Class II UIC Webinar Series

GROUNDWATER PROTECTION COUNCIL

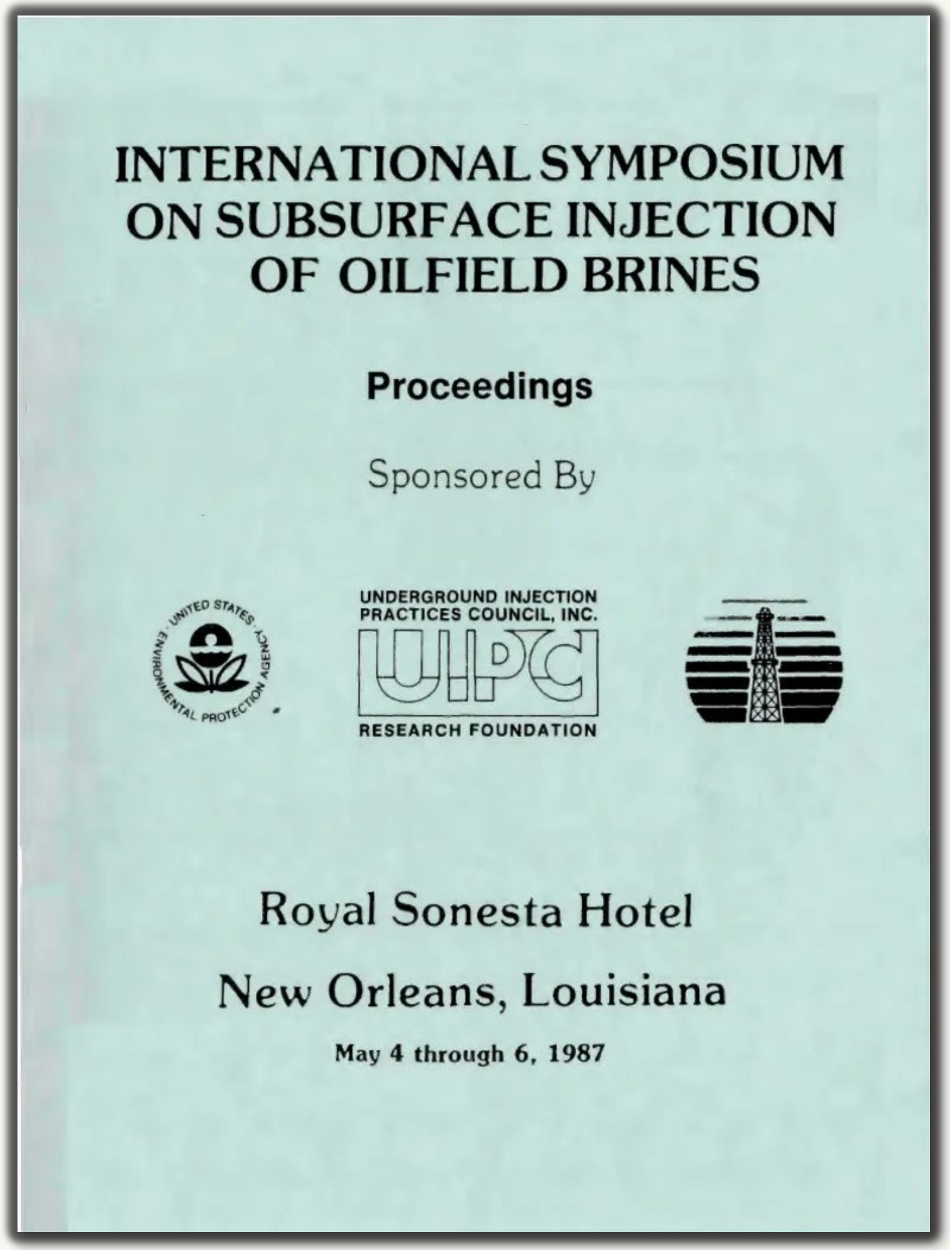
ALL CONSULTING
GOVERNMENT RELATIONS - ENERGY - PLANNING - TECHNOLOGY
ENGINEERING - ENVIRONMENTAL

* Webinar Series Kick-Off *

Class II Underground Injection Control (UIC) Program
Technical History and Program Evolution

Introduction and Overview of the Class II UIC Program

In this introductory start of the Webinar Series, a general history of the program will be presented and various major components, drilling & completion practices/variations, permitting & regulatory requirements, various types of well testing, operational considerations, monitoring & reporting, risk management, injection induced seismicity, fluid migration, and well closure.



INTERNATIONAL SYMPOSIUM ON SUBSURFACE INJECTION OF OILFIELD BRINES

Proceedings

Sponsored By

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

UNDERGROUND INJECTION PRACTICES COUNCIL, INC.
UIPC
RESEARCH FOUNDATION

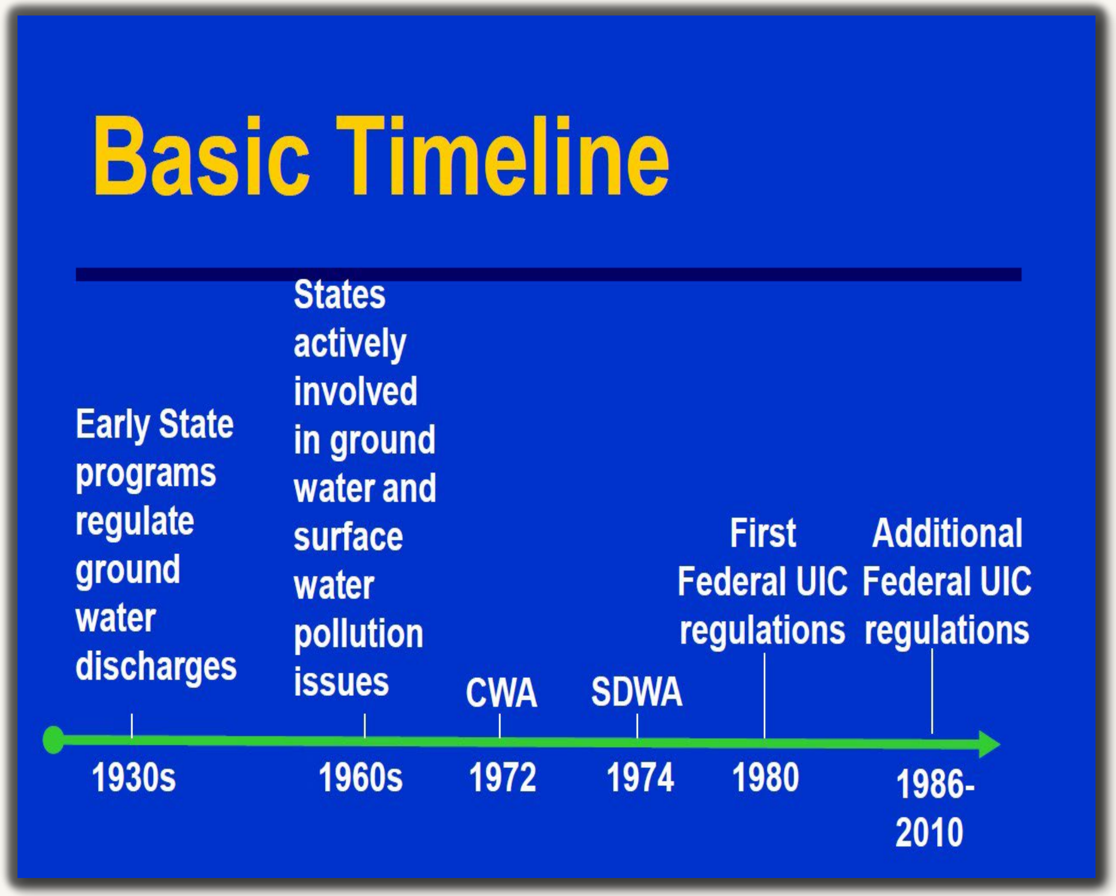
Royal Sonesta Hotel

New Orleans, Louisiana

May 4 through 6, 1987

History of the UIC Class II Program

- **Prior to 1930's**: Produced water "discharged"
- **1930s**: The first documented oilfield brine disposal via underground injection
- **1972**: Congress passes Clean Water Act (CWA)
- **1974**: The Safe Drinking Water Act (SDWA) is passed
- **Early 1980s**: Federal UIC regulations under Parts 144 thru147
- **1980**: EPA starts awarding primacy to oil and gas producing states



