BELL CREEK TEST SITE – INITIATION OF PRODUCTION AND INJECTION SIMULATION

Plains CO_2 Reduction (PCOR) Partnership Phase III
Task 4 – Milestone M16

Prepared for:

Andrea T. McNemar

National Energy Technology Laboratory
U.S. Department of Energy
3610 Collins Ferry Road
PO Box 880
Morgantown, WV 26507-0880

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Prepared by:

Hui Pu
John A. Hamling
Charles D. Gorecki
Edward N. Steadman

Energy & Environmental Research Center
University of North Dakota
15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018

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BELL CREEK TEST SITE – INITIATION OF PRODUCTION AND INJECTION SIMULATION

The Plains CO_2 Reduction (PCOR) Partnership, led by the Energy & Environmental Research Center (EERC), is working with Denbury Onshore LLC (Denbury) to determine the effect of large-scale injection of carbon dioxide (CO_2) into a deep clastic reservoir for the purpose of simultaneous CO_2 enhanced oil recovery (EOR) and CO_2 storage at the Bell Creek oil field, which is owned and operated by Denbury. The CO_2 will be obtained from the ConocoPhillips Lost Cabin gas-processing plant in Fremont County, Wyoming, which currently generates approximately 50 million cubic feet of CO_2 per day. The CO_2 will be transported to the site and injected into an oil-bearing sandstone reservoir in the Lower Cretaceous Muddy (Newcastle) Formation at a depth of approximately 4500 feet (1372 meters). The activities at Bell Creek will inject an estimated 1.1 million tons of CO_2 annually, much of which will be permanently stored.

Denbury will carry out the injection and production operations, while the EERC will provide support for the site characterization, modeling and simulation, and risk assessment and will aid in the development of the monitoring, verification, and accounting (MVA) plan to address CO_2 migration risks and mitigation strategies. The PCOR Partnership has developed an approach that integrates site characterization, modeling and simulation, risk assessment, and MVA into an iterative process to produce meaningful results for large-scale CO_2 storage projects.

A technical team that includes Denbury, the EERC, and others are conducting a variety of activities to determine the baseline characteristics of the target injection reservoir and surround strata. These characteristics have been utilized to construct a dynamic reservoir model capable of simulating the production and injection response of the reservoir and evaluating underground fluid migration potentials over the injection and postinjection phase of the project. The simulation results will provide a mechanism for assessing various injection strategies and guide long-term monitoring protocols. The Bell Creek Phase III demonstration project will provide data to support the design and implementation of an injection/production scheme, thus providing a unique opportunity to develop a set of cost-effective simulation and monitoring protocols for large-scale (>1 million tons per year) combined CO_2 EOR and CO_2 storage in a clastic formation.

BELL CREEK TEST SITE PRODUCTION AND INJECTION SIMULATION WORK PLAN

With the goal of providing a comprehensive assessment of CO_2 storage behavior and potential while supporting Denbury's EOR efforts, members of the PCOR Partnership have initiated a production and injection simulation program to aid in understanding the behavior of injected CO_2 and reservoir fluids over the injection and postinjection project periods. Modeling and simulation are important for assessing reservoir sweep, CO_2 storage efficiencies, and potential out-of-zone fluid migrations. This type of assessment is an essential input to the integrated risk assessment and MVA plans, which in turn helps to ensure that the maximum benefit to the EOR process is achieved in a safe and efficient manner.

As part of the Bell Creek CO_2 EOR and CO_2 storage project, production and injection simulation activities are being conducted, and the work plan will include the following:

- Characterize and model the study area using advanced geological modeling.
- History-match Bell Creek static model parameters regarding production and injection history; pressure, volume, temperature (PVT) tests; and address and predict minimum miscibility pressure.
- 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.
- Determine the area affected by the injection process to guide MVA activities.
- Construct a 3-D coupled geomechanical model to identify, anticipate, and evaluate the potential risk for out-of-zone fluid migration caused by reservoir integrity in order to guide the monitoring program.

The history match is being performed utilizing production and injection rates, water cut, and pressure data from the field dates spanning from 1967 to 2010. Numerical tuning was first performed in order to reduce the computational time while maximizing the accuracy of the model. A satisfactory history match of primary production (1967–1971) and liquid production rate has been achieved. Current focus on achieving satisfactory history matching on utilizing additional reservoir properties is under way.

The history match will be used as the baseline for evaluation of CO_2 EOR and long-term storage, improved understanding of CO_2 migration through the reservoir, project risk, and prediction of the long-term fate of injected CO_2. These simulations will in turn aid in the guidance of monitoring activities to assure that data acquisition occurs at optimal points and/or optimal locations during and after injection to maximize the utility of the data acquired.

Prior to the start of injection, the current geologic model will be updated with seismic data, petrophysical well log interpretation, and core analysis data, which will be acquired during the installation of a monitoring well during the winter of 2011. In addition to the new information

gathered from the monitoring well, which will be vital for reducing uncertainties in the injection simulation results, the monitoring well will also allow for the implementation of a broad array of monitoring techniques and technologies. These technologies will provide data points to check the validity of the simulation results and provide updated time-lapse data that can be used to update simulation parameters, thereby assuring agreement between predictions and the physical reservoir response.

