

Lessons learned from a statewide survey of brine disposal and seismicity in Kansas

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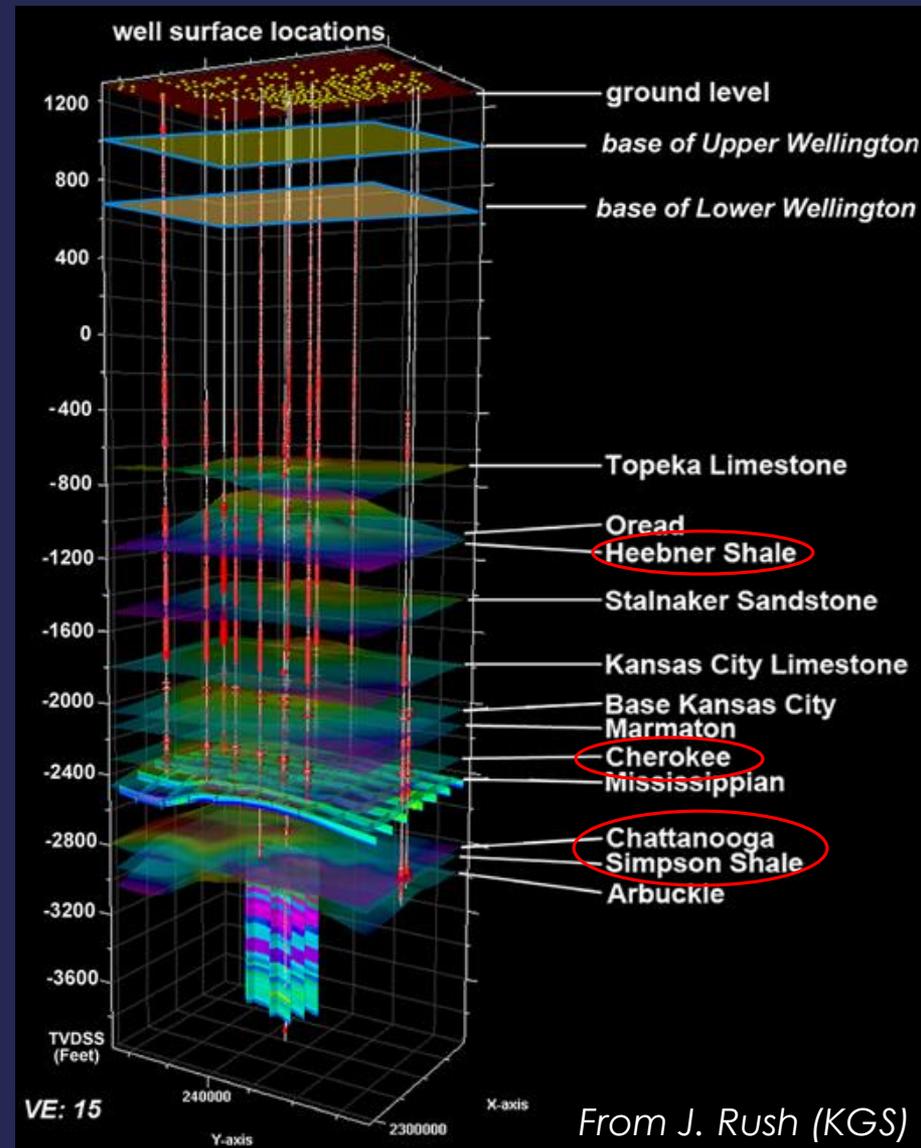
Kansas Geological Survey

University of Kansas

November 15, 2016

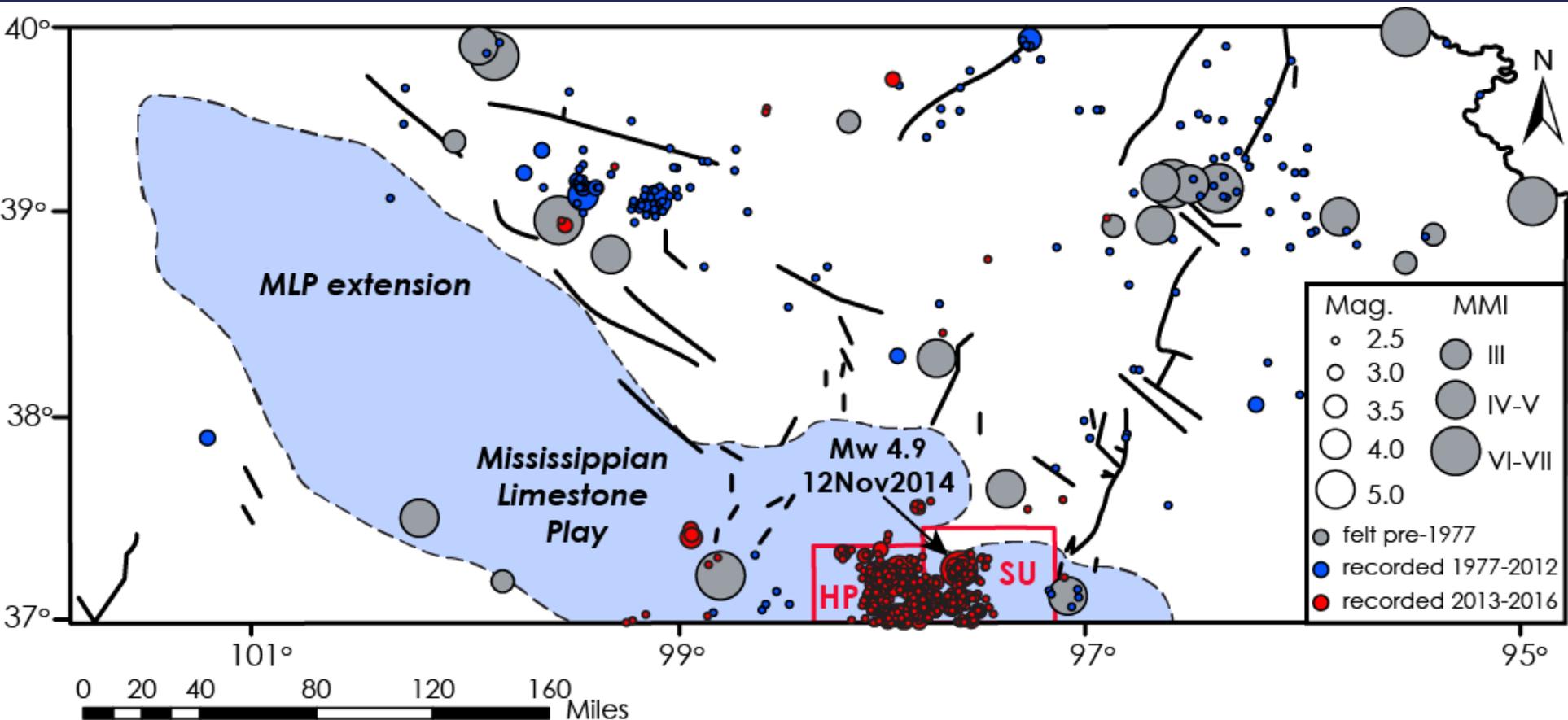
Arbuckle Group: Prime disposal site?

- Factors:
 - Depth & separation from USDW
 - Thickness
 - Permeability
 - Confinement
 - Pressure
- 47 Class I and 4947 Class II SWD wells in KS

