Groundwater and Potential Impacts to Yahara Lake Levels

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UW Extension Cooperative Extension

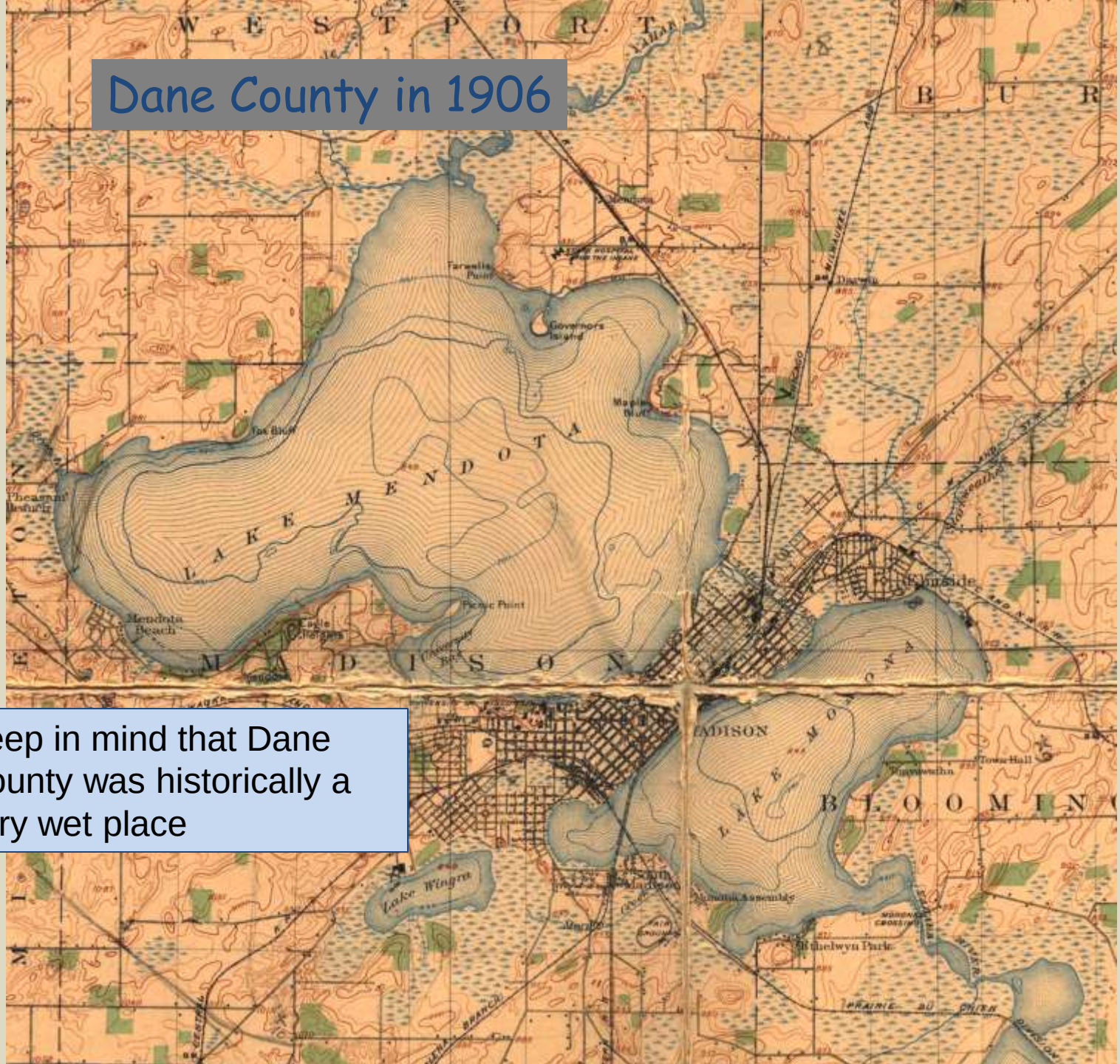
Wisconsin Geological & Natural History Survey

Questions…

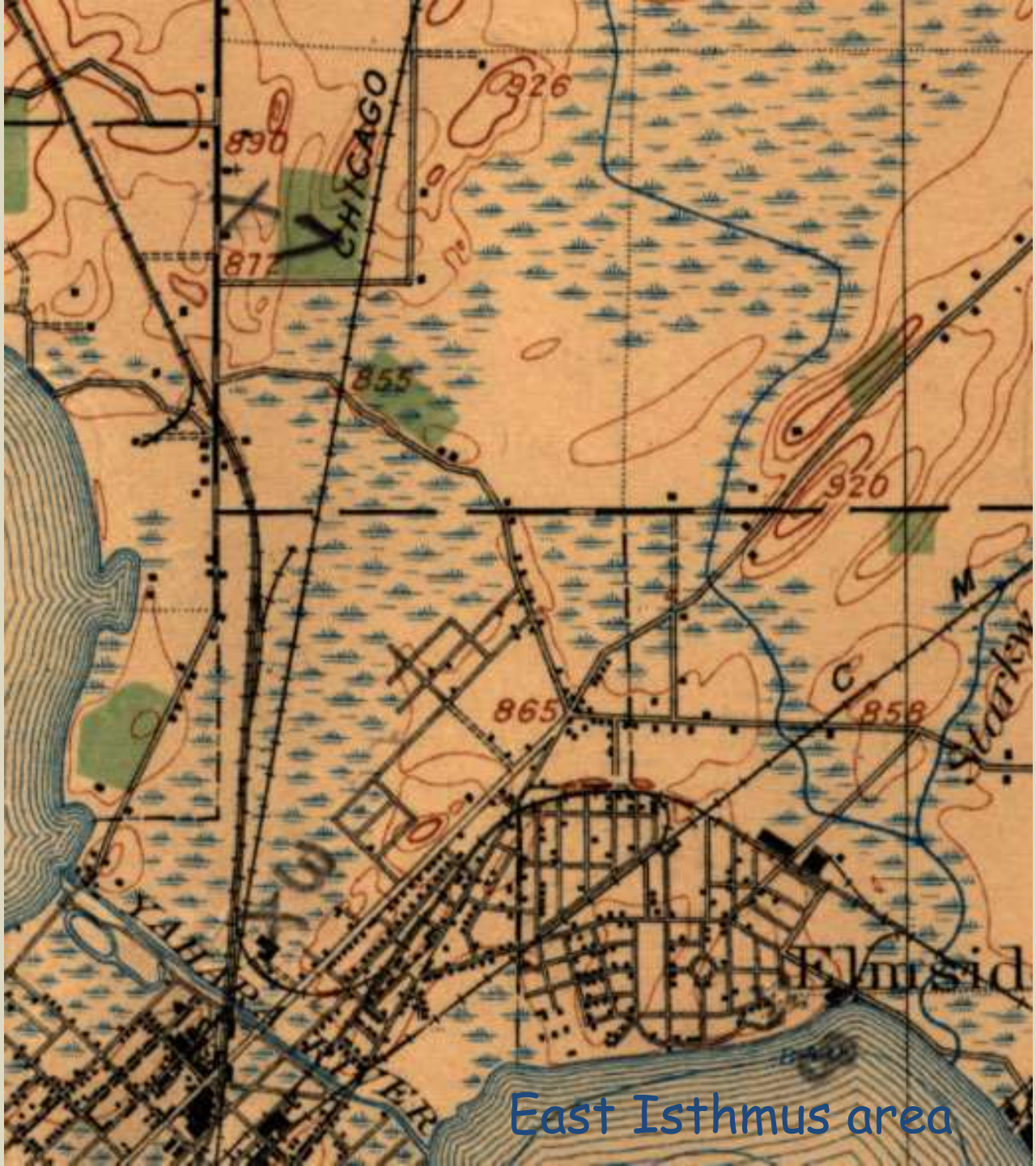
How does groundwater affect the Yahara Lakes, and vice versa?

1. Are groundwater levels changing?
2. Is this part of the high water/flooding problems?
3. What can we do about that?
4. What is the impact of subsurface geology, like the extent of the Eau Claire aquitard?

Dane County in 1906



Keep in mind that Dane County was historically a very wet place



East Isthmus area

In Dane County, lakes and groundwater are directly and intimately connected.

The two components of connection are <u>water levels</u> and <u>water discharge.</u>

In general, the lakes “anchor” the water table. At the lake shore, the water table and the lake level are essentially the same. The water table moves up and down along with the lake level (with a slight lag).

As we move away from the lakes the water table might be higher or lower than the lake level.

