2020 & 2021 Earthquakes with consistent hotspots relative to Geologic Provinces

- Central KS Uplift
- Salina basin
- Hugoton embayment (Anadarko basin)
- Sedgwick basin
- Nemaha Uplift
- Forest City basin
- Cherokee basin
Earthquake Station Coverage: Kansas

USGS = 4 permanent

KGS operated stations = 30
STATUS: Request to Provide Data Needed for Improved Analysis ofInjection Practices to Study Influence on Seismicity

Class II wells of interest:
- all wells permitted for Arbuckle or deeper disposal
- all wells permitted for rates greater than 2000 bpd

Data of interest:
- actual daily volumes for all, rather than average daily volumes for some and monthly volumes for others
- daily operating pressures
- metered injectate
- monthly reporting of daily measurements
- annual SFL (after 24 hour shut in), representative fluid samples of injectate for density measurement

These data:
- would allow us to integrate most significant injection data from all industries and municipalities currently permitted for Arbuckle disposal.
- would provide opportunities to understand the response of the Arbuckle system in a fashion that could help customize regulations for local characteristics.
- might help to better understand the longer-term consequences of local and regional injection practices.

• Representative Elizabeth Bishop (retired)
• District 88 - Democrat
KEY PARTS OF THE ACTUAL PROPOSED BILL

HOUSE BILL NO.

By Committee on Appropriations

AN ACT requiring operators of Class II wells to submit certain reports to
the state corporation commission; amending K.S.A. 55-150 and K.S.A.
2020 Supp. 55-901 and repealing the existing sections.

Be it enacted by the Legislature of the State of Kansas:

Section 1. K.S.A. 55-150 is hereby amended to read as follows: 55-
150. As used in this act unless the context requires a different meaning:

(a) "Class II disposal well" means a well that inject fluids:

(1) That are brought to the surface in connection with natural gas
storage operations, or conventional oil or natural gas production and
may be commingled with waste waters from gas plants which are an
integral part of production operations, unless those waters are classified
as a hazardous waste at the time of injection; and

(2) for enhanced recovery of oil or natural gas.

(b) The state corporation commission is hereby directed to adopt
such rules and regulations as may be just and equitable to carry out
the provisions of this section. The commission shall promulgate rules
and regulations that require an owner or operator of a class II disposal
well permitted to dispose at the Arbuckle formation or deeper at a rate
greater than 2000 barrels per day to submit annually a static fluid level
as taken after a 24-hour shut-in and a representative fluid sample of
injectate for density measurement, and monthly reports detailing for all
such wells:

(1) Actual daily volume of metered injectate disposal; and

(2) daily operating pressures.
• Three wells offered by Berexco were constructed with restrictions at the bottom of the tubing reducing ID to less than 1.7” in one and 1.5” in other two. One had bottom hole obstacle—lost packer.

• Additional well suggested by Berexco was part of Wellington study, Arbuckle is cased off with only 20’ perf zone.

• Sandridge offered more than 30 wells with 6 prime targets with large diameter tubing.

• Sandridge very willing but liability issues ended discussions.

• Plan B—other suitable wells were identified and suffered from either liability issues or ‘what is in it for us’.

• Plan C—KCC controlled abandoned wells list had a half dozen possible, counsel from KCC—none viable.
Jewell County Cluster

Earthquake history
~3 in 1929
M3.0 in 2013
Basement Structure: contours & aeromag
Harper and Sumner Counties

2013 – 2014
USGS

2015 – 2020
KGS

2020 – 2021
KGS

560 Felt Earthquakes & Annual Injection Volume

- earthquake
- annual volume

- year
- magnitude
- volume (bbl)
Arbuckle pressures have been steadily increasing since around 2012 with a marked leveling off around 2016.
504 Earthquakes and Injection History: Hutchinson (2 mi radius)

4.9M 1/19/2020
Wichita Area Earthquakes

- 2015 to Oct 2020
- Nov 2020 to Present
Wichita Earthquakes and Local Stations

- 157 Wichita earthquakes (2 mi radius)
- KGS catalog earthquakes 2015-present

Arbuckle pressure has been steadily increasing since around 2003 with a marked change in slope around 2011.

KGS catalog earthquakes 2015-present

2 mi radius

normalized P (psi)


magnitude

1 2 3 4


magnitude

1 2 3 4

15 mi radius
Sequence of Earthquakes > M2 Wichita Cluster Between Thanksgiving and March 15, 2021
Probability of Wichita Area Felt Earthquakes

- Probability of felt natural earthquake in any 7-month time window
  - Number of earthquakes: 1, Probability: 99.9%
  - Number of earthquakes: 2, Probability: 5.5%
  - Number of earthquakes: 3, Probability: 0.2%
  - Number of earthquakes: 4, Probability: 0.003%
  - Number of earthquakes: 5, Probability: 0.0000%
  - Number of earthquakes: 6, Probability: 0.0000%
  - Number of earthquakes: 7, Probability: 0.0000%

- Probability of felt natural earthquake on a historic 30-year cycle
  - Probability of a 73-year earthquake drought: 0%

Graphs showing the probability of felt earthquakes by magnitude and year.
Hydraulic Diffusivity

Now that statistically there is very likely an anthropogenic influence an in-depth investigation has begun

search radius at various lag times for reasonable diffusivity (3 m$^2$/s), will be used to guide and inform our investigation

one month (6 mi) 6 months (14 mi) 12 months (21 mi)

Adamson-3

Oxy

Class I Class II 10 mi Wichita cluster
2020-Present Class I Disposal Volumes (daily within 15 mi)

~6 months
2020 Class I Disposal Volumes (monthly within 15 mi)

~ 6 months
2020 Class II Disposal Volumes (monthly within 15 mi)

~4 month average for all within 15 miles

~7 months
2020 Class I & II Disposal Volumes (monthly within 15 mi)

The graph shows the monthly disposal volumes from December 2019 to July 2021, with dates on the x-axis and magnitude on the y-axis. The volumes are represented by black dots, and the line graph indicates trends over the year.
Any Conclusions for Current Analysis?

- Wichita cluster
  - no smoking gun.
  - We are trying to integrate all the data we have.
  - Spatially, temporally, and statistically under sampled problem w/ inconsistent methodologies.
- Hutchinson cluster has responded how we suspected last year with recent events showing unique clustering.
- Seismicity in Harper/Sumner Co is responding consistent with total injected volumes and we are looking at all possible influences at injection changes with time.
- Over the last 10 years pressures in much of the Sedgwick basin have likely exceeded the triggering threshold.
- Cumulative injection has likely pushed much of the region above the triggering threshold, so activities that have historically not triggered earthquakes now might.