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

PHASE III ACTIVITIES

Task 1 – Regional Characterization (Wesley D. Peck)

Highlights

- Attended and presented two presentations at the North America Energy Ministers Trilateral (NAEMT) Meeting in Mexico City and Villahermosa, Mexico, held April 11–15, 2016.
- Attended and presented at the Esri Petroleum GIS Conference held April 26–27, 2016, in Houston, Texas. The presentation discussed and gave examples of how the Energy & Environmental Research Center (EERC) uses geographic information systems (GIS) in carbon capture, utilization, and storage (CCUS)/carbon capture and storage (CCS) research activities.
- Continued efforts to update Deliverable (D) 81, Regional Carbon Sequestration Atlas (update), including:
  - Continued updating text, statistics, and CO_2 sources.
  - Updated text in regard to the Fort Nelson and Aquistore projects, geologic storage, and the new green oil page.
  - Applied review comments to the preface through Chapter 3.
  - Revised text on the Bell Creek project pages.
  - Updated CCS projects in the PCOR Partnership region.
  - Started to work on Chapter 6 (regulatory) information.
- Participated in a conference call with a science policy fellow at the Institute for Defense Analyses (IDA) Science and Technology Policy Institute. His team is working on an update to the National Earth Observations Assessment and wanted to discuss the usefulness of the data sets used to populate both the PCOR Partnership CO_2 sources database and the oil and gas characterization database. The usefulness and our satisfaction with each data set were scored.
- Updated the CO_2 Sources database with 2014 U.S. Environmental Protection Agency (EPA) data.
- Continued activities to update the content of the **PCOR Partnership general database**, including the following:
  - Updated North Dakota Petra projects with the latest general well information from the state's online resources: 41 new North Dakota wells added.
  - Updated North Dakota injection data.
  - Updated Saskatchewan and Manitoba projects.
  - Continued downloading well logs from the Wyoming Oil and Gas Conservation Commission Web site. Began rescanning API (American Petroleum Institute) well number

files to detect and record Log ASCII Standard (LAS) files within the PCOR Partnership region.
  - Continued database preventive maintenance of Petra projects.
- Continued preparation of draft value-added document on efforts assessing data from the PCOR Partnership Decision Support System (DSS) on large point sources and potential sinks.
- With regard to the **Williston Basin** CO_2 Storage Sink Relative Permeability Laboratory Characterization:
  - Completed relative permeability testing of the third sample (Broom Creek Formation).
  - Stopped relative permeability testing of the fourth sample (vuggy Lodgepole limestone) part way through the testing after continual pressure issues. The system was cleaned in preparation for the next Lodgepole sample with more uniform pore size distribution.
- With regard to the **Aquistore** project's static modeling and dynamic predictive simulations effort:
  - Received approval for D93 entitled "Geological Modeling and Simulation Report for the Aquistore Project" on April 6, 2016.
  - Received an analysis report for the recent pulsed-neutron log (PNL) of the injection well from a Petroleum Technology Research Centre (PTRC) representative.
  - Received results of PNL and spinner log on the injection well run in February 2016 from a Schlumberger Carbon Services representative. Results are inconsistent, with the spinner log indicating 30% of injection CO_2 entering the basal Deadwood perforations; however, the PNL does not report significant CO_2 saturation for this interval.
  - Held monthly internal Aquistore update meeting.
  - Continued work on the simulation model, including:
    - Incorporated hourly field injection data.
    - Worked on a history match of the field pressure, including the injector and observation well pressure responses.
    - Ran the thermal-incorporated simulation, using changes in the downhole temperature in the wellbore model to evaluate any differences in the results. Reprocessed daily average rate for faster, more accurate thermal simulation.
    - Worked on modifications and testing of a new grid system to shorten the simulation run time.

