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Critical Challenges. Practical Solutions.

Energy & Environmental Research Center (EERC)

NORTH DAKOTA CLASS VI LESSONS LEARNED

Groundwater Protection Council Annual Meeting
Oklahoma City, Oklahoma
February 28, 2024

Caitlin Olsen
Principal Policy and Regulatory Strategist

AGENDA

1. **North Dakota's CCS Background**

2. **Lessons Learned:**
   - ❑ Regulatory Challenges
   - ❑ Site Characterization
     - ▪ Coring
     - ▪ Logging
     - ▪ Seismics
     - ▪ Modeling and Simulation
   - ❑ Project Design
   - ❑ Public Engagement and Outreach
   - ❑ Incentive Programs

CRITICAL CHALLENGES.
PRACTICAL SOLUTIONS.

We are one of the world's leading developers of cleaner, more efficient energy to power the world and environmental technologies to protect and clean our air, water, and soil.

CORE RESEARCH PRIORITIES

Coal Utilization & Emissions

Carbon Management

Oil & Gas

Alternative Fuels & Renewable Energy

Energy–Water

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PCOR PARTNERSHIP

2003–2005 – PCOR Partnership: Characterization

2005–2008 – PCOR Partnership: Field Validation

2007–2019 – PCOR Partnership: Commercial Demonstration

2019–2024 – **PCOR Partnership Initiative:** Commercial Deployment

2024-2034 – PCOR Partnership: Sustained Commercial Deployment

U.S. DEPARTMENT OF ENERGY | NATIONAL ENERGY TECHNOLOGY LABORATORY

UAF Institute of Northern Engineering
University of Alaska Fairbanks

University of Wyoming | School of Energy Resources

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PCOR Partnership

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North Dakota Industrial Commission

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University of Wyoming | School of Energy Resources

REGULATING GEOLOGIC STORAGE OF CARBON DIOXIDE

INTERSTATE OIL AND GAS COMPACT COMMISSION

The Interstate Oil and Gas Compact Commission (IOGCC) is a multistate government agency that champions the conservation and efficient recovery and storage of domestic oil and gas resources while protecting human health and safety and the environment.

In 2002, the IOGCC formed the **Carbon Geologic Storage Task Force (CGS Task Force)** to answer the question:

> **Are state or federal governments the most appropriate regulator for the dedicated storage of CO_2?**

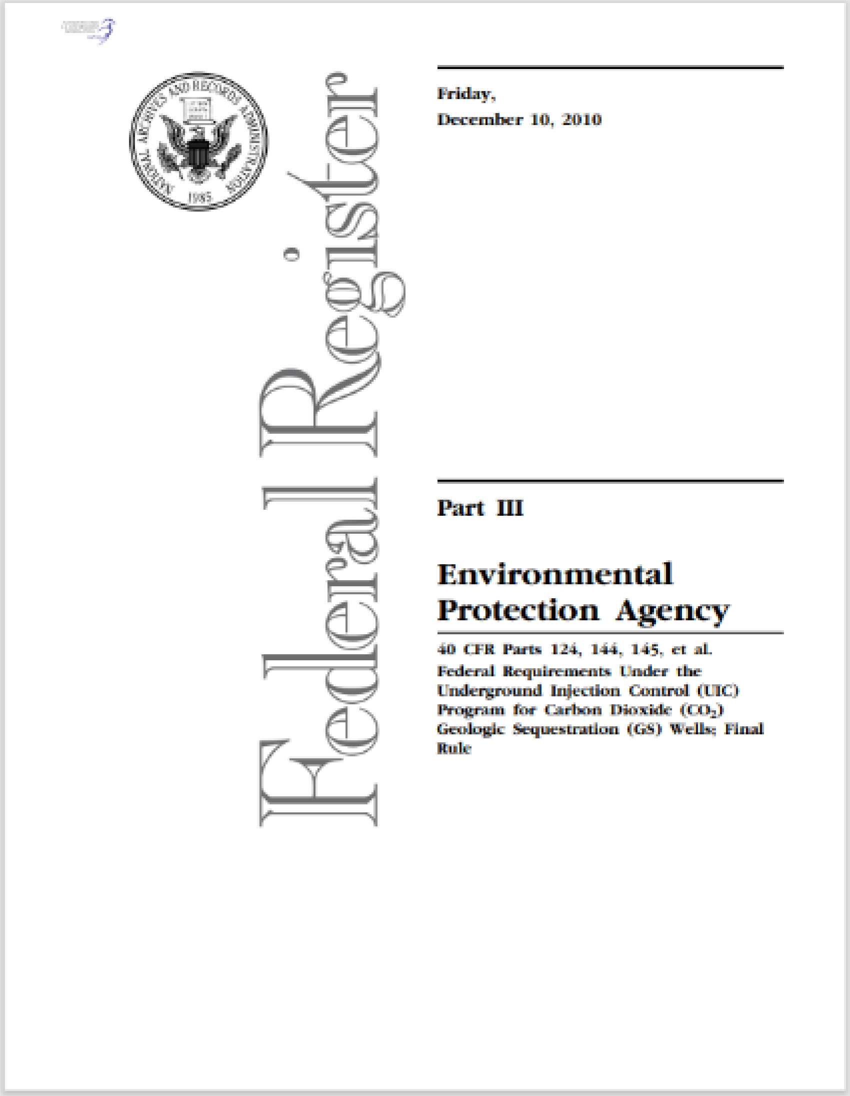
The CGS Task Force comprises representation from IOGCC member states, oil and gas agencies, DOE, and the Regional Carbon Sequestration Partnerships.

GEOLOGIC STORAGE PERMITS IN NORTH DAKOTA

EPA believes that States are in the best position to implement UIC–GS programs, and by allowing for independent Class VI primacy, EPA encourages States to take responsibility for implementation of Class VI regulations. The Agency's UIC program believes that this may, in turn, help provide for a more comprehensive approach to managing GS projects by promoting the integration of GS activities under SDWA into a broader framework for States managing issues related to CCS that may lie outside the scope of the UIC program or other EPA programs. This would harness the unique efficiencies States can offer to promote adoption of GS technology that incorporates issues in the broader scope of CCS, while ensuring that USDWs are protected through the UIC regulatory framework. Allowing States to apply only for Class VI primacy will also shorten the primacy approval process. EPA's willingness to accept independent primacy applications for Class VI wells applies only to Class VI well primacy and does not apply to any other well class under SDWA section 1422 (i.e., I, III, IV, and V).

https://www.govinfo.gov/content/pkg/FR-2010-12-10/pdf/2010-29954.pdf

(page 77242)


