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BETC/0026/4

ASSESSMENT OF POTENTIAL INCREASED OIL PRODUCTION
BY POLYMER-WATERFLOOD
IN NORTHERN AND SOUTHERN MID-CONTINENT OIL FIELDS

PROGRESS REPORT
FOR THE QUARTER ENDING SEPTEMBER 30, 1978

Contract No. EW-78-C-19-0026

Submitted to

U. S. Department of Energy
Division of Energy Technology

by

GRUY FEDERAL, INC.
2500 Tanglewilde, Suite 150
Houston, Texas 77063

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CONSULTANTS IN ENERGY SYSTEMS

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October 15, 1978

1911 JEFFERSON DAVIS HWY., SUITE 500
ARLINGTON, VIRGINIA 22202
703/920-0113

Mr. John McGhee
Department of Energy
Bartlesville Energy Research Center
Post Office Box 1398
Bartlesville, Oklahoma 74003

Re: Kewanee (Gulf) Mid-Continent
Polymer/Water Study
Contract No. EW-78-C-19-0026

Dear Mr. McGhee:

The enclosed quarterly report details progress on the subject contract. The six tasks are proceeding at varying rates. As initially envisioned, the first three tasks would center around geological and engineering aspects of the reservoir and injection program, and an economic review of the program. It was anticipated that these three tasks would be largely completed during the first six to seven months on the project. The purchase of Kewanee by Gulf has caused some delay in work effort within these tasks. As noted in the quarterly report, if data are not forthcoming from Gulf by November 1, Gruy Federal, Inc. will recommend completion of the tasks with publicly available data.

The three remaining tasks are proceeding at an accelerated rate. Gruy Federal, Inc. now has the GE Terminal operational, and we are selectively screening fields in the Mid-Continent area for potential polymer programs.

Overall, the program is basically on schedule. We have lost time with the Kewanee/Gulf purchase, but hope to catch up on those tasks dependent on Gulf inputs.

We are also adding to our technical staff. Mr. Jerry Watson, a geologist, will be working on the project, as will Ms. Dolores Portugal, a computer programmer. Ms. Portugal previously worked at Texas A & M University on the GURC #153 project.

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Mr. John McGhee
October 15, 1978
Page Two

Gruy Federal, Inc. is pleased to be working with DOE on this project, and we welcome your comments and inputs on the study.

Sincerely,

GRUY FEDERAL, INC.

A handwritten signature in cursive script, reading "Rodney W. Pease".

Rodney W. Pease
Senior Geologist

RWP:paw
Enclosure

cc: Mr. C. C. (Bill) Linville, U.S. DOE-BETC
Mr. Robert Anderson, U.S. DOE, HQ
Contract Officer, U.S. DOE-BETC
Finance Officer, U.S. DOE-BETC

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FIRST QUARTERLY TECHNICAL PROGRESS REPORT

ASSESSMENT OF POTENTIAL INCREASED OIL PRODUCTION BY POLYMER-WATERFLOOD IN NORTHERN AND SOUTHERN MID-CONTINENT OIL FIELDS

CONTRACT NO. EW-78-C-19-0026

I. INTRODUCTION

This document is the first quarterly report on the "Assessment of Potential Increased Oil Production by Polymer-Waterflood in Northern and Southern Mid-Continent Oil Fields" under Contract No. EW-78-C-19-0026 between Gruy Federal, Inc. and the Bartlesville Energy Technology Center, U.S. Department of Energy.

Gruy Federal, Inc. submitted an unsolicited proposal to DOE to perform studies of a polymer waterflood project jointly funded by DOE and Kewanee Oil Company. In addition to reviewing the reservoir characteristics and engineering and economic aspects of the polymer program, Gruy proposed to establish screening criteria that would be applied to Mid-Continent oil fields in an effort to identify potential candidates for the polymer flood technique.

Development of the subject field, the Stanley Stringer Field, located in Osage County, Oklahoma, T27N, R6E, was commenced in 1926. Production is from Lower Pennsylvanian sands at depths of 2900-2950 feet. Secondary recovery operations by waterflood techniques were initiated in the late 1950's. Kewanee Oil Company and the United States Energy and Research Development Administration (ERDA) entered into a joint agreement in 1975 with the objective of demonstrating the efficiency and economics of recovering tertiary oil from this highly heterogeneous reservoir (which has been successfully waterflooded, but is nearing the economic limit) by injecting a polymer slug of tapered concentration to improve sweep

efficiency in the reservoir. The reservoir was flooded with polymer solution over a 372-day period ending June 22, 1977. The subsequent year's results were reported in Kewanee's third (and final) annual report.

