Available water supply from deep aquifers: Model simulations

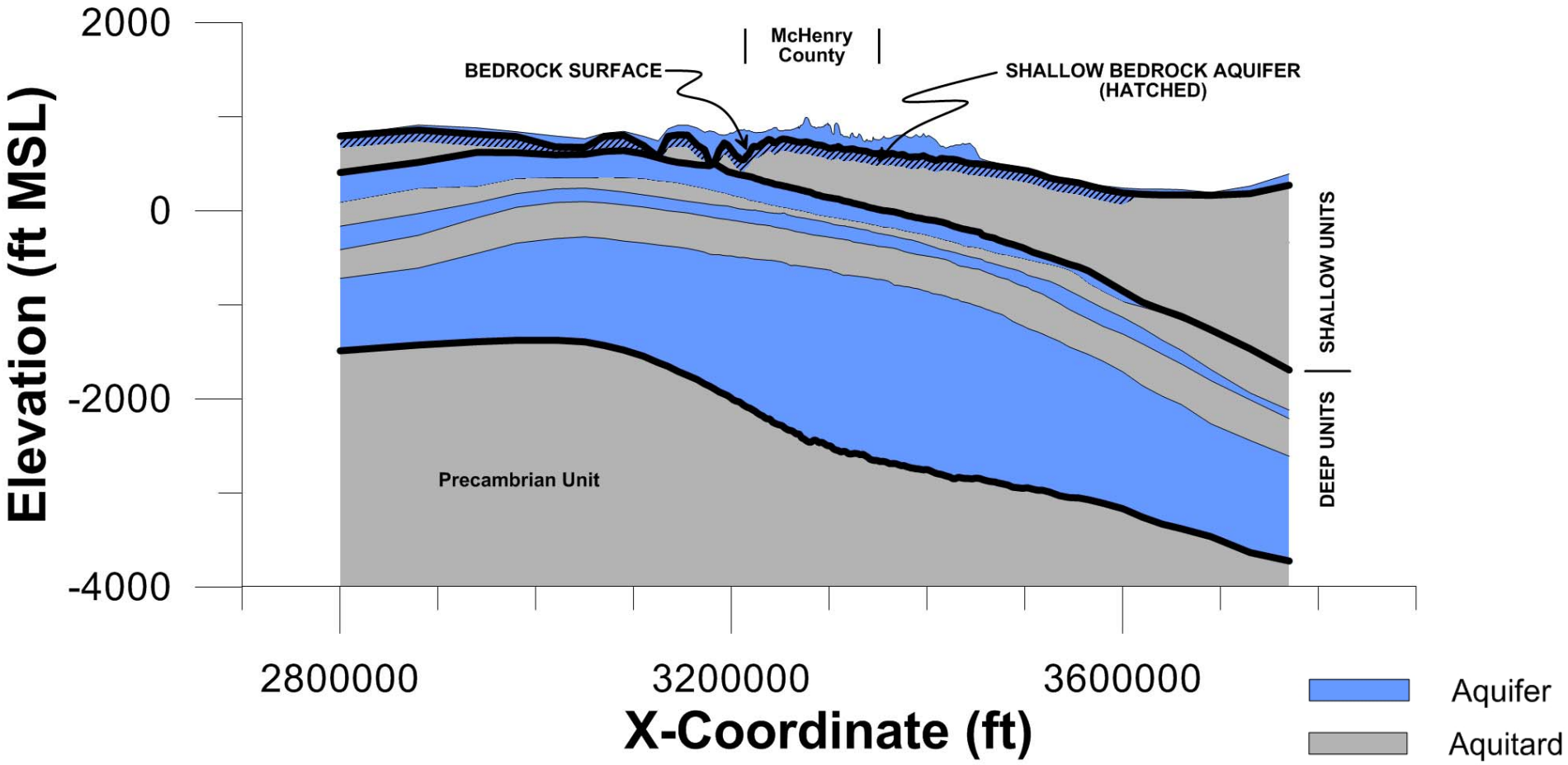
Daniel Abrams

Scott Meyer

George Roadcap

April 22, 2014

Shallow and Deep Aquifer Units

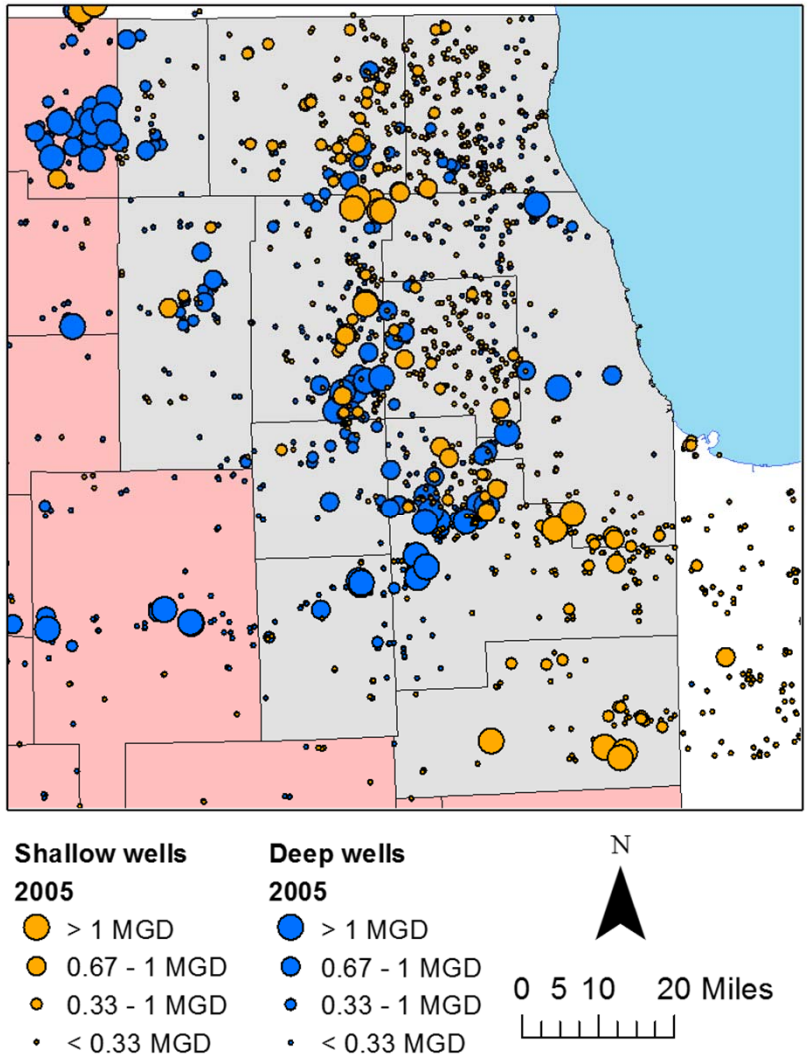


Shallow and Deep Aquifer Units

	HYDROSTRATIGRAPHIC UNIT	MODEL LAYER
QUATERNARY MATERIALS	Wadsworth Unit	1
	Haeger-Beverly Unit	2
	Yorkville-Batestown Unit	3
	Tiskilwa Unit	4
	Ashmore Unit	5
	Winnebago-Upper Glasford Unit	6
	Upper Glasford Sand Unit	7
	Lower Glasford Unit	8
	Lower Glasford Sand Unit	9
BEDROCK	Upper Bedrock Unit	10
	Silurian-Devonian Carbonate Unit	11
		12
		13
	Maquoketa Unit	14
		15
	Galena-Platteville Unit	16
		17
	Ancell Unit	18
	Prairie du Chien-Eminence Unit	19
	Potosi-Franconia Unit	20
	Ironton-Galesville Unit	21
	Eau Claire Unit	22
	Mt. Simon Unit	23
		24
		25
		26

Shallow

Deep

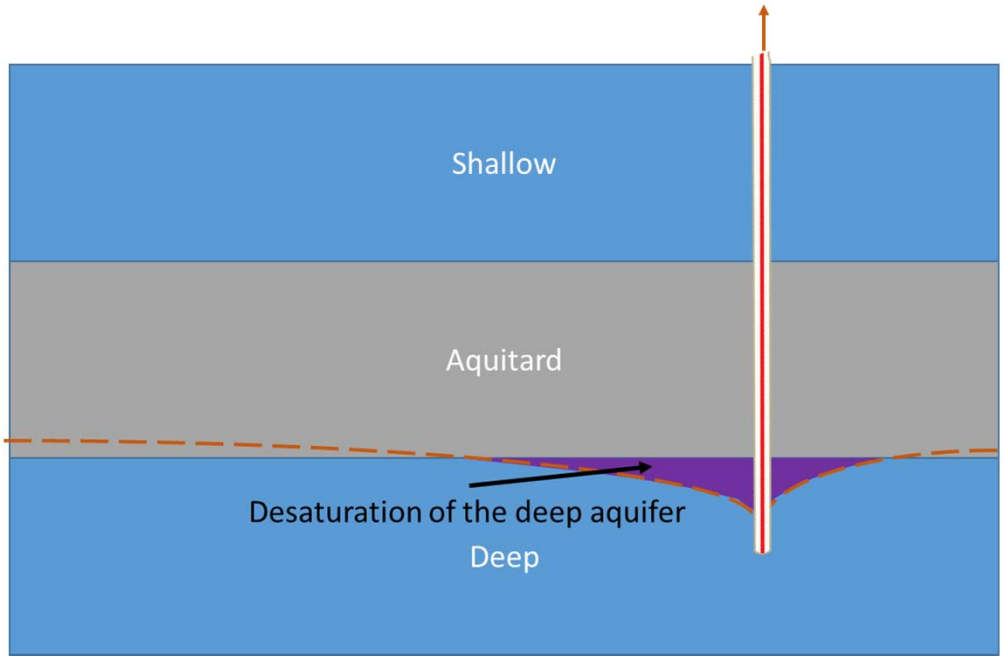


Partial desaturation of the deep aquifer (Ancell)

- Deep groundwater withdrawals result in drawdown of deep heads

- Deep drawdown may:
  - Induce flow from the shallow aquifer to the deep aquifer
  - Induce upward flow of saline water from deep units (i.e. Mt. Simon) that are not used as aquifers
  - Lead to partial desaturation

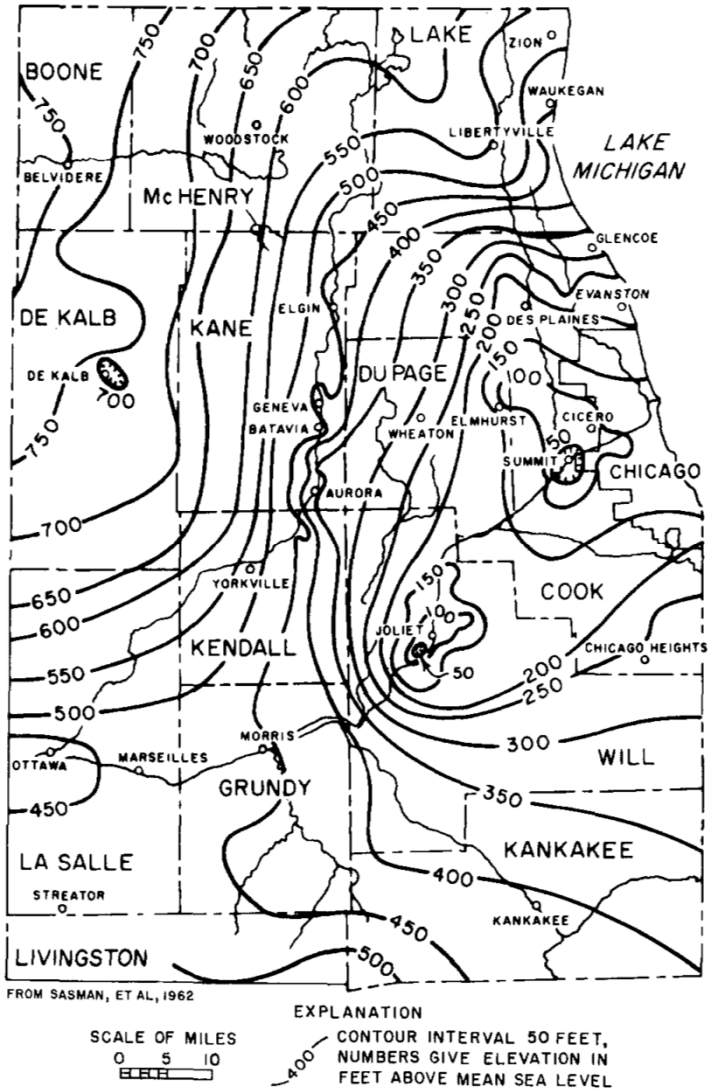
- Partial desaturation leads to:
  - Loss in transmissivity
  - Redox changes



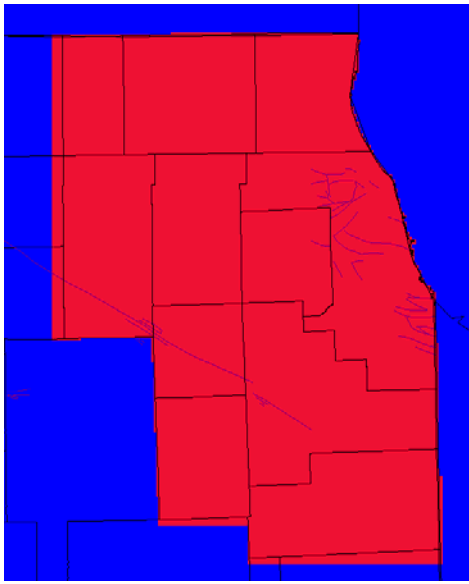
Potential yield of deep aquifers in NE Illinois?

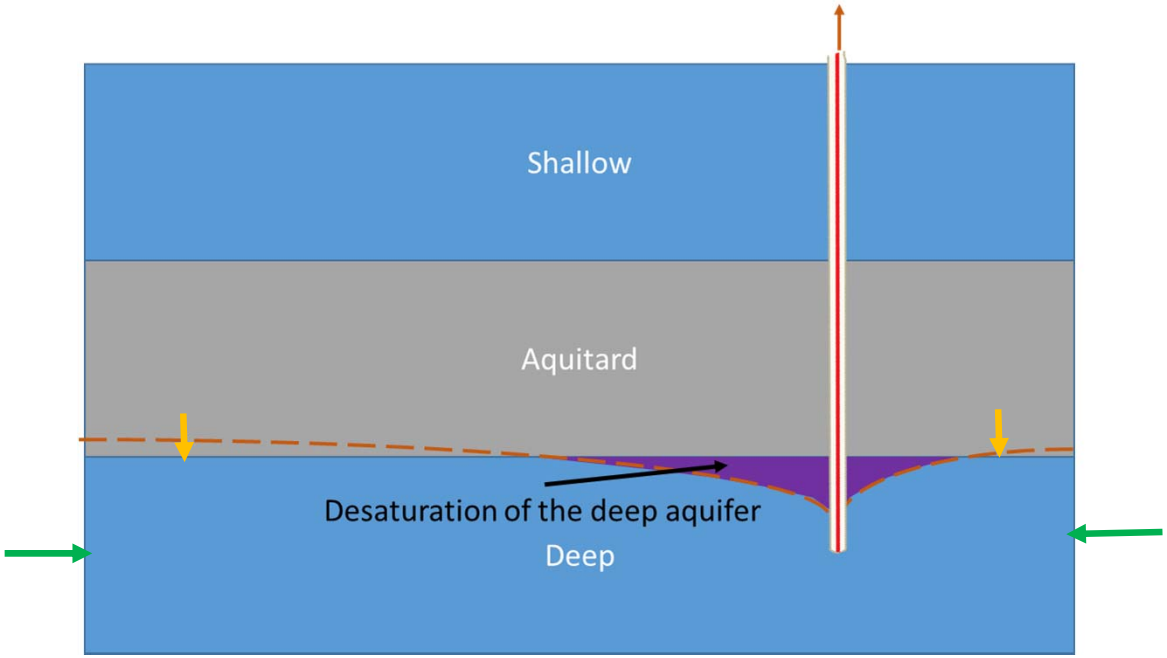
- Suter (1959): 46 MGD
- Walton (1964): 65 MGD

- These methodologies were designed to prevent desaturation of the Ironton-Galesville
- Methodologies assume:
  - Pumping centers (not individual wells)
  - Steady state conditions



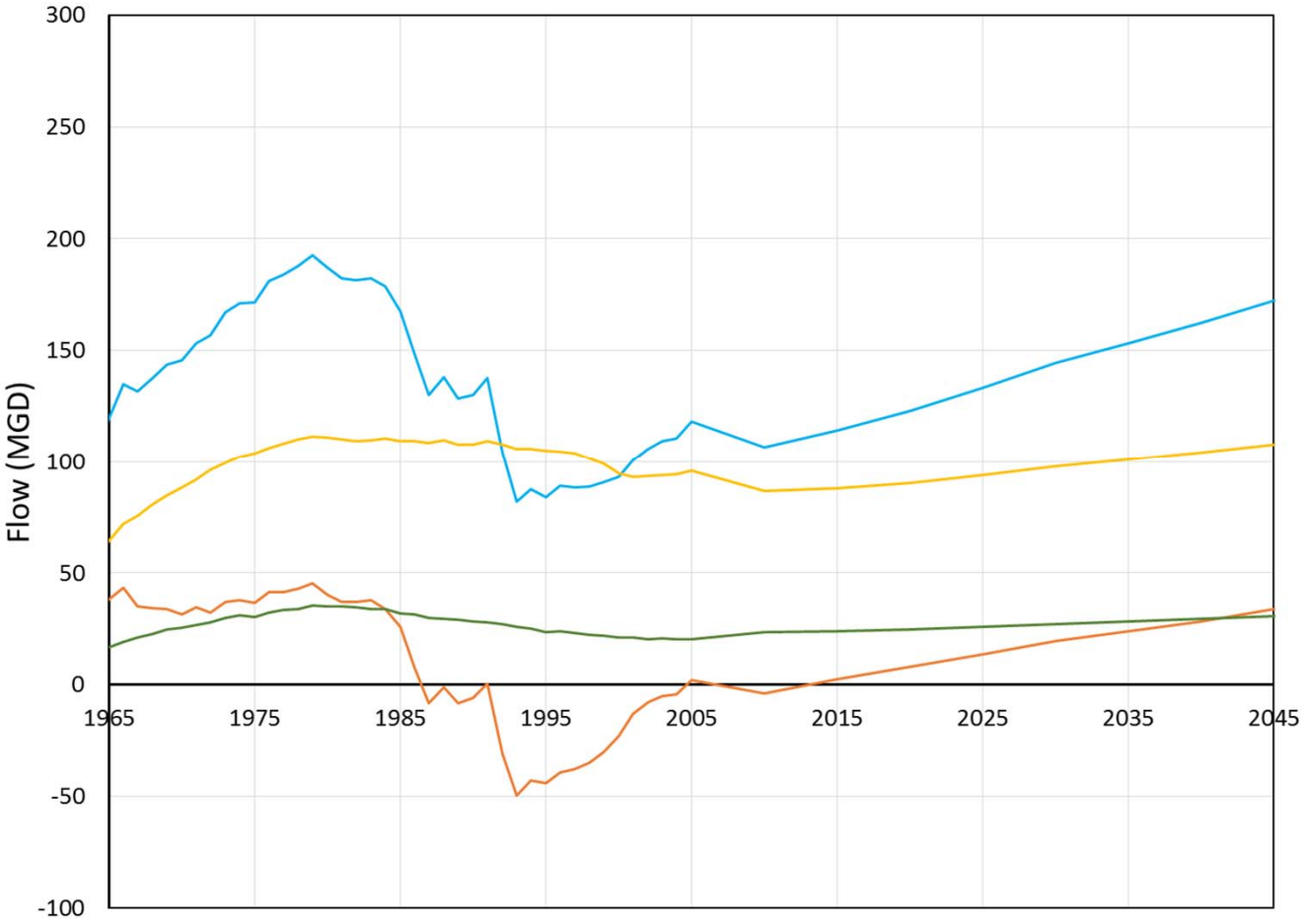
Water balance in the deep aquifer of Northeastern Illinois

