Wisconsin Geological
and Natural History Survey
DIVISION OF EXTENSION
UNIVERSITY OF WISCONSIN–MADISON

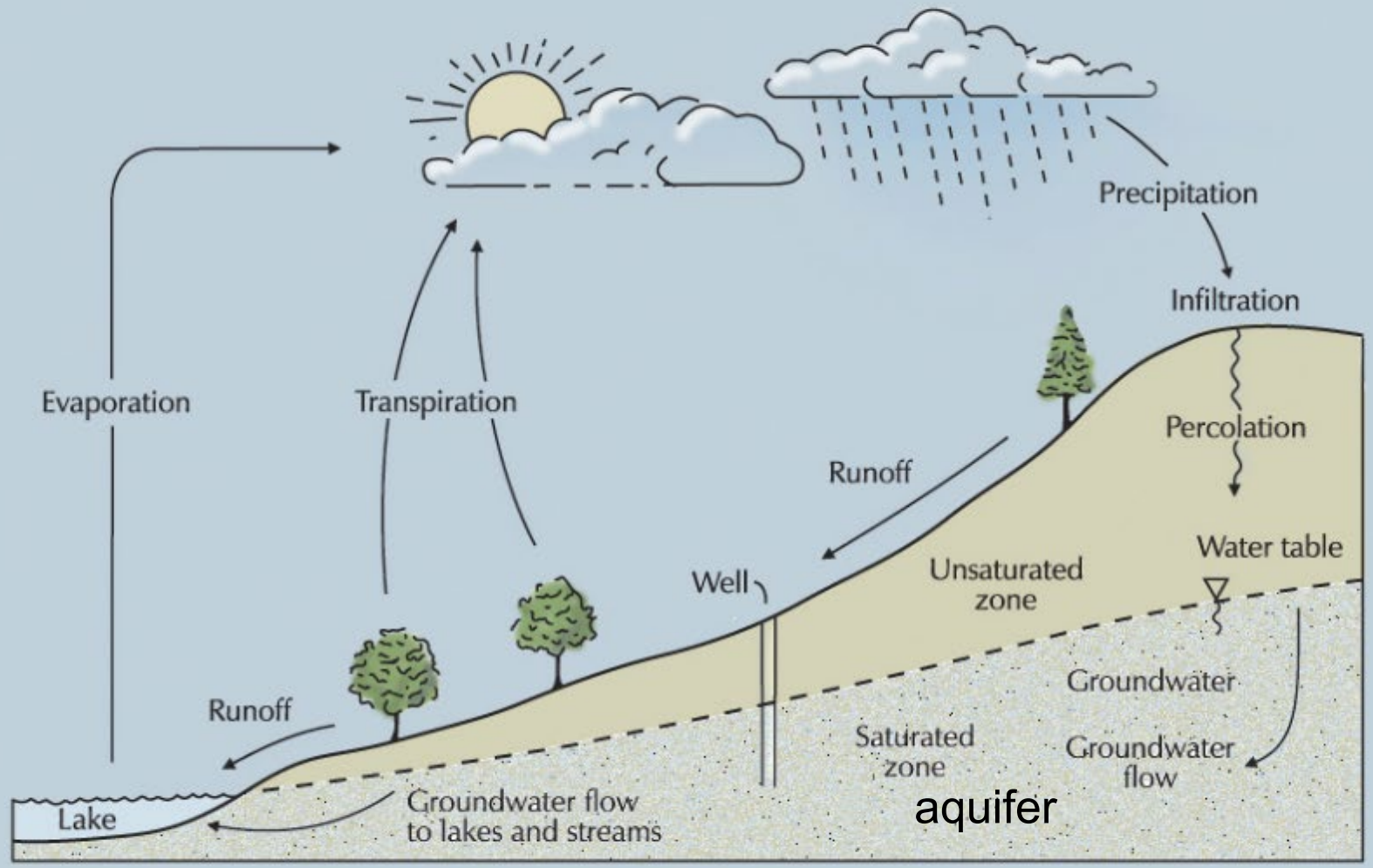
Dane County groundwater flow model

Overview for Badger Mill Creek stakeholder group

6/12/2024

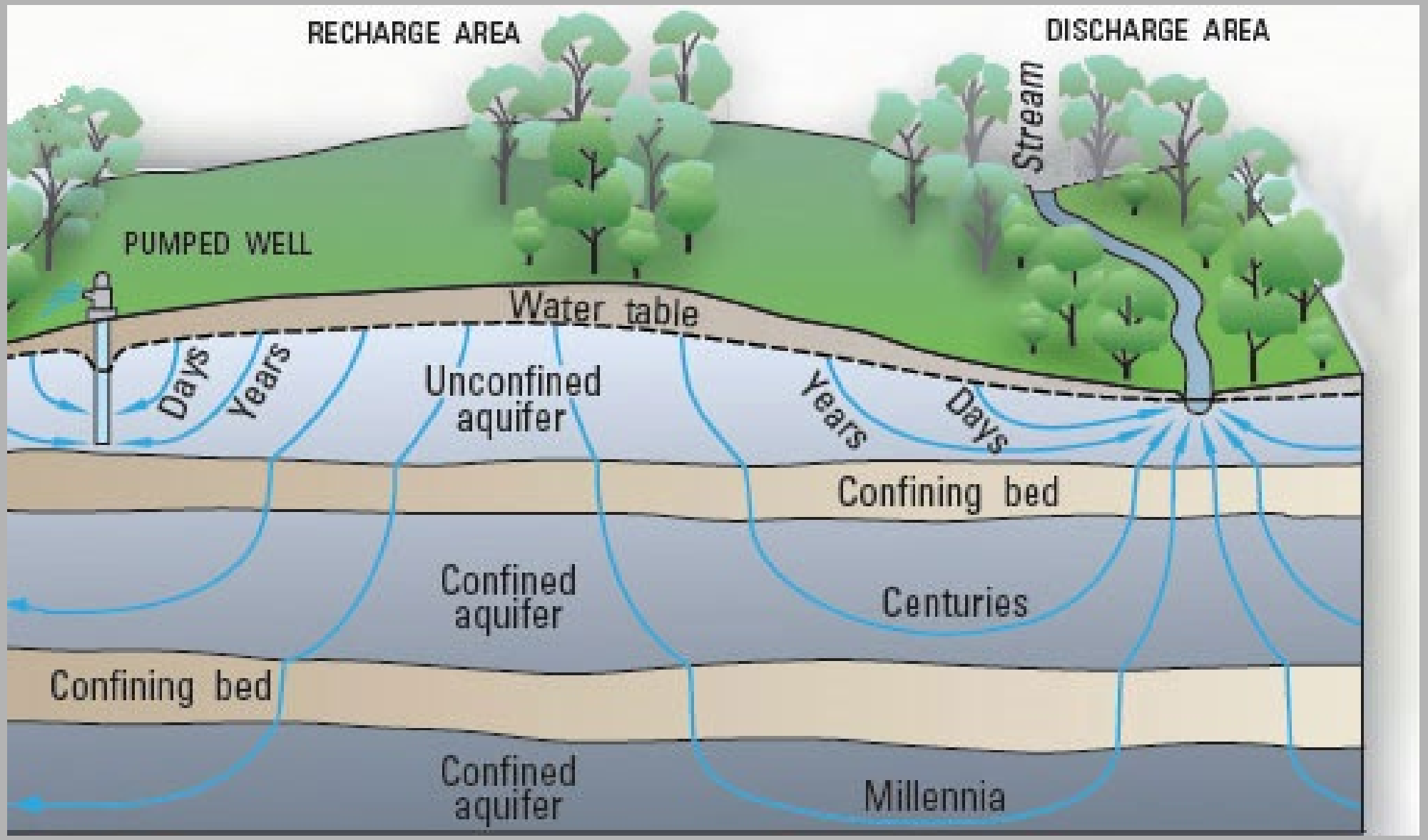
Anna Fehling, Wisconsin Geological and Natural History Survey

All water is part of the water cycle…

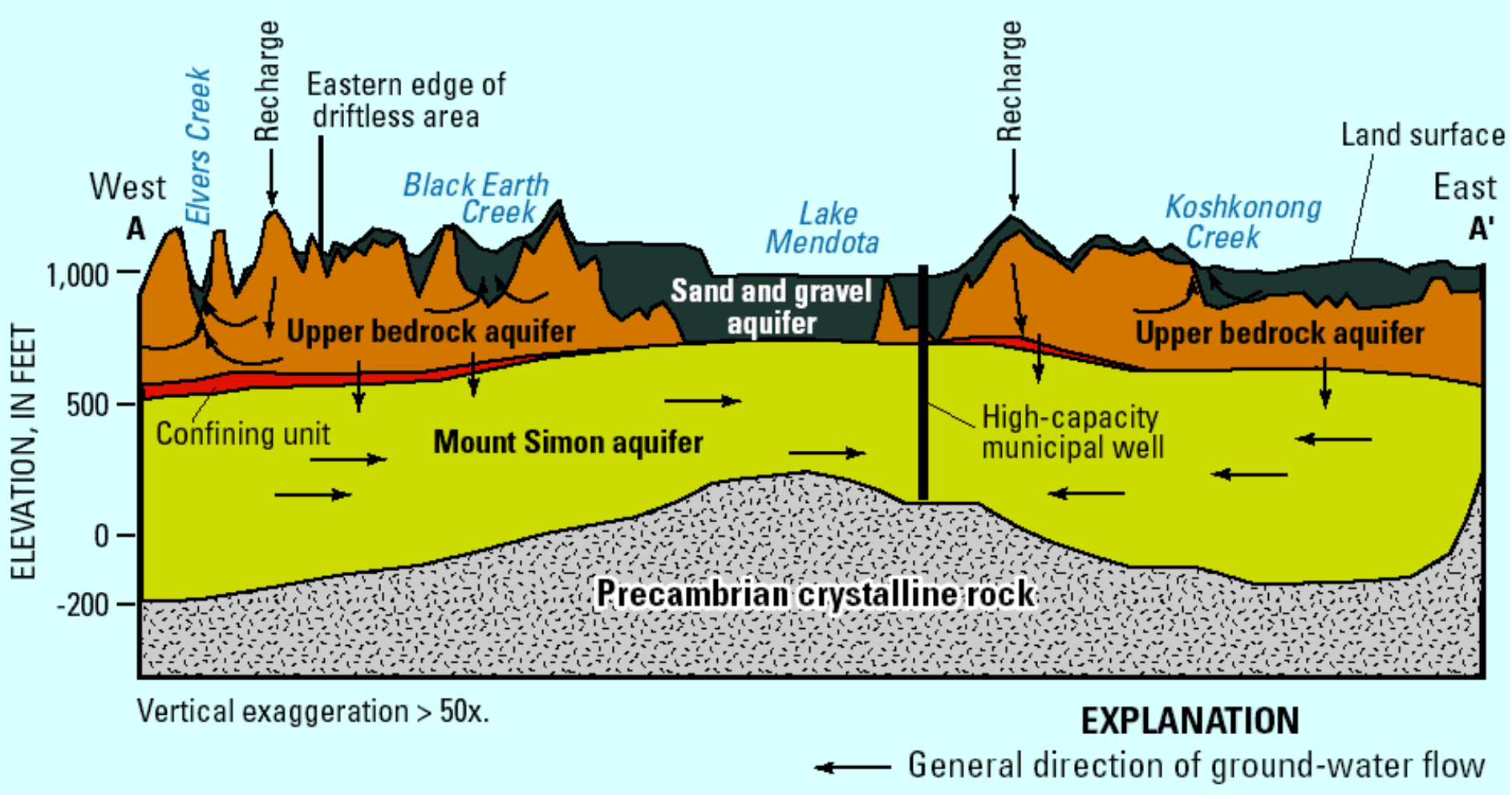


Aquifers are geologic units (sand and gravel, sandstone, etc) that can store and transmit significant quantities of groundwater

Groundwater moves from recharge to discharge areas



Generalized cross-section in Dane County



Hunt, R.J. et al., 2001 (USGS)

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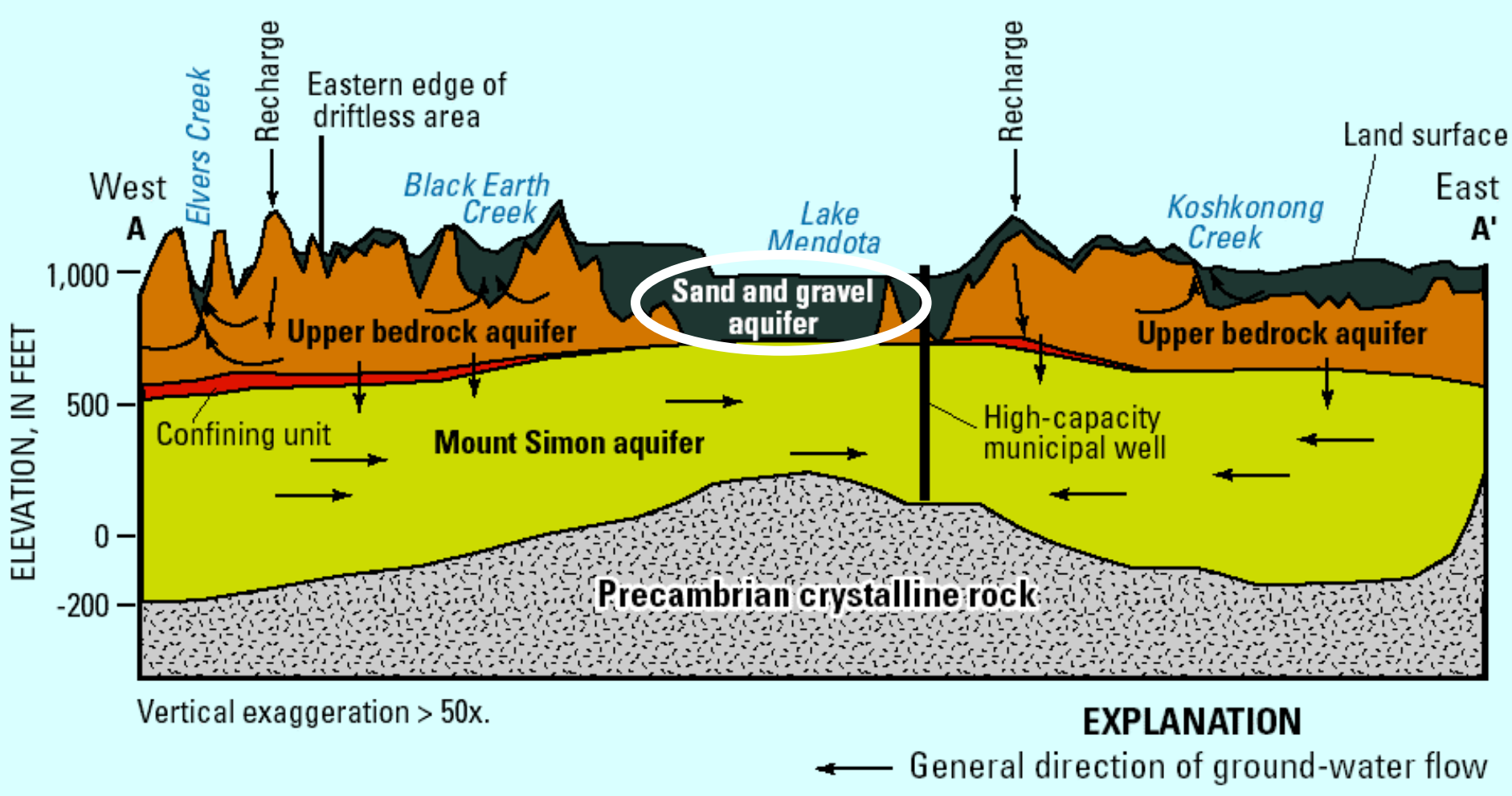

