CITY OF EAU CLAIRE

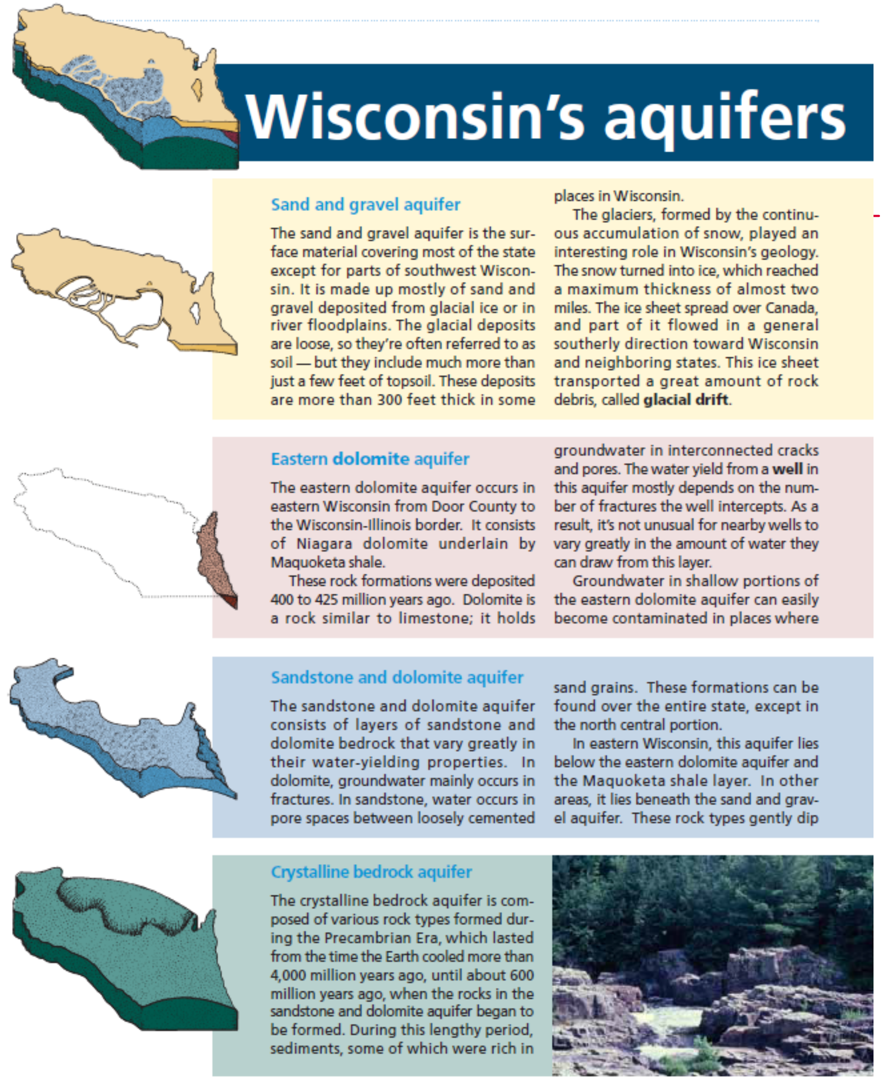
AQUIFER PRODUCTIVITY AND SUSTAINABLE USE

Work Session
June 7, 2022

GANNETT FLEMING

4 Aquifers - Statewide

- Sand and Gravel
- Eastern Dolomite
- Sandstone and Dolomite
- Crystalline Bedrock
- Eau Claire is underlain by 3 of the 4
  - Sand and Gravel – very productive
  - Sandstone – moderate productivity
  - Crystalline – infrequently tapped locally



Wisconsin's aquifers

Sand and gravel aquifer

The sand and gravel aquifer is the surface material covering most of the state except for parts of southwest Wisconsin. It is made up mostly of sand and gravel deposited from glacial ice or in river floodplains. The glacial deposits are loose, so they're often referred to as soil — but they include much more than just a few feet of topsoil. These deposits are more than 300 feet thick in some places in Wisconsin.

The glaciers, formed by the continuous accumulation of snow, played an interesting role in Wisconsin's geology. The snow turned into ice, which reached a maximum thickness of almost two miles. The ice sheet spread over Canada, and part of it flowed in a general southerly direction toward Wisconsin and neighboring states. This ice sheet transported a great amount of rock debris, called **glacial drift**.

Eastern dolomite aquifer

The eastern dolomite aquifer occurs in eastern Wisconsin from Door County to the Wisconsin-Illinois border. It consists of Niagara dolomite underlain by Maquoketa shale.

These rock formations were deposited 400 to 425 million years ago. Dolomite is a rock similar to limestone; it holds groundwater in interconnected cracks and pores. The water yield from a **well** in this aquifer mostly depends on the number of fractures the well intercepts. As a result, it's not unusual for nearby wells to vary greatly in the amount of water they can draw from this layer.

Groundwater in shallow portions of the eastern dolomite aquifer can easily become contaminated in places where

Sandstone and dolomite aquifer

The sandstone and dolomite aquifer consists of layers of sandstone and dolomite bedrock that vary greatly in their water-yielding properties. In dolomite, groundwater mainly occurs in fractures. In sandstone, water occurs in pore spaces between loosely cemented sand grains. These formations can be found over the entire state, except in the north central portion.

In eastern Wisconsin, this aquifer lies below the eastern dolomite aquifer and the Maquoketa shale layer. In other areas, it lies beneath the sand and gravel aquifer. These rock types gently dip

Crystalline bedrock aquifer

The crystalline bedrock aquifer is composed of various rock types formed during the Precambrian Era, which lasted from the time the Earth cooled more than 4,000 million years ago, until about 600 million years ago, when the rocks in the sandstone and dolomite aquifer began to be formed. During this lengthy period, sediments, some of which were rich in

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Glacial Outwash, Sand and Gravel Aquifer at Eau Claire

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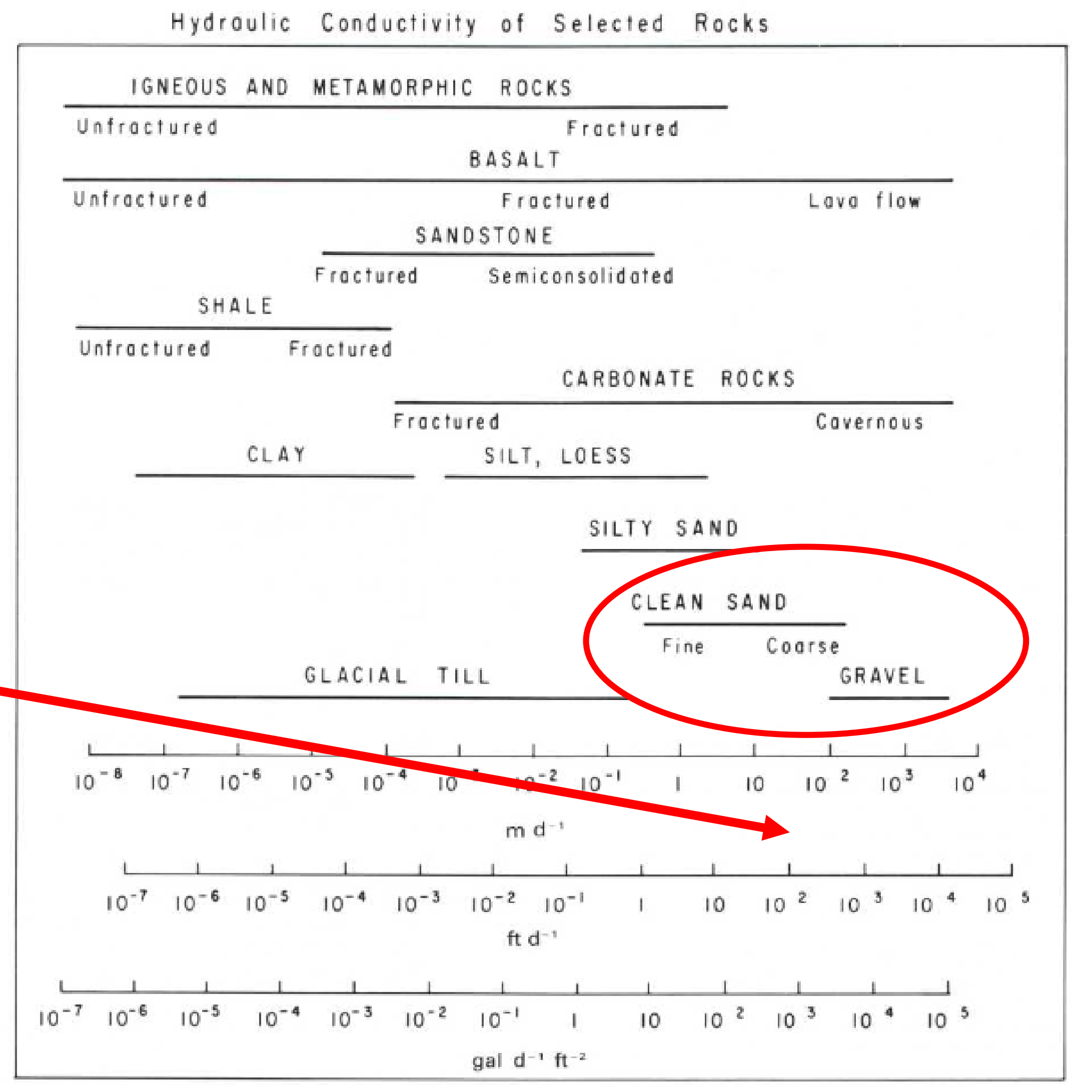
High Hydraulic Conductivity

Eau Claire Sand
and Gravel Aquifer



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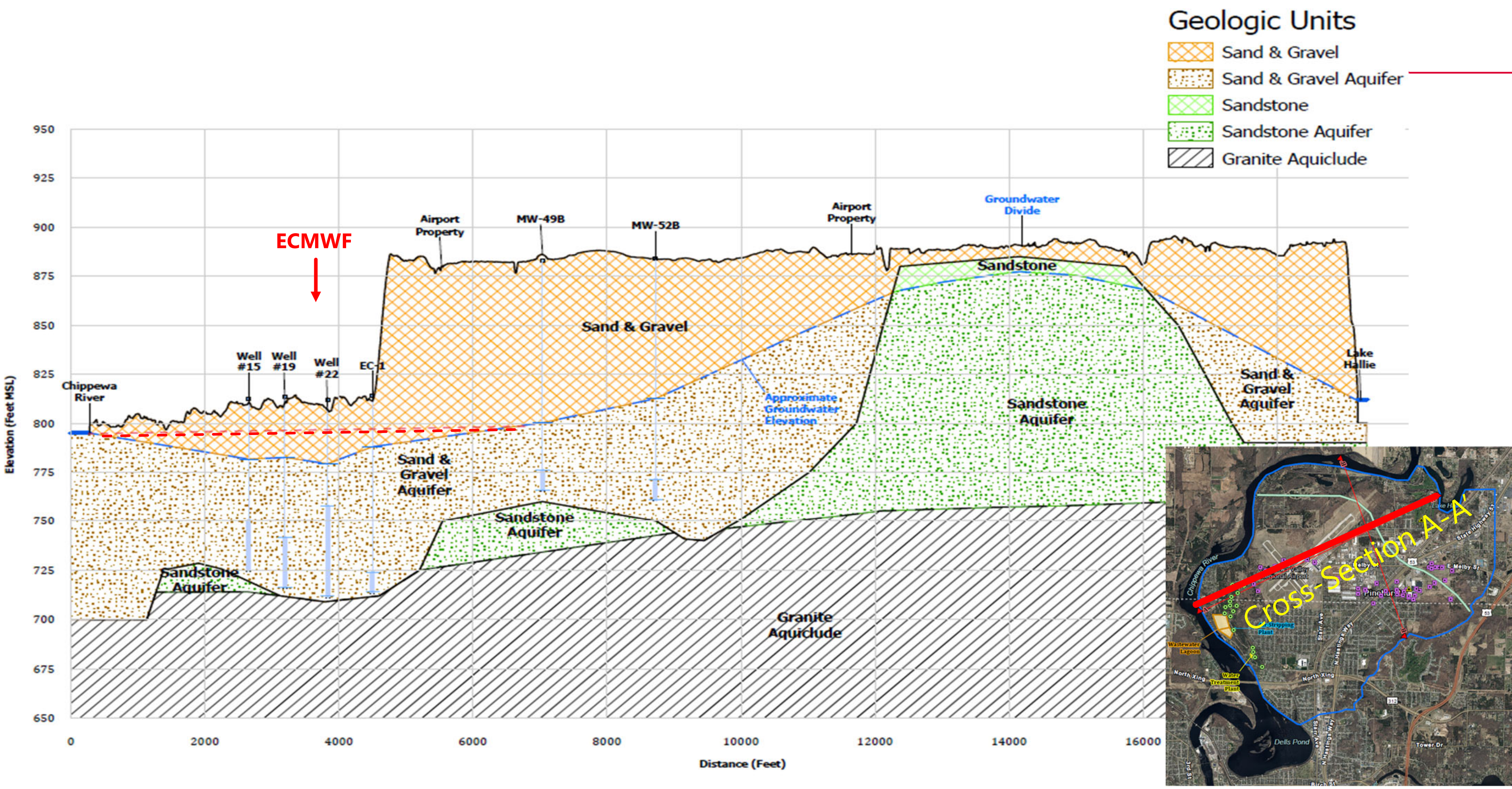
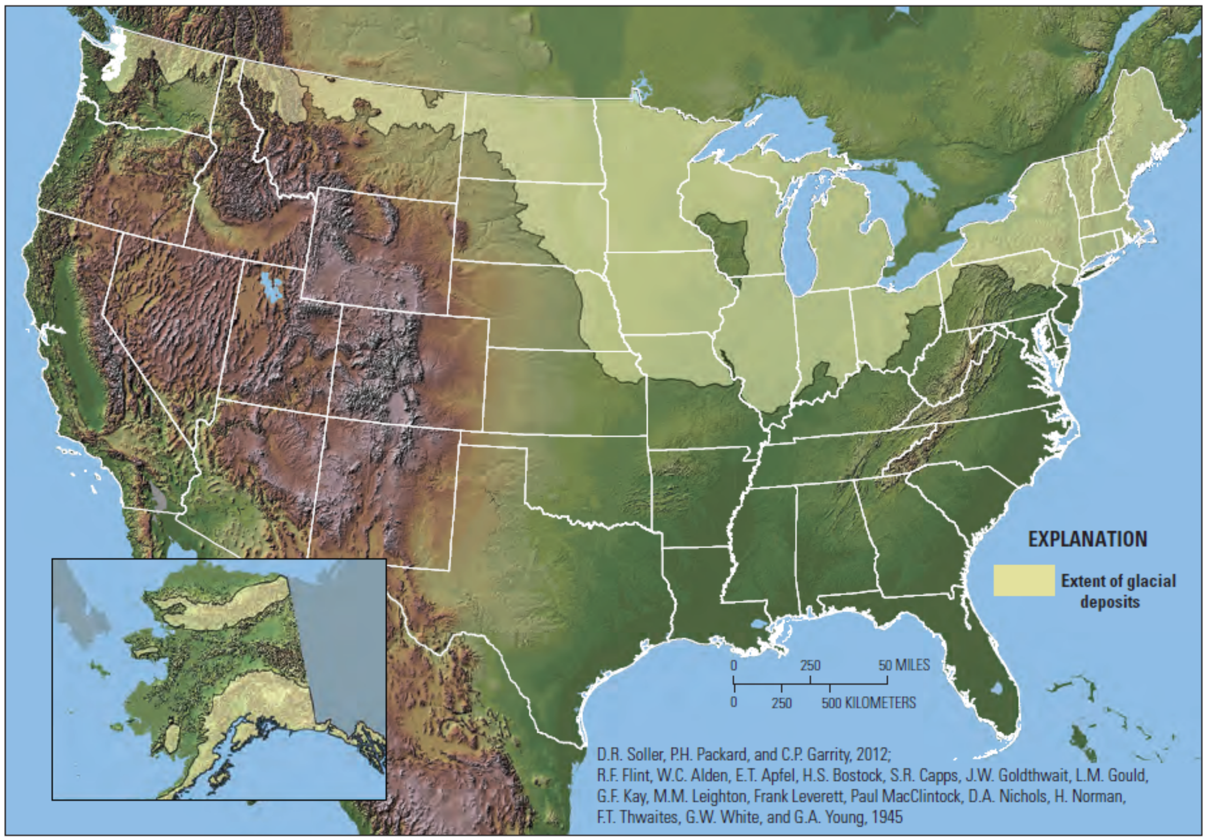
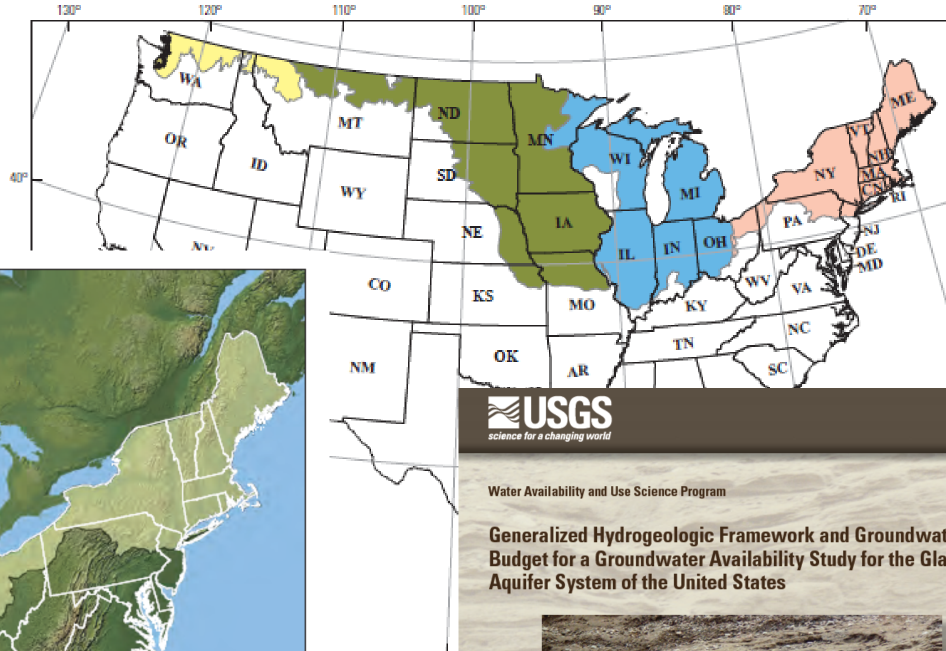
Cross-Section A – A’, Looking Northwest, (Vertically Exaggerated)



