

# ***The Plains CO<sub>2</sub> Reduction (PCOR) Partnership: Demonstrating Carbon Dioxide Storage in the United States and Canada***

**International Forum on Recent Developments of CCS Implementation  
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# Presentation Outline

- Plains CO<sub>2</sub> Reduction (PCOR) Partnership
- Bell Creek project
- Aquistore project
- Basal Cambrian project
- Fort Nelson project
- Zama project
- Outreach activities





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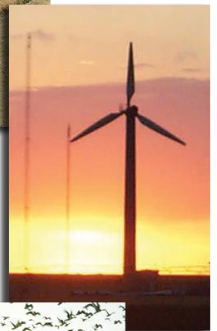
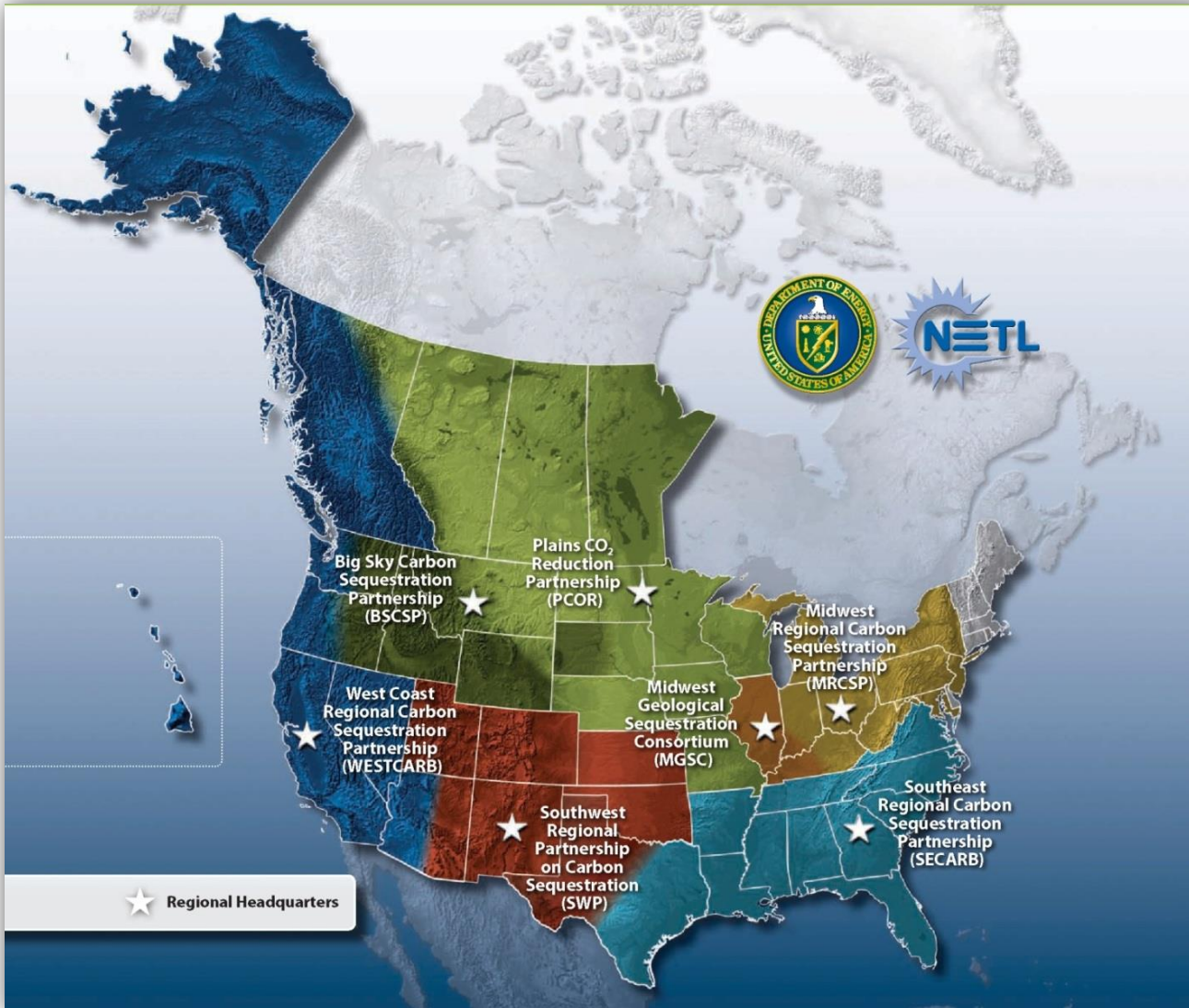
- Cleaner, more efficient energy technologies to guarantee clean, more reliable energy supplies for the United States and the world.
- Environmental technologies to protect and clean our air, water, and soil.





# PCOR Partnership Region

- Nine states
- Four Canadian provinces
- 3,579,594 km<sup>2</sup>  
(1,382,089 mi<sup>2</sup>)



# PCOR Partnership

<b>PCOR Partnership 2003 – Present</b>														
														
														
														
														
														
														
														



