Chippewa County Groundwater Study

3rd Stakeholders Group Meeting

Chippewa Falls, WI

03/18/2014

USGS science for a changing world

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

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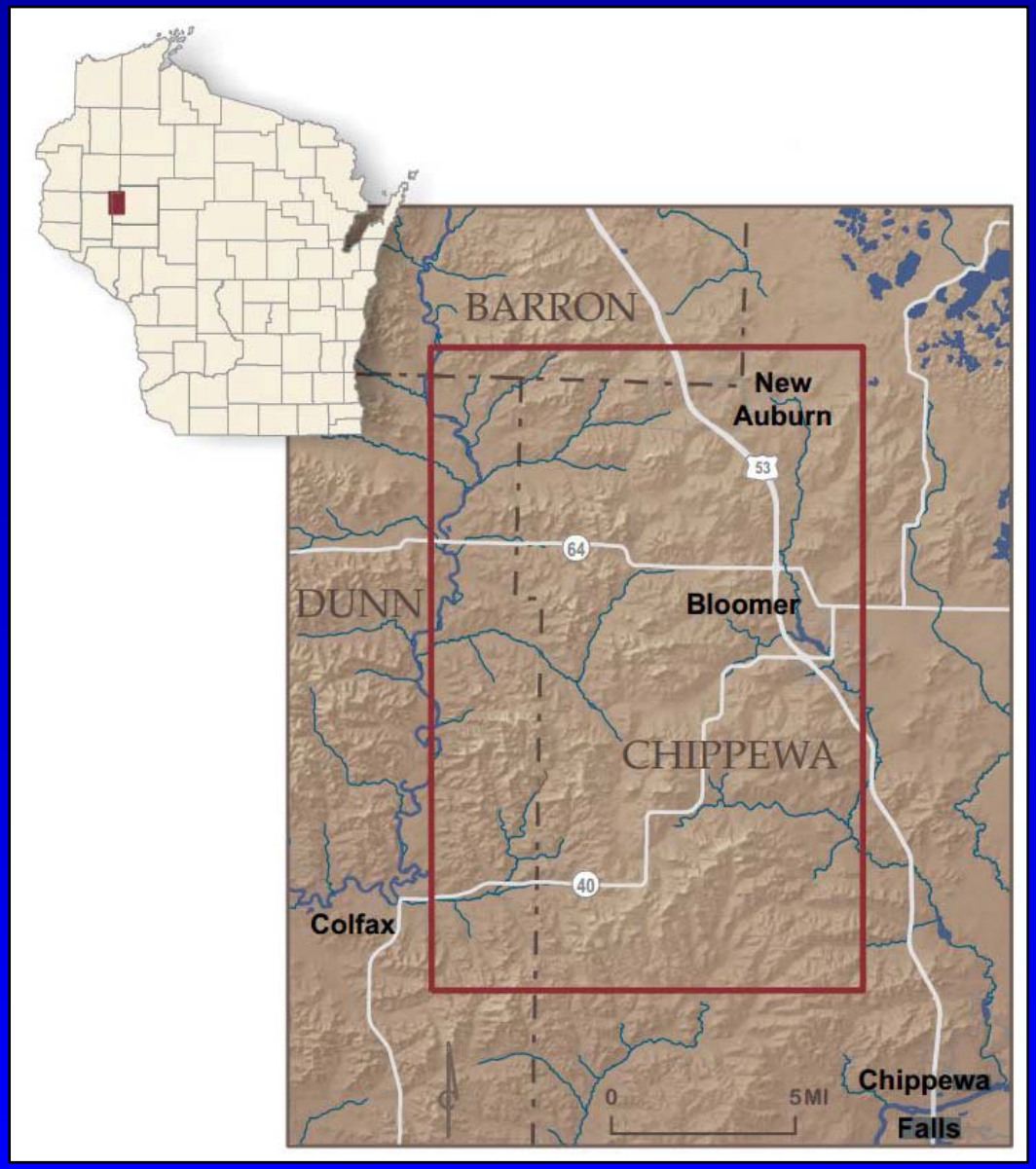
Wisconsin Geological & Natural History Survey

Today's outline

- Brief review of study *(WGNHS / USGS)*
- Progress to date *(WGNHS / USGS / Chippewa Co.)*
  - Subsurface data collection
  - Hydrostratigraphy
  - Water-use data collection
  - Compilation of site data for modeling
  - Soil water balance (SWB) modeling
- Focused stakeholders discussion
  - SWB, reclamation, and future scenario testing
- What's next ?
- Other agenda items to include / discussion ?

Review of study

Study area



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-mine recharge and pumping rates
  - Test future scenarios *(e.g., peak mine, post mine reclamation)* 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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Preliminary MODFLOW Model Construction
Chippewa County Groundwater Study

Michael N. Fienen

USGS Wisconsin Water Science Center

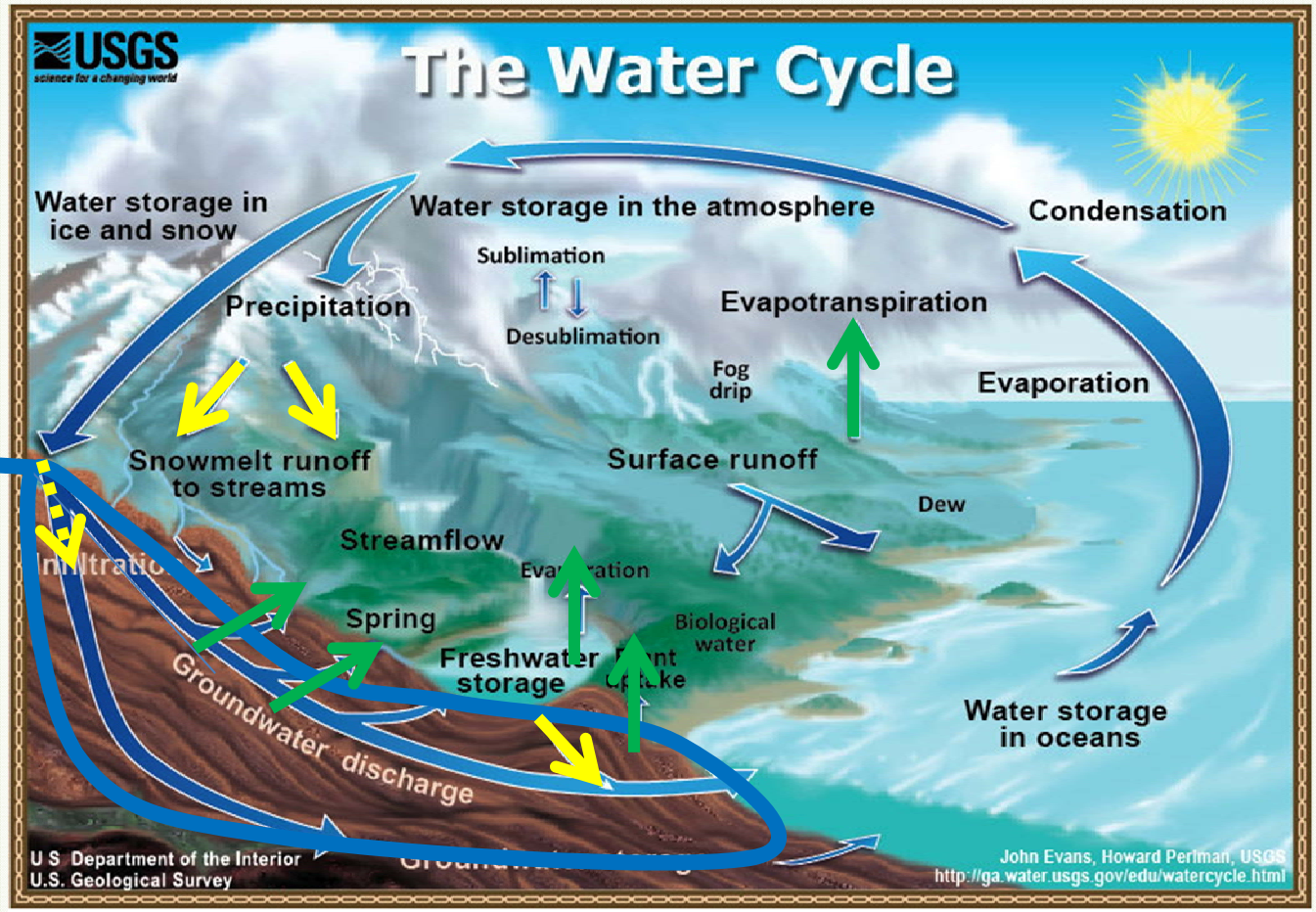
Chippewa County Groundwater Study—Stakeholders Meeting
Chippewa County Courthouse, Chippewa Falls, WI March 18, 2014

Groundwater in the Hydrologic Cycle

Groundwater System

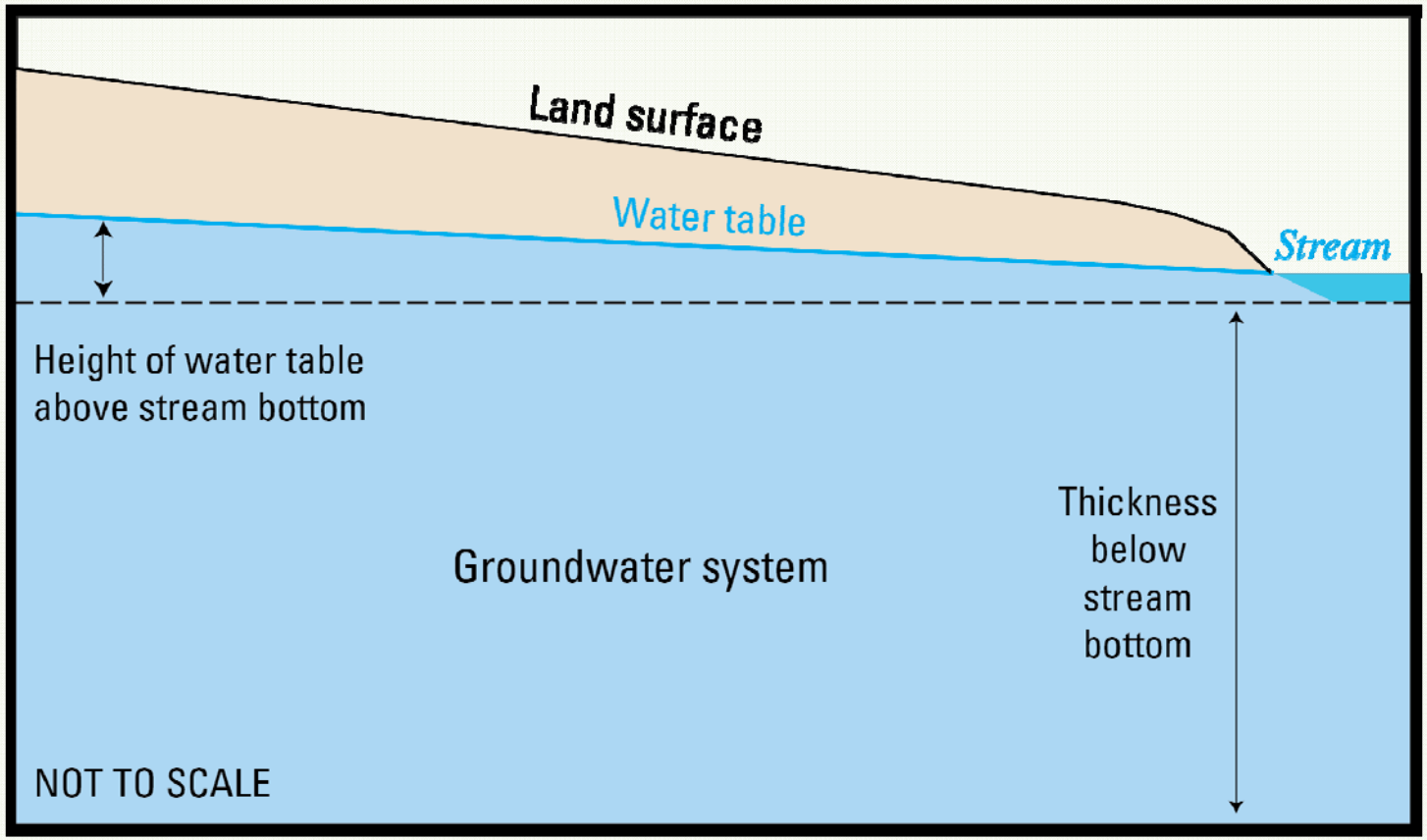
Water Entering the System

Water Exiting the System



USGS

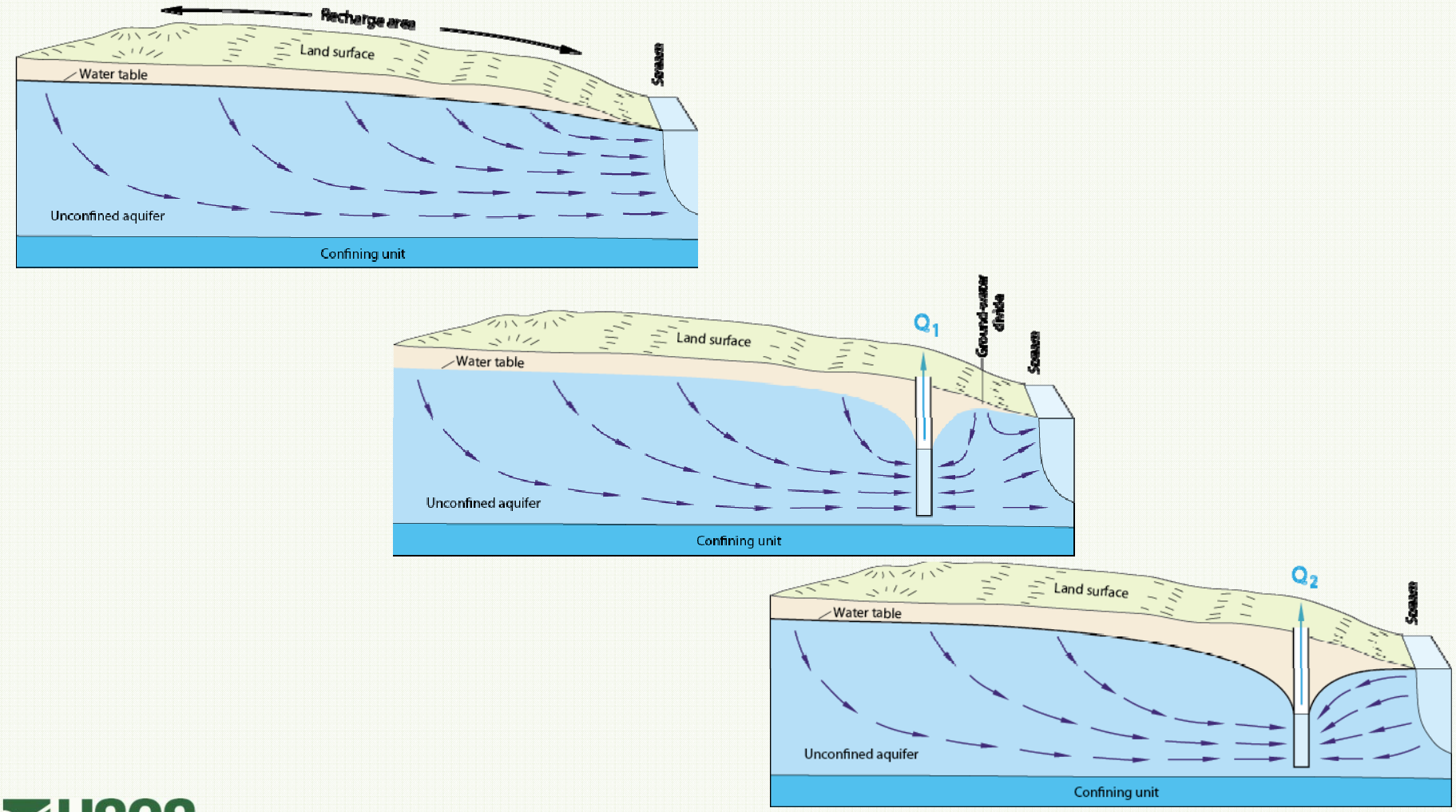
An aside: the myth of sustainable yield



http://pubs.usgs.gov/circ/1323/

USGS

Interaction with streams is dynamic



from Alley, Reilly, and Franke, USGS Circular 1186, 1999

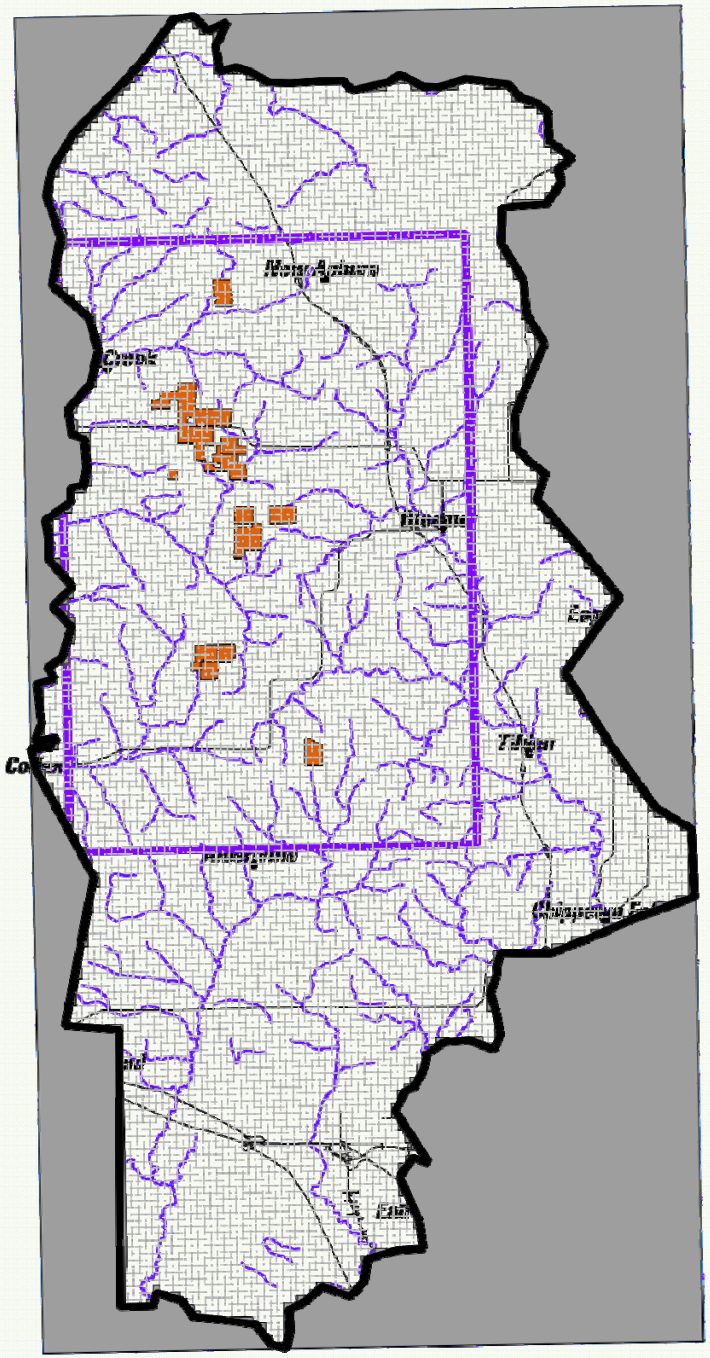
Building a MODFLOW Model: Basics

Start with a basemap

Focus in on area of interest

Extend out to hydrologic boundaries

Add a computational grid

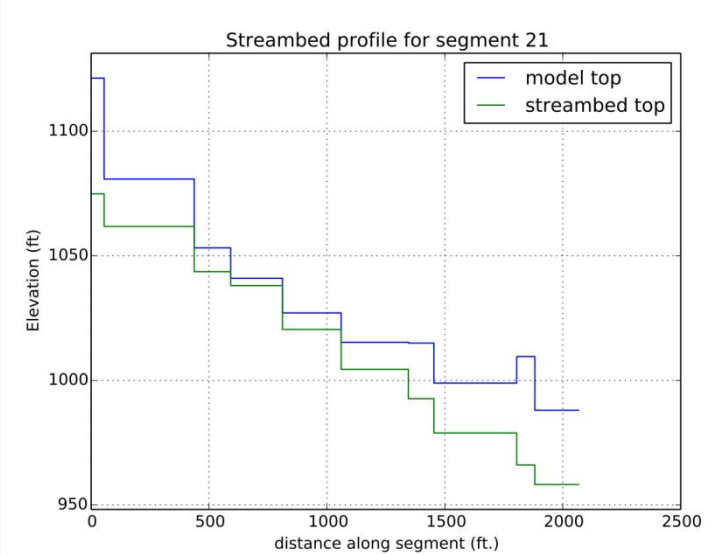


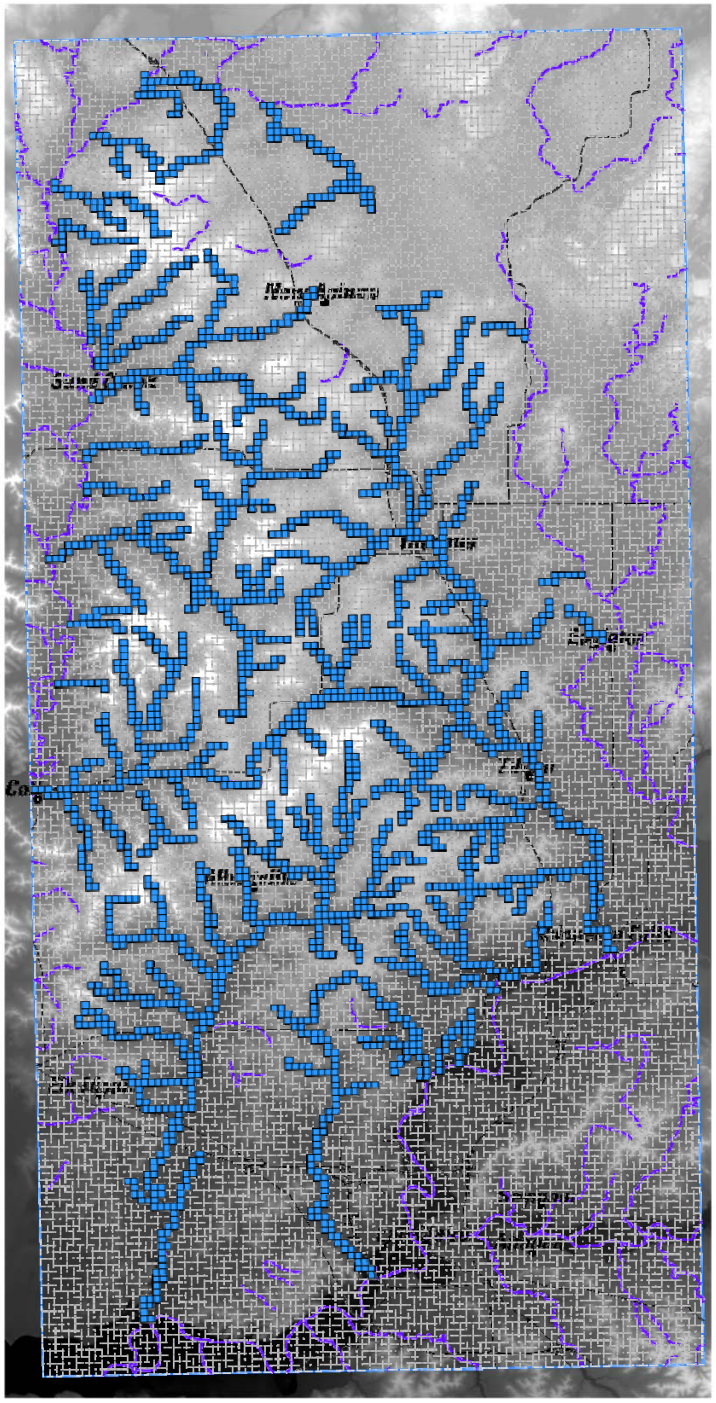
Building a MODFLOW Model: Streams and Elevation