Extent of Glacial Deposits Northern Tier of the US





Central Region Glacial Aquifers are – *Highly Productive*

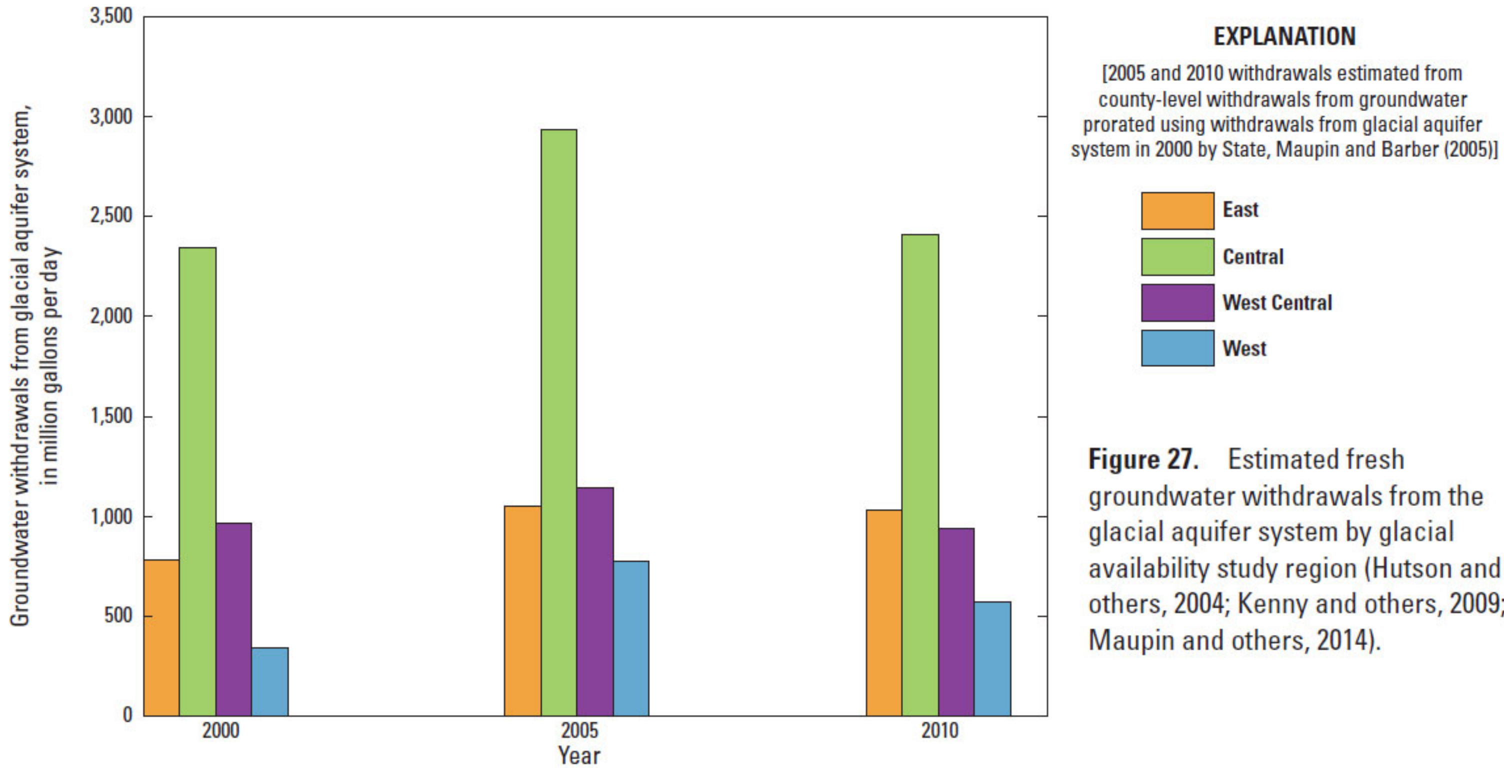


Figure 27. Estimated fresh groundwater withdrawals from the glacial aquifer system by glacial availability study region (Hutson and others, 2004; Kenny and others, 2009; Maupin and others, 2014).

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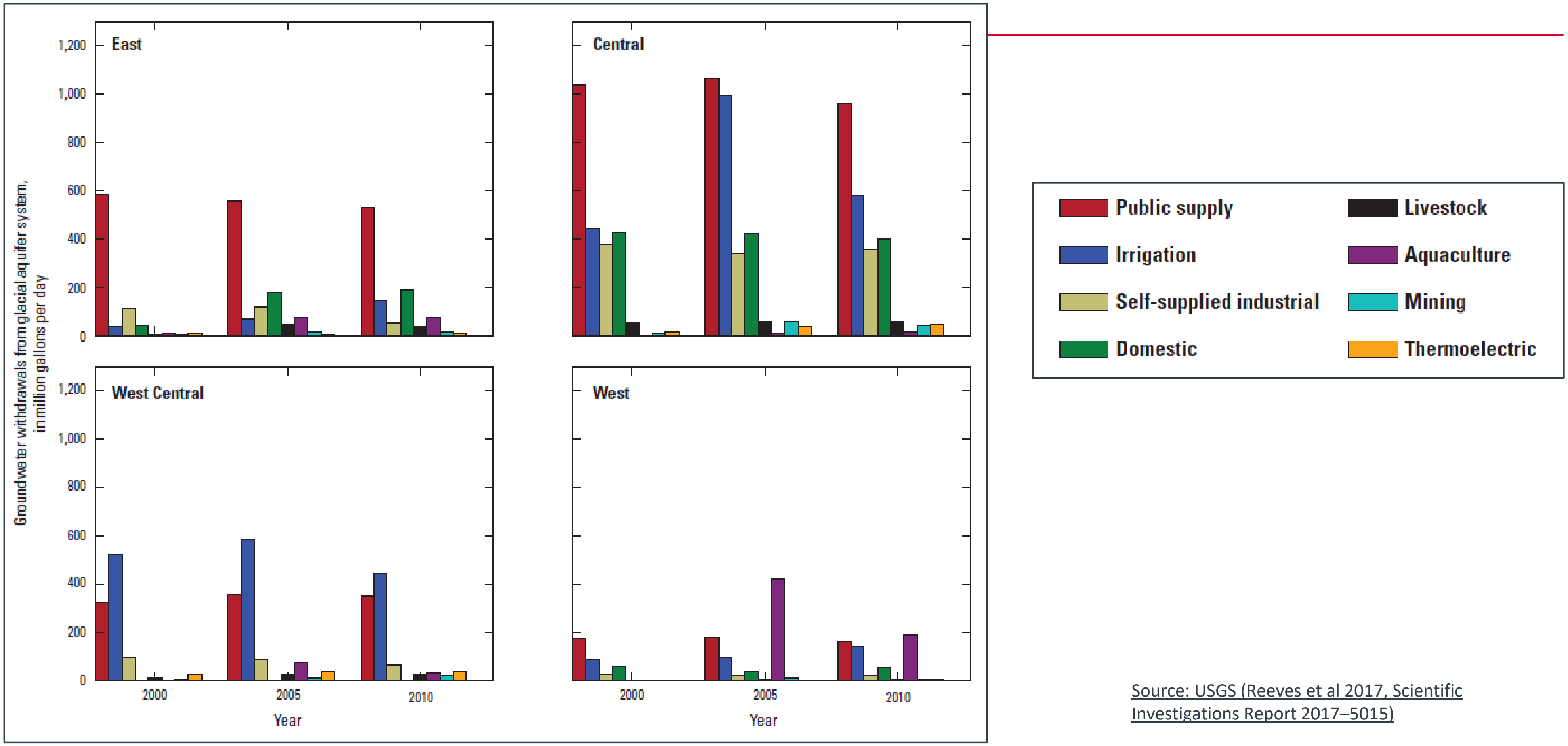
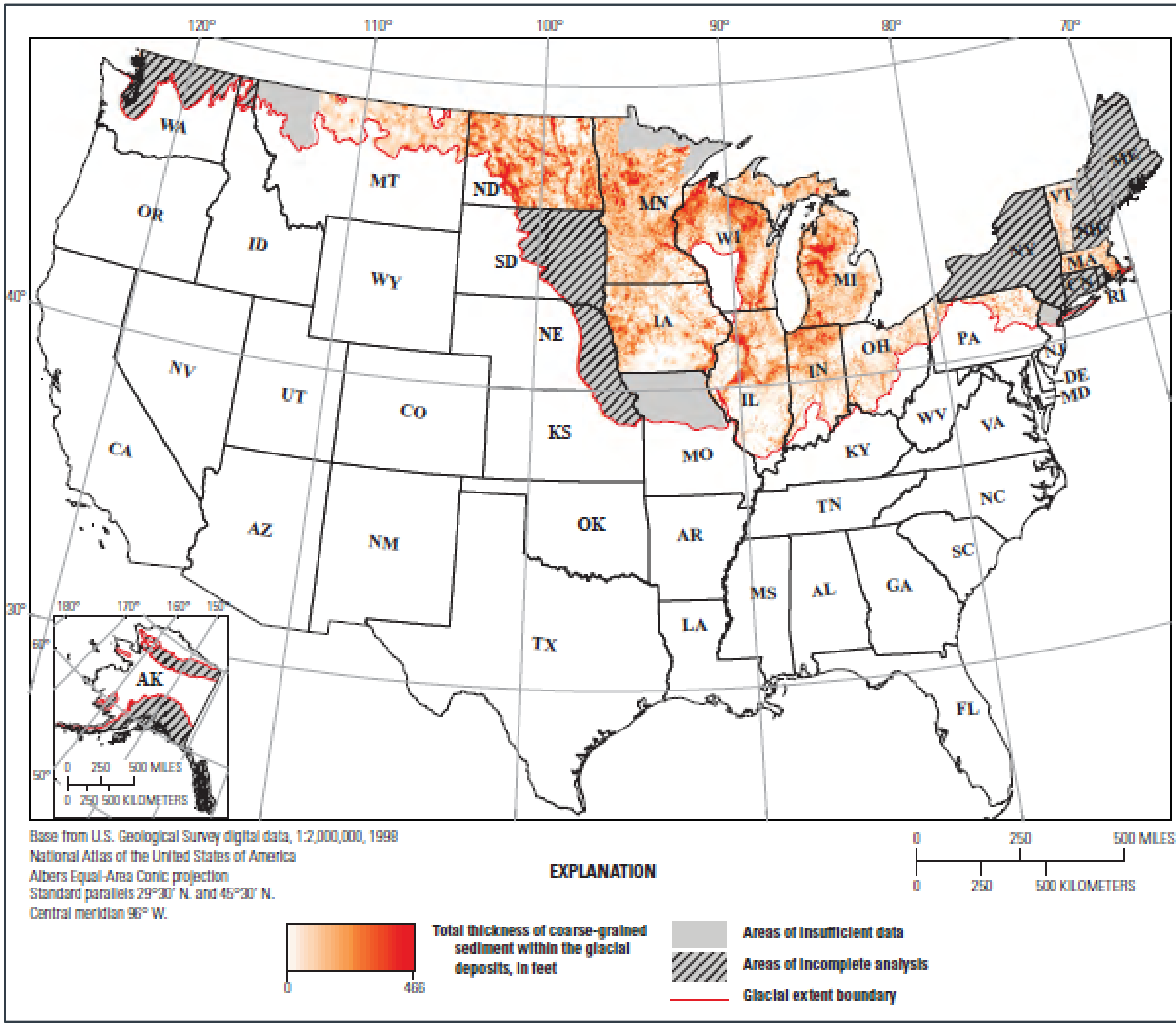
Source: USGS (Reeves et al 2017, Scientific Investigations Report 2017–5015)

Central Region Glacial Aquifer is – *Highly Productive & Economic Driver*



Source: USGS (Reeves et al 2017, Scientific Investigations Report 2017–5015)

Total Thickness of Sand and Gravel in Glacial Deposits from Well Logs



Total thickness of coarse-grained sediment within the glacial deposits, in feet

0 466

Source: USGS (Reeves et al 2017, Scientific Investigations Report 2017–5015)

