



Geologic Sequestration of CO₂ and Class VI Wells

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UIC Inspector Training

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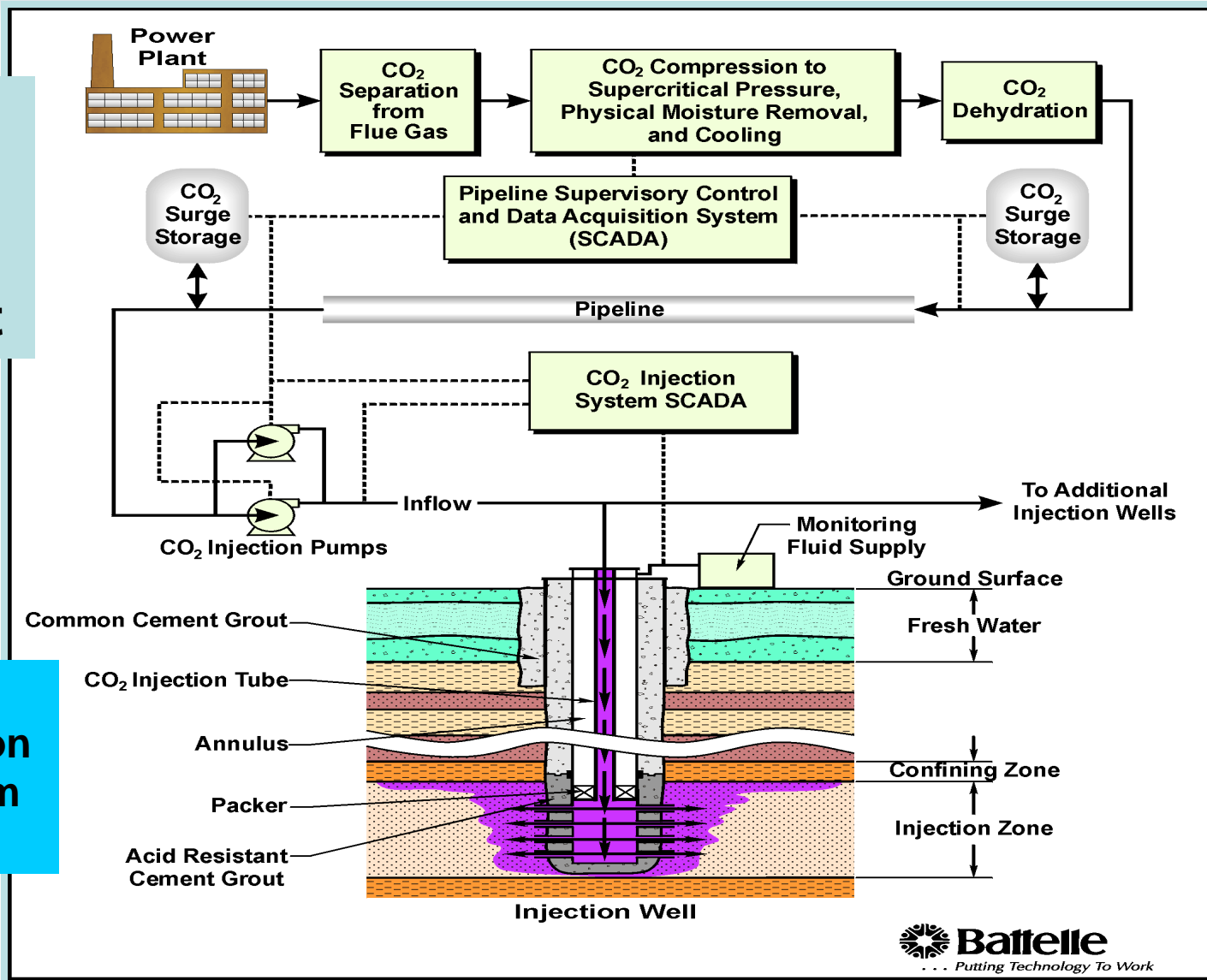
Presentation Overview

- Carbon Capture and Storage, Geologic Sequestration and Class VI Rule Background
- Class VI Requirements



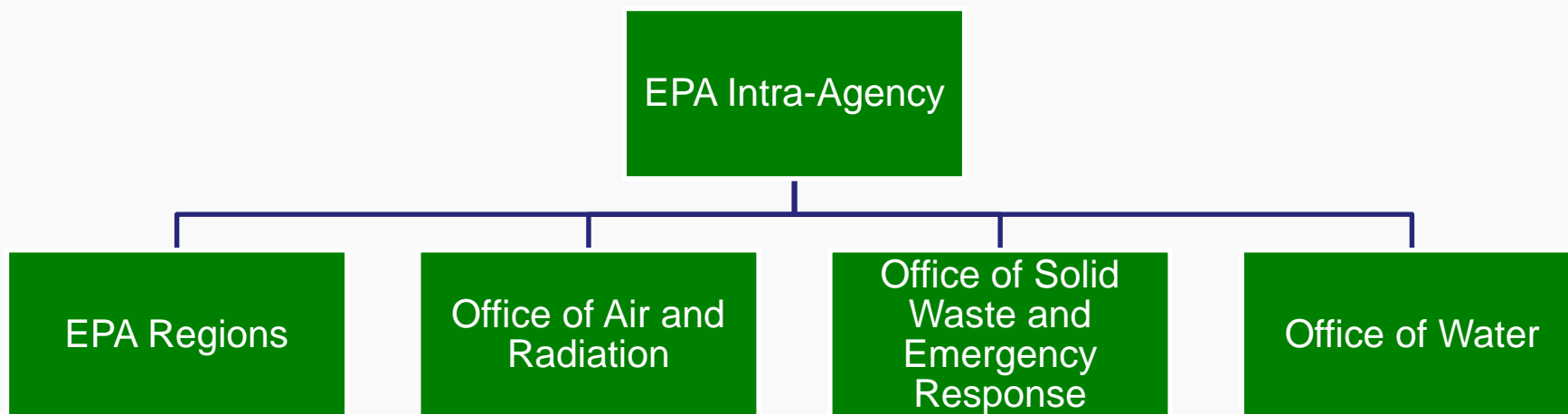
Carbon Capture and Storage, Geologic Sequestration (GS) and Class VI Rule Background

