

# A NEW GROUNDWATER FLOW MODEL FOR DANE COUNTY, WISCONSIN

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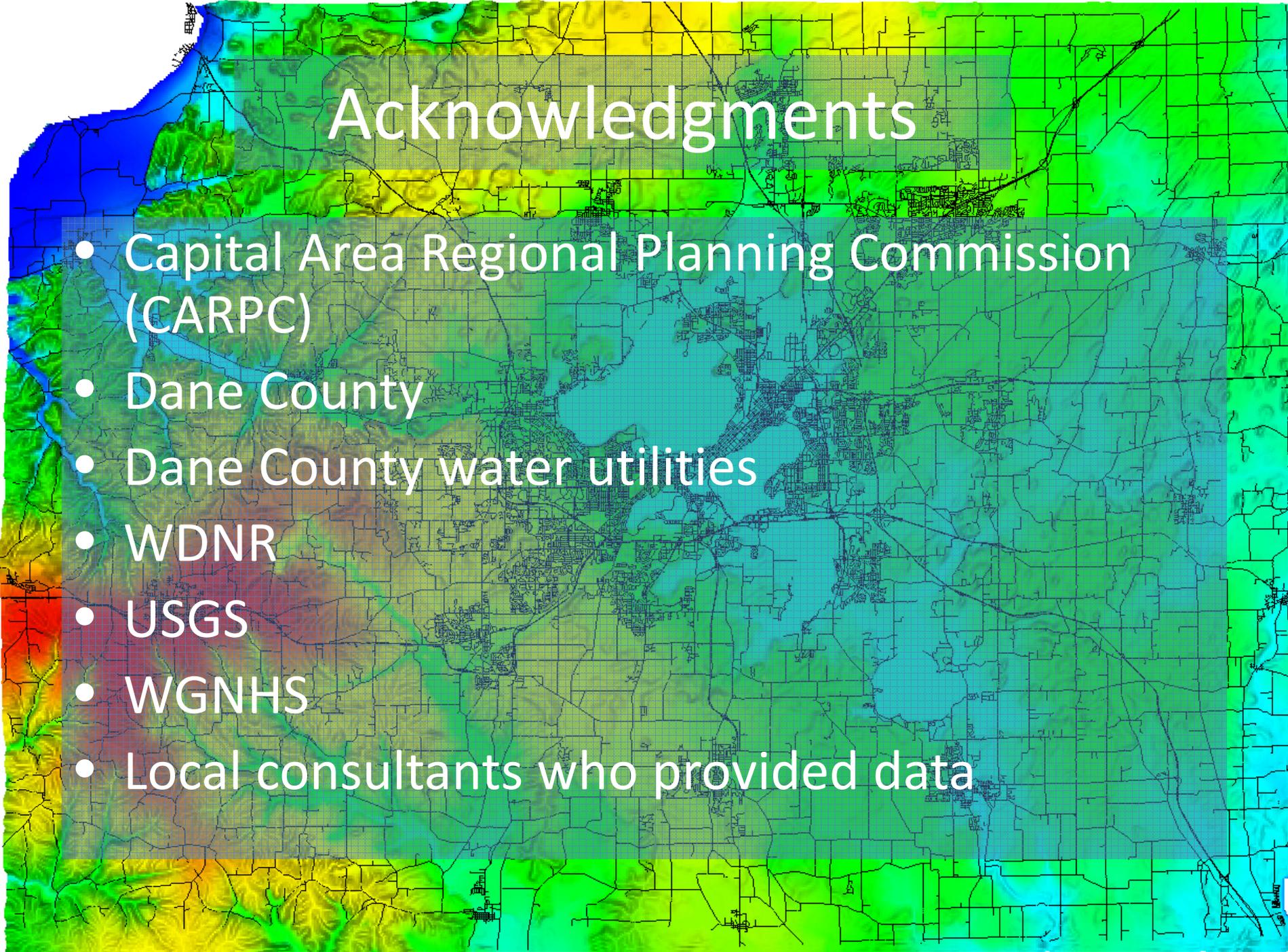
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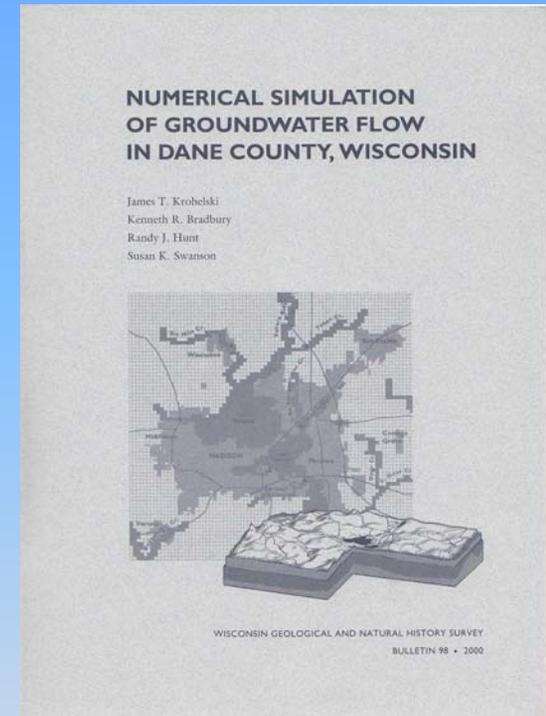


# Acknowledgments

- Capital Area Regional Planning Commission (CARPC)
- Dane County
- Dane County water utilities
- WDNR
- USGS
- WGNHS
- Local consultants who provided data

# Background:

- existing groundwater flow model was constructed in 1994; report (Bulletin 98) published in 2000
- steady state only, fixed lake and stream levels
- model is in regular use today, but is not adequate for many questions
- we know many current predictions are not correct

