

Carbon Sequestration at the Louisiana Office of Conservation

Corey Shircliff and Laura Sorey
Louisiana Department of Natural Resources
Office of Conservation – Injection & Mining Division

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Presentation Outline

- I. Louisiana Injection and Mining Division
- II. Class VI Primacy Process
- III. Carbon Sequestration Wells
- IV. Permit and Regulatory Process
- V. Permit Technical Content
- VI. Monitoring after a project begins
- VII. Wrap up and questions

Louisiana Department of Natural Resources



Office of Mineral Resources

Office of Conservation

Office of Coastal Management

Pipelines Division

Environmental Division

Geological Oil and Gas

Engineering Regulatory

Engineering Administrative

Injection and Mining

Louisiana Injection and Mining Division

What We Do

The 1974 Safe Drinking Water Act (SDWA) established national UIC Program under the EPA and charged them to:

- * Establish Technical Regulations for UIC Program
- * Define the Underground Source of Drinking Water (USDW)
- * Establish Injection Well Classifications

Office of Conservation was granted primacy of the UIC program in 1982.

Injection Well Class Types

Class I	Industrial (Hazardous & Non-Hazardous) or Municipal Waste
Class II	Oil & Gas Related (<i>SWD, EOR, Storage</i>)
Class III	Solution Mining (Caverns)
Class IV	Hazardous Waste above or into USDW
Class V	Wells not covered under the remaining classifications
Class VI	Carbon Sequestration



Regulations

Louisiana Administrative Code	Statewide Order	Subject or Regulation
LAC 43:XVII.103 Chapter 1	Statewide Order No. 29-N-1, Chapter 1	Class I Non-Hazardous Waste Injection
LAC 43:XVII Chapter 2	Statewide Order No. 29-N-2, Chapter 2	Class I Hazardous Waste Injection
LAC 43:XIX Chapter 4	Statewide Order No. 29-B, Chapter 4	Class II Injection/Disposal Well Regulations
LAC 43:XIX Chapter 3	Statewide Order No. 29-B, Chapter 3	Onsite storage, treatment and disposal of oilfield waste. Primarily oilfield pit regulations, but also has some general requirements for Class II disposal wells
LAC 43:XVII Chapter 3	Statewide Order No. 29-M, Chapter 3	Class II Hydrocarbon Storage in Salt Dome Cavities
LAC 43:XVII Chapter 33	Statewide Order No. 29-M-3, Chapter 33	Class III Solution-Mining Injection Wells
LAC 43:XVII Chapter 36	Statewide Order No. 29-N-6, Chapter 36	Class VI Geologic Sequestration of Carbon Dioxide
LAC 43:XVII.103 Chapter 1	Statewide Order No. 29-N-1, Chapter 1	Class V Injection Wells not included in Class I, II, III, IV or VI
LAC 43:XVII Chapter 37	Statewide Order No. 29-M-5, Chapter 37	*Class V Storage Wells in Solution-Mined Salt Dome Cavities (Hydrogen, Helium, Ammonia, Compressed Air, etc.)

**recently submitted to Louisiana State Register and awaiting promulgation.*



Louisiana Injection and Mining Division

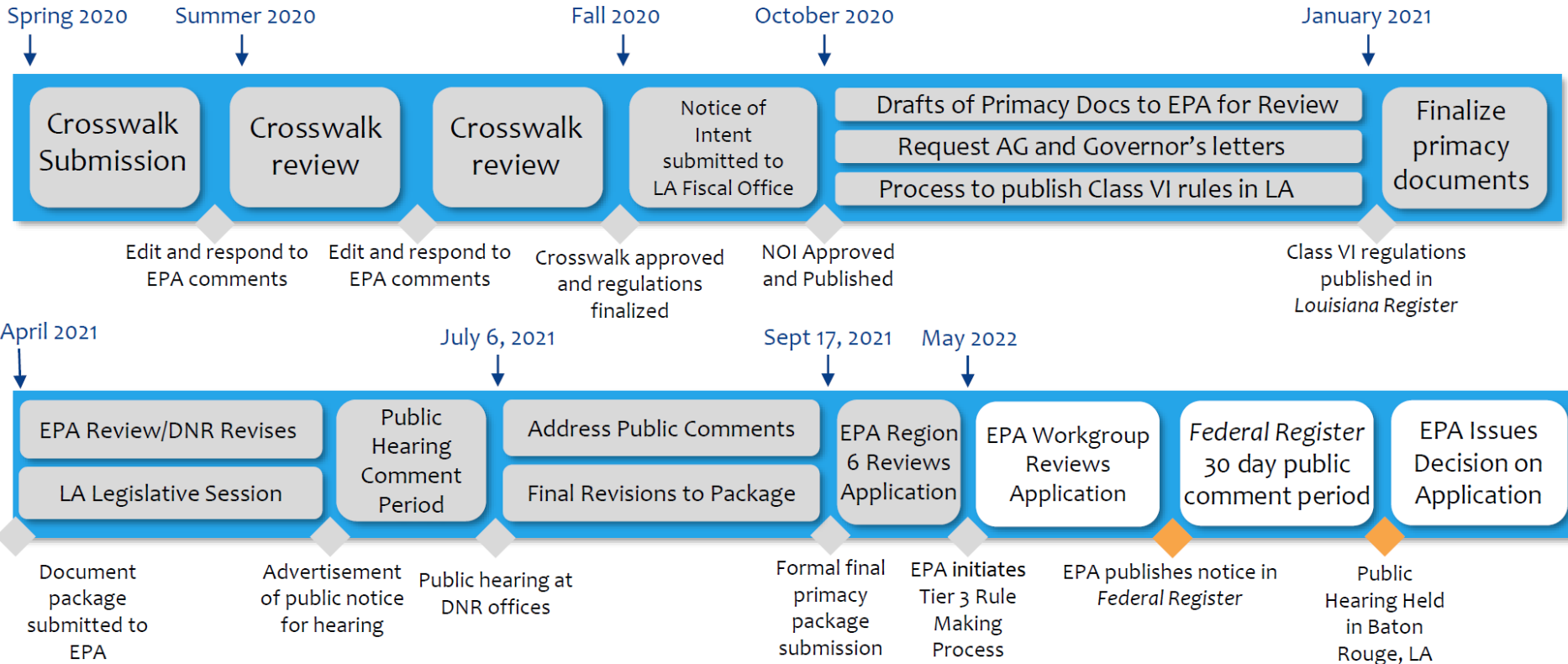
What We Do

- * Regulate Class I – V wells as a United States Environmental Protection Agency Primacy Program
 - * Seeking Class VI primacy currently
- * Responsible for permitting, compliance, and enforcement for all injection wells in Louisiana
- * Primary responsibility is to prevent endangerment of the Underground Source of Drinking Water from injection activities.



