KELLAHIN AND KELLAHIN
ATTORNEYS AT LAW
EL PATIO BUILDING
117 NORTH GUADALUPE
POST OFFICE BOX 2265
SANTA FE, NEW MEXICO 87504-2265

W. THOMAS KELLAHIN*

*NEW MEXICO BOARD OF LEGAL SPECIALIZATION
RECOGNIZED SPECIALIST IN THE AREA OF
NATURAL RESOURCES-OIL AND GAS LAW

JASON KELLAHIN (RETIRED 1991)

TELEPHONE (505) 982-4285
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March 29, 1993

Mr. William J. LeMay
Oil Conservation Division
State Land Office Building
310 Old Santa Fe Trail, Room 219
Santa Fe, New Mexico 87501

HAND DELIVERED

10724

RECEIVED
MAR 29 1993
OIL CONSERVATION DIVISION

RE: Application of Meridian Oil, Inc.
for an Unorthodox Well Location
and Downhole Commingling,
San Juan County, New Mexico
Rhodes C #101 Well

Dear Mr. LeMay:

On behalf of Meridian Oil, Inc. please find enclosed our Application for an unorthodox well location and downhole commingling as referenced above, which we request be set for hearing on the next available Examiner's docket now scheduled for April 22, 1993.

By copy of this letter and application, sent certified mail-return receipt requested, we are notifying all interested parties offsetting the subject well and its proposed spacing and proration unit of their right to appear at the hearing and participate in this case, including the right to present evidence either in support of or in opposition to the application and that failure to appear at the hearing may preclude them from any involvement in this case at a later date. Also, all parties entitled to notice are hereby informed that pursuant to the Division Memorandum 2-90 all parties appearing in this case are requested to file a Pre-Hearing Statement with the Division no later than 4:00 p.m. on Friday, April 16, 1993.

Also enclosed is our suggested advertisement for this case.

Very truly yours,

W. Thomas Kellahin

WTK/lam
Enclosures

cc: **with Enclosures**
Alan Alexander - Meridian Oil Inc.

By Certified Mail - Return Receipt
All Parties Listed on Exhibits B & C of Application

ltrt329c.330

PROPOSED ADVERTISEMENT

10724

Case ____________: **Application of Meridian Oil Inc. for an unorthodox gas well location and downhole commingling, San Juan County, New Mexico.** Applicant seeks approval to downhole commingle West Kutz-Pictured Cliffs Gas Pool and the Basin-Fruitland Coal Gas Pool production within the wellbore of its proposed Rhodes C #101 Well to be drilled at an unorthodox gas well location for both the West Kutz-Pictured Cliffs Gas Pool and the Basin-Fruitland Coal Gas Pool, being 100 feet FSL and 2270 feet FWL, (Unit N) Section 30, T28N, R11W, NMPM, San Juan County, New Mexico. Said well is to be dedicated a standard 316.02 acre gas spacing unit for the Basin-Fruitland Coal Gas Pool being W/2 of Section 30 and to a standard 158.06 acre gas spacing unit for the West Kutz-Pictured Cliffs Gas Pool being the SW/4 of Section 30. The well is located approximately 7 miles south from Bloomfield, New Mexico.

STATE OF NEW MEXICO
ENERGY, MINERALS AND NATURAL RESOURCES DEPARTMENT
OIL CONSERVATION DIVISION

IN THE MATTER OF THE HEARING CALLED BY THE OIL CONSERVATION DIVISION FOR THE PURPOSE OF CONSIDERING:

APPLICATION OF MERIDIAN OIL INC. FOR AN UNORTHODOX GAS WELL LOCATION AND DOWNHOLE COMMINGLING SAN JUAN COUNTY, NEW MEXICO.

CASE: 10724

APPLICATION

Comes now MERIDIAN OIL INC., ("Meridian") by and through its attorneys Kellahin and Kellahin, and applies to the New Mexico Oil Conservation Division for approval to downhole commingle West Kutz-Pictured Cliffs Gas Pool and the Basin-Fruitland Coal Gas Pool production within the wellbore of its proposed Rhodes C #101 Well to be drilled at an unorthodox gas well location for both the Basin Fruitland Coal Gas Pool and the West Kutz-Pictured Cliffs Gas Pool being 100 feet FSL and 2270 feet FWL, (Unit N) Section 30, T28N, R11W, NMPM, San Juan County, New Mexico. The W/2 of Section 30 is to be dedicated to the subject well forming a standard 316.02 acre gas spacing unit for the Basin-Fruitland Coal Gas Pool. The SW/4 of Section 30 is to be dedicated to the subject well forming a standard 158.06 acre gas spacing unit for the West Kutz-Pictured Cliffs Gas Pool.

In support of its application, Meridian states:

(1) Meridian is the operator for the proposed Rhodes C #101 Well to be drilled at an unorthodox gas well location 100 feet FSL and 2270 feet FWL (Unit N), Section 30, T28N, R11W, NMPM, San Juan County, New Mexico as shown on Exhibit "A" attached.

(2) Said location is an unorthodox gas well location for both the Basin-Fruitland Coal Gas Pool and the West Kutz-Pictured Cliffs Gas Pool being only 100 feet from the south line and 370 feet from the east side of its spacing unit rather than the required 790 feet from the outer boundaries of the spacing units for both pools.

(3) The T. L. Rhodes "C" Lease consists of all of Section 30 and the N/2 of Section 31, T28N, R11W, NMPM, with all of the interest owners (royalty, working and overriding riding royalty) being common.

(4) The proposed surface location is based in part upon topographical limitation imposed in the S/2 of said Section 30 by the "NAPI" irrigation project.

(5) While the proposed well location is unorthodox pursuant to Division rules, it only encroaches upon offsetting spacing units which have ownerships identical to the subject spacing unit and therefore correlative rights will not be impaired.

(6) The Well is to be drilled so that production from the Basin-Fruitland Coal Gas Pool and the West Kutz-Pictured Cliffs Gas Pool can be downhole commingled in the wellbore.

(7) The W/2 of Section 30 being 316.02 acres is to be dedicated to any production from the Basin-Fruitland Coal Gas Pool which is spaced on 320-acre gas spacing units.

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(10) In accordance with Division Rule 303-C-1.(b), the Applicant states and will demonstrate at hearing:

1. That drilling the Rhodes C #101 Well initially for downhole commingling in the wellbore is necessary because it is not otherwise economic to

attempt to drill and complete a separate well for either Fruitland Coal Gas or Pictured Cliffs Gas production nor is it economic to attempt to dually complete those formations in the proposed well.

2. That there will be no crossflow between the two zones commingled.

3. That the ownership in each of the two spacing units is common between the two pools and no impairment of correlative rights will occur.

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(12) Meridian has selected to drill the proposed well in the SW/4 instead of the NW/4 of Section 30 because that location appears to have a greater opportunity for a successful although marginal Fruitland formation well.

(13) In addition, the SW/4 of Section 30 is a standard location for a Fruitland Coal Gas Well while the NW/4 is an unorthodox location.

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(15) Applicant requests that this matter be docketed for hearing on the Division's Examiner docket now scheduled for April 22, 1993.

(16) Copy of this application has been sent to all offsetting operators to the two spacing units as set forth on Exhibits B and C.

WHEREFORE Applicant requests that this matter be set for hearing on April 22, 1993 before a duly appointed Examiner of the Oil Conservation Division and that after notice and hearing as required by law, the Division enter its order granting this application.

Respectfully submitted

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app329c.330

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RHODES C # 101 WELL
100'FSL,2270'FWL
SECTION 30-28N-11W