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

Highlights

- Submitted a value-added fact sheet update entitled "CO_2 "Huff 'n' Puff" Validation Test" on April 7, 2016, for review. Received approval on April 27, 2016.
- Continued revisions to the updated Phase II Lignite fact sheet based on review comments.
- Presented on the PCOR Partnership and CCS to 21 teachers attending a workshop on the afternoon of April 21, 2016, at the EERC. This was a part of the activities of the North Dakota Science Teachers Association 2016 Spring Collaborative Conference Preconference STEM (Science, Technology, Engineering, and Mathematics) Networking Sessions held in Grand Forks, North Dakota. Provided the teachers with PCOR Partnership outreach materials.
- Continued work on content for D13 (Public Site Update) for the PCOR Partnership public Web site. Completed research on event tracking to include in the standard operating procedures contained in the appendix of D13.

- Participated in the Regional Carbon Sequestration Partnerships (RCSP) outreach working group monthly call on April 28, 2016. Discussions included the status of the U.S. Department of Energy (DOE) Outreach Best Practices Manual (BPM) update and a number of technical and policy references dealing with the status of CCS in respect to the Paris Agreement on Climate Change.
- Responded to an inquiry from a partner regarding CO_2 volumes for the Bell Creek demonstration.
- Continued efforts with regard to the public Web site (www.undeerc.org/pcor), including the following:
  - Received approval from PCOR Partnership management for the following Web site actions:
    - Add a new landing page for partners.
    - For select pages, upgrade the look ("What is CO_2 Sequestration?" and "What is CO_2?") and content (Technical Reports, Terrestrial Sequestration, and Wetlands pages).
  - Continued ongoing identification and repair of broken links.
- Continued collaborative efforts with Prairie Public Broadcasting (PPB), including the following:
  - Initiated the scheduling for an interview for the Bell Creek (D21) documentary for May 12, 2016.
  - Continued work on documentary D22 (Coal and the Modern Age):
    - Prepared 20 pages of draft script for the introduction of the first industrial revolution in the United States, 15 pages of draft script for the development of the second industrial revolution, and 30 pages of draft script for the use of coal today and in the future. Met with PPB in Fargo, North Dakota, on April 8 and April 22, 2016, to review the script and the draft video materials.
    - Conducted Web and literature searches for suitable historical photos and video for use in documentary D22.

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

Highlights

- Continued working on the regulatory permitting document for the PCOR Partnership region (D76 – Regional Regulatory Perspective). The goal of this document is to help PCOR Partnership states and provinces through the permitting process. Continued compiling rules, regulations, and statutes crosswalk worksheets and flowcharts for various scenarios of CCS geologic storage and for CO_2 enhanced oil recovery (EOR) for each of the PCOR Partnership states and provinces.
  - Continued regulatory crosswalk data gathering for the state of Missouri.
  - Edited crosswalk documents.
- Began initial planning of the 2016 PCOR Partnership Regulatory Roundup.
- Met to discuss D76 progress, the upcoming Interstate Oil and Gas Compact Commission (IOGCC) and PCOR Partnership Regulatory Roundup meetings, and the PCOR Partnership Annual Membership Meeting.

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

Highlights

- **Bell Creek** test site activities included the following:
  - Received approval on April 5, 2016, for D36 entitled "Bell Creek Wellbore Integrity Study" on March 30, 2016, upon completion of Denbury Onshore (Denbury) review. No changes were requested by Denbury or DOE. D36 was initially submitted to DOE on May 19, 2014.
  - Attended the Computer Modelling Group (CMG)-hosted Webinar on April 6, 2016, entitled "Advanced Parallelization Techniques to Optimize and Boost Simulator & Hardware Performance." The knowledge gained will be used in the geomechanical simulation efforts.
  - Worked on the schedule for the PCOR Partnership Site Characterization BPM (D35).
  - Continued work on **modeling**, including the following:
    - Completed the Bell Creek regional (county-size) model, which is ready for CO_2 simulation efforts.
    - Continued work on the Bell Creek near-surface model. This model will be used to help understand the effect of CO_2 storage on the near-surface environment.
    - Worked with Bell Creek seismic data for use in modeling efforts, including extracting geobodies and relating seismic and well log signatures to facies interpretations for depositional environments.
    - Continued work on the Version 3 model, including reviewing previous depositional environment interpretation using seismic data. Preparing for a similar workflow to be performed using data from the most recent seismic campaign once it arrives.
    - Continued work on improving the 3-D mechanical earth model (MEM), including:
      - Obtained geomechanical modeling data from processed PNL, density, and synthetic sonic logs.
      - Continued to improve the geomechanical properties (Poisson's ratio and Young's modulus) with logs.

