EERC | UNIVERSITY OF NORTH DAKOTA

Critical Challenges. Practical Solutions.

Energy & Environmental Research Center (EERC)

Williston Basin Associated CO_2 Storage Field Laboratory

DE-FE 0031694

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U.S. Department of Energy

National Energy Technology Laboratory

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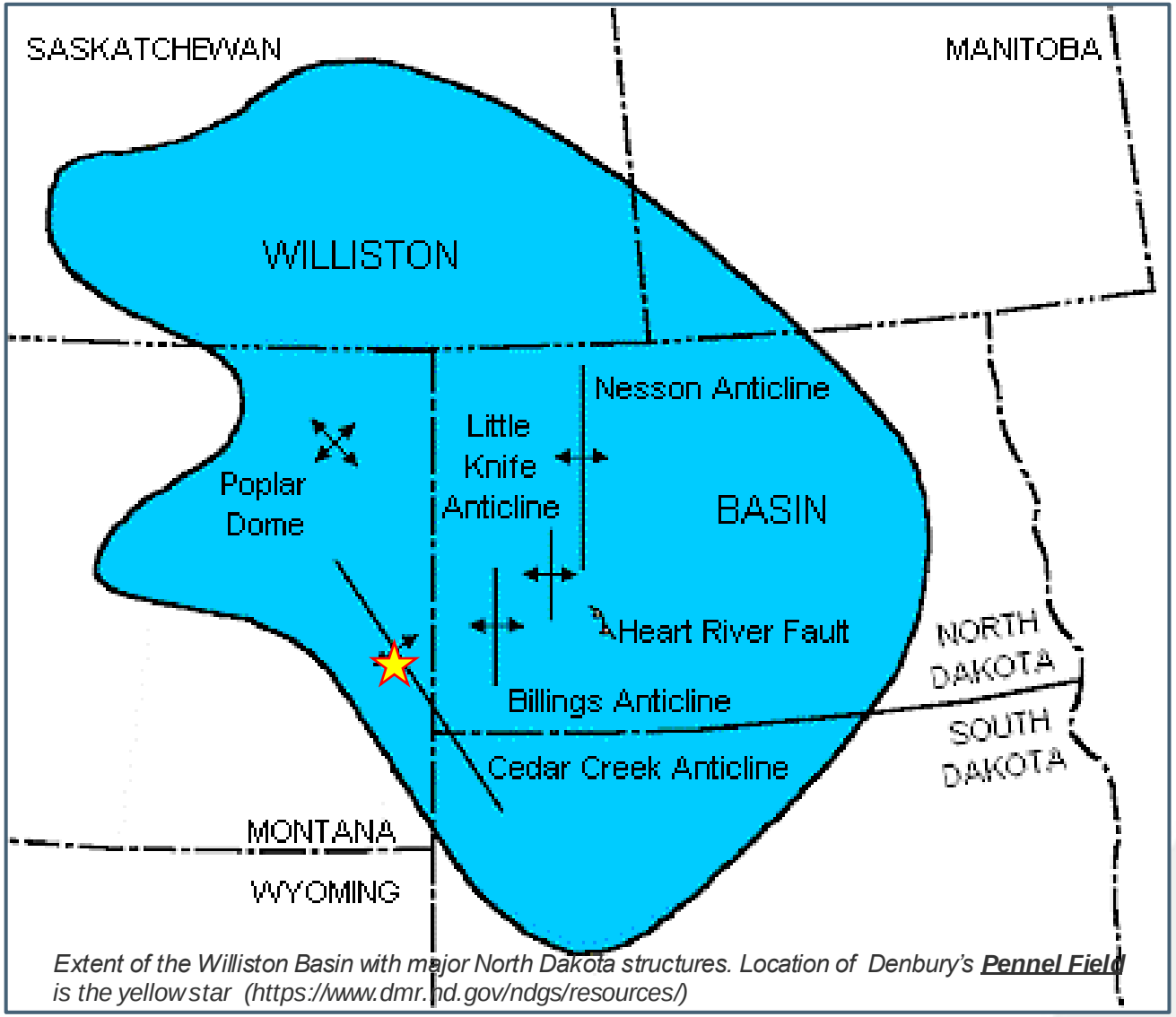
PRESENTATION OUTLINE

- Project Background
- Project Goal
- Geophysical Monitoring
- Characterization
- Benefits

OVERALL PROJECT GOAL AND OBJECTIVES

Goal:

To advance associated geologic storage of carbon dioxide (CO_2) in the Williston Basin through injection into a stacked geologic reservoir complex that includes a residual oil zone (ROZ)

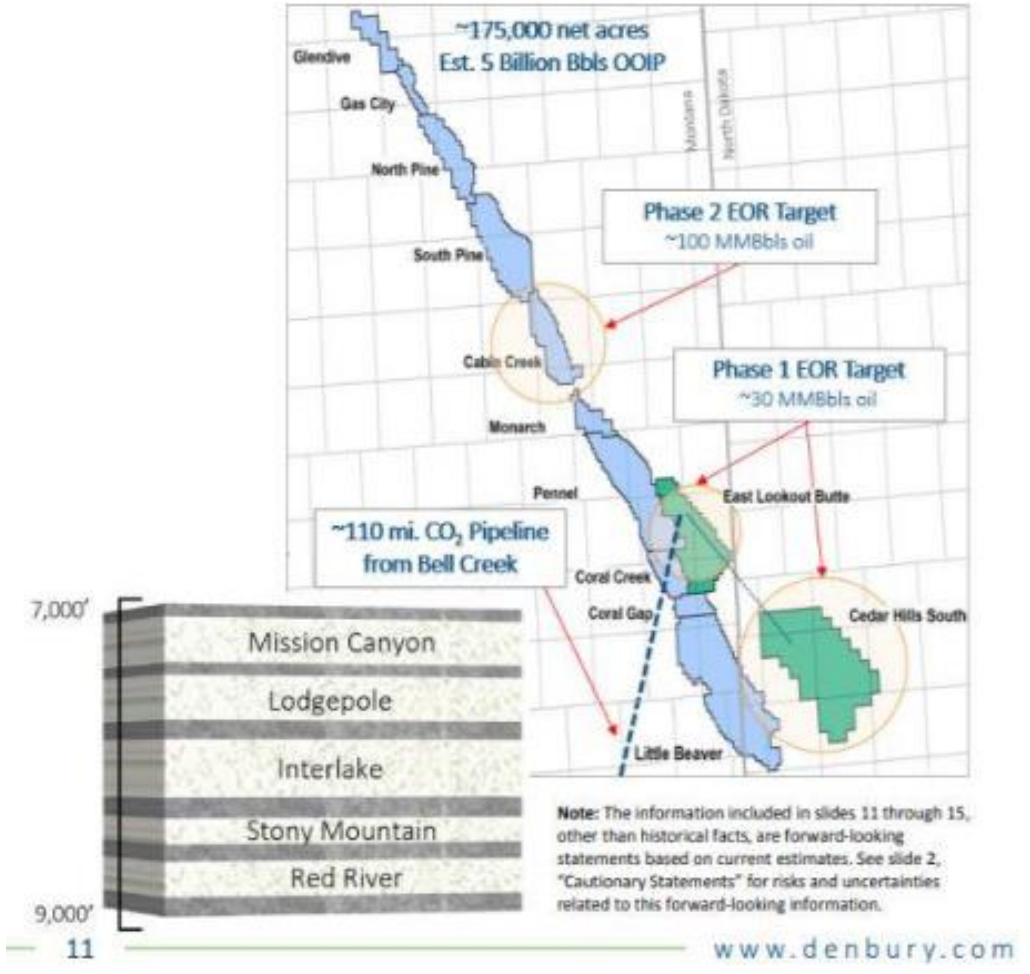


*Extent of the Williston Basin with major North Dakota structures. Location of Denbury's **Pennel Field** is the yellow star (https://www.dmr.nd.gov/ndgs/resources/)*

