



Developing CO₂-EOR and Associated Storage within the Residual Oil Zone Fairways of the Powder River Basin, Wyoming

DE-FE0031738

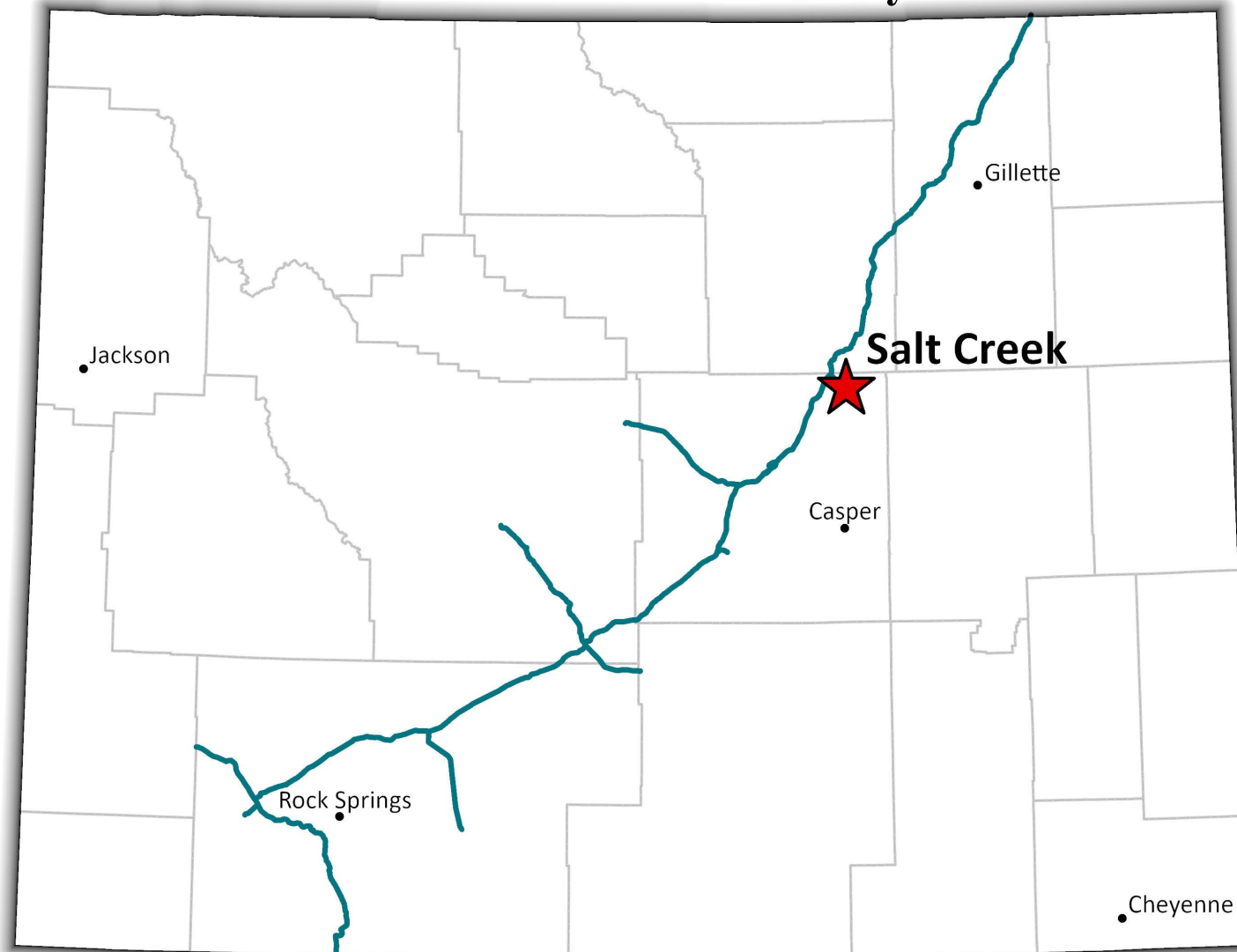
2024 FECM/NETL Carbon Management Research Project Review Meeting

Carbon Transport and Storage

Pittsburgh, PA

August 6, 2024

Location of Field Laboratory

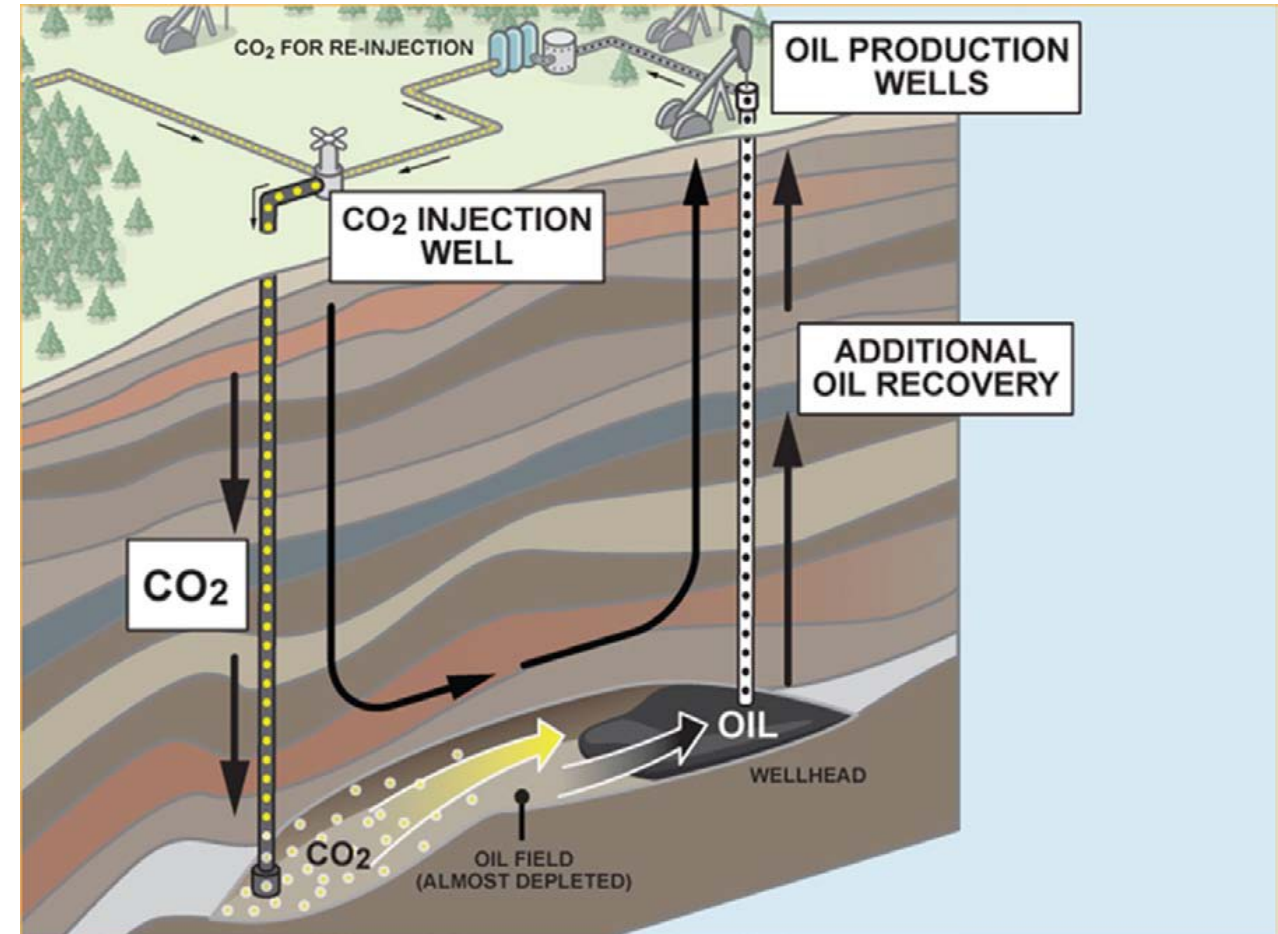


CO₂-Enhanced Oil Recovery (EOR)

Tap in-place and mobilize stranded oil and permanently store CO₂

Residual Oil Zone (ROZ)-CO₂ Storage

Quantify potentially large sequestration targets to determine economic viability





Key Components of the Project

The Goals of this Project are Two-Fold:

1) CO₂-EOR Assessment

Produce incremental barrels of oil from Residual Oil Zones not currently developed.

2) Residual Oil Zone (ROZ) CO₂ Storage

Evaluate permanent storage potential of CO₂ within an ROZ.

The combination of these two goals is intended to determine the economic feasibility of permanently storing CO₂ in ROZs with the additional benefit of producing incremental barrels of oil that would otherwise be stranded.



The Four Project Objectives

1. Characterize ROZ Fairway Resource in the Salt Creek Area
2. Develop a Detailed Review of Mechanisms Influencing the Efficiency and Permanence of ROZ-Associated CO₂ Storage
3. Examine Alternative CO₂ Injection and Storage Strategies for Optimizing Both Oil Recovery and CO₂ Storage
4. Establish the Commercial Viability of Oil Recovery and Associated CO₂ Storage for the ROZ Fairway at Salt Creek



Residual Oil Zones (ROZ)

Residual Oil Zones (ROZ) are a naturally occurring phenomenon where oil has been displaced from its original position within a trap, leaving a zone of low oil saturation within the formerly saturated reservoir rock.



