

# **THE OIL CONSERVATION COMMISSION**

**CASE NO. 14001 & 14002**

# **EXHIBIT**

# **25**



**WATERFLOOD FEASIBILITY STUDY FOR THE  
PROPOSED QUAIL QUEEN UNIT  
(QQU)**

**LEA COUNTY,  
NEW MEXICO**

**CHESAPEAKE ENERGY CORPORATION**

**AUGUST, 2007**

**WATERFLOOD FEASIBILITY STUDY FOR THE QUAIL  
QUEEN UNIT (QQU) PROJECT**

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# Quail Queen Waterflood Feasibility Study

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# Quail Queen Waterflood Feasibility Study

## List of Attachments/Appendices

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## EXECUTIVE SUMMARY

### QUAIL QUEEN UNIT (QQU) PROPOSED WATERFLOOD

#### I. Purpose

Determine the feasibility of unitizing and implementing secondary recovery operations in the Queen sandstone in the Quail Field in Lea County, New Mexico.

#### II. Description

|  |                              |
|--|------------------------------|
| Location .....                                   | Lea Co., NM                  |
| Producing Formation .....                        | Queen                        |
| Number of Wells.....                             | 12 Active, 3 TA, 5 P&A, 1 DH |
| Daily Production (average over three mos.) ..... | 23 BO, 0 MCF, 56 BW          |
| Reservoir Parameters                             |                              |
| Depth, average .....                             | 5,100'                       |
| Productive Area .....                            | 1,150 acres                  |
| Unitized Area .....                              | 840 acres                    |
| Reservoir Temperature.....                       | 113°F                        |
| Initial Reservoir Pressure .....                 | 1,848 Psi                    |
| Bubble Point Pressure .....                      | 1255 Psi                     |
| Current Reservoir Pressure .....                 | 450 Psi                      |
| Oil Gravity .....                                | 33° API                      |
| Gas Gravity .....                                | 0.9                          |
| Initial Solution GOR, est.....                   | 300 Scf/Bbl                  |

#### III. Recovery and Reserves

|  |           |
|--|-----------|
| Original Oil In Place .....                                | 4,467 Mbo |
| Cumulative Primary Recovery 7/1/2007 .....                 | 788 Mbo   |
| Cumulative Secondary Recovery, estimated to 7/1/2007 ..... | 11.4 Mbo  |
| Remaining Developed Primary .....                          | 78.7 Mbo  |
| Proved Behind Pipe.....                                    | 0 Mbo     |
| Ultimate Primary.....                                      | 867 Mbo   |
| Ultimate Primary Recovery Efficiency.....                  | 19 %      |
| Percent of Primary Recovered to 7/1/2007 .....             | 91%       |
| Secondary Reserves .....                                   | 725 Mbo   |
| Estimate of Total Recovery .....                           | 1,592 Mbo |
| Estimate of Total Recovery Efficiency.....                 | 36 %      |

#### IV. Capital Requirements

##### Initial Phase (Phase I) Capital Requirement:

|  |            |
|--|------------|
| Convert six wells to injection (\$100k, each) .....        | \$ 600,000 |
| Re-Enter and Restore Csg Integrity, Quail State SWD 1 .... | \$ 125,000 |
| Injection Lines 10,030 feet x \$12/ft.....                 | \$ 120,360 |

|  |            |
|--|------------|
| Water Supply, Hornet St 1 Workover/Pipeline..... | \$ 250,000 |
| Battery Upgrades/Centralization.....             | \$ 500,000 |
| Injection Facility .....                         | \$ 500,000 |

**Sub-Total ..... \$ 2,095,360**

Second Phase (Phase II) Capital Requirement:

|   |              |
|---|--------------|
| Drill 1 Injector (\$1MM) & One Producer(\$1.2MM)..... | \$ 2,200,000 |
| Re-Enter Mobil 1 as injection well .....              | \$ 200,000   |
| Battery Upgrades/Centralization.....                  | \$ 500,000   |

**Sub Total..... \$ 2,900,000**

**Grand Total ..... \$ 4,995,360**

## INTRODUCTION

The purpose of this engineering and geological study is to determine the feasibility of conducting secondary recovery waterflood operations in the Queen sand in the Quail Field; and whether these waterflood operations can recover additional reserves in sufficient quantities to be economically successful.

The Quail Field is located approximately 25 miles southwest of Hobbs, New Mexico in Lea County as shown in Attachment No. 1. The field was discovered in 1967 by Atlantic Richfield's State BG Well No. 1. After drilling to a total depth of 10,350' and finding the targeted Bone Springs non-commercial, the well was plugged back to the Queen, at 5,126'-5,336', and a completion was made in May, 1967.

The Queen sands that are continuous throughout the field and the most consistently productive have been sub-divided into two distinct zones, B and C. These two Queen sands will be the focus of this study. The "C" sand has the most prolific pore volume and areal extent of the two intervals. Several wells were cored with a maximum permeability range of 20-40 md and maximum porosity range of 20-23%. Logs from eighteen of the twenty wells were analyzed by NuTech Energy Alliance. PVT data was determined based on petroleum engineering correlations and not actual reservoir samples due to the lack of early time fluid samples and the existing advanced state of reservoir depletion. The reservoir is solution gas drive based on production performance. The estimated original reservoir pressure was 1,848 psi and engineering correlations indicate a bubble point pressure of 1,255 psi. Estimated current reservoir pressure is between 400 and 500 psi based on recent testing in Atlantic Richfield No. 1 during 2006.

The proposed 840 acre unit is made up of 9 tracts in Sections 11, 13 and 14 in Township 19 South and Range 34 East. Participation in the unit by working interest and royalty owners is determined by prorating each tract's contribution to the unit in four categories including: useable wellbores, average rate of production, ultimate primary recovery and reservoir pore volume.

There are twelve current producers, three temporarily abandoned wells and three plugged and abandoned wells in the field. The field has been developed on forty acre spacing. Current

production is 23 Bopd, 0 Mcfpd and 56 Bwpd. Cumulative production from the Queen is 799,248 BO, 524,385 MCF and 1,590,829 BW. Remaining primary PDP reserves are 78.7 MSTBO. Current watercut is 70 percent.

Information upon which this study and the estimates are based was obtained from Chesapeake, third parties and public records and is assumed to be correct. The study was conducted utilizing methods and procedures regularly used by petroleum engineers to estimate oil and gas reserves for properties of this type and character. However, future performance is dependent on many variables and often unpredictable factors. For this reason, Chesapeake cannot be held liable for the accuracy or completeness of these estimates.

## **FIELD DEVELOPMENT**

After the discovery by Atlantic Richfield's State BG No. 1 in 1967, development continued for several years with the drilling of five additional wells but during the early and mid-seventies development drilling stalled. With the rising oil prices in the late seventies there was a resurgence of drilling when the well count peaked at 15 wells by the early eighties. Since then, primary depletion occurred up until 1997 when disposal of the fields produced water began in the Queen sand that was opened in the Quail State SWD No. 1. The total disposal volume for the field increased to approximately 100 bwpd by the year 2000 and continued at this rate through 2003. Oil response was observed in several of the offsets to the SWD during 2000-2003. The disposal was decreased and sporadic from 2004 until 2005 when casing problems occurred and the disposal well was temporarily abandoned. The current field map is included as Attachment No. 2 with well names and locations. Oil production is currently 23 bopd from twelve wells declining at an exponential yearly rate of approximately 5 percent. The field production plot as well as the individual well production plots, are included in Appendix A.

## **GENERAL GEOLOGY**

The Quail Queen Field, covering approximately 800 acres, is situated locally in western central Lea County, New Mexico and regionally near the Northwest Shelf shelf margin of the Delaware Basin. The field consists of several thin north-northwest to south-southeast trending sandstones that pinch out to the east and west. The Queen Formation is Middle Guadalupian (Permian) in age overlain by the Seven Rivers and underlain by the Grayburg, both of which produce on the Northwest Shelf. During Guadalupian time, the Northwest Shelf was dominated by mixed shallow-water carbonate and siliciclastic sedimentation on a broad low-relief ramp.

## **DETAILED GEOLOGY**

The Queen Formation was deposited on the Northwest Shelf in a backreef, shallow, evaporitic, marginal marine environment behind the Goat Seep shelf-edge complex. In general these deposits are composed of interfingering siliciclastics, carbonates, and evaporates (sandstone, dolomite, sandy and anhydritic dolomite, and shale). The Queen pay is described as a medium to fine-grained, subangular to subrounded friable sandstone with slight dolomite cement, silt, and occasional large round frosted quartz grains. Queen pay can get up to 10 feet thick with porosities ranging from 8-22%.



## **PRIMARY PERFORMANCE AND RESERVES**

The current state of primary depletion is approximately 91 percent in this field and the average well produces a little less than 2 BOPD. The remaining primary reserves of approximately 79 MBO will predominantly come from three wells, the Quail State 2, State BG 2 and 3. The remaining nine active producers are at or near their ultimate primary performance capacity. Unless it is determined to waterflood this field soon, then the economic viability of this field will end. Attachment No. 3 is a structure map with the ultimate oil and gas recoveries along with the cumulative water production posted for each well. Ultimate recoveries were determined by decline curve analysis on each producing well. Production is more controlled by stratigraphy than structure as illustrated by the structure map. The structure dips from north to south at a rate of approximately 100 feet per mile. The best ultimate well in the field, the Atlantic Richfield No. 1 is one of the lowest structurally but is near the thickest part of the Queen sand. The average ultimate oil produced per well is approximately 44 MBO.

As mentioned earlier, the Queen sand has been subdivided into the Queen B and Queen C sands which are consistently present throughout the proposed unit area. Attachment 4 is a cross section with every well log in the field showing the Queen B & C which is the targeted common source of supply. This cross section also contains the perforated intervals for each well. Net isopach maps with over 14 percent density porosity over the Queen B and Queen C are included as Attachments 5 and 6. These maps were used to calculate the reservoir pore volume. Also shown is the proposed waterflood unit boundary. Average porosity and water saturations for the Queen B and Queen C were determined based on the Nu-Tech log analysis. Cross plots of porosity versus water saturation are included as Attachment Nos. 7 and 8. Volumetric original oil in place (OOIP) for the Queen B and Queen C sands has been calculated and is included in Appendix B. The OOIP for the Queen B is 988,800 STB and for the Queen C is 3,478,673 STB. The combined OOIP is 4,467,473 STB. Seventy-eight percent of the OOIP is in the Queen C sand.

Based on an investigation of all the pertinent data including well files, well logs and well histories, all of the current wells in the field have been perforated and adequately stimulated in the Queen B and Queen C sand intervals. Hence there are no remaining behind pipe or non-producing reserves in this field in the targeted waterflood sand intervals. The remaining secondary reserve potential and how best to recover it will be the focus as the study continues.

## **SECONDARY RESERVE ANALYSIS**

Based on the historical performance, the Quail Queen Field is a solution gas drive reservoir. Primary recovery will be approximately 19 percent of the OOIP leaving 81 percent of the OOIP in play. The approach to water flood recovery potential in the Quail Queen Field includes the analysis of an actual case example, within the field, of sustained low volume disposal of produced water into the producing Queen zones of interest in the Quail State SWD #1. Also a nearby Queen waterflood analogy, the West Pearl Queen Unit, that was unitized and flooded beginning in 1964 will be evaluated. And lastly, a calculation of secondary performance utilizing generic relative permeability data, since this type core data is not available from any of the field wells, will be examined.

The Queen has been successfully flooded for years in the Permian Basin and, as mentioned, there is

a nearby analogy in the West Pearl Queen Unit approximately 2.5 to 3 miles to the southeast. In addition, the floodability of the Queen in the Quail field was demonstrated during the late nineties and early 2000's, when the Quail State No. 1 was converted to salt water disposal in the field's producing interval. Approximately 207,000 barrels of produced water, according to IHS records, was disposed of from 1997 to 2004 and oil increases as well as drastic GOR decreases were observed in several of the offset producing wells. Attachment No. 9 is a montage of the production plots for the four producers in the proposed eighty acre five spot pattern in this area. The field production curve as well as the individual plots on the State BG 3, Quail State 2, 3Y, 4 and 6 in Appendix B show clear evidence of moderate secondary response during the time of disposal into Quail State SWD #1. Approximately 22 percent, of the reservoir pore volume for this eighty acre five-spot pattern was injected into the center SWD well over a seven year period. During this time it is estimated that approximately 11,400 barrels of secondary oil was produced from five offset wells. The resulting positive response in five of the six direct producing offsets is an encouraging result that provides strong support to the waterflood program planned for this area. A waterflood analysis of the eighty acre five-spot pattern centered around the Quail State SWD #1 is included as Attachment No. 10. The disposal of produced water in the Quail State SWD #1 and subsequent results provide, in effect, a successful eighty acre five spot waterflood pilot for the field. Hence, there is a strong case for the secondary waterflood reserves developed for the proposed Quail Queen Unit (QQU) as being proven undeveloped when the unit order is received from the NMOCD.

The West Pearl Queen Unit (WPQU) was unitized in the summer of 1964. The proposed unitized interval in Quail Queen is correlative to the unitized interval in the WPQU and the reservoir parameters are similar. However, the upper part of the Queen is productive in West Pearl whereas it is wet or tight in the Quail area. The WPQU is located approximately 3 miles to the southeast of the Quail Field as shown in Attachment No. 11. It is approximately three times the size, at 2,520 acres, of the proposed Quail Queen Unit. The ultimate primary recovery in the WPQU was 2,686,000 STB which was 80 percent depleted upon unitization. In the 49 years since discovery, the WPQU has produced over 5 million barrels of oil. The secondary to primary (S:P) ratio is 0.88. The WPQU was developed on 40 acre spacing and the waterflood pattern for the WPQU was eighty acre five-spots which is also the proposed pattern for the QQU. If the QQU has a similar S:P ratio as the WPQU then the secondary reserves will be 763 MBO. Attachment No. 12 is a comparison of the proposed QQU to the analogous WPQU.

The last method used to estimate secondary recovery in the QQU is to calculate the recovery based on relative permeability data compiled by the 1984 National Petroleum Council. There is not any relative permeability data obtained from any of the core retrieved in the Quail Field area. Therefore it is necessary to use the default relative permeability relationships and parameters similar to those presented by Molina on page 2-23 to 2-24 of Smith & Cobb's "Waterflooding" text. These default relationships and parameters are based on the 1984 National Petroleum Council's Technical Committee recommendations. The waterflood calculations are presented in detail in Appendix No. C. The relative permeability curve, Attachment No. 13, was used to create the fractional flow curve which is shown in Attachment No. 14.

The volumetric sweep efficiency is a function of the mobility ratio and the permeability variation. The mobility ratio is 0.57 which is very favorable. The permeability variation, based on several of the cores taken in the Quail Field, is 0.828 and its calculation is shown in Attachment No. 15. The mobility ratio and permeability variation indicates a secondary recovery of 15.6 percent. The waterflood recovery is estimated to be 697,156 STB yielding a S:P ratio of 0.805 which is in reasonable agreement to the analogous WPQU S:P ratio of 0.88.

The injection rate per well, based on analogy, will be 200 – 300 BPD with initial injection pressures in the 1,500 to 2,000 psi range. As fillup is approached the injection pressures will increase so the injection system should be designed for 3,000 psi. Fillup volume is 1,423,862 BBLS with a current gas saturation of 14%. If an average injection rate of 200 BPD per injection well can be maintained then fillup will occur in less than three years.

## UNIT PARTICIPATION

Attachment No. 16 is a tract map with the proposed 840 acre unit area shown. Noticeably missing from the proposed unit area is the 120 acre tract in the southeast quarter of Section 14. This 120 acre tract is a Federal tract that is unleased and cannot be nominated due to an ongoing sand dune lizard study scheduled for completion by 2009. Once this study is completed and if the results allow for the leasing of this tract, Chesapeake will make every effort to include this tract in the unit. Section 4 in the Unit Agreement stipulates the method for expansion of the unit and any future expansion of this unit will follow these guidelines.

There are nine tracts included in the unit with 100 percent of the minerals owned by the state of New Mexico. Participation in the unit by working interest and royalty owners is determined by prorating each tract's contribution to the unit in four categories including: useable wellbores, average rate of production, ultimate primary recovery and reservoir pore volume. The proposed weight factor for each category is as follows:

|  |     |
|--|-----|
| Useable Wellbores .....                            | 40% |
| Average Monthly Rate (April - June, 2007).....     | 40% |
| Ultimate Primary Recovery as of July 1, 2007 ..... | 10% |
| Reservoir Pore Volume.....                         | 10% |

The tract participation factors (TPF) for each of the nine tracts are shown in Attachment No. 17. A list of the working interest owners with their proposed unit participation, based on these tract participation factors, is shown in Attachment No. 18.

## WATER SUPPLY

The maximum daily volume of injection water required is approximately 300 BPD for each of the six injection wells or 1,800 BPD. Two different sources of water have been determined. The first and most economical will come from the Chesapeake 100 % operated Hornet State No. 1 located approximately one mile to the northwest in section 3 of T-19S R-34E. This well, drilled in 2003 to a depth of 13,796 feet, is awaiting a recompletion to the 3<sup>rd</sup> Bone Spring(BS), 10,559-69 feet. It is currently shut-in after making an original completion in the Wolfcamp in early 2004. The 3<sup>rd</sup> BS is a 44 feet thick dolomitic zone with about ten feet on top of water. The water will be tested for compatibility with the Queen and an idea of what the water producing capacity of this dolomite is, will be determined. If compatible, the rest of the zone will be perforated upon such time as the water is needed for injection in the QQU. Hopefully, this zone will provide the needed water for the unit. However, if it proves to lack the ability to produce the volumes required, then the second source of supply will be pursued. The West/East and South Pearl Queen Units, 2 to 3 miles to the southeast are all operated by Xeric Oil and Gas Corporation. Chesapeake has contacted Xeric and

they are agreeable to provide additional water as needed up to the 2,100 BPD needed. This option will cost more than the Hornet State option due to having to install a longer distance pipeline and involves a major road crossing.

## CAPITAL REQUIREMENTS

The capital expenditures listed below are estimates by the Enhanced Oil Recovery Group based on industry experience and knowledge of the current market. The actual costs may be different depending on the market conditions at the time of expenditure. The operations group is currently reviewing these costs for accuracy. The capital costs are based on a two phase implementation process over 1.5 to 2 years. Due to the current state of useable wellbores in the proposed unit area no additional drill wells are proposed to be drilled in Phase one. Six producers will be converted to injection in Phase I. Attachments 19 and 20 are maps that show the proposed development plans, Phase I & II, respectively. Restoring the casing integrity of the Quail State SWD 1 in Phase I and the cost to install injection facilities and production facility upgrades are included for both phases. A two mile pipeline from the Hornet State No. 1 facility to the centralized QQU battery is included for delivery of 1,800 to 2,500 BWPD source water. Other costs in Phase II include drill cost for two wells and re-entry of the Mobil #1 as an injector

### Initial Phase (Phase I) Capital Requirement:

|   |            |
|---|------------|
| Convert six wells to injection (\$100k, each)-----          | \$ 600,000 |
| Re-Enter and Restore Csg Integrity, Quail State SWD 1 ----- | \$ 125,000 |
| Injection Lines 10,030 feet x \$12/ft -----                 | \$ 120,360 |
| Water Supply, Hornet St 1 Workover/Pipeline-----            | \$ 250,000 |
| Battery Upgrades/Centralization-----                        | \$ 500,000 |
| Injection Facility -----                                    | \$ 500,000 |

**Sub-Total ----- \$ 2,095,360**

### Second Phase (Phase II) Capital Requirement:

|  |              |
|--|--------------|
| Drill 1 Injector (\$1MM) & One Producer(\$1.2MM) ----- | \$ 2,200,000 |
| Re-Enter Mobil 1 as injection well -----               | \$ 200,000   |
| Battery Upgrades/Centralization-----                   | \$ 500,000   |

**Sub Total----- \$ 2,900,000**

**Grand Total ----- \$ 4,995,360**

## ECONOMIC ANALYSIS

The project evaluation has been based on future net cash flow, defined as that amount of future net income estimated to accrue to the 100% working interest and 79% net revenue interest by operating the project to the estimated limit of profitability.

