Salts, Seismicity, and the Search for a Solution
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Oil and gas (O&G) production are critical to the economy of Oklahoma, and our region. In Oklahoma, employment in the O&G sector has more than doubled since 2001, now representing 5% of the state’s work force. According to the Oklahoma Energy Resource Board (OERB), this industry accounted for 27.1 billion dollars in gross state product in 2013 and supported 15.5 billion dollars in earnings.

Much of this recent economic success has occurred due to new technologies such as horizontal drilling and hydro-fracturing, allowing O&G companies to extract greater volumes of oil and gas compared to previous decades. However, one consequence of O&G exploration is management and proper disposal of various waste products: drilling mud, produced water, and flow-back water—the latter two being most abundant.

Extremely high volumes of water, mixed with salts and compounds, are used during the hydro-fracturing process. Additionally, the hydro-fracturing process can release geologic water from deep below the normal drinking water aquifers. These deep geologic waters, known as “produced water”, are essentially ancient oceans, and therefore can be extremely saline and sodic. When some of this produced water flows up to the surface with the original water used for hydro-fracturing, this is known as “flow-back”.

After the drilling well is installed, produced water often accompanies the oil and gas that is extracted over the well’s lifetime, which can last many years. The volume of this produced water varies between geologic formations. Consider that the Mississippian formation is currently producing about 500,000 barrels (21 million gallons) of saline water per day.

Both flow-back and produced water must be disposed of safely and economically. While some of these waters are of sufficient quality to be used in stream and pond augmentation or irrigation, much of it is too salty. This water can range in salinity from 30,000 (similar to ocean salinity) to 250,000 mg/L of total dissolved solids (TDS), depending on its geologic formation origin. This excessive salinity coupled with the high volumes of water produced has made disposal a significant challenge for the industry.
Because of the excessive salinity and volume of water in need of disposal, the most economical option for disposal has historically been deep-well injection. Deep-well injection involves pumping the saline water into geologic formations that are located deep below drinking water aquifers. The process of deep-well injection is heavily regulated by the EPA to protect drinking water resources.

While this form of disposal has been successful for decades, the combination of increased injection volumes, rates and depths are leading to increased seismic activity. In 2015 Oklahoma experienced 904 earthquakes with magnitude 3 or greater, which according to the Oklahoma State Geological Survey Director and Seismologist, was due to a perfect storm of conditions and excessive deep-well injection into the Arbuckle. Essentially, deep-well injection of excessive water volumes into the Arbuckle formation at excessive depths near the granite “basement” resulted in the largest increase in seismicity in history.

The Oklahoma Corporation Commission (regulating body for the O&G industry) has reacted to this problem by limiting the depth and volume of deep-well injection into the Arbuckle; however, the problem still persists. While some have suggested solving the problem by moving the injection wells into formations other than the Arbuckle, this is impractical and would essentially cripple the O&G industry. No other formations have the ability to accept such large volumes of water. Therefore, alternatives to deep-well injection must be developed.

Because the greatest volumes of water in need of disposal tend to be extremely saline, disposal options are limited. Such water is not suitable for traditional irrigation. One acre of cropland could only handle about 45 barrels once every several years--a single well located in the Mississippian formation would require about 4 acres/day for disposal.

Others have proposed reusing the produced water for algal fuel production, hydro-fracturing, and cooling water. However, such secondary uses do not result in true disposal or elimination of the biggest contaminant of concern: salt. As a result, many sophisticated treatment technologies have been developed for removing salt from produced waters, resulting in water that can be used for drinking, irrigation, or stream augmentation. The problem with most of these technologies is that they require high amounts of energy and capital, often uneconomical for highly saline waters. Even if an energy-efficient technology was developed to remove the salt from the water, there still remains the need to dispose of the separated solid salt in a safe manner.

In order to eliminate the earthquakes, an economical alternative to deep-well injection must be developed. Ultimately, this means finding a use for enormous amounts of salt or salt water. The search continues for a solution to keep the ground below us and our economy stable.

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