Implementing Tile-Drainage Treatment Wetlands to Reduce Nitrogen Loading at the Watershed Scale:

Lake Bloomington Drinking Watersheds Project "Proof of Concept Program"

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and
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These 7 Midwestern States produce 21% of the World's Corn

- The best rain-fed agricultural soils in the world

- Highest fertilizer application in the world
- Land has been drained to optimize production

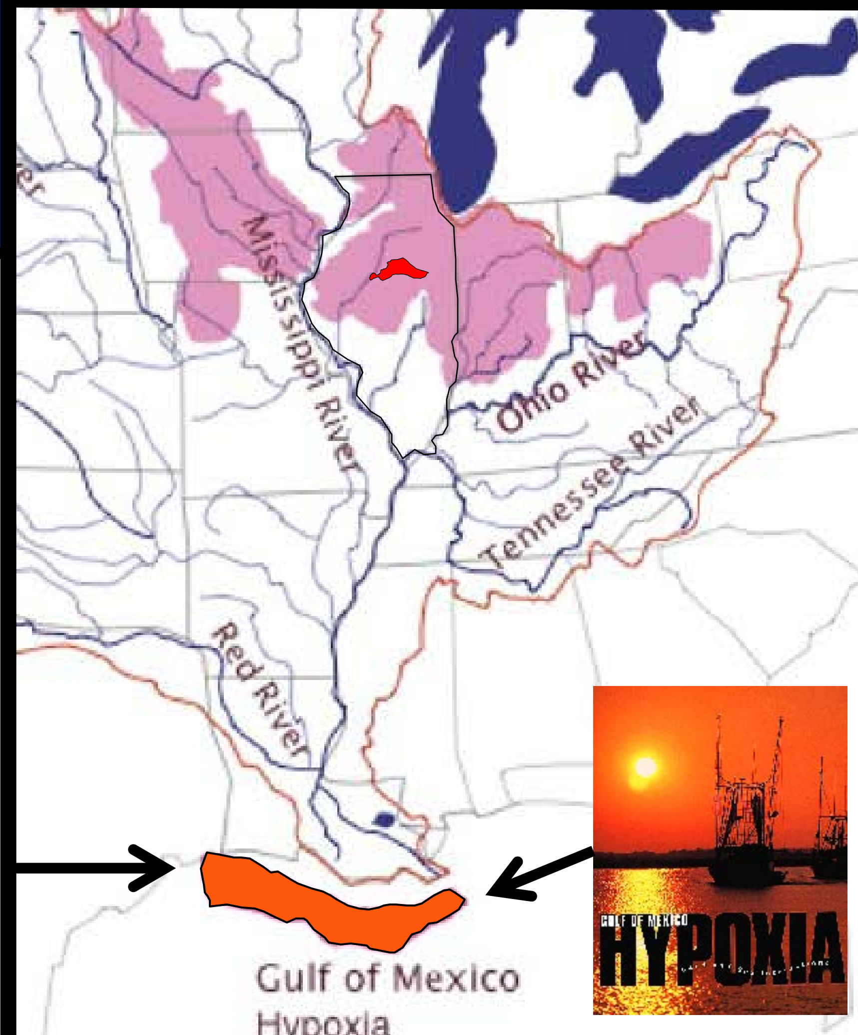
Modern Day Tile Systems

Goal is to move water to the Gulf as fast as possible

Area in pink = 95 million acres

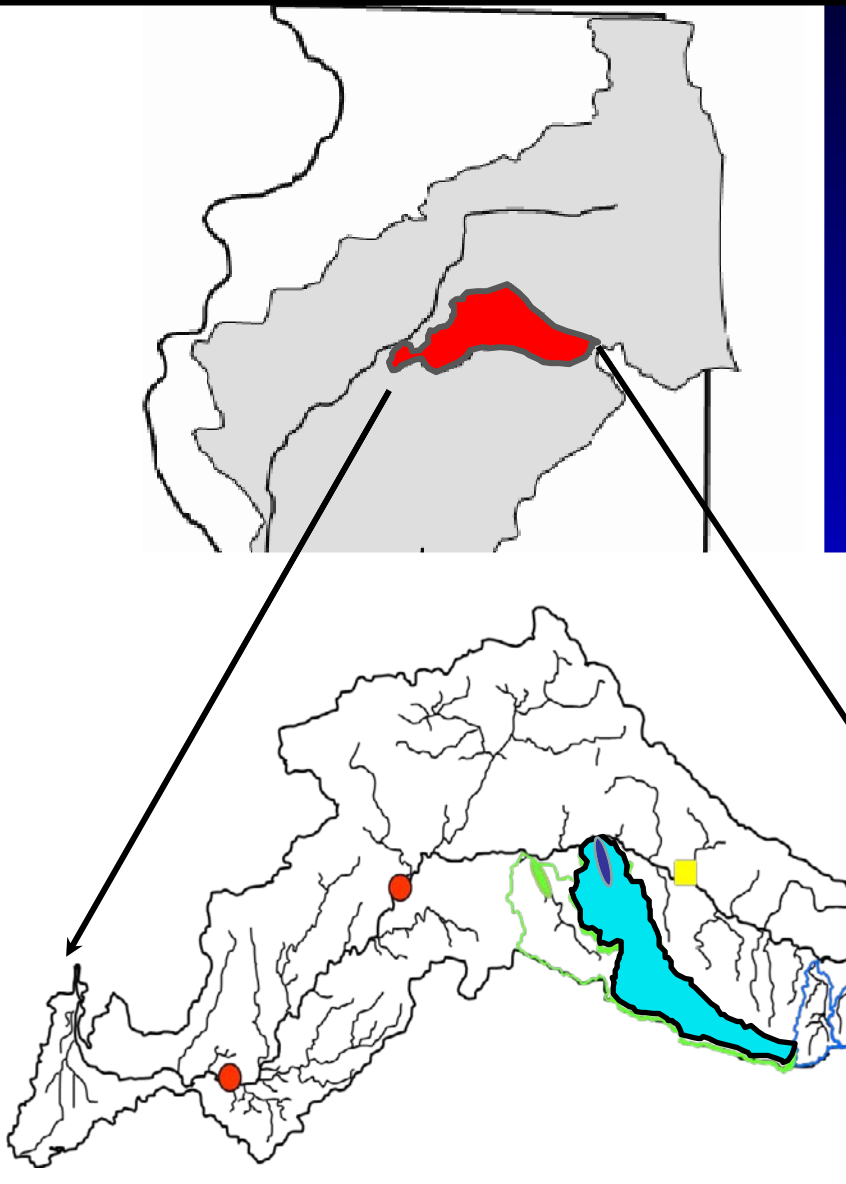
Contributes 90% of the nitrate-N flux to the Gulf
0.86 Million metric tons

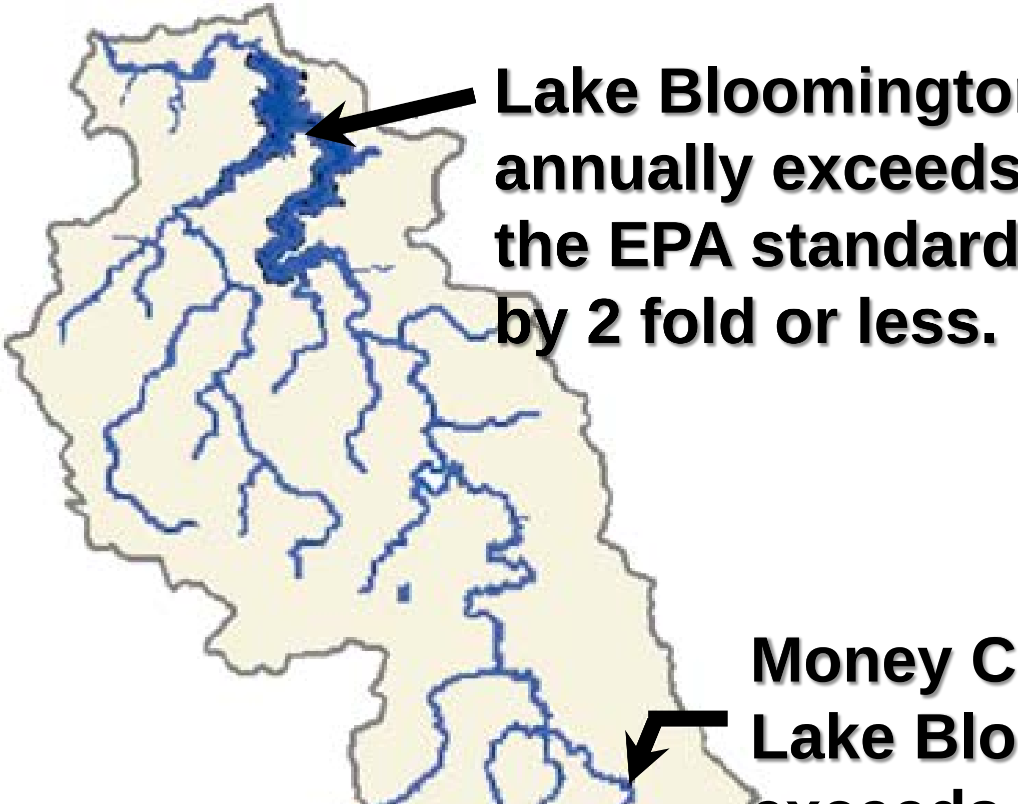
80% of this nitrate-N flux (or 72% of the nitrate-N entering the Gulf) is a result of tile-drainage from the area in pink.



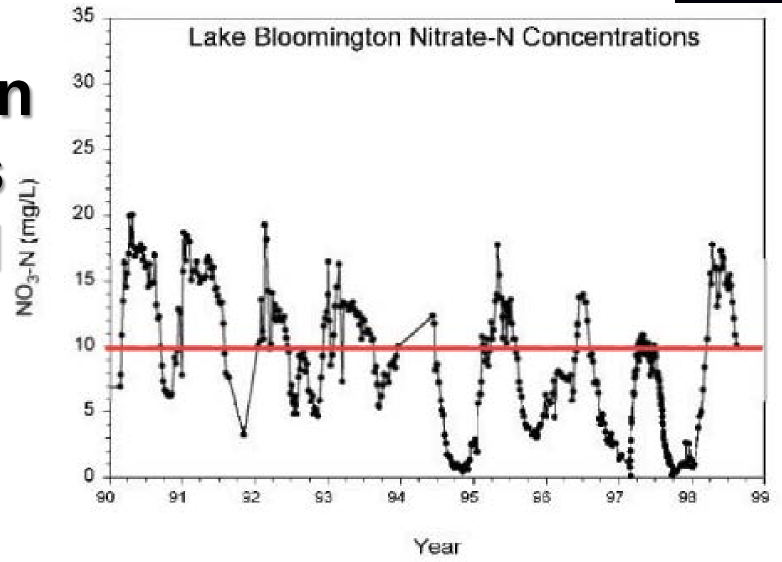
Focus on Mackinaw River basin

- **Representative of the tile-drained Midwest**
- **Two sub-basins supply drinking water to 80,000+ people in Bloomington/Normal**
- **Lake Bloomington historically exceeds EPA's 10 ppm drinking water nitrate standard**
- **Urgent need to implement practices that reduce nitrates yet maintain current agricultural production**

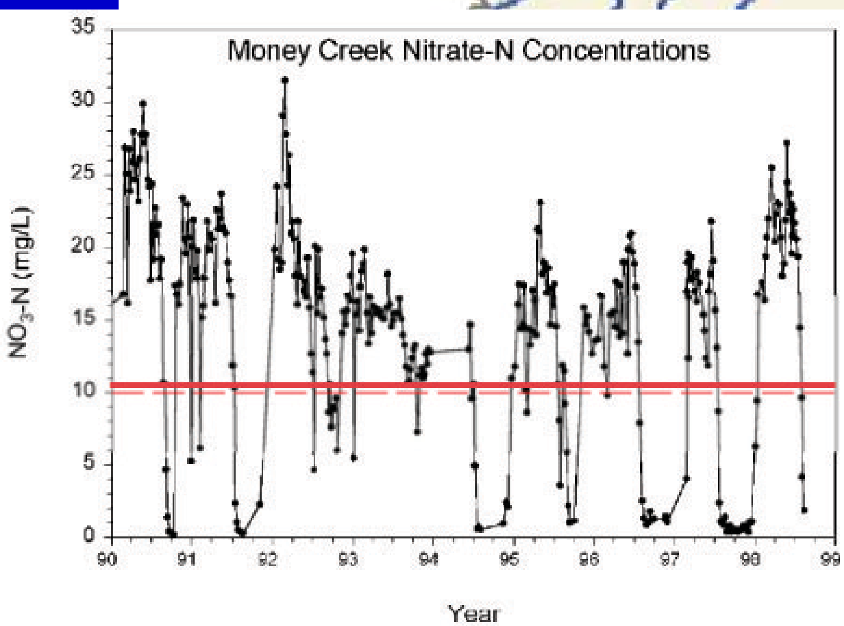




Lake Bloomington annually exceeds the EPA standard by 2 fold or less.