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

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

Highlights

- Received final approval for D44 entitled "Bell Creek Test Site – Drilling and Completion Activities Report" on April 5, 2016. No changes were requested by Denbury or DOE. D44 was initially submitted to DOE on May 30, 2014.
- Submitted the final report for D42 entitled "Bell Creek Test Site – Injection Experimental Design Package" on April 5, 2016, upon completion of Denbury's review, which required no changes. D42 was initially submitted to DOE on October 30, 2013, and approved February 11, 2014.

Task 6 – Infrastructure Development (Melanie D. Jensen)

Highlights

- Attended the free Webcast entitled "The Effects of Volatility on the Natural Gas Markets…and Implications for Coal," put on by the American Coal Council on April 14, 2016.
- Continued update of the 2011 value-added CO_2 capture technologies overview document:
  - Reviewed mineralization technologies to determine update/elimination needs.
  - Continued to incorporate and edit the chemical absorption technology updates. References, especially those available online, were checked to ensure that the links are not broken. New references were added as appropriate. Figures were updated or replaced, as necessary.
- Provided information about an electrochemical CO_2 capture technology to a partner.

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).

Highlights

- Received final approval for D49 entitled "Bell Creek Test Site – Transportation and Injection Operations Report" on March 31, 2016.

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

Highlights

- Submitted final revisions to the DOE Operating Carbon Storage Project BPM lead on April 1, 2016.
- Continued work on the Bell Creek Test Site – BPM – Monitoring for CO_2 Storage and CO_2 EOR (D51):
  - Provided sections to a consultant from CETER for review and addition of sections.
  - Made revisions based on review and commentary provided by a consultant from CETER.
- Continued revision of D66 (Bell Creek Test Site – Simulation Report [Update 4]) based on comments from Denbury, including oil–water relative permeability curves, discussion of liquid–gas relative permeability hysteresis effect, sweep efficiency, and seismic description.
- Submitted a list of values to be obtained from Denbury about the Lost Cabin Gas Plant and the Bell Creek Field. These values will improve the accuracy of the life-cycle analysis of Bell Creek Field oil production via EOR.
- Continued investigation of InSAR data to inform analysis and interpretation of future InSAR analyses in Bell Creek.
- **Bell Creek** injection-phase site activities included the following:
  - Sent vendor agreement renewals to Denbury and Schlumberger through 2017.
  - Continued reservoir pressure and distributed temperature monitoring of the 05-06 OW (observation well) from the permanent downhole monitoring (PDM) system using the

casing-conveyed pressure–temperature gauges (PTGs) and fiber-optic distributed temperature system (DTS):
  - ♦ Near-continuous operation since April 2012.
  - ♦ All systems are fully operational.
- Continued dynamic reservoir pressure and multiphase fluid flow simulation efforts:
  - ♦ Continued 4-D vertical seismic profile (VSP) analysis and interpretation, including adjustment to the horizons interpretation and generation of data slices of 4-D VSP differences and comparing 4-D VSP maps with 4-D surface seismic difference maps.
  - ♦ Worked on seismic and well log interpretation for geologic modeling of Phases 3–5 of Bell Creek Field.
  - ♦ Continued work on water-flooding history matching for the Phase 3 regional model. The open boundary and sharp change of water injection rate make the matching process difficult as more uncertainties are involved in the process.
  - ♦ Constructed and worked on a long-term CO_2 migration model at reservoir scale for the Bell Creek oil field based on the Version 2 geologic model with coarse cells. The purpose of the model is to see how CO_2 migrates in the reservoir over 10,000 years. Started testing the two simulation cases: gravity only and gravity plus diffusion.
  - ♦ Initiated testing of several simulation cases on a new cluster node based on the Windows system versus the Linux system on the old node. Compared simulation speeds and found a notable improvement in speed of 25%. Reviewed and compared several simulation results from the simulation cluster.
- Continued passive seismic monitoring of 04-03 OW using the borehole seismic array:
  - ♦ Near-continuous operation since May 22, 2013.
  - ♦ Two full data drives were returned to the EERC from the Bell Creek Field.
- Notified by Denbury that the 4-D seismic data processing from the 2015 seismic campaign has been completed. Delivery of the data from Denbury on hard drive(s) to EERC is expected in May or June 2016.
- Used the most recent publicly available data to determine that cumulative total CO_2 gas injection is 4,489,133 metric tons through January 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).