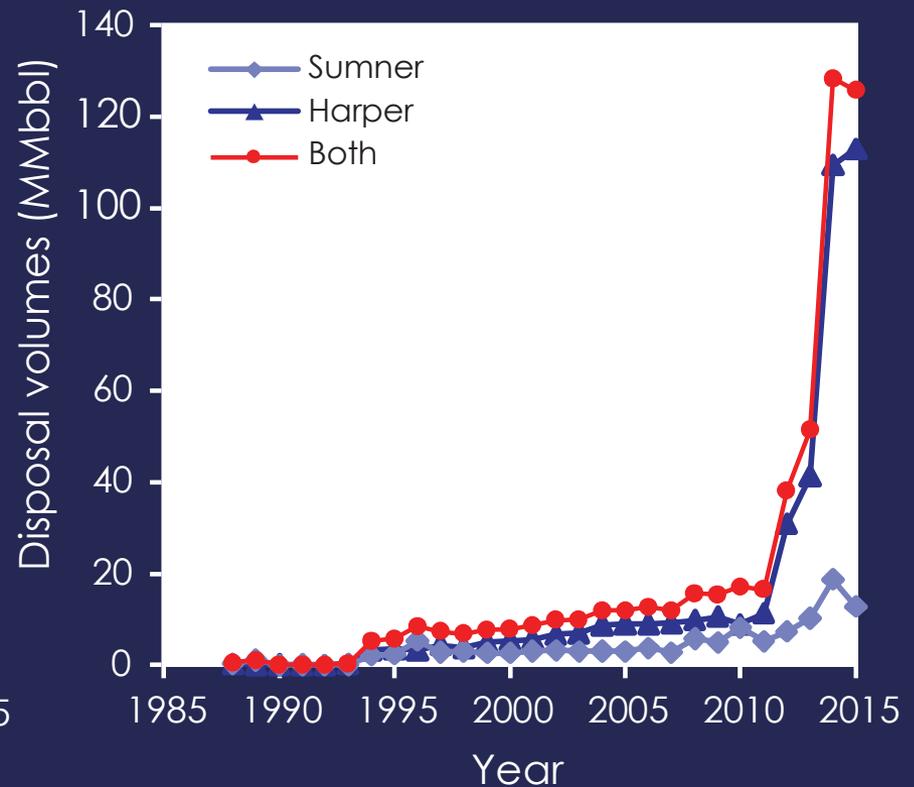
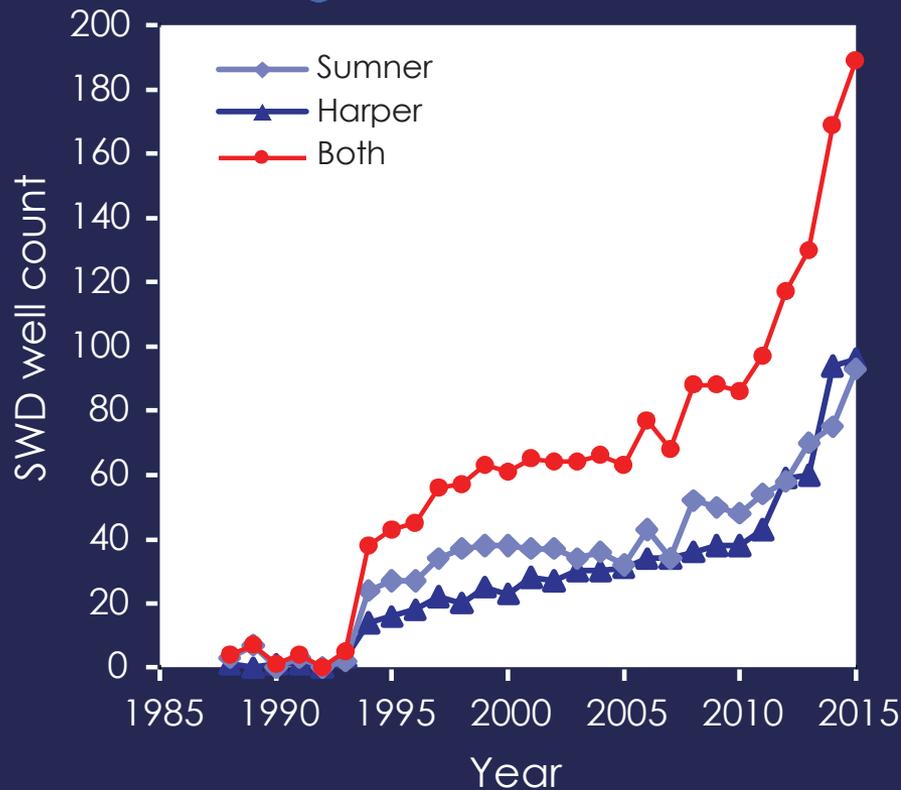


Historical versus recent seismicity

- 1977-2012: 197 EQs, 15 \geq M3.0
- 2013-2016: ~2500 EQs, >1000 (M2.0-2.9), 117 (\geq M3.0)



Brine disposal trends

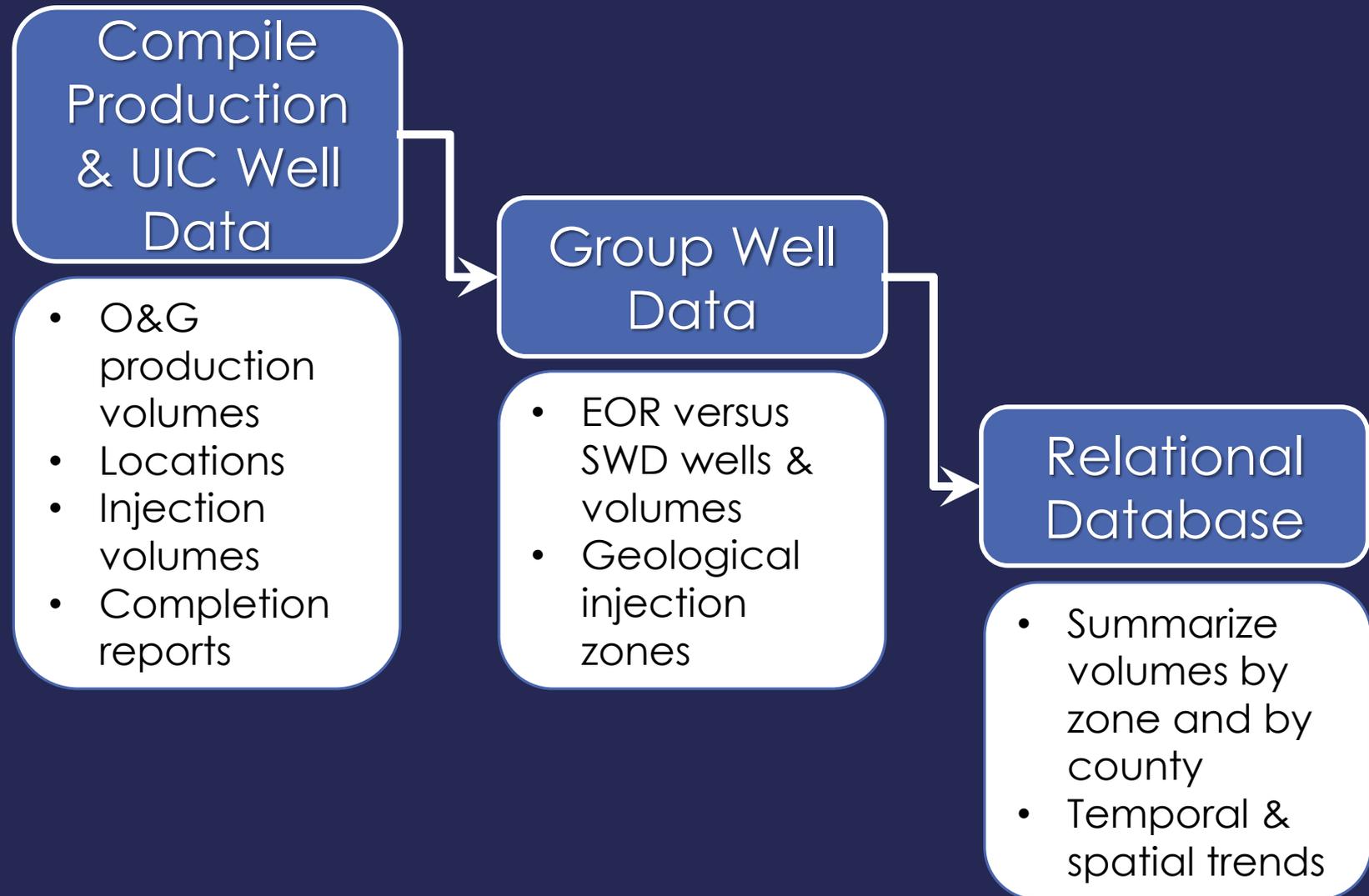


- Well count has more than tripled since 2005
- 10-fold increase in disposal volumes since 2005
- Largest increase between 2013 & 2014; slight decrease in 2015

