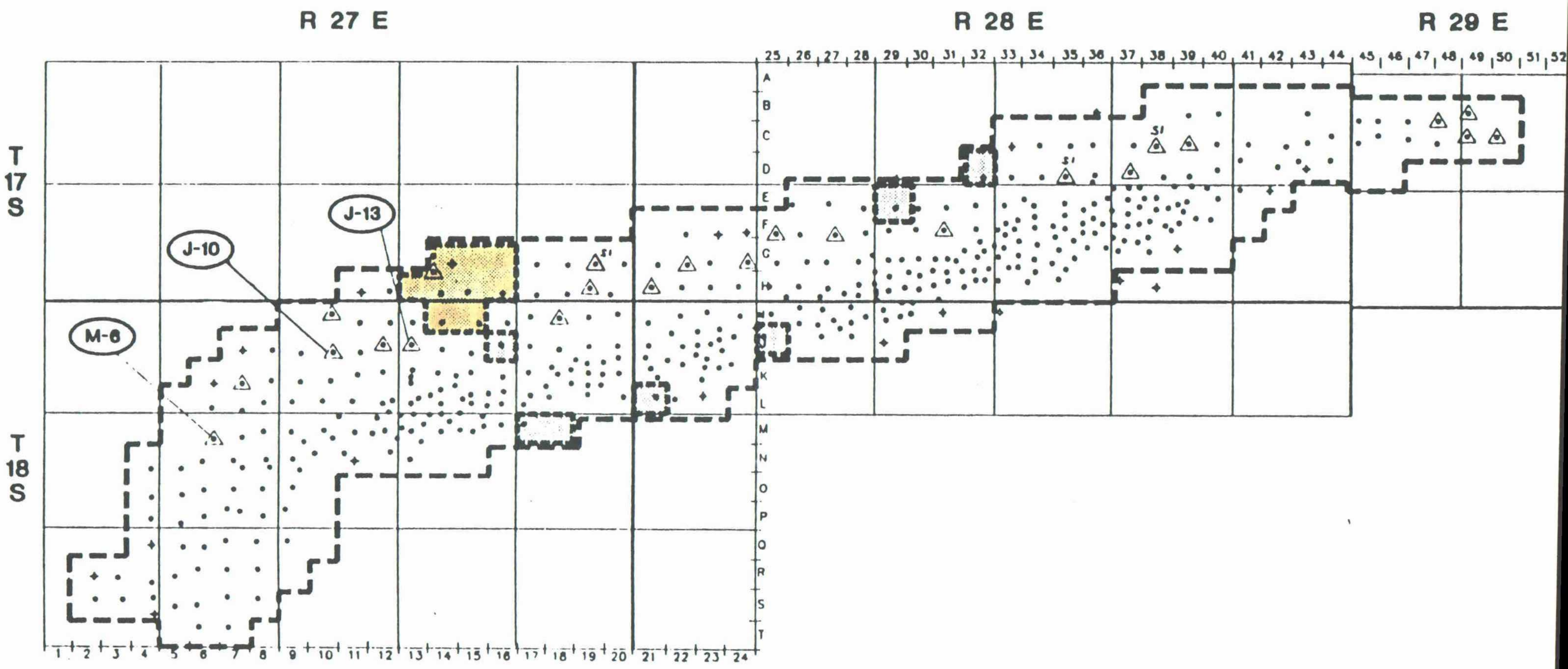
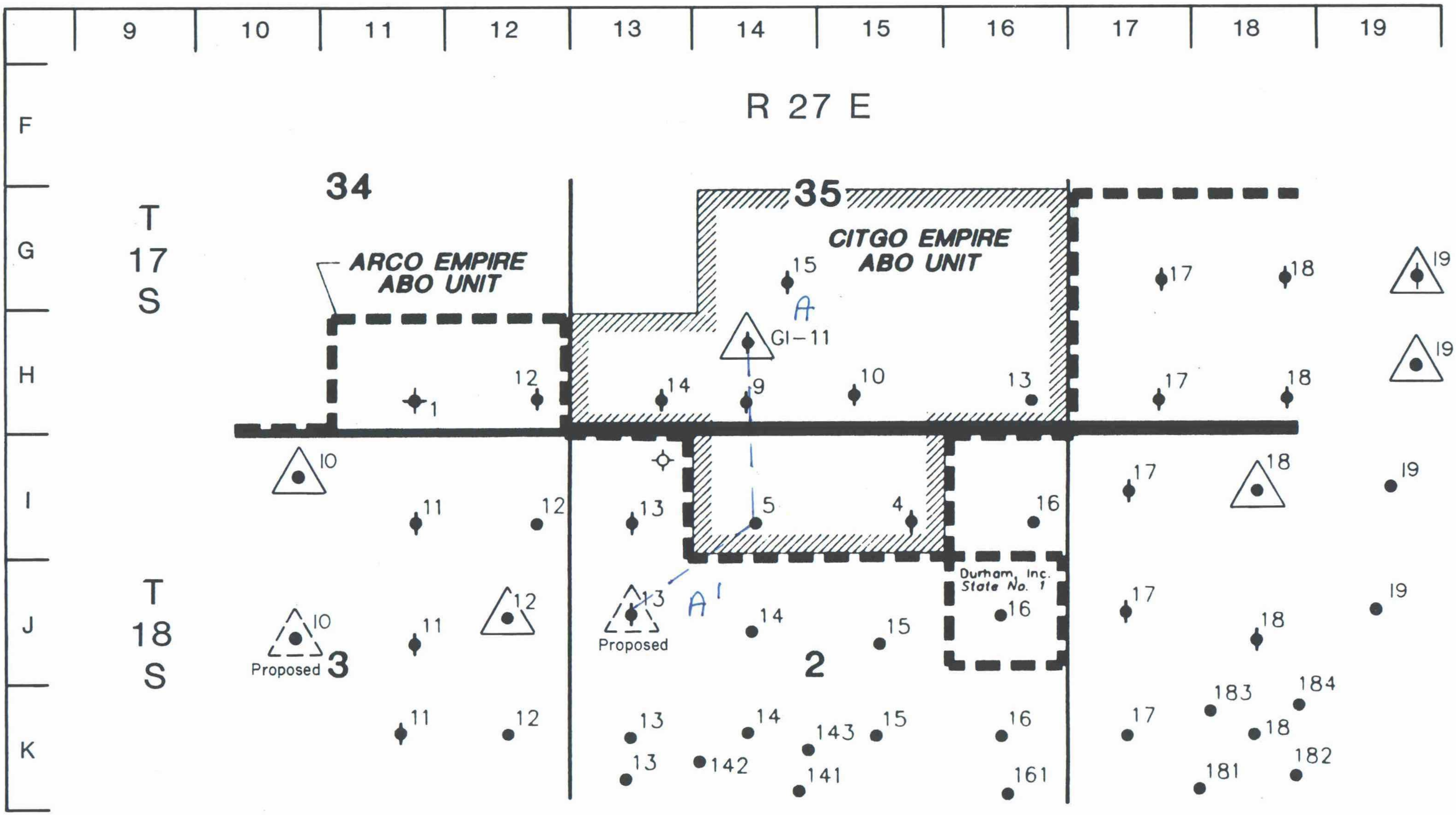
BEFORE EXAMINER STOGNER
Oil Conservation Division
OXY Exhibit No. 1
Case No. 9931

EMPIRE ABO UNIT
Eddy County, New Mexico





△ PROPOSED INJECTION WELL

▲ INJECTION WELL

▲ INACTIVE INJECTION WELL

● PRODUCING WELL

● INACTIVE PRODUCING WELL

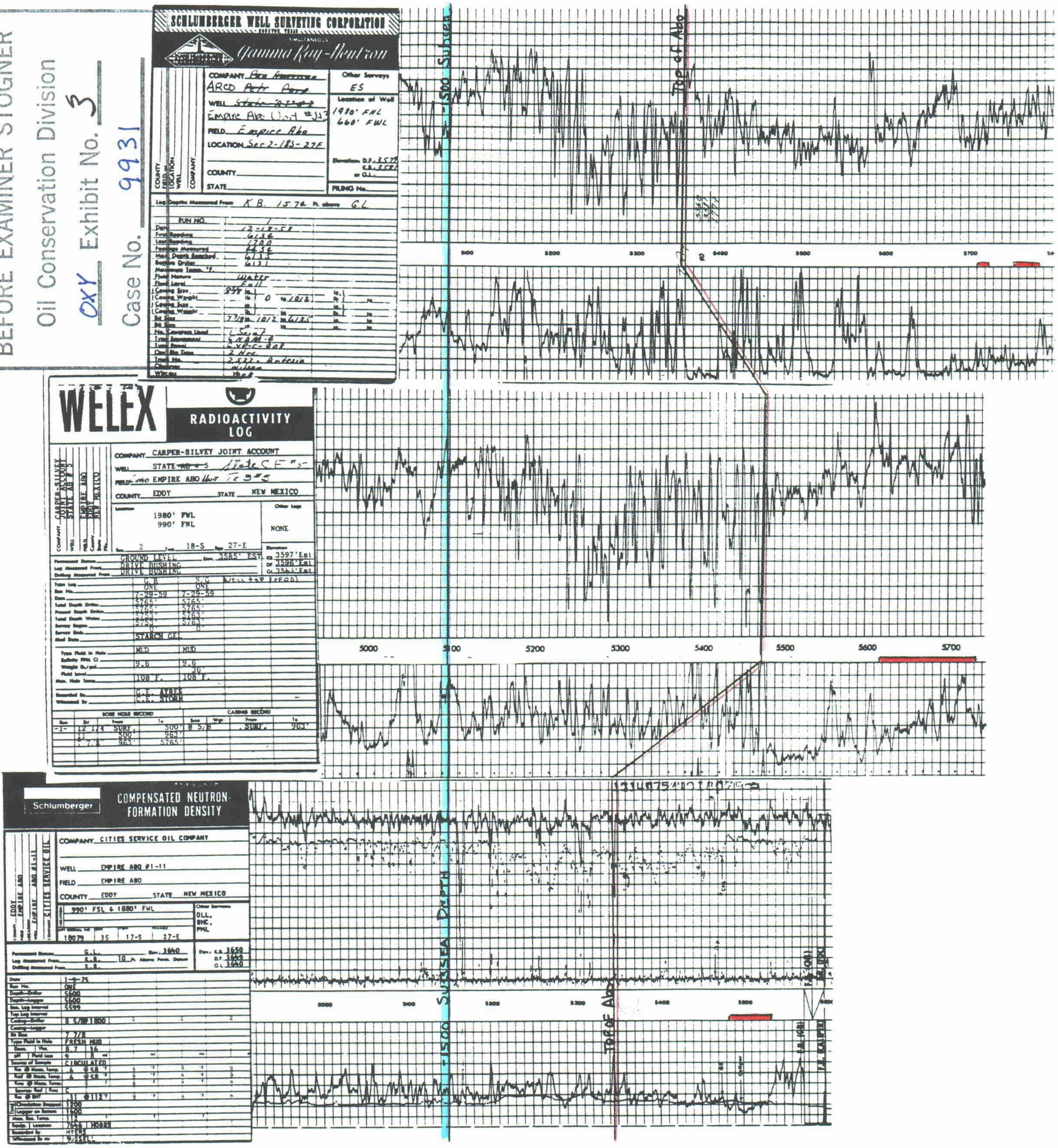
BEFORE EXAMINER STOGNER
Oil Conservation Division
OXY Exhibit No. 2
Case No. 9931

EMPIRE ABO FIELD
EDDY CO., NEW MEXICO
WELL STATUS

SCALE: 1":1500'   JUNE, 1990

A'

BEFORE EXAMINER STOGNER
Oil Conservation Division
OXY Exhibit No. 3
Case No. 9931



SCHLUMBERGER WELL SURVEYING CORPORATION
HOUSTON, TEXAS
SIMULTANEOUS
Gamma Ray-Neutron

COMPANY ~~Pan American~~
ARCO Petr Corp.
WELL ~~State "AT" #2~~
Empire Abo Unit #J13
FIELD Empire Abo
LOCATION Sec 2-18S-27E
COUNTY
STATE
Other Surveys: ES
Location of Well: 1980' FNL 660' FWL
Elevation: D.F. 3577 K.B. 3581 or G.L.
FILING No.
Log Depths Measured From K.B. 15.74 Ft. above G.L

RUN NO.	1
Date	12-18-58
First Reading	6136
Last Reading	1700
Footage Measured	4436
Max. Depth Reached	6135
Bottom Driller	6131
Maximum Temp. °F.	
Fluid Nature	Water
Fluid Level	Full
Casing Size	8 5/8 in.
Casing Weight	lb. 0 to 1012
Bit Size	7 7/8 in. 1012 to 6135
No. Counters Used	1 Scint
Type Equipment	GNAM-4
Type Panel	GXP-C-80P
Opr. Rig Time	2 Hrs
Truck No.	2522 Artesia
Observer	Wilson
Witness	Reed

WELEX
RADIOACTIVITY LOG

COMPANY CARPER-SILVEY JOINT ACCOUNT
WELL STATE ~~AB # 5~~ State C E #5
FIELD ~~EMPIRE ABO~~ Empire Abo Unit "E" 3 #5
COUNTY EDDY STATE NEW MEXICO
Location 1980' FWL 990' FNL
Other Logs NONE
Sec. 2 Twp. 18-S Rge. 27-E
Permanent Datum GROUND LEVEL Elev. 3585' EST.
Elevation KB 3597' Est DF 3596' Est GL 3585' Est
Log Measured From DRIVE BUSHING
Drilling Measured From DRIVE BUSHING
(Well top Eroded)

Type Log	G.R	S.G
Run No.	ONE	ONE
Date	7-29-59	7-29-59
Total Depth Driller	5765'	5765'
Present Depth Driller	5765'	5765'
Total Depth Welex	5753'	5763'
Survey Begins	5753'	5763'
Survey Ends	0'	0'
Mud Data	STARCH GEL	
Type Fluid in Hole	MUD	MUD
Salinity PPM Cl		
Weight lb./gal.	9.6	9.6
Fluid Level		36'
Max. Hole Temp.	108 F.	108 F.
Recorded By	G.E. AYRES	
Witnessed By	C.E. STORM	

BORE HOLE RECORD / CASING RECORD

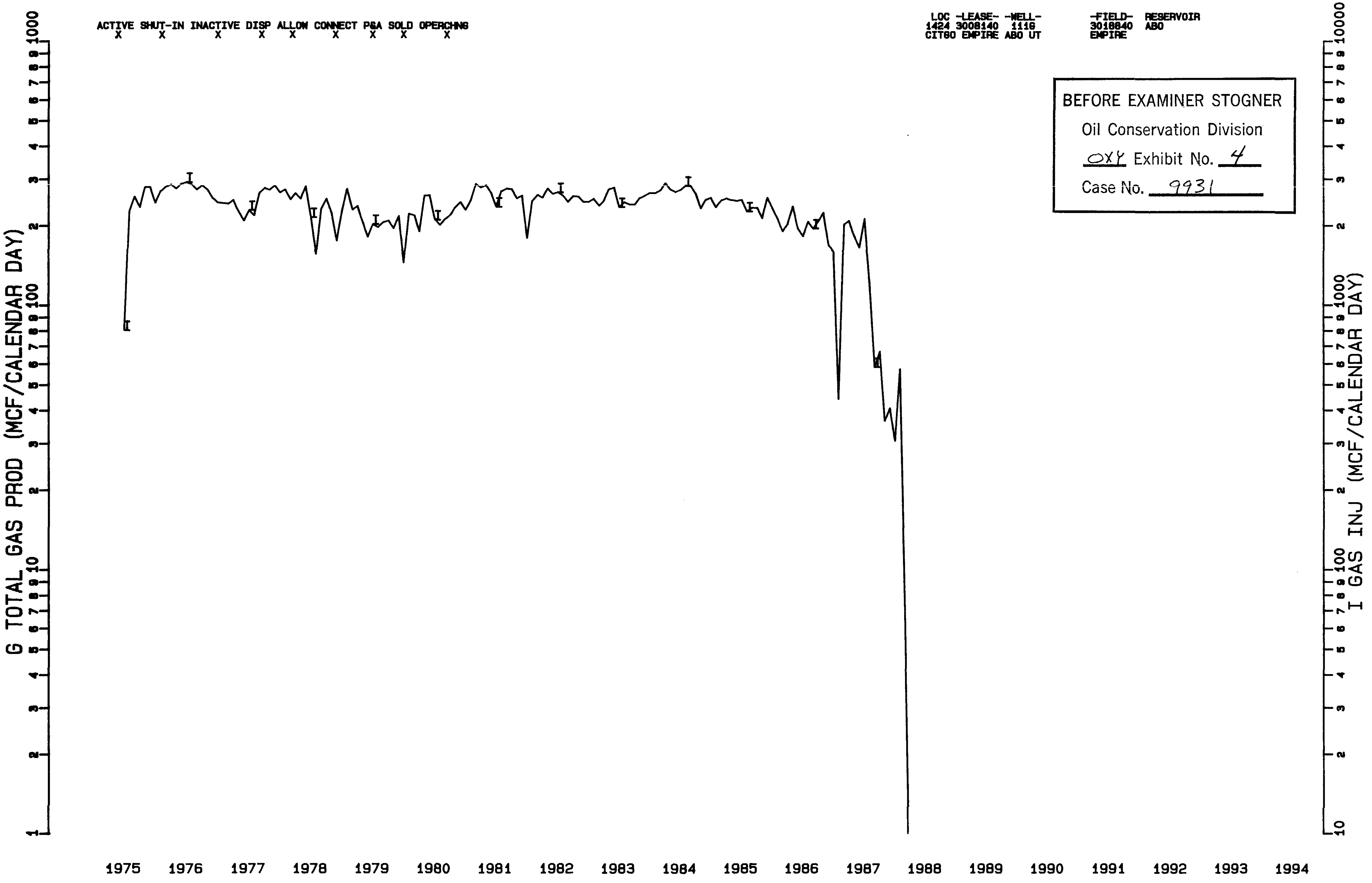
Run	Bit	From	To	Size	Wgt	From	To
-1-	12 1/4	SURF.	500'	8 5/8		SURF.	963'
	11	500'	963'				
	7 7/8	963'	5765'				

Schlumberger
COMPENSATED NEUTRON-FORMATION DENSITY

COMPANY CITIES SERVICE OIL COMPANY
WELL EMPIRE ABO #1-11
FIELD EMPIRE ABO
COUNTY EDDY STATE NEW MEXICO
LOCATION 990' FSL & 1880' FWL
Other Services: DLL, BHC, PML
18079 Sec. 35 Twp. 17-S Range 27-E
Permanent Datum G.L. Elev. 3640
Log Measured From K.B. 10 Ft. Above Perm. Datum
Drilling Measured From K.B.
Elev.: K.B. 3650 D.F. 3649 G.L. 3640

Date	1-9-75	
Run No.	ONE	
Depth—Driller	5600	
Depth—Logger	5600	
Btm. Log Interval	5599	
Top Log Interval		
Casing—Driller	8 5/8 @ 1800	
Casing—Logger		
Bit Size	7 7/8	
Type Fluid in Hole	FRESH MUD	
Dens. | Visc.	8.7	36
pH | Fluid Loss	9	8 ml
Source of Sample	CIRCULATED	
Rm @ Meas. Temp.	.6	@ 58 °F
Rmf @ Meas. Temp.	.6	@ 58 °F
Rmc @ Meas. Temp.		
Source: Rmf | Rmc	C	
Rm @ BHT	.31	@ 112 °F
Circulation Stopped	1200	
Logger on Bottom	1600	
Max. Rec. Temp.	112 °F	
Equip. | Location	7656	HOBBS
Recorded By	MYERS	
Witnessed By	RUSSELL	

A



BEFORE EXAMINER STOGNER

Oil Conservation Division

OXY Exhibit No. 4

Case No. 9931

BEFORE EXAMINER STOGNER
Oil Conservation Division
OXY Exhibit No. 6
Case No. 9931

CITGO EMPIRE ABO UNIT

ECONOMIC IMPACT OF REDUCED OIL PRODUCTION

WELL #305

	OIL	GAS	GOR
MARCH 1990	122 BBL	23,036 MCF	188,020 CF/BBL
ESTIMATED OIL RATE ● 400,000 GOR	58 BBL	23,036 MCF	400,000 CF/BBL
LOSS	64 BBL		

ECONOMIC IMPACT 64 BBL/MONTH•$18.00/BBL = $1,152/MONTH

ANNUALIZED LOSS $1,152 • 12 MONTHS = $13,824/YEAR

smm 5/15/90

BEFORE EXAMINER STOGNER
Oil Conservation Division
OXY Exhibit No. 7
Case No. 9931

CITGO EMPIRE ABO UNIT
ANALYSIS OF NATURAL GAS LIQUID PRODUCTION

NGL YIELDS

	GALLONS/MCF
NOVEMBER 1986	2.187
AUGUST 1988	2.564
JANUARY 1990	3.135

NGL YIELDS HAVE INCREASED 43% SINCE 11-86

IF YIELDS RETURN TO 11-86 LEVELS WITH OFFSET INJECTION, OXY WILL LOSE 30% OF CURRENT NGL PRODUCTION
[2.187/3.135 = 70%]

smm 5/14/90

BEFORE EXAMINER STOGNER
Oil Conservation Division
OXY Exhibit No. 8
Case No. 9931

CITGO EMPIRE ABO UNIT

ECONOMIC IMPACT OF REDUCED NGL PRODUCTION

	NGL VOLUME	NGL VALUE
CURRENT YIELD	92,200 GAL	$20,695
NOV. 1986 YIELD (70% OF CURRENT)	64,540 GAL	$14,485
LOSS	27,660 GAL	$ 6,210

ANNUALIZED LOSS $6210 X 12 MONTHS = $74,520

NOTE: NGL SALES REPRESENT 31% OF TOTAL GAS VALUE.
BASIS: MARCH 1990 SALES VOLUMES FROM PHILLIPS GAS STATEMENT

smm 5/14/90

BEFORE EXAMINER STOGNER
Oil Conservation Division
OXY Exhibit No. 2
Case No. 9931

BLOWDOWN EVALUATION
EMPIRE ABO UNIT
ABO RESERVOIR
EDDY COUNTY, NEW MEXICO
January, 1985

by
Timothy J. Detmering
ARCO Oil and Gas Company
Midland, Texas

ARCO Oil and Gas Company
Permian District
Post Office Box 1610
Midland, Texas 79702
Telephone 915 684 0149

Joe R. Hastings
District Engineer — West

April 3, 1984

WORKING INTEREST OWNERS
EMPIRE ABO UNIT

Gentlemen:

The following report documents our analysis of blowdown timing for the Empire Abo Unit. It is our recommendation, based on the information presented, that residue gas injection be continued to the year 1995. Basis for this recommendation is the optimizing of energy recovery and the maximizing of undiscounted cash flow. This recommendation does not, however, preclude reservoir blowdown at an earlier date should changes in market conditions and/or reservoir performance deem it more economical to do so. If you have any questions about any of the information presented in this report, please feel free to give me a call at (915)684-0149 or contact David Douglas at (915)684-0163.

Yours very truly,

Joe R. Hastings

Joe R. Hastings

JRH:sc
Att.

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TABLE OF CONTENTS

TABLES AND FIGURES

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SUMMARY

SUMMARY

Recovery of energy from the Empire Abo Unit will be maximized by initiating residue gas sales in 1995. As a result of maximizing energy recovery, the working and royalty interest owners of the Empire Abo Unit will maximize their undiscounted net income. The impact of blowdown is summarized in Table 1, on page 2.

TABLE 1. Evaluation of Blowdown Timing Based on Constant Operating and Overhead Costs, and Constant Product Prices.

Blowdown Start Date	Unit Oil Reserves After 1/85 (MSTB)	Unit NGL Reserves After 1/85 (MSTB)	Unit Gas Reserves After 1/85[1] (MMSCF)	Undiscounted Net Income BFIT (MM$)	Gross Energy Recovery (Trill. BTU)
1/85	7415	4527	82641	361	251
1/90	11350	5369	69244	399	268
1/95	13929	6292	52153	410	274
1/03	15663	7951	21406	357	264

Table 2. Prices, Tax Rates, and Costs Used in Economic Calculations.

Oil Prices	
Tier 1:	$30.00/BBL, Base Price: $19.00/BBL
Tier 2:	$30.00/BBL, Base Price: $22.00/BBL
Gas Price:	$2.90/MCF
NGL Prices	
Ethane:	$0.22/gal
Propane:	$0.35/gal
Butane:	$0.52/gal
Gasoline:	$0.63/gal
Production Tax Rates	
Severance Tax:	3.75%
Emergency School Tax:	3.15%
Ad Valorem Tax:	0.18%
Windfall Profits Tax Rates	
Tier 1:	70%
Tier 2:	60%
Operating Costs	
With Gas Injection:	$7020M/year
Without Gas Injection:	$6468M/year
Overhead Costs:	$990M/year

---

[1] Storage gas owned by Gas Company of New Mexico has been deducted from the Unit gas reserves (3.7 BCF).

CONCLUSIONS AND RECOMMENDATION

CONCLUSIONS

1. Energy recovery, which is the sum of the heating values of the recovered oil, natural gas liquids (NGL), and residue gas, is maximized by starting blowdown in 1995.

2. Continued residue gas injection until 1995 will allow the Empire Abo Unit to take advantage of the gravity drainage mechanism of the Empire Abo reservoir. Thus, the Unit will recover more oil reserves than it would by starting blowdown in 1985. The additional recovery is the result of allowing the thin oil column in the back-reef area to migrate downdip to the fore-reef area where the oil column is thicker and the oil can be economically and efficiently produced.

3. Continued residue gas injection until 1995 also enables the Unit to recover additional NGL reserves. The additional recovery is the result of lean gas sweeping the free gas in the gas cap and lean gas stripping NGL's out of the oil remaining in the gas cap.

4. In order to realize increased oil and NGL recoveries it is necessary to use residue gas for fuel. Fuel use, combined with venting, causes residue gas recovery to decrease with continued gas injection.

5. The impact of blowdown on present worth is a function of the discount rate used in the economic calculations. Undiscounted economics favor starting blowdown in 1995. As higher and higher discount rates are applied to the cash flows, the optimum blowdown start date moves toward 1985. At a discount rate of 7 percent or more the optimum blowdown start date is 1985.

RECOMMENDATION

Based on undiscounted economics and prevention of waste it is recommended that the Empire Abo Unit continue to inject residue gas until 1995, at which time residue gas sales should begin.

INTRODUCTION

INTRODUCTION

This study was initiated to determine when residue gas sales should begin at the Empire Abo Unit. Currently, residue gas is injected into the gas cap to increase recoveries of oil and NGL's. Residue gas is a saleable product and the Unit is foregoing income from residue gas sales to realize more income from oil and NGL sales. Blowdown should begin when the value of the potential residue gas recovery exceeds the value of the oil and NGL recoveries that depend upon residue gas injection.

Two separate numeric simulation studies were conducted to analyze the impact of blowdown timing on oil, gas, and NGL rates and recoveries. ARCO's two-dimensional, multi-component simulator was used to predict the NGL content of the produced gas. This simulator is referred to as the compositional model in this report. ARCO's three-dimensional, three phase simulator was used to predict oil and gas production rates and recoveries. This simulator is referred to as the black oil model in this report.

Both models were required to analyze blowdown timing because of limitations inherent in each. The compositional model is specifically designed to calculate recoveries of individual reservoir fluid components. Thus, the compositional model can predict rates and recoveries of the NGL components - ethane, propane, butane, and gasoline. However, the complexity of the compositional model precludes the use of gas coning correlations. Because of the significant impact of gas coning on oil rates and recoveries at Empire Abo, gas coning correlations are necessary to accurately forecast oil production. Therefore, the black oil model, which includes gas coning correlations, was run to predict accurate oil rates and recoveries.

Gas production is accurately predicted by both simulators. The forecast calculated by the black oil model was used as a matter of convenience.

The setup and design of the compositional model is discussed in reference 4. The black oil model is discussed in reference 3 and Appendix A. Appendix C contains the results of the black oil model history match including plots comparing calculated versus actual well performances.

FIELD HISTORY
AND GEOLOGY

FIELD HISTORY AND GEOLOGY

History

The Empire Abo Field is located approximately 8 miles southeast of Artesia, in Eddy County, New Mexico. Development of the Abo reservoir began with the drilling of Amoco's Malco "A" No. 1 (Unit designation M-14) in November 1957. Drilling was rapid and extensive following this successful completion. The productive Abo reservoir in this field consists of 11,339 acres located in portions of Township 17 South, Ranges 27, 28, and 29 East, and Township 18 South, Ranges 27 and 28 East (Figure 1).

Approximately 97 percent of the reservoir was unitized into the ARCO operated Empire Abo Unit in October 1973 (Ref. 2). The intent of the unitization was to conserve reservoir energy by producing from the low GOR wells, thus minimizing free gas production. In this way the Unit has taken better advantage of the gravity drainage mechanism and has increased ultimate oil and NGL recoveries as compared to competitive, primary depletion.

An engineering study conducted in 1975 indicated ultimate oil recovery would be improved by selective infill drilling on 20 acre spacing. A subsequent study conducted in 1977 concluded further increases in oil recovery would result from selective infill drilling on 10 acre spacing (Ref. 3). A total of 160 infill wells were drilled as a result of these studies.

A voidage limit of 56,912 RVBPD was established by the New Mexico Oil Conservation Commission for the Empire Abo Unit to ensure controlled depletion of the reservoir. An engineering study completed in 1983 indicated removing this voidage limit, and replacing it with a gas production limit of 65 MMCFPD, would enable the Unit to operate more efficiently and recover additional oil and NGL reserves (Ref. 1). The gas production limit went into effect in May 1984.

Field performance is shown in Figure 2. Basic reservoir data is listed in Table 3.

Geology

The Empire Abo field produces from a transgressive, carbonate, barrier reef buildup of lower Leonardian (Permian) age. This reef is one of several in a long trend flanking the northern edge of the Delaware Basin. The reef grew from southwest to northeast. It is approximately 12½ miles long and 1½ miles wide. Parallel to the reef trend, the reef dips 1 degree from southwest to northeast. Perpendicular to this trend the reef dips sharply at 10 to 20 degrees from crest to fore-reef, or north to south. The average depth of the reef is 5800 feet and the thickness averages 300 feet.

The trapping mechanism at Empire Abo is both stratigraphic and structural. The reef dips below the oil water contact to the south and east. Permeability pinch outs to the north and west occur as a result of carbonate muds, green shales, and anhydrite inclusions.

Porosity development is erratic and cannot be correlated between wells. Development is the result of leaching of abundant detrital fossil fragments, dolomitization, and recrystallization. The most prolific porosity development is found in the reef core. There is no apparent intercrystalline porosity.

Vertical fracturing, which contributes to the gravity drainage mechanism of the reservoir, is apparently due to local slumping as well as large scale settling and some tectonic activity. Fracture orientation is generally 0 to 45 degrees from vertical and is parallel to the reef trend. These fractures apparently link up the erratic porosity development and provide excellent pressure communication in the reservoir.

Table 3. Empire Abo Unit Reservoir Data Summary.

General

Discovery	November 1957
Well Status - October 1984	
Producers	228
Injectors	21
Shut-In	146

Current Status - October 1984

Unit Allowable (BOPD)	6533
Oil Production (BOPD)	6373
Gas Production (MCFD)	61599
Producing GOR (CF/BO)	9665
Gas Injection (MCFD)	31699
Water Production (BWPD)	7761
Average Depth to Top of Reef, Feet	5767
Productive Acres	8993

Formation

Type Rock	Vugular Dolomite
Average Net Pay Thickness, Feet	183
Average Porosity, % (Log Data)	6.4
Water Saturation, %, Main Reef	8.6
Original Gas Oil Contact, Feet Subsea	-1750
Original Water Oil Contact, Feet Subsea	-2665
Reservoir Mid-point, Feet Subsea	-2264

Reservoir Fluid

Original Reservoir Pressure, psi at -2264 (Pi)	2359
Original Bubble Point Pressure, psia at -2264 (Pbpi)	2231
Oil Formation Volume Factor at Pbpi, RVB/STB (Boi)	1.606
Gas Formation Volume Factor at Pbpi, RVB/SCF (Bgi)	0.00098
Gas in Solution at Pbpi, SCF/STBO (Rsi)	1250
Oil Viscosity at Pbpi, centipoise (μoi)	0.387

Reservoir Volumetric Data

Original Oil-in-Place (MMSTBO)	383.2
Original Gas-in-Place (BCF)	483.4
Estimated Ultimate Recoveries (Total Reservoir)	
Oil (MMSTBO)	224.7
(% of OOIP)	58.6
Gas (BCF)	465.8
(% of OGIP)	96.4

EMPIRE ABO UNIT

EDDY COUNTY, NEW MEXICO

FIGURE 1

REVISED: 4 - 15 - 83

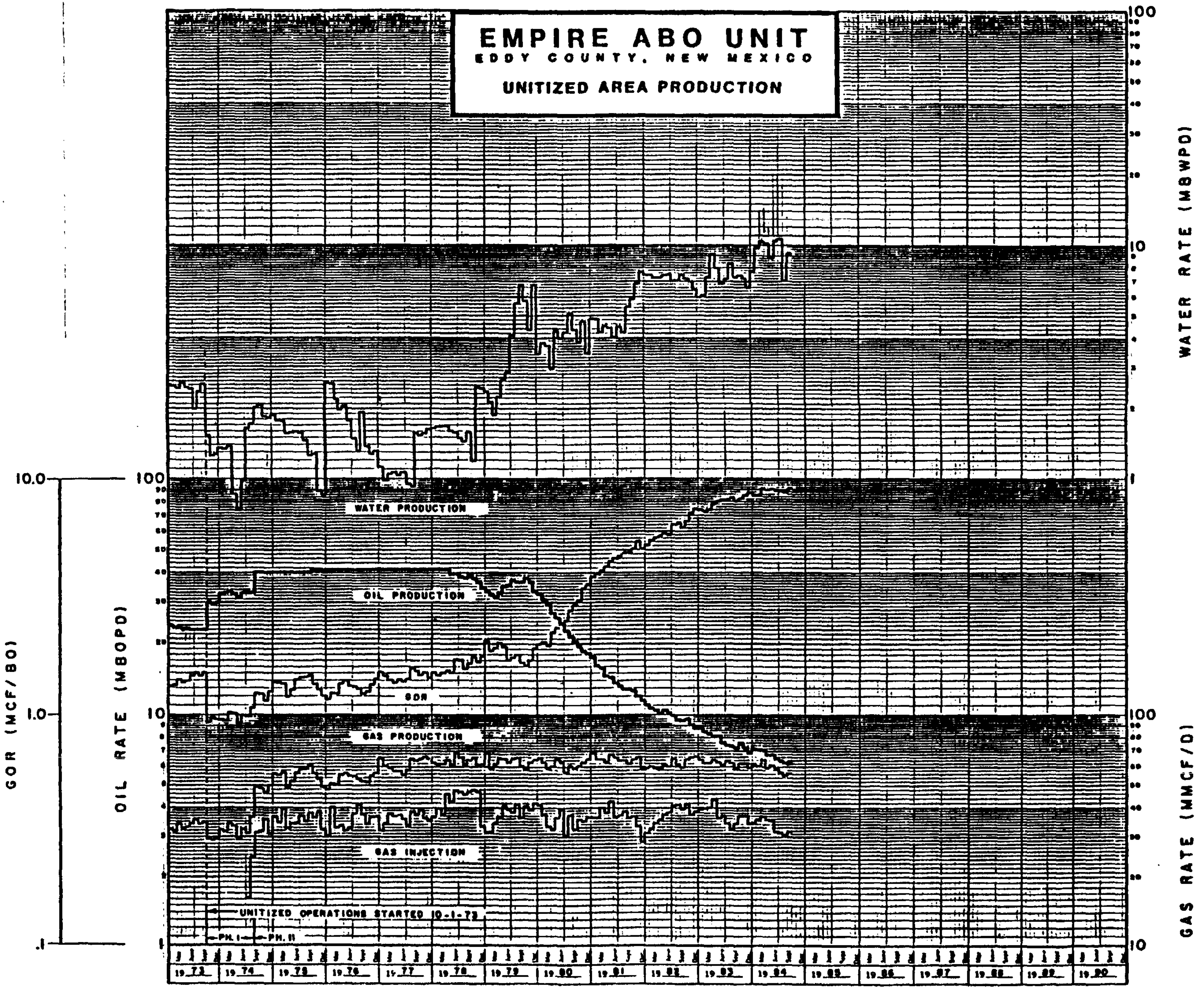
0 320 2640 5280

LEGEND

▨ NON-PARTICIPATING TRACT ON UNIT EFFECTIVE DATE OF SEPT. 1, 1975

UNIT BOUNDARY
TRACT BOUNDARY
TRACT NUMBER
PT PARTIAL TRACTS

FIGURE 2


EMPIRE ABO UNIT
EDDY COUNTY, NEW MEXICO
UNITIZED AREA PRODUCTION
WATER RATE (MBWPD)
GAS RATE (MMCF/D)
OIL RATE (MBOPD)
GOR (MCF/BO)
WATER PRODUCTION
OIL PRODUCTION
GOR
GAS PRODUCTION
GAS INJECTION
UNITIZED OPERATIONS STARTED 10-1-73
PH. I
PH. II
100
10
1
10.0
1.0
.1
19 73
19 74
19 75
19 76
19 77
19 78
19 79
19 80
19 81
19 82
19 83
19 84
19 85
19 86
19 87
19 88
19 89
19 90

PERFORMANCE PROJECTIONS

PERFORMANCE PROJECTIONS

Projections were calculated for starting blowdown at 1/1/85, 1/1/90, 1/1/95, and at the economic limit of gas injection - 1/1/03. Computer time limitations prohibited calculating forecasts for starting blowdown at every year between 1/1/85 and 1/1/03. However, the recoveries of residue gas, NGL's, and oil appear to be continuous functions of blowdown timing (Figures 3 through 5). Therefore, recoveries for blowdown start dates other than 1/1/85, 1/1/90, 1/1/95, and 1/1/03 can be approximated by linear interpolation with no significant error.

As illustrated in Figures 3 through 5, starting blowdown immediately recovers the most residue gas and the least oil and NGL's. For every year that blowdown is delayed, residue gas recovery decreases, and oil and NGL recoveries increase. The curves labeled "Unit" in Figures 3 through 5 reflect a net oil interest of 87.5 percent, a net NGL interest of 21.875 percent, and a net residue gas interest of 65.625 percent.

Starting blowdown in 1985 yields the highest residue gas recovery because fuel use is lowest for this case. The injection compressors are shut down immediately and the lives of the extraction plants are as short as possible.

NGL recovery increases with delayed blowdown because the injected lean gas strips more NGL's out of the oil in the gas cap and sweeps out more enriched gas.

Oil recovery increases with delayed blowdown because the reservoir pressure decline is slowed. Slower pressure decline has three effects: one, incrementally higher pressure differentials between the reservoir and the wellbores; two, lower oil viscosities; three, more oil migration from the back-reef, where the oil column is too thin to be produced, to the fore-reef, where the oil column is thicker and can be economically and efficiently produced. A more thorough explanation of the impact of blowdown on oil rates and reserves is found in Appendix B.

In order to compare the value of the residue gas lost to the value of the oil and NGL's gained by continued gas injection, it is useful to examine the energy recovery for each blowdown case studied. Energy recovery is calculated by multiplying the heating value of each product by its recovery. Thus, instead of making a comparison of BBLS of oil to MCF of gas, a comparison of BTU's of oil to BTU's of gas is made. This calculation determines which blowdown timing will recover the most energy and therefore minimize waste. This is an important criterion not only for the Unit but also for the State and Federal regulatory bodies that oversee the Unit's operations.

Of the four cases simulated, starting blowdown in 1995 recovers the most energy (Figure 6). It is possible that starting blowdown either shortly before or shortly after 1995 will actually recover more energy than starting blowdown exactly in 1995. However, Figure 6 indicates that 1995 is a good approximation of the optimum blowdown start date in terms of energy recovery. Continuing to inject residue gas after 1995 would provide incremental recoveries of oil and NGL's as compared to starting blowdown in 1995. However, the energy expended through fuel use would be greater than the incremental energy recovered as oil and NGL's.

Complete projections of field performance are illustrated in Figures 7 through 10. A summary of the energy recoveries is found in Appendix D.

FIGURE 3

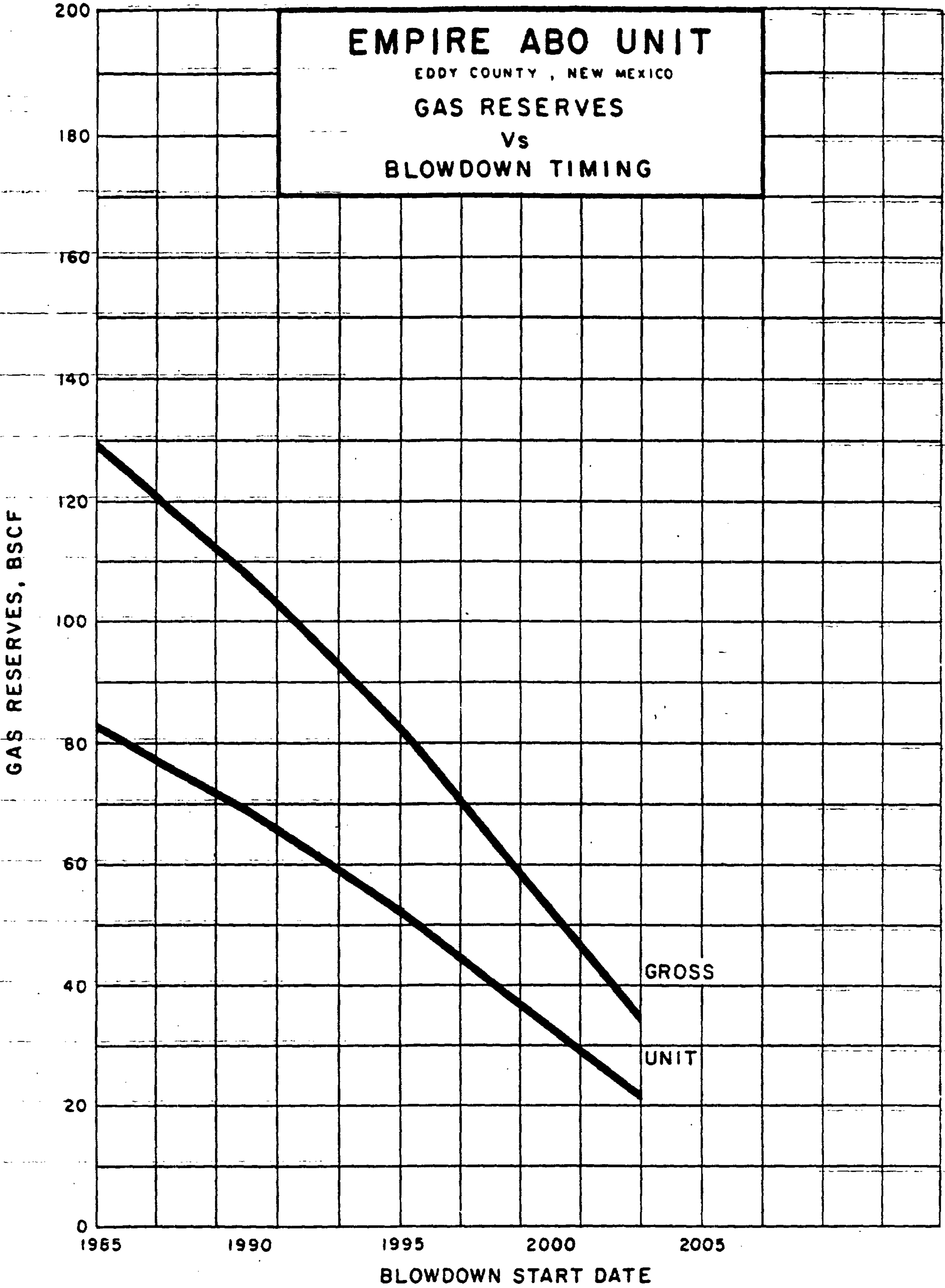

EMPIRE ABO UNIT
EDDY COUNTY , NEW MEXICO
GAS RESERVES
Vs
BLOWDOWN TIMING
GAS RESERVES, BSCF
200
180
160
140
120
100
80
60
40
20
0
1985
1990
1995
2000
2005
BLOWDOWN START DATE
GROSS
UNIT

FIGURE 4

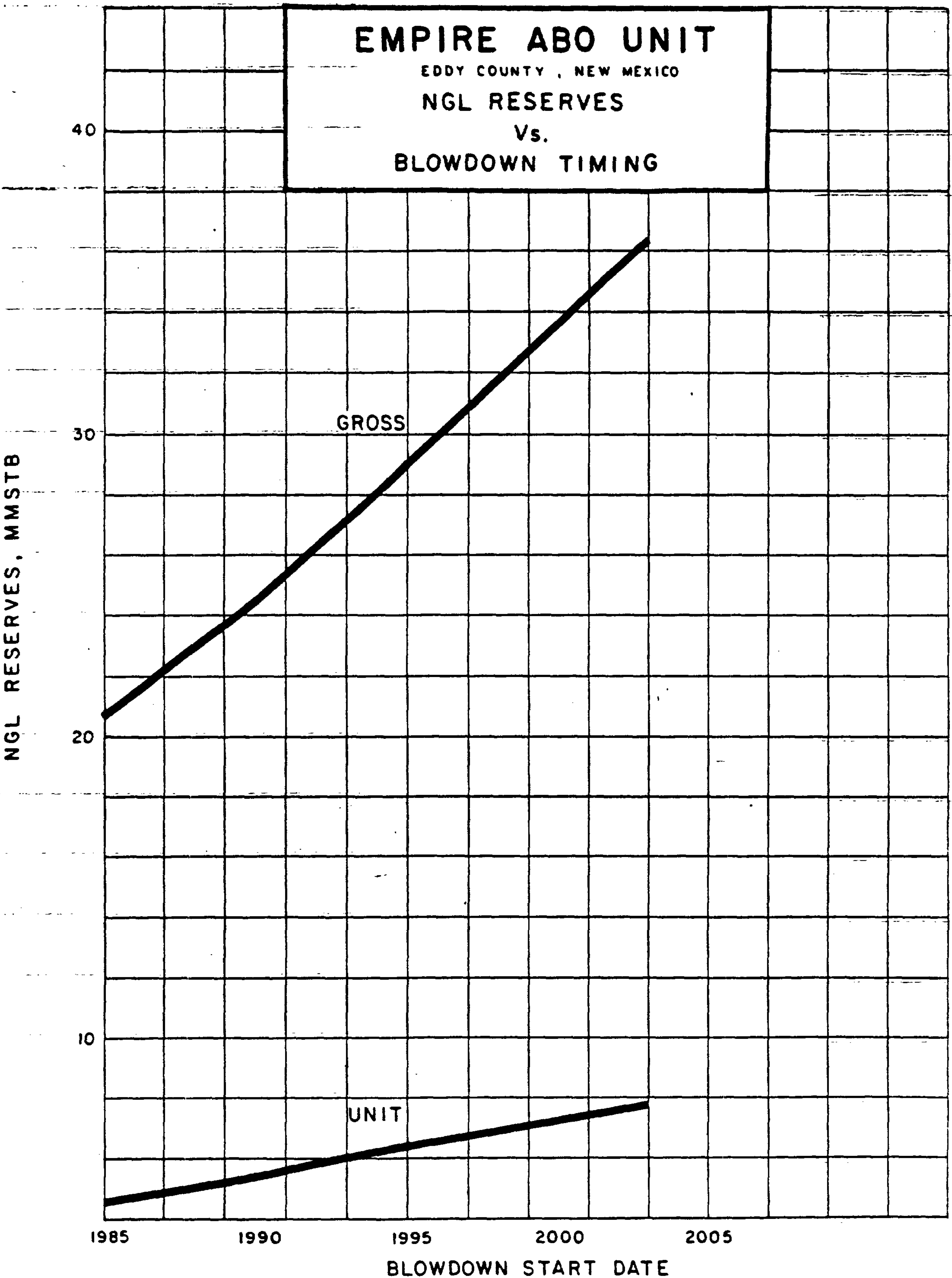

EMPIRE ABO UNIT
EDDY COUNTY, NEW MEXICO
NGL RESERVES
Vs.
BLOWDOWN TIMING
40
30
20
10
GROSS
UNIT
NGL RESERVES, MMSTB
1985
1990
1995
2000
2005
BLOWDOWN START DATE

FIGURE 5

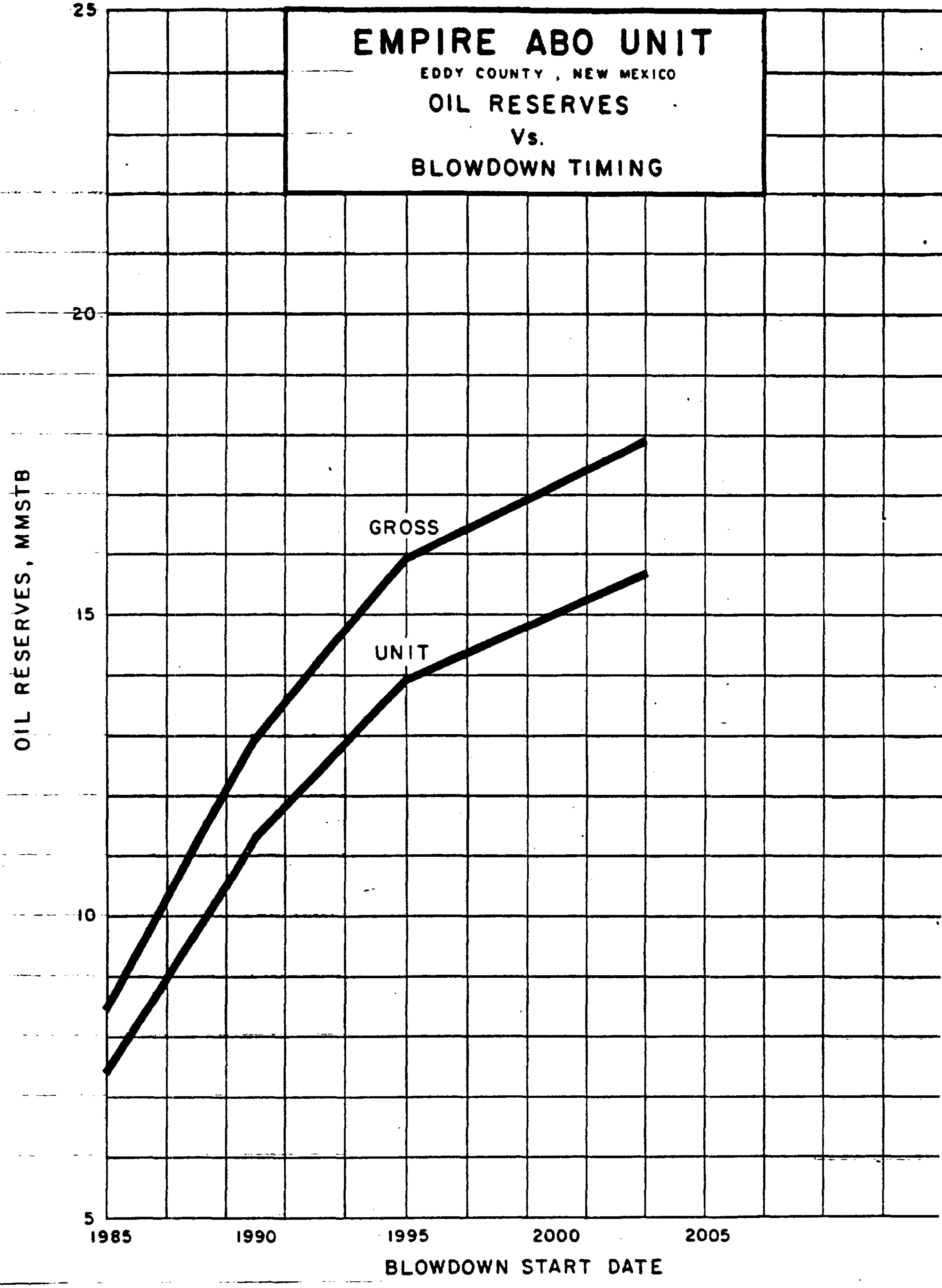

EMPIRE ABO UNIT
EDDY COUNTY , NEW MEXICO
OIL RESERVES
Vs.
BLOWDOWN TIMING
GROSS
UNIT
OIL RESERVES, MMSTB
25
20
15
10
5
1985
1990
1995
2000
2005
BLOWDOWN START DATE

FIGURE 6

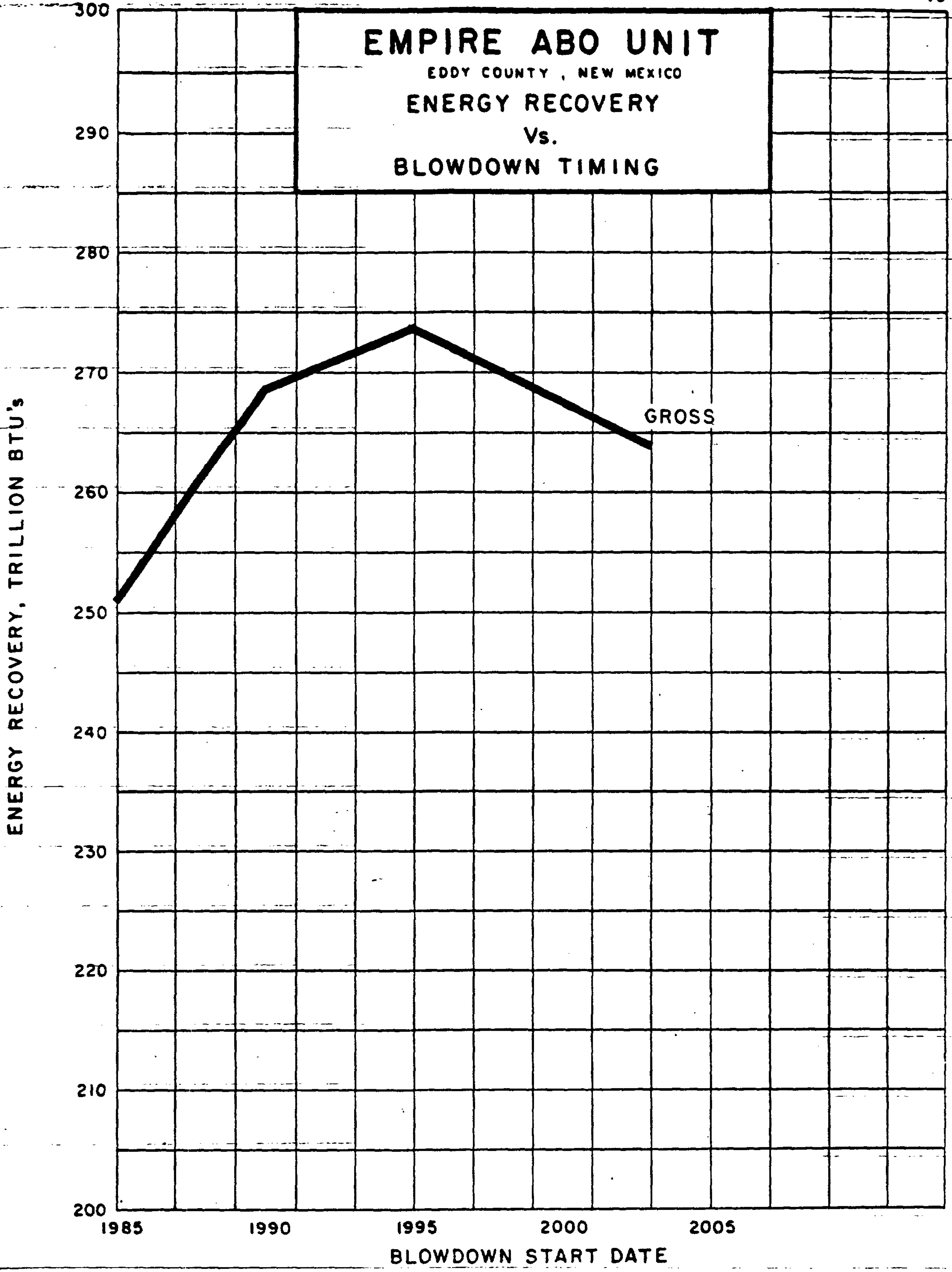

EMPIRE ABO UNIT
EDDY COUNTY, NEW MEXICO
ENERGY RECOVERY
Vs.
BLOWDOWN TIMING
GROSS
ENERGY RECOVERY, TRILLION BTU's
300
290
280
270
260
250
240
230
220
210
200
1985
1990
1995
2000
2005
BLOWDOWN START DATE

FIGURE 7

EMPIRE ABO UNIT

EDDY COUNTY, NEW MEXICO

PREDICTED RESERVOIR PERFORMANCE FOR BLOWDOWN AT 1-1-85

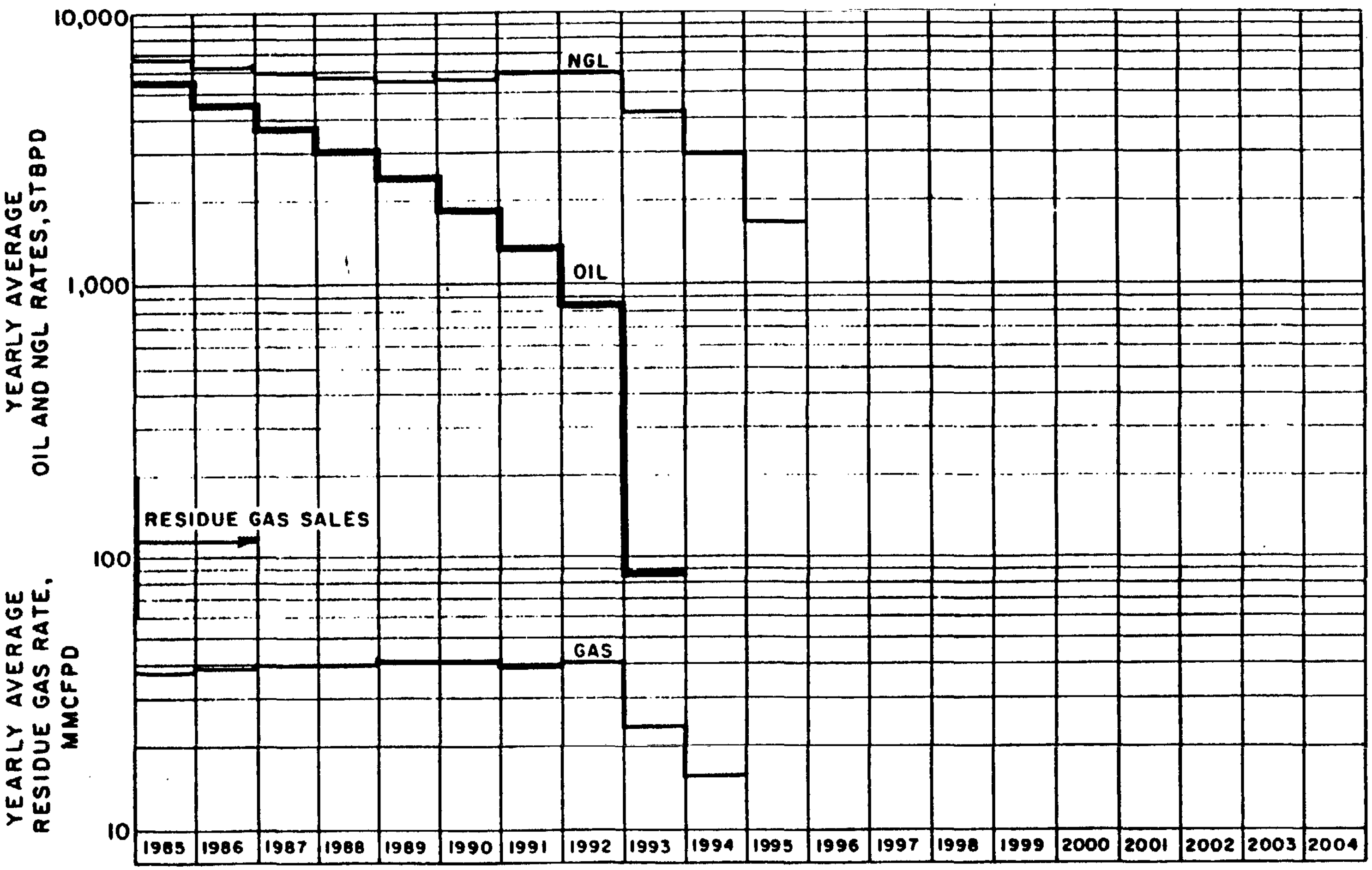


FIGURE 8

EMPIRE ABO UNIT

EDDY COUNTY, NEW MEXICO

PREDICTED RESERVOIR PERFORMANCE FOR BLOWDOWN AT 1-1-90

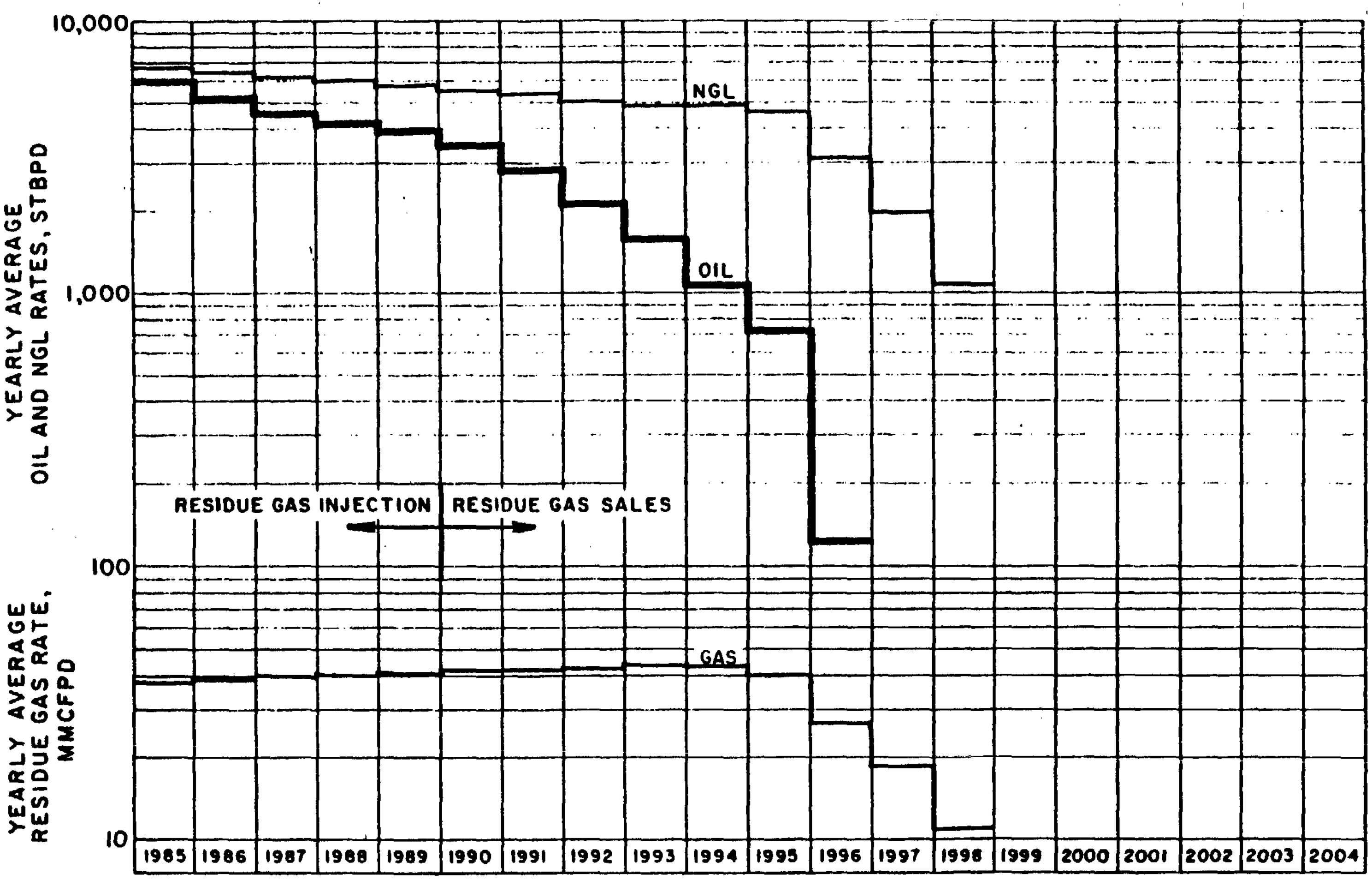


FIGURE 9

EMPIRE ABO UNIT

EDDY COUNTY, NEW MEXICO

PREDICTED RESERVOIR PERFORMANCE FOR BLOWDOWN AT 1-1-95

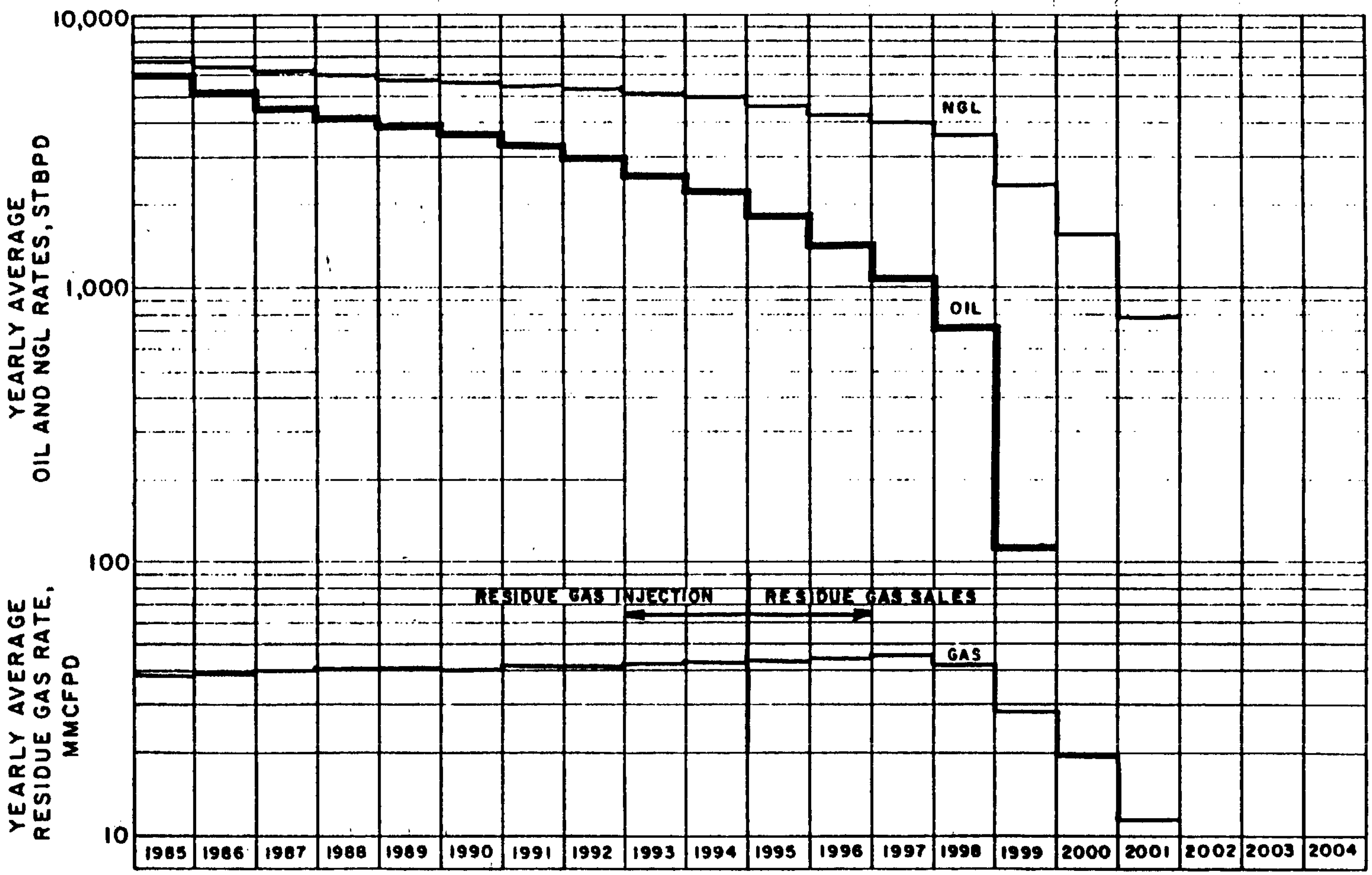
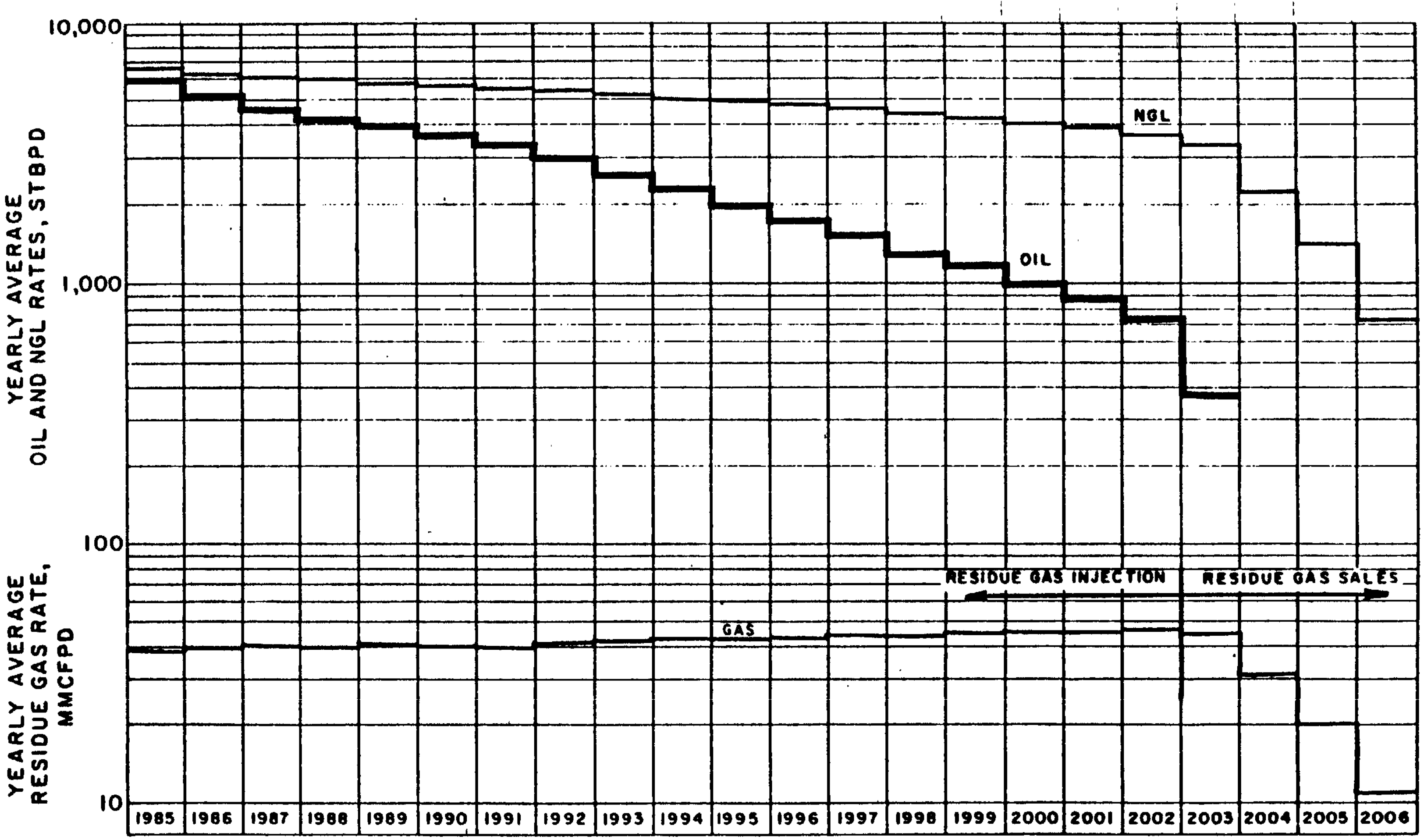


FIGURE 10

EMPIRE ABO UNIT

EDDY COUNTY, NEW MEXICO

PREDICTED RESERVOIR PERFORMANCE FOR BLOWDOWN AT 1-1-03



ECONOMIC EVALUATION

ECONOMIC EVALUATION

As shown in Figure 11, the economics of blowdown depend upon the discount rate used in the calculations. This is to be expected since starting blowdown immediately would increase short-term income, and therefore would be advantageous at high discount rates, whereas delaying blowdown would increase long-term income, and therefore would be advantageous at low discount rates. The recommendation to start blowdown in 1995 is based on undiscounted economics and prevention of waste.

The BFIT economics were calculated assuming a 100 percent working interest, an 87.5 percent net oil interest, a 62.625 percent net gas interest, and a 21.875 percent net NGL interest. The present worth reference date is 1-1-85. A summary of the impact of blowdown timing is presented in Table 4. Table 5 lists the prices, tax rates, and costs used in the economic calculations. Detailed summaries of the economics are found on pages 21 though 24.