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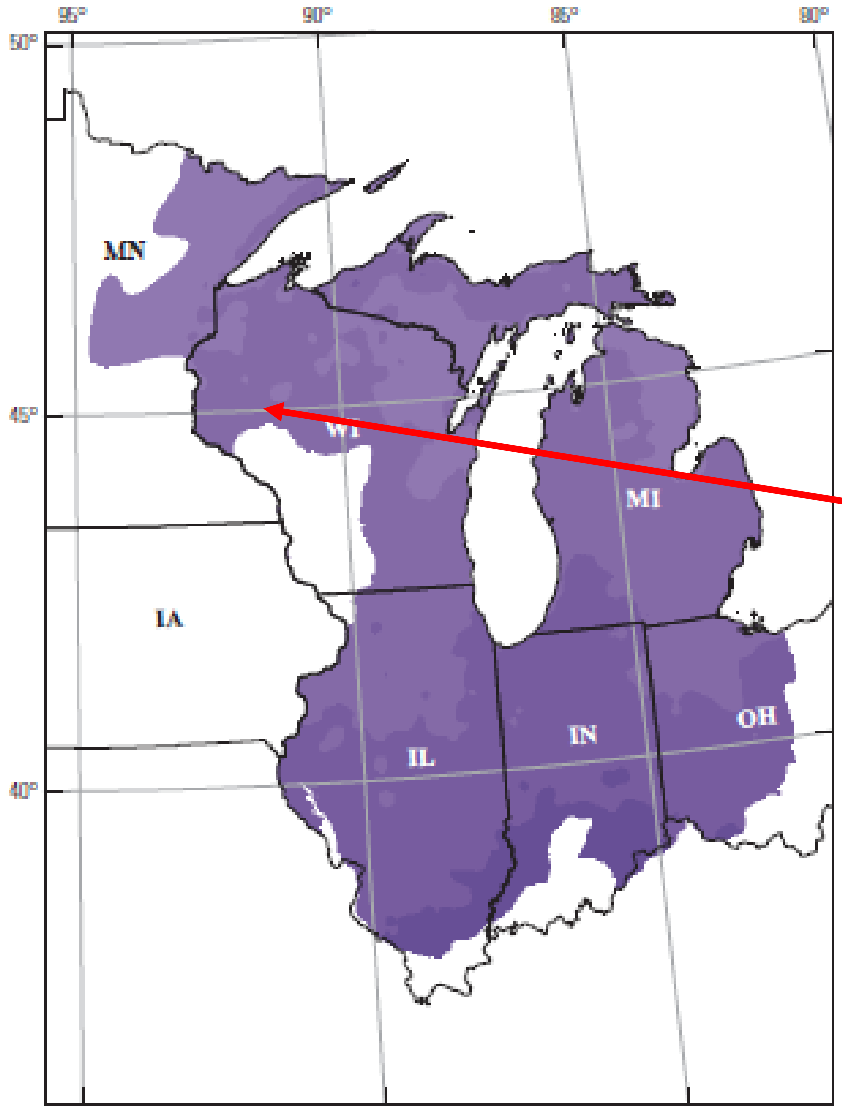
Central Region - Annual Precipitation (Inches)

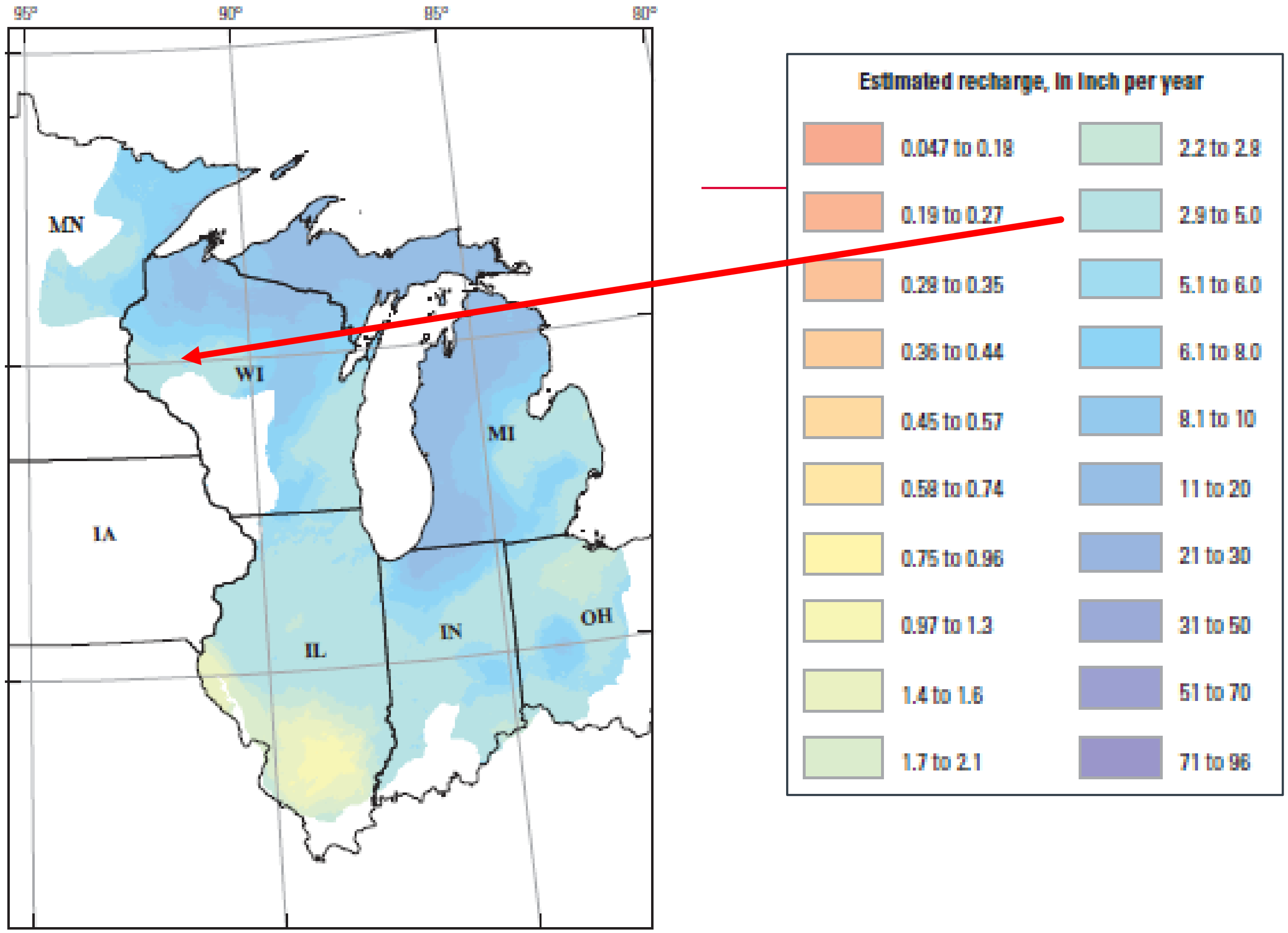


Precipitation, in inch per year

- 1.8 to 10
- 11 to 14
- 15 to 18
- 19 to 24
- 25 to 31
- 32 to 37
- 38 to 44
- 45 to 48
- 49 to 54
- 55 to 260

Source: USGS (Reeves et al 2017, Scientific Investigations Report 2017–5015)

Central Region - Annual Groundwater Recharge (Inches)



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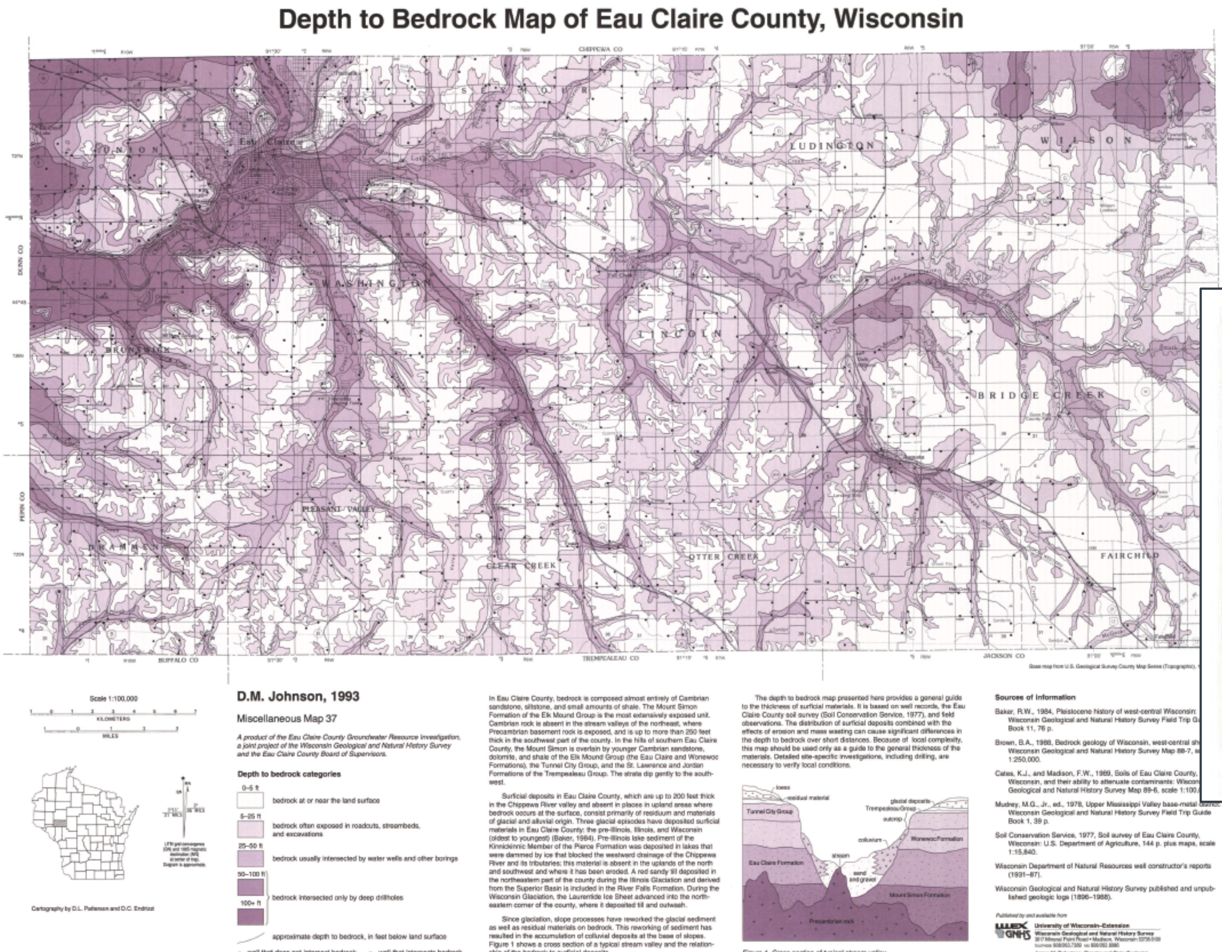
Source: USGS (Reeves et al 2017, Scientific Investigations Report 2017–5015)

Glacial Valleys with Sand and Gravel



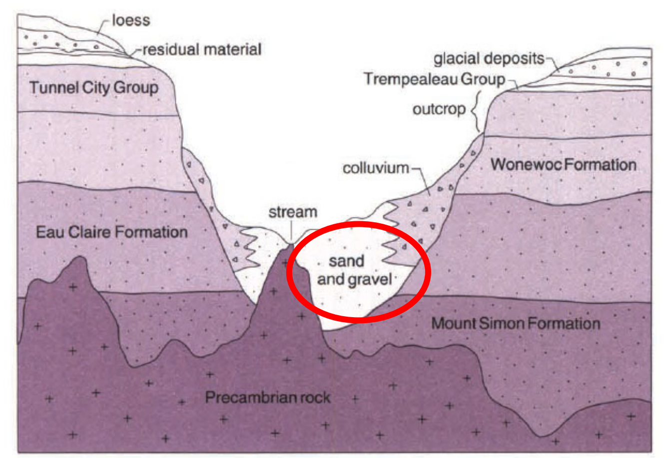
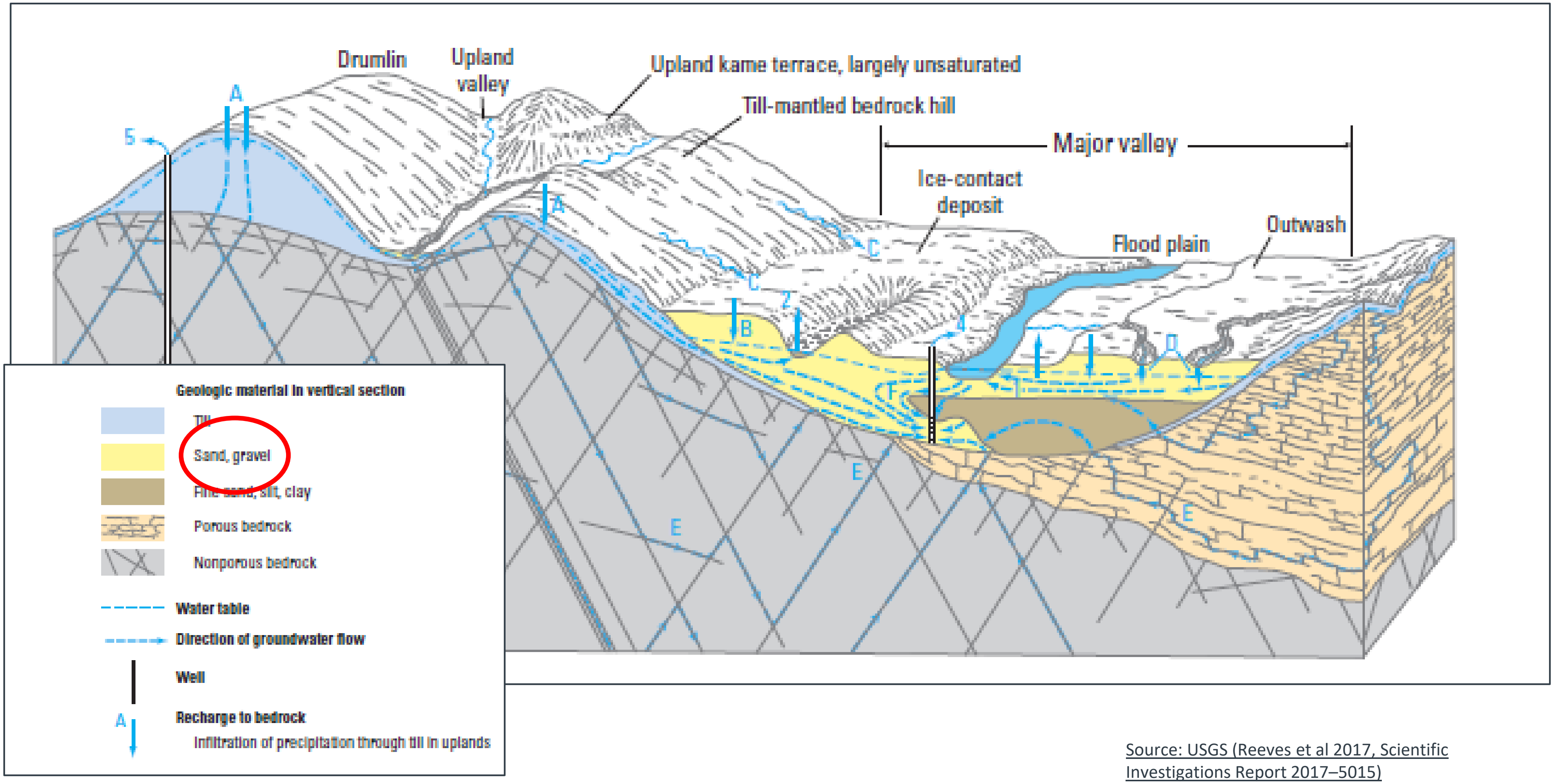


Figure 1. Cross section of typical stream valley.