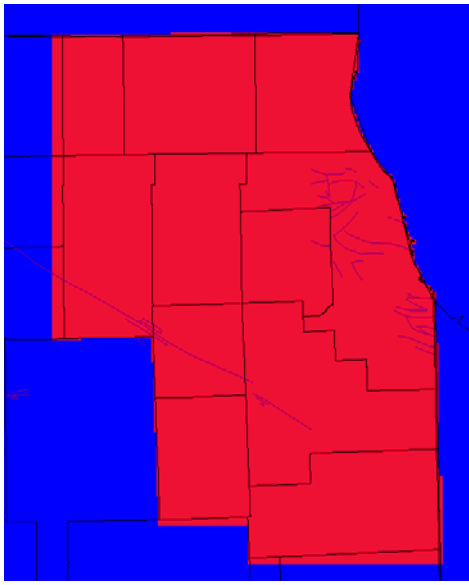


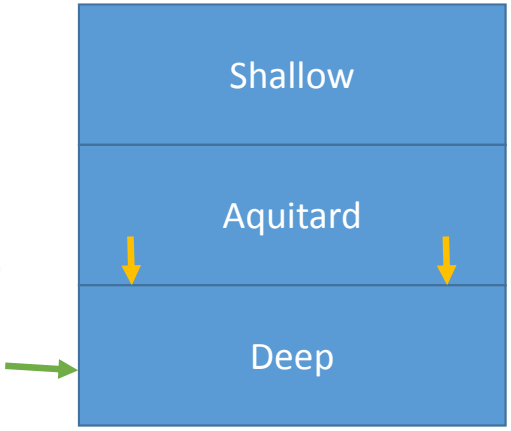


Deep pumping =
Net lateral flow +
Net vertical flow +
Change in storage

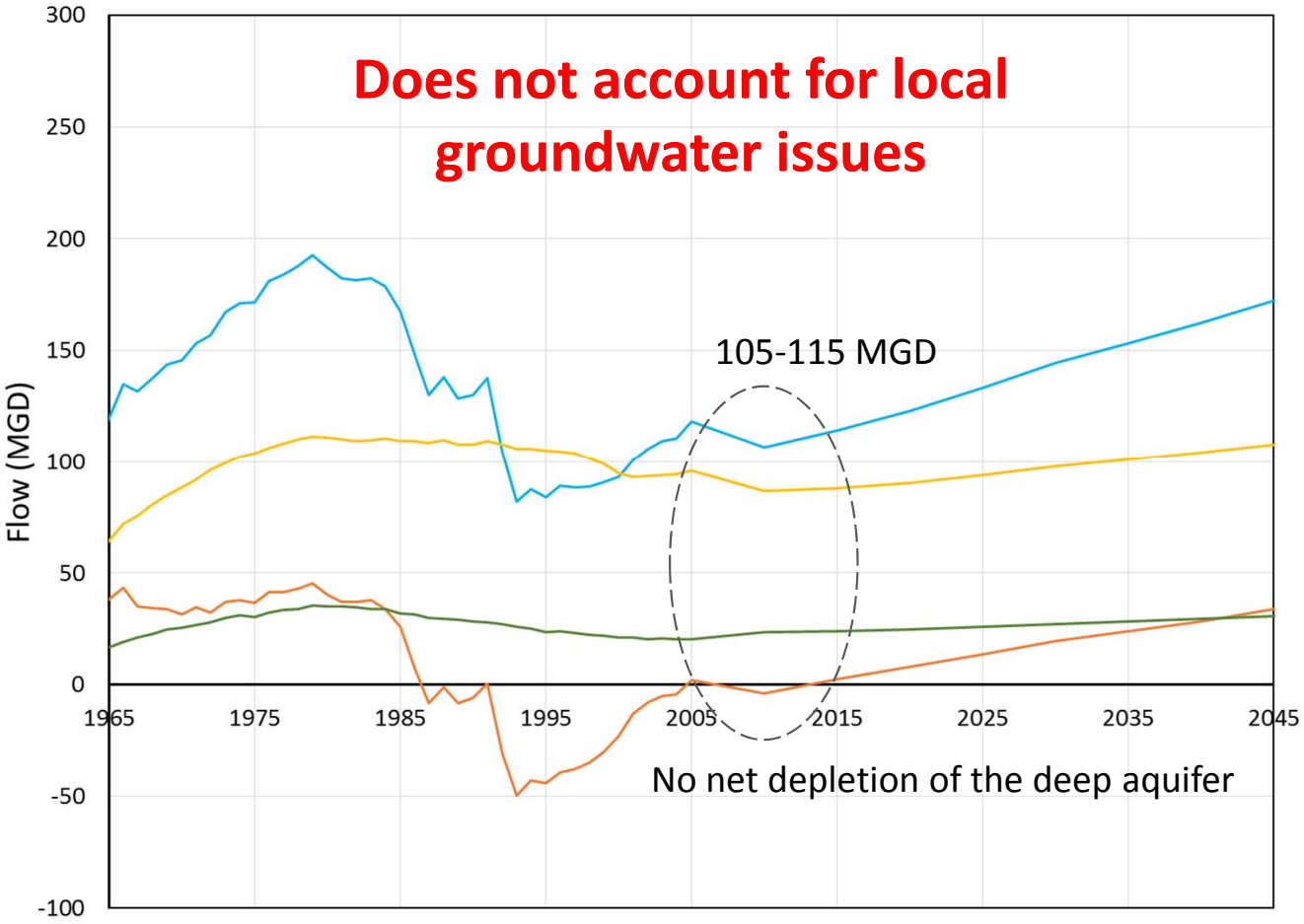
Water balance in the deep aquifer

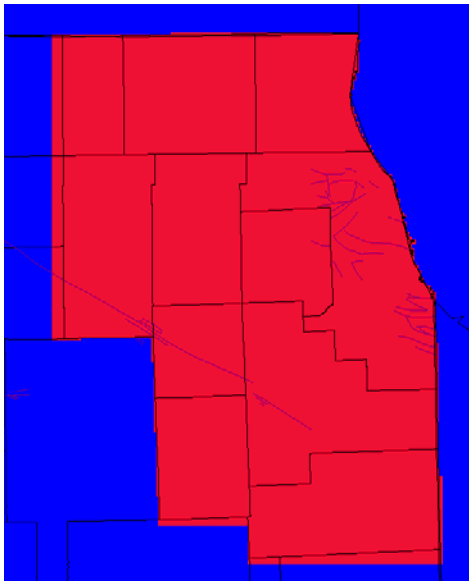


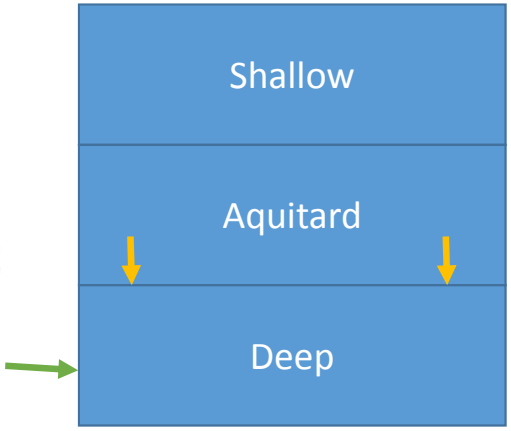




Water balance in the deep aquifer



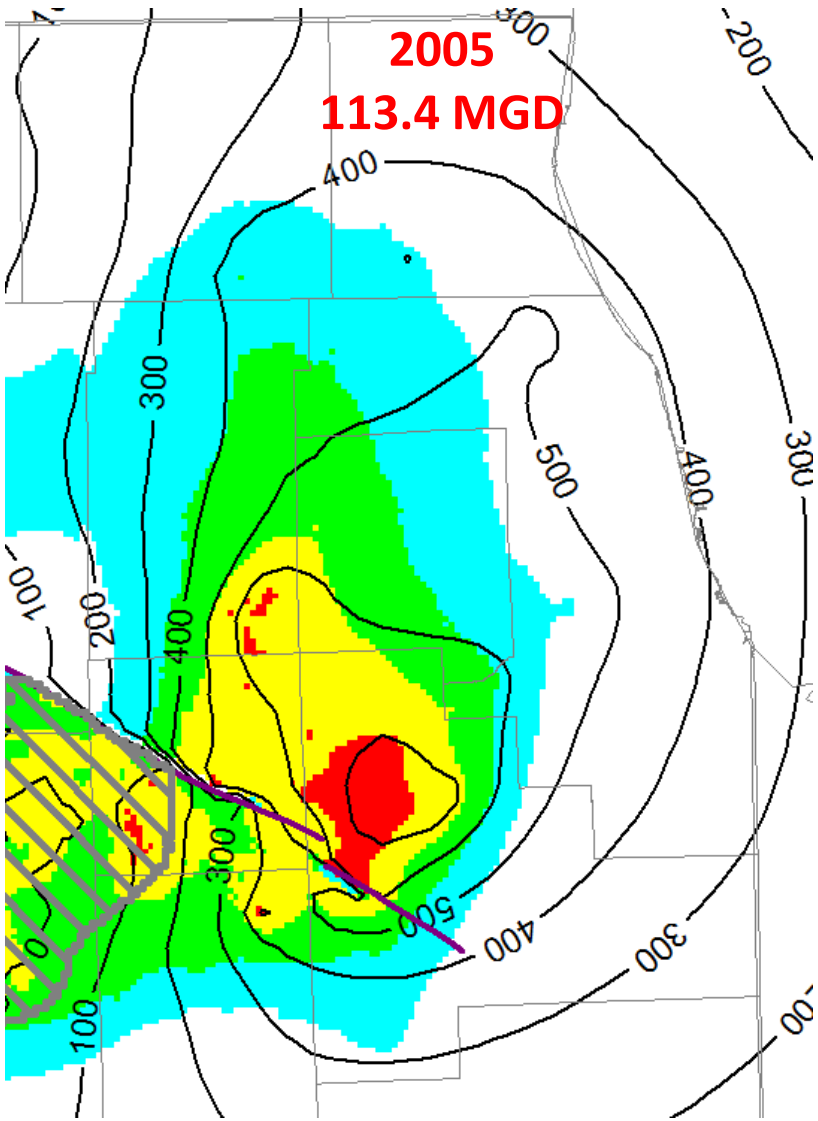


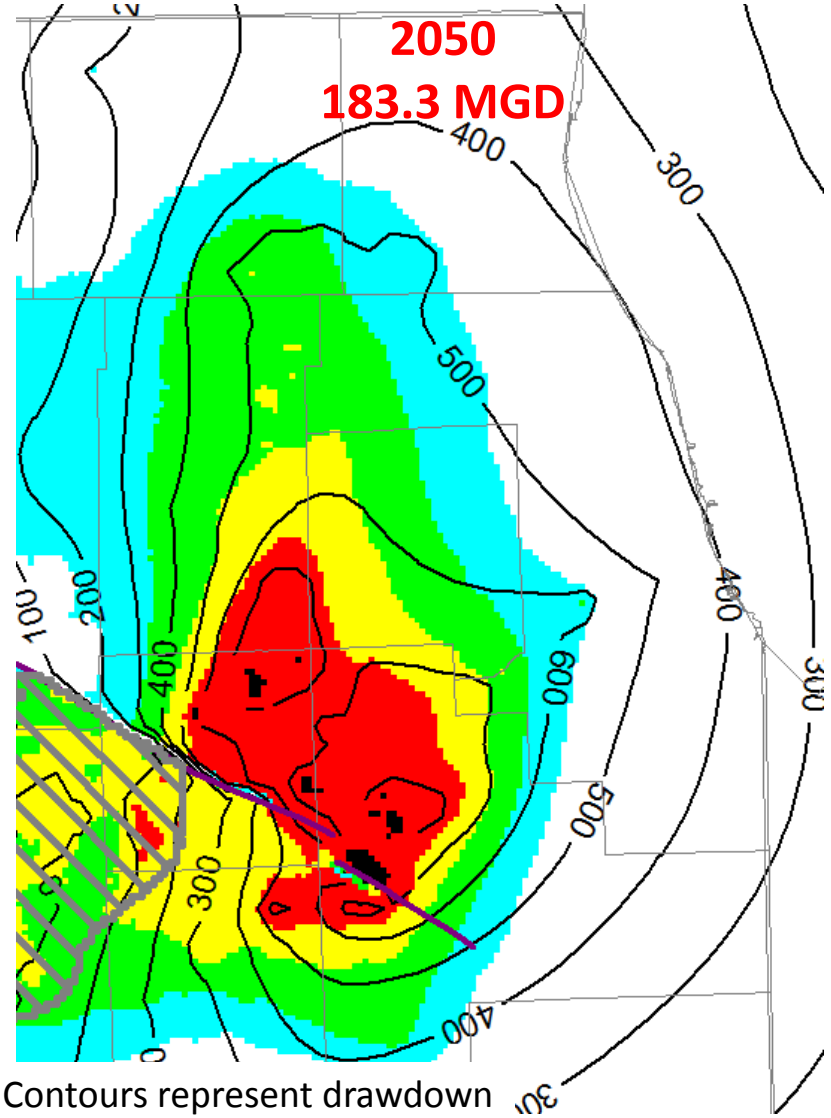


Baseline

Head above Ancell

- 200-300 ft
- 100-200 ft
- <100 ft (Saturated)
- Partial desaturation
- Complete desaturation





* Contours represent drawdown

Aurora Wells

Head above Ancell

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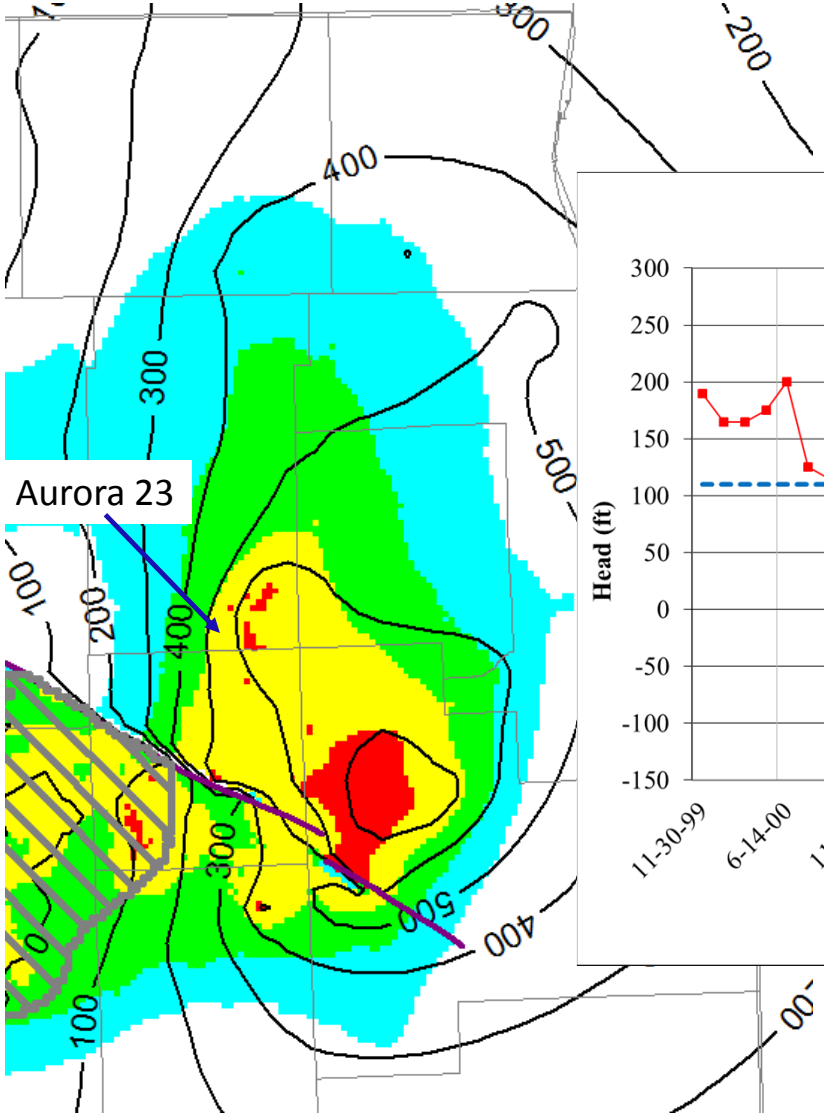

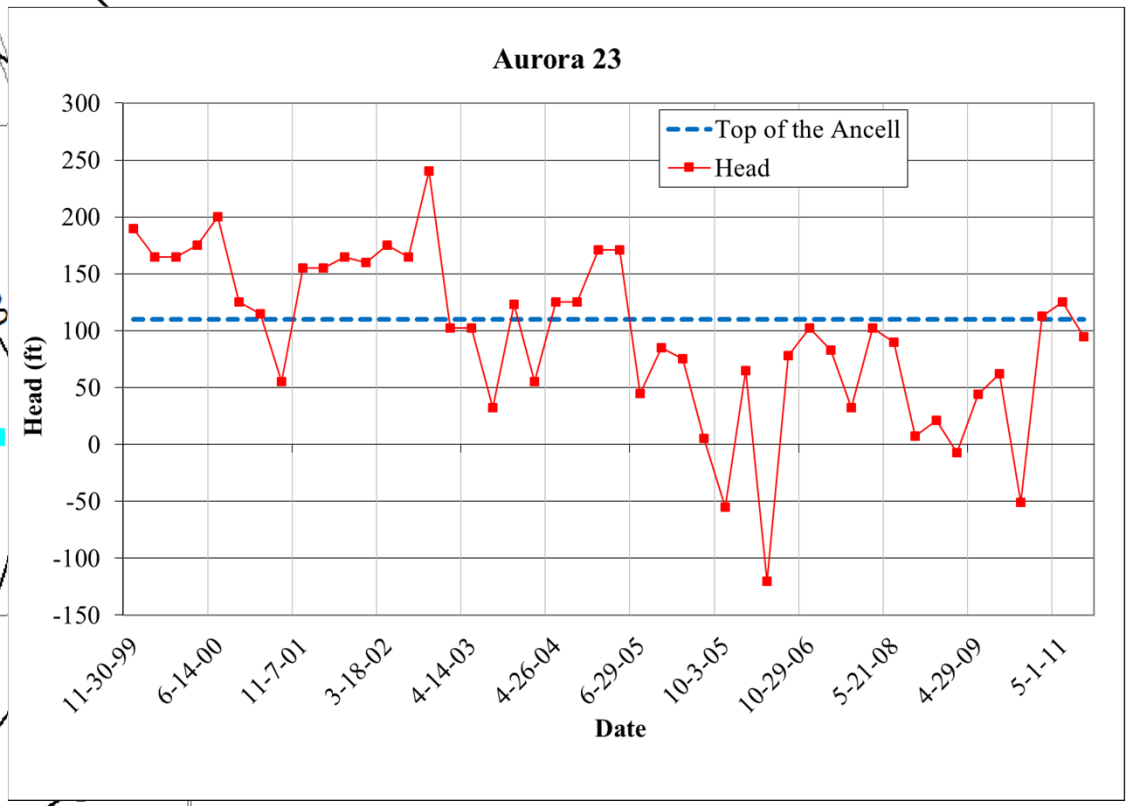

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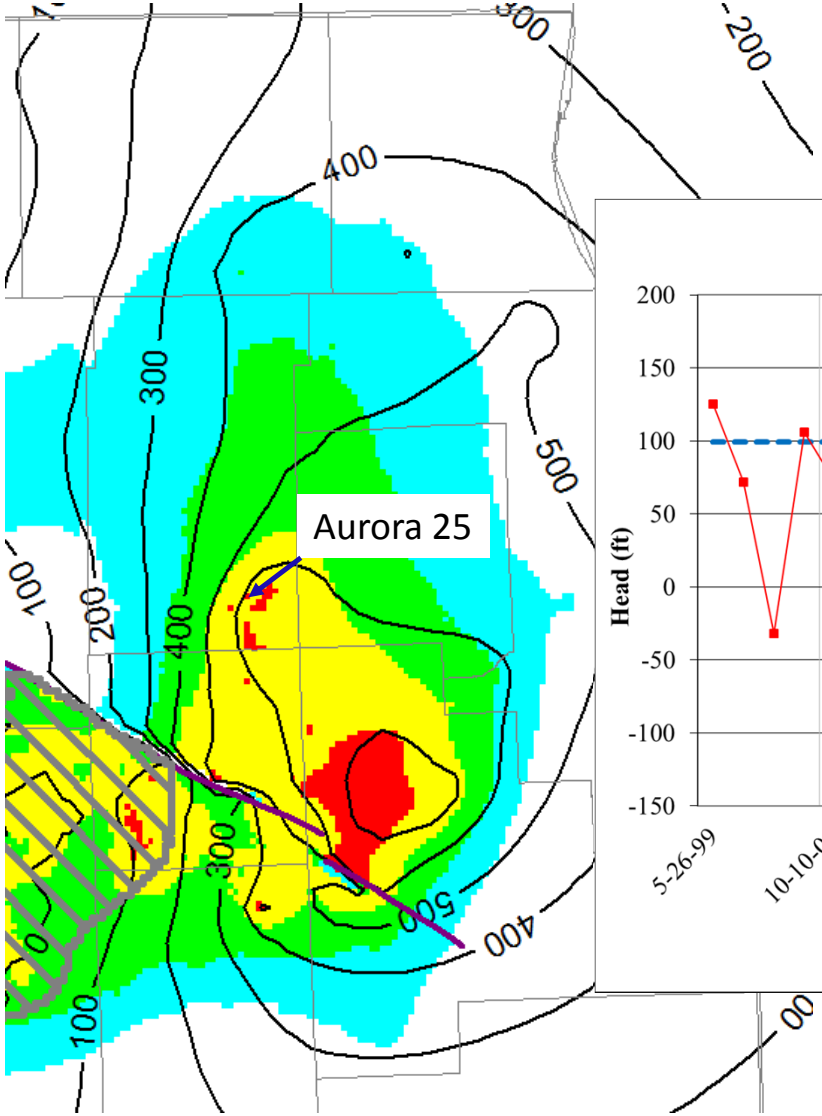
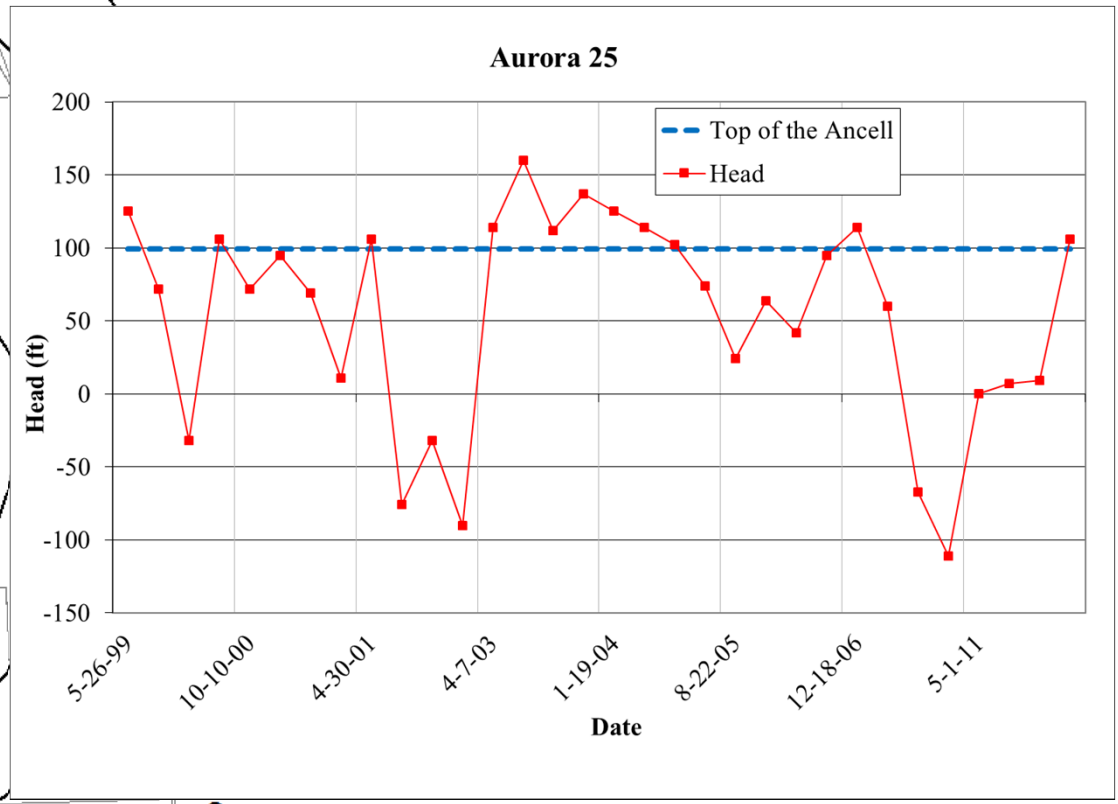
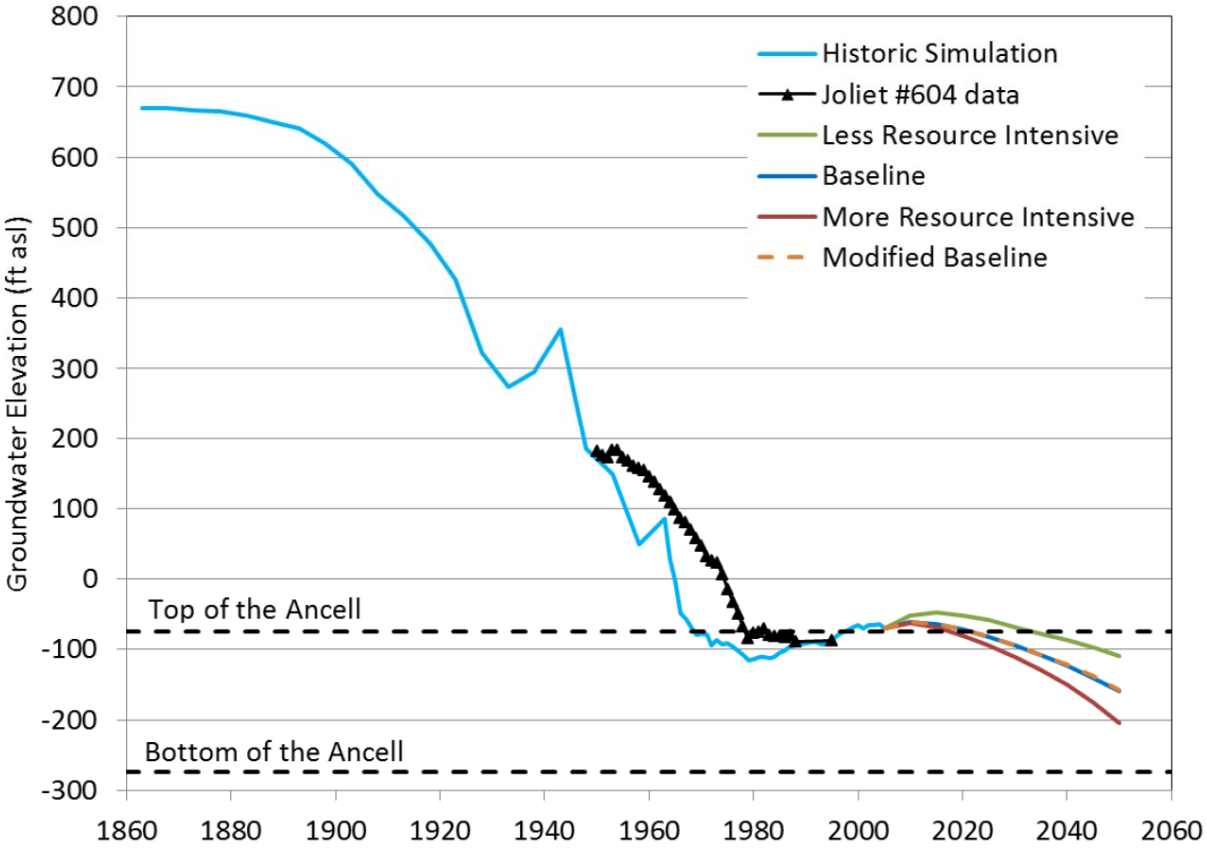
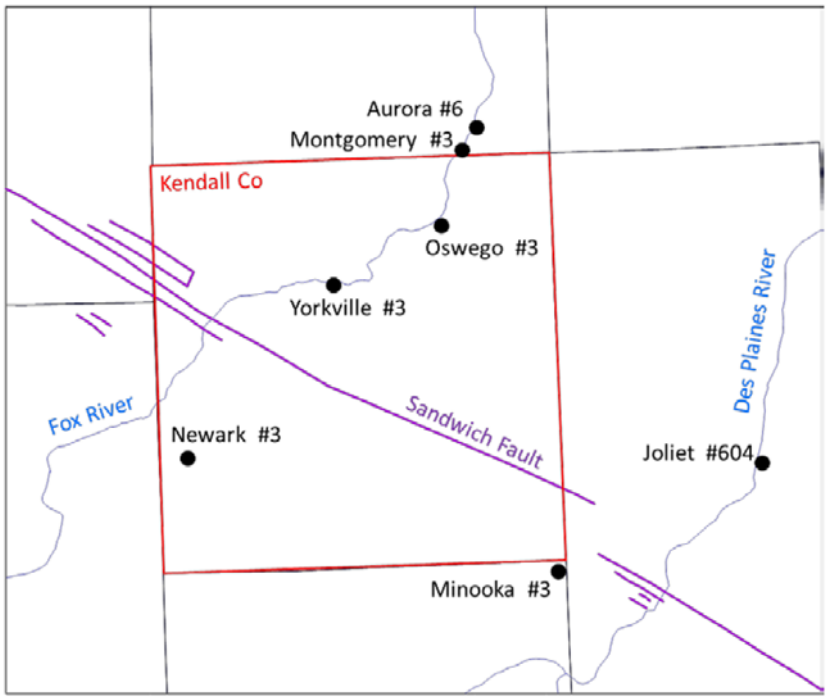