The product prices, operating costs and capital requirements were estimated by Chesapeake Energy

Corporation. An initial oil price of \$70 per barrel was held constant throughout the life of the project. Initial operating expenses started at current levels and were escalated in proportion to the escalating fluid volumes. Severance taxes appropriate for the state of New Mexico were applied to the oil and gas revenue. No provision was made for depreciation, depletion or State and Federal income taxes. No consideration was given to possible surplus and/or salvage values or to the cost of properly plugging and abandoning the wells at the conclusion of secondary operations. Attachment No. 21 includes a total unit plot including the estimated secondary performance. Attachment No. 22 are the total project economics including both phase I and phase II to the 100 percent unit working interest.

Economic data and parameters associated with the secondary operations are:

#### Revenue and Expense Forecast

|   |                     |
|---|---------------------|
| Gross revenue less severance/ad valorem tax ----- | \$36,321,230        |
| Operating expense-----                            | <u>\$ 4,255,307</u> |
| Net operating income -----                        | \$32,065,923        |

#### Present Worth

|                         |              |
|-------------------------|--------------|
| Discounted at 10% ----- | \$9,094,7480 |
| Discounted at 25% ----- | \$2,878,1220 |

|                      |        |
|----------------------|--------|
| Rate of Return ----- | 78.09% |
|----------------------|--------|

|                                       |      |
|---------------------------------------|------|
| Discounted Return on Investment ----- | 3.28 |
|---------------------------------------|------|

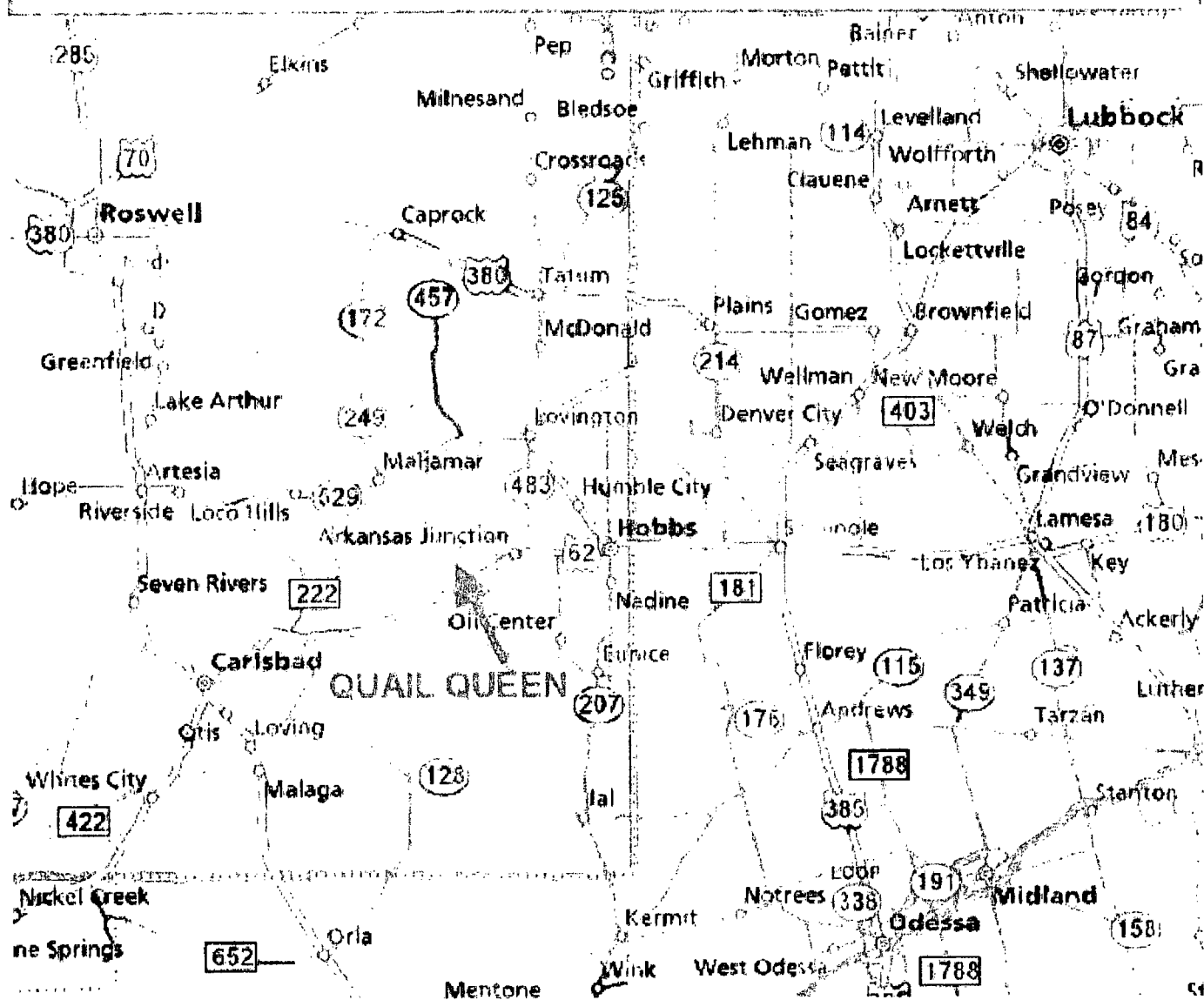
#### CONCLUSIONS

1. The field is a strong flood candidate
2. Waste will occur and up to 763 MBO in secondary reserves will be lost, if not flooded.
3. The fields primary reserves are 91 percent depleted.
4. There has been a case example in the field of response to water injection.
5. There is strong economic incentive to flood the field now.

#### RECOMMENDATIONS

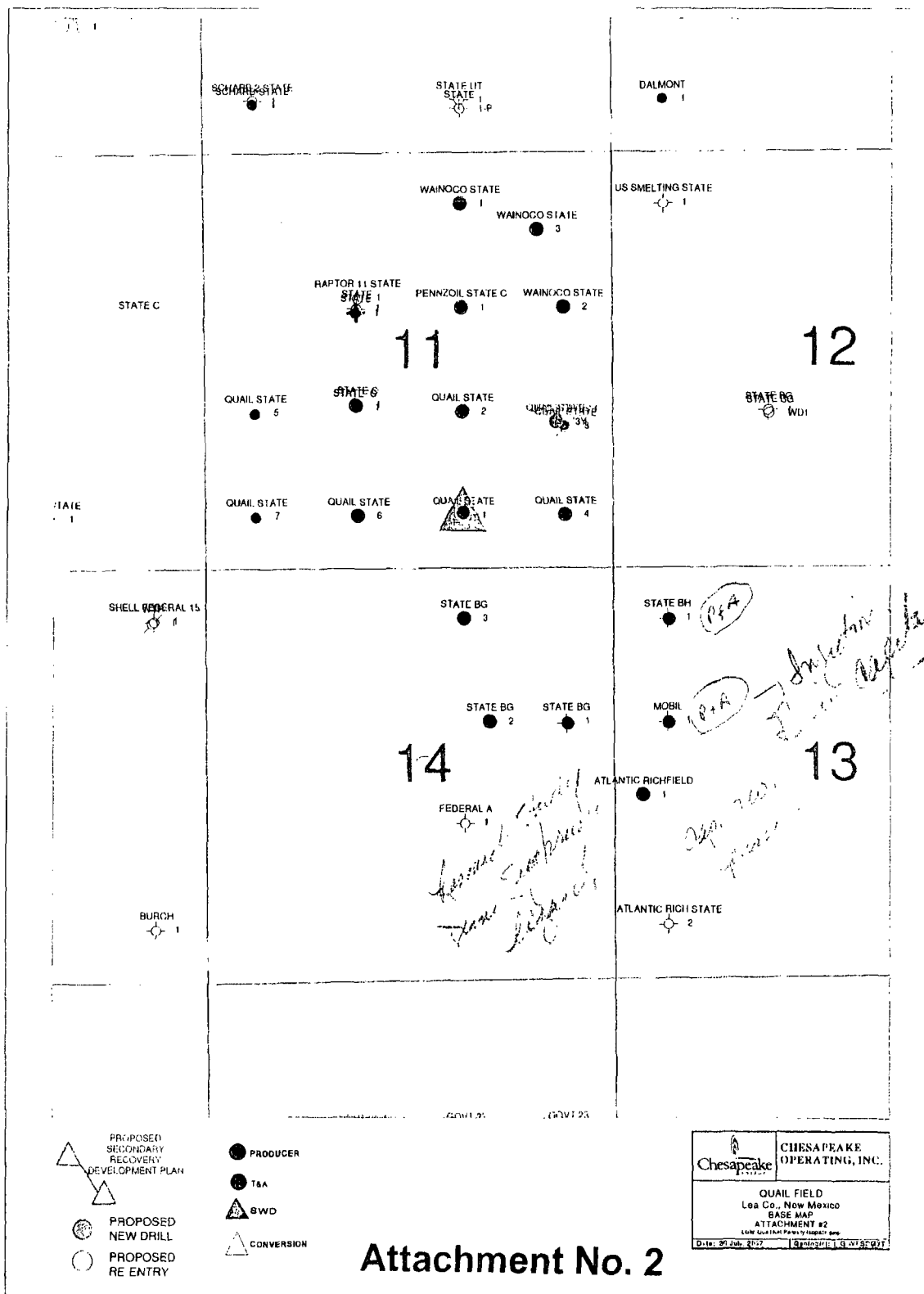
1. Form a unit as soon as possible.
2. Implement Phase I of the flood plan.
3. Observe and analyze the initial flood behavior
4. Perform additional drilling and conversions as needed.

