Chippewa County Groundwater Study

5th Stakeholders Group Meeting

Chippewa Falls, WI

04/20/2016

USGS science for a changing world

Chippewa County Land Conservation and Forest Management "Stewardship for Sustainability"

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Today's outline

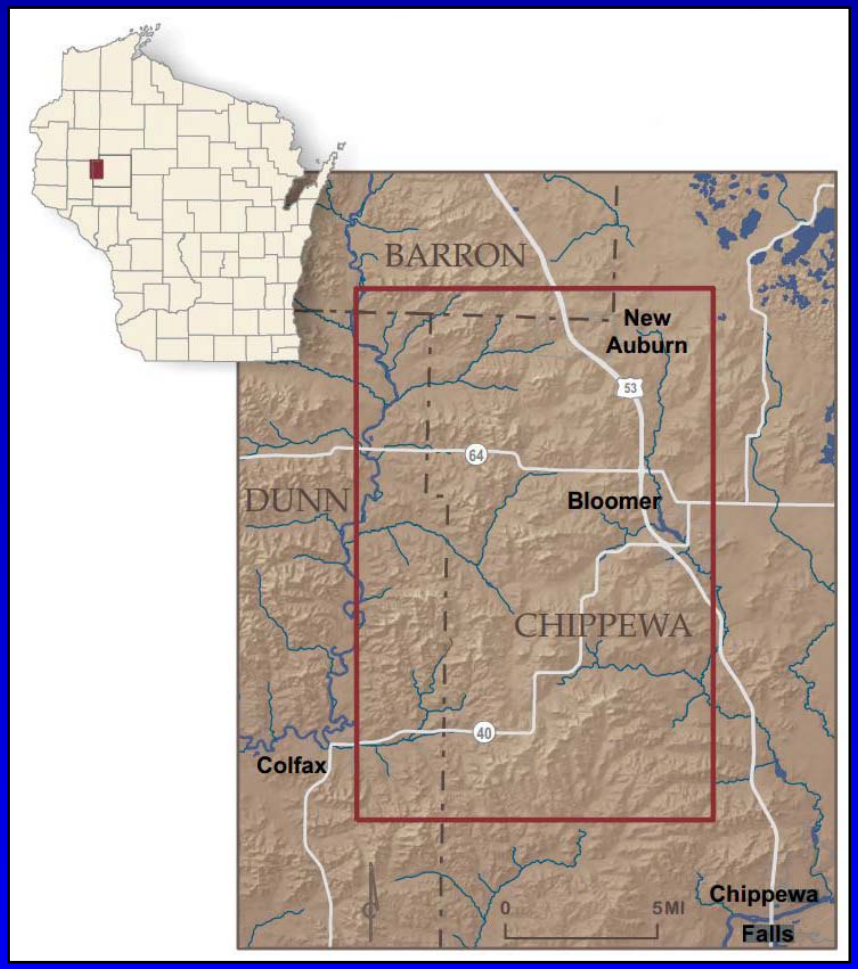
- Brief review of study *(WGNHS / USGS)*
- Progress to date *(WGNHS / USGS / Chippewa Co.)*
  - Groundwater model development and calibration
  - Soil-water-balance (SWB) modeling and infiltration testing
  - Scenario testing – Mine and irrigated agriculture build-out
- Discussion on scenarios and model progress *(All)*
- What's next ?
- Update on a new water-level monitoring study

Study overview

- Started fall 2012

  Project team
  - WGNHS
  - USGS
  - Chippewa Co. LCFM

  Stakeholders group
  - All active sand mining companies
  - WI Farmers Union
  - WI DNR
  - Trout Unlimited
  - Local farmers and citizens



- 5-year study effort
  - Technical investigation and modeling
  - Outreach and reporting through 2017

Study overview

Frac sand mining

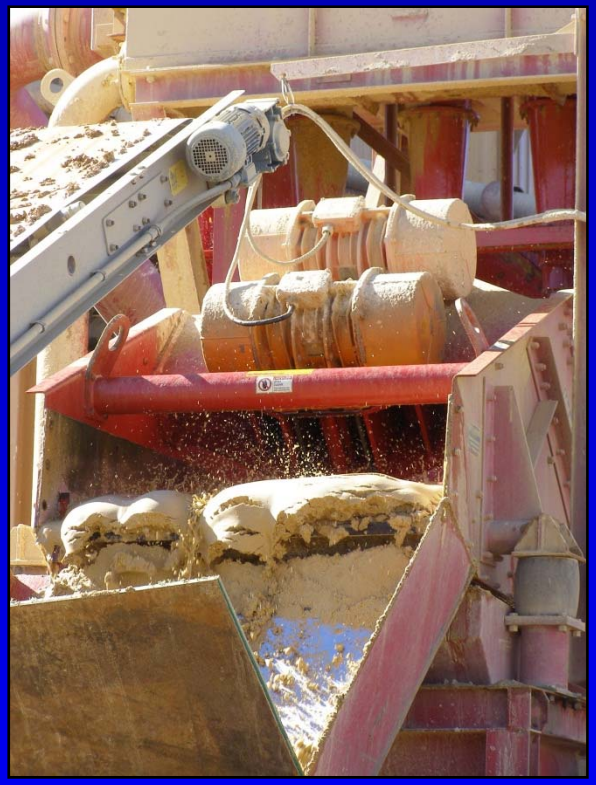


Photo: Chippewa Co.

Water used to wash sand, transport sand onsite and control dust

Study overview

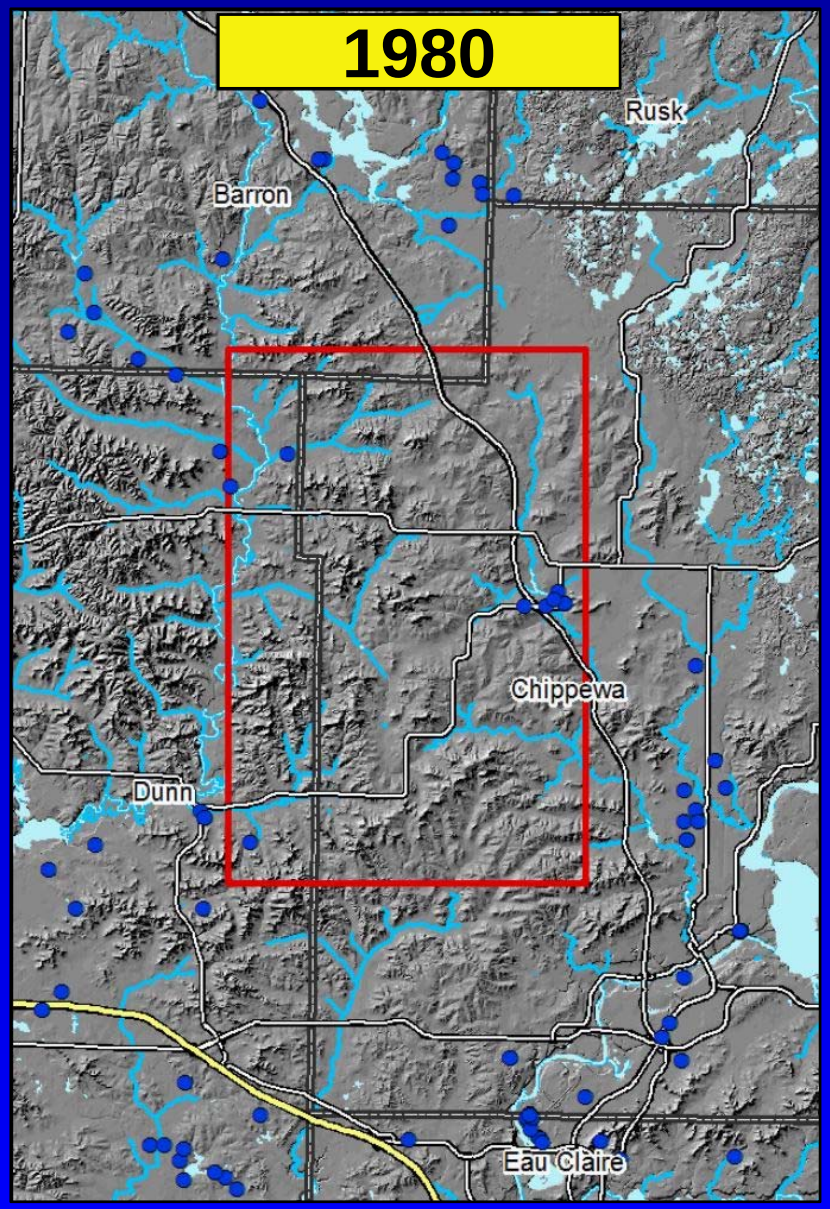
Municipal supply

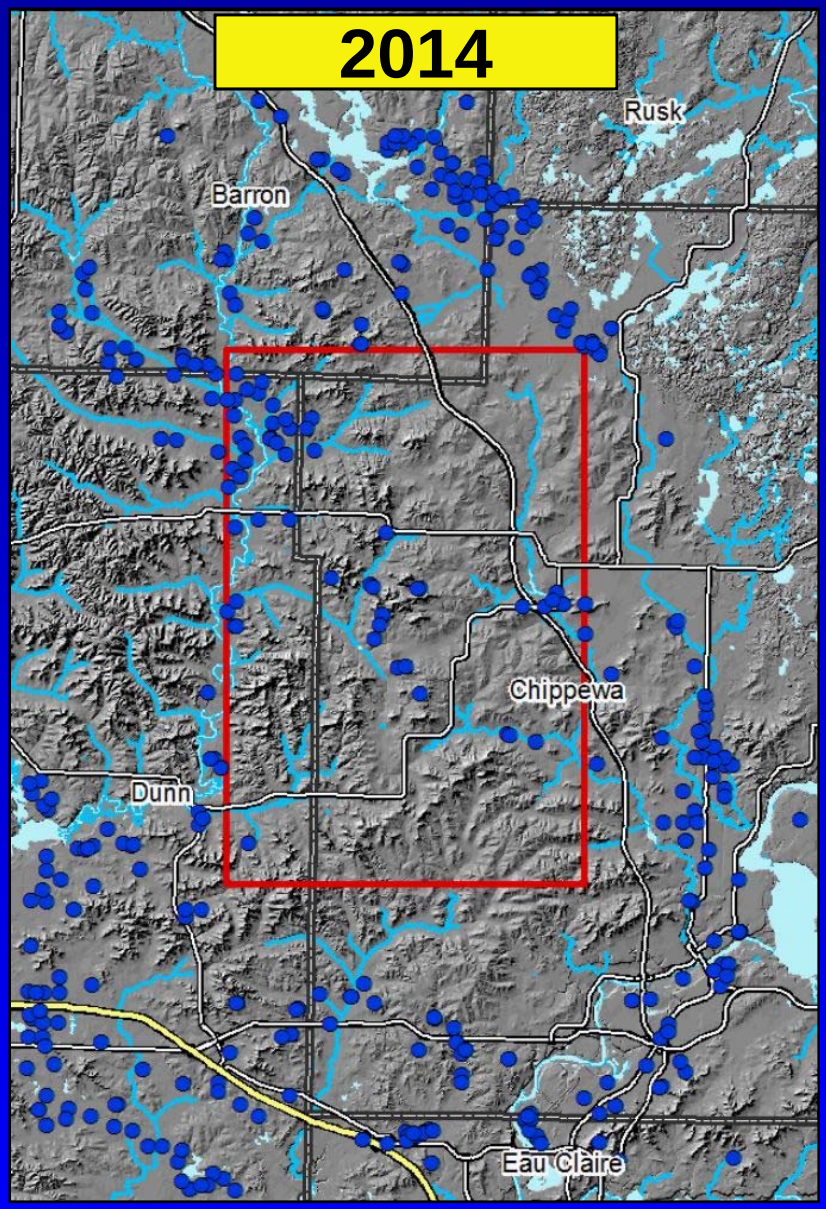
Irrigated agriculture

Study overview

- Why do we care?
  - Pumping in upland areas near headwaters of streams
  - Intensifying water-use practices
  - Changes to landscape and implications for groundwater recharge
  - Long-term water resource management and sustainability

Intensifying water-use practices





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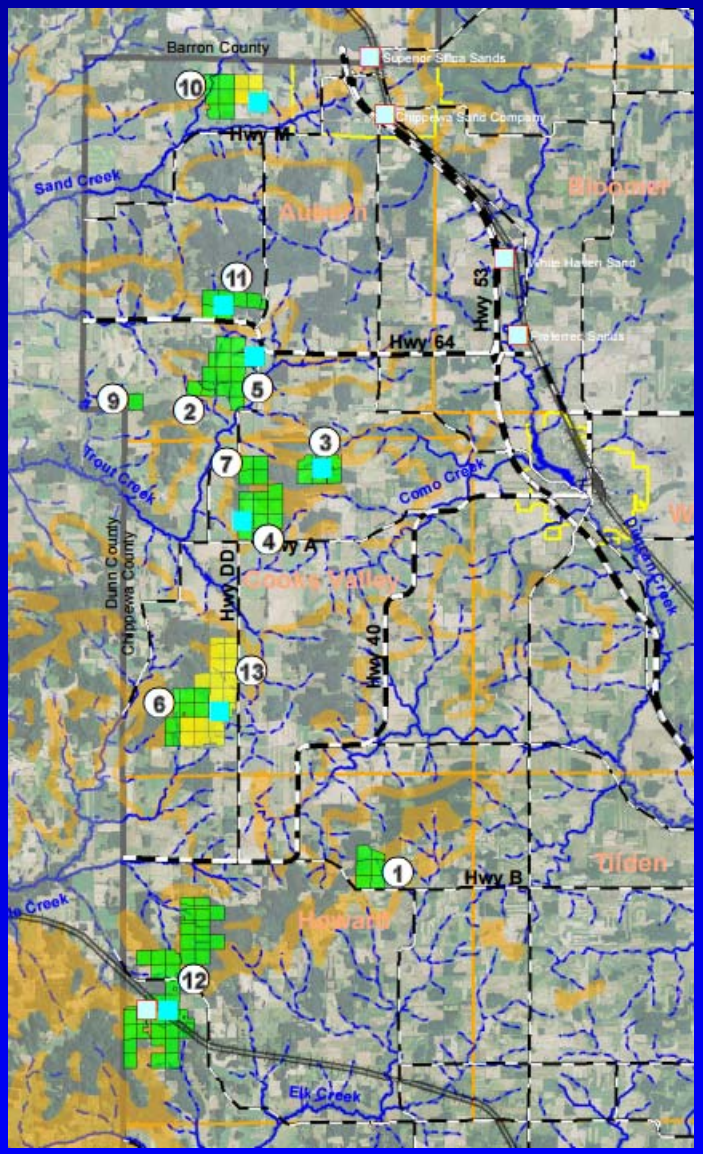
Changes to landscape



- Permitted mines
- Application received

Expansion of industrial sand mining

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Review of study

Objectives

- **Modeling** - develop soil-water-balance (recharge) and groundwater flow models to evaluate current and future water use and landscape changes on the hydrologic system
  - Calibrate MODFLOW model to pre/early-mine recharge and pumping rates
  - Test future scenarios *(e.g., least developed, most developed)* which incorporate changes in recharge *(e.g., soil types, vegetative cover, hill slope geometry)* and pumping rates
  - Evaluate potential impacts to water levels and base flow to streams
- **Outreach** - disseminate the study results to stakeholders and the general public
- **Transferability**- transfer the study results to similar geologic and hydrologic settings as appropriate

Review of study – workflow and schedule

TABLE 1 - Project Workflow and Activities Schedule

Calendar Year	2012				2013				2014				2015				2016				2017			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Data collection / Interp.																								
- Collect and compile well & geophysical data			X	X	X	X																		
- Analyze & process				X	X	X	X	X																
- Interpretation (i.e., build model layers)							X	X	X	X														
Soil-water-balance model																								
- Collect climate/soils data			X	X	X	X																		
- Collect land use and elevation data			X	X	X	X																		
- Build model						X	X																	
- Review model							X	X																
- Define scenarios							X	X																
- Conduct model runs								X	X															
- Complete/Format results									X	X														
Groundwater model, calibration																								
- Construct model grid and decide on modeling packages					X	X	X	X																
- Build hydrological model								X	X	X	X	X	X	X										
- Calibrate model												X	X	X	X									
- Compile/Format results														X	X	X	X							
Scenario testing																								
- Define test scenarios										X	X	X	X	X	X	X	X	X						
- Conduct model runs																X	X	X	X					
- Compile/Format results																		X	X	X				
Transferability																								
- Conduct analysis																	X	X						
- Compile/Format results																			X	X				
Fact sheet																								
- Identify purpose/content (WGNHS)			X	X																				
- Prepare & finalize drafts (WGNHS)				X	X																			
- Print & distribute (WGNHS)					X																			
Public outreach meetings																								
- Identify purpose/content			X	X																				
- Conduct public outreach meetings					X																			
- Conduct stakeholders meetings - Specific times TBD					X		X			X				X				X						
Reporting																								
- Complete annual report (Chippewa Co LCFM)					X				X				X				X							
- Complete interim project report (WGNHS)												X												
- Complete final project report (WGNHS / USGS)																							X	
				Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	
Federal Fiscal Year (USGS)					2013				2014				2015				2016				2017			
State Fiscal Year (WGNHS)				2013				2014				2015				2016				2017				

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Construction and Calibration of a Groundwater Flow Model in Chippewa County

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mod•el |ˈmädl|

noun

• a simplified description, esp. a mathematical one, of a system or process, to assist *calculations* and *predictions*.

ORIGIN late 16th cent. (denoting a set of plans of a building): from French ***modelle***, from Italian ***modello***, from an alteration of Latin ***modulus*** (see **modulus**).

