Improved Oil Recovery in Fluvial Dominated Deltaic Reservoirs of Kansas - Near-Term

**Quarterly Report
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**By:
D. W. Green; G. P. Willhite; A. Walton; D. McCune
R. Reynolds; M. Michnick; L. Watney**

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U.S. Department of Energy
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P.O. Box 880
Morgantown, West Virginia 26507-0880

By
The University of Kansas Center for Research, Inc.
Lawrence, Kansas 66045

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IMPROVED OIL RECOVERY
IN FLUVIAL DOMINATED DELTAIC RESERVOIRS OF KANSAS - NEAR-TERM

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Program Manager
Don W. Green
University of Kansas
Lawrence, Kansas

Principal Investigators
Don W. Green
G. Paul Willhite

Co-Investigators
A. Walton, D. McCune, R. Reynolds, M. Michnick, L. Watney

DOE Project Officer
Rhonda P. Lindsey
Bartlesville Project Office

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"U.S./DOE PATENT CLEARANCES NOT REQUIRED
PRIOR TO PUBLICATION OF THIS DOCUMENT"

Objectives

The objective of this project is to address waterflood problems of the type found in Morrow sandstone reservoirs in southwestern Kansas and in Cherokee Group reservoirs in southeastern Kansas. Two demonstration sites operated by different independent oil operators are involved in this project. The Stewart Field is located in Finney County, Kansas and is operated by North American Resources Company. The Nelson Lease is located in Allen County, Kansas, in the N.E. Savonburg Field and is operated by James E. Russell Petroleum, Inc.

General topics to be addressed are 1) reservoir management and performance evaluation, 2) waterflood optimization, and 3) the demonstration of recovery processes involving off-the-shelf technologies which can be used to enhance waterflood recovery, increase reserves, and reduce the abandonment rate of these reservoir types.

In the Stewart Project, the reservoir management portion of the project conducted during Budget Period 1 involved performance evaluation. This included 1) reservoir characterization and the development of a reservoir database, 2) volumetric analysis to evaluate production performance, 3) reservoir modeling, 4) laboratory work, 5) identification of operational problems, 6) identification of unrecovered mobile oil and estimation of recovery factors, and 7) identification of the most efficient and economical recovery process.

To accomplish these objectives the initial budget period was subdivided into three major tasks. The tasks were 1) geological and engineering analysis, 2) laboratory testing, and 3) unitization. Due to the presence of different operators within the field, it was necessary to unitize the field in order to demonstrate a field-wide improved recovery process. This work was completed and the project moved into Budget Period 2.

Budget Period 2 objectives consisted of the design, construction, and operation of a field-wide waterflood utilizing state-of-the-art, off-the-shelf technologies in an attempt to optimize secondary oil recovery. To accomplish these objectives the second budget period was subdivided into five major tasks. The tasks were 1) design and construction of a waterflood plant, 2) design and construction of a water injection system, 3) design and construction of tank battery consolidation and gathering system, 4) initiation of waterflood operations and reservoir management, and 5) technology transfer. Tasks 1-3 have been completed and water injection began in October 1995.

In the Savonburg Project, the reservoir management portion involves performance evaluation. This work included 1) reservoir characterization and the development of a reservoir database, 2) identification of operational problems, 3) identification of near wellbore problems such as plugging caused from poor water quality, 4) identification of unrecovered mobile oil and estimation of recovery factors, and 5) preliminary identification of the most efficient and economical recovery process i.e., polymer augmented waterflooding or infill drilling (vertical or horizontal wells).

To accomplish this work the initial budget period was subdivided into four major tasks. The tasks included 1) geological and engineering analysis, 2) waterplant optimization, 3) wellbore cleanup and pattern changes, and 4) field operations. This work was completed and the project has moved into Budget Period 2.

The Budget Period 2 objectives consisted of continual optimization of this mature waterflood in an attempt to optimize secondary and tertiary oil recovery. To accomplish these objectives the second budget period is subdivided into six major tasks. The tasks were 1) waterplant development, 2) profile modification treatments, 3) pattern changes, new wells and wellbore cleanups, 4) reservoir development (polymer flooding), 5) field operations, and 6) technology transfer.

Summary of Technical Progress

Stewart Field Project

Task II.1 - Design/Construct Waterflood Plant

Summary of work in last quarter

No major work.

Summary of planned work for next quarter

None planned at this time, but adaptations will be made as necessary.

Task II.2 - Design/Construct Injection System

Summary of work in last quarter

No major work.

Summary of planned work for next quarter

No additional construction work planned at this time.

Task II.3 - Design/Construct Battery Consolidation and Gathering System

Summary of work in last quarter

No major work.

Summary of planned work for next quarter

Make adaptations as needed for an efficient cost effective operation.

Task II.4 - Waterflood Operations and Reservoir Management

Summary of work in last quarter

Installed a 640 pumping unit and 2-inch insert pump on the Bulger 7-4 to replace the 320 unit and the 1.75-inch pump. Installed a 320 pumping unit on the Meyer 10-1 and also lowered the tubing and installed a 1.75-inch pump. The 320 unit replaced a 114 unit on the Meyer 10-1. These two artificial lift upgrades were performed as a result of rising fluid levels.

Ongoing pump changes, installation of tubing anchors, stroke length changes and speeding up pumping units were performed during the quarter on several wells. These changes are made as a result of the well testing program that identifies wells with production problems, rising fluid levels, abnormal

production trends and low pump efficiencies. The changes that were made are a continued effort to maximize oil production and keep all the wells near a pumped off condition.