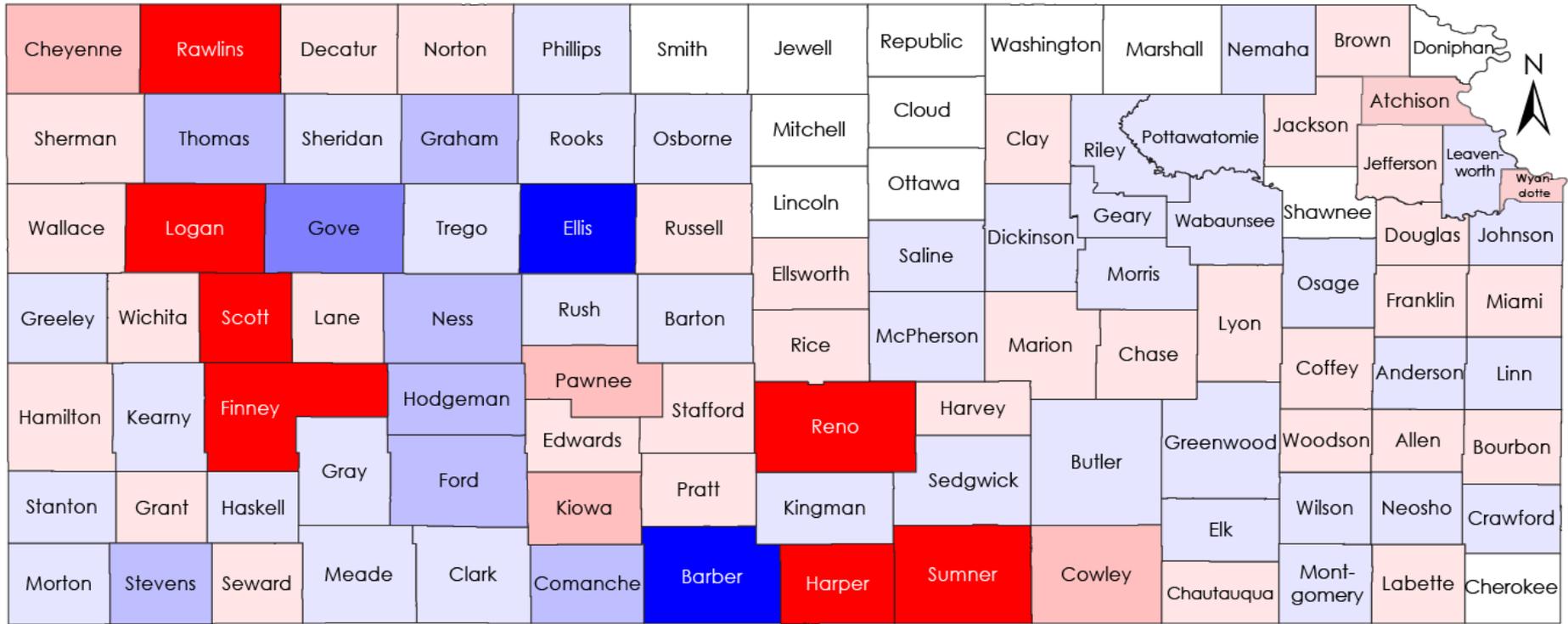
Study goals

1. What are statewide trends in O&G production and brine disposal, and how do they compare to counties affected by seismicity?
 - Saltwater disposal or enhanced oil recovery?
 - Disposal zones?
 - Quantities, rates?
2. What factors are contributing to the recent seismicity?
 - Regional or local geology?
 - Operational considerations?
3. Are there mitigation strategies that can be employed?

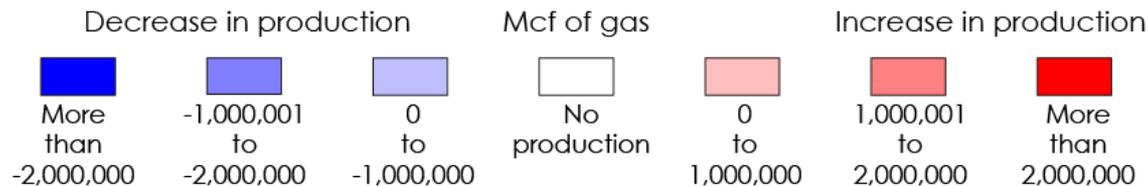
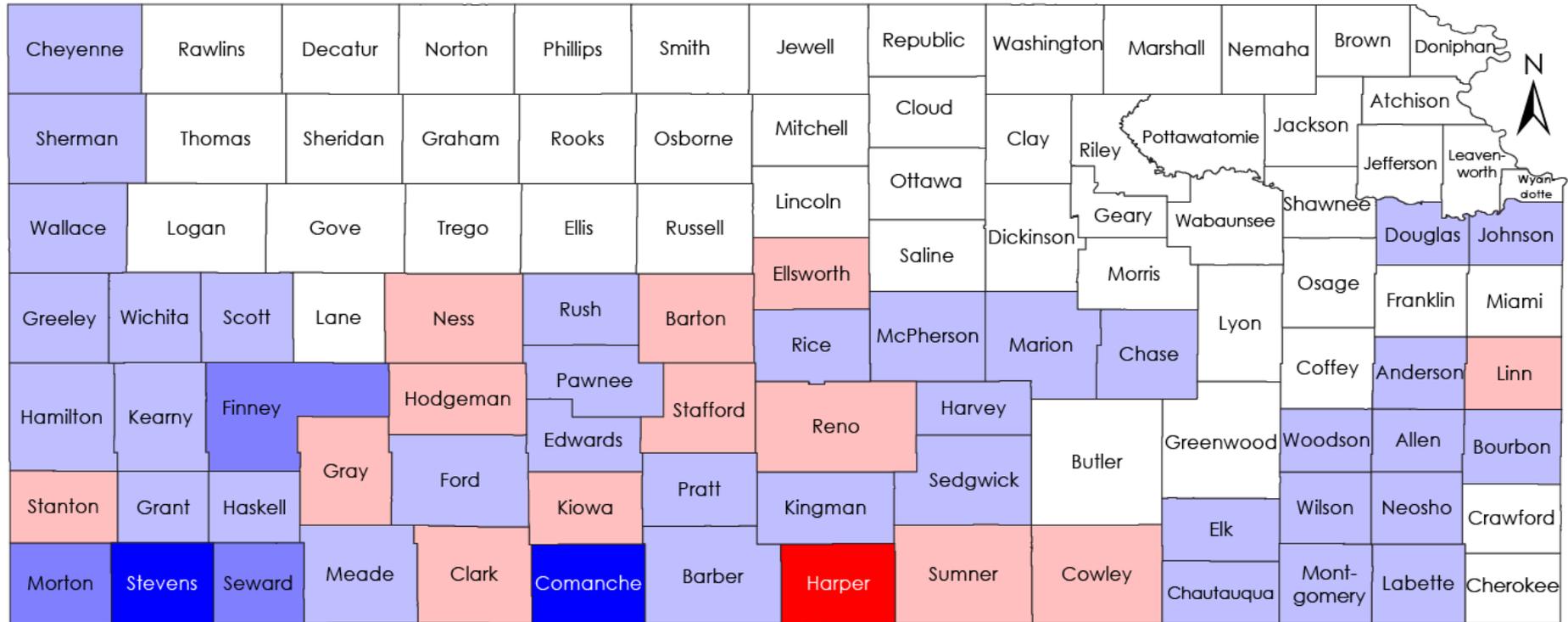
Workflow



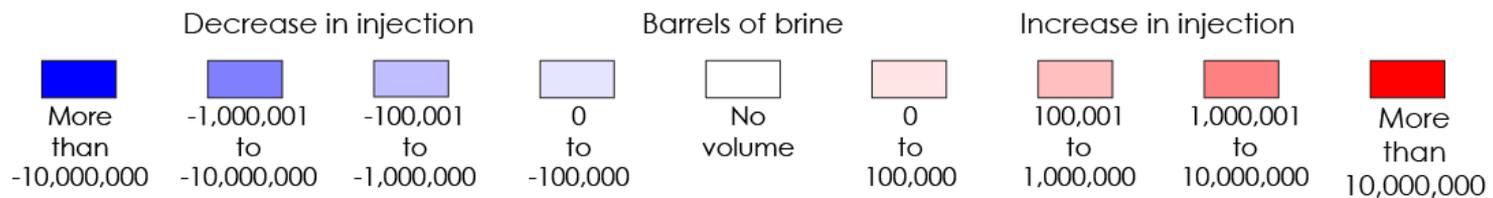
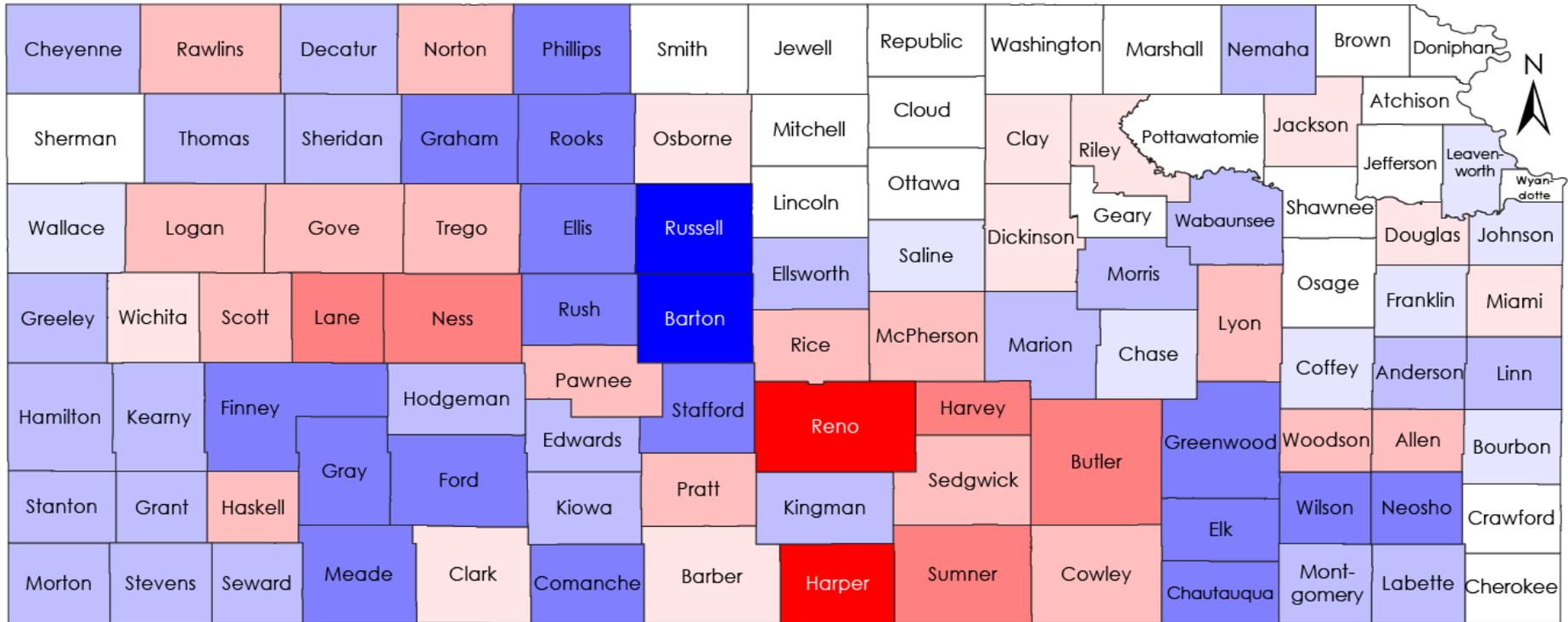
Change in oil production: 2013-2014