Federal Register

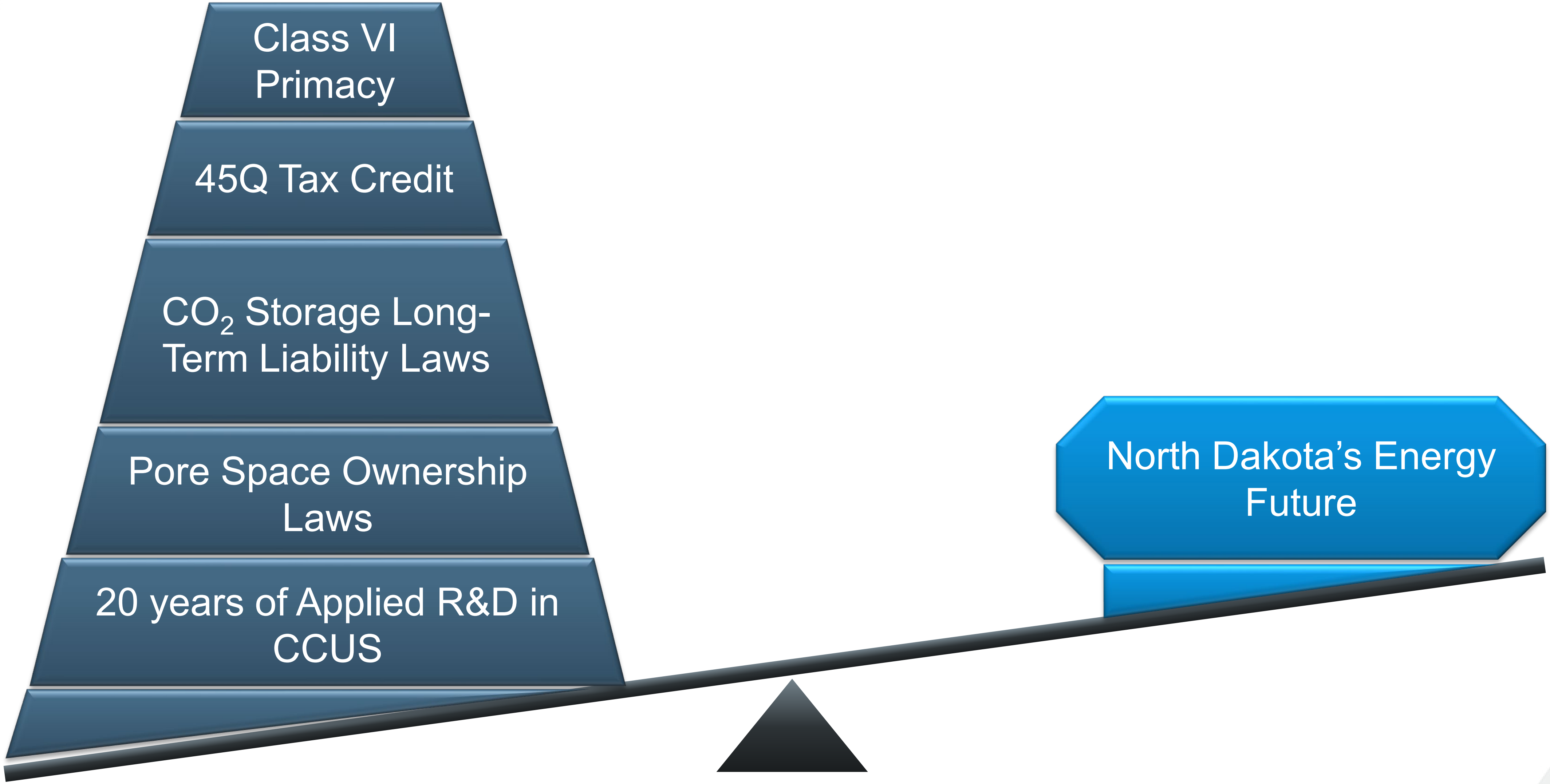
Friday,
December 10, 2010

Part III

Environmental Protection Agency

40 CFR Parts 124, 144, 145, et al.
Federal Requirements Under the Underground Injection Control (UIC) Program for Carbon Dioxide (CO_2) Geologic Sequestration (GS) Wells; Final Rule

