Plains CO_2 Reduction (PCOR) Partnership Monthly Update
July 1–31, 2015

PHASE III ACTIVITIES

Task 1 – Regional Characterization (Wesley D. Peck)

Highlights

- Downloaded a fresh dataset of U.S. CO_2 sources from the U.S. Environmental Protection Agency (EPA) Web site for the annual updating of CO_2 sources within the PCOR Partnership region.
- Continued working with data for the annual updating of carbon dioxide (CO_2) sources within the Plains CO_2 Reduction (PCOR) Partnership region.
- Worked on compiling regional characterization data for the Mission Canyon Formation.
- Modified the scope of work for the Williston Basin relative permeability laboratory work to include brine permeability and to include PCOR Partnership partner Stefan Bachu, Alberta Innovates – Technology Futures (AITF), as a coauthor on a peer-reviewed paper. Reviewed relative permeability and interfacial tension work conducted by Stefan Bachu and Brant Bennion in preparation for this work and to ensure the scope was adequate for creating a similar product.
- Worked on renewing several Schlumberger software licenses.
- Worked on preparations regarding the extension to Budget Period (BP) 4.
- Continued on gathering data for value-added formation evaluations within the PCOR Partnership region.
- The model was updated with a new grid system. This model will be used to evaluate the CO_2 plume distribution during longer simulation runs.
- Worked on optimizing the simulation runs using CMOST history-matching software (part of Computer Modelling Group's (CMG's) GEM software package). The simulations were optimized to run twice as fast as the previous runs using new numerical parameters.
- Met to discuss updates to the PCOR Partnership Decision Support System (DSS).
- Updated information and continued work on the partners-only DSS Web site:
  - Updated the PCOR Partnership Annual Meeting information on the partners-only DSS Web site.
  - Made changes and updated CO_2 sources.
  - Continued database preventive maintenance of Petra projects.
  - Updated North Dakota and Montana Petra projects with the latest general well information from each state's online resource: 136 new North Dakota wells and five new Montana wells were added.

  - Extracted 2013 Saskatchewan oil pool into database-friendly format. Updated Saskatchewan oilfields' shapefile with the updated oil pools information collected. Will be using the information collected to run analyses on ranking the oil fields/pools.
  - Worked on importing retrieved Wyoming LAS logs into Petra project
  - Updated North Dakota and Manitoba monthly production information.
  - Updated South Dakota, Saskatchewan, and Manitoba wells.
- With regard to the **Aquistore** project's static modeling and dynamic predictive simulations effort:
  - Continued to update database with daily injection data from Petroleum Technology Research Centre (PTRC).
  - Updated simulation model with thinner layers for selected zones to more accurately predict CO_2 arrival at observation wells and match pressure response.
  - Worked on the Aquistore poster for the U.S. Department of Energy (DOE) Carbon Storage R&D Project Review Meeting in August.
  - Worked on comparing properties in the static model with the history-matched simulation model properties. The purpose is to compare the two models to ensure changes made to achieve a history match make sense with the known geologic data.
  - Worked on sensitivity analysis and update of the simulation model.
  - A summer graduate student intern has been helping with Aquistore modeling activities. He has been reviewing previously developed static and dynamic models, including comparing the current dynamic history-matched simulation model with the static model to compare properties. This information will be used to reinvestigate the model data for accuracy, and the static model will be updated as necessary.
  - Worked on updating model properties to more closely match the pressure response in simulation results.
  - Worked on filtering noise from the field data for use in the simulations.

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

Highlights

- Finalized and submitted an abstract for a poster for the DOE Carbon Storage R&D Project Review Meeting in August.
- Continued preparation of materials for the poster "PCOR Partnership Outreach – A Multifaceted Program" for the DOE Carbon Storage R&D Project Review Meeting in August.
- On July 27, the Task 2 team took part in a monthly outreach update call with Aquistore personnel.
- Held a quarterly update meeting with PCOR Partnership senior managers. Prepared a list of action items resulting from the meeting and prepared draft slides for an internal follow-up session.
- Reviewed Deliverable 11 (D11) (Outreach Action Plan) in anticipation of the next update.
- Reviewed the content of the poster "PCOR Partnership Outreach – A Decade of Achievement" (created for the Carbon Storage R&D Project Review Meeting held in Pittsburgh, Pennsylvania, August 20–22, 2013). Made a list of elements that should be updated or modified for future meeting posters.