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

	January 2016 Injection
Total, Mscf	4,129,816
Total, U.S. tons[2]	236,219
Total, metric tons[2]	214,502
Cumulative Total, Mscf [2]	86,429,286
Cumulative Total, U.S. tons[2,3]	4,943,619
Cumulative Total, metric tons[2,3]	4,489,133

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/U.S. ton and 19.253 Mscf/metric ton.

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

- As of December 31, 2015, the most recent month of record, 2.807 million tonnes of total gas (composition of approximately 98% CO2) has been purchased for injection into the Bell Creek Field, equating to an estimated 2.753 million tonnes of CO2 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 CO2 storage volume estimate by correcting the gas purchase volume (approximately 98% CO2) obtained from Denbury's custody transfer meter with gas compositional data.

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

	December 2015 Gas Volume
Monthly Total Gas Purchased, MMscf[2]	1717
Monthly Total Gas Purchased, million tons[2]	0.098
Monthly Total Gas Purchased, million tonnes[2]	0.089
Cumulative Total Gas Purchased, MMscf[2,3]	54,034
Cumulative Total Gas Purchased, million tons[2,3]	3.091
Cumulative Total Gas Purchased, million tonnes[2,3]	2.807
Cumulative Total CO_2 Stored, MMscf[3,4]	53,003
Cumulative Total CO_2 Stored, million tons[3,4]	3.032
Cumulative Total CO_2 Stored, million tonnes[3,4]	2.753

[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 gas CO_2 stored volumes are ***CORRECTED*** for gas composition.

- Continued injection-phase sampling work, including the following:
  - Traveled to Miles City, Montana, for field work at the Bell Creek test site April 4–7, 2016. Distributed landowner packages for all groundwater monitoring activities that occurred after August 2015.
- A summary of all oil and CO_2 gas stream samples collected for analyses to date is provided in Table 3.
- Tentatively scheduled Bell Creek oil compositional monitoring sampling trip for the first week of May 2016. Anticipate collection from six of ten wells for the oil evolution monitoring program. The remaining four wells are not currecntly producing sufficient volumes of oil for collection at this time.
- Continued work on a final overview water quality compilation landowner package covering the entire project.

Table 3. Oil and CO_2 Gas Stream Sampling and Analyses

Stream(s)	Dates Sampled
Production: Oil[1]	Jan 2014, March 2014,[2] May 2014, June 2014, July 2014, Sept 2014, Oct 2014,[2] Jan 2015,[2,3] May 2015,[3,4] June 2015,[3] Nov 2015[3,5]
Production: CO_2 Gas[1]	Sept 2014,[2] Nov/Dec 2014, Jan 2015,[6] March 2015, July 2015
Purchase/Recycle: CO_2 Gas[7]	May 2014,[8] June 2014, July 2014, Sept 2014, Oct 2014, April 2015, July 2015, Sept 2015, Jan 2016

[1] Wells 56-14R, 32-02, and 05-06 unless otherwise noted.
[2] Wells 56-14R and 32-02 only.
[3] Samples collected but not analyzed.
[4] Wells 32-02 and 05-06 only.
[5] Wells 56-14R and 05-06 only.
[6] Well 05-06 only.
[7] Both purchase and recycle streams unless otherwise noted.
[8] Purchase stream only.

Task 10 – Site Closure (John A. Hamling/Larry J. Pekot)

Highlights

- This task was initiated at the start of BP5 on April 1, 2016.

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

Highlights

- This task was initiated at the start of BP5 on April 1, 2016.

Task 12 – Project Assessment (Loreal V. Heebink)

Highlights

- Nothing to note at this time.