Oil Saturation (S_o)

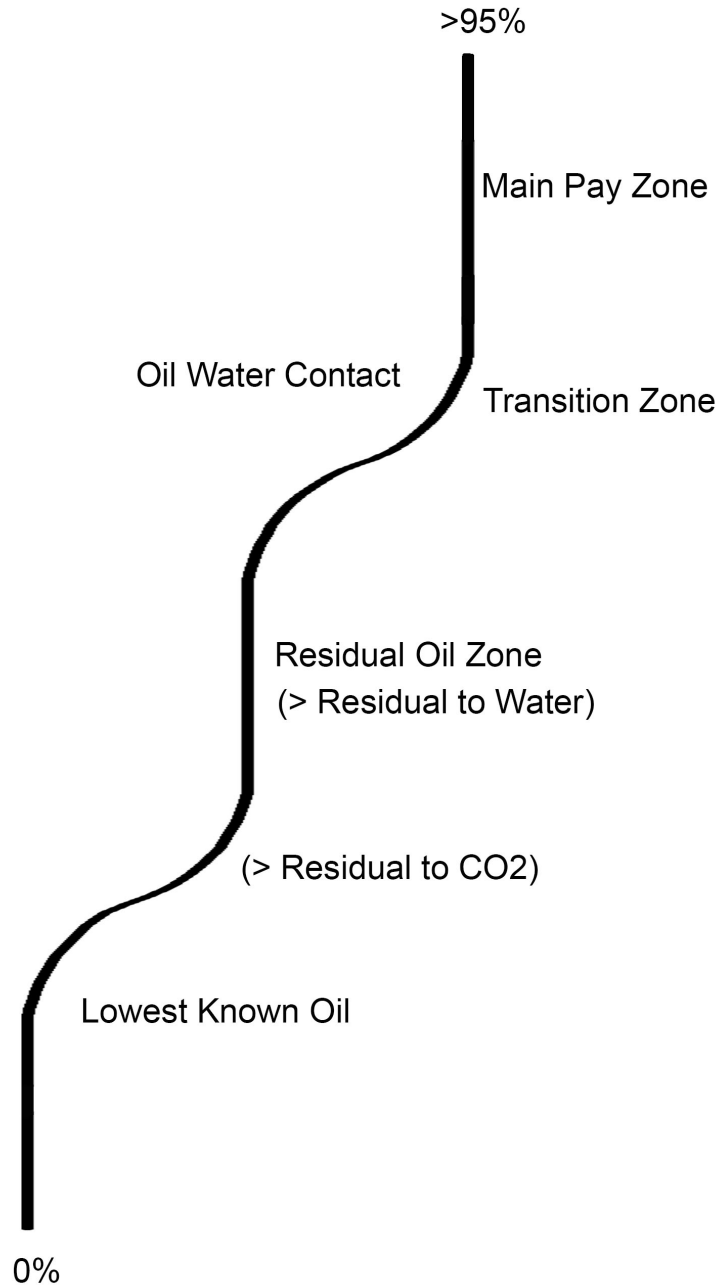
Main Pay Zone (MPZ)

Transition Zone (TZ)

Oil-Water-Contact (OWC)

Residual Oil Zone (ROZ)

Lowest Known Oil (LKO)



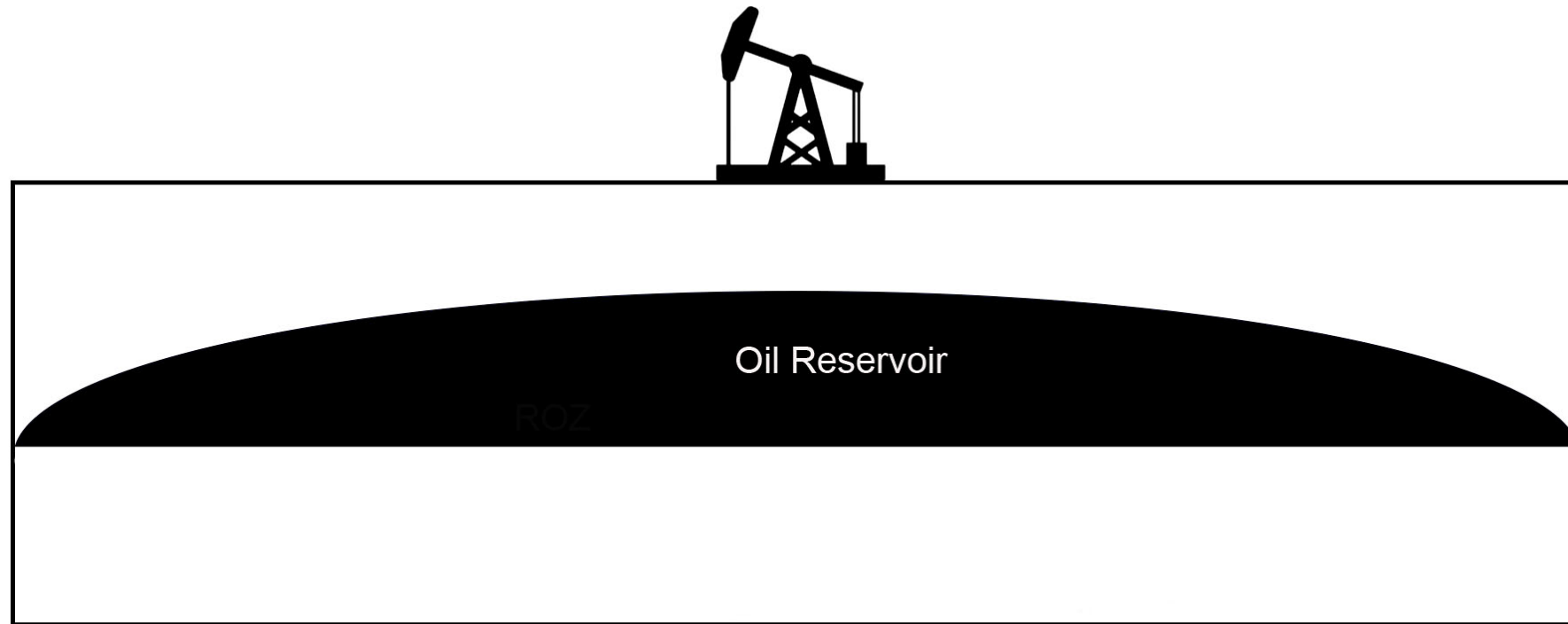
ROZ Types

There are 3 types of ROZ (*Melzer, S*):

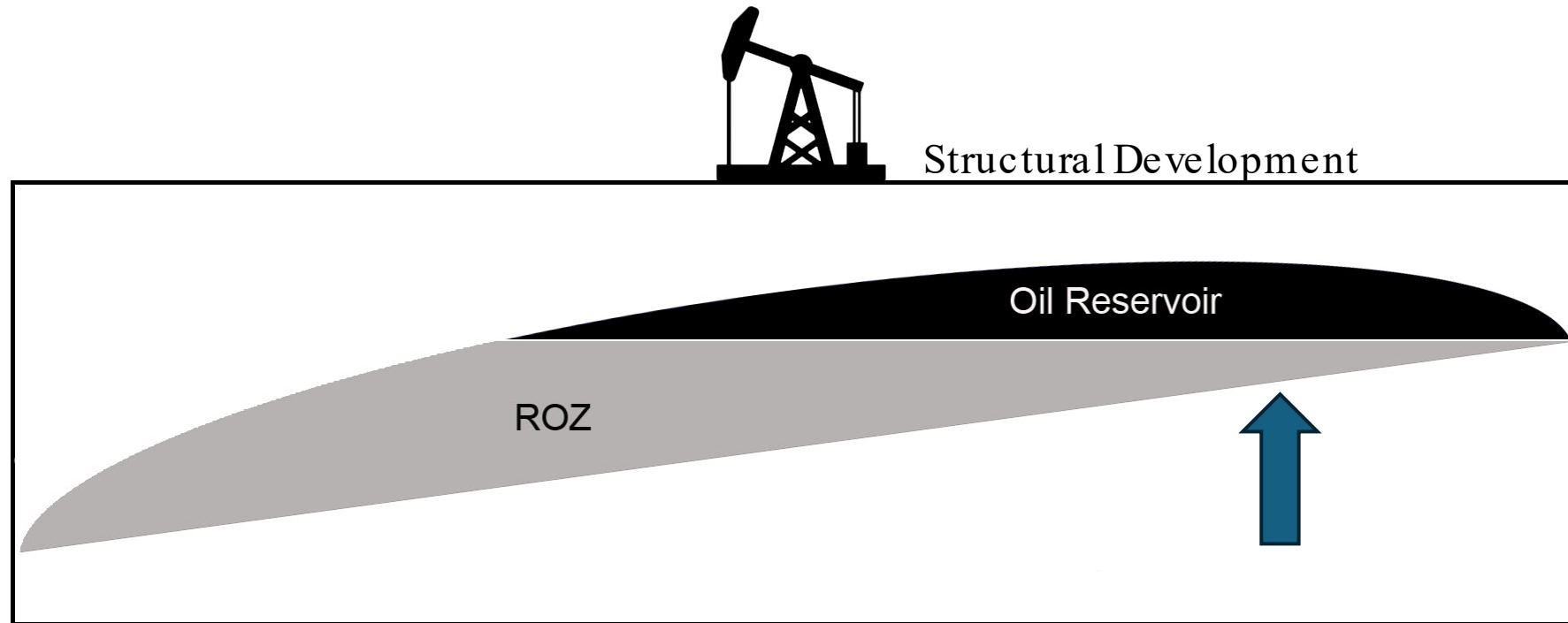
- Type I is the result of tectonics and the development of a titled Oil-Water-Contact
- Type II occurs where oil has migrated out of an existing trap
- Type III is the result of a natural water drive where oil is pushed down dip