Joliet heads





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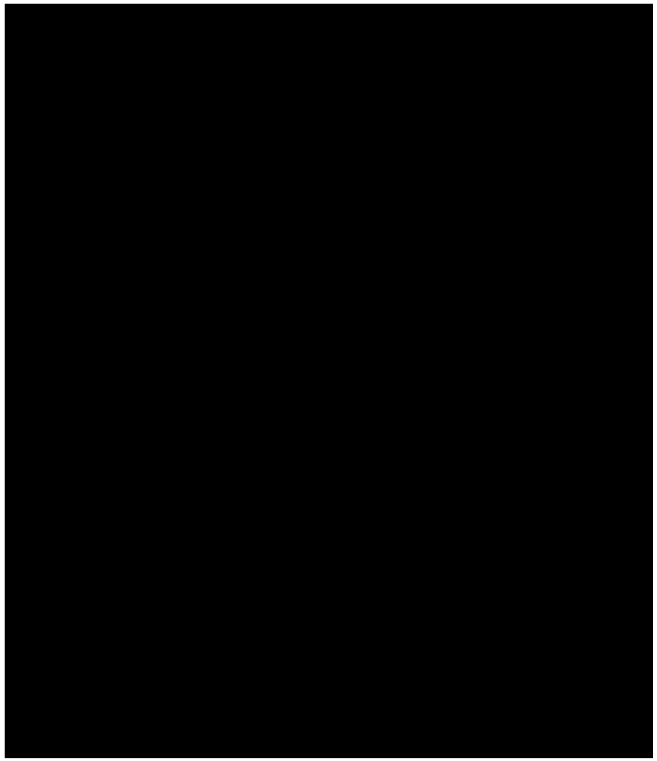
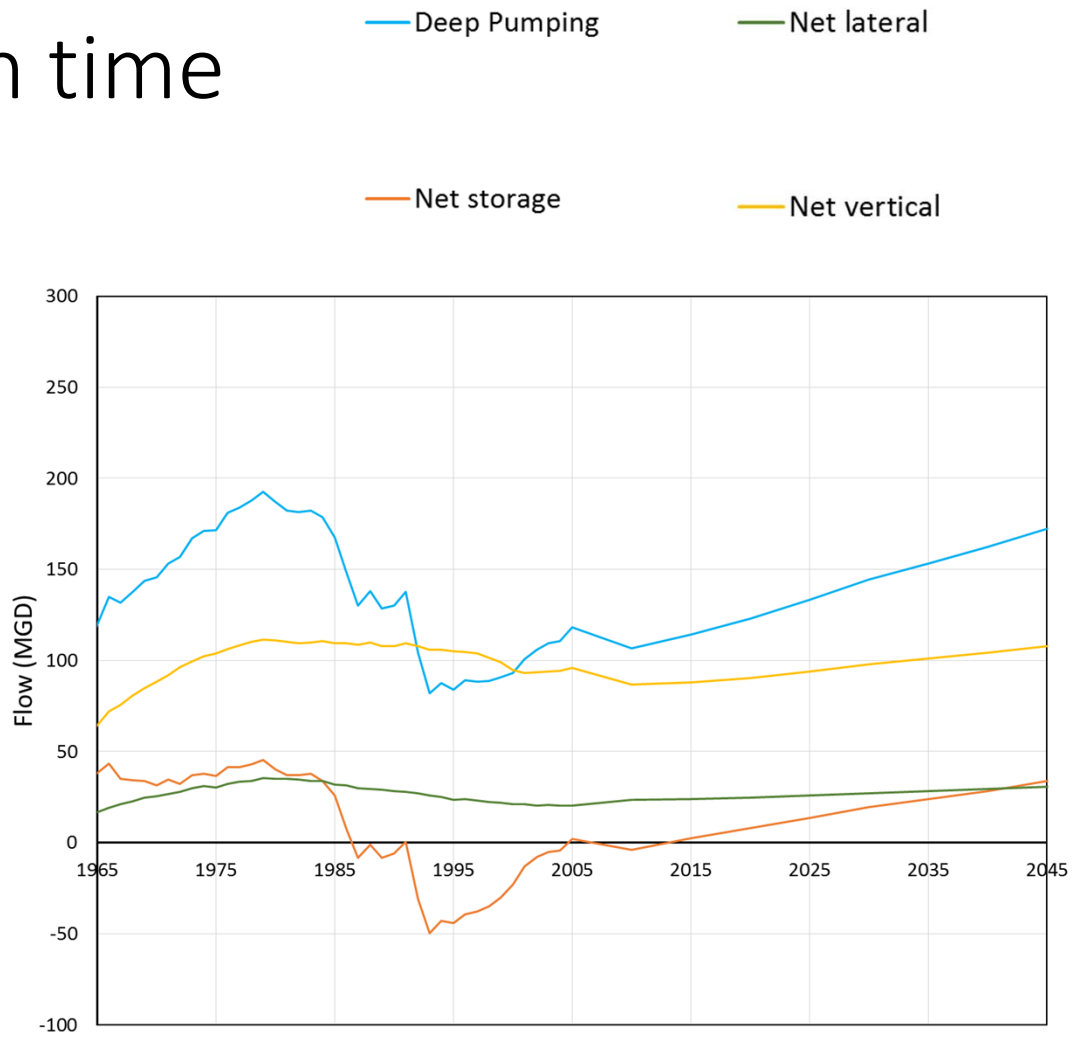
Available head through time



Head above Ancell

- 200-300 ft
- 100-200 ft
- <100 ft (Saturated)
- Partial desaturation
- Complete desaturation

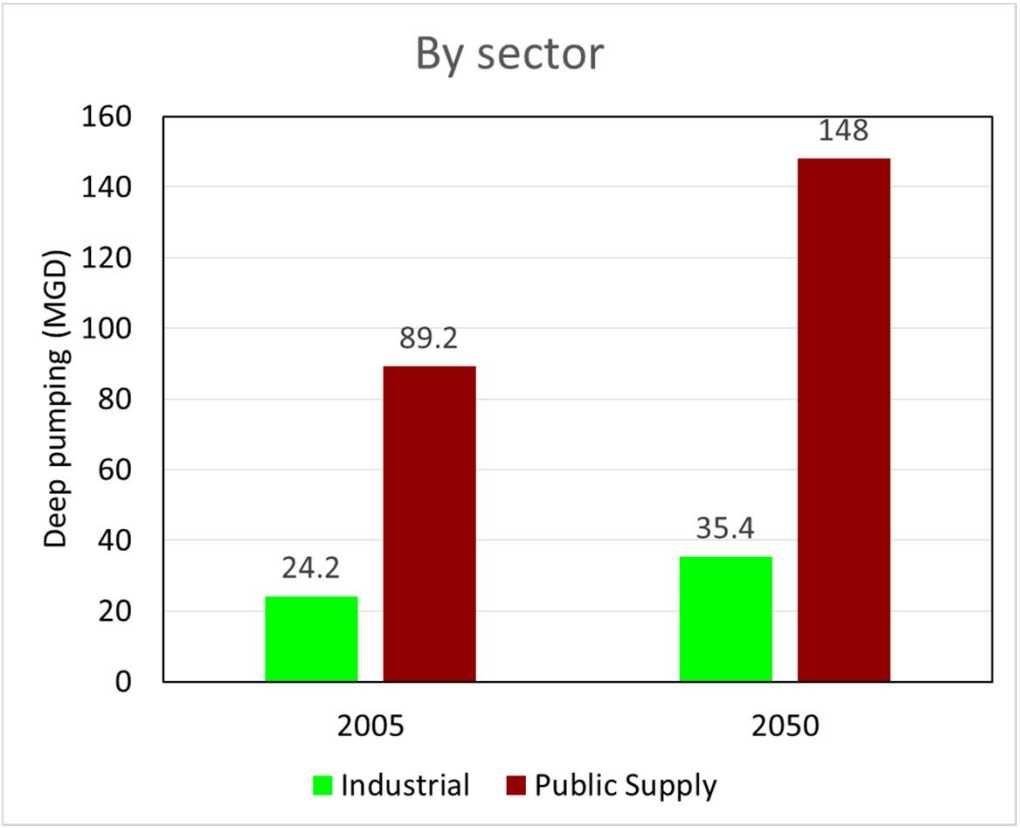


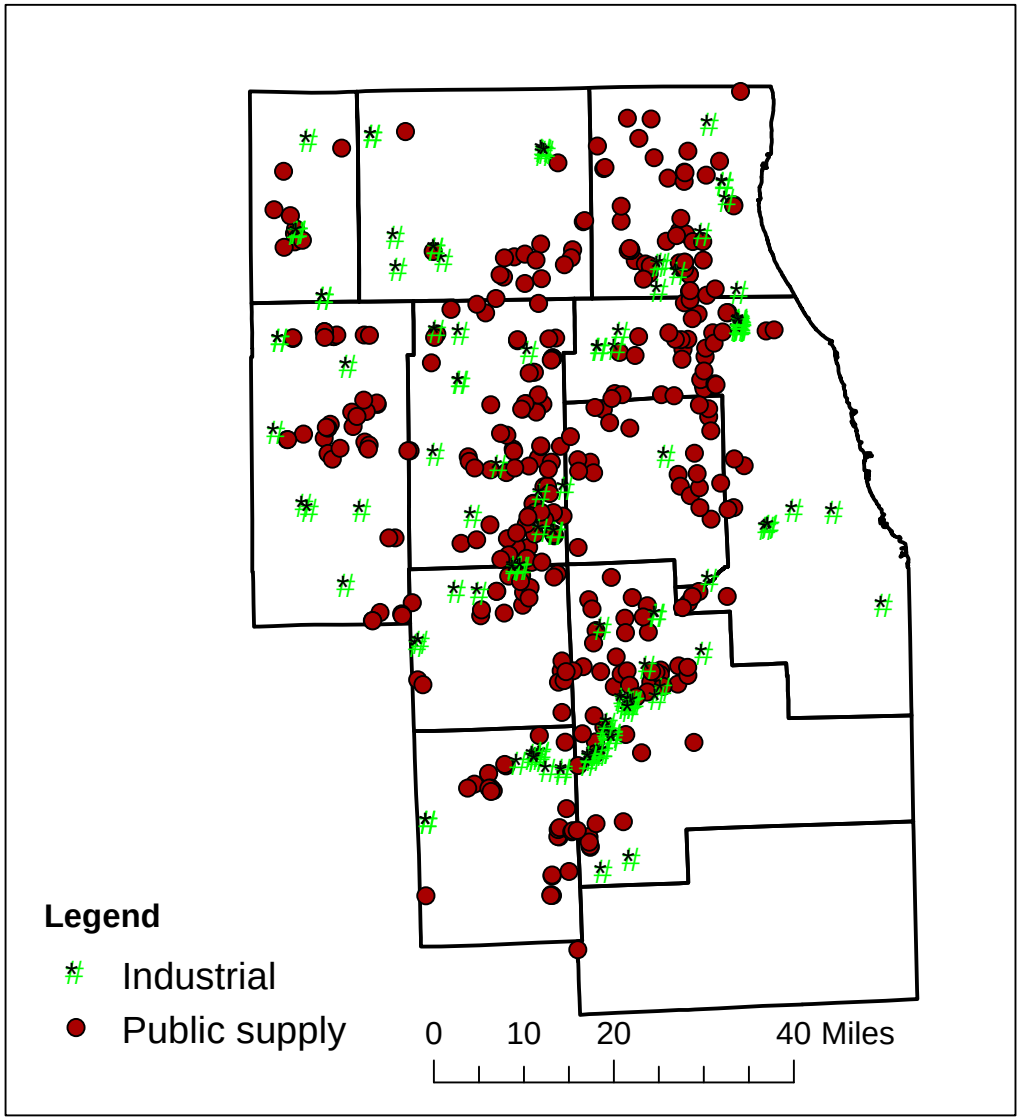
* Contours represent drawdown

Individual impacts by:

- Pumping sector:
  - Industry
  - Public Supply
- Quantity used
  - Divide into four groups of equal use, classify per water individual water usage
- County

By sector


By sector
Deep pumping (MGD)
160
140
120
100
80
60
40
20
0
24.2
89.2
35.4
148
2005
2050
Industrial
Public Supply


Legend
Industrial
Public supply
0
10
20
40 Miles

By sector (2005)

Head above Ancell

- 200-300 ft
- 100-200 ft
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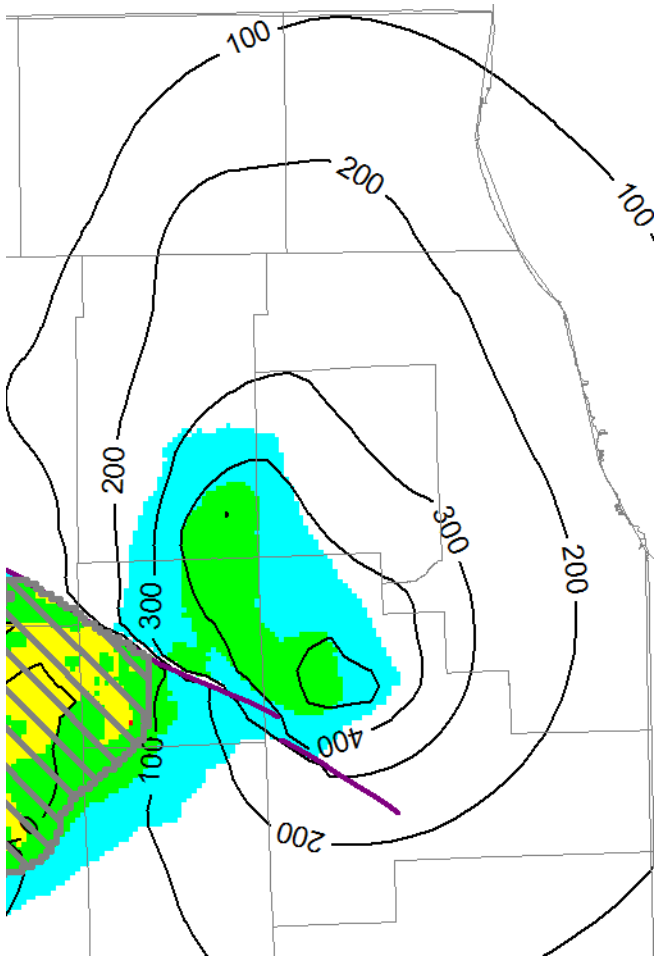
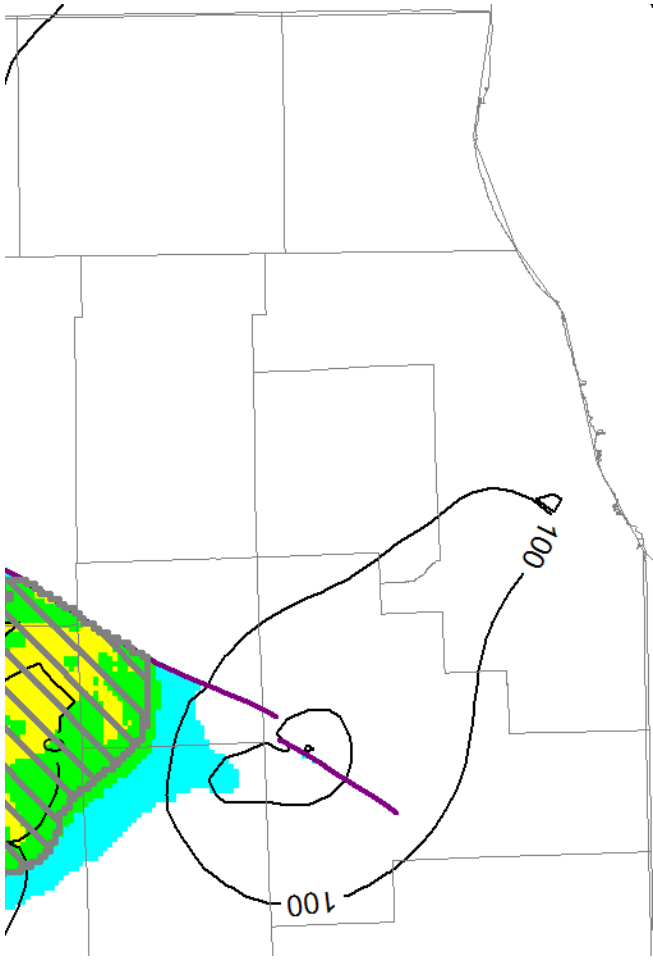
- Partial desaturation
- Complete desaturation

Public supply
89.2 MGD



Industry
24.2 MGD



By sector (2050)

