Bell Creek CO_2 EOR Case History

Presented by Julie Deese

20th Annual CO_2 Flooding Conference

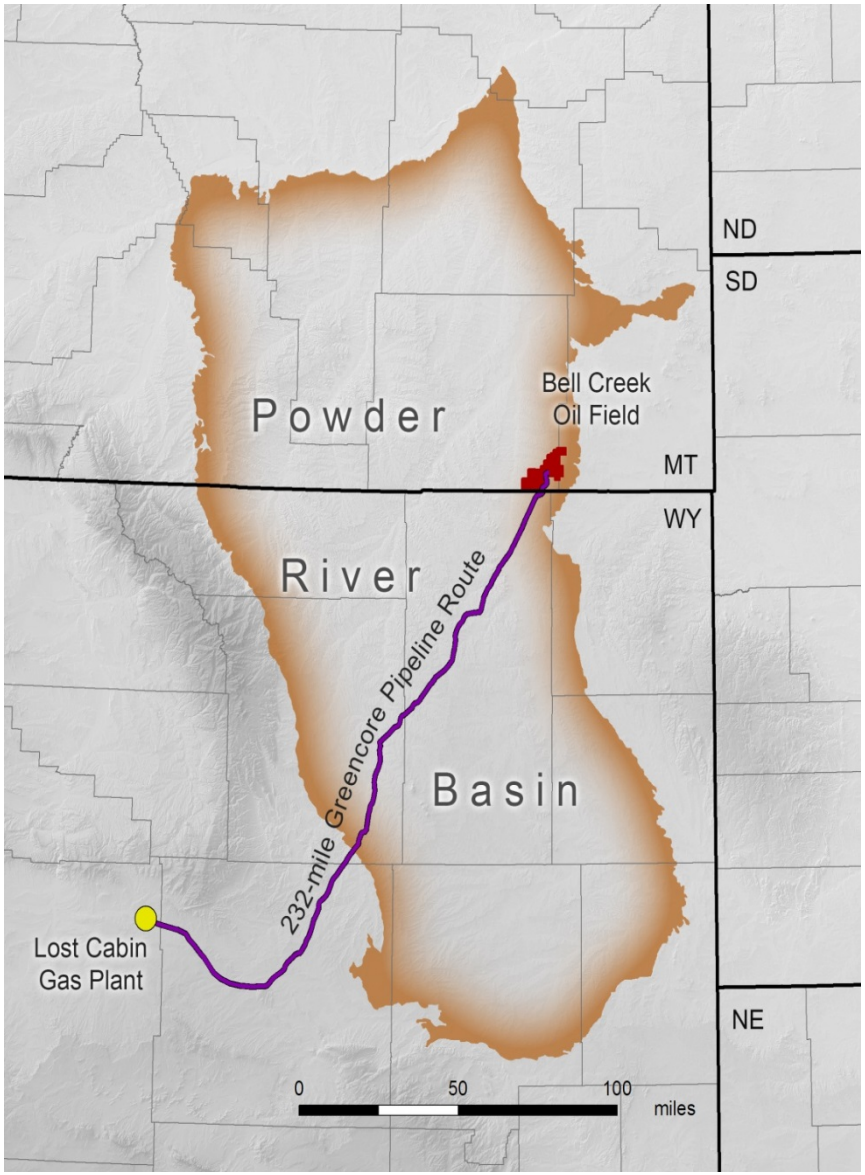
December 11-12, 2014

Midland, Texas

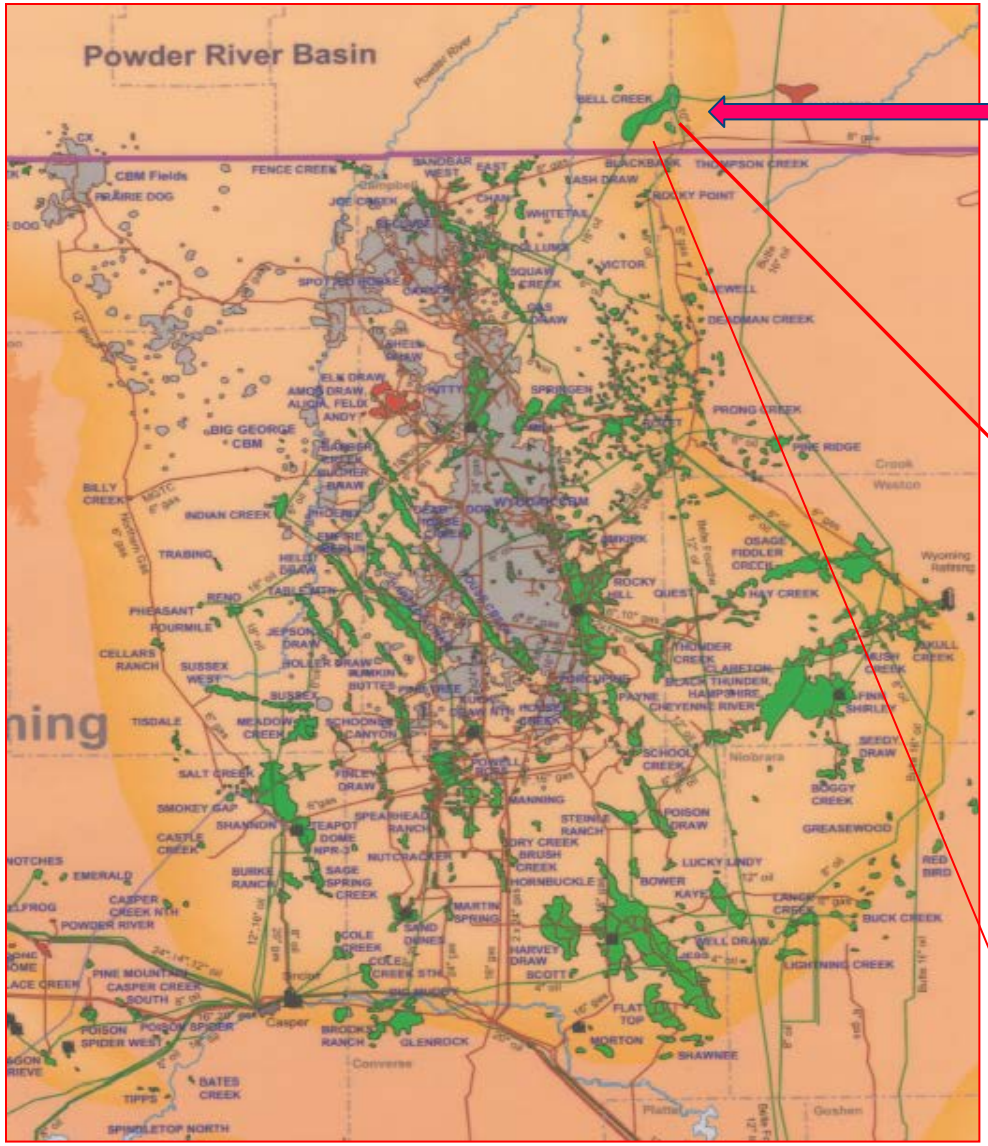
Outline

- Bell Creek History
- Development Plan
- CO_2 Supply
- Operations Summary
- Surveillance Program
- Challenges
- Milestones

Bell Creek Field – U.S. Location



Bell Creek Field – U.S. Location