Gruy Federal, Inc. entered into an advance agreement with the Department of Energy for this study effective June 10, 1978. A fully executed copy of the final contract was received by Gruy Federal, Inc. in September 1978.

The Scope of Work and Objectives of the project are included here for reference. Subsequent sections will address each of the tasks described in the Scope of Work.

SCOPE OF WORK

The Contractor shall:

1. Conduct a detailed field study of the Burbank-Bartlesville sand reservoir, located in the north half of the Stanley Stringer Field, Osage County, Oklahoma. Contractor will give special attention to: (a) reservoir features and characteristics, well histories, and production through the waterflood stage; and (b) a study of the reservoir rock fluid system, including clay mineral content and distribution.
2. Conduct a technical review of the polymer-injection program initiated June 16, 1976.
3. Evaluate the results of the polymer-waterflood program with respect to (a) increased recoverable oil, and (b) overall cost effectiveness, including the effect of oil price.

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4. Review the geological/engineering characteristics of oil fields now in waterflood in the northern and southern Mid-Continent regions, based on (a) results of the North Stanley polymer-waterflood program; and (b) all basic screening parameters for polymer injection.
5. Review the geological/engineering characteristics of oil fields now in primary production in this region with regard to parameters for polymer-waterflood injection.
6. Determine ranges of future increased oil productivity from applications of the polymer injection process for waterflood mobility control in the region as functions of technology and price.

OBJECTIVES

The objectives of this program are:

1. Appraisal of relationship between reservoir characteristics of the field and results of the polymer waterflood.
2. Quantitative assessment of relationships between reservoir characteristics and results and costs of polymer injection.
3. Definition of parameters for screening and selecting reservoirs for the use of polymers in improving waterflood mobility ratio, including relationship between reservoir characteristics and necessary pilot projects.

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4. Evaluation of future potential enhanced oil recovery from polymer waterflood, with special attention to near-term payoff for the northern and southern Mid-Continent regions.

II. PROGRESS TO DATE

A. Detailed Geological and Engineering Study of the DOE-Kewanee Polymer Augment Waterflood (Task I)

As initially planned, this task was to be performed in the following sequence:

- Choose format of field study.
- Gather data from operator, BERC, and other sources (GURC, etc.).
- If samples exist and it is deemed necessary to develop further understanding of clay-polymer-fluid interactions, obtain these studies.
- Perform study.
- Extract all information meaningful to further development of the screening criteria for polymer-augment waterfloods.

This portion of the project was initiated with a thorough review of the background material contained in the annual project reports. To date, three annual reports (the third

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being the final report) comprise the available data on the Stanley Stringer project. These reports deal primarily with the engineering aspects of the polymer-augment waterflood. Information on the geology of the field is quite sparse.

Prior to the purchase of Kewanee by Gulf Oil Company, an agreement had been reached between Gruy Federal, Inc. and Kewanee whereby Kewanee would provide electric logs, core analyses, and sections of cores to Gruy Federal, Inc. With the subsequent purchase by Gulf, the situation is somewhat unsettled. Kewanee personnel familiar with the project have left the firm, and Kewanee's files are currently stored in a warehouse. Gulf may release some data in the near future.

In the event additional information on the reservoir cannot be obtained from Gulf, Gruy Federal will use the existing annual reports, supplemented by data from the scientific literature (primarily AAPG publications on the Burbank and Stanley Stringer fields), geologic maps prepared by the Bureau of Indian Affairs, and data obtainable (if no longer proprietary) from electric log service companies and core analysis firms. In this case, however, a less detailed geologic study will result.

Figure 1 depicts the study plan as envisioned by Gruy Federal, Inc. The "Primary" and "Secondary" inputs of Figure 1 represent the basic log/core data and annual reports, respectively.