Focus in on the stream network

Assign streams to model cells

Routing water downstream/downhill

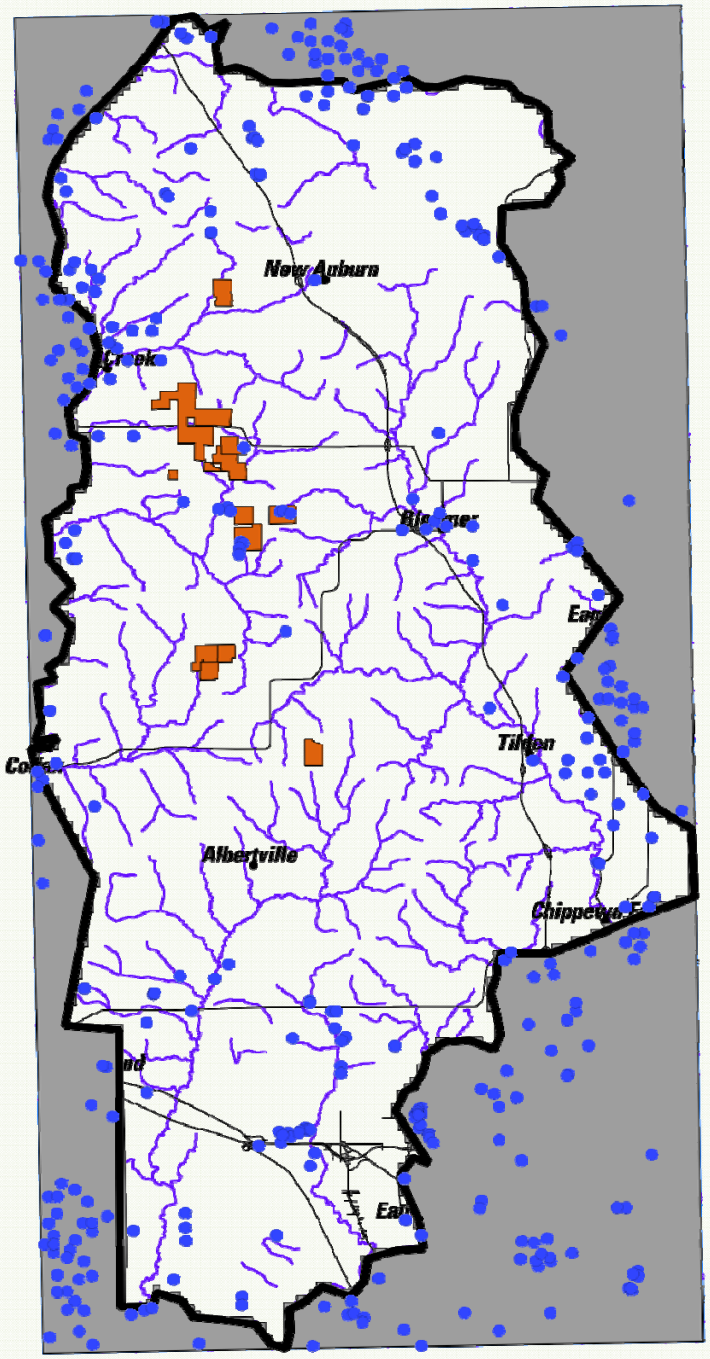




Building a MODFLOW Model—Water Use

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

2012 high-capacity well locations provided by the WI DNR



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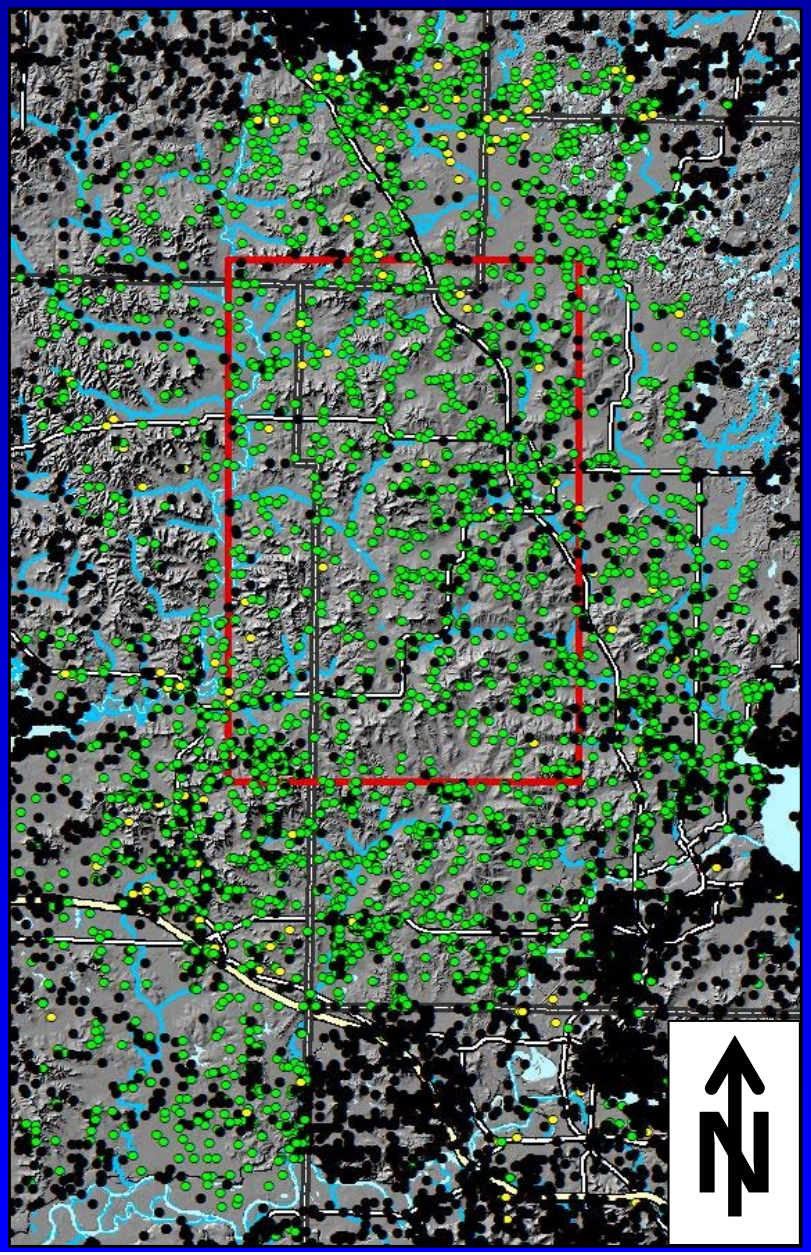
Subsurface data collection

- **Well construction reports** *(DNR)*
- Driller's descriptions of cuttings in the field

Subsurface data collection



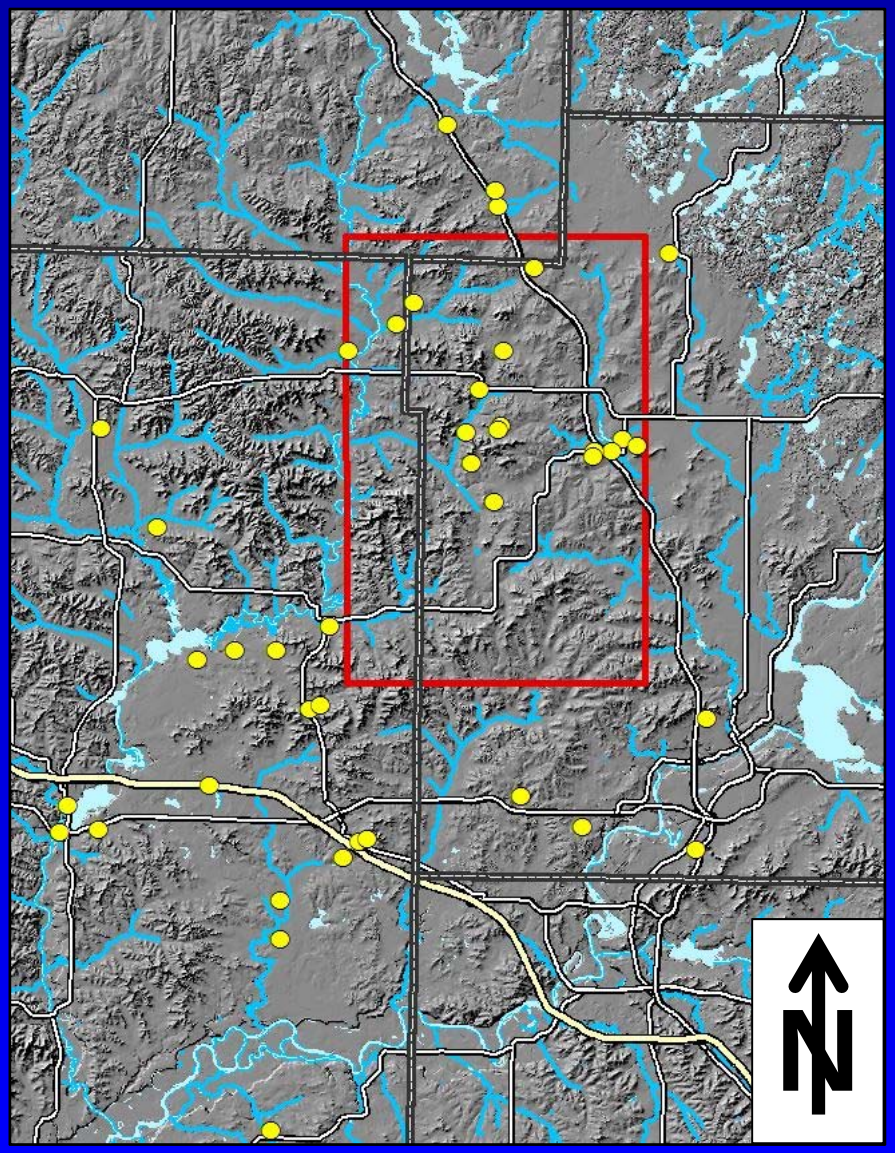
- **Well construction reports** *(DNR)*
- Driller's descriptions of cuttings in the field
- Provides information about
  - Depth to bedrock
  - Depth to Precambrian rock
- Hydrogeologic data
  - Estimates of hydraulic conductivity (well development)
  - Water levels (for calibration)

Subsurface data collection

Geologic logs *(WGNHS)*

- Cuttings from municipal supply or other high-capacity wells
- Evaluated by WGNHS geologists in the laboratory

Subsurface data collection



Geologic logs *(WGNHS)*

- Cuttings from municipal supply or other high-capacity wells
- Evaluated by WGNHS geologists in the laboratory
- Many recent cutting sets have been obtained directly within the study area
- Higher quality than drillers logs

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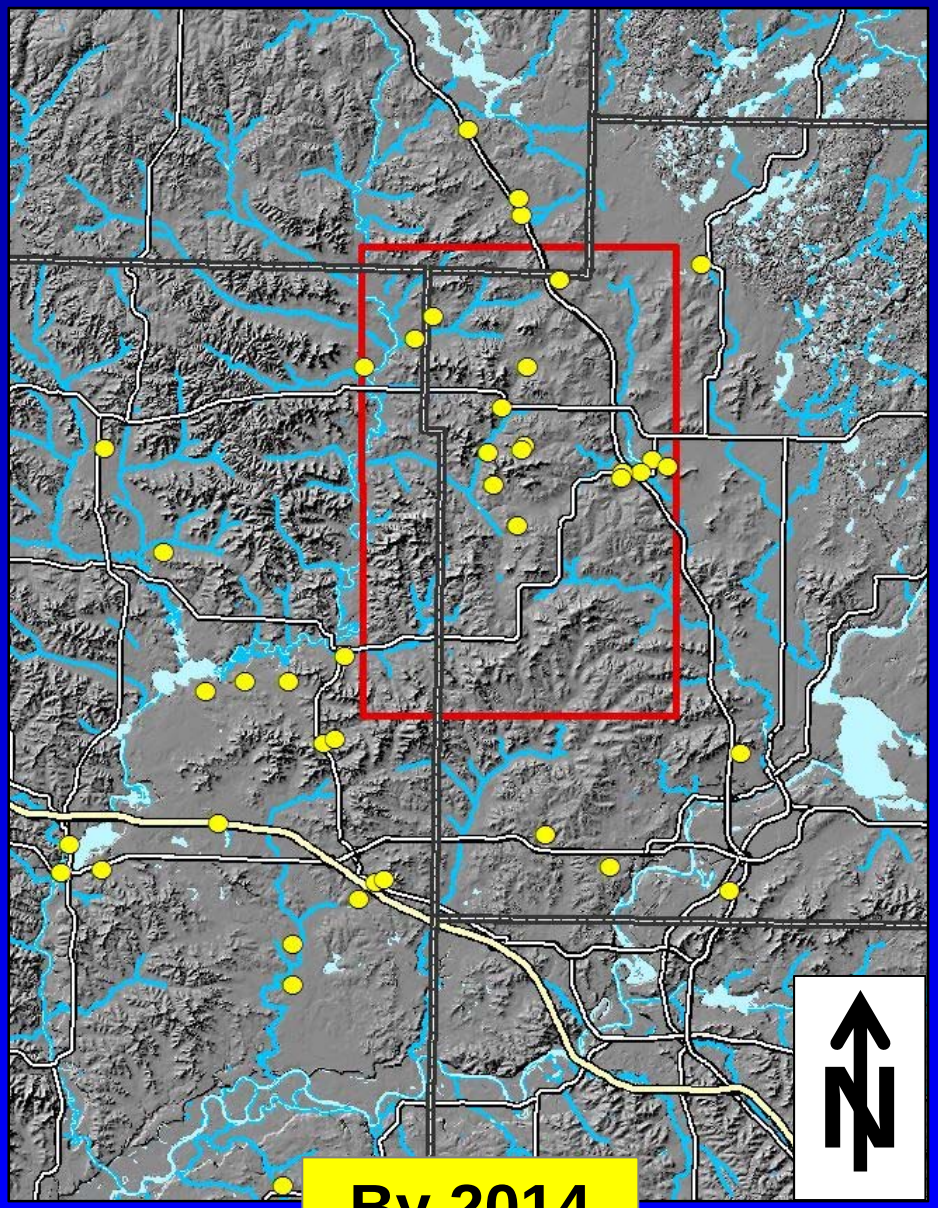
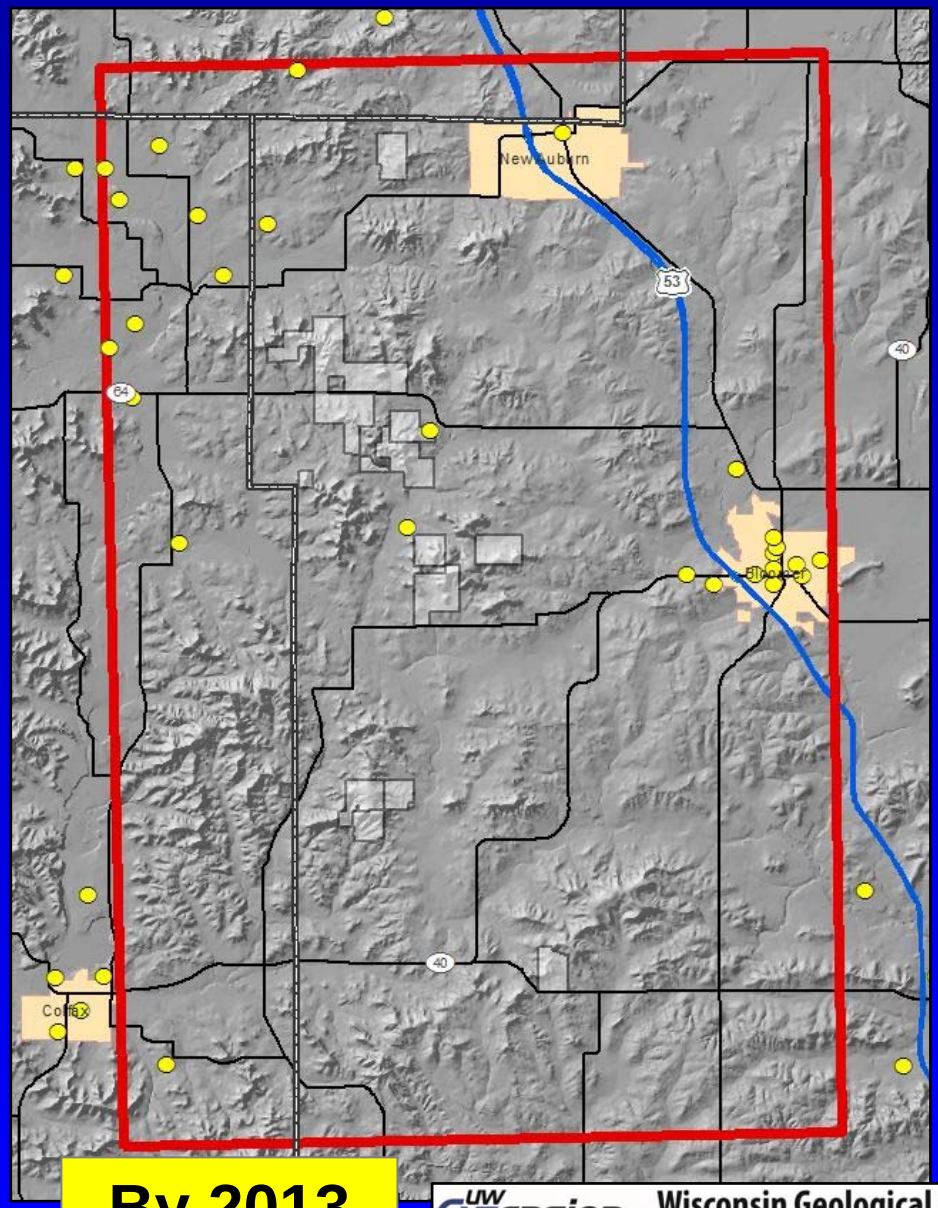
Subsurface data collection



By 2014



By 2013

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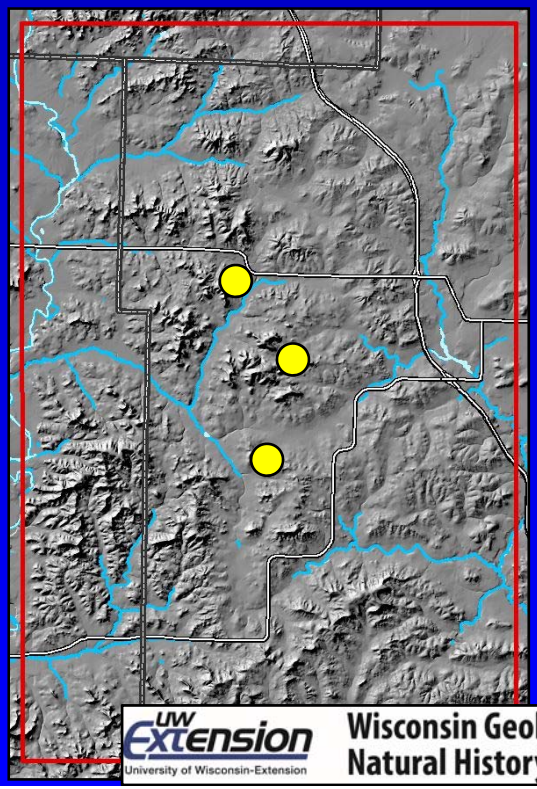
Subsurface data collection

Geophysical logs

- Superior Silica (2011)
- Preferred Sands (2011)
- Dan Stiehl farm (2013)



Provides detailed information about geology and hydrogeology

Allows for detailed hydrogeological characterization

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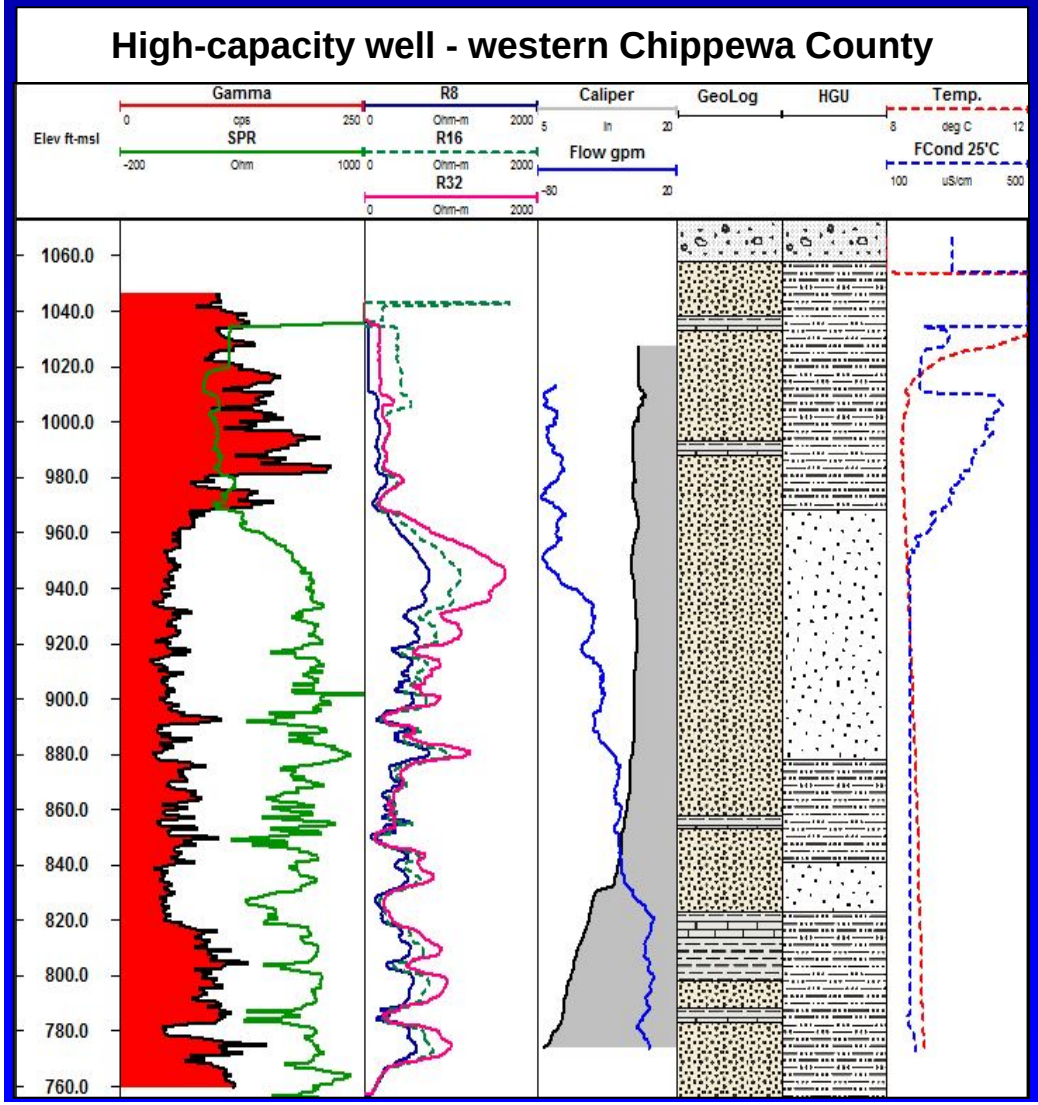
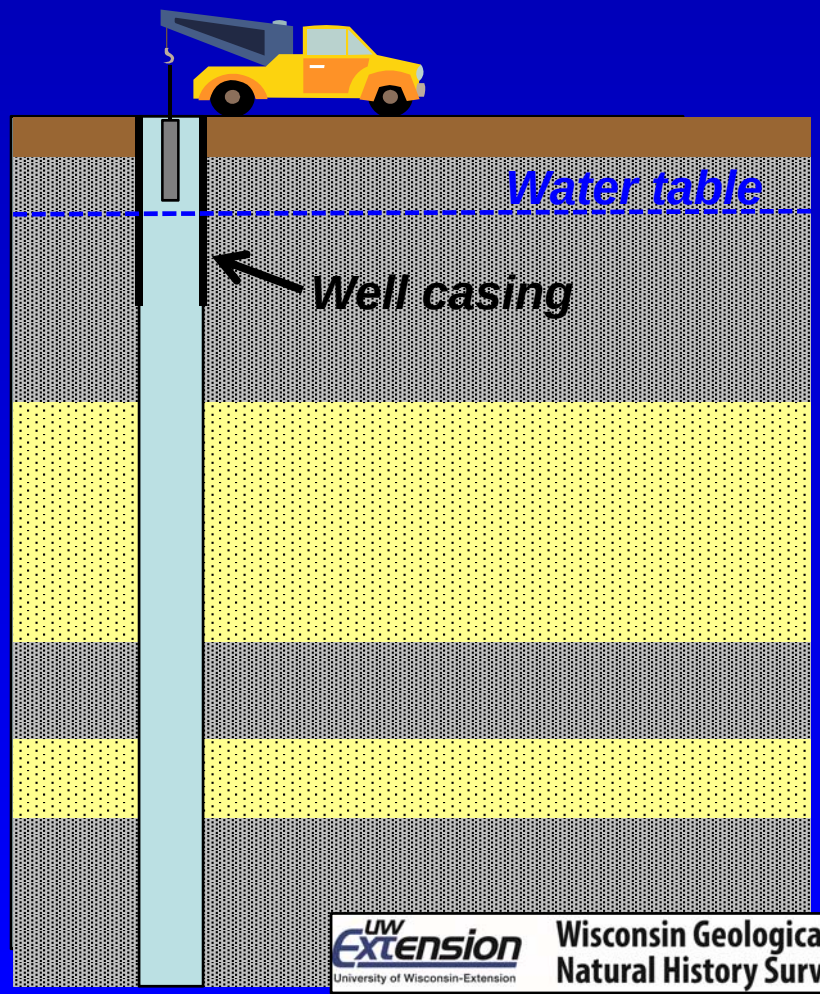
Subsurface data collection

