

# Obtaining EPA Class VI Injection Well Permits:

## Overview of Technical Criteria to be Addressed

Presented by:  
Candace Cady, CandaceCCadyConsulting, LLC

Date:  
March 8, 2022

# Introduction



Obtaining a Class VI injection well permit for geological sequestration of carbon dioxide begins with the **preparation of an extensive permit application** in which the applicant demonstrates to the permitting authority (EPA) that the Class VI wells will be sited in an area with a suitable geologic system for geologic sequestration and that the wells will be constructed, operated, and ultimately closed in such a manner as to ensure the protection of underground sources of drinking water (USDWs) from long-term subsurface storage of carbon dioxide.

# EPA Guidance Documents



- Project Plan Development (Aug 2012)
- Site Characterization (May 2013)
- Area of Review (AoR) Evaluation & Corrective Action (May 2013)
- Construction (May 2012)
- Testing & Monitoring (Mar 2013)
- Recordkeeping, Reporting, & Data Management (Sept 2016)
- Financial Responsibility Requirements (July 2011)
- Environmental Justice Considerations (June 2011)
- Public Participation Requirements (June 2011)
- Plugging, Post-Injection Site Care, & Site Closure (Dec 2016)
- FAQ for Class VI and Subpart RR Reporting (9/2016)
- Primacy Manual for State UIC Directors (4/2014)
- Implementation Manual for UIC Program Directors (1/2018)

# Technical Criteria



- Site Characterization
- Area of Review (AoR) Delineation
- Corrective Action
- Injection Well Construction
- Testing and Monitoring during Operation
- Plugging, Post-Injection Site Care (PISC), and Site Closure
- Financial Responsibility

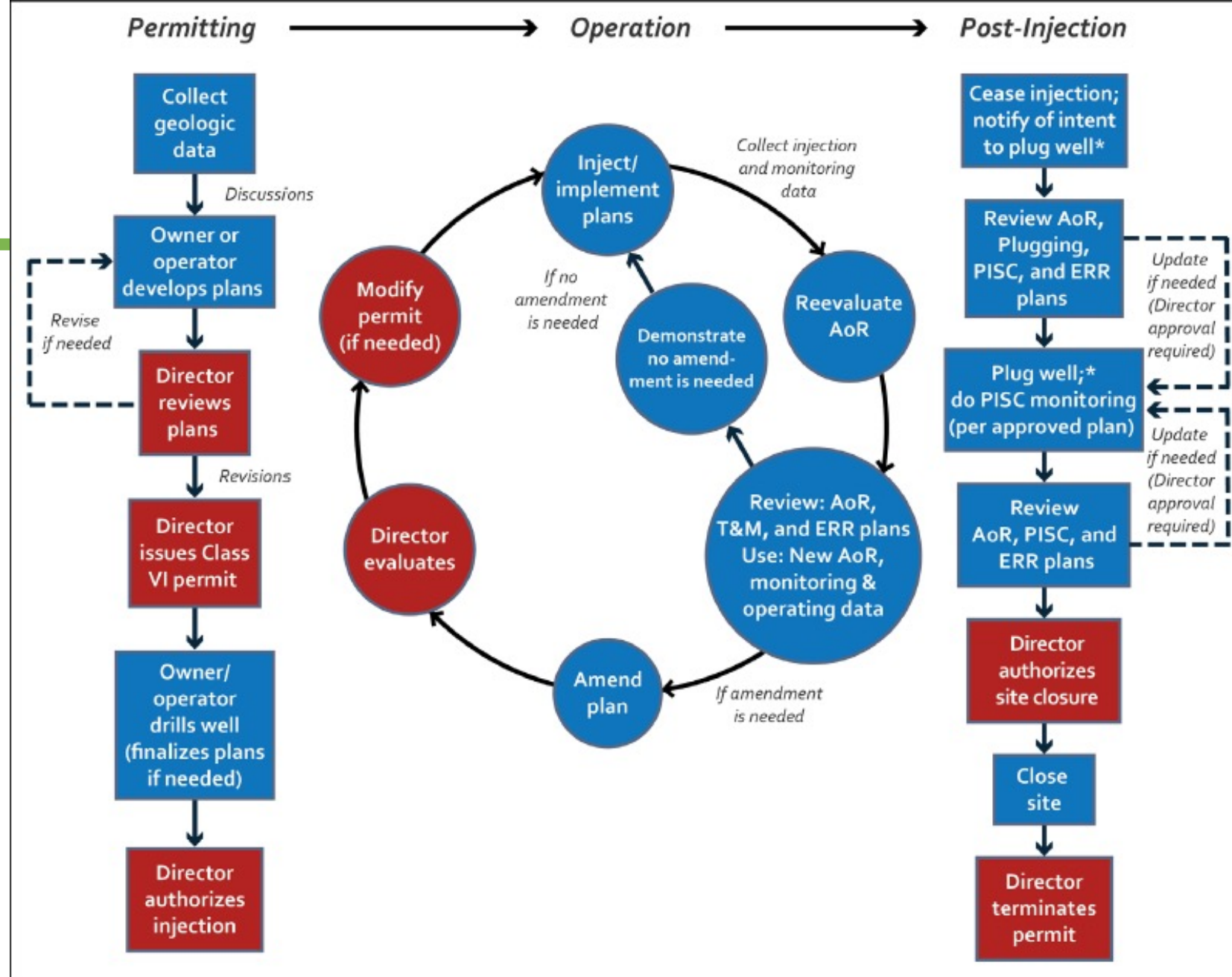
# Required Project Plans for Class VI Wells