Steps to Class VI Primacy

Louisiana Department of Natural Resources



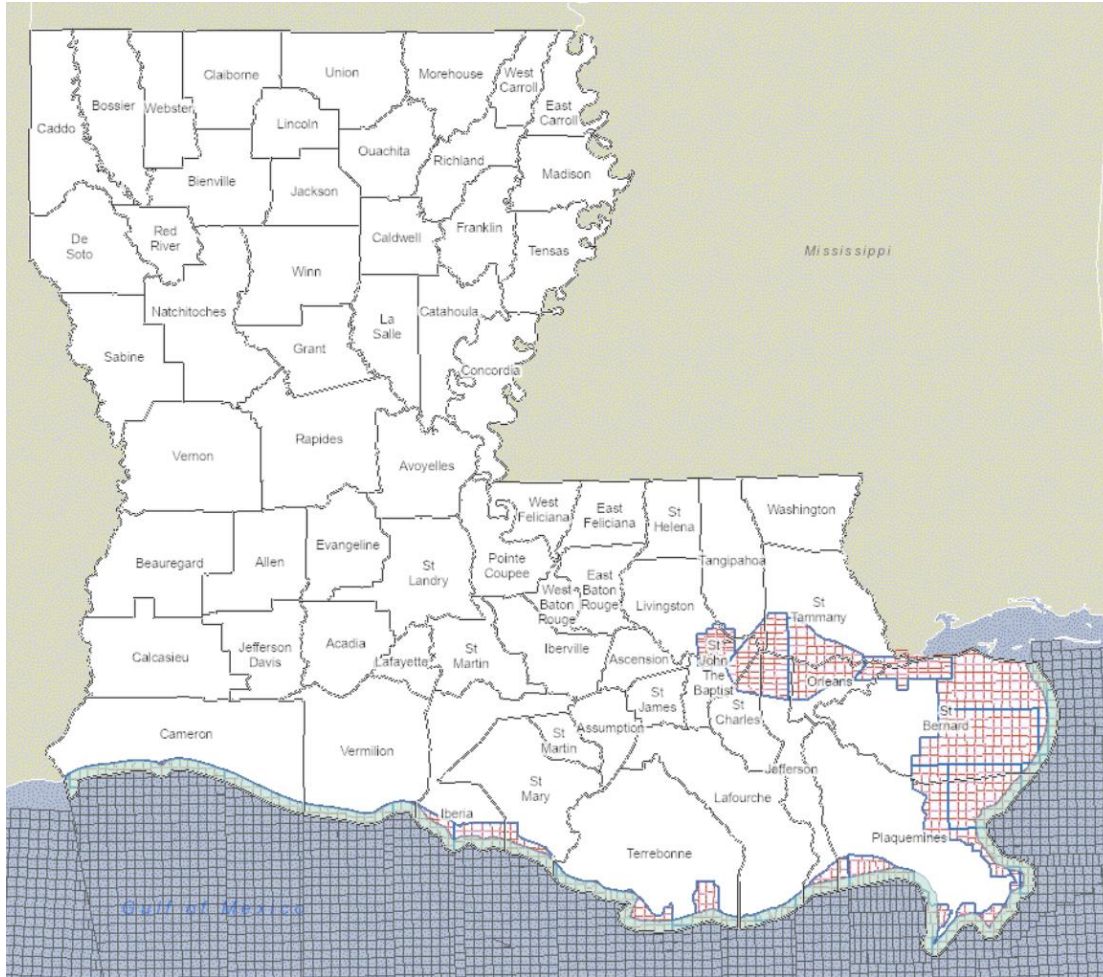
Per 40 CFR 145.31(e), the EPA Administrator will issue a final decision on the Primacy Application within 90 days of the application being declared administratively complete.

CONTACT INFORMATION

Steve Lee, Director
 LDNR Injection and Mining Division
 225-342-5569
stephen.lee@la.gov

CCS in Louisiana

Louisiana Department of Natural Resources



❖ Interest in Louisiana

- ❖ South LA focus
- ❖ Saline aquifers most popular
- ❖ No CO₂ sequestration in salt caverns
- ❖ Seven (7) administratively complete applications under review/pending review in Louisiana¹ (as of July 15 2022)
- ❖ Louisiana Class VI regulations promulgated January 2021²

