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

PHASE III ACTIVITIES

Task 1 – Regional Characterization (Wesley D. Peck)

Highlights

- Continued compiling information for the Plains CO_2 Reduction (PCOR) Partnership Atlas (5th edition) due August 2015, including calculation of new saline storage numbers divided by state/province and researching current carbon market information.
- With regard to the upcoming U.S. Department of Energy (DOE) National Energy Technology Laboratory (NETL) Atlas V:
  - Worked on modifications.
- With regard to the partners-only decision support system (DSS) Web site:
  - Continued work on reformatting the Bell Creek-related information.
  - Continued collecting images from the last version of the PCOR Partnership Atlas to put in the image gallery.
  - Continued to assemble a presentation on the DSS online mapping services to showcase the capabilities for viewing results in a comprehensive and interactive framework.
  - Updated North Dakota and Montana Petra projects with the latest general well information from each state's online resource as follows: 314 new North Dakota wells and seven new Montana wells.
  - Updated the North Dakota well injection information and production data and South Dakota, Saskatchewan, and Manitoba project information.
- Continued work on several value-added reports, including the following:
  - Continued work on the Inyan Kara Formation report, requested geologic modeling data, located the saltwater disposal well injection data for the Dakota aquifer, and began writing text.
  - Continued work on the report summarizing methods of original oil in place and carbon dioxide (CO_2) storage calculations.
  - Continued efforts on the Cedar Creek Anticline white paper, including modifying the CO_2 enhanced oil recovery (EOR) section.
- With regard to the **Aquistore** project's static modeling and dynamic predictive simulations effort:
  - Received request for additional data generated by the simulations from a Science and Engineering Research Committee (SERC) member. Exported simulation data for Cases 2 and 3.
  - Continued working with Petroleum Technology Research Centre (PTRC) SERC regarding the Aquistore simulation model.

- Began work on a presentation entitled "Geologic Modeling and Simulation at the Aquistore Site: A Guide to MVA (monitoring, verification, and accounting) Deployment" for the upcoming 14th Annual CCUS (Carbon Capture, Utilization, and Storage) Conference (CCUS-14) (April 28 – May 1, 2015).
- PTRC is working to improve injectivity of the injection well (they initially had lower than expected/needed injection rates). We have offered our services.
- Injection is expected to begin the week of April 16, 2015.

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

Highlights

- Provided outline of a talk entitled "Energy and Quality of Life – Drilling Down" to be given April 17, 2015, for the University of North Dakota Harold Hamm School of Geology and Geological Engineering Annual Spring Banquet (50 expected attendance).
- Continued efforts to expand the type and presentation of statistics for overall past outreach activities and for planning.
- Continued to gather information on audience feedback systems for use with public presentations and focus groups.
- Attended the 10th Annual Southeast Regional Carbon Sequestration Partnership (SECARB) Stakeholders' Meeting March 11–12, 2015, in Atlanta, Georgia.
- 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.
- Initiated efforts to obtain site footage of the Kemper County facility.
- Completed a review of the 4th edition Atlas (revised) and provided comments to the Atlas team as a first step in contributing to the preparation of the 5th edition Atlas due in August 2015.
- Participated in the monthly Aquistore Outreach and Advisory Working Group call on March 26, 2015, and discussed updates for the outreach best practices manual (BPM).
- Prepared and submitted draft tables to the Outreach Working Group (OWG) that characterized the Phase II and III field activities, the settings and management structures of the projects, and the types of outreach undertaken for each of the projects.
- Reviewed an outreach update and exchanged e-mail correspondence with the Aquistore outreach lead in lieu of participating in the monthly Aquistore Outreach Advisory Panel conference call.
- Continued efforts with regard to the public Web site (www.undeerc.org/pcor), including the following:
  - Reviewed and updated candidate pages for Web updates based on discussions with EERC programmers.
  - Reviewed and updated the standard operating procedure developed in July of 2014 for Web page tracking using Google Analytics.
  - Continued ongoing identification and repair of broken links.
  - Discussed scope and budget estimates for the public Web site with the EERC Web programmers.
  - Move forward on several Web page updates following internal review.

  - Continued efforts to revise and update the carbon cycle page on the public Web site, focusing on graphic and interactive elements.
- Continued collaborative efforts with Prairie Public Broadcasting (PPB), including the following:
  - PPB staff attended the North Dakota Science Teachers Association Spring Meeting on March 20 and 21, 2015, in Bismarck, and this is expected to result in requests for outreach materials.
  - Continued editing Parts 3 and 4 of the four-part education video, and sent action items to PPB.
  - Continued to review historical sources for the coal documentary, including *Energy and the English Industrial Revolution* by E.A. Wrigley, *Power to the People* by Kandar and others, and *Getting the Coal Out* by Diana Tittle.

