for Tomorrow's Agriculture

TRANSFORMING DRAINAGE.ORG

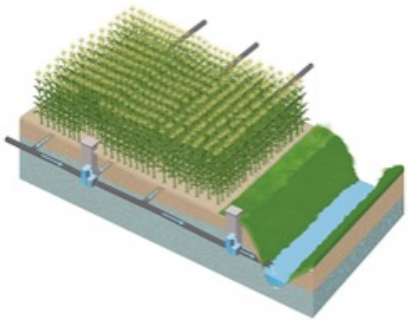
Managing Water for Tomorrow's Agriculture

Project Outcome: Extension publications were co-authored by teams of Transforming Drainage researchers, peer-reviewed by experts, and are available online. ...

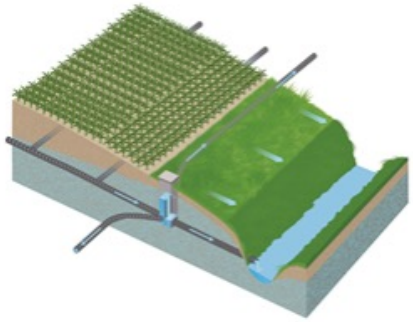
Read more

Researching findings were made available to producers, drainage contractors, and conservation agencies through **nine Extension publications.** "*Questions and Answers about Drainage Water Recycling for the Midwest*" won an **ASABE Blue Ribbon Award.**

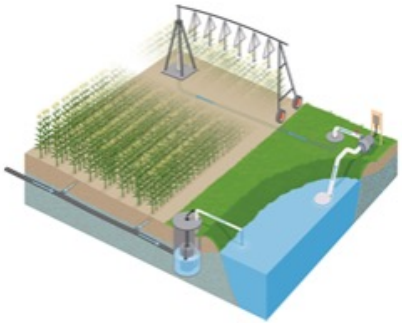
CONTROLLED DRAINAGE



SATURATED BUFFERS



DRAINAGE WATER RECYCLING

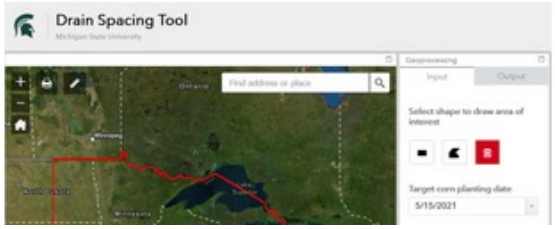


Tools Overview

A variety of tools were developed as part of the Transforming Drainage project to help with planning, evaluating, and exploring subsurface tile drainage systems and practices that can be implemented to improve water management.

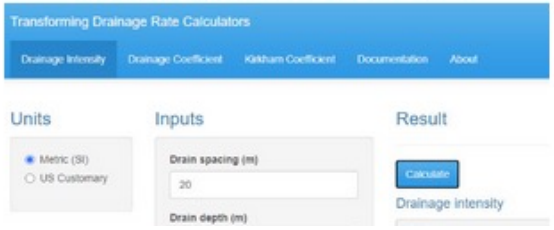
Drain Spacing Tool

The Drain Spacing Tool estimates the optimum drain spacing that maximizes economic return on investment in the drainage system.



Drainage Rate Calculator

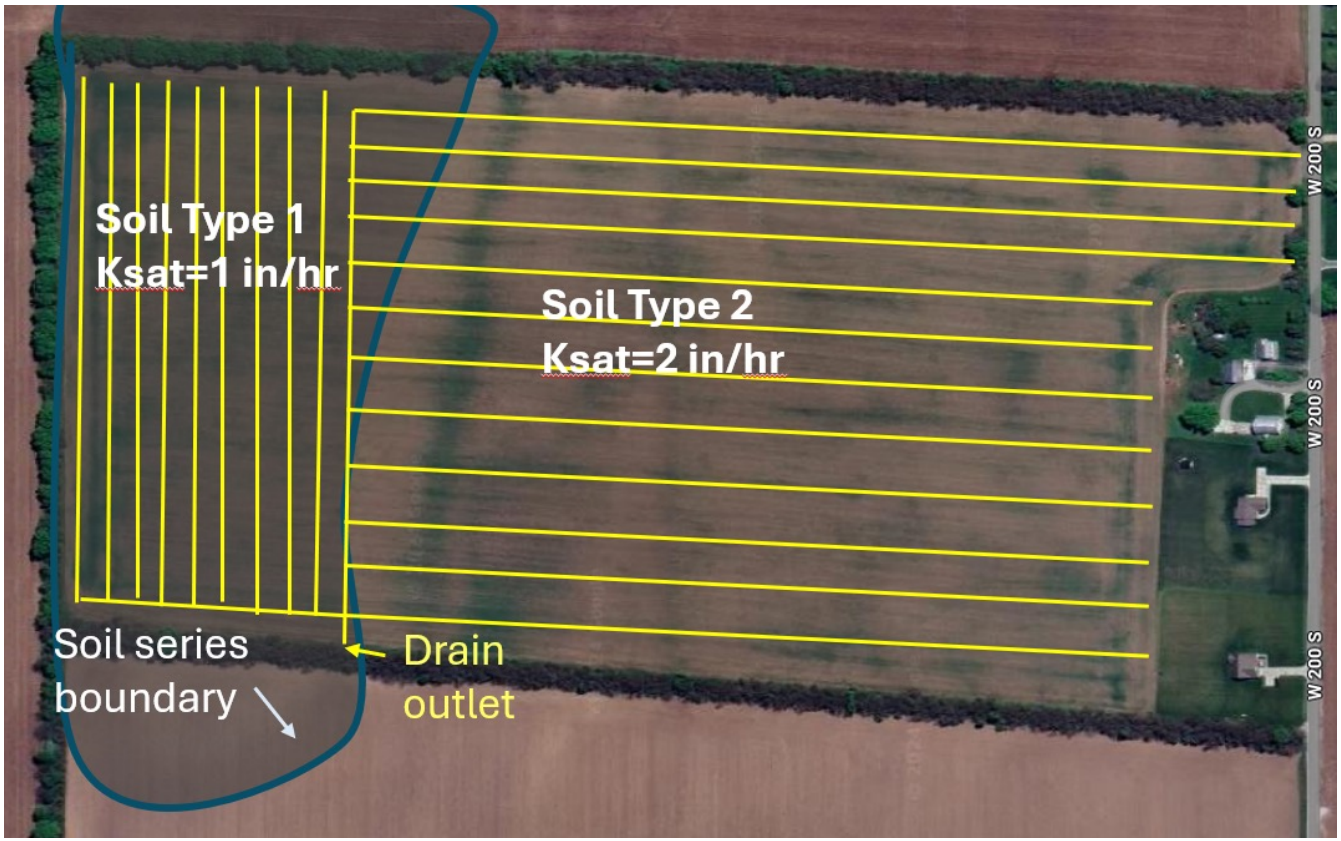
This tool calculates the three standard coefficients (drainage rates) for characterizing hydraulic properties of subsurface drainage systems.