Head above Ancell

- 200-300 ft
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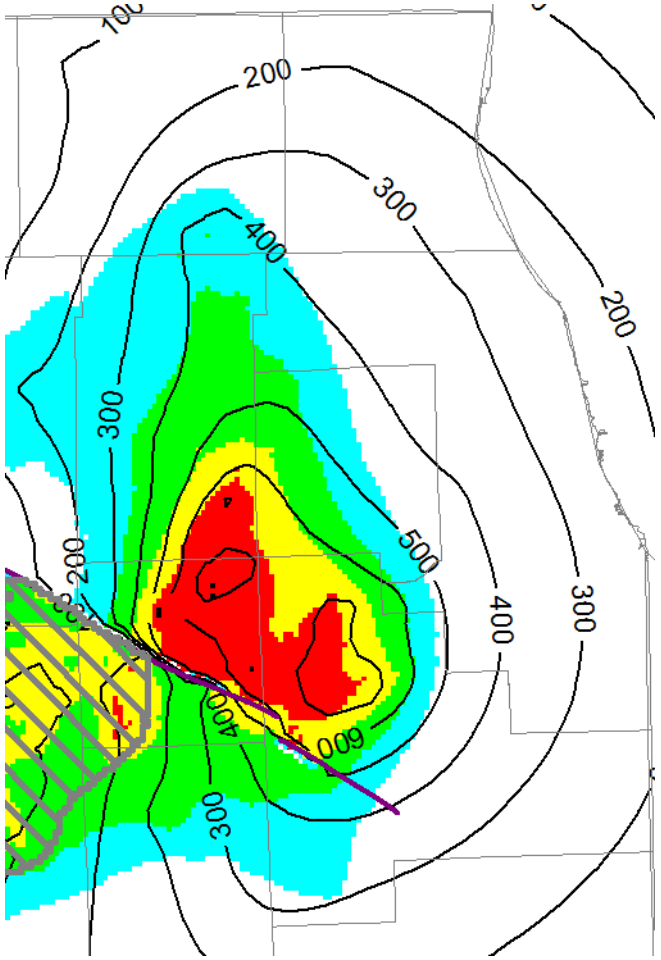
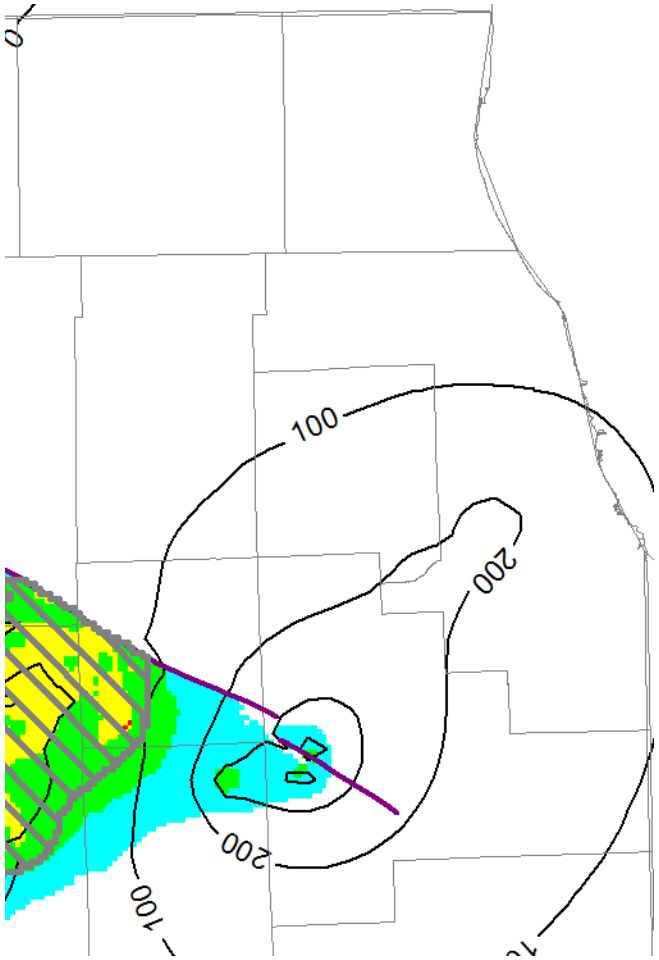
- Complete desaturation

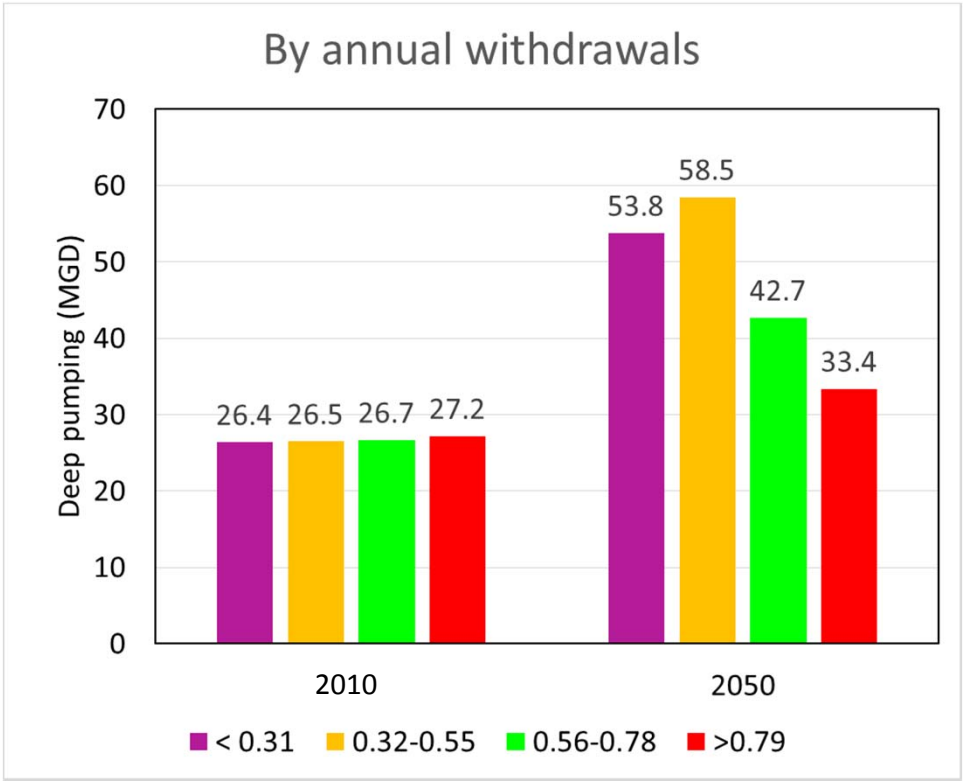
Public supply
148.0 MGD

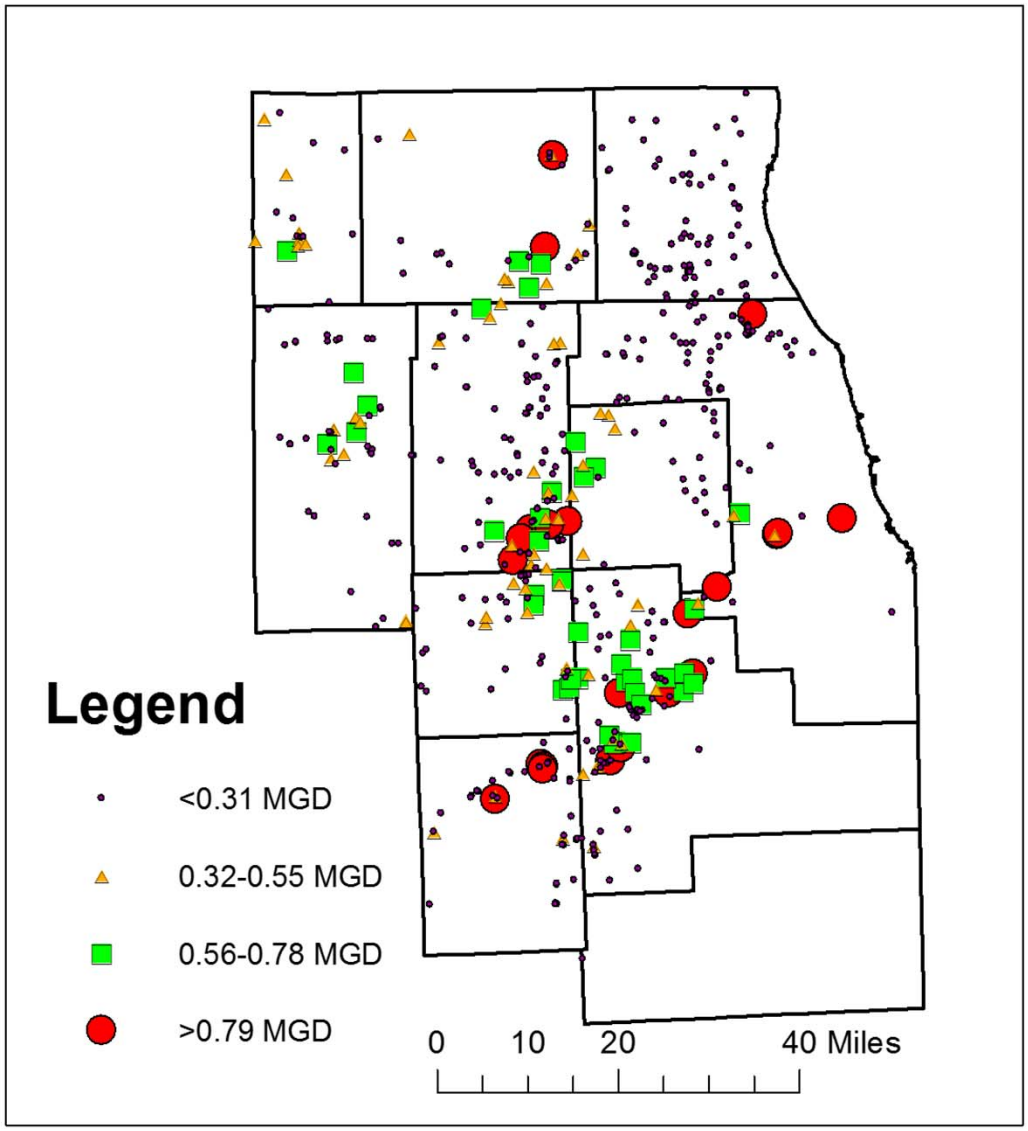


Industry
35.4 MGD

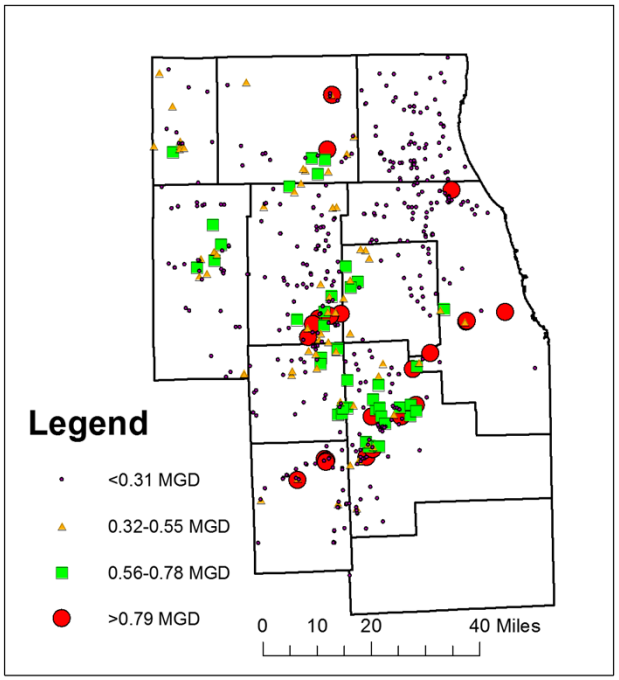


By annual withdrawals (in 2010)





By annual withdrawals (2010)



Head above Ancell

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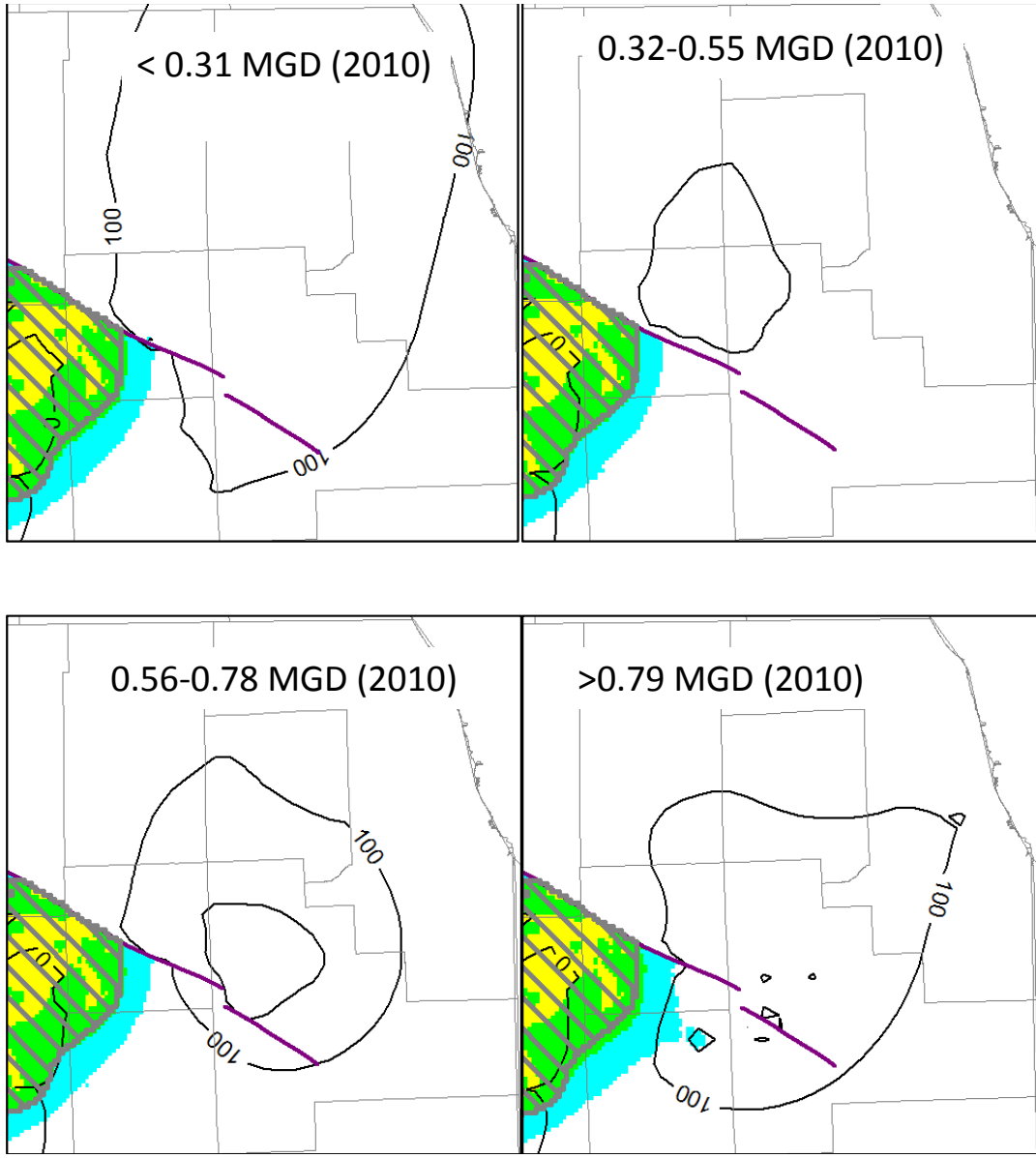
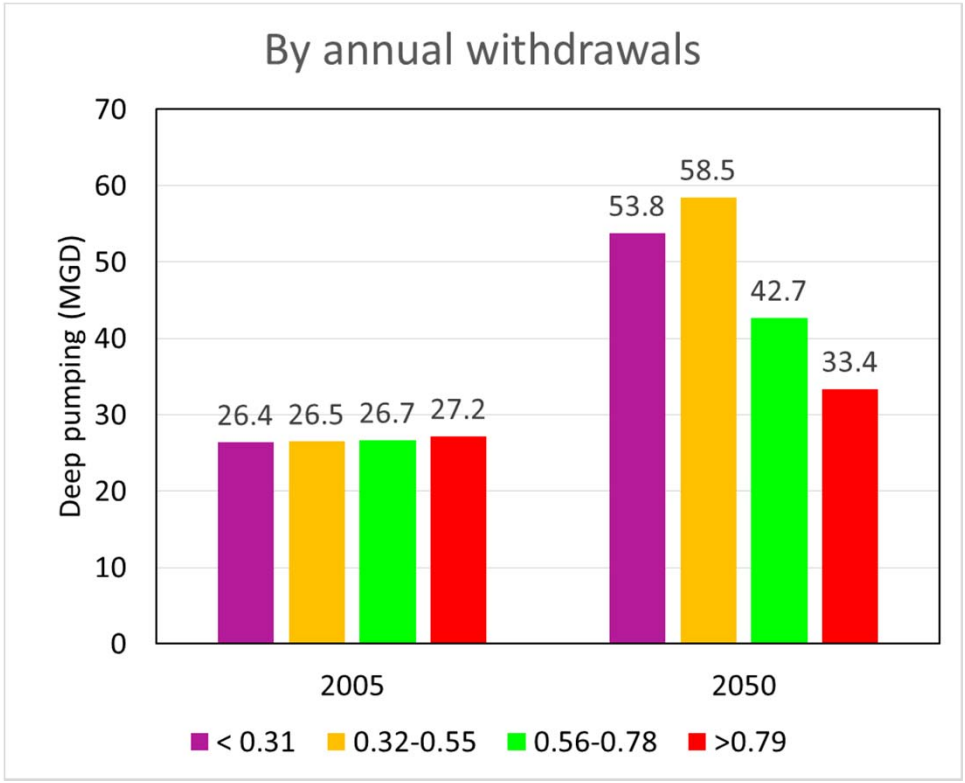
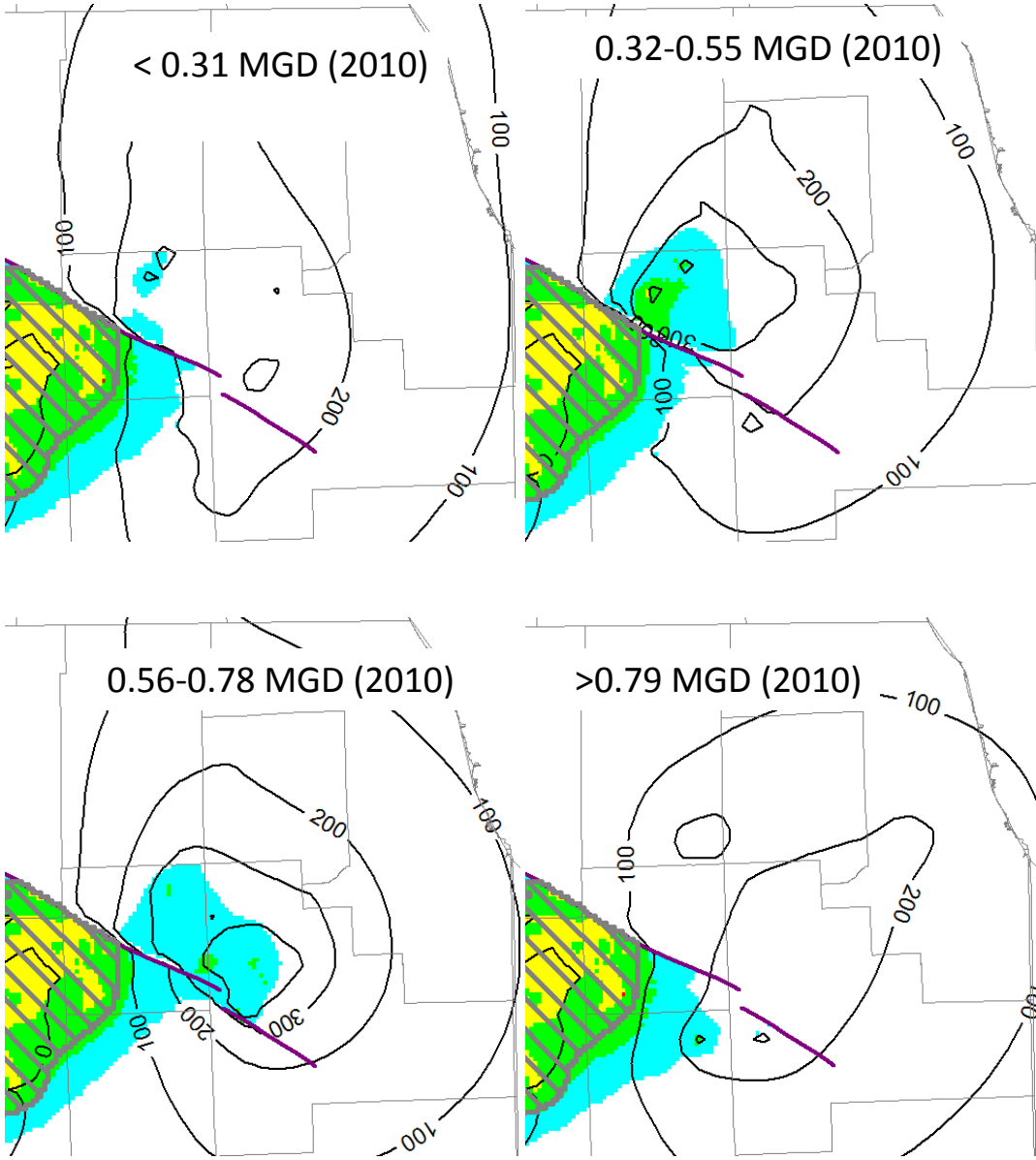
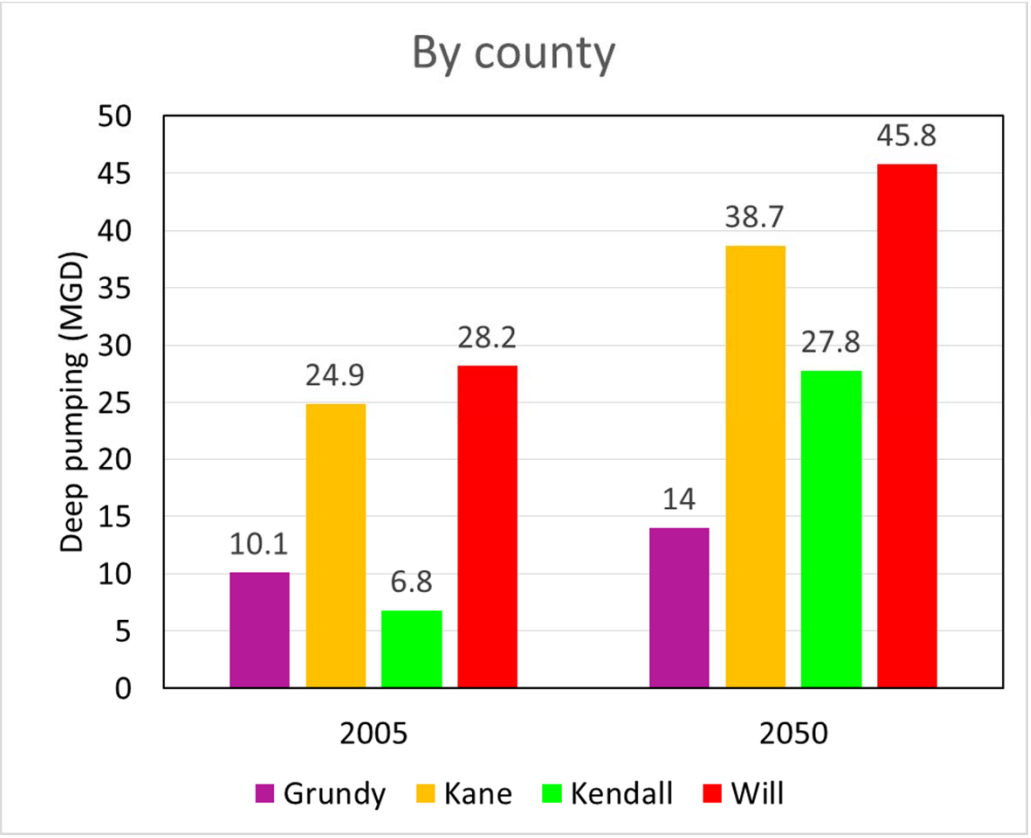