¹<https://www.epa.gov/uic/class-vi-wells-permitted-epa>

²http://www.dnr.louisiana.gov/assets/OC/im_div/uic_sec/43v17_2021.pdf#page=149

Carbon Sequestration Wells

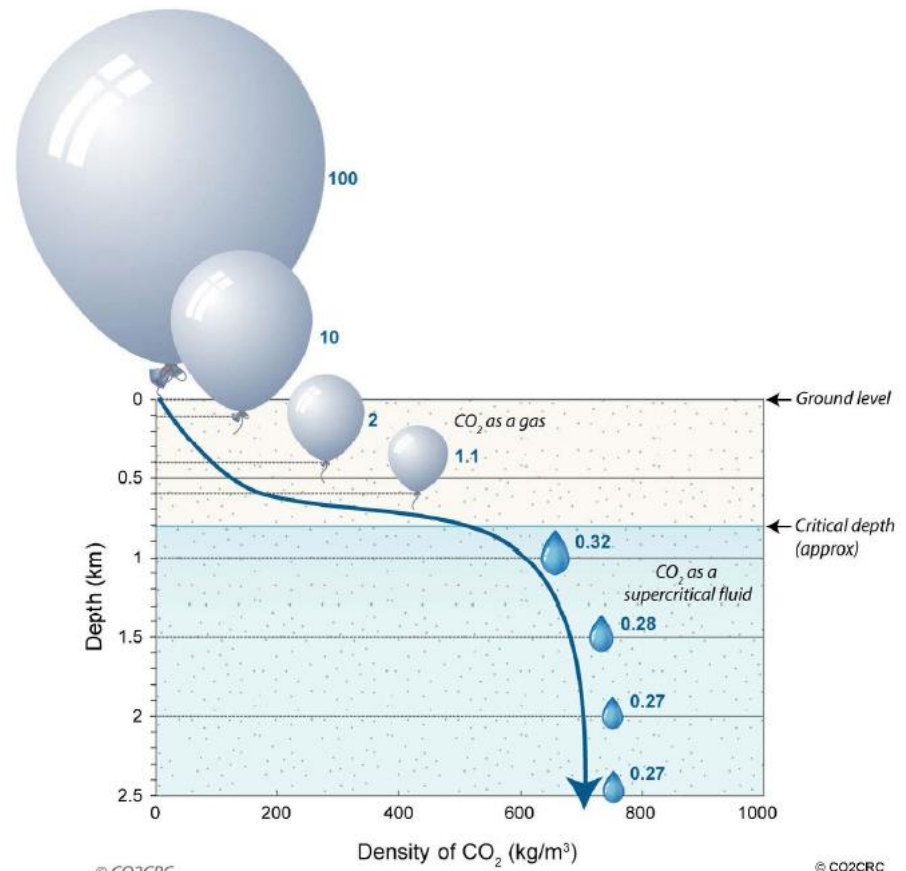
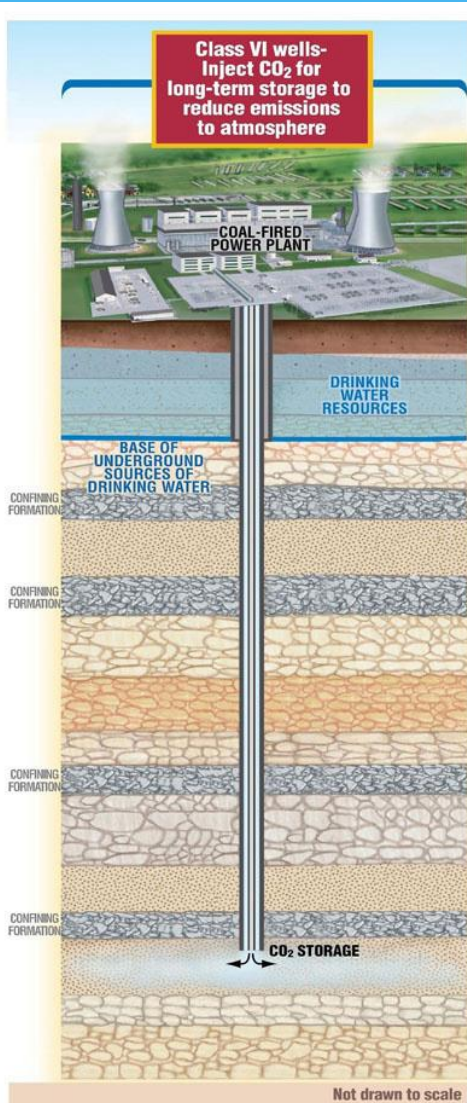
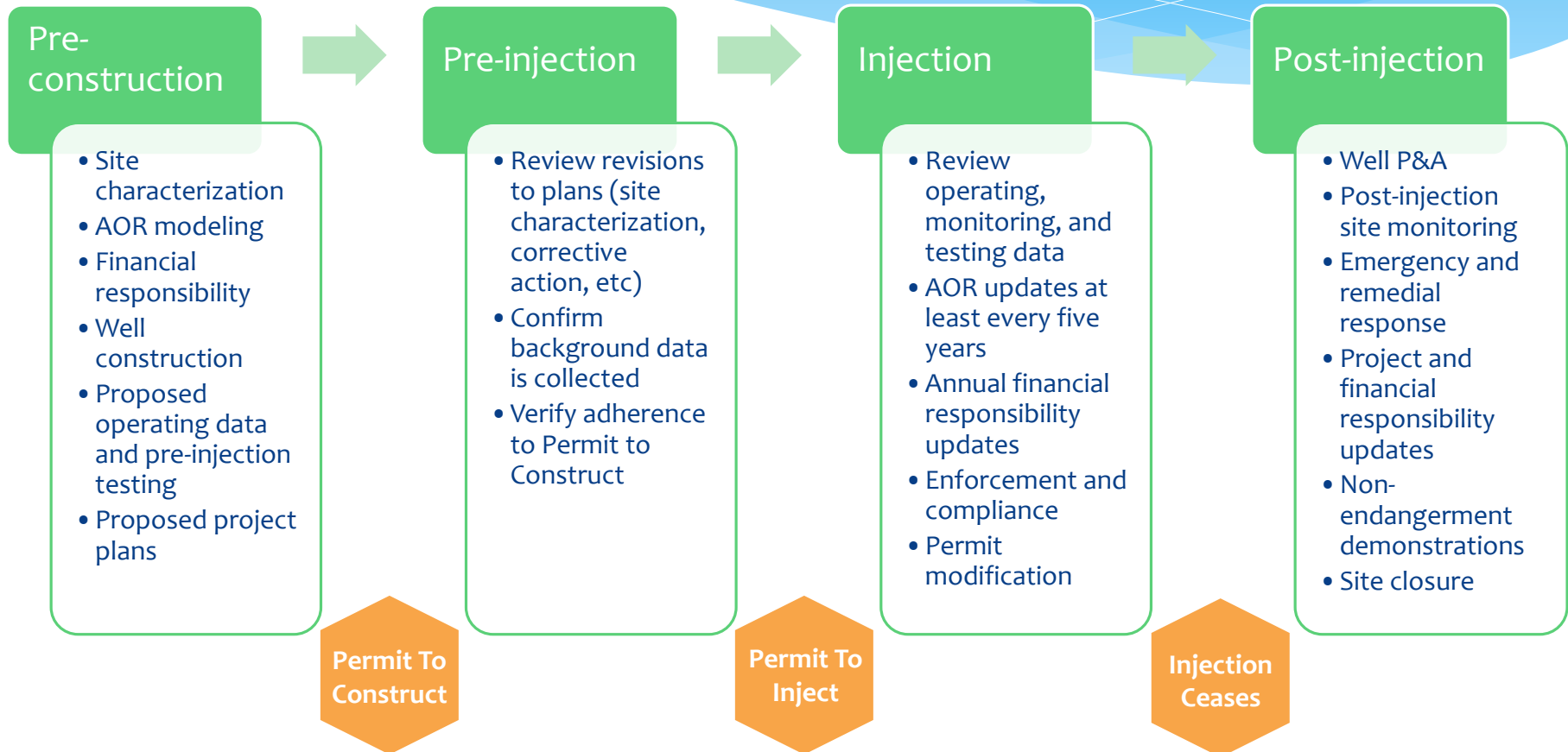