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from: New Oxford American Dictionary

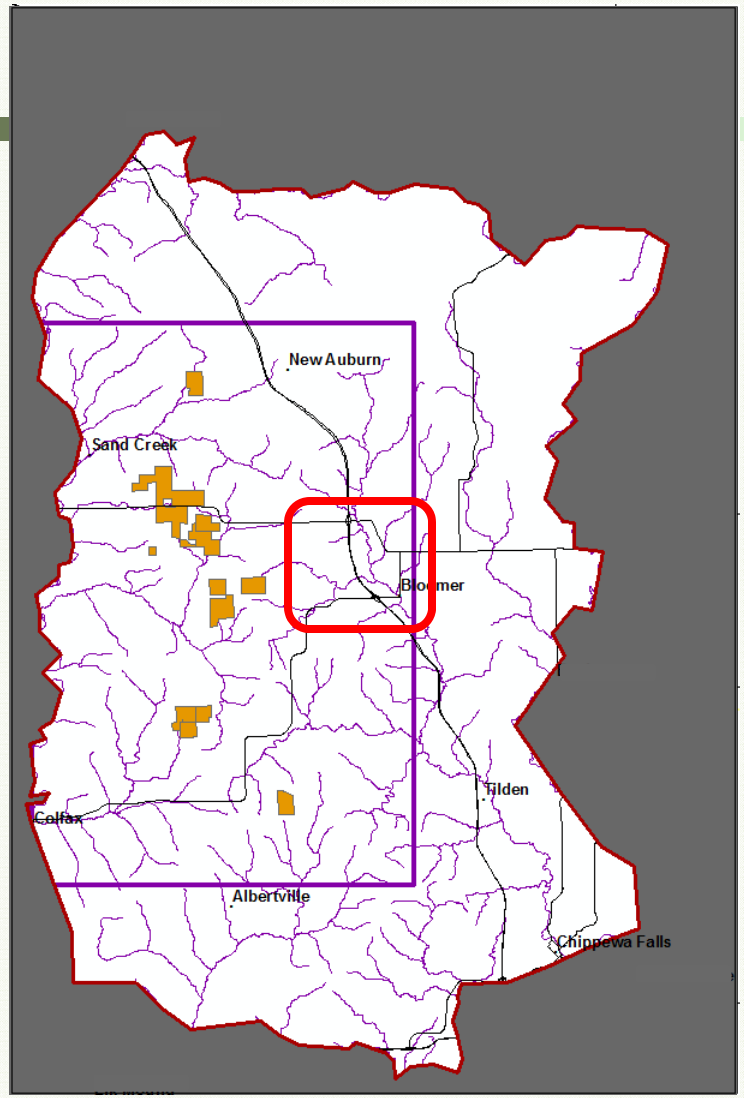
Building a MODFLOW Model: Basics

Start with a basemap

Focus in on area of interest

Extend out to hydrologic boundaries

Add a computational grid



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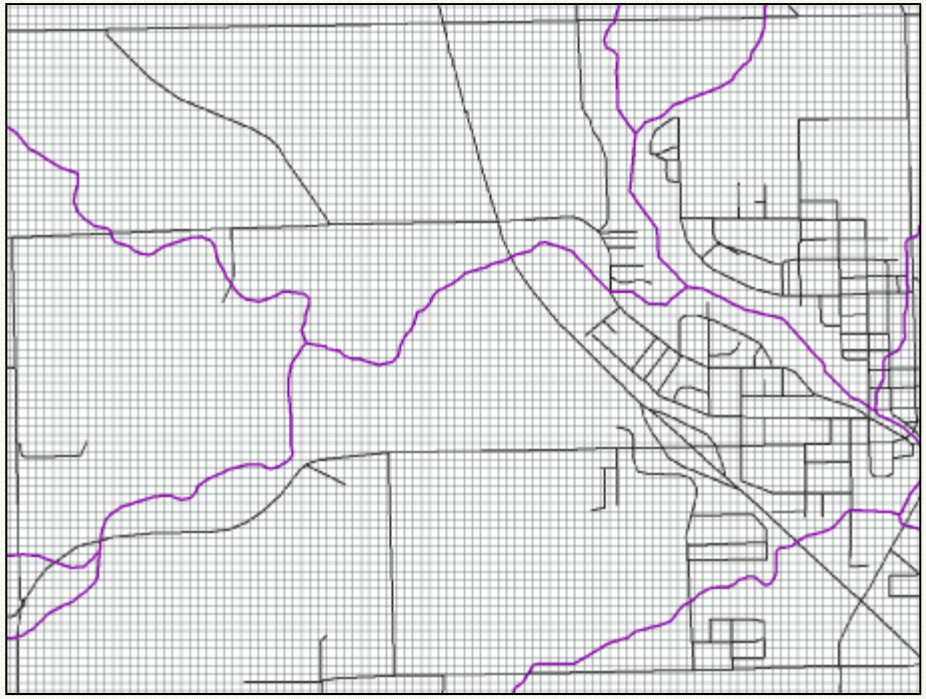
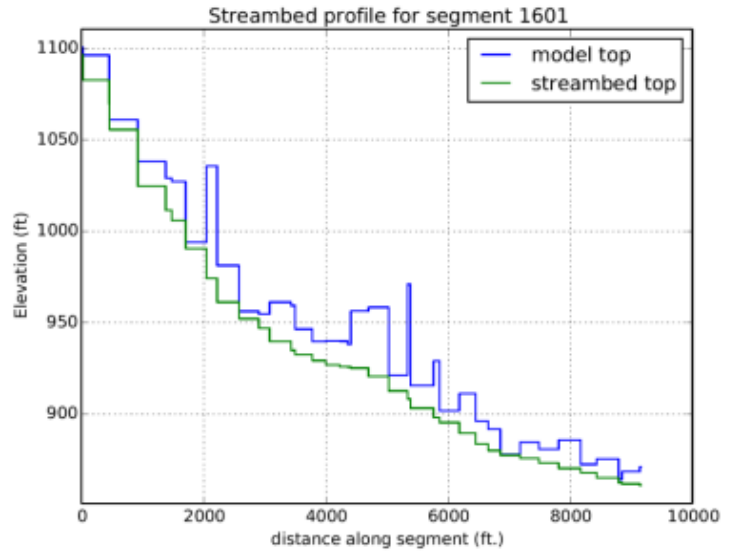


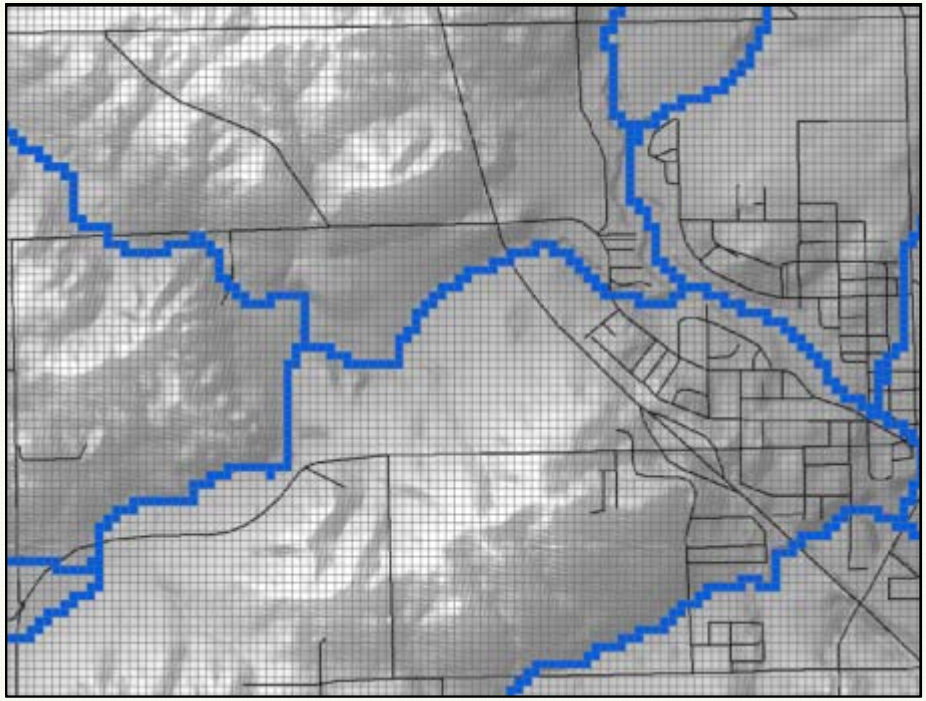
Building a MODFLOW Model: Streams and Elevation

Focus in on the stream network

Assign streams to model cells

Routing water downstream/downhill





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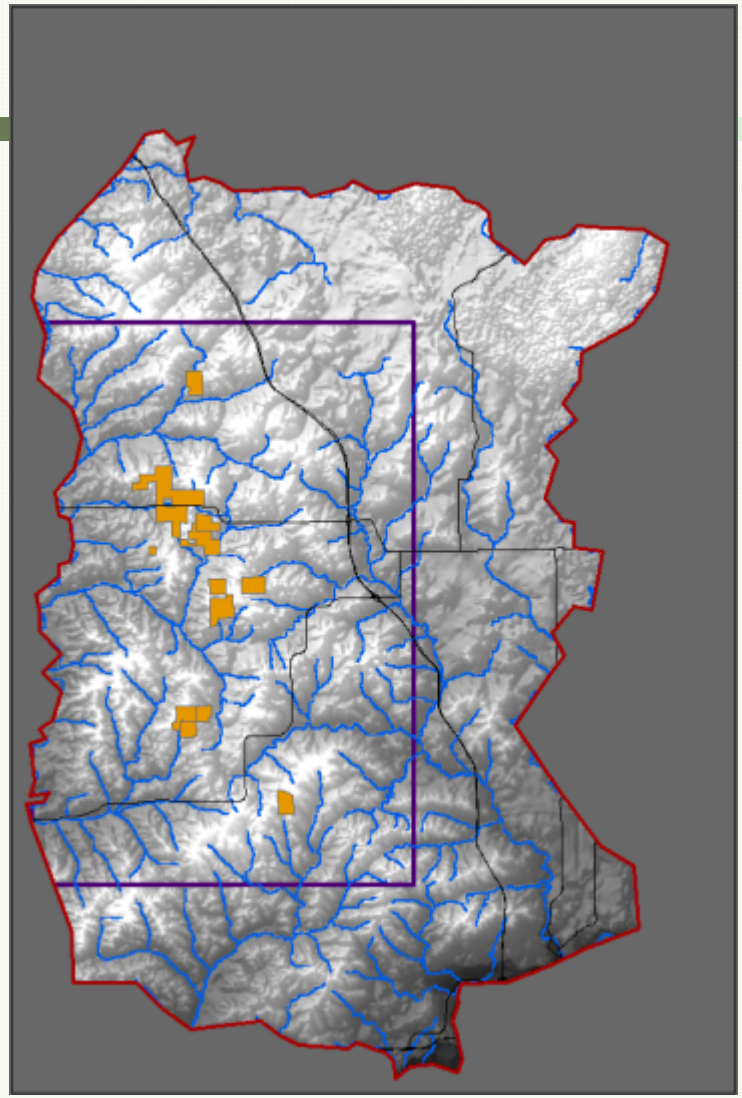
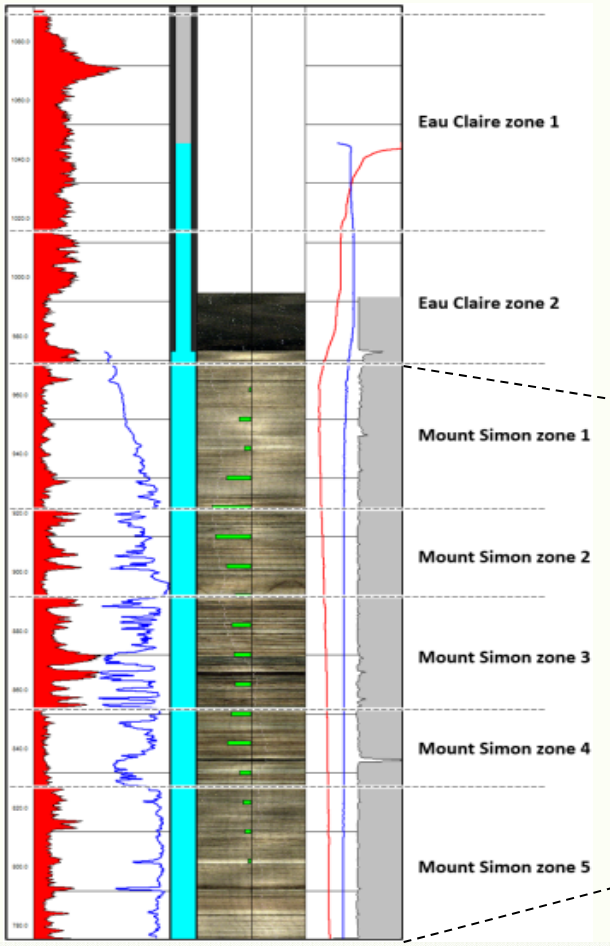
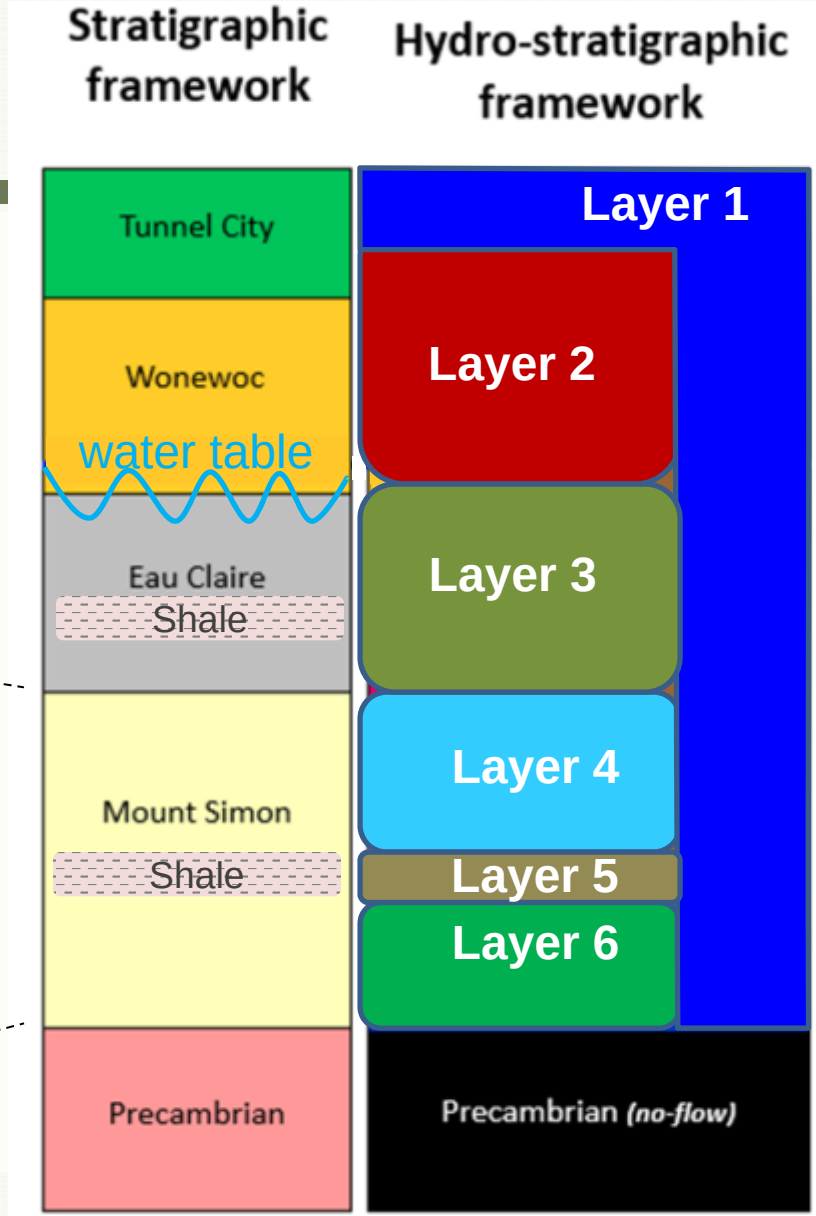


Building a MODFLOW Model: Hydrostratigraphy





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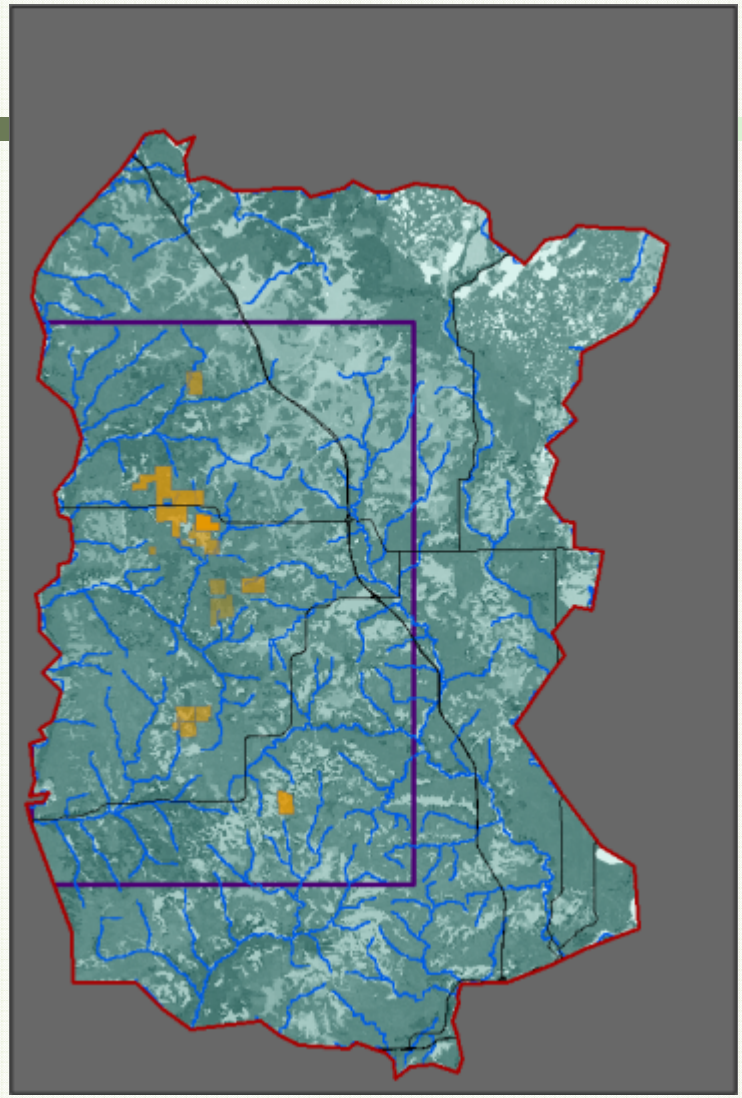
Building a MODFLOW Model: Recharge

Add groundwater recharge from the Soil-Water-Balance model

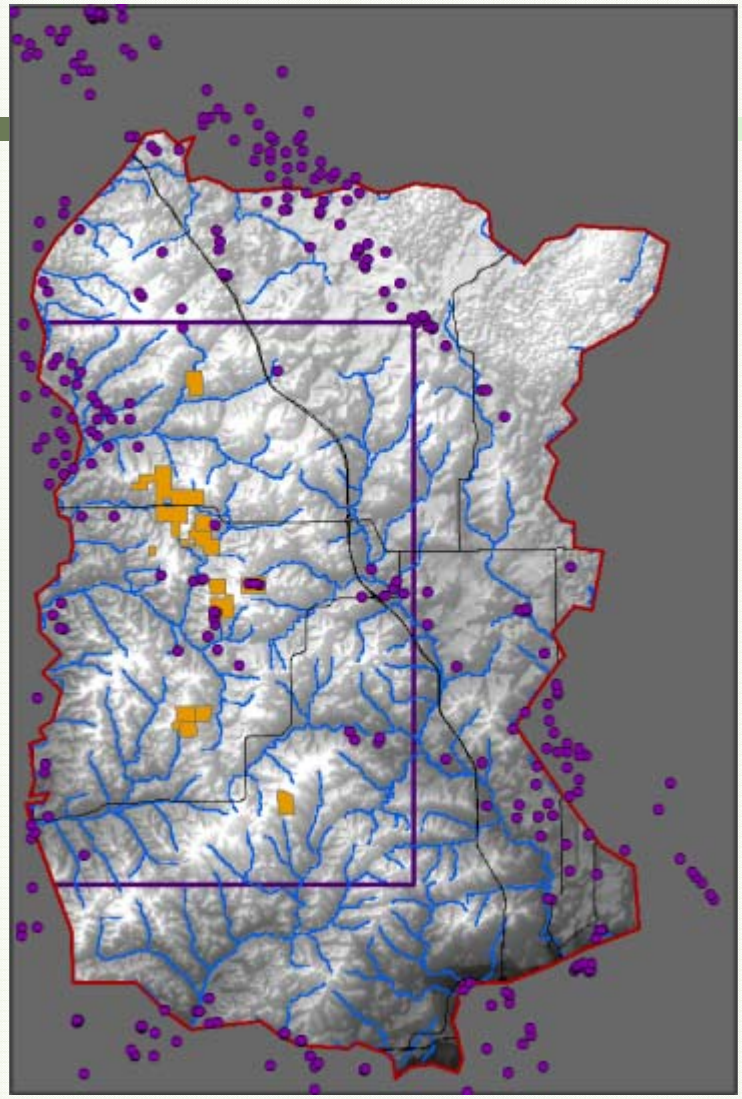
Darker colors = higher recharge



Building a MODFLOW Model: Water Use

Add groundwater wells to simulate pumping for mines, towns, and agriculture

2011-13 high-capacity withdrawals provided by the WI DNR; Locations refined by WGNHS



