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EVALUATION
OF
ABNORMALLY PRESSURED
GAS RESERVOIR

By

Jawad Radhi Rustam

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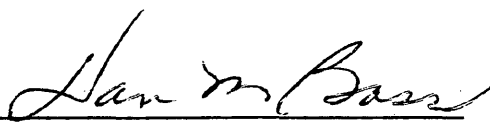
An Engineering report submitted to the faculty and the Board of Trustees of the Colorado School of Mines in partial fulfillment of the requirements for the degree of Master of Engineering (Petroleum Engineer).

Golden, Colorado

Date 9/22/82

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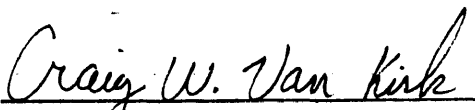
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TABLE OF CONTENTS

	<u>Page</u>
LIST OF TABLES	iv
LIST OF FIGURES	v
ACKNOWLEDGEMENTS	ix
INTRODUCTION	1
RESULTS	3
RECOMMENDATIONS	5
PROCEDURE	6
DISCUSSION	31
CURVES OF PERFORMANCE	32
TABLES OF RESULTS	72
APPENDIX A	146
INPUT DATA	147
APPENDIX B	149
a. Computer Program for Calculating Bottom Hole Flowing Pressure for Each Well	150
b. Computer Program for Calculating the Drainage Volume and Average Reservoir Pressure	154
c. Computer Program for Future Prediction	158
d. Subroutine PSEUDO	163
e. Subroutine ZFAC	164
f. Subroutine VISGAS	165
g. Subroutine FRICT	166
h. Subroutine WATRAD	167
REFERENCES	168

LIST OF TABLES

<u>Table</u>	<u>Page</u>
1	Time and Calculated Past Performance
	Average Reservoir Pressure 72
2	(X) and (Y) Function Values 73
3	Past Performance Pressure Based on Material
	Balance Equation 74
4	Prediction 1, When $Q_w/Q_g > 0$ Shut Well In. . . 76
5	Prediction 2, When No Limit on Water
	Production 80
6	Prediction 3, When $Q_w/Q_g \geq .002$ bbl/scf Shut
	Well In 98
7	Prediction 4, When $Q_w/Q_g \geq .004$ bbl/scf Shut
	Well In 111
8	Prediction 5, When $Q_w/Q_g > 0$, Set Gas Rate at
	1×10^6 scf/day 124
9	Data for Calculating Specific Producing
	Capacity 142
10	Calculated specific producing capacity . . . 143
11	Vertical Distribution of Producing Capacity .144
12	Data for Calculating Future Production Rates .145

LIST OF FIGURES

<u>Figure</u>		<u>Page</u>
1	Gas Production History	32
2	Condensate Production History	33
3	Well Stream Gas Production History	34
4	Water Production History	35
5	Top of the Formation	36
6	Bottom of the Formation	37
7	Sample Log	38
8	The Isopach Map of the Reservoir	39
9	Past Performance Pressure for Well No. 1	40
10	" " " " Well No. 2	41
11	" " " " Well No. 3	42
12	" " " " Well No. 4	43
13	" " " " Well No. 5	44
14	Well Stream Gas Production History for Well No. 1	45
15	Well Stream Gas Production History for Well No. 2	46
16	Well Stream Gas Production History for Well No. 3	47
17	Well Stream Gas Production History for Well No. 4	48

<u>Figure</u>		<u>Page</u>
18	Well Stream Gas Production History for Well No. 5	49
19	Calculated Average Reservoir Pressure History	50
20	P/Z - Gp	51
21	Modified Material Balance Equation	52
22	Perforation Location	53
23	Fractional Producing Capacity Distribution	54
24	Cumulative Pore Volume Distribution	55
25	Average Reservoir Pressure History Based on Material Balance Equation	56
26	Pressure Behavior for Prediction (1)	57
27	Gas Production Behavior for Prediction (1)	58
28	Water Production Behavior for Prediction (1).	59
29	Pressure Behavior for Prediction (2)	60
30	Gas Production Behavior for Prediction (2)	61
31	Water Production Behavior for Prediction (2).	62
32	Pressure Behavior for Prediction (3)	63
33	Gas Production Behavior for Prediction (3)	64
34	Water Production Behavior for Prediction (3).	65
35	Pressure Behavior for Prediction (4).	66
36	Gas Production Behavior for Prediction (4).	67
37	Water Production Behavior for Prediction (4).	68

<u>Figure</u>		<u>Page</u>
38	Pressure Behavior for Prediction (5)	69
39	Gas Production Behavior for Prediction (5) .	70
40	Water Production Behavior for Prediction (5)	71

The author wishes to dedicate this thesis
to:

The people of the Republic
of Iraq;
His advisor - Dr. D.M. Bass;
His parents;
His wife; and
His brothers and sisters.

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INTRODUCTION

This study was done on an abnormally pressured gas reservoir containing five wells. Some wells produce natural gas, condensate and water; while the other wells produce only natural gas and condensate. Figure 1, 2, 3 and 4 show the performance of the field prior to this study.

The current available data on this reservoir was:

- 1) Flowing well head pressure
- 2) Daily gas production rate, scf/day
- 3) Daily condensate production rate, bbl/day
- 4) Daily water production rate, bbl/day
- 5) Some logs on all wells
- 6) Structural maps of the field.

From those data the following were determined:

- 1) Bottom hole flowing pressure for each well as a function of time
- 2) Average reservoir pressure monthly intervals
- 3) Initial pressure of the reservoir
- 4) Original gas in-place
- 5) Size of the water aquifer.

Based on these data, future predictions were made for the following conditions:

- 1) Prediction 1 - When $Q_w/Q_g > 0$ shut well in
- 2) Prediction 2 - When no limit on water production

- 3) Prediction 3 - When $Q_w/Q_g \geq 0.002$ bbl/scf shut well
in
- 4) Prediction 4 - When $Q_w/Q_g \geq 0.004$ bbl/scf shut well
in
- 5) Prediction 5 - When $Q_w/Q_g > 0$ set gas rate at
 1×10^6 scf/day.

RESULTS

The following results were obtained:

- 1) The original gas in-place was determined to be 220.00×10^9 scf by material balance equation, and 200.24×10^9 scf by volumetric method. The material balance value was used for all predictions.
- 2) The ratio of aquifer radius to gas radius (r_a/r_g) was calculated to be 2.39.
- 3) The ultimate recovery determined for the various predictions are:
 - a. For Prediction 1, 21.4×10^9 scf gas and zero bbl water were produced in 39 months (field abandonment). Table 4 shows the results.
 - b. For Prediction 2, 56.99×10^9 scf gas and 484.11×10^3 bbl water were produced in 39 months, and 76.03×10^9 scf gas and 2053.09×10^3 bbl water were produced during 320 months (field abandonment). Table 5 shows the results.
 - c. For Prediction 3, 56.98×10^9 scf gas and 379.38×10^3 bbl water were produced in 39 months, and 74.18×10^9 scf gas and 1624.55×10^3 bbl water were produced during 220 months (field abandonment). Table 6 shows the results.
 - d. For Prediction 4, 56.99×10^9 scf gas and $484.11 \times$

10^3 bbl water were produced in 39 months, and 74.19×10^9 scf gas and 1635.38×10^3 bbl water were produced during 220 months (field abandonment). Table 7 shows the results.

- e. For Prediction 5, 25.22×10^9 scf gas and 123.96×10^3 bbl water were produced in 39 months, and 54.24×10^9 scf gas and 1938.27×10^3 bbl water were produced during 320 months (field abandonment). Table 8 shows the results.

RECOMMENDATIONS

As a result of this study, the following is recommended:

- 1) Install equipment to handle produced water.
- 2) An economic evaluation be performed to determine if the field should continue to be produced after 39 months.

PROCEDURE

In this study, the net gas pore volume was determined to be 588.0×10^6 cu ft. from an isopach map. This map was constructed by contouring the top and the bottom of the formation (Figures 5 and 6) which were obtained from logs. One of these logs is shown in Figure 7. Using the method of reference (5), the isopach map, Figure 8 was constructed. Since only 5 points were available and only one well indicated a gas-water-contact, a dome-type structure was assumed. The maps were constructed based on this assumption.

Based on core and log data, the range of porosity was 22% to 31%. The average porosity was calculated using Equation (1) and resulted in a value of 26%.

$$\bar{\Phi}_i = \frac{\sum_{j=1}^{n \cdot Z} h_j \Phi_{ij}}{\sum_{j=1}^{n \cdot Z} h_j} \quad (1)$$

where:

$\bar{\Phi}_i$ = average porosity, percentage

j = index

$n \cdot Z$ = number of zones

h = zone thickness, ft

Φ_i = zone porosity, percentage.

From logs, the water saturation was determined to range from 15% to 44%. The average value for water saturation was calculated to be 30% by using Equation (2):

$$\bar{S}_{wi} = \frac{n \cdot Z}{\sum_{j=1}^{n \cdot Z}} S_{wij} / n \cdot Z \quad (2)$$

where:

\bar{S}_{wi} = average connate water saturation, percent

S_{wi} = connate water saturation in the zone, percent.

But if Equation (3) is used for determining average hydrocarbon pore volume:

$$\bar{\phi}_i \times (1 - \bar{S}_{wi}) = \frac{n \cdot Z}{\sum_{j=1}^{n \cdot Z}} h_j \phi_{ij} (1 - S_{wi})_j / \frac{n \cdot Z}{\sum_{j=1}^{n \cdot Z}} h_j \quad (3)$$

and Equation 1 for $\bar{\phi}_i$, then an average value of \bar{S}_{wi} is calculated to be 31.0%.

Only one value of bottom hole shut-in pressure was available, this value was measured in Well No. 4 on June 25, 1977 and determined to be 7791.0 psig. Therefore, bottom hole flowing pressures were calculated in order to determine the behavior of reservoir pressure with time. To determine bottom hole flowing pressure for the wells, the condensate was assumed to be produced as a gas from the reservoir and condensed at the surface. The produced condensate was converted to its gas equivalent (4) using Equation (4):

$$GE_c = Q_c \times 133,000 \times \gamma_c / M_c \quad (4)$$

where:

$$M_c = 6048 / (\text{API} - 5.9), \text{ and}$$

$$\gamma_c = 141.5 / (131.5 + \text{API}).$$

The volume of gas flowing in the tubing was calculated using Equation (5):

$$QG_t = Q_g + GE_c \quad (5)$$

where:

M_c = molecular weight of the condensate

API = API gravity of the condensate

γ_c = specific gravity of the condensate

GE_c = the gas equivalent of the condensate, scf/day

Q_c = condensate flow rate, bbl/day

Q_g = surface gas flow rate, scf/day

QG_t = well stream gas flow rate, scf/day.

A vertical flow equation, published by Katz (6), was used to calculate the bottom hole flowing pressure based on the surface flowing pressure, the calculated well stream gravity

and the calculated well stream gas flow rate, Equation 6.

$$P_s = \sqrt{\frac{(Q G_t^2 + 4 \times 10^4 \times A \times H \times 2.7183^5 \times P^2)}{(4 \times 10^6 \times A \times H)}} \quad (6)$$

where:

$$A = S / (2.7183^5 - 1.0)$$

$$S = .0375 \times \gamma_w \times X / (T \times Z)$$

$$\gamma_w = (R \gamma_g + 4584 \gamma_c) / (R + 132,800 \gamma_c / M_c)$$

$$H = D^5 / (\gamma_w \times T \times Z \times F \times X)$$

$$F = 30.9208 \times 10^{-3} \times B / \mu_g^{-.065}$$

$$B = Q G_t^{-.065} \times D^{.058} \times \gamma_w^{-.065}$$

P_s = the pressure at the bottom of the interval (X),
psia

P = the pressure at the top of the interval (X),
psia

γ_w = well stream gas gravity

X = depth interval, ft

T = temperature at the bottom of the interval
depth, °R

Z = gas compressibility factor

R = initial surface gas-condensate ratio of the production, scf of dry gas per barrel of condensate

γ_g = average specific gravity of the gas produced from the surface separator (s), air = 1.00

D = inside diameter of the tubing, inch

μ_g = gas viscosity, cp

Equation 6 is solved incrementally until total depth is reached, at which time P_s is equal to the bottom hole flowing pressure.

When a well was producing free water, a two phase flow equation was used to calculate the flowing bottom hole pressure, Equation 7.

$$P_{BHF} = P_{WH} + \sum_{k=1}^{k=100} \Delta P_{ck} \quad (7)$$

where:

$$\Delta P_{ck} = \left[\frac{1}{144} \frac{\bar{\rho} + \tau_f}{1 - W_t \frac{q_g}{4637 A_p^2 \bar{p}}} \right] \cdot X$$

$$\bar{\rho} = \frac{W_t + \rho_L V_b A_p}{q_t + V_b + A_p}$$

$$\tau_f = \frac{f \rho_L V_t^2}{2g_c d_h} \left[\frac{q_L + V_b \frac{A_p}{A_t}}{q_t + V_b \frac{A_p}{A_t}} + \Gamma \right]$$

$$W_t = W_L + W_g$$

$$W_L = 4.0509 \times 10^{-3} \times Q_w$$

$$W_g = q_g / 379 \times \gamma_w \times 28.97$$

$$q_g = 3.27 \times 10^{-7} \times QG_t \times Z \times T/\bar{P}$$

$$\bar{P} = P_{k-1} + \Delta P_a / 2$$

$$\rho_L = W_L / q_L$$

$$q_L = 6.49 \times 10^{-5} \times Q_w$$

$$\rho_g = W_g / q_g$$

$$q_t = q_L + q_g$$

$$N_b = 1488 \rho_1 d_h V_b / \mu_1$$

$$N_{Re} = 1488 \rho_1 d_h V_t / \mu_1$$

$$V_b = (.546 + 8.74 \times 10^{-6} N_{Re}) \sqrt{g d_h} \text{ for } N_b < 3000$$

$$V_b = \frac{1}{2} V_{bi} + \sqrt{V_{bi}^2 + \frac{13.59 \mu_L}{\rho_L \sqrt{d_h}}} \quad \text{for } 3000 < N_p < 8000$$

$$V_{bi} = (.251 + 8.74 \times 10^{-6} N_{Re}) \sqrt{g d_h}$$

$$V_b = (.35 + 8.74 \times 10^{-6} N_{Re}) \sqrt{g d_h} \quad \text{for } N_p \geq 8000$$

$$\Gamma = \left[(.013 \text{ Log } \mu_L) / d_h^{1.38} \right] -$$

$$.681 + .232 \text{ Log } V_t - .428 \text{ Log } d_h \quad \text{for } V_t < 10 \text{ and}$$

$$\Gamma > -.065 V_t$$

$$\Gamma = \left[.0127 \text{ Log } (\mu_l + 1) / d_h^{1.415} \right] - .709 - .162 \text{ Log } V_t -$$

$$.888 \text{ Log } d_h, \text{ for } V_t \geq 10, \text{ and}$$

$$\Gamma > - \frac{V_b A_p}{q_t + V_b A_p} (1 - \bar{\rho}_L)$$

The terms were defined as follows:

k = depth increment

P_{BHF} = bottom hole flowing pressure, psia

- P_{WH} = well head flowing pressures psia
- ΔP_{ck} = calculated pressure drop within the depth interval, psia
- $\bar{\rho}$ = average fluid density, lb/cu ft
- W_t = total mass flow rate, lb/sec
- W_L = liquid mass flow rate, lb/sec
- Q_w = water flow rate, bbl/day
- W_g = gas mass flow rate, lb/sec
- q_g = corrected gas flow rate, cu ft/sec
- T = temperature at depth (X) °R
- ΔP_a = assumed pressure drop within the depth interval, psia
- ρ_L = water density, lb/cu ft
- q_L = water flow rate, cu ft/sec
- ρ_g = gas density, lb/cu ft
- q_t = total volume flow rate, cu ft/sec
- A_p = flow area of pipe, sq ft
- V_b = the bubble rise velocity, ft/sec
- g = acceleration of gravity, ft/sec²
- N_{Re} = Reynolds number

- N_b = bubble Reynolds number
 μ_L = water viscosity, cp
 τ_f = the wall friction-loss, lb/sq ft/ft
 f = friction factor
 v_t = total fluid velocity, (q_t/A_p), ft/sec
 g_c = gravitational constant,
 ft-lb_(mass)/lb_(force) - sec²
 Γ = liquid distribution coefficient, ft/sec

When the calculated pressure drop (ΔP_{ck}) was less than the assumed pressure drop (ΔP_a) it was necessary to decrease ΔP_a . The solution required that the two values of ΔP be within .001 psi before the calculated values were accepted as being correct. Equation (7) is solved incrementally until total depth is reached.

After calculation of bottom hole flowing pressure for each well as a function of time, the values were screened. More weight given to the values of flowing well head pressure measured by dead weight tester and to reported change in value after a reported sequence of constant values.

These screened bottom hole flowing pressure values were plotted against cumulative gas well stream production for each well (Figures 9, 10, 11, 12 and 13). Plots of cumulative gas well stream production for each well as a function

of time are presented in Figures 14, 15, 16, 17 and 18. These figures were used in selecting values of bottom hole flowing pressure for each well at common times. The calculated bottom hole flowing pressure for each well and the flow rate of each well were used to determine the drainage volume and the drainage volume average pressure for each well. Equation (8) was used to determine these values.

$$DV_j = C_j \times \text{Exp} \left[(A_j \times (P_e^2 - P_{wj}^2) / QG_j) + 1 \right] \quad (8)$$

where:

$$C_j = 3.14159 \times \phi \times h_j \times r_{wj}^2$$

$$A_j = .00708 \times 5.615 \times h_j \times k_{gj} \times T_a / (\mu_{gj} \times Z_j \times P_a \times T)$$

Everything is known in Equation (8) except (P_e) and (DV_j) at common times for each well. Since P_e is the same for all wells at the same instance in time, therefore assume a value for P_e and solve Equation (8) for DV_j . Equation (8) was solved repeatedly with assumed value of P_e until Equation (9) was satisfied.

$$DVT_c \cong \sum_{j=1}^n DV_j \quad (9)$$

where:

j = well number

QG = gas flow rate, scf/day

h = thickness of pay zone, ft

k_g = gas permeability, md

T_a = reference temperature, $^{\circ}R$

T = formation temperature, $^{\circ}R$

P_a = reference pressure, psia

P_w = bottom hole flowing pressure, psia

r_e = drainage radius, ft

r_w = well bore radius, ft

DVT_c = total drainage volume for the reservoir.