Figure A-26: Density of Carbon Dioxide as a Function of Depth.
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Regulatory Process

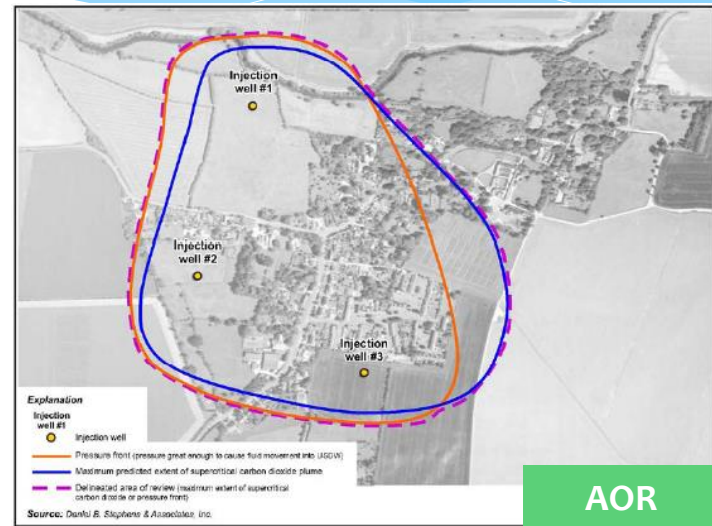
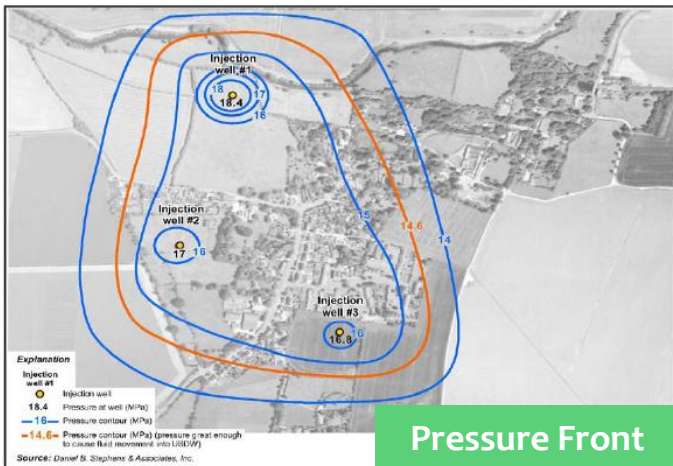
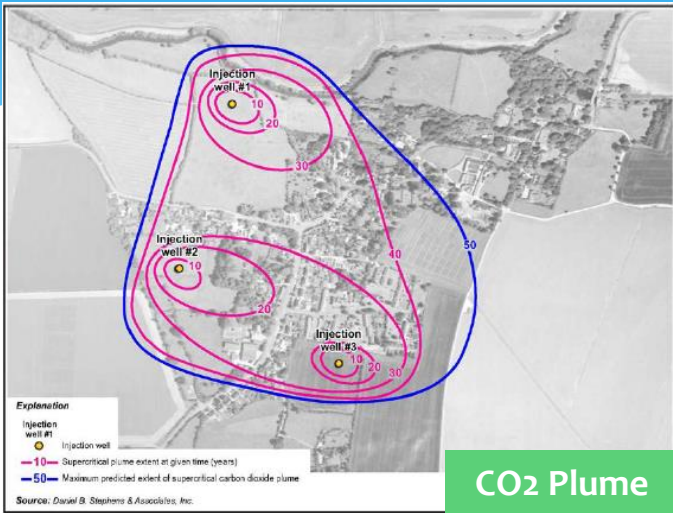


Permit Technical Content

Area of Review (AOR)

- * “the region surrounding the *geologic sequestration project* where USDWs may be endangered by the injection activity, and is delineated using computational modeling that accounts for the physical and chemical properties of all phases of the injected *carbon dioxide stream* and displaced fluids, and is based on available site characterization, monitoring, and operational data as set forth in §§3615.B. and 3615.C.” - LAC 46.XVII.3601.A
- * **AOR = Plume Extent + Pressure Front**
- * Pressure front is extent of sufficient pressure to force injection zone fluid into the USDW
- * Must be reevaluated at least every five years, or when monitoring and operational conditions warrant
- * Updates must incorporate monitoring data and any changes in operating conditions
- * **Importance of a fully characterized AOR cannot be overstated**

Permit Technical Content



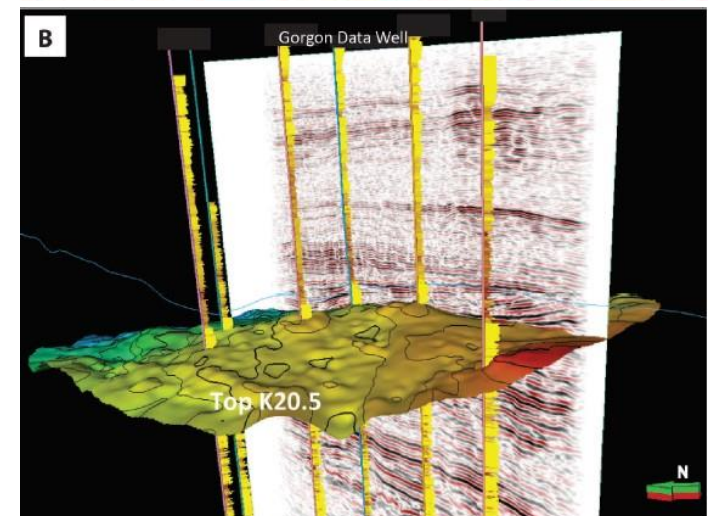
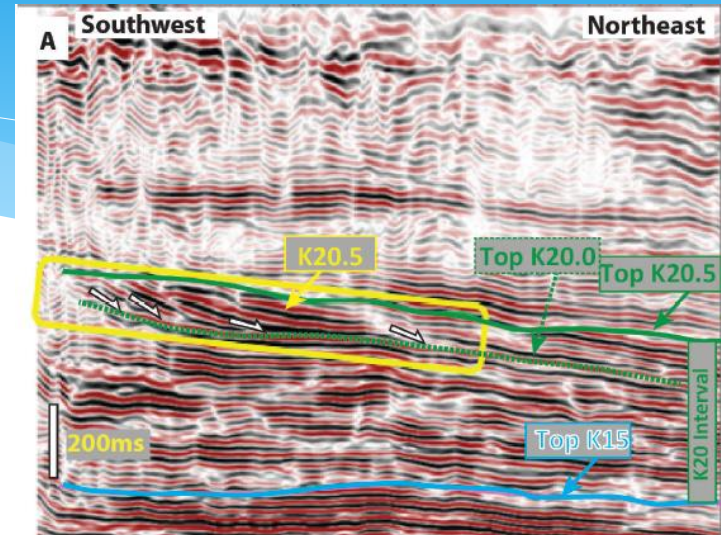
Modified from EPA, "Underground Injection Control (UIC) Program Class VI Well Area of Review Evaluation and Corrective Action Guidance"