Gas Storage

The Unit and the Gas Company of New Mexico (GCONM) have an agreement whereby the Unit stores gas for GCONM. The return rate to GCONM is limited to 65 percent of the residue gas sales rate. It was assumed in the economic calculations that GCONM will take their gas back at the maximum permissible rate. The returnable gas volume was approximately 3.7 BCF in December 1984.

TABLE 4. Evaluation of Blowdown Timing Based on Constant Operating and Overhead Costs, and Constant Product Prices.

Blowdown Start Date	Unit Oil Reserves After 1/85 (MSTB)	Unit NGL Reserves After 1/85 (MSTB)	Unit Gas Reserves After 1/85[1] (MMSCF)	Undiscounted Net Income BFIT (MM$)	Gross Energy Recovery (Trill. BTU)
1/85	7415	4527	82641	361	251
1/90	11350	5369	69244	399	268
1/95	13929	6292	52153	410	274
1/03	15663	7951	21406	357	264

Table 5. Prices, Tax Rates, and Costs Used in Economic Calculations.

Oil Prices
Tier 1: $30.00/BBL, Base Price: $19.00/BBL
Tier 2: $30.00/BBL, Base Price: $22.00/BBL

Gas Price: $2.90/MCF

NGL Prices
Ethane: $0.22/gal
Propane: $0.35/gal
Butane: $0.52/gal
Gasoline: $0.63/gal

Production Tax Rates
Severance Tax: 3.75%
Emergency School Tax: 3.15%
Ad Valorem Tax: 0.18%

Windfall Profits Tax Rates
Tier 1: 70%
Tier 2: 60%

Operating Costs
With Gas Injection: $7020M/year
Without Gas Injection: $6468M/year

Overhead Costs: $990M/year

---

[1] Storage gas owned by Gas Company of New Mexico has been deducted from the Unit gas reserves (3.7 BCF).

FIGURE 11

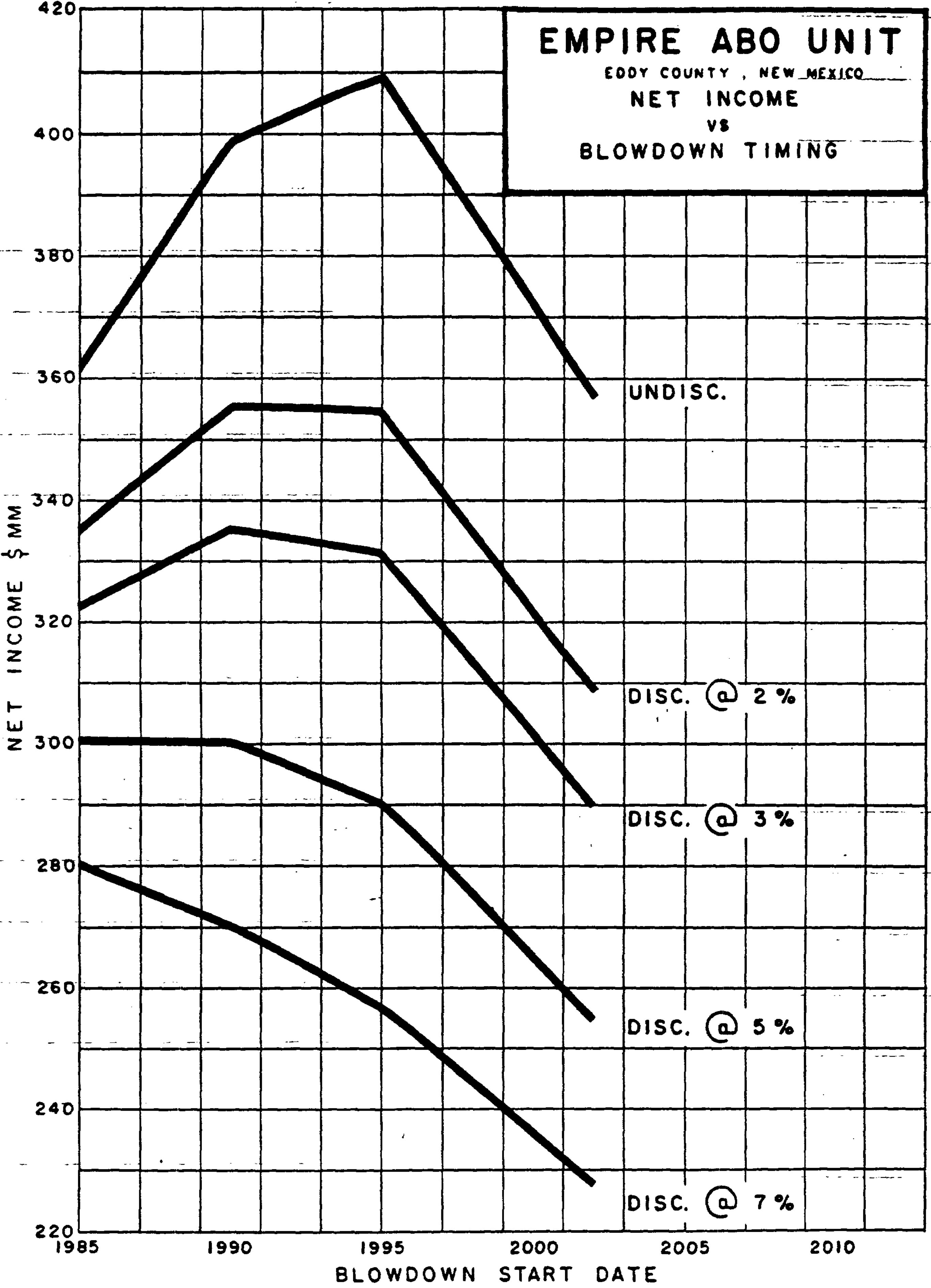

EMPIRE ABO UNIT
EDDY COUNTY , NEW MEXICO
NET INCOME
VS
BLOWDOWN TIMING
UNDISC.
DISC. @ 2 %
DISC. @ 3 %
DISC. @ 5 %
DISC. @ 7 %
NET INCOME $MM
420
400
380
360
340
320
300
280
260
240
220
1985
1990
1995
2000
2005
2010
BLOWDOWN START DATE

TABLE 6

EMPIRE ABO UNIT
BLOWDOWN AT 1/1/1985
Detail of Economic Calculations

YEAR	GROSS OIL PRODUCTION (MSTB)	GROSS GAS PRODUCTION (MMCF)	GROSS GAS SALES[1] (MMCF)	GROSS NGL PRODUCTION (MSTB)	NET REVENUE (M$)	PRODUCTION TAXES (M$)	OVH & OPR COSTS (M$)	WINDFALL PROFITS TAX (M$)	BFIT CASH FLOW (M$)
1985	2026	23725	10034	2475	76741	5587	7458	12684	51013
1986	1632	23725	14235	2304	77506	5642	7458	10217	54189
1987	1340	23725	14472	2178	69832	5084	7458	8389	48901
1988	1104	23725	14710	2085	63731	4640	7458	6912	44722
1989	878	23725	14947	2046	58053	4226	7458	3427	42942
1990	675	23725	14710	2072	52285	3806	7458	2634	38386
1991	484	23662	14434	2168	46970	3419	7458	1521	34572
1992	304	21965	12959	2159	39324	2863	7458	528	28475
1993	31	14746	8553	1539	21795	1587	7458	12	12739
1994		9965	5680	1076	14052	1023	7458		5571
1995		5522	3148	595	7757	565	7458		-266
	8474		127938	20697	528045	38442	82038	46324	361243

---

1. Storage gas owned by Gas Company of New Mexico has been deducted from gross gas sales (3.7 BCF)

TABLE 7

EMPIRE ABO UNIT
BLOWDOWN AT 1/1/1990
Detail of Economic Calculations

YEAR	GROSS OIL PRODUCTION (MSTB)	GROSS GAS PRODUCTION (MMCF)	GROSS GAS SALES[1] (MMCF)	GROSS NGL PRODUCTION (MSTB)	NET REVENUE (M$)	PRODUCTION TAXES (M$)	OVH & OPR COSTS (M$)	WINDFALL PROFITS TAX (M$)	BFIT CASH FLOW (M$)
1985	2150	23725		2451	64547	4699	8010	13460	38378
1986	1869	23725		2341	56798	4135	8010	11701	32952
1987	1666	23725		2244	51132	3722	8010	10430	28970
1988	1531	23725		2169	47355	3447	8010	9591	26307
1989	1430	23725		2107	44461	3237	8010	8953	24261
1990	1261	23725	11220	1996	57225	4166	7458	7895	37707
1991	1025	23725	15184	1909	61944	4510	7458	5166	44811
1992	777	23725	15421	1833	55575	4046	7458	1349	42722
1993	574	23725	15659	1785	50461	3674	7458	218	39111
1994	383	23477	15459	1773	45027	3278	7458		34291
1995	259	22057	14337	1685	39226	2856	7458		28912
1996	45	14808	9625	1123	22866	1665	7458		13744
1997		10026	6617	732	14736	1073	7458		6205
1998		5836	3910	397	8570	624	7458		488
	12970		107468	24545	619923	45130	107172	68763	398858

---

1. Storage gas owned by Gas Company of New Mexico has been deducted from gross gas sales (3.7 BCF)

TABLE 8

EMPIRE ABO UNIT
BLOWDOWN AT 1/1/1995
Detail of Economic Calculations

YEAR	GROSS OIL PRODUCTION (MSTB)	GROSS GAS PRODUCTION (MMCF)	GROSS GAS SALES[1] (MMCF)	GROSS NGL PRODUCTION (MSTB)	NET REVENUE (M$)	PRODUCTION TAXES (M$)	OVH & OPR COSTS (M$)	WINDFALL PROFITS TAX (M$)	BFIT CASH FLOW (M$)
1985	2150	23725		2451	64547	4699	8010	13460	38378
1986	1869	23725		2341	56798	4135	8010	11701	32952
1987	1666	23725		2244	51132	3722	8010	10430	28970
1988	1531	23725		2169	47355	3447	8010	9591	26307
1989	1430	23725		2107	44461	3237	8010	8953	24261
1990	1328	23725		2050	41589	3028	8010	8314	22237
1991	1216	23725		2001	38479	2801	8010	6128	21540
1992	1080	23725		1953	34740	2529	8010	3009	21192
1993	946	23725		1900	31026	2259	8010	360	20397
1994	822	23725		1844	27573	2007	8010		17556
1995	664	23725	12169	1690	42310	3080	7458		31771
1996	518	23725	16183	1556	49243	3585	7458		38200
1997	394	23725	16370	1459	46059	3353	7458		35248
1998	259	21872	15310	1307	39940	2908	7458		29575
1999	45	14684	10279	854	23304	1697	7458		14150
2000		9934	7053	551	15034	1095	7458		6482
2001		5707	4109	287	8626	628	7458		540
	15918		81473	28764	662215	48209	132306	71946	409755

---

1. Storage gas owned by Gas Company of New Mexico has been deducted from gross gas sales (3.7 BCF)

TABLE 9

EMPIRE ABO UNIT
BLOWDOWN AT 1/1/2003
Detail of Economic Calculations

YEAR	GROSS OIL PRODUCTION (MSTB)	GROSS GAS PRODUCTION (MMCF)	GROSS GAS SALES[1] (MMCF)	GROSS NGL PRODUCTION (MSTB)	NET REVENUE (M$)	PRODUCTION TAXES (M$)	OVH & OPR COSTS (M$)	WINDFALL PROFITS TAX (M$)	BFIT CASH FLOW (M$)
1985	2150	23725		2451	64547	4699	8010	13460	38378
1986	1869	23725		2341	56798	4135	8010	11701	32952
1987	1666	23725		2244	51132	3722	8010	10430	28970
1988	1531	23225		2169	47355	3447	8010	9591	26307
1989	1430	23725		2107	44461	3237	8010	8953	24261
1990	1328	23725		2050	41589	3028	8010	8314	22237
1991	1216	23725		2001	38479	2801	8010	6128	21540
1992	1080	23725		1953	34740	2529	8010	3009	21192
1993	946	23725		1900	31026	2259	8010	360	20397
1994	822	23725		1844	27573	2007	8010		17556
1995	720	23725		1786	24689	1797	8010		14882
1996	631	23725		1721	22127	1611	8010		12506
1997	552	23725		1660	19848	1445	8010		10393
1998	473	23725		1594	17540	1277	8010		8253
1999	417	23725		1530	15850	1154	8010		6686
2000	360	23725		1467	14137	1029	8010		5098
2001	315	23725		1398	12729	927	8010		3792
2002	259	23725		1327	11027	803	8010		2214
2003	135	22582	12294	1209	27074	1971	7458		17645
2004		15424	11015	808	23529	1713	7458		14358
2005		10211	7361	579	15648	1139	7458		7050
2006		5399	3900	268	8261	601	7458		201
	17900		34570	36347	650155	47331	174012	71946	356867

---

1. Storage gas owned by Gas Company of New Mexico has been deducted from gross gas sales (3.7 BCF)

REFERENCES

REFERENCES

1. Detmering, T.J., Improved Plan of Depletion - Empire Abo Unit- Abo Reservoir, ARCO Oil and Gas Company, Midland Texas, April 1983.

2. Field Management Study - Abo Reservoir - Empire Abo Pool, October 1970.

3. Foster, H.P., Engineering Study - Empire Abo Unit - Abo Reservoir, ARCO Oil and Gas Company, Midland Texas, November 1977.

4. Shumbera, D.A., A Compositional Study of Proposed Alternatives for Future Operation of Empire Abo, ARCO Oil and Gas Company, Dallas, Texas, August 1982.

5. Shumbera, D.A. and Staggs, H.M., Empire Abo Unit Performance Projection, ARCO Oil and Gas Company, Dallas, Texas, June 1984.

APPENDIX A

APPENDIX A

Black Oil Numeric Simulator Description and Design

BLACK OIL NUMERIC SIMULATOR DESCRIPTION AND DESIGN

Modeled Area

A representative slice (Figures A1 and A2) of the reservoir was modeled as opposed to modeling the entire reservoir due to manpower and computer time limitations. This slice is representative of the entire field with the exception of the extreme east and west ends. The east end has experienced a considerable amount of water influx while the west end appears to be a solution gas drive reservoir rather than a gravity drainage reservoir. The combined volume of these two portions of the reservoir is less than 10 percent of the total reservoir volume.

H.P. Foster modeled this same slice in 1977 to study the impact of infill drilling. The success of Foster's model study, as illustrated by the close agreement of his oil forecast and actual production (Figure A3), demonstrates the results of the slice model can be scaled up to provide forecasts of the entire field's performance. Unfortunately, all of Foster's projections assumed blowdown in 1985 and therefore it was necessary to make additional simulator runs to study the impact of blowdown at later dates.

The numeric reservoir simulator used for the cross-sectional slice model is ARCO's three-dimensional, three phase, unsteady state, compressible flow, semi-implicit model. This black oil model numerically solves the partial differential equations which describe simultaneous oil, gas, and water flow between reservoir segments in three dimensions.

Model Set Up And Data Preparation

For the numeric model to accurately predict future performance, it must be set up dimensionally to properly reflect fluid movement in the reservoir. The cross-sectional slice model is 6 rows wide (east to west), 22 layers in the vertical direction, and 18 columns from back-reef to fore-reef as shown in Figure A4. The six rows are each 330 ft wide for a total width of 1980 ft. The outside rows are used to reflect well drainage areas. Each layer in the vertical direction is 25 ft thick. The third dimension of the cells, in the back-reef to fore-reef direction, varies from 370 ft to 600 ft. The smaller cells are used in the down dip heart of the reef to give adequate definition of flow characteristics during projections while the larger cells are used in areas where fluid movement is slower or relatively unimportant. The cells are aligned parallel to the dip of the reef base to eliminate artificial impediments to north-south fluid movements and to adequately determine how well the fluid migrates to the down dip areas under different schemes of operation. The wells shown in Figure A4 are the actual field wells within the modeled area.

Porosity values were obtained by applying porosity index curves (Figure A5) to open hole neutron logs. These values formed the basis for volume calculations for the numeric model. Core data analysis indicates porosity varies as the log of permeability (Figure A6). Using this relationship, permeability values for each two foot interval of each well were calculated from the porosity values. These values were the basis for porosity and permeability maps of each individual layer in the model. Computer programs were used for sorting this digitized data to obtain gross and net pay, average porosity, and permeability values for any grouping desired. Isopach maps were made of each layer to determine pore volumes and permeabilities for each of the 2376 cells in the model.

Interstitial water saturations were based on the 1970 numeric model simulation and checked by analysis of logs obtained during the 20 acre infill drilling program. Fluid data relationships (Figure A7 and A8) are from a composite of analyses from five different wells which were selected to give good coverage of the reservoir.

Reservoir pressure data in the area of the slice is very good. At least two wells, and sometimes more, were tested during each annual BHP survey giving an adequate pressure history for the area. Oil, gas, and water production data are also good. The New Mexico Oil Conservation Commission requires annual tests with well production reported by months.

The gas oil relative permeability data (Figure A9) is the same as that used in the 1970 numeric simulation of the entire field.

Gas Coning

Because of the gas coning characteristics of the Empire Abo reservoir it is desireable to include the effects of gas coning by individual wells. This is especially true during the latter part of the history match and during the projections as the wells are being produced at high total fluid rates.

Individual well performances are controlled in the three dimensional model by correlations derived from simulations of individual type-wells with a two dimensional, R-Z (radial-vertical), multi-phase, compressible flow simulator. Multiple projections were made at various reservoir producing rates to relate producing GOR to average oil saturation in the well cell columns. The characteristics of the R-Z Coning simulator closely approximate the column of cells for each well in the three dimensional simulator. These derived correlations were input into the slice model and used to control the performance of each well during its life (Figures A10-A12). The oil column height used in these correlations is analogous to the distance from the top of the perforated interval in the well cell column to the gas cap. It is based on the average oil saturation in this column.

One well, the G-21, was not controlled in the slice model with a coning correlation. It was fractured during its early life and appeared to have a gas channel in the cement. It was controlled by producing the required amount of gas from a cell in the gas cap to match its producing history. The G-21 is a last row, back-reef producer and was shut-in during all projections.

History Match

The history match obtained during the 1977 model study extended from 1959 to 1977. The seven years that have lapsed since this history match was completed had to be added in order to have the correct saturation and pressure distributions at the start of the forecasts. Furthermore, these seven years of additional history had to be added without changing the reservoir description so that the previous history match would not be altered. This was accomplished by adjusting only the coning correlations during the new history match period. Care was taken to ensure that these adjustments did not affect the producing wells prior to 1977.

As in the 1977 history matching process, oil rates were input and the simulator calculated water and gas production rates. The coning correlations were adjusted after each trial run of the simulator to obtain a match of gas production rates for each well. Five infill wells were drilled in the slice area between 1977 and 1984: J-221, J-222, J-233, J-234, and K-231. These were included in the history match.

The results of the history match, including plots comparing actual well performances versus calculated performances, are presented in Appendix C. The black oil simulator matched individual well gas production rates, water production rates, and average reservoir pressures from 1959 to 1984.

Forecasts

During the forecasting period the produced gas rate was limited to a field rate of 67 MMCFPD. This rate is the sum of the Unit allowable and the average rate of non-participating tracts in the field. Inflow performance analysis indicates this field rate will be maintained until the reservoir pressure is reduced to approximately 200 psi. Reinjection was set at 58 percent of the produced gas rate based on past performance of the gas plants and forecasts of reinjection volumes calculated by the compositional model. A bottom hole pressure limit of 200 psi was set for each well to control production at low reservoir pressures. This replaces the productivity index used by Foster in his forecasts and more closely simulates actual constraints on production caused by wellbore hydraulics and surface equipment.

Scale Up

Examination of Figure A13 leads to the conclusion that the slice is representative of the field but that its oil decline is not synchronous with the actual field decline. Higher voidage rates in the slice during the mid-70's apparently caused gas coning to occur earlier in the slice than in the rest of the field. As a result, the slice oil decline is leading the field by approximately 2 years. Therefore, the oil forecasts for starting blowdown in 1985, 1990, 1995, and 2003 were calculated by starting blowdown in the simulator in 1983, 1988, 1993, and 2001, respectively. These forecasts were scaled up based on the ratio of the hydrocarbon pore volumes of the slice and the field.

FIGURE A-1

AtlanticRichfieldCompany
North American Producing Division
Permian District Midland Texas

EMPIRE ABO POOL
TOP OF REEF
EDDY COUNTY, NEW MEXICO
C.I. = 50'

FIGURE A-2

AtlanticRichfieldCompany
North American Producing Division
Permian District Midland, Texas

EMPIRE ABO POOL
BASE OF REEF
EDDY COUNTY, NEW MEXICO
C.I. = 50'

NOTE ONLY ABO WELLS AND COMPLETION STATUS SHOWN

FIGURE A-3

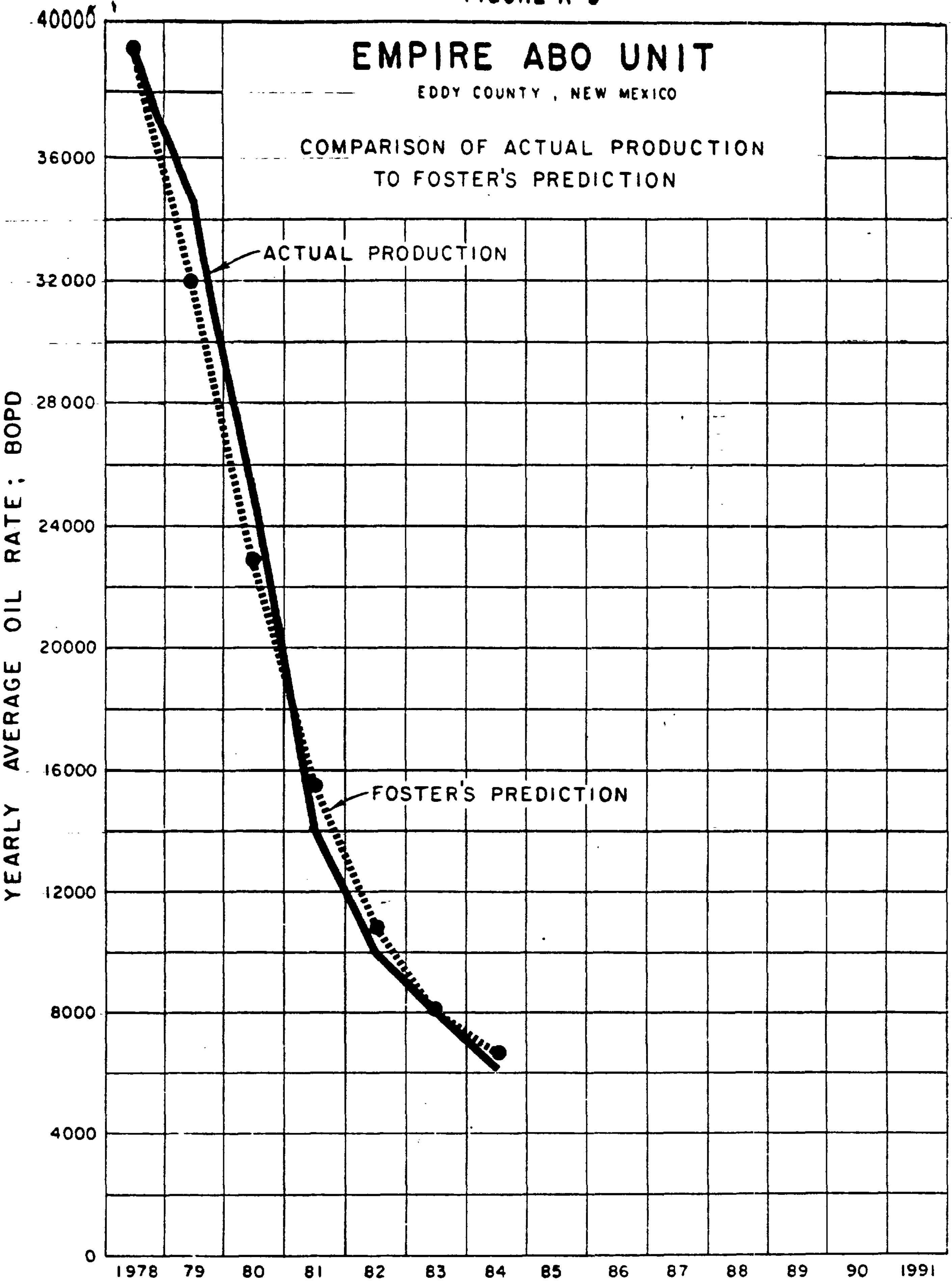

EMPIRE ABO UNIT
EDDY COUNTY, NEW MEXICO
COMPARISON OF ACTUAL PRODUCTION TO FOSTER'S PREDICTION
ACTUAL PRODUCTION
FOSTER'S PREDICTION
YEARLY AVERAGE OIL RATE: BOPD
40000
36000
32000
28000
24000
20000
16000
12000
8000
4000
0
1978
79
80
81
82
83
84
85
86
87
88
89
90
1991

FIGURE A-4

EMPIRE ABO UNIT

EDDY COUNTY, NEW MEXICO

THREE DIMENS

FIGURE A-5

ENGINEERING COMMITTEE
EMPIRE ABO RESERVOIR-MAIN REEF AREA

CORE POROSITY VS. NEUTRON STD. COUNTS PER SEC. FOR SCHLUMBERGER
AND WELEX LOGS
CONDITIONS: OPEN HOLE 7 7/8" DIAMETER

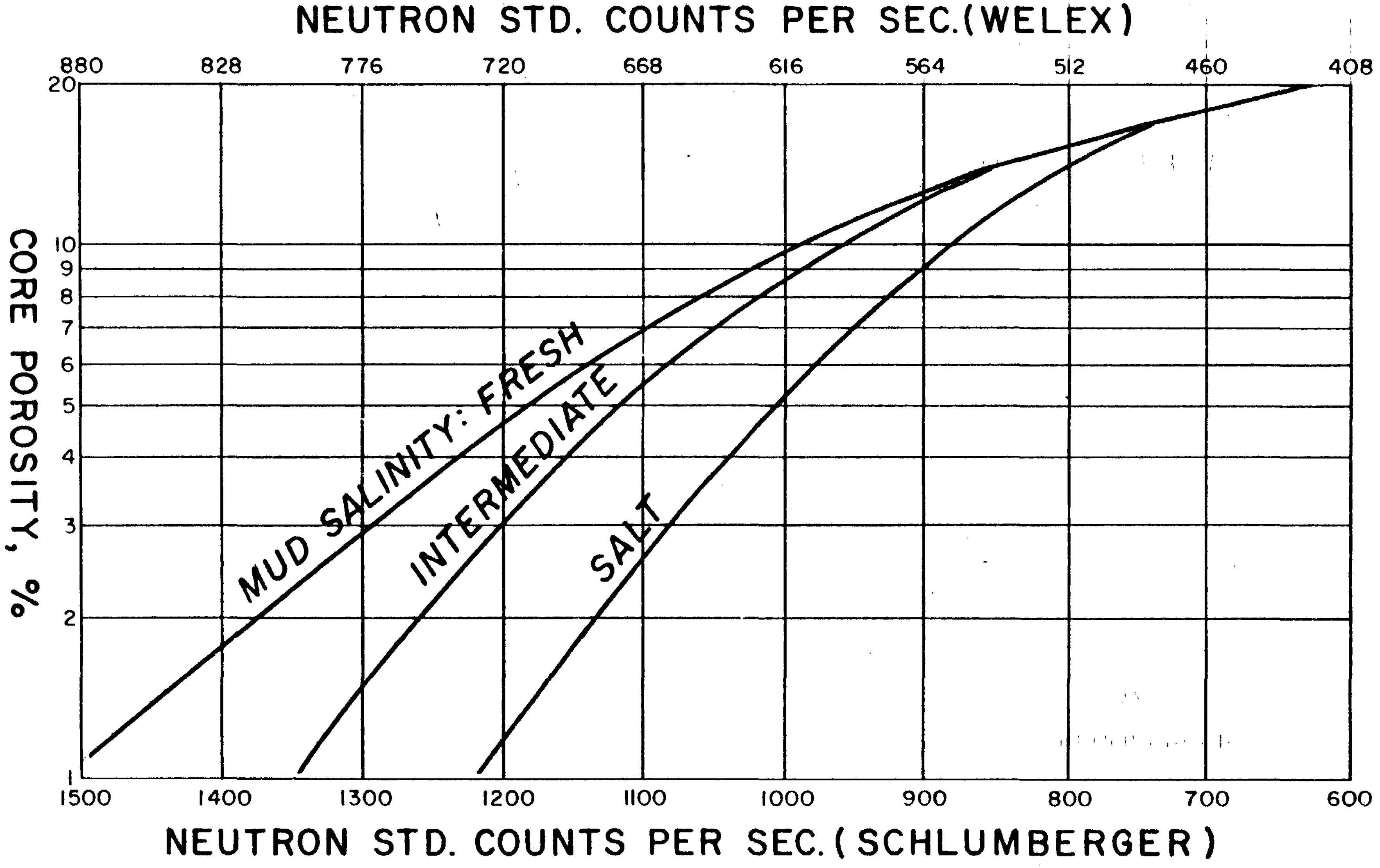


FIGURE A-6

EMPIRE ABO UNIT

EDDY COUNTY, NEW MEXICO

CORE PERMEABILITY VS. POROSITY

USING SORT BY POROSITY RANGES

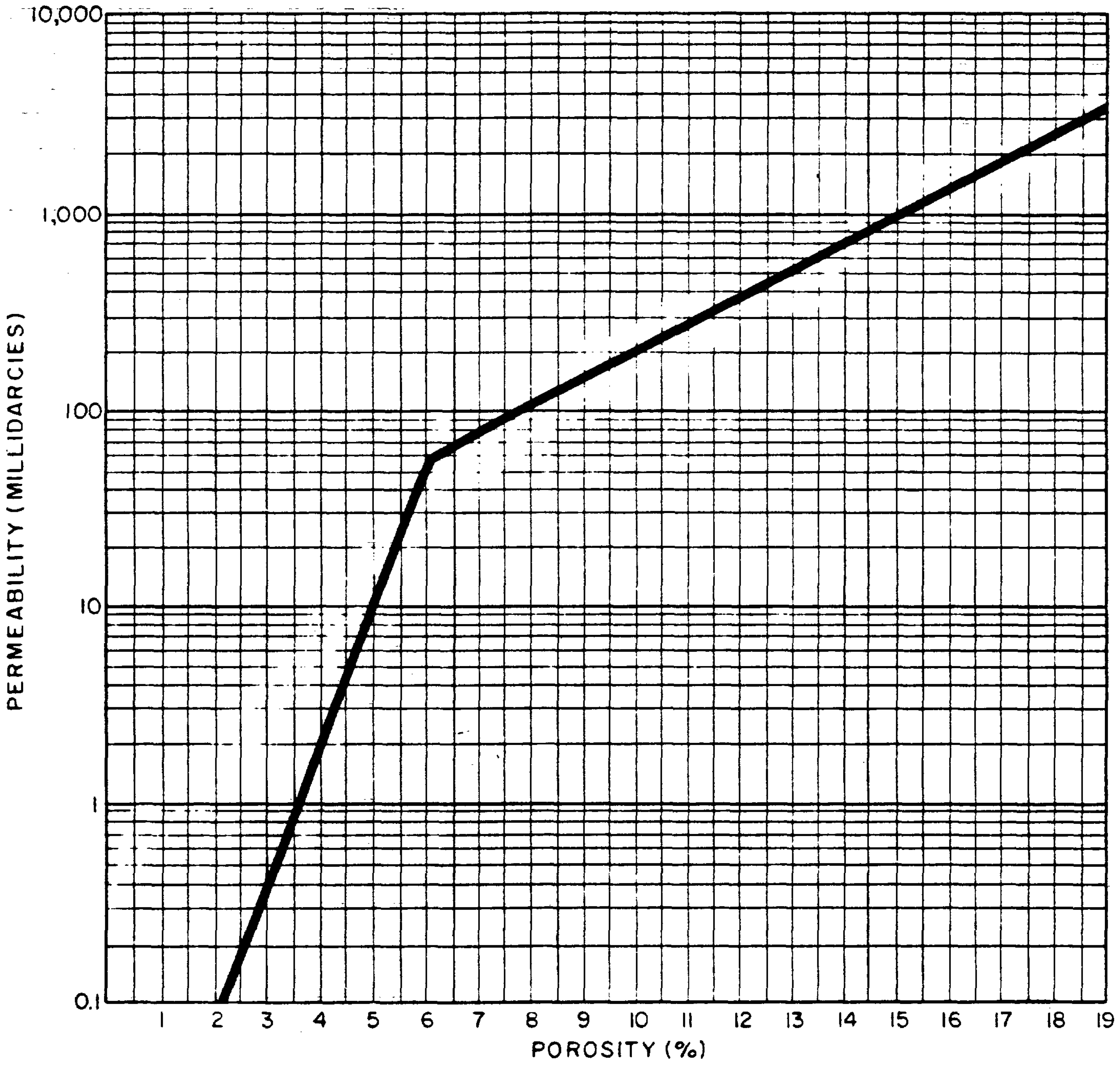


FIGURE A-7

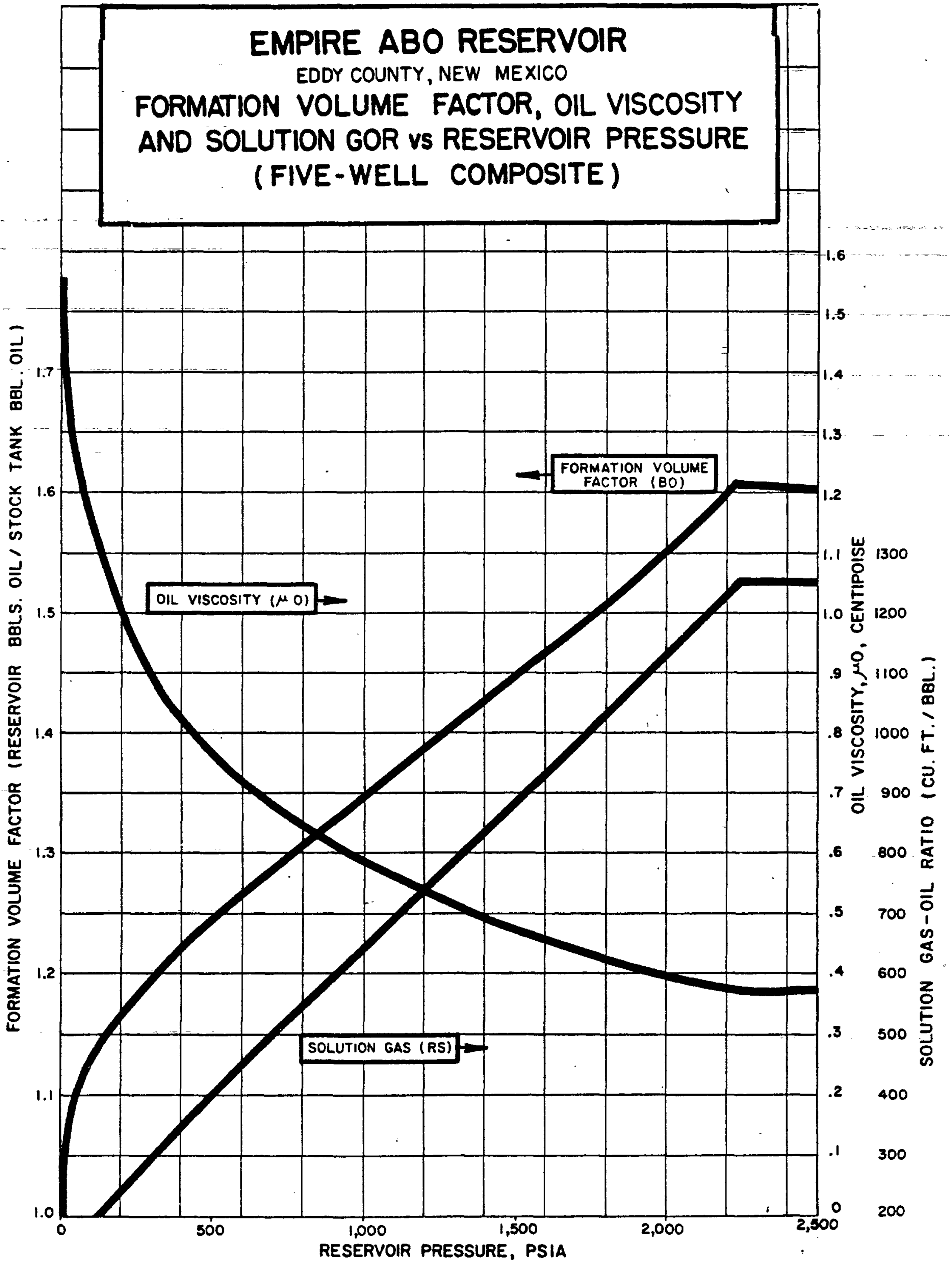

EMPIRE ABO RESERVOIR
EDDY COUNTY, NEW MEXICO
FORMATION VOLUME FACTOR, OIL VISCOSITY AND SOLUTION GOR vs RESERVOIR PRESSURE
(FIVE-WELL COMPOSITE)
FORMATION VOLUME FACTOR (BO)
OIL VISCOSITY (μ O)
SOLUTION GAS (RS)
FORMATION VOLUME FACTOR (RESERVOIR BBLS. OIL / STOCK TANK BBL. OIL)
1.0
1.1
1.2
1.3
1.4
1.5
1.6
1.7
OIL VISCOSITY, μO, CENTIPOISE
0
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0
1.1
1.2
1.3
1.4
1.5
1.6
SOLUTION GAS-OIL RATIO (CU. FT. / BBL.)
200
300
400
500
600
700
800
900
1000
1100
1200
1300
0
500
1,000
1,500
2,000
2,500
RESERVOIR PRESSURE, PSIA

FIGURE A-8

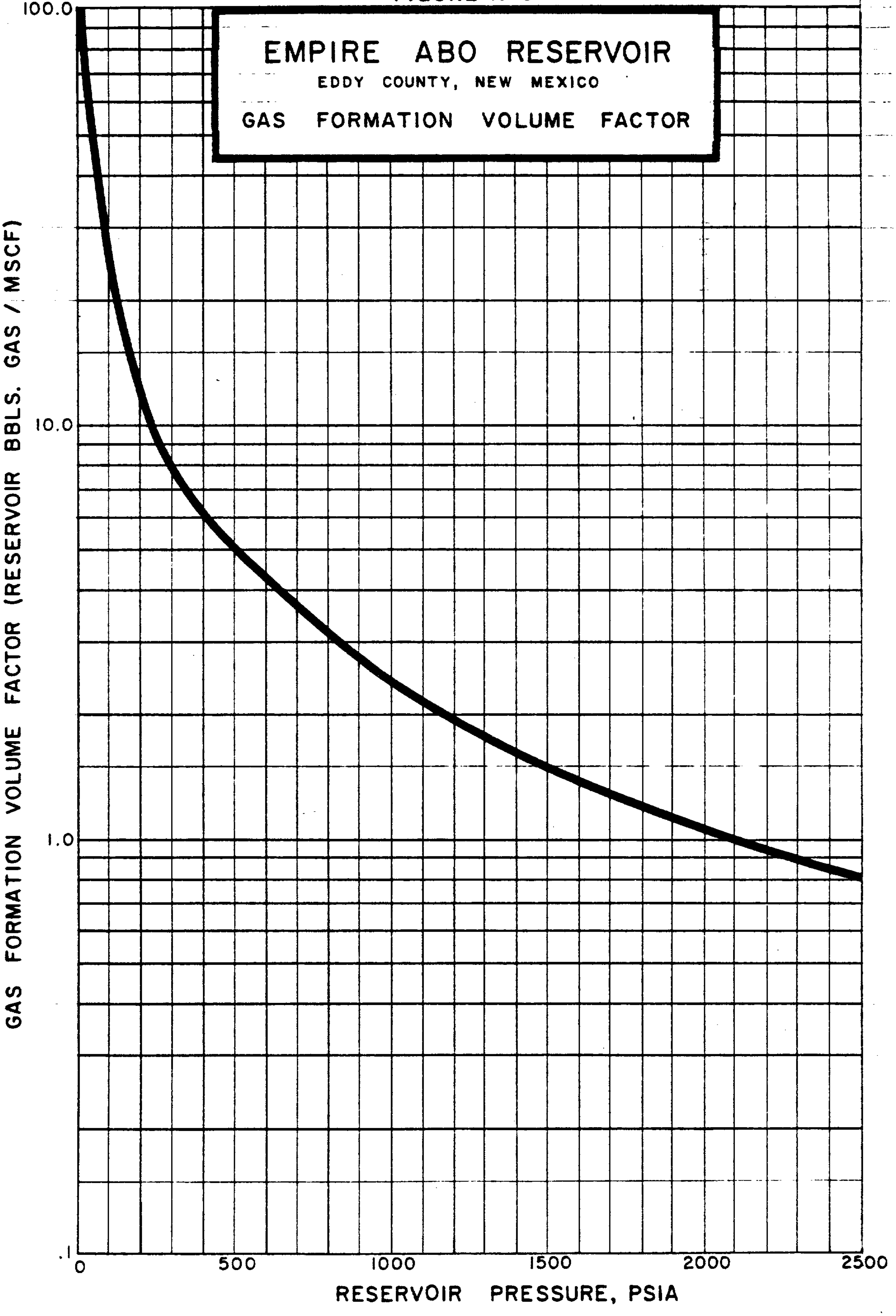

EMPIRE ABO RESERVOIR
EDDY COUNTY, NEW MEXICO
GAS FORMATION VOLUME FACTOR
GAS FORMATION VOLUME FACTOR (RESERVOIR BBLS. GAS / MSCF)
100.0
10.0
1.0
.1
0
500
1000
1500
2000
2500
RESERVOIR PRESSURE, PSIA

FIGURE A-9

EMPIRE ABO UNIT

EDDY COUNTY, NEW MEXICO

ABO RESERVOIR
HISTORY-MATCH GAS-OIL RELATIVE PERMEABILITY CURVE

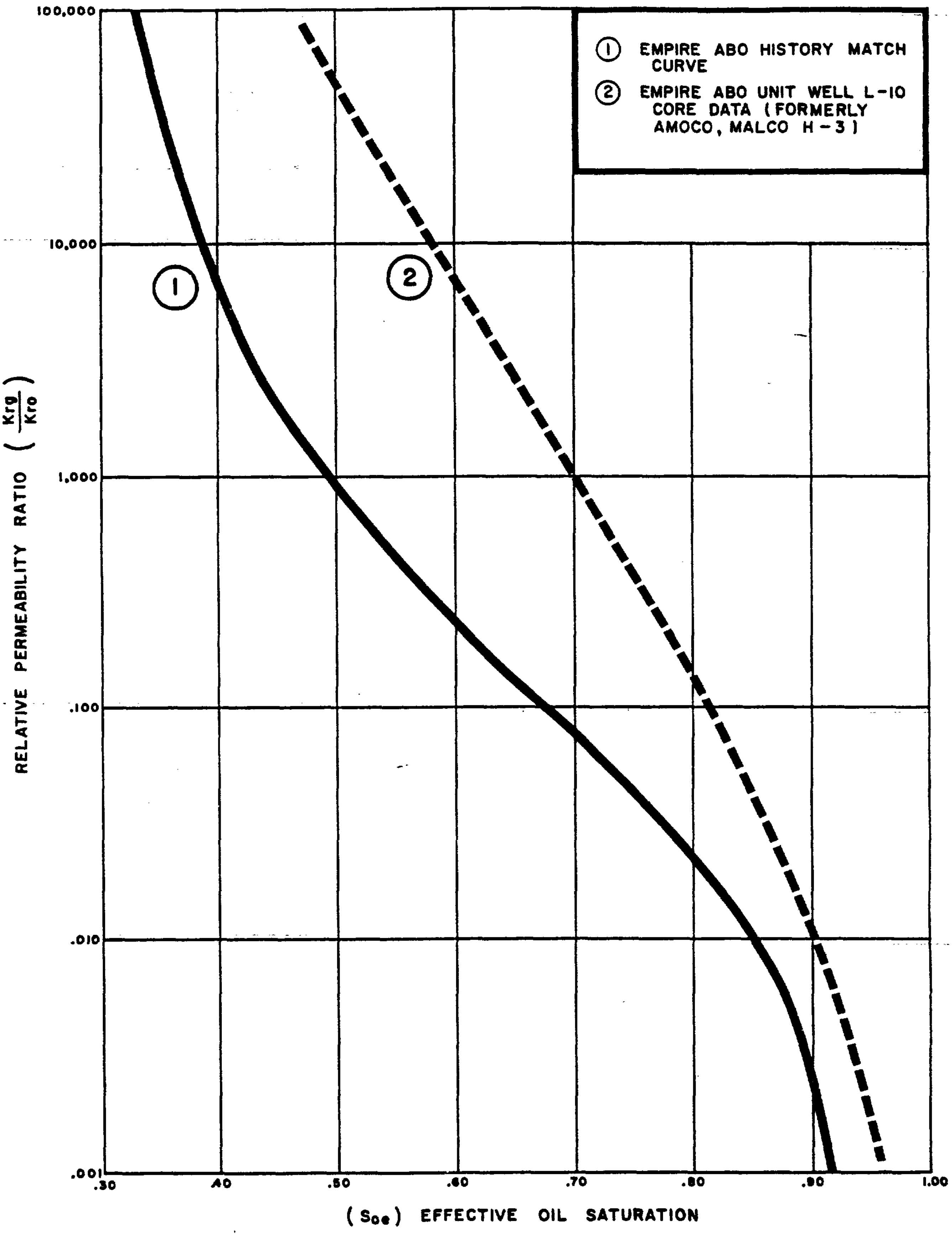


FIGURE A-10

EMPIRE ABO UNIT

EDDY COUNTY, NEW MEXICO

CONING CORRELATION CALCULATED BY RADIAL CONING MODEL FOR WELL K-23

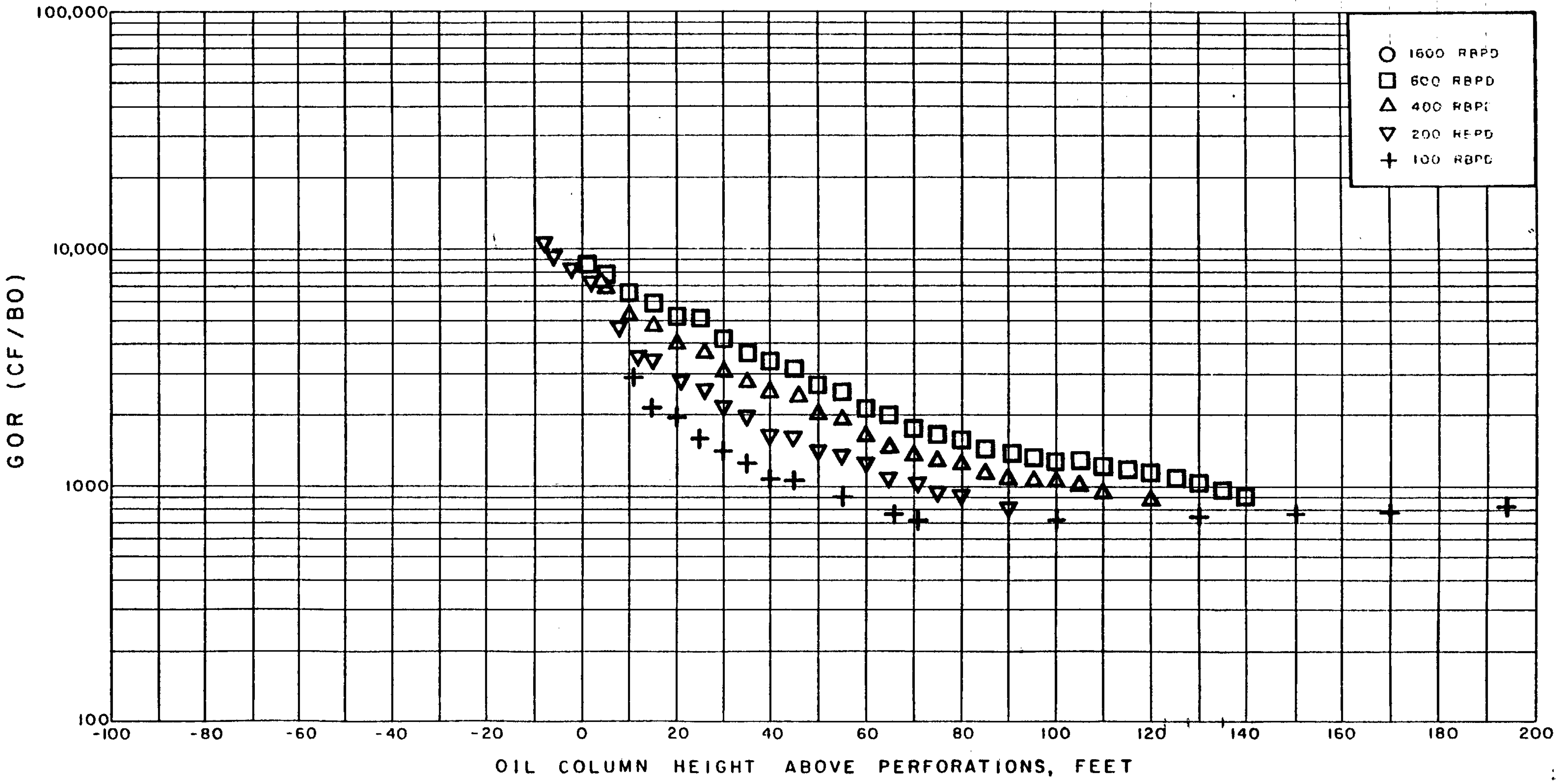


FIGURE A-11

EMPIRE ABO UNIT

EDDY COUNTY, NEW MEXICO

CONING CORRELATION CALCULATED BY RADIAL CONING MODEL FOR WELL H-24

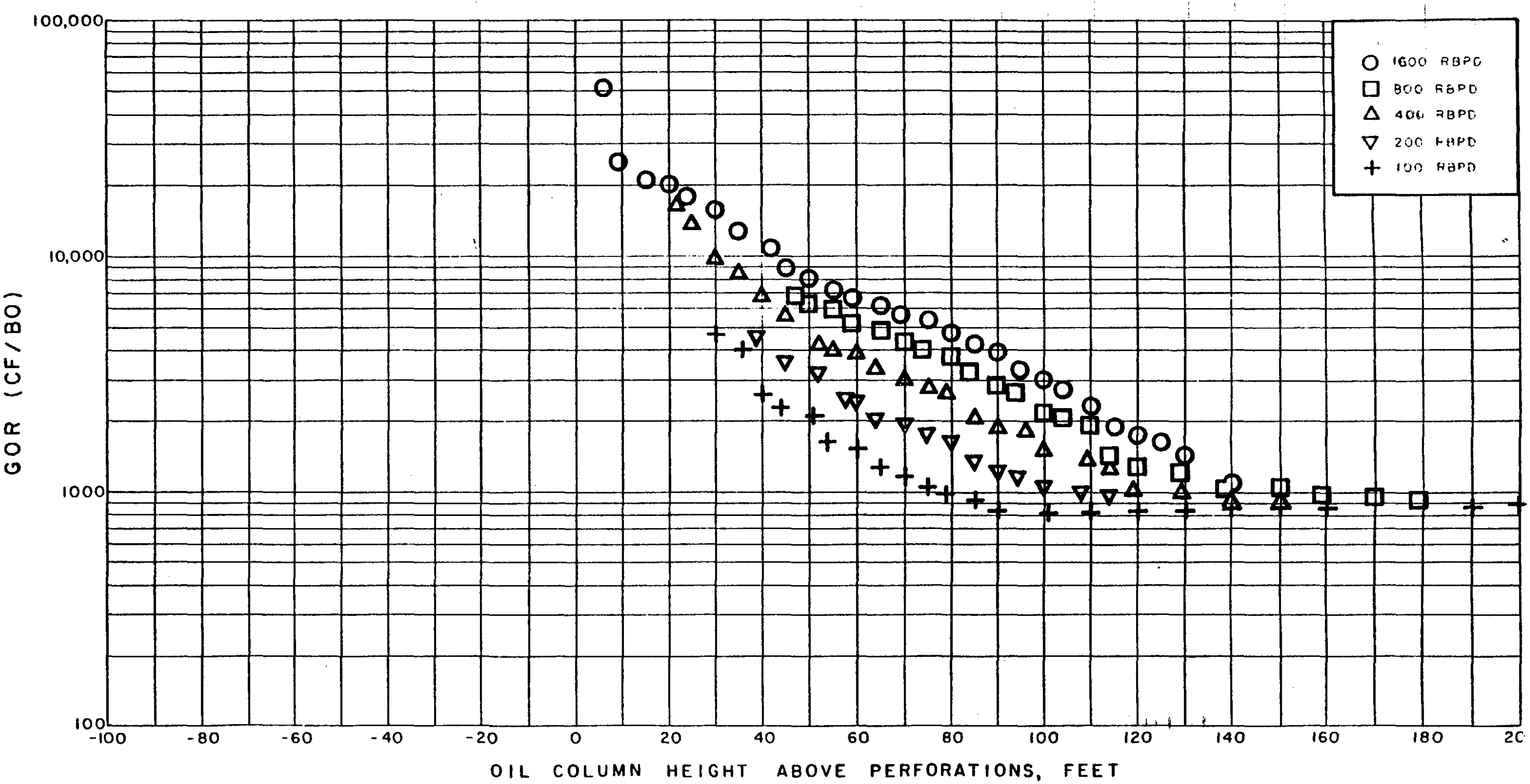


FIGURE A-12

EMPIRE ABO UNIT

EDDY COUNTY, NEW MEXICO

CONING CORRELATION CALCULATED BY RADIAL CONING MODEL FOR WELL G-25

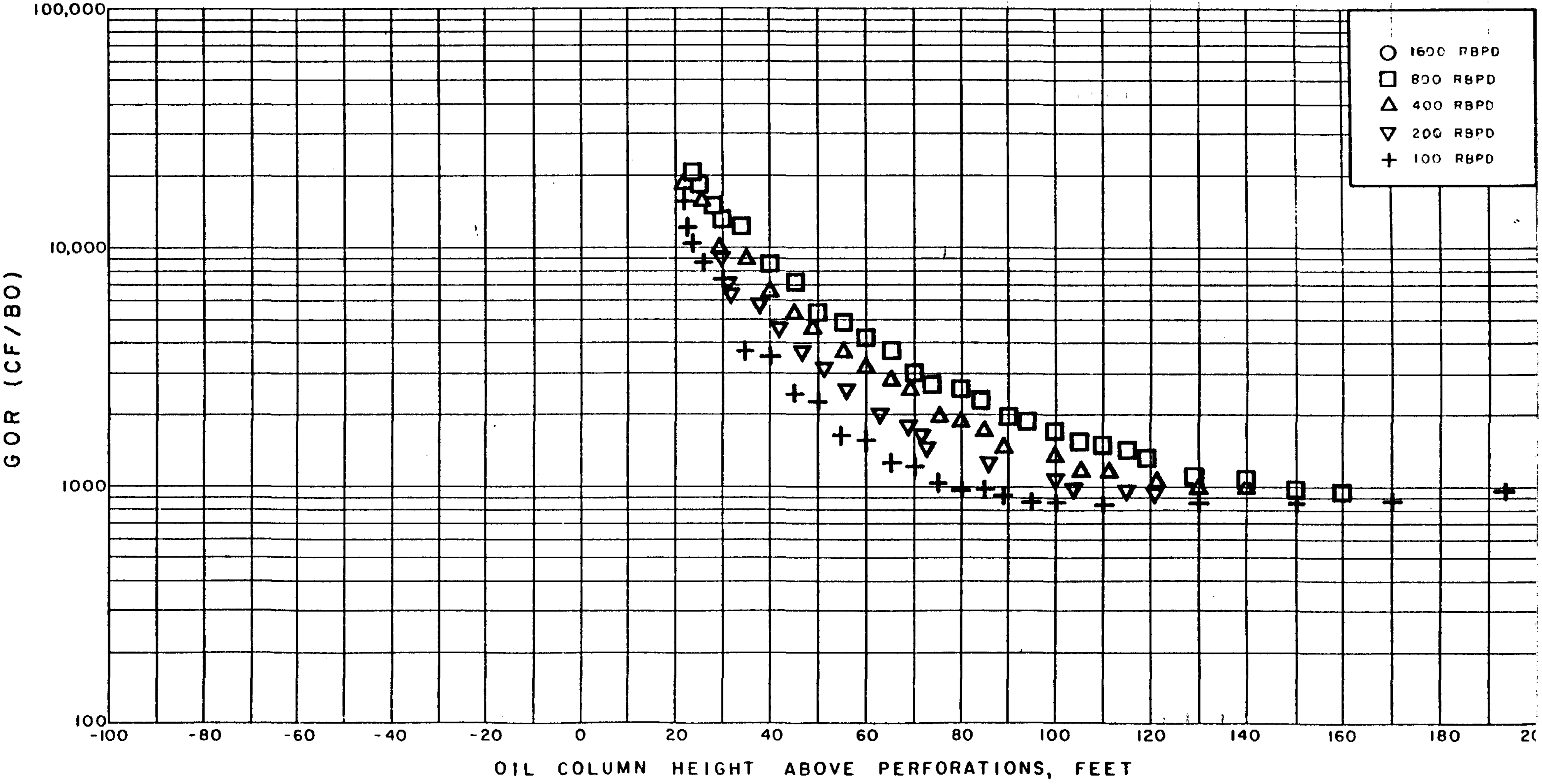
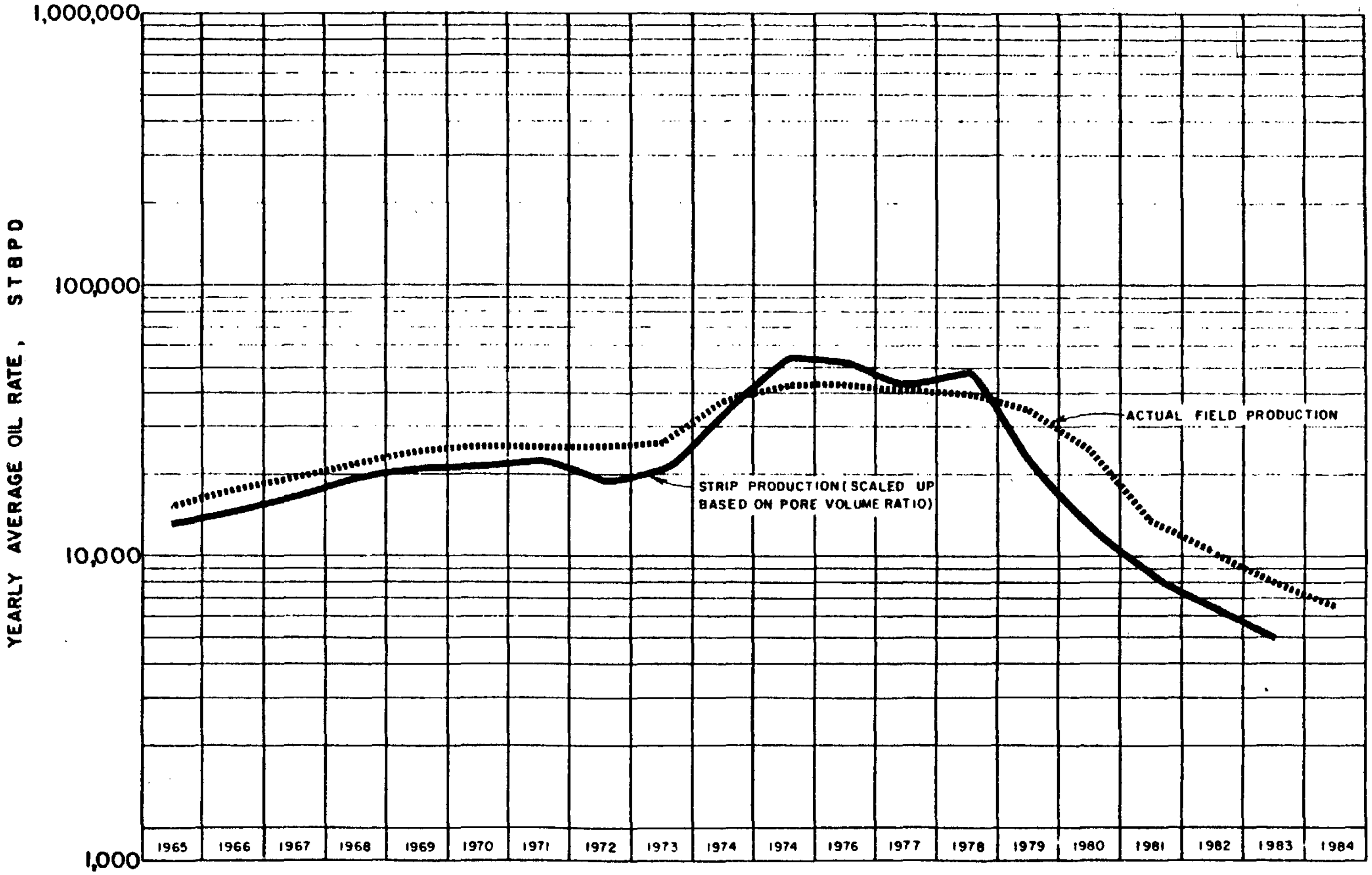


FIGURE A-13

EMPIRE ABO UNIT

EDDY COUNTY, NEW MEXICO

COMPARISON OF STRIP AND FIELD OIL RATES



APPENDIX B

APPENDIX B

Discussion of Oil Rate and Reserve Forecasts

DISCUSSION OF OIL RATE AND RESERVE FORECASTS

The incremental oil reserves recovered by delaying blowdown are the result of extending the field life which allows additional migration of oil from the back-reef to the fore-reef. This is illustrated in figures B1 through B5 in which the gas cap, oil column and water column are mapped for one row of cells in the simulator. Figure B1 is the saturation distribution at the start of the oil rate forecasts which is 1/1/83 in the slice and represents 1/1/85 in the field. Figure B2 is the saturation distribution at the economic limit for starting blowdown in 1985. Approximately 50 ft of oil in the back-reef area (columns 3, 4, and 5) has migrated to the fore-reef area. Compare this to Figure B5 which is the saturation distribution at the economic limit for starting blowdown in 2003. Here the migration of oil is roughly three times that for starting blowdown in 1985.

The incremental oil rates obtained by continued gas injection are the result of slowing the pressure decline of the reservoir. Although the recovery mechanism at Empire Abo is gravity drainage, which is relatively independent of reservoir pressure, the production mechanism is fluid expansion, which is very sensitive to reservoir pressure. The effect of reservoir pressure on oil rates is most easily explained using Equation 1 which is an expression of Darcy's law for linear fluid flow in permeable beds:

$$Q_o = \frac{Ko \Delta P}{\mu_o L} , \quad ....(1)$$

where

Q_o = Oil rate, BOPD,

K_o = Effective Oil Permiability, Darcies,

ΔP = Pressure differential across the bed, psi,

μ_o = Oil viscosity, cp, and

L = Length, ft.

The pressure dependent terms in Equation 1 are ΔP and μo. Assuming the only significant difference in the four blowdown cases is reservoir pressure, the ratio of the oil rates for any two cases can be expressed as:

$$Q_{o1}/Q_{o2} = (\Delta P/\mu_o)_1/(\Delta P/\mu_o)_2 \; . \; ....(2)$$

Using the oil rate forecast for starting blowdown in 2003, the oil rate forecasts for starting blowdown in 1985, 1990 and 1995 were calculated using Equation 2. If the differences in oil rates between the four cases are due entirely to the differences in reservoir pressures, then the forecasts calculated using Equation 2 should match the simulator calculated forecasts. The results of these calculations are illustrated in Figures B6 through B8. The agreement of the forecasts indicates the incremental oil rates obtained by delaying blowdown are due entirely to the incrementally higher reservoir pressures.