Salt Creek is a Type II ROZ

Original Reservoir

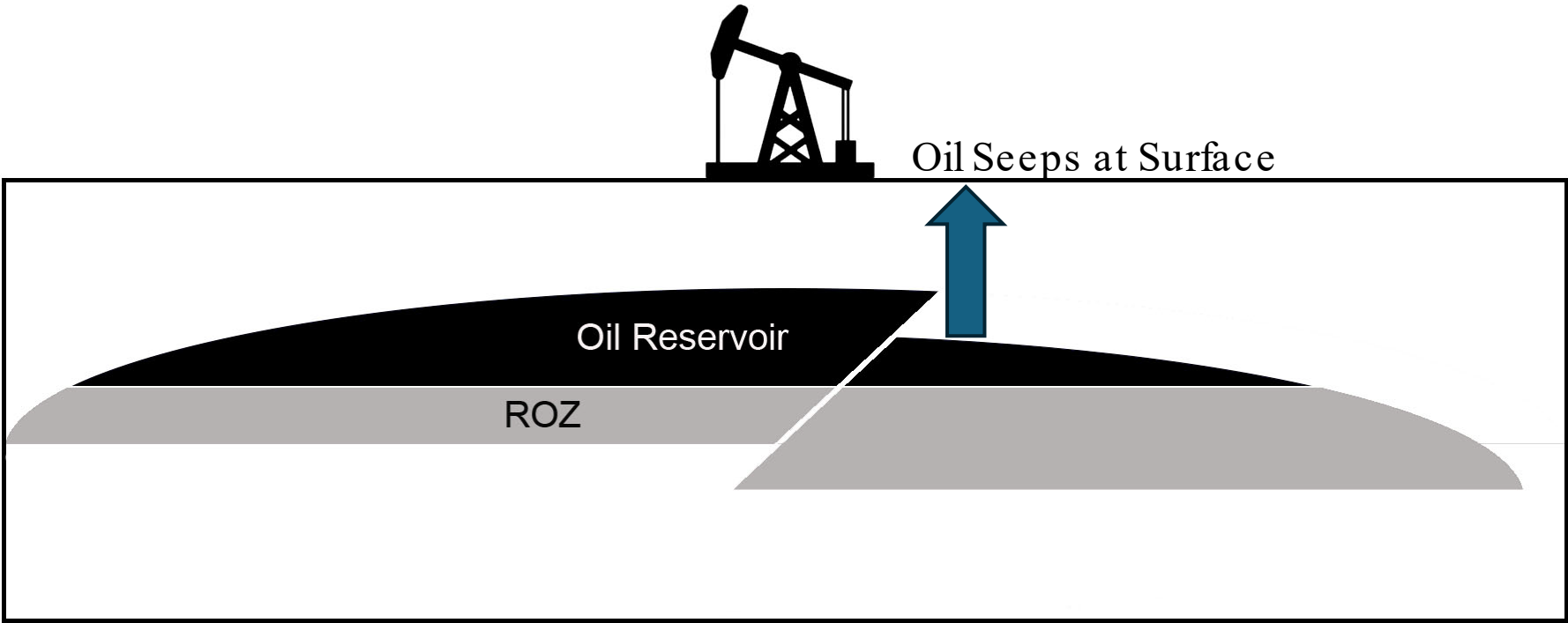


Type I ROZ

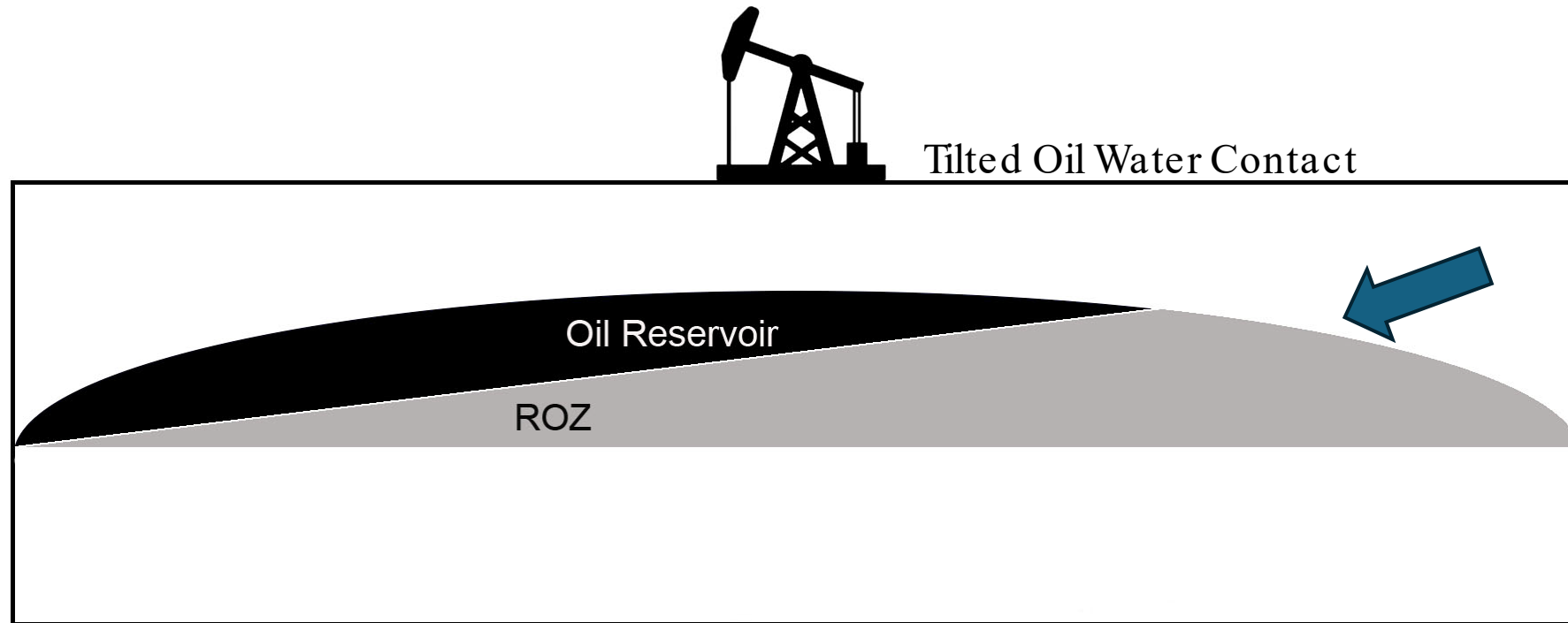




Type II ROZ



Type III ROZ



Project Award Funding

Department of Energy Award

\$2.84 million

Cost Share

\$1.64 million





Project Background

Project Award Date – June 2019

Project End Date – December 2025

Work on the project was initiated in 2019 with a two-year project timeline. Several events transpired resulting in delays to the project. These include a change in operator, impacts associated with the COVID pandemic, collapse in oil prices, delays in obtaining the necessary federal permits to drill and a delay in moving from Budget Period 1 to Budget Period 2.

These delays required several no-cost extensions for the project.



Project Timeline

2020

Project Kickoff

***Received data from site host/industry partner**

Started work on preliminary geologic model

2021

Developed simulation models to assess potential geo-lab locations

***Determined OOIP and Recovery Factors**

***Facies analysis was conducted for ROZ determination**

***Assessed methodologies for water saturation calculations**

Low oil prices and impacts from COVID caused delays

Submitted proposed locations and geo-lab design for review and approval

2022

Change in PI for project

***Change in site host/industry partner**

Granted 12 month no-cost extension

2023

Change in PI for project

Submitted permit application to drill in Q1

Received permit to drill at end of Q3

***Drilled well in Q4**

Granted 3 month no-cost extension

2024

Change in PI for project

Delay in moving from BP1 to BP2

Granted 12 month no-cost extension

Project Participants

Industry Partner – Contango Oil and Gas Company

Principal Investigator – Enhanced Oil Recovery Institute (EORI)

Subaward – Advanced Resources International (ARI)

Center For Economic Geology and Research (CEGR)

Contractor – Core Laboratories (Core Labs)



