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

PHASE III ACTIVITIES

Task 1 – Regional Characterization (Wesley D. Peck)

Highlights

- Presented on well integrity in a presentation entitled "Well Integrity" at the IEA Greenhouse Gas (IEAGHG) R&D Carbon Capture and Storage (CCS) Summer School held July 17–23, 2016, in Regina, Saskatchewan, Canada.
- Continued efforts to update Deliverable (D) 81, Regional Carbon Sequestration Atlas (update), including the following:
  - Completed draft text on carbon markets.
  - Worked on addressing missing/open pages.
  - Added information and rearranged pages through Chapter 7.
  - Continued task-level review as draft sections were completed.
- 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: 96 new North Dakota wells and six new Montana wells added.
  - Updated North Dakota production data.
  - Updated South Dakota and Manitoba projects.
  - Continued database preventive maintenance of Petra projects.
- Searched for North Dakota oil fields with no waterflood activities for charaterization modeling efforts. Worked on digitizing well logs.
- With regard to the **Williston Basin** CO_2 Storage Sink Relative Permeability Laboratory Characterization:
  - Completed testing as able on the first Mission Canyon sample. Testing was stopped after beginning the 30% CO_2 condition because of sample damage.
  - Completed relative permeability testing on a second Mission Canyon Formation sample. This sample tested more smoothly than the first Mission Canyon Formation sample.
  - A representative from North Dakota State University completed CT scans for two post-relative permeability samples that were sent on July 1, 2016. The CT scans should shed light on internal flow pathways that developed during relative permeability testing and resulted in loss of differential pressure.
  - Shifted the focus to data interpretation and drafting the value-added report, with all relative permeability testing complete.

- With regard to the **Aquistore** project's static modeling and dynamic predictive simulations effort:
  - Presented an update on the Aquistore injection, field activities, and modeling and simulation work to the PCOR Partnership Technical Advisory Board (TAB) on a WebEx July 26, 2016.
  - Participated in a Science and Engineering Research Committee (SERC) conference call on July 27, 2016. Discussed the Aquistore Annual Technical Meeting, which will be held August 16, 2016, in Ottawa, Ontario, Canada.
  - Continued to download and process injection and pressure data as available.

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

Highlights

- Submitted D13 (Public Site Updates) on July 21, 2016.
- Submitted an update on July 18, 2016, to the public PCOR Partnership Web site (www.undeerc.org/pcor) to provide access to a CO_2 enhanced oil recovery (EOR) life cycle analysis (LCA) model for the paper submitted to the *International Journal of Greenhouse Gas Control* (IJGCC). Received approval on July 21, 2016. A new page and an updated page went live July 21, 2016.
- Submitted the value-added "Household Energy and Carbon Web Pages Report" for the April 1 – June 30, 2016, quarter on July 25, 2016. Received approval July 27, 2016.
- Provided a first draft of the Greenhouse Gas Control Technologies (GHGT)-13 Conference outreach paper to the coauthors for review and comments. Made revisions.
- Continued work on D16 – Fort Nelson Test Site Fact Sheet (update), including content development for a new four-page layout. Discussed with the internal Fort Nelson lead.
- Provided written comments to the Regional Carbon Sequestration Partnerships (RCSP) Outreach Working Group (OWG) lead for the agenda of the OWG call. Participated in the OWG call on July 21, 2016.
- Continued collaborative efforts with Prairie Public Broadcasting (PPB), including the following:
  - Continued work on documentary D21 (the Bell Creek Story), including the following:
    - Reviewed photos and notes from the site filming trip to the Bell Creek Field on June 28, 2016.
    - Continued interview planning. Charlie Gorecki and Tom Doll, Energy & Environmental Research Center (EERC), will be interviewed in August 2016. Nick Azzolina, The CETER Group (CETER), will be interviewed at a date to be determined. Three other individuals are being contacted.
    - Continued concept review and script and interview question development.
  - Continued work on documentary D22 (Coal and the Modern Age):
    - Sent to Andrea Dunn a request to move D22 from its current due date of July 31, 2016, to January 31, 2017. This request was approved. The project management plan (PMP) will be updated accordingly.
    - Gathered additional background information focused on railroads and coal (past and present).

- ♦ Traveled to northern California July 12–15, 2016, to interview Dr. Julio Friedmann [Lawrence Livermore National Laboratory (LLNL)] and perform location filming with PPB.
- ♦ Continued concept review and script and interview question development.
- ♦ Arrangements are being made to interview Sean Adams, University of Florida, on August 17, 2016.

