A Groundwater Flow Model for Columbia County, Wisconsin
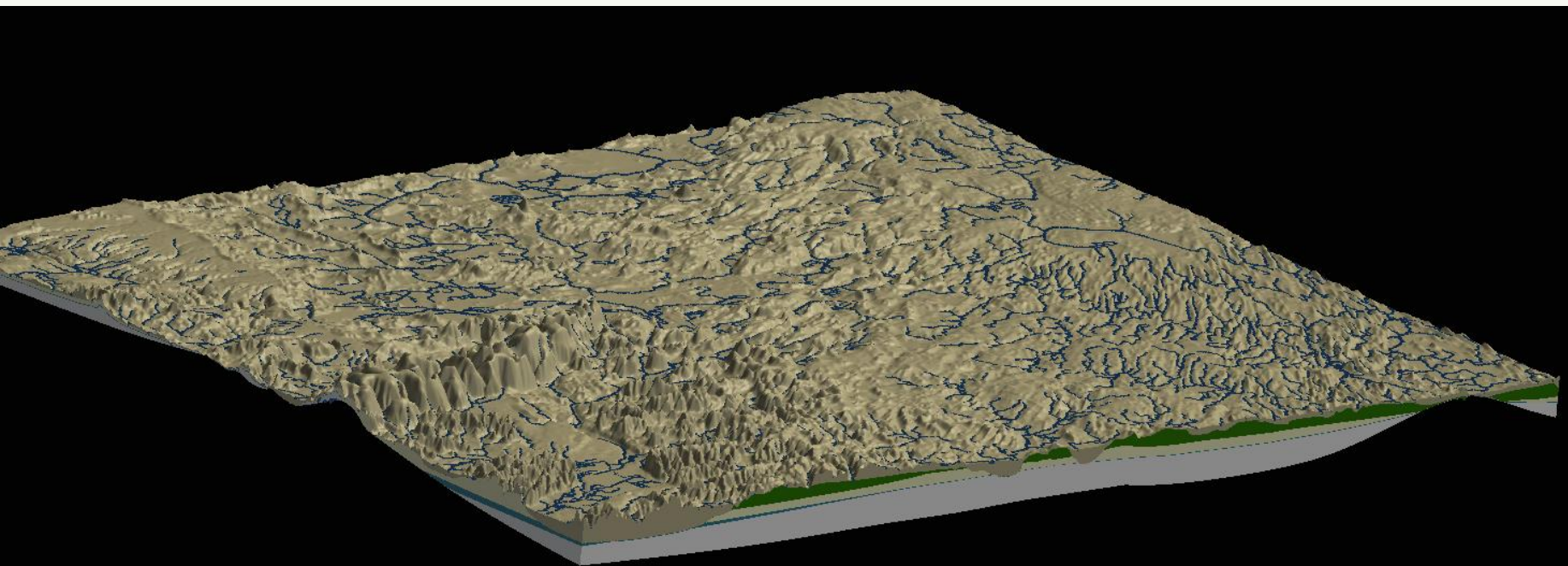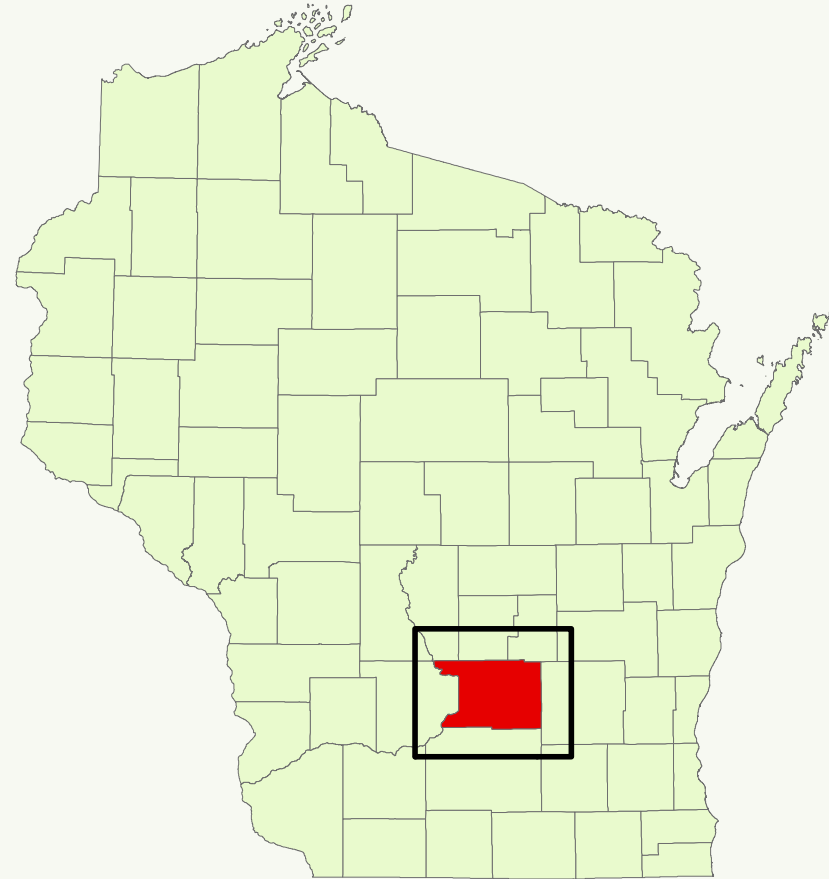
Andrew Leaf (USGS), Madeline Gotkowitz (WGNHS), and Charles Dunning (USGS)

USGS

UW Extension

Columbia County

- Groundwater used exclusively for water supply

- >20% of almost 3,000 groundwater samples exceeded drinking water standard of 10 mg/L nitrate

Project Goals

- Identify areas of the county where groundwater is susceptible to contamination

- Identify important groundwater recharge areas in the county, and the connection of groundwater to valued streams, springs and lakes

- Understand effects of well design on well water quality; identify the best locations and depths for siting new wells

Approach – project phases

1. **Baseline groundwater information**
    *   Water table map
    *   Recharge map
    *   Groundwater susceptibility map

2. **Bedrock geologic map**
    *   See posters by Esther Stewart and Jay Zambito (WGNHS)

3. **Hydrogeologic investigation and groundwater flow model**
    *   Delineation of important surfaces (Bedrock, Tunnel City, and Precambrian)
    *   Geophysical logging and packer testing
    *   Groundwater model

