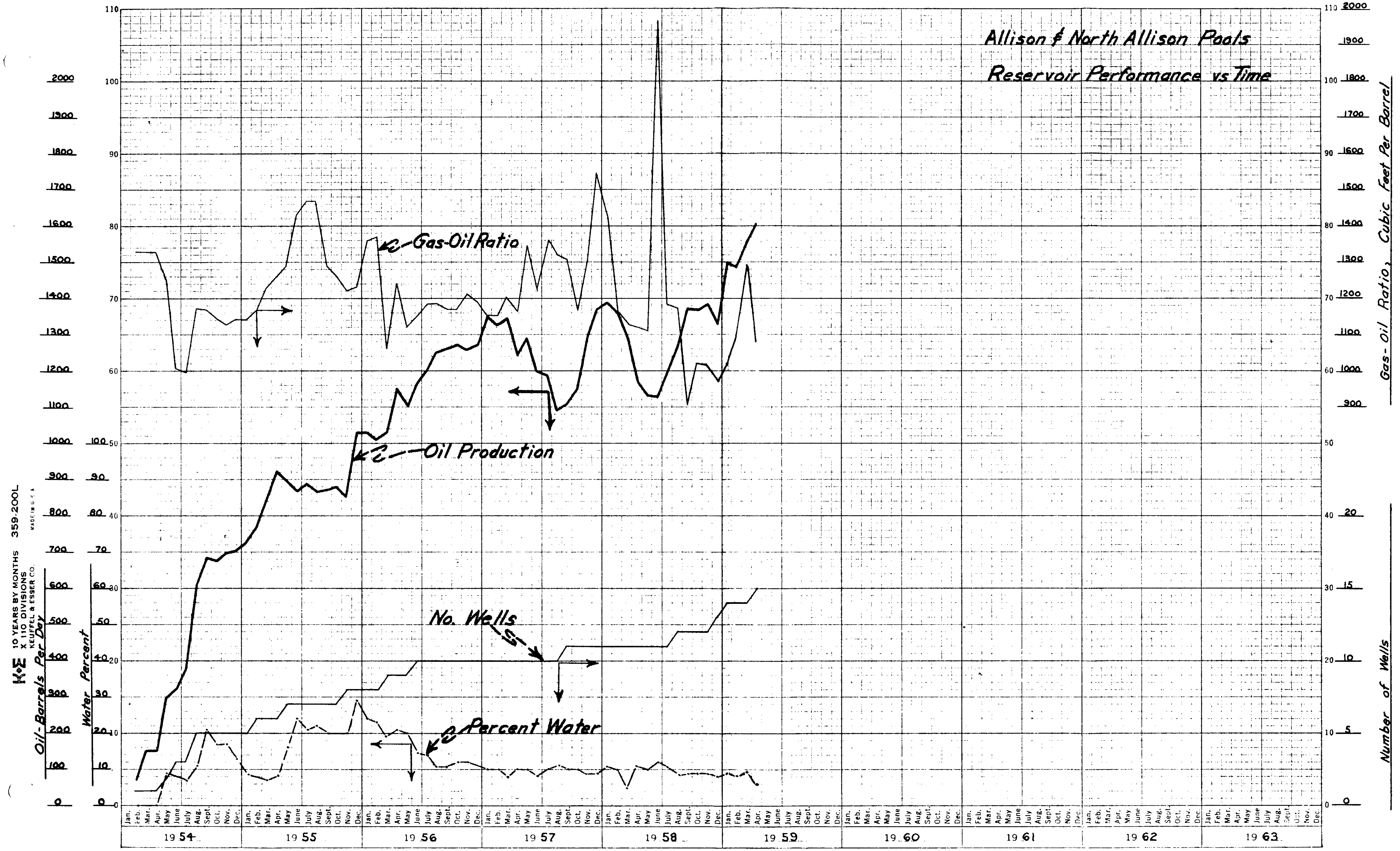