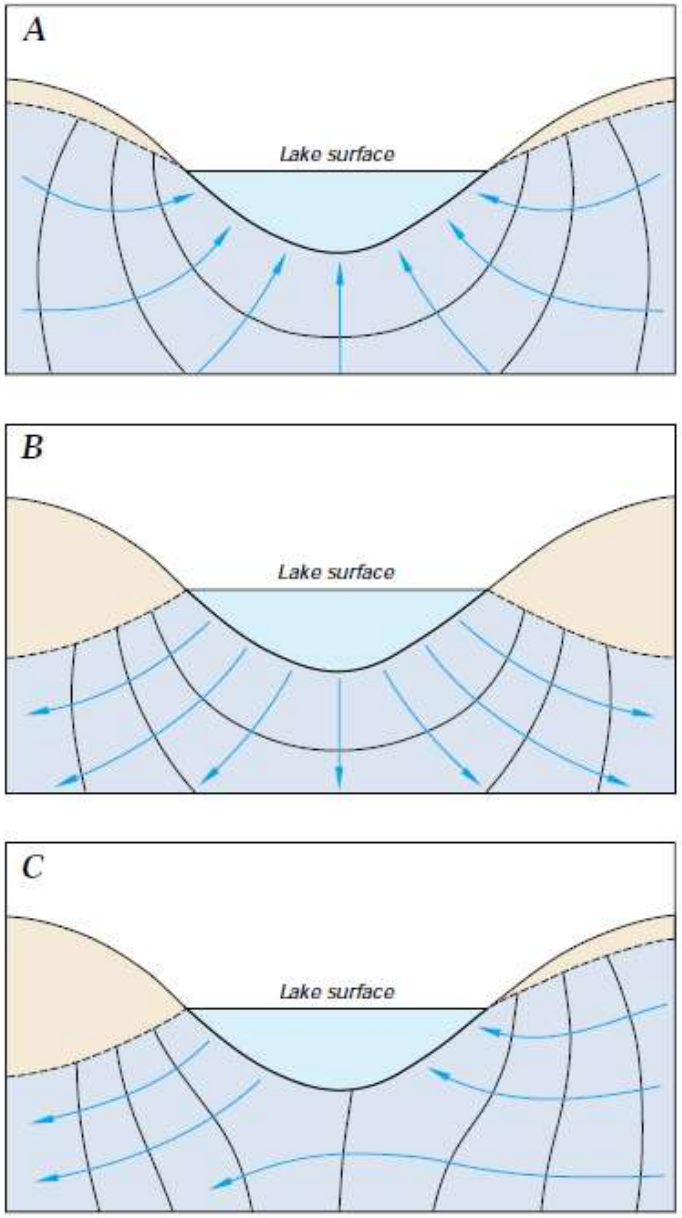


Figure 16. Lakes can receive ground-water inflow (A), lose water as seepage to ground water (B), or both

Water moves from groundwater to the lakes, and vice versa.

This means that groundwater is an important component of lake water budgets.

Pumping can reduce this discharge. This has happened in the Madison area.

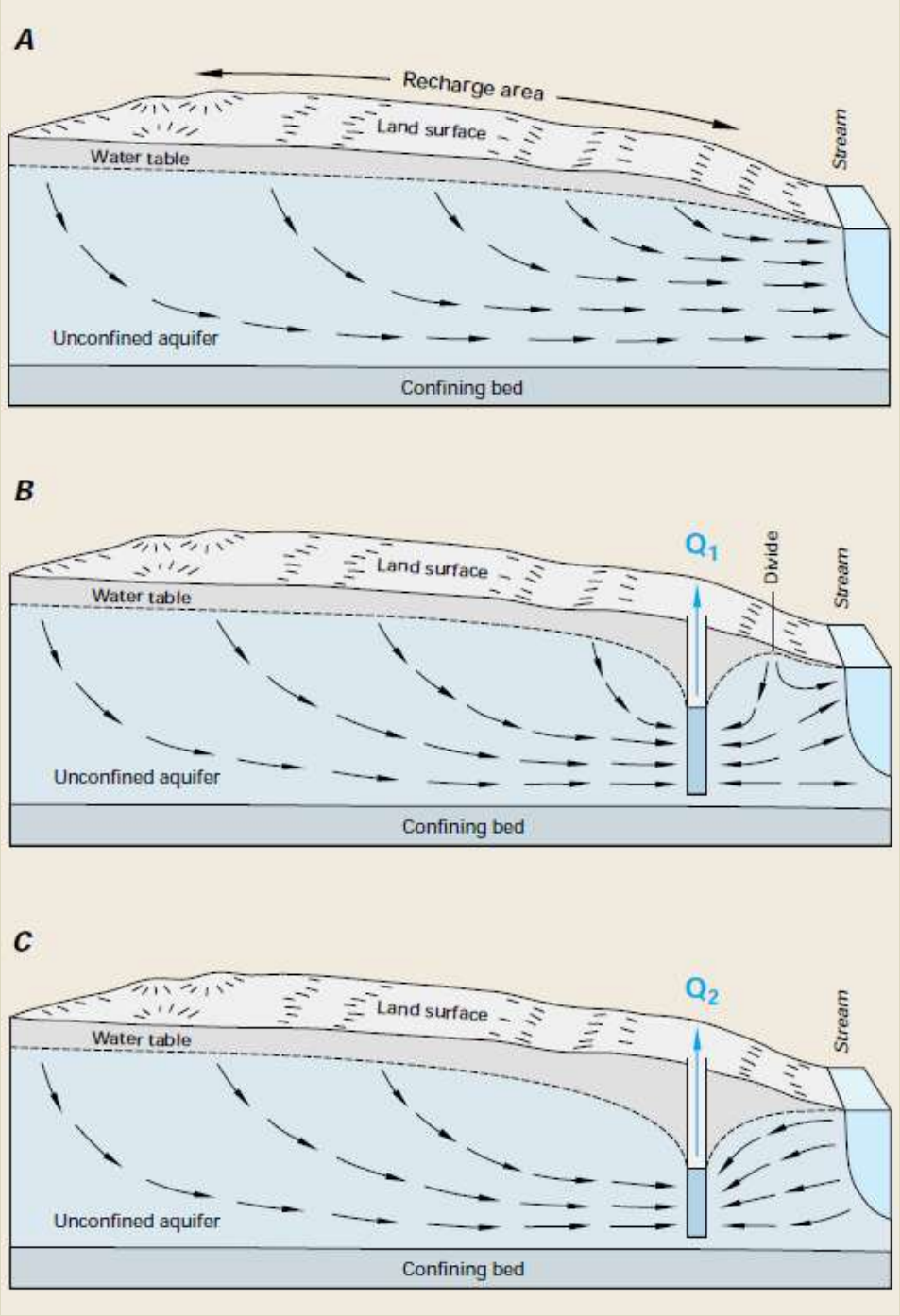
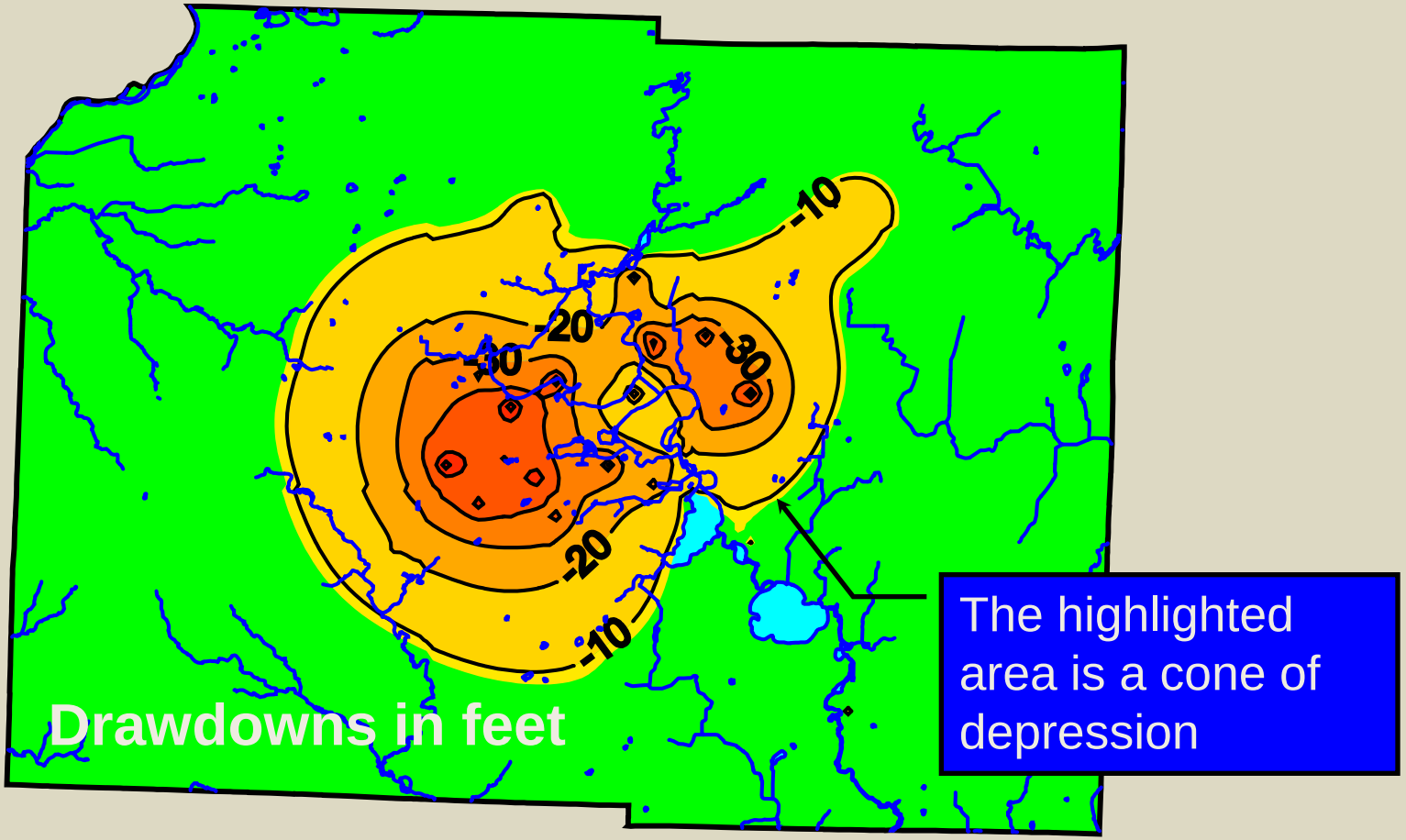
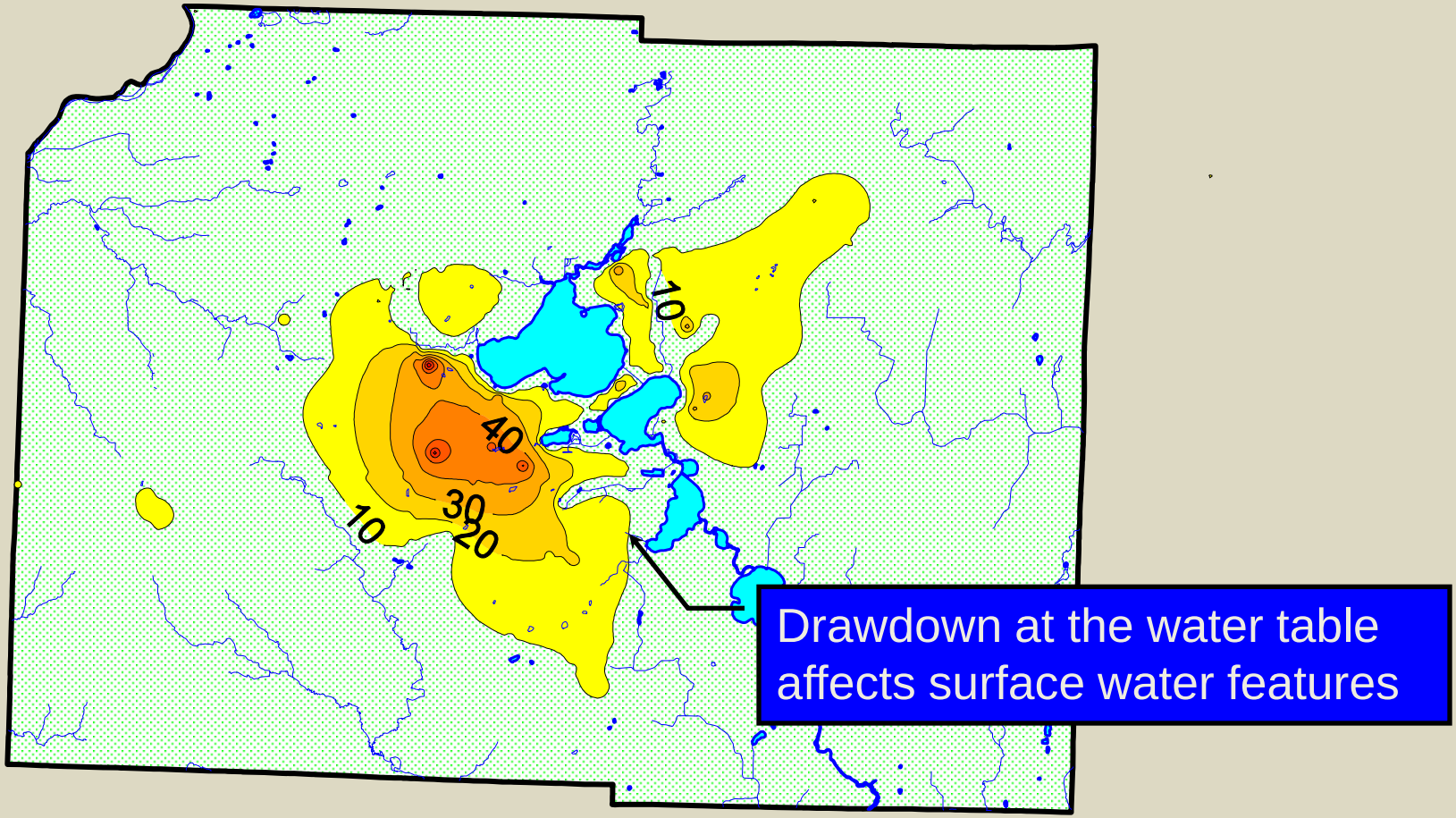