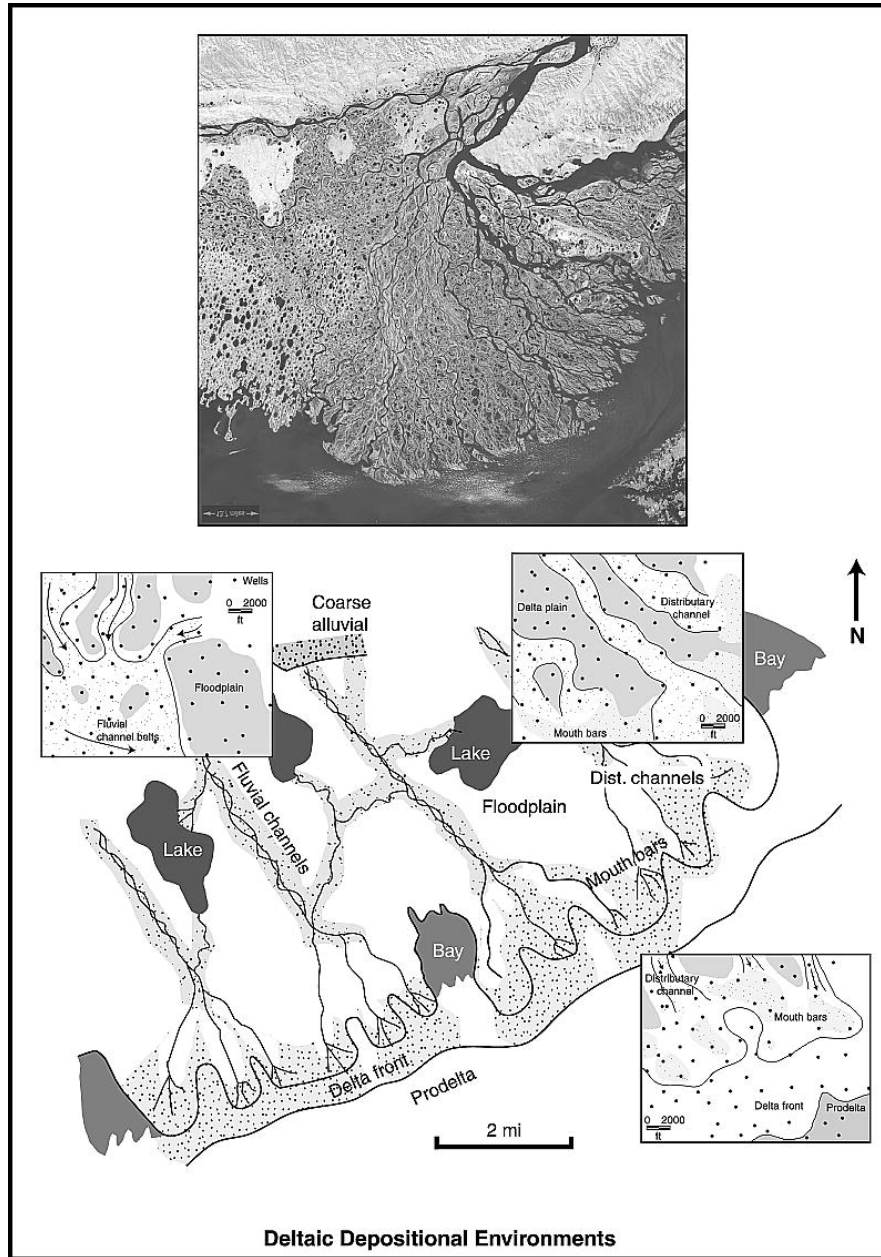


Project Location

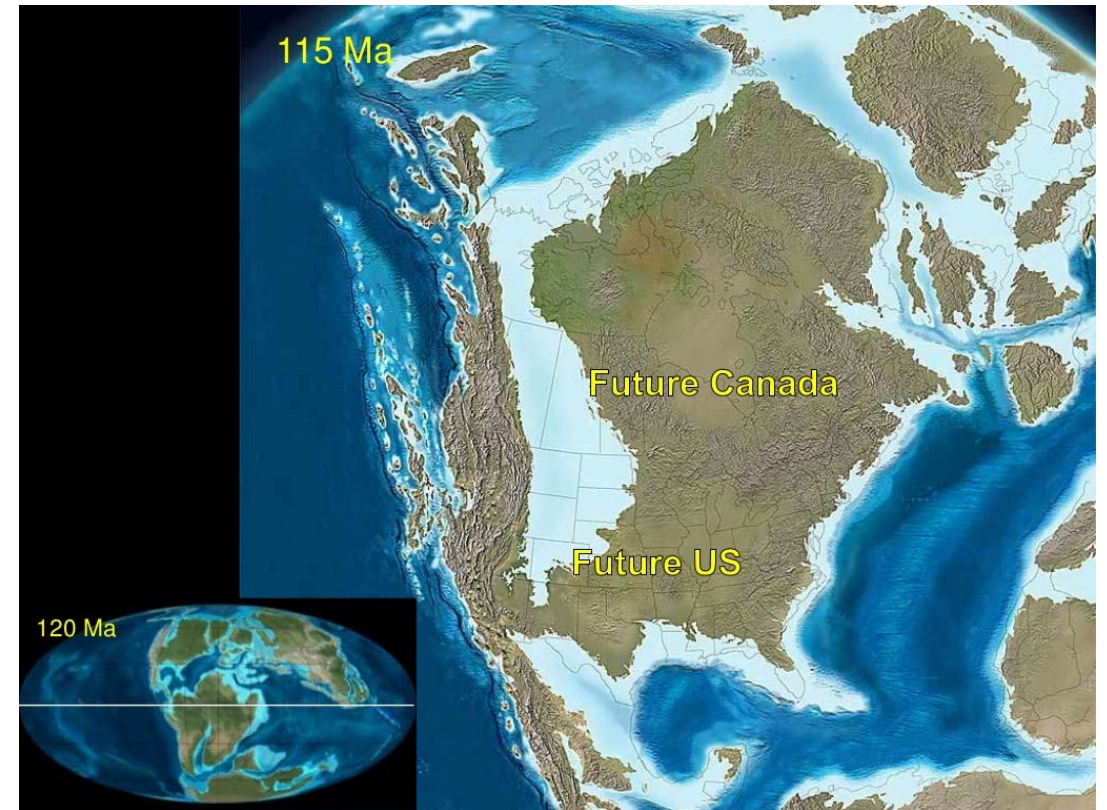
The Field Laboratory for this project is located within the Salt Creek oil field in the southwestern portion of the Powder River Basin.

The Salt Creek oil field is one the largest CO₂-EOR projects in the United States. Injection of CO₂ at the field began in 2003 and has since injected more than 150 million tons (MMCF) of CO₂ and has produced more than 40 million barrels (MMBBLs) of incremental oil attributed to CO₂-EOR.

The primary injection and production zones are the Wall Creek 1 and Wall Creek 2 sandstones within the Cretaceous Frontier Formation.

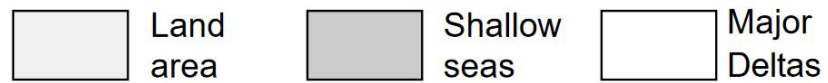
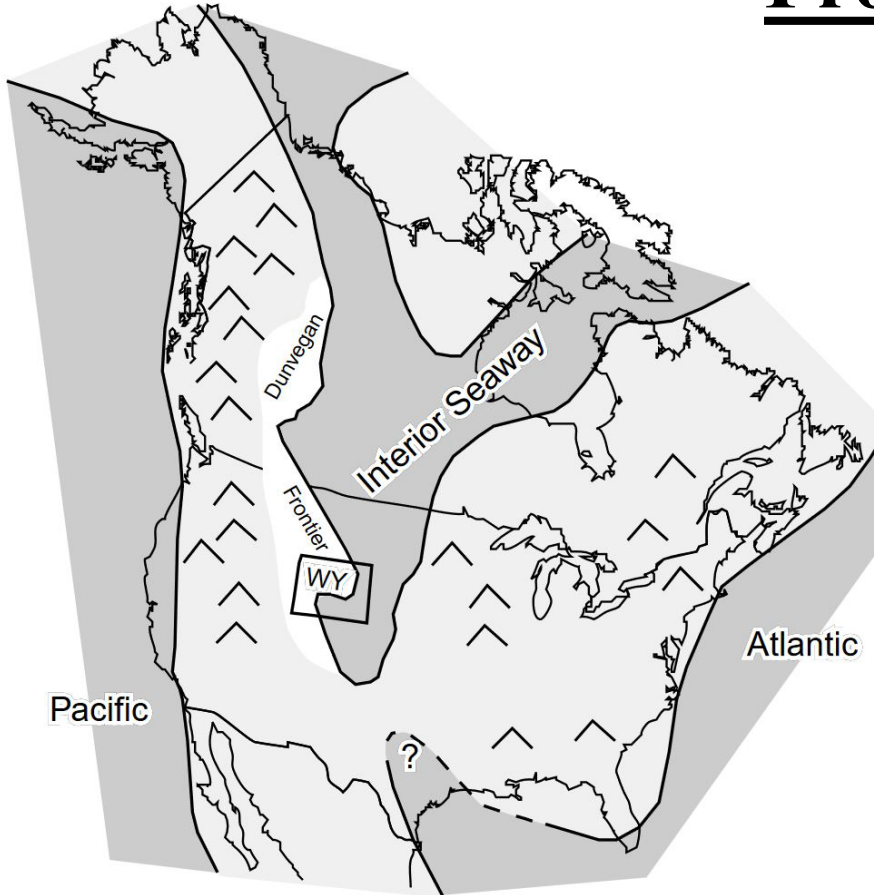