- Continued to revise the draft Phase II project fact sheets, including meetings with project personnel to discuss content, with a focus on addressing comments from senior management regarding Northwest McGregor and the results section regarding the Lignite fact sheet.
- Continued efforts with regard to the public Web site (www.undeerc.org/pcor), including the following:
  - Continued work on PCOR Partnership public Web site updates, including addressing comments from internal review.
  - Continued ongoing identification and repair of broken links.
- Continued collaborative efforts with Prairie Public Broadcasting (PPB), including the following:
  - Traveled to White Salmon, Washington, June 29 – July 1, 2015, for a documentary D22 interview.
  - Continued preparations and scheduling for upcoming D22 interviews in North Dakota and Minnesota.
  - Traveled to Fargo, North Dakota, July 27, 2015, to work with PPB on the upcoming documentary.
  - Continued preparations for filming in relation to D22, including an interview at the Energy & Environmental Research Center (EERC) tentatively scheduled for mid-August. Discussed arrangements and revised questions for the interviewee.
    - Prepared interview questions.
  - Continued work on Education Presentations Video Series Parts 3 and 4.

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

Highlights

- Staff traveled to Deadwood, South Dakota, July 22–23, 2015, to host and present at the 2015 PCOR Partnership Regulatory Roundup.
- Attended the University of Wyoming's Enhanced Oil Recovery Institute's 9th Annual CO_2 Enhanced Oil Recovery (EOR) Conference and workshops in Casper, Wyoming, July 14–16, 2015.
- Discussed recommendations on Class II to Class VI UIC (underground injection control) transition with the Interstate Oil and Gas Compact Commission (IOGCC) Environment and Safety Chairman through e-mail correspondence.
- Continued gathering information for value-added report on rules, regulations, and statutes for various scenarios of CCS geologic storage and for CO_2 EOR for each of the PCOR Partnership states and provinces.
- Created a poster on carbon capture and storage (CCS) permitting in the PCOR Partnership Program region for the DOE Carbon Storage R&D Project Review meeting in August.
- Continued planning for D8, Permitting Review – Update 2, due September 30, 2015, including checking the status of the North Dakota primacy application and changes to the Canadian and U.S. EPA regulations.

Task 4 – Site Characterization and Modeling (James A. Sorensen)

Highlights

- **Bell Creek** test site activities included the following:
  - Held a 4-day JewelSuite software training session July 28–31. Baker Hughes led this training at the EERC facilities. Several EERC staff attended. The software package will be used in future geo-modeling and simulation activities. One advantage of this software package is the use of VARI grids, which offer better flexibility for CMG in near-wellbore region phenomena simulation.
  - Updated databases with well information to ensure the most accurate data are available for use on the PCOR Partnership DSS and in future products.
  - Worked on creating facies logs for wells in the Bell Creek Field. These logs will be important as control points for a multiple-point statistics facies distribution that will be performed in the model.
  - Worked on the inversion of the reprocessing of the 3-D surface seismic data, including building the initial model for prestack inversion, extracting statistical wavelets from the data, and correlating wells with the seismic data. Held an internal meeting to discuss results and a path forward on using 3-D seismic data inversion to compute geomechanical properties to support the modeling efforts.
  - Continued working on improving the 3-D rock mechanical properties using additional information from well logs, pulsed neutron logs (PNLs), lab data, and 3-D seismic data.
  - Worked on creating detailed cross sections in Phases 3–6 to determine both lateral and vertical facies associations. This will serve as a knowledge base for modeling efforts in Phases 3–6.
  - Conducted literature review regarding geostatistical applications in geological modeling, including multiple-point statistics for facies modeling processes.
  - Continued analyzing the formation tops in the Version 2 geologic model. Tops are being adjusted as needed to create a more realistic structure which, in turn, will lead to better simulation and history-matching results.
  - Worked on quality control of Bell Creek reservoir top picks in all phases of the field.
  - Worked on adding core logs into the model to reflect wells with core samples.
  - Adjusted the well tops for several formations for a number of wells.
  - Worked on testing the time shift between previous and newly processed seismic data to assess any differences.
  - Finished picking horizons using the 3-D baseline seismic data.
  - Initiated modeling efforts on Bell Creek Phases 3–7. Initial efforts are focused on reservoir tops quality control and facies log construction.
  - Summer graduate student interns continued preparing Bell Creek data for modeling.
  - Continued work on the PCOR Partnership site characterization best practices manual (BPM) (D35).
  - Continued exploring the geomechanics module of COMSOL multiphysics and investigating the application of this software to the Bell Creek geomechanical simulation work.
  - Continued work on Applied Geology Laboratory activities, which included the following:
    - With regard to the 33-14R core (collected April 2013):
      - Continued work on the permeability-to-air report.