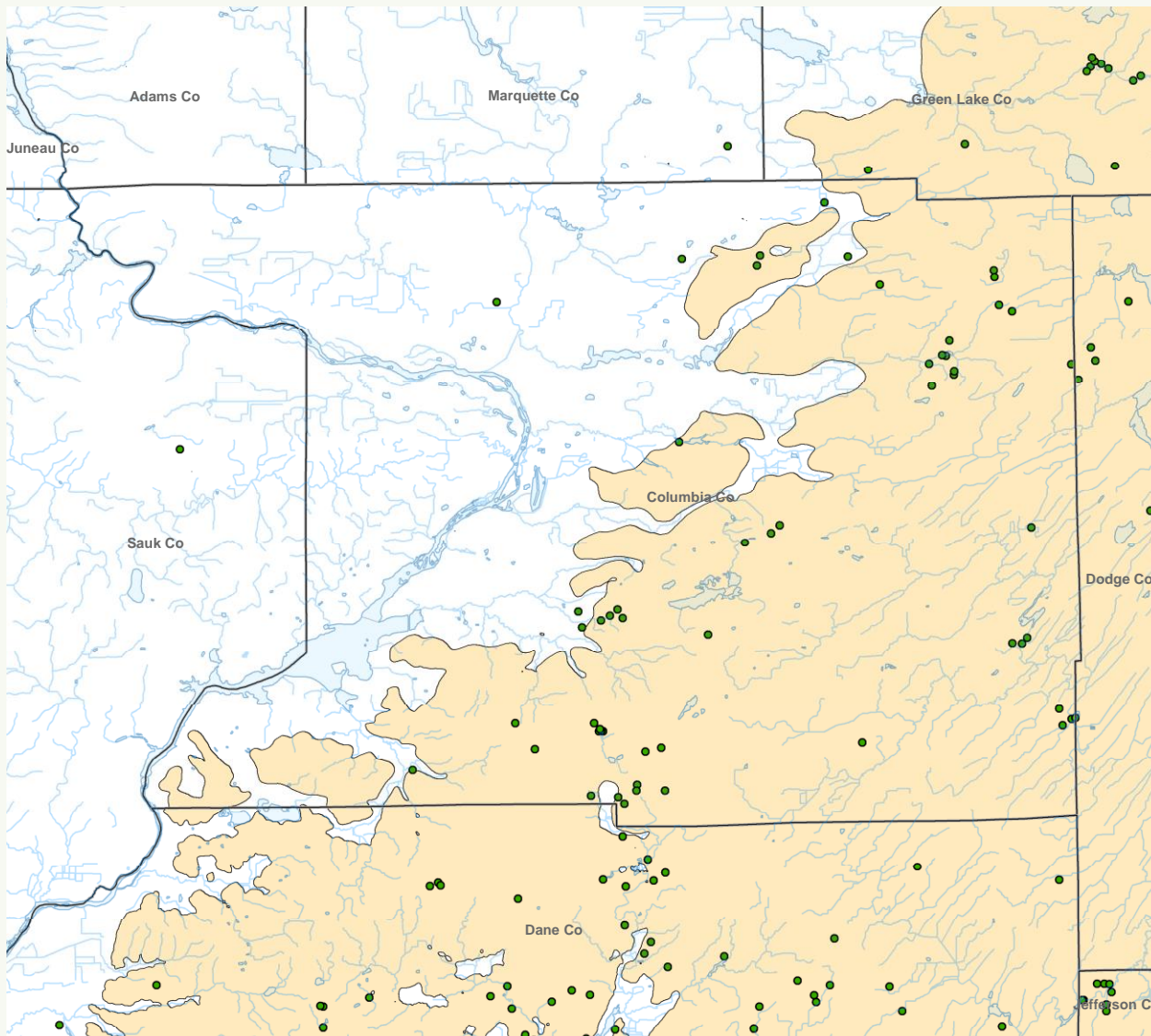# Hydrostratigraphic questions
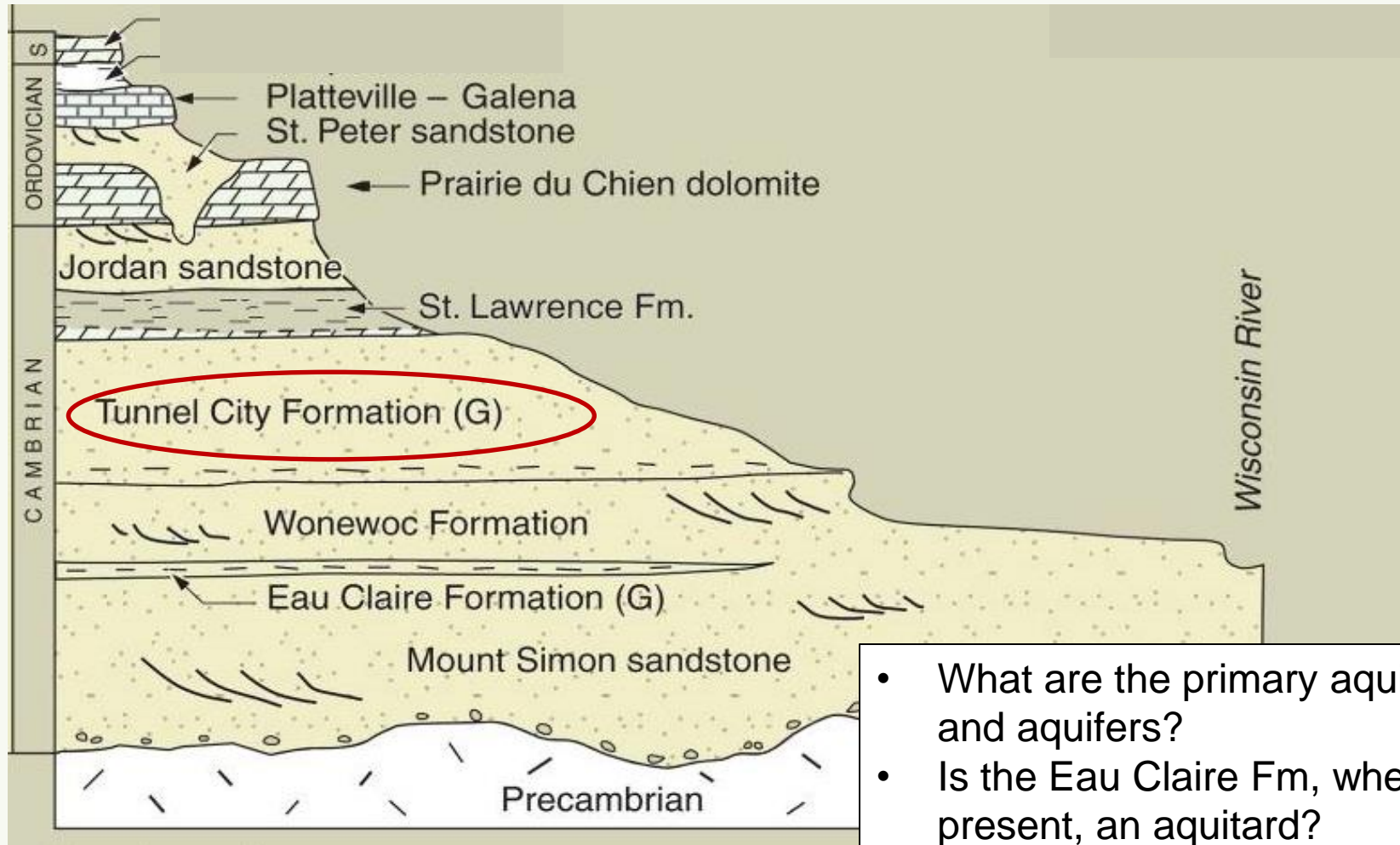
- What are the primary aquitards and aquifers?
- Is the Eau Claire Fm, where present, an aquitard?
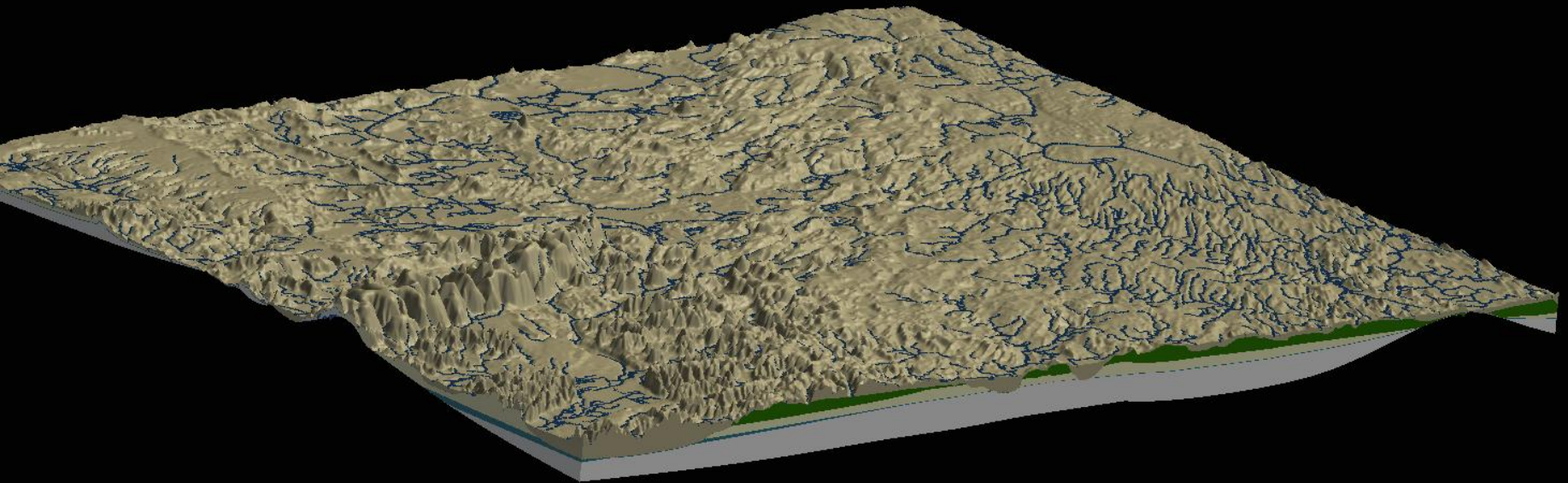
Packer testing and geophysical logging
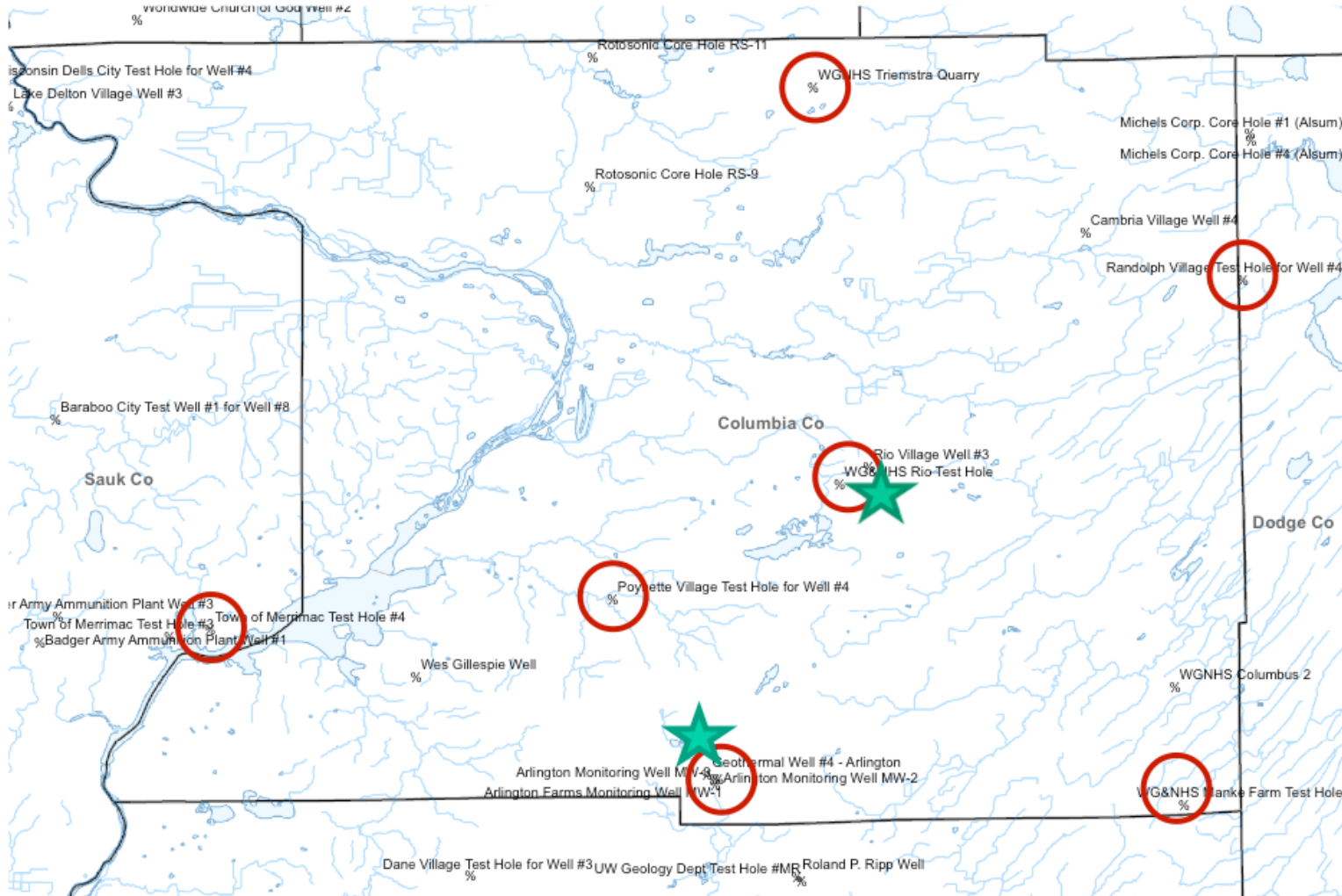
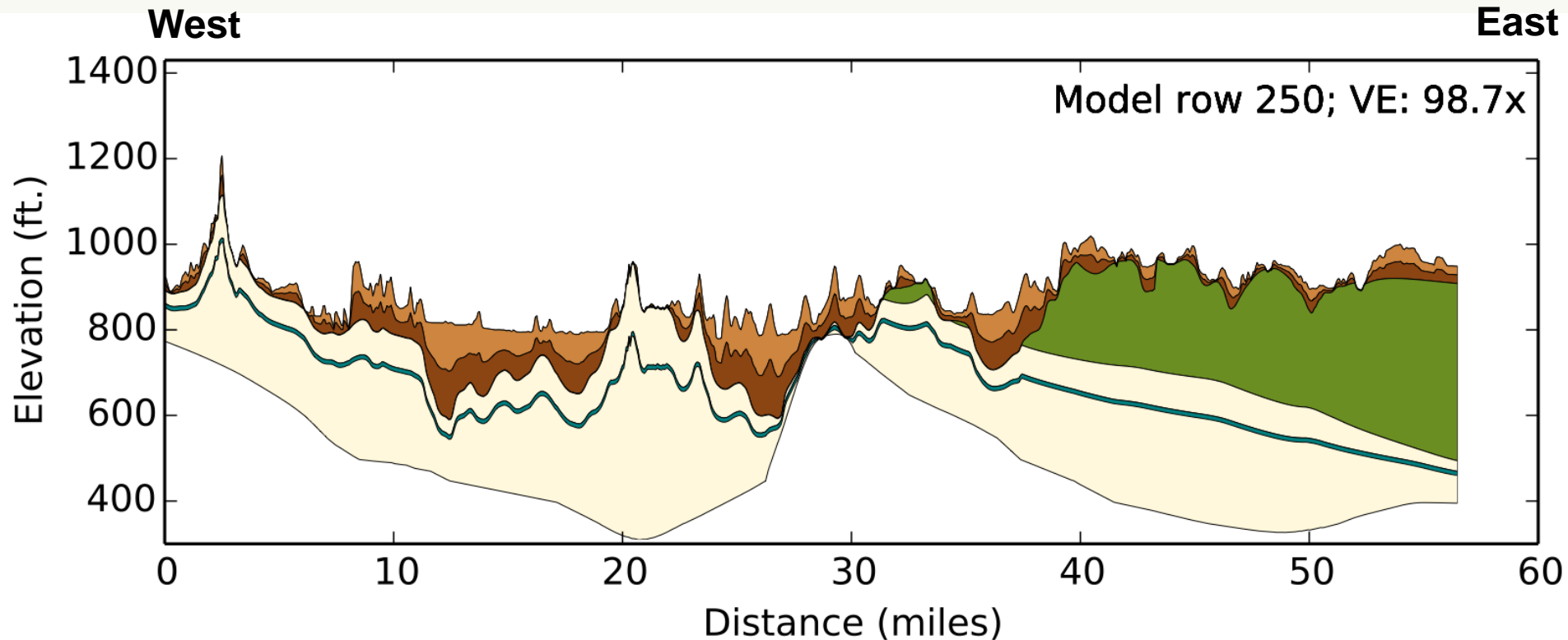○ Geophysical logs

⭐ Packer tests

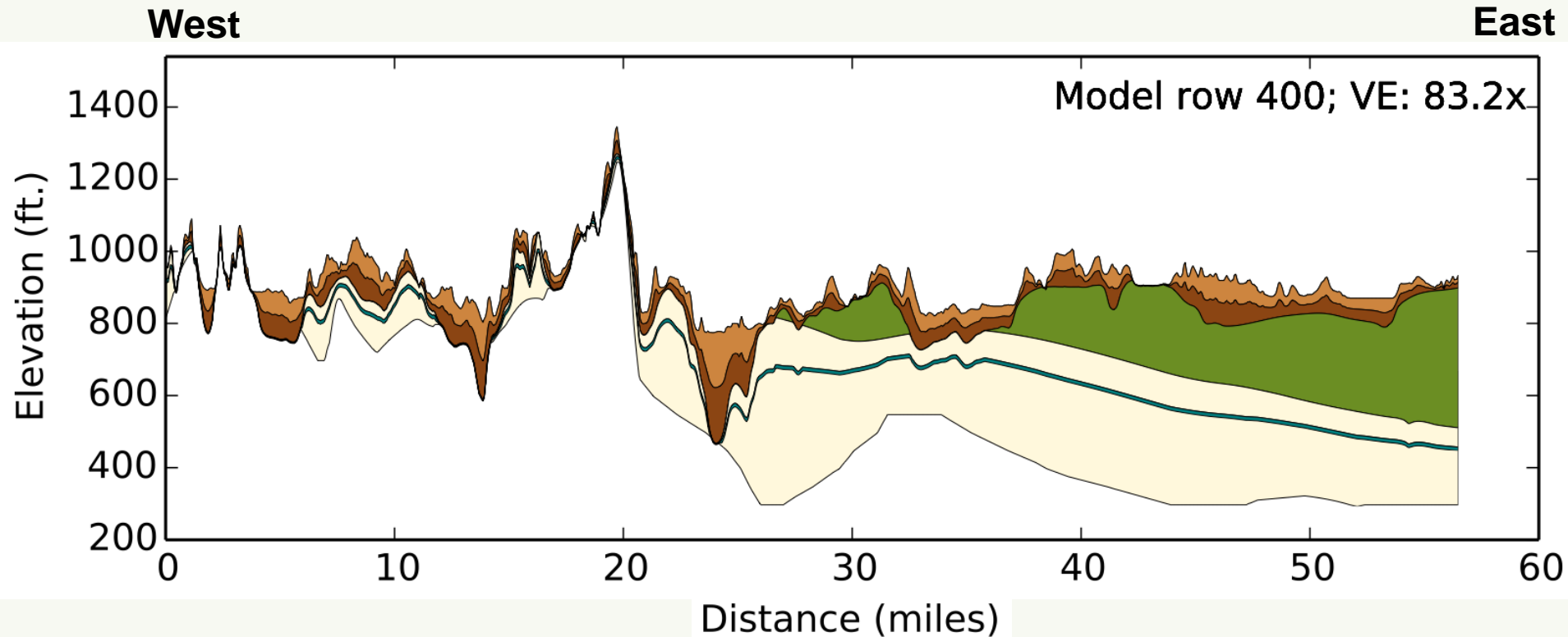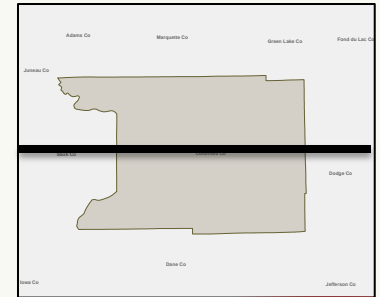# Extent of Tunnel City

