ANNUAL ASSESSMENT REPORT

Plains CO_2 Reduction (PCOR) Partnership Phase III
Task 12 – Deliverable D57

(for the period October 1, 2010, through September 30, 2011)

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EXECUTIVE SUMMARY

The Plains CO_2 Reduction (PCOR) Partnership is one of seven Regional Carbon Sequestration Partnerships (RCSPs) competitively awarded by the U.S. Department of Energy National Energy Technology Laboratory in 2003 as part of a national plan to mitigate greenhouse gas emissions. The PCOR Partnership is led by the Energy & Environmental Research Center (EERC) at the University of North Dakota in Grand Forks, North Dakota, and includes over 90 stakeholders from the public and private sector in Phase III. The PCOR Partnership region includes all or part of nine U.S. states and four Canadian provinces.

Phase III, the development phase, a 10-year effort (2007–2017), is an extension of the characterization (Phase I) and validation (Phase II) phases and is intended to confirm that carbon dioxide (CO_2) capture, transportation, injection, and storage can be achieved safely, permanently, and economically over extended periods in the PCOR Partnership region.

The Phase III efforts of the PCOR Partnership include two large-volume demonstration tests that focus on injecting CO_2 into deep geologic formations for CO_2 storage. The Fort Nelson demonstration involves monitoring, verification, and accounting (MVA) support for the injection of CO_2 captured from one of the largest gas-processing plants in North America into a saline formation in British Columbia, Canada. The Bell Creek demonstration involves injection of CO_2 into formations in the Powder River Basin in the northern Great Plains region of North America for the dual purpose of CO_2 storage and enhanced oil recovery. Other activities in Phase III include the following: 1) continue to gather regional characterization data to verify the ability of the target formations to store CO_2, 2) facilitate the development of the infrastructure required to transport CO_2 from sources to the injection sites, 3) facilitate development of the rapidly evolving North American regulatory and permitting framework, 4) develop opportunities for PCOR Partnership partners to capture and store CO_2, 5) establish a technical framework by which carbon credits can be monetized for CO_2 stored in geologic formations, 6) continue collaboration with other RCSPs, and 7) provide outreach and education for CO_2 capture and storage stakeholders and the general public.

Budget Period 4 (Program Years [PYs] 3–8 of Phase III) began October 1, 2009. Significant progress was made in PY4 (October 1, 2010 – September 30, 2011) on the Bell Creek demonstration project. Efforts were focused on the collection, evaluation, and interpretation of historic data sets and included information-gathering trips to Plano, Texas; Broadus, Montana; Hulett, Wyoming; Houston, Texas; and Denver, Colorado. Laboratory evaluations were initiated on outcrop samples representative of Bell Creek reservoir rock. An MVA work plan was

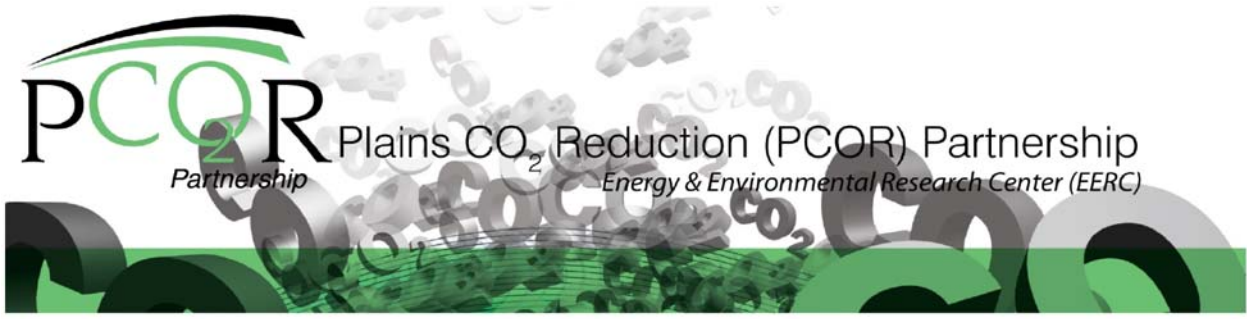
developed for the surface, near-surface, existing wellbores, and deep monitoring wells, and plans are well under way for baseline and deep monitoring sampling to begin before the end of 2011.

Activities for the Fort Nelson demonstration project continued to progress in PY4, and included further geological interpretation, laboratory evaluations, risk assessment, and MVA planning. Significant updates were made to the static geologic model, and dynamic simulation evaluations continued. RAs were updated using an expert panel approach, and laboratory evaluations were conducted on core samples from a test well.

All other tasks also continued to effectively support program goals. Regional characterization continues, and significant progress was made in the geologic characterization of the Rival oil field in northwestern North Dakota. Capture technologies are under review, relationships with regional regulators grow stronger, and new outreach products (documentaries and atlases) are under creation. An expert review of the entire PCOR Partnership Phase III program was conducted in March 2011, and as a result, plans are under way for the selection of a technical advisory board.

Activities that will lead to the initiation of CO_2 injection in both demonstration sites will continue during PY5 (2011–2012). Operational monitoring and modeling activities will continue to be performed to verify that injection operations do not adversely impact human health or the environment and that the CO_2 injected has been safely stored, with minimal risk of natural release. All other support tasks will also continue to be implemented.

This report presents an update of Phase III PCOR Partnership activities from October 1, 2010, through September 30, 2011 (PY4), and planned activities for the following year.



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INTRODUCTION

The Plains CO_2 Reduction (PCOR) Partnership is one of seven regional partnerships operating under the U.S. Department of Energy (DOE) National Energy Technology Laboratory (NETL) Regional Carbon Sequestration Partnership (RCSP) Program. The PCOR Partnership is led by the Energy & Environmental Research Center (EERC) at the University of North Dakota (UND) in Grand Forks, North Dakota, and includes over 90 stakeholders from the public and private sector in Phase III. The Phase III membership as of September 30, 2011, is listed in Table 1. The PCOR Partnership region includes all or part of nine states (Iowa, Minnesota, Missouri, Montana, Nebraska, North Dakota, South Dakota, Wisconsin, and Wyoming) and four Canadian provinces (Alberta, British Columbia, Manitoba, and Saskatchewan).

The RCSP Program falls within the infrastructure element of NETL's Carbon Sequestration Program and is a government–industry effort tasked with determining the most suitable technologies, regulations, and infrastructure needs for carbon capture and storage (CCS) on the North American continent.

The RCSP Program initiative is being implemented in three phases:

- Phase I – Characterization Phase (2003–2005): characterized opportunities for carbon sequestration.
- Phase II – Validation Phase (2005–2009): conducted small-scale field validation tests.
- Phase III – Development Phase (2007–2017): conducting large-volume carbon storage demonstration tests (Figure 1).

The PCOR Partnership's efforts are in support of NETL's Carbon Sequestration Program by helping to develop technologies to store carbon dioxide (CO_2) in order to reduce greenhouse gas (GHG) emissions without adversely influencing energy use or hindering economic growth.

The PCOR Partnership's efforts will help enable technologies to overcome a multitude of economic, social, and technical challenges, including cost-effective CO_2 capture through successful integration with fossil fuel conversion systems, effective CO_2 monitoring and verification, permanence of underground CO_2 storage, and public acceptance.

Table 1. PCOR Partnership Membership Phase III (October 1, 2007 – present, inclusive)

DOE NETL	Great River Energy	North Dakota Industrial Commission Oil and Gas Research Council
UND EERC	Halliburton	North Dakota Natural Resources Trust
Abengoa Bioenergy New Technologies	Hess Corporation	North Dakota Petroleum Council
Air Products and Chemicals	Huntsman Corporation	North Dakota Pipeline Authority
Alberta Department of Energy	Husky Energy Inc.	Otter Tail Power Company
Alberta Department of Environment	Interstate Oil and Gas Compact Commission	Oxand Risk & Project Management Solutions
Alberta Innovates – Technology Futures	Indian Land Tenure Foundation	Petroleum Technology Research Centre
ALLETE	Iowa Department of Natural Resources	Petroleum Technology Transfer Council
Ameren Corporation	Lignite Energy Council	Pinnacle, a Halliburton Service
American Coalition for Clean Coal Electricity	Manitoba Geological Survey	Prairie Public Broadcasting
American Lignite Energy	Marathon Oil Company	Pratt & Whitney Rocketdyne, Inc.
Apache Canada Ltd.	MEG Energy Corporation	Ramgen Power Systems, Inc.
Aquistore	Melzer Consulting	RPS Energy Canada Ltd.
Baker Hughes Incorporated	Minnesota Power	Saskatchewan Ministry of Industry and Resources
Basin Electric Power Cooperative	Minnkota Power Cooperative, Inc.	SaskPower
Biorecro AB	Missouri Department of Natural Resources	Schlumberger
Blue Source, LLC	Missouri River Energy Services	Shell Canada Energy
BNI Coal, Ltd.	Montana–Dakota Utilities Co.	Spectra Energy
British Columbia Ministry of Energy, Mines, and Petroleum Resources	Montana Department of Environmental Quality	Suncor Energy Inc.
British Columbia Oil and Gas Commission	National Commission on Energy Policy	TAQA North, Ltd.
Computer Modelling Group, Inc.	Natural Resources Canada	TGS Geological Products and Services
Dakota Gasification Company	Nebraska Public Power District	University of Alberta
Denbury Onshore LLC	North American Coal Corporation	University of Regina
Eagle Operating, Inc.	North Dakota Department of Commerce Division of Community Services	Weatherford Advanced Geotechnology
Eastern Iowa Community College District	North Dakota Department of Health	Western Governors' Association
Enbridge Inc.	North Dakota Geological Survey	Westmoreland Coal Company
Encore Acquisition Company	North Dakota Industrial Commission Department of Mineral Resources, Oil and Gas Division	Williston Basin Interstate Pipeline Company
Energy Resources Conservation Board/ Alberta Geological Survey	North Dakota Industrial Commission Lignite Research, Development and Marketing Program	Wisconsin Department of Agriculture, Trade and Consumer Protection
Environment Canada		Wyoming Office of State Lands and Investments
Excelsior Energy Inc.		Xcel Energy
Great Northern Project Development, LP		

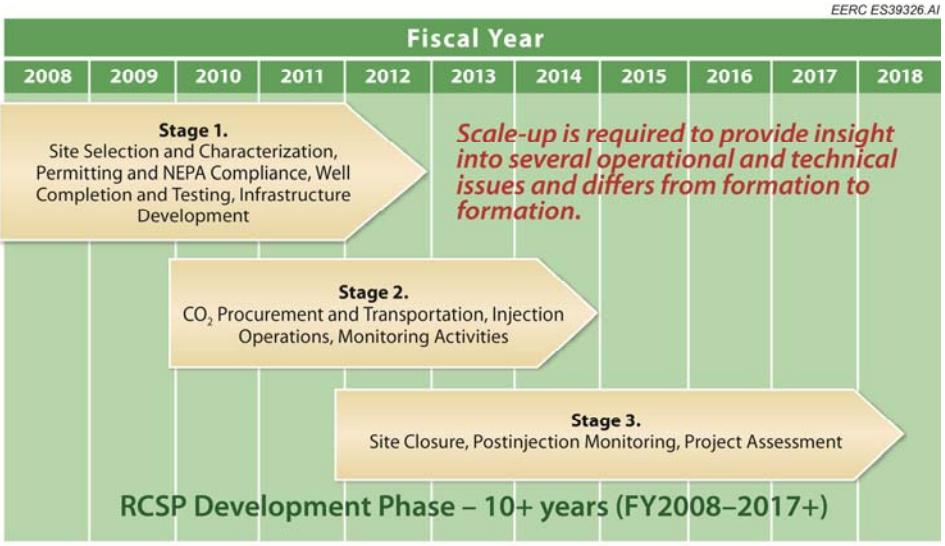


Figure 1. RCSP development phase: scaling up toward commercialization (figure taken from DOE NETL).

The PCOR Partnership was established in the fall of 2003. Phase I was focused on characterizing sequestration opportunities in the region. In the fall of 2005, the PCOR Partnership launched its 4-year Phase II program focused on carbon storage field validation projects. These Phase II projects were designed to build core local technical expertise and experience needed to facilitate future large-scale CO_2 sequestration efforts in the region's subsurface and terrestrial settings. In the fall of 2007, the PCOR Partnership initiated its 10-year Phase III program focused on implementing two commercial-scale geologic carbon sequestration demonstration projects in the region.

Phase III is divided into three budget periods (BPs), running from October 1, 2007, to September 30, 2017:

BP3: October 1, 2007 – September 30, 2009
BP4: October 1, 2009 – September 30, 2015
BP5: October 1, 2015 – September 30, 2017
Note: BP1 and BP2 were effective in Phase II.

The overall mission of the Phase III program is to 1) gather characterization data to verify the ability of the target formations to store CO_2, 2) facilitate the development of the infrastructure required to transport CO_2 from sources to the injection sites, 3) facilitate development of the rapidly evolving North American regulatory and permitting framework, 4) develop opportunities for PCOR Partnership partners to capture and store CO_2, 5) establish a technical framework by which carbon credits can be monetized for CO_2 stored in geologic formations, 6) continue collaboration with other RCSPs, and 7) provide outreach and education for CO_2 capture and storage stakeholders and the general public.

In Phase III, the PCOR Partnership is building on the information generated in its characterization (Phase I) and validation (Phase II) phases. The PCOR Partnership plans to fully utilize the infrastructure of its region to maximize CO_2 injection volumes. A programmatic development phase (Phase III) goal is implementation of large-scale field testing involving at least 1 million tons (Mt) of CO_2 per project. Each of the RCSP's large-volume injection tests is designed to demonstrate that the CO_2 storage sites have the potential to store regional CO_2 emissions safely, permanently, and economically for hundreds of years.

The PCOR Partnership is working toward the establishment of two demonstration sites. The sites are located 1) in Denbury Onshore LLC's (Denbury's) Bell Creek oil field in Powder River County, southeastern Montana, and 2) near Spectra Energy's (Spectra) Fort Nelson gas-processing facility, situated near Fort Nelson, British Columbia, Canada (Figure 2).

Original plans were for a demonstration site project located in the Williston Basin, a large sedimentary basin lying within the PCOR Partnership region, located in eastern Montana, western North and South Dakota, and southern Saskatchewan and Manitoba. The results of Phase I and II activities indicated that this basin has the potential for hosting world-class CO_2 sequestration projects. Unfortunately, negotiations for a site and CO_2 supply within the Williston Basin reached a stalemate in the spring of 2009.

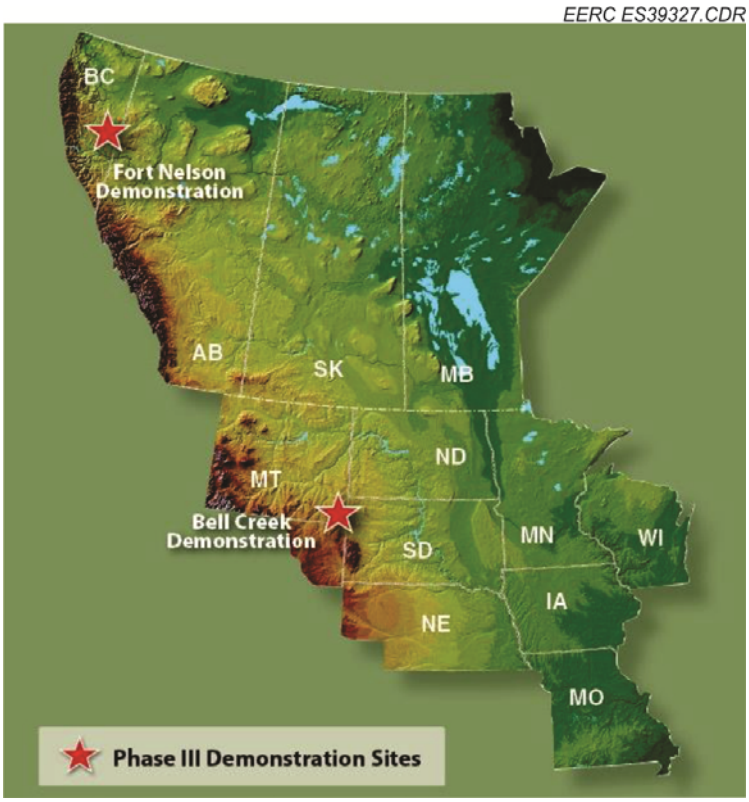


Figure 2. PCOR Partnership Phase III demonstration sites.

PCOR Partnership management realized that there was substantial interest in the development of a commercial CO_2 storage–enhanced oil recovery (EOR) project and knew there were numerous oil-bearing horizons within its region. Therefore, the PCOR Partnership worked diligently to pursue alternative site options, and a collaborative project idea with Encore Acquisition Company (Encore) was developed. Encore proposed to carry out the injection process, while the EERC would conduct CO_2 monitoring, verification, and accounting (MVA) activities at the site. The project, to be conducted in the Bell Creek oil field in Powder River County, southeastern Montana, would provide a superb opportunity to develop a set of cost-effective MVA protocols for large-scale CO_2 storage associated with an EOR operation. Negotiations were well under way to formalize an agreement with Encore, when, on October 31, 2009, Encore and Denbury entered into a definitive agreement providing for the merger of Encore with and into Denbury. On March 9, 2010, the merger was approved. Discussions between the EERC and Denbury continued, and a nondisclosure agreement was prepared. After postacquisition activities slowed, an invitation to present on October 13, 2010, at Denbury headquarters was received.

After that October 2010 meeting, the collaborative efforts for the Bell Creek test site ramped up quickly. Project-planning activities included the preparation of several experimental design packages, covering geological characterization, baseline hydrogeology, and geomechanics. Significant effort was focused on the collection, evaluation, and interpretation of historic data sets. Trips to Denbury corporate offices in Plano, the Bell Creek field office, the Houston Bureau of Economic Geology, and the Denver Core Research Center were conducted to

collect existing well data. Laboratory evaluations for porosity, permeability, mineralogy, composition, and relative permeability were initiated on outcrop samples representative of Bell Creek reservoir rock. An MVA work plan was developed for the surface, near-surface, existing wellbores, and deep monitoring wells, and in March 2011, baseline MVA activities were initiated. Baseline sampling is anticipated to begin in November 2011, and after authorization for a deep monitoring well was granted from DOE, drilling is anticipated before the end of 2011.

In collaboration with Spectra, the PCOR Partnership is pursuing a large-scale integrated CCS project near Spectra's existing Fort Nelson natural gas-processing facility in northeast British Columbia, Canada. The Fort Nelson facility is one of the largest sour gas-processing plants in North America. This plant processes gas from an extensive network of approximately 620 miles of gathering pipelines servicing the Horn River producing basin. The sour CO_2 (approximately 95% CO_2 and 5% hydrogen sulfide [H_2S]) developed by this process will be pipelined a short distance to a storage site. The PCOR Partnership's MVA efforts will help Spectra determine whether deep underground saline reservoirs and associated infrastructure in the Fort Nelson area are appropriate for CCS.

During BP4, Program Year (PY) 4, Spectra and the EERC continued collaborative efforts to further geological interpretation, laboratory evaluations, risk assessment (RA), and planning of MVA activities for the Fort Nelson demonstration project. Significant updates were made to the static geologic model, and dynamic simulations are under evaluation to predict the areal footprints of CO_2 and propagation of pressure buildup in the project area. RAs were updated using an expert panel approach, and laboratory evaluations were conducted on core samples from a test well. Numerous conference calls and in-person meetings were held with key project staff from both the EERC and Spectra in an effort to keep on target with required reporting activities as well as site preparation demands.

The PCOR Partnership's objectives for the demonstration projects are as follows: 1) conduct a successful Bell Creek demonstration to verify that the region's large number of oil fields have the potential to store significant quantities of CO_2 in a safe, economical, and environmentally responsible manner and 2) conduct a successful Fort Nelson demonstration to verify the economic feasibility of using the region's carbonate saline formations for safe, long-term CO_2 storage. During Phase III, the PCOR Partnership will continue to refine storage resource estimates and evaluate other factors relevant to regional storage goals.

APPROACH

The PCOR Partnership is identifying practical CO_2 storage options for the PCOR Partnership region, characterizing the technical issues, enhancing the public's understanding of CO_2 storage, identifying the most promising opportunities for storage in the region, and detailing an action plan for the demonstration of regional CO_2 storage opportunities.

The PCOR Partnership is achieving its Phase III mission through a series of 16 tasks, as shown in Figure 3. These tasks include 1) Regional Characterization; 2) Public Outreach and Education; 3) Permitting and National Environmental Policy Act (NEPA) Compliance; 4) Site

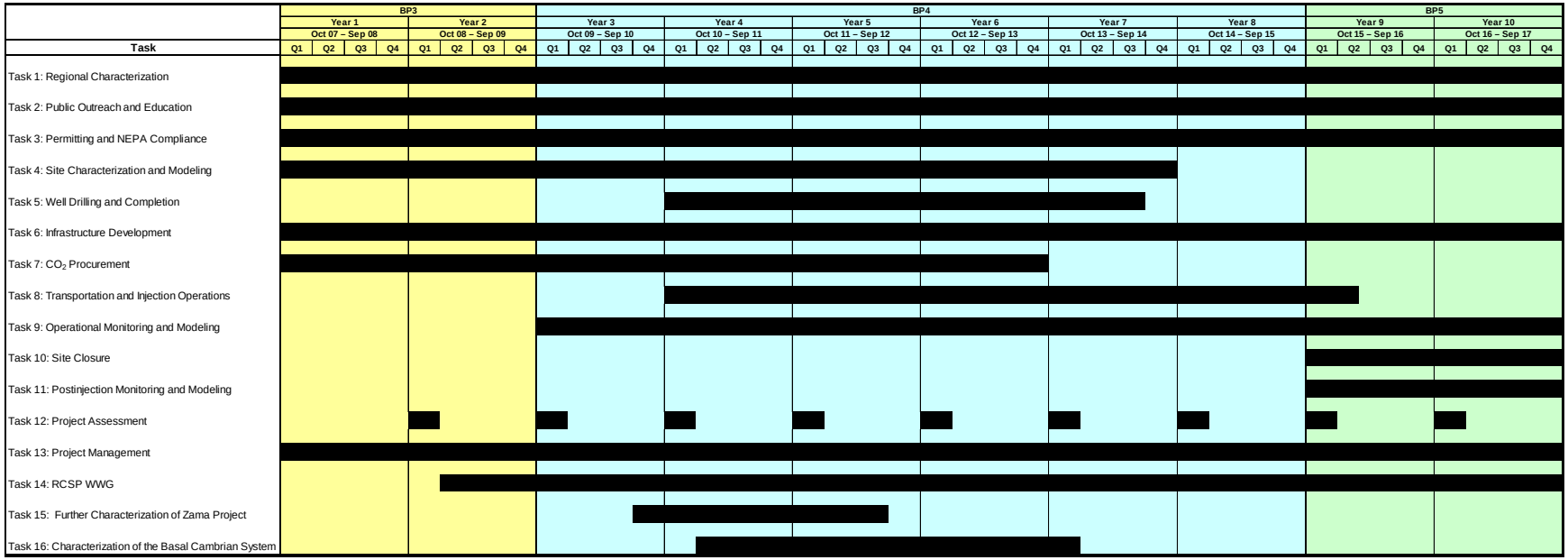


Figure 3. Phase III tasks.

Characterization and Modeling; 5) Well Drilling and Completion; 6) Infrastructure Development; 7) CO_2 Procurement; 8) Transportation and Injection Operations; 9) Operational Monitoring and Modeling; 10) Site Closure; 11) Postinjection Monitoring and Modeling; 12) Project Assessment; 13) Project Management; 14) RCSP Water Working Group (WWG) Coordination; 15) Further Characterization of the Zama Acid Gas EOR, CO_2 Storage, and Monitoring Project; and 16) Characterization of the Basal Cambrian System. Table 2 contains the responsibility matrix of these 16 tasks.

The EERC entered into a cooperative agreement with DOE NETL for Phase III activities in late September 2007. Phase III is a 10-year project, in three BPs, running from October 1, 2007, to September 30, 2017. This Annual Assessment Report summarizes the activities for PY4 (October 1, 2010 – September 30, 2011) for Phase III.

ASSESSMENT SUMMARY

In BP3, the focus of the program was to select two regionally significant, yet different, geologic formations for large-volume (approximately 1 Mt of CO_2 a year) commercial tests designed to demonstrate that CO_2 storage sites have the potential to store regional CO_2 emissions safely, permanently, and economically for hundreds of years. The Fort Nelson test site was selected in December 2007 and involves MVA support for the injection of up to 2 Mt/year CO_2 captured from one of the largest gas-processing plants in North America into a saline formation in British Columbia, Canada. The Bell Creek test site was selected in September 2009 and involves injection of CO_2 into formations in the PRB in southeastern Montana for the dual purpose of CO_2 storage and EOR.

Table 2. Phase III Responsibility Matrix

Phase III Task Title	Task Leader
Task 1 – Regional Characterization	Wesley D. Peck
Task 2 – Public Outreach and Education	Daniel J. Daly
Task 3 – Permitting and NEPA Compliance	Lisa S. Botnen
Task 4 – Site Characterization and Modeling	James A. Sorensen
Task 5 – Well Drilling and Completion	John A. Hamling
Task 6 – Infrastructure Development	Melanie D. Jensen
Task 7 – CO_2 Procurement	John A. Harju
Task 8 – Transportation and Injection Operations	Melanie D. Jensen
Task 9 – Operational Monitoring and Modeling	Charles D. Gorecki
Task 10 – Site Closure	TBA
Task 11 – Postinjection Monitoring and Modeling	TBA
Task 12 – Project Assessment	Katherine K. Anagnost
Task 13 – Project Management	Charles D. Gorecki
Task 14 – RCSP Water Working Group Coordination	Ryan J. Klapperich
Task 15 – Further Characterization of the Zama Acid Gas EOR, CO_2 Storage, and Monitoring Project	James A. Sorensen
Task 16 – Characterization of the Basal Cambrian System	Wesley D. Peck

Strong project management is crucial to the success of any project. The PCOR Partnership project management team focuses on providing timely completion of milestones, quality deliverables, accurate and timely project reports as directed in the Federal Assistance Reporting Checklist, and effective communication between the PCOR Partnership and DOE NETL management. All required deliverables, milestones, and project reports were completed on schedule during PY4. These included 23 required reports, achievement of mandatory milestones, and four quarterly progress reports. Several value-added (noncontractual) reports were also prepared including "Current Status of CO_2 Capture Technology Development and Application" and "Challenges and Opportunities in the Carbon Capture and Storage and Water Nexus: A Technology Gap Assessment."

In October 2010, the PCOR Partnership participated in a RCSP annual project review meeting in Pittsburgh, Pennsylvania, and hosted the 2010 partners-only annual meeting in Minneapolis, Minnesota. In September 2011, the PCOR Partnership hosted the 2011 annual meeting in Denver, Colorado, to ensure that program goals are being met. EERC staff was also asked to present an overview and update of Phase III PCOR Partnership activities in March 2011 before the IEA Greenhouse Gas R&D Programme (IEAGHG) expert review of the RCSPs, in Arlington, Virginia. Throughout PY4, the PCOR Partnership was represented at over 54 conferences and meetings and submitted 34 abstracts, all but four of which were accepted, had one author decline, and three abstracts currently remain in review. The PCOR Partnership also submitted 23 (deliverable) technical papers and gave nearly 60 presentations (oral and poster combined).

The PCOR Partnership continued to post technical information about its program on its public Web site, with 2765 site visits from 64 countries in PY4. Over 450 copies of the PCOR Partnership Atlas, 3rd Edition Revised, were distributed in PY4, and over 1600 DVD documentaries were distributed. Through these foregoing efforts, the CO_2 storage community is kept informed of the PCOR Partnership's accomplishments and activities.

Project management cannot be considered complete without identification of technical and nontechnical risks that may threaten successful project implementation. Accordingly, the PCOR Partnership developed a programmatic risk management plan in April 2011 to document individual project risks, consequences, and impacts. During PY4, the EERC worked closely with the Fort Nelson demonstration site owners/operators to prepare a 2011 update to the 2010 first-round RA. Although this assessment includes business-sensitive information and is confidential, the PCOR Partnership shares with the CCS community the methodologies used during the assessment.

In BP4, the focus of the program is to inject CO_2 at commercial scale at the two demonstration sites. For each site, the critical steps/decision points are 1) securing a CO_2 source, 2) permitting for pipelines and injection, 3) infrastructure development, 4) CO_2 injection, and 5) MVA implementation. Several years of injection and monitoring will be required in BP4 to move into the BP5 site closure and project wrap-up activities.

The CO_2 source has been secured for both the Fort Nelson and Bell Creek sites. In both cases, the CO_2 source is a natural gas-processing facility. Spectra owns the gas-processing

facility near the Fort Nelson site. The source of CO_2 for the Bell Creek site is the ConocoPhillips Lost Cabin Natural Gas-Processing Facility, and Denbury has secured the CO_2 from that facility for 15 years.

Permitting of the sites required that the EERC complete DOE environmental questionnaires for both the Fort Nelson and Bell Creek demonstration projects. The Fort Nelson demonstration project received categorical exclusion in 2010, and a categorical exclusion for the Bell Creek demonstration project was received in 2011. A permitting action plan was prepared for the Bell Creek project in August 2011 and described the regulatory and permitting steps taken by the EERC and Denbury to conduct the project.

The PCOR Partnership continues to establish and maintain excellent relationships with regional regulatory authorities. EERC staff participate fully in International Oil and Gas Compact Commission (IOGCC) efforts and served on its Pipeline Transportation Task Force. In fact, John Harju, EERC Associate Director for Research, was appointed to the IOGCC Executive Committee and will continue to serve until 2012. He was also appointed by the U.S. Secretary of Energy to serve as a member of the National Petroleum Council for the 2010–2011 membership term. In addition, the PCOR Partnership hosted its third annual regulatory workshop in June 2011, where oil and gas and pipeline regulators met informally to develop strategies to work past state/provincial boundaries and to establish rules and regulations outside of federal mandate. These relationships will prove invaluable as permitting activities progress.

For the Fort Nelson CCS project, the pipeline route is under development, and preliminary pipeline-permitting processes have begun. For the Bell Creek demonstration project, construction of the 232-mile Greencore CO_2 pipeline to the Bell Creek oil field has begun and is anticipated to be complete in December 2012.

The success of the PCOR Partnership Program will be evidenced by a region that has a supportive population, an accommodating regulatory environment, and, ultimately, a vibrant commercial CCS industry. Through its outreach and education activities, its rapport with regional regulators and federal decision makers, and its ongoing collaborative MVA activities with supportive partners, the PCOR Partnership is well on its way to achieving its goals.

This Annual Assessment Report provides information about the foregoing activities in more detail and is organized as set forth below:

- Progress update and budget status of the 14 tasks (Tasks 1–9 and 12–16) that were active in BP4, PY4 (October 1, 2010 – September 30, 2011)

- Accomplishments achieved during BP4, PY4 (October 1, 2010 – September 30, 2011)

- Description of planned BP4, PY5 (October 1, 2011 – September 30, 2012) activities

It should be noted that Tasks 10 and 11 will not be initiated until BP5.

