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

PHASE III ACTIVITIES

Task 1 – Regional Characterization (Wesley D. Peck)

Highlights

- Attended the Research Experience in Carbon Sequestration (RECS) Course in Birmingham, Alabama, held June 12–20, 2016. The program offers graduate students and early career professionals hands-on field research experience in areas related to carbon capture, utilization, and storage (CCUS) and is hosted by Southern Company and the Southeast Carbon Sequestration Partnership.
- Attended the 2016 ESRI GIS (geographic information systems) User Conference in San Diego, California, held June 27–30, 2016.
- Participated in a Webinar on June 20, 2016, hosted by the U.S. Department of Energy (DOE) National Energy Technology Laboratory (NETL) to introduce the newest National Risk Assessment Partnership (NRAP) tools on the Energy Data Exchange (EDX) workspace: the Multiple Source Leakage Reduced-Order Model (MSLR) and the Ground Motion Prediction Applications to Potential Induced Seismicity (GMPIS).
- Continued efforts to update Deliverable (D) 81, Regional Carbon Sequestration Atlas (update), including:
  - Continued updating and adding information through Chapter 6.
  - Added image and text to the Aquistore project pages.
  - Worked on text and figures on the topic of life cycle analysis (LCA). Discussed a figure with a consultant from The CETER Group (CETER).
  - Worked on carbon market research.
  - Compiled CO_2 enhanced oil recovery (EOR) tax incentive information for Colorado, Montana, Wyoming, Texas, Louisiana, North Dakota, and Oklahoma.
- Worked with a summer intern to select potential oil fields for production-based CO_2 storage calculations.
- Responded to a question from the Institute for Defense Analyses (IDA) Science and Technology Policy Institute, a group that is preparing the 2016 National Earth Observations Assessment. They wanted to ensure that they had accurately represented the PCOR Partnership rating of the relative impacts of Earth-observing data sources used in our work with the National Carbon Sequestration Database and Geographic Information System (NATCARB).
- 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: 84 new North Dakota wells and eight new Montana wells added.
  - Updated North Dakota production data.
  - Updated South Dakota, Manitoba, and Saskatchewan projects with well and production data, as available.
  - Continued database preventive maintenance of Petra projects.
- With regard to the **Williston Basin** CO_2 Storage Sink Relative Permeability Laboratory Characterization:
  - Completed relative permeability testing on the fifth sample (second Lodgepole limestone).
  - Initiated relative permeability testing for the sixth sample (Mission Canyon Formation).
  - Working with the data from previous samples.
- With regard to the **Aquistore** project's static modeling and dynamic predictive simulations effort:
  - Attended Computer Modelling Group's (CMG's) 37th Technical Symposium held June 13–14, 2016, in Calgary, Alberta, Canada. Presented on history matching in a presentation entitled "An Update of Aquistore CO_2 Storage Simulation."
  - Attended a CMOST Workshop held June 15–17, 2016, in Calgary, Alberta, Canada.
  - Participated in a Science and Engineering Research Committee (SERC) conference call.
  - Continued to download and process injection and pressure data as available.
  - Conducted preliminary simulations to investigate reservoir performance and storage at higher injection rates.

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

Highlights

- Received approval for D17 entitled "General Phase III Information PowerPoint Presentation (Update 7)" on June 8, 2016.
- Received approval for D11 entitled "Outreach Action Plan (Update 2)" on June 9, 2016.
- Presented on carbon capture and storage (CCS) and the PCOR Partnership at the annual Lignite Energy Council (LEC) teacher workshop in Bismarck, North Dakota, on June 14, 2016. Distributed outreach packet (atlas, PowerPoint, and DVDs). Ninety-seven teachers were in attendance.
- Received notification on June 14, 2016, that the abstracts entitled "Regionwide and Project-Level Outreach – The PCOR Partnership Approach" and "Engaging Teachers to Facilitate Learning – PCOR Partnership Outreach in Action" were accepted for oral and poster presentations, respectively, at the Greenhouse Gas Control Technologies (GHGT)-13 Conference in Lausanne, Switzerland, November 14–18, 2016. The poster was withdrawn.
- Received notification on June 14, 2016, that the abstract entitled "Communicating about the Geological Storage of Carbon Dioxide – Comparing Public Outreach for CO_2-EOR and Saline Storage Projects" (Norm Sacuta, Petroleum Technology Research Centre [PTRC], is corresponding author) was accepted for oral presentation at the GHGT-13 Conference in Lausanne, Switzerland, November 14–18, 2016.
- Completed a draft of D13 (Public Site Update) for the PCOR Partnership public Web site.