Bell Creek Field

Location:

- Southeast corner of Montana
- Northern Powder River Basin
- 84 miles NE of Gillette, Wyoming

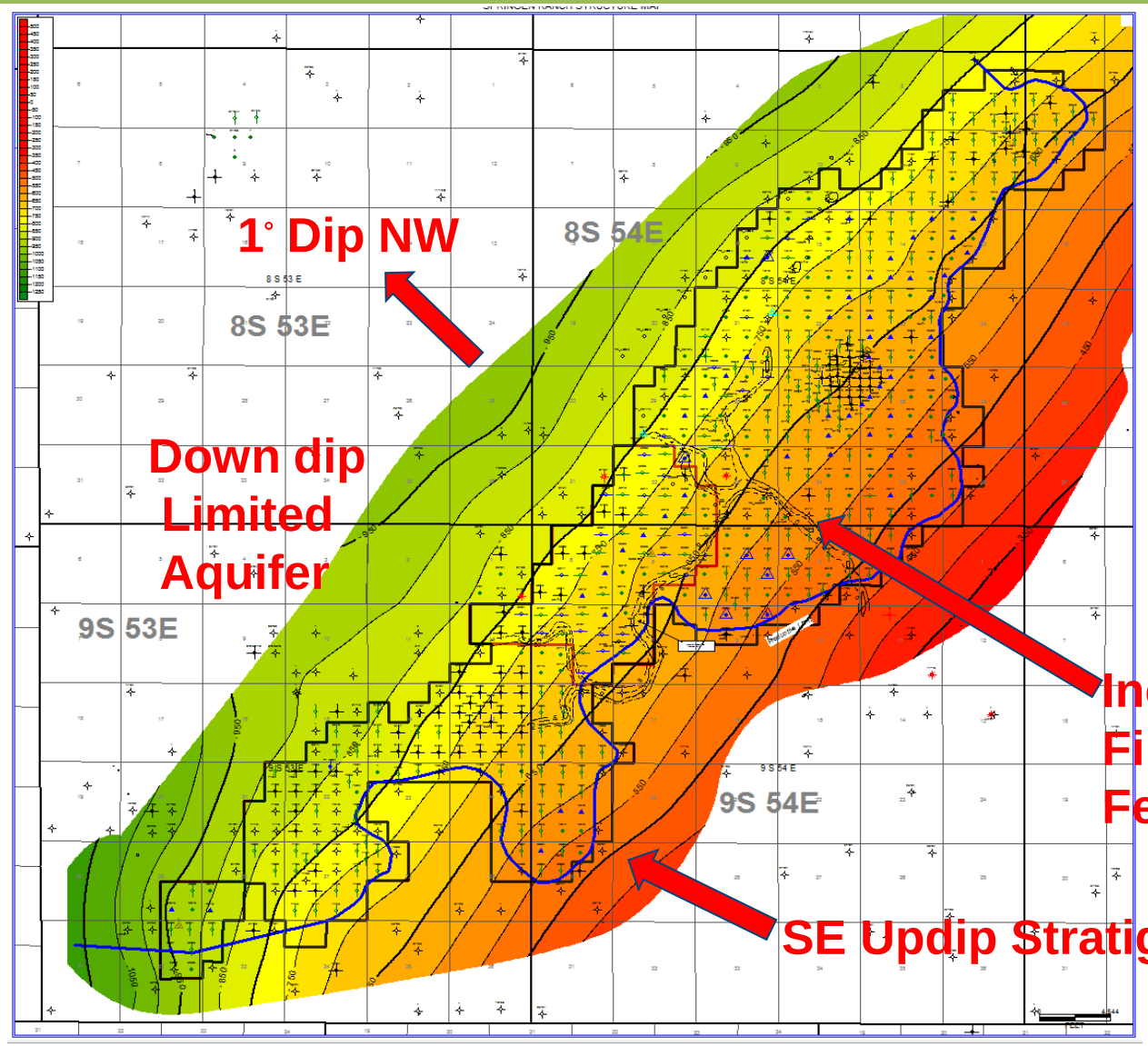
Bell Creek Field History

- Discovered in 1967 and Covers 21,771 Acres (15 x 3.5 miles)
- Field was developed in 2 years (450 wells)
- 7 Waterflood Units formed in 1970 (Pressure depletion)
- Est. OOIP = 340 MMBO (Cum Prod: 133MMbo, 39% Recovery)