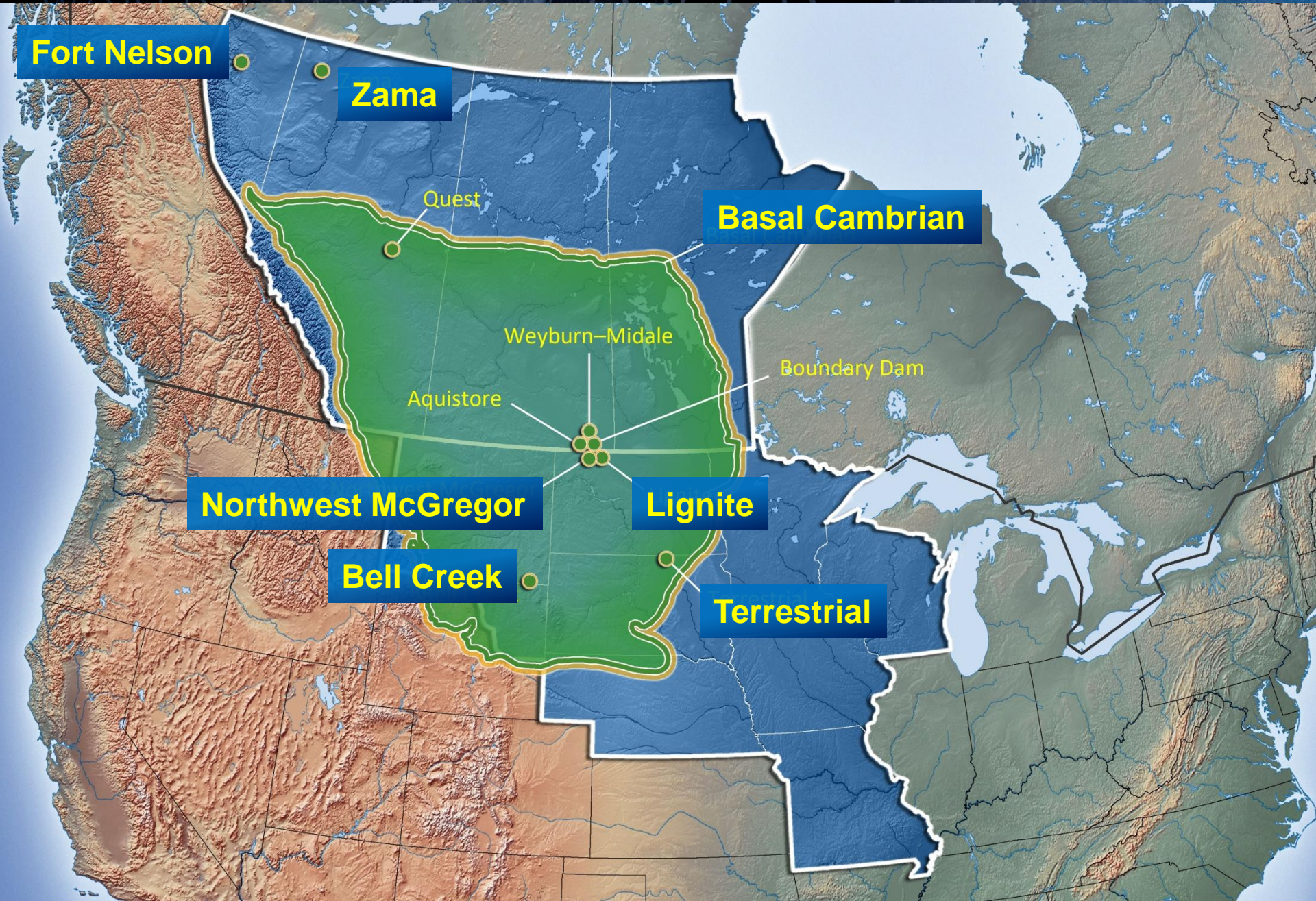
# Commercial-Scale Demonstration Phase

- 1-million-tonnes CO<sub>2</sub>/year-or-greater-scale demonstration.
- Ongoing and effective public outreach.
- Continued regional characterization.
- Continued involvement in other CO<sub>2</sub> storage projects in the region.
- Continued involvement in development of carbon capture and storage (CCS) and CO<sub>2</sub>/enhanced oil recovery (EOR) regulations.