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:
  - Reviewed "Regulation for Underground Storage of CO_2 Passed by U.S. States" by Holly Javedan, Massachusetts Institute of Technology.
  - Investigated current regulatory and legislative actions within the PCOR Partnership area.
  - Continued review of the draft introduction and background section.
  - Discussed the draft report on a conference call with a consultant from CETER.
  - Began editing Chapters 1–4.

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

Highlights

- **Bell Creek** test site activities included the following:
  - Continued work on the PCOR Partnership Site Characterization Best Practices Manual (BPM) (D35), including working on the executive summary and reorganizing the outline to better align with D102 – Adaptive Management Approach BPM.
  - Continued writing text for the static modeling section for the upcoming Task 9 D66 (Bell Creek Test Site – Simulation Report [Update 5]), related to the near-surface and regional-scale models and pulsed-neutron logging (PNL) campaigns. Created map and images.
  - Continued work on **modeling**, including the following:
    - ♦ Worked on importing the processed fall 2015 seismic data into the model for interpretation.
    - ♦ Worked on conducting an attribute analysis of the fall 2015 seismic data.
    - ♦ Worked on generating seismic decomposition volume with Petrel in order to create images using the fall 2015 seismic data set.
    - ♦ Input perforated intervals for injection analysis in the 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 to incorporate technology updates and new technologies into the update of the 2011 capture technologies overview document.
- Presented on CO_2 transport and worked as a mentor for the students at the IEAGHG CCS Summer School held July 17–23, 2016, in Regina, Saskatchewan, Canada.
- Worked on travel plans for attendance at the NETL Capture Technology Project Review Meeting in Pittsburgh, Pennsylvania, August 8–12, 2016.

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 July 26, 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 June 30, 2016, the most recent month of record, 3.220 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 ***3.162 million tonnes of CO_2 stored***.
- Presented "Adaptive Approach to Modeling and Monitoring 5 Million Tonnes of CO_2 Injection at the Bell Creek Oil Field" at the IEAGHG Modelling and Monitoring Network Meeting held July 7–8, 2016, in Edinburgh, Scotland. The presentation was sent to DOE under separate cover on July 5, 2016.
- The minimum miscibility pressure (MMP) paper entitled "Rapid and Simple Capillary-Rise/Vanishing Interfacial Tension Method to Determine Crude Oil Minimum Miscibility Pressure: Pure and Mixed CO_2, Methane, and Ethane" was formally accepted by *Energy and Fuels* after very minor revisions. The authors include Steven B. Hawthorne, David J. Miller, Lu Jin, and Charles D. Gorecki. The paper provides a simplification of the capillary-rise/vanishing interfacial tension method to measure MMP. The paper has been formally published in the online version and is citable. Open access is now available.
- EERC personnel traveled along with representatives from Denbury to meet with two representatives from Arcis at the Arcis facilities in Calgary, Alberta, Canada, on July 18, 2016. The purpose of the meeting was to discuss and review final processing of the Bell Creek 3-D seismic data.
- Continued working on organizing a Schlumberger-led logging workshop. This is planned to be held at the EERC in early fall and will include logging tools, applications, principles, processing, and interpretation.
- Continued work on D66 (Bell Creek Test Site – Simulation Report [Update 5]), including the following:

  - Worked on the outline.
  - Drafted the introduction and two sections.
  - Conducted literature review of CO_2 flooding field cases to use as supporting references.
  - Used information from D66 to work on the draft of a GHGT-13 paper.
- Finalized the spreadsheet LCA model posted on the PCOR Partnership public Web site by Task 2 personnel. A references tab was added, along with minor editing changes. Worked with a consultant from CETER to incorporate these changes. Work using this model is presented in a paper recently published by IJGGC, which directs readers to the PCOR Partnership Web page focused on the model. The EERC is pursuing open access for this paper.
- E-mailed a Denbury representative with a follow-up request for additional information critical for completing the site-specific Bell Creek LCA work. Denbury agreed to supply data and will review and approve its use prior to publication.
- **Bell Creek** injection-phase site activities included the following:
  - 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.
    - Traveled to the Bell Creek Field July 11–13, 2016, to download DTS unit and MOREVision data, which included:
      - DTS data: March 23 – July 11, 2016 (this is the first acquired data since the unit was repaired March 23, 2016).
      - MOREVision data: October 31, 2015 – February 29, 2016 and March 23 – July 11, 2016.
  - Continued modeling and simulation efforts:
    - Analyzed production–injection data for the whole Bell Creek Field for CO_2 flooding. Integrated the processed CO_2 flooding data through April 2016 into the Bell Creek Phase 3 simulation model and adjusted the simulation model to match the production data. The data will be used in D66.
    - Generated simulation results for use in D66.
    - Successfully matched the CO_2 flooding history for Phase 3 and prepared the results for the D66 report.
    - Worked on designing new continuous CO_2 injection (CCI) and water alternating gas (WAG) predictive simulation cases for oil production and CO_2 storage prediction.
    - Generated plots for CO_2 flooding and storage performance analysis for the entire field, including oil production, water production and injection, and gas production, injection, and storage.
    - Constructed ten simulation cases with the main impurities observed in recycled gas using the 7-component PVT model in the Bell Creek Phase 1 and 2 areas for long-term performance prediction and comparison.
  - Continued passive seismic monitoring of 04-03 OW using the borehole seismic array:
    - Near-continuous operation since May 22, 2013.
  - Continued working with the processed fall 2015 seismic monitor data received from Denbury:

- Worked to add Montana State Plane and NAD 1927 UTM coordinates to the headers of the newly arrived Bell Creek 3-D seismic data sets. The EERC has legacy work on the seismic data using these two coordinate systems. For reasons unknown, the new data came to the EERC as NAD 83 UTM 13N, a different projection from what had been provided in the past.
- Loaded data into the processing/interpretation software (after coordinate conversion).
- Worked on quality assurance/quality control of the data.
- Created preliminary 4-D images showing reservoir and time-lapse differences.
- Continued well-tie and horizon interpretation.
- Continued interpretation by integration with well logs.

- Downloaded GIS files for use with InSAR analysis from TRE Canada.
- Used the most recent publicly available data to determine that cumulative total CO_2 gas injection is 5,246,581 metric tons through May 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 May 2016 (cumulative totals May 2013 to May 2016)[1]

	May 2016 Injection
Total, Mscf	3,622,008
Total, U.S. tons[2]	207,173
Total, metric tons[2]	188,127
Cumulative Total, Mscf[2]	101,012,416
Cumulative Total, U.S. tons[2,3]	5,777,751
Cumulative Total, metric tons[2,3]	5,246,581

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 June 30, 2016, the most recent month of record, 3.220 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 3.162 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.
- Continued injection-phase sampling work. Traveled to Gillette, Wyoming, July 18–22, 2016, to distribute landowner packages and collect samples. Specifics include the following:
  - ♦ Completed distribution of final landowner packages. Key summaries and landowner letters were provided for each landowner.
  - ♦ Delivered release notification letter for the Fox Hills wells to the landowner.
  - ♦ Collected oil samples with a representative from Denbury from the following wells: 56-14R, 32-02, 05-06, 04-04, 28-02, 21-10, and 21-14.
  - ♦ Collected purchase/recycle CO_2 gas samples from the Bell Creek Field.
- A summary of all oil and CO_2 gas stream samples collected for analyses to date is provided in Table 3.
- Continued analyzing the "miscible" phase data generated for several different pressures.
- Traveled to Gillette, Wyoming, July 25–29, 2016, for soil-gas profile station and Fox Hills wells sampling.
- Created a Bell Creek soil gas sample GeoPDF map based on available data.

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

	June 2016 Gas Volume
Monthly Total Gas Purchased, MMscf[2]	1059
Monthly Total Gas Purchased, million tons[2]	0.061
Monthly Total Gas Purchased, million tonnes[2]	0.055
Cumulative Total Gas Purchased, MMscf[2,3]	62,004
Cumulative Total Gas Purchased, million tons[2,3]	3.547
Cumulative Total Gas Purchased, million tonnes[2,3]	3.220
Cumulative Total CO_2 Stored, MMscf[3,4]	60,879
Cumulative Total CO_2 Stored, million tons[3,4]	3.482
Cumulative Total CO_2 Stored, million tonnes[3,4]	3.162

[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.

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] May 2016,[6] July 2016[7]
Production: CO_2 Gas[1]	Sept 2014,[2] Nov/Dec 2014, Jan 2015,[8] March 2015, July 2015
Purchase/Recycle: CO_2 Gas[9]	May 2014,[10] June 2014, July 2014, Sept 2014, Oct 2014, April 2015, July 2015, Sept 2015, Jan 2016, July 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] Wells 56-14R, 05-06, 04-04, 28-02, 21-10, and 21-14.
[7] Wells 56-14R, 32-02, 05-06, 04-04, 28-02, 21-10, and 21-14.
[8] Well 05-06 only.
[9] Both purchase and recycle streams unless otherwise noted.
[10] Purchase stream only.