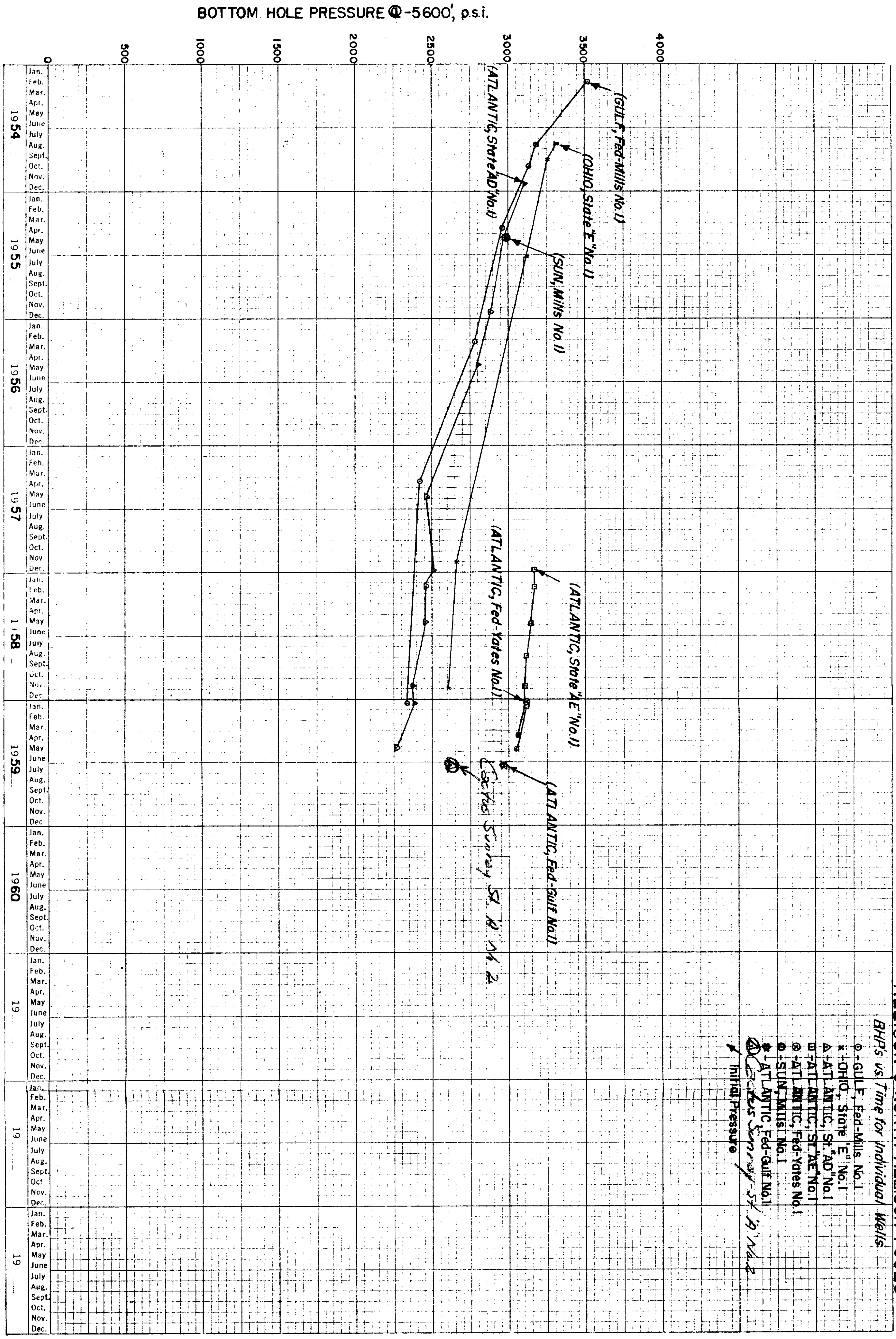