PROJECT OBJECTIVES

The project goal will be accomplished by:

- Generating field-based data on CO_2 enhanced oil recovery (EOR) and associated CO_2 storage in stacked reservoirs;
- Characterization of the ROZ for associated storage; and
- Evaluate an MVA technique for its applicability to associated storage in stacked reservoirs.

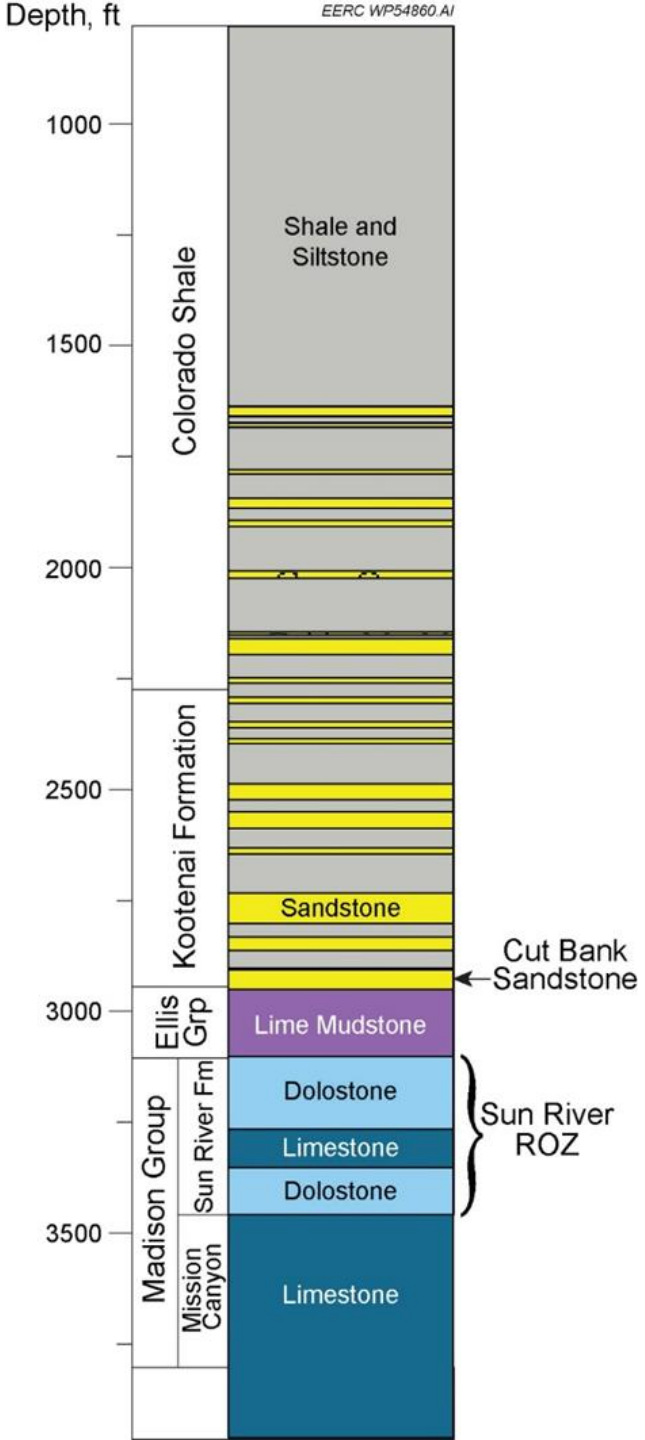


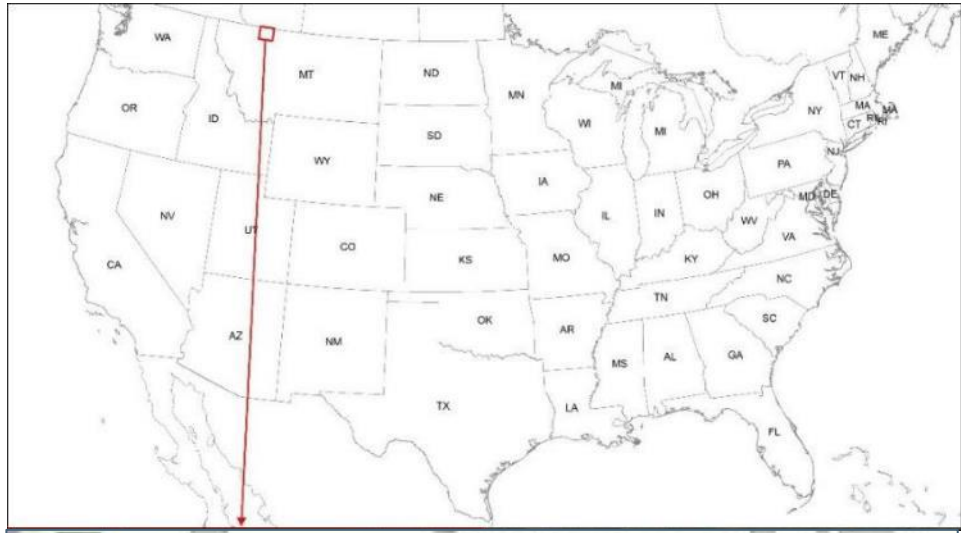
PROJECT BACKGROUND

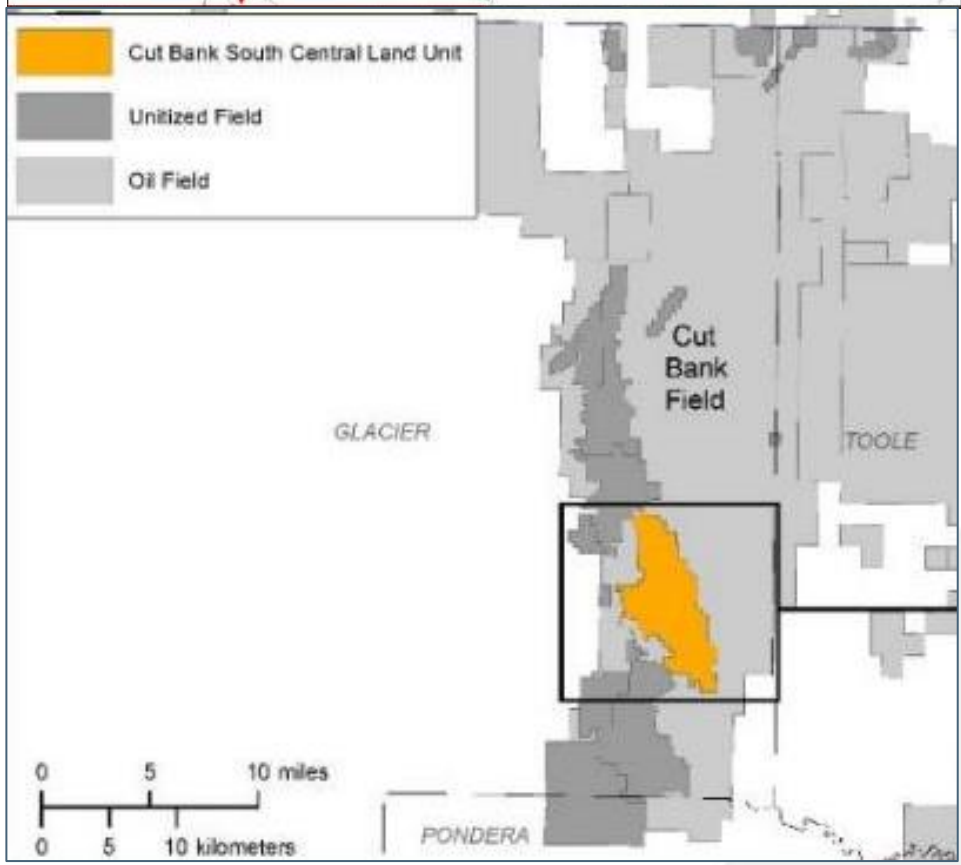
- Area of investigation: South Central Cut Bank Unit (SCCBU), Cut Bank, Montana.

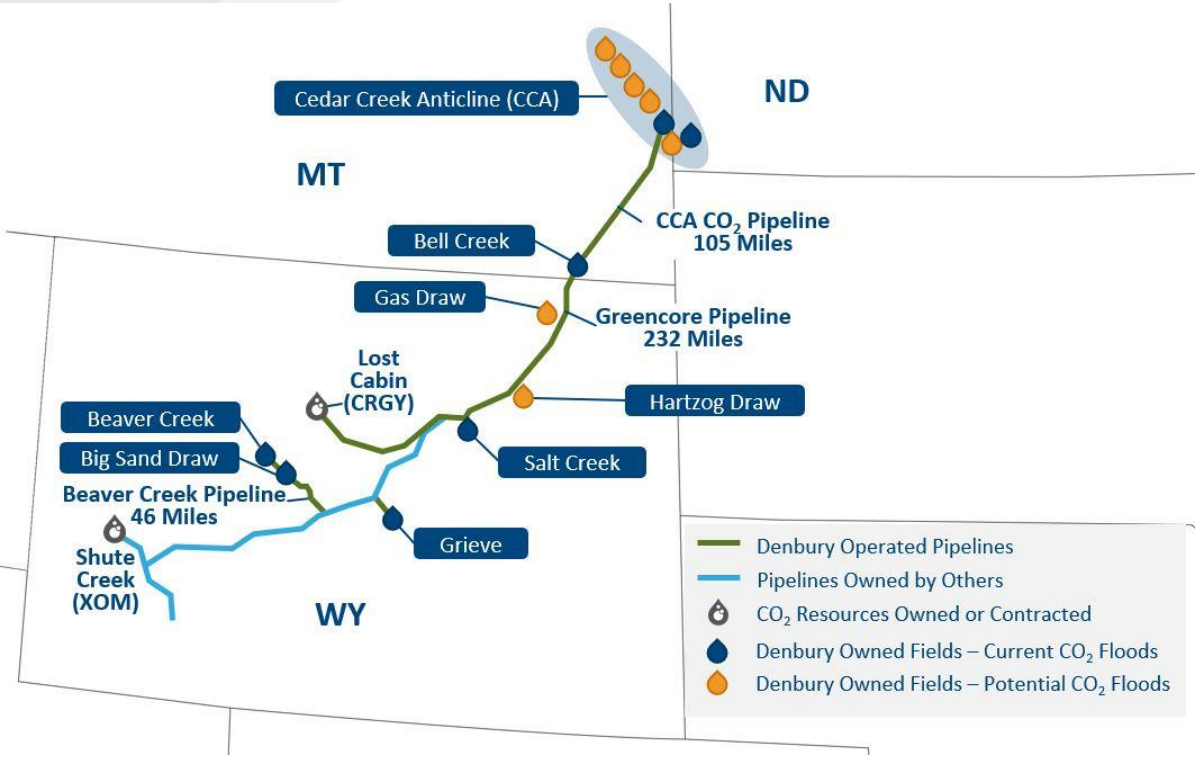
- Two formations of interest:
  - Lower Cut Bank Formation
    - Main pay
    - Sandstone
  - Sun River Formation
    - Residual oil zone (ROZ)
    - Dolomite

- CO_2 is sourced from the Kevin Dome ~25 miles to the east.