FIGURE 1
 DIAGRAMATIC REPRESENTATION OF GRUY'S EXAMINATION
 OF KEWANNEE'S POLYMER AUGMENT WATERFLOOD PROJECT

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B. Conduct Technical Review of the Polymer Injection Program
in this Field (Task II)

Data for this portion of the project are to be obtained from:

- BETC - quarterly and annual reports
- Operator - information not filed
- Dow Chemical - with permission of operator

This task also requires inputs from the operator. Kewanee's three annual reports have been reviewed and a literature search conducted covering both laboratory and field data to provide the background necessary for such a technical review. Significant areas of concentration in this background study are:

- Effect of cation exchange on polyacrylamide solutions.
- Effect of soluble minerals on polyacrylamide solutions.
- Effect of resident and makeup water composition on polyacrylamide solutions.
- Absorption of polyacrylamides on clay surfaces.
- Retention of polyacrylamides in porous rocks and the effects of clay on retention.
- Protection of polymer solutions from shear degradation.

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This review of the technical literature ensures that Gruy Federal's understanding of polymer-augmented waterflooding techniques is absolutely current.

C. Evaluate the Results of the Polymer Augment Waterflood in This Field (Task III)

Evaluating the results of the polymer augment waterflood depends in part in sorting out the additions to production caused by well repair, channel block treatments, and the polymer-augmented waterflood. As can be seen from Figure 1, the results of the polymer waterflood, the reservoir interpretations, and cost data must be brought together to accomplish a complete evaluation of the process. We will begin this evaluation as soon as sufficient results from Tasks I and II are obtained.

D. Review Geological and Engineering Characteristics of Oil Fields Now in Waterflood as Candidates for Polymer Augmentation (Task IV)

We have made significant progress toward this goal. A GE time-sharing computer terminal has been installed in our Houston office, providing Gruy Federal with immediate access to the data base maintained by the Petroleum Data Service (PDS) at the University of Oklahoma. Raj Kumar attended the orientation program given by GE on August 8, 1978. The logic has been developed to query the data base for this specific section of the project. The basis for that logic is outlined below.

For an existing waterflood to be considered a good candidate for the polymer-augment technique it should meet four general criteria:

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1. It should be a reservoir within the technical limits of the process (see Table 1).
2. It should be in an early to medium stage of depletion. This is in part a function of field size.
3. It should be large enough to support the added expenditures and necessary geologic and engineering studies.
4. Wells should be sufficiently closely spaced so that the project lifetime is reasonable.

Reservoirs will be screened under the four general criteria above, as follows:

Under general criterion 1:

Established technical screening criteria will be applied to ensure that only those fields currently under waterflood which meet those criteria are included in the remainder of the study. This can be done with automated processing of the data. Table 1 lists generally accepted screening criteria based on previous studies.

Under general criterion 2:

Several tests of the current status of a field have been developed, using numbers that are easily available from the International Landman and Oil Scout Association's annual compilations and from documents filed with state regulatory agencies. To be considered a current waterflood (one worthy

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TABLE 1

PRESENT SCREENING CRITERIA FOR POLYMER AUGMENT WATERFLOODS

PARAMETER	LEWIN 1976	GURC #148	NPC 1976	CHANG, 1978	
				XANTHAN	POLYACRYLAMIDE
Viscosity, cp	<200		<200	<200 (5-125)	<200 (5-125)
Gravity, °API	>18 (>16)	>20			
Depth	NC	NC	NC		
Temperature, °F	<100	<225	<200	<160	<200
Permeability, millidarcies	>20	25- 1500	30- 1500	>20	>20
Fraction of oil in place before EOR (P.V.)	50	$SO > SO_r$	>25	>10 (mobile)	>10 (mobile)
Water oil mobility				>1	>1
Water-oil ratio	<15	<15	<15	<15	<15

The preferred lithology is sandstone.

Reservoirs with strong water drives, large gas caps, and gross channeling or major natural fractures should be avoided.

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of further consideration as a prospect for polymer water-flood), a field should meet the following criteria:

- a. The number of abandoned wells is less than half the total. (In old floods there are many abandoned wells.)
- b. The ratio of cumulative production to the number of current wells is less than some yet-undefined limit. As waterflood projects near the end of their lifetimes, this ratio becomes very large since only a few wells are still producing and they produce ever-decreasing amounts of oil.
- c. The current water/oil ratio of produced fluid is within acceptable limits. This ratio is obtainable in some states in the project area but not in others. Where data are available, they will be used in conjunction with the above specific tests of current status of the field.
- d. The total recovery to date is less than 60% of original oil in place. The figures required for this test may not be in the data bank, however.