Collecting a geophysical log





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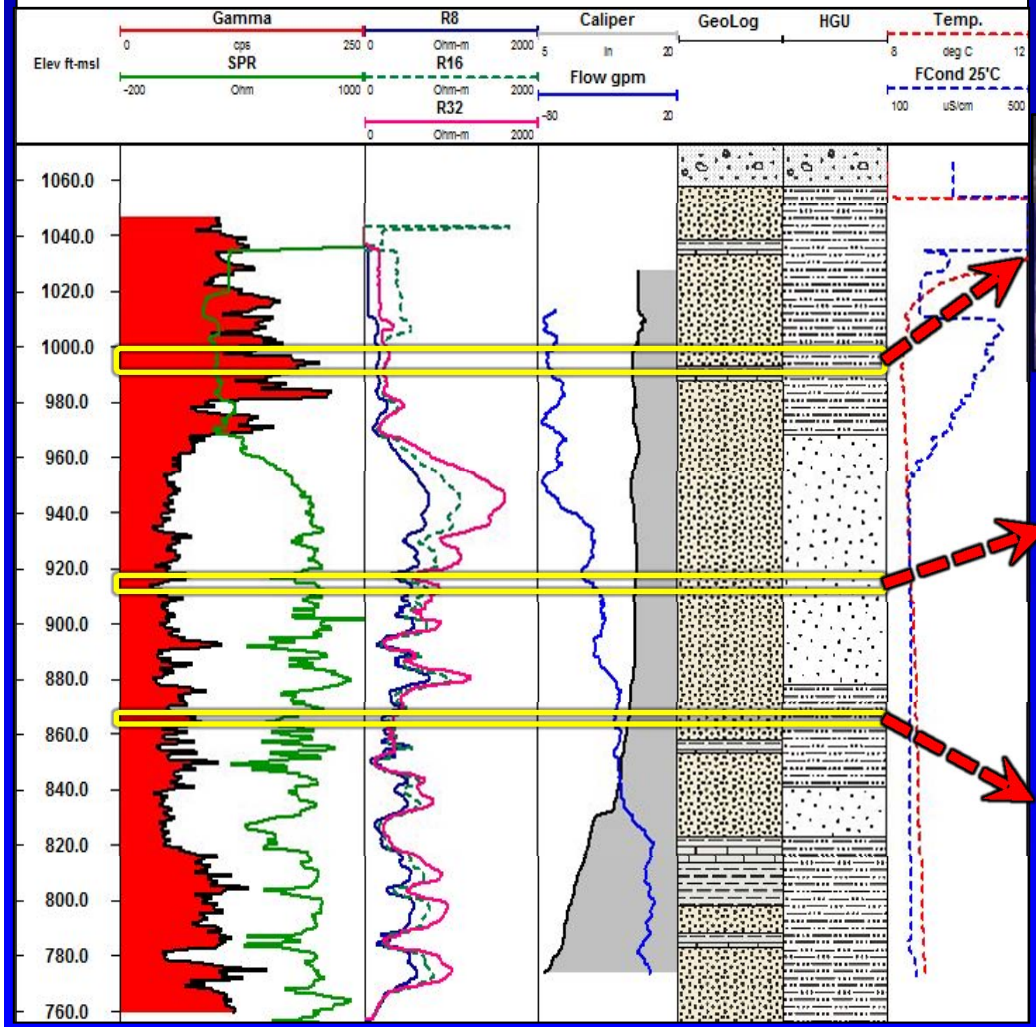
Subsurface data collection

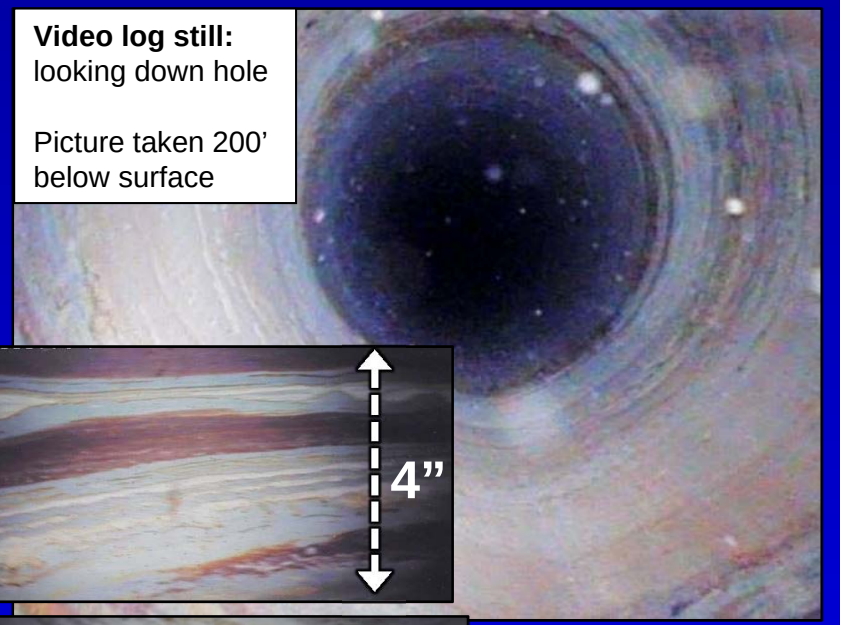
Geophysical log of a 320' irrigation well

High-capacity well - western Chippewa County



Video log still:
looking down hole

Picture taken 200' below surface



Video log stills:
looking at wall of hole

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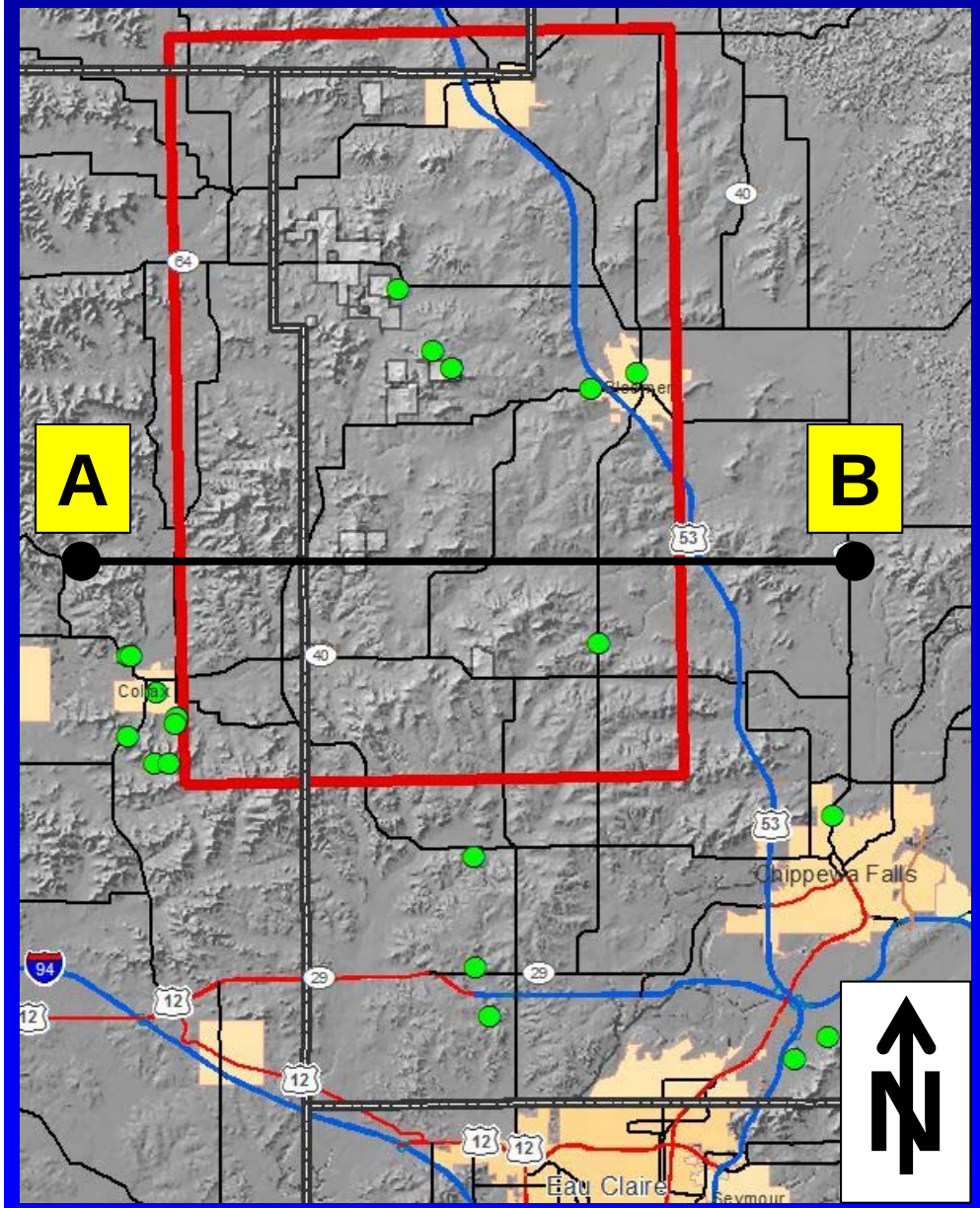
Hydrostratigraphic interpretation



Where we left off in 2013

The conceptual framework presented in 2013

- Using geologic logs, Geophysical logs, and outcrops…
- General dip and location of bedrock units
- Presence of aquifer and aquitard units

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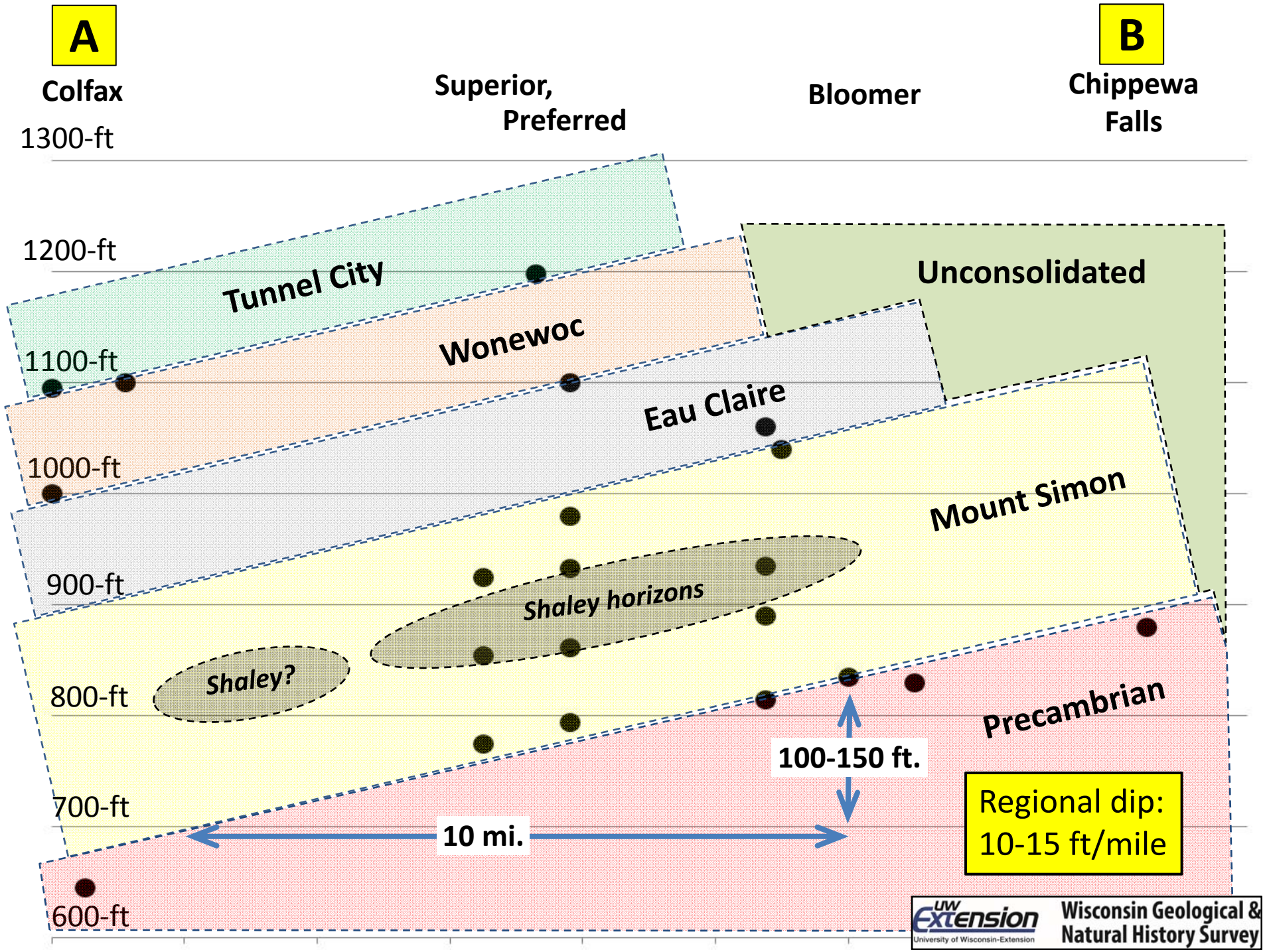
A
B
Colfax
Superior, Preferred
Bloomer
Chippewa Falls
1300-ft
1200-ft
1100-ft
1000-ft
900-ft
800-ft
700-ft
600-ft
Tunnel City
Wonewoc
Eau Claire
Mount Simon
Unconsolidated
Shaley horizons
Shaley?
Precambrian
100-150 ft.
10 mi.
Regional dip: 10-15 ft/mile
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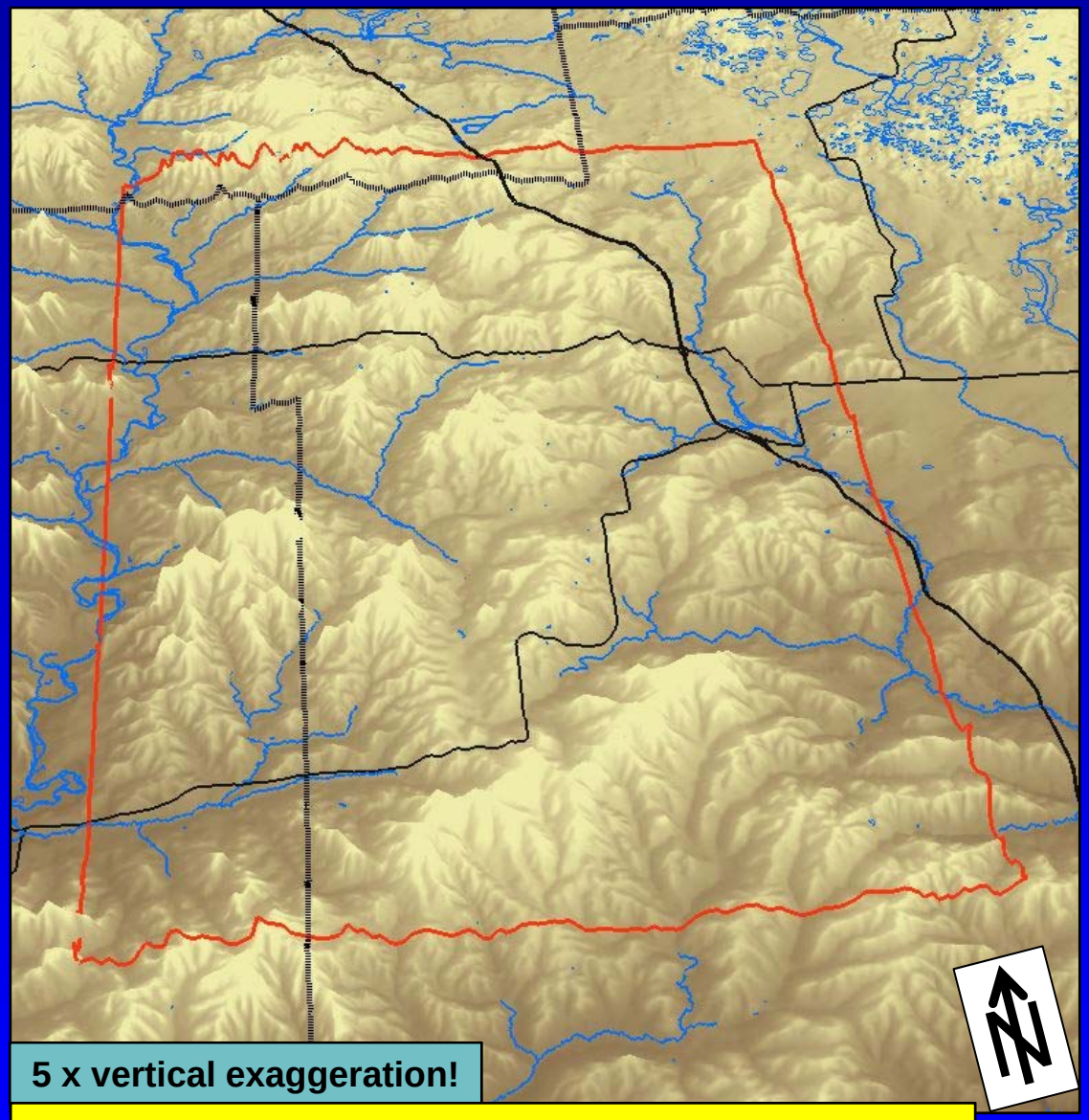
Hydrostratigraphic interpretation



5 x vertical exaggeration!

Oblique view looking north over study area

Land surface elevation *(ft-msl)*

1,365 ft

1,150 ft

935 ft

720 ft

msl = mean sea level

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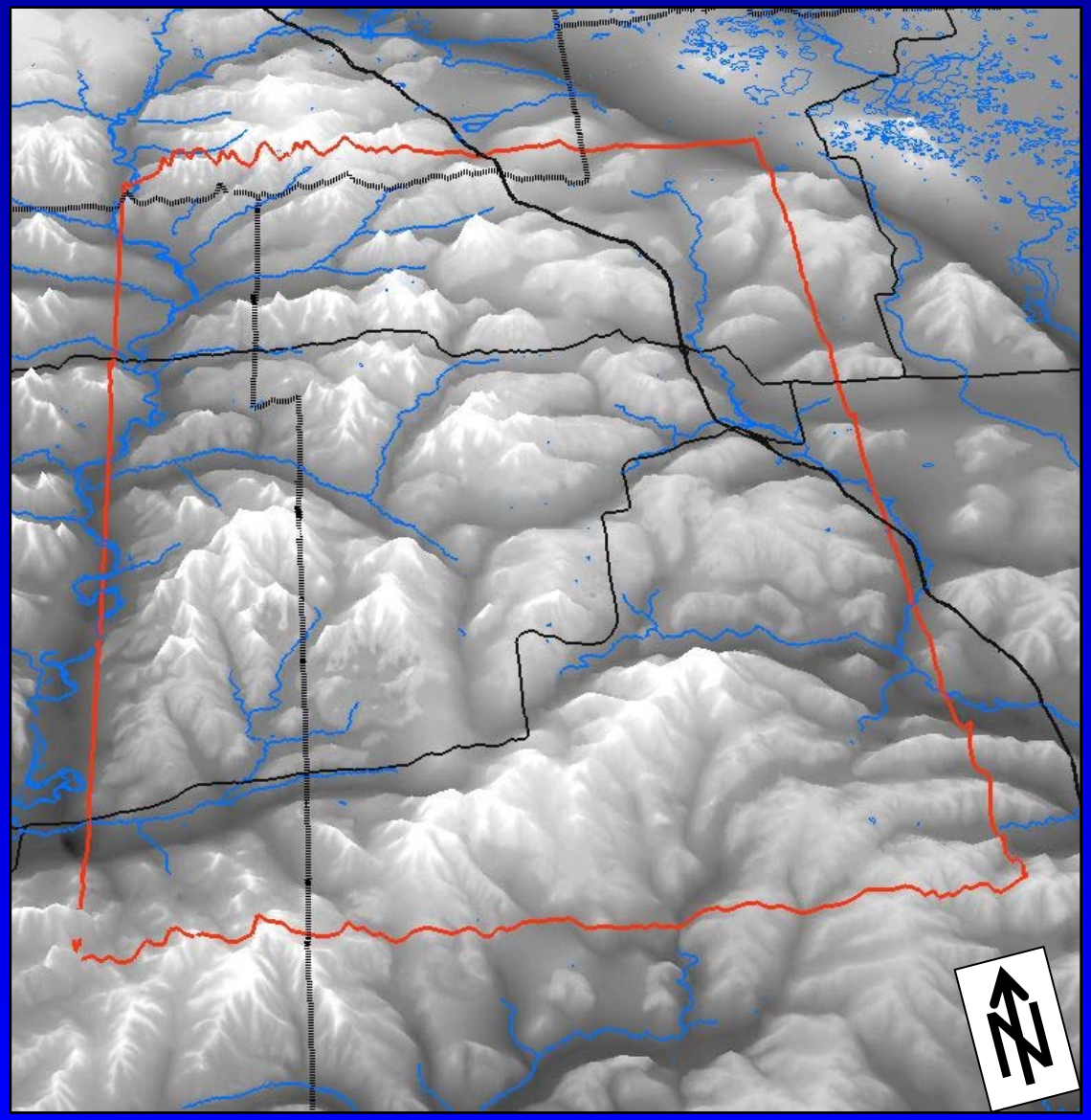
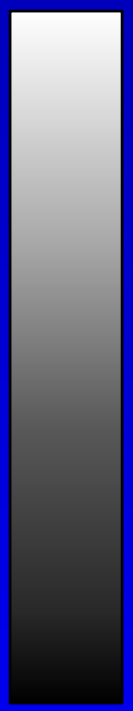
Hydrostratigraphic interpretation