- Area of Review (AoR) and Corrective Action Plan
  - Testing and Monitoring Plan (includes Quality Assurance and Surveillance Plan (QASP))
  - Injection Well Plugging Plan
  - Post-Injection Site Care (PISC) and Site Closure Plan
  - Emergency and Remedial Response Plan
- +
- Well Construction and Operations Plan
  - Stimulation Plan, if necessary
  - Financial Responsibility

# Process for Developing, Approving, & Amending Project Plans for Class VI Permit

Taken from EPA Class VI Project Plan Development Guidance



\*Owners or operators may choose to keep the injection well open as a monitoring well; see the ~~Draft~~ UIC Program Class VI Well Plugging, PISC, and Site Closure Guidance for additional information.

# Site Characterization



## ➤ Regional Evaluation

1. Characterize regional geology, hydrogeology & local structural geology
2. Gather information on all wells, subsurface clean-up sites, surface water bodies, mines & quarries, surface structures, land ownership boundaries, roads, and faults
3. Study seismic history

## ➤ Detailed Analysis

1. Study faults & fractures in AoR
2. Collect data on the depth, areal extent & thickness of the injection & confining zones, and facies changes.
3. Characterize mineralogy of the injection & confining zones
4. Characterize porosity, permeability, & capillary pressure of the injection & confining zones

# Site Characterization (cont.)



## ➤ Detailed Analysis (cont.)

5. Perform geomechanical characterization
6. Characterize hydrology & hydrogeology of the AoR
7. Characterize geochemistry
8. Perform geophysical characterization

## ➤ During / After Class VI Well Drilling

1. Perform formation testing
2. Analyze cores
3. Characterize injection zone fluids



# Site Characterization (cont.)



- During / After Class VI Well Drilling (cont.)
  4. Calculate fracture pressures
  5. Characterize injection zone hydrogeologic properties
  6. Analyze carbon dioxide stream compatibility
  7. Update site characterization data based on pre-injection logs & tests.

# AoR & Corrective Action



- Prior to receiving approval to construct a Class VI well, the applicant must:
  1. Collect relevant site characterization and proposed operational data
  2. Determine relevant proposed operational data that will inform the AoR multiphase modeling
  3. Develop an AoR and Corrective Action Plan
  4. Perform AoR multiphase modeling and delineation
  5. Identify & assess artificial penetrations within the AoR
- Prior to receiving approval to inject carbon dioxide, the applicant must:
  1. Collect and/or update relevant site & operational data that will inform AoR multiphase modeling
  2. Identify any needed updates to the AoR and Corrective Action Plan

# AoR & Corrective Action (cont.)



- Prior to receiving approval to inject carbon dioxide (cont.)
  3. Finalize AoR multiphase modeling & delineation
  4. Perform corrective action on those artificial penetrations (wells) that may serve as a conduit for fluid movement
- During injection and post-injection site care (PISC), the applicant must:
  1. Reevaluate the AoR periodically, at least once every five (5) years
  2. If phased corrective action is approved or when additional corrective action is warranted based on AoR reevaluations, perform corrective action.

# AoR Delineation Using Computational Models



## ➤ Data Requirements

1. regional & site-specific geology & hydrogeology
2. proposed & existing operational data – injection pressures, rates, total volumes over lifetime of GS project, number of Class VI wells, total depth of Class VI wells, etc.

