Plains CO_2 Reduction (PCOR) Partnership Monthly Update
October 1–31, 2016

PHASE III ACTIVITIES

Task 1 – Regional Characterization (Wesley D. Peck)

Highlights

- Received approval for Deliverable (D) 1 entitled "Review of Source Attributes" on October 6, 2016.
- Continued efforts on the Regional Carbon Sequestration Atlas (D81), including the following
  - Compiled new text regarding Class VI wells.
  - Obtained updated information regarding the Quest project.
  - Initiated the initial internal editing process.
- Continued work on draft text for an update to the Bell Creek portion of the PCOR Partnership members-only Decision Support System Web site. Updated content on site development; site operations; characterization; monitoring, verification, and accounting (MVA); and modeling/simulation activities. This is undergoing internal review.
- Continued activities to update the content of the **PCOR Partnership general database**, including the following:
  - Updated North Dakota and Montana Petra projects with the latest general well information from each state's online resources: 44 new North Dakota wells and five new Montana wells added.
  - Updated North Dakota monthly production data.
  - Began importing the additional Wyoming well logs into Petra.
  - Continued database preventive maintenance of Petra projects.
- With regard to the **Aquistore** project's static modeling and dynamic predictive simulations effort:
  - Continued to download and process injection and pressure data as available.
  - Sent a paper entitled "A Numerical Simulation Update of the Aquistore CO_2 Storage Project" for the American Institute of Chemical Engineers (AIChE) conference (to be held November 13–18, 2016) to a representative at Petroleum Technology Research Centre (PTRC) for final review.
  - Participated in a Science and Engineering Research Committee (SERC) call on October 5, 2016, that was focused on the pulsed-neutron log (PNL) logging that Schlumberger has performed in the injection and observation wells.
  - Used CMOST to evaluate history match.

Task 2 – Public Outreach and Education (Daniel J. Daly)

Highlights

- Submitted Documentary D21 entitled "The Bell Creek Story – CO_2 in Action" to the U.S. Department of Energy (DOE) National Energy Technology Laboratory (NETL) for review on October 31, 2016.
- Submitted the value-added "Household Energy and Carbon Web Pages Report" for the July 1 – September 30, 2016, quarter on October 27, 2016.
- Continued work on a draft of the Bell Creek fact sheet (D15), including initial internal review.
- Continued the development of two value-added facts sheets (Enhanced Oil Recovery [EOR] 101 and Green Oil), including revisions based on an initial review.
- Participated in the Outreach Working Group monthly conference call on October 20, 2016.
- Continued efforts with regard to the public Web site (www.undeerc.org/pcor), including the following:
  - Continued work on updates to the public PCOR Partnership Web site, including the following:
    - A new Partners-Only landing page.
    - A new look for the following pages: What Is CO_2?, What Is CO_2 Sequestration?, and Terrestrial Sequestration.
    - New print-friendly page PDFs for the three pages above as well as for the following pages: CO_2 Sequestration Projects and Technical Posters.
  - Continued ongoing identification and repair of broken links.
- Scheduled a review screening on Documentary D21 (The Bell Creek Story – CO_2 in Action) with Denbury Onshore (Denbury) personnel for November 7, 2016, in Plano, Texas.
- Continued collaborative efforts with Prairie Public Broadcasting (PPB), including the following:
  - Continued work on Documentary D22 (Coal and the Modern Age), including the following:
    - Discussed storyline changes and an action plan with a representative from PPB and Energy & Environmental Research Center (EERC) management on October 14, 2016.

Task 3 – Permitting and NEPA (National Environmental Policy Act) Compliance (Charles D. Gorecki)

Highlights

- Received approval for D8 entitled "Permitting Review – Update 3" on October 11, 2016.
- Attended the Interstate Oil and Gas Compact Commission (IOGCC) Annual Meeting in Little Rock, Arkansas, held October 2–4, 2016.
- Continued the review and edit, with a consultant from The CETER Group (CETER), of the regulatory permitting document for the PCOR Partnership region (D76 – Regional Regulatory Perspective).

Task 4 – Site Characterization and Modeling (Charles D. Gorecki)

Highlights

- Continued work on the PCOR Partnership Site Characterization Best Practices Manual (BPM) (D35):
  - Held a meeting to discuss D35. Discussion centered on associated storage versus dedicated storage. Also discussed terminology such as carbon capture and storage (CCS); carbon capture, utilization, and storage (CCUS); geologic storage, etc. Adjusted the BPM outline to reflect these discussions. Wrote introductory text for the BPM that discusses these ideas.
  - Continued modifications to the outline. Modified and added to the executive summary and the introduction.
- Worked on planning a petrophysics training event to be led by PCOR Partnership member Eric Pasternack, Outsource Petrophysics, at the EERC. The training is currently scheduled for mid-December 2016.