FIGURE B-1

EMPIRE ABO UNIT

EDDY COUNTY, NEW MEXICO

SATURATIONS AT 1985

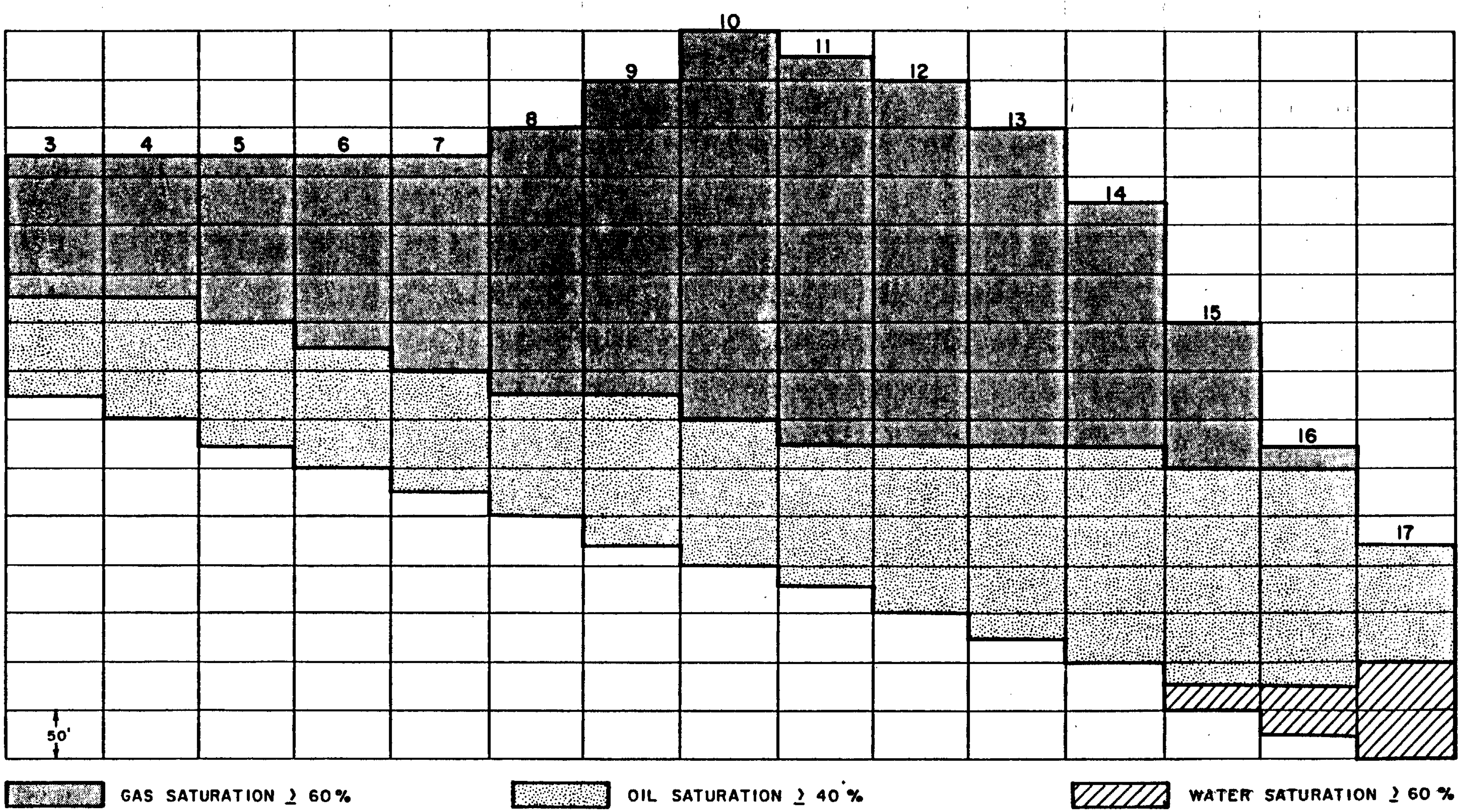


FIGURE B-2

EMPIRE ABO UNIT

EDDY COUNTY, NEW MEXICO

SATURATIONS AT 1995 FOR BLOWDOWN AT 1985

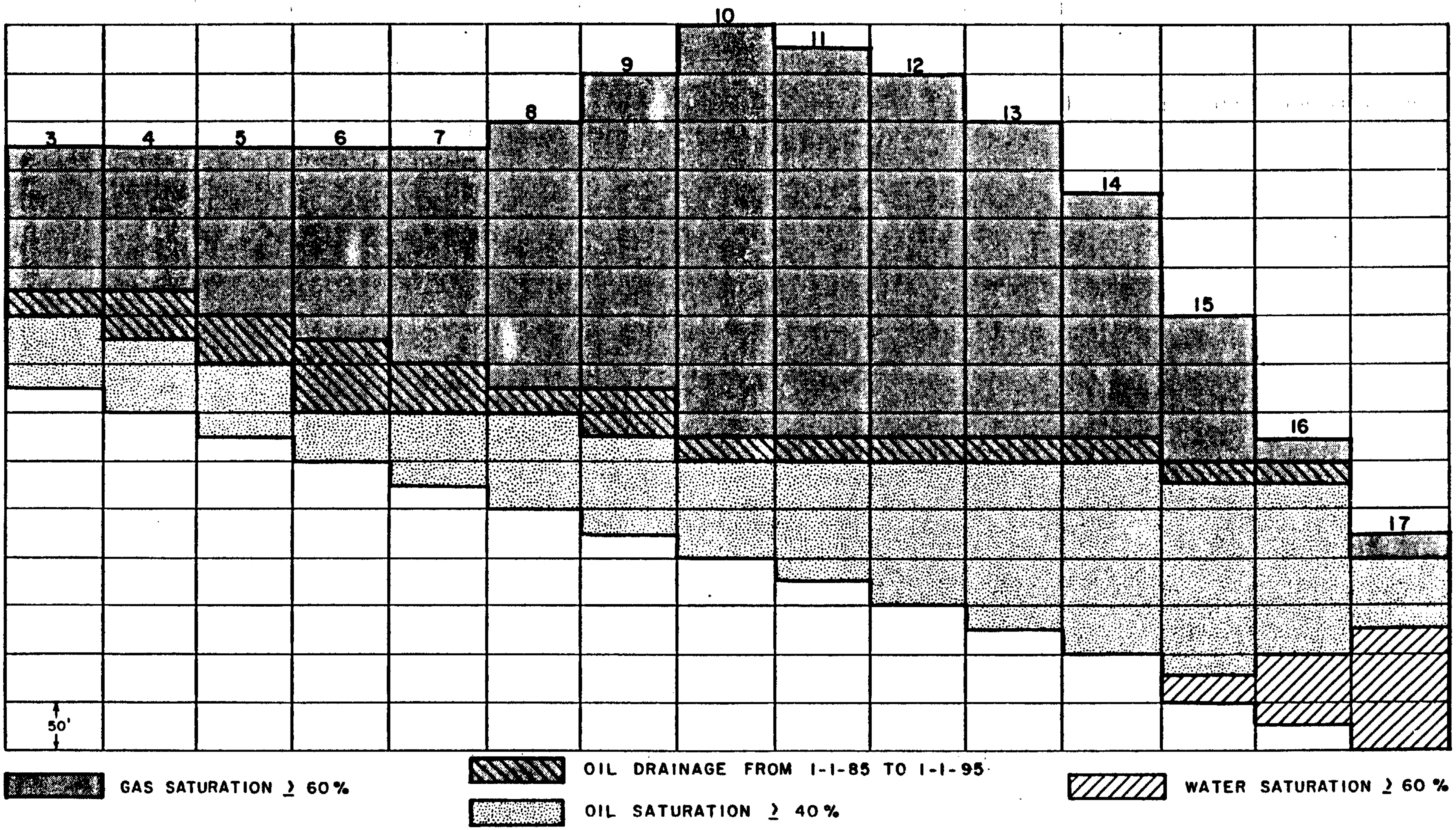


FIGURE B-3

EMPIRE ABO UNIT

EDDY COUNTY, NEW MEXICO

SATURATIONS AT 1998 FOR BLOWDOWN AT 1990

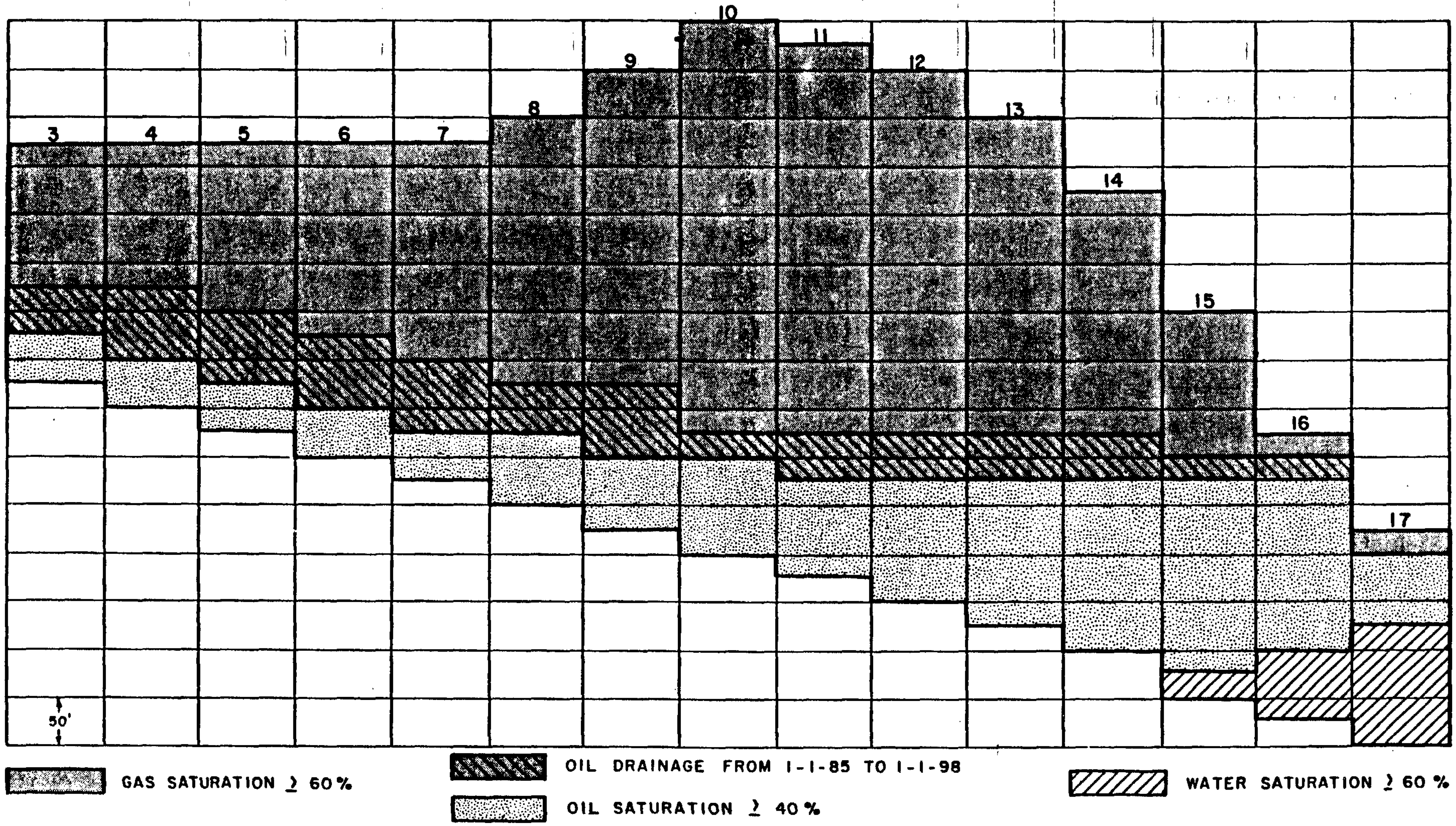


FIGURE B-4

EMPIRE ABO UNIT

EDDY COUNTY, NEW MEXICO

SATURATIONS AT 2001 FOR BLOWDOWN AT 1995

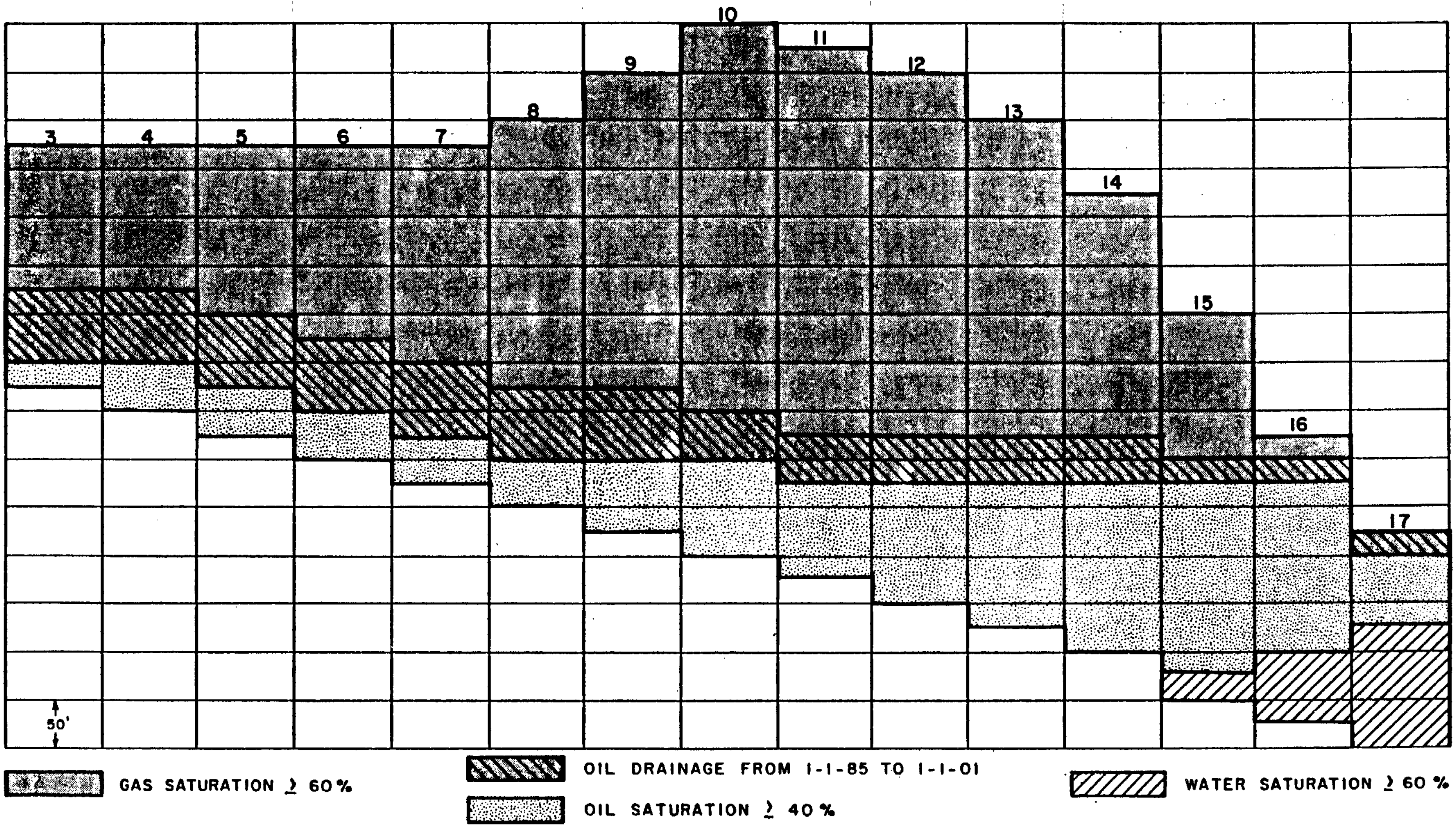


FIGURE B-5

EMPIRE ABO UNIT

EDDY COUNTY, NEW MEXICO

SATURATIONS AT 2006 FOR BLOWDOWN AT 2003

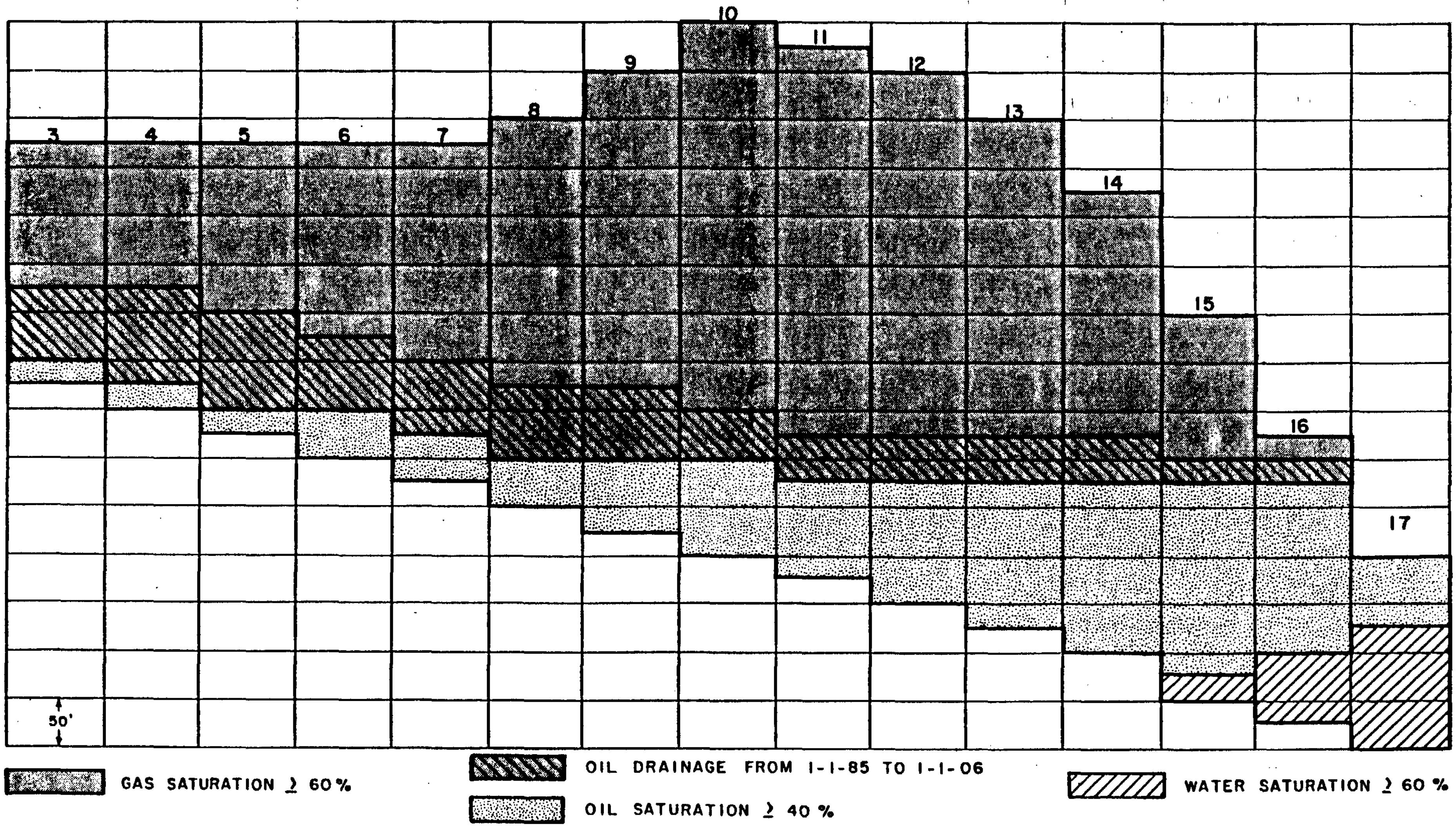


FIGURE B-6

EMPIRE ABO UNIT

EDDY COUNTY, NEW MEXICO

COMPARISON OF SIMULATOR FORECASTS TO
FORCASTS CALCULATED USING EQUATION A2
BLOWDOWN AT 1/1/85

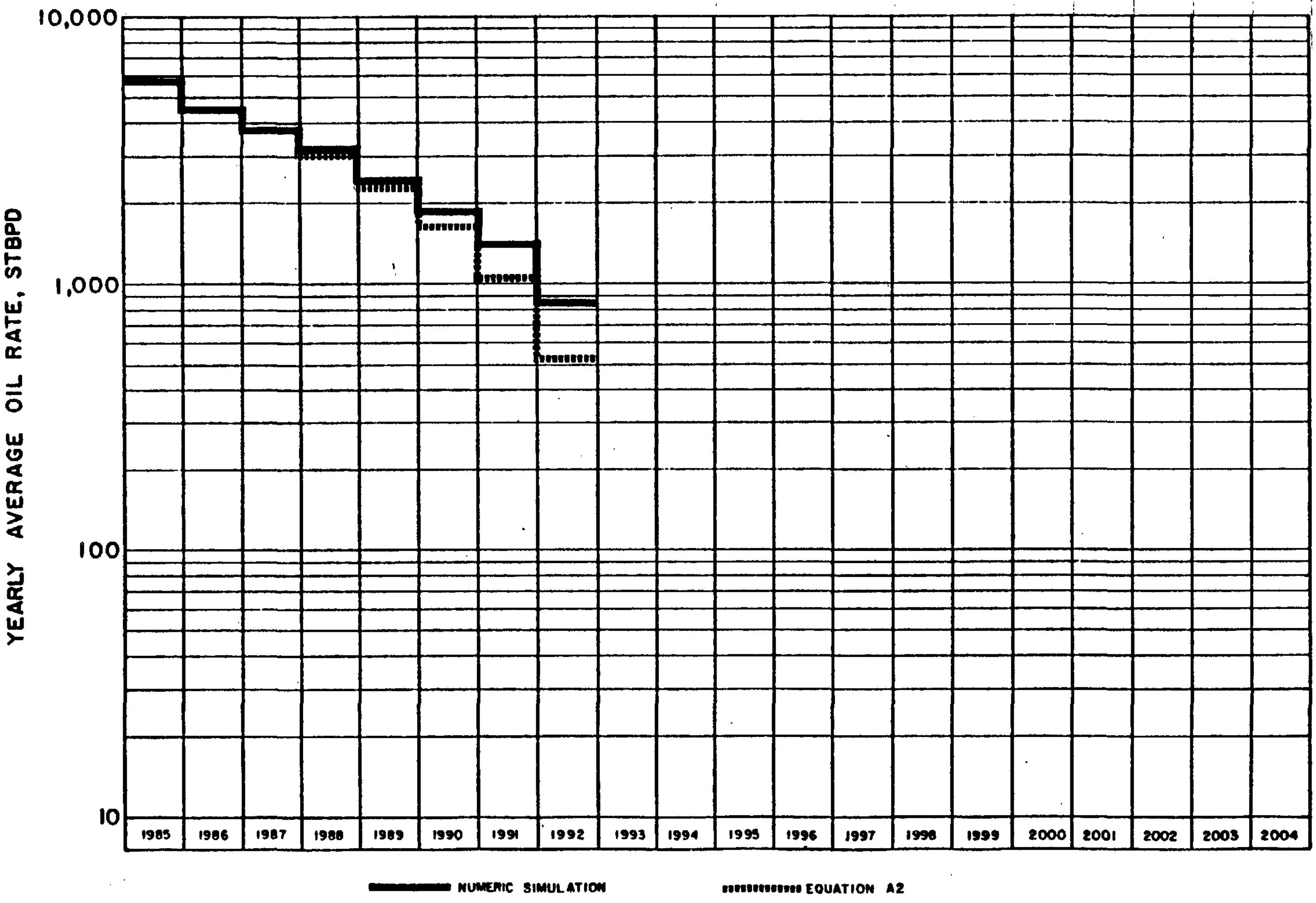


FIGURE B-7

EMPIRE ABO UNIT

EDDY COUNTY, NEW MEXICO

COMPARISON OF SIMULATOR FORECASTS TO
FORCASTS CALCULATED USING EQUATION A2
BLOWDOWN AT 1/1/90

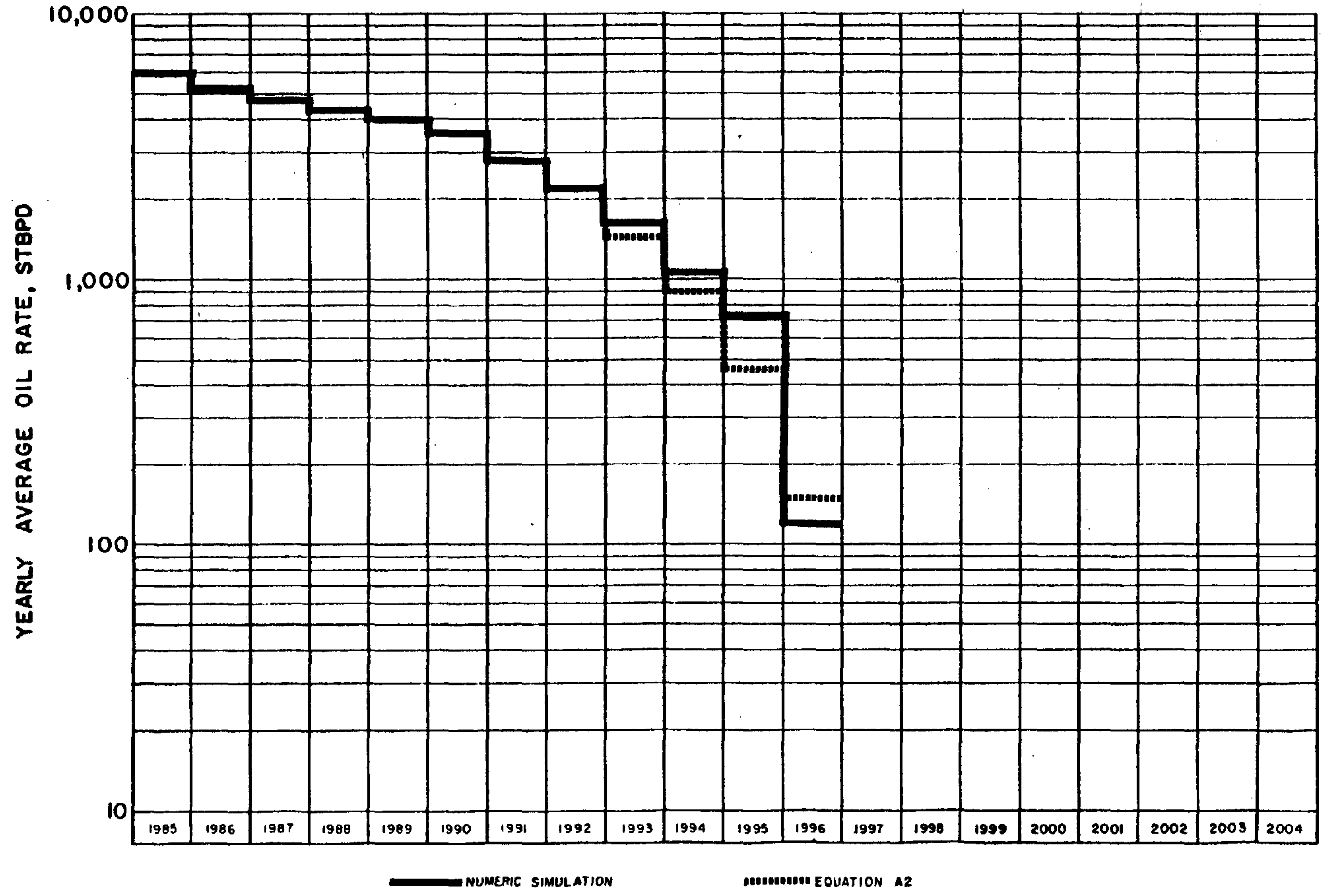
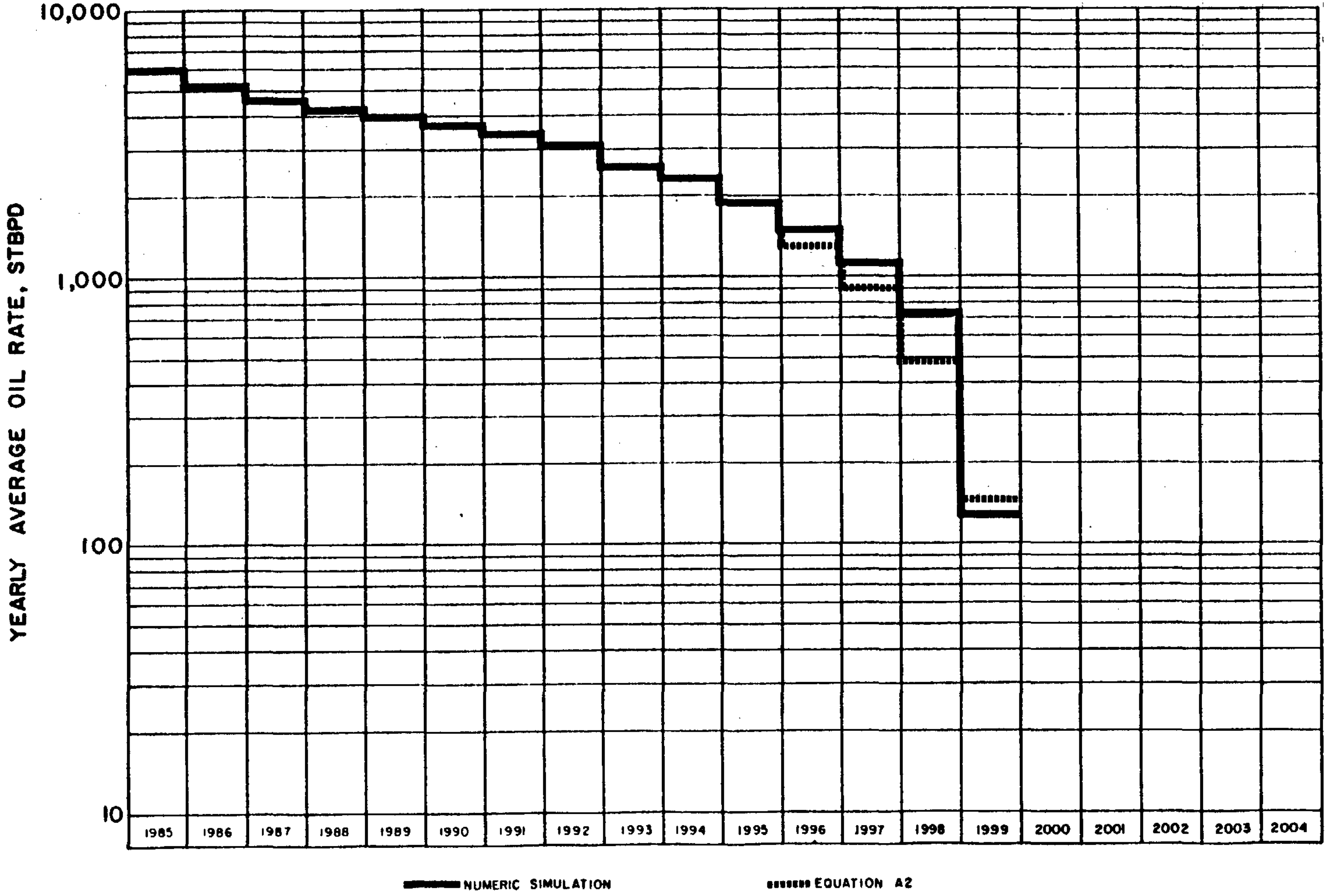


FIGURE B-8

EMPIRE ABO UNIT

EDDY COUNTY, NEW MEXICO

COMPARISON OF SIMULATOR FORECASTS TO
FORCASTS CALCULATED USING EQUATION A2
BLOWDOWN AT 1/1/95



APPENDIX C

APPENDIX C

Black Oil Numeric Simulator History Match

TABLE C1
HISTORY MATCH RESULTS

	Actual	Model	% Difference
Gross Oil Production, STB	5,959,309	5,959,309	None
Gross Gas Production, MCF	11,853,407	11,326,669	-4.4
Average Reservoir Pressure, psi	1,003	1,028	2.5
Individual Well Gas Production, MCF			
J-22	1,887,197	1,762,151	-6.6
I-22	966,476	1,001,867	3.7
K-22	1,590,347	1,561,049	-1.8
K-23	1,587,784	1,583,831	-0.3
J-231	783,200	646,498	-17.5
J-221	1,191,748	1,015,900	-14.8
J-222	24,662	10,835	-56.1
J-233	836,810	801,228	-4.3
J-234	392,735	446,310	13.6
K-231	826,495	754,031	-8.8
H-22	382,146	371,110	-2.9
H-21	451,068	454,988	0.9
G-21	932,739	916,871	-1.7

FIGURE C-1

EMPIRE ABO UNIT

EDDY COUNTY, NEW MEXICO

SLICE MODEL HISTORY-MATCH

ACTUAL GOR FROM SLICE AREA COMPARED
TO NUMERIC MODEL CALCULATIONS

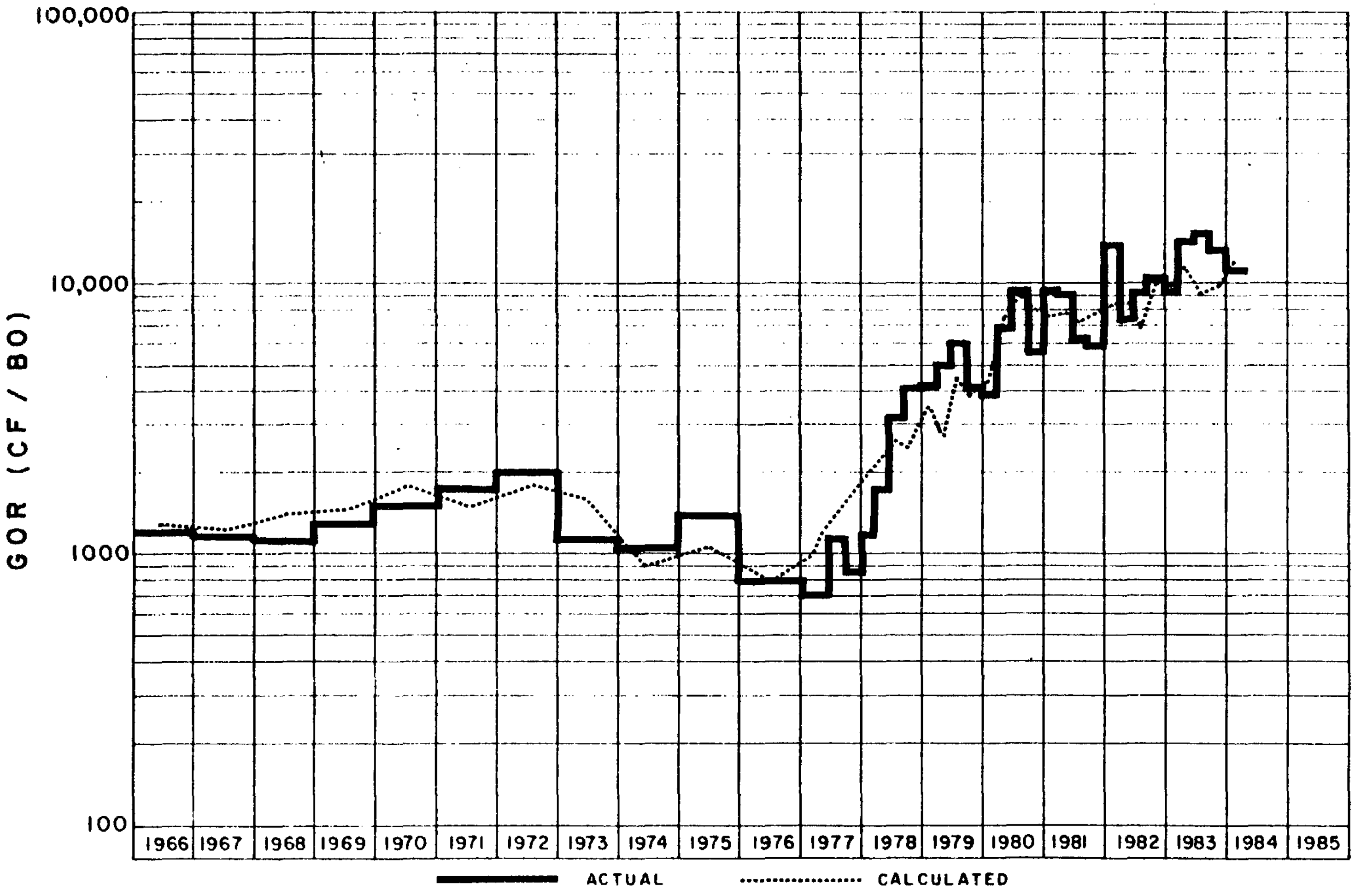


FIGURE C-2

EMPIRE ABO UNIT

EDDY COUNTY, NEW MEXICO

SLICE MODEL HISTORY MATCH

ACTUAL WELL PERFORMANCE COMPARED
TO NUMERIC MODEL CALCULATIONS

WELL J-22

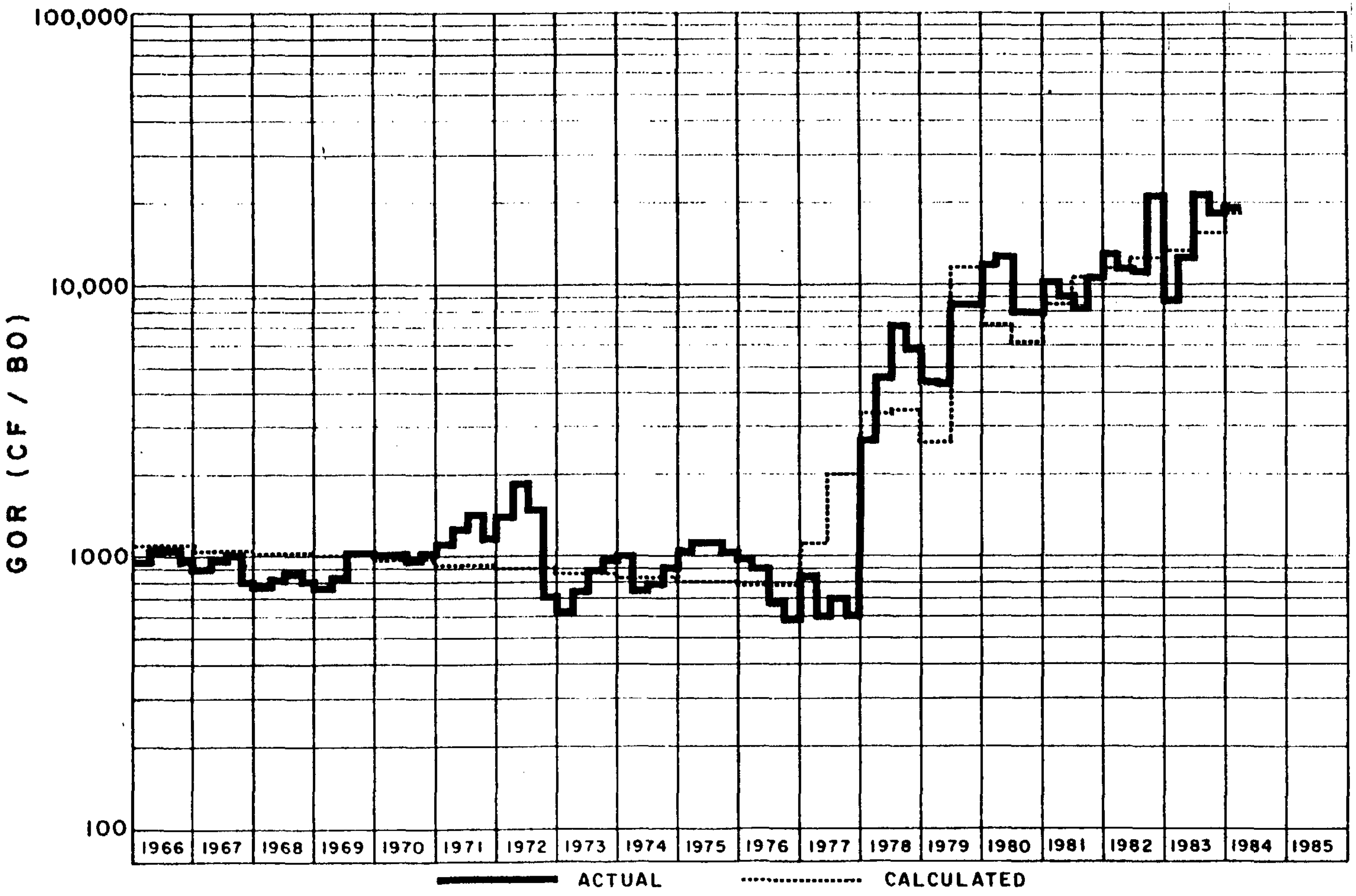


FIGURE C-3

EMPIRE ABO UNIT

EDDY COUNTY, NEW MEXICO

SLICE MODEL HISTORY MATCH

ACTUAL WELL PERFORMANCE COMPARED
TO NUMERIC MODEL CALCULATIONS

WELL I-22

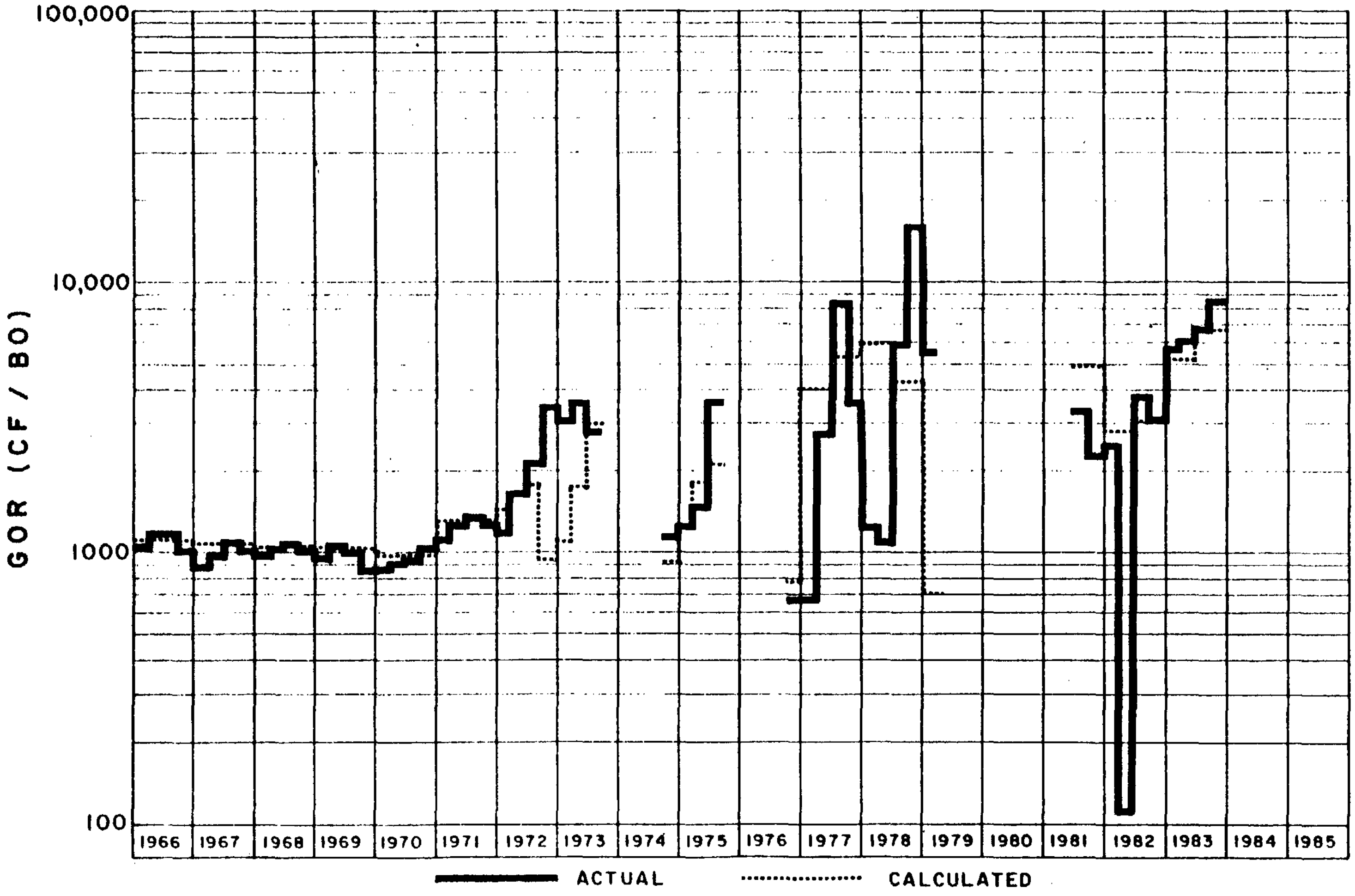


FIGURE C-4

EMPIRE ABO UNIT

EDDY COUNTY, NEW MEXICO

SLICE MODEL HISTORY MATCH

ACTUAL WELL PERFORMANCE COMPARED
TO NUMERIC MODEL CALCULATIONS

WELL K-22

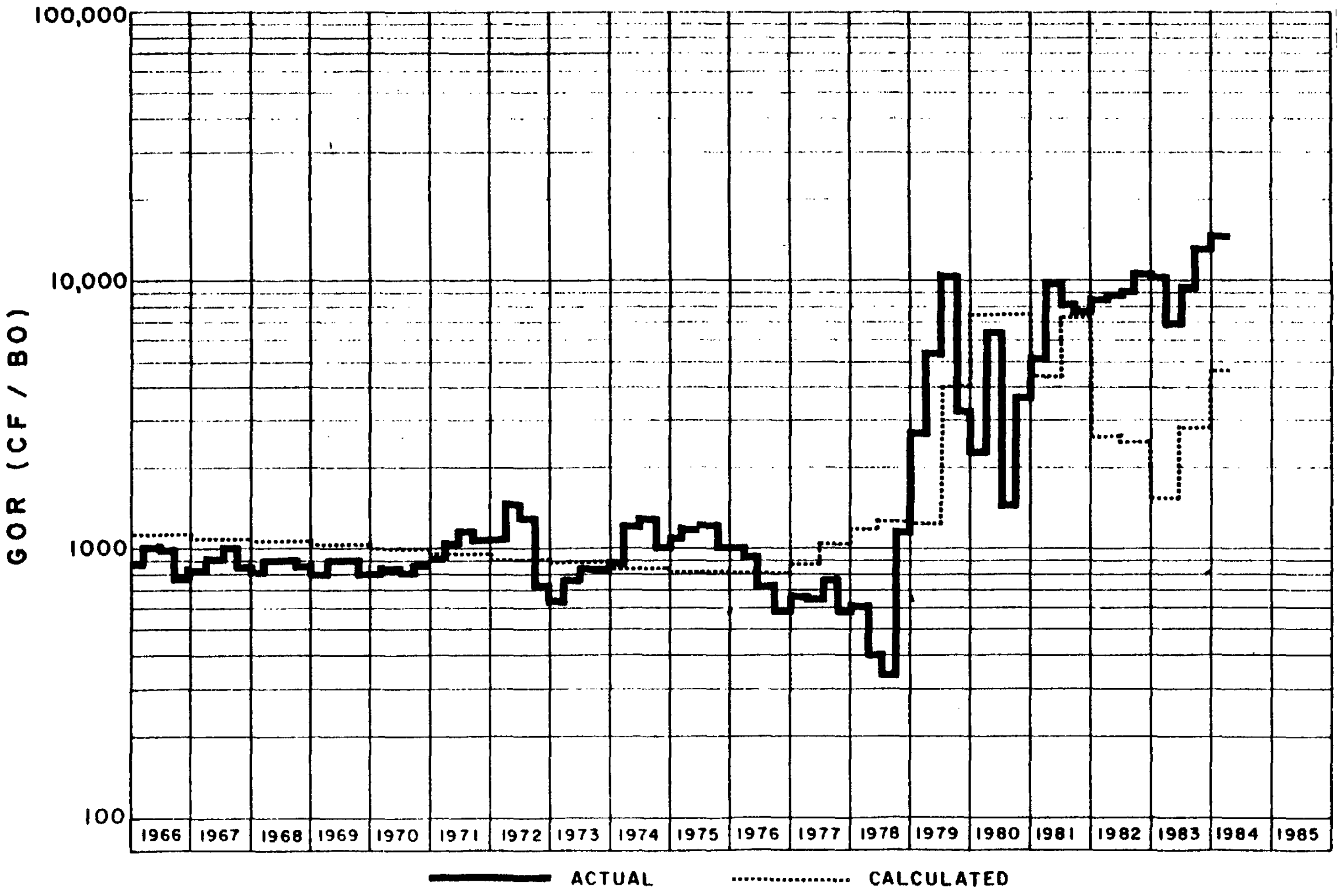


FIGURE C-5

EMPIRE ABO UNIT

EDDY COUNTY, NEW MEXICO

SLICE MODEL HISTORY MATCH

ACTUAL WELL PERFORMANCE COMPARED
TO NUMERIC MODEL CALCULATIONS

WELL K-23

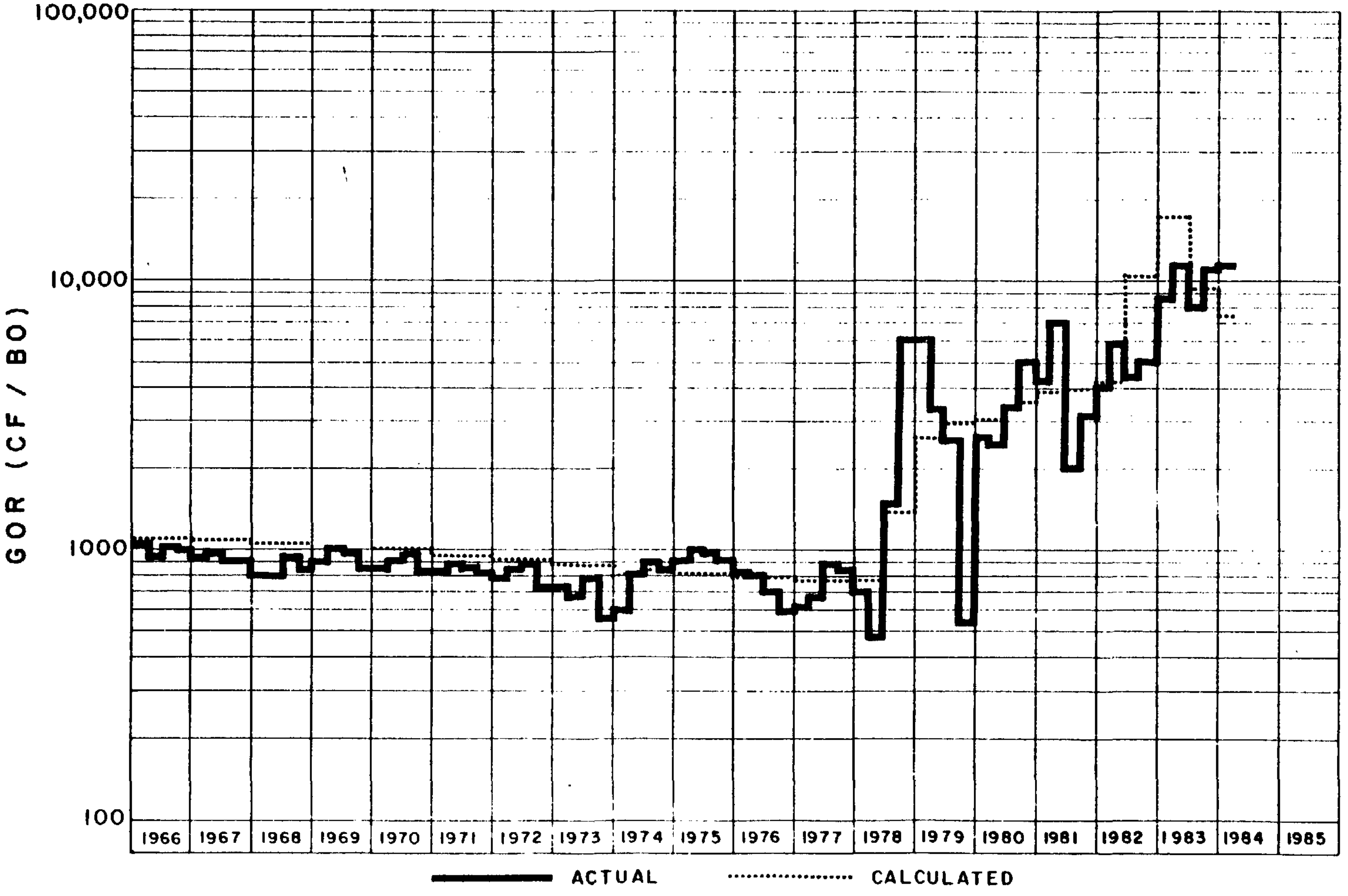


FIGURE C-6

EMPIRE ABO UNIT

EDDY COUNTY, NEW MEXICO

SLICE MODEL HISTORY MATCH

ACTUAL WELL PERFORMANCE COMPARED
TO NUMERIC MODEL CALCULATIONS

WELL J-231

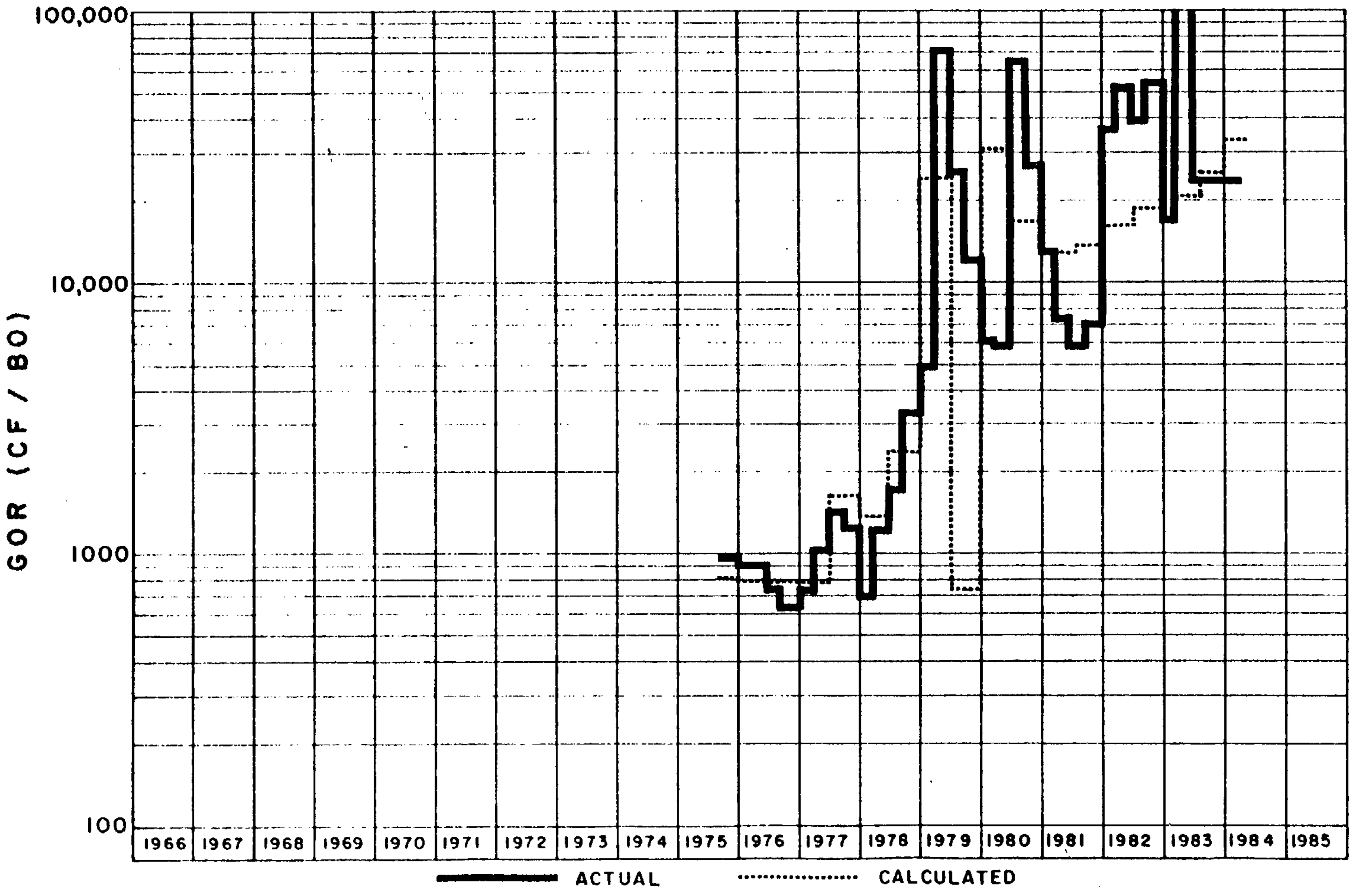


FIGURE C-7

EMPIRE ABO UNIT

EDDY COUNTY, NEW MEXICO

SLICE MODEL HISTORY MATCH

ACTUAL WELL PERFORMANCE COMPARED
TO NUMERIC MODEL CALCULATIONS

WELL J-221

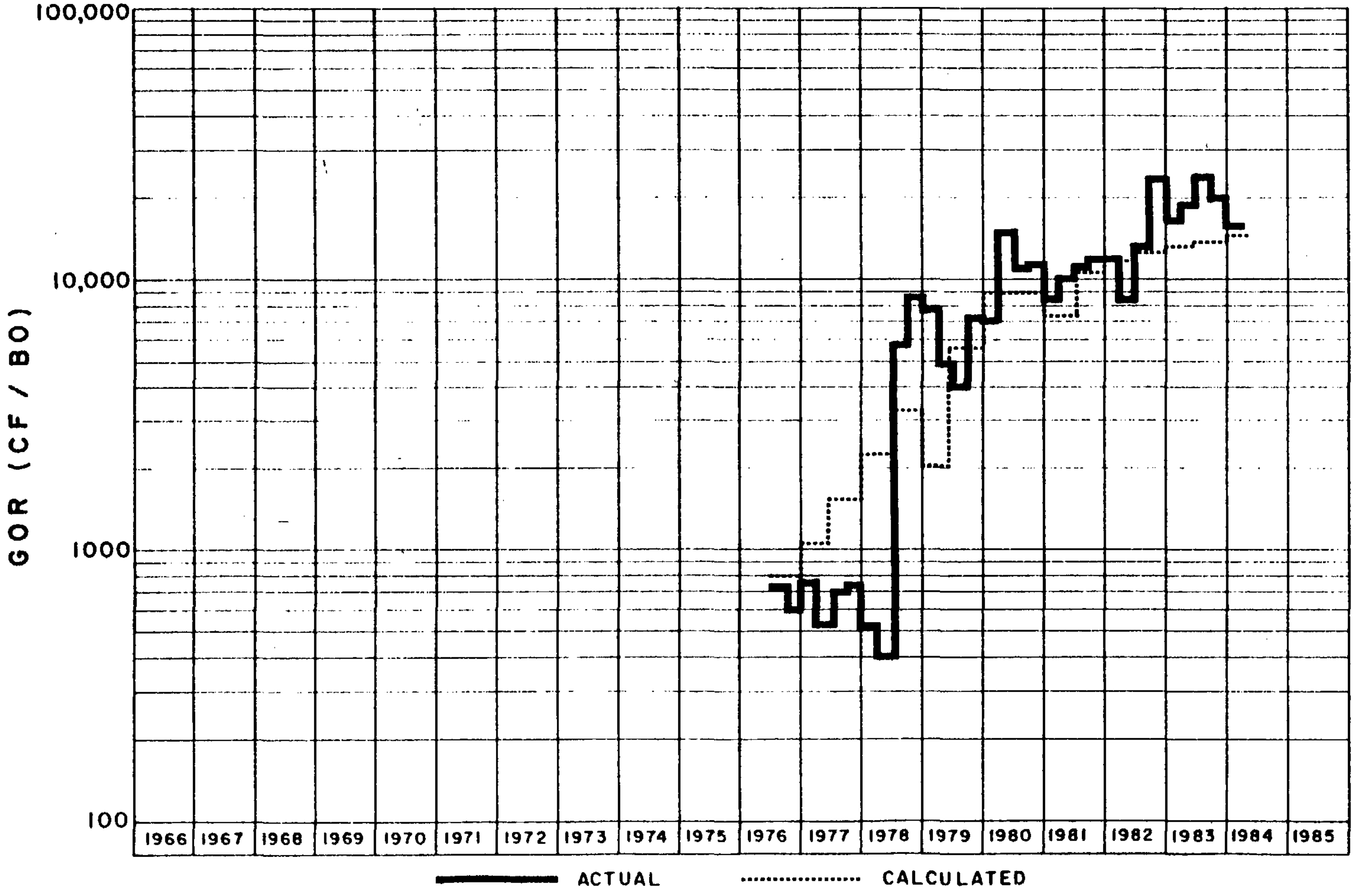


FIGURE C-8

EMPIRE ABO UNIT

EDDY COUNTY, NEW MEXICO

SLICE MODEL HISTORY MATCH

ACTUAL WELL PERFORMANCE COMPARED
TO NUMERIC MODEL CALCULATIONS

WELL J-222

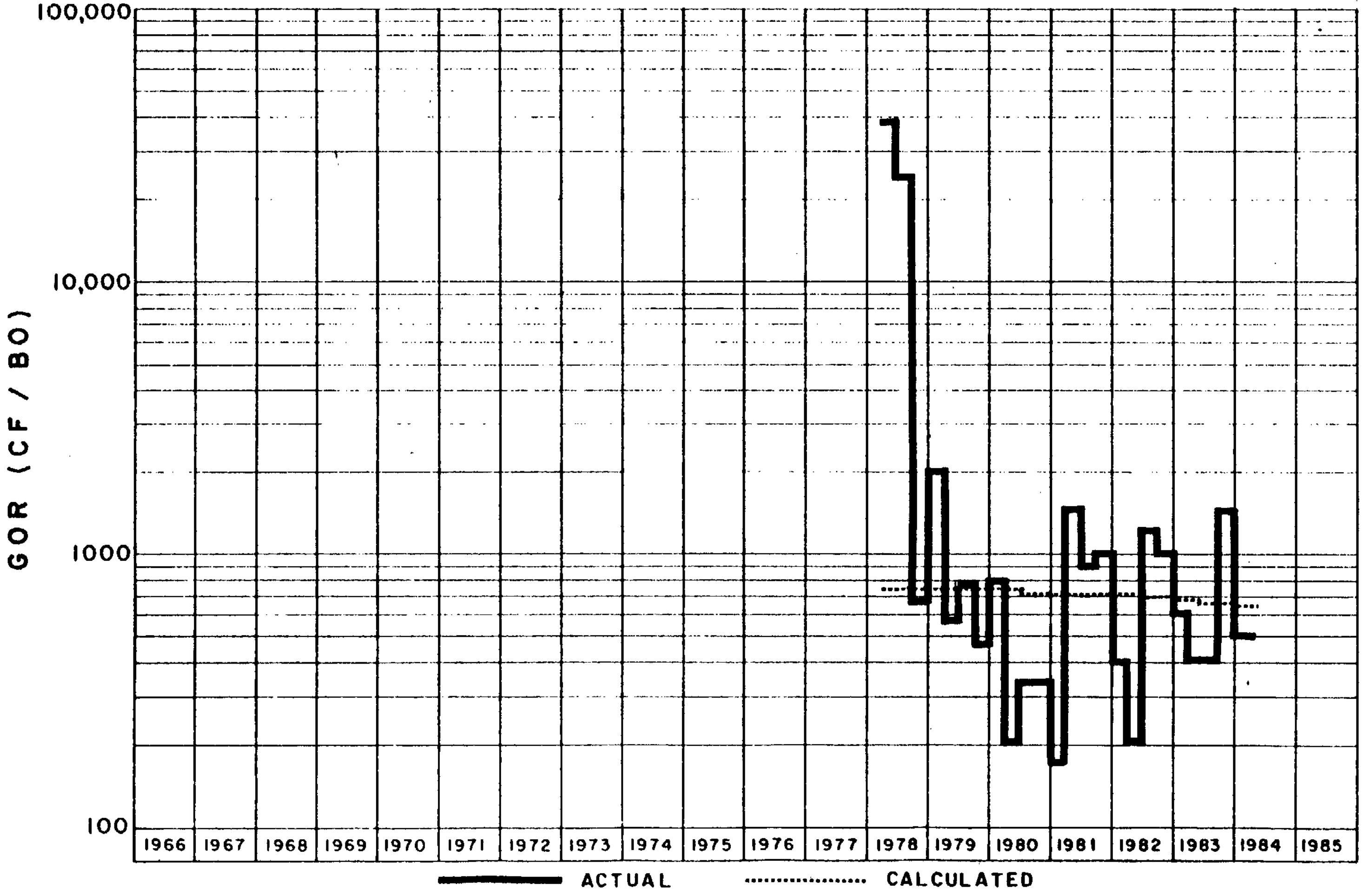


FIGURE C-9

EMPIRE ABO UNIT
EDDY COUNTY, NEW MEXICO

SLICE MODEL HISTORY MATCH

ACTUAL WELL PERFORMANCE COMPARED
TO NUMERIC MODEL CALCULATIONS

WELL J-233

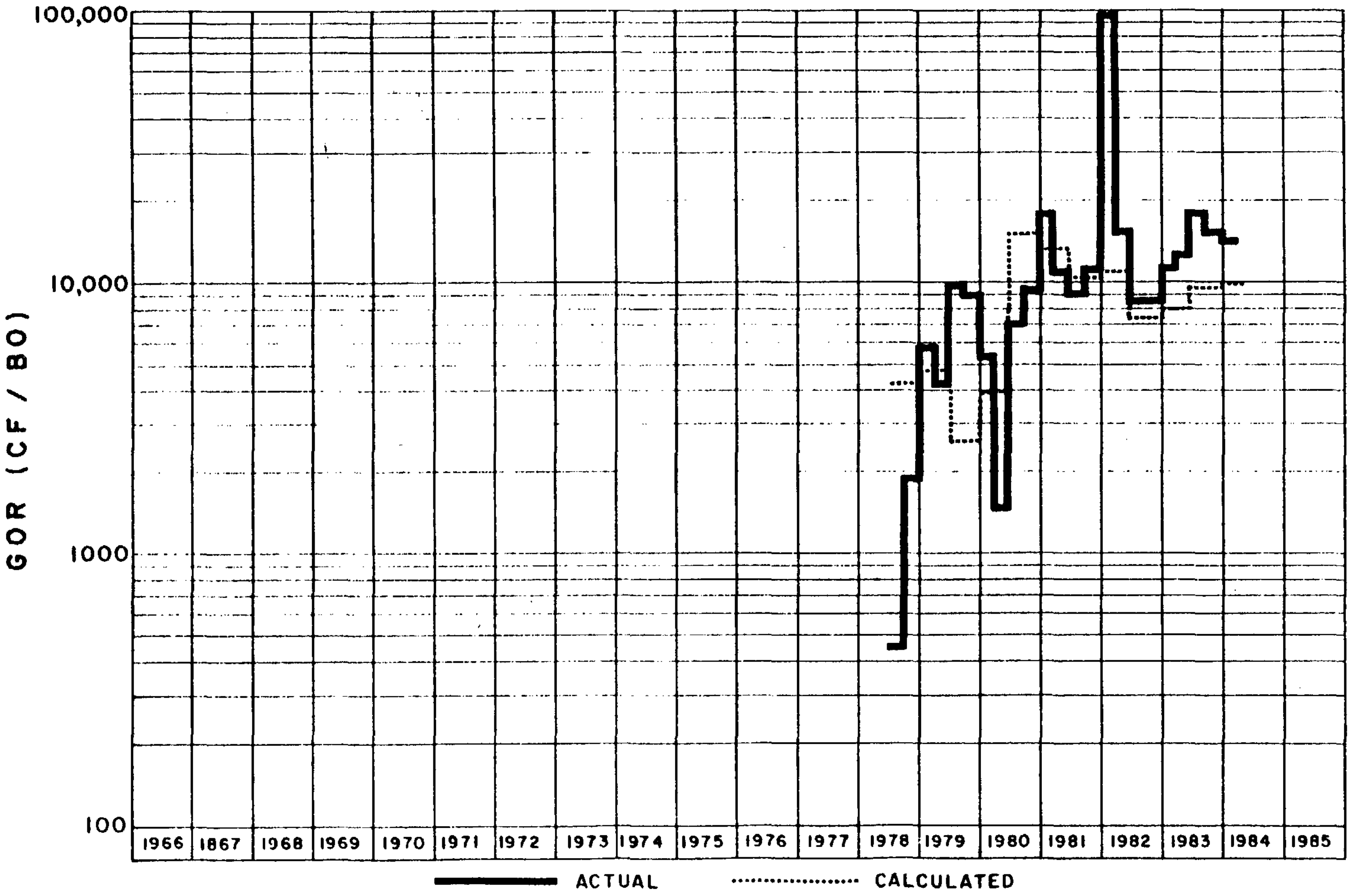


FIGURE C-10

EMPIRE ABO UNIT

EDDY COUNTY, NEW MEXICO

SLICE MODEL HISTORY MATCH

ACTUAL WELL PERFORMANCE COMPARED
TO NUMERIC MODEL CALCULATIONS

WELL J-234

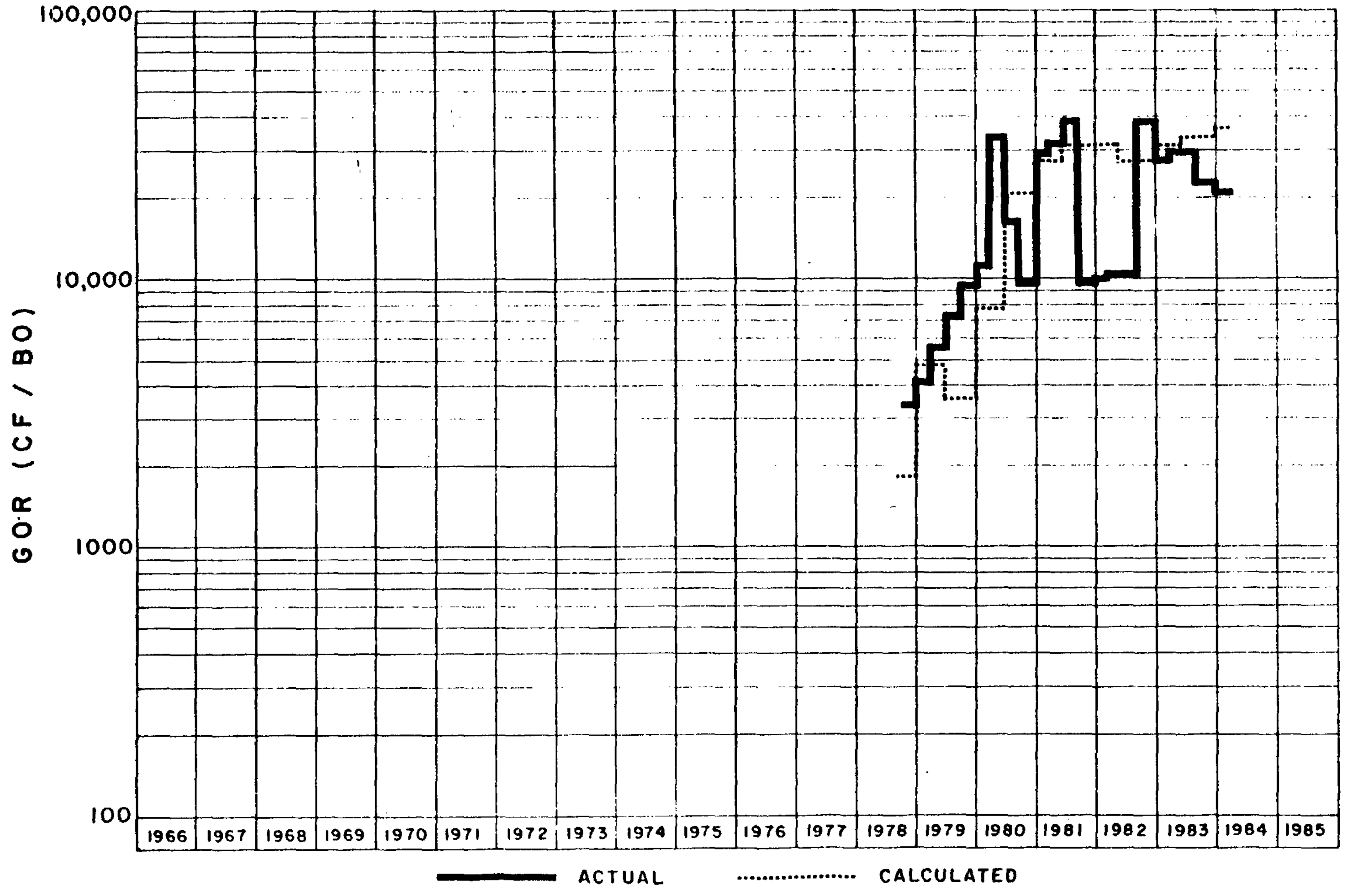


FIGURE C-11

EMPIRE ABO UNIT

EDDY COUNTY, NEW MEXICO

SLICE MODEL HISTORY MATCH

ACTUAL WELL PERFORMANCE COMPARED
TO NUMERIC MODEL CALCULATIONS

WELL K-231

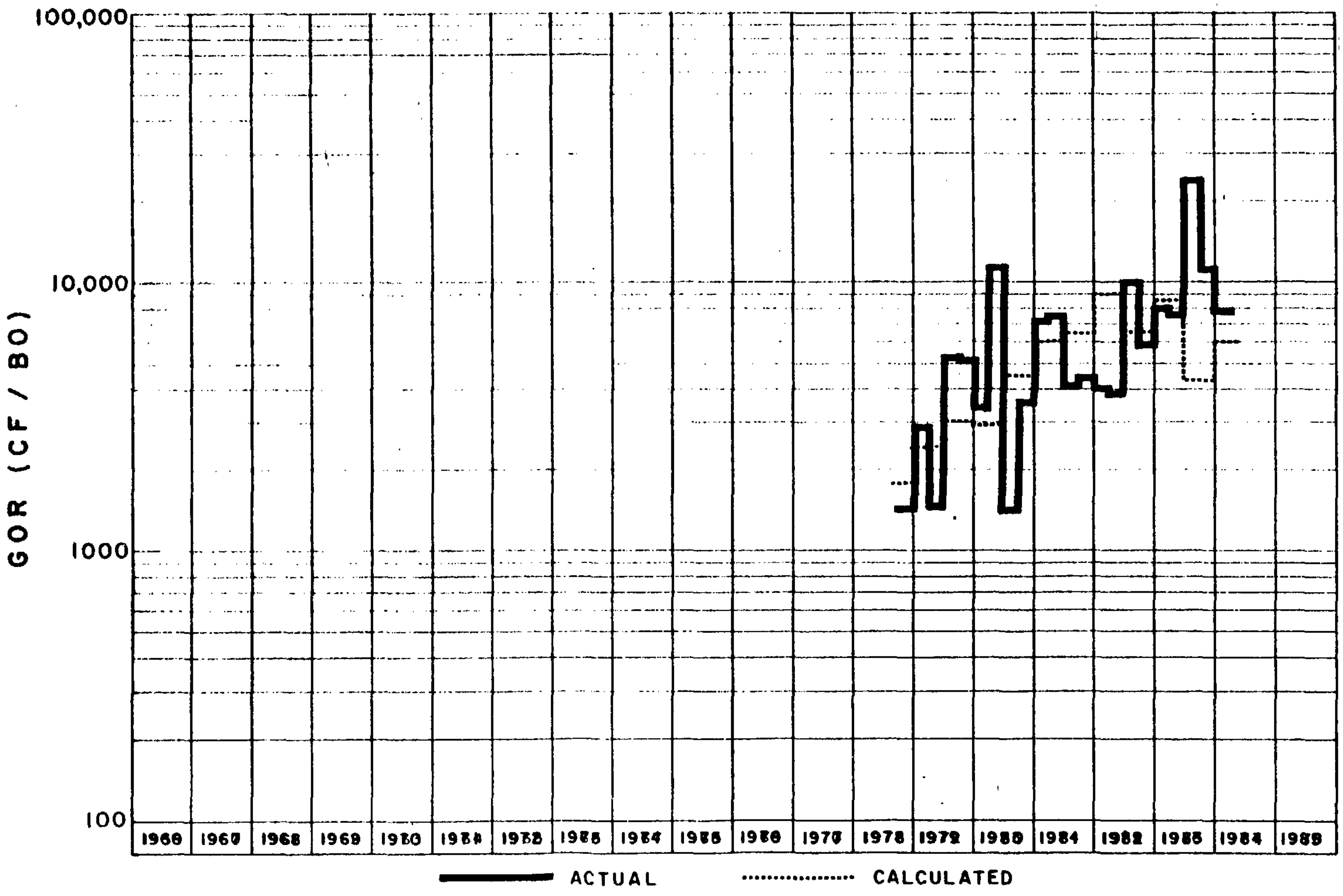


FIGURE C-12

EMPIRE ABO UNIT

EDDY COUNTY, NEW MEXICO

SLICE MODEL HISTORY MATCH

ACTUAL WELL PERFORMANCE COMPARED
TO NUMERIC MODEL CALCULATIONS

WELL H-22

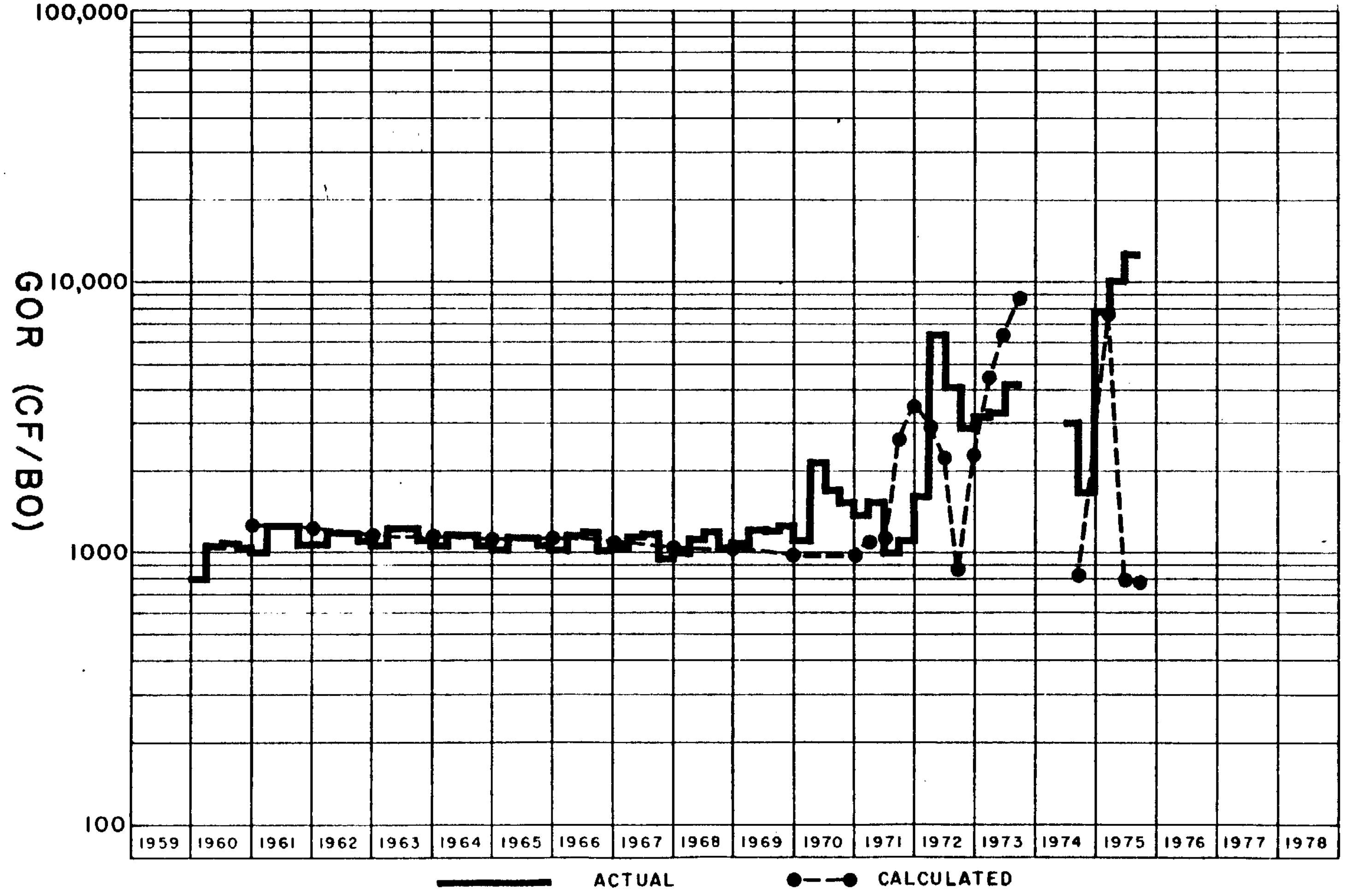


FIGURE C-13

EMPIRE ABO UNIT

EDDY COUNTY, NEW MEXICO

SLICE MODEL HISTORY MATCH

ACTUAL WELL PERFORMANCE COMPARED
TO NUMERIC MODEL CALCULATIONS

WELL H-21

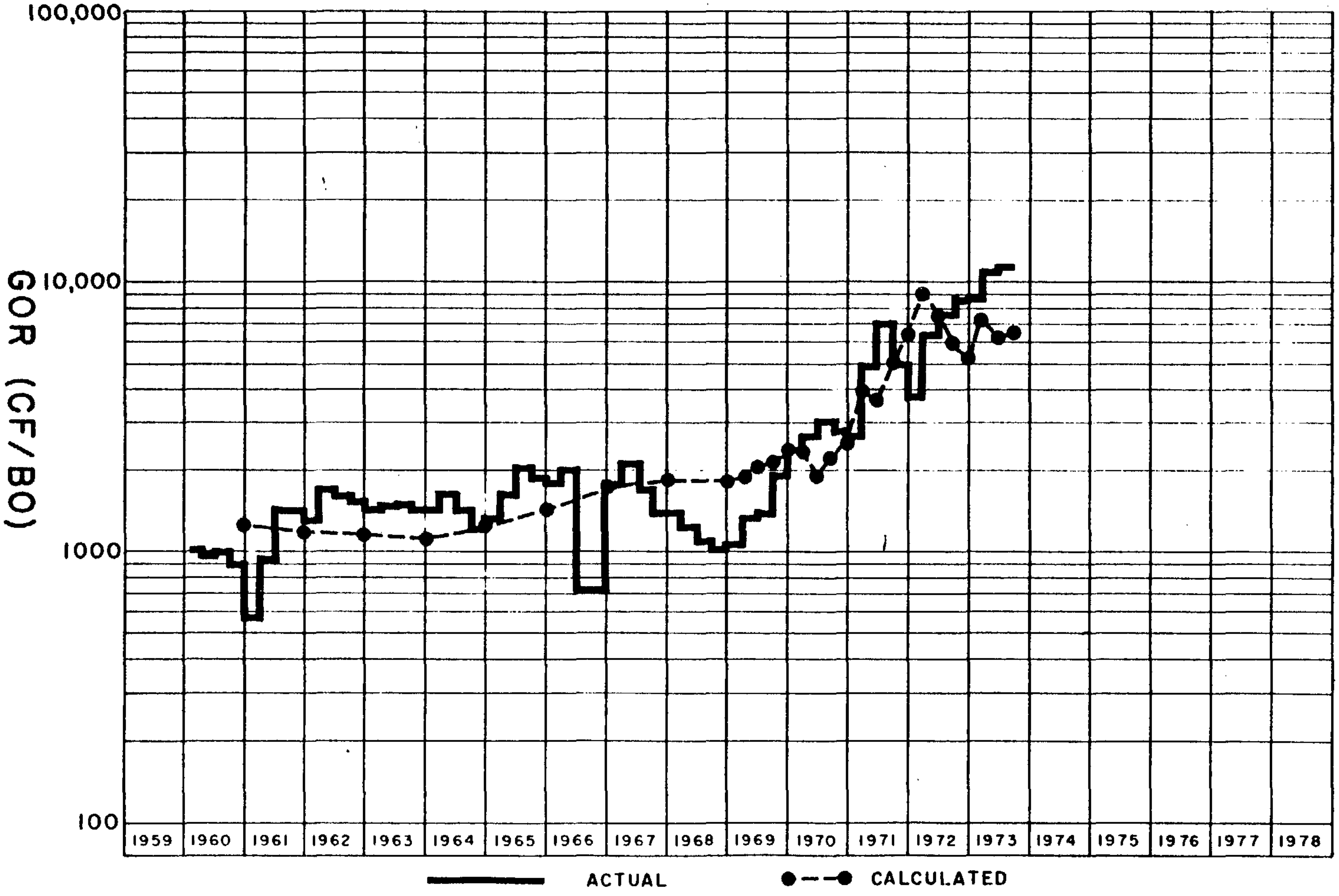


FIGURE C-14

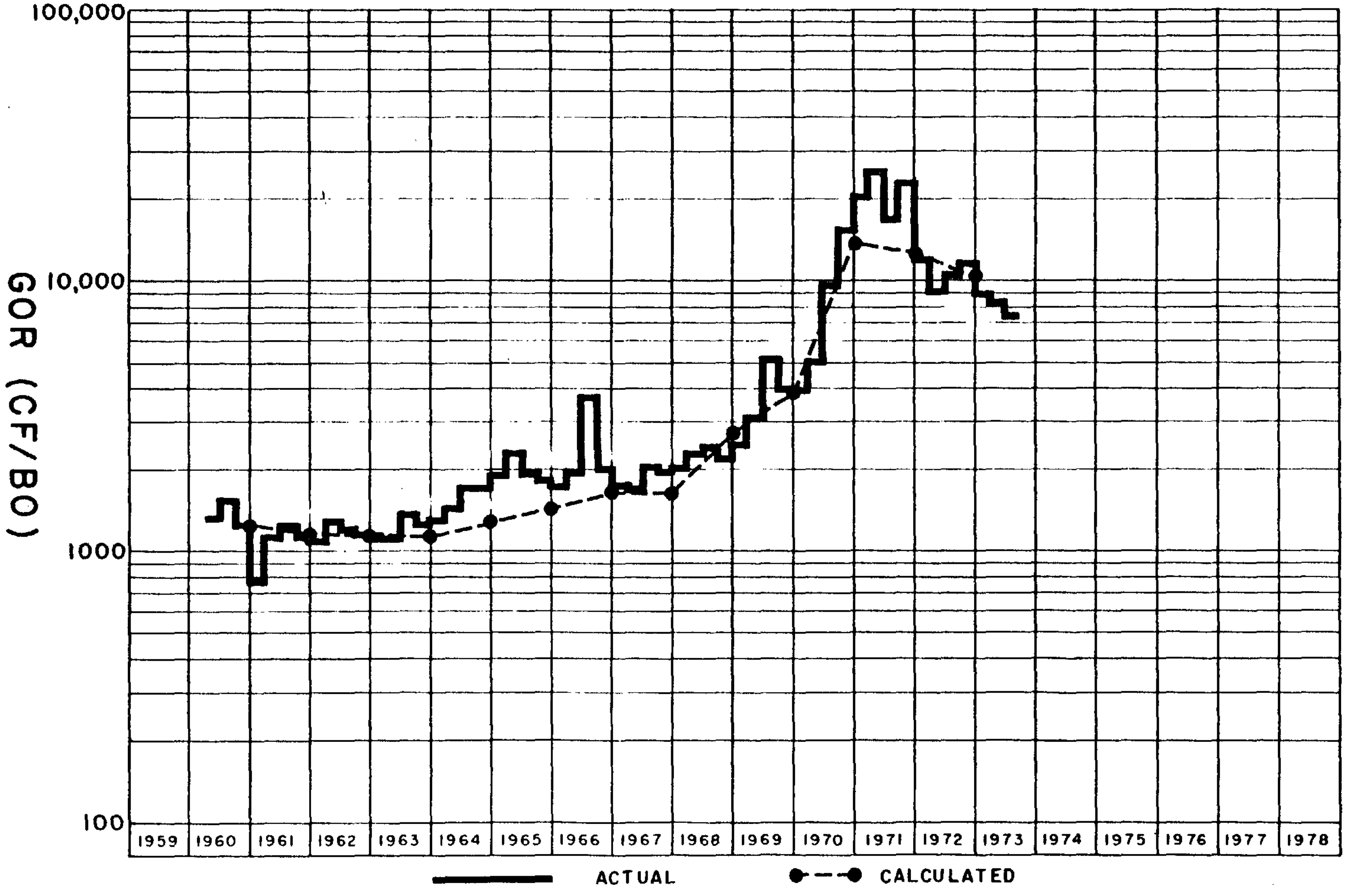
EMPIRE ABO UNIT

EDDY COUNTY, NEW MEXICO

SLICE MODEL HISTORY MATCH

ACTUAL WELL PERFORMANCE COMPARED
TO NUMERIC MODEL CALCULATIONS

WELL G-21



APPENDIX D

APPENDIX D

Energy Recoveries

Energy Recoveries

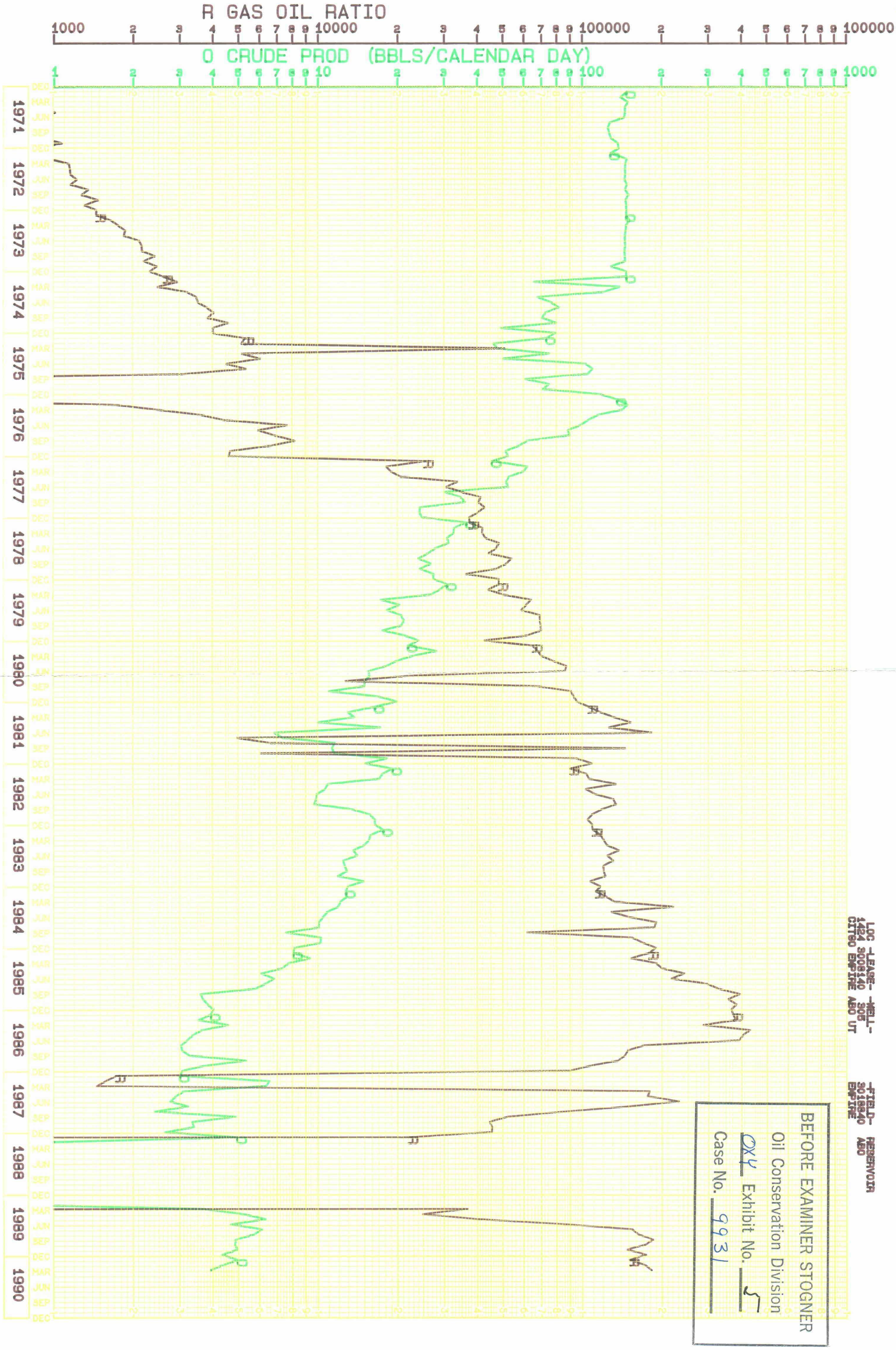
Energy recovery is calculated by multiplying the remaining reserves of each product by its heating value. Table D1 lists the heating values of each product. Table D2 lists the energy recovery for the four blowdown cases studied.