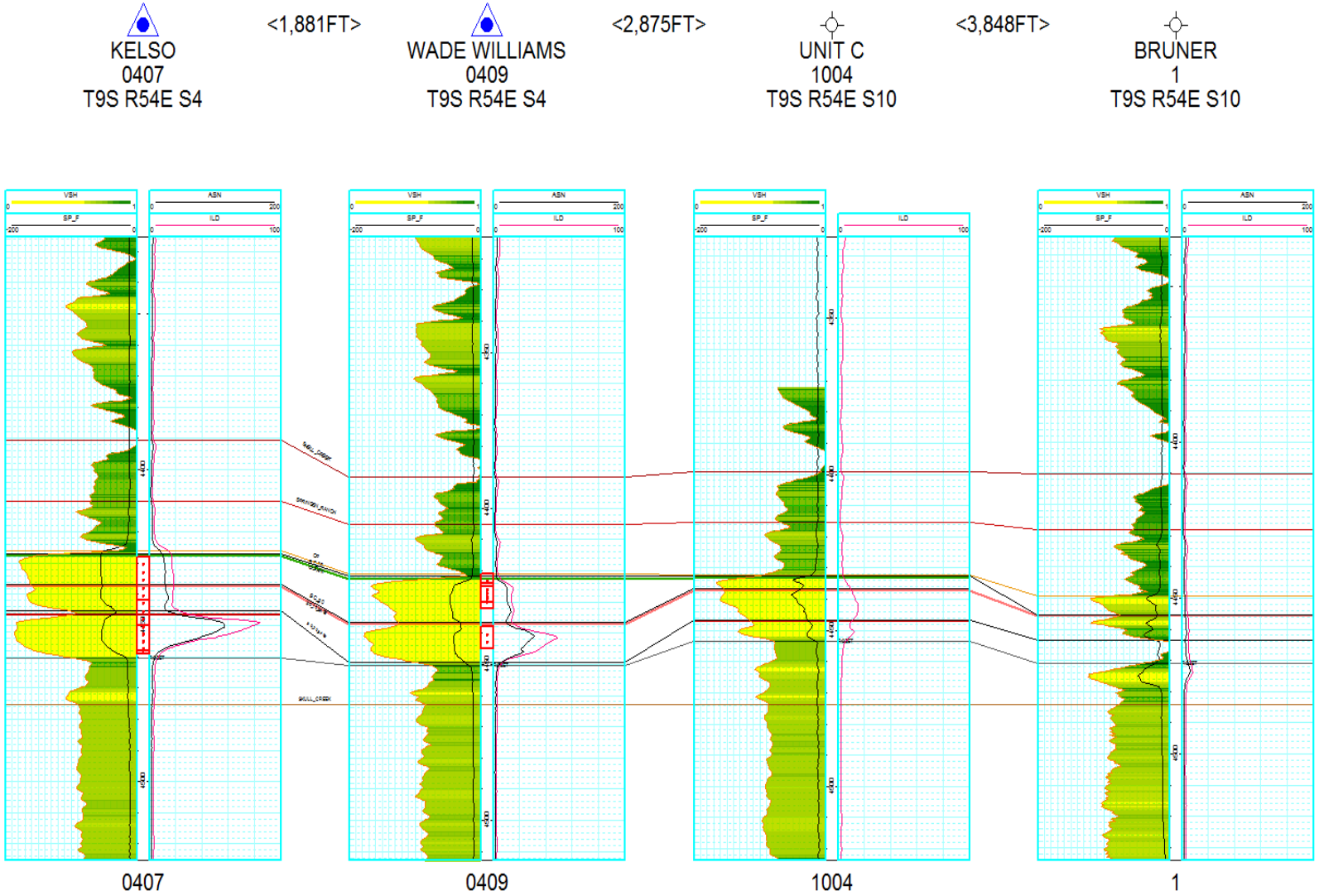
Muddy Formation

- **Muddy Sandstone**
  - Depth: 4300-4500 feet
  - Gross Thickness: 30-45 feet
  - Permeability: 425 -1,175 md
  - Effective Porosity: 17-35%
  - Dip: 1º NW
  - Aquifer: small - none