CO₂ Capture and Transport





Coordination on Carbon Capture and Storage (CCS) and Carbon Capture, Utilization and Storage (CCUS)





Federal Register

Friday,
July 25, 2008

Part II

Environmental Protection Agency

40 CFR Parts 144 and 146
Federal Requirements Under the
Underground Injection Control (UIC)
Program for Carbon Dioxide (CO₂)
Geologic Sequestration (GS) Wells;
Proposed Rule

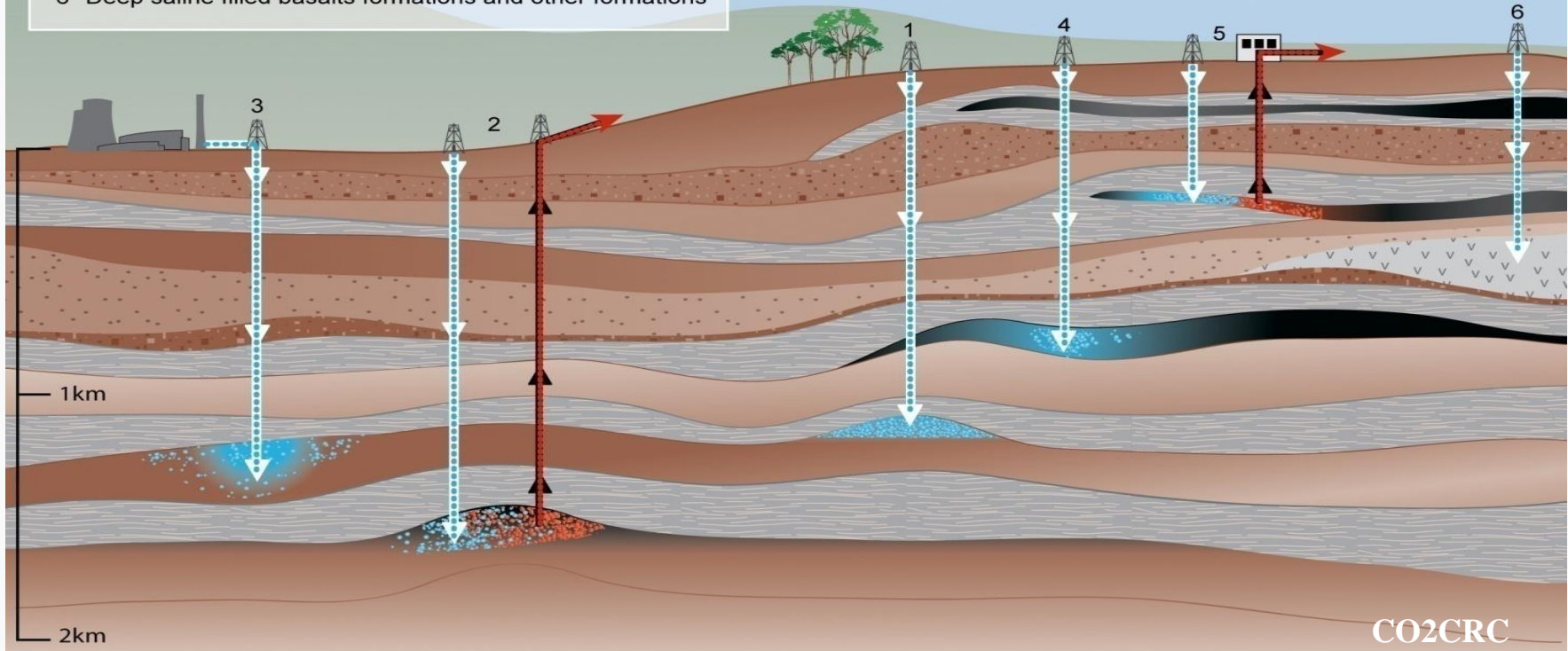
Class VI Rulemaking

- **Proposed Rule for GS of CO₂**
 - Announced by Administrator: October 11, 2007
 - Signed by Administrator: July 15, 2008
- **NODA** published in 2009
- **Final Rule** published on December 10, 2010, revises UIC Program to address Geologic Sequestration via Class VI wells