Top of bedrock elevation *(ft-msl)*



msl = mean sea level

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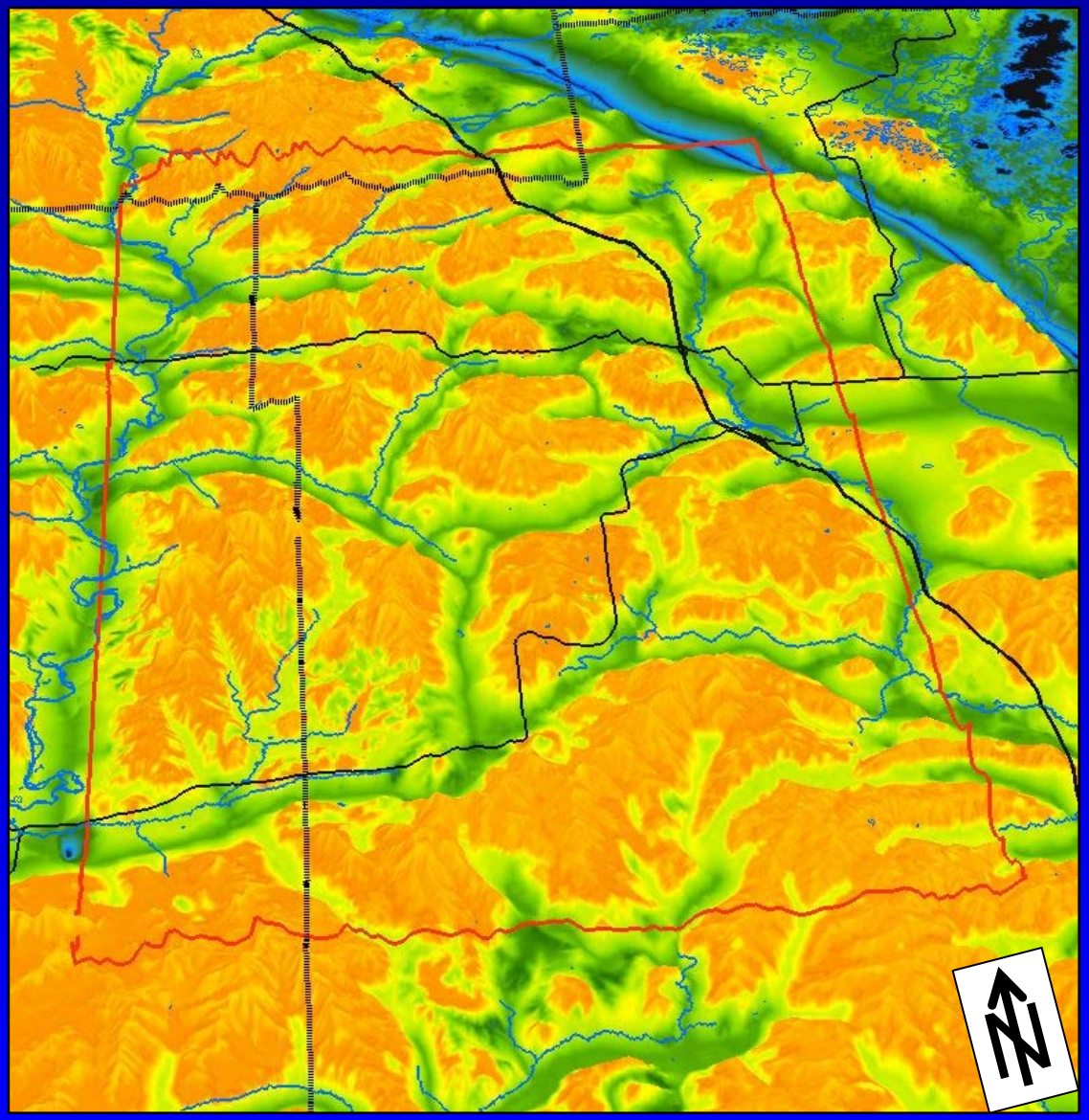
Hydrostratigraphic interpretation



Depth to bedrock
(below land surface)

~ Unconsolidated aquifer thickness

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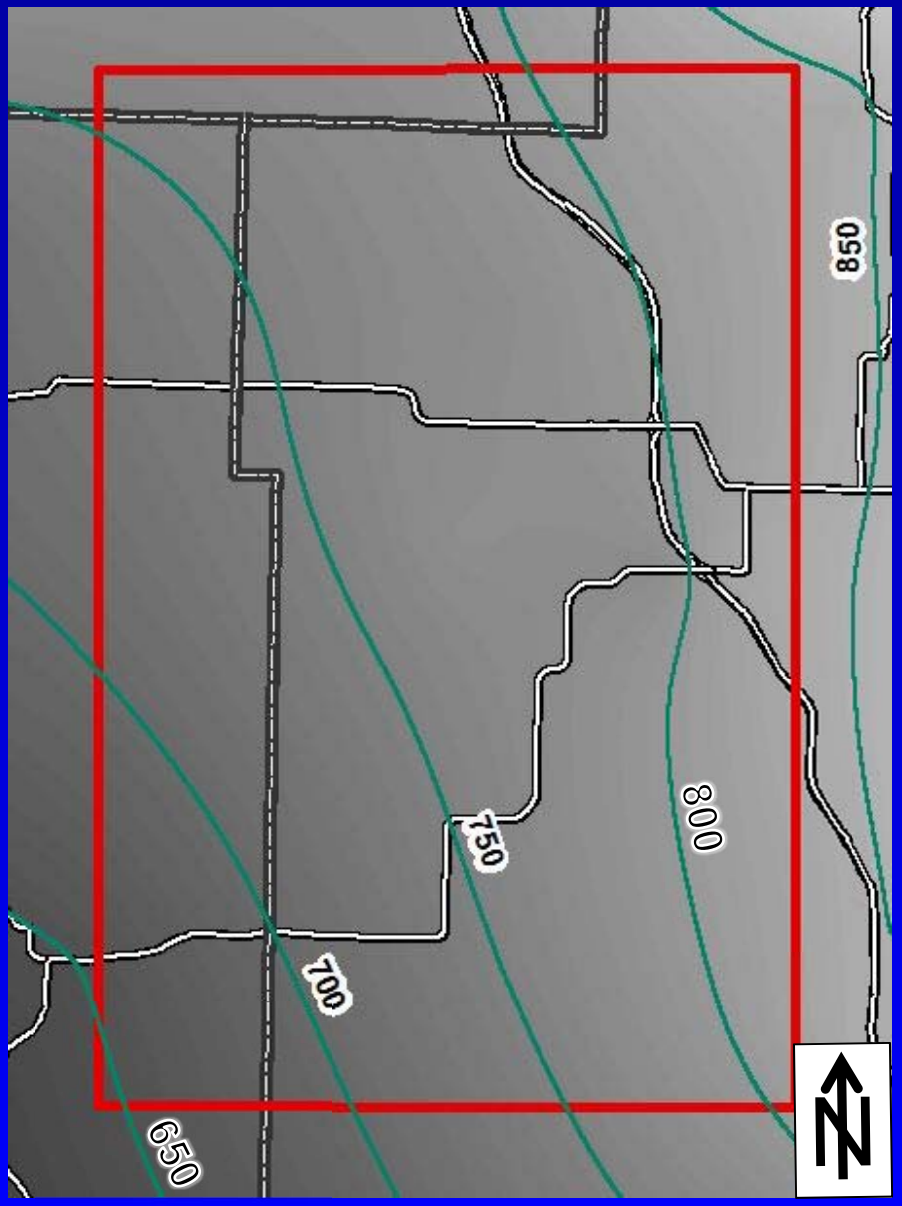
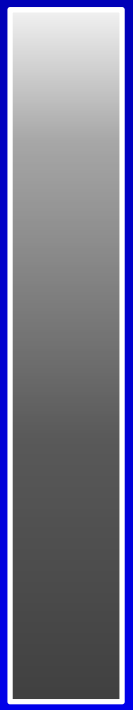
Hydrostratigraphic interpretation



Top of Precambrian elevation *(ft-msl)*



850 ft

750 ft

650 ft

Bottom of GW model

msl = mean sea level

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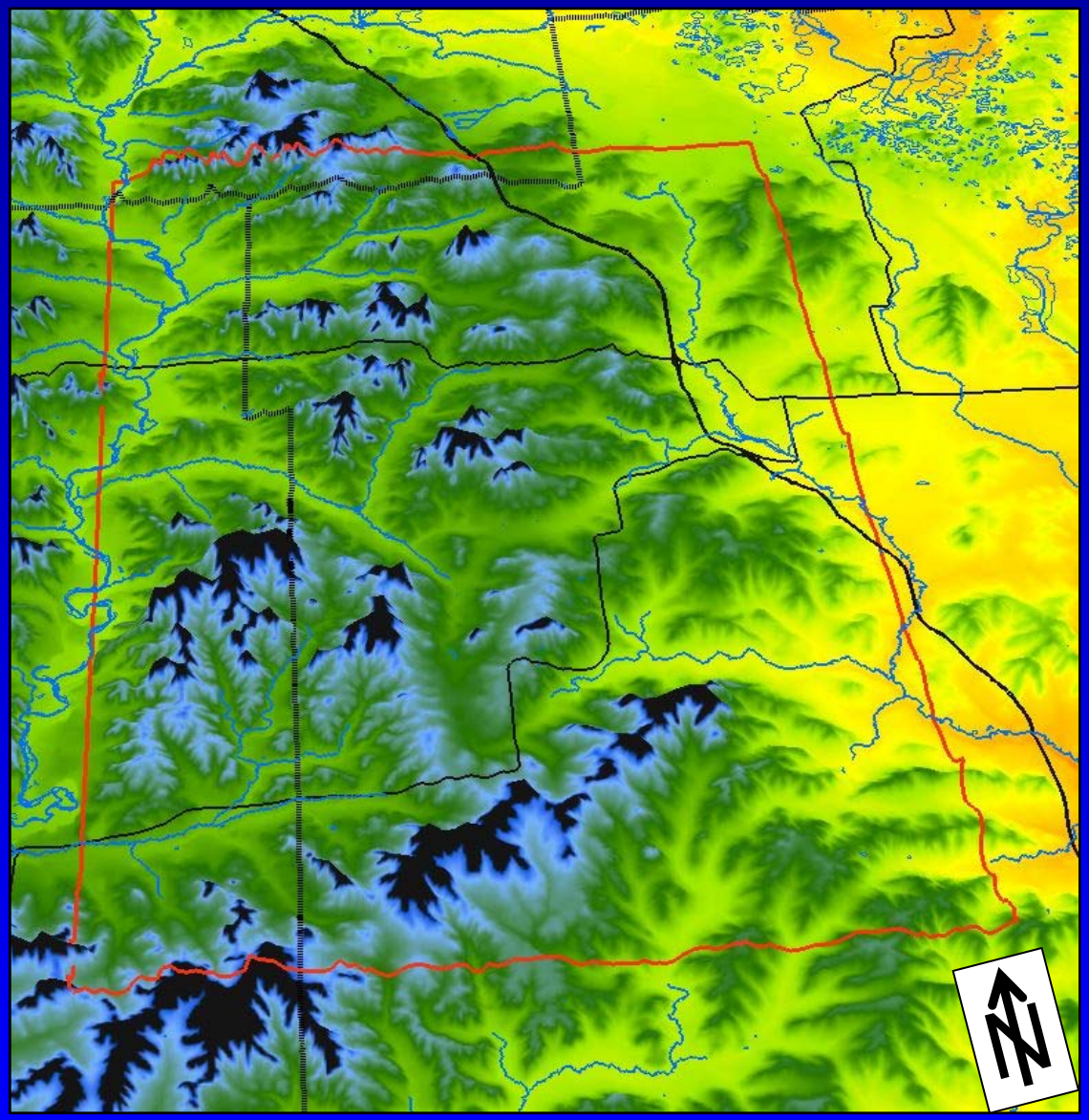
Hydrostratigraphic interpretation



Depth to Precambrian
(below land surface)

0 ft

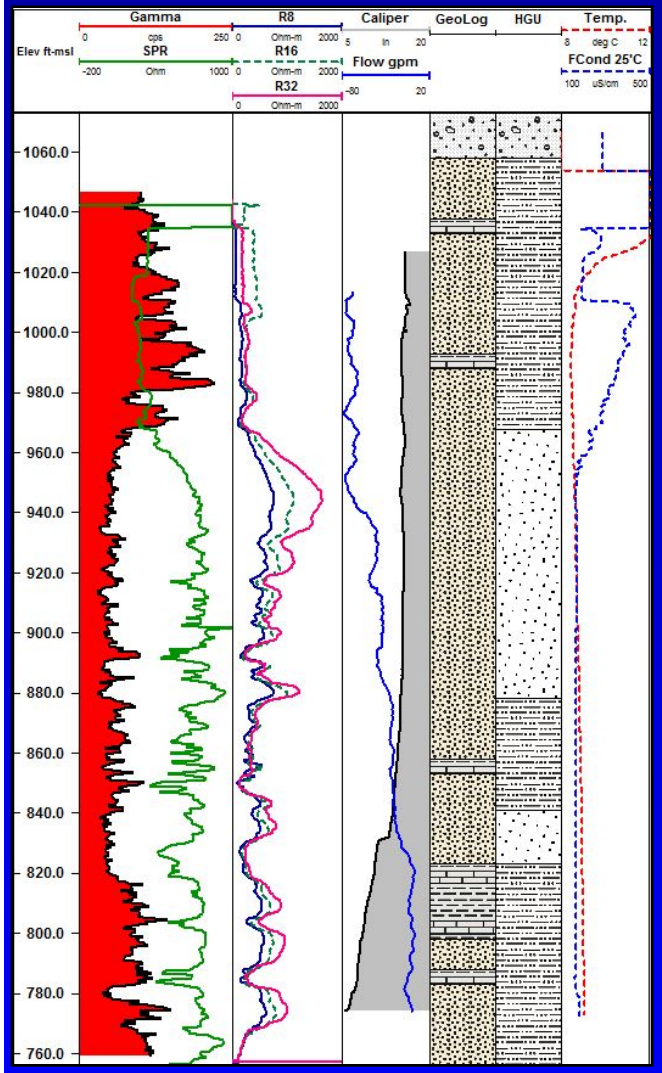
150 ft

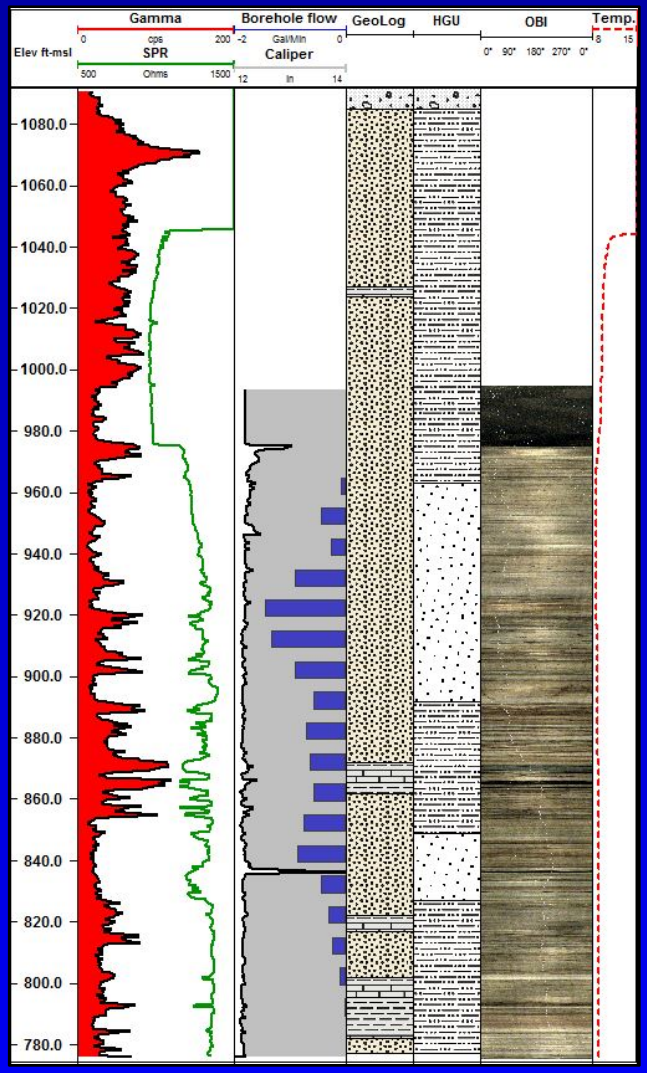
300 ft

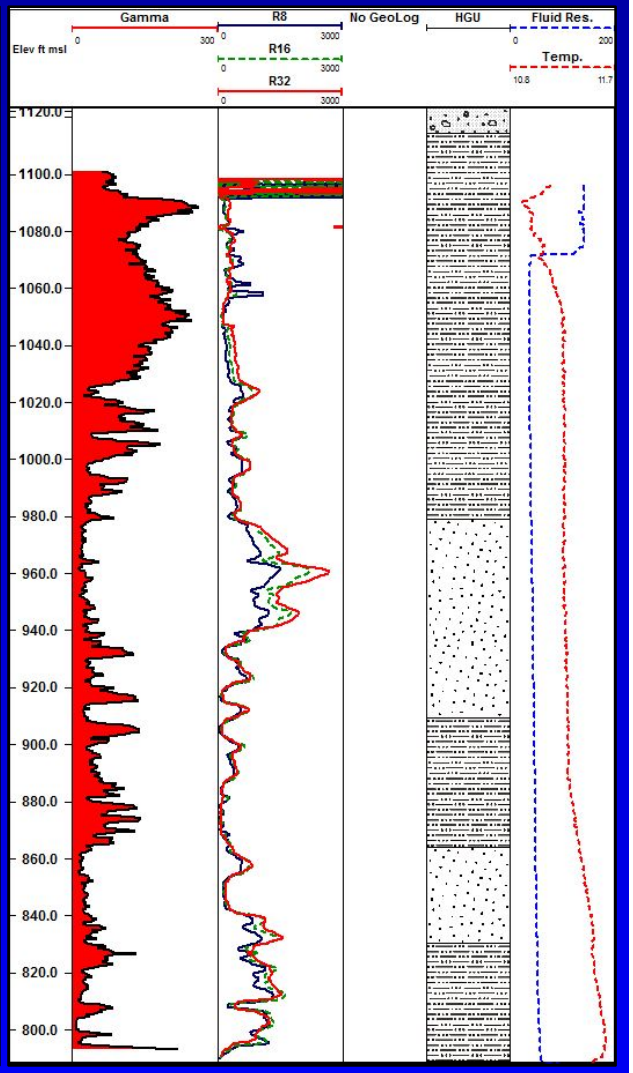
450 ft

660 ft

Hydrostratigraphic interpretation







Dan Stiehl Farm **Superior Silica** **Preferred Sands**

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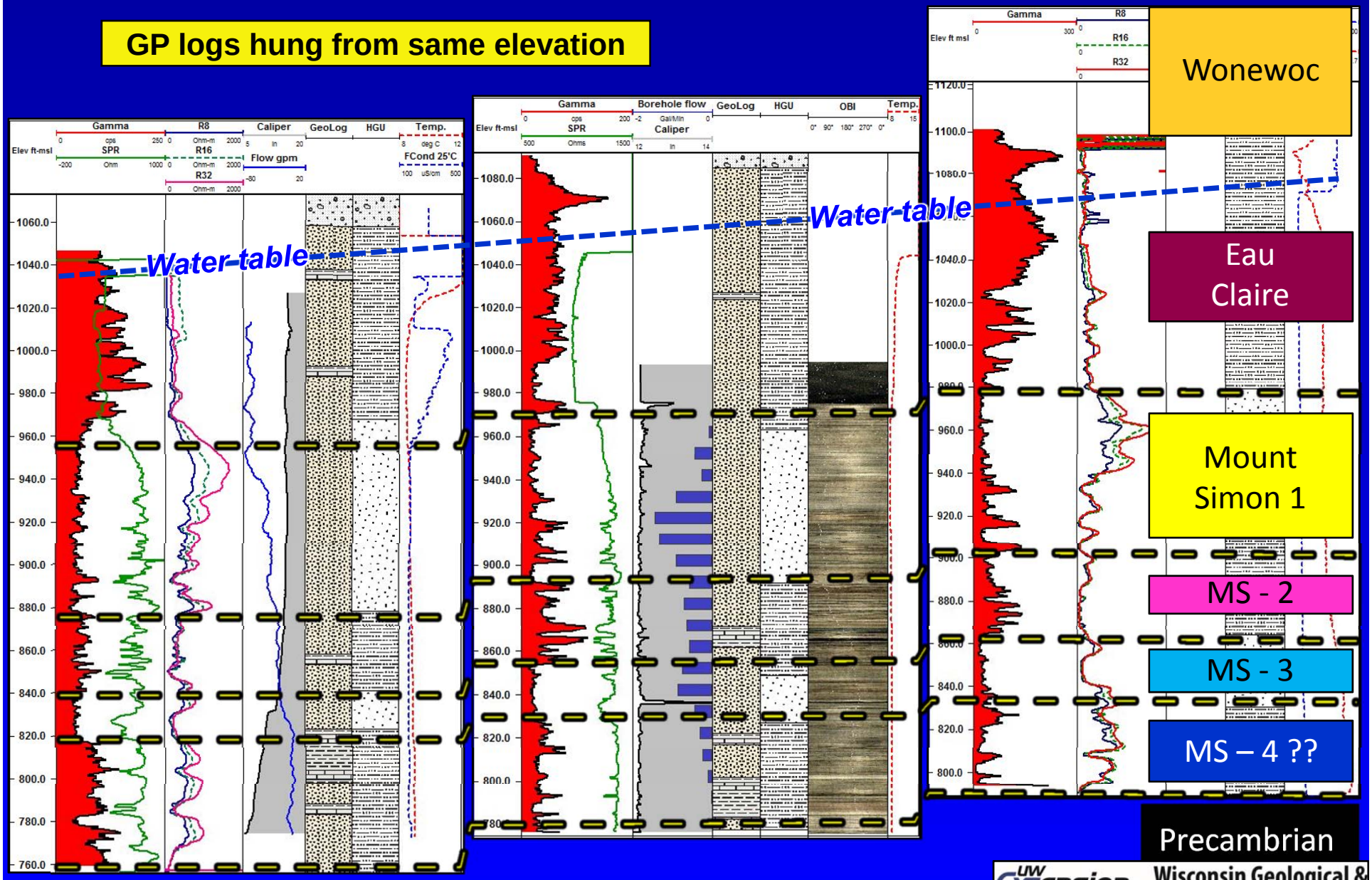
Hydrostratigraphic interpretation

GP logs hung from same elevation



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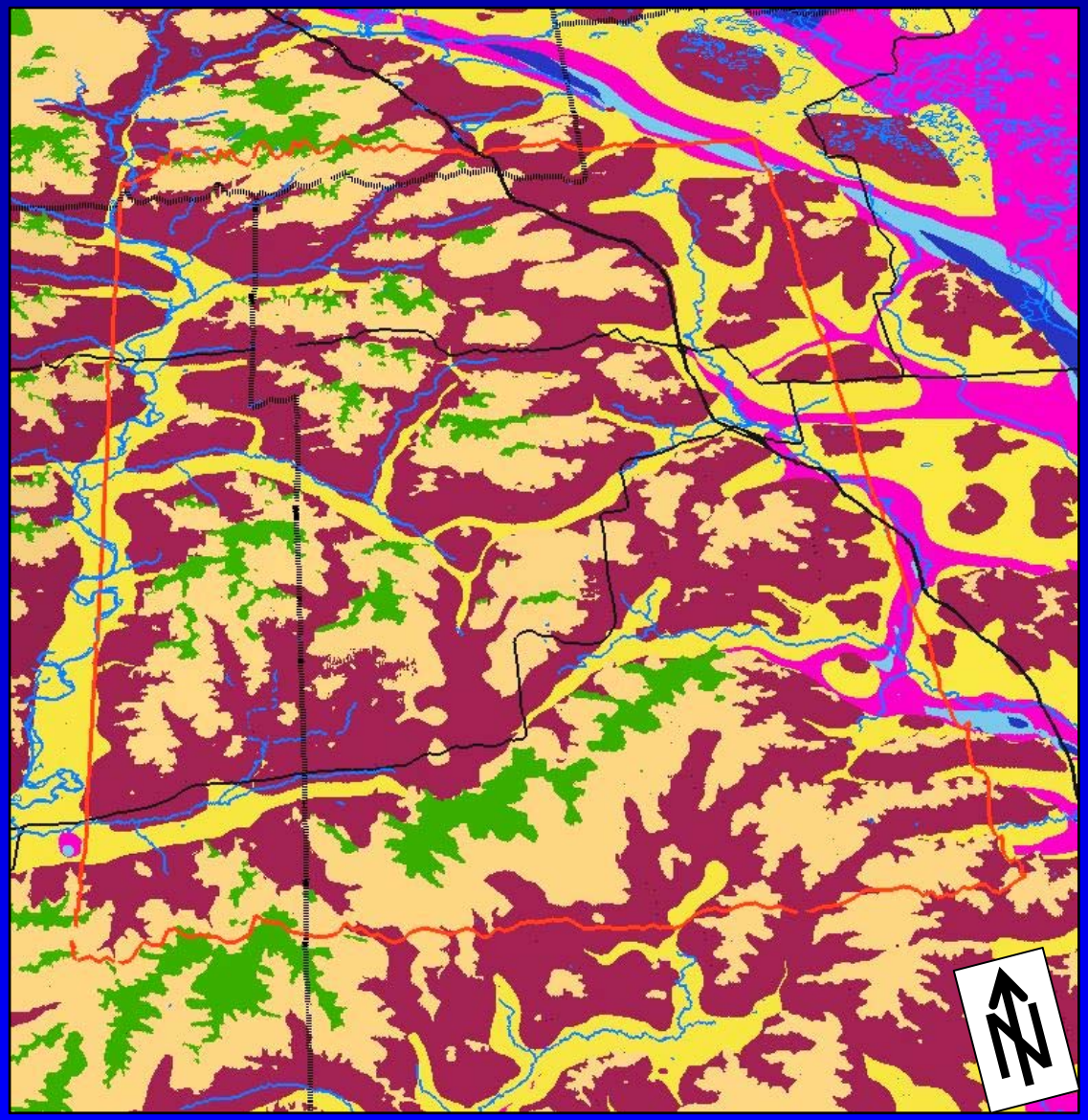
Hydrostratigraphic interpretation



