FACTSHEET FOR PARTNERSHIP FIELD VALIDATION TEST

Partnership Name	Midwest Geological Sequestration Consortium		
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Field Test Information: Field Test Name	Task 8: Enhanced Oil Recovery 1 – Huff 'n Puff		
Test Location	Loudon Oilfield, Fayette County, Illinois		
Amount and Source of CO_2	Tons: 43	Source: Air Liquide (refinery or ethanol plant)	
Field Test Partners (Primary Sponsors)	Petco Petroleum Corp.		

Summary of Field Test Site and Operations:

Thirteen sites were screened and evaluated based on depth, formation pressure, temperature, stratigraphic importance and operator support. The site selected was the Owens lease within the Louden Oil Field in Fayette County, Illinois. Geologically, the field is a very large anticlinal structure that was discovered in 1938 and has produced nearly 400 million barrels of oil. The Mississippian Weiler Sandstone was the target reservoir for this field test at an average depth of 1,550 feet. The Weiler is a deltaic deposit consisting of fine- to very fined-grained, well-cemented quartzose sandstone having good well-to-well continuity. Extensive well information gathered from geophysical logs and core descriptions was used to characterize the Weiler Sandstone in the immediate area surrounding the Owens Lease. The average reservoir temperature is 78°F (25.6°C) with an average thickness of 15.6 feet, average porosity of 19.5% and average horizontal permeability of 154 md. The formation water has been tested at 104,000 mg/L total dissolved solids (TDS). This site is rural agricultural land that is flat lying (> 2% slope), dissected beyond the project area, by small creeks and has been part of an existing oil field for over 65 years.

For the first EOR test, a Huff 'n Puff (HNP) injection process was designed. A HNP has three components: the injection period (huff), the soak period (or shut-in), and the production period (puff). For a HNP test, CO_2 is injected into an oil producing well, not an injection well.

This project was designed to inject carbon dioxide into a producing well as a gas, allow the gas to soak for a period of time (approx. 1 week), place the well back on production and measure the amount of fluids produced. About 43 tons were injected in the gas phase over 5 days. Modeling suggested about the same time period for this volume. The baseline oil rate of 1 barrel of oil per day was established using the lease tank records during a three month period preceding the field test. During the two months following the soak period, 93 barrels of oil were produced above the pre-CO_2 baseline oil rate. Water rates fell immediately to 2/3 of the pre-injection rate.

Gas samples collected within the annulus zone of the injection well 8 months after CO_2 injection was terminated, continue to contain CO_2 concentrations greater than 60%. Consequently, the corrosion inhibitor treatment plan has continued. Corrosion was indicated at two different times; however interpretation of the results suggested that CO_2 was probably not the cause and that oxygen (air) had entered the wellbore via the casing valve. This was likely the cause of the corrosion.

Research Objectives:

The common goal is to demonstrate that geologic sequestration is a safe and permanent method to mitigate GHG emissions. This Huff 'n Puff project will evaluate the potential for a combined geological sequestration of CO_2 and enhanced oil recovery method in mature Illinois oil reservoirs. This test schedule consists of a total of thirteen months which include site evaluation, evaluation of well data, injection of CO_2, modeling, and MMV efforts.

Summary of Modeling and MMV Efforts: (Use the table provided for MMV)

- ***Geophysical methods*:**

Electromagnetic Induction **(EMI)** and High Resolution Electrical Earth Resistivity **(HREER)** was be used to measure conductivity and resistivity to indicate changes in soil moisture that may have been caused by migrating CO_2. These methods were run in pre- and post-injection stages (P/P).

- ***Geochemical methods:***

Monitoring the changes in major and trace constituents as well as pH, alkalinity, stable and radioactive isotopes, gases, and chemical composition of ground water were used to elucidate the potential impact of CO_2 migration.