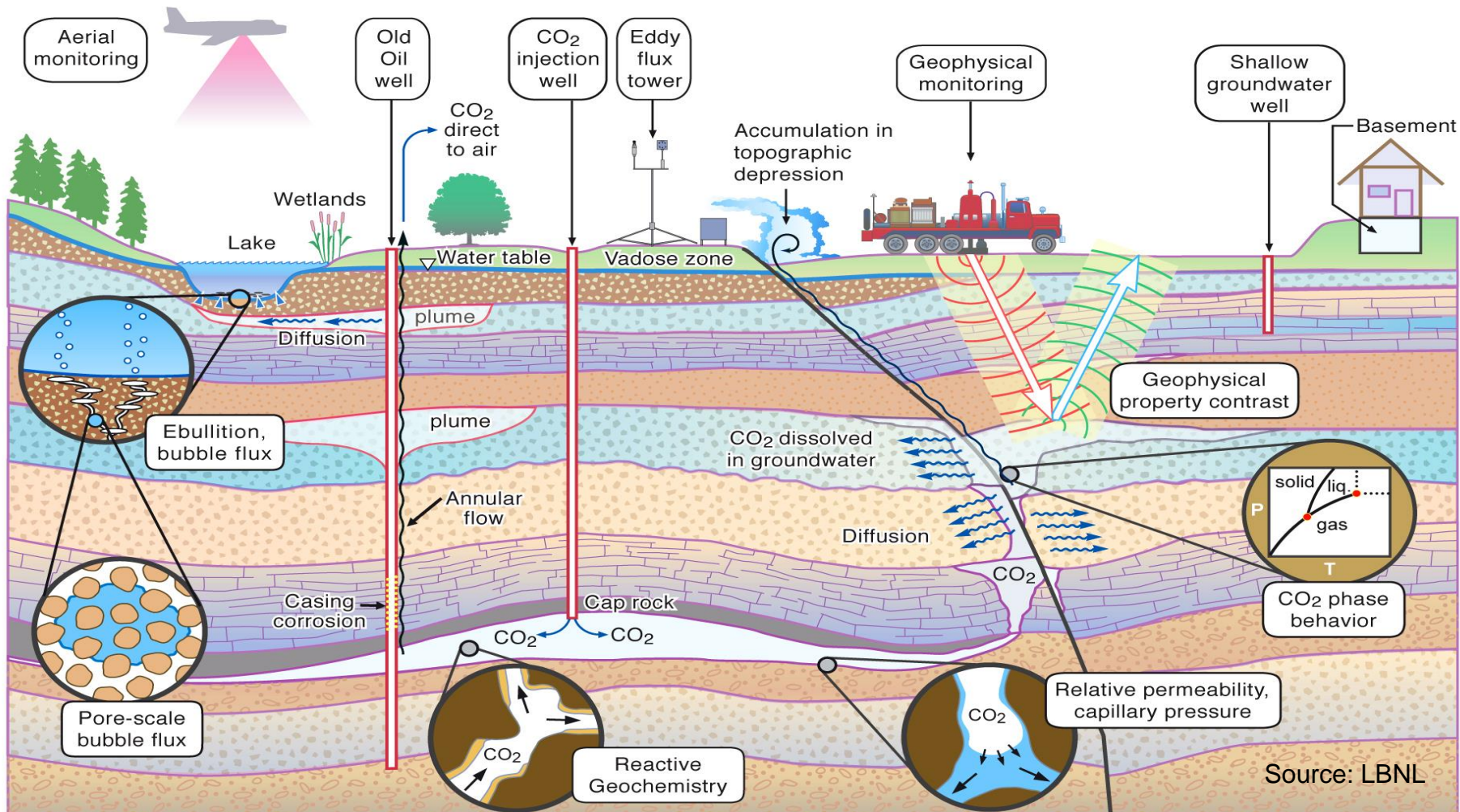
Geologic Sequestration Scenarios

Geological Storage Options for CO₂

- 1 Depleted oil and gas reservoirs
- 2 CO₂-driven enhanced oil recovery
- 3 Deep saline formations
- 4 Deep unmineable coal seams
- 5 CO₂-driven enhanced coal bed methane recovery
- 6 Deep saline filled basalts formations and other formations



CO₂ Storage Mechanisms, Monitoring & Potential Leakage Pathways





Class VI Primacy and Direct Implementation

- As of September 7, 2011
 - EPA directly implements the Class VI Program in all States, Tribes, and Territories except North Dakota
- States may apply for Class VI primacy at any time
 - States without Safe Drinking Water Act (SDWA) § 1422 primacy must apply to implement a new § 1422 Program
 - States with § 1422 primacy for Classes I, II, III and V must submit a program revision to add Class VI
- State primacy applications
 - North Dakota application received June 2013
 - North Dakota Class VI Primacy was approved 4/24/18