Table D1. Heating Values for Oil, NGL's, and Residue Gas.

Product	Heating Value
Residue Gas	1,010,000 BTU/MCF
Ethane	65,889 BTU/gal
Propane	90,962 BTU/gal
Butane	102,918 BTU/gal
Gasoline	110,071 BTU/gal
Oil	5,500,000 BTU/STB

TABLE D2. Energy Recoveries.

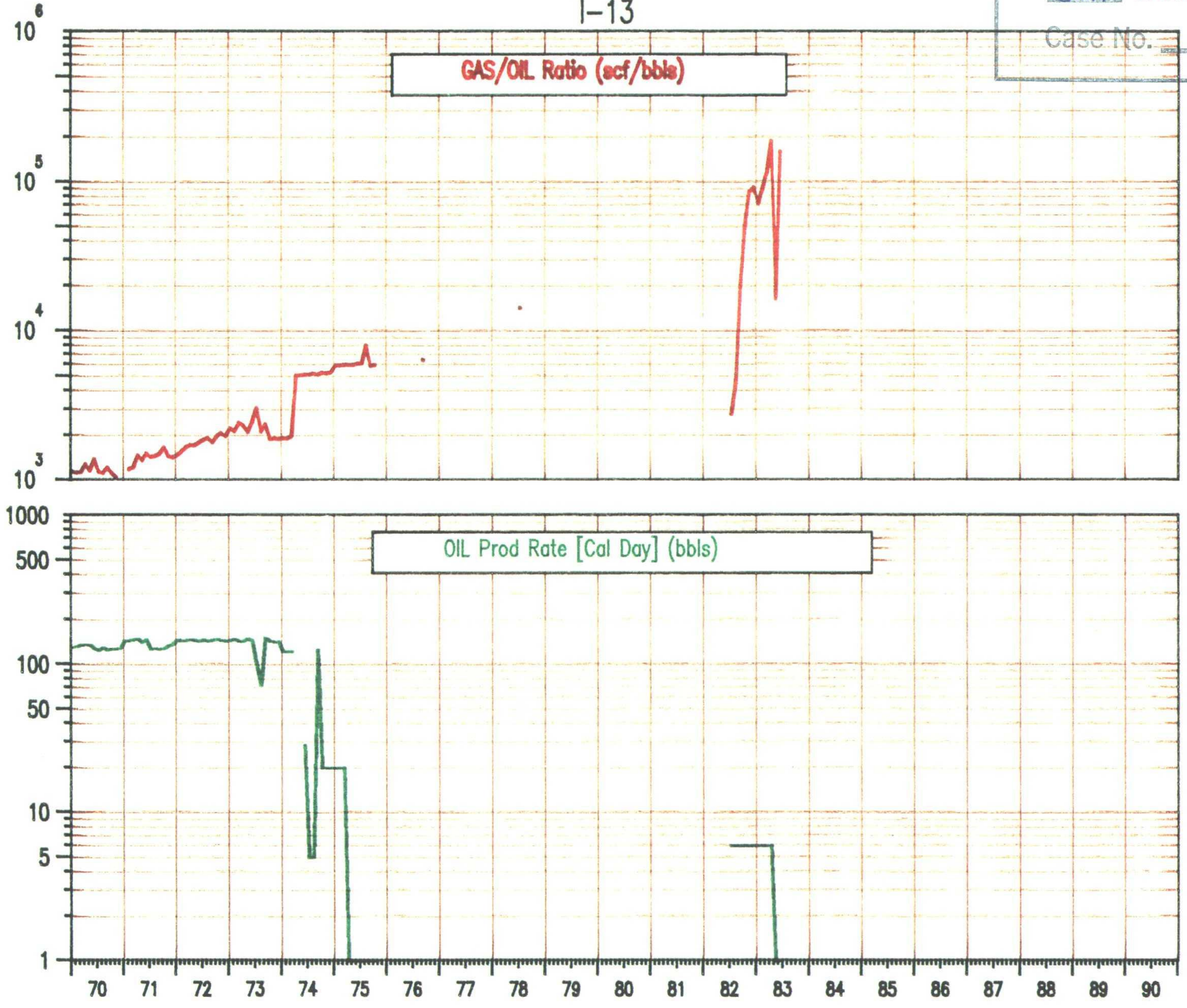
Blowdown Start Date	1/1/85		1/1/90		1/1/95		1/1/03	
	Volume	Energy (MMMBTU)	Volume	Energy (MMMBTU)	Volume	Energy. (MMMBTU)	Volume	Energy (MMMBTU)
Residue Gas	131609 MCF	132925	111195 MCF	112307	85150 MCF	86002	38297 MCF	38680
Ethane	416806 Mgal	27463	490449 Mgal	32315	564156 Mgal	37172	704748 Mgal	46435
Propane	240444 Mgal	21871	282455 Mgal	25693	329201 Mgal	29945	417943 Mgal	38017
Butane	159758 Mgal	16442	192443 Mgal	19806	229020 Mgal	23570	293266 Mgal	30182
Gasoline	52541 Mgal	5750	65562 Mgal	7216	85728 Mgal	9436	110649 Mgal	12179
Oil	8474 MSTB	46607	12970 MSTB	71335	15919 MSTB	87555	17900 MSTB	98450
		251058		268672		273680		263943



BEFORE EXAMINER STOGNER
Oil Conservation Division
OXY Exhibit No. 5
Case No. 9931

BEFORE EXAMINER STOGNER
Oil Conservation Division
OXY Exhibit No. #10
Case No. 9931

EMPIRE ABO UNIT
I-13



ARCO Oil and Gas Company ◆
Central District
Post Office Box 1610
Midland, Texas 79702
Telephone 915 688 5200

BEFORE EXAMINER STOGNER
Oil Conservation Division
OXY Exhibit No. 11
Case No. 9931

May 21, 1990

TO: Working Interest Owners

RE: Empire Abo Unit Nos. G-24, F-27, F-31
Secs. 31, 32, 33 of T17S-R28E
Eddy County, Texas
AFE No. 915289

Dear Working Interest Owners:

Enclosed please find AFE No. 915289 for $143,100 gross to workover wells F-27, G-24, and F-31 in the Empire Abo Unit. Justification from engineer, Gary Smallwood, and other supporting documentation is included for your information. ARCO respectfully requests your prompt approval of this work. To approve, please sign and return one (1) copy of the AFE to:

ARCO Oil and Gas Company
ATTN: Janet L. McCleery - MIO 394
P.O. Box 1610
Midland, Texas 79702

If you have questions, please don't hesitate to call me at 915 688-5544 or Gary Smallwood at 915 688-5359.

Sincerely,

Janet L. McCleery

Janet L. McCleery
Operations Analyst
Southwest District

Attachments

ARCO Oil and Gas Company

Title
Empire Abo Unit Nos. G-24, F-27, F-31
Lower Perforations; Squeeze old perfs.

☒ Original authorization
☐ Revision #
Economics ☒ Required ☐ Not required

Location: Sec. 31, 32 & 33; 17S-28E Eddy Co., NM
State/county code: 30-015
AFE number: 915289
Originated by/Department: Smallwood/Engineering
District: NW-Central L40
Project or program identifier:
Field name/Play name/Prospect name: Empire Abo
Field/play code: 064185
Book property code(s): 6434266 -01
Lease record number:
Subject to prod. payment other fundings ☐ Yes ☒ No
Well plan prepared ☒ Yes ☐ No
Organization code:
Co-owner operator AFE No.(s)/Property code:

✓	Purpose of authorization		
☐	New drilling	Development	%
☐	Recompletion	Exploratory	%
X	Workover	Other	
☐	Drill old well deeper		

Reason for drilling
☐ Rate ☐ Tertiary Recovery ☐ Secondary Recovery
☐ Develop Reserves ☐ Replacement ☐ Service
☐ Combined Reserve - rate - %

Budget information

BI code 1	Amount	BI code 2	Amount
453	52.550		

Approved capital program: budget year 19 N.A.
☐ Original budget ☐ Approved L.E. ☐ Other:
Project included in approved program ☐ Yes ☐ No
Current year expenditure can be funded by approved capital allocation ☐ Yes ☐ No
If no, amount of additional capital to be requested $

✓ **Primary objective of drilling** (definition on reverse side)
☐ Oil only
☐ Gas only
☐ Oil/Gas
Signature Dist. Engineer and/or Exploration group: J A Nicholson

Component AFE No.(s)	Description and justification	Gen/Sub Account codes	On hand	Capital	Expense	Total
	Workovers	9501			143,100	143,100
Other	Use reverse side if more lines are needed See detail on back					

Opns mgr — Operator: AOGC
Gross totals: 143,100 143,100
Engineering — A.O.G.C. interest decimal: 3 6 7 2 2 7 8 0
Net A.O.G.C. share: 52,550 52,550

Technical Audits (✓)
Budget — Present worth AFIT | Invest Efficiency AFIT | Rate of return % AFIT
Procedural — BC — Chance factor (%)

			Lower		Upper
Gross Range Requested	13% Lower	Capi			
	43% Upper	Exp	124,700		204,000
Net Range Requested	13% Lower	Capi			
	43% Upper	Exp	45,793		74,914

ngWI .753087%
pense $1078
gf

Exploration — Co-owner approval signature ☐ Edward I Behr Jr
Evaluation — Date 6/11/90 Company OXY USA INC.
Land mgt — Estimated start date 5/90 Estimated completion date 6/90

Forecast (Net $)	Prior year	Current year	Thereafter
Capital	$	$	$
Expense	$	$ 52,550	$

Approvals (check highest level required)

☒ Other — II — Date 5/14/90
☐ Vice President-A O G C — Date
☐ Vice President-A O G C — Date
☐ Senior Vice President-A O G C — Date
☐ President-A O G C — Date

Authorized expenditure limit table No.- 123-1

☐ Executive Vice President - A R Co — Date
☐ President-A R Co — Date
☐ Chairman of the Board — Date
☐ Board of Directors — Date
☐ — Date

AR3B-382-N

ARCO Oil and Gas Company is a Division of AtlanticRichfieldCompany

uthorization for Expenditure

Title

AFE No.

Component AFE No.(s)	Description and justification	Gen/Sub Account codes	Gross Amounts—In whole dollars only			
			On hand	Capital	Expense	Total
	G-24 Workover				44,700	44,700
	F-27 Workover				44,700	44,700
	F-31 Workover				53,700	53,700

Note: *Include any amounts shown on this page in totals on reverse side.*

Definition of primary objective of drilling.	**Oil only:** Refers to a well drilled where primary objective is oil only or oil and casinghead gas. **Gas only:** Refers to a well drilled where primary objective is gas only or gas and condensate. **Oil and/or gas:** Refers to drilling in areas where primary objective is dual or uncertain.
Definition of reason for drilling.	***Develop reserves:*** Applies to wells drilled to develop new or additional proved reserves and attendant productive capacity. All exploratory wells plus development wells that meet the above criteria, fall in this classification. **Rate:** Applies to wells drilled to accelerate the production of existing proved reserves. **Combination reserves and rates:** Applies to wells whose economic justification is partially based on additional reserves to be developed with attendant productive capacity added, and partially based on the accelerated recovery of existing developed proved reserves. For this classification, show the percent of the economic justification which is applicable to the rate portion of the well. **Secondary recovery:** Applies to wells drilled in connection with a secondary recovery project. These may be infill wells, wells drilled to fill out flood patterns, or wells drilled to replace producers converted to injection or supply service. **Replacement:** Applies to wells drilled to replace wells that have ceased to produce. **Service:** Applies to wells drilled for the purpose of supporting production in an existing field such as gas, water, steam, and air injection; salt water disposal, water supply for injection, observation, and injection for in-situ combustion; etc. ***Tertiary recovery:*** Recovery tertiary reserves

ARCO Oil and Gas Company 5/7/90 **Authorization for Expenditure**

☒ Original authorization
☐ Revision #

Economics ☒ Required ☐ Not required

Title
Empire Abo Unit Nos. G-24, F-27, F-31
Lower Perforations; Squeeze old perfs.

Location: Sec. 31, 32 & 33; 17S-28E Eddy Co., NM
State county code: 30-015
AFE number: 915289

Originated by/Department: Smallwood/Engineering
District: NW-Central L40
Project or program identifier:

Field name/Play name/Prospect name: Empire Abo
Field/play code: 064185
Book property code(s): 6434266 -01

Lease record number:
Subject to prod payment other fundings: ☐ Yes ☒ No
Well plan prepared: ☒ Yes ☐ No
Organization code:
Co-owner operator AFE No.(s)/Property code:

Purpose of authorization

☐	New drilling	Development	%
☐	Recompletion	Exploratory	%
X	Workover	Other	
☐	Drill old well deeper		

Reason for drilling

☐ Rate ☐ Tertiary Recovery ☐ Secondary Recovery
☐ Develop Reserves ☐ Replacement ☐ Service
☐ Combined Reserve - rate %

Budget information

BI code 1	Amount	BI code 2	Amount
453	52.550		

Approved capital program: budget year 19 N.A.
☐ Original budget ☐ Approved L.E. ☐ Other:
Project included in approved program ☐ Yes ☐ No
Current year expenditure can be funded by approved capital allocation ☐ Yes ☐ No
If no, amount of additional capital to be requested $

Primary objective of drilling (definition on reverse side)

☐ Oil only
☐ Gas only
☐ Oil/Gas

Signature Dist. Engineer and/or Exploration group: J A Nicholson

Component AFE No.(s)	Description and justification	Gen/Sub Account codes	On hand	Capital	Expense	Total
	Workovers	9501			143,100	143,100
Other	Use reverse side if more lines are needed See detail on back					

Gross amounts-in whole dollars only

Technical Audits (✓)

Opns. mgr
Engineering
Budget
Procedural BC
Exploration
Evaluation
Land mgr

Operator: AOGC
Gross totals: 143,100 | 143,100
A.O.G.C. interest decimal: 3 6 7 2 2 7 8 0
Net A.O.G.C. share: 52,550 | 52,550
Present worth AFIT · Invest Efficiency AFIT
Rate of return % AFIT
Chance factor (%)

			Lower	Upper
Gross Range Requested	13% Lower	Cap		
	43% Upper	Exp	124,700	204,000
Net Range Requested	13% Lower	Cap		
	43% Upper	Exp	45,793	74,914

Co-owner approval signature ☐
Date: 5/11/90 Company: OXY USA INC.

Forecast (Net $)	Prior year	Current year	Thereafter
Capital	$	$	$
Expense	$	$ 52,550	$

Estimated start date: 5/90
Estimated completion date: 6/90

Approvals (check highest level required)

Authorized expenditure limit table No.- 123-1

☒ Opns. Date 5/14/90
☐ Vice President-A O G C Date
☐ Vice President-A O G C Date
☐ Senior Vice President-A O G C Date
☐ President-A O G C Date

☐ Executive Vice President - A R Co. Date
☐ President-A R Co. Date
☐ Chairman of the Board Date
☐ Board of Directors Date
☐ Date

AP3B 362-N

ARCO Oil and Gas Company is a Division of AtlanticRichfieldCompany

Authorization for Expenditure

Page | of

Title

AFE No.

Component AFE No.(s)	Description and justification	Gen/Sub Account codes	Gross Amounts—In whole dollars only			
			On hand	Capital	Expense	Total
	G-24 Workover				44,700	44,700
	F-27 Workover				44,700	44,700
	F-31 Workover				53,700	53,700

Note: Include any amounts shown on this page in totals on reverse side.

Definition of primary objective of drilling.

Oil only:
Refers to a well drilled where primary objective is oil only or oil and casinghead gas.
Gas only:
Refers to a well drilled where primary objective is gas only or gas and condensate.
Oil and/or gas:
Refers to drilling in areas where primary objective is dual or uncertain.

Definition of reason for drilling.

Develop reserves:
Applies to wells drilled to develop new or additional proved reserves and attendant productive capacity. All exploratory wells plus development wells that *meet the above criteria*, fall in this classification.
Rate:
Applies to wells drilled to accelerate the production of existing proved reserves.
Combination reserves and rates:
Applies to wells whose economic justification is partially based on additional reserves to be developed with attendant productive capacity added, and partially based on the accelerated recovery of existing developed proved reserves. For this classification, show the percent of the economic justification which is applicable to the rate portion of the well.
Secondary recovery:
Applies to wells drilled in connection with a secondary recovery project. These may be infill wells, wells drilled to fill out flood patterns, or wells drilled to replace producers converted to injection or supply service.
Replacement:
Applies to wells drilled to replace wells that have ceased to produce.
Service:
Applies to wells drilled for the purpose of supporting production in an existing field such as gas, water, steam, and air injection; salt water disposal, water supply for injection, observation, and injection for in-situ combustion; etc.
Tertiary recovery:
Recovery tertiary reserves

ARCO Oil & Gas **Internal Correspondence**

Date: May 18, 1990

Subject: Empire Abo Unit Lowering Perforations
Gas Injection Well Nos. F-27, F-31 and G-24
Eddy Co., New Mexico

From/Location: G. B. Smallwood MIO-723

Telephone: 688-5359

To/Location: J. A. Nicholson MIO-531

We recommend approval of the attached AFE for workover of the three subject gas injection wells in the Empire Abo Unit. AOGC operates the unit with a 36.7% working interest and a 31.6% oil NRI, 24.3% gas NRI and 8.07% NGL NRI. The total gross estimated cost of the three well perforating and squeezing program is $143M with a net cost to ARCO of $52.5M.

In 1984, Schumbera and Staggs completed the Empire Abo Unit Performance Projection. The projection emphasized the future of NGL performance to the unit. Two of the key findings of this projection were:

1. Half to three-quarters of the amount of each NGL component remaining in the year 1981 resides in the residual oil in the gas cap.

2. Most future NGL recovery can be attributed to contacting of residual oil with lean gas. Sweep efficiency will have an important effect.

Incremental reserves for this project are based on a comparison of the average NGL content of the entire Unit's produced gas(3.86 gal/mcf) with that of the target injection area. The target area has a NGL content of 5.25 gal/mcf. It was assumed that by moving injection gas to the area of higher NGL's that liquids would be recovered at the same rate as predicted for the field but at the higher starting point of 5.25 gal/mcf. We assumed that 3 MMCFPD per well would contact NGL's in the target area. The NGL's are recovered at the incremental rate of 1.315 gal/mcf. The rate reflects the plant's 93% overall recovery efficiency. These numbers are considered somewhat conservative since each injection well is likely to inject as much as 6 MMCFPD.

A review of the field's injection wells indicated that 45% of all injection gas had entered only 3 of the 16 gas injection wells, implying the obvious need to redistribute injection gas. Lowering the perforations in the three subject wells is consistent with our plan to redistribute gas and improve sweep efficiencies. We have attached a simple illustration showing the concept of improved sweep and NGL recovery as Figure 1B.

We have reviewed the cost estimates to kill and squeeze the subject wells with the drilling department. We were concerned that it might be extra troublesome to kill these wells. They have been on gas injection for a long time and it seemed likely they would drink a lot of fluid. It appears there are sufficient funds to cover such a case. In addition we agreed to move the completion packer above the old perforations and run tailpipe below them. See the attached wellbore schematics. This should assure future mechanical integrity tests and help protect the squeeze job from matrix acid treatments of the new perforations.

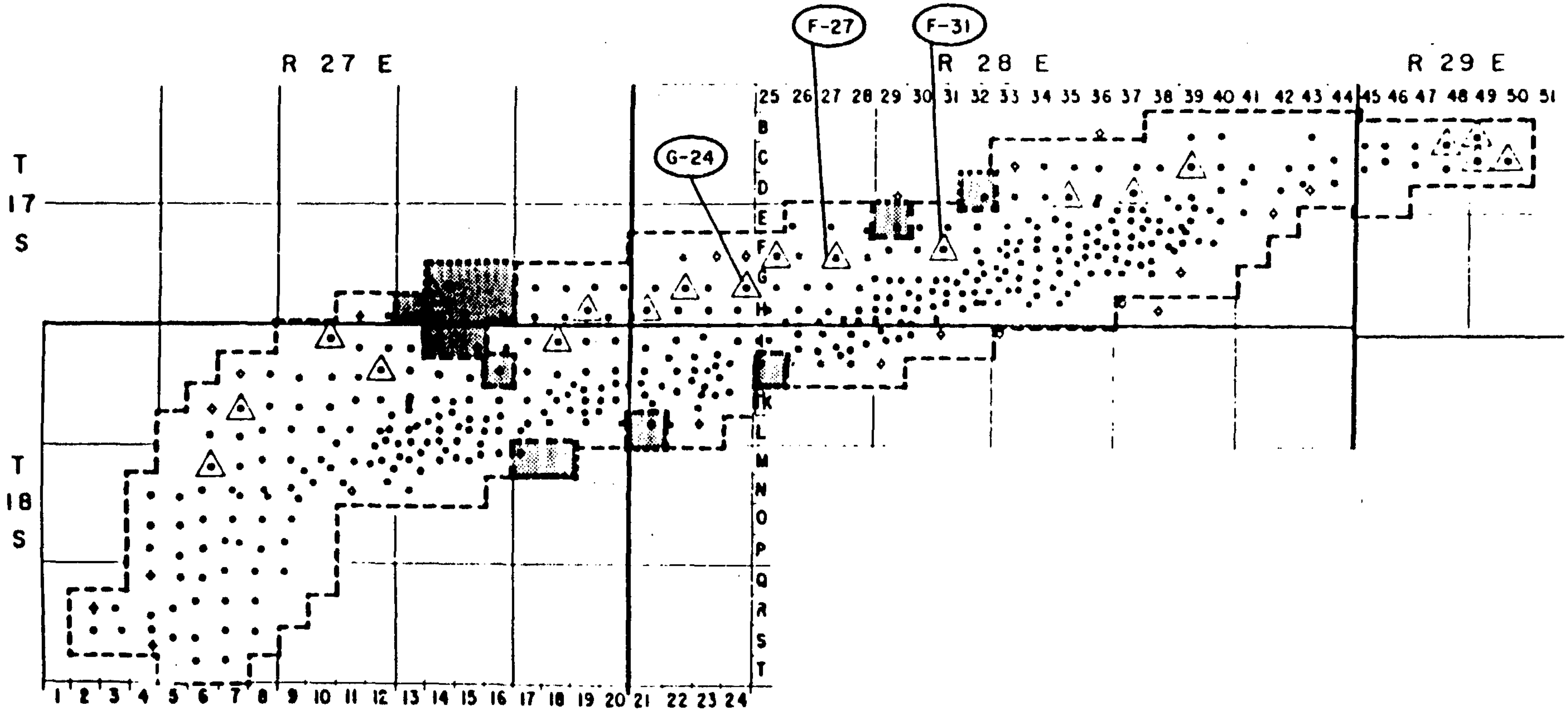
The workover of Well F-27 and G-24 includes squeezing existing perforations and perforating deeper. The workover of Well F-31 includes squeezing existing perforations, drilling out a CIBP and repairing a highly probable casing leak.

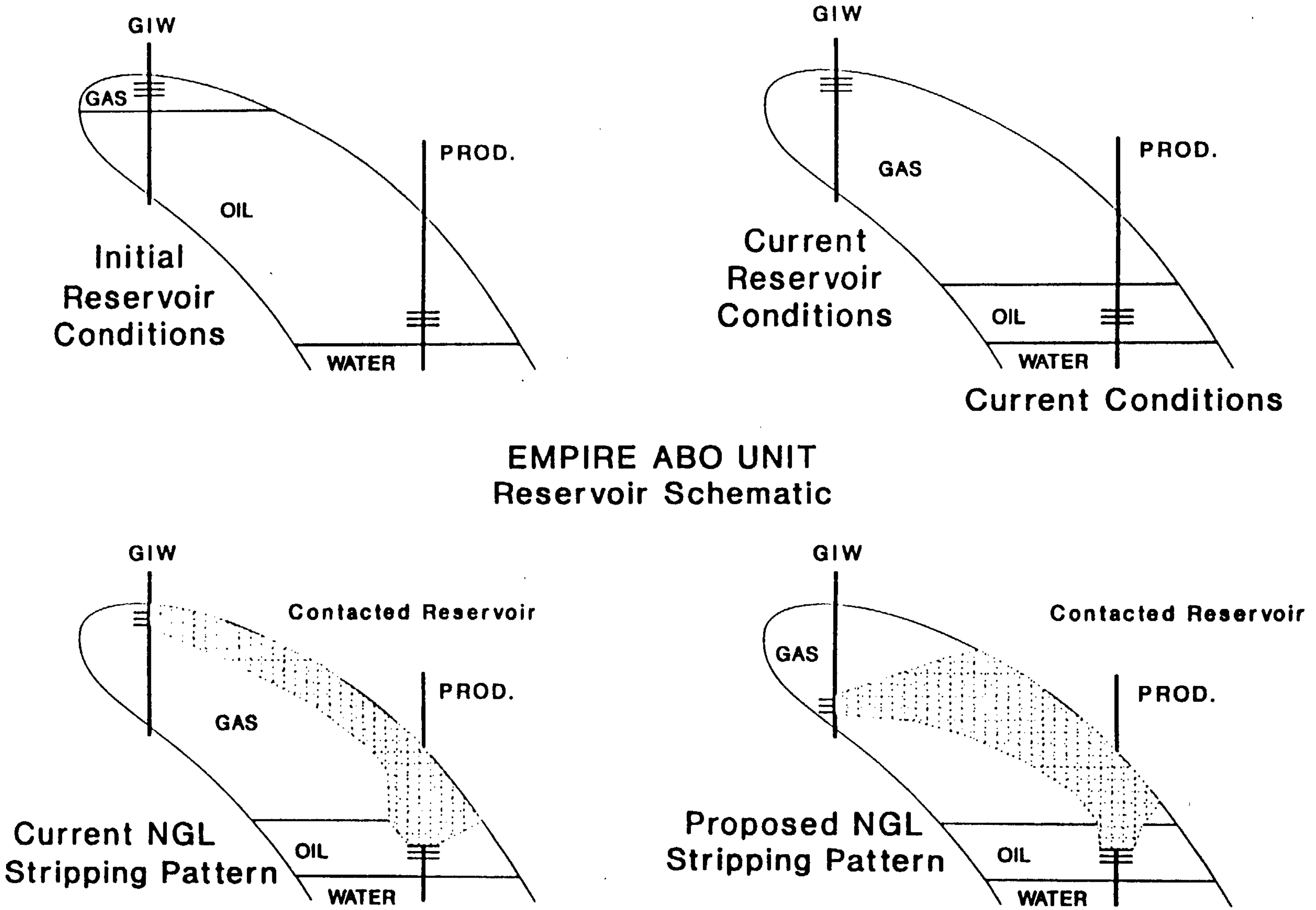
We recommend approval of the three proposed workovers.

Gary B Smallwood

Gary B. Smallwood
Sr. Engineer

EMPIRE ABO UNIT
Eddy County, New Mexico

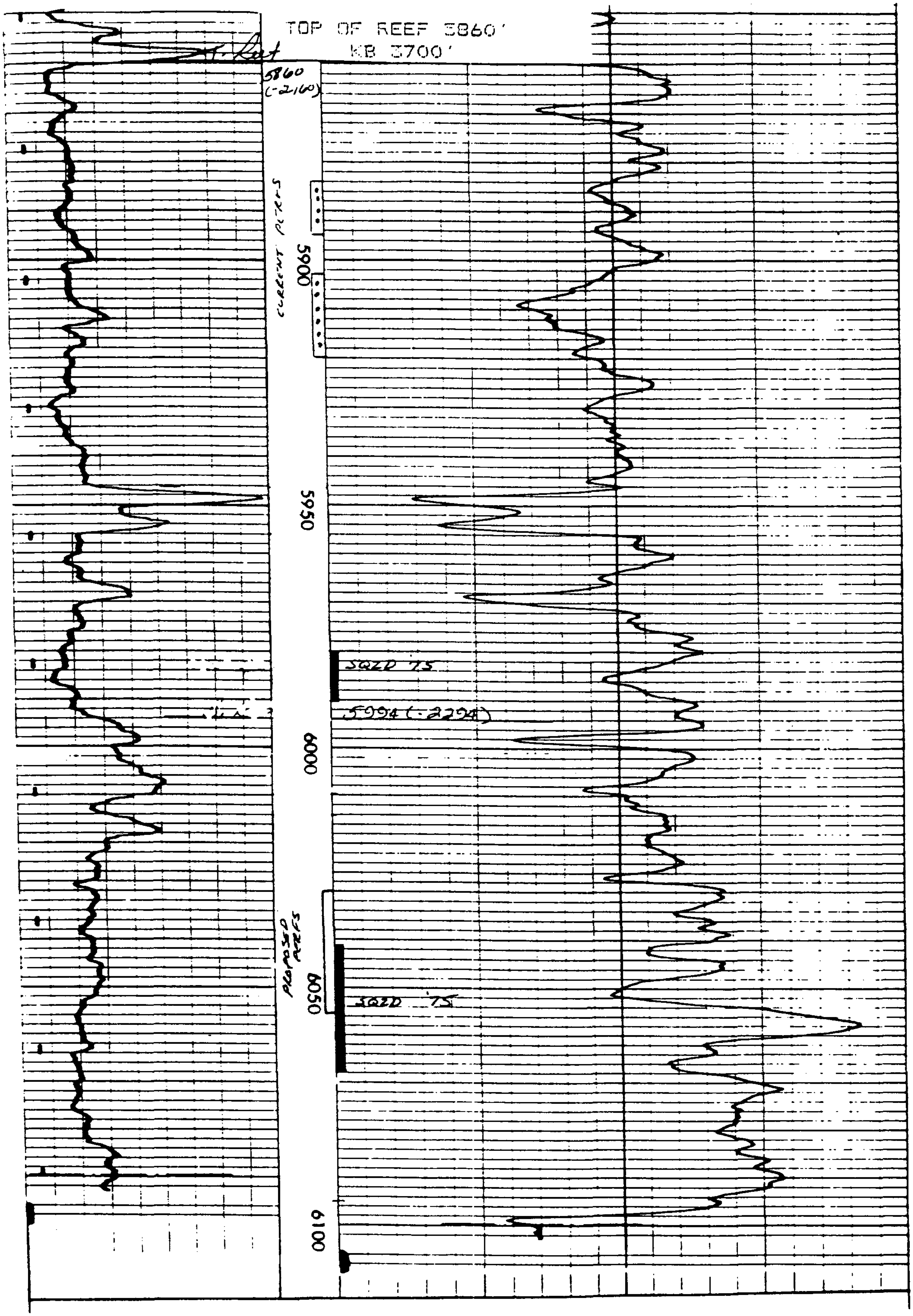


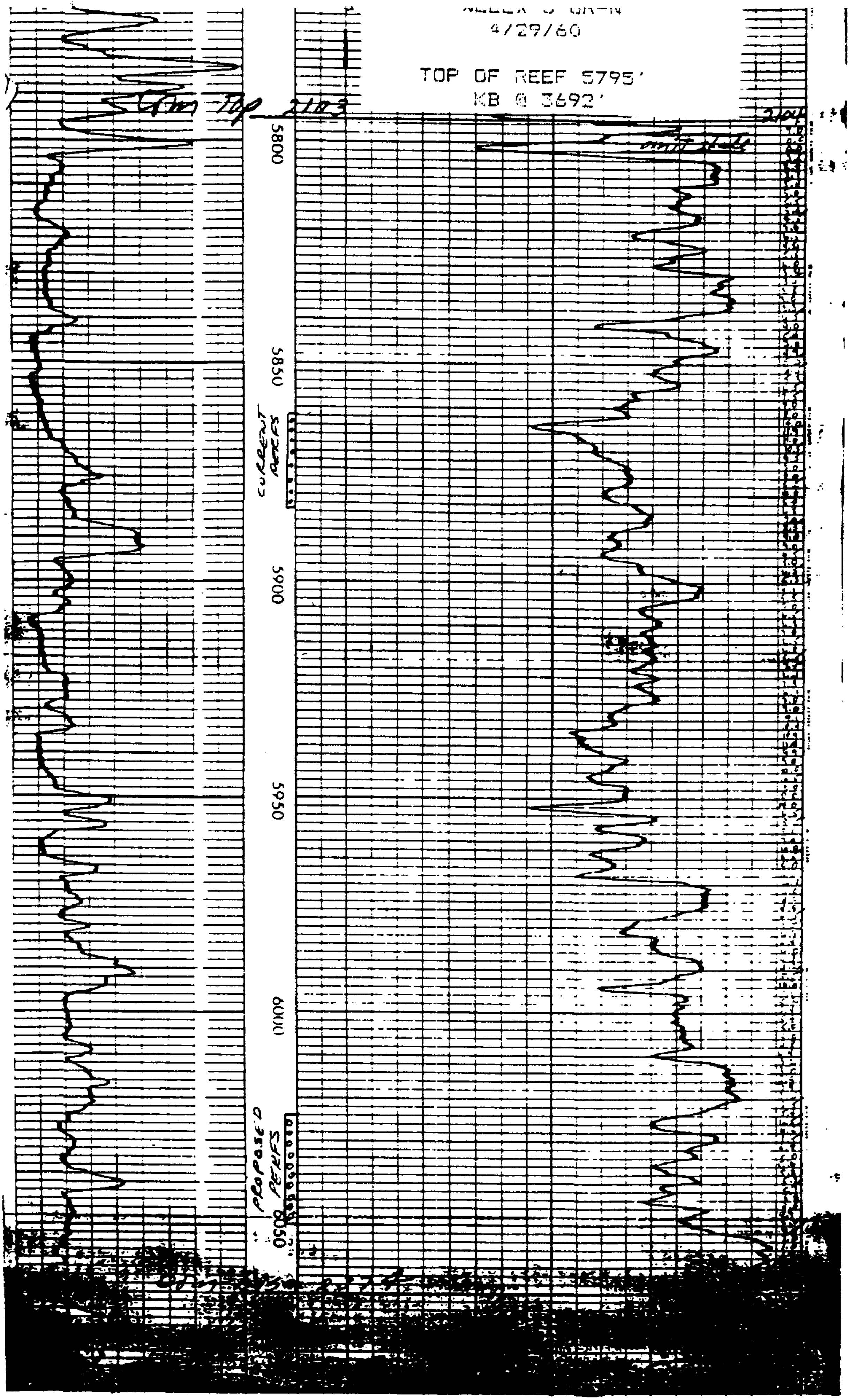


EMPIRE ABO UNIT
Reservoir Schematic

Figure 1B

WELEX [illegible] GR-N
[illegible]/23/60



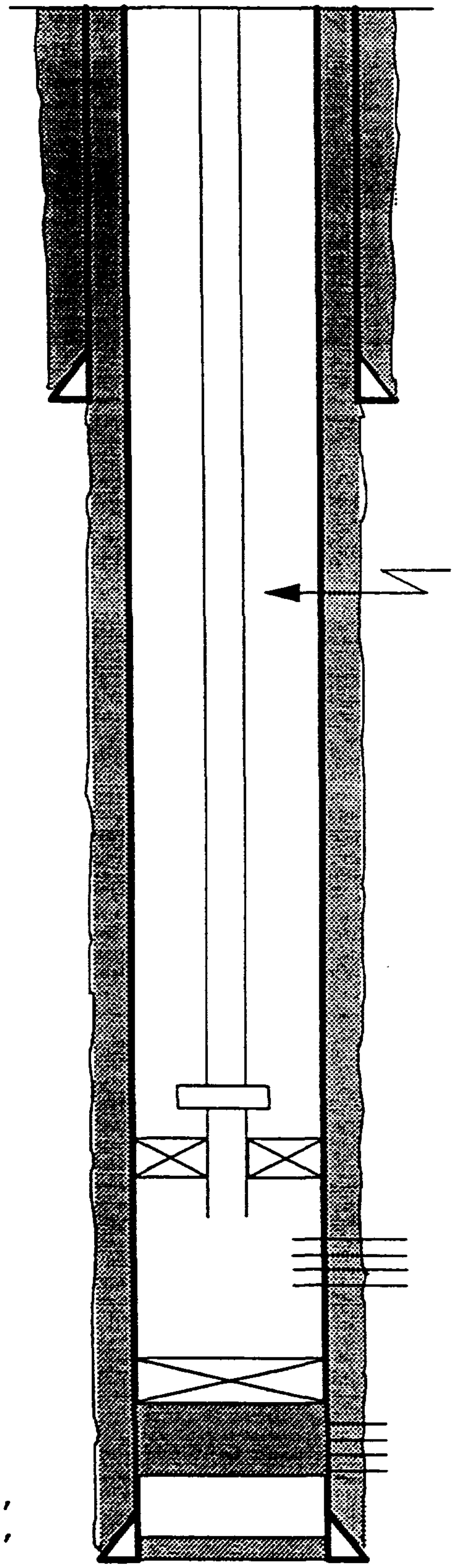


4/29/60

TOP OF REEF 5795'
KB @ 3692'

Empire Abo Unit F-27 GIW

SUBJECT: PRESENT STATUS *BY: D.C. BRETCHES*



DATUM: RKB(11')

8-5/8" 28# J55 Surf CSG
set @ 1003'. CMTD w/ 450 sx.
TOC: SURF

184 jts 2-3/8" 4.7# 8RDEUE
J55 IPC TBG Btm'd @ 5790'

ER Receptacle w/ 1.81" R Profile
Baker 5-1/2" Lok Set PKR @ 5790'
1 jt 2-3/8" 4.7# 8RDEUE J55 IPC TBG

Open Abo Perfs 5884,86,88,93,95,
5905,07,09,11,13,18,& 20 (12 holes)

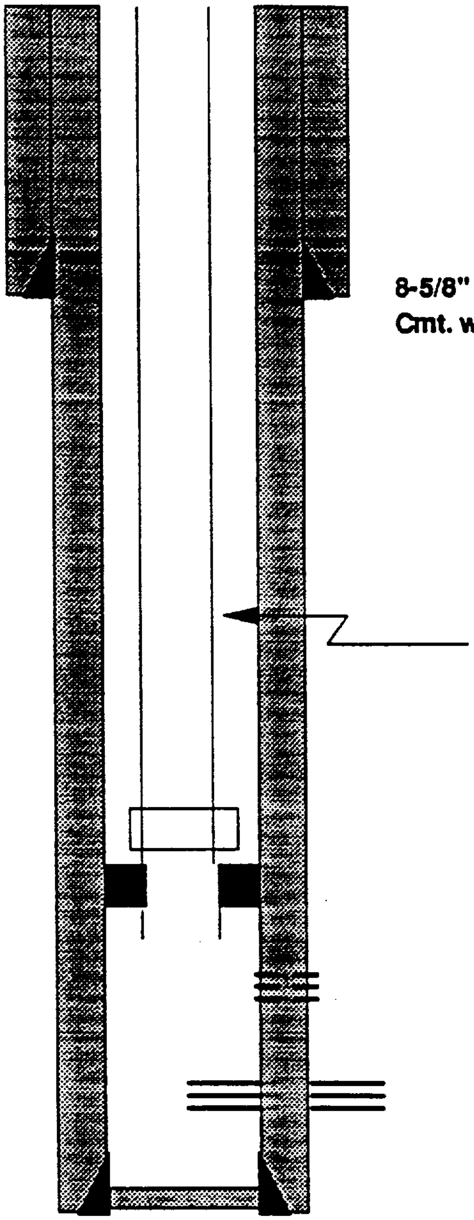
CR set @ 5941'

Squeezed Abo Perfs
5980-90' (20 holes) $ 6041-68' (15 holes)
Squeezed w/ 150 sx cmt

PBD: 5941'
TD: 6108'

5-1/2" 15.5# J55 Prod CSG
set @ 6108'. CMTD w/ 170 units &
150 sx. TOC: Surf

Empire Abo Unit F-27 GIW
Proposed Status



8-5/8" 28# J55 @ 1003'.
Cmt. w/450 sx

2-3/8" 4.7# EUE
J55 IPC

ER Receptacle w/ 1.81" R Profile
Baker 5-1/2" Lok set with
1 jt. 2-3/8" 4.7# EUE J55 IPC Tbg.

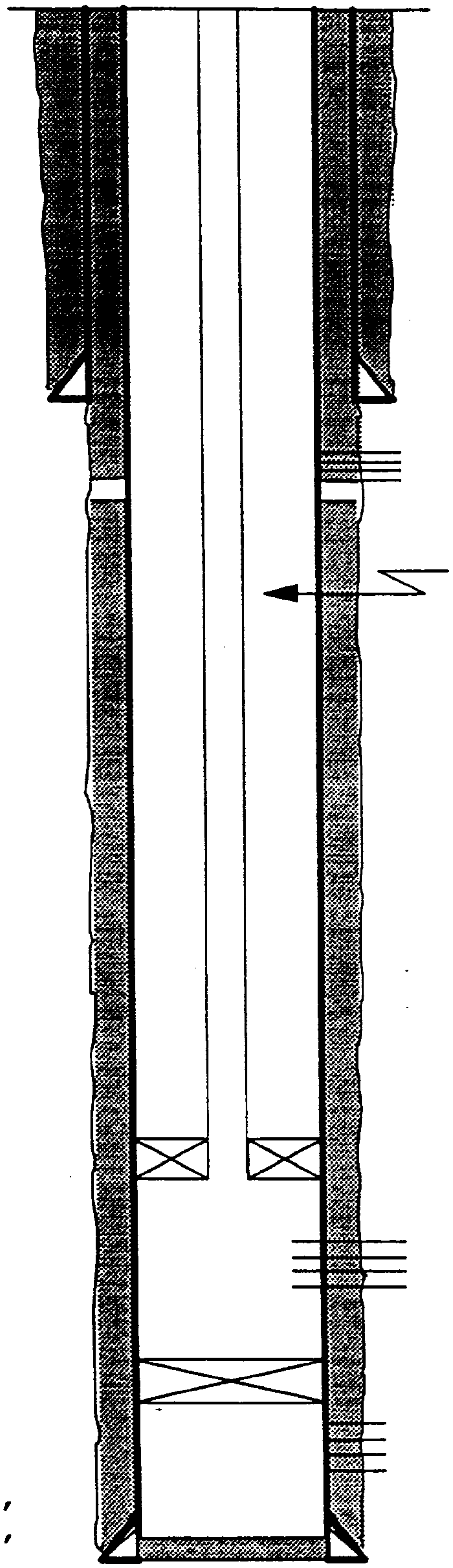
Squeezed Abo Perfs 5884'-5920'
12 holes.

Proposed Abo perfs. 6030'-55' (50 holes)

5-1/2" 15.5# J55 @ 6108'.
PBD= 6070'
TD= 6108'

Empire Abo Unit F-31 GIW

SUBJECT: PRESENT STATUS *BY: D.C. BRETCHES*



DATUM: GL

8-5/8" 23# SW SJ Surf CSG
set @ 1000'. CMTD w/ 650 sx.
TOC: SURF

Squeeze perfs @ 1248'

184 jts 2-3/8" 4.7# 8RDEUE
J55 IPC TBG Btm'd @ 5753'

Guiberson H-1 Hydraulic Holddown Anchor
Guiberson KVL-30 Production Packer
set @ 5753'

Open Abo Perfs 5828,34,40,50,55,
60,69,76,81, & 87 (10 holes)

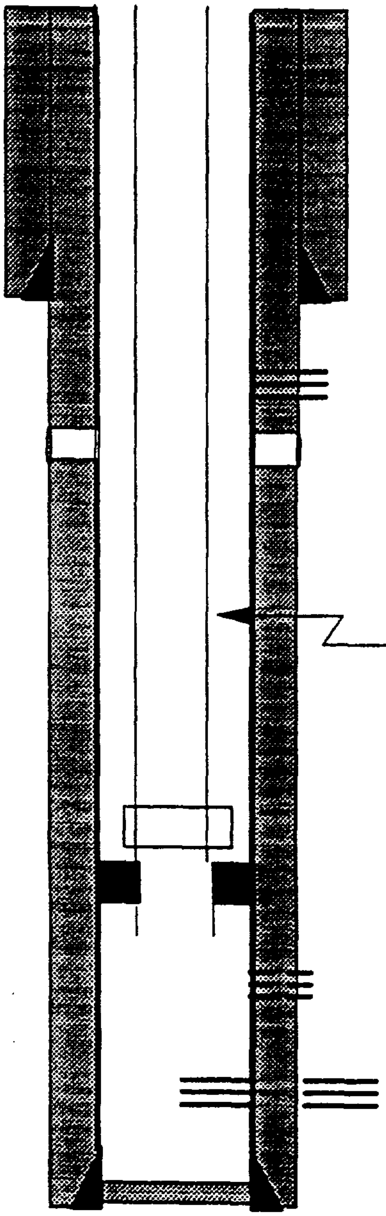
CIBP set @ 6050'

Isolated Abo Perfs
6107-34' (54 holes)

PBD: 6050'
TD: 6175'

4-1/2" 9.5# & 11.6# J55 Prod CSG
set @ 6175'. CMTD w/ 800 sx
TOC: Surf

Empire Abo Unit F-31 GIW
Proposed Status



8-5/8" 23 ppf, SW, SJ @ 1000'
Cmt. w/650 sx

Squeeze perfs. @ 1248'

2-3/8" 4.7# EUE
J55 IPC

Baker FL on/off w/1.81" R Profile
Baker 5-1/2" Lok set with
1 jt. 2-3/8" 4.7# EUE J55 IPC Tbg.

Squeezed Abo Perfs 5828'-87'
10 holes.

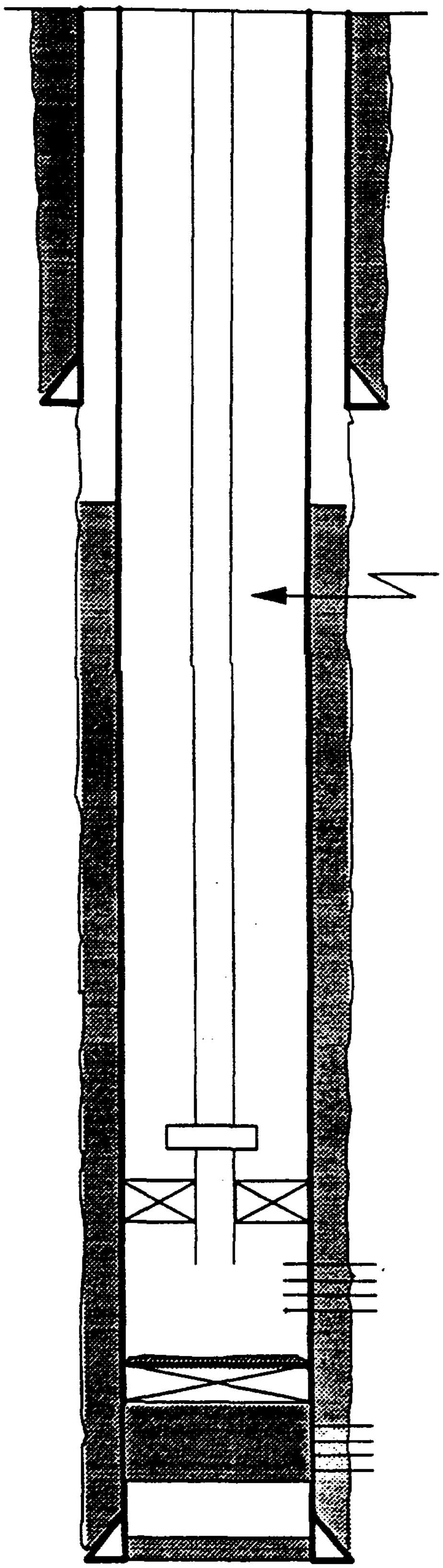
Proposed Abo perfs. 6107-34' (54 holes)

4-1/2" 9.5 & 11.6 ppf, J-55 @ 6175'
PBD= 6157'
TD= 6175'

Empire Abo Unit G-24

SUBJECT: PRESENT STATUS *BY: D.C. BRETCHES*

DATUM: GL



8-5/8" 28# J55 Surf CSG
set @ 750'. CMTD w/ 250 sx.
TOC: SURF

186 jts 2-3/8" 4.7# 8RDEUE
J55 IPC TBG Btm'd @ 5787'

ER Receptacle w/ 1.81" R Profile
Baker 5-1/2" Lok Set PKR @ 5787'
1 jt 2-3/8" 4.7# 8RDEUE J55 IPC TBG

Open Abo Perfs
5862-83' (22 holes)

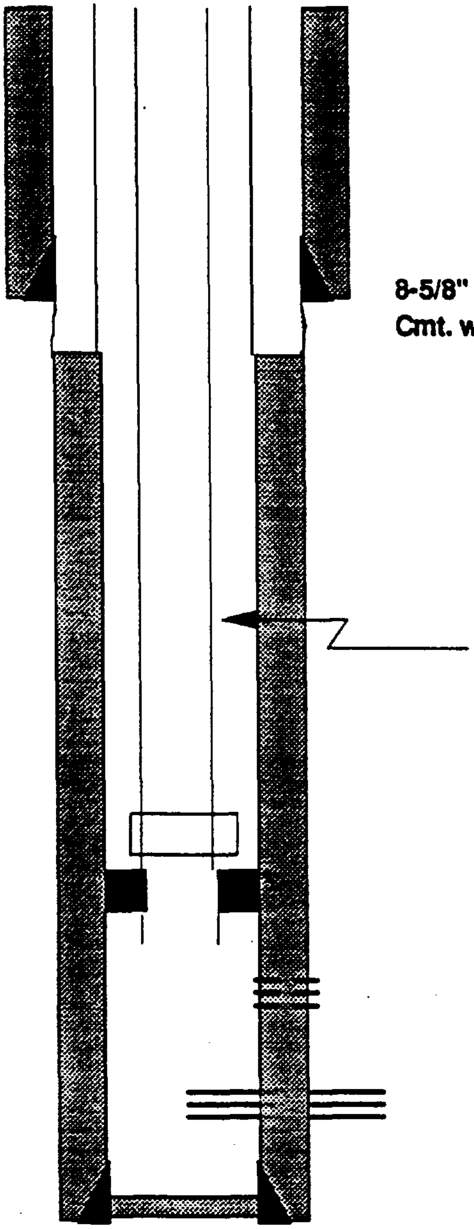
Top of fill on CR @ 5952'

5-1/2" CR set @ 5960
Original Abo Perfs
6024-44' (40 holes)
Squeezed w/ 175 sx cmt

PBD: 5952'
TD: 6106'

5-1/2" 15.5# J55 Prod CSG
set @ 6104'. CMTD w/ 1100 sx
TOC: 1000' - Calculated

Empire Abo Unit G-24 GIW
Proposed Status



8-5/8" 28# J55 @ 750'.
Cmt. w/ 250 sx

2-3/8" 4.7# EUE
J55 IPC

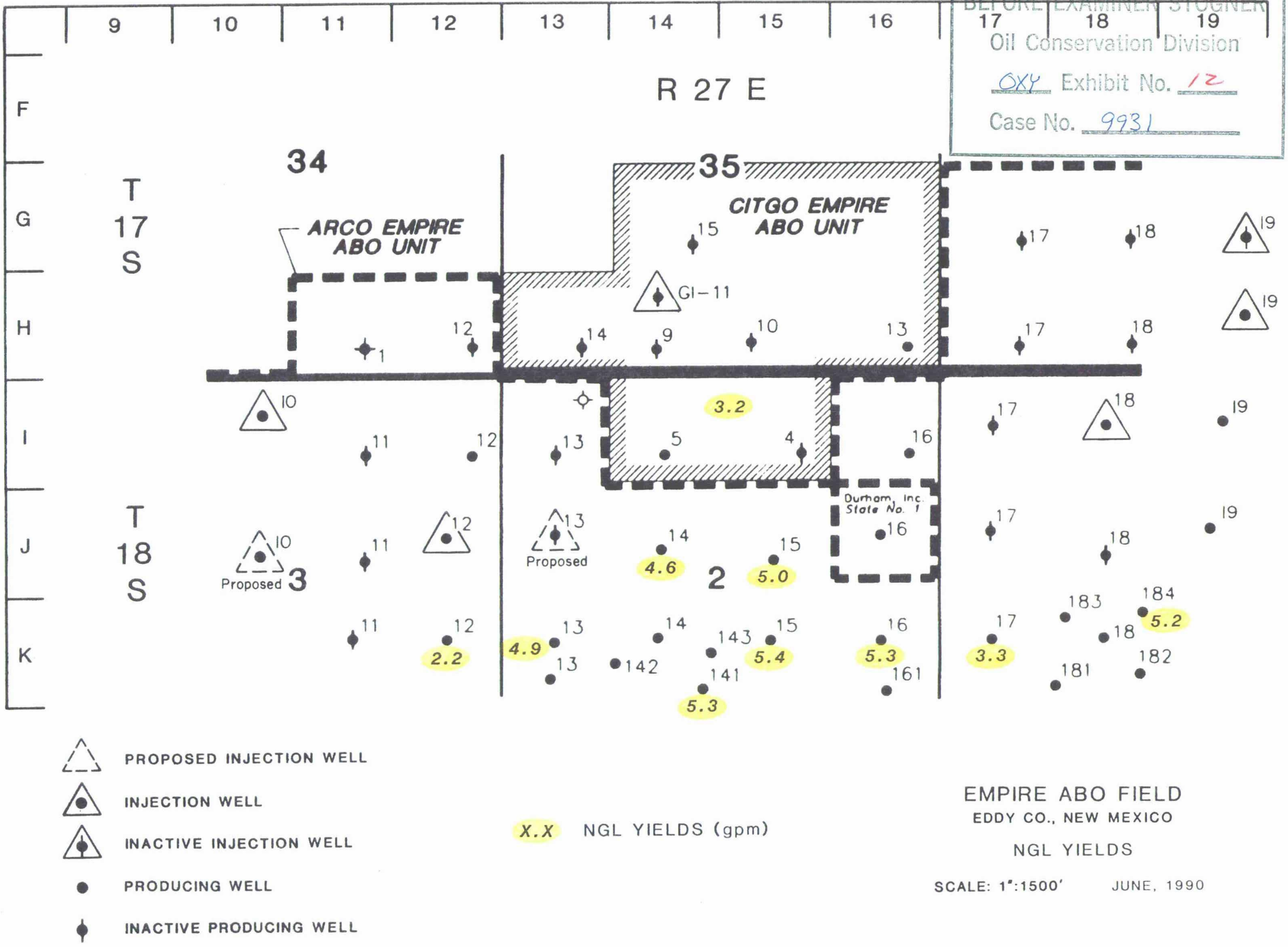
ER Receptacle w/ 1.81" R Profile
Baker 5-1/2" Lok set with
1 jt. 2-3/8" 4.7# EUE J55 IPC Tbg.

Squeezed Abo Perfs 5862'-83'
(22 holes).

