

Application of Reservoir Characterization and  
Advanced Technology to Improve Recovery and  
Economics in a Lower Quality Shallow Shelf San  
Andres Reservoir

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## **OBJECTIVES**

The Class 2 Project at West Welch was designed to demonstrate the use of advanced technologies to enhance the economics of improved oil recovery (IOR) projects in lower quality Shallow Shelf Carbonate (SSC) reservoirs, resulting in recovery of additional oil that would otherwise be left in the reservoir at project abandonment. Accurate reservoir description is critical to the effective evaluation and efficient design of IOR projects in the heterogeneous SSC reservoirs. Therefore, the majority of Budget Period 1 was devoted to reservoir characterization. Technologies being demonstrated include:

1. Advanced petrophysics
2. Three-dimensional (3-D) seismic
3. Crosswell bore tomography
4. Advanced reservoir simulation
5. Carbon dioxide (CO<sub>2</sub>) stimulation treatments
6. Hydraulic fracturing design and monitoring
7. Mobility control agents

## **SUMMARY OF TECHNICAL PROGRESS**

West Welch Unit is one of four large waterflood units in the Welch Field in the northwestern portion of Dawson County, Texas. The Welch Field was discovered in the early 1940's and produces oil under a solution gas drive mechanism from the San Andres formation at approximately 4800 ft. The field has been under waterflood for 30 years and a significant portion has been infill-drilled on 20-ac density. A 1982-86 pilot CO<sub>2</sub> injection project in the offsetting South Welch Unit yielded positive results. Recent installation of a CO<sub>2</sub> pipeline near the field allowed the phased development of a miscible CO<sub>2</sub> injection project at the South Welch Unit.

The reservoir quality at the West Welch Unit is poorer than other San Andres reservoirs due to its relative position to sea level during deposition. Because of the proximity of a CO<sub>2</sub>

source and the CO<sub>2</sub> operating experience that would be available from the South Welch Unit, West Welch Unit is an ideal location for demonstrating methods for enhancing economics of IOR projects in lower quality SSC reservoirs. This Class 2 project concentrates on the efficient design of a miscible CO<sub>2</sub> project based on detailed reservoir characterization from advanced petrophysics, 3-D seismic interpretations and crosswell tomography interpretations.

During this quarter interwell seismic surveys were successfully acquired for CO<sub>2</sub> monitoring purposes and processing of the data initiated. Surveillance of the focus area indicated increasing response to the CO<sub>2</sub> injection. Two wells were waggled to water to remediate gas breakthroughs.

## **INTERWELL SEISMIC**

In the fourth quarter of 1999, Advanced Reservoir Technologies, working with OXY personnel, planned and setup the first round of CO<sub>2</sub> monitor surveys to be carried out on six interwell seismic survey lines in the south pattern of the study area. The six lines were chosen to provide good radial coverage around the south observation (source) well, 4852. The additional (receiver) wells used in this work were 4822, 4827, 4828, 4841, 4843, and 4844 (Figure 2).

Because of potential high pressures and presence of hydrogen sulfide gas (H<sub>2</sub>S), it was necessary to build and deploy a special wellhead lubricator of approximately 120 feet in length. This is believed to be the tallest lubricator ever used in a well logging operation, and was deployed from a 165 foot crane brought to the site. Because of the required use of this one-of-a-kind lubricator, only one survey line at a time could be acquired. The operations were successful, providing a very good set of data to be used to monitor the location of CO<sub>2</sub> within the reservoir. This data were being processed and analyzed at the end of the fourth quarter.

## **3-D SEISMIC INTEGRATION**

No activities involving 3-D seismic integration were undertaken during the fourth quarter of 1999.

## **NUMERICAL SIMULATION**

No simulation work was conducted during the fourth quarter of 1999.

## **FIELD DEMONSTRATION PHASE**

Through December 1999 a total of 3.2 BCF of CO<sub>2</sub> had been injected into the project area since initiation in October 1997. Overall oil and gas production fell off during October and November probably in response to the reduced CO<sub>2</sub> injection rates in September. 4811 was

wagged to water injection in late November to reduce gas breakthrough in 4843. Similarly, 4805 was wagged to water in late December to reduce gas breakthrough in 4844. Monthly performance for the focus area during the fourth quarter of 1999 is shown on Table 1.

The oil response seen in 4847 and 4854 during the third quarter continued in the fourth quarter with the WOR on 4847 decreasing from 11 to 6. Oil production in 4844-the first well to respond- continued to increase. Also 4843 experienced an oil response during the quarter. The location of wells being effected by the project is shown on Figure 2.