- ♦ With regard to the 56-14R full-core plugs (collected March 2013):
  - Continued work on final report, including a brine permeability study.

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

This task ended in Quarter 3 – BP4, Year 7 (June 2014).

Task 6 – Infrastructure Development (Melanie D. Jensen)

Highlights

- Continued internal PCOR Partnership management review of a value-added report entitled "Assessing Temporary Storage Options to Manage Variable-Rate CO_2 Emissions for Use During Enhanced Oil Recovery." Following DOE review, the authors plan to submit the manuscript for possible publication in *Energy & Environmental Science*.

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)

Highlights

- Continued preparation of D49 (due September 30, 2015), the Bell Creek Test Site Transportation and Injection Operations Report.

Task 9 – Operational Monitoring and Modeling (Charles D. Gorecki)

Highlights

Bell Creek injection-phase site activities included the following:

- Attended the 2015 U.S. Rock Mechanics Geomechanics Symposium and Workshop in San Francisco, California, held June 27 – July 1, 2015.
- Continued development of D66, the modeling and simulation report (due August 31, 2015). Provided a copy to senior management for review.
- Began creating a poster for the DOE Carbon Storage R&D Project Review Meeting focused on minimum miscibility pressure experimentation.
- Continued verification experimentation of mobilized hydrocarbons using methane, CO_2, and ethane.
- Continued miscible-phase sampling of mobilized hydrocarbons using methane, CO_2, and ethane.
- Continued to monitor the seismic acquisition system via remote check-in and e-mail updates.
- On July 6–8, 2015, EERC personnel with guidance from Geospace (the recoding system vendor) representatives traveled to Hulett, Wyoming, to fix the 04-03 OW borehole seismic array at the Bell Creek Field. The system was troubleshot, repaired, and returned to operation. Evidence suggested the issue was related to an extreme weather event in the field.
  - The borehole seismic array in 04-03 OW ceased recording on July 29, 2015. A manual restart was necessary to power down and power up the system.

- Seismic inversion of the reprocessed baseline 3-D was completed. Three depth domain volumes of elastic parameters were delivered for import to Petrel for the geomechanical model analysis.
- The next 3-D surface seismic survey at the Bell Creek Field is expected to begin shortly after August 19, 2015. A visit during the survey to get contact information, observer logs, survey information, and parameter sheet is planned.
- Continued Bell Creek field simulation and history-matching efforts.
- Continued development of Bell Creek near-surface monitoring, verification, and accounting (MVA) sampling strategies for FY2016.
- Began planning for a trip to Denver to view Bell Creek cores tentatively for August 10–11, 2015. This core viewing activity would be used to support the facies modeling work for Bell Creek.
- Continued working on preliminary planning for a potential PNL campaign centering on Phases 1–4. This process includes identifying wells important for monitoring CO_2 saturation changes during injection, wells needing additional characterization data, and wells important for understanding sweep efficiency in specific geologic conditions and the impacts of water alternating gas (WAG) compared to continuous CO_2 injection (CCI).
- Requested and received velocity data for the reprocessed 3-D survey from Denbury.
- Staff traveled to Houston, Texas, to attend CMG's CMOST, WINPROP, and reservoir training July 8–15, 2015.
- Completed repair/replacement of all field sampling equipment. Started preparing all equipment for the next sample event (tentatively scheduled for late August).
- Completed building model for seismic 3-D baseline.
- Successfully installed GeoTomo MiVu software for processing microseismic data on the geophysics workstation.
- Continued work on numerical tuning for the simulation model to reduce run time and improve computational efficiency.
- Worked on analyzing flow boundaries for Phase 1 and 2 areas to ensure simulations accurately match connectivity and fluid flow between the phases.
- Integrated the new oil–water relative permeability curves into the SCAL database. The total number of relative permeability curves includes five individual sets from two wells: three sets from BC 22-03 and two sets from BC 05-06 OW.
- Worked on analyzing individual well performance in the simulation models. Well properties are being updated based on well log and core analysis data. This work is to improve simulation results on an individual well basis. Results have been successful thus far.
- Communicated with Core Labs regarding invoicing and shipping of 05-06 OW SCAL (special core analysis) samples from Houston to the EERC.
- Discussed the completed SCAL work conducted by Core Labs. A new scope of work is being developed for the EERC to conduct a series of relative permeability tests using oil and CO_2 in the determination of the hysteresis effect on these rocks.
- Continued determination of Bell Creek crude oil density to get API (American Petroleum Institute) gravity.
- Used predictive simulation results to investigate several parameters, including hydrocarbon pore volume injected for CCI and WAG, incremental oil recovery, CO_2 utilization factor, and CO_2 storage amount.