- Responded to an inquiry by Sarah Wade, lead for the Regional Carbon Sequestration Partnerships (RCSP) Outreach Working Group (OWG), on scheduling and topics for upcoming meetings and conference calls.
- Participated in the monthly OWG conference call on June 16, 2016. The subject was outreach budgets.
- Continued efforts with regard to the public Web site (www.undeerc.org/pcor), including the following:
  - Continued work on future updates, including preparing technical reports for uploading to the public PCOR Partnership Web site based on the search engine optimization standard operating procedures (SOPs) and worked on a new page for CO_2 EOR LCA.
  - Continued ongoing identification and repair of broken links.
- Continued collaborative efforts with Prairie Public Broadcasting (PPB):
  - Continued work on documentary D21 (the Bell Creek Story), including the following:
    - Finalized arrangements and traveled to the Bell Creek oil field site on June 28, 2016, with PPB personnel for filming, including aerial filming of the field and pipeline route.
    - Continued script development.
  - Continued work on documentary D22 (Coal and the Modern Age), including the following:
    - Continued script development and revisions, including additional research, based on internal review sessions.
    - Identified three potential interviewees and made arrangements to travel to LLNL in California to obtain an interview and do location filming.
    - Discussed scheduling with Energy & Environmental Research Center (EERC) senior PCOR Partnership management and PPB.
    - Discussed content and next steps with EERC senior PCOR Partnership managers.
    - Discussed itinerary and arrangements for a mid-July 2016 California trip to conduct an interview with Dr. Friedmann at Lawrence Livermore National Laboratory (LLNL) and shoot locations in the area. Developed interview questions.
    - Traveled to the Gillette, Wyoming, area June 27–29, 2016, for filming, including aerial filming of surface coal mines and power plants.

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 and discussed the first draft with a consultant from CETER and a senior EERC manager.
  - Reviewed Alberta, Canada, regulations on CCS.
- Prepared for participation in the International Oil and Gas Compact Commission (IOGCC) Annual Conference. The planned participation at the Groundwater Protection Council (GWPC) meeting is in conflict with the PCOR Partnership Annual Meeting.

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 preparation of an initial draft of the executive summary and internal discussion meetings.
  - Continued work on **modeling**, including the following:
    - Completed the preliminary Bell Creek near-surface model. Researched the reaction between CO_2 and various lithologies. This model will be used to help understand the effect of CO_2 storage on the near-surface environment. The model will be reviewed with the team and updated as needed.
    - Placed "hard" (measured) petrophysical property data in bins determined by our revised facies interpretation (according to our updated understanding of the Muddy Formation deposition) in the Version 3 facies model. This process will highlight specific differences between well log-interpreted facies and enable petrophysical property distributions to occur in a specific manner. The Fall 2015 seismic monitor data have been received and are being used to inform facies-modeling activities in the northern end of the Bell Creek Field (Phases 3–7).
    - Created 4-D seismic difference displays for use in modeling, simulation, and presentations.

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 update of the 2011 value-added CO_2 capture technologies overview document.
- Submitted the *Energy & Environmental Science* manuscript on June 15, 2016. This was a reformat of the manuscript that was included in the value-added report entitled "Assessing Temporary Storage Options to Manage Variable-Rate CO_2 Emissions for Use During Enhanced Oil Recovery."
- Prepared slides for a presentation on CO_2 pipelines that the task lead will give at the International Energy Agency Greenhouse Gas R&D Programme (IEAGHG) CCS Summer School to be held July 17–23, 2016, in Regina, Saskatchewan, Canada. The task lead will present the information and mentor attendees.