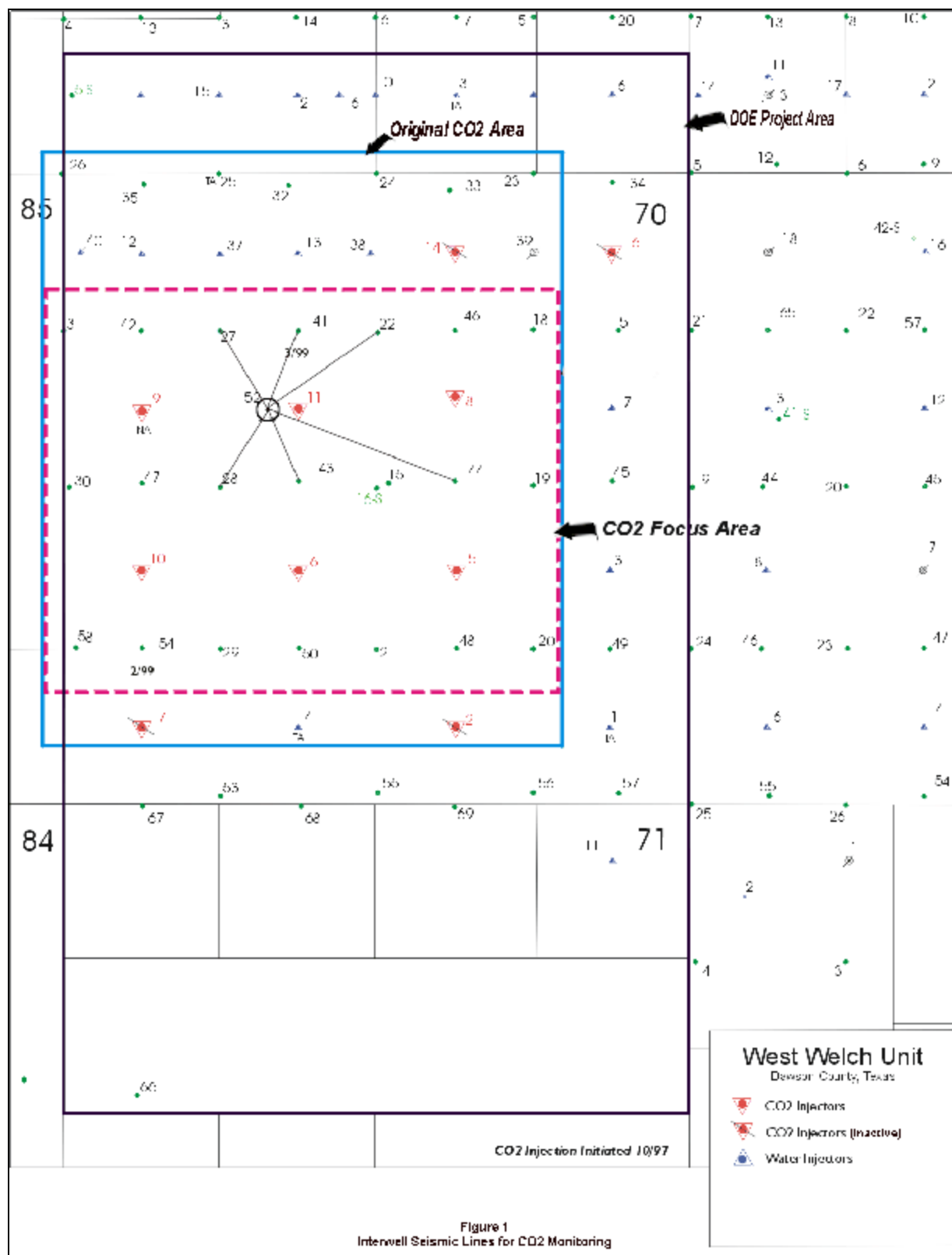
At the current injection rates only 3.5% of the hydrocarbon pore volume is being processed by CO2 annually. Unless a method can be found to increase injection rates, it will be difficult to fully evaluate the CO2 potential in the project area during the remaining Budget Period 2 time frame.

## **AREA PREPARATION AND CONSTRUCTION**

There was no construction, stimulation or workovers done in the DOE project area during the fourth quarter of 1999.

## **TECHNOLOGY TRANSFER**

Justice, Jim, J. C. Woerpel, G. W. Watts, W. Waddell, " Interwell Porosity and Permeability from Biot-Gassmann with Shear & Compressional Tomography and Cross-Plots," Annual SEG Meeting, Houston 11/2/1999.