Model construction

- 300 ft. uniform spacing, 6 layers, 4.8 million cells
- MODFLOW-NWT, SFR and MNW2 packages
- Recharge estimated with Soil Water Balance Code
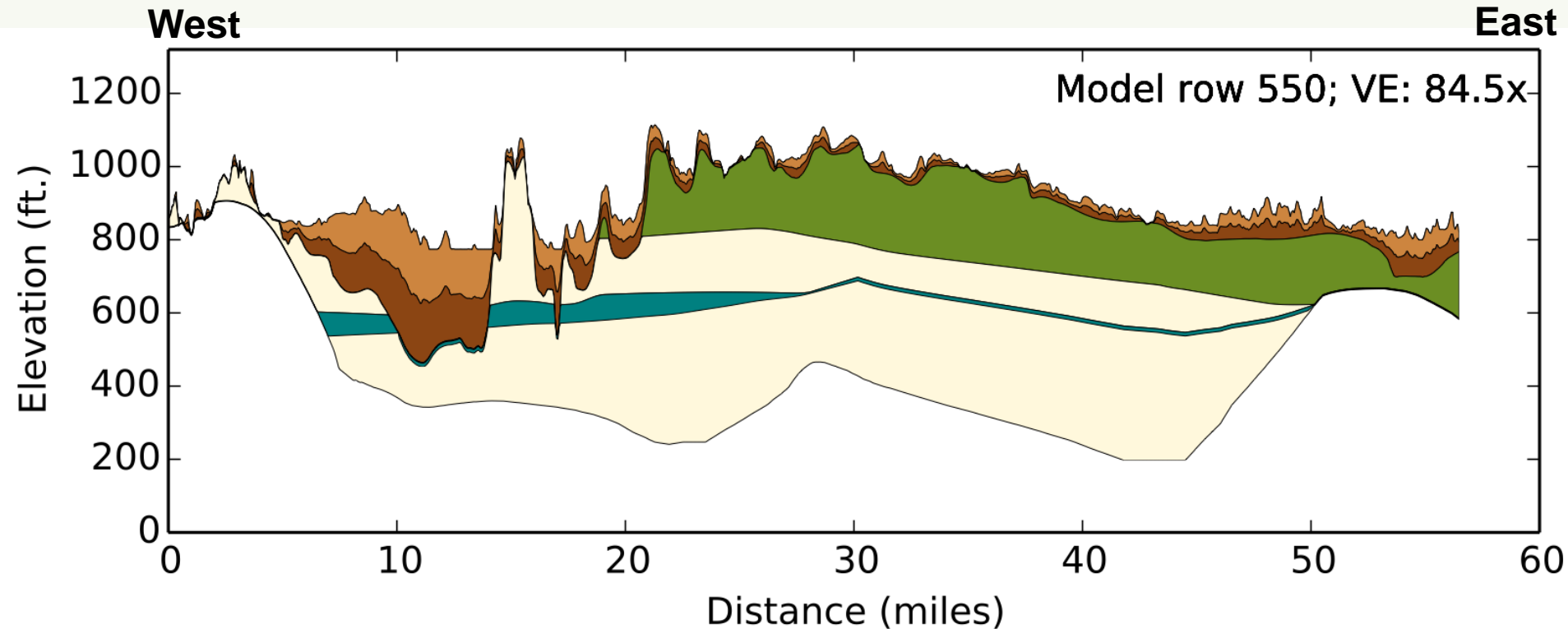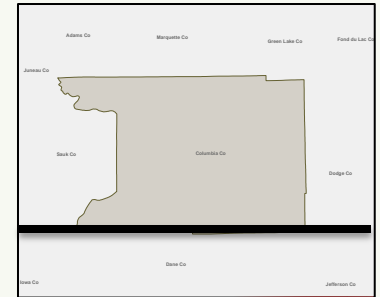- Specified flux boundaries estimated with GFLOW

Layer structure – northern Columbia Co.

West

East

Model row 250; VE: 98.7x

Layer structure – central Columbia Co.

West

East

Model row 400; VE: 83.2x

Layer structure – southern Columbia Co.

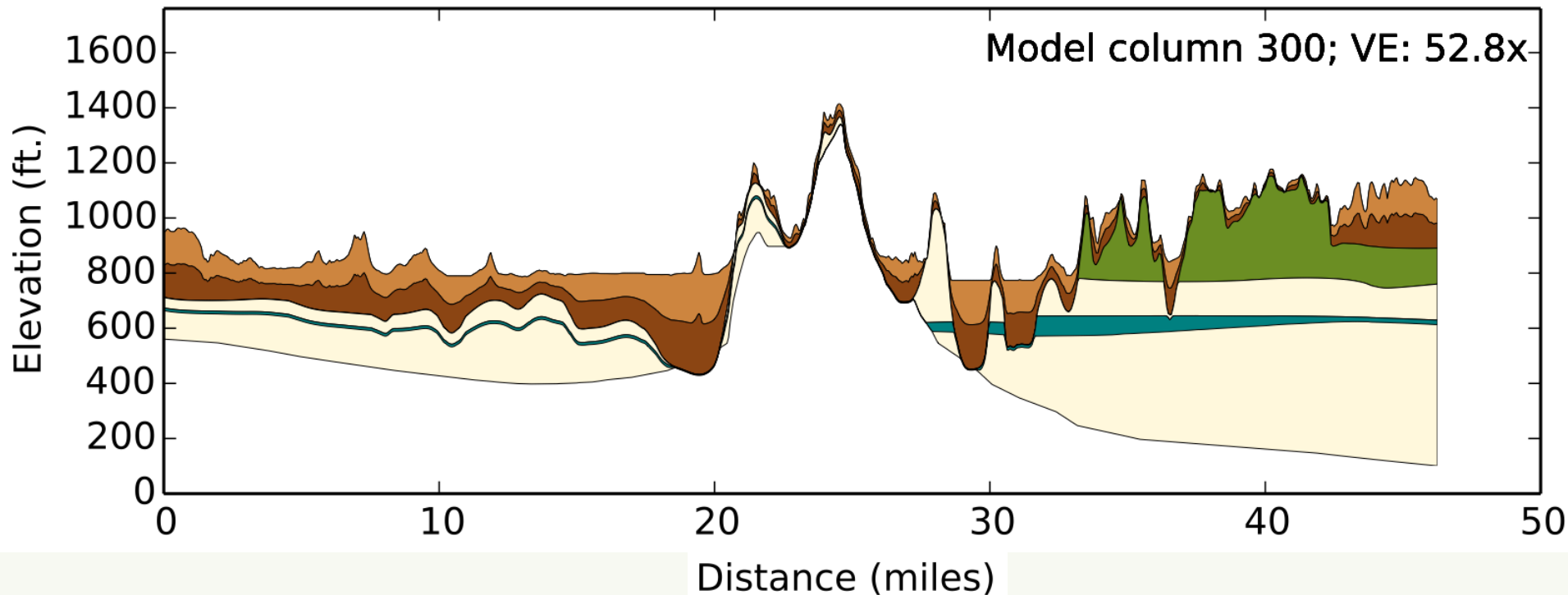A Groundwater flow model for Columbia County, WI   March 12, 2014

Layer structure – western Columbia Co.

Layer structure – eastern Columbia Co.