- * Theoretical AOR based on max extent of multiphase CO₂ plume **AND** maximum extent of pressure effects

Permit Technical Content

Site Characterization

- * Informs the design and calibration of CO₂ plume models
- * Geologic maps - structure, cross-sections, isopachs, fault plane, etc.
 - * Account for regional geology, area of review (AOR), and hydrology
 - * Characterize structure, stratigraphy, lithology, and faulting for confining and injection zones
- * Reservoir characteristics - mineralogy, porosity, permeability, capillary pressure, formation fluid, etc.
 - * May initially be based on offset wells but must be verified by well logs and coring within the AOR and from the injectors
 - * Data collection via stratigraphic test wells
 - * Strategic core collection

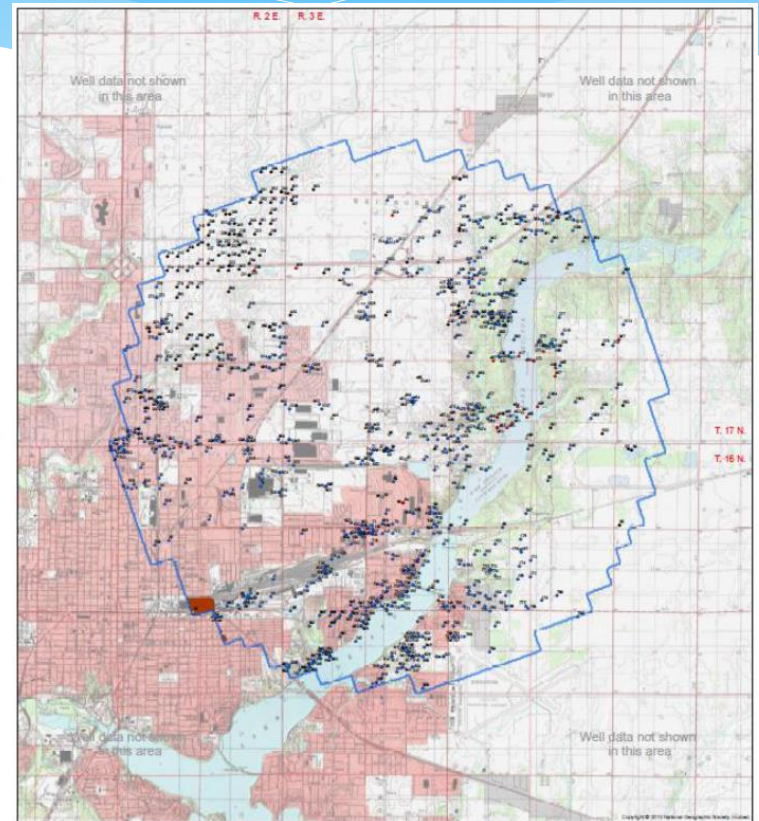


Permit Technical Content

- * Class V Stratigraphic Test Well
 - * Permitted through IMD
 - * Useful tool for site characterization
 - * Can be utilized for logging, core collection, injectivity tests, etc.
 - * CO₂ cannot be injected as test fluid
 - * Possible future utilization as a monitor well or an injector
 - * May need to include CO₂ compatible materials depending on operational plans
 - * “How close is close enough to be site specific?”
 - * **Not required by regulations but is being strongly encouraged to ensure site specific information is included in the Class VI application.**

Permit Technical Content

- * Archer Daniels Midland – Decatur, IL
 - * Injection zone: Mt. Simon sandstone
 - * Upper confining zone: Eau Claire basal shale overlain by limestone and siltstone
 - * Lower confining zone: granitic basement
 - * Injection interval avg. porosity = 22% and avg. permeability = 25 mD
 - * CCS #2 perms: 6630-6825' MD
 - * AOR area = 34.17 square miles; $r \approx 3.30$ miles
 - * 1,065 wells within AOR; the only wells to penetrate upper confining zone are associated with the CCS project



Modified from “Area of Review and Corrective Action Plan for ADM CCS#2 — Modified January 2017”

Permit Technical Content

- * Computational Modeling
 - * **Static/geologic model** – geologic structure, lithology, stratigraphy, porosity and intrinsic permeability distribution, reservoir characteristics, etc.
 - * **Reservoir simulation** – models the flow of the multiphase CO₂ plume through the pore space. Accounts for CO₂ phase transition (supercritical/liquid/gas), CO₂ dissolution with brine and oil, density and thermal effects, etc.
 - * *Reactive transport modeling* – mineral dissolution and precipitation, effects of trace constituents in the CO₂ stream (e.g., H₂S, So_x), mineralization as a trapping mechanism; may be required
 - * IMD will use CMG GEM but no particular modeling software is required – RESQML file submissions and detailed technical report
 - * IMD will review the inputs and approach but will not reconstruct the model
 - * Must be updated **at least every five years** or as warranted by operating and monitoring conditions

Permit Technical Content

- * Geomechanical studies

- * Important for determining maximum surface injection pressure (MASIP)

- * **Fractures** – fracture finder, caliper, video, acoustic logs, etc.