Proposed Abo perfs. 6024'-50' (52 holes)

5-1/2" 15.5# J55 @ 6104'. TOC @ 1000' Calc.
PBD= 6068'
TD= 6106'

BEFORE EXAMINER STOGNER
Oil Conservation Division
OXY Exhibit No. 12
Case No. 9931



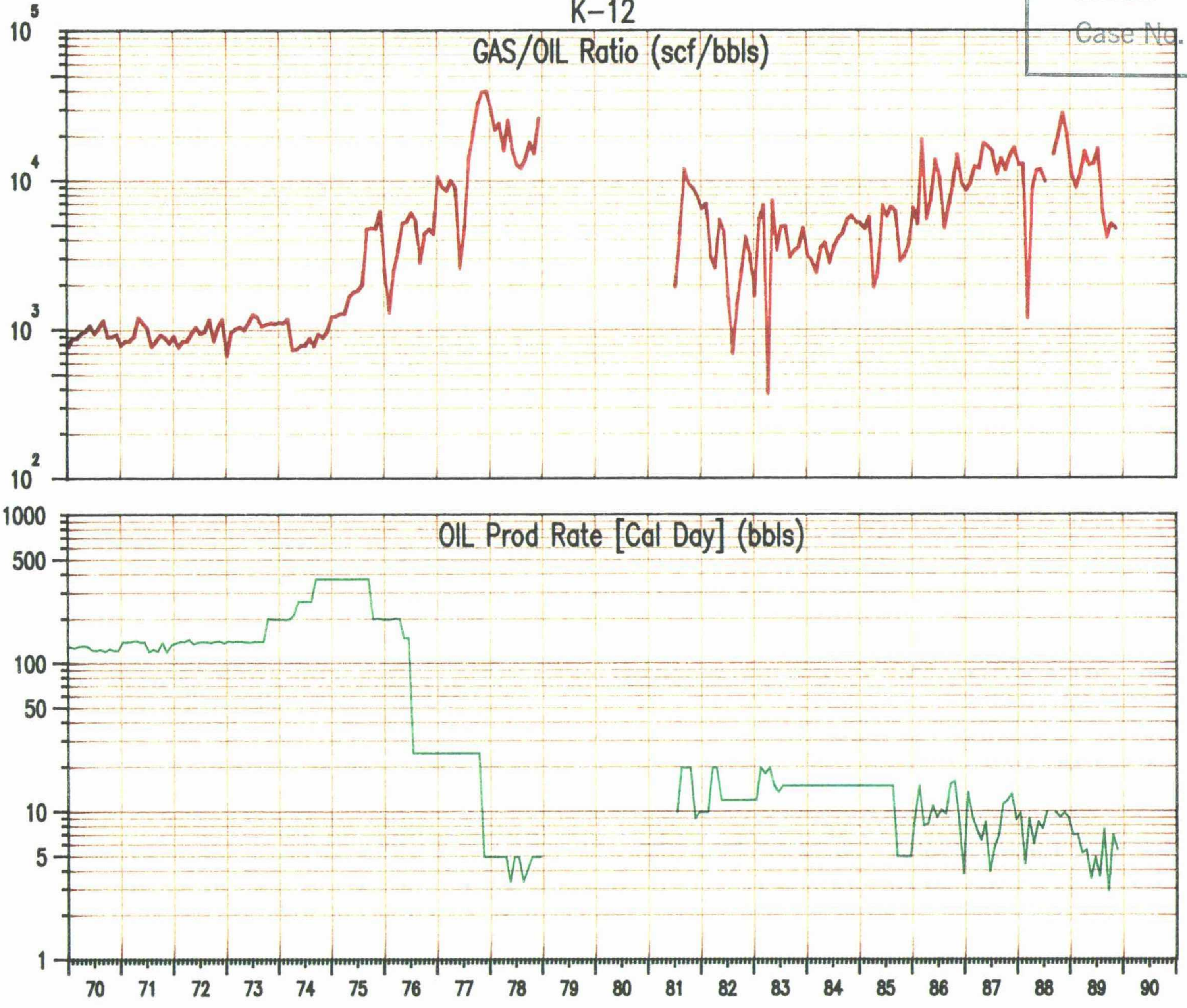
EMPIRE ABO FIELD
EDDY CO., NEW MEXICO
NGL YIELDS

SCALE: 1":1500'   JUNE, 1990

BEFORE EXAMINER STOGNER
Oil Conservation Division
OXY Exhibit No. 13
Case No. 9931

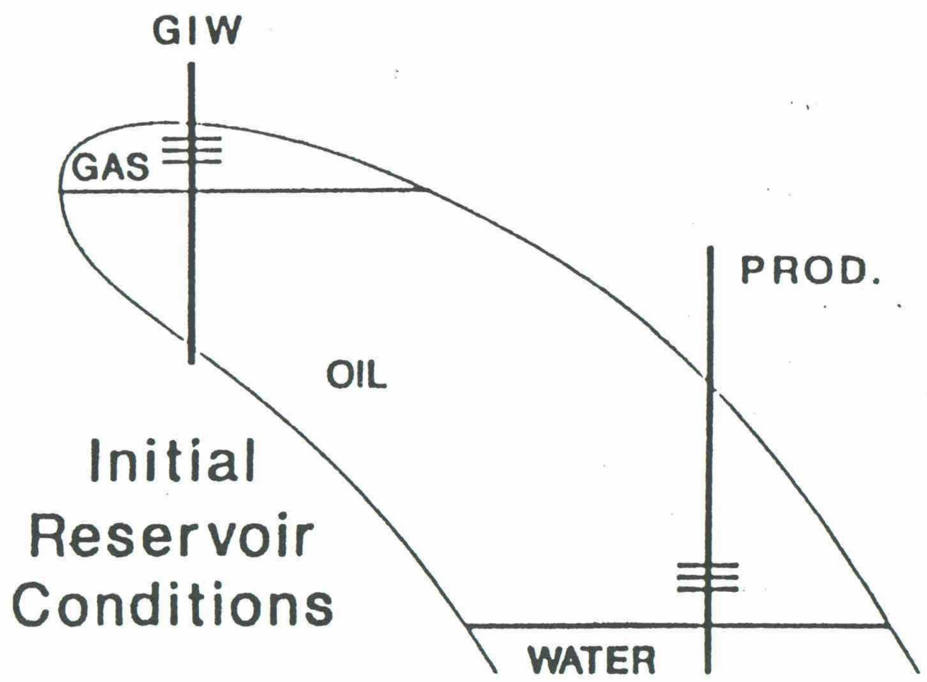
EMPIRE ABO UNIT

K-12

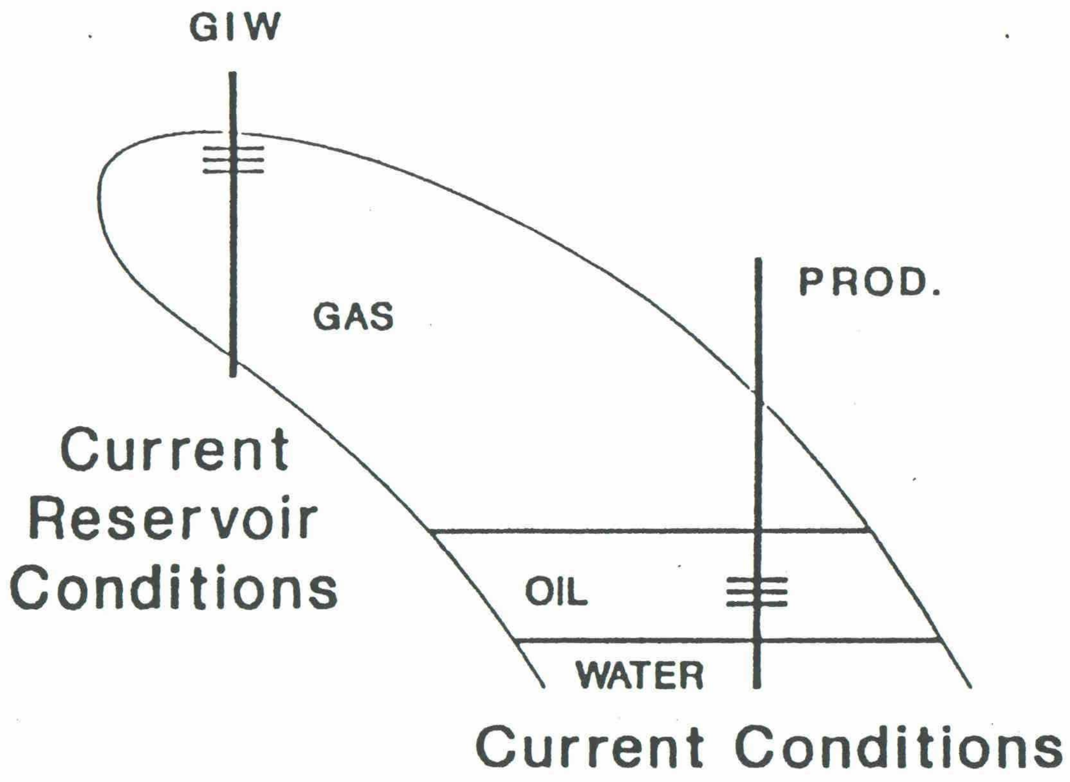


BEFORE EXAMINER STOGNER
Oil Conservation Division
OXY Exhibit No. 14
Case No. 9931

EMPIRE ABO UNIT
Reservoir Schematic

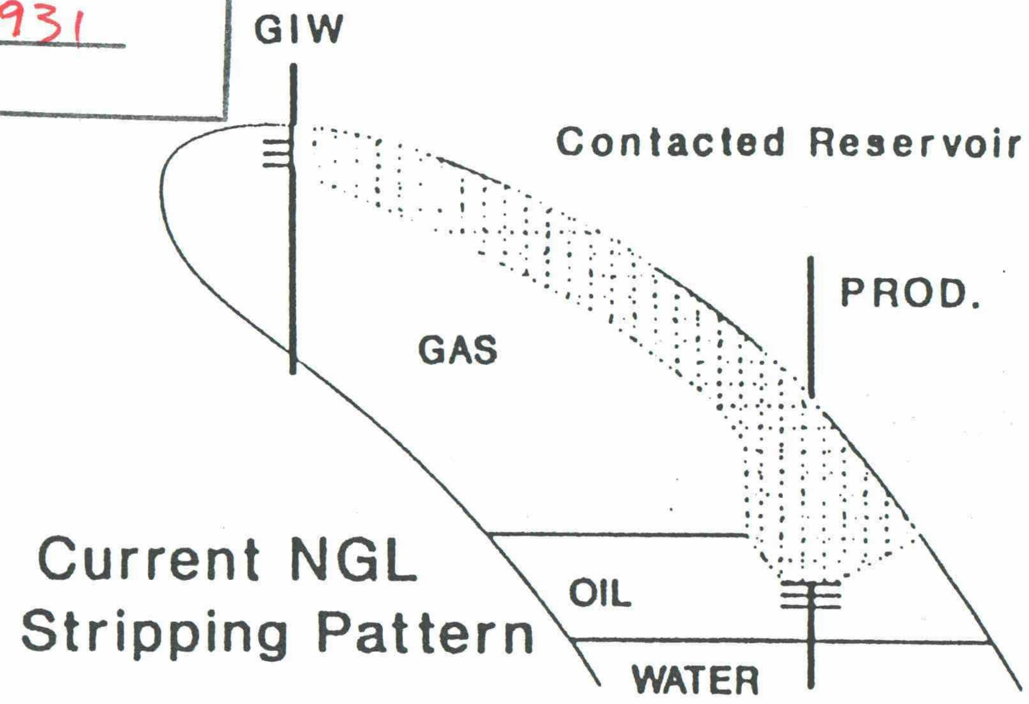


Initial Reservoir Conditions

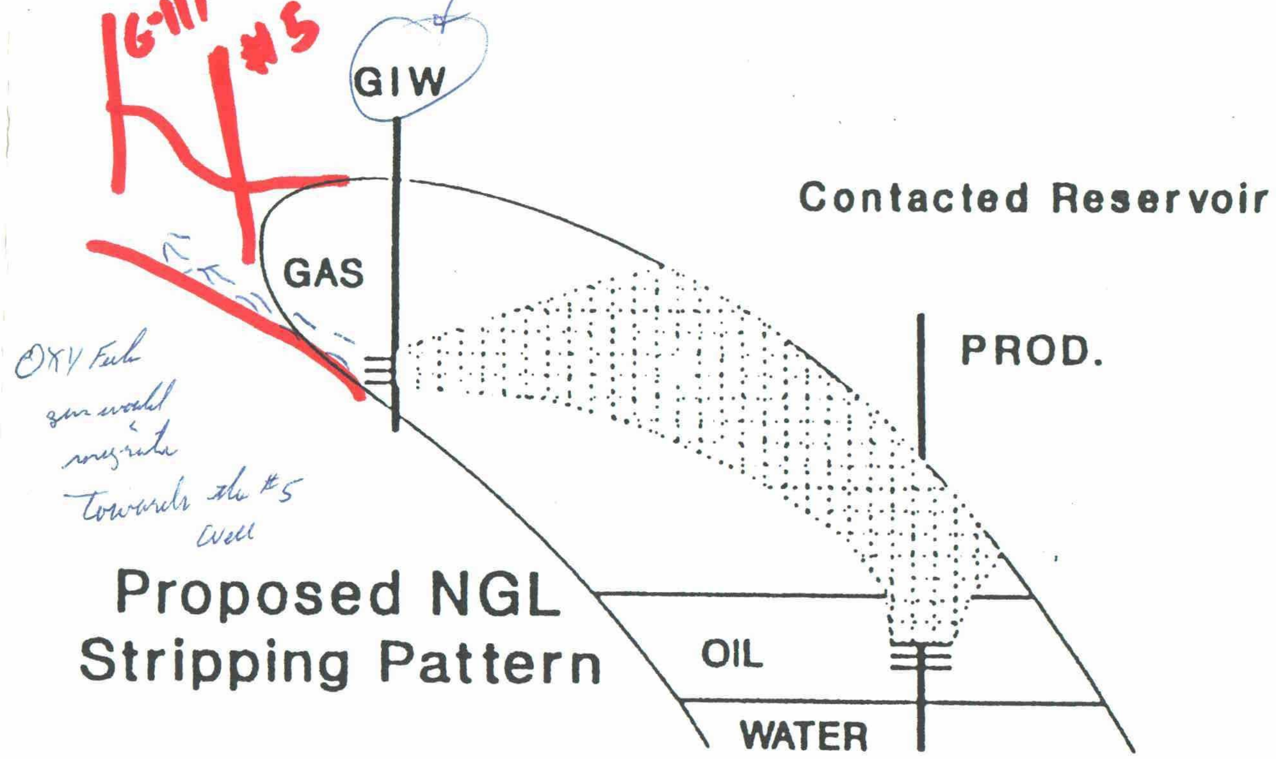


Current Reservoir Conditions

Current Conditions



Current NGL Stripping Pattern



OXY Feels gas would migrate towards the #5 well

Proposed NGL Stripping Pattern

BEFORE EXAMINER STOGNER

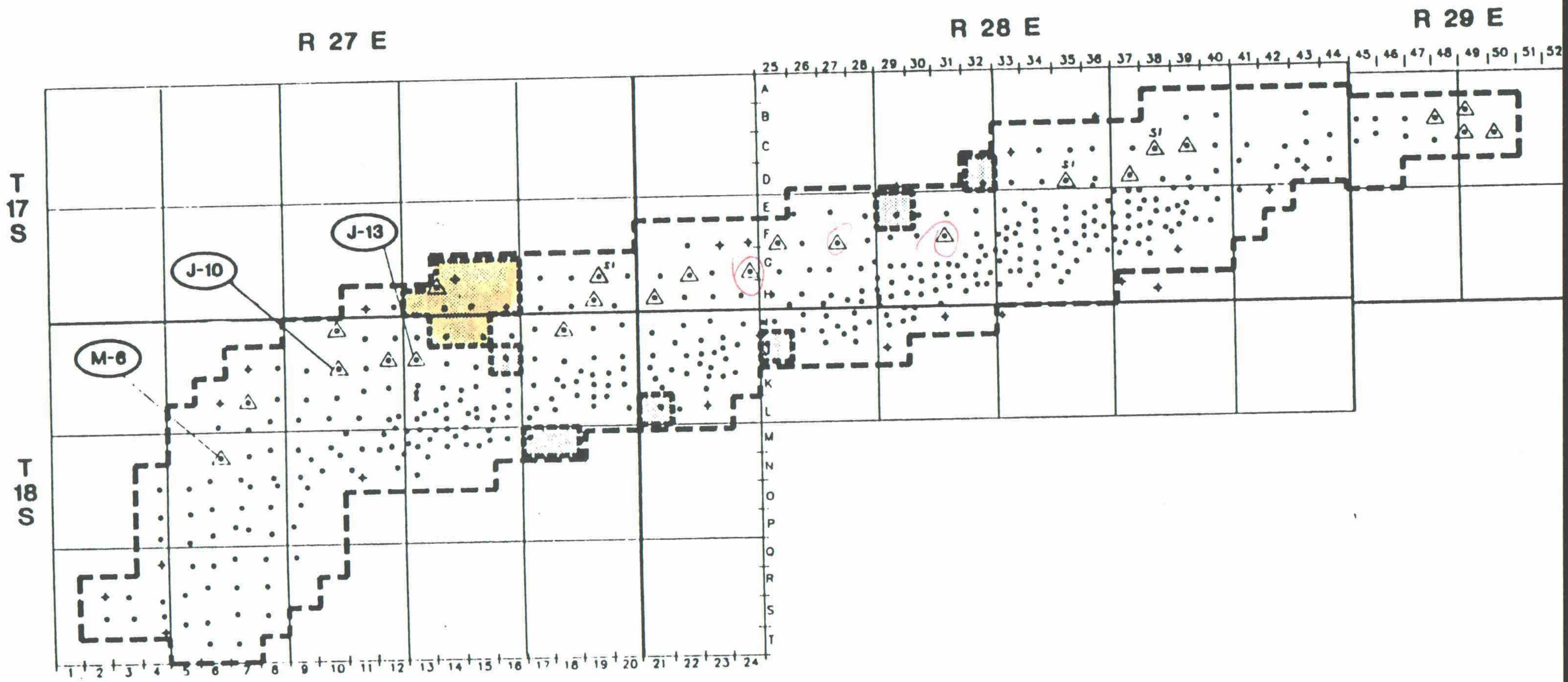
Oil Conservation Division

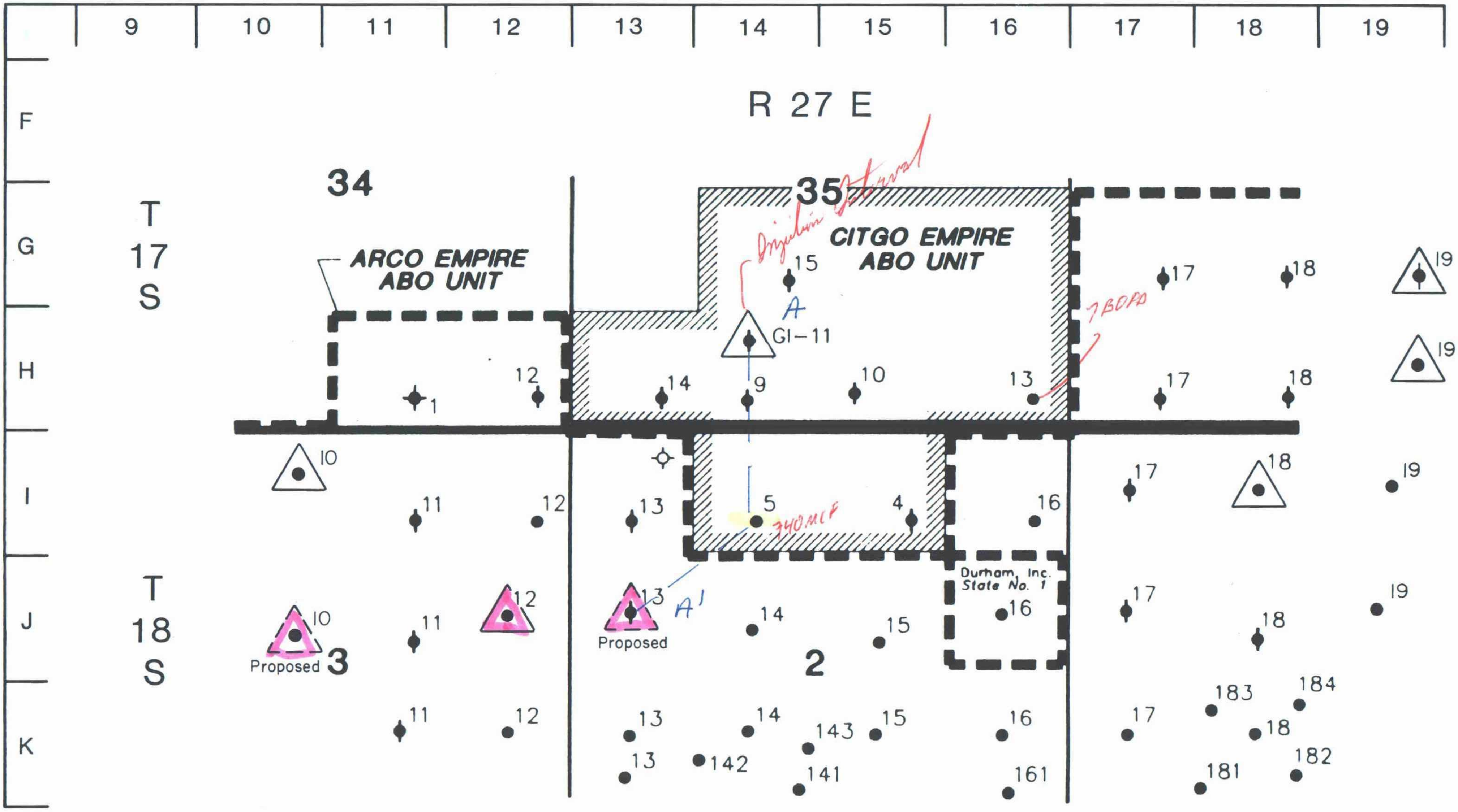
OXY Exhibit No. 1

Case No. 9931

EMPIRE ABO UNIT

Eddy County, New Mexico





△ PROPOSED INJECTION WELL

△ INJECTION WELL

△ INACTIVE INJECTION WELL

● PRODUCING WELL

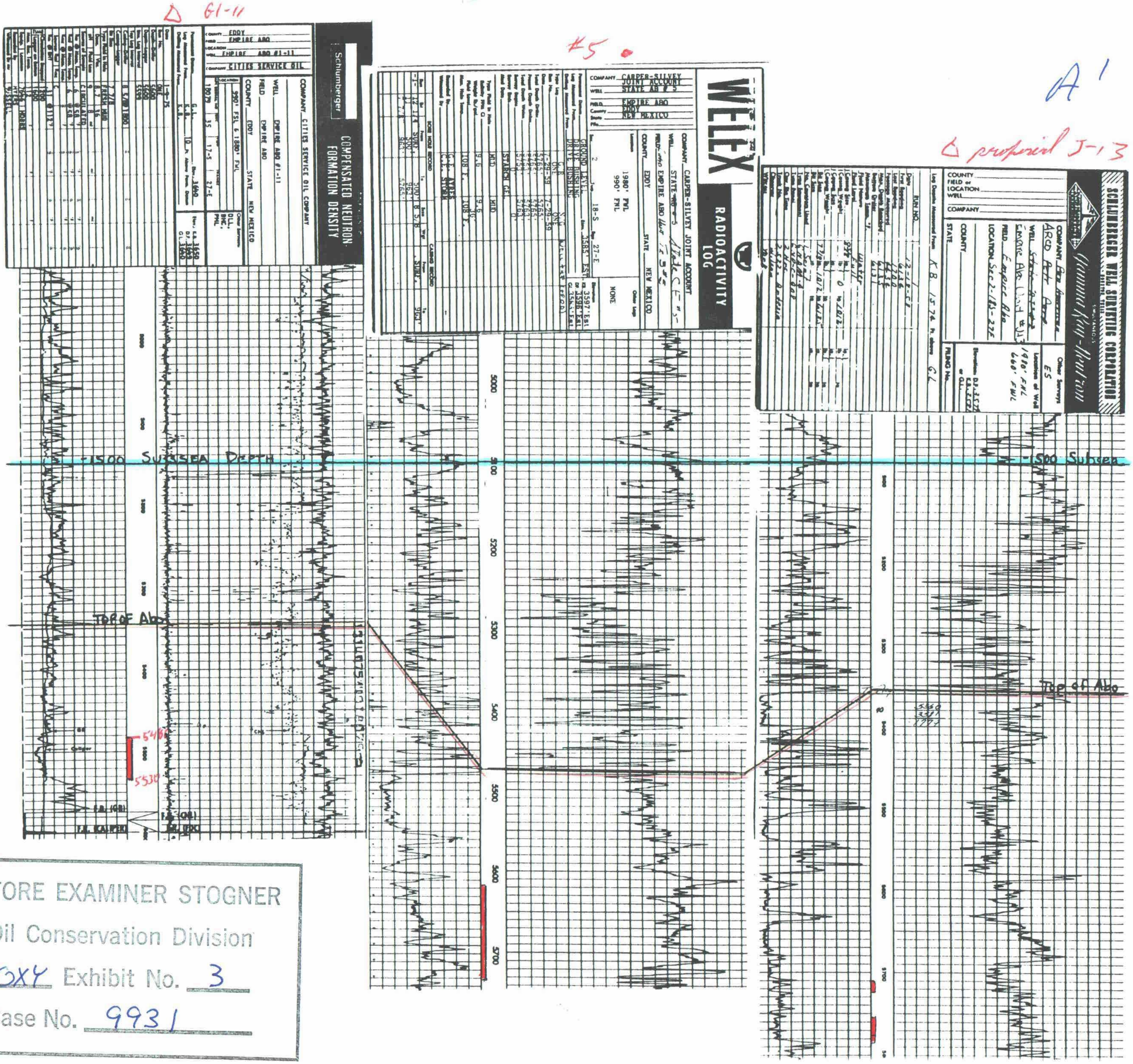
● INACTIVE PRODUCING WELL

BEFORE EXAMINER STOGNER
Oil Conservation Division
OXY Exhibit No. 2
Case No. 9931

3/4 of 1% of ARCO's Unit.

EMPIRE ABO FIELD
EDDY CO., NEW MEXICO
WELL STATUS

SCALE: 1":1500' JUNE, 1990

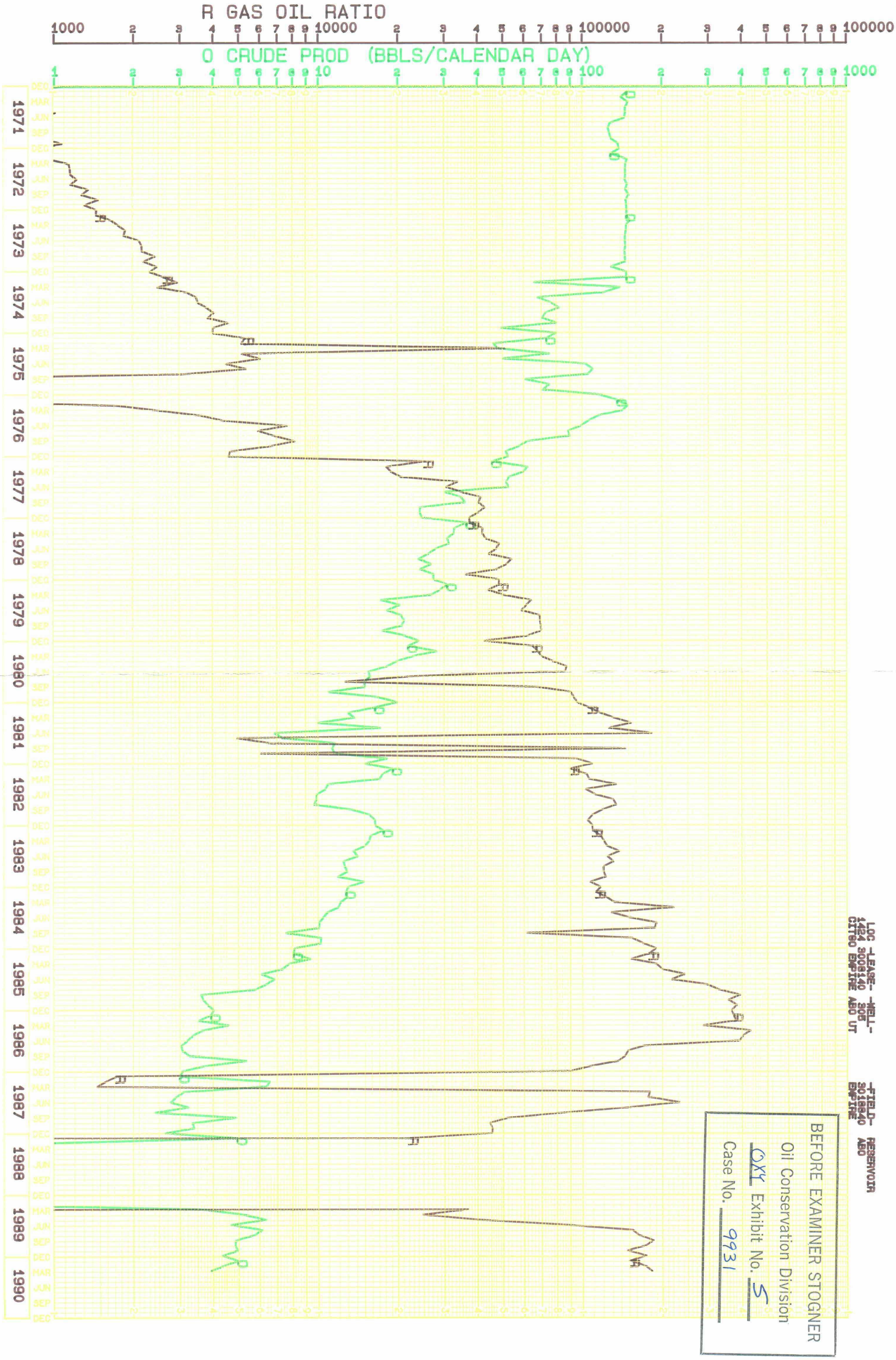


BEFORE EXAMINER STOGNER

Oil Conservation Division

OXY Exhibit No. 3

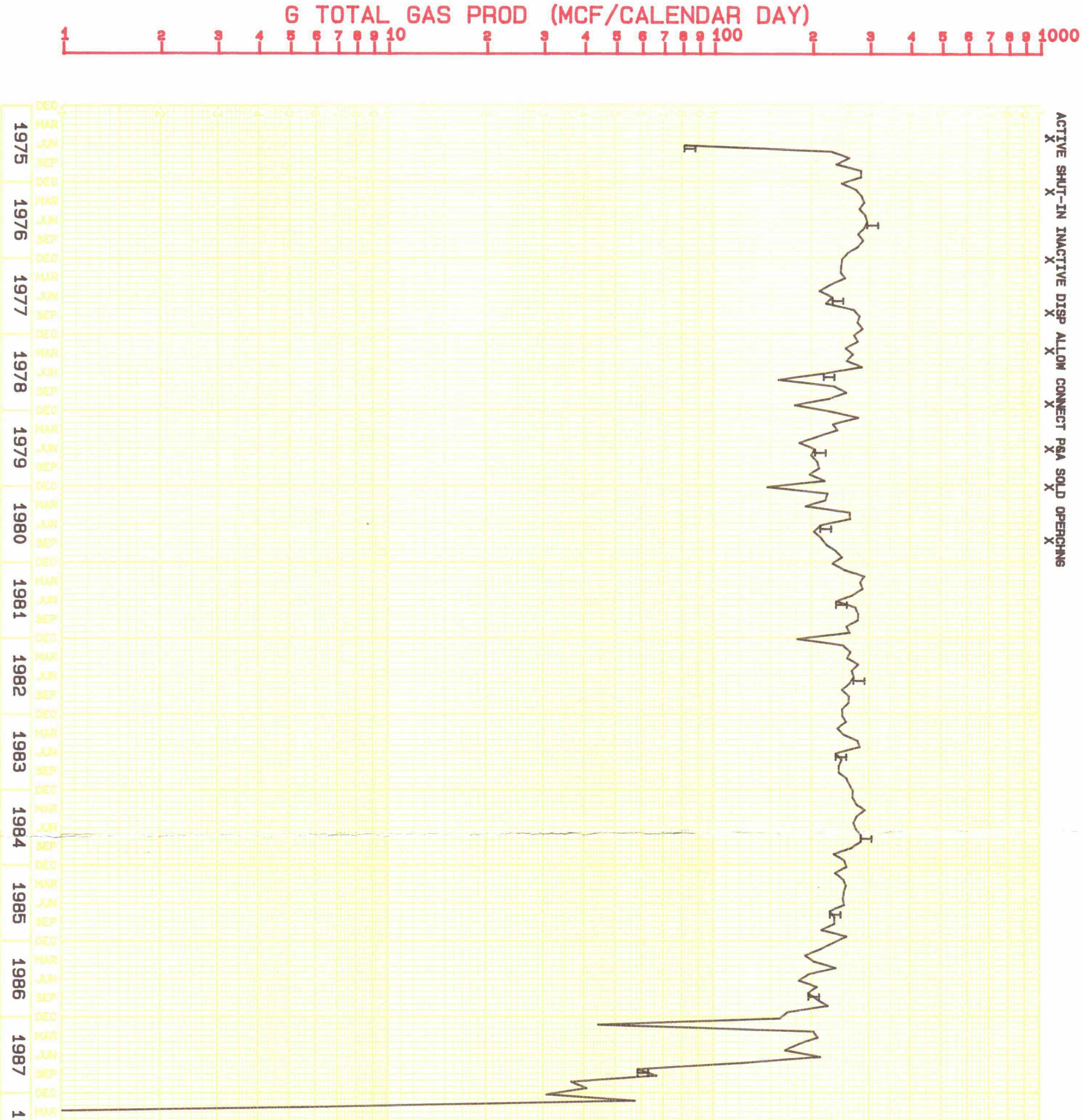
Case No. 9931



LOC -LEASE- -WELL-
1424 3008140 305
CITGO EMPIRE ABO UT

-FIELD- RESERVOIR
3018840 ABO
EMPIRE

BEFORE EXAMINER STOGNER
Oil Conservation Division
OXY Exhibit No. 5
Case No. 9931



BEFORE EXAMINER STOGNER
Oil Conservation Division
OXY Exhibit No. 4
Case No. 9931

BEFORE EXAMINER STOGNER
Oil Conservation Division
OXY Exhibit No. 6
Case No. 9931

CITGO EMPIRE ABO UNIT

ECONOMIC IMPACT OF REDUCED OIL PRODUCTION

WELL #305

	OIL	GAS	GOR
MARCH 1990	122 BBL	23,036 MCF	188,020 CF/BBL
ESTIMATED OIL RATE ● 400,000 GOR	58 BBL	23,036 MCF	400,000 CF/BBL
LOSS	64 BBL		

ECONOMIC IMPACT 64 BBL/MONTH•$18.00/BBL ▪ $1,152/MONTH

ANNUALIZED LOSS $1,152 • 12 MONTHS ▪ $13,824/YEAR

smm 5/15/90

BEFORE EXAMINER STOGNER
Oil Conservation Division
OXY Exhibit No. 2
Case No. 9931

CITGO EMPIRE ABO UNIT

ANALYSIS OF NATURAL GAS LIQUID PRODUCTION

NGL YIELDS

	GALLONS/MCF
NOVEMBER 1986	2.187
AUGUST 1988	2.564
JANUARY 1990	3.135

NGL YIELDS HAVE INCREASED 43% SINCE 11-86

**IF YIELDS RETURN TO 11-86 LEVELS WITH
OFFSET INJECTION, OXY WILL LOSE 30%
OF CURRENT NGL PRODUCTION
[2.187/3.135 = 70%]**

smm 5/14/90

BEFORE EXAMINER STOGNER
Oil Conservation Division
OXY Exhibit No. 8
Case No. 9931

CITGO EMPIRE ABO UNIT

ECONOMIC IMPACT OF REDUCED NGL PRODUCTION

	NGL VOLUME	NGL VALUE
CURRENT YIELD	92,200 GAL	$20,695
NOV. 1986 YIELD (70% OF CURRENT)	64,540 GAL	$14,485
LOSS	27,660 GAL	$ 6,210

ANNUALIZED LOSS $6210 X 12 MONTHS = $74,520

NOTE: NGL SALES REPRESENT 31% OF TOTAL GAS VALUE.
BASIS: MARCH 1990 SALES VOLUMES FROM PHILLIPS GAS STATEMENT

smm 5/14/90

BEFORE EXAMINER STOGNER
Oil Conservation Division
OXY Exhibit No. 9
Case No. 9931

BLOWDOWN EVALUATION
EMPIRE ABO UNIT
ABO RESERVOIR
EDDY COUNTY, NEW MEXICO
January, 1985

by
Timothy J. Detmering
ARCO Oil and Gas Company
Midland, Texas

ARCO Oil and Gas Company
Permian District
Post Office Box 1610
Midland, Texas 79702
Telephone 915 684 0149

Joe R. Hastings
District Engineer — West

April 3, 1984

WORKING INTEREST OWNERS
EMPIRE ABO UNIT

Gentlemen:

The following report documents our analysis of blowdown timing for the Empire Abo Unit. It is our recommendation, based on the information presented, that residue gas injection be continued to the year 1995. Basis for this recommendation is the optimizing of energy recovery and the maximizing of undiscounted cash flow. This recommendation does not, however, preclude reservoir blowdown at an earlier date should changes in market conditions and/or reservoir performance deem it more economical to do so. If you have any questions about any of the information presented in this report, please feel free to give me a call at (915)684-0149 or contact David Douglas at (915)684-0163.

Yours very truly,

Joe R. Hastings

Joe R. Hastings

JRH:sc
Att.

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TABLE OF CONTENTS

TABLES AND FIGURES

APPENDIXES

SUMMARY

SUMMARY

Recovery of energy from the Empire Abo Unit will be maximized by initiating residue gas sales in 1995. As a result of maximizing energy recovery, the working and royalty interest owners of the Empire Abo Unit will maximize their undiscounted net income. The impact of blowdown is summarized in Table 1, on page 2.

TABLE 1. Evaluation of Blowdown Timing Based on Constant Operating and Overhead Costs, and Constant Product Prices.

Blowdown Start Date	Unit Oil Reserves After 1/85 (MSTB)	Unit NGL Reserves After 1/85 (MSTB)	Unit Gas Reserves After 1/85[1] (MMSCF)	Undiscounted Net Income BFIT (MM$)	Gross Energy Recovery (Trill. BTU)
1/85	7415	4527	82641	361	251
1/90	11350	5369	69244	399	268
1/95	13929	6292	52153	410	274
1/03	15663	7951	21406	357	264

Table 2. Prices, Tax Rates, and Costs Used in Economic Calculations.

Oil Prices	
Tier 1:	$30.00/BBL, Base Price: $19.00/BBL
Tier 2:	$30.00/BBL, Base Price: $22.00/BBL
Gas Price:	$2.90/MCF
NGL Prices	
Ethane:	$0.22/gal
Propane:	$0.35/gal
Butane:	$0.52/gal
Gasoline:	$0.63/gal
Production Tax Rates	
Severance Tax:	3.75%
Emergency School Tax:	3.15%
Ad Valorem Tax:	0.18%
Windfall Profits Tax Rates	
Tier 1:	70%
Tier 2:	60%
Operating Costs	
With Gas Injection:	$7020M/year
Without Gas Injection:	$6468M/year
Overhead Costs:	$990M/year

---

[1] Storage gas owned by Gas Company of New Mexico has been deducted from the Unit gas reserves (3.7 BCF).

CONCLUSIONS AND RECOMMENDATION

CONCLUSIONS

1. Energy recovery, which is the sum of the heating values of the recovered oil, natural gas liquids (NGL), and residue gas, is maximized by starting blowdown in 1995.

2. Continued residue gas injection until 1995 will allow the Empire Abo Unit to take advantage of the gravity drainage mechanism of the Empire Abo reservoir. Thus, the Unit will recover more oil reserves than it would by starting blowdown in 1985. The additional recovery is the result of allowing the thin oil column in the back-reef area to migrate downdip to the fore-reef area where the oil column is thicker and the oil can be economically and efficiently produced.

3. Continued residue gas injection until 1995 also enables the Unit to recover additional NGL reserves. The additional recovery is the result of lean gas sweeping the free gas in the gas cap and lean gas stripping NGL's out of the oil remaining in the gas cap.

4. In order to realize increased oil and NGL recoveries it is necessary to use residue gas for fuel. Fuel use, combined with venting, causes residue gas recovery to decrease with continued gas injection.

5. The impact of blowdown on present worth is a function of the discount rate used in the economic calculations. Undiscounted economics favor starting blowdown in 1995. As higher and higher discount rates are applied to the cash flows, the optimum blowdown start date moves toward 1985. At a discount rate of 7 percent or more the optimum blowdown start date is 1985.

RECOMMENDATION

Based on undiscounted economics and prevention of waste it is recommended that the Empire Abo Unit continue to inject residue gas until 1995, at which time residue gas sales should begin.

INTRODUCTION

INTRODUCTION

This study was initiated to determine when residue gas sales should begin at the Empire Abo Unit. Currently, residue gas is injected into the gas cap to increase recoveries of oil and NGL's. Residue gas is a saleable product and the Unit is foregoing income from residue gas sales to realize more income from oil and NGL sales. Blowdown should begin when the value of the potential residue gas recovery exceeds the value of the oil and NGL recoveries that depend upon residue gas injection.

Two separate numeric simulation studies were conducted to analyze the impact of blowdown timing on oil, gas, and NGL rates and recoveries. ARCO's two-dimensional, multi-component simulator was used to predict the NGL content of the produced gas. This simulator is referred to as the compositional model in this report. ARCO's three-dimensional, three phase simulator was used to predict oil and gas production rates and recoveries. This simulator is referred to as the black oil model in this report.

Both models were required to analyze blowdown timing because of limitations inherent in each. The compositional model is specifically designed to calculate recoveries of individual reservoir fluid components. Thus, the compositional model can predict rates and recoveries of the NGL components - ethane, propane, butane, and gasoline. However, the complexity of the compositional model precludes the use of gas coning correlations. Because of the significant impact of gas coning on oil rates and recoveries at Empire Abo, gas coning correlations are necessary to accurately forecast oil production. Therefore, the black oil model, which includes gas coning correlations, was run to predict accurate oil rates and recoveries.

Gas production is accurately predicted by both simulators. The forecast calculated by the black oil model was used as a matter of convenience.

The setup and design of the compositional model is discussed in reference 4. The black oil model is discussed in reference 3 and Appendix A. Appendix C contains the results of the black oil model history match including plots comparing calculated versus actual well performances.

FIELD HISTORY
AND GEOLOGY

FIELD HISTORY AND GEOLOGY

History

The Empire Abo Field is located approximately 8 miles southeast of Artesia, in Eddy County, New Mexico. Development of the Abo reservoir began with the drilling of Amoco's Malco "A" No. 1 (Unit designation M-14) in November 1957. Drilling was rapid and extensive following this successful completion. The productive Abo reservoir in this field consists of 11,339 acres located in portions of Township 17 South, Ranges 27, 28, and 29 East, and Township 18 South, Ranges 27 and 28 East (Figure 1).

Approximately 97 percent of the reservoir was unitized into the ARCO operated Empire Abo Unit in October 1973 (Ref. 2). The intent of the unitization was to conserve reservoir energy by producing from the low GOR wells, thus minimizing free gas production. In this way the Unit has taken better advantage of the gravity drainage mechanism and has increased ultimate oil and NGL recoveries as compared to competitive, primary depletion.

An engineering study conducted in 1975 indicated ultimate oil recovery would be improved by selective infill drilling on 20 acre spacing. A subsequent study conducted in 1977 concluded further increases in oil recovery would result from selective infill drilling on 10 acre spacing (Ref. 3). A total of 160 infill wells were drilled as a result of these studies.

A voidage limit of 56,912 RVBPD was established by the New Mexico Oil Conservation Commission for the Empire Abo Unit to ensure controlled depletion of the reservoir. An engineering study completed in 1983 indicated removing this voidage limit, and replacing it with a gas production limit of 65 MMCFPD, would enable the Unit to operate more efficiently and recover additional oil and NGL reserves (Ref. 1). The gas production limit went into effect in May 1984.

Field performance is shown in Figure 2. Basic reservoir data is listed in Table 3.

Geology

The Empire Abo field produces from a transgressive, carbonate, barrier reef buildup of lower Leonardian (Permian) age. This reef is one of several in a long trend flanking the northern edge of the Delaware Basin. The reef grew from southwest to northeast. It is approximately 12½ miles long and 1½ miles wide. Parallel to the reef trend, the reef dips 1 degree from southwest to northeast. Perpendicular to this trend the reef dips sharply at 10 to 20 degrees from crest to fore-reef, or north to south. The average depth of the reef is 5800 feet and the thickness averages 300 feet.

The trapping mechanism at Empire Abo is both stratigraphic and structural. The reef dips below the oil water contact to the south and east. Permeability pinch outs to the north and west occur as a result of carbonate muds, green shales, and anhydrite inclusions.

Porosity development is erratic and cannot be correlated between wells. Development is the result of leaching of abundant detrital fossil fragments, dolomitization, and recrystallization. The most prolific porosity development is found in the reef core. There is no apparent intercrystalline porosity.

Vertical fracturing, which contributes to the gravity drainage mechanism of the reservoir, is apparently due to local slumping as well as large scale settling and some tectonic activity. Fracture orientation is generally 0 to 45 degrees from vertical and is parallel to the reef trend. These fractures apparently link up the erratic porosity development and provide excellent pressure communication in the reservoir.

Table 3. Empire Abo Unit Reservoir Data Summary.

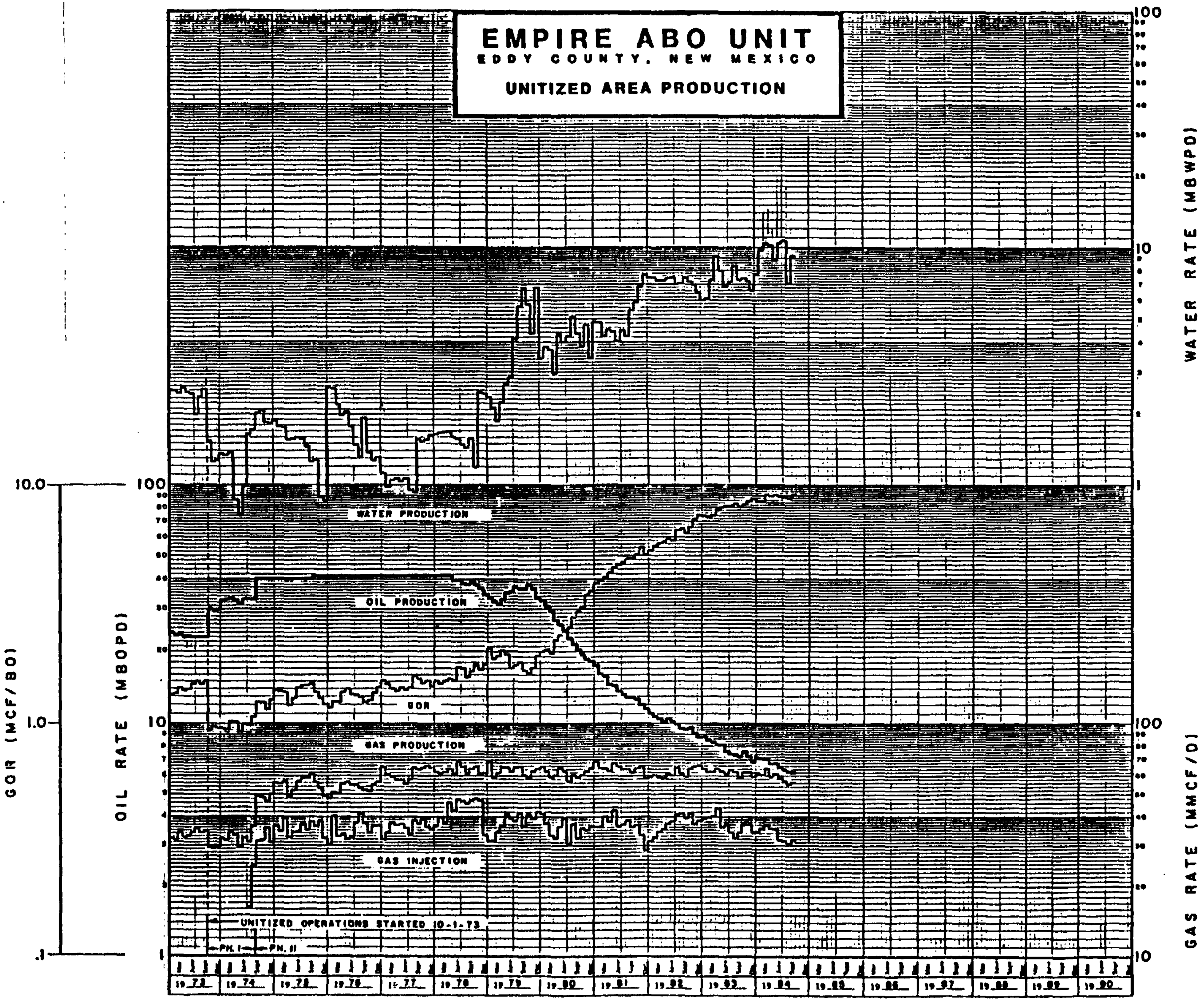
General	
Discovery	November 1957
Well Status - October 1984	
Producers	228
Injectors	21
Shut-In	146
Current Status - October 1984	
Unit Allowable (BOPD)	6533
Oil Production (BOPD)	6373
Gas Production (MCFD)	61599
Producing GOR (CF/BO)	9665
Gas Injection (MCFD)	31699
Water Production (BWPD)	7761
Average Depth to Top of Reef, Feet	5767
Productive Acres	8993
Formation	
Type Rock	Vugular Dolomite
Average Net Pay Thickness, Feet	183
Average Porosity, % (Log Data)	6.4
Water Saturation, %, Main Reef	8.6
Original Gas Oil Contact, Feet Subsea	-1750
Original Water Oil Contact, Feet Subsea	-2665
Reservoir Mid-point, Feet Subsea	-2264
Reservoir Fluid	
Original Reservoir Pressure, psi at -2264 (Pi)	2359
Original Bubble Point Pressure, psia at -2264 (Pbpi)	2231
Oil Formation Volume Factor at Pbpi, RVB/STB (Boi)	1.606
Gas Formation Volume Factor at Pbpi, RVB/SCF (Bgi)	0.00098
Gas in Solution at Pbpi, SCF/STBO (Rsi)	1250
Oil Viscosity at Pbpi, centipoise (μoi)	0.387
Reservoir Volumetric Data	
Original Oil-in-Place (MMSTBO)	383.2
Original Gas-in-Place (BCF)	483.4
Estimated Ultimate Recoveries (Total Reservoir)	
Oil (MMSTBO)	224.7
(% of OOIP)	58.6
Gas (BCF)	465.8
(% of OGIP)	96.4

EMPIRE ABO UNIT

EDDY COUNTY, NEW MEXICO

FIGURE 1

FIGURE 2


EMPIRE ABO UNIT
EDDY COUNTY, NEW MEXICO
UNITIZED AREA PRODUCTION
WATER RATE (MBWPD)
GAS RATE (MMCF/D)
OIL RATE (MBOPD)
GOR (MCF/BO)
10.0
1.0
.1
100
10
1
WATER PRODUCTION
OIL PRODUCTION
GOR
GAS PRODUCTION
GAS INJECTION
UNITIZED OPERATIONS STARTED 10-1-73
PH. I
PH. II
19 73
19 74
19 75
19 76
19 77
19 78
19 79
19 80
19 81
19 82
19 83
19 84
19 85
19 86
19 87
19 88
19 89
19 90

PERFORMANCE PROJECTIONS

PERFORMANCE PROJECTIONS

Projections were calculated for starting blowdown at 1/1/85, 1/1/90, 1/1/95, and at the economic limit of gas injection - 1/1/03. Computer time limitations prohibited calculating forecasts for starting blowdown at every year between 1/1/85 and 1/1/03. However, the recoveries of residue gas, NGL's, and oil appear to be continuous functions of blowdown timing (Figures 3 through 5). Therefore, recoveries for blowdown start dates other than 1/1/85, 1/1/90, 1/1/95, and 1/1/03 can be approximated by linear interpolation with no significant error.

As illustrated in Figures 3 through 5, starting blowdown immediately recovers the most residue gas and the least oil and NGL's. For every year that blowdown is delayed, residue gas recovery decreases, and oil and NGL recoveries increase. The curves labeled "Unit" in Figures 3 through 5 reflect a net oil interest of 87.5 percent, a net NGL interest of 21.875 percent, and a net residue gas interest of 65.625 percent.

Starting blowdown in 1985 yields the highest residue gas recovery because fuel use is lowest for this case. The injection compressors are shut down immediately and the lives of the extraction plants are as short as possible.

NGL recovery increases with delayed blowdown because the injected lean gas strips more NGL's out of the oil in the gas cap and sweeps out more enriched gas.

Oil recovery increases with delayed blowdown because the reservoir pressure decline is slowed. Slower pressure decline has three effects: one, incrementally higher pressure differentials between the reservoir and the wellbores; two, lower oil viscosities; three, more oil migration from the back-reef, where the oil column is too thin to be produced, to the fore-reef, where the oil column is thicker and can be economically and efficiently produced. A more thorough explanation of the impact of blowdown on oil rates and reserves is found in Appendix B.

In order to compare the value of the residue gas lost to the value of the oil and NGL's gained by continued gas injection, it is useful to examine the energy recovery for each blowdown case studied. Energy recovery is calculated by multiplying the heating value of each product by its recovery. Thus, instead of making a comparison of BBLS of oil to MCF of gas, a comparison of BTU's of oil to BTU's of gas is made. This calculation determines which blowdown timing will recover the most energy and therefore minimize waste. This is an important criterion not only for the Unit but also for the State and Federal regulatory bodies that oversee the Unit's operations.

Of the four cases simulated, starting blowdown in 1995 recovers the most energy (Figure 6). It is possible that starting blowdown either shortly before or shortly after 1995 will actually recover more energy than starting blowdown exactly in 1995. However, Figure 6 indicates that 1995 is a good approximation of the optimum blowdown start date in terms of energy recovery. Continuing to inject residue gas after 1995 would provide incremental recoveries of oil and NGL's as compared to starting blowdown in 1995. However, the energy expended through fuel use would be greater than the incremental energy recovered as oil and NGL's.

Complete projections of field performance are illustrated in Figures 7 through 10. A summary of the energy recoveries is found in Appendix D.

FIGURE 3

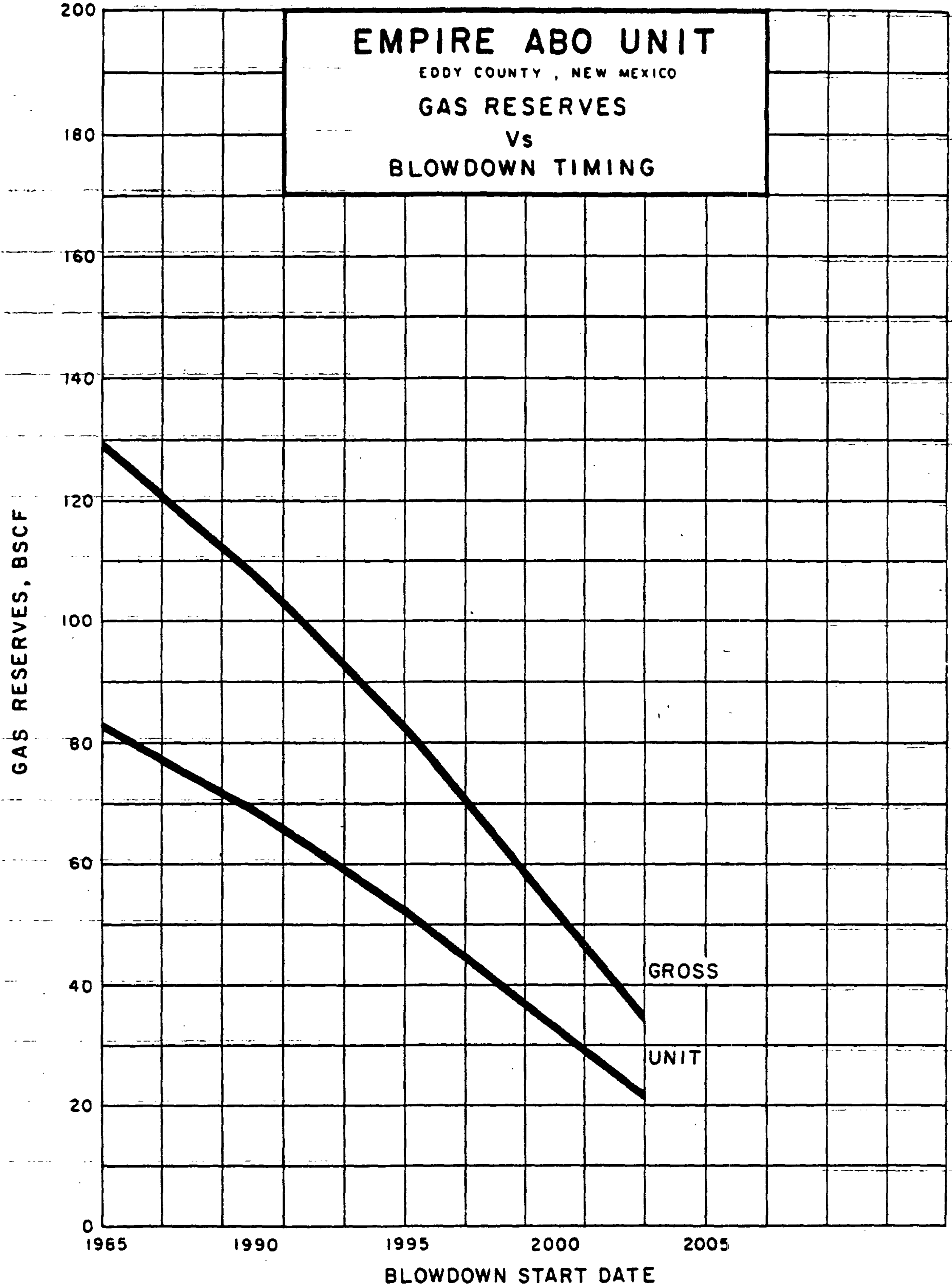

EMPIRE ABO UNIT
EDDY COUNTY , NEW MEXICO
GAS RESERVES
Vs
BLOWDOWN TIMING
GAS RESERVES, BSCF
200
180
160
140
120
100
80
60
40
20
0
1965
1990
1995
2000
2005
BLOWDOWN START DATE
GROSS
UNIT

FIGURE 4

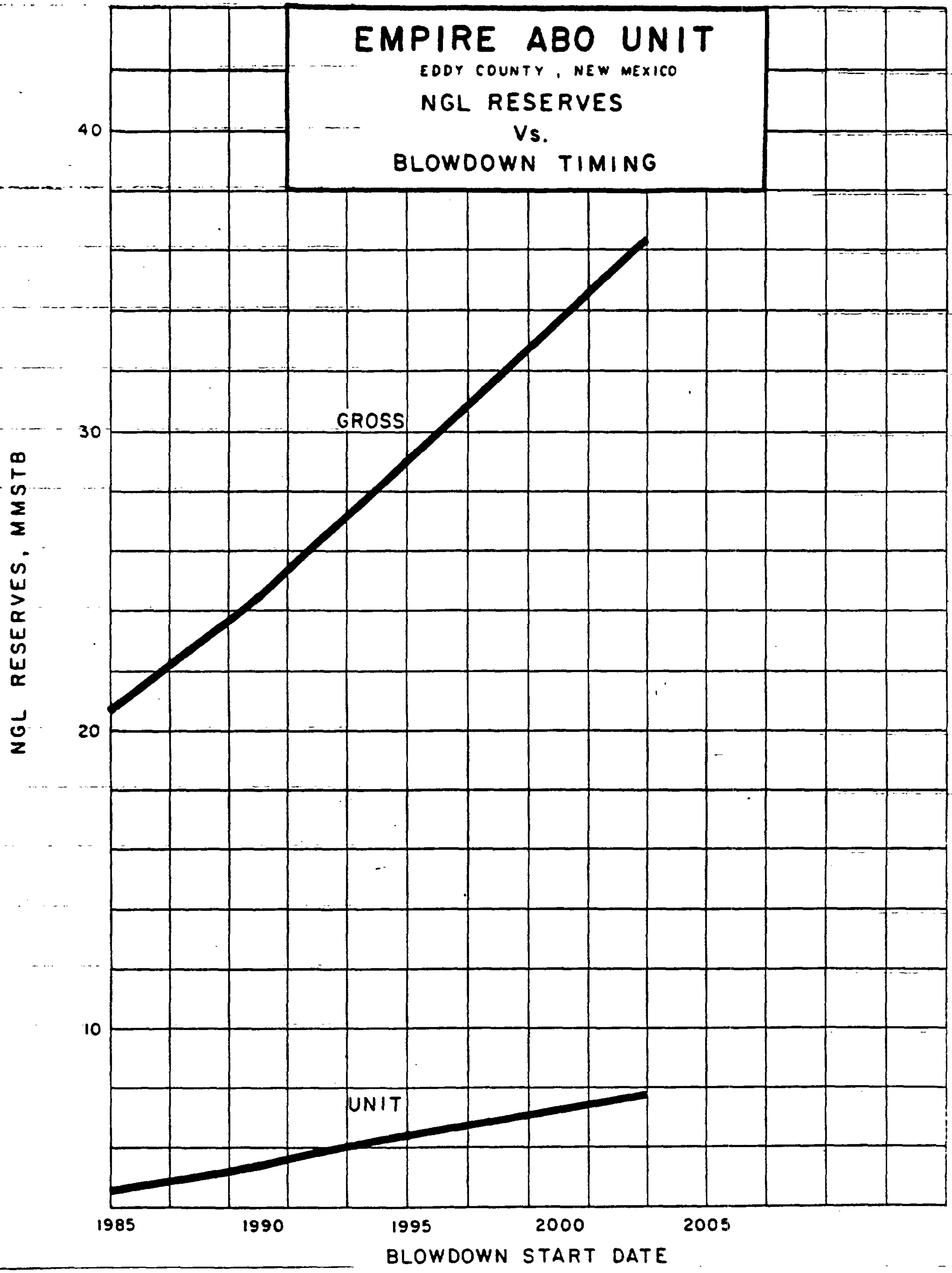

EMPIRE ABO UNIT
EDDY COUNTY , NEW MEXICO
NGL RESERVES
Vs.
BLOWDOWN TIMING
NGL RESERVES, MMSTB
40
30
20
10
GROSS
UNIT
1985
1990
1995
2000
2005
BLOWDOWN START DATE

FIGURE 5

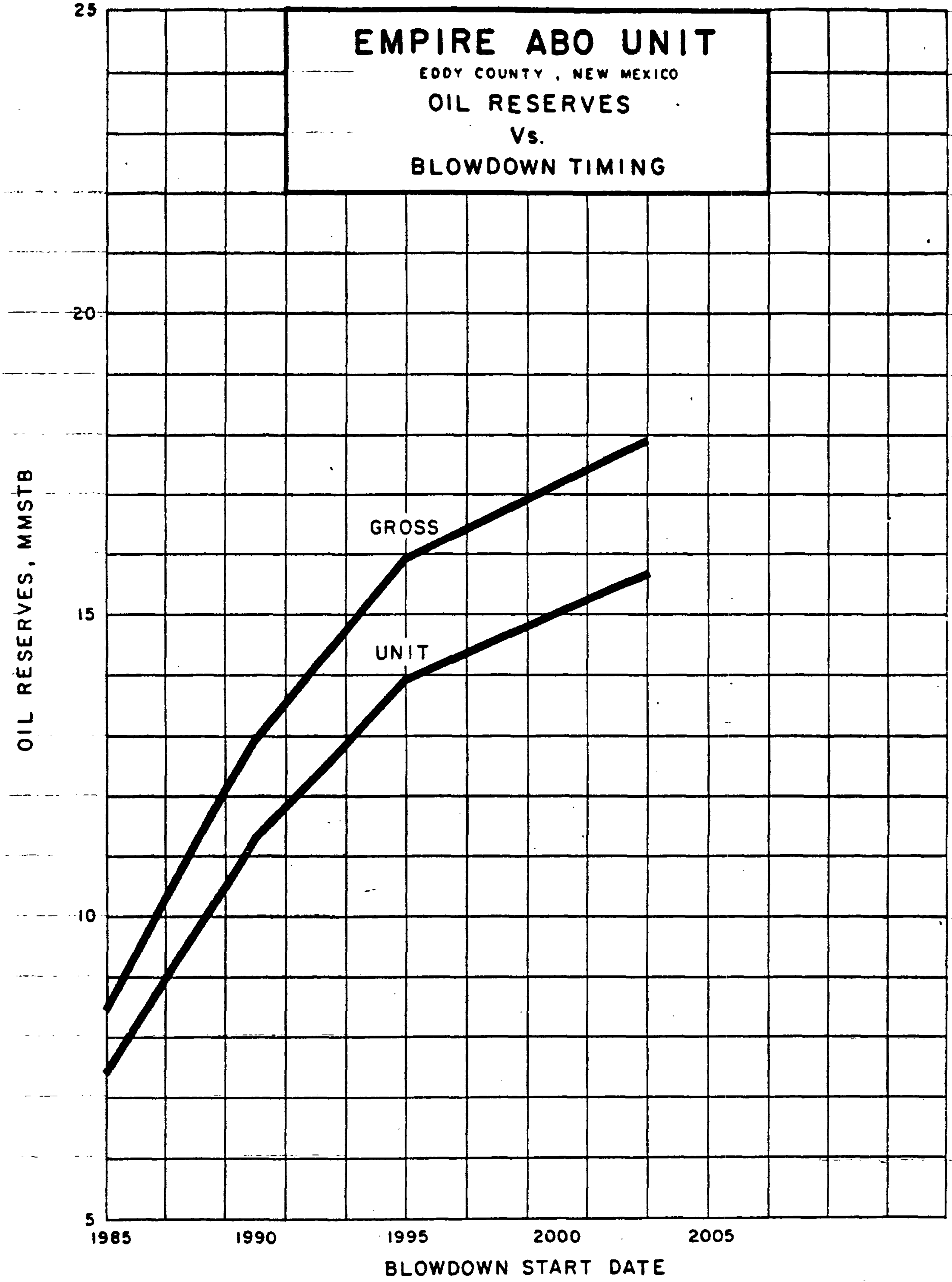

EMPIRE ABO UNIT
EDDY COUNTY , NEW MEXICO
OIL RESERVES
Vs.
BLOWDOWN TIMING
GROSS
UNIT
OIL RESERVES, MMSTB
25
20
15
10
5
1985
1990
1995
2000
2005
BLOWDOWN START DATE

FIGURE 6

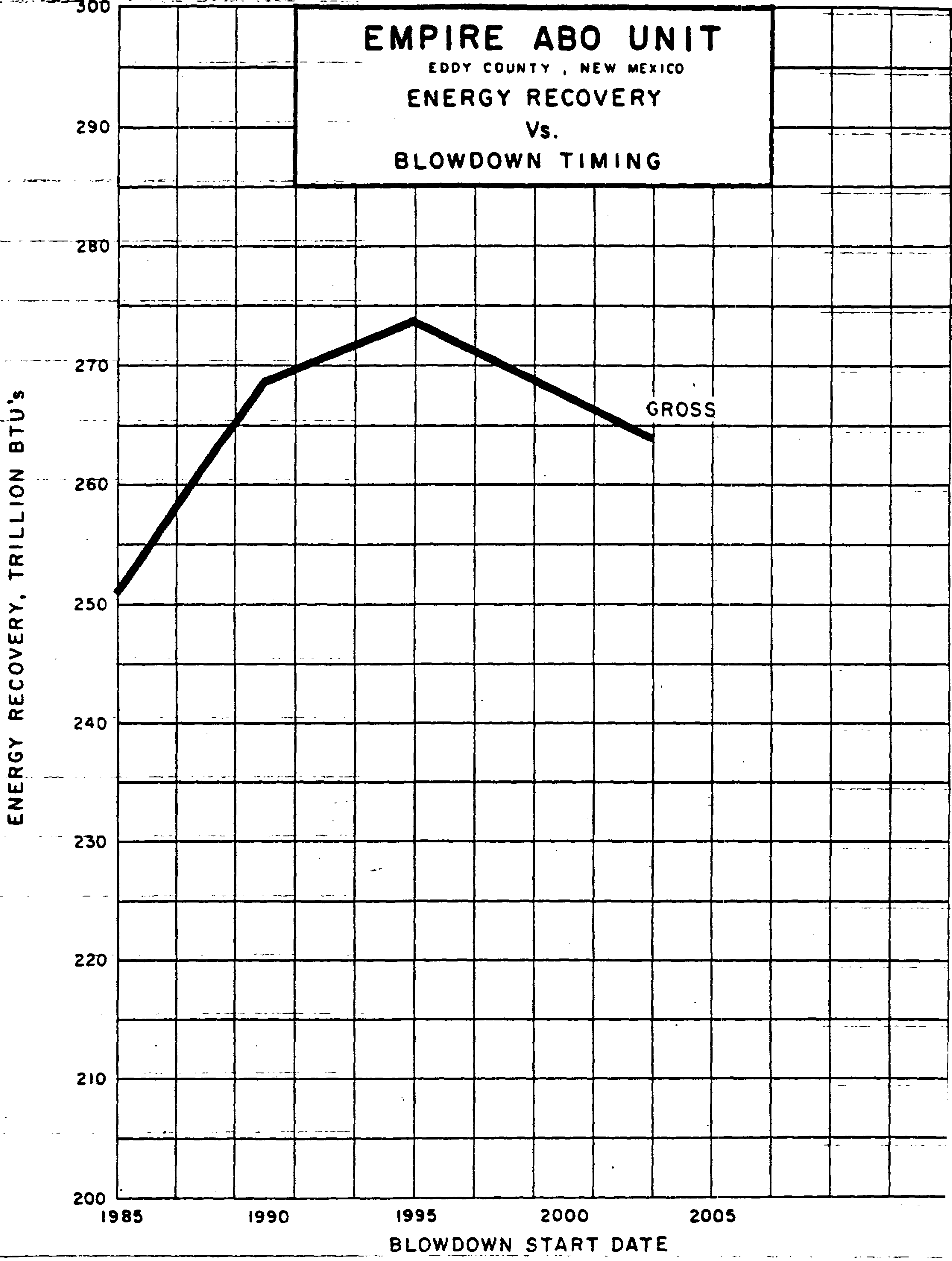

EMPIRE ABO UNIT
EDDY COUNTY , NEW MEXICO
ENERGY RECOVERY
Vs.
BLOWDOWN TIMING
GROSS
ENERGY RECOVERY, TRILLION BTU's
300
290
280
270
260
250
240
230
220
210
200
1985
1990
1995
2000
2005
BLOWDOWN START DATE

FIGURE 7

EMPIRE ABO UNIT

EDDY COUNTY, NEW MEXICO

PREDICTED RESERVOIR PERFORMANCE FOR BLOWDOWN AT 1-1-85

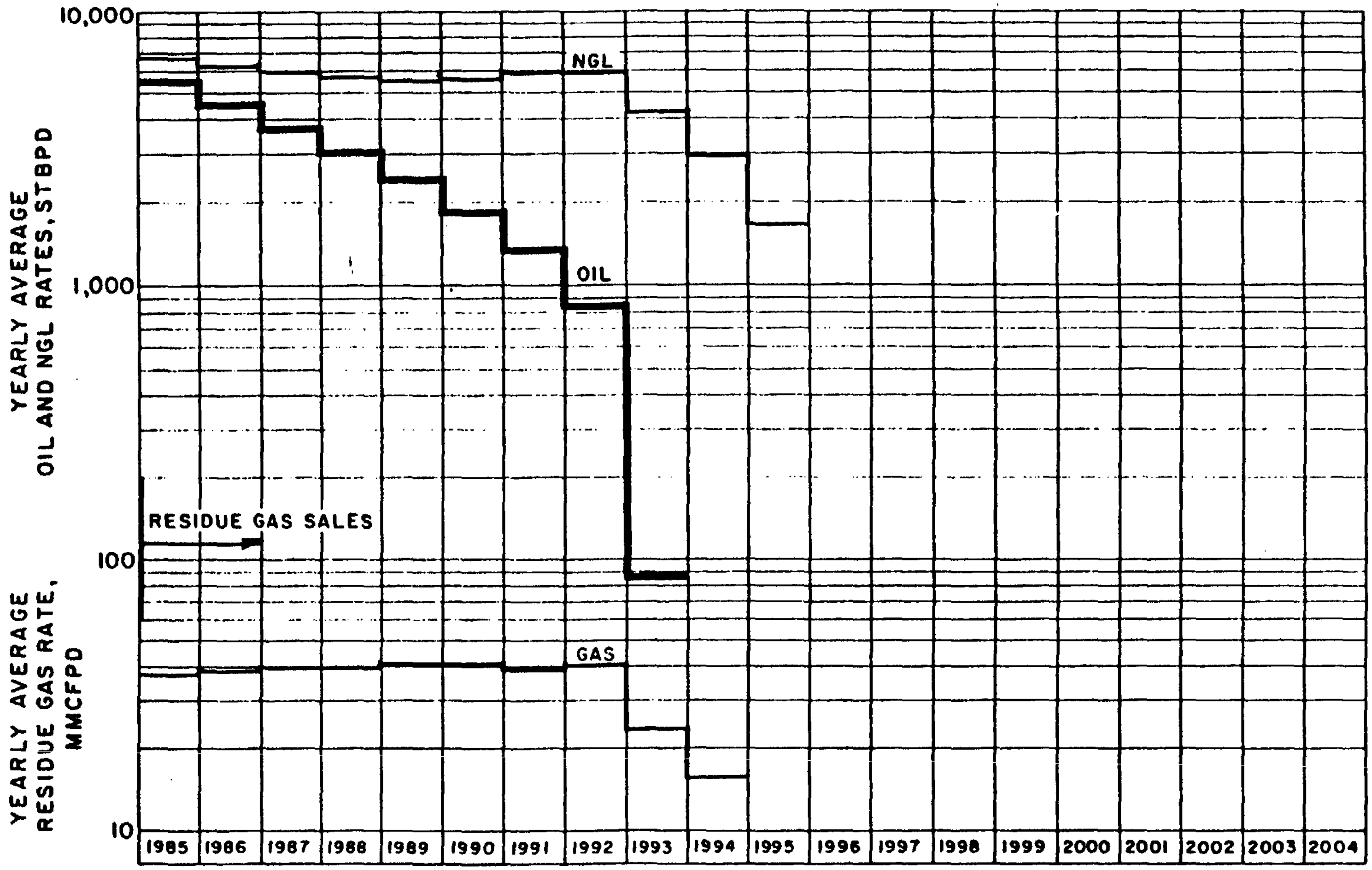


FIGURE 8

EMPIRE ABO UNIT

EDDY COUNTY, NEW MEXICO

PREDICTED RESERVOIR PERFORMANCE FOR BLOWDOWN AT 1-1-90

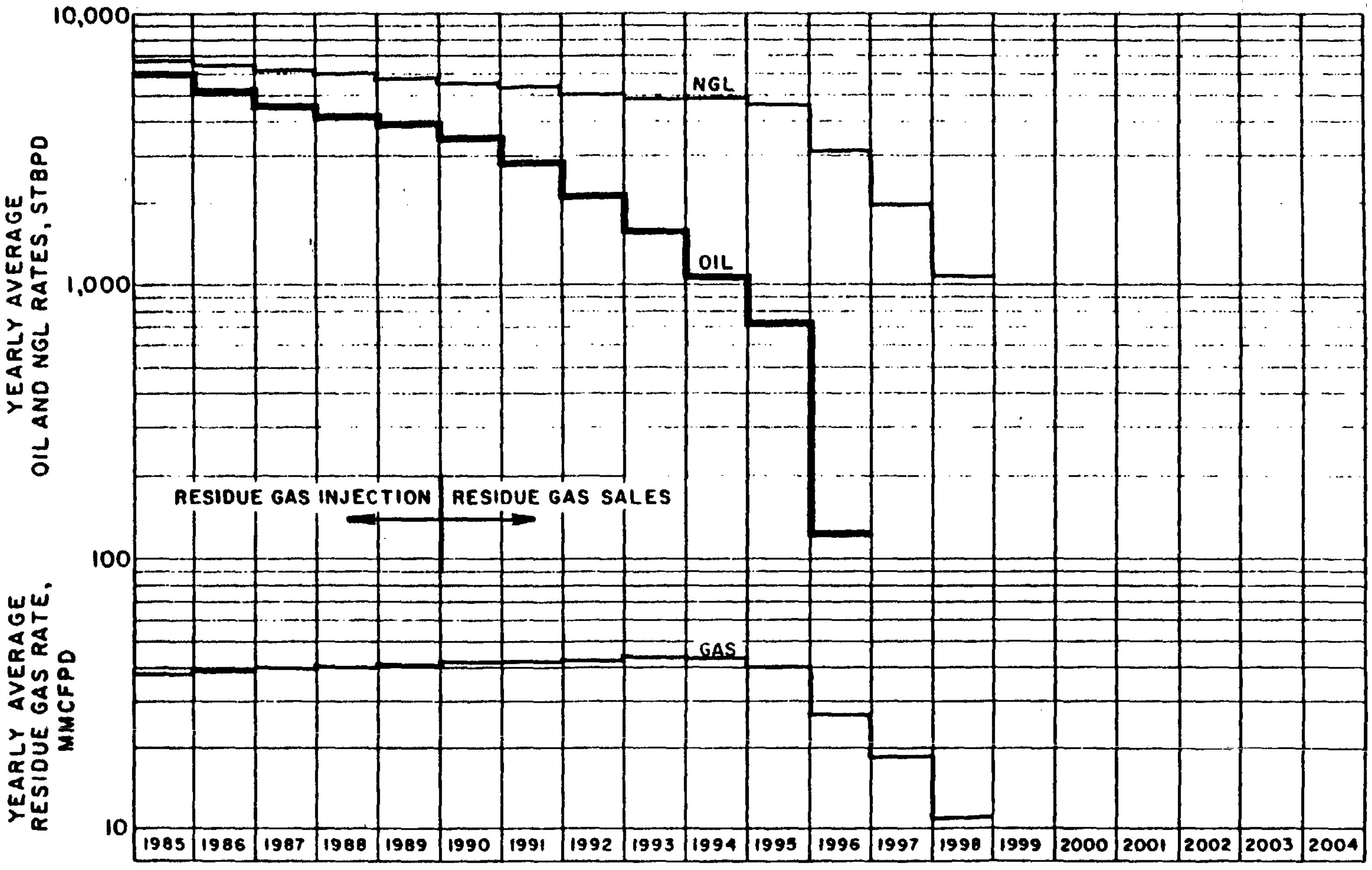


FIGURE 9

EMPIRE ABO UNIT

EDDY COUNTY, NEW MEXICO

PREDICTED RESERVOIR PERFORMANCE FOR BLOWDOWN AT 1-1-95

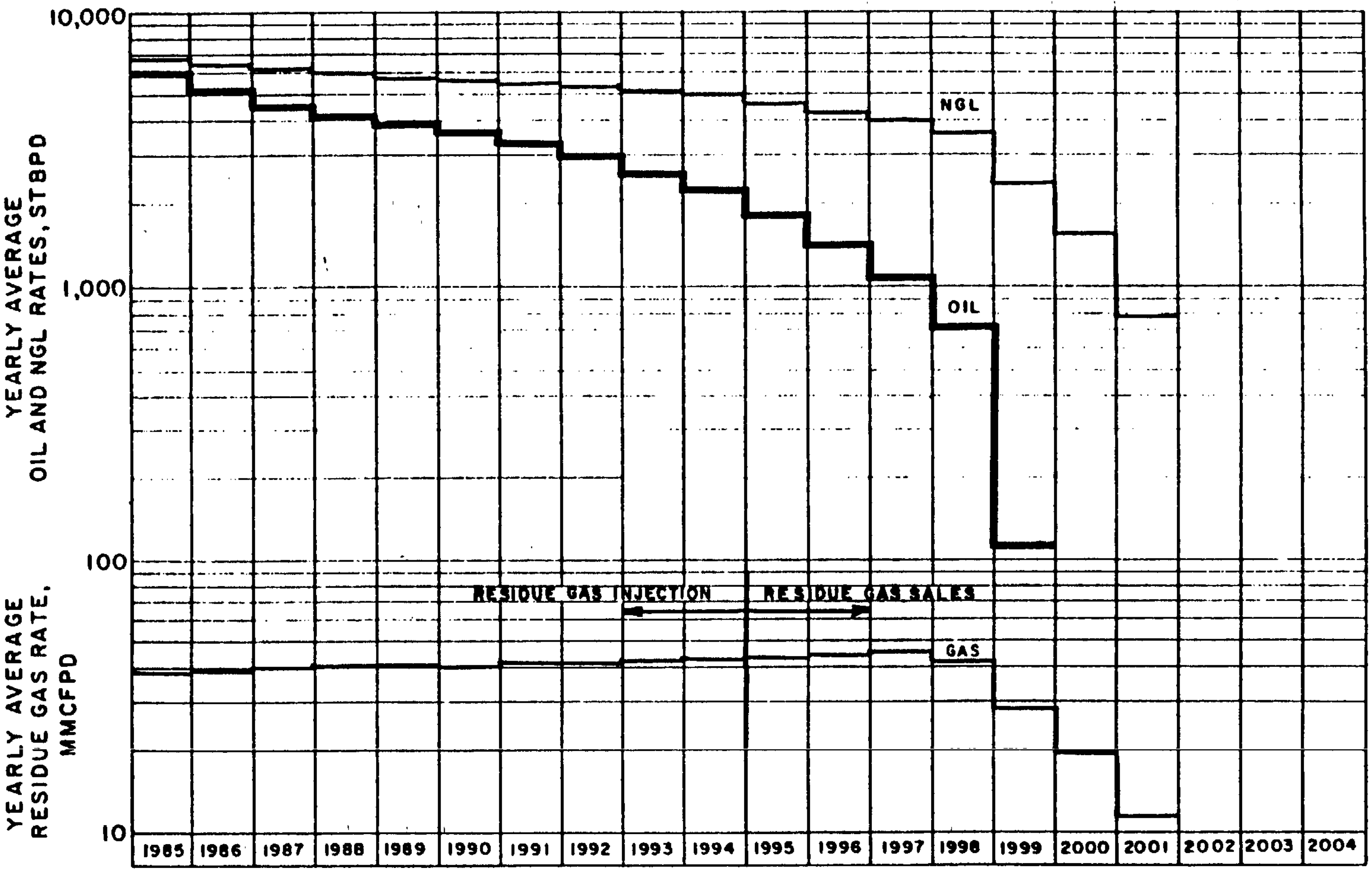
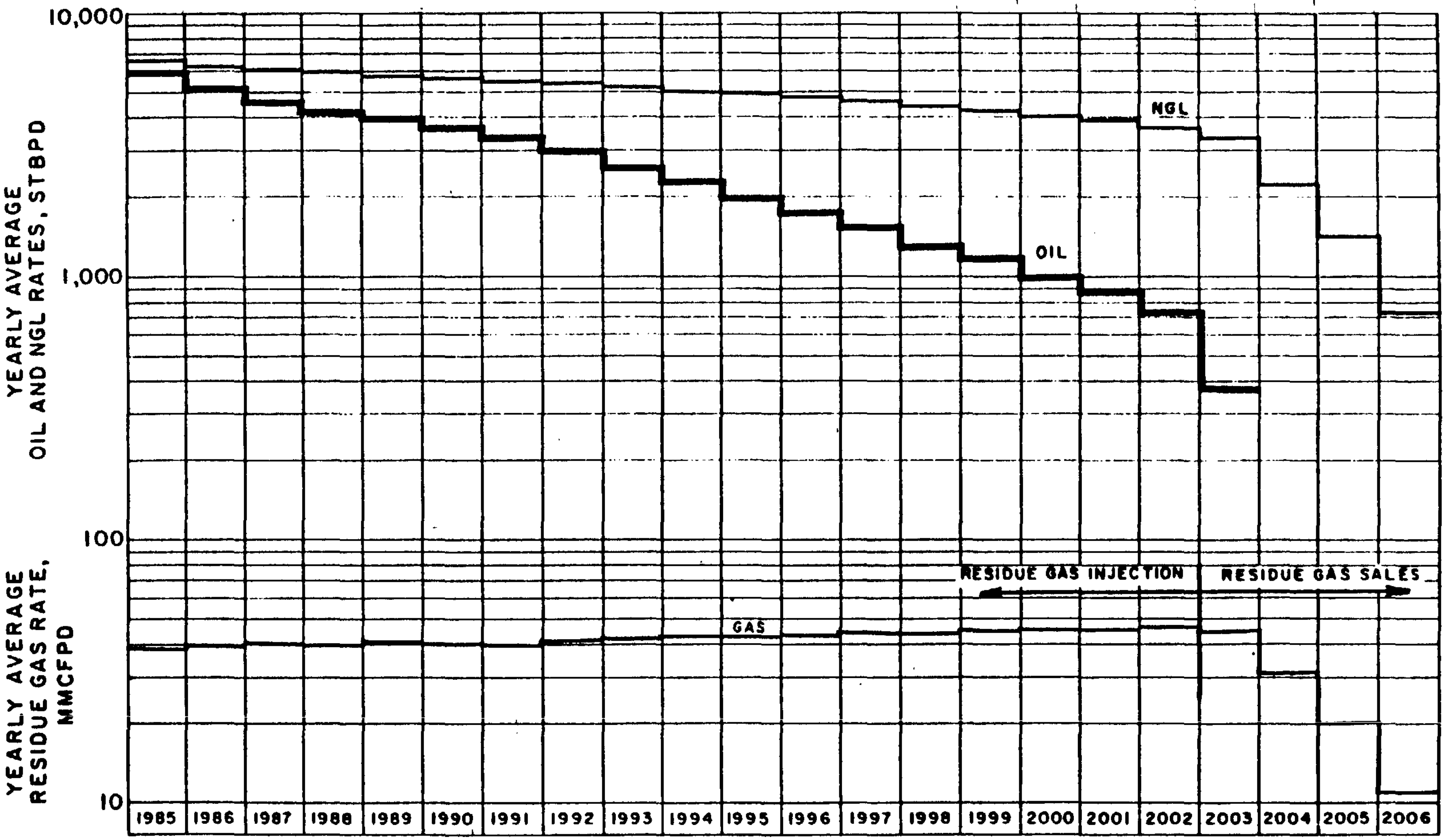


FIGURE 10

EMPIRE ABO UNIT

EDDY COUNTY, NEW MEXICO

PREDICTED RESERVOIR PERFORMANCE FOR BLOWDOWN AT 1-1-03



ECONOMIC EVALUATION

ECONOMIC EVALUATION

As shown in Figure 11, the economics of blowdown depend upon the discount rate used in the calculations. This is to be expected since starting blowdown immediately would increase short-term income, and therefore would be advantageous at high discount rates, whereas delaying blowdown would increase long-term income, and therefore would be advantageous at low discount rates. The recommendation to start blowdown in 1995 is based on undiscounted economics and prevention of waste.