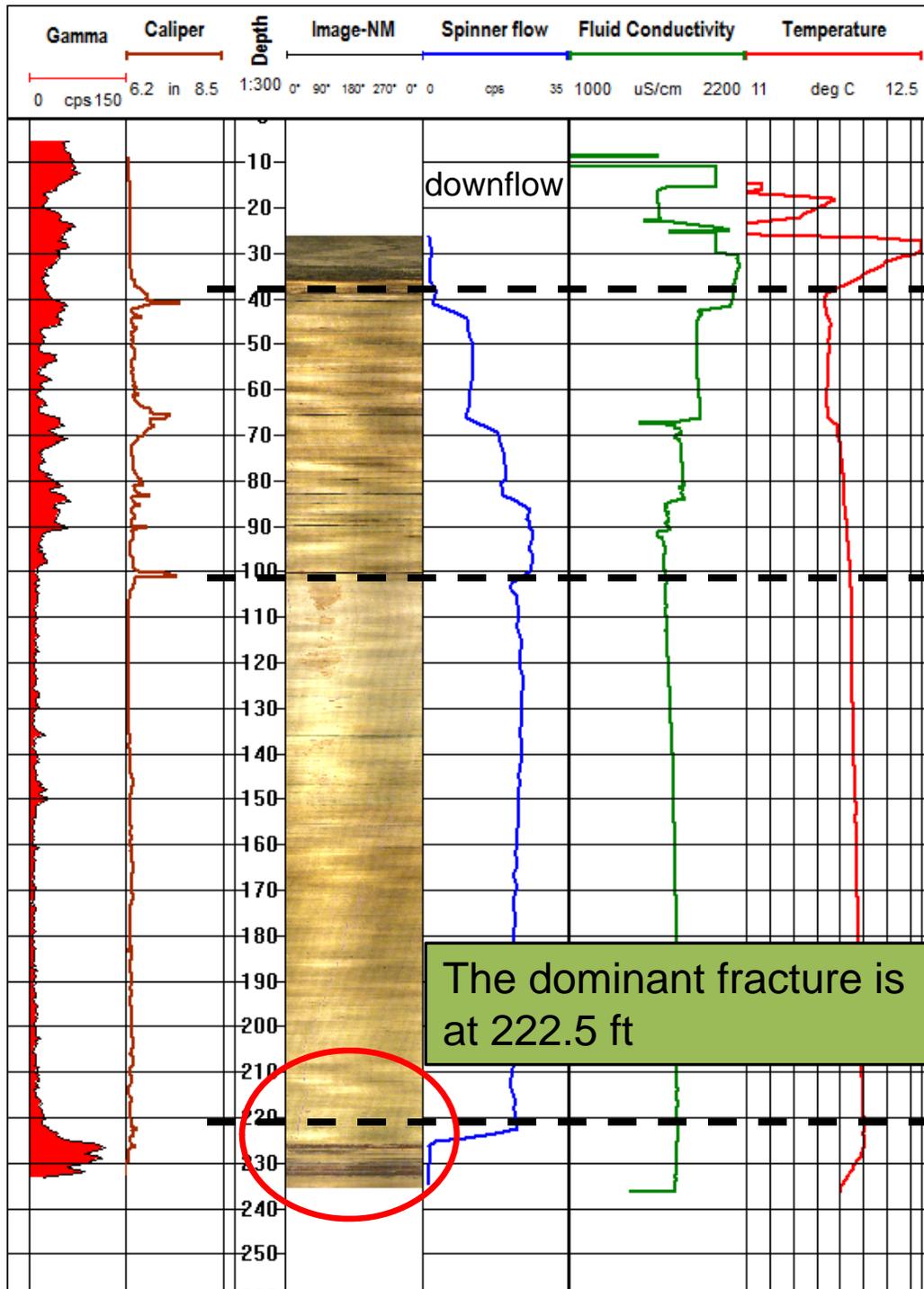


WGNHS Bulletin 98

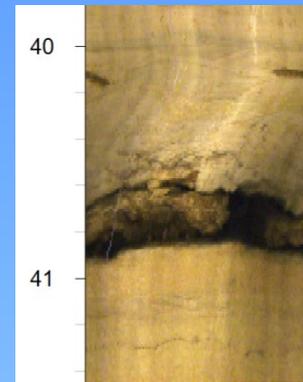
## What has changed since 1994:

- better computers, improved modeling and calibration codes
- new bedrock and glacial geologic maps of Dane County
- vastly improved understanding of bedrock hydrogeology (e.g., Eau Claire aquitard, Tunnel City Group)
- greatly increased understanding of subregions of the regional model from inset groundwater and surface water modeling
- many new wells constructed; more subsurface data available

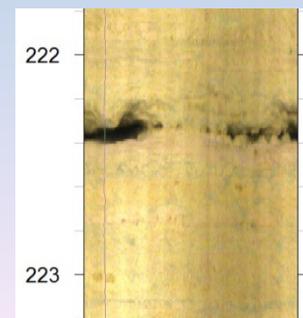
The “old” model fostered much of this work!



## OBI images



Example of new data: geophysical, optical and flowmeter logs; flow through fractures in sandstone



# Comparison: MODFLOW 3D models

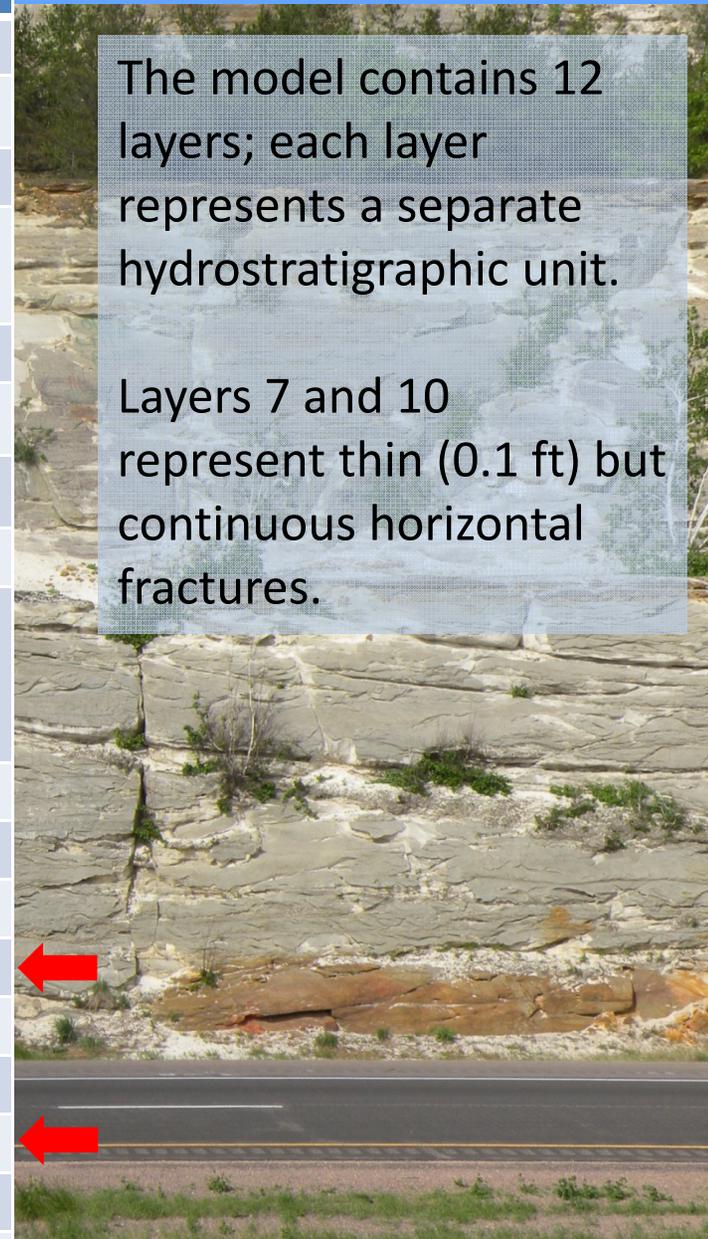
## 2000 model

- 200 rows, 240 columns, 4 layers
- 1300-ft node spacing
- uniform K in aquifers
- PCG solver
- constant-head surface-water features
- crude multi-node wells
- trial and error calibration
- steady

## 2013 model

- 479 rows, 638 columns, 12 layers
- 360-ft node spacing
- variable K in aquifers
- Newton-Raphson solver
- streamflow routing
- lake stage package
- multi-node wells
- PEST calibration
- transient

Model Layer(s)	Hydrostratigraphic unit
1 and 2	Near-surface rock
	Modern stream sediment
	Subglacial till
	Glacial meltwater sediment
	Offshore sediment
	Hummocky collapsed till
	Lakes and lake sediment
3	Windblown sand
3	"upper bedrock" (Sinnipee, Ancell, Prairie du Chien)
4	Jordan
5	St Lawrence
6	Upper Tunnel City
7	TC fracture
8	Lower Tunnel City
9	Wonewoc
10	WW fracture
11	Eau Claire
12	Mt Simon