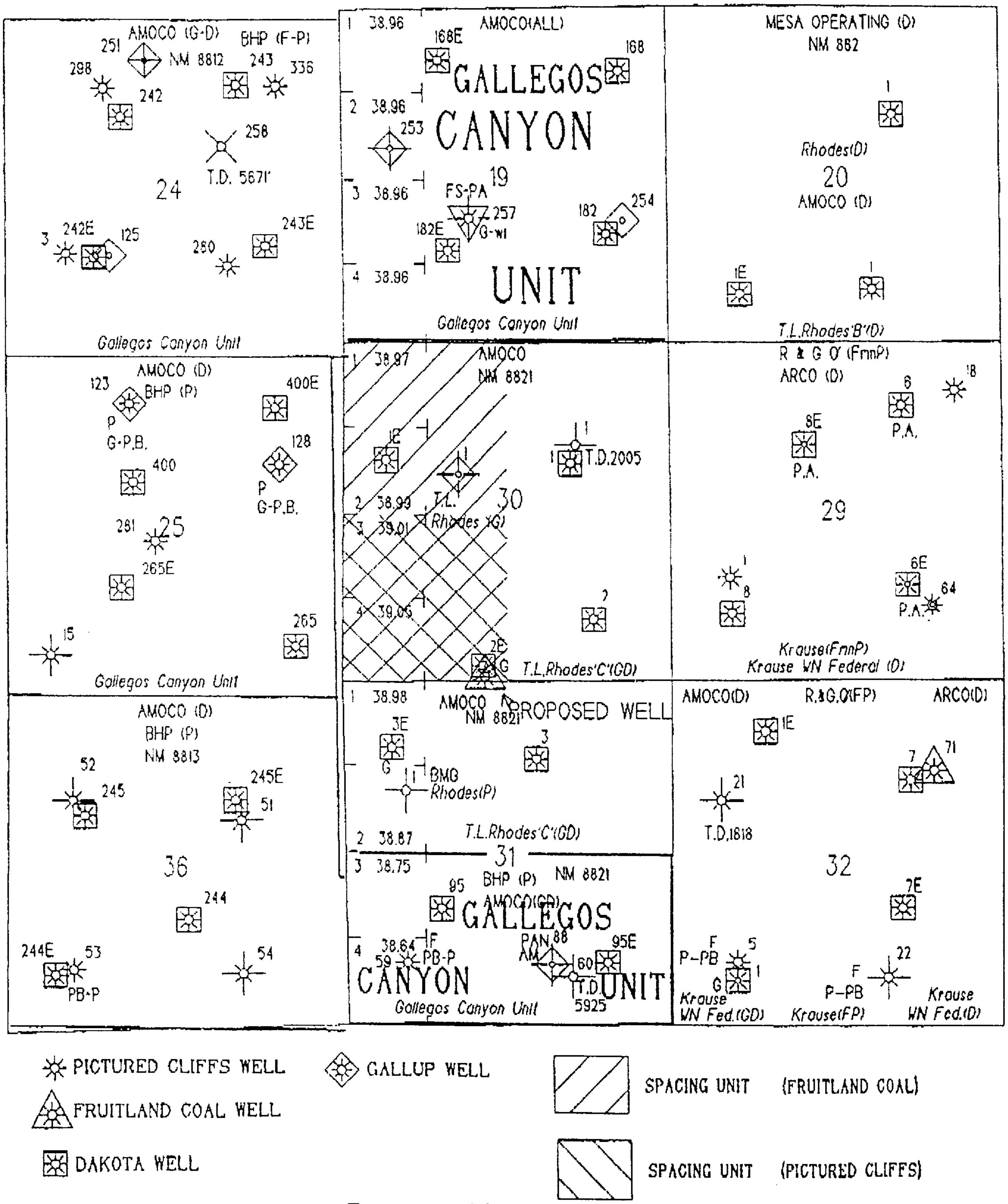


EXHIBIT "A"

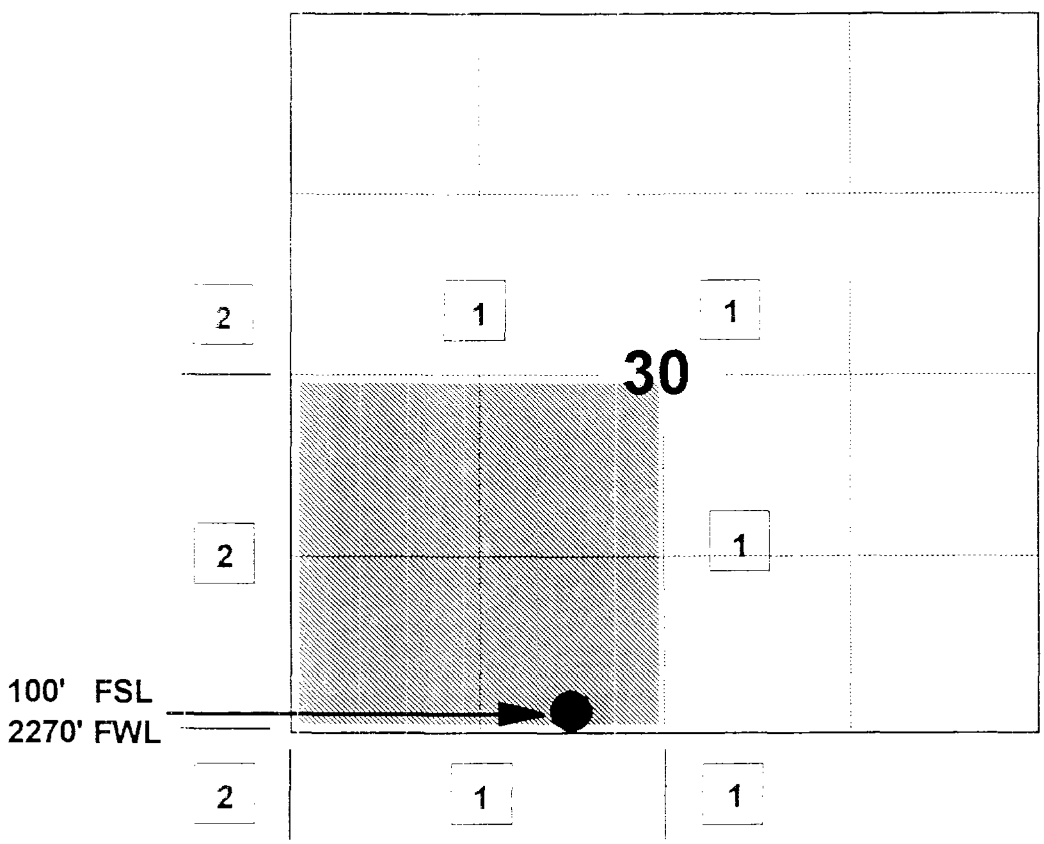
MERIDIAN OIL INC

OFFSET OPERATOR \ OWNER PLAT

RHODES C #101

Fruitland Coal \ Pictured Cliffs Formations Commingle

Township 28 North, Range 11 West



1) Merdian Oil Inc

2) Amoco Production Company PO Box 800, Denver, CO 80202

EXHIBIT B

Pictured Cliffs Formation

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OFFSET OPERATOR \ OWNER PLAT

RHODES C #101

Fruitland Coal \ Pictured Cliffs Formations Commingle

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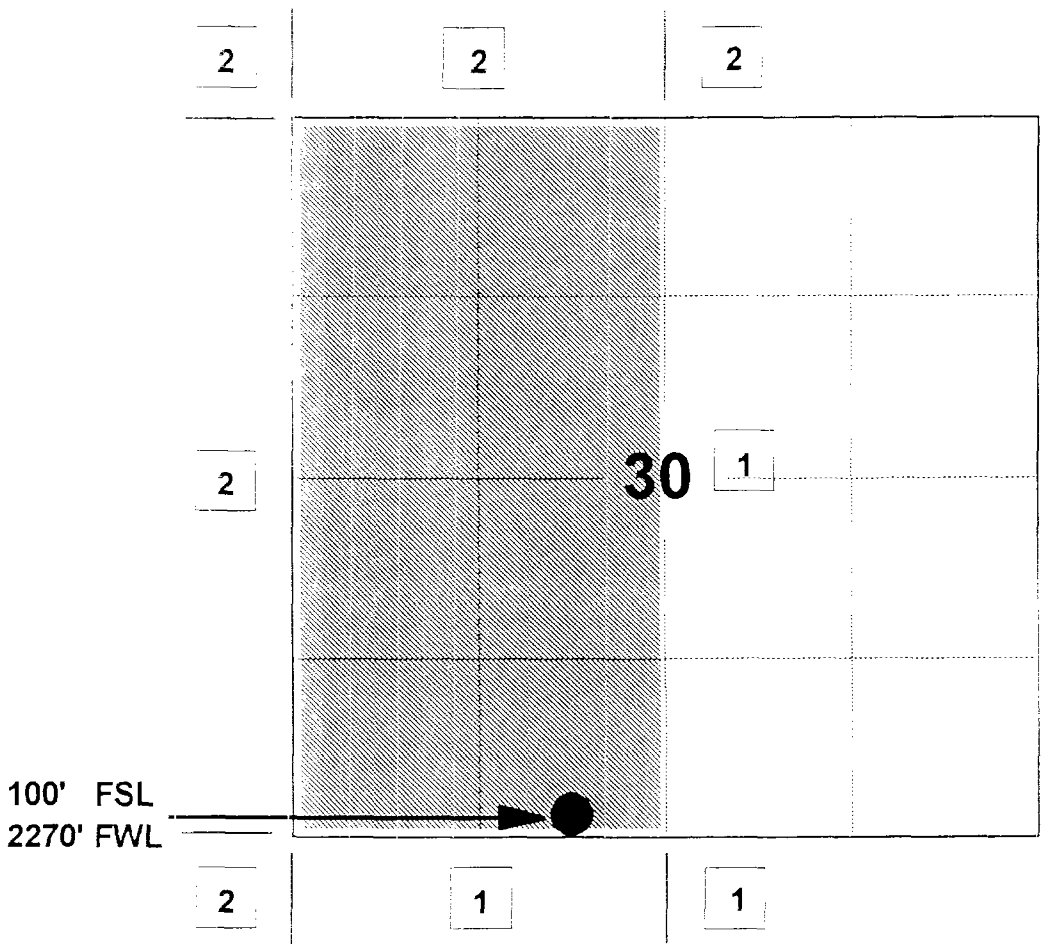