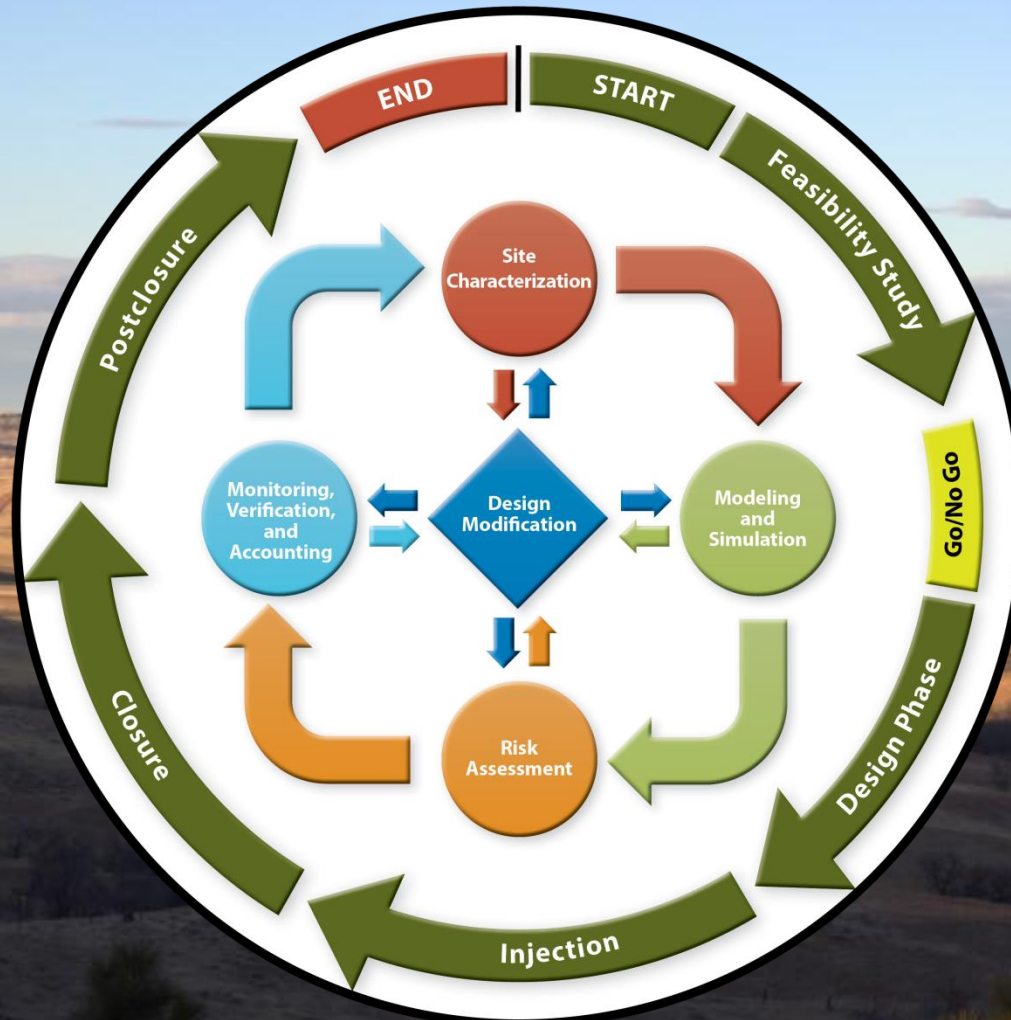
# PCOR Partnership Field-Based Projects





# The PCOR Partnership's Integrated Approach to Program Development

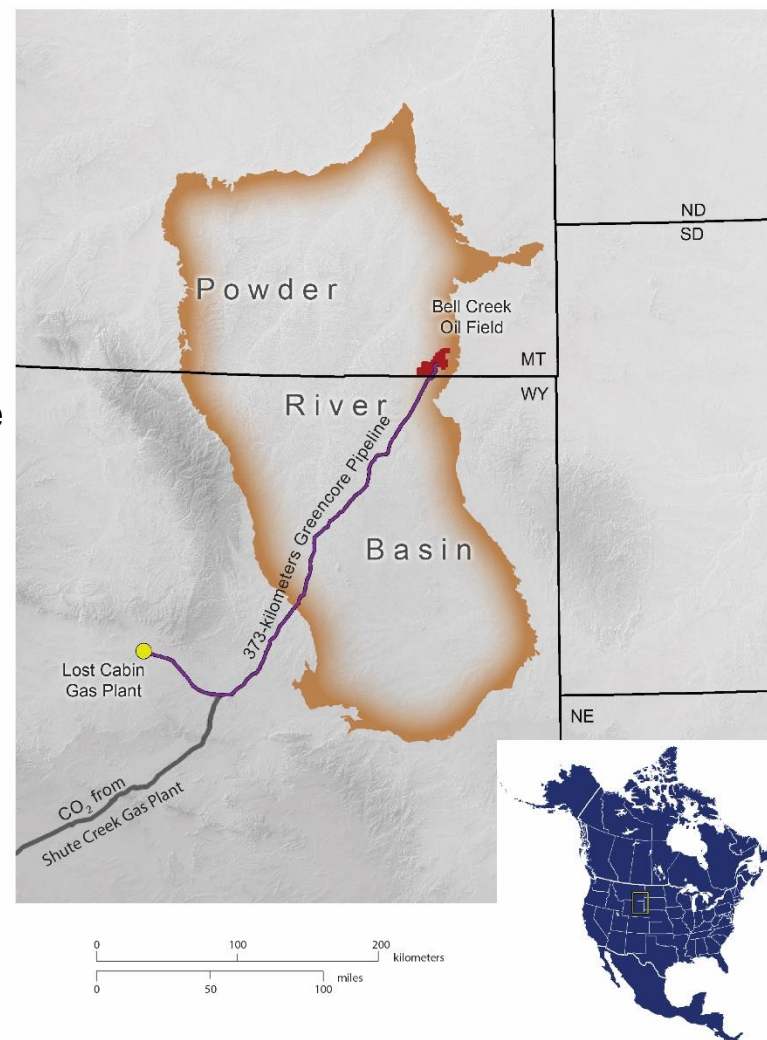
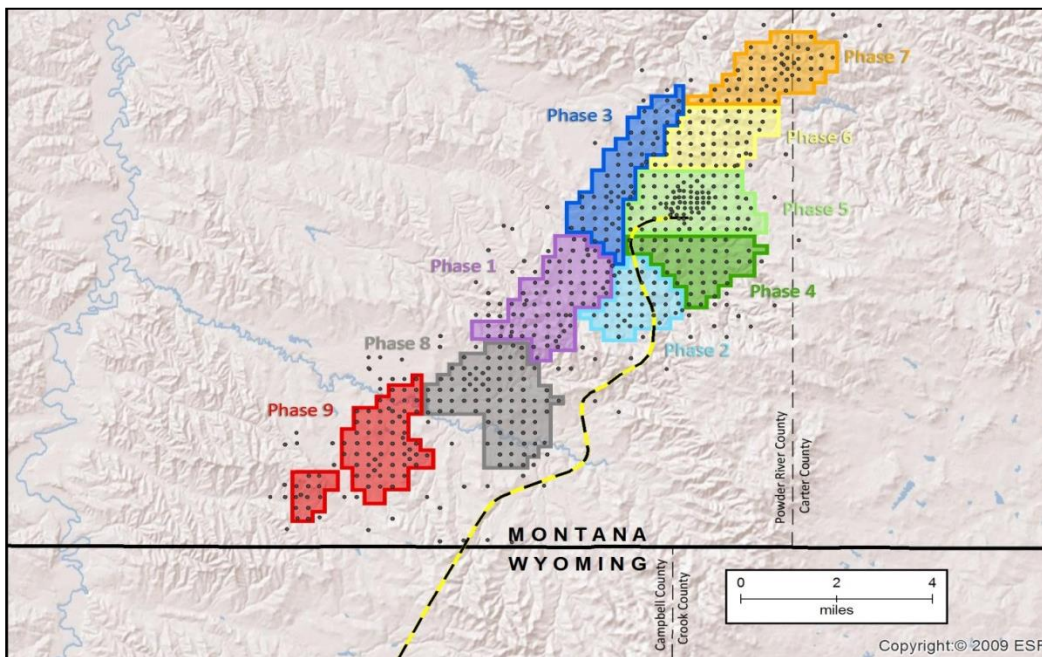
**Focused on Site Characterization, Modeling and Simulation, and Risk Assessment to Guide Monitoring, Verification, and Accounting (MVA) Strategy**





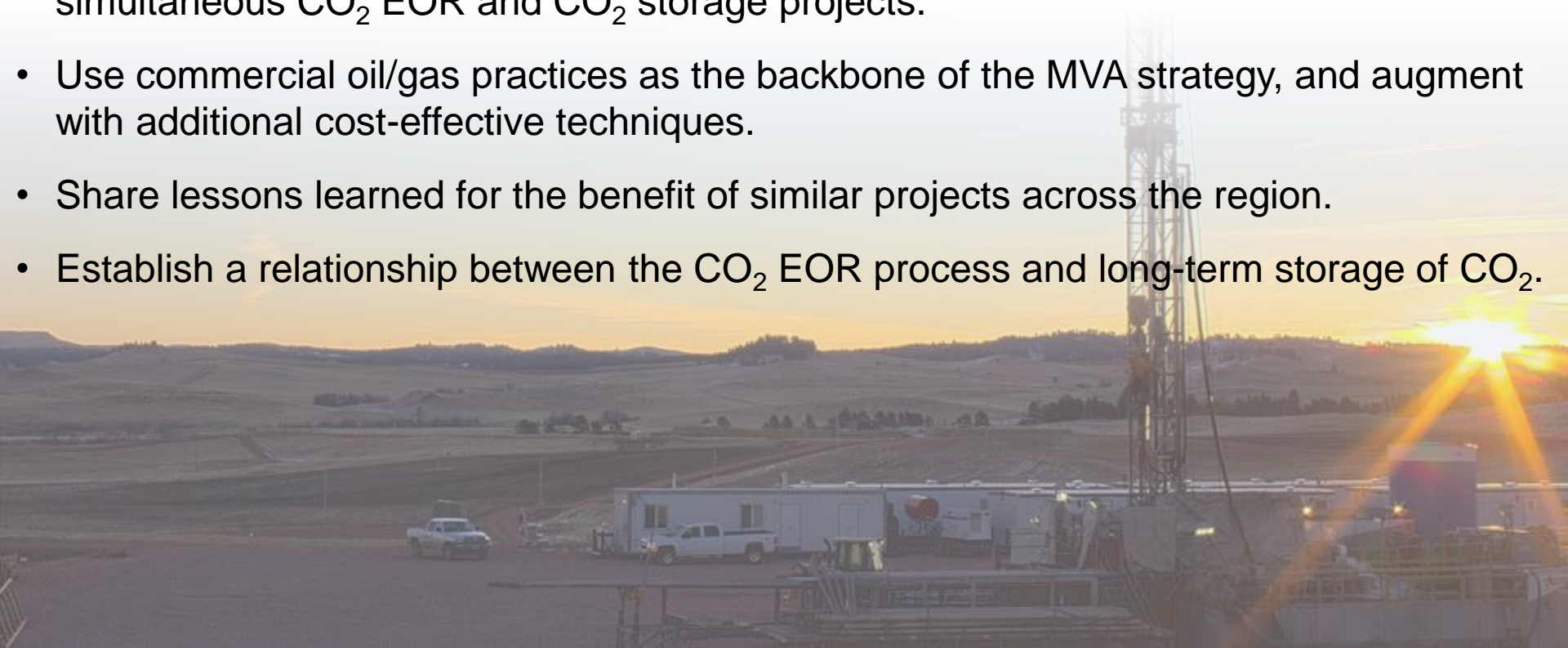
# Bell Creek CO<sub>2</sub> EOR and Associated Storage Project

- The Bell Creek oil field is operated by Denbury Onshore LLC.
- CO<sub>2</sub> is sourced from ConocoPhillips' Lost Cabin natural gas-processing plant and Exxon's Shute Creek gas-processing plant.
- The EERC is studying the interrelationship between EOR and incidental CO<sub>2</sub> storage at a commercial-scale project.