Task 13 – Project Management (Charles D. Gorecki)

Highlights

- Petro Harvester Oil & Gas, LLC, joined the PCOR Partnership as a member.
- Based on a discussion with Sarah Forbes of DOE Headquarters, contact was made with a representative of the California Area Resources Board. The PCOR Partnership volunteered to present for a WebEx on May 12, 2016, pertaining to development of qualification methods for the California Low Carbon Fuel Standard, specifically addressing maintaining wellbore integrity throughout CCS.
- Submitted an abstract for presentation at the 5th U.S.–China Symposium on CO_2 Emission Control to be held June 5–7, 2016, in Hangzhou, China. The abstract gives an overview of the PCOR Partnership's CO_2 storage activities.
- Reviewed and commented on the current draft of the DOE Simulation and Risk Assessment BPM. The comments were submitted to DOE on April 1, 2016, along with text for specific

sections of the document as requested. A second request for comments and additional text was received from the authors of the BPM. The document was reviewed and comments provided by the requested due date of April 27, 2016.

- Participated in a DOE BPM synergy Webinar on April 21, 2016. Discussions included the remaining text needs and time line to complete the documents.
- Held the PCOR Partnership Technical Advisory Board (TAB) meeting April 5–6, 2016, in New Orleans, Louisiana. Topics discussed included ongoing work at the Bell Creek and Aquistore Projects, outreach activities (including Bell Creek documentaries), BPMs, and the concept of a PCOR Partnership regional vision for inclusion in the next version of the atlas. TAB members in attendance included James Erdle, Lynn Helms, Ray Hattenbach, Steve Melzer, Neil Wildgust, Stefan Bachu, and Bill Jackson. Mike Jones, while not able to attend the meeting in person, was able to participate in the discussion on April 6, 2016, via phone. Other meeting attendees included Dave Nakles (facilitator) and EERC personnel Charles Gorecki, Jim Sorensen, Ed Steadman, John Harju, and Scott Ayash.
- Continued planning the 2016 PCOR Partnership Annual Membership Meeting, including creating the meeting Web pages.
- Held a task leader meeting April 14, 2016. Topics discussed included the BP5 award, recently submitted journal articles, the TAB meeting held April 5–6, 2016, upcoming conference participation, Bell Creek and Aquistore project updates, recent interest in PCOR Partnership membership, and task leader updates.
- Completed deliverables and milestones in April:
  - March monthly update
  - 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:
  - Made a formal agreement with Elsevier to complete the IJGGC Special Issue as a digital version.
  - Assigned reviewers to all three remaining papers.
  - Completed the review of an author-submitted revision.
  - Returned two of the three submissions to authors for revision.
  - Completed review of submissions.
- Held quarterly conference call on April 27, 2016. The following topics were dicussed:
  - Update on status of Special Issue and associated submissions.
  - Goals for the upcoming year.
  - Potential ideas for the WWG Annual Meeting at the August National Energy Technology Laboratory (NETL) Carbon Storage R&D Meeting.
- Continued discussions with a consultant from CETER regarding the status of remaining submissions for the IJGGC Special Issue, the April conference call, and options for the WWG annual meeting.

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

- April 3–6, 2016: Traveled to New Orleans, Louisiana, to host, present, and participate in the TAB Annual Meeting.
- April 6–8, 2016: Traveled to Washington, D.C., to attend the Carbon Capture Infrastructure Workshop.
- April 4–7, 2016: Traveled to Miles City, Montana, for site work at the Bell Creek Field.
- April 11–15, 2016: Traveled to Mexico City and Villahermosa, Mexico, to attend the NAEMT Carbon Capture Utilization & Sequestration Working Group Meeting.
- April 18–22, 2016: Off-site staff member traveled to the EERC offices in Grand Forks, North Dakota, for meetings and work on state and provincial regulation flowcharts and crosswalk documents.
- April 19–21, 2016: Traveled to Bismarck, North Dakota, to attend the LEC Spring Conference.
- April 22, 2016: Traveled to Fargo, North Dakota, to participate in meetings with PPB.
- April 25–28, 2016: Traveled to Houston, Texas, to attend the Esri Petroleum GIS Conference.

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