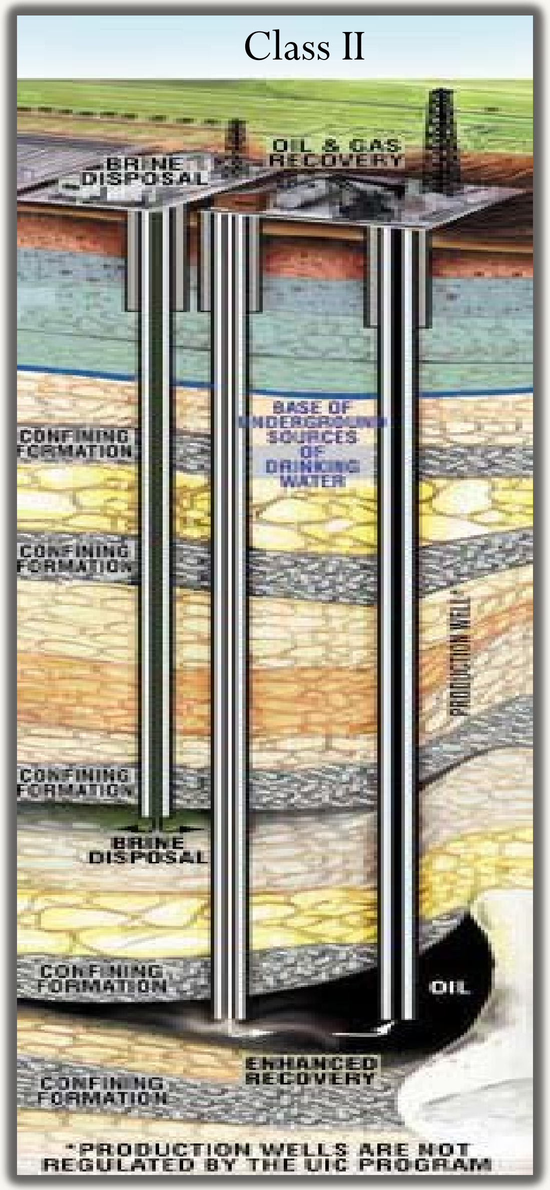
Source: EPA, 2018

Class II Wells

- Class II saltwater disposal wells (SWDs) are used to inject fluids and/or gases associated as byproducts from the drilling, completion, stimulation and treatment, production, and operations of oil and natural gas wells and facilities. Disposal wells typically inject back into depleted oil and gas reservoirs or into saline reservoirs that are not productive of oil and gas.

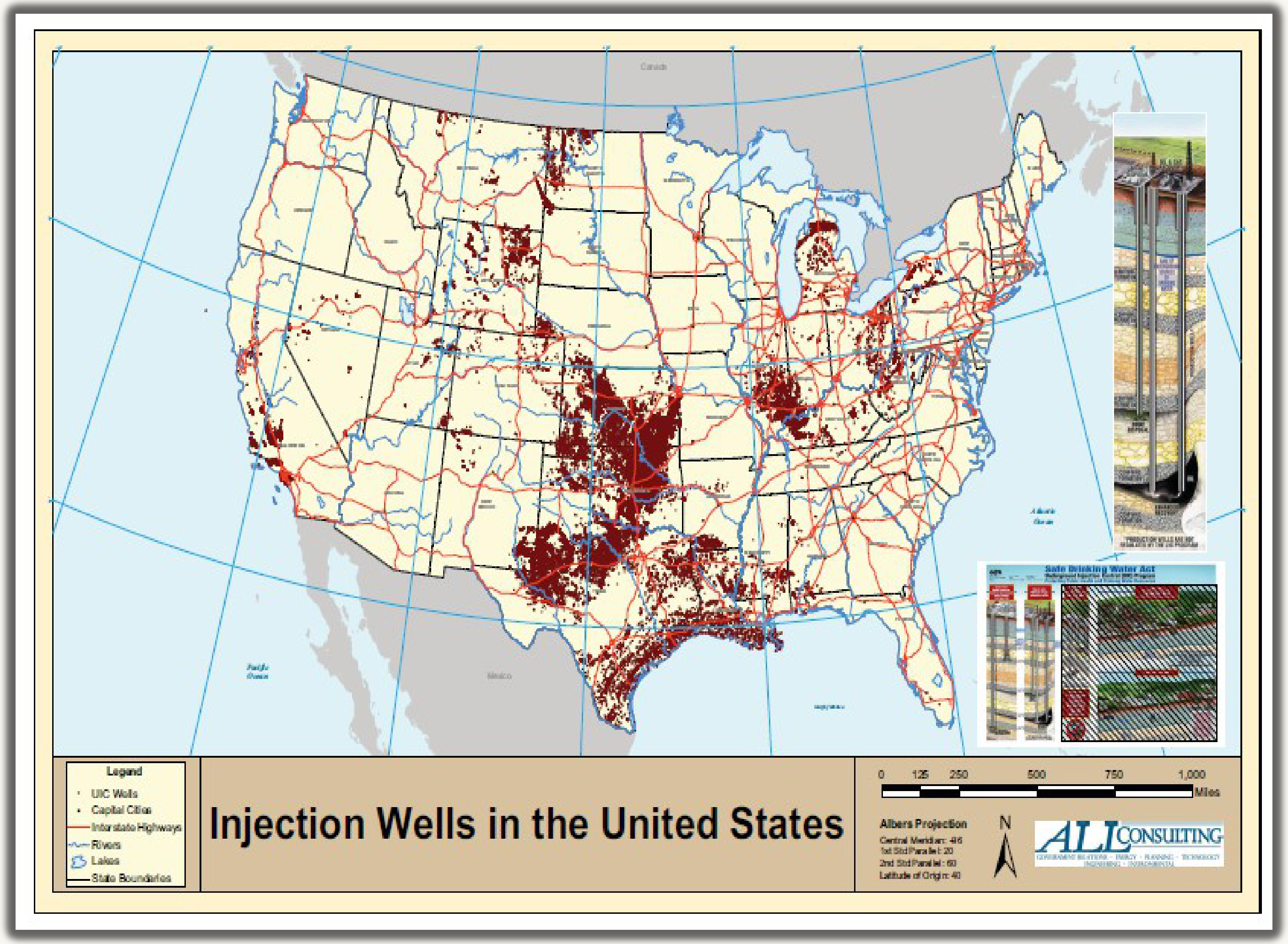
- Class II enhanced recovery injection wells are used to inject fluids and/or gases (brine, fresh or brackish waters, steam, polymers, natural gas, flue gas, and carbon dioxide) back into the producing oil and gas reservoir for additional residual oil recovery or for reservoir pressure maintenance. Class II enhanced recovery wells represent approximately 80% of all Class II injection wells in the United States.

- Class II liquid storage wells are used to inject fluids that are at standard temperature and standard pressure into underground caverns for storage. The United States Strategic Petroleum Reserve is an example of Class II storage.



UIC Class II Injection Wells

- There are over 180,000 Class II wells in the U.S.
- It is estimated that over two billion gallons of fluids are injected into Class II wells every day in the United States.
- 33 states have Class II wells and 31 states, and 3 territories have primacy of their Class II program
- U.S. EPA shares regulatory responsibility for Class II in 6 states – AZ, IA, ID, NY, PA, and VA.



Class II UIC Fluids Allowed

- Class II saltwater disposal wells are used to inject fluids and/or gases associated as byproducts from the operations of oil and natural gas wells and facilities.
- Disposal wells typically inject back into:
  - Depleted oil and gas reservoirs
  - Saline reservoirs that are not productive of oil and gas.
- These fluid waste streams fall under the exemption of the Resources Conservation and Recovery Act (RCRA) for oil and gas fluid waste.

Source: ALL Consulting, 2020

EPA United States Environmental Protection Agency

Exemption of Oil and Gas Exploration and Production Wastes from Federal Hazardous Waste Regulations

Printed on paper that contains at least 30 percent postconsumer fiber.

Exempt E&P Wastes

- Produced water
- Drilling fluids
- Drill cuttings
- Rigwash
- Drilling fluids and cuttings from offshore operations disposed of onshore
- Geothermal production fluids
- Hydrogen sulfide abatement wastes from geothermal energy production
- Well completion, treatment, and stimulation fluids
- Basic sediment, water, and other tank bottoms from storage facilities that hold product and exempt waste
- Accumulated materials such as hydrocarbons, solids, sands, and emulsion from production separators, fluid treating vessels, and production impoundments
- Pit sludges and contaminated bottoms from storage or disposal of exempt wastes
- Gas plant dehydration wastes, including glycol-based compounds, glycol filters, and filter media, backwash, and molecular sieves
- Workover wastes
- Cooling tower blowdown
- Gas plant sweetening wastes for sulfur removal, including amines, amine filters, amine filter media, backwash, precipitated amine sludge, iron sponge, and hydrogen sulfide scrubber liquid and sludge
- Spent filters, filter media, and backwash (assuming the filter itself is not hazardous and the residue in it is from an exempt waste stream)
- Pipe scale, hydrocarbon solids, hydrates, and other deposits removed from piping and equipment prior to transportation
- Produced sand
- Packing fluids
- Hydrocarbon-bearing soil
- Pigging wastes from gathering lines
- Wastes from subsurface gas storage and retrieval, except for the non-exempt wastes listed on page 11
- Constituents removed from produced water before it is injected or otherwise disposed of
- Liquid hydrocarbons removed from the production stream but not from oil refining
- Gases from the production stream, such as hydrogen sulfide and carbon dioxide, and volatilized hydrocarbons
- Materials ejected from a producing well during blowdown
- Waste crude oil from primary field operations
- Light organics volatilized from exempt wastes in reserve pits, impoundments, or production equipment

Non-Exempt Wastes

- Unused fracturing fluids or acids
- Gas plant cooling tower cleaning wastes
- Painting wastes
- Waste solvents
- Oil and gas service company wastes such as empty drums, drum rinsate, sandblast media, painting wastes, spent solvents, spilled chemicals, and waste acids
- Vacuum truck and drum rinsate from trucks and drums transporting or containing non-exempt waste
- Refinery wastes
- Liquid and solid wastes generated by crude oil and tank bottom reclaimers [1]
- Used equipment lubricating oils
- Waste compressor oil, filters, and blowdown
- Used hydraulic fluids
- Waste in transportation pipeline related pits
- Caustic or acid cleaners
- Boiler cleaning wastes
- Boiler refractory bricks
- Boiler scrubber fluids, sludges, and ash
- Incinerator ash
- Laboratory wastes
- Sanitary wastes
- Pesticide wastes
- Radioactive tracer wastes
- Drums, insulation, and miscellaneous solids

[1] Although non-E&P wastes generated from crude oil and tank bottom reclamation operations (e.g., waste equipment cleaning solvent) are non-exempt, residuals derived from exempt wastes (e.g., produced water separated from tank bottoms) are exempt. For a further discussion, see the Federal Register notice, Clarification of the Regulatory Determination for Waste from the Exploration, Development, and Production of Crude Oil, Natural Gas and Geothermal Energy, March 22, 1993, Federal Register Volume 58, Pages 15284 to 15287.