Building a MODFLOW Model: Calibration

Add stream baseflow targets

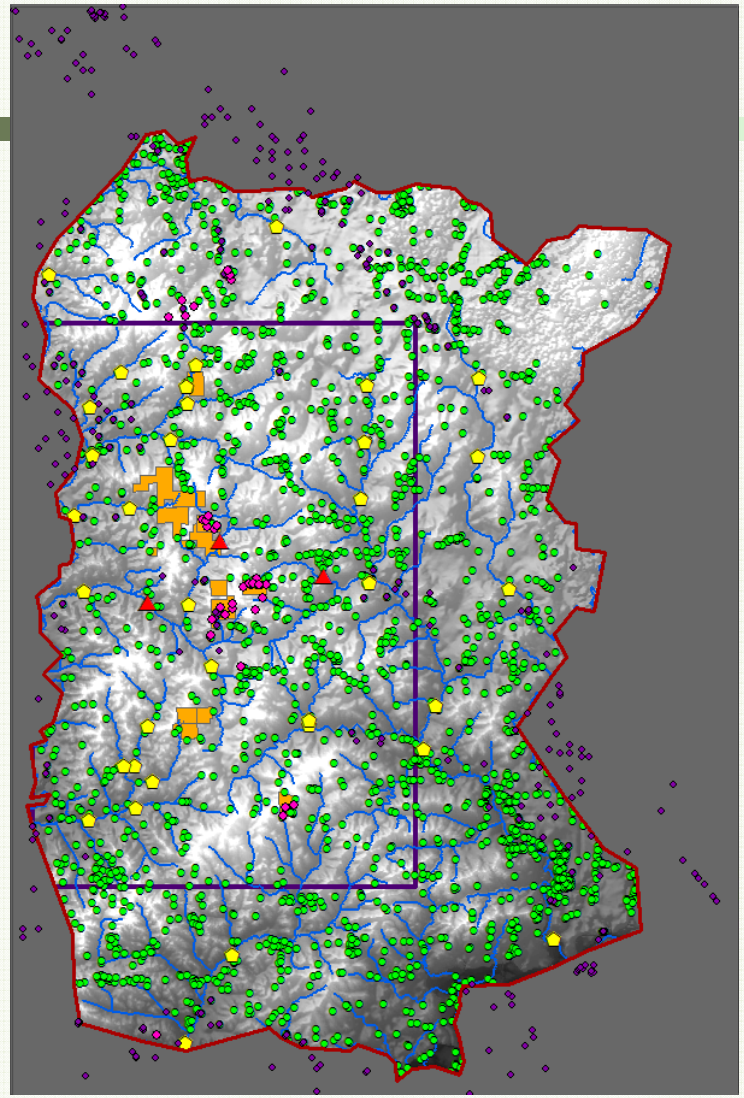
- Gaging stations
- Synoptic measurements

Add water level targets

- Well construction reports
- Mine borings and monitor wells

Target weights assigned by:

1. Locational & vertical accuracy
2. Number of measurements
3. Balance between water levels and flows



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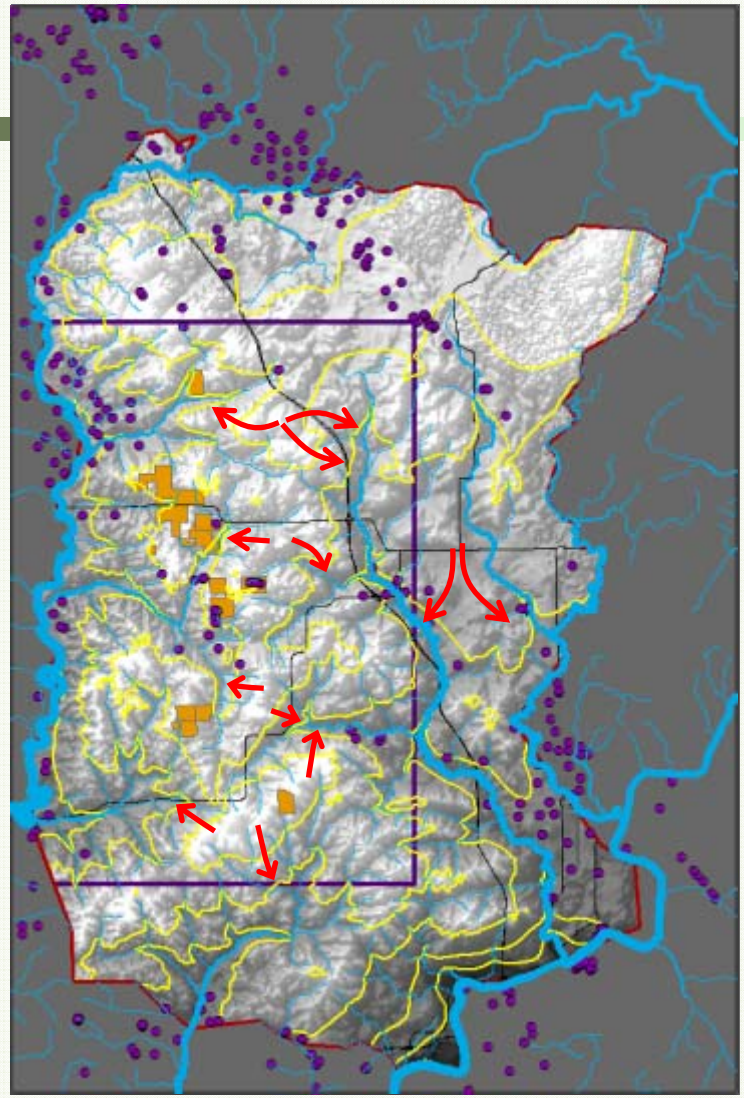
Calibration

Building a MODFLOW Model: Simulation Results

Calibrated Properties:

- 1 permeability value per layer
- Spatially variable recharge (SWB)

Simulate water levels…
and baseflows



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Year two: measuring infiltration

Estimating Groundwater Recharge

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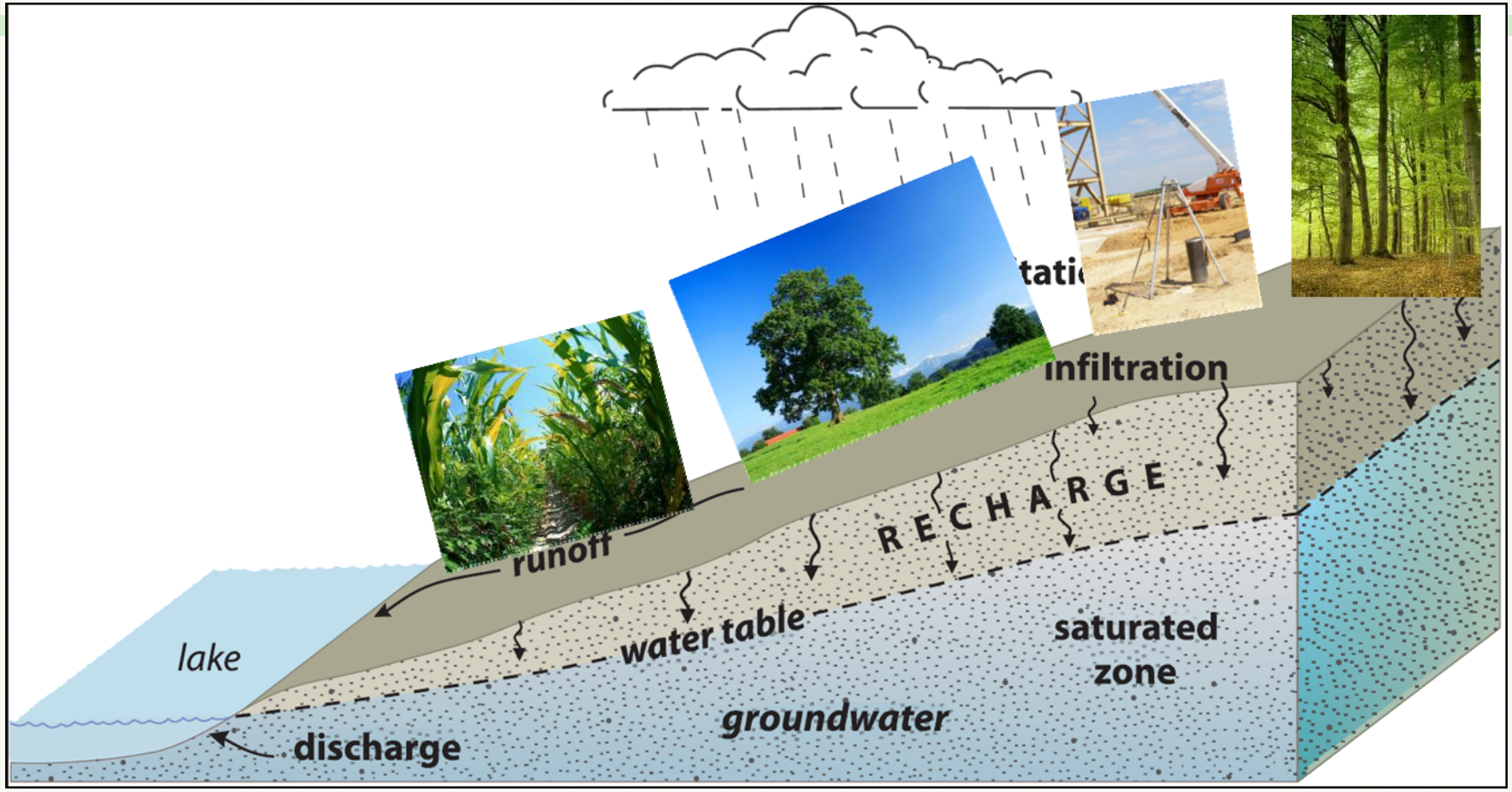
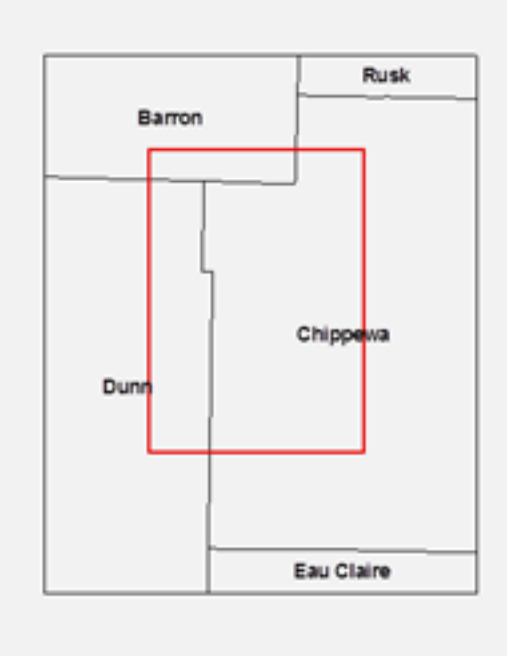
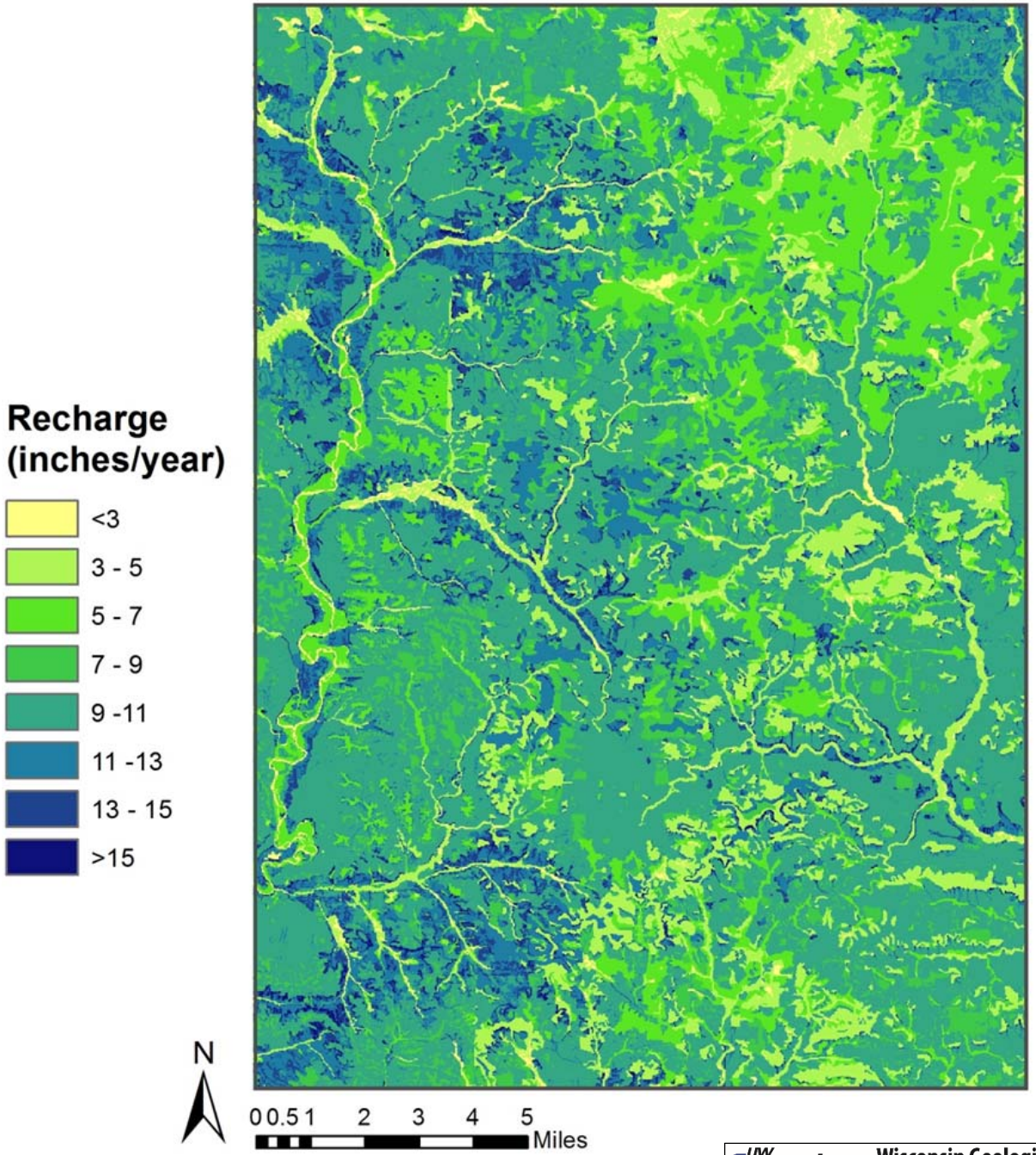
Recharge is water that enters the groundwater system

R = Precipitation – Runoff – Interception – Evapotranspiration



Estimated recharge, 1993





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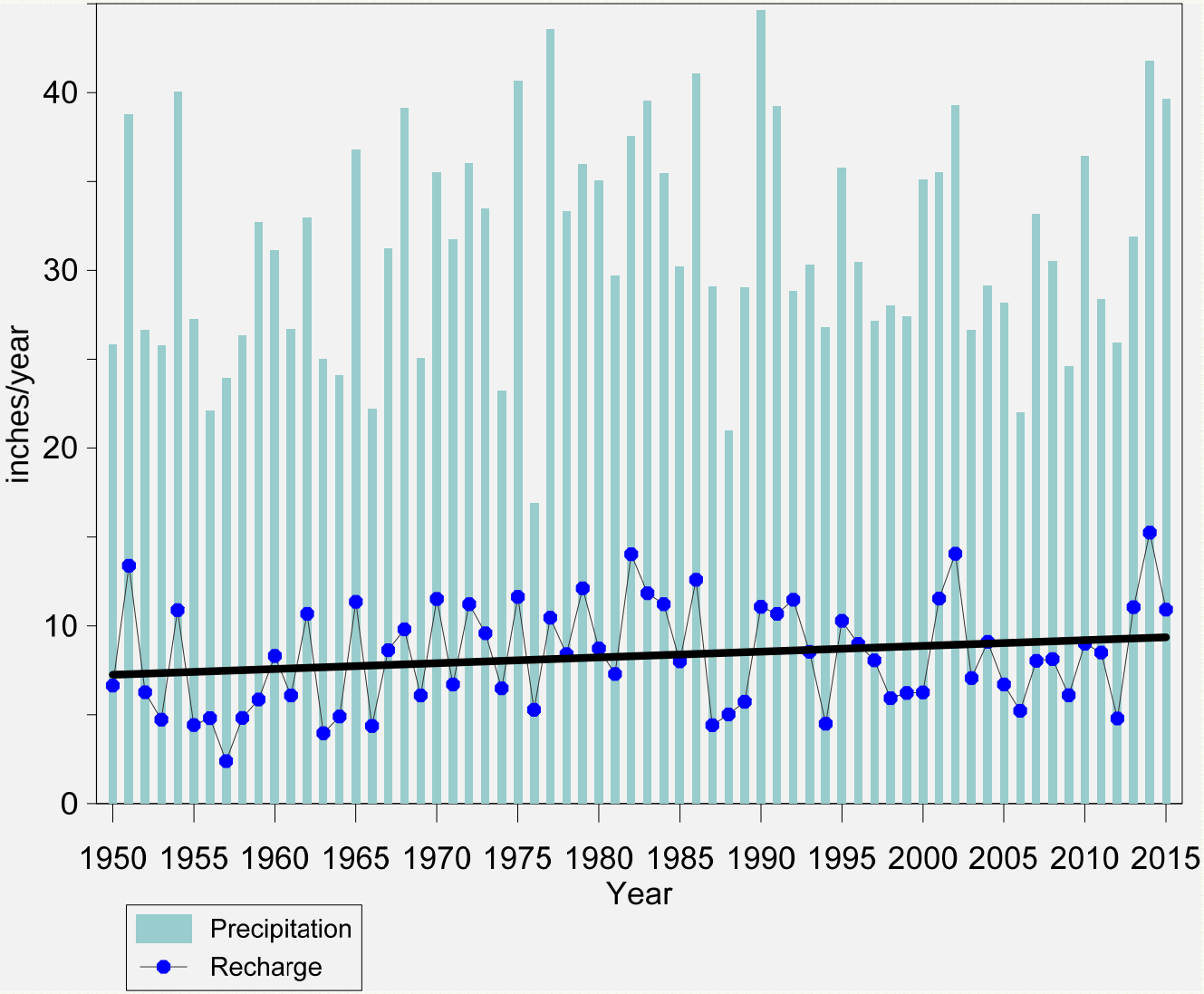
Estimated annual recharge, 1950 - 2015