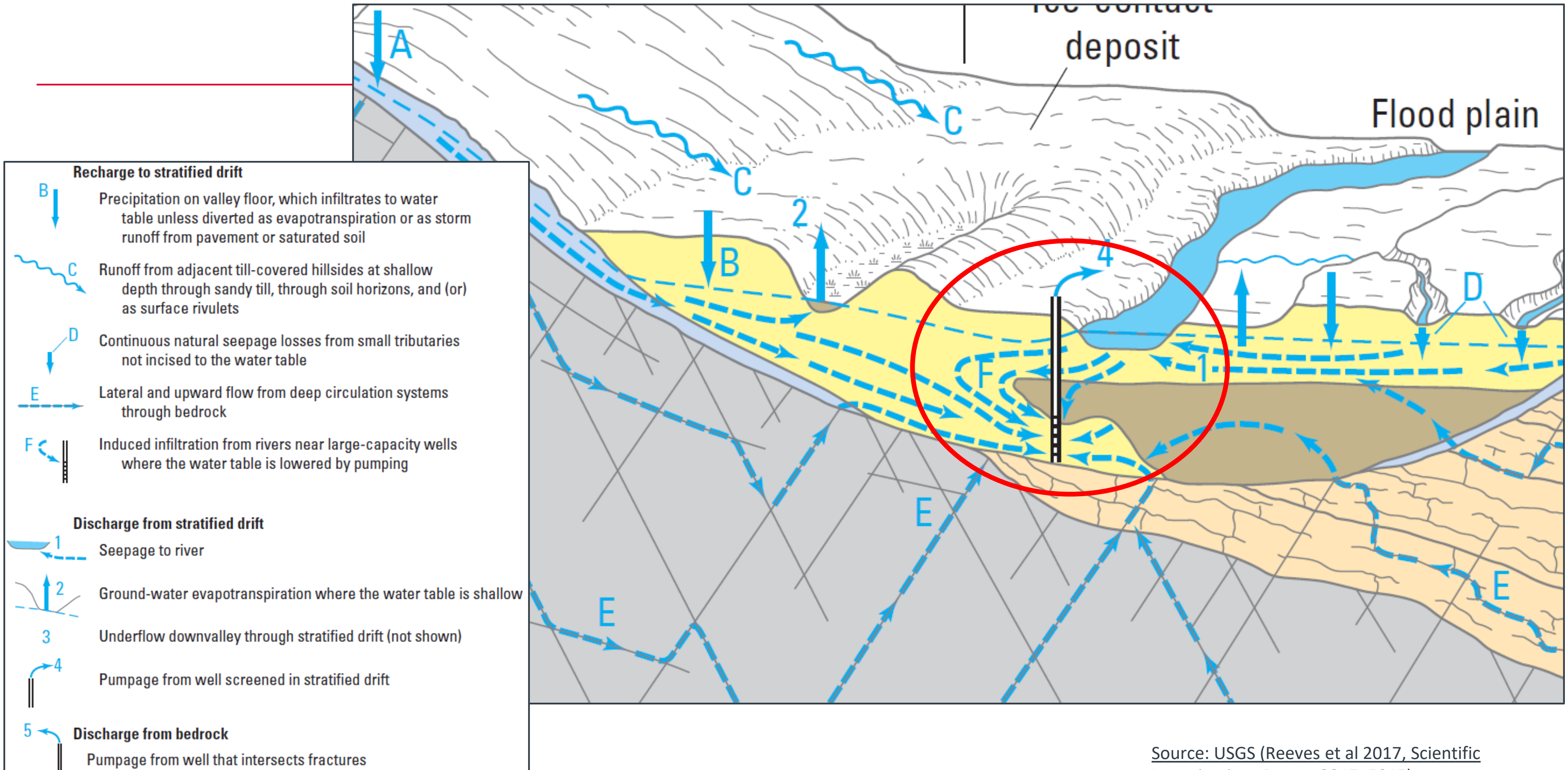
Source: WGNHS Miscellaneous Map 37 (Johnson 1993)

Typical Glacial Valley with Sand and Gravel



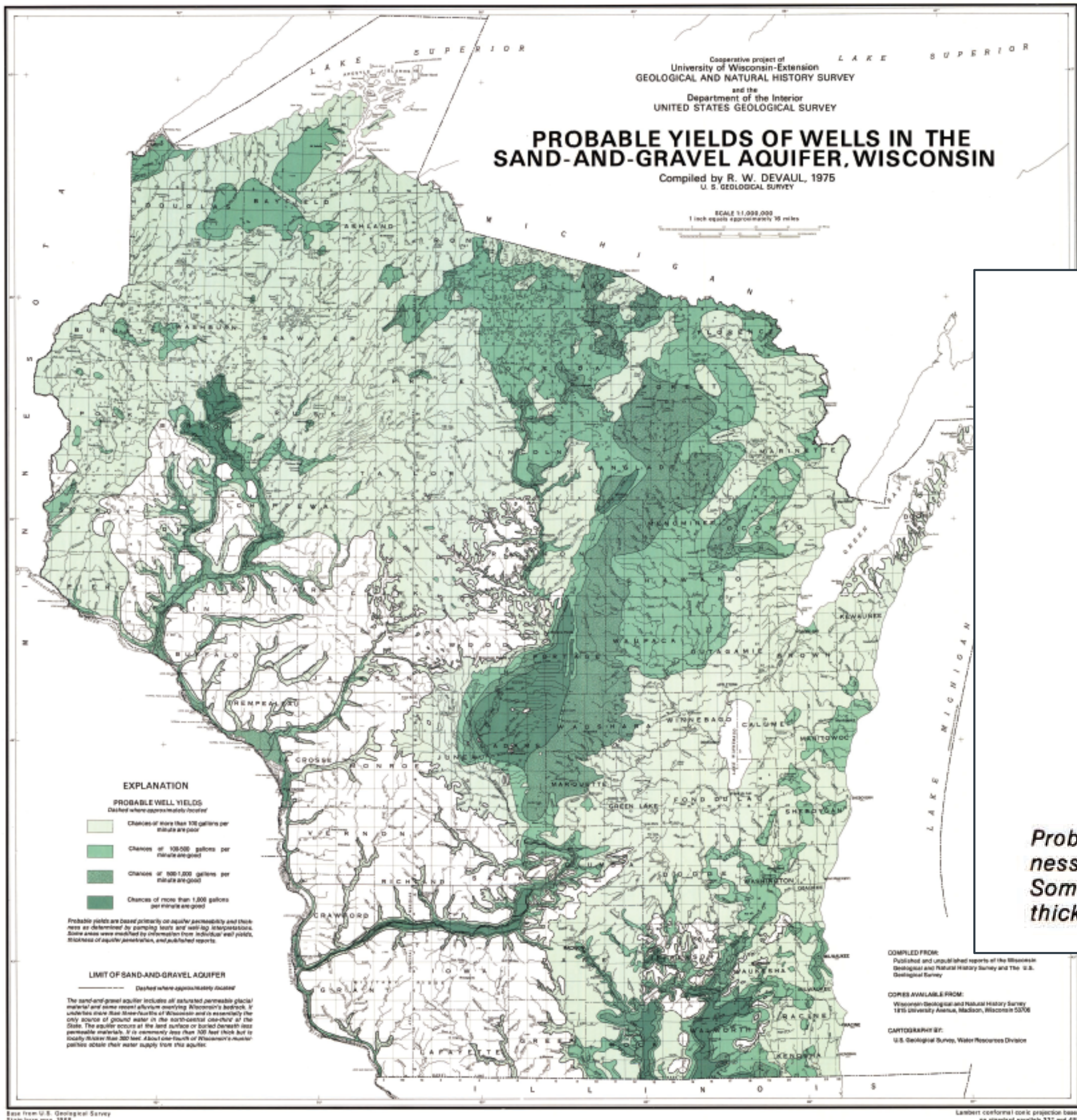
Source: USGS (Reeves et al 2017, Scientific Investigations Report 2017–5015)

Typical Glacial Valley with Sand and Gravel & Recharge Components



Source: USGS (Reeves et al 2017, Scientific Investigations Report 2017–5015)

Probable Well Yields in Sand and Gravel



EXPLANATION

PROBABLE WELL YIELDS

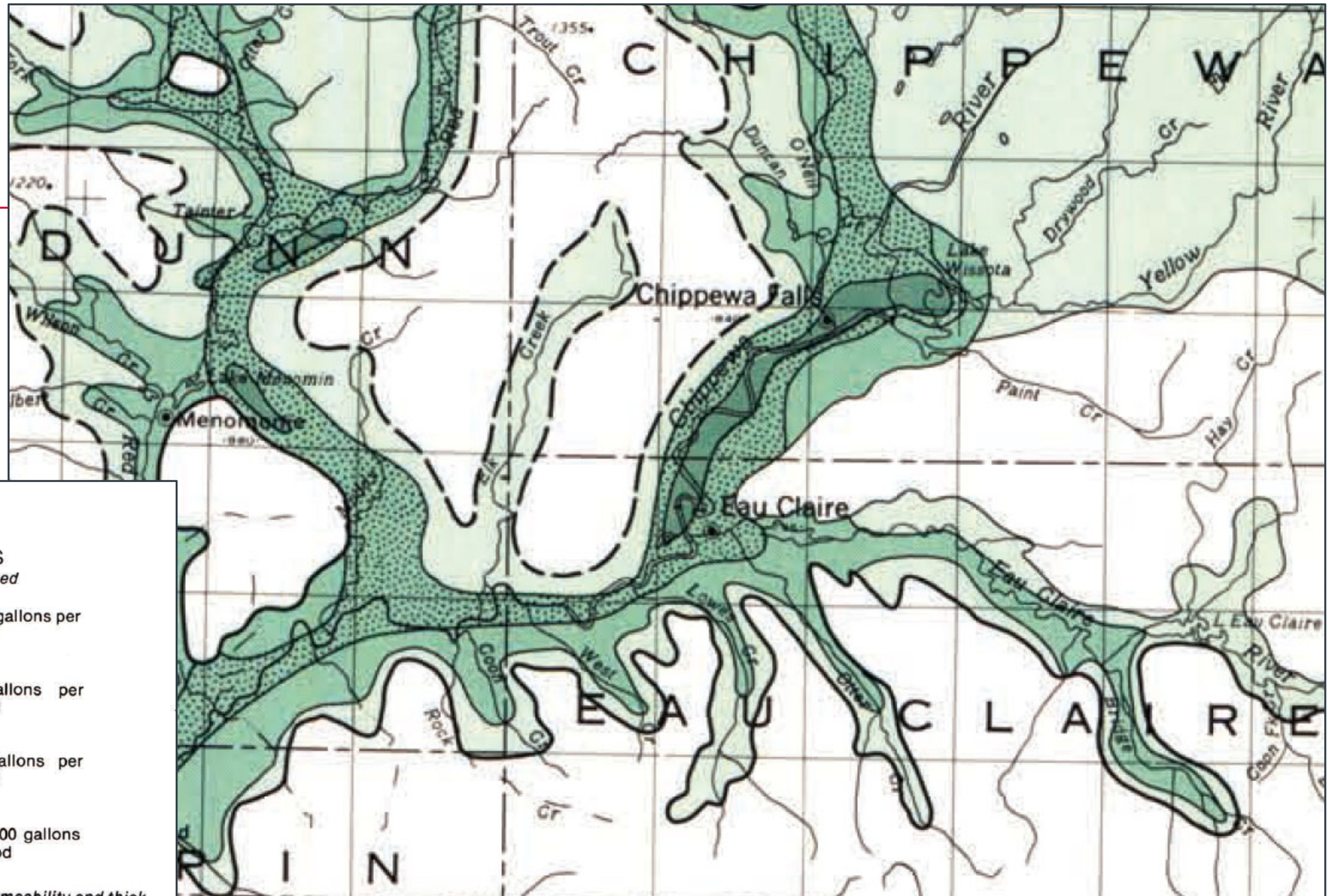
Dashed where approximately located

- Chances of more than 100 gallons per minute are poor
- Chances of 100-500 gallons per minute are good
- Chances of 500-1,000 gallons per minute are good
- Chances of more than 1,000 gallons per minute are good

Probable yields are based primarily on aquifer permeability and thickness as determined by pumping tests and well-log interpretations. Some areas were modified by information from individual well yields, thickness of aquifer penetration, and published reports.

Source: WGNHS Miscellaneous Map 54 (Devaul, 1975)

Probable Well Yields in Sand and Gravel



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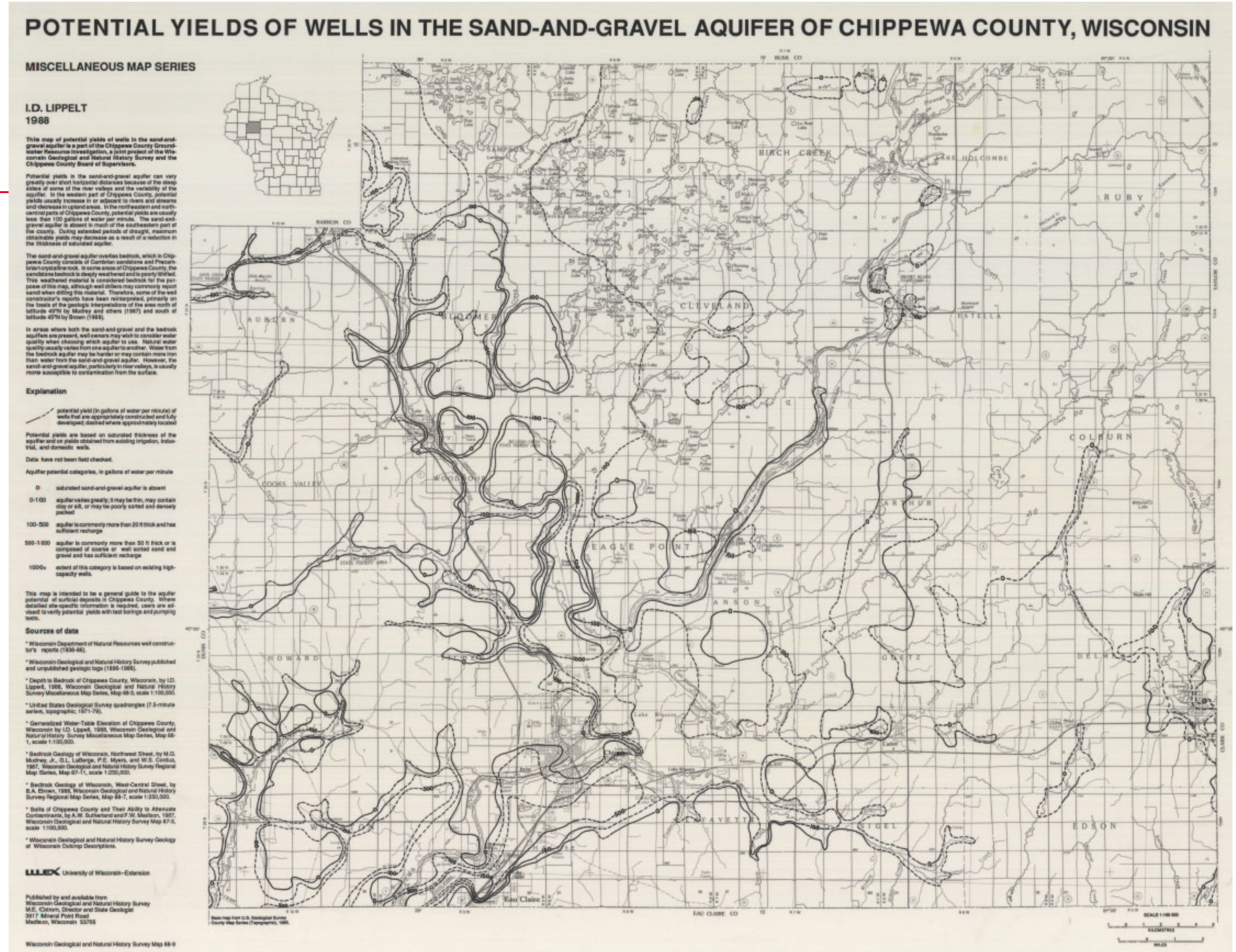
Source: WGNHS Miscellaneous Map 54 (Devaul, 1975)

