OBJECTIVES

• Discuss how the world of water disposal has changed with evolving resource development practices.

• Provide an overview of the issues and challenges facing operators associated with planning, operation, and risk management at SWD facilities.

• Demonstrate how Best Management Practices are used to address these issues.
TOPICS TO BE COVERED

• Injection History and Changing Injection Dynamics
• UIC Regulation
• Public Opposition
• Siting
• Fires and Spills
• Containment Options
• TENORM and Solids Disposal
• Water Protection
• Mechanical Integrity
• Geology
• Induced Seismicity

Commercial Salt Water Disposal Well Facility, Eagle Ford Shale Area, South Texas
Source: ALL Consulting, 2012
INJECTION HISTORY

- Underground injection has been used a water management practice since operators began enhanced oil recovery in the 1930’s.

- Injection volumes have been relatively consistent since the 1970s.
  - Note: Between 2007 and 2012, U.S. oil and gas production increased by 29% and 22%, respectively from 2007 to 2012, but water production increased by less than 1%.

- Historically, Class II injection wells have been used for EOR or disposal for the vast majority of water produced from oil or gas wells.

- Shale revolution shifting injection from EOR to disposal.

- Although there have been and will continue to be changes and advancements, the major tool for produced and flowback water management remains Class II wells.

Source: www.water.epa.gov
REGULATION & PRIMACY

• There are approximately 180,000 Class II wells in the U.S.

• About 20% or 36,000 of Class II wells are disposal wells.

• 40 states and 2 Indian Tribes have primacy of their Class II program.

Source: EPA 2017
• Compliance information is available throughout Texas and the Eagle Ford:
  • Most violations are for late/no reporting (86%)
  • MIT failures are next highest (5%)
  • Breakout of injected fluid accounts for 3%

• Simple environmental ESAs are inadequate for evaluating SWDs
  • Assessing Corrosion
  • Well integrity/confinement
  • Area of review/USDWs
  • Communication/Containment

SWD Violations (2011)

- Reporting
- MIT Failure
- Breakout of Inj Fluid
- Packer Depth
- Injection Pressure
- Confinement
- Annular Pressure
- Unauthorized Commercial Facility
PUBLIC OPPOSITION

Increasing disposal volumes leads to increasing injection opposition.

Source: www.gosangelo.com
Source: www.bradfordtoday.com
Source: www.ecowatch.com
SITING CONSIDERATIONS

- Proximity to water production (oil and gas production) areas
- Industrial area with fewer neighbors
- Geology
  - Adequate disposal capacity
  - Avoid faulting
- Large area for turn-around
- Road Network
  - Easy highway access
  - Wide straight roads
- Avoid sensitive receptors
  - Floodplain
  - Waterbodies

Source: ODNR, 2013
NOT AN IDEAL LOCATION

Source: Google Earth, 2015
Lightning-Induced Fires
- The Bakken in North Dakota and Eagle Ford in south Texas have seen lightning strikes ignite hydrocarbons at brine disposal facilities
- May result in injury and costly litigation

Brine and Water Spills
- Tank Maintenance
- Adequate secondary containment
- Well designed unloading facilities

Lightning-induced fire near Alexander, N.D. in 2014
Source: McKenzie County/Karolin Rockvoy, 2014
• Three common berm options:
  • Steel dike
  • Concrete dike
  • Earthen dike with min. 30 mil liner
• Must be capable of containing fluids in event of release.
• Concrete unloading pad with drain and sump to collect any spillage is required.
TENORM AND SOLIDS DISPOSAL

- NORM is naturally-occurring radioactive material which commonly contains uranium, thorium, radium, or lead-210.

- TENORM (technologically enhanced concentrated by man-made actions (aka, technologically enhanced) in tank bottoms, pipe scale, and filter media.

- Radium-226 and Radium-228 are the predominant TENORM issues with oil and gas.

- TENORM generally regulated by state health departments.

- Requirements for testing or manifesting of TENORM solid wastes.
  - At Ohio Class II SWD facilities, solids are required to be tested for TENORM.
  - Solids may potentially be manifested for out of state shipment without testing.

