FACTSHEET FOR PARTNERSHIP FIELD VALIDATION TEST

Partnership Name	Midwest Geological Sequestration Consortium		
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Field Test Information: Field Test Name	Task 9: Enhanced Oil Recovery 2 – Well Conversion		
Test Location	To be determined		
Amount and Source of CO_2	Tons: 2500	Source: Air Liquide (refinery or ethanol plant)	
Field Test Partners (Primary Sponsors)	Petco Petroleum Corp. (expected)		

Summary of Field Test Site and Operations:

Five different oilfields were screened and evaluated based on depth, formation pressure, temperature, stratigraphic importance, and operator support. Currently, the primary location of the well conversion EOR pilot would be 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 or Cypress Sandstones are the target reservoirs at an average depth of 1,550 feet. The Weiler is a deltaic deposit consisting of fine- to very fine-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. The average reservoir temperature is 78^{o}F (25.6^{o}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). The oil field lies beneath a combination of forested and rural agricultural land that is generally flat lying (> 2% slope) and can be dissected by small stream or rivers.

Over 100 sites within the Loudon Oil field were evaluated and reduced to 32 sites based on the pattern of the wells surrounding a central water injector, the water injector's pressure and water injection rate, and the number of geologic units open in the water injector. These 32 sites were visited to acquire surface information. Surface screening criteria included wells in flood plains, proximity to houses, ponds and major roads. About one-half of the 32 sites passed the surface screening process and were further screened for subsurface criteria that included the existence of a liner within the original casing and the number of geologic units open in the water injection well. Four sites were given high ratings and the process of building geologic and reservoir models for each site has been undertaken. Model development for two of the sites is in progress and data for the other two sites are being assembled.

Because this project will occur during winter months, road weight restrictions must be honored, so screening of the four sites will be re-visited with the local road commissioners to ensure that CO_2 delivery to the site can be continuous during the pilot injection period. The Illinois Basin has unique formation pressures and temperatures in the oil reservoirs where waterfloods occur such that a liquid CO_2 flood is possible. The liquid flood may be possible because the minimum miscible oil/CO_2 pressure is lower than commonly found in oil reservoirs due to the reservoir temperature being less than the critical temperature of CO_2. Consequently, our flood pattern EOR pilot will attempt a liquid CO_2 flood. However, if it is impossible to sustain liquid CO_2 in the subsurface, an immiscible CO_2 gas flood will be conducted and a liquid flood will be attempted in a future EOR pilot.

This pilot project is designed to inject CO_2 continuously (approx. 30-60 days) into a dedicated injection well while four surrounding oil producing wells are active. All CO_2 that is not released into the atmosphere during oil production will be assumed to have been sequestered within the reservoir. The CO_2 will be injected at the fastest rate possible so that the CO_2 will move further from the wellbore allowing for greater CO_2 oil contact. The injected CO_2 will likely displace and/or dissolve in the brine within the reservoir and will be absorbed by the oil. Sorption of the CO_2 to the oil will cause the oil to swell, lower its viscosity, and reduce the interfacial tension that holds the oil in the pore spaces. This swelling and lowered viscosity increases the relative mobility of the oil and thus increases oil production rates and volumes.

A total of 2,500 tons of CO_2 has been proposed to be injected for this project. Geologic and reservoir modeling will be used to determine the duration of the injection period and volume of CO_2 injected. An operational plan has been developed that includes limited time for acquisition of MMV baseline data. The injection well will have the tubing and rods pulled and will be inspected prior to CO_2 injection. The tubing and casing will be pressure tested. Any remedial work to the injection well will need to be performed prior to CO_2 injection.

CO_2 Injection: The MGSC pump skid will be used to increase CO_2 pressure from around 250-350 psig at the truck and discharge to a maximum of 1,500 psig. The injection will be kept at a constant pressure instead of a constant rate, although pumps need to inject the CO_2 at rates near 2-4 bbl/min. The CO_2 will then be pumped through the MGSC propane gas fired heater to raise the temperature from -10 to +10 degrees F to 40 - 60 degrees F. in order to avoid any hydrate formation. Corrosion inhibitor will be applied to the producing wells only. No inhibitor will be applied to the injector. Careful measurements of the volume and rate of fluids (oil, water, gas) produced from the four production wells will be made prior to CO_2 injection and throughout the entire production phase.