Likely Extent of Agricultural Drainage

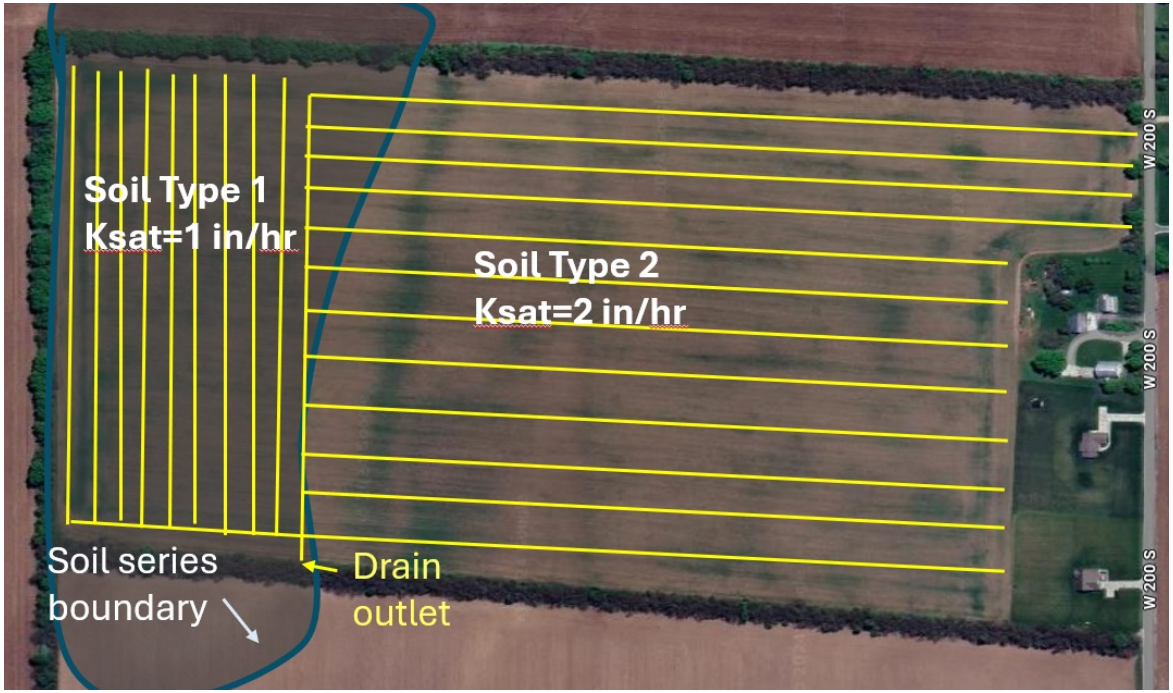
This tool identifies agricultural areas that are likely to have been drained for crop production in the Midwestern USA.