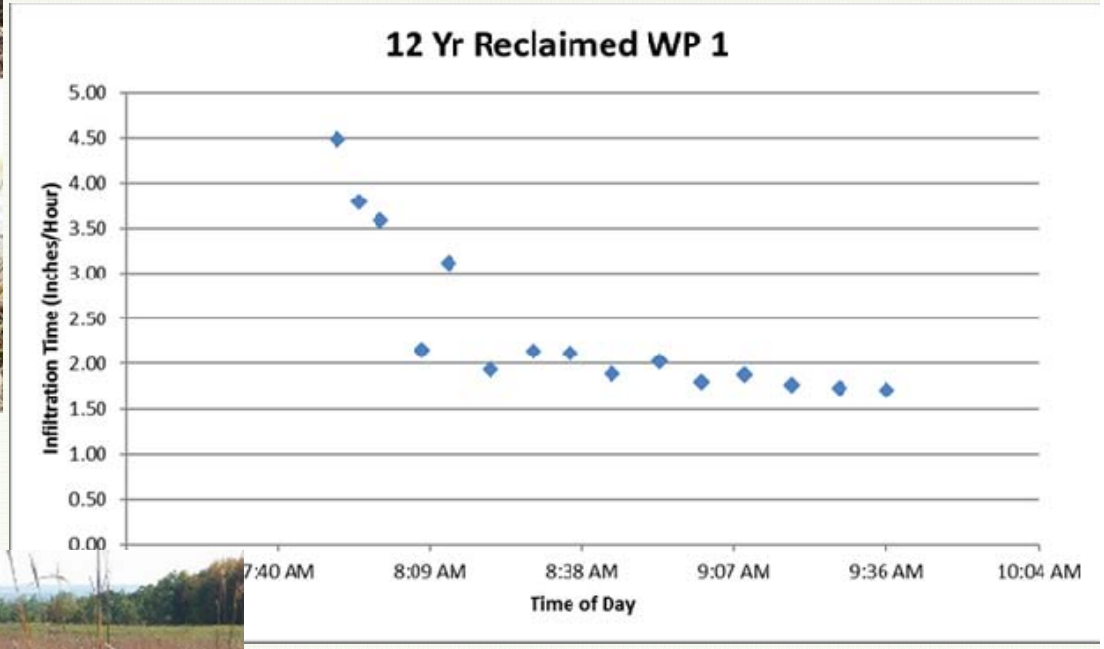


Precipitation
Average 31 in/yr
Min. 17 in/yr
Max. 45 in/yr

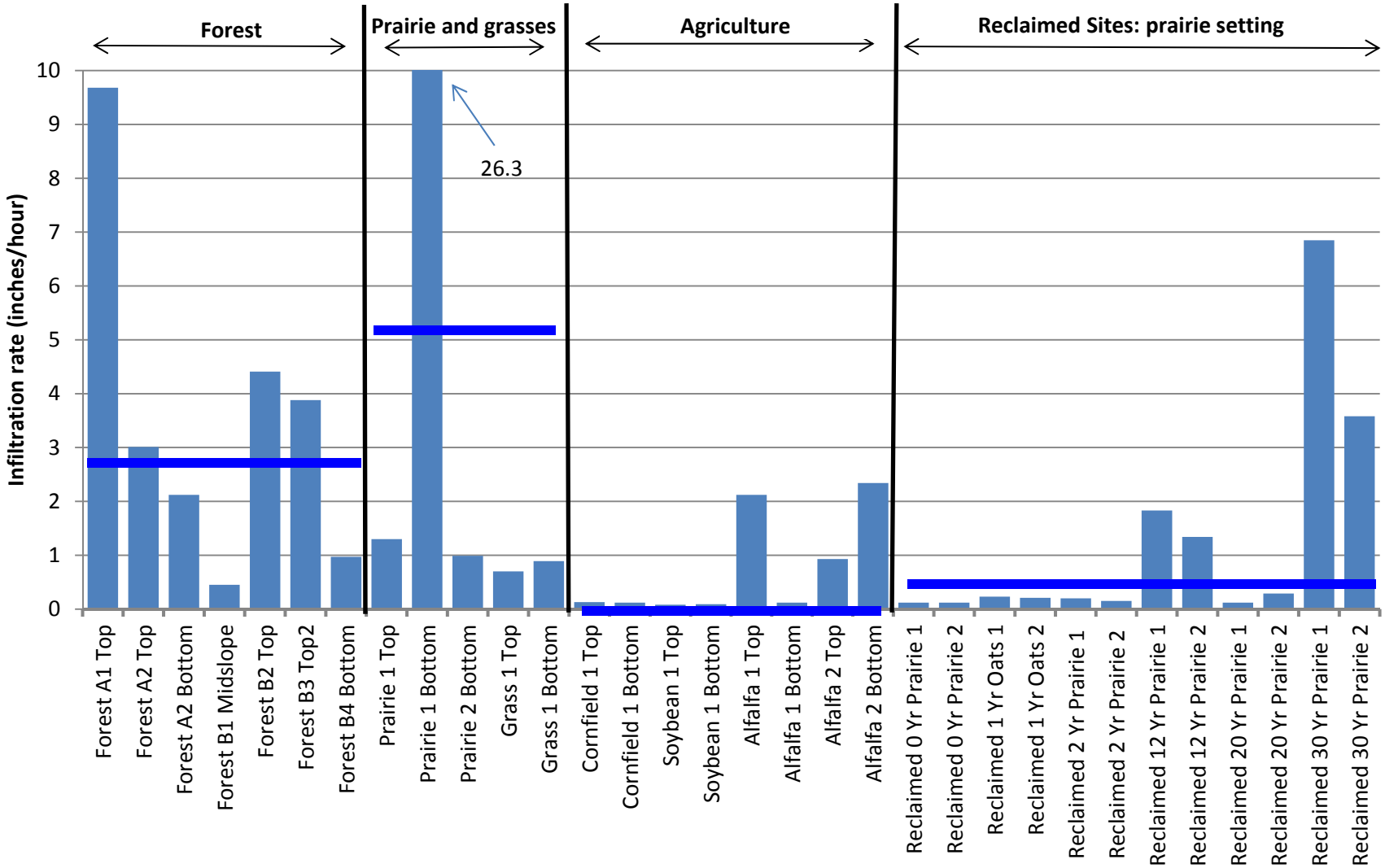
Recharge
Average 8.3 in/yr
Min. 2.4 in/yr
Max. 15 in/yr

Photo: S. Ebel, 6/15/12

Infiltration tests, n = 43



2014: Infiltration*



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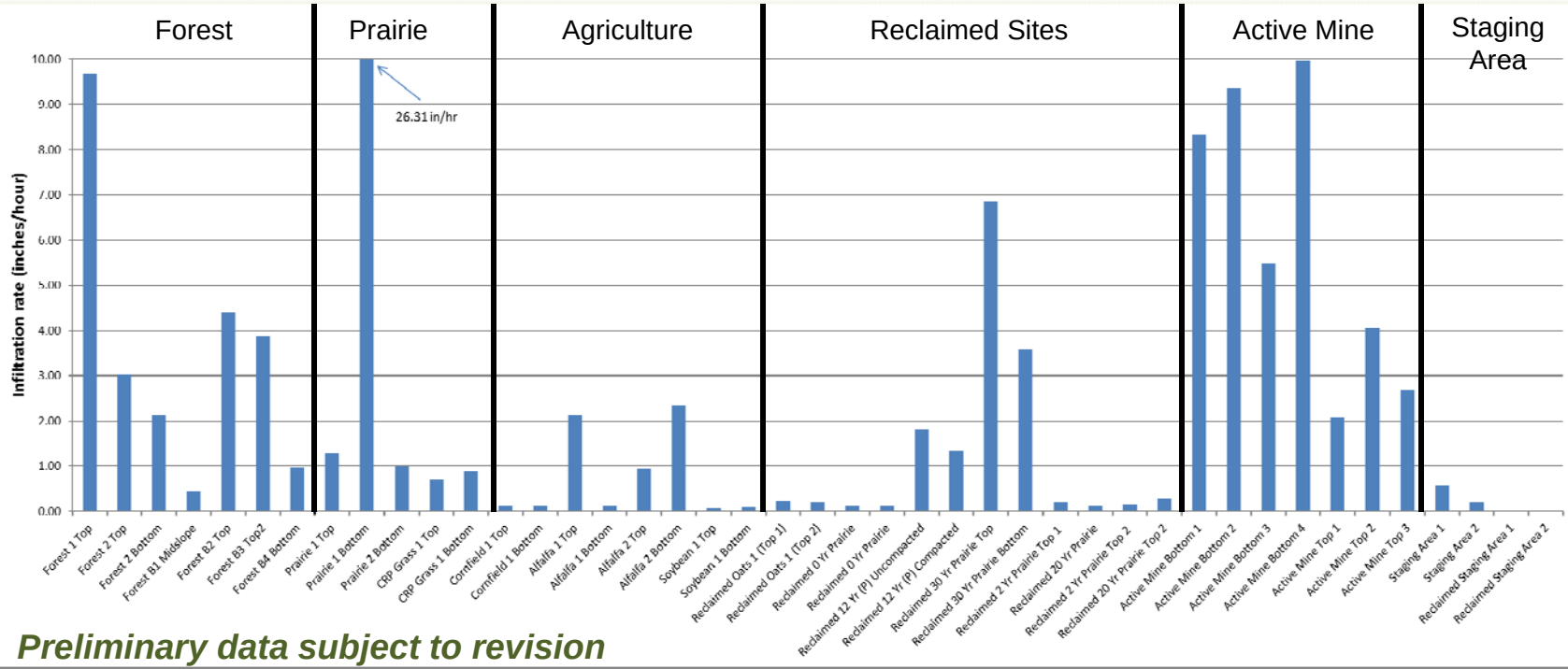
How much infiltration occurs during mining?

Since 1960, average annual precipitation has increased by 5%; heavy precipitation events are twice as frequent

Photos: S. Ebel

Kucharik, et al., Physical Geography 2010, 31 (1).

2015: Infiltration*



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2015: Infiltration

Conclusions: infiltration tests*

Design and operational practices affect infiltration during mining

- extent of staging areas, degree of compaction
- mining to elevation of fine-grain, well-cemented sandstone

Visual inspection and infiltration measurements show high runoff and ponding over much (but not all) of an active mine; recharge decreases overall during operation

Reclamation practices can, over time, achieve high infiltration (research is on-going…)

Recharge may return to similar or greater rates under grassland or prairie reclamation land use

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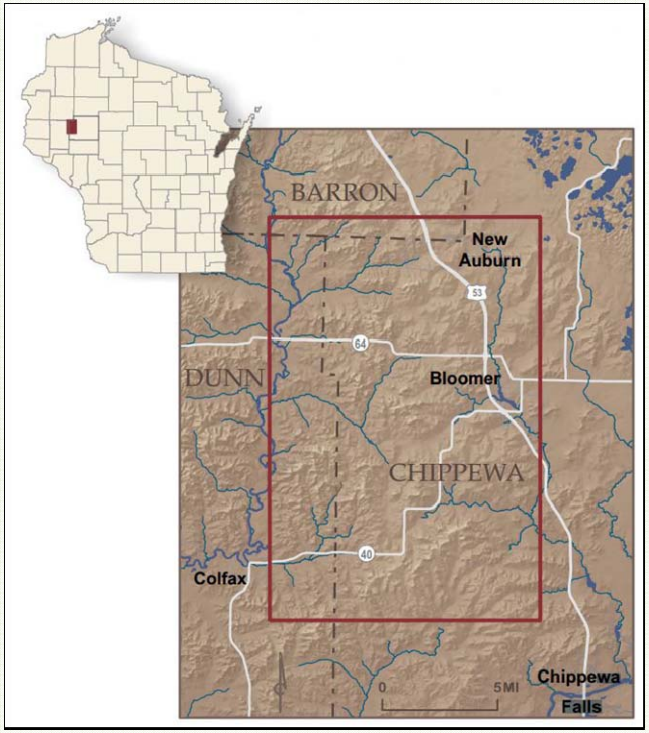
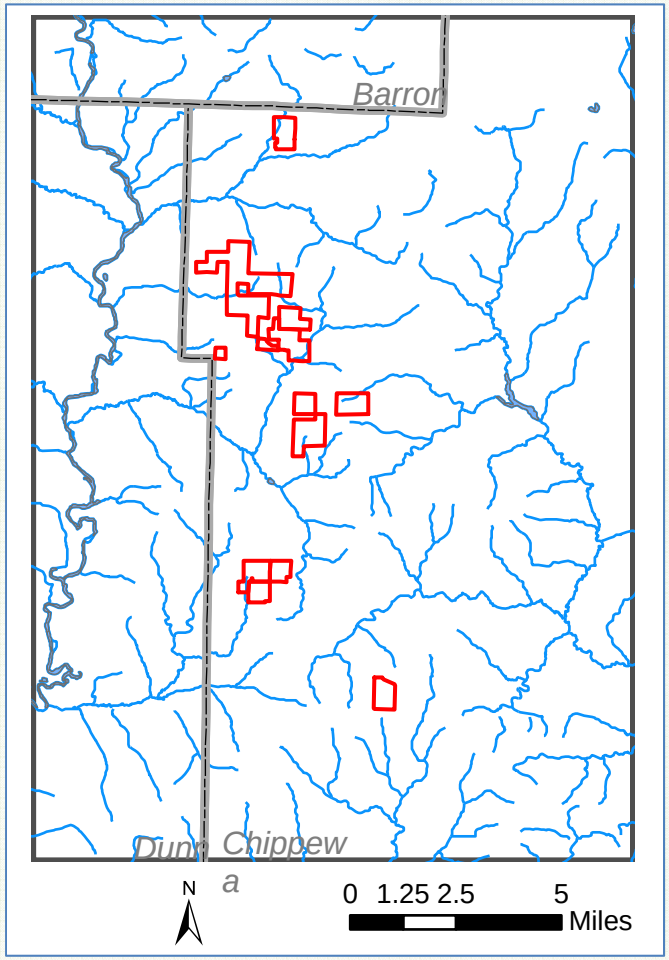
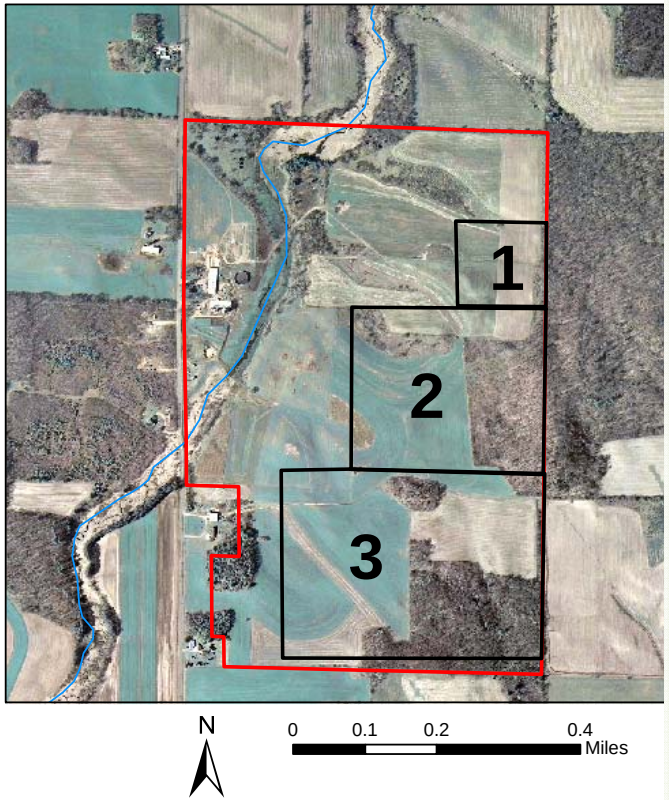
Estimating recharge in mined and reclaimed areas

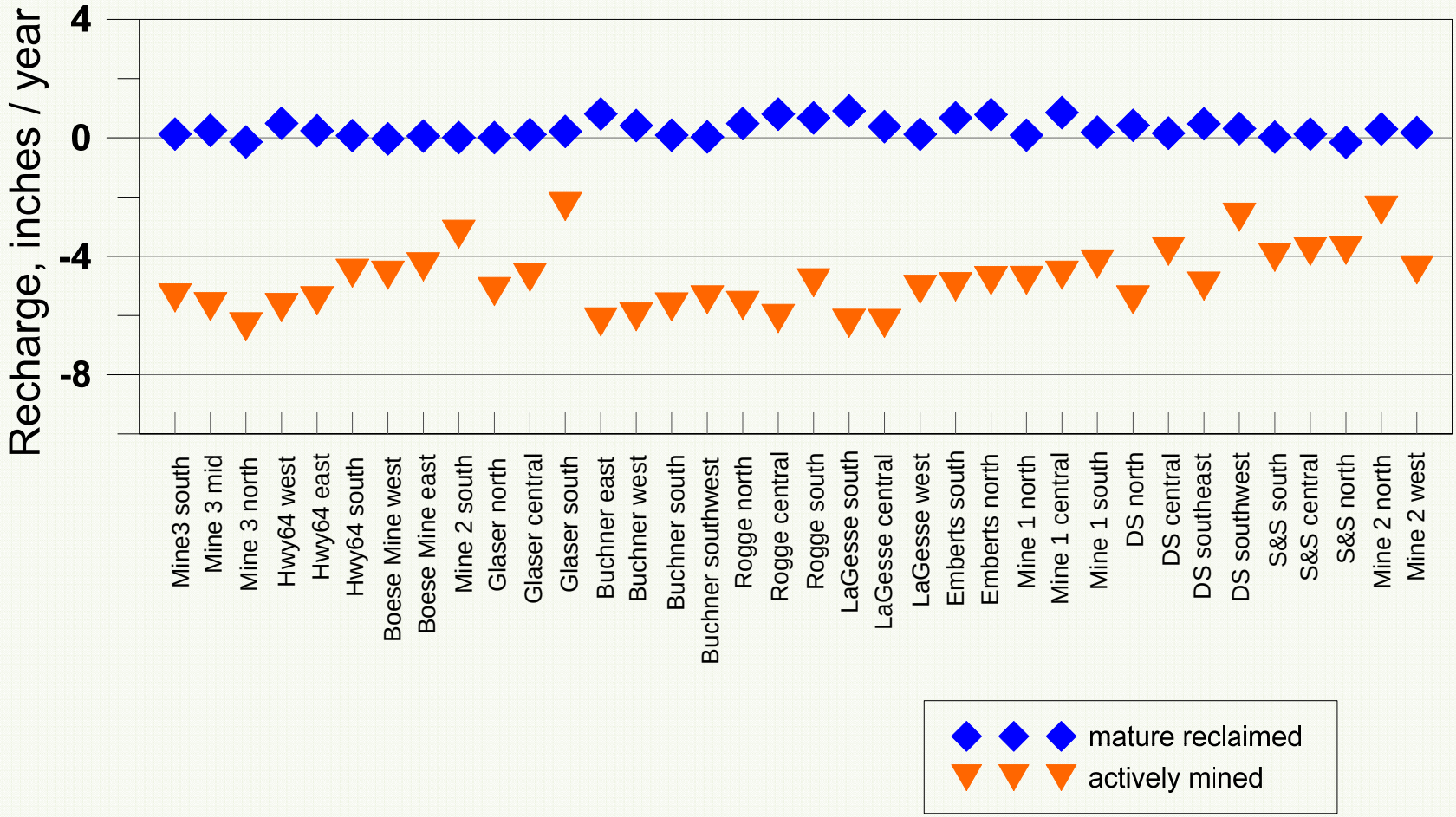




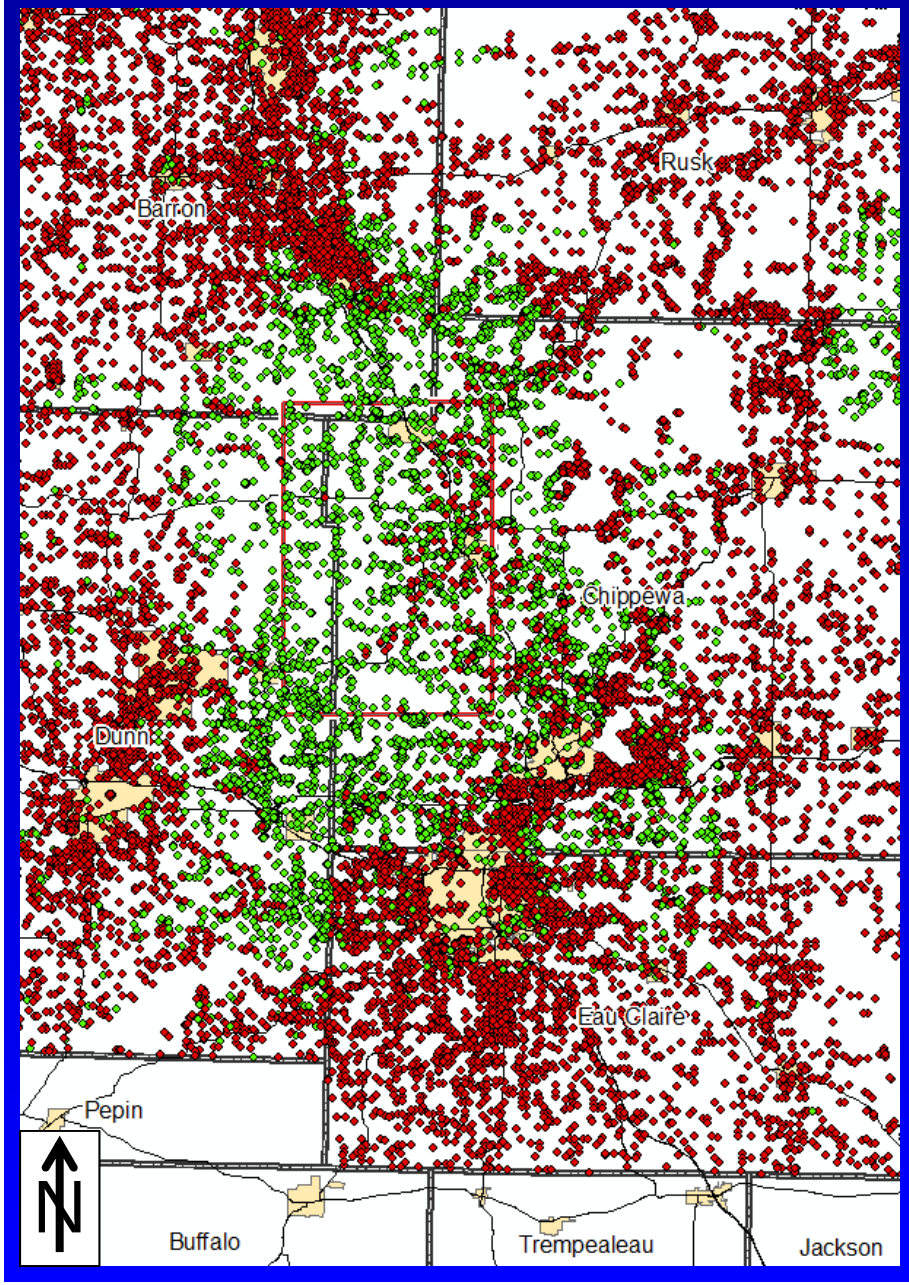
Years:	1 - 5	6 - 10	11 - 15	16 - 20	21 - 25	26 - 30
Area 1	quarry	early reclaimed	early reclaimed	mature reclaimed	mature reclaimed	mature reclaimed
Area 2	existing	quarry	early reclaimed	early reclaimed	mature reclaimed	mature reclaimed
Area 3	existing	existing	quarry	early reclaimed	early reclaimed	mature reclaimed