BP4, PY4 ACTIVITIES (2010–2011)

Progress Report

BP3 included the first 2 years of Phase III, with activities initiated October 1, 2007. Thirteen tasks were originally scheduled for Phase III. A new task, Task 14, was added during PY2 of BP3. Out of the 14 tasks, 12 tasks were active during BP4, PY3. In February 2011, DOE approved moving former Subtask 1.4 to a newly created Task 15 and added a new task, Task 16, as shown in Figure 3. Out of the 16 tasks, 14 tasks were active during BP4, PY4. The progress update for those tasks is presented within this section. This Assessment Annual Report (Deliverable [D] 57) details activities beginning October 1, 2010, through the end of BP4, PY4, or September 30, 2011.

In April 2011, DOE recognized a change from Edward N. Steadman to Charles D. Gorecki as the overall EERC program manager and principal investigator (PI), who provides leadership in fully coordinating and integrating the activities of the PCOR Partnership. To facilitate the management of this project, task leaders were designated, as shown in Table 2.

Task 1 – Regional Characterization

The PCOR Partnership continues to refine the characterization of sources, geologic sinks, and infrastructure within its region. The goal is to further refine the assessment of the region's CO_2 production and storage potential in an effort to optimize source–sink opportunities within the region. This continued regional characterization will be used to refine capacity estimates for DOE NETL's national atlas and to provide context for extrapolating the results of the large-scale demonstrations.

Activities and Results

Phase III regional characterization efforts for BP4, PY4 (October 1, 2010 – September 30, 2011) are addressed below.

Review and Update Attribute Data for CO_2 Source Locations Within the Region

The PCOR Partnership maintains a database of significant stationary regional point sources of CO_2. The database is key in the development of CO_2 capture–transportation–sequestration scenarios that have the potential to reduce GHG emissions in the PCOR Partnership region. To maintain a reasonably current status, the data set undergoes an annual review during which new or missing sources are identified and added, CO_2 emission rates are updated, and facility locations are verified. The review also identifies which sources in the database are no longer active. The review that took place in PY4 addressed all of these areas. As of September 15, 2011, the updated PCOR Partnership database contains 906 sources that produce an estimated 606.45 Mt of CO_2 annually. This compares to the September 2010 values of 966 sources producing an estimated 594.37 Mt of CO_2 annually.

In 2008, the PCOR Partnership instituted a minimum CO_2 emission rate of 15,000 tons/yr for sources contained in the database. This lower limit puts the focus on larger sources that will be more cost-effective to address with respect to capture and storage. Many sources produced less CO_2 during the past calendar year as a result of efficiency gains, changes in production or, in the case of the natural gas transmission stations, because the emission estimation methodology changed. A total of 88 sources were removed because they no longer produced the minimum amount of CO_2 required for inclusion in the PCOR Partnership database. Occasionally, the name of a source is found to have changed in an emission data set. The PCOR Partnership database was modified to reflect the name change of 62 sources since October 1, 2010.

Second Target Area Characterization (Rival oil field) Continued

In PY2, the PCOR Partnership completed a detailed geologic site characterization for its first target area, the Dickinson Lodgepole Mounds (including the Eland oil field) near Dickinson, North Dakota. In PY3, work began in the Rival oil field, located in northwestern North Dakota, and continued throughout PY4 (Figure 4). This field has been identified as a potential target area for CO_2 storage and CO_2 EOR activities and is currently home to an acid gas injection disposal unit in Burke County, North Dakota.

Site characterization and 3-D geologic modeling of the Rival Field were completed in PY4. Predictive static 3-D geologic models were built with the goal of better understanding spatial distribution of reservoir properties across the 100-square-mile study area centered on the Rival Field. As part of the characterization efforts, additional core analyses were performed by the EERC Applied Geology Laboratory to complement historically available data. Several well data normalization and petrophysical analysis techniques were performed on the geophysical logs available from the 312 wells. A petrophysical model was built with the following interpreted properties: effective porosity, net-to-gross, permeability, water saturation, temperature, and pressure.

Characterization and modeling have confirmed the four potential flow zones described by Besserer (Besserer, 1998). The Midale and Rival Members were found to each contain two vuggy flow zones in which hydrocarbons are present, separated by layers of shaley marl with little to no flow properties. Incremental oil recovery (IOR) can be acquired from continuation of the horizontal drilling program in the Rival Member and tertiary CO_2 flooding in both the Midale and Rival Members. A proposed path forward includes updating original oil in place and oil–water contacts, uncertainty analysis, history matching, and performing predictive simulation to determine CO_2-based IOR and CO_2 storage volumes.

Jason Braunberger, Research Scientist, presented “Characterization and Facies Modeling of the Midale and Rival ‘Nesson’ Beds in the Mississippian Madison Group, Burke County, North Dakota” on June 28, 2011, at the Rocky Mountain Section of the American Association of Petroleum Geologists (AAPG) 60th Annual Meeting in Cheyenne, Wyoming (www.rms-aapg.org/2011_meeting). The oral presentation was designated “best” in the session entitled “CO_2 EOR and Sequestration I.”

Figure 4. Location of the Rival oil field in northwestern North Dakota within the PCOR Partnership region.

An abstract on characterization and modeling of the Rival oil field for potential CO_2 EOR was submitted in September 2011 for the AAPG 2012 Annual Conference & Exhibition (http://www.aapg.org/longbeach2012). Authors will be notified of acceptance or rejection in November 2011.

Refine Storage Analogs for Specific Geologic Horizons Within the Regional Basins

There are eight depositional basins lying fully or partially within the PCOR Partnership region. Efforts are under way to expand the number of assessed target formations in these basins, including the Red River and Dakota Formations in the Williston Basin. The largest of these efforts is aimed at characterizing the basal Cambrian saline system lying across the Alberta and Williston Basins. This effort was reassigned its own task (Task 16) in 2011. Also in PY4, discussions were begun on the availability of water quality analysis for specific geologic horizons across the region and the utility of such data in the greater scheme of regional characterization.

Work with Geological Surveys/Oil and Gas Divisions

As efforts in the Bell Creek oil field increased, contact was focused on the Montana Board of Oil and Gas Conservation attached to the Montana Department of Natural Resources. This delayed plans in PY4 to pursue a collaborative venture with the Nebraska Geological Survey and/or the Nebraska Oil and Gas Commission to aid in the assessment of carbon storage

opportunities in that state. Plans are still under way to prepare reports for the baseline and characterization data received from the states of Missouri and Iowa regarding the potential geologic storage of CO_2 in those states.

PCOR Partnership Atlas

The PCOR Partnership Atlas provides an introduction into the concept of global climate change and CCS, as well as a regional profile of CO_2 sources and potential sinks across the nearly 1.4 million square miles of the PCOR Partnership region of central North America. This atlas is slated for revision on a biennial basis, i.e., 2009, 2011, etc., which are the alternate years for DOE NETL's update of the carbon sequestration atlas of the United States and Canada.

Efforts to reinvent the PCOR Partnership Atlas, 4th edition, were undertaken in PY4. This includes new images, new text, and a new size (for easier transportability).

This atlas continues to serve as an excellent resource as well as a valuable outreach tool, and the upcoming expanded version will increase its value in this respect. It is distributed to partners, visitors, educators, libraries, and conference attendees and is available upon request, including via the public PCOR Partnership Web site. Approximately 450 atlases (3rd edition, revised) were distributed in PY4. Overall, since its first printing in 2005, over 3200 atlases have been distributed.

Updating the DSS Web Site (www2.undeerc.org/website/PCORP)

Since the site redesign was reported to DOE NETL in September 2009, modifications and refinement to the partners-only Decision Support System (DSS, © 2007–2011 EERC Foundation) are continually undertaken to ensure the timely dissemination of data and information as well as to help improve the quality and efficacy to our partners for their carbon management decisions. Efforts undertaken in PY4 include the following:

- Continually updated the home page to keep partners apprised of the latest PCOR Partnership activities.

- Continually updated the Downloadable Resources page with new resources dedicated to CO_2 regulations.

- Developed several new pages for the Carbon Markets section.

- Revised the Products Database search page to provide a more intuitive and streamlined interface in response to the ever-growing number of products housed there (over 600 and counting).

- Periodically updated the Keep Me Informed page to provide pertinent information to the partners.

- Created an annual meeting section to showcase highlights from the PCOR Partnership 2010 Annual Meeting and Workshop held October 19–21, 2010, in Minneapolis, Minnesota. Highlights from the 2011 annual meeting held September 12–14, 2011, in Denver, Colorado, will be added soon.

- Significantly redesigned the geographic information systems (GIS) portion of the DSS using Adobe® Flex™. These modifications are most apparent from the user interface perspective, but also extend behind the scenes. The less obvious changes have taken place with the GIS layers moving to a geodatabase platform to take advantage of data management and performance benefits. The latest user interface redesign integrates seamless background maps provided as map services by Esri (Environmental Systems Research Institute, Inc.). This allows for the presentation of the regional characterization data on high-resolution satellite and aerial photography as well as topographic and thematic-based road maps (Figure 5).

EERC staff faced challenges with programming the new features on the partners-only DSS, including Flash and GIS. Flash is the leading program for creating fast-loading animations, which has dramatically enhanced the Web site. However, there were unique challenges to combining GIS software, data, and programming that created time overruns. Staff were on a steep learning curve and had fallen behind by approximately a month with their planned activities. Ultimately, as familiarity with the programs grew, lost time was recaptured.

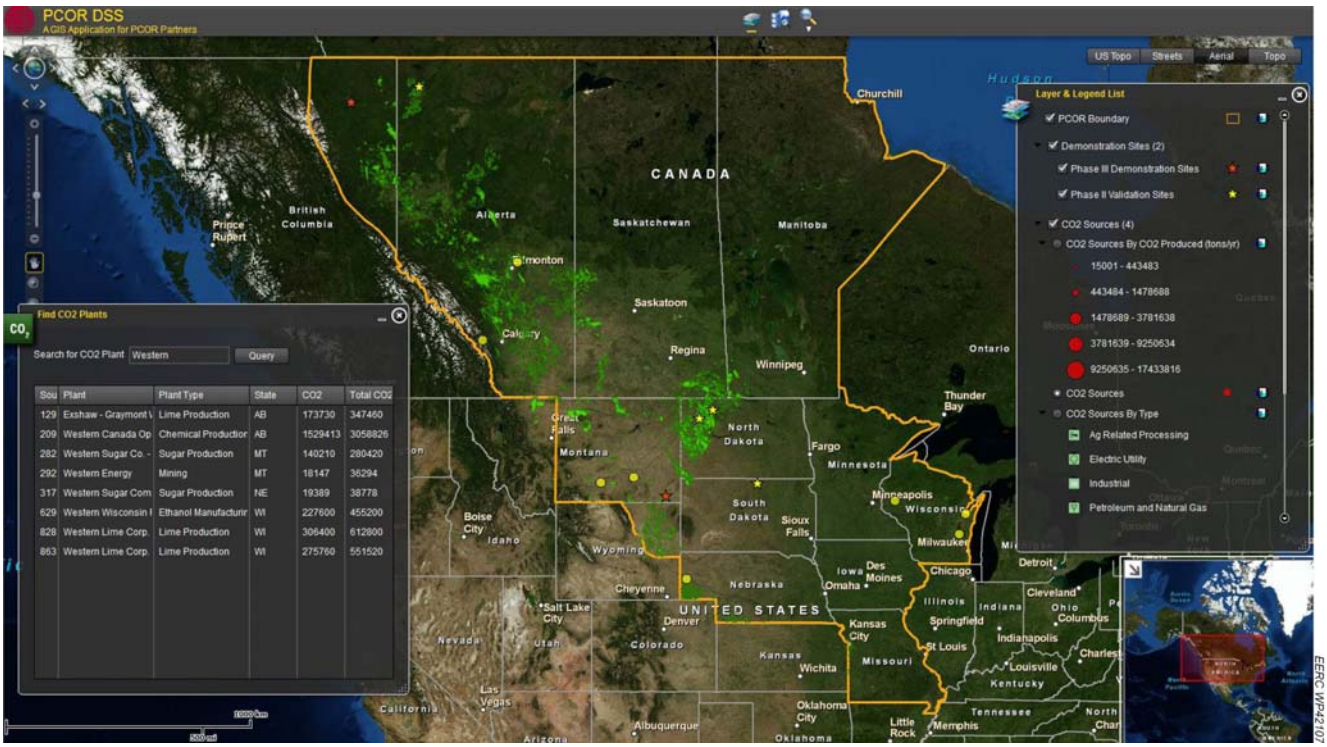


Figure 5. Screen shot of the revised interactive GIS map.

Development of a Demonstration Project Reporting System (DPRS)

Collection of information specific to the demonstration sites is ongoing in an effort to populate a Web-based interface to house the data and facilitate communication and interpretation of the data. A new DPRS was created to provide structured access to data from the PCOR Partnership Phase III demonstration projects at Bell Creek and Fort Nelson. Each project has its own section, with the following subcategories:

- Background and Scope of Work
- Benefits to the Region
- Characterization Data
- Modeling
- Monitoring, Verification, and Accounting
- Risk Management
- Regulations and Permitting
- Site Operations
- Products

The DPRS is an important addition to the DSS and will improve the nature and accessibility of the various demonstration project data and ultimately augment the well-established outreach and communication efforts of the PCOR Partnership Program.

Further Characterization of the Zama Acid Gas EOR, CO_2 Storage, and Monitoring Project

Effective February 23, 2011, in the the Statement of Project Objectives (SOPO), Subtask 1.4 – Further Characterization of the Zama Acid Gas EOR, CO_2 Storage, and Monitoring Project became new Task 15. No overall budget modifications were required. The time line also remained the same; i.e., work was initiated in July 2010 and will continue through April 2012.

DOE NETL Carbon Sequestration Atlas of the United States and Canada (Atlas III)

The primary purpose of Atlas III is to update U.S.–Canadian CO_2 storage potential and provide updated information on the activities of DOE's seven RCSPs as well as DOE's Carbon Sequestration Program and international CCS collaborations. In order to support Atlas III efforts, the PCOR Partnership participated in multiple conference calls in PY3 to discuss progress of the data compilation and provided data via NATCARB (DOE NETL's distributed NATional CARBon Sequestration Database and Geographic Information System), including aggregated characterized saline aquifer data, recalculated regional coal capacity information, and new GIS layers. Atlas III was released in PY4 on December 1, 2010.

Foundations of CCS Geology Workshop

Prior to the 2011 annual meeting, a workshop entitled "Foundations of CCS Geology" (Figure 6) was held on September 12, 2011, in Denver, Colorado. The half-day introductory

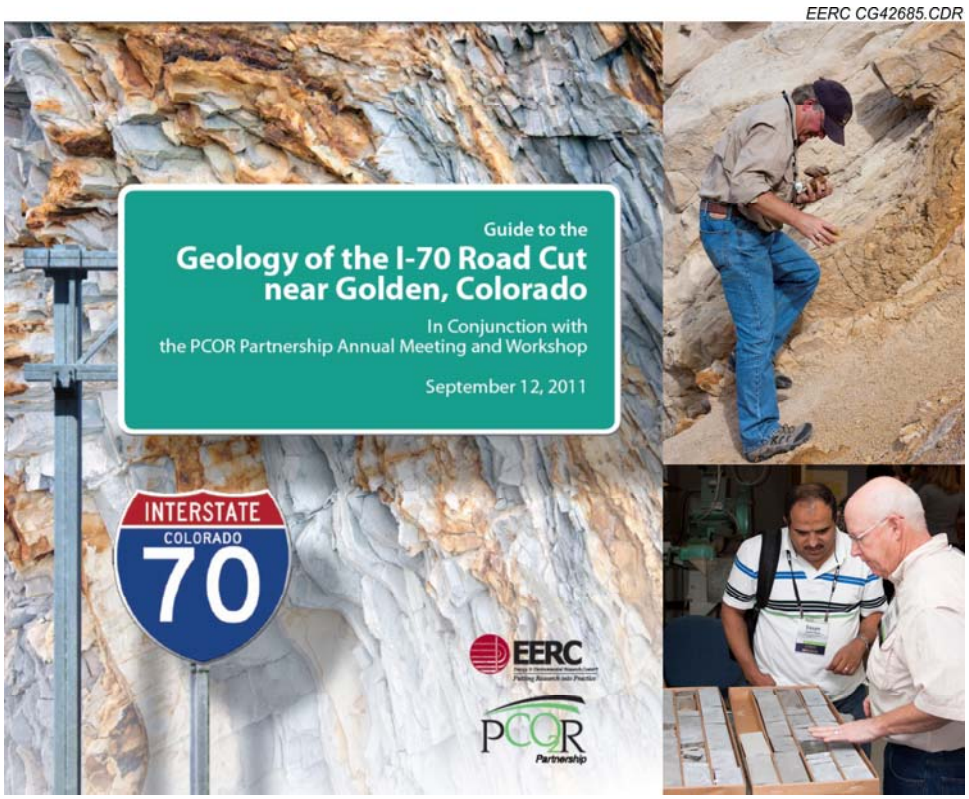


Figure 6. Montage of images from the Foundations of CCS Geology Workshop held September 12, 2011, in Denver, Colorado.

workshop was designed for everyone involved in or associated with CCS projects and provided an explanation of key geology concepts, along with rock specimens and activities. The tools, techniques, and vocabulary of the geologist were also emphasized throughout the workshop. This workshop was developed to provide a nontechnical overview of basic geology and its relationship to the concepts of CCS and CO_2 EOR. The workshop included a 30-minute oral presentation, followed by a trip to the U.S. Geological Survey (USGS) Core Research Center (CRC) and then to the Interstate 70 outcrop. At the CRC, a tour was given of the facility, core samples representative of PCOR Partnership projects subsurface (sinks and seals) were displayed, and an oral presentation on well logging was given by a representative of Schlumberger Carbon Services. This was then followed by a trip to the I-70 road cut just west of Denver, where participants were able to view a surface representation of the geologic formations usually found underground. Over 60 people attended this workshop.

RCSP GIS Working Group

The task lead attended and participated in the RCSP GIS Working Group meeting held in conjunction with the 2010 RCSP Annual Review Meeting in Pittsburgh, Pennsylvania, on October 5–7, 2010. Prior to the 10th Annual Conference on Carbon Capture and Sequestration (CCS-10), questions were prepared for consideration by the working group regarding the design and functionality of its proposed database.

North American Carbon Atlas Partnership (NACAP)

The United States, Canada, and Mexico have formed a joint CO_2-mapping initiative called NACAP. The goal of NACAP is for each country to identify, gather, and share data for CO_2 stationary sources and geologic storage sites. The NACAP members will then display these sources and storage sites in a GIS for North America. Development of this GIS system supports the Carbon Sequestration Program, the objectives of the North American Energy Working Group (NAEWG), and current topics being discussed under the Canada–U.S. Clean Energy Dialogue. It is expected that this initiative will serve as a key opportunity to foster collaboration among the three countries in the area of CCS. Results of this initiative are expected to be published in a NACAP Atlas (www.netl.doe.gov, accessed December 2011). The PCOR Partnership program manager shares commitment to this effort with the regional characterization task lead. During PY4, the task lead attended and presented at the NACAP meeting held November 2, 2010, in Ottawa, Ontario, Canada. In follow-up to the meeting, a 3-page summary of the methodologies used for CO_2 storage resource capacity calculations was drafted for review and comment. Input was also provided upon request to several DOE NETL project managers about discrepancies discovered in the Canadian GIS data provided to NACAP.

Training and Presentations

Information was presented on the PCOR Partnership at EUEC 2011 (Energy, Utility & Environment Conference, www.euec.com,) in Phoenix, Arizona. An EERC booth displayed PCOR Partnership outreach materials, e.g., DVDs, atlases, etc., at the event.

GIS programming staff attended the Esri Developer Summit held March 7–10, 2011, in order to better apply GIS programming advancements to the partners-only Web applications.

GIS programming staff attended the Esri International Users Conference as well as a 2-day training session in San Diego. This effort will bolster programming capabilities with respect to online GIS and DSS capabilities.

Task 2 – Public Outreach and Education

This task provides outreach and education mechanisms to raise awareness regarding CO_2 storage opportunities in the region as well as outreach to select target audiences concerned with the demonstration activities.

Activities and Results

Accomplishments during BP4, PY4 (October 1, 2010 – September 30, 2011) are described below:

- EERC employees attended 54 meetings/conferences and 10 workshops plus a field trip, resulting in approximately 14,694 external participants who were exposed to the PCOR Partnership name, messaging, and informational materials. Specifically, the PCOR

Partnership outreach activities included three poster presentations and 53 oral presentations. The following quantities of outreach materials were distributed:

- PCOR Partnership documentary entitled "Nature in the Balance: CO_2 Sequestration" – 143
- PCOR Partnership documentary entitled "Reducing Our Carbon Footprint: The Role of Markets" – 137
- PCOR Partnership documentary entitled "Out of the Air: Into the Soil" – 138
- PCOR Partnership documentary entitled "Managing Carbon Dioxide: The Geologic Solution" – 424
- PCOR Partnership documentary entitled "Global Energy and Carbon: Tracking Our Footprint" – 792
- PCOR Partnership Atlas, 3rd edition, revised – 451
- PCOR Partnership product list – 190

Outreach Planning

An update to the PCOR Partnership outreach action plan (D11) was prepared in March 2010. This plan describes the activities undertaken and products developed to help raise awareness of both the practice of CO_2 storage in general and the PCOR Partnership specifically. The next version of the plan is scheduled for March 2016.

Public Web Site (www.undeerc.org/pcor)

The public PCOR Partnership Web site will be updated and expanded as appropriate, with major updates on a biennial basis. The next update (D13) is scheduled for July 31, 2012.

Google Analytics is utilized to track activity for the PCOR Partnership public Web site (Figure 7). Presently, site traffic includes both internal (EERC and PCOR Partnership staff) and external audiences. During PY4, there were 2765 visits to the public Web site, of which 1681 were unique visitors. Analysis showed that visitors stop to visit approximately three Web pages. The average time on the site was 3.24 minutes. 57.69% of the visitors were new to the public Web site. The bounce rate of the 2765 visits is 46.47%, meaning that 1285 of the visits did not go past the home page. There were 9210 page views in PY4. The top five pages that received the most views are shown in Table 3.

The PCOR Partnership public Web site received traffic from 64 countries in PY4. Of the 2765 visits, 74% of the Web traffic was domestic, while 26% was international. International

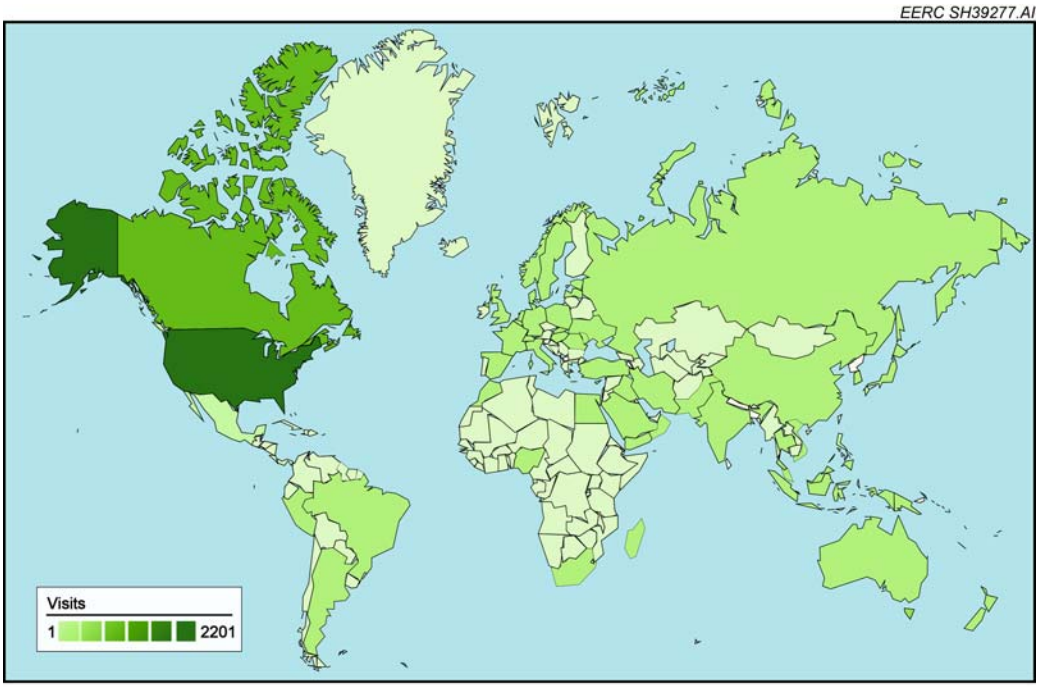


Figure 7. Map of PCOR Partnership global Web traffic (source: Google Analytics).

Table 3. PCOR Partnership Public Web Site Content Overview

Page	Page Title	Page Views	% Page Views
www.undeerc.org/pcor/about/default.aspx	About the Partnership	784	8.51
www.undeerc.org/pcor/co2seqprojects/default.aspx	CO_2 Sequestration Projects	699	7.59
www.undeerc.org/pcor/videogallery/default.aspx	Video Gallery	589	6.40
www.undeerc.org/pcor/newsandpubs/default.aspx	News and Publications	588	6.38
www.undeerc.org/region/default.aspx	CO_2 and Storage in the Region	425	4.61

traffic, as depicted in Figure 10, was primarily from Canada. The countries with the highest number of visits included Canada (236), the United Kingdom (99), India (36), France (31), Japan (29), Australia (28), Poland (28), China (25), and South Korea (27).

Fact Sheets

Fact sheets have been created with general background information on the PCOR Partnership Phase III program and a profile on each of the demonstration projects. These fact sheets, along with the ones developed in previous phases, will be updated as needed. Other fact sheets may be developed as needed.

In February 2011, a new fact sheet (D15) was created in collaboration with Denbury for the Bell Creek Integrated CO_2 EOR and Storage Project. The general program fact sheet in addition to the fact sheets for the two demonstration projects were all updated in April 2011 to include the name of the new program manager.

PowerPoint Presentations

PowerPoint presentations have been developed for Phase III general activities as well as for each of the demonstration projects. In PY4, all three general outreach PowerPoint presentations received attention.

A new PowerPoint presentation was created in collaboration with Denbury for the Bell Creek test site (D18) in March 2011. The general Phase III information PowerPoint presentation (D17) was updated and approved for general use in May 2011.

After discussions with Spectra, a modified version of the Fort Nelson test site PowerPoint presentation was prepared in June 2011. This PowerPoint endeavored to undertake a step-by-step (slide-by-slide) review of the geology under the Fort Nelson planned injection site. Several discussions regarding this presentation were held with Spectra personnel; however, it has not yet received final approval for general use. Collaborative efforts are ongoing.

Outreach Working Group

The RCSP Outreach Working Group (OWG), comprising representatives from each of the seven regional partnerships, recognizes the importance of conducting public outreach in tandem with successful field tests. Its members pool their experiences and resources in an effort to provide a foundation for future commercialization efforts and even more extensive outreach efforts. Based on contributions by the outreach leads of the seven regional partnerships, DOE NETL's outreach best practices manual entitled "Public Outreach and Education for Carbon Storage Projects" was released in December 2009.

Examples of the PCOR Partnership's participation in the OWG during PY4 include the following:

- Participation in the monthly OWG conference calls and other calls as needed.

- Preparation of a poster entitled "Outreach Best Practices: A Practical Foundation for the Future" on behalf of the OWG and presented it at the 2010 RCSP Annual Review Meeting held on October 5–7, 2010, in Pittsburgh, Pennsylvania.

- Participation in preparation of an abstract, paper, and public outreach and education workshop held May 4, 2011, during CCS-10 in Pittsburgh, Pennsylvania.

- Participation in June and July 2011 in the update of video shots and "baseball-style" fact cards for the demonstration projects organized by the OWG for the 4th Carbon Sequestration Leadership Forum (CSLF) Ministerial Meeting held in September 2011 in Beijing, China.

- Preparation began of a presentation and poster on the outreach best practices manual for the Society of Petroleum Engineers (SPE) Forum Series entitled "CO_2 Geological

Storage: Will We Be Ready in Time?" scheduled for October 9–14, 2011, in The Algarve, Portugal.

Posters

Posters intended for a general audience are under development. In March 2009, a general outreach poster (D24) was completed. Efforts were undertaken for individual posters profiling the demonstration projects. In collaboration with Denbury, a Bell Creek test site poster (D27) bearing the heading "CO_2 Emissions Go to Work to Produce More Oil" was prepared in September 2011 for general audiences (Figure 8).

The Fort Nelson test site poster (D26), similar to the concept of the Bell Creek test site poster, will diagram the geology under the Fort Nelson demonstration project. A draft poster was

Figure 8. Bell Creek test site poster (September 2011).

prepared in March 2011, followed by several discussions with Spectra personnel. It has not yet received final approval for general use. Collaborative efforts are ongoing.

Documentaries and Video Products

A spectrum of video products are developed to meet the need of general and site-level outreach. Thirty-minute broadcast-quality documentaries are produced in partnership with Prairie Public Broadcasting (PPB), are broadcast in the PPB market area, are made available to other public broadcasting markets for possible broadcast, are placed on the public Web site, and are available as DVDs. Video segments and products intended for use in PowerPoint presentations and public Web pages are also developed.

In PY4, an additional 15 video segments were created from the documentary products and other materials held by PPB. The clips are under 5 minutes in length and are intended to supplement the PowerPoint presentations and the publicly accessible Web site. In addition, three short videos were licensed for educational use from John Perez Graphics and Design, LLC, and have been added to the public Web site (Figure 9). These three short videos were also shown at a booth during the 2011 PCOR Partnership annual meeting.