# PCOR Partnership Objectives

- Safely and permanently achieve CO<sub>2</sub> storage on a commercial scale in conjunction with EOR.
- Demonstrate that oil-bearing formations are viable sinks with significant storage capacity to help meet near-term CO<sub>2</sub> storage objectives.
- Establish MVA methods to safely and effectively monitor commercial-scale simultaneous CO<sub>2</sub> EOR and CO<sub>2</sub> storage projects.
- Use commercial oil/gas practices as the backbone of the MVA strategy, and augment with additional cost-effective techniques.
- Share lessons learned for the benefit of similar projects across the region.
- Establish a relationship between the CO<sub>2</sub> EOR process and long-term storage of CO<sub>2</sub>.





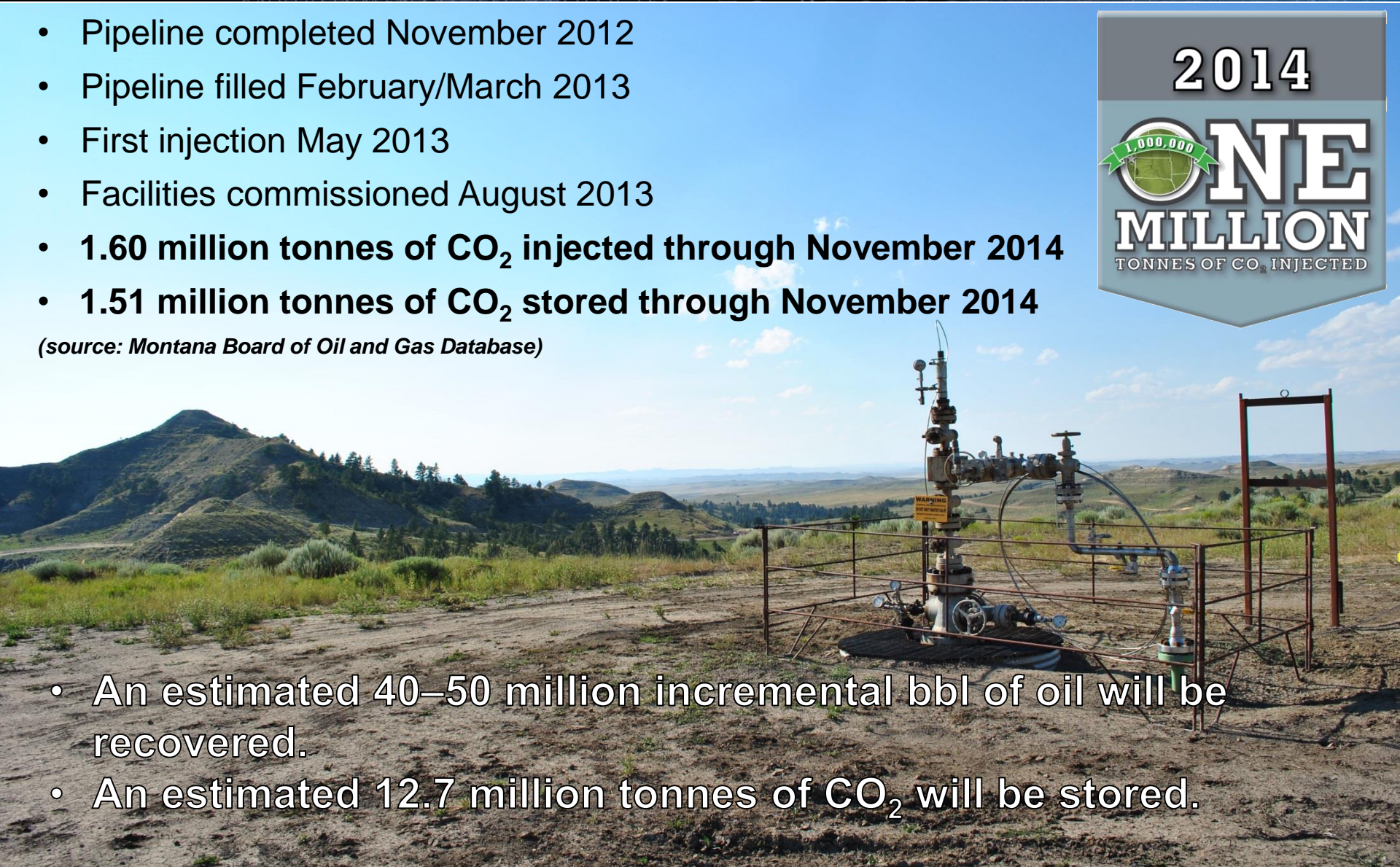
# CO<sub>2</sub> Injection Is Ongoing!!!

- Pipeline completed November 2012
- Pipeline filled February/March 2013
- First injection May 2013
- Facilities commissioned August 2013
- **1.60 million tonnes of CO<sub>2</sub> injected through November 2014**
- **1.51 million tonnes of CO<sub>2</sub> stored through November 2014**