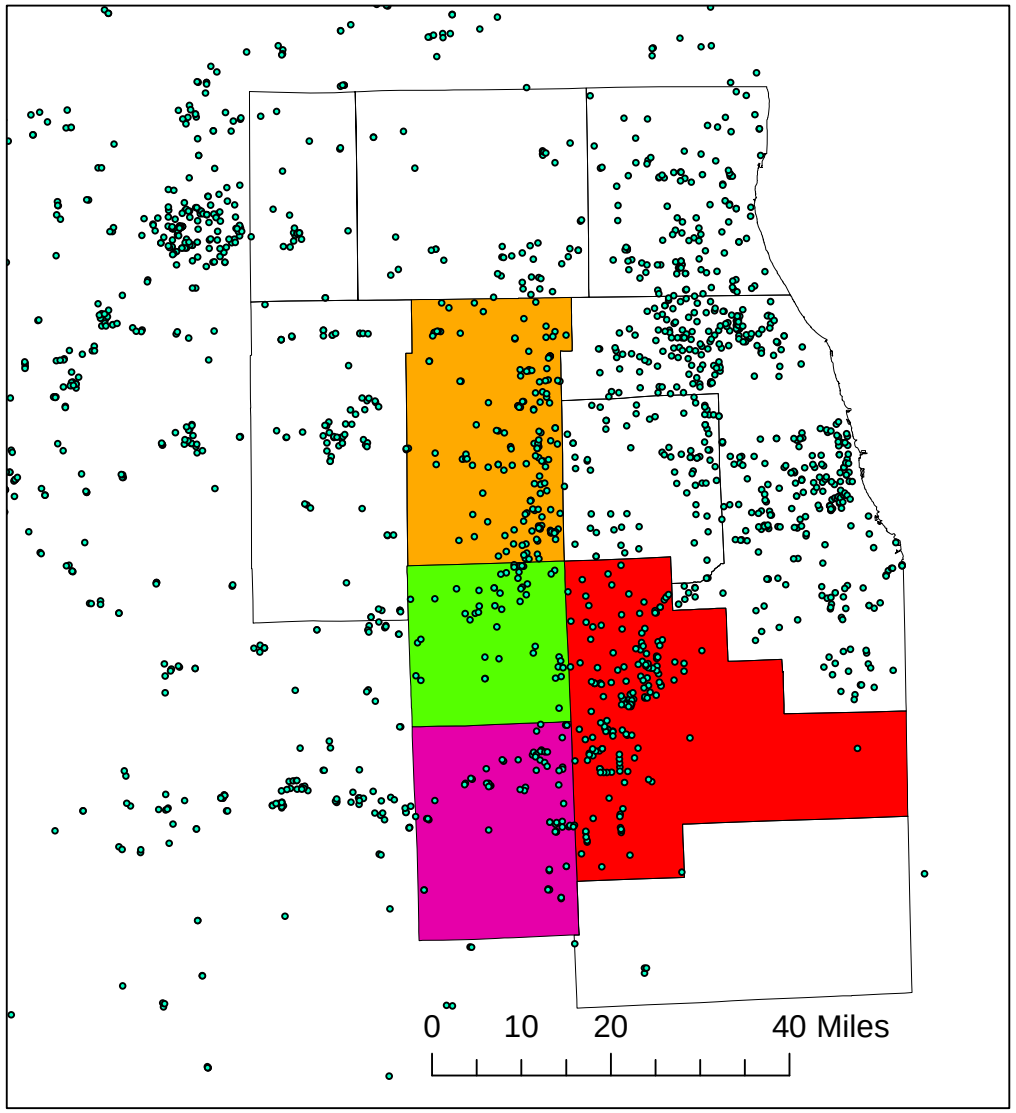
By annual withdrawals (2010)



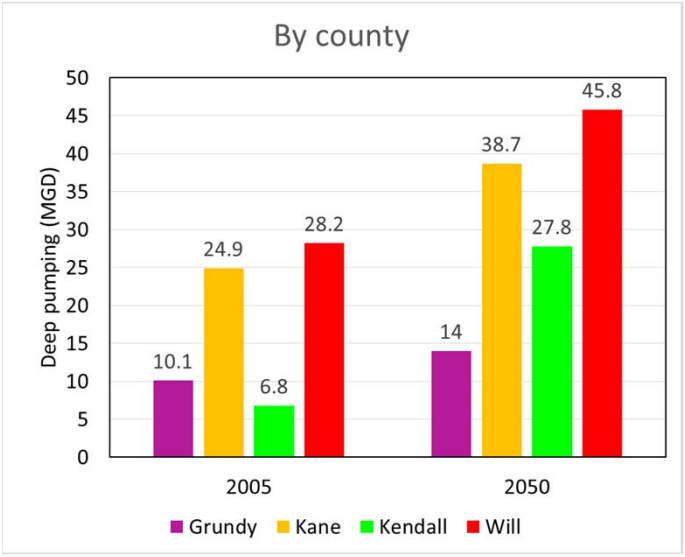


By county


By county
Deep pumping (MGD)
50
45
40
35
30
25
20
15
10
5
0
10.1
24.9
6.8
28.2
14
38.7
27.8
45.8
2005
2050
Grundy
Kane
Kendall
Will


0
10
20
40 Miles

By county (2005)



Head above Ancell

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- 100-200 ft
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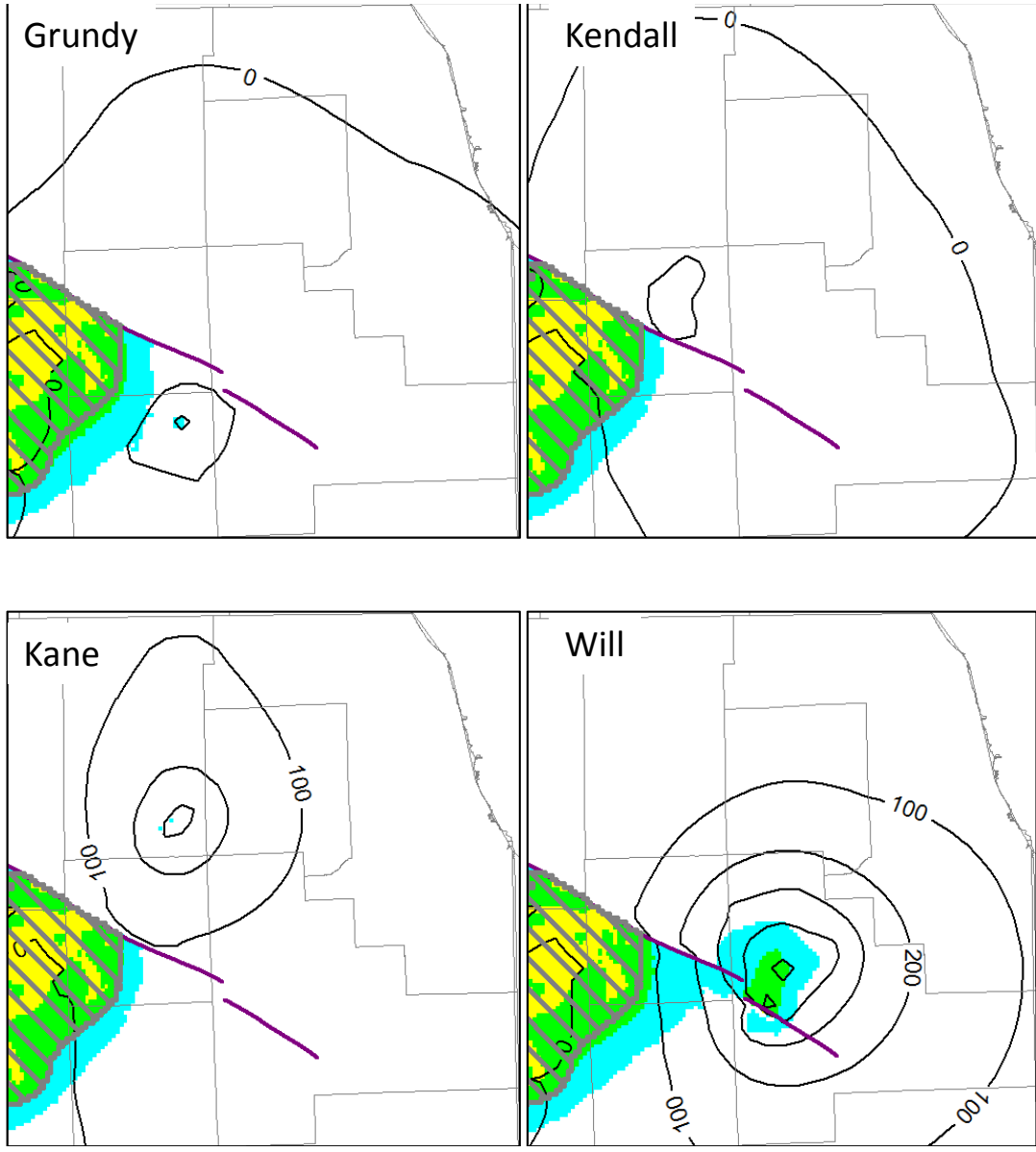
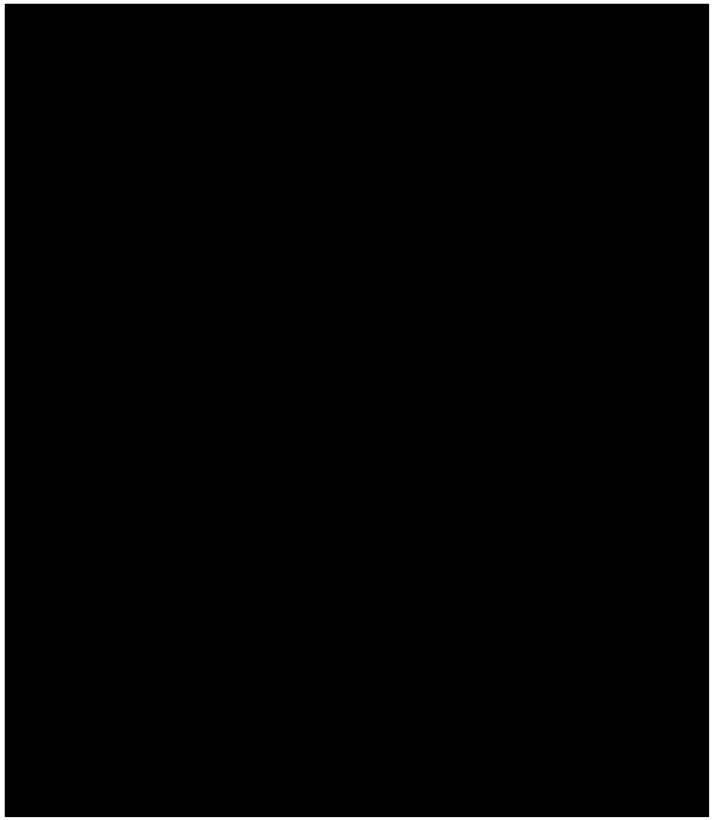
- Complete desaturation



Flow to the deep aquifer



St. Charles bedrock valley appears to be an important source of water to the deep aquifer in Kane County.

Flux into the Ancell as % recharge

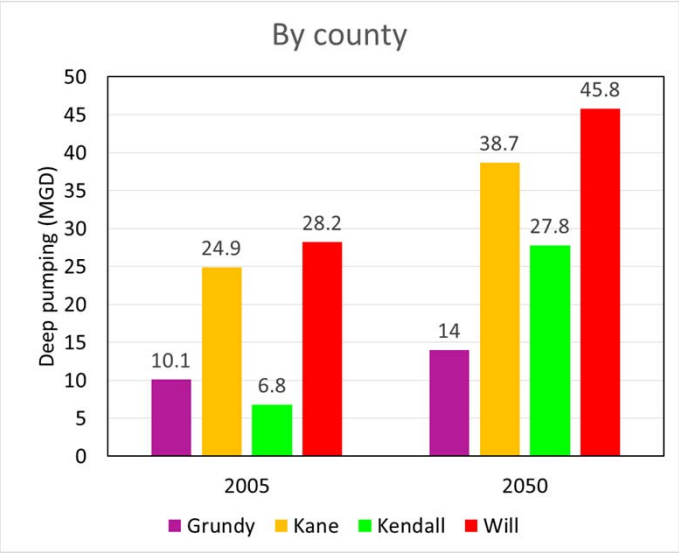
- < 1%
- 1-5%
- 5-10%
- 10-50%
- >50%

White- flow is out of the top of the Ancell

Black- St. Pete desaturated

*Average recharge is 0.00163 ft/day

By county (2005)



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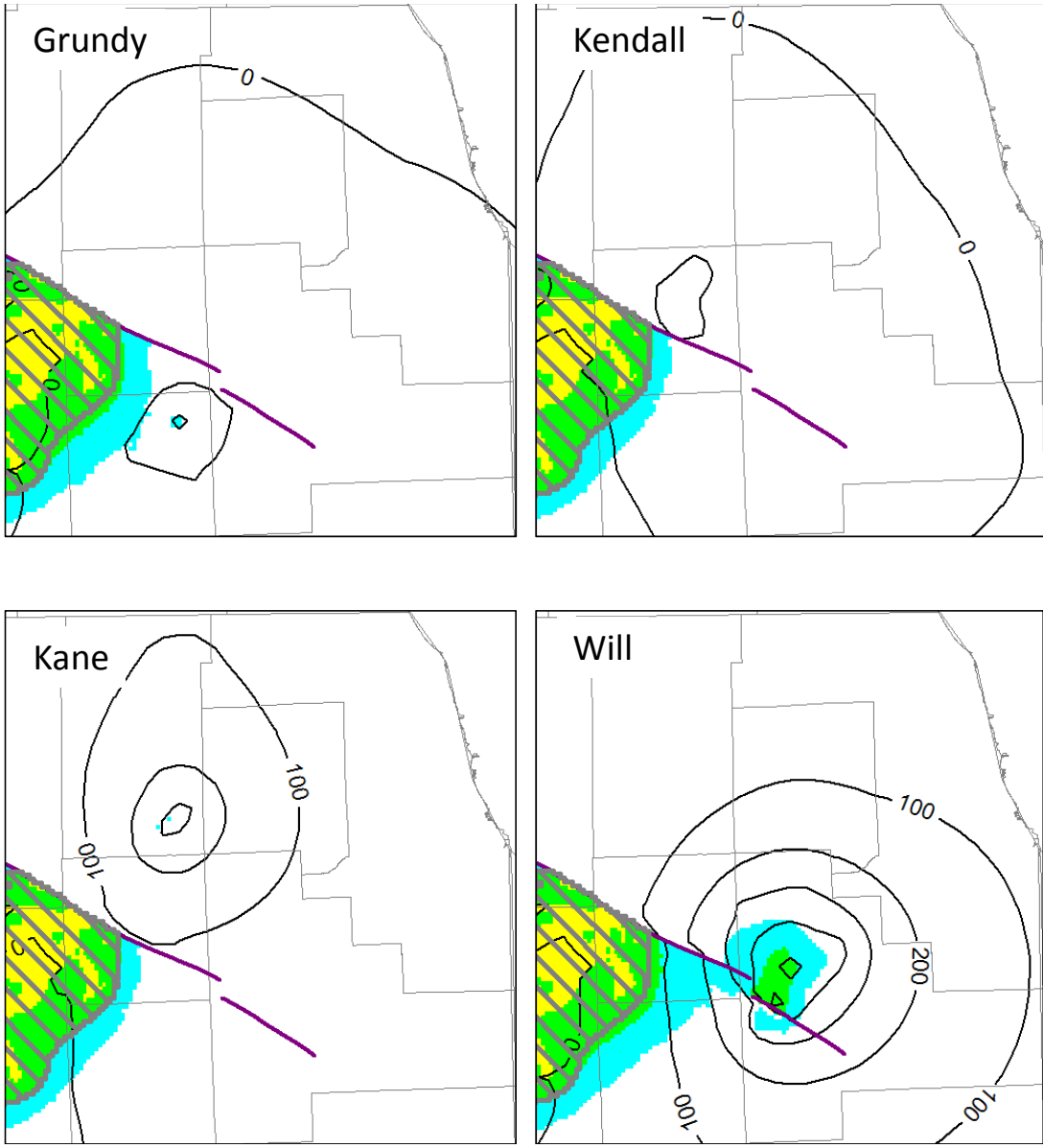
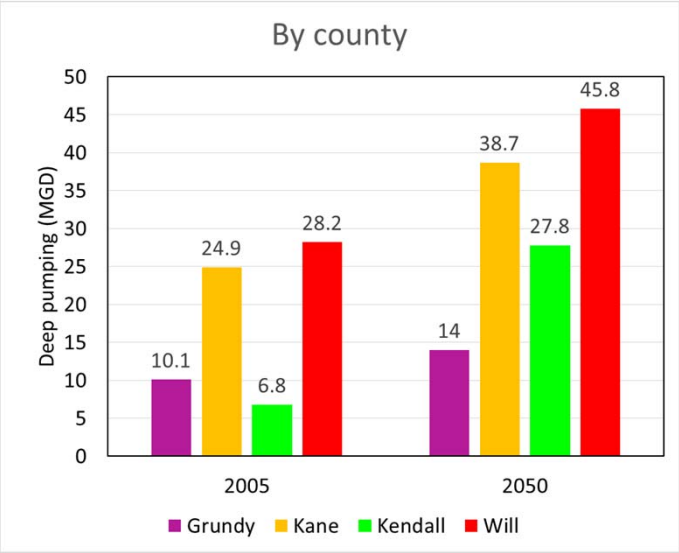


By county (2050)



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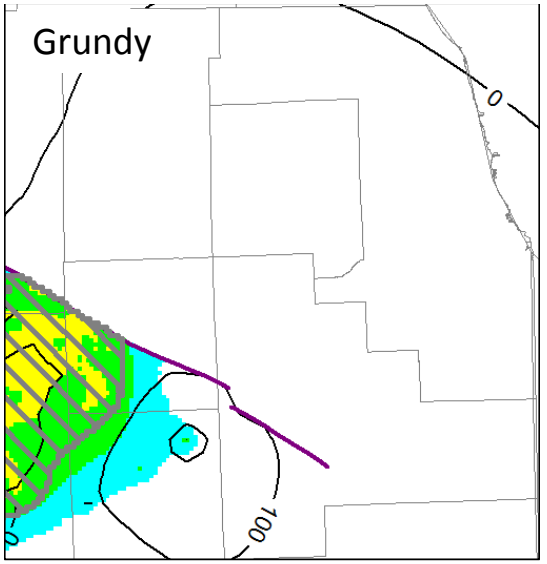
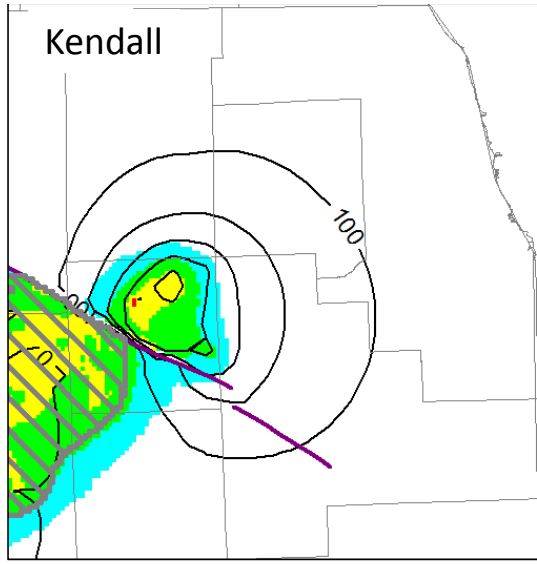
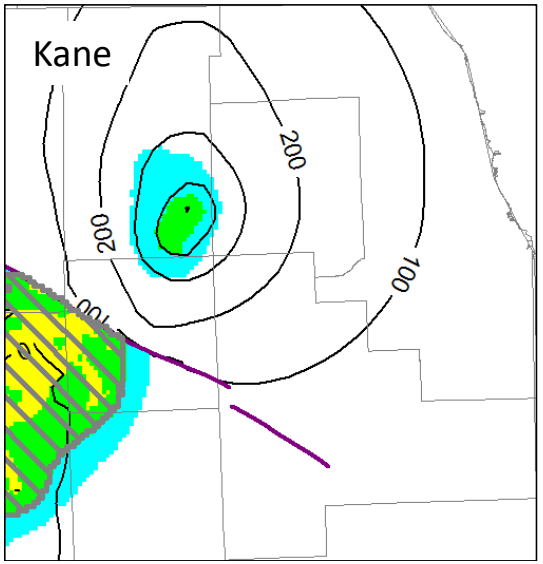
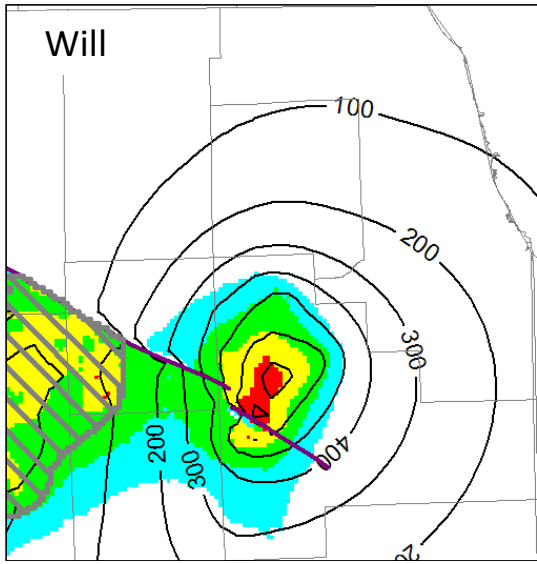