These four tests should provide an adequate measure of the current status of an ongoing waterflood project. The limits proposed are quite arbitrary and subject to refinement as we work with the data base.

Under general criterion 3:

Several tests of field size have been developed.

- a. First and most direct, if the quantity of oil originally in place is included in the PDS data base, this number, less the cumulative production, establishes the amount of oil remaining. Only a small portion of this remaining oil is accessible by the polymer-augmented waterflood process, the amount depending upon the field's characteristics and history. At any rate, provided the field passes the proposed current status tests (general criterion 2 above), then some fraction of the oil should be accessible to the process. Therefore, we will estimate the total potential of the field by polymer-augment; if it is less than one million barrels the field will be rejected at this time. This figure (1mm) is tentative and may require some adjustment.
- b. If the quantity of oil originally in place is not known, but enough information is in the data bank to estimate it using established correlations, we will estimate this number and proceed as above.
- c. If original oil in place cannot be estimated, then we will use cumulative production as an indicator of future production, and all fields which have produced less than one million barrels as of 1976 will be rejected as candidates for this process.

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Under criterion 4:

Only one test will be employed to estimate project lifetimes. Since project lifetime is related to permeability (injectivity) and well spacing, a factor incorporating these two parameters will be developed. However, field experience with the polymer-augment process shows that generally no drastic decrease in injectivity is noted when polymer solution is injected. Therefore, if a waterflood has acceptable well spacings for sufficiently short total project life, it will probably be acceptable for the polymer-augmented waterflood process as well. Exceptions to this general rule of thumb occur, but at present they cannot be systematically predicted.

As the screening process on the PDS data base has proceeded, candidates for potential polymer-augment waterflood have been identified and are discussed in Section E below.

E. Review Geology and Engineering Characteristics of Fields Now Under Primary Production in the Region as Possible Candidates for the Polymer-Waterflood Process (Task V)

Gruy Federal has screened all oil fields currently in production in the Mid-Continent region as candidates for the polymer-augmented waterflood process. The screening program has been adjusted for differences in record keeping in different states. The result of this first screening is a master list of all fields for which enough information exists in the PDS data file to identify potential candidates. In general this list contains:

- those fields where the gravity of the crude oil is known to be in the range 20°-40°API. (The incremental benefit of

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polymer augment waterflood over an ordinary waterflood decreases with decreasing oil viscosity.)

- those fields where the number of producing wells is greater than five and the cumulative production is greater than 1,000,000 barrels of oil.

Removed from this list are:

- Reservoirs which are known to have strong water drive or large gas caps,
- Reservoirs producing from carbonates or shale,
- Reservoirs whose permeability is low,
- Reservoirs with temperatures in excess of 200⁰,
- Reservoirs less than five feet thick.

This procedure should select those fields that are potential candidates. The list obtained, however, will contain many fields which would not be considered good candidates if more information were available; for example, those for which permeability is not in the PDS file but is known from other sources to be too low, or those for which the lithology of the producing formation is not labeled in the PDS file but is known to be other than sand. The list will also contain many fields already under waterflood, many of which will be too mature (see criterion 2, Section D).

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The bulk of the work toward objectives IV and V will consist of selecting the very good candidates, both those under primary production and those under waterflood, from this list to be used with the Kewanee data and with cost data (see Figure 2) in order to provide a realistic economic evaluation under Part F of this contract.

The highly preliminary list of fields obtained to this point is contained in the Appendix.

F. Determine Ranges of Future Increased Oil Production from the Polymer Water Process in the Project Area (Task VI)

This part of the project has begun. Raj Kumar is developing a model which will use the following information:

- $K + K_h$
- Spacing/total acreage
- Amount of oil left in place
- Fraction of oil left in place accessible to the polymer-water technique
- Cost data (assuming water source is available)
- Depth
- Reservoir volume

DIAGRAMATIC REPRESENTATION OF GRUY'S ANALYSIS OF
THE ASSESSMENT OF MID-CONTINENT RESERVOIRS FOR
EOR POTENTIAL BY POLYMER AUGMENT WATERFLOOD

FIGURE 2

Part of this information can be extracted directly from the PDS data base; part of it is highly interpretive and can only be generated after a more detailed study is made of each reservoir (see Figure 3).