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 an abstract entitled "Adaptive Approach to Modeling and Monitoring 5 million tonnes of CO_2 Injection at the Bell Creek Oil Field" to be presented at the IEAGHG Modelling and Monitoring Network Meeting to be held July 7–8, 2016, in Edinburgh, Scotland. Prepared and sent the presentation for the meeting to Denbury for review/comment.
- Attended CMG's 37th Technical Symposium held June 13–14, 2016, in Calgary, Alberta, Canada. Presented on Bell Creek simulation and history matching in a presentation entitled "A Systematic Simulation Study of CO_2 Flooding in the Bell Creek Oil Field."
- Attended the American Rock Mechanics Symposium in Houston, Texas, June 26–29, 2016, as well as workshops June 24–25, 2016.
- Worked on planning a logging workshop. This workshop will be led by Schlumberger at the EERC and will include logging tools, applications, principles, processing, and interpretation.
- Submitted cover photo selections to DOE Operating Carbon Storage Project BPM lead on June 15, 2016.
- Continued to work on acquiring data from Denbury for the Bell Creek Field-specific LCA models.
- Submitted LCA journal article entitled "How Green Is My Oil? A Detailed Look at Greenhouse Gas Accounting for CO_2–Enhanced Oil Recovery (CO_2–EOR) Sites" prior to resubmission to the IJGGC. The article was published on June 21, 2016, in Volume 51, August 2016, pages 369–379. The authors include Nicholas A. Azzolina and David V. Nakles of CETER; Wesley D. Peck, John A. Hamling, Charles D. Gorecki, Scott C. Ayash, and Thomas E. Doll of the EERC; and L. Stephen Melzer of Melzer Consulting.
- Continued working on preparing a Web page for the LCA spreadsheet model to place on the public PCOR Partnership Web site. Work conducted using this model was presented in the IJGGC article (see previous bullet). An overview tab was added to the spreadsheet to give basic information about the model and include the EERC disclaimer and DOE acknowledgment and disclaimer.
- **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.
  - Continued dynamic reservoir pressure and multiphase fluid flow simulation efforts, including:
    - Consistent progress since April 2011.
    - Matching waterflooding history of Phase 3 in the Bell Creek oilfield. Because of the open boundary of this phase, there is uncertainty of fluid flow between phases.
    - Working on the CO_2 flooding simulation model for Bell Creek Phase 3, tuning simulation settings to improve the running speed. Successfully debugged issues during the CO_2 flooding stage in the simulation model.
    - History-matching production and injection through April 2016.

- Processed CO_2 flooding data from November 2014 to January 2016 for the Bell Creek Phase 3 simulation model. The data will be used in Update 5 of the D66 Report "Bell Creek Test Site – Simulation Report" due August 31, 2016.
- Continued passive seismic monitoring of 04-03 OW using the borehole seismic array:
  - Near-continuous operation since May 22, 2013.
- Received Fall 2015 seismic monitor data from Denbury. The data cover part of the Bell Creek Phase 2 area and all of Bell Creek Phases 3–6.
- Used the most recent publicly available data to determine that cumulative total CO_2 gas injection is 5,058,454 metric tons through April 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 April 30, 2016, the most recent month of record, 3.100 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 3.004 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.
- Received notification that Denbury took a first look at the time-lapse InSAR data processing. Preliminary results for Bell Creek Phase 4 show promise. TRE Canada is working on methodology to interpret data for Bell Creek Phases 1–3. Results are anticipated to be provided to the EERC in July 2016.
- Continued "miscible"-phase sampling of Bell Creek crude oil at various conditions.
- A summary of all oil and CO_2 gas stream samples collected for analyses to date is provided in Table 3.
- Analyzed and processed data for 21 soil gas sample bags collected at soil gas profile stations in the Bell Creek Field on May 24, 2016.
- Reviewed field data from the May 25, 2016, Fox Hills groundwater-monitoring event.

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

	April 2016 Injection
Total, Mscf	3,751,764
Total, U.S. tons[2]	214,595
Total, metric tons[2]	194,866
Cumulative Total, Mscf [2]	97,390,408
Cumulative Total, U.S. tons[2,3]	5,570,578
Cumulative Total, metric tons[2,3]	5,058,454

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.