The BFIT economics were calculated assuming a 100 percent working interest, an 87.5 percent net oil interest, a 62.625 percent net gas interest, and a 21.875 percent net NGL interest. The present worth reference date is 1-1-85. A summary of the impact of blowdown timing is presented in Table 4. Table 5 lists the prices, tax rates, and costs used in the economic calculations. Detailed summaries of the economics are found on pages 21 though 24.

Gas Storage

The Unit and the Gas Company of New Mexico (GCONM) have an agreement whereby the Unit stores gas for GCONM. The return rate to GCONM is limited to 65 percent of the residue gas sales rate. It was assumed in the economic calculations that GCONM will take their gas back at the maximum permissible rate. The returnable gas volume was approximately 3.7 BCF in December 1984.

TABLE 4. Evaluation of Blowdown Timing Based on Constant Operating and Overhead Costs, and Constant Product Prices.

Blowdown Start Date	Unit Oil Reserves After 1/85 (MSTB)	Unit NGL Reserves After 1/85 (MSTB)	Unit Gas Reserves After 1/85[1] (MMSCF)	Undiscounted Net Income BFIT (MM$)	Gross Energy Recovery (Trill. BTU)
1/85	7415	4527	82641	361	251
1/90	11350	5369	69244	399	268
1/95	13929	6292	52153	410	274
1/03	15663	7951	21406	357	264

Table 5. Prices, Tax Rates, and Costs Used in Economic Calculations.

Oil Prices
- Tier 1: $30.00/BBL, Base Price: $19.00/BBL
- Tier 2: $30.00/BBL, Base Price: $22.00/BBL

Gas Price: $2.90/MCF

NGL Prices
- Ethane: $0.22/gal
- Propane: $0.35/gal
- Butane: $0.52/gal
- Gasoline: $0.63/gal

Production Tax Rates
- Severance Tax: 3.75%
- Emergency School Tax: 3.15%
- Ad Valorem Tax: 0.18%

Windfall Profits Tax Rates
- Tier 1: 70%
- Tier 2: 60%

Operating Costs
- With Gas Injection: $7020M/year
- Without Gas Injection: $6468M/year

Overhead Costs: $990M/year

---

[1] Storage gas owned by Gas Company of New Mexico has been deducted from the Unit gas reserves (3.7 BCF).

FIGURE 11

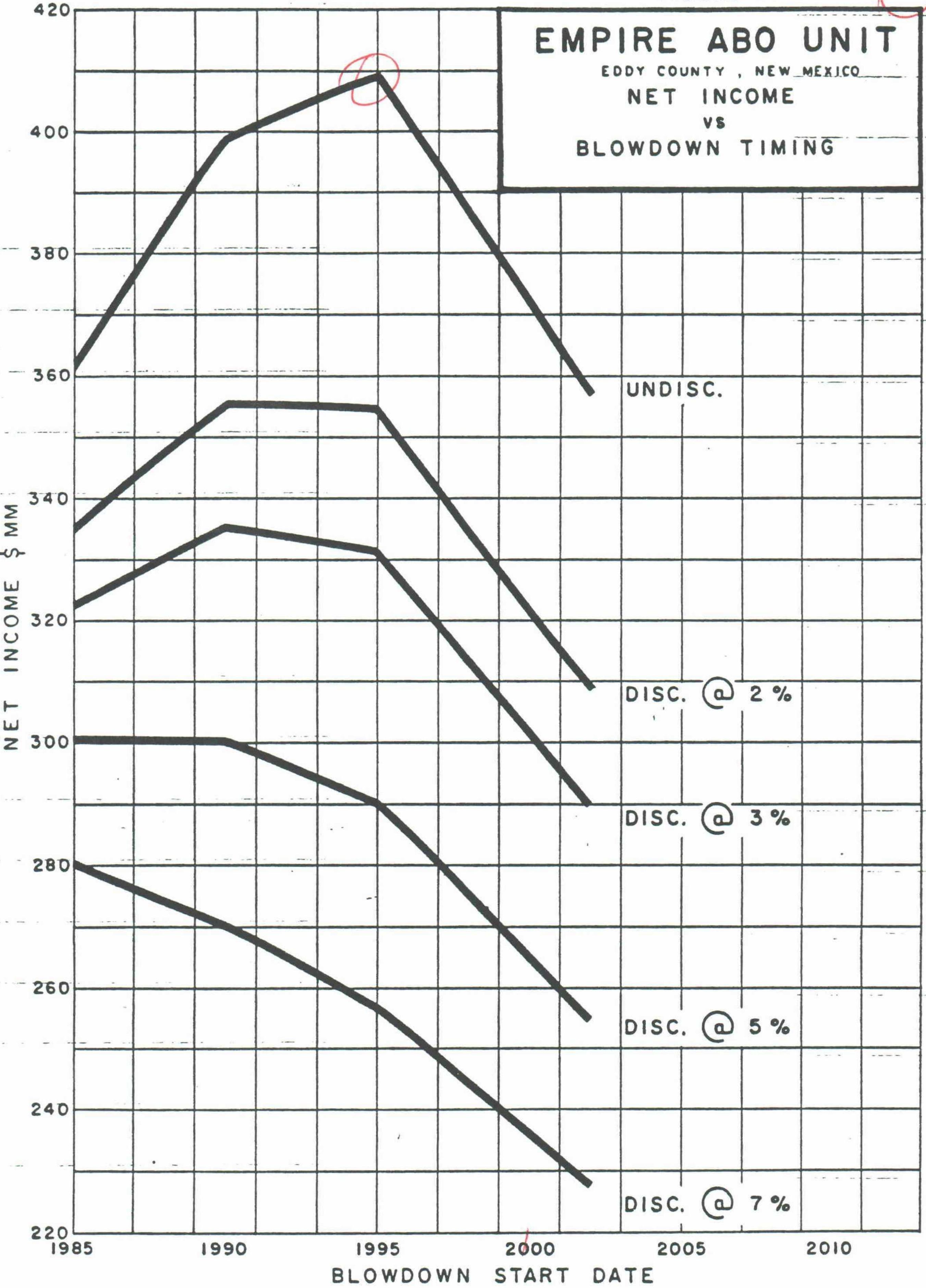

EMPIRE ABO UNIT
EDDY COUNTY , NEW MEXICO
NET INCOME
VS
BLOWDOWN TIMING
NET INCOME $MM
420
400
380
360
340
320
300
280
260
240
220
1985
1990
1995
2000
2005
2010
BLOWDOWN START DATE
UNDISC.
DISC. @ 2 %
DISC. @ 3 %
DISC. @ 5 %
DISC. @ 7 %

TABLE 6

EMPIRE ABO UNIT
BLOWDOWN AT 1/1/1985
Detail of Economic Calculations

YEAR	GROSS OIL PRODUCTION (MSTB)	GROSS GAS PRODUCTION (MMCF)	GROSS GAS SALES[1] (MMCF)	GROSS NGL PRODUCTION (MSTB)	NET REVENUE (M$)	PRODUCTION TAXES (M$)	OVH & OPR COSTS (M$)	WINDFALL PROFITS TAX (M$)	BFIT CASH FLOW (M$)
1985	2026	23725	10034	2475	76741	5587	7458	12684	51013
1986	1632	23725	14235	2304	77506	5642	7458	10217	54189
1987	1340	23725	14472	2178	69832	5084	7458	8389	48901
1988	1104	23725	14710	2085	63731	4640	7458	6912	44722
1989	878	23725	14947	2046	58053	4226	7458	3427	42942
1990	675	23725	14710	2072	52285	3806	7458	2634	38386
1991	484	23662	14434	2168	46970	3419	7458	1521	34572
1992	304	21965	12959	2159	39324	2863	7458	528	28475
1993	31	14746	8553	1539	21795	1587	7458	12	12739
1994		9965	5680	1076	14052	1023	7458		5571
1995		5522	3148	595	7757	565	7458		-266
	8474		127938	20697	528045	38442	82038	46324	361243

---

1. Storage gas owned by Gas Company of New Mexico has been deducted from gross gas sales (3.7 BCF)

TABLE 7

EMPIRE ABO UNIT
BLOWDOWN AT 1/1/1990
Detail of Economic Calculations

YEAR	GROSS OIL PRODUCTION (MSTB)	GROSS GAS PRODUCTION (MMCF)	GROSS GAS SALES[1] (MMCF)	GROSS NGL PRODUCTION (MSTB)	NET REVENUE (M$)	PRODUCTION TAXES (M$)	OVH & OPR COSTS (M$)	WINDFALL PROFITS TAX (M$)	BFIT CASH FLOW (M$)
1985	2150	23725		2451	64547	4699	8010	13460	38378
1986	1869	23725		2341	56798	4135	8010	11701	32952
1987	1666	23725		2244	51132	3722	8010	10430	28970
1988	1531	23725		2169	47355	3447	8010	9591	26307
1989	1430	23725		2107	44461	3237	8010	8953	24261
1990	1261	23725	11220	1996	57225	4166	7458	7895	37707
1991	1025	23725	15184	1909	61944	4510	7458	5166	44811
1992	777	23725	15421	1833	55575	4046	7458	1349	42722
1993	574	23725	15659	1785	50461	3674	7458	218	39111
1994	383	23477	15459	1773	45027	3278	7458		34291
1995	259	22057	14337	1685	39226	2856	7458		28912
1996	45	14808	9625	1123	22866	1665	7458		13744
1997		10026	6617	732	14736	1073	7458		6205
1998		5836	3910	397	8570	624	7458		488
	12970		107468	24545	619923	45130	107172	68763	398858

---

1. Storage gas owned by Gas Company of New Mexico has been deducted from gross gas sales (3.7 BCF)

TABLE 8

EMPIRE ABO UNIT
BLOWDOWN AT 1/1/1995
Detail of Economic Calculations

YEAR	GROSS OIL PRODUCTION (MSTB)	GROSS GAS PRODUCTION (MMCF)	GROSS GAS SALES[1] (MMCF)	GROSS NGL PRODUCTION (MSTB)	NET REVENUE (M$)	PRODUCTION TAXES (M$)	OVH & OPR COSTS (M$)	WINDFALL PROFITS TAX (M$)	BFIT CASH FLOW (M$)
1985	2150	23725		2451	64547	4699	8010	13460	38378
1986	1869	23725		2341	56798	4135	8010	11701	32952
1987	1666	23725		2244	51132	3722	8010	10430	28970
1988	1531	23725		2169	47355	3447	8010	9591	26307
1989	1430	23725		2107	44461	3237	8010	8953	24261
1990	1328	23725		2050	41589	3028	8010	8314	22237
1991	1216	23725		2001	38479	2801	8010	6128	21540
1992	1080	23725		1953	34740	2529	8010	3009	21192
1993	946	23725		1900	31026	2259	8010	360	20397
1994	822	23725		1844	27573	2007	8010		17556
1995	664	23725	12169	1690	42310	3080	7458		31771
1996	518	23725	16183	1556	49243	3585	7458		38200
1997	394	23725	16370	1459	46059	3353	7458		35248
1998	259	21872	15310	1307	39940	2908	7458		29575
1999	45	14684	10279	854	23304	1697	7458		14150
2000		9934	7053	551	15034	1095	7458		6482
2001		5707	4109	287	8626	628	7458		540
	15918		81473	28764	662215	48209	132306	71946	409755

---

1. Storage gas owned by Gas Company of New Mexico has been deducted from gross gas sales (3.7 BCF)

TABLE 9

EMPIRE ABO UNIT
BLOWDOWN AT 1/1/2003
Detail of Economic Calculations

YEAR	GROSS OIL PRODUCTION (MSTB)	GROSS GAS PRODUCTION (MMCF)	GROSS GAS SALES[1] (MMCF)	GROSS NGL PRODUCTION (MSTB)	NET REVENUE (M$)	PRODUCTION TAXES (M$)	OVH & OPR COSTS (M$)	WINDFALL PROFITS TAX (M$)	BFIT CASH FLOW (M$)
1985	2150	23725		2451	64547	4699	8010	13460	38378
1986	1869	23725		2341	56798	4135	8010	11701	32952
1987	1666	23725		2244	51132	3722	8010	10430	28970
1988	1531	23225		2169	47355	3447	8010	9591	26307
1989	1430	23725		2107	44461	3237	8010	8953	24261
1990	1328	23725		2050	41589	3028	8010	8314	22237
1991	1216	23725		2001	38479	2801	8010	6128	21540
1992	1080	23725		1953	34740	2529	8010	3009	21192
1993	946	23725		1900	31026	2259	8010	360	20397
1994	822	23725		1844	27573	2007	8010		17556
1995	720	23725		1786	24689	1797	8010		14882
1996	631	23725		1721	22127	1611	8010		12506
1997	552	23725		1660	19848	1445	8010		10393
1998	473	23725		1594	17540	1277	8010		8253
1999	417	23725		1530	15850	1154	8010		6686
2000	360	23725		1467	14137	1029	8010		5098
2001	315	23725		1398	12729	927	8010		3792
2002	259	23725		1327	11027	803	8010		2214
2003	135	22582	12294	1209	27074	1971	7458		17645
2004		15424	11015	808	23529	1713	7458		14358
2005		10211	7361	579	15648	1139	7458		7050
2006		5399	3900	268	8261	601	7458		201
	17900		34570	36347	650155	47331	174012	71946	356867

---

[1] Storage gas owned by Gas Company of New Mexico has been deducted from gross gas sales (3.7 BCF)

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REFERENCES

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4. Shumbera, D.A., A Compositional Study of Proposed Alternatives for Future Operation of Empire Abo, ARCO Oil and Gas Company, Dallas, Texas, August 1982.
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APPENDIX A

APPENDIX A

Black Oil Numeric Simulator Description and Design

BLACK OIL NUMERIC SIMULATOR DESCRIPTION AND DESIGN

Modeled Area

A representative slice (Figures A1 and A2) of the reservoir was modeled as opposed to modeling the entire reservoir due to manpower and computer time limitations. This slice is representative of the entire field with the exception of the extreme east and west ends. The east end has experienced a considerable amount of water influx while the west end appears to be a solution gas drive reservoir rather than a gravity drainage reservoir. The combined volume of these two portions of the reservoir is less than 10 percent of the total reservoir volume.

H.P. Foster modeled this same slice in 1977 to study the impact of infill drilling. The success of Foster's model study, as illustrated by the close agreement of his oil forecast and actual production (Figure A3), demonstrates the results of the slice model can be scaled up to provide forecasts of the entire field's performance. Unfortunately, all of Foster's projections assumed blowdown in 1985 and therefore it was necessary to make additional simulator runs to study the impact of blowdown at later dates.

The numeric reservoir simulator used for the cross-sectional slice model is ARCO's three-dimensional, three phase, unsteady state, compressible flow, semi-implicit model. This black oil model numerically solves the partial differential equations which describe simultaneous oil, gas, and water flow between reservoir segments in three dimensions.

Model Set Up And Data Preparation

For the numeric model to accurately predict future performance, it must be set up dimensionally to properly reflect fluid movement in the reservoir. The cross-sectional slice model is 6 rows wide (east to west), 22 layers in the vertical direction, and 18 columns from back-reef to fore-reef as shown in Figure A4. The six rows are each 330 ft wide for a total width of 1980 ft. The outside rows are used to reflect well drainage areas. Each layer in the vertical direction is 25 ft thick. The third dimension of the cells, in the back-reef to fore-reef direction, varies from 370 ft to 600 ft. The smaller cells are used in the down dip heart of the reef to give adequate definition of flow characteristics during projections while the larger cells are used in areas where fluid movement is slower or relatively unimportant. The cells are aligned parallel to the dip of the reef base to eliminate artificial impediments to north-south fluid movements and to adequately determine how well the fluid migrates to the down dip areas under different schemes of operation. The wells shown in Figure A4 are the actual field wells within the modeled area.

Porosity values were obtained by applying porosity index curves (Figure A5) to open hole neutron logs. These values formed the basis for volume calculations for the numeric model. Core data analysis indicates porosity varies as the log of permeability (Figure A6). Using this relationship, permeability values for each two foot interval of each well were calculated from the porosity values. These values were the basis for porosity and permeability maps of each individual layer in the model. Computer programs were used for sorting this digitized data to obtain gross and net pay, average porosity, and permeability values for any grouping desired. Isopach maps were made of each layer to determine pore volumes and permeabilities for each of the 2376 cells in the model.

Interstitial water saturations were based on the 1970 numeric model simulation and checked by analysis of logs obtained during the 20 acre infill drilling program. Fluid data relationships (Figure A7 and A8) are from a composite of analyses from five different wells which were selected to give good coverage of the reservoir.

Reservoir pressure data in the area of the slice is very good. At least two wells, and sometimes more, were tested during each annual BHP survey giving an adequate pressure history for the area. Oil, gas, and water production data are also good. The New Mexico Oil Conservation Commission requires annual tests with well production reported by months.

The gas oil relative permeability data (Figure A9) is the same as that used in the 1970 numeric simulation of the entire field.

Gas Coning

Because of the gas coning characteristics of the Empire Abo reservoir it is desireable to include the effects of gas coning by individual wells. This is especially true during the latter part of the history match and during the projections as the wells are being produced at high total fluid rates.

Individual well performances are controlled in the three dimensional model by correlations derived from simulations of individual type-wells with a two dimensional, R-Z (radial-vertical), multi-phase, compressible flow simulator. Multiple projections were made at various reservoir producing rates to relate producing GOR to average oil saturation in the well cell columns. The characteristics of the R-Z Coning simulator closely approximate the column of cells for each well in the three dimensional simulator. These derived correlations were input into the slice model and used to control the performance of each well during its life (Figures A10-A12). The oil column height used in these correlations is analogous to the distance from the top of the perforated interval in the well cell column to the gas cap. It is based on the average oil saturation in this column.

One well, the G-21, was not controlled in the slice model with a coning correlation. It was fractured during its early life and appeared to have a gas channel in the cement. It was controlled by producing the required amount of gas from a cell in the gas cap to match its producing history. The G-21 is a last row, back-reef producer and was shut-in during all projections.

History Match

The history match obtained during the 1977 model study extended from 1959 to 1977. The seven years that have lapsed since this history match was completed had to be added in order to have the correct saturation and pressure distributions at the start of the forecasts. Furthermore, these seven years of additional history had to be added without changing the reservoir description so that the previous history match would not be altered. This was accomplished by adjusting only the coning correlations during the new history match period. Care was taken to ensure that these adjustments did not affect the producing wells prior to 1977.

As in the 1977 history matching process, oil rates were input and the simulator calculated water and gas production rates. The coning correlations were adjusted after each trial run of the simulator to obtain a match of gas production rates for each well. Five infill wells were drilled in the slice area between 1977 and 1984: J-221, J-222, J-233, J-234, and K-231. These were included in the history match.

The results of the history match, including plots comparing actual well performances versus calculated performances, are presented in Appendix C. The black oil simulator matched individual well gas production rates, water production rates, and average reservoir pressures from 1959 to 1984.

Forecasts

During the forecasting period the produced gas rate was limited to a field rate of 67 MMCFPD. This rate is the sum of the Unit allowable and the average rate of non-participating tracts in the field. Inflow performance analysis indicates this field rate will be maintained until the reservoir pressure is reduced to approximately 200 psi. Reinjection was set at 58 percent of the produced gas rate based on past performance of the gas plants and forecasts of reinjection volumes calculated by the compositional model. A bottom hole pressure limit of 200 psi was set for each well to control production at low reservoir pressures. This replaces the productivity index used by Foster in his forecasts and more closely simulates actual constraints on production caused by wellbore hydraulics and surface equipment.

Scale Up

Examination of Figure A13 leads to the conclusion that the slice is representative of the field but that its oil decline is not synchronous with the actual field decline. Higher voidage rates in the slice during the mid-70's apparently caused gas coning to occur earlier in the slice than in the rest of the field. As a result, the slice oil decline is leading the field by approximately 2 years. Therefore, the oil forecasts for starting blowdown in 1985, 1990, 1995, and 2003 were calculated by starting blowdown in the simulator in 1983, 1988, 1993, and 2001, respectively. These forecasts were scaled up based on the ratio of the hydrocarbon pore volumes of the slice and the field.

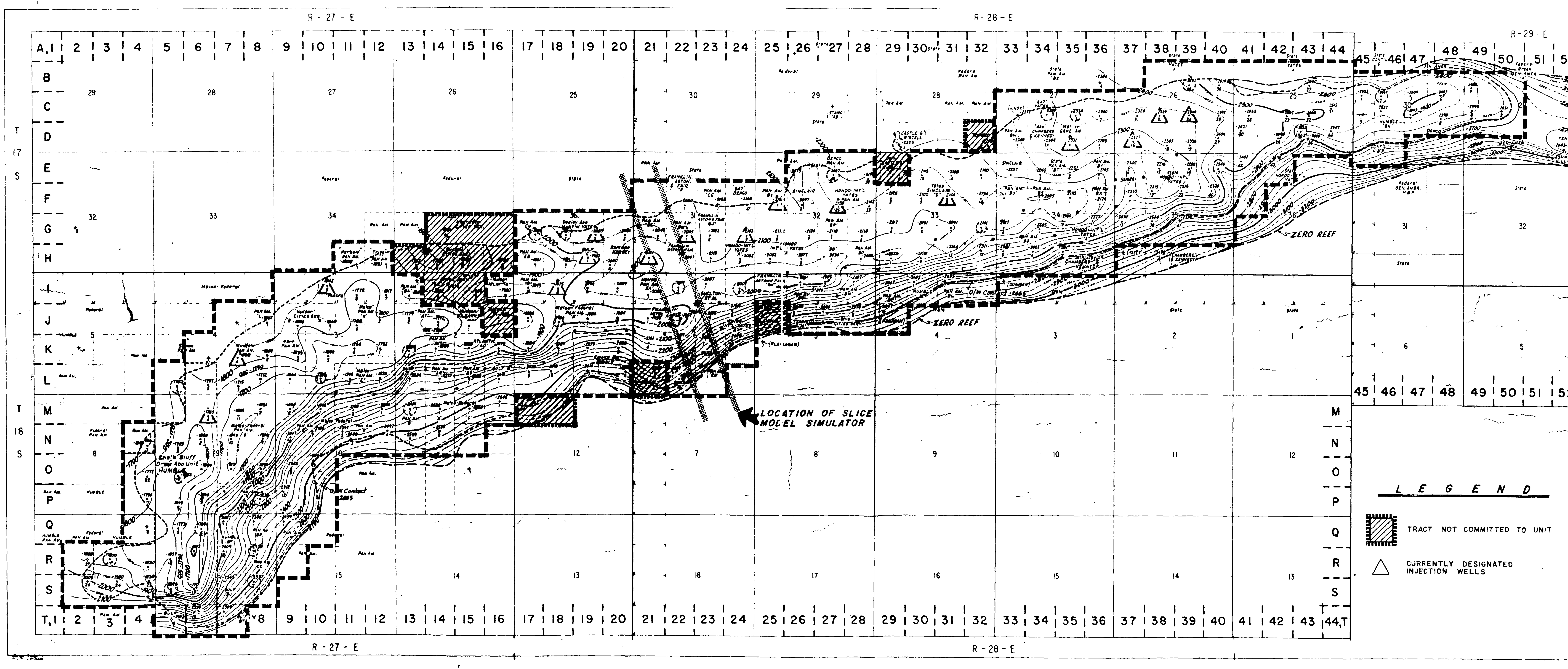


FIGURE A-1

AtlanticRichfieldCompany
North American Producing Division
Permian District Midland Texas

EMPIRE ABO POOL
TOP OF REEF
EDDY COUNTY, NEW MEXICO
C.I. = 50'

0 1/4 1/2 1-MI.

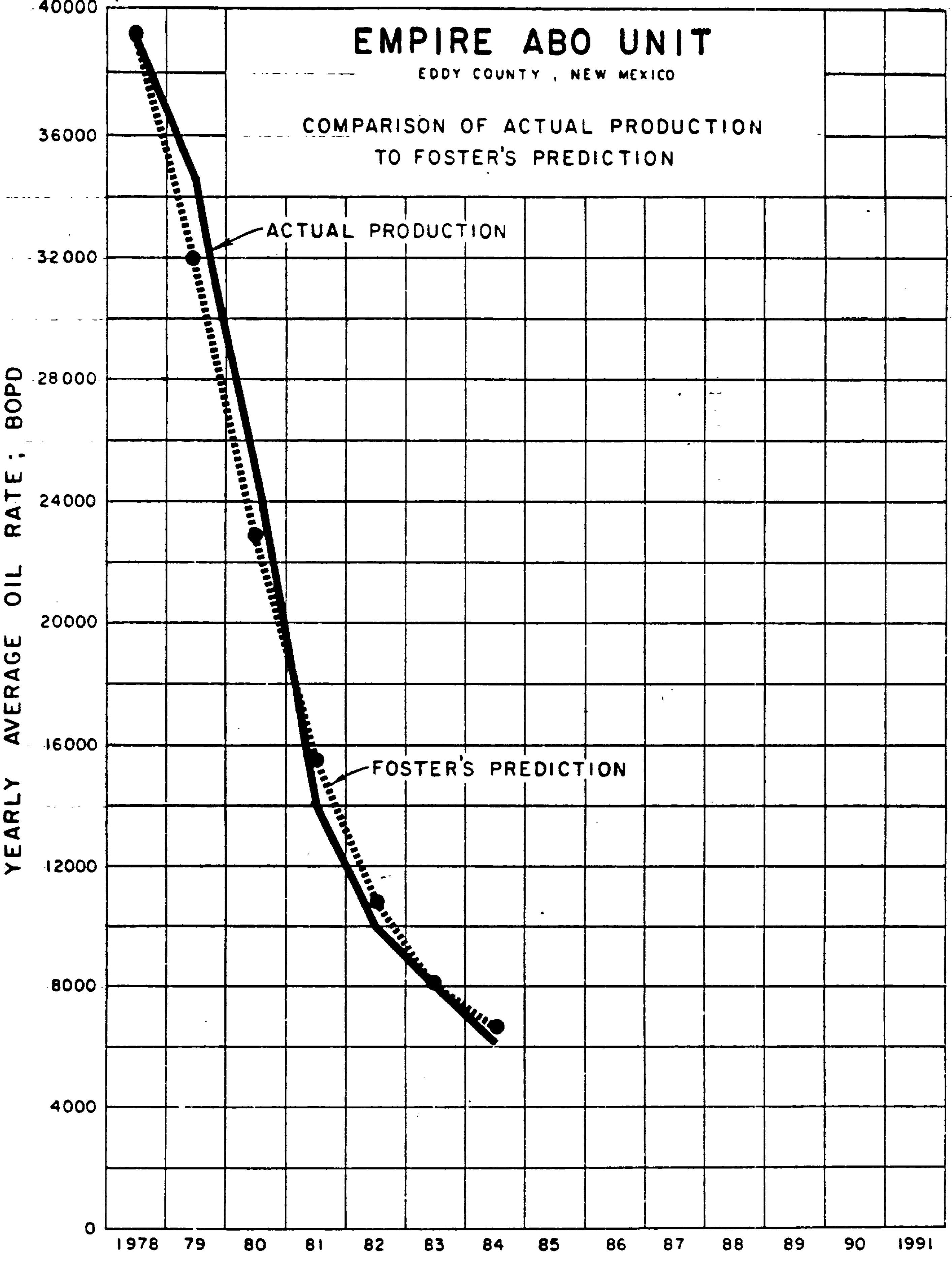
FIGURE A-2

AtlanticRichfieldCompany
North American Producing Division
Permian District Midland, Texas

EMPIRE ABO POOL
BASE OF REEF
EDDY COUNTY, NEW MEXICO
C.I. = 50'

NOTE: ONLY ABO WELLS AND COMPLETION STATUS SHOWN

FIGURE A-3


EMPIRE ABO UNIT
EDDY COUNTY, NEW MEXICO
COMPARISON OF ACTUAL PRODUCTION TO FOSTER'S PREDICTION
ACTUAL PRODUCTION
FOSTER'S PREDICTION
YEARLY AVERAGE OIL RATE; BOPD
40000
36000
32000
28000
24000
20000
16000
12000
8000
4000
0
1978
79
80
81
82
83
84
85
86
87
88
89
90
1991

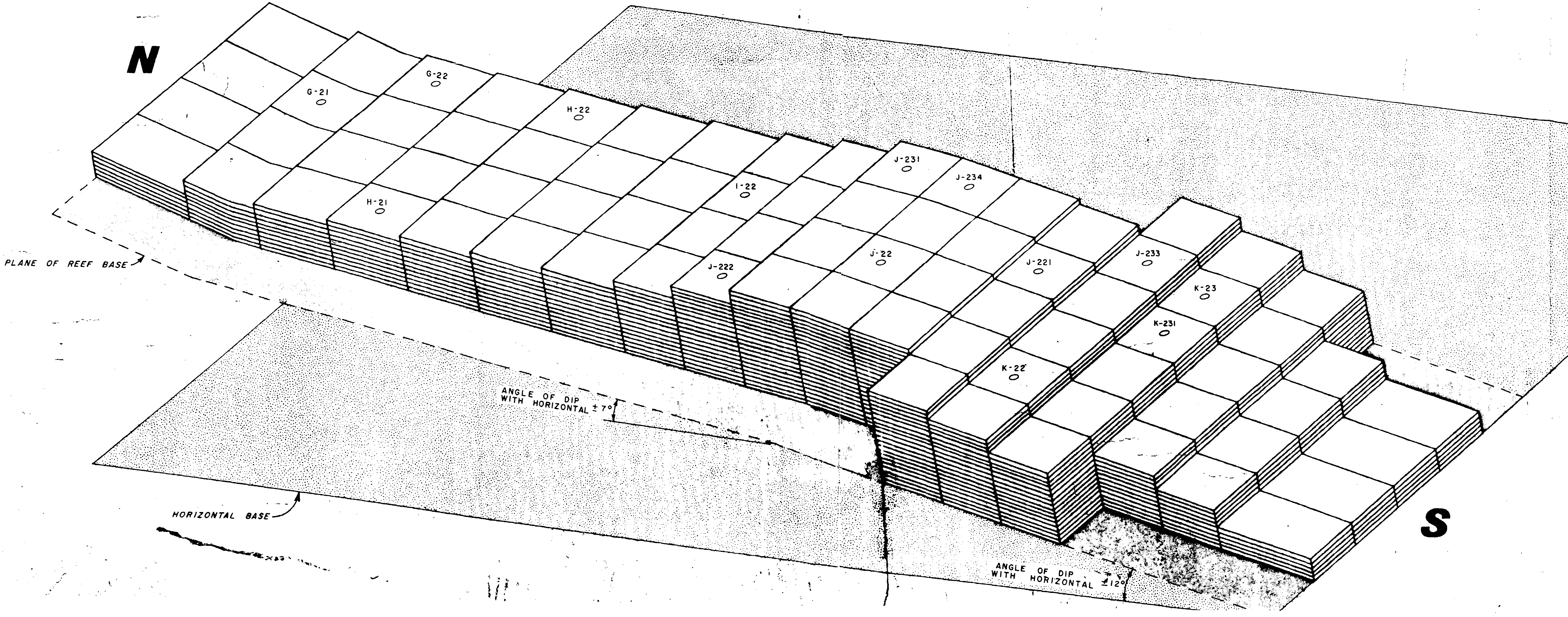


FIGURE A-4

EMPIRE ABO UNIT

EDDY COUNTY, NEW MEXICO

THREE DIMENSIONAL
REPRESENTATION OF
MODEL GRIDDING

FIGURE A-5

ENGINEERING COMMITTEE
EMPIRE ABO RESERVOIR-MAIN REEF AREA

CORE POROSITY VS. NEUTRON STD. COUNTS PER SEC. FOR SCHLUMBERGER AND WELEX LOGS
CONDITIONS: OPEN HOLE 7⅞" DIAMETER

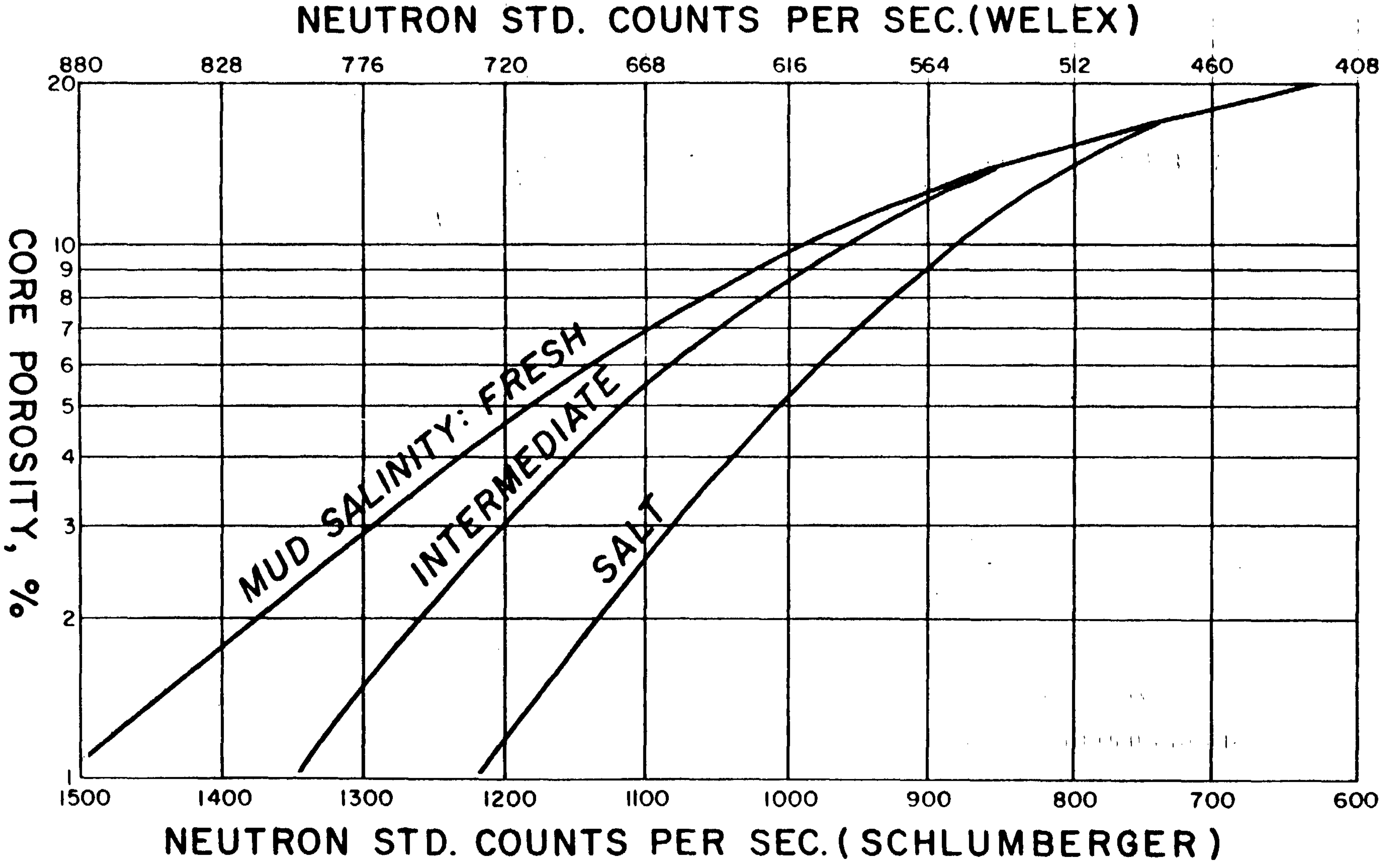


FIGURE A-6

EMPIRE ABO UNIT

EDDY COUNTY, NEW MEXICO

CORE PERMEABILITY VS. POROSITY

USING SORT BY POROSITY RANGES

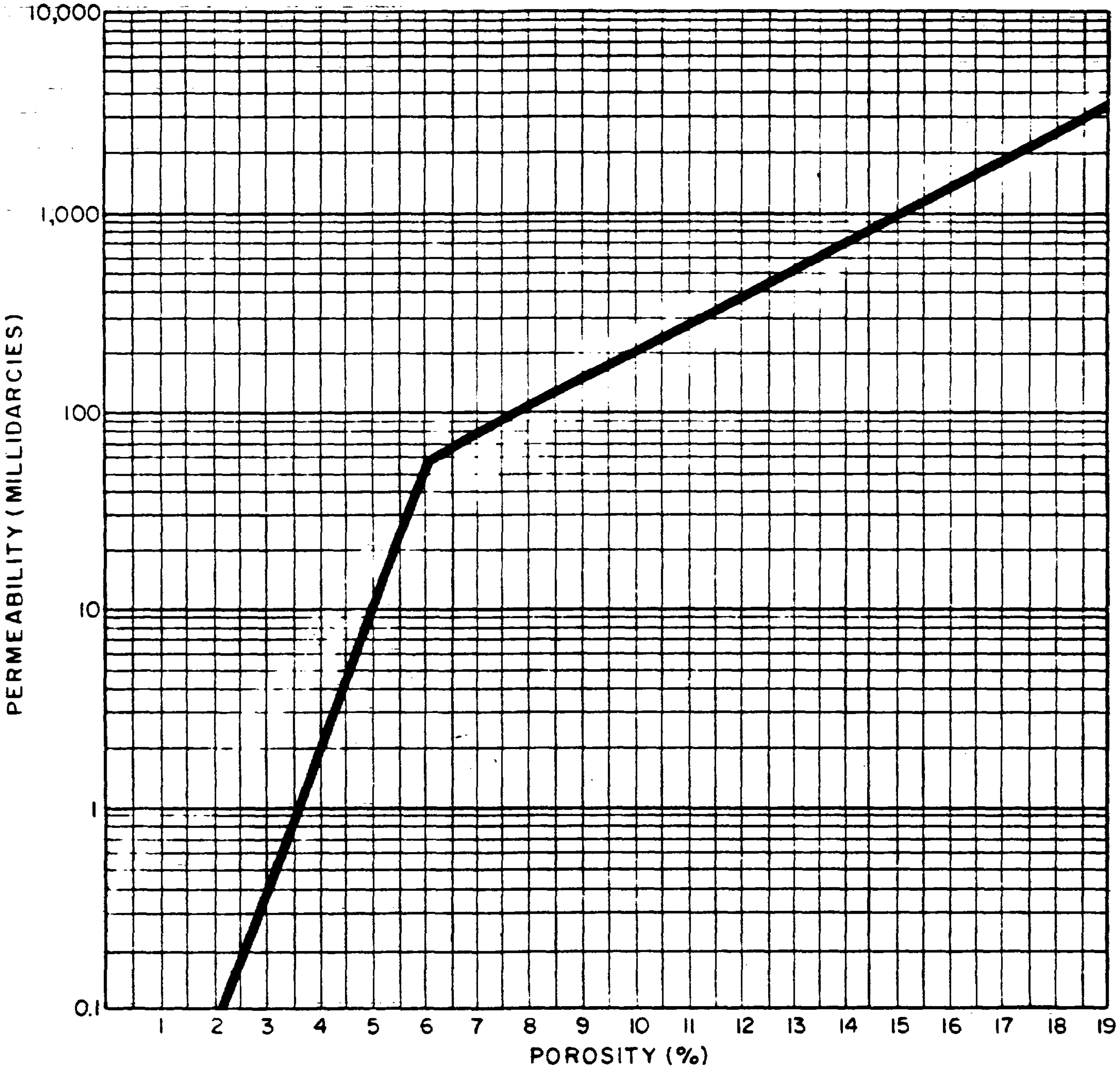


FIGURE A-7

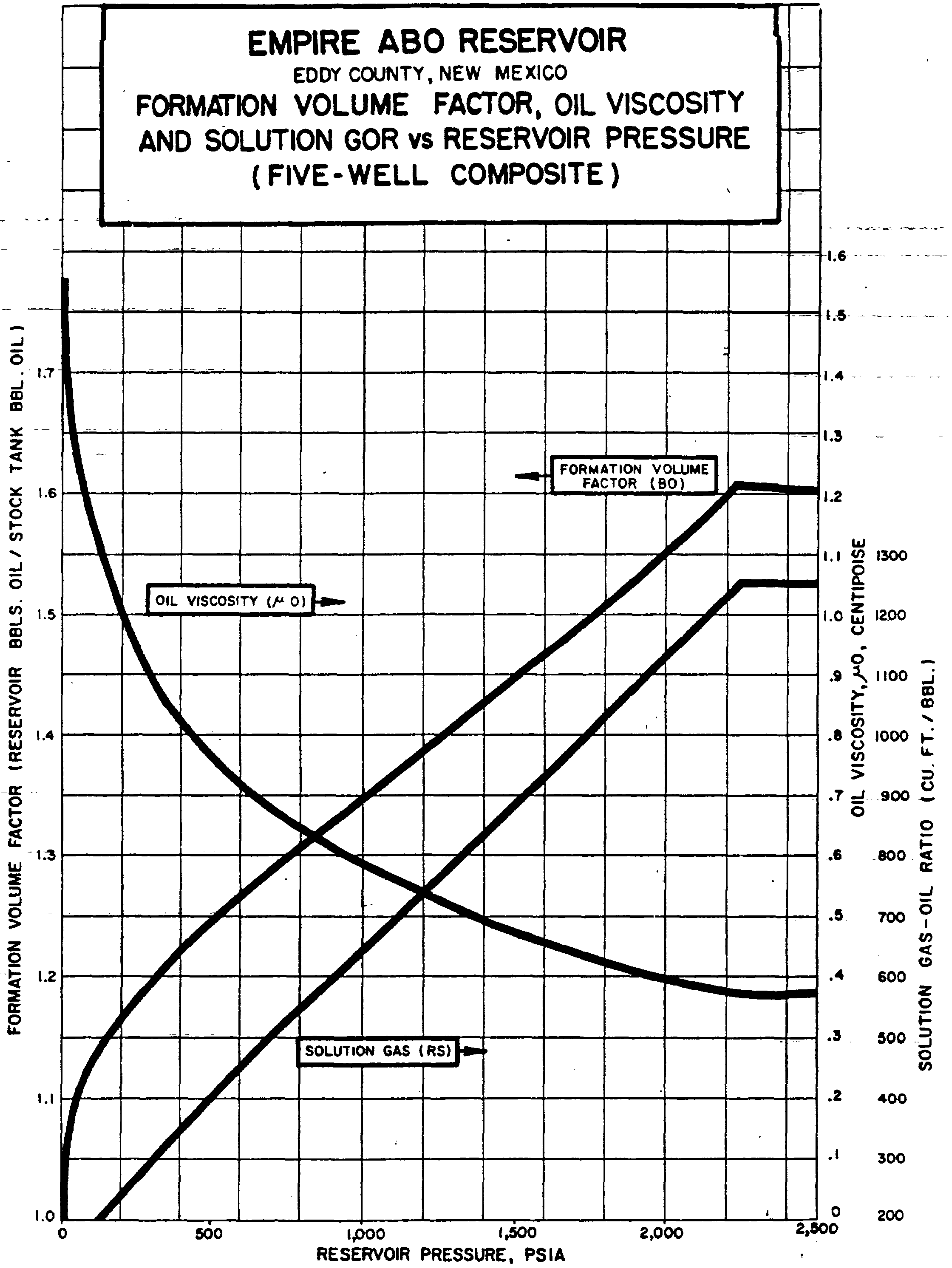

EMPIRE ABO RESERVOIR
EDDY COUNTY, NEW MEXICO
FORMATION VOLUME FACTOR, OIL VISCOSITY AND SOLUTION GOR vs RESERVOIR PRESSURE
(FIVE-WELL COMPOSITE)
FORMATION VOLUME FACTOR (BO)
OIL VISCOSITY (μ O)
SOLUTION GAS (RS)
FORMATION VOLUME FACTOR (RESERVOIR BBLS. OIL / STOCK TANK BBL. OIL)
1.0
1.1
1.2
1.3
1.4
1.5
1.6
1.7
OIL VISCOSITY, μO, CENTIPOISE
0
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0
1.1
1.2
1.3
1.4
1.5
1.6
SOLUTION GAS-OIL RATIO (CU. FT. / BBL.)
200
300
400
500
600
700
800
900
1000
1100
1200
1300
0
500
1,000
1,500
2,000
2,500
RESERVOIR PRESSURE, PSIA

FIGURE A-8

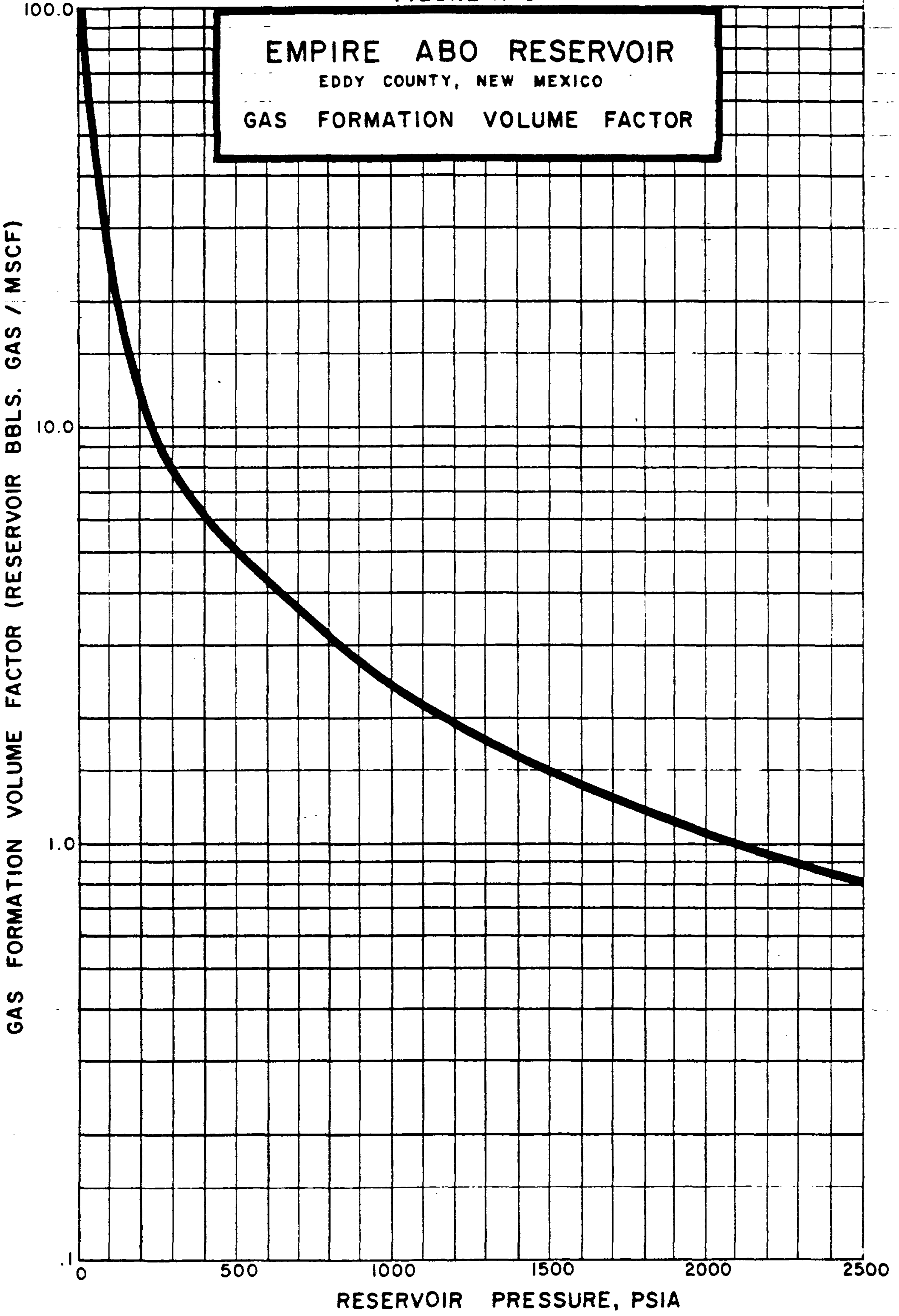

EMPIRE ABO RESERVOIR
EDDY COUNTY, NEW MEXICO
GAS FORMATION VOLUME FACTOR
100.0
10.0
1.0
.1
0
500
1000
1500
2000
2500
RESERVOIR PRESSURE, PSIA
GAS FORMATION VOLUME FACTOR (RESERVOIR BBLS. GAS / MSCF)

FIGURE A-9

EMPIRE ABO UNIT

EDDY COUNTY, NEW MEXICO

ABO RESERVOIR
HISTORY-MATCH GAS-OIL RELATIVE
PERMEABILITY CURVE

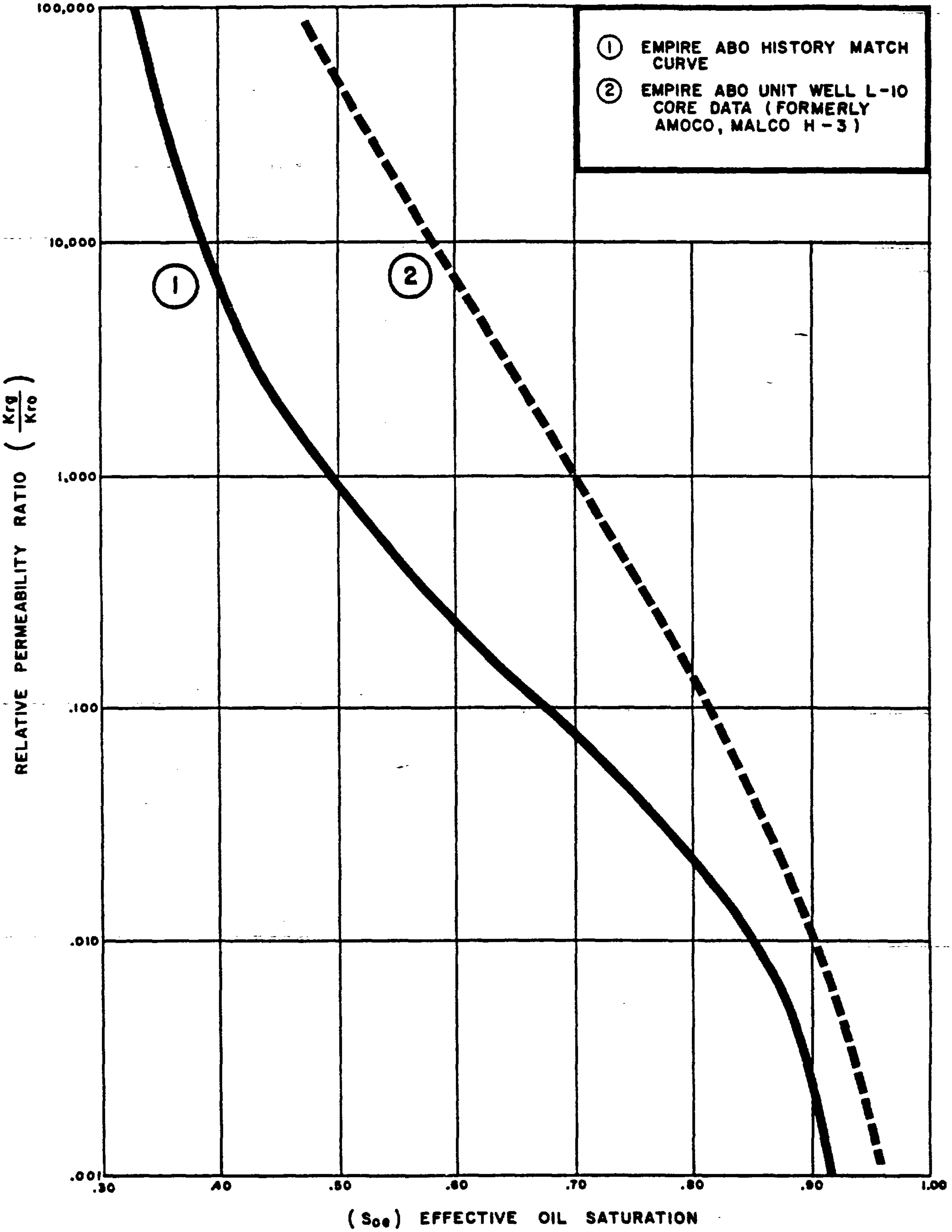


FIGURE A-10

EMPIRE ABO UNIT

EDDY COUNTY, NEW MEXICO

CONING CORRELATION CALCULATED BY RADIAL CONING MODEL FOR WELL K-23

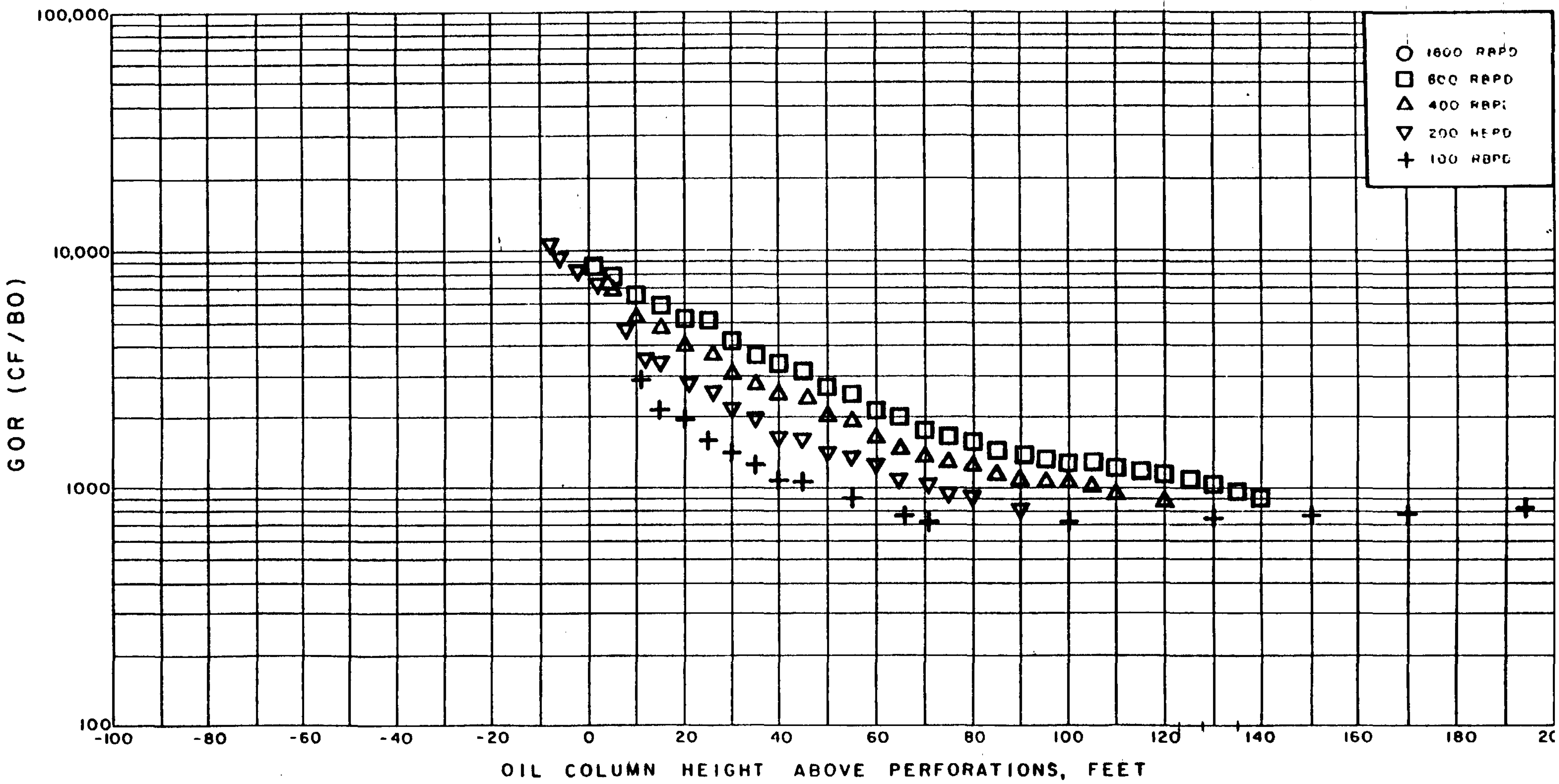
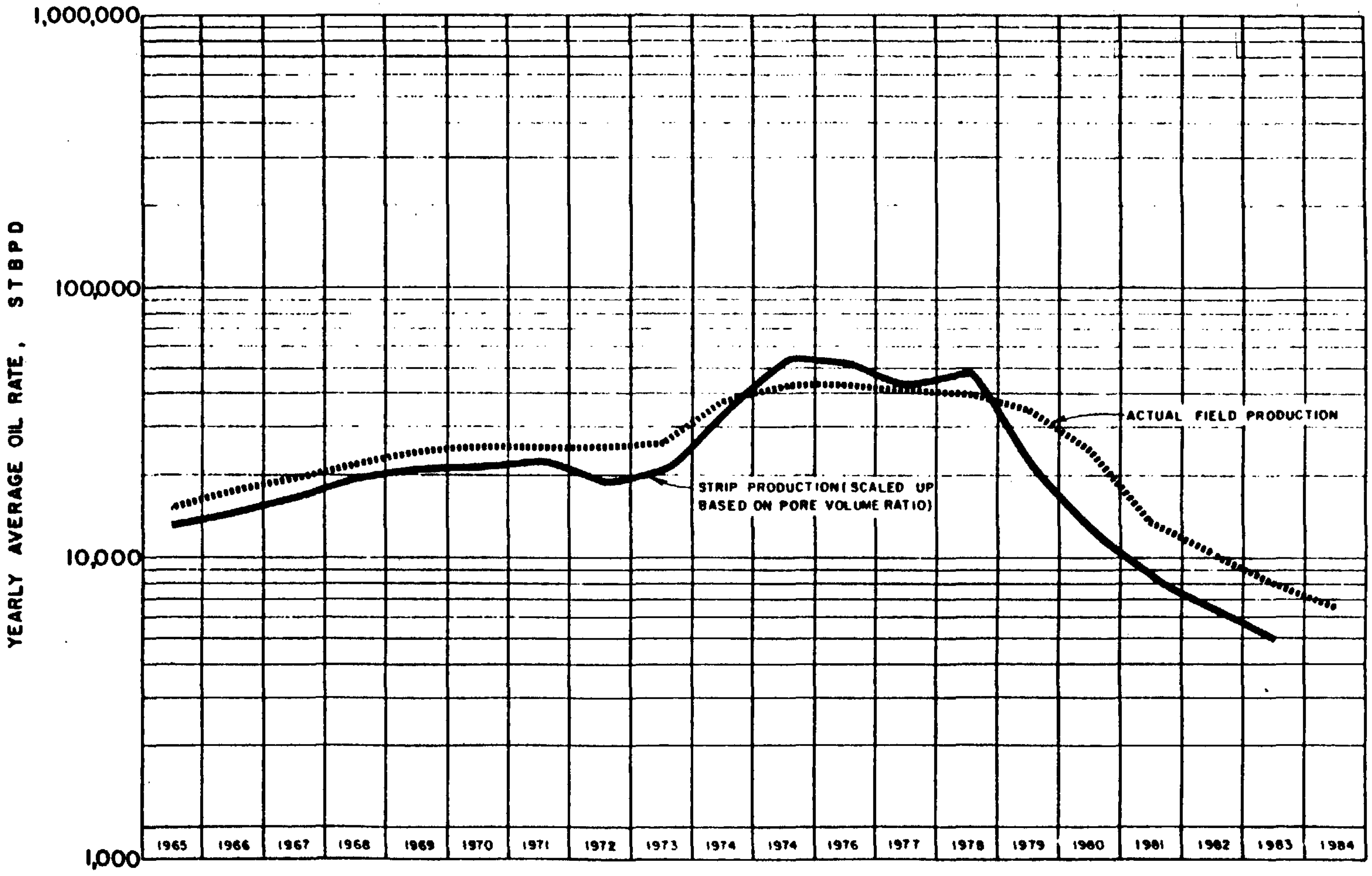


FIGURE A-13

EMPIRE ABO UNIT

EDDY COUNTY, NEW MEXICO

COMPARISON OF STRIP AND
FIELD OIL RATES



APPENDIX B

APPENDIX B

Discussion of Oil Rate and Reserve Forecasts

DISCUSSION OF OIL RATE AND RESERVE FORECASTS

The incremental oil reserves recovered by delaying blowdown are the result of extending the field life which allows additional migration of oil from the back-reef to the fore-reef. This is illustrated in figures B1 through B5 in which the gas cap, oil column and water column are mapped for one row of cells in the simulator. Figure B1 is the saturation distribution at the start of the oil rate forecasts which is 1/1/83 in the slice and represents 1/1/85 in the field. Figure B2 is the saturation distribution at the economic limit for starting blowdown in 1985. Approximately 50 ft of oil in the back-reef area (columns 3, 4, and 5) has migrated to the fore-reef area. Compare this to Figure B5 which is the saturation distribution at the economic limit for starting blowdown in 2003. Here the migration of oil is roughly three times that for starting blowdown in 1985.

The incremental oil rates obtained by continued gas injection are the result of slowing the pressure decline of the reservoir. Although the recovery mechanism at Empire Abo is gravity drainage, which is relatively independent of reservoir pressure, the production mechanism is fluid expansion, which is very sensitive to reservoir pressure. The effect of reservoir pressure on oil rates is most easily explained using Equation 1 which is an expression of Darcy's law for linear fluid flow in permeable beds:

$$Q_o = \frac{Ko\Delta P}{\mu_o L} \text{ , } \quad \ldots\ldots\ldots\ldots(1)$$

where

Q_o = Oil rate, BOPD,

K_o = Effective Oil Permiability, Darcies,

ΔP = Pressure differential across the bed, psi,

μ_o = Oil viscosity, cp, and

L = Length, ft.

The pressure dependent terms in Equation 1 are ΔP and μo. Assuming the only significant difference in the four blowdown cases is reservoir pressure, the ratio of the oil rates for any two cases can be expressed as:

$$Q_{o1}/Q_{o2} = (\Delta P/\mu_o)_1/(\Delta P/\mu_o)_2 \;.\;..........(2)$$

Using the oil rate forecast for starting blowdown in 2003, the oil rate forecasts for starting blowdown in 1985, 1990 and 1995 were calculated using Equation 2. If the differences in oil rates between the four cases are due entirely to the differences in reservoir pressures, then the forecasts calculated using Equation 2 should match the simulator calculated forecasts. The results of these calculations are illustrated in Figures B6 through B8. The agreement of the forecasts indicates the incremental oil rates obtained by delaying blowdown are due entirely to the incrementally higher reservoir pressures.