Sanctioning CO_2 EOR Development at CCA

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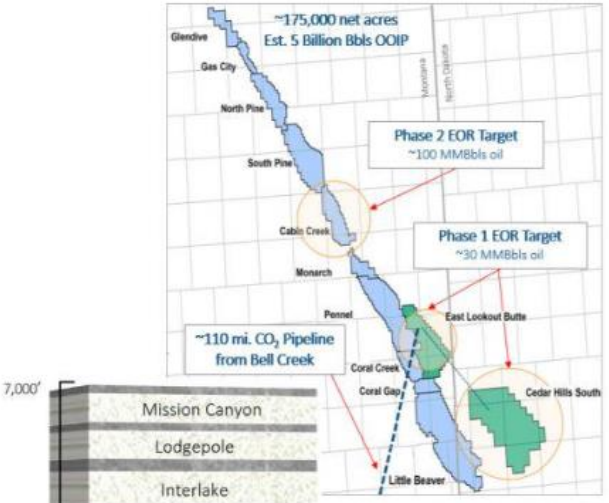
Cedar Creek Anticline Overview

EOR Formation Details	
Initial Formations Targeted	Red River Interlake Stony Mountain
Field Discovery Timeframe (Oil)	1930's (Discovery) 1950's (Development)
Formation Type	Dolomite
Depth	7,000 – 9,000 ft
Original Reservoir Pressure	3,600 – 4,140 psi
CO_2 Flood Type	Miscible
API Gravity	29-38
Average Perm	5 md
Average Porosity	11.4%
OOIP	~5 Billion Barrels
Oil Recovered to Date	~700 Million Barrels
Est. Tertiary Recovery Factor	8 – 15%



Note: The information included in slides 11 through 15, other than historical facts, are forward-looking statements based on current estimates. See slide 2, "Cautionary Statements" for risks and uncertainties related to this forward-looking information.