Allison & North Allison Pools
Reservoir Performance vs Time
Gas-Oil Ratio
Oil Production
No. Wells
Percent Water
Oil-Barrels Per Day
Water Percent
Gas-Oil Ratio, Cubic Feet Per Barrel
Number of Wells
K+E 10 YEARS BY MONTHS X 110 DIVISIONS 359-200L
KEUFFEL & ESSER CO. MADE IN U.S.A.
1954
1955
1956
1957
1958
1959
1960
1961
1962
1963

K&E 10 YEARS BY MONTHS X 110 DIVISIONS 359-200L
KEUFFEL & ESSER CO. MADE IN U.S.A.



BASIC DATA
ALLISON AND NORTH ALLISON POOLS

1. Physical Properties of Reservoir Rock
   - A. Porosity - 5.15% (Avg. of 5 cores)
   - B. Permeability - 107.2 md. (Avg. of 5 cores)
   - C. Saturation - estimated 75% oil, 25% water
   - D. Type of porosity - matrix and vugular

2. Structural Features
   - A. WOC - undetermined
   - B. GOC - none observed
   - C. Gross pay thickness - Bough "C" - 30-50'
   - D. Arithmetic avg. net pay thickness - 8.94'
   - E. Dip - gentle, 100' to 150' per mile
   - F. Anticlinal structure - limits undefined

3. Fluid Characteristics
   - A. Average oil gravity - 48° API
   - B. Salinity of water - 107,316 ppm, NaCl
   - C. Saturation pressure - 3150 psig
   - D. Solution gas-oil ratio - 1517 CF/B at 3150 psia
   - E. Formation volume factor - 1.821 at 3518 psi
   - F. Viscosity of oil - .19 cp at 3150 psi
   - G. Compressibility of saturated oil at 156°F - from 3150 psi to 5000 psi - 23.03×10^{-6} Vol/vol/psi

4. Pressures And Temperatures
   - A. Original pressure - 3518 psig
   - B. Reservoir temperature - 156°F
   - C. January, 1959, weighted average pressure at -5600' - 2734 psig (Shut-in from 72 hours to 168 hours prior to test)
   - D. Average productivity index - 5.01 (Range: 2.22 - 11.88)

5. Statistical Data
   - A. Oil production rate - 47,447 barrels for April, 1959
   - B. Cumulative oil production to 5-1-59 - 1,998,553 barrels
   - C. Average GOR - see graph
   - D. Water production - see graph
   - E. Well count - 18 producing, 1 drilling, 2 dry

6. Well Completion Methods - Casing Perforations Most Common

7. Area Within Recommended Boundary - 2320 Acres

8. Average Well Density - 80 Ac/Well

9. Disposition of Gas for Month of April, 1959
   - A. Vent - 7810 MCF
   - B. Lease - 1374 MCF
   - C. Sold - 47,162 MCF (Sinclair, Magnolia, Phillips)

ALLISON POOL
LEA COUNTY, NEW MEXICO
SUMMARY OF CORE ANALYSES

OPERATOR:	Gulf	Gulf	Magnolia	Magnolia	Magnolia	Average
LEASE AND WELL:	Fed. Mills #1	Fed. Mills #2	Fed. Childers #1	Fed. Childers #2	Fed. Cox #2	-
PAY INTERVAL FROM CORE:	9677-9698'	9694-9705.3'	9687-9704'	9692-9717'	9708-9711.2'	-
NET PAY FROM CORE:	11.0'	9.4'	4.5'	10.4'	3.2'	7.7'
WEIGHTED AVERAGE POROSITY:	6.7%	8.1%	1.8%	3.5%	1.3%	5.15%
WEIGHTED AVERAGE PERMEABILITY:	301 md.	80.6 md.	.7 md.	6.0 md.	.3 md.	107.2 md.