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

- Nothing to note at this time.

Task 13 – Project Management (Charles D. Gorecki)

Highlights

- Held a TAB WebEx on July 26, 2016. An update on the Aquistore injection, field activities, and modeling and simulation work was presented. Seven of the nine TAB members were able to participate and provided feedback on the work presented. The next TAB activity is a meeting to be held in conjunction with the PCOR Partnership Annual Membership Meeting and Workshop for those TAB members who will be in attendance.
- Continued work on D102 – Adaptive Management Approach BPM, including the following:
  - Held a WebEx meeting on July 1, 2016, with a consultant from CETER. Discussed definitions of phases and technical activities involved in the adaptive management

approach. These definitions will serve as a consistent basis across all PCOR Partnership BPMs.
  - Reviewed and revised the latest version of the document summary. Worked with a consultant from CETER.
  - Held a WebEx meeting on July 18, 2016, with a consultant from CETER. Discussed new and revised figures for the document.
- Continued planning the PCOR Partnership Annual Membership Meeting and Workshop to be held September 13–15, 2016, in Grand Forks, North Dakota, including the following:
  - Sent an e-mail blast July 19, 2016, asking for opinions on the topics for the premeeting workshop, inviting members to become special event sponsors, and reminding attendees about hotel accommodations. Received feedback from the members on the premeeting workshop to do a combined CO_2 capture and storage half-day seminar with tours of the EERC characterization laboratories and the CO_2 capture pilot facilities.
  - Began calling speakers and received confirmation for more than one-half of the presentations thus far.
- Began planning a side meeting of the PCOR Partnership TAB to be held in conjunction with the PCOR Partnership Annual Membership Meeting and Workshop in September 2016.
- Held a task leader meeting June 13, 2016. Topics discussed included recent and upcoming conference participation, Bell Creek and Aquistore project updates, PCOR Partnership Annual Membership Meeting and Workshop planning, and task leader updates.
- Completed deliverables and milestones in July:
  - June monthly update
  - Task 2: D13 – Public Site Updates
  - Task 13: D58/D59 – Quarterly Progress Report/Milestone Quarterly Report

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

Highlights

- Distributed WWG meeting notes from the April 2016 conference call.
- Provided Andrea McNemar with an update on WWG activities via phone conversation.
- With regard to the IJGGC Special Issue:
  - Returned two papers to authors for a third round of revisions. Both sets of revisions are minor and will complete the work on these submissions.
  - Approved the final revision of a submission. This is the third completed paper. Five papers remain in the revision phase and are nearing completion.
- Continued preparations for the WWG Annual Meeting to be held August 17, 2016, in Pittsburgh, Pennsylvania, including the following:
  - Distributed the meeting announcement on July 6, 2016.
  - Invited Robert Trautz to present on the Electric Power Research Institute's BEST (brine extraction and storage test) project.
  - Invited Dr. Radisav Vidic and William Hall as potential guest speakers.
  - Invited additional participants from DOE's crosscutting groups projects.
  - Reviewed meeting plans and hotel arrangements.
  - Formalized the agenda and an e-mail blast for distribution of the agenda.
  - Created outline and initiated slides for presentation of WWG activities.

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

- July 2–9, 2016: traveled to Edinburgh, Scotland, to attend the IEA Greenhouse Gas R&D Modeling and Monitoring Network Conference and field trip.
- July 11–13, 2016: traveled to Glendive, Montana, for data download from MOREVision and DTS units at the Bell Creek observation well.
- July 12–15, 2016: traveled to San Francisco, California, for location shoots and to conduct interviews for the upcoming coal documentary (D22).
- July 16–24, 2016: traveled to Regina, Saskatchewan, to attend and present at the IEA Greenhouse Gas International Interdisciplinary Carbon Capture & Sequestration Summer School.
- July 17–19, 2016: traveled to Calgary, Alberta, for meetings with Arcis.
- July 18–22, 2016: traveled to Miles City, Montana, to collect oil samples from Denbury staff.
- July 19–21, 2016: traveled to Bismarck, North Dakota, to attend the WBI Energy Customer Meeting and the NDIC Special Session.
- July 25–29, 2016: traveled to Gillette, Wyoming, to sample soil-gas profile stations and Fox Hills wells.

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