Big Sand Draw CO₂ Flood Update

Wyoming EOR CO₂ Conference

July 16, 2015 | Casper, Wyoming
Big Sand Draw CO₂ Flood Update

Outline

• Geography & History
• Geology & Reservoir Properties
• Historical Production & Pre-CO₂ Operations
• CO₂ Flood Development Plan
• Completions & Workovers
• Facilities
• Questions
Big Sand Draw Field
Oil Unit & Gas Unit Acquisition

Wyoming

Beaver Creek Unit

Oil Unit – 2013 Legacy Reserves

Gas Unit – 2014 Anadarko Petroleum
Big Sand Draw
Geology & Reservoir Characteristics – Tensleep

- Trap – Faulted Anticline
- 2.5 mi long x 1 mile wide
- Anticlinal Relief: ~800’
- Aeolian Sandstone
- Depth: 7,500 feet
- Average Porosity: 12.6%
- Average Permeability: 50 md
- Average Pay Thickness: ~280 feet
- Gravity: 34° API
- Oil Unit: ~ 1,740 acres
- Gas Unit: ~ 1,926 acres
- BHPi: 3,300 psi
- BHT - 190° F
- Tensleep Cumulative Prod: 54.7 MMBO
- Strong Water Drive
Big Sand Draw Tensleep
Production History (1945-2013)

1st Production: 1945 (17 Initial Wells + 23 Infill)
Peak Rate: 8,600+ Bopd (1954 – 12 Wells)
Cum Oil: 55 MMbo
Rem: 0.3 MMbo
2013 Rate: 110 Bopd + 49,000 Bwpd (16 current active completions)
BSD – Pre CO\(_2\) Operations

Operations

- Devon Began Operating in February ’13
- 9 Tensleep Producers, 7 Phosphoria Producers

Tensleep Prod: 160 BOPD + 49,000 BWPD

- >99.5% Water Cut (strong water drive)
- Surface Discharge
- Marginal Economics
Big Sand Draw – Reservoir Model
Courtesy: Mi3 Petroleum Engineering

- Geologic & Reservoir Model
- History Match
- Development Plans
- Gravity Stable
- Production Simulations
Big Sand Draw Tensleep
Reservoir Characterization

- **EORI Lab Results** (Sheena Xie, Rituraj Borgohain, Haifeng Jiang, Curtis Chopping, Tashi Herzmark)
  - 33.7° API Gravity
  - 4.2% wax & <1% asphaltenes
  - Wax precipitation @ 70.9°F
  - Slim Tube MMP 2,700 – 2,800 psi
  - Rising Bubble MMP 2,502 psi (Hycal)
  - Swelling test
  - Viscosity reduction from 2.6 cp to 0.6 cp at 60 mol% CO₂@ 3000 psi
Big Sand Draw Tensleep
Proposed Development for EOR

Current Operations 2015:
- 19 Injectors
  - 10 new drill
  - 9 conversions
- 14 producers
  - 2 new drill
  - 12 existing wells

Future Operations:
- 19 Total Injectors
- 26 Total Producers
  - 12 additional producers
    - 8 new drill (2 in 2015)
    - 4 existing (2 in 2015)
- 3 Monitor Wells
Big Sand Draw
Workovers & Completions Outline

- Historical Wellbore Configuration & Completions
- Casing Evaluation
- Wellbore Repair & Squeeze Work
- Stimulations
- New Well Completions
- Current Wellwork Status
Big Sand Draw - Tensleep

Historical Completions

- 7” Casing set @ top of Tensleep
- Early wells had OH natural completions
- Liners run across OH in 1950’s
- Permeable Sandstone with dolomitic stringers
- Perfs typically stimulated with small mud cleaning acid treatment
- Some perforated completions were not stimulated
- Some wells had small gelled crude sand frac stimulations
- Tensleep Recompletions squeezed off water or set CIBP’s and moved up hole
- Grandeur or Basal Phosphoria, Embar, other Oil Unit pay
Big Sand Draw - Tensleep

Casing Evaluation

• Casing Inspection Options
  – Caliper
  – Casing Inspection Logs – Magnetic flux
  – Ultrasonic – Requires fluid level
    o Metal thickness
    o Cement evaluation
• Bond Logs
• Pressure test casing
Big Sand Draw - Tensleep
Wellbore Repair & Squeeze Work

- Leak or Perforation Squeezes
  - Cement under cement retainers
  - Establish Pump-in Rate to help size squeeze
  - Halliburton’s WellLock Resin

- Liners Run - 9 total (Chrome alloy across Tensleep and Basal Phosphoria)
  - Open Hole Liners - 4
  - Full Length Liners - 5

- Future conformance work
  - Cement Squeezes
  - Scab Liner Packers - Left gaps in perforations in some wells for packer seat
Big Sand Draw - Tensleep