Figure C–1. In a schematic hydrologic setting where ground water discharges to a stream under natural conditions (A), placement of a well pumping at a rate (Q_1) near the stream will intercept part of the ground water that would have discharged to the stream (B). If the well is pumped at an even greater rate (Q_2), it can intercept additional water that would have discharged to the stream in the vicinity of the well and can draw water from the stream to the well (C).

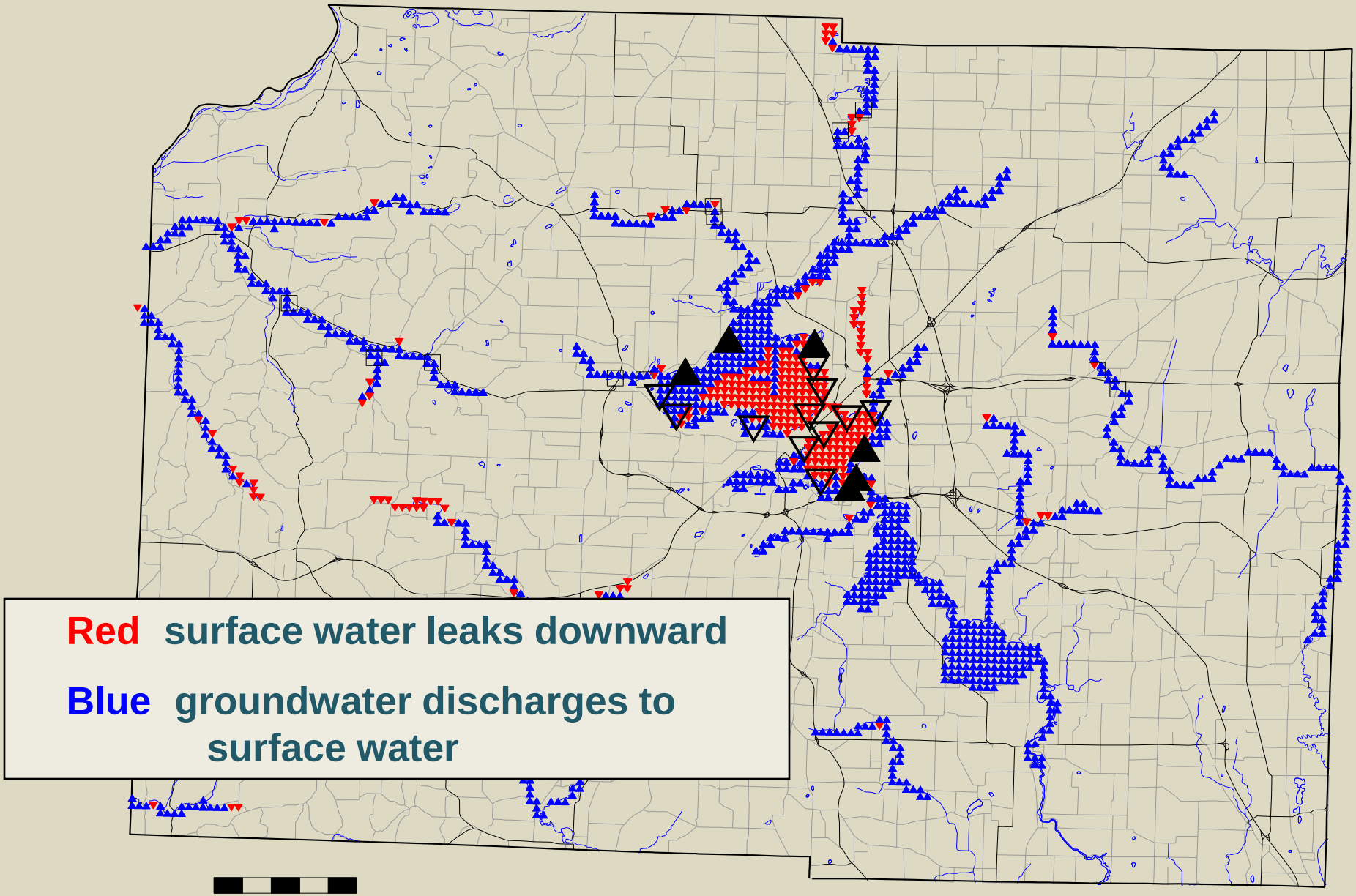
Municipal water use in the Madison area causes significant drawdown, or lowering of water levels, in the deep sandstone aquifer...



