Plains CO_2 Reduction (PCOR) Partnership Monthly Update
November 1–30, 2016

PHASE III ACTIVITIES

Task 1 – Regional Characterization (Wesley D. Peck)

Highlights

- Continued internal review and minor edits on the update to the PCOR Partnership Atlas Deliverable (D) 81.
- Completed draft text for an update to the Bell Creek portion of the PCOR Partnership members-only Decision Support System (DSS) Web site. Updated content on the PCOR Partnership regional background; characterization; monitoring, verification, and accounting (MVA); and modeling/simulation activities. This is undergoing internal review prior to incorporation on the DSS Web site.
- 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: 105 new North Dakota wells and three new Montana wells added.
  - Updated North Dakota monthly production data.
  - Updated South Dakota and Manitoba well and production data.
  - Continued database preventive maintenance of Petra projects.
- With regard to **Williston Basin** CO_2 Storage Sink Relative Permeability Laboratory Characterization:
  - Continued work on the final value-added report, due January 31, 2017.
- 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.
  - Presented "A Numerical Simulation Update of the Aquistore CO_2 Storage Project" at the American Institute of Chemical Engineers (AIChE) Conference held November 13–18, 2016, in San Francisco, California.

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

Highlights

- Submitted D15 Fact Sheet (Update) entitled "Bell Creek Integrated CO_2 EOR and Storage Project" on November 30, 2016.

- Requested review of several pages (What Is CO_2?, What Is CO_2 Sequestration?, Terrestrial Sequestration, and Technical Reports) and one new page (Partners-Only Landing Page) for the public PCOR Partnership Web site update on November 3, 2016. Received approval on November 9, 2016. These updates went live November 10, 2016.
- Continued the development and internal review of two value-added fact sheets (Enhanced Oil Recovery [EOR] 101 and Green Oil).
- Continued work on the value-added update of the Phase II Terrestrial Sequestration fact sheet.
- Continued efforts with regard to the public Web site (www.undeerc.org/pcor), including the following:
  - Continued ongoing identification and repair of broken links.
- Senior EERC PCOR Partnership managers traveled to Plano, Texas, for a screening of Documentary D21 "The Bell Creek Story – CO_2 in Action" with Denbury Onshore (Denbury) personnel on November 7, 2016, and noted Denbury's comments.
- Continued collaborative efforts with Prairie Public Broadcasting (PPB), including the following:
  - Continued work on Documentary D22 (Coal and the Modern Age), including the following:
    - Performed additional research to add to the script.
    - Began incorporating recent interviews into the script.
    - Continued to review the script based on comments.

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

Highlights

- Received approval on November 2, 2016, to extend the D76, Regulatory Perspective Regarding the Geologic Storage of CO_2 in the PCOR Partnership Region, deliverable date to January 31, 2017.
- Held a conference call with a consultant from CETER to discuss comments from the internal review and the path forward.

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

Highlights

- Continued work on the PCOR Partnership Site Characterization Best Practices Manual (BPM) (D35):
  - Continued modifications to the outline.
  - Modified and added to the executive summary.
  - Continued writing text for the body.
  - Continued initial internal review of sections throughout the writing process.
- Continued planning a petrophysics training event to be led by PCOR Partnership member Eric Pasternack, Outsource Petrophysics. The event will be held at the EERC and the North Dakota Geological Survey Wilson M. Laird Core and Sample Library.
- Continued to evaluate and input Bell Creek petrophysical property distributions into the Version 3 model.