Stimulations

- Acidize Tensleep Perforations w/ 15% HCl & solvent package diverting with ball sealers or rock salt
  - Limit BHTP to 5000 psi
  - Frac Gradient 0.80 psi/ft
  - Reservoir Pressure 3,200 psi
Big Sand Draw - Tensleep
Injection Well Configuration – New Wells

- 5.5” Long string Casing
- Super Chrome Alloy Csg across Tensleep
  - Minimizes Corrosion
  - Maintains Packer Seat
  - Perf Conformance Control
- Nickel Plated Retrievable Packers
- 2 7/8” Fiberglass Lined L-80 Tubing
Big Sand Draw - Tensleep

Production Well Configuration – New Wells

• 7” Longstring Casing

  New wells have Super Chrome Alloy Csg through Tensleep
    - Minimizes Corrosion over the years
    - Perf Conformance Control

• 2 7/8” L-80 Tubing

• Monel Plated ESP’s with VFD’s (+/- 1,500 BTFPD)

• Dual 3/8” Dia Cap Strings for Corr/Scale Inhibitors & Asphaltene Inhibition

• Set ESP 100’ – 200’ above perforations despite high fluid levels
  - High PIP keeps CO₂ in dense phase
  - Less cooling – less paraffin & asphaltenes?

• Gas meters on csg will help determine gas volumes through ESP
Big Sand Draw Tensleep
Wellwork Status

Current Status

• Workovers – 21 completed
  o 9 Injectors
  o 12 Producers

• Drill Wells – 12 completed
  o 10 Injectors
  o 2 Producers

2015 Plans

• Workovers – 2 producers
• Drill Wells – 2 producers – Q4 2015
• Monitor Wells – 3 workovers

Future Workovers

• Recomplete Producers to chase oil bank down structure
Big Sand Draw
CO2 Flood Facilities
Big Sand Draw - Facilities
Began Injection April 2014

Injection Flow Lines
• Approx 9 miles
• SCH 80 SMLS API 5L X52Q PSL2/ASTM A333 Gr6 NACE
• External coating 3M 6233

Production flow lines
• Approx 24 miles
• 4” SCH 80 SMLS API 5L X52Q PSL2/ASTM A333 Gr6 NACE
• External coating DuPont NapGard Gold
Big Sand Draw - Facilities
Sinclair Pipeline - Oil Sales

**BSD Pipeline Sales**
- Sinclair had an abandoned line running to Bairoil
- Sinclair erected storage tank and pump station

**BCU Pipeline Sales**
- Repurposed line to transport BCU crude
- Began operation 5/26/2015
- Eliminates 15 truckloads per day
Big Sand Draw
CO₂ Flood Facilities - Overview

• New injection lines & wellheads (carbon steel)

• Plant Design Capacity 60 MMCFD CO₂
  • Current Compression Capacity 30 MMCFD
  • Additional 30 MMCFD Compression in 4th Qtr ’15
  • Mole Sieve Dehydration
  • Operating at 400 - 2,000 psig

• Production Facility - 400 psi Inlet
  • Higher back pressure on producing wells
  • Compression reduced to 2 stages - Lower LOE

• Electric Generation 5.6 MW Load (7.0 MW Capacity)

• Production Facility Began Commissioning in May 2015
Big Sand Draw
Average Daily Oil Production: 2013 - Present

Began Injection 4/24/2014
Big Sand Draw CO$_2$ Flood Update

Questions?
Thank you.
Big Sand Draw

History

• 1917 The Producers and Refiners Corporation Commences the Drilling of the First Well (Frontier Formation) at Big Sand Draw
• 1932 Formation of the Big Sand Draw Gas Unit
• 1939 Sinclair-Wyoming Oil Company Purchases the Big Sand Draw Gas Unit
• 1944 Major Oil Reserves are Discovered by Sinclair in the Tensleep Sandstone and the Big Sand Draw Oil Unit is Formed
• 1975 Sinclair Sells the Both the Big Sand Draw Oil and Gas Units to Amoco Production Company
• 1988 Amoco Sells the Big Sand Draw Gas Unit to Howell Petroleum Corp.
• 1988 Amoco Sells the Big Sand Draw Oil Unit to Wold Oil Properties Inc.
• 2005 Wold Sells the Big Sand Draw Oil Unit to Nance Petroleum Corporation
• 2008 Nance Sells the Big Sand Draw Oil Unit to St. Mary’s Land & Exploration Co.
• 2010 St. Mary’s Sells the Big Sand Draw Oil Unit to Legacy Reserves Operating LP
• 2013 Howell Sells the Big Sand Draw Gas Unit to Anadarko E&P Onshore LLC
• 2013 Legacy Sells the Big Sand Draw Oil Unit to Devon Energy Production Company LP
• 2014 Anadarko Sells the Big Sand Draw Gas Unit to Devon Energy Production Company LP
• 2014 Devon Initiates CO₂ Flood in the Tensleep at Big Sand Draw