Frontier Delta Systems During the Cretaceous

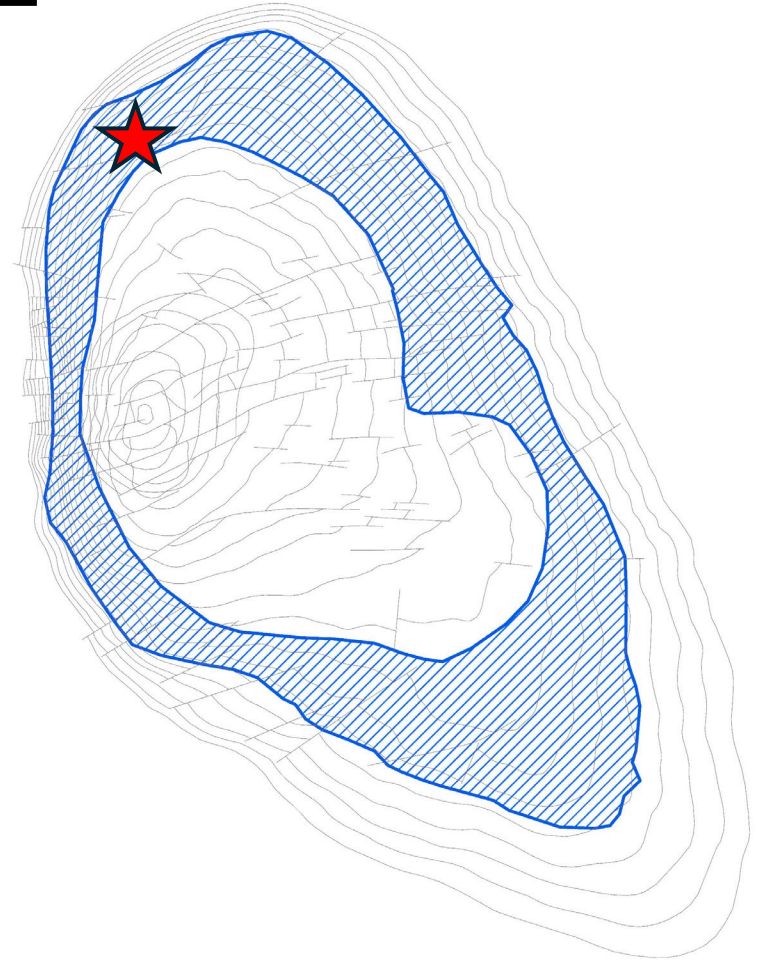
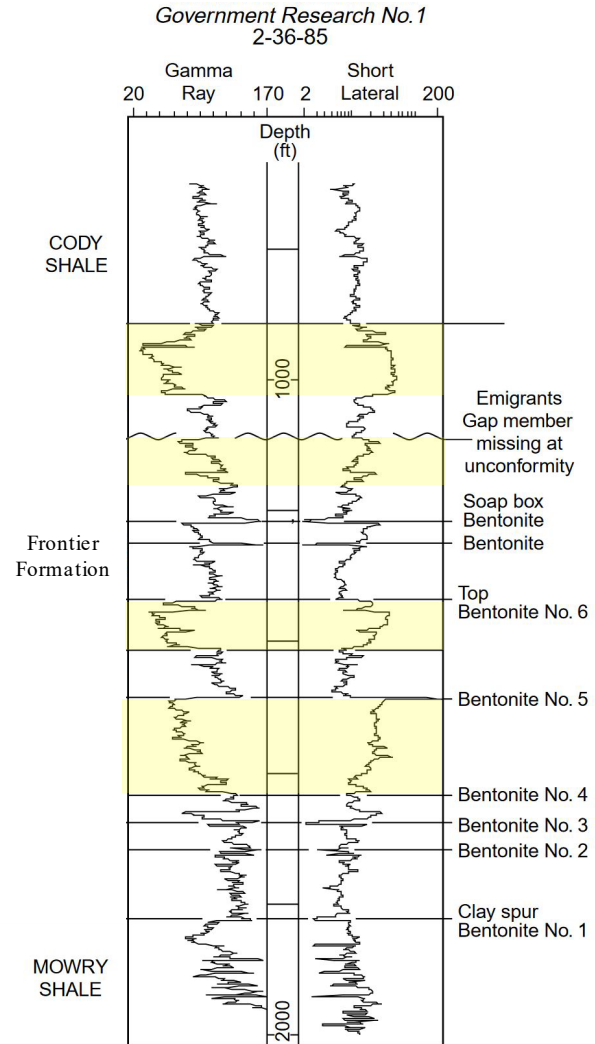


From Blakey, R.

Project Location Details



Bhattacharya, J. & Willis, B., 2001





Well Information

Spudded – October 2023

Completed – December 2023

Well Name – Lou 17RDWC2NW14

API – 4902524128

Location – TWS 40 N RNG 79 W Section 14

Target – Wall Creek Sandstones (Frontier Formation)

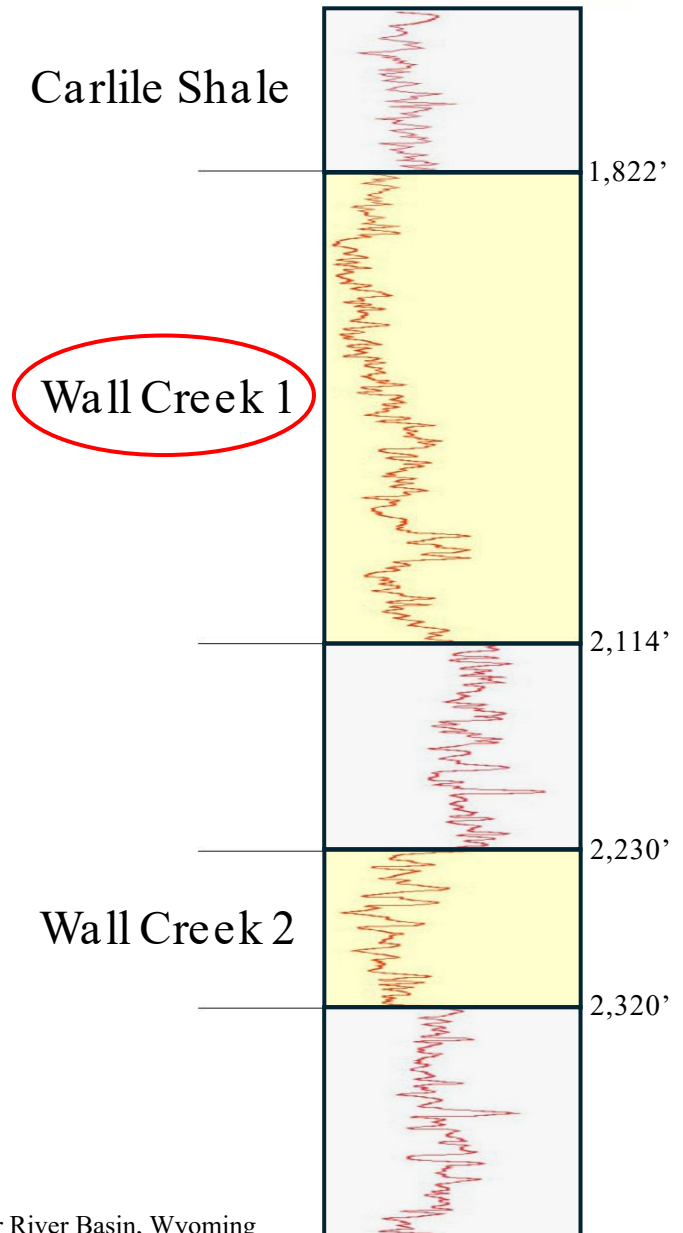
TD – 2,440'