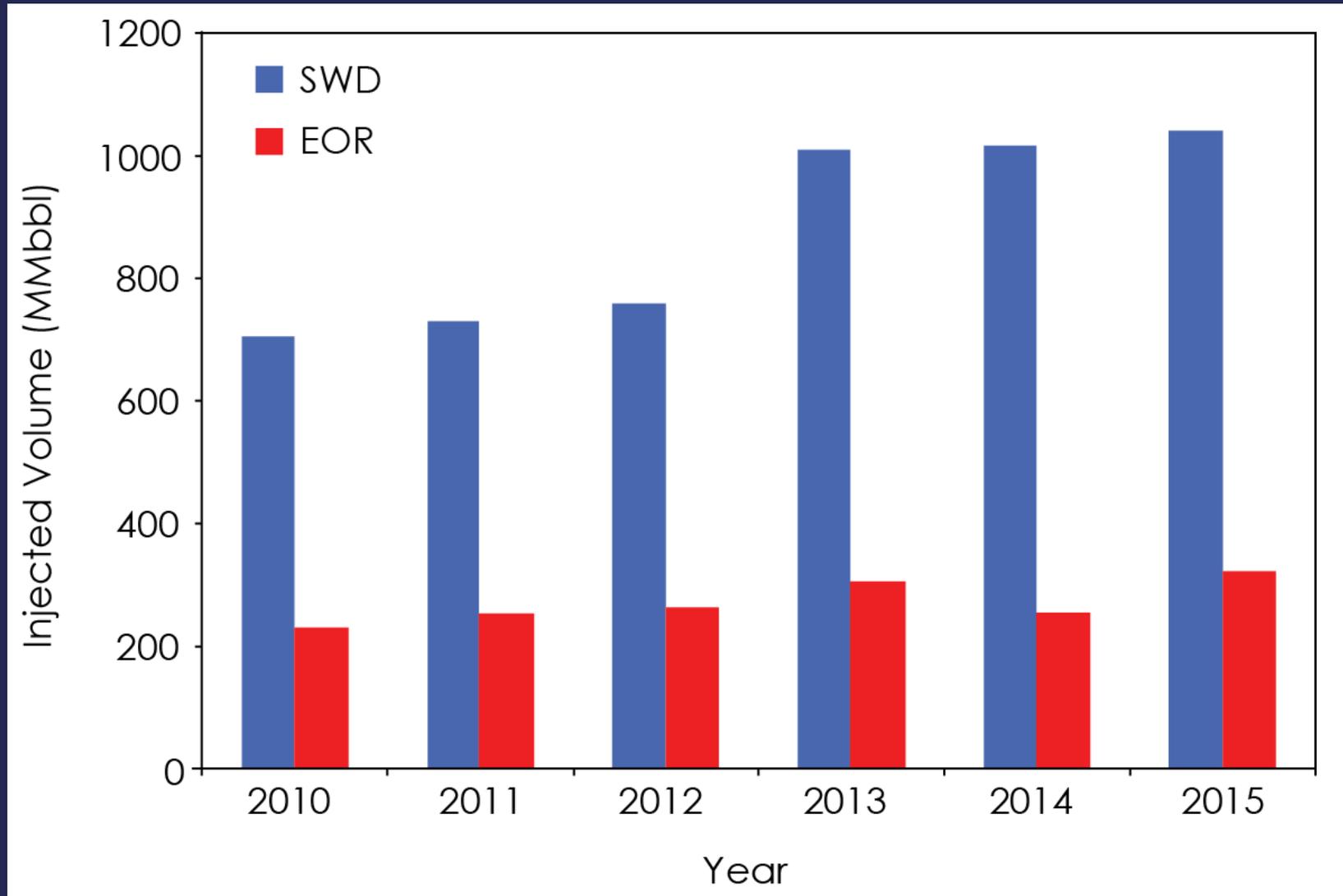
Change in gas production: 2013-2014



Change in disposal volumes: 2013-2014

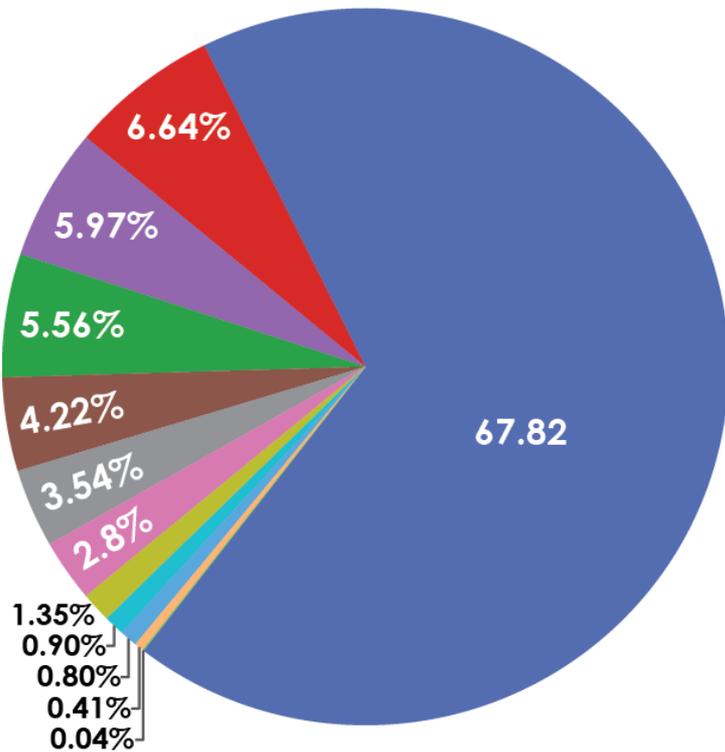


Saltwater disposal or EOR?