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 searching and reviewing capture technologies 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 November 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 September 30, 2016, the most recent month of record, 3.374 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 ***3.318 million tonnes of CO_2 stored.***
- Submitted M52 entitled "Bell Creek Test Site – Analysis of Extended Pulsed-Neutron Log Campaign Data Completed" on November 29, 2016.
- Received approval of a revision of D66 (Bell Creek Test Site – Simulation Report [Update 4]) on October 13, 2016, with comments from Denbury incorporated.
- Presented "Lessons Learned in Near-Surface Monitoring for Large-Scale CO_2 Storage" at the AIChE Conference held November 13–18, 2016, in San Francisco, California.
- Traveled to Plano, Texas, on November 7, 2016, for pulsed-neutron log (PNL) planning, geophysics and InSAR (interferometric synthetic aperture radar) discussion and to finalize and review comments on Bell Creek-related 13th International Greenhouse Gas Control Technologies (GHGT-13) Conference presentations.
- Held a Schlumberger-led geophysical logging training workshop at the EERC October 31 – November 4, 2016. It covered tools, principles, applications, and processing of various geophysical logging techniques that can be used to collect data for modeling and MVA.
- Continued work on a Bell Creek MVA value-added report. Conducted a series of WebEx meetings with a representative from CETER to review and discuss InSAR, modeling, PNL, and seismic activities at Bell Creek for use in the value-added report. Initiated internal review.
- **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.
    - Completed 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 Phase Areas 1–3. Predictive simulation is complete for Bell Creek Phase Areas 1 and 2. Long-term simulations of CO_2 migration are complete for Bell Creek Phase Areas 3–7.
    - Ran simulation cases for history match in the Bell Creek Phase Area 4 simulation model on the primary depletion stage.
    - Calculated original oil, gas, and water in place in the Bell Creek Phase Area 4 simulation model based on the Version 2 geologic model and compared the results to the production history.
    - Converted the initial Version 3 geologic model to a simulation model. Integrated completion data, PVT data, and production history into the dynamic model.
- 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.
    - Performed inversion for S-wave velocity at Bell Creek using HampsonRussell, a geophysical processing and interpretation software package.
- Continued Bell Creek microseismic data processing, including the following:
    - Installed a new version of GeoTomo software. This included MiVu (microseismic tool), VECON (modeling tool), and GeoThrust (surface seismic tool). Began using the new MiVu version to process microseismic data.
- Received concurrence from Denbury on the expanded Bell Creek PNL program. Eleven (11) wells (Bell Creek Phase Areas 1 and 3) will be logged starting December 2016, and four wells will be logged next spring (2017). Discussed the expanded Bell Creek PNL program with representatives from Denbury and Schlumberger.
- Used the most recent publicly available data to determine that cumulative total CO_2 gas injection is 5,949,584 metric tons through September 30, 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 September 30, 2016, the most recent month of record, 3.374 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 3.318 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 (approximately 98% CO_2) obtained from Denbury's custody transfer meter with gas compositional data.
- Worked with a representative from Denbury on the fourth round of oil sample collection from a select group of wells in Bell Creek.
- Completed analyses of oil samples collected from 2014 through October 2016 from the Bell Creek oil field for oil compositional monitoring. Completed initial data reduction. The data are undergoing internal review.
- Analyzed 35–40 soil–gas samples collected at the Bell Creek Field site during the October 2016 sampling event. This represents one of the last small-scale sampling events

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

	September 2016 Injection
Total, Mscf	3,876,658
Total, tons[2]	221,739
Total, tonnes[2]	201,353
Cumulative Total, Mscf[2]	114,547,343
Cumulative Total, tons[2,3]	6,551,927
Cumulative Total,tonnes[2,3]	5,949,584

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]

	September 2016 Gas Volume
Monthly Total Gas Purchased, MMscf[2]	1613
Monthly Total Gas Purchased, million tons[2]	0.092
Monthly Total Gas Purchased, million tonnes[2]	0.084
Cumulative Total Gas Purchased, MMscf[2,3]	64,959
Cumulative Total Gas Purchased, million tons[2,3]	3.716
Cumulative Total Gas Purchased, million tonnes[2,3]	3.374
Cumulative Total CO_2 Stored, MMscf[3,4]	63,872
Cumulative Total CO_2 Stored, million tons[3,4]	3.653
Cumulative Total CO_2 Stored, million tonnes[3,4]	3.318

[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.

- (soil–gas profile stations only) that will be conducted. This work was conducted in order to provide a data set to look at long-term annual trends in natural soil gas variability.
- Collected purchase/recycle CO_2 gas samples from the Bell Creek Field on November 29, 2016.
- A summary of all oil and CO_2 gas stream samples collected for analyses to date is provided in Table 3.
- Continued laboratory preparations for a value-added hysteresis study.

Table 3. Oil and CO_2 Gas Stream Sampling and Analyses

Date Sampled	Purchase/ Recycle[1]	Production Stream by Development Phase, Well[1] Phase 1				Phase 3			Phase 4		
		56-14R	32-02	05-06	04-04	28-02	21-10	21-14	34-09	34-07	34-03
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			O	OG							
Mar 2015		G	G	G							
Apr 2015	PR										
Jun 2015		O	O	O							
Jul 2015	PR	G	G	G							
Sep 2015	PR										
Nov 2015		O		O							
Jan 2016	PR										
Apr/May 2016		O	O	O	O	O	O	O			
Jun/Jul 2016	PR	O		O	O	O	O	O			
Aug/Sep 2016		O	O		O	O	O	O	O		
Oct 2016				O							
Nov 2016[2]	PR	O	O		O	O			O	O	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