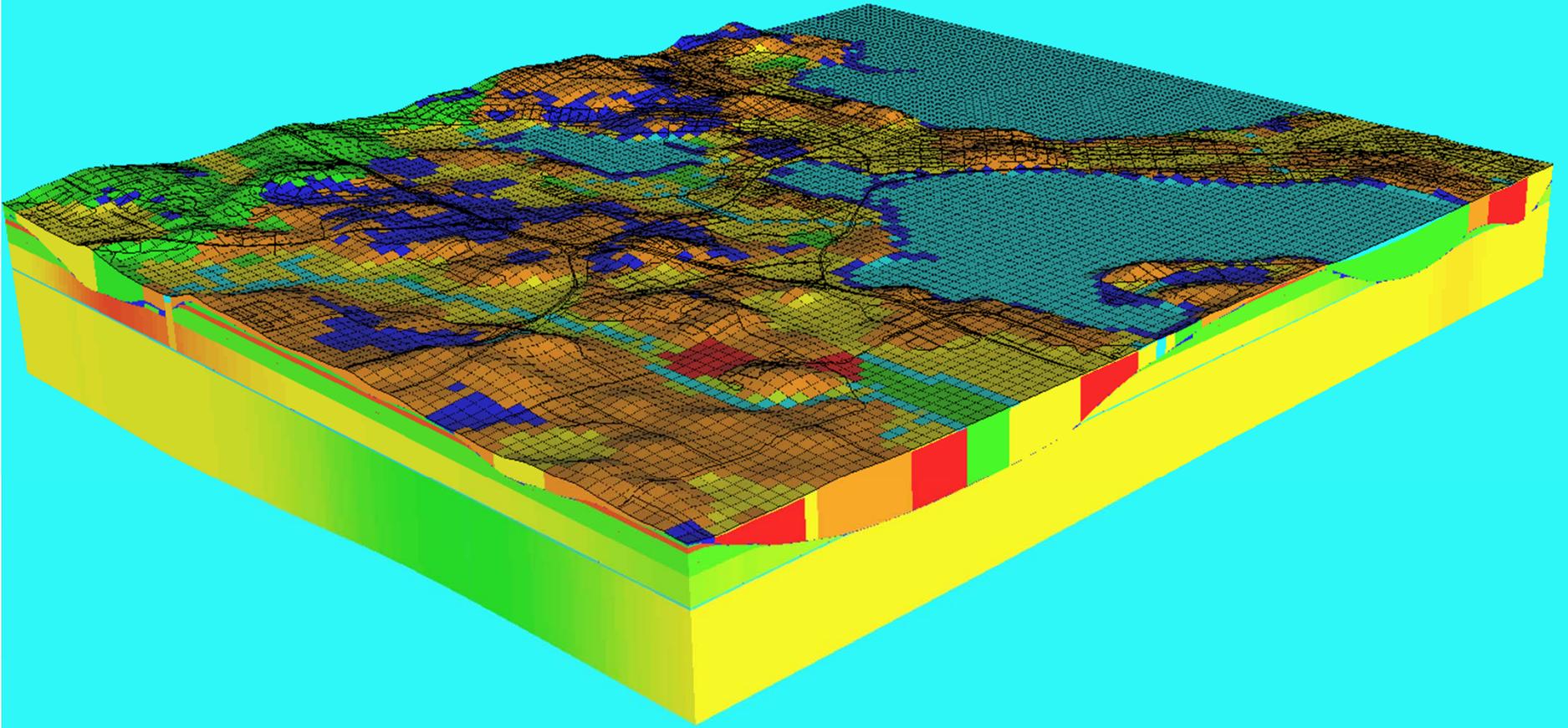


The model contains 12 layers; each layer represents a separate hydrostratigraphic unit.

Layers 7 and 10 represent thin (0.1 ft) but continuous horizontal fractures.