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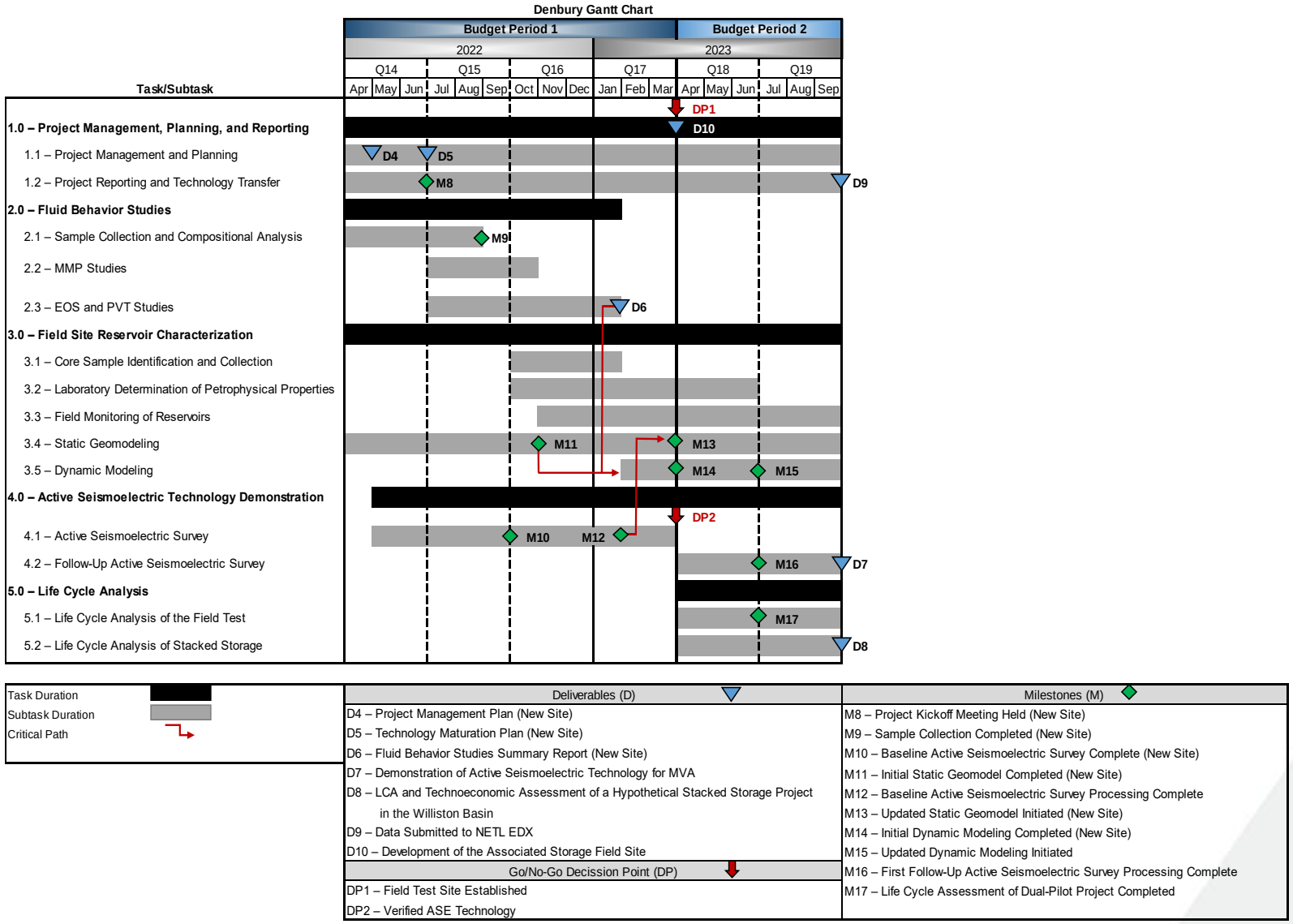
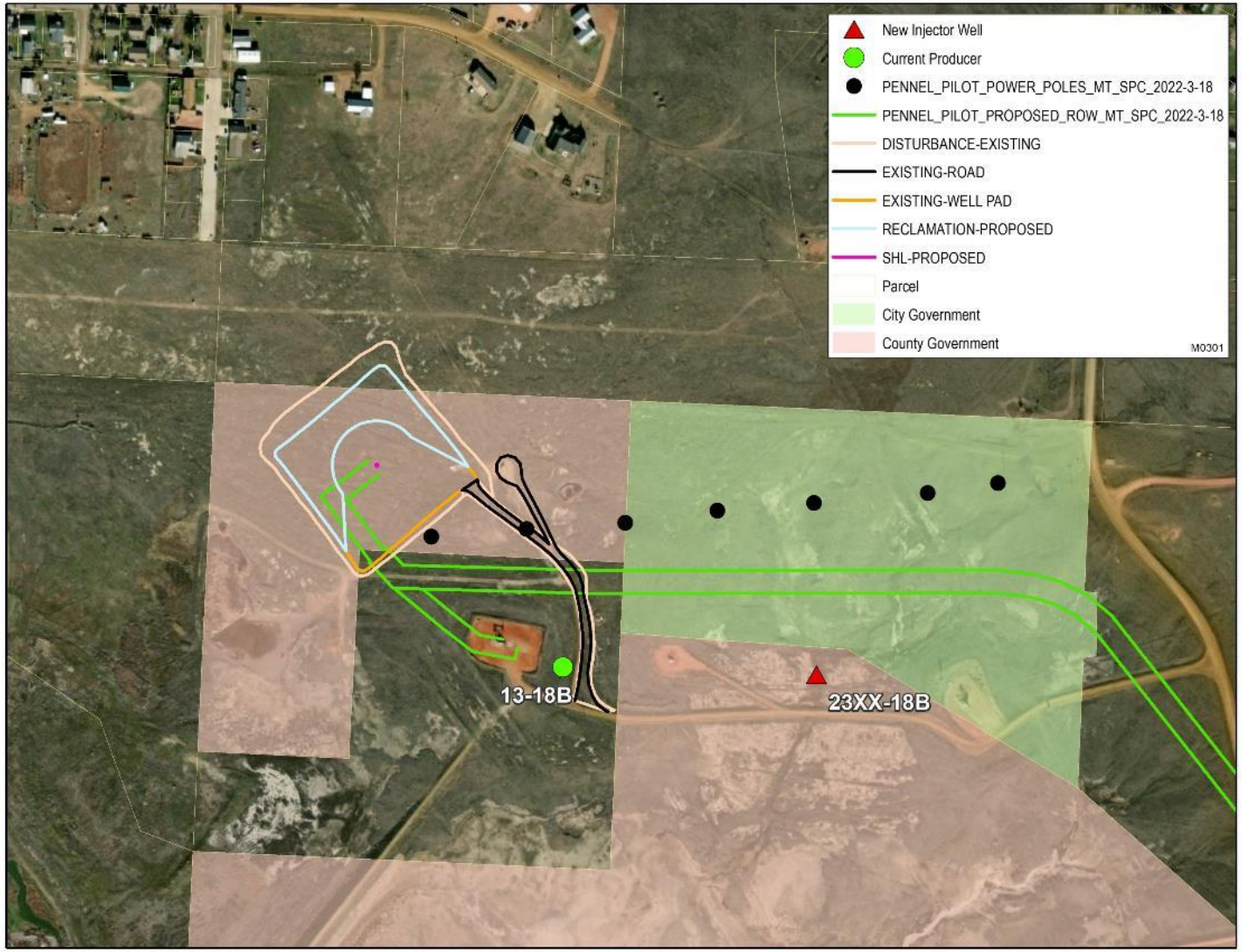
TIMELINE

- The Go/No-Go Discission Points will be determined by March 31, 2023.
  - Based on the successful demonstration that a field lab has been established.
- The project duration for the new site is 18 months. The final deliverables will be submitted in September 2023.