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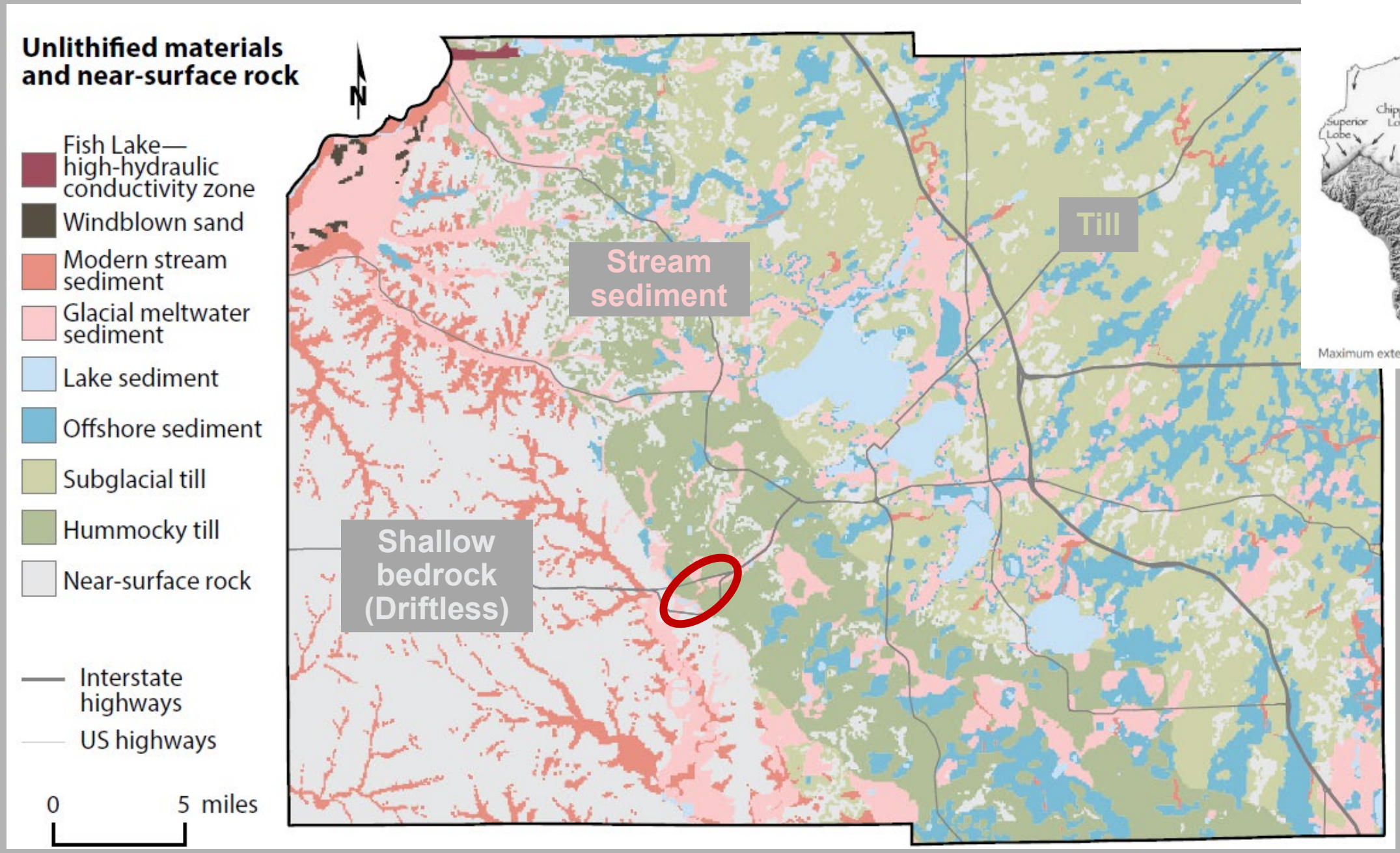
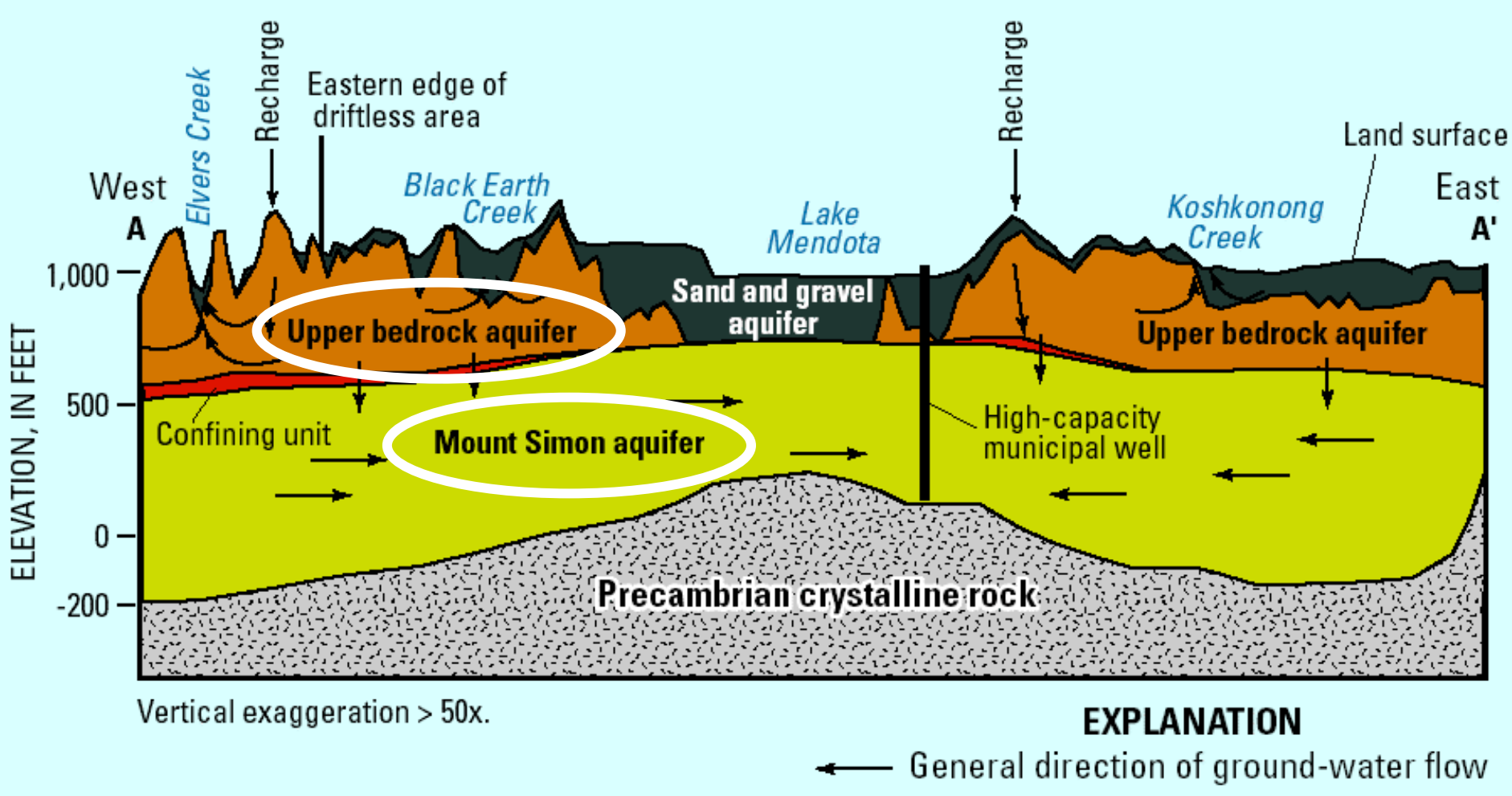


Maximum extent of the last glaciers in Wisconsin.

Generalized cross-section in Dane County

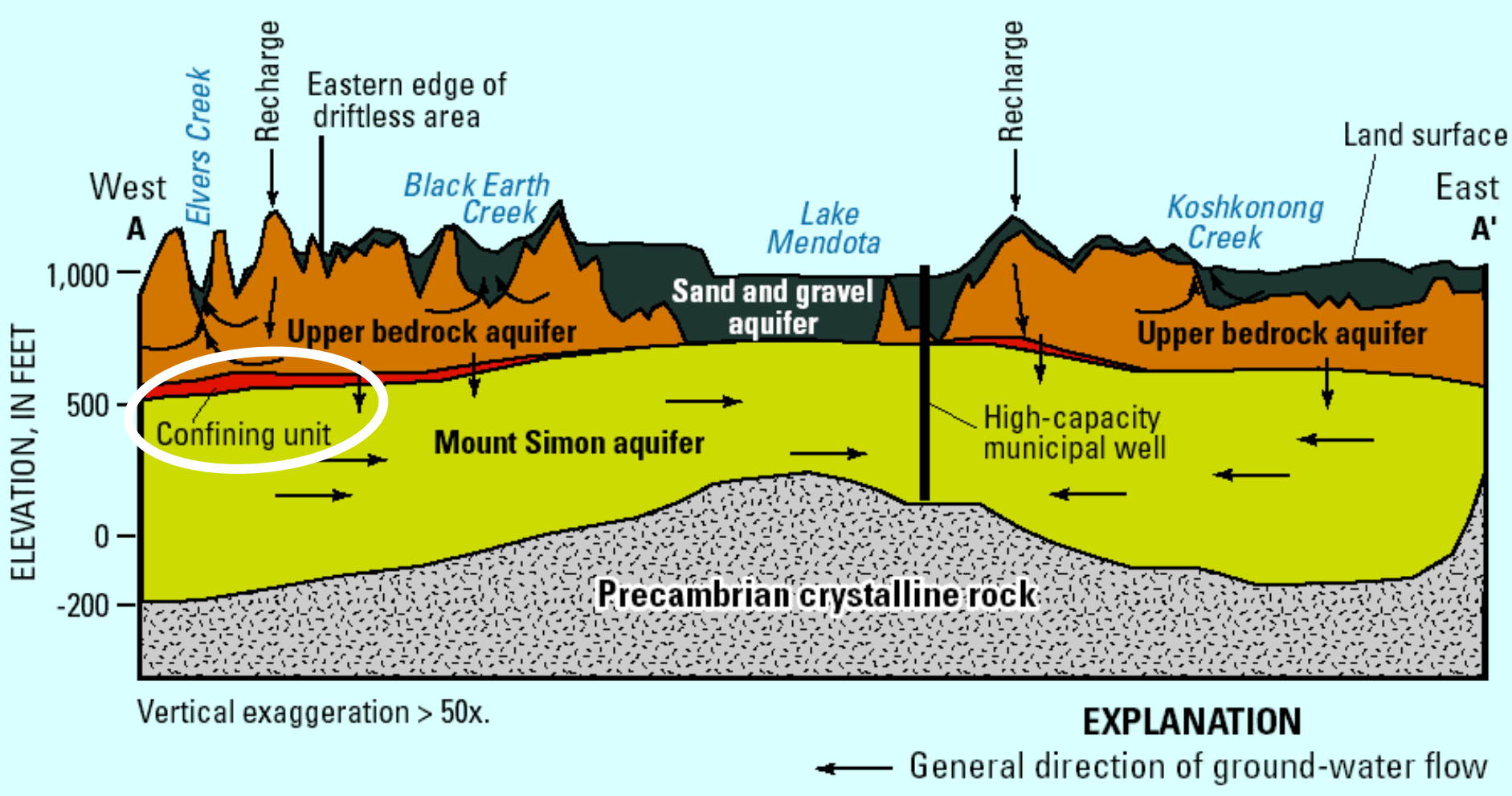


Hunt, R.J. et al., 2001 (USGS)

Bedrock aquifers- dolomite and sandstone

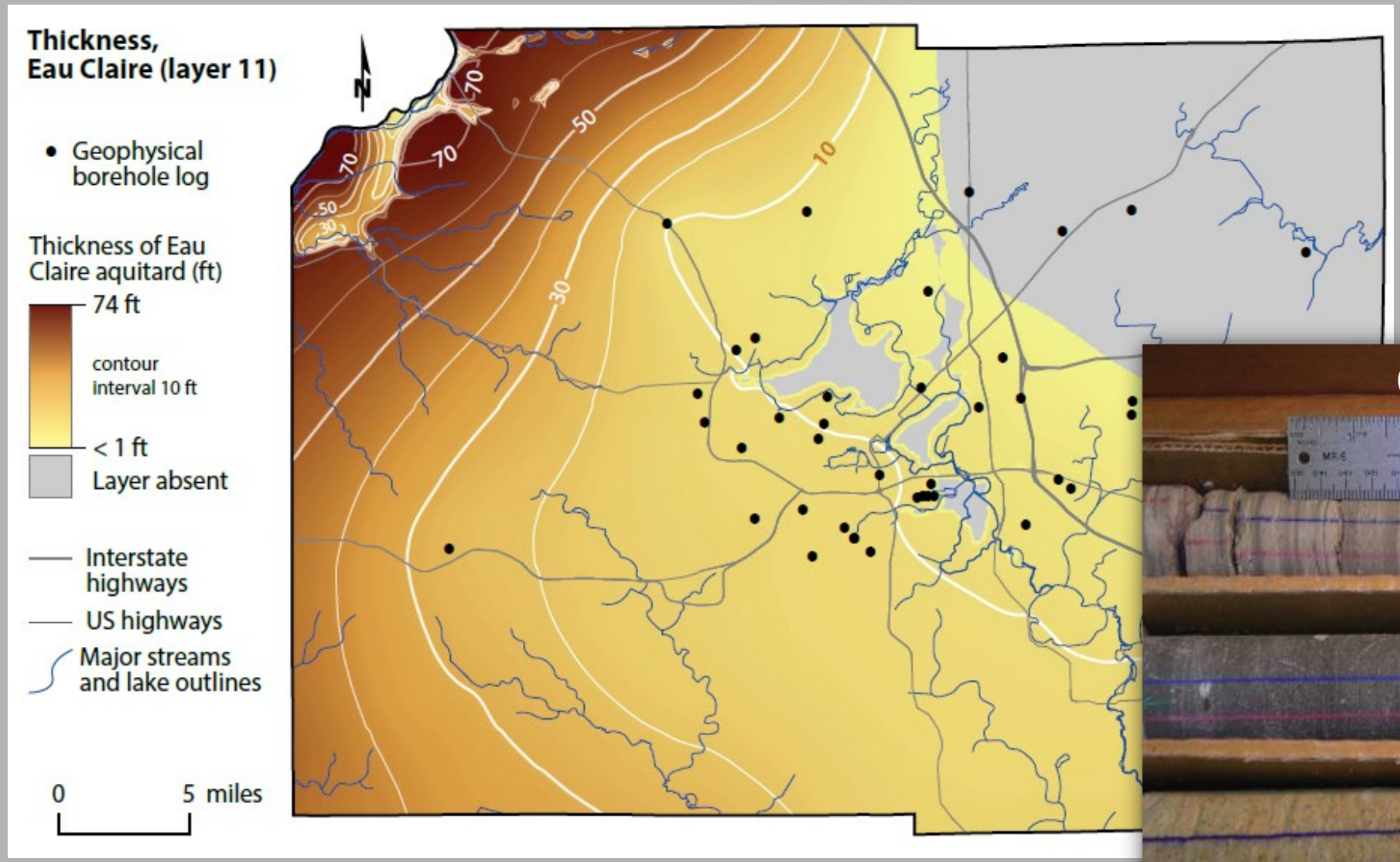
Core sample of the Wonewoc sandstone

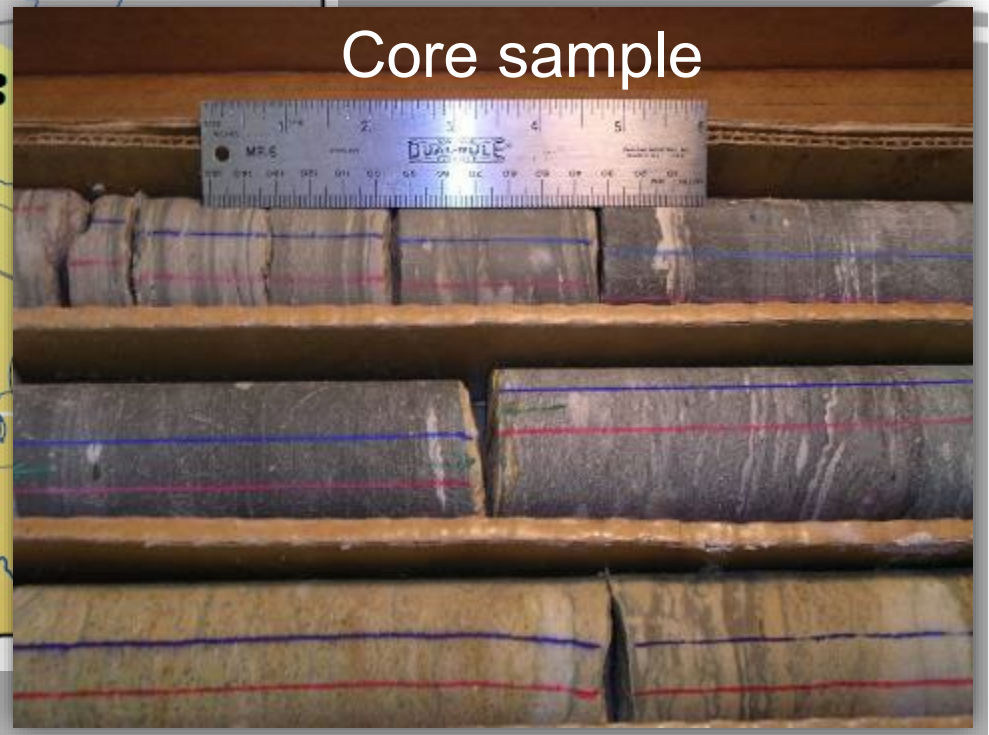
Generalized cross-section in Dane County