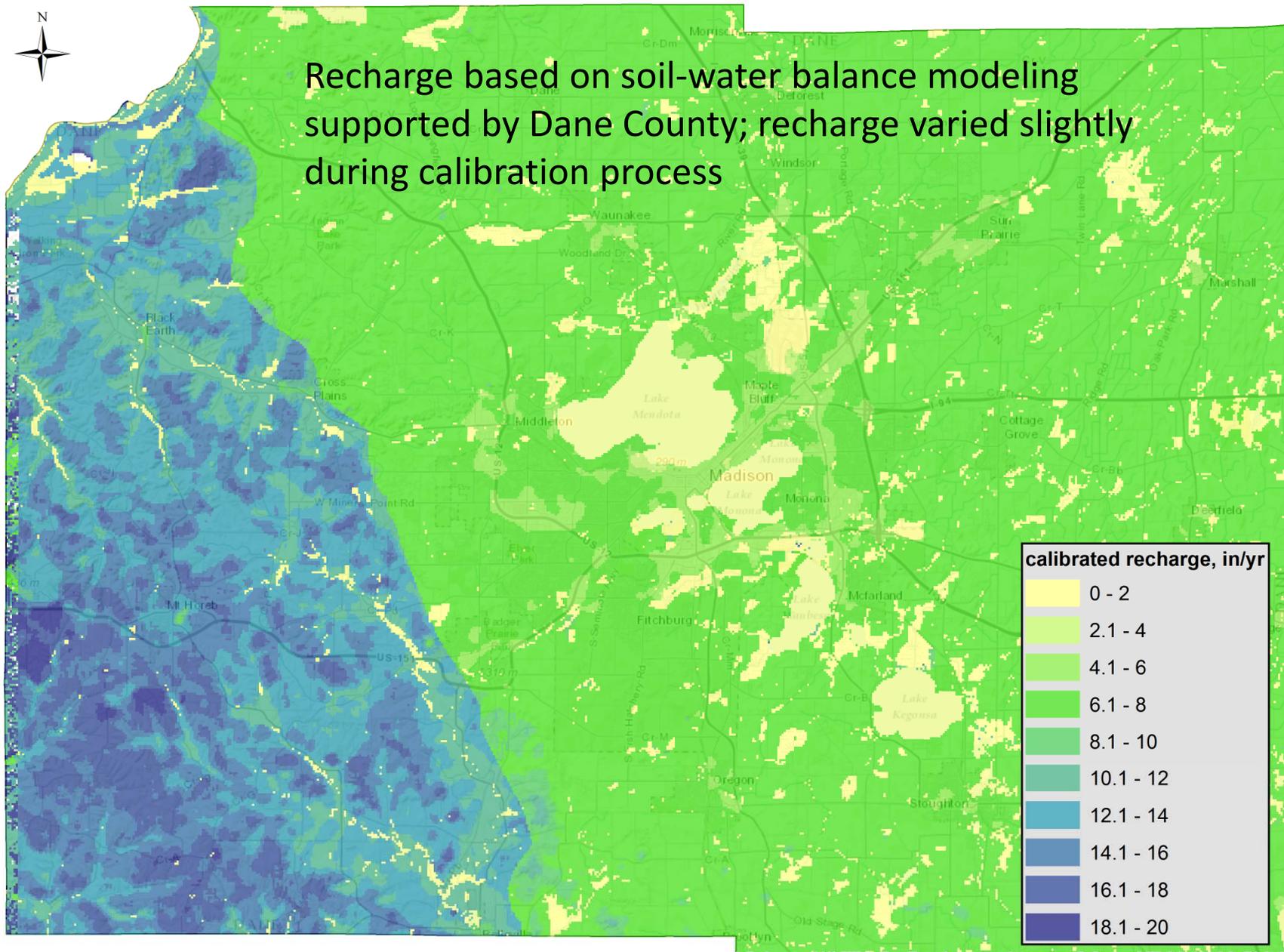
# Visualization of model structure

Colors represent hydraulic conductivity



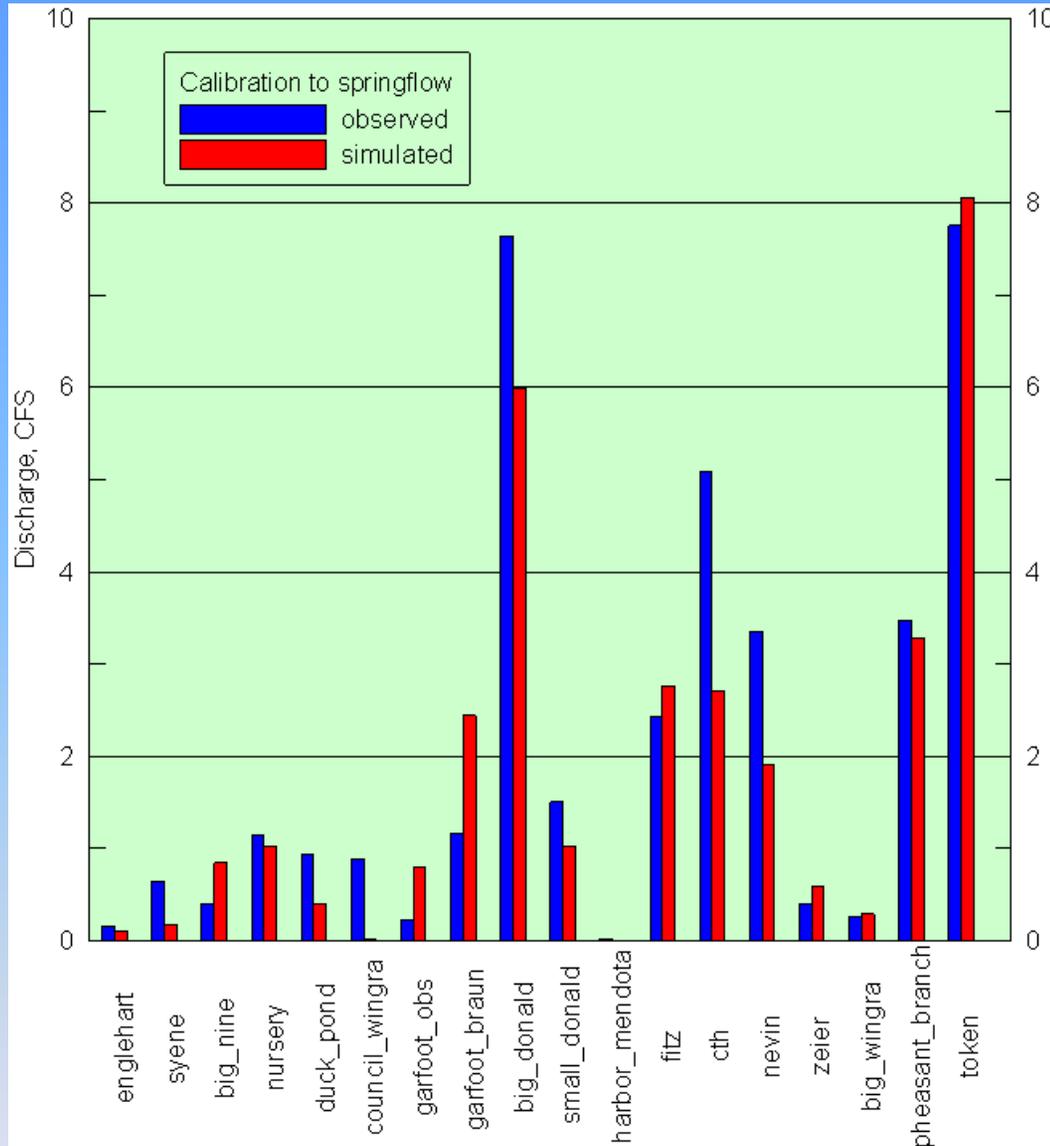


Recharge based on soil-water balance modeling supported by Dane County; recharge varied slightly during calibration process



calibrated recharge, in/yr	
0 - 2	Yellow
2.1 - 4	Light Green
4.1 - 6	Green
6.1 - 8	Light Blue
8.1 - 10	Medium Blue
10.1 - 12	Dark Blue
12.1 - 14	Very Dark Blue
14.1 - 16	Dark Purple
16.1 - 18	Medium Purple
18.1 - 20	Dark Purple