# QUAIL QUEEN LOCATOR MAP

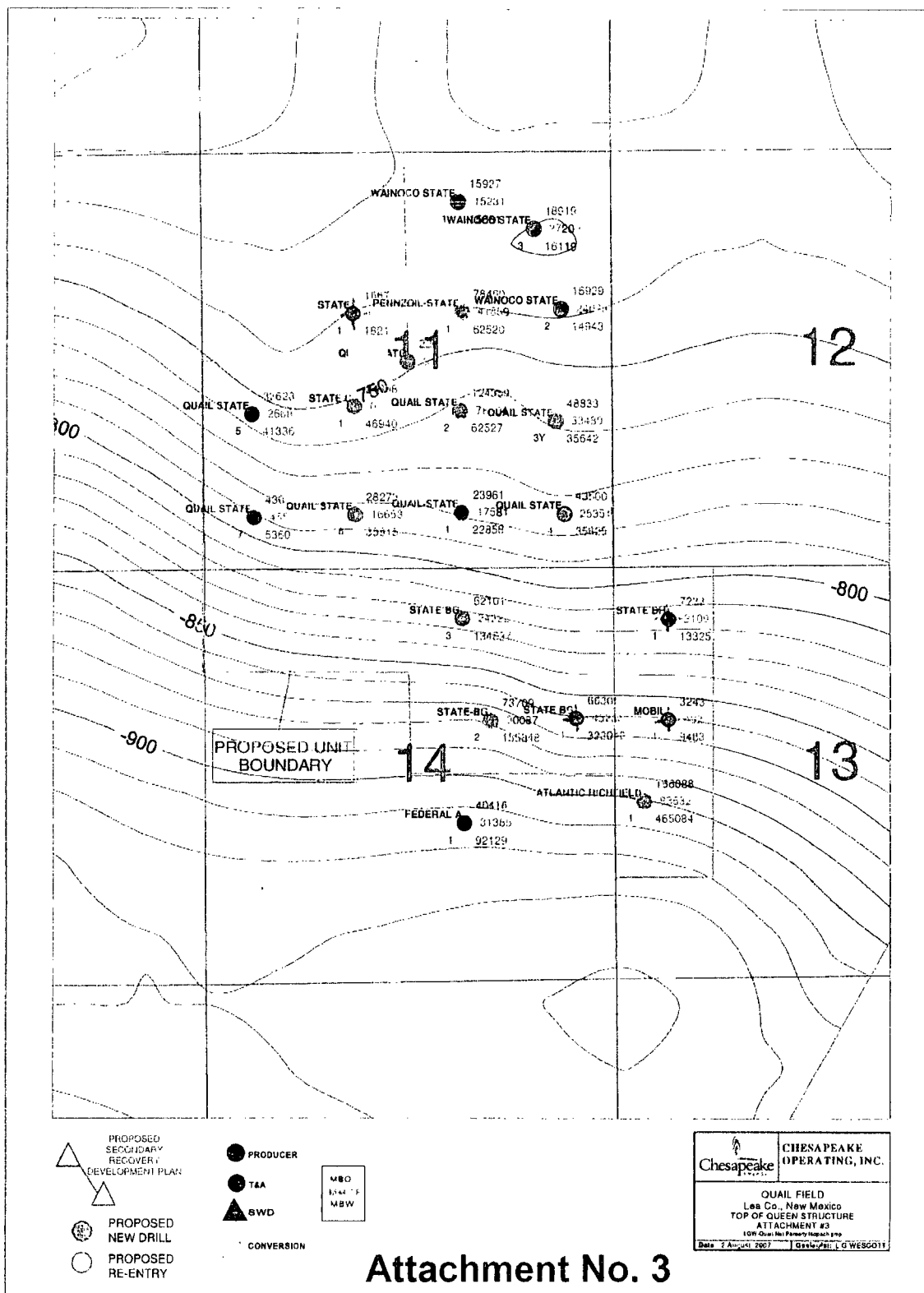


ATTACHMENT #1

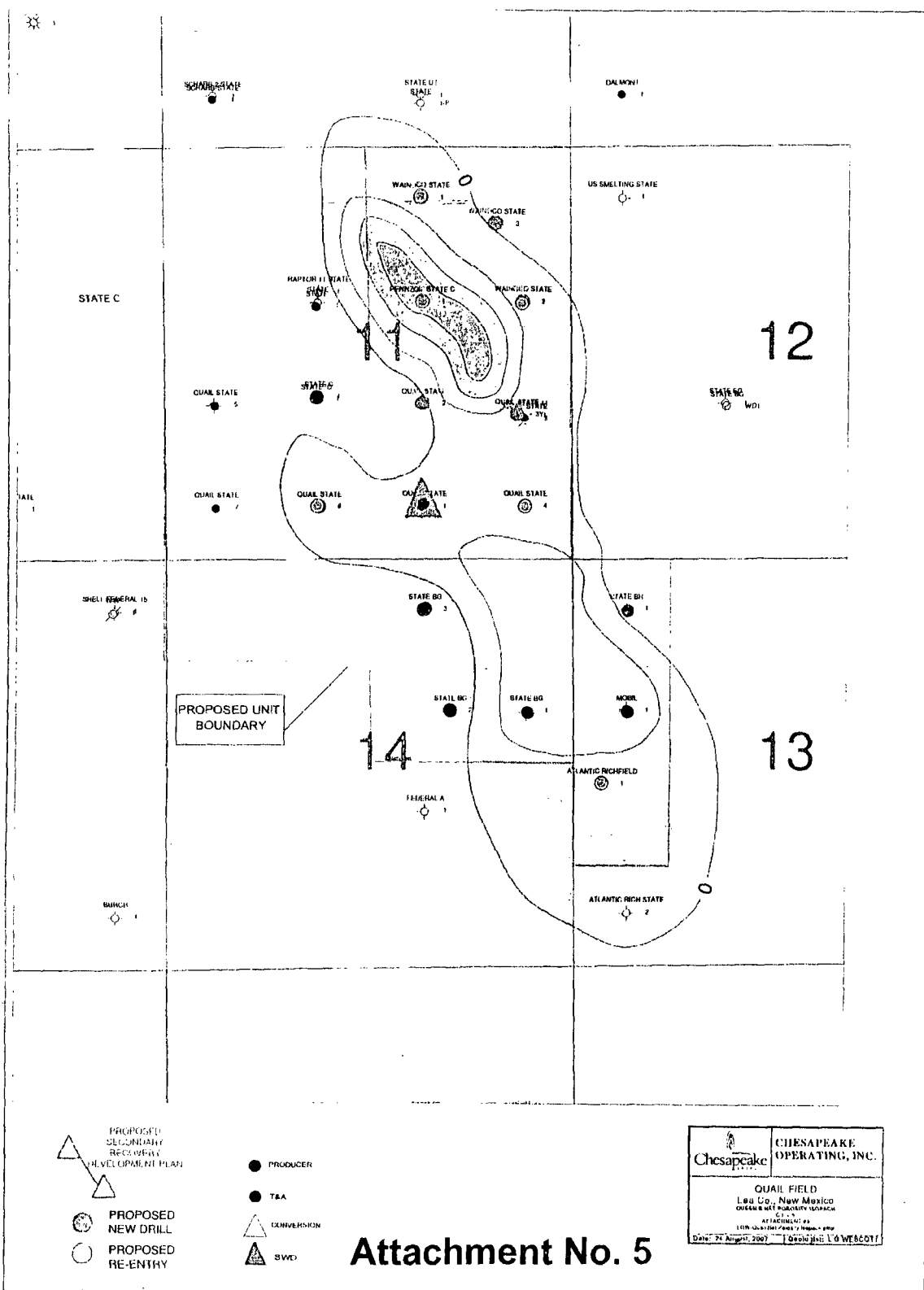
Attachment No. 1



Attachment No. 2



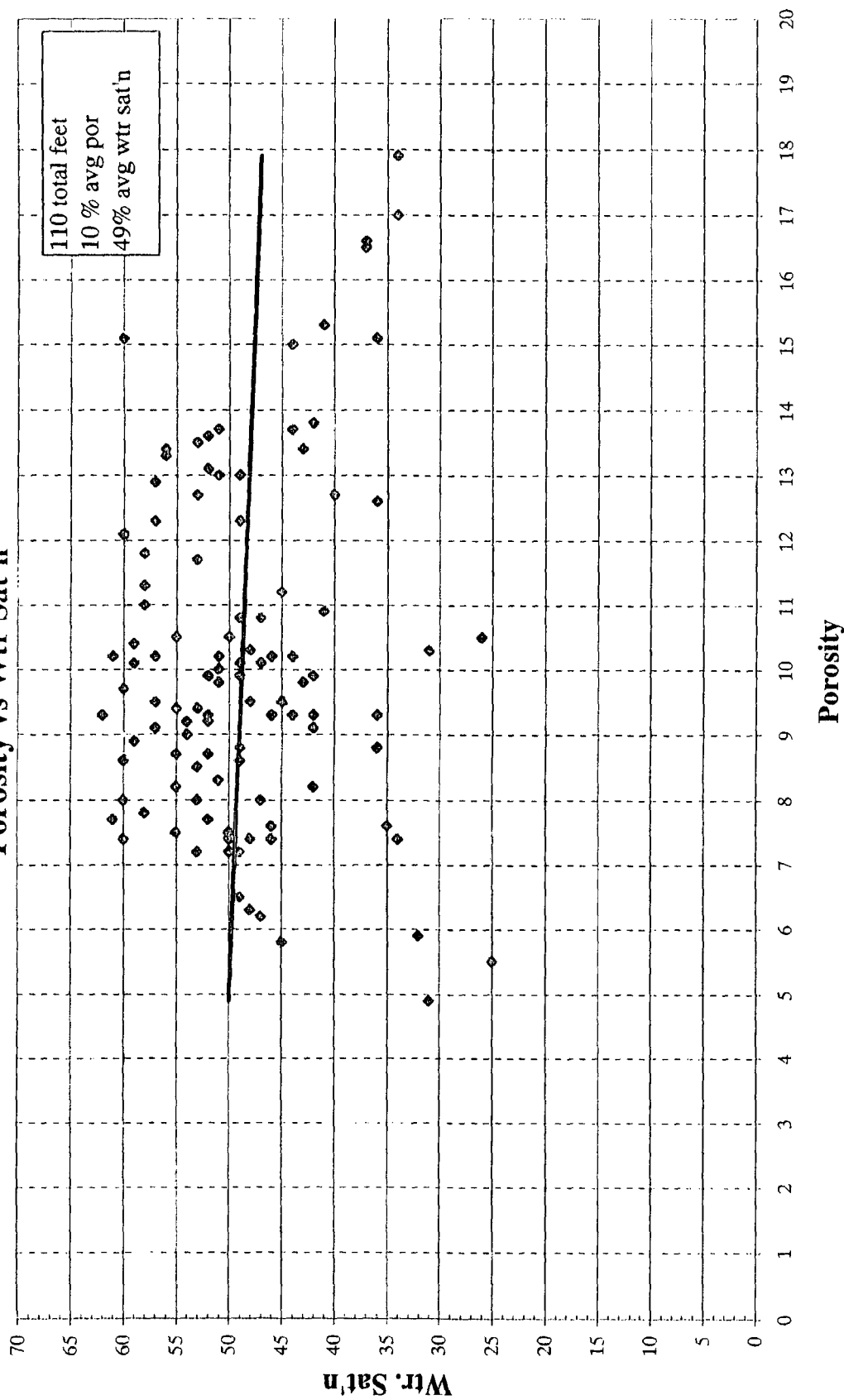




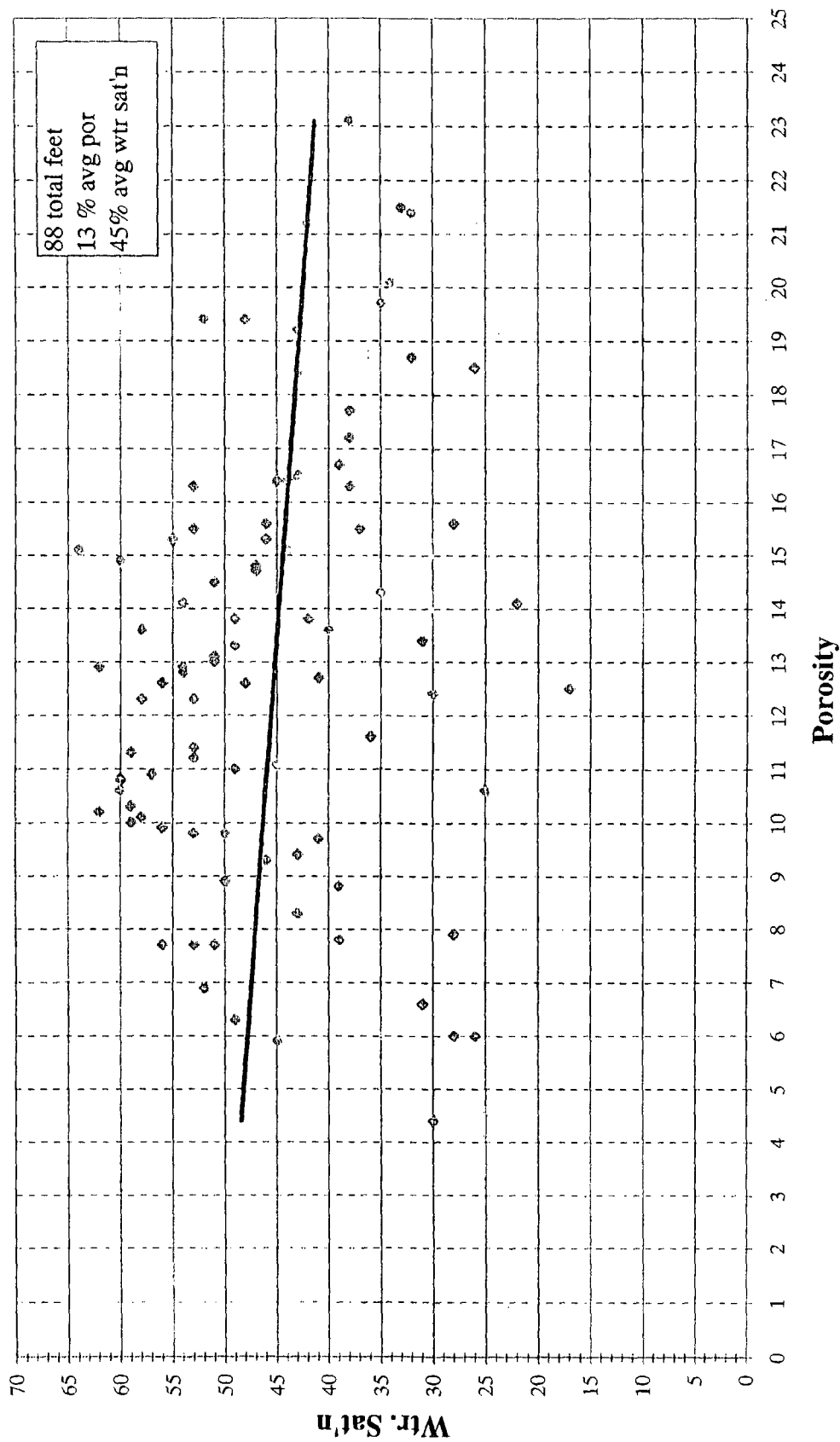
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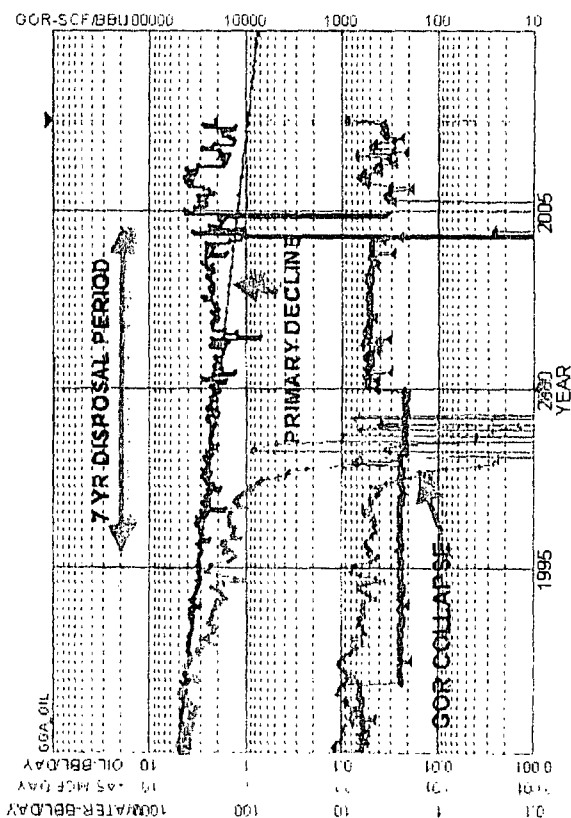
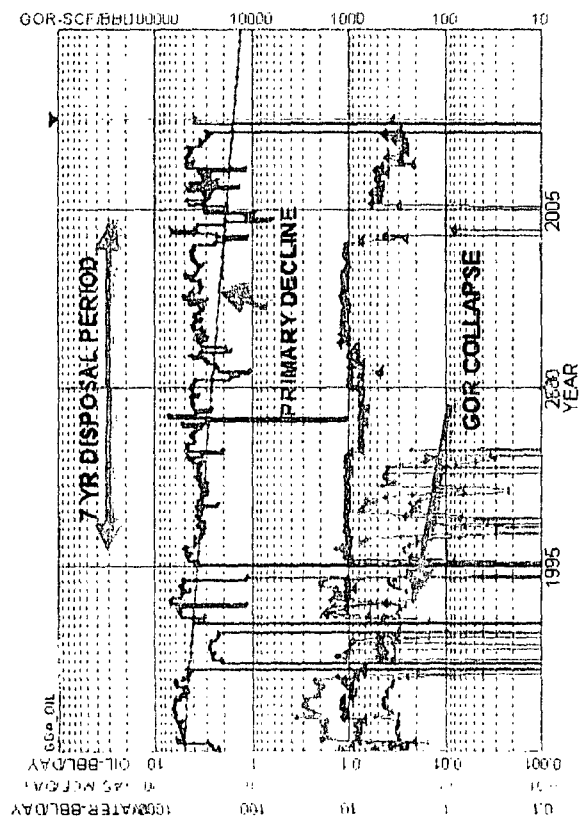
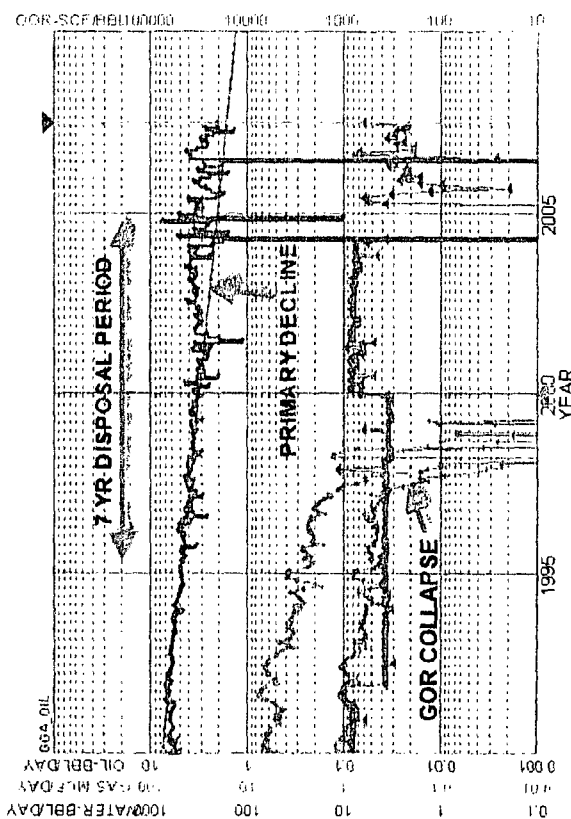
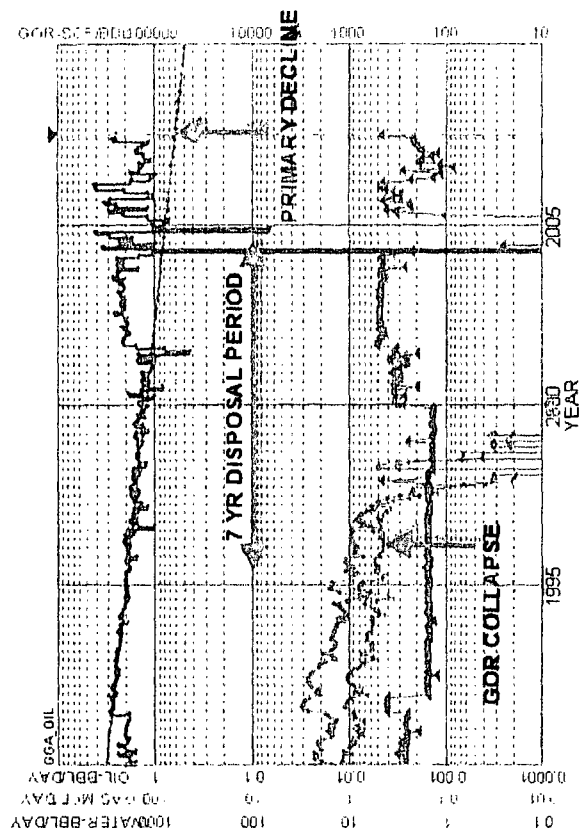
# Quail Queen B - Nu-Tech Porosity vs Wtr Sat'n



# Quail Queen C - Nu-Tech Porosity vs Wtr Sat'n



# 4 WELL MONTAGE CENTERED AROUND QUAIL STATE SWD #1



# **Quail Queen Waterflood Analysis** **of the Eighty Acre Five-Spot Pattern Centered** **Around Quail State #1**

| Well          | Primary to 7/1/2007 |                  | Secondary to 7/1/2007 |                  |                  | Total            |        |
|---------------|---------------------|------------------|-----------------------|------------------|------------------|------------------|--------|
|               | Oil,BBLS            | Pattern Fraction | Pattern Oil,BBLS      | Pattern Oil,BBLS | Pattern Fraction | Pattern Oil,BBLS |        |
| Quail State 2 | 105,378             | 0.25             | 26,345                | 1,764            | 1.00             | 1,764            | 28,109 |
| Quail State 4 | 37,307              | 0.25             | 9,327                 | 2,061            | 1.00             | 2,061            | 11,388 |
| State BG 3    | 40,894              | 0.25             | 10,224                | 3,227            | 1.00             | 3,227            | 13,451 |
| Quail State 6 | 23,878              | 0.25             | 5,970                 | 2,230            | 1.00             | 2,230            | 8,200  |
| Quail State 1 | 23,961              | 1.00             | 23,961                | -                | 1.00             | -                | 23,961 |
|               | 231,418             |                  | 75,825                | 9,282            |                  | 9,282            | 85,107 |

**OOIP reservoir parameters for the 80 acre pattern:**

Acres = 80

Avg height = 12.5 feet

Average porosity = 12%

Average water sat'n = 45%

**Pore Volume (PV) =  $7758 \cdot A \cdot h \cdot \Phi$**   
 =  $7758 \cdot 80 \cdot 12.5 \cdot 0.12$   
 = 930,960 BBLS

**OOIP =  $(PV \cdot (1 - S_w)) / \beta_{oi}$**   
 =  $(930,960 \cdot (1 - 0.45)) / 1.15$   
 = 445,242 STB

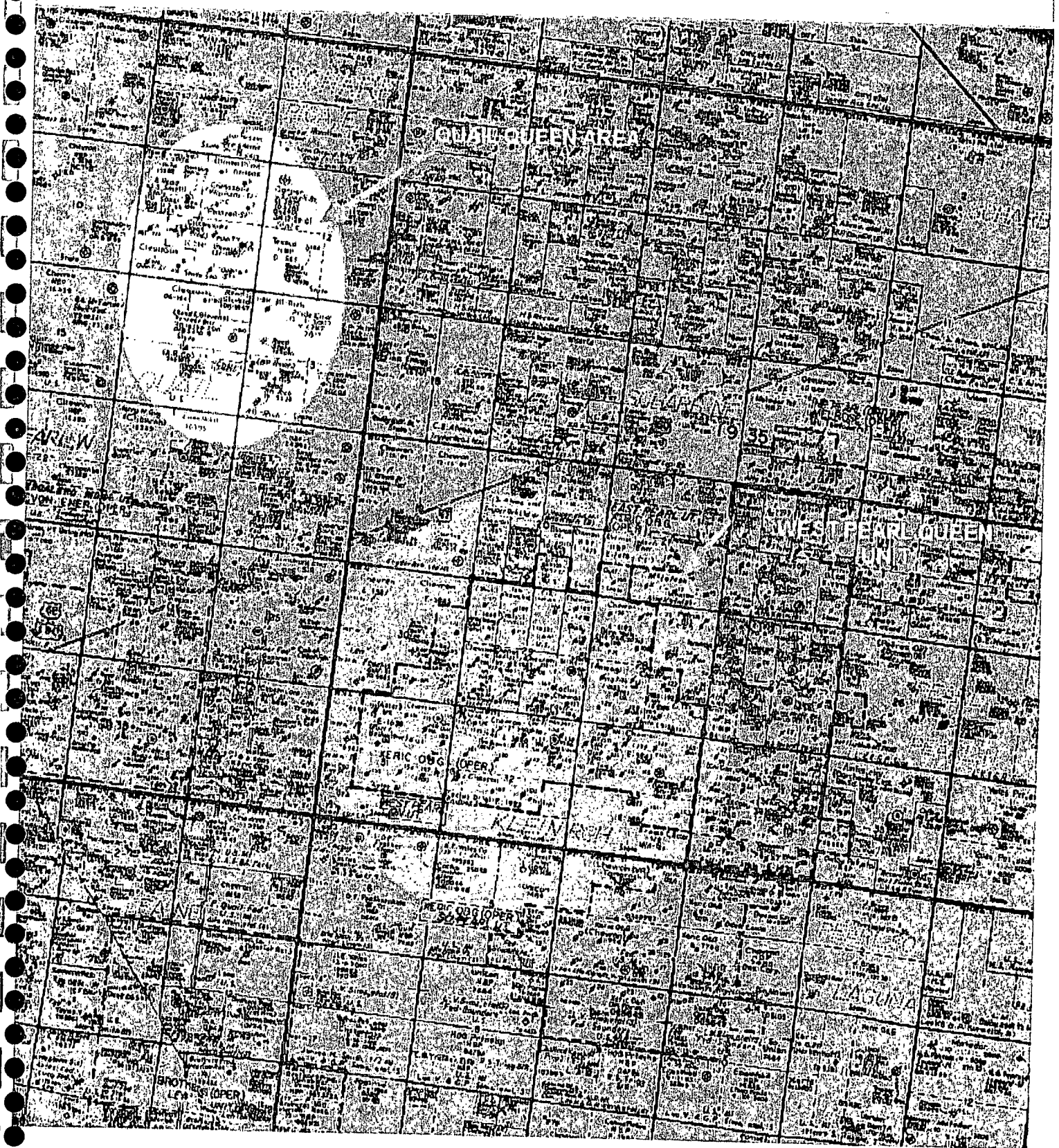
**SWD/Injection to Date:**

206,908 BBLS water injected over seven years  
 0.22 pore volumes injected

**As of 7/1/2007:**

|                                      |                |                         |
|--------------------------------------|----------------|-------------------------|
| <b>Primary Recovery Efficiency</b>   | <b>17.03 %</b> |                         |
| <b>Secondary Recovery Efficiency</b> | <b>2.08 %</b>  | with 22% of PV injected |
| <b>Total</b>                         | <b>19.11 %</b> |                         |

# WEST PEARL QUEEN LOCATOR MAP



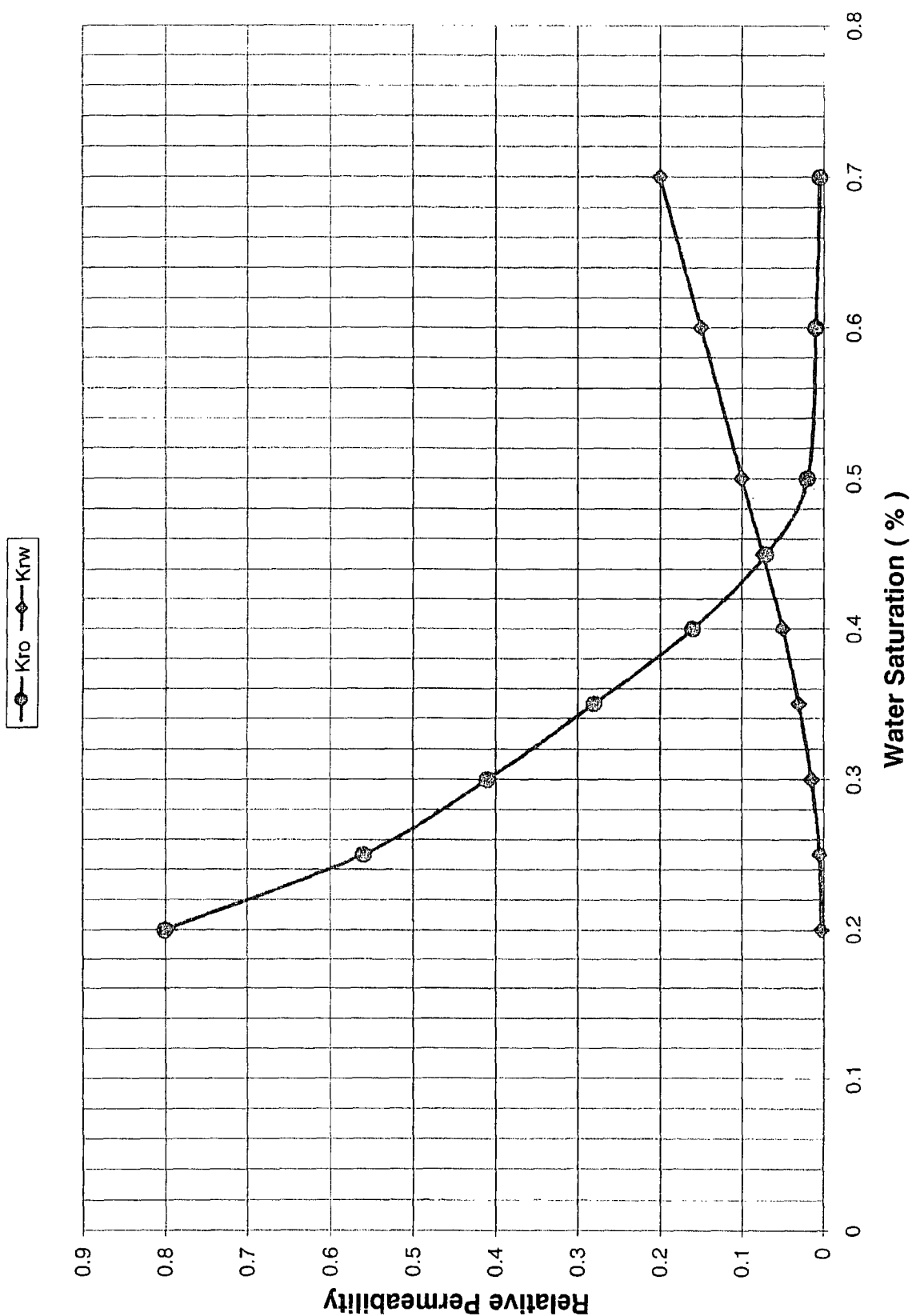
ATTACHMENT #11

# **QQU vs WPQU Waterflood Analogy**

| Item of Comparison     | Proposed QQU | Existing WPQU |
|------------------------|--------------|---------------|
| Net Area (acres)       | 840          | 2,520         |
| Thickness (feet)       | 12.5         | 18            |
| Depth (feet)           | 5,100        | 4,900         |
| Line Pressure (psia)   | 1,848        | 1,776         |
| Bubble Point (psia)    | 1,255        | 1,400         |
| $B_{oi}$               | 1.15         | 1.18          |
| Porosity (%)           | 13           | 16.7          |
| $\Phi h$               | 1.625        | 3.0           |
| Volume ( $\Phi A$ cft) | 1,365        | 7,560         |
| $S_w$ (%)              | 45           | 54            |
| OOIP (MBO)             | 4,467        | 22,763        |
| Primary (MBO)          | 867          | 2,686         |
| % Primary              | 19.4         | 11.8          |
| Secondary (MBO)        | 725          | 2,374         |
| % Secondary            | 16           | 10            |
| Sec: Pri               | 0.83         | 0.88          |
| <b>Total (MBO)</b>     | <b>1,592</b> | <b>5,060</b>  |
| <b>% Total</b>         | <b>0.36</b>  | <b>0.22</b>   |