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

Highlights

- Continued planning the 2015 Regulatory Roundup, scheduled for July 22–23, 2015, in Deadwood, South Dakota, including preparing a draft agenda; discussing potential speakers; and discussing with Interstate Oil and Gas Compact Commission (IOGCC) representatives the regulatory topics for the 2015 PCOR Partnership regulatory meeting, including several IOGCC products.
- Participated in a conference call on March 26, 2015, with the IOGCC regarding the transition of Class II wells to Class VI. This topic will be discussed at the committee meeting (May 19, 2015) held in conjunction with the IOGCC Annual Meeting in Salt Lake City. Provided documentation on this issue and an agenda for the committee meeting, to include suggested industry and regulatory speakers and discussion topics with the committee.
- Began working on a PowerPoint related to Class II well-to-Class VI transition to be presented at an International Energy Agency meeting in Paris, France, in late April.
- Reviewed the U.S. Environmental Protection Agency (EPA) and other Web sites regarding permits and changes to the Class VI regulations.
- Worked on updating regulatory pages for the PCOR Partnership Atlas.
- Discussed updates to the regulatory section of the public Web site.
- Continued planning for Deliverable 8 (D8), Permitting Review – Update 2, due September 30, 2015, including checking the status of North Dakota primary 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:
  - Continued preparing for the geomechanical simulations, including conducting a review of literature related to the use of CMG and other software packages for designing a geomechanical simulation process. The model reservoir properties and rock mechanical properties were also prepared for simulation.

- Continued improving the rock mechanical properties (e.g., Young's modulus, Poisson's Ratio) and reservoir stresses using synthetic well logs (e.g., sonic logs) in the 3-D Mechanical Earth Model. Continued setting up practice simulations in CMG GEM to check the efficiency of the software for the simulation of CO_2 plume development during and after injection.
- Received 3 PowerLog licenses. This software will be used for petrophysical analyses. A PowerLog training session will be led by PCOR Partnership partner Eric Pasternack of Outsource Petrophysics, Inc., at the EERC in the near future.
- Scheduled and prepared for a project update meeting with Denbury on April 13, 2015, in Plano, Texas. Topic areas include updates regarding Bell Creek geologic interpretation, seismic, near-surface monitoring, pressure and temperature monitoring, and discussion regarding potential future work such as scalable, automated, semipermanent seismic array (SASSA), tracer surveys, and pulsed-neutron logging (PNL).
- Held an in-house review of the updated facies interpretation of the Bell Creek Field which incorporates both electrolog, seismic, and core data. Progress on this interpretation will be presented to Denbury at a WebEx April 6, 2015, and in person April 13, 2015, in Plano, Texas.
- Continued preparing the site characterization BPM, due August 31, 2015.
- Participated in a WebEx with Schlumberger to discuss fluid saturation interpretation results from the four PNLs collected in October/November 2014. Schlumberger participants included Bob Butch, Lee Swagger, Wayne Rowe, and Gabriel Velasquez.
- Requested and received from Schlumberger effective porosity logs from the PNL work in a different format that is more conducive to integration with simulation results.
- Used the 3-D model, updated facies interpretation, injection/production, and seismic data to examine wells in Phase 1 for their utility related to a potential tracer study that may be conducted in the field.
- Began investigating statistical methods for analyzing variability within PNL results.
- Worked on performing comparison of effective porosity values from PNL data to effective porosity properties in the simulation model in order to identify areas of the simulation model with results that diverge from field observations.
- Performed experiments to determine the effect of 2 mol% methane in CO_2 on Bell Creek crude oil. There was no measurable effect of the added methane on MMP (minimum miscibility pressure) compared to MMP values determined earlier in March 2015 using pure CO_2.
- Efforts have been made to gain a better understanding of the transition between the Skull Creek and Muddy Formations. Activities included literature review of both formations in the Bell Creek Field and greater Powder River Basin and basic petrophysical analysis including facies correlation and comparison to previous interpretations. This work has implications in our understanding of the Muddy depositional model.
- Held weekly modeling/simulation meetings to discuss PNL processing. The PNL workflow regarding new calculation for lithology, effective porosity, and fluid saturations within the Muddy Formation was presented. This workflow was built and processed within Schlumberger's Techlog software.
- Continued investigating options regarding microseismic data-processing services.
- Continued developing ideas for a Bell Creek journal article related to facies modeling to be prepared in collaboration with Denbury.