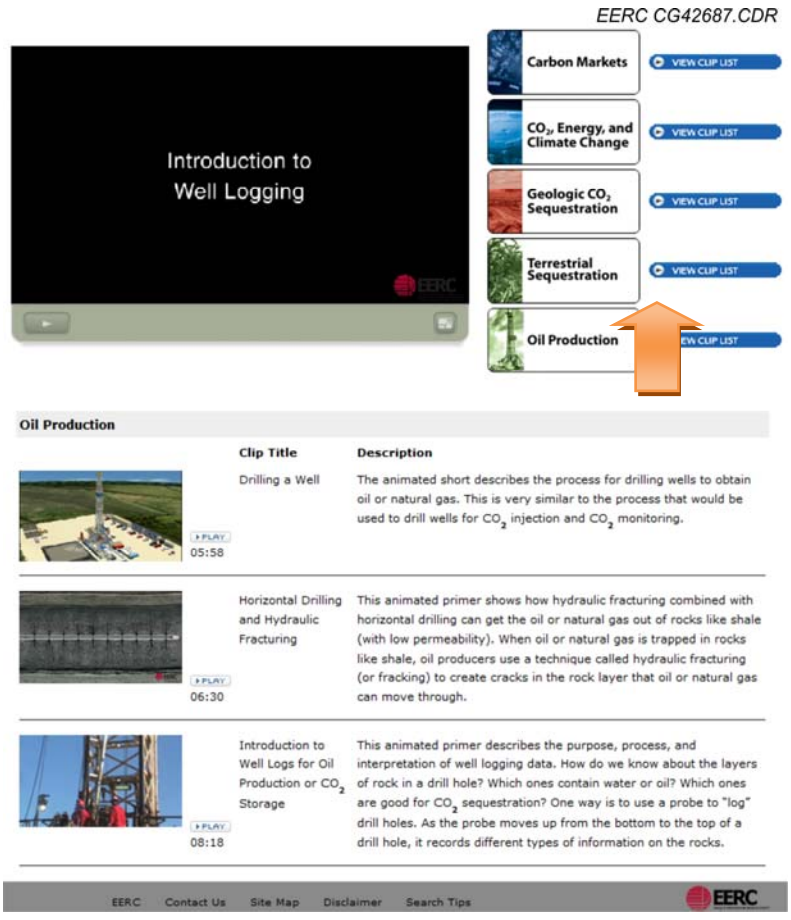


Figure 9. Screen shot of new oil production/CO_2 storage video clips (www.undeerc.org/PCOR/videogallery).

"Global Energy and Carbon: Tracking Our Footprint" premiered on October 18, 2010, on Prairie Public Television. This documentary follows families in the United States, India, and Cameroon to examine how energy is used in three economies: industrialized, emerging, and developing. During PY4, nearly 800 DVDs of this documentary were distributed. Efforts are under way to create video clips to be housed on the public Web site.

The Bell Creek (D21) and Fort Nelson (D22) demonstration site documentaries are due in November 2014 and August 2015, respectively. In PY4, documentary production activity plans (concept, shot list, FAQs) were prepared and discussed in collaboration with both site's owners/operators. Plans are under way to film monitoring activities at the Bell Creek test site in fall 2011.

Documentaries – U.S. Television Coverage

In PY4, the PCOR Partnership received public television exposure of documentaries in 28 states, as shown in Figure 10. There were 221 total telecasts of the documentary throughout the United States. The number of telecasts by documentary are as follows: "Global Energy and Carbon: Tracking our Footprint" (151), "Our Carbon Footprint: The Role of Markets" (37), "Out of the Air – Into the Soil: Land Practices that Reduce Atmospheric Carbon Levels" (32), and "Managing CO_2: the Geologic Solution" (1). Efforts are currently under way to also track the Canadian telecasts.

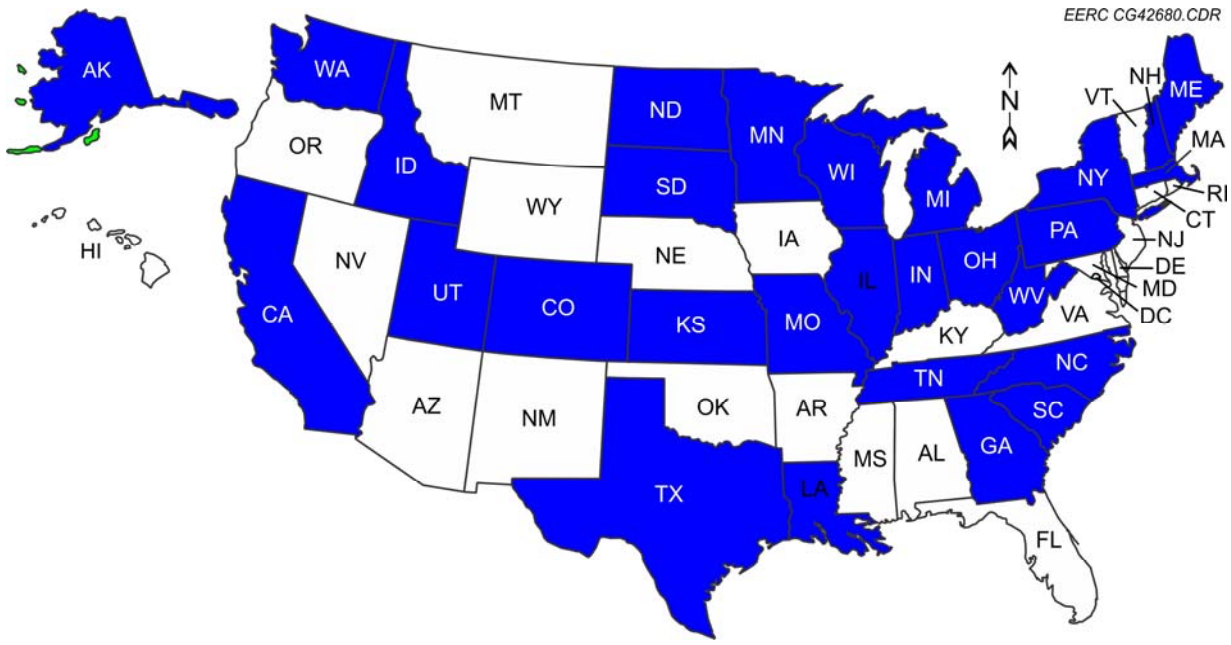


Figure 10. States airing broadcasts of various PCOR Partnership documentaries.

Additional Outreach Activities

The outreach team continues to identify and act on opportunities to provide outreach both at the regional level and in the vicinity of the demonstration projects. Activities undertaken in PY4 include the following:

- Continued development of a database for more formal outreach tracking efforts, e.g., tracking the distribution of outreach materials, media coverage, presentations, conference attendance, and exhibit booth displays.

- Assisted with the development of the Foundations of CCS Geology Workshop that was held in conjunction with the 2011 PCOR Partnership Annual Meeting in Denver, Colorado.

- Discussed a potential filming of the EERC Applied Geology Laboratory PCOR Partnership activities for video-based outreach.

- Discussed plans for three sets of focus group activities for different portions of the PCOR Partnership region to help with messaging and development of individual outreach and education products and capabilities.

- Discussed ideas for the development of a CCS-based interactive game to be housed on the public Web site.

- Continued review of a variety of information resources (e.g., spreadsheets of global natural gas storage sites, global occurrences of natural CO_2 deposits, global occurrences of natural gas processing facilities, and proposed coal-fired facilities in the northern Great Plains) to supplement ongoing activities outreach and education efforts.

- Continued discussions with the Indian Land Tenure Foundation (ILTF); the ILTF has hired a full-time person to work on energy and carbon issues, and ILTF suggested that this new hire make a 3-day visit to the EERC to learn about PCOR Partnership capabilities and to discuss opportunities for collaboration.

- Continued plans with EERC library staff to develop outreach strategies involving regional libraries. For the second year in a row, this included an exhibit booth displaying PCOR Partnership atlases, DVDs, and fact sheets at the North Dakota Library Association's annual conference.

- Participated in regional teacher education seminars including:

  – In June 2011, gave presentations and distributed outreach materials to a group of approximately 50 teachers at the North Dakota Petroleum Council's (NDPC's) 2011 Teacher Education Seminar (www.ndoil.org) held in Bismarck, North Dakota.

- Also in June 2011, gave a presentation and distributed outreach materials to a group of approximately 133 teachers at the Lignite Energy Council's (LEC's) 2011 Lignite Education Seminar: Energy, Economics, and Environment (www.lignite.com) held in Bismarck, North Dakota.

- In August 2011, delivered a 3-hour presentation on sequestration at the PPB "master" teacher training session held on Saturday, August 27, in Fargo, North Dakota. These master teachers will, in turn, facilitate sessions at PPB's Teacher Training Institute scheduled for November 18–19, 2011.

- Participated in the Weyburn–Midale Outreach Advisory Panel including the following:

  - Participation in advisory teleconferences.

  - Discussion on opening an information display in the Weyburn city hall and ongoing focus group and survey work.

- Participated in the Aquistore Project Communications Advisory Group.

Task 3 – Permitting and NEPA Compliance

The overall goal of Task 3 is to advance the regulatory and permitting framework for CO_2 storage projects in North America as well as to assist the demonstration site owners as necessary in obtaining the permits and approvals needed for the projects to comply with state, provincial, and federal requirements.

Activities and Results

The PCOR Partnership continues to stay abreast of federal legislative actions occurring in the United States and Canada and follows the developments of various state, provincial, and regional initiatives. Internal documents that outline the activities of these groups are updated on a regular basis. Reviews continue of publications relating to the regulation of CO_2 sequestration, MVA issues, and carbon market developments. Updates are provided to task leaders with regard to federal, state, and provincial actions. In addition, the regulatory section on the DSS is updated regularly.

Accomplishments during BP4, PY4 (October 1, 2010 – September 30, 2011) also included the following:

- Prepared and distributed a handout entitled "Regulatory Roundup" (Figure 11) at the 2010 PCOR Partnership Annual Meeting and 3rd Annual Regulatory Meeting, covering U.S. Environmental Protection Agency (EPA) activities, the U.S. Presidential Interagency Task Force on CCS, and general regulatory activity throughout the PCOR Partnership region.

- Completed review of Craig Hart's paper on Phase III of the RCSP Program, including financial, legal, and regulatory barriers.

Figure 11. Cover of the 8-page Regulatory Roundup (October 2010 version).

- Assisted the Aquistore project (a PCOR Partnership partner) by reviewing and commenting on its project description to ensure compliance with the Canadian Environmental Assessment Act. Once our comments were incorporated, Aquistore submitted its project description to the Canadian federal government for determination of the level of environmental review that will be required for its project.

- Provided input on May 20, 2011, to the Global CCS Institute on its document entitled "A Review of Existing Best Practice Manuals for Carbon Dioxide Storage and Regulation."

NEPA Environmental Questionnaires

The EERC was required to prepare the DOE environmental questionnaire (EQ) for both the Bell Creek and Fort Nelson demonstration projects (D27 and D28). DOE's NEPA implementation procedures require consideration of the potential environmental consequences of all proposed actions. DOE must determine, as early as possible, whether such actions require an environmental assessment (EA) or an environmental impact statement (EIS), or if they qualify for categorical exclusion. DOE suggested the most intensive NEPA scenario be addressed.

The Fort Nelson demonstration project EQ was submitted to DOE April 2, 2008. A categorical exclusion was determined by DOE (for the performance period 2008–2010) in

February 2010. In December 2010, a categorical exclusion (for the performance period 2011–2017) was received. In March 2011, an environmental questionnaire for the Bell Creek demonstration project was prepared, and on July 14, 2011, a categorical exclusion was signed.

Assistance in the Development of the EA

If DOE had determined that an EA was necessary for the Bell Creek project, the Cooperative Agreement with the EERC would be modified to reduce the award value for DOE to contract directly with an organization to prepare the appropriate document. However, the EERC received a categorical exclusion. Efforts are under consideration to redefine SOPO Subtask 3.2 now that an EA is not necessary. A significant amount of effort will, however, be expended in interfacing with the commercial partners and their respective subcontractors with regard to NEPA compliance activities.

General Permitting Assistance

The EERC interfaces with relevant regulatory agencies within the PCOR Partnership region as well as with federal regulatory agencies (United States and Canada) to understand the regulatory framework for project implementation. The EERC determines anticipated permitting activities for potential projects in all states and provinces of the PCOR Partnership region.

On January 20, 2011, an update on EPA's mandatory greenhouse gas reporting rules was sent to the PCOR Partnership partners. It advised that data collection was to begin on January 1, 2011, with the first reports due to EPA in March 2012. Rules have also been finalized under the Safe Drinking Water Act for the injection of CO_2 for geologic sequestration. The PCOR Partnership has completed, or is in the process of reviewing, all of these regulations and analyzing the impacts they may have on our partners and the CCS industry.

In September 2011, a brief document entitled "Permitting Review – Basic EPA Requirements" (D4) was prepared as a synopsis of the necessary requirements to conduct a geologic CO_2 storage project in the United States. The information provided gave a broad overview of the regulatory requirements and the authorities involved. As of September 2011, EPA has the authority to permit CO_2 geologic storage wells in all 50 states. Additionally, EPA requires geologic storage projects to comply with the Mandatory Reporting of Greenhouse Gases Rule (MRR; 40 Code of Federal Regulations [CFR] 98).

On November 16, 2010, a breakfast meeting of the PCOR Partnership's regulatory group was held during the IOGCC Annual Meeting in Tucson, Arizona.

Third Annual PCOR Partnership Regulatory Meeting

The 2009 regulatory meeting looked at the regulatory regime associated with subsurface injection of CO_2. At the meeting held in 2010, there was an effort to embrace a larger community by also addressing pipelines and focusing on the efficient movement of CO_2 throughout the region. In 2011, the meeting was held on June 29–30, 2011, in conjunction with the IOGCC Midyear Meeting in Bismarck, North Dakota. A primary goal of the meeting was to continue to

develop strategies to work past state/provincial boundaries. There were 19 attendees, including representatives from North Dakota, South Dakota, Missouri, Montana, Nebraska, Wyoming, Alberta, British Columbia, and Saskatchewan and representatives of IOGCC, Melzer Consulting, Premier Oil Recovery, and Carnegie Mellon University.

An update on the EPA rules was also provided, as follows:

Mandatory Reporting of Greenhouse Gases Rule. EPA finalized its MRR, which consists of Subparts A though UU, late last year. Subpart W of the rule addresses petroleum and natural gas systems. A facility is covered by the rule if it emits greater than 25,000 metric tons per year (MT/year) of CO_2. However, the definition of what constitutes a "facility" is unique for this subpart, in that it is all-encompassing and covers various activities that are located in a single hydrocarbon basin and under common ownership or common control.

Subparts RR and UU refer to the injection of CO_2. Subpart RR covers any well or group of wells that inject CO_2 for long-term geologic storage and all wells permitted as Class VI wells (next section provides more information on this new well class). Such facilities are required to report 1) mass of CO_2 received, 2) mass of CO_2 produced (i.e., mixed with produced oil, gas, or other fluids), 3) mass of CO_2 emitted from surface leakage, 4) mass of CO_2 equipment leaks and vented CO_2 emissions from sources between the injection flowmeter and the injection wellhead or between the production flowmeter and the production wellhead, and 5) the mass of CO_2 sequestered in subsurface geologic formations (this amount is calculated from other quantities). Subpart RR reporters must also 1) develop and implement an EPA-approved "monitoring, reporting, and verification" (MRV) plan and 2) report source(s) of the CO_2.

Research and development (R&D) projects can apply for an exemption to this requirement. Subpart UU refers to EOR business-as-usual CO_2 injection and requires operators injecting CO_2 for the purposes of EOR to report, on an annual basis, the amount of CO_2 being injected and the source of the CO_2. EOR operators can "opt in" to Subpart RR should they desire. R&D projects receiving a Subpart RR exemption must report under Subpart UU.

Geologic Sequestration (GS) Class VI Wells. EPA has also finalized requirements for the development of a new class of wells (Class VI) under the authority of the Safe Drinking Water Act's Underground Injection Control (UIC) Program.

There are numerous elements to the Class VI Rule that deal with various aspects of permitting and operating a UIC Class VI injection well. These elements include the following:

- Site characterization requirements
- AoR (area of review) delineation and reevaluation
- Well construction and operation requirements

- Testing and monitoring requirements
- Site-specific project plan development
- Financial responsibility for the life of the project
- Postinjection site care monitoring – 50-yr default
- Injection depth waiver
- Provides consideration for wells transitioning from Class II (enhanced resource recovery wells) to Class VI (straight storage wells)

Additionally, there are a series of guidance documents that have been developed or are being developed to provide information and possible approaches for addressing each of these elements. These guidance documents follow the sequence of activities that an owner or operator will perform over time at a proposed and permitted geologic sequestration site.

Finally, in an effort to assist states in moving forward with CCS projects, the PCOR Partnership intends to collaborate with IOGCC to propose an effort to DOE to develop guidance that would identify barriers and opportunities in the areas of operational and postoperational liability and property rights amalgamation and acquisition, both of which the EPA rule does not address.

Interstate Oil and Gas Compact Commission

IOGCC is a multistate government agency that promotes the conservation and efficient recovery of domestic oil and natural gas resources while protecting health, safety, and the environment. The PCOR Partnership participates in IOGCC activities. In fact, John Harju currently chairs IOGCC's Energy Resources, Research, and Technology Committee and serves on the Carbon Capture and Geologic Storage Task Force. In addition, he serves on the Pipeline Transportation Task Force (PTTF) and is the subcommittee chairman. IOGCC's PTTF was formed in April 2009 to undertake a scoping on behalf of states on the issue of CO_2 pipeline transportation. The main outcome of the task force was to produce a report to help states and other stakeholders begin to understand the issues that will need to be addressed in citing and regulating new CO_2 pipelines. The EERC coauthored the topical report entitled "A Policy, Legal, and Regulatory Evaluation of the Feasibility of a National Pipeline Infrastructure for the Transport and Storage of Carbon Dioxide" for the reporting period beginning April 1, 2009, and ending December 31, 2010.

Development of a Permitting Action Plan

The EERC is required to develop a permitting action plan in conjunction with the site owner in accordance with relevant local, state, and federal regulatory requirements for the Bell Creek project. In August 2011, D29 – Permitting Action Plan was prepared describing the regulatory and permitting steps taken by the EERC as well as its partner Denbury to conduct the

Bell Creek field demonstration test. Additionally, relevant federal and state regulatory summaries were provided.

Bell Creek Test Site

A project meeting was held with Denbury in October 2010, where a status update on its activities at the Bell Creek site was given. Based on information presented, on October 28, 2010, several extensions were proposed to DOE and subsequently granted: 1) D28 – the Bell Creek Test Site – Environmental Questionnaire, extended from October 31, 2010, to March 31, 2011, and 2) D29 – Permitting Action Plan, extended from January 31, 2011, to August 31, 2011.

In addition to the environmental questionnaire and permitting action plan described above, the following activities were completed in PY4:

- Reviewed Montana drilling permit guidelines for potential monitoring wells at the Bell Creek project site.

- Held discussions with the Montana Board of Oil and Gas Conservation to review regulatory requirements and finalize plans for the proposed monitoring well at the Bell Creek site.

- Reviewed the Bureau of Land Management's procedures for permitting seismic exploration on federal lands.

Fort Nelson Test Site

The PCOR Partnership has been supporting Spectra's permitting efforts for the Fort Nelson demonstration. Legislative and regulatory actions by the province of British Columbia are continually followed for the effect they may have on the Fort Nelson demonstration project. Monthly conference calls were held where the status of permitting activities and British Columbia government participation were regularly discussed.

Plug and Abandon Wells and Land Reclamation of Lignite Project Site

On February 14, 2011, the PCOR Partnership received approval for a cost increase to plug and abandon five wells located at the Lignite field validation test site in the southeast quarter of Section 36 in Burke County, North Dakota (Figure 12). After permissions to proceed were received from the appropriate North Dakota regulatory agencies and approved subcontracts were in place, the process of plugging and abandoning the wells began in September 2011. The bridge plug from Well 36-15 was removed, and the plug was cemented over pursuant to regulatory authorization. Site reclamation activities commenced in October 2011, and over the next 2 years, weed spraying has been scheduled and fencing will be maintained.

Figure 12. Plugging operations at the Lignite Field validation test site.

Presentations and Training

- Attended and presented on North Dakota's framework for CCS at the 6th Annual Clean Carbon Policy Summit & Project in Austin, Texas.

- Participated in a Webinar sponsored by the North Dakota Pipeline Authority covering North Dakota's regulatory requirements for pipelines.

- Attended the Ground Water Protection Council's "Underground Injection Control: The National Ground Water Protection Program" 2011 Conference held January 24–26 in Austin, Texas.

- Participated in an Argus Media Webinar entitled "U.S. Environmental Policy: Through the Eyes of the 112th Congress."

- Participated in an EPA Webinar entitled "GHG Reporting Program Webinar: Subpart W (Petroleum and Natural Gas Systems)."

- Participated in EPA's GHG Reporting Program Webinar: Subparts RR (Geologic Sequestration) and UU (Underground Injection of CO_2).

- Attended the Texas Carbon Capture and Storage Association 4th Annual Preconference Workshop on CCS in Austin, Texas.

- Attended the University of Texas Carbon and Climate Change Conference in Austin, Texas.

- Attended the 10th Annual Conference on Carbon Capture & Sequestration in Pittsburgh, May 2–5, 2011. While in Pittsburgh, participated in the Fort Nelson update meeting with DOE officials and project partners.

- On May 24, 2011, participated in EPA's training Webinar focused on the Greenhouse Gas Reporting Program's Geologic Sequestration of CO_2 (40 CFR, Part 98, Subpart RR).

- On May 26, 2011, participated in the North Dakota Pipeline Authority's Webinar entitled "Transporting North Dakota's Natural Gas," which focused on pipeline development in the state.

- Attended a workshop on June 1 and 2 entitled "2011 CO_2 Geologic Sequestration and Water Resources Workshop," and participated in the theme entitled "Water Quality and Impact Assessment/Risk Prediction," sponsored by EPA and hosted by Lawrence Berkeley National Laboratory, which focused on research needs related to geologic carbon storage with a specific focus on water resources.

- Attended the Enhanced Oil Recovery Institute (EORI) Fifth Annual CO_2 Conference on July 13 and 14, 2011, in Casper, Wyoming.

- Attended the 2011 PCOR Partnership Annual Meeting and Workshop on September 12–14 in Denver, Colorado.

- Participated in EPA's webinar entitled "Geologic Sequestration Financial Responsibility Implementation Workshop and Webcast."

Task 4 – Site Characterization and Modeling

This task involves selecting the two field-based large-scale demonstration sites and developing baseline characterization data and petrophysical models for such sites.

Activities and Results

Accomplishments during BP4, PY4 (October 1, 2010 – September 30, 2011) are described as follows.

Williston Basin Test Site

All activities were performed the first two years of Phase III when the EERC was still working under the assumption that it would have a Williston Basin test site. D30 – Geomechanical Experimental Design Package was completed under this subtask.

Fort Nelson Demonstration Site

The primary objective of the Fort Nelson project is to verify and validate the concept of utilizing one of North America's large number of saline formations for large-scale CO_2 injection, proposed to be up to 2 Mt a year, of anthropogenic CO_2 for permanent storage.

In June 2011, assistant project leads were designated to help keep the demonstration site activities on track when the project lead is out of the office. For the Fort Nelson project, Jim Sorensen is the EERC project lead, and Lisa Botnen is the EERC assistant project lead.

CSLF Recognition and Progress Reports

At its October 2009 London meeting, the CSLF recognized the Fort Nelson CCS project as a collaborative research project that meets CSLF priorities. Subsequently, and in coordination with Spectra, the PCOR Partnership submitted to the CSLF Secretariat required project status reports on January 14, 2011, and July 15, 2011. Progress at the Fort Nelson site was reported as follows:

- Project areas related to geological interpretation, laboratory evaluations, RA, and planning of MVA activities are all ongoing and progressing.

- Locations, geometries, and materials for the project's second exploratory well and for an extensive 3-D seismic program are planned for completion in 2012.

- A significant update to the static geologic model was completed, and dynamic simulations are being evaluated to predict areal footprint of CO_2 and propagation of pressure buildup in the project area.

- Mercury injection capillary pressures have been estimated on rock cores sampled from the exploratory well.

- Cuttings from the exploratory well have been exposed to supercritical CO_2 and H_2S in a batch reactor at conditions representative of the "near wellbore" and "deep reservoir" environments. Analytical work including x-ray diffraction (XRD), scanning electron microscope (SEM), optical mineralogy, and geochemical modeling, is ongoing.

- RAs have been updated using an expert panel approach. The update is based on newly acquired data sets that facilitate a better interpretation of the extent and geometry of the injection target.

- Laboratory evaluation of reservoir properties has been conducted on core samples obtained from the C-61-E test well. Relevant properties, including mechanical strength, porosity, permeability, and capillary entry pressures, have been obtained.

- Geologic modeling and simulation have continued in this reporting period. Significant effort is being put forth to obtain a thorough understanding of the pressure regimes in this reservoir. This will lead to an improved understanding of the anticipated migration pathways and ultimate extent of stored volumes of CO_2.

In addition, storage gap information was provided upon request to the CSLF Technical Group on August 5, 2011, that will be used for the update of the CSLF Technology Roadmap (TRM) of 2010. The update is planned to take place in spring 2012.

Monthly and Quarterly Project Management Meetings

The project management teams from both the EERC and Spectra agreed to hold regular conference calls to keep project efforts moving forward. In PY4, conference calls were held on October 28, 2010, and January 20, February 24, March 22, April 20, May 25, June 13, and September 6, 2011.

The project management teams also decided to hold in-person meetings approximately each calendar quarter to discuss progress. In PY4, meetings were held as follows:

- December 2, 2010, in Calgary, Alberta, Canada
- January 11 and 12, 2011, in Grand Forks, North Dakota
- March 1 and 2, 2011, in Grand Forks, North Dakota
- May 4, 2011, dinner meeting held in conjunction with CCS-10 in Pittsburgh, Pennsylvania
- July 20 and 21, 2011, in Vancouver, British Columbia, Canada
- September 13, 2011, side meeting held in conjunction with the PCOR Partnership Annual Meeting in Denver, Colorado

In-House Project Update Meetings

In an effort to keep the EERC project management team updated and coordinate activities, in-house meetings were scheduled on the following dates: May 23; August 1, 15, and 29; and September 26, 2011. At these meetings, action items are reviewed, deliverables and reports are discussed, and project updates are given.

Fort Nelson Test Site Geochemical Evaluations and Modeling

Laboratory tests will be conducted on samples of the target injection formation and key sealing formations under reservoir conditions to assess the geochemical reactions anticipated to occur between the injected gas and the rocks and fluids of the reservoir and seal.

Fort Nelson Cap Rock Petrographic Analysis

Petrographic assessment was performed on primary cap rock samples from the Fort Nelson demonstration project reservoir. To gain a thorough understanding of the sealing capabilities of the Fort Simpson and Muskwa Shales, three samples (Figure 13) were taken from cap rock intervals of the C-61-E test well core in January 2011 and delivered to the EERC shortly thereafter. These samples were characterized, with emphasis on geochemical stability, mineralogy, and rock properties pertinent to geochemical assessment. Separate analyses were conducted in order to collect properties, provide supporting data, correlate findings, and provide illustrations and explanations of results. Specifically, testing included the following:

- XRD for bulk mineralogy
- X-ray fluorescence (XRF) for trace element analysis
- Petrographic analysis via thin section for mineralogy and rock fabric descriptions
- QEMSEM (quantitative elemental mapping using scanning electron microscopy) or mineralogical mapping
- SEM with EDS (energy-dispersive spectroscopy) for mineralogical identification and rock fabric descriptions
- CHN/S (carbon–hydrogen–nitrogen/sulfur analyzer) measurements for elemental composition information
- Surface area to determine reactive surface
- Skeletal density to support mineralogy and examination of total vs. effective porosity and degree of cementation
- ICP–MS **(**inductively coupled plasma–mass spectroscopy/atomic emission spectroscopy) to examine trace element abundance

Fort Nelson Geochemical Report

In preparation for a geochemical status report (D41, due December 2011), efforts were undertaken to prepare the results of the geochemical experiments conducted over the course of 2009–2011, including the petrological and geochemical analysis work performed on cuttings and chips from Fort Nelson reservoir and seal formations.

Figure 13. Photographs of Fort Nelson cap rock samples as received. These samples represent three cap rock intervals in the Fort Nelson area.

Fort Nelson Test Site Baseline Geology Determination

Efforts for the collection, evaluation, and interpretation of historic data sets continued in PY4. Reconciliation began of the various data packages associated with the 2009 wellbore characterization and core analyses to ensure the quality and accuracy of data relative to the specific rock formation intervals under evaluation. Preparation of a site characterization report (D65) is well under way.

Shallow groundwater sampling and analysis have been under way for the location of the first exploratory well. Development of a sampling and analysis plan for shallow groundwater monitoring of the second exploratory well was initiated in PY4. The site owner/operator has plans to drill a second exploratory well in winter 2011–2012, depending on corporate approval.

In the meantime, a draft outline was prepared for the near-surface and surface MVA plan for the Fort Nelson project. This outline provided the framework for a long-term approach to monitoring the potable groundwater sources, vadose zone, soils, and local rivers and streams within a predefined area for the project.

In the June 2010 geologic model, the surface of the Slave Point Formation was adjusted for better history matching, with special attention to the Clark Lake A pool to better understand the regional pressure profile. Efforts on the fourth version of the geologic model (July 2011 version) continued in PY4, including the identification of 30–40 wells in the Fort Nelson area with additional LAS data (well logs).

Geomechanical Rock Properties and Stress Regime Determination for the Fort Nelson Test Site

The geomechanical properties of the reservoir and cap rock and stress regime in the area will be determined to assess the mechanical integrity of the system and potential for rock fracturing. An in-depth review of available information on the stress regime and structural features in the area of the reservoir will be conducted to identify structures such as faults or dissolution areas. In PY4, work continued on development of the geomechanical model and the associated data collection for the geomechanical simulation, including the lab data, equivalent formation data, and expected data.

Fort Nelson CCS Project Risk Management Plan (RMP)

Risk management activities were relocated to Task 9.

Bell Creek Demonstration Site

The Bell Creek oil field in southeastern Montana has been identified as a PCOR Partnership Phase III demonstration site. Detailed subsurface mapping and characterization are being conducted in advance of a large-scale combined CO_2 EOR and CO_2 storage project injection. Site characterization activities will be conducted to develop predictive models that address three critical issues to determine the ultimate effectiveness of the target formation: 1) the capacity of the target formation, in this case, an oil reservoir within an established oil field; 2) the mobility and fate of the CO_2 at near-, intermediate-, and long-term time frames; and 3) the potential for out-of-zone migration of the injected CO_2 outside of the field or into overlying formations and/or the surface environment. Key site characterization parameters that are being addressed include properties of the reservoir and seal rocks, properties of the fluids in the reservoir and overlying fluid-bearing formations, and the production and operational history of the target oil reservoir.

In June 2011, assistant project leads were designated to help keep demonstration site activities on track when the project lead is out of the office. For the Bell Creek project, Charles Gorecki is the EERC project lead, and John Hamling is the EERC assistant project lead.

Bell Creek Test Site Baseline Geology Determination

Bell Creek test site baseline geology determination work includes:

- Development of a geological characterization experimental design package (D31) that describes specific approaches and analytical techniques.
- Collection, evaluation, and interpretation of historic data sets.
- Acquisition, evaluation, and interpretation of new data sets, including data collected from field-based site characterization activities.

- Creation of a geologic model of the strata at the appropriate scales.

- Drilling, logging, testing, and coring of monitoring wells in the injection and overlying formations.