When the total calculated drainage volume was less than the volume determined from an isopach map, it was necessary to increase the assumed value of P_e . Equation (9) was required to converge to within one million cubic feet.

The average pressure in a well's drainage volume is given by Equation (10):

$$\bar{P}_j = \frac{\int_{r_{wj}}^{r_{ej}} 2\pi P_{rj} r_j dr_j}{\int_{r_{wj}}^{r_{ej}} 2\pi r_j dr_j} \quad (10)$$

The approximate distribution in a flowing well's drainage volume is given by Equation (11).

$$P_{r_j}^2 \cong P_{w_j}^2 + (P_e^2 - P_{w_j}^2) \times \frac{\ln(r_j/r_{w_j})}{\ln(r_{e_j}/r_{w_j})} \quad (11)$$

Solving Equation 11 for pressure and substituting into Equation 10 results in an expression for \bar{P} in the gas well's drainage volume.

$$\bar{P}_j = \frac{\left[\int_{r_{w_j}}^{r_{e_j}} 2r_j \sqrt{P_{w_j}^2 + (P_e^2 - P_{w_j}^2) \times \frac{\ln(r_j/r_{w_j})}{\ln(r_{e_j}/r_{w_j})}} \times dr_j \right]}{(r_{e_j}^2 - r_{w_j}^2)} \quad (12)$$

The integration for \bar{P} can be accomplished by graphical or summation of the following terms as a multiple of an incremental r .

$$f(r_j) = 2r_j \times \sqrt{P_{w_j}^2 + (P_e^2 - P_{w_j}^2) \times \frac{\ln(r_j/r_{w_j})}{\ln(r_{e_j}/r_{w_j})}} \quad (13)$$

$f(r_j)$ is evaluated at different values of r_j until r_j is equal to r_e . The area under the curve is calculated by Equation (14):

$$\text{Area}_j = \sum_{k=1}^{100} \frac{f(r_j)_k + f(r_j)_{k-1}}{2} \times ((r_j)_k - (r_j)_{k-1}) \quad (14)$$

This area was substituted into Equation 12 for the integral and the average pressure in the well's drainage volume was determined. After calculating \bar{P} for all the wells, the average pressure of the reservoir was obtained by using Equation 15:

$$P_{\text{average}} = \frac{\text{No. of wells}}{\sum_{j=1}^{\text{No. of wells}}} \bar{P}_j \times DV_j / DVT_c \quad (15)$$

These calculated values of average reservoir pressure are tabulated in Table 1 and plotted in Figure 19 (see Computer Program Number Two).

Average reservoir pressure over deviation factor (P/Z), was plotted as a function of cumulative gas production (Figure 20). The extrapolation of the curve of $P/Z = 0$ gave a value of gas in-place of 440×10^9 scf. Extrapolation of the curve to $G_p = 0$, gave a value of $P_i/Z_i = 6165.6$ psia. By trial and error solution, initial reservoir pressure (P_i) was obtained to be 7300 psia, this value is less than the reported value of 7791 psia, but will be used in making prediction because it fits the generated pressure data.

The original gas in-place was calculated by the volumetric method using the pore volume from the isopach map and the estimated initial reservoir pressure.

$$G = 35.35 \times (P_i/Z_i)/(T) \times \text{hydrocarbon pore volume}$$

$$G = 35.35 \times 6165.6/(640) \times 588 \times 10^6$$

$$G = 200.24 \times 10^9 \text{ scf.}$$

This value of original gas in-place is much smaller than the value obtained from the $P/Z - G_p$ plot. Because two wells are already producing water and the large difference in the two values of gas in-place, one would expect water influx. The presence of water influx prohibits the use of $P/Z - G_p$ plot for determining gas in-place (10). Hence, another verification of the gas in-place value must be found.

Since the magnitude of the water aquifer is unknown, a rearranged version of the material balance equation was used as the alternate method.

$$\frac{G \left(\frac{Z_j}{P_j} - \frac{Z_i}{P_i} \right)}{P_i - P_j} + \frac{G Z_i}{P_i (1 - S_{wi})} \left[(C_w S_{wi} + C_f) + \left(\frac{r_a^2}{r_g^2} - 1 \right) (C_f + C_w) \right] =$$

$$\left(G_{pj} \frac{Z_j}{P_j} + A \times 5.615 \times W_{pj} B_w \right) / (P_i - P_j) \quad (16)$$

where:

$$A = T_a / (P_a \times T)$$

G = initial gas in-place, scf

P = reservoir pressure at time t , psia

P_i = initial reservoir pressure, psia

C_w = average water compressibility, psi^{-1}

C_f = average formation compressibility, psi^{-1}

r_a = radius of the aquifer, ft

r_g = radius of the gas reservoir, ft

G_p = cumulative well stream gas production, scf

W_p = cumulative water production, bbl

B_w = water formation volume factor, res. bbl/
surface bbl

Equation 16 can be rearranged so as to represent an equation of a straight line (9), such that:

$$Y = mX - a \quad (17)$$

where:

$$Y = (Z_j/P_j - Z_i/P_i)/(P_i - P_j) \quad (18)$$

$$X = (GP_j Z_j/P_j + A \times 5.615 \times W_{pj} B_w)/(P_i - P_j) \quad (19)$$

$$a = \frac{Z_i}{P_i(1-S_{wi})} \times \left[(C_w S_{wi} + C_f) + (r_a^2/r_g^2 - 1) \times (C_f + C_w) \right] \quad (20)$$

The slope of the straight line is the reciprocal of the original gas in-place.

Values of (X) and (Y) were calculated from past performance data and are presented in Table 2 and Figure 21. The points which fit the straight line were extrapolated to get the value of the intercept a. Only the straight line portion was used because it indicates that the aquifer has reached pseudo steady state flow conditions. From the straight line portion, the value of gas in-place was found to be 220.0×10^9 scf and the intercept (a) equal to -12.6×10^9 . Using Equation 20 with $C_f = 6 \times 10^{-6}$ psi⁻¹ (13) and $C_w = 4 \times 10^{-6}$ psi⁻¹ (4) the value of (r_a/r_g) was found to be 2.39.

In order to determine the rate of advance of the water front, it is necessary to determine the residual gas saturation in the water invaded zone. Well No. 3 started producing water during the sixth month of operation, therefore the cumulative water influx at the end of six months of production was calculated using the Hurst Van Everdinger unsteady state water influx relationship, Equation 21.

$$W_e = \frac{\psi 2\pi}{5.61} h C_e r_g^2 \phi \sum_{j=1}^n Q(t_{Dn} - t_{Dj-1})(\Delta P_j) \quad (21)$$

where:

ψ = shape factor

$$C_e = C_w S_{wi} + C_f$$

$$t_D = \frac{.006328 kt}{\mu_w \phi C_e r_g^2}, \quad t \text{ in days}$$

$$\Delta P_i = \frac{P_i - P_1}{2} \quad \text{for } j = 1$$

$$\Delta P_j = \frac{(P_{j-2} - P_j)}{2} \quad \text{for } j \geq 2$$

$Q(t_D)$ = dimensionless water influx function

The water influx at the end of six months was determined to be 3.722 MM bbls, or 20.896 MM cubic feet.

The pore volume invaded by water at this time can be estimated by Equation 22.

$$\Delta V_{wi} = \left[W_{ei} - W_{e0} - (W_{pi} B_{wi} - W_{p0} B_{w0}) \right] / (1 - S_{gr} - S_{wi}) \quad (22)$$

From the plot of the fractional producing capacity, Figure 23, the minimum depth of zero producing capacity was selected. The cumulative pore volume of originally gas saturated rock

below this depth was determined from Figure 24. The depth at which the producing capacity equals to zero is 9632 ft, the volume of originally gas saturated pore space below this depth was 44.3×10^6 cu ft. Substituting these values into Equation 23 and solving for S_{gr} results in a value of 22.8%.

Based on the value of gas in-place, initial reservoir pressure and the size of the aquifer calculated in previous steps, a future prediction for the reservoir was done. The method of prediction was based on the water influx calculated from material balance equation and the water influx from the unsteady state equation (Hurst and Van Everdinger (12)).

Water influx from material balance equation is:

$$W_{em} = \left\{ G_{pj} \times \frac{Z_j}{P_j} + A \times 5.615 \times W_{pj} \times B_w - G \left[\left(\frac{Z_j}{P_j} - \frac{Z_i}{P_i} \right) + \frac{Z_i}{P_i (1 - S_{wi})} \times (C_w S_{wi} + C_f) (P_i - P_j) \right] \right\} / (A \times 5.615) \quad (23)$$

The calculation of future performance was performed as follows:

- a) A contract gas flow rate was set for each well
- b) A minimum flowing bottom hole pressure for each well was calculated based on the predetermined rate and for a well head flowing pressure equal to 975 psig.

- c) The specific productivity for each well was determined by Equation 24 from past production data.

$$C_{pj} = Q_{gas_j} / ((P_e^2 - P_w^2) \times h_{gj}) \quad (24)$$

where:

C_{pj} = specific productivity index, scf/day/psi² - ft

Q_{gas_j} = gas flow rate, scf/day at some pressure, P_w

h_{gj} = number of feet perforated above gas-water-contact, ft.

- d) The gas production rate for each well was calculated using Equation 25.

$$Q_{G_j} = C_{pj} \times h_{grj} \times (P_e^2 - P_{minj}^2) \quad (25)$$

where:

h_{grj} = remaining number of feet perforated.

The data used to determine the values of C_p are presented in Table (9).

Based on the data of Table (9), the specific producing capacity of each well was calculated and presented in Table (10).

A cumulative producing capacity curve above a given depth was generated using the specific producing capacities and the location of each well's perforated interval as shown

in Figure 22. The reservoir was divided into nine unequal vertical intervals, A through I. The producing capacity of each interval was calculated and is shown in Table (11).

The fractional specific producing capacity above a designated depth is shown in Figure 23. For the purpose of calculating future production rates, data in Table (12) were assumed for each well.

- e) The cumulative gas produced from the reservoir was calculated from Equation 26.

$$G_{pj} = \left(\sum_{j=1}^{n \cdot w} QG_j \right) \times \text{delta time} + G_{pj-1} \quad (26)$$

$n \cdot w$ = number of wells

- f) The water production rate for each well was calculated by Equation 27.

$$Q_{wj} = \frac{C_{pj} K_{wj} \mu_{gj} Z_j P_a T}{K_{gj} \mu_w \times 5.615 \times T_a} \times h_{wj} (P_e - P_{minj}) \quad (27)$$

where:

h_{wj} = number of feet perforated below gas water contact

- g) The cumulative water production was calculated by

Equation 28:

$$W_{pj} = \left(\sum_{j=1}^{n \cdot w} Q_{wj} \right) \times \text{delta time} + W_{pj-1} \quad (28)$$

- h) The height of the present gas-water-contact had to be calculated at each future time step to determine the water and gas producing capacity. The cumulative pore volume invaded by water can be calculated using Equation 29.

$$V_{wn} = \sum_{j=1}^n \Delta V_{wj} \quad (29)$$

where:

$$\Delta V_{wj} = \left\{ (W_{ej} - W_{ej-1})(5.615) - (W_{pj} B_w - W_{pj-1} B_w) \right. \\ \left. (5.615) + \left[\sum_{k=1}^{j-1} \frac{V_{wk}}{B_{gk}} S_{grk} \right] (Bg_j - Bg_{j-1}) \right\} / \\ (1 - S_{wi} - S_{grj}) \quad (30)$$

Bg_k = gas formation volume factor at pressure P_k ,
cu ft/scf.

After calculating V_{wn} , data of Figure 24 were used to calculate the height of the gas water interface at that time.

- i) From a plot of k_{rg} and k_{rw} as a function of water saturation in the literature (8), a relationship illustrating the effect of saturation changes on effective permeability to gas and water. The value of k_{rg} at 30% water saturation was determined to be .85 and the value k_{rw} at 77% water saturation was determined to be .35. Using these values, absolute permeability was calculated to be 353 md and water permeability in the invaded zone was determined to be 123 md.

Predictions were made for five cases of projected well flow conditions. The cases are:

- Prediction 1: The produced water could not be disposed of so that a well was shut in when it first started producing water (Table 4).
- Prediction 2: It was assumed that a well could produce all the water that entered the well bore (Table 5).
- Prediction 3: It was assumed that a well would not flow with a liquid-gas ratio greater than 1/500 (bbl/scf) (Table 6).
- Prediction 4: It was assumed that a well would not flow at a liquid-gas ratio greater than 1/250 (bbl/scf) (Table 7).

Prediction 5: It was assumed that when a well started producing water, its gas rate would be reduced to 1 MM scf/day (Table 8). The results of the above cases are shown in Figure 26 through 40.

Figure 26 shows the reservoir pressure behavior of Prediction 1. The average reservoir pressure was 4744 psia after 39 months at which time the reservoir was shut in.

Figure 27 shows the gas production behavior of Prediction 1. The gas produced during this 39 months was 21.4×10^9 scf.

Figure 28 shows the water production behavior of Prediction 1, in this prediction no water production was permitted.

Figure 29 shows the reservoir pressure behavior of Prediction 2. The pressure was 3670 psia after 39 months and 3072 psia after 320 months.

Figure 30 shows the gas production behavior of Prediction 2. The amount of gas produced was 56.99×10^9 scf after 39 months. The maximum amount of gas produced was 76.03×10^9 scf after 320 months.

Figure 31 shows the water production behavior of Prediction 2. The amount of water produced was 484.11×10^3 bbl after 39 months. The maximum amount of water produced was 2053.09×10^3 bbl after 320 months.

Figure 32 shows the reservoir pressure behavior of Prediction 3. The pressure was 3670 psia after 39 months and 3139 psia after 220 months.

Figure 33 shows the gas production behavior of Prediction 3. The amount of gas produced was 56.98×10^9 scf after 39 months. The maximum amount of gas produced was 74.18×10^9 scf after 220 months.

Figure 34 shows the water production behavior of Prediction 3. The amount of water produced was 379.38×10^3 bbl after 39 months. The maximum amount of water produced was 1624.55×10^3 bbl after 220 months.

Figure 35 shows the reservoir pressure behavior of Prediction 4. The pressure was 3670 psia after 39 months and 3139 psia after 220 months.

Figure 36 shows the gas production behavior of Prediction 4. The amount of gas produced was 56.99×10^9 scf after 39 months. The maximum amount of gas produced was 74.19×10^9 scf after 220 months.

Figure 37 shows the water production behavior of Prediction 4. The amount of water produced was 484.11×10^3 bbl after 39 months. The maximum amount of water produced was 1635.38×10^3 bbl after 220 months.

Figure 38 shows the reservoir pressure behavior of Prediction 5. The pressure was 4664 psia after 39 months and 3701 psia after 320 months.

Figure 39 shows the gas production behavior of Prediction 5. The amount of gas produced was 25.22×10^9 scf after 39 months. The maximum amount of gas produced was 51.39×10^9 scf after 320 months.

Figure 40 shows the water production behavior of Prediction 5. The amount of water produced was 123.96×10^3 bbl after 39 months. The maximum amount of water produced was 1939.27×10^3 bbl after 320 months.

DISCUSSION

Prediction 1 is not a desirable result, because only 21.4×10^9 of gas are recovered. Predictions 2,3 and 4 indicate approximately 56.99×10^9 scf of gas can be recovered if water production is permitted. This production procedure represents an increase in recovery of 35.54×10^9 scf of gas.

Prediction 2,3 and 4 are approximately the same and they appear to be feasible. The rate of water influx into the wells is such that the cut off value of 4 bbl/Mscf and the maximum case (Prediction 2) essentially identical. The production cut off value of 2 bbl/Mscf caused the wells to be shut-in two months earlier. Prediction 5 may be the most realistic because it may represent actual well performance.

Based on Prediction 2,3,4 and 5 it would be necessary to have water handling equipment to handle from 1×10^3 bbl to 2×10^3 bbl water per month. From these predictions, it would appear that the gas recovery in the first 39 months is between 25.22×10^9 scf and 56.99×10^9 scf.

Based on Prediction 2,3 and 4 only, 17.2×10^9 scf of gas will be produced in the time between 39 months and abandonment at 220 months. Prediction 5 indicates that 20.49×10^9 scf of gas will be produced in the time period between 39 months and 220 months. An economic evaluation needs to be made for this 189 month period to determine if the reservoir should continue to be produced.

In Prediction 2 and 4, the wells watered out in the following sequence: Well 3 at 8 months; Well 2 at 24 months; Well 4 at 43 months, Well 5 at 90 months; and Well 1 at 220 months. The economic evaluation of the period after 43 months, when only two wells are producing, is absolutely essential.