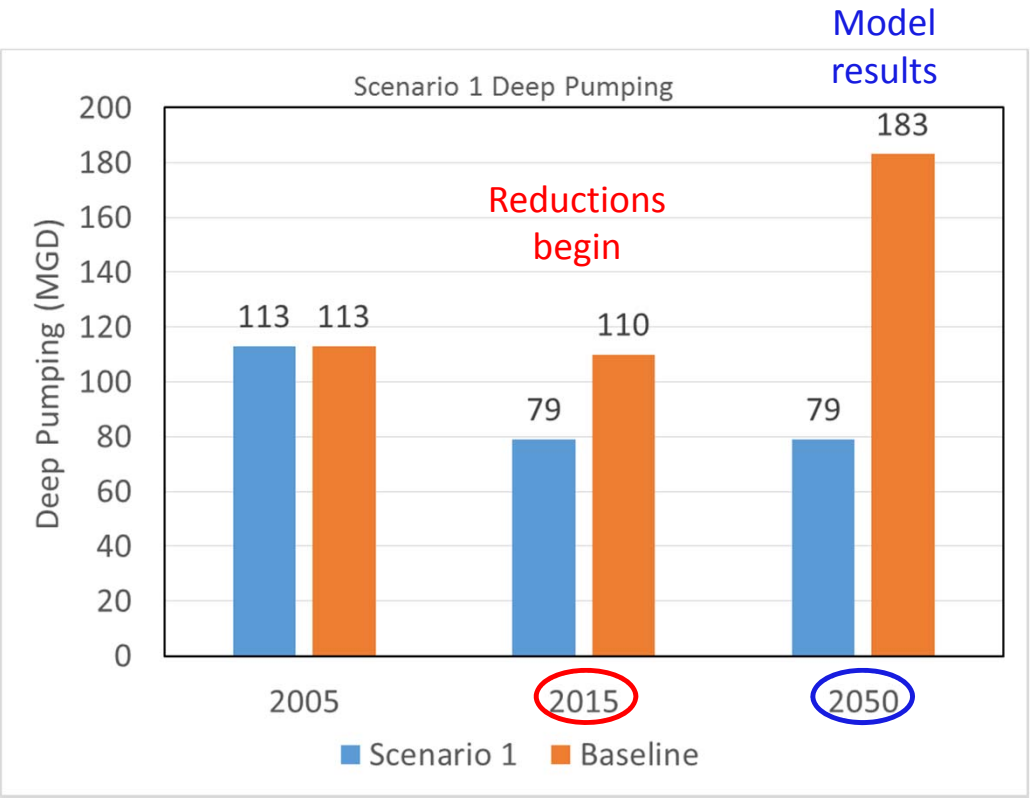






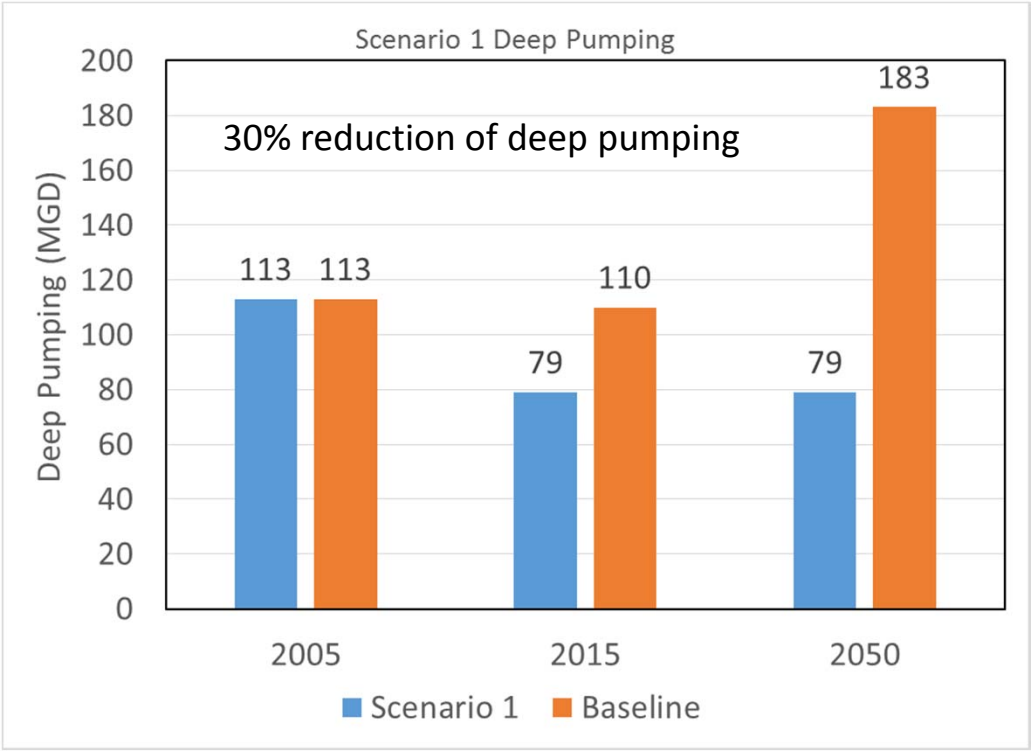
How much water is available?

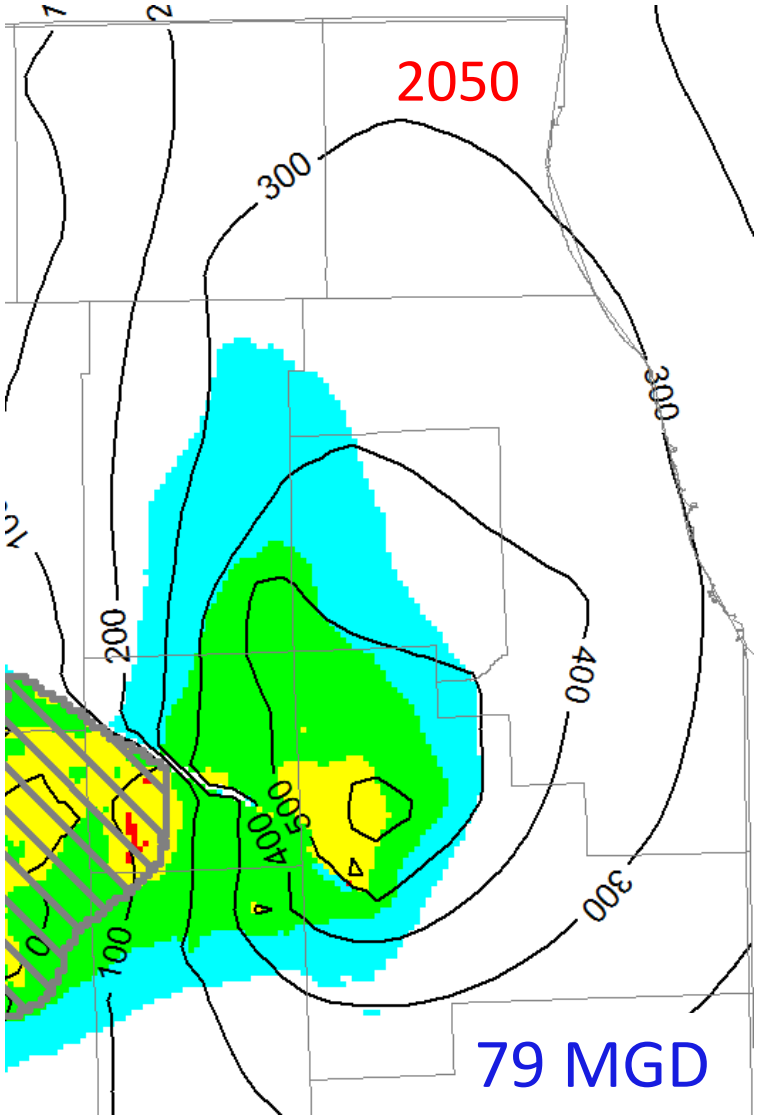
- Hypothetical model scenarios
  - Deep pumping reduced or eliminated starting in 2015
  - Model results simulated for the year 2050
    - Available head above the top of the Ancell
    - Drawdown
- Goal: avoid desaturation of the Ancell inn the year 2050



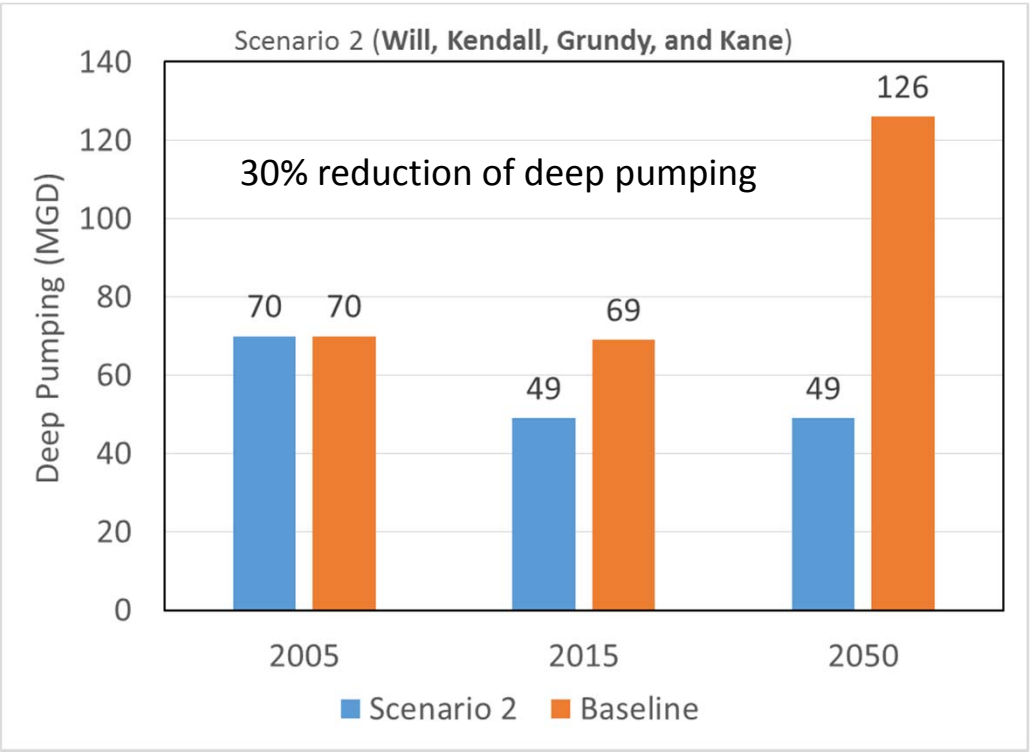
Scenario 1: Ubiquitous reduction

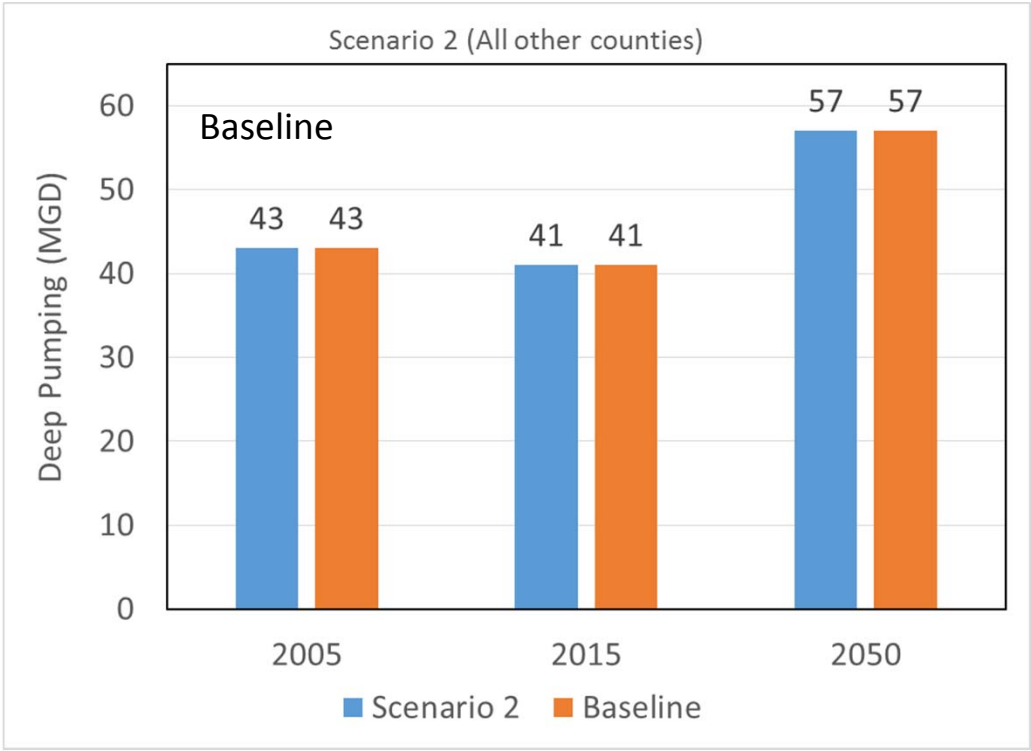
- Every deep well in northeastern Illinois pumps 70% of 2005 rates





Scenario 2: Reduction in 4 counties



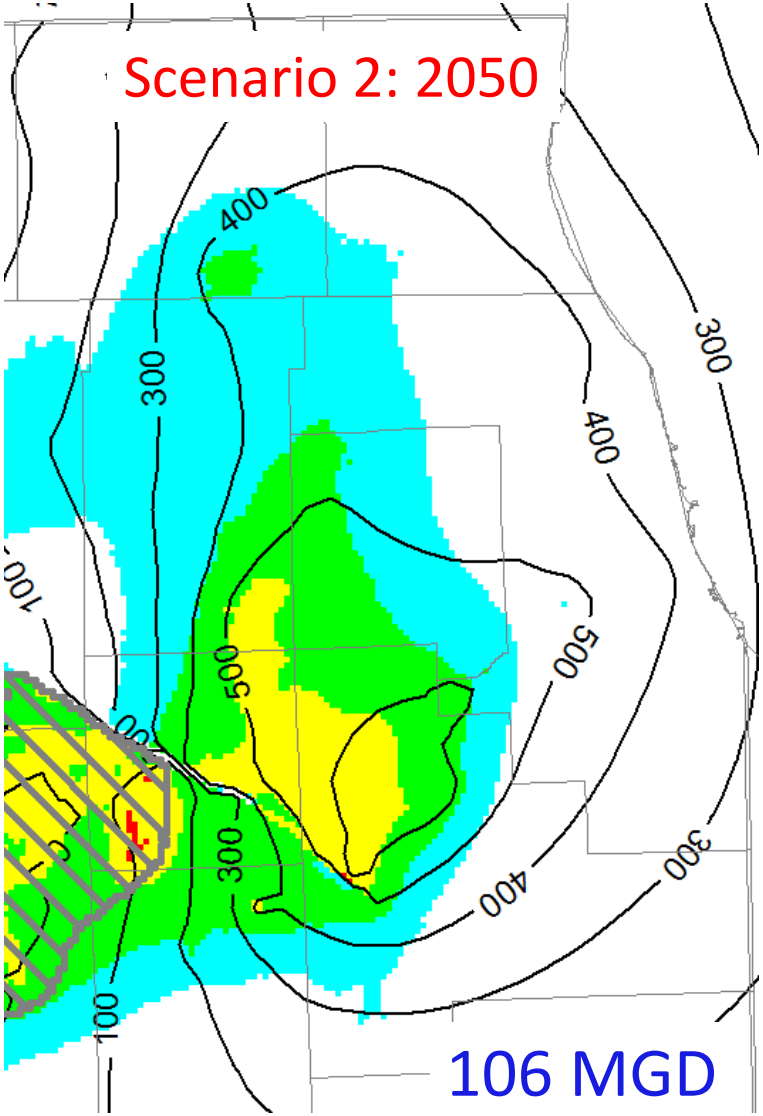


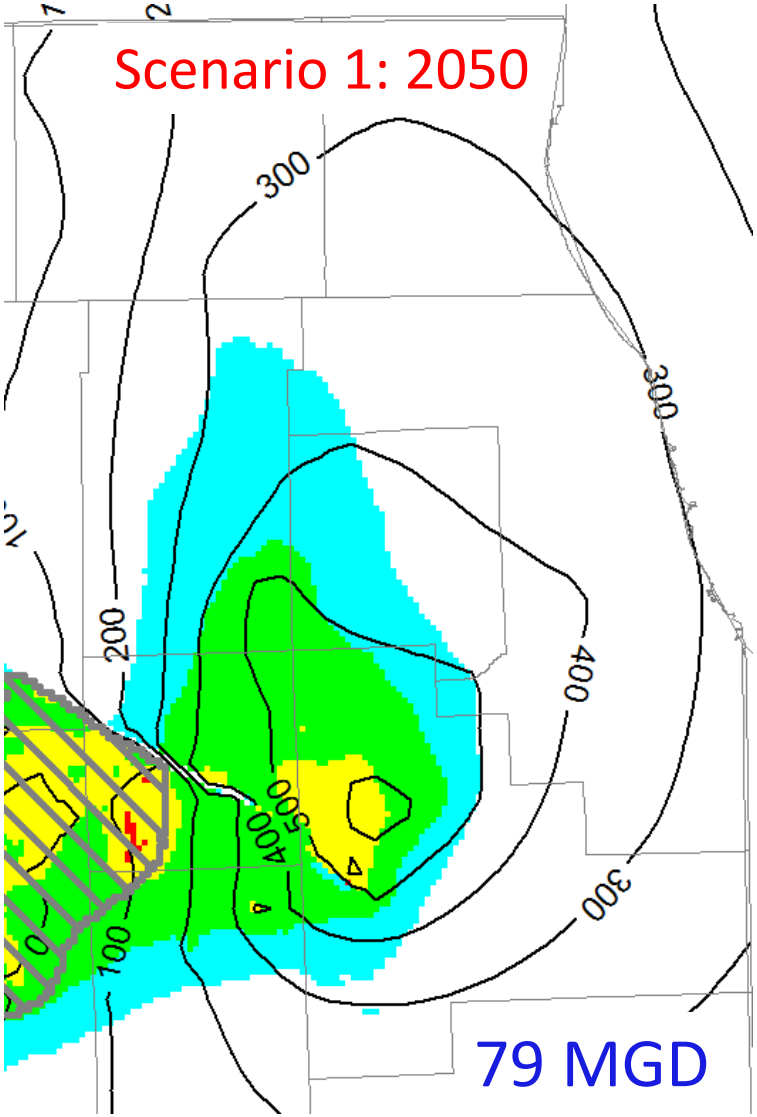
- 30% reduction in deep pumping from 2005 rates in:
  - Will, Kane, Kendall, and Grundy
- All else pump per baseline

Scenario 2: Reduction in 4 counties

- 2 cells are partially desaturated

- Deep withdrawals in 2050 are 106 MGD





Head above Ancell

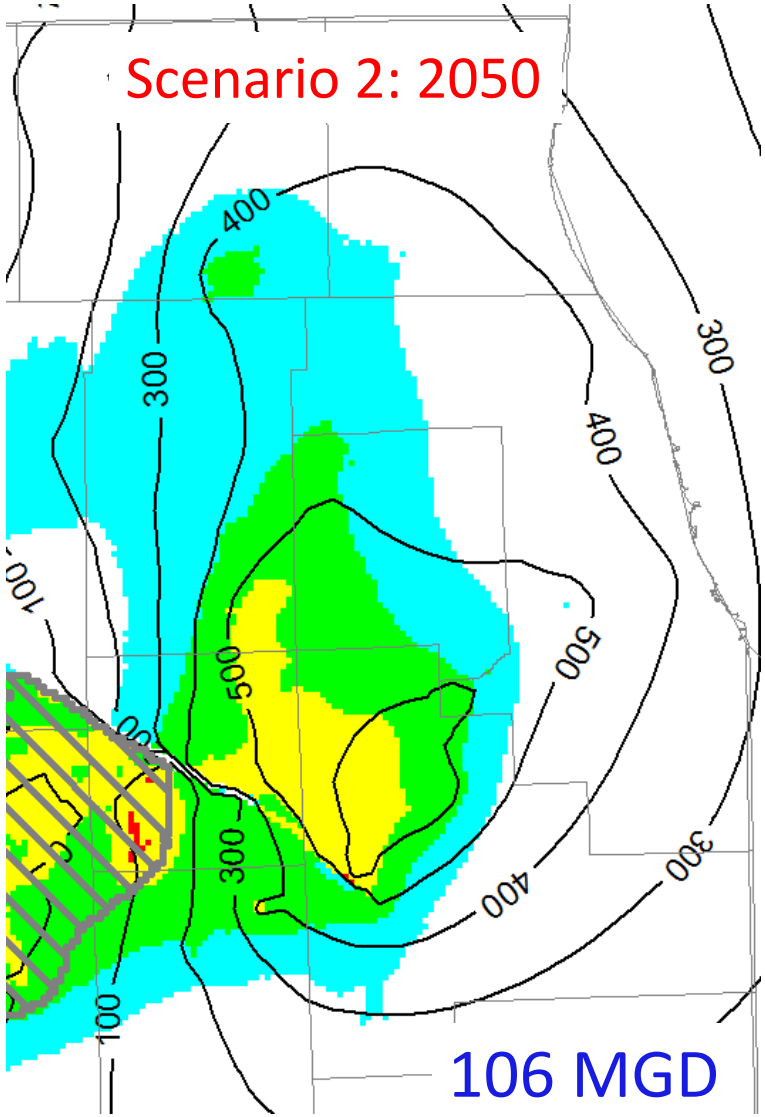
200-300 ft

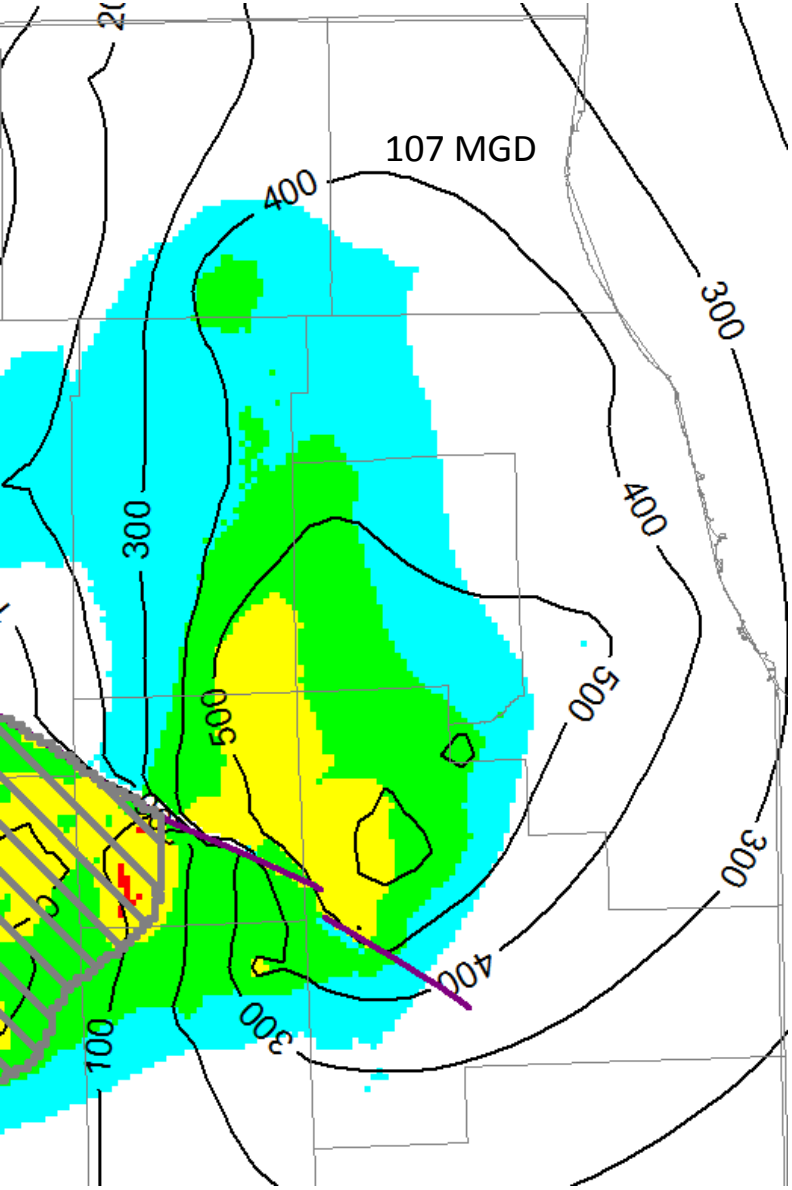
100-200 ft

<100 ft (Saturated)