NET PAY BY WELLS
ALLISON AND NORTH ALLISON POOLS

OPERATOR, LEASE & WELL	NET PAY, FT.
Ada Oil Co.	
Adams St. No. 1	6
Atlantic Refining Co.	
Federal-Gulf No. 1	20
Federal-Yates No. 1	9
State "AD" No. 1	4
State "AE" No. 1	13
Cactus Drilling Co.	
Sunray State "A" No. 1	10
Sunray State "A" No. 2	4
Gulf Oil Corp.	
Mills (Fed.) No. 1	11
Mills (Fed.) No. 2	9
Magnolia Petroleum Co.	
Childers (Federal) No. 1	7
Childers (Federal) No. 2	12
Cox (Federal) No. 1	7
Cox (Federal) No. 2	3
Ohio Oil Co.	
State "A" No. 1	5
State "A" No. 2	10
Sun Oil Co.	
R. G. Mills No. 1	9
Trice Production Co.	
Merrill No. 1	13

Arithmetic Average Thickness - 8.94'

VOLUMETRIC CALCULATION
FOR OIL IN PLACE - 40 ACRE TRACT
ALLISON AND NORTH ALLISON POOLS
LEA AND ROOSEVELT COUNTIES,
NEW MEXICO

$$N_1 = \frac{7758 \times \phi \times (1 - Sw) \times h \times A}{B_o}$$

$$= \frac{7758 \times .0515 \times (1 - .25) \times 8.94 \times 40}{1.821}$$

= 58,841 barrels

A recovery factor of 30% is believed to be reasonable for the Allison and North Allison Pools. Recoverable oil per 40-acre location would therefore be:

Recoverable oil = .30 x N_1

= .30 x 58,841 barrels

= 17,652 barrels

Definition of Symbols:

N_1 = Original oil in place per 40 acre tract, stock tank barrels

ϕ = Porosity as a fraction, .0515

Sw = Interstitial water saturation, fraction of pore space - .25

h = Net pay thickness, feet - 8.94

A = Area for which oil in place is being calculated - 40 acres

B_o = Original oil formation volume factor, barrels of reservoir space per barrel of stock tank oil - 1.821

7758 = Number of barrels per acre-foot

VARIATIONS REQUIRED IN APPLIED
DATA TO ACCOUNT FOR OIL PRODUCED
GULF MILLS NO. 1 WELL
ALLISON POOL

Estimated Recoverable Oil For 40 Acre Tract Assigned To Gulf's Federal Mills No. 1 is:

$$\text{Recoverable Oil} = \frac{7758 \times \phi \times A \times h \times (1-S_w) \times R.F.}{B_o}$$

$$= \frac{7758 \times .067 \times 40 \times 11 \times (1-.25) \times .30}{1.821}$$

$$= 28{,}258 \text{ STB}$$

RF is the recovery factor and is estimated to be 30%. Other symbols in the above equation are defined on the Exhibit showing volumetric calculations for oil in place.

The measured oil production from Gulf's Federal Mills No. 1 was 273,437 barrels as of May 1, 1959. The tabulation below shows what each variable in the above equation would have to be to account for the volume of oil actually produced from the tract as of May 1, 1959, if all variables but one are equal to their applied values. In reviewing this Table, it should be remembered that 28,258 STB is the estimated ultimate recovery of oil that was originally situated beneath the 40-acre tract. The 273,437 barrel figure is what the well has actually produced and of course the well is still producing. An even greater variation in the applied values and required values would exist if the required values were based on actual ultimate recovery.

	Applied Values	Required Values
Net Pay	11 feet	106.4 feet
Porosity	6.7%	64.8%
Recovery Factor	30%	290.3%
Water Saturation	25%	≈0%
Formation Volume Factor	1.821	0.188

All applied values are measured except water saturation and recovery factor. Water saturation usually occurs between 15% and 60% but cannot be less than 0%. Recovery factor will occur normally between 15% and 50%.