Class VI Implementation

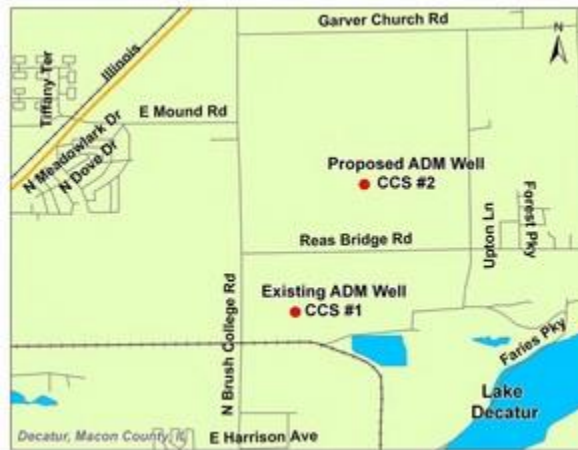
- **Implementation**

- EPA has issued 6 permits

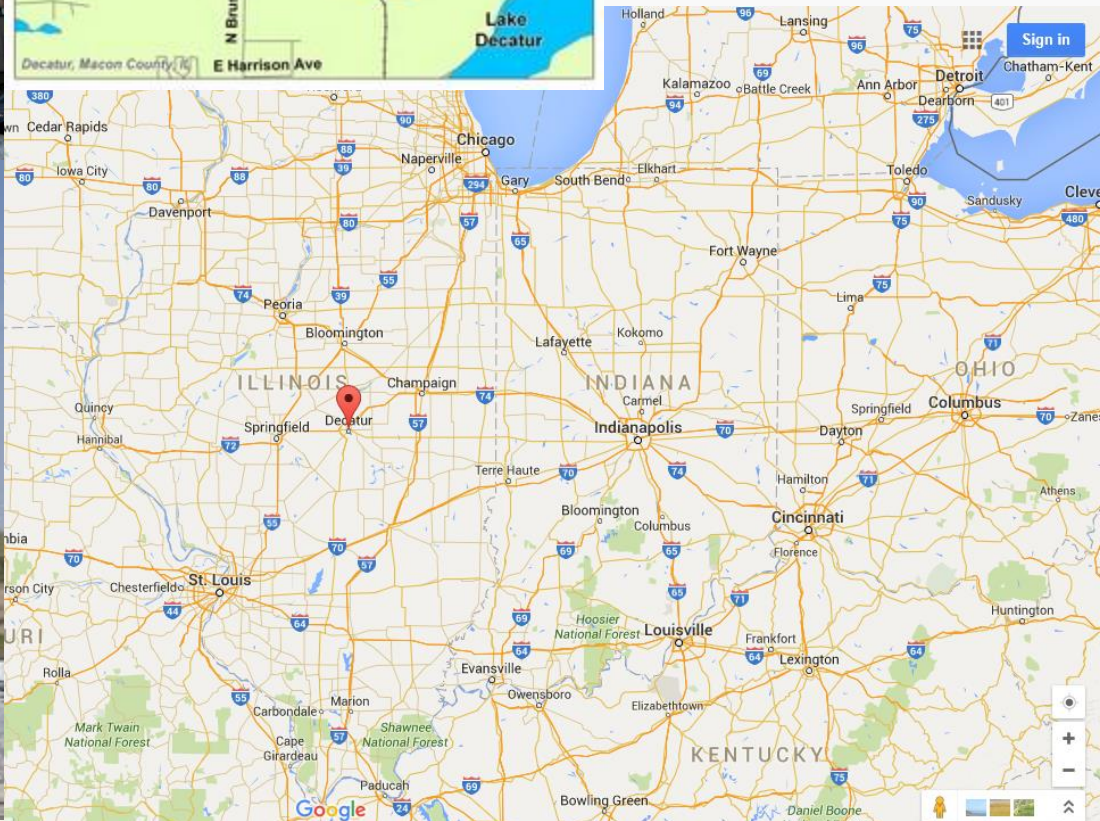
- Archer Daniels Midland (ADM), Decatur, IL (2 permits)
- The FutureGen Alliance, Jacksonville, IL (DOE suspended funding in 2015
4 permits – permits have expired)

- **Limitations on CCS**

- Limited policies to support or encourage climate change mitigation/carbon capture technology deployment
- Resources/financing of projects
- There has been a strong emphasis on enhanced oil recovery (EOR) to store CO₂ (CCUS) due to economics but EOR alone can't achieve the large-scale/long-term emissions reductions needed



Archer Daniels Midland (ADM) Decatur, IL Ethanol Plant



MGSC

Decatur, IL
ADM 2013
300,000 tons/y today;
Over 900,000 tons to date
1 M tons/y shortly

999,215 Mt 11/11 – 11/14
Under IL EPA Class I permit
Repermitted as EPA Class VI



Final class VI permit

ADM - Project Photos (June 2013)



Four Compressor Train



Compressor & Auxiliaries

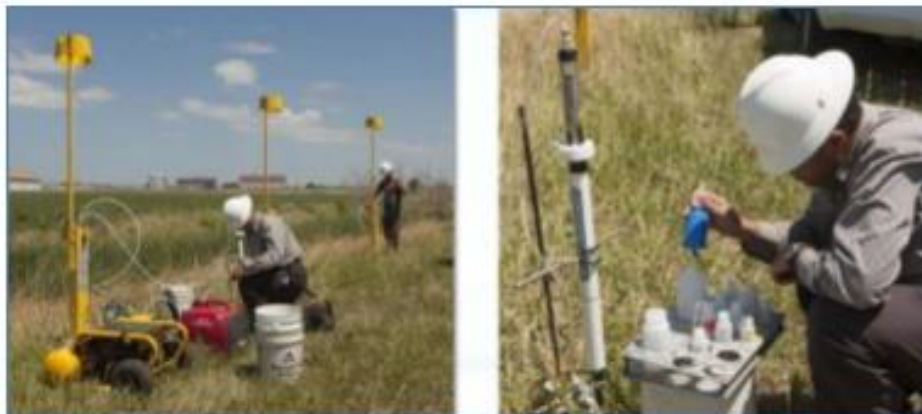


Dehydration System



8" High Pressure transmission Line

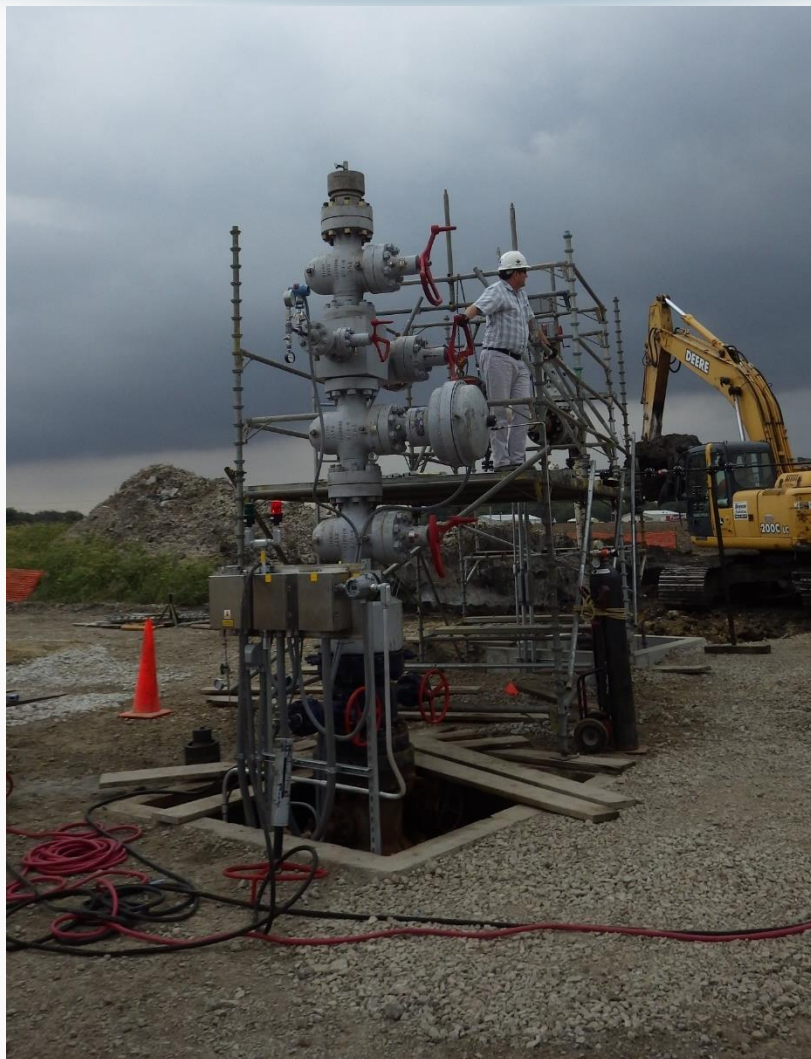
ADM - Project Monitoring Photos (June 2013)