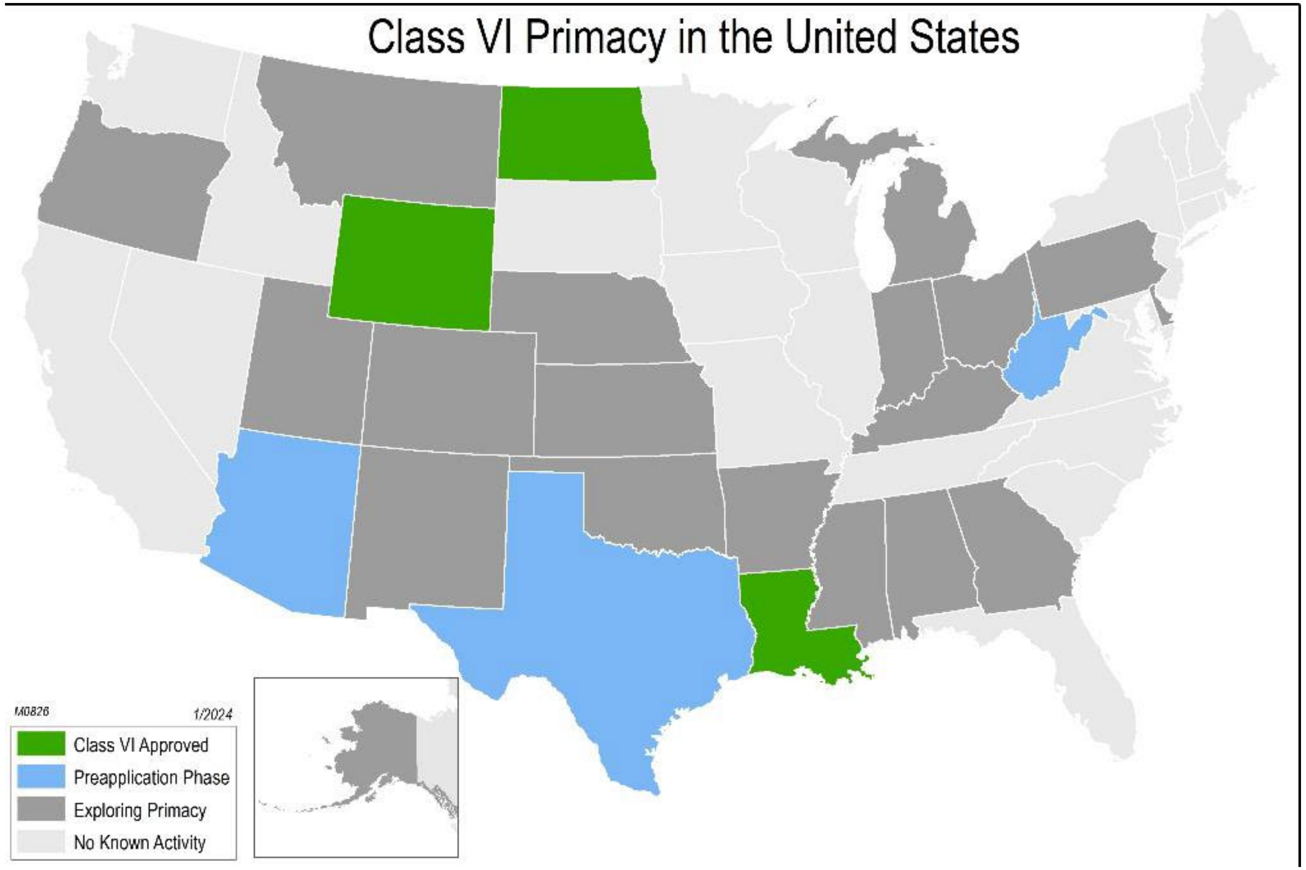
NORTH DAKOTA'S LEVERAGE



EPA UNDERGROUND INJECTION CONTROL (UIC) PROGRAM

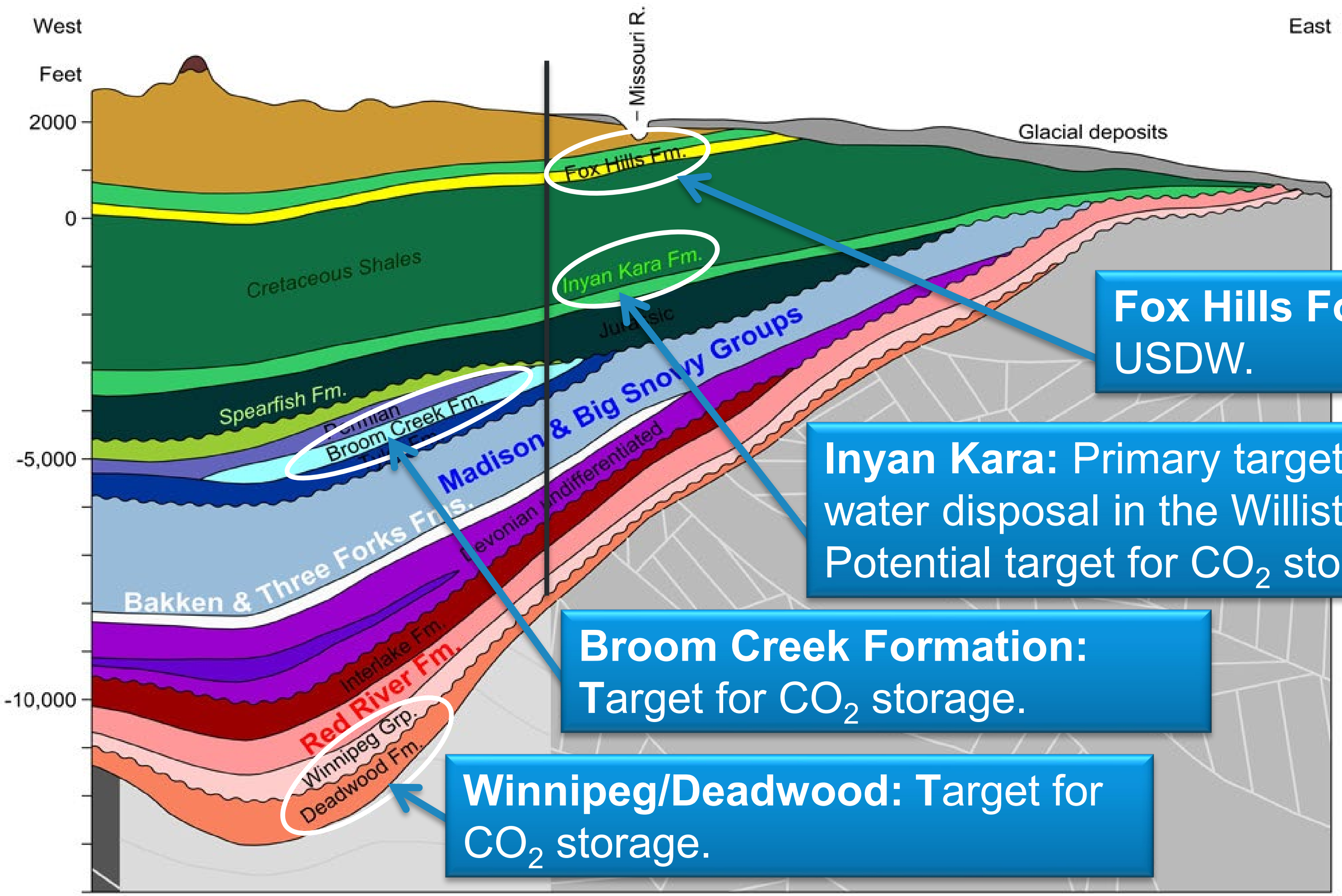
UIC Program Standards:

1) **Protection of underground sources of drinking water (USDWs)**
2) Injection zone
3) Confining zones (upper and lower)
4) Area of review (AOR) and corrective action
5) Wellbore integrity demonstration



Class I	Class II	Class III	Class IV	Class V	Class VI
Hazardous and nonhazardous fluids (industrial and municipal wastes).	Brines and other fluids associated with oil and gas production, including CO_2 EOR.	Fluids associated with solution mining of minerals.	Hazardous or radioactive wastes. This class is banned by EPA.	Nonhazardous fluids into or above a USDW and are typically shallow.	Injection of CO_2 for long-term storage.

NORTH DAKOTA GEOLOGY



Fox Hills Formation: Lowest USDW.

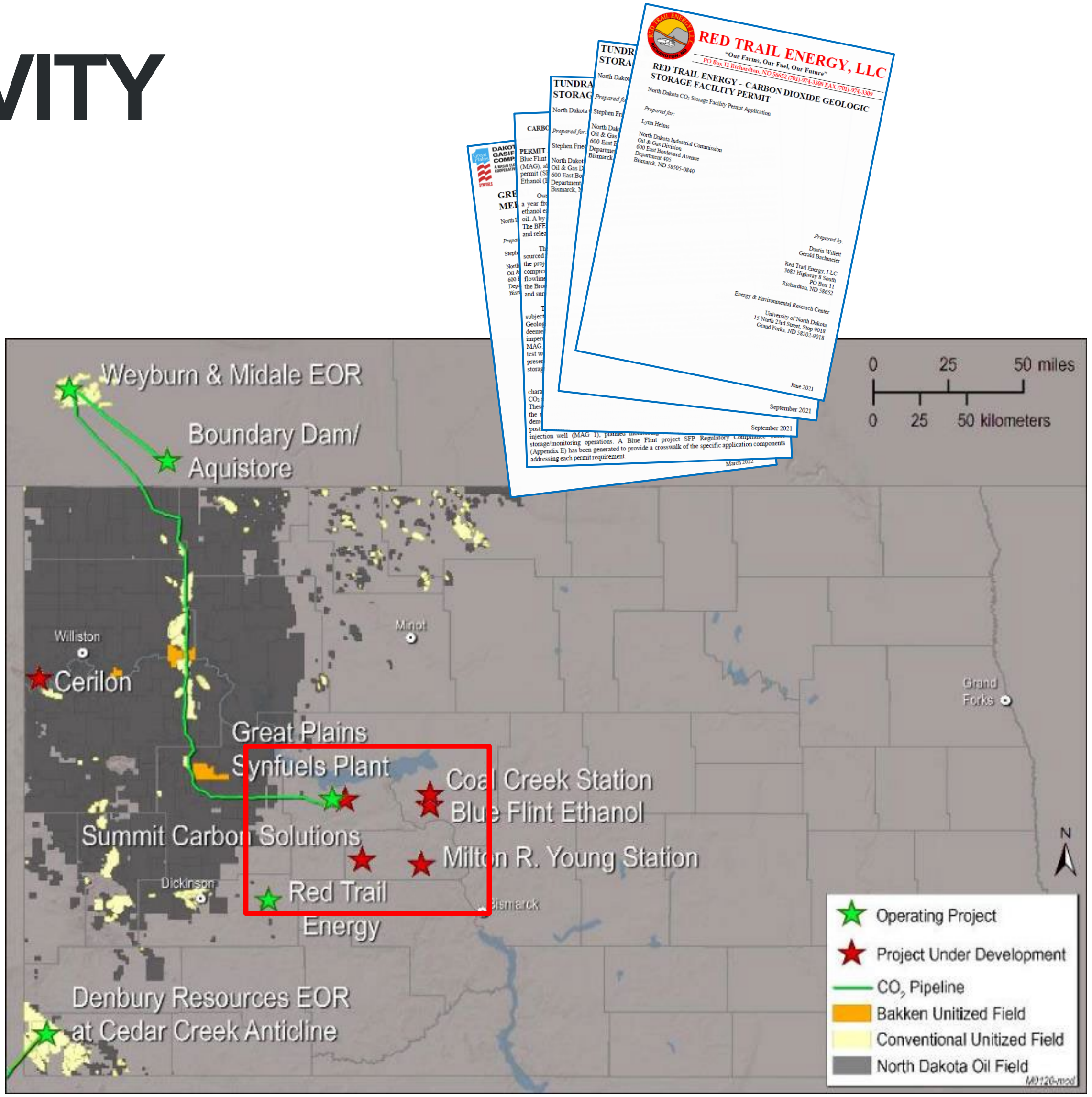
Inyan Kara: Primary target for produced water disposal in the Williston Basin. Potential target for CO_2 storage.