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EXHIBIT C

Fruitland Coal Formation

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100'FSL,2270'FWL
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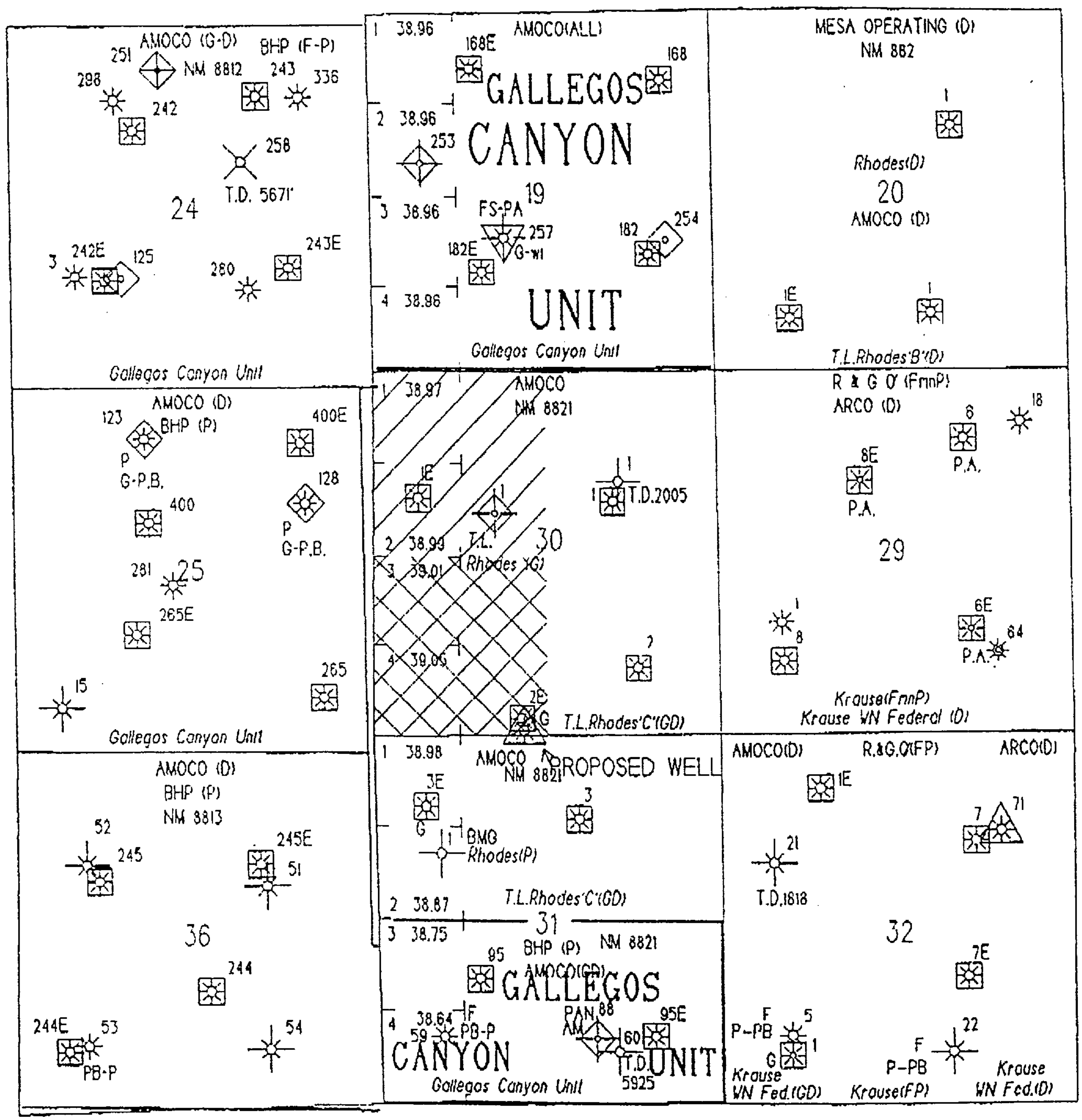

PICTURED CLIFFS WELL

GALLUP WELL

FRUITLAND COAL WELL

DAKOTA WELL

SPACING UNIT (FRUITLAND COAL)

SPACING UNIT (PICTURED CLIFFS)

EXHIBIT "A"

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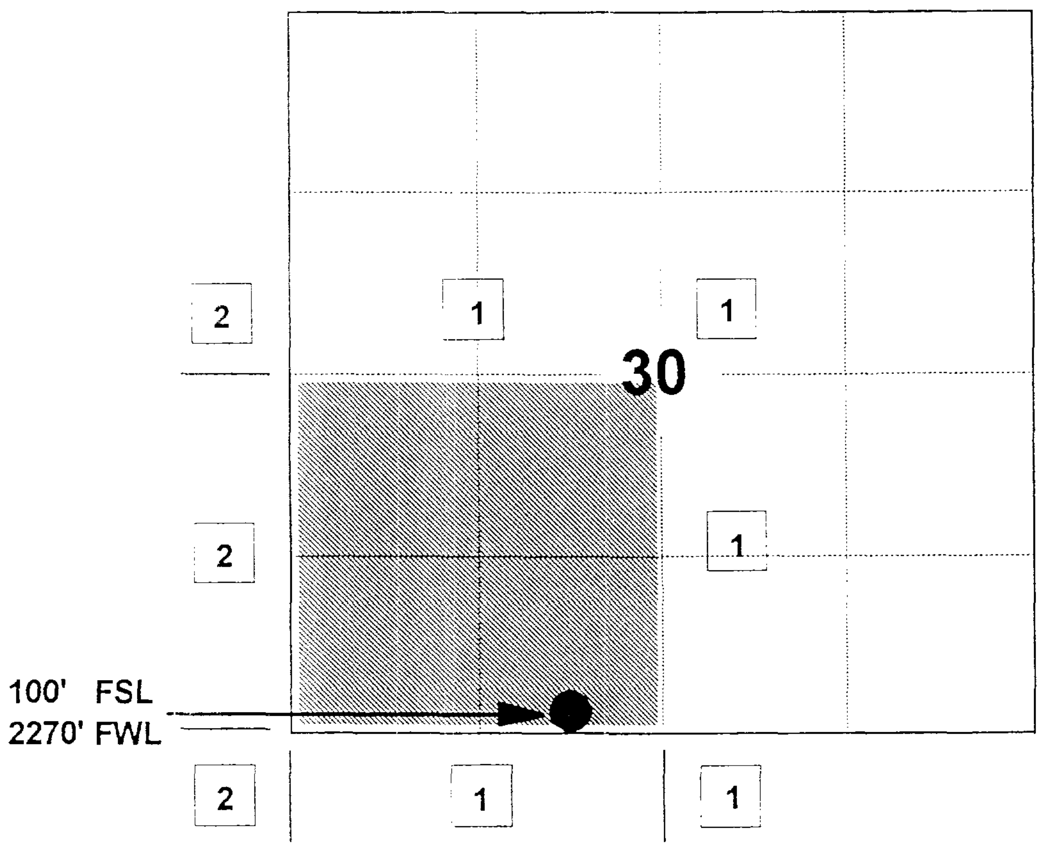
OFFSET OPERATOR \ OWNER PLAT

RHODES C #101

Fruitland Coal \ Pictured Cliffs Formations Commingle

Township 28 North, Range 11 West



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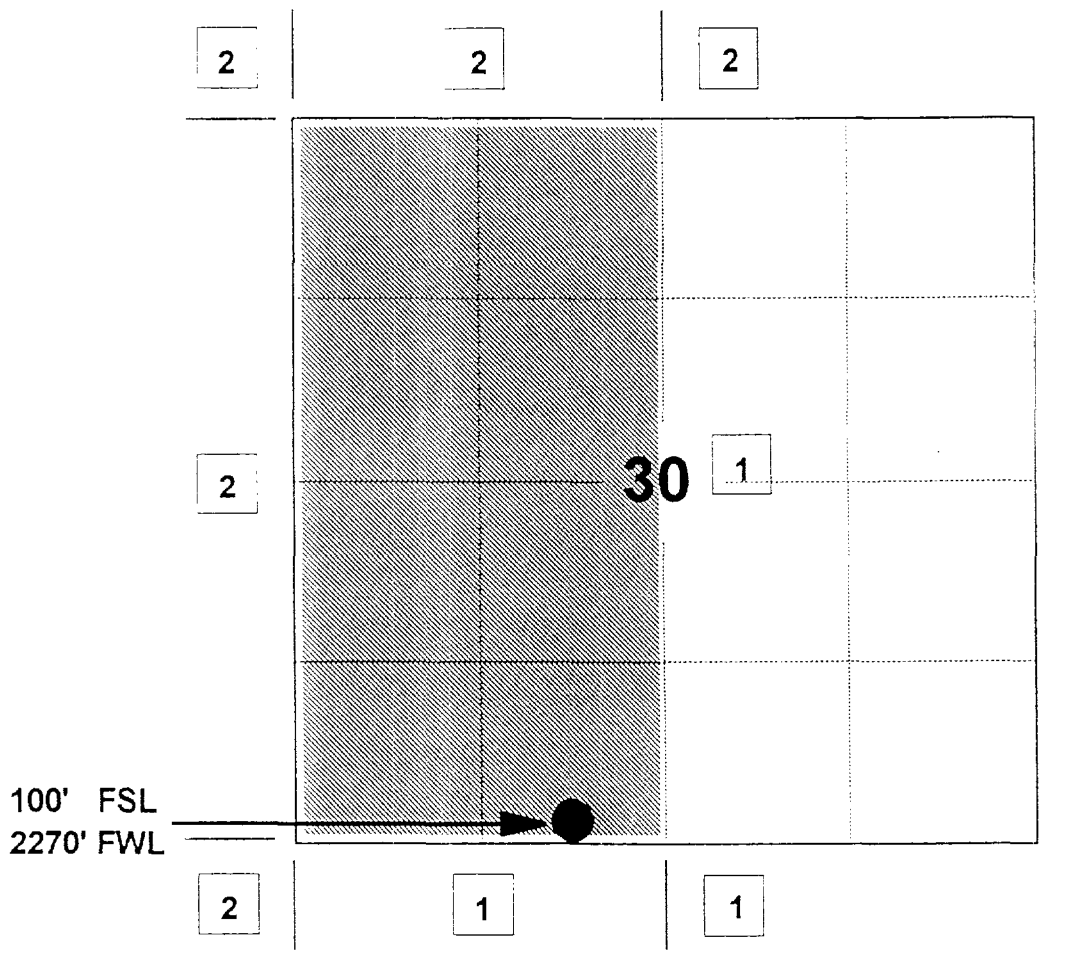

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APPLICATION OF MERIDIAN OIL INC. FOR AN UNORTHODOX GAS WELL LOCATION AND DOWNHOLE COMMINGLING SAN JUAN COUNTY, NEW MEXICO.