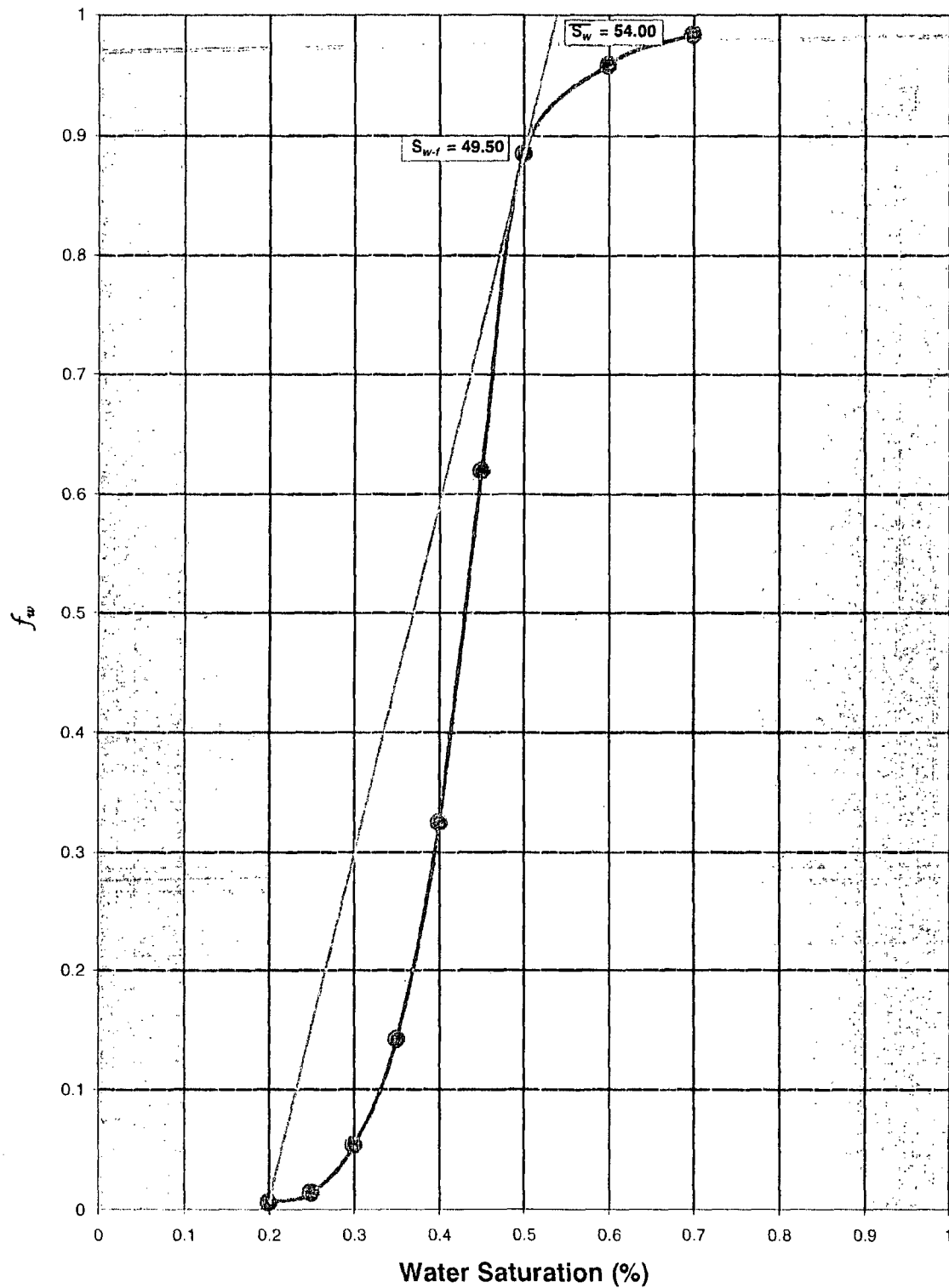
# Generic Sandstone Relative Permeability Curves



Attachment No. 13

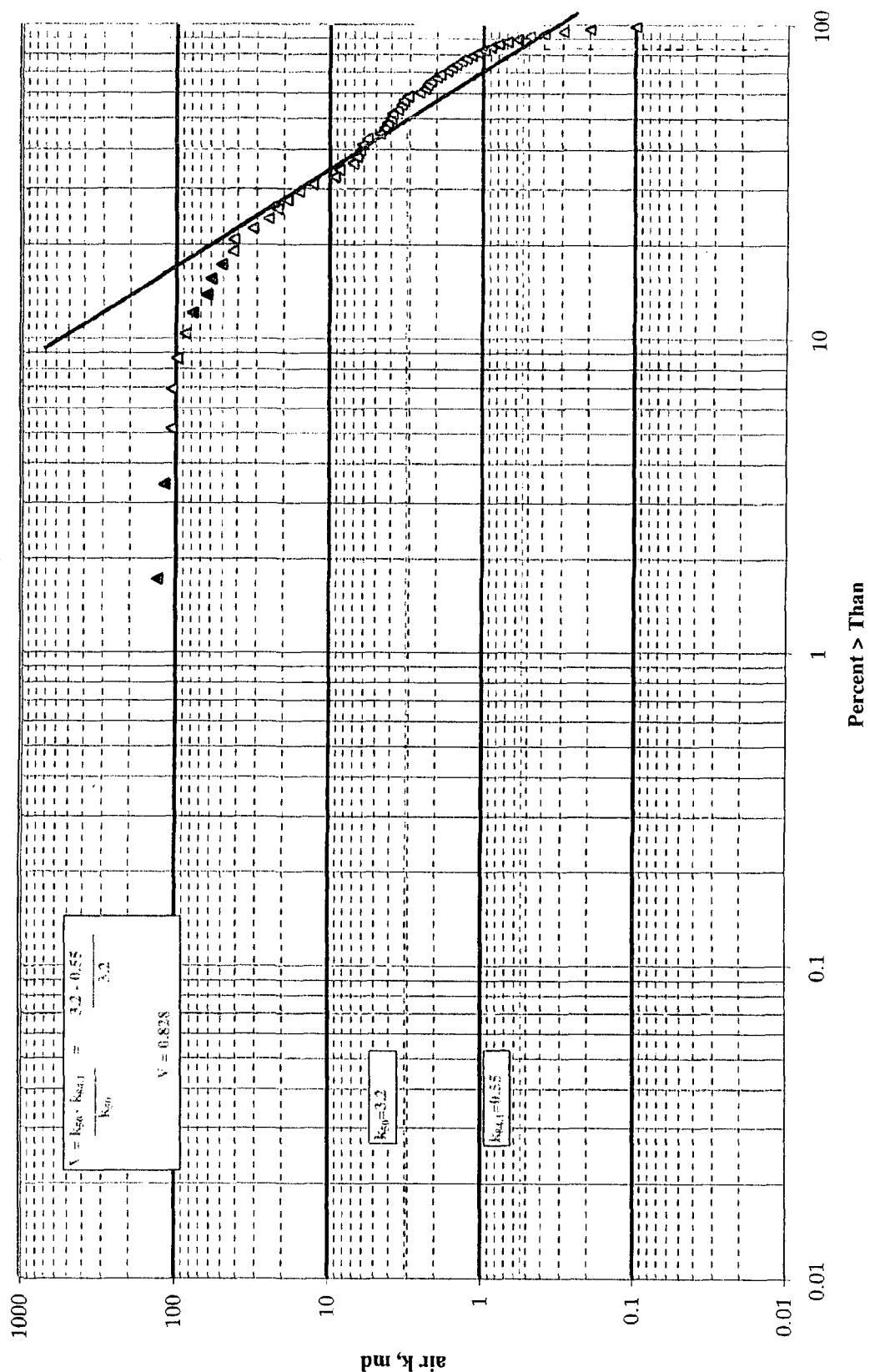
# Fractional Flow Curve

Based on Generic Sandstone Relative Permeability Data  
Fractional Flow Curve

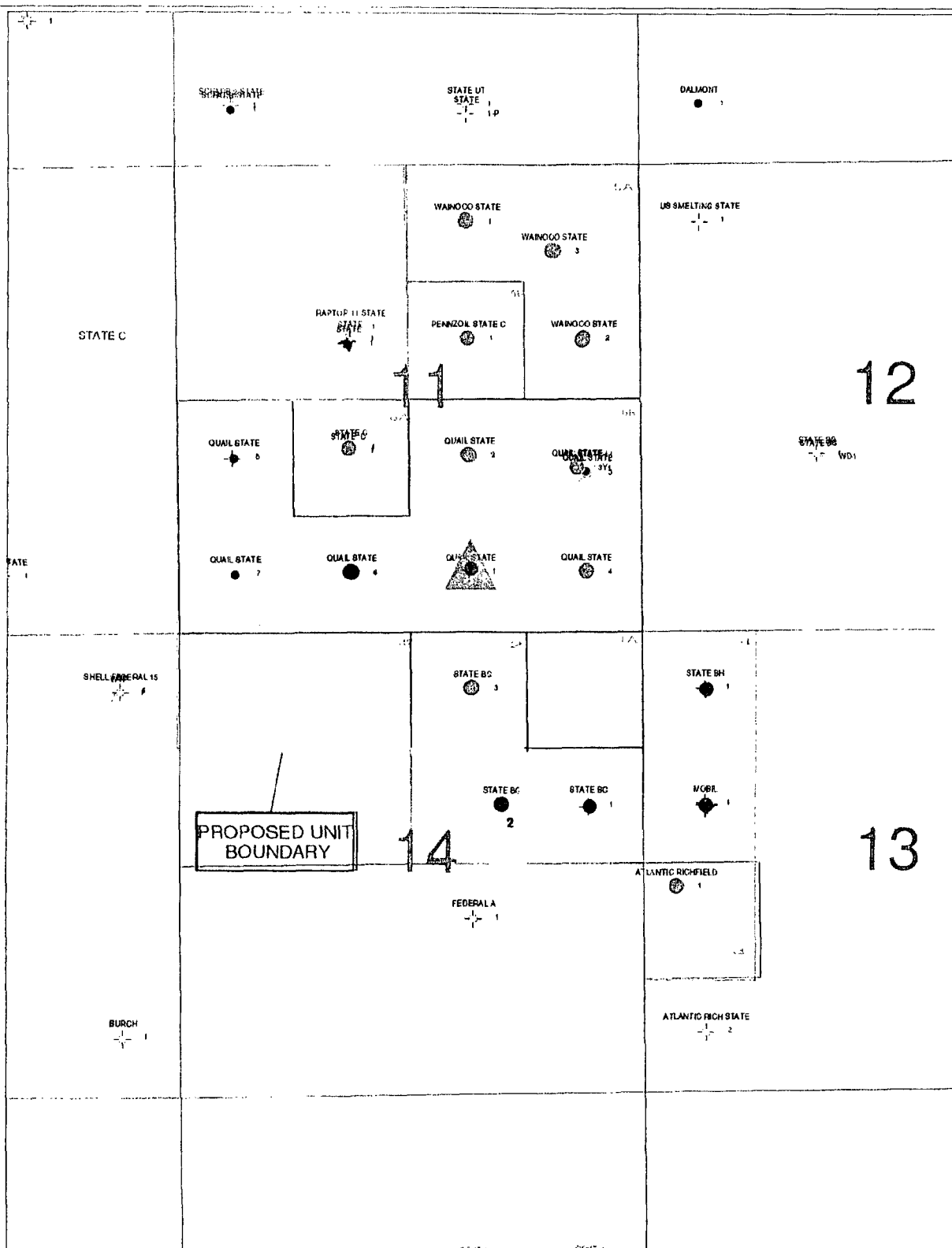


# Quail Queen Field

Vertical Perm Variation



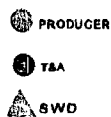
Attachment No. 15



PROPOSED  
SECONDARY  
RECOVERY  
DEVELOPMENT PLAN

PROPOSED  
NEW DRILL

PROPOSED  
RE-ENTRY



CONVERSION



Attachment No. 16

|  |                               |
|--|-------------------------------|
| Chesapeake   | CHESAPEAKE<br>OPERATING, INC. |
| QUAIL FIELD<br>Lea Co., New Mexico<br>QUEEN TRACT MAP<br>ATTACHMENT #16<br>LDM: Quail Field Property Group |                               |
| Drawn: 10 April 2007   | Designed: L. S. WESCOTT       |

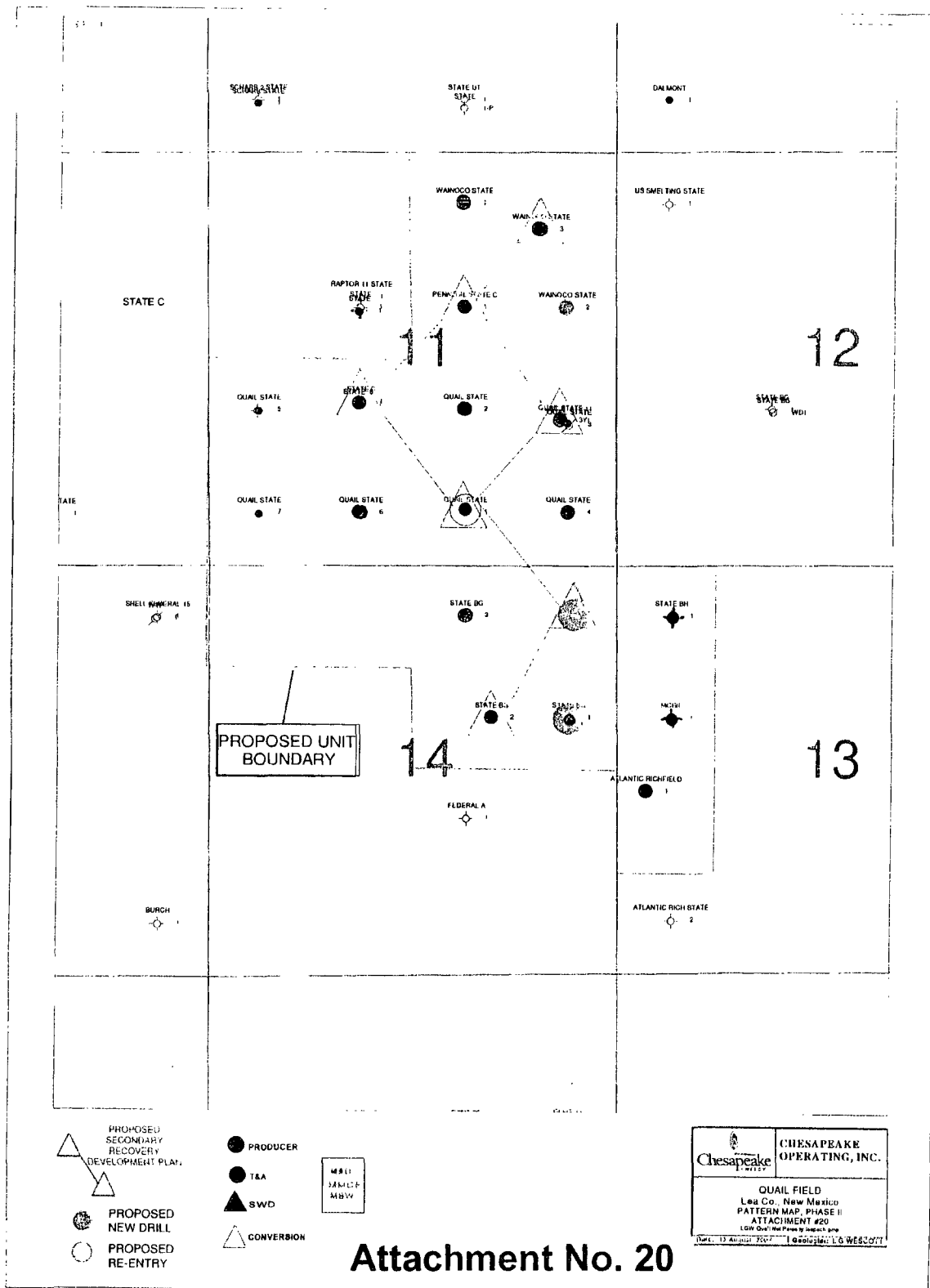
TPF AU17.xls  
TPFAttachment No. 17

Attachment No. 17

**QUAIL QUEEN UNIT**  
**WIO Unit Participation BASED ON TPF'S**

| Tracts Unit Participation Fraction   | Total of        |            |
|--|-----------------|------------|
|  | All Tract's TPF |            |
|  | 1.0000          |            |
| Working Interest Owner   | UNIT WI         | UNIT NRI   |
| Chesapeake Exploration LP  | 0.88926063      | 0.70642158 |
| Roy G. & Opal Barton Revocable Trust, Roy G. Barton Jr., aka George Barton Trust | 0.00321336      | 0.00250642 |
| Pintail Production Company, Inc.   | 0.02570688      | 0.02005137 |
| New Mexico Western Mineral, Inc.   | 0.00642672      | 0.00501284 |
| Read & Stevens, Inc.   | 0.00671780      | 0.00524708 |
| Joe M. & Nancy Wigley  | 0.00022952      | 0.00017903 |
| MRT Ltd  | 0.00022952      | 0.00017903 |
| William D. Bradshaw  | 0.00022952      | 0.00017903 |
| CLM Production Company   | 0.00022952      | 0.00017903 |
| Patricia L. Pruitt   | 0.00022952      | 0.00017903 |
| Laura K. Read  | 0.00022952      | 0.00017903 |
| Marion P. Riley  | 0.00022952      | 0.00017903 |
| Pride Energy Company   | 0.01426171      | 0.01188476 |
| First Century Oil Inc.   | 0.00365079      | 0.00285275 |
| Fisco Inc.   | 0.00365079      | 0.00285275 |
| Gene A. Snow Operating   | 0.00182572      | 0.00142683 |
| All Tex Royalty Ltd  | 0.04367894      | 0.03275921 |
|  |                 |            |
|  |                 |            |
|  | 1.00000000      | 0.79226879 |