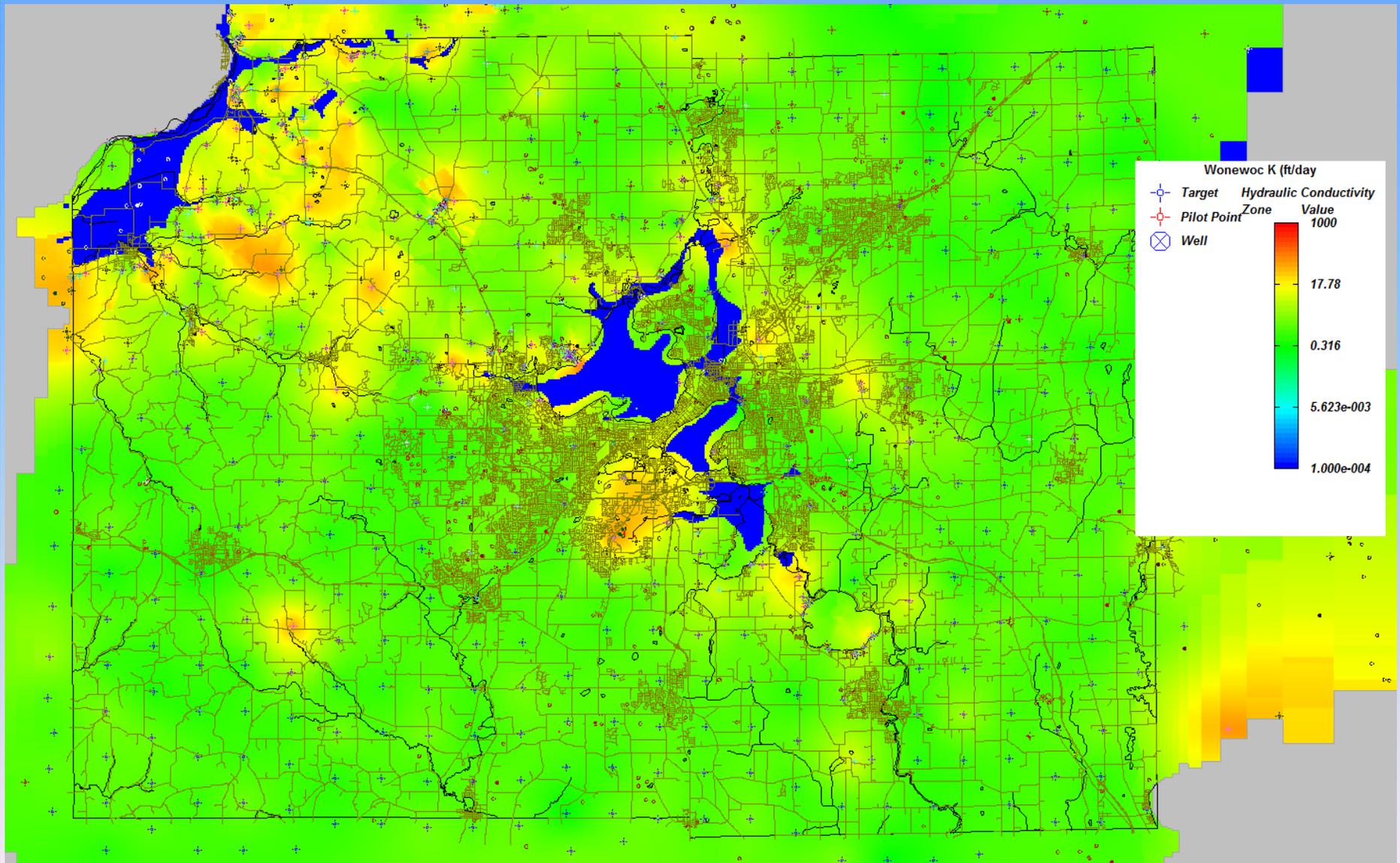
0 5 10 20 Miles

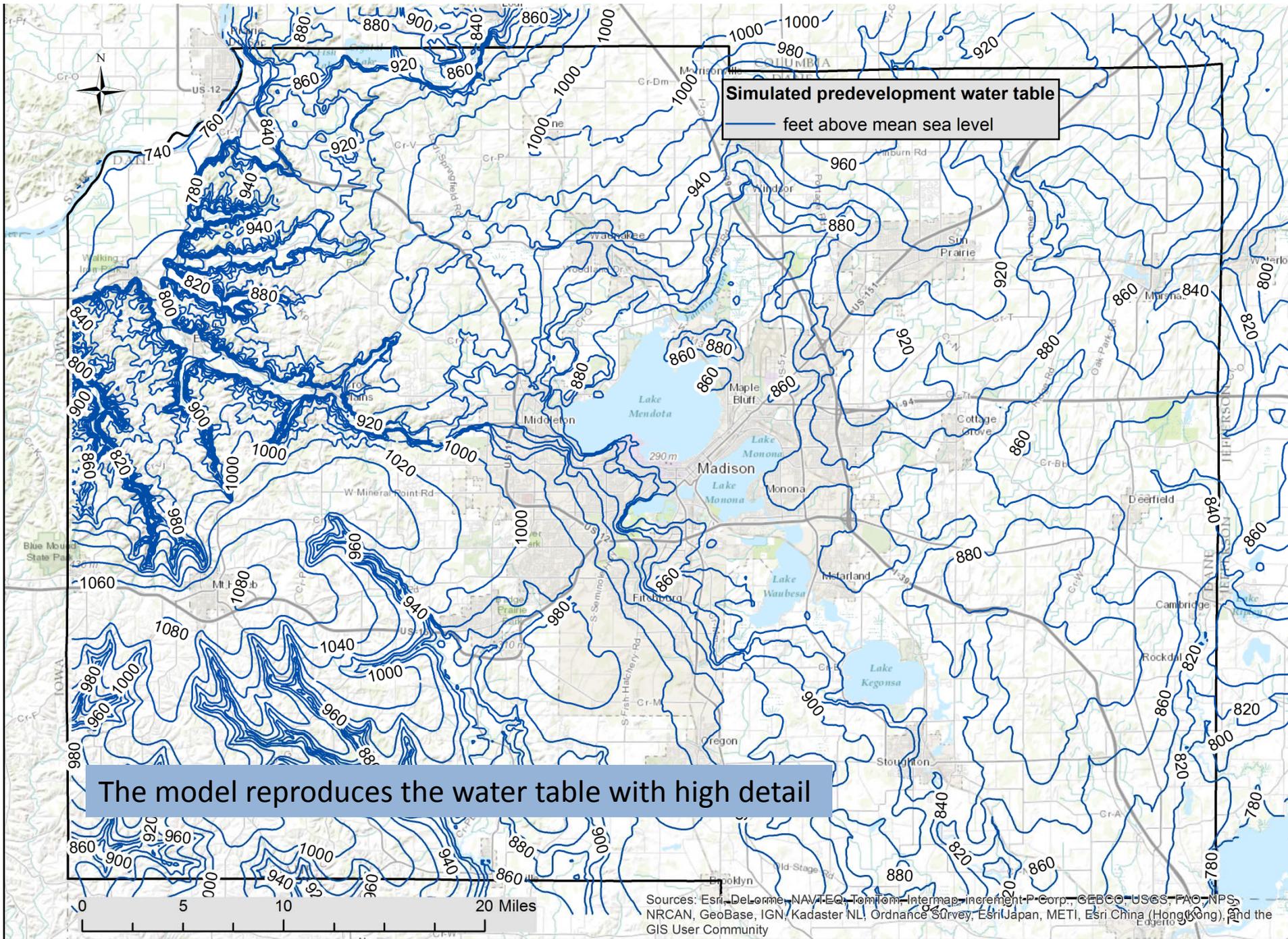


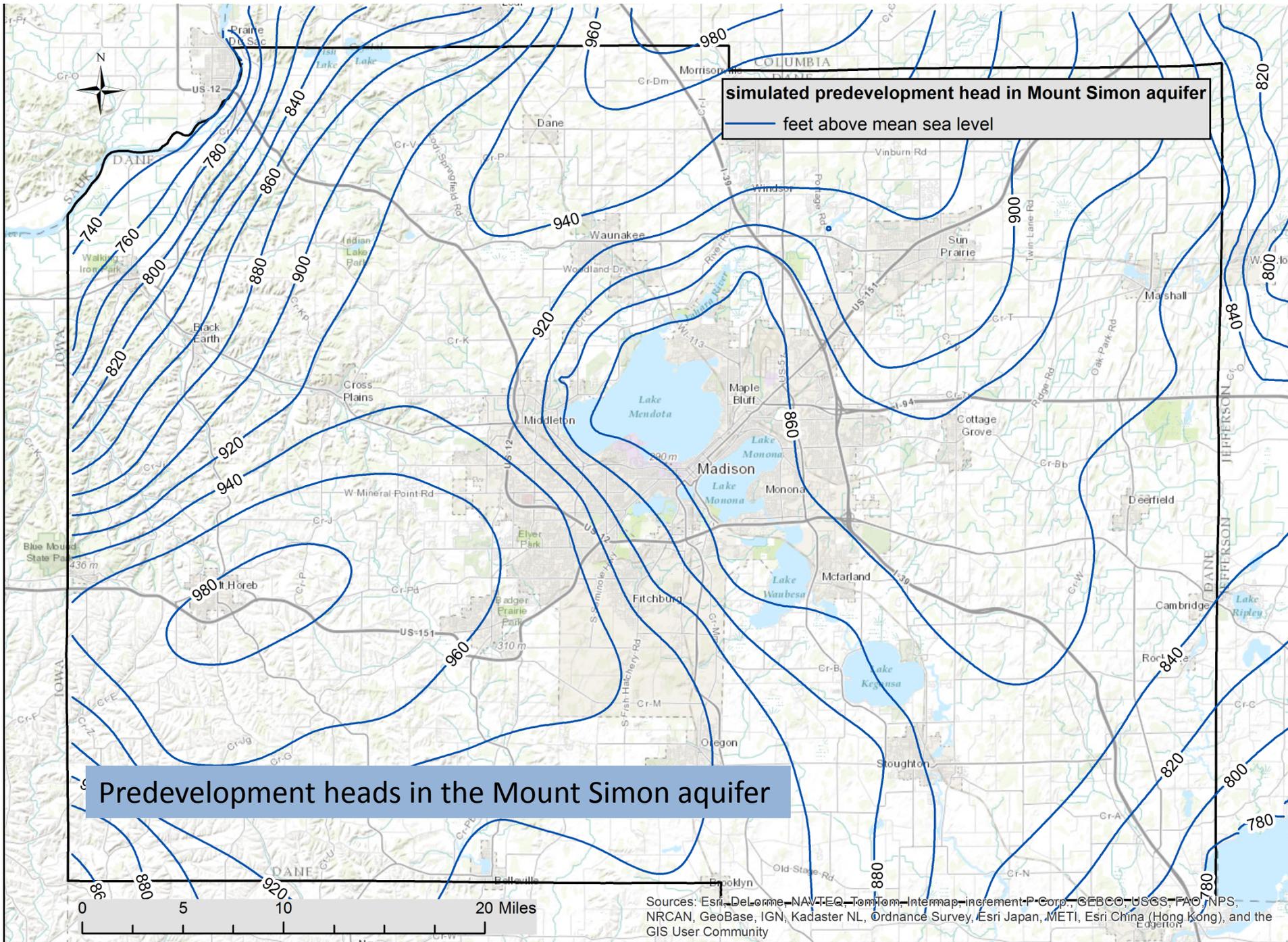
The model includes all the major springs in Dane County; these served as important calibration targets.

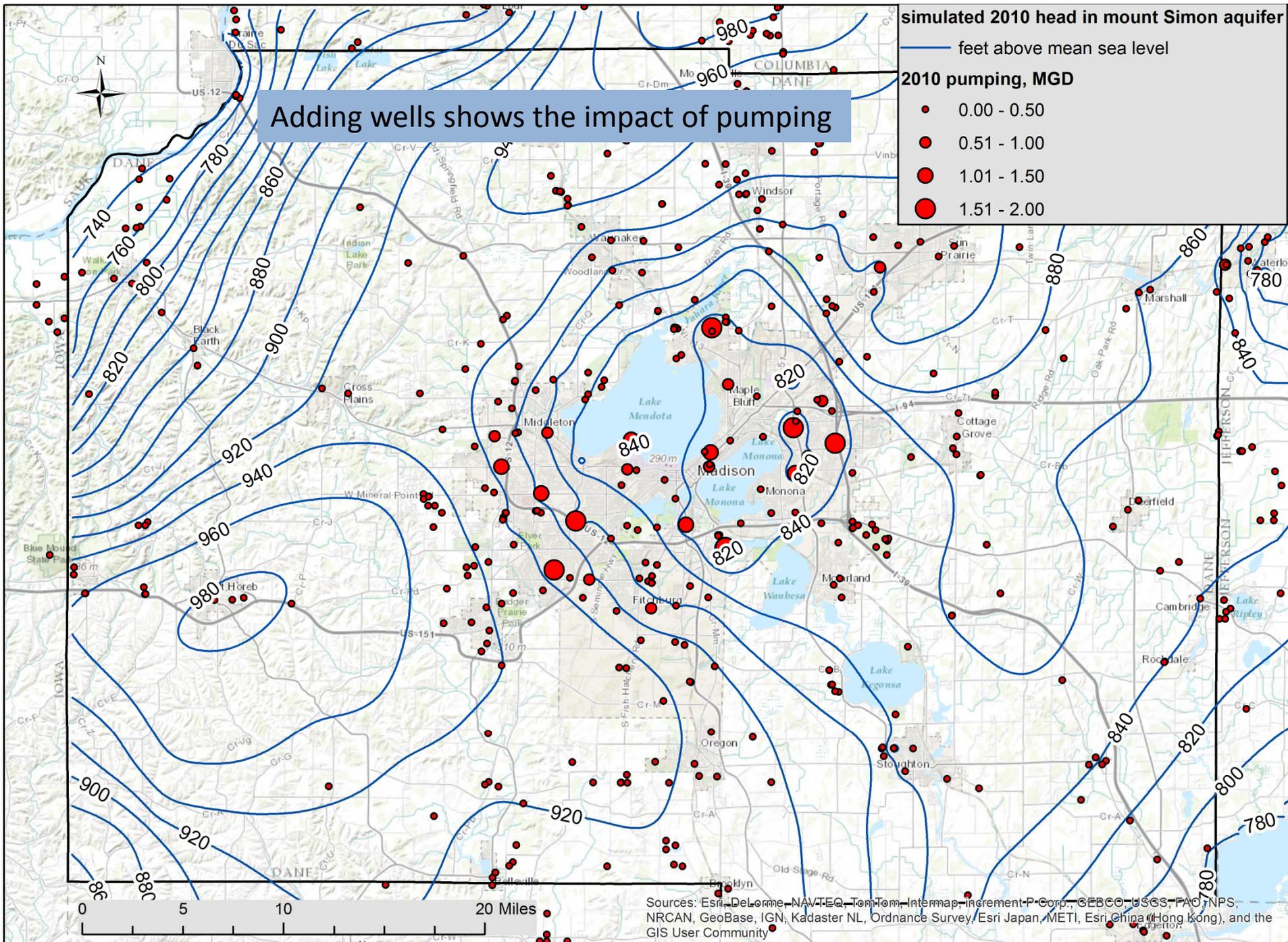
Other calibration targets include heads, streamflow, vertical head differences, and borehole flow rates.