A geological characterization experimental design package (D31) that describes specific approaches and analytical techniques was prepared in January 2011 (an extension was granted in November 2010 to move the due date from November 2010 to January 2011). The Bell Creek demonstration project is a unique opportunity to develop a set of cost-effective MVA protocols for large-scale (>1 Mt per year) CO_2 sequestration in a clastic formation. The baseline geological characterization work that will be conducted over the course of this project will also provide valuable data to support the design and implementation of an injection/production scheme for large-scale CO_2 storage and EOR.

Denbury and state regulatory agency databases were mined to gather a variety of data. Efforts included cataloging, evaluation, and integration of reservoir characterization data from Denbury for the Bell Creek oil field. In addition, EERC staff made several trips to gather information. These included a trip in March 2011 to Denbury's headquarters in Plano, Texas, to search and review well files. Nearly 600 well files were located, scanned, and labeled. During a trip to Denbury's Bell Creek field office in April 2011, all relevant on-site well file information was electronically scanned to aid in field evaluation. Periodic updates and data from ongoing oil field activities are received from Denbury on an ongoing basis.

New data sets were acquired during several trips. The Bureau of Economic Geology Houston Research Center confirmed the existence and location of 71 cores from the field. In March 2011, EERC and Denbury staff met in Houston and viewed eight cores taken from the Phase 1 area (18 boxes of core), created a WellSight Systems MudLog program to record the core descriptions, and documented locations to take future core plug samples from USGS core stored in Denver, Colorado. In June and July 2011, trips were made to a Muddy Formation outcrop near Hulett, Wyoming, to examine and collect representative samples of Bell Creek reservoir rock. Denbury staff came along during the July trip. In September 2011, both EERC and Denbury staff examined geologic core from the Bell Creek Field at the Denver USGS office. USGS provided samples from a well in the Phase 1 development area for thin-section preparation and further in-house laboratory testing. Results will be shared with USGS as an agreed upon condition of receiving samples.

Arrangements were made for the collection of lidar (light detection and ranging) elevation data for the Bell Creek Field. In July 2011, the data were collected and the EERC began correction of surface locations and elevation data of all wells for both surface monitoring and geologic characterization modeling activities.

Work continued on the development of a geologic model. Well tops were loaded into Techlog for 98 wells with sonic and density curves. Feedback was received from Denbury on the model methodology, and a new cross section was created to assist in the core analysis tests for the monitoring well.

Bell Creek Test Site Baseline Hydrogeology Evaluation

A baseline hydrogeological experimental design package (D34) describing the specific approaches and techniques that will be used to conduct project activities was completed in May 2011. A hydrogeological evaluation will be carried out to determine what influence existing hydrogeological conditions may have on the injection and storage of CO_2 at the Bell Creek Field test site. With respect to CO_2 EOR, the primary objective of the PCOR Partnership at Bell Creek is to provide Denbury with technical support that adds value to its planned operations. The acquisition of baseline hydrogeological characterization data will provide Denbury with data that will support the development of effective injection and production schemes.

Existing groundwater well logs in the Bell Creek Field were reviewed to determine suitability for sampling. Development began on a near-surface (surface waters, groundwater, and soil gas) testing plan. Actual sampling activities are anticipated to initiate in November 2011.

Petrophysical Evaluations for the Bell Creek Test Site

Testing of the outcrop samples representative of Bell Creek reservoir rock was initiated for porosity, permeability, mineralogy, composition, and relative permeability. A report of the petrophysical properties and relative permeability was drafted. In addition, a plan was developed for the resaturation of old cores (vintage ~1960s) in order to perform geochemical and geomechanical testing.

Plans are under way for a series of in-house laboratory tests on three separate facies including:

- Making thin sections for optical microscopy.
- Performing XRD on ground samples.
- Using a profilometer for analyzing/validating porosity, pore geometry, and size.
- Obtaining porosity and permeability measurements.
- Conducting CO_2/water/oil relative permeability tests.
- Conducting uniaxial and triaxial compression tests.
- Performing QEMSCAN analysis for mineralogy of samples.

A full set of analyses is also planned for the core, which will be collected from the monitoring well in the Bell Creek oil field during the fall/winter of 2011.

Geochemical Evaluations and Modeling for the Bell Creek Test Site

Laboratory tests will be conducted on samples of the target injection formation and key sealing formations under reservoir conditions to assess the geochemical reactions anticipated to occur between the injected gas and the rocks and fluids of the reservoir and seal.

Geomechanical Rock Properties and Stress Regime Determination for the Bell Creek Test Site

The geomechanical properties of the reservoir and cap rock and stress regime in the area are examined to assess the mechanical integrity of the system and potential for rock fracturing. An in-depth review of available information on the stress regime and structural features in the area of the reservoir will be conducted to identify structures such as faults or dissolution areas. In October 2010, a geomechanical experimental design package (D87) describing the specific approaches and analytical techniques that will be used to conduct project activities was prepared.

Existing warehouse core from Bell Creek wells was obtained for review and limited testing in 2011, and the results of core analyses will provide a basis for developing accurate models that can be used to predict the effects that large-scale CO_2 injection can have on reservoir and cap rock. In September 2011, a draft report was prepared on the analysis done for determining the mechanisms of subnormal pressure generation in the Bell Creek Field and their implications to CO_2 storage. Also in PY4, the creation of a mechanical earth model was discussed to assist in understanding the geomechanical behavior during CO_2 injection.

Assessment of Wellbore Integrity and Leakage Potential at the Bell Creek Test Site

It is not possible to determine the "exact" state of all wellbores within an oil field; consequently, both "real" field data and analytical or numerical simulations will be combined to quantify processes associated with the hydraulic integrity of the wells. A variety of activities focused on determining the potential for wellbore leakage in the Bell Creek oil field and the surrounding area were initiated in PY4. These activities include the following:

- Publicly available well log data were obtained from the Montana Board of Oil and Gas Conservation.

- Well log data were used to identify the tops of key formations within the Bell Creek oil field and its surrounding area. Specifically, the tops for the Cretaceous Muddy Formation, which serves as the reservoir rock for the Bell Creek oil field, were identified. Potential seal formations were also identified.

- The well log data were used to create thickness isopach maps and identify major structural elements of the Bell Creek oil field.

- The acquisition of publicly available data on well drilling, completion, operation, and abandonment was initiated.

- A request for nonpublicly available data on well drilling, completion, operation, and abandonment was submitted to Denbury.

Task 5 – Well Drilling and Completion

The PCOR Partnership is working with Denbury, the operator of the Bell Creek oil field, to develop engineering designs for the installation of a dedicated monitoring and characterization well in the Bell Creek oil field. The feasibility of reentry into existing wells within the field which could provide additional downhole monitoring points is also under evaluation.

The development of operational plans for the injection and recycling of CO_2 over the duration of the project will also be conducted. Because the host site for the Bell Creek large-volume CO_2 injection test is an operational oil field already undergoing large-volume water injection activities, existing wells will be utilized for CO_2 injection, oil production, and monitoring. These wells are currently being reworked to accommodate long-term injection of supercritical CO_2. The EERC will provide technical support for these activities; however, the actual drilling, completion, and/or reconditioning of injection and production wells will be conducted by Denbury, while the EERC will be responsible for the drilling of a new monitoring well in the field, with support provided by Denbury. Activities under this task commenced October 1, 2010.

Activities and Results

Accomplishments during BP4, PY4 (October 1, 2010 – September 30, 2011) included the following.

MVA Work Plan

A work plan was prepared (and approved by Denbury) for the surface, near-surface, existing wellbores, and deep monitoring wells. The MVA plan will also include:

- Detailed maps with sample Bell Creek oil field Phase I field locations.
- Landowner maps (inputting the plats into GIS).
- Cost estimates.
- A health and safety plan.
- A detailed existing deep well map.

Baseline MVA Activities

In March 2011, the baseline MVA was initiated. These activities can be broken into two main groups (surface and near-surface, and deep MVA). In preparation for the activities, the EERC mobile office and lab trailers were located at the Bell Creek site in July 2011 (Figure 14).

Figure 14. EERC mobile office and lab trailers situated at the Bell Creek test site.

Development of an Installation and Operation Plan that Minimizes Impacts to Oil Field Operations

Samples representative of the Muddy sandstone (the reservoir at Bell Creek) were obtained and examined for petrophysical and geochemical attributes. These activities will aid in the design and selection of appropriate MVA technologies utilized at the site.

A set of condensed notes and a requirements checklist was prepared for CO_2 injection projects pertaining to the characterization and MVA activities required by EPA's UIC Class VI injection well requirements released on November 20, 2010, and which went into effect January 1, 2011, to ensure all U.S.-based PCOR Partnership work remains in compliance with EPA regulations.

Surface and Near-Surface MVA Program

- Prepared a landowner permission form for use during the surface baseline sampling program as well as detailed sampling maps and an explanatory handout to accompany the landowner permission form.

- Received Bureau of Land Management surface access permission for the soil gas and water baseline monitoring programs.

- A baseline soil gas survey will be performed over the entire Bell Creek oil field. Arrival of the gas chromatograph and, accordingly, start of the baseline sampling at the site were delayed. Sampling is now anticipated to begin on November 1, 2011, and will include several (at least four) repeat surveys to capture the seasonal variations in the soil gas content.

- A shallow groundwater-monitoring program will be conducted, including shallow groundwater monitoring in selected groundwater wells throughout the Bell Creek Field, focusing on the Phase 1 area. This baseline activity is anticipated to begin in November 2011 and will include several repeat surveys to capture seasonal variation in shallow groundwater composition.

- Surface water sampling will take place in conjunction with soil gas and shallow groundwater-monitoring activities.

Deep MVA Program

Activities associated with a deep monitoring well were authorized in Modification 20 to the PCOR Partnership award in April 2011. The activities included drilling, testing, logging, and completing a deep monitoring well in the Phase 1 area of the Bell Creek Field to gather additional baseline data and a point in the field to monitor CO_2 as it moves between injectors and producers. Because of contractor drilling schedules, the estimated spud date for the monitoring well has been delayed from October to November/December 2011.

Efforts to determine the effects and impact of downhole MVA equipment on oil field operations included the design and order of a specialty wellhead required for the MVA program. The specialty well head permits permanent downhole-monitoring (PDM) technologies to be utilized in conjunction with other wireline-deployed downhole-monitoring technologies such as pulsed neutron well logs and borehole seismic tools.

Efforts for the installation of downhole MVA equipment as part of the well completion process included material procurement and design of PDM equipment for the monitoring well in conjunction with Sandia Technologies and Denbury.

Monitoring Scheme Design

- Met with Denbury Bell Creek field office personnel and performed reconnaissance of two proposed monitoring well sites in order to determine accessibility issues.

- Obtained a high-resolution areal imagery of the Bell Creek Field for use in monitoring site evaluations.

- Investigated and selected equipment for use in coring the monitoring well.

- Created a well prognosis containing all currently available relevant information pertaining to operational and well design issues for two proposed monitoring well locations.

- Modified the monitoring well design to account for additional requirements necessary to deploy PDM pressure gauges and distributed temperature sensors.

- Contracted with Sandia Technologies to consult in the design and deployment of the PDM system in the monitoring well.

- Reviewed all plugged and abandoned wells in the Phase 1 area to assess the feasibility of reentry and outfitting as additional monitoring wells.

- Incorporated well evaluation information into a GIS format database for special risk and/or monitoring assessments for the Phase 1 injection area.

- Finalized the monitoring well design.

- Continued work on wells in Phases 2, 3, and 7 for potential reentry and deployment of additional monitoring and data collection.

- Selected service providers and finalized the well-logging and coring service program for the monitoring well in cooperation with Denbury.

- Selected and contracted a drilling company and associated service providers to drill and characterize a dedicated monitoring well.

Additional activities completed in PY4 include the following:

In November 2011, provided comments on the working draft of the NETL "Best Practices Manual for Drilling, Well Installation, Permitting, Operations, Mitigation, and Closure in Deep Geologic Formations."

Presentations and Conferences

- Attended the IEAGHG 7th Monitoring Network Meeting in Potsdam, Germany, to remain apprised of current and planned CCS monitoring activities performed around the world.

- Toured the Ketzin (Germany) injection site and examined wellhead completions which incorporated multiple monitoring systems similar to proposed Bell Creek monitoring technologies.

- Attended the 2011 PCOR Partnership Annual Meeting and Workshop on September 12–14 in Denver, Colorado, and presented an update on Bell Creek activities on September 14.

Task 6 – Infrastructure Development

This task facilitates the infrastructure planning required for CCS to be implemented on a wide-scale regional basis as well as the development of the specific infrastructure associated with the capture, dehydration, compression, and pipeline transportation of CO_2 from its source to a Bell Creek oil field for EOR. The infrastructure development for the Bell Creek test site will be performed by Denbury, with EERC personnel documenting the activities, interfacing with source facility engineers and vendors, and providing assistance as needed.

Activities and Results

Accomplishments during BP4, PY4 (October 1, 2010 – September 30, 2011) included the following.

Regional Infrastructure Planning

Efficient and cost-effective implementation of CCS on a wide scale will require a complete understanding of the PCOR Partnership region's infrastructure needs. It will also necessitate the development of a regional pipeline vision connecting various CO_2 sources with the most likely geologic storage opportunities. Activities include the following.

CO_2 Emission Sources

In September 2011, the annual update and quality assurance/quality control of the CO_2 emission source master data spreadsheet was completed (performed in conjunction with Task 1).

Capture Technology Overview

A value-added report entitled "Current Status of CO_2 Capture Technology Development and Application" was finalized in January 2011. This report provided a comprehensive overview of the current status of carbon capture technology development and application. The overview covers technologies that apply to the three combustion platforms: precombustion, during combustion (oxycombustion and chemical-looping combustion), and postcombustion (Figure 15). The technologies reviewed fall into the categories of physical and chemical absorption; physical and chemical adsorption; mixed absorption and adsorption; oxygen-, hydrogen-, and CO_2-permeable membrane processes; cryogenic processes; mineralization; and photosynthesis and chemical and biochemical reduction processes as well as alternative mass transfer techniques. The document provides an overview of the technical basis for each separation method and information on nearly 100 technologies and/or research efforts. A summary table of the capture technologies included in the report was added as an appendix, and the entire report was submitted in March 2011.

Efforts to adapt the capture technologies table (from the appendix) for the DSS began. The interactive table will feature the following information not included in the original table:

- Short summaries of each of the technologies.
- Identification of the public information sources that best describe each of the technologies listed. The programming needed to produce the interactive site was initiated.

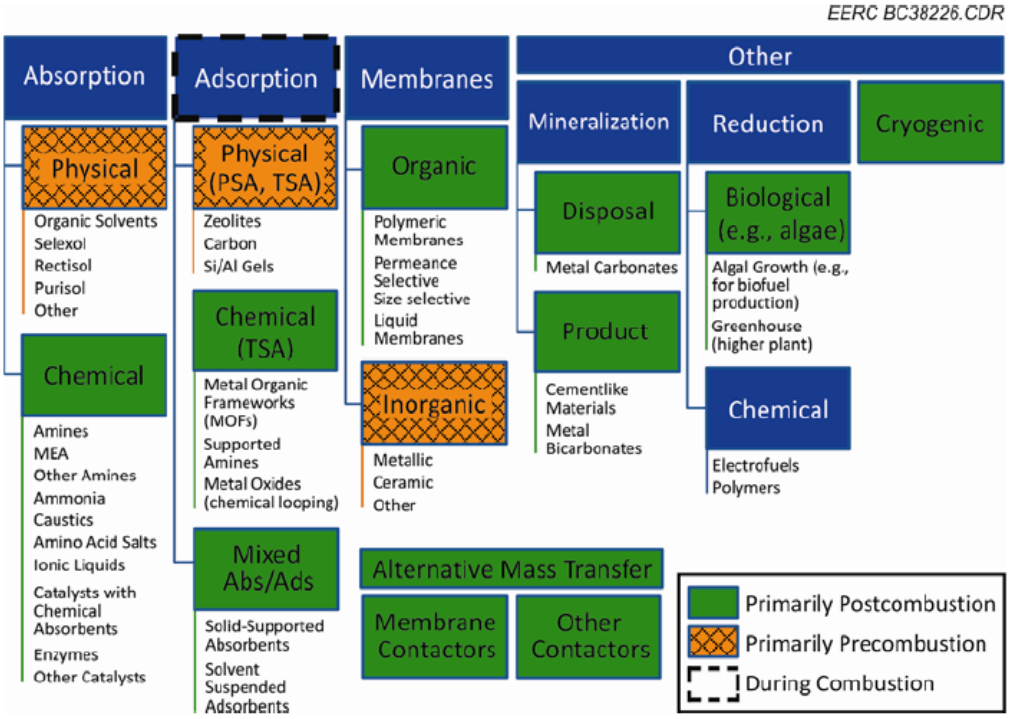


Figure 15. Carbon capture technology categories.

Ongoing Support for Regional CO_2 Compression and Pipeline Activities

The majority of research on CCS has been on capture, injection, and subsequent monitoring of the CO_2 plume in a secure geologic setting, with little attention paid to compression or pipeline transport. In March 2011, a report entitled "Opportunities and Challenges Associated with CO_2 Compression and Transportation During CCS Activities" was finalized. The opportunities for improved compression and transport efficiency and cost that were identified include:

- Precise compressor design made possible through a more thorough understanding of the behavior of mixed CO_2 streams near the critical point of CO_2.
- Better integration of CO_2 capture and compression, especially with respect to the use of the heat generated during interstage cooling.
- Improvement of compression efficiency through the exploration of compression pathways that also include liquefaction and pumping of the CO_2.
- Advanced compressor design, such as the shockwave technology under development by Ramgen.
- Development of compressor electric drives and associated components that can operate at higher power rankings more reliably and efficiently.

- Development of a large-scale CO_2 pipeline network and the establishment of common carrier CO_2 stream composition requirements.

These opportunities will be updated on a biennial basis.

Preparation of Technical Brief

A technical brief entitled "CO_2 Pipelines" (Figure 16) was finalized in September 2011. It included technical information regarding pipeline design, capacity, risks, stream composition, and costs. It was made available to the PCOR Partnership at the 2011 annual meeting and is currently housed on the partners-only Web site at www2.undeerc.org/website/pcorp/ProductsDB/pdfs/PipelineTechnicalBrief2011revisedPWG.pdf.

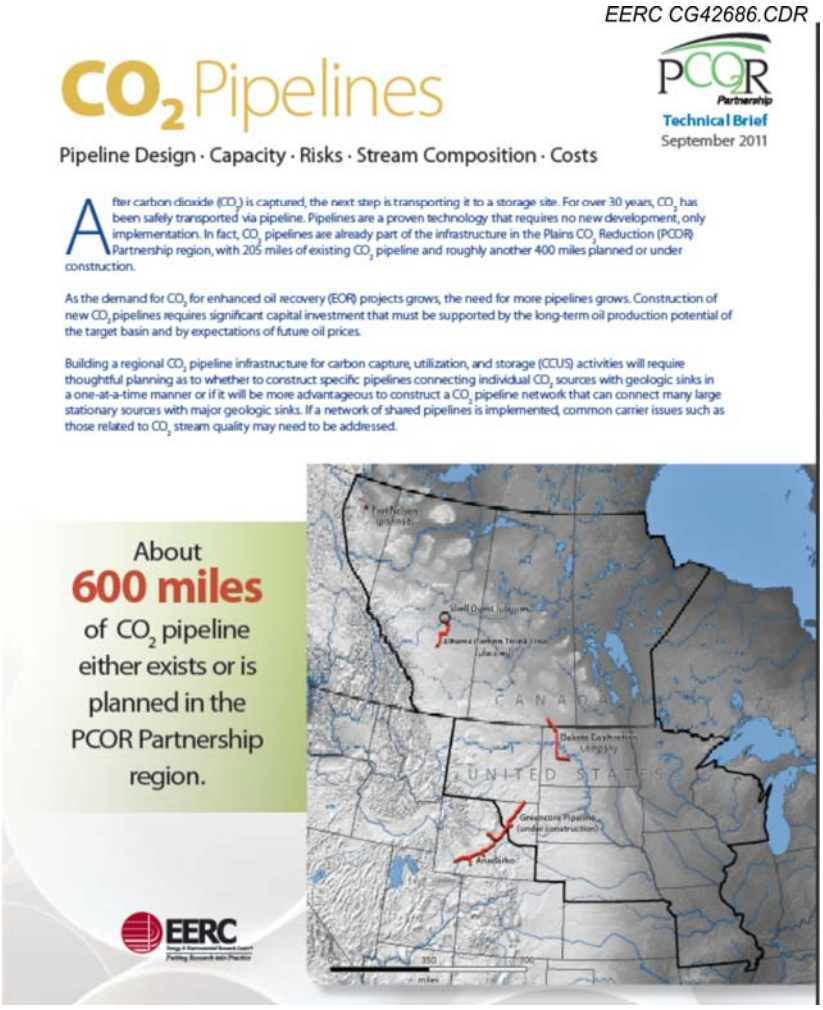


Figure 16. Technical brief on CO_2 pipelines prepared in September 2011.

RCSP Pipeline Atlas Working Group (PAWG)

DOE NETL was in the process of developing a national CO_2 pipeline atlas that served to highlight the state-of-the-science investigations on the development of CO_2 pipeline networks. The document was planned to emphasize ongoing pipeline studies, compare pipeline modeling efforts, and provide visual representation of CO_2 source and sink locations throughout the United States and Canada. Similar to Atlas III, this document would serve as a public outreach tool and help readers understand the complexities associated with connecting emission sources to appropriate sinks. A working group was formed that consists of members from the RCSPs and NETL, and periodic teleconferences were planned, focusing on discussing the content and format of the pipeline atlas, finalizing the RCSP template, and establishing a timetable for pipeline atlas completion. The kickoff conference call of PAWG was held on October 21, 2009, and a second call was held in November 2009. No further action was taken or calls scheduled since that time.

Bell Creek Test Site Infrastructure Development

Efforts are under way to identify, catalog, and quantitatively describe the infrastructure planning required for the cost-effective distribution of CO_2 within the Bell Creek oil field injection scheme. Activities were anticipated to begin in July 2010, but were delayed until December 2010. A written document was prepared for PCOR Partnership management that summarized publicly available background information related to the CO_2 capture technology used at the Lost Cabin gas plant, the CO_2 pipeline from the gas plant to the Bell Creek Field, and downhole pressure and depth at the Bell Creek Field for use in determining compression needs both at the Lost Cabin plant and for recompression at the Bell Creek Field. This document was prepared in conjunction with Task 8.

Ramgen Compression Technology Slipstream Test

The applicability of the Ramgen Power Systems compressor technology to CO_2 streams will be evaluated. The EERC will partner with Ramgen Power Systems, LCC, to perform these activities. Initial subcontracted activities with Ramgen ended on September 30, 2009, with the submittal of a topical report on the Preliminary Design of Advanced Compression Technology (D47). This report summarized Ramgen Power Systems activities relative to integration of the Ramgen compression technology with a power plant.

Since June 2011, efforts have concentrated on gathering information about the well depth, diameter, downhole pressure, downhole temperature, etc., that will be needed to develop Bell Creek in-field compression specifications. The Ramgen compressor must be able to meet these specifications to be considered for implementation at the site.

Additional Activities

Additional activities completed in PY4 included the following:

- Responded to a partner's request for a summary of capture technologies used in each of the RCSP Phase III demonstration projects.

- Responded to a partner's request for information about CO_2 capture and storage costs.

- Responded to an e-mail request for information about the use of CO_2 captured from a flue gas stream in soda pop. Information about plants that capture their CO_2 and sell it for use in the food-processing industry was prepared and sent.

- Addressed a question from a partner regarding estimated acid gas concentrations in coal-fired power plant flue gas.

Presentations and Training

- Task staff attended CCS-10 held in Pittsburgh, Pennsylvania, on May 2–5, 2011.

- Research staff attended and presented at the Electric Power Research Institute (EPRI)-sponsored Health and Environmental Toxicity of Amines for Post-Combustion Capture Conference in Palo Alto, California, on August 16 and 17, 2011.

- Attended the NETL CO_2 Capture Technology Meeting held August 22–26, 2011 in Pittsburgh, Pennsylvania (www.netl.doe.gov/events/11conferences/co2capture).

Task 7 – CO_2 Procurement

This task documents CO_2 procurement procedures for CCS and EOR activities in the PCOR Partnership region. This task provides for EERC personnel to interface with commercial partners with respect to CO_2 procurement in the region as a means of documenting critical pathways for future projects.

Activities and Results

Accomplishments during BP4, PY4 (October 1, 2010 – September 30, 2011) included the following activities.

Ongoing Monitoring and Assessment of the Commercial Issues of CO_2 Procurement

Through numerous discussions with industrial partners as well as Internet and other literature searches, efforts are ongoing to keep abreast of the various commercial issues associated with CO_2 procurement, such as contractual pricing mechanisms for CO_2, other potential customers, etc.

Procurement Plan and Agreement Facilitation

In 2009, Encore (now merged into Denbury) entered into a purchase and sale agreement to procure a CO_2 supply in the Bell Creek Field. Under the terms of the agreement, Denbury will purchase all of the volumes available from the Lost Cabin Gas Plant located in Fremont County, Wyoming. Initially, the volumes are estimated to be approximately 50 million cubic feet per day.

The initial term of the contract is 15 years (source: www.allbusiness.com/company-activities-management/company-structures-ownership/12587712-1.html#ixzz1h5QRno9b).

Efforts continued in PY4 to document the nonproprietary business activities that are conducted to develop a CO_2 procurement plan and agreement for the Bell Creek project. A number of project meetings and project management discussions were held, specifically on October 13 and 14, 2010; and February 16, May 10–11, and July 27, 2011.

Task 8 – Transportation and Injection Operations

This task consists of monitoring and documenting commercial partner activities related to compression and transport of CO_2 via pipeline to the Bell Creek site, particularly as they relate to on-site injection. This task does not cover activities for the Fort Nelson site.

Activities and Results

Accomplishments during BP4, PY4 (October 1, 2010 – September 30, 2011) included the following activities.

Monitoring and Assessment of Commercial Operations

CO_2 transport and injection will be conducted by Denbury as part of the commercial EOR project. The EERC will monitor and assess these operations.

The task lead became familiarized with surface facilities design at an EOR injection site and reviewed information located in *Nontechnical Guide to Petroleum Geology, Exploration, Drilling, and Production* (2nd edition) by Norman J. Hyne, Ph.D. Data were collected about CO_2 stream generation and infrastructure needs for the Bell Creek demonstration. During a search of publicly available literature, information was gathered about the CO_2 capture technology used at the Lost Cabin gas plant, the CO_2 pipeline from the gas plant to the Bell Creek Field, and downhole pressure and depth at the Bell Creek Field for use in determining compression needs both at the Lost Cabin plant and for recompression at the Bell Creek Field. This information was summarized in a written document for the PCOR Partnership management.

To expand the task knowledge base, an EERC representative will attend the PetroSkills course in Midland, Texas, in early October 2011 to receive training on the design of CO_2 injection and processing facilities for EOR.

Task 9 – Operational Monitoring and Modeling

This task develops data sets for the large-volume CO_2 injection tests that 1) verify that injection operations do not adversely impact human health or the environment and 2) validate the storage of CO_2 for the purpose of developing an understanding of the process for monetizing carbon credits.

Activities and Results

Accomplishments during BP4, PY4 (October 1, 2010 – September 30, 2011) include the following.

RCSP Sim/Risk Working Group

The Inter-Partnership Simulation and RA (Sim/Risk) Working Group consists of members from the RCSPs and NETL that hold periodic teleconferences and prepare content for a best practices manual on RA and simulation for geologic CO_2 storage. Activities in PY4 include the following:

- Attended the 2010 RCSP Annual Review Meeting in Pittsburgh, Pennsylvania, including participation in the RCSP Sim/Risk Working Group side meeting.

- Participated in the Sim/Risk Working Group conference calls on November 2, 2010; and January 18, May 24, June 21, August 23, and September 27, 2011.

- Volunteered to present the modeling progress update report in either November or December 2011 during the Sim/Risk monthly conference call.

- Completed review of the RCSP Sim/Risk best practices manual.

Bell Creek Test Site

Site Characterization, Modeling, and Monitoring

In September 2011, a Site Characterization, Modeling, and Monitoring Report was completed. The report detailed the EERC's role at the Bell Creek test site as including support for site characterization, reservoir modeling and simulation, assessment of the subsurface technical risks, and assisting in the development of the MVA plan to address site risks. An integrated and iterative approach to site characterization, modeling and simulation, RA, and MVA will be utilized that will allow the program to be adaptive in nature, thereby maximizing utility of the overall program.

Reservoir Modeling

Attributes such as injectivity, fluid production, and reservoir dynamics will be modeled using relevant software packages. The ultimate fate of the CO_2 over short-, intermediate-, long-, and extremely long-term time frames will be predicted. A report on the specific results of the Bell Creek oil field simulations was prepared in August 2011 and included the following:

- A preliminary numerical simulation program was initiated to 1) characterize and model the study area using advanced geologic modeling; 2) history-match Bell Creek static model parameters regarding pressure, volume, temperature (PVT) tests, address and predict minimum miscibility pressure; and 3) utilize predictive simulations to aid in the

development of effective strategies for monitoring an integrated CO_2 EOR and long-term CO_2 storage project.

- A 3-D static geologic model of the Bell Creek study area has been created to provide a geologic framework for future reservoir simulation activities. The Peng–Robinson equation of state was tuned to match experimental PVT tests in order to predict CO_2 minimum miscible pressure. A host of petrophysical well logs, core analysis, and well history data was integrated into a 3-D geologic model of the Phase 1 and surrounding areas within the Bell Creek oil field to be utilized in conjunction with a planned workflow to simulate and evaluate potential injection strategies for the field.

Seismic Surveys

Efforts continued to determine the operational issues and pricing associated with seismic activities.

Mechanism of Subnormal Pressure

Efforts to prepare a report on the mechanism of subnormal pressure in the Bell Creek Field continued, including the following:

- Worked on collecting relevant literature for overpressurization of sandstone reservoirs.

- Documented modeling efforts and the potential cause and implications of the initial subnormal pressure regime in the Bell Creek Field.

- Worked on the implications of subnormal pressure and repressurization to recharge and leaking potential.

Additional activities involving the Bell Creek test site included the following:

- Studied the NIPER (National Institute for Petroleum and Energy Research) report on reservoir characterization of the Bell Creek Field.

- Studied the NIPER report (NIPER-713) for insight into Muddy Formation outcrop characteristics.

- Began preliminary modeling to determine response and sensitivity of thermal perturbation and its potential as a PDM technology.

- Continued work on the model on heating temperature variations.

- Participated in CCS-10, including a poster presentation on May 3, entitled “The Plains CO_2 Reduction (PCOR) Partnership’s Phase III Bell Creek Integrated CO_2 EOR and Storage Project.”

Fort Nelson Test Site

Injection Zone Modeling

Attributes such as injectivity, fluid production, and reservoir dynamics will be modeled using relevant software packages. The ultimate capacity of the injection zone and the fate of the CO_2 over short-, intermediate-, long-, and extremely long-term time frames will be predicted. A report on the simulation modeling was prepared in August 2011 and included the following:

- The static geologic model was updated based on commercially available well data, acquisition of existing 2-D and 3-D seismic surveys, log analysis, and core results. It has resulted in a more realistic static geologic model (Version 3) of the test site.