Source: Carpenter, 2016
AREA OF REVIEW (AOR)

• **AOR investigation**
  • Determine AOR using fixed radius (¼ to ½ mile) or zone of endangering influence equation
  • Identify potential conduits and ensure proposed measures are adequate to protect USDWs
  • Conduct an evaluation of all wells within the AOR

• **Corrective Action**
  • Monitoring of problem wells
  • Remedial cementing
  • Plugging or re-open and re-plugging of inadequately plugged wells

Source: DMRM, 2006
WATER PROTECTION

• The surface casing is set to protect all USDWs.

• Depending upon the depth of the injection well, intermediate casing(s) may be set.

• The production casing is set and cemented above the top of the injection zone.

• State regulations on production casing cement height in different states can vary from 100 to 300 feet.

• This construction provides multiple layers of USDW protection.

Source: DOGRM, 2013
A well has **Mechanical Integrity** if:

- **Internal Integrity**
  - There is no significant leak in the casing, tubing, or packer; and

- **External Integrity**
  - There is no significant fluid movement into an underground source of drinking water (USDW) through vertical channels adjacent to the injection wellbore.

The **Mechanical Integrity Failure** occurs when:

- A gauge pressure loss of 5% or greater occurs during an MIPT (or a pressure loss greater than 5 psi in Class I wells);
- The annulus of the well cannot be completely filled with water;
- The annulus of the well cannot maintain pressure;
- While injecting, water flows from the casing valve when it is open, thus indicating a communication problem in the well;
- There is a vacuum on the annulus when the casing valve is opened;
- An inspector arrives at the well for a scheduled test, but the operator is absent or unprepared for the test.
WELL TESTING REQUIREMENTS

• Both federal and state regulatory agencies have specific disposal well testing requirements.

• Part I and Part II of (internal and external) mechanical integrity tests (MIT) have to be demonstrated prior to injection.

• Five-year MIT or continuous monitoring for mechanical integrity is a regulatory requirement.

• Other tests that are deemed necessary by regulatory agencies, such as temperature logs, tracer surveys, noise logs, or pressure fall-off tests can be required on a case-by-case basis.
FAVORABLE GEOLOGIC CONDITIONS

• Proper geological evaluation is critical to a successful large-scale disposal operation.

• Knowledge of local geologic conditions and regional variation is highly important in selecting optimal disposal intervals.
  • For example, PA only has 8 active disposal wells due to a lack of adequate disposal zones through a majority of the state.

• As opposed to relatively shallow EOR operations, higher volumes of water are now being injected at greater depths and in many cases near basement rock (Arbuckle in the Woodford and Ellenberger in Permian and Barnett plays).

• With induced seismicity playing a big role in Class II operations, avoidance of geologic structures and the proximity of a disposal zone to the Precambrian basement must be considered.

Source: ALL Consulting, 2014
INDUCED SEISMICITY (IS)

• Induced seismicity associated with the oil and gas industry has become a national issue in the United States.

• Many states, including Arkansas, Kansas, Ohio, Oklahoma, and Texas, have developed or are developing regulations to address concerns regarding alleged induced seismicity related to oil and gas development.

• The main focus has been directed at Class II saltwater disposal operations (SWD).

Source: StatesFirst, 2015
SEISMIC MONITORING

- Single or multi-sensor monitoring system.
- Real-time epicenter and hypocenter location.
- Data processing to determine likely cause of seismic event (e.g. mine blast, injection, etc.)
- Automatic notification emails pre-determined contacts upon exceedance of event thresholds.

Note: the quantity and locations of seismometers and accelerometer will be determined based on site-specific conditions and considerations.

Source: ALL Consulting, 2016
IS MITIGATION

- Accepted mitigation uses modified traffic light systems:
  - Green Zone: Operations continue as planned
  - Yellow Zone: Increase monitoring as appropriate, reduce injection volume and/or pressure, and notify regulatory agency.
  - Red Zone: Further limit or cease injection and notify regulatory agency.
- A plan must be in place to resume standard injection when certain parameters are met.
SUMMARY

• Water disposal volumes have remained relatively constant, but the methods used to manage the water have evolved.

• Well planned and properly constructed Class II disposal wells will continue to be the best practice for managing flowback and produced water in the shale plays.

• SWD facilities face many issues, most of which are manageable with proper planning, training, and experience.

• Induced seismicity is currently the hot topic for Class II SWD wells, but can be managed with proper planning, monitoring, and mitigation.
Contact Information

J. Daniel Arthur, P.E., SPEC
Project Manager
darthur@all-llc.com
ALL Consulting
1718 S. Cheyenne Ave.
Tulsa, OK 74119
www.all-llc.com