Estimated difference in recharge compared to pre-mining



Scenario testing – *Mine build-out*



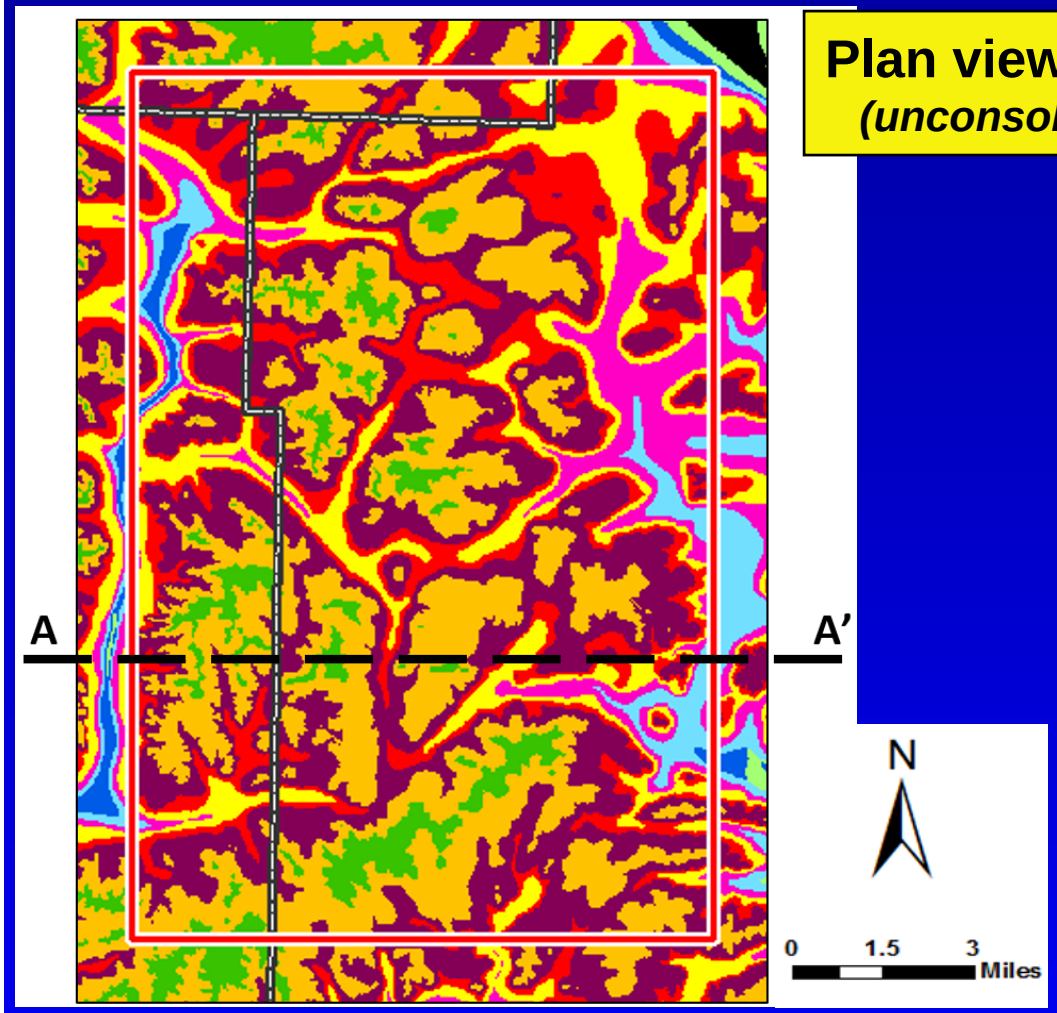
Well construction records (WCRs)

- WGNHS data refinements
  - Green = verified locations
  - Red = non-verified locations

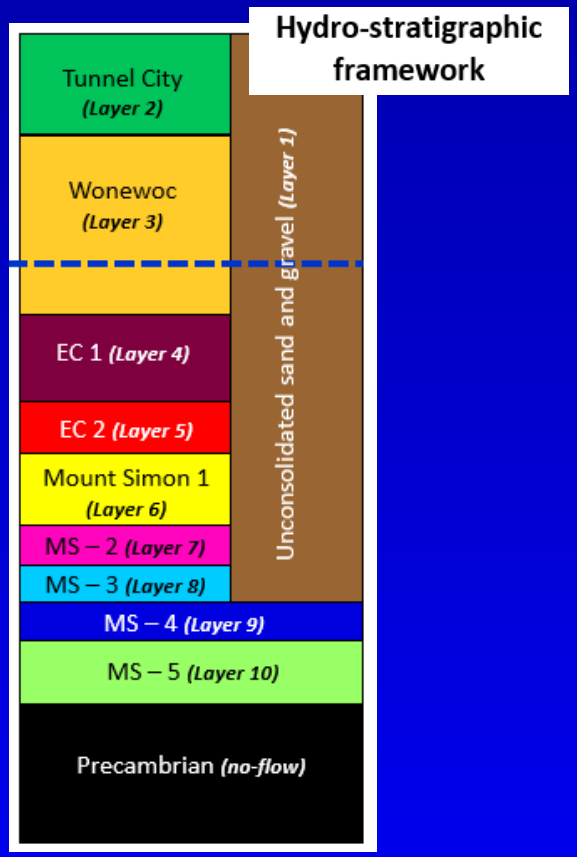
Other data sources include:

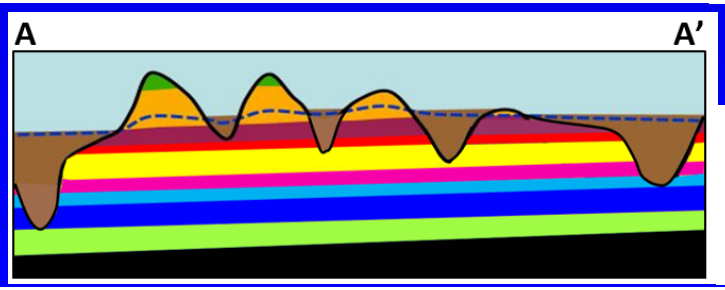
- **Geophysical logs**
- Geologic logs from cuttings
- Geologic maps
- **Sand mine plans & maps**
- Outcrops

Scenario testing – *Mine build-out*



Plan view showing bedrock units
(unconsolidated materials not shown)





Vertical scale: Approx. 600 feet

Profile along A-A' showing all units
(unconsolidated materials are in brown)

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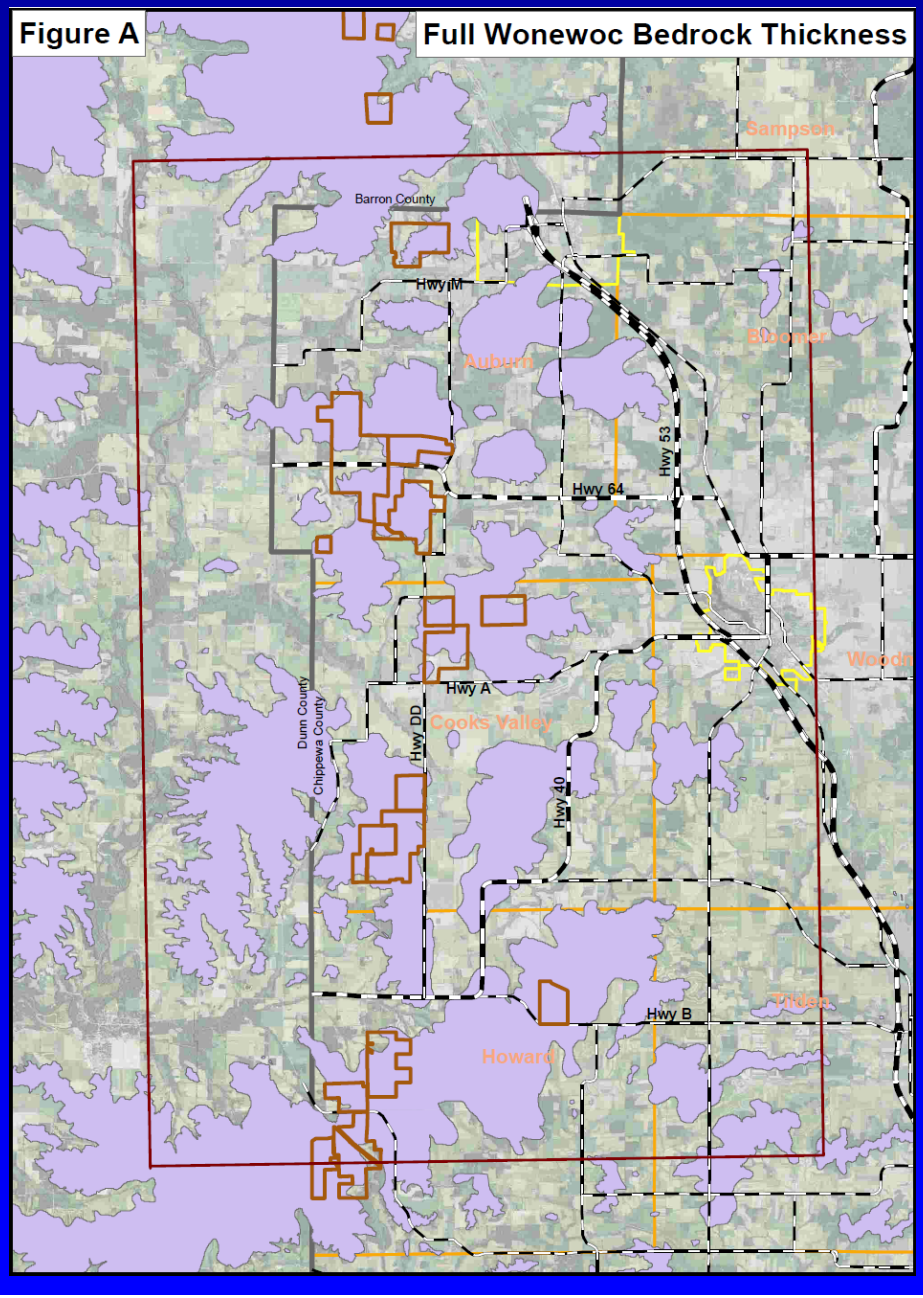
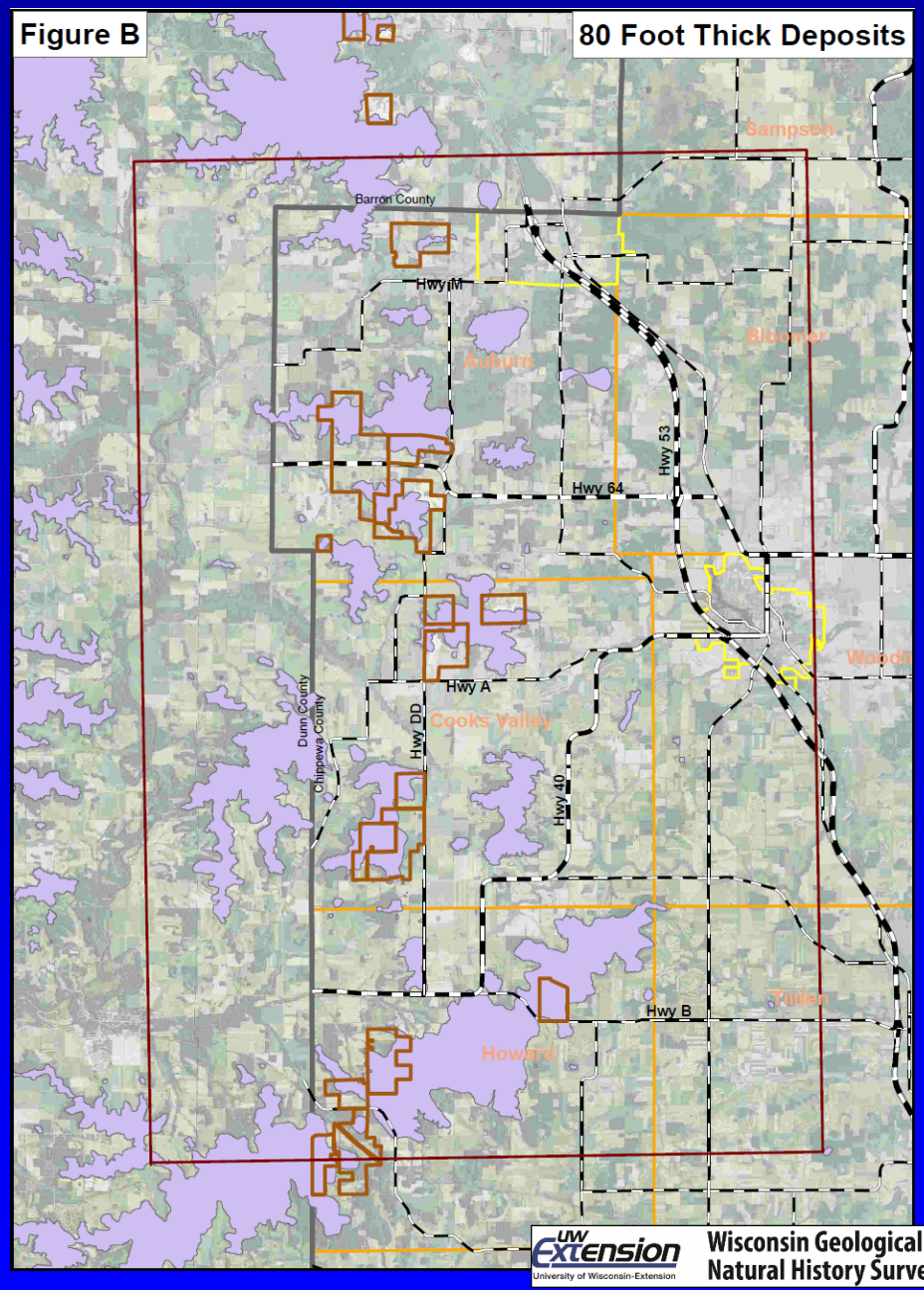
Scenario testing – *Mine build-out*





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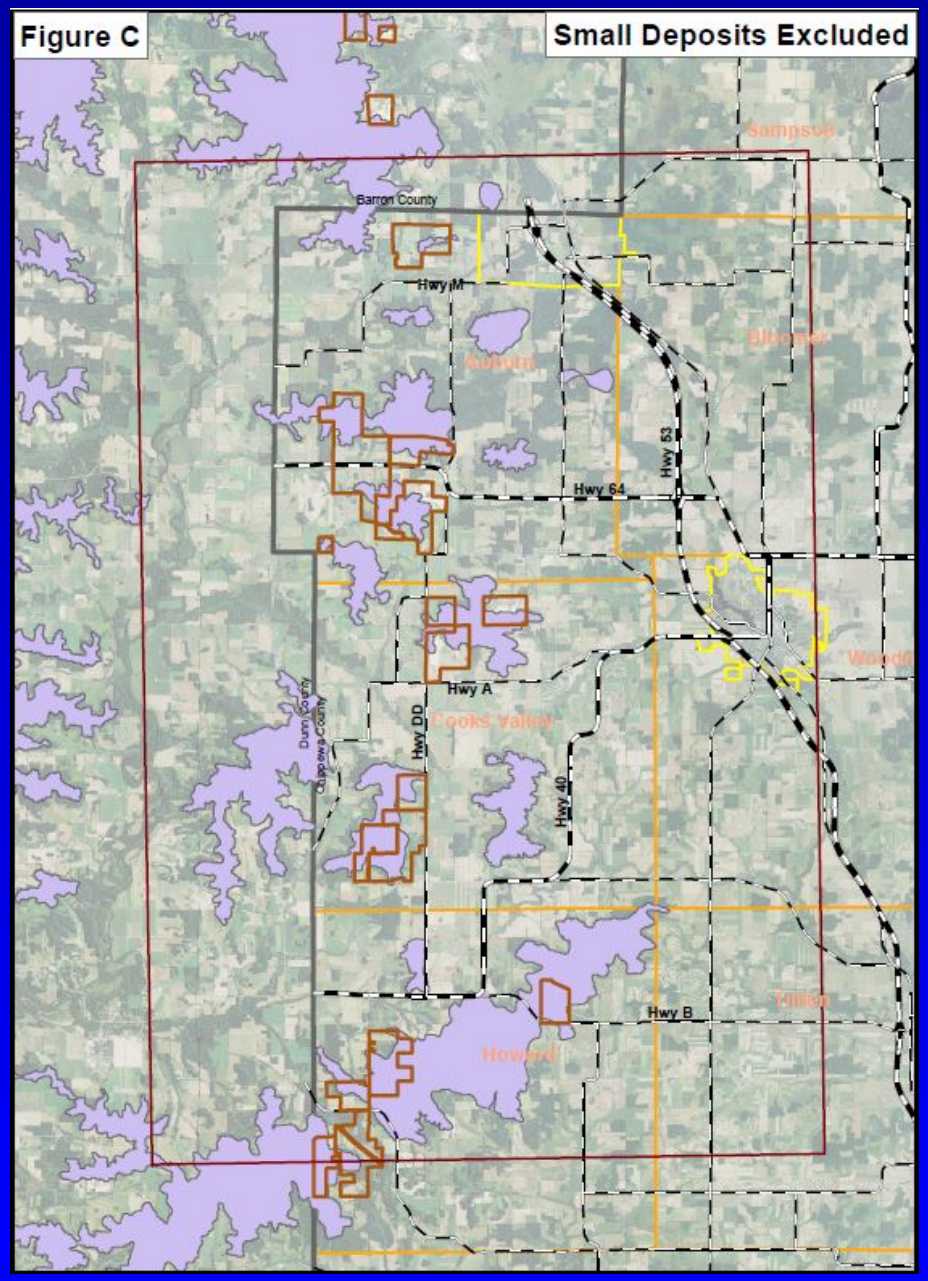