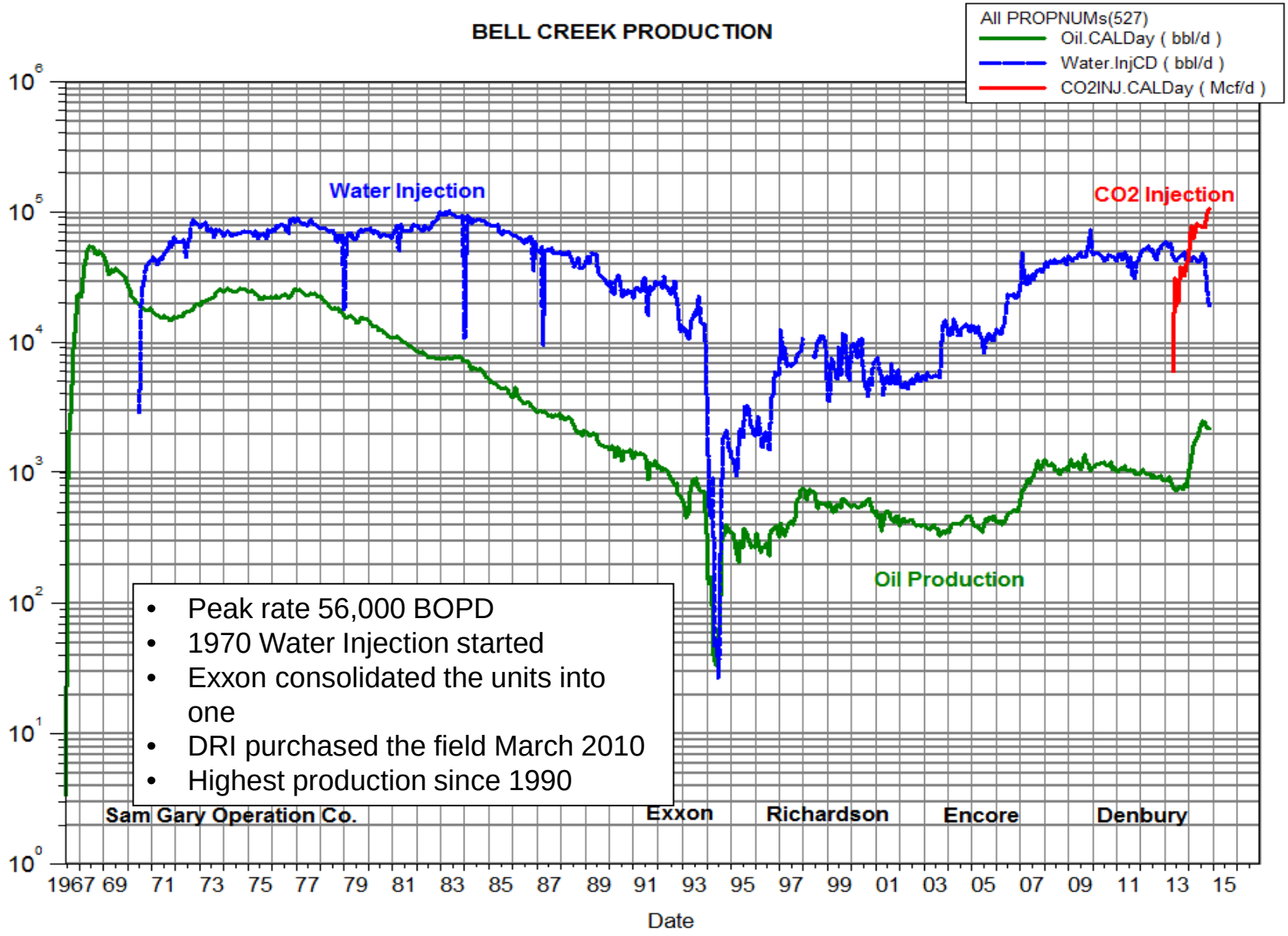
Bell Creek Muddy Structure Map



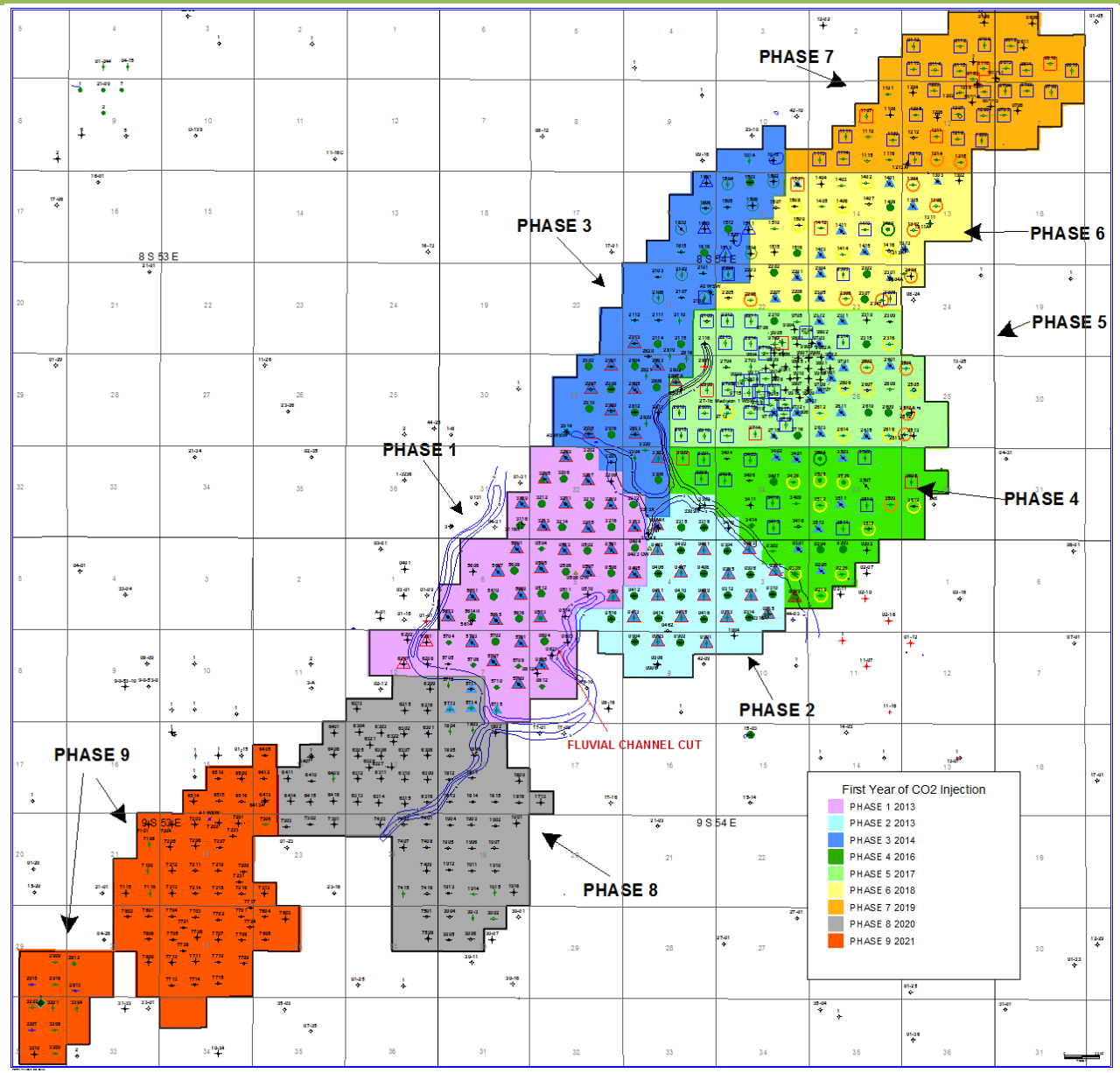
Up Dip Stratigraphic Trap