Tools for deciding on drain spacing

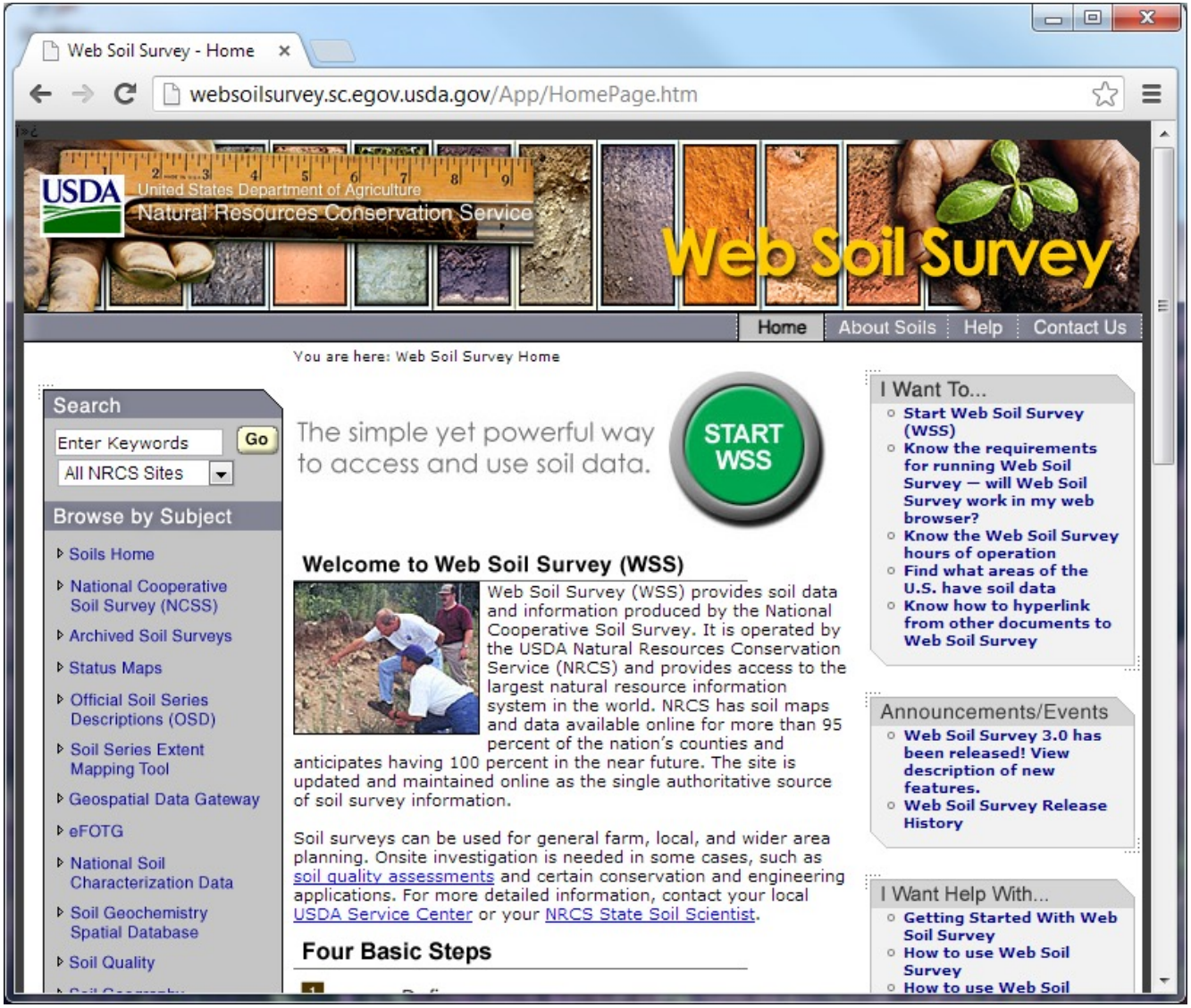


Optimal Tile Spacing Depends on Soil

- Optimal spacing depends on the soil hydraulic conductivity and the depth to a restricting soil layer.
- Narrower spacing is needed in soils with low soil hydraulic conductivity or a shallow depth to the restricting layer.

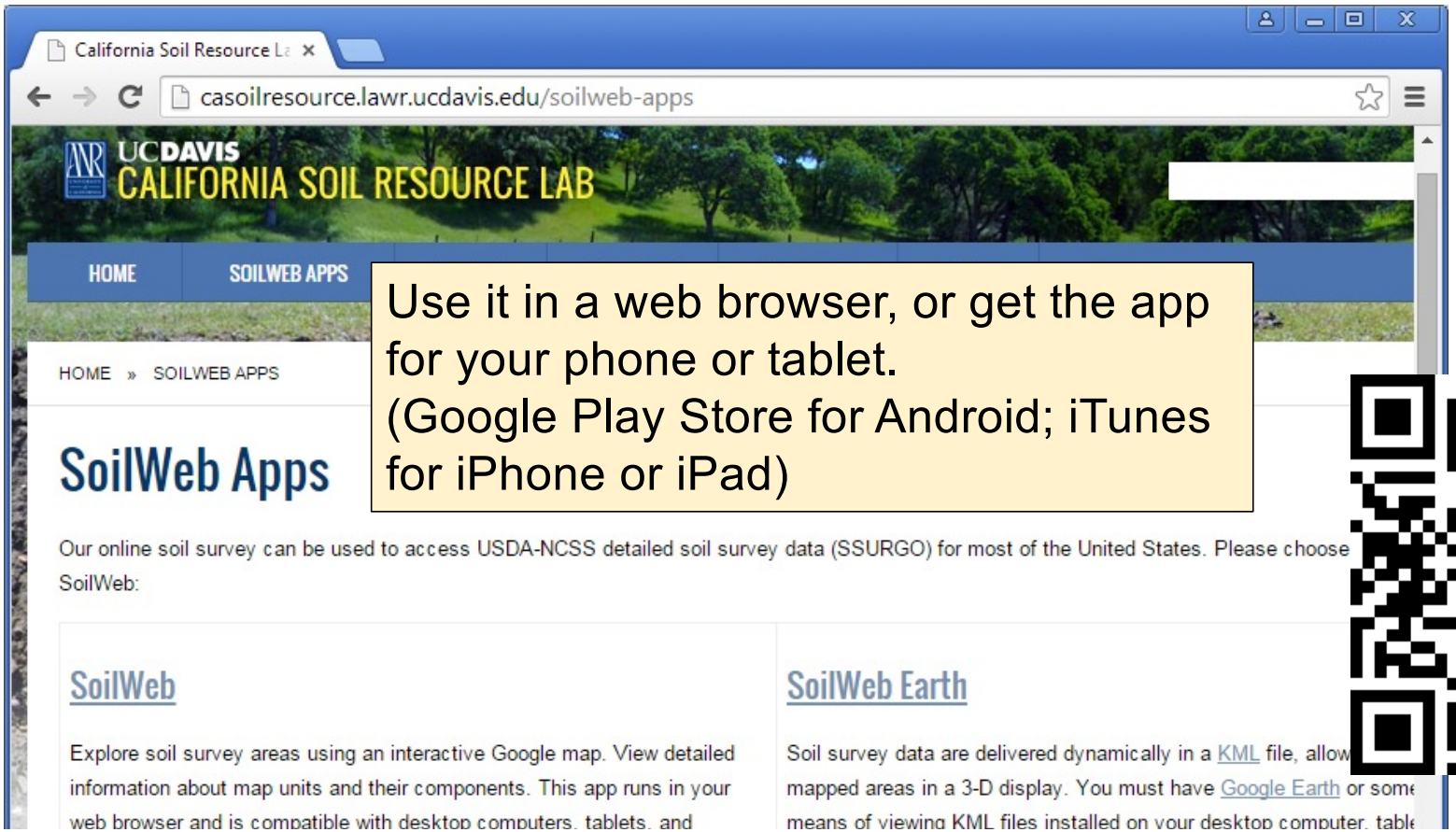


Find out about soils at any location through the Soil Survey



Another option for the Soil Survey: SoilWeb Apps

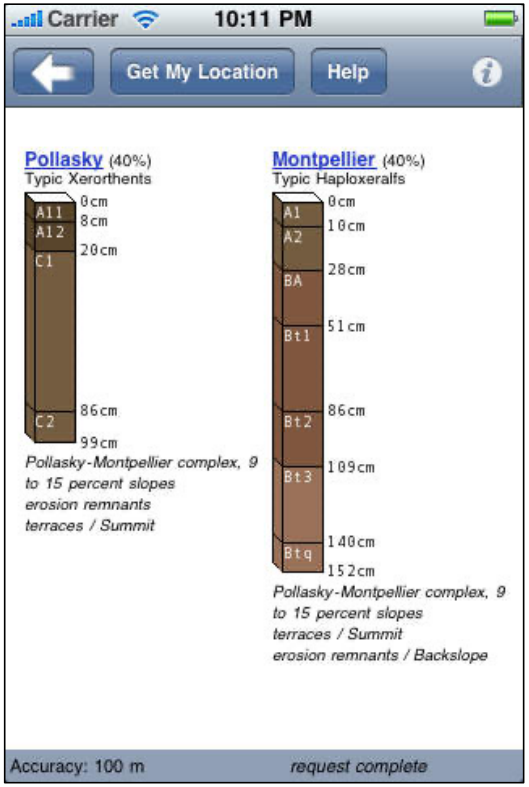
http://casoilresource.lawr.ucdavis.edu/gmap/