PENNEL CO_2 INJECTION PILOT

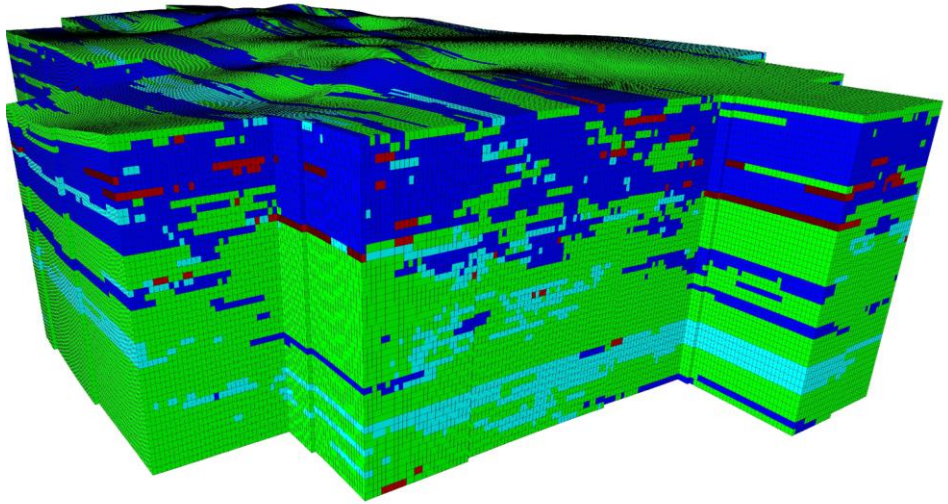
- Two wells will be used
  - Existing producing well
  - Newly drilled injection well
- Core and logs will be acquired during drilling
- Fluid sampling in the main pay and ROZ's
- CO_2 is sourced from the Greencore Pipeline
- Injection strategy is being planned and will take place in late 2022 to early 2023

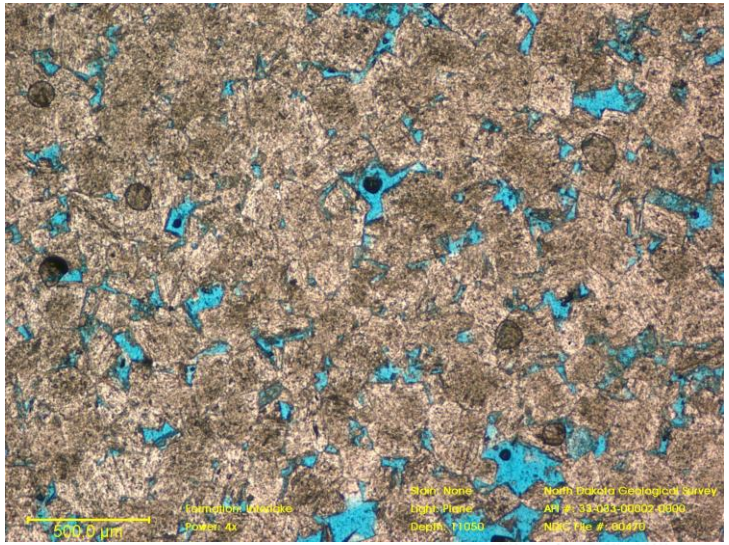


Pennel Interlake Characterization

Geomodel and Simulation

- Core and fluid analysis will provide additional detail for geologic modeling and reservoir simulation
- EERC is developing plans for numerical simulation scenarios focused on the injection site
- Interpretation of existing Pennel 3D seismic survey for characterizing subsurface structure
- Characterize the reservoirs with high resolution seismic techniques integrated with modeling and simulation.



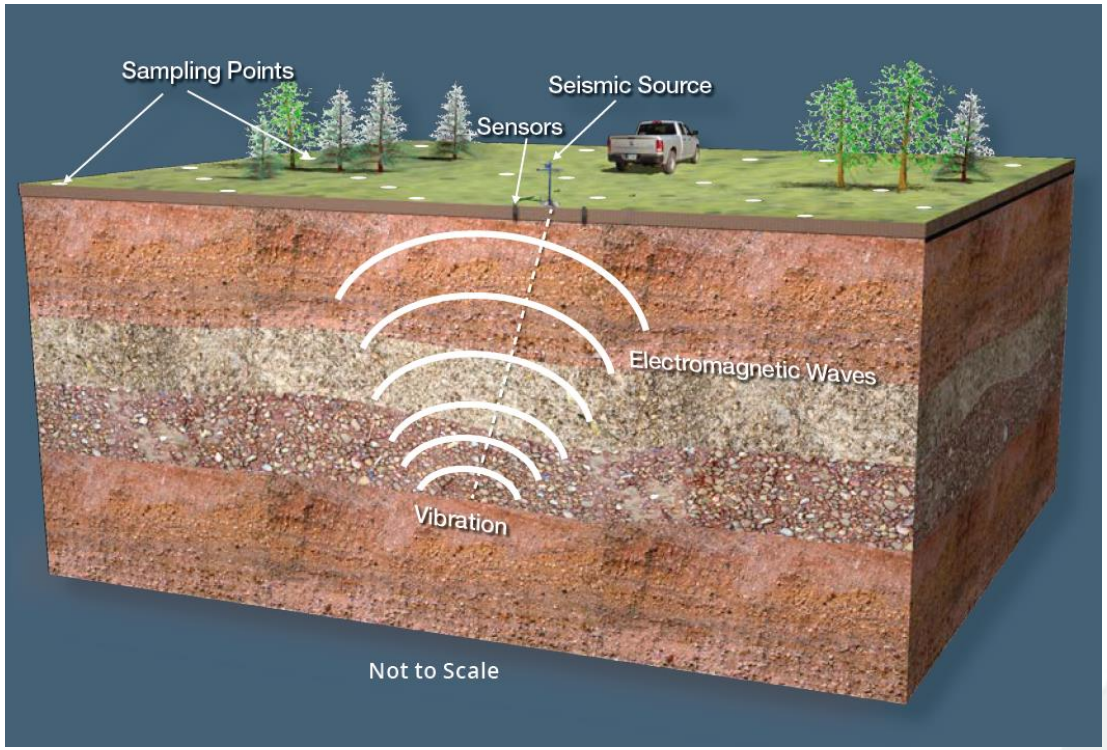


PENNEL INTERLAKE GEOPHYSICAL MODELING

- Design and perform experimental Active Seismoelectric (ASE) test in September 2022 to refine field design specifications and parameters for baseline survey.