*(source: Montana Board of Oil and Gas Database)*



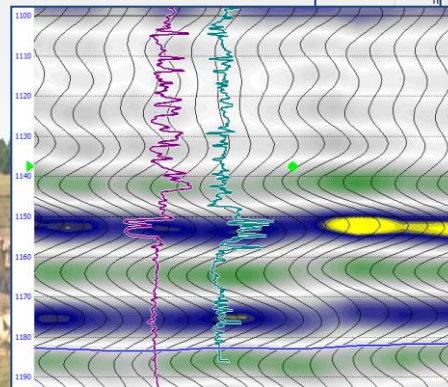
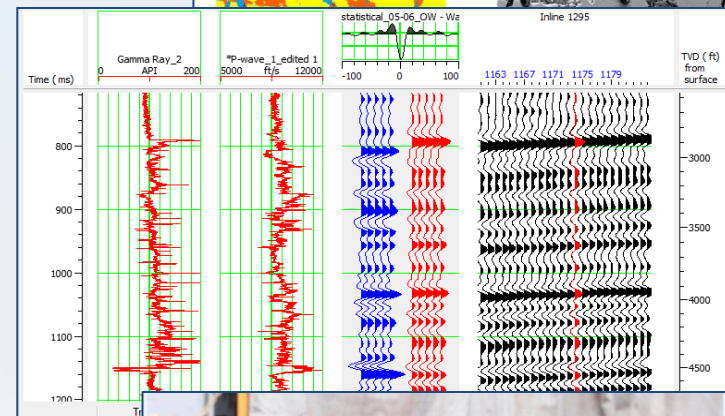
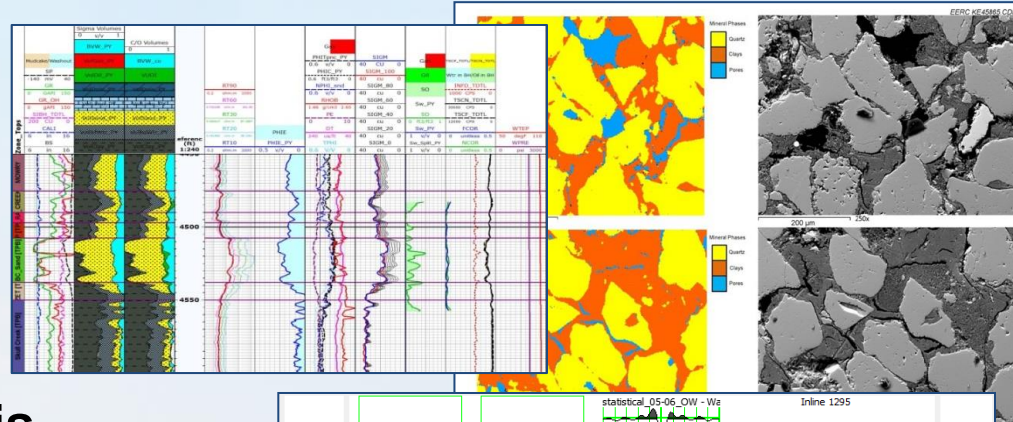
- An estimated 40–50 million incremental bbl of oil will be recovered.
- An estimated 12.7 million tonnes of CO<sub>2</sub> will be stored.





# Site Characterization

- Well file integration
- Lidar (light detection and ranging) collection
- Outcrop investigations
- Drilling characterization wells
- New core collection and analysis
- Special core analysis (SCAL) and pressure–volume–temperature (PVT) testing
- Existing core analysis
- 104-km<sup>2</sup> (40-mi<sup>2</sup>) 3-D seismic survey
- Baseline 3-D vertical seismic profiles (VSPs)
- Pulsed-neutron logs (PNLs)





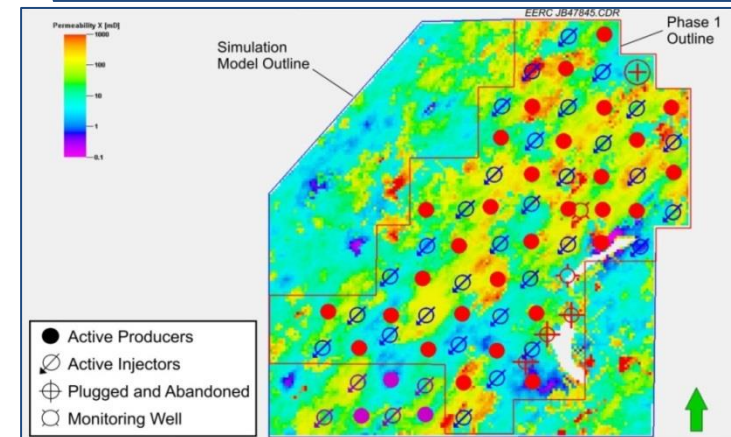
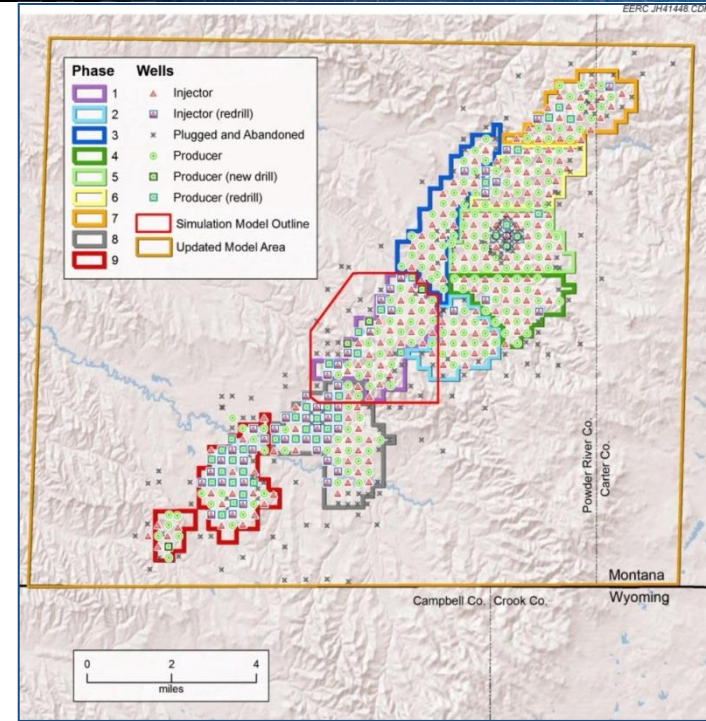
# Modeling and Simulation

## Models

- 518-km<sup>2</sup> (200-mi<sup>2</sup>) domain models
- 20-km<sup>2</sup> (7.75-mi<sup>2</sup>) multiphase flow numerical simulation models
- PVT and equation-of-state modeling
- 1-D and 3-D Mechanical Earth Model
- Shallow-subsurface geochemical modeling
- Near-surface flow model

## Simulation

- Phases 1 and 2 (separate) history matching and predictive simulation complete.
- Phases 1 and 2 combined history matching is under way.