Broom Creek Formation: Target for CO_2 storage.

Winnipeg/Deadwood: Target for CO_2 storage.

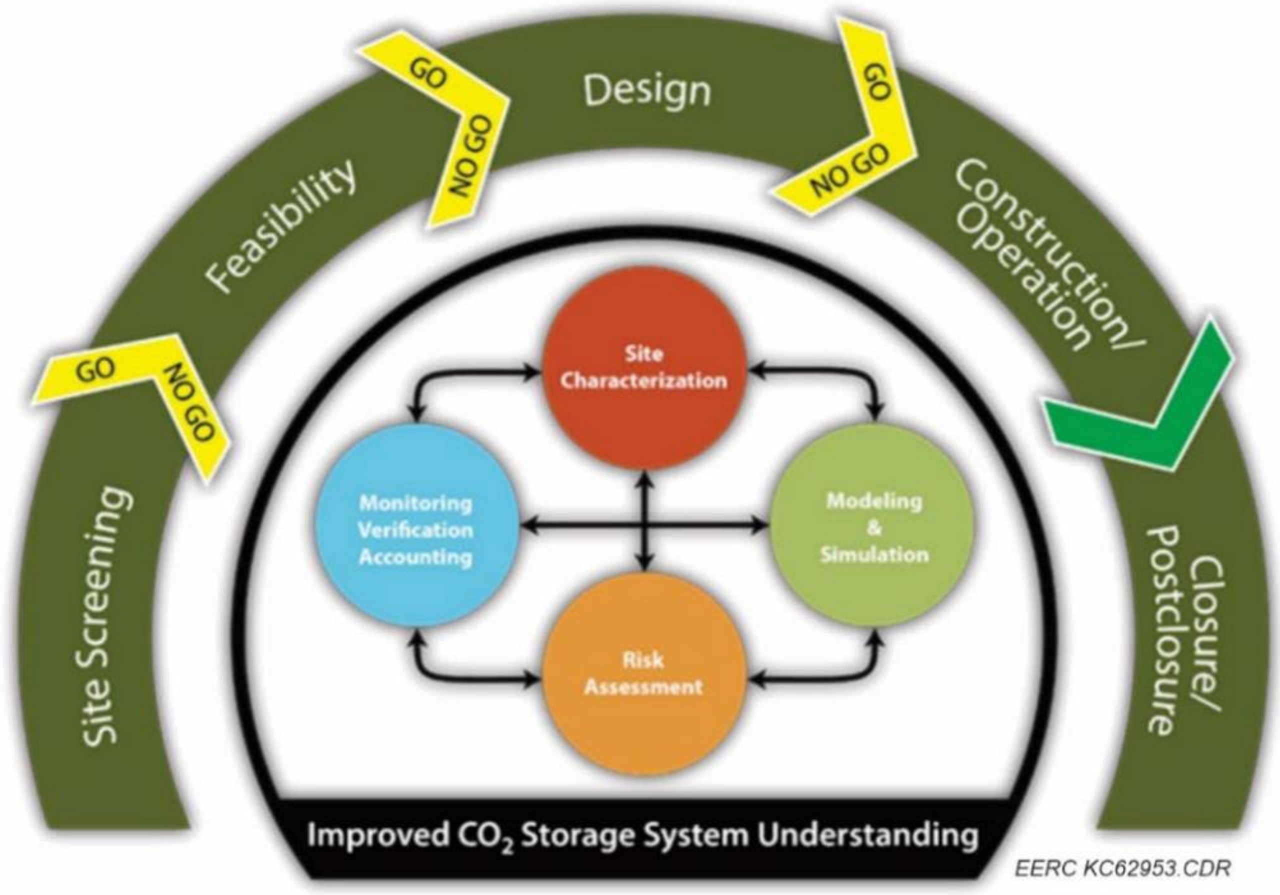
NORTH DAKOTA CCS ACTIVITY

- 6 storage facility permits issued
  - 3 pending permits
- 2 sites actively injecting CO_2
- 100,000 acres of pore space unitized and amalgamated
- Total permitted storage capacity of 256 million tonnes and growing!