Money Creek which feeds Lake Bloomington annually exceeds the EPA standard by >2 fold

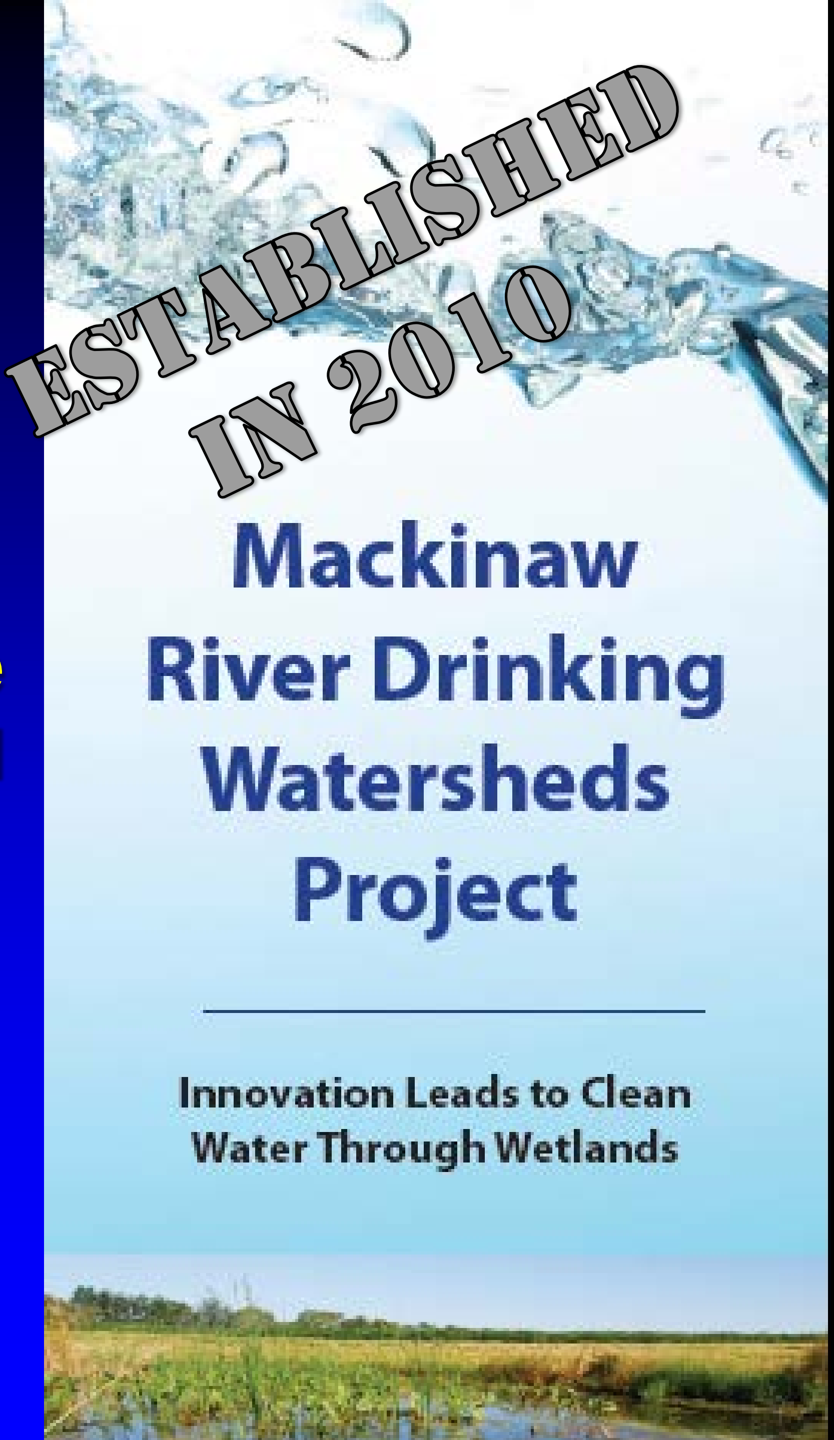


Goal:

To construct Tile-Drainage wetlands throughout the Lake Bloomington watershed.

To reduce nitrate loading to Lake Bloomington, the source of water for 80,000 people and Bloomington and Normal, IL.

A proof of concept study that proposes a more sustainable solution to pollution rather than a sole engineering solution



Jeff Walk, Maria Lemke, Krista Kirkham & Ashley Maybanks

Suzy Friedman, Terry Noto, Karen Chapman

Jonathan Thayn

Kent Bohnhoff

Jackie Kraft

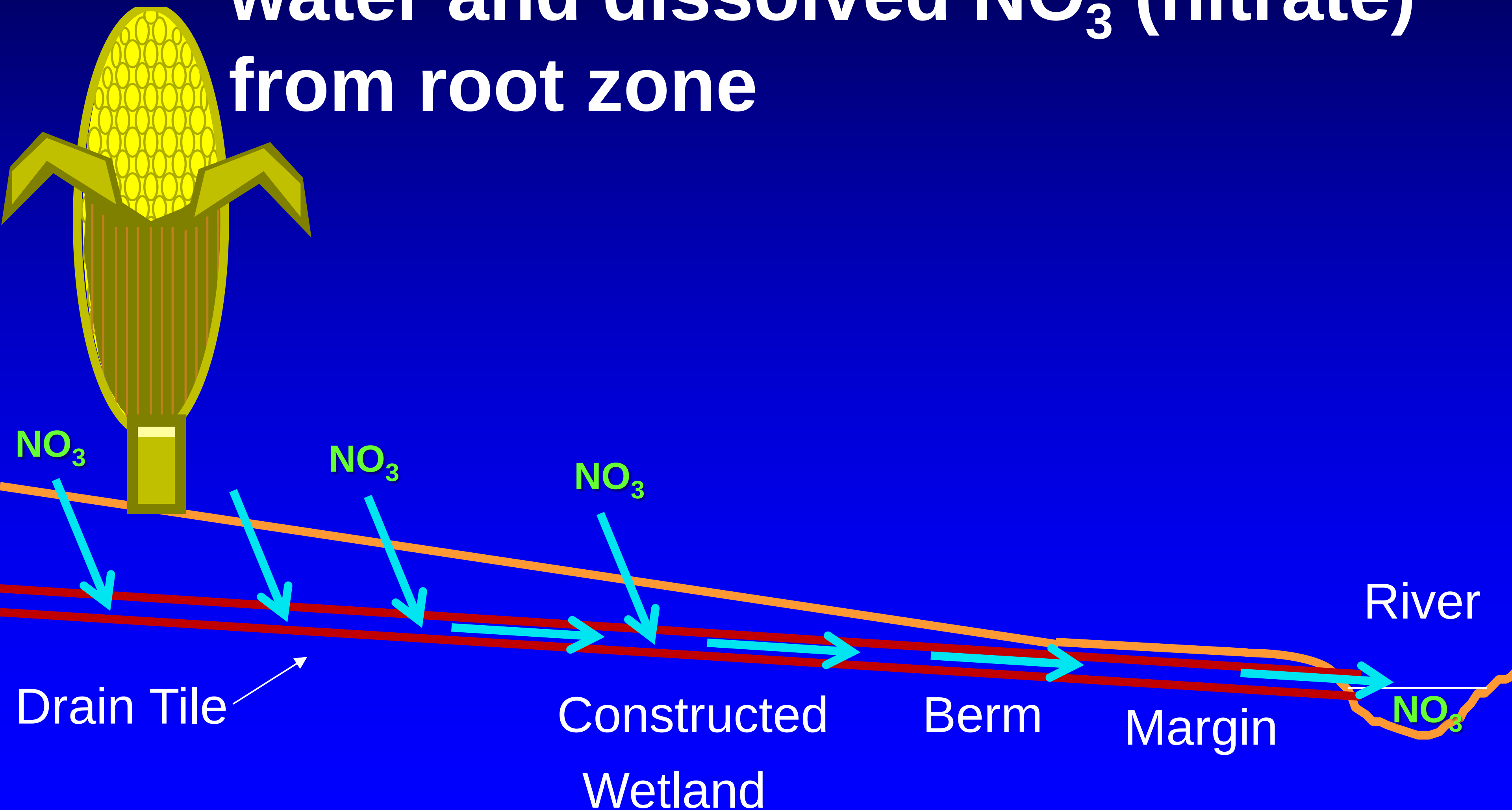
David Kovacic , Mike Wallace, Miran Day

Jonathan Evers

Rick Twait

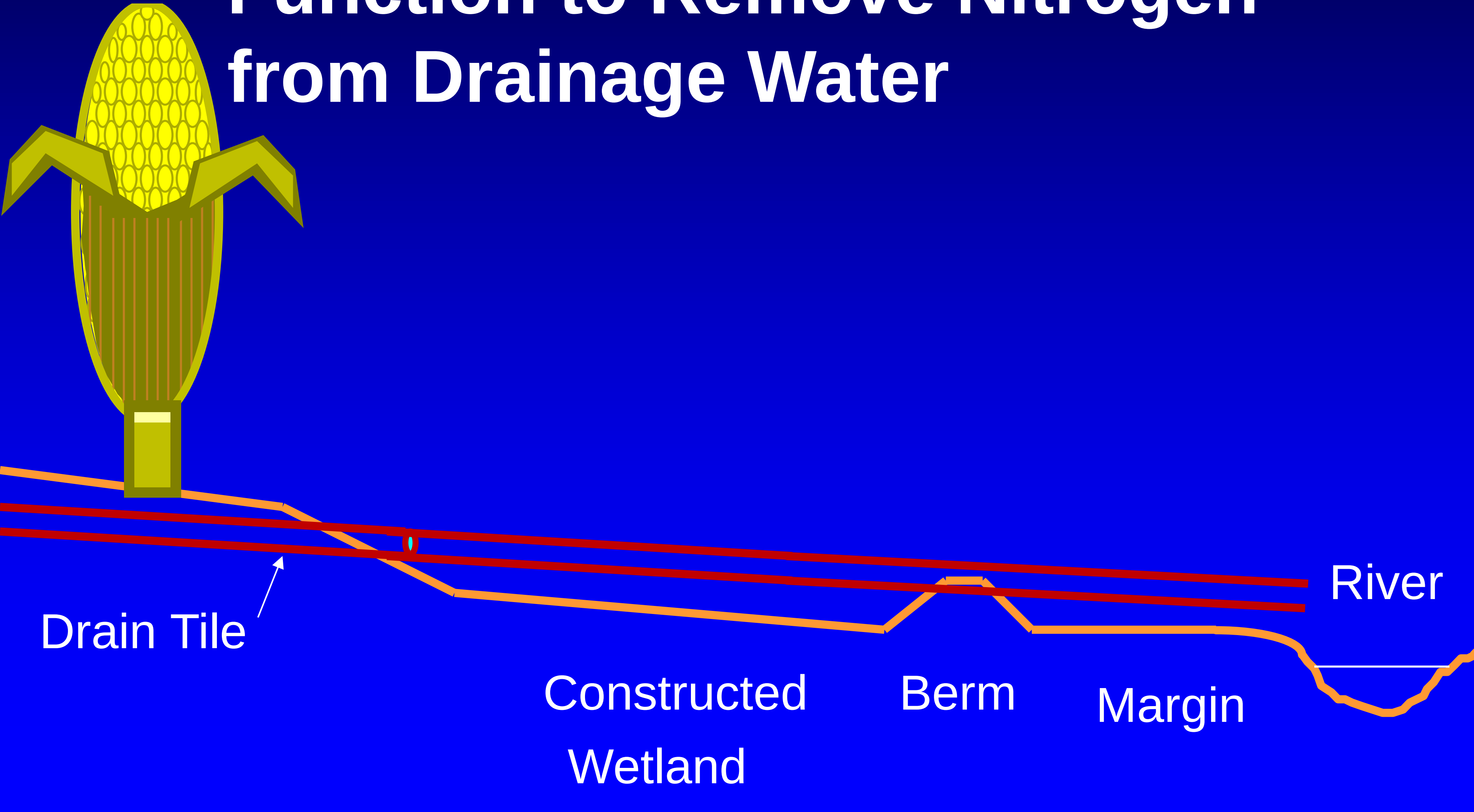
Why Tile-Drainage Wetlands????

Typical tile drainage line shunts water and dissolved NO_3 (nitrate) from root zone