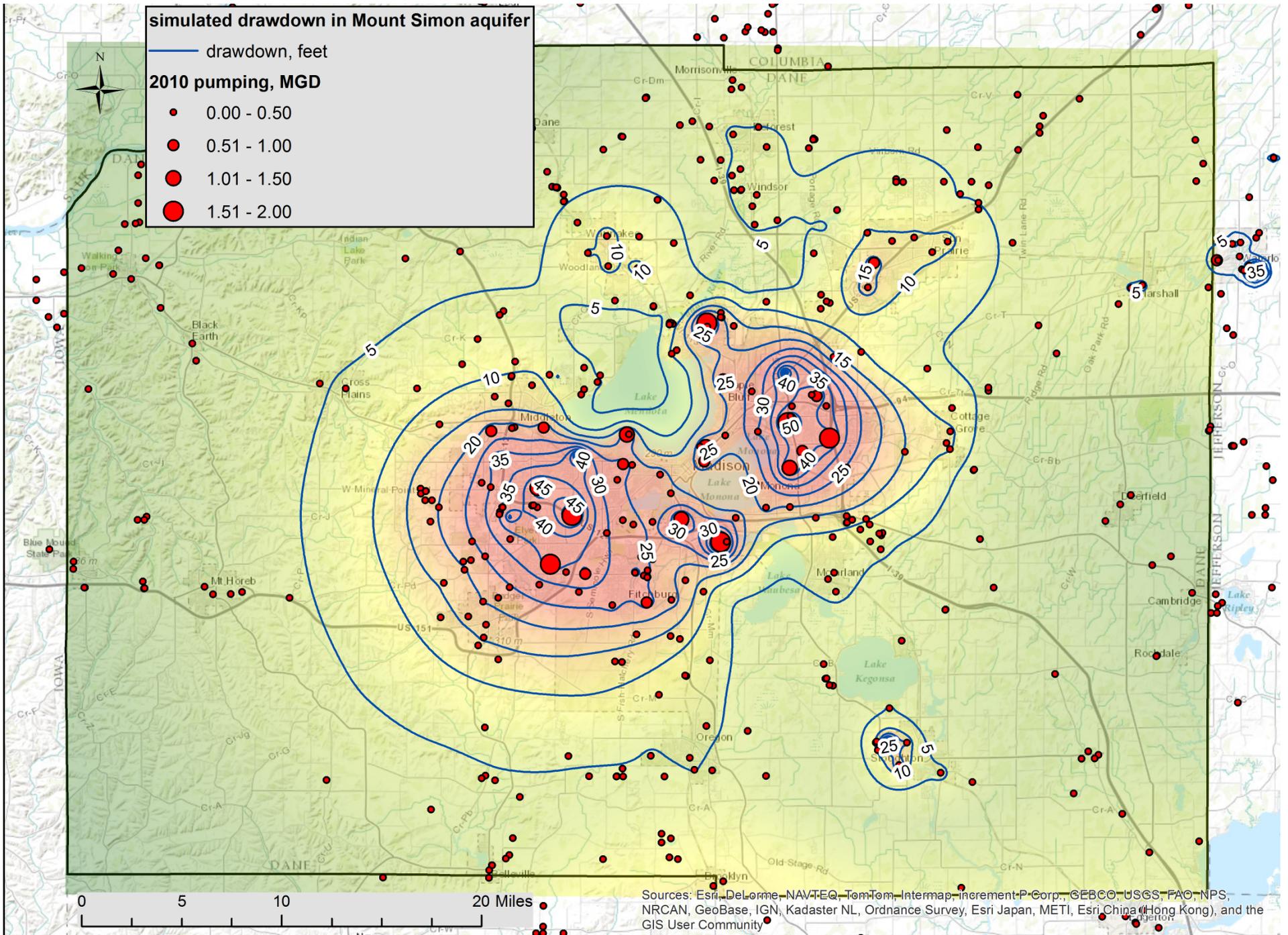
Calibration used the parameter estimation code PEST with pilot points, with variable K in major aquifer units



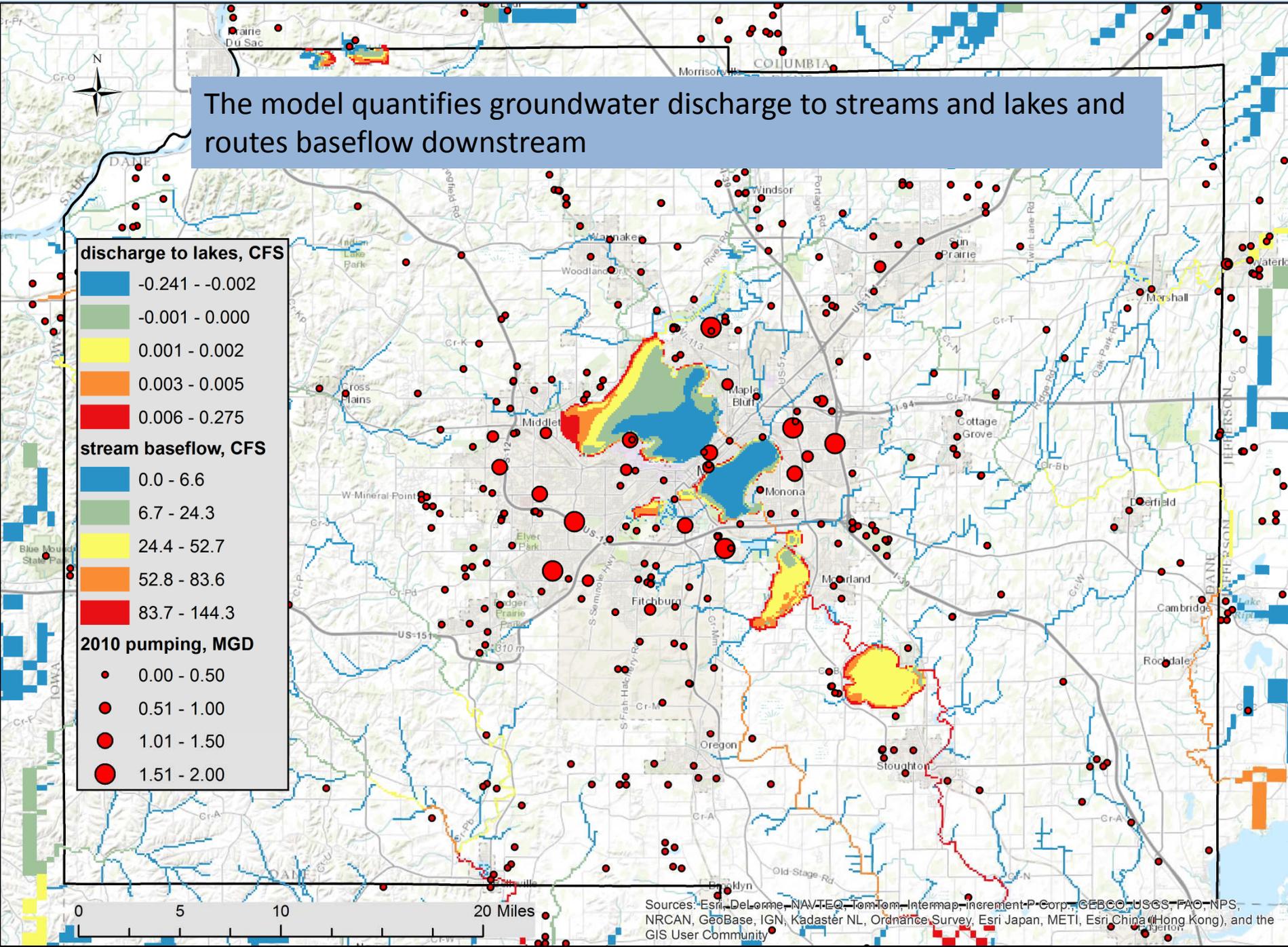








The model quantifies groundwater discharge to streams and lakes and routes baseflow downstream