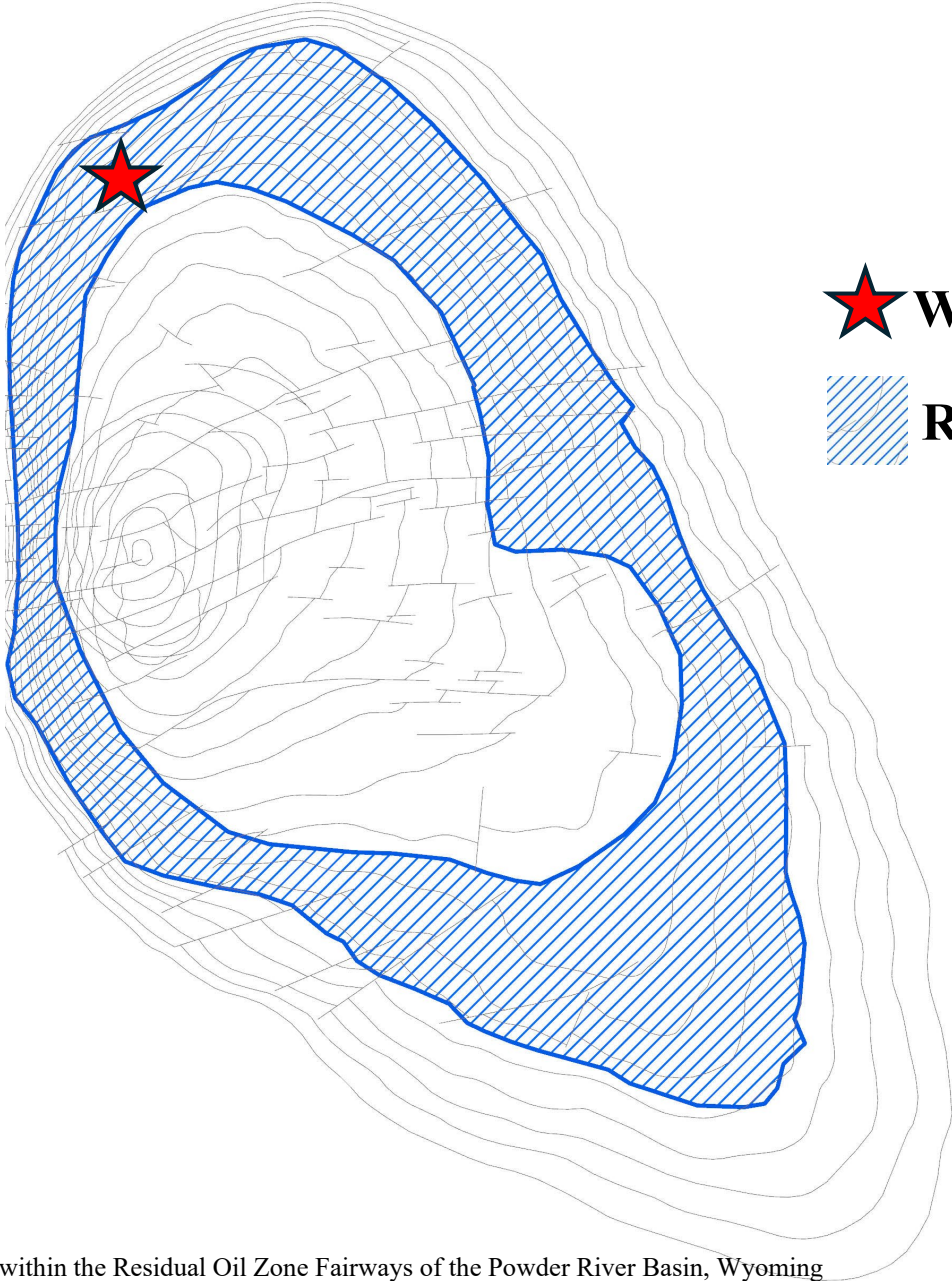
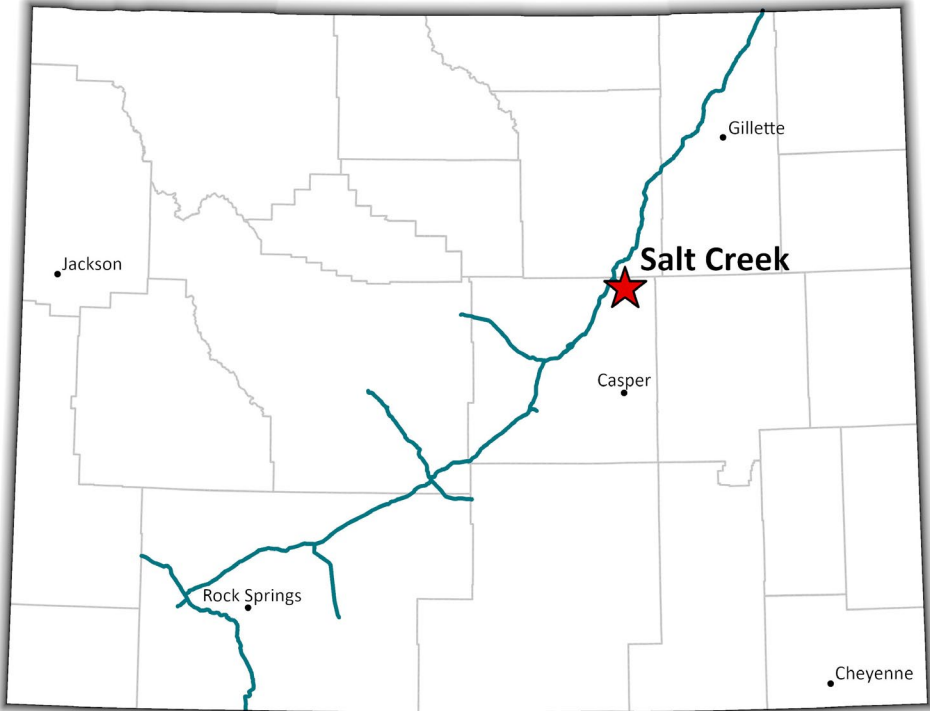
Core Collected – 160'