Partial desaturation

Complete desaturation





Scenario 3: Reduce by county

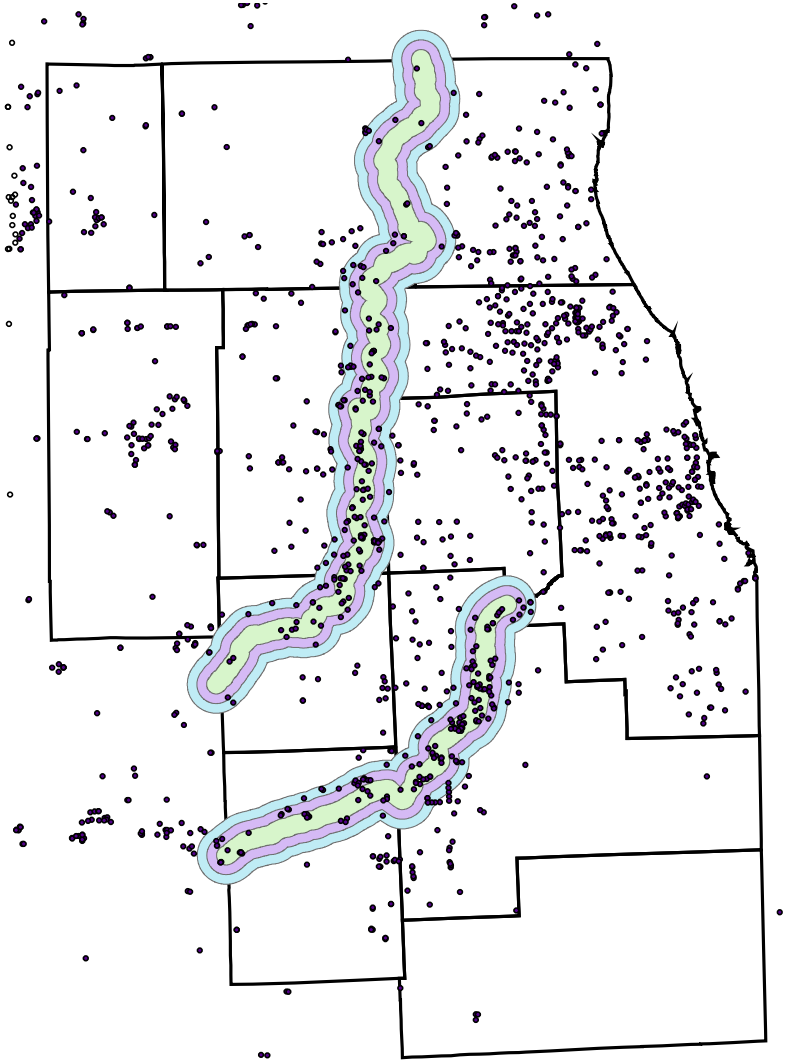
- Will: 60% of 2005 rates
- Kane/Kendall/Grundy: 80% of 2005 rates
- All others: pump per baseline

2050 pumping: 104 MGD

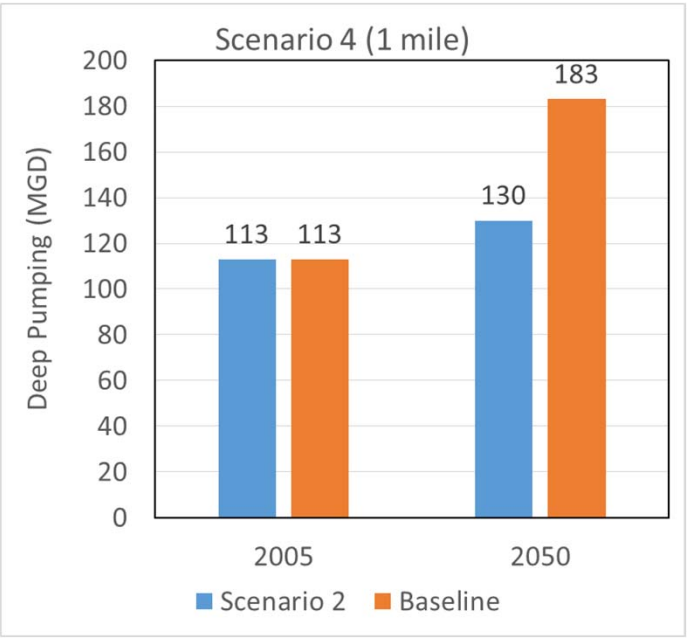
Management plan for replacing deep groundwater

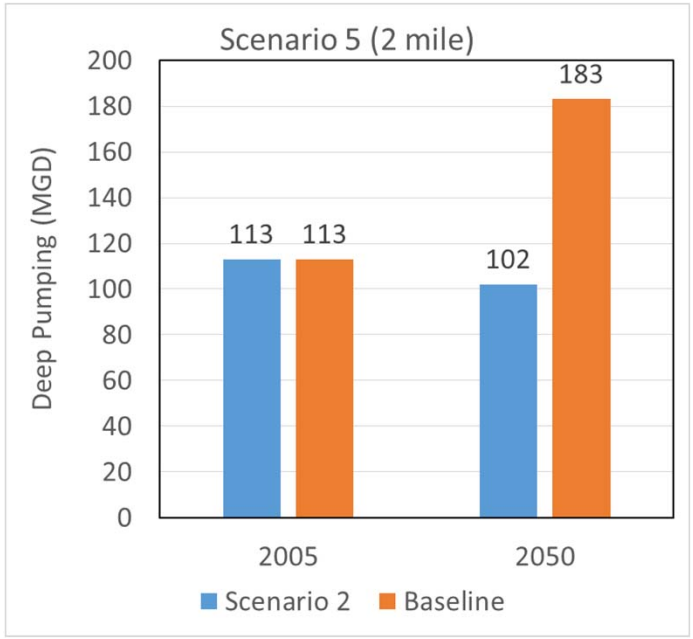
- Replace with surface water?

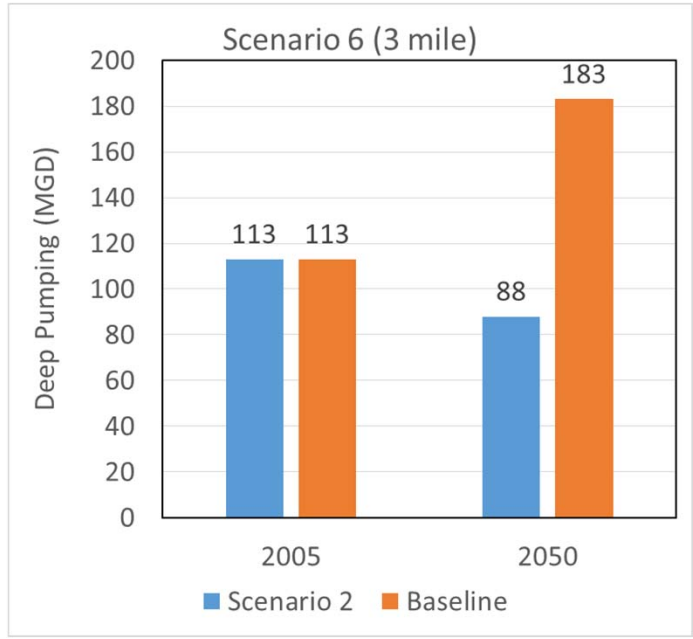
- Model set-up
  - Eliminate pumping within a specified distance from the main branches of the Fox or Des Plaines Rivers (starting in 2015)
    - 1 mile
    - 2 miles
    - 3 miles
  - All else grows per baseline



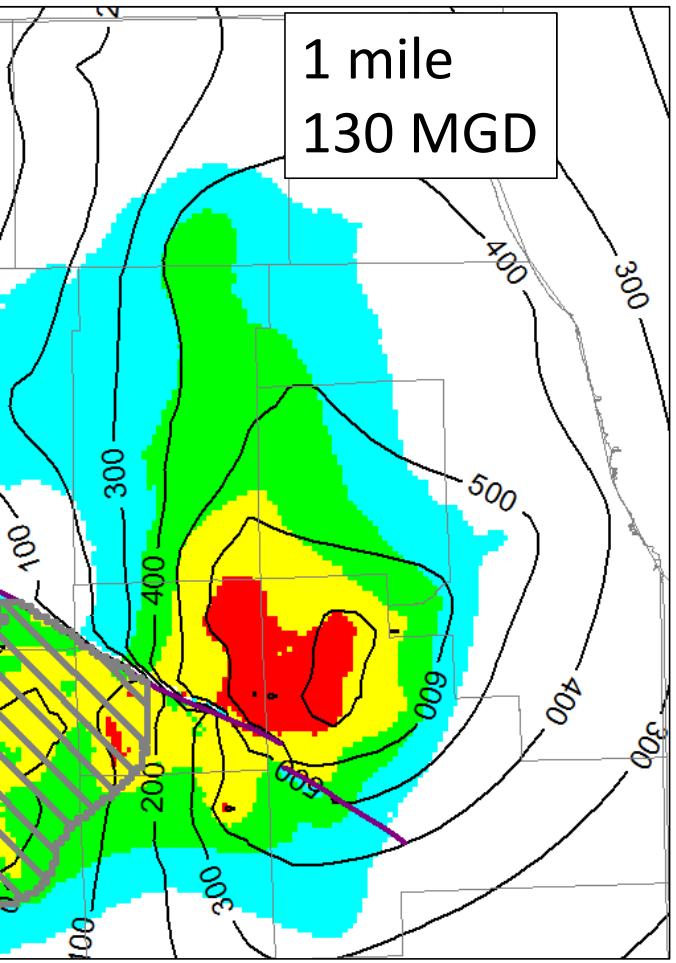
Scenarios 4-6: Eliminate deep pumping near streams

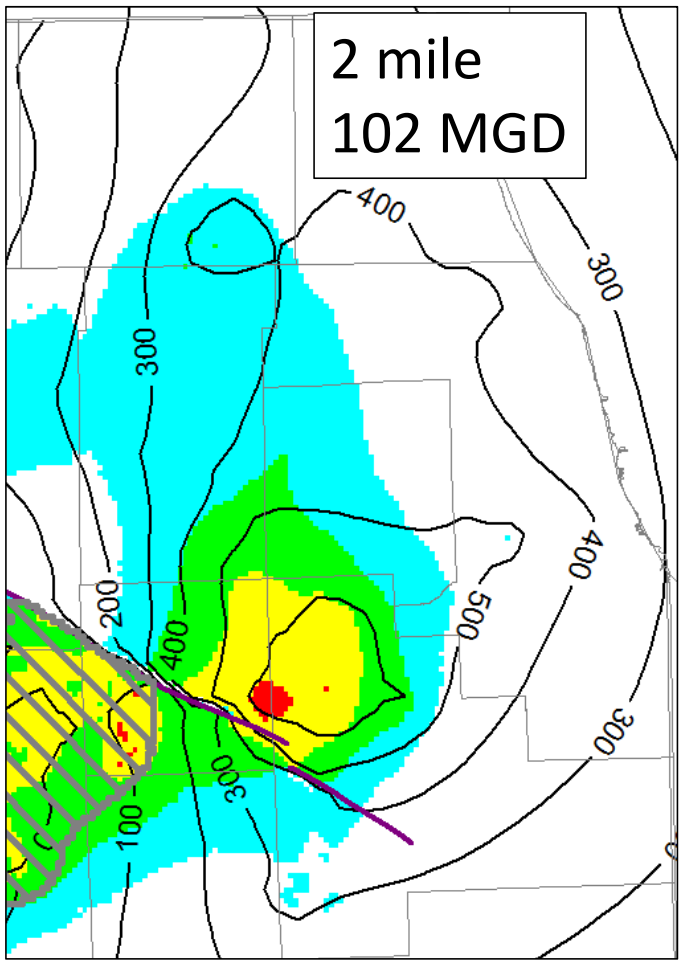


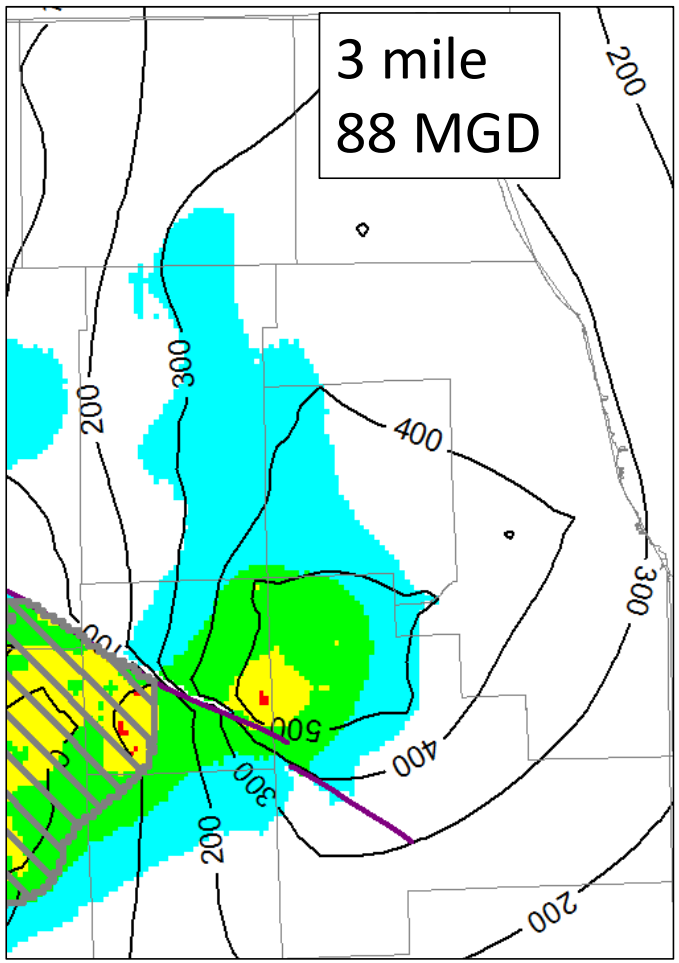




Scenarios 4-6: Eliminate deep pumping near streams

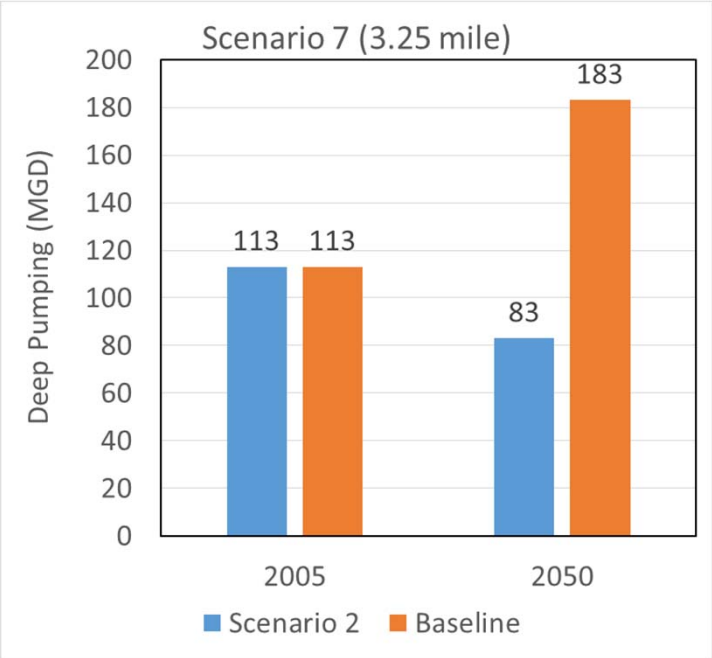


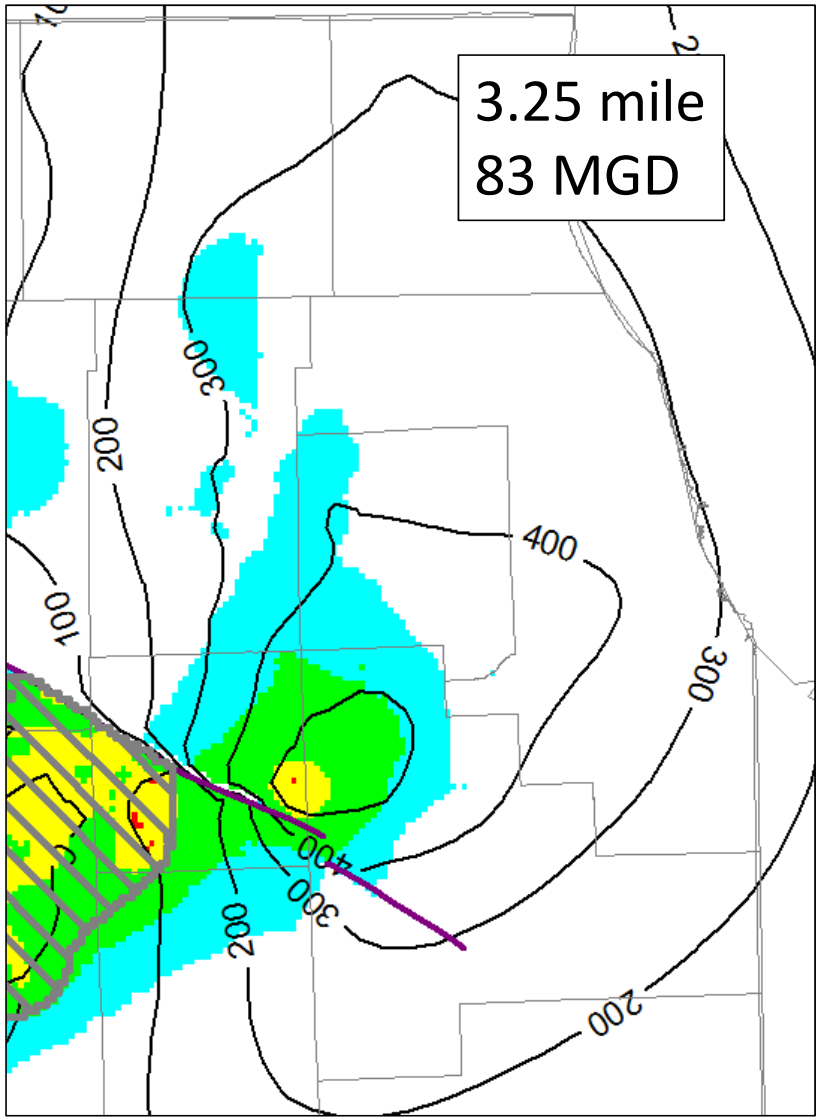




Scenario 7: Eliminate pumping near streams to avoid desaturation of the deep aquifer