Historical & Denbury Production



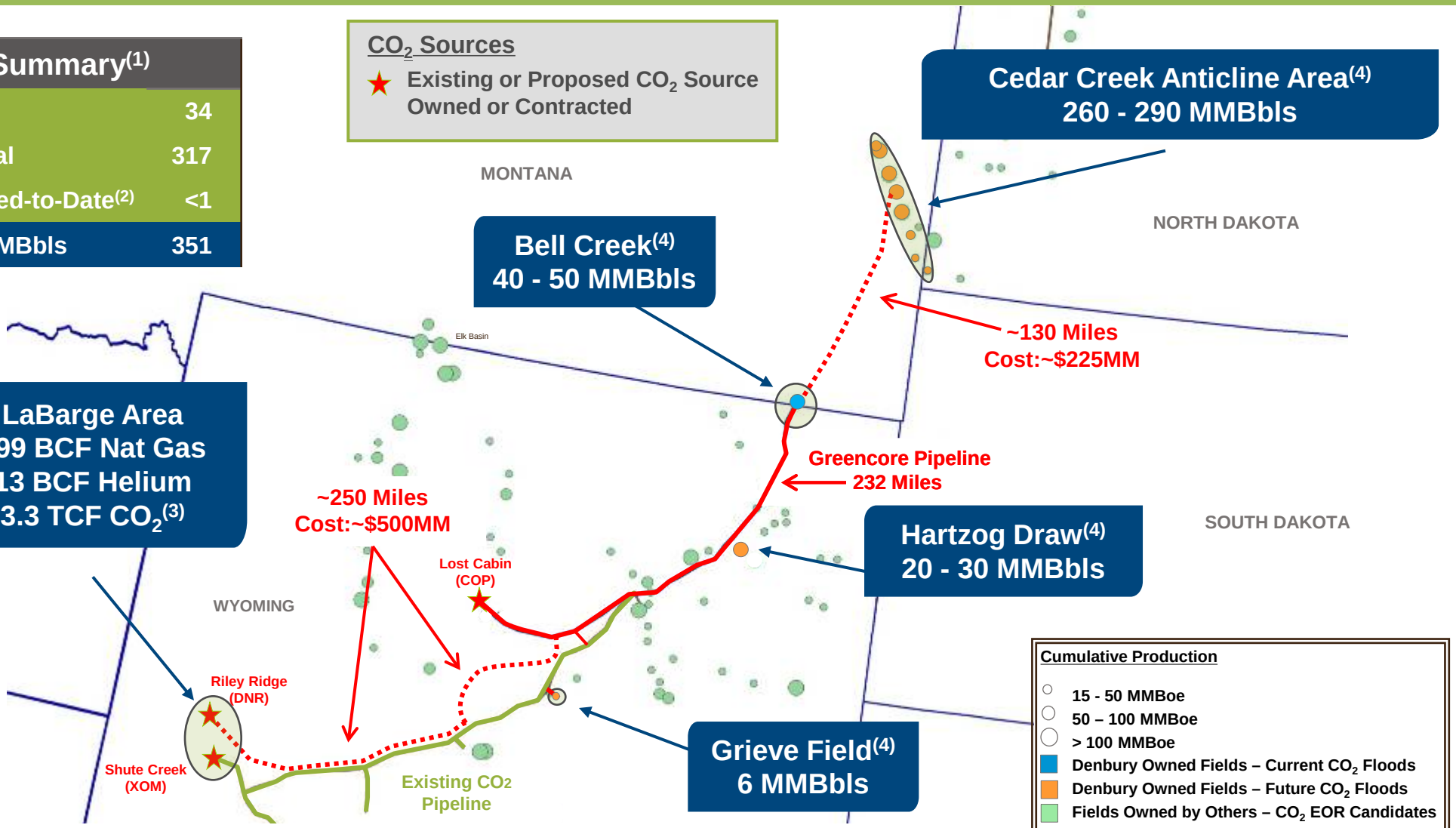
Bell Creek CO_2 Phase Development Map



CO_2 EOR in Rocky Mountain Region:

Control of CO_2 Sources & Pipeline Infrastructure Provides a Strategic Advantage

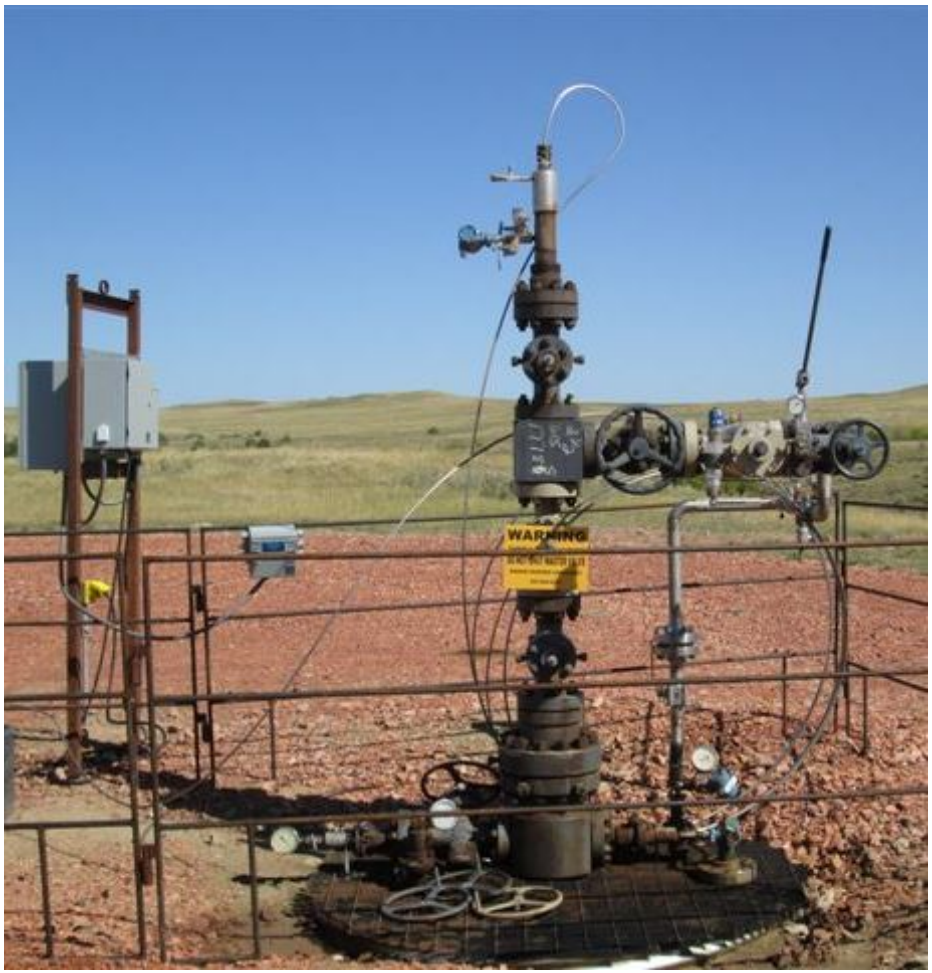
Summary[1]	
Proved	34
Potential	317
Produced-to-Date[2]	<1
Total MMBbls	351



(1) Proved tertiary oil reserves based on year-end 12/31/13 SEC proved reserves. Potential includes probable and possible tertiary reserves estimated by the Company as of 12/31/13, using approximate mid-points of ranges, based on a variety of recovery factors.
(2) Produced-to-date is cumulative tertiary production through 12/31/13.
(3) Reported on a gross working interest or 8/8^{ths} basis, except for overriding royalty interest in LaBarge Field.
(4) Field reserves shown are estimated total potential tertiary reserves, including cumulative tertiary production through 12/31/13.

Wellhead Configuration / Monitoring

- Producer with Capillary String



- Injector (CO_2 or Water)

Test Site Production Manifold

Test Site Injection Manifold

EOR Facility

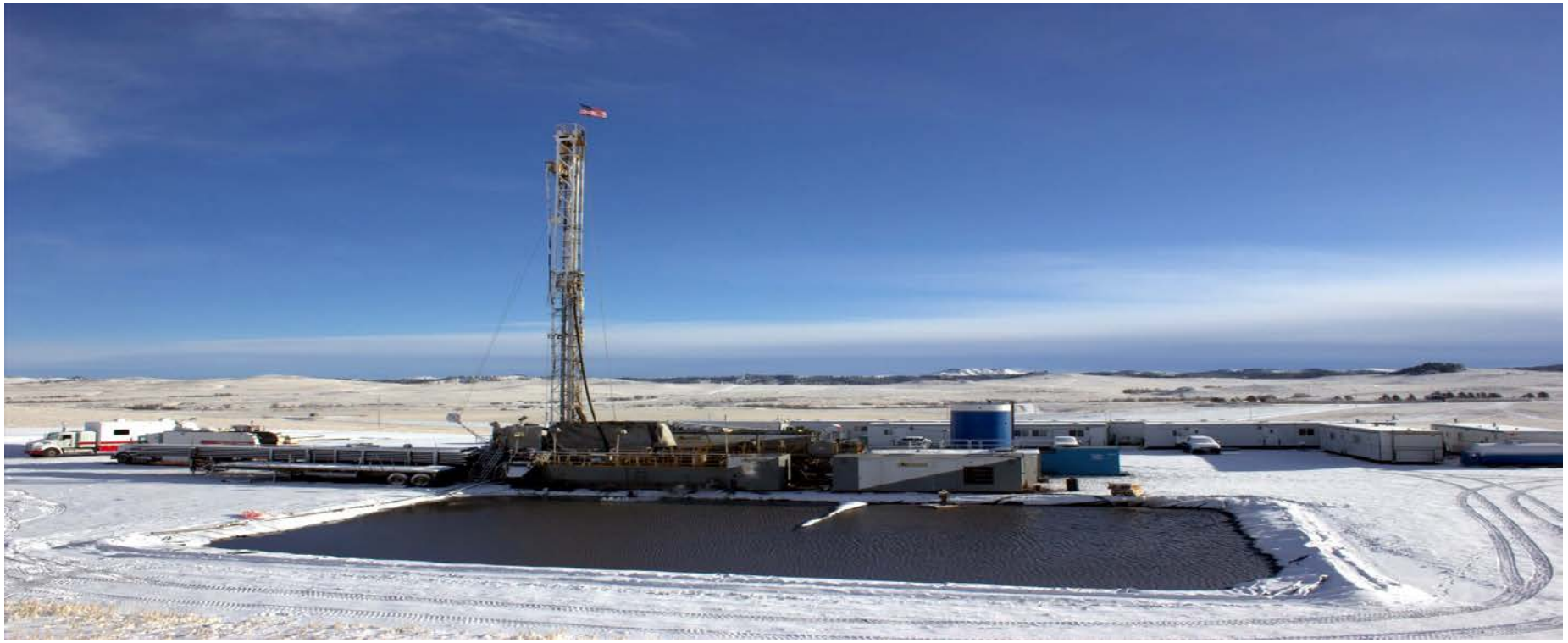
Manifold Building: High & Low Pressure Piping & Water, CO_2 Purchase and Recycle Distribution