Stratigraphic framework	Hydro-stratigraphic framework	
Tunnel City	Tunnel City	Quaternary Sand and gravel
Wonewoc	Wonewoc	
Water table		
Eau Claire	Eau Claire	
Mount Simon	Mount Simon 1	
	MS - 2	
	MS - 3	
	MS – 4 ??	
Precambrian	Precambrian (No-flow boundary	

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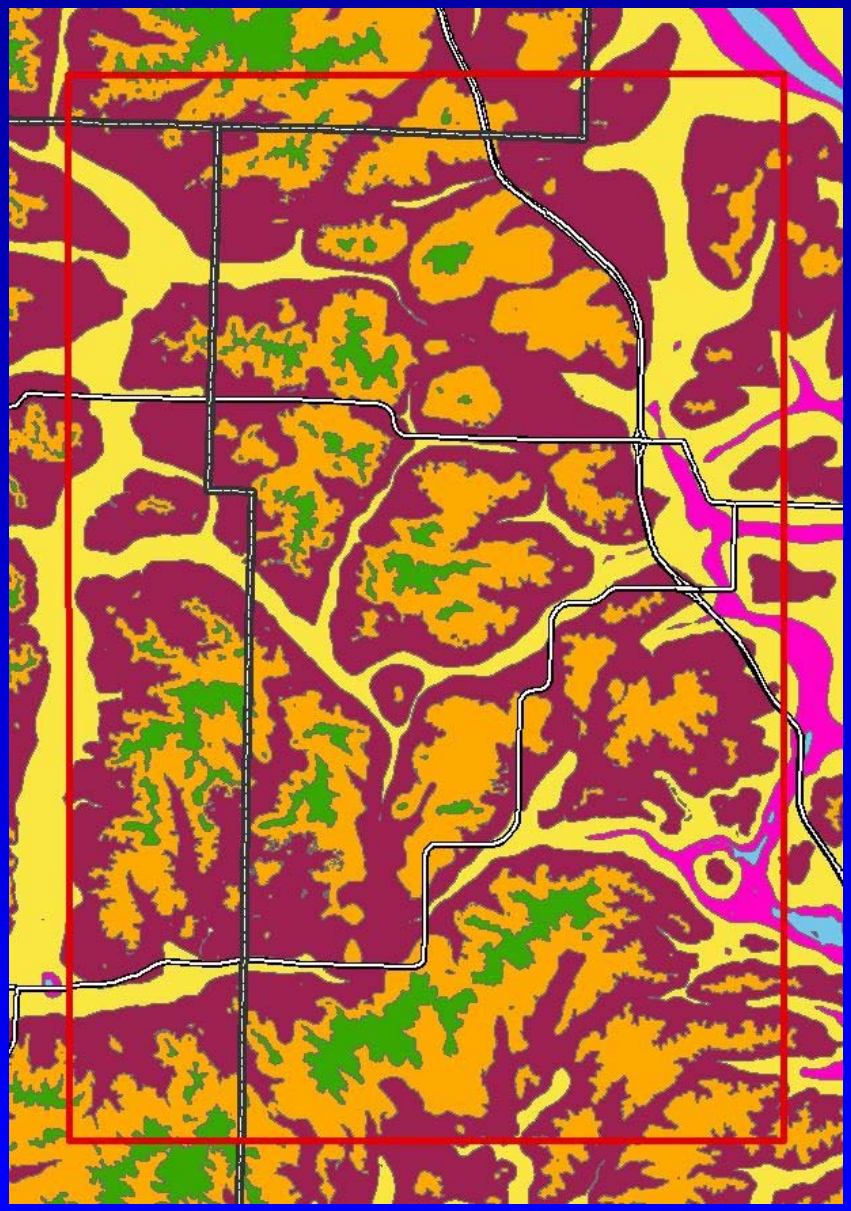
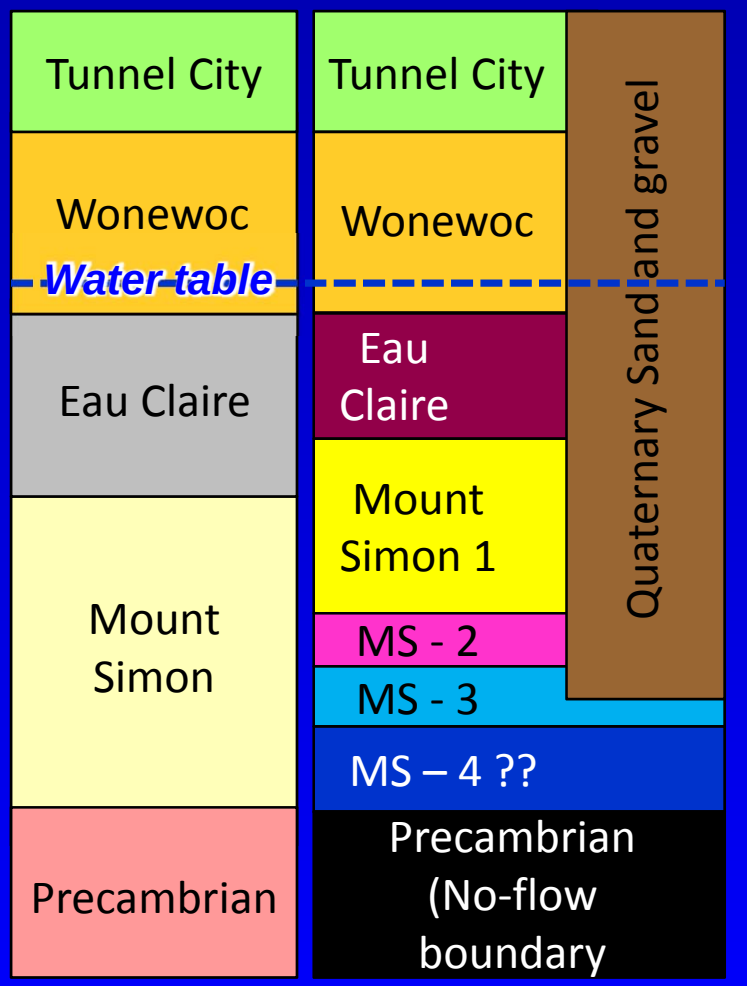
Hydrostratigraphic interpretation





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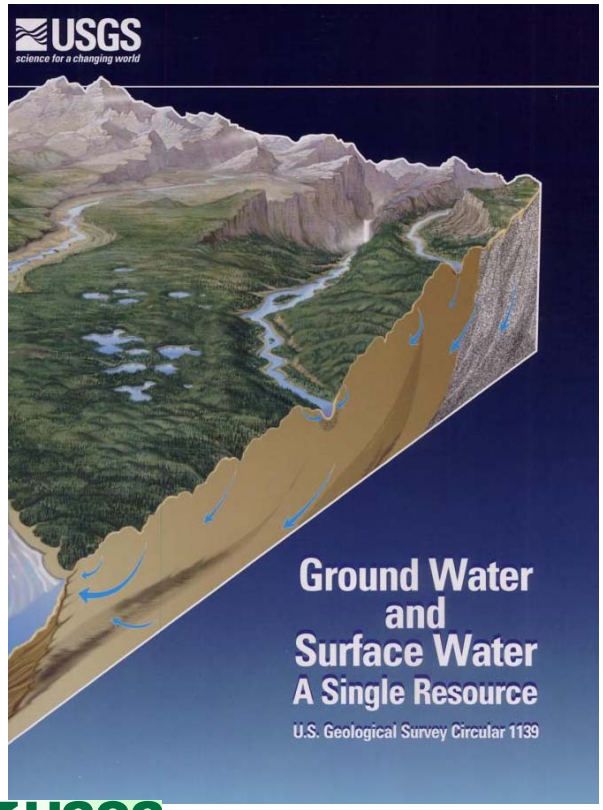
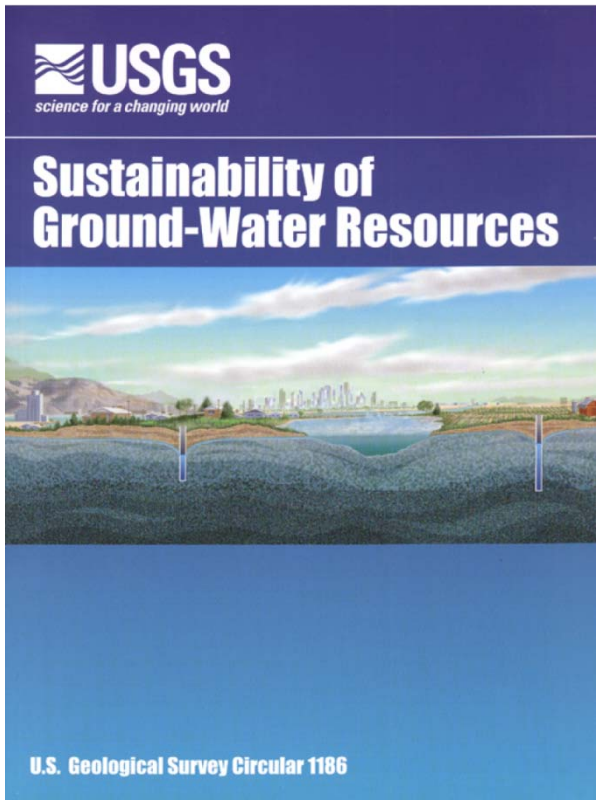
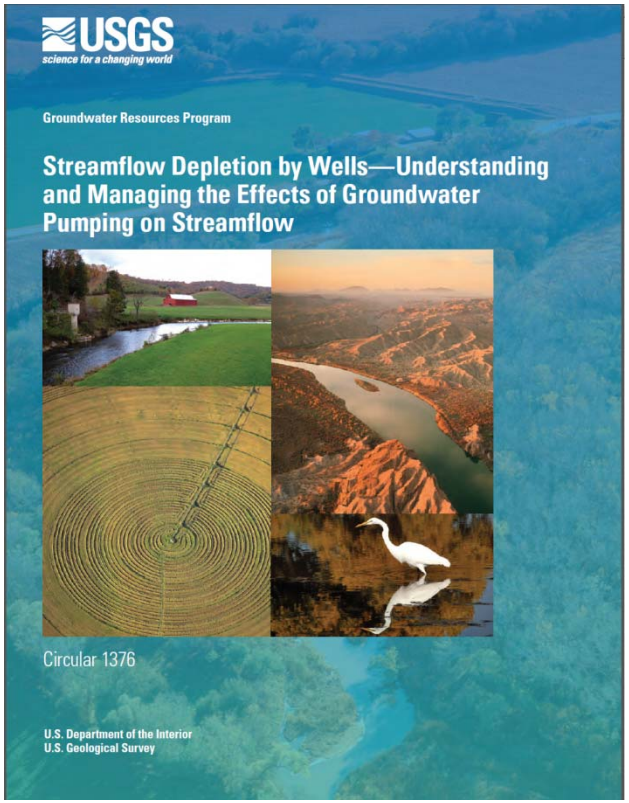
Why Does Water Use Matter?

- Groundwater and surface water are connected

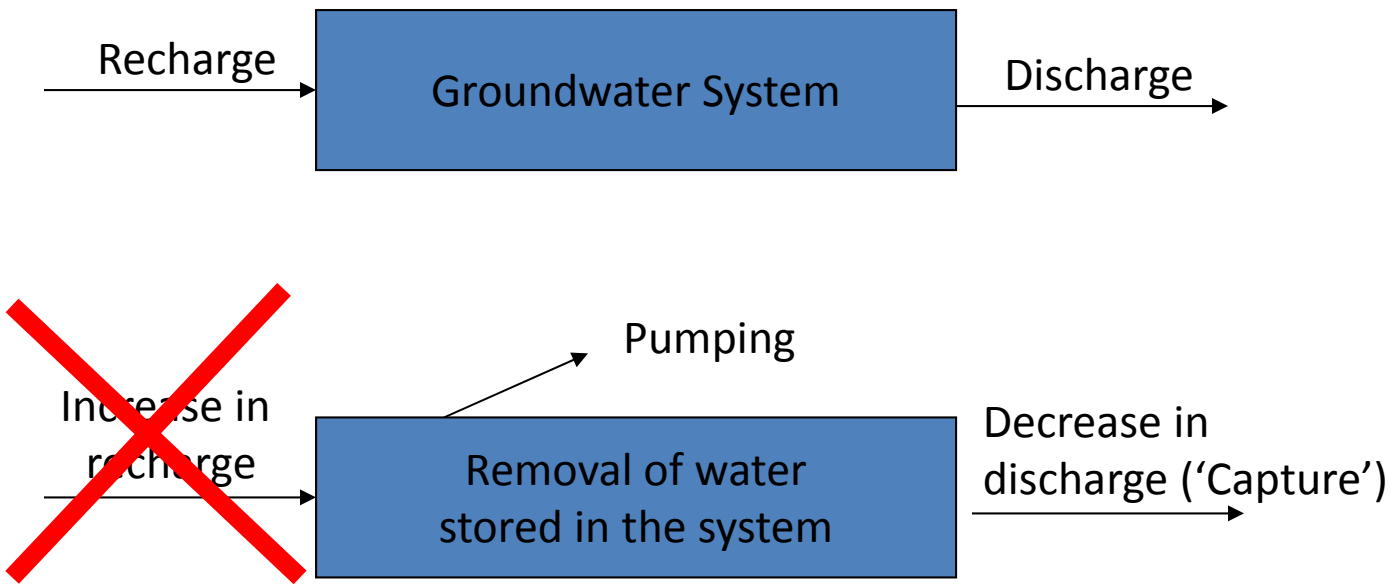






USGS
science for a changing world

Water Use & 'Capture'

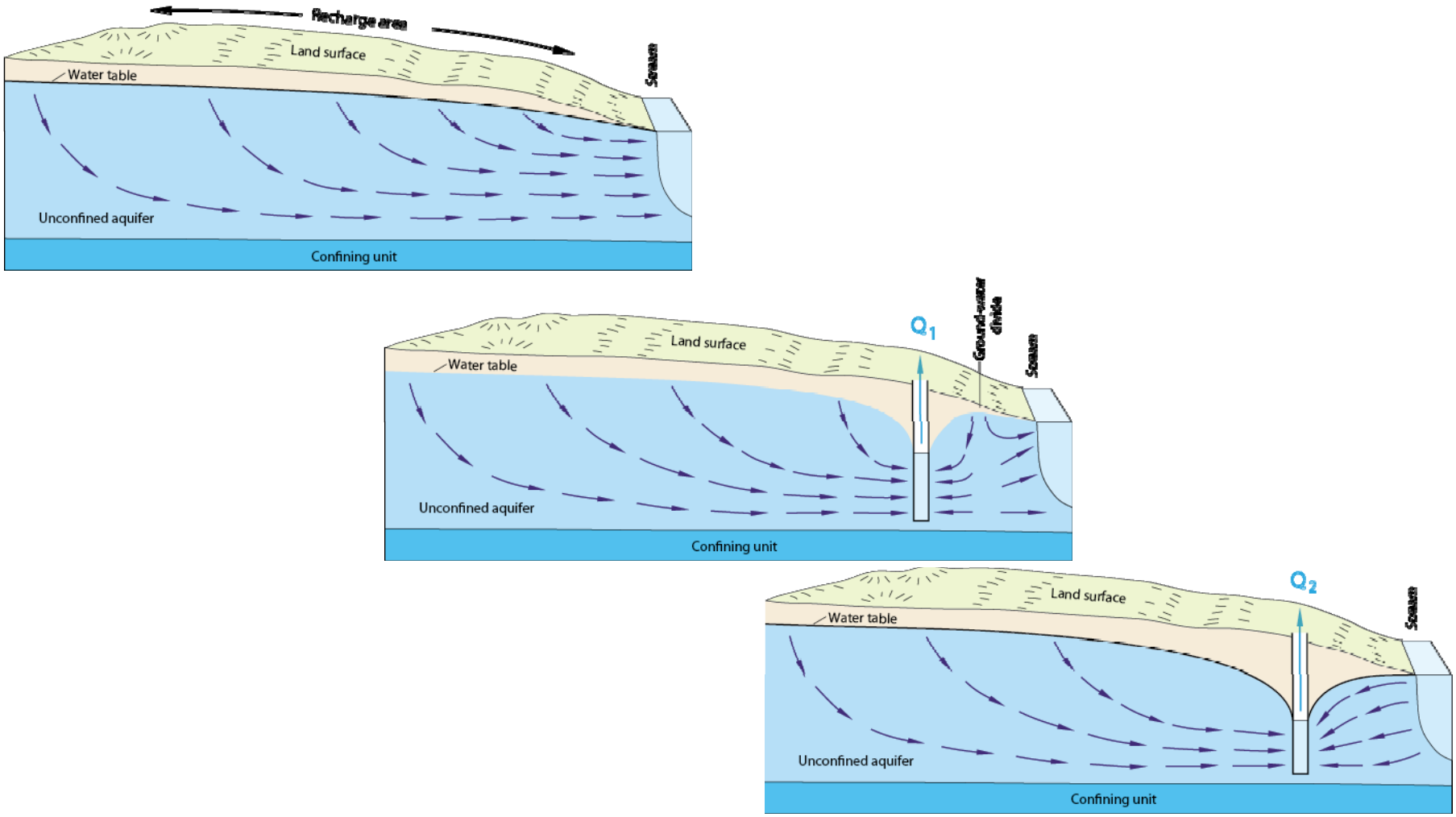


- Capture depends on aquifer geometry and properties, and the well's proximity to streams (including depth)

Alley and others, 1999 – Sustainability of Ground-Water Resources

USGS science for a changing world

Water Use & 'Capture'



from Alley, Reilly, and Franke, USGS Circular 1186, 1999

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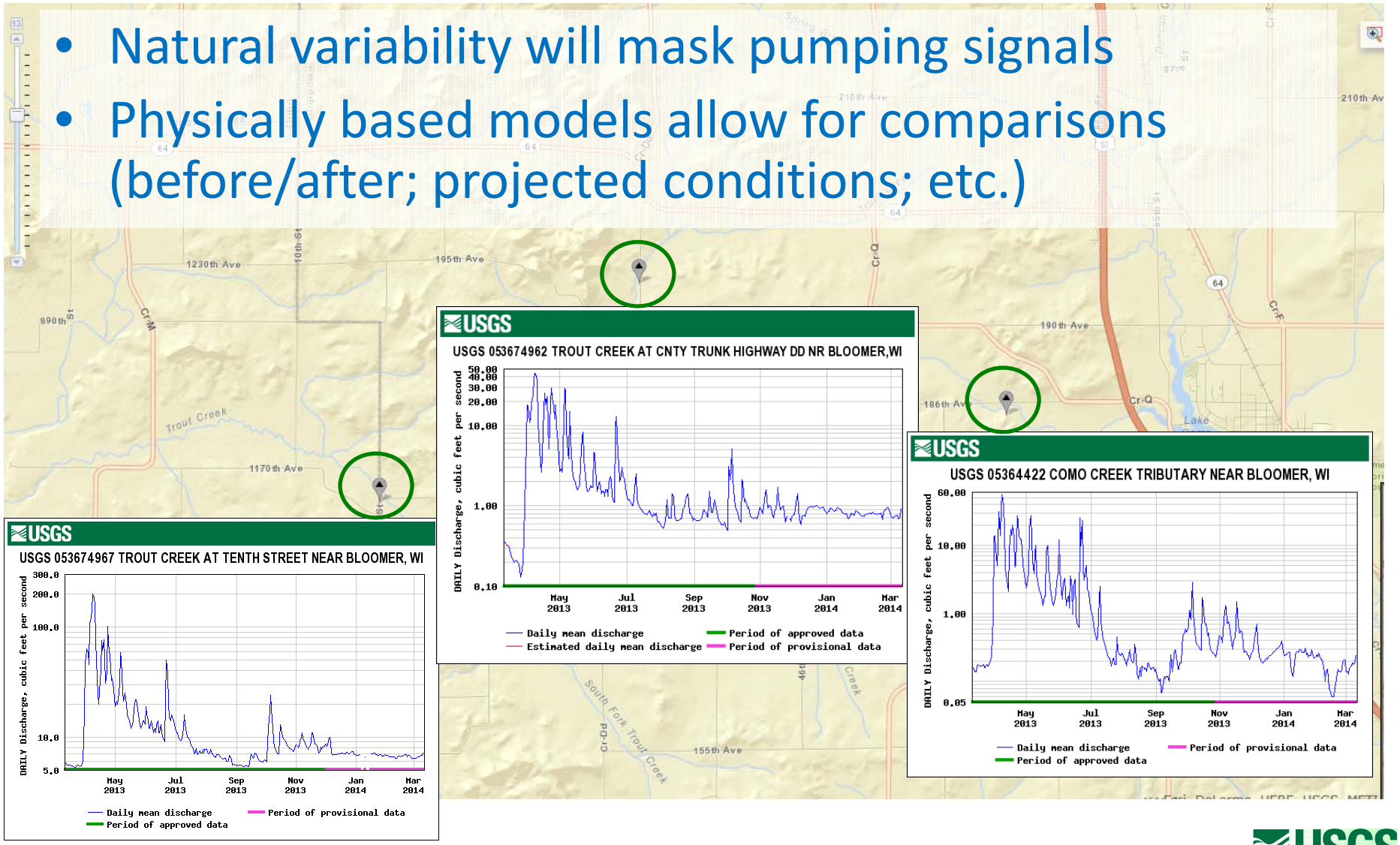
Continuous Streamflow Gages

- Natural variability will mask pumping signals
- Physically based models allow for comparisons (before/after; projected conditions; etc.)