- * **Ductility** – triaxial load test on core sample

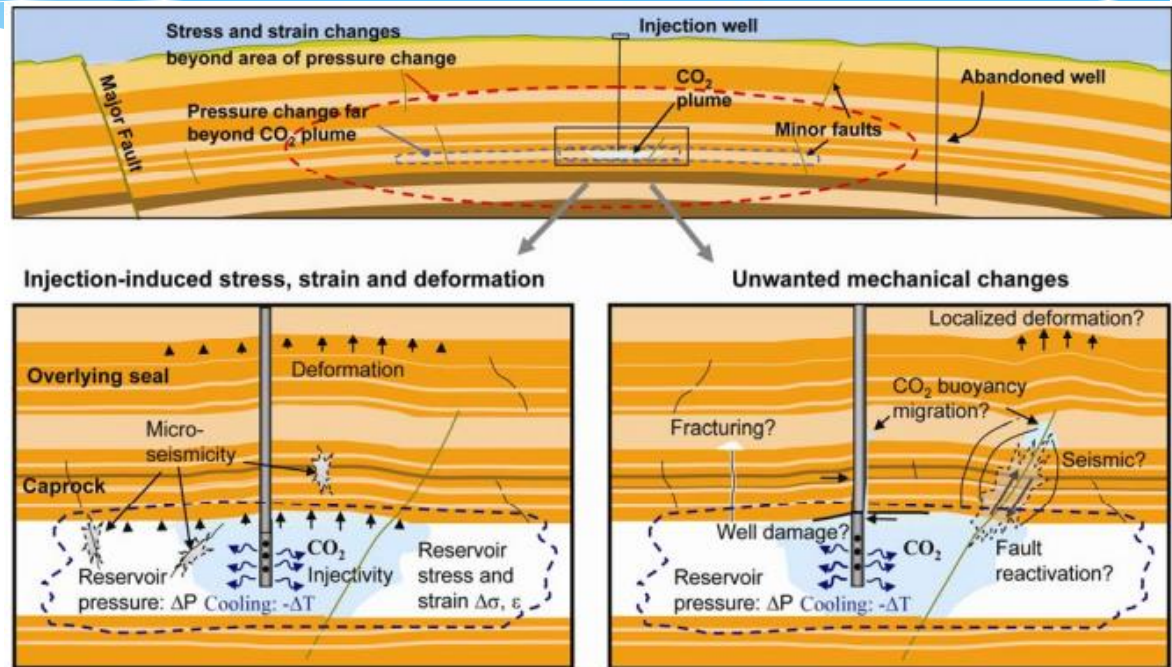
- * **In situ stress regime**

- * Geomechanical risks

- * Fractures leading to loss of containment

- * Fault activation

- * Induced seismicity that can be felt at the surface



Modified from Rutqvist, 2012.

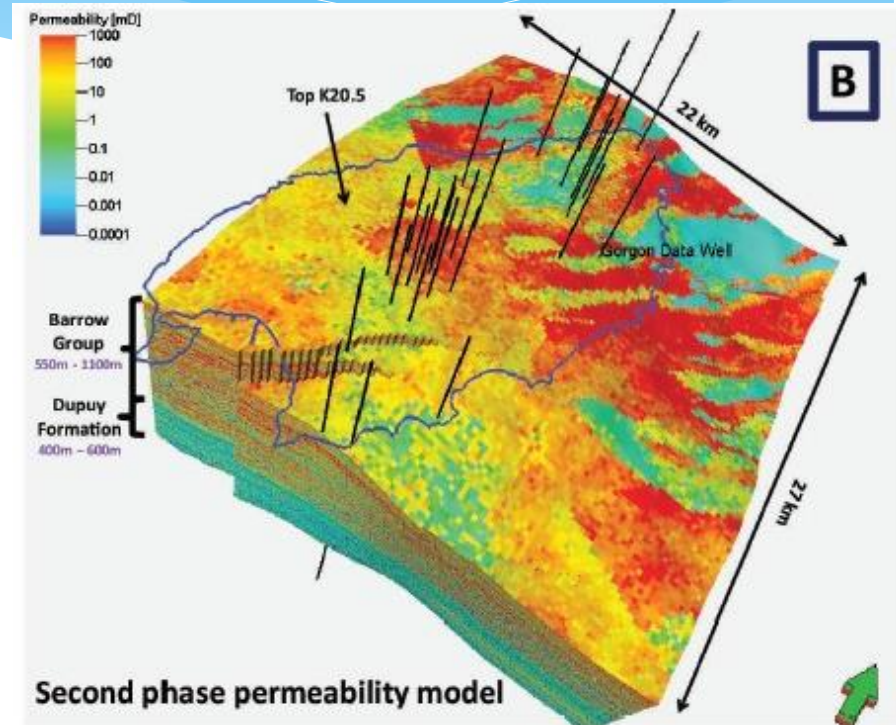
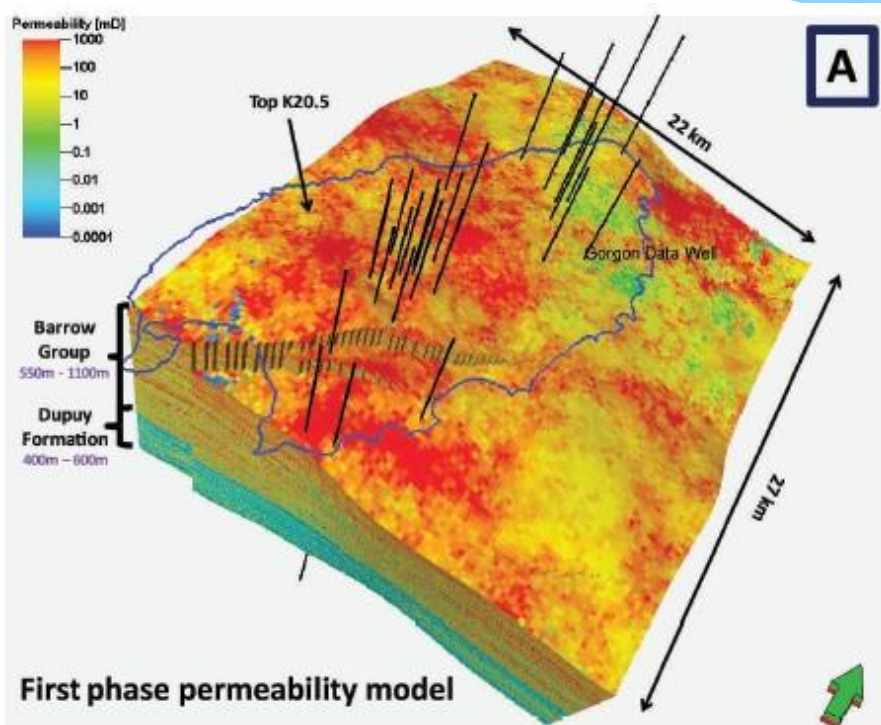
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Geophysical Characterization	SEISMIC						GRAVITY		ELECTRICAL/EM			MAGNETIC
	2D	3D	VSP	3D-VSP	Cross-well	Borehole microseismic	Aerial & surface gravity	Borehole gravity	Natural source	Controlled source	ERT	Aerial & surface magnetic
Near borehole and shallow subsurface			W	W	W	W		W		W		
Field-wide subsurface studies	W	W		W		P	W		W	W		W
Stratigraphy	W	W	W	W	W		W	W	P	P	W	P
Thickness	W	W	W	W	W			W			W	
Structure 0 - 100 m				P		P	P		P	P	P	P
Structure 100 m - 1 km	W	W		W	W	W	P	P	P	P	W	P
Structure > 1km	W	W		W	P	W	W	P	W	W	P	W
Fault/fracture	W	W		W	W	W	P		W	W	P	
Porosity							P	W	W	W	W	
Pore pressure	P	W	P		P							
Abandoned wells											W	W