## ➤ Model Development

1. Conceptual model of proposed injection site
2. Determination of processes to be modeled - multiphase flow (required), reactive transport, geomechanical.
3. Computational model design
4. Executing the computational model

## ➤ AoR Delineation Based on Model Results

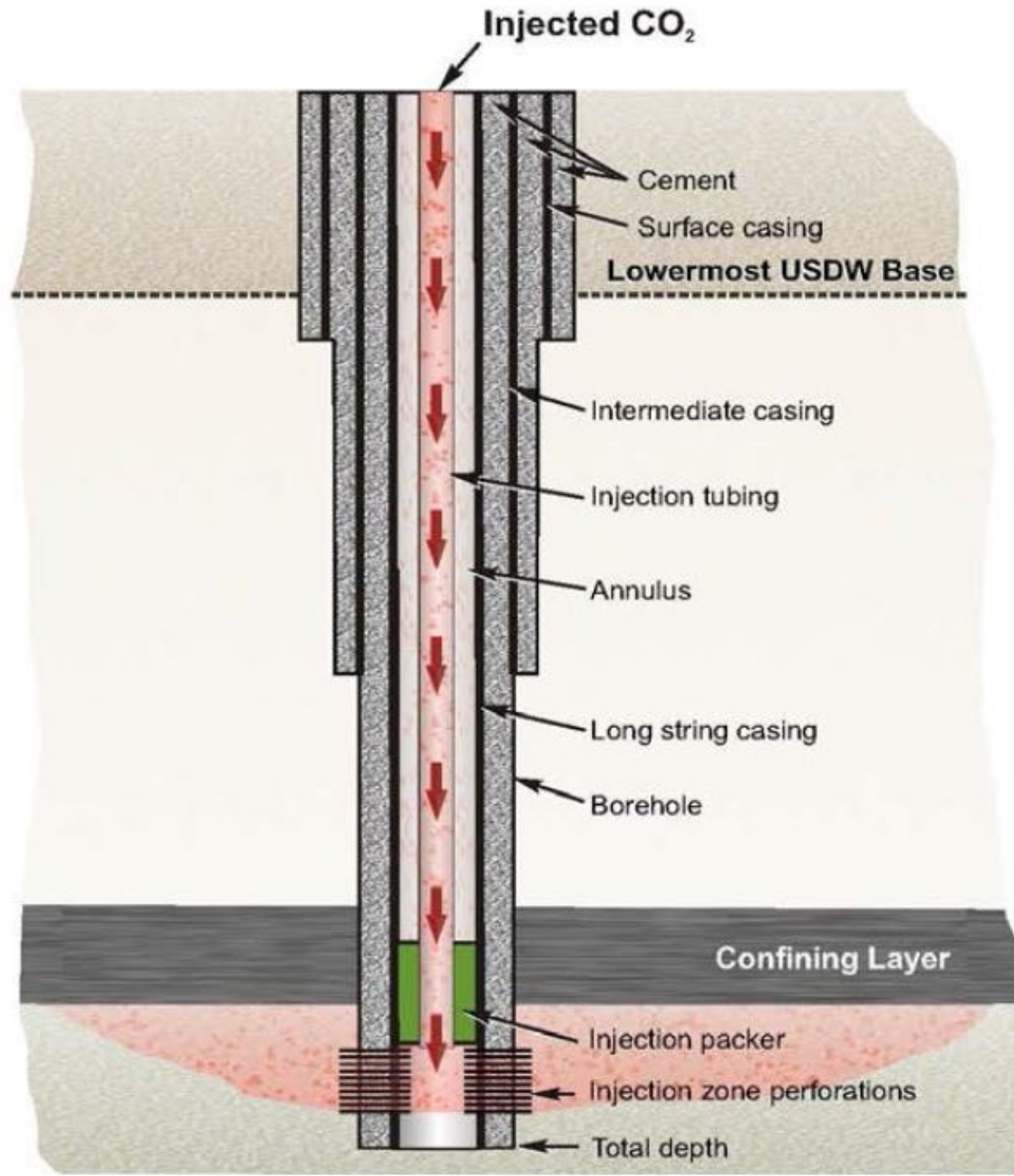
The boundaries of the AoR are based on simulated predictions of the extent of the separate-phase (i.e., supercritical, liquid, or gaseous) plume and pressure front. The pressure front may be defined as the minimum pressure within the injection zone necessary to cause fluid flow from the injection zone into the formation matrix of the USDW through a hypothetical conduit (i.e., artificial penetration) that is perforated in both intervals.

# Identifying Artificial Penetrations & Performing Corrective Action (CA)



- Identifying Artificial Penetrations within AoR
  1. Historical Research
  2. Site Reconnaissance
  3. Aerial & Satellite Imagery Review
  4. Geophysical Surveys
- Assessing Identified Abandoned Wells
- Performing Corrective Action on Wells within AoR
  1. Plugging of Wells within AoR
  2. Remedial Cementing
- Repeat the process in the three bullets above after the periodic AoR re-evaluation.