BELL CREEK TEST SITE PRODUCTION AND INJECTION SIMULATION WORK INITIATED

A variety of activities focused on geologic modeling and reservoir simulation history matching and prediction were initiated in December 2010. These activities include the following:

- PVT history matching between laboratory data and predicted results for three fluid samples are in agreement. Results indicate that miscibility for oil samples can be achieved at approximately 2800 psia.

- A 3-D geologic model was constructed using a stratigraphic framework, yielding a structural model into which rock and fluid petrophysical properties were populated (Figure 1). The current geologic model is only of the Phase 1 area and that a full field model and simulations will be started in spring of 2012. This 3-D geologic model, which will be updated based on new data acquired during the installation of the monitoring well, was used as input for history matching and will provide the groundwork for future predictive reservoir simulations.

- Efforts for the reservoir simulation study were initiated in July 2011 and are under way using GEM, a 3-D compositional reservoir simulator developed by Computer Modelling Group. The model includes 67 production wells, 35 injection wells (31 of them are converted injection), and one monitoring well.

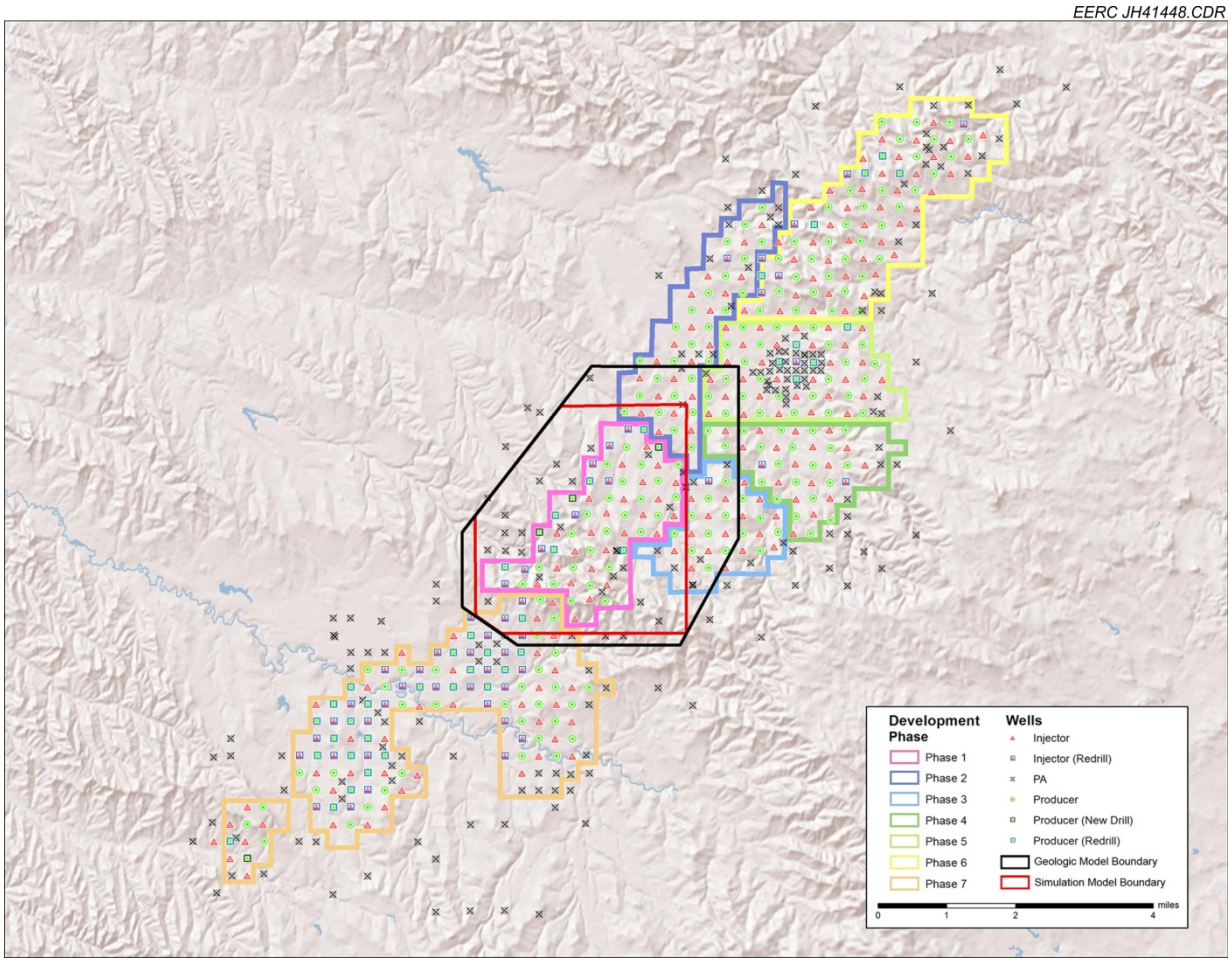

Figure 1. Map showing the geologic model boundary (black), the simulation model boundary (red), and their relation to the planned Bell Creek project development phases.