Continued to monitor production and injection rates, water supply volumes, and injection pressures. Continued the ongoing testing of producing wells with test trailers and fluid level instruments. A general increase in the water/oil ratio in a few of the better producers occurred during the quarter and has resulted in a slight decrease in the total field oil production. Ongoing allocation of the injection volumes in the injection wells were performed based on response in producers and injectors, but overall field injection rates have remained constant at 5700 BWPD. Daily production and injection rates for the field are displayed on the attached plot.

North American Resources Company entered into a sales agreement on the Stewart Field waterflood with PetroSantander, Inc. of Houston, TX in September. The sale is scheduled to be finalized October 10, 1997 and PetroSantander will take over operations of the Stewart waterflood on October 11, 1997.

Summary of planned work for next quarter

Continue to monitor for response at producing wells with well tests and fluid levels. Update the reservoir computer model and simulate when applicable. Monitor water treatment program. Upgrade pumping equipment as necessary.

Task II.5 - Technology Transfer

Summary of work in last quarter

Continued to publicize information on the Stewart Field's increased oil production. Presentations on the Stewart Field were presented on August 25th at the annual meeting of the Kansas Independent Oil and Gas Association in Wichita, Kansas and September 11th at the Kiwanis meeting in Lawrence, Kansas.

Operators throughout the region continue to visit the field to view the state-of-the-art waterflood installation and computerized monitoring system.

Summary of planned work for next quarter

Continue to publicize information on the Stewart Field's increased oil production. A presentation is scheduled at a symposium sponsored by the University of Wyoming Enhanced Oil Recovery Institute for October 29-30 in Casper, WY.

Summary of Technical Progress

Savonburg Field Project

Task II.1 - Water Plant Development

Summary of work in last quarter

In order to improve the quality of the injection water, the following changes were made in July:

- 1) A different chemical pump was installed for the polymer feed.
- 2) Another chemical pump was placed in service for adding bleach to the system.
- 3) An Ecosol meter was re-installed in the water transfer line.
- 4) The air flotation unit discharge tank was thoroughly cleaned, jetted and treated with bleach.

During July, the plant was operated at a reduced pressure and volume due to the lack of available water. Poor water quality and filter plugging caused this shortfall.

The water injection system received a thorough cleaning during August. All tanks and lines were flushed and cleaned and filters changed.

Summary of planned work for next quarter

The water plant will be continually monitored and optimized as problems arise.

Task II.2 - Profile Modification Treatments

Summary of work in last quarter

A channel-block treatment was performed on well H-14.

Summary of work planned for next quarter

At quarter's end efforts are being made to prepare well RW-8 for a gel-polymer treatment. As time allows, more wells will be treated during the next quarter.

Task II.3 - Pattern Changes and Wellbore Cleanup

Summary of work in last quarter

Well O-1 was reperforated in the B-3 zone and tubing and a packer were installed in H-13 in July. Several wells received surface repairs to equipment in August.

A channel-block treatment was performed on well H-14.

Wells KW-7, KW-11, RW-2 and RW-6 were acidized through coiled tubing in September.

The following wells were serviced during the second quarter: H-20, H-22 and H-30 (three times). The service was required to replace joints of 1" pumping string that developed leaks, and to service pumps.

Summary of planned work for next quarter

Wells will be tested, cleaned and worked on as needed.

Task II.4 - Reservoir Development (Polymer Flooding)

Summary of work in last quarter

Waiting on a decision to implement polymer flooding.

Summary of work for next quarter

Waiting on a decision to implement polymer flooding.

Task II.5 - Field Operations

Summary of work in last quarter

Normal field operations have included: 1) monitoring wells on a daily basis, 2) repairing waterplant, piping, and wells as required, 3) collecting daily rate and pressure data, and 4) solving any other daily field operational problem that might occur.

<u>Month</u>	<u>Oil Production</u>
October 1993	26.4 B/D
November 1993	30.7 B/D
December 1993	32.0 B/D
January 1994	30.8 B/D
February 1994	30.9 B/D
March 1994	30.3 B/D
April 1994	29.1 B/D
May 1994	28.5 B/D
June 1994	30.3 B/D
July 1994	28.9 B/D
August 1994	24.6 B/D
October 1994	23.0 B/D
November 1994	25.7 B/D
December 1994	27.8 B/D
January 1995	27.0 B/D
February 1995	25.3 B/D
March 1995	22.4 B/D
April 1995	22.4 B/D

May 1995	25.0 B/D
June 1995	23.9 B/D
July 1995	26.8 B/D
August 1995	25.2 B/D
September 1995	24.8 B/D
October 1995	24.4 B/D
November 1995	24.4 B/D
December 1995	26.3 B/D
January 1996	28.0 B/D
February 1996	29.2 B/D
March 1996	27.2 B/D
April 1996	26.7 B/D
May 1996	26.6 B/D
June 1996	24.9 B/D
July 1996	25.4 B/D
August 1996	26.5 B/D
September 1996	26.1 B/D
October 1996	27.1 B/D
November 1996	26.4 B/D
December 1996	27.8 B/D
January 1997	26.9 B/D
February 1997	26.9 B/D
March 1997	27.5 B/D
April 1997	26.3 B/D
May 1997	25.5 B/D
June 1997	24.6 B/D
July 1997	23.5 B/D
August 1997	24.3 B/D
September 1997	23.8 B/D

Summary of planned work for next quarter

Field operations will be continued.

Task II.6 - Technology Transfer

Summary of work in last quarter

A plant tour was conducted for Mike Madden of BDM/Oklahoma in June.

Summary of planned work for next quarter

The field will be visited by other operators from the area.

Stewart Waterflood Daily Totals