# Typical Class VI Well Schematic



# Injection Well Construction & Operations



- Design to prevent fluid movement outside injection zone. Considerations include:
  1. Demonstrating internal & external mechanical integrity
  2. Casing
  3. Tubing
  4. Cement
  5. Packer
- Design for logging & workovers. Considerations include:
  1. Well must be designed to accommodate tools – casing diameter & curvature of well (well verticality)
  2. Continuous monitoring of annulus
- Design for down hole stresses. Considerations include:
  1. Pressure from injectate
  2. Pressure from formation
  3. Tensile stress from weight of casing & tubing
  4. Compressive stress during installation

# Injection Well Construction & Operations (cont.)



- Design for down hole stresses (cont.)
  5. Temperature extremes & changes
  6. Corrosion
- Design primary cementing program. Considerations include:
  1. Cement placement – single or multiple stages
  2. Cement compatibility – CO<sub>2</sub> stream & formation fluids
  3. Cement bond & variable density logs on surface & long string casings; determine condition of cement behind casing
- Design tubing & packer assembly. Considerations include:
  1. Injection of CO<sub>2</sub> must be through tubing
  2. Tubing & packer must be compatible with same stresses as casing
  3. Packer placement considerations



# Injection Well Construction & Operations (cont.)



- Design surface & down hole shut-off devices
  1. Alarms & automatic surface shut-off systems are required
  2. Down hole shut-off systems may be required at discretion of UIC Program Director
- Establish operating parameters
  1. Injection pressure must not exceed 90% of injection zone fracture pressure except during stimulation,
  2. Injection tubing-long string casing annulus be filled with a non-corrosive fluid & annular pressure between tubing & casing be maintained at a pressure higher than the injection pressure,
  3. Mechanical integrity of the well system must be maintained.

# Testing & Monitoring during Operations



## ➤ Mechanical Integrity Testing (MIT)

### 1. Internal MI

- a. Annulus Pressure Test – required as initial internal MIT
- b. Annulus Pressure Monitoring – continuous APM required
- c. Radioactive Tracer Survey, with UIC Director approval

### 2. External MI

- a. Oxygen Activation Log
- b. Temperature Log
- c. Noise Log
- d. Alternative Methods for External MIT – with written approval from EPA Administrator

# Testing & Monitoring during Operations (cont.)



## ➤ Operational Testing & Monitoring During Injection

1. Analysis of CO<sub>2</sub> stream – with sufficient frequency to yield representative data
2. Continuous monitoring of injection rate & volume
3. Continuous monitoring of injection pressure
4. Corrosion monitoring – quarterly using method a - c
  - a. Use of corrosion coupons
  - b. Use of corrosion loop
  - c. Use of alternative method – approved by UIC Director
  - d. UIC Director may require use of a casing inspection log (CIL) periodically
5. Pressure Fall-Off Testing – at least once every 5 years

# Testing & Monitoring during Operations (cont.)



## ➤ Ground Water Quality & Geochemical Monitoring

1. Class VI Rule requires periodic monitoring of ground water quality & geochemical changes above the confining zone(s)
2. Design of the monitoring well network
  - a. Perforated interval of monitoring wells
  - b. Monitoring well placement
  - c. Phased monitoring well installation
3. Monitoring well construction
4. Collection & analysis of ground water samples

## ➤ Plume & Pressure Front Tracking

1. Direct Pressure Front Tracking – required by Class VI Rule
2. Plume & Pressure Front Tracking Using Indirect Geophysical Techniques – seismic, electric geophysical, gravity methods – required by Class VI Rule
3. Use of geochemical ground water monitoring in plume tracking – considerations.

# Emergency Response & Remediation



- As part of the permit application, the owner or operator must provide the Director [EPA] with an emergency and remedial response plan that describes actions the owner or operator must take to address movement of the injection or formation fluids that may cause an endangerment to a USDW during construction, operation, and post-injection site care periods.

# Post-Injection Site Care (PISC) & Site Closure



- PISC is the time period immediately following cessation of injection until site closure is authorized.
- Class VI Rule requires monitoring during PISC period.
- PISC monitoring timeframe default is 50 years, HOWEVER the rule provides flexibility to allow operator to propose an alternative timeframe other than 50 years.

# Financial Responsibility (40 CFR 146.85)



- The owner or operator must demonstrate and maintain financial responsibility with Director-approved qualifying instrument(s) that is(are) sufficient to cover the cost of:
  - Corrective Action
  - Injection well plugging
  - Post-injection site care and site closure, and
  - Emergency and remedial response.
- The financial responsibility instrument(s) must be sufficient to address endangerment of underground sources of drinking water.
- The qualifying financial responsibility instrument(s) must comprise protective conditions of coverage as described in detail in 40 CFR 146.85.

Thank you!