Hunt, R.J. et al., 2001 (USGS)

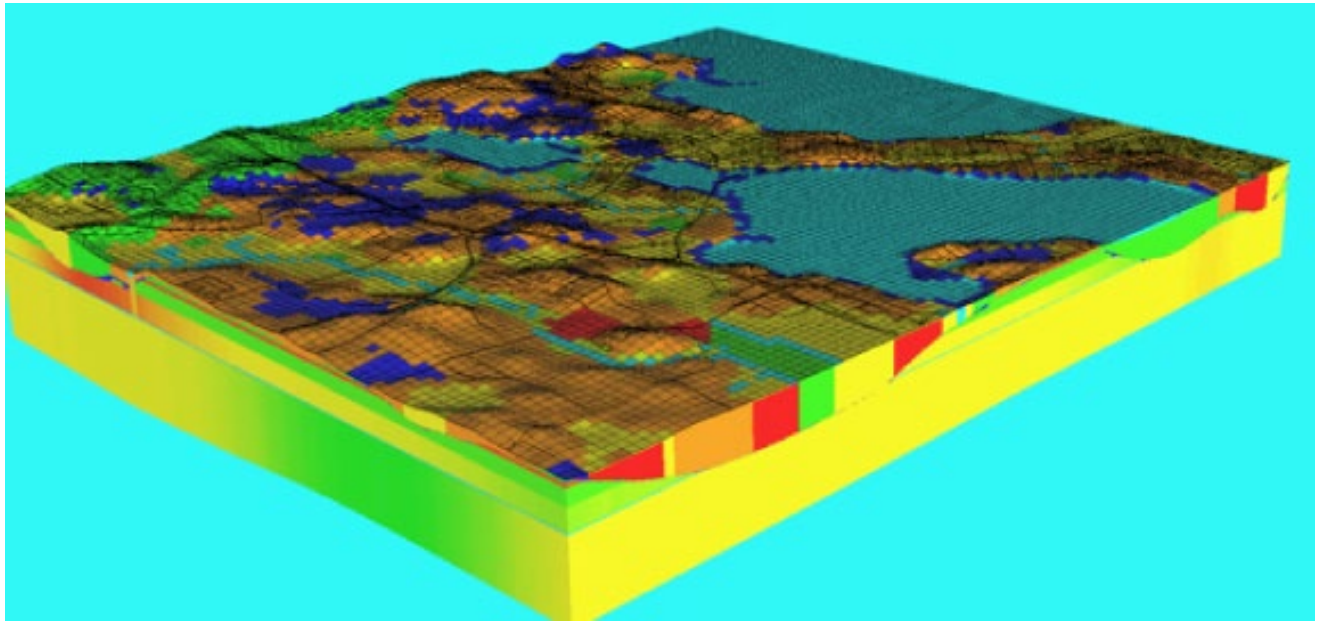
Eau Claire shale aquitard





What is a groundwater flow model?

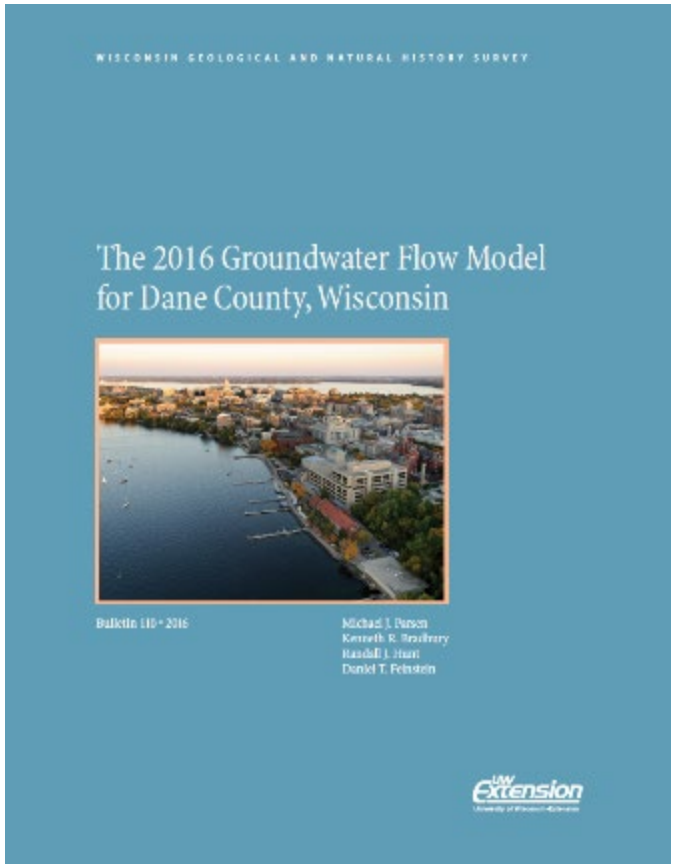
- Computer code that solves mathematical equations describing groundwater flow
- Geology, wells, and streams are simplified into a 3D grid



View of model grid. Colors represent hydraulic conductivity.

Dane County groundwater flow model

- Released in 2016
- MODFLOW-NWT
- 12 layers, 360 ft cells
- Steady state representing 2006-2010



WGNHS Bulletin 110
Parsen and others, 2016

Age		Stratigraphic name		2016 model		Type
Era	Period	Group	Formation			
				1	Unlithified I (fine-grained lake deposits within glacial Lake Yahara area; elsewhere, till and meltwater stream deposits)	
				2	Unlithified II (till and meltwater stream deposits)	
Paleozoic	Ordovician		Maquoketa	3	Upper bedrock	aquifers
		Sinnipee	Galena			
			Decorah			
			Platteville			
		Ancell	Glenwood			
			St. Peter			
		Prairie du Chien				
	Cambrian	Trempealeau	Jordan	4	Jordan	
			St. Lawrence	5	St. Lawrence	
		Tunnel City	Lone Rock, Mazomanie	6	Tunnel City—upper	
				7	Tunnel City *(fracture layer)*	
				8	Tunnel City—lower	
		Elk Mound	Wonewoc	9	Wonewoc	
				10	Wonewoc *(fracture layer)*	
			Eau Claire	11	Eau Claire	aquitard
			Mount Simon	12	Mount Simon	aquifer
Precambrian		Various unnamed units				

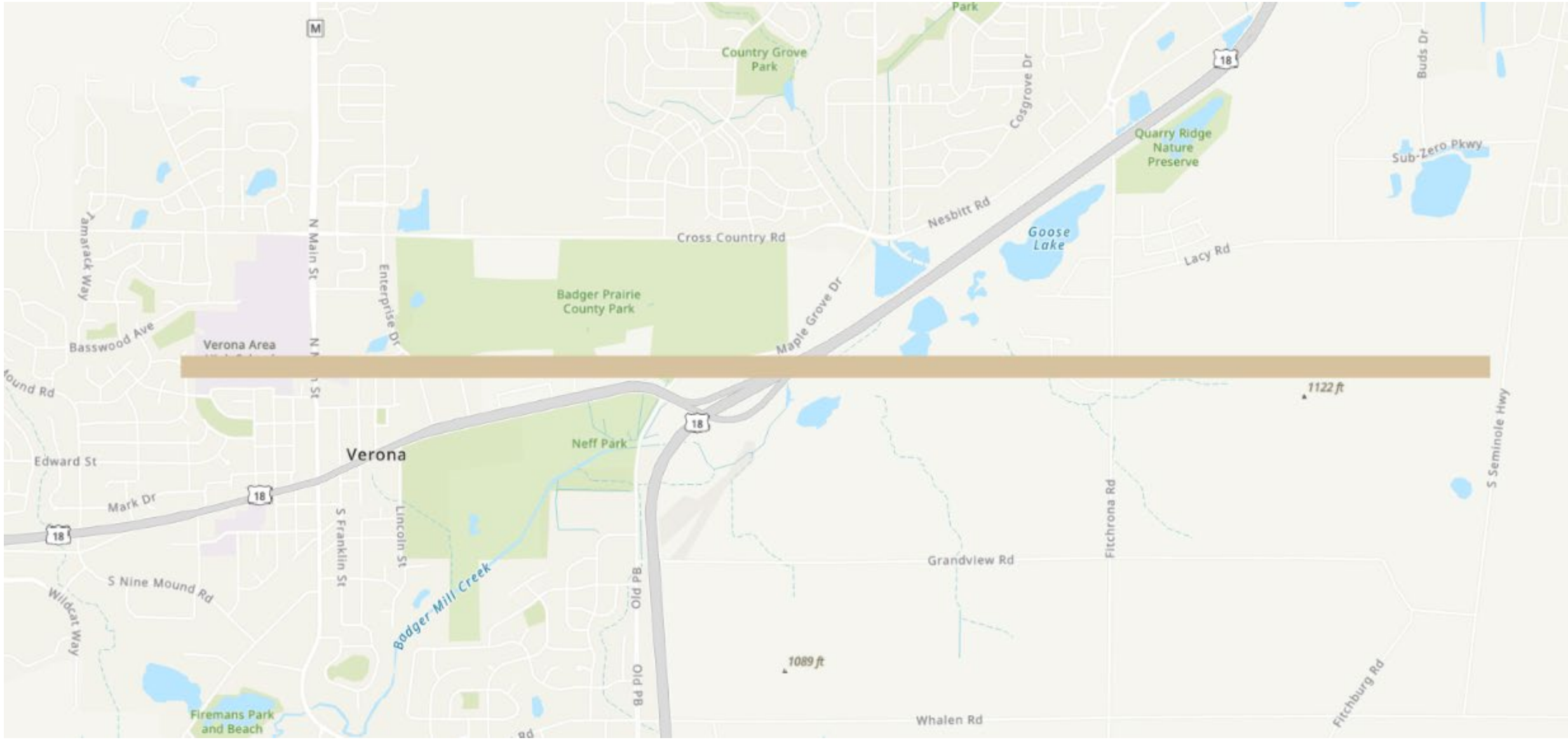
Geology:

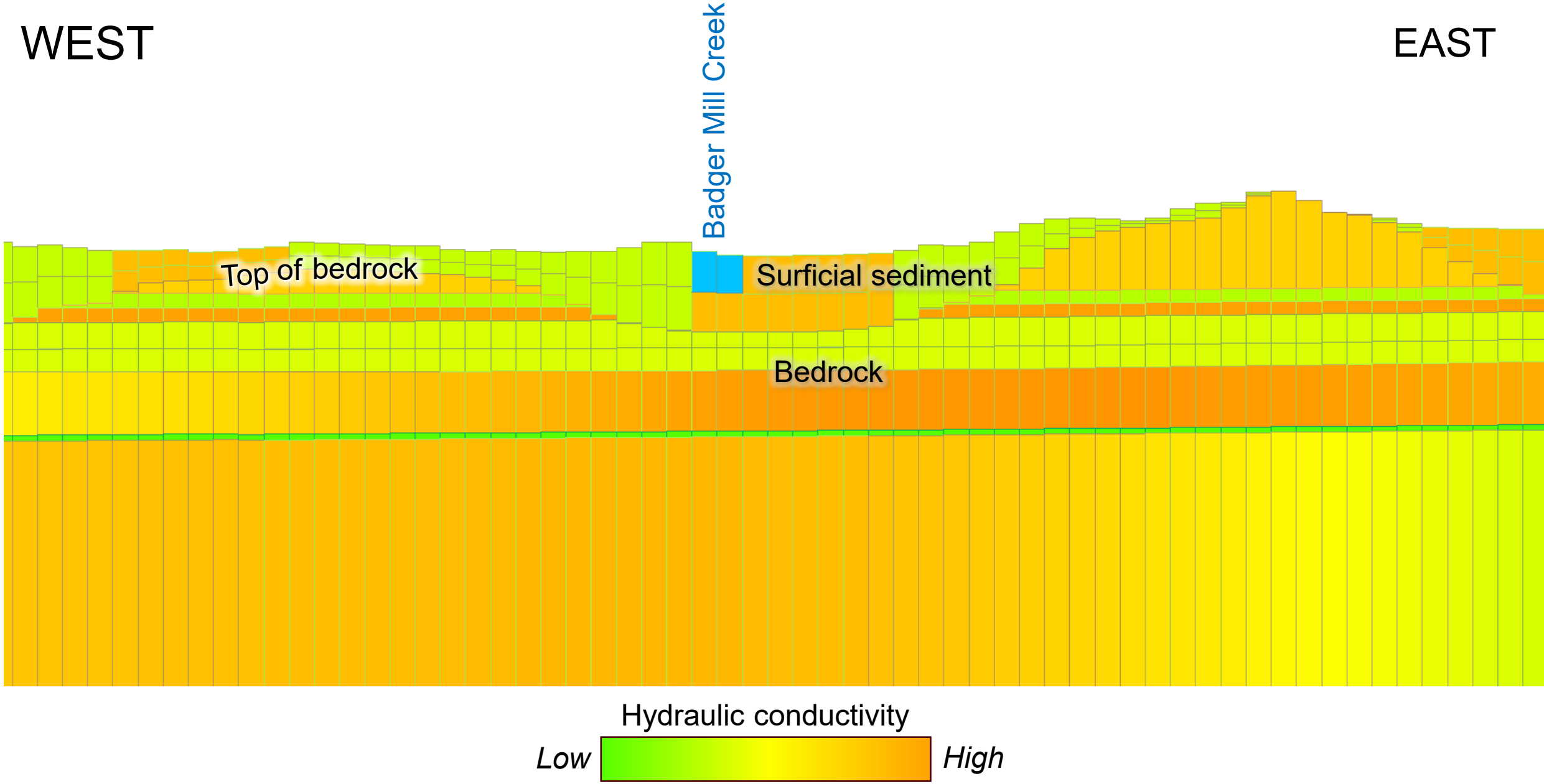
12 layers

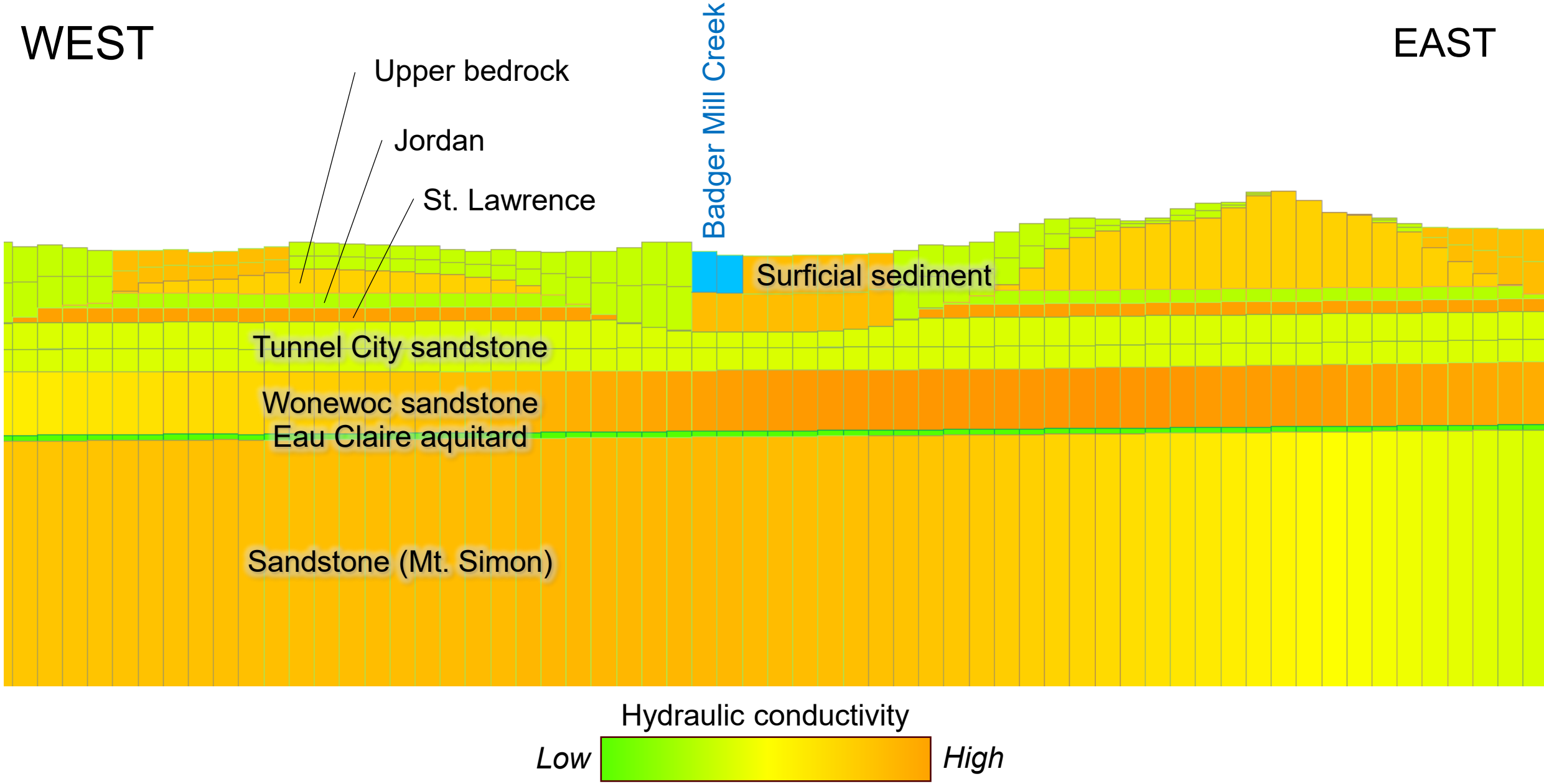
Each represents a hydrostratigraphic unit