ECONOMICS OF DRILLING ONE WELL PER 40 ACRES IN ALLISON AND NORTH ALLISON POOLS

REVENUE

Oil

(17,652) (1.0 - .125) ($2.95) =	$	45,566
Less Severance Taxes At $0.1369/BO.		2,115
Gross Oil Revenue Less Severance Taxes.	$	43,451

Gas

(17,652) (1.0 - .125) (3.540) ($0.08)	$	4,374
Less Severance Taxes At 0.0264 Of Value		115
Gross Gas Revenue Less Severance Taxes.	$	4,259
Total Gross Revenue Less Severance Taxes.	$	47,710

COSTS

Development

Drilling.	$	175,000
Pumping Equipment		30,000
Flow Lines.		1,600
Total Development Cost.	$	206,600

Operating

($0.08) (17,652).	$	1,412
Total Costs	$	208,012
Loss Per 40-Acre Well	$	160,302

CONDITIONS

Recoverable Oil In Place Per 40 Acres		17,652 barrels
Average Gas-Oil Ratio Throughout Life		3,540 cubic feet per bbl.
Oil Price	$	2.95 per barrel
Casinghead Gas Price.	$	0.08 per MCF
Operating Cost.	$	0.08 per barrel
Royalty		1/8

All Wells Completed At Same Time

RESULTS OF INVESTIGATION OF DRAINAGE
ALLISON AND NORTH ALLISON POOLS

CASE	I	II	III
OPERATOR WELL LOCATION	Atlantic Fed. Yates #1 SE NE Sec. 35 T-8S, R-36E	Ohio State E-6859"A"#2 SE SE Sec. 2 T-9S, R-36E	Cactus Sunray St. "A" #1 NW NE Sec. 2 T-9S, R-36E
OIL IN PLACE BY VOLUMETRIC CALCULATION FOR 80 AC., STB	118,470	112,959	112,959
CALCULATED PRODUCTION BY EXPANSION OF RESERVOIR FLUIDS & ROCK ABOVE BUBBLE POINT (3518-3150 psi), STB	1,414	1,588	1,588
CALCULATED PRODUCTION BY EXPANSION OF RESERVOIR FLUIDS BELOW BUBBLE POINT, STB	1,815	12,204	6,131
PRESSURE INCREMENT FOR CALCULATION BELOW BUBBLE POINT, psi	3150-3059	3150-2602	3150-2803
TOTAL CALCULATED PRODUCTION FROM EXPANSION FOR 80 AC. TRACT, STB	3,229	13,792	7,719
ACTUAL MEASURED PRODUCTION FROM WELL AS OF DATE OF LAST PRESSURE, STB	14,653	124,399	19,053
PRODUCTION DUE TO DRAINAGE FROM OTHER AREAS, STB	11,424	110,607	11,334
CALCULATED DRAINAGE AREA, ACRES	360	720	200

SAMPLE CALCULATION
FOR PRODUCTION DUE TO
EXPANSION OF RESERVOIR
FLUID & ROCK—80 ACRE
TRACT SITUATED ABOUT
ATLANTIC'S FEDERAL YATES NO. 1

Calculation of original oil-in-place:

$$N_1 = \frac{7758 \times \phi \times h \times (1-S_w) \times A}{B_o}$$

$$= \frac{7758 \times .0515 \times 9 \times (1-.25) \times 80}{1.821}$$

= 118,470 Stock Tank Barrels

Calculation of production due to expansion of reservoir fluids and rock above the bubble point:

Pressure increment is from 3518 psi down to 3150 psi.

$$\Delta N = \frac{N_{f1}\ Bo_{f1} \left[(C_{om} - C_{wm}) + \left(\frac{C_{wm} + C_f}{S_{o1}} \right) \right] \Delta P \times 10^{-6} - B_w\ \Delta W_p}{Bo_{f2}}$$

$$= \frac{118,470 \times 1.821 \left[(23.03 - 3.1) + \left(\frac{3.1 + 6.5}{.75} \right) \right] 368 \times 10^{-6} - 0}{1.837}$$

= 1414 STB

Calculation of production due to reservoir fluid expansion below the bubble point:

Pressure increment is from 3150 psi down to 3059 psi. The latter pressure was measured on April 21, 1959.