CASE: 10729

A P P L I C A T I O N

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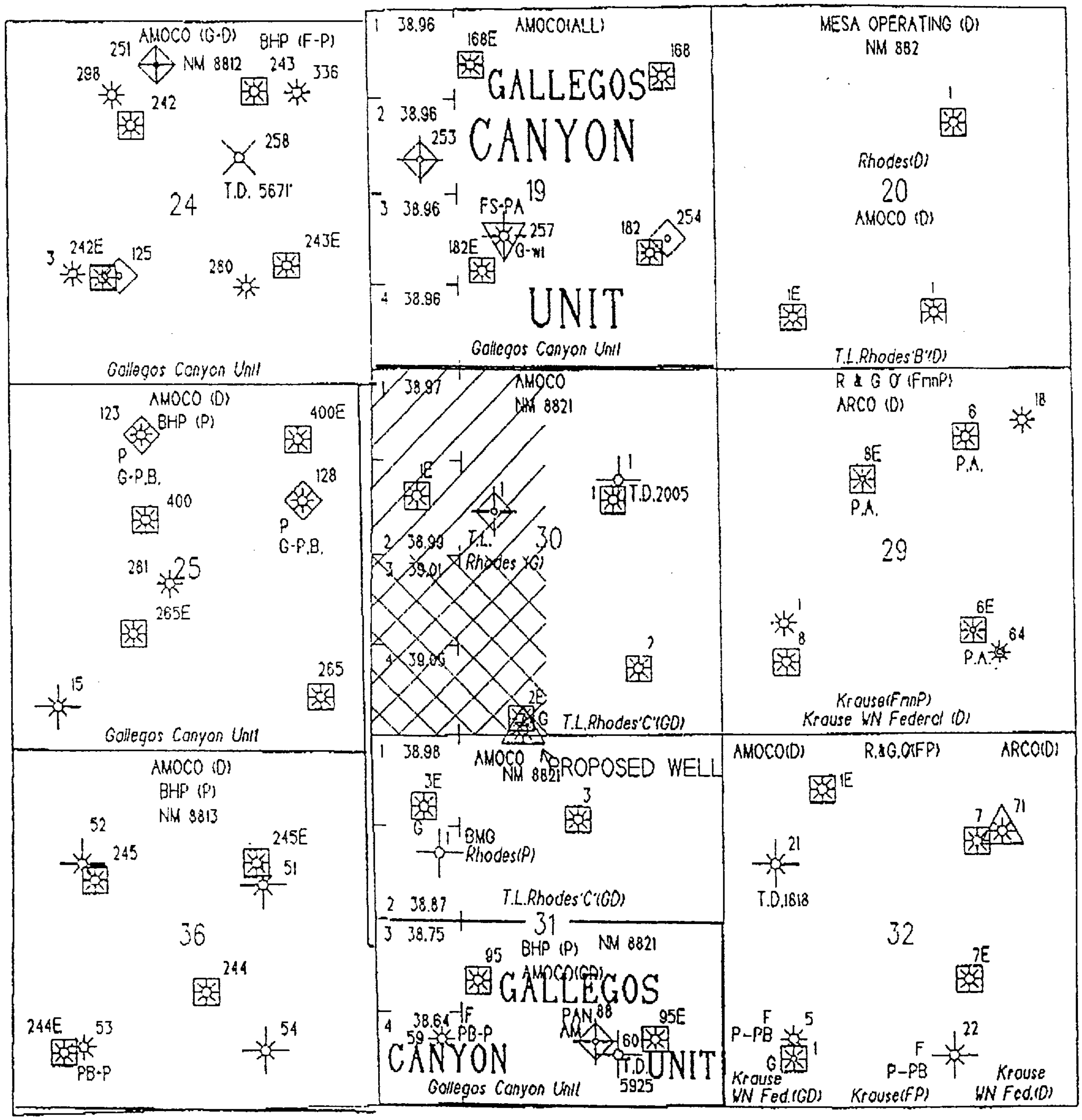

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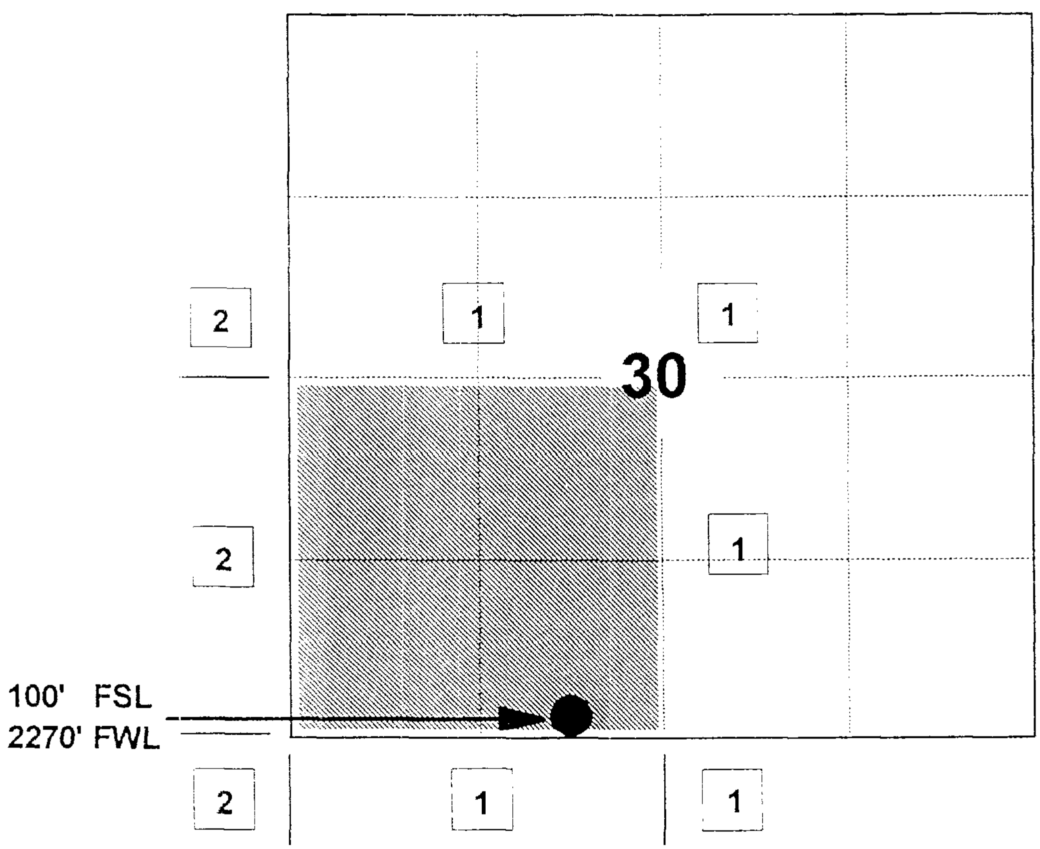
Fruitland Coal \ Pictured Cliffs Formations Commingle