Layers vary in thickness and are absent in some parts of model

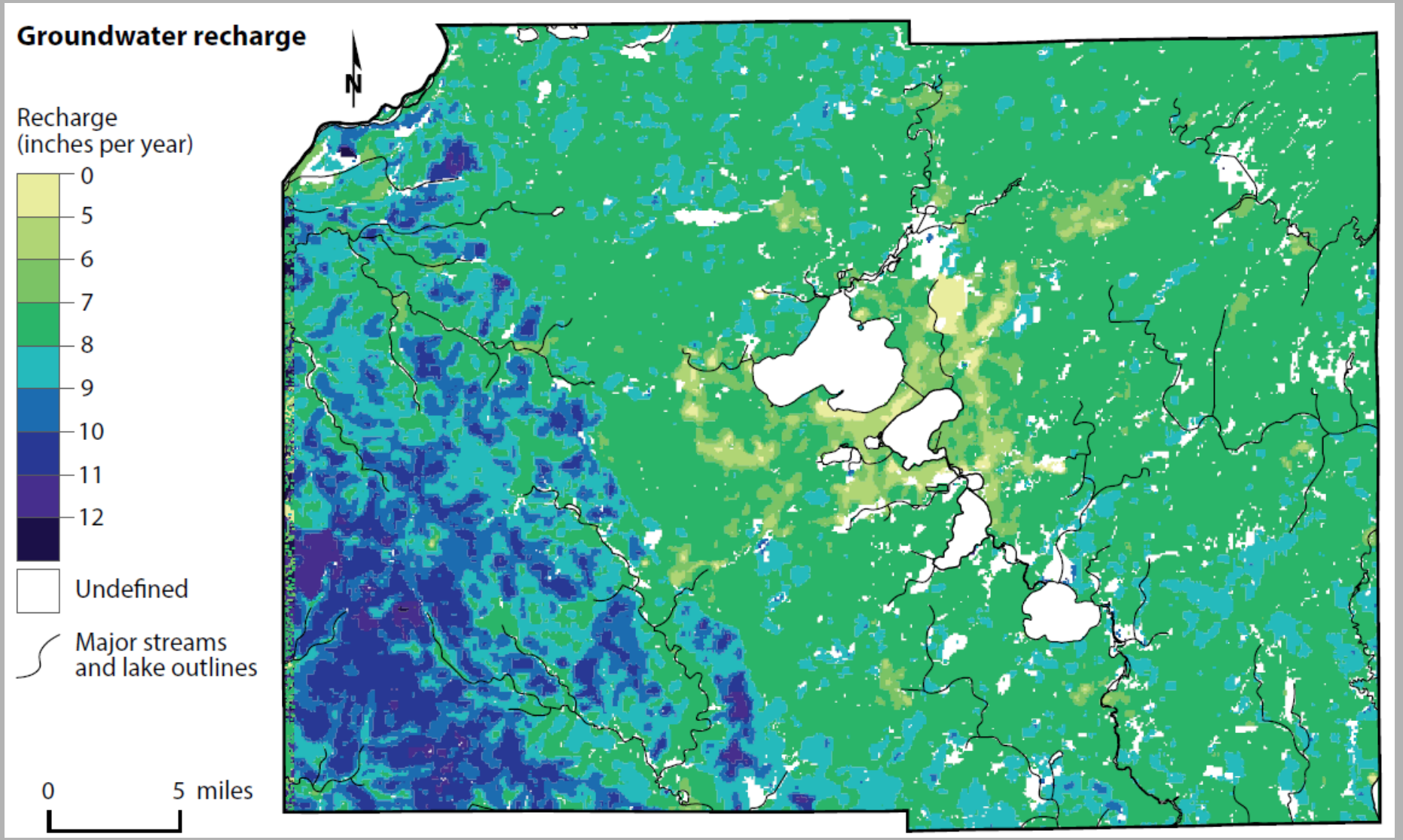
Cross section through Badger Mill Creek at outfall




WEST
EAST
Badger Mill Creek
Top of bedrock
Surficial sediment
Bedrock
Hydraulic conductivity
Low
High

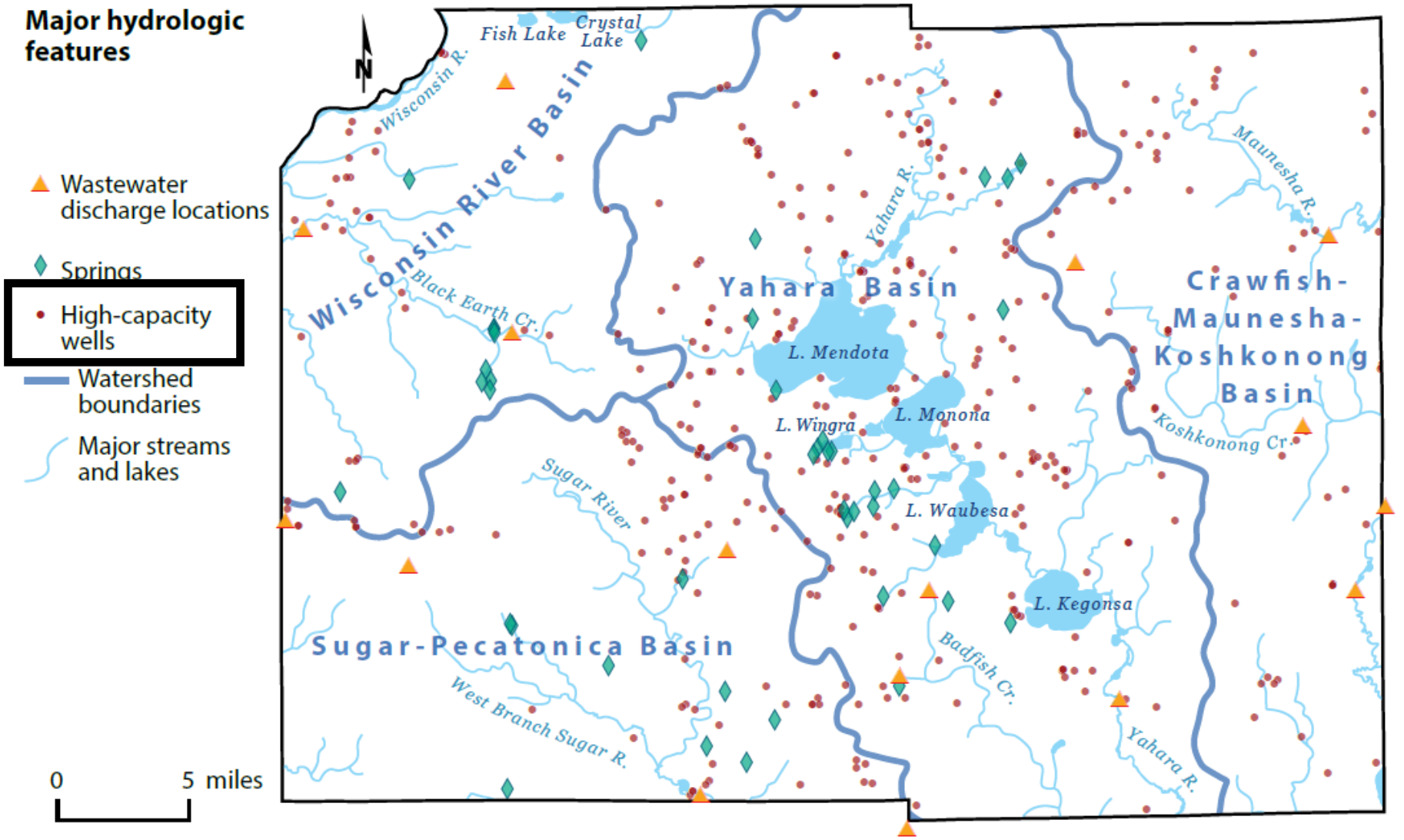

WEST
EAST
Badger Mill Creek
Upper bedrock
Jordan
St. Lawrence
Surficial sediment
Tunnel City sandstone
Wonewoc sandstone
Eau Claire aquitard
Sandstone (Mt. Simon)
Hydraulic conductivity
Low
High

Groundwater recharge



- Developed with soil-water balance model
- Parameter to test climate change effects