The economic model itself is a separate segment of the total contract effort and can be constructed in advance of the time when it is needed (See Figure 4).

III. MILESTONE AND STATUS REPORT

Figure 5 shows the significant milestones and principal tasks of Contract EW-78-C-19-0026. This chart was given in the first progress report submitted after the effective starting date was received. (Gruy received a final, fully executed copy of the contract on September 21, 1978.)

As discussed in the preceding sections, work to date has progressed without delay in areas where Gruy Federal has had access to basic data. Such is the case with Tasks IV, V and VI, which for the most part have involved developing screening criteria and querying the Petroleum Data Service. Economic modeling efforts have also moved ahead on schedule.

Problems have developed with Tasks I, II and III as a result of inevitable delays caused by the purchase of Kewanee by Gulf. If Gulf cannot provide the requested data by November 1, Gruy Federal will recommend to DOE that the geologic portions of Tasks I, II, and III be conducted using available data, to include:

- Annual Kewanee reports
- Data from the open literature

FIGURE 3
ECONOMIC ANALYSIS OF MID-CONTINENT OIL FIELDS
FOR EOR BY POLYMER AUGMENT WATERFLOODING

ECONOMIC
MODEL

- $K + K_h$
- SPACING
- AMOUNT OIL LEFT IN PLACE
- ESTIMATE OF OIL ACCESSIBLE (FRACTION OF ABOVE)
- COST DATA (ASSUME WATER AVAILABLE)
- DEPTH
- RESERVOIR VOLUME

FIGURE 4
SCHEMATIC OF ECONOMIC MODEL

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- Geologic maps from the Bureau of Indian Affairs
- Possible extrapolation of Burbank Field studies (adjacent to the Stanley Stringer Field)

Overall, the project is on schedule. Where efforts have been slowed (Tasks I, II, and III), redirection has allowed Tasks IV, V and VI to develop somewhat ahead of schedule. With the decision by November 1 concerning availability of geologic data, the project should move ahead as originally scheduled.

SUMMARY OF PRINCIPAL TASKS AND TIME COMMITMENTS FOR CONTRACT

EW-78-C-19-0026

1. DETAIL STUDY OF RESERVOIR

REVIEW TECHNICAL REPORTS ON PROJECT
GATHER DATA NECESSARY
PERFORM DETAIL STUDIES GEOLOGIC + ENGINEERING
REFINE STUDIES

2. TECHNICAL REVIEW OF POLYMER INJECTION PROGRAM

STUDY POLYMER INJECTION HISTORY
PERFORM TECHNICAL ASSESSMENT OF POLYMER INJECTION PROGRAM

3. EVALUATION OF POLYMER WATERFLOOD PROGRAM

DEVELOP TECHNIQUES FOR CALCULATING EVALUATIONS
PERFORM EVALUATION OF PROGRAM COST EFFECTIVENESS INCREASED RECOVER
FINALIZE RESULTS

4. REVIEW OF FIELD UNDER WATERFLOOD AS CANDIDATES FOR POLYMER-WATER PROCESS

DETERMINE WHICH FIELD ARE UNDER WATERFLOOD
OBTAIN DATA
SCREEN AND VERIFY DATA

5. REVIEW OF OTHER FIELDS IN CONTRACT REGION AS CANDIDATES FOR POLYMER-WATER DISPLACEMENT PROCESS

DETERMINE WHICH FIELDS TO OBTAIN DATA ON
OBTAIN DATA
SCREEN AND VERIFY DATA

6. MAKE PREDICTIONS ON RANGE OF INCREASED OIL PRODUCTION FROM POLYMER-WATERFLOOD PROCESS AS FUNCTION OF TECHNOLOGY + PRICE

MAKE PREDICTIONS ON FUTURE PRODUCTION DUE TO POLYMER WATER
DRAFT FINAL REPORT

FIGURE 5 - Milestone Schedule and Status Report. Original Task/Time Schedule shown along with work completed to date (dashed lines represent portion of tasks completed).