- Continued developing an outline and executive summary of the PCOR Partnership MVA BPM.
- Continued working on Milestone 51 (M51) "Bell Creek Test Site – Initial Analysis for First Large-Scale Repeat Pulsed-Neutron Logging Campaign Post-Significant CO_2 Injection Completed," (due August 31, 2015).
- A graduate student intern continued working on processing the microseismic data collected at Bell Creek.
- Submitted M50 "2 Years of Near-Surface Assurance Monitoring Completed" (due July 31, 2015).
- With regard to the DOE BPMs:
  - Replied to DOE working group coordinators with comments on the DOE Simulation and Risk Assessment BPM outline.
  - Participated in the DOE Carbon Storage and Well Management Systems BPM conference call.
  - Participated in the DOE Carbon Storage and Well Management Systems BPM conference call. Reviewed the final draft of the BPM with compiled DOE–Regional Carbon Sequestration Partnerships (RCSP) team comments for submission to DOE on July 10.
  - Submitted the final draft outline for the DOE Carbon Storage and Well Management Systems BPM to DOE on July 10.
- Completed update of Montana Board of Oil and Gas (MBOG) CO_2 injection data through April 2015 for estimating CO_2 net storage. The data were provided to DOE as an update to the PCOR Partnership weekly update e-mail and added to the April–June quarterly report.
- Used the most recent publicly available data to determine that cumulative CO_2 gas injection is 2,539,042 metric tons through April 30, 2015 (Table 1).
- Continued injection-phase sampling work, including the following:
  - Activities completed from the Bell Creek MVA sampling event (June 22–27, 2015):
    - ♦ Completed quality assurance and quality control (QA/QC) and data inventory of handheld meter field data sheets and gas bag samples.
    - ♦ Completed Micro GC (gas chromatography) analysis on over 200 total soil gas samples, including QA/QC samples (i.e., blanks and duplicates) from all of Phases 1 and 2.
      - Initiated data processing.

Table 1. Bell Creek CO_2 Gas Injection Totals for April 2015 (cumulative totals May 2013 to April 2015)

	April 2015 Injection
Total, Mscf	3,280,561
Total, U.S. tons*	187,643
Total, metric tons*	170,392
Cumulative Total, Mscf [+]	48,884,167
Cumulative Total, U.S. tons*[+]	2,796,097
Cumulative Total, metric tons*[+]	2,539,042

Source: MBOG database.

* There has been a lag in posting of injection/production volumes to the MBOG database. This was calculated utilizing a conversion of 17.483 Mscf/U.S. ton and 19.253 Mscf/metric ton.

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

- ♦ Completed processing results from the seven collected groundwater parameter readings in Phases 1 and 2 and the surrounding region, including the two Fox Hills Formation wells (MW0504 and MW3312) as all parameters are within expected ranges.
  - Statistical analyses (i.e., outlier tests, box plots, etc.) were completed based on all baseline field results by water type, as well as compared to operational monitoring results for possible outliers. No outliers of significance were observed.
  - Based on the results, there is no need to conduct detailed laboratory analyses on the two groundwater samples from the Fox Hills Formation.
- ♦ Completed data download from the MOREVision and Qorex systems as well as swapped out the GeoPro HDDs (hard disk drives).
- ♦ Completed general maintenance at EERC field office and SGPSs (soil gas profile stations).