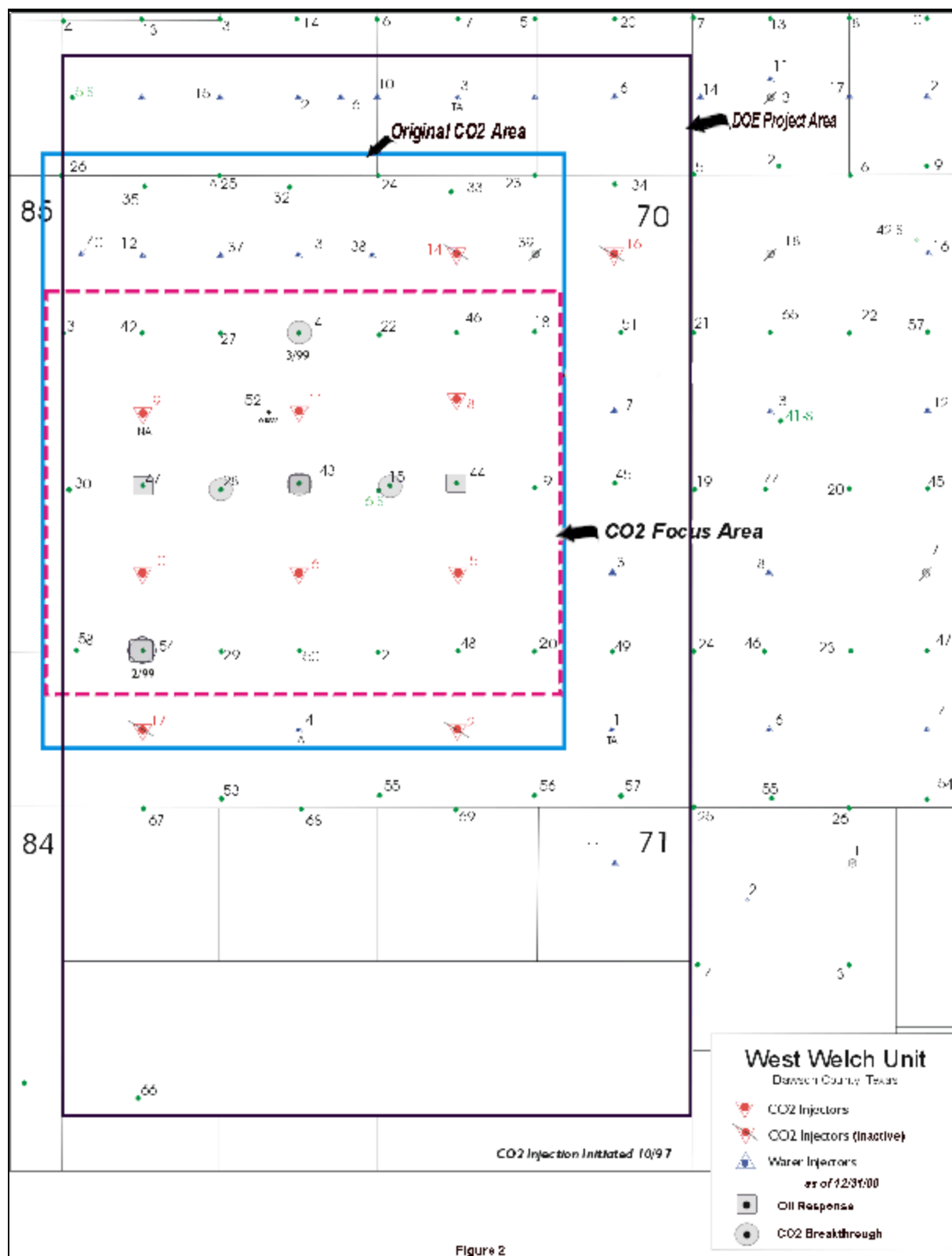


Table 1				
CO2 Focus Area Performance				
Fourth Quarter - 1999				
West Welch Unit DOE Project				
Dawson County, Texas				
	Oct	Nov	Dec	4th Qtr
Injection				
Average CO2 injection rate (mcf/d)	3023	3552	2812	3124
# of Injectors on CO2	6	6	5	
Average rate per injector (mcf/d)	504	592	562	520
% HCPV injected	0.3%	0.3%	0.3%	0.9%
Cum % HCPV injected	7.0%	7.3%	7.6%	7.6%
Average water injection rate (bwpd)	0	123	452	
# of Injectors on water	0	1	1	
Average rate per injector	0	123	452	452
Water+CO2 % HCPV injected	0.3%	0.4%	0.4%	
Water+CO2 Cum % HCPV injected	7.2%	7.6%	0.8%	0.8%
Production				
Base oil production (bopd)	144	143	142	
Actual oil production (bopd)	132	135	158	
Incremental oil production (bopd)	-12	-8	16	0
Cum % OOIP	0.0%	0.0%	0.0%	
Gas production (mcf/d)	403	369	565	446
Gas production as % injection	13%	10%	20%	14%
Base WOR	13	13	13	
WOR	6	6	5	