Oil in place at bubble point is 118,470 bbls - 1414 bbls = 117,056 STB

Since gas liberation in the reservoir is a differential process, the barrels of stock tank oil-in-place must be changed to residual differential barrels. This is done as follows:

$$N_d = N_f \frac{B_{of}}{B_{od}}$$

$$= 117,056 \left(\frac{1.831}{1.860} \right)$$

= 115,604 Residual Differential Barrels

Differential reservoir production below the bubble point is as follows:

$$\Delta N_d = \frac{N_{d1}\left[B_{g2}(R_{sd1} - R_{sd2}) + \frac{G_{F1}}{N_{d1}}(B_{g2} - B_{g1}) - (B_{od1} - B_{od2}) \right] - B_w \Delta W_p}{(B_{od2} - B_{g2}R_{sd2} + B_{g2}R_{sdm})}$$

$$= \frac{115{,}604\left[.826\ (1.525 - 1.455) + 0 - (1.860 - 1.831) \right] - 0}{(1.831 - .826 \times 1.455 + .826 \times 1.490)}$$

$$= 1790 \text{ RDB}$$

The above differential production can be converted to flash production as follows:

$$\Delta N_f = \Delta N_d \left(\frac{B_{od}}{B_{of}} \right)_m = 1790 \left(\frac{1.847}{1.821} \right) = 1815 \text{ STB}$$

Note: Flash production is considered to be equivalent to stock tank production.

Total calculated production from original reservoir pressure to 3059 psi is:

1414 STB + 1815 STB = 3229 STB

Nomenclature for Material Balance Calculations

a	=	$p_{sc}T/2.92$, (RVB)(PSIA)/(MSCF)
B_{of}	=	Flash PVT basis, oil formation volume factor, RVB/STB
B_{od}	=	Differential PVT basis, oil formation volume factor, RVB/RDB
B_g	=	Gas formation volume factor, RVB/MSCF
B_w	=	Water formation volume factor, RVB/STB
c_o	=	Oil compressibility, RVB per MMRVB per PSI
c_w	=	Water compressibility, RVB per MMRVB per PSI
c_f	=	Formation (rock) compressibility, RVB per MMRVB per PSI
c_t	=	Total (average) compressibility of fluid-rock system, RVB per MMRVB per PSI
G_{d1}	=	Total reservoir gas in-place (differential PVT basis) at pressure p_1, MMSCF (In retrograde systems below the dew point this is the gas equivalent of both the gas and liquid phases in the reservoir: total mols in-place times conversion factor from mols to standard cubic feet.) (In oil reservoirs this is the sum of the free gas and the gas in solution.)
ΔG_d	=	Decrease in total (differential) gas in-place over interval, MMSCF
G_{F1}	=	Reservoir free gas in-place at pressure p_1, MMSCF
ΔG_F	=	Reservoir free gas produced over an interval, MMSCF
ΔG_{sp}	=	Separator gas production over interval, MMSCF (For non-volatile oil reservoirs and gas reservoirs, this is the actual separator gas produced. For volatile oil reservoirs, this is the separator gas which would be obtained if there were no liquid condensing out from the reservoir free gas produced.)
ΔG_p	=	Total surface gas production over interval, MMSCF
ΔG_R	=	Actual separator gas produced over interval (for volatile oil systems), MMSCF
$\left(\frac{\Delta G_F}{\Delta N_C}\right)$	=	Total reservoir free gas production to yield one stock tank barrel of condensate (for volatile oil systems), MSCF/STB.
$\left(\frac{\Delta G_{RF}}{\Delta G_F}\right)$	=	Separator gas obtained from a unit of total reservoir free gas produced (for volatile oil systems), SCF/SCF

ΔG_{sl} = Reservoir gas equivalent of separator liquid (for gas reservoirs), MMSCF

$(GE)_{sl}$ = Equivalent "reservoir gas" of separator liquid per stock tank barrel of oil production (for gas reservoirs), MSCF/STB. (This is the mols of separator liquid, per STB of oil obtained, times the conversion factor from mols to standard cubic feet. This is usually for the high pressure separator liquid. If the reported gas production includes the low pressure separator gas, this is for the low pressure separator liquid.)