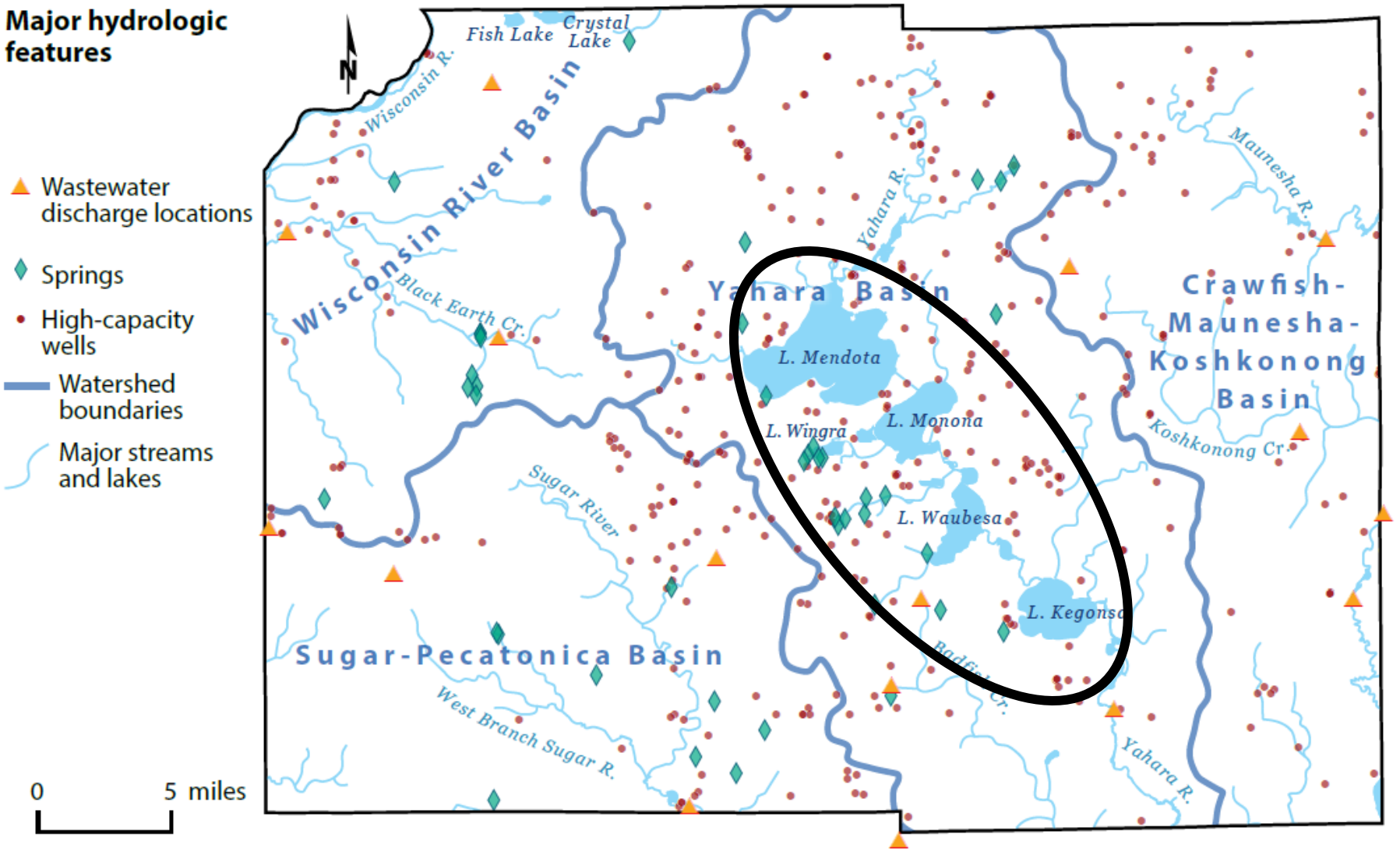
Groundwater pumping



- 2006-2010 pumping & effluent discharge rates

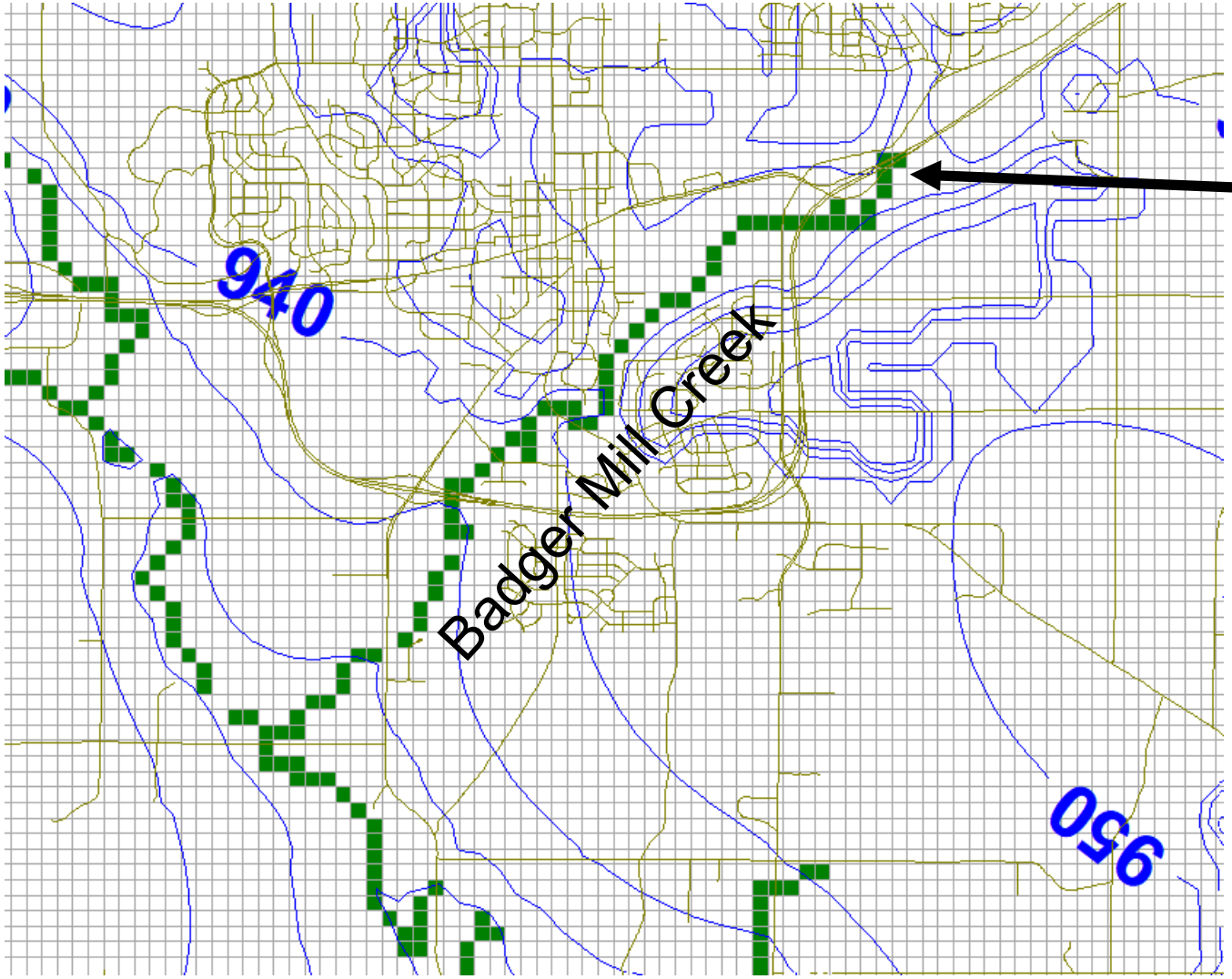
Typical municipal well pump

Lakes



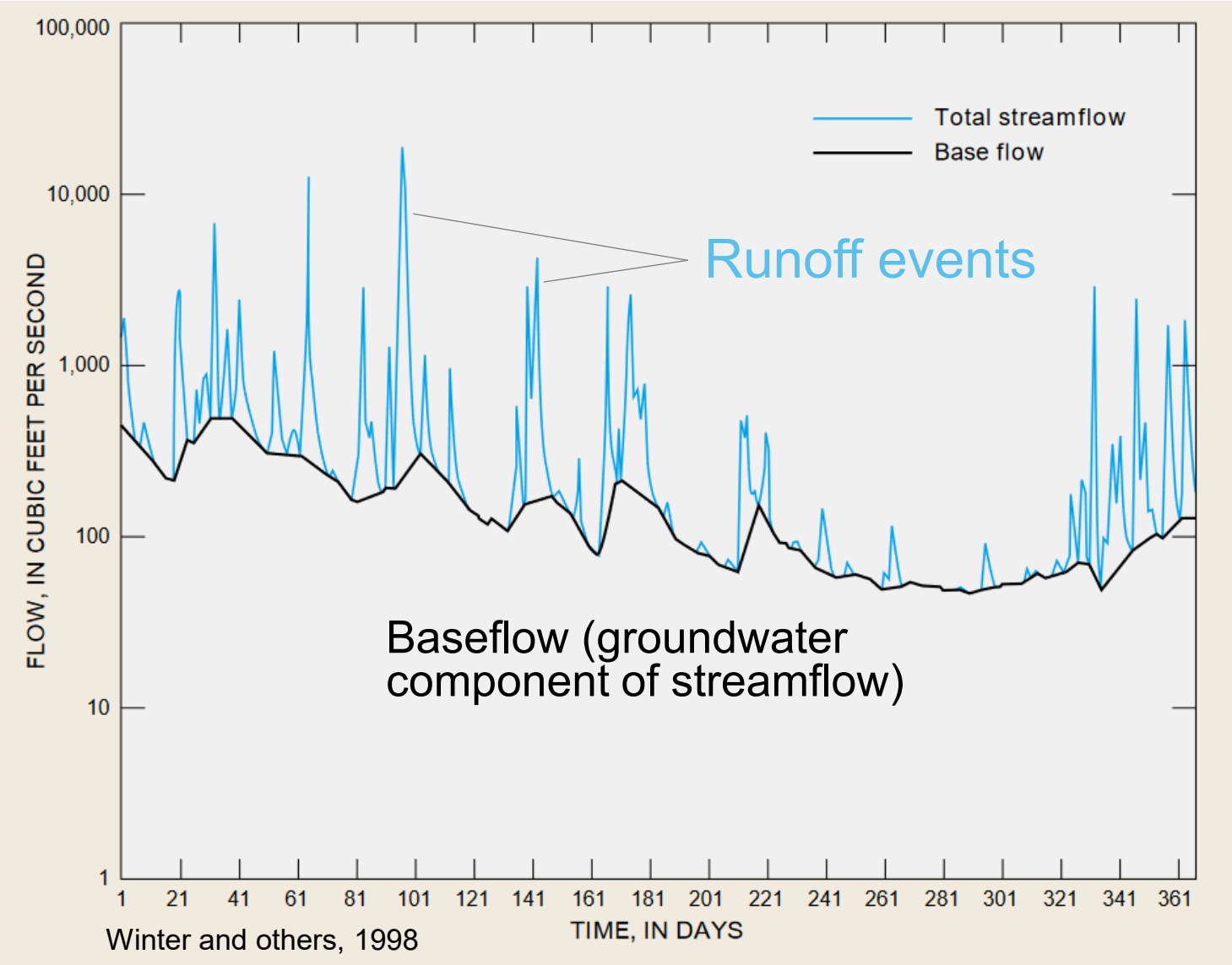
- Major lakes represented
- No stormwater basins

Streams



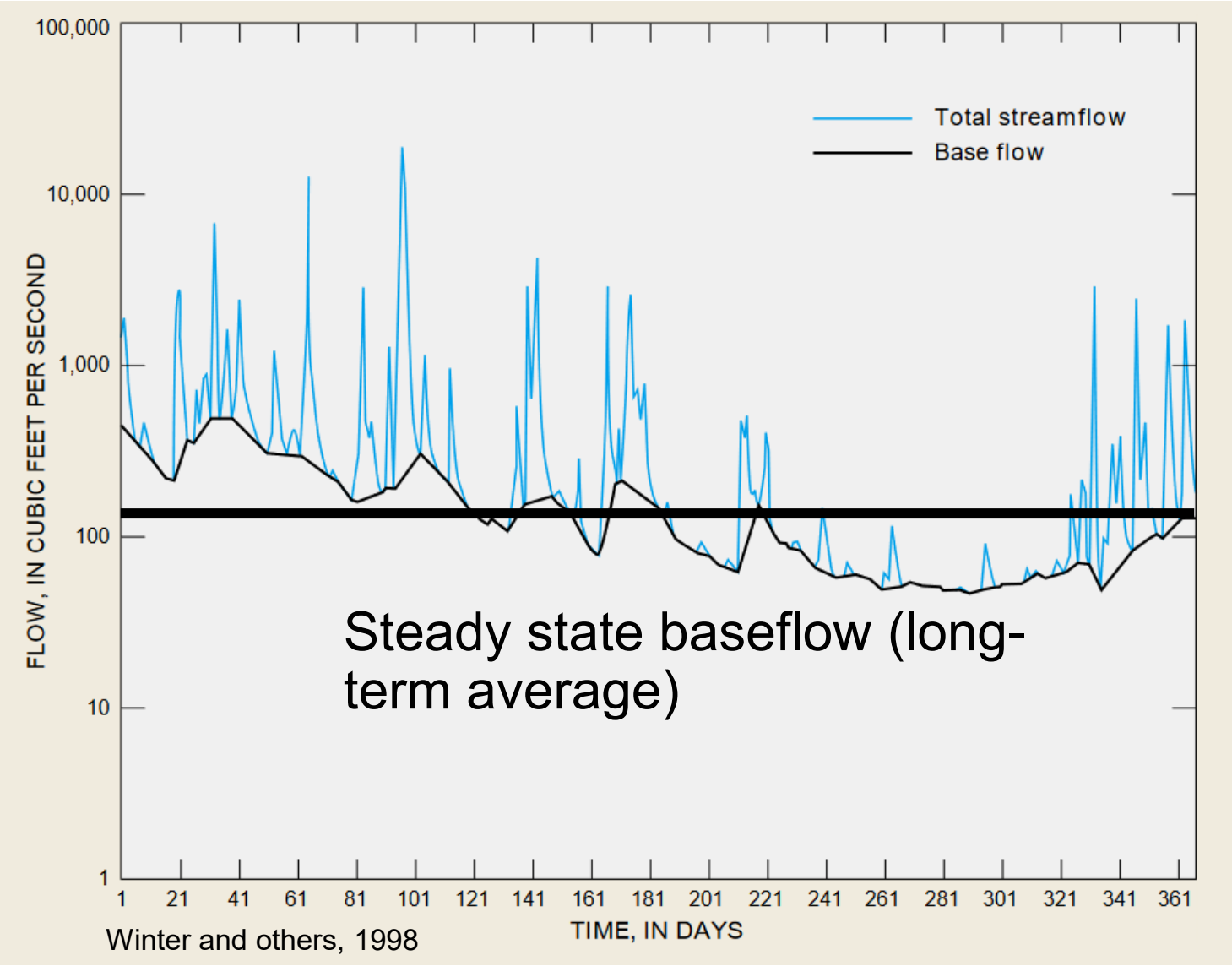
- Effluent added to headwaters
- Streams can either lose or gain water from the aquifer
- Model simulates baseflow in each cell

Streams



- Model simulates baseflow (not surface water runoff)

Streams



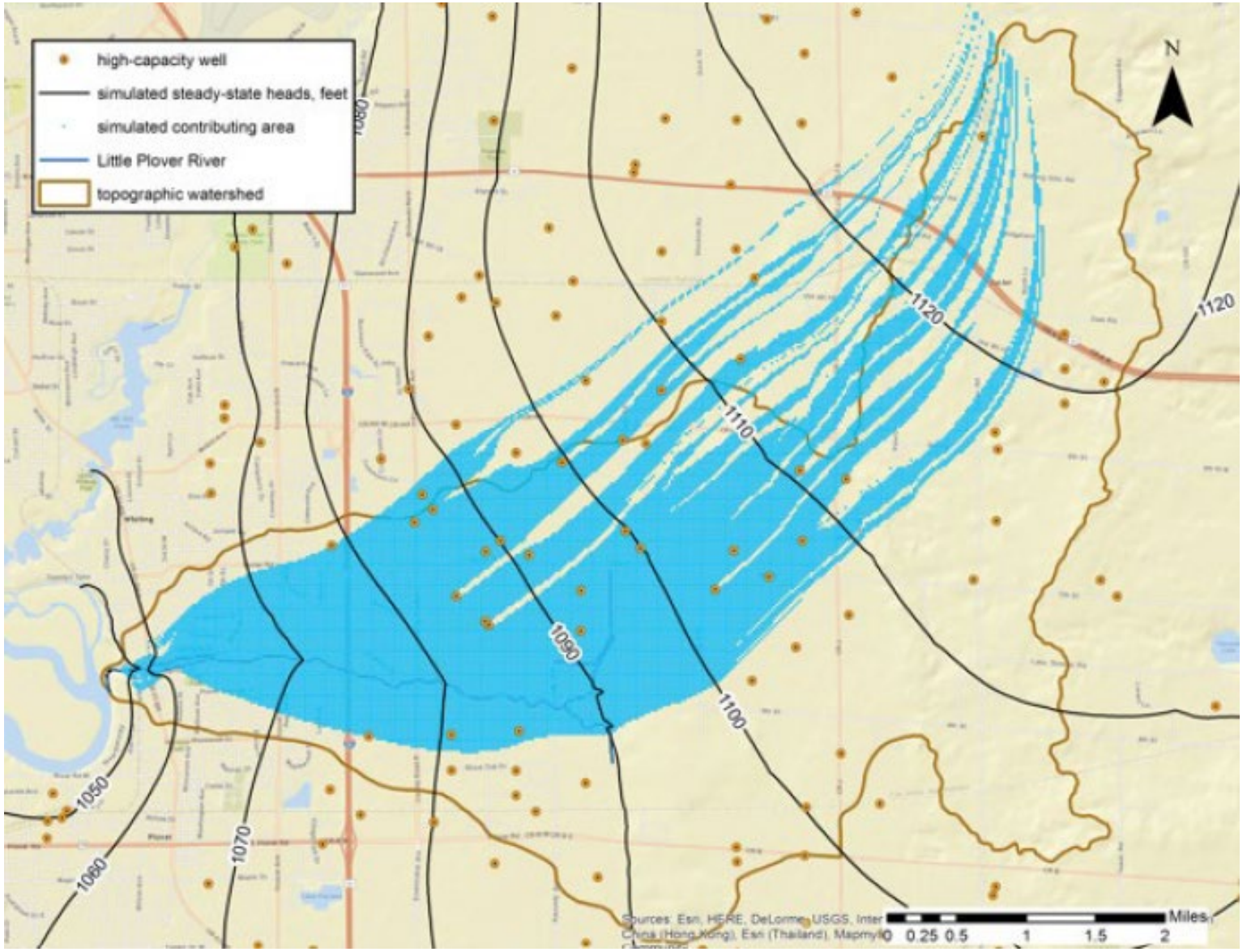
- Model simulates baseflow (not surface water runoff)

Model capabilities

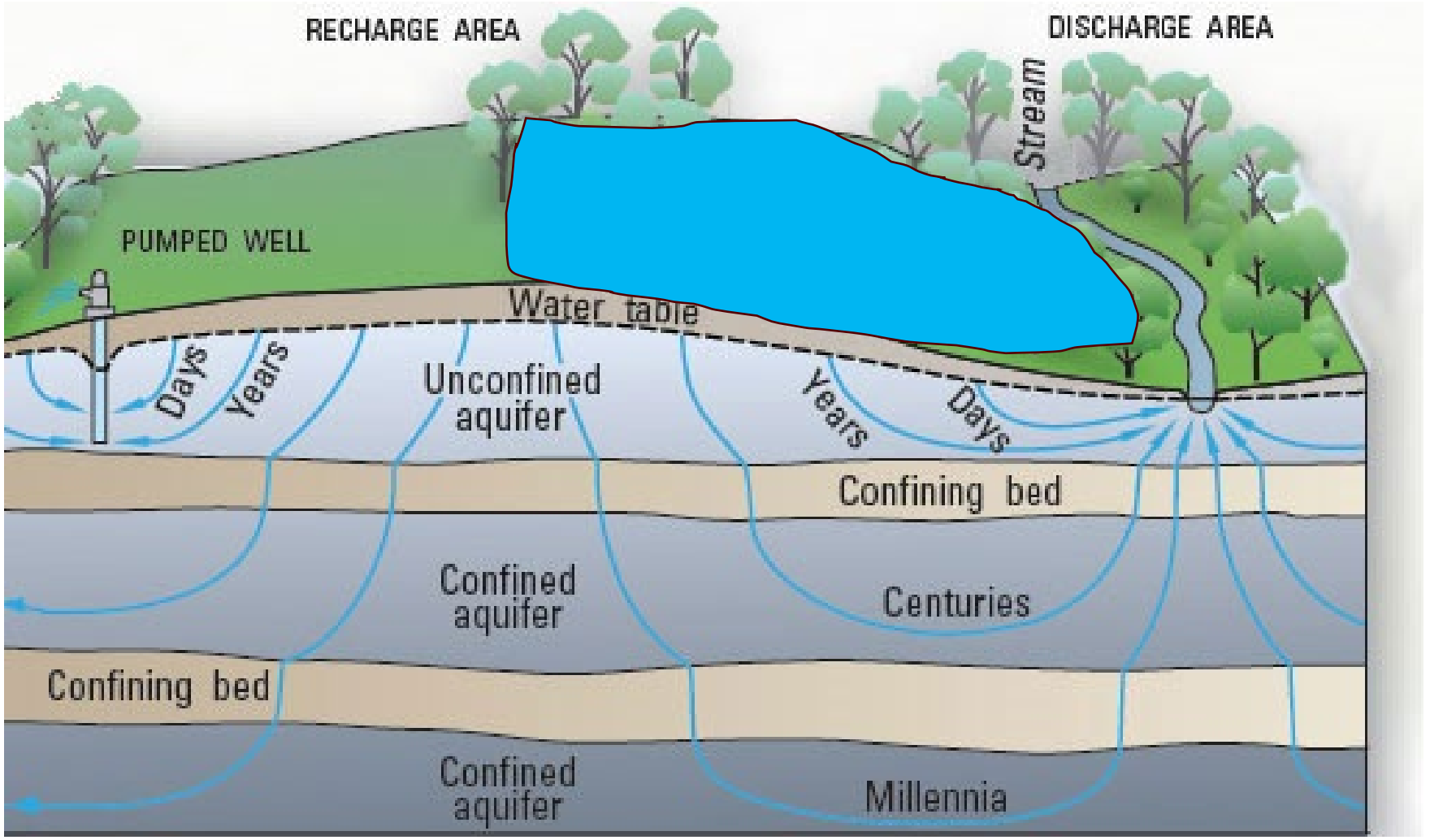
- Capture zones, travel times, flow directions
- Changes to baseflow or groundwater levels from pumping (2006-2010) or climate change (recharge)
- Provide framework for more detailed studies