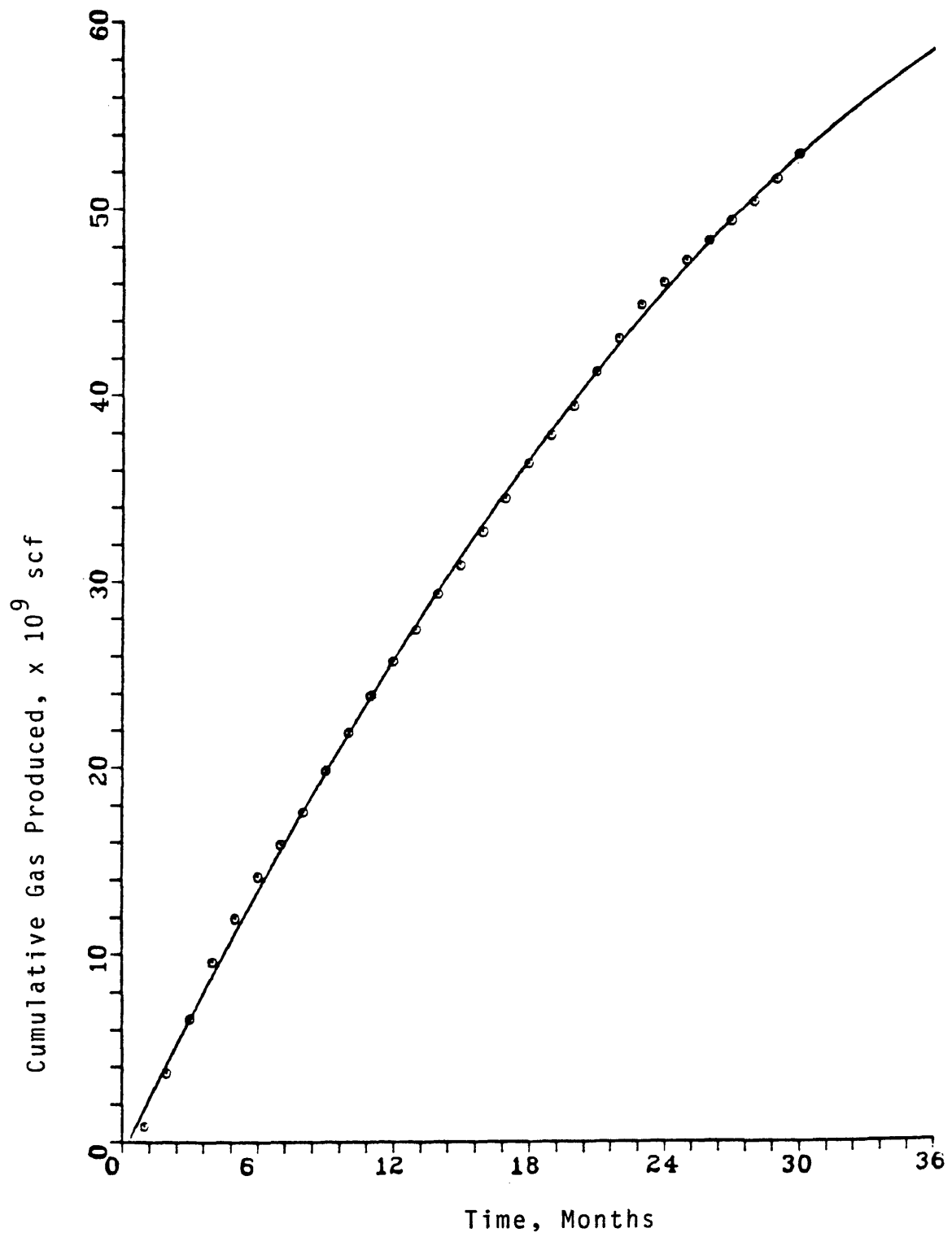


Figure 1. Gas Production History

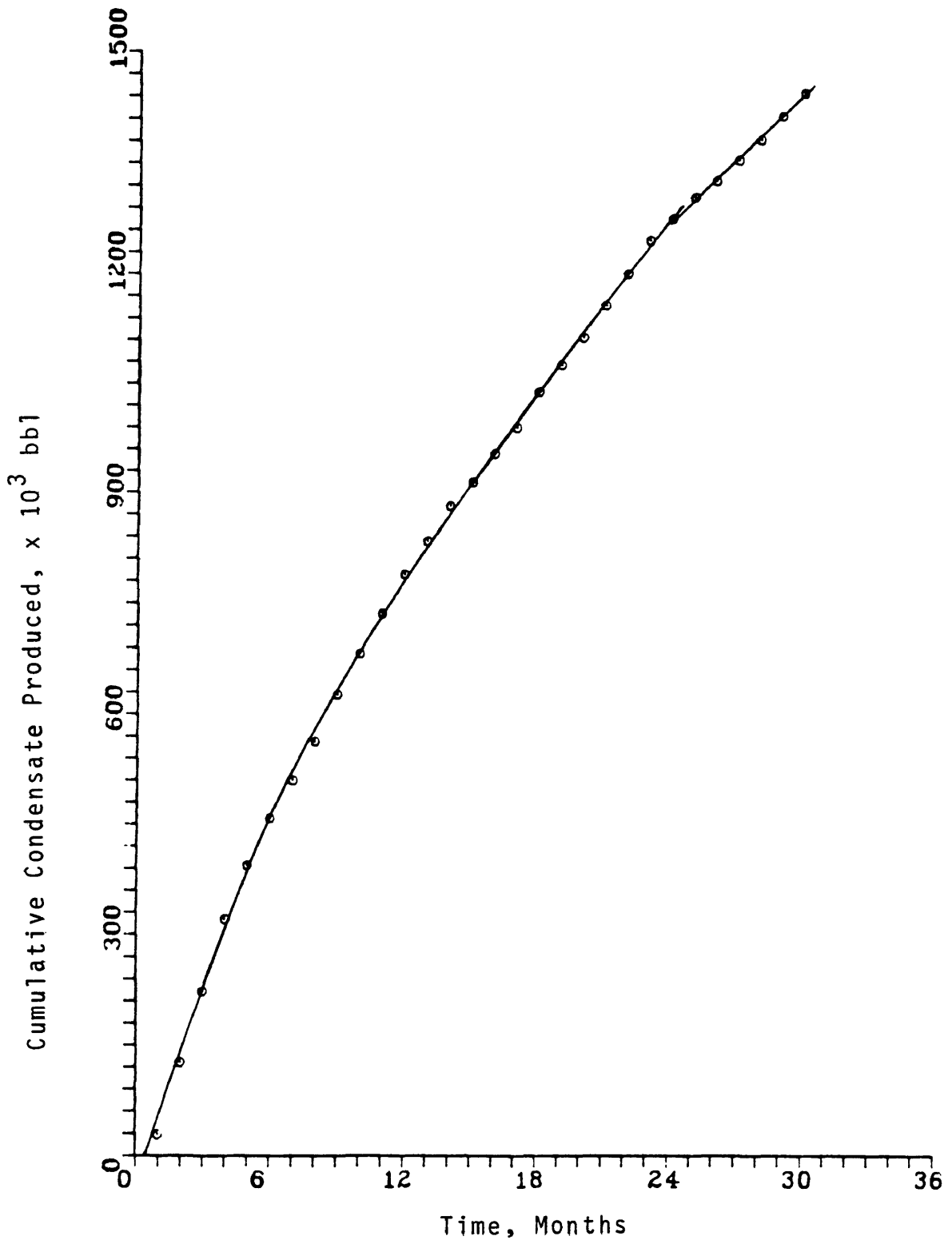


Figure 2. Condensate Production History

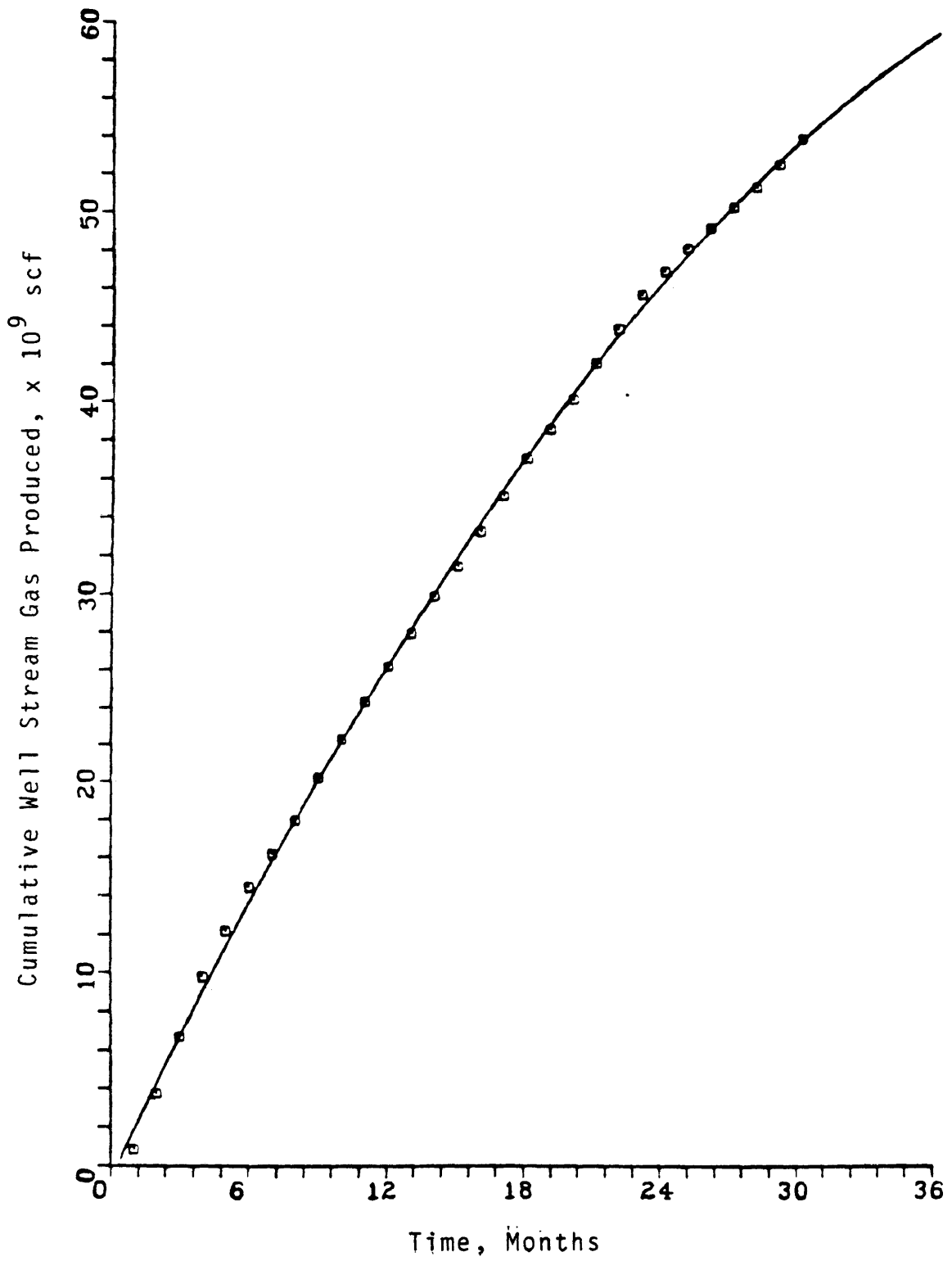


Figure 3. Well Stream Gas Production History

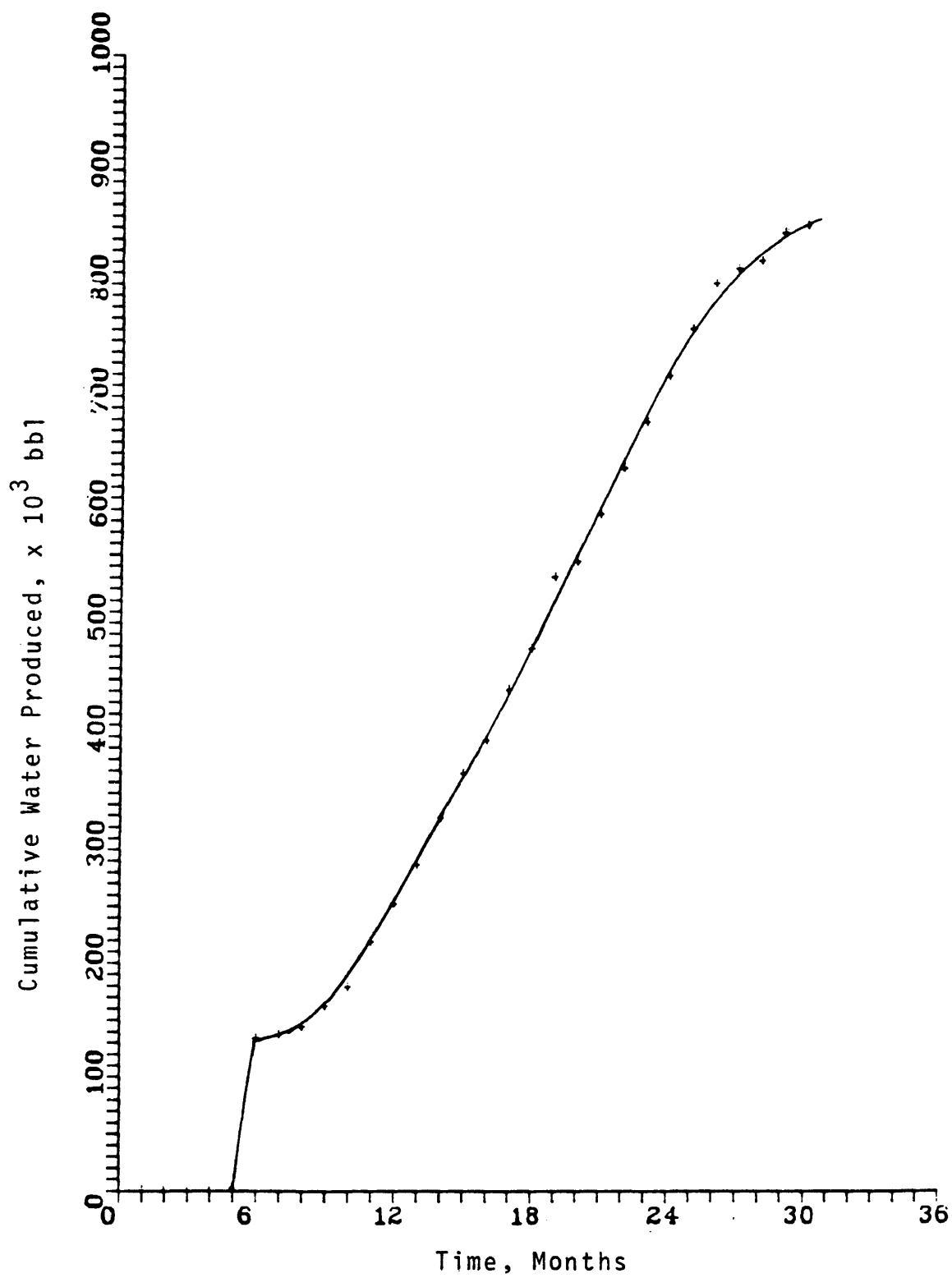


Figure 4. Water Production History

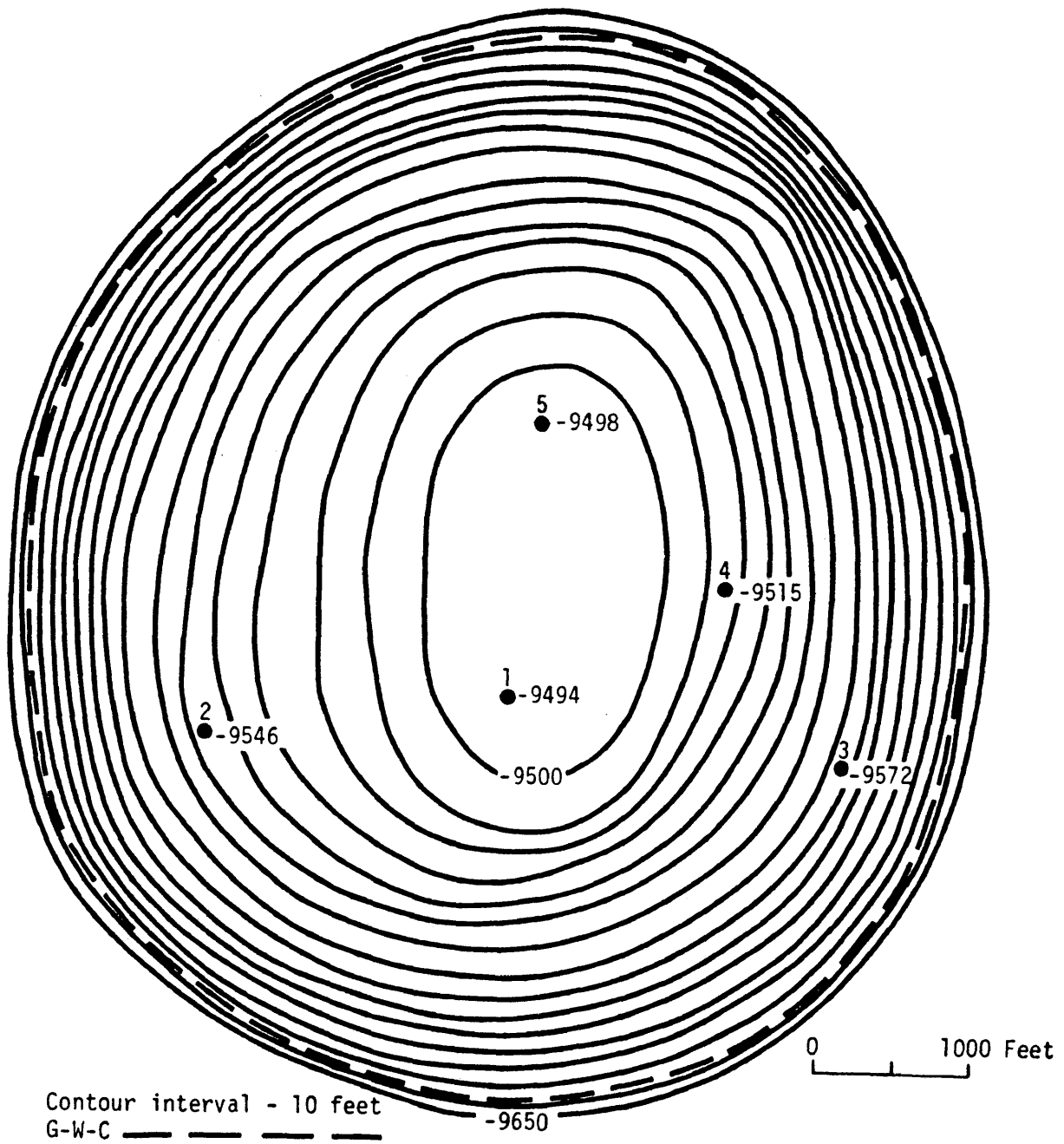


Figure 5. Top of the Formation

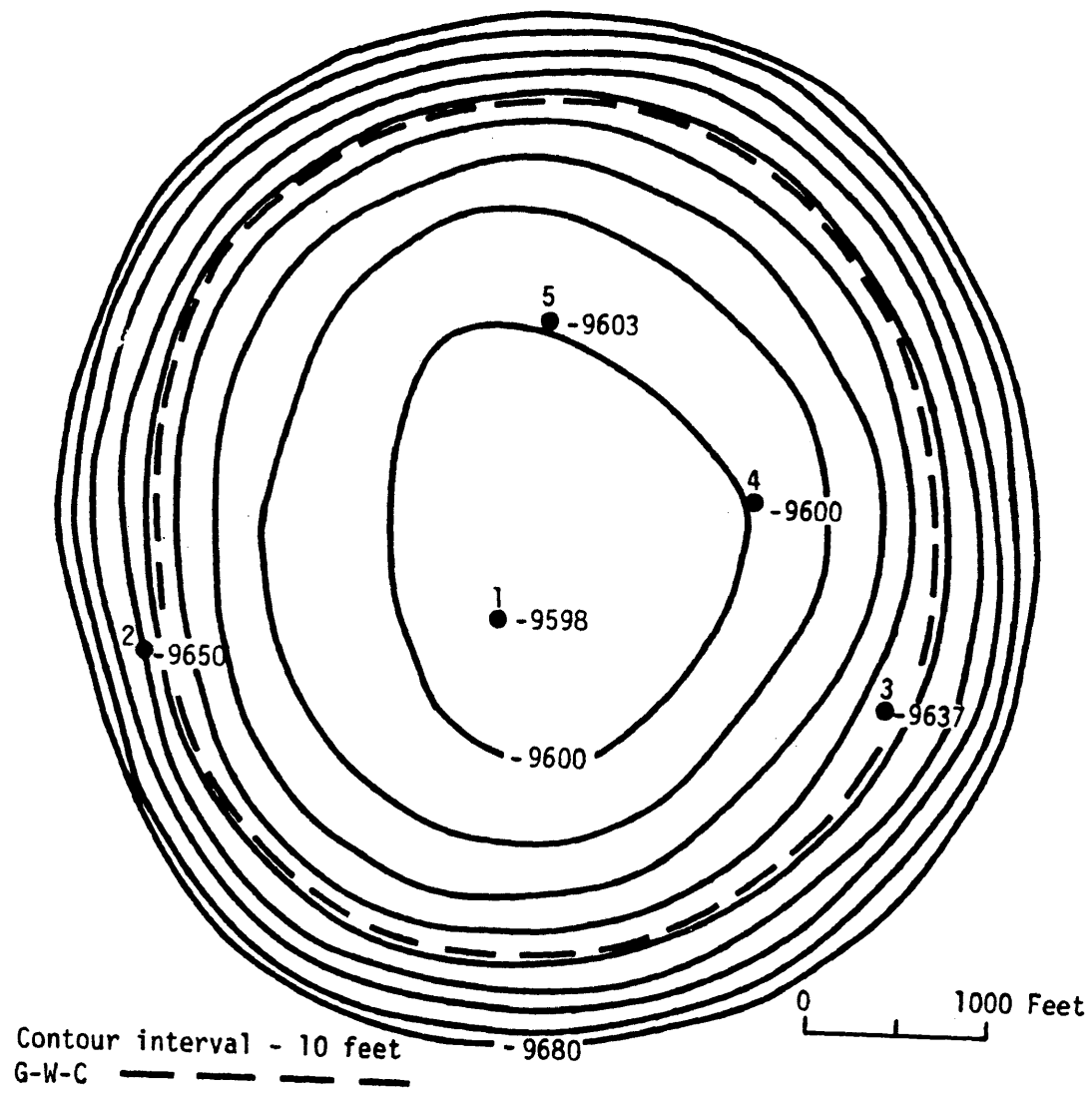