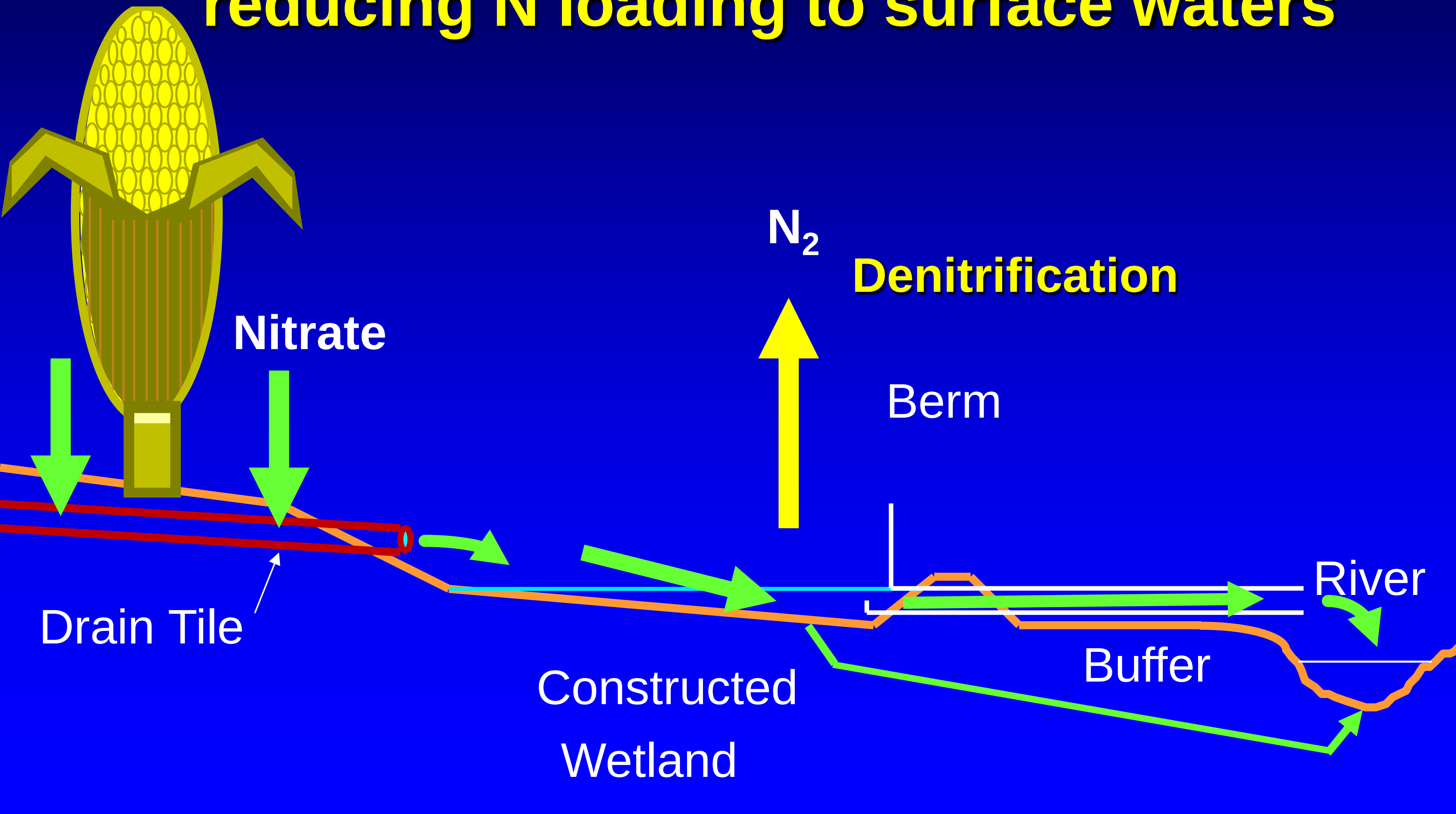


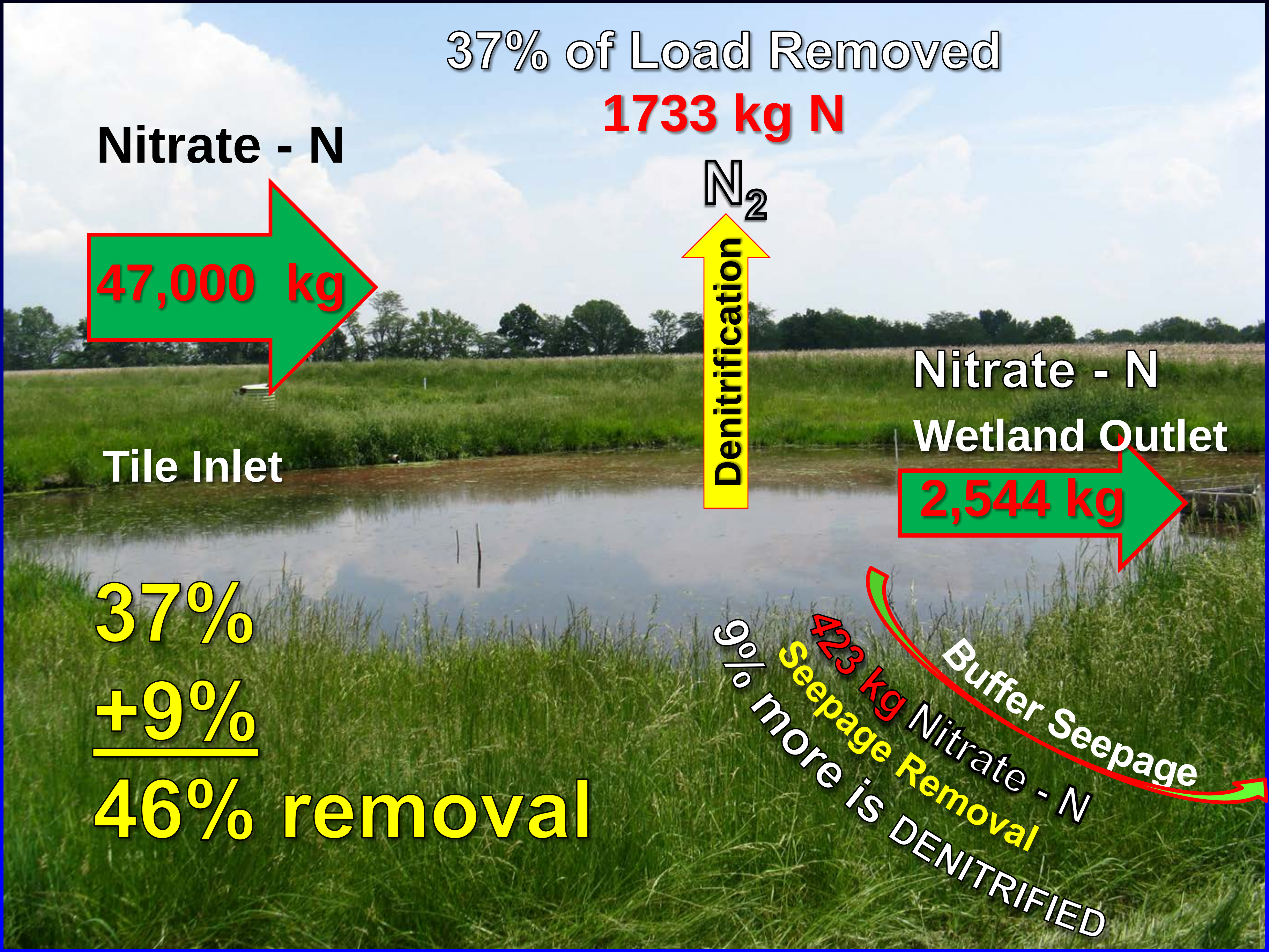
Why Tile-Drainage Wetlands????

Constructed Wetlands Could Function to Remove Nitrogen from Drainage Water



If the concept worked it would: Allow farmers to continue tile drainage and fertilizer use to maintain production, while reducing N loading to surface waters





37% of Load Removed
1733 kg N
Nitrate - N
47,000 kg
N_2
Denitrification
Tile Inlet
Nitrate - N
Wetland Outlet
2,544 kg
37%
+9%
46% removal
423 kg Nitrate - N
Seepage Removal
9% more is DENITRIFIED
Buffer Seepage

Subsequent Wetland Studies support our initial results

- Research with the city of Bloomington at Lake Bloomington
- Research with The Nature Conservancy at the Franklin Demonstration Farm
- Adoption of this work in Iowa
  - implementing this concept in IOWA CREP wetlands program
- We believe that tile-drainage wetlands can help to reduce nitrate loading to drinking water reservoirs and to rivers

"Global Rule"

Verhoven et al. 2006

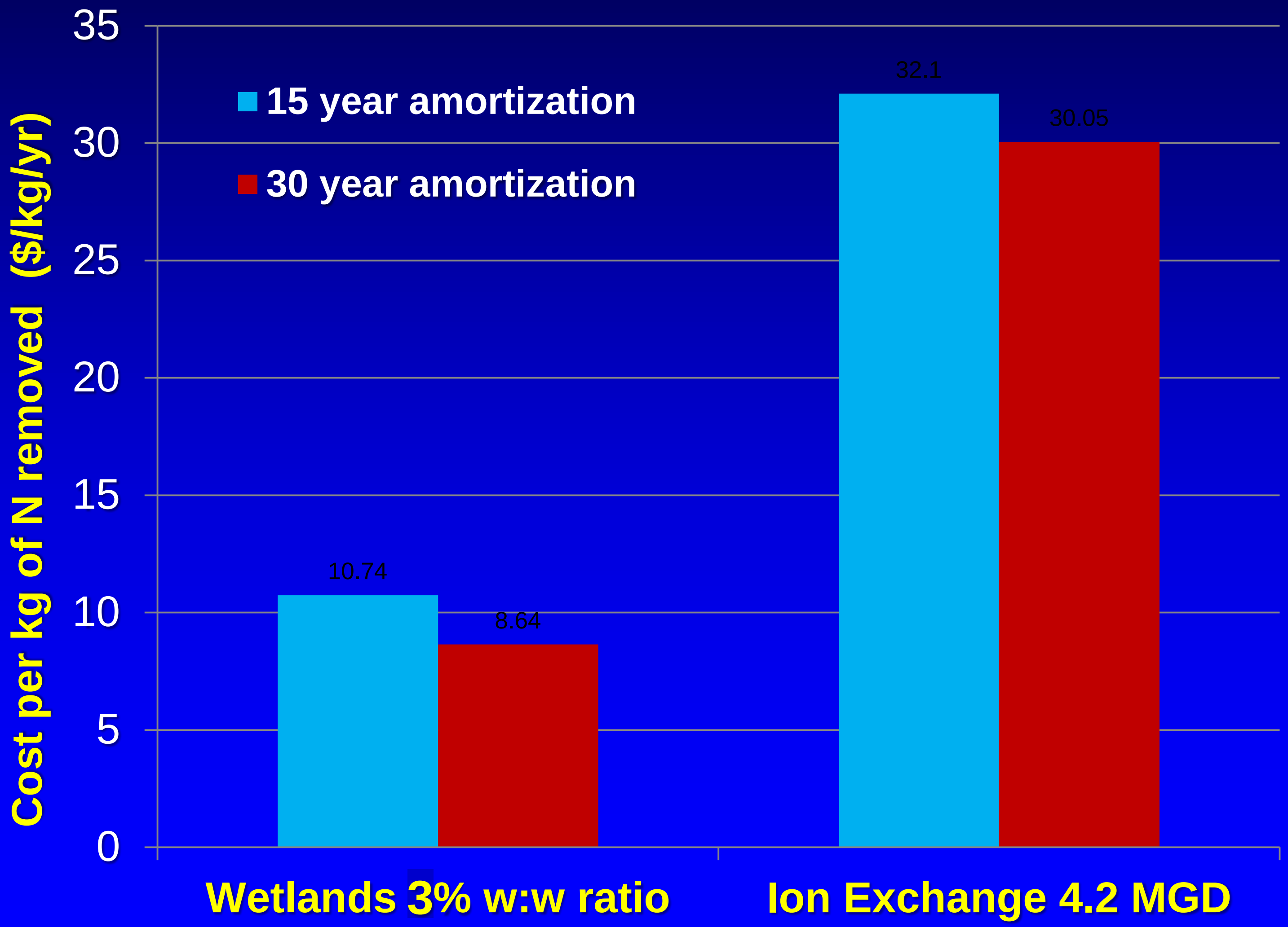
Wetland nitrate removal data (U.S., Sweden, & China) suggests that a ratio of **2-7%** wetlands to watershed area can significantly improve water-quality

To obtain 45% NO_3 removal

Must convert approximately 2.5% of the cropped area to wetlands or 1,075 acres of the LB watershed

Economic Analysis - Comparing Wetland to Ion Exchange Removal Costs per kg N

Based on TNC's Franklin Demonstration Farm Wetlands Report – by R.E. Heimlich



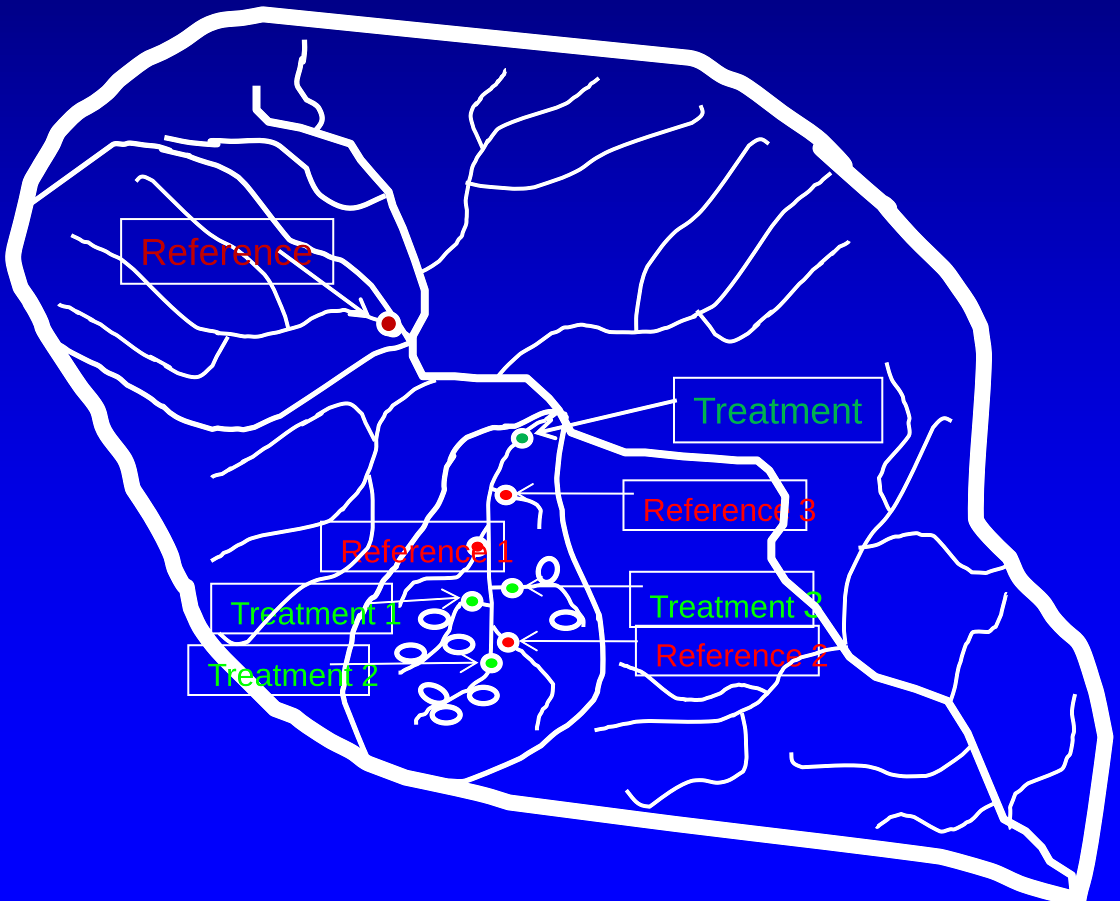
However !