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APPENDIX

LIST OF FIELDS MEETING PRELIMINARY SCREENING REQUIREMENTS

ARKANSAS

Waterfloods Not Removed

Buckner - Travis Peak
Center - Hogg
El Dorado, East - Old
El Dorado, South - Nacatoch
Falcon - Tokio
Fouke - Paluxy
Fouke - Tokio
Fouke N. - Paluxy
Garland City Old - Paluxy
Genoa - Paluxy
Gum Creek - Nacatoch, Blossom, Tokio
Hibank - Meakin
Hibank - Nacatoch
Hillsboro - Nacatoch
Irma - Tokio
Lewisville Old Town - Paluxy

Lisbon Old - Nacatoch
McKinney Bayou - Paluxy
New London - Cotton Valley
Nick Springs, West - Meakin
Pace City - Glen Rose
Smackover - Travis Peak
Snow Hill - Cotton Valley
Stamps - Paluxy
Stephens - Buckrange
Stephens - Hogg
Stephens - Smart Area
Urbana - Gregory and Urbana
Urbana - Travis Peak
Wesson - Buckrange-Blossom
Wesson - Travis Peak
Woodley, West-Nacatoch

COLORADO

Waterfloods Removed

Adena-D
Badger Creek-J
Bison-J
Border-J
Cimarron-J
Darby Creek-D
Elm Grove-D
Hiawatha-Wasatch
Iles - Sundance

Kjer-D
Nile-D
Park-D
Pawnee-J
Redwing-J
Roderick-J
Rush Willadel-J
Third Creek-J

KANSAS

Waterfloods Not Removed

Ash Creek-Arbuckle
Burkett-Bartlesville
Cabin Valley-Layton
*Cahoj - Lansing, Kansas City
Colony, West-Squirrel
**Donald-Mississippian

Moran-Bartlesville
Muddy Creek-Bartlesville
Oro-Pennsylvanian
*Schadel South-Mississippian
*Sharon-Mississippian
Smock-Sluss-Bartlesville

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KANSAS (continued)

*Dubois-Burgess
*Elsmore Shoestring-Bartlesville
*Fralick, West-Mississippian
*Garnett Shoestring-Cherokee
*Ironclad-Lansing, Kansas City

*Sunny Slope-Marmaton
*Thrall-Agaard-Bartlesville
*Vavoch-Lansing, Kansas City
*Wilhelm-Lansing, Kansas City

* Lithology is not contained in PDS file.

**Lithology labeled as chert.

NEBRASKA

Waterfloods Not Removed

Ackman - Lansing, Kansas City
Ave - Griffin-J
Battensperger-J
Bed Canyon - Regan
Bridgeport - D
Brush Creek-Lansing, Kansas City
Dry Creek-Lansing, Kansas City
Enders-J
Ferquist-J
Filon-J
Ittner-J
Johnson-Dakota
Kimball-Dakota

Midway - Lansing, Kansas City
Midway, North-Kansas City
Olsen J
Potter Southwest Muddy - D&J
Silver Creek-Lansing, Kansas City
Simpson-J
Singleton-J
Sleepy Hollow-B-Pennsylvanian
Sloss-J
Spearow D-G-J
Torgeson-J
Vendene-D
Waitman-J

NEW MEXICO

Waterfloods not removed. Some may not be sand.

Bisti Lower - Gallup
Caprock - Queen
Cave - Grayburg
Cha Cha - Gallup
Corbin - Queen
Devils Fork - Gallup
Dollarhide - Queen
Double L - Queen
E-K Seven Rivers - Queen
Hackberry-North
Hare - Simpson
High Lonesome - Queen
Hobbs-Blinbry

Hospah South - Lower
Hospah South - Upper
Langlie Mattix-Seven Rivers
Many Rock - Gallup
Mesa - Queen
Midway - ABO
Pearl - Queen
Saywer - West
Square Lake Grayburg-San Andres
Tres Papalotes-Pennsylvanian
Turkey Track Queen-Grayburg
Vacuum - Glorietta
Young-Queen

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OKLAHOMA

Waterfloods not removed.