  Sensor: electric dipoles.
  Source: Vibroseis truck or similar seismic source.
  Recorded Signal: electromagnetic wave generated by displacement of fluids in pore space dipole layers caused by the seismic waves.
  Results: depth displays directly below the sensor where the amplitude of the recorded signal is related to fluid properties.
  Application: direct hydrocarbon indication, potential CO_2 monitoring.
  Benefit: cost-effective, low-impact method.

- Field activities will also include a 3D seismic survey acquired simultaneously with 3D DAS VSP for improved characterization of the Interlake Interval and for a quality baseline for future monitoring efforts



Cut Bank Baseline ASE Survey

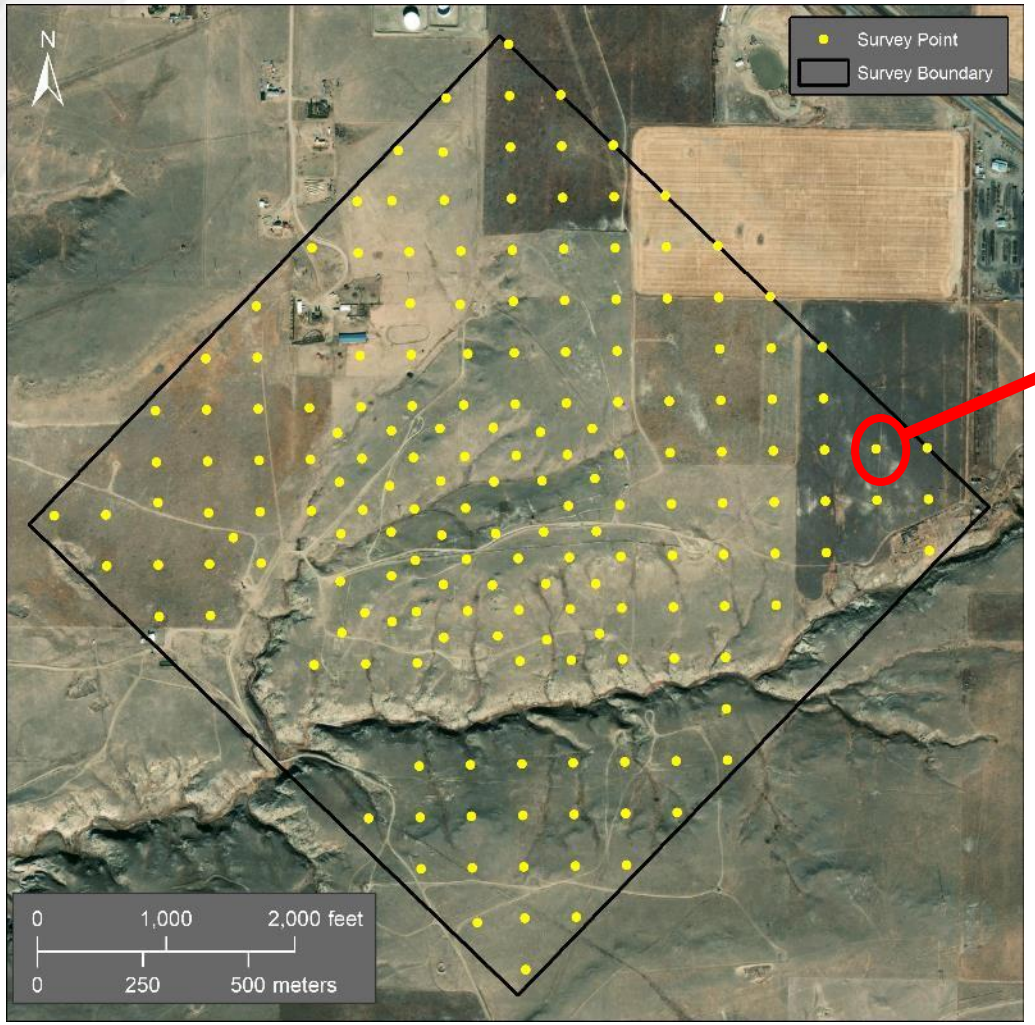
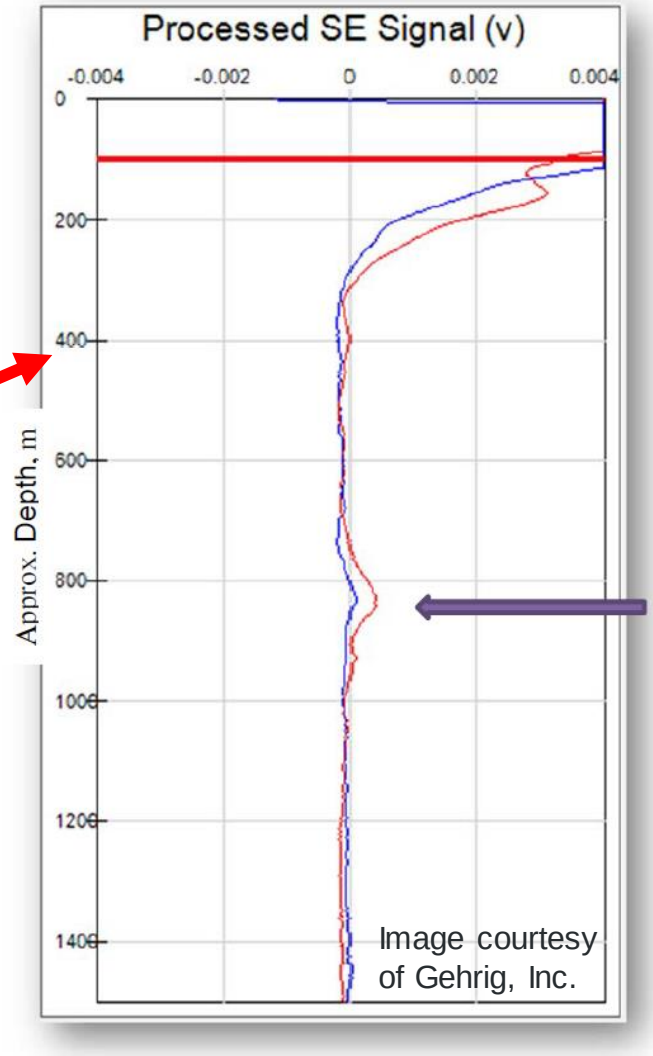


Diagram 3. ASE Sounding at Station 89



Seismoelectric response observed at the reservoir level at some locations. Advanced processing and modeling are being conducted to enhance data and understand the observed response.