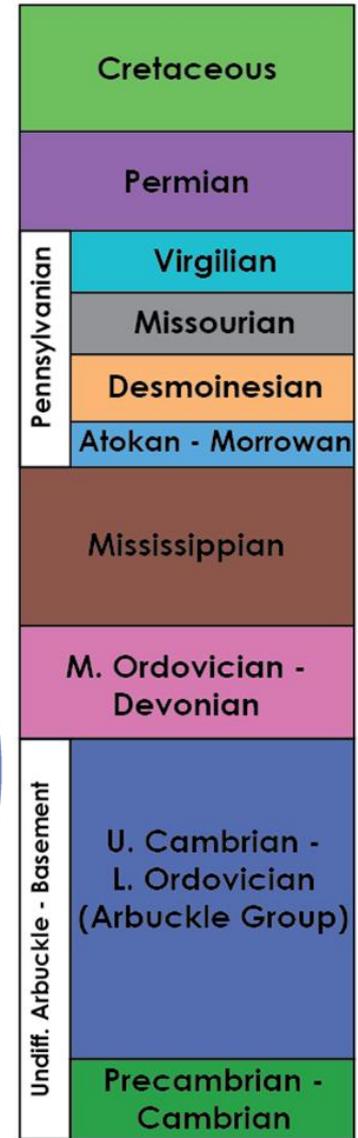
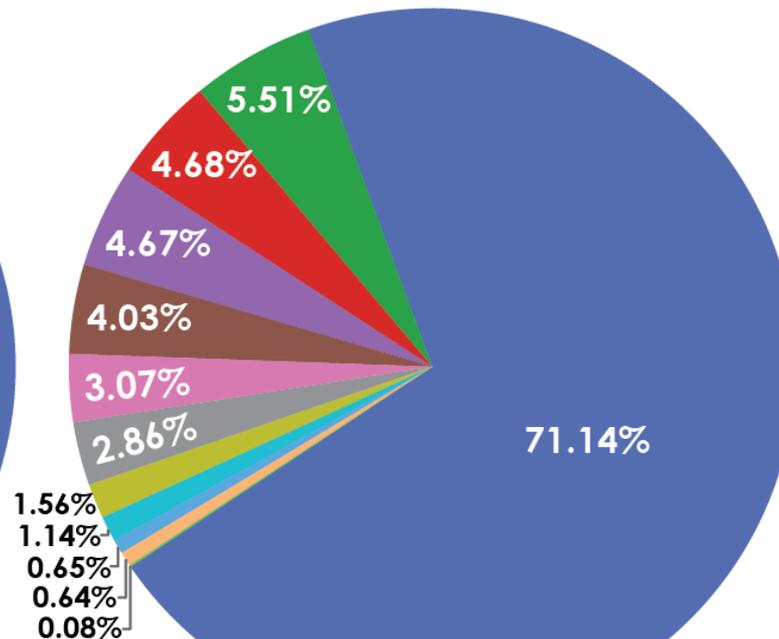