Use it in a web browser, or get the app for your phone or tablet.
(Google Play Store for Android; iTunes for iPhone or iPad)

Download the app for iPhone or Android:
SoilWeb App (from California Soil Resource Lab)

Google Play Store for Android;
iTunes for iPhone or iPad

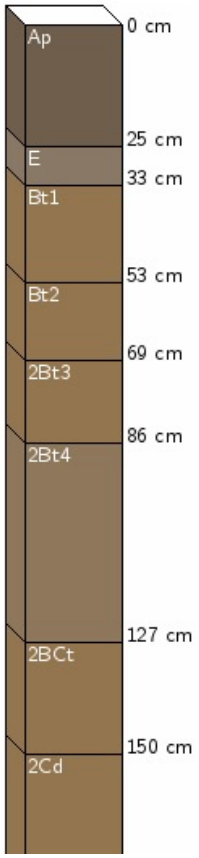


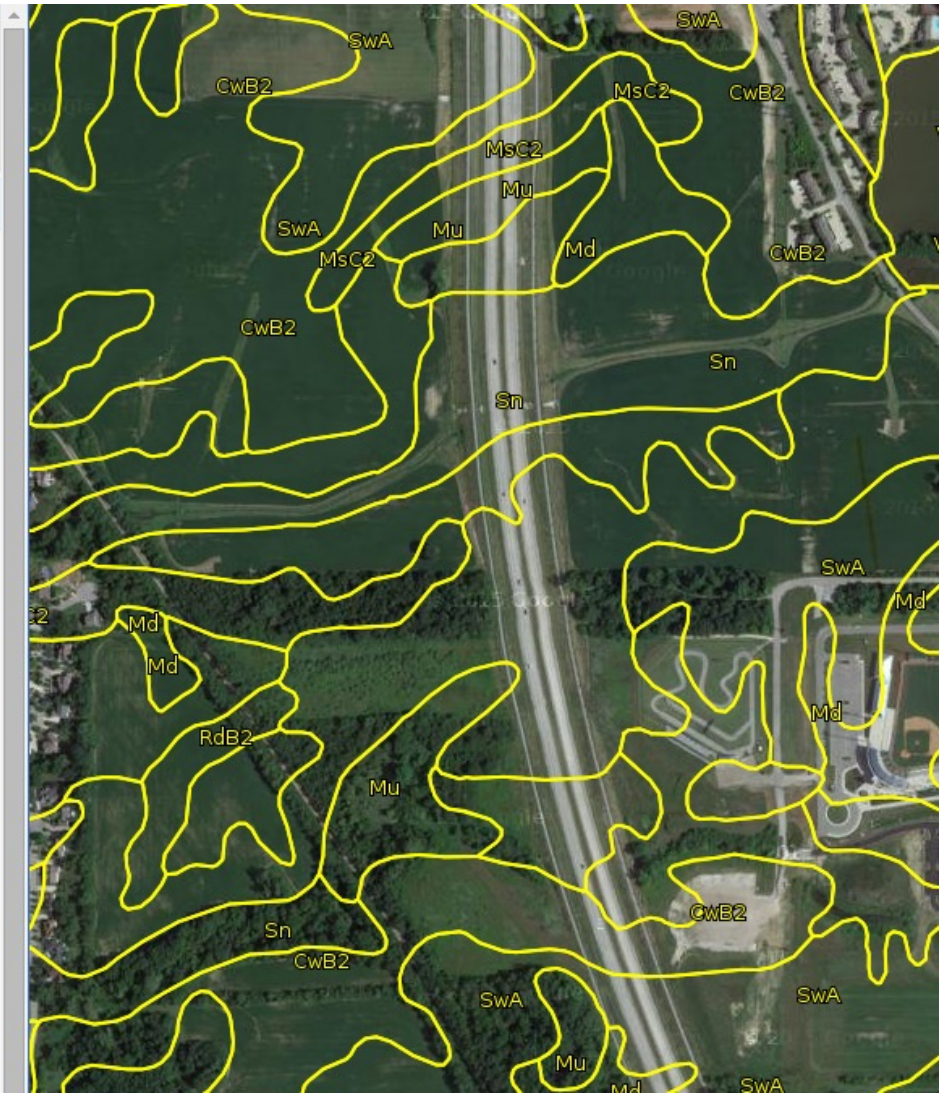
Map Unit Name: ***Starks-Fincastle complex, 0 to 2 percent slopes*** Symbol: ***SwA***
Component Name: ***Fincastle***
Component Key: 11977785
Soil Data Explorer | Series Extent Explorer
Official Series Description