**Shallow Groundwater
Sampling**



**Soil Gas and CO₂ Flux
Networks**

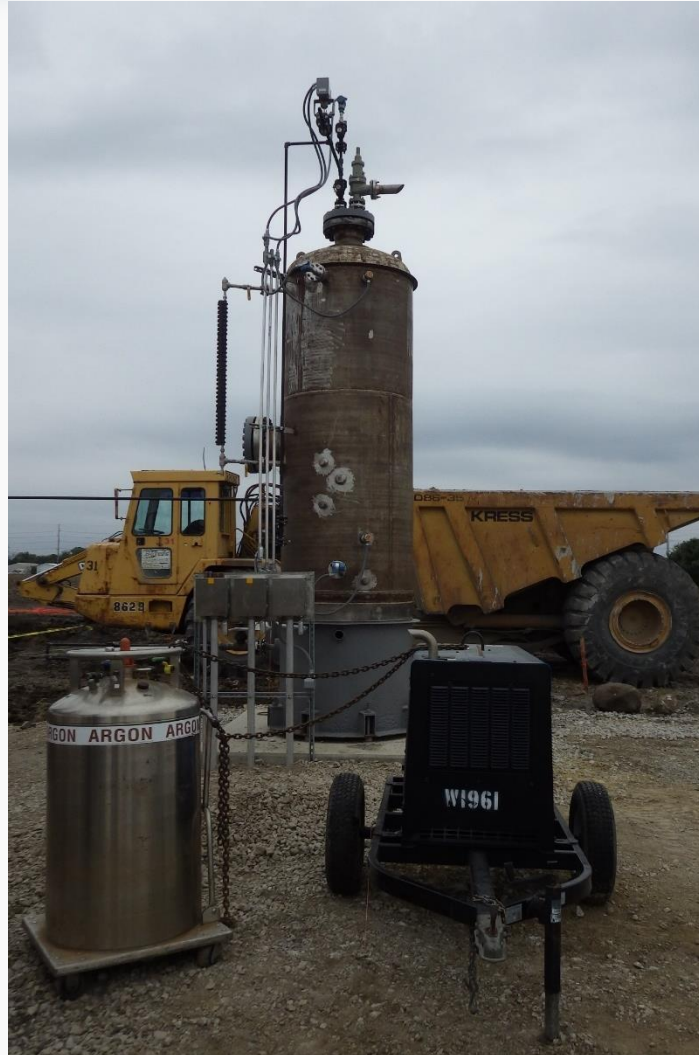


CCS #2 Wellhead Under Construction



CCS #2 Finished Wellhead Injecting

CCS #2 Annulus Tank





Temperature Logging Tool



Lubricator for Temperature Logging

Logging Truck





Flow Meter



**Corrosion Monitor
Coupon Loop**



At 240 MW, Petra Nova is the world's largest post-combustion carbon capture facility installed on an existing coal-fueled power plant.



NRG's WA Parish Plant SW of Houston

The captured CO₂ will be used in EOR increasing production from 300 to 15000 bopd In the West Ranch Field.