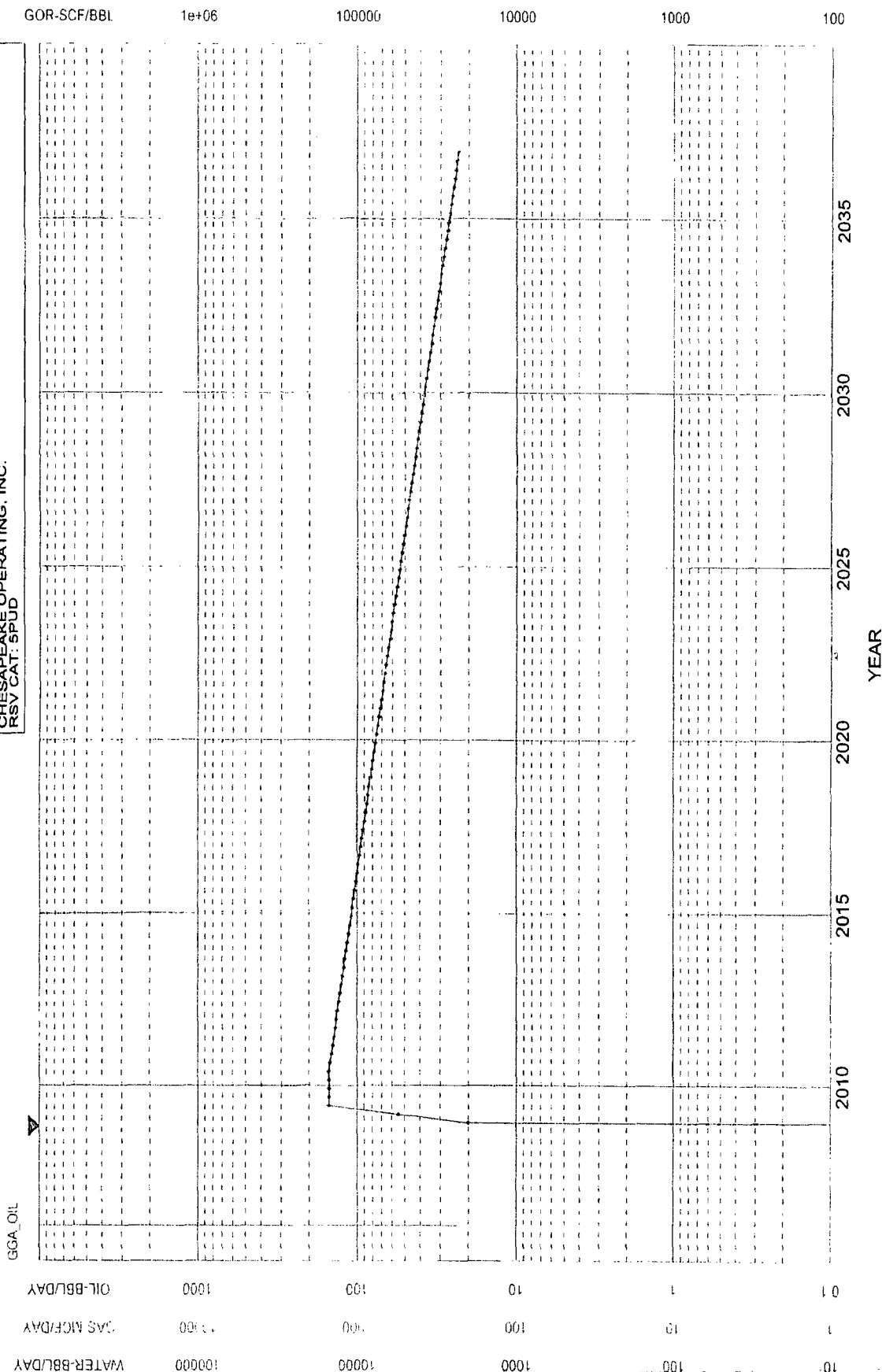






# SEQ #:1380 QUAIL QUEEN UNIT WATERFLOOD CASE

QUAIL  
LEA, NM  
CHESAPEAKE OPERATING, INC.  
RSV CAT: SPUD



| OIL-BBL/DAY   | GAS-MCF/DAY  | WATER-BBL/DAY | GOR-SCF/BBL  |
|---------------|--------------|---------------|--------------|
| Qual= GGA0306 | Ref= 11/2008 | Ref= 11/2008  | Ref= 11/2008 |
| Cum= 1        | Cum= 0       | Cum= 0        | Cum= 0       |
| Rem= 725061   |              |               |              |
| EUR= 725062   |              |               |              |
| Yrs= 28.164   |              |               |              |
| Qref= 0.0     |              |               |              |
| De= 0.000000  |              |               |              |
| Dmin= 0.000   |              |               |              |
| b= 0.000000   |              |               |              |
| Qab= 23.1     |              |               |              |

Lease: QUAIL QUEEN UNIT WATERFLO  
 Field: QUAIL  
 Operator: CHESAPEAKE OPERATING,  
 County: IEA State: NM  
 Oil Differential: 0.000000 \$/BBL  
 Gas Differential: 1.080663 \$/MCF

DATE : 08/14/2007  
 TIME : 16:34:58  
 DBS : CHK0101  
 SETTINGS : CHK0707M  
 SCENARIO : GGA0707

# RESERVES AND ECONOMICS

AS OF DATE: 07/2007

| --END--<br>MO-YEAR | GROSS OIL<br>PRODUCTION<br>-----MMBLS----- | GROSS GAS<br>PRODUCTION<br>-----MMCF----- | NET OIL<br>PRODUCTION<br>-----MMBLS----- | NET GAS<br>PRODUCTION<br>-----MMCF----- | NET OIL<br>PRICE<br>-----\$/BBL----- | NET GAS<br>PRICE<br>-----\$/MCF----- | NET<br>OIL SALES<br>-----M\$----- | NET<br>GAS SALES<br>-----M\$----- | TOTAL<br>NET SALES<br>-----M\$----- |
|--------------------|--|---|--|---|--------------------------------------|--------------------------------------|-----------------------------------|-----------------------------------|-------------------------------------|
| 07-2007            | 0.000                                      | 0.000                                     | 0.000                                    | 0.000                                   | 70.000                               | 0.000                                | 0.002                             | 0.000                             | 0.002                               |
| 12-2007            | 0.000                                      | 0.000                                     | 0.000                                    | 0.000                                   | 70.000                               | 0.000                                | 0.008                             | 0.000                             | 0.008                               |
| 12-2008            | 0.723                                      | 0.000                                     | 0.573                                    | 0.000                                   | 70.000                               | 0.000                                | 40.108                            | 0.000                             | 40.108                              |
| 12-2009            | 42.989                                     | 0.000                                     | 34.056                                   | 0.000                                   | 70.000                               | 0.000                                | 2383.930                          | 0.000                             | 2383.930                            |
| 12-2010            | 54.104                                     | 0.000                                     | 42.861                                   | 0.000                                   | 70.000                               | 0.000                                | 3000.277                          | 0.000                             | 3000.277                            |
| 12-2011            | 50.745                                     | 0.000                                     | 40.200                                   | 0.000                                   | 70.000                               | 0.000                                | 2814.001                          | 0.000                             | 2814.001                            |
| 12-2012            | 47.299                                     | 0.000                                     | 37.470                                   | 0.000                                   | 70.000                               | 0.000                                | 2622.930                          | 0.000                             | 2622.930                            |
| 12-2013            | 44.088                                     | 0.000                                     | 34.926                                   | 0.000                                   | 70.000                               | 0.000                                | 2444.833                          | 0.000                             | 2444.833                            |
| 12-2014            | 41.094                                     | 0.000                                     | 32.555                                   | 0.000                                   | 70.000                               | 0.000                                | 2278.830                          | 0.000                             | 2278.830                            |
| 12-2015            | 38.304                                     | 0.000                                     | 30.344                                   | 0.000                                   | 70.000                               | 0.000                                | 2124.097                          | 0.000                             | 2124.097                            |
| 12-2016            | 35.703                                     | 0.000                                     | 28.284                                   | 0.000                                   | 70.000                               | 0.000                                | 1979.871                          | 0.000                             | 1979.871                            |
| 12-2017            | 33.279                                     | 0.000                                     | 26.363                                   | 0.000                                   | 70.000                               | 0.000                                | 1845.437                          | 0.000                             | 1845.437                            |
| 12-2018            | 31.019                                     | 0.000                                     | 24.573                                   | 0.000                                   | 70.000                               | 0.000                                | 1720.132                          | 0.000                             | 1720.132                            |
| 12-2019            | 28.913                                     | 0.000                                     | 22.905                                   | 0.000                                   | 70.000                               | 0.000                                | 1603.335                          | 0.000                             | 1603.335                            |
| 12-2020            | 26.950                                     | 0.000                                     | 21.350                                   | 0.000                                   | 70.000                               | 0.000                                | 1494.469                          | 0.000                             | 1494.469                            |
| S TOT              | 475.209                                    | 0.000                                     | 376.461                                  | 0.000                                   | 70.000                               | 0.000                                | 26352.260                         | 0.000                             | 26352.260                           |
| AFTER              | 249.852                                    | 0.000                                     | 197.933                                  | 0.000                                   | 70.000                               | 0.000                                | 13855.293                         | 0.000                             | 13855.293                           |
| TOTAL              | 725.061                                    | 0.000                                     | 574.394                                  | 0.000                                   | 70.000                               | 0.000                                | 40207.551                         | 0.000                             | 40207.551                           |

| --END--<br>MO-YEAR | AD VALOREM<br>TAX<br>-----M\$----- | PRODUCTION<br>TAX<br>-----M\$----- | DIRECT OPER<br>EXPENSE<br>-----M\$----- | INTEREST<br>PAID<br>-----M\$----- | CAPITAL<br>REPAYMENT<br>-----M\$----- | EQUITY<br>INVESTMENT<br>-----M\$----- | FUTURE NET<br>CASHFLOW<br>-----M\$----- | CUMULATIVE<br>CASHFLOW<br>-----M\$----- | CUM. DISC.<br>CASHFLOW<br>-----M\$----- |
|--------------------|------------------------------------|------------------------------------|---|-----------------------------------|---------------------------------------|---------------------------------------|---|---|---|
| 07-2007            | 0.000                              | 0.000                              | 5.000                                   | 0.000                             | 0.000                                 | 0.000                                 | -4.999                                  | -4.999                                  | -4.979                                  |
| 12-2007            | 0.000                              | 0.001                              | 25.001                                  | 0.000                             | 0.000                                 | 0.000                                 | -24.993                                 | -29.992                                 | -29.288                                 |
| 12-2008            | 0.552                              | 3.325                              | 63.616                                  | 0.000                             | 0.000                                 | 0.000                                 | -27.385                                 | -57.376                                 | -55.471                                 |
| 12-2009            | 32.795                             | 197.628                            | 274.947                                 | 0.000                             | 0.000                                 | 2095.360                              | -216.799                                | -274.175                                | -332.955                                |
| 12-2010            | 41.273                             | 248.723                            | 450.519                                 | 0.000                             | 0.000                                 | 2900.000                              | -640.239                                | -914.414                                | -810.559                                |
| 12-2011            | 38.711                             | 233.281                            | 553.724                                 | 0.000                             | 0.000                                 | 0.000                                 | 1988.286                                | 1073.872                                | 548.844                                 |
| 12-2012            | 36.082                             | 217.441                            | 236.496                                 | 0.000                             | 0.000                                 | 0.000                                 | 2132.911                                | 3206.783                                | 1874.447                                |
| 12-2013            | 33.632                             | 202.677                            | 220.438                                 | 0.000                             | 0.000                                 | 0.000                                 | 1986.087                                | 5194.870                                | 2997.714                                |
| 12-2014            | 31.349                             | 188.915                            | 205.470                                 | 0.000                             | 0.000                                 | 0.000                                 | 1853.096                                | 7047.965                                | 3949.530                                |
| 12-2015            | 29.220                             | 176.088                            | 191.519                                 | 0.000                             | 0.000                                 | 0.000                                 | 1727.271                                | 8775.236                                | 4756.064                                |
| 12-2016            | 27.236                             | 164.131                            | 178.515                                 | 0.000                             | 0.000                                 | 0.000                                 | 1609.989                                | 10385.225                               | 5439.492                                |
| 12-2017            | 25.387                             | 152.987                            | 166.394                                 | 0.000                             | 0.000                                 | 0.000                                 | 1500.670                                | 11885.895                               | 6018.603                                |
| 12-2018            | 23.663                             | 142.599                            | 155.095                                 | 0.000                             | 0.000                                 | 0.000                                 | 1398.775                                | 13284.670                               | 6509.321                                |
| 12-2019            | 22.056                             | 132.916                            | 144.564                                 | 0.000                             | 0.000                                 | 0.000                                 | 1303.798                                | 14588.468                               | 6925.138                                |
| 12-2020            | 20.559                             | 123.891                            | 134.749                                 | 0.000                             | 0.000                                 | 0.000                                 | 1215.270                                | 15803.738                               | 7277.485                                |
| S TOT              | 362.515                            | 2184.602                           | 3006.047                                | 0.000                             | 0.000                                 | 4995.360                              | 15803.738                               | 15803.738                               | 7277.485                                |
| AFTER              | 190.600                            | 1148.604                           | 1249.260                                | 0.000                             | 0.000                                 | 10.000                                | 11256.827                               | 27060.566                               | 9094.750                                |
| TOTAL              | 553.115                            | 3333.206                           | 4255.307                                | 0.000                             | 0.000                                 | 5005.360                              | 27060.564                               | 27060.566                               | 9094.750                                |

|                      | OIL       | GAS   |                           | P.W. % | P.W., M\$ |
|----------------------|-----------|-------|---------------------------|--------|-----------|
| GROSS WELLS          | 1.0       | 0.0   | LIFE, YRS.                | 5.00   | 14906.022 |
| GROSS ULT., MB & MMF | 725.062   | 0.000 | DISCOUNT %                | 8.00   | 10972.667 |
| GROSS CUM., MB & MMF | 0.000     | 0.000 | UNDISCOUNTED PAYOUT, YRS. | 10.00  | 9094.748  |
| GROSS RES., MB & MMF | 725.061   | 0.000 | DISCOUNTED PAYOUT, YRS.   | 12.00  | 7621.411  |
| NET RES., MB & MMF   | 574.394   | 0.000 | UNDISCOUNTED NET/INVEST.  | 14.00  | 6446.749  |
| NET REVENUE, M\$     | 40207.555 | 0.000 | DISCOUNTED NET/INVEST.    | 16.00  | 5496.724  |
| INITIAL PRICE, \$    | 70.000    | 0.000 | RATE-OF-RETURN, PCT.      | 25.00  | 2878.122  |
| INITIAL N.I., PCT.   | 79.220    | 0.000 | INITIAL W.I., PCT.        | 40.00  | 1106.350  |
|                      |           |       |                           | 60.00  | 276.008   |
|                      |           |       |                           | 100.00 | -154.909  |

# **APPENDIX A**

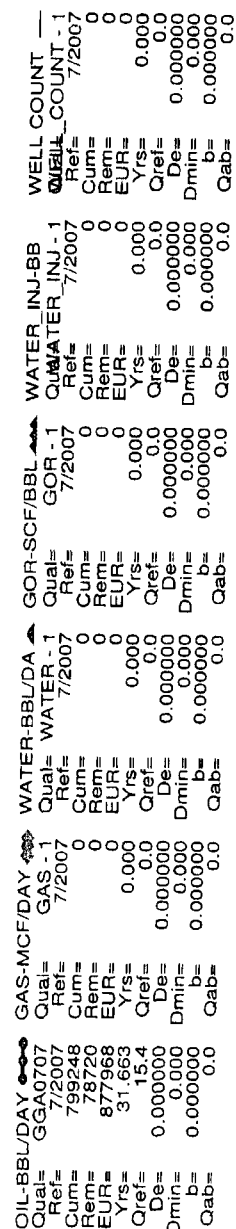
**FIELD PRODUCTION PLOT WITH PRIMARY  
FORECAST**

**INDIVIDUAL WELL PRODUCTION PLOTS WITH  
PRIMARY FORECAST**

**PROPOSED QUAIL QUEEN UNIT  
WATERFLOOD FEASIBILITY STUDY**

**AUGUST, 2007**

**QUAIL TOTAL FIELD**  
12 ACTIVE WELLS PLUS  
8 INACTIVE WELLS



GOR-SCF/BBL

100000

10000

1000

100

10

SEQ #814 ATLANTIC RICHFIELD 1

QUAIL

LEA, NM

CHESAPEAKE OPERATING, INC.

RSV CAT: 1PDP

OIL

WATER-BBL/DAY  
GAS-MCF/DAY  
OIL-BBL/DAY

10000  
100  
10

1000  
100  
10

100  
10  
1

10  
1  
0.1

1  
0.1  
0.001

YEAR

7071727374757677787980818283848586878889909192939495969798990001000304050607080910111213141516171819202122232425262728293031323334

OIL-BBL/DAY  
Qual= GGA0707  
Ref= 7/2007  
Cum= 152273  
Rem= 13815  
EUR= 166088  
Yrs= 25.997  
Qref= 2.6  
De= 5.000000  
Dmin= 0.000  
b= 0.000000  
Qab= 0.7

GAS-MCF/DAY  
Ref= 7/2007  
Cum= 83682

WATER-BBL/DAY  
Ref= 7/2007  
Cum= 465004

GOR-SCF/BBL  
Ref= 7/2007  
Cum= 24326

# SEQ #:1363 WAINOCO STATE 1

QUAIL QUEEN  
LEA, NM  
CHESAPEAKE OPERATING, INC.  
RSV CAT: 1PDP

GOR-SCF/BBL

100000

10000

1000

100

10

OIL

OIL-BBL/DAY

10

1

0.1

0.01

0.001

GAS-MCF/DAY

1000

100

10

1

WATER-BBL/DAY

10000

1000

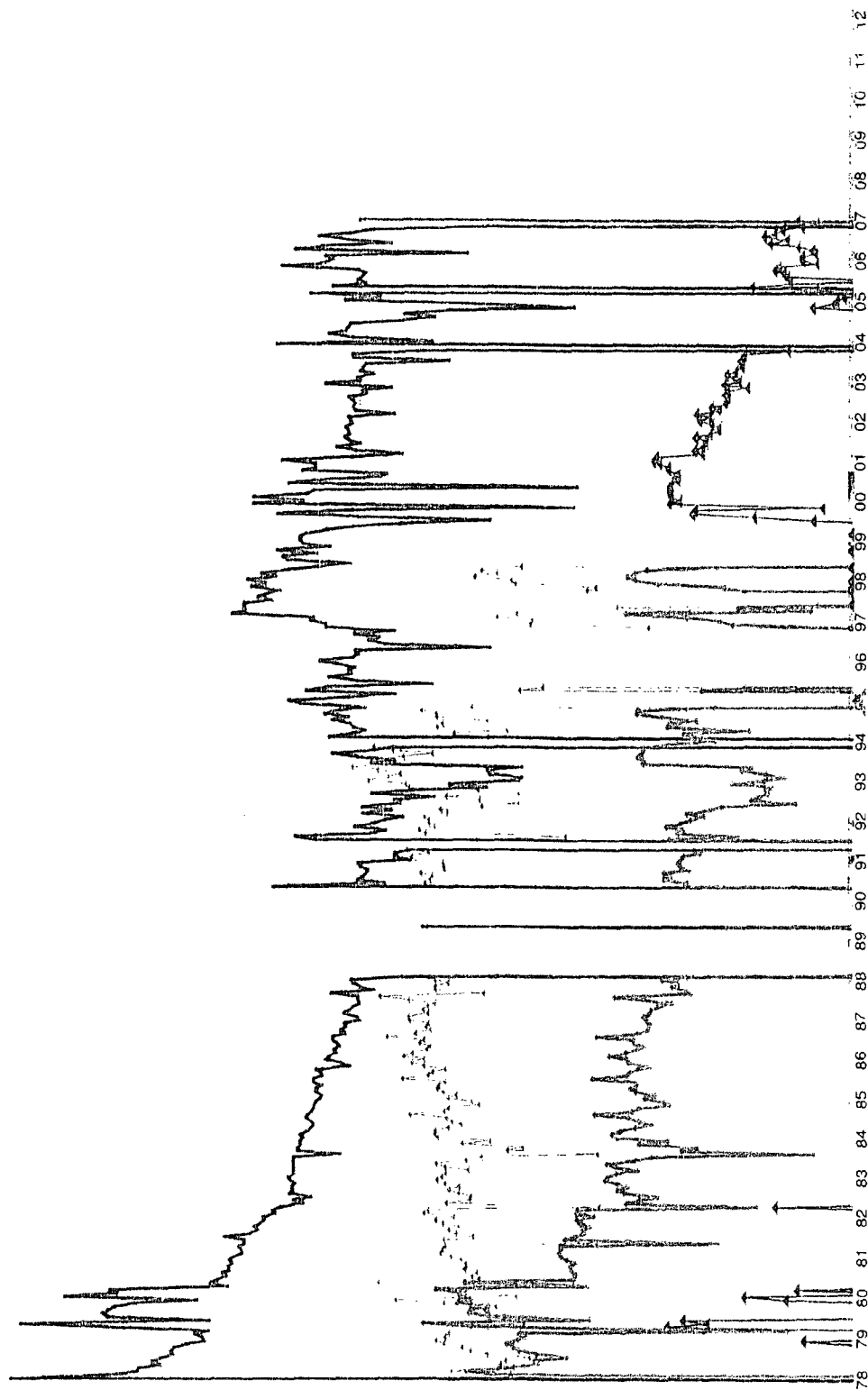
100

10

1

YEAR

OIL-BBL/DAY Ref= 7/2007 Cum= 15927  
GAS-MCF/DAY Ref= 7/2007 Cum= 15231  
WATER-BBL/DAY Ref= 7/2007 Cum= 15898  
GOR-SCF/BBL Ref= 7/2007 Cum= 0



GOR-SCF/BBL

100000

10000

1000

100

10

SEQ #1362 WAINOCO STATE 2

QUAIL QUEEN

LEA, NM

CHESAPEAKE OPERATING, INC.