- Attended the Midwest Regional Carbon Sequestration 2016 Annual Partners Meeting held November 2, 2016, in Columbus, Ohio.
- Attended the GHGT-13 Conference held November 14–18, 2016, in Lausanne, Switzerland. Charlie Gorecki, John Hamling, Neil Wildgust, and Nick Bosshart served as chairs or cochairs for sessions at the conference. All presentations and a PDF of a poster were provided to DOE under separate cover on November 14. 2016. Presentations, with the corresponding PCOR Partnership task, included the following:
  - Task 1: Relative Permeability of Williston Basin CO_2 Storage Targets
  - Task 1: Numerical Modeling of the Aquistore CO_2 Storage Project (poster)
  - 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
- Completed PCOR Partnership Programmatic and Bell Creek-specific risk assessment workshops. These were led via WebEx by project consultants from CETER with the purpose of updating the risk registers and assessing the likelihood of occurrence and severity of impact should the risk occur. This information will be used to help track the risk profiles of the Bell Creek project and overall PCOR Partnership program.
- Worked on compiling project information for the upcoming IEA Greenhouse Gas R&D Programme Fiscal Year 2017 (FY17) Expert Review to be held January 23–27, 2017, in Pittsburgh, Pennsylvania. Selected and submitted three technical documents highlighting the PCOR Partnership's work to the Peer Review panel:
  - Plains CO_2 Reduction (PCOR) Partnership Atlas, 4th Edition, Revised
  - Fort Nelson Carbon Capture and Storage Feasibility Study – A Best Practices Manual for Storage in a Deep Carbonate Saline Formation
  - How Green Is My Oil? A Detailed Look at Greenhouse Gas Accounting for CO_2 Enhanced Oil Recovery (CO_2 EOR) Sites
- Submitted a revised list of recommended FY17 quarterly DOE-tracked milestones upon DOE's request.
- Worked with a consultant from CETER to revise the draft Adaptive Management Approach Best Practices Manual (D102), incorporating comments received from PCOR Partnership Technical Advisory Board (TAB) members.
- Held a task leader meeting November 1, 2016. Topics discussed included interviewing additional personnel, planning for the upcoming Regional Carbon Sequestration Partnership Expert Review, upcoming conferences and meetings, and task updates. Also discussed the continued commercial interest in PCOR Partnership membership.

- Held the first planning meeting for the 2017 PCOR Partnership Annual Membership Meeting on November 21, 2016. Topics discussed included possible locations, potential dates, and the focus/goal of the meeting.
- Worked on selecting a date for the 2017 annual TAB meeting.
- Completed deliverables and milestones in October:
  - October monthly update
  - Task 2: D15 – Bell Creek Integrated CO_2 EOR and Storage Project Fact Sheet (update)
  - Task 9: M52 – Bell Creek Test Site – Analysis of Extended Pulsed-Neutron Log Campaign Data Completed

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

Highlights

- Held quarterly WWG conference call on November 16, 2016. Discussed progress on the *International Journal of Greenhouse Gas Control* (IJGGC) Special Issue and the outline for D107 (Journal Article or Topical Report – Major Research Focuses for Water and CCS).
- Continued work on the IJGGC Special Issue (D106) due December 30, 2016.
- Continued work on a draft outline for D107 with a consultant from CETER.

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

- November 1–3, 2016: traveled to Columbus, Ohio, to attend the Midwest Regional Carbon Sequestration Partnership 2016 Annual Partners Meeting.
- November 6–8, 2016: traveled to Plano, Texas, for meetings with Denbury regarding the PCOR Partnership Bell Creek documentary, PNL planning, geophysics and InSAR discussion, and Bell Creek-related GHGT-13 Conference presentations.
- November 9–19, 2016: traveled to Lausanne, Switzerland, to attend and present at the 13th Conference on Greenhouse Gas Control Technologies.
- November 13–18, 2016: traveled to San Francisco, California, to present at the AIChE Annual Meeting.

EERC DISCLAIMER

warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement or recommendation by the EERC.

ACKNOWLEDGMENT

This material is based upon work supported by DOE NETL under Award No. DE-FC26-05NT42592.

DOE DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government, nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

NDIC DISCLAIMER

This report was prepared by the EERC pursuant to an agreement partially funded by the Industrial Commission of North Dakota, and neither the EERC nor any of its subcontractors nor NDIC nor any person acting on behalf of either:

(A) Makes any warranty or representation, express or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or

(B) Assumes any liabilities with respect to the use of, or for damages resulting from the use of, any information, apparatus, method, or process disclosed in this report.

Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by NDIC. The views and opinions of authors expressed herein do not necessarily state or reflect those of the NDIC.