Source: EPA, 2002

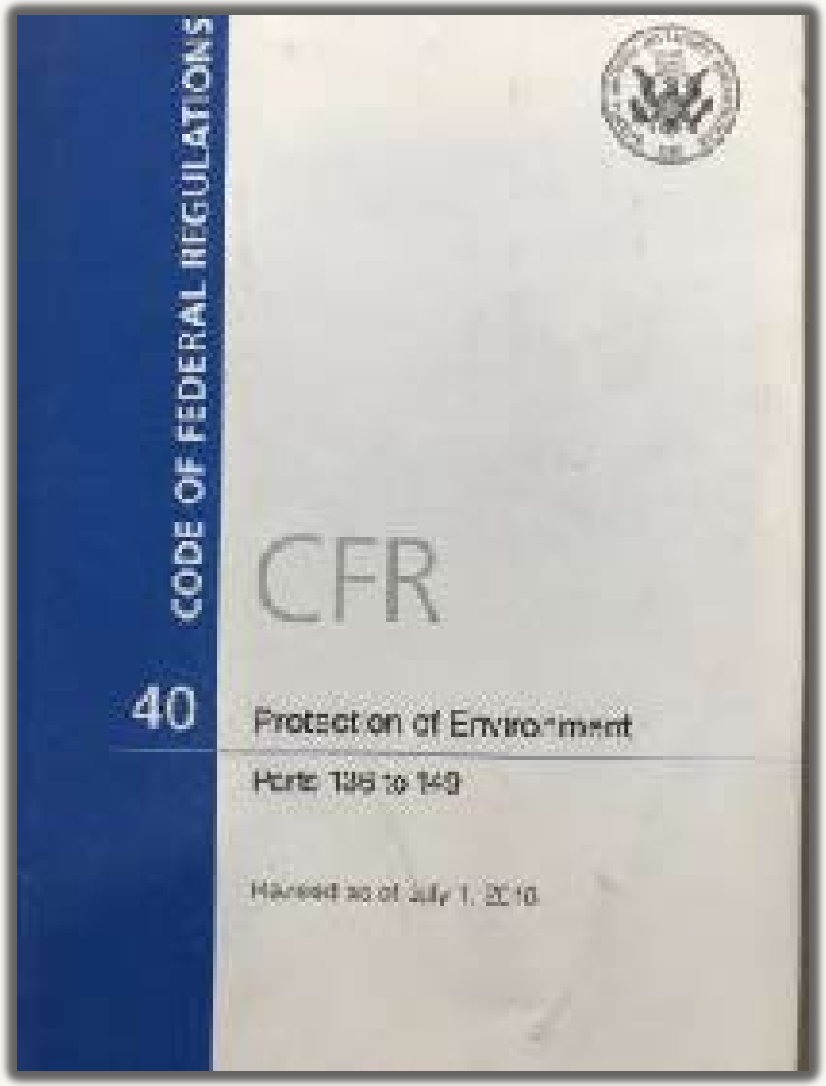
UIC Class II – State Primacy

- EPA may grant States, Tribes, or Territories primacy with primary enforcement for all or parts of the UIC Program
- SDWA Section 1425 requires Class II primacy applicants to demonstrate their standards are effective in preventing endangerment to Underground Sources of Drinking Water (USDW)
- Class II primacy programs must promulgate regulations that are as stringent as EPA's requirements and at minimum.

Source: ALL Consulting, 2024

UIC Class II - State Primacy Approval

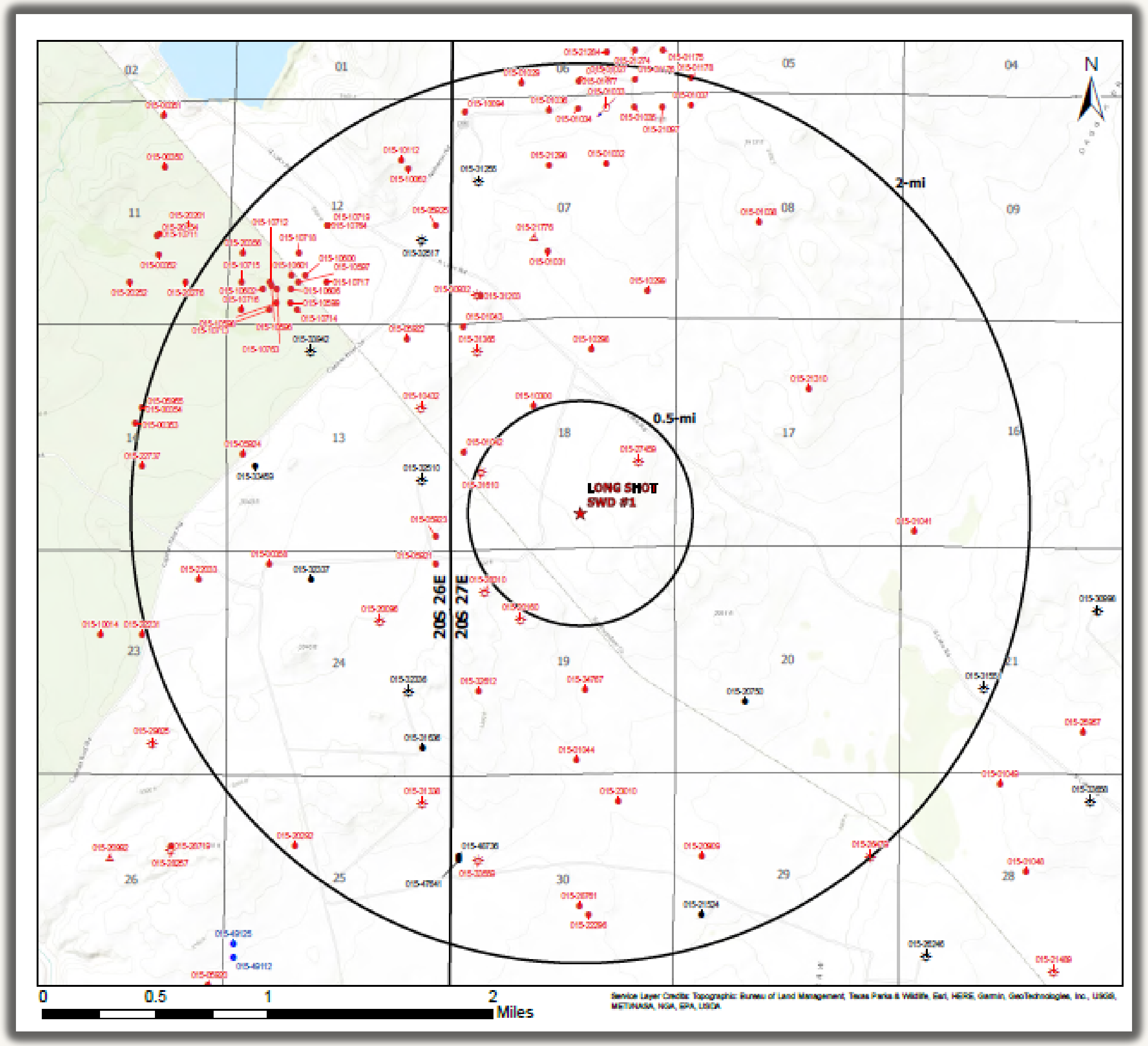
- Currently, EPA has approved UIC Class II primacy programs for 31 states and 3 territories
- EPA retains direct implementation of Class II programs in Arizona, Florida, Idaho, Iowa, Minnesota, New York, Pennsylvania, and Virginia.
- The core elements for a Class II primacy application or program revisions under is under 40 CFR Part 145 which identifies six core elements for a UIC primacy application or substantial program revision.