Township 28 North, Range 11 West



1) Merdian Oil Inc

2) Amoco Production Company PO Box 800, Denver, CO 80202

EXHIBIT B

Pictured Cliffs Formation

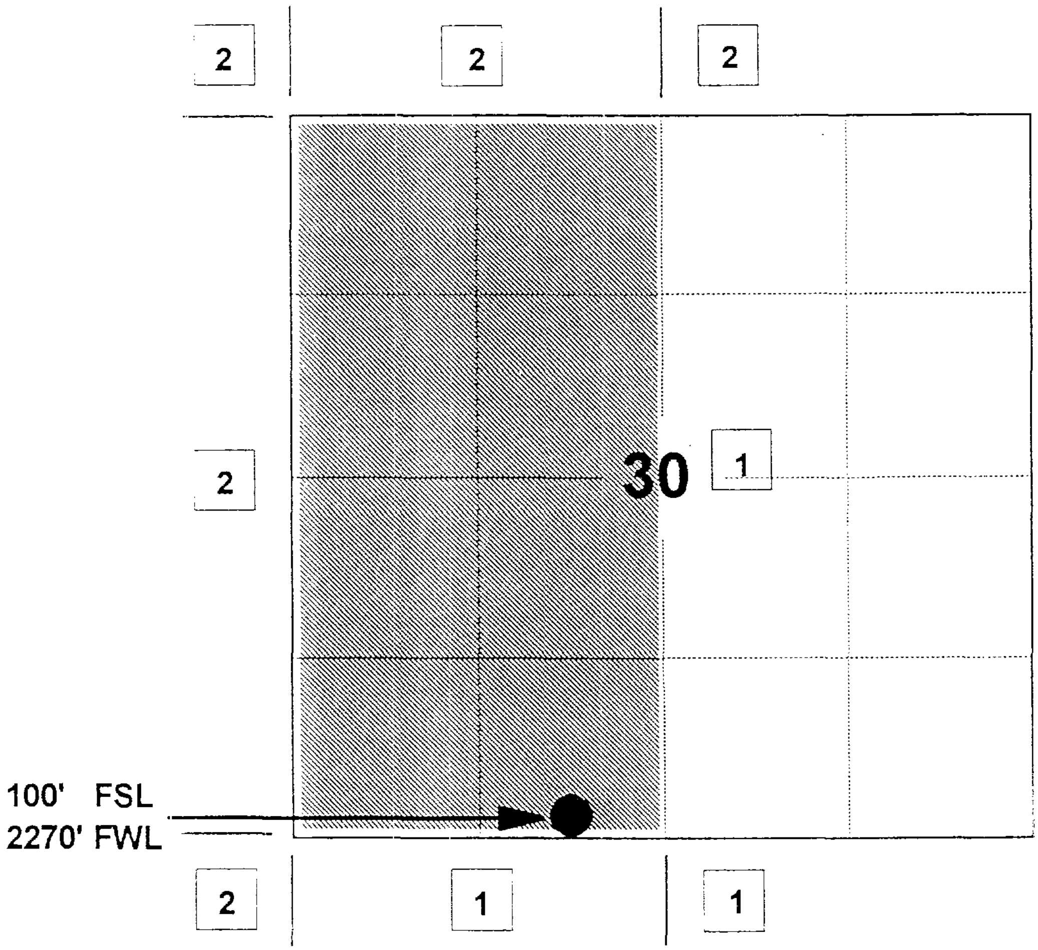
MERIDIAN OIL INC

OFFSET OPERATOR \ OWNER PLAT

RHODES C #101

Fruitland Coal \ Pictured Cliffs Formations Commingle

Township 28 North, Range 11 West



1) Merdian Oil Inc

2) Amoco Production Company PO Box 800, Denver, CO 80202

EXHIBIT C

Fruitland Coal Formation

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May 21, 1993

HAND DELIVERED

Michael E. Stogner
Oil Conservation Division
310 Old Santa Fe Trail
Santa Fe, New Mexico 87501

Re: Meridian Oil Inc.
DHC cases

Dear Mike:

I have enclosed a 5.25 floppy disk which contains the DHC allocation formula for NMOCD Cases 10721 through 10725. In addition, I have enclosed a hard copy of that formula for each case and printed such that it can be attached to the respective order as an exhibit. Please call me if you need anything else.

Tom

RHODES C #101

MONTHLY GAS PRODUCTION ALLOCATION FORMULA

GENERAL EQUATION

$$Q = Qftc + Qpc$$

WHERE: Qt = TOTAL MONTHLY PRODUCTION (MCF/MONTH)

Qftc = FRUITLAND COAL (FTC) MONTHLY PRODUCTION
Qpc = PICTURED CLIFFS (PC) MONTHLY PRODUCTION (MCF/MONTH)

REARRANGING THE EQUATION TO SOLVE FOR Qftc:

Qftc = Qt - Qpc

ANY PRODUCTION RATE OVER WHAT IS CALCULATED FOR THE PICTURED CLIFFS (PC) USING THE APPLIED FORMULA IS FRUITLAND COAL (FTC) PRODUCTION.

PICTURED CLIFFS (PC) FORMATION PRODUCTION FORMULA IS:

Qpc = Qpci * e^{-(Dpc)*(t)}

WHERE: Qpci = INITIAL PC MONTHLY FLOW RATE (CALCULATED FROM FLOW TEST)

Dpc = PICTURED CLIFFS MONTHLY DECLINE DATE DETERMINED FROM:

MATERIAL BALANCE (FIELD ANALOGY):
VOLUMETRIC RESERVES (LOG ANALYSIS)
G f(P*) = 1.05 MMCF/PSI x P* X Rf

P* = INITIAL RESERVOIR PRESSURE (7 DAY SIBHP)
RF = RECOVERY (FIELD ANALOGY): = 0.85

THUS: **Qftc = Qt - Qpci * e^{-(Dpc)*(T)}**

WHERE: (t) IS IN MONTHS

REFERENCE: Thompson, R. S., and Wright, J. D., "Oil Property Evaluation", pages 5-2, 5-3.

RHODES C #101

DETERMINATION OF Qpci:
(INITIAL PICTURED CLIFFS MONTHLY PRODUCTION)

$$\underline{Qpci = Qt(1) * Qpc(p) \backslash \{Qpc(p) + Qftc\ (p)\}}$$

WHERE:

Qt(1) = FIRST MONTH TOTAL PRODUCTION (MCF)

Qpc(p) = FINAL PICTURED CLIFFS FLOW TEST (MCFPD)

Qftc(p) = FINAL FRUITLAND COAL FLOW TEST (MCFPD)

RHODES C #101

MONTHLY GAS PRODUCTION ALLOCATION FORMULA

GENERAL EQUATION

Qt = Qftc + Qpc

WHERE: Qt = TOTAL MONTHLY PRODUCTION (MCF/MONTH)

Qftc = FRUITLAND COAL (FTC) MONTHLY PRODUCTION
Qpc = PICTURED CLIFFS (PC) MONTHLY PRODUCTION (MCF/MONTH)

REARRANGING THE EQUATION TO SOLVE FOR Qftc:

Qftc = Qt - Qpc

ANY PRODUCTION RATE OVER WHAT IS CALCULATED FOR THE PICTURED CLIFFS (PC) USING THE APPLIED FORMULA IS FRUITLAND COAL (FTC) PRODUCTION.

PICTURED CLIFFS (PC) FORMATION PRODUCTION FORMULA IS:

Qpc = Qpci * e^{-(Dpc)*(t)}

WHERE: **Qpci** = INITIAL PC MONTHLY FLOW RATE (CALCULATED FROM FLOW TEST)

Dpc = PICTURED CLIFFS MONTHLY DECLINE RATE CALCULATED FROM:
Dpc = **(Qpci-Qpcabd)/Np(pc)**
See Determination of Qpci and PC Estimated Ultimate Recovery (EUR)
Qpcabd = 300 MCF/M

WHERE: **Np(pc)** = PICTURED CLIFFS ESTIMATED ULTIMATE RECOVERY (EUR)
P*x 1.05 MMCF/PSI x Rf**
P* = INITIAL RESERVOIR PRESSURE (7 DAY SIBHP)
RF = RECOVERY (FIELD ANALOGY): = 0.85
** DETERMINED FROM MATERIAL BALANCE (FIELD ANALOGY) AND VOLUMETRIC RESERVES (LOG ANALYSIS)

By calculating PC EUR FROM SIBHP and determining PC initial flow rate, Dpc can then be estimated utilizing the previously described parameters

THUS: **Qftc = Qt - Qpci * e^{-(Dpc)*(t)}**

WHERE: **(t) IS IN MONTHS**

REFERENCE: Thompson, R. S., and Wright, J. D., "Oil Property Evaluation", pages 5-2, 5-3, 5-4.

RHODES C #101

DETERMINATION OF Qpci:
(INITIAL PICTURED CLIFFS MONTHLY PRODUCTION)

Qpci = Qt(1) X Qpc(p) / {Qpc(p) + Qftc (p)}

WHERE:

Qt(1) = FIRST MONTH TOTAL PRODUCTION (MCF)

Qpc(p) = FINAL PICTURED CLIFFS FLOW TEST (MCFPD)

Qftc(p) = FINAL FRUITLAND COAL FLOW TEST (MCFPD)

RHODES C #101

EXAMPLE DETERMINATION OF:

(a) Np(pc)	PC EUR
(b) Qpci	INITIAL PC MONTHLY FLOW RATE
(c) Dpc	PC MONTHLY DECLINE RATE

(a) DETERMINATION OF Np(pc)

Np(pc) = 1.05 (MMCF/PSI) X P*(PSI) X Rf

P* = 300 PSI (FROM 7 DAY SIBHP)

Np(pc) = 1.05 MMCF/PSI X 300 PSI X 0.85

<u>Np(pc) = 267.8 MMCF</u>

(b) DETERMINATION OF Qpci

Qpci = Qt(1) X {Qpc(p)/(Qpc(p) + Qftc(p))}

Qt(1) =	15,000 MCF	1ST MONTH TOTAL PRODUCTION
Qpc(p) =	500 MCF/D	PC FLOW TEST
Qftc(p) =	400 MCF/D	FTC FLOW TEST

Qpci = 15,000 MCF/M X {500 MCF/D/(500 MCF/D + 400 MCF/D)}

<u>Qpci = 8,333 MCF/M</u>

(c) DETERMINATION OF Dpc

Dpc = (Qpci - Qpcabd)/Npc

Qpcabd = 300 MCF/M

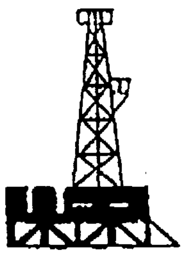
Dpc =(8,333MCF/M - 300MCF/M)/(267,800MCF)

<u>Dpc = 0.030/M</u>

<u>THUS: Qftc = Qt(MCF/M) - 8,333(MCF/M) X e^{-(0.030(1/M)) X t(M)}</u>

TELECOPIER FORM

MERIDIAN OIL



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HUERFANO UNIT #549

In order to facilitate an economic Pictured Cliffs completion three requirements must be met. It is the combination of these three requirements that determines the economic status and completion method (PC single completion, PC-FTC Dual, PC-FTC commingle) utilized. These three requirements are as follows:

RESERVES Np(pc)

FLOW RATE (Qpci)

COSTS (Investment and Operating)

Shown in the following example are the parameters and calculations used to determine Pictured Cliffs initial rate (Qpci), Pictured Cliffs Estimated Ultimate Recovery (Np(pc)), and Pictured Cliffs decline rate (Dpc). Additionally, estimated costs associated with each completion method and economic sensitivities (figures 1-3) are attached to show the effects of PC reserves (Np(pc)), initial PC rates (Qpci), and completion method (costs).