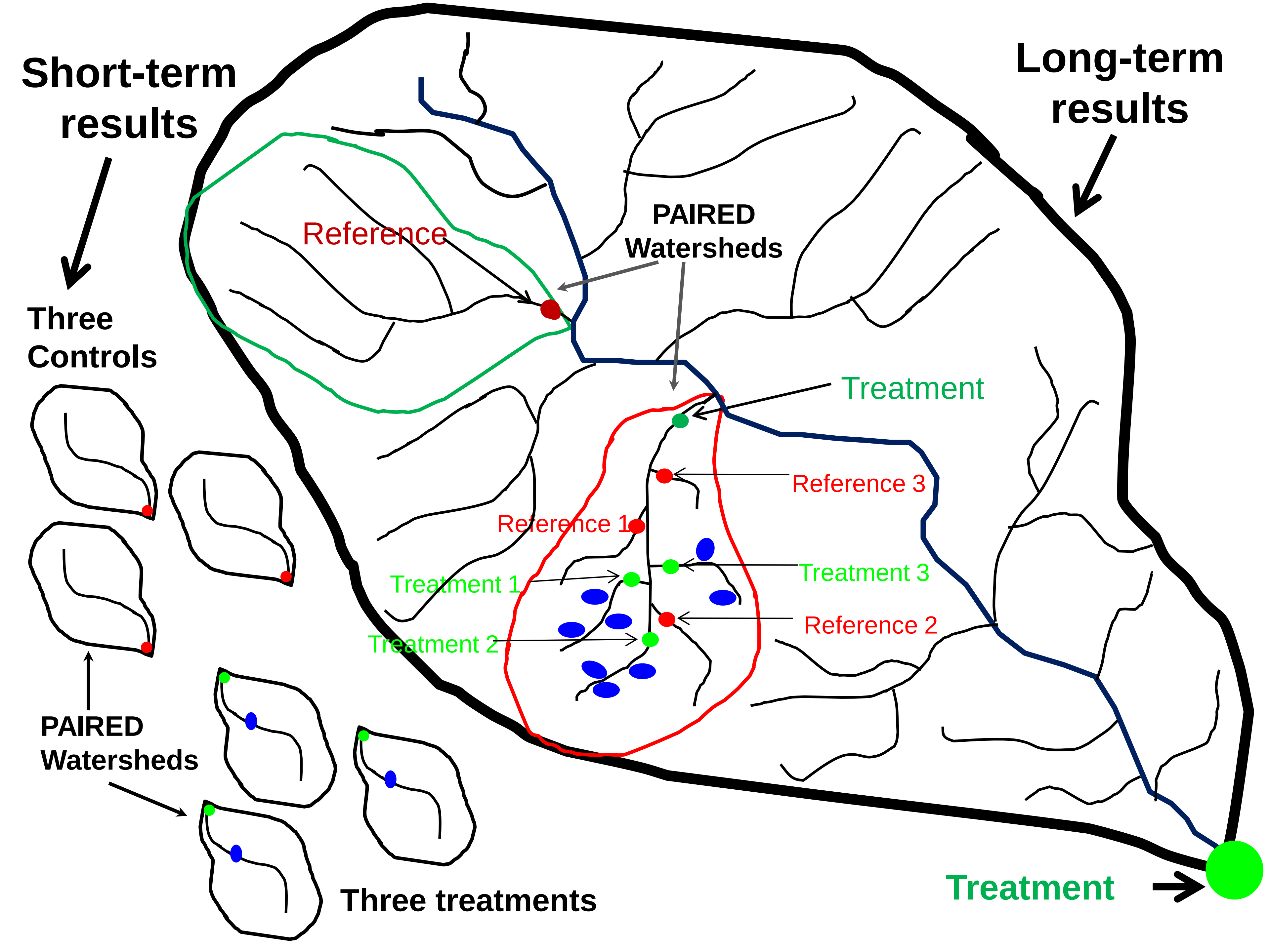
- Nobody has shown that tile-drainage wetlands can improve the quality of water leaving an entire watershed.
- Before investing in this strategy throughout the Midwest we must show that tile-drainage wetlands can improve water quality at the watershed scale.
- We are collaborating with TNC & EDF in a proof-of-concept Tile-drainage wetland study in the Lake Bloomington, IL watershed.

Funding agencies like to see quick results.

- Proximate goal: (3-5 years)
  - Establish tile –drainage wetlands on small paired sub-watersheds to demonstrate the effectiveness of tile-drainage wetlands in reducing nitrate- N at the watershed or stream scale.
- Ultimate goal: (10-20 years)
  - Use constructed wetlands to reduce nitrate-N in Lake Bloomington

A small sub-watershed approach offers the best chance to find a cause and effect relationship of wetlands and water quality.





Short-term results
Long-term results
Three Controls
PAIRED Watersheds
Reference
PAIRED Watersheds
Treatment
Reference 3
Reference 1
Treatment 3
Treatment 1
Reference 2
Treatment 2
PAIRED Watersheds
Three treatments
Treatment

Lake Bloomington Watershed Workshop

LA 336/438 Studio/Workshop

Department of Landscape Architecture 2011
University of Illinois at Urbana-Champaign

- **Using the following:**

1. USGS maps
2. Soil maps
3. Hydrology maps
4. USGS DEM data
5. Color infrared photography
6. NRCS aerial photography
7. Google earth
8. Bing maps
9. Lidar data
10. Parcel data
11. Range and township maps
12. ArcGIS

Task of workshop

Site wetland and control paired watersheds

Stream Order/Watershed Order

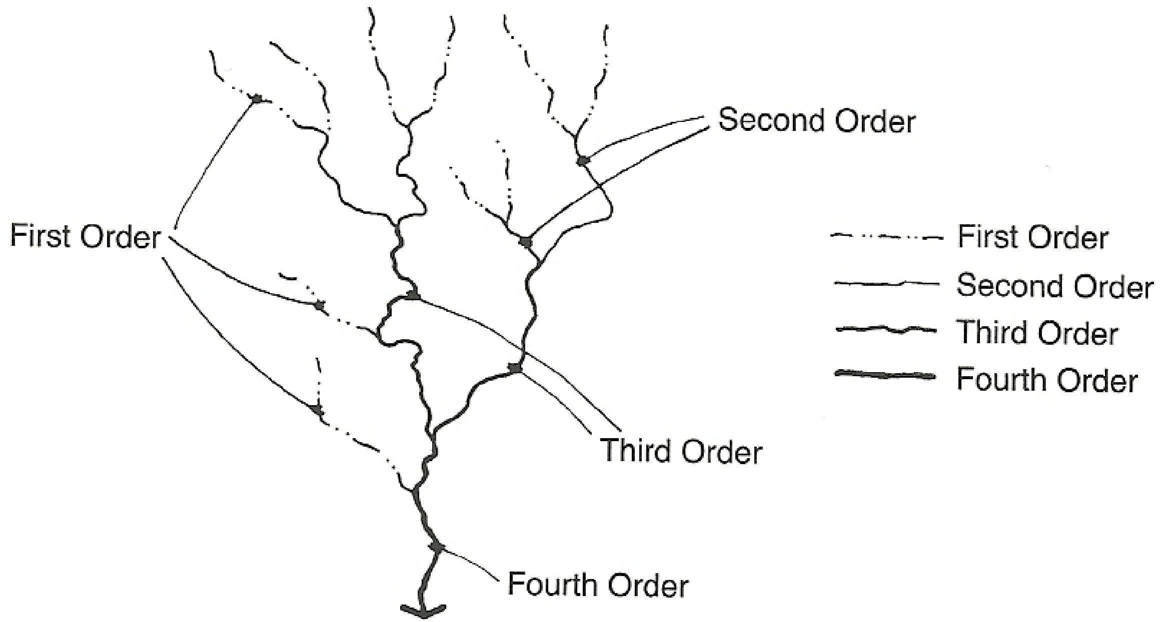
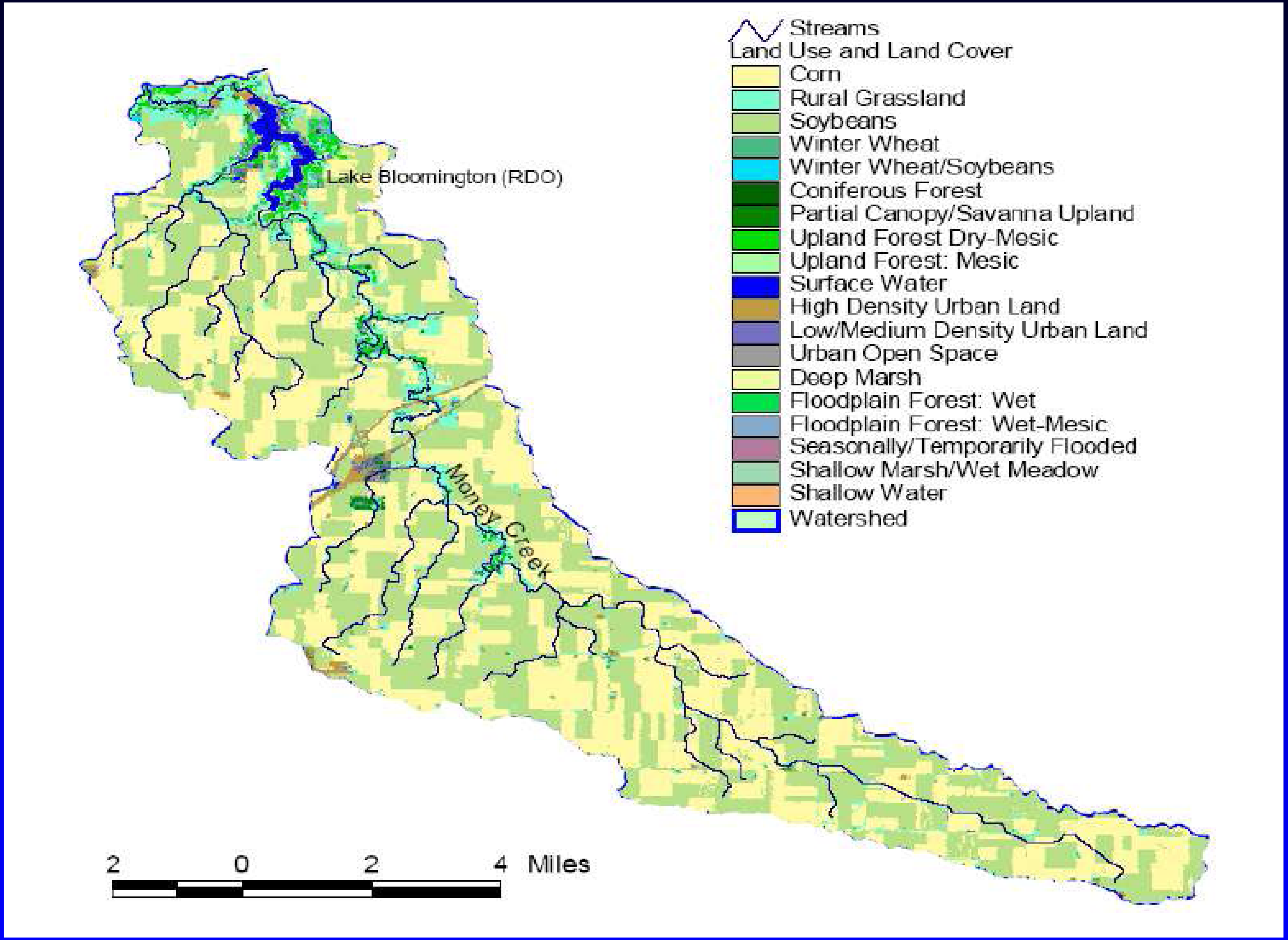


Fig. 9.1 Stream order classification according to rank in the drainage network. This follows the scheme originally defined by American hydrologist Robert Horton.