Injection zones by volume

2010

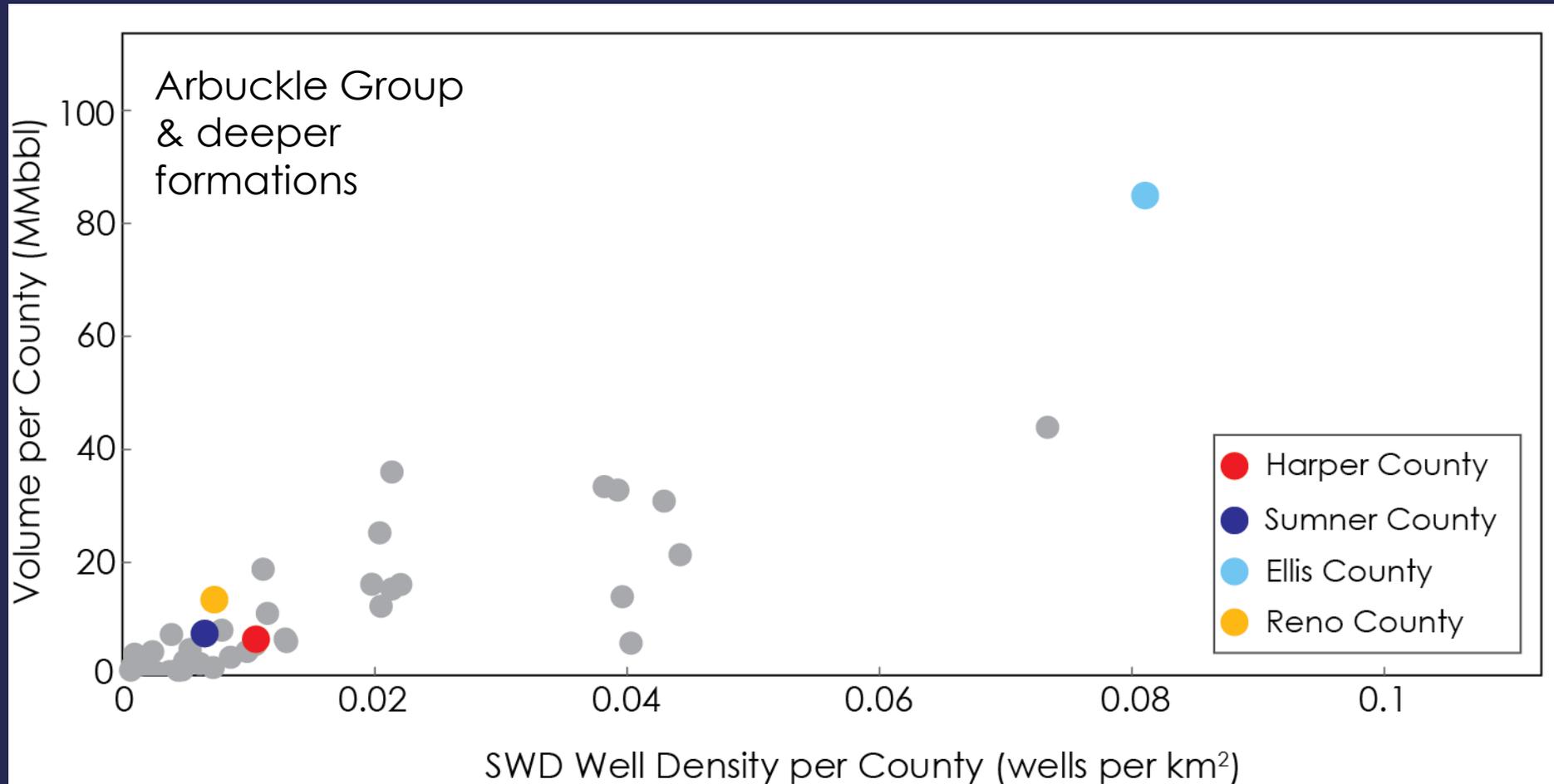


2014



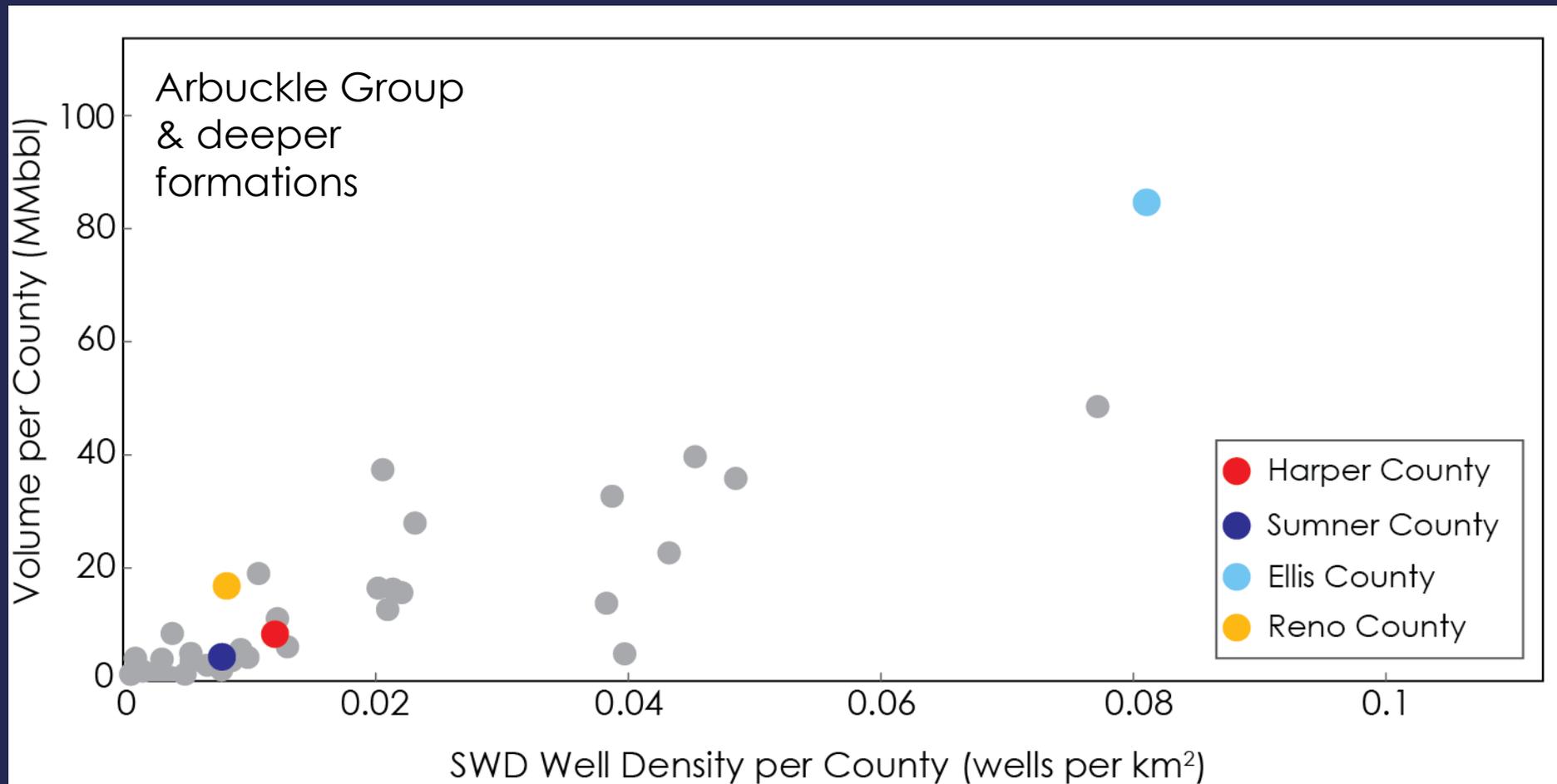
Well density vs. volume

2010



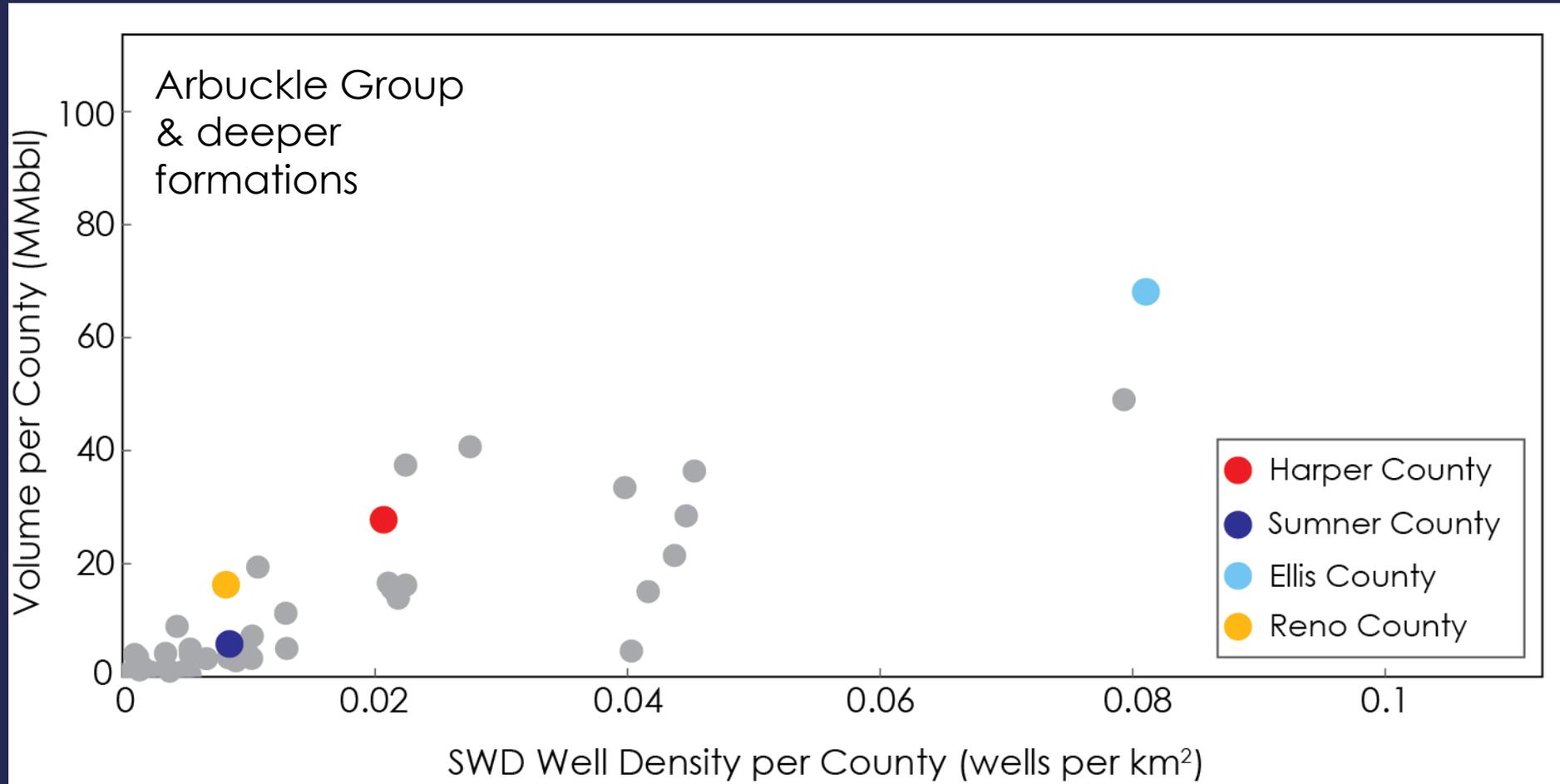
Well density vs. volume

2011



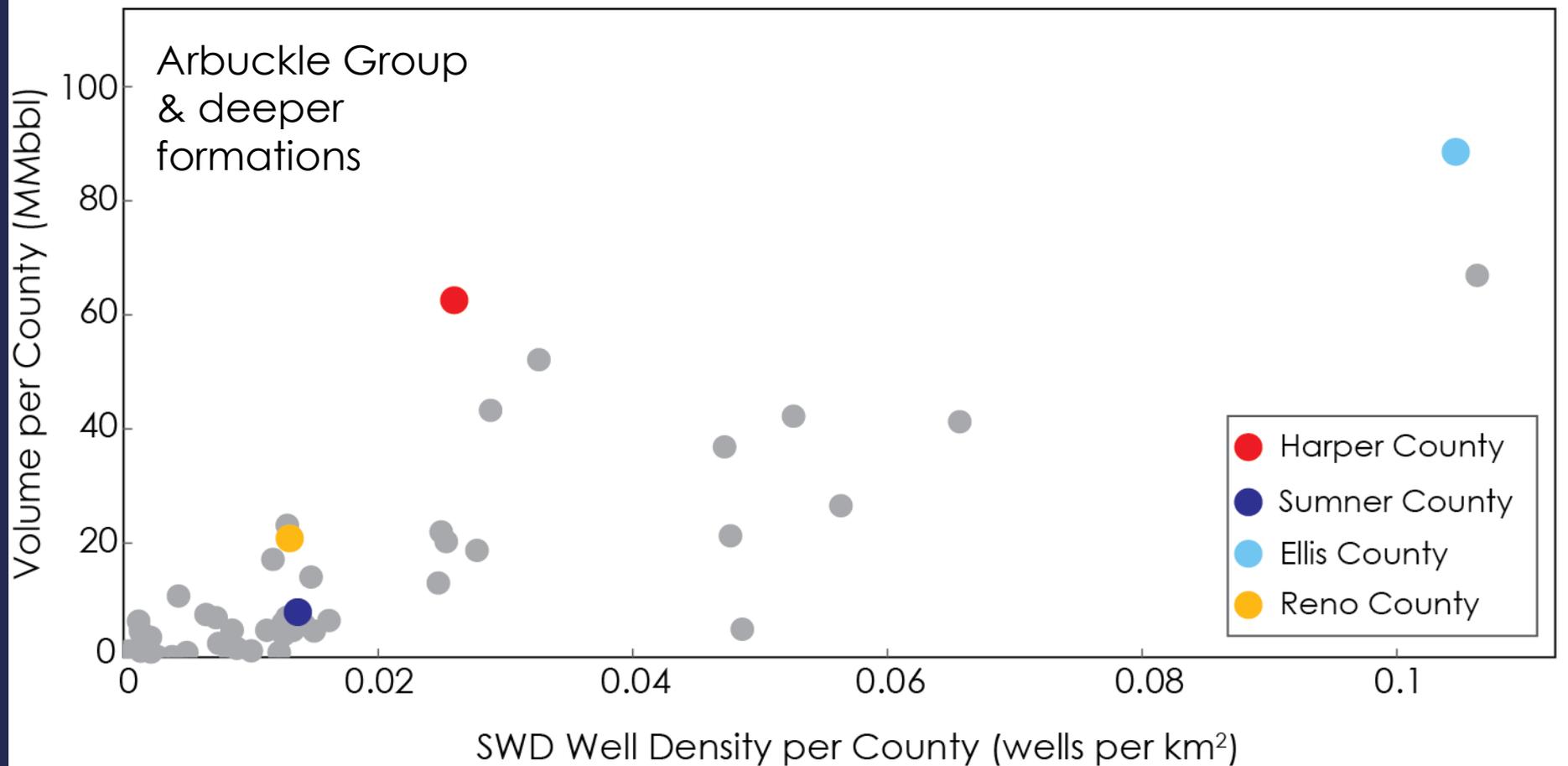
Well density vs. volume

2012



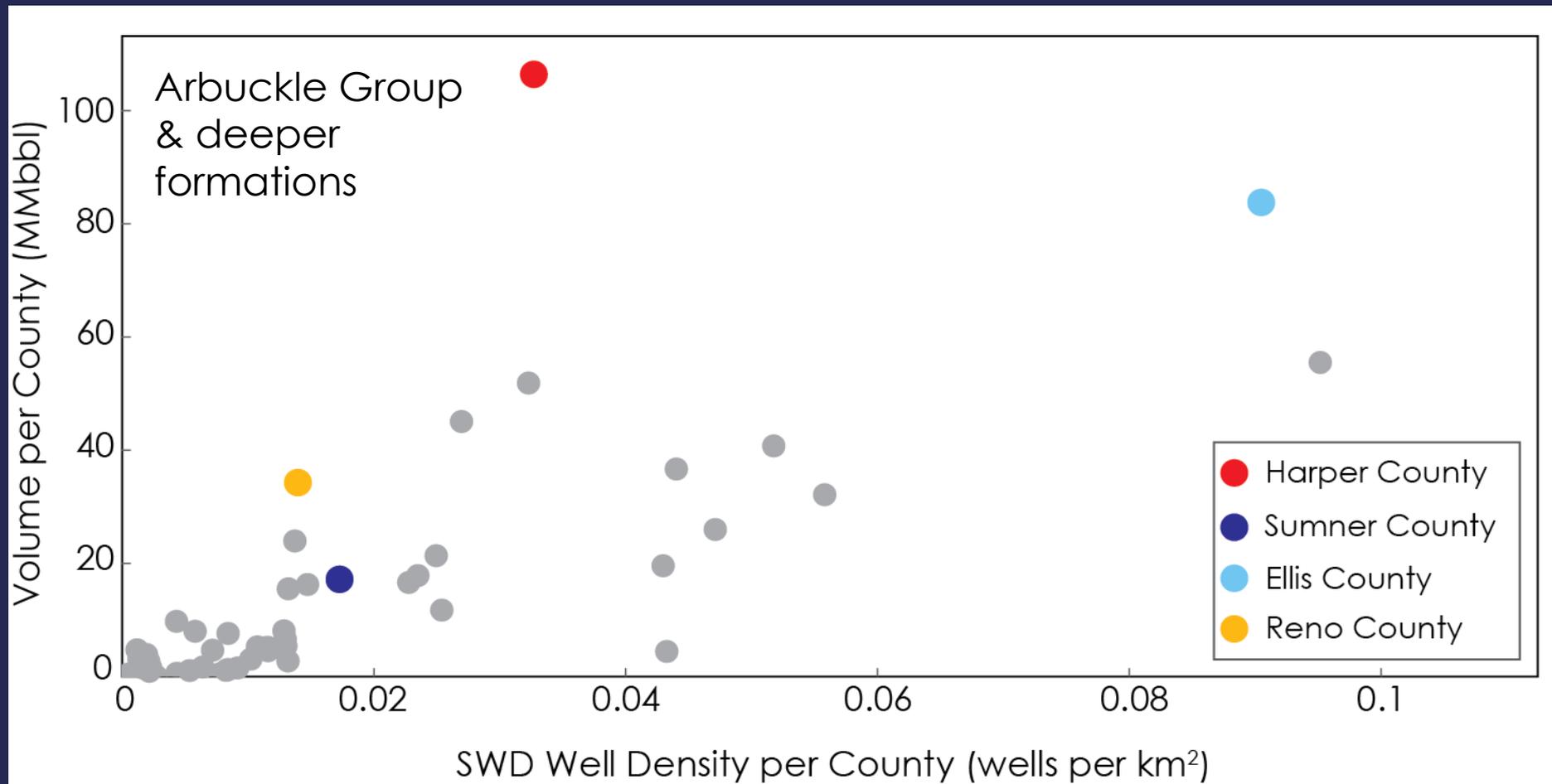
Well density vs. volume

2013



Well density vs. volume

2014

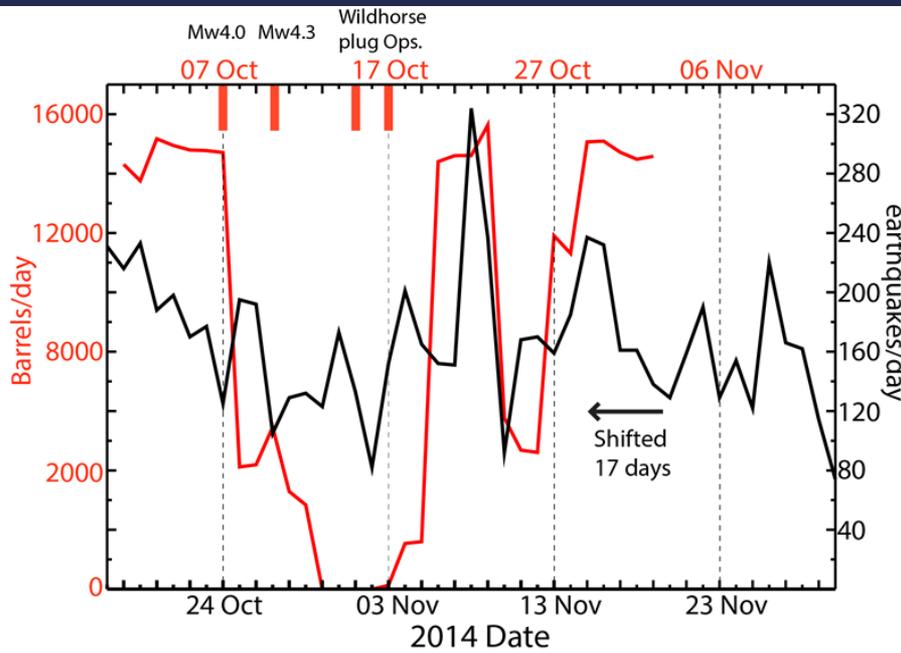