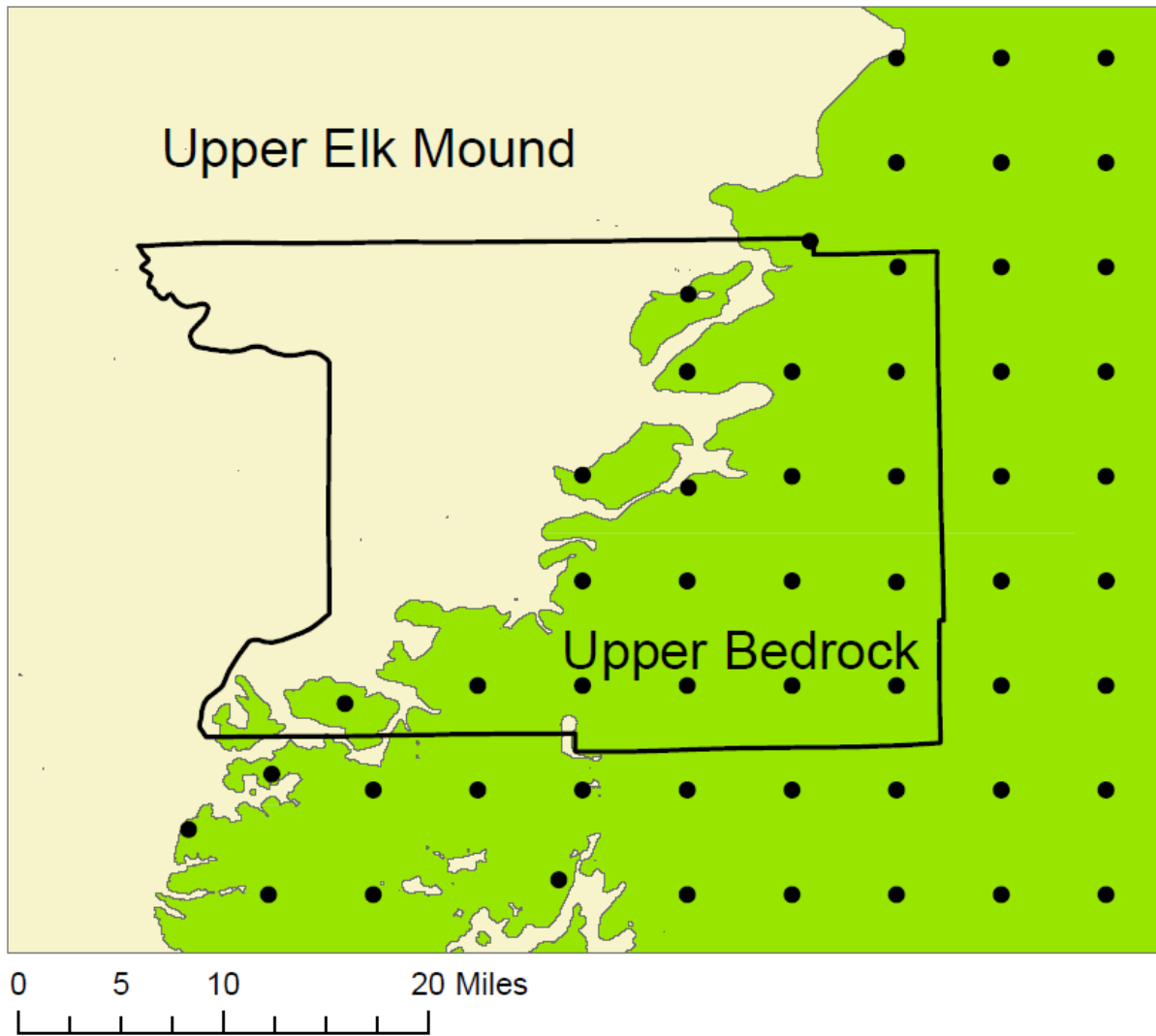A Groundwater flow model for Columbia County, WI   March 12, 2014
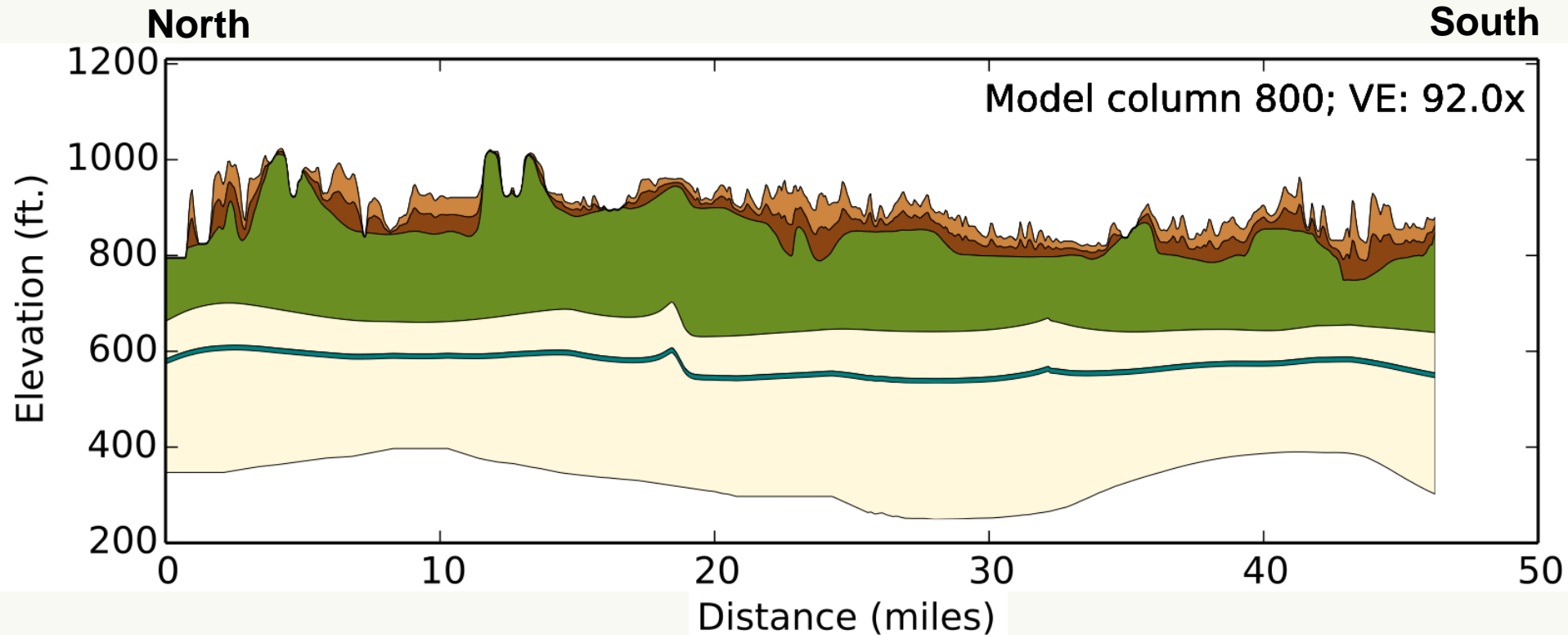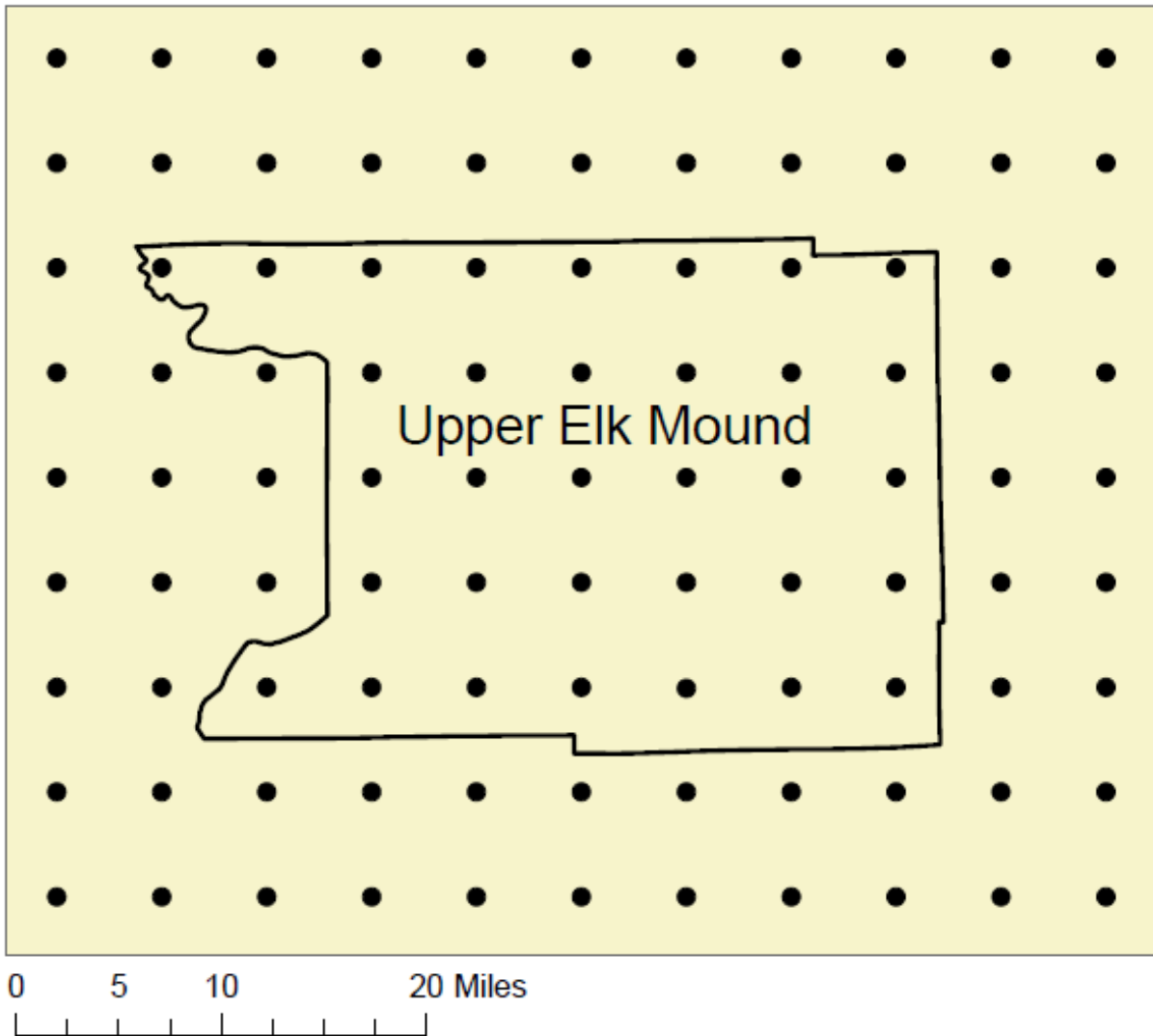
Hydraulic Conductivity – Layers 1 and 2
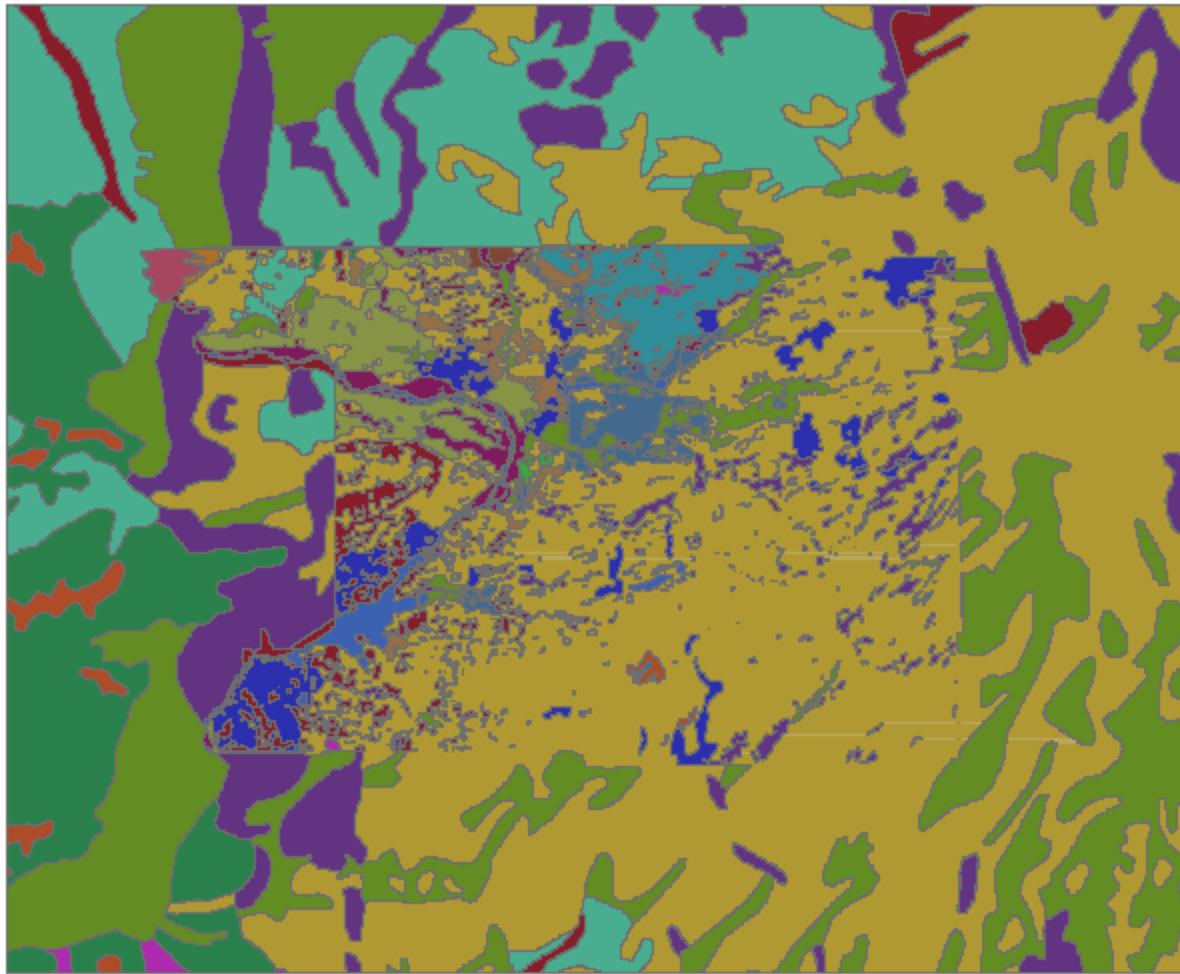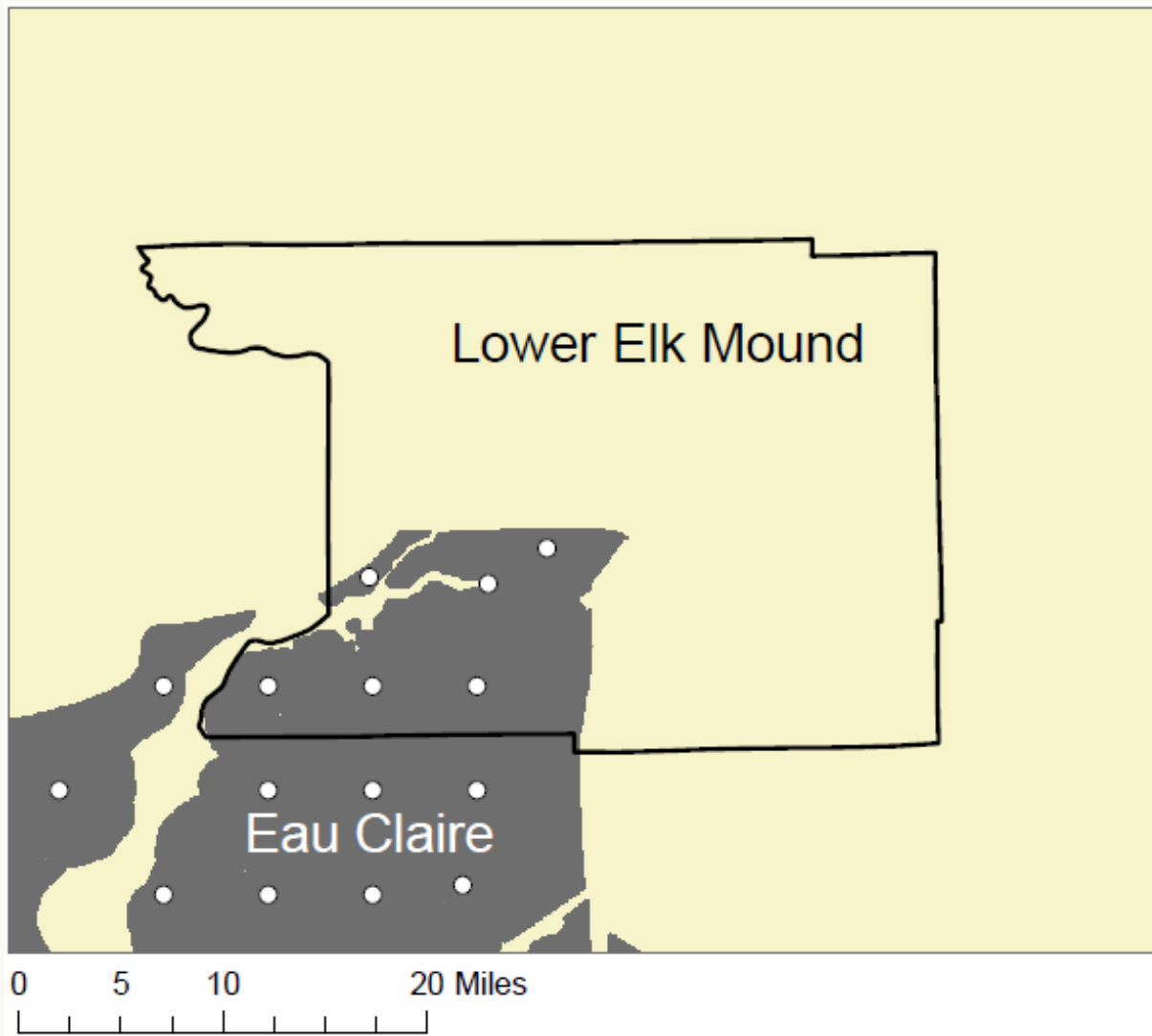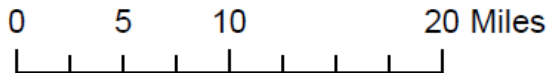