RSV CAT: 1PDP

OIL

OIL BBL/DAY

GAS MCF/DAY

WATER-BBL/DAY

10

1000

1000

1

100

100

0.1

10

10

0.01

1

1

0.001

0.1

0.1

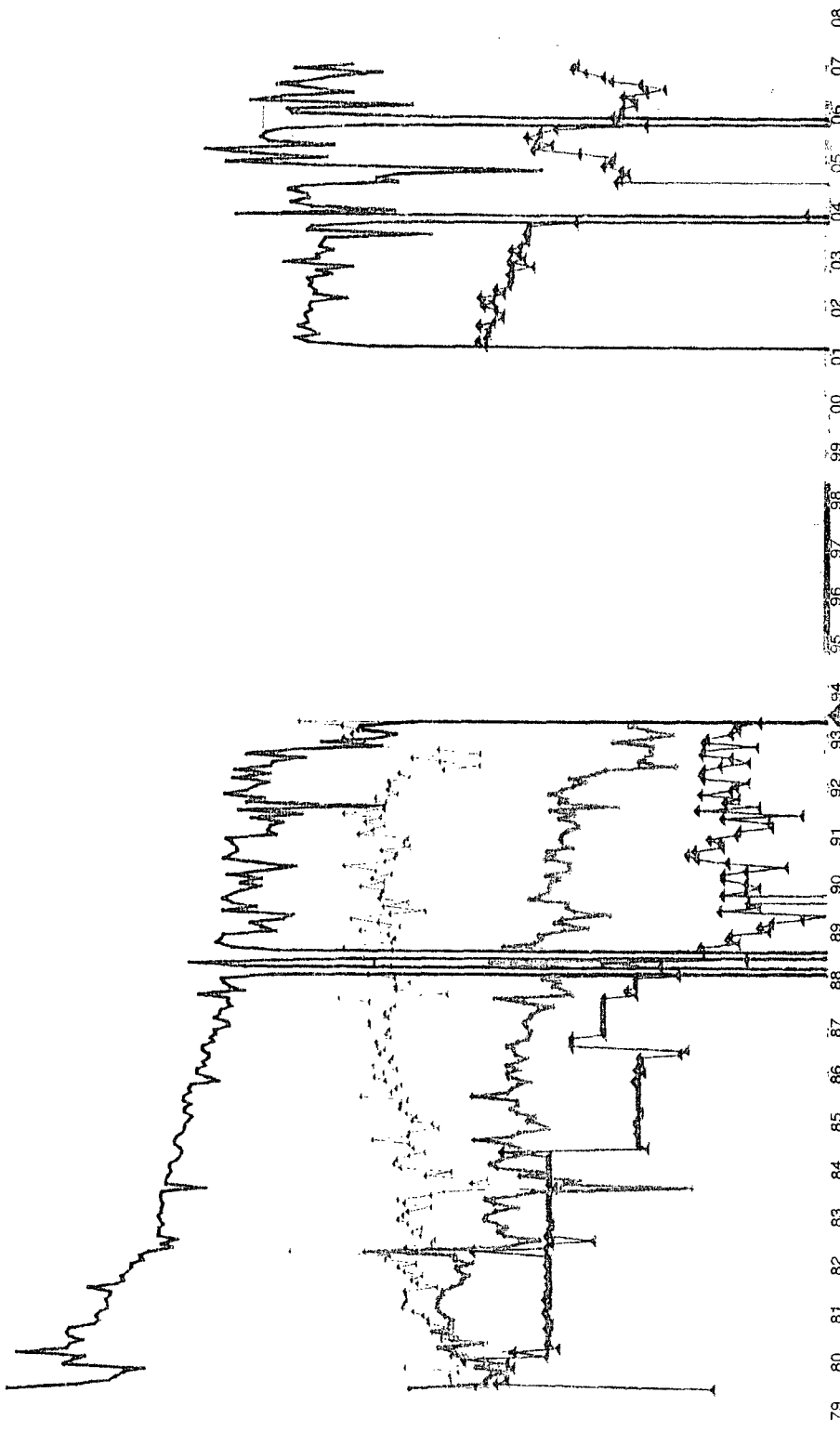
YEAR

OIL-BBL/DAY  
Ref= 7/2007  
Cum= 16929

GAS-MCF/DAY  
Ref= 7/2007  
Cum= 24075

WATER-BBL/DAY  
Ref= 7/2007  
Cum= 15188

GOR-SCF/BBL  
Ref= 7/2007  
Cum= 0



GOR-SCF/BBL

100000

10000

1000

100

10

SEQ #1361 WAINOCO STATE 3

QUAIL QUEEN

LEA NIMBLEAKE OPERATING, INC.

RES CAT: 1PDP

OIL

OIL-BBL/DAY

GAS MCF/DAY

WATER-BBL/DAY

10

1000

10000

1

10

1000

0.1

1

100

0.01

0.1

10

0.001

0.01

1

YEAR

09

08

07

06

05

04

03

02

01

00

99

98

97

96

95

94

93

92

91

90

89

88

87

86

85

84

83

82

81

80

OIL-BBL/DAY 7/2007 Ref= 18919 Cum= 0

GAS-MCF/DAY 7/2007 Ref= 27209 Cum= 0

WATER-BBL/DAY 7/2007 Ref= 16399 Cum= 0

GOR-SCF/BBL 7/2007 Ref= 0 Cum= 0

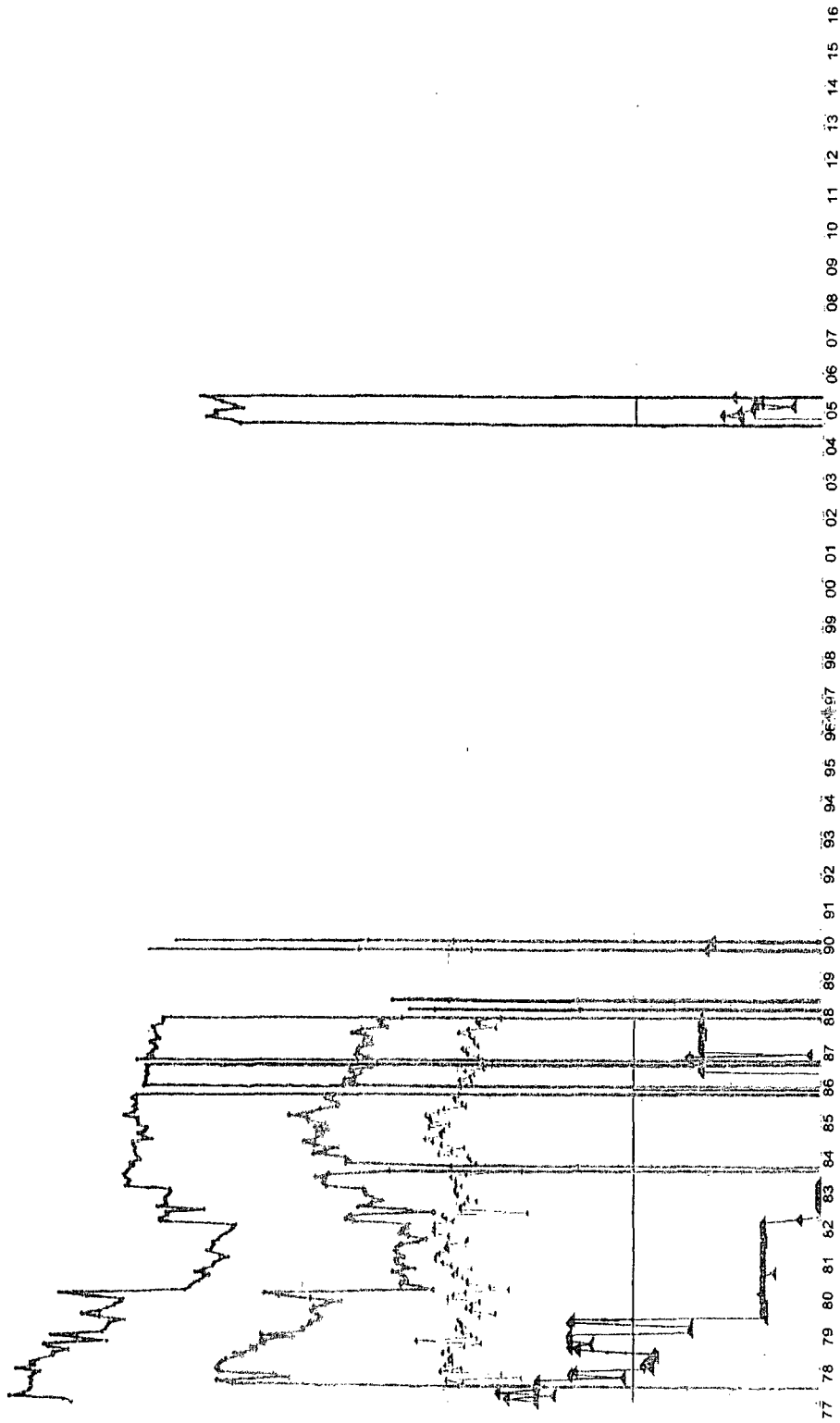


|             |        |       |      |     |     |
|-------------|--------|-------|------|-----|-----|
| WELL COUNT  | 1000   | 100   | 10   | 1   | 0.1 |
| GOR-SCF/BBL | 100000 | 10000 | 1000 | 100 | 10  |

SEQ #:1370 QUAIL STATE 1 SI INJ  
 QUAIL  
 LEA, NM  
 CHESAPEAKE OPERATING, INC.  
 RSV CAT: 1PDP

OIL

|               |       |      |     |      |       |
|---------------|-------|------|-----|------|-------|
| WATER-BBL/DAY | 10000 | 1000 | 100 | 10   | 1     |
| GAS-MCF/DAY   | 100   | 10   | 1   | 0.1  | 0.01  |
| OIL-BBL/DAY   | 10    | 1    | 0.1 | 0.01 | 0.001 |



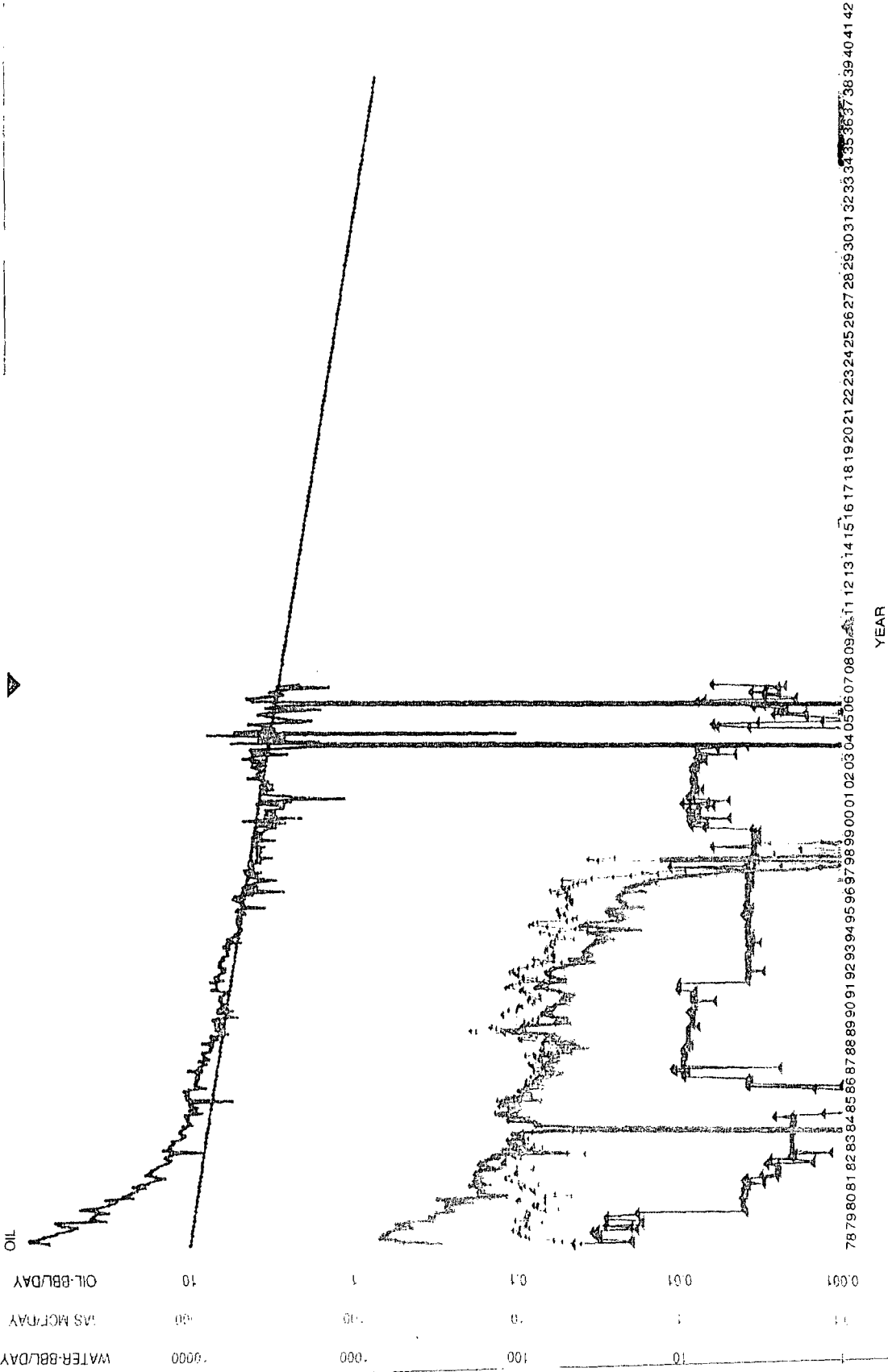
YEAR

|               |         |        |       |      |        |       |       |          |        |          |        |
|---------------|---------|--------|-------|------|--------|-------|-------|----------|--------|----------|--------|
| OIL-BBL/DAY   | CEC0407 | 7/2007 | 23961 | 0    | 23961  | 0.419 | 0.0   | 0.000000 | 0.000  | 0.000000 | 0.0    |
| Qual=         | 7/2007  | Ref=   | 17581 | Cum= | 7/2007 | Ref=  | 23472 | Cum=     | 7/2007 | Ref=     | 206908 |
| WATER-BBL/DAY | 7/2007  | Ref=   | 23472 | Cum= | 7/2007 | Ref=  | 0     | Cum=     | 7/2007 | Ref=     | 142    |
| GAS-MCF/DAY   | 7/2007  | Ref=   | 23472 | Cum= | 7/2007 | Ref=  | 0     | Cum=     | 7/2007 | Ref=     | 142    |
| WATER-BBL/DAY | 7/2007  | Ref=   | 23472 | Cum= | 7/2007 | Ref=  | 0     | Cum=     | 7/2007 | Ref=     | 142    |
| GOR-SCF/BBL   | 7/2007  | Ref=   | 23472 | Cum= | 7/2007 | Ref=  | 0     | Cum=     | 7/2007 | Ref=     | 142    |
| WATER-INJ-BB  | 7/2007  | Ref=   | 23472 | Cum= | 7/2007 | Ref=  | 0     | Cum=     | 7/2007 | Ref=     | 142    |
| WELL COUNT    | 7/2007  | Ref=   | 23472 | Cum= | 7/2007 | Ref=  | 0     | Cum=     | 7/2007 | Ref=     | 142    |

GOR-SCF-BBL 100000 10000 1000 100 10

SEC # 1369 QUAIL STATE 2

QUAIL QUEEN  
LEA NM  
CHESAPEAKE OPERATING, INC.  
RSV CAT: 1PDP



| OIL-BBL/DAY   | GAS-MCF/DAY | WATER-BBL/DAY | GOR-SCF/BBL |
|---------------|-------------|---------------|-------------|
| Qual= GGA0707 | Ref= 7/2007 | Ref= 7/2007   | Ref= 7/2007 |
| Cum= 107142   | Cum= 78634  | Cum= 62942    | Cum= 0      |
| EUR= 124369   |             |               |             |
| Yrs= 31.663   |             |               |             |
| Qref= 2.7     |             |               |             |
| De= 4.239793  |             |               |             |
| Dmin= 0.000   |             |               |             |
| b= 0.000000   |             |               |             |
| Qab= 0.7      |             |               |             |

78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42

YEAR

14

CHESAPEAKE OPERATING, INC.  
3SV CAT: 1B0B



|             |             |
|-------------|-------------|
| OIL-BBL/DAY | GOR-SCF/BBL |
| Qual=       | Ref=        |
| GGA0707     | 7/2007      |
| Ref=        | Cum=        |
| 7/2007      | 36129       |
| Cum=        |             |
| 46709       |             |
| Rem=        |             |
| 2124        |             |
| EUR=        |             |
| 48833       |             |
| Yrs=        |             |
| 6.249       |             |
| Qref=       |             |
| 1.3         |             |
| De=         |             |
| 12.408345   |             |
| Omin=       |             |
| 0.000       |             |
| b=          |             |
| 1.100000    |             |
| Qab=        |             |
| 0.7         |             |

# SEQ #1367 QUAIL STATE 4

QUAIL STATE  
 CHESSAPEAKE OPERATING, INC.  
 RSV CAT: 1PDP

GOR SCF/BB:

100000

10000

1000

100

10

OIL

OIL-BBL/DAY

GAS MCF/DAY

WATER-BBL/DAY

10

0

10000

1

2

1000

0.1

1

100

0.01

0.1

10

0.001

0.01

1

YEAR

OIL-BBL/DAY  
 Qual= GGA0707  
 Ref= 7/2007  
 Cum= 39368  
 EUR= 4132  
 Yrs= 43500  
 Qref= 11.748  
 De= 1.4  
 Dmin= 8.362479  
 b= 0.000  
 Qab= 1.100000  
 0.7

GAS-MCF/DAY  
 Ref= 7/2007  
 Cum= 25358

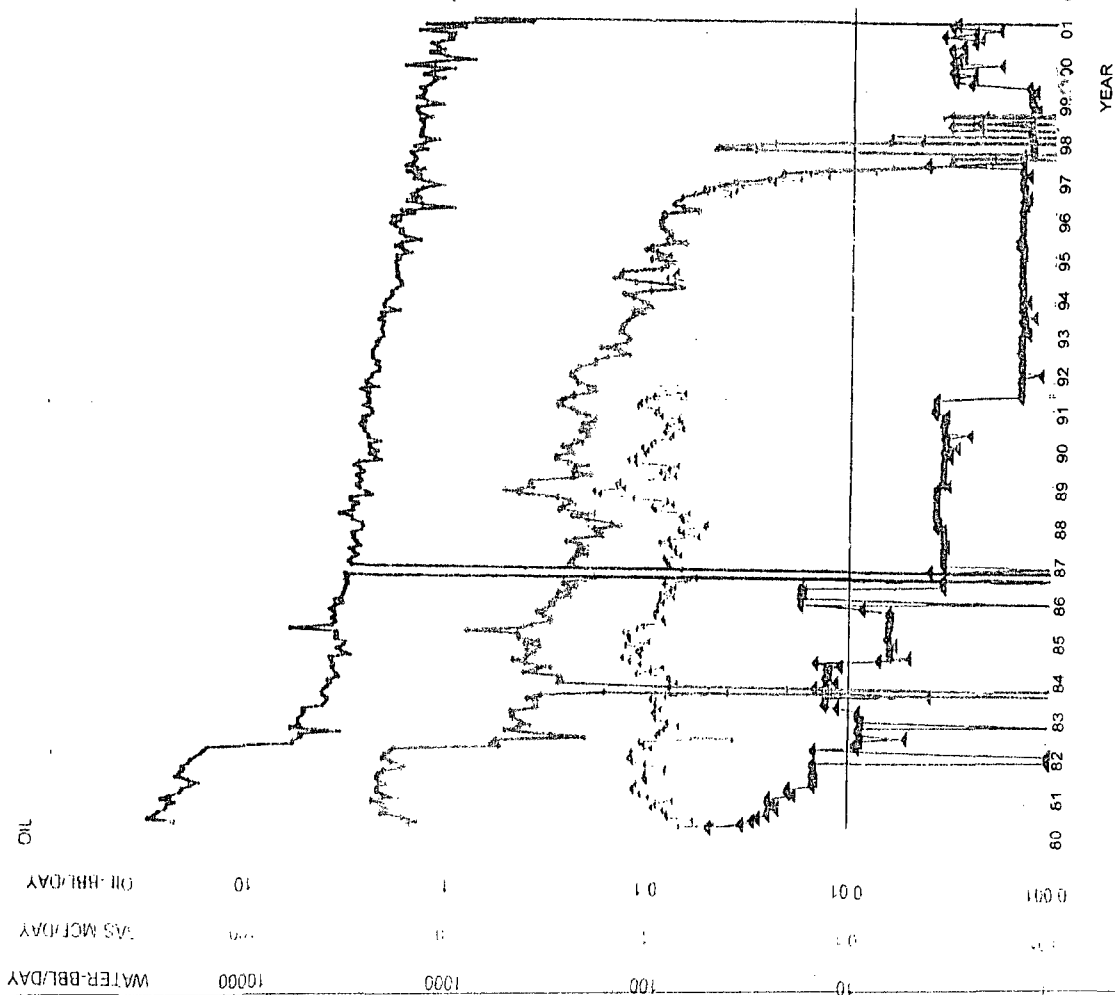
WATER-BBL/DAY  
 Ref= 7/2007  
 Cum= 36434