Potential Well Yields in Sand and Gravel of Chippewa County

Source: WGNHS Miscellaneous Map 54 (Devaul, 1975)



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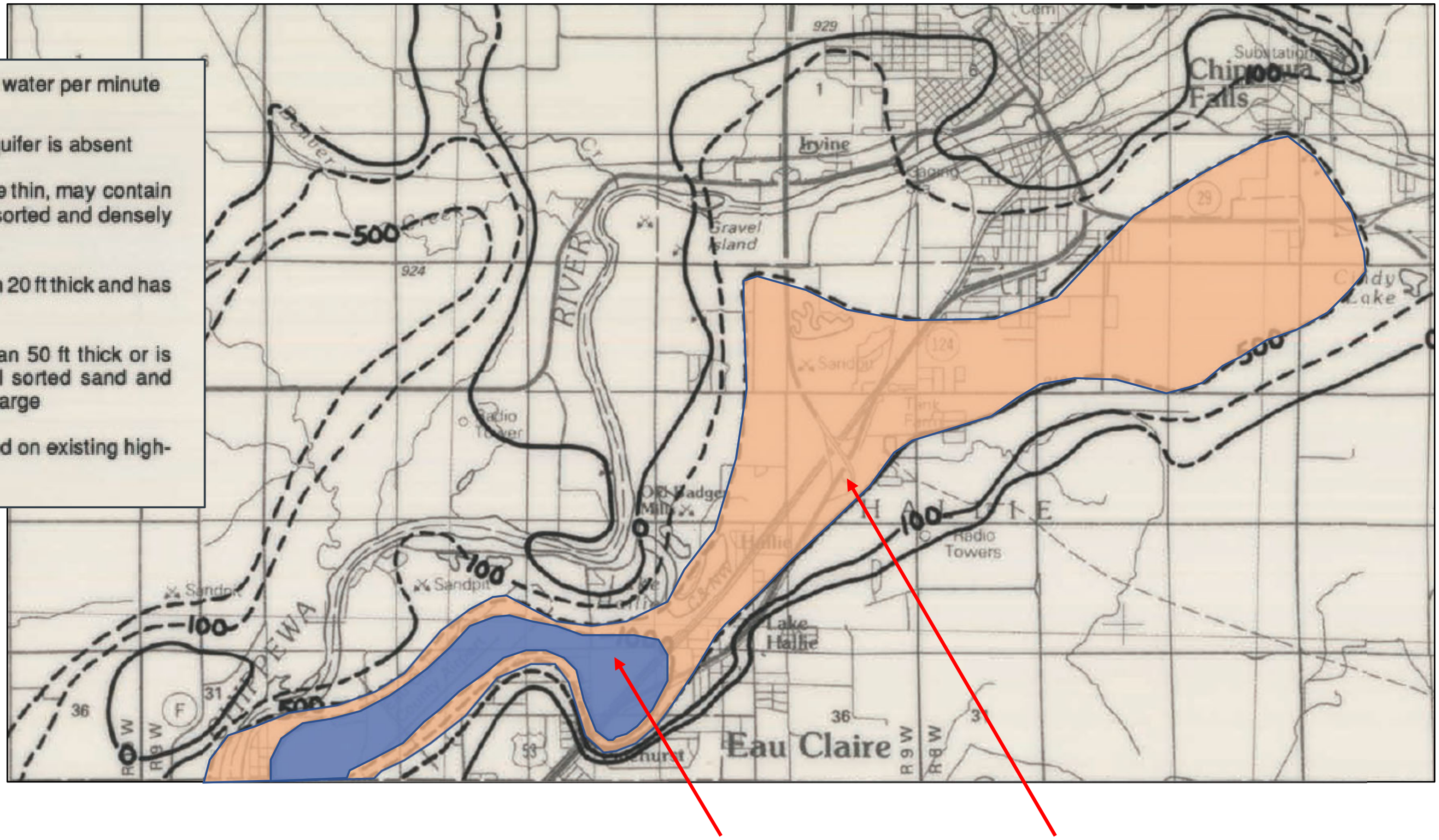
Potential Well Yields in Sand and Gravel of Chippewa County

Aquifer potential categories, in gallons of water per minute

0	saturated sand-and-gravel aquifer is absent
0-100	aquifer varies greatly; it may be thin, may contain clay or silt, or may be poorly sorted and densely packed
100-500	aquifer is commonly more than 20 ft thick and has sufficient recharge
500-1000	aquifer is commonly more than 50 ft thick or is composed of coarse or well sorted sand and gravel and has sufficient recharge
1000+	extent of this category is based on existing high-capacity wells.



Source: WGNHS Miscellaneous Map 102 (Lippelt, 1988)

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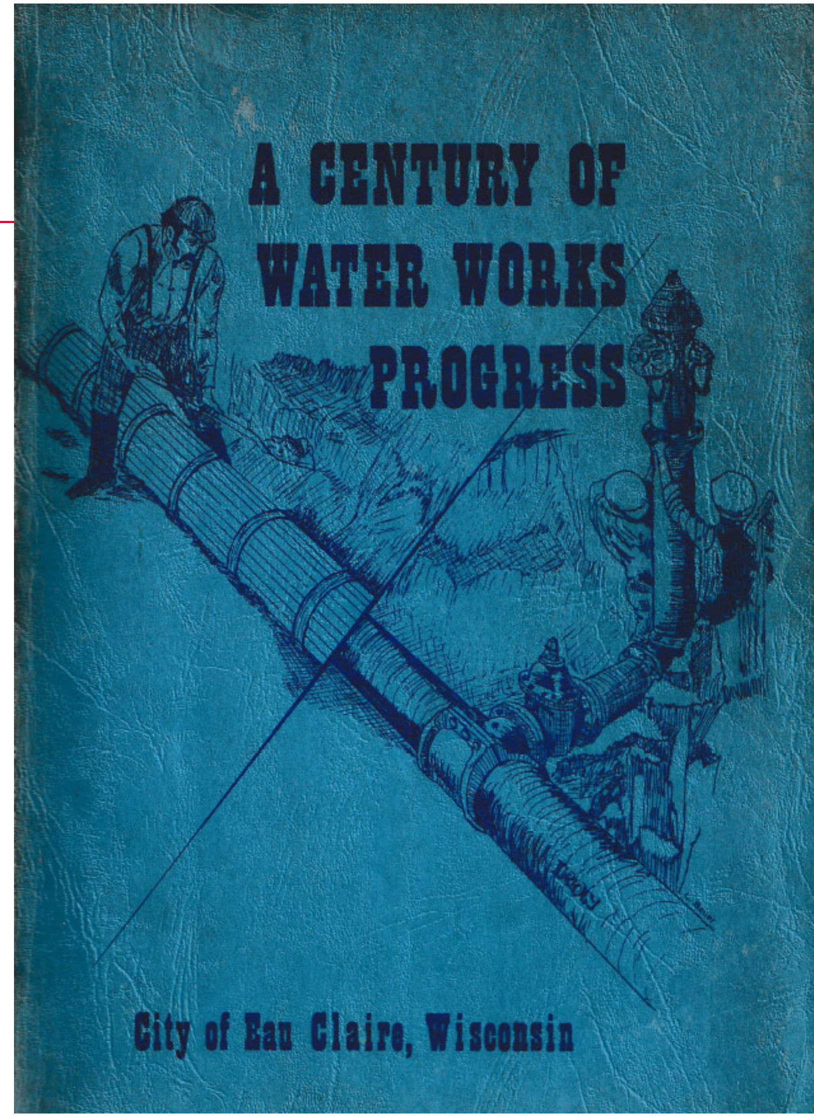
Eau Claire - Water

- Readily developed resource
  - "Shallow" wells with High Capacity
- Sand & Gravel Aquifer
  - Relatively thick
  - Porous
  - Permeable
- Available water with desirable quality
- Continual Replenishment
  - Interconnected to the Chippewa and other Rivers
  - Very large upland region underlain by Sand and Gravel
- Demonstrated reliability – about 140 years of history



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Eau Claire Municipal Wellfield Characteristics

Well ID	Wellfield Location	Year In Service	Approx Surface EL.	Approx Pumping Rates (GPM)	Approximate Distance from River Edge (FT)	Screen Length (FT)	05/2021 GW Depth (FT)	Pumping Rates South	Pumping Rates North
Well #6	Mid	1955 (1962)	803	800	960	34	14.6	800	
Well #8	North	1941	807	1080	1,420	40	23.9		1,080
Well #9	North	1947	809	2130	1,340	30	27.3		2,130
Well #11	North	1947	810	1330	2,140	34	31		1,330
Well #12	South	1954	804	2000	580	34	14	2,000	
Well #13	South	1962	804	1400	650	30	15.8	1,400	
Well #14	North	1968	808	1380	1,620	38	27.6		1,380
Well #15	North	1968	811	1450	2,400	25	30.5		1,450
Well #16	North	1975	808	1100	1,960	35	27.8		1,100
Well #17	North	1975	806	1200	2,390	35	26.4		1,200
Well #18	South	1977	808	2100	720	35	17.3	2,100	
Well #19	North	1992	810	1100	2,420	25	31		1,100
Well #21	South	1992	808	1300	980	35	14.8	1,300	
Well #22	North	2017	811	1600	2,090	46	32.4		1,600
Well #23	North	2017	817	1500	1,750	25	40.1		1,500
Well #24	North	2019	811	600	1,820	35	24		600
								Subtotal	
								7,600	14,470

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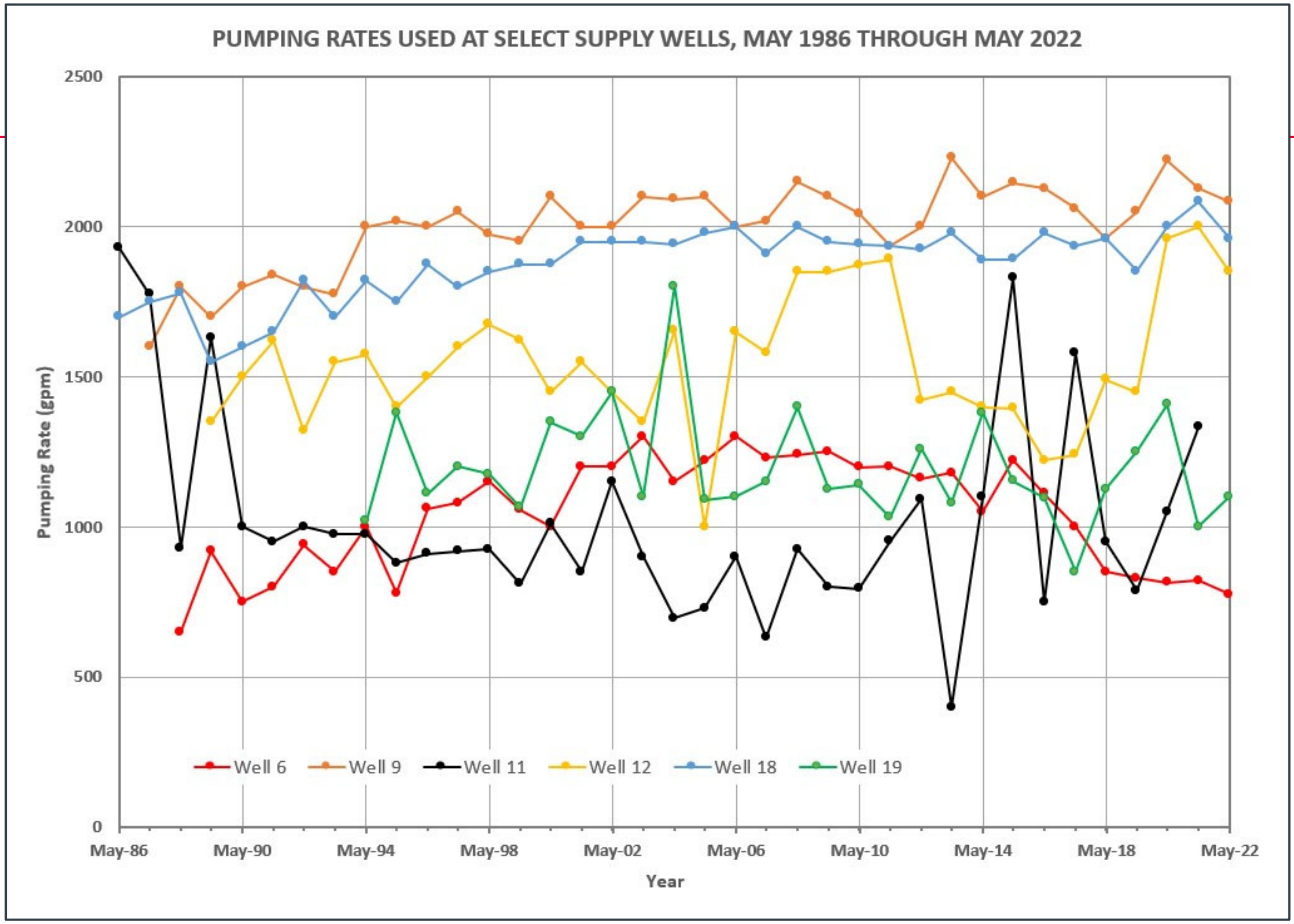
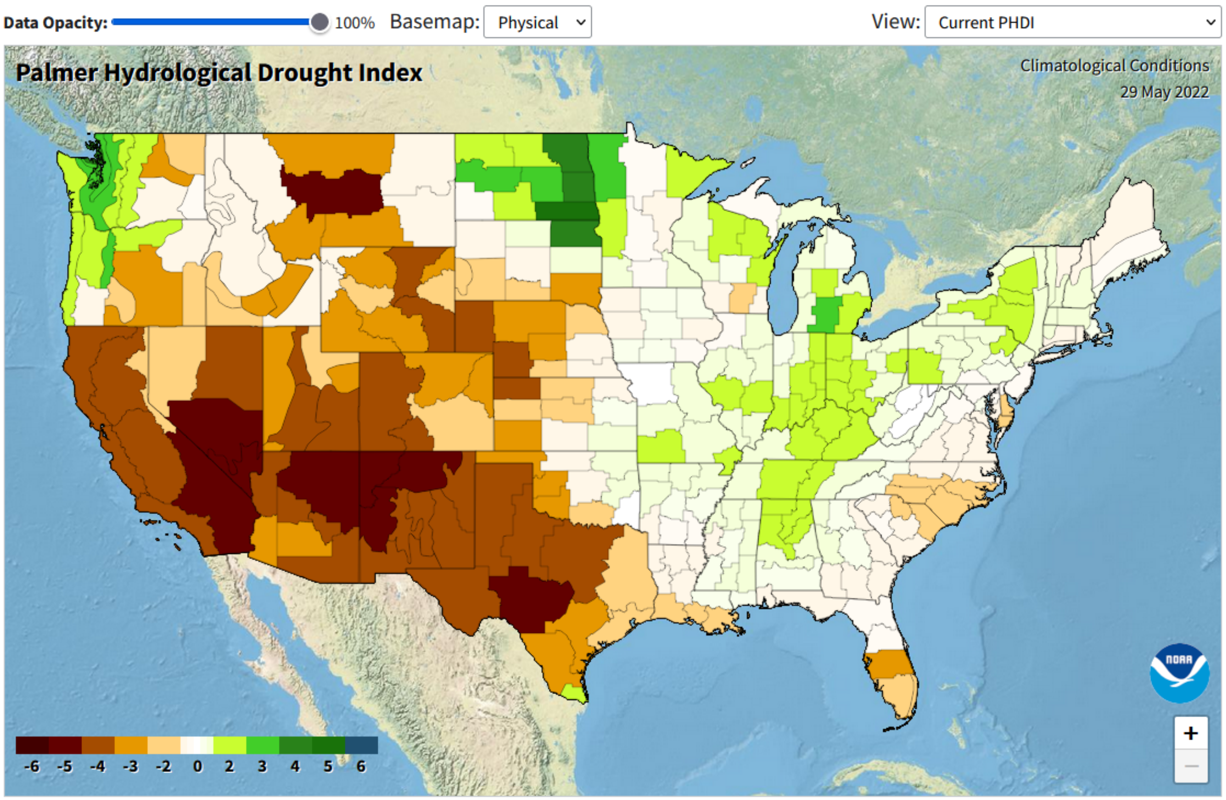
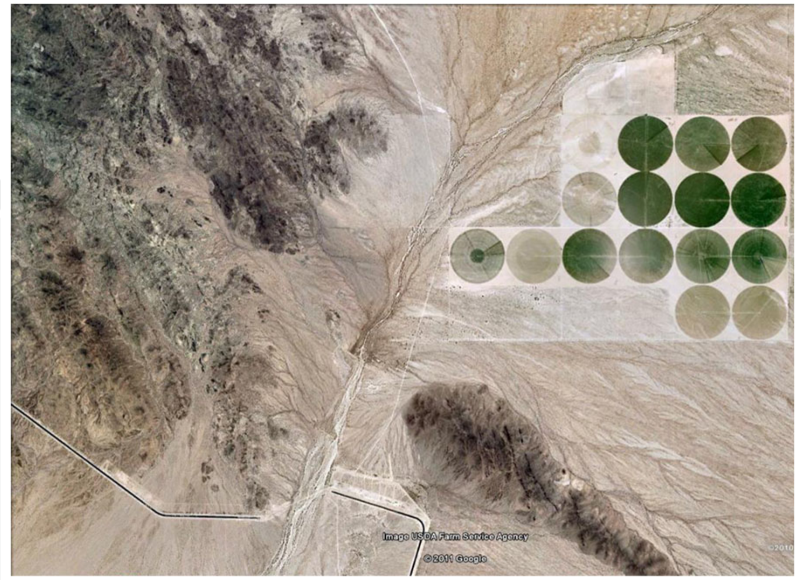
ECMWF – Range of Well Pumping Rates – Selected Wells