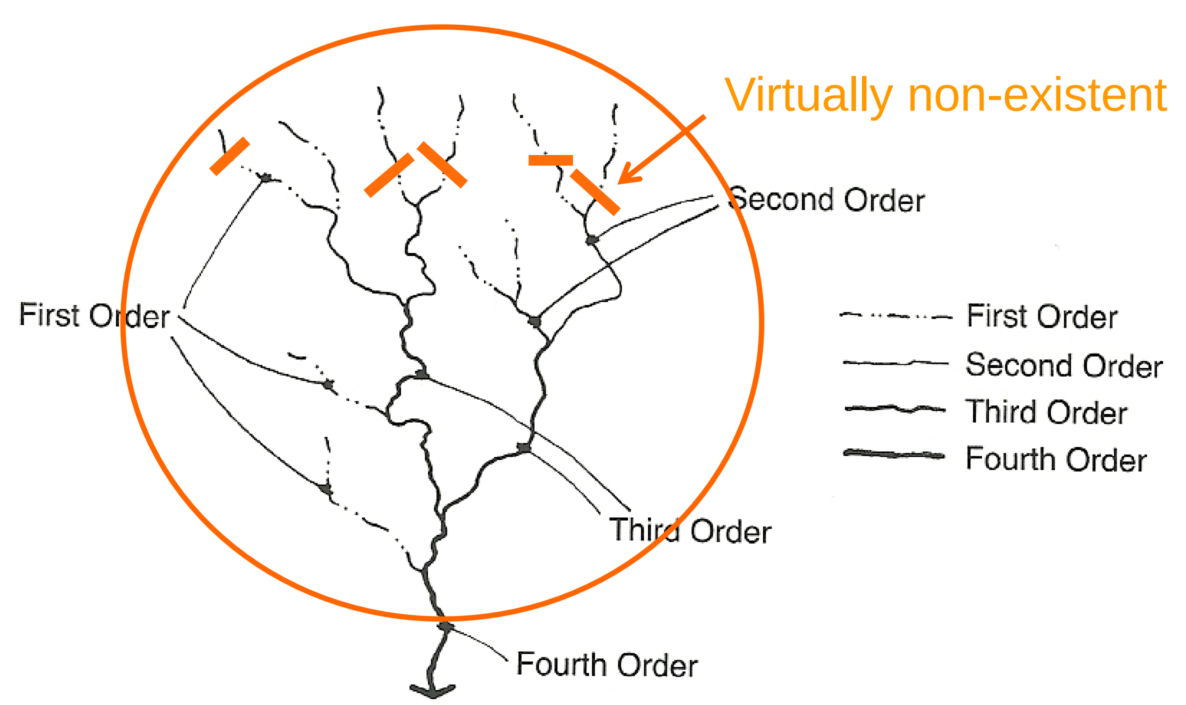
Kovacic



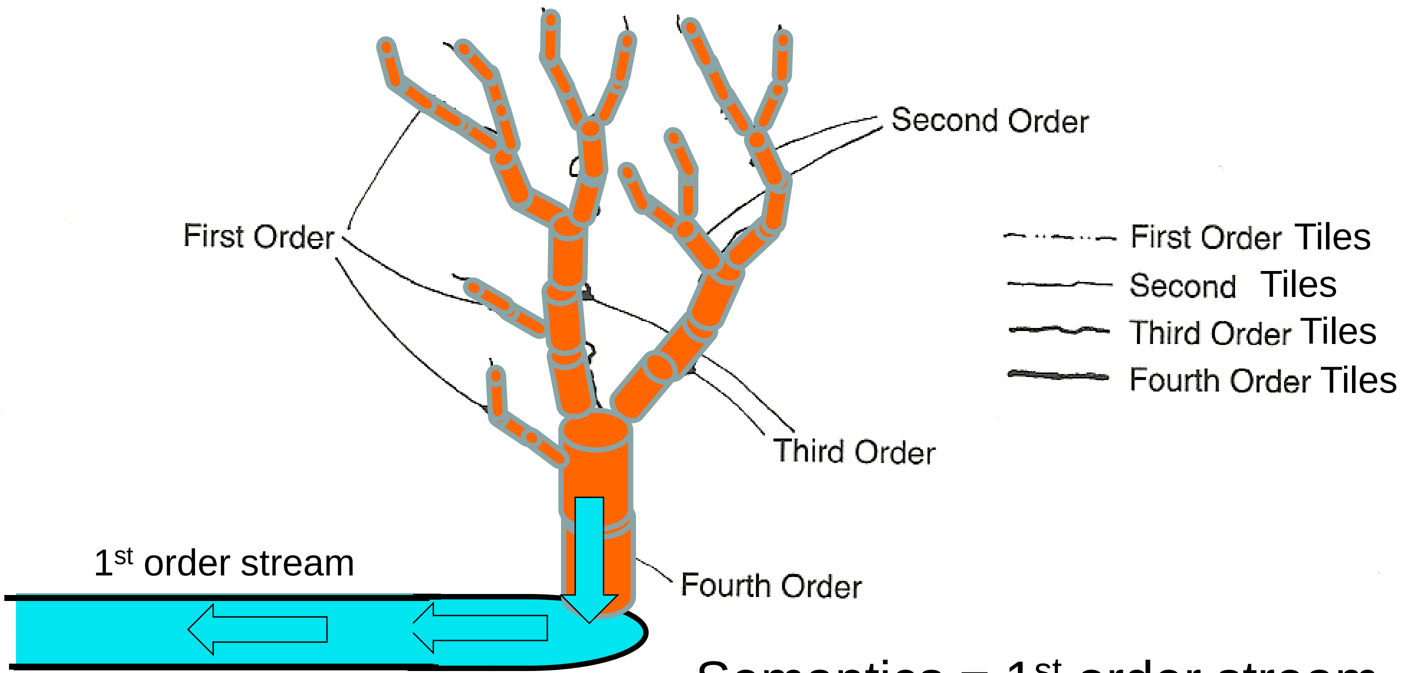
Streams
Land Use and Land Cover
Corn
Rural Grassland
Soybeans
Winter Wheat
Winter Wheat/Soybeans
Coniferous Forest
Partial Canopy/Savanna Upland
Upland Forest Dry-Mesic
Upland Forest: Mesic
Surface Water
High Density Urban Land
Low/Medium Density Urban Land
Urban Open Space
Deep Marsh
Floodplain Forest: Wet
Floodplain Forest: Wet-Mesic
Seasonally/Temporarily Flooded
Shallow Marsh/Wet Meadow
Shallow Water
Watershed
Lake Bloomington (RDO)
Money Creek
2 0 2 4 Miles

Summer 2011 conducted an on the ground evaluation

- Only one pair met our initial requirements.
  - A tile drainage opening into a stream, so that we could readily test if wetlands placed at the end of a tile drainage system could change stream water quality.

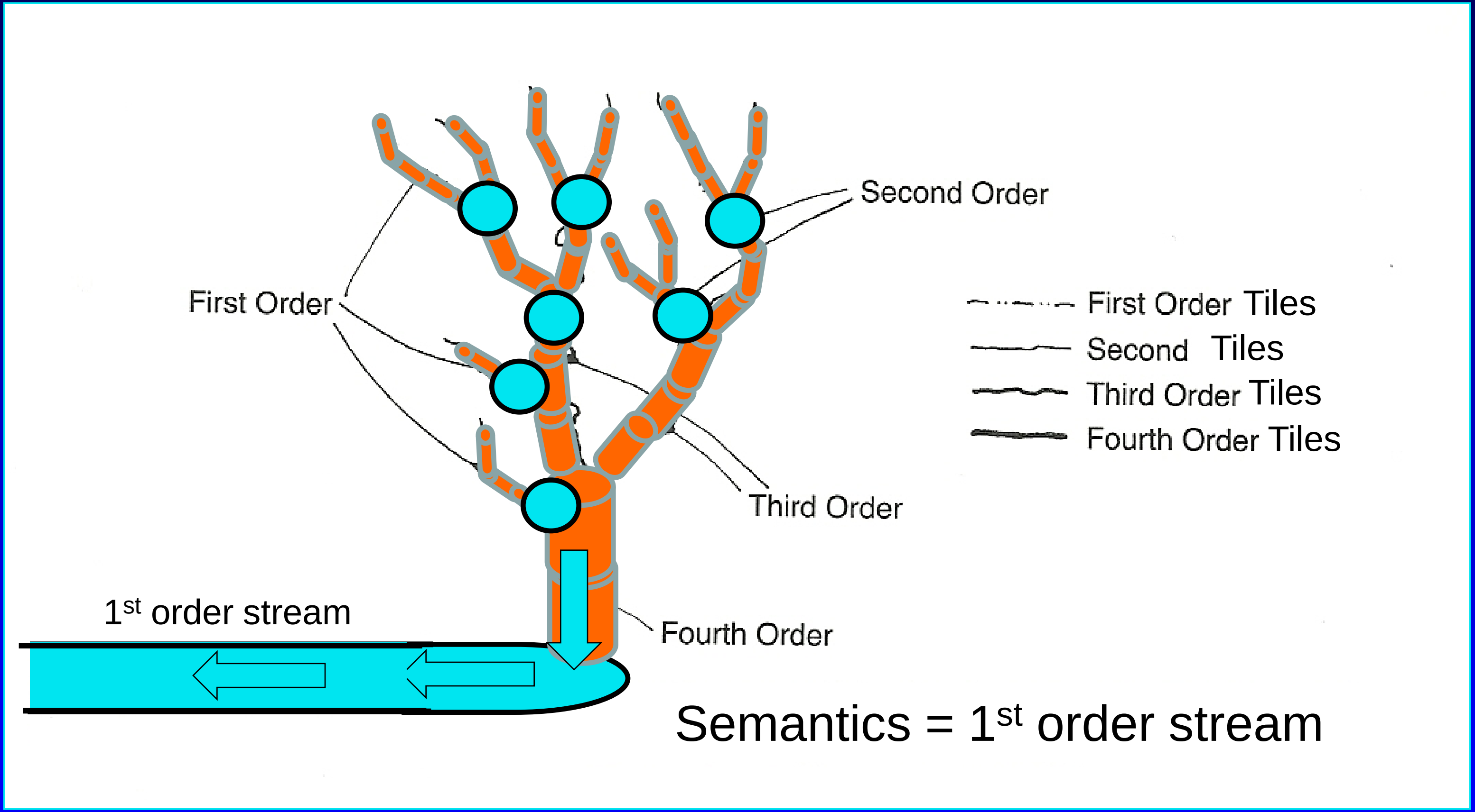


Tile Order/Tile Drainage Order confusion



Semantics = 1st order stream

Tile Interception Wetlands



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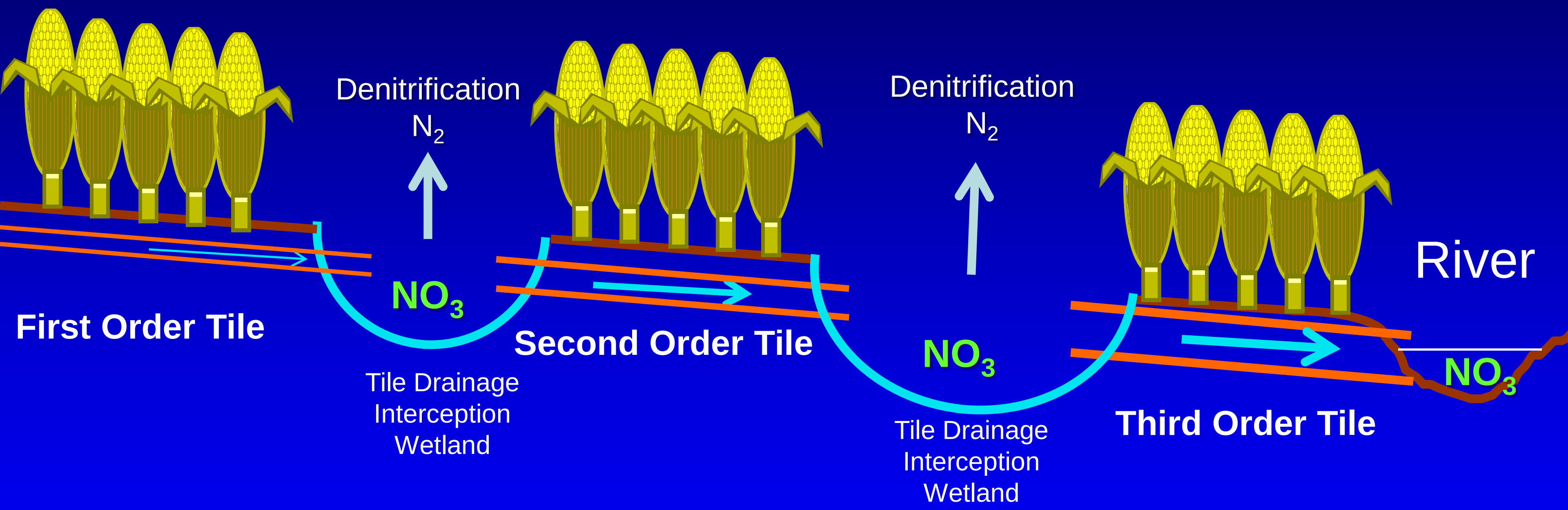
Tile Drainage Interception Wetlands

Critical Difference between Tile Drainage and Tile Interception Wetlands is the Lack of an Adjacent Open Stream Channel



Early Conclusions

- What we anticipated does not exist to a great extent –
- We have found a few sites that will work for experimental paired watershed sites (Tile to open stream systems).
- We have to create a new definition of a watershed for our project. This would be based on a stream hierarchy system, but we would be looking at tiles only.
- “Streams” do exist, but are largely underground. Most sites where open streams can be found drain huge areas 1,000 - 4,000 acres

Early Conclusions

- INTERCEPTION WETLANDS must be the approach that we use
- To site wetlands in large watersheds will require the creation of a major database that allows us to work remotely
- The database must be a highly structured system to organize and study the watershed and reduce time and labor.
- Database must allow us to identify tile drains in the field so that we can intercept them with wetlands.

Requirements of the database

1. **Provide unique naming system for all sub-basins in the watersheds**
2. **Determine surface drainage characteristics at several tiers**
3. **Provide maximum definition of elevations**
4. **Determine surface characteristics**
5. **Provide a tool to locate tile drainage systems and determine effective drainage**
6. **Determine land ownership**
7. **Determine existing wetlands, depressions**
8. **Determine areas of any basin or any plot of ground**
9. **Provide information for the location, sizing, and construction of wetlands**
10. **Provide a database that can be adapted for use by all project workers**

- **Using the following:**

1. USGS maps
2. Soil maps
3. Hydrology maps
4. USGS DEM data
5. Color infrared photography
6. NRCS aerial photography
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Hypothetical Hierarchical Nesting of sub-basins (Tiers 1 through) in the Lake Bloomington watershed

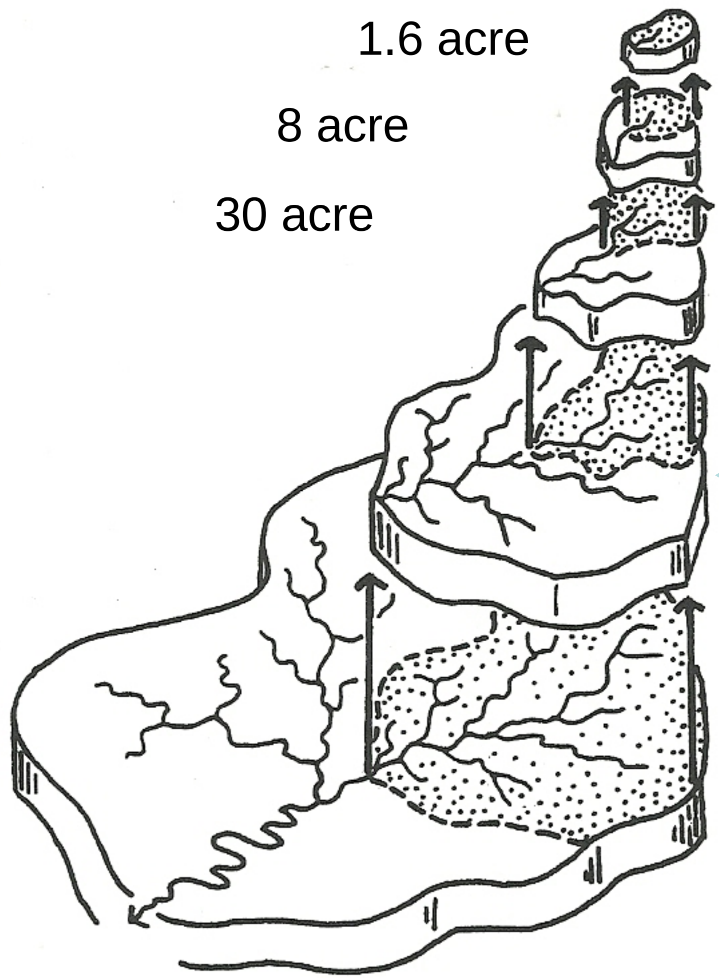
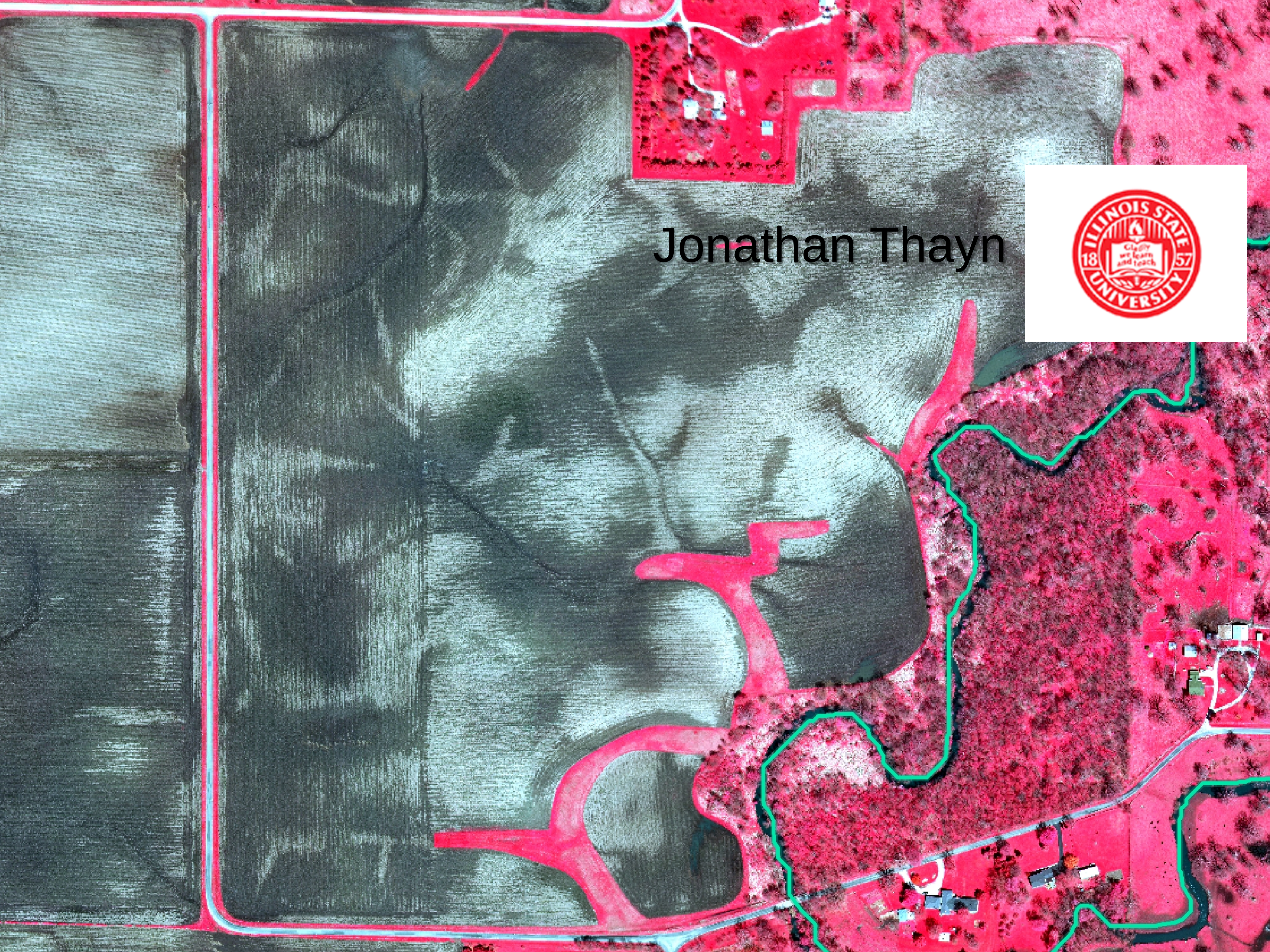