Modified from EPA, "Underground Injection Control (UIC) Program Class VI Well Site Characterization Guidance"

W = well suited (already in use for site characterization with good results)
P = potential (could be used, but better alternatives available or results lack desired resolution)

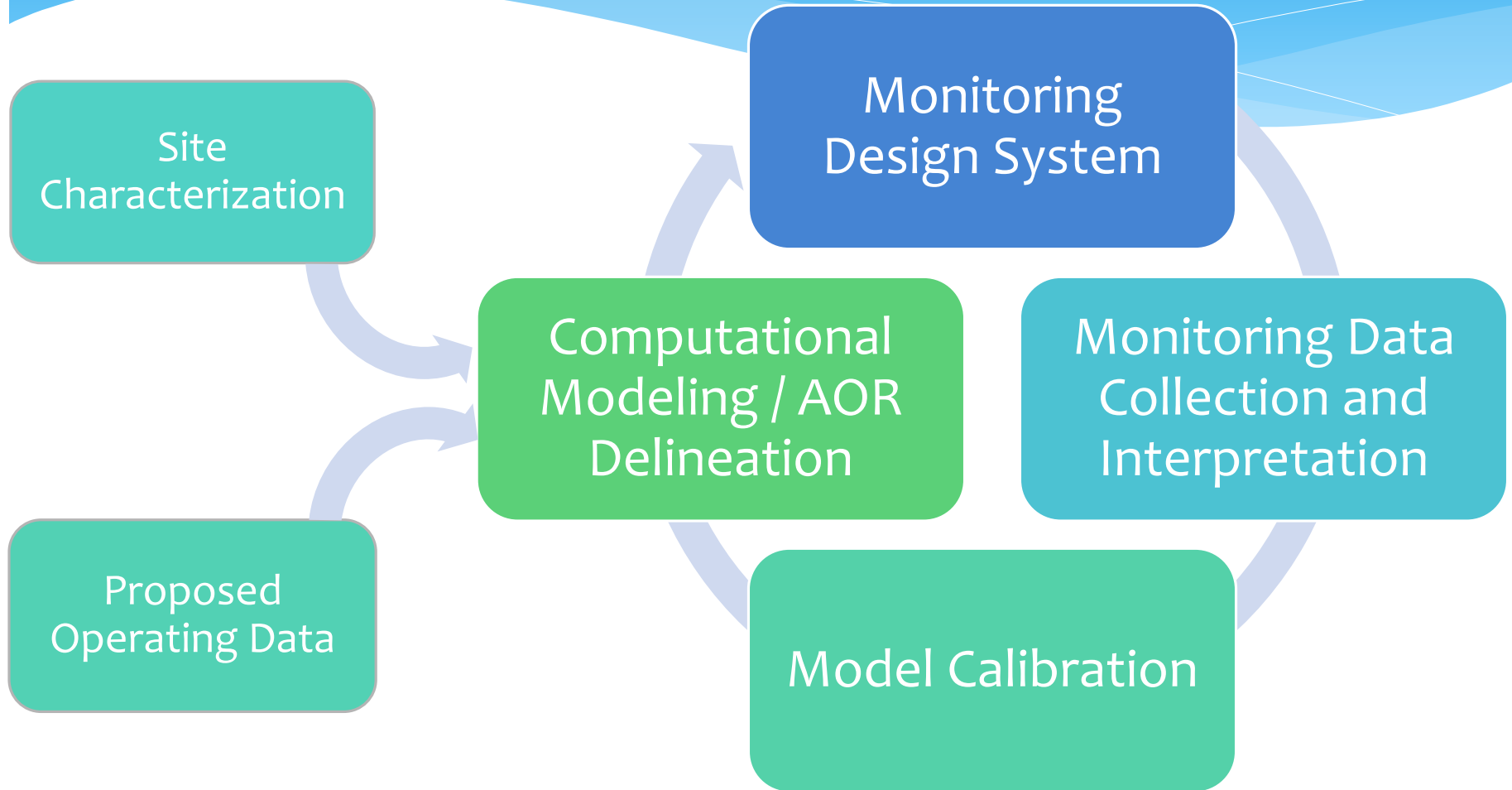
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Modified from Barranco et al, 2013.

Reservoir Models – structural framework, facies modeling, porosity and permeability models, history matching,