Overview: Goals and Objectives (cont.)

BP2

- Determine the reservoir response to pilot injection activities in a stacked complex in the context of associated CO_2 storage
- Determine the effectiveness of ASE technology for ROZ characterization and MVA in a stacked storage complex
- Conduct detailed life cycle analyses (LCAs) of the project field injection test and a hypothetical stacked storage project in the central portion of the Williston Basin

BP2 (New Site)
Start Date: 4/1/2023
End Date: 9/30/2023

SCOPE OF WORK

Subtask 2.1 –Sample Collection and Compositional Analysis

The fluids used in this project will be collected from one or more oil production streams in each reservoir of the stacked storage complex.

Samples will be analyzed to determine:

- hydrocarbon composition
- fundamental oil properties (PVT)

Task Milestone: Sample Collection Completed

SCOPE OF WORK (cont.)

Subtask 3.4 – Static Geomodeling

- Historical well log
- Core data
- Petrophysical analyses
- Fluid samples

Data collected under Subtasks 3.2 and 3.3 will be used to modify the static geomodels of the stacked storage complex within the field study area.

Task Milestone: Static Geomodel

SCOPE OF WORK (cont.)

Subtask 3.5 – Dynamic Modeling

Data generated by the following will be used to conduct history matching and pressure transient analysis:

- Fluid Behavior Studies
- Laboratory Determination of Petrophysical Properties
- Field Monitoring of Reservoirs
- Static Geomodeling

The results will be used to predict field test performance and evaluate schemes for CO_2 storage optimization in the reservoirs of the stacked storage complex.

Task Milestone: Dynamic Modeling

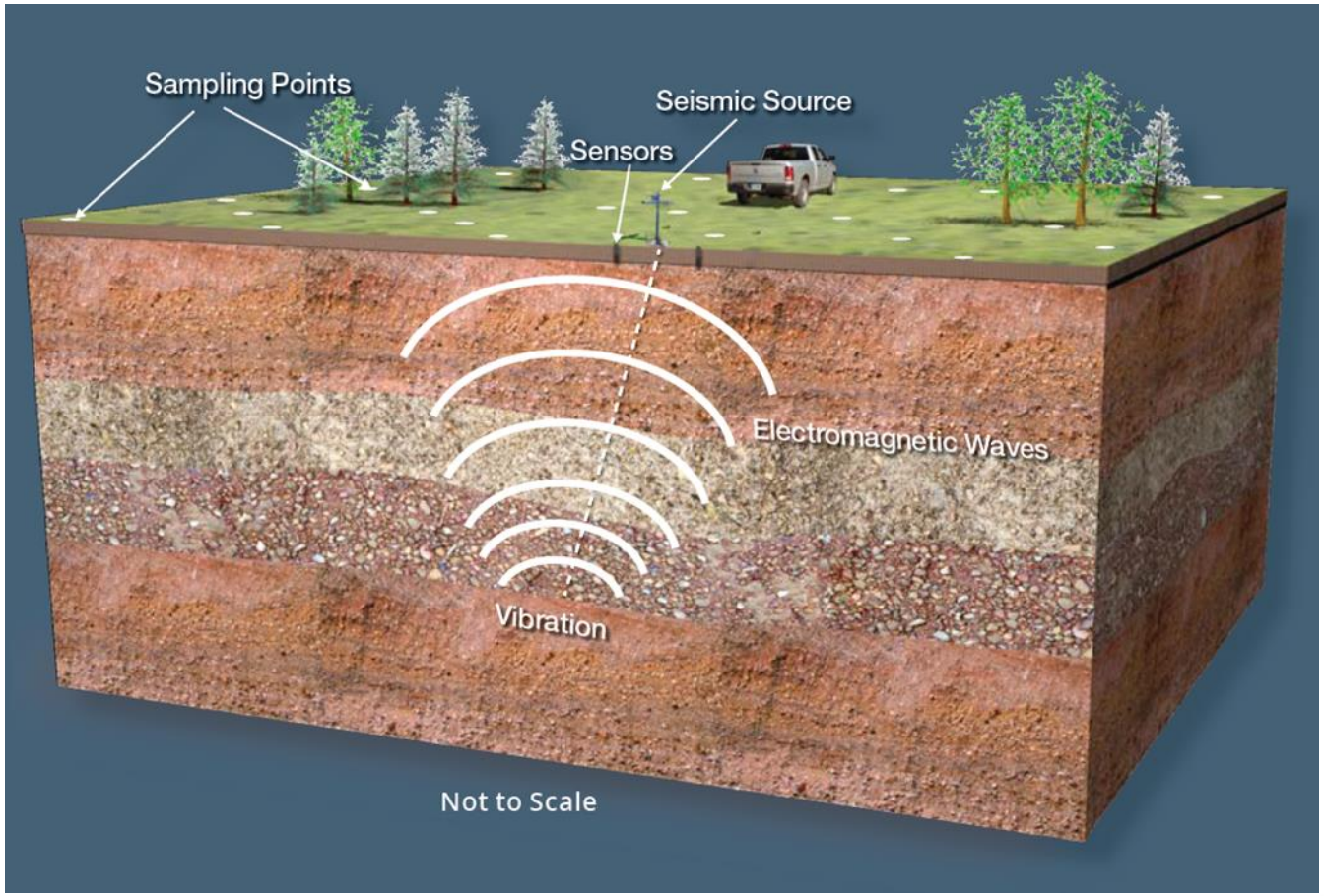
SCOPE OF WORK (cont.)

Subtask 4.2 – Follow-Up Active Seismoelectric Survey

Data from the survey will be processed to identify changes in the distribution of fluid saturations in the stacked storage complex

Analysis of the data will include evaluation of ASE using:

- MVA method for CO_2 injection,
- suitability for time-lapse monitoring,
- ability of the method to screen for ROZs



Task Milestone: Follow-Up Active Seismoelectric Survey

SCOPE OF WORK (cont.)