0   5   10   20 Miles
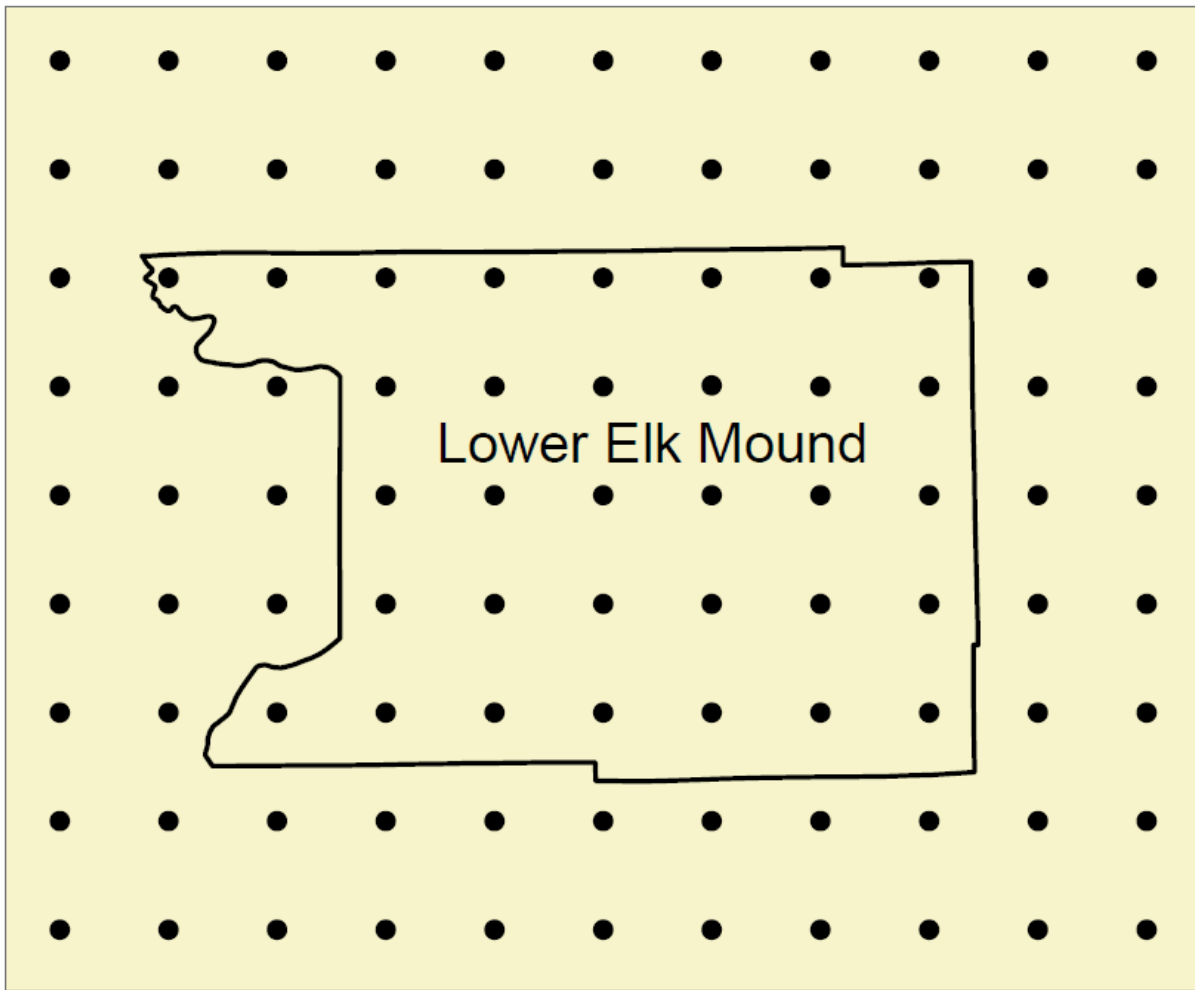
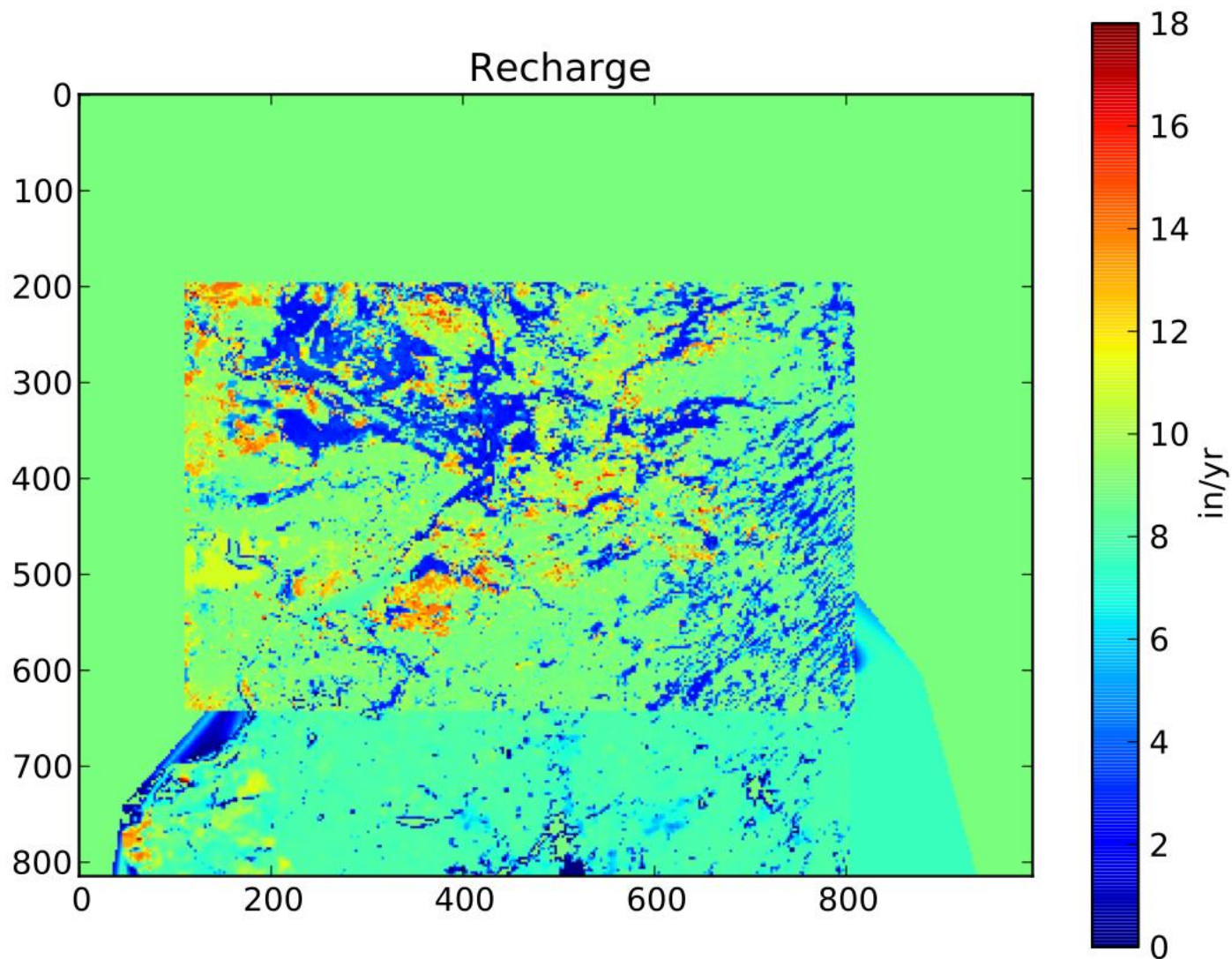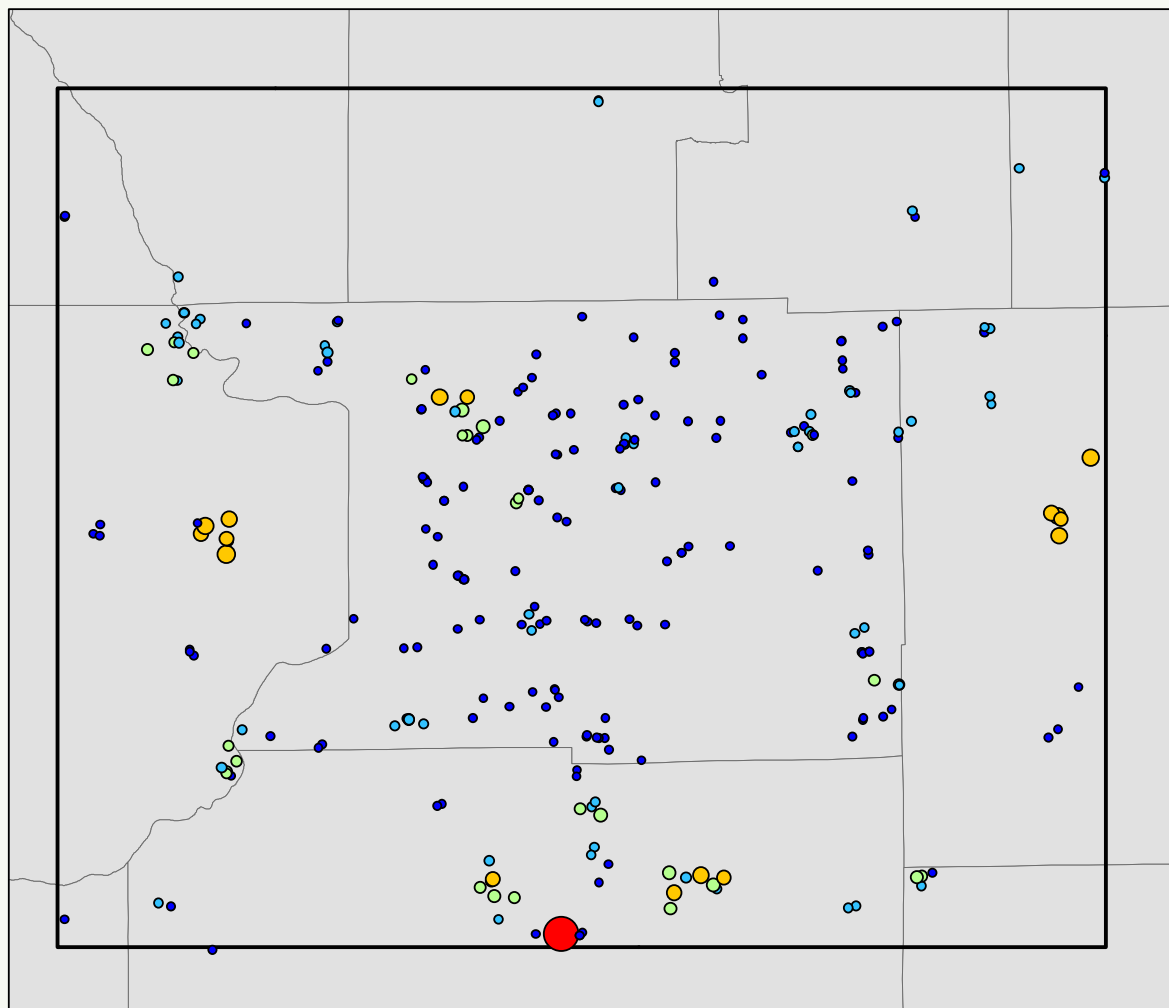# Hydraulic Conductivity – Layer 3