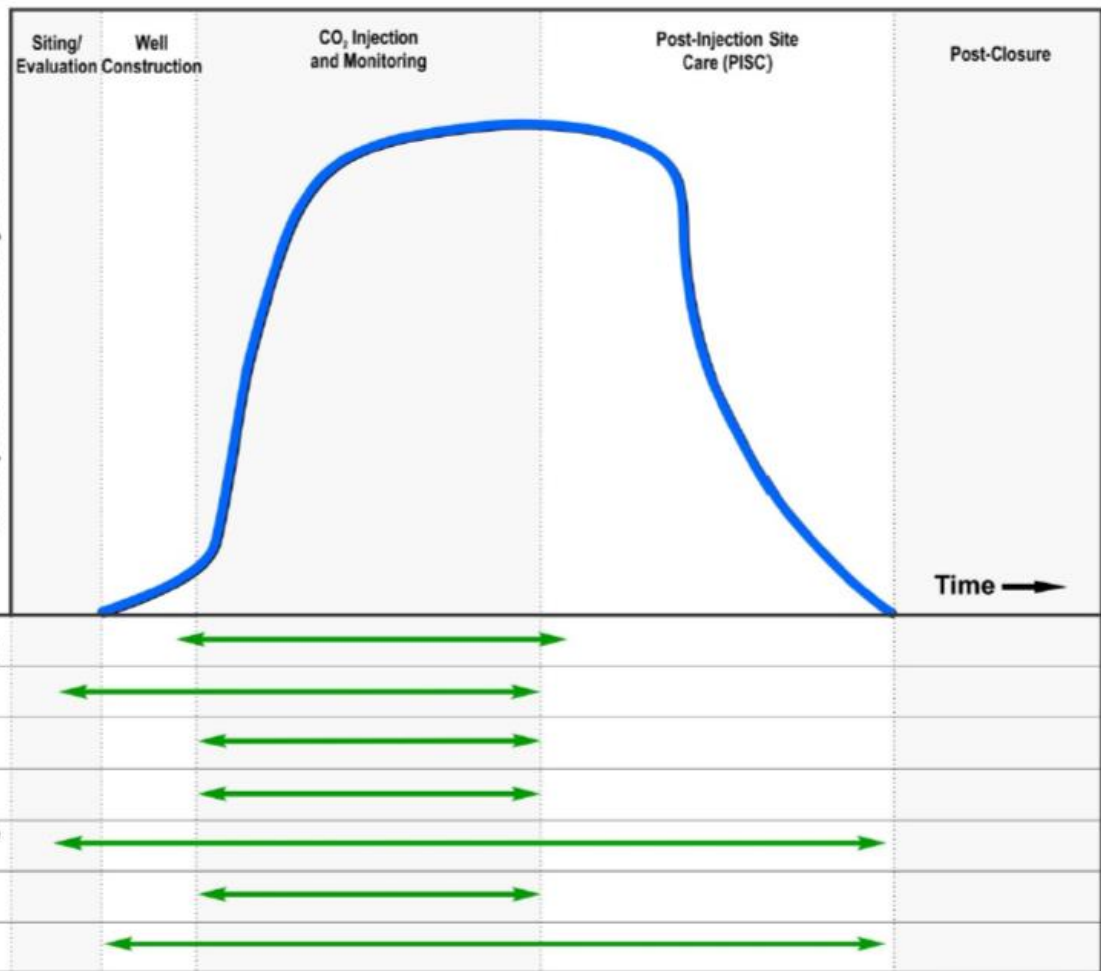
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Monitoring After a Project Begins

Regulatory citations in chart refer to Title 40 Code of Federal Regulations (CFR) Part 146

Example Potential Project Risk



Modified from EPA, "Underground Injection Control (UIC) Program Class VI Well Testing and Monitoring Guidance"

Monitoring After a Project Begins

- * Groundwater Quality Above the Confining Zone
 - * Testing to detect changes in groundwater chemistry that may indicate loss of containment; compare to baseline data collected during site characterization
 - * Regulations require “periodic” sampling but EPA recommends quarterly
- * Plume and Pressure Front Tracking
 - * Results necessary for model comparison and verification
 - * *In situ fluid pressure monitoring* – e.g., pressure transducers in monitoring wells
 - * *Indirect geophysical monitoring* – seismic, gravity, electromagnetic, electrical
 - * *Groundwater geochemical monitoring* – detection of CO₂ plume in monitoring wells; adjusted sampling procedures for high temp/pressure conditions
 - * *Computational modeling* – part of required AOR updates
- * Surface Air/Soil Gas Monitoring
 - * May be required to detect movement of CO₂ leakage
 - * Incorporates baseline data but other technologies may be approved

Environmental Justice

- * Class VI applicants will be required to conduct an EJ review and submit that report with their application. IMD has proposed in our primacy application to the EPA that we will conduct a preliminary screening to help identify the presence of an EJ community within the AOR for the injection project. If a community is identified, we will send the application to a qualified third-party contractor with expertise in EJ to conduct a full evaluation.
- * An enhanced public comment period may extend the public comment period for the application, may require a more inclusive public participation process, including targeted public outreach and creation of better visual tools and approachable language, or may be supplemented in other ways recommended by the reviewer
- * LDNR currently lacks statutory authority to make the results of an EJ review part of the actual permit decision.
- * A weighing of siting, environmental effects, and a cost benefit analysis is required in the application as a result of *Save Ourselves, Inc., et al vs. the Louisiana Environmental Control Commission, et al* . The five required question responses, colloquially known as the “Louisiana Constitutional Considerations,” the “IT Question Responses,” or the “Save Ourselves Questions,” are hereafter the “SOS Decision Questions”, and are presented in Appendix II. Answers to these questions must provide adequate detail with sufficient justification and supporting data to enable LOC to conduct a balanced review of environmental, social, economic and other factors as required by the Louisiana Constitution.

Key Louisiana Takeaways

Additional things to know

While IMD doesn't have primacy yet, we've had preliminary meetings with many potential applicants and have begun reviewing technical information.

Existing wells within AOR (artificial penetrations) will have to be addressed.

Sequestration in salt caverns will not be permitted.

“Thou shalt not frack.”

Due to concerns around some formations in NW Louisiana, we've encourage potential applicants in this area to speak with IMD sooner rather than later.

Any AOR that crosses or approached boundaries of other jurisdictions (e.g., neighboring states and federally recognized Tribes) may trigger additional review. IMD is currently working with Texas, Arkansas, and Mississippi on this process.

Some applicants plan to drill Class V stratigraphic test wells to gather reservoir data.

Environmental justice reviews will be required for all Class VI wells.

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- U.S. Environmental Protection Agency. (2017, January). United States Environmental Protection Agency Underground Injection Control Permit Class VI – Permit Number: IL-115-6A-0001 – Facility Name: CCS#2.

Questions?

CONTACT INFORMATION

Corey Shircliff

Corey.shircliff@la.gov

225-342-5586

Laura Sorey

laura.sorey@la.gov

225-342-5581

Useful Links

[Louisiana Regulations for Injection and Mining](#)

[Office of Conservation - Injection & Mining](#)

[EPA Class VI Wells](#)

[Gulf Coast Carbon Center](#)

[Groundwater Protection Council](#)