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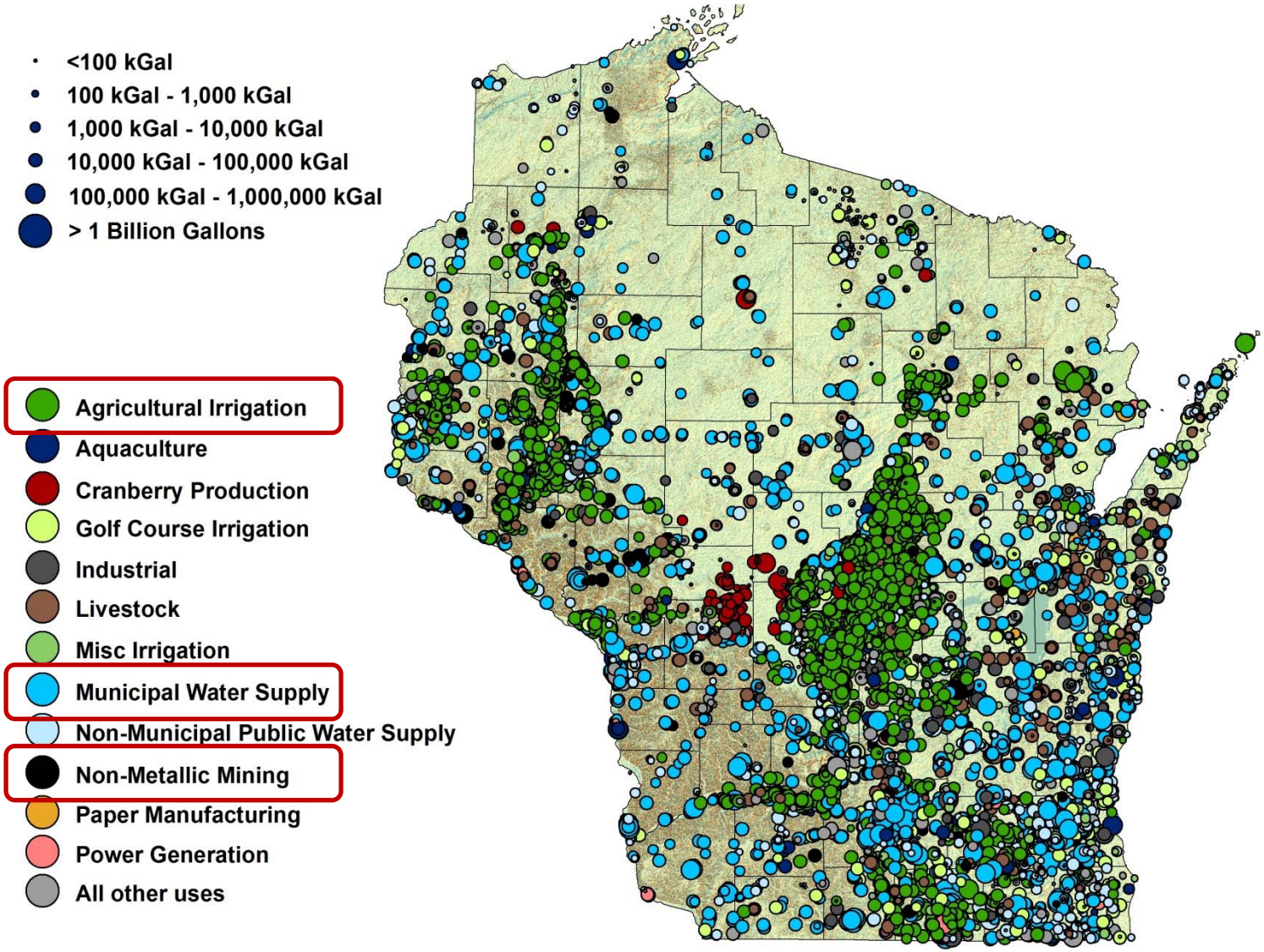
Groundwater Use in Wisconsin:

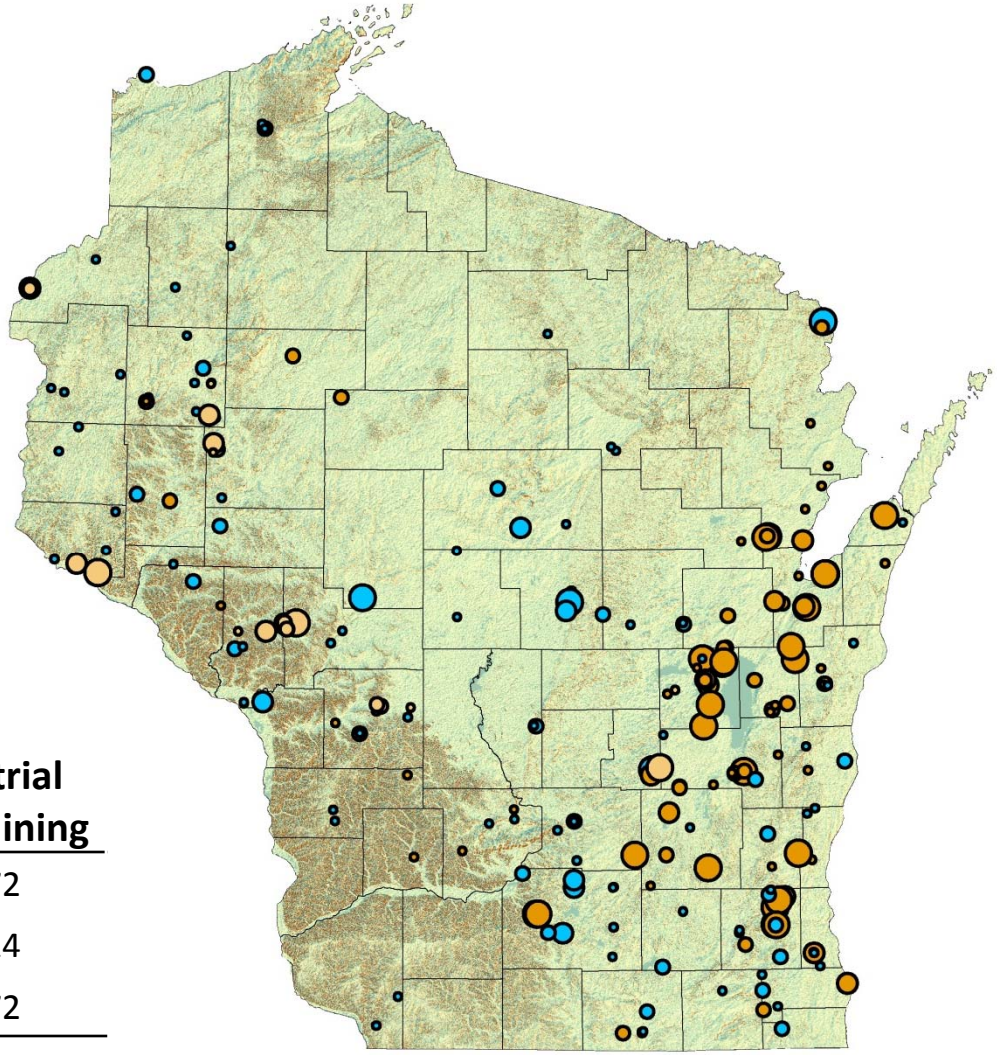
2012 Withdrawals



Non-Metallic Mining Withdrawals:

Average Withdrawal Volume

- Dewatering Water
- Process Water (excluding frac sand)
- Industrial Sand Processing



Million Gallons/yr	Quarry Dewatering	Non-Metallic Mining Processing	Industrial Sand Mining
2011	108.73	33.04	56.72
2012	84.22	22.38	40.14
2013	108.20	15.94	34.72

Water Use Focus in Chippewa County

Industrial sand mining

- ~250 - 400 feet deep (Mount Simon Sandstone)
- Pump: ~20 - 95 million gallons per year per well
- Number of wells: 0 – 3 wells per mine

Municipal supply

- ~150 - 300 ft deep
- Pump: ~88 million gallons per year
- Number of wells: 4 (plus other villages)

Irrigated agriculture

- ~100 - 300 feet deep
- Pump: <10 - 30 million gallons per year per well (varies by well & year)
- Number of wells: >20 in model area, >100 in surrounding area

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Well information supplied by WiDNR

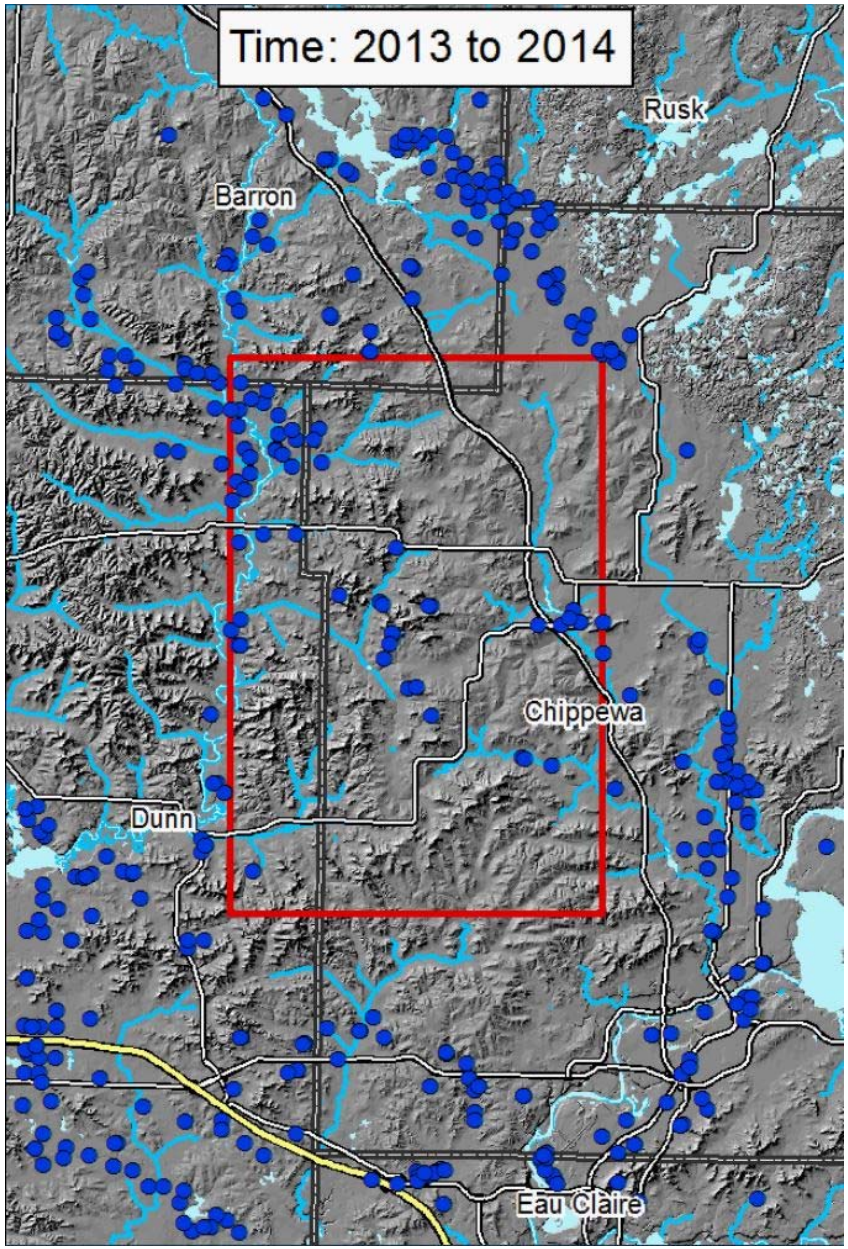
Water Use Focus in Chippewa County

Time-lapse video of well locations…

Time-lapse video compiled from WiDNR historical records of hi-capacity wells

Water Use Focus in Chippewa County

Hi-capacity wells installed prior to 2014 based on WiDNR historical records



Proppant Sand Water Footprint

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Proppant Sand Water Footprint

Figure 38. Flow Chart of Biofuel and Embedded Water

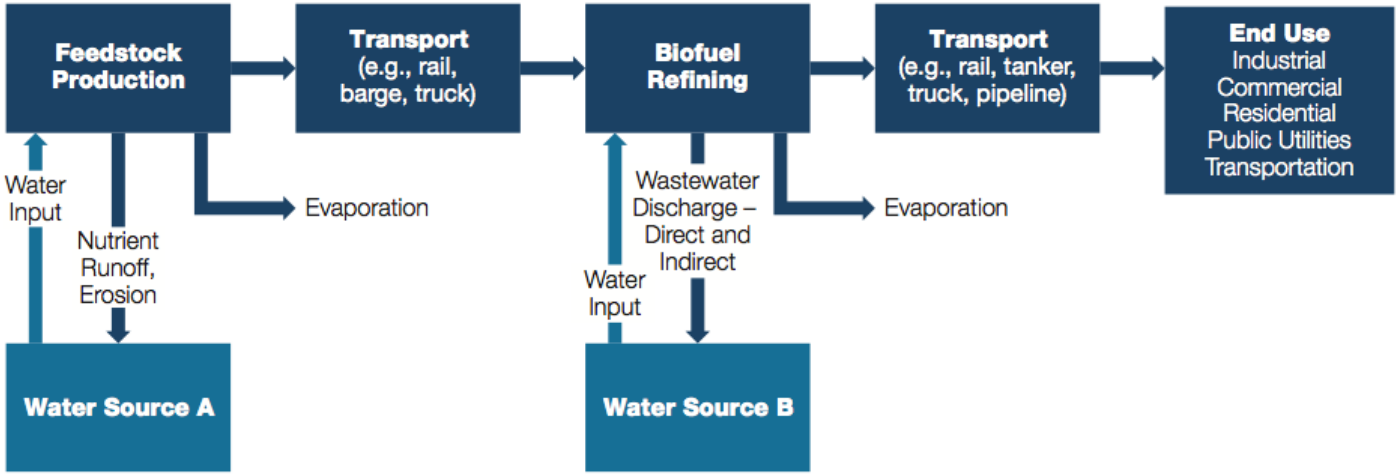
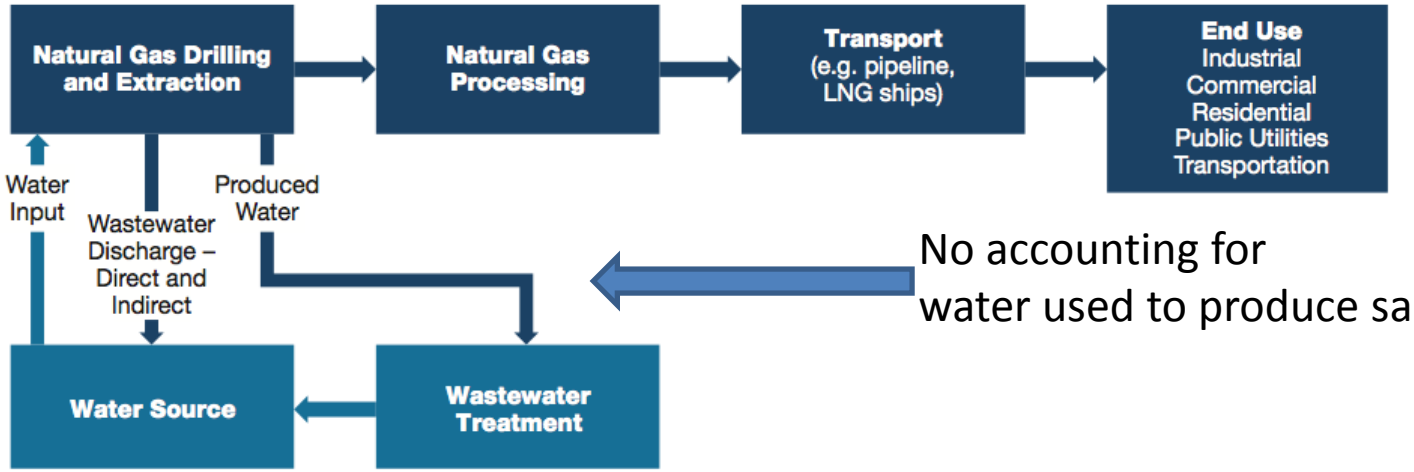


Figure 10. Flow Chart of Natural Gas and Embedded Water



No accounting for water used to produce sand

Figures from Water and Energy Nexus: A Literature Review
Prepared by Water in the West, Stanford University

Today's outline

- Brief review of study *(WGNHS / USGS)*
- Progress to date *(WGNHS / USGS / Chippewa Co.)*
  - Subsurface data collection
  - Hydrostratigraphy
  - Water-use data collection
  - **Compilation of site data for modeling**
  - Soil water balance (SWB) modeling
- Focused stakeholders discussion
  - SWB, reclamation, and future scenario testing
- What's next ?
- Other agenda items to include / discussion ?

Progress to date – Data collection

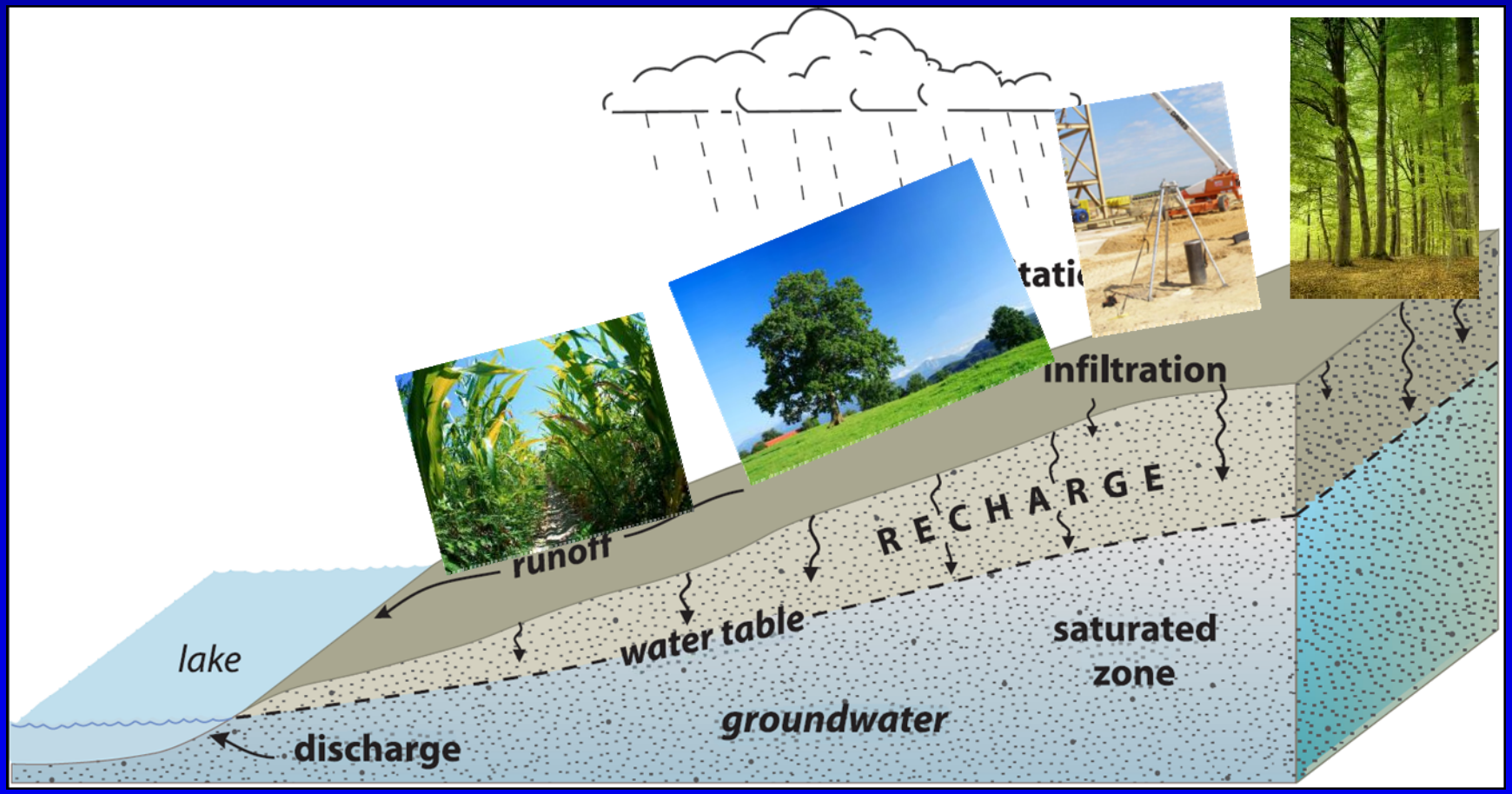
- Compilation of site data by Chippewa Co. LCFM

Today's outline

- Brief review of study *(WGNHS / USGS)*
- Progress to date *(WGNHS / USGS / Chippewa Co.)*
  - Subsurface data collection
  - Hydrostratigraphy
  - Water-use data collection
  - Compilation of site data for modeling
  - **Soil water balance (SWB) modeling**
- Focused stakeholders discussion
  - SWB, reclamation, and future scenario testing
- What's next ?
- Other agenda items to include / discussion ?

Recharge (R) is water that enters the groundwater system

R = Precipitation – Runoff – Interception – Evapotranspiration



Soil water balance model

Is one of many methods used to estimate recharge

Useful to estimate change in R over time, given a set of changes to the landscape

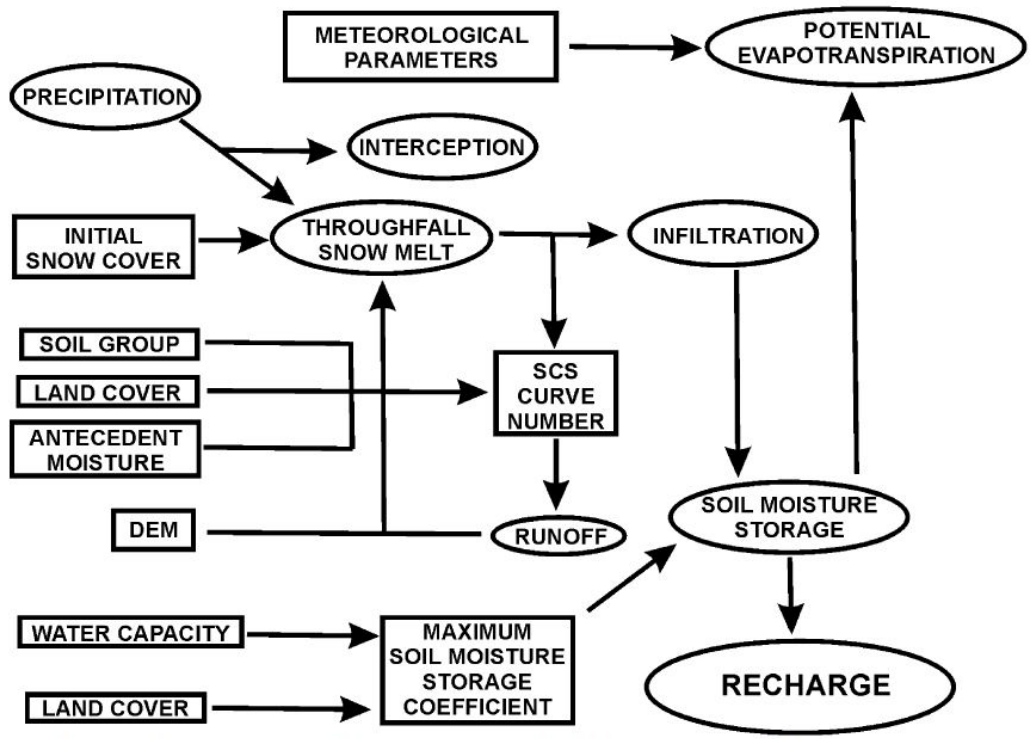


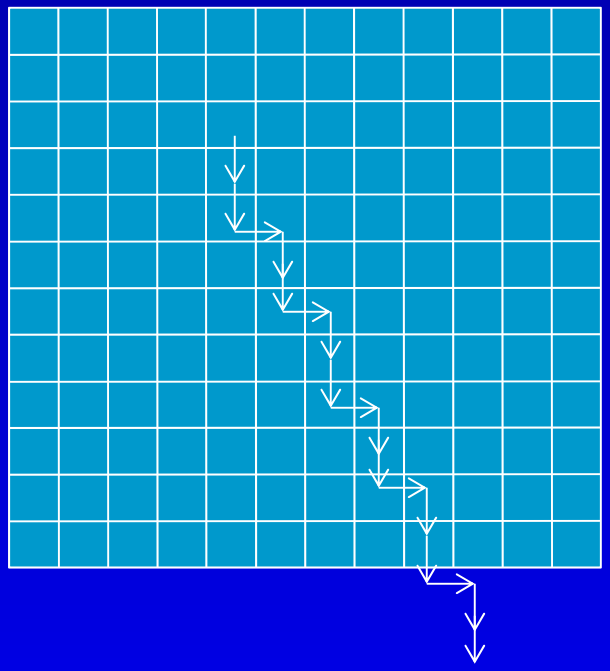
Fig. 1 A simplified flow chart for the soil–water balance (SWB) model. The *ovals* represent the major components of the water budget; the *rectangles* are the physical characteristics of the site. *DEM* digital elevation model, *SCS* Soil Conservation Service