GOR-SCF/BB  
 Ref= 7/2007  
 Cum= 0

79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23

|             |        |       |      |     |     |
|-------------|--------|-------|------|-----|-----|
| WELL COUNT  | 1000   | 100   | 10   | 1   | 0.1 |
| GOR-SCF/BBL | 100000 | 10000 | 1000 | 100 | 10  |

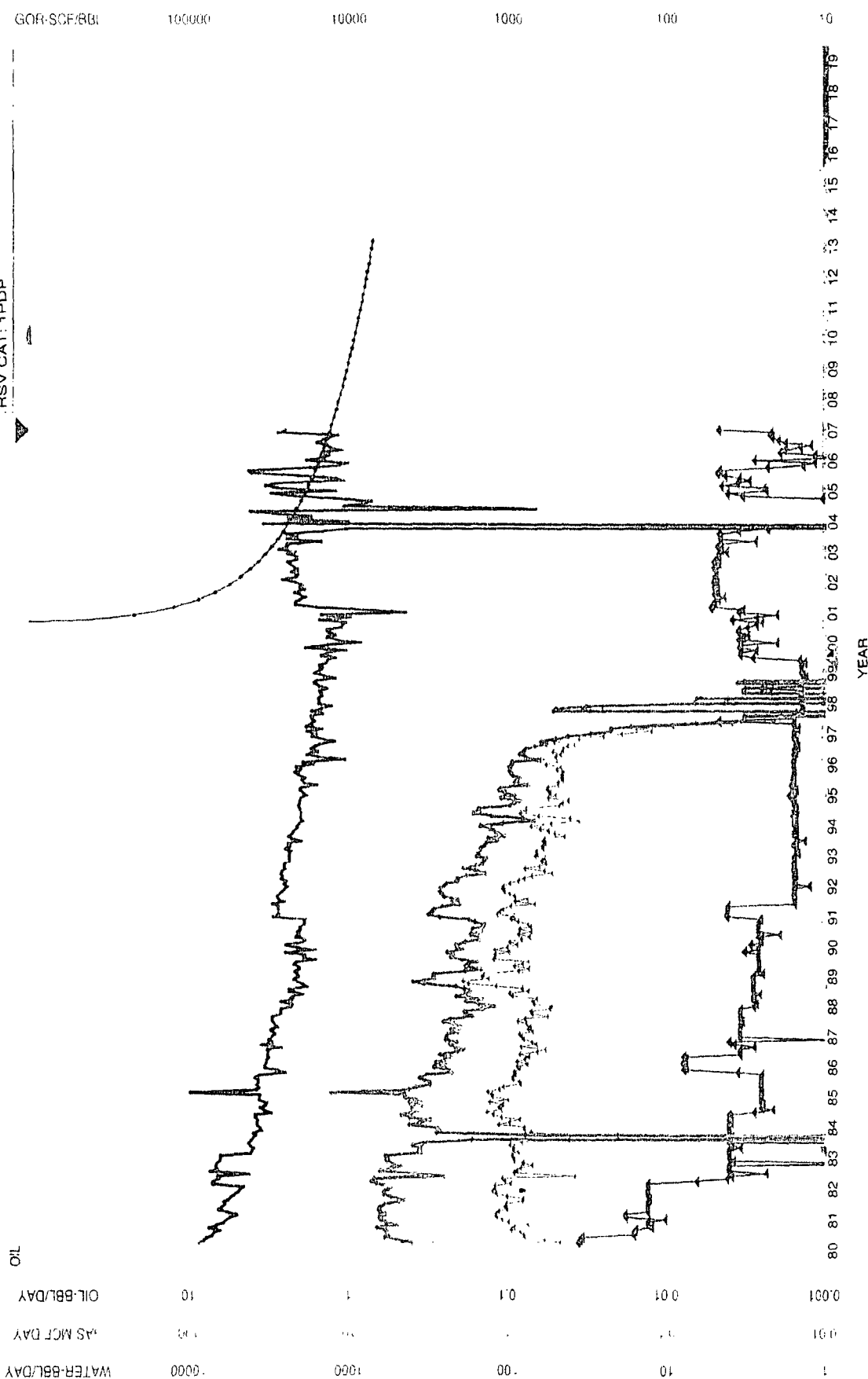
SEQ #: 1366 QUAIL STATE 5 SI  
 QUAIL  
 LEA, NM  
 CHESAPEAKE OPERATING, INC.  
 RSV CAT: 2PDSI



|             |          |              |             |              |            |
|-------------|----------|--------------|-------------|--------------|------------|
| OIL-BBL/DAY | CEC0407  | WATER-BBL/DA | GOR-SCF/BBL | WATER-INJ-BB | WELL COUNT |
| Ref=        | 7/2007   | Ref=         | 7/2007      | Ref=         | 7/2007     |
| Cum=        | 32623    | Cum=         | 41336       | Cum=         | 0          |
| EUR=        | 32623    |              |             |              |            |
| Yrs=        | 0.419    |              |             |              |            |
| Qref=       | 0.0      |              |             |              |            |
| De=         | 0.000000 |              |             |              |            |
| Dmin=       | 0.000    |              |             |              |            |
| b=          | 0.000000 |              |             |              |            |
| Qab=        | 0.0      |              |             |              |            |

# SEQ #:1365 QUAIL STATE 6

QUAIL QUEEN  
LEA NM  
CHESAPEAKE OPERATING, INC.  
RSV CAT: 1PDP



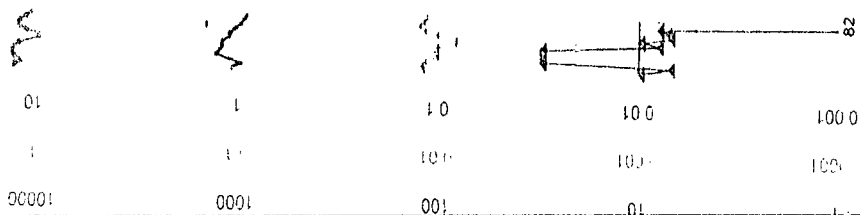
| OIL-BBL/DAY   | GAS-MCF/DAY | WATER-BBL/DAY | GOR-SCF/BBL |
|---------------|-------------|---------------|-------------|
| Qual= GGA0707 | Ref= 7/2007 | Ref= 7/2007   | Ref= 7/2007 |
| Cum= 26108    | Cum= 16653  | Cum= 36260    | Cum= 0      |
| Rem= 2165     |             |               |             |
| EUR= 28273    |             |               |             |
| Yrs= 6.334    |             |               |             |
| Qref= 1.3     |             |               |             |
| De= 12.408345 |             |               |             |
| Dmin= 0.000   |             |               |             |
| b= 1.100000   |             |               |             |
| Qab= 0.7      |             |               |             |

|             |        |       |      |     |     |
|-------------|--------|-------|------|-----|-----|
| WELL COUNT  | 1000   | 100   | 10   | 1   | 0.1 |
| GOR-SCF/BBL | 100000 | 10000 | 1000 | 100 | 10  |

SEQ #: 1364 QUAIL STATE 7 SI  
 QUAIL QUEEN  
 LEA NM  
 CHESAPEAKE OPERATING, INC.  
 RSV CAT: 2PDSI

OIL

WATER-BBL/DAY  
 GAS MCF/DAY  
 OIL-BBL/DAY



YEAR

OIL-BBL/DAY  
 Qual= CEC0407  
 Ref= 7/2007  
 Cum= 429  
 EUR= 0  
 Yrs= 1.419  
 Qref= 0.0  
 De= 0.000000  
 Dmin= 0.000  
 b= 0.000000  
 Qab= 0.0

GAS-MCF/DAY  
 Ref= 7/2007  
 Cum= 455

WATER-BBL/DAY  
 Ref= 7/2007  
 Cum= 5360

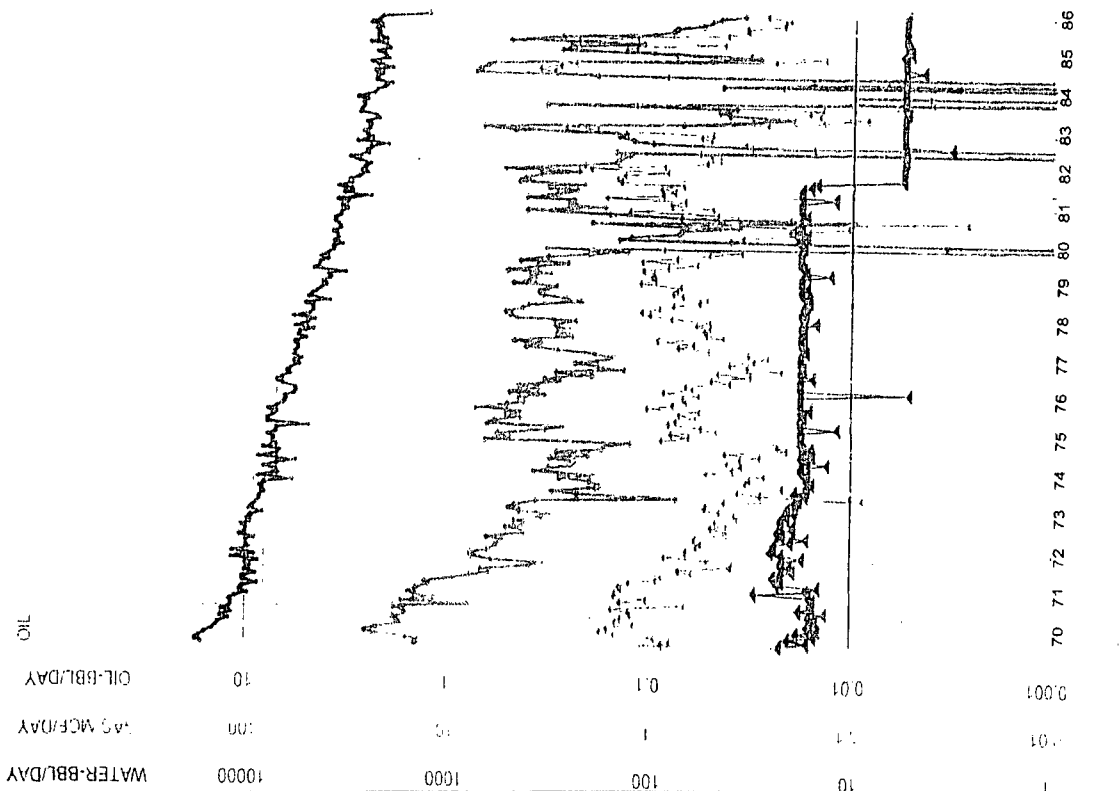
GOR-SCF/BBL  
 Ref= 7/2007  
 Cum= 0

WATER-INJ-BB  
 Ref= 7/2007  
 Cum= 0

WELL COUNT  
 Ref= 7/2007  
 Cum= 13

|             |        |       |      |     |     |
|-------------|--------|-------|------|-----|-----|
| WELL COUNT  | 1000   | 100   | 10   | 1   | 0.1 |
| GOR-SCF/BBL | 100000 | 10000 | 1000 | 100 | 10  |

SEQ #:1376 FEDERAL A 1 SI  
QUAIL QUEEN  
LEA NM  
CHESAPEAKE OPERATING, INC.  
RSV CAT: 1PDSI



|               |       |         |      |        |      |       |      |       |       |     |       |          |    |          |      |     |
|---------------|-------|---------|------|--------|------|-------|------|-------|-------|-----|-------|----------|----|----------|------|-----|
| OIL-BBL/DAY   | Qual= | CEC0407 | Ref= | 7/2007 | Cum= | 40416 | Yrs= | 0.419 | Qref= | 0.0 | Dmin= | 0.000000 | b= | 0.000000 | Qab= | 0.0 |
| GAS-MCF/DAY   | Qual= | CEC0407 | Ref= | 7/2007 | Cum= | 31385 | Yrs= | 0.419 | Qref= | 0.0 | Dmin= | 0.000000 | b= | 0.000000 | Qab= | 0.0 |
| WATER-BBL/DAY | Qual= | CEC0407 | Ref= | 7/2007 | Cum= | 92129 | Yrs= | 0.419 | Qref= | 0.0 | Dmin= | 0.000000 | b= | 0.000000 | Qab= | 0.0 |
| GOR-SCF/BBL   | Qual= | CEC0407 | Ref= | 7/2007 | Cum= | 5088  | Yrs= | 0.419 | Qref= | 0.0 | Dmin= | 0.000000 | b= | 0.000000 | Qab= | 0.0 |
| WATER-INJ-BB  | Qual= | CEC0407 | Ref= | 7/2007 | Cum= | 4462  | Yrs= | 0.419 | Qref= | 0.0 | Dmin= | 0.000000 | b= | 0.000000 | Qab= | 0.0 |
| WELL COUNT    | Qual= | CEC0407 | Ref= | 7/2007 | Cum= | 197   | Yrs= | 0.419 | Qref= | 0.0 | Dmin= | 0.000000 | b= | 0.000000 | Qab= | 0.0 |



GOR-SCF/BBL

100000

10000

1000

100

10

SEQ # 901 PENNZOIL STATE 1

QUAIL  
LEA NM  
CHESAPEAKE OPERATING, INC.  
RSV CAT: 1PDP

OIL

WATER-BBL/DAY  
GAS-MCF/DAY  
OIL-BBL/DAY10000  
100  
101000  
100  
10100  
10  
110  
1  
0.11  
0.1  
0.01

YEAR

OIL-BBL/DAY 7/2007 78460  
Ref= 7/2007  
Cum= 78460

GAS-MCF/DAY 7/2007 41859  
Ref= 7/2007  
Cum= 41859

WATER-BBL/DAY 7/2007 62870  
Ref= 7/2007  
Cum= 62870

GOR-SCF/BBL 7/2007 10772  
Ref= 7/2007  
Cum= 10772

|             |        |       |        |       |      |
|-------------|--------|-------|--------|-------|------|
| WELL COUNT  | 1e+07  | 1e+06 | 100000 | 10000 | 1000 |
| GOR-SCF/BBL | 100000 | 10000 | 1000   | 100   | 10   |

SEQ #:1379 STATE BH 1 SI  
 QUAIL QUEEN  
 LEA, NM  
 CHESAPEAKE OPERATING, INC.  
 RSV CAT: UNKNOWN

OIL

|               |     |    |   |     |     |
|---------------|-----|----|---|-----|-----|
| WATER-BBL/DAY | 100 | 10 | 1 | 0.1 | 0.0 |
| GAS-MCF/DAY   | 10  | 10 | 1 | 0.1 | 0.0 |
| OIL-BBL/DAY   | 100 | 10 | 1 | 0.1 | 0.0 |

|    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 | 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90 | 91 | 92 | 93 | 94 | 95 | 96 | 97 | 98 | 99 | 00 | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 |
|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|

YEAR

|               |        |        |      |      |       |       |          |          |          |          |      |
|---------------|--------|--------|------|------|-------|-------|----------|----------|----------|----------|------|
| OIL-BBL/DAY   | Qual=  | Ref=   | Cum= | Rem= | EUR=  | Yrs=  | Qref=    | De=      | Dmin=    | b=       | Qab= |
| CEC0407       | 7/2007 | 7/2007 | 7232 | 0    | 7232  | 0.419 | 0.0      | 0.000000 | 0.000    | 0.000000 | 0.0  |
| GAS-MCF/DAY   | Ref=   | Cum=   | Rem= | EUR= | Yrs=  | Qref= | De=      | Dmin=    | b=       | Qab=     |      |
| 7/2007        | 2109   | 7232   | 0    | 7232 | 0.419 | 0.0   | 0.000000 | 0.000    | 0.000000 | 0.0      |      |
| WATER-BBL/DAY | Ref=   | Cum=   | Rem= | EUR= | Yrs=  | Qref= | De=      | Dmin=    | b=       | Qab=     |      |
| 7/2007        | 13333  | 7232   | 0    | 7232 | 0.419 | 0.0   | 0.000000 | 0.000    | 0.000000 | 0.0      |      |
| GOR-SCF/BBL   | Ref=   | Cum=   | Rem= | EUR= | Yrs=  | Qref= | De=      | Dmin=    | b=       | Qab=     |      |
| 7/2007        | 13333  | 7232   | 0    | 7232 | 0.419 | 0.0   | 0.000000 | 0.000    | 0.000000 | 0.0      |      |
| WATER-INJ-BB  | Ref=   | Cum=   | Rem= | EUR= | Yrs=  | Qref= | De=      | Dmin=    | b=       | Qab=     |      |
| 7/2007        | 13325  | 7232   | 0    | 7232 | 0.419 | 0.0   | 0.000000 | 0.000    | 0.000000 | 0.0      |      |
| WELL COUNT    | Ref=   | Cum=   | Rem= | EUR= | Yrs=  | Qref= | De=      | Dmin=    | b=       | Qab=     |      |
| 7/2007        | 13325  | 7232   | 0    | 7232 | 0.419 | 0.0   | 0.000000 | 0.000    | 0.000000 | 0.0      |      |

SEQ #: 1374 MOBIL 1 SI  
 QUAIL QUEEN  
 LEA NM  
 CHESAPEAKE OPERATING, INC.  
 RSV CAT: 2PDSI

|               | WELL COUNT | 1000  | 100  | 10   | 1     | 0.1    |
|---------------|------------|-------|------|------|-------|--------|
| GOR-SCF/BBL   | 100000     | 10000 | 1000 | 100  | 10    | 10     |
| WATER-BBL/DAY | 10000      | 1000  | 100  | 10   | 1     | 0.1    |
| GAS-MCF/DAY   | 100        | 10    | 1    | 0.1  | 0.01  | 0.001  |
| OIL-BBL/DAY   | 10         | 1     | 0.1  | 0.01 | 0.001 | 0.0001 |

YEAR

OIL-BBL/DAY  
 Qual= CEC0407  
 Ref= 7/2007  
 Cum= 3243  
 EUR= 0.419  
 Yrs= 0.0  
 De= 0.000000  
 Dmin= 0.000  
 b= 0.000000  
 Qab= 0.0

GAS-MCF/DAY  
 Ref= 7/2007  
 Cum= 492

WATER-BBL/DAY  
 Ref= 7/2007  
 Cum= 492

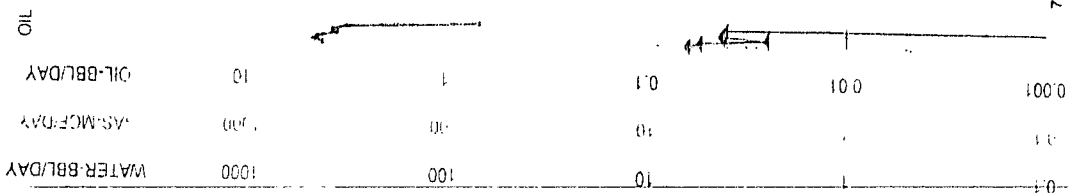
WATER-BBL/DA  
 Ref= 7/2007  
 Cum= 9483