▲ Soil Profiles

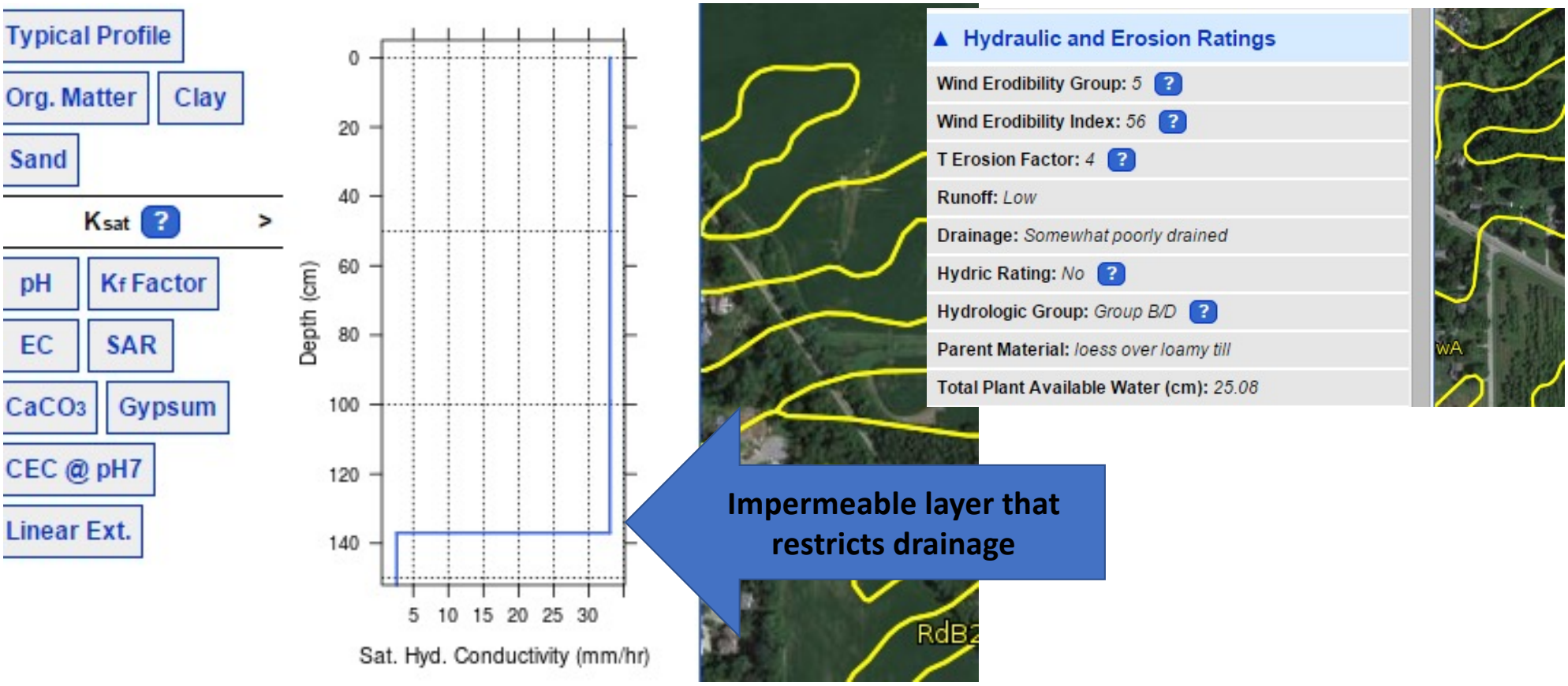
Typical Profile >

Org. Matter | Clay
Sand | Ksat
pH | Kf Factor
EC | SAR
$CaCO_3$ | Gypsum
CEC @ pH7
Linear Ext.