Hydrogeology Journal (2007) 15: 433–444 DOI 10.1007/s10040-007-0160-6

Soil Water Balance Model

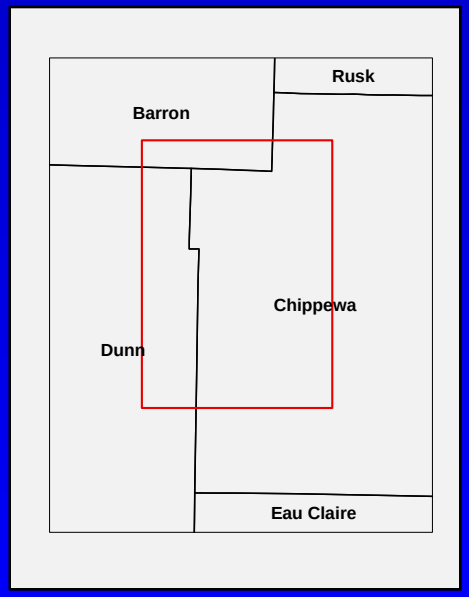
Recharge = Precipitation - Evapotranspiration - Soil Storage – Runoff

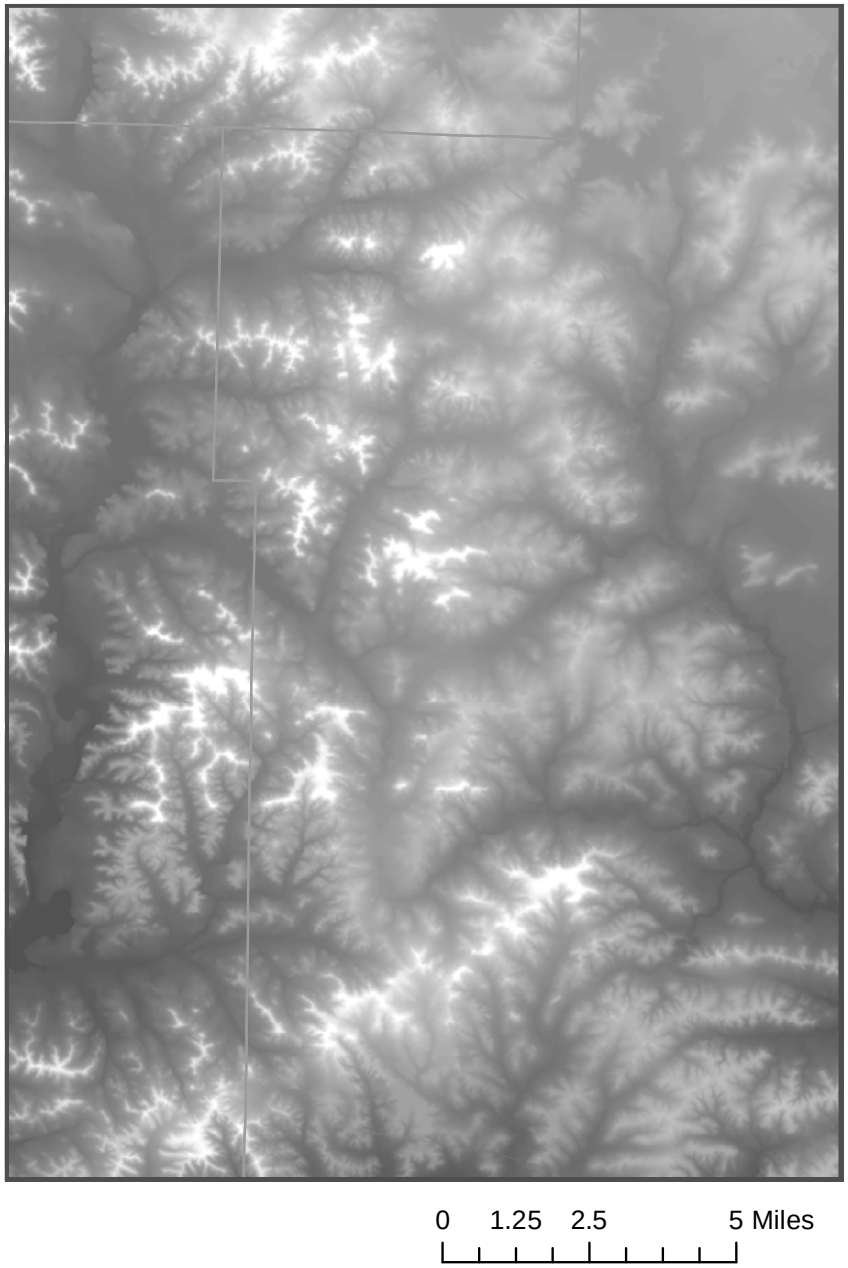
- Equation applied to each cell
- Daily precipitation is evaporated, stored, or recharges groundwater
- Recharge is limited by soil permeability and storage; any excess water runs off to next down- gradient cell
- Repeat until all runoff infiltrates or reaches surface water



Land surface slope:

runoff rate and direction based on elevation





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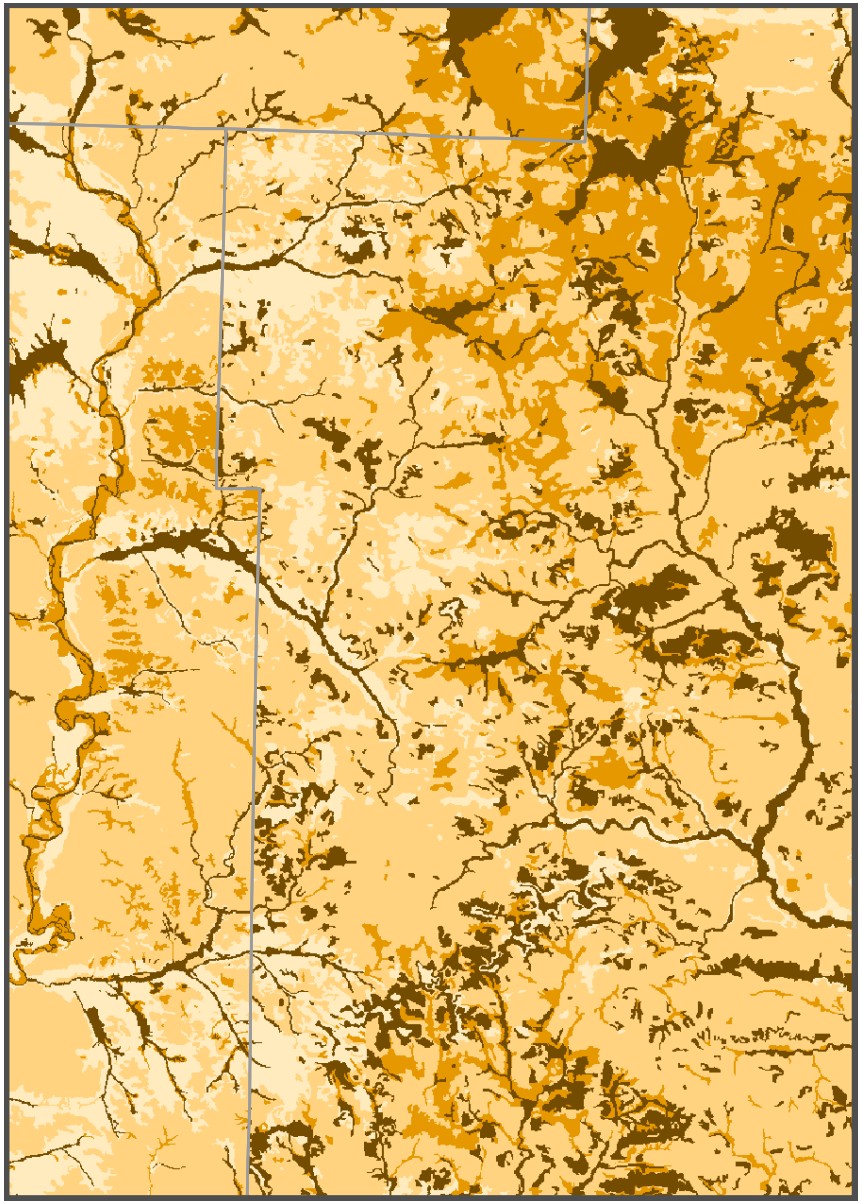
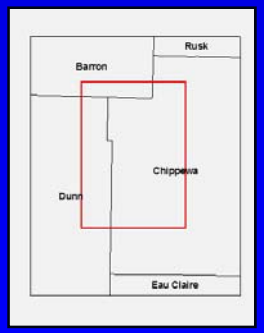
Soil Hydrologic Group: infiltration and runoff

A	high infiltration, low runoff
B	↓
C	
D	low infiltration, high runoff





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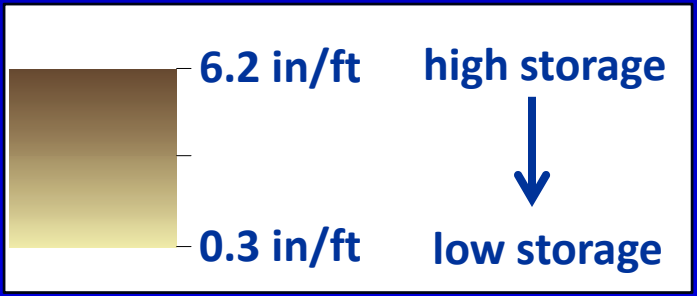
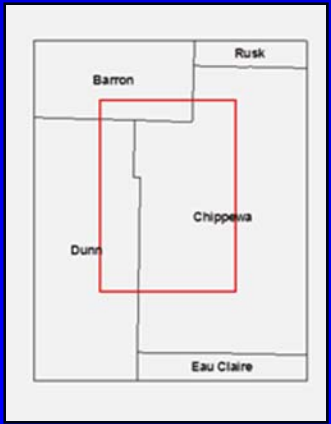
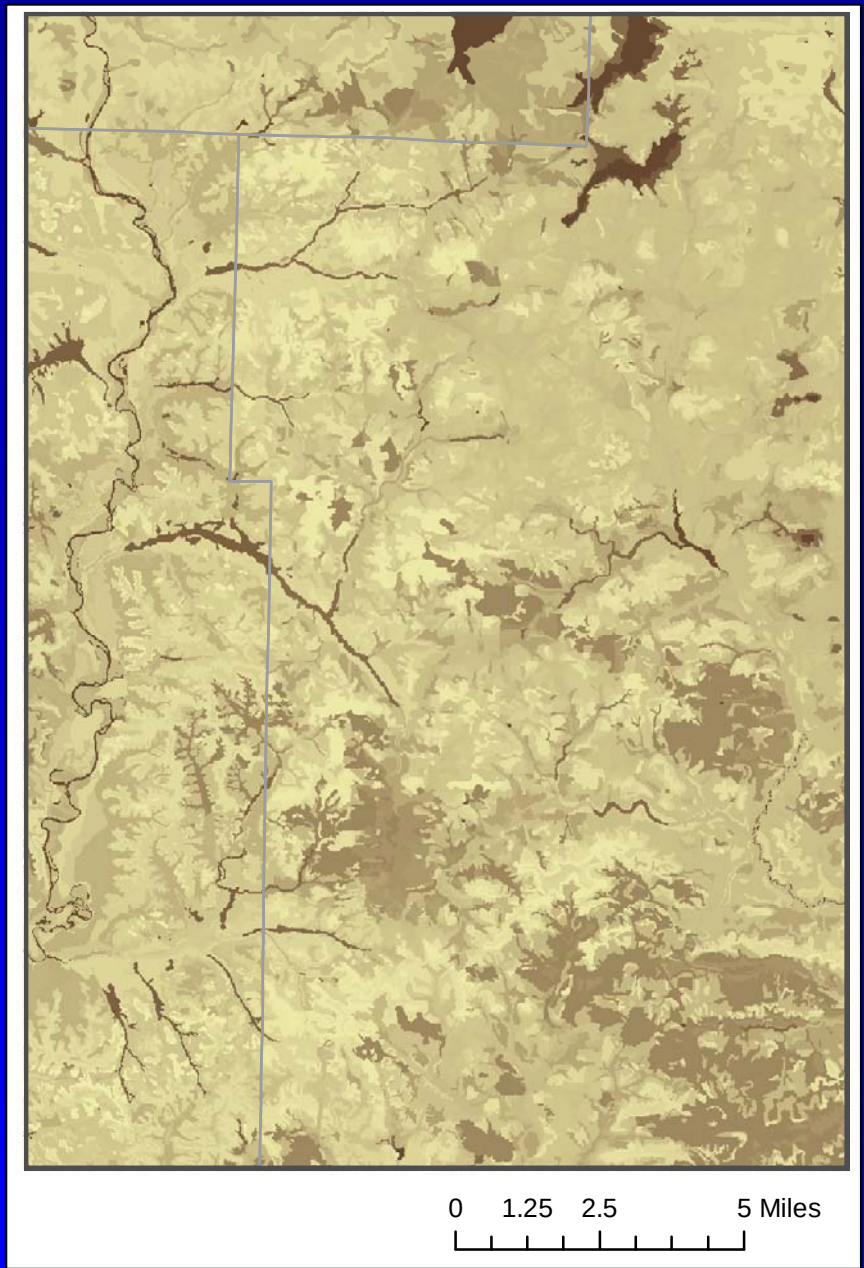
Available Water Storage:

Soil moisture maintains vegetation during dry periods, allowing for more plant uptake, but decreases water available for recharge







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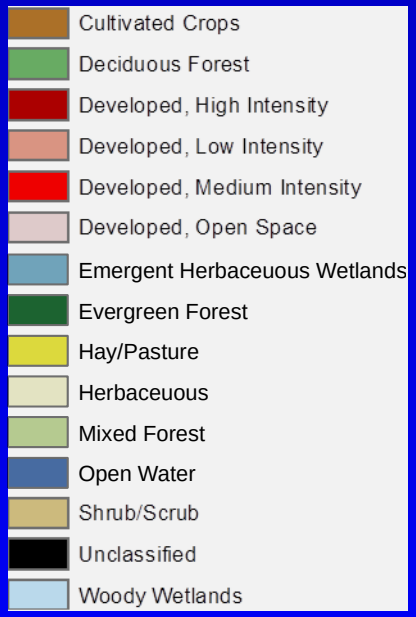
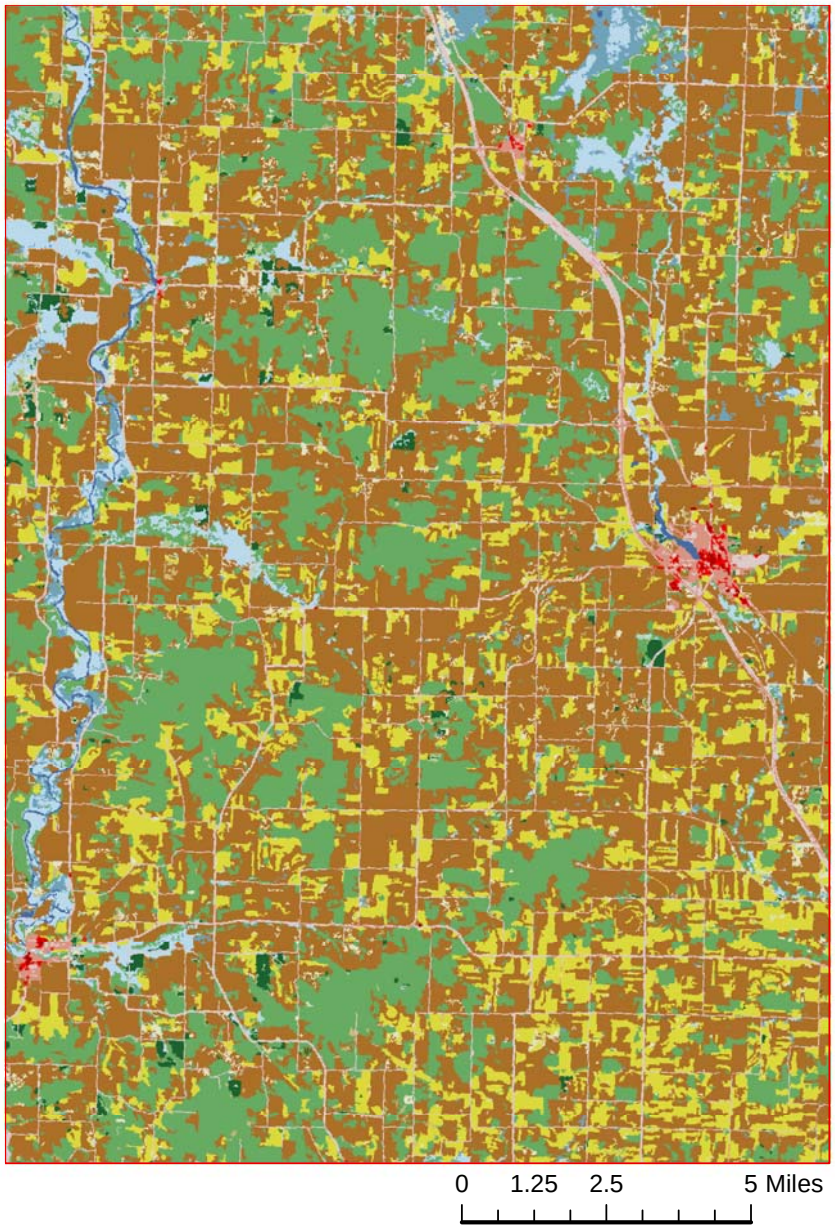
Land Use:

Evapotranspiration, interception, and runoff

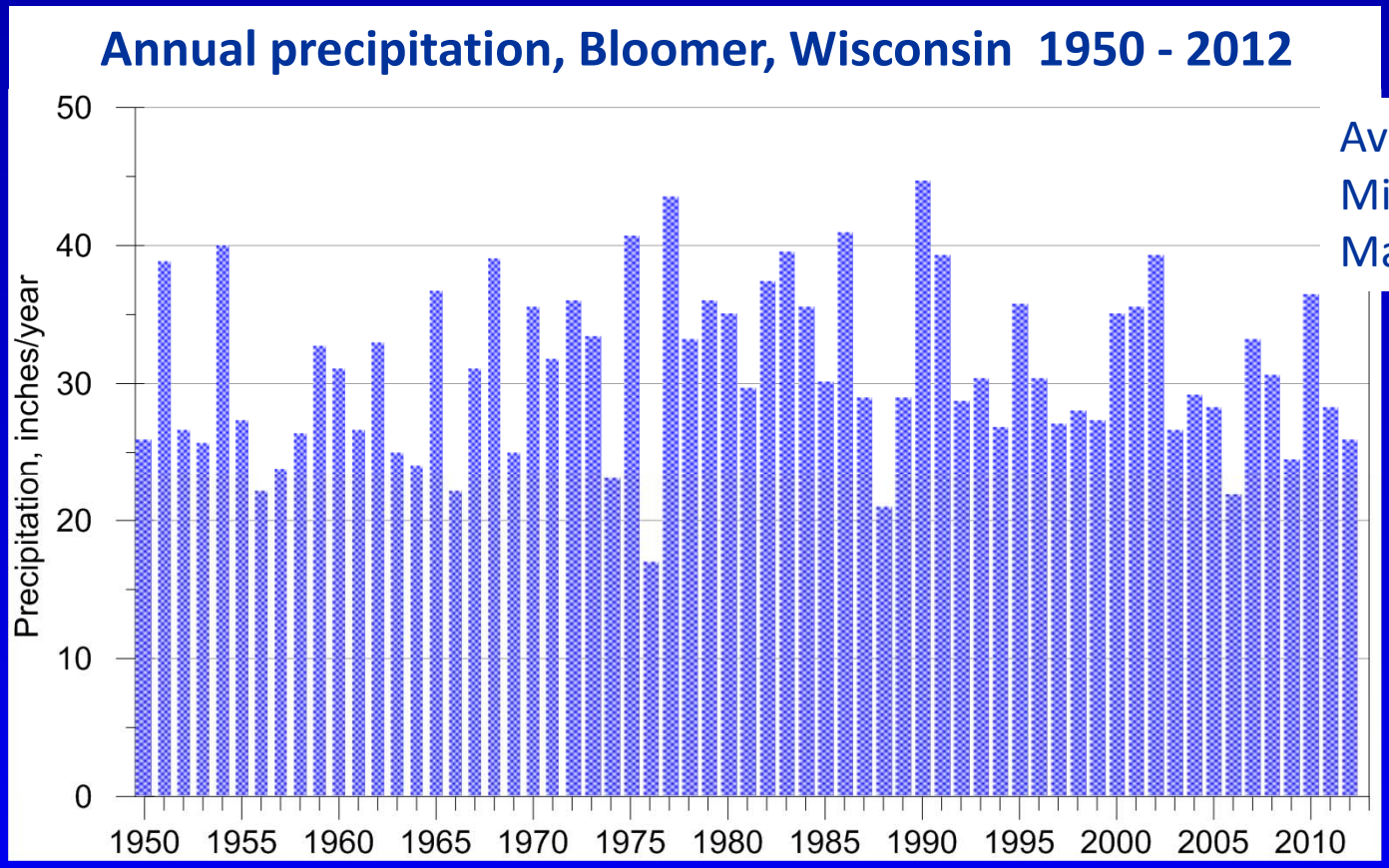




Climate

Precipitation – Snow or rain

Temperature – Evapotranspitation by plants, snow melt



Average 31 inches
Min. 17 inches
Max. 44.5 inches

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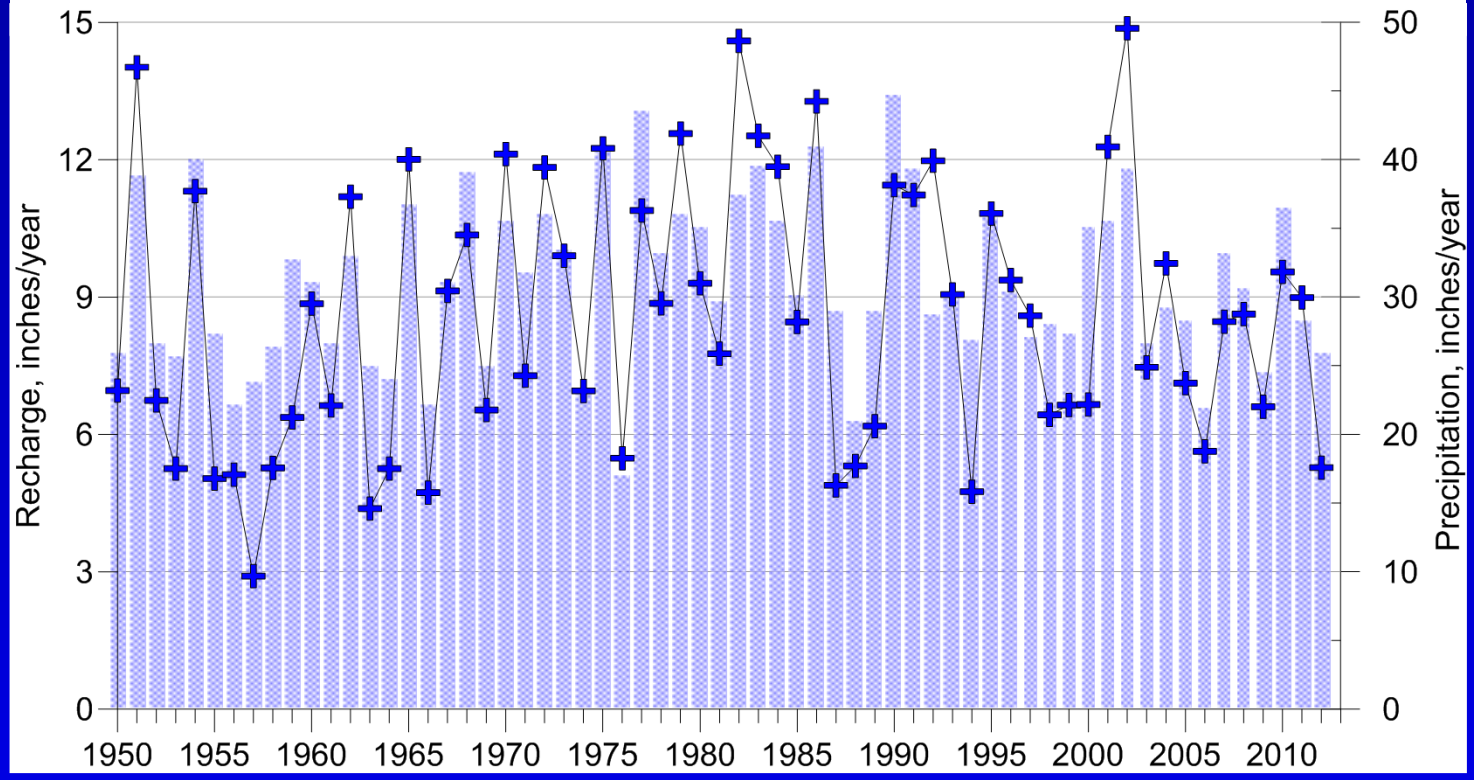
Estimated annual average recharge, 1950 - 2012



Recharge
Precipitation

Average 8.5 inches
Min. 3 inches
Max. 15 inches

In the study area, about 27% of precipitation recharges groundwater.