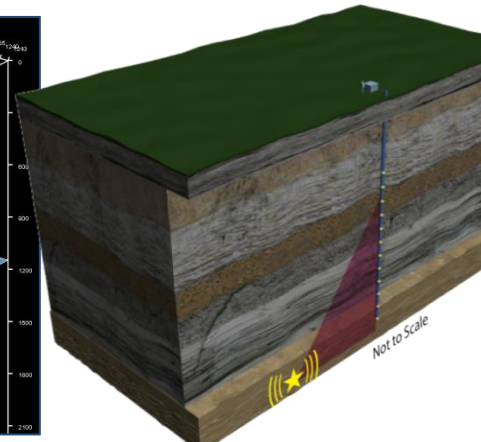
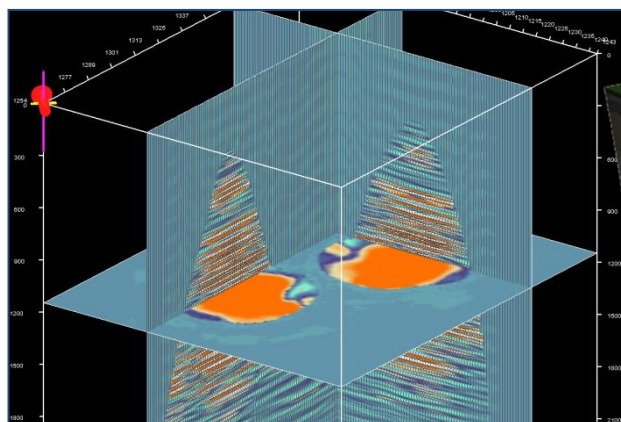
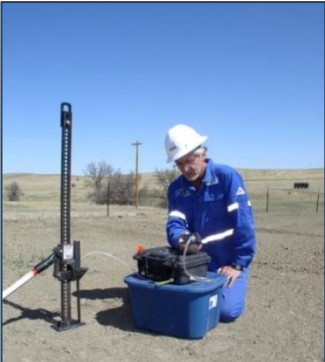


## Surface and Near-Surface Activities

- Baseline soil gas and water monitoring are complete.
- Regular sampling events are under way.

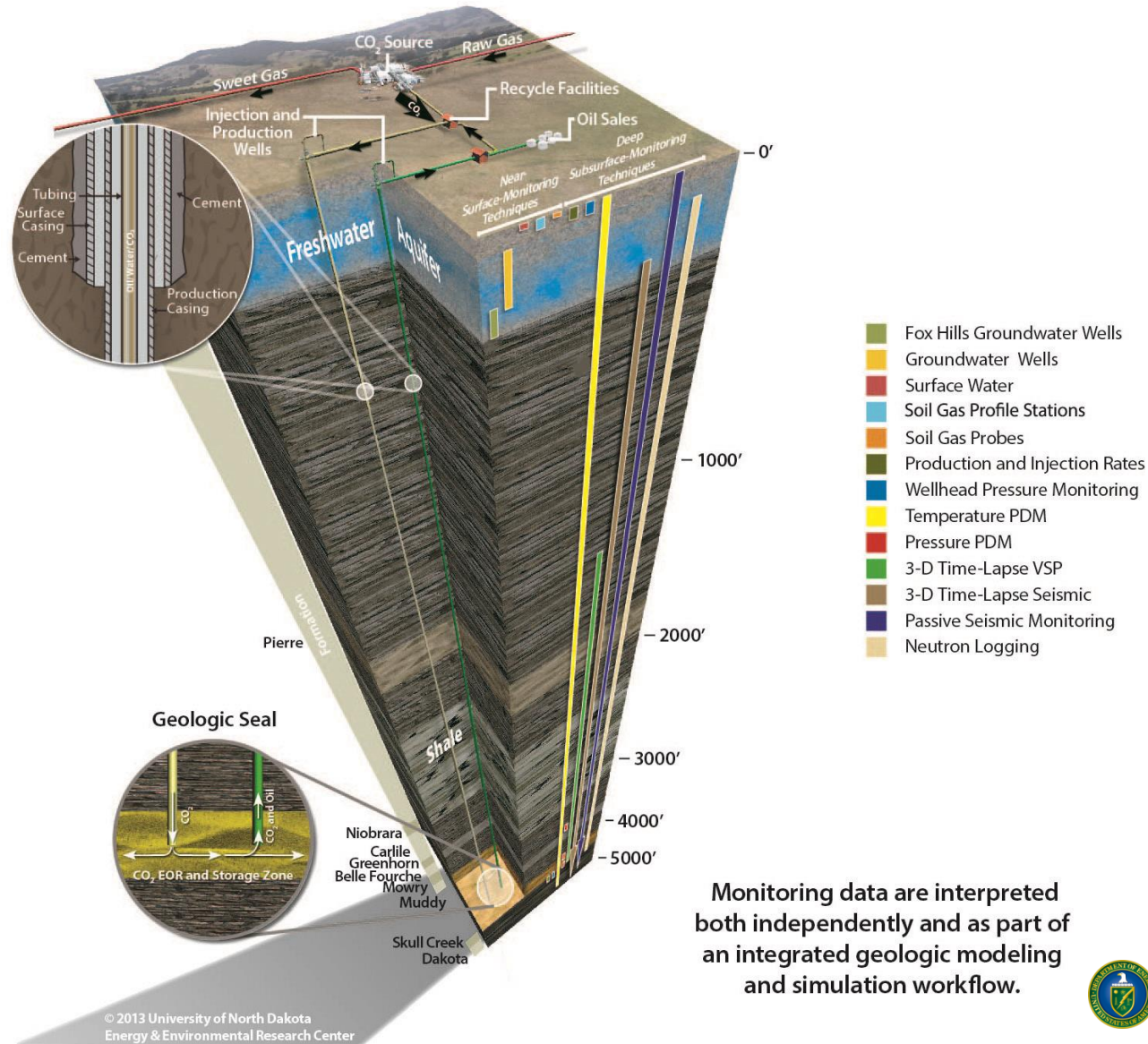
## Subsurface Activities

- Repeat PNLs collected (31 to date)
- Passive seismic monitoring (1 year complete)
- Downhole pressure and temperature monitoring
- Time-lapse seismic collected (surface and VSP)





# Path Forward – Operational Monitoring



Monitoring data are interpreted both independently and as part of an integrated geologic modeling and simulation workflow.

# Other PCOR Partnership Program Components

- Aquistore project
- Basal Cambrian project
- Fort Nelson project
- Zama project
- Regional characterization
- Public outreach
- Regulatory involvement
- Water Working Group

Denbury

Spectra  
Energy

Apache  
CANADA LTD.

ptrc  
Petroleum Technology  
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# Aquistore Project