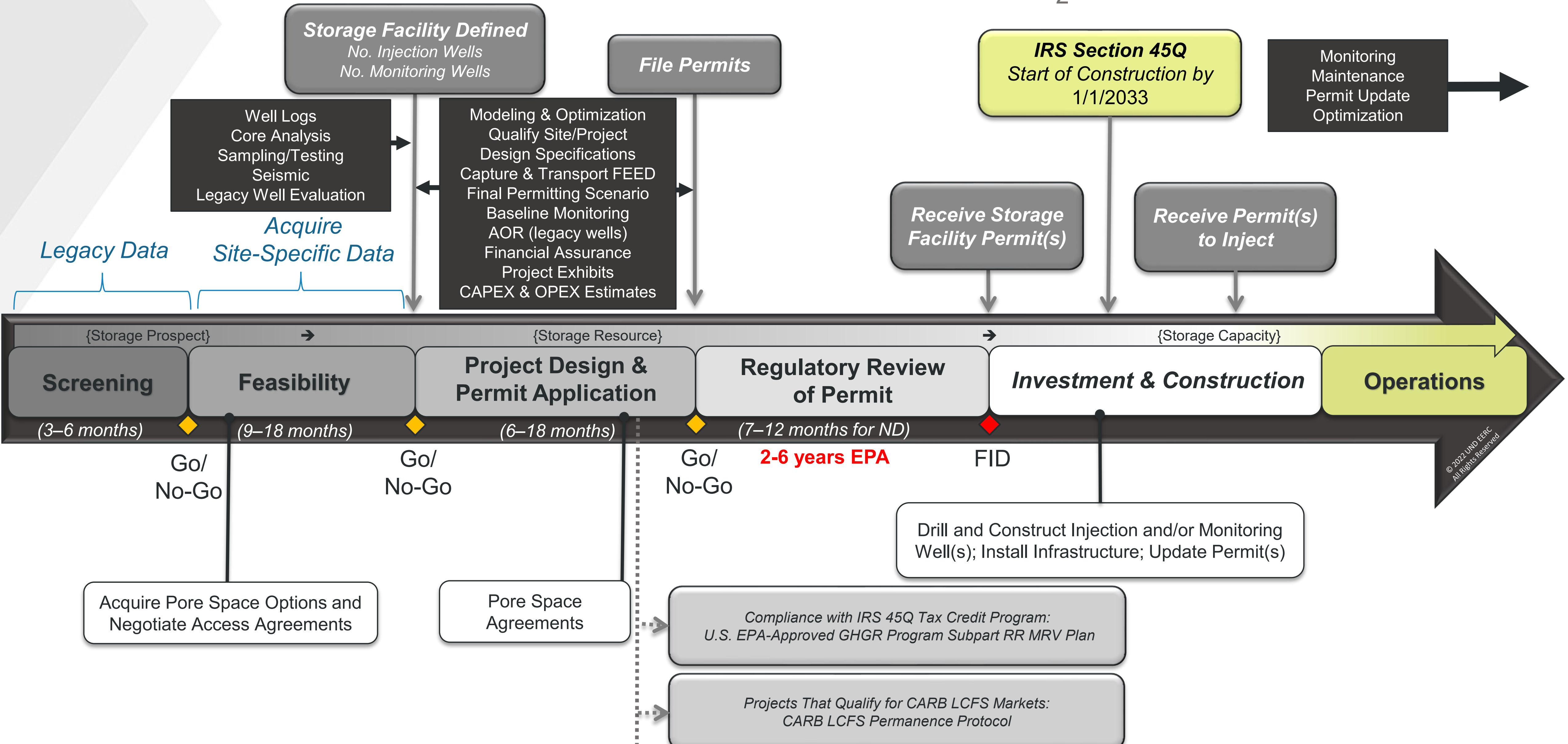



PERMITTING
GEOLOGIC STORAGE
OF CARBON DIOXIDE

LESSONS LEARNED: REGULATORY CHALLENGES



TIMELINE TO IMPLEMENT CARBON CAPTURE AND GEOLOGIC CO_2 STORAGE IN NORTH DAKOTA



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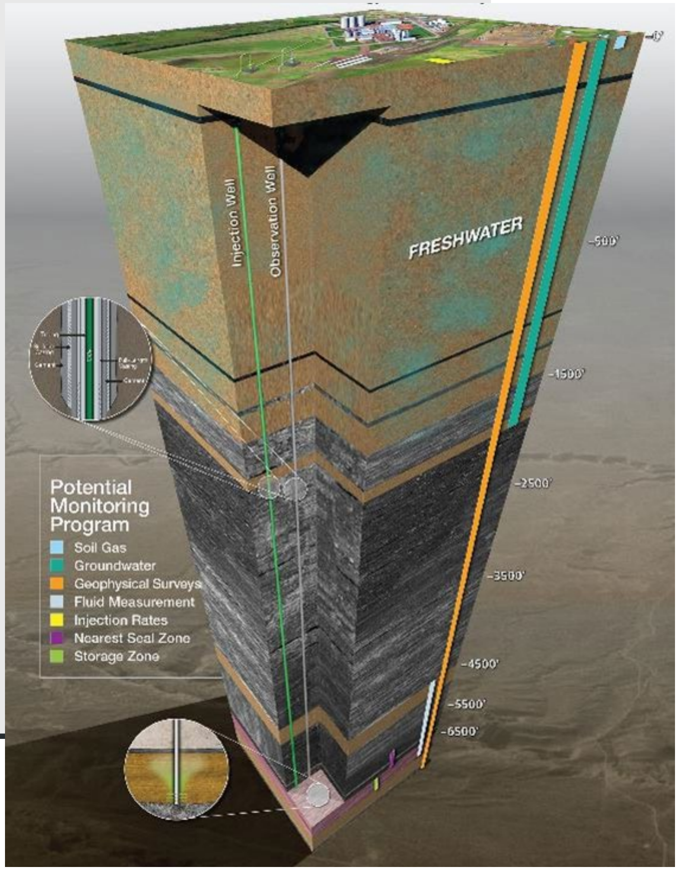
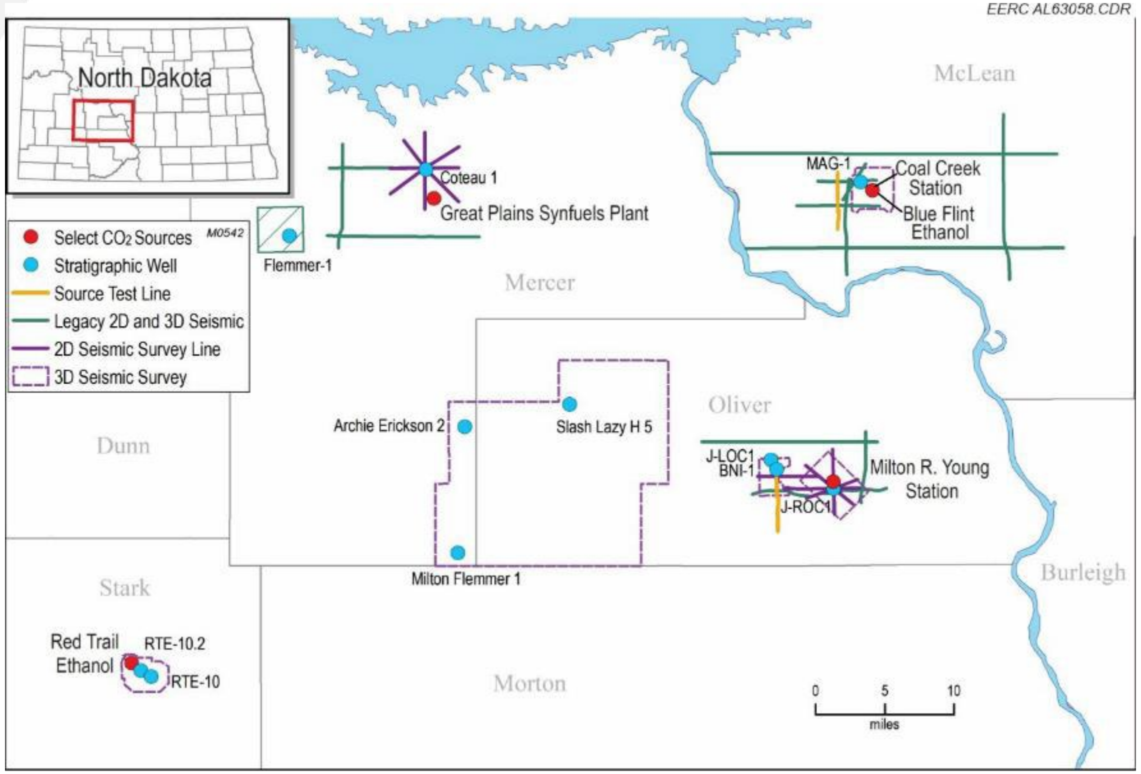
LESSONS LEARNED: REGULATORY CHALLENGES

NORTH DAKOTA CO_2 STORAGE FACILITY PERMIT (CLASS VI) SECTIONS

- ❑ Pore Space Access
- ❑ Geologic Exhibits
- ❑ Geologic Model Construction and Numerical Simulation of CO_2 Injection
- ❑ Area of Review
- ❑ Testing and Monitoring Plan
- ❑ Postinjection Site Care and Facility Closure Plan
- ❑ Emergency and Remedial Response Plan
- ❑ Worker Safety Plan
- ❑ Well Casing and Cementing Program
- ❑ Plugging Plan
- ❑ Injection Well and Storage Operations
- ❑ Financial Assurance and Demonstration Plan



LESSONS LEARNED: SITE SELECTION AND CHARACTERIZATION



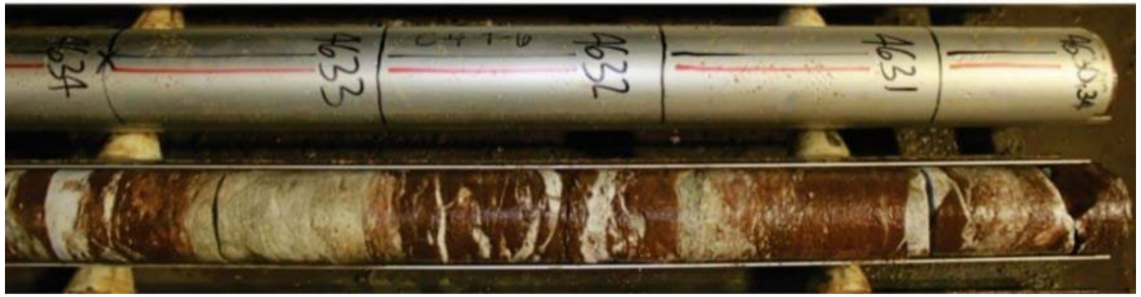
Coring

Logging/Injection Testing/Sampling

Seismic Surveys

LESSONS LEARNED: CORING

- Site-specific core is often necessary
- Benefits of viewing from the field
- Recommend whole core (rather than sidewall)
- Recommend at least 50 ft from upper and lower confining zones
  – Characterizing secondary sealing formations and dissipation zones
- Use a longer core barrel assembly when coring the stratigraphic test well to reduce rig time and overall drilling cost



LESSONS LEARNED: CORING

- Saltwater gel-based drilling fluid is preferable for core analysis effective permeability.
- Invert-based drilling fluid is preferable for stability while drilling coring and logging and avoiding washouts.
- Washouts ultimately will affect logging later and result in higher uncertainty in petrophysical analysis.