– Activities completed from the sampling trip (April 24–30, 2015):
- ♦ Laboratory GC confirmation analyses (26 samples) are complete.
- ♦ Landowner packages (groundwater results) previously approved by Denbury are being finalized and printed to be distributed to landowners. Tentative distribution date(s) are July 27–29.
- ♦ Completed QA/QC review of database; minor corrections and updates were made.

Task 10 – Site Closure (to be announced [TBA])

- This task is anticipated to be initiated in Quarter 1 – BP5, Year 9 (October 2015).

Task 11 – Postinjection Monitoring and Modeling (TBA)

- This task is anticipated to be initiated in Quarter 1 – BP5, Year 9 (October 2015).

Task 12 – Project Assessment (Loreal V. Heebink)

Highlights
- Nothing to note at this time.

Task 13 – Project Management (Charles D. Gorecki)

Highlights
- Attended the WBI Energy Customer Meeting in Deadwood, South Dakota, July 21–22, 2015.
- Submitted supporting documentation for the extension for BP4, including an update to the PCOR Partnership statement of project objectives and in-kind cost-share backup documentation.
- Began working on posters for six accepted abstracts to the DOE Carbon Storage R&D Project Review Meeting.
- Held a task leader meeting July 9, 2015. Topics discussed included hiring; the BP4 extension, including budgets and deliverables; project updates; upcoming conferences/meetings; and task leader updates.
- Continued preparing for the PCOR Partnership Annual Membership Meeting. Continued working on the agenda, awaiting confirmation from one presenter.

- Completed deliverables and milestones in June:
  - June monthly update
  - Task 13: D58/D59 – Quarterly Progress Report/Milestone Quarterly Report
  - Task 9: M50 – Bell Creek Test Site – 2 years of Near-Surface Assurance Monitoring Completed

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

Highlights

- Distributed agenda and Doodle for the July Conference Call. With DOE's approval, the July call was waived because of lack of participation.
- Request to waive August call was received due to the scheduling of the WWG Annual Meeting on August 18, 2015.
- Distributed notes from the June 2015 call.
- Received permission to drop the "BPM" title from D80 due to lack of research leading to "best practices" in the field of water and CCS.
- Continued development of the WWG Summary Document (D80, due November 30, 2016) draft with a consultant from CETER. We discussed draft text and revisions.
- Continued preparing for the WWG Annual Meeting to be held in August in Pittsburgh, Pennsylvania. Reviewed hotel arrangements and the menu. The meeting will focus on the development of the WWG BPM and its relation to the DOE BPMs being developed.
- Continued preparations for a poster to be presented at the DOE Carbon Storage R&D Project Review Meeting.
- Distributed reminder e-mail that the abstract deadline is approaching for the Special Issue of *International Journal of Greenhouse Gas Control* (*IJGGC*) on the "Nexus of Water and Carbon Capture and Storage." Abstracts were due July 17, 2015.
  - Received one abstract submission from a WWG member for the Special Issue of *IJGGC* on the "Nexus of Water and Carbon Capture and Storage" and several others from outside authors.
  - Began drafting text for an introductory paper to be published in the issue.
- Completed Elsevier Editorial System training in preparation for handling submissions for the Special Issue of *IJGGC* on the "Nexus of Water and Carbon Capture and Storage."

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 26 – July 8, 2015: traveled to San Francisco, California, to attend the 2015 U.S. Rock Mechanics Geomechanics Symposium and Workshop.

- June 29 – July 1, 2015: traveled to White Salmon, Washington, to work as a technical advisor on the Coal and the Modern Age documentary.
- July 6–8, 2015: traveled to Hulett, Wyoming, to do maintenance on the 04-03 OW borehole array recording system at Bell Creek.
- July 8–18, 2015: traveled to Houston, Texas, to attend three CMG courses (CMOST July 9–10, WINPROP July 13–14, and Reservoir Simulation July 15–17).
- July 13–17, 2015: traveled to Casper, Wyoming, to attend the EOR CO_2 Conference and workshops.
- July 20–22, 2015: traveled to Deadwood, South Dakota, to attend the WBI Energy Customer Meeting.
- July 21–23, 2015: traveled to Deadwood, South Dakota, to host the PCOR Partnership Regulatory Roundup.
- July 27–28, 2015: traveled to Fargo, North Dakota, to work with PPB for the upcoming documentary.

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