Drawdowns in the deep aquifer can affect the water table…reducing flow in streams and water levels in wetlands



Groundwater discharge to lakes and streams



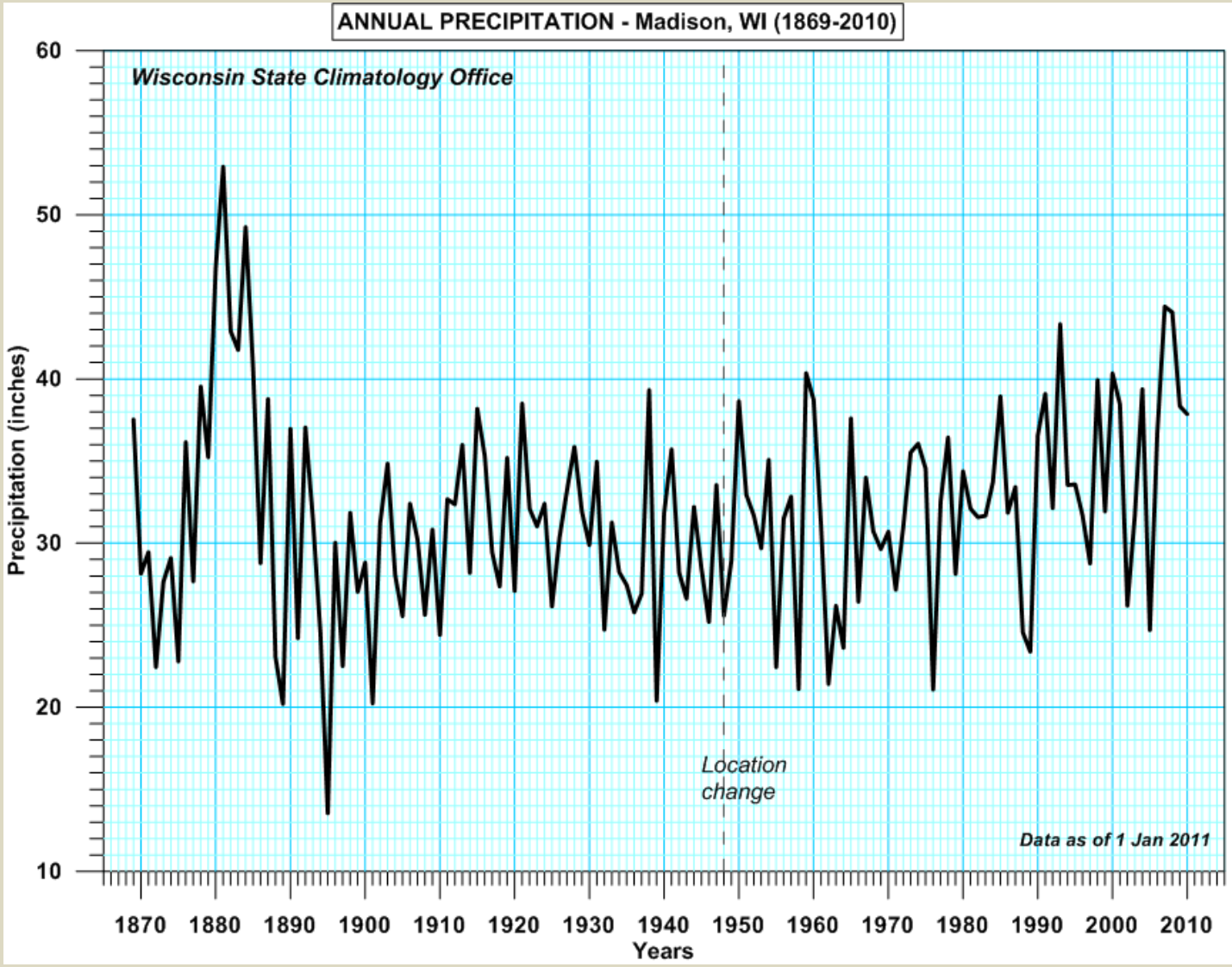
Questions…

How does groundwater affect the Yahara Lakes, and vice versa?

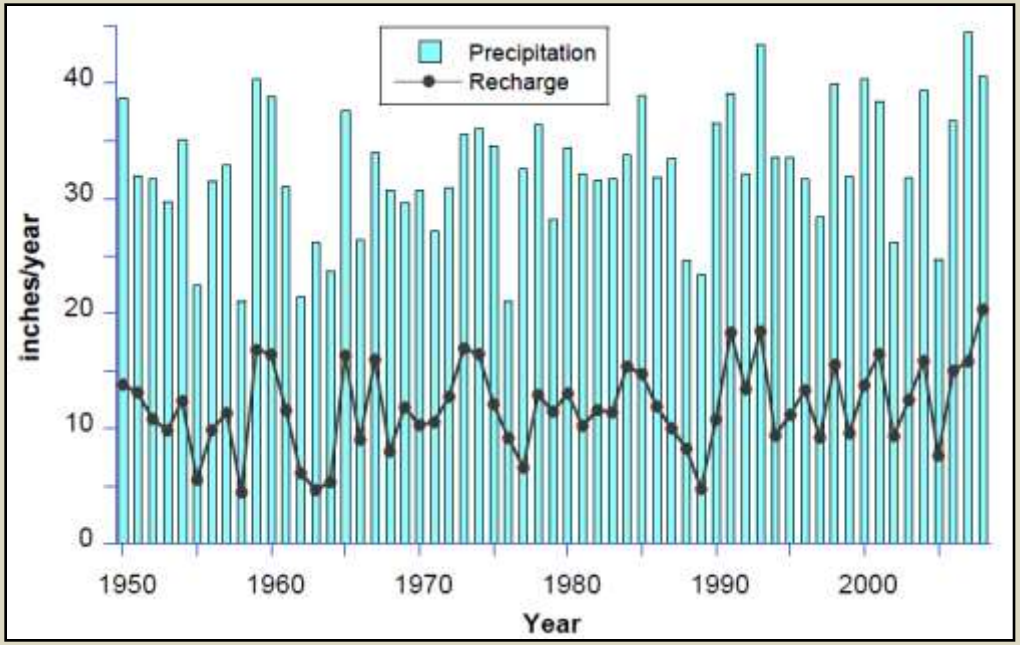
1. Are groundwater levels changing?

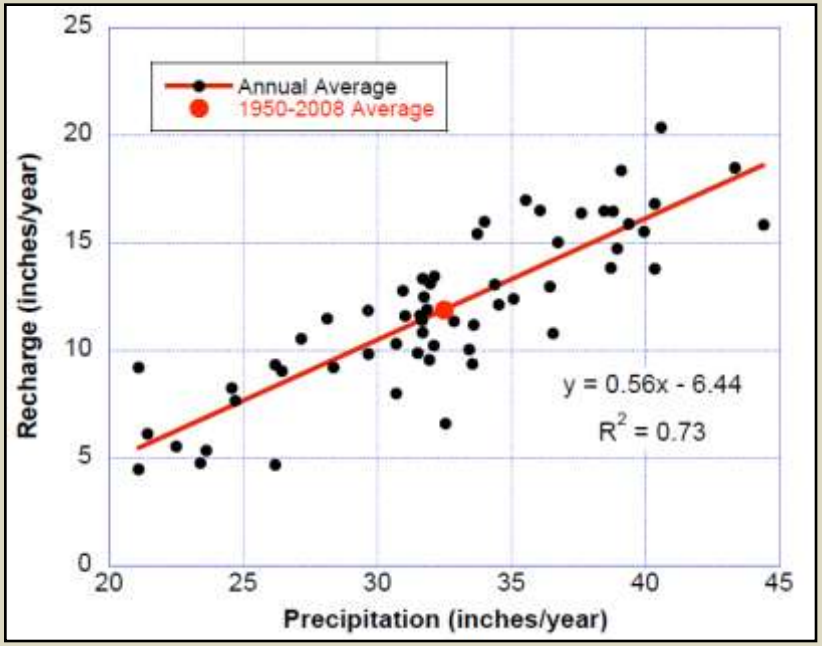
   Yes, groundwater levels in Dane County have recently been rising, as a result of increased recharge. We do not know whether this trend will continue.