Task 5 – Well Drilling and Completion (John A. Hamling)

This task ended in Quarter 3 – Budget Period (BP) 4, Year 7 (June 2014).

Task 6 – Infrastructure Development (Melanie D. Jensen)

Highlights

- Continued work on the update of the 2011 CO_2 capture technologies overview document by researching capture technologies mentioned in online news articles for possible inclusion.

Task 7 – CO_2 Procurement (John A. Harju)

This task ended in Quarter 4 – BP4, Year 6 (September 2013).

Task 8 – Transportation and Injection Operations (Melanie D. Jensen)

This task ended in Quarter 4 – BP4, Year 8 (September 2015).

Task 9 – Operational Monitoring and Modeling (John A. Hamling and Larry J. Pekot)

Highlights

- Submitted a memo on October 21, 2016, regarding official updated volumes of metric tons of CO_2 purchased for injection and metric tons of CO_2 stored at Bell Creek. As of August 31, 2016, the most recent month of record, 3.290 million tonnes of total gas (composition of approximately 98% CO_2) has been purchased for injection into the Bell Creek Field, equating to an estimated ***3.235 million tonnes of CO_2 stored***.
- Submitted D105 entitled "Comparison of Non-EOR and EOR Life Cycle Assessments" on October 31, 2016. This report has been provided to Denbury for concurrent review.
- Held a Bell Creek project update meeting with Denbury on October 17, 2016, in Plano, Texas. Discussions included the fall 2016 PNL program, a geophysics update, InSAR

(interferometric synthetic aperture radar) analysis, a geomodeling and simulation update, the Bell Creek-specific life cycle assessment, and general topics.

- Finalized plans for a geophysical logging workshop. This Schlumberger-led training at the EERC began October 31, 2016, and will continue through November 4, 2016. The training will cover tools, principles, applications, and processing of various geophysical logging techniques that can be used to collect data for modeling and MVA.
- Drafted a paper entitled "The Value of 4-D Seismic Monitoring at the Bell Creek – A Mature Oilfield Undergoing CO_2 Enhanced Oil Recovery" to be presented at a European Association of Geoscientists and Engineers (EAGE) conference. The paper is due January 2017.
- Continued work on a Bell Creek MVA value-added report, including a section on surface water activities.
- **Bell Creek** injection-phase site activities included the following:
  - Continued reservoir pressure and distributed temperature monitoring of 05-06 OW (observation well) from the permanent downhole monitoring system using the casing-conveyed pressure–temperature gauges and fiber-optic distributed temperature system:
    - Near-continuous operation since April 2012.
    - Continued processing the 05-06 OW data sets through July 11, 2016.
  - Continued dynamic reservoir pressure and multiphase fluid flow simulation efforts:
    - Consistent progress since April 2011.
    - History matching is complete for Bell Creek Phases 1–3. Predictive simulation is complete for Bell Creek Phases 1 and 2. Long-term simulations of CO_2 migration are complete for Bell Creek Phases 3–7.
    - Continued processing production/injection historical data for wells in Bell Creek Phase 4 and nearby areas and developing a simulation model to be used for history matching and predictive simulations of the Bell Creek Phase 4 area. Integrated approximately 50 years of production/injection data into the Bell Creek Phase 4 simulation model, covering primary production, waterflooding, and CO_2 EOR stages in the phase.
    - Worked on debugging the Bell Creek Phase 4 simulation model for the primary production stage; the eastern and southern parts of the reservoir in this phase have complex geologic conditions.
  - Continued working with the fall 2015 4-D surface seismic data set from Bell Creek, including the following:
    - Continued 4-D seismic data analysis and interpretation. Analysis included data from May 22 – September 5, 2013.
    - Performed an initial run of prestack inversion to examine the pressure effect in the Bell Creek oil field. Worked on well-based velocity model generation, angle gather generation, extraction of wavelets, correlation of wells, and building an initial model. Applied inversion analysis to the volume to generate S-wave and P-wave velocities, density, V_p/V_s ratio, and P-impedance and S-impedance volumes for the baseline (2012) data.
  - Continued Bell Creek microseismic data processing, including the following:
    - Worked to improve the automation of the data processing using the MiVu software modules Model Building, Survey Design, and Visualization.
    - Created the first iteration of a 3-D model for event location and magnitude estimation.