- A dynamic model based on the completed Version 3 geologic model was constructed for the purpose of matching the historical gas and water production, water disposal data, and scattered bottomhole pressures (BHPs) in nearby areas to the gas pools. Through the history-matching process, the geologic model was validated and improved by decreasing the realistic range of several key geologic properties, including permeability, fault transmissibility, vertical-to-horizontal permeability ratio (k_v/k_h), and others.

- Both injection locations (C-47-E and C-61-E) appear to have sufficient capacities to accommodate target injection volumes. However, the location C-47-E is a better option compared to C-61-E because the injected sour CO_2 had a more contained CO_2 footprint and did not contact the adjacent gas pools during the 100-year simulation period. The BHPs in the C-47-E location were predicted to be 1000 to 3000 kPa lower than the BHPs at the C-61-E location.

The following recommendations are suggested to be included in any future modeling and simulation studies:

- Collection of more geologic information in the C-47-E area by means of drilling, coring, and logging of a new well and acquisition of a new 3-D seismic survey over the predicted CO_2 plume footprint.

- Integration of various physical phenomena such as geochemical reactions, geomechanical behaviors, and thermal effects into the dynamic model to comprehensively understand the sink–seal system for more reliable predictions.

Risk Management Activities for the Fort Nelson Test Site

- Prepared a draft Fort Nelson RA “path forward” document.

- Participated in a conference call on December 2 with Spectra to discuss the next-round RA.

- Held a RA meeting with Spectra personnel and Nakles Consulting on January 11–12, 2011.

- Held a history match and RA meeting in Grand Forks on March 1 and 2.

- In May 2011, prepared a draft 2010 subsurface technical RA, including the following information:

  - This risk update itself represents the first major risk communication document for the Fort Nelson project since RA2009. It provides an update on the risks associated with the original project injection plan as well as an alternative injection plan. This risk update improves upon earlier risk communication by accounting for uncertainty through Monte Carlo simulation. The data show that Spectra, as a responsible operator with a strong health and safety program, adapted to potential risks identified in the first-round RA.

  - Moving forward, it is likely the next risk update (RA2011) will be the next primary risk communication document for the project, besides targeted briefings for internal stakeholders. However, as the project progresses to design and construction and beyond, the risk communication activities will increase and move more toward communication with the external stakeholders.

Presentations and Training

- Attended the 2010 RCSP Annual Review Meeting in Pittsburgh, Pennsylvania, including participation in the RCSP Sim/Risk Working Group side meeting and a dinner meeting with Spectra to discuss the Fort Nelson CCS feasibility project.

- Presented at the IEAGHG Modeling Network Meeting scheduled for April 27–29, 2011, in Perth, Australia.

- In June 2011, participated in the IEAGHG 6th RA Network Meeting in Pau, France, including a site visit to the Lacq project.

- Modeling staff attended Schlumberger's Petrel seismic visualization and interpretation training course in Houston.

- Modeling staff attended a 3-day simulation software training session, entitled "CO_2-Based EOR Miscible Flood" with Computer Modelling Group on January 24–26 in Calgary, Alberta, Canada.

- Modeling staff participated in a Subsurface CO_2 Modeling Short Course in Minneapolis, Minnesota.

- Modeling staff participated in Petrel Reservoir Engineering training in Houston, Texas.

- Modeling staff participated in a 3-day PEICE (Petroleum Institute for Continuing Education) training course entitled “Fundamentals of Reservoir Simulation.”

- Modeling personnel attended an Applied Petroleum Technology Academy training course on CO_2 flooding in Casper, Wyoming.

Task 10 – Site Closure

This task was not active in BP4, PY4.

Task 11 – Postinjection Monitoring and Modeling

This task was not active in BP4, PY4.

Task 12 – Project Assessment

This task communicates and disseminates all Phase III activities detailed in annual progress reports. Reports summarize program progress, accomplishments, program recognition, travel, planned activities, and goals.

Activities and Results

Accomplishments during BP4, PY4 (October 1, 2010 – September 30, 2011) include the following.

Assessment was conducted for the tasks during the period October 1, 2009 – September 30, 2010. A project assessment annual report (D57) was submitted on December 23, 2010.

Task 13 – Project Management

This task focuses on ensuring the overall success of the entire program by providing experienced management and leadership to each of the individual tasks and to the program as a whole. The PI and task leaders meet regularly to report the progress of their tasks and discuss any issues and corrective actions necessary. Task leaders are also responsible to provide the PI with written weekly updates. These updates include highlights (including trip reports), issues (i.e., budget, staffing, technical issues, etc.), opportunities, and travel plans. The monthly, quarterly, and yearly updates can be found on the PCOR Partnership DSS.

Activities and Results

Accomplishments during BP4, PY4 (October 1, 2010 – September 30, 2011) include the following.

Progress Reports

Quarterly progress reports (D58), each including a milestone report (D59), were submitted to DOE and the PCOR Partnership partners 1 month after the end of each calendar quarter. In

addition, monthly progress reports are submitted to the DOE NETL project manager shortly after month end and are also posted on the partners-only Web site. Informal weekly updates are e-mailed to the DOE NETL project manager.

IEAGHG Expert Review of the RCSPs

DOE requires that an independent technical review of the Phase III program be periodically conducted. In October 2010, the PCOR Partnership provided an update as to the current status of recommendations detailed by the 2008 expert review panel.

DOE selected IEAGHG to undertake the expert review held in March 2011. IEAGHG has extensive experience with CO_2 injection projects worldwide and has organized a number of independent technical reviews. In order to review the Phase III activities, IEAGHG appointed an independent international panel of experts drawn from on-shore CO_2 injection projects under way in Canada, Europe, and Australia.

The PCOR Partnership submitted project information forms (PIFs) on February 2, 2011, for each of its demonstration projects, namely the Fort Nelson Saline Formation Demonstration and the Bell Creek CO_2 Sequestration and EOR Demonstration. The required PowerPoint presentation was submitted on February 28, 2011, and the hour-long presentation was given before the expert panel on March 15, 2011, in Arlington, Virginia. Immediately following the presentation, the PCOR Partnership management team participated in a 90-minute question-and-answer session. On August 12, 2011, responses to the expert review panel's comments and recommendations were submitted. An outcome of note stemming from the expert panel's review was the recommendation to create a technical advisory board to provide scientific and/or operational guidance to the PCOR Partnership Program, including both demonstration sites (Modification 21 to the PCOR Partnership award provided funding and authorization for such an advisory board).

DOE Contract (DE-FC26-05NT42592) Modifications

The PCOR Partnership Phase II cooperative agreement was amended (Amendment 9) to include Phase III activities in September 2007. The agreement has been amended or modified an additional 12 times through September 2011. During PY4, the following modifications were issued.

In response to EERC Proposal No. 2011-0098 sent in November 2010 and revised in January 2011, DOE issued Modification 19 effective February 23, 2011. This modification included an updated SOPO and authorized the following:

- Moved Subtask 1.4 – Further Characterization of the Zama Acid Gas EOR, CO_2 Storage, and Monitoring Project to a new task (Task 15) under the same title. No overall budget modifications are required. This task was initiated in July 2010 and will continue through April of 2012.

- Added a new task, Task 16 – Basal Cambrian Saline Formation Characterization. The PCOR Partnership and Alberta Innovates – Technology Futures (AITF) will participate in a 3-year project aimed at determining the CO_2 storage capacity of the Basal Cambrian saline formation system. The EERC requested $1,679,543 from DOE for this add-on work. The EERC intends to seek in-kind cost share from AITF and other participating organizations and will report the same to DOE if appropriate documentation is obtained. This task was initiated in January 2011 and is expected to continue through December 2013.

- Added a new deliverable, D88 – Programmatic Risk Management Plan, under Task 13.

- Transferred the $1,500,000 assigned for the EIS work from BP3 to BP4.

In response to formal request(s), DOE issued Modification 20 effective April 28, 2011. This modification included an updated SOPO and authorized the following:

- Drilling, testing, logging, and completing a deep monitoring well in the Phase 1 area of the Bell Creek Field. The drilling of this well gives the PCOR Partnership Program a unique opportunity to gather additional baseline data and a point in the field to monitor CO_2 as it moves between injectors and producers. The likely subcontractor for these activities will be Denbury.

- Retrieval and testing core from the deep monitoring well. The likely subcontractor for these activities will be Denbury.

- Changing the PI from Ed Steadman to Charles Gorecki.

In response to formal request(s), DOE issued Modification 21 effective September 14, 2011. This modification included an updated SOPO and authorized the following:

- Additional funding for plugging the Lignite Phase II field site wells and reclaiming the environment ($159,815) and creating a PCOR Partnership advisory board ($149,410)

- Removal of the NEPA clearance clause for the Bell Creek site

- Incremental funding in the amount of $4,317,616

Project Management Plan

In March 2011, an updated project management plan incorporating changes to the PCOR Partnership Program was submitted. Revisions to the plan will be submitted as necessary.

Annual Meetings

Regular project meetings (annual or as otherwise directed) will be held to ensure that project management and PCOR Partnership partner goals are being met. During PY4, two such meetings were held as follows:

- The 2010 PCOR Partnership Annual Meeting and Workshop, which attracted 74 attendees representing 45 organizations from 16 states, the District of Columbia, and four Canadian provinces, was held on October 19–21, 2010, in Minneapolis, Minnesota. The 2010 annual meeting provided an overview of carbon management topics, including updates on CCS activities at the world, U.S., Canadian, and regional partnership levels as well as information, on where CCS is heading and the regulations, economics, and policies that are shaping its direction. The meeting also provided summaries of the PCOR Partnership's completed and ongoing activities, including its large-scale demonstration projects, outreach efforts, capture information and risk management strategies. In addition to the meeting, a half-day workshop was held on October 19, 2010, and featured an interactive group exercise where participants, using Implications Wheel® software, identified the implications of conducting an EOR and saline GS project. Participants also identified opportunities and challenges associated with each project.

- The 2011 PCOR Partnership Annual Meeting was held September 13–14, 2011, in Denver, Colorado, and attracted 83 attendees representing 42 organizations from 12 states, the District of Columbia, and four Canadian provinces (Figure 17). The 2011 annual meeting provided an overview of carbon management topics, including CCS, regulatory updates, media relations, and outreach strategies. The meeting also provided summaries of the PCOR Partnership's completed and ongoing activities. In addition to the meeting, a workshop entitled "Foundations of CCS Geology" was held on September 12, 2011. The half-day introductory workshop was designed for everyone involved in or associated with CCS projects and provided an explanation of key geology concepts, along with rock specimens and activities. The tools, techniques, and vocabulary of the geologist were also emphasized throughout the workshop.

RCSP Support

- The PCOR Partnership was asked to coordinate the RCSP WWG. In December 2008, a proposal to add this new task was submitted to DOE. This task began January 2009 and is ongoing through 2017.

- Members of the GIS, Outreach, Water, and Sim/RA Working Groups took part in scheduled conference calls.

- The PCOR Partnership's PI served as Chairman for NAEWG's Subcommittee on CO_2 Storage Capacity Estimation, also known as the Methodology Subcommittee. This subcommittee discusses geologic storage capacity coefficients and the methodology for estimations. The data sharing of this group will lead to a solid foundation in the area of CO_2

Figure 17. The 2011 annual meeting participants.

capture and sequestration mapping and estimations in North America. This subcommittee coordinates its activities closely with NAEWG–NACAP. In PY4, the PI participated in NACAP-5 held April 5 and 6 in Morgantown, West Virginia (see also Task 1 for additional NACAP efforts).

CCS is one of the topics that both the United States and Canada have expressed interest in to continue discussions. The U.S.–Canada Clean Energy Dialogue is led on the U.S. side by the DOE Office of Policy and International Affairs. At the request of DOE, the PCOR Partnership participated in the U.S.–Canada Clean Energy Dialogue: Carbon Capture and Storage: Collaboration in Large-Scale Demonstrations and Tests, North American Knowledge Sharing Arrangement (NAKSA) meeting hosted by DOE and held November 29 – December 1, 2010, in Columbus, Ohio. The purpose of the meeting was for participants to share their views, lessons learned, and experiences with respect to CCS activities and to determine efficient and effective ways to move forward on knowledge sharing.

DOE Fossil Energy Techlines

A DOE Fossil Energy Techline "DOE-Sponsored Field Test Finds Potential for Permanent Storage of CO_2 in Lignite Seams" was posted online November 4, 2010. This techline reported that opportunities to permanently store carbon in unminable seams of lignite may be more widespread than previously documented. This finding supports national efforts to address climate change through long-term storage of CO_2 in underground geologic reservoirs (www.fe.doe.gov/news/techlines/2010/10054-Field_Test_Demonstrates_CO2_Storag.html).

An e-mail was sent to the partnership about the DOE Fossil Energy Techline posted online regarding the Lignite field validation project and included a link to the Lignite Regional Technology Implementation Plan located in the products database housed on the DSS.

Programmatic Risk Management Plan

A programmatic RMP (D88) will be developed and submitted to DOE to document program and individual project risks, consequences, and impacts. This requirement was added to

the SOPO in February 2011, and the initial plan was submitted in April 2011. An overview is summarized below:

- A total of 40 potential risks to the PCOR Partnership Program were identified in four general risk categories: 1) external risks (n = 19), 2) technical risks (n = 8), 3) organizational risks (n = 9), and 4) project management risks (n = 4). Table 4 contains examples of technical and nontechnical risk categories. Probability and severity scores were assigned to each risk by the program task leaders. These inputs were evaluated using Monte Carlo simulations to generate risk maps presenting the most probable (average) and the 90th percentile probability and severity scores. Based on an arbitrary combined score of 0.2 as a threshold (probability × severity = 0.2), it was observed that only five of the 40 risks exceeded the threshold in the 90th percentile threat scenario and that no risks exceeded the threshold for the most probable threat scenario (i.e., the combined score of the five external risks dropped below the threshold value of 0.2). All of the risks exceeding the threshold in the 90th percentile scenario were external risks that are related to the withdrawal of the industry partners from the demonstration tests, changes in the national climate policy of the United States and/or Canada, and lack of availability of qualified regulatory staff for conducting technical review and permitting of the demonstration tests.

- The PCOR Partnership intends to update the programmatic risk map later in 2011 or early 2012 by reaching out to the commercial operators as well as additional CCS experts to reevaluate the list of potential program risks and the preliminary probability and severity scores. At the same time, the PCOR Partnership will begin to examine risk response strategies for those risks that remain to be a potential concern to the program and will initiate an effort to review the current program-monitoring plans to ensure that the necessary data to evaluate these risks are being collected at the proper level and in a timely manner. The program management monitoring plan will be adjusted, if necessary, to satisfy this risk-monitoring program need.

Annual Carbon Capture and Sequestration Conference

Nine PCOR Partnership staff participated in CCS-10 held May 2–5, 2011, in Pittsburgh, Pennsylvania. Six oral presentations were given, one poster was presented, and staff participated in several working group side meetings.

Table 4. Examples of Nontechnical and Technical Risk Categories

Nontechnical	Technical
• Significant changes in scope of work	• Contamination of drinking water
• Poor communication	• Contamination of hydrocarbon production or gas pools
• Loss of data or records	
• Permitting difficulty	• Atmospheric leakage along wellbores
• Schedule delays	• Induced seismic activity
• Budget constraints	• Mechanical changes to reservoir
	• Loss of injectivity

Annual Review Meeting

- Four PCOR Partnership staff participated in the RCSP Annual Review Meeting held October 5–7, 2010, in Pittsburgh, Pennsylvania. One oral presentation was given, five posters were presented, and staff participated in several working group side meetings.

- In preparation for the Carbon Storage Program Infrastructure Annual Review Meeting scheduled for November 15–17, 2011, plans are under way to give one oral presentation and present one poster.

PCOR Partnership Partners

The PCOR Partnership has significant support and participation from its partners. As of September 30, 2011, over 90 partners are supporting Phase III activities.

New partners added in PY4 include the following:

- British Columbia Oil and Gas Commission (October 2010)
- Halliburton and Pinnacle, a Halliburton service (January 2011)
- Husky Energy Inc. (January 2011)

Task Leader Meetings

Approximately once a month a meeting is held with all the task leaders, the PI/program manager, budget personnel, and support staff. These meetings are convened in order to share information, create time lines for the completion of products, and disseminate data.

Carbon Sequestration Leadership Forum

CSLF promotes collaborative research, development, and demonstration projects that reflect member priorities. CSLF may recognize collaborative projects that 1) facilitate the development of improved cost-effective technologies for the separation and capture of CO_2 for transport and long-term safe storage, 2) make these technologies broadly available internationally, and 3) identify and address wider issues relating to CCS. The RCSP project, comprising the seven regional partnerships including the PCOR Partnership, was recognized by CSLF at its Berlin meeting in September 2005.

The PCOR Partnership's Fort Nelson CCS Project was granted CSLF recognition in October 2009 and is one of 35 such projects formally recognized. The PCOR Partnership has received project recognition for not only one project, but two projects. the Zama Acid Gas EOR, CO_2 Storage, and Monitoring Project received recognition in 2007. In PY4, the PCOR Partnership submitted a progress update in January 2011 to CSLF on both of its recognized projects. It also provided requested information in August 2011 regarding both the Fort Nelson and Zama projects to the CSLF Technical Group for its gaps analysis that will be used for the update of the 2010 CSLF Technology Roadmap. The update is planned to take place in spring 2012. Updated information was also provided upon request regarding the PCOR Partnership Phase II and III projects for inclusion in a CSLF fact sheet on the NETL RCSP Program.

In late February/early March 2011, PCOR Partnership management staff attended the CSLF Storage and Monitoring Projects Interactive Workshop held in Saudi Arabia. PCOR Partnership staff participated in the 4-Kingdoms CCS Initiative Technical Workshop held February 28, 2011, and presented on both the Fort Nelson and Zama projects at the CSLF Storage and Monitoring Projects Interactive Workshop held March 1 and 2, in Al Khobar, Saudi Arabia (Figure 18).

Advisory Board Meetings

Stemming from the IEAGHG expert review of the PCOR Partnership Phase III Program, the PCOR Partnership is following the review panel's recommendation and creating a technical advisory board. This advisory board will provide independent review of the PCOR Partnership technical activities and advice on the consistency of these technical activities with the primary objectives of the Program. In September 2011, DOE awarded funding to cover the administrative and travel costs associated with at least one board meeting annually. Efforts are now under way to solicit technical experts interested in providing voluntary service on the board. The dates for the first advisory board meeting will be announced by March 31, 2012 (M36).

Task 14 – RCSP Water Working Group Coordination

In order to investigate the relationship between water and CCS, members of the RCSPs have formed the WWG. Each RCSP has its own unique set of challenges related to water utilization and the implementation of CCS activity, and the WWG will help to address those concerns. The PCOR Partnership leads the RCSP WWG comprising appropriate stakeholders. The RCSP WWG was initiated in January 2009. The purpose of the WWG is to address the wide variety of concerns and opportunities at the nexus of carbon storage and water resources. Development of documents under this task is led by the EERC, with input from all WWG participants.

Figure 18. John Harju, EERC Associate Director for Research, participating in the CSLF Storage and Monitoring Projects Interactive Workshop in Saudi Arabia (http://cslforum.org, accessed December 2011).

Activities and Results

Accomplishments during BP4, PY4 (October 1, 2010 – September 30, 2011) include the following.

New Task Leader Appointed

- Effective April 1, 2011, Ryan Klapperich assumed responsibility for Task 14.

Monthly Conference Calls

A total of 24 monthly conference calls (Milestone [M] 23) have taken place overall, nine of which were completed in PY4, as follows: October 26, 2010; December 23, 2010; January 19, 2011; March 22, 2011; April 21, 2011; May 5, 2011; June 23, 2011; July 26, 2011; and August 24, 2011. DOE NETL waived the requirement for conference calls during the months of November 2010, February 2011, and September 2011. Minutes of the calls are submitted to the WWG the subsequent month following a call.

Status of the WWG

The WWG has completed the following items:

- Produced a white paper that identified a wide variety of nexus of water and CCS, provided a comprehensive review of related processes and concepts, and began identifying the various challenges and opportunities.

- Discussed stakeholder involvement in the WWG, including the challenges of identifying and communicating with stakeholder groups, and developing a message. A mission statement was created:

  "The mission of the RSCP WWG is to provide a resource of knowledge, insight, and guidance to stakeholders involved with water and water resources and their relationship to the developing technology of CCS."

- Developed a water and CCS fact sheet and presentation that summarized work in the white paper, provided public outreach for the WWG, and have been distributed/presented at several conferences.

- Developed a technologies gap assessment (see below).

Challenges and Opportunities in the CCS and Water Nexus: A Technology Gap Assessment

In May 2010, the WWG members met to conduct a workshop on the challenges and opportunities associated with the CCS–water nexus. In September 2011, the document providing

a technology gap assessment based on that workshop and subsequent discussions within the WWG was finalized.

It was determined that there are many challenges related to maintaining the integrity of current water supplies, meeting new water demands, developing and managing new water resources, developing appropriate regulatory regimes, meeting stakeholder expectations, and controlling costs. These challenges open the door for opportunities in the form of technological advances in water treatment, utilization, and minimization; subsurface monitoring and modeling; capture technology development; and public education. With careful development of CCS, the WWG believes that these challenges can be met and many of the opportunities realized.

In the future, the WWG expects to play an advisory role in the development of CCS technology, informing stakeholders of the various challenges they can expect to encounter with respect to water. The group will now use this technology gap assessment to develop outreach materials and engage in dialogue with stakeholder groups. Through this dialogue, the WWG can refine the list of challenges and opportunities and provide industry, government, and a variety of public groups with accurate, relevant, useful information as they each play a role in the development of CCS technology.

The WWG may also be able to form partnerships with other RCSP working groups to better facilitate the delivery of this message among the partnerships and to other stakeholder groups. In this way, the WWG can be an effective voice throughout the lifetime of the RCSP Program and make the greatest impact from its limited resources.

Annual Meetings

The third annual WWG meeting (M24) was held on May 5, 2011, in Pittsburgh, Pennsylvania, following the conclusion of the 10th Annual CCS Conference. The following presentations were given at the meeting:

- Opening Presentation – Ryan Klapperich, EERC
- Current NETL Water Projects – Andrea McNemar, NETL
- Utilization of NATCARB Database – Peter Kobos, Sandia National Laboratory
- Expansion of the NATCARB Database – Maneesh Sharma and Frank LaFone

A NATCARB Database discussion followed the presentations, along with a discussion on the overall mission of the WWG – beyond the technologies gap assessment, including future products, outreach to stakeholder groups, cooperative research between the partnerships, and other program ideas. The meeting concluded following updates given by each of the participating regional partnerships.

Methodology Document

A methodology document (D79) to estimate the resource that might be available in different reservoirs will be generated as storage projects are developed. Because of the lack of water produced in current RCSP storage projects, on December 15, 2009, DOE waived the requirement for water resource estimation methodology documents originally due February 2010

and May 2011. The fact sheet submitted April 30, 2010, replaced the former. The technology gaps assessment document described above replaced the latter. The first methodology document will be submitted November 2012.

Miscellaneous Activities

- Discussed the potential for the WWG to advise further development of the NATCARB database and potential for development of client-focused WWG fact sheets.

- Provided feedback on the development of a brine database.
- Compiled a list of potential stakeholder groups for an outreach document.

Conferences and Training

- Presented the WWG canned PowerPoint presentation at the 2011 American Water Resources Association (AWRA) Spring Specialty Conference on Managing Climate Change Impacts on Water Resources: Adaptation Issues, Options and Strategies on April 20, 2011, in Baltimore, Maryland (www.awra.org/meetings/Baltimore2011Call).

- Attended the 10th Annual Conference on Carbon Capture and Sequestration on May 2–5, 2011, and hosted the WWG annual meeting on May 5, 2011, in Pittsburgh, Pennsylvania.

- Updated the WWG canned presentation for a group member to use at the Mountain West Water Institute "Waters of the West Workshop" on July 19, 2011, in Salt Lake City, Utah.

- Attended the PCOR Partnership Annual Meeting and Workshop held September 12–14, 2011, in Denver, Colorado.

- Attended the 2011 Ground Water Protection Council Annual Forum on September 24–28, 2011, in Atlanta, Georgia.

Task 15 – Further Characterization of the Zama Acid Gas EOR, CO_2 Storage, and Monitoring Project

The Zama oil field in Alberta, Canada, was one of the geologic storage validation test sites during Phase II of the program. This project focused on the injection of acid gas into a partially depleted oil field for the simultaneous purpose of acid gas disposal, CO_2 storage, and EOR. Because of the useful results and positive outcomes developed throughout the Phase II project, the site owner, Apache Canada Ltd. (Apache), was amenable to participation in follow-on characterization efforts at the Zama site. Accordingly, in June 2010, DOE NETL approved furtherance of the work that was performed in the Zama oil field during Phase II. A new deliverable was added for this new work, i.e., D86, which will provide an updated regional technology implementation plan for the Zama project.

Activities and Results

Accomplishments during BP4, PY4 (October 1, 2010 – September 30, 2011) include the following.

Modification 19 (February 2011) to the PCOR Partnership award authorized relocation of this work from Task 1, Subtask 1.4 to a newly created Task 15.

Apache was planning to divest certain conventional properties in Canada, including its EOR project in the Zama Field located in Alberta. However, during a meeting held in Calgary on June 22, 2011, Apache revealed that it will be retaining ownership and operation of the Zama Field. Because of Apache's corporate planning strategies and personnel redistribution, efforts to initiate the seismic profiles, logging suites, and MVA activities were delayed. The EERC continues to be optimistic that efforts to initiate the seismic profiles, logging suites, and MVA activities will be back on track soon. They were originally slated to begin in January 2011. An e-mail received in September from Apache stated that some decisions on how Apache is proceeding with Zama may be available in the near future.

CSLF Recognition and Progress Reports

CSLF recognized the Zama Acid Gas EOR, CO_2 Sequestration, and Monitoring Project at its Paris meeting in March 2007. In PY4, and in coordination with Apache, the PCOR Partnership submitted to the CSLF Secretariat required project status reports on January 14, 2011, and July 15, 2011. In addition, storage gaps information was provided upon request to the CSLF Technical Group on August 5, 2011, that will be used for the update of the CSLF TRM of 2010. The update is planned to take place spring 2012.

Cement Integrity Studies, Wellbores

There are a number of potential areas where casing/cement failure may be of concern with respect to the long-term (up to 500-year) containment of the stored injectate. The following activities occurred in PY4:

Laboratory work has continued with the following experiments:

- Wellbore casing steels are being exposed for durations of 15 and 28 days to mixtures of CO_2 and H_2S. Experiments are carried out at reservoir conditions analogous to Zama (2100 psi, 160°F). Analytical work is focused on deriving the nature and rates of degradation observed.

- Rock samples are also being exposed under the same conditions to determine if mineralogical changes are observed. If observed, rates and quantification of change will be determined.

- Petrophysical properties were uploaded into the geologic model.

- Initial petrophysical analysis was undertaken for the “F” Pool.

Static and Dynamic Modeling

A new site-specific model of the “F” Pool target injection zone is under development. This preliminary model will provide Apache with the necessary information required to determine sweep efficiency, wellbore placement, and further understanding of the heterogeneity of the reef structure.

The preliminary static geologic model was developed utilizing as much as 50 years worth of reservoir-specific data (core analyses, wireline logs, facies distributions of the pinnacles, etc.) provided by Apache.

The dynamic model construction was completed using a single static realization, and initial simulations were performed for model validation and history match. In addition, modification of different reservoir parameters is under way for improving the predictions. The WinProp PVT model was revised for improved predictions of minimum miscibility pressure.

Gas-Phase Behavior and Rock Interactions Studies

Natural Resources Canada (NRCan) has expressed an interest in providing resources for additional laboratory analyses that may lead to a better understanding of the effect of acid gas on carbonate reservoir rock and the anhydrite cap rock material sealing the system. Discussions with NRCan were conducted to establish laboratory experiments dedicated to the effects of impurities (flue gas) on reservoir materials.

In the meantime, relevant literature was reviewed on relative permeability and capillary pressure data for heterogeneous carbonate rocks, and the utility of different numerical methods was evaluated.

Abstracts and Presentations

- Presented on the Zama project to the Second France/European Union–Canada Workshop on CCS held on March 30 and 31, 2011, in Paris.

- Submitted in September 2011 an abstract to the SPE Improved Oil Recovery Symposium entitled “Compositional Flow Simulation Study of Simultaneous Acid Gas EOR and CO_2 Storage at Apache’s Zama F Pool.”

Task 16 – Basal Cambrian System Characterization

As part of the ongoing effort to characterize the northern Great Plains region of North America, a 3-year project is under way with a goal of determining the potential for geologic storage of CO_2 in rock formations of the Basal Cambrian System. This sequence of saline formations is continuous throughout much of the PCOR Partnership region and underlies many of the area’s large point sources of CO_2. The Basal Cambrian System represents a regionally

significant target for CCS but is an area that has not previously been systematically evaluated with respect to CO_2 storage resource.

Because the Basal Cambrian System occurs in large parts of both the United States and Canada, this project is under way by the EERC in cooperation with AITF as a binational effort. The EERC will work closely with key partners in the United States to evaluate the American portion of the Basal Cambrian System. AITF is leading a multiprovince team to conduct a similar evaluation for the Canadian portion of this system.

Activities and Results

Accomplishments during BP4, PY4 (January 1, 2011 – September 30, 2011) include the following.

Activities for this task were authorized in Modification 19 to the PCOR Partnership award and were initiated in January 2011. Activity ramped up in June 2011, and an in-house report detailing CO_2 emissions, likely stream compositions, and reference annotations was completed in September 2011.

CO_2 Source Characterization

In September 2011, a value-added report was prepared entitled "Overview of U.S. Sources that Overlay the Basal Cambrian Deadwood Formation." The stationary sources emitting more than 100,000 tonnes CO_2/year that overlay the U.S. portion of the Basal Cambrian Deadwood Formation were identified. Sources that met the minimum emission limit included electricity generation, ethanol production, cement/clinker production, lime production, fuel/chemical production, petroleum refining, and institutional heat/power facilities. Table 5 summarizes the number of and annual emissions for each type of source.

Geological Characterization

Significant effort has been devoted to fully understanding the geological and hydrogeological character of the Basal Cambrian System. Baseline geological characterization of the Basal Cambrian aquifer system in the greater Williston Basin area of North Dakota, South Dakota, and Montana has been completed. These characterization data were compiled in a manner to synchronously develop the 2-D and 3-D models that will be used to derive volumetric storage calculations and dynamic simulations. The characterization effort formally defined the region of interest by the underlying geological framework of the northern Great Plains (Figure 19). Development of a full report is under way, and completion is anticipated in February 2012.