N_{f1} = Flash oil in-place at pressure p_1, MSTB (Reservoir oil volume in-place divided by flash formation volume factor.)

ΔN_f = Decrease in flash oil in-place over interval, MSTB

N_{d1} = Differential oil in-place at pressure p_1, MRDB (Reservoir oil volume in-place divided by differential formation volume factor.)

ΔN_d = Decrease in differential oil in-place over interval, MRDB

ΔN_p = Surface oil production over interval, MSTB
For volatile oil reservoirs this is the oil obtained from the saturated reservoir oil production only and does not include the oil condensed out from the reservoir free gas production. For non-volatile oil reservoirs and for gas reservoirs this is the total stock tank oil production.

ΔN_c = Oil which condenses out of reservoir free gas production at surface (for volatile oil systems), MSTB

ΔN_R = Actual oil production over interval for volatile oil systems, MSTB ($\Delta N_R = \Delta N_c + \Delta N_p$)

n = Lb.-mols of hydrocarbons in-place in reservoir

p = Average reservoir pressure, PSIG for oil reservoirs, PSIA for gas reservoirs

Δp = Reservoir pressure decrease during interval, PSI

p_{sc} = Standard pressure, PSIA (14.7 for most states; in Louisiana it is 15.03 PSIA)

R_{sf} = Flash PVT basis, solution gas-oil ratio, MSCF/STB

R = Gas constant (for gas reservoirs) = 10.73 (ft^3)(PSIA) per (^{o}R) (lb. mol)

$(R_s)_{sp}$ = Gas in solution in separator liquid, MSCF/STB

R_{sd} = Differential PVT basis, solution gas-oil ratio, MSCF/RDB

S_o = Oil saturation, fraction of total pore space

S_w = Water saturation, fraction of total pore space

T = Reservoir temperature, °R = (°F plus 460)

T_{sc} = Standard temperature, °R (T_{sc} = 520 °R)