Hydraulic Conductivity – Layer 4

Upper Elk Mound

0   5   10   20 Miles

Hydraulic Conductivity – Layer 5

Hydraulic Conductivity – Layer 6

Recharge
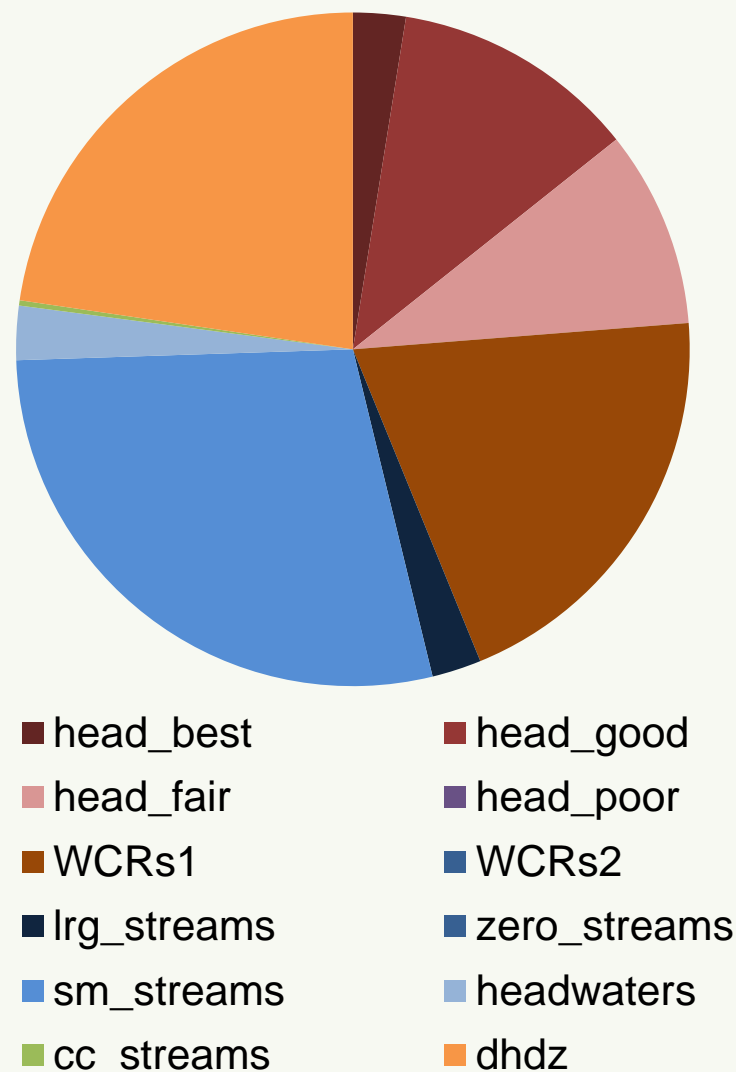
Pumping

Pumping Rates (gpm)
- 0 - 42
- 43 - 118
- 119 - 265
- 266 - 483
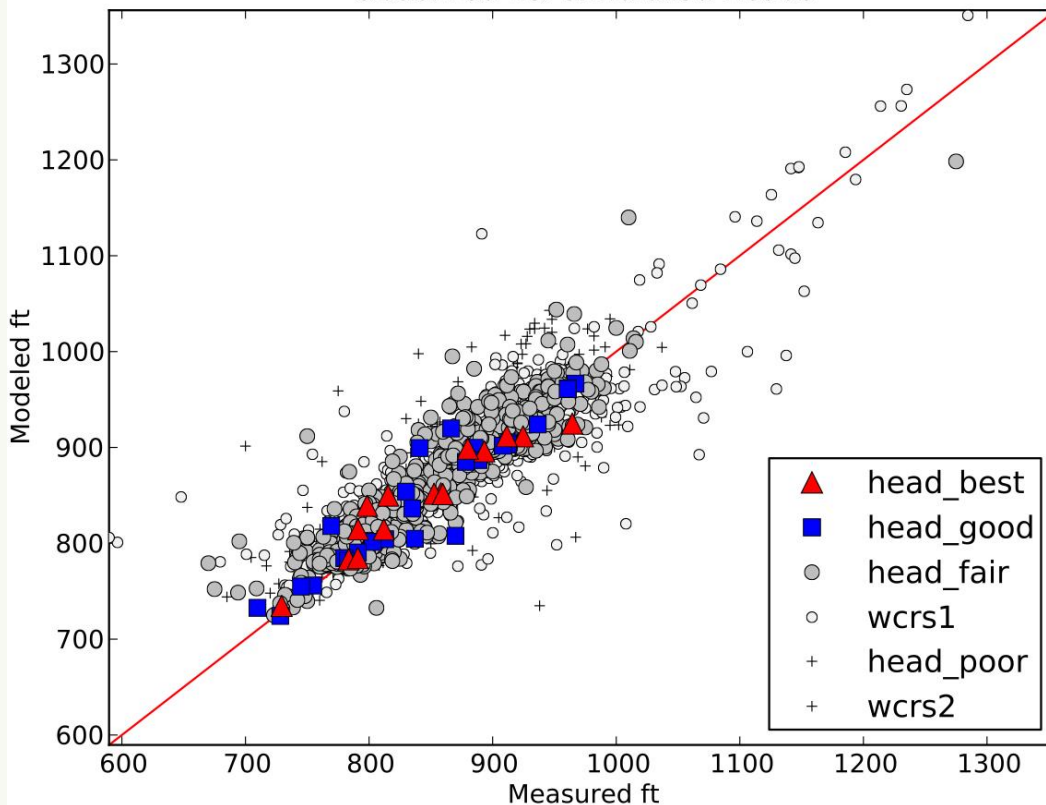- 484 - 1,309

0   5   10   20 Miles

Model Calibration

- PEST with SVD-Assist and Tikhonov regularisation

- 597 adjustable parameters

- 3939 head targets from the National Water Information System (NWIS) and Well Construction Reports (WCRs)

- 91 baseflow targets from NWIS and measured by WGNHS
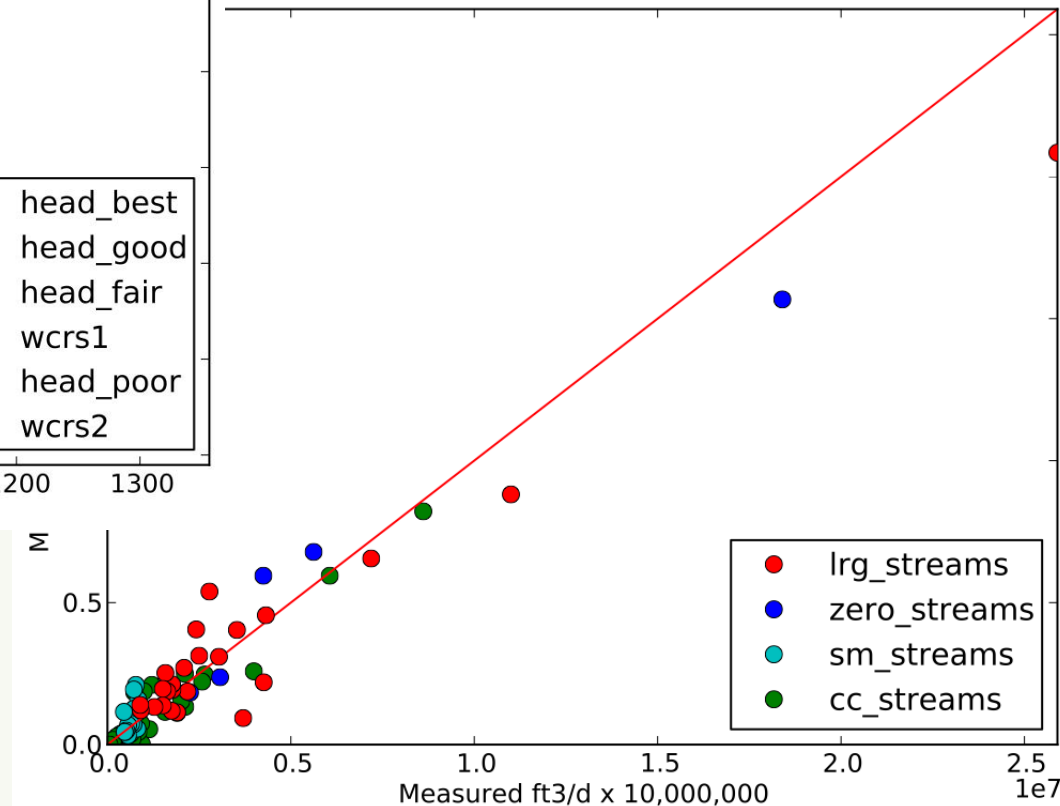
- 4 vertical head difference targets

- head_best
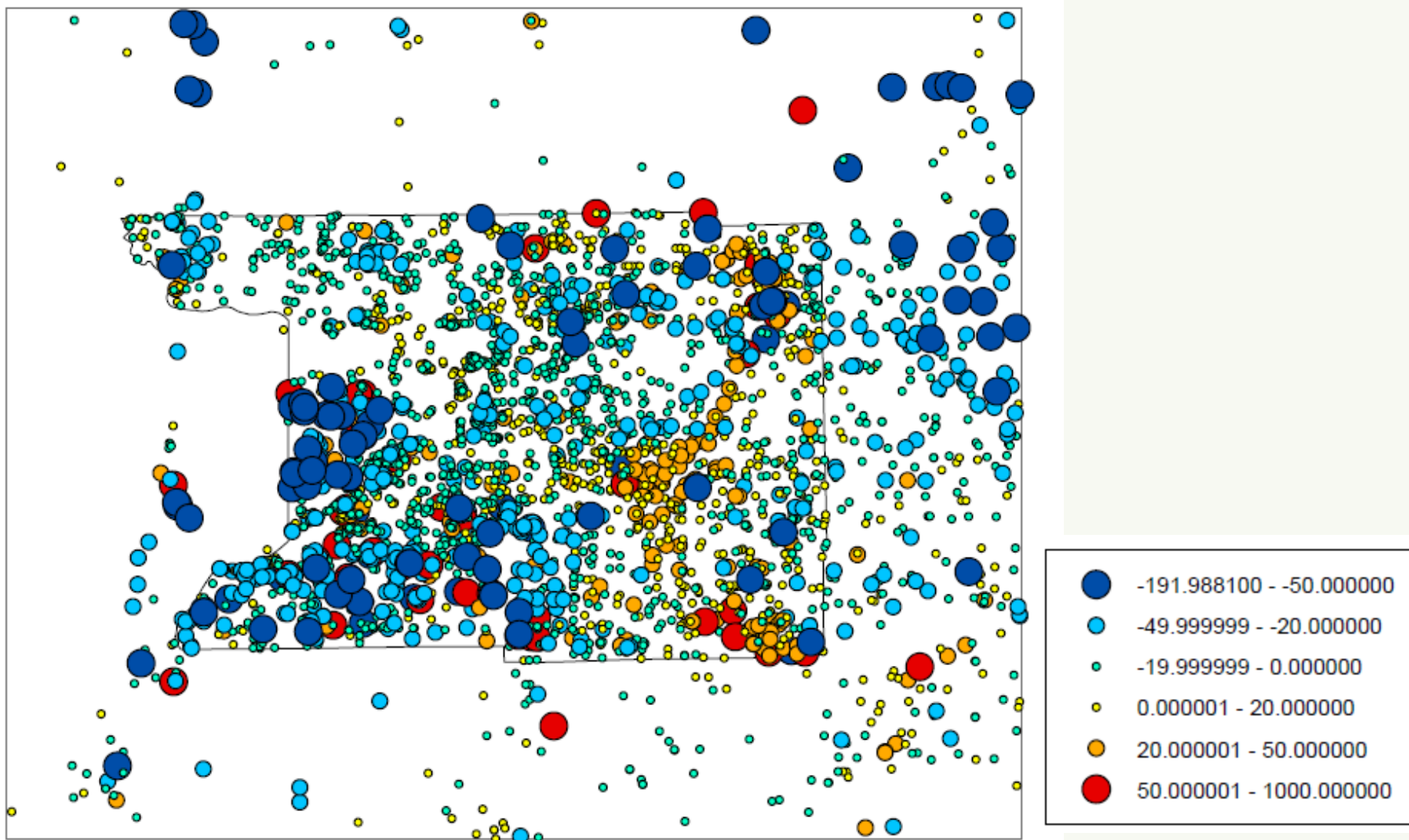- head_good
- head_fair
- head_poor
- WCRs1
- WCRs2
- lrg_streams
- zero_streams
- sm_streams
- headwaters
- cc_streams
- dhdz

Model Calibration

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
Model Calibration – head residuals

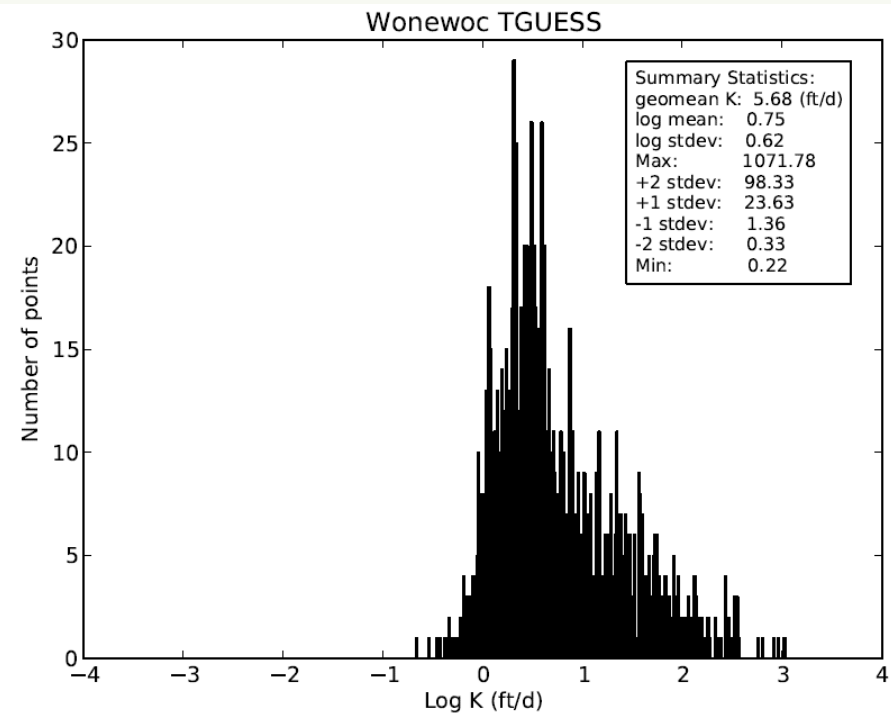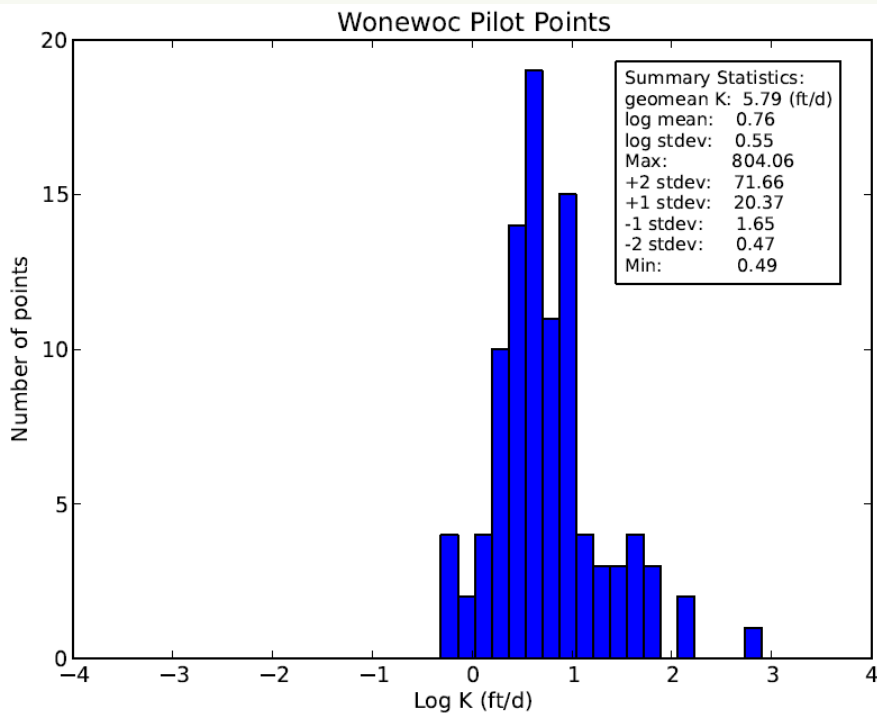|	
●	-191.988100 - -50.000000
●	-49.999999 - -20.000000
●	-19.999999 - 0.000000
●	0.000001 - 20.000000
●	20.000001 - 50.000000
●	50.000001 - 1000.000000