Fig. 9.2 Illustration of the nested hierarchy of lower-order basins within a large drainage basin.


Jonathan Thayn
ILLINOIS STATE UNIVERSITY
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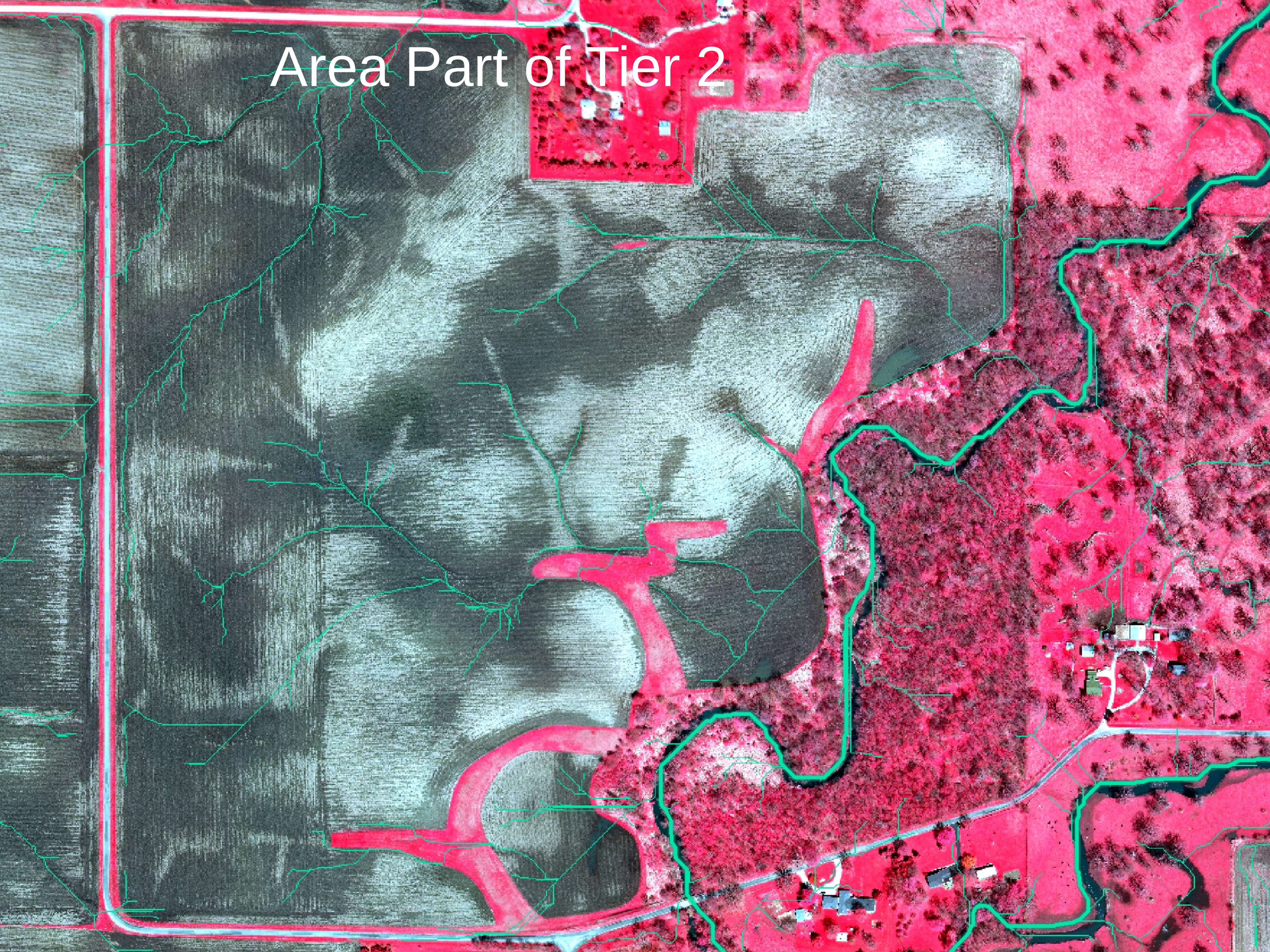