Source: EPA, 2018

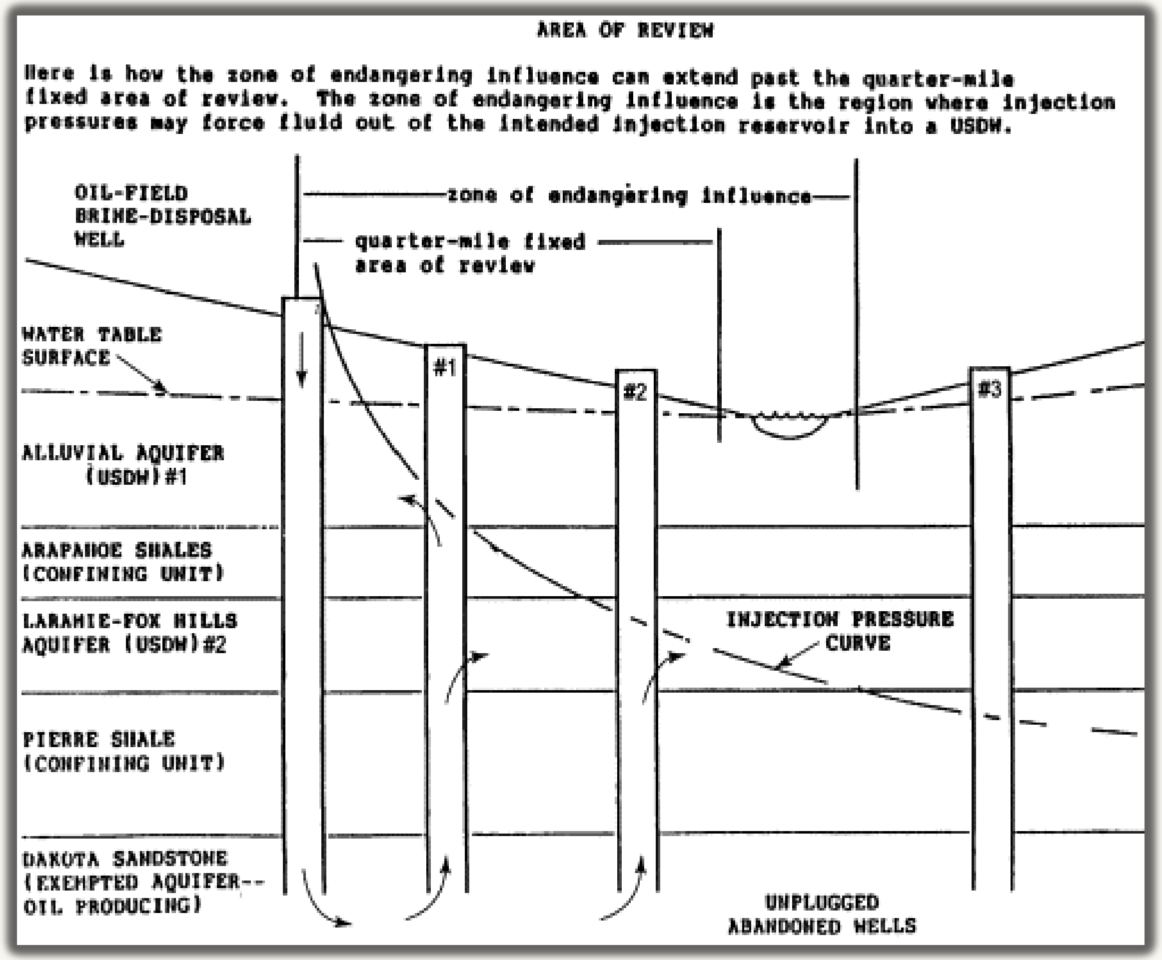
Area Of Review (AOR)

- All primacy states and EPA uses either a fixed radius or equation for calculating an AOR for a Class II disposal well.
- Fixed-radius AORs generally range from ~¼- to ~2-miles.
- When calculated the AOR, the “zone of endangering influence” or ZOEI is the approved method.
- Some primacy states have allowed for variances to the area of review based on pressure and volumetric calculations to ensure unplugged or improperly plugged wells are not impacted.



Source: ALL Consulting 2022

Zone of Endangering Influence



Steve Platt & Dave Rectenwald, 2005

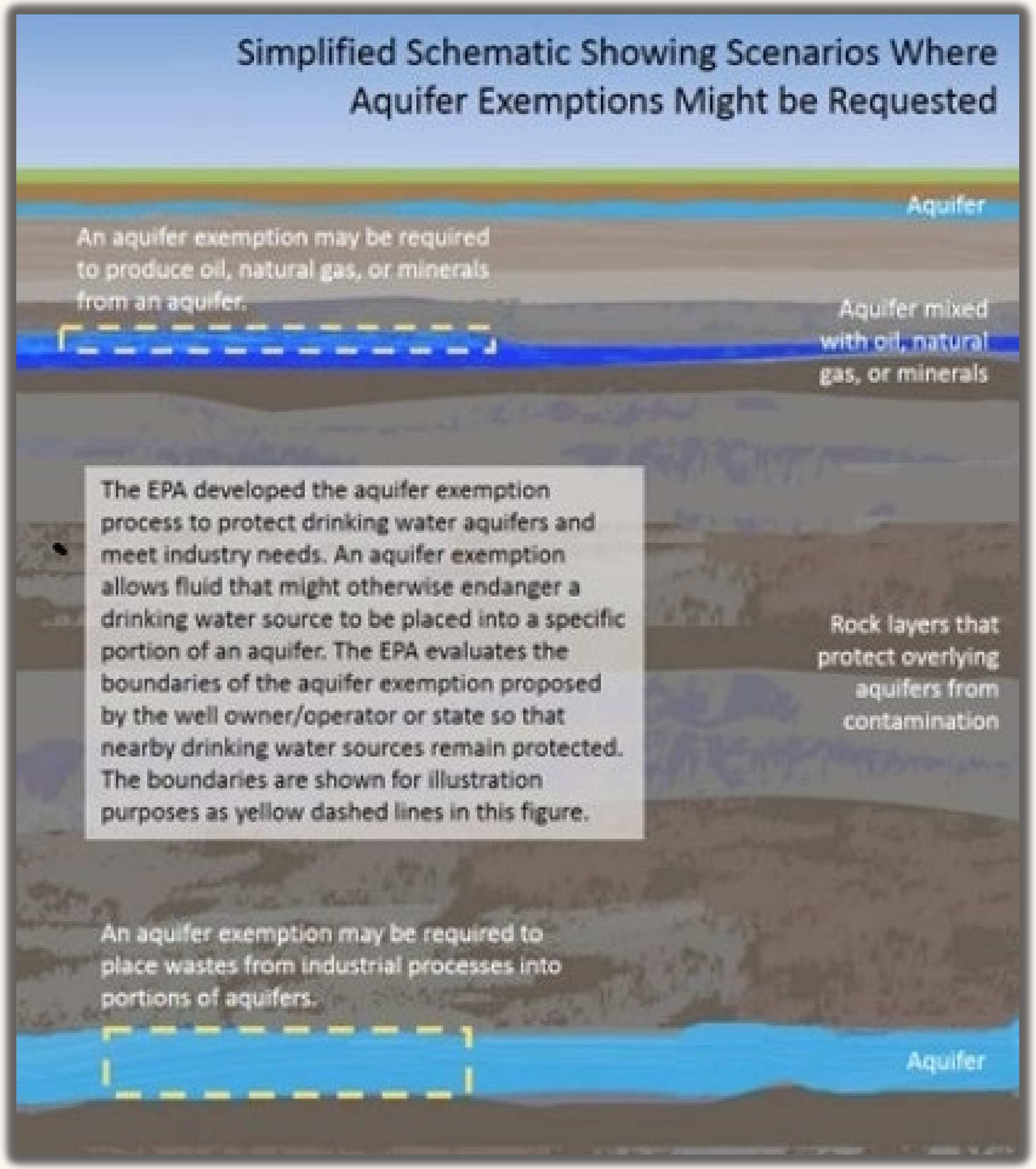
- The ZOEI is used by Class II regulatory agencies to calculate the potential for fluid migration out of the injection zone and into a USDW.
- ZOEI can be calculated from site-specific data using a modified *Theis* equation defined in EPA regulations.
- The ZOEI is the area with a radius of lateral distance in which the reservoir pressure within the injection zone may cause the migration of injected or native formation fluids into the USDW.
- Endangerment is defined as a pressure increase that has the potential to cause a column of formation fluid that would allow fluids to enter a USDW.

Underground Sources of Drinking Water (USDW)

- USDW - Codified in 40 CFR 146.3: A USDW is an aquifer or portion of an aquifer that:
  - Supplies any public water system or contains a quantity of ground water sufficient to supply a public water system,
  - Currently supplies drinking water for human consumption, or
  - Contains fewer than 10,000 mg/L total dissolved solids (TDS) and is not an exempted aquifer.
- While the U.S. EPA defines a USDW as containing less than 10,000 mg/L total TDS, some states, such as California and Texas, have adopted an injection well surface casing protection standard for freshwater aquifers that contain less than 3,000 mg/L TDS

Aquifer Exemptions

- **Exempted Aquifer**: UIC regulations allow EPA to exempt aquifers that do not currently serve as a source of drinking water and will not serve as a source of drinking water in the future based on certain criteria.
- **Basis**: 40 CFR 144.16 allows EPA to exempt certain USDWs from SDWA protection based on the following criteria:
  - Contains oil or minerals
  - Recovery is impracticable
  - Contaminated
  - Contains TDS greater than 3,000 mg/L



Source: EPA, 2024

Robert S. Kerr Environmental Lab

ADA, OK LABORATORY — **US EPA OFFICE OF RESEARCH AND DEVELOPMENT**

At a Glance

The Robert S. Kerr Environmental Research Center (RSKERC) in Ada, OK, is a major federal research facility operated by the Office of Research and Development (ORD). ORD scientists in Ada conduct research on groundwater, subsurface contaminant remediation, and ecosystem restoration. ORD activities have significant impacts on the Ada region, including advancing science, positively impacting the economy, and contributing to the regional community.

Science: ORD is a world-class research organization, and the research conducted by scientists in Ada has broad impacts, including supporting decision making at local, regional, and national levels. Among many different areas of study, Ada has several unique research capabilities, including laboratories, field equipment, and test wells to perform specialized subsurface investigations on groundwater contaminant transport, and develop and assess technologies for remediating groundwater contamination.