What are the data telling us?

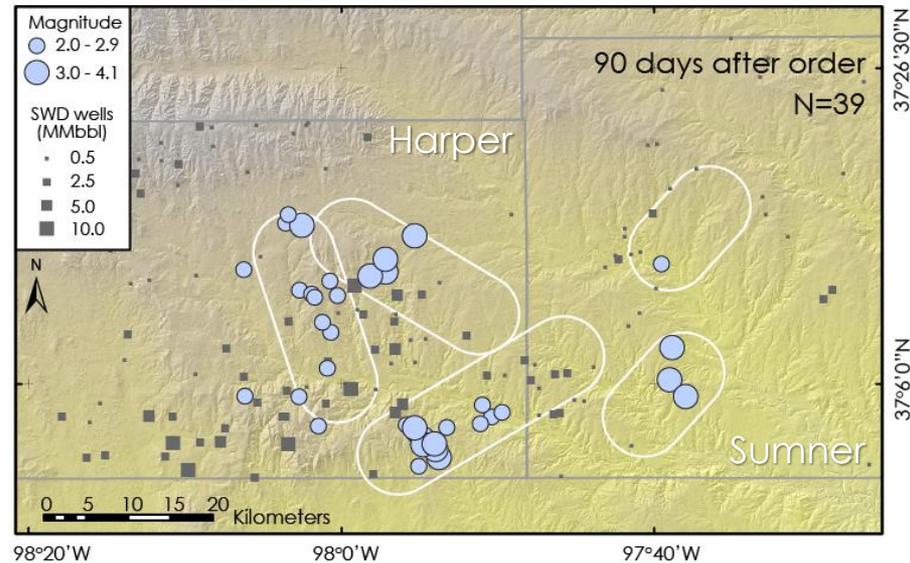
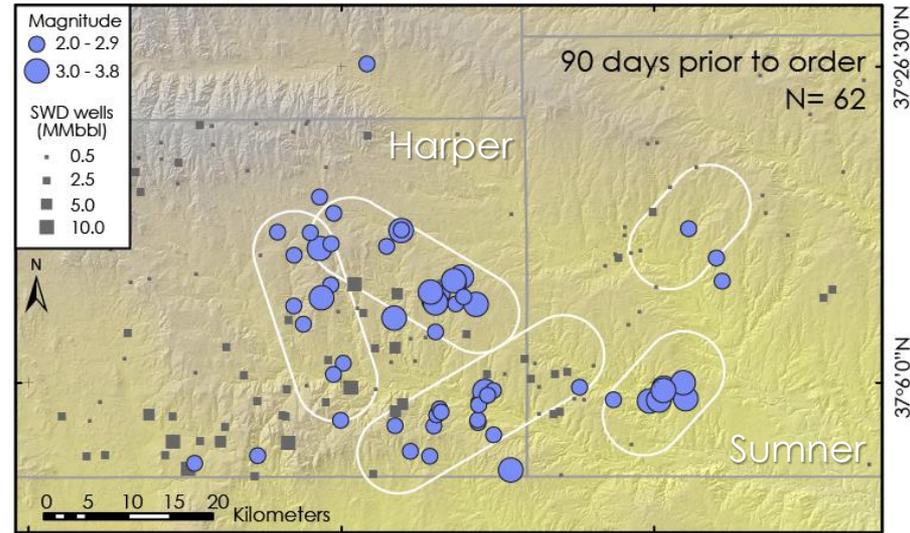
1. Brine disposal in Harper has surpassed all other counties in the state
2. Per-well-volumes in Harper are significantly higher than other large volume disposal counties
 - Harper vols. quadrupled, but well counts only increased 68% (41 to 68)
 - Ellis disposes of 84 MMbbl via 3x the wells (210)
3. Reducing per-well-volumes could be an effective mitigation strategy