- Continued working on Version 3 of the geologic model, including integration of a 3-D seismic amplitude map, logs, and core to develop detailed geobody, depositional environment, and facies interpretations. Several PowerPoint slides were developed and presented to the project team during the weekly Bell Creek modeling and simulation meetings.
- Applied Geology Laboratory activities included the following:
  - Held a lab meeting to discuss an update on porosity, permeability, mineralogy, and Klinkenberg correction factors.
  - With regard to the 33-14R core (collected April 2013):
    - Lab analyses are complete.
    - Continued work on the permeability-to-air report.
  - With regard to the 56-14R full-core plugs (collected March 2013):
    - Updated size and shape analysis data.
    - Lab analyses are complete.
- Sorted available special core analysis (SCAL) reports from Core Lab for the Bell Creek 0506-OW well. Will work with Core Lab to receive the remaining files.

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

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

Task 6 – Infrastructure Development (Melanie D. Jensen)

Highlights

- Continued work on the update to D85 "Opportunities and Challenges Associated with CO_2 Compression and Transport During CCS (carbon capture and storage) Activities" (due May 31, 2015), including summarizing the energy requirements and economics of compression and liquefaction and the basis for each method.
- A value-added report entitled "Assessing Temporary Storage Options to Manage Variable-Rate CO_2 Emissions for Use During Enhanced Oil Recovery" continued undergoing internal PCOR Partnership management review. Following DOE review, the authors plan to submit the manuscript for possible publication in *Energy & Environmental Science*.
- Continued to search for technologies for the CO_2 capture technologies update overview.

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

- Compiled and summarized information about the capture method and CO_2 stream composition for the Lost Cabin gas-processing plant, the Great Plains Synfuels Plant, and Boundary Dam for the PCOR Partnership team leader, who requested the information while at an international conference.

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

Highlights

- **Bell Creek** injection-phase site activities included the following:
  - Presented at a workshop entitled "Research Issues in Gas Migration along Wellbores" in Calgary, Alberta, March 12, 2015.
  - Researched depositional environments for object modeling input into the near-surface model.
  - Made minor changes/corrections to DOE Atlas V.
  - Began preparing for PCOR Partnership annual meeting workshop.
  - Began planning and preparation for the upcoming semiannual Bell Creek surface and near-surface sampling event (tentatively scheduled for the last week in April or the first week in May).
  - Began contacting landowners ahead of upcoming field event.
  - Began to develop alternate strategies for reduced monitoring, moving toward a commercially viable MVA strategy, specifically regarding frequency and focusing on key indicator analytes.
  - Began planning and preparation for the meeting with Denbury, April 13, 2015, in Plano, Texas, including compiling comprehensive update binders for the project team.
  - Worked on history-matching the new updated model. The overall production and injection profile in the Phase 1 area has been matched, including various parameters, e.g., primary and secondary oil, water and gas production, and water injection.
  - Worked on history-matching in Phase 2 section, including examining the geologic structure, permeability, water saturation and relative permeability distributions in the combined region, and identifying ways to improve matching performance.
  - Investigated optimal wells for a potential tracer study.
  - Worked on investigating PNL statistics and near-surface model. After successfully reprocessing the PNLs inside the Muddy Formation, the workflow was adapted to reprocess the PNL data for the overlying formations. New lithology, effective porosity, and fluid saturations will be computed to provide petrophysical data needed to populate the near-surface model. Additionally, PNL statistical analysis was evaluated to determine the best way of reducing model uncertainty and to remove error from the model outputs. This will help clean up the interpreted logs and remove artifacts of model error.
  - Continued to work with Denbury personnel to collect periodic oil and gas samples from select wells in the Phase 1 area. Although no oil and gas samples were collected during March 2015, a plan is being devised to collect one gas and one oil sample from each of the three production wells (32-02, 56-14, and 05-06) on an estimated quarterly basis. The next round of samples are planned to be collected during the semiannual Bell Creek surface and near-surface sampling event.
  - Continued analysis of processed permanent downhole monitoring data.
  - Specifications were put out for bid for the purchase of a geophysics-specific workstation.
  - Discussed decline curve analysis for Bell Creek wells.
  - Held a WebEx with Schlumberger March 24, 2015, and discussed pulsed-neutron interpretations for the most recent fieldwork, including the monitor passes for four wells.
  - Spoke with Trevor MacDougal of Qorex regarding distributed temperature sensing (DTS) data anomaly which occurred between April 4 and May 21, 2014. The analysis

determined that the system is performing within the system accuracy specification of ±2°C and that temperature offset is particularly sensitive to the temperature change of the surface cable near the freezing point of 0°C.