- ***Soil gas sampling:***

Concentrations of CO_2 and CH_4 were measured in the vadose zone (P/P) to determine if elevated levels of CO_2 occurred. Due to saturation of the soil zone during the majority of the test very few measurements were taken and subsequent identification of the source of elevated soil gas and evaluation of ecosystem impacts were not possible using this technique.

- ***Well Logging:***

Well logging represents the best tool to validate the integrity of the injection well, monitor storage formation and seal, and measure seismic velocities, moisture, gas content, salinity, and hydrocarbon content around well casing. Three different type of well logging methods were used pre and post injection: Gamma Ray log, Cement Bond Log and Reservoir Saturation Tool **(RST)**. Pre- and post-log interpretation is not completed at this time. Originally the Ultrasonic Imaging tool was planned, but in the field the tool was unable to detect an image which was likely due to the buildup of scale on the wellbore surface. The Cement Bond Log was substituted for this.

- ***Ground water monitoring:***

Ground water monitoring was conducted by measuring quality and flow direction in shallow ground water and in the production well. The goal was to monitor changes in water quality after the CO_2 injection to validate the integrity of the seal formation, injection well, and other potential immigration pathways to the biosphere (P/P).

- ***Subsurface pressure and temperature, gas content and fluid chemistry:***

Gas content, fluid chemistry, and pressure of formation and temperature of the wellhead, downhole and annulus zone were monitored continuously to determine reactions of the injected CO_2 to formation matrix and fluid, provide a level of safety to the operators, and to insure integrity of the formation and seal (pre, during, and post injection).

- ***Measuring CO_2 injection rate, Volume, and isotopic composition:***

To validate the volume of CO_2 injected into the formation, the injection rate was monitored during the injection at the injection wells. Isotopic composition of CO_2 was used to trace CO_2 migration to validate the injection well and formation integrity.

- ***Groundwater and Geochemical Modeling:***

Groundwater models were developed using **MODFLOW**, a widely accepted, finite-difference based, groundwater flow model. An analytical elements model, such as GFLOW, was used to develop a conceptual model for groundwater flow. The results of the modeling effort were used to estimate the time for potential contaminants to travel outside the area of the injection site and provide an estimate of any risk to nearby water supplies, should CO_2 leakage occur (P/P). Also the software **PHREEQC** was applied for thermodynamic modeling of shallow groundwater samples and injection-formation brine samples to gain experience in using water quality data and chemical modeling as a technique for detecting releases of injected CO_2 P/P).

Accomplishments to Date:

The injection period and post-injection oil well response has been completed. However, post-injection MMV continues. For nearly 5 days, 43 tons of CO_2 were injected. Incremental oil production during the first two months following the soak period was 93 barrels. Results indicate that the CO_2 pattern flood of the Illinois Basin oilfield may have an added-value benefit as a pre-cursor to build and invest in the infrastructure necessary to establish a sequestration industry within the Basin.

Summarize Target Sink Storage Opportunities and Benefits to the Region:

This project evaluated the potential for geological sequestration of CO_2 in mature Illinois oil reservoirs as part of an enhanced oil recovery program. If deemed commercial on an operator-by-operator basis, further development using this technology could be expanded by oil producers, but is beyond the scope of this study area. This type of CO_2 injection can significantly boost short-term oil production and generate quick payouts, especially at attractive oil prices. The primary injected zone has basin-wide applicability having accounted for nearly 30% of the 4.1 billion barrels of produced oil. These HNP treatments could benefit our numerous small lease operators who cannot afford the cost of facilities, planning, and operation of a multi-well CO_2 WAG process.

Cost:

Total Field Project Cost: $222,100

DOE Share: $196,600
89%

Non-Doe Share: $ 25,500
11%

Field Project Key Dates:

Baseline Completed: **Mar 2007**

Drilling Operations Begin: **N/A**

Injection Operations Begin: **Mar 2007**

MMV Events: **Jan 2007 -Present**

Field Test Schedule and Milestones (Gantt Chart):

Injection Complete March 2007
MMV Continuing
Draft Final Report – mid-December 2007