This example is for the Huerfano Unit #549, but the methodology is applicable for each of the commingle applications submitted (Rhodes C #'s 101 & 102, Whitley A #100, McAdams #500, and the Rowley Com #500). The variations in the Np(pc)'s are due to the specific drill block parameters (thickness, porosity, water saturation). Costs will be similar and the economic sensitivities are applicable for each case.

HUERFANO UNIT #549

MONTHLY GAS PRODUCTION ALLOCATION FORMULA

GENERAL EQUATION

$$Qt = Qftc + Qpc$$

WHERE: Qt = TOTAL MONTHLY PRODUCTION (MCF/MONTH)

Qftc = FRUITLAND COAL (ftc) MONTHLY PRODUCTION
Qpc = PICTURED CLIFFS (pc) MONTHLY PRODUCTION (MCF/MONTH)

REARRANGING THE EQUATION TO SOLVE FOR Qftc:

Qftc = Qt - Qpc

ANY PRODUCTION RATE OVER WHAT IS CALCULATED FOR THE PICTURED CLIFFS (PC) USING THE APPLIED FORMULA IS FRUITLAND COAL (FTC) PRODUCTION.

PICTURED CLIFFS (PC) FORMATION PRODUCTION FORMULA IS:

Qpc = Qpci X e^{-(Dpc) X (t)}

WHERE: **Qpci** = INITIAL PC MONTHLY FLOW RATE (CALCULATED FROM FLOW TEST)

Dpc = PICTURED CLIFFS MONTHLY DECLINE RATE CALCULATED FROM:
Dpc = (Qpci-Qpcabd)/Np(pc)
See Determination of Qpci and PC Estimated Ultimate Recovery (Np(pc))
Qpcabd = 300 MCF/M

WHERE: Np(pc) = PICTURED CLIFFS ESTIMATED ULTIMATE RECOVERY (EUR)
Np(pc) = **P X 1.08 MMCF/PSI** X Rf**
P* = INITIAL RESERVOIR PRESSURE (SIBHP)
RF = RECOVERY (FIELD ANALOGY): = 0.85
** DETERMINED FROM MATERIAL BALANCE (FIELD ANALOGY) AND VOLUMETRIC RESERVES (LOG ANALYSIS)

By calculating Np(pc) from SIBHP and determining Qpci, Dpc can then be calculated utilizing the previously described parameters. See derivation of Dpc, item (c) on page 4.

THUS: **Qftc = Qt - Qpci X e^{-(Dpc) X (t)}**
WHERE: **(t) IS IN MONTHS**

REFERENCE: Thompson, R. S., and Wright, J. D., "Oil Property Evaluation", pages 5-2, 5-3, 5-4.

HUERFANO UNIT #549

DETERMINATION OF Qpci:
(INITIAL PICTURED CLIFFS MONTHLY PRODUCTION)

Qpci = Qt(1) X Qpc(p) / {Qpc(p) + Qftc (p)}

$$Q_{pci} = Q_t(1) \times Q_{pc}(p) / \{Q_{pc}(p) + Q_{ftc}(p)\}$$

WHERE:

Qt(1) = FIRST MONTH TOTAL PRODUCTION (MCF)

Qpc(p) = FINAL PICTURED CLIFFS FLOW TEST (MCFPD)

Qftc(p) = FINAL FRUITLAND COAL FLOW TEST (MCFPD)

HUERFANO UNIT #549

EXAMPLE DETERMINATION OF:

(a) Np(pc)	PC EUR	
(b) Qpci	INITIAL PC MONTHLY FLOW RATE	
(c) Dpc	PC MONTHLY DECLINE RATE	

(a) DETERMINATION OF Np(pc)

(see page 5 for Np(pc) derivation)

Np(pc) = 1.08 (MMCF/PSI) X P*(PSI) X Rf

P* = 300 PSI (FROM SIBHP)

Np(pc) = 1.08 MMCF/PSI X 300 PSI X 0.85

Np(pc) = 275.4 MMCF

(b) DETERMINATION OF Qpci

Qpci = Qt(1) X {Qpc(p)/(Qpc(p) + Qftc(p))}

Qt(1) =	15,000 MCF	1ST MONTH TOTAL PRODUCTION
Qpc(p) =	500 MCF/D	PC FLOW TEST
Qftc(p) =	400 MCF/D	FTC FLOW TEST

Qpci = 15,000 MCF/M X {500 MCF/D/(500 MCF/D + 400 MCF/D)}

Qpci = 8,333 MCF/M

(c) DETERMINATION OF Dpc

Dpc = (Qpci - Qpcabd)/Np(pc)

Qpcabd = 300 MCF/M

Dpc =(8,333MCF/M - 300MCF/M)/(275,400MCF)

Dpc = 0.029/M

THUS: Qftc = Qt(MCF/M) - 8,333(MCF/M) X e^{-(0.029(1/M)) X t(M)}

HUERFANO UNIT #549

A. DETERMINATION OF PC RESERVES Np(pc)= (HCPV X Bg X Rf)

Volumetric Evaluation (averages are for subject 160 acre drill block)

a.	(t)	thickness	=	35.0	ft
b.	(phi)	porosity	=	15.0	%
c.	(Sw)	H2O saturation	=	55.0	%
d.	(Rf)	Recovery Factor	=	85.0	%
e.	(rcf)	Reservoir Cubic Feet	@ reservoir conditions		
f.	(scf)	Standard Cubic Feet	@standard conditions		

1. HCPV = HYDROCARBON PORE VOLUME (rcf)

= t (ft) X a (ft^2) X phi X (1-Sw)

= 35 (ft) X 160 (acres) X 43,560 (ft^2/acre) X 0.15 X (1-0.55)

= 16,465,680 ft^3 1mmrcf = 1,000,000 ft^3

HCPV = 16.466 mmrcf

2. Bg = FORMATION VOLUME FACTOR (scf/rcf)

UTILIZING THE REAL GAS LAW TO DETERMINE THE FORMATION VOLUME FACTOR (Bg):

REAL GAS LAW states: P V = Z n R T

Rearranging to solve for n: n = P V / Z R T

assuming: nr = ns

WHERE: nr = NUMBER OF MOLES OF GAS AT RESERVOIR CONDITION

ns = NUMBER OF MOLES OF GAS AT SURFACE CONDITIONS

THUS: Pr Vr/ Zr Tr R = Ps Vs / Zs Ts R

Rearranging: Vs/Vr = Bg = Zs Ts Pr / Zr Tr Ps

assuming:

Zs	=	1.00		
Zr	=	0.94		
Ts	=	60	*F	or 520 *R
Tr	=	100	*F	or 560 *R
Ps	=	15.025 psia		
Pr	=	Determined from build-up test		

Bg = FORMATION VOLUME FACTOR (scf/rcf)= Zs Ts Pr / Zr Tr Ps

= (scf/rcf) {1.00 X 520 (*R) X Pr (psia)}/ {0.94 X 560 (*R) X 15.025 (psia)}

Bg = 0.0657 {scf/ (rcf psia)} X Pr (psia)

3. EUR = HCPV X Bg X Rf

= 16.466 (mmrcf) X 0.0657 {scf/(rcf psia)} X Pr (psia) X 0.85

Np(pc) = 1.08 (mmscf/psia) X Pr (psia) X 0.85

HUERFANO UNIT #549

B. PICTURED CLIFFS DRILLING /COMPLETION COST SUMMARY

1. STAND ALONE SINGLE PC COMPLETION

ESTIMATED COSTS:	TANGIBLE (M$)	INTANGIBLE (M$)	TOTAL (M$)
	183.39	136.12	319.51

2. FTC/PC DUAL COMPLETION*

ESTIMATED COSTS:	TANGIBLE (M$)	INTANGIBLE (M$)	TOTAL (M$)
	173.49	93.67	267.16

3. FTC/PC COMMINGLE COMPLETION*

ESTIMATED COSTS:	TANGIBLE (M$)	INTANGIBLE (M$)	TOTAL (M$)
	91.69	93.67	185.36

*PICTURED CLIFFS COSTS ONLY

C. ECONOMIC SUMMARY

FIGURES 1-3 PICTURED CLIFFS RESERVES VS RATE OF RETURN (%)