LESSONS LEARNED: LOGGING

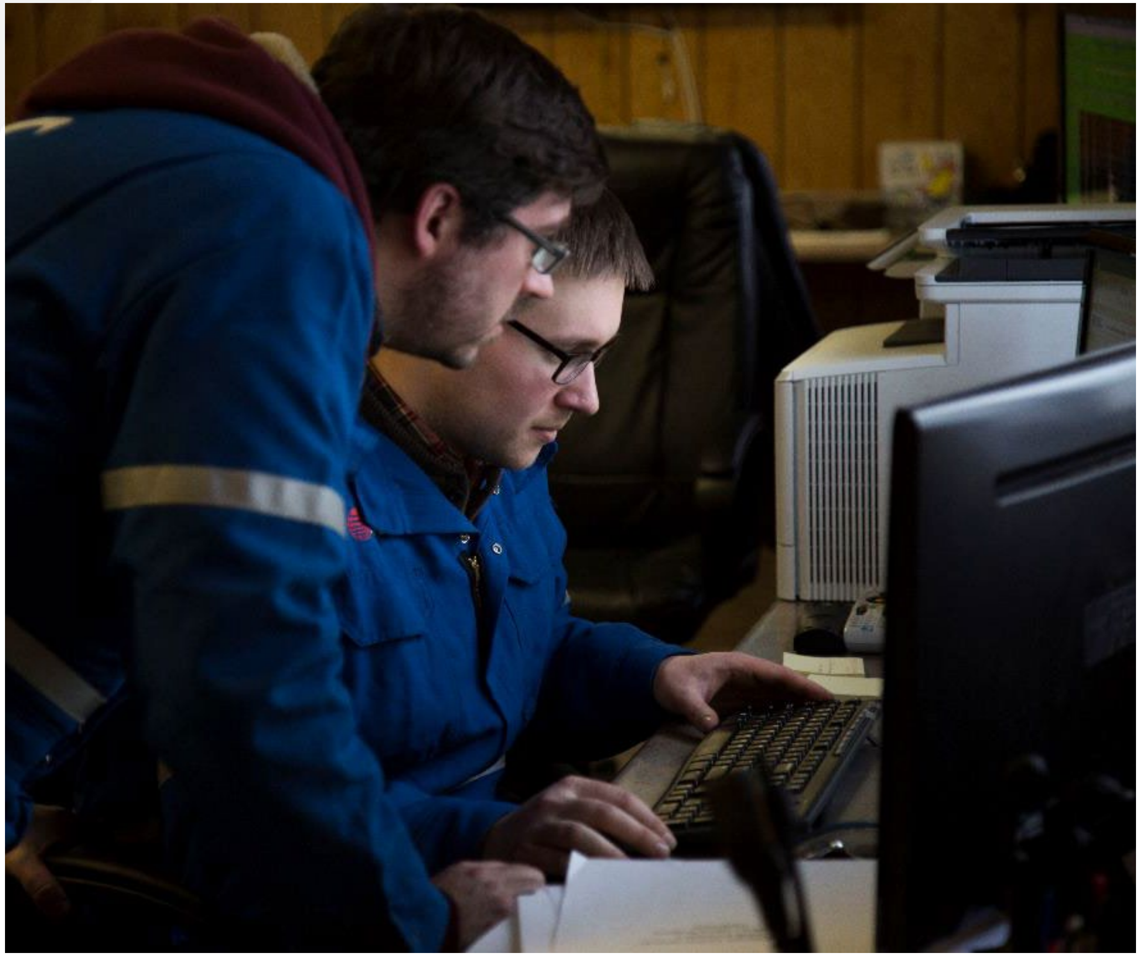
- Alternatives to SP logs
- Tips for MDT testing
- Value-add from NMR and geochemical logs

	Surface Section
OH[1]/CH[2]	Log
OH	Triple combo (resistivity, density, porosity, GR[3], caliper, and SP)
OH	Acoustic compression and shear (dipole sonic)
CH	CCL[4]-ultrasonic log–VDL[5]–GR–temperature log
OH/CH	**Long-String Section**
OH	Triple combo (resistivity, density, porosity, GR, caliper, and SP (if using conductive mud); GR run to surface (0')
OH	NMR
OH	Spectral GR
OH	Capture spectroscopy
OH	Dipole sonic log (compression and shear waves)
OH	Acoustic, electric, or optical borehole imaging
OH	Fluid sampling
OH	Formation pressure testing
OH	Stress testing
OH	Sidewall cores (as a backup option *if* whole core fails)
CH	CCL–ultrasonic log–VDL–GR–temperature log

1 Openhole.
2 Cased hole.
3 Gamma ray.
4 Casing-collar locator.
5 Variable-density log: ultrasonic log for radial cement bond.

Source: Livers-Douglas et al., 2022

LESSONS LEARNED: GEOPHYSICAL DATA



- Use existing site seismic data if possible
- Timing of survey acquisition
- Source tests in area around active mines
- Processing routines

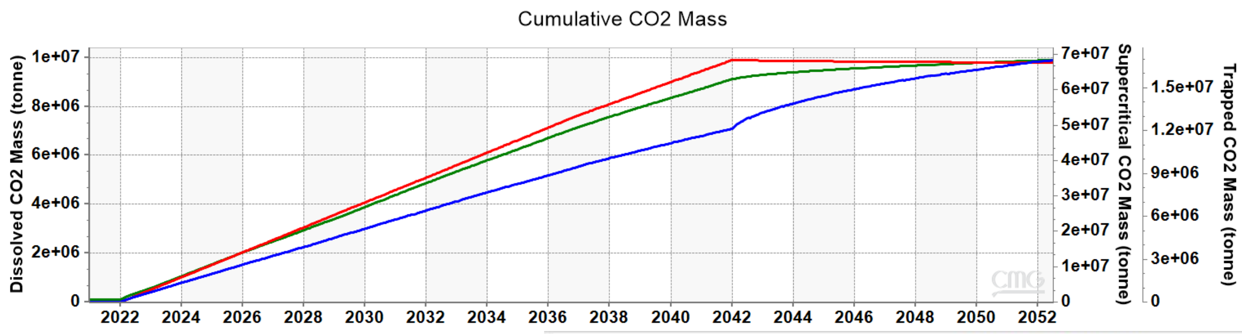
LESSONS LEARNED: MODELING AND SIMULATION