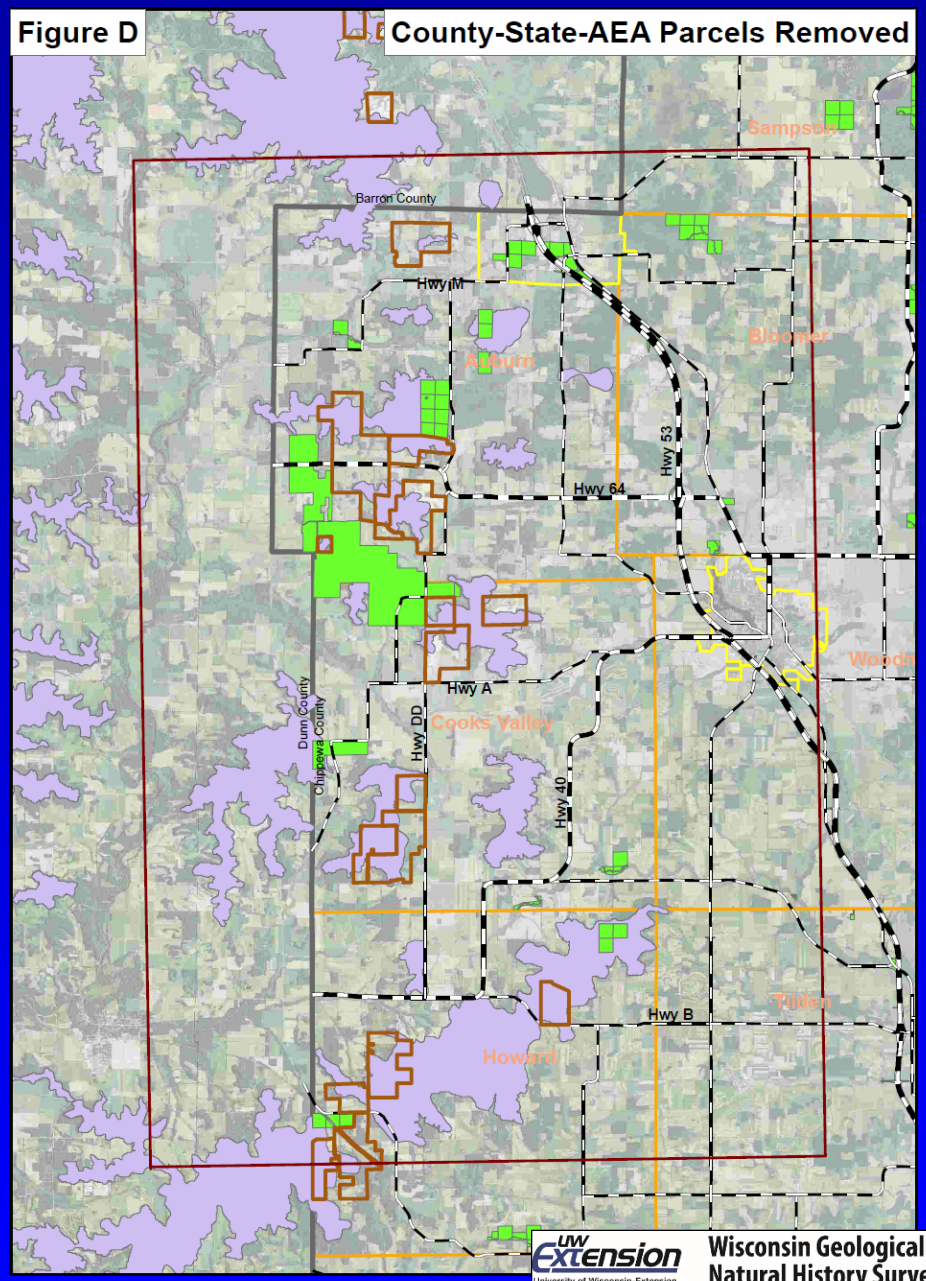

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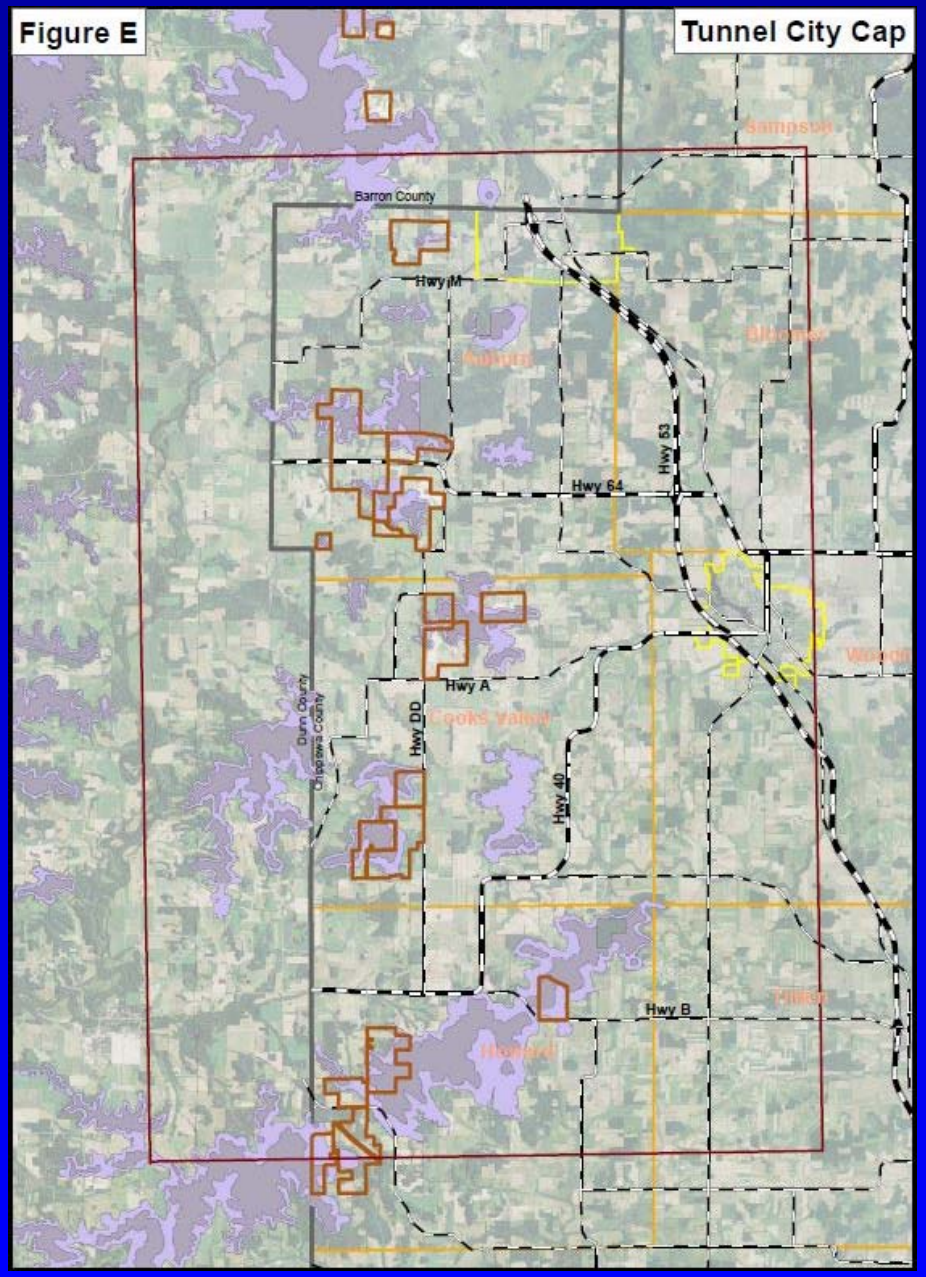

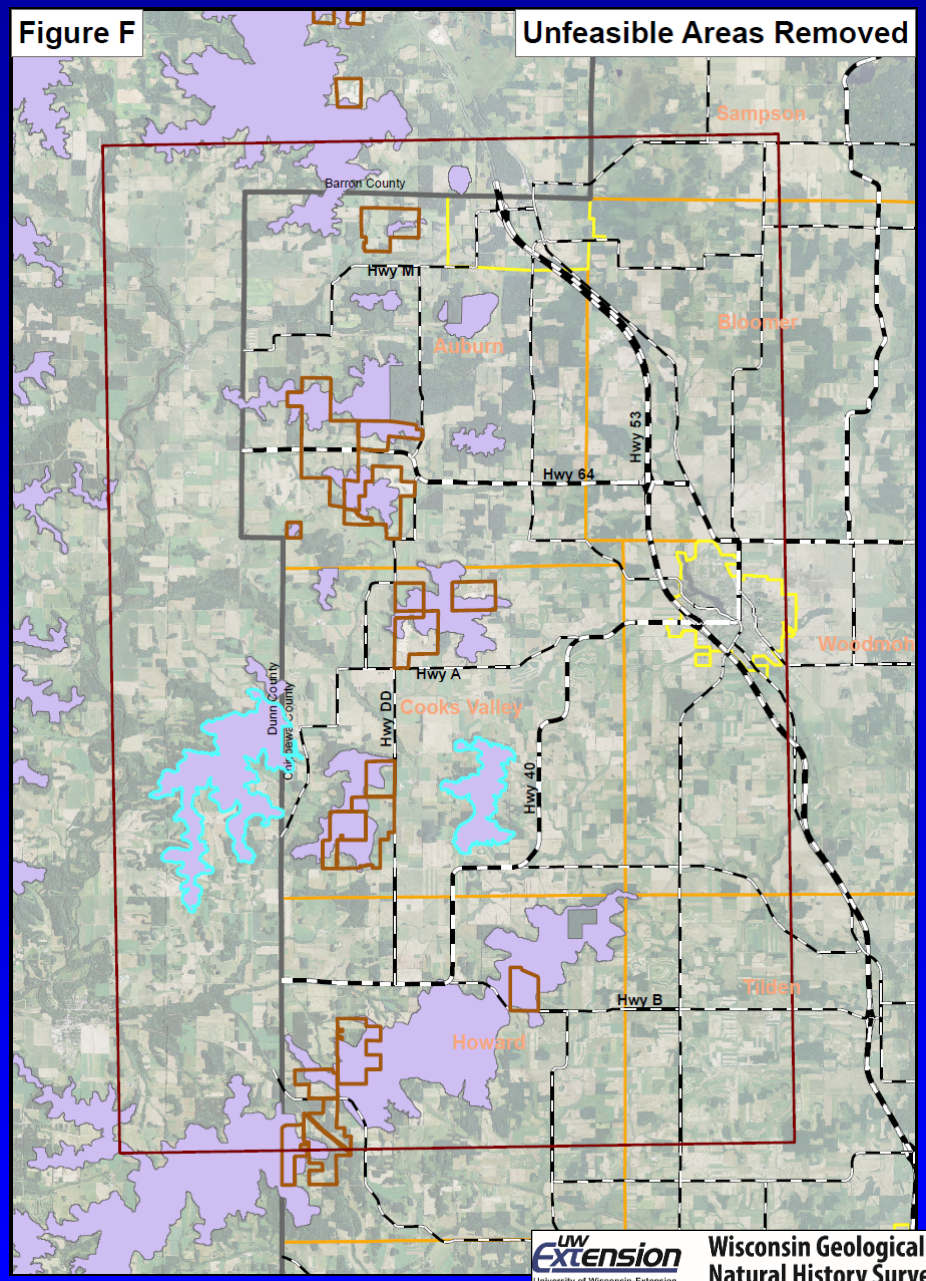

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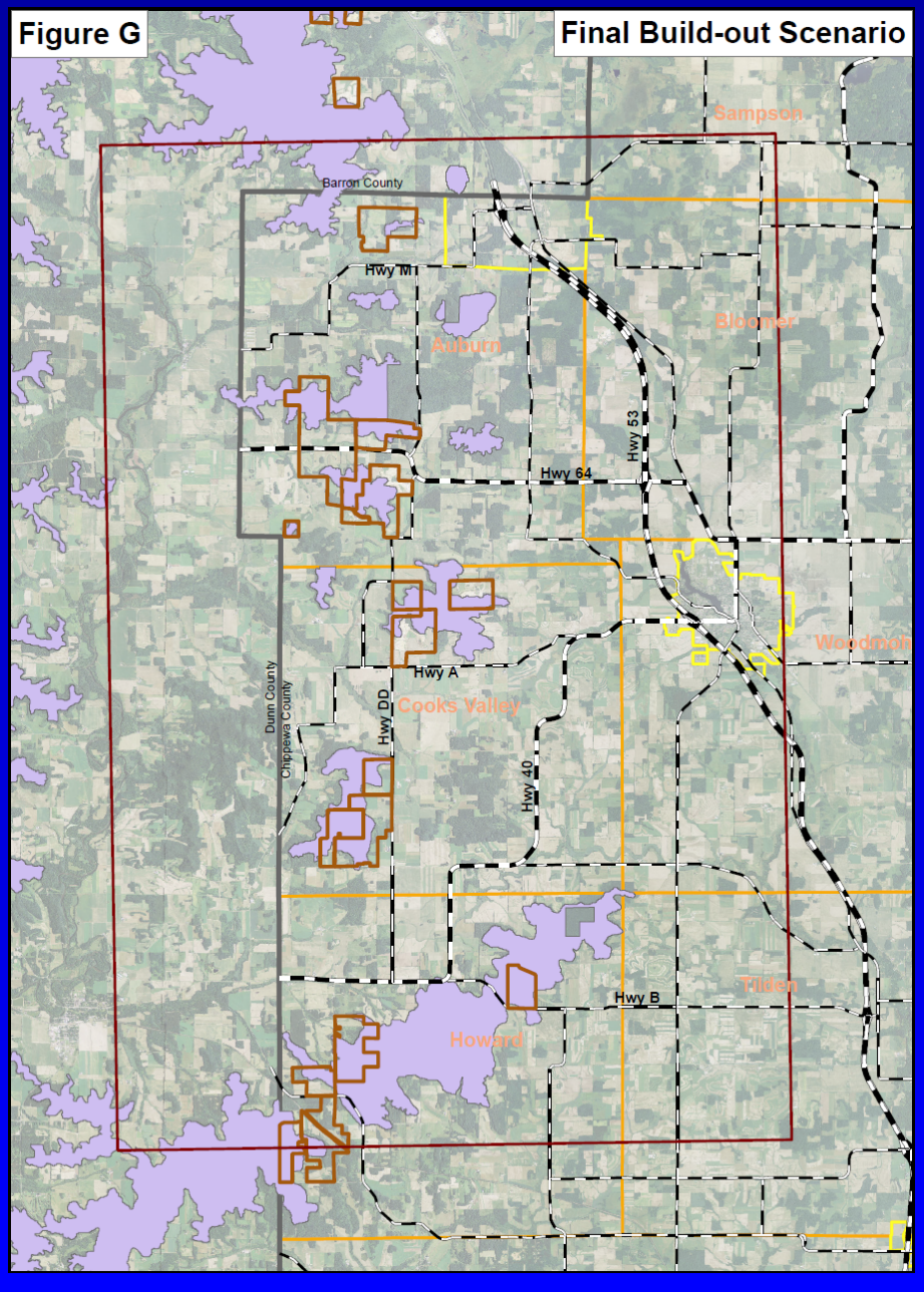
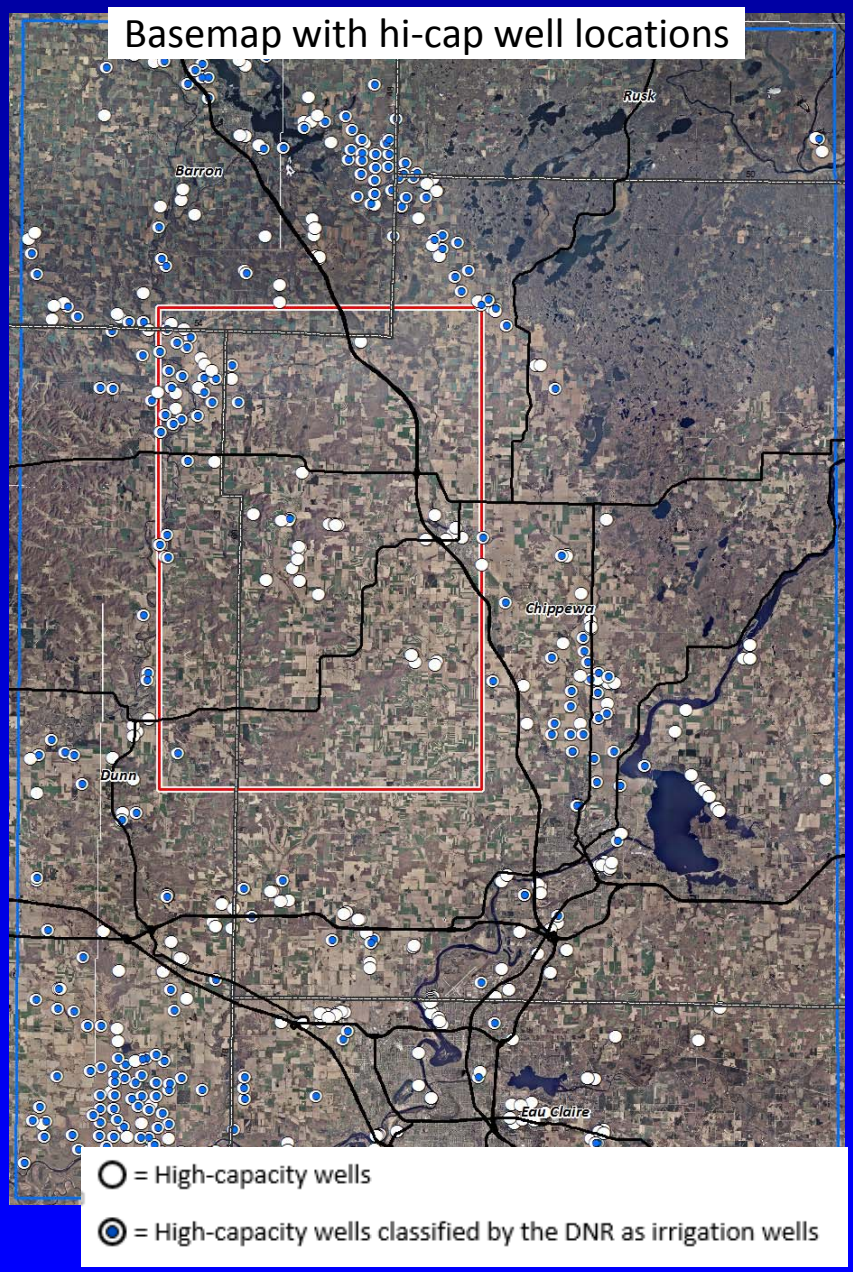


For modeling scenarios,

- Mine footprints will expand within remaining areas (shaded purple)
- Recharge will be modified according to infiltration tests and soil-water-balance results
- Recharge is expected to decrease during mining
- Recharge is expected to rebound following reclamation