Table 5. Basal Cambrian System Source Types and Their Annual CO_2 Emissions

Source Type	Number	Annual CO_2 Emissions, tonnes
Cement/Clinker Production	1	957,488
Electricity Generation	22	62,807,471
Ethanol Manufacturing	6	2,038,944
Fuels/Chemicals Production	1	2,920,000
Institutional Heat and Power	1	726,260
Lime Production	1	132,688
Minerals Processing/Lime Production	1	7,942,052
Petroleum Refining	6	3,669,890
Total	39	81,194,793

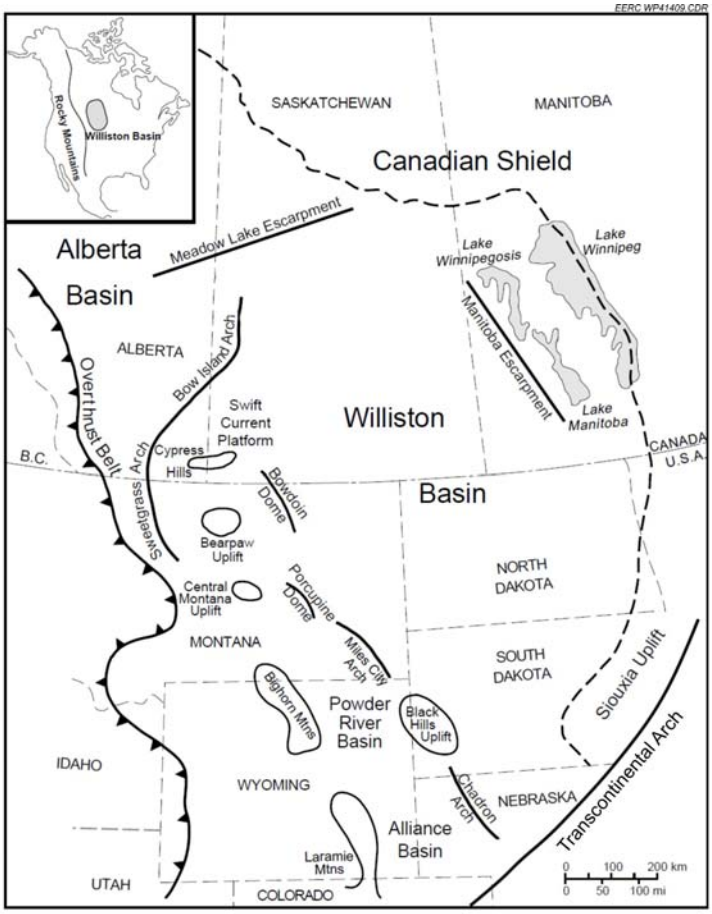


Figure 19. Geological framework of the northern Great Plains.

Storage Capacity Evaluation

A regional estimate will be developed of the available storage capacity within the Basal Cambrian System and the effects of potential large-scale multiple-point injection scenarios. A geologic model is under development and refinement.

Storage Integrity

An assessment of the general overall integrity of the Basal Cambrian System will be conducted. It is necessary that the characterization and storage capacity evaluation be under way in order to begin the assessment. Because the capacity evaluation did not begin until August 2011, the start date for the storage integrity assessment initiation was delayed until August 2011 as well. Initiation was originally set for May 2011. Dynamic simulations and laboratory activities have begun.

Joint U.S.–Canada Basal Aquifer Project, A Binational Effort

Members of the steering and technical committees include the following:

United States
- DOE NETL
- EERC
- Lawrence Berkeley National Laboratory
- Princeton University

Canada
- AITF
- Alberta Innovates – Energy & Environmental Solutions
- Canmetenergy
- Manitoba Innovation, Energy, and Mines
- Manitoba Water Stewardship
- Natural Resources Canada
- Petroleum Technology Research Centre
- Saskatchewan Energy & Resources
- TOTAL E&P Ltd.

The following project meetings were held in PY4:

- October 28, 2010 – Kickoff Meeting in Edmonton, Alberta, Canada (PCOR Partnership staff were unable to attend because of weather-related travel cancellations).

- February 2, 2011 – Technical and Steering Committee Meetings in Calgary, Alberta, Canada.

- May 25, 2011 – Technical and Steering Committee Meetings at NETL offices in Pittsburgh, Pennsylvania.

- June 22, 2011 – Project meeting in Calgary, Alberta, Canada.

- June 27–28, 2011 – Hosted a working meeting with AITF and Saskatchewan Energy and Resources staff at the EERC.

- September 14, 2011 – Technical and Steering Committee Meetings held in conjunction with the PCOR Partnership Annual Meeting in Denver, Colorado.

  Presentations

- Participated in the CCS-10 in Pittsburgh, Pennsylvania, including the following:

  – Wes Peck gave an oral presentation on May 4 entitled "Application of the U.S. Department of Energy (DOE) CO_2 Storage Resource Estimation on the Deadwood Formation, Williston Basin."

  – Stefan Bachu gave an oral presentation (coauthored by Wes Peck) on May 4 entitled "The Potential for and Possible Effects of CO_2 Storage in the Basal Aquifer in the Northern Plains – Prairie Region of North America: A Joint United States–Canada Project."

- Delivered a presentation entitled "Characterization of the Basal Aquifer System" at the PCOR Partnership Annual Meeting in Denver, Colorado, on September 14, 2011.

- Prepared a poster entitled "CO_2 Storage Characterization of the Basal Aquifer System in the Northern Great Plains – Prairie Region of North America" for presentation at the Carbon Storage Program Infrastructure Annual Review Meeting scheduled for November 16, 2011, in Pittsburgh, Pennsylvania.

COST STATUS

The currently approved budget for Phase III is shown in Table 6.

Table 6. PCOR Partnership Phase III Budget (as of 9/30/11)

	BP3 Year 1 – Year 2 10/1/07 – 9/30/09		BP4 Year 3 – Year 8 10/1/00 – 9/30/15		BP5 Year 9 – Year 10 10/1/015 – 9/30/17		Total	
DOE Share*	$4,209,149	54.59%	$57,479,431	74.37%	$9,668,307	80.00%	$71,356,887	73.50%
Nonfederal Cost Share								
Cash**	$887,428		$2,411,971		$0		$3,299,399	
Noncash	$2,613,890		$17,400,865		$2,417,076		$22,431,831	
Total Nonfederal Cost Share	$3,501,318	45.41%	$19,812,836	25.63%	$2,417,076	20.00%	$25,731,230	26.50%
Total	$7,710,467	100.00%	$77,292,267	100.00%	$12,085,383	100.00%	$97,088,117	100.00%

* Includes $1.5M in BP4 for environmental impact statement analysis to be contracted directly by DOE should it be necessary.

** Cash as recognized by DOE.

On September 30, 2011, the PCOR Partnership completed its second year of BP4 activities (PY4, October 1, 2010 – September 30, 2011). Actual cash expenditures of DOE and nonfederal sources, as well as noncash cost share reported through September 30, 2011, are listed in Table 7.

Table 7. BP4 Funding

Organization	Approved Budget, $	Actual Costs Incurred, $
DOE Share – Cash*	55,979,431	12,250,846
Nonfederal Share – Cash	2,411,971	1,061,833
Nonfederal Share – In-Kind	17,400,865	16,949,204
Total	75,792,267	30,261,883

*Does not include $1.5M for EIS.

SCHEDULE STATUS

Table 8 contains all of the Phase III deliverables, milestones, and submission dates for the reporting period. Table 9 provides a Gantt chart for the reporting period.

Table 8. PCOR Partnership Phase III, BP3 and BP4 (through 9/30/2011) Deliverables and Milestones

Title/Description	Due Date	Actual Completion Date
Year 1 – Quarter 1 (October–December 2007)		
D37: Task 4 – Fort Nelson Test Site – Geological Characterization Experimental Design Package	12/31/07	12/28/07
D63: Task 13 – Project Management Plan	12/31/07	12/28/07
M17: Task 4 – Fort Nelson Test Site Selected	12/31/07	12/28/07
Year 1 – Quarter 2 (January–March 2008)		
D38: Task 4 – Fort Nelson Test Site – Geomechanical Experimental Design Package	1/31/08	1/31/08
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	1/31/08	1/31/08
D11: Task 2 – Outreach Plan	3/31/08	3/31/08
D27: Task 3 – Environmental Questionnaire – Fort Nelson Test Site	3/31/08	4/02/08
D30: Task 4 – Williston Basin Test Site – Geomechanical Experimental Design Package	3/31/08	3/31/08
M1: Task 1 – Three Target Areas Selected for Detailed Characterization	3/31/08	3/20/08
M18: Task 4 – Fort Nelson Test Site Geochemical Work Initiated	3/31/08	3/19/08
Year 1 – Quarter 3 (April–June 2008)		
D14: Task 2 – General Phase III Fact Sheet	4/30/08	4/30/08
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	4/30/08	4/30/08
D17: Task 2 – General Phase III Information PowerPoint Presentation	5/30/08	5/30/08
M3: Task 3 – Start Environmental Questionnaire for Williston Basin Test Site	6/30/08	6/27/08
M6: Task 4 – Williston Basin Test Site Geochemical Work Initiated	6/30/08	6/30/08
M7: Task 4 – Williston Basin Test Site Geological Characterization Data Collection Initiated	6/30/08	6/30/08
Year 1 – Quarter 4 (July–September 2008)		
D12: Task 2 – Demonstration Web Pages on the Public Site	7/31/08	7/31/08
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	7/31/08	7/31/08
D1: Task 1 – Review of Source Attributes	9/30/08	9/26/08
M2: Task 1 – Demonstration Project Reporting System (DPRS) Prototype Completed	9/30/08	9/26/08
Year 2 – Quarter 1 (October–December 2008)		
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	10/31/08	10/31/08
D20: Task 2 – Documentary Support to PowerPoint and Web Site	12/31/08	12/31/08
D57: Task 12 – Project Assessment Annual Report	12/31/08	12/31/08

Continued . . .

Table 8. PCOR Partnership Phase III, BP3 and BP4 (through 9/30/2011) Deliverables and Milestones (continued)

Title/Description	Due Date	Actual Completion Date
Year 2 – Quarter 2 (January–March 2009)		
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	1/31/09	1/30/09
M21: Task 14 – Outline of White Paper on Nexus of CO_2 Capture and Sequestration (CCS) and Water, Part Subtask 14.2 – White Paper on Nexus of CCS and Water	2/28/09	2/27/09
D24: Task 2 – PCOR Partnership Region Sequestration General Poster	3/31/09	3/31/09
Year 2 – Quarter 3 (April–June 2009)		
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	4/30/09	4/30/09
M23: Task 14 – Monthly WWG Conference Call Held	4/30/09	4/15/09
D2: Task 1 – First Target Area Completed	5/29/09	5/29/09
M23: Task 14 – Monthly WWG Conference Call Held	5/29/09	5/29/09
D16: Task 2 – Fort Nelson Test Site Fact Sheet	5/29/09	5/29/09
M24: Task 14 – WWG Annual Meeting Held	5/31/09	5/07/09
M23: Task 14 – Monthly WWG Conference Call Held	6/30/09	6/25/09
Year 2 – Quarter 4 (July–September 2009)		
M23: Task 14 – Monthly WWG Conference Call Held	N/A	Not required
D19: Task 2 – Fort Nelson Test Site PowerPoint Presentation	7/31/09	7/31/09
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	7/31/09	7/31/09
M22: Task 14 – Draft White Paper – Nexus of CCS and Water Available for Comments	8/17/09	8/18/09 (DOE) 8/21/09 (WWG)
M23: Task 14 – Monthly WWG Conference Call Held	8/31/09	8/25/09
D1: Task 1 – Review of Source Attributes	9/30/09	9/25/09
D3: Task 1 – Permitting Review – One State and One Province	9/30/09	9/30/09
D9: Task 1 – Updated DSS	9/30/09	9/29/09
D47: Task 6 – Report on the Preliminary Design of Advanced Compression Technology	9/30/09	9/30/09
D77: Task 13 – Risk Management Plan Outline	9/30/09	9/18/09
M4: Task 4 – Bell Creek Test Site Selected	9/30/09	9/30/09
M5: Task 4 – Bell Creek Test Site – Data Collection Initiated	9/30/09	9/30/09
M23: Task 14 – Monthly WWG Conference Call Held	9/30/09	9/22/09

Continued . . .

Table 8. PCOR Partnership Phase III, BP3 and BP4 (through 9/30/2011) Deliverables and Milestones (continued)

Title/Description	Due Date	Actual Completion Date
Year 3 – Quarter 1 (October–December 2009)		
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	10/30/09	11/02/09
D78: Task 14 – Final White Paper on the Nexus of CCS and Water	10/30/09	10/28/09
M23: Task 14 – Monthly WWG Conference Call Held	10/31/09	10/26/09
M23: Task 14 – Monthly WWG Conference Call Held	11/30/09	11/16/09
D57: Task 12 – Project Assessment Annual Report	12/31/09	12/31/09
M23: Task 14 – Monthly WWG Conference Call Held	12/31/09	Waived by DOE
Year 3 – Quarter 2 (January–March 2010)		
D13: Task 2 – Public Site Updates	1/15/10	1/15/10
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	1/31/10	1/29/10
M23: Task 14 – Monthly WWG Conference Call Held	1/31/10	1/6/10
D79: Task 14 – Water Resource Estimation Methodology Document	2/28/10	Waived by DOE
M23: Task 14 – Monthly WWG Conference Call Held	2/28/10	2/25/10
D11: Task 2 – Outreach Plan	3/31/10	3/31/10
M23: Task 14 – Monthly WWG Conference Call Held	3/31/10	3/23/10
Year 3 – Quarter 3 (April–June 2010)		
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	4/30/10	4/30/10
M23: Task 14 – Monthly WWG Conference Call Held	4/30/10	4/28/10
M23: Task 14 – Monthly WWG Conference Call Held	5/31/10	5/13/10
D17: Task 2 – General Phase III Information PowerPoint Presentation (update)	6/30/10	6/30/10
D19: Task 2 – Fort Nelson Test Site PowerPoint Presentation (update)	6/30/10	6/29/10
M23: Task 14 – Monthly WWG Conference Call Held	6/30/10	6/23/10
M24: Task 14 – WWG Annual Meeting Held	6/30/10	5/13/10
Year 3 – Quarter 4 (July–September 2010)		
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	7/31/10	7/29/10
M23: Task 14 – Monthly WWG Conference Call Held	7/31/10	7/28/10
M23: Task 14 – Monthly WWG Conference Call Held	8/31/10	8/31/10
D1: Task 1 – Review of Source Attributes	9/30/10	9/20/10
D52: Task 9 – Fort Nelson Test Site – Site Characterization, Modeling, and Monitoring Plan	9/30/10	9/30/10
M9: Task 4 – Bell Creek Test Site Geologic Model Development Initiated	9/30/10	9/30/10
M23: Task 14 – Monthly WWG Conference Call Held	9/30/10	Waived by DOE

Continued . . .

Table 8. PCOR Partnership Phase III, BP3 and BP4 (through 9/30/2011) Deliverables and Milestones (continued)

Title/Description	Due Date	Actual Completion Date
Year 4 – Quarter 1 (October–December 2010)		
D87: Task 4 – Bell Creek Test Site – Geomechanical Experimental Design Package	10/30/10	10/29/10
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	10/31/10	10/29/10
M23: Task 14 – Monthly WWG Conference Call Held	10/31/10	10/26/10
M23: Task 14 – Monthly WWG Conference Call Held	11/30/10	Waived by DOE
D57: Task 12 – Project Assessment Annual Report	12/31/10	12/23/10
M23: Task 14 – Monthly WWG Conference Call Held	12/31/10	12/13/10
Year 4 – Quarter 2 (January–March 2011)		
M8: Task 4 – Bell Creek Test Site Wellbore Leakage Data Collection Initiated	1/15/11	1/14/11
D31: Task 4 – Bell Creek Test Site – Geological Characterization Experimental Design Package	1/31/11	1/27/11
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	1/31/11	1/31/11
M23: Task 14 – Monthly WWG Conference Call Held	1/31/11	1/19/11
M28: Task 4 – Bell Creek Geological Experimental Design Package Completed	1/31/11	1/27/11
D15: Task 2 – Bell Creek Test Site Fact Sheet	2/28/11	2/28/11
M23: Task 14 – Monthly WWG Conference Call Held	2/28/11	Waived by DOE
D10: Task 1 – Demonstration Project Reporting System Update	3/31/11	3/25/11
D18: Task 2 – Bell Creek Test Site PowerPoint Presentation (Update)	3/31/11	3/31/11
D26: Task 2 – Fort Nelson Test Site Poster	3/31/11	3/31/11
D28: Task 3 – Environmental Questionnaire – Bell Creek Test Site	3/31/11	3/30/11
D85: Task 6 – Report – Opportunities and Challenges Associated with CO_2 Compression and Transportation During CCS Activities	3/31/11	3/31/11
M23: Task 14 – Monthly WWG Conference Call Held	3/31/11	3/22/11

Continued . .

Table 8. PCOR Partnership Phase III, BP3 and BP4 (through 9/30/2011) Deliverables and Milestones (continued)

Title/Description	Due Date	Actual Completion Date
Year 4 – Quarter 3 (April–June 2011)		
M30: Task 5 – Bell Creek Test Site Baseline MVA Initiated	4/01/11	3/24/11
M23: Task 14 – Monthly WWG Conference Call Held	4/30/11	4/21/11
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	4/30/11	4/29/11
D88: Task 13 – Programmatic Risk Management Plan	4/30/11	4/29/11
D17: Task 2 – General Phase III Information PowerPoint Presentation (Update)	5/31/11	5/31/11
D34: Task 4 – Bell Creek Test Site – Baseline Hydrogeological Final Report	5/31/11	5/31/11
M23: Task 14 – Monthly WWG Conference Call Held	5/31/11	5/5/11
D19: Task 2 – Fort Nelson Test Site PowerPoint Presentation (Update)	6/30/11	6/30/11
M23: Task 14 – Monthly WWG Conference Call Held	6/30/11	6/23/11
M24: Task 14 – WWG Annual Meeting Held	6/30/11	5/5/11
Year 4 – Quarter 4 (July–September 2011)		
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	7/31/11	7/28/11
M23: Task 14 – Monthly WWG Conference Call Held	7/31/11	7/26/11
D29: Task 3 – Permitting Action Plan	8/31/11	8/31/11
D66: Task 9 – Bell Creek Test Site – Simulation Report	8/31/11	8/31/11
D67: Task 9 – Fort Nelson Test Site – Simulation Report	7/31/11	8/31/11
M23: Task 14 – Monthly WWG Conference Call Held	8/31/11	8/24/11
D1: Task 1 – Review of Source Attributes	9/30/11	9/21/11
D4: Task 1 – Permitting Review – Basic EPA Requirements[+]	9/30/11	9/30/11
D9: Task 1 – Updated DSS	9/30/11	9/23/11
D25: Task 2 – Bell Creek Test Site Poster	9/30/11	9/30/11
D50: Task 9 – Bell Creek Test Site – Site Characterization, Modeling, and Monitoring Plan	9/30/11	9/30/11
M23: Task 14 – Monthly WWG Conference Call Held	9/30/11	Waived by DOE
M31: Task 9 – Bell Creek Test Site – Site Characterization, Modeling, and Monitoring Plan Completed	9/30/11	9/30/11
M33: Task 16 – Basal Cambrian Baseline Geological Characterization Completed	9/30/11	9/29/11

[+] Name change requested September 28, 2011, and approved October 3, 2011.

Table 9. PCOR Partnership Phase III, BP4, PY3 and PY4 Gantt Chart

Continued…

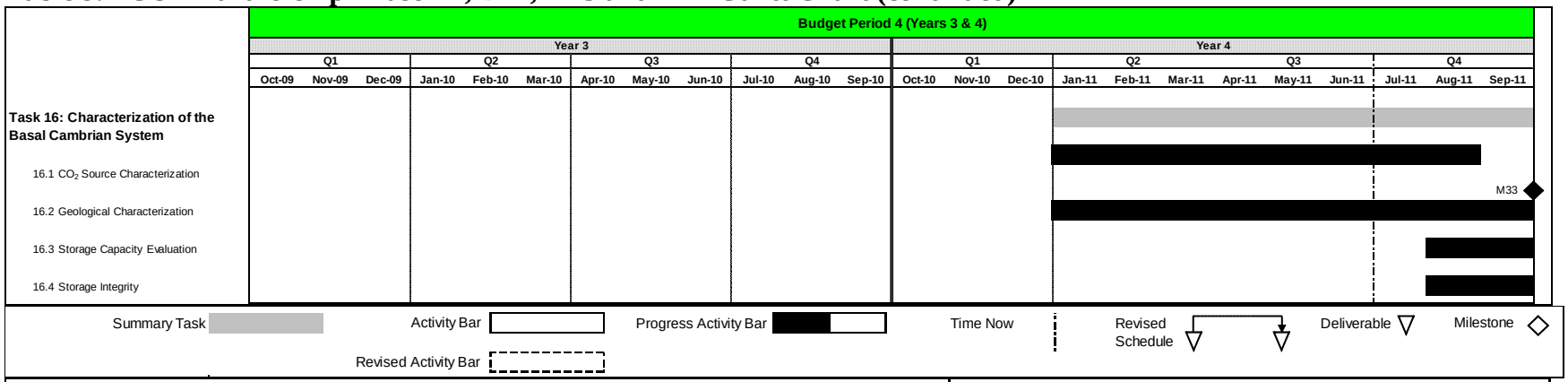
Table 9. PCOR Partnership Phase III, BP4, PY3 and PY4 Gantt Chart (continued)

Continued…

Table 9. PCOR Partnership Phase III, BP4, PY3 and PY4 Gantt Chart (continued)

Continued…

Table 9. PCOR Partnership Phase III, BP4, PY3 and PY4 Gantt Chart (continued)



Key for Deliverables (D)			
D1	Review of Source Attributes	D29	Permitting Action Plan
D4	Permitting Review – Basic EPA Requirements	D31	BC Test Site – Geological Characterization Experimental Design Package
D9	Updated DSS	D34	BC Test Site – Baseline Hydrogeological Experimental Design Package
D10	DPRS Update	D50	BC Test Site – Site Characterization, Modeling, and Monitoring Plan
D11	Outreach Plan	D52	FN Test Site – Site Characterization, Modeling, and Monitoring Plan
D13	Public Site Updates	D57	Project Assessment Annual Report
D15	Bell Creek (BC) Test Site Fact Sheet	D58	Quarterly Progress Report
D16	Fort Nelson (FN) Test Site Fact Sheet	D59	Milestone Quarterly Report
D17	General Phase III Information PowerPoint Presentation	D66	BC Test Site – Simulation Report
D18	BC Test Site PowerPoint Presentation	D67	FN Test Site – Simulation Report
D19	FN Test Site PowerPoint Presentation	D78	White Paper – Nexus of CCS and Water
D20	Video Support to PowerPoint and Web Site	D81	Regional Carbon Sequestration Atlas (update)
D24	PCOR Partnership Region CO_2 Storage General Poster	D85	Report – Opportunities and Challenges Associated with CO_2 Compression and Transportation During CCS Activities
D25	BC Test Site Poster		
D26	FN Test Site Poster	D87	BC Test Site – Geomechanical Experimental Design Package
D28	BC Test Site – Environmental Questionnaire	D88	Programmatic Risk Management Plan

Key for Milestones (M)	
M8	BC Test Site – Wellbore Leakage Data Collection Initiated
M9	BC Test Site – Geological Model Development Initiated
M23	Monthly WWG Conference Call Held
M24	WWG Annual Meeting Held
M28	BC Test Site – Geological Characterization Experimental Design Package Completed
M30	BC Test Site – Baseline MVA Activities Initiated
M31	BC Test Site – Site Characterization, Modeling, and Monitoring Plan Completed
M33	Basal Cambrian Baseline Geological Characterization Completed

PLANNED ACTIVITIES

Task 1 – Regional Characterization

During the next program year (October 1, 2011 – September 30, 2012), the following activities will be undertaken:

- Review and update attribute data for existing sources. Add additional attributes as necessary for characterization. Incorporate new sources as they come online (D1).

- Continue to work with the geological surveys/oil and gas divisions of the states and provinces to develop greater detail of the field and reservoir data.

- Complete the update of the regional carbon sequestration atlas (D81) for distribution at the 2012 PCOR Partnership Annual Meeting.

- Update the DPRS.

- Complete the detailed characterization of the Rival Field by March 2012.

Task 2 – Public Outreach and Education

During the next program year (October 1, 2011 – September 30, 2012), the following activities will be undertaken:

- Update the public PCOR Partnership Web site by July 2012.

- Update the PowerPoint presentations for Phase III general activities (D17), the Bell Creek demonstration (D18), and the Fort Nelson demonstration (D19). Other PowerPoint presentations may be developed as needed.

- Continue to develop video products to meet the needs of general and site-level outreach.

- Identify and act on opportunities to provide outreach both at the regional level and in the vicinity of the demonstrations, and address needs with respect to general information on CO_2 storage as well as information on the specific demonstration projects. Activities may include public presentations; assembly of materials for the press and for specific audiences, including middle and high school students; conducting focus groups and undertaking other means of gaining audience feedback to gauge the knowledge of target audiences as well as the effectiveness of outreach materials; and working with outreach and education professionals in an effort to improve the effectiveness of outreach and education activities.

- Continue participation in the RCSP OWG, the Weyburn–Midale Outreach Advisory Panel, and the Aquistore Project Communications Advisory Group.

Task 3 – Permitting and NEPA Compliance

During the next program year (October 1, 2011 – September 30, 2012), the following activities will be undertaken:

- Continue to gather information on current and planned CO_2 storage-related regulations at the state, province, and federal levels.

- Continue to facilitate the Regulatory Roundup meeting with regulators in the PCOR Partnership region.

- Interface with relevant regulatory agencies within the PCOR Partnership region as well as with federal regulatory agencies (United States and Canada) to understand the regulatory framework for project implementation. This may include planning a fourth regulatory meeting and any additional meetings as needed.

- Continue participation in IOGCC activities, as well as in the North Dakota CCS Task Force.

Task 4 – Site Characterization and Modeling

During the next program year (October 1, 2011 – September 30, 2012), the following activities will be undertaken:

- Fort Nelson test site

  – Prepare a report detailing the geochemical evaluations and modeling by December 15, 2011.

  – Prepare a site characterization report by December 30, 2011.

- Bell Creek Test Site

  – Initiate production and injection simulation activities by January 13, 2012.
  – Complete the wellbore leakage data collection by March 31, 2012.
  – Prepare a site characterization report by September 30, 2012.

Task 5 – Well Drilling and Completion

During the next program year (October 1, 2011 – September 30, 2012), the following activities will be undertaken:

- Continue to refine knowledge of the key reservoir parameters that control injectivity (i.e., nature of porosity, permeability, and fracture networks) for the Bell Creek test.

- Determine the injectivity of the target reservoir formation in the area of the selected injection location for the Bell Creek test.

- Develop an injection scheme that meets the technical and economic needs for the Bell Creek test project.

- Prepare an injection experimental design package report by September 2012.

- Continue baseline MVA activities.

Task 6 – Infrastructure Development

During the next program year (October 1, 2011 – September 30, 2012), the following activities will be undertaken:

- Prepare a report entitled "A Phased Approach to Building Pipeline Network for CO_2 Transportation During CCS" by June 2012.

- Prepare a report entitled "Issues Associated with Integration of Advanced Compression Technology into a CO_2 Storage Project" by September 2012.

- Complete the interactive capture technologies table on the DSS.

- Develop an interactive table of compression technologies for the DSS.

- Continue to investigate regional infrastructure needs. Information will be made available for possible inclusion in the DSS.

- Continue to assist commercial partners with the activities required to develop the infrastructure to deliver CO_2 to the EOR site for the Bell Creek demonstration.

- Further investigate the issues associated with integration of advanced compression technology into a CO_2 storage project, and lay the groundwork for potential incorporation of the Ramgen technology into the Bell Creek demonstration project.

- Continue to work with the EERC's Partnership for CO_2 Capture (PCO_2C) Program in order to share resources and maximize the use of DOE funding.

Task 7 – CO_2 Procurement

During the next program year (October 1, 2011 – September 30, 2012), the following activities will be undertaken:

- Continue to interface with commercial partners with respect to CO_2 procurement for CCS and EOR activities in the region.

- Continue to keep abreast of the various commercial issues associated with CO_2 procurement, such as contractual pricing mechanisms for CO_2, other potential customers, etc.

Task 8 – Transportation and Injection Operations

During the next program year (October 1, 2011 – September 30, 2012), the following activities will be undertaken:

- Monitor and assess the CO_2 transport and injection operations conducted by the site owner/operator of the Bell Creek test site.

Task 9 – Operational Monitoring and Modeling

During the next program year (October 1, 2011 – September 30, 2012), the following activities will be undertaken:

- Update the injection zone simulation modeling for the Fort Nelson test site by August 2012.

- Update the reservoir simulation modeling for the Bell Creek test site by August 2012.

Task 10 – Site Closure

No activity is anticipated during the next program year.

Task 11 – Postinjection Monitoring and Modeling

No activity is anticipated during the next program year.

Task 12 – Project Assessment

During the next program year (October 1, 2011 – September 30, 2012), the following activities will be undertaken:

- Prepare the Annual Project Assessment Report (D57).

Task 13 – Project Management

During the next program year (October 1, 2011 – September 30, 2012), the following activities will be undertaken:

- Continue to ensure timely production of deliverables and overall project management.

- Continue to expand the PCOR Partnership's membership base.

- Organize the newly created technical advisory board, and plan at least one meeting prior to the next annual meeting.

- Plan the next annual meeting.

- Continue to participate in and support RCSP efforts.

- Revise the project management plan as necessary.

Task 14 – RCSP Water Working Group Coordination

During the next program year (October 1, 2011 – September 30, 2012), the following activities will be undertaken:

- Continue to conduct monthly WWG conference calls.

- Plan and conduct the fourth annual meeting of the WWG.

Task 15 – Further Characterization of the Zama Acid Gas EOR, CO_2 Storage, and Monitoring Project

During the next program year (October 1, 2011 – April 30, 2012), the following activities will be undertaken:

- The regional technology implementation plan document developed in Phase II for the Zama project will be updated (D86) to incorporate the results of the added-on Phase III work.

Task 16 – Basal Cambrian System Characterization

During the next program year (October 1, 2011 – September 30, 2012), the following activities will be undertaken:

- Complete the Basal Cambrian static geologic model in December 2011.

- Prepare a report detailing the geological characterization of the Basal Cambrian System in the Williston Basin in February 2012.

- Continue participation in the binational Basal Aquifer Project steering and technical committee meetings.

PLANNED SCHEDULE

Table 9 contains all of the Phase III deliverables, milestones, and submission dates for PY5 (October 1, 2011 – September 30, 2012). Table 10 provides a Gantt chart for PY5.