Agra, West - Cleveland	*Camp, Southwest - Dornick Hills
Alabama - Pennsylvanian	Candy Creek - Bartlesville
Alden, NE - Bromide	Carthage, Northeast - Morrow Sand
Allen Dist - Cromwell	*Cary - Pennsylvanian
Almeda - Bartlesville	*Cement - Permian
Apache - Pontotoc	Chitwood, Northwest - Deese Sand
*Ara - Dornick Hills	Civit, Northeast - First Deese
*Ara, N - Deese	Dykeman
Arcadia, NE - Second Wilcox	Cleveland - Layton
Ardmore - Pennsylvanian	Cole District - Pennsylvanian
Arno, W - Prue	Como, Southeast - Upper Morrow
Atlantic - Wayside	Conservation - Deese
Bold Hill - Glen	Coon Creek - Second Wilcox
Bandwheel - Various Pennsylvanian	Corn, South - Second Wilcox
Barker - Pennsylvanian	Council Hill District - Dutcher
Barnsdale - Bartlesville	Country Club - Various Pennsylvanian
Bearden, Northwest - Booch	Coweta District - Dutcher
*Beaver - Hoxbar	Coyle - Layton
*Beggs District, North - Youngstown	Coyle, South - Layton
Bethel, North - Cromwell	Crescent - Layton
Bethel, West - Cromwell	Cromwell - Various Pennsylvanian
Birch Creek - Bartlesville	Cromwell, East - Cromwell
*Bixby - Glenn - Taneha - Dutcher -	Cromwell, South - Cromwell
Mississippian - Wilcox	Cushing - Layton
Blackland - Burgess	Davis - Bromide
Blackwell - Pennsylvanian	Davis, Northeast - Oil Creek
Bowden - Bartlesville	Denver, Southeast - Bartlesville
Bowlegs - Gircrease	Dewey - Wayside Pennsylvanian
Boynton - Leidecker	Dill - Cromwell
*Bradley, North - First Bromide	Dill, Northeast - Cromwell
*Bradley, Southwest - Bromide	*Domes - Pond Creek - Stray
Britton - Second Wilcox	Dora - Thurman
Brock - Pennsylvanian	*Dover & Hennessey - Cleveland
*Brock, West - Pennsylvanian Deese	Duncan, West - Pennsylvanian
Broken Arrow District - Bartlesville	Earlsboro - Earlsboro
*Bruner - Vern - Burgess	Earlsboro, East - Earlsboro
Buchner - Booch - Cromwell	Earlsboro, South - Calvin
Bulldog - Peru	*Edmond, East South Unit -
Burbank - Layton	Bartlesville
Burton, Southwest - Morrow	Elgin, South - Ramsey
*Butler - Pennsylvanian - Wilcox	*Eola - Simpson
Cache Creek - Pontotoc	Eola - Robberson - Pontotoc
*Camp - Deese	Essaquanahdale - Pontotoc

GRUY FEDERAL, INC.

OKLAHOMA (continued)

Evansville, Northwest - Bartlesville
Falls, Northeast - Second Wilcox
Fish - Booch
Fitts, West - Cromwell
Frederick, South - Canyon
Fuhrman - Gilcrease
*Garber - Permian
Gar Creek - Gilcrease
*Garden Grove - Prue
Garr - Cleveland
*Greenville, Northeast - Dornick Hills
Grief Creek - Upper Booch
Hallett - Cleveland
Hamilton Switch - Gleen
Happy Hill, East - Prue Sand
Harwin, East - Cottage Grove
Haskill - Dutcher
Hawkins, Northwest - Second Booch
**Hawley - Mississippian Chat
Haydenville District - Gilcrease
Healdton - Pennsylvanian
Helsel, West - First Bromide Simpson
*Henderson - Cisco
*Henryetta District - Pennsylvanian
Hewitt - Pennsylvanian
Hewitt, East - Deese
*Hewitt, Northwest - Tussy Sand
*Hickory Creek District - Oswego
Hickory Creek, South - Wayside
Hobart, Northwest - Springer
Holdenville - Booch
Holdenville, East - Booch
Holdenville, West - Booch
*Homer, Southwest - Springer
*Hoyt - Skinner
Hubbard - Pennsylvanian
Hucmac, North - Morrow
Ingalls - Skinner
Isom Springs - Stray
Jackson - Booch
*Jenks - Perryman - Red Fork - Bartlesville -
Taneha - Dutcher - Mississippian
Jesse - Deese
Jones - Cleveland
Keokuk - Misener
Keyes District - Keyes Sand
*Komalty District - Pennsylvanian
Konawa - Earlsboro
Konaws - Thurman
Konawa, West - Earlsboro
Laffon, Southeast - Dutcher Sand
Langston - Misener
Lauderdale - Layton
Leonard District - Layton
Lewis - Simpson Bromide
Little Cheif, Northeast -
Red Fork
Little River - Cromwell
Little River, East - Cromwell
*Loco - Ponotoco
*Loco, West - Pennsylvanian
Lone Grove, Southwest - Deese
Lovell - Hoover
Lyons & Quinn - Senora
Madill, North - Third Bromide
Mammoth, Northeast - Skinner
Maramec - Layton
Marshall - Tonkawa
Maud - Misener
Maysville, East - Bromide
Midwell - Morrow
Milfay - First Wilcox
Moore, Northwest
Morris District - Upper Booch
Mount Hope, NW - Red Fork
Mt. Veron - Red Fork
Mt. Veron, SW - Lower Skinner
Natura District - Glenn
Naval Reserve - Bartlesville
Navel Reserve, S - Second Wilcox
*Nellie, SW - Hoxbar
*New Cushing - Prue
*New Hope - Deese
New Noble - Bromide
Norfolk - Prue
Norfolk, W - Prue
Okemah - Deaner
Okemah, N - Gilcrease
Okmulgee District - Bartlesville
Olympic - Senora