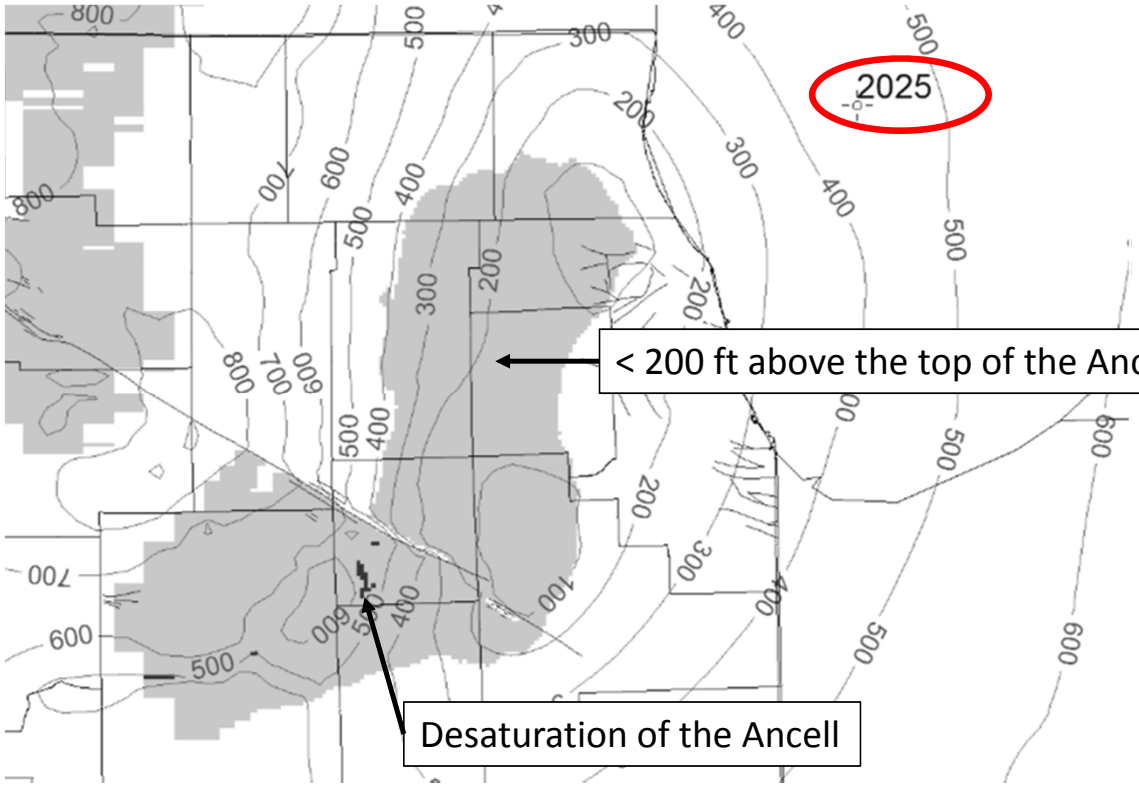
- Requires a 3.25 mile buffer around surface waters

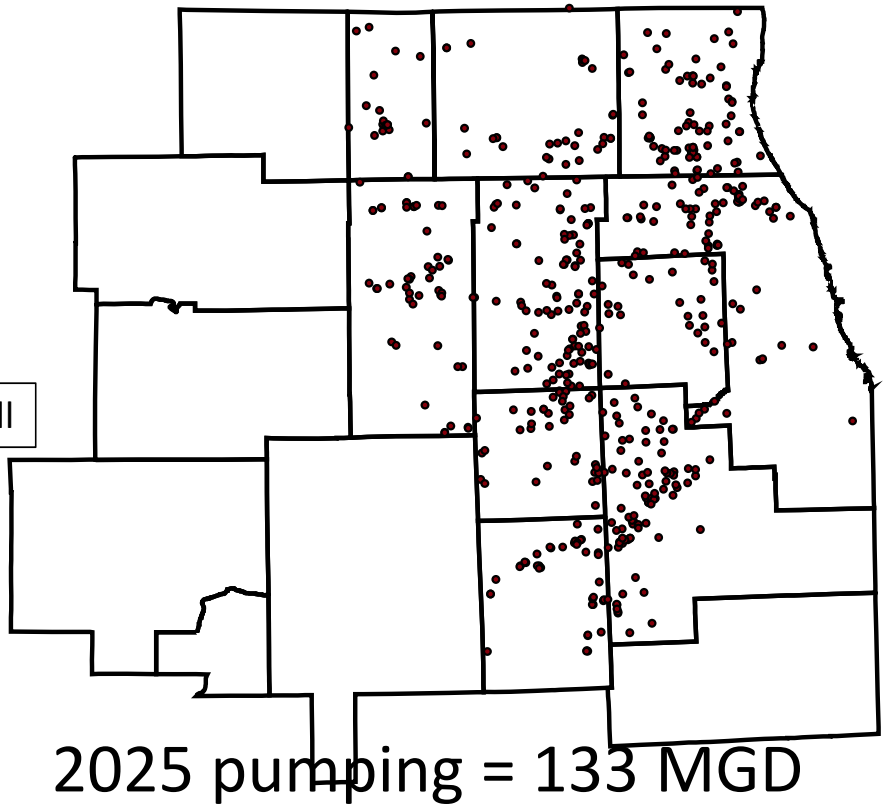




Scenario 8: “Smeared” pumping

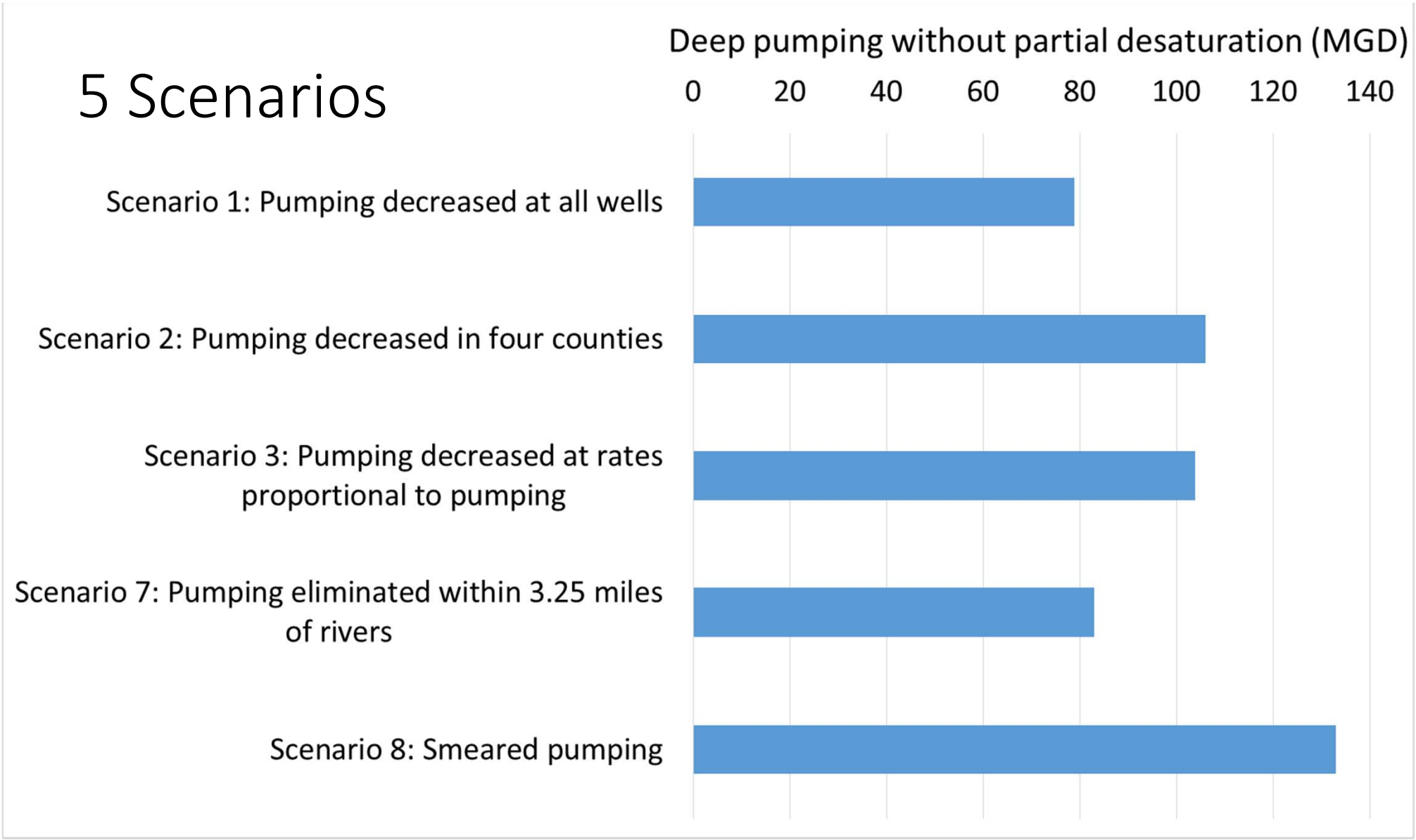
Divided total deep pumping for each year equally amongst all deep wells starting in 2015, ran until desaturation occurs





2025 pumping = 133 MGD

5 Scenarios


Deep pumping without partial desaturation (MGD)
0
20
40
60
80
100
120
140
Scenario 1: Pumping decreased at all wells
Scenario 2: Pumping decreased in four counties
Scenario 3: Pumping decreased at rates proportional to pumping
Scenario 7: Pumping eliminated within 3.25 miles of rivers
Scenario 8: Smeared pumping

Future work

- Consult with the NWPA to develop scenarios, each of which will have an “available deep groundwater supply”
- Scenarios with a dynamic well network for future simulations
- Scenarios that eliminate zones where the head is less than 200 ft above the top of the Ancell

Questions?

- dbabrams@illinois.edu
- 217-693-7656

SAVE THE DATE!

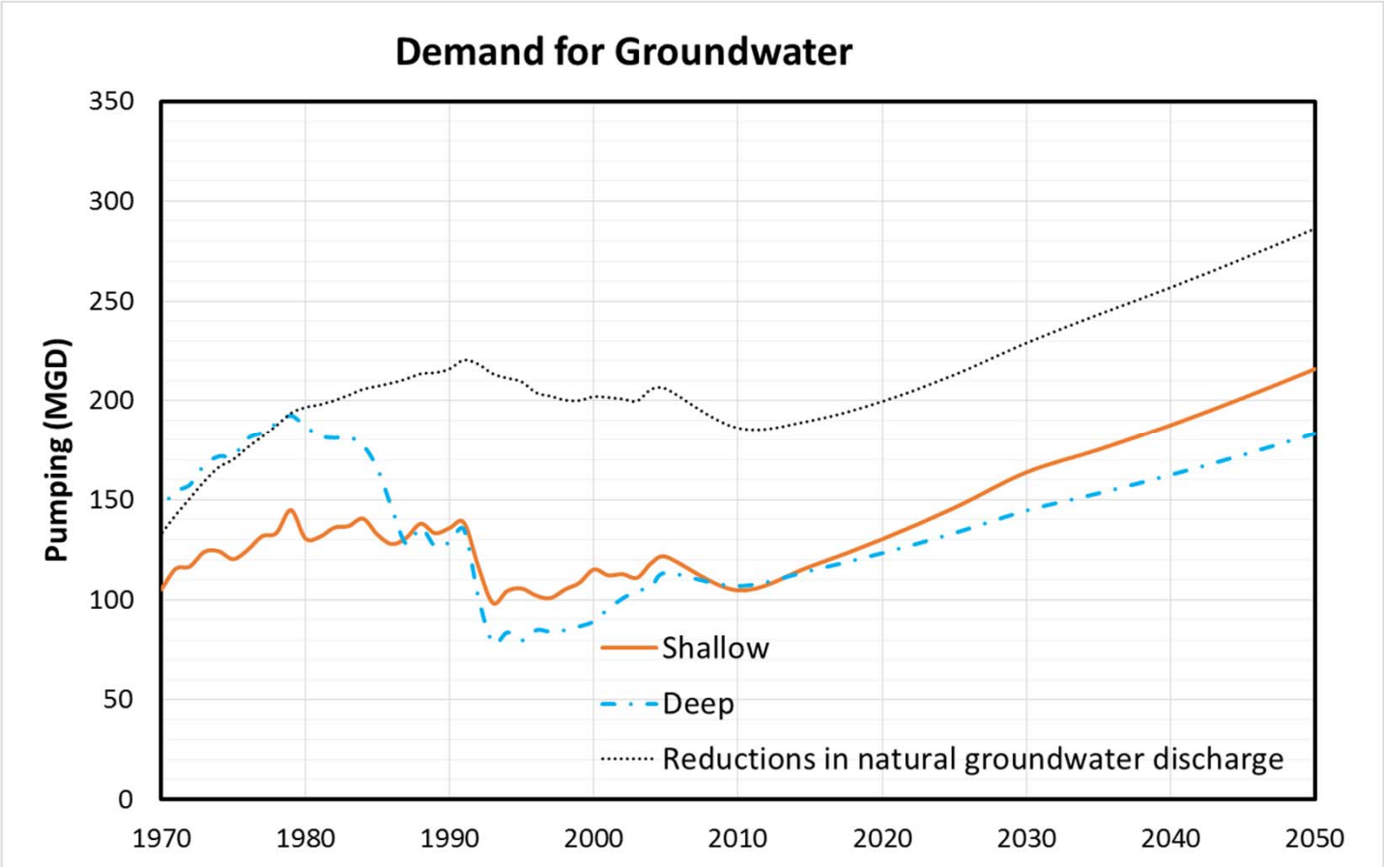
Tuesday
May 27th
2pm-4pm

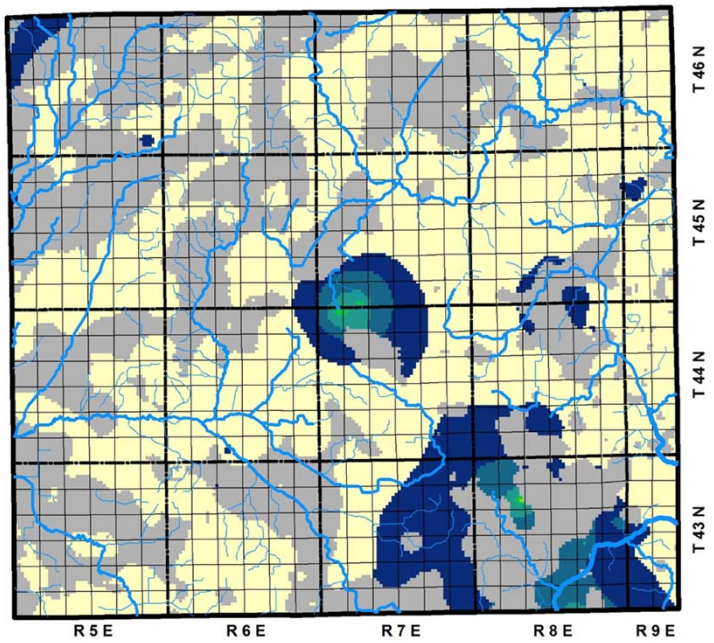
Presentation of the Groundwater Study for Water Supply Planning in Kendall County, Illinois

For any questions please contact:
Kendall County Planning & Zoning Manager- Angela Zubko
AZubko@co.kendall.il.us or 630-553-4139

Location:
Village of Oswego
Village Board Room
1st floor
100 Parkers Mill
Oswego, IL 60543

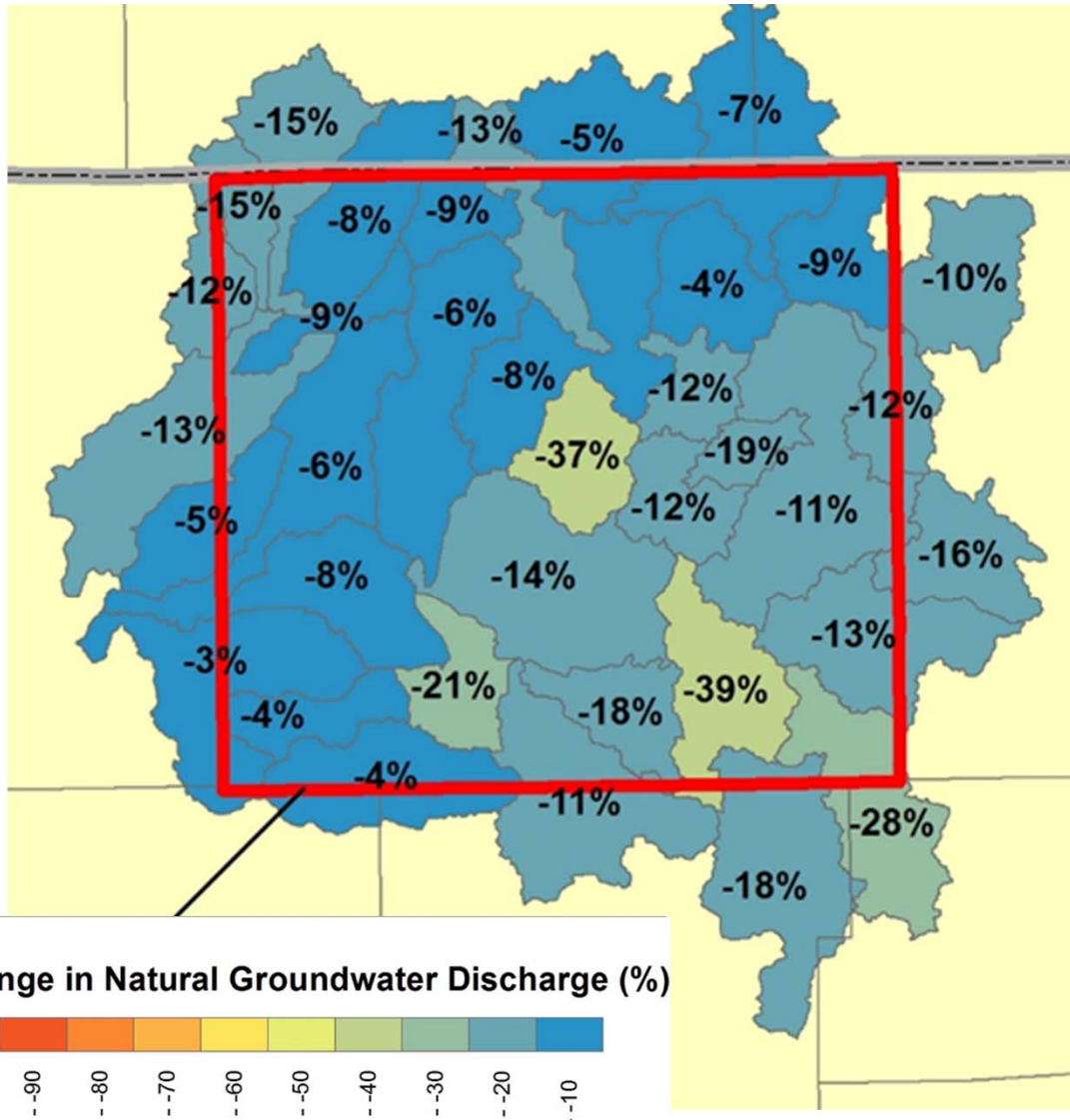
Shallow pumping and reductions in natural groundwater discharge





Drawdown Since Predevelopment (ft)

5 - 10
11 - 20
21 - 30
31 - 40
41 - 50
51 - 60
61 - 70
71 - 80
81 - 90
91 - 100
101 - 110

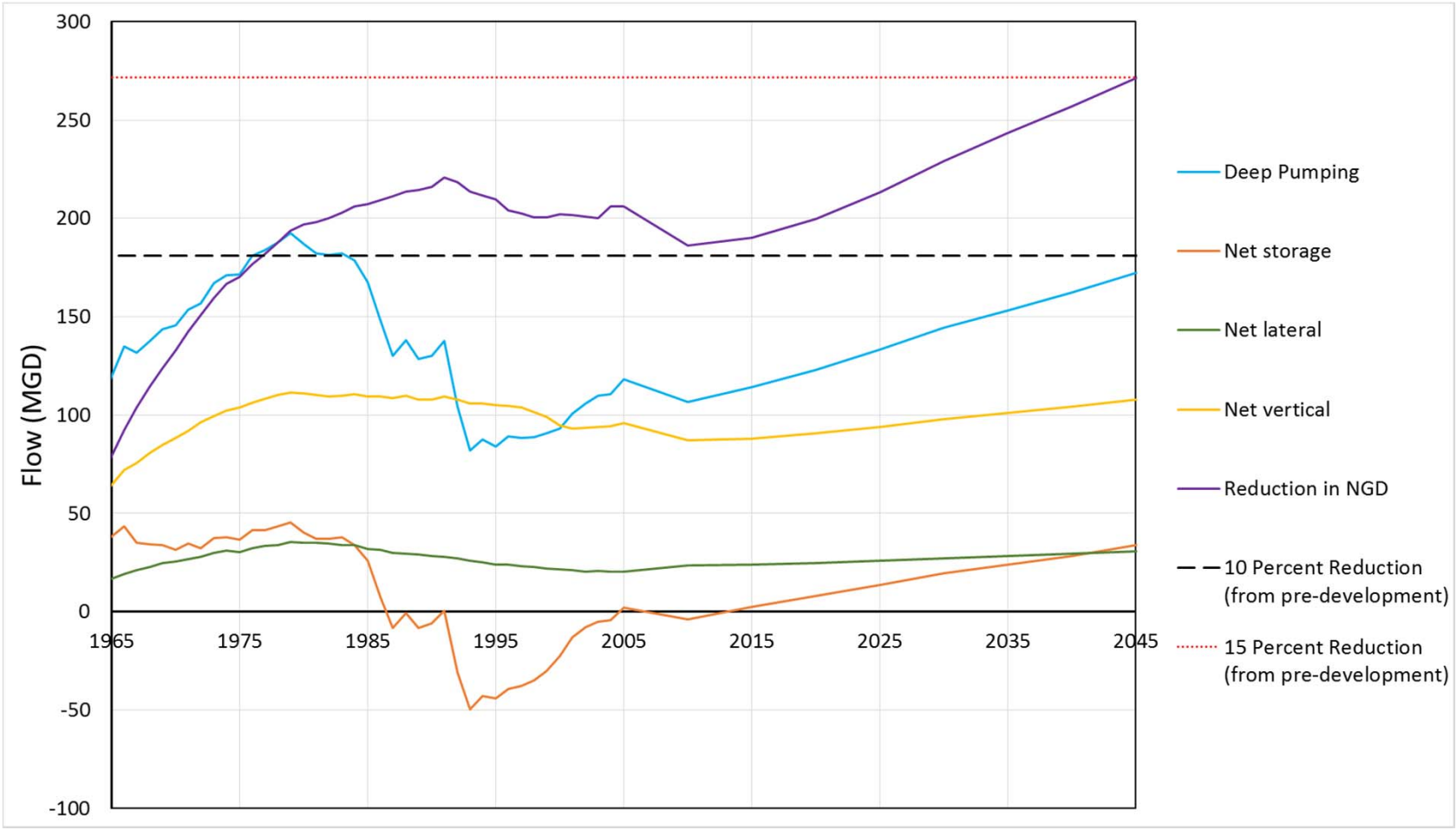


Change in Natural Groundwater Discharge (%)

-91 - -100
-81 - -90
-71 - -80
-61 - -70
-51 - -60
-41 - -50
-31 - -40
-21 - -30
-11 - -20
0 - -10

Reduction in NGD

Watson et al. (2014) use a 20% reduction as their ecological limit



Spatial variations in reductions in NGD