FIGURE B-1

EMPIRE ABO UNIT

EDDY COUNTY, NEW MEXICO

SATURATIONS AT 1985

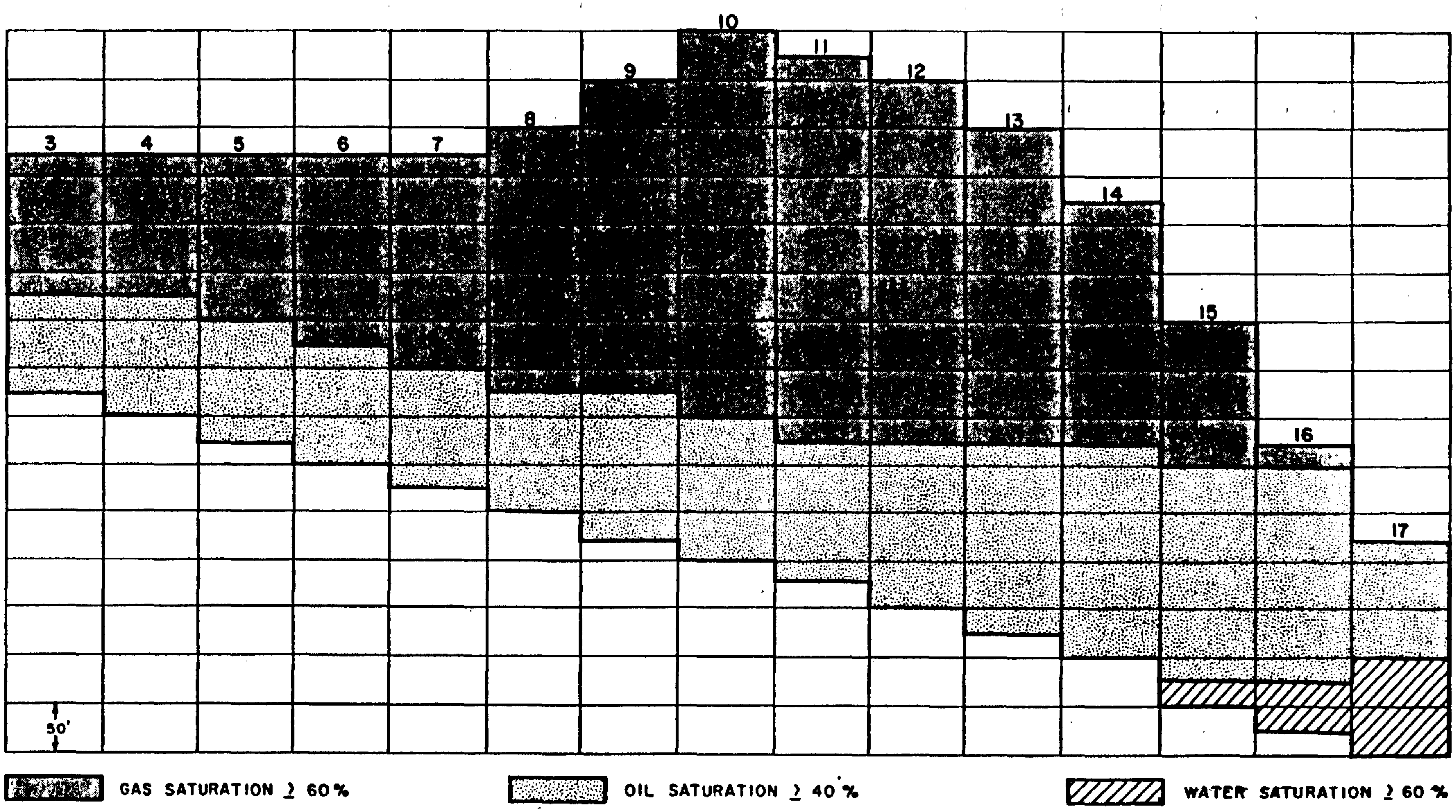


FIGURE B-2

EMPIRE ABO UNIT

EDDY COUNTY, NEW MEXICO

SATURATIONS AT 1995 FOR BLOWDOWN AT 1985

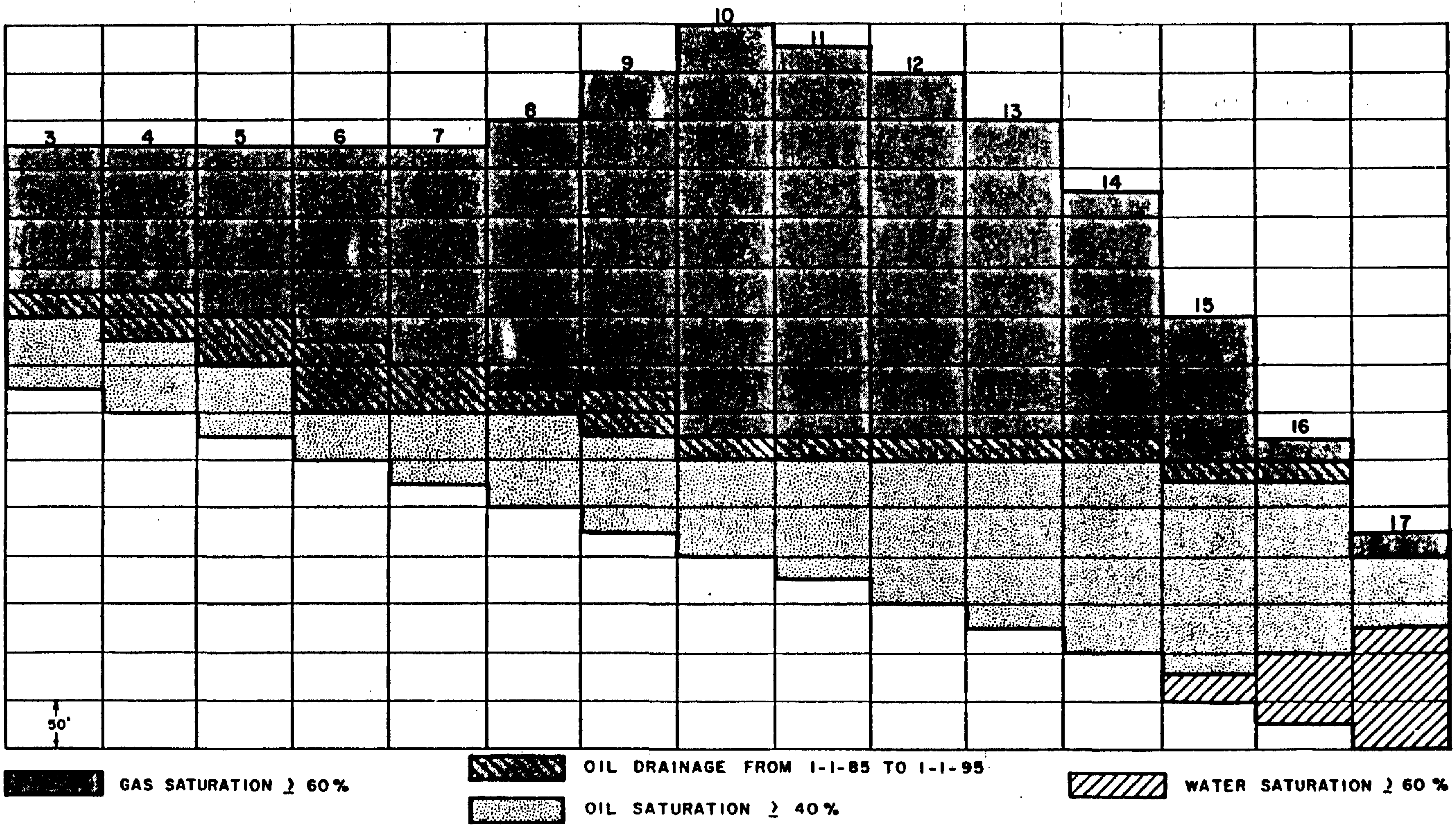


FIGURE B-3

EMPIRE ABO UNIT

EDDY COUNTY, NEW MEXICO

SATURATIONS AT 1998 FOR BLOWDOWN AT 1990

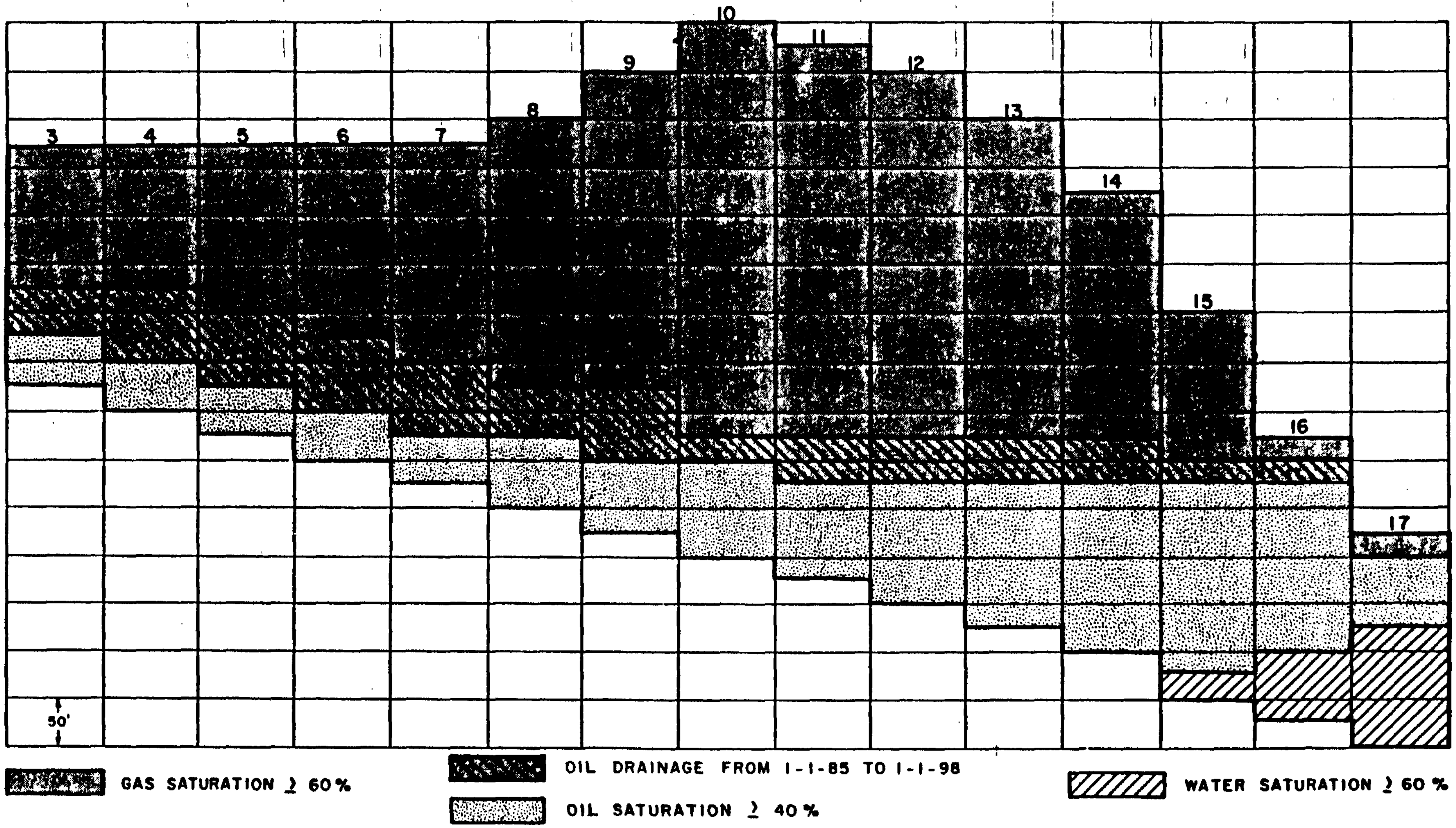


FIGURE B-4

EMPIRE ABO UNIT

EDDY COUNTY, NEW MEXICO

SATURATIONS AT 2001 FOR BLOWDOWN AT 1995

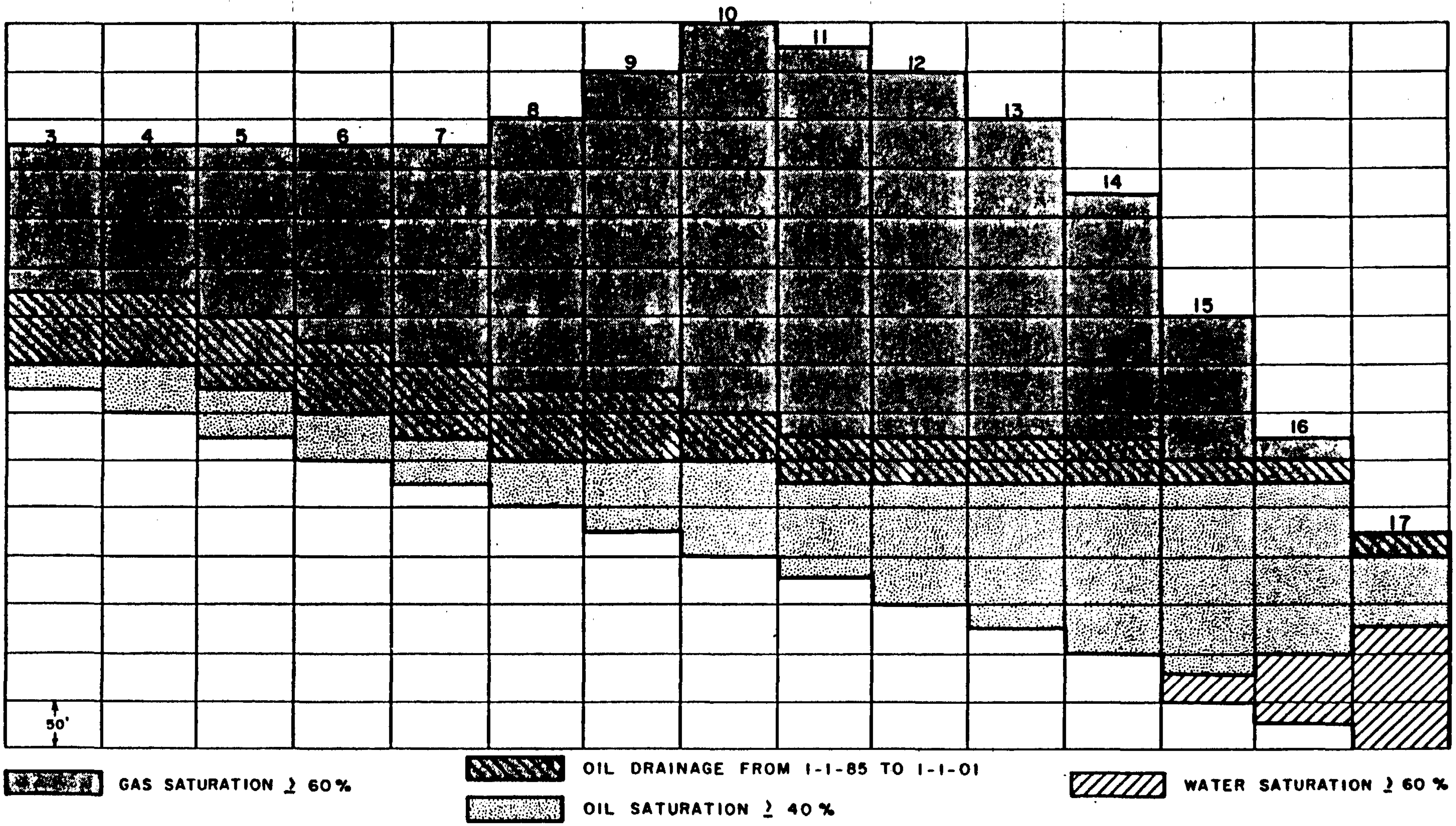


FIGURE B-5

EMPIRE ABO UNIT

EDDY COUNTY, NEW MEXICO

SATURATIONS AT 2006 FOR BLOWDOWN AT 2003

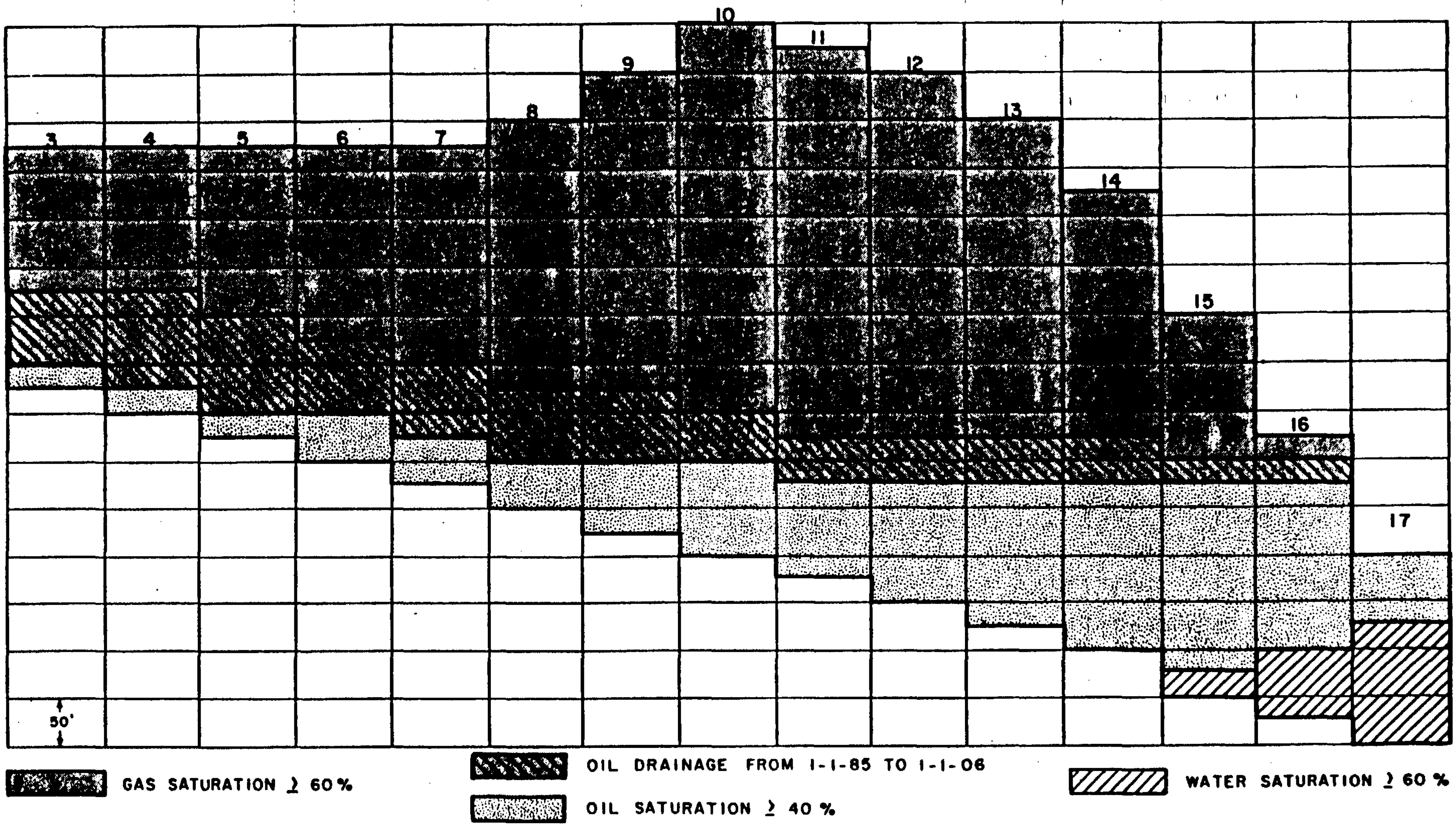


FIGURE B-6

EMPIRE ABO UNIT

EDDY COUNTY, NEW MEXICO

COMPARISON OF SIMULATOR FORECASTS TO
FORCASTS CALCULATED USING EQUATION A2
BLOWDOWN AT 1/1/85

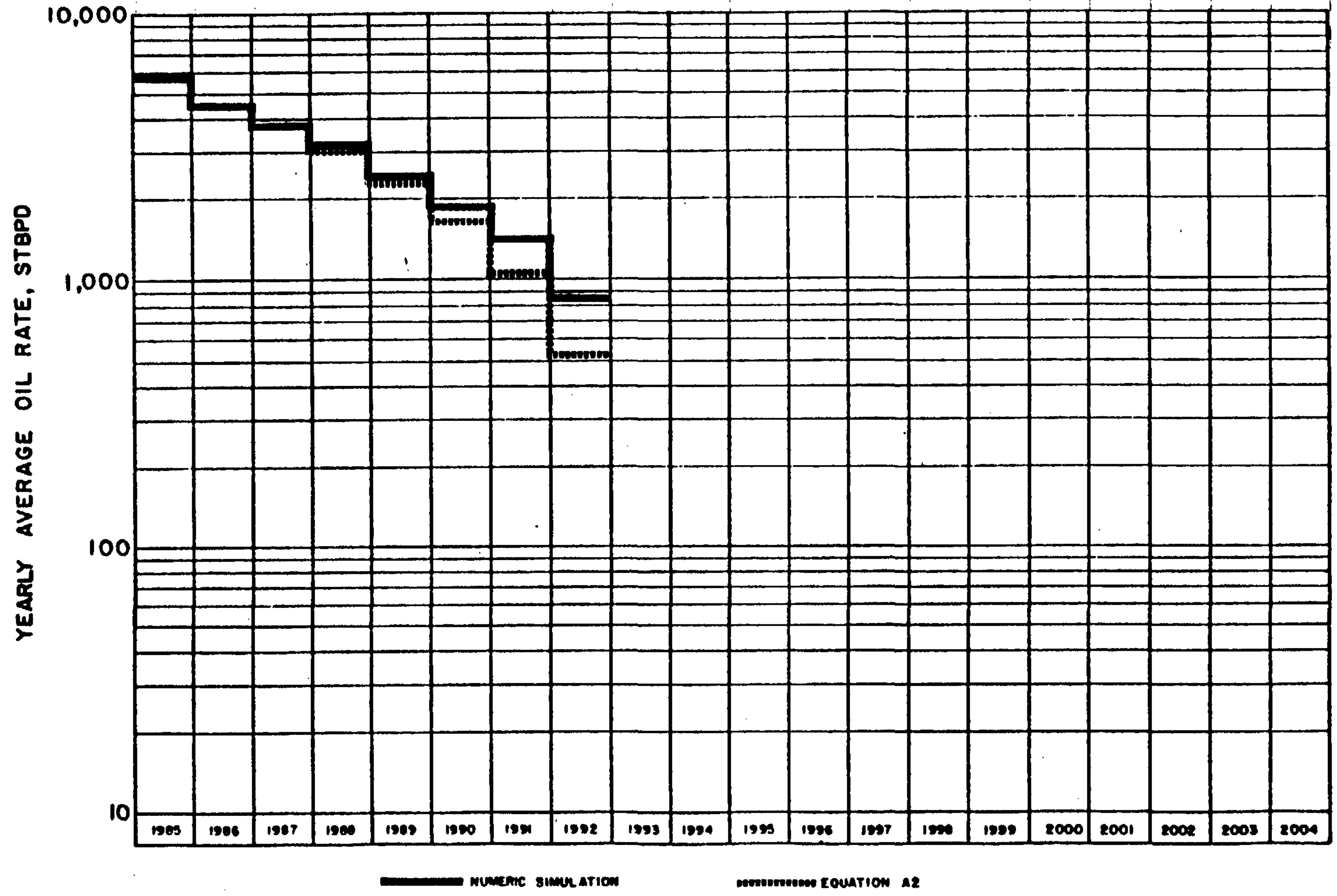


FIGURE B-7

EMPIRE ABO UNIT

EDDY COUNTY, NEW MEXICO

COMPARISON OF SIMULATOR FORECASTS TO
FORCASTS CALCULATED USING EQUATION A2
BLOWDOWN AT 1/1/90

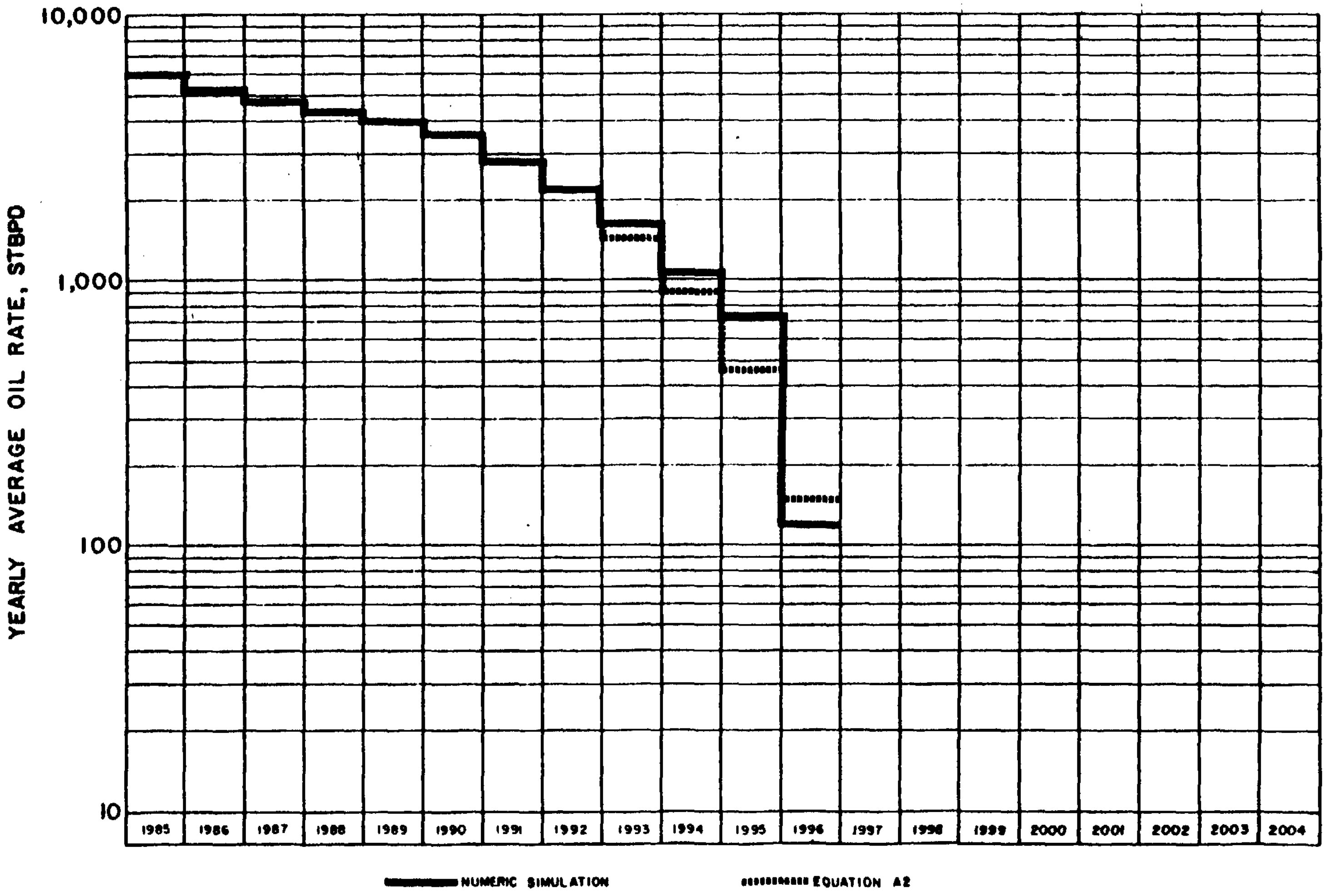


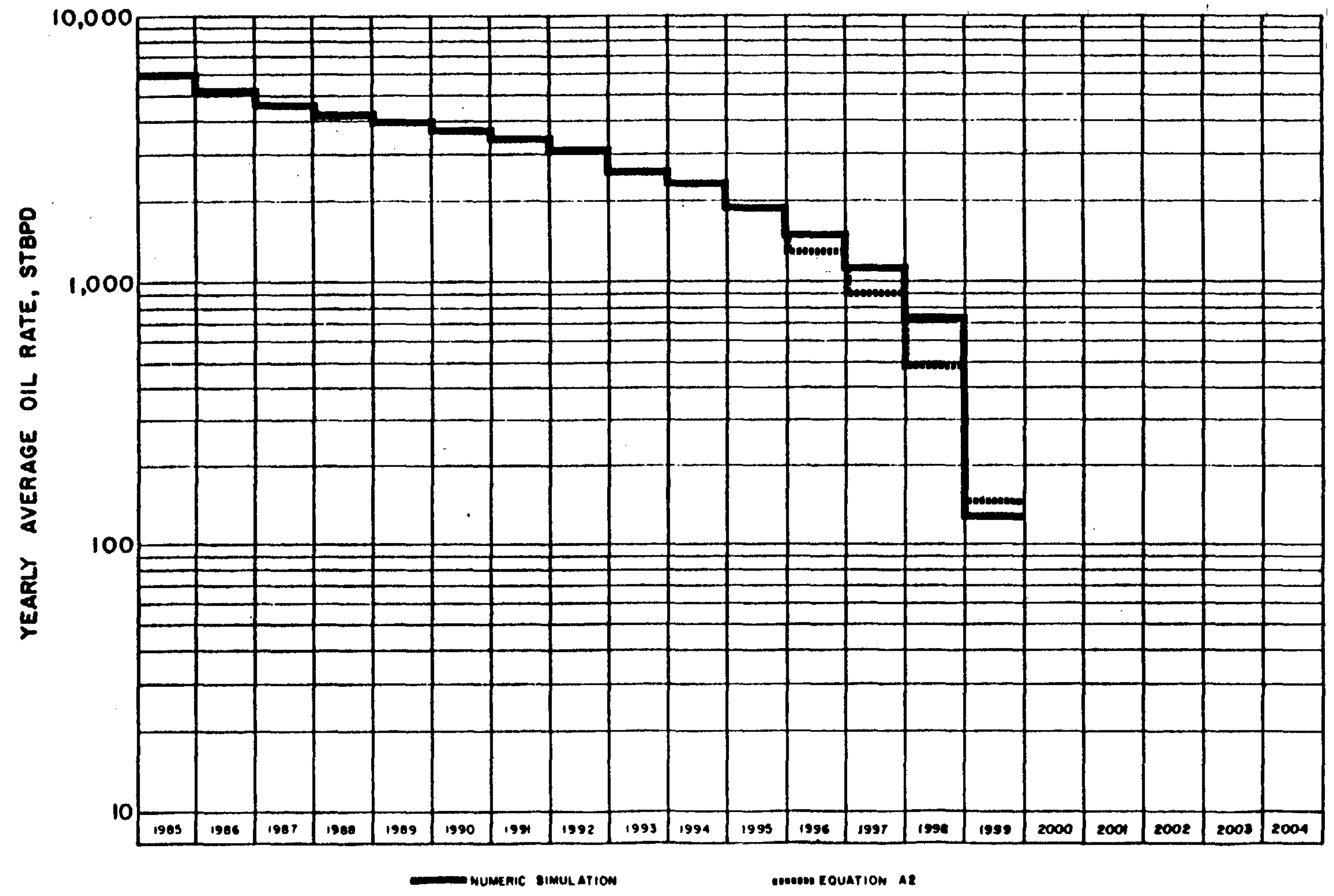
FIGURE B-8

EMPIRE ABO UNIT

EDDY COUNTY, NEW MEXICO

COMPARISON OF SIMULATOR FORECASTS TO FORCASTS CALCULATED USING EQUATION A2

BLOWDOWN AT 1/1/95



APPENDIX C

Black Oil Numeric Simulator History Match

TABLE C1
HISTORY MATCH RESULTS

	Actual	Model	% Difference
Gross Oil Production, STB	5,959,309	5,959,309	None
Gross Gas Production, MCF	11,853,407	11,326,669	-4.4
Average Reservoir Pressure, psi	1,003	1,028	2.5
Individual Well Gas Production, MCF			
J-22	1,887,197	1,762,151	-6.6
I-22	966,476	1,001,867	3.7
K-22	1,590,347	1,561,049	-1.8
K-23	1,587,784	1,583,831	-0.3
J-231	783,200	646,498	-17.5
J-221	1,191,748	1,015,900	-14.8
J-222	24,662	10,835	-56.1
J-233	836,810	801,228	-4.3
J-234	392,735	446,310	13.6
K-231	826,495	754,031	-8.8
H-22	382,146	371,110	-2.9
H-21	451,068	454,988	0.9
G-21	932,739	916,871	-1.7

FIGURE C-1

EMPIRE ABO UNIT

EDDY COUNTY, NEW MEXICO

SLICE MODEL HISTORY-MATCH

ACTUAL GOR FROM SLICE AREA COMPARED
TO NUMERIC MODEL CALCULATIONS

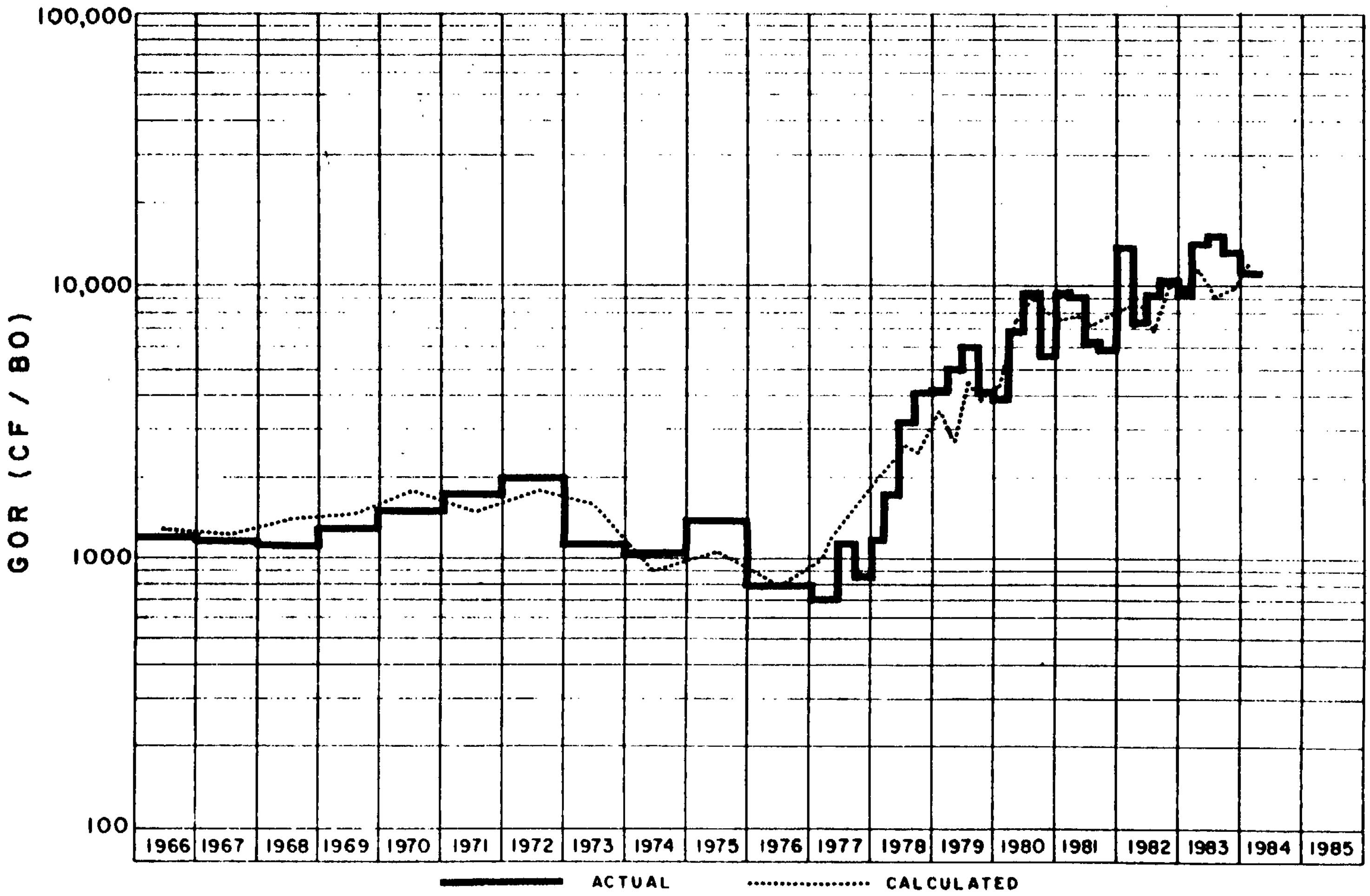


FIGURE C-2

EMPIRE ABO UNIT

EDDY COUNTY, NEW MEXICO

SLICE MODEL HISTORY MATCH

ACTUAL WELL PERFORMANCE COMPARED
TO NUMERIC MODEL CALCULATIONS

WELL J-22

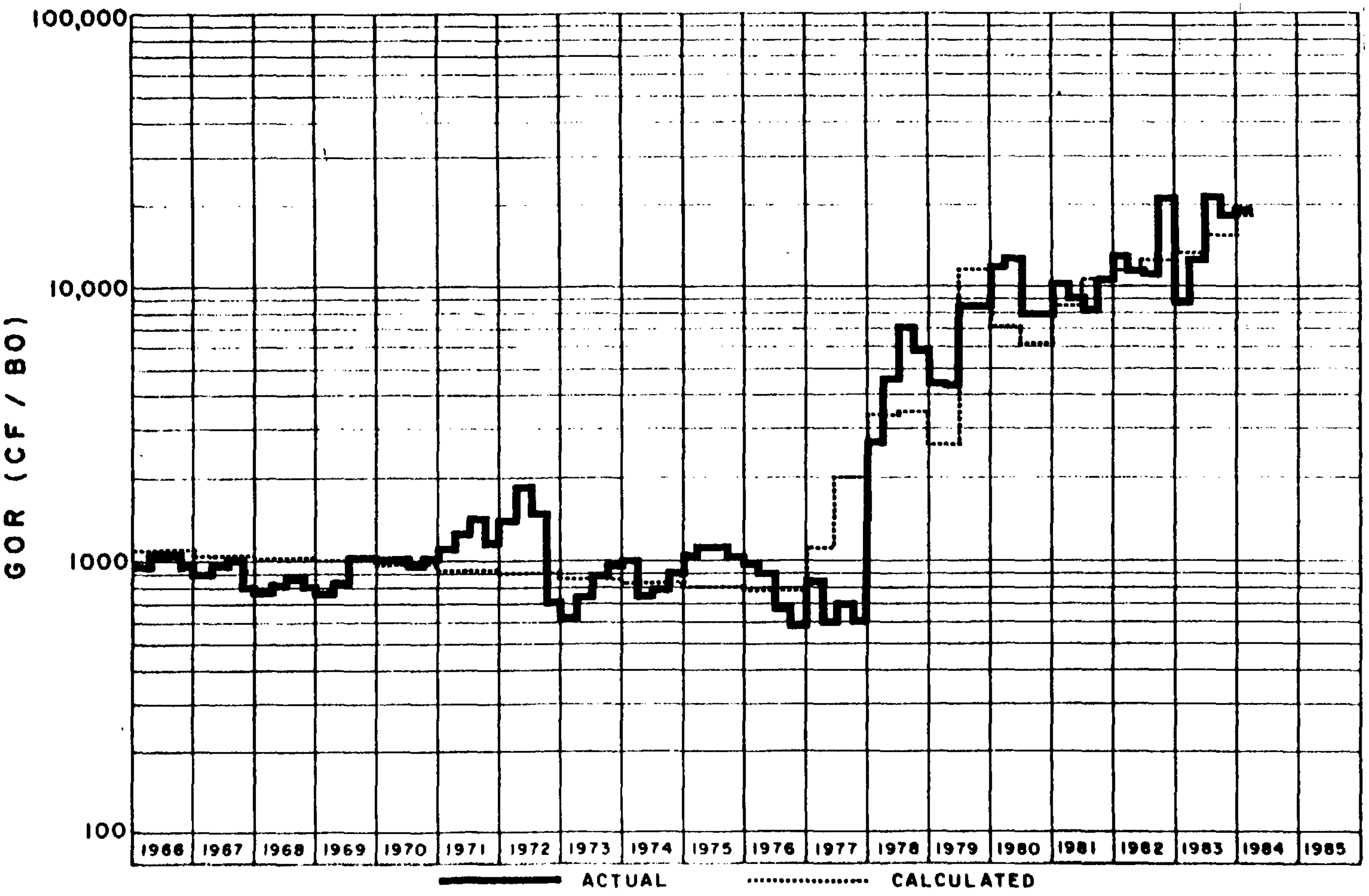


FIGURE C-3

EMPIRE ABO UNIT

EDDY COUNTY, NEW MEXICO

SLICE MODEL HISTORY MATCH

ACTUAL WELL PERFORMANCE COMPARED
TO NUMERIC MODEL CALCULATIONS

WELL I-22

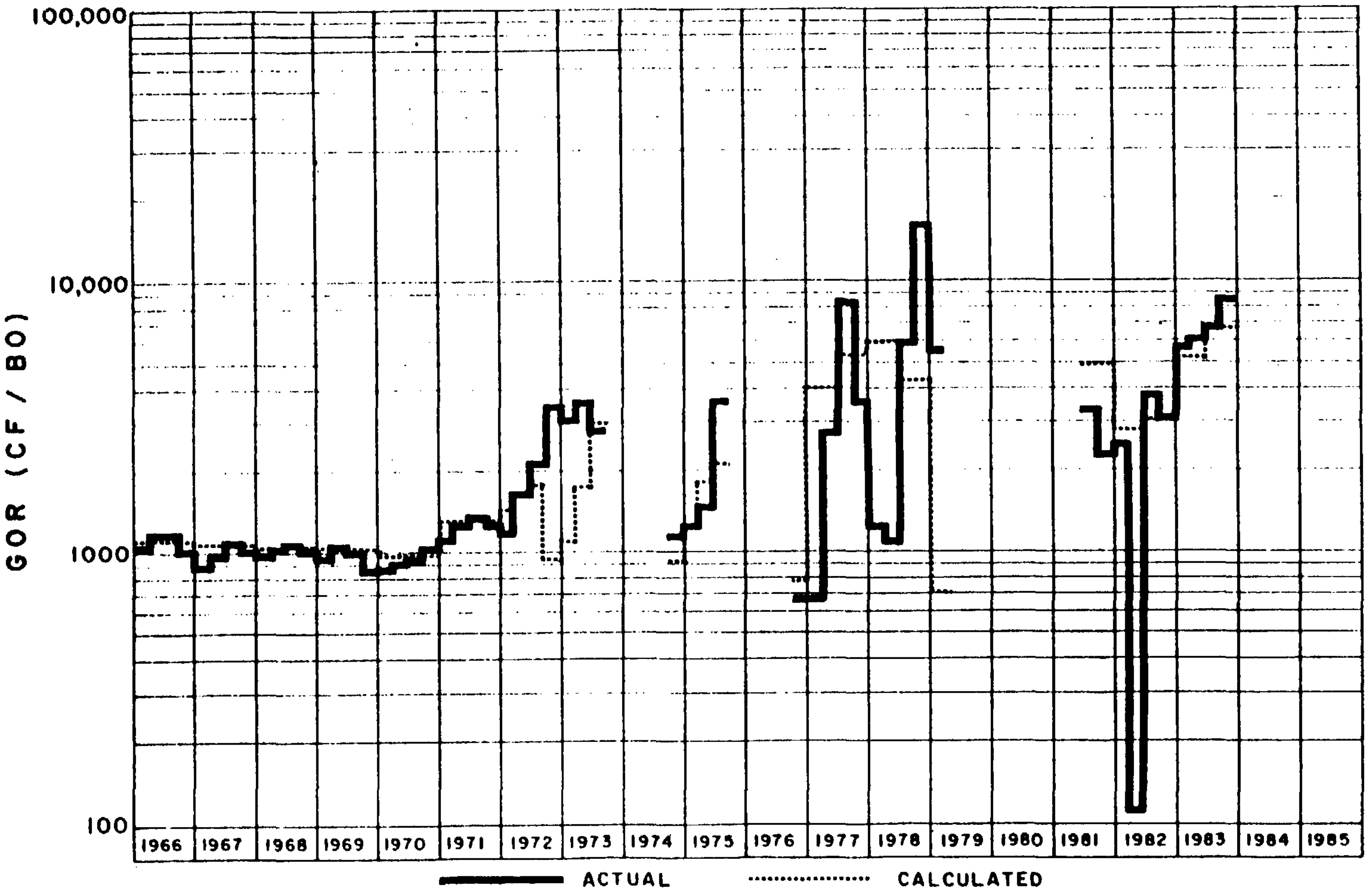


FIGURE C-4

EMPIRE ABO UNIT

EDDY COUNTY, NEW MEXICO

SLICE MODEL HISTORY MATCH

ACTUAL WELL PERFORMANCE COMPARED
TO NUMERIC MODEL CALCULATIONS

WELL K-22

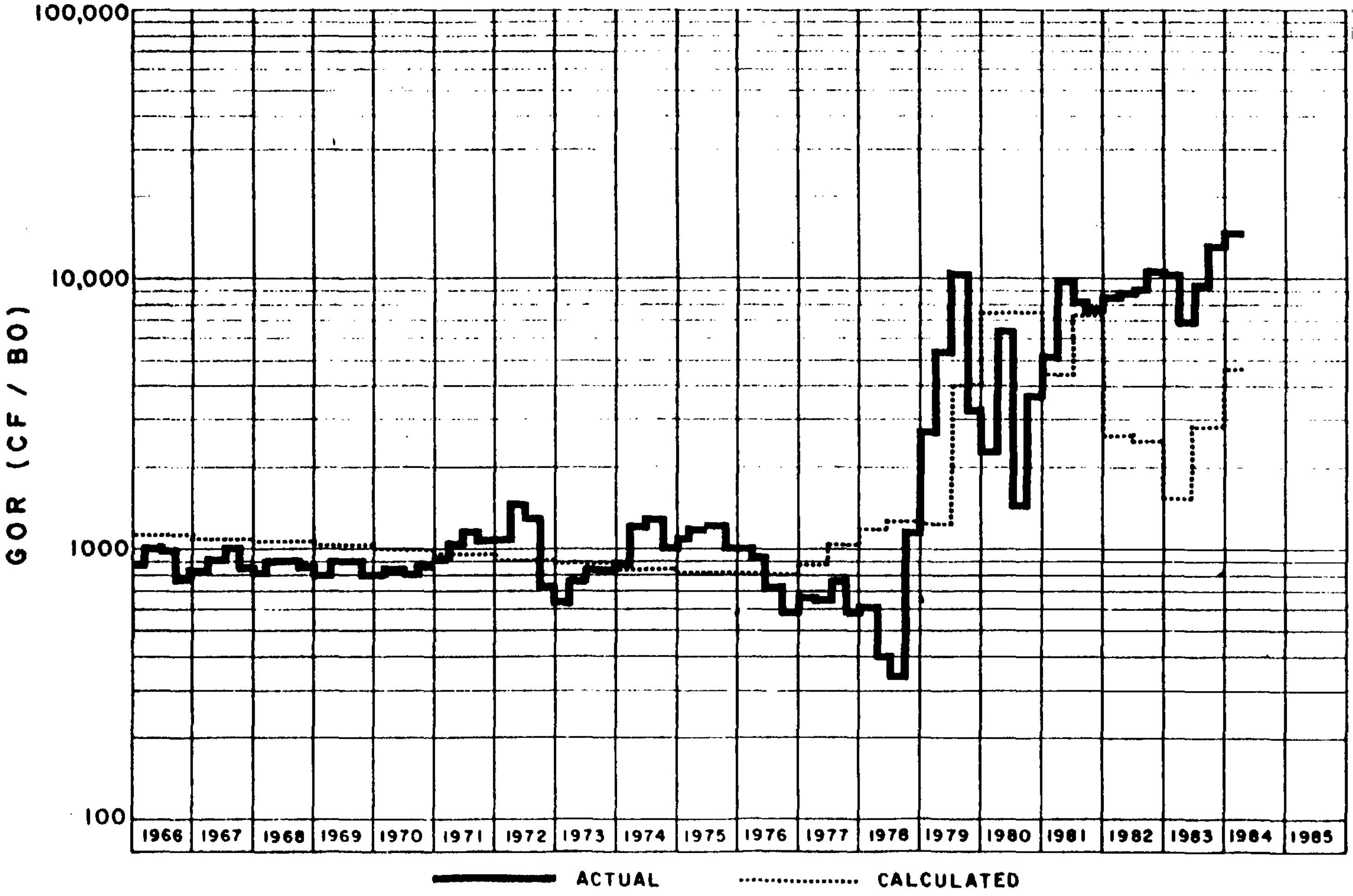


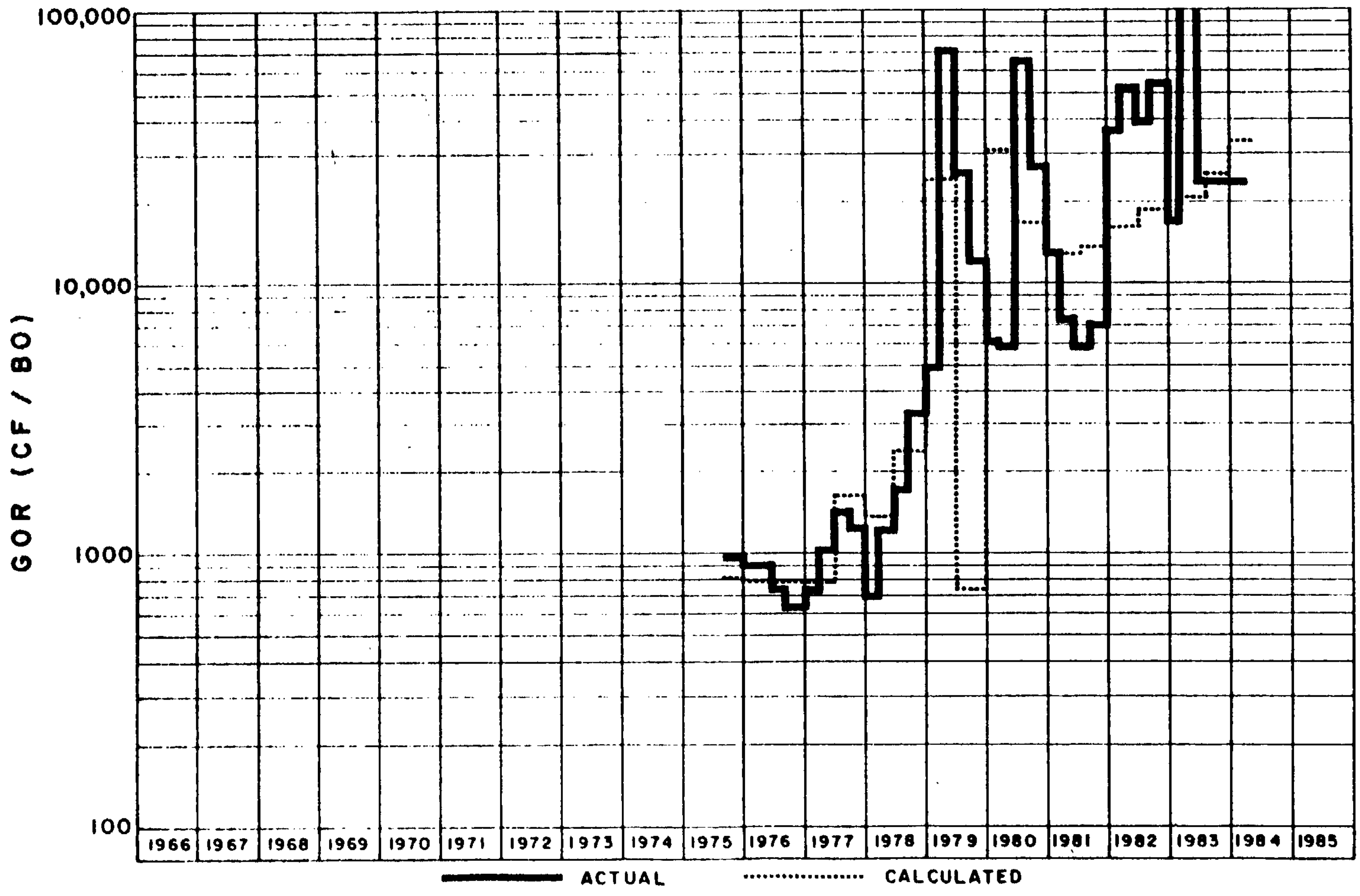
FIGURE C-6

EMPIRE ABO UNIT

EDDY COUNTY, NEW MEXICO

SLICE MODEL HISTORY MATCH

ACTUAL WELL PERFORMANCE COMPARED
TO NUMERIC MODEL CALCULATIONS



WELL J-231

FIGURE C-7

EMPIRE ABO UNIT

EDDY COUNTY, NEW MEXICO

SLICE MODEL HISTORY MATCH

ACTUAL WELL PERFORMANCE COMPARED
TO NUMERIC MODEL CALCULATIONS

WELL J-221

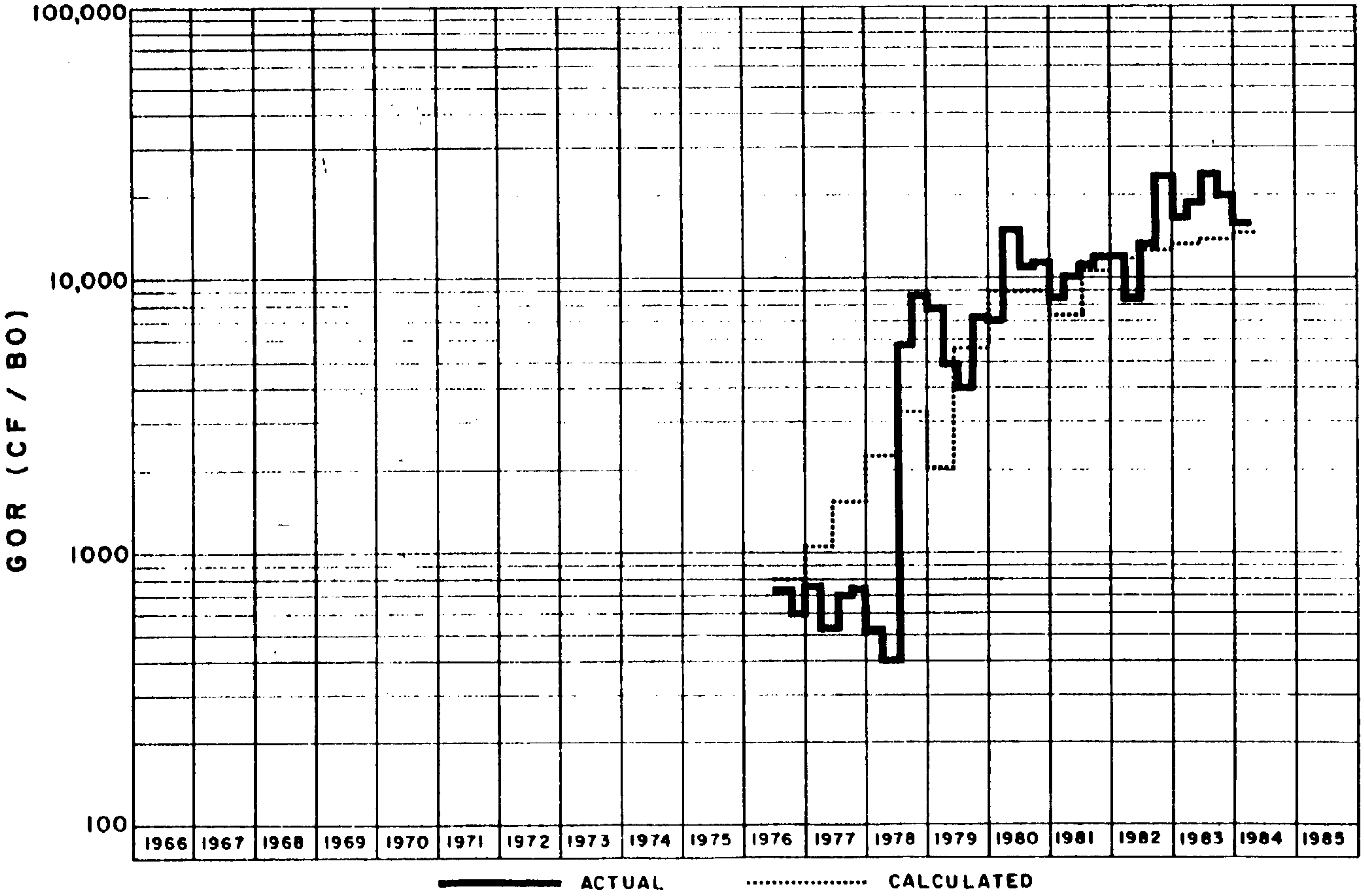


FIGURE C-8

EMPIRE ABO UNIT

EDDY COUNTY, NEW MEXICO

SLICE MODEL HISTORY MATCH

ACTUAL WELL PERFORMANCE COMPARED
TO NUMERIC MODEL CALCULATIONS

WELL J-222

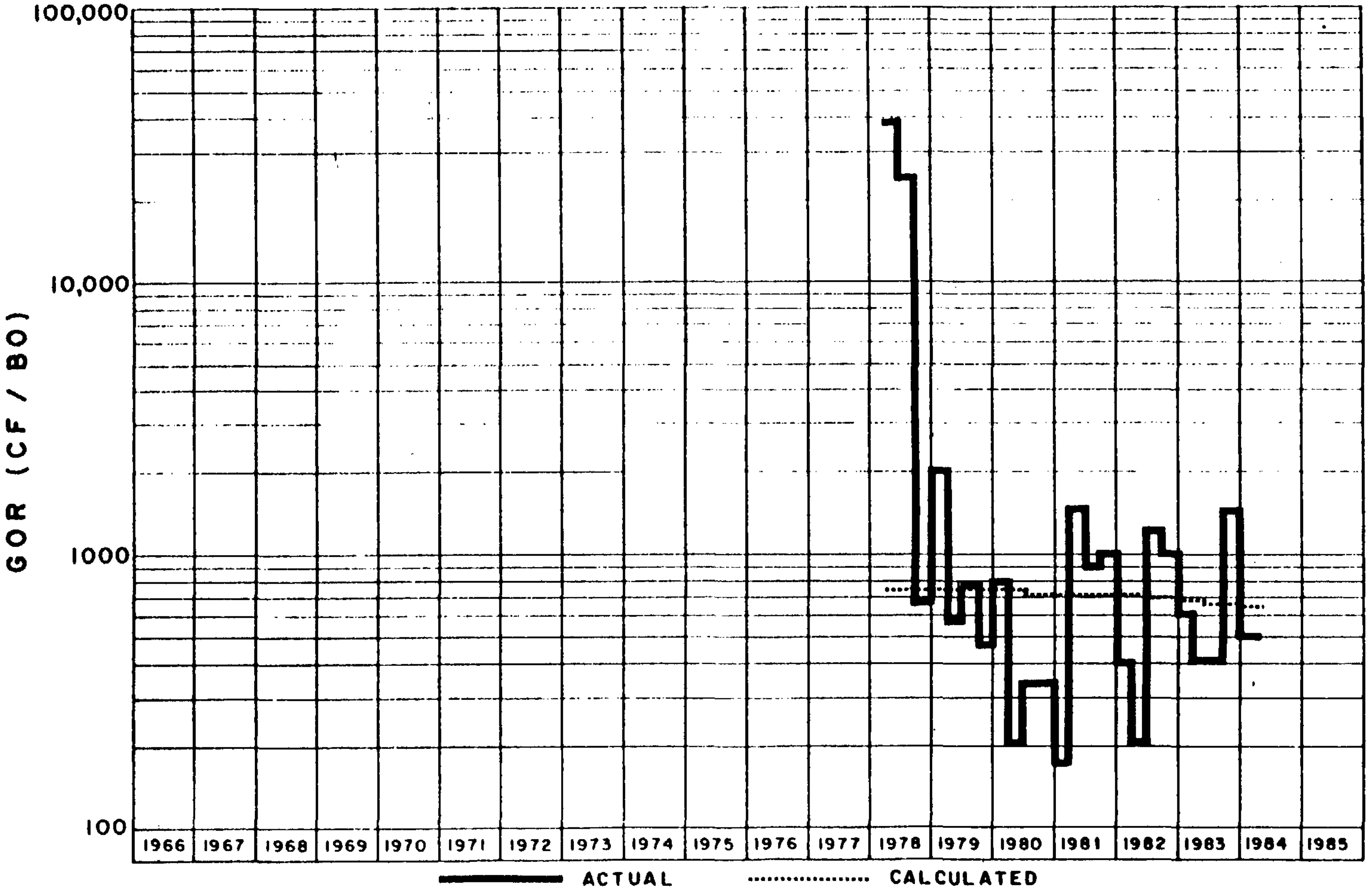


FIGURE C-9

EMPIRE ABO UNIT

EDDY COUNTY, NEW MEXICO

SLICE MODEL HISTORY MATCH

ACTUAL WELL PERFORMANCE COMPARED
TO NUMERIC MODEL CALCULATIONS

WELL J-233

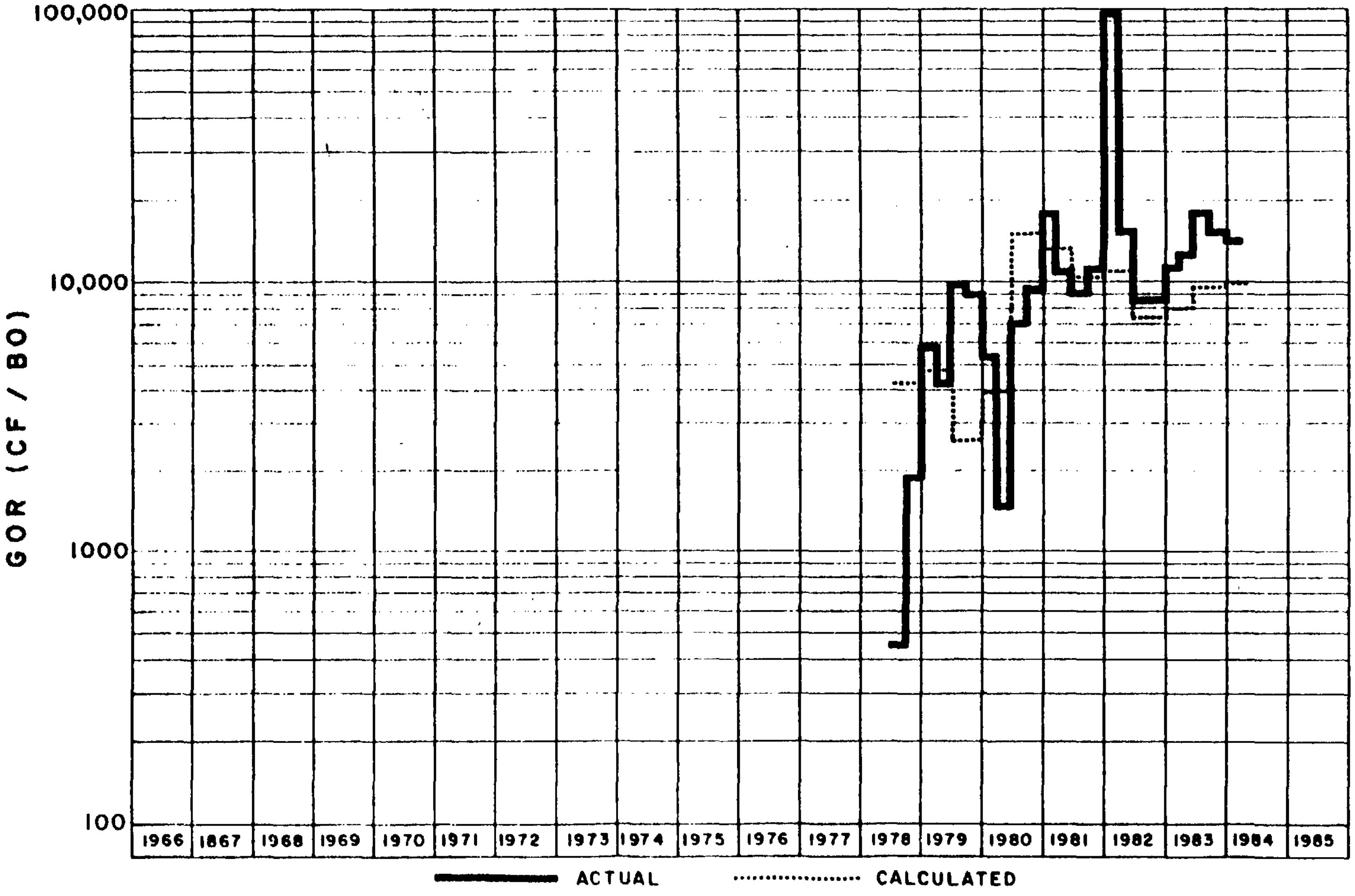


FIGURE C-10

EMPIRE ABO UNIT

EDDY COUNTY, NEW MEXICO

SLICE MODEL HISTORY MATCH

ACTUAL WELL PERFORMANCE COMPARED
TO NUMERIC MODEL CALCULATIONS

WELL J-234

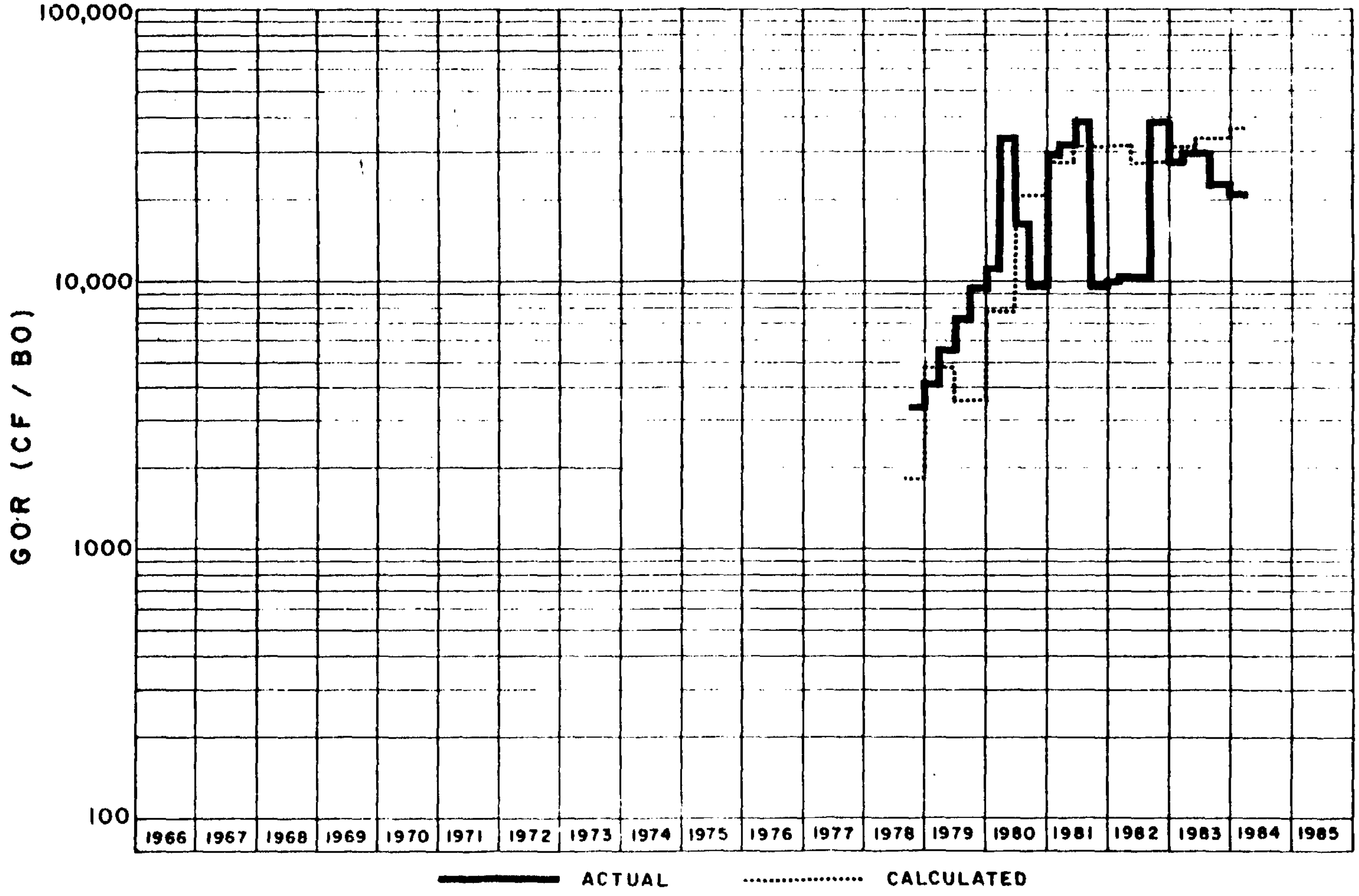


FIGURE C-11

EMPIRE ABO UNIT

EDDY COUNTY, NEW MEXICO

SLICE MODEL HISTORY MATCH

ACTUAL WELL PERFORMANCE COMPARED
TO NUMERIC MODEL CALCULATIONS

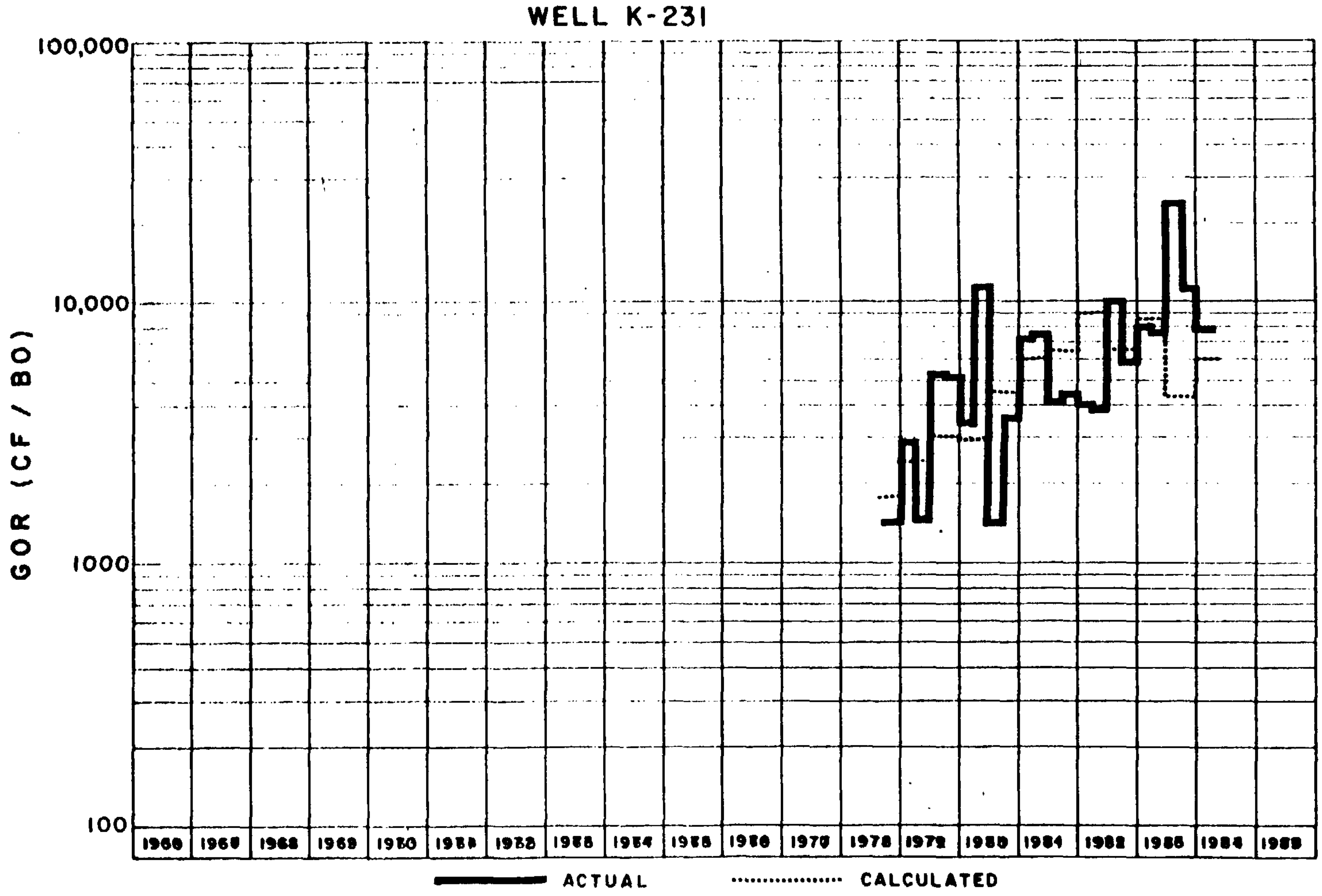


FIGURE C-12
EMPIRE ABO UNIT
EDDY COUNTY, NEW MEXICO

SLICE MODEL HISTORY MATCH
ACTUAL WELL PERFORMANCE COMPARED
TO NUMERIC MODEL CALCULATIONS

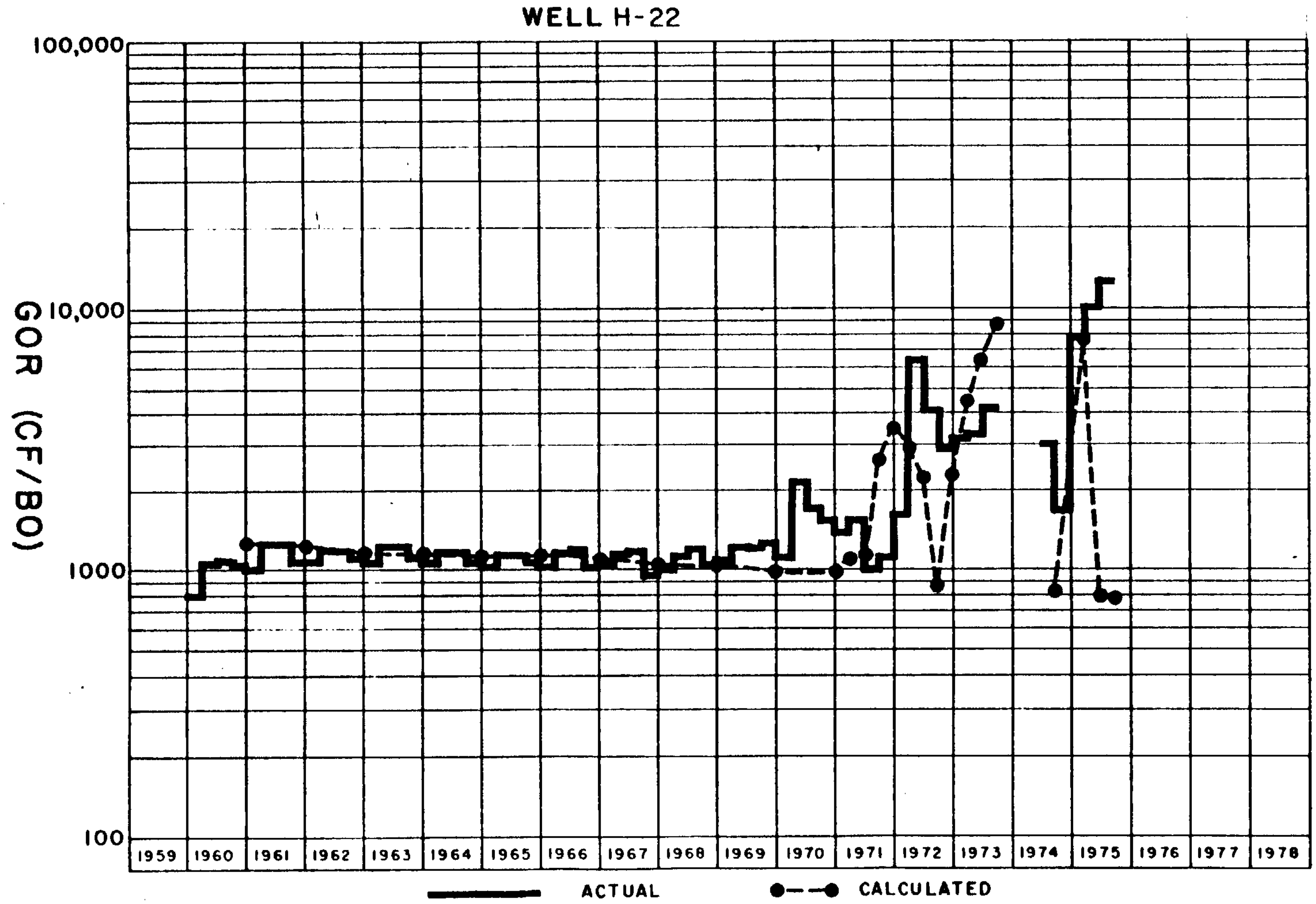


FIGURE C-13

EMPIRE ABO UNIT

EDDY COUNTY, NEW MEXICO

SLICE MODEL HISTORY MATCH

ACTUAL WELL PERFORMANCE COMPARED
TO NUMERIC MODEL CALCULATIONS

WELL H-21

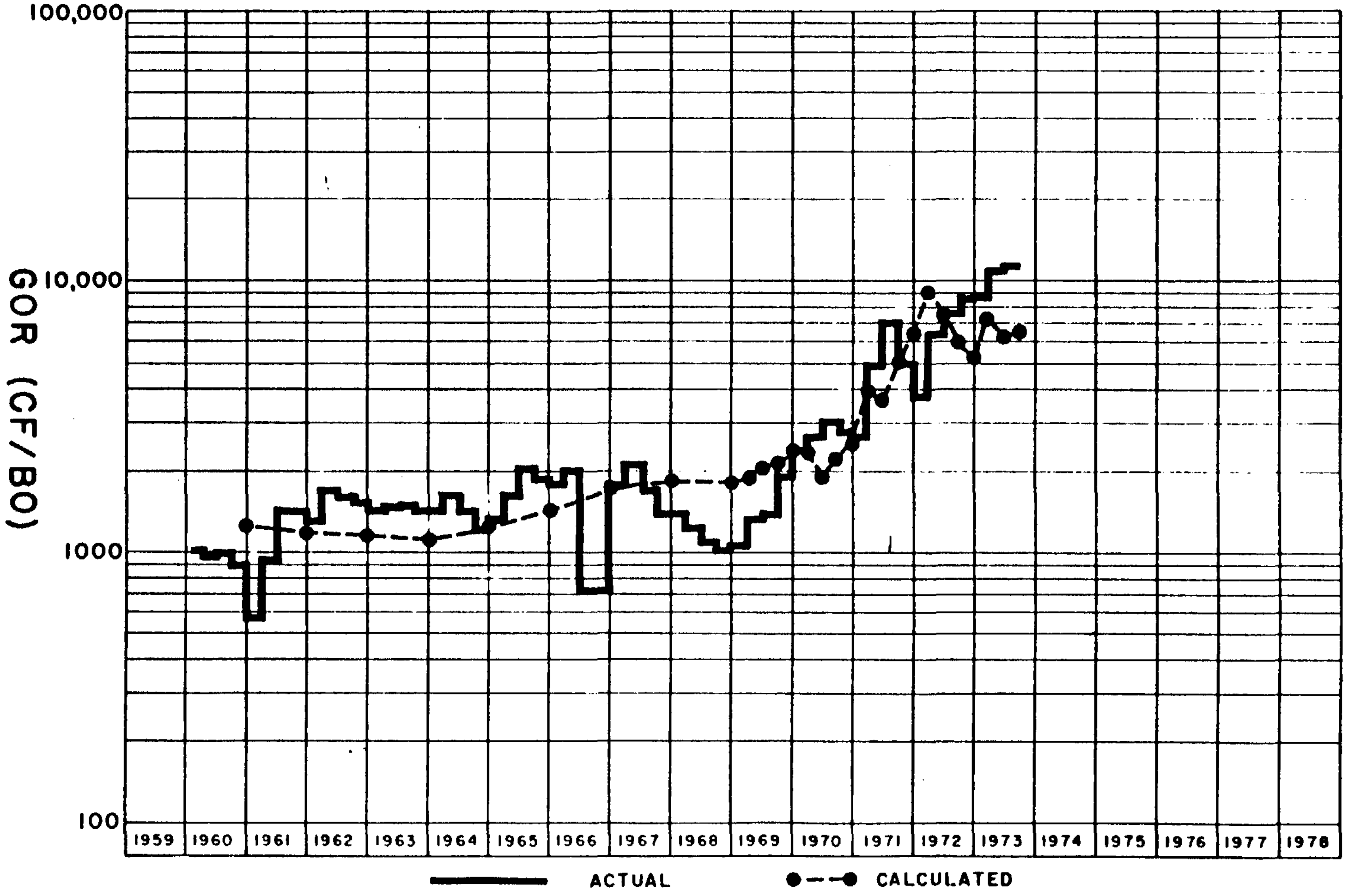


FIGURE C-14

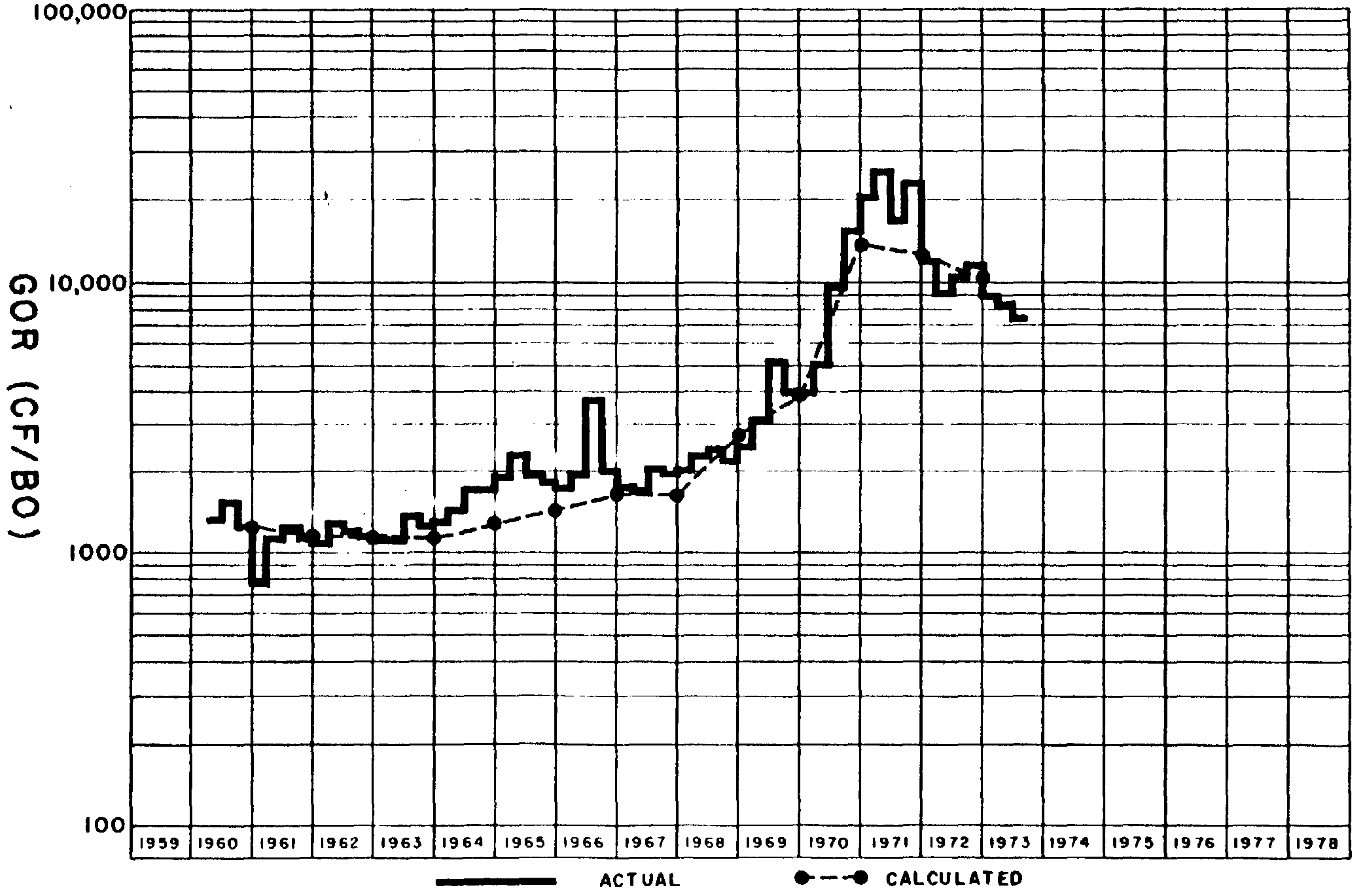
EMPIRE ABO UNIT

EDDY COUNTY, NEW MEXICO

SLICE MODEL HISTORY MATCH

ACTUAL WELL PERFORMANCE COMPARED
TO NUMERIC MODEL CALCULATIONS

WELL G-21



APPENDIX D

Energy Recoveries

Energy recovery is calculated by multiplying the remaining reserves of each product by its heating value. Table D1 lists the heating values of each product. Table D2 lists the energy recovery for the four blowdown cases studied.