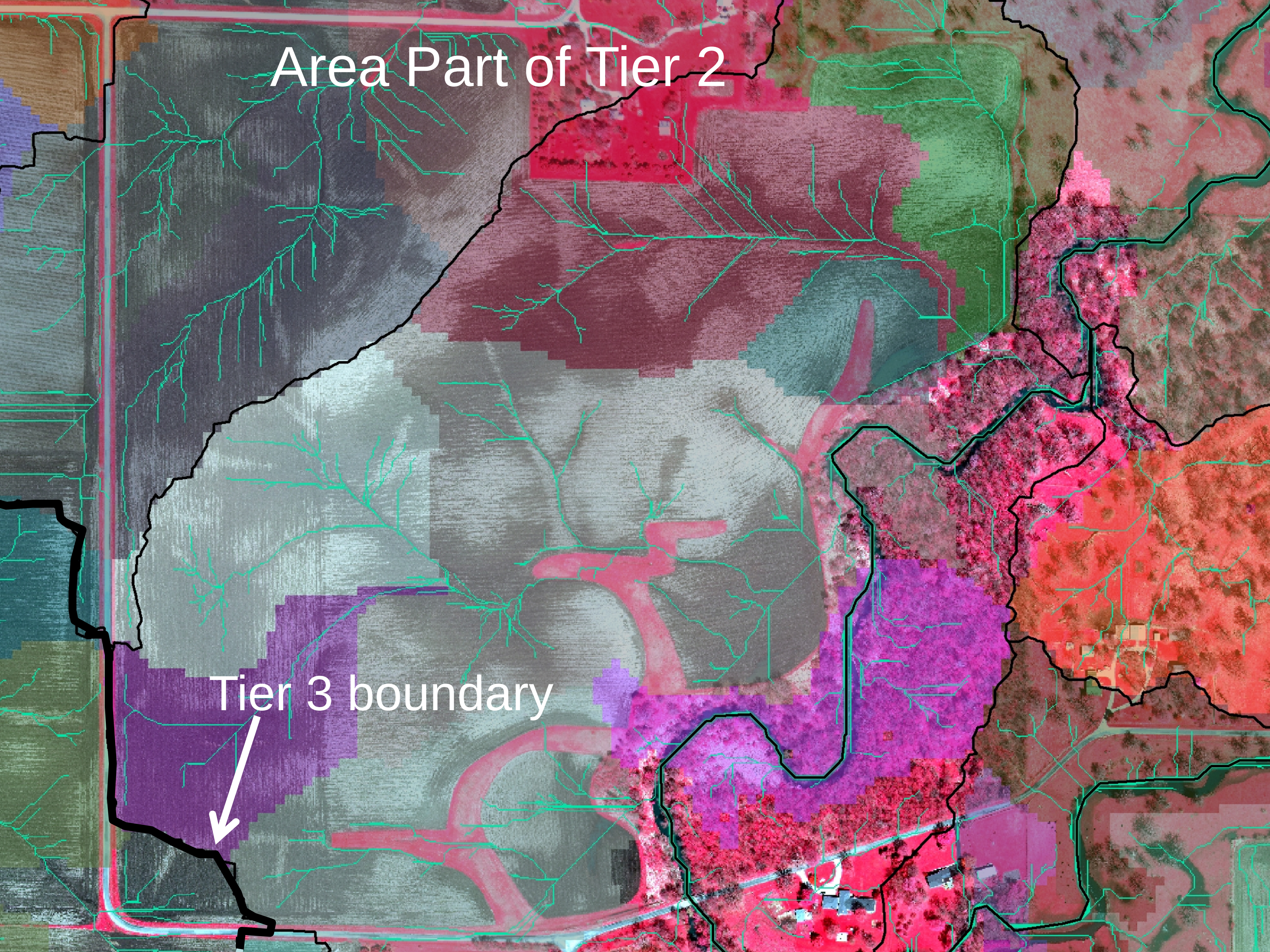
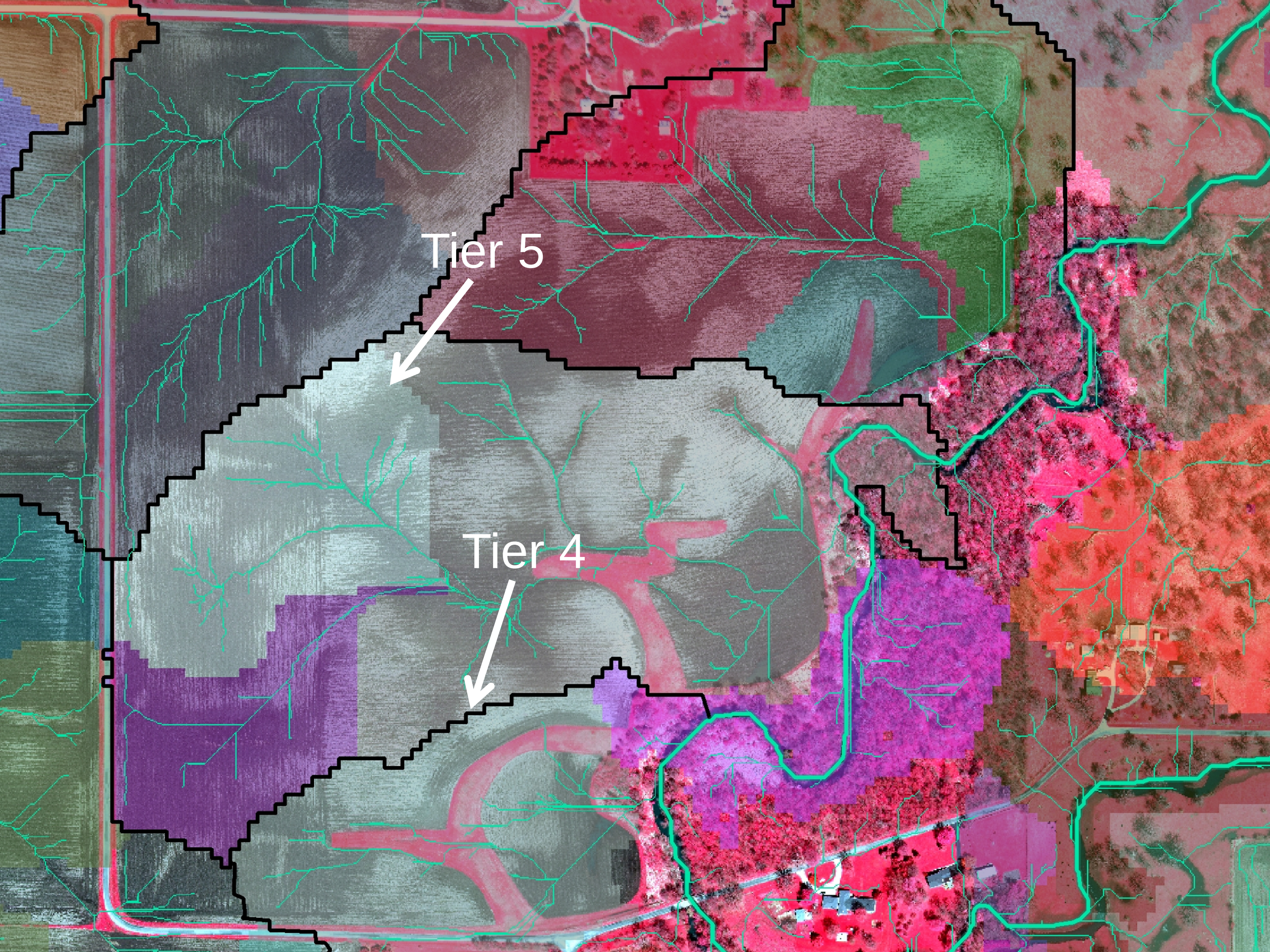
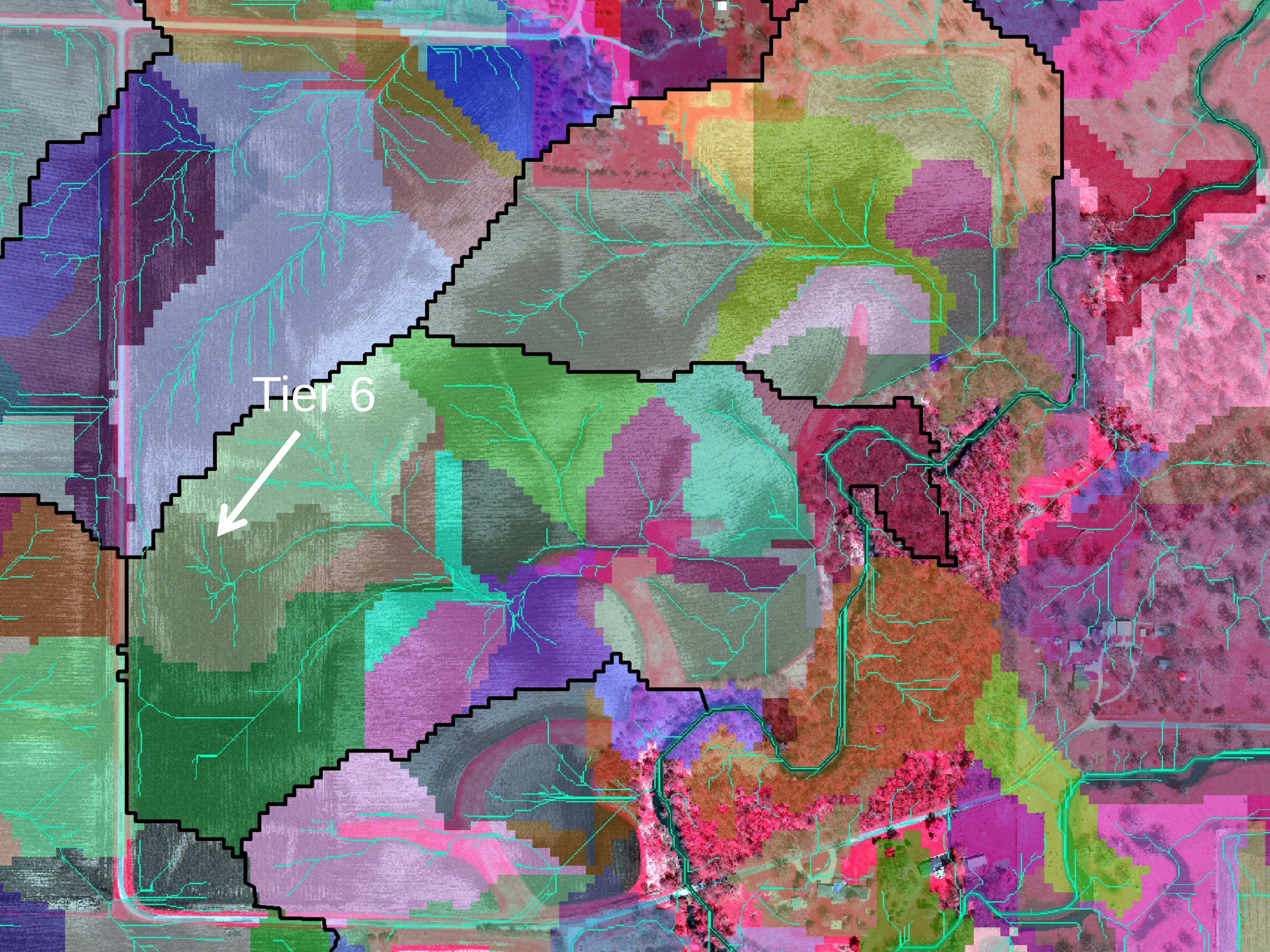
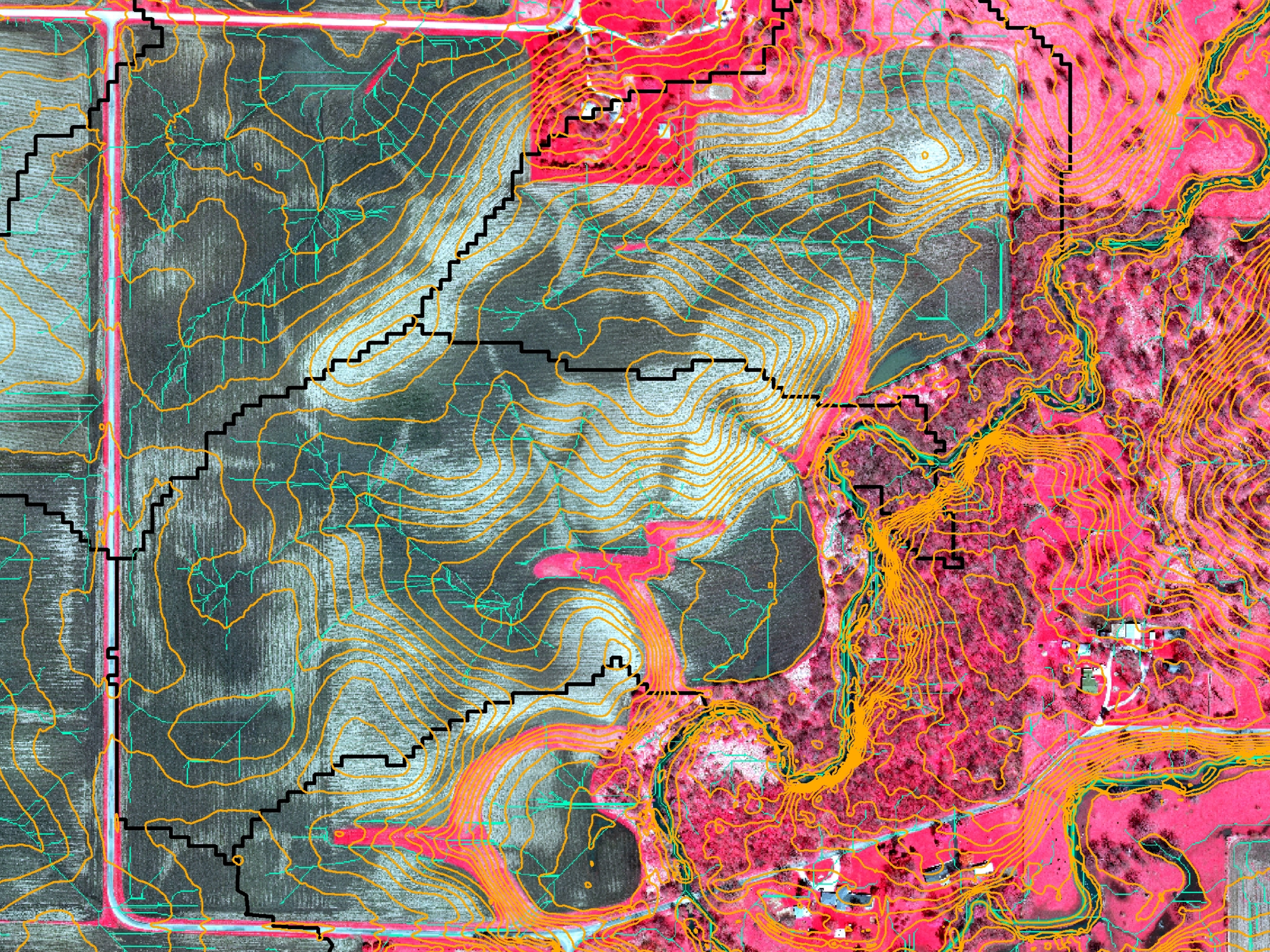
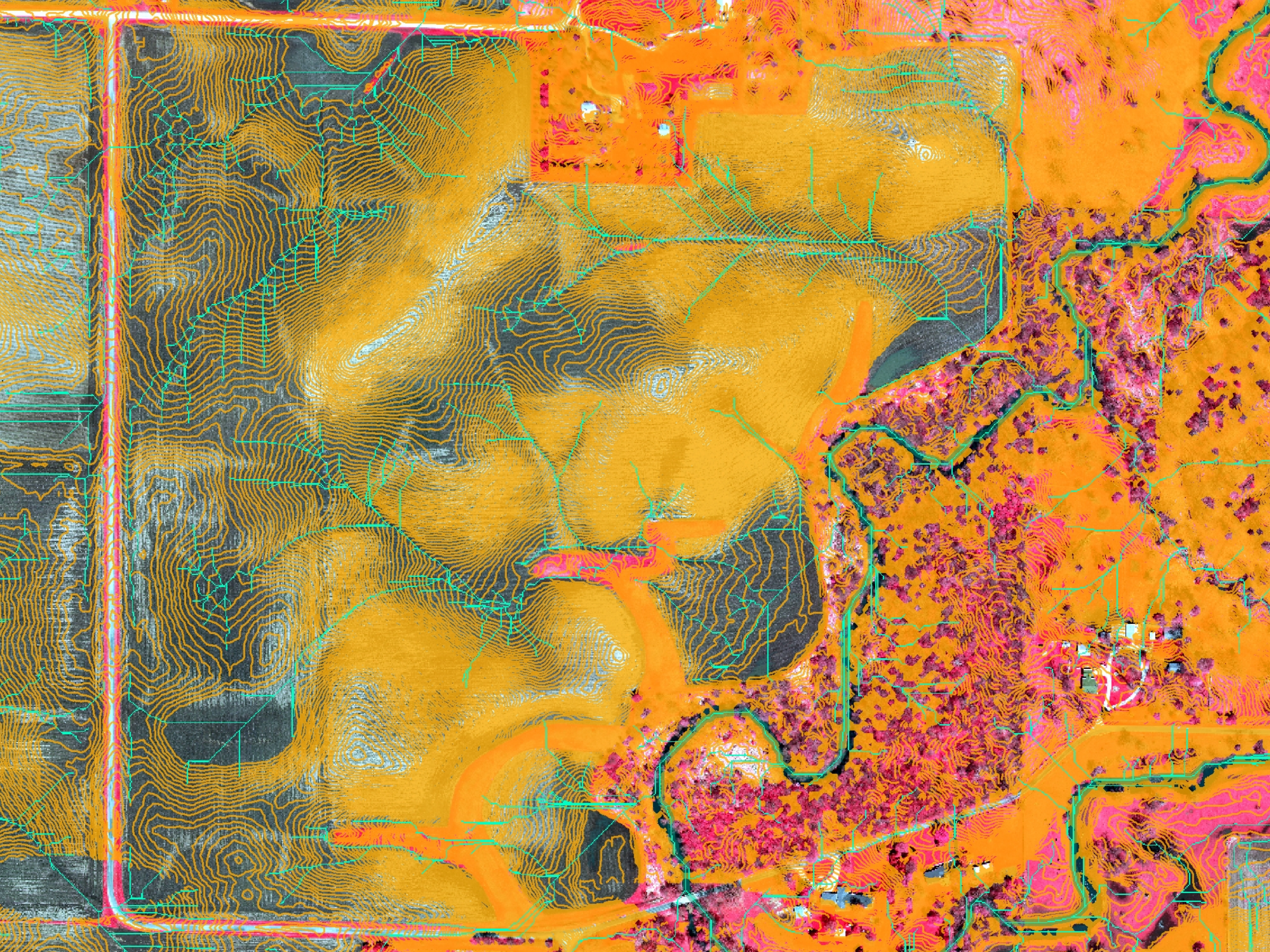