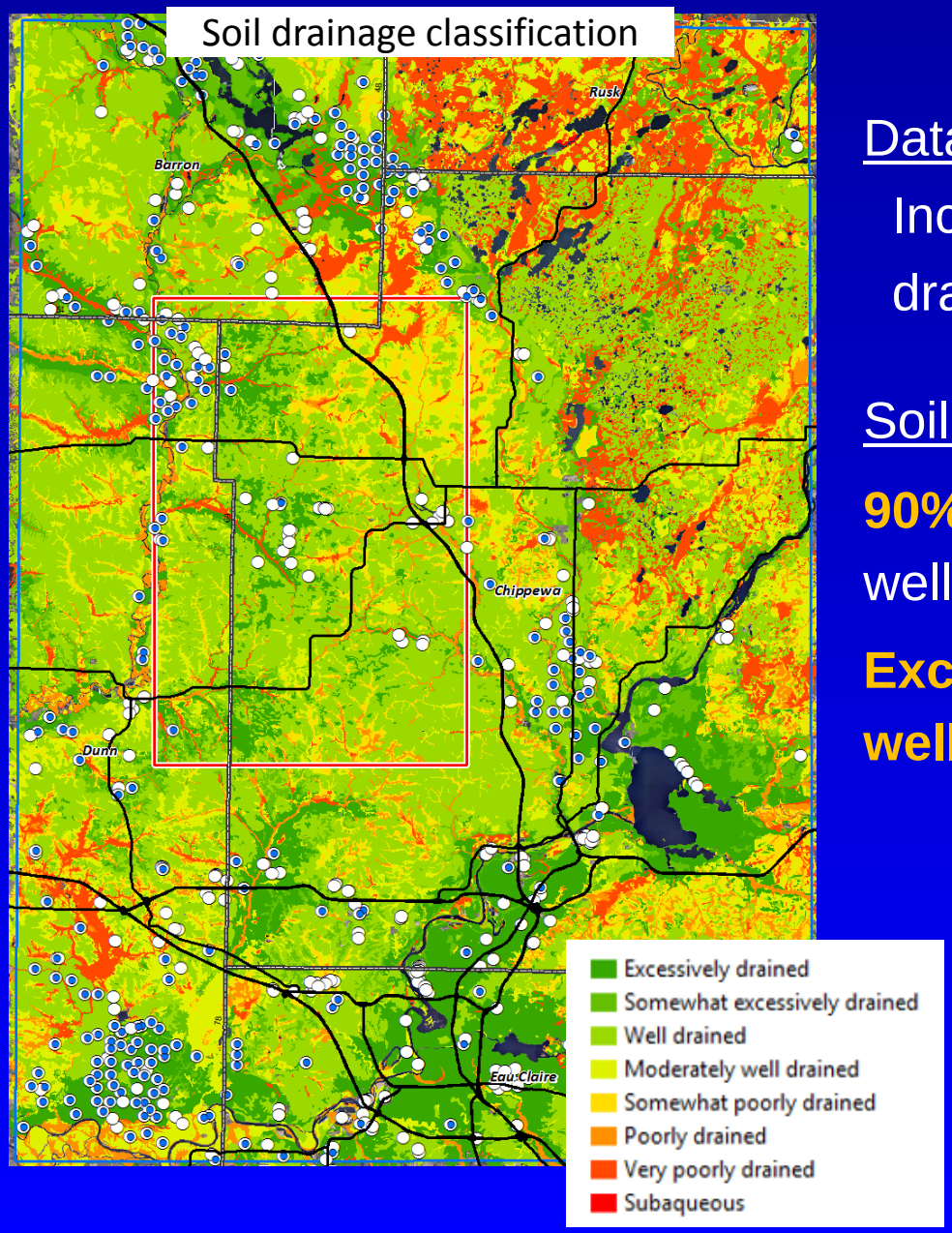
Scenario testing – *Irrigated ag. build-out*



How could we identify lands that could be irrigated in the future?

Let's start by understanding where irrigation wells are located today…

Scenario testing – *Irrigated ag. build-out*



Dataset: USDA-NRCS 2014 soil map

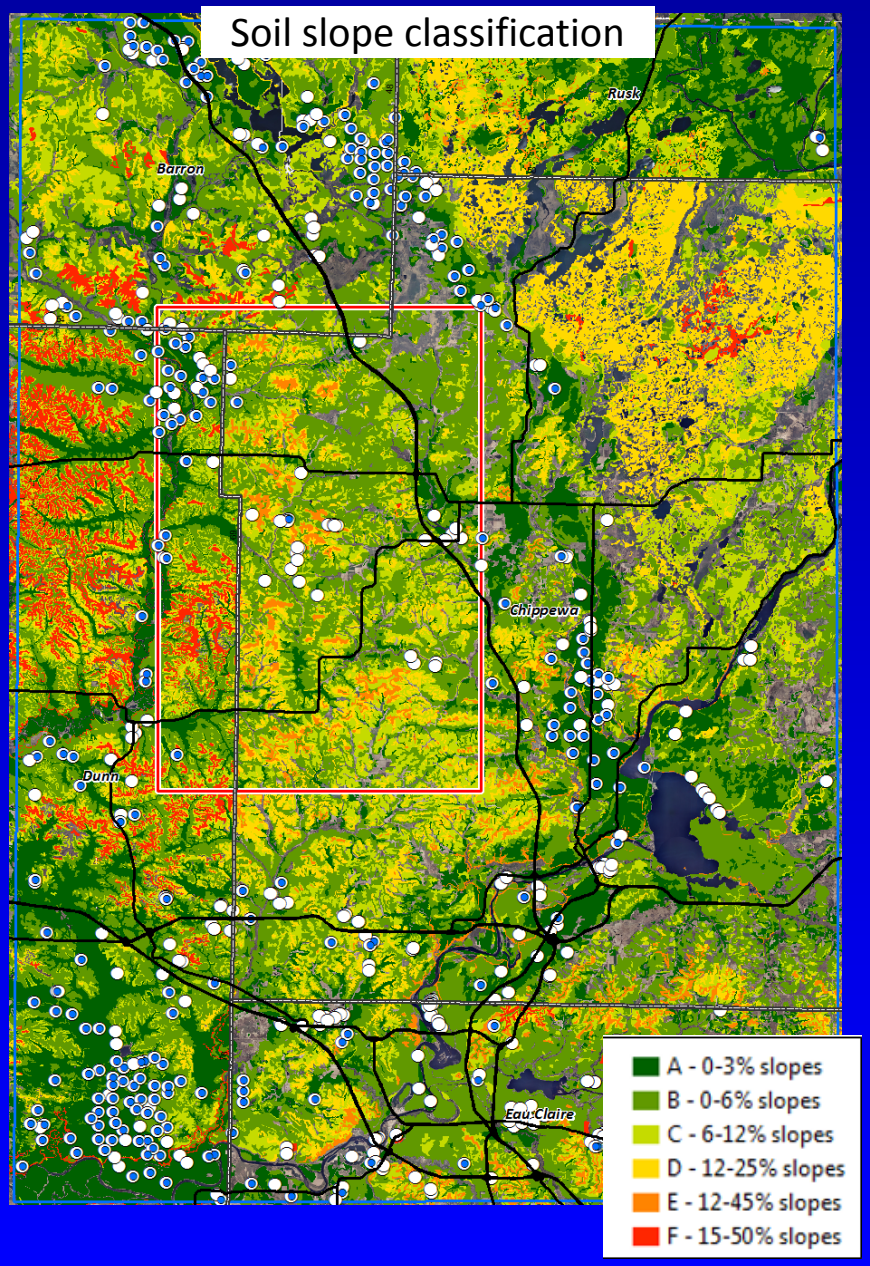
Includes information on soil type, drainage, and slopes

Soil drainage:

90% of existing high-capacity irrigation wells are on soils classified as:

Excessively drained to moderately well drained

Scenario testing – *Irrigated ag. build-out*



Dataset: USDA-NRCS 2014 soil map

Soil slope:

96% of existing high-capacity irrigation wells are on soils classified as:

A (0-3%), B (0-6%), or C (6-12%) slopes

Confirmed by farmers, UWEX irrigation experts and local well drillers…

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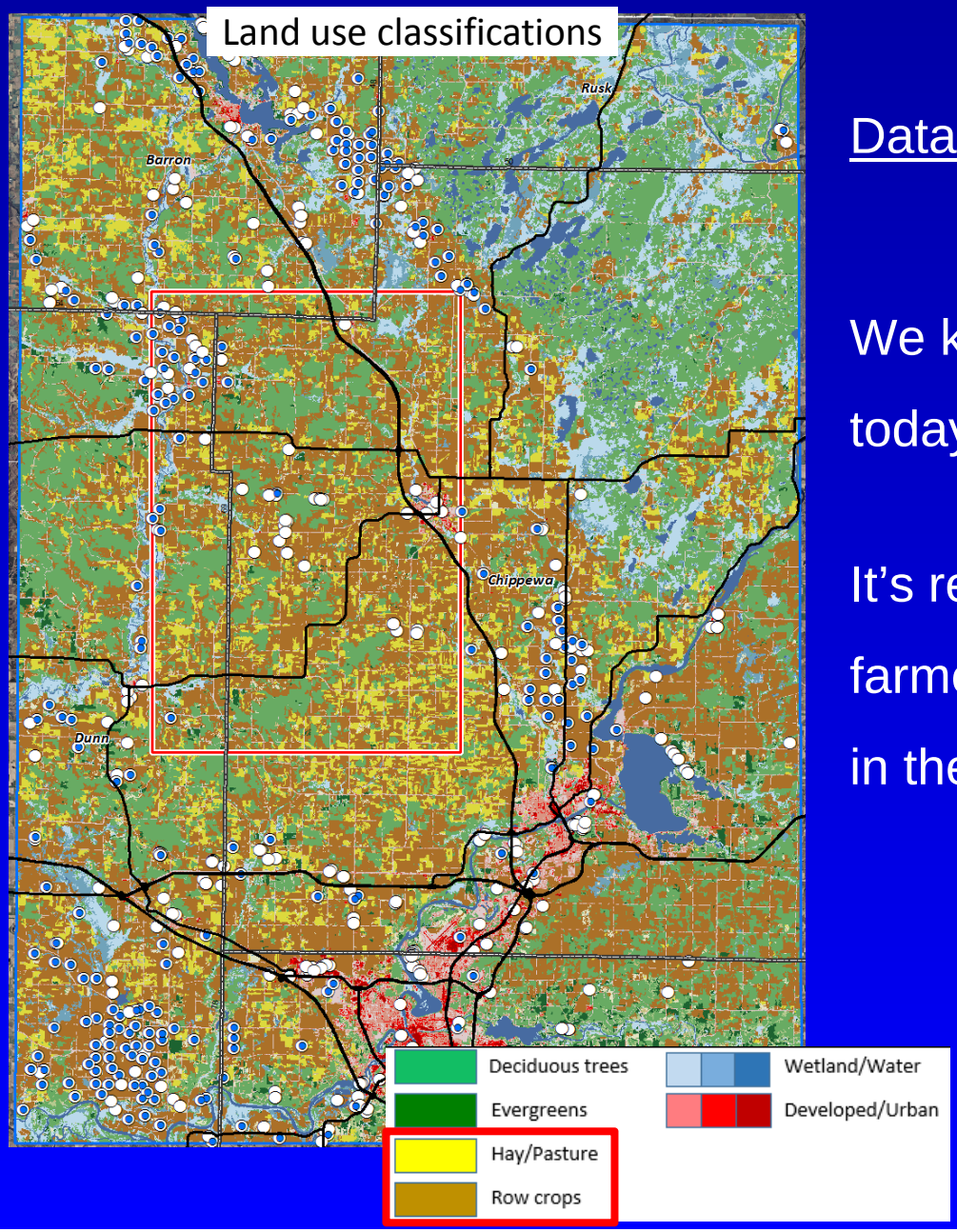
Scenario testing – *Irrigated ag. build-out*



Dataset: National Land Cover Database (NLCD) 2011

We know where farming is occurring today (hay/pasture or row crops)

It's reasonable to assume the extent of farmed lands will not change markedly in the future

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Scenario testing – *Irrigated ag. build-out*

Combining the soils and land use data…

Soil properties:

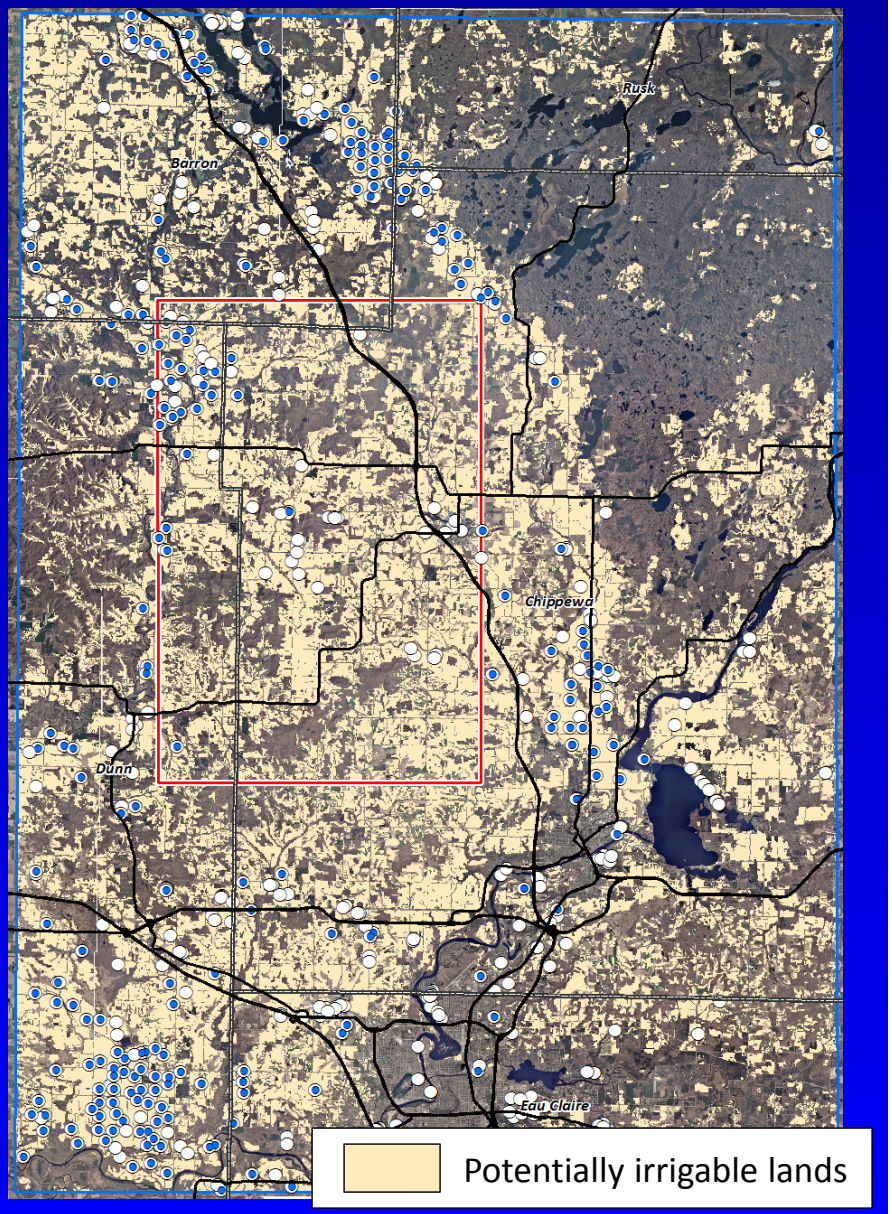
- slopes 0-12%
- excessively to mod. well drained

Land use properties:

- currently ag (hay/pasture or row crop)

…provides a coverage of

"Potentially irrigable lands"



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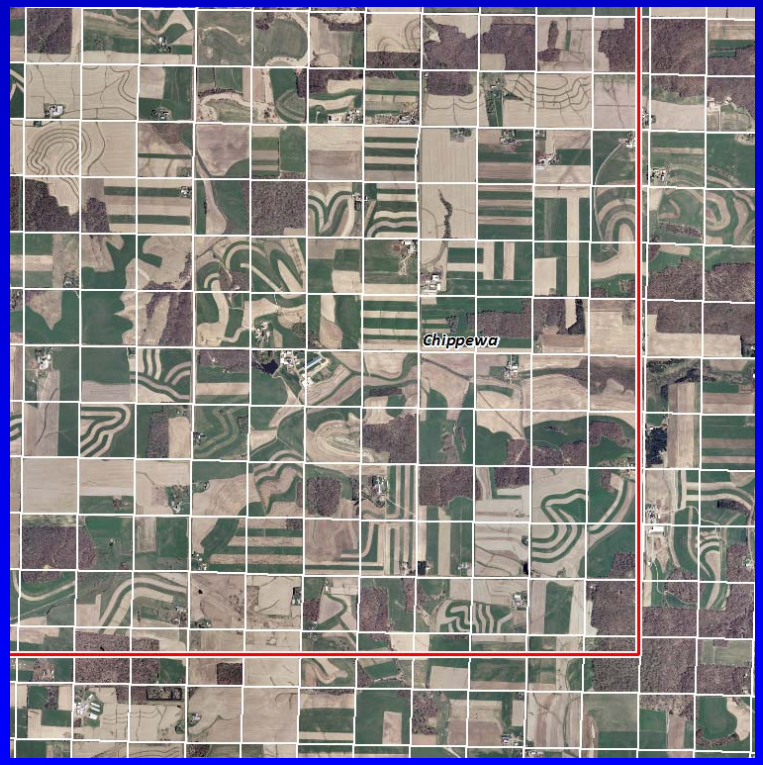
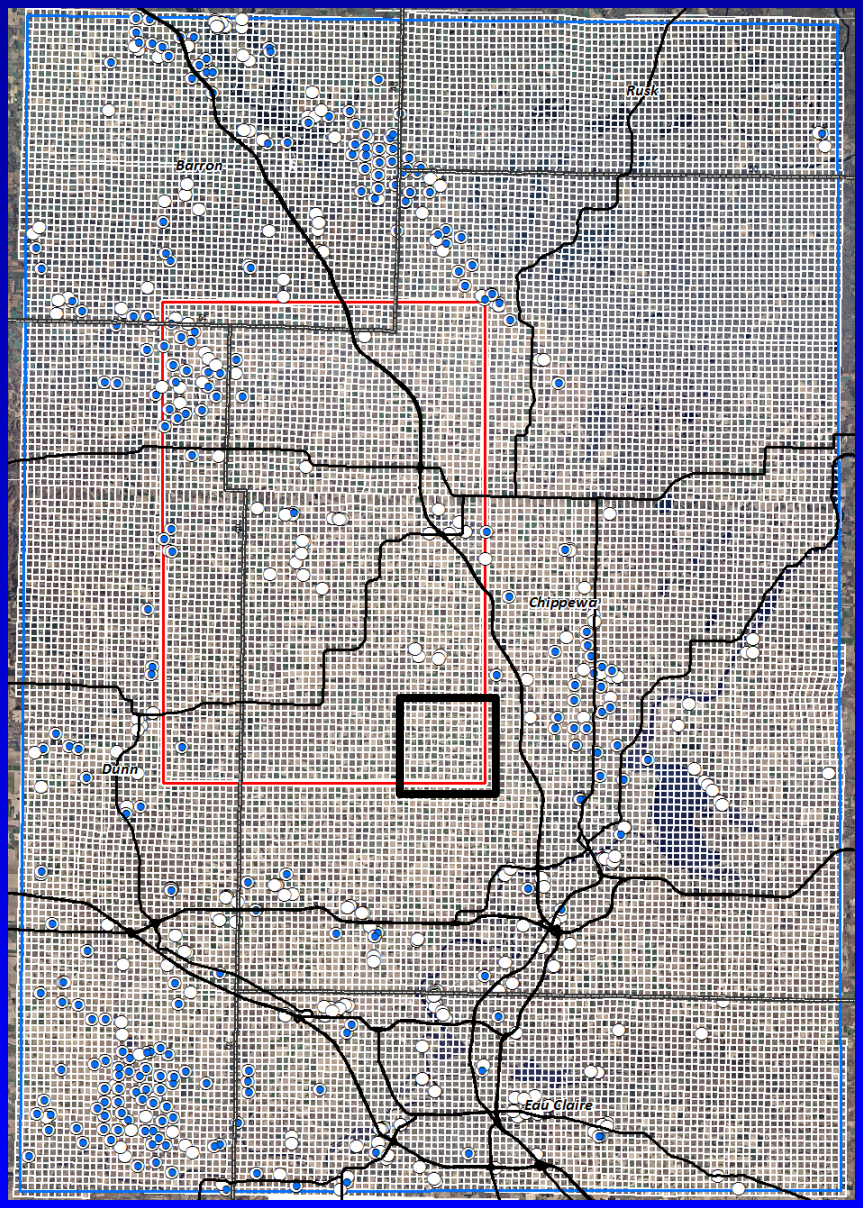
Scenario testing – *Irrigated ag. build-out*