Capture zone

- Example from Little Plover River model
- Recharge in capture zone would eventually reach stream
- (pumping outside of capture zone still affects flow)

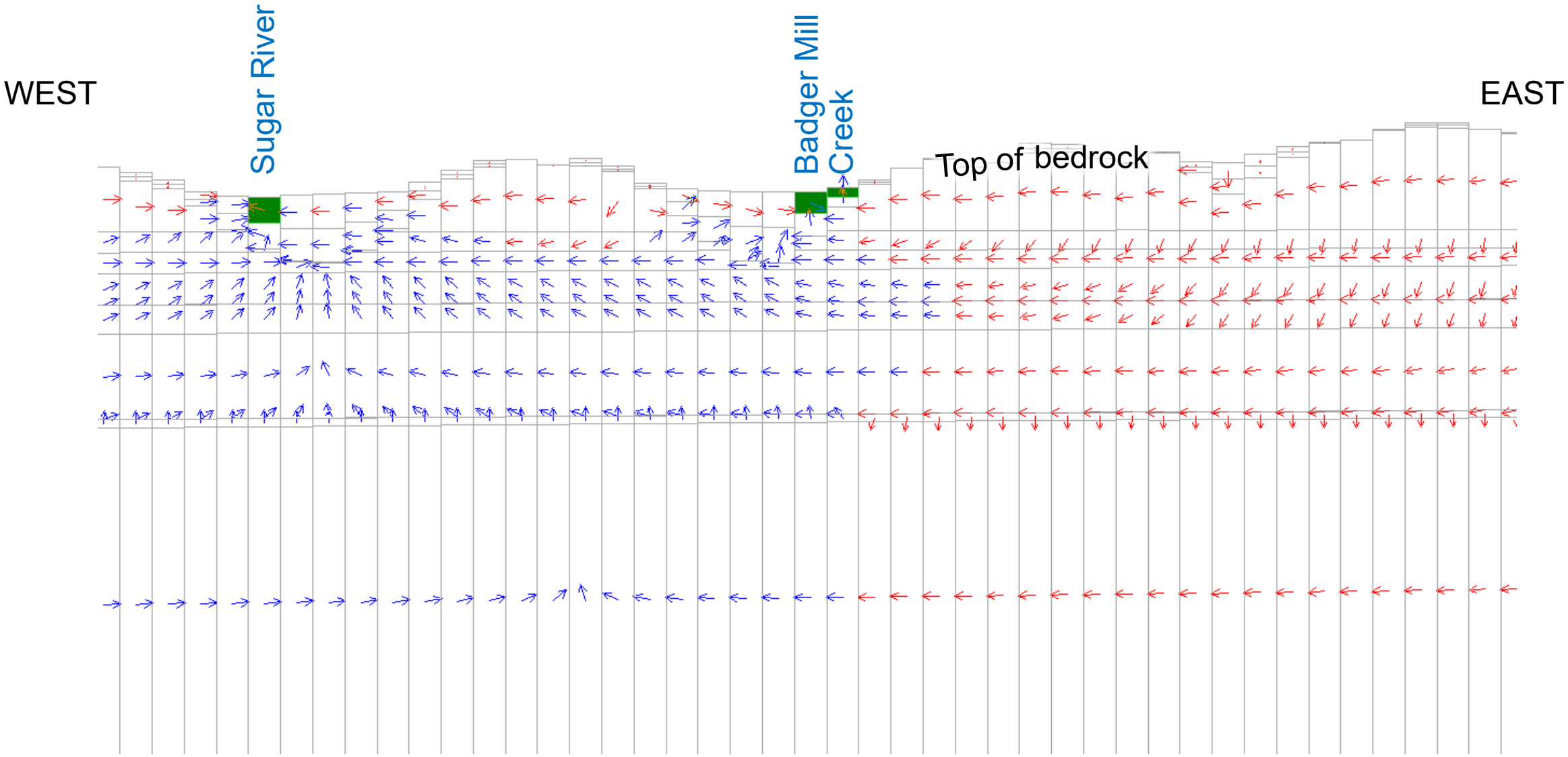


Capture zone in 3D

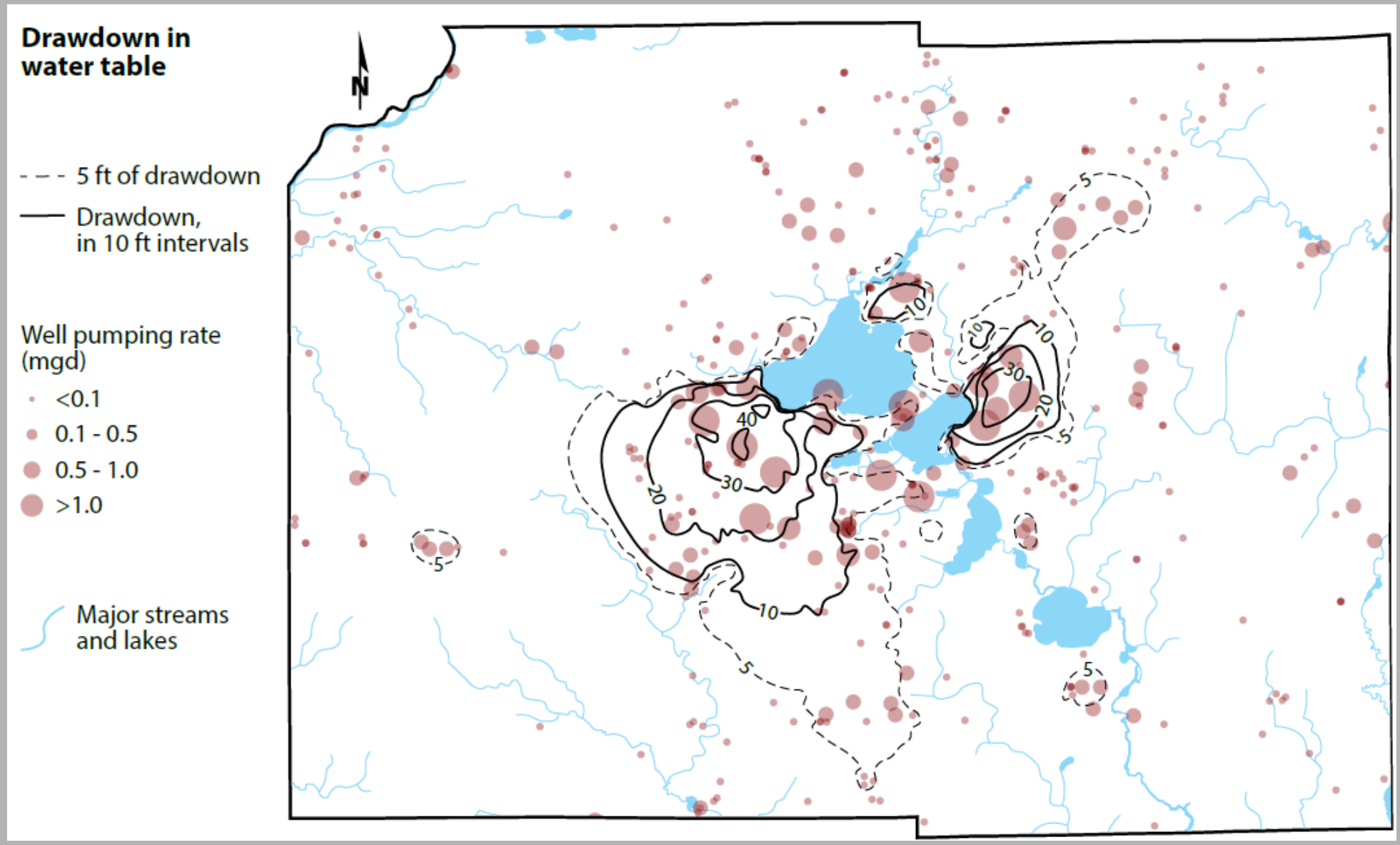


Model can simulate travel times for each flow path

Flow direction and volume



Changes to water table from pumping

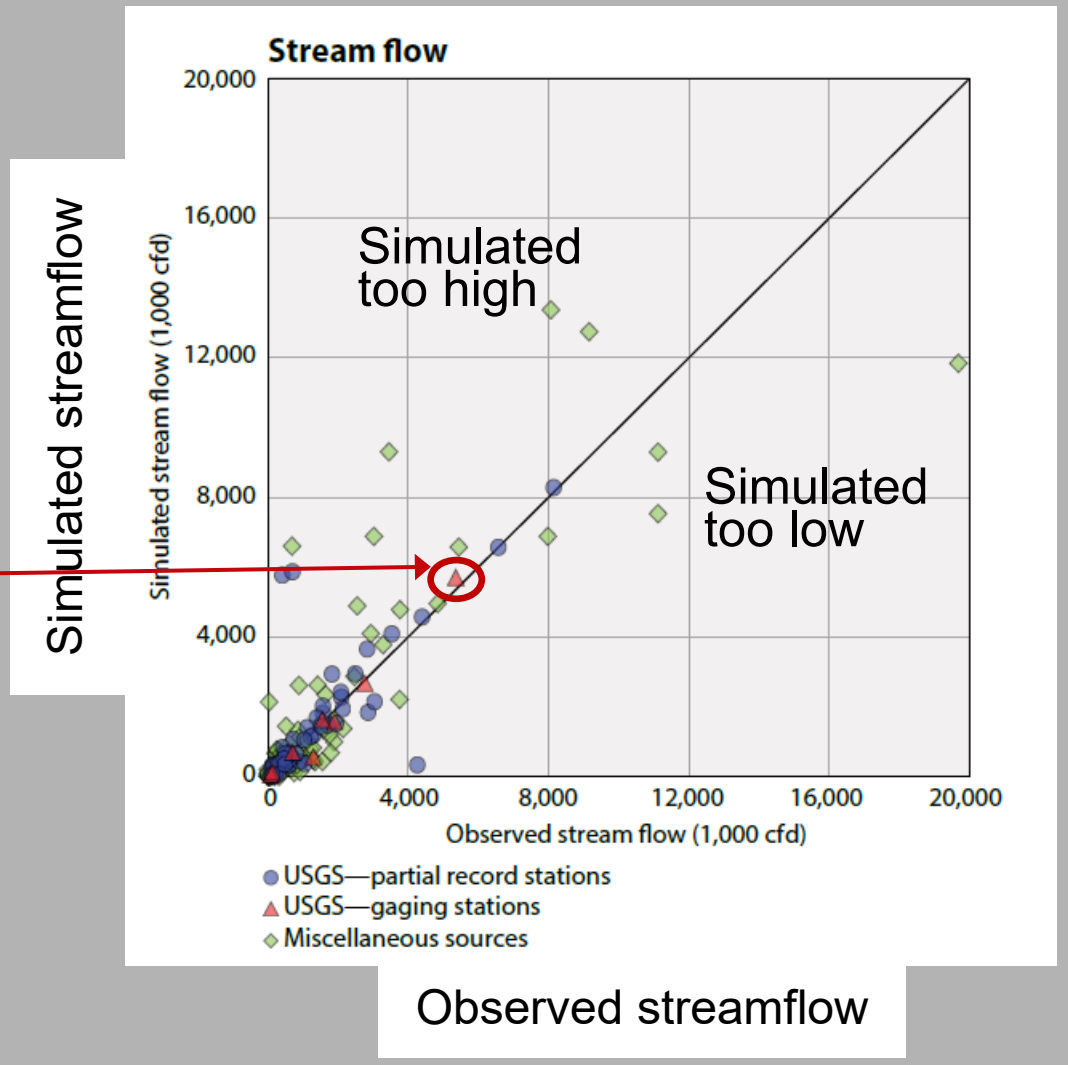


Badger Mill Creek considerations

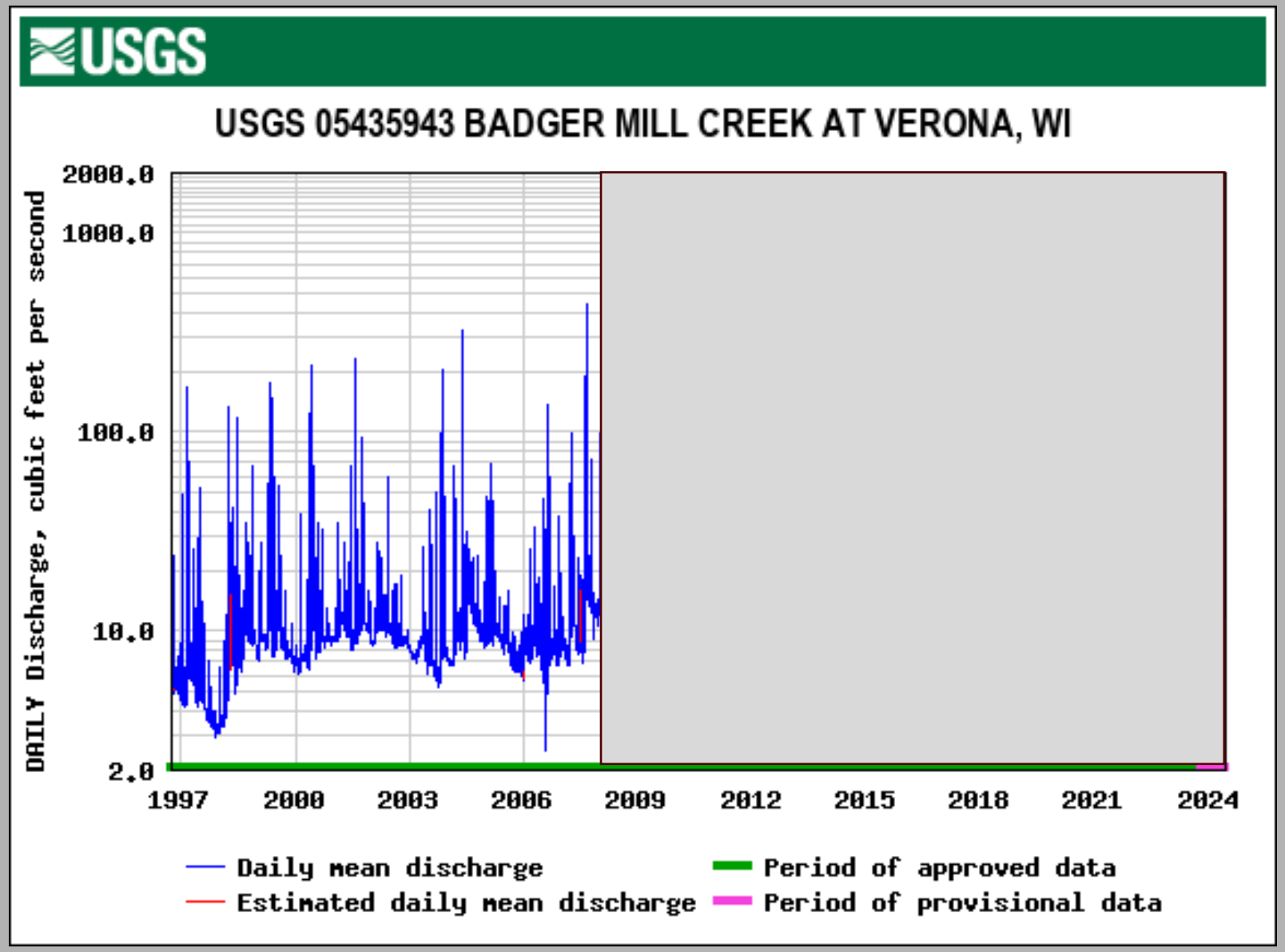
- Model performance
- Geology
- Hydrology