Area Part of Tier 2

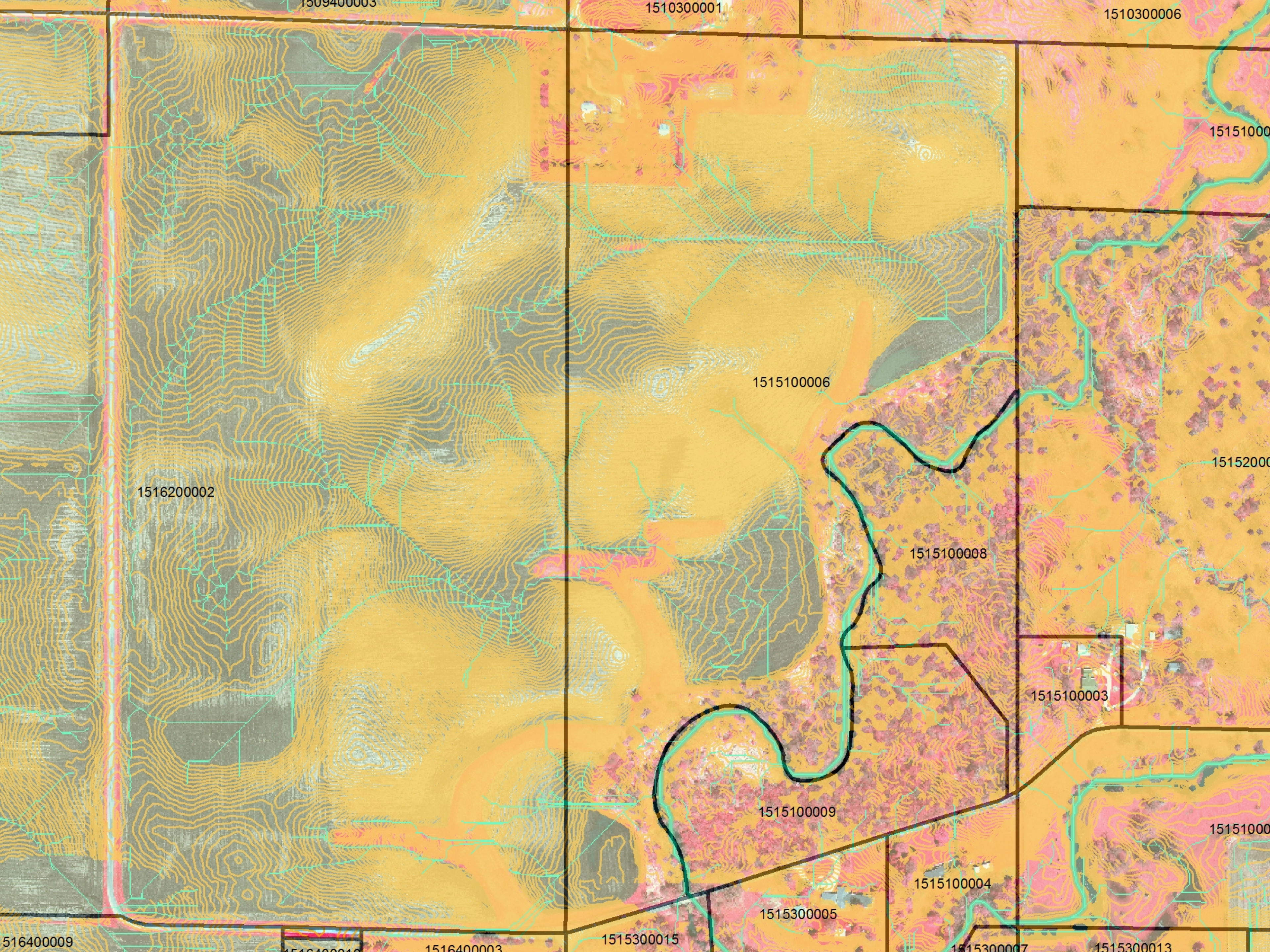

Area Part of Tier 2
Tier 3 boundary


Tier 5
Tier 4


Tier 6



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1516400003

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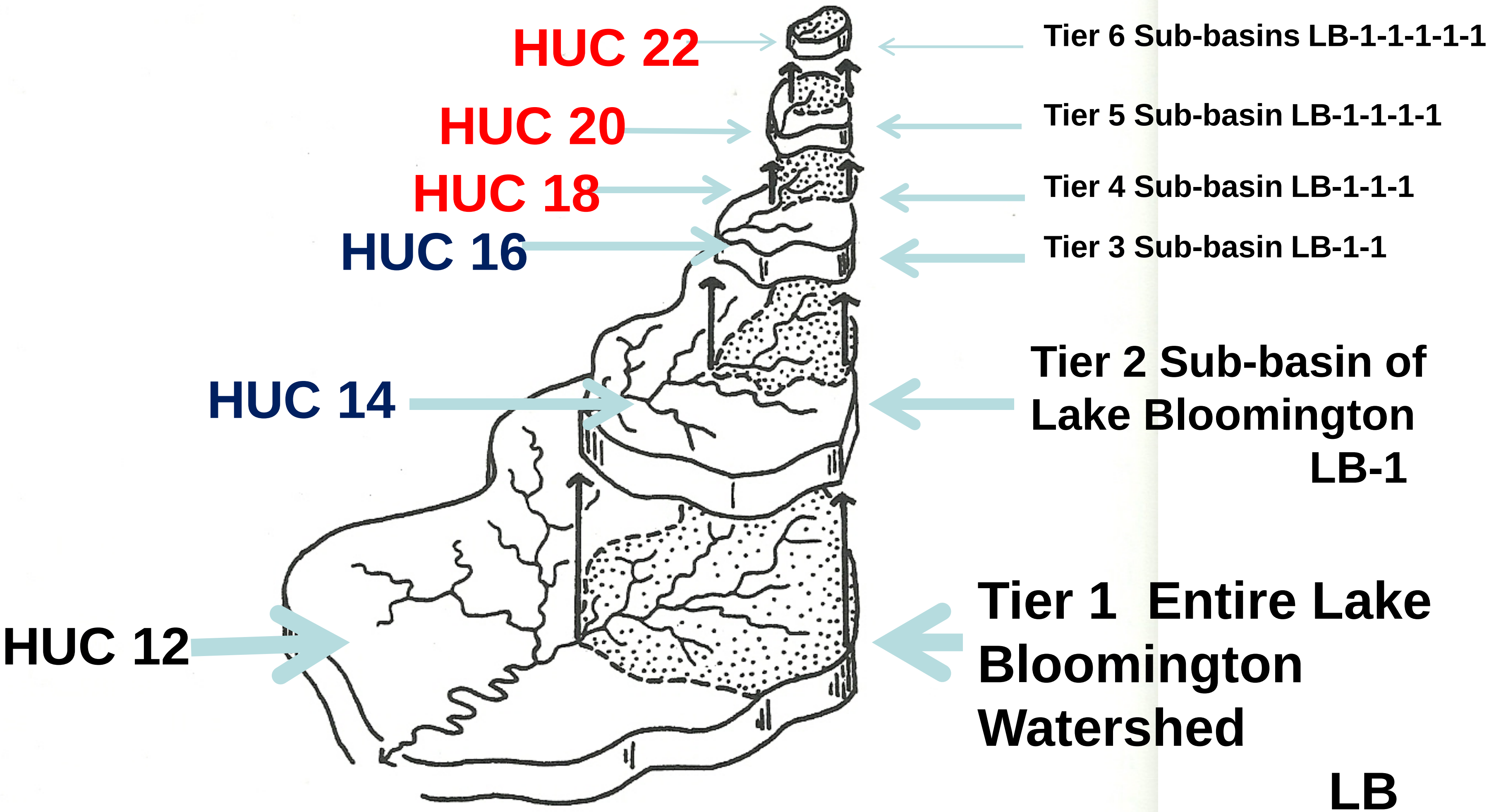
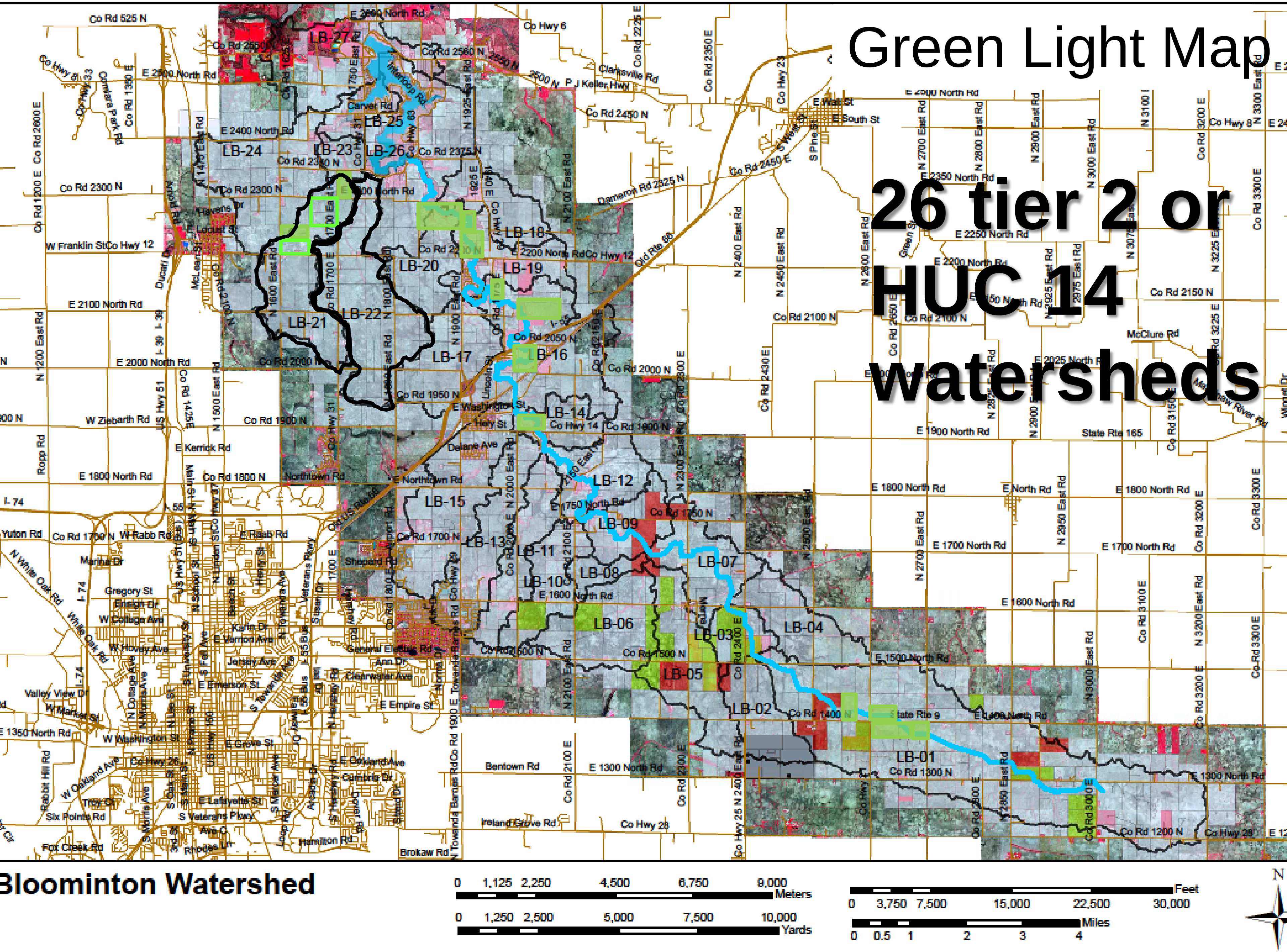


Green Light Map

26 tier 2 or HUC 14 watersheds



Bloominton Watershed

Outreach Program

- Most important part of project
- Rely on voluntary Landowner Cooperation
- Using the above information specialists from:

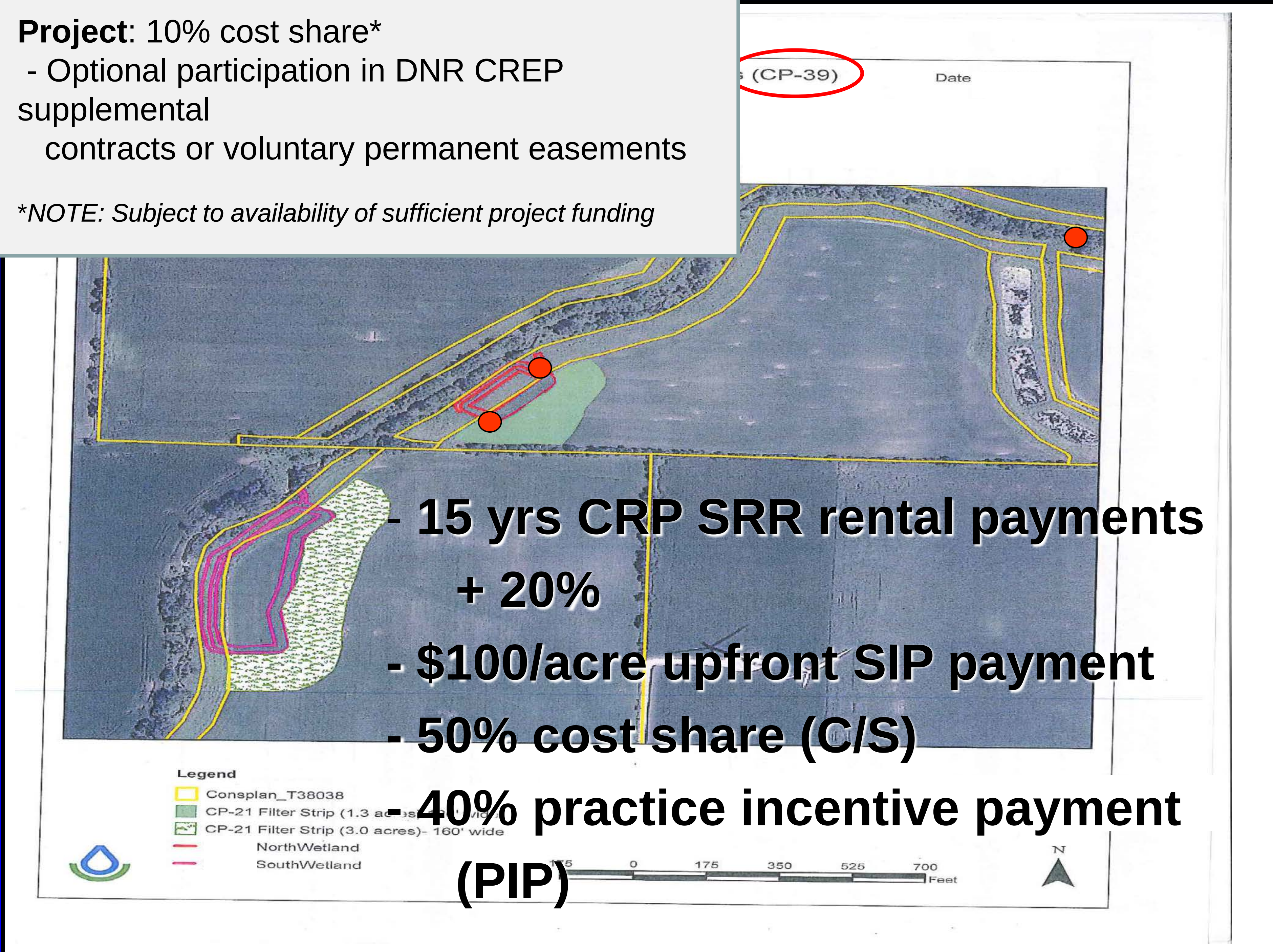
Kent Bohnhoff   Jackie Kraft   Ashley Maybanks

  – identify the optimal areas for wetland construction, contact the landowners, and work with those interested in the program.
- CP-39 Constructed Wetlands Program

Project: 10% cost share*

- Optional participation in DNR CREP supplemental contracts or voluntary permanent easements

**NOTE: Subject to availability of sufficient project funding*



- 15 yrs CRP SRR rental payments + 20%
- $100/acre upfront SIP payment
- 50% cost share (C/S)
- 40% practice incentive payment (PIP)

Can We Sign You Up?

WEL
Wetlands Ecology Laboratory
UNIVERSITY OF ILLINOIS – CHAMPAIGN
DEPT. LANDSCAPE ARCHITECTURE
DIRECTOR: D.A. KOVACIC, PH.D.