Precipitation in Madison has been increasing slightly since the 1970s



How does precipitation affect recharge?

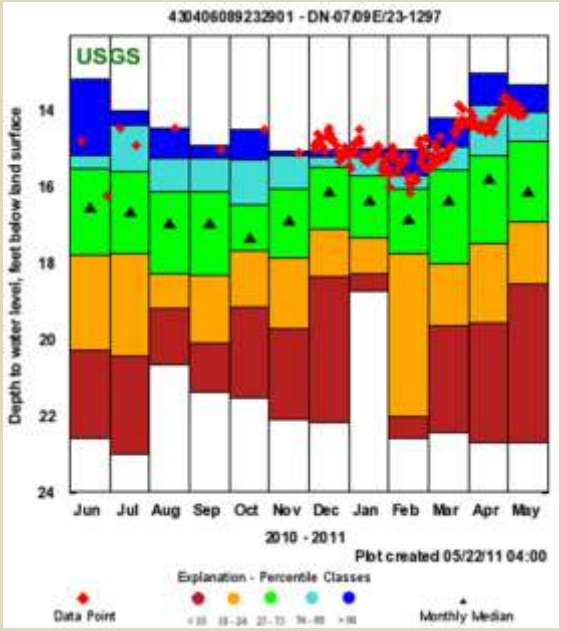


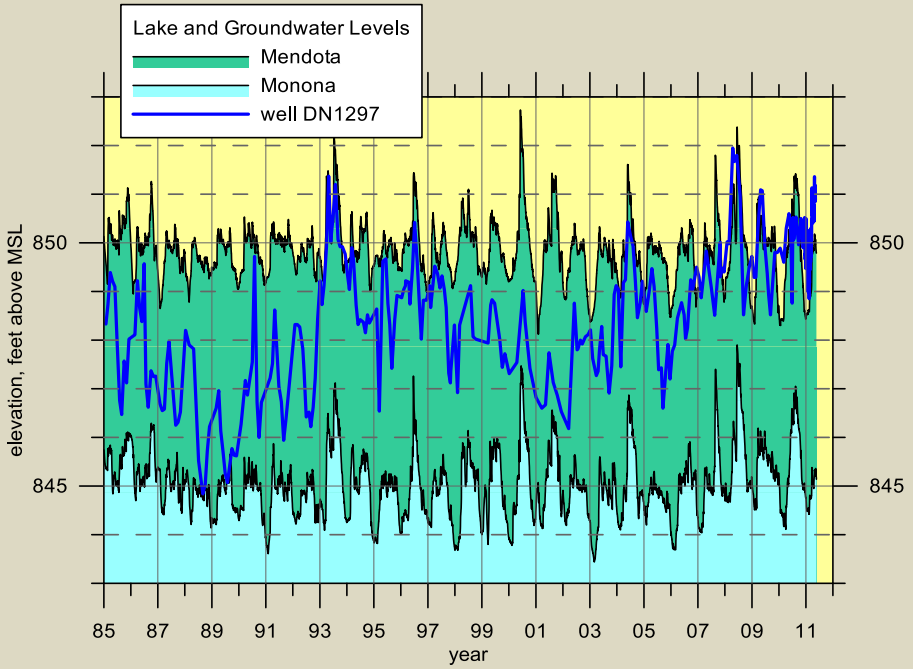


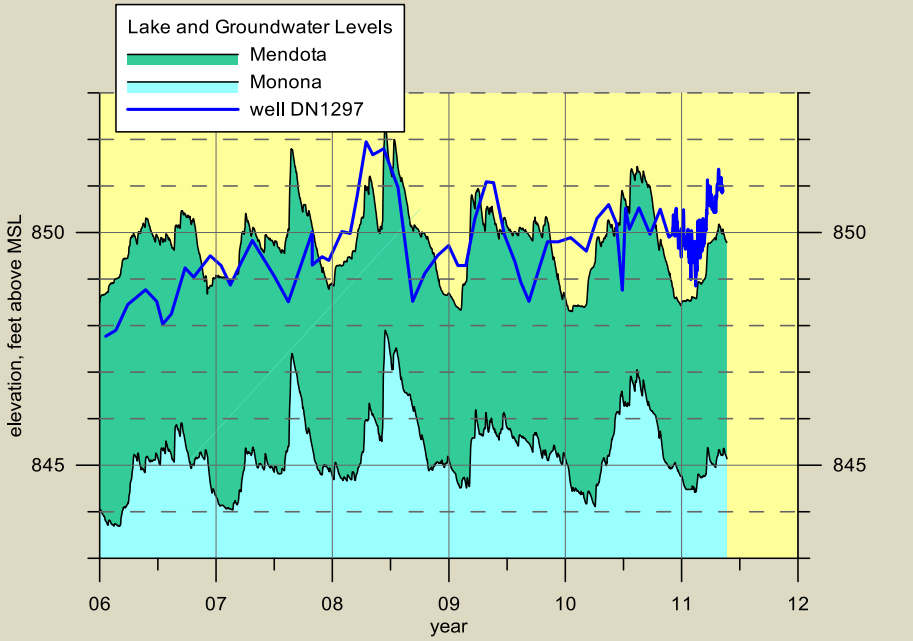
Shallow groundwater levels in Wisconsin respond rapidly to recharge. Groundwater recharge varies with time, and increases linearly with annual precipitation. Precipitation totals from 2006 to 2008 were the highest in many years. The precipitation and recharge shown here are for Dane County.

Records of long-term monitoring well on West Washington St compared with local lake levels.

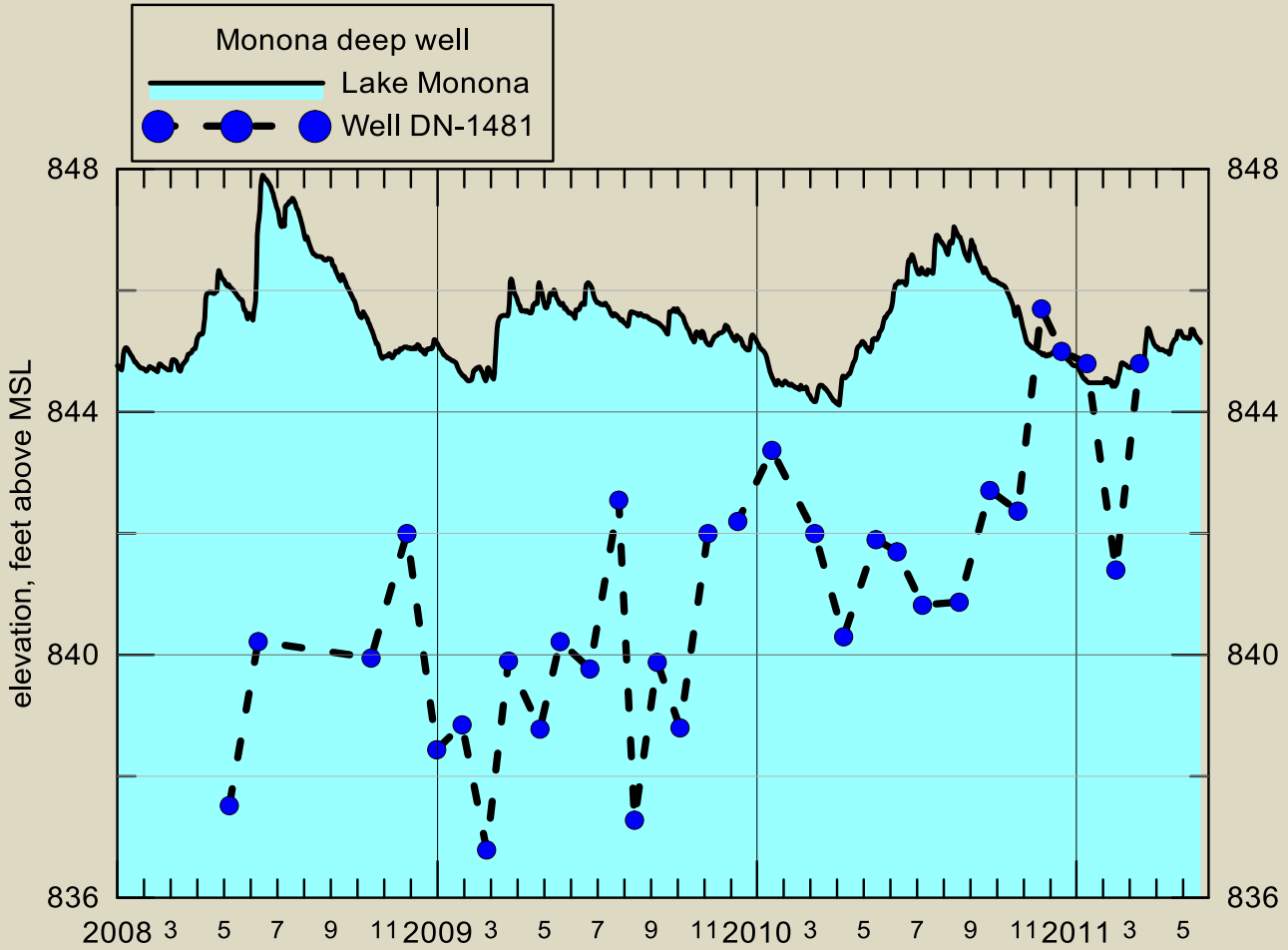
Well is currently near record highs.