Community Engagement: EPA is a key contributor to the Ada community. Employees work with local students through a mentoring program at East Central University (ECU) and Water Fest, an annual interactive educational event for local 5th graders. EPA scientists work with ECU, the City of Ada, and the Chickasaw Nation in a water policy and management center – the Oka' Institute (Oka' is the Chickasaw and Choctaw word for water).

Economic Impacts: The Ada lab creates $3.4 million in disposable income from federal jobs and spends and additional $3.7 million on contracts, grants, and supplies and equipment. These dollars are injected into the local economy annually as workers buy goods and services in the community, supporting additional jobs and spending and increasing overall economic output for the community.

Did you know?

- In addition to federal scientists, the lab provides 48 on-site jobs to post-doctoral researchers, student contractors, and facility staff.
- The Ada lab is a leader in sustainability. It is EPA's first carbon-neutral lab, and uses geothermal heat pumps, energy efficient heating and air conditioning, and water efficient plumbing to reduce energy and water use and reduce GHG emissions.
- The lab includes a 110-acre field site comprised of woodlands, open fields and ponds for ecosystem and groundwater research studies.

Ada Laboratory Impacts by the Numbers

Ada (Pontotoc County), OK		
91 Total jobs at the laboratory	**$7.1 million** Annual payroll, on-site contracts, and grant dollars supported by lab	**48** Federal jobs on-site
16 Post-doctoral, student, and visiting researchers on-site	**8/1/2016** 50th Anniversary of the Lab and signing of an MOU between ORD and the Chickasaw Nation	**65.1%** Reduction in water use since 2007
$4 million Energy and maintenance savings		**12.1%** Reduction in energy use since 2003

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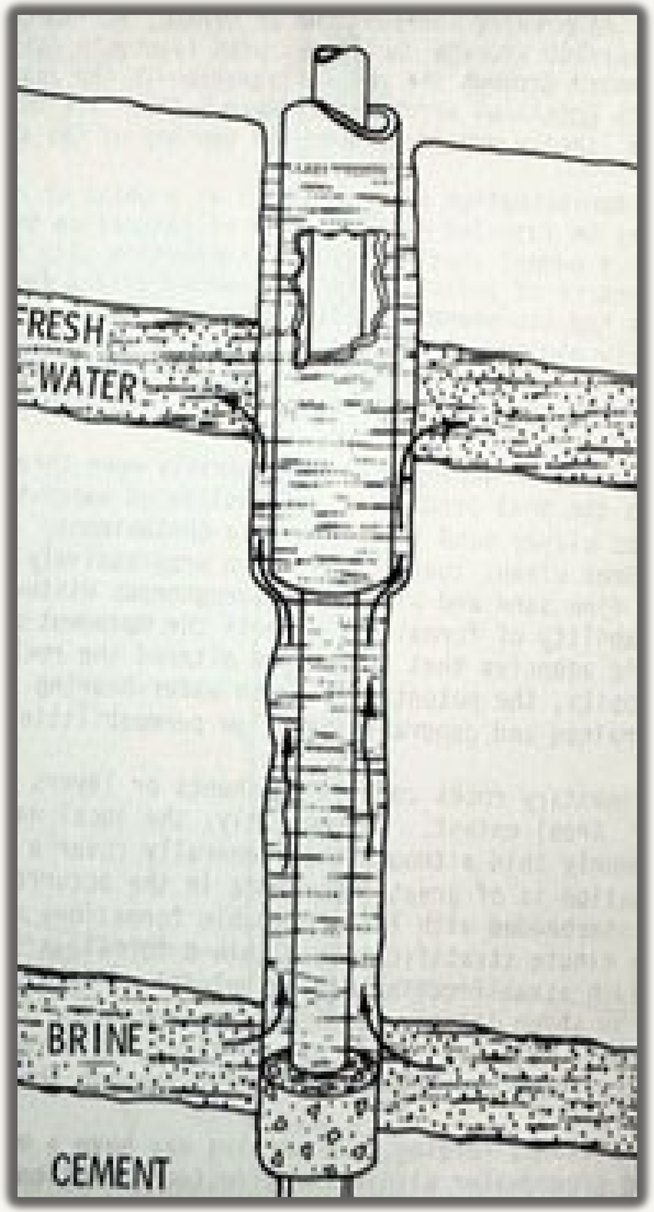
Turn over for more science!

Source: EPA, 2024



Source: TGS, Tulsa's Physical Environment, 1971

Part I and II Mechanical Integrity Testing (MIT)

- Demonstrating Mechanical Integrity:
  - Class II injection wells must demonstrate two (2) parts of mechanical integrity prior to commencement of injection operations.
  - Under 40 CFR 146.8 it states that an injection well has mechanical integrity if:
    - Part I (Internal Mechanical Integrity) – There is no significant leak in the production casing, injection tubing, or the packer.
    - Part II (External Mechanical Integrity) – There is no significant fluid movement into USDWs through vertical channels adjacent to the injection wellbore.

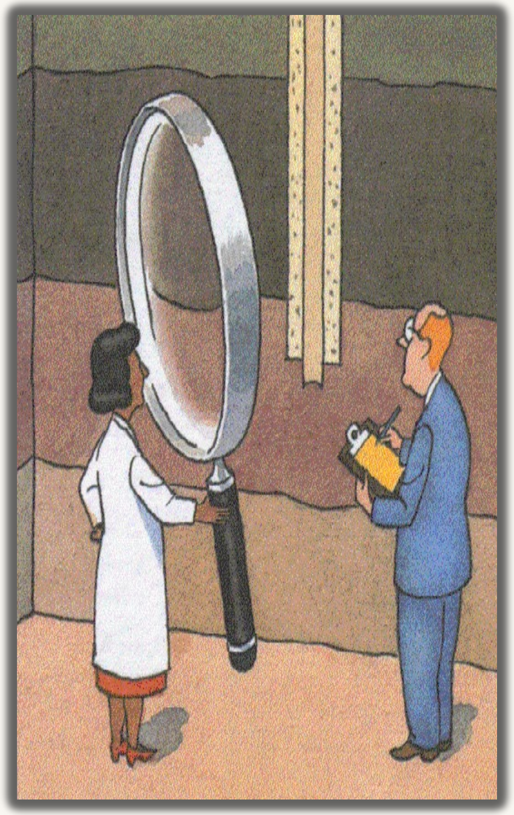
Source: ALL Consulting, 2015

Part I - Internal Mechanical Integrity

- Part I of mechanical integrity is typically demonstrated by what is called the Standard Annulus Pressure Test (SAPT).
- An initial SAPT is conducted prior to commencement of injection operations.
- Then an internal mechanical MIT must be conducted and passed once every five years.
- Alternate testing methods may be allowed depending on circumstances, well configurations, etc.

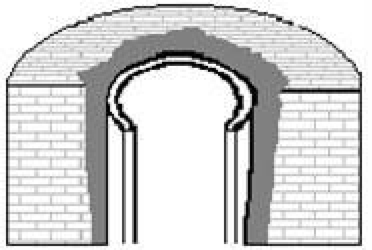
Part II – External Mechanical Integrity (MIT)

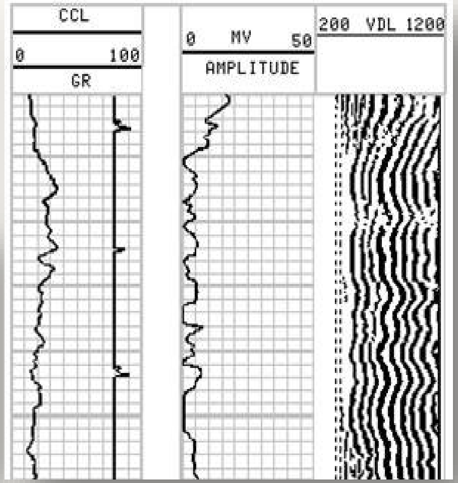
- External MIT is required to demonstrate that there is no significant fluid movement into USDWs through vertical channels adjacent to the injection wellbore.
- Part II of mechanical integrity is commonly accomplished by the review of cementing records and calculation of the top of cement or by temperature log or CBL to determine that the top of cement above the injection zone behind the production casing meets the regulatory requirements.
- Additional testing such as a radioactive tracer survey may be required to demonstrate Part II of mechanical integrity.