GRUY FEDERAL, INC.

OKLAHOMA (continued)

*Oneta - Dutcher
Orchard City - Misener
Overbrook, S - Deese
*Palacine, S - Hoxbar - Arbuckle
*Panther Creek, SW - Deese
Pauls Valley, SE - Oil Creek
Pawhuska - Bartlesville
Payne - Hart
Payson - Lower Skinner
Payson, E - Lower Skinner
Pearsonia - Layton
Peck - Viola
Pollyanna - Glenn
Ponca City - Pennsylvanian
Ponds Creek - Pennsylvanian
Praque - Senora
Prairedale - Hoxbar
Purdy, SE - Springe
Ralston District - Skinner
Randett, SW - Pennsylvanian
Ringwood - Prue
Robberson - Pontotoc
Rosanna - Booch
Rosenwald - Cromwell
Royal - Rose Pennsylvanian
Sacred Heart - Earlsboro
Sasakwa - Booch
Schlegel, N - Red Fork
Searlight, N - Wilcox
Seminole - Calvin
Shawnee - Earlsboro
Shawnee, NE - Wilcox
Sholem & Alechem, NW - Pennsylvanian
Sivells Bend - Pennsylvanian
Soldier Creek - Pontotoc
Sooner Trend - Layton
Sparks, E - Prue
Spaulding - Booch
Spencer District - Red Fork
Saint Louis - Calvin
Stillwater - Red Fox
*Stone Bluff - Pennsylvanian
Sylvian - First Wilcox
Tatums, NE - Goodwin
Terlton - Layton

Terlton, N - Prue
Tidal Osage - Ordovician
Tiger Flats - Senora
Tonkawa, E - Red Fork
Transco, NW - Lower Calvin
Trimue, N - Canyon
Tuskegee, E - Dutcher
Velma, W - Deese
Victory Hill - Earlsboro
Weleetka, W - Booch
*Wellston, N - First Wilcox
West Point, S - Bartlesville
Wetley - Hunton
Wewoka - Booch
Wewoka Townsite - Pennsylvania
Wildhorse - Pennsylvania
Wilzetta - Prue
Witcher - Bartlesville
*Woodrow - Arbuckle
Woolaroc - Skinner
Woolsey - Pontotoc - Glenn
Yale & Quay - Prue
*Yale, SW - Prue
Yeager - Pennsylvanian
Youngstown - Glenn

*Lithology is not contained in PDS file.
**Lithology labeled as chert.

GRUY FEDERAL, INC.

TEXAS DISTRICT 10

Waterfloods Not Removed

Bechthold - Tonkawa
Bradford - Tonkawa
Farnsworth Morrow - Upper
Follet, West-Cherokee
Hansford, North-Cherokee
Kiowa Creek Morrow Oil - Upper

Panhandle (Osbourne Area)
Panhandle - Red Cave
Panhandle (Carson Co.)
R.H.F. - Morrow
Shane Southeast - Morrow