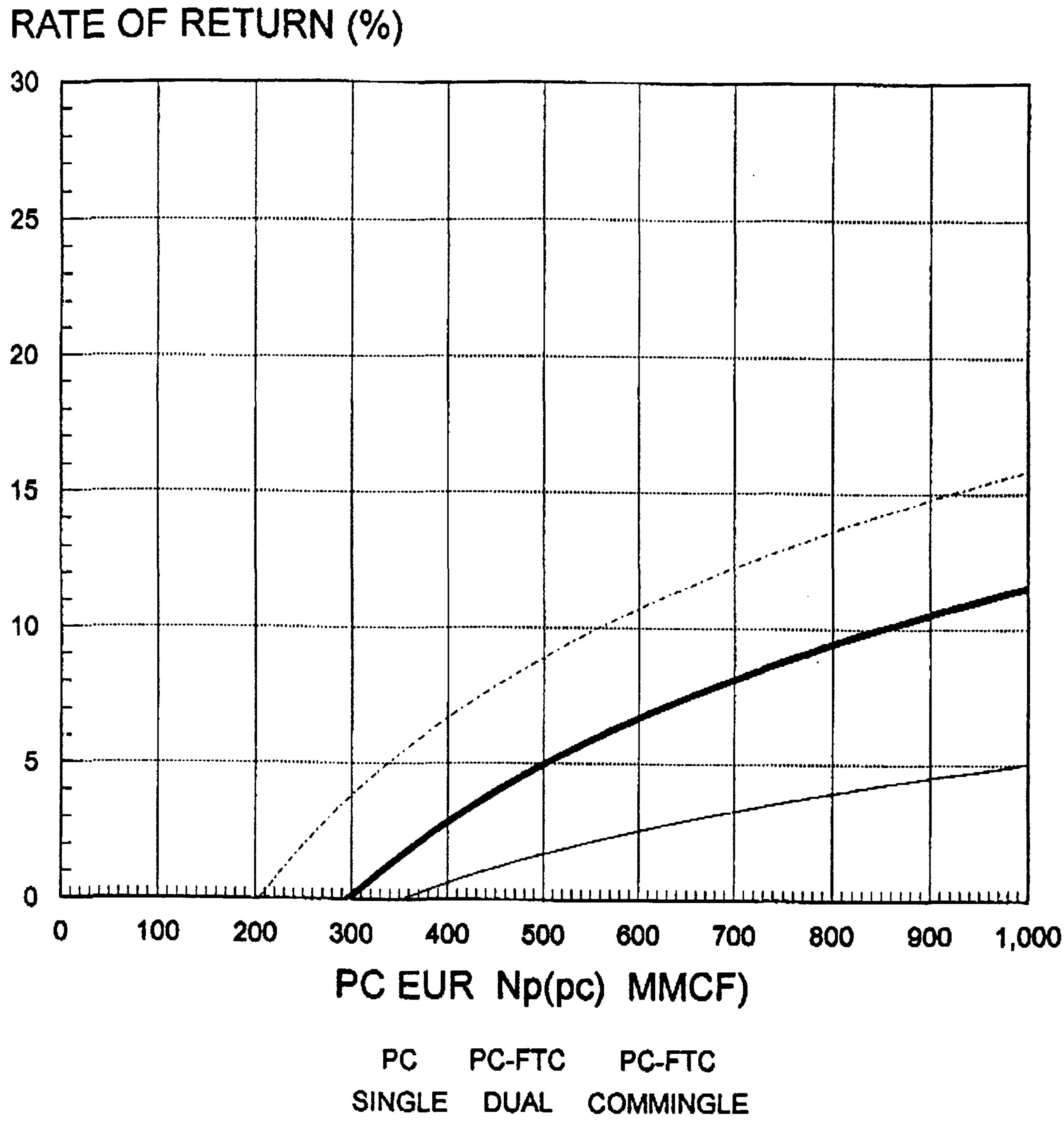
THREE CASES PER FIGURE (FTC/PC COMMINGLE, FTC/PC DUAL, PC SINGLE)