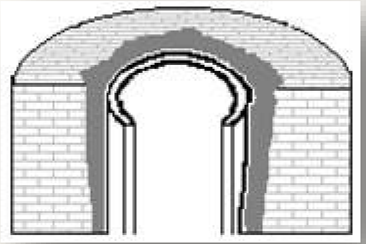
Cement Bond Long Interpretation

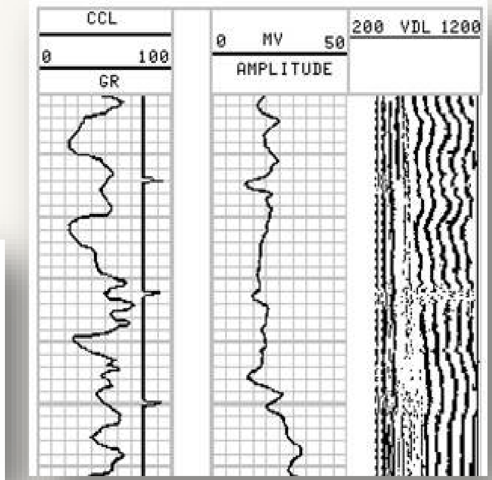
Good Cement
- Low Amplitude
- Strong VDL



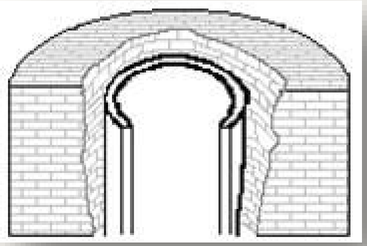


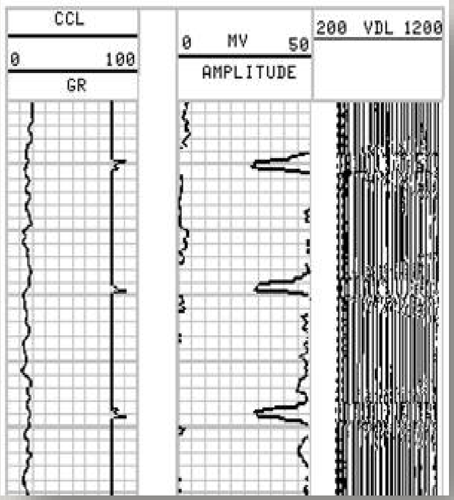
Partial Cement
- Varied Amplitude
- Varied VDL



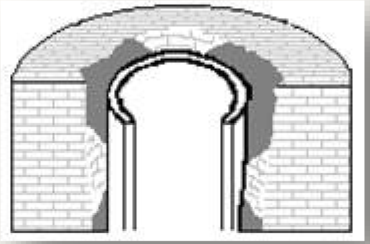


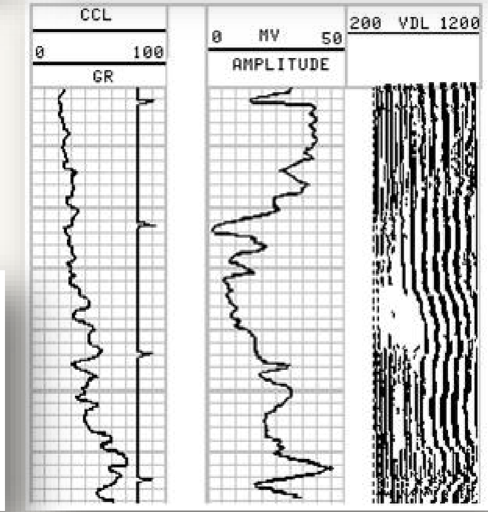
No Cement
- High Amplitude
- VDL Straight
- Collars "Ringing"



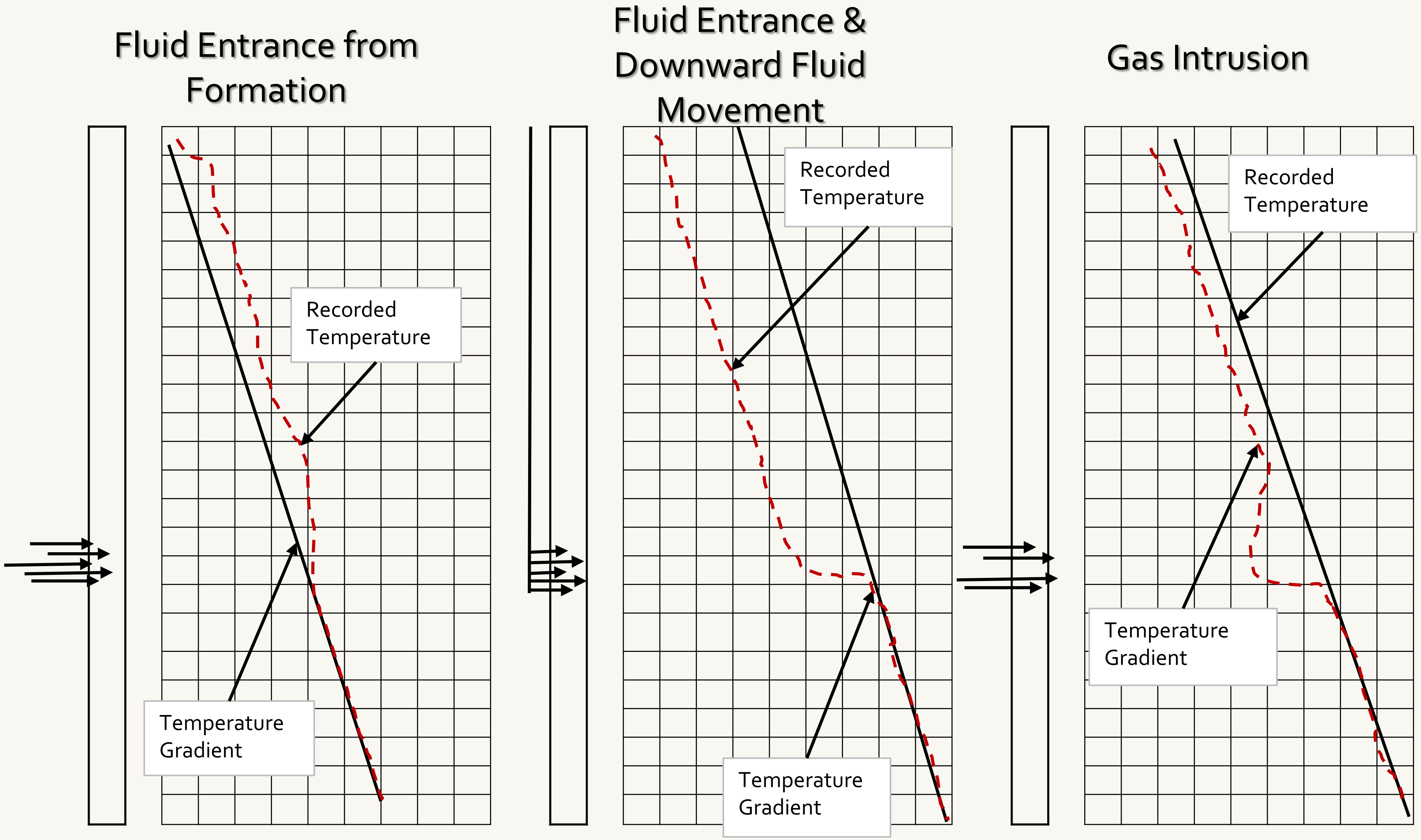


Microannulus
- Varied Amplitude
- Varied VDL
- Pressured/No Pressure





Temperature Log Interpretation

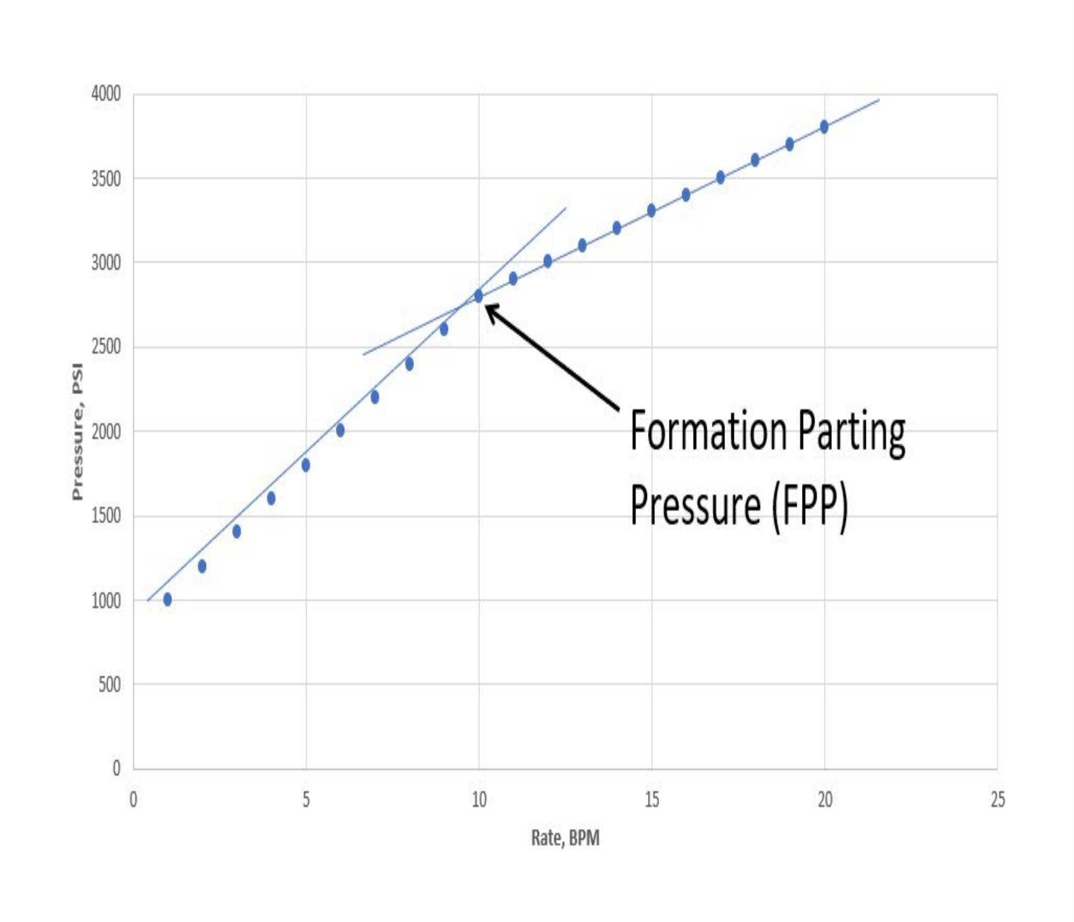


Maximum Allowable Operating Parameters

- The maximum allowable surface injection pressure (MASIP) is based by regulatory rules and is set by:
  - A formula developed by the regulatory agency;
  - Based on a fracture gradient for the proposed injection reservoir;
  - Some States base MASIP on a per foot pressure gradient.
  - Regulators may also allow or even require that step-rate testing (SRT) be performed to determine MASIP.