- Submitted a revised fall 2016 PNL logging program to a representative at Denbury based on discussions held at the update meeting on October 17, 2016, in Plano, Texas. Fifteen candidate wells in Bell Creek Phases 1 and 4 were selected for repeats, with acquisition of eleven Bell Creek Phase 1 production wells scheduled for December 2016 and acquisition of four Bell Creek Phase 4 production wells scheduled for spring 2017 (pending sufficient CO_2 breakthrough). The wells are located in the seismic study area, so the PNL data from these wells could be used in production analysis, static modeling, seismic study, and dynamic simulation.
- Used the most recent publicly available data to determine that cumulative total CO_2 gas injection is 5,748,231 metric tons through August 31, 2016. This value represents the total gas volume injected, which includes purchase and recycle streams and is NOT corrected for a gas composition of approximately 98% CO_2 (Table 1).
- As of August 31, 2016, the most recent month of record, 3.290 million tonnes of total gas (composition of approximately 98% CO_2) has been purchased for injection into the Bell Creek Field, equating to an estimated 3.235 million tonnes of CO_2 stored (Table 2), with the difference comprising other trace gases in the purchase gas stream. A separate methodology from that used to calculate total gas injected was used to calculate a cumulative associated CO_2 storage volume estimate by correcting the gas purchase volume A summary of all oil and CO_2 gas stream samples collected for analyses to date is provided in Table 3.
- Worked on analyzing oil samples from the Bell Creek oil field for oil compositional monitoring.
- Continued looking into modeling options as a way to validate experimental data from the vanishing interfacial technique. This technique is used to determine minimum miscibility pressure (MMP).

Table 1. Bell Creek CO_2 Gas Injection Totals for August 2016 (cumulative totals May 2013 to August 2016)[1]

	August 2016 Injection
Total, Mscf	2,994,354
Total, tons[2]	171,272
Total, tonnes[2]	155,527
Cumulative Total, Mscf[2]	110,670,685
Cumulative Total, tons[2,3]	6,330,188
Cumulative Total,tonnes[2,3]	5,748,231

Source: Montana Board of Oil and Gas (MBOG) database.

[1] There has been a lag in posting of injection/production volumes to the MBOG database. Total gas injection volumes are ***NOT CORRECTED*** for gas composition and include the combined purchased and recycled gas streams.

[2] This was calculated utilizing a conversion of 17.483 Mscf/ton and 19.253 Mscf/tonnes.

[3] Cumulative totals are for the period from May 2013 to the month listed.

Table 2. Cumulative Total Gas Purchased and Estimated Associated CO_2 Storage Volumes for the Bell Creek Field[1]

	August 2016 Gas Volume
Monthly Total Gas Purchased, MMscf[2]	833
Monthly Total Gas Purchased, million tons[2]	0.048
Monthly Total Gas Purchased, million tonnes[2]	0.043
Cumulative Total Gas Purchased, MMscf[2,3]	63,346
Cumulative Total Gas Purchased, million tons[2,3]	3.623
Cumulative Total Gas Purchased, million tonnes[2,3]	3.290
Cumulative Total CO_2 Stored, MMscf[3,4]	62,277
Cumulative Total CO_2 Stored, million tons[3,4]	3.562
Cumulative Total CO_2 Stored, million tonnes[3,4]	3.235

[1] Conversion factors of 17.483 Mscf/ton and 19.253 Mscf/tonne were used to calculate volumes.
[2] Total gas purchased volumes are *NOT CORRECTED* for gas composition.
[3] Cumulative totals are for the period from May 2013 to the month listed.
[4] Total CO_2 stored volumes are *CORRECTED* for gas composition.

(approximately 98% CO_2) obtained from Denbury's custody transfer meter with gas compositional data.

Table 3. Oil and CO_2 Gas Stream Sampling and Analyses

		Production Stream by Development Phase, Well[1]							
		Phase 1				Phase 3			Phase 4
Date Sampled	Purchase/ Recycle[1]	56-14R	32-02	05-06	04-04	28-02	21-10	21-14	34-09
Jan 2014		O	O	O					
Mar 2014		O	O						
May 2014	P	O	O	O					
Jun 2014	PR	O	O	O					
Jul 2014	PR	O	O	O					
Sep 2014	PR	OG	OG	O					
Oct 2014	PR	O	O						
Nov/Dec 2014		OG	OG	G					
Jan 2015[2]			O	OG					
Mar 2015		G	G	G					
Apr 2015	PR								
Jun 2015[2]		O	O	O					
Jul 2015	PR	G	G	G					
Sep 2015	PR								
Nov 2015[2]		O		O					
Jan 2016	PR								
Apr/May 2016[2]		O	O	O	O	O	O	O	
Jun/Jul 2016[2]	PR	O		O	O	O	O	O	
Aug/Sep 2016[2]		O	O		O	O	O	O	O
Oct 2016[2]				O					

[1] P = purchase CO_2 gas stream, R = recycle CO_2 gas stream, O = produced oil stream, and G = produced CO_2 gas stream.
[2] Oil samples collected but not yet analyzed.