Confining Unit – Carlile Shale

Assessed EOR-ROZ Target – **Wall Creek 1**

BHT – 112 F





★ Well Location

▨ ROZ Area





Preliminary Storage and Recovery Estimation

Wall Creek 1 ROZ Reservoir Properties

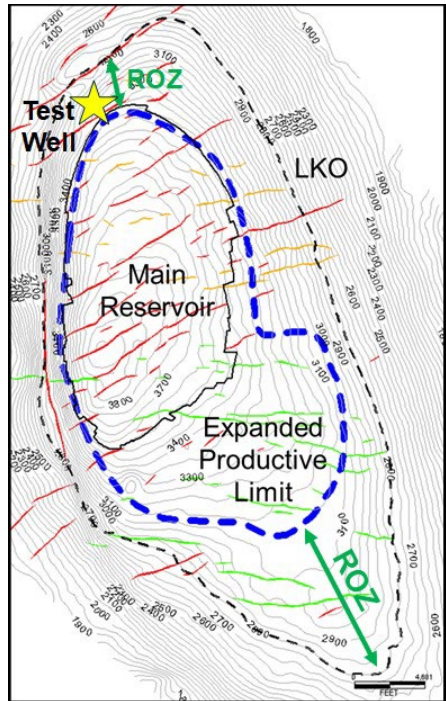
~300' thick

ROZ Area ~ 7,500 acres

10 to 15% Porosity

15 to 25% Oil Saturation

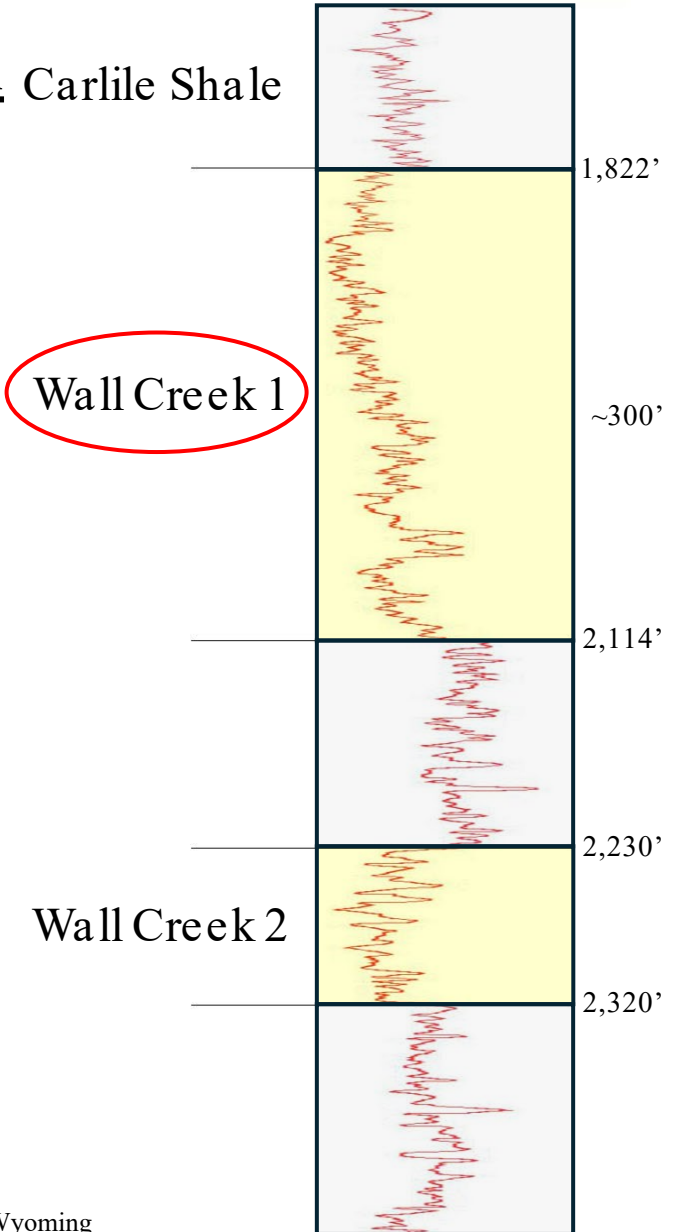
Recovery Factor 15%



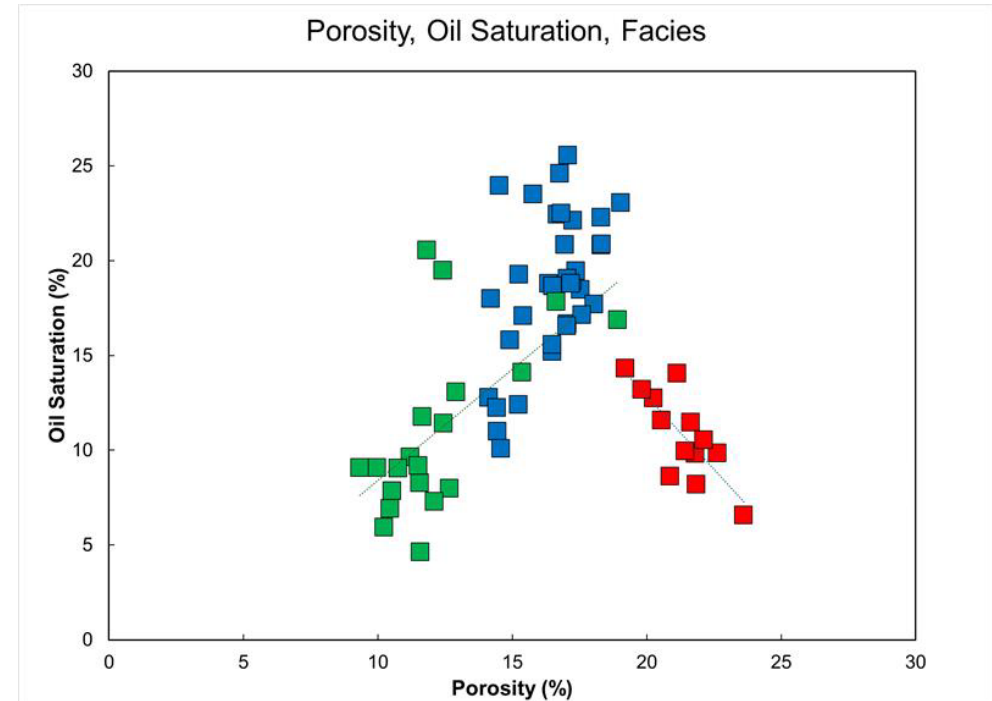
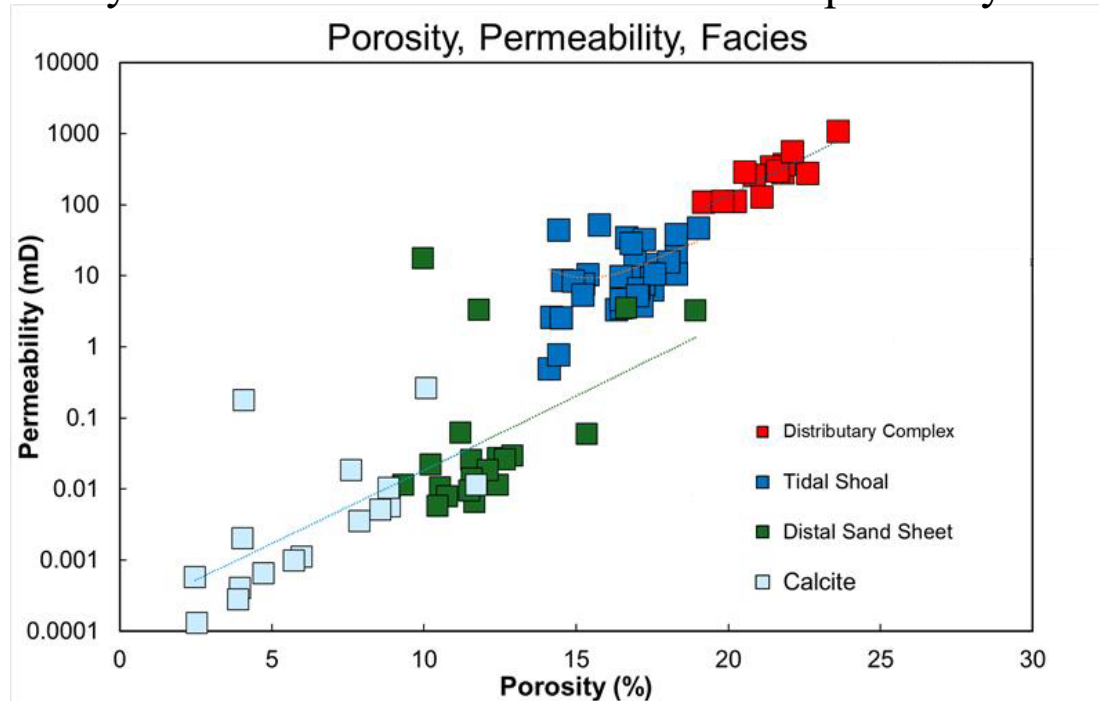
Using a Volumetric Estimation
 $N = 7758 * \text{Acres} * \text{height} * \text{porosity} * (1 - \text{Water Saturation})$
 436,387,500 barrels of oil (bo) in place

Assuming a 15% Recovery Factor in an ROZ
 ~65.5 MMbo Recoverable

Assuming 1 tonne of CO₂ per barrel of oil
 ~65.5 MMtonnes CO₂ Stored



Analytical Results from CoreLabs as Interpreted by ARI



Facies Name	Porosity (%)			Permeability (mD)			So (%)		
	Low	High	Mean	Low	High	Mean	Low	High	Mean
Distributary Complex	19	24	21	107.6	1056.3	318.7	6.6	14.3	10.8
Tidal Shoal/Estuarine	14	19	16	0.49	51.65	14.14	10.1	25.6	18.6
Distal Sand Sheet/Transitional Marine	9	19	12	0.01	17.7	1.4	4.6	20.6	11.0
Calcite	2	12	6	0.0001	0.26	0.03	3.6	36.9	19.6



Estimation Based on Core

Wall Creek 1 Facies

Distributary Complex – OIP 15 to 43 MMbo

Average Porosity ~ 21%

Average Oil Saturation \geq 10.8%

Tidal Shoal/Estuary – OIP 6 to 20 MMbo

Average Porosity ~ 16%

Average Oil Saturation \geq 18.6%

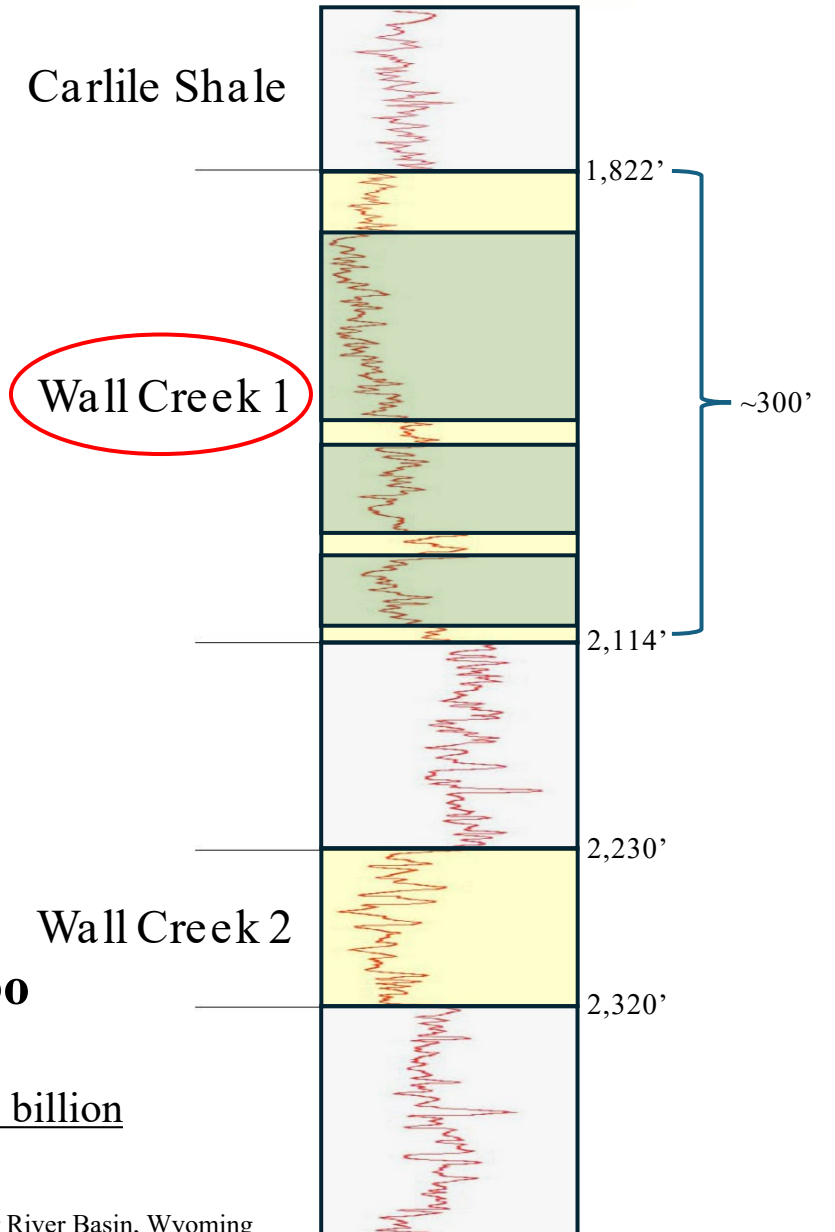
Distal Sand Sheet – OIP 2 to 18 MMbo

Average Porosity ~ 12%

Average Oil Saturation \geq 11%

****Cumulative ROZ OIP is likely between 24 and 81 MMbo**

Assuming \$75 per barrel oil – Revenue is estimated to be between \$2 and \$6 billion