Step-Rate Testing (SRT)

- Every Class II primacy state and in an EPA direct implementation state sets the initial maximum allowable surface injection pressure (MASIP) by either formula, fracture gradient, or by a fixed psi/foot (ranges from ~0.2 psi/foot to ~0.5 psi/foot).
- Class II operators can request to perform a SRT (or may be required by the regulatory agency) using either the state regulatory guidelines or EPA's step rate guidance to perform a SRT in an effort to increase MASIP.
- SRT state guidelines and EPA guidance can vary considerably, and standardization of step rate testing and interpretation can be somewhat complicated.



Source: ALL Consulting, 2020

SRT Guidance Summary

- When the concept of SRTs was first developed, many of the influencing details and challenges with these tests were not anticipated.
- Guidance documents generally agree on the fundamentals of SRT.
- These guidance documents generally DO NOT acknowledge challenges, detailed procedures, or best practices for conducting or interpreting SRTs.
- SRT interpretation can be highly subjective due to issues such as geologic conditions, stratified injection zones, completion methods, lack of stable pumping, injection fluid temperature, and other details that can impact the shape of the curve and/or create multiple inflection points.

SRT Conclusions

1. SRTs can be a subjective method for assessing formation parting or closure pressures, especially in stratified or heterogeneous and/or low to moderately permeable injection zones.

2. SRTs can be a subjective testing method and is subject to misinterpretation as a result of testing methods, formation characteristics, geologic conditions, and other influences.

3. Testing practices/procedures can be critical for effective test analysis.

4. Failure to account for influences can result in highly questionable test results or uninterpretable results.

5. New technologies and refined methods continue to be developed and utilized for testing purposes.

Injection Induced Seismicity and Seismic Monitoring

- Any seismic event needs to be thoroughly investigated, and every potential source examined prior to determining the cause of seismicity.
- Potential other sources of seismicity can include:
- Tectonic (natural) seismic events;
- Hydraulic fracturing induced seismic events (which has been scientifically documented in several oil and gas producing states); and
- Massive fluid withdrawals from the unconventional horizonal reservoirs, which can lead to compaction of the reservoir and induced seismicity.

Induced Seismicity Working Group

(A Collaboration Example)

StatesFirst
An Initiative of the IOGCC & GWPC

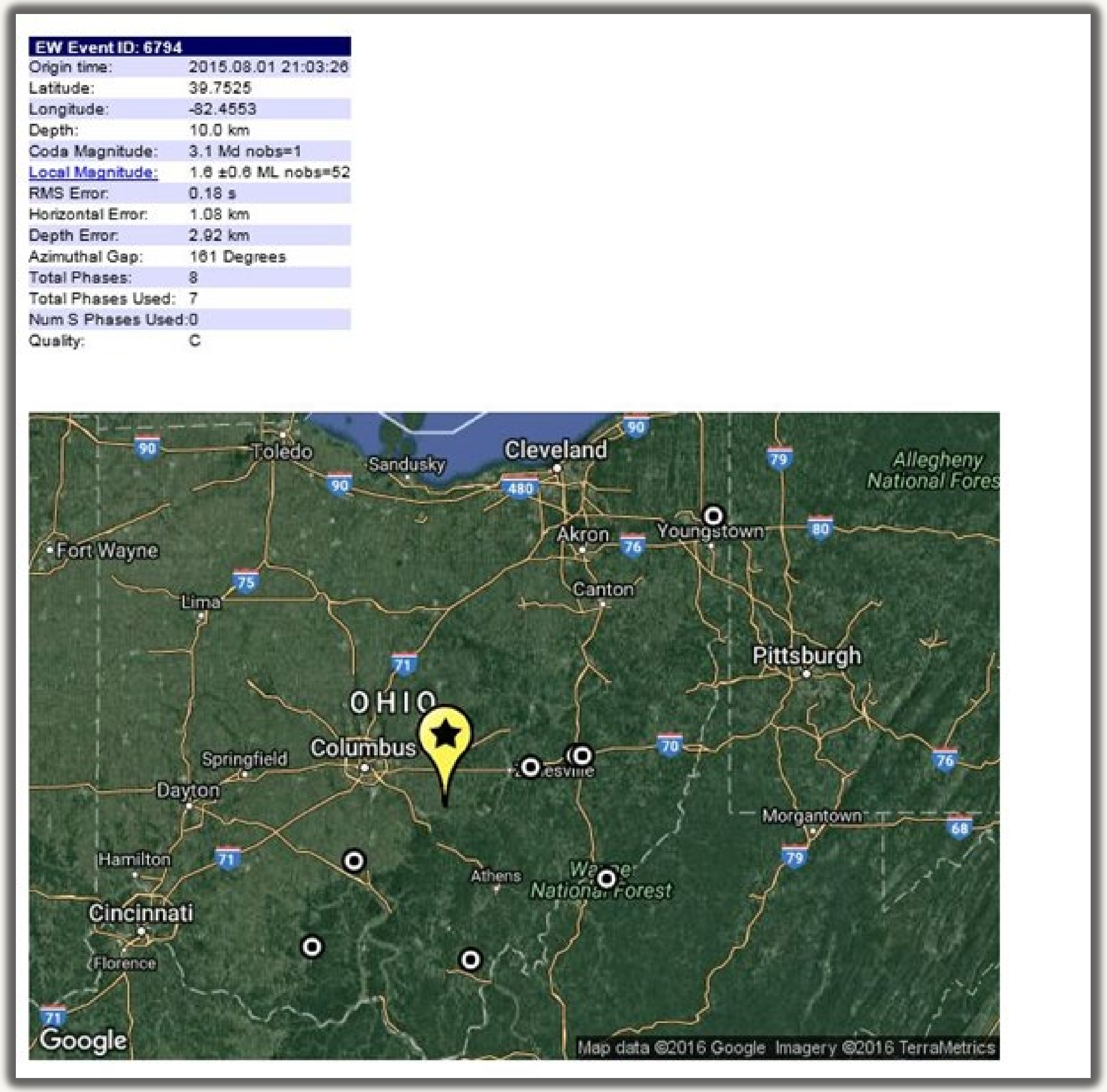
Source: www.statesfirstinitiative.org

Injection-Induced Seismicity

- Injection-induced seismicity has been attributed to the increase in pore pressure within a geologic reservoir along with the decrease in effective stress on an optimally oriented fault within the principal stress direction.

- Injection-induced seismicity was first documented in 1962 near Denver, Colorado at the Rocky Mountain Arsenal disposal well.

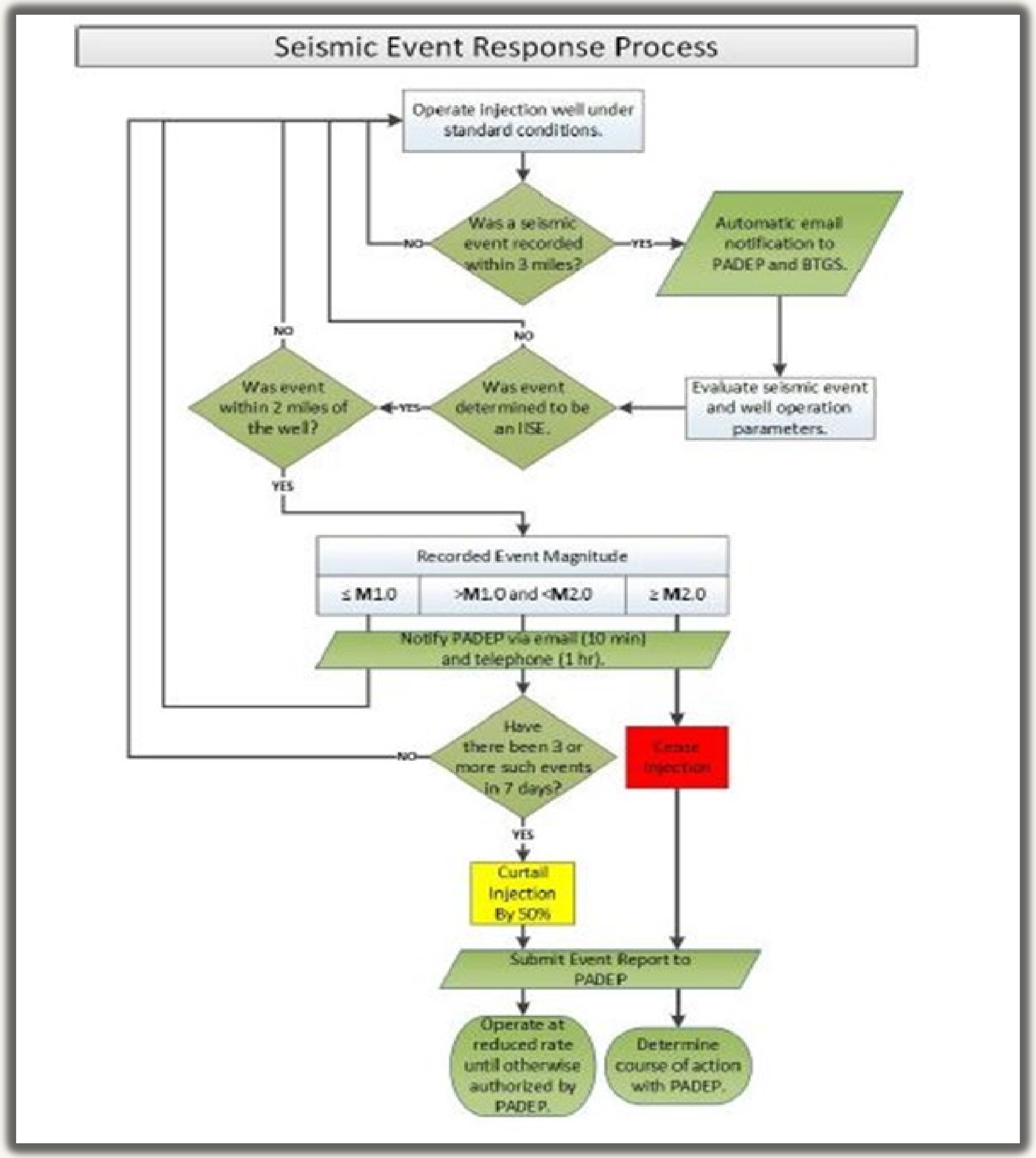
- With the advent of unconventional play development in the United States, the need for additional large capacity Class II SWDs expanded across the oil and gas producing states, which led to the increases in injection-induced seismicity.



