OVERVIEW OF THE BELL CREEK COMBINED CO_2 STORAGE AND CO_2 ENHANCED OIL RECOVERY PROJECT

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ABSTRACT

The Plains CO_2 Reduction (PCOR) Partnership, led by the Energy & Environmental Research Center (EERC), is working with Denbury Onshore LLC (Denbury) on a combined carbon dioxide (CO_2) enhanced oil recovery (EOR) and CO_2 storage demonstration project in the Bell Creek oil field. The Bell Creek oil field is wholly owned and operated by Denbury, transects portions of both Powder River and Carter Counties, Montana, USA, and covers just under 22,000 acres (89 km^2). The Bell Creek project will evaluate the potential for combined CO_2 EOR and CO_2 storage in the PCOR Partnership region, which will both reduce net CO_2 emissions and recover an anticipated 35 million barrels of incremental oil.

Denbury will source approximately 50 million cubic feet (1.4 million cubic meters) of CO_2 a day from the Lost Cabin gas-processing plant in Fremont County, Wyoming, which is owned by ConocoPhillips. The CO_2 will be transported to the Bell Creek oil field via a

232-mile- (373 km)-long pipeline 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 Muddy Formation is characterized by high porosity (>25%), high permeability (>400 mD) sandstone. The activities at Bell Creek will inject an estimated 1 million tons of CO_2 annually beginning in the first quarter of 2013, much of which will be permanently stored.

The Bell Creek demonstration project will provide a unique opportunity to develop cost-effective monitoring, verification, and accounting (MVA) protocols for a large-scale (>1 million tons a year) combined CO_2 EOR and storage project in a clastic formation. The effectiveness of the MVA activities will be at least partially dependent on developing a thorough characterization, modeling, and risk assessment effort. The baseline geological characterization work that is being conducted over the course of the project will provide valuable data to support the design and implementation of an injection/production scheme for large-scale CO_2 EOR and storage at the Bell Creek oil field.

Characterization and simulation work was initiated in 2011 utilizing historic data, including well logs, core analysis, production rates, and pressure surveys that have been conducted in the field since 1968 when it was first developed. An initial geologic model and preliminary simulation results indicate that the Bell Creek oil field is an ideal candidate for long-term CO_2 storage in terms of reservoir capacity, flow properties, and confinement. Modeling and simulation work will be continually updated throughout the lifetime of the project based on new data acquisitions in order to guide the monitoring program and to better predict the lateral migration of CO_2 over time.

To aid in this effort, a monitoring and characterization well was completed in January 2012. The well is located in the central portion of the Bell Creek oil field between an injection well and a production well. A host of state-of-the-art data and geologic core samples were acquired, which will allow for better understanding of the geologic environment and the ability to calibrate historic information to a suite of modern high-resolution data. In addition to data acquisition, the monitoring well was outfitted with a distributed temperature-monitoring system and three downhole casing conveyed pressure gauges, which will provide continuous real-time data of the primary reservoir and overlying strata. The monitoring well was specifically designed in a manner so as to allow for periodic on-demand access for time-lapse well-based measurements via well logs and borehole seismic surveys. Data acquired from these time-lapse measurements will in turn be utilized to monitor CO_2 migration between an injection and production well, update reservoir simulation results, and guide the overall monitoring program.

In addition to the dedicated monitoring well, production and injection wells will be outfitted with a variety of pressure, temperature, and flow rate sensors that will further supplement MVA data and allow correlation of data throughout the rest of the field. It is also anticipated that a small portion of active production or injection wells may be reentered to provide supplemental downhole measurements.

Monitoring of the surface, near-surface, and deep subsurface environment is an essential component of any carbon storage project. The primary objective is to obtain critical data to

verify site security and assess variances within the predicted injection program. The MVA plan has been divided into separate shallow and deep subsurface monitoring plans. The purpose of the shallow plan, which includes soil gas- and water-sampling activities, is to establish preinjection conditions for naturally occurring CO_2 present in the surface and near-surface environment and to provide a source of data to compare postinjection conditions during the project's lifetime. The goal of the deep subsurface monitoring plan, which includes well-based measurements, borehole seismic surveys, and surface seismic surveys, is to track the movement of CO_2 in the reservoir, evaluate the recovery efficiency of the CO_2 EOR program, identify fluid migration pathways, and determine the ultimate fate of injected CO_2 in addition to providing updated data for simulation work.

The PCOR Partnership's philosophy is to combine site characterization, modeling and simulation, risk assessment, and MVA strategies into an iterative process to produce descriptive integrated results. Elements of any of these activities are crucial for understanding and developing the other activities. Based on this approach, site characterization, modeling and simulation, risk assessment, or MVA activities will be continually refined throughout the lifetime of the project based on the results of the other activities, improving the overall program.