Records of well DN1481 in Monona compared to the level of Lake Monona. Water levels have been rising for the past three years.



Questions…

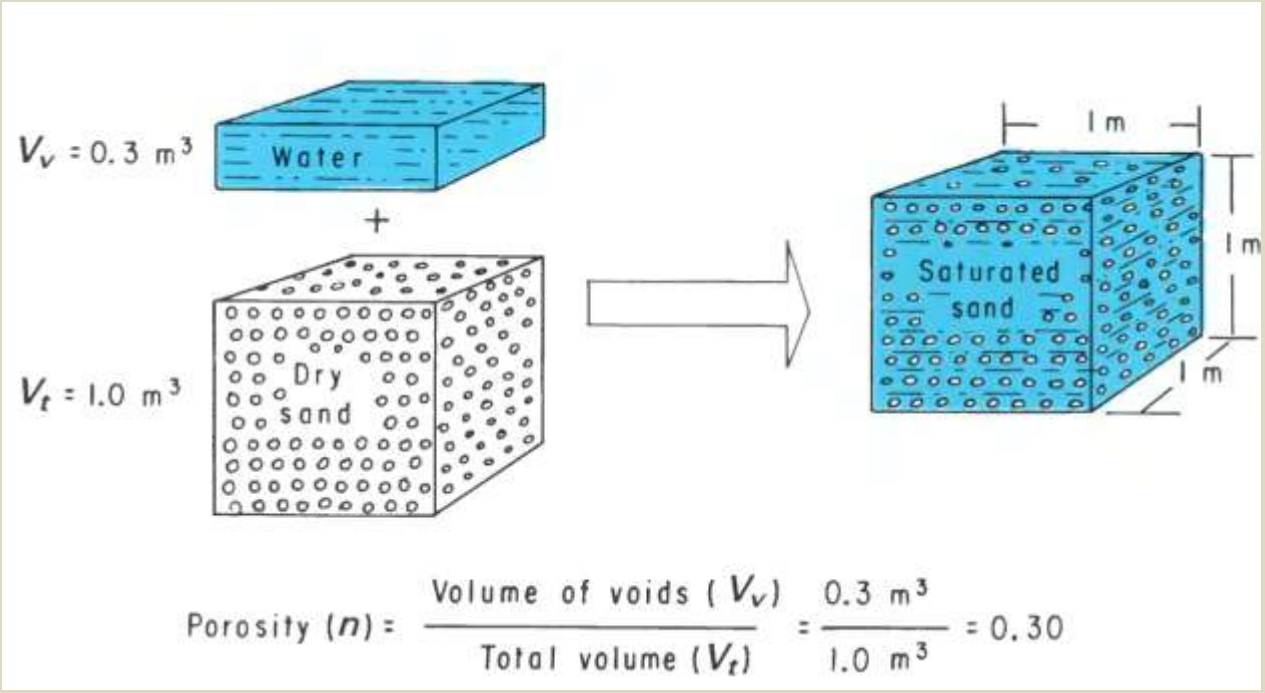
How does groundwater affect the Yahara Lakes, and vice versa?

1. Are groundwater levels changing?
2. Is this part of the high water/flooding problems?

Yes. Water-table rise has occurred in many places in southern Wisconsin, leading to flooding problems.

The porosity principle…

why groundwater rises more rapidly than surface water



Geologic materials are mostly solid, with porosity determined by the spaces between mineral grains or fractures. For this reason small changes in recharge or discharge can lead to large changes in groundwater levels.

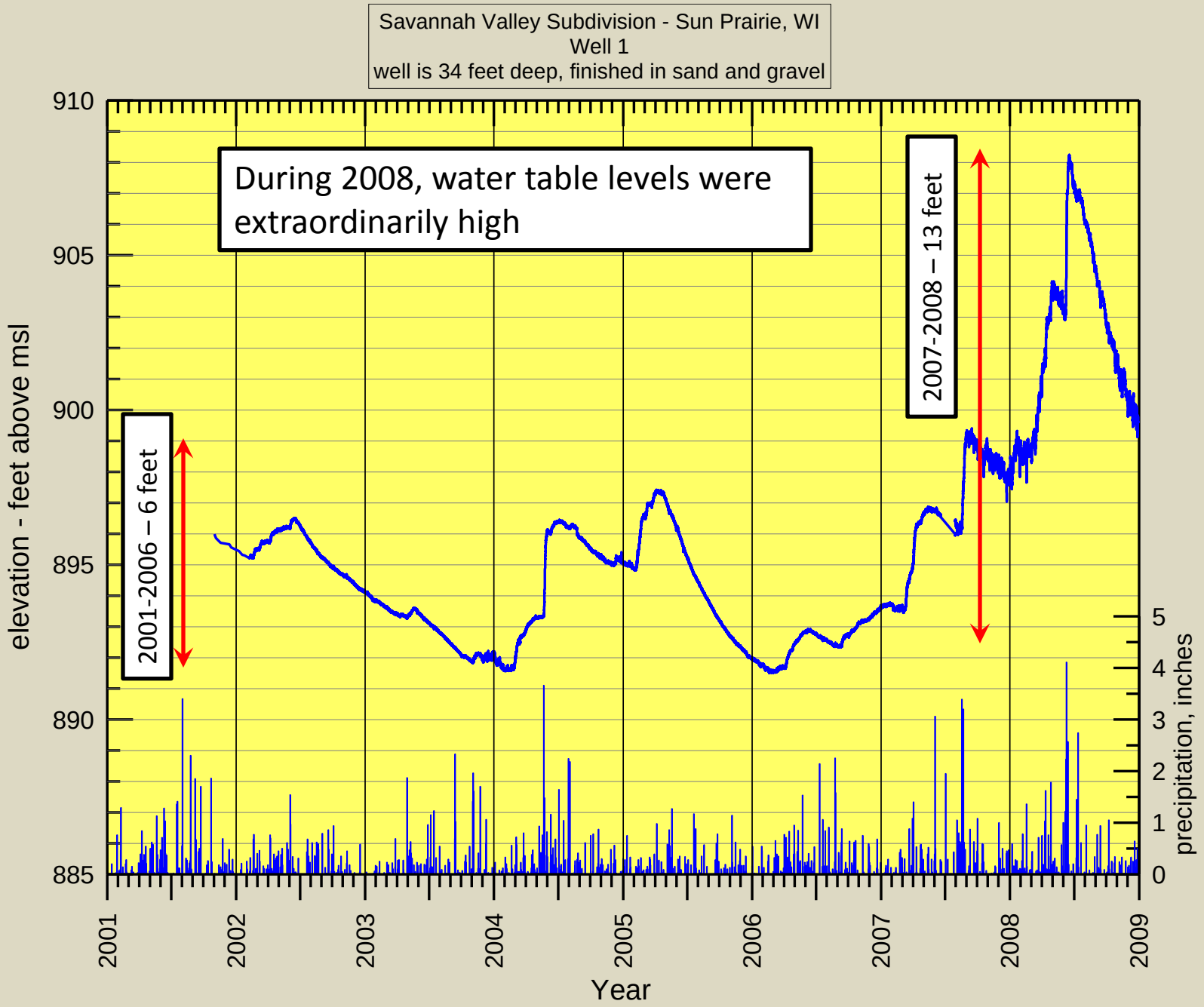
How groundwater levels can change

Consider the addition or withdrawal of 6 inches of recharge to/from the following aquifer systems. How much might the water table rise (or fall)?