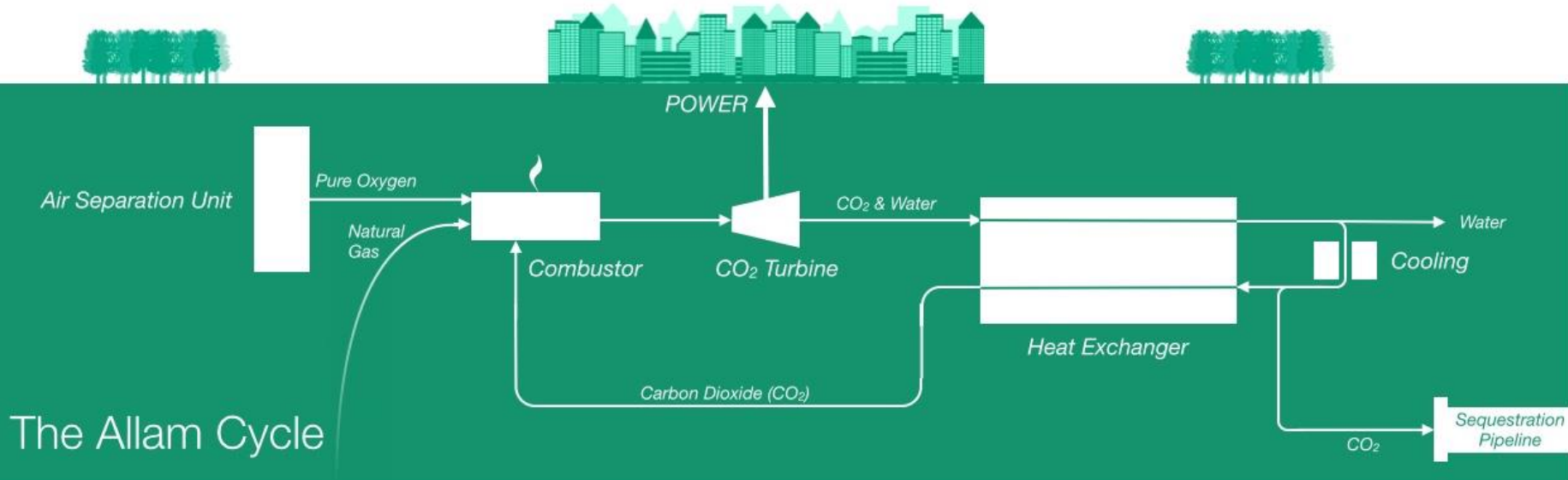
Net Power LLC - La Porte, Texas



This 50 MW demonstration plant is the world's largest attempt to use carbon dioxide as a working fluid to drive a turbine to generate electricity. Therefore, CO₂ emissions from natural gas combustion to generate electricity are zero. Combustion testing began 5/31/18.



The Net Power Plant Uses the Allam Cycle Shown Below





Class VI Requirements



Class VI Requirements: 40 CFR § 146.82 – 146.95

- 146.82: Required Class VI permit information
- 146.83: Minimum criteria for siting
- 146.84: Area of Review and corrective action
- 146.85: Financial Responsibility
- 146.86: Injection Well Construction
- 146.87: Logging, Sampling, and Testing (prior to operation)
- 146.88: Injection Well Operation
- 146.89: Mechanical Integrity
- 146.90: Testing and Monitoring
- 146.91: Reporting and Recordkeeping
- 146.92: Injection Well Plugging
- 146.93: Post-Injection Site Care and Site closure
- 146.94: Emergency and Remedial Response
- 146.95: Injection Depth Waiver requirements



Class VI Rule Background

Considerations for GS

- Large Volumes
- Buoyancy
- Viscosity (Mobility)
- Corrosivity



UIC Program Elements

- Site Characterization
- Area of Review (AoR)
- Well Construction
- Well Operation
- Site Monitoring
- Post-Injection Site Care
- Public Participation
- Financial Responsibility
- Site Closure

New well class established:
Class VI



Class VI Requirements: Overview

- Wells used for injection of CO₂ for geologic sequestration
- Class VI wells by permit only
- Lifetime permit duration including the post-injection monitoring period
- Allow for transitioning from: Class I, II, or V wells or monitoring/stratigraphic wells
- Are flexible to accommodate project variability
 - In injection formation, volume and duration
 - Enable research and use of new, innovative technologies



Class VI Site Characterization Requirements

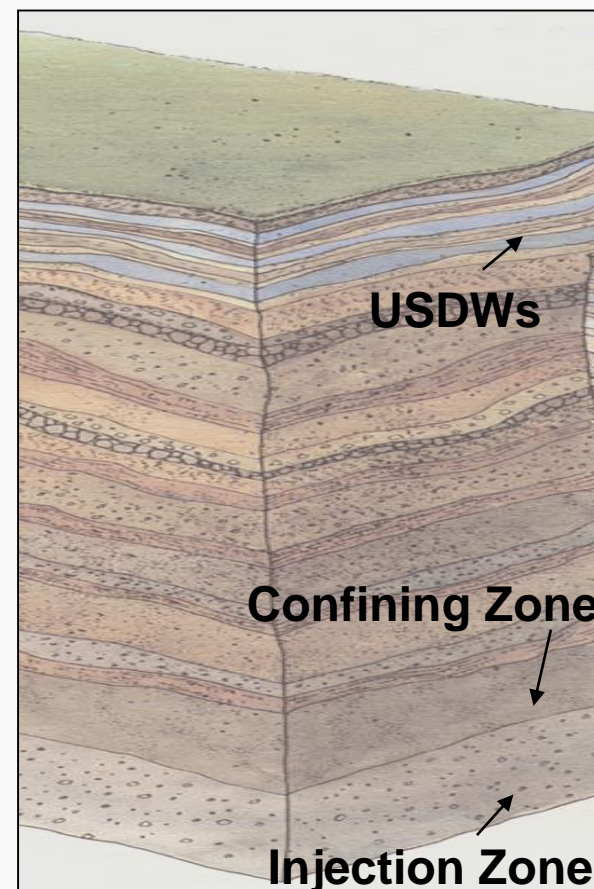
- Tailored, detailed geologic site characterization requirements (40 CFR § 146.82, 146.83 and 146.87)
 - Identification and characterization of injection and confining zone(s)
 - Establish baseline information and comprehensive project information prior to GS project construction and operation



Class VI Site Characterization Requirements

GS Rule Approach

- Director has discretion to require identification of additional confining zones
- Owners and Operators submit information on the following
 - Structure
 - Stratigraphy
 - Seismicity
 - Baseline geochemistry