# Change in surface water baseflows due to pumping

**change in baseflow, CFS**

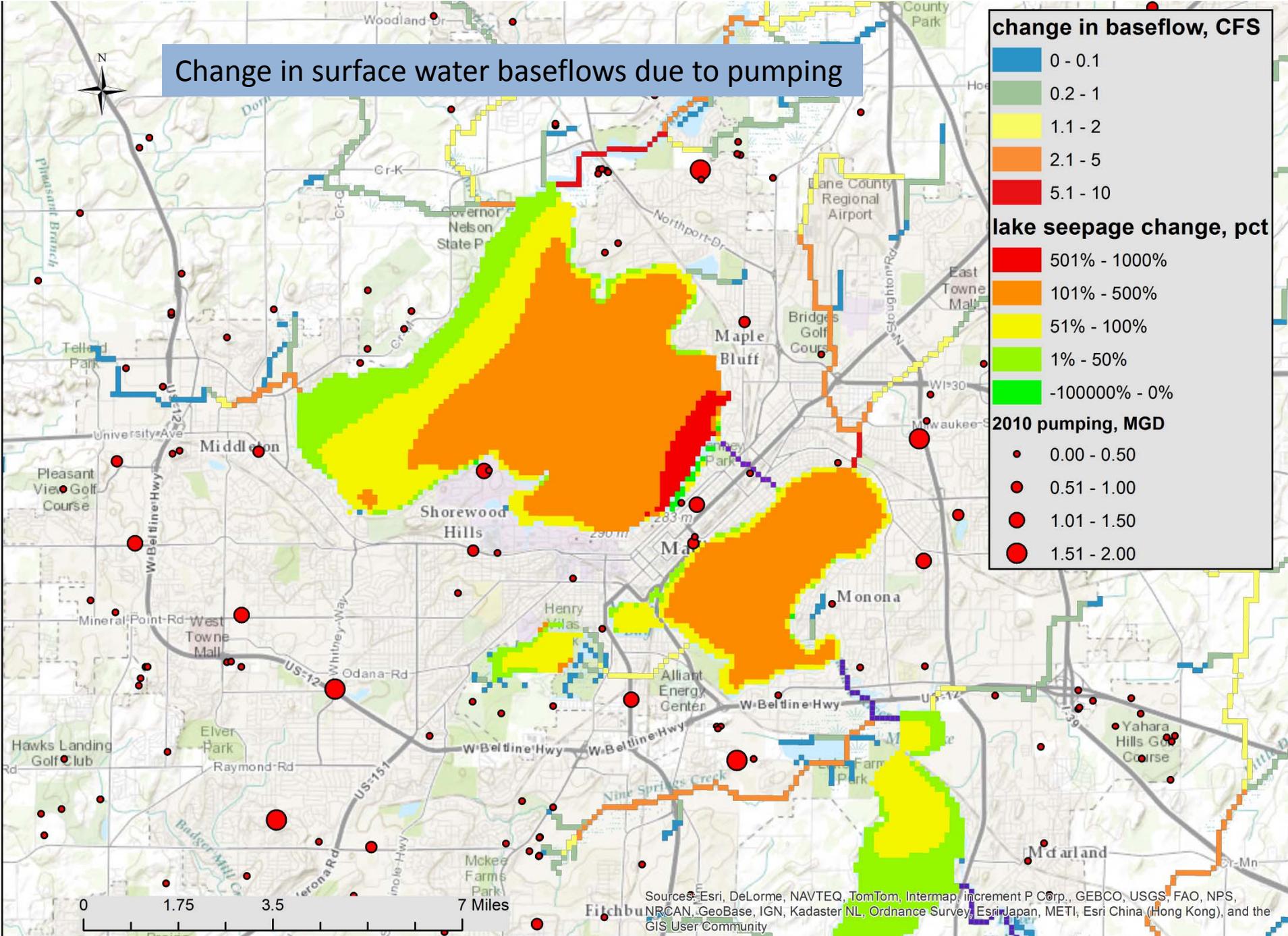
- 0 - 0.1
- 0.2 - 1
- 1.1 - 2
- 2.1 - 5
- 5.1 - 10

**lake seepage change, pct**

- 501% - 1000%
- 101% - 500%
- 51% - 100%
- 1% - 50%
- 100000% - 0%

**2010 pumping, MGD**

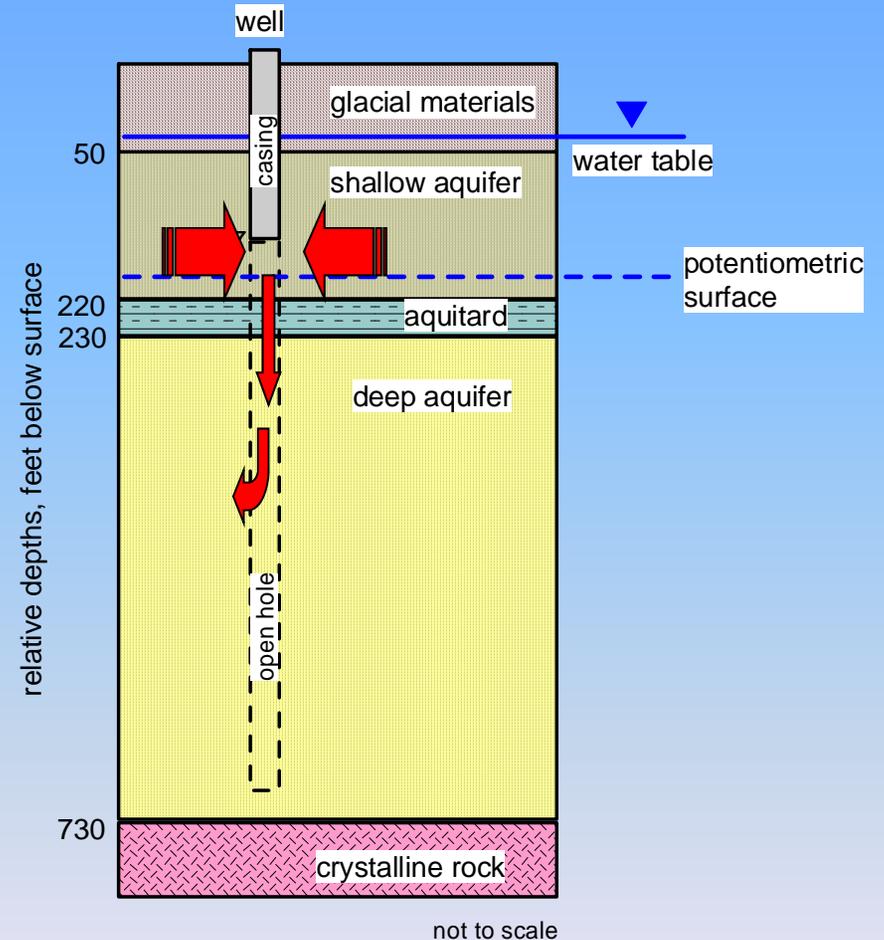
- 0.00 - 0.50
- 0.51 - 1.00
- 1.01 - 1.50
- 1.51 - 2.00