1. Clean sand, central Wisconsin, 30% porosity: 20 inches

2. Poorly sorted sand or sandstone, 15% porosity (typical over much of Wisconsin): 40 inches

3. Fractured rock, 1% porosity (typical of Door County and parts of northern Wisconsin): 600 inches (50 feet)


Savannah Valley Subdivision - Sun Prairie, WI
Well 1
well is 34 feet deep, finished in sand and gravel
During 2008, water table levels were extraordinarily high
2001-2006 – 6 feet
2007-2008 – 13 feet
elevation - feet above msl
910
905
900
895
890
885
precipitation, inches
5
4
3
2
1
0
2001
2002
2003
2004
2005
2006
2007
2008
2009
Year

Flooding made roads impassible

High water table flooded this basement and caused this homeowner to have to construct a drainage system

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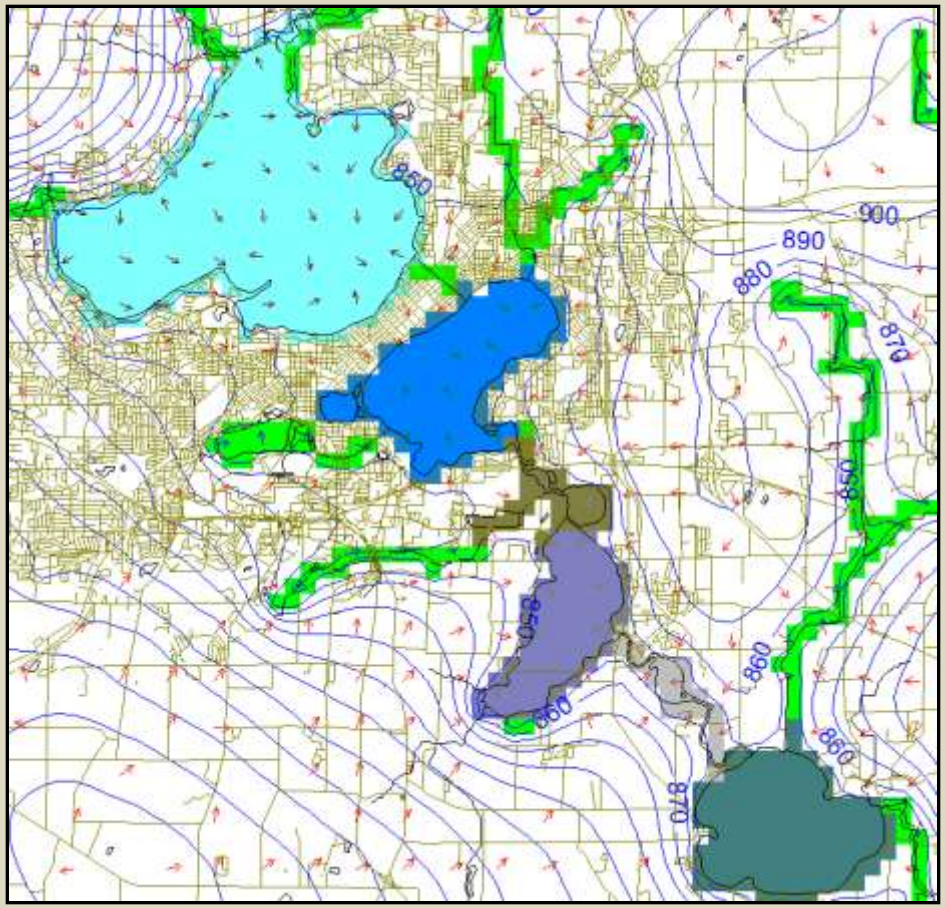
3. What can we do about that?

Holding the lakes at a lower stage would lower nearby water levels. And, avoid building in areas with shallow groundwater.

For the Yahara Lakes/River system, water management requires a good understanding of the water budgets of different parts of the system. In the past, the groundwater discharge component wasn't always considered.

Using the existing Dane County model we can make some estimates of groundwater discharge to the lake/river system. At present, these estimates are somewhat crude because the model is steady state only. When the new Dane County model is completed next year we will be able to make much improved estimates.



Lakes and streams are discretized into model cells. Currently the lakes are somewhat crudely represented.

Lake groundwater budgets

Lake	historic	current	change	pct change
	(cfs)	(cfs)	(cfs)	
Mendota	23.9	4.4	-19.5	-82%
Monona	8.7	-1.5	-10.2	-117%
Waubesa	10.3	6.5	-3.8	-37%
Kegonsa	10.2	8.8	-1.4	-14%
Wingra	3.3	1.2	-2.1	-64%
total	*56.4*	*19.4*	*-37*	*-66%*

Simulated changes in direct groundwater contribution to Madison Lakes resulting from onshore pumping *(note that total Dane Co pumping is about 75 CFS)*

Model simulations show that groundwater discharge to the Yahara Chain is significant

	Baseline	125% recharge with 2008 June max stages
flow to/from river nodes in basin	discharge to surface water in basin	discharge to surface water in basin
Flow out	7.2	5.75
Flow in	113.2	155.36
Net	106.0	149.60

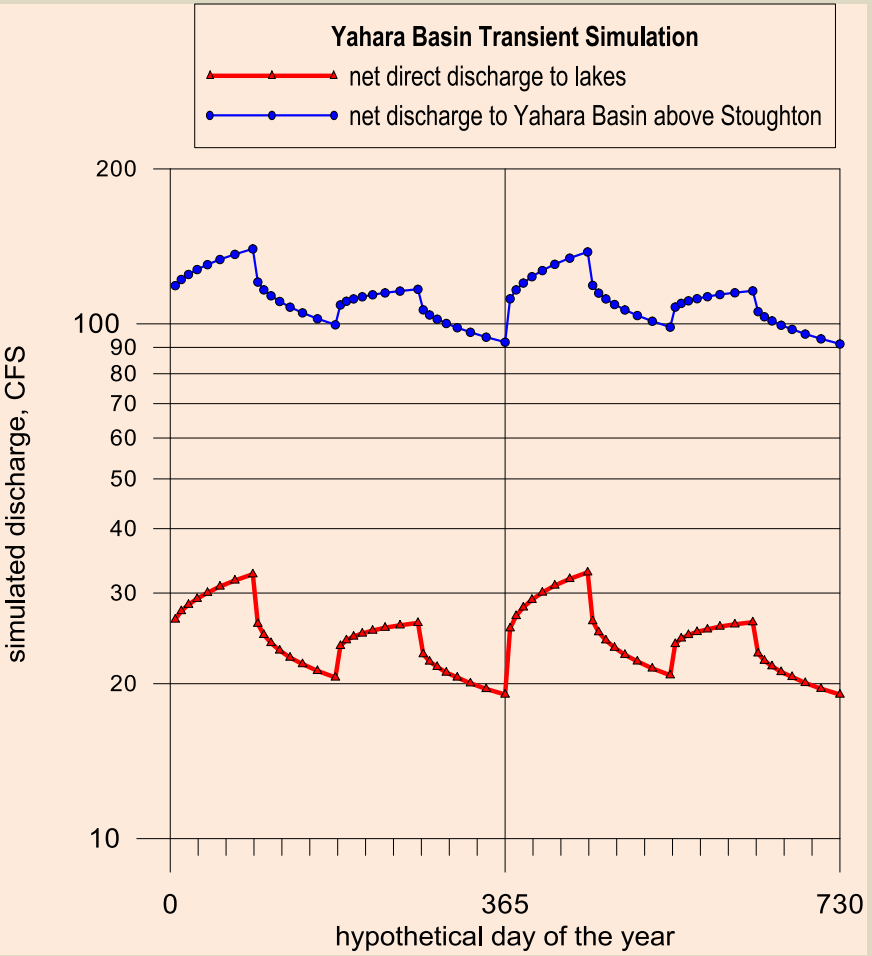
Simulated groundwater discharge (CFS) to river nodes in the Yahara basin above Stoughton and below the Columbia County line.

A crude simulation of transient groundwater discharge to the Yahara Chain

The lower plot shows direct groundwater discharge to the lakes. This direct discharge varies between 20 and about 35 CFS over the simulation period.

The upper plot represents groundwater discharge to the entire Yahara basin above Stoughton and below the Columbia County line. Net discharge to the entire basin varies between about 90 and 150 CFS.

This simulation is for a hypothetical average year.