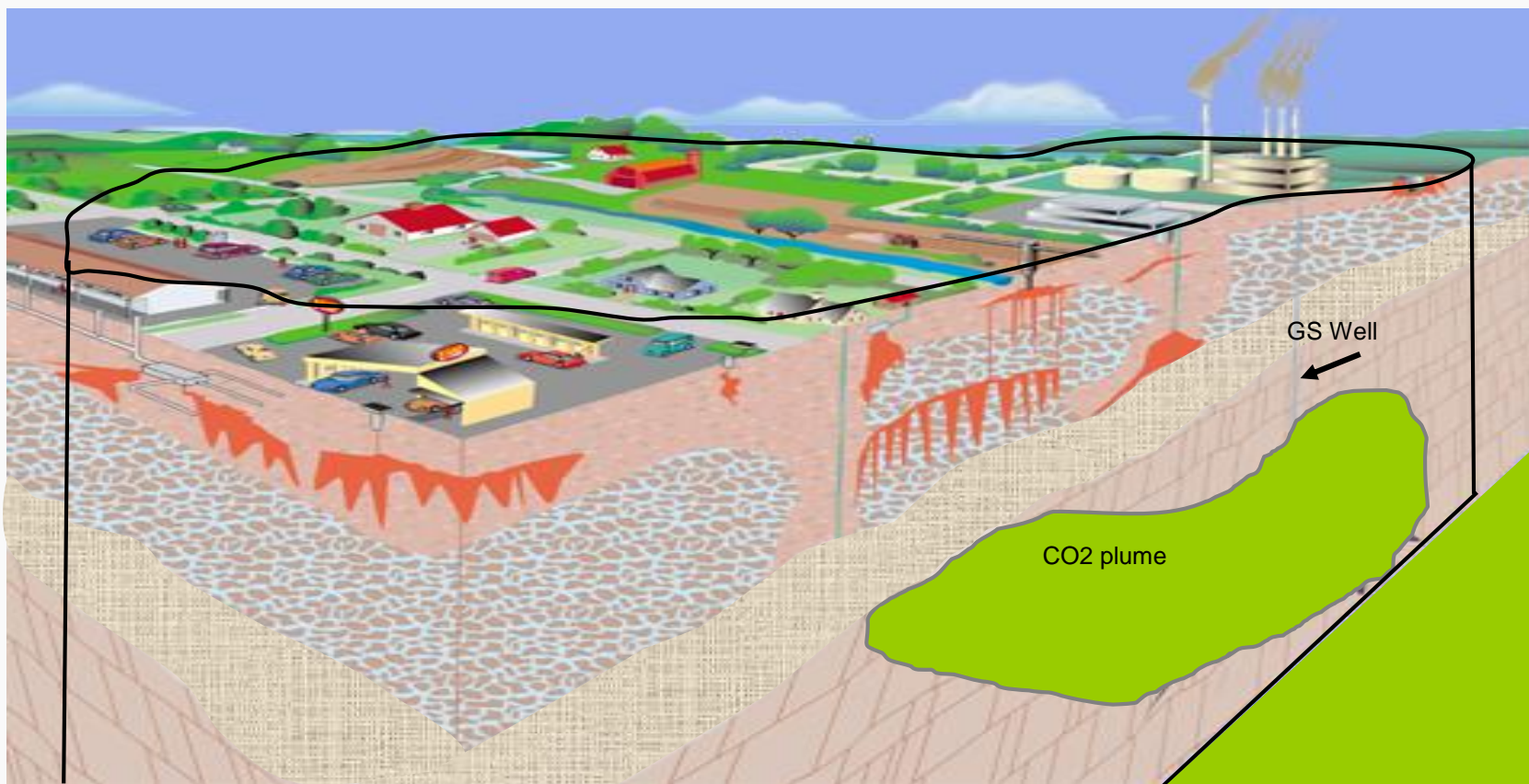




Class VI Area of Review and Corrective Action Requirements

- Required at 40 CFR § 146.84
 - Initial delineation of the Area of Review (AoR)
 - Using computational modeling which accounts for the injected CO₂ plume and the area of elevated pressure
 - Relies upon site characterization data
 - Periodic re-evaluation of the AoR at a minimum of every 5 years
 - Relies upon operational and monitoring data
- Allows for phased corrective action of abandoned wells in the AoR at the UIC Director's discretion

Class VI Area of Review

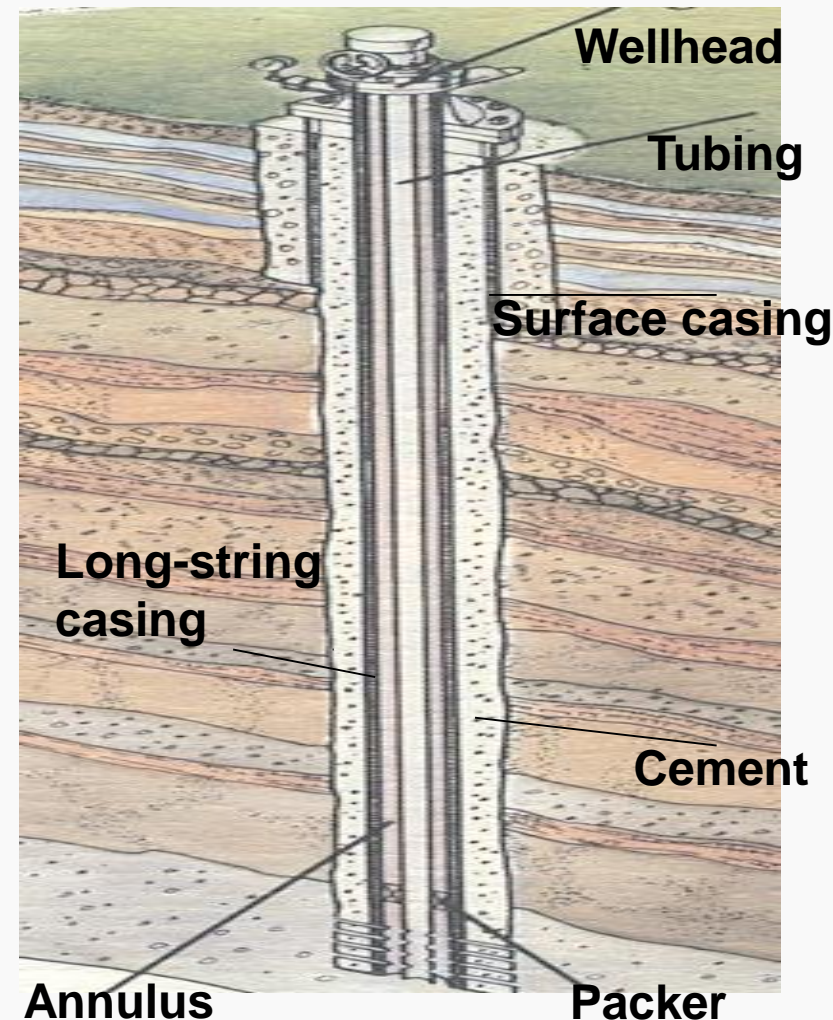




Class VI Well Construction Requirements

GS Rule Approach

- Inject below USDWs (unless an injection depth waiver is issued)
- Long-string casing cemented in place for its entire length
- Surface casing through the base of the lowermost USDW and cemented to surface