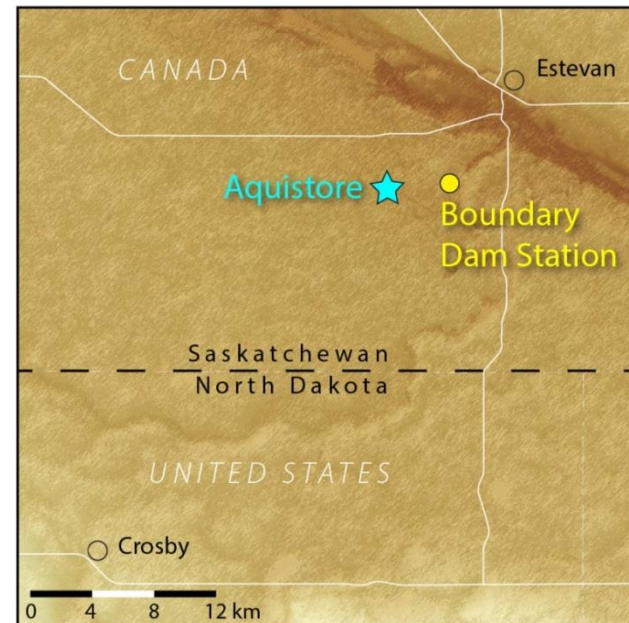
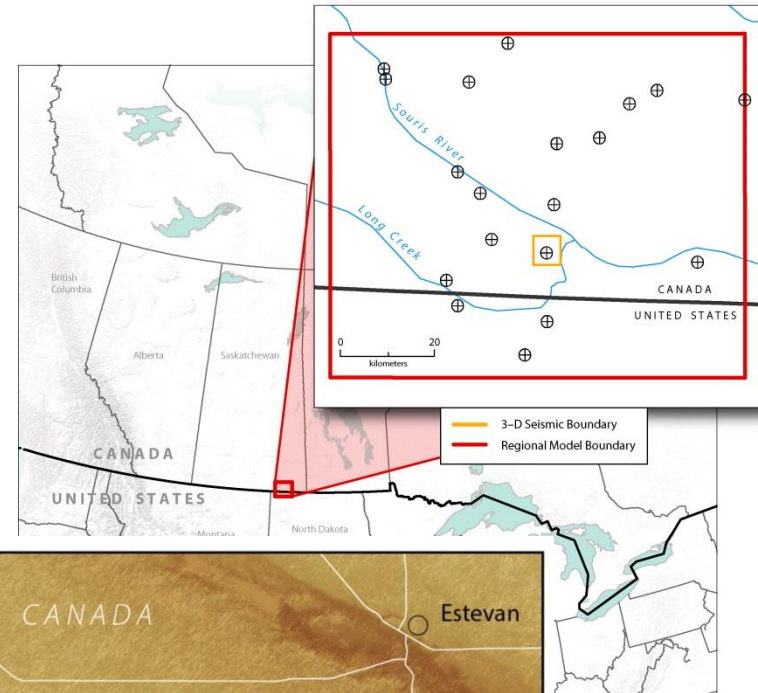


- CO<sub>2</sub> from the Boundary Dam power plant in southeastern Saskatchewan will be injected into a saline formation.
  - Target zone is Deadwood Formation, 3200 m (10,500 ft) depth, >50 m (>150 ft) thick
  - PCOR Partnership activities include:
    - Core analysis
    - Static and dynamic modeling
    - Public outreach
    - Participation in Aquistore Science and Engineering Research Council (SERC)



# Aquistore Modeling

- Initial phase of modeling and simulation completed.
- Geocellular models centered on the injection and observation wells:
  - Coarse-scale regional extent encompassing 9507 km<sup>2</sup> (3671 mi<sup>2</sup>).
  - Finer-scaled area of 34 km<sup>2</sup> (13 mi<sup>2</sup>).
  - Six flow zones (sandstone-dominated) and five intermediate low/no-flow zones were identified, along with the capping shale of the Ice Box Formation.





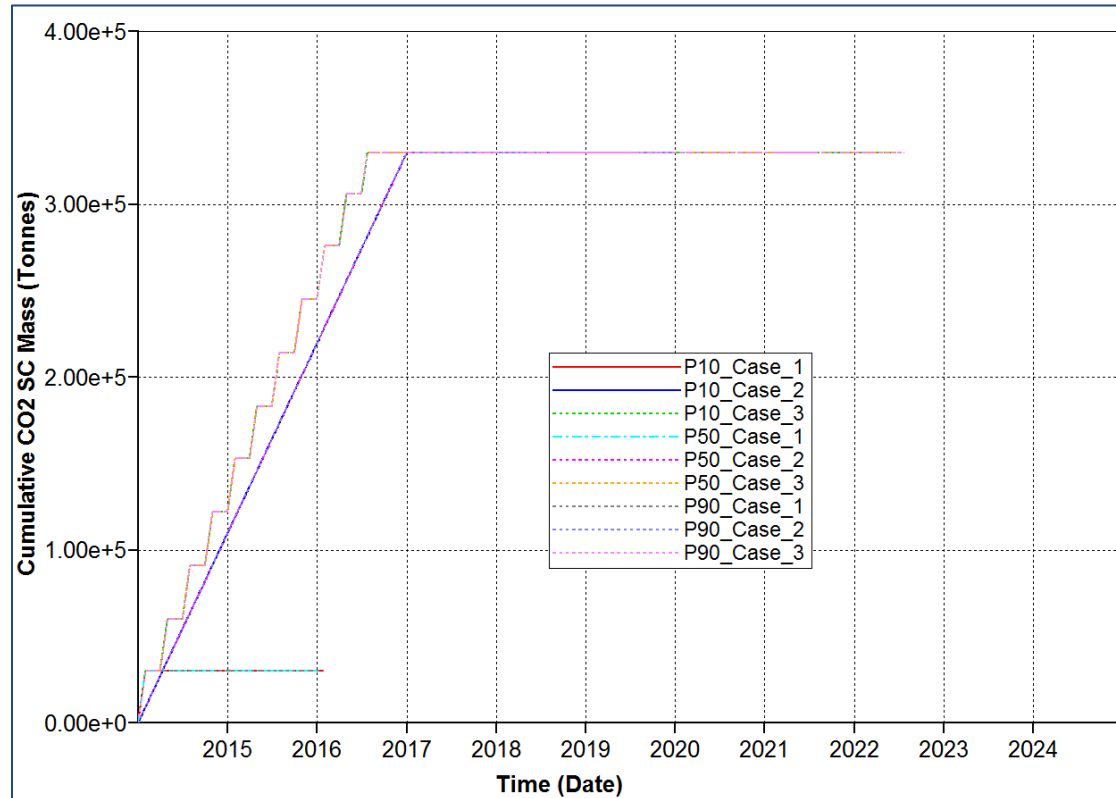
# Simulation Test Cases

- **Case 1:** 1000 tonnes/day for 30 days, followed by a 2-year postinjection observation.
- **Case 2:** 330,000 tonnes over 3 years. The rate is about 301 tonnes/day.
- **Case 3:** 1000 tonnes/day for 30 days, followed by 60 days noninjection, then another 1000 tonnes/day for 30 days. This start–stop–start pattern was repeated until 330,000 tonnes was injected (933 days).
- All three cases were analyzed based on three realizations P10, P50, and P90.