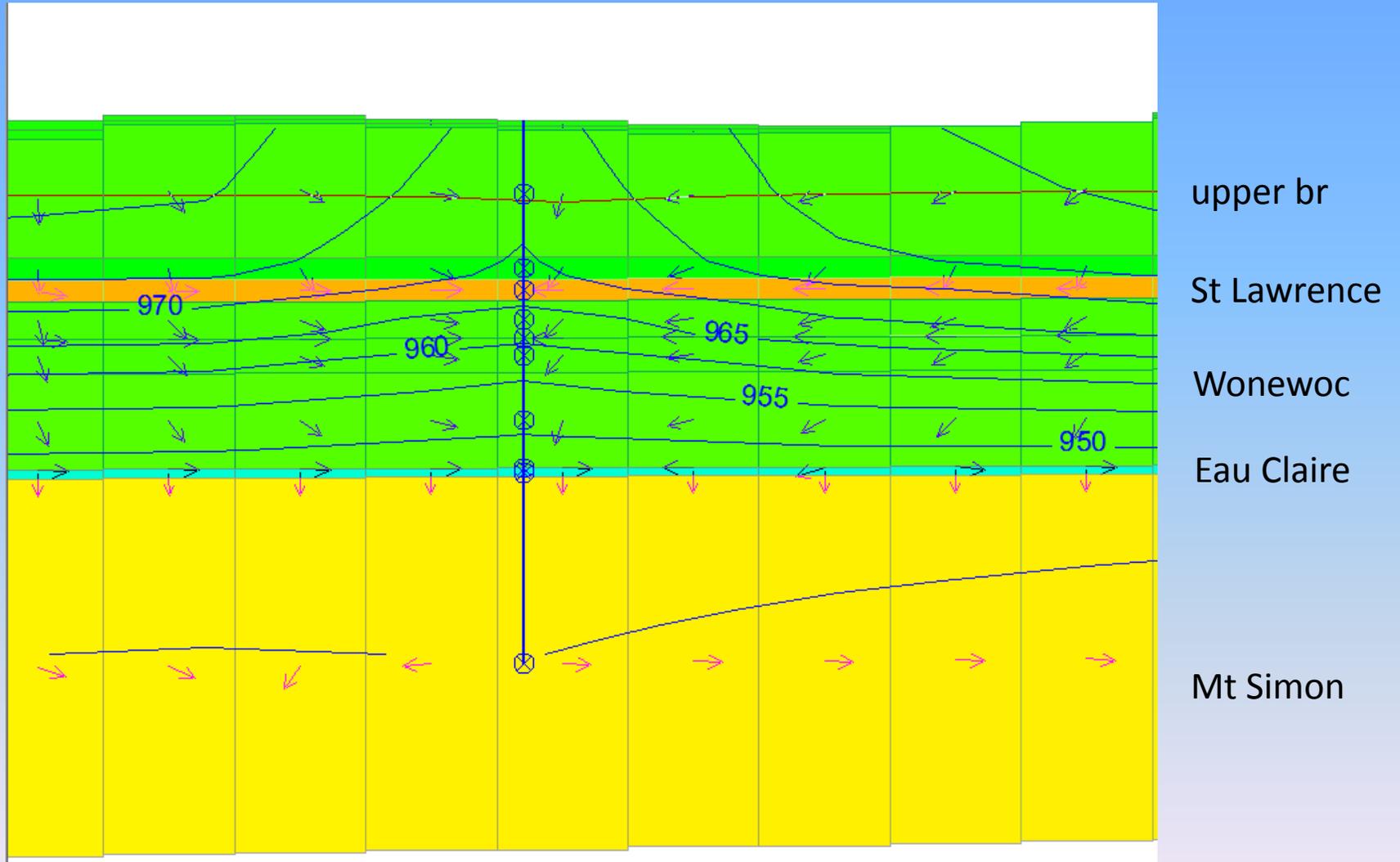
Sources: Esri, DeLorme, NAVTEQ, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), and the GIS User Community

# Cross-connecting wells

- a problem in Dane County (and elsewhere)
- model includes 589 wells
- 31 of these are unused and cross-connected
- about 100 others are used but cross connected
- the model quantifies ambient flow through these wells as between 3 and 5 MGD for the county – a significant amount of water.



# Example of cross-connected well near Verona





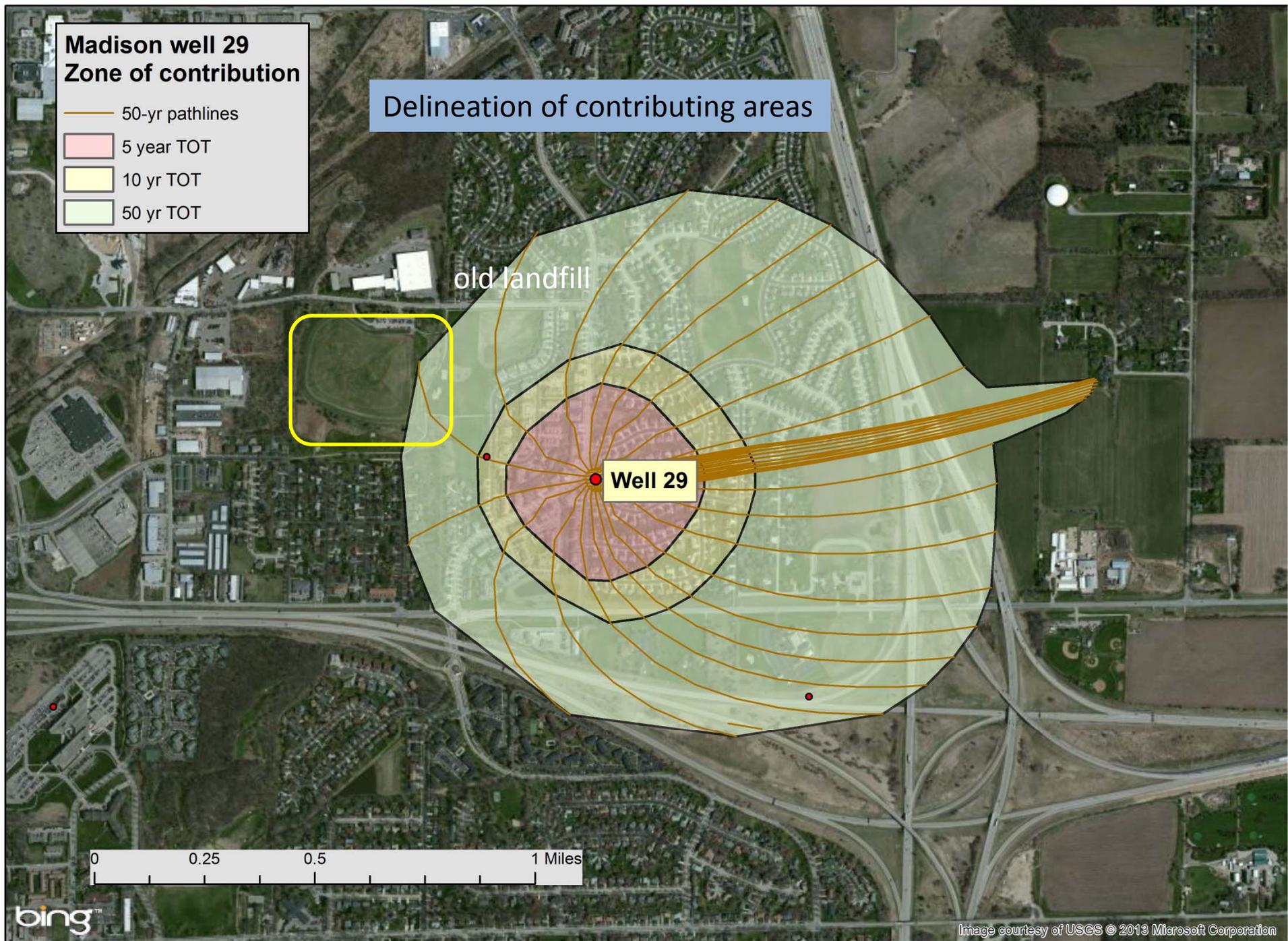
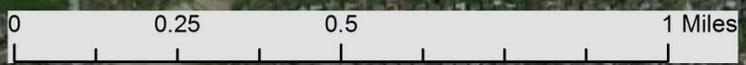
**Madison well 29  
Zone of contribution**

- 50-yr pathlines
- 5 year TOT
- 10 yr TOT
- 50 yr TOT

Delineation of contributing areas

old landfill

Well 29



# A decision-support tool for...



- Understanding the impacts of new well siting; science-based evaluation of alternative sites
- Groundwater/surface water relationships; quantifying the impacts of pumping on springs and lakes
- Response of groundwater to short- and long-term climate changes
- Effects of land use change
- Wellhead protection, impacts of cross-connected wells
- Evaluation of well and water quality problems

Questions...?