FIGURE 1 INITIAL RATE = 100 MCF/D
FIGURE 2 INITIAL RATE = 200 MCF/D
FIGURE 3 INITIAL RATE = 300 MCF/D

PICTURED CLIFFS

ECONOMIC EVALUATION

COMPLETION TECHNIQUE SENSITIVITY

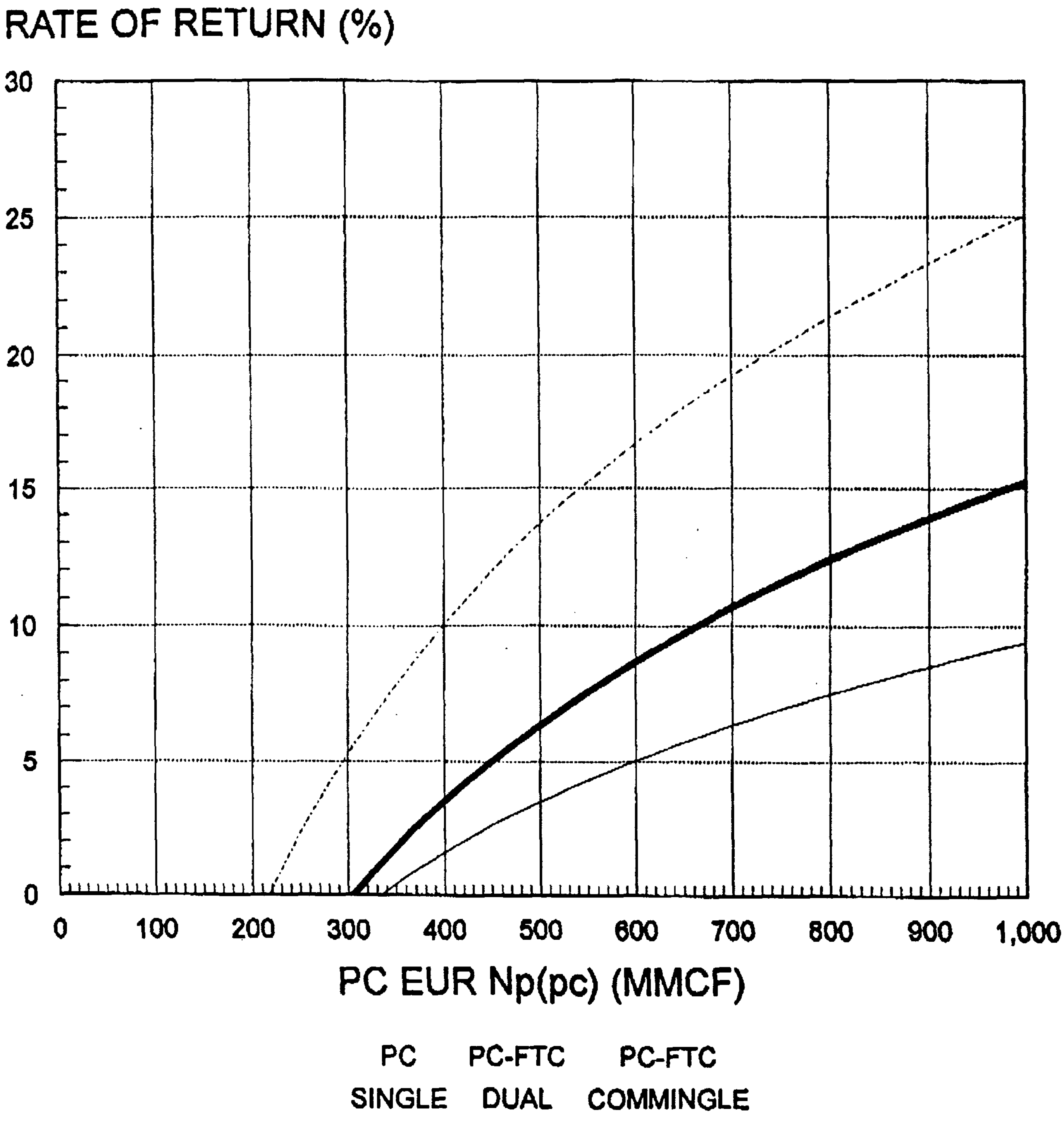


INITIAL RATE (Qpci) = 100 MCF/D
OR 3,000 MCF/M
FIGURE 1

PICTURED CLIFFS

ECONOMIC EVALUATION

COMPLETION TECHNIQUE SENSITIVITY

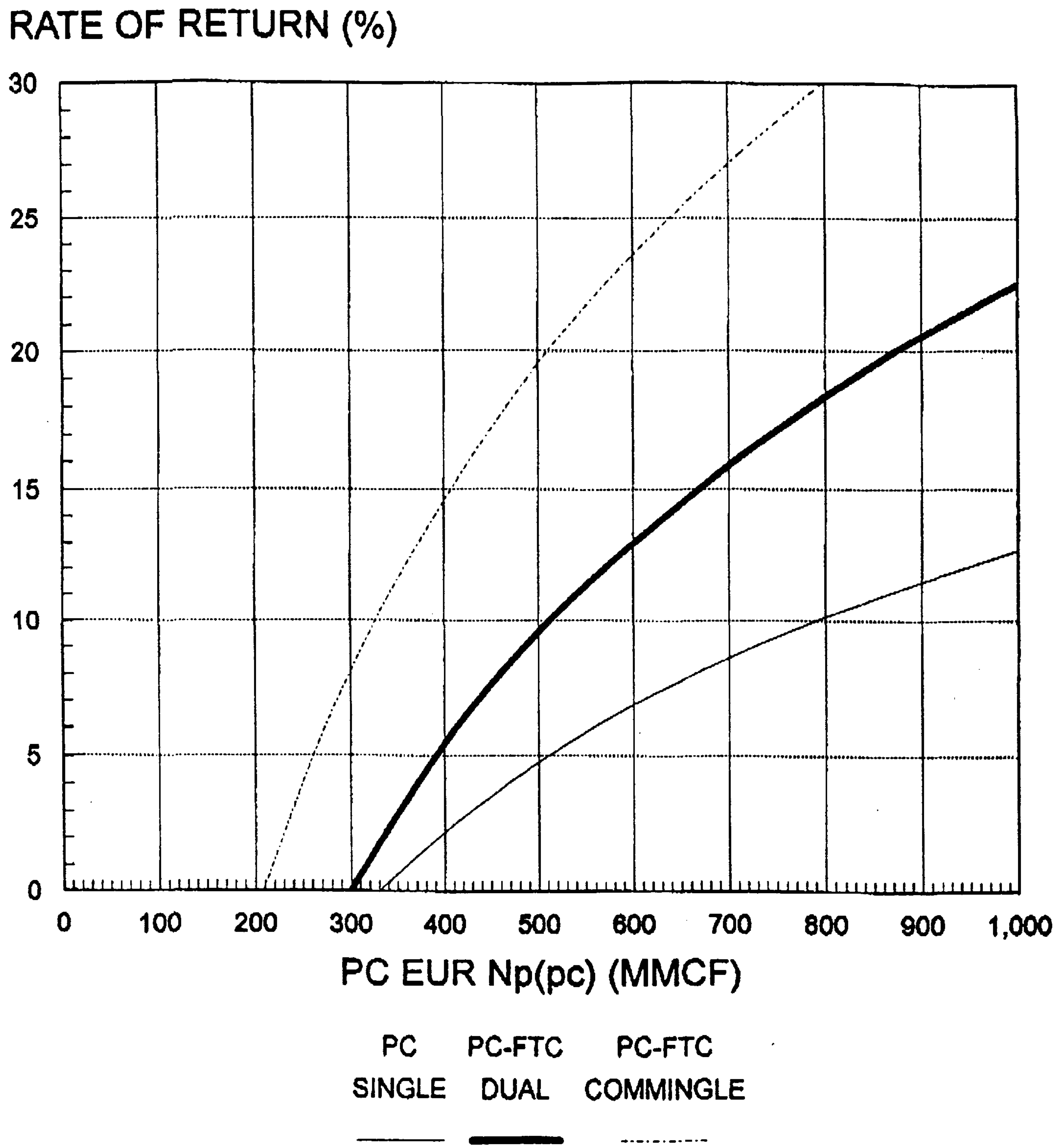


INITIAL RATE (Qpci) = 200 MCF/D
OR 6,000 MCF/M
FIGURE 2

MERIDIAN OIL ID:5053269781 JUN 15 '95 8:01 No.004 P.09

ECONOMIC EVALUATION

COMPLETION TECHNIQUE SENSITIVITY



INITIAL RATE (Qpci) = 300 MCF/D
OR 9,000 MCF/M
FIGURE 3

	WELL	POOL		OWNERSHIP		NSL		ECONOMICS
		FTC	PC	FTC	PC	FTC	PC	SUB ECON
1.	Rhodes C#101	BFTC	W-K	Comm	Comm	NSL	NSL	FTC - PC
2.	Rhodes C#102	BFTC	W-K	Comm	Comm	OK	NSL	FTC - PC
3.	Whitley A#100	BFTC	W-K	Comm	Comm	OK	NSL	FTC - PC
4.	Rowley Com#500	BFTC	FK	Diff	Diff	OK	NSL	PC -Margin
5.	McAdams #500	BFTC	FK	Diff	Diff	OK	OK	PC

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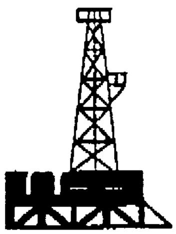
MERIDIAN OIL



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to plot, they yield results on a time basis, and they're deceptively easy to analyze. Decline curves are also one of the oldest methods of predicting reserves.

Decline curves, as used today, are simply a plot of production rate versus time on semilog, log-log, or specially scaled paper. The most common plot is semilog. When the logarithm of producing rate is plotted versus linear time, a straight line often results. This phenomenon is referred to as "exponential decline" and is similar to the decay of a radioactive element. Exponential decline is also referred to as constant percentage decline because of terminology used in the early 1900's. Occasionally, someone will state that exponential decline and constant percentage decline are different. This is not true; they are synonyms for decline curves which plot as a straight line on semi-log paper.

Often the data will not plot as a straight line on semi-log paper, but instead will "curve up" or be concave upwards. This situation, in which the decline rate continuously decreases with time, can usually be modeled with a hyperbolic equation. In cases of this type, the well is said to be experiencing "hyperbolic decline." A special case of hyperbolic decline is known as "harmonic decline."

5.1 DECLINE CURVE EQUATIONS

5.1.1 *Exponential Decline*

The equation of a straight line on semilog paper can be written as

$$q = q_i e^{-Dt} \quad (5\text{-}1)$$

where

- q = producing rate at time t, vol/unit time
- q_i = producing rate at time 0, vol/unit time
- D = nominal exponential decline rate, 1/time
- t = time
- e = base of natural logarithms, (2.718....)

Any system of units can be used as long as the product **Dt** is unitless and q and q_i are expressed in the same units. Equation 5-1 can be "derived" by stating that the decline rate at any time is proportional to the production rate, but there is no theoretical foundation for this "derivation." The theoretical foundation for exponential decline will be discussed later.

5.1.1.1 *Nominal and Effective Decline Rates*

Equation (5-1) *defines* the nominal decline rate (D). In dealing with production data, we intuitively think in terms of "effective" decline rate. For example, if we are told that a well produced 100 BOPD one year ago and now produces 50 BOPD, we naturally feel that the well declined at a rate of 50% per year. Imagine our surprise when the engineer says it is declining at 69.3% per year! Which one of the these is correct? Both of them are. Effective decline is defined as

$$D_e = \frac{q_i - q}{q_i} \quad (5\text{-}2)$$

for a given time period. The relationship between **D** and $\mathbf{D_e}$ can be derived as follows. We take **t** to be one time period (a year, perhaps). Since $\mathbf{q_i}$ and **q** are the same for both definitions of decline rate we can solve equations 5-1 and 5-2 for q and set the results equal:

$$q = q$$

$$q_i e^{-D} = q_i - q_i D_e$$

(t has been set to 1)

factor out q_i

$$q_i e^{-D} = q_i(1 - D_e)$$

Nominal decline as a function of effective decline is

$$D = -\ln(1 - D_e) \quad (5\text{-}3)$$

or

Effective decline as a function of nominal decline is

$$D_e = 1 - e^{-D} \quad (5\text{-}4)$$

The authors strongly prefer the use of nominal decline rather than effective decline for reasons which will be discussed throughout the rest of the chapter.

One of the major reasons for using nominal decline has to do with changing the time units on decline rate. With nominal decline, a yearly rate can be changed to a monthly rate simply by dividing by 12. *This is not possible with effective decline!* In order to convert yearly effective rate to monthly effective rate, the *twelfth root* of $1 - D_e$ must be taken. Taking the twelfth root or raising a number to the twelfth power is not difficult, but it is not intuitive. An example will illustrate the above ideas.

Example 5-1
Nominal and Effective Decline Rates

Given that a well has declined from 100 BOPD to 96 BOPD during a one month period.

A) Predict the rate after 11 more months using nominal exponential decline.

B) Same as A using effective decline.

A) Using Nominal Decline

q_i = 100 BOPD

q = 96 BOPD

t = 1 month

$$D = \left[\ln\left(\frac{q_i}{q}\right)\right]/t \quad (5\text{-}1)$$

D = .04082/mo

Find rate at end of 1 year.

$$q = q_i e^{-Dt}$$

PRIMARY EQ

$$q = 100e^{-.04082\,(12)}$$

q = 61.27 BOPD

B) Using Effective Decline

$$D_e = \frac{q_i - q}{q_i} \quad (5\text{-}2)$$

$$D_e = \frac{100 - 96}{100}$$

D_e = .04/month

Convert to yearly

$$1 - D_{ey} = (1 - D_{em})^{12}$$

$$1 - D_{ey} = (1 - .04)^{12}$$

D_{ey} = .3875/year

Find rate at end of 1 year

$$q = q_i\,(1 - D_e)$$

$$q = 100(1 - .3873)$$

q = 61.27 BOPD

The authors find it much easier to use nominal decline. No matter what the units on **D** and **t**, it is only necessary to multiply by the appropriate time factor to cause the product **Dt** to be unitless. Try to predict the rate 22½ months from now using effective decline — it's not worth the effort.

5.1.1.2 *Cumulative Production*

In oil property evaluation, we are more interested in the amount of oil produced each year than the rate at any given time. In order to determine the cumulative oil production (N_p) at any