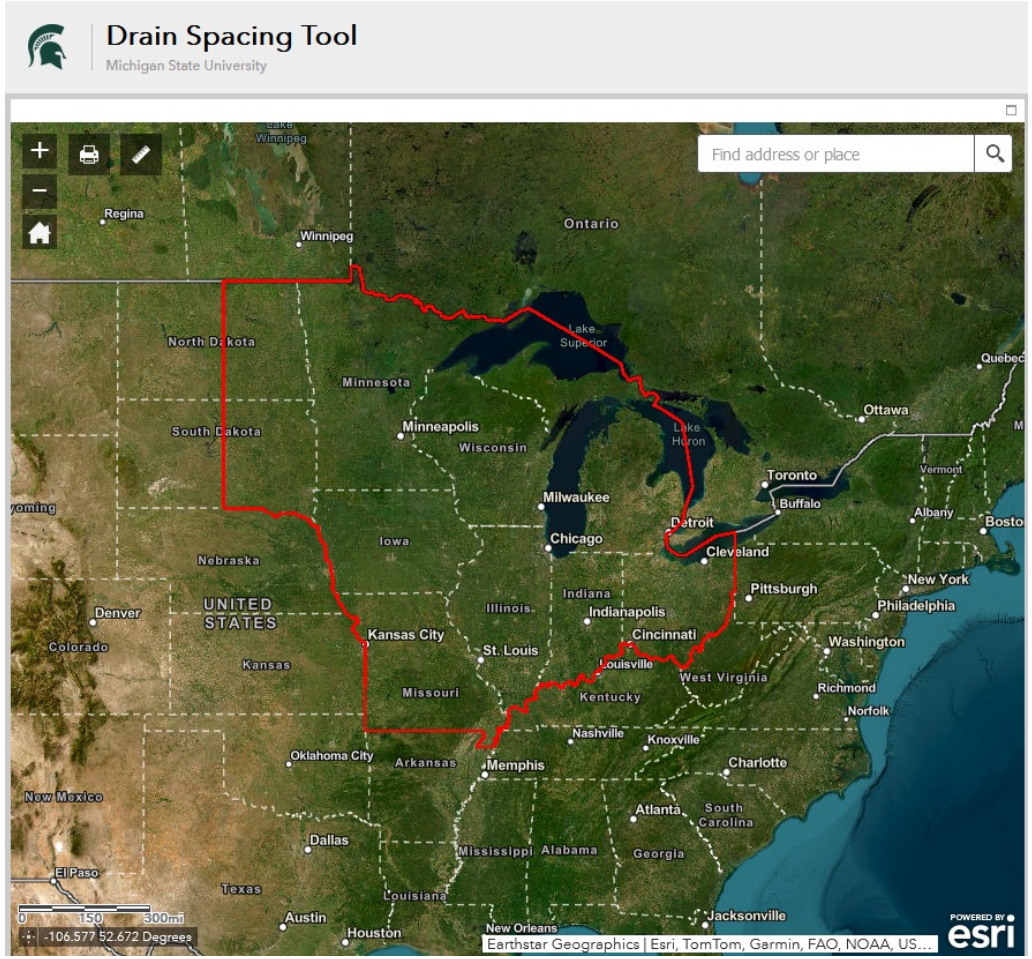


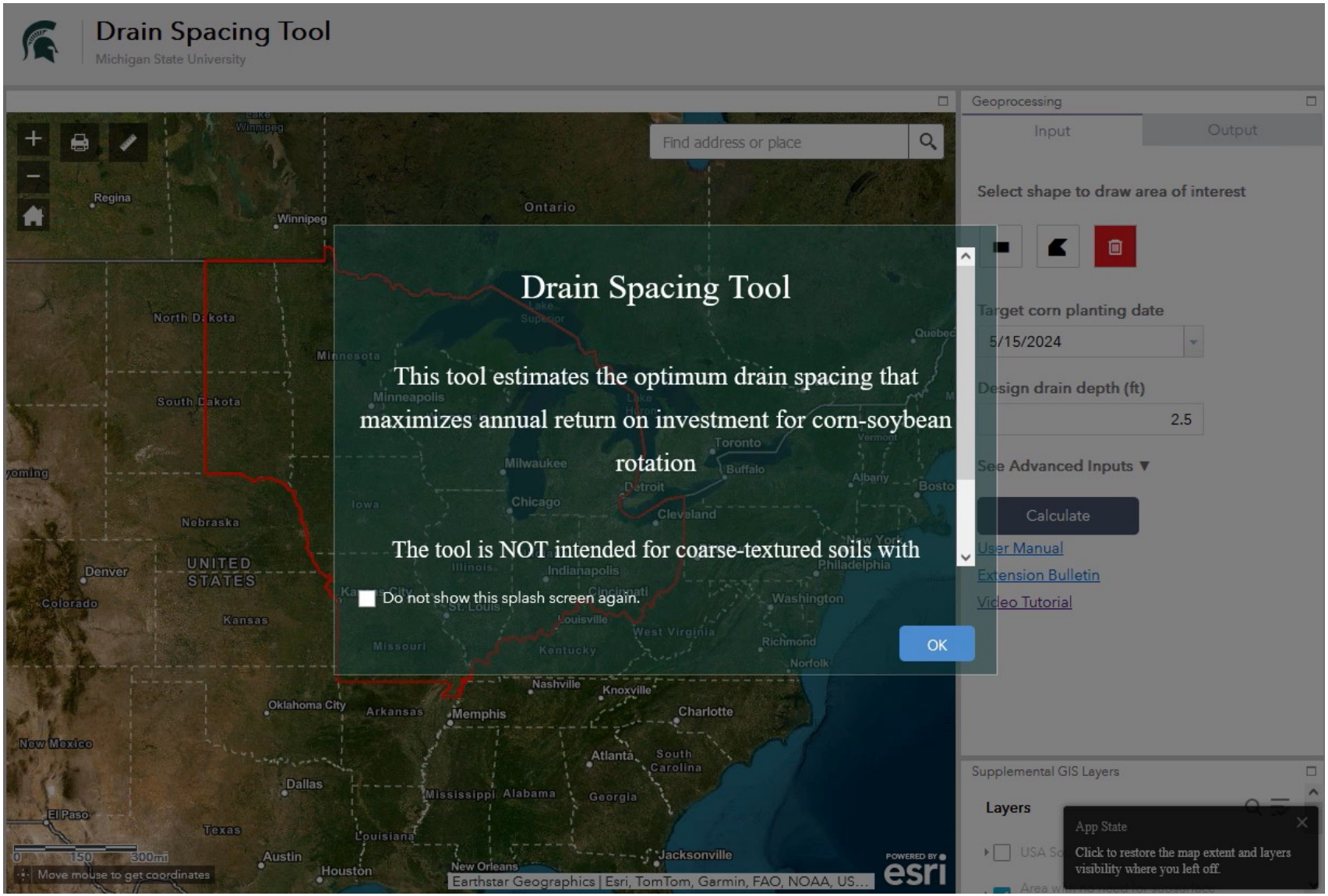


Soil hydraulic conductivity by depth shows why this soil is poorly drained.



Drain Spacing Tool – Michigan State University



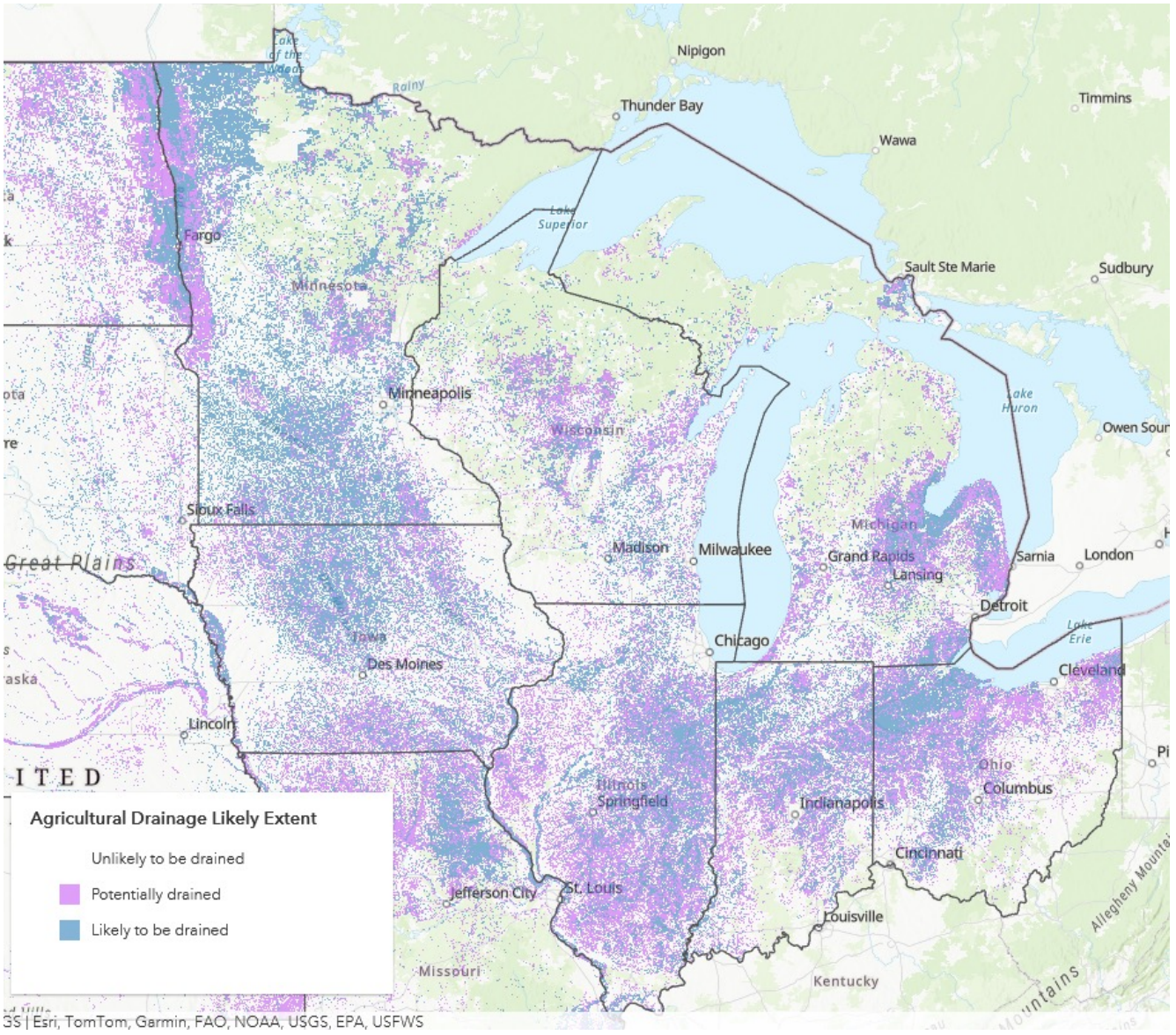

Drain Spacing Tool
Michigan State University
Find address or place
Drain Spacing Tool
This tool estimates the optimum drain spacing that maximizes annual return on investment for corn-soybean rotation
The tool is NOT intended for coarse-textured soils with
Do not show this splash screen again.
OK
Geoprocessing
Input
Output
Select shape to draw area of interest
Target corn planting date
5/15/2024
Design drain depth (ft)
2.5
See Advanced Inputs
Calculate
User Manual
Extension Bulletin
Video Tutorial
Supplemental GIS Layers
Layers
App State
Click to restore the map extent and layers visibility where you left off.
Move mouse to get coordinates
Earthstar Geographics | Esri, TomTom, Garmin, FAO, NOAA, US...
esri