Current Drought Index for Continental US





Typical Agricultural Pumping, Arizona

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Projected Southwest US Conditions to 2080

- USGS projects decreased streamflow
- Citing a changing climate and modeled radiative climate forcing's

  "an imposed, natural, or anthropogenic disturbance of the Earth's energy balance with space"

- At Representative Concentration Pathway (RCP) 4.5
  - 51% of SW US basins impacted by 2080
  - Appreciable baseflow reductions

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Journal of Hydrology X

journal homepage: www.sciencedirect.com/journal/journal-of-hydrology-x

Changing climate drives future streamflow declines and challenges in meeting water demand across the southwestern United States

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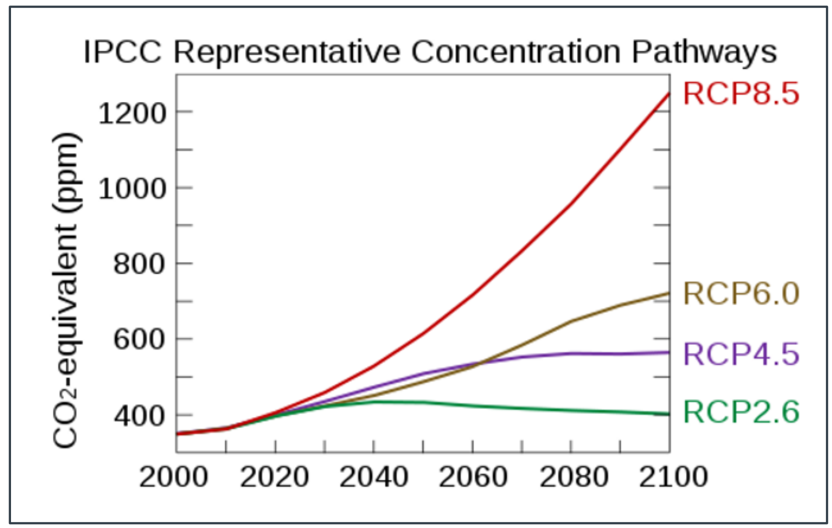

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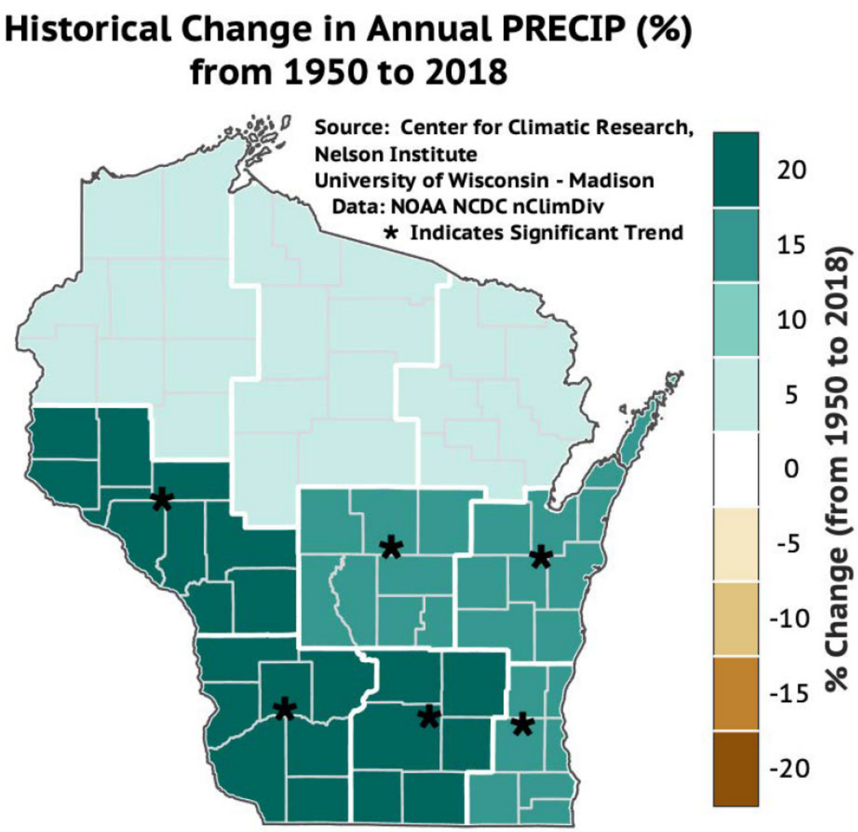
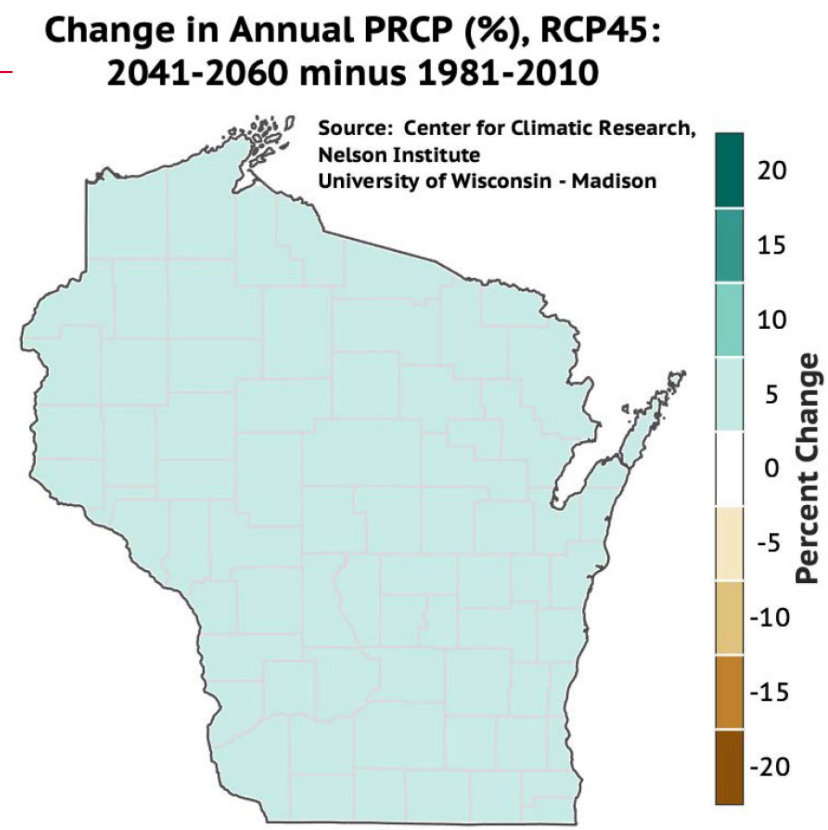
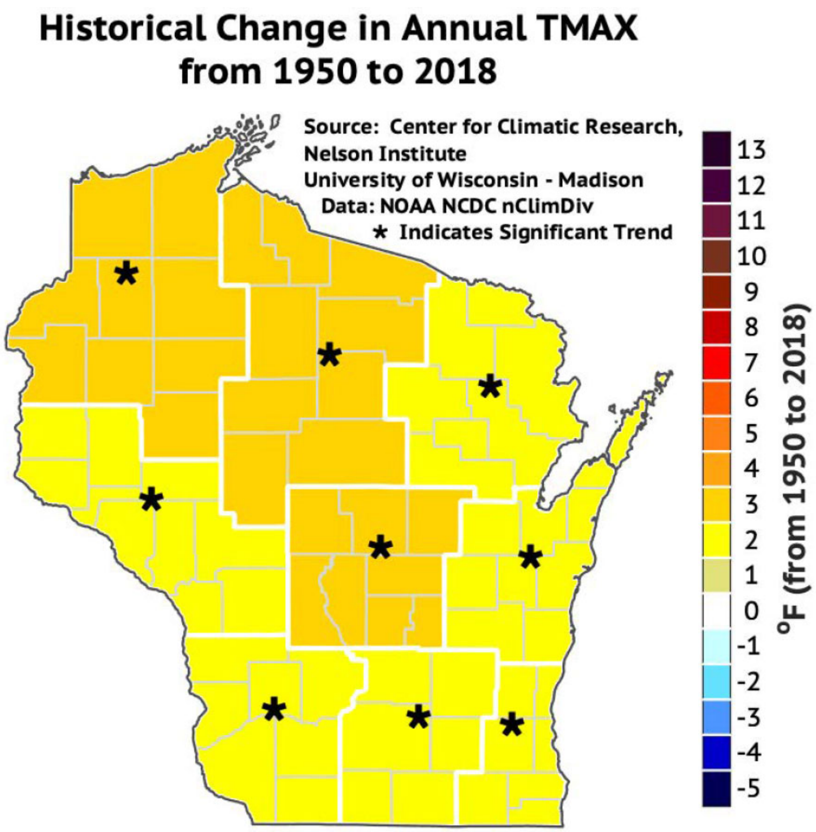
Precipitation Patterns – Historical & Projected at RCP4.5

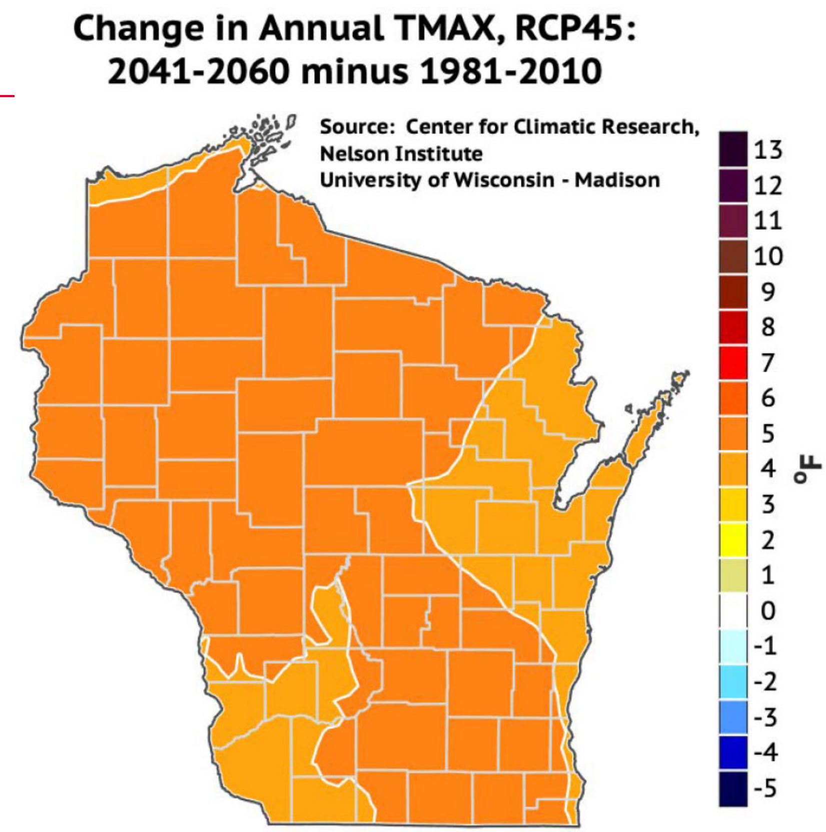




Source: Wisconsin Initiative on Climate Change Impacts (WICCI)
https://wicci.wisc.edu/