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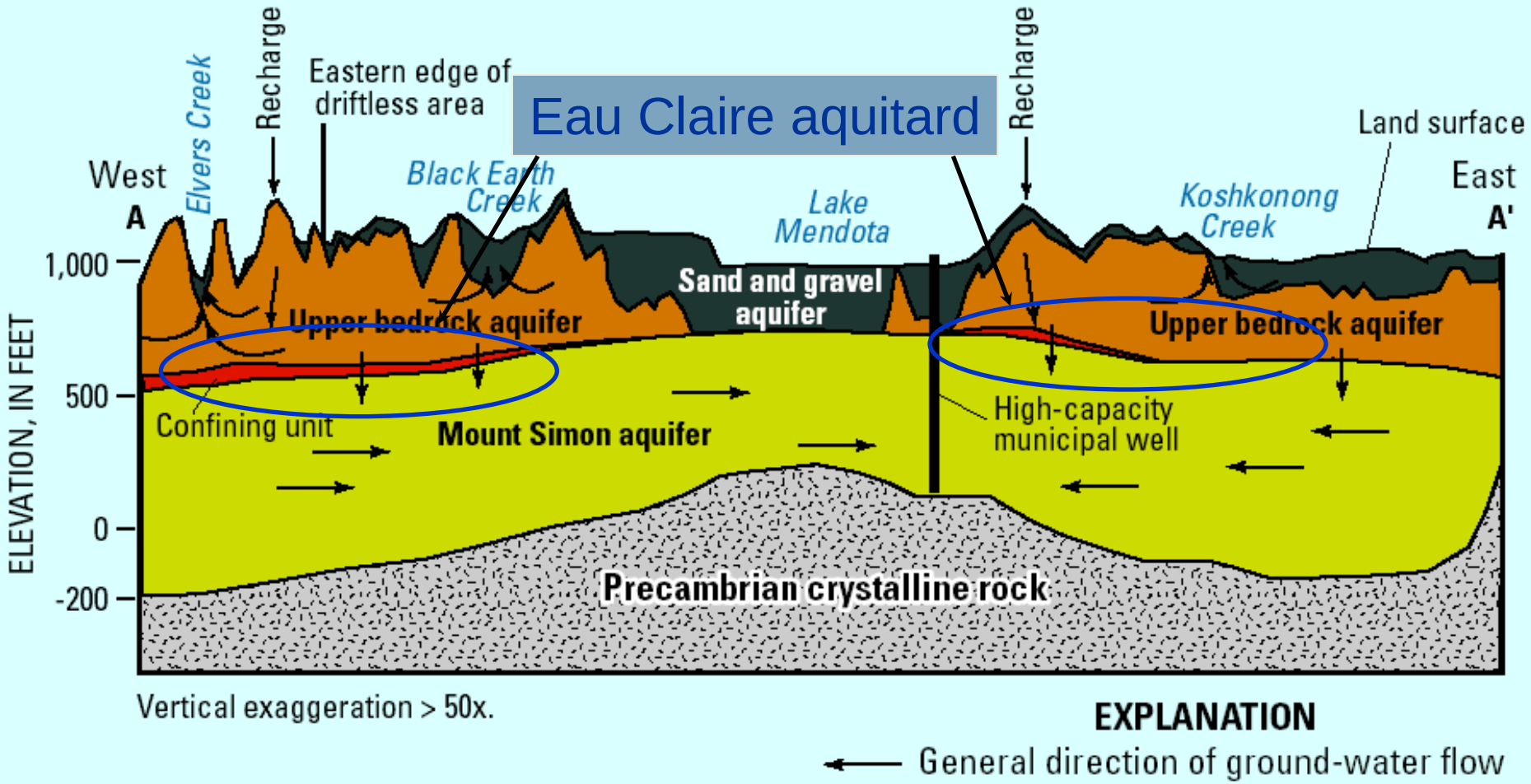
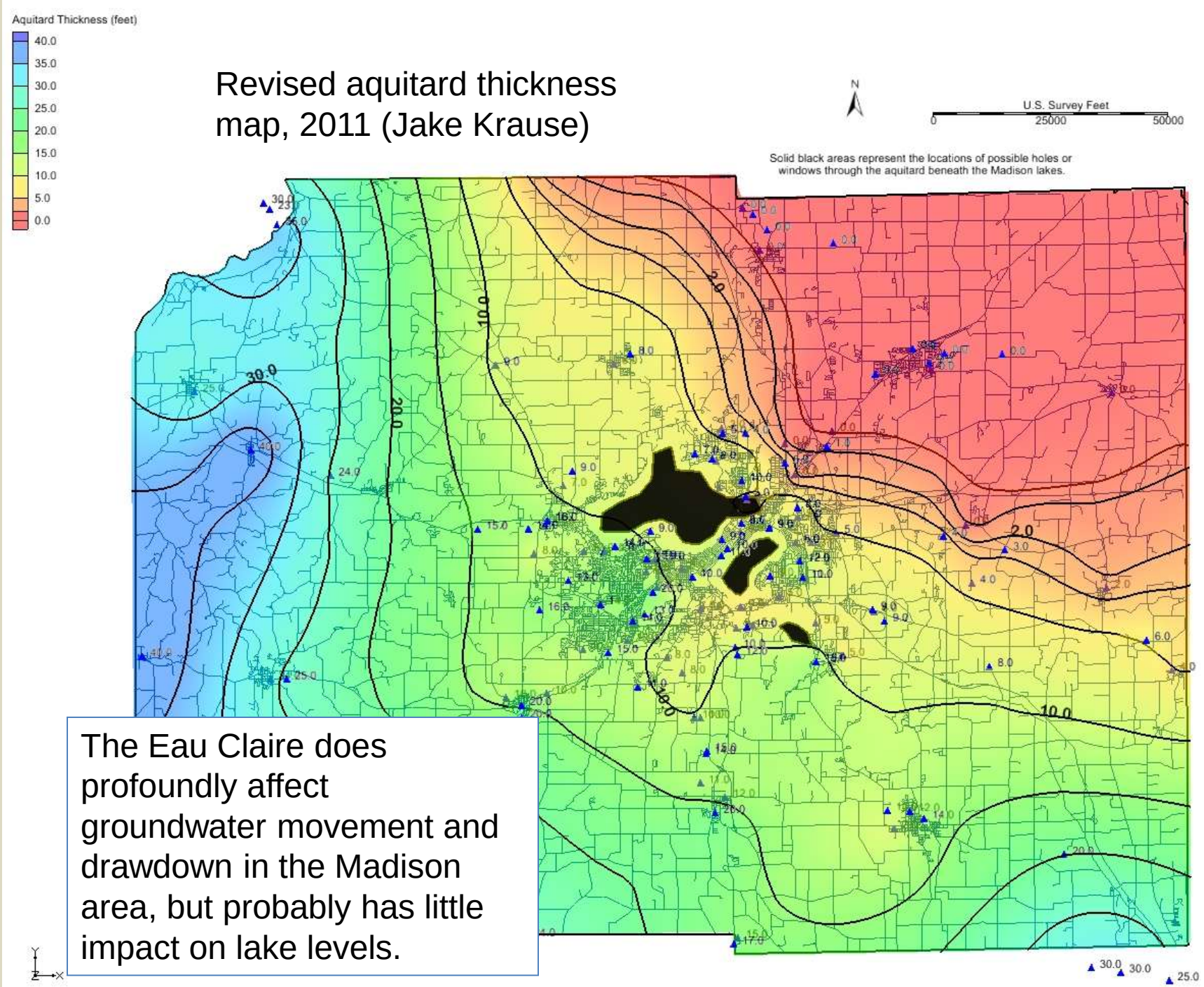


West-East cross section showing the upper aquifers and the lower (Mount Simon) aquifer. Schematic flow-lines also are included to illustrate the local and regional ground-water flow that occurs in the county.


Aquitard Thickness (feet)
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Revised aquitard thickness map, 2011 (Jake Krause)
N
U.S. Survey Feet
0
25000
50000
Solid black areas represent the locations of possible holes or windows through the aquitard beneath the Madison lakes.
The Eau Claire does profoundly affect groundwater movement and drawdown in the Madison area, but probably has little impact on lake levels.

What about reduced pumping (e.g. Oscar Mayer)? Is that causing flooding?

It probably adds to the problem. Model simulations suggest that reduced high-capacity pumping, from either industry or municipal wells, could cause the water table to rebound several feet. In an area with naturally shallow groundwater this could be significant. But, these same areas are also the most vulnerable to water-table rise caused by high lake levels, and it is difficult to sort out the two effects.

Simulations with the new model should help address this question more definitively.

Summary thoughts

- Groundwater levels and lake levels impact each other
- At the shore, lake levels “anchor” the water table
- The lake/river system receives significant inflow from groundwater
- Local pumping has little impact on lake levels, because the lakes are large and are part of a river system