Model performance - streamflows

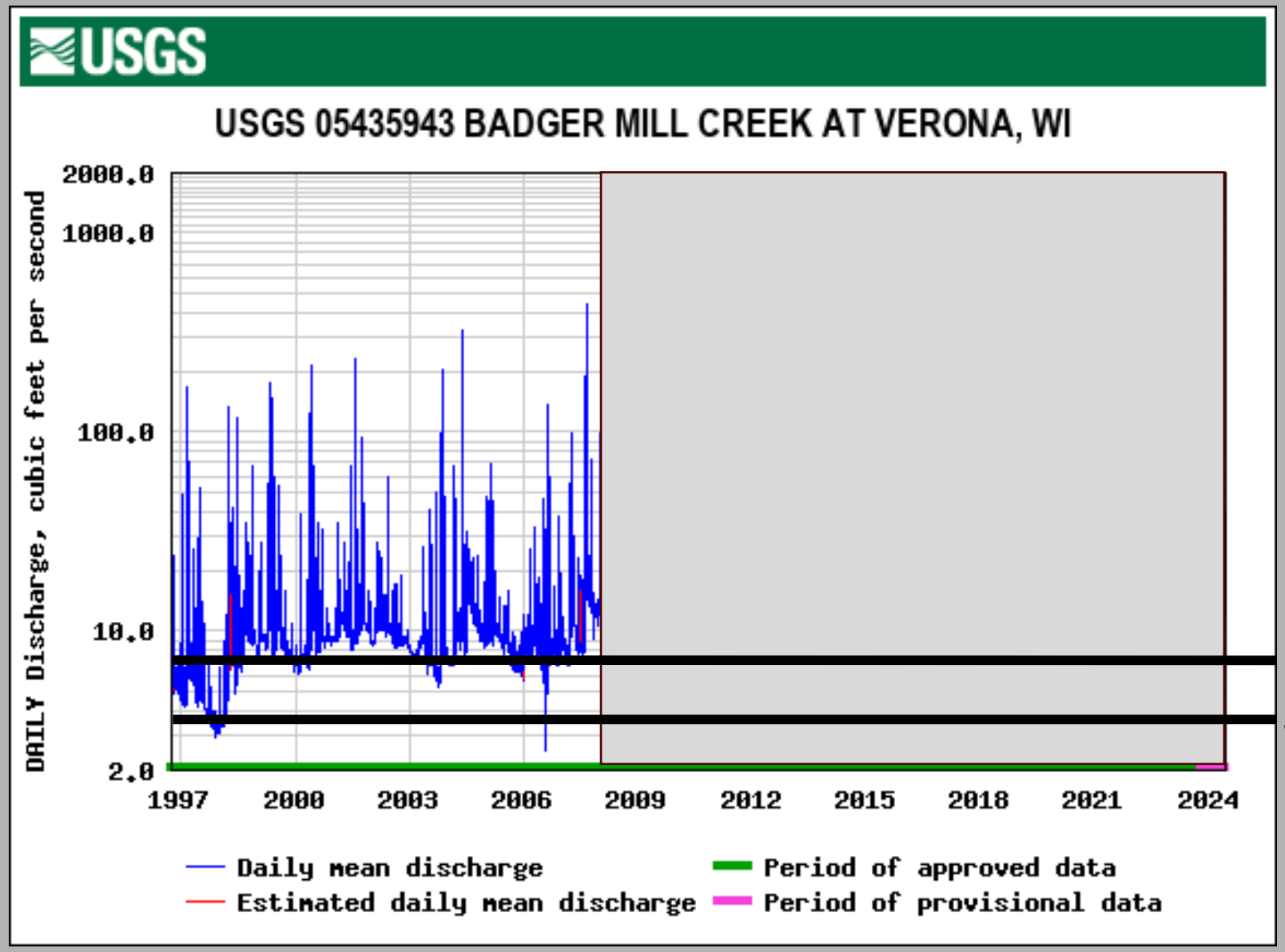
- In a regional model, some streams simulate more than measured; some less
- Large streams with gages are most important
  - Example is ~**70 cfs**
  - Effluent discharge is 5 cfs



Badger Mill Creek flow



Badger Mill Creek flow

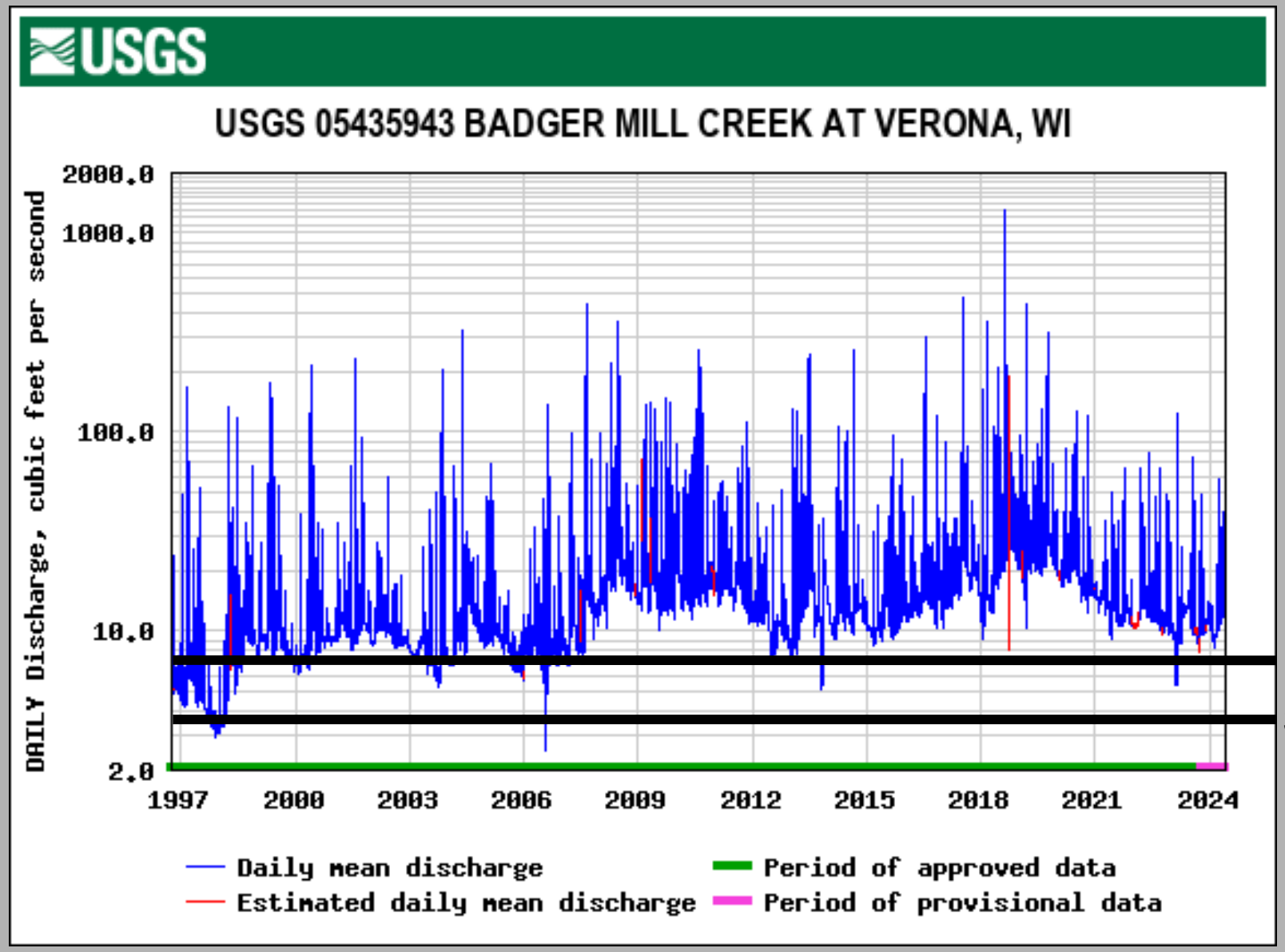


Simulated lower than observed

Observed (model target, ~7 cfs)

Simulated (~3.5 cfs)

Badger Mill Creek flow



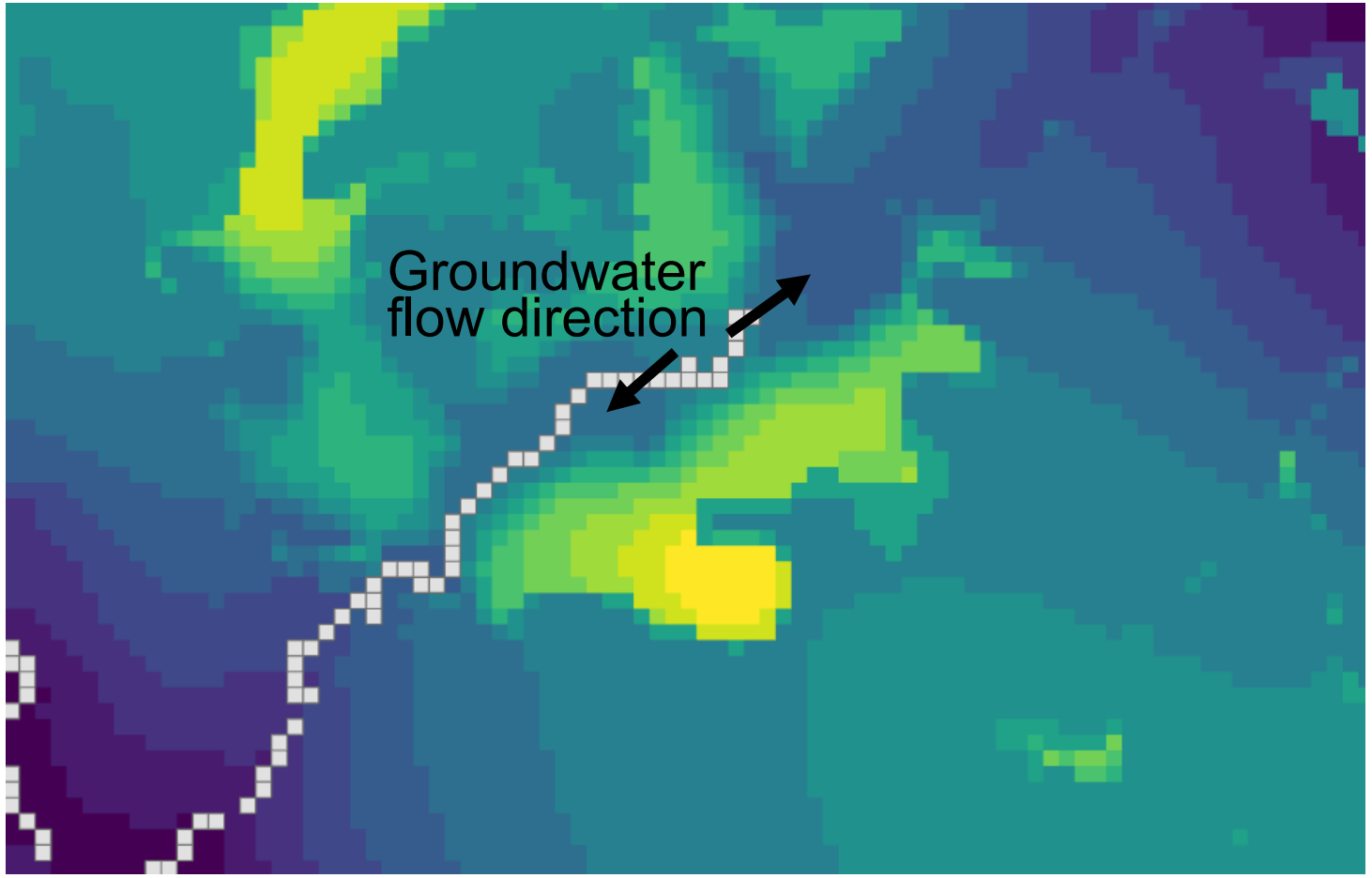
- Simulated lower than observed
- Recent flow is higher than target flow
- Climate and stormwater changes

Observed (model target, ~7 cfs)

Simulated (~3.5 cfs)

Hydrologic setting

Water table map



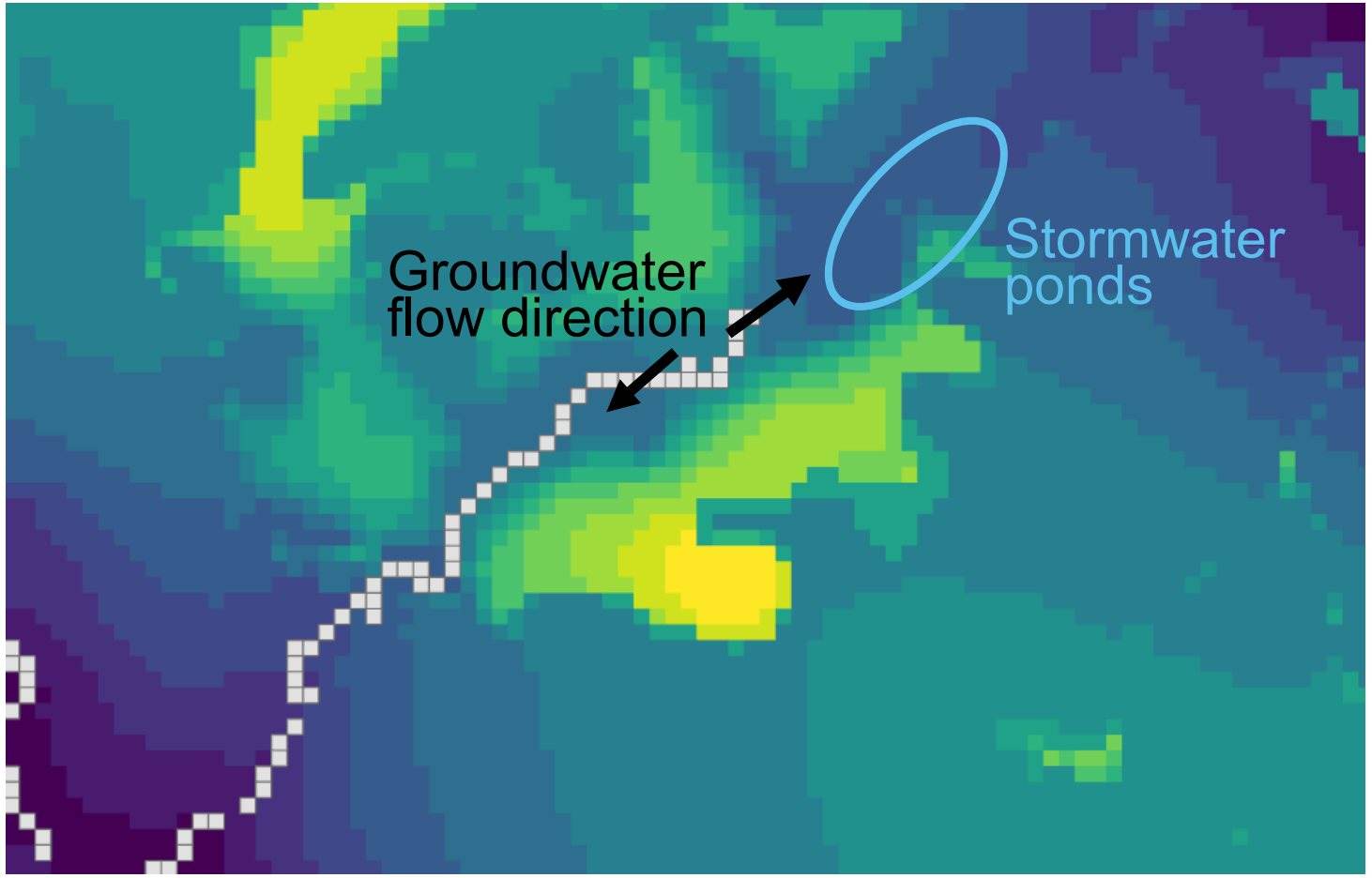
Water table elevation

Low *High*

- Groundwater simulated lower than stormwater ponds
  - Streamflow simulated too low; likely water table too
- Flows opposite stormwater drainage
  - Groundwater basins don’t always match surface drainage
- Lack data to evaluate