Model Calibration – flux residuals
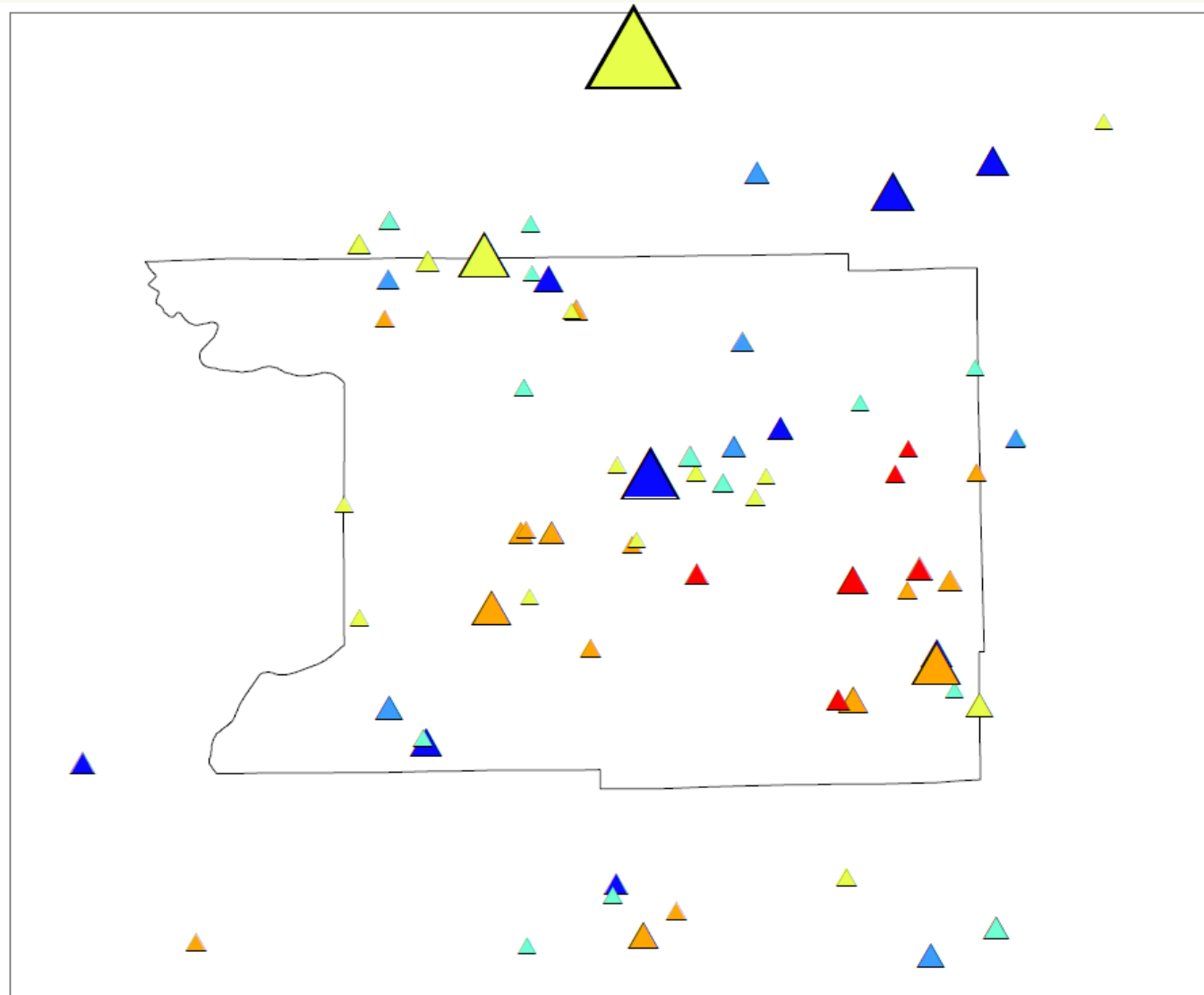
Flux residuals (percent error)

- ▲ -94 - -50
- ▲ -49 - -20
- ▲ -19 - 0
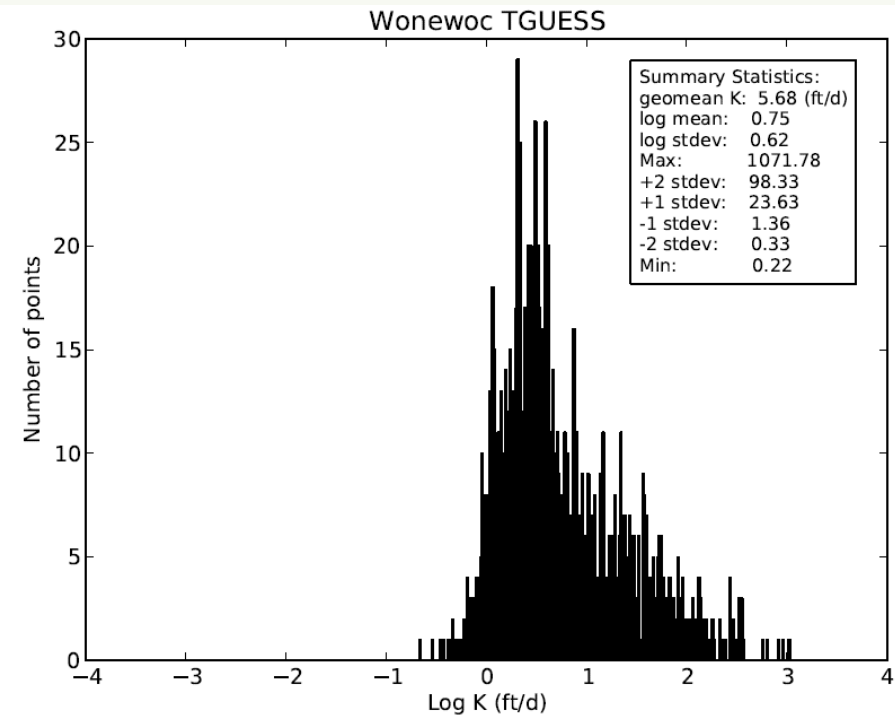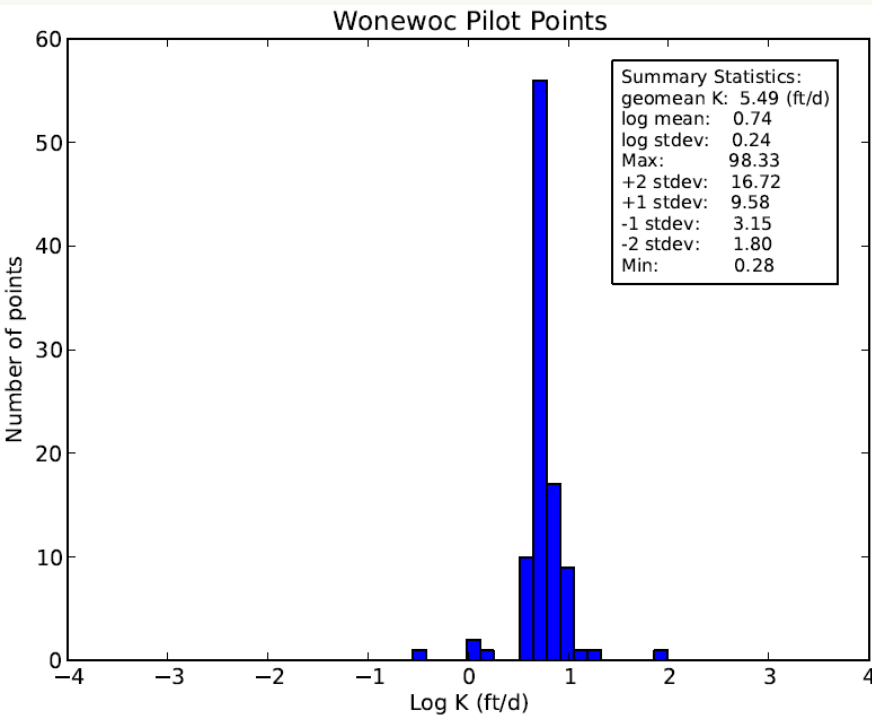- ▲ 1 - 20
- ▲ 21 - 50
- ▲ 51 - 500

Model Calibration – K- distribution
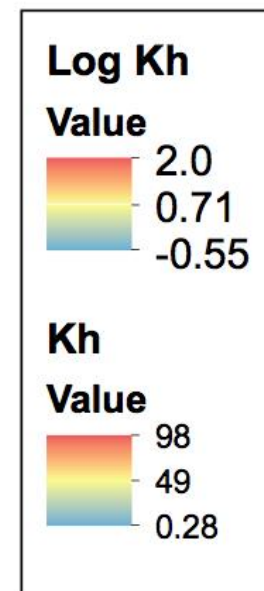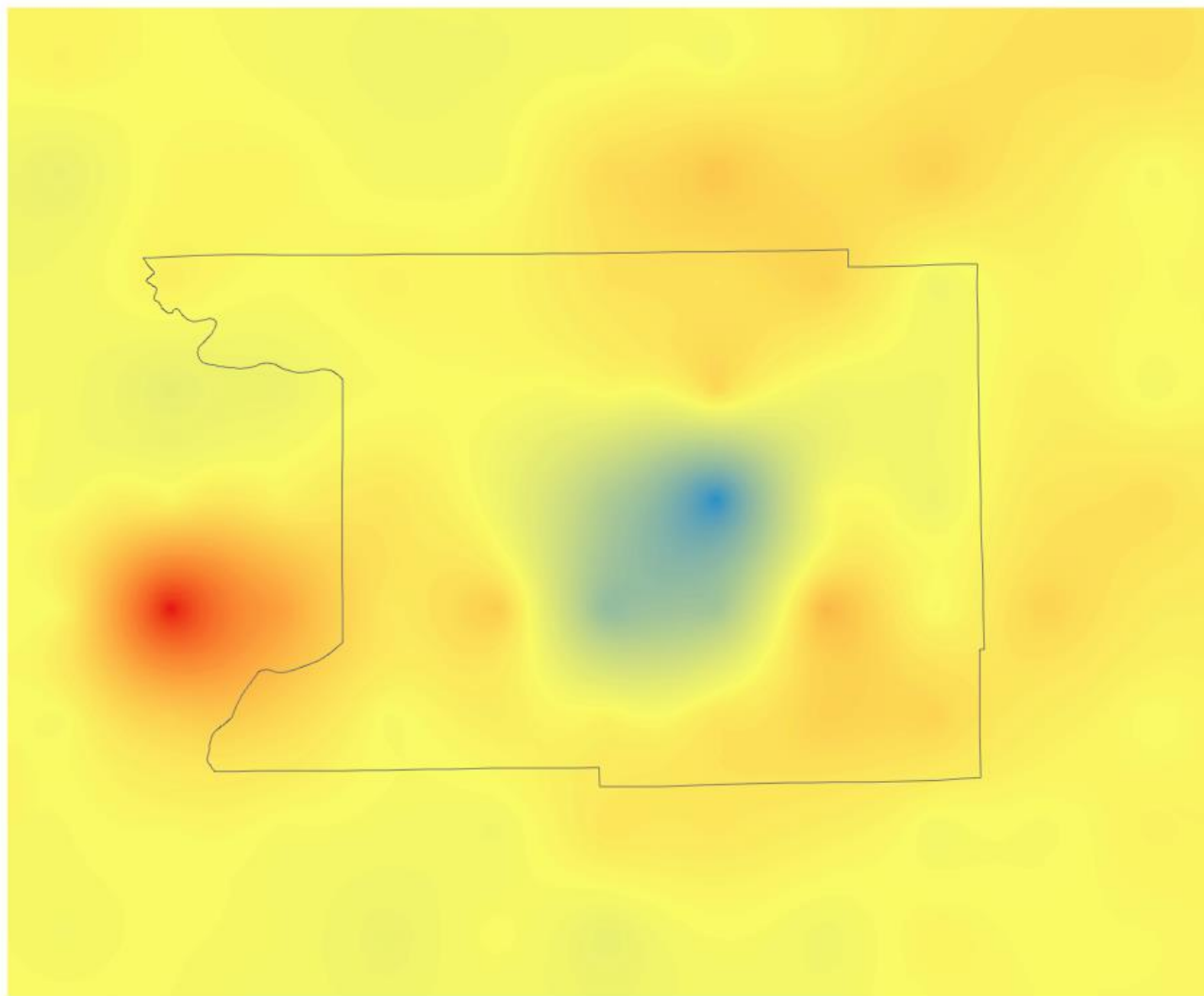
Opt 3 – No bounds on Pilot Points
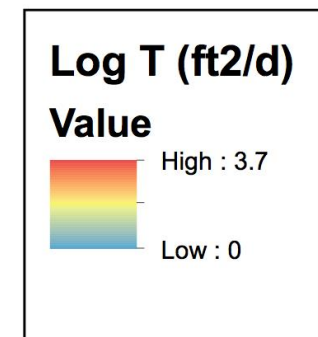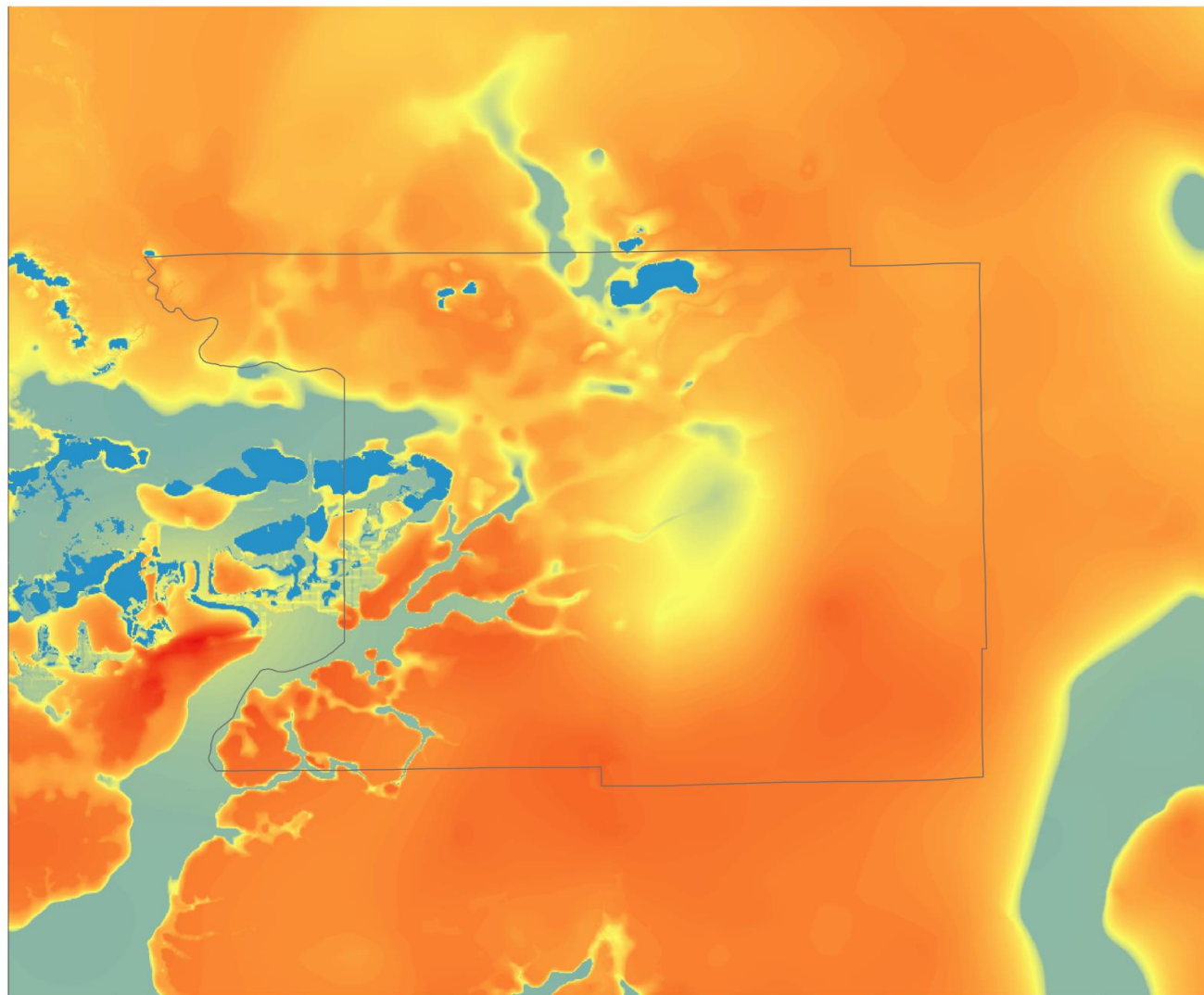
Model Calibration – K- distribution