V = Volume, ft^3

V_p = Total pore space in reservoir, MRVB

V_g = Reservoir hydrocarbon volume (for gas reservoirs), MRVB

W_1 = Water in place at pressure p_1, MRVB

ΔW_e = Water influx (encroachment) over interval, MRVB

ΔW_p = Water production over interval, MSTB

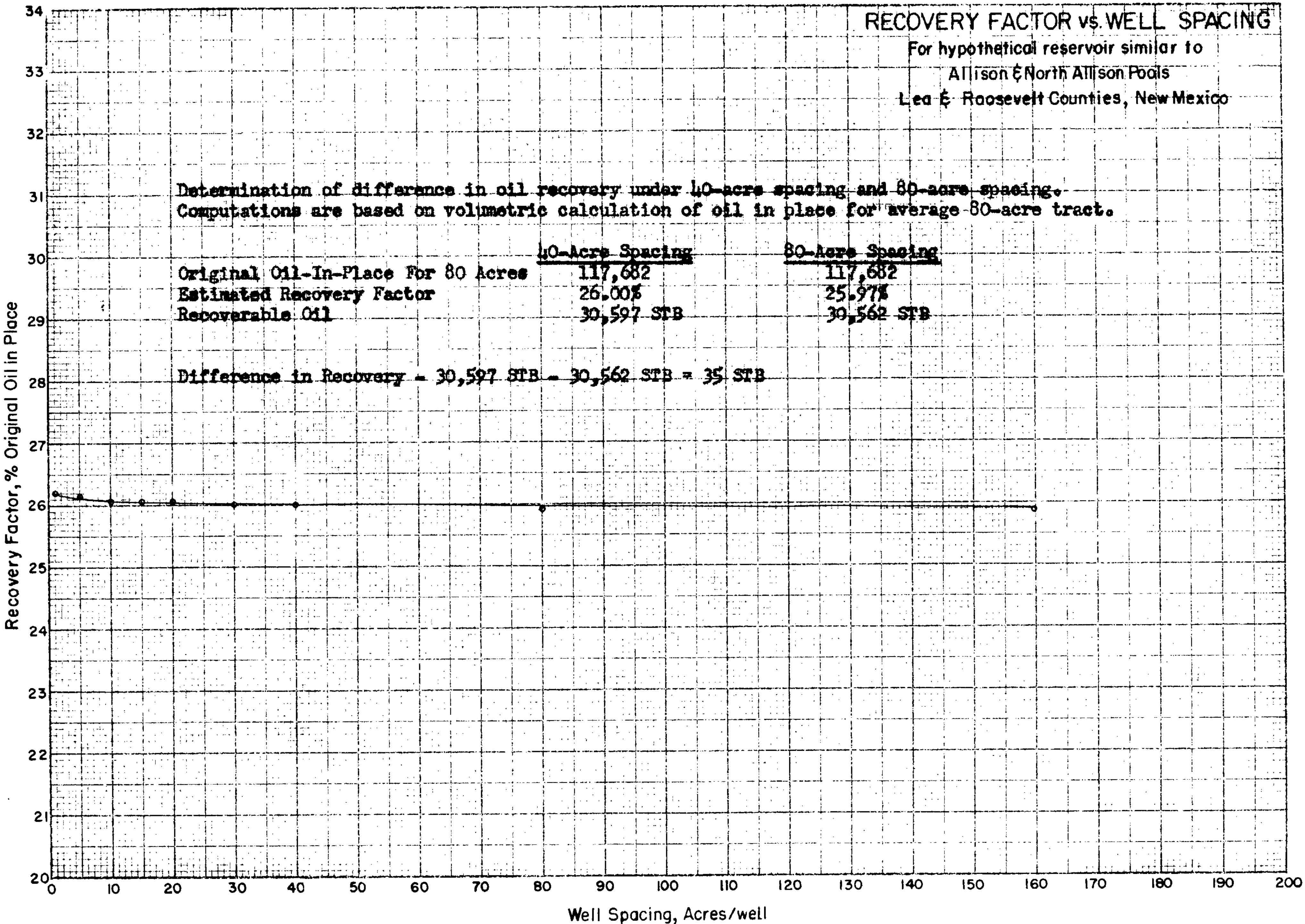
z = Compressibility factor in $pV = znRT$, gas equation (For retrograde systems below the dew point this is for the average hydrocarbons in place, gas plus liquid phases.)

sub m = To refer to average pressure over an interval or to value of a PVT factor at average pressure over an interval.

sub b = To refer to bubble point pressure.

sub 1 = To refer to pressure, in-place values, and PVT factors, at start of an interval.

sub 2 = To refer to pressure, in-place values, and PVT factors, at end of an interval.


RECOVERY FACTOR vs. WELL SPACING
For hypothetical reservoir similar to
Allison & North Allison Pools
Lea & Roosevelt Counties, New Mexico
Determination of difference in oil recovery under 40-acre spacing and 80-acre spacing.
Computations are based on volumetric calculation of oil in place for average 80-acre tract.
40-Acre Spacing
80-Acre Spacing
Original Oil-In-Place For 80 Acres 117,682 117,682
Estimated Recovery Factor 26.00% 25.97%
Recoverable Oil 30,597 STB 30,562 STB
Difference in Recovery = 30,597 STB - 30,562 STB = 35 STB
Recovery Factor, % Original Oil in Place
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
Well Spacing, Acres/well
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200

ADDITIONAL COST TO DEVELOP ALLISON AND NORTH ALLISON POOLS ON 40 ACRES

29 Additional Wells on 40-Acre Spacing.

Each costs	$175,000	to drill
Flow lines	1,600	
Pumps	30,000	
	$206,600	

29 x 206,600 = $5,991,400

Additional Pool Recovery on 40-Acre Spacing:

29 wells x 35 bbls/well = 1015 STB additional recovery for pool