Research Objectives:

The goal of this pilot is to demonstrate that geologic sequestration is a safe and permanent method to mitigate GHG emissions. This EOR project will evaluate the potential for a combined geological sequestration of CO_2 and enhanced oil recovery method in mature Illinois oil reservoirs. The establishment of a demand for CO_2 in EOR projects is important to building infrastructure necessary for a CO_2 sequestration industry. This pilot schedule consists of a total of twelve months which includes site evaluation, evaluation of well data, injection of CO_2, modeling and MMV efforts. Geologic and reservoir modeling will be used to determine how much CO_2 will be injected.

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

- ***Geophysical methods*:**

Electromagnetic Induction **(EMI)** and High Resolution Electrical Earth Resistivity **(HREER)** are being evaluated as techniques to measure conductivity and resistivity to indicate changes in soil moisture that maybe caused by migrating CO_2. If used, these methods will be 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 will be used to elucidate the impact of CO_2 migration.

- ***Soil gas sampling:***

Also, concentrations of CO_2 and CH_4 will be attempted in the vadose zone (P/P) to detect elevated levels of CO_2, identify source of elevated soil gas, and evaluate ecosystem impacts. Previous experience has proven that the vadose zone is often too saturated for effective analysis to take place.

- ***Well Logging:***

The best tools 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 will be considered: Gamma Ray log, Ultra Sonic Instrument **(USI)**, and Reservoir Saturation Tool **(RST)** which are run pre and post injection.

- ***Ground water monitoring:***

Ground water monitoring will be used to measure quality and flow direction in shallow ground water and in the production well, to monitor changes in water quality after CO_2 injection to validate integrity of the seal formation, injection well, and other potential migration 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 wellhead, downhole and annulus zones will be monitored continuously to determine reactions of injected CO_2 to the formation matrix and fluid, provide a level of safety to operators, and to insure the 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 will be monitored. In addition, the isotopic composition of the injected CO_2 will be determined. The isotopic data may provide source tracking information that will help to trace CO_2 migration in order to validate injection well and formation integrity.

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

A site specific groundwater model will be developed using **MODFLOW**, a widely accepted, finite-difference based, groundwater flow model. An analytical elements model, such as GFLOW, may be used to develop a conceptual model for groundwater flow. The results of the modeling effort will estimate the time for potential contaminants that could be associated with CO_2 injection to travel outside the area of the injection site. This estimate will help identify risks to nearby water supplies, should CO_2 leakage occur (P/P). Also the software **PHREEQCI** and/or Geochemist Workbench would be 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:

Several sites have screened to identify those with highest probability of CO_2 response during operations. Geologic models and reservoir models are being developed to help with this process. Equipment has been ordered to convert the surface producing equipment to accommodate the conversion of the water injector to a CO_2 injector and for data acquisition of the gas casing rates.

Summarize Target Sink Storage Opportunities and Benefits to the Region:

This project will evaluate the potential for geological sequestration of CO_2 in mature Illinois oil reservoirs as part of an enhanced oil recovery program. If deemed commercial, further development using this technology could be expanded by oil producers but is beyond the scope of this study area. This type stimulation 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 EOR project treatments will provide information to numerous small lease operators that will consider starting their own CO_2 floods based on these test pilots.

Cost:

Total Field Project Cost: $638,000

DOE Share: 91% **$578,000**

Non-Doe Share: 9% **$ 60,000**

Field Project Key Dates:

Baseline Completed:	**Dec 2007 – Jan 2008**
Drilling Operations Begin:	**N/A**
Injection Operations Begin:	**Feb 2008**
MMV Events:	**Jan 2008 – Jul 2009**

Field Test Schedule and Milestones (Gantt Chart):

Final Site Selection December 2007
Injection February to April 2008