Opt 5 – Pilot points bounded at +/- 2 stdev of log TGUESS

Example K-field results, Layer 4

Example T-field results, Layer 4

Log T (ft2/d)
Value
High : 3.7
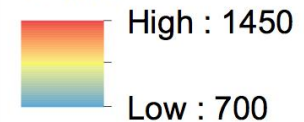Low : 0

Head and SFR results

Simulated baseflow (cfd)
- 0 - 596,390
- 596,391 - 2,008,900
- 2,008,901 - 4,460,750
- 4,460,751 - 7,609,050
- 7,609,051 - 10,726,500
- 10,726,501 - 13,384,500
- 13,384,501 - 19,489,000
- 19,489,001 - 26,384,500
- 26,384,501 - 36,330,000
- 36,330,001 - 75,749,500

Heads (ft)

Value

High : 1450

Low : 700

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UW EXTENSION
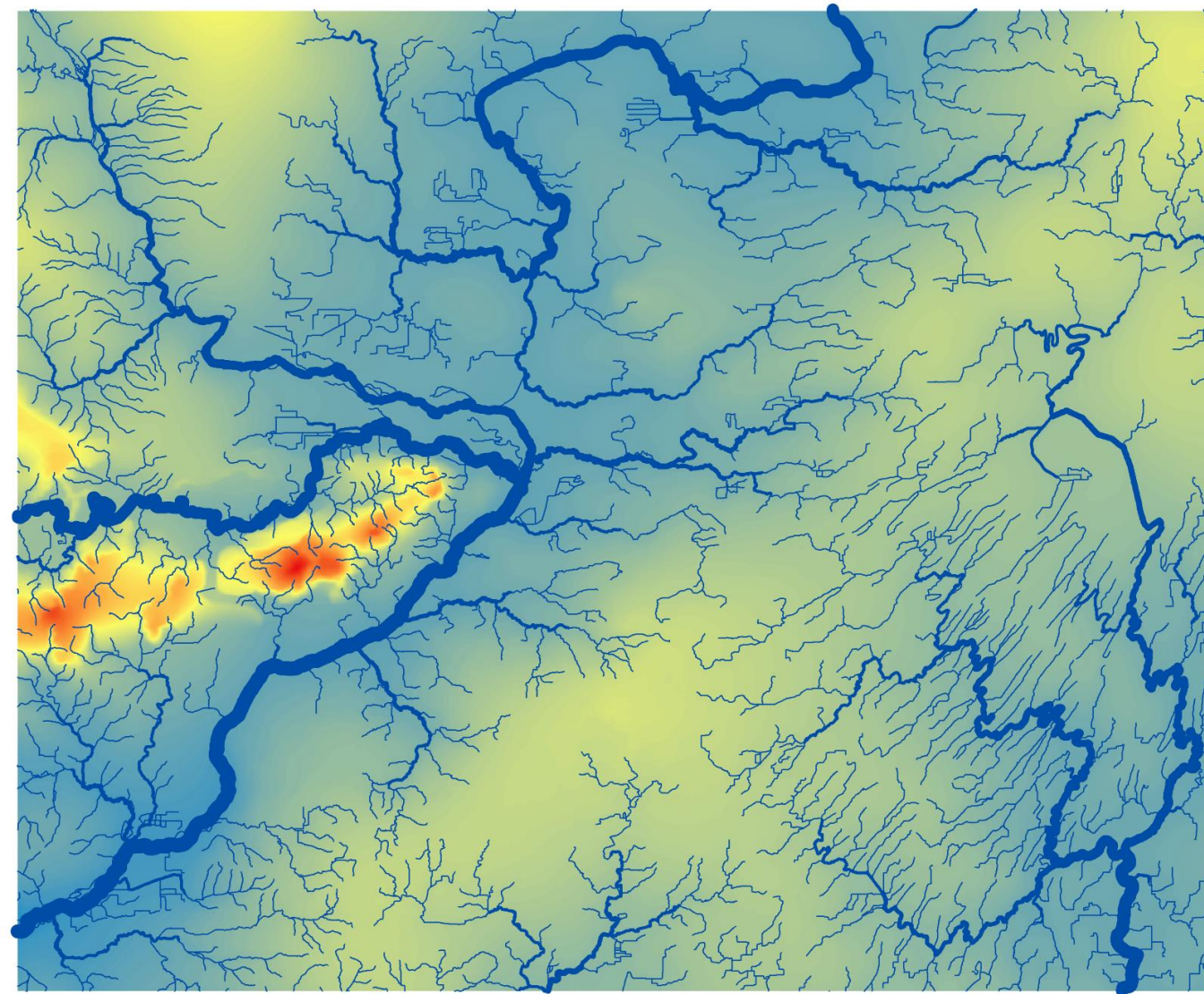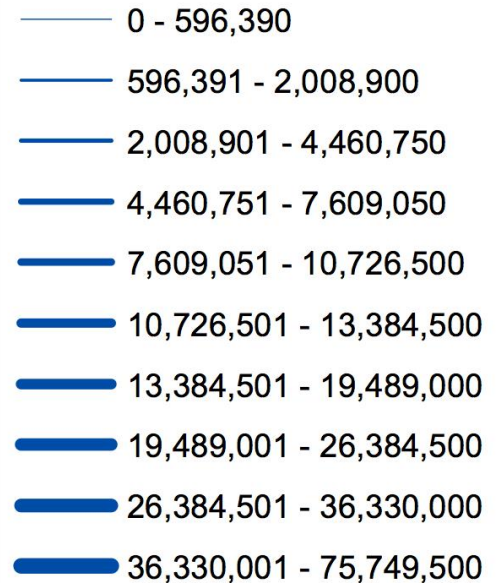
Vertical head gradients

vertical head difference (ft)
High : 15.7047
Low : -20.4083
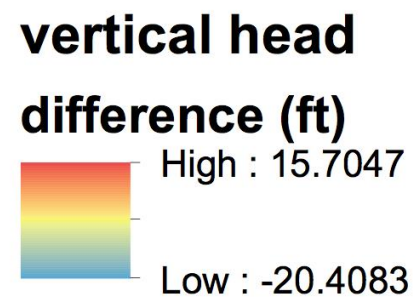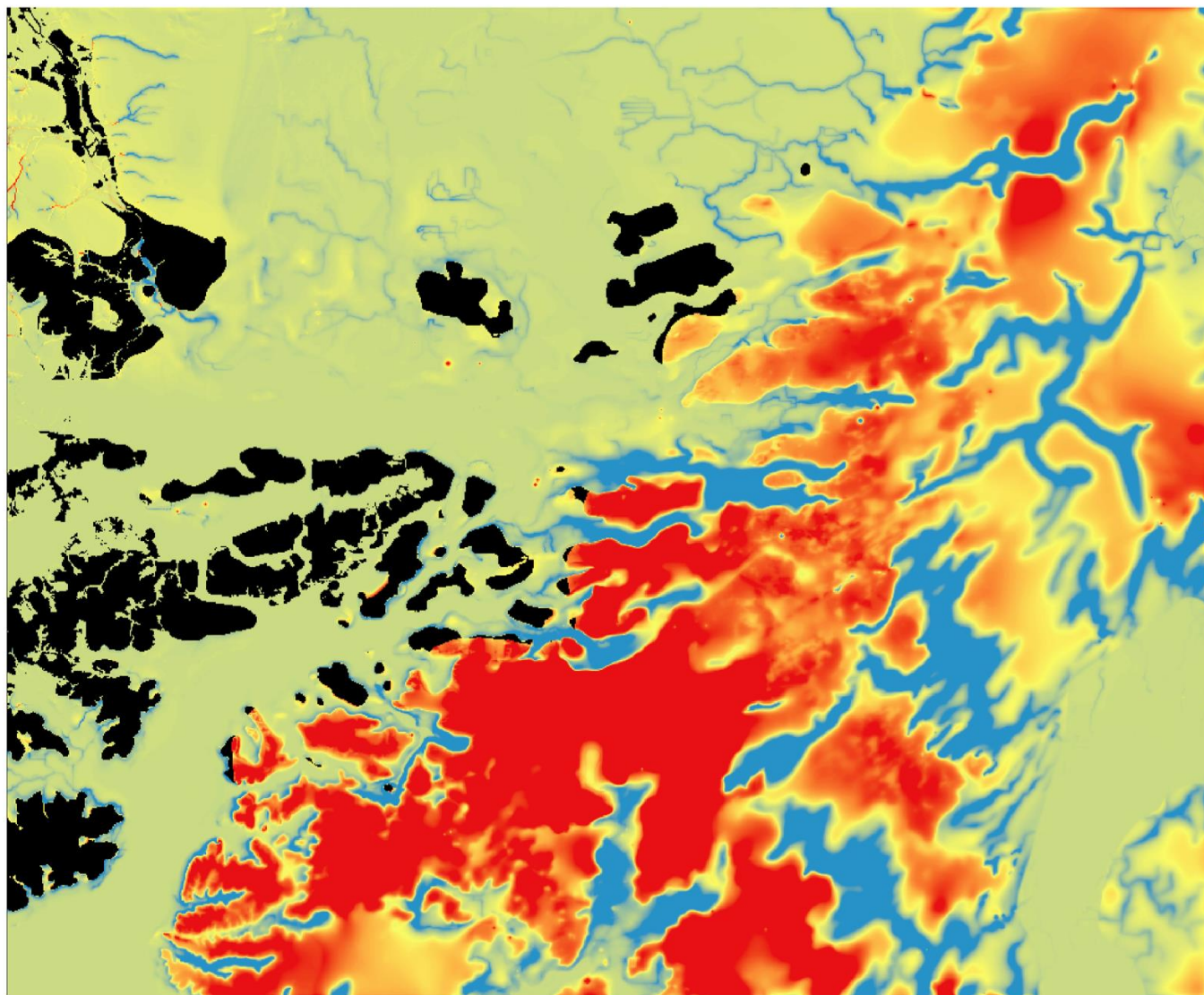
Model applications

- Municipal capture zones

- Identification of recharge and discharge areas

- Future well design

- Inset modeling

- Nitrate questions???

Many thanks to Columbia County for funding this work