Temperature Patterns – Historical & Projected at RCP4.5

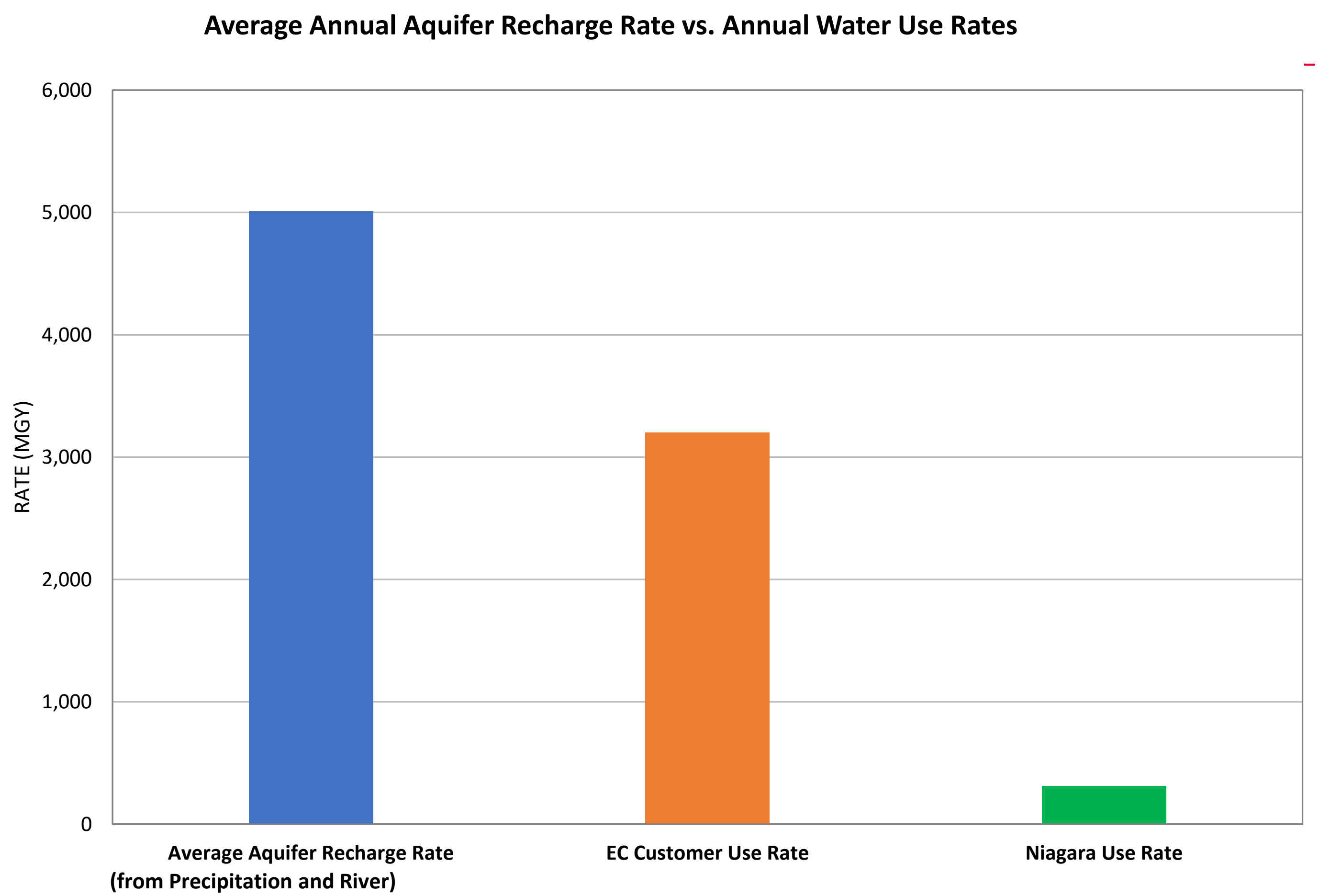




Source: Wisconsin Initiative on Climate Change Impacts (WICCI)
https://wicci.wisc.edu/

Modeling Results and Aquifer Recharge

Aquifer Recharge from Precipitation and Induced Recharge from River



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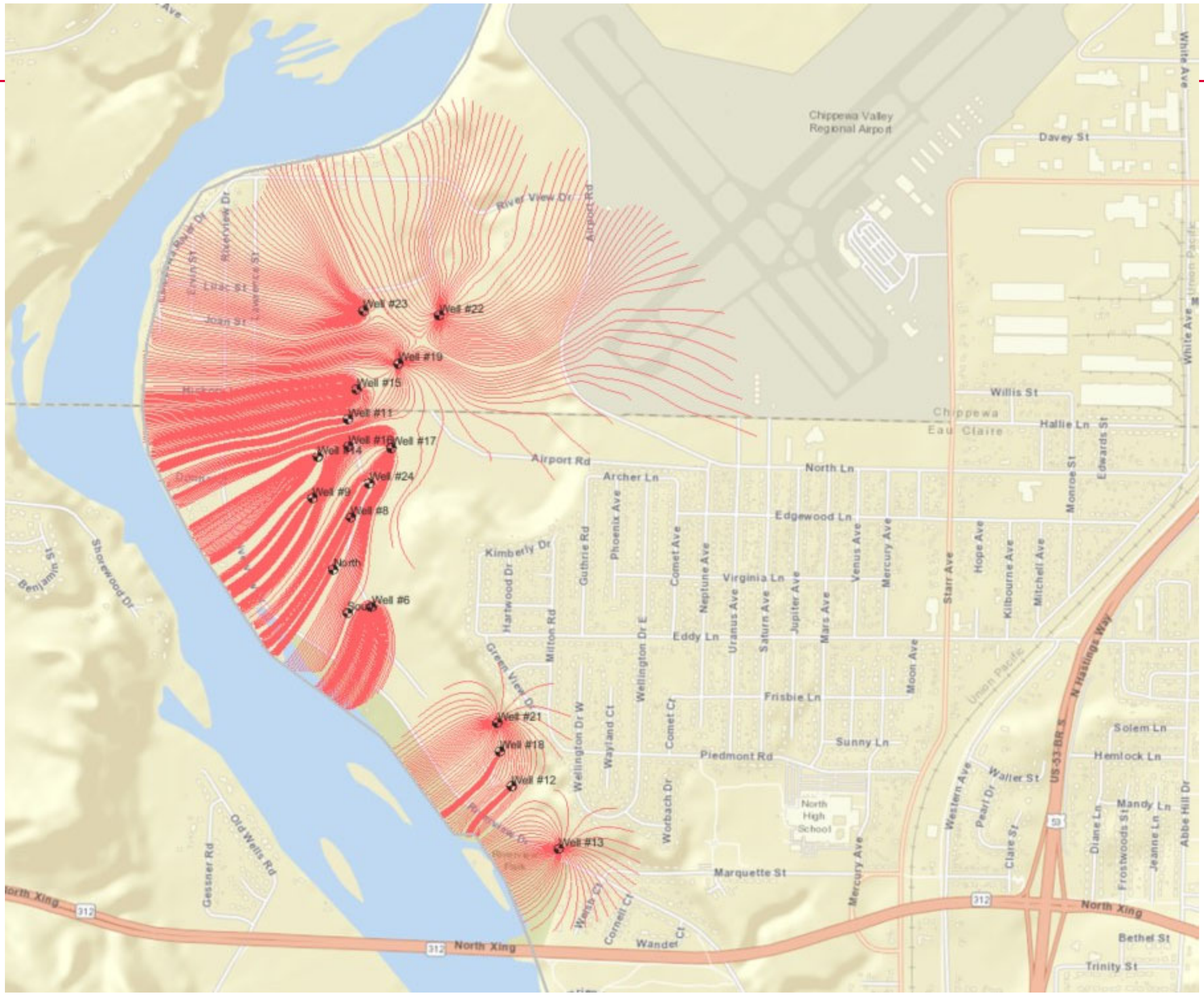
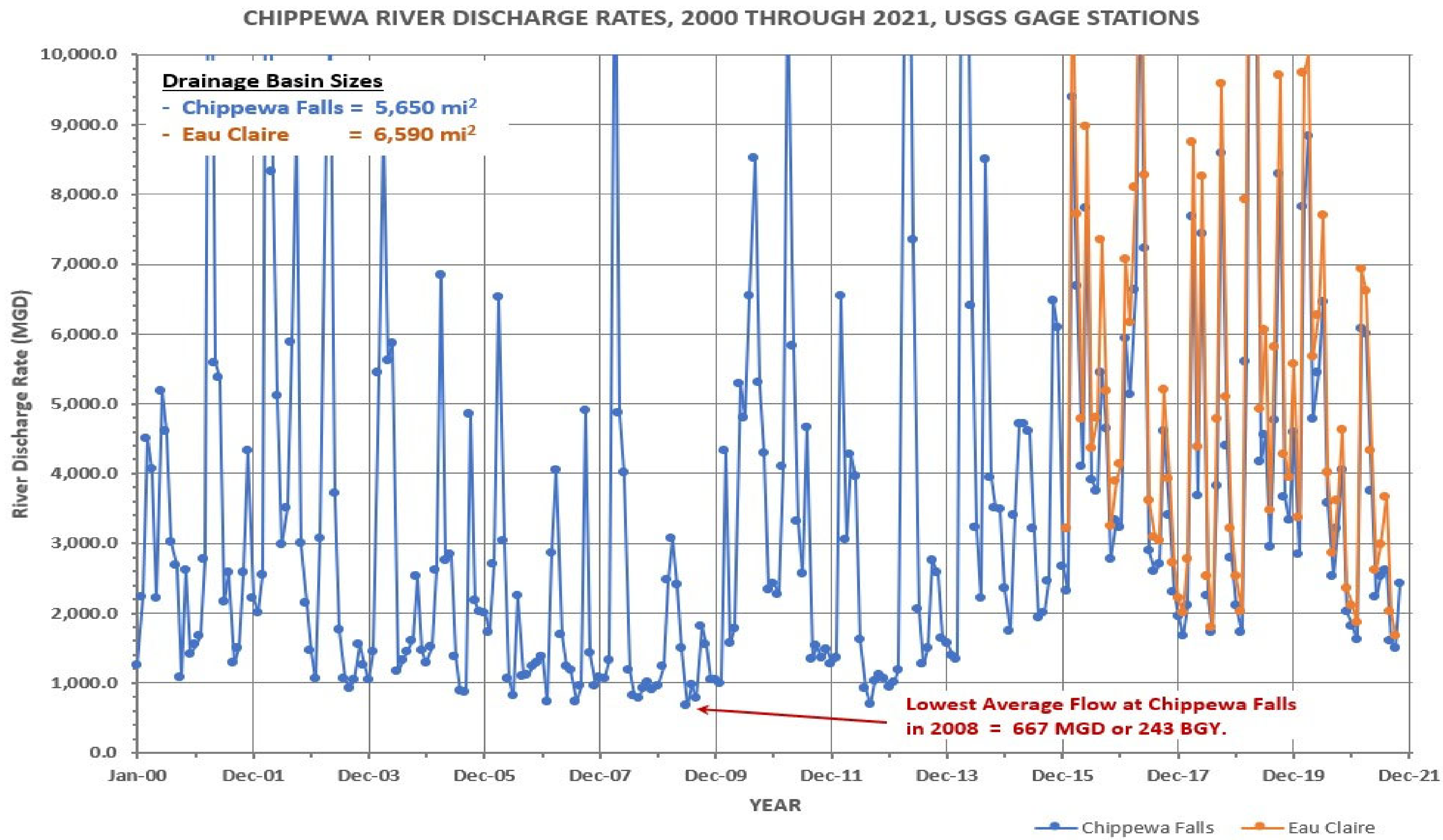
Simulated Groundwater Flow Lines to Pumping Wells
Wellfield Withdrawal Rate During Typical Peak Demand Month





Very High Baseflow Rates in the Chippewa River Can Support Groundwater Recharge to an Adjacent Pumped Aquifer.

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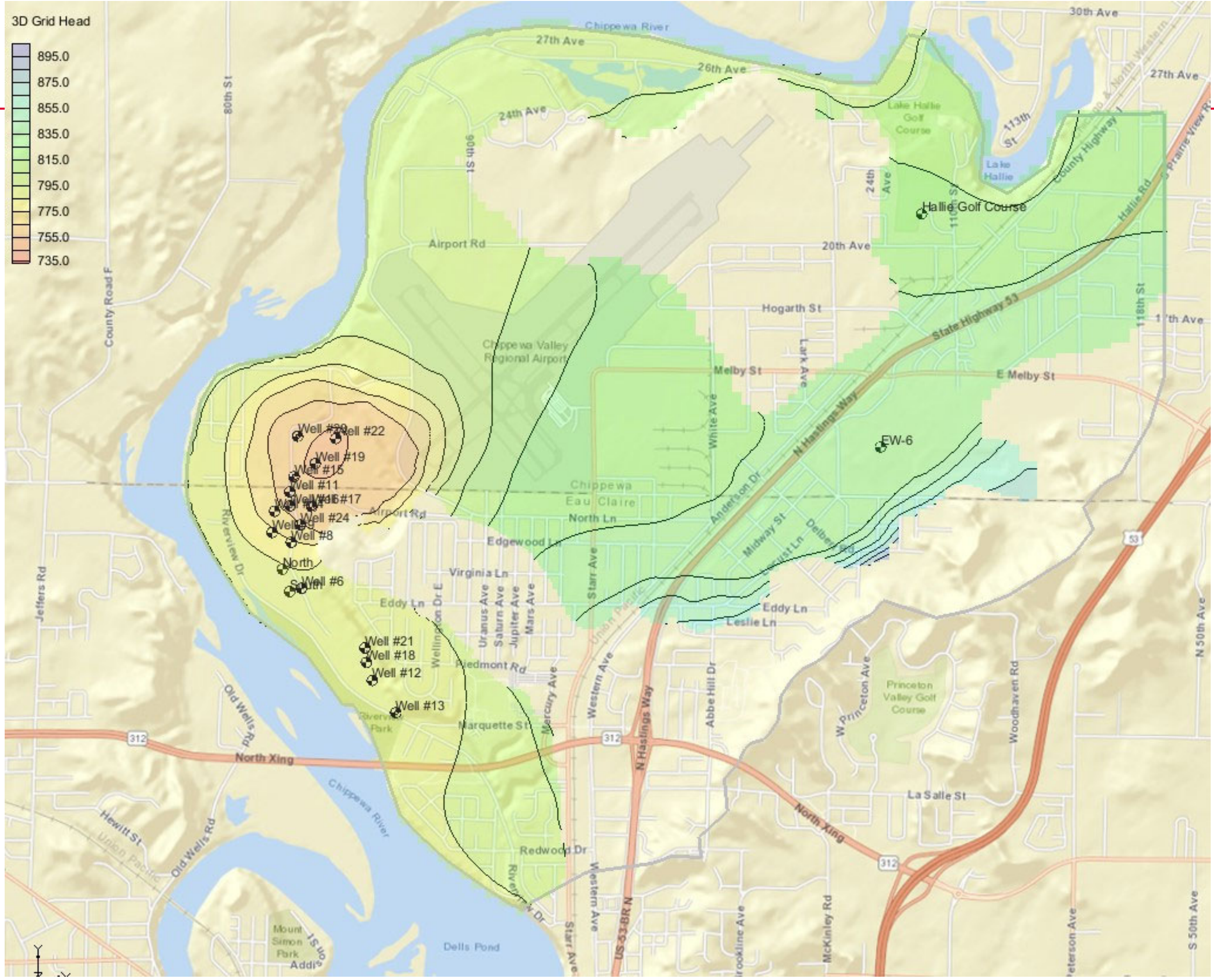
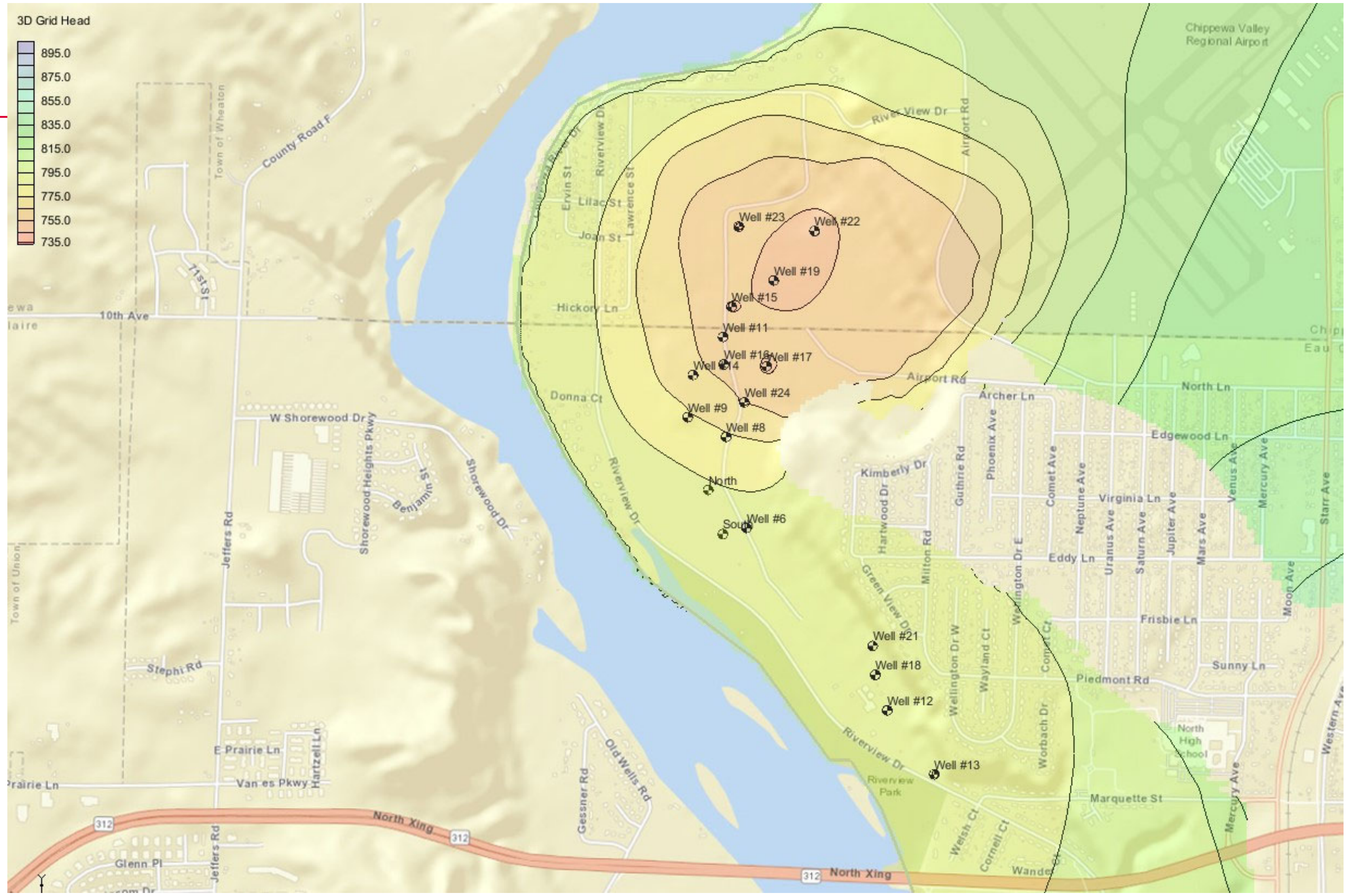
Simulated Groundwater Elevations During Peak-Rate Pumping