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

	April 2016 Gas Volume
Monthly Total Gas Purchased, MMscf[2]	1271
Monthly Total Gas Purchased, million tons[2]	0.073
Monthly Total Gas Purchased, million tonnes[2]	0.066
Cumulative Total Gas Purchased, MMscf[2,3]	59,689
Cumulative Total Gas Purchased, million tons[2,3]	3.414
Cumulative Total Gas Purchased, million tonnes[2,3]	3.100
Cumulative Total CO_2 Stored, MMscf[3,4]	58,604
Cumulative Total CO_2 Stored, million tons[3,4]	3.352
Cumulative Total CO_2 Stored, million tonnes[3,4]	3.044

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

- Final landowner packages have been printed for distribution to landowners. Key summaries, landowner letters, and consistent formatting are provided for each landowner. A Denbury representative has approved the packages for distribution, which will occur in the coming weeks.

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

- **General Electric Global Research Oil & Gas Technology Center (GE) joined the PCOR Partnership as a paying member.**
- Attended and presented at the 5th U.S.–China Symposium on CO_2 Emission Control held in Hangzhou, China, June 5–7, 2016. The presentation gave an overview of the PCOR Partnership's CO_2 storage activities.
- Presented an overview of the PCOR Partnership program in a presentation entitled "The Plains CO_2 Reduction (PCOR) Partnership: Guiding CCS Deployment in Central North America" at the Annual CCUS Conference held June 14–16, 2016, in Tysons, Virginia.
- Presented an update of the PCOR Partnership to Andrea McNemar during her visit to the EERC on June 21, 2016.
- Attended the 2016 Carbon Sequestration Leadership Forum (CSLF) Mid-Year Meeting held June 27–30, 2016, in London, United Kingdom.
- Received confirmation that nine PCOR Partnership abstracts have been accepted for GHGT-13. One was withdrawn, as it was accepted as a poster; therefore, eight will be presented.
- Continued work on D102 – Adaptive Management Approach BPM. A draft document of definitions was prepared and is under internal review.
- Provided suggestions for cover images of the DOE Simulation and Risk Assessment BPM. These were sent to the DOE points of contact for this document.
- Continued planning the 2016 PCOR Partnership Annual Membership Meeting. Discussed topics including potential speakers, agenda, workshop topic, evening events, and sponsors.
- Completed deliverables and milestones in June:
  - May monthly update

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

Highlights

- Received approval for D101 entitled "Water Working Group Web Site Content Update" on June 1, 2016.
- With regard to the IJGGC Special Issue:
  - Discussed and made revisions to the introductory manuscript with a consultant from CETER.
  - Comments were received for one paper, resulting in the paper being returned to the author for minor revisions.

- Discussed WWG activities with Andrea McNemar during her visit to the EERC on June 21, 2016.
- With regard to the WWG Annual Meeting:
  - Selected August 17, 2016, at the Sheraton Station Square in Pittsburgh, Pennsylvania.
  - Began development of agenda, meeting announcements, and signage.
  - Discussed plans and potential visitors and presenters 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

- June 2–8, 2016: Traveled to Hangzhou, China, to attend and present at the 5th U.S.–China Symposium on CO_2 Emission Control Science Technology.
- June 8–16, 2016: Traveled to Tysons, Virginia, to attend and present at the CCUS Conference.
- June 10–19, 2016: Traveled to Calgary, Alberta, Canada, to attend the CMG Technical Symposium.
- June 12–21, 2016: Traveled to Birmingham, Alabama, to attend the Education in CCUS training and conference.
- June 13–14, 2016: Traveled to Bismarck, North Dakota, to present at the LEC Teacher Seminar.
- June 23–30, 2016: Traveled to Houston, Texas, to attend American Rock Mechanics Association (ARMA) 50th U.S. Rock Mechanics Symposium and workshops.
- June 24–30, 2016: Traveled to San Diego, California, to attend the ESRI User Conference.
- June 27–29, 2016: Traveled to Gillette, Wyoming, to film with PPB for documentary.
- June 27–30, 2016: Traveled to London, United Kingdom, to attend the 2016 CSLF Mid-Year Meeting.

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