Table D1. Heating Values for Oil, NGL's, and Residue Gas.

Product	Heating Value
Residue Gas	1,010,000 BTU/MCF
Ethane	65,889 BTU/gal
Propane	90,962 BTU/gal
Butane	102,918 BTU/gal
Gasoline	110,071 BTU/gal
Oil	5,500,000 BTU/STB

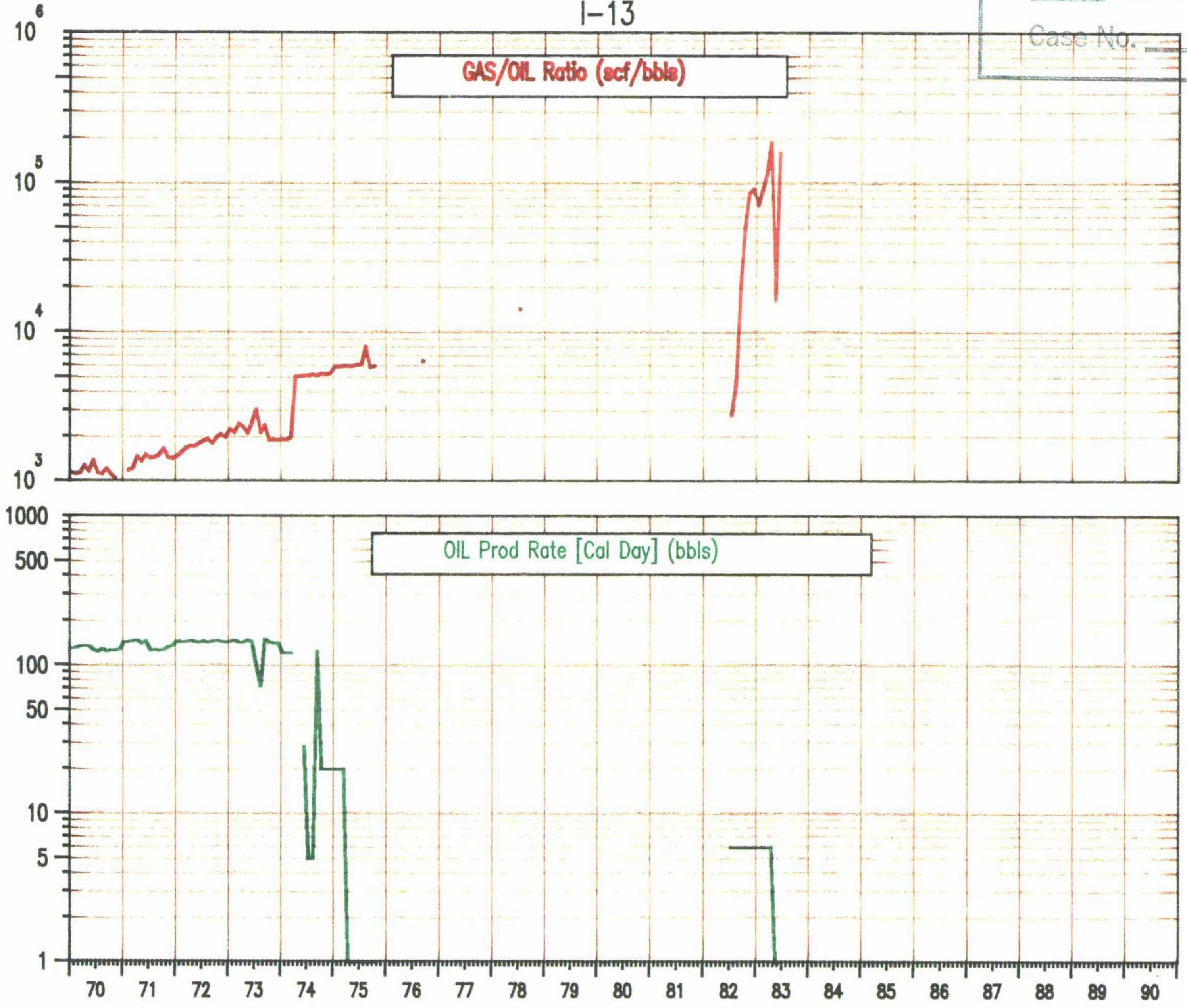
TABLE D2. Energy Recoveries.

Blowdown Start Date	1/1/85		1/1/90		1/1/95		1/1/03	
	Volume	Energy (MMMBTU)	Volume	Energy (MMMBTU)	Volume	Energy (MMMBTU)	Volume	Energy (MMMBTU)
Residue Gas	131609 MCF	132925	111195 MCF	112307	85150 MCF	86002	38297 MCF	38680
Ethane	416806 Mgal	27463	490449 Mgal	32315	564156 Mgal	37172	704748 Mgal	46435
Propane	240444 Mgal	21871	282455 Mgal	25693	329201 Mgal	29945	417943 Mgal	38017
Butane	159758 Mgal	16442	192443 Mgal	19806	229020 Mgal	23570	293266 Mgal	30182
Gasoline	52541 Mgal	5750	65562 Mgal	7216	85728 Mgal	9436	110649 Mgal	12179
Oil	8474 MSTB	46607	12970 MSTB	71335	15919 MSTB	87555	17900 MSTB	98450
		251058		268672		273680		263943

BEFORE EXAMINER STOGNER
Oil Conservation Division
OXY Exhibit No. 10
Case No. 9931

EMPIRE ABO UNIT

I-13



ARCO Oil and Gas Company
Central District
Post Office Box 1610
Midland, Texas 79702
Telephone 915 688 5200

BEFORE EXAMINER STOGNER
Oil Conservation Division
OXY Exhibit No. 11
Case No. 9931

May 21, 1990

TO: Working Interest Owners

RE: Empire Abo Unit Nos. G-24, F-27, F-31
Secs. 31, 32, 33 of T17S-R28E
Eddy County, Texas
AFE No. 915289

Dear Working Interest Owners:

Enclosed please find AFE No. 915289 for $143,100 gross to workover wells F-27, G-24, and F-31 in the Empire Abo Unit. Justification from engineer, Gary Smallwood, and other supporting documentation is included for your information. ARCO respectfully requests your prompt approval of this work. To approve, please sign and return one (1) copy of the AFE to:

ARCO Oil and Gas Company
ATTN: Janet L. McCleery - MIO 394
P.O. Box 1610
Midland, Texas 79702

If you have questions, please don't hesitate to call me at 915 688-5544 or Gary Smallwood at 915 688-5359.

Sincerely,

Janet L. McCleery

Janet L. McCleery
Operations Analyst
Southwest District

Attachments

ARCO Oil and Gas Company

☒ Original authorization
☐ Revision #

Economics ☒ Required ☐ Not required

Title
Empire Abo Unit Nos. G-24, F-27, F-31
Lower Perforations; Squeeze old perfs.

Location: Sec. 31, 32 & 33; 17S-28E Eddy Co., NM
State/county code: 30-015
AFE number: 915289

Originated by/Department: Smallwood/Engineering
District: NW-Central L40
Project or program identifier:

Field name/Play name/Prospect name: Empire Abo
Field/play code: 064185
Book property code(s): 6434266 -01

Lease record number:
Subject to prod. payment other fundings: ☐ Yes ☒ No
Well plan prepared: ☒ Yes ☐ No
Organization code:
Co-owner operator AFE No.(s)/Property code:

✓	Purpose of authorization			Reason for drilling
☐	New drilling	☐	Development %	☐ Rate ☐ Tertiary Recovery ☐ Secondary Recovery
☐	Recompletion	☐	Exploratory %	☐ Develop Reserves ☐ Replacement ☐ Service
X	Workover		Other	
☐	Drill old well deeper			☐ Combined Reserve - rate - %

✓ Primary objective of drilling (definition on reverse side)
☐ Oil only
☐ Gas only
☐ Oil/Gas

Signature Dist. Engineer and/or Exploration group: J. Nicholson

Budget information

BI code 1	Amount	BI code 2	Amount
453	52.550		

Approved capital program: budget year 19 N.A.
☐ Original budget ☐ Approved L.E. ☐ Other:
Project included in approved program ☐ Yes ☐ No
Current year expenditure can be funded by approved capital allocation ☐ Yes ☐ No
If no, amount of additional capital to be requested $

Component AFE No.(s)	Description and justification	Gen/Sub Account codes	On hand	Capital	Expense	Total
	Workovers	9501			143,100	143,100
Other	Use reverse side if more lines are needed See detail on back					

Technical Audits (✓)
Opns. mgr
Engineering
Budget
Procedural BC
Exploration
Evaluation
Land mgr

Operator: AOGC
A.O.G.C. interest decimal .36722780

Gross totals			143,100	143,100
Net A.O.G.C. share			52,550	52,550

Present worth AFIT | Invest Efficiency AFIT | Rate of return % AFIT
Chance factor (%)

			Lower	Upper
Gross Range Requested	13% Lower	Cap		
	43% Upper	Exp	124,700	204,000
Net Range Requested	13% Lower	Cap		
	43% Upper	Exp	45,793	74,914

Co-owner approval signature: ☐ Edward I Bel
Date: 6/11/90
Company: OXY USA INC.

Forecast (Net $)	Prior year	Current year	Thereafter
Capital	$	$	$
Expense	$	$ 52,550	$

Estimated start date: 5/90
Estimated completion date: 6/90

wI .753070%
pense $1078
JJ

Approvals (check highest level required)
Authorized expenditure limit table No.- 123-1

Other ☒	Date 5/14/90	Executive Vice President - A R Co ☐	Date
Vice President-A O G C ☐	Date	President-A R Co ☐	Date
Vice President-A O G C ☐	Date	Chairman of the Board ☐	Date
Senior Vice President-A O G C ☐	Date	Board of Directors ☐	Date
President-A O G C ☐	Date	☐	Date

AH3B-382-N

ARCO Oil and Gas Company is a Division of AtlanticRichfieldCompany

uthorization for Expenditure

Title

AFE No.

Component AFE No.(s)	Description and justification	Gen/Sub Account codes	Gross Amounts—In whole dollars only			
			On hand	Capital	Expense	Total
	G-24 Workover				44,700	44,700
	F-27 Workover				44,700	44,700
	F-31 Workover				53,700	53,700

Note: Include any amounts shown on this page in totals on reverse side.

Definition of primary objective of drilling.

Oil only:
Refers to a well drilled where primary objective is oil only or oil and casinghead gas.
Gas only:
Refers to a well drilled where primary objective is gas only or gas and condensate.
Oil and/or gas:
Refers to drilling in areas where primary objective is dual or uncertain.

Definition of reason for drilling.

Develop reserves:
Applies to wells drilled to develop new or additional proved reserves and attendant productive capacity. All exploratory wells plus development wells that meet the above criteria, fall in this classification.
Rate:
Applies to wells drilled to accelerate the production of existing proved reserves.
Combination reserves and rates:
Applies to wells whose economic justification is partially based on additional reserves to be developed with attendant productive capacity added, and partially based on the accelerated recovery of existing developed proved reserves. For this classification, show the percent of the economic justification which is applicable to the rate portion of the well.
Secondary recovery:
Applies to wells drilled in connection with a secondary recovery project. These may be infill wells, wells drilled to fill out flood patterns, or wells drilled to replace producers converted to injection or supply service.
Replacement:
Applies to wells drilled to replace wells that have ceased to produce.
Service:
Applies to wells drilled for the purpose of supporting production in an existing field such as gas, water, steam, and air injection; salt water disposal, water supply for injection, observation, and injection for in-situ combustion; etc.
Tertiary recovery:
Recovery tertiary reserves

ARCO Oil and Gas Company 5/7/90 **Authorization for Expenditure**

☒ Original authorization
☐ Revision #

Economics ☒ Required ☐ Not required

Title
Empire Abo Unit Nos. G-24, F-27, F-31
Lower Perforations; Squeeze old perfs.

Location: Sec. 31, 32 & 33; 17S-28E Eddv Co., NM
State county code: 30-015
AFE number: 915289

Originated by/Department: Smallwood/Engineering
District: NW-Central L40
Project or program identifier:

Field name/Play name/Prospect name: Empire Abo
Field/play code: 064185
Book property code(s): 6434266 -01

Lease record number:
Subject to prod payment other fundings: ☐ Yes ☒ No
Well plan prepared: ☒ Yes ☐ No
Organization code:
Co-owner operator AFE No (s)/Property code:

✓ **Purpose of authorization**

	New drilling	Development	%
	Recompletion	Exploratory	%
X	Workover	Other	
	Drill old well deeper		

Reason for drilling

☐ Rate ☐ Tertiary Recovery ☐ Secondary Recovery
☐ Develop Reserves ☐ Replacement ☐ Service
☐ Combined Reserve - rate %

Budget information

BI code 1	Amount	BI code 2	Amount
453	52.550		

Approved capital program: budget year 19 N.A.
☐ Original budget ☐ Approved L.E. ☐ Other:
Project included in approved program ☐ Yes ☐ No
Current year expenditure can be funded by approved capital allocation ☐ Yes ☐ No
If no, amount of additional capital to be requested $

✓ **Primary objective of drilling** (definition on reverse side)

Oil only
Gas only
Oil/Gas

Signature
Dist. Engineer and/or Exploration group
J A Nicholson

Component AFE No.(s)	Description and justification	Gen/Sub Account codes	On hand	Capital	Expense	Total
	Workovers	9501			143,100	143,100
Other	Use reverse side if more lines are needed See detail on back					

Gross amounts-in whole dollars only

Technical Audits (✓)

Opns mgr
Engineering
Budget
Procedural BC
Exploration
Evaluation
Land mgr

Operator: AOGC
AOGC interest decimal: 3 6 7 2 2 7 8 0

	Capital	Expense	Total
Gross totals		143,100	143,100
Net A O G C share		52,550	52,550

Present worth AFIT - Invest Efficiency AFIT
Rate of return % AFIT
Chance factor (%)

			Lower	Upper
Gross Range Requested	13% Lower	Cap		
	43% Upper	Exp	124,700	204,000
Net Range Requested	13% Lower	Cap		
	43% Upper	Exp	45,793	74,914

Co-owner approval signature ☐
Date: 5/11/90 Company: OXY USA INC.

Forecast (Net $)	Prior year	Current year	Thereafter
Capital	$	$	$
Expense	$	$ 52,550	$

Estimated start date: 5/90
Estimated completion date: 6/90

Approvals (check highest level required)
Authorized expenditure limit table No.- 123-1

☒ Date 5/14/90
Vice President - A O G C ☐ Date
Vice President - A O G C ☐ Date
Senior Vice President - A O G C ☐ Date
President - A O G C ☐ Date

Executive Vice President - A R Co ☐ Date
President - A R Co ☐ Date
Chairman of the Board ☐ Date
Board of Directors ☐ Date
☐ Date

AR3B 382-N

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Authorization for Expenditure

Page | of

Title

AFE No.

Component AFE No.(s)	Description and justification	Gen/Sub Account codes	Gross Amounts—In whole dollars only			
			On hand	Capital	Expense	Total
	G-24 Workover				44,700	44,700
	F-27 Workover				44,700	44,700
	F-31 Workover				53,700	53,700

Note: Include any amounts shown on this page in totals on reverse side.

Definition of primary objective of drilling.

Oil only:
Refers to a well drilled where primary objective is oil only or oil and casinghead gas.
Gas only:
Refers to a well drilled where primary objective is gas only or gas and condensate.
Oil and/or gas:
Refers to drilling in areas where primary objective is dual or uncertain.

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Rate:
Applies to wells drilled to accelerate the production of existing proved reserves
Combination reserves and rates:
Applies to wells whose economic justification is partially based on additional reserves to be developed with attendant productive capacity added, and partially based on the accelerated recovery of existing developed proved reserves. For this classification, show the percent of the economic justification which is applicable to the rate portion of the well
Secondary recovery:
Applies to wells drilled in connection with a secondary recovery project. These may be infill wells, wells drilled to fill out flood patterns, or wells drilled to replace producers converted to injection or supply service.
Replacement:
Applies to wells drilled to replace wells that have ceased to produce
Service:
Applies to wells drilled for the purpose of supporting production in an existing field such as gas, water, steam, and air injection; salt water disposal, water supply for injection, observation, and injection for in-situ combustion; etc
Tertiary recovery:
Recovery tertiary reserves

ARCO Oil & Gas Internal Correspondence

Date: May 18, 1990

Subject: Empire Abo Unit Lowering Perforations
Gas Injection Well Nos. F-27, F-31 and G-24
Eddy Co., New Mexico

From/Location: G. B. Smallwood MIO-723

Telephone: 688-5359

To/Location: J. A. Nicholson MIO-531

We recommend approval of the attached AFE for workover of the three subject gas injection wells in the Empire Abo Unit. AOGC operates the unit with a 36.7% working interest and a 31.6% oil NRI, 24.3% gas NRI and 8.07% NGL NRI. The total gross estimated cost of the three well perforating and squeezing program is $143M with a net cost to ARCO of $52.5M.

In 1984, Schumbera and Staggs completed the Empire Abo Unit Performance Projection. The projection emphasized the future of NGL performance to the unit. Two of the key findings of this projection were:

1. Half to three-quarters of the amount of each NGL component remaining in the year 1981 resides in the residual oil in the gas cap.
2. Most future NGL recovery can be attributed to contacting of residual oil with lean gas. Sweep efficiency will have an important effect.

Incremental reserves for this project are based on a comparison of the average NGL content of the entire Unit's produced gas(3.86 gal/mcf) with that of the target injection area. The target area has a NGL content of 5.25 gal/mcf. It was assumed that by moving injection gas to the area of higher NGL's that liquids would be recovered at the same rate as predicted for the field but at the higher starting point of 5.25 gal/mcf. We assumed that 3 MMCFPD per well would contact NGL's in the target area. The NGL's are recovered at the incremental rate of 1.315 gal/mcf. The rate reflects the plant's 93% overall recovery efficiency. These numbers are considered somewhat conservative since each injection well is likely to inject as much as 6 MMCFPD.

A review of the field's injection wells indicated that 45% of all injection gas had entered only 3 of the 16 gas injection wells, implying the obvious need to redistribute injection gas. Lowering the perforations in the three subject wells is consistent with our plan to redistribute gas and improve sweep efficiencies. We have attached a simple illustration showing the concept of improved sweep and NGL recovery as Figure 1B.

We have reviewed the cost estimates to kill and squeeze the subject wells with the drilling department. We were concerned that it might be extra troublesome to kill these wells. They have been on gas injection for a long time and it seemed likely they would drink a lot of fluid. It appears there are sufficient funds to cover such a case. In addition we agreed to move the completion packer above the old perforations and run tailpipe below them. See the attached wellbore schematics. This should assure future mechanical integrity tests and help protect the squeeze job from matrix acid treatments of the new perforations.

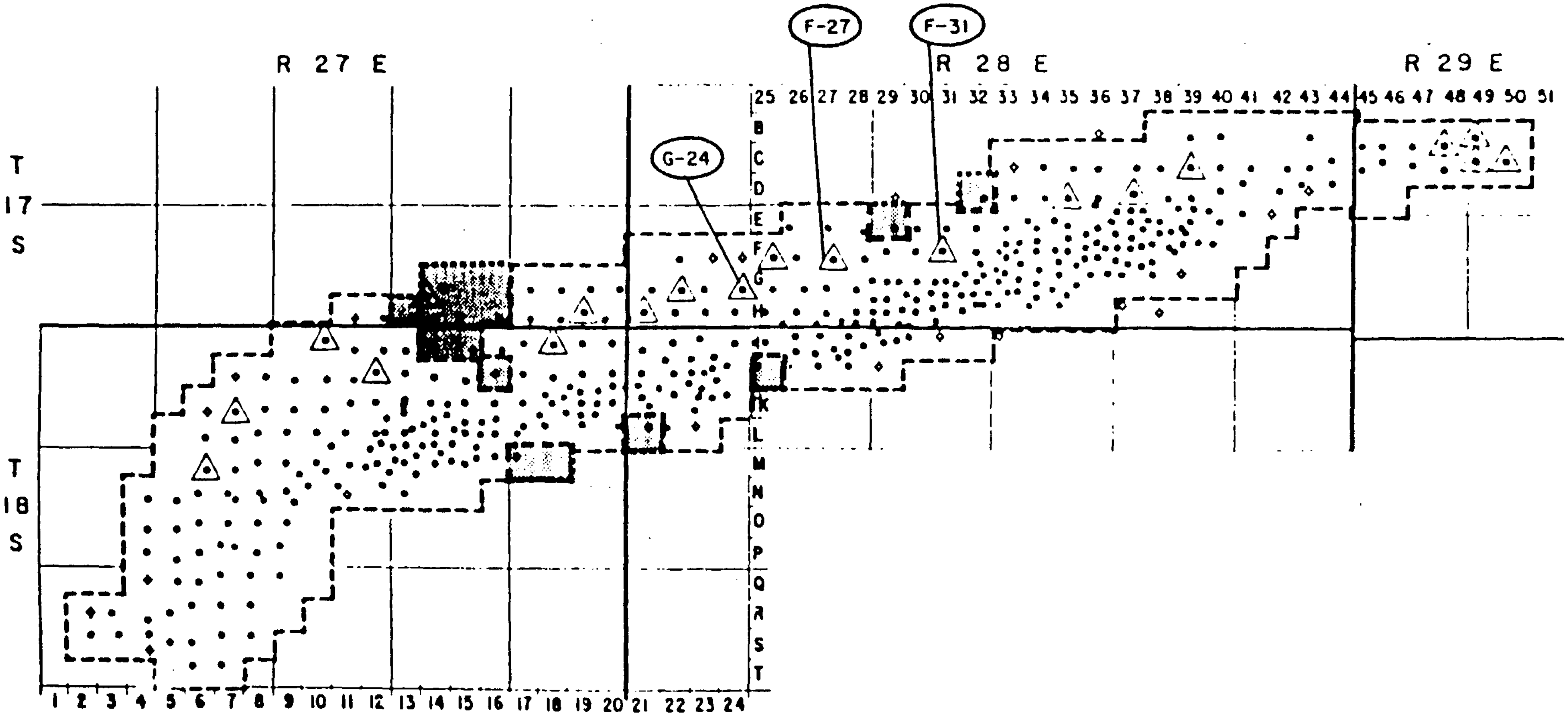
The workover of Well F-27 and G-24 includes squeezing existing perforations and perforating deeper. The workover of Well F-31 includes squeezing existing perforations, drilling out a CIBP and repairing a highly probable casing leak.

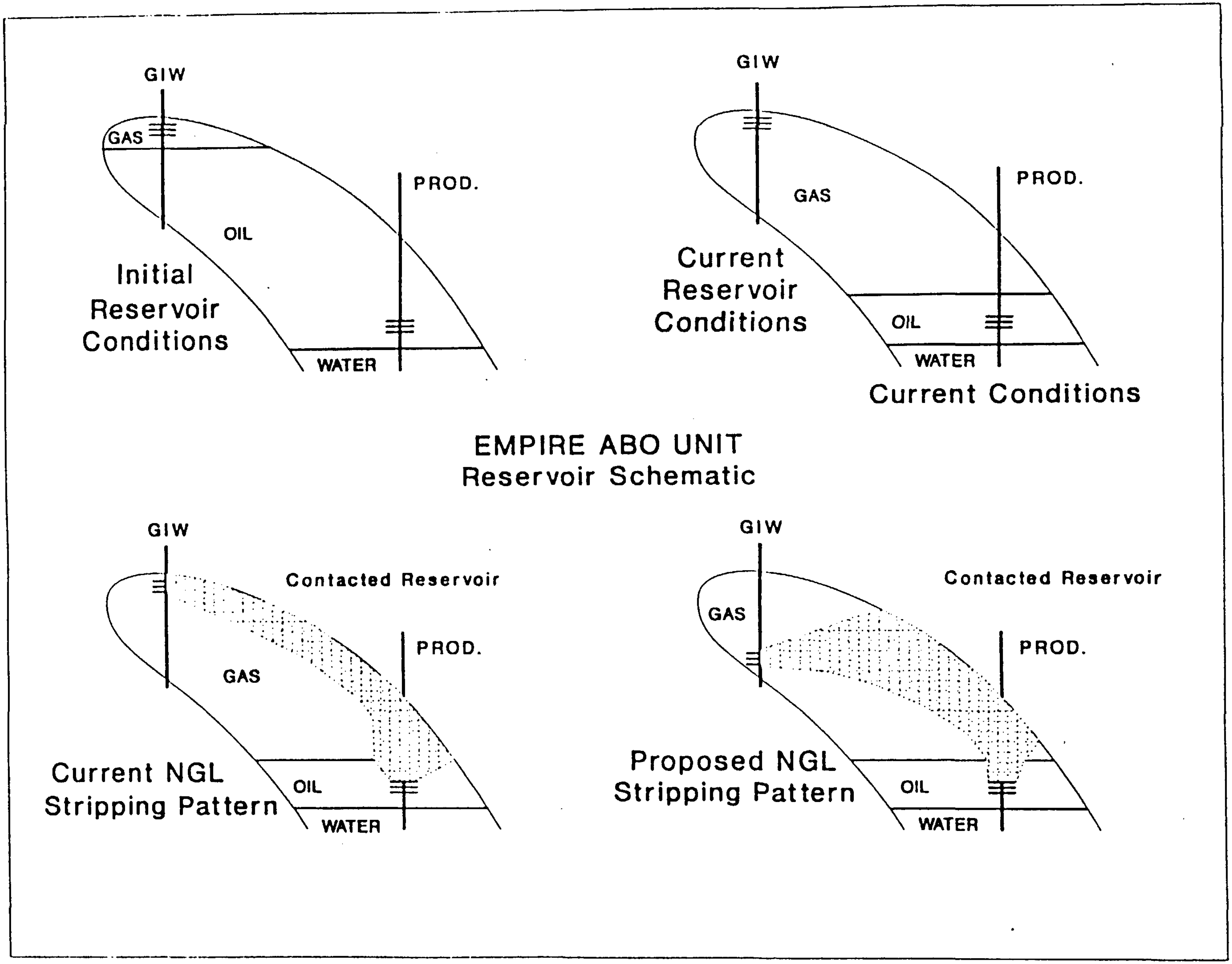
We recommend approval of the three proposed workovers.

Gary B Smallwood

Gary B. Smallwood
Sr. Engineer

EMPIRE ABO UNIT
Eddy County, New Mexico

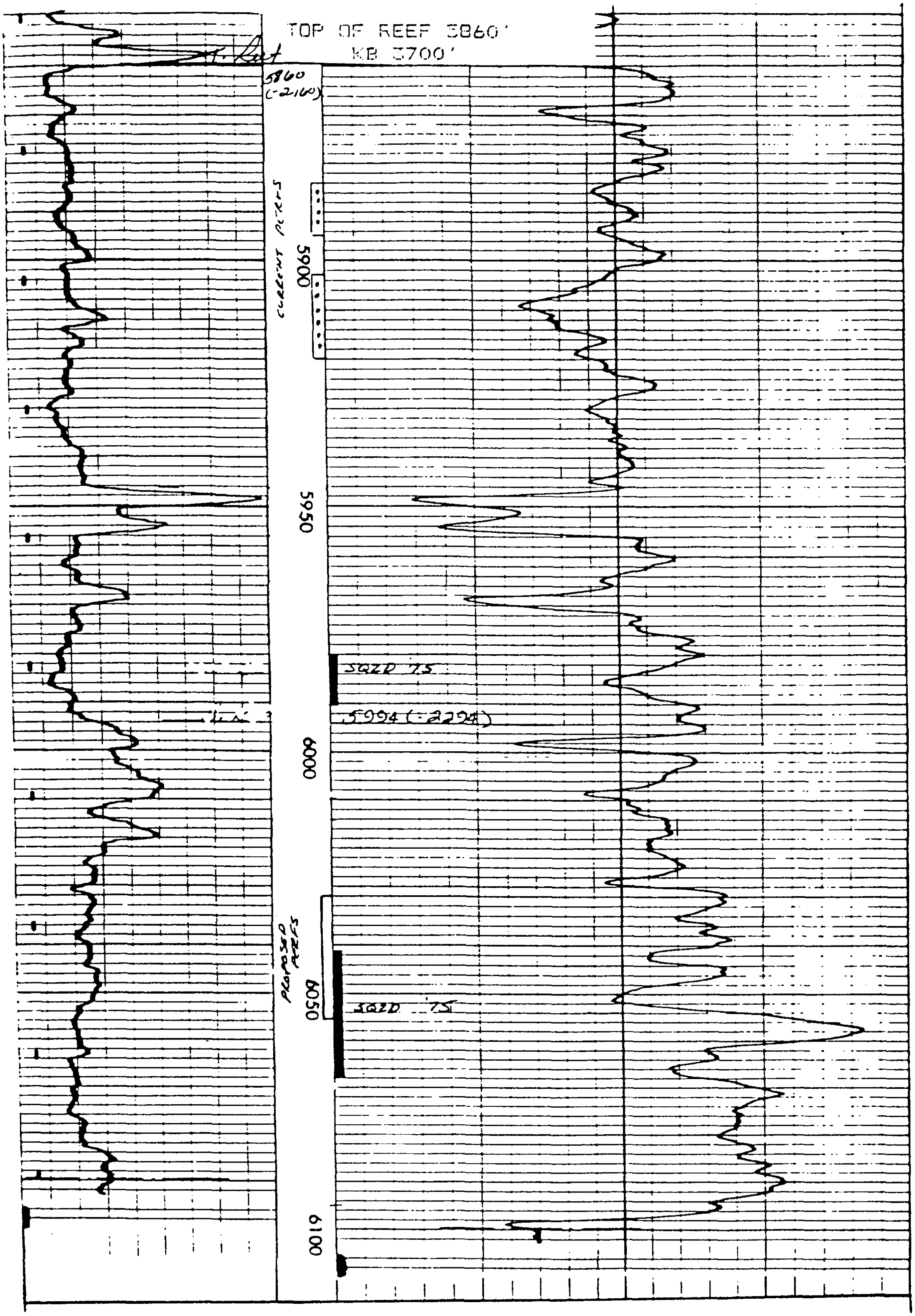




EMPIRE ABO UNIT
Reservoir Schematic

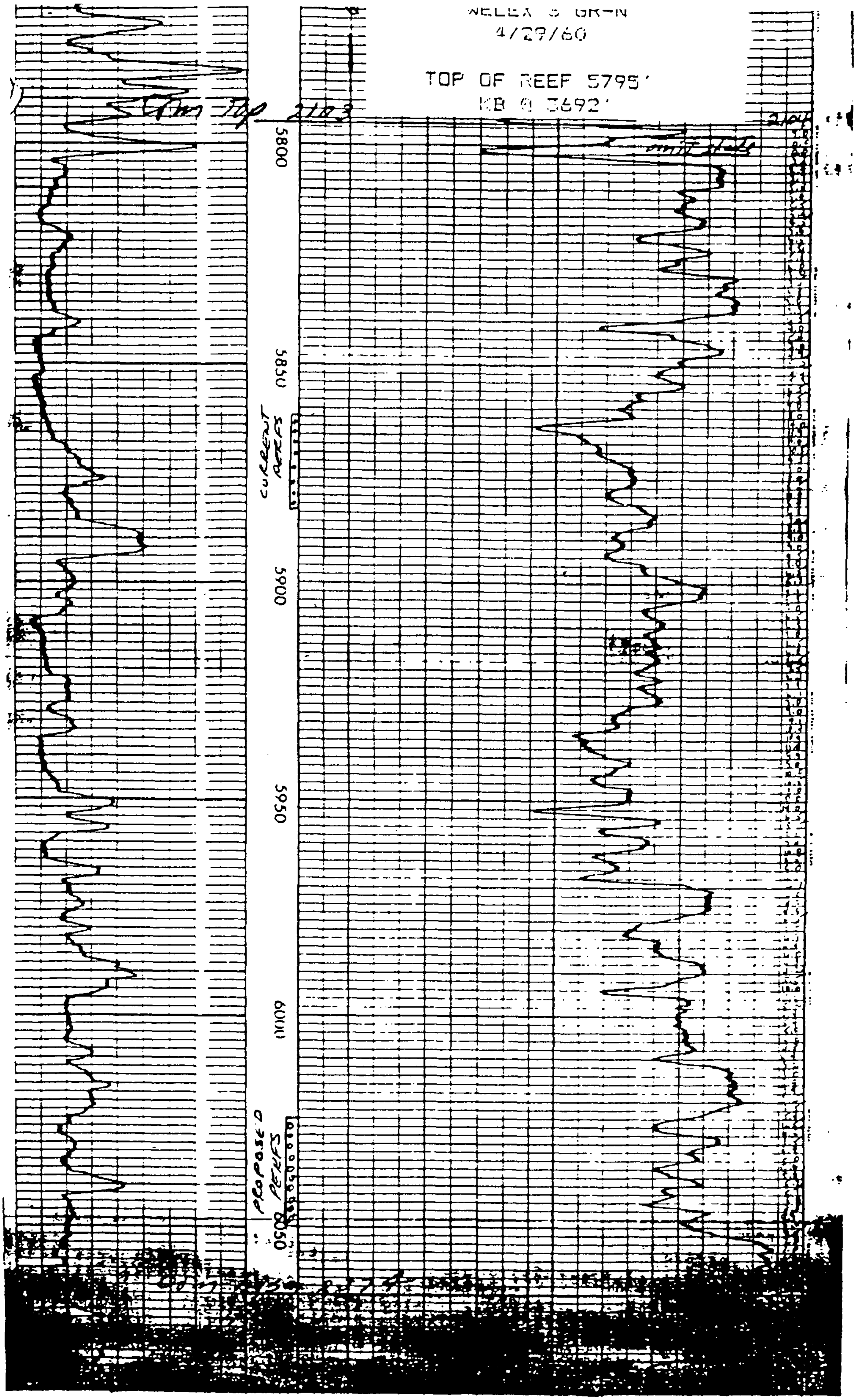
Figure 18

WELEX '' GR-N
3/23/60



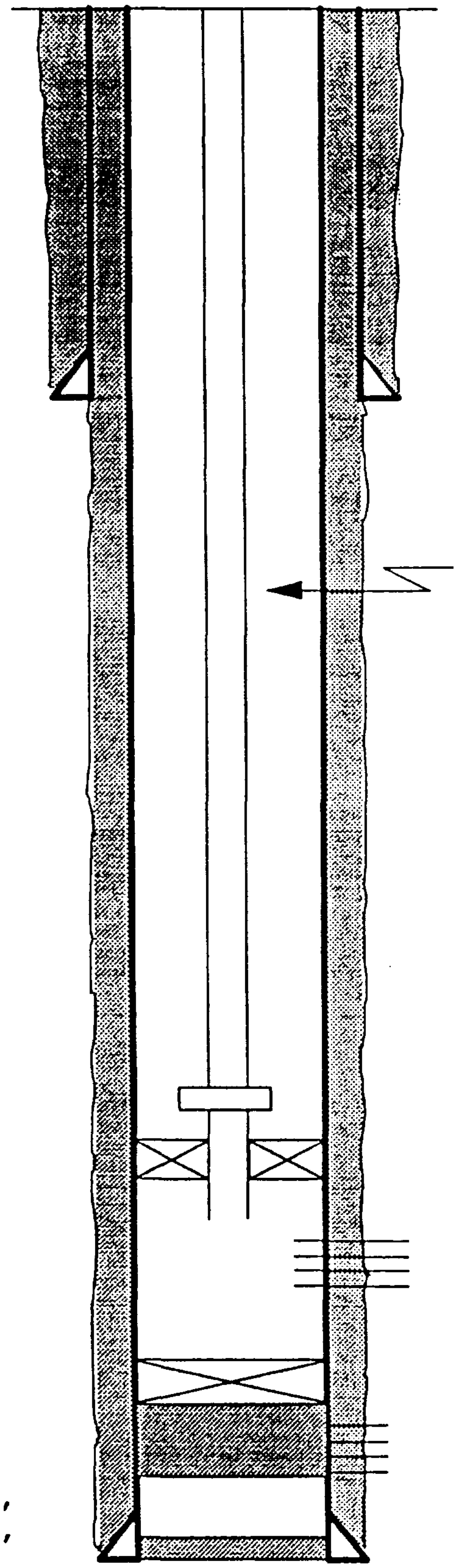
WELEX S GR-N
4/29/60

TOP OF REEF 5795'
KB @ 3692'



Empire Abo Unit F-27 GIW

SUBJECT: PRESENT STATUS *BY: D.C. BRETCHES*



DATUM: RKB(11')

8-5/8" 28# J55 Surf CSG
set @ 1003'. CMTD w/ 450 sx.
TOC: SURF

184 jts 2-3/8" 4.7# 8RDEUE
J55 IPC TBG Btm'd @ 5790'

ER Receptacle w/ 1.81" R Profile
Baker 5-1/2" Lok Set PKR @ 5790'
1 jt 2-3/8" 4.7# 8RDEUE J55 IPC TBG

Open Abo Perfs 5884,86,88,93,95,
5905,07,09,11,13,18,& 20 (12 holes)

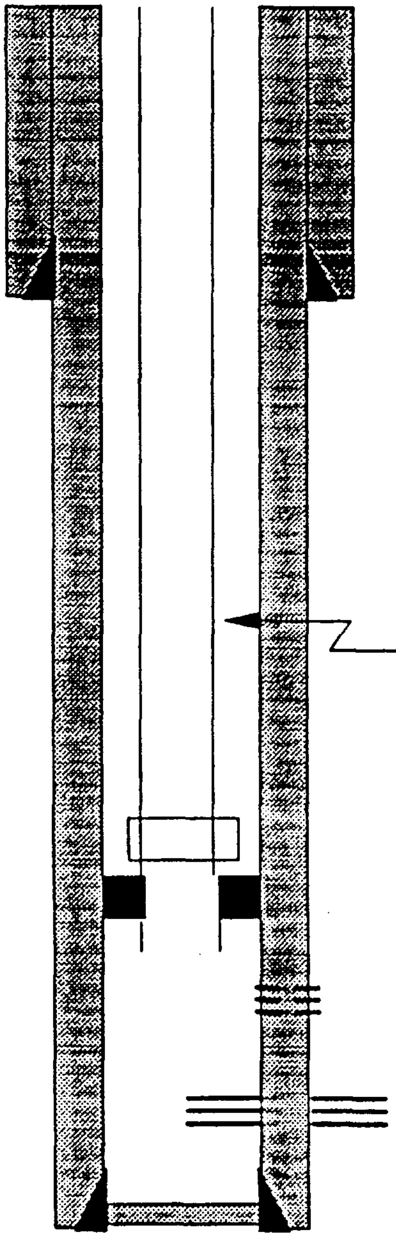
CR set @ 5941'

Squeezed Abo Perfs
5980-90' (20 holes) $ 6041-68' (15 holes)
Squeezed w/ 150 sx cmt

PBD: 5941'
TD: 6108'

5-1/2" 15.5# J55 Prod CSG
set @ 6108'. CMTD w/ 170 units &
150 sx. TOC: Surf

Empire Abo Unit F-27 GIW
Proposed Status



8-5/8" 28# J55 @ 1003'.
Cmt. w/450 sx

2-3/8" 4.7# EUE
J55 IPC

ER Receptacle w/ 1.81" R Profile
Baker 5-1/2" Lok set with
1 jt. 2-3/8" 4.7# EUE J55 IPC Tbg.

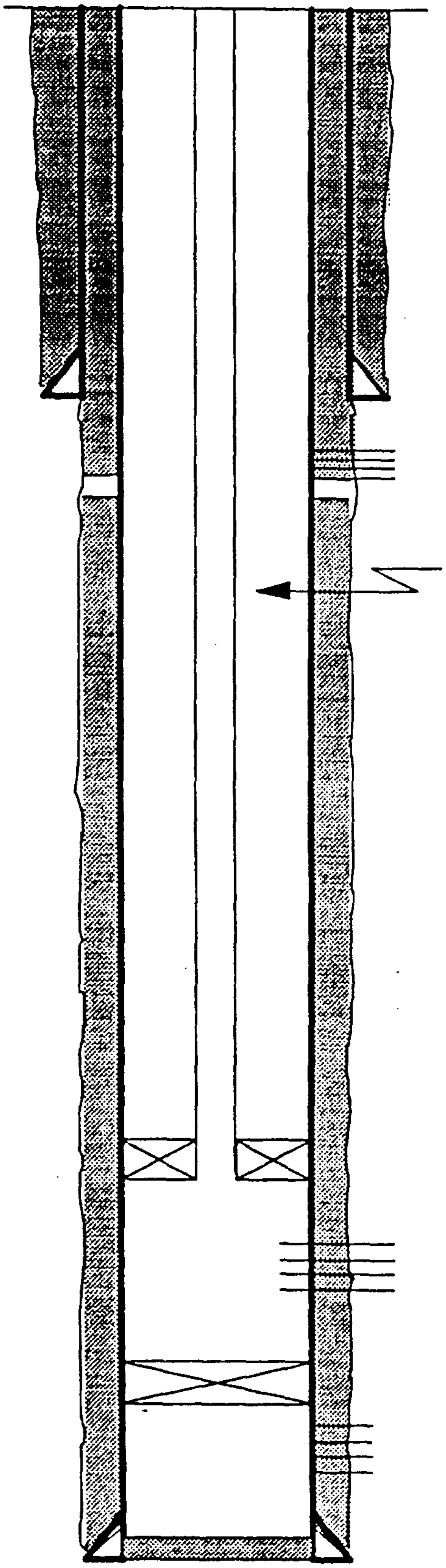
Squeezed Abo Perfs 5884'-5920'
12 holes.

Proposed Abo perfs. 6030'-55' (50 holes)

5-1/2" 15.5# J55 @ 6108'.
PBD= 6070'
TD= 6108'

Empire Abo Unit F-31 GIW

SUBJECT: PRESENT STATUS *BY: D.C. BRETCHES*



DATUM: GL

8-5/8" 23# SW SJ Surf CSG
set @ 1000'. CMTD w/ 650 sx.
TOC: SURF

Squeeze perfs @ 1248'

184 jts 2-3/8" 4.7# 8RDEUE
J55 IPC TBG Btm'd @ 5753'

Guiberson H-1 Hydraulic Holddown Anchor
Guiberson KVL-30 Production Packer
set @ 5753'

Open Abo Perfs 5828,34,40,50,55,
60,69,76,81, & 87 (10 holes)

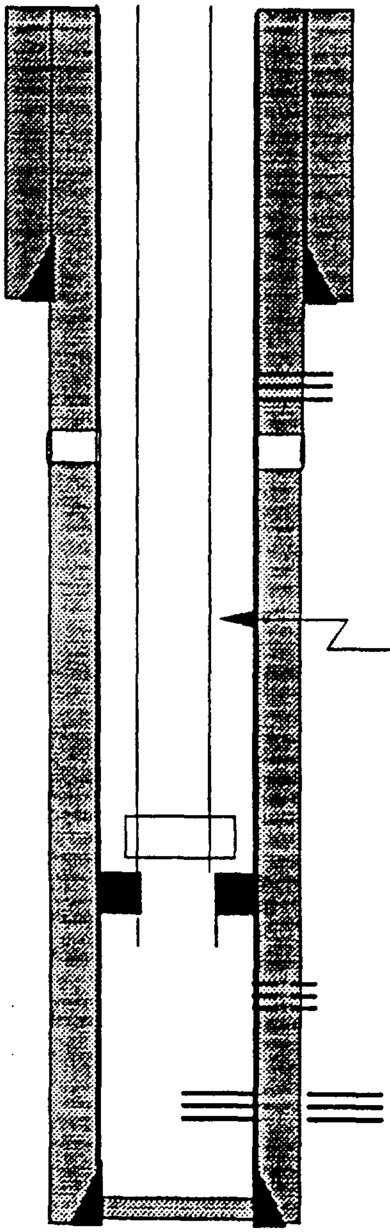
CIBP set @ 6050'

Isolated Abo Perfs
6107-34' (54 holes)

PBD: 6050'
TD: 6175'

4-1/2" 9.5# & 11.6# J55 Prod CSG
set @ 6175'. CMTD w/ 800 sx
TOC: Surf

Empire Abo Unit F-31 GIW
Proposed Status



8-5/8" 23 ppf, SW, SJ @ 1000'
Cmt. w/650 sx

Squeeze perfs. @ 1248'

2-3/8" 4.7# EUE
J55 IPC

Baker FL on/off w/1.81" R Profile
Baker 5-1/2" Lok set with
1 jt. 2-3/8" 4.7# EUE J55 IPC Tbg.

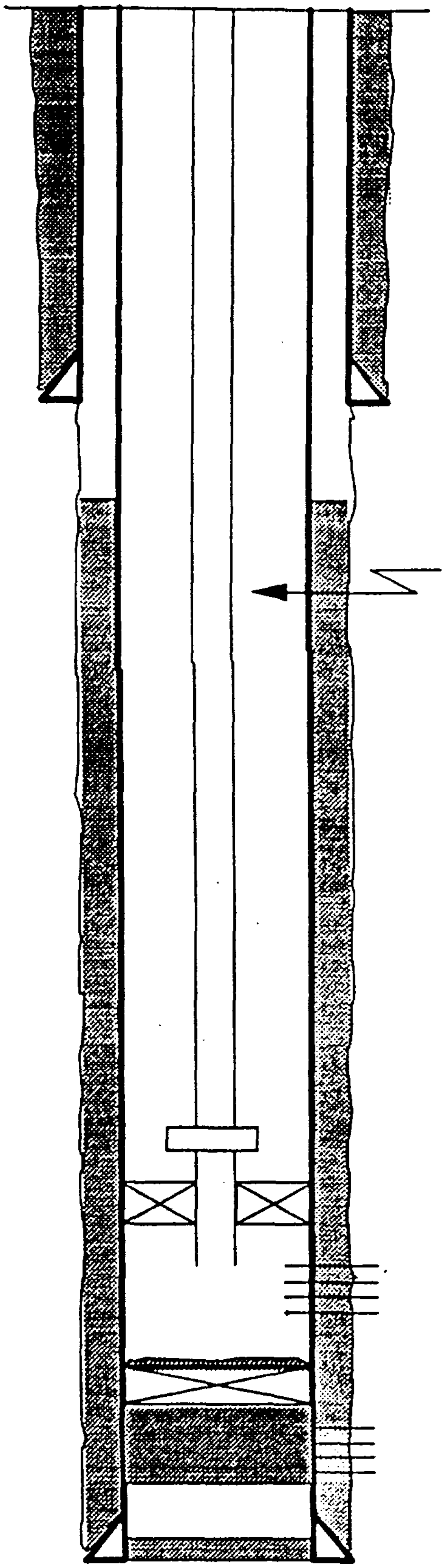
Squeezed Abo Perfs 5828'-87'
10 holes.

Proposed Abo perfs. 6107-34' (54 holes)

4-1/2" 9.5 & 11.6 ppf, J-55 @ 6175'
PBD= 6157'
TD= 6175'

Empire Abo Unit G-24

SUBJECT: PRESENT STATUS *BY: D.C. BRETCHES*



DATUM: GL

8-5/8" 28# J55 Surf CSG
set @ 750'. CMTD w/ 250 sx.
TOC: SURF

186 jts 2-3/8" 4.7# 8RDEUE
J55 IPC TBG Btm'd @ 5787'

ER Receptacle w/ 1.81" R Profile
Baker 5-1/2" Lok Set PKR @ 5787'
1 jt 2-3/8" 4.7# 8RDEUE J55 IPC TBG

Open Abo Perfs
5862-83' (22 holes)

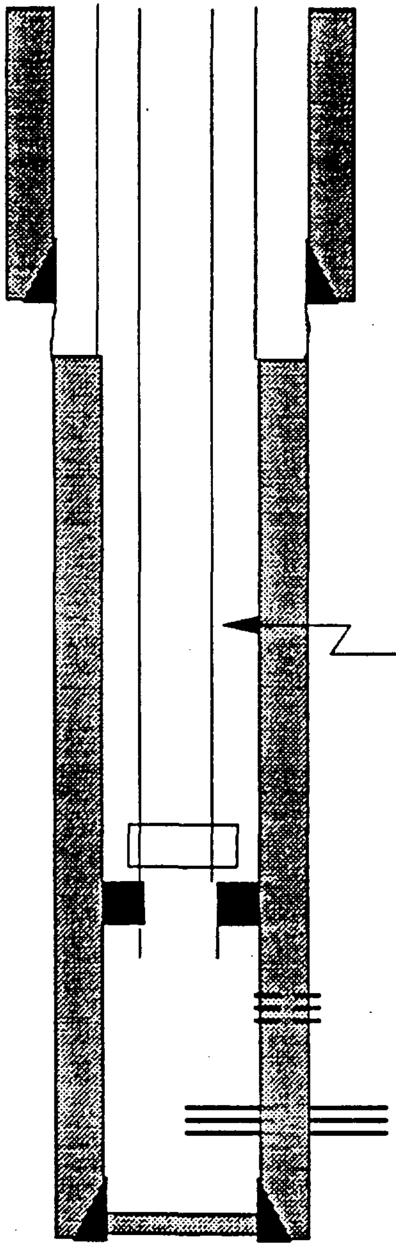
Top of fill on CR @ 5952'

5-1/2" CR set @ 5960
Original Abo Perfs
6024-44' (40 holes)
Squeezed w/ 175 sx cmt

PBD: 5952'
TD: 6106'

5-1/2" 15.5# J55 Prod CSG
set @ 6104'. CMTD w/ 1100 sx
TOC: 1000' - Calculated

Empire Abo Unit G-24 GIW
Proposed Status



8-5/8" 28# J55 @ 750'.
Cmt. w/ 250 sx

2-3/8" 4.7# EUE
J55 IPC

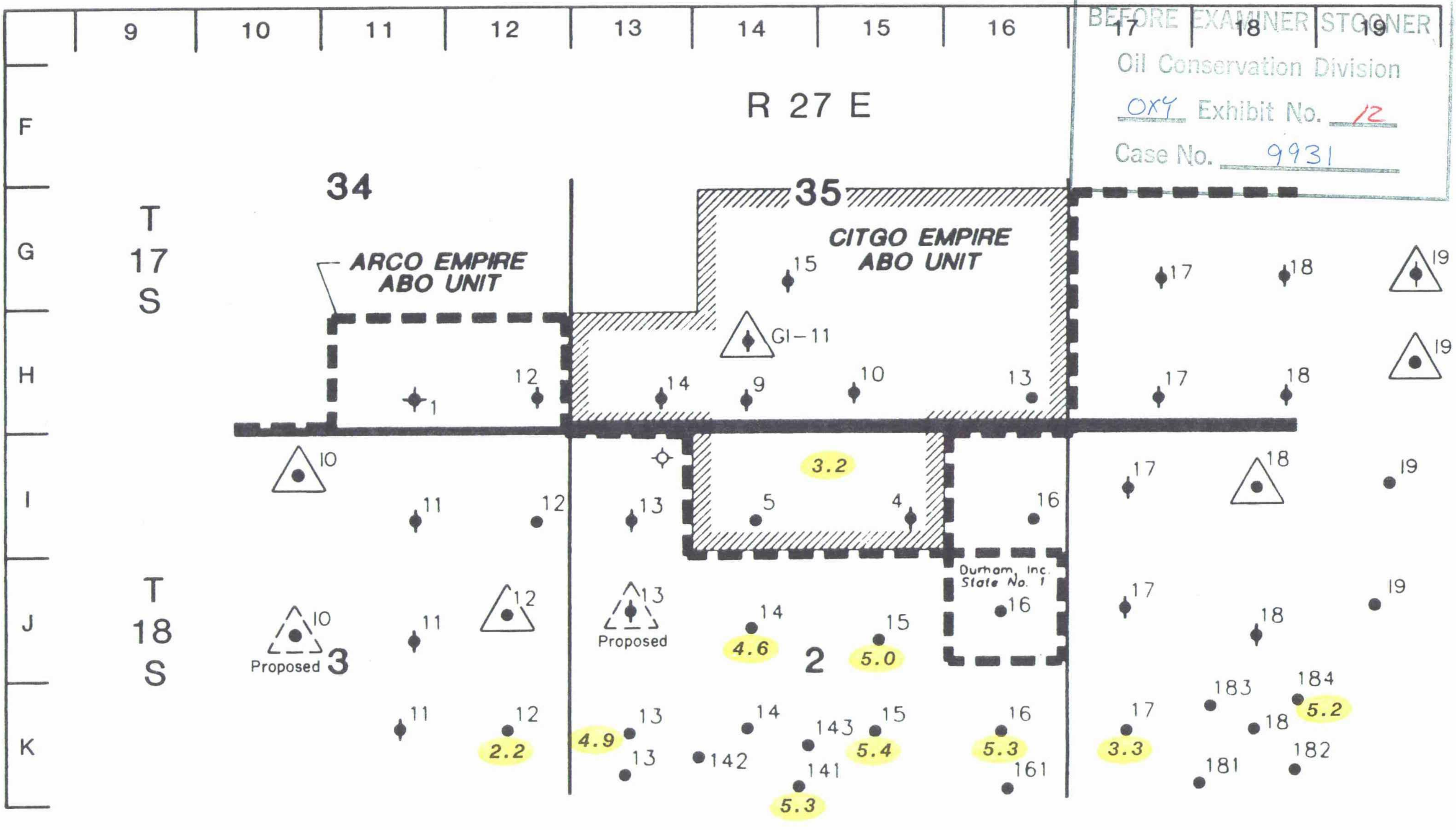
ER Receptacle w/ 1.81" R Profile
Baker 5-1/2" Lok set with
1 jt. 2-3/8" 4.7# EUE J55 IPC Tbg.

Squeezed Abo Perfs 5862'-83'
(22 holes).

Proposed Abo perfs. 6024'-50' (52 holes)

5-1/2" 15.5# J55 @ 6104'. TOC @ 1000' Calc.
PBD= 6068'
TD= 6106'

BEFORE EXAMINER STOGNER
Oil Conservation Division
OXY Exhibit No. 12
Case No. 9931



- △ PROPOSED INJECTION WELL
- ▲ INJECTION WELL
- △ INACTIVE INJECTION WELL
- ● PRODUCING WELL
- ♦ INACTIVE PRODUCING WELL

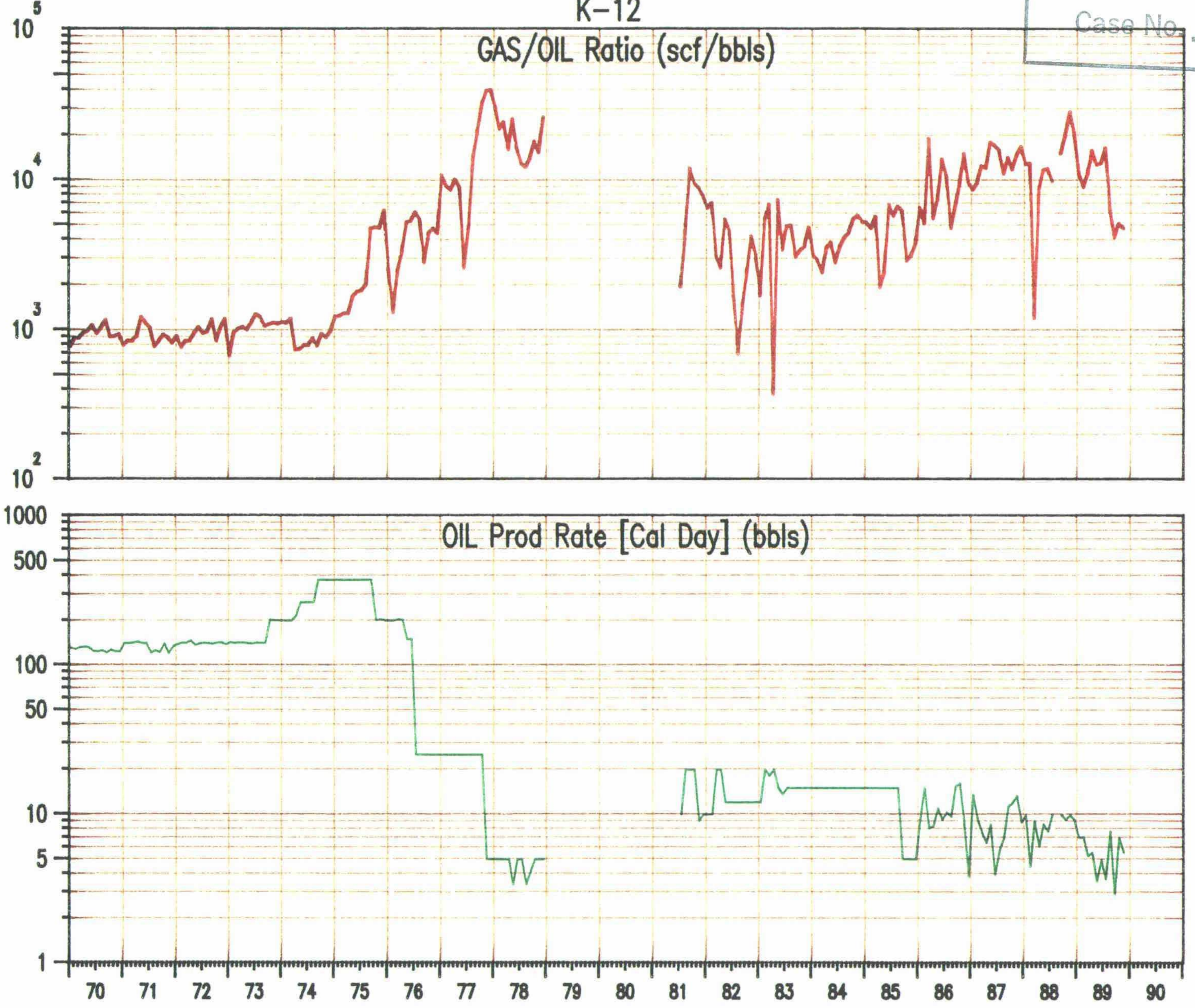
X.X NGL YIELDS (gpm)

EMPIRE ABO FIELD
EDDY CO., NEW MEXICO
NGL YIELDS

SCALE: 1":1500' JUNE, 1990

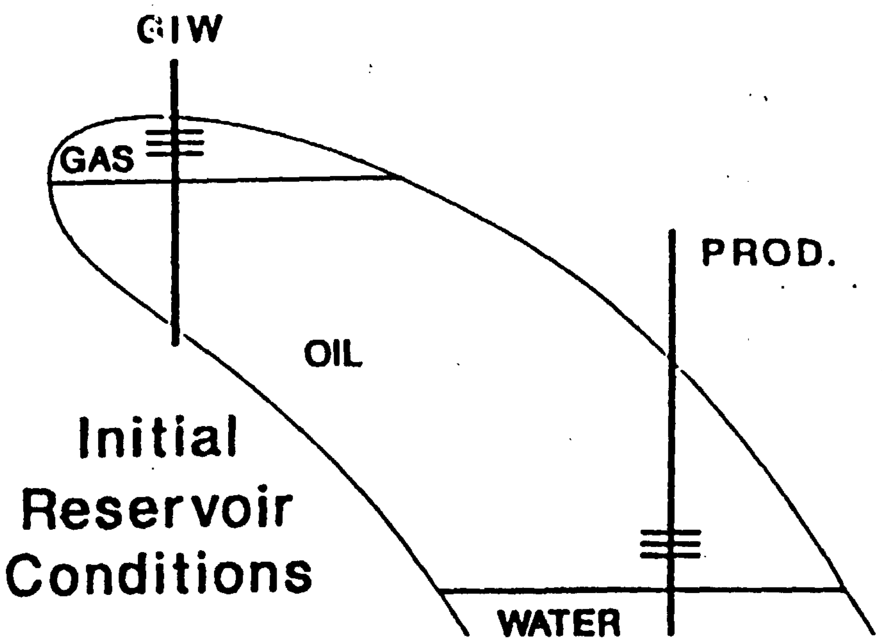
BEFORE EXAMINER STOGNER
Oil Conservation Division
OXY Exhibit No. 13
Case No. 9931

EMPIRE ABO UNIT
K-12

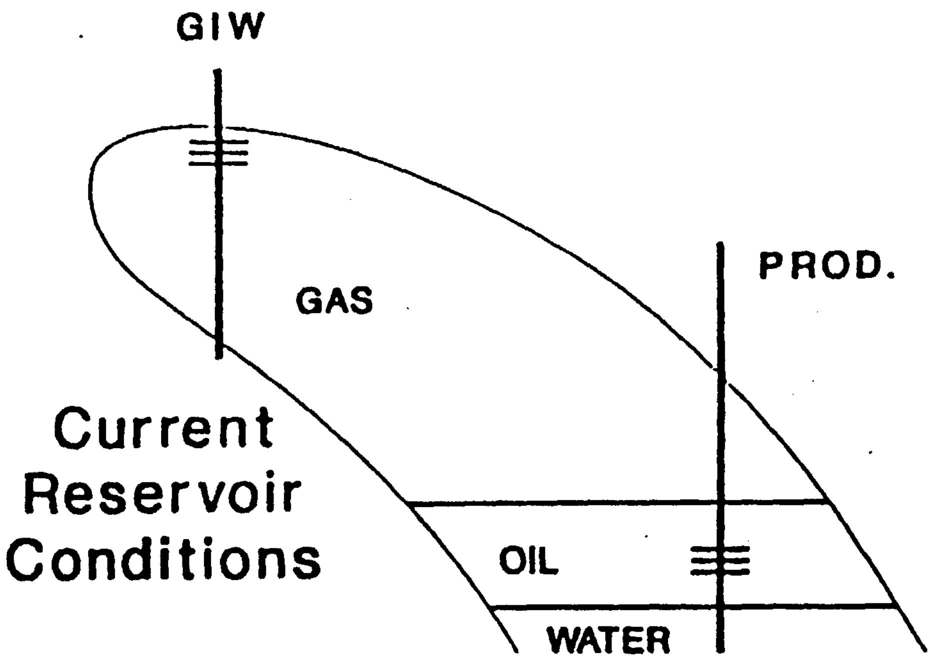


BEFORE EXAMINER STOGNER
Oil Conservation Division
OXY Exhibit No. 14
Case No. 9931

EMPIRE ABO UNIT
Reservoir Schematic

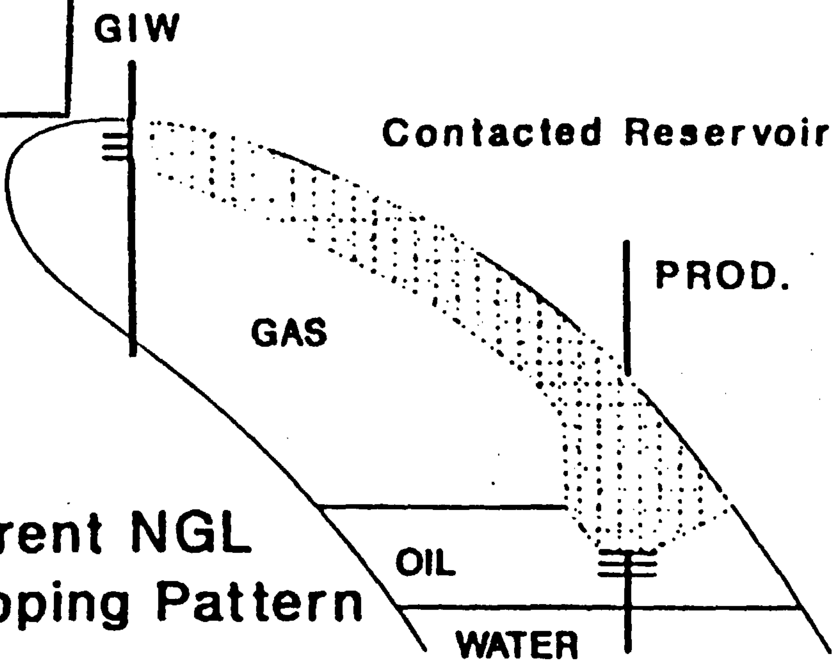


Initial Reservoir Conditions

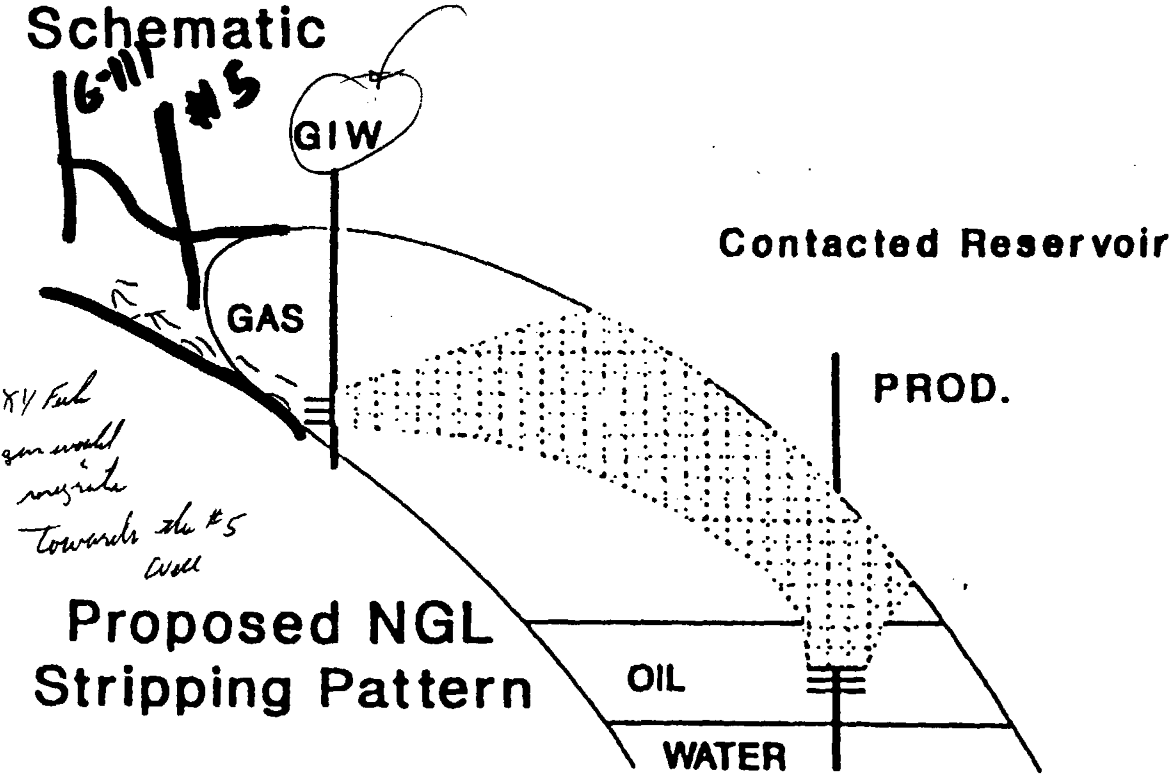


Current Reservoir Conditions

Current Conditions



Current NGL Stripping Pattern



OXY Feels gas would migrate towards the #5 well

Proposed NGL Stripping Pattern

```
1S55I  LAST RETURN CODE WAS 0000
*  STEP 7  PRINT STAT WELL LIST FOR SELECTED OPERATOR(S)
// DLBL IJSYSU2,'USER.VSAM.CATALOG.TWO',,VSAM,CAT=IJSYSCT
// DLBL SYS011,'OCD.MASTER.OPER',,VSAM,CAT=IJSYSU2
// DLBL SYS012,'OCD.MASTER.POOL',,VSAM,CAT=IJSYSU2
// DLBL SYS010,'OCD.MASTER.LEASE',,VSAM,CAT=IJSYSU2
// DLBL SYS008,'TAPE.FILE'
// EXTENT SYS008,WIMEDA,1,0,1,10000
// EXEC STAT1291,SIZE=64K
```