Source: Cambrian Well Service, 2016

Injection Induced Seismicity

- In most cases, injection-induced seismicity has been caused by injection into a geologic formation that either directly overlies or is has avenues of communication with Precambrian basement rocks, where most seismicity occurs.
- Since about 2009, injection-induced seismicity related to Class II SWD operations in the unconventional play areas have been documented in several states, including Arkansas, Colorado, Kansas, New Mexico, Ohio, Oklahoma, Texas, West Virginia, and Alberta, Canada.



Source: ALL Consulting, 2017

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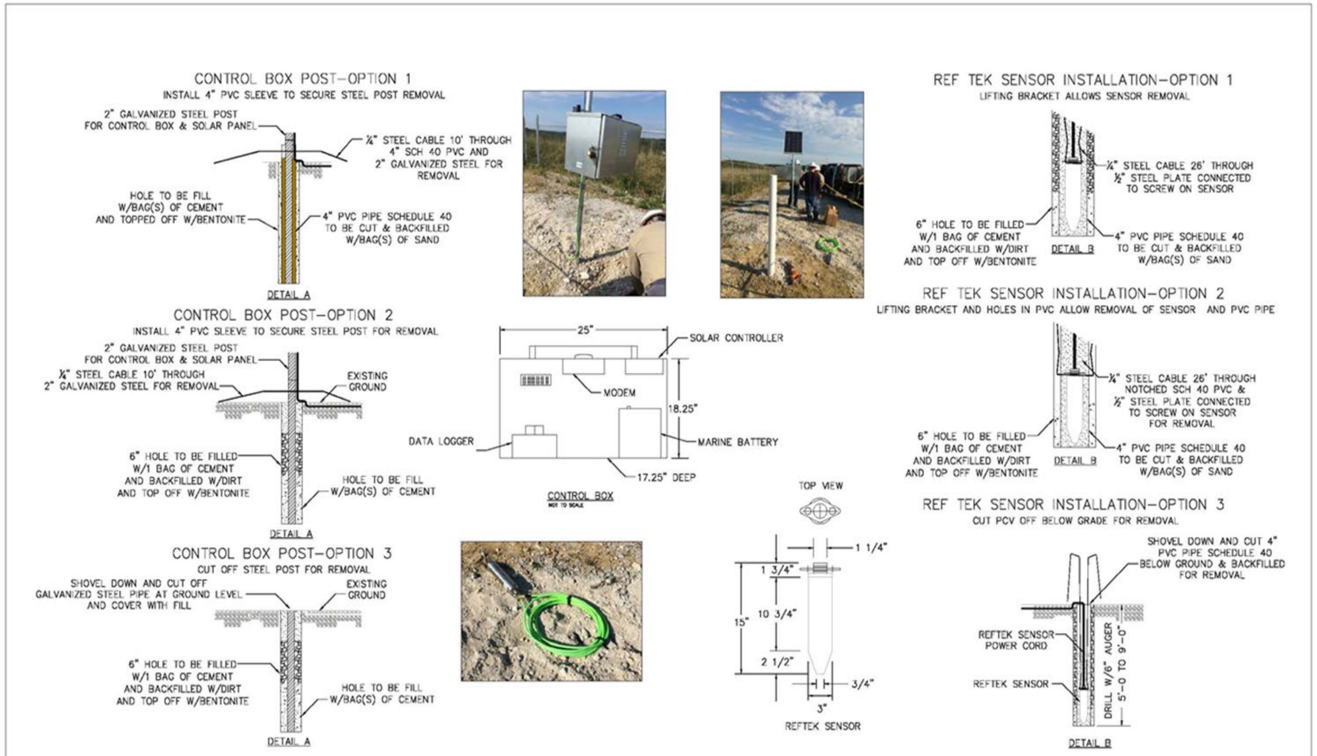
Seismic Monitoring and Mitigation

- With the increase in seismicity in various areas of the United States, Class II primacy states implemented regulatory measures or passed new regulations to address injection-induced seismicity. These measures included:

- Installation of greater statewide seismic monitoring or local private networks to further enhance the ability to monitor and record seismic events.

- Some states (such as Ohio and Pennsylvania) developed or required Class II-D owners/operators to install local seismic networks around new Class II SWDs.



Source: ALL Consulting, 2022

National UIC Technical Workgroups

- EPA developed UIC National Technical Workgroups to work on technical issues arising within the UIC Program
- Formerly the "National Mechanical Integrity Test Workgroup", these workgroups have worked to develop/approve new MIT methods, addressed issues like induced seismicity & aquifer exemptions, and provided sound study on key program issues!
- Comprised on representatives from EPA headquarters and each regional office and from six primacy states.
- Over the years, this workgroup has prepared a number of important technical publications to assist UIC regulators.

MINIMIZING AND MANAGING POTENTIAL IMPACTS OF INJECTION-INDUCED SEISMICITY FROM CLASS II DISPOSAL WELLS: PRACTICAL APPROACHES

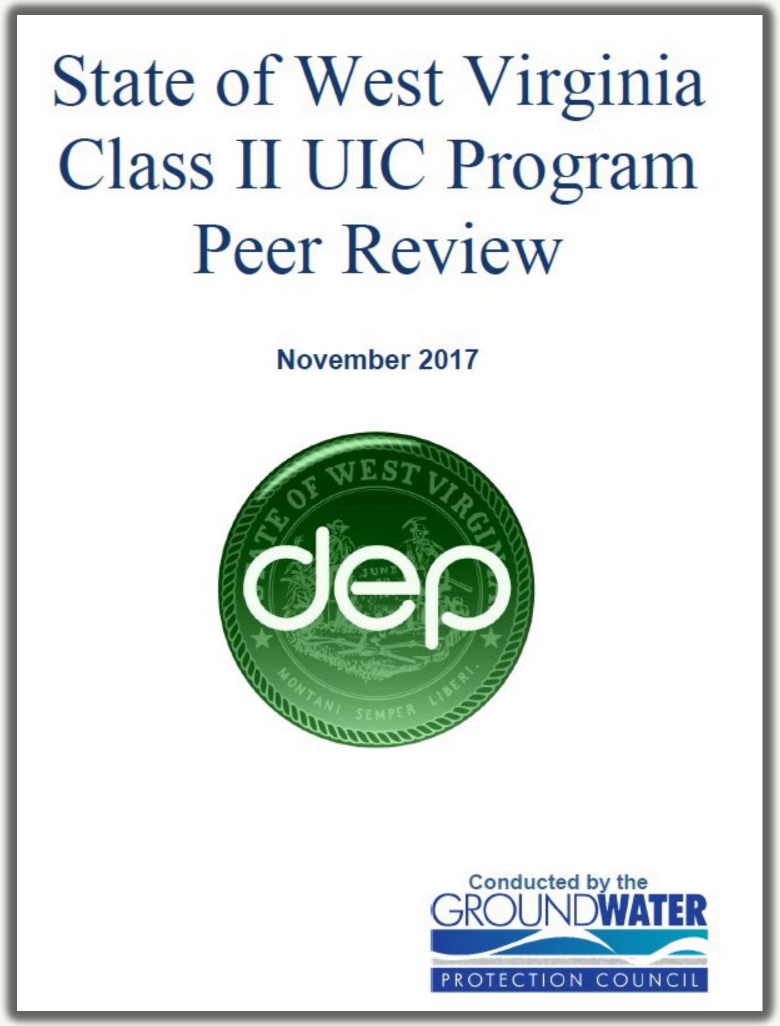
Underground Injection Control National Technical Workgroup
US Environmental Protection Agency
Washington, DC

Draft December 24, 2013

Source: EPA, 2013

Significant Events & Ongoing Program Evolution

- Significant events that have been impacting the Class II programs include:
  - Increase seismicity activity in New Mexico and Texas allegedly associated with Class II SWDs;
  - Saltwater surface purges in Oklahoma;
  - Abandoned well blowouts in Texas; and
  - Allegations of SWD impacts to production wells and drilling activity.
- All of these types of events have led to changes to Class II regulatory programs with increased guidance and policy development, Peer Review, or even new rule implementation in an effort to address these significant events impacting different State Class II regulatory programs.



Source: GWPC 2017

Questions?

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