Potential for Induced Seismicity and Current Mitigation Efforts within Oklahoma

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Acknowledgements

Industry contributors to RPSEA and fault database

Oklahoma Independent Petroleum Association (OIPA)

USGS – providing many different temporary seismic stations

Significant Input from the Oklahoma Corporation Commission

Oklahoma Secretary of Energy and Environment

OU Mewbourne College of Earth and Energy
Oklahoma’s Increase in Earthquakes

Earthquake rates per year

### Magnitude 4 or Greater Earthquakes

- 1882-2008: 9
- 2009-2013: 3
- 2014: 15
- 2015: 0.1

### Magnitude 3 or Greater Earthquakes

- 1980-2008: 585
- 2009: 246
- 2010: 20
- 2011: 67
- 2012: 42
- 2013: 40
- 2014: 109
- 2015: 1.6
Area of greatest increase is about 15% of Oklahoma. Captures areas of significant waste-water disposal wells.
Cumulative Seismicity in Oklahoma

SWD well volumes (bbl/mon) in 2013

- up to 150,000
- 150,000 - 500,000
- greater than 500,000
- Regional Faults
- County

Summary of UIC Well Volumes in 2013 by Geologic Zone of Completion

Murray 2014, OGS OF1-2014

Index Location Map for Oklahoma
Mapped Faults in Oklahoma

Faults are compiled from industry contributions and published literature.
Interagency Cooperation

OCC UIC Program

- New Permit & Existing Permits

Data

- Fault Maps
- Earthquake Information
- Injection and Operational Data

OGS

- Optimally Oriented Faults
- Fault Database Project
- Earthquake Monitoring and Reporting
- Additional Studies

Industry, DOE and State of OK Support

- Industry Fault Database Contributors & OIPA
- Improvements to Seismograph Network
- Reservoir & Geomechanical Modeling RPSEA

Additional Studies

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Fault Database Project

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Improvements to Seismograph Network

- Improvements to Seismograph Network
Oklahoma Corporation Commission UIC Program

- The Underground Injection Control (UIC) program was created in 1974 by the Safe Drinking Water Act.
  - All wastes injected underground are required to comply.
- Oil Gas Conservation Division (OGCD) received primacy to run the UIC program for oil and gas activities in 1981.
  - Class II wells under the UIC definition
- Class II wells are classified in two types
  - 2D wells are Disposal Wells (SWD)
  - 2R wells are Enhance Recovery Wells (EOR).
    - EOR wells re-inject produced water back into the same producing formation to help extract the remaining oil.
  - In Oklahoma there are 4,626 SWD Wells and 7,037 EOR Wells
OCC UIC Program

- 2D or **Disposal wells** take waste-water and inject it into the subsurface

This water is not generally what we think of as water
  - High salinity >> sea water
  - Other hydro-carbon and chemical constituents

This waste-water comes from two primary sources
  - Naturally occurring water that is removed with oil and gas ("Produced" Water)
  - Hydraulic fracturing ("Flowback" Water) - relatively small amount of total volume

- Of the 4,626 disposal wells, there are 969 wells that are authorized for disposal into the Arbuckle formation.
OCC Traffic Light Protocol (Modified Permits)

1. Check location of proposed well with permitting map

2. If well location is within 3 miles of optimally oriented fault, within 6 miles of a seismic cluster, or within an area of interest ask operator for a technical meeting

3. Ask operator to demonstrate level of risk of induced seismicity (technical data)

4. Require application to go to hearing

5. Staff will take neutral position
Evolution of Area Of Interest

- Area Of Interest (AOI) includes seismic cluster.

  1. Cluster is defined as an area consisting of at least two events with epicenters within 0.25 miles of each other, with at least one event with a magnitude 3.0 or greater.

  2. AOI is a 10 km (6 mi) buffer from the cluster’s center.

Provided by the OCC
Areas of Interest

Date: 3/11/2015
OGCD Area Of Interest Arbuckle 2D Actions

- All Arbuckle Disposal Wells must provide the following:
  1. Operators must provide information to the OGCD that the Arbuckle disposal wells within the area of interest are not in contact or communication with the crystalline basement rock.
  2. Wells found not to be in contact or in communication with the crystalline basement will be allowed to resume normal operations.
  3. Wells found to be in contact or in communication with the crystalline basement must plug back.

- Directive sent out March 18th, operators have 7 days to begin reporting. Operators will have until April 18th to provide their information to the OGCD.

- Operators who do not provide this information or do not have an approved plugging schedule will be required to reduce their disposal volumes by 50% until they satisfy the directive.
Summary

- The rate of seismicity has increased dramatically and so has the seismic hazard
  - Earthquake preparedness is being communicated to the public

- Continue to provide data products to stakeholders and identifying new data sources

- Multi-agency cooperation and data exchange and sharing are critical in addressing issues with informed science

- Developing a greater understanding of physical processes in Oklahoma will help to inform future mitigation strategies