Class VI Well Construction and Operation Requirements

- Establishes specific standards for Class VI well construction and operation (40 CFR § 146.81, 146.86 and 146.88)
 - Construction materials must be compatible with the injectate and formation fluids
 - Owners or operators must establish site specific operational conditions
 - Use of automatic shut-off devices



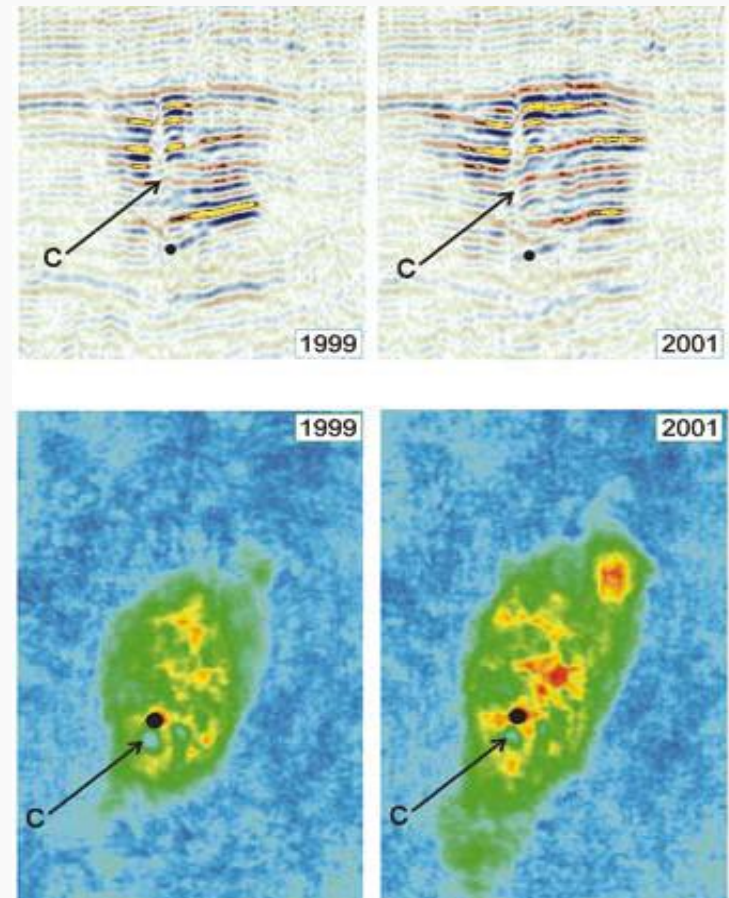
Class VI Testing and Monitoring Requirements

- Requires tailored testing and monitoring at each GS project (40 CFR § 146.88, 146.89 and 146.90)
 - Monitoring/sampling of the CO₂ (i.e., physical and chemical characteristics)
 - Mechanical integrity testing of injection wells
 - Ground water monitoring
 - Surface-air/soil-gas monitoring at the UIC Director's discretion

Class VI Testing and Monitoring Requirements

GS Rule Approach

- Determine extent of CO₂ movement and associated area of elevated pressure (pressure front)
- Techniques, frequency, and spatial resolution of CO₂ plume and pressure front monitoring are not specified in the regulations



Seismic Monitoring Results at Sleipner



Class VI Project Plan Requirements

- Five project-specific plans must be developed, submitted and updated during the life of a GS project
 - Area of Review and Corrective Action (40 CFR § 146.84)
 - Testing and Monitoring (40 CFR § 146.90)
 - Injection Well Plugging (40 CFR § 146.92)
 - Post-Injection Site Care and Closure (40 CFR § 146.93)
 - Emergency and Remedial Response (40 CFR § 146.94)
- The final plans become enforceable permit conditions



Class VI Financial Responsibility (FR) Requirements

- Clarifies and expands FR requirements (40 CFR § 146.85) to ensure funds are available for all phases over the life of a GS project including
 - Project Operation
 - Corrective Action
 - Well Plugging
 - Emergency and Remedial Response
 - Post Injection Site Care (PISC) and Site Closure



Class VI Post-Injection Site Care Requirements

- Required, at 40 CFR § 146.93, appropriate monitoring and other actions (e.g., corrective action) needed following cessation of injection to ensure that USDWs are not endangered
- During the PISC period, the owner or operator will
 - Monitor the CO₂ plume and the associated area of elevated pressure
 - Update models and project plans, as appropriate
 - Perform corrective action, as appropriate
 - Ensure USDW protection
- The PISC period ends with a non-endangerment demonstration approved by the UIC Director



Class VI Post-Injection Site Care Requirements

- Determining the PISC timeframe
 - A 50 year default timeframe with associated modeling information
 - An **alternative** PISC timeframe determined during the permitting process based on modeling information
 - An updated, refined PISC timeframe may
 - Be informed by monitoring and operational information and modeling updates
 - Result in PISC plan updates and a permit modification



Class VI Injection Depth Waiver Requirements

- Injection depth waiver for Class VI wells (40 CFR § 146.95)
 - Available to owners or operators applying for a Class VI permit to inject above the lowermost USDW or between USDWs
 - Additional requirements to ensure protection of USDWs above and below the injection zone
 - Accommodates varied geologic settings and uses GS capacity at a range of depths