Applied quarter-quarter section grid based on Public Land Survey System (PLSS)

Quarter-quarter section = approx. 40 acres, what we'll refer to as a "field"





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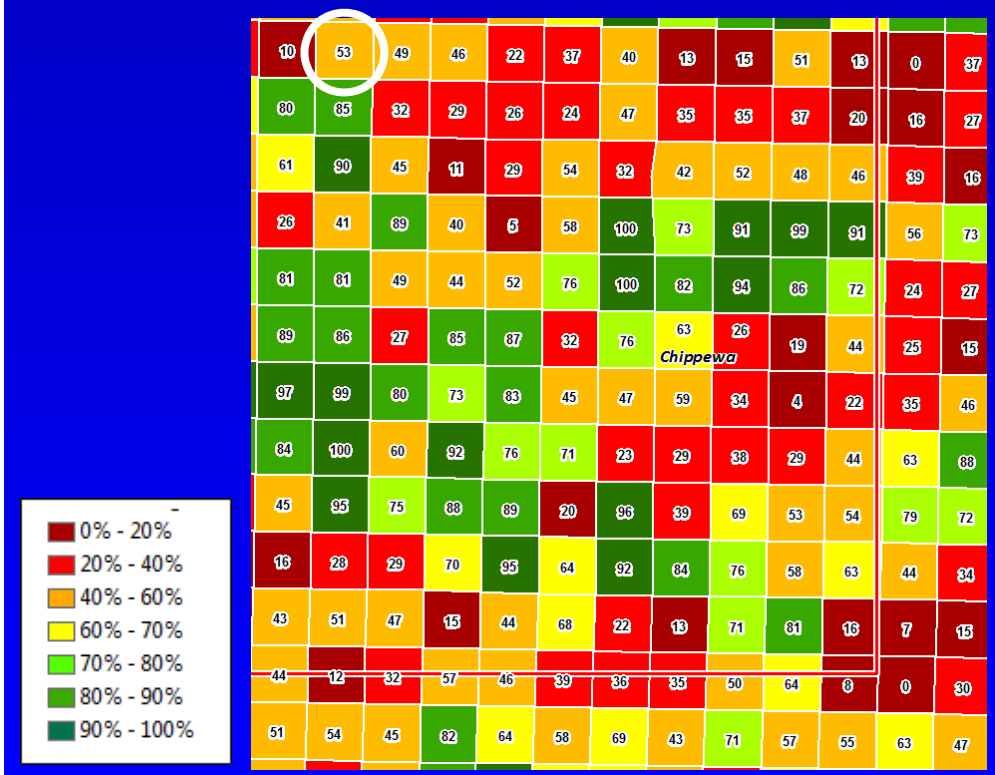
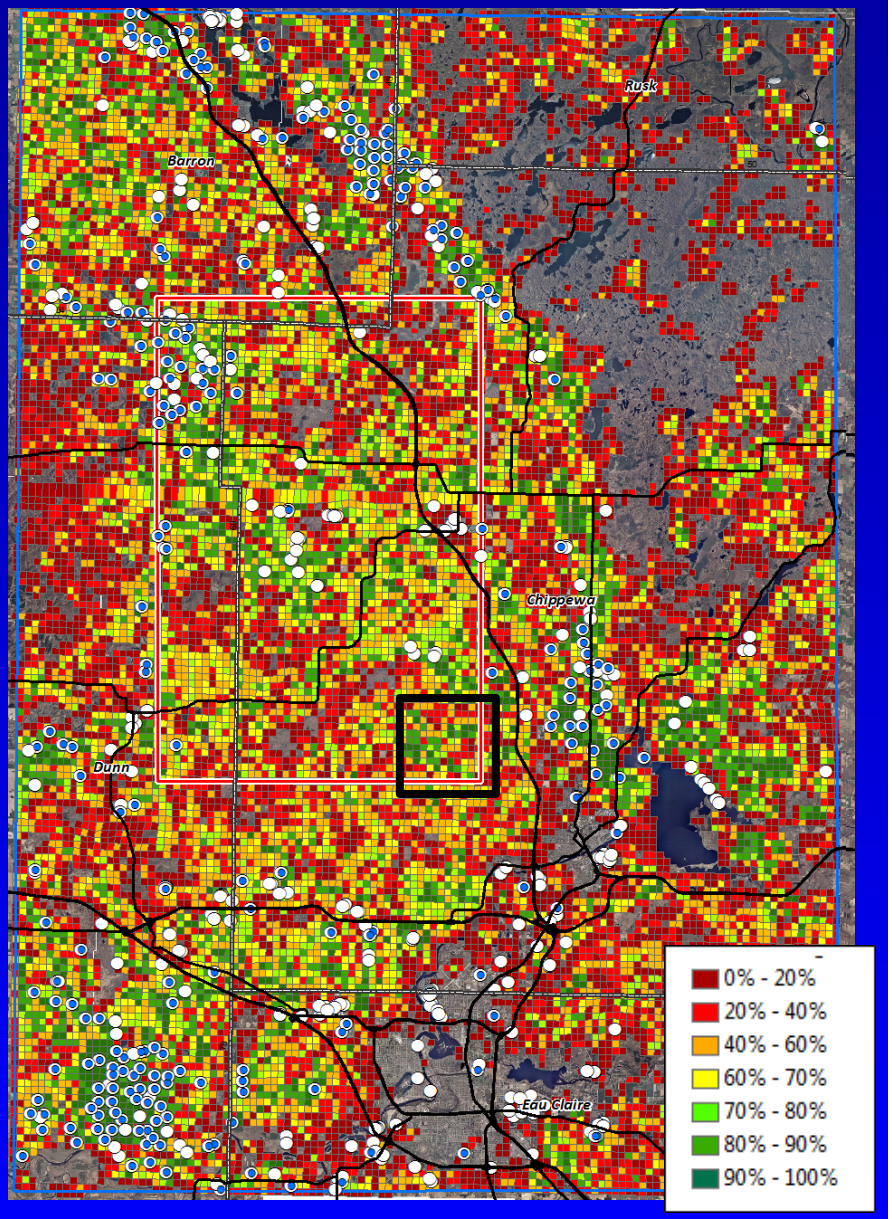
Scenario testing – *Irrigated ag. build-out*

Using these grids we can calculate the percentage of potentially irrigable land for each field

Each number is a percent (%)





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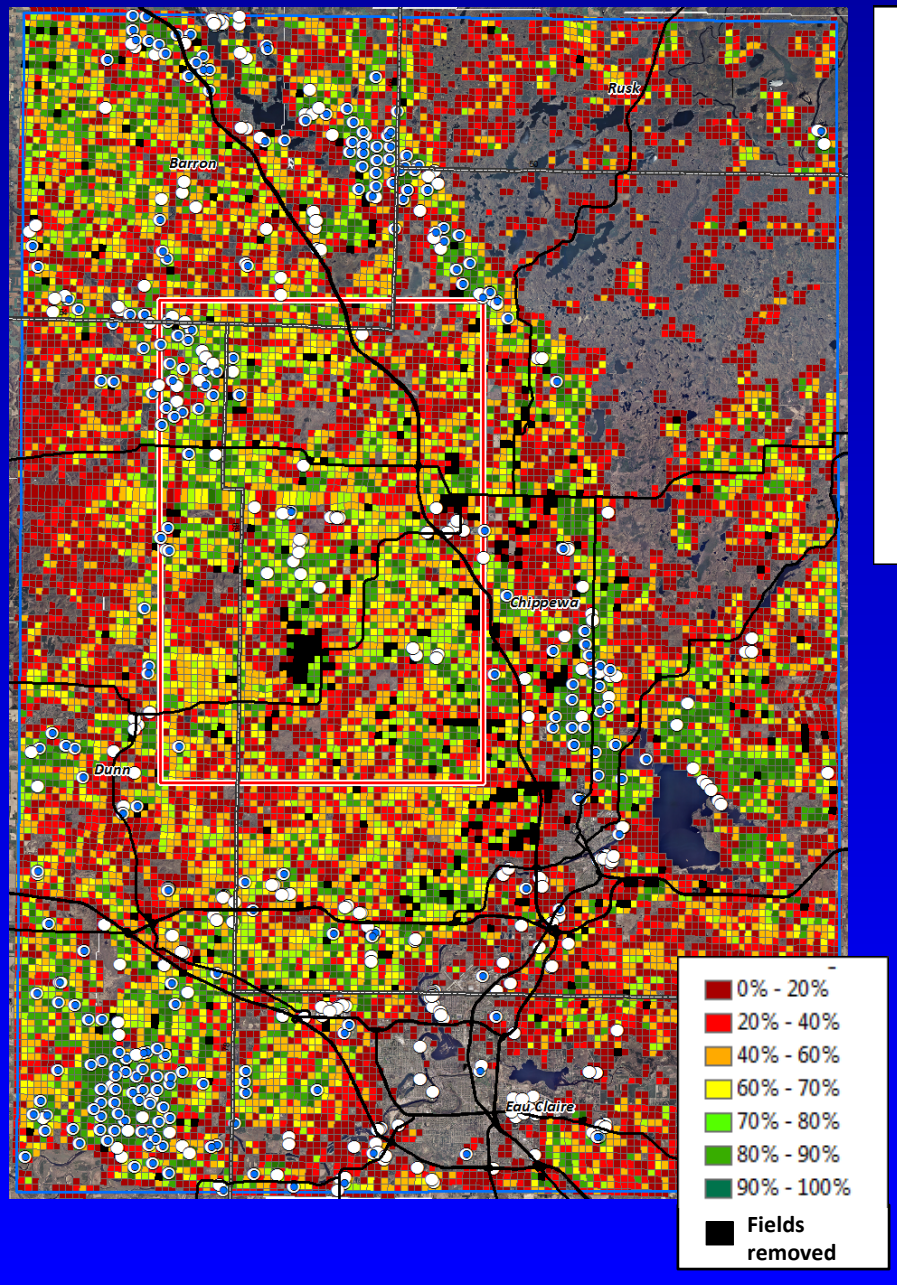
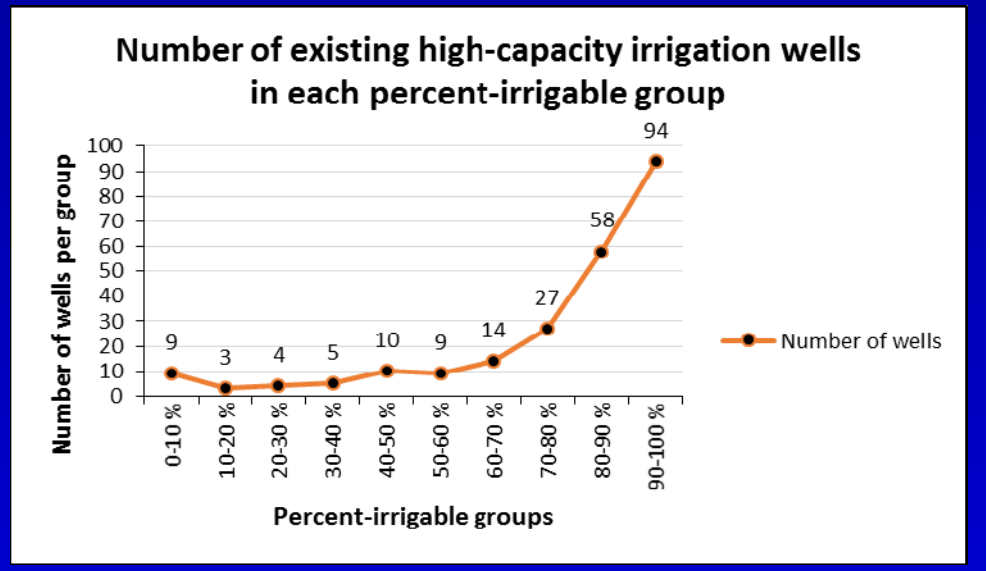
Scenario testing – *Irrigated ag. build-out*





Fields with > 70% potentially irrigable lands are reasonable for adding wells for future scenario testing

Additional considerations:

- Farmer knowledge/feedback
- Appropriate pumping rates
- Offsets from streams (DNR regs)

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Today's outline

- Brief review of study *(WGNHS / USGS)*
- Progress to date *(WGNHS / USGS / Chippewa Co.)*
  - Groundwater model development and calibration
  - Soil-water-balance (SWB) modeling and infiltration testing
  - Scenario testing – Mine and irrigated agriculture build-out
- Discussion on scenarios and model progress *(All)*
- **What's next ?**
- Update on a new water-level monitoring study

What's next?

- Complete calibration of MODFLOW model
- Finalize future scenario runs
- Develop transferable takeaways
- Complete final project report

Upcoming meetings and deliverables

- **Public meeting tonight at the Bloomer Middle School**
  - **6:30 – 8:00 pm Public meeting**
  - **8:00 – 9:30 pm Meet and greet with project team**
- Next meeting dates to be determined
  - Public roll-out in late 2017
- Deliverables
  - Final report – Q3 2017 (final model, scenarios, transferability results)

Today's outline

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- Discussion on scenarios and model progress *(All)*
- What's next ?
- **Update on a new water-level monitoring study**

Water-level monitoring pilot study in Chippewa, Dunn, and Eau Claire Counties

Update on a new study…

Collaborating partners include:

- WGNHS, USGS, DNR
- Wellntel
- Chippewa, Dunn, and Eau Claire County Land Conservation Depts.

Goals:

- Instrument 20 wells with real-time water-level monitoring equipment (Wellntel units) within the "Tri-county" area
- USGS/WGNHS to deploy 5 units and each county to deploy 5 units
- Test the effectiveness and performance of the Wellntel monitoring equipment
- Collect additional water-level data
- Foster cross-border collaboration

Wellntel

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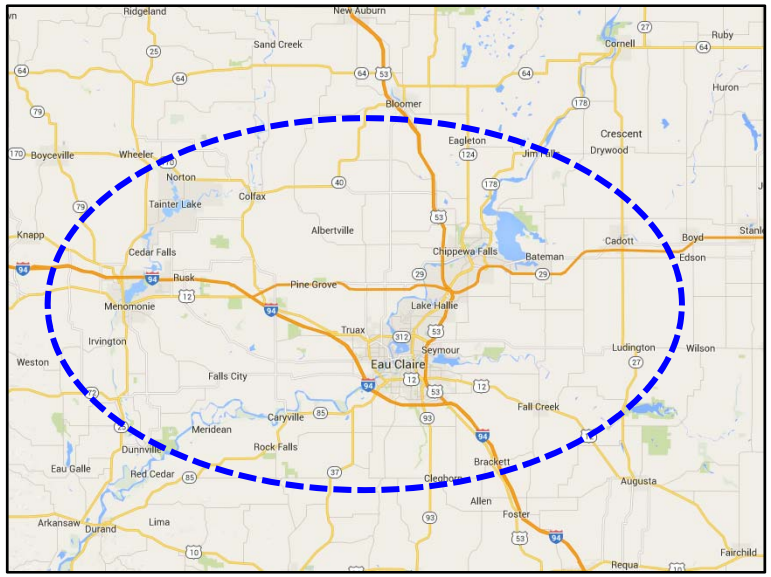
Water-level monitoring pilot study in Chippewa, Dunn, and Eau Claire Counties

Status:

- Counties have deployed 9 Wellntel units
- WGNHS/USGS has deployed a standard water-level system in Chippewa Co.

Timeline:

- Complete installations during 2016 and collect 1 year of data
- Potential to add some of these wells into the Statewide network long-term



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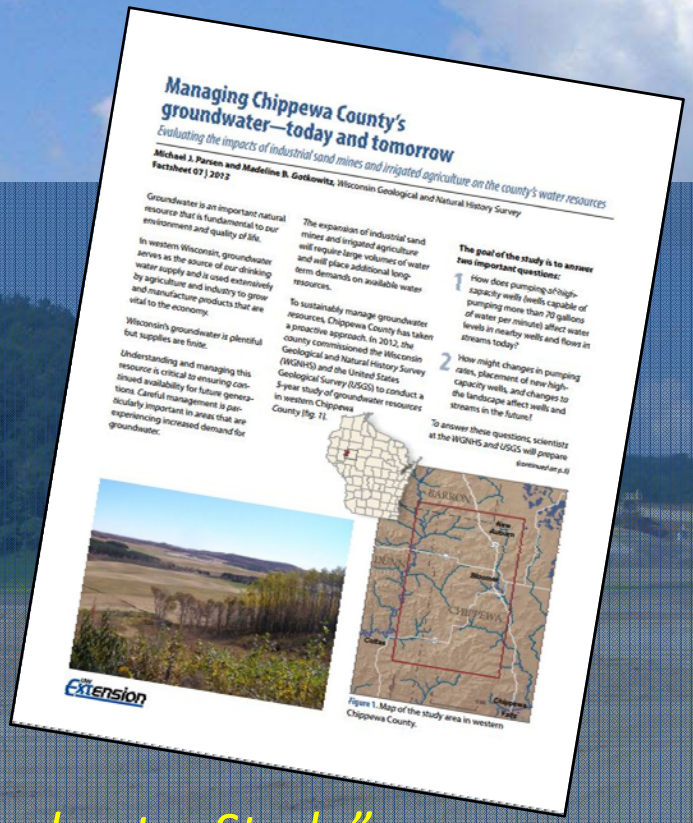
Chippewa County Groundwater Study

Thank you! Questions?



Managing Chippewa County's groundwater—today and tomorrow

Evaluating the impacts of industrial sand mines and irrigated agriculture on the county's water resources

Michael J. Parsen and Madeline B. Gotkowitz, Wisconsin Geological and Natural History Survey

Factsheet 07 | 2012

Groundwater is an important natural resource that is fundamental to our environment and quality of life.

In western Wisconsin, groundwater serves as the source of our drinking water supply and is used extensively by agriculture and industry to grow and manufacture products that are vital to the economy.

Wisconsin's groundwater is plentiful but supplies are finite.

Understanding and managing this resource is critical to ensuring continued availability for future generations. Careful management is particularly important in areas that are experiencing increased demand for groundwater.

The expansion of industrial sand mines and irrigated agriculture will require large volumes of water and will place additional long-term demands on available water resources.

To sustainably manage groundwater resources, Chippewa County has taken a proactive approach. In 2012, the county commissioned the Wisconsin Geological and Natural History Survey (WGNHS) and the United States Geological Survey (USGS) to conduct a 5-year study of groundwater resources in western Chippewa County (fig. 1).

The goal of the study is to answer two important questions:

1. How does pumping of high-capacity wells (wells capable of pumping more than 70 gallons of water per minute) affect water levels in nearby wells and flows in streams today?
2. How might changes in pumping rates, placement of new high-capacity wells, and changes to the landscape affect wells and streams in the future?

To answer these questions, scientists at the WGNHS and USGS will prepare

(continued on p.4)

Figure 1. Map of the study area in western Chippewa County.

To find out more visit the

WGNHS website:

www.wisconsingeologicalsurvey.org

Or,

Chippewa County website:

co.chippewa.wi.us/lcfm and

click on the link *"Chippewa County Groundwater Study"*

USGS science for a changing world

Chippewa County Land Conservation and Forest Management "Stewardship for Sustainability"

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Wisconsin Geological & Natural History Survey