A Groundwater Flow Model for Columbia County, Wisconsin

Andrew Leaf (USGS), Madeline Gotkowitz (WGNHS), and Charles Dunning (USGS)
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
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

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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.

Model row 250; VE: 98.7x
Layer structure – southern Columbia Co.
Layer structure – western Columbia Co.

Model column 300; VE: 52.8x
Layer structure – eastern Columbia Co.

Model column 800; VE: 92.0x
Hydraulic Conductivity – Layers 1 and 2
Hydraulic Conductivity – Layer 3

Upper Elk Mound

Upper Bedrock

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Hydraulic Conductivity – Layer 5

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Extension
Recharge

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Pumping

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

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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
Model Calibration

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Model Calibration – flux residuals

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Model Calibration – K-distribution

Opt 3 – No bounds on Pilot Points

Wonewoc Pilot Points

Summary Statistics:
- Geomean K: 5.79 (ft/d)
- Log mean: 0.76
- Log std dev: 0.55
- Max: 804.06
- +2 std dev: 71.66
- +1 std dev: 20.37
- -1 std dev: 1.65
- -2 std dev: 0.47
- Min: 0.49

Wonewoc TGUESS

Summary Statistics:
- Geomean K: 5.68 (ft/d)
- Log mean: 0.75
- Log std dev: 0.62
- Max: 1071.78
- +2 std dev: 98.33
- +1 std dev: 23.63
- -1 std dev: 1.36
- -2 std dev: 0.33
- Min: 0.22
Model Calibration – K- distribution

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

Summary Statistics:
geomean K: 5.49 (ft/d)
log mean: 0.74
log stdev: 0.24
Max: 98.33
+2 stdev: 16.72
+1 stdev: 9.58
-1 stdev: 3.15
-2 stdev: 1.80
Min: 0.28

Summary Statistics:
geomean K: 5.68 (ft/d)
log mean: 0.75
log stdev: 0.62
Max: 1071.78
+2 stdev: 98.33
+1 stdev: 23.63
-1 stdev: 1.36
-2 stdev: 0.33
Min: 0.22
Example K-field results, Layer 4
Example T-field results, Layer 4
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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Vertical head gradients
Model applications

- Municipal capture zones
- Identification of recharge and discharge areas
- Future well design
- Inset modeling
- Nitrate questions???

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