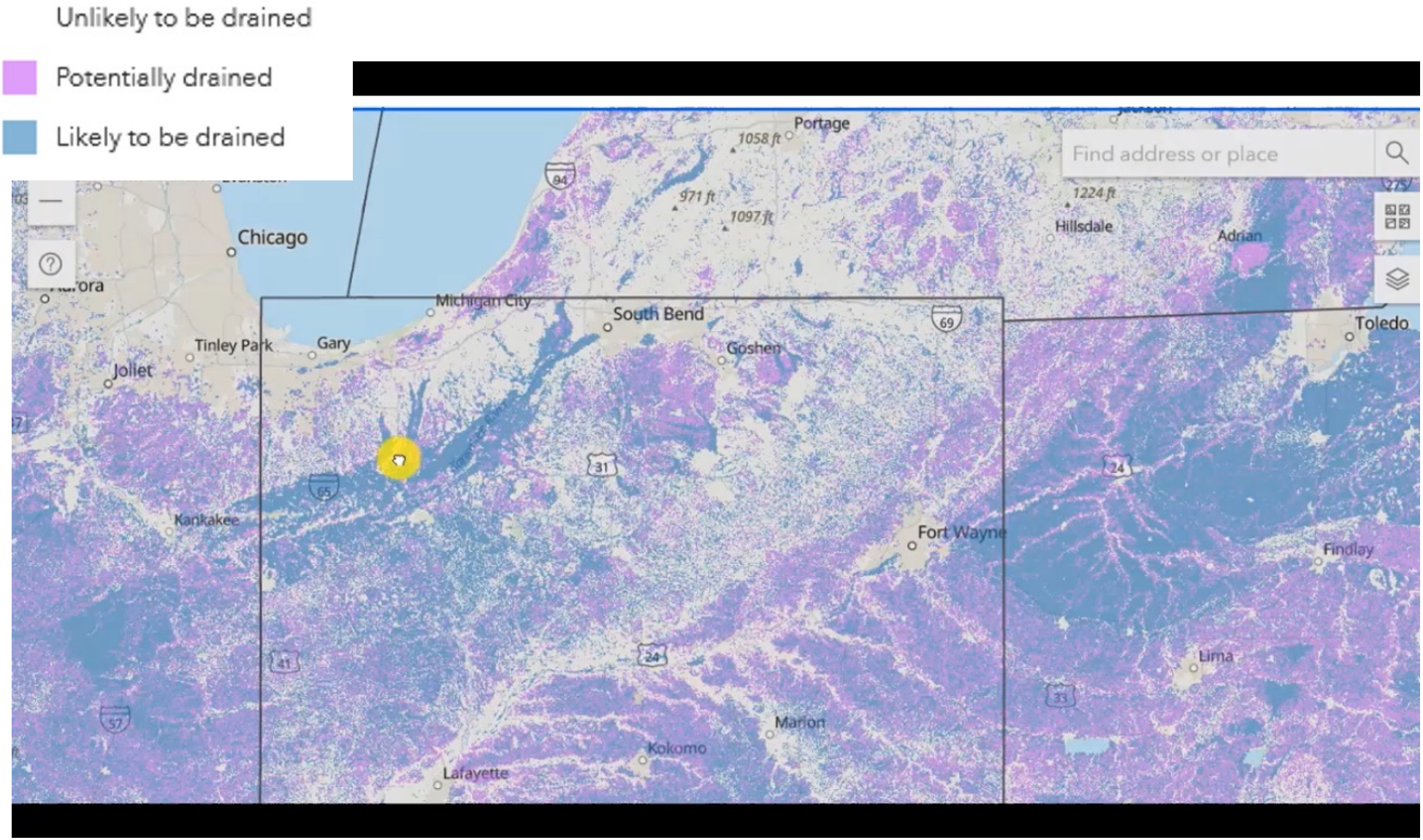
TRANSFORMING DRAINAGE.ORG

Managing Water for Tomorrow's Agriculture

There is no definitive map of drained areas, but the **"Likely Drained Area Tool"** provides an estimate of likely drained areas in the Midwest