Task 10 – Site Closure (John A. Hamling)

Highlights

- Nothing to note at this time.

Task 11 – Postinjection Monitoring and Modeling (John A. Hamling and Larry J. Pekot)

Highlights

- Nothing to note at this time.

Task 12 – Project Assessment (Loreal V. Heebink)

Highlights

- Continued compiling the annual report.

Task 13 – Project Management (Charles D. Gorecki)

Highlights

- Hosted a meeting with Richard Esposito, Southeast Regional Carbon Sequestration Partnership (SECARB), to discuss updates related to PCOR Partnership and SECARB among other research projects on October 25, 2016, at the EERC.
- Submitted eight papers for the 13th International Greenhouse Gas Control Technologies (GHGT-13) Conference to be held November 14–18, 2016, in Lausanne, Switzerland. The paper titles and associated PCOR Partnership task are as follows:
  - Task 1: Relative Permeability of Williston Basin CO_2 Storage Targets
  - Task 1: Numerical Modeling of the Aquistore CO_2 Storage Project
  - Task 2: Regionwide and Project-Level Outreach – The PCOR Partnership Approach
  - Task 9: Monitoring 3.2 million tons of CO_2 at the Bell Creek Oil Field
  - Task 9: 4-D Seismic Monitoring of Injected CO_2 Enhances Geological Interpretation, Reservoir Simulation, and Production Operations
  - Task 9: Impact of CO_2 Impurity on MMP and Oil Recovery Performance of Bell Creek Oil Field
  - Task 9: Effects of Reservoir Temperature and Percent Levels of Methane and Ethane on CO_2/Oil MMP Values as Determined Using Vanishing Interfacial Tension/Capillary Rise
  - Task 9: A Life Cycle Analysis of Incremental Oil Produced via CO_2 EOR
- Worked on addressing a request to revise the PCOR Partnership case studies for the DOE Simulation and Risk Assessment BPM received from Sarah Wade. The revised case studies and comments on the draft Simulation and Risk Assessment BPM were submitted to Ms. Wade on October 14, 2016.
- Received a request from DOE to review and provide comments on a DOE NETL Regional Carbon Sequestration Partnerships (RCSP) poster for the GHGT-13 Conference. The poster was reviewed and comments were provided on October 31, 2016.
- Received feedback from PCOR Partnership Technical Advisory Board (TAB) members, Stefan Bachu and Ray Hattenbach, on the Adaptive Management Approach BPM (D102). Once all comments from TAB have been received, a revised version of the document will be issued.

- Held a task leader meeting October 10, 2016. Topics discussed included Bell Creek and Aquistore project updates, the upcoming RCSP peer review, past and upcoming conferences, upcoming training opportunities, and task leader updates.
- Completed deliverables and milestones in October:
  - September monthly update
  - Task 2: D21 – Bell Creek Test Site 30-minute Documentary
  - Task 9: D105 – Comparison of Non-EOR and EOR Life Cycle Assessments
  - Task 13: D58/D59 – Quarterly Progress Report/Milestone Quarterly Report

Task 14 – RCSP Water Working Group (WWG) Coordination (Ryan J. Klapperich)

Highlights

- With regard to the *International Journal of Greenhouse Gas Control* (IJGGC) Special Issue:
  - Continued final revisions to the introduction article with a consultant from CETER.
  - Discussed final reviews with a consultant from CETER. All reviews are complete.
- Continued work on a draft outline for D107 (Journal Article or Topical Report – Major Research Focuses for Water and CCS).

Task 15 – Further Characterization of the Zama Acid Gas EOR, CO_2 Storage, and Monitoring Project (Charles D. Gorecki)

This task ended in Quarter 2 – BP4, Year 7 (February 2014).

Task 16 – Characterization of the Basal Cambrian System (Wesley D. Peck)

This task ended in Quarter 2 – BP4, Year 7 (March 2014).

Travel/Meetings

- October 1–5, 2016: traveled to Little Rock, Arkansas, to attend the IOGCC Annual Meeting.
- October 16–18, 2016: traveled to Plano, Texas, to attend a meeting with Denbury and to attend the Society of Geophysicists Annual Meeting.
- October 26–28, 2016: traveled to Washington, D.C., to attend the U.S. Energy Association Panel Discussion on Carbon, Capture, Utilization, & Storage Act.

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