# Results

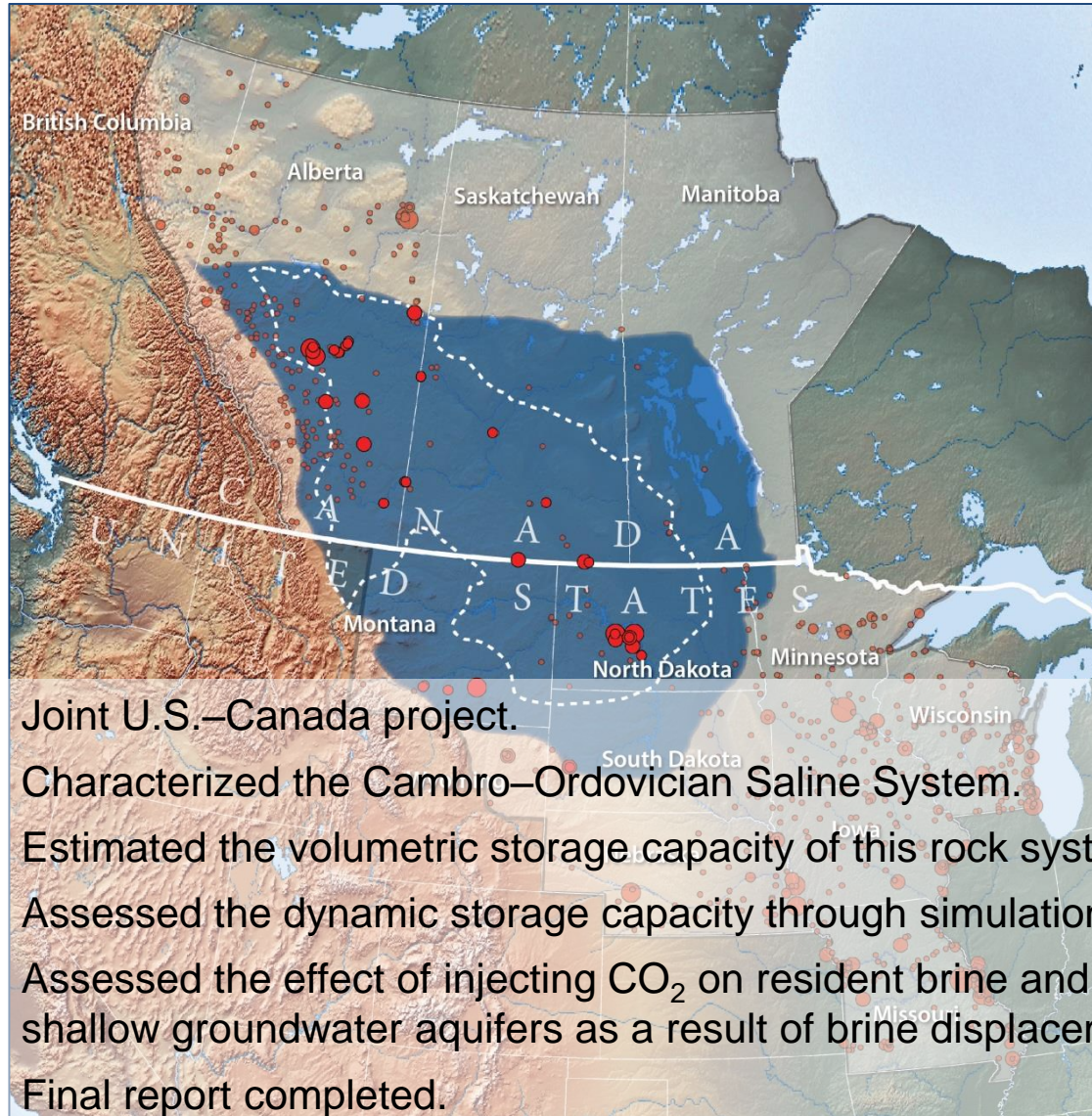
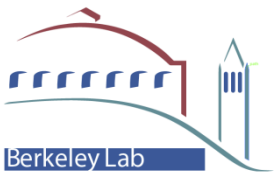
- Simulations using existing two-well configuration show that CO<sub>2</sub> storage is feasible.



## Future Work

- Expand fine-scale model.
- Include injection data (pressures and volumes) and maximize storage efficiency.

# Basal Cambrian Project



- Joint U.S.–Canada project.
- Characterized the Cambro–Ordovician Saline System.
- Estimated the volumetric storage capacity of this rock system.
- Assessed the dynamic storage capacity through simulations.
- Assessed the effect of injecting CO<sub>2</sub> on resident brine and on shallow groundwater aquifers as a result of brine displacement.
- Final report completed.





# Fort Nelson CCS in a Deep Saline Formation

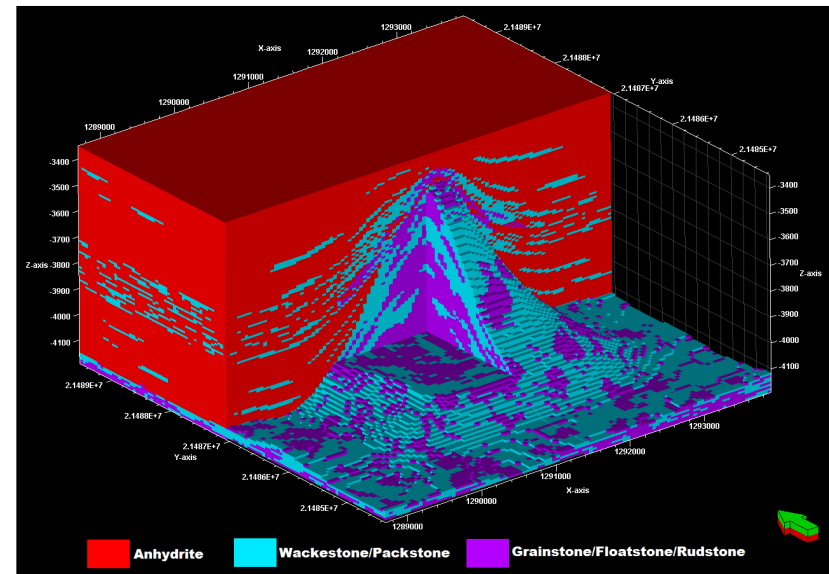
## Fort Nelson CCS Feasibility Study

- CCS in a deep saline formation.
- Completed a best practices manual for MVA.



## Zama Acid Gas EOR and Storage

- Operated by Apache Canada Ltd.
- Static and dynamic modeling activities completed.
- Regional technology implementation plan created.

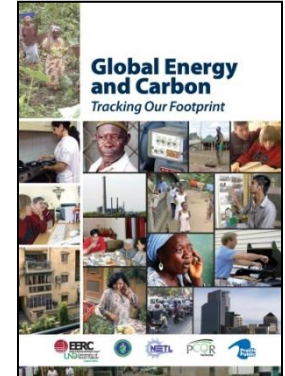


# PCOR Partnership Outreach Activities

- Documentaries
  - “Installing a Casing-Conveyed Permanent Downhole Monitoring (PDM) System” (completed)
  - “Coal and the Modern Age” (filming)
  - D21 Bell Creek documentary (discussing with Denbury)
- Education
  - Seminars, collaborations with educators and focus groups.
  - Working group with nongovernmental organizations, Canadian CCS projects, and other Regional Carbon Sequestration Partnerships (RCSPs).
  - Four-part Energy, Carbon, and CCS Education video series with Prairie Public Broadcasting.
- Web site updates
- Posters



## 2012 Platinum Best of Show Aurora Award!



## PDM Documentary





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