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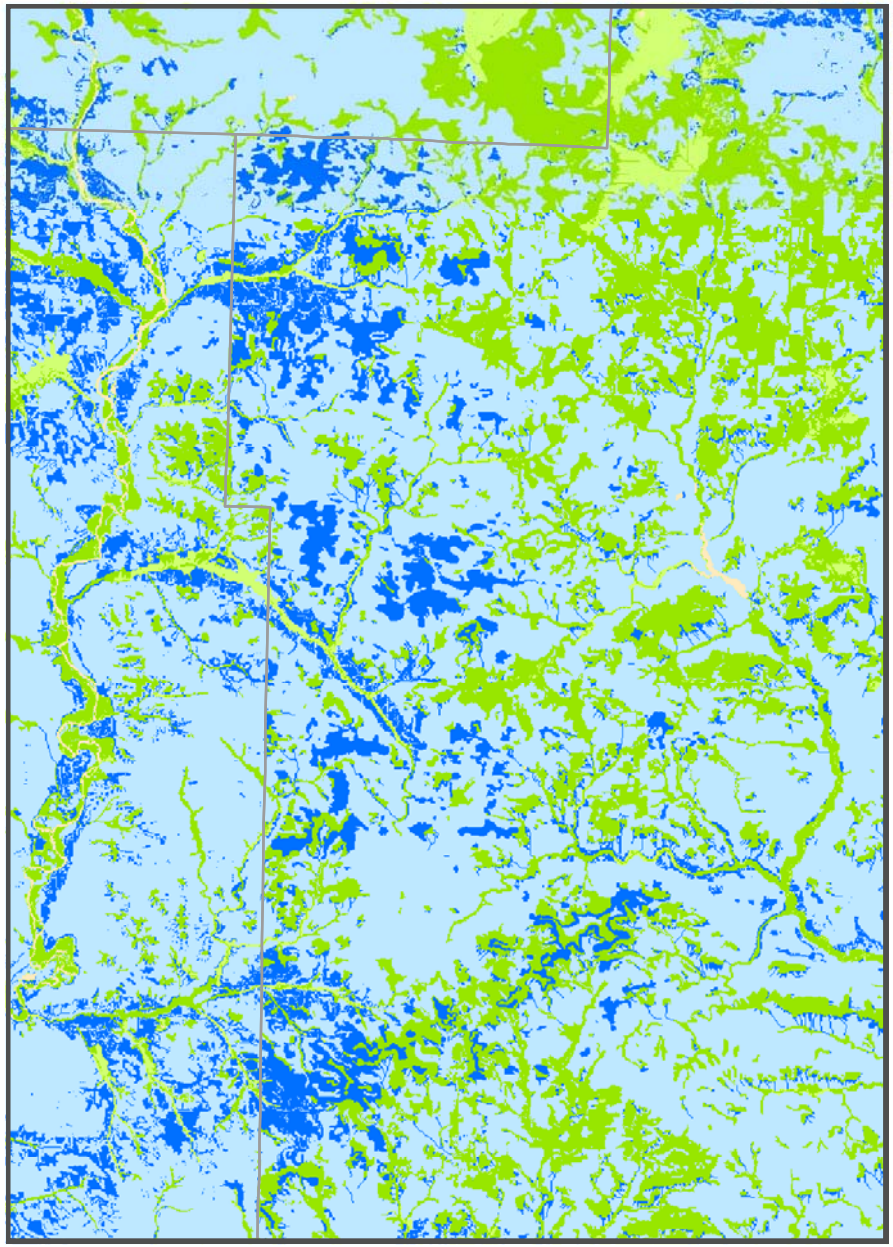
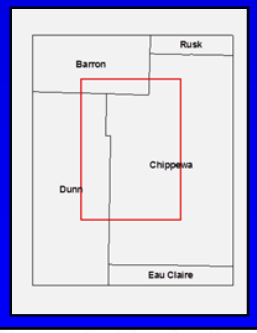
Estimated recharge, 2001



Recharge, inches/year

- 0 - 2
- 2 - 4
- 4 - 8
- 8 - 16
- > 16



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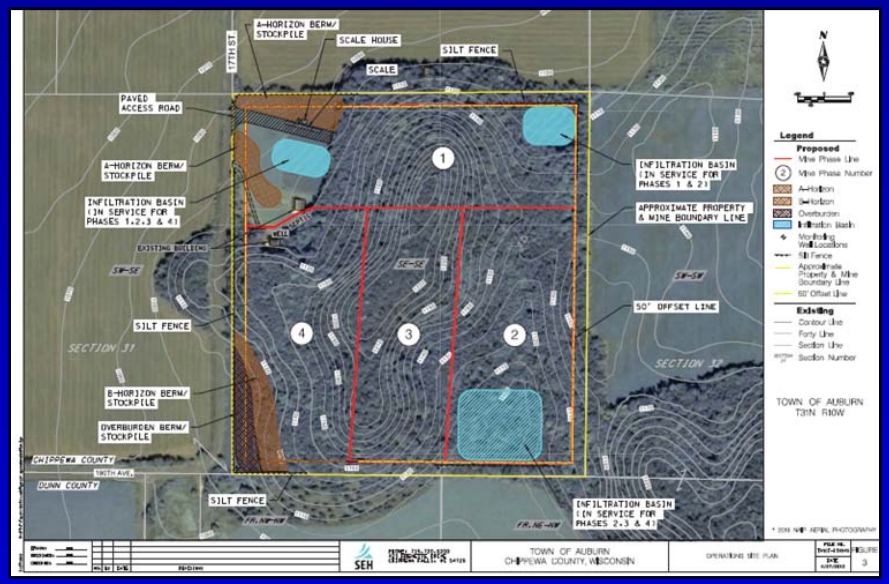
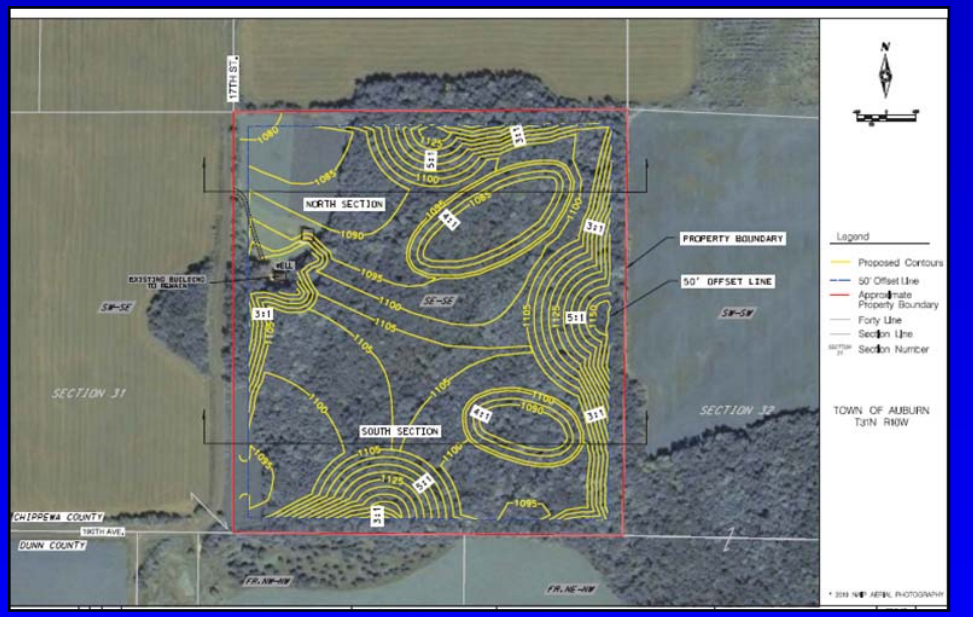
What post-mine conditions will effect recharge?

- Topography
- Land cover
  - tree canopy, pasture, etc.
- Soil compaction
- Fines in sub-soil
- Runoff control
- Constructed infiltration areas?
- Non-mined areas?





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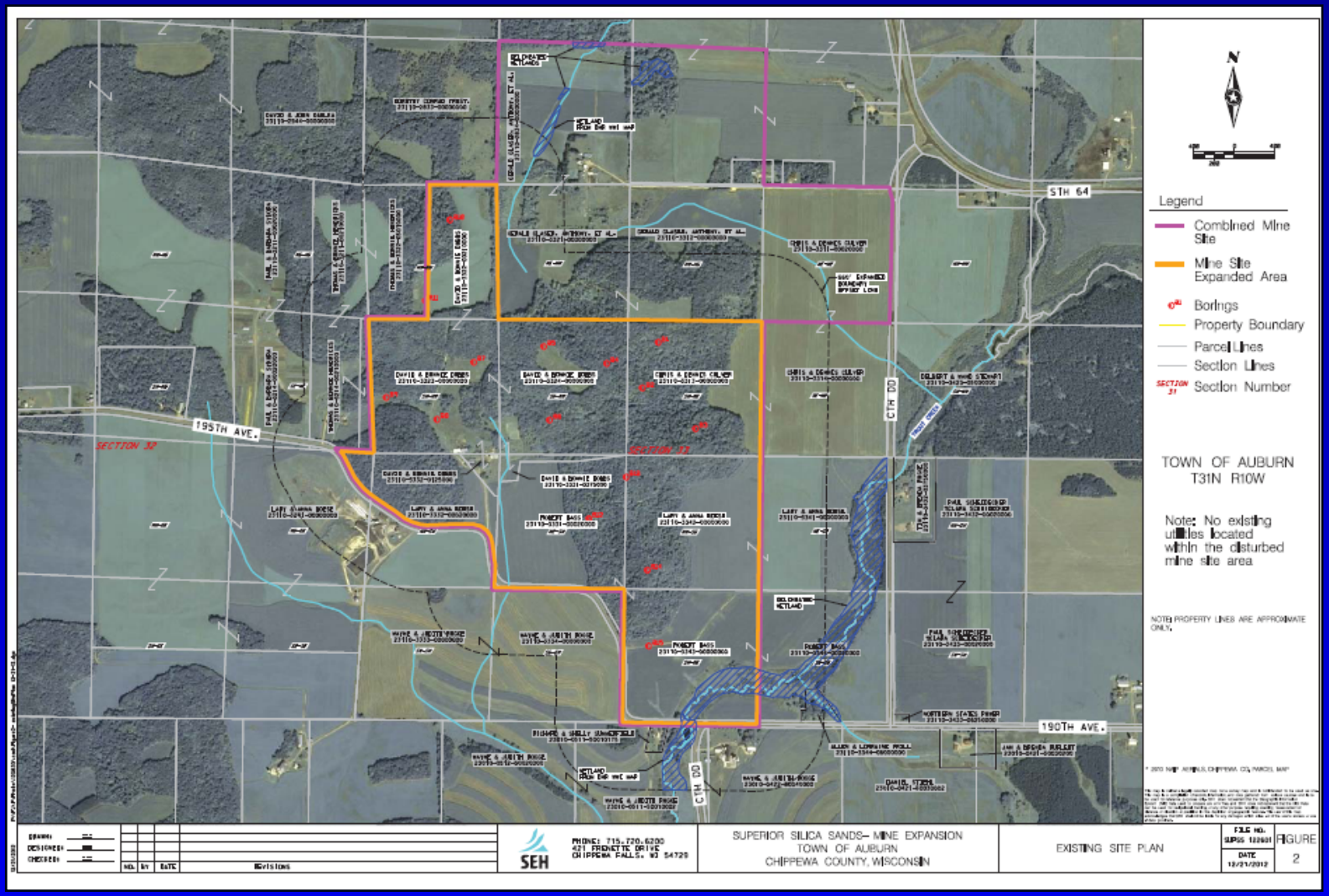

- Topography
- Land cover
  - tree canopy, pasture, etc.
- Soil compaction
- Fines in sub-soil

- Runoff control
- Constructed infiltration areas?
- Non-mined areas?

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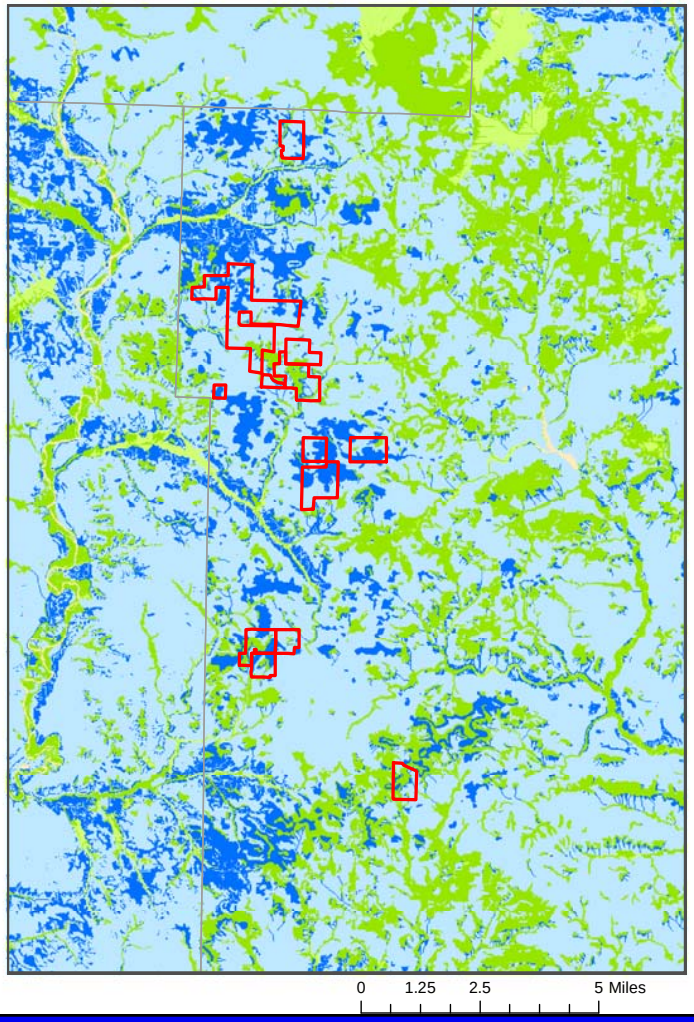
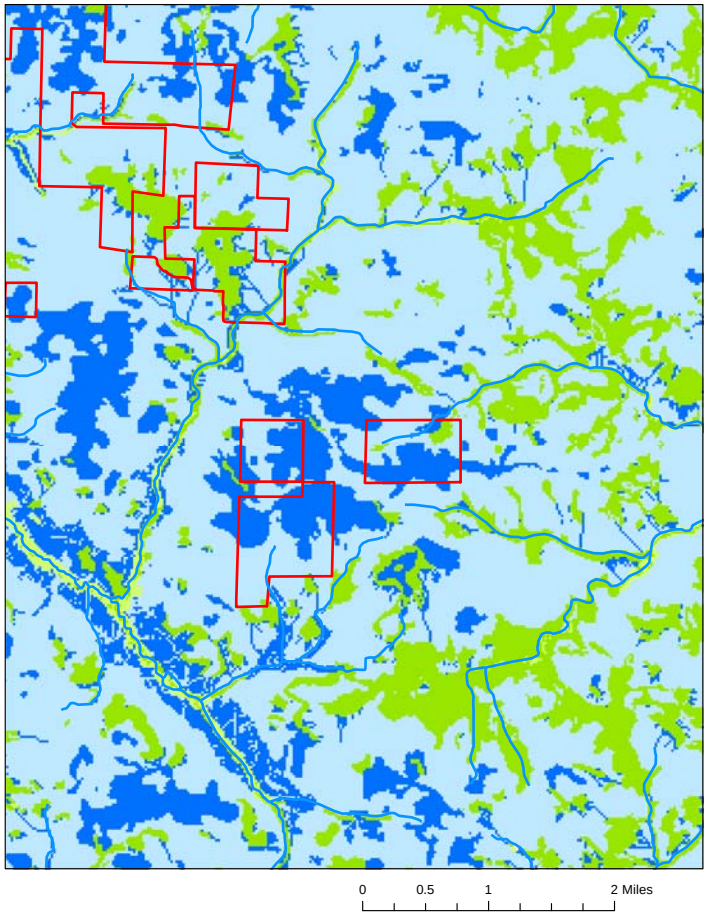
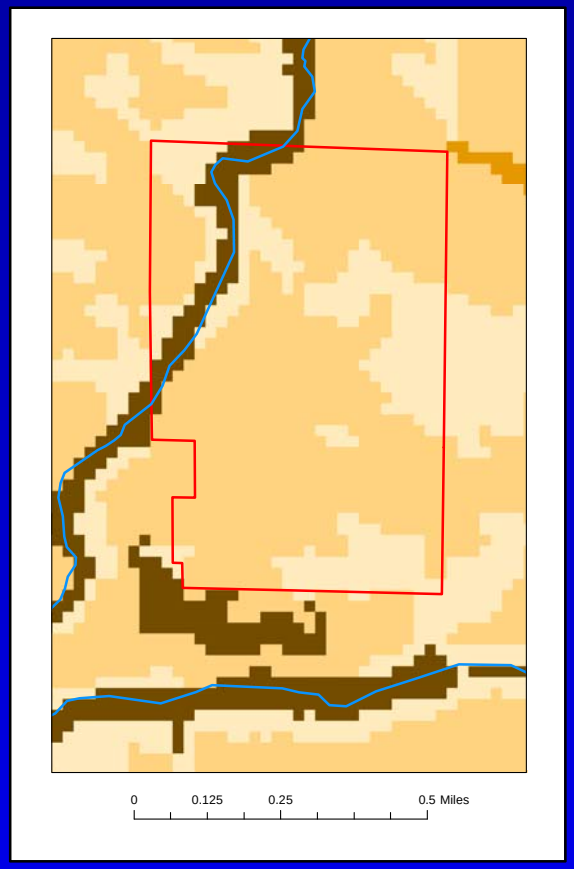
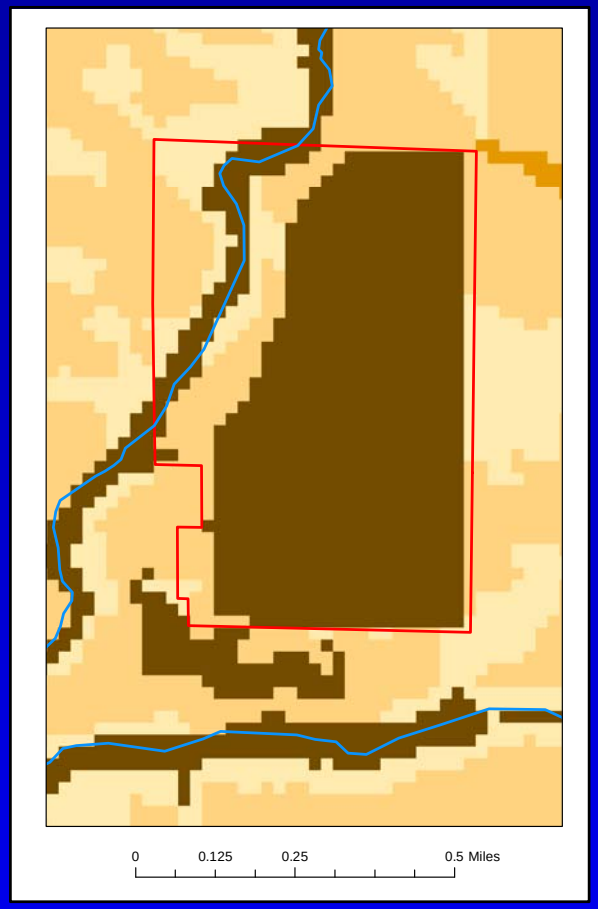

0
1.25
2.5
5 Miles

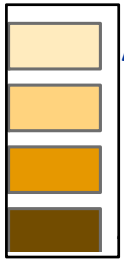

0
0.5
1
2 Miles

Soils pre-mine, high infiltration



Are reclaimed areas compacted?





A **high infiltration, low runoff**

B

C

D **low infiltration, high runoff**

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Wisconsin Geological & Natural History Survey

Today's outline

- Brief review of study *(WGNHS / USGS)*
- Progress to date *(WGNHS / USGS / Chippewa Co.)*
  - Subsurface data collection
  - Hydrostratigraphy
  - Water-use data collection
  - Compilation of site data for modeling
  - Soil water balance (SWB) modeling
- **Focused stakeholders discussion**
  - SWB, reclamation, and future scenario testing
- What's next ?
- Other agenda items to include / discussion ?

Focused stakeholders discussion

- Soil-water-balance (SWB) modeling, reclamation, and future scenario testing…
  - Discussion starter by WGNHS
  - Examples of reclamation plans and early stages of mine reclamation (Chippewa Co. and mine companies)
  - New UW-River Falls study overview
  - Group discussion about what post-reclamation conditions might look like in western Chippewa Co.

Today's outline

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What's next...

- Finish building model layers
  - Subsurface data available in the near future can still be integrated into the hydrostratigraphic interpretation
- Build groundwater flow model
- Integrate today's focused stakeholders outcomes into preliminary future scenario testing
- Compile data for model calibration
  - Stream flows, water levels in wells

Upcoming meetings and deliverables

- **Public meeting tonight at the Bloomer Middle School**
  - **5:00 – 7:00pm Outreach workstations**
  - **7:00 – 9:00 pm Public meeting**
- Next meetings (2015 annual update)
  - Stakeholders meeting – Q1 2015
  - General public meeting – Q1 2015
- Deliverables
  - Interim report – Q4 2014 (data collection and SWB modeling results)
  - Final report – Q3 2017 (final model, scenarios, transferability results)

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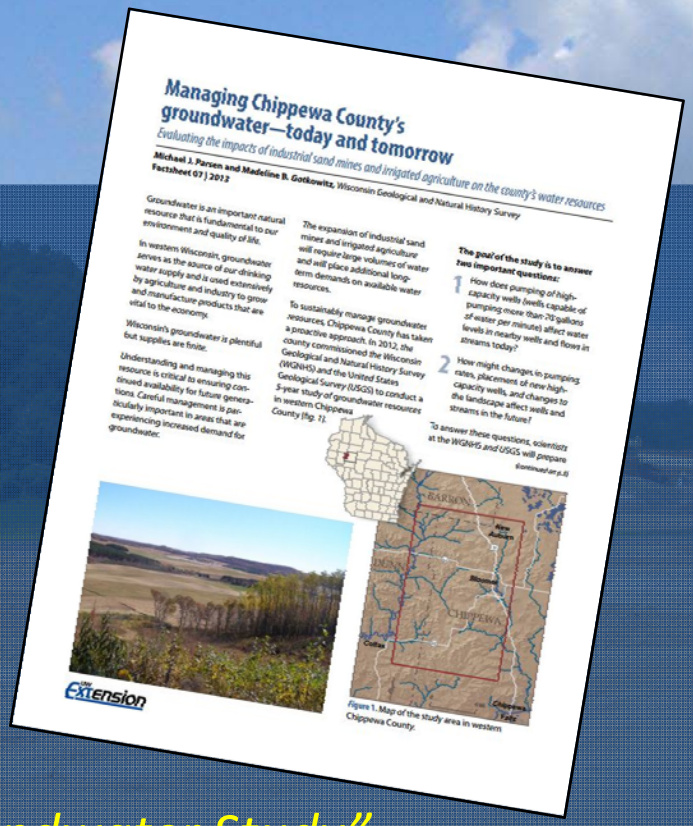
Chippewa County Groundwater Study

3rd Stakeholders Group Meeting



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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