Subtask 5.1 – Life Cycle Analysis of the Field Test

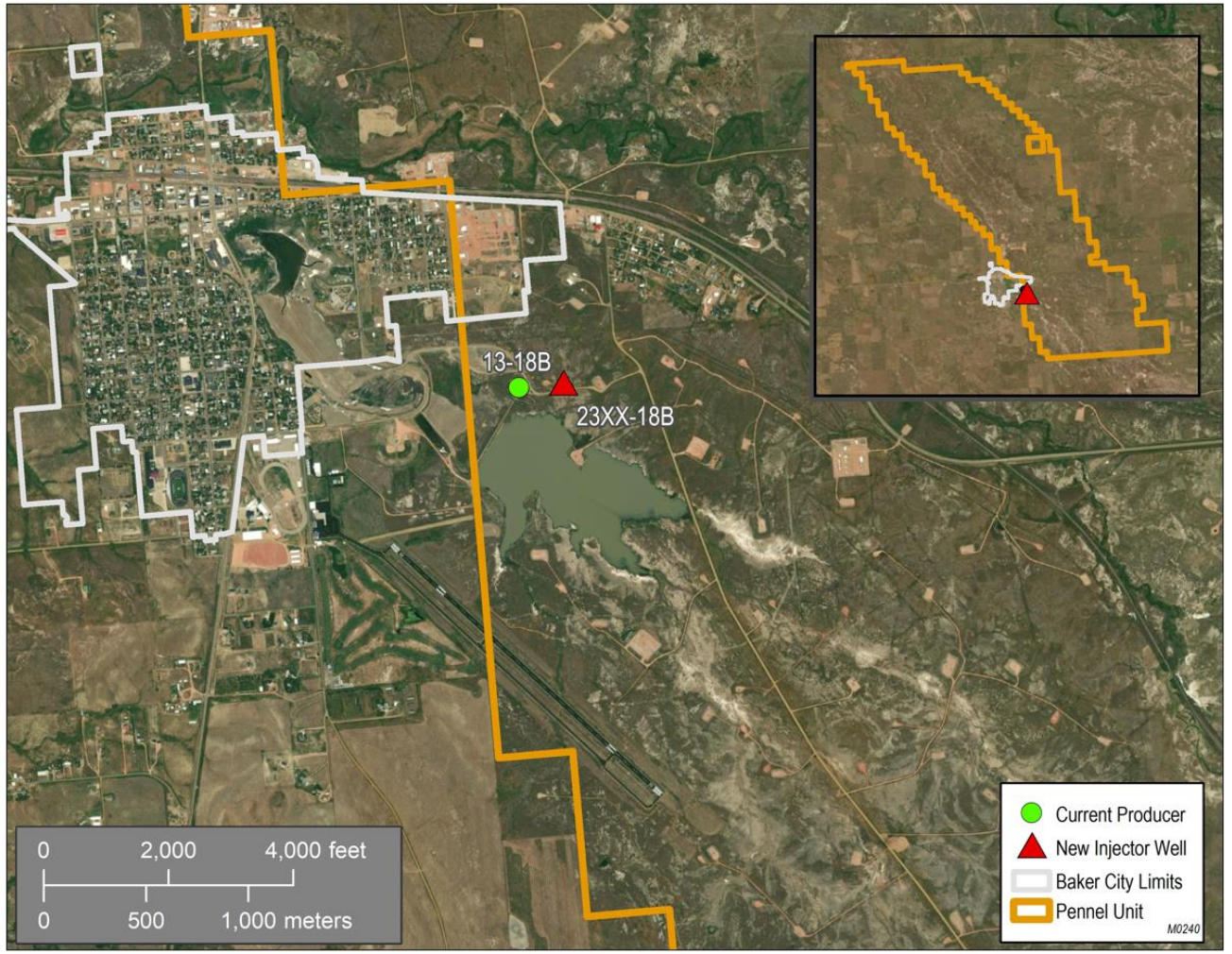
BP1 and BP2 data generated will be used to conduct an LCA of the project field test:

- Technical assessment
- Economic assessment
- Regional applicability

Task Milestone: Life Cycle Analysis Assessment of Dual-Pilot Project

PROJECT BENEFITS

- Address the technical and economic barriers to the deployment of carbon capture, utilization, and storage (CCUS) in the Williston Basin and will be readily transmissible to other North American basins.
- Provide approaches for characterizing associated CO_2 storage in stacked complexes and demonstrate the impact of implementing CCUS through life cycle analyses.
- Successful execution of the project will provide CO2-EOR project developers with the information needed to address and overcome uncertainties in CO2-EOR implementation and capitalize on the benefits of stacked reservoirs, thereby contributing to the growth of associated storage projects.



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THANK YOU

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Overview: Goals and Objectives

BP1

- Determine the baseline reservoir characteristics of the stacked storage complex
- Determine the effects of hydrocarbon gas impurities in the recycled CO_2 stream from stacked reservoirs on the optimization of CO_2 EOR and associated storage
- Predict seismoelectric response based on a forward model and acquire a baseline active seismoelectric (ASE) survey across the study field.

BP1 (New Site)
Start Date: 4/1/2022
End Date: 3/31/2023

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Task/Subtask Breakdown

- Task 1 – Project Management, Planning, and Reporting
  - Subtask 1.1 – Project Management and Planning
  - Subtask 1.2 – Project Reporting and Technology Transfer
- Task 2 – Fluid Behavior Studies
  - Subtask 2.1 – Sample Collection and Compositional Analysis
  - Subtask 2.2 – MMP Studies
  - Subtask 2.3 – EOS and PVT Studies
- Task 3 – Field Site Reservoir Characterization
  - Subtask 3.1 – Core Sample Identification and Collection
  - Subtask 3.2 – Laboratory Determination of Petrophysical Properties
  - Subtask 3.3 – Field Monitoring of Reservoirs
  - Subtask 3.4 – Static Geomodeling
  - Subtask 3.5 – Dynamic Modeling
- Task 4 – Active Seismoelectric Technology Demonstration
  - Subtask 4.1– Active Seismoelectric Survey
  - Subtask 4.2 – Follow-Up Active Seismoelectric Survey
- Task 5 – Life Cycle Analysis
  - Subtask 5.1 – Life Cycle Analysis of the Field Test
  - Subtask 5.2 – Life Cycle Analysis of Stacked Storage

Deliverables

Task/Subtask Number	Deliverable Title	Due Date
1.1	D4 – Project Management Plan	Submitted on May 2nd
1.1	D5 –Technology(ies) Maturation Plan (TMP)	Submitted on July 6, 2022
2.3	D6 – Fluid Behavior Studies Summary Report	January 31, 2023
4.2	D7 – Demonstration of Active Seismoelectric Technology for MVA	September 30, 2023
5.2	D8 – LCA and Technoeconomic Assessment of a Hypothetical Stacked Storage Project in the Williston Basin	September 30, 2023
1.2	D9 – Data Submitted to NETL EDX	September 30, 2023
1.0	D10 – Development of the Associated Storage Field Site	March 31, 2023

Major Project Risks

- Lack of time in budget period 2
- Inability to maintain schedule of tasks
- Budget insufficient to complete project
- Insufficient data availability
- Lack of technical expertise
- Regulatory requirements
- Resource availability
- Inefficient communication leads
- Loss of PI, task lead, or key researcher(s) to health matters or attrition
- Fieldwork-based injuries
- Site access for fieldwork
- Weather Incidents Delay for Fieldwork

Project Overview

- Generate field-based data on CO_2 EOR-associated storage in stacked reservoirs
- Characterize ROZ for associated storage
- Evaluate a monitoring, verification, and accounting (MVA) technique for its applicability to associated storage in stacked complexes

	Budget Period 1		Budget Period 2		Total	
	DOE Funds	Cost Share	DOE Funds	Cost Share	DOE Funds	Cost Share
EERC – Prime	$2,384,367	$596,092	$1,111,221	$277,805	$3,495,588	$873,897
Performance Dates	2/1/2019 – 3/31/2023		4/1/2023 – 9/30/2023			