Compressor Building

Surveillance

- Quarterly BHP Surveys
  - ~10-15 throughout the field
    - ΔP between Phases & with time
- Injection Profiles
  - Baseline on all Phases prior to CO_2
  - Repeated if necessary
- BCU 05-06OW (EERC)
- Repeat PNL (EERC)
- Permanent VSP (EERC)
  - Continuous recording by EERC
- 4D Seismic

BCU 05-06OW: Drilled & Completed (EERC) – January 2012



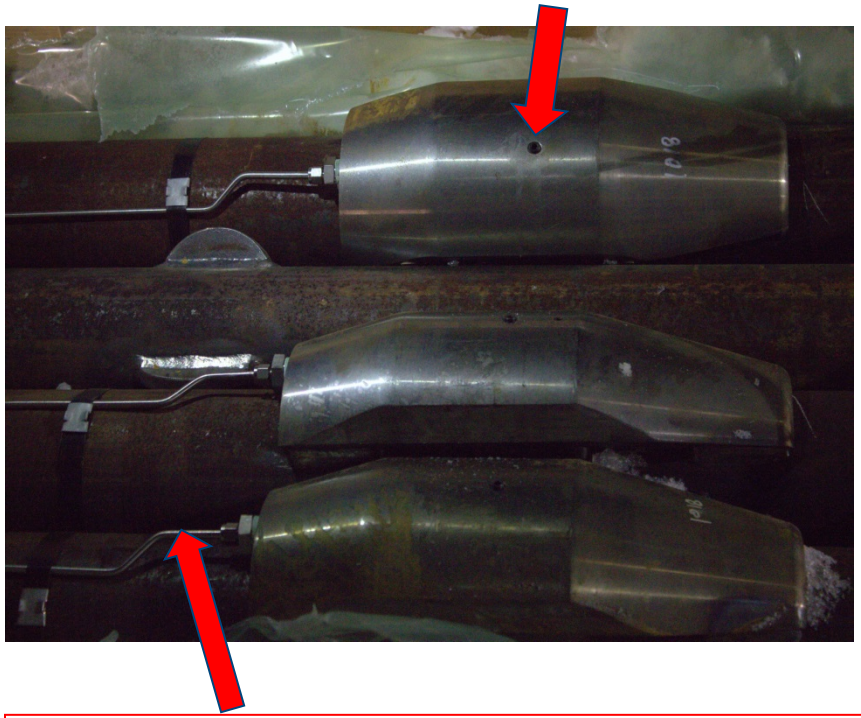
- Installed Permanent Downhole Monitoring System
  - Pressure/Temperature Gauges
    - Placed approximately 20 feet apart in the Muddy (2 gauges)
  - Perforating Charges
    - Set off by hydraulic pressure thru a ¼" line filled with hydraulic fluid
  - DTS (Distributed Temperature System)
    - Fiber optic cable clamped along the outside of the production casing