GOR-SCF/BBL  
 Ref= 7/2007  
 Cum= 2969

WATER\_INJ-BB  
 Ref= 7/2007  
 Cum= 8039

WELL COUNT  
 Ref= 7/2007  
 Cum= 3

SEQ #: 1377 STATE 1 SI  
QUAIL QUEEN  
LEA, NM  
CHESAPEAKE OPERATING, INC.  
RSV CAT: 2PDSI



| OIL-BBL/DAY   | GAS-MCF/DAY | WATER-BBL/DA | GOR-SCF/BBL | WATER_INJ-BB | WELL COUNT  |
|---------------|-------------|--------------|-------------|--------------|-------------|
| Qual= CEC0407 | Ref= 7/2007 | Ref= 7/2007  | Ref= 7/2007 | Ref= 7/2007  | Ref= 7/2007 |
| Qmax= 1667    | Cum= 0      | Cum= 1821    | Cum= 962    | Cum= 1020    | Cum= 7      |
| Rem= 0        |             |              |             |              |             |
| EUR= 1667     |             |              |             |              |             |
| Yrs= 0.419    |             |              |             |              |             |
| Qref= 0.0     |             |              |             |              |             |
| De= 0.000000  |             |              |             |              |             |
| Omin= 0.000   |             |              |             |              |             |
| b= 0.000000   |             |              |             |              |             |
| Qab= 0.0      |             |              |             |              |             |

GOR-SCF/BBL

100000

10000

1000

100

10

SEQ #:922 STATE C 1

QUAIL  
LEA, NM  
CHESAPEAKE OPERATING, INC.  
RSV CAT: 1PDP

OIL

OIL-BBL/DAY

GAS-MCF/DAY

WATER-BBL/DAY

0

1000

10000

1

10

100

0.1

10

100

0.01

1

10

0.001

0.1

1

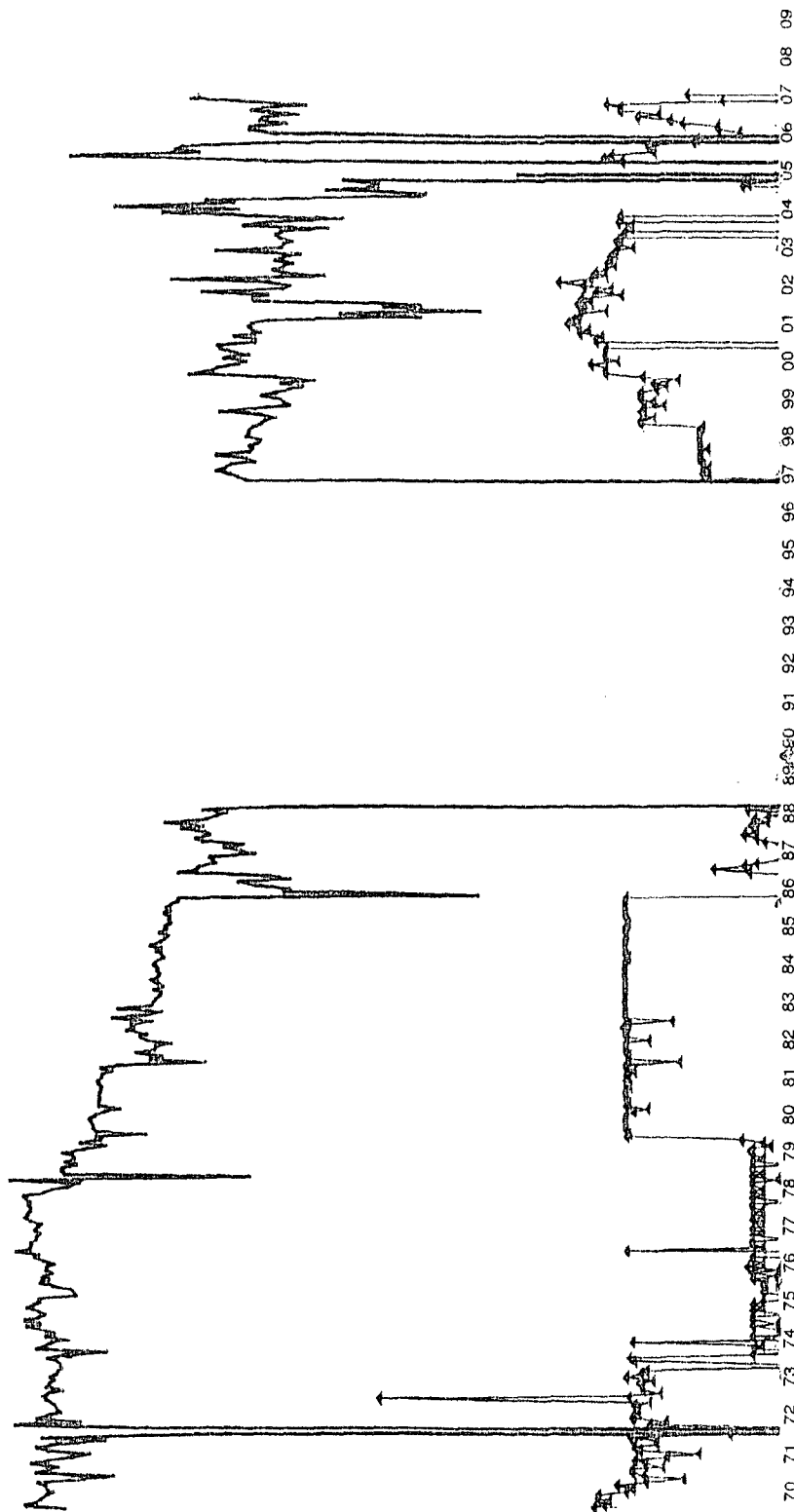
YEAR

OIL-BBL/DAY  
Ref= 7/2007  
Cum= 24898

GAS-MCF/DAY  
Ref= 7/2007  
Cum= 0

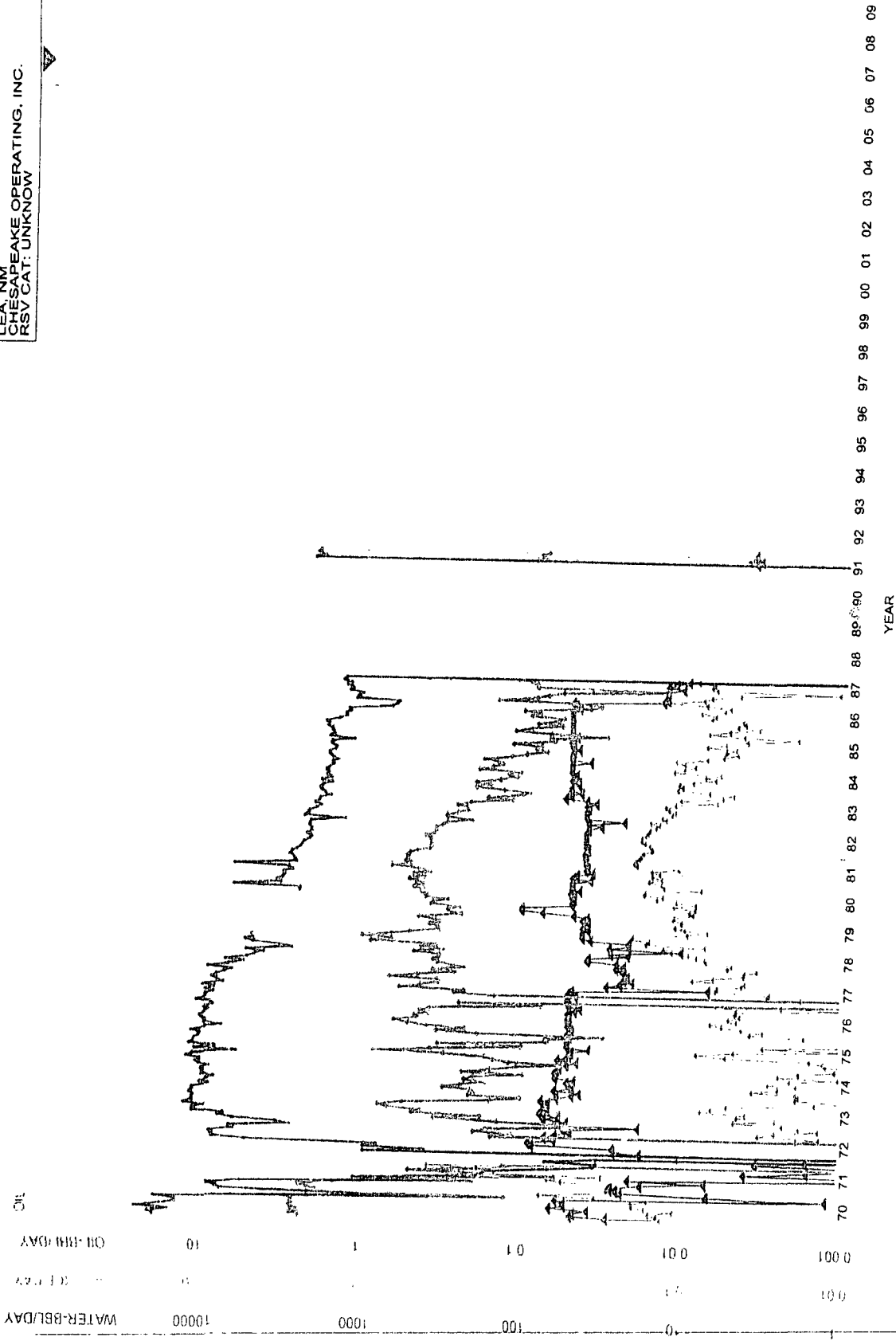
WATER-BBL/DAY  
Ref= 7/2007  
Cum= 47219

GOR-SCF/BBL  
Ref= 7/2007  
Cum= 866



|             |       |        |        |       |      |
|-------------|-------|--------|--------|-------|------|
| WELL COUNT  | 1e+07 | 1e+06  | 100000 | 10000 | 1000 |
| GOR-SCF/BBL | 1e+06 | 100000 | 10000  | 1000  | 100  |

SEQ #:1378 STATE BG 1 SI  
 QUAIL QUEEN  
 LEA, NM  
 CHESAPEAKE OPERATING, INC.  
 RSV CAT: UNKNOWN



|               |       |         |      |        |      |        |      |        |      |       |     |     |       |          |    |          |      |     |
|---------------|-------|---------|------|--------|------|--------|------|--------|------|-------|-----|-----|-------|----------|----|----------|------|-----|
| OIL-BBL/DAY   | Qual= | CEC0407 | Ref= | 7/2007 | Cum= | 66301  | EUR= | 66301  | Yrs= | 0.419 | De= | 0.0 | Dmin= | 0.000000 | b= | 0.000000 | Qab= | 0.0 |
| GAS-MCF/DAY   | Qual= | CEC0407 | Ref= | 7/2007 | Cum= | 45236  | EUR= | 45236  | Yrs= | 0.419 | De= | 0.0 | Dmin= | 0.000000 | b= | 0.000000 | Qab= | 0.0 |
| WATER-BBL/DAY | Qual= | CEC0407 | Ref= | 7/2007 | Cum= | 321428 | EUR= | 321428 | Yrs= | 0.419 | De= | 0.0 | Dmin= | 0.000000 | b= | 0.000000 | Qab= | 0.0 |
| GOR-SCF/BBL   | Qual= | CEC0407 | Ref= | 7/2007 | Cum= | 33805  | EUR= | 33805  | Yrs= | 0.419 | De= | 0.0 | Dmin= | 0.000000 | b= | 0.000000 | Qab= | 0.0 |
| WATER-INJ-BB  | Qual= | CEC0407 | Ref= | 7/2007 | Cum= | 57047  | EUR= | 57047  | Yrs= | 0.419 | De= | 0.0 | Dmin= | 0.000000 | b= | 0.000000 | Qab= | 0.0 |
| WELL COUNT    | Qual= | CEC0407 | Ref= | 7/2007 | Cum= | 0      | EUR= | 0      | Yrs= | 0.419 | De= | 0.0 | Dmin= | 0.000000 | b= | 0.000000 | Qab= | 0.0 |

GOR-SCF/BBL

100000

10000

1000

100

10

SEQ #:1372 STATE BG 2

QUAIL QUEEN

LEASING

OPERATING, INC.

RSV CAT: TPDP

OIL

OIL BBL/DAY

-AS MCF/DAY

WATER-BBL/DAY

10

100

1000

1

10

100

0.1

1

10

0.01

0.1

1

0.001

0.01

0.1

77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38

YEAR

OIL-BBL/DAY  
Qual= CEC0407  
Ref= 7/2007  
Cum= 52522  
Rem= 21187  
EUR= 73709  
Yrs= 30.082  
Qref= 3.2  
De= 3.700000  
Dmin= 0.000  
b= 0.000000  
Qab= 1.0

GAS-MCF/DAY  
Ref= 7/2007  
Cum= 30087

WATER-BBL/DAY  
Ref= 7/2007  
Cum= 156536

GOR-SCF/BBL  
Ref= 7/2007  
Cum= 0

GOR-SCF/BBL

100000

10000

1000

100

10

SEQ #:1371 STATE BG 3

QUAL NM QUEEN

CHESAPEAKE OPERATING, INC.

RSV CAT: 1PDP

OIL

OIL-BBL/DAY

GAS-MCF/DAY

WATER-BBL/DAY

10

100

10000

1

10

1000

0.1

10

100

0.01

1

10

0.001

0.1

10

78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39

YEAR

OIL-BBL/DAY  
Qual= GGA0707  
Ref= 7/2007  
Cum= 44121  
EUR= 17980  
Yrs= 30.082  
Cref= 2.7  
De= 3.678537  
Dmin= 0.000  
b= 0.000000  
Qab= 0.9

GAS-MCF/DAY  
Ref= 7/2007  
Cum= 24222

WATER-BBL/DAY  
Ref= 7/2007  
Cum= 135030

GOR-SCF/BBL  
Ref= 7/2007  
Cum= 0



# Quail Queen Field OOIP Calculation

## Appendix B

### Reservoir Parameters:

$$\text{BHT} = 113^{\circ}\text{F}$$

$$p_i = 1,848 \text{ psi}$$

$$P_{sp} (\text{est.}) = 100 \text{ psi}$$

$$p_b = 1,255 \text{ psi}$$

$$T_{sp} (\text{est.}) = 90^{\circ}\text{F}$$

$$R_{si} = 300 \text{ cf/bbl}$$

$$\text{Gas } G = 0.9$$

$$\beta_{oi} = 1.15$$

$$\text{Oil } G = 33^{\circ} \text{ API}$$

$$\beta_{ob} = 1.15$$

$$p_{ab} = 250 \text{ psi}$$

$$\beta_{oab} = 1.04$$

$$p_{cur} = 450 \text{ psi}$$

$$\beta_{ocur} = 1.06$$

### OOIP Calculation:

#### Queen B

$$\begin{aligned} \text{OOIP} &= \frac{7758 * Ah * \Phi * (1-S_w)}{\beta_{oi}} = \frac{7758 * 2874 * 0.10 * (1-0.49)}{1.15} \\ &= 988,800 \text{ STB} \end{aligned}$$

#### Queen C

$$\begin{aligned} \text{OOIP} &= \frac{7758 * Ah * \Phi * (1-S_w)}{\beta_{oi}} = \frac{7758 * 7212 * 0.13 * (1-0.45)}{1.15} \\ &= 3,478,673 \text{ STB} \end{aligned}$$

#### Queen B and Queen C

$$\text{OOIP} = 988,800 + 3,478,673 = \boxed{4,467,473 \text{ STB}}$$

## Appendix C

### Proposed Quail Queen Unit Waterflood Calculations

#### Reservoir Parameters:

|                      |                        |                           |
|----------------------|------------------------|---------------------------|
| BHT = 113°F          | $p_i = 1,848$ psi      | $P_{sp}$ (est.) = 100 psi |
| $p_b = 1,255$ psi    | $T_{sp}$ (est.) = 90°F | $R_{si} = 300$ cf/bbl     |
| Gas G = 0.9          | $\beta_{oi} = 1.15$    | Oil G = 33° API           |
| $\beta_{ob} = 1.15$  | $p_{ab} = 250$ psi     | $\beta_{oab} = 1.04$      |
| $p_{cur} = 450$ psi  | $\beta_{ocur} = 1.06$  | $\mu_{ocur} = 4.21$ cp    |
| $\mu_{wcur} = 0.915$ |                        |                           |

1. As previously calculated in Appendix B

$$\text{OOIP} = N = 4,467,473 \text{ STB}$$

2. Oil Saturation at primary abandonment pressure of 250 psi

$$\begin{aligned} S_{or-pri} &= (1 - \Delta N_p / N) (\beta_{oab} / \beta_{oi}) (1 - S_w) \\ &= [1 - (866,568 / 4,467,473)] (1.04 / 1.15) (1 - 0.45) \\ &= (0.8060) (0.9043) (0.55) \\ &= 0.4009 \end{aligned}$$

Estimating water injection to start by July 1, 2008 then oil saturation at start of flood is calculated with current pressure and another 8,390 bbls of oil produced.

$$\begin{aligned} S_{ocur} &= [1 - (874,958 / 4,467,473)] (1.06 / 1.15) (1 - 0.45) \\ &= (0.8041) (0.9217) (0.55) \\ &= 0.4077 \end{aligned}$$

$$3. \text{ Mobility Ratio} = \lambda_w / \lambda_o = (k_{rw} / \mu_w) / (k_{ro} / \mu_o)$$

Mobility of the water in the water bank

The fractional flow curve shows the average water saturation in the water bank is 54 percent. At this water saturation the relative permeability curve shows the  $k_{rw}$  to be 0.12. The viscosity of the water at 450 psi is 0.915.

$$\lambda_w = k_{rw} / \mu_w = 0.12 / 0.915 = 0.13$$

Mobility of the oil in the oil bank

In the oil bank the relative permeability to oil is 100 percent.

$$\lambda_o = k_{ro} / \mu_o = 1.0 / 4.21 = 0.23$$

$$\text{Mobility Ratio} = M = 0.13 / 0.23 = \boxed{0.57}$$

M is less than 1 which is favorable for waterflooding because it is easier for water to displace oil in the reservoir.

#### 4. Permeability Variation (See Attachment No. 15)

$$V = \frac{k_{50} - k_{84}}{K_{50}} = \frac{3.2 - 0.55}{3.2} = \frac{2.65}{3.2} = \boxed{0.828}$$

V less than 0.75 is good, so this value indicates a fairly high level of variation.

#### 5. Volumetric Sweep Efficiency

Empirical correlation with 100 layer Higgins-Leighton streamtube model show WOR = 25,  $E_v = 70\%$  and at a WOR = 50,  $E_v = \boxed{72\%}$

Refer to Fig.'s 6.22 and 6.23, Page 206, Wilhite's SPE Text Vol. 3.

#### 6. Waterflood Recovery

$$\begin{aligned} \text{Secondary Reserves} &= 7758 Ah \Phi (S_{or-pri} - S_{or}) E_v / \beta_{ocut} \\ &= [7758 * 10,086 * 0.13 (0.4009 - 0.30) 0.72] / 1.06 \\ &= \boxed{697,156 \text{ STB}} \end{aligned}$$

$$\text{Secondary Recovery Factor} = 697,156 / 4,467,473 = \boxed{0.156}$$

$$\text{Secondary : Primary Ratio} = 697,156/866,568 = \boxed{0.805}$$

7. Gas Saturation estimated at start of flood

Assume injection begins July 1, 2008

$$\begin{aligned} S_{oc} &= (1 - \Delta N_p / N) (\beta_{ocur} / \beta_{oi}) (1 - S_w) \\ &= (1 - (866,568/4,467,473)) (1.06 / 1.15) (1-0.45) \\ &= 0.806 * 0.9217 * 0.55 \\ &= \boxed{0.4085} \end{aligned}$$

$$\begin{aligned} S_{gc} &= 1 - S_{oc} - S_w \\ &= 1 - 0.4085 - 0.45 \\ &= \boxed{0.14} \end{aligned}$$

8. Water Injection at Fillup

$$\begin{aligned} W_{if} &= 7758 A\Phi h S_{gc} \\ &= 7758 (1788) (0.13) (5.64) (0.14) \\ &= \boxed{1,423,862 \text{ BBLS}} \end{aligned}$$