- Provided Denbury a near-surface monitoring presentation that we presented at the Carbon Management Technology Conference on October 21–23, 2013, based on a request.
- Conducted a literature review for induced seismicity related to CO_2 injection.
- Set up a combined simulation model for Phases 1 and 2 which includes all production and injection wells in the region. Determined parameters and constraints (e.g., perforation intervals, barrier locations, etc.) that will be used in the simulations, and worked on checking the preliminary simulation results. Updated the model with reservoir properties.
- Continued database entry for tracking data drives for the borehole array and recording system.
- Continued injection-phase sampling work, including the following:
  - Completed processing of over 210 soil gas samples collected from Phases 1 and 2 for the December 2014 quarterly sampling event.
    - Laboratory gas chromatography (GC) confirmation analyses were also completed for the 12 selected soil gas samples as part of the quality assurance/quality control (QA/QC) procedure.
  - Completed the field (Micro Quad) and laboratory GC produced gas analyses for three production wells:
    - 32-02 (sampled in November 2014)
    - 56-14 and 05-06 (sampled in December 2014)
- Based on the most recent publicly available data, cumulative CO_2 injection is 1,660,570 metric tons through November 30, 2014 (Table 1).
- Continued the literature review for CO_2 EOR simulation strategies.

Table 1. Bell Creek CO_2 Injection Totals for November 2014 (cumulative totals May 2013 to November 2014)

	November 2014 Injection
Total, Mscf	3,046,040
Total, U.S. tons*	174,229
Total, metric tons*	158,211
Cumulative Total, Mscf [+]	31,970,963
Cumulative Total, U.S. tons*[+]	1,828,689
Cumulative Total, metric tons*[+]	1,660,570

Source: Montana Board of Oil and Gas (MBOG) database.

* There is an approximately 2–3-month 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.

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

- Submitted the annual assessment (D57) on December 30, 2014.

Task 13 – Project Management (Charles D. Gorecki)

Highlights

- Continued preliminary efforts for the Adaptive Management Approach BPM (D102, due June 2015).
- Spoke with Jim Rawson about Bell Creek geology and Trevor Richards regarding potential involvement with additional seismic activities at Bell Creek.
- Continued planning for the 2015 annual meeting to be held in Chicago, Illinois, in September, including:
  - On March 24, 2015, sent out an e-mail with save-the-date information.
- Began planning travel and preparing a presentation for the workshop on CCS–EOR Utilization and Storage hosted by the Global Carbon Capture and Storage Institute in Beijing, China, April 16, 2015.
- Continued planning for a visit from DOE NETL personnel on April 8–9, 2015, including preparing a draft agenda and PCOR Partnership update.
- Requested and received an extension to May 31, 2015, for D85 (Task 6), originally due March 31, 2015.
- Began preparing for a presentation entitled "Implementing Carbon Capture and Storage: An Overview of the Plains CO_2 Reduction Partnership" for CCUS-14 (April 28 – May 1, 2015).
- Held a task leader meeting March 17, 2015. Topics discussed included brief updates on Bell Creek and Aquistore and focused discussion on the next edition of the PCOR Partnership Atlas.
- Held the winter Technical Advisory Board (TAB) meeting March 3–5, 2015, in Phoenix, Arizona.
- Attended and presented at the International Forum on Recent Developments of CCS Implementation (http://co2quest.eu/ccsforum15.htm) in Athens, Greece, March 26–27, 2015.
- Deliverables and milestones completed in February:
  - February monthly update
  - Task 13: M36 – TAB meeting scheduled
  - Task 14: M23 – monthly Water Working Group (WWG) call held

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

Highlights

- Held the monthly conference call on March 25, 2015. Discussed development of the current WWG BPM, pursued writing a special journal edition of the International Journal of

Greenhouse Gas Control (IJGGC) on the "Nexus of CCS and Water," and planned to host the annual WWG meeting during DOE's annual partnership review meeting in August.
- Distributed February conference call minutes.
- Attended and presented at a DOE-sponsored workshop held at Lawrence Livermore National Library on March 16, 2015. The focus of the workshop was extracted-water projects associated with CCS.
- Finalized changes to the draft WWG BPM (D80, due November 30, 2016) annotated outline, and distributed the outline to the WWG.
- Continued collaborative efforts with The CETER Group, Inc., including the following:
  - Discussed last month's WWG conference call.
  - Reviewed revisions for the BPM, and discussed suggestions for the annual meeting.
  - Discussed development of a solicitation for the special edition of IJGCC.

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

- February 27 – March 5, 2015: traveled to Phoenix, Arizona, to attend the PCOR Partnership TAB meeting, and other partner meetings.
- March 10–12, 2015: traveled to Atlanta, Georgia, to attend the SECARB annual meeting.
- March 11–13, 2015: traveled to Calgary, Alberta, Canada, to present at the Research Issues in Gas Migrating along Wellbores Workshop.
- March 14–16, 2015: traveled to Livermore, California, to present at the Enhanced Water Recovery Workshop hosted by DOE.
- March 24–29, 2015: traveled to Athens, Greece, to present at the International Forum on Recent Developments of Carbon Capture & Sequestration Implementation.

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