https://transformingdrainage.org/tools/drained-area-tool/

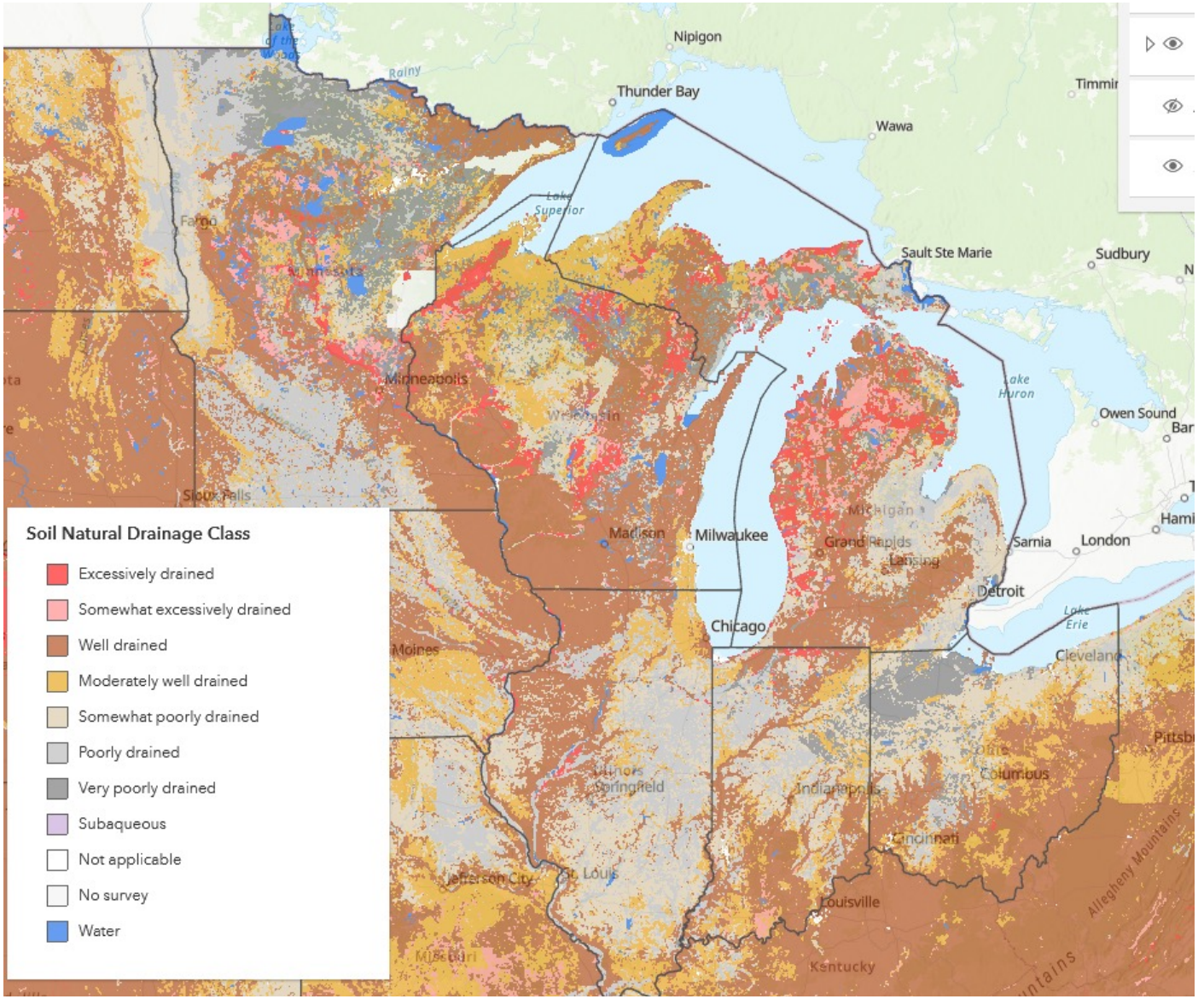



Unlikely to be drained
Potentially drained
Likely to be drained
Find address or place
Portage
1058 ft
971 ft
1097 ft
1224 ft
Hillsdale
Adrian
Chicago
Michigan City
South Bend
Goshen
Toledo
Tinley Park
Gary
Joliet
Kankakee
Fort Wayne
Findlay
Lima
Marion
Kokomo
Lafayette
94
69
31
65
24
41
57
33

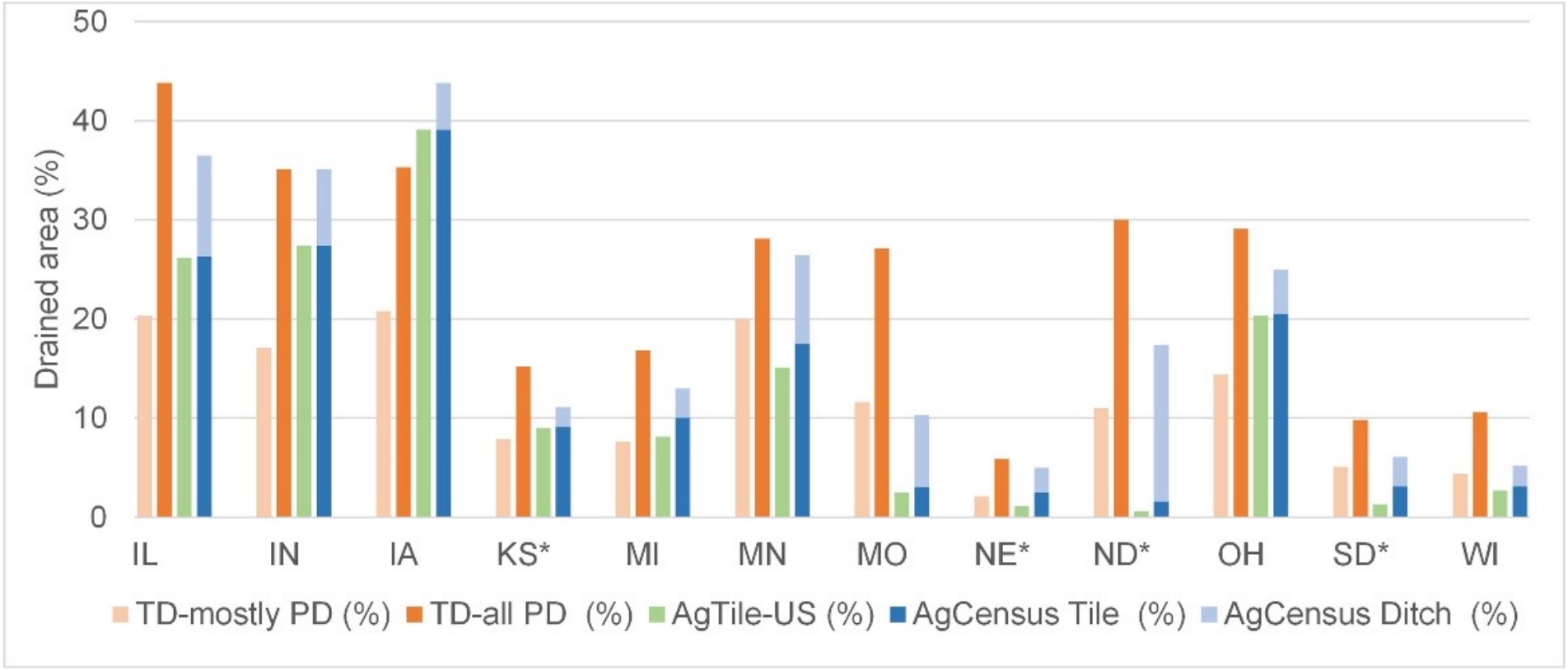
Based on **soil natural drainage class**, a property in the USDA NRCS Soil Survey

(Map from soilexplorer.net.

Grey means poorly drained, just like the soils themselves.)



Estimated drained land by state



Agricultural water management continues to be important.

We have the technology to expand our goals in drainage.

Goals as we plan drainage systems of the future

- Reduce uncertainty and risk related to water availability

- Reduce nutrient losses from agricultural fields

Questions?