Figure 6. Bottom of the Formation

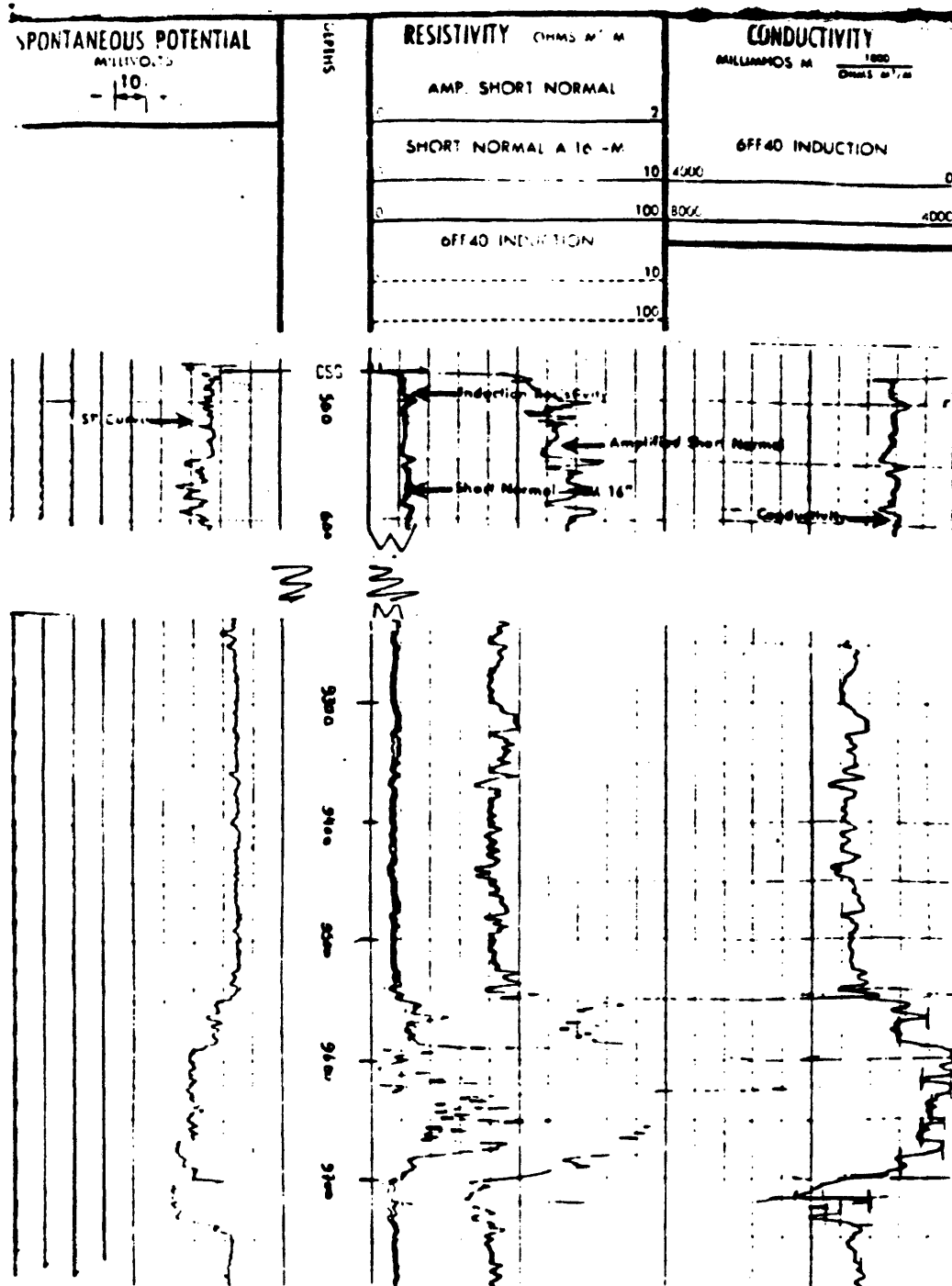


Figure 7. Sample Log

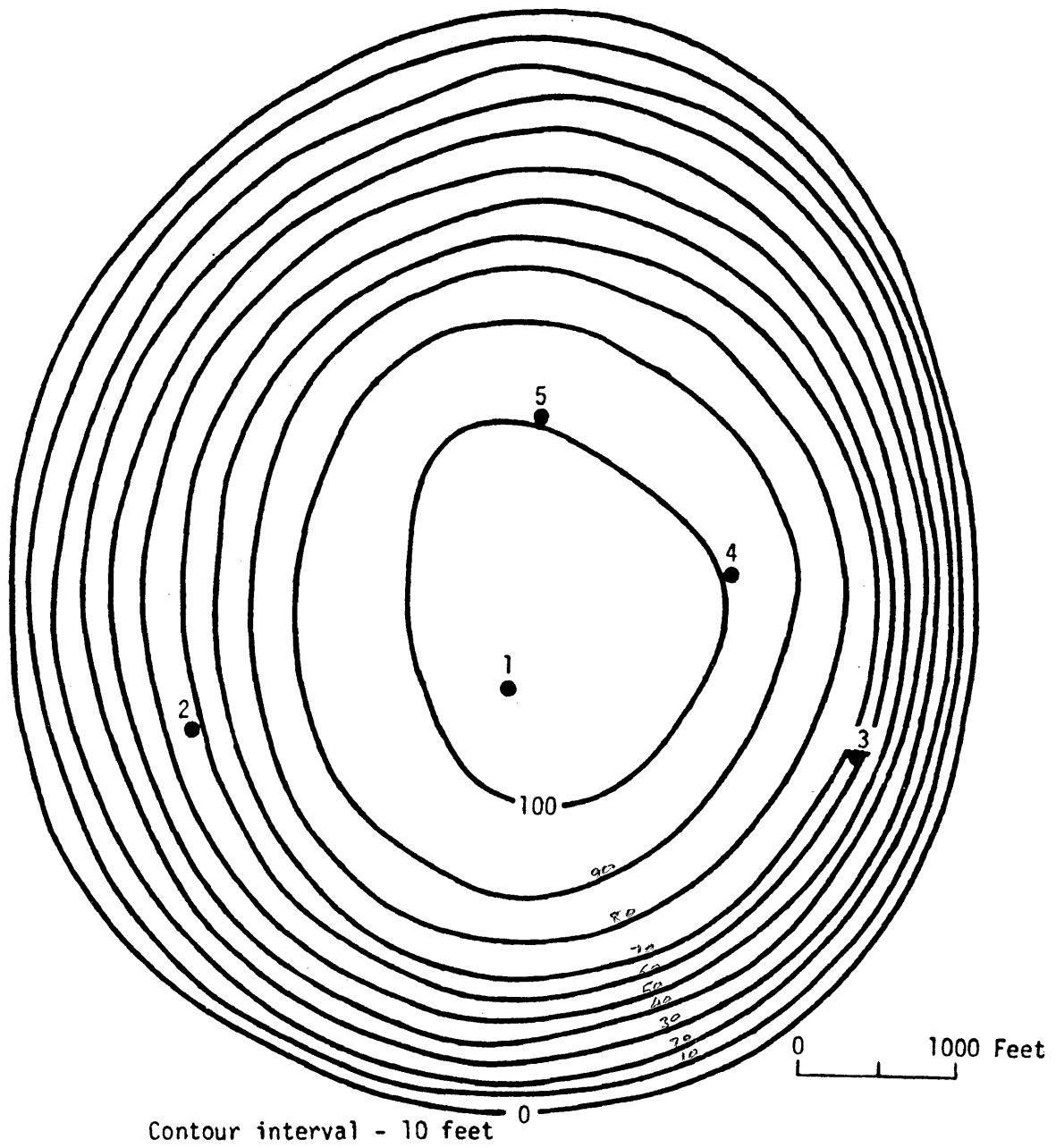


Figure 8. The Isopach Map of the Reservoir

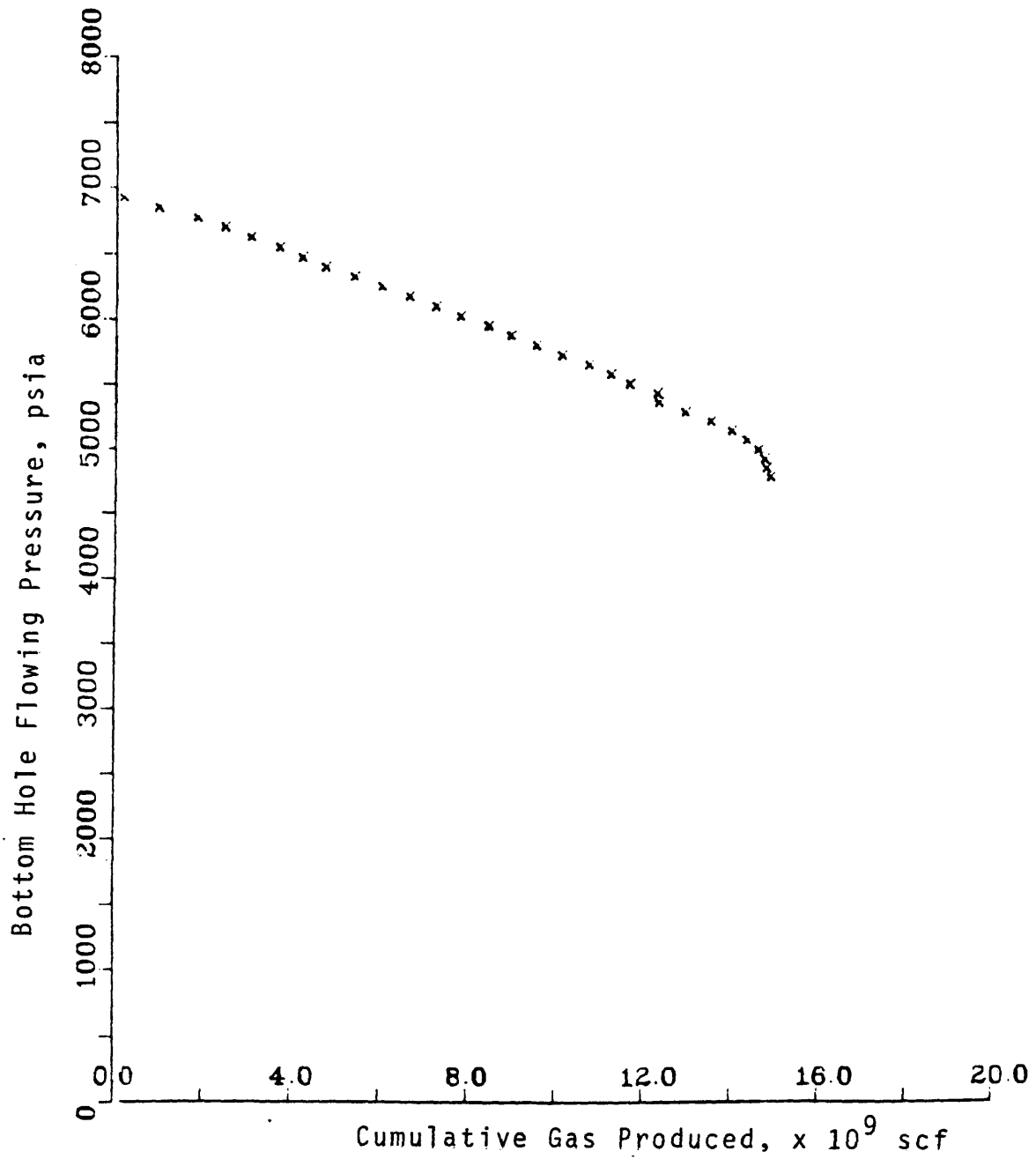


Figure 9. Past Performance Pressure for Well No. 1

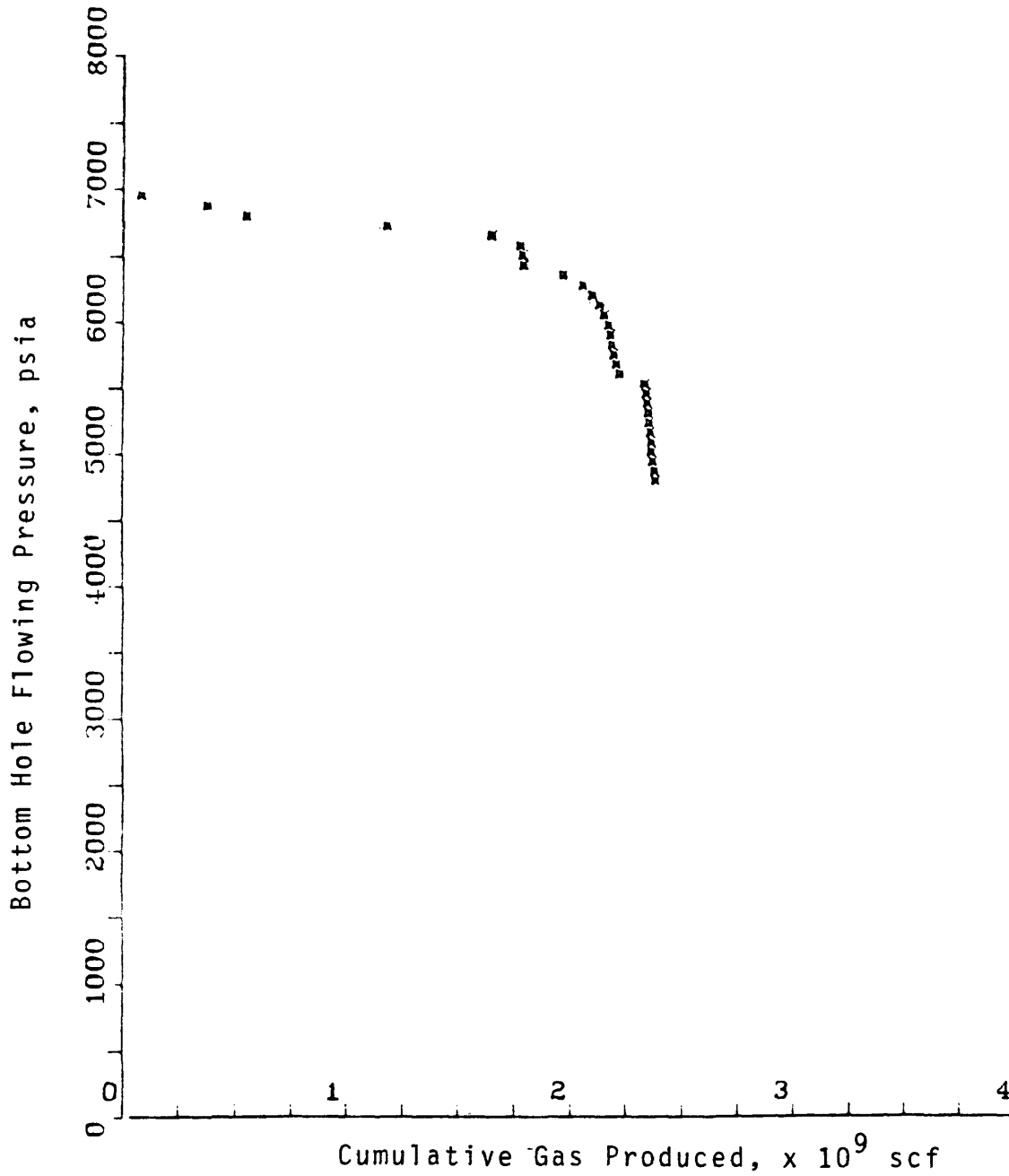


Figure 10. Past Performance Pressure for Well No. 2

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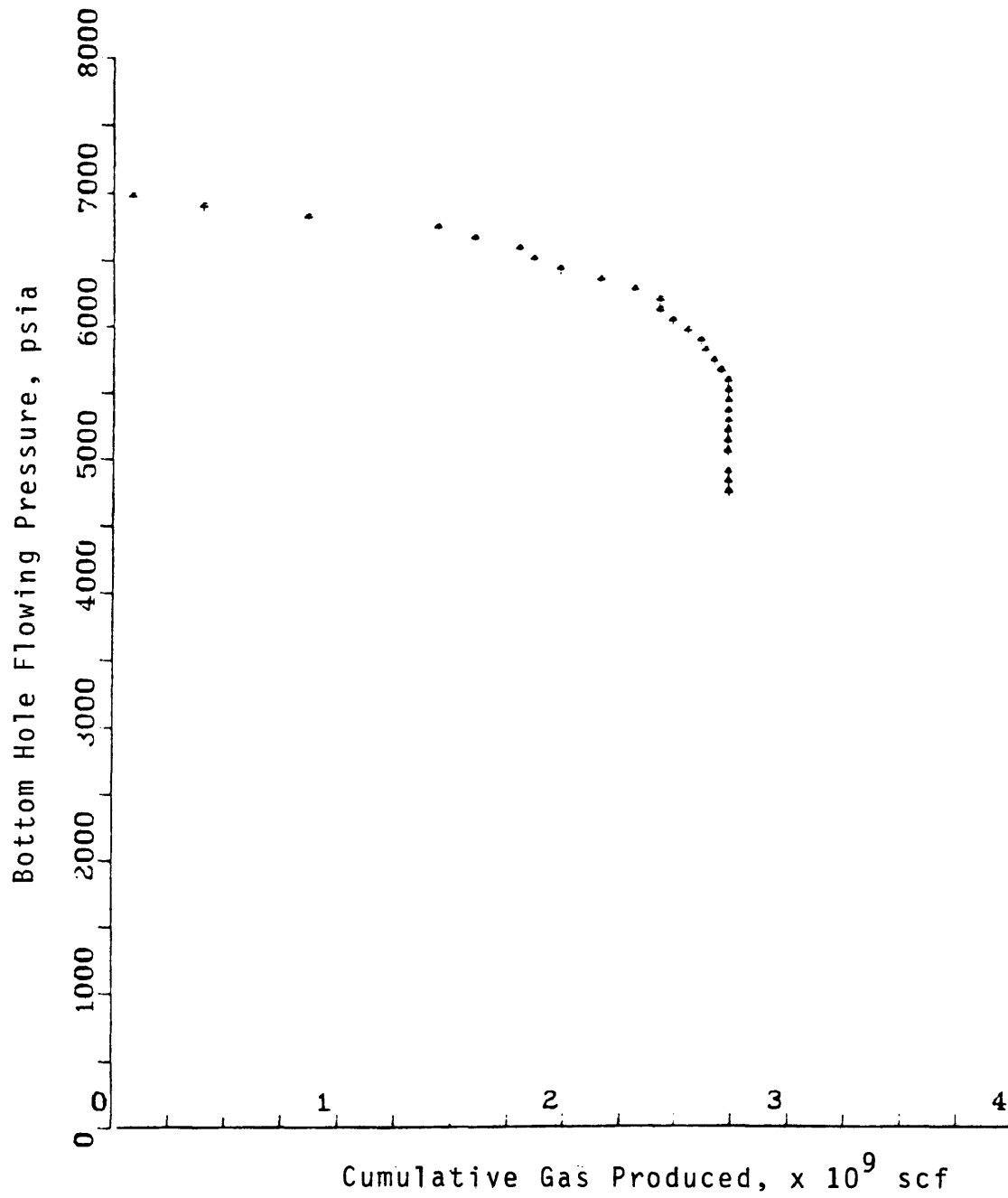


Figure 11. Past Performance Pressure for Well No. 3

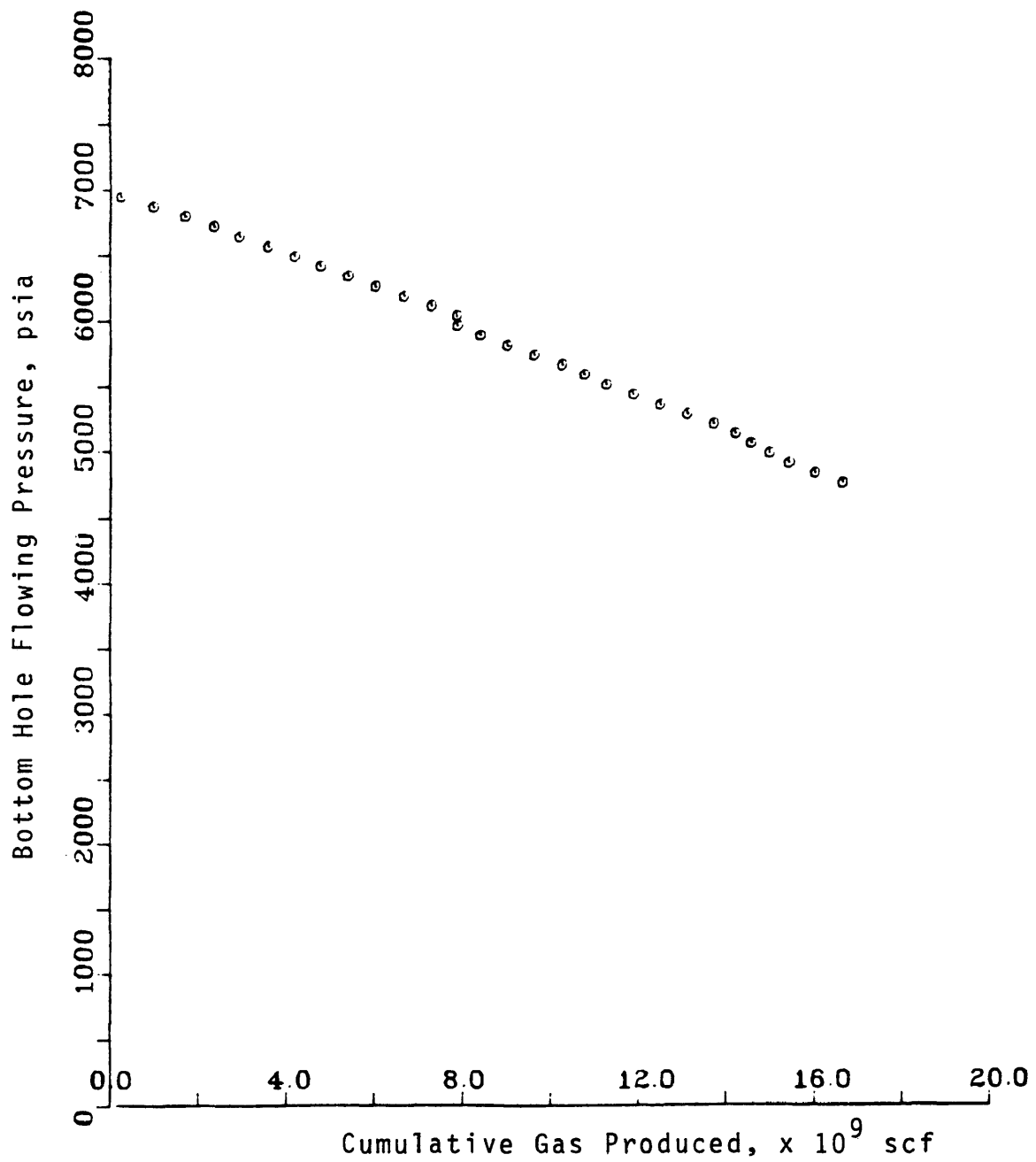


Figure 12. Past Performance Pressure for Well No. 4

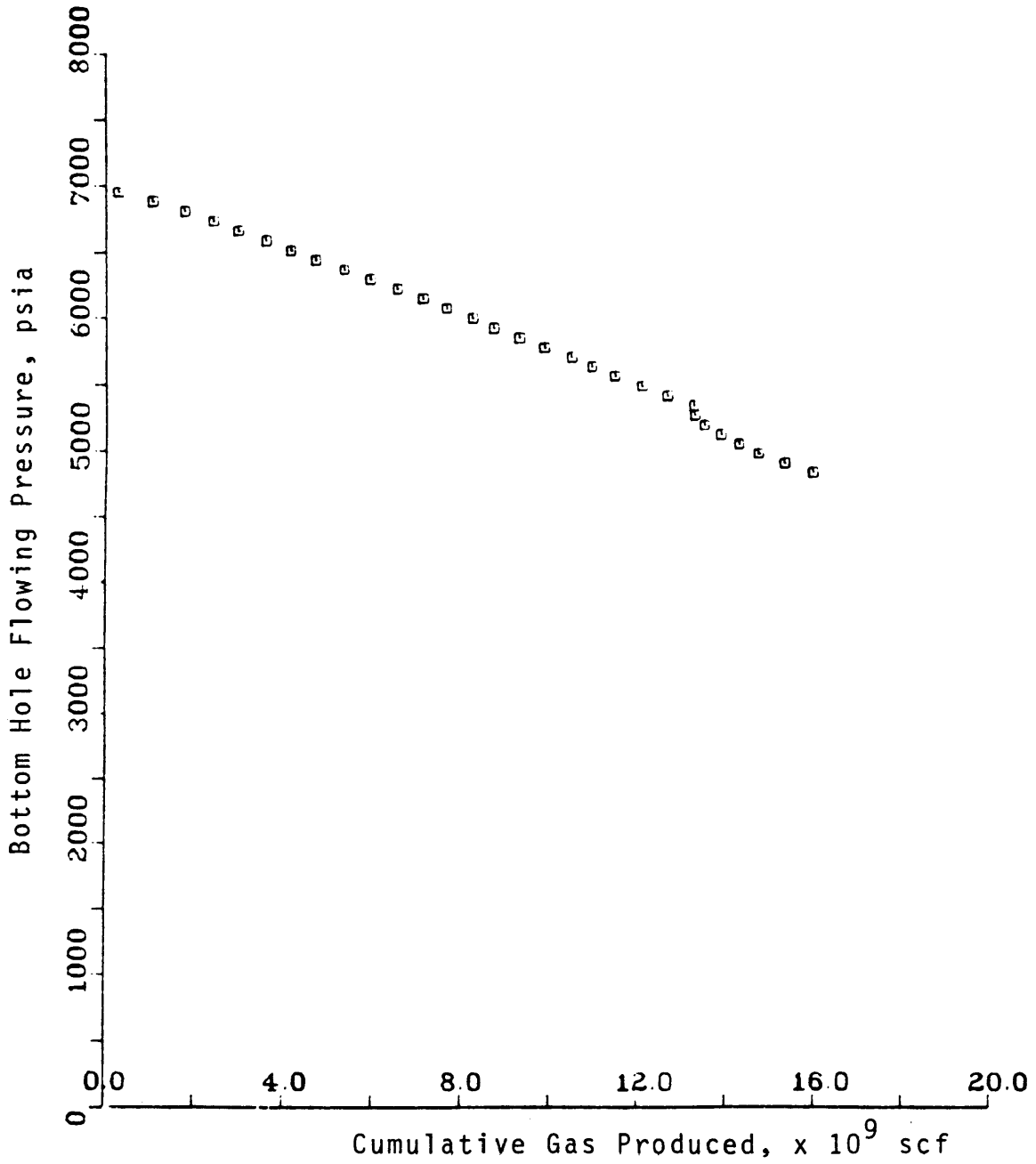


Figure 13. Past Performance Pressure for Well No. 5

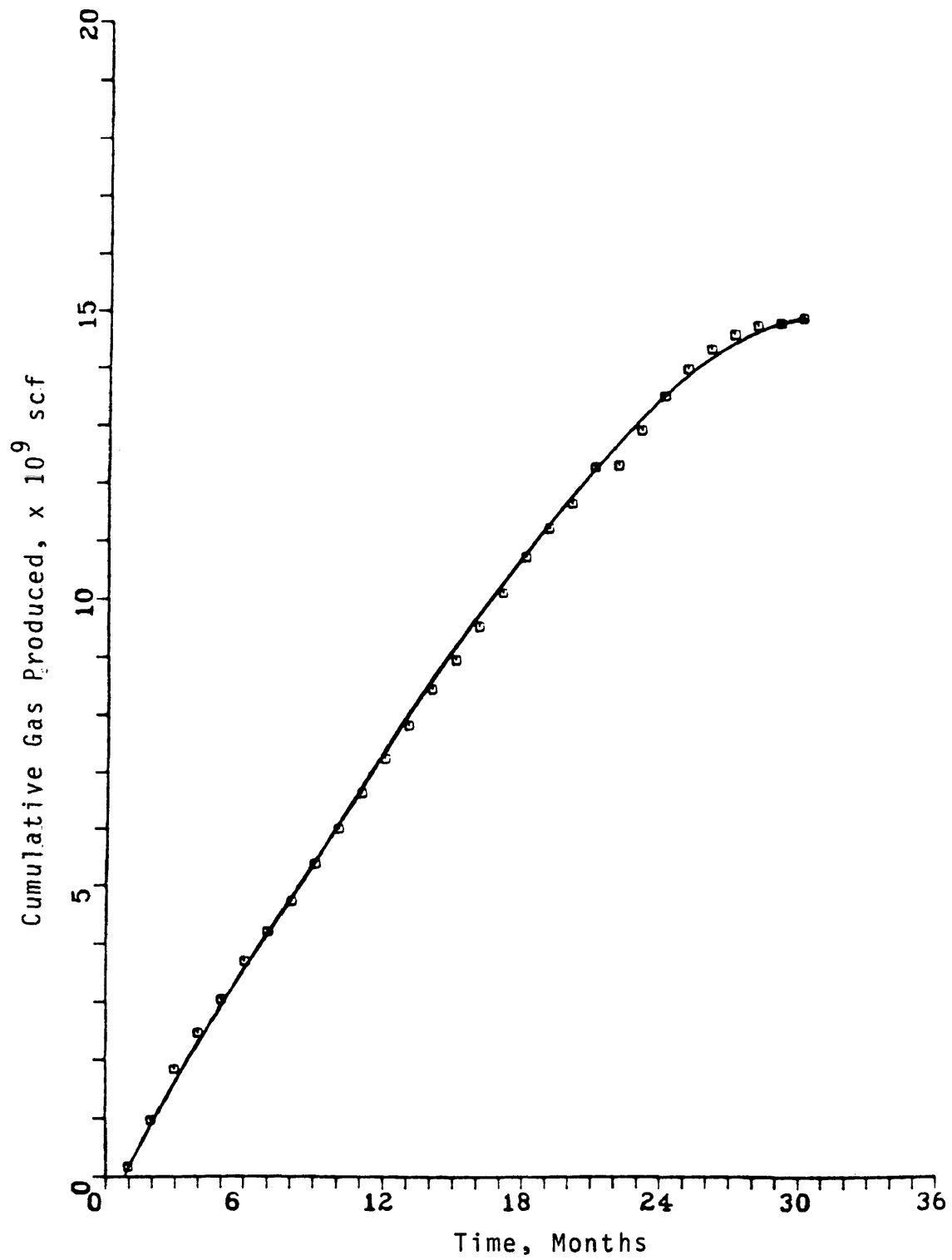


Figure 14. Well Stream Gas Production History for Well No. 1

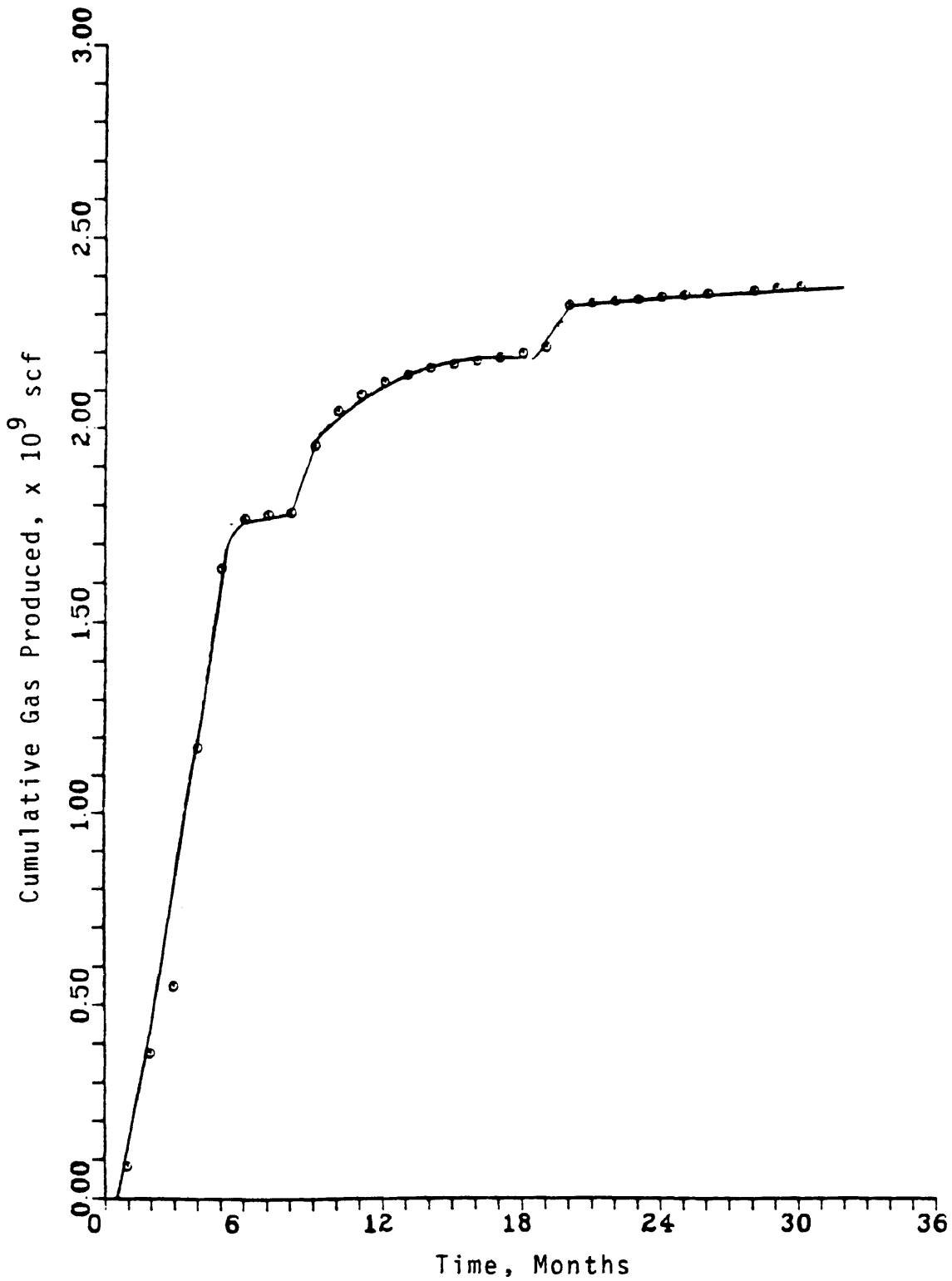


Figure 15. Well Stream Gas Production History for Well No. 2

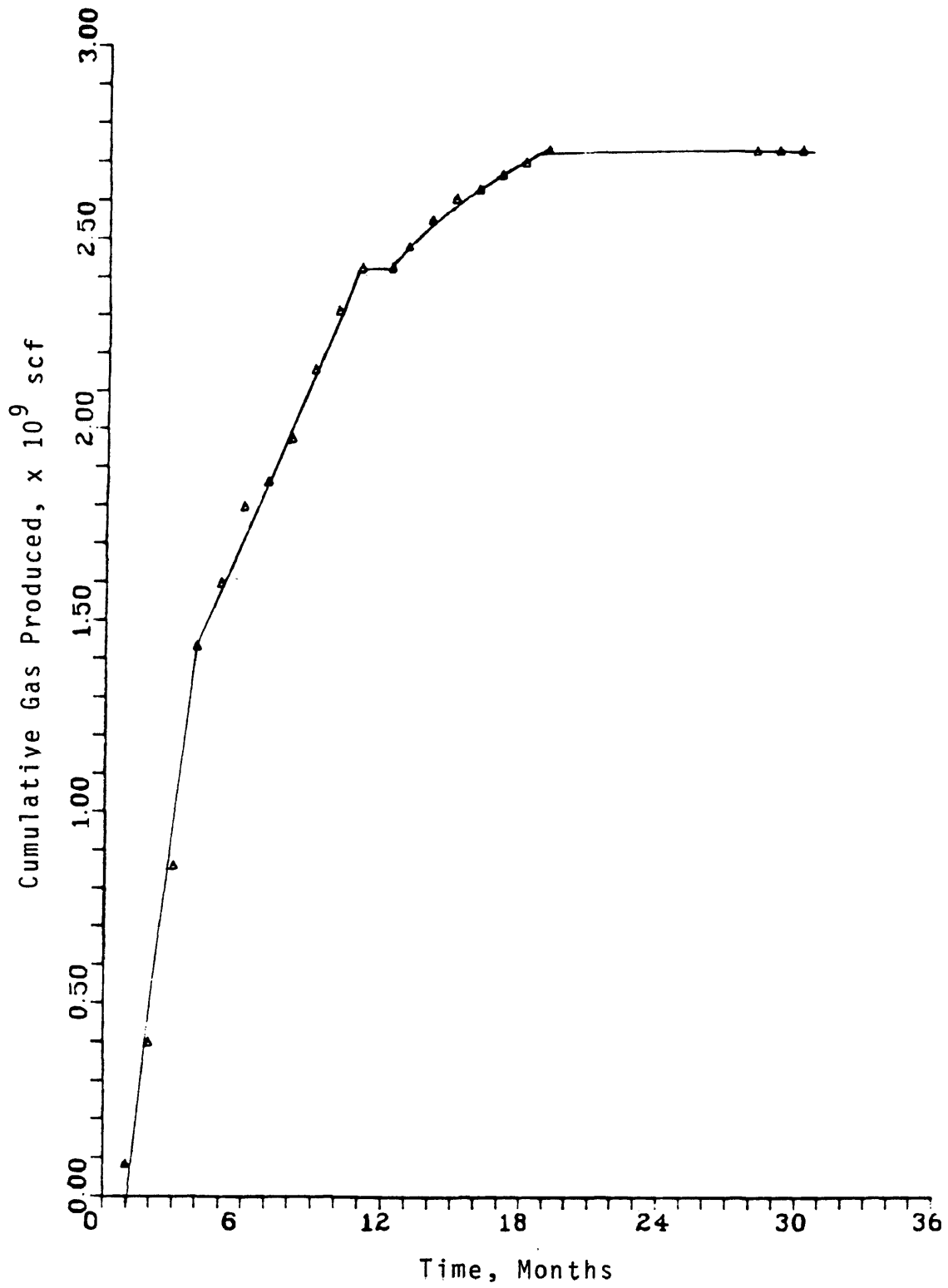


Figure 16. Well Stream Gas Production History for Well No. 3

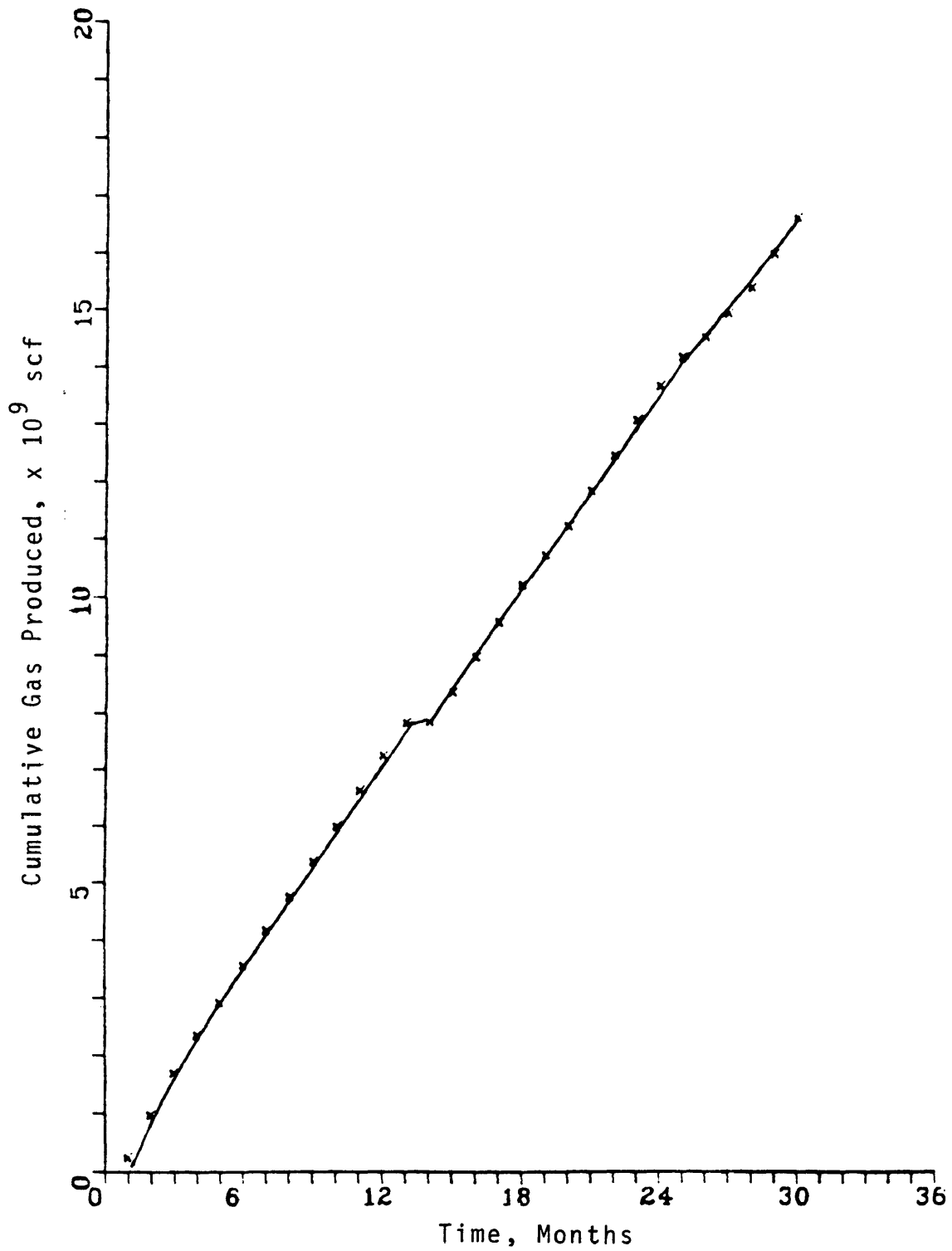


Figure 17. Well Stream Gas Production History for Well No. 4

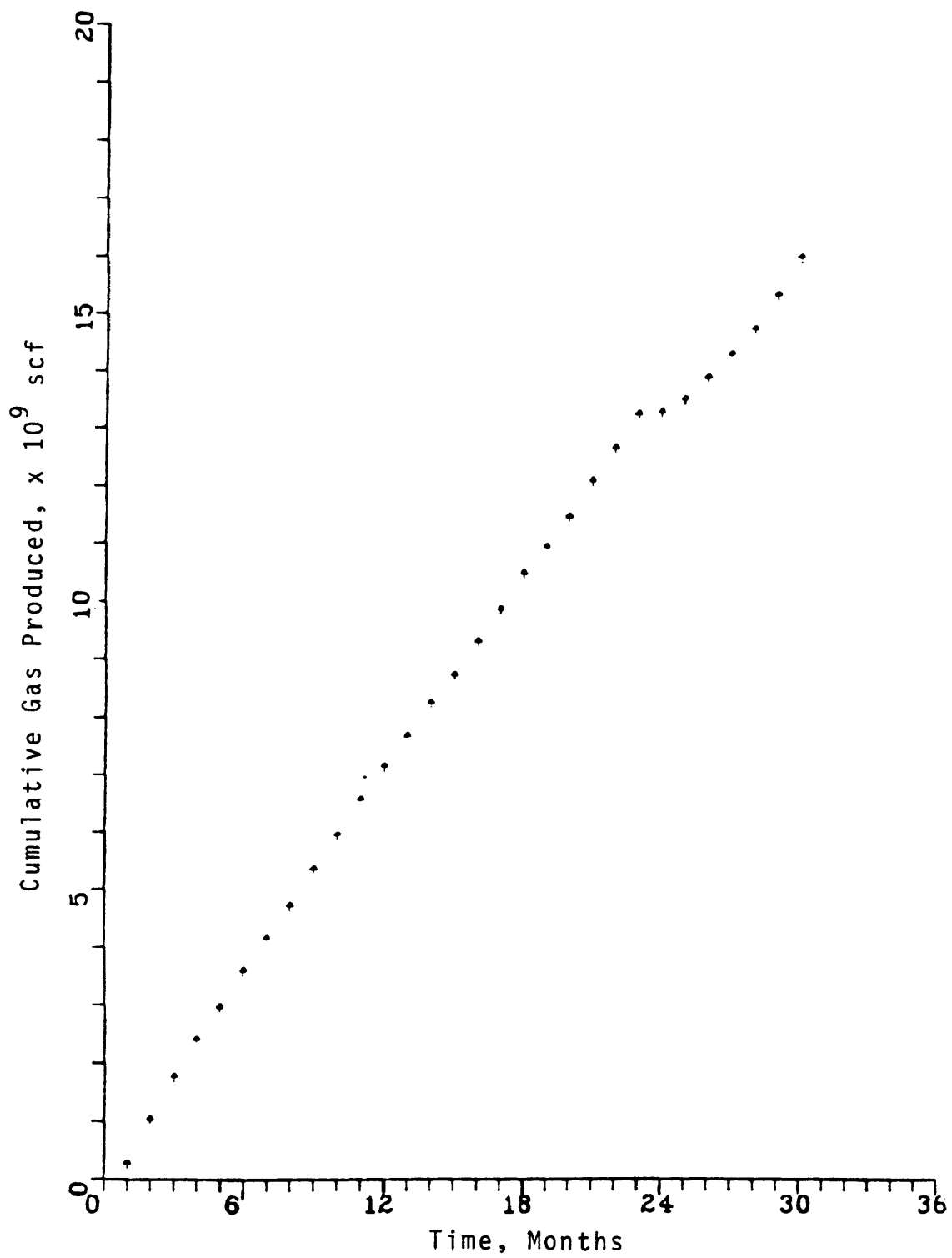


Figure 18. Well Stream Gas Production History for Well No. 5

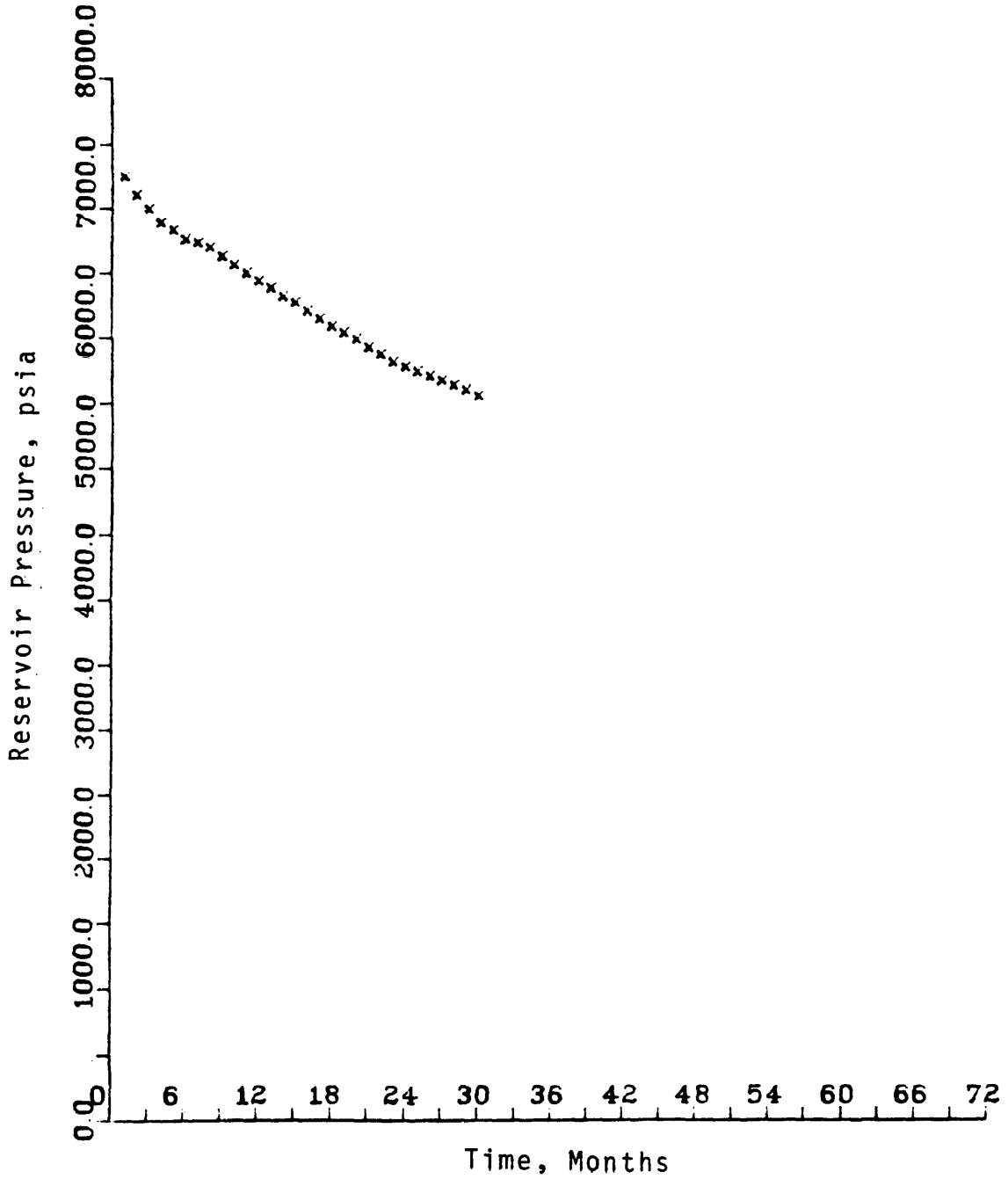


Figure 19. Calculated Average Reservoir Pressure History

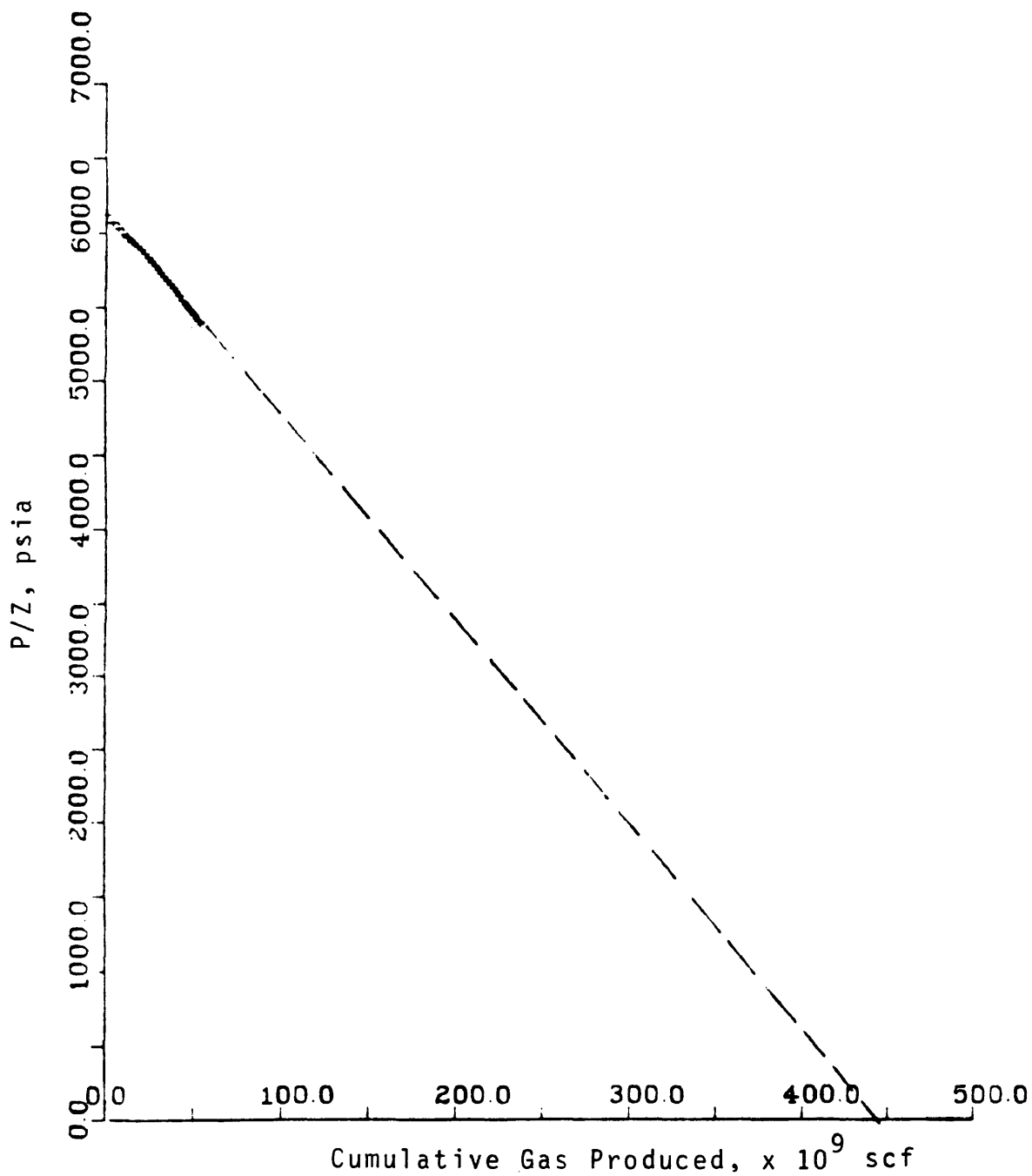


Figure 20. P/Z Against Cumulative Gas Produced

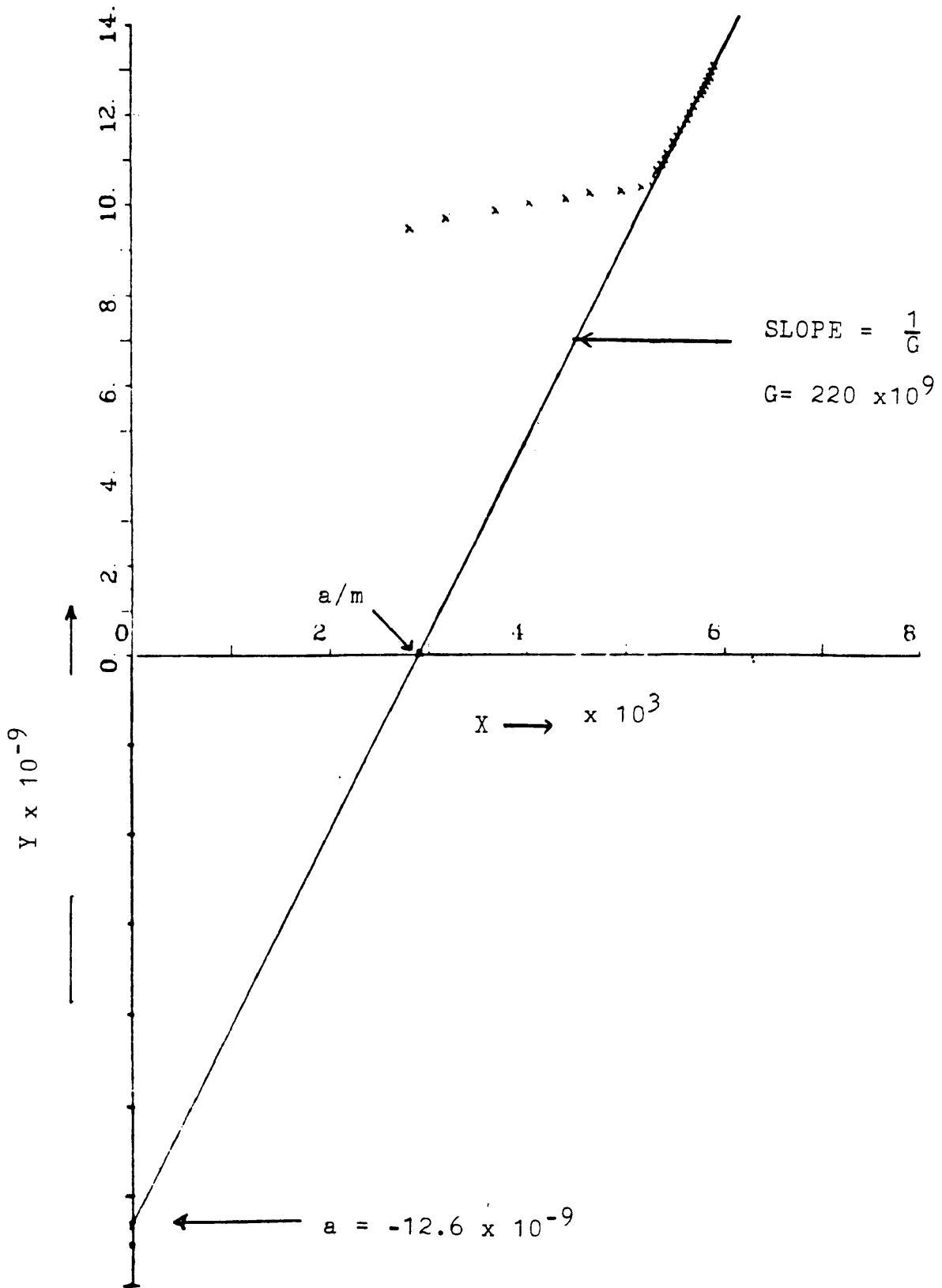


Figure 21. Modified Material Balance Equation

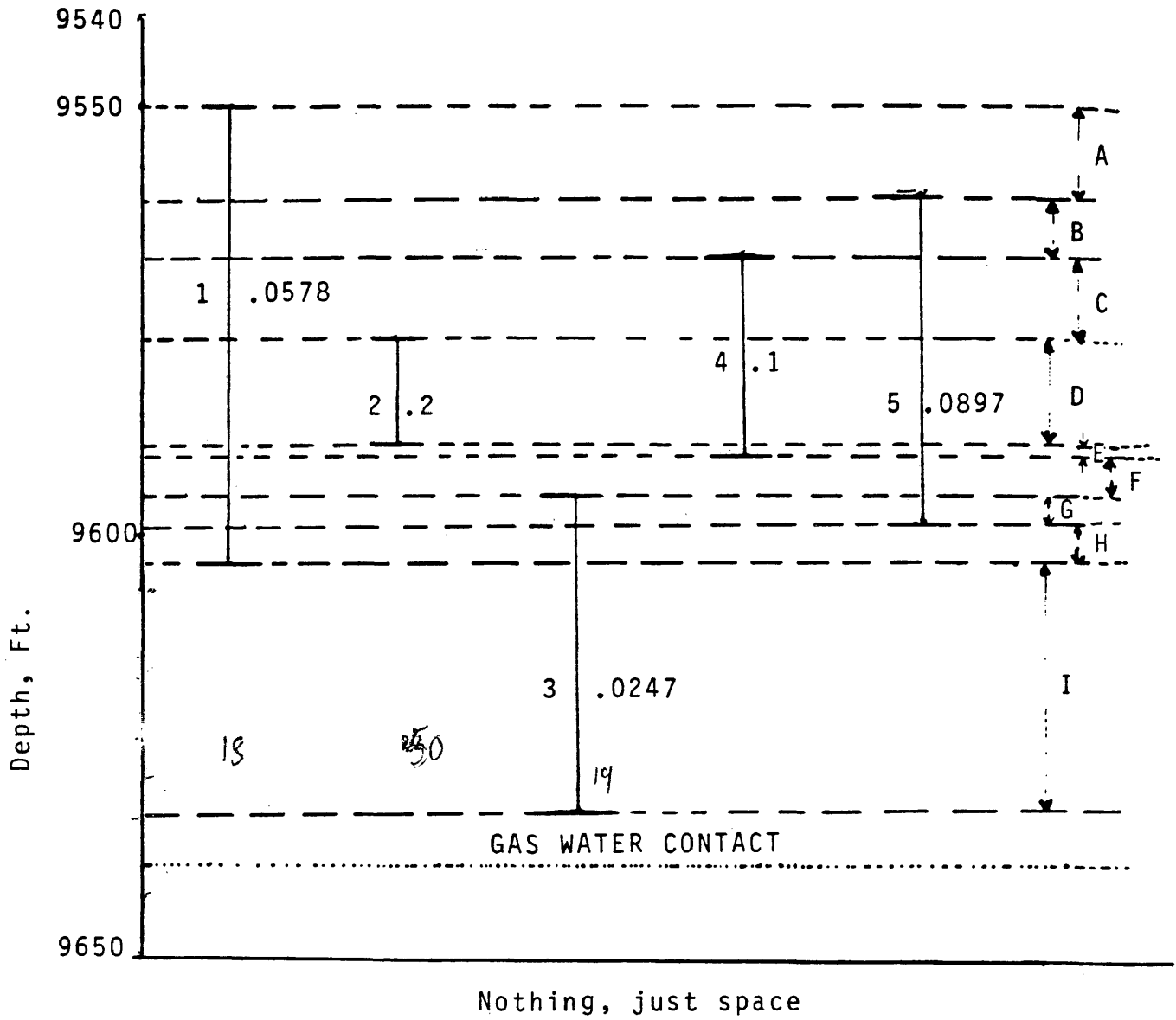


Figure 22. Location of Perforation and the Specific Producing Capacity

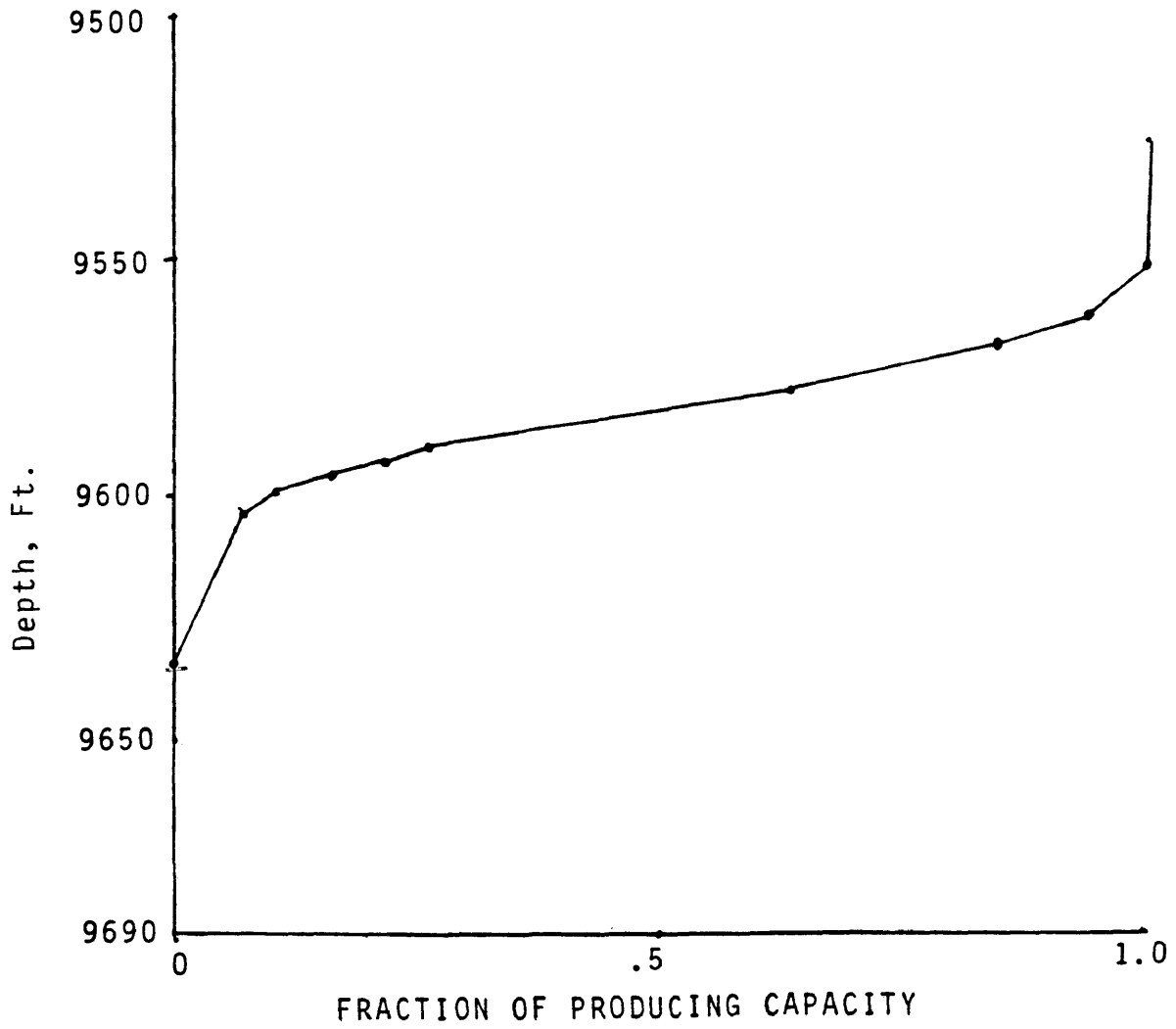


Figure 23. Fractional Producing Capacity vs. Depth

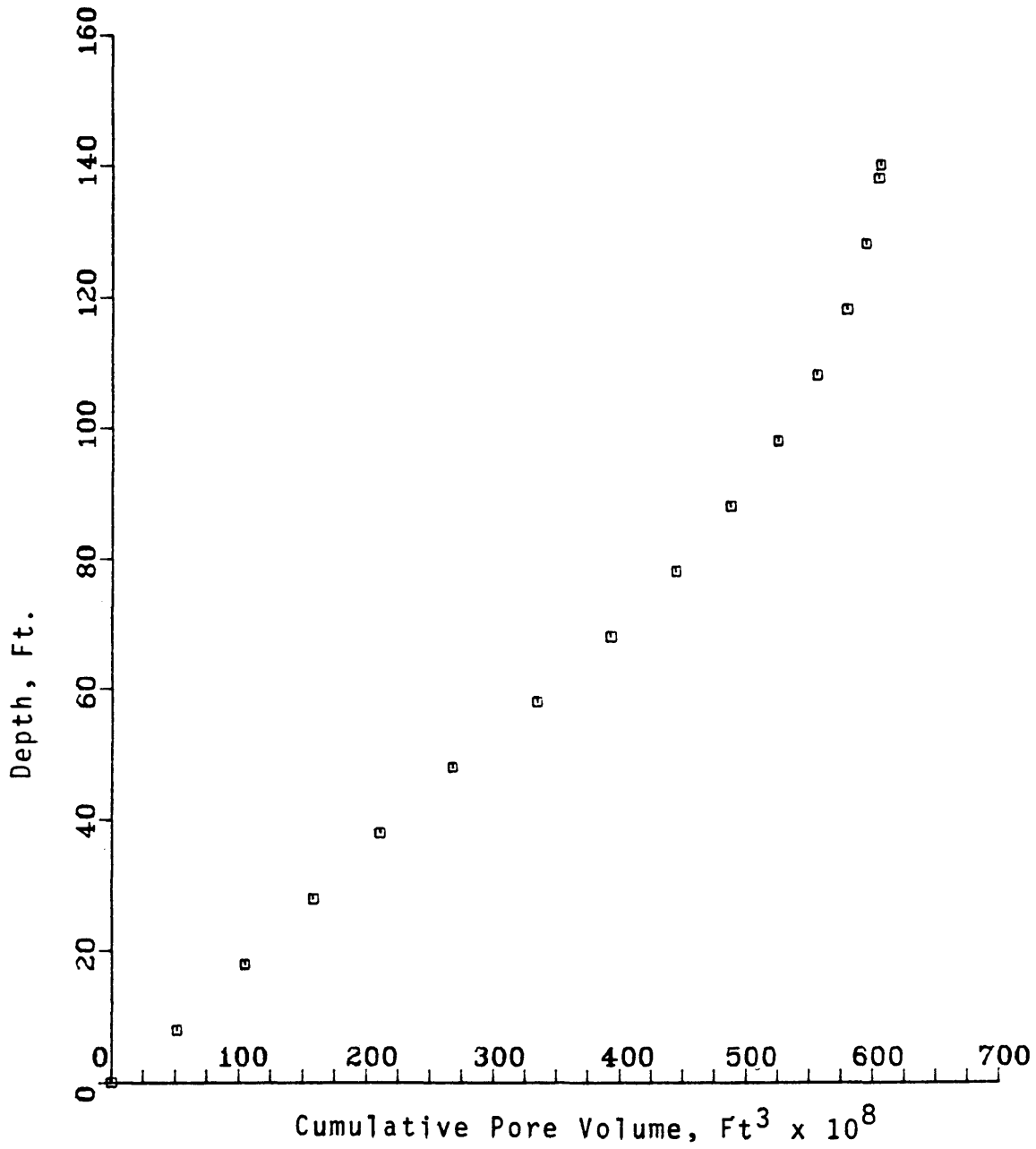


Figure 24. Pore Volume Distribution Above Original Gas-Water-Contact

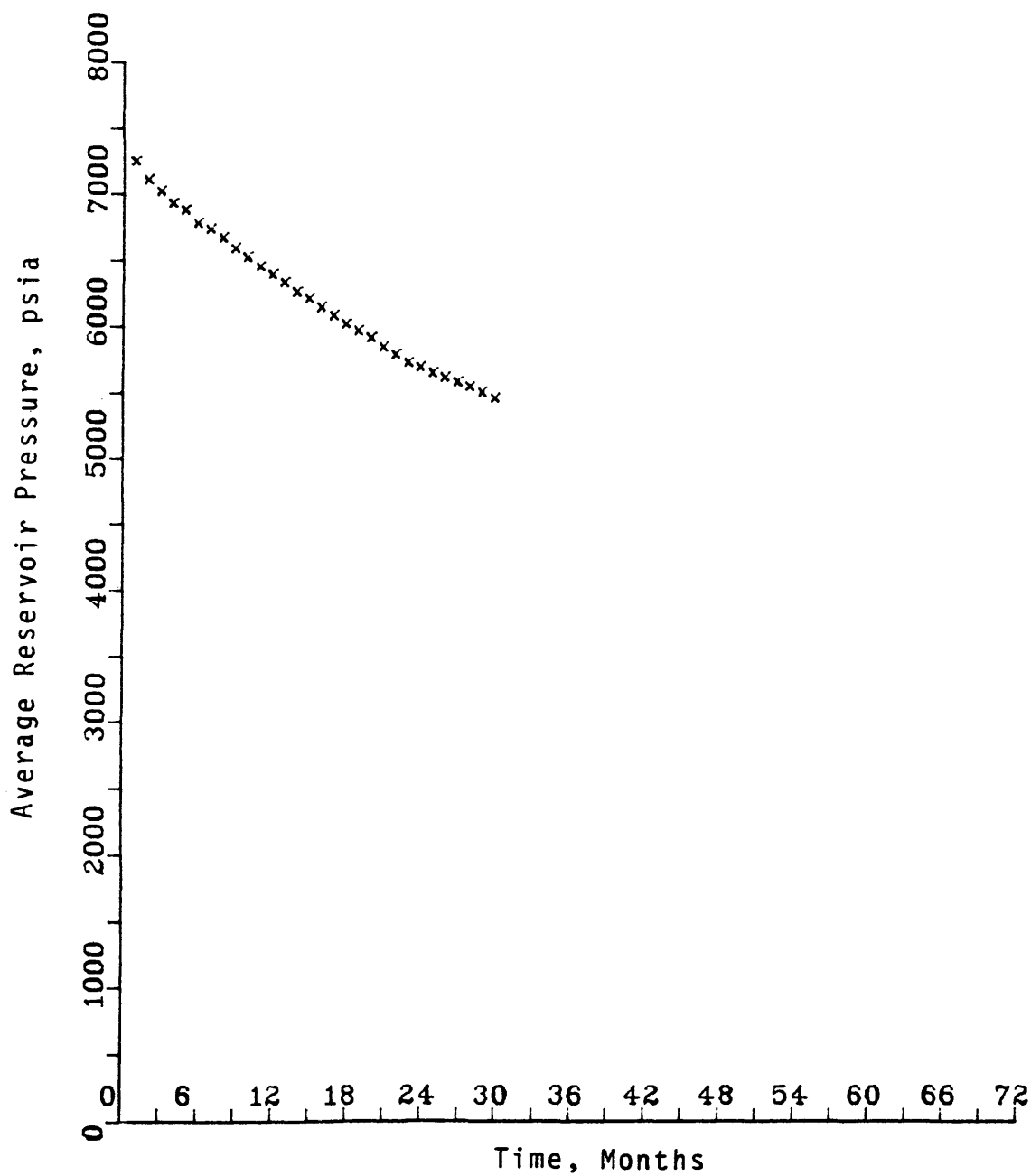


Figure 25. Average Reservoir Pressure, Based on Material Balance

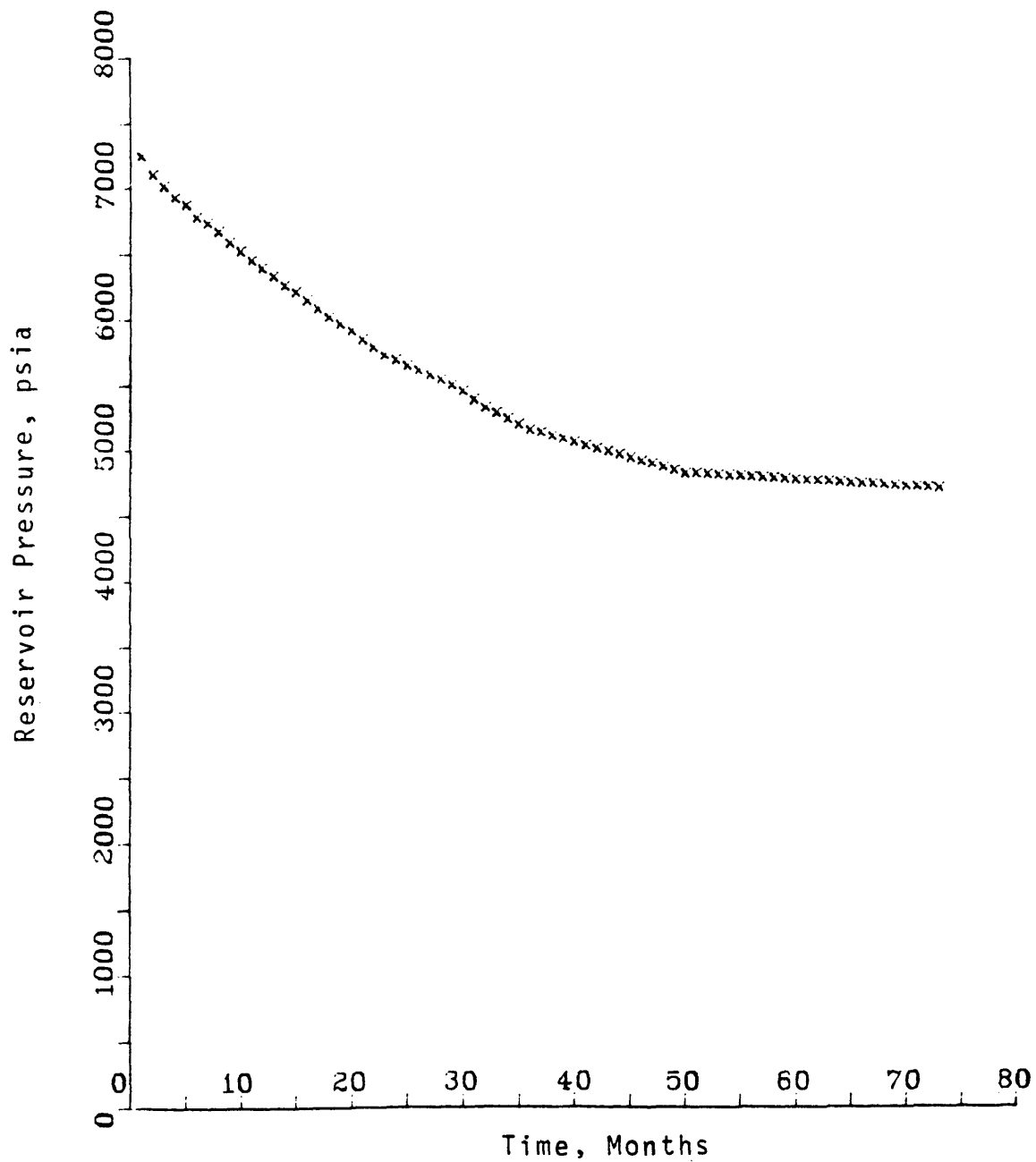


Figure 26. Pressure Behavior for Prediction 1

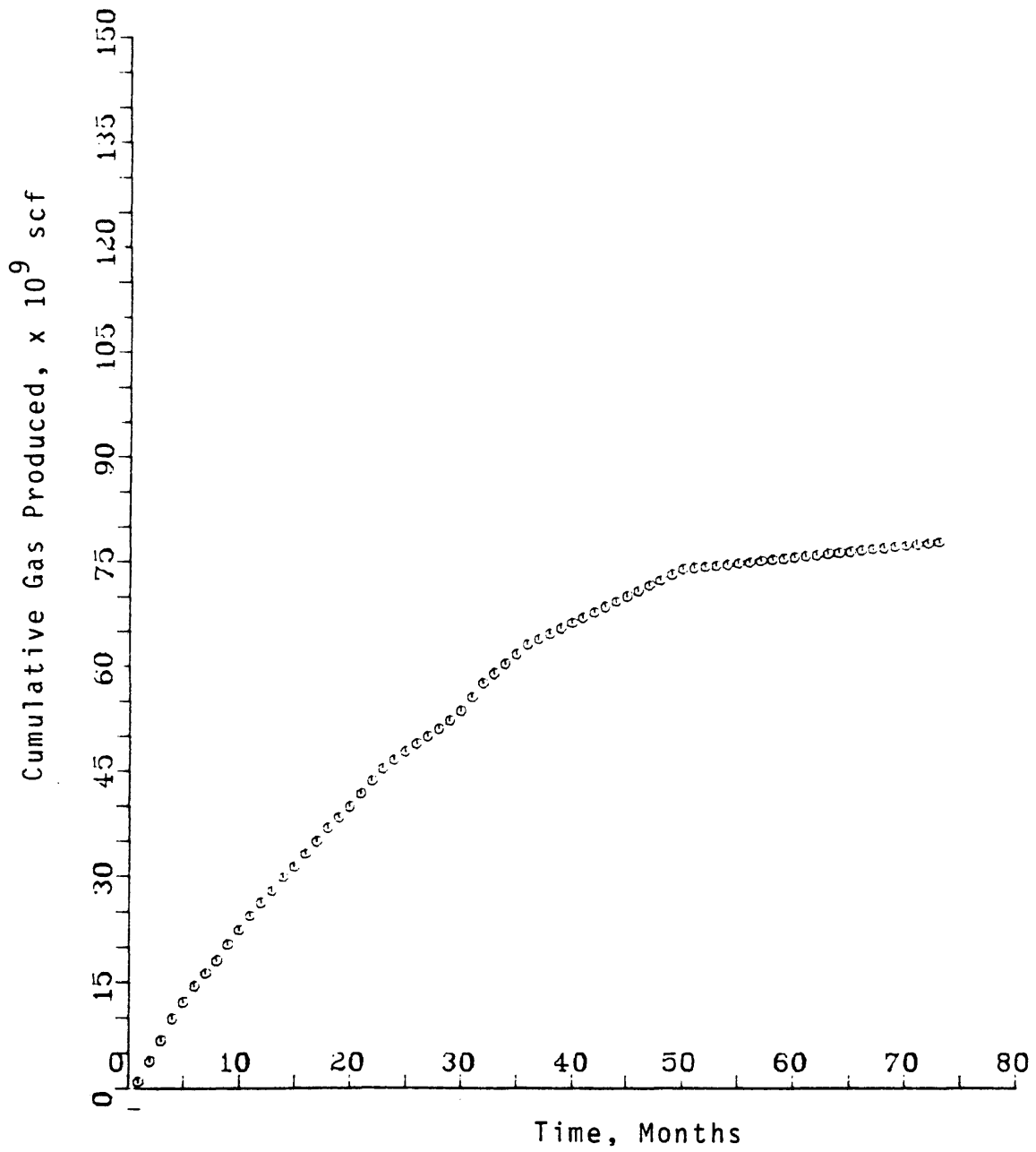


Figure 27. Gas Production Behavior for Prediction 1

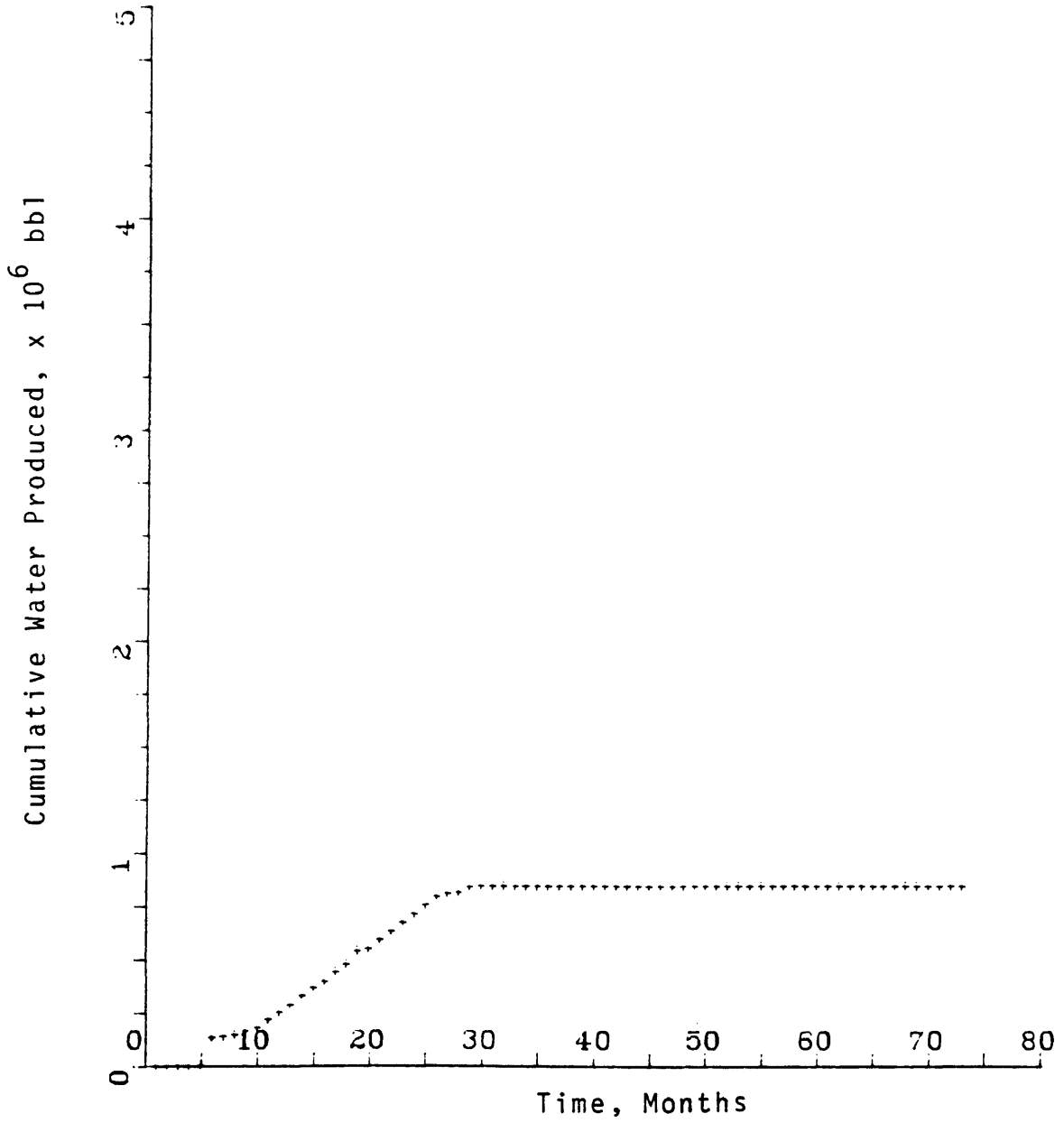


Figure 28. Water Production Behavior for Prediction 1

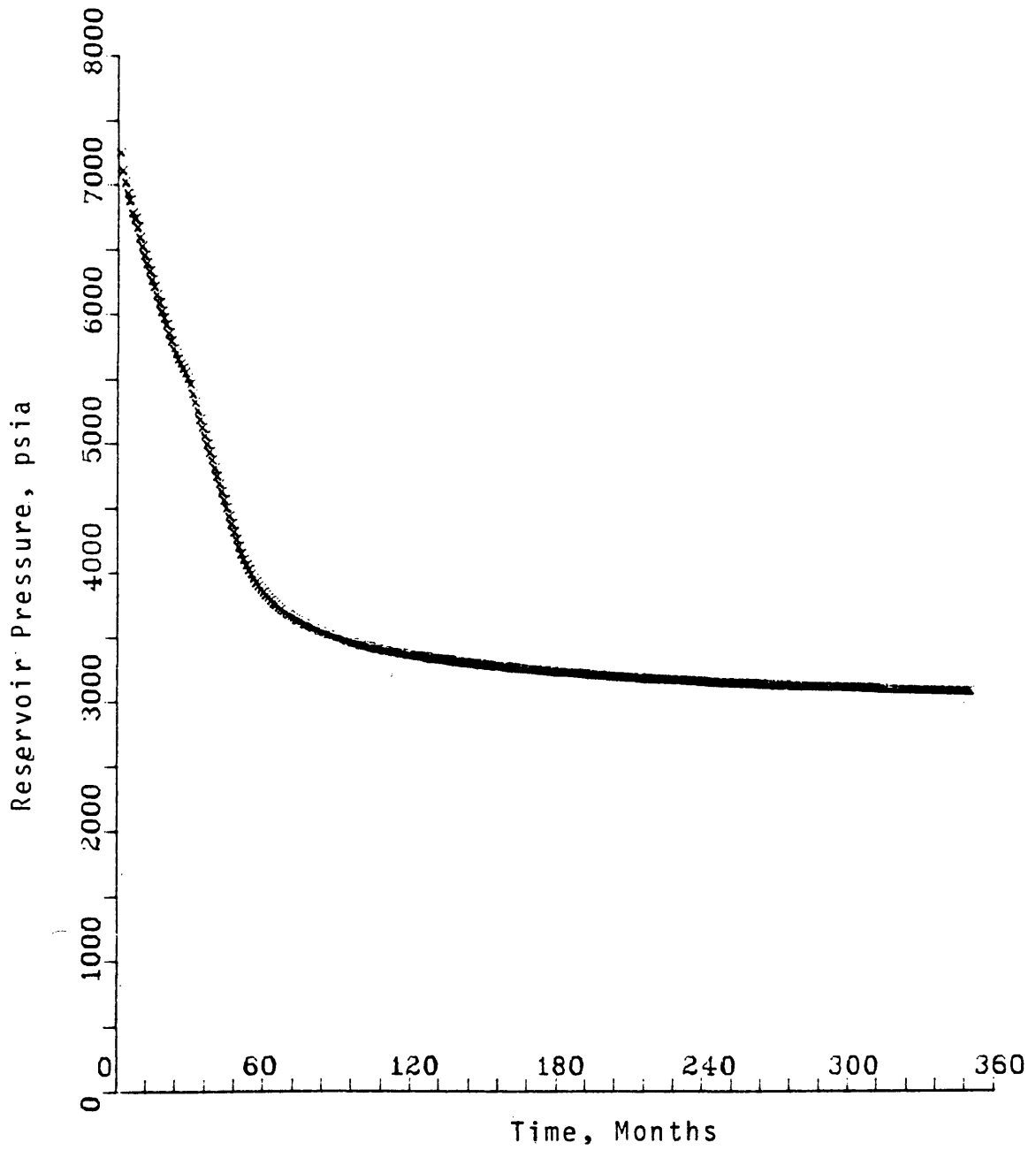


Figure 29. Pressure Behavior for Prediction 2