Analysis & Modeling

Log Analysis

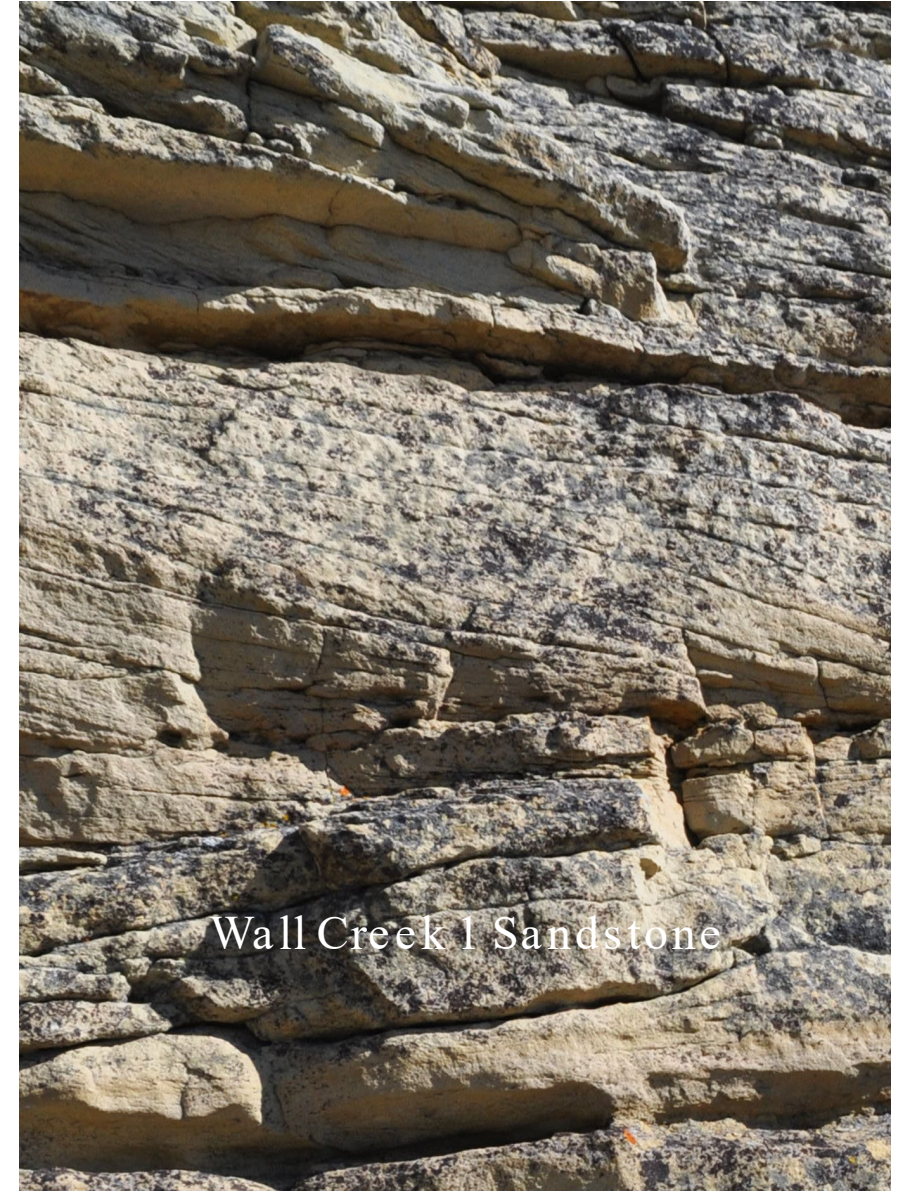
- Lithology
- Facies Determination
- Fluid Saturation

Core Analysis

- CT Imaging
- Total and Spectral Gamma
- Routine Core Analysis
- Unconventional Core Analysis (Shale evaluation)

Modeling

- Lithology
- Fluid Saturation
- OOIP



Project Milestones During Budget Period 1

During Budget Period 1 key tasks that were completed include the installation and operation of a geo-laboratory within the ROZ in the Salt Creek oil field.

Available geologic and reservoir data from the site host was collected. This included all information necessary to prepare an initial geologic and reservoir flow model.

Information from numerous wells within the project area, peripheral reservoir performance data (production/injection) and core were used to calibrate the model. The model was used to determine an appropriate site location for the ROZ geo-laboratory and test well.

Whole core and log suites collected from the test well were then incorporated into a numerical simulation model. This information on test site selection, establishing the geo-laboratory and characterizing the ROZ resources was provided in a comprehensive Project Report at the end of BP1.



Project Scope During Budget Period 2

In Budget Period 2, processed and analyzed geologic data and flow performance from the test well will be integrated to update the numerical model. This update includes detailed core studies to understand the capillarity, porosity, permeability and oil saturation profiles of the reservoir.

Budget Period 2 also includes CO₂ core flooding which will provide insights into relative permeability and the ability to reduce immobile oil saturation. ROZ development scenarios will be developed and executed (numerically) to optimize storage efficiency and oil recovery.

These results will be incorporated into a lifecycle analysis, partnered with a techno-economic assessment, to demonstrate the viability and the net present value (NPV) of a CO₂ flood in the Salt Creek ROZ. The results could then be used to estimate additional ROZ potential in Wyoming's Powder River Basin.



Wall Creek 1 Core

Project Summary



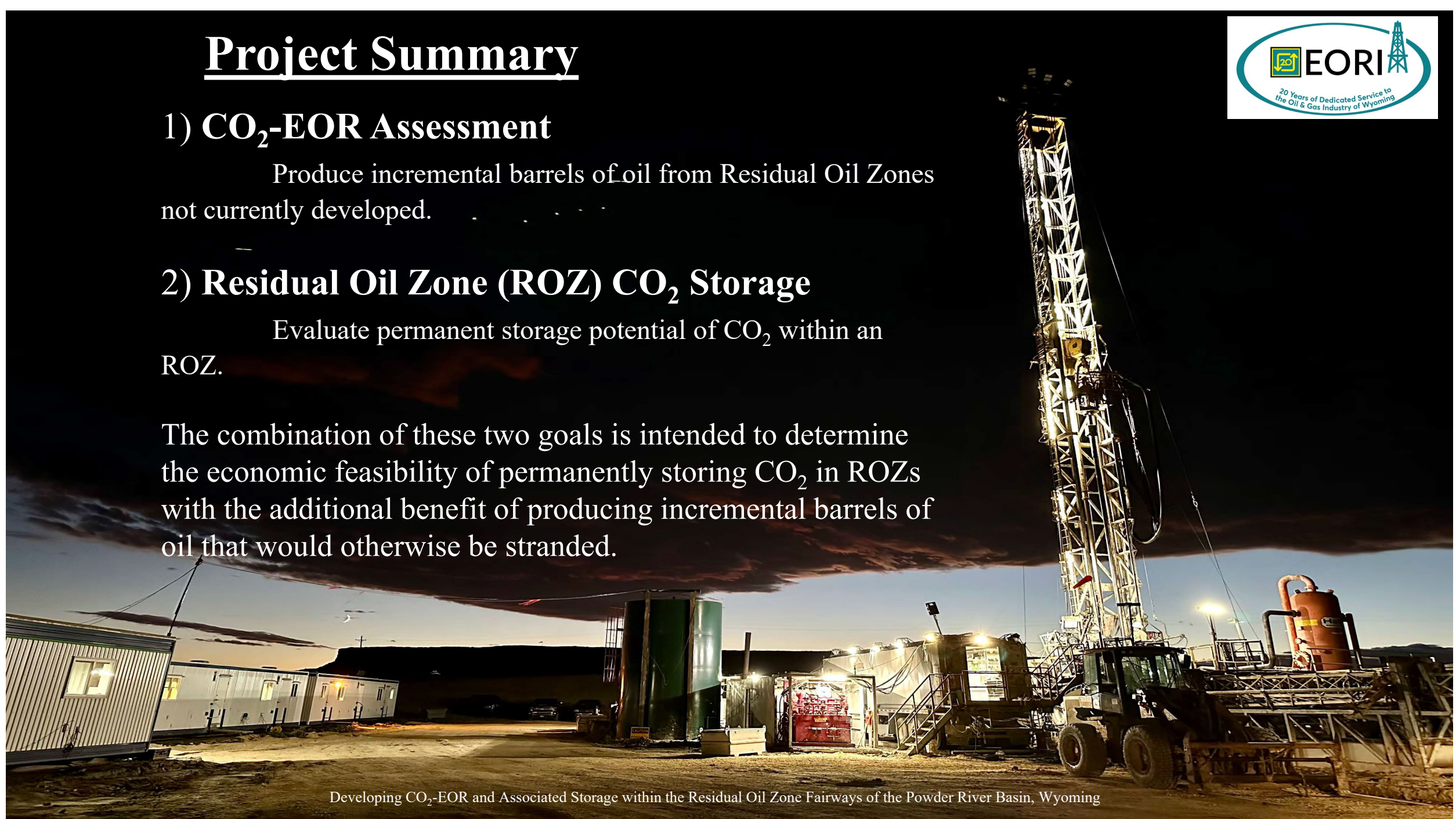
1) CO₂-EOR Assessment

Produce incremental barrels of oil from Residual Oil Zones not currently developed.

2) Residual Oil Zone (ROZ) CO₂ Storage

Evaluate permanent storage potential of CO₂ within an ROZ.

The combination of these two goals is intended to determine the economic feasibility of permanently storing CO₂ in ROZs with the additional benefit of producing incremental barrels of oil that would otherwise be stranded.



Questions



Thank You

Nick Jones – PG

Enhanced Oil Recovery Institute

njones@uwyo.edu