Simulated Groundwater GW Elevations During Peak-Rate Pumping



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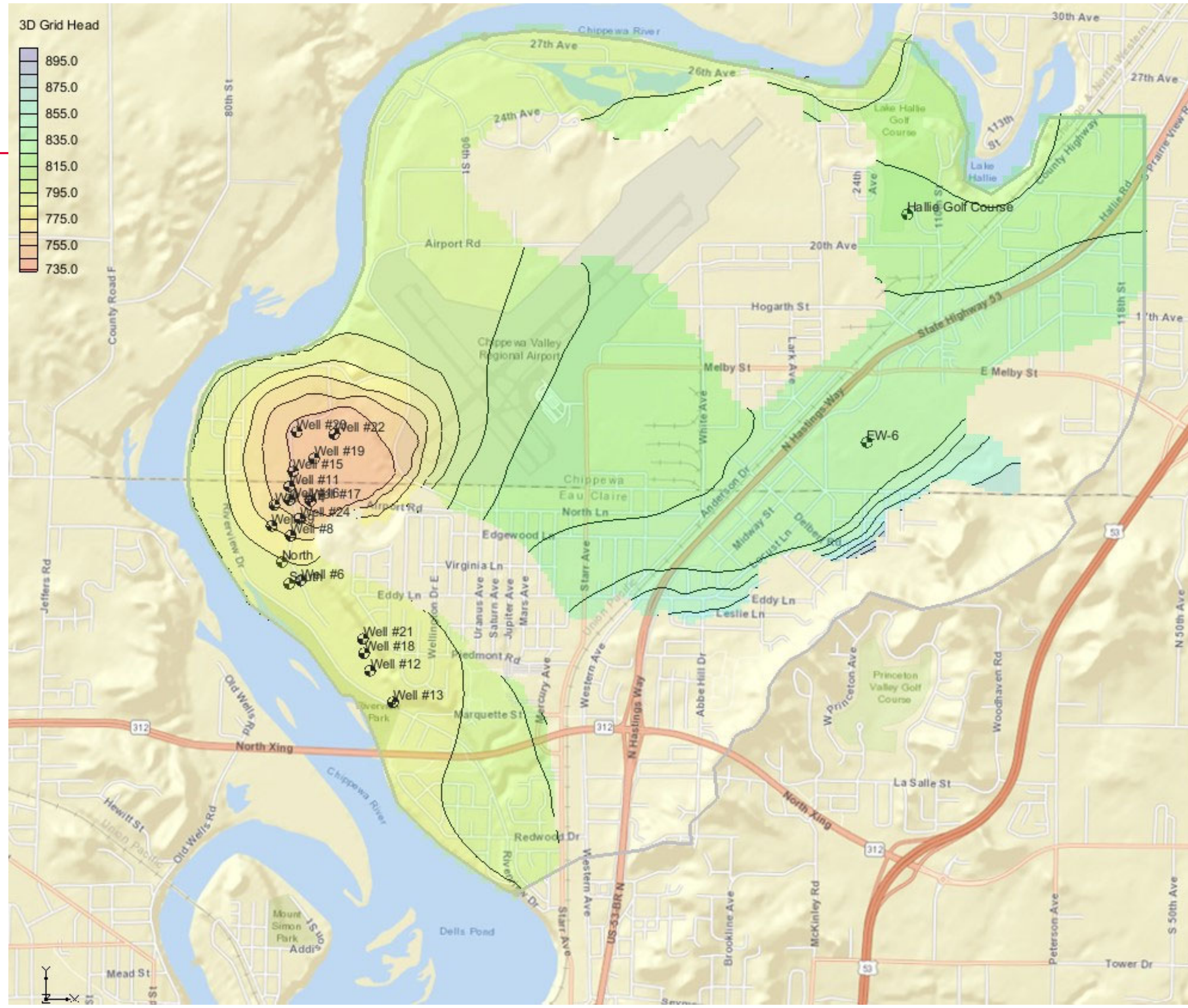
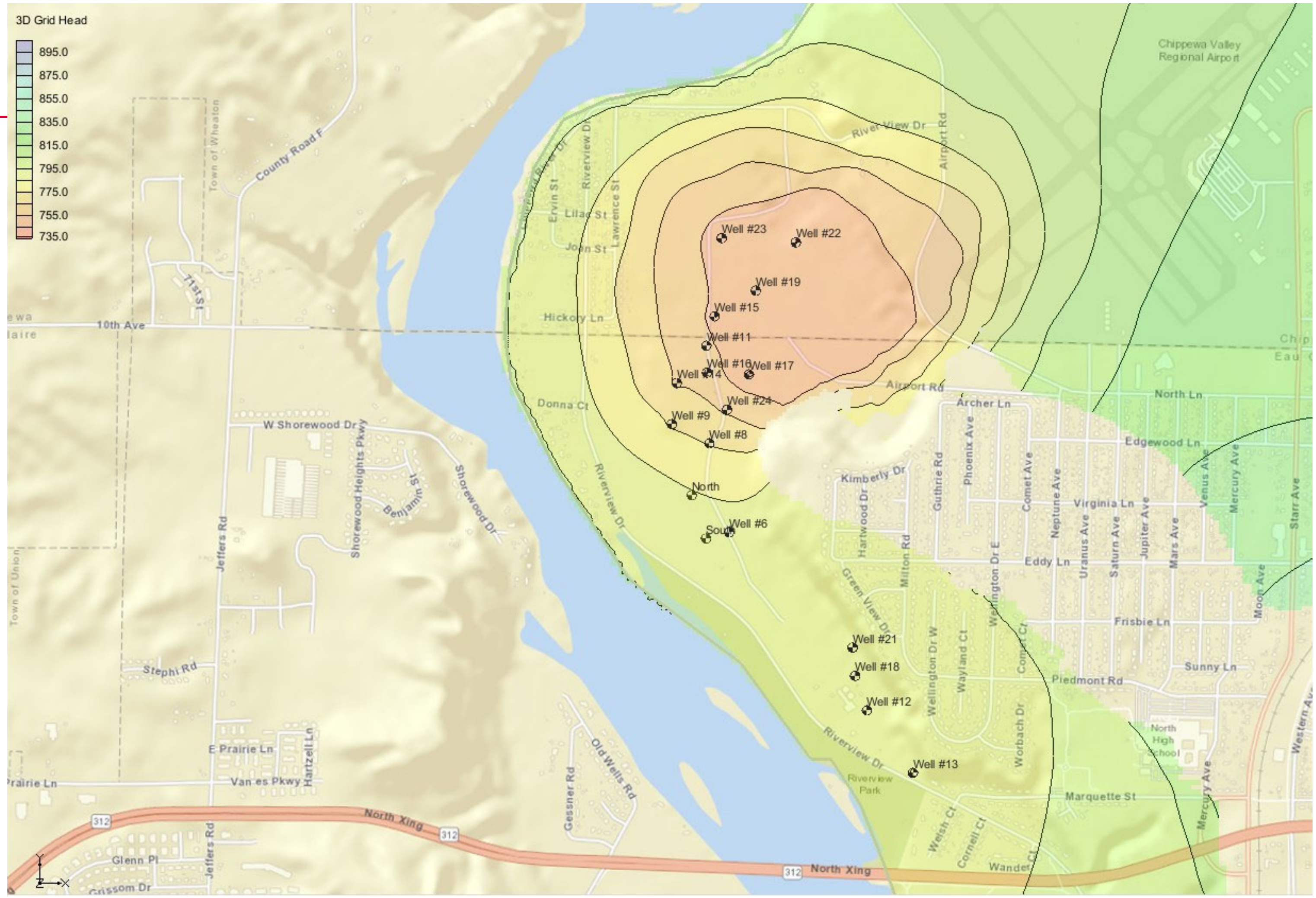
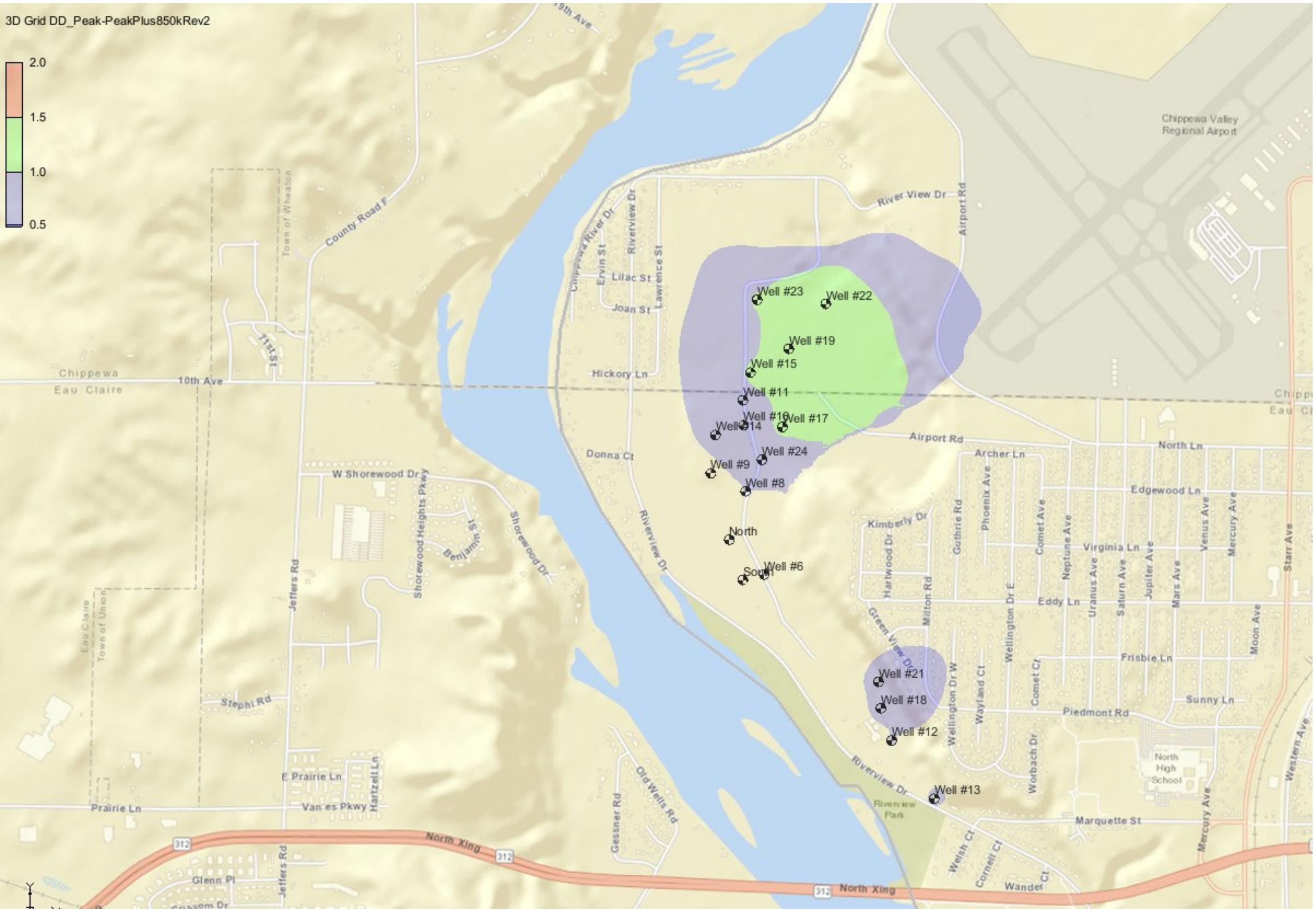
Simulated GW Elevations During Peak-Rate + 0.850 MGD Pumping



Simulated GW Elevations During Peak-Rate + 0.850 MGD Pumping



Simulated Drawdown from Additional 0.850 MGD Wellfield Withdrawal



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