BCU 05-06OW

- Pressure

- Pressure Pad

Port that sits against the wellbore



Capillary string that connects to gauges

BCU 05-06OW

- Fiber Optic

Records temperature at 4-hr intervals every 3.3 ft from TD to surface

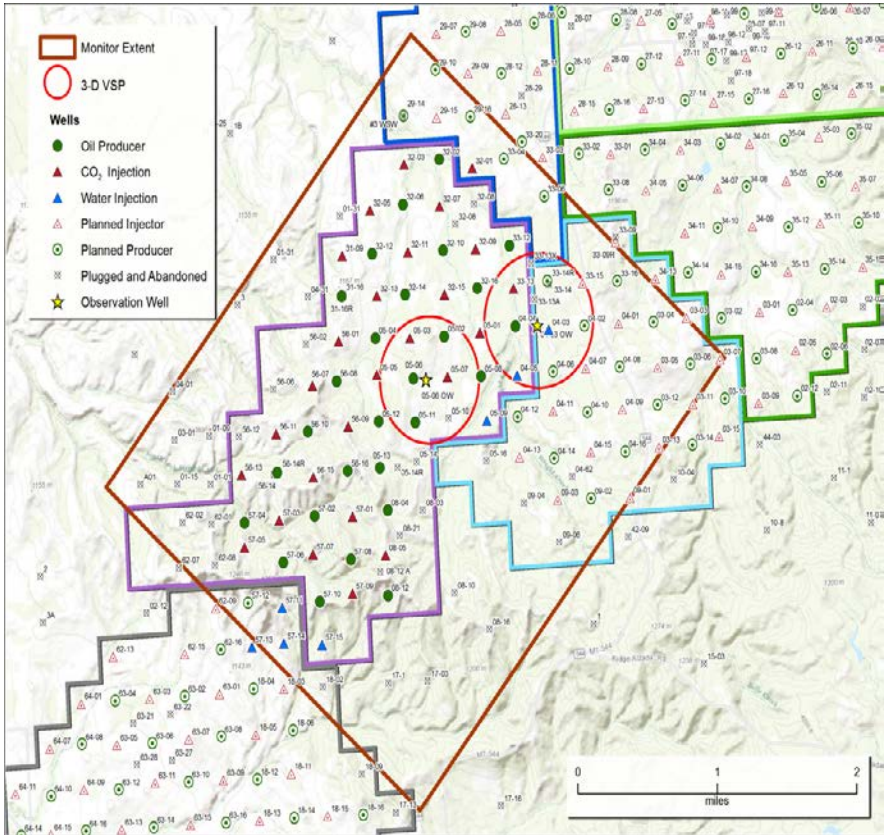
- Perforating

Set off by hydraulic pressure through a ¼" line filled with hydraulic fluid

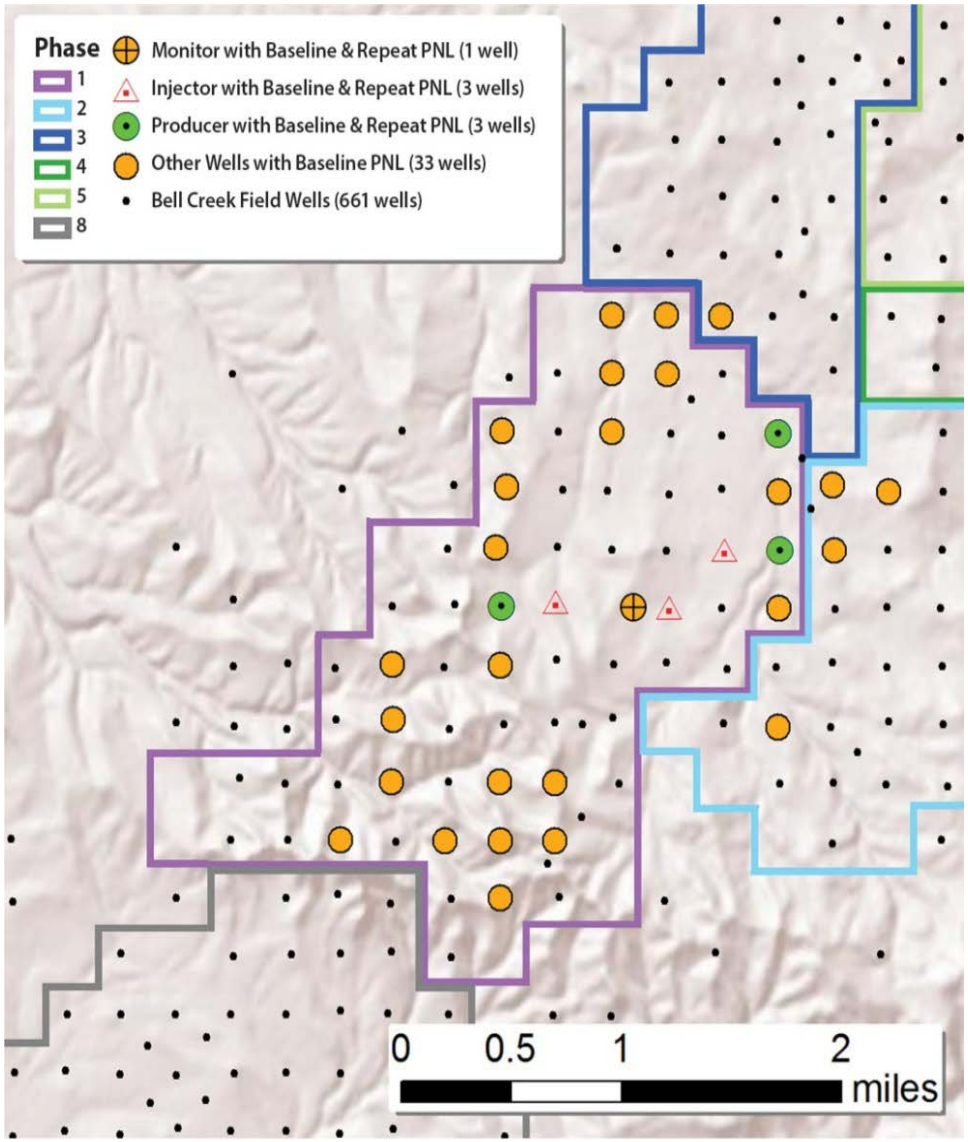
BCU 05-06OW

4D Seismic

- 10 sq. mile post-injection surface survey pending
- Centered on Phases 1 & 2
- Field Work ~Late 2014
- Processing ~Late ‘14/ Early ‘15
- Interpretation ~1st Half 2015
- 4D differencing may show the injected CO_2 plume.



Time-Lapse PNL Campaign (EERC)



- Map of wells showing where baseline and repeat PNLs are collected
- Time-Lapse monitoring will identify how CO_2 moves through the reservoir

Operational Consideration: BLM

- BLM Approval EA/POD
  - 9-12 months
- BLM Restrictions
  - March 15th-July 15th
    - Sage Grouse
    - Raptors
    - Large Game

Operational Consideration: Field Location

Operational Consideration: Paraffin

- Challenges:
  - Oil cloud point ~95˚
  - Tubular buildup typically from 1,000’-3,500’
  - Flowlines plugging off
    - Paraffin / Asphaltenes
    - Freezing issues w/high CO_2 (GLR)
  - Limited well file information (polymer jobs)

- Solutions:
  - Continuous chemical treatment (via cap-string)
  - Routine batch chemical treatments
  - Trial & Error
    - Each well is unique
  - Hot oil
  - Bleach Treatments

Operational Challenge: Winter Weather

Recent Bell Creek Milestones

➢ 2nd Quarter 2013	Phase 1 CO_2 Injection Began *(State's 1st CO_2 Injection Oil Field)*
➢ 2nd Quarter 2013	1st Producer Opened
➢ 3rd Quarter 2013	First CO_2 Oil Sales
➢ 4th Quarter 2013	Phase 2 CO_2 Injection Started
➢ 1st Quarter 2014	Anadarko Interconnect Pipeline Completed
➢ 1st Quarter 2014	1st Recycle Compressor Operational
➢ 1st Quarter 2014	Phase 2 Production Started
➢ 4th Quarter 2014	Phase 3 CO_2 Injection Started

The End…