Table 10. PCOR Partnership Phase III, BP4, PY5 Deliverables and Milestones

Title/Description	Due Date	Actual Completion Date
Year 5 – Quarter 1 (October–December 2011)		
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	10/31/11	
D65: Task 4 – Fort Nelson Test Site – Site Characterization Report	10/31/11	
M23: Task 14 – Monthly WWG Conference Call Held	10/31/11	
M29: Task 4 – Fort Nelson Site Characterization Report Completed	10/31/11	
M23: Task 14 – Monthly WWG Conference Call Held	11/30/11	
D41: Task 4 – Fort Nelson Test Site – Geochemical Final Report	12/15/11	
M32: Task 4 – Fort Nelson Geochemical Final Report Completed	12/15/11	
D57: Task 12 – Project Assessment Annual Report	12/31/11	
M23: Task 14 – Monthly WWG Conference Call Held	12/31/11	
M34: Task 16 – Basal Cambrian Static Geologic Model Completed	12/31/11	
Year 5 – Quarter 2 (January–March 2012)		
M16: Task 4 – Bell Creek Test Site – Initiation of Production and Injection Simulation	1/13/12	
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	1/31/12	
D81: Task 1 – Regional Carbon Sequestration Atlas (Update)	1/31/12	
M23: Task 14 – Monthly WWG Conference Call Held	1/31/12	
D91: Task 16 – Report – Geological Characterization of the Basal Cambrian System in the Williston Basin	2/29/12	
M23: Task 14 – Monthly WWG Conference Call Held	2/29/12	
D5: Task 1 – Second Target Area Completed	3/31/12	
D18: Task 2 – Bell Creek Test Site PowerPoint Presentation (Update)	3/31/12	
M10: Task 4 – Bell Creek Test Site Wellbore Leakage Data Collection Completed	3/31/12	
M23: Task 14 – Monthly WWG Conference Call Held	3/31/12	

Continued . . .

Table 10. PCOR Partnership Phase III, BP4, PY5 Deliverables and Milestones (continued)

Title/Description	Due Date	Actual Completion Date
Year 5 – Quarter 3 (April–June 2012)		
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	4/30/12	
D86: Task 15 – Updated Regional Implementation Plan for Zama	4/30/12	
M23: Task 14 – Monthly WWG Conference Call Held	4/30/12	
D17: Task 2 – General Phase III Information PowerPoint Presentation (Update)	5/31/12	
M23: Task 14 – Monthly WWG Conference Call Held	5/31/12	
D19: Task 2 – Fort Nelson Test Site PowerPoint Presentation (Update)	6/30/12	
D84: Task 6 – Report – A Phased Approach to Building Pipeline Network for CO_2 Transportation During CCS	6/30/12	
M23: Task 14 – Monthly WWG Conference Call Held	6/30/12	
M24: Task 14 – WWG Annual Meeting Held	6/30/12	
Year 5 – Quarter 4 (July–September 2012)		
D13: Task 2 – Public Site Updates	7/31/12	
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	7/31/12	
D67: Task 9 – Fort Nelson Test Site – Simulation Report	7/31/12	
M23: Task 14 – Monthly WWG Conference Call Held	7/31/12	
D66: Task 9 – Bell Creek Test Site – Simulation Report	8/31/12	
M23: Task 14 – Monthly WWG Conference Call Held	8/31/12	
D1: Task 1 – Review of Source Attributes	9/30/12	
D10: Task 1 – DPRS Update	9/30/12	
D42: Task 5 – Bell Creek Test Site – Injection Experimental Design Package	9/30/12	
D64: Task 4 – Bell Creek Test Site – Site Characterization Report	9/30/12	
D82: Task 6 –Report – Issues Associated with Integration of Advanced Compression Technology into a CO_2 Storage Project	9/30/12	
M23: Task 14 – Monthly WWG Conference Call Held	9/30/12	

Table 11. PCOR Partnership Phase III, BP4, PY5 and PY6 Gantt Chart

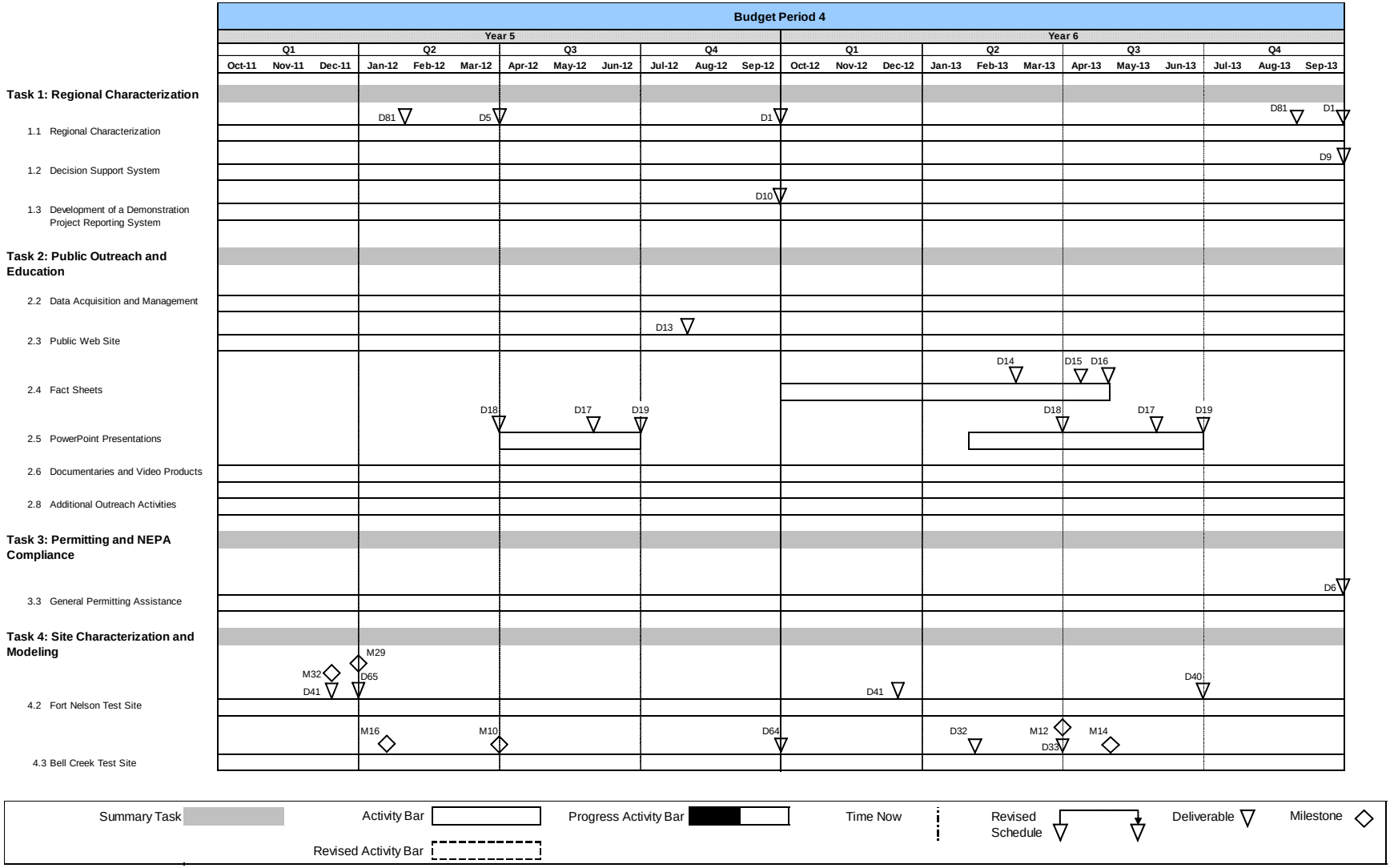


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Table 11. PCOR Partnership Phase III, BP4, PY5 and PY6 Gantt Chart (continued)

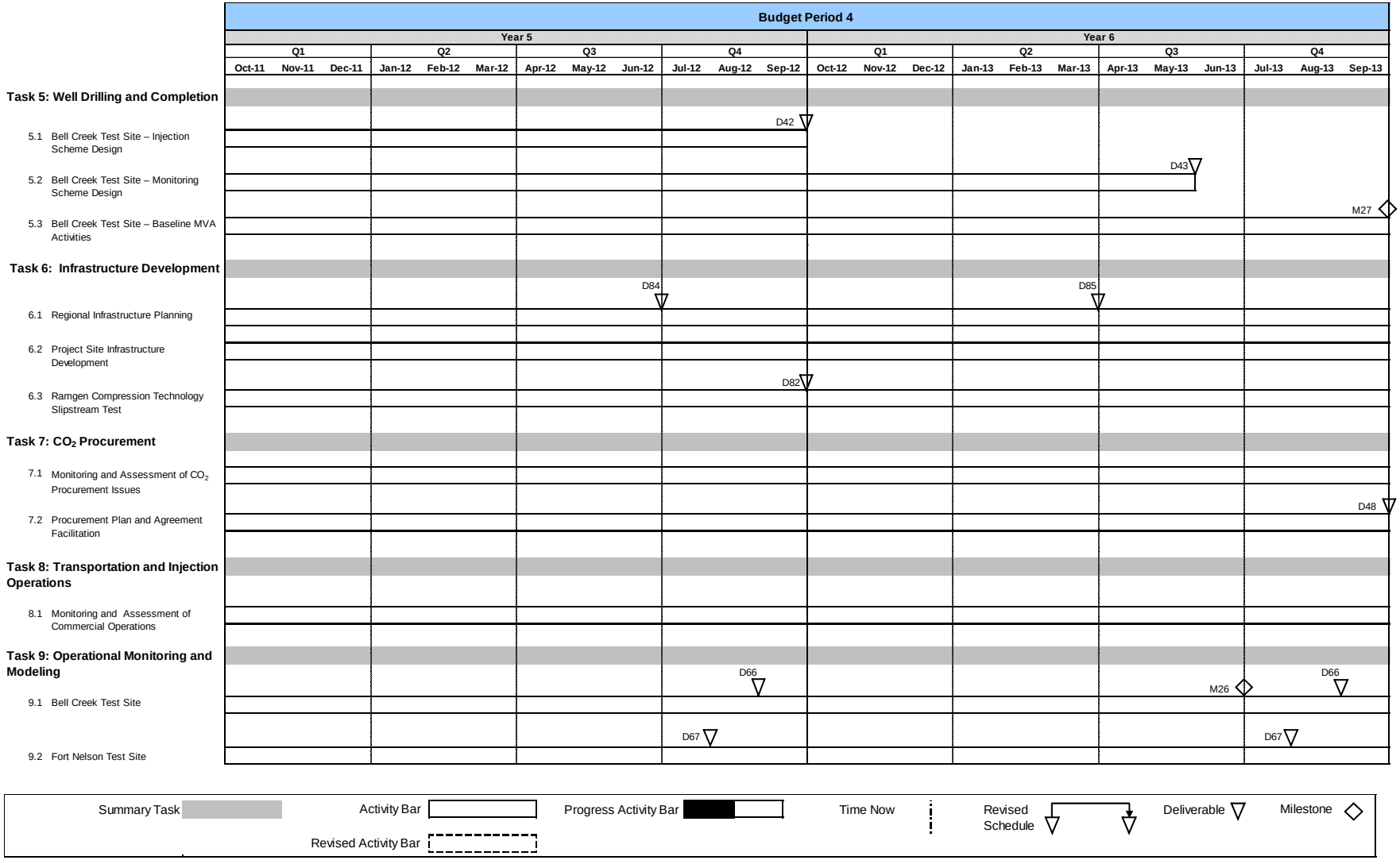

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Table 11. PCOR Partnership Phase III, BP4, PY5 and PY6 Gantt Chart (continued)

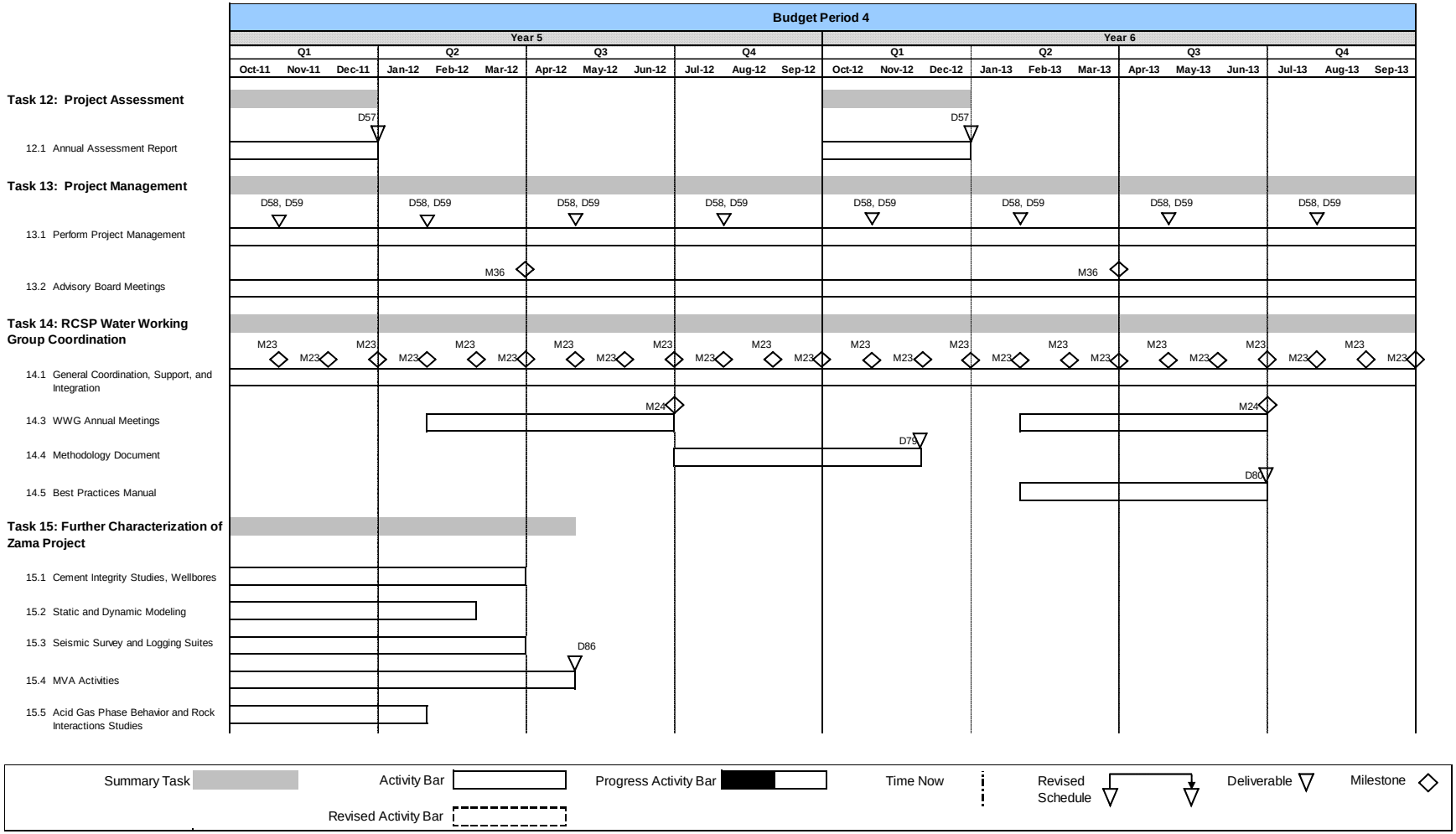

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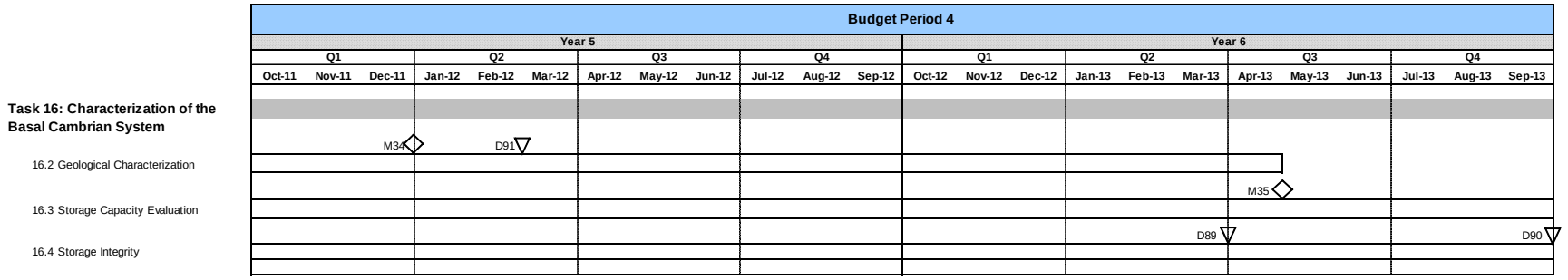
Table 11. PCOR Partnership Phase III, BP4, PY5 and PY6 Gantt Chart (continued)



Summary Task | Activity Bar | Progress Activity Bar | Time Now | Revised Schedule | Deliverable | Milestone

Revised Activity Bar

Key for Deliverables (D) ▼			
D1	Review of Source Attributes	D58	Quarterly Progress Report
D5	Second Target Area Completed	D59	Milestone Quarterly Report
D6	Permitting Review – Update	D64	BC Test Site – Site Characterization Report
D9	Updated DSS	D65	FN Test Site – Site Characterization Report
D10	DPRS Update	D66	BC Test Site – Simulation Report
D13	Public Site Updates	D67	FN Test Site – Simulation Report
D14	General Phase III Fact Sheet	D79	Report – Water Resource Estimation Methodology
D15	BC Test Site Fact Sheet	D80	Best Practices Manual – Nexus of Water and Carbon Storage Activities
D16	Fort Nelson Test Site Fact Sheet	D81	Regional Carbon Sequestration Atlas
D17	General Phase III Information PowerPoint Presentation	D82	Report – Issues Associated with Integration of Advanced Compression Technology into a CO_2 Storage Project
D18	BC Test Site PowerPoint Presentation		
D19	FN Test Site PowerPoint Presentation	D84	Report – A Phased Approach to Building Pipeline Network for CO_2 Transportation During CCS
D32	BC Test Site – Geomechanical Final Report		
D33	BC Test Site – Geochemical Final Report	D85	Report – Opportunities and Challenges Associated with CO_2 Compression and Transportation During CCS Activities
D40	FN Test Site – Geomechanical Report		
D41	FN Test Site – Geochemical Report	D86	Updated Regional Technology Implementation Plan for Zama
D42	BC Test Site – Injection Experimental Design Package	D89	Report – Geochemical Evaluation of the Basal Cambrian System
D43	BC Test Site – Monitoring Experimental Design Package	D90	Report – Wellbore Evaluation of the Basal Cambrian System
D48	BC Test Site – Procurement Plan and Agreement Report	D91	Report – Geological Characterization of the Basal Cambrian System in the Williston Basin
D57	Project Assessment Annual Report		

Key for Milestones (M) ◆	
M10	BC Test Site – Wellbore Leakage Data Collection Completed
M12	BC Test Site – Geochemical Work Completed
M14	BC Test Site – Geological Characterization Data Collection Completed
M16	BC Test Site – Initiation of Production and Injection Simulations
M23	Monthly WWG Conference Call Held
M24	WWG Annual Meeting Held
M26	BC Test Site – CO_2 Injection Initiated
M27	BC Test Site – MVA Equipment Installation and Baseline MVA Activities Completed
M29	FN Test Site – Site Characterization Report Completed
M32	Fort Nelson – Geochemical Report Completed
M34	Basal Cambrian Static Geological Model Completed
M35	Basal Cambrian Dynamic Capacity Estimation Completed
M36	Annual Advisory Board Meeting Scheduled

PROJECT RECOGNITION/TRAVEL (BP4, PY4)

Project Recognition

John Harju continued his appointment by U.S. Secretary of Energy Steven Chu to serve as a member of the National Petroleum Council for the 2010–2011 membership term.

John Harju continued his appointment as the Chairman of the Energy Resources, Research, and Technology Committee of the IOGCC. His term runs through January 2012.

John Harju continued to serve on DOE's Unconventional Resources Technology Advisory Committee (URTAC), which provides advice to the U.S. Secretary of Energy on the development and implementation of activities related to unconventional natural gas and other petroleum resources.

Travel

EERC staff travel extensively in its operation of the PCOR Partnership. The PCOR Partnership was represented at 35 conferences (presented at 19), one conference-related abstract review, 19 off-site meetings, and nine on-site meetings. Staff also traveled for 19 training seminars and 15 project-related activities. The following briefly summarizes the nature and extent of those trips:

- October 1–6, 2010: Attended Schlumberger software training entitled "Petrel Structural Modeling" in Houston, Texas.
- October 4–6, 2010: Presented at the 6th Annual Clean Carbon Policy Summit & Expo in Austin, Texas.
- October 4–7, 2010: Attended and participated in the 2010 RCSP Annual Review Meeting in Pittsburgh, Pennsylvania.
- October 6–7, 2010: Attended the LEC Annual Meeting in Bismarck, North Dakota.
- October 12–14, 2010: Presented a project update at Denbury headquarters in Plano, Texas.
- October 18–21, 2010: Hosted the PCOR Partnership Annual Meeting and Workshop in Minneapolis, Minnesota.
- October 19–23, 2010: Attended Computer Modelling Group's software training entitled "CO_2-Based Enhanced Oil Recovery (Miscible Flood) Course" in Houston, Texas.
- October 29 – November 3, 2010: Presented at the 2010 Geological Society of America Annual Meeting held in Denver, Colorado.
- November 1–3, 2010: Participated in the NACAP meeting held in Ottawa, Ontario, Canada.
- November 7–9, 2010: Presented at the Petroleum Technology Alliances of Canada (PTAC) conference held in Calgary, Alberta, Canada.
- November 14–18, 2010: Participated in the IOGCC 2010 Annual Meeting held in Tucson, Arizona.
- November 29 – December 1, 2010: Participated in the U.S.–Canada Clean Energy Dialogue: NAKSA meeting held in Columbus, Ohio.

- November 29 – December 3, 2010: Participated in the Fort Nelson site quarterly progress meeting in Calgary, Alberta, Canada.
- December 1, 2010: Attended the North Dakota Industrial Commission meeting in Bismarck, North Dakota.
- December 4–10, 2010: Participated in the 8th Annual EOR Carbon Management Workshop in Houston, Texas, and attended the 16th Annual CO_2 Flooding Conference in Midland, Texas.
- December 12–15, 2010: Attended Schlumberger Petrel Fracture Modeling training in Houston, Texas.
- December 16, 2010: Attended an outreach meeting with PPB in Fargo, North Dakota.
- January 15–20, 2011: Attended a 2-day CMOST simulation software training course with Computer Modelling Group in Houston, Texas.
- January 24–27, 2011: Attended the 2011 Groundwater Protection Council's UIC Conference in Austin, Texas.
- January 24–27, 2011: Attended a 3-day simulation software training session, entitled "CO_2–based EOR Miscible Flood," with Computer Modelling Group in Calgary, Alberta, Canada.
- January 28 – February 6, 2011: Attended a Petrel Seismic Visualization and Interpretation software training course with Schlumberger in Houston, Texas.
- January 29 – February 5, 2011: Presented at the 14th Annual Energy, Utility, and Environment Conference in Phoenix, Arizona.
- January 30 – February 3, 2011: Attended The Canadian Institute's 5th Annual CCS Conference in Calgary, Alberta, Canada.
- January 30 – February 3, 2011: Participated in the steering committee meeting for the Basal Cambrian System project in Calgary, Alberta, Canada.
- February 8–10, 2011: Attended the Carbon Capture and Storage Association's 4th Annual Preconference Workshop on CCS in Austin, Texas.
- February 8–11, 2011: Attended meetings with Natural Resources Canada, National Research Council, and others to discuss potential areas of collaboration in Ottawa, Ontario, Canada.
- February 11, 2011: Traveled to PPB's offices to discuss education outreach activities in Fargo, North Dakota.
- February 12–21, 2011: Attended a 3-day simulation software training session, entitled "CO_2-Based EOR Miscible Flood," with the Computer Modelling Group in Houston, Texas.
- February 13–18, 2011: Attended a 2-day CMOST and 1-day Wellbore Modeling in STARS simulation training sessions in Calgary, Alberta, Canada.
- February 14–20, 2011: Presented at the European CCS Demonstration Project 2011 Network Sharing Event held in Brindisi, Italy.
- February 15–17, 2011: Met with Denbury at its headquarters in Plano, Texas.
- February 16 and 17, 2011: Traveled to locate a hotel and meeting space for the 2011 PCOR Partnership Annual Meeting in Denver, Colorado.
- February 19–24, 2011: Attended a SPE Reservoir Simulation Symposium, as well as a training course on history matching, in The Woodlands, Texas.

- February 25 – March 4, 2011: Presented at the CSLF Storage Projects Interactive Workshop in Al Khobar, Saudi Arabia.
- February 28 – March 2, 2011: Attended Schlumberger's Petrel Reservoir Engineering simulation software training in Houston, Texas.
- March 6–18, 2011: Traveled to Denbury's headquarters to search, retrieve, and scan Bell Creek-related documents in Plano, Texas.
- March 7–8, 2011: Participated in an advisor's meeting and abstract review for the 10th Annual Conference on Carbon Capture and Sequestration in Pittsburgh, Pennsylvania.
- March 7–11, 2011: Attended the 2011 Esri Developer Summit in Palm Springs, California.
- March 8–11, 2011: Reviewed core samples from the Bell Creek Field at the Bureau of Economic Geology in Houston, Texas.
- March 14–16, 2011: Participated in the IEAGHG 2011 Expert Review of Regional Carbon Sequestration Partnerships in Arlington, Virginia.
- March 16, 2011: Participated in an education activities meeting at PPB offices in Fargo, North Dakota.
- March 28 – April 3, 2011: Presented at the 2nd France–Canada Workshop on Carbon Capture and Storage in Paris, France.
- April 4–7, 2011: Participated in the 5th North American Carbon Atlas Partnership Workshop in Morgantown, West Virginia.
- April 11–17, 2011: Traveled to Denbury's Bell Creek field office to review well files and scout monitoring well sites near Broadus, Montana.
- April 22–30, 2011: Presented at the IEAGHG Joint Modelling and Wellbore Network Meeting in Perth, Australia.
- April 30 – May 3, 2011: Traveled to the 19th Williston Basin Petroleum Conference in Regina, Saskatchewan.
- April 22–30, 2011: Presented at the IEAGHG Joint Modelling and Wellbore Network Meeting in Perth, Australia.
- April 30 – May 3, 2011: Traveled to the 19th Williston Basin Petroleum Conference in Regina, Saskatchewan.
- May 1–5, 2011: Presented at the 10th Annual Conference on CCS in Pittsburgh, Pennsylvania.
- May 15–17, 2011: Participated in an Aquistore Project Science and Engineering Research Committee meeting in Chicago, Illinois.
- May 15–19, 2011: Participated in Schlumberger's Petrel Reservoir Engineering training in Houston, Texas.
- May 18–19, 2011: Participated in a partner meeting with Eagle Operating in Bismarck, North Dakota.
- May 24–25, 2011: Participated in a United States–Canada Basal Aquifer Project meeting in Pittsburgh, Pennsylvania.
- May 25–26, 2011: Traveled to a meeting with Denbury in Plano, Texas.
- May 31 – June 2, 2011: Attended the 2011 CO_2 Geologic Sequestration & Water Resources Workshop in Berkeley, California.
- June 3–10, 2011: Attended the IEAGHG 7th Monitoring Network Meeting held June 7–9 in Potsdam, Germany.

- June 7–8, 2011: Presented at the NDPC Teacher Education Seminar on June 8 in Bismarck, North Dakota.
- June 13–15, 2011: Participated in the NDPC board meeting and social in Denver, Colorado.
- June 14–24, 2011: Attended the IEAGHG 6th Risk Assessment Network Meeting held June 21–23 in Pau, France.
- June 15–16, 2011: Visited the USGS CRC and the I-70 road cut to prepare for the annual meeting workshop in Denver, Colorado.
- June 19–23, 2011: Participated in the Subsurface CO_2 Modeling course held in Minneapolis, Minnesota.
- June 20–21, 2011: Presented at the 2011 Lignite Education Seminar: Energy, Economics and Environment on June 21 in Bismarck, North Dakota.
- June 20–23, 2011: Traveled in preparation for a July outcrop field trip visit to and around Hulett, Wyoming.
- June 21–23, 2011: Participated in the Ammerman Experience Effective Media Communications Seminar in Sugar Land, Texas.
- June 21–24, 2011: Participated in partner discussion with Husky Energy, Apache and PTRC in Calgary, Alberta, Canada.
- June 24–30, 2011: Presented at the AAPG–RMS 2011 Annual Meeting in Cheyenne, Wyoming.
- June 26–30, 2011: Participated in the IOGCC 2011 Midyear Issues Summit in Bismarck, North Dakota.
- June 29–30, 2011: Held the PCOR Partnership Regulatory Roundup in Bismarck, North Dakota.
- July 5–8, 2011: Situated two mobile trailers (field offices) at the Bell Creek Field in southeastern Montana.
- July 5–9, 2011: Traveled to begin soliciting landowner permissions for the baseline monitoring work in the Bell Creek Field area.
- July 8–15, 2011: Attended the Esri International User Conference and a preconference course entitled “Building Web Applications Using ArcGIS API for Flex” (www.esri.com/events/user-conference/agenda/index.html) in San Diego, California.
- July 10–13, 2011: Led an outcrop field trip near Hulett, Wyoming.
- July 12–14, 2011: Attended the EORI Fifth Annual CO_2 Conference in Casper, Wyoming.
- July 18–22, 2011: Participated in the facilitation and quarterly management meetings with Spectra regarding the Fort Nelson CCS Project in Vancouver, British Columbia, Canada.
- July 20–27, 2011: Participated in meetings with oil and gas producers and the National Petroleum Council’s Committee on Resource Development in Houston and The Woodlands, Texas.
- July 24–30, 2011: Traveled to continue construction of the Fort Nelson geologic model to Calgary, Alberta, Canada.
- July 26–27, 2011: Participated in a meeting with Denbury at its headquarters in Plano, Texas.