Hydrologic setting

Water table map



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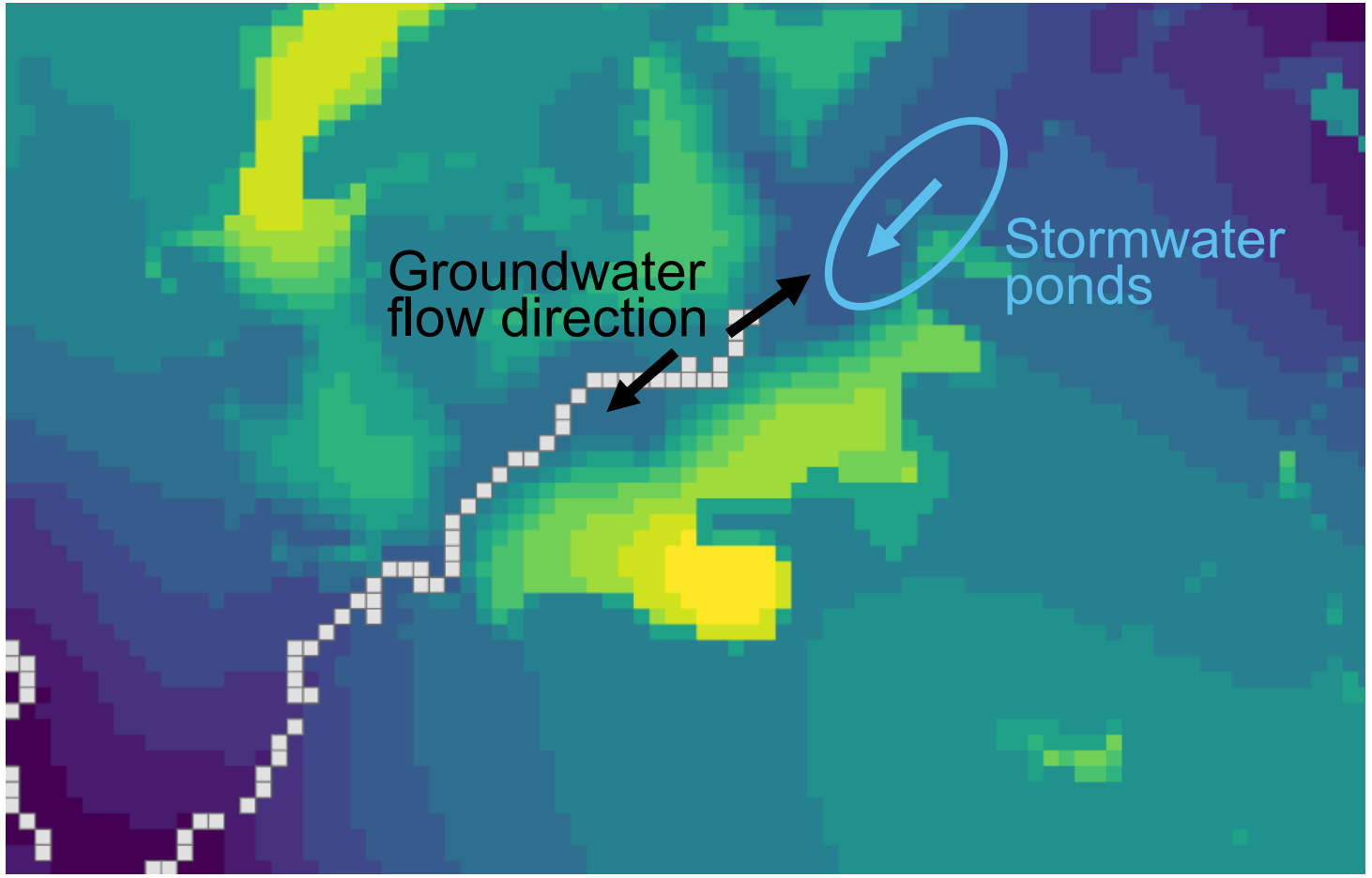

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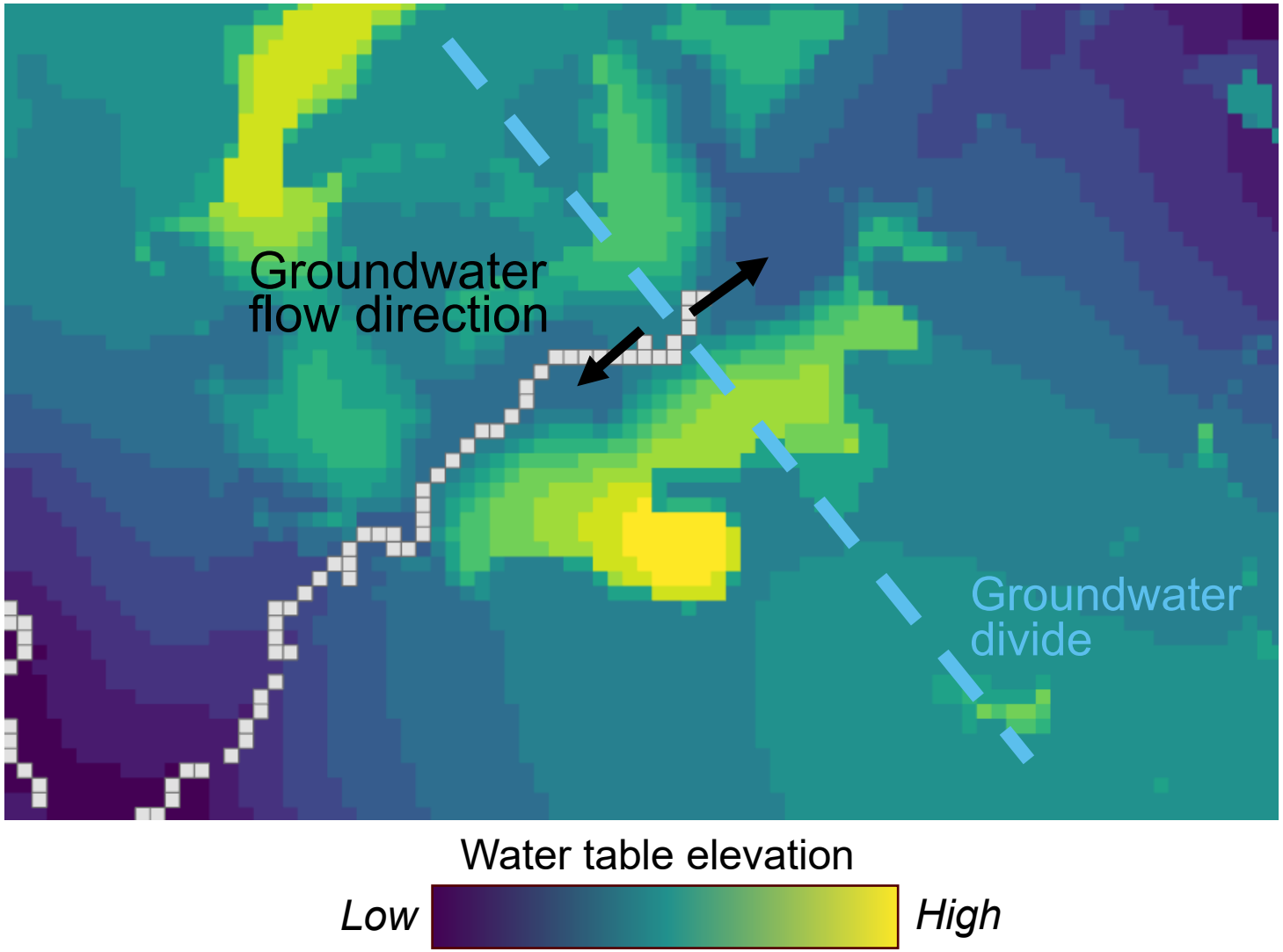
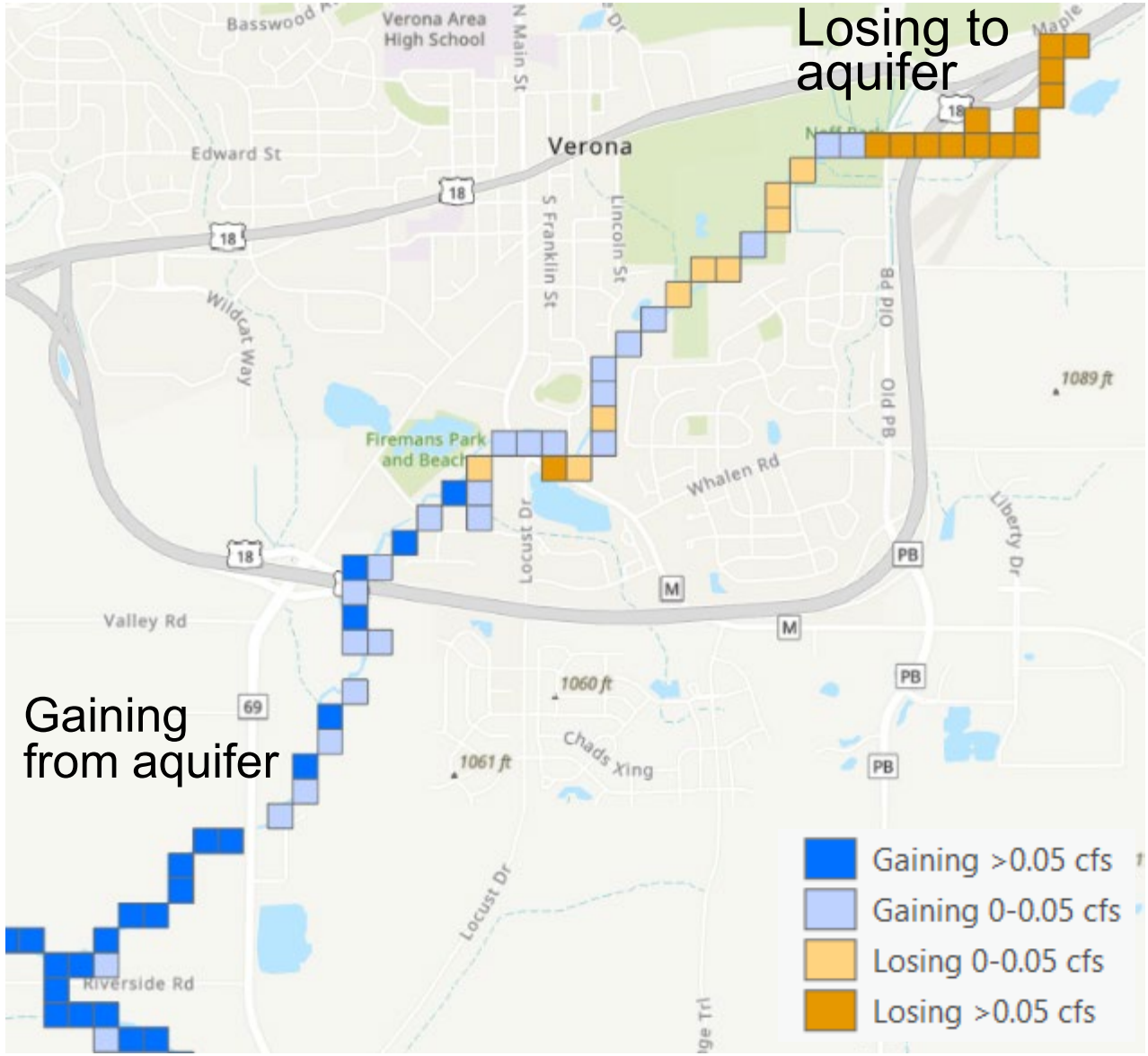
Hydrologic setting - implications

Water table map



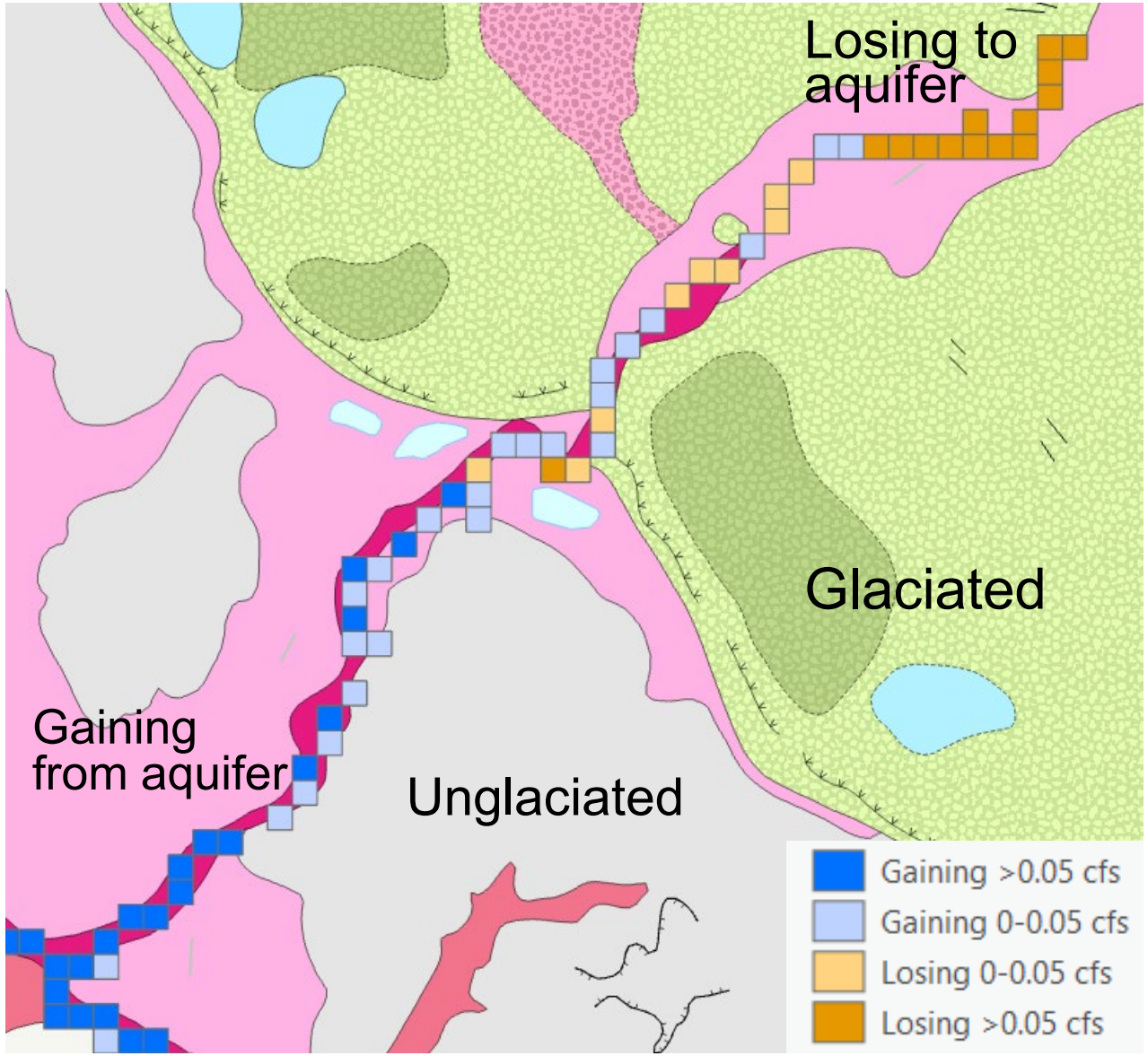
- Small stream, close to major divide
- Uncertainty in position of the divide affects uncertainty for BMC simulations

Geologic setting



- BMC simulated to lose flow at headwaters and gain flow downstream of moraine
- Consider geology for any future work

Geologic setting



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Summary

- Considerations for BMC
  - Small stream near divide in regional model
  - 2006-2010 pumping rates and recharge
  - Model focus on groundwater vs. surface water
- Model is a powerful tool
  - Simulate flow directions, capture zones – with uncertainty (not to parcel level)
  - Test sensitivity of model to changes
- Detailed studies merit additional work
  - Assemble/collect streamflow, water levels, geology to evaluate and recalibrate

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Questions?

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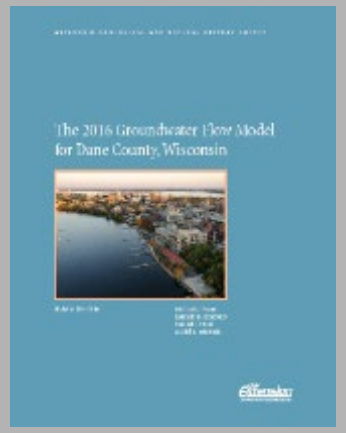
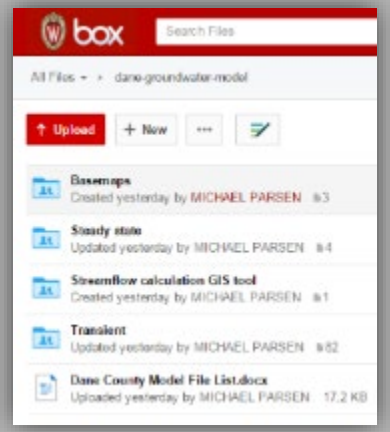
anna.fehling@wisc.edu

Model resources



Model report

User's Manual



Model files

https://home.wgnhs.wisc.edu/dane-county-groundwater-model/