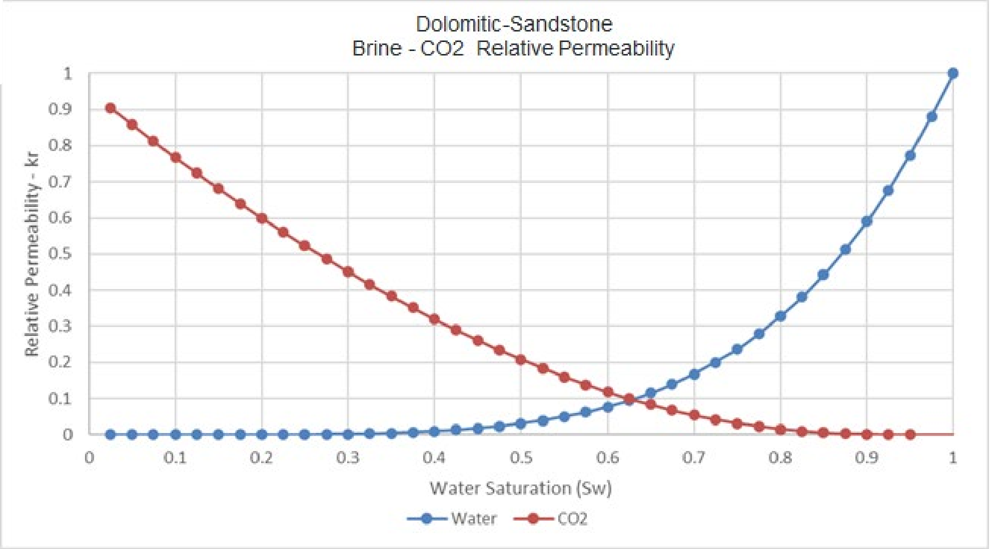
Discuss with regulator:

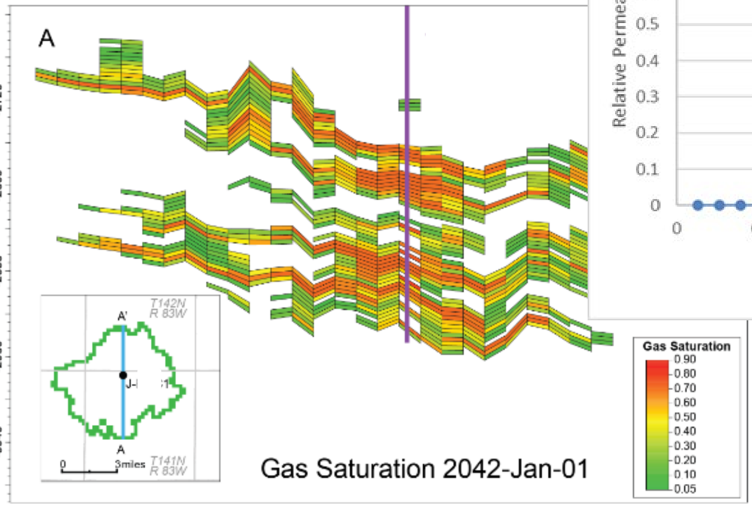
- Types of files
- Software packages

Clearly list in permit:

- Inputs and assumptions
- Constraints
- Sensitivity testing



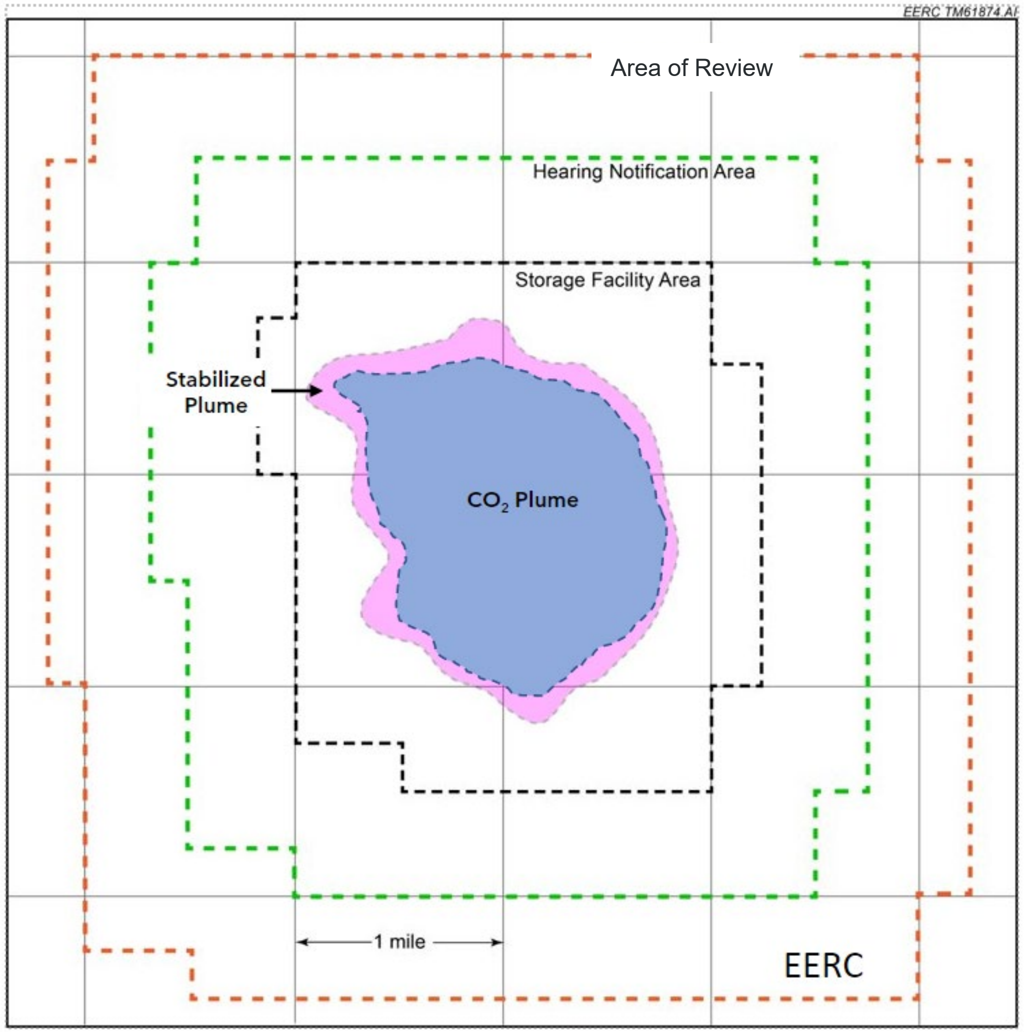




LESSONS LEARNED: MODELING AND SIMULATION

- **CO_2 plume** – Simulated boundary at end of injection.
- **Stabilized plume** – Simulated boundary at postinjection stabilization.
- **Storage facility area** – Boundary + buffer

  (pore space lease and amalgamation area).
- **Hearing notification area** – ½ mile from the storage facility area boundary (mineral estate and surface estate).
- **AOR/evaluation area** – 1 mile from the storage facility area boundary (default minimum AOR).



Livers-Douglas et al., 2022

LESSONS LEARNED: MODELING AND SIMULATION

Establish the Site Stratigraphy and Properties

- Simplify the storage complex stratigraphy into hydrostratigraphic units.
- Use the best available site characterization data to estimate the average depth, thickness, pressure, temperature, porosity, permeability, and salinity for each unit.