- July 26–31, 2011: Attended the Esri training course entitled "Introduction to Geoprocessing Scripts Using Python (9.3)" in Vienna, Virginia (http://training.esri.com/gateway/index.cfm?fa=catalog.courseDetail&CourseID=50089911_9.X).
- August 1–5, 2011: Traveled to the Bell Creek Field and surrounding area in southeastern Montana to contact landowners regarding project activities.
- August 4–5, 2011: Traveled to the Bell Creek Field for a site visit.
- August 9–11, 2011: Participated in a risk assessment meeting for the Aquistore Project in Regina, Saskatchewan, Canada.
- August 14–20, 2011: Participated in the Eventbrite CO_2 Flooding School training and field trip in Casper, Wyoming.
- August 16–17, 2011: Presented at the EPRI Health and Environmental Toxicity of Amines for Post-Combustion Capture Conference in Palo Alto, California.
- August 16–19, 2011: Attended Esri Building Geodatabases training course in Broomfield, Colorado.
- August 21–26, 2011: Attended the 2011 CO_2 Capture Technology Meeting in Pittsburgh, Pennsylvania.
- August 27, 2011: Presented at the PPB master teacher training session in Fargo, North Dakota.
- September 5–9, 7–13, and 18–23, 2011: Traveled to the Lignite field validation test site (Phase II) for site work near Kenmare, North Dakota.
- September 8, 2011: Presented at the Lignite Technology Development Workshop in Bismarck, North Dakota.
- September 11–14, 2011: Held the 2011 PCOR Partnership Annual Meeting and Foundations of CCS Geology Workshop in Denver, Colorado.
- September 15, 2011: Held a Basal Aquifer Project meeting in Denver, Colorado.
- September 13–17, 2011: Participated in a 3-day PEICE training course entitled "Fundamentals of Reservoir Simulation" in Houston, Texas.
- September 17–22, 2011: Attended the 2011 Society of Core Analysts Symposium in Austin, Texas (www.regonline.com/custImages/239450/2011TechnicalProgram.pdf).
- September 19–22, 2011: Attended the IPIECA workshop entitled "Addressing the Remaining Gaps in Knowledge for CCS" in Washington, D.C. (www.ipieca.org/event/20110506/addressing-remaining-gaps-knowledge-ccs).
- September 20–23, 2011: Attended the NDPC annual meeting in Medora, North Dakota.
- September 24–29, 2011: Participated in Schlumberger's training course entitled "Petrel Reservoir Engineering 2011" in Houston, Texas.
- September 25–28, 2011: Attended the 2011 Ground Water Protection Council Annual Forum in Atlanta, Georgia (www.gwpc.org/meetings/forum/forum.htm).

Materials presented at these meetings are available to partners on the PCOR Partnership DSS Web site (www2.undeerc.org/website/pcorp/ProductsDB/Default.aspx).

PHASE III PRODUCTS/PUBLICATIONS

During PY4, the PCOR Partnership submitted 31 abstracts, all but four of which were accepted; the author declined one and three are currently in review. The PCOR Partnership submitted eight journal articles and gave 56 presentations (oral and poster combined). In addition, it completed 23 deliverable reports (six of which were finalized), four milestone reports (one of which was finalized), and 17 progress reports (monthlies, quarterlies, and annual combined) and prepared two value-added products, and prepared several conference call and meeting minutes.

Abstracts

Submitted and Accepted for Presentation (26)

Bachu, S., Steadman, E.N., and Smith, S.A., 2011, The potential for, and possible effects of CO_2 storage in the Basal Aquifer of the Northern Plains – Prairie Region of North America—a joint US–Canada project [abs.]: 10th Annual Carbon Capture & Sequestration Conference, Pittsburgh, Pennsylvania, May 2–5, 2011.

Braunberger, J.R., Bremer, J.M., Liu, G., Gorecki, C.D., Peck, W.D., Steadman, E.N., and Harju, J.A., 2011, Characterization and modeling using macrofacies and microfacies intervals of the Midale and Rival "Nesson" beds in the Mississippian Madison Group, Burke County, North Dakota [abs.]: Abstract for the American Association of Petroleum Geologists – Rocky Mountain Section (AAPG–RMS) 2011 Annual Conference, Cheyenne, Wyoming, June 25–29, 2011.

Braunberger, J.R., Bremer, J.M., Liu, G., Gorecki, C.D., Peck, W.D., Steadman, E.N., and Harju, J.A., 2011, Characterization, petrography, and static geologic modeling of an unconventional carbonate reservoir, intervals of the Midale and Rival "Nesson" beds in the Mississippian Madison Group, Burke County, North Dakota [abs.]: American Association of Petroleum Geologists (AAPG) 2012 Annual Convention & Exhibition, Long Beach, California, April 22–25, 2012.

Bremer, J.M., Lindeman, C.D., Mibeck, B.A.F., Huffman, B.W., Gorecki, C.D., Smith, S.A., Steadman, E.N., and Harju, J.A., 2011, Laboratory analysis of Newcastle/Muddy outcrop samples as analogs to Bell Creek Field, Powder River County, Montana [abs.]: American Association of Petroleum Geologists – Rocky Mountain Section (AAPG – RMS) 2011 Annual Conference, Cheyenne, Wyoming, June 25–29, 2011.

Gorecki, C.D., Hamling, J.A., Steadman, E.N., and Harju, J.A., 2011, Integrating CO_2 EOR and CO_2 storage in the Bell Creek oil field [abs.]: 2012 Carbon Management Technology Conference, Orlando, Florida, February 7–9, 2012.

Gorecki, C.D., Klapperich, R.J., Bremer, J.M., Holubnyak, Y.I., and McNemar, A., 2010, Regional Carbon Sequestration Partnership—Water Working Group [abs.]: American Water Resources Association (AWRA) Spring Specialty Conference, Baltimore, Maryland, April 18–20, 2011.

Gorecki, C.D., Sorensen, J.A., Klapperich, R.J., Smith, S.A., Botnen, L.S., Steadman, E.N., and Harju, J.A., 2011, An integrated characterization, modeling, risk assessment, and monitoring

plan for the Fort Nelson CCS project [abs.]: 10th Annual Carbon Capture & Sequestration Conference, Pittsburgh, Pennsylvania, May 2–5, 2011.

Gorecki, C.D., Sorensen, J.A., Klapperich, R.J., Smith, S.A., Botnen, L.S., Steadman, E.N., and Harju, J.A., 2011, An integrated characterization, modeling, risk assessment, and monitoring plan for the Fort Nelson CCS project [abs.]: TCCS-6, the Trondheim CCS Conference for CO_2 Capture, Transport and Storage, Trondheim, Norway, June 14–16, 2011.

Gorecki, C.D., Sorensen, J.A., Klapperich, R.J., Botnen, L.S., Steadman, E.N., and Harju, J.A., 2011, A risk-based monitoring plan for the Fort Nelson CCS project [abs.]: 2012 Carbon Management Technology Conference, Orlando, Florida, February 7–9, 2012.

Gorecki, C.D., Sorensen, J.A., Steadman, E.N., and Harju, J.A., 2011, The Plains CO_2 Reduction Partnership's Phase III Bell Creek integrated CO_2 EOR and storage project [abs.]: 10th Annual Carbon Capture & Sequestration Conference, Pittsburgh, Pennsylvania, May 2–5, 2011.

Holubnyak, Y.I., Mibeck, B.A., Bremer, J.M., Smith, S.A., Sorensen, J.A., Steadman, E.N., and Harju, J.A., 2011, 3-D geochemical modeling of CO_2-based huff 'n' puff oil recovery at the Northwest McGregor oil field [abs.]: Abstract for the American Association of Petroleum Geologists – Rocky Mountain Section (AAPG-RMS) 2011 Annual Conference, Cheyenne, Wyoming, June 25–29, 2011.

Holubnyak, Y.I., Smith, S.A., Sorensen, J.A., Steadman, E.N., and Harju, J.A., 2011, Geochemical modeling of acid gas (H_2S and CO_2) EOR/storage at Zama, Alberta, Canada [abs.]: American Association of Petroleum Geologists – Rocky Mountain Section (AAPG – RMS) 2011 Annual Conference, Cheyenne, Wyoming, June 25–29, 2011.

Holubnyak, Y.I., Smith, S.A., Sorensen, J.A., Steadman, E.N., and Harju, J.A., 2011, Geochemical modeling of acid gas (H_2S and CO_2) EOR/storage at Zama, Alberta, Canada [abs.]: ATCE 2011—Society of Petroleum Engineers Annual Technical Conference and Exhibition, Denver, Colorado, October 30 – November 2, 2011.

Klapperich, R.J., Cowan, R.M., Gorecki, C.D., Liu, G., Kalenze, N.S., and Botnen, L.S., 2011, Extraction of formation water from CO_2 storage reservoirs [abs.]: 2011 Ground Water Protection Council Annual Forum, Atlanta, Georgia, September 24–28, 2011.

Knudsen, D.J., Peck, W.D., and Bachu, S., 2011, CO_2 storage characterization of the basal aquifer system in the northern Great Plains prairie region of North America [abs.]: American Association of Petroleum Geologists (AAPG) 2012 Annual Convention & Exhibition, Long Beach, California, April 22–25, 2012.

Knudsen, D.J., Saini, D., Gorecki, C.D., Peck, W.D., Sorensen, J.A., Steadman, E.N., and Harju, J.A., 2011, Using multiple-point statistics for conditioning a Zama pinnacle reef facies model to production history [abs.]: American Association of Petroleum Geologists (AAPG) 2012 Annual Convention & Exhibition, Long Beach, California, April 22–25, 2012.

Knudsen, D.J., Smith, S.A., Sorensen, J.A., Gorecki, C.D., Steadman, E.N., and Harju, J.A., 2011, Characterization and modeling of an EOR, H_2S disposal, and CO_2 storage project in the Zama Subbasin, Northern Alberta, Canada [abs.]: American Association of Petroleum Geologists – Rocky Mountain Section (AAPG – RMS) 2011 Annual Conference, Cheyenne, Wyoming, June 25–29, 2011.

Peck, W.D., and Bachu, S., 2011, CO_2 storage characterization of the basal aquifer system in the northern plains – prairie region of North America [abs.]: U.S. Department of Energy (DOE) Carbon Storage Program Infrastructure Annual Review Meeting (Featuring DOE's Regional Carbon Sequestration Partnerships), Pittsburgh, Pennsylvania, November 15–17, 2011.

Peck, W.D., Gorecki, C.D., Knudsen, D.J., Bremer, J.M., Steadman, E.N., and Harju, J.A., 2011, Application of the U.S. Department of Energy CO_2 storage resource estimation methodology on the Deadwood Formation, Williston Basin [abs.]: 10th Annual Carbon Capture & Sequestration Conference, Pittsburgh, Pennsylvania, May 2–5, 2011.

Steadman, E.N., Harju, J.A., Anagnost, K.K., Botnen, L.S., Daly, D.J., Gorecki, C.D., Jensen, M.D., Peck, W.D., Smith, S.A., and Sorensen, J.A., 2011, The Plains CO_2 Reduction (PCOR) Partnership—a regional carbon sequestration partnership conducting large-scale field tests [abs.]: 10th Annual Carbon Capture & Sequestration Conference, Pittsburgh, Pennsylvania, May 2–5, 2011.

Steadman, E.N., Harju, J.A., Botnen, L.S., Daly, D.J., Gorecki, C.D., Jensen, M.D., Peck, W.D., Smith, S.A., Sorensen, J.A., and Anagnost, K.K., 2010, The Plains CO_2 Reduction (PCOR) Partnership—demonstrating carbon management options for the central interior of North America [abs.]: 2011 American Association of Petroleum Geologists – Rocky Mountain Section (AAPG – RMS) Meeting, Cheyenne, Wyoming, June 25–29, 2011.

Steadman, E.N., Harju, J.A., Botnen, L.S., Daly, D.J., Gorecki, C.D., Jensen, M.D., Peck, W.D., Smith, S.A., Sorensen, J.A., and Anagnost, K.K., 2011, The Plains CO_2 Reduction (PCOR) Partnership—investigating carbon management options in North America's interior plains [abs.]: 2011 New Horizons in Oil and Gas Conference, Rapid City, South Dakota, October 5–8, 2011.

Steadman, E.N., Harju, J.A., Gorecki, C.D., Botnen, L.S., Daly, D.J., Jensen, M.D., Peck, W.D., Sorensen, J.A., Smith, S.A., Hamling, J.A., Klapperich, R.J., and Anagnost, K.K., 2011, The Plains CO_2 Reduction (PCOR) Partnership—a regional carbon sequestration partnership in the interior plains of North America [abs.]: EUEC 2012 Energy, Utility & Environment Conference, Phoenix, Arizona, January 30 – February 1, 2012.

Steadman, E.N., Harju, J.A., Gorecki, C.D., Pavlish, B.M., Jensen, M.D., Zygarlicke, C.J., and Anagnost, K.K., 2011, Carbon management strategies—commercial deployment studies focused on CO_2 capture and storage and the use of biomass fuels to reduce carbon emissions [abs.]: 2012 Carbon Management Technology Conference, Orlando, Florida, February 7–9, 2012.

Steadman, E.N., Harju, J.A., Sorensen, J.A., Smith, S.A., Gorecki, C.D., Daly, D.J., Jensen, M.D., Botnen, L.S., Peck, W.D., and Anagnost, K.K., 2011, The Plains CO_2 Reduction (PCOR) Partnership—collaborative U.S.–Canada carbon capture and storage demonstration activities [abs.]: 10th Annual Carbon Capture & Sequestration Conference, Pittsburgh, Pennsylvania, May 2–5, 2011.

Wade, S., Greenberg, S., Cumming, L., Tollefson, L., Garrett, G., Myhre, R., Daly, D.J., and Peterson, T., 2011, An approach for tailoring public outreach programs [abs.]: 10th Annual Carbon Capture & Sequestration Conference, Pittsburgh, Pennsylvania, May 2–5, 2011.

Submitted and Rejected for Presentation (four)

Braunberger, J.R., Bremer, J.M., Liu, G., Gorecki, C.D., Sorensen, J.A., Steadman, E.N., and Harju, J.A., 2010, Characterization and modeling using macrofacies and microfacies intervals of the rival "Nesson" beds in the Mississippian Lower Charles Formation, Burke County, North Dakota [abs.]: American Association of Petroleum Geologists (AAPG) 2011 Annual Convention & Exhibition, Houston, Texas, April 10–13, 2011.

Bremer, J.M., Lindeman, C.D., Mibeck, B.A.F., Huffman, B.W., Gorecki, C.D., Smith, S.A., Steadman, E.N., Harju, J.A., and Miller, D.J., 2011, Laboratory analysis of Newcastle/Muddy outcrop samples as analogs to Bell Creek Field, Powder River County, Montana [abs.]: 25th International Symposium of the Society of Core Analysts, Austin, Texas, September 18–21, 2011.

Gorecki, C.D., Klapperich, R.J., Bremer, J.M., Holubnyak, Y.I., and McNemar, A., 2010, Regional carbon sequestration partnership—water working group [abs.]: American Association of Petroleum Geologists (AAPG) 2011 Annual Convention & Exhibition, Houston, Texas, April 10–13, 2011.

Gorecki, C.D., Liu, G., Bremer, J.M., Sorensen, J.A., Steadman, E.N., and Harju, J.A., 2010, Modeling and monitoring the Northwest McGregor huff 'n' puff EOR project [abs.]: 73rd European Association of Geoscientists & Engineers (EAGE) Conference & Exhibition incorporating SPE EUROPEC 2011, Vienna, Austria, May 23–26, 2011.

Submitted, Accepted, and Declined by Author (one)

Gorecki, C.D., Sorensen, J.A., Klapperich, R.J., Smith, S.A., Botnen, L.S., Steadman, E.N., and Harju, J.A., 2011, An integrated characterization, modeling, risk assessment, and monitoring plan for the Fort Nelson CCS project [abs.]: TCCS-6, the Trondheim CCS Conference for CO_2 Capture, Transport and Storage, Trondheim, Norway, June 14–16, 2011.

Presentations (53)

Botnen, L.S., 2010, North Dakota's framework for carbon capture & storage (CCS): Presented at the 6th Annual Clean Carbon Policy Summit & Project Expo, Austin, Texas, October 5, 2010.

Braunberger, J.R., 2011, Rival model update: Presented at the Rival Project Update Meeting with TAQA North, Ltd., Grand Forks, North Dakota, March 24–25, 2011.

Braunberger, J.R., Bremer, J.M., Liu, G., Gorecki, C.D., Peck, W.D., Steadman, E.N., and Harju, J.A., 2011, Characterization and facies modeling of the Midale and Rival "Nesson" beds in the Mississippian Madison group, Burke County, North Dakota: Presented at the 2011 American Association of Petroleum Geologists – Rocky Mountain Section (AAPG – RMS) Meeting, Cheyenne, Wyoming, June 25–29, 2011.

Bremer, J.M., Lindeman, C.D., Mibeck, B.A.F., Huffman, B.W., Gorecki, C.D., Smith, S.A., Steadman, E.N., and Harju, J.A., 2011, Laboratory analysis of Newcastle–Muddy outcrop samples as analogs to the Bell Creek field, Powder River County, Montana: Presented at the 2011 American Association of Petroleum Geologists – Rocky Mountain Section (AAPG – RMS) Meeting, Cheyenne, Wyoming, June 25–29, 2011.

Cowan, R.M., and Pavlish, B.M., 2011, CO_2 separation and capture—status, challenges, and opportunities: Presented at the 61st Annual Environmental Engineering Conference, Lawrence, Kansas, April 14, 2011.

Daly, D.J., 2011, Energy and CO_2 management—carbon capture and storage: Presented at the North Dakota Petroleum Council Teacher Education Seminar, Bismarck, North Dakota, June 8, 2011.

Daly, D.J., 2011, Energy and CO_2 management—carbon capture and storage: Presented at the 2011 Lignite Education Seminar, Bismarck, North Dakota, June 21, 2011.

Daly, D.J., 2011, Plains CO_2 Reduction (PCOR) Partnership outreach and education: Presented at the Fort Nelson Quarterly Meeting, Vancouver, British Columbia, July 20–21, 2011.

Daly, D.J., and Crocker, C.R., 2011, Plains CO_2 Reduction Partnership Prairie Public Broadcasting education activities planning: Presented to Prairie Public Broadcasting personnel and area teachers, Grand Forks, North Dakota, January 26, 2011.

Gorecki, C.D., 2011, Plains CO_2 Reduction (PCOR) Partnership and extraction of formation water from carbon dioxide (CO_2) storage reservoirs: Presented to U.S. Department of Energy National Energy Technology Laboratory, Grand Forks, North Dakota, April 18, 2011.

Gorecki, C.D., 2011, The Plains CO_2 Reduction (PCOR) Partnership – Fort Nelson CCS feasibility project: Presented at the IEA Greenhouse Gas R&D Programme 2011 Modelling Network Meeting, Perth, Australia, April 27–29, 2011.

Gorecki, C.D., 2011, Plains CO_2 Reduction (PCOR) Partnership overview and saline aquifer efforts: Presented to C12 Energy personnel, Grand Forks, North Dakota, June 7, 2011.

Gorecki, C.D., 2011, Plains CO_2 Reduction (PCOR) Partnership update: Presented at the Plains CO_2 Reduction (PCOR) Partnership Annual Meeting, Denver, Colorado, September 13–14, 2011.

Gorecki, C.D., Liu, G., and Bailey, T.P., 2011, History matching efforts on Fort Nelson project: Presented at the History Matching Update Meeting with Spectra Energy, Grand Forks, North Dakota, March 1, 2011.

Gorecki, C.D., and Moffatt, D., 2011, An integrated characterization, modeling, risk assessment, and monitoring plan for the Fort Nelson CCS project: Presented at the 10th Annual Carbon Capture & Sequestration Conference, Pittsburgh, Pennsylvania, May 2–5, 2011.

Hamling, J.A., 2011, Bell Creek CO_2 EOR and CO_2 storage demonstration project, Montana: Presented at the Plains CO_2 Reduction (PCOR) Partnership Annual Meeting, Denver, Colorado, September 13–14, 2011.

Harju, J.A., 2011, Energy & Environmental Research Center (EERC): Presented to Cargill Corn Milling North America personnel, Grand Forks, North Dakota, January 28, 2011.

Harju, J.A., 2010, The PCOR Partnership's efforts to facilitate regional CCS deployment: Presented at the 8th Annual EOR Carbon Management Workshop, Houston, Texas, December 6–7, 2010.

Harju, J.A., and Steadman, E.N., 2010, PCOR Partnership program overview—adding value to Denbury Resources' Rocky Mountain operations: Presented at the Bell Creek Project Discussion Meeting, Plano, Texas, October 13–14, 2010.

Holubnyak, Y.I., Hawthorne, S.B., Mibeck, B.A., Miller, D.J., Bremer, J.M., Smith, S.A., Sorensen, J.A., Steadman, E.N., and Harju, J.A., 2010, Geochemical interactions of CO_2 with reservoir fluid and rocks of Powder River Basin: Presented at the 2010 Geological Society of America (GSA) Annual Meeting, Denver, Colorado, October 31 – November 3, 2010.

Holubnyak, Y.I., Mibeck, B.A., Bremer, J.M., Smith, S.A., Gorecki, C.D., Sorensen, J.A., Steadman, E.N., and Harju, J.A., 2010, Geochemical modeling of huff 'n' puff oil recovery with CO_2 at the Northwest McGregor oil field: Presented at the 2010 Geological Society of America (GSA) Annual Meeting, Denver, Colorado, October 31 – November 3, 2010.

Holubnyak, Y.I., Rygalov, V., Smith, S.A., Sorensen, J.A., Steadman, E.N., and Harju, J.A., 2010, Introducing new statistical methods in geochemical kinetics modeling for better estimations of CO_2–water–rock interactions: Presented at the 2010 Geological Society of America (GSA) Annual Meeting, Denver, Colorado, October 31 – November 3, 2010.

Klapperich, R.J., 2011, 3rd Annual RSCP Water Working Group meeting opening presentation: Presented at the Regional Carbon Sequestration Partnership Water Working Group annual meeting, Pittsburgh, Pennsylvania, May 5.

Klapperich, R.J., Gorecki, C.D., Bremer, J.M., Holubnyak, Y.I., and McNemar, A., 2011, Regional Carbon Sequestration Partnership Water Working Group: Presented at the 2011 American Water Resources Association Spring Specialty Conference, Baltimore, Maryland, April 18–20, 2011.

Peck, W.D., 2011, Characterization of the basal aquifer system: Presented at the Plains CO_2 Reduction (PCOR) Partnership Annual Meeting, Denver, Colorado, September 13–14, 2011.

Peck, W.D., 2011, Characterization of the Basal Cambrian System – update: Presented at the Basal Aquifer Project Joint Technical and Steering Committee Meeting, Pittsburgh, Pennsylvania, May 25, 2011.

Peck, W.D., 2011, Geologic concepts and CCS: Presented at the Plains CO_2 Reduction (PCOR) Partnership Annual Meeting Workshop, Denver, Colorado, September 12, 2011.

Peck, W.D., 2010, North American Carbon Atlas workshop. Presented at the North American Carbon Atlas Workshop, Ottawa, Ontario, Canada, November 1–3, 2010.

Peck, W.D., 2010, PCOR Partnership regional characterization activity: Presented at the Plains CO_2 Reduction (PCOR) Partnership Quarterly Group Meeting, Grand Forks, North Dakota, December 14, 2010.

Peck, W.D., 2010, Plains CO_2 Reduction (PCOR) Partnership Decision Support System update: Presented at the 2010 PCOR Partnership Annual Meeting & Workshop, Minneapolis, Minnesota, October 19–21, 2010.

Peck, W.D., Knudsen, D.J., Bremer, J.M., and Gorecki, C.D., 2011, Application of the U.S. Department of Energy's CO_2 storage resource estimation methodology on the Deadwood Formation, Williston Basin: Presented at the 10th Annual Carbon Capture & Sequestration Conference, Pittsburgh, Pennsylvania, May 2–5, 2011.

Peck, W.D., and Steadman, E.N., 2011, Plains CO_2 Reduction (PCOR) Partnership update: Presented at EUEC 2011 Energy, Utility & Environment Conference, Phoenix, Arizona, January 31 – February 2, 2011.

Schmidt, D.D., 2010, Evaluation of key factors affecting successful oil production in the Bakken Formation, North Dakota: Presented at SPE ATW—Maximizing Tight Oil in the Bakken, Keystone, Colorado, August 4–6, 2010.

Smith, S.A., 2011, Zama acid gas EOR, CO_2 storage, and monitoring project: Presented at the 2nd France–Canada Workshop on Carbon Capture and Storage, Paris, France, March 30, 2011.

Sorensen, J.A., 2010, Simultaneous EOR and CCS – experiences in the Zama oil field: Presented at the Petroleum Technology Alliance Canada (PTAC) Conference, Calgary, Alberta, November 8, 2010.

Sorensen, J.A., and Gorecki, C.D., 2010, Energy & Environmental Research Center—Oil and Gas Group overview: Presented at the Bell Creek Project Discussion Meeting, Plano, Texas, October 13–14, 2010.

Sorensen, J.A., and Schmidt, D.D., 2010, EERC activities in the Williston Basin—examining the Bakken and Dickinson Lodgepole mound plays: Presented at the Bell Creek Project Discussion Meeting, Plano, Texas, October 13–14, 2010.

Steadman, E.N., 2010, PCOR Partnership program overview: Presented to Jeff Jennings of Harris, Brown & Klemer, Inc., Grand Forks, North Dakota, December 16, 2010.

Steadman, E.N., 2011, Plains CO_2 Reduction (PCOR) Partnership CCS demonstrations: Presented at the European CCS Project Network Knowledge-Sharing Meeting, Brindisi, Italy, February 16, 2011.

Steadman, E.N., 2010, Plains CO_2 Reduction (PCOR) Partnership update: Presented at the 2010 PCOR Partnership Annual Meeting & Workshop, Minneapolis, Minnesota, October 19–21, 2010.

Steadman, E.N., 2011, Plains CO_2 Reduction (PCOR) Partnership update: Presented to Doosan Power Systems personnel, Grand Forks, North Dakota, April 13, 2011.

Steadman, E.N., 2011, Plains CO_2 Reduction (PCOR) Partnership update: Presented to Nebraska Public Power District personnel, Grand Forks, North Dakota, July 28, 2011.

Steadman, E.N., 2011, The Plains CO_2 Reduction (PCOR) Partnership: Presented at the Lignite Technology Development Workshop, Bismarck, North Dakota, September 8, 2011.

Steadman, E.N., 2011, The Plains CO_2 Reduction (PCOR) Partnership—a regional carbon sequestration partnership conducting large-scale field tests: Presented at the 10th Annual Carbon Capture & Sequestration Conference, Pittsburgh, Pennsylvania, May 2–5, 2011.

Steadman, E.N., 2011, The Plains CO_2 Reduction (PCOR) Partnership—collaborative U.S.–Canada carbon capture and storage demonstration activities: Presented at the 10th Annual Carbon Capture & Sequestration Conference, Pittsburgh, Pennsylvania, May 2–5, 2011.

Steadman, E.N., and Harju, J.A., 2011, Fort Nelson Carbon Capture and Storage Project: Presented at the Carbon Sequestration Leadership Forum (CSLF) Storage and Monitoring Projects Interactive Workshop, Al Khobar, Saudi Arabia, March 1, 2011.

Steadman, E.N., Gorecki, C.D., Harju, J.A., and Nakles, D.V., 2011, The Plains CO_2 Reduction (PCOR) Partnership Program: Presented at the IEA Greenhouse Gas R&D Programme 2011 Expert Review of Regional Carbon Sequestration Partnerships (RCSPs) – Phase III, Arlington, Virginia, March 15, 2011.

Steadman, E.N., and Harju, J.A., 2011, Plains CO_2 Reduction (PCOR) Partnership: Presented to Indian Land Tenure Foundation personnel, Grand Forks, North Dakota, February 9, 2011.

Steadman, E.N., and Harju, J.A., 2010, Plains CO_2 Reduction (PCOR) Partnership update: Presented at the Regional Carbon Sequestration Partnerships (RCSP) Annual Review Meeting, Pittsburgh, Pennsylvania, October 5, 2010.

Steadman, E.N., and Harju, J.A., 2011, Zama acid gas EOR, CO_2 storage, and monitoring project: Presented at the Carbon Sequestration Leadership Forum (CSLF) Storage and Monitoring Projects Interactive Workshop, Al Khobar, Saudi Arabia, March 1, 2011.

Steadman, E.N., Harju, J.A., Botnen, L.S., Daly, D.J., Gorecki, C.D., Jensen, M.D., Peck, W.D., Smith, S.A., Sorensen, J.A., Braunberger, J.R., and Anagnost, K.K., 2010, The Plains CO_2 Reduction (PCOR) Partnership—demonstrating carbon management options for the central interior of North America: Presented at the 2011 American Association of Petroleum Geologists – Rocky Mountain Section (AAPG – RMS) Meeting, Cheyenne, Wyoming, June 25–29, 2011.

Steadman, E.N., Harju, J.A., Jensen, M.D., and Peck, W.A., 2011, Plains CO_2 Reduction (PCOR) Partnership: Presented to Cargill Corn Milling North America personnel, Grand Forks, North Dakota, January 28, 2011.

Steadman, E.N. (author), and Hill, K. (presenter), 2011, Key issues presented in the identification of suitable storage sites for CO_2: Presented at Carbon Capture & Storage (CCS) World Australia 2011, Melbourne, Australia, August 30 – September 1, 2011.

Posters Presentations (three)

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The publication *Carbon Dioxide Sequestration and Related Technologies* is shown in Figure 20.

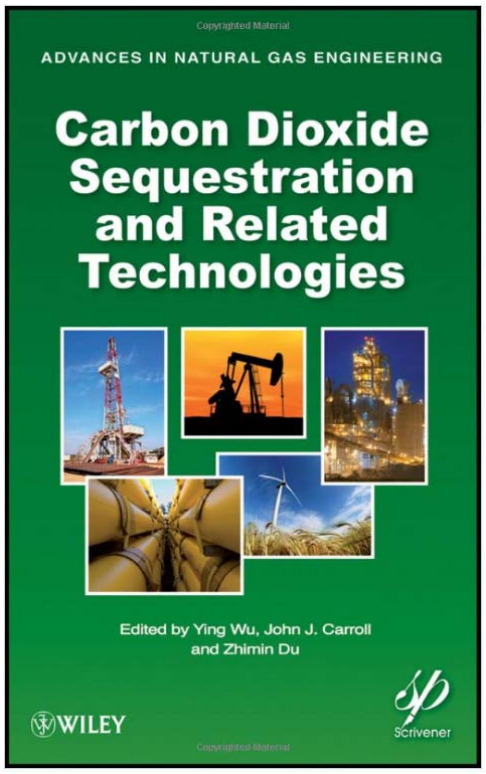

Figure 20. Chapters 20 and 21 in *Carbon Dioxide Sequestration and Related Technologies* were written by EERC staff (Copyright © 2011 by Scrivener Publishing LLC, all rights reserved) (www.amazon.com/, accessed December 2011).

DELIVERABLES/MILESTONES

Deliverables (23, six final)

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Progress Reports

Monthlies **(12 submitted)**

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Annual Assessment **(one submitted, one final)**

Steadman, E.N., Harju, J.A., Romuld, L., Sorensen, J.A., Daly, D.J., Gorecki, C.D., Smith, S.A., Jensen, M.D., Botnen, L.S., Peck, W.D., Anagnost, K.K., and Votava, T.J., 2010, Plains CO_2 Reduction (PCOR) Partnership Phase III annual assessment report: Task 12 Deliverable D57 (October 1, 2009 – September 30, 2010) for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, EERC

Publication 2011-EERC-02-02, Grand Forks, North Dakota, Energy & Environmental Research Center, December.

Meeting Minutes **(eight)**

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