Mitigation: Volumes reductions

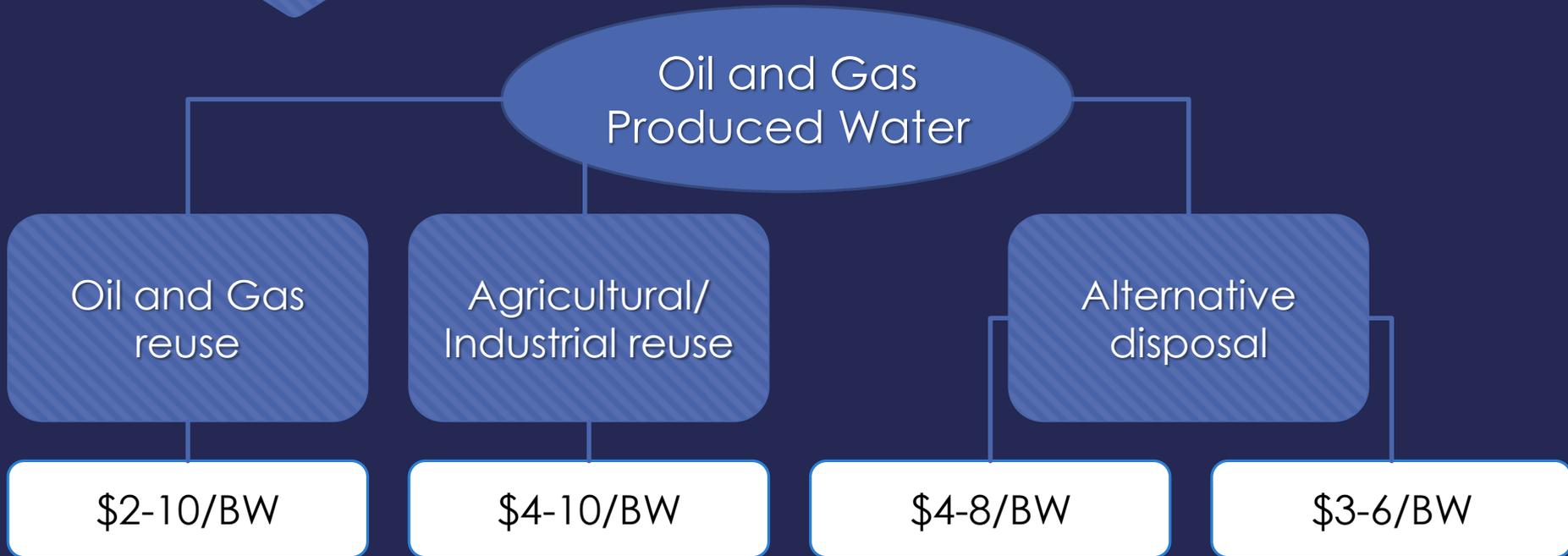
- KCC order, 03/15
 - 60% reduction
- Variable results due to complex geology



From McNamara et al. (2015)



Mitigation: Water reuse



- Distance to wellsite
- Treatment required
- Compatibility issues

- Desalinate to freshwater
- Additional transfer cost
- Solid waste disposal

- Desalinate for discharge
- Additional transfer cost
- Solid waste disposal

- Forced evaporation
- Surface storage
- Residual brine disposal

Issues to be resolved

1. Improve knowledge of subsurface faults and fractures
2. Expand understanding of reservoir properties
 - Depleted oil and gas reservoirs
 - Deep saline aquifers
3. Develop understanding of water distributions and chemistries (e.g., TDS and chlorides)
4. Develop regulatory framework for reuse

Summary & conclusions

- 75% of disposal in the state occurs in the Arbuckle and deeper formations
- Recent spate of earthquakes was preceded by a large increase in brine disposal volumes
- Large volumes can be safely injected into the Arbuckle, but concentrated high-rate disposal may be problematic
- Mitigation strategies include increasing the number of disposal wells, volumes cut-backs, and produced water reuse

Acknowledgements

Data sources:

- Kansas Corporation Commission
- Kansas Department of Commerce
- Kansas Geological Society's Walters Digital Library

Funding:

- USGS-EHP Grant G16AP00022

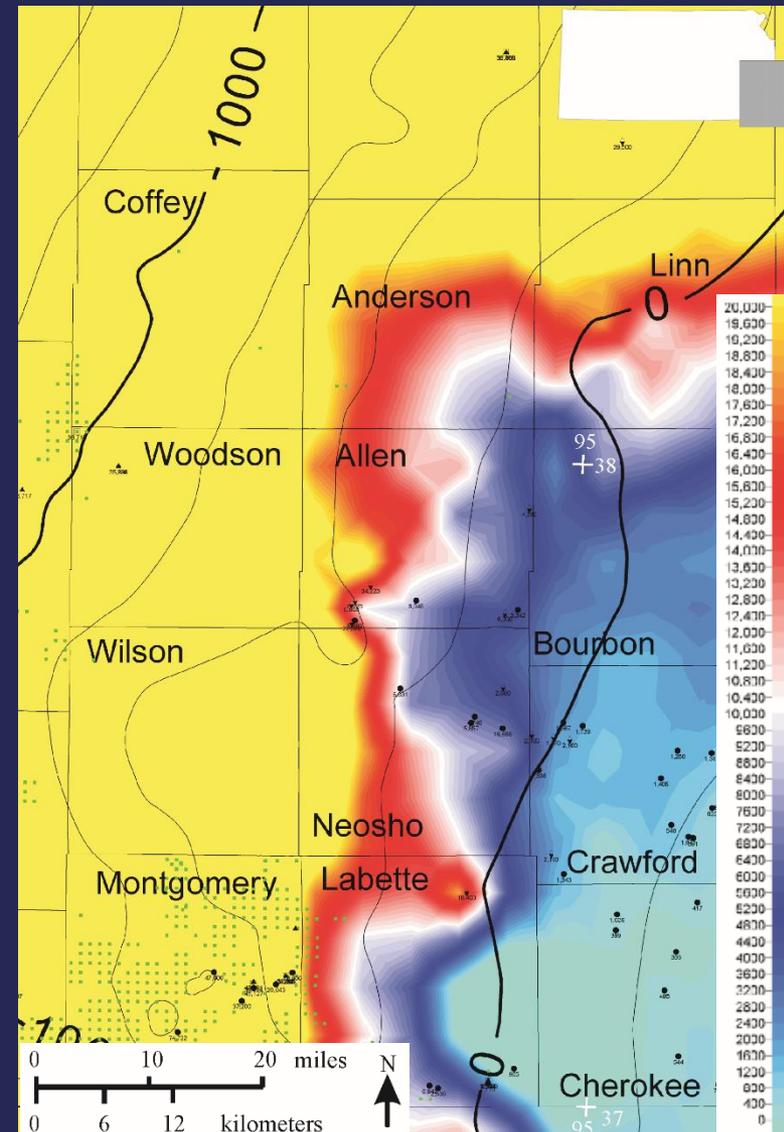
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Questions?

Challenges for reuse

- Produced water is complex
 - TDS; dispersed oil; dissolved and volatile organic compounds
 - Heavy metals; radionuclides; bacteria
 - Biocides, scale and corrosion inhibitors, etc.
- Compositions are spatially variable



Carr et al. (2005)