↓

Use the ASLMA Excel Workbook to Derive Additional Inputs Needed for the ASLMA Model

- Derive the hydraulic conductivity and specific storage for each unit.
- Compute the initial hydraulic heads for each unit.
- Place a CO_2 injection well at the center of the coordinate reference system (0, 0).
- Convert the CO_2 mass injection rate into an equivalent-volume injection of formation fluid.
- Establish the effective permeability of the hypothetical leaky wellbore and the distances from the injection well to quantify the formation fluid leakage up a leaky wellbore located at progressively greater distances from the injection well.
- Use the ASLMA User Guide for reference and to inform additional inputs.

↓

Integrate ASLMA Model Outputs with Results from Numerical Reservoir Simulation

- Run the ASLMA Model using the included custom scripting and generate standardized outputs.
- Derive the incremental leakage to the lowermost underground source of drinking water (USDW) by taking the difference between the baseline (no CO_2 injection) and injection cases.
- If applicable, generate results for cases with and without the leaky wellbore open to a saline aquifer (thief zone) located between the primary seal (cap rock) and the USDW.
- Derive the storage reservoir pressure buildup-USDW incremental leakage relationship.
- Using the derived relationship in the preceding step, generate potential incremental leakage maps based on the pressure buildup in response to CO_2 injection as determined by a compositional simulator.

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Delineate Risk-Based Area of Review (AoR)

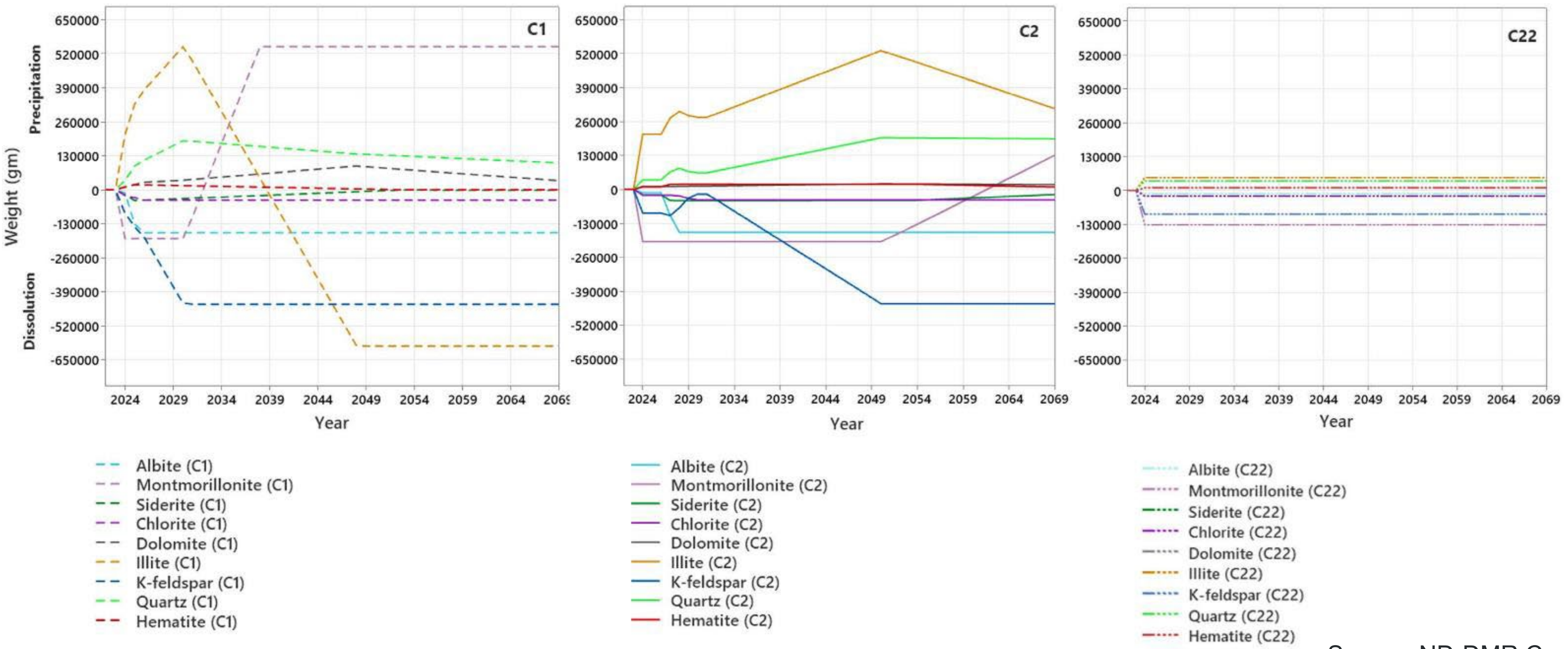
- Apply threshold criteria to the incremental leakage maps to delineate a risk-based AoR.
- Assess the sensitivity of the risk-based AoR to different input assumptions or risk judgments.

Risk-Based AOR Delineation

Alternative method (from EPA Method 1 and 2) for delineating the AOR for locations that are already overpressurized relative to overlying aquifers.

LESSONS LEARNED: MODELING AND SIMULATION

Geochemical Modeling



Source: ND-DMR Casefile #30122

LESSONS LEARNED: PROJECT DESIGN

- Allow flexibility for CO_2 composition variation
- Casing-conveyed vs. tubing-conveyed pressure gauges
- CO_2 resistant casing and cement in all potential injection areas
- DTS/DAS casing-conveyed fiber-optic sensing

LESSONS LEARNED: PUBLIC ENGAGEMENT AND OUTREACH

- Be early, be proactive
- Have timely communication of project and/or regulatory developments
- Demonstrate transparency
- Build the trust needed for community support of a geologic CO_2 storage project

PUBLIC ENGAGEMENT

- Keep messages consistent across all target audiences.
- Messaging should be proactive and reactive.
- Share information with all stakeholders in advance of any field activities.
- Provide ample opportunities for stakeholder questions to be heard and answered.
- Anticipate questions and concerns and have responses ready.

INCENTIVE PROGRAMS

45Q Tax Credits

- Projects beginning construction before January 1, 2033, can claim credits for 12 years after operations begin.
- Provides for direct payment for 45Q credits.
- Tax credit for CO_2 stored in a qualified EOR project: $60/tonne.
  - Tax credit from direct air capture (DAC): $130/tonne.
- Tax credit for CO_2 stored in a saline formation: $85/tonne.
  - Tax credit from DAC: $180/tonne.

West Coast LCFS Markets

- Credits trading up to $50–$90 per ton (Feb 2023–2024).
- Stacked with 45Q.

North Dakota Incentives

- No sales tax on capture-related infrastructure.
- No sales tax on CO_2 sold for EOR.
- No sales tax on construction of pipeline.
- Property tax-exempt for 10 years (equipment).
- Coal conversion tax: tax reduction with CO_2 capture (up to 50%).
- No sales tax on CO_2 EOR infrastructure.
- 0% extraction tax for 20 years for CO_2 EOR.

Image Credit – EERC

KEY TAKEAWAYS

- It starts with states taking the lead in regulating all aspects of carbon dioxide storage.
  – Overlays such as forced pooling, release of long-term regulatory responsibility, and title transfer incentivizes and enables storage projects.
  – The permitting process is often better defined for states that have primacy than the EPA.

- Permit development is defined into several key categories with specific information detailed for each plan type.

- Implementing lessons learned from site characterization and feasibility efforts will allow for smoother regulatory approval.

- Project developers should meet with regulators and project stakeholders early and often.

- Incentive programs aim to encourage fuel producers and importers to invest in low-carbon technologies, increase the availability of low-carbon fuels, and reduce overall GHG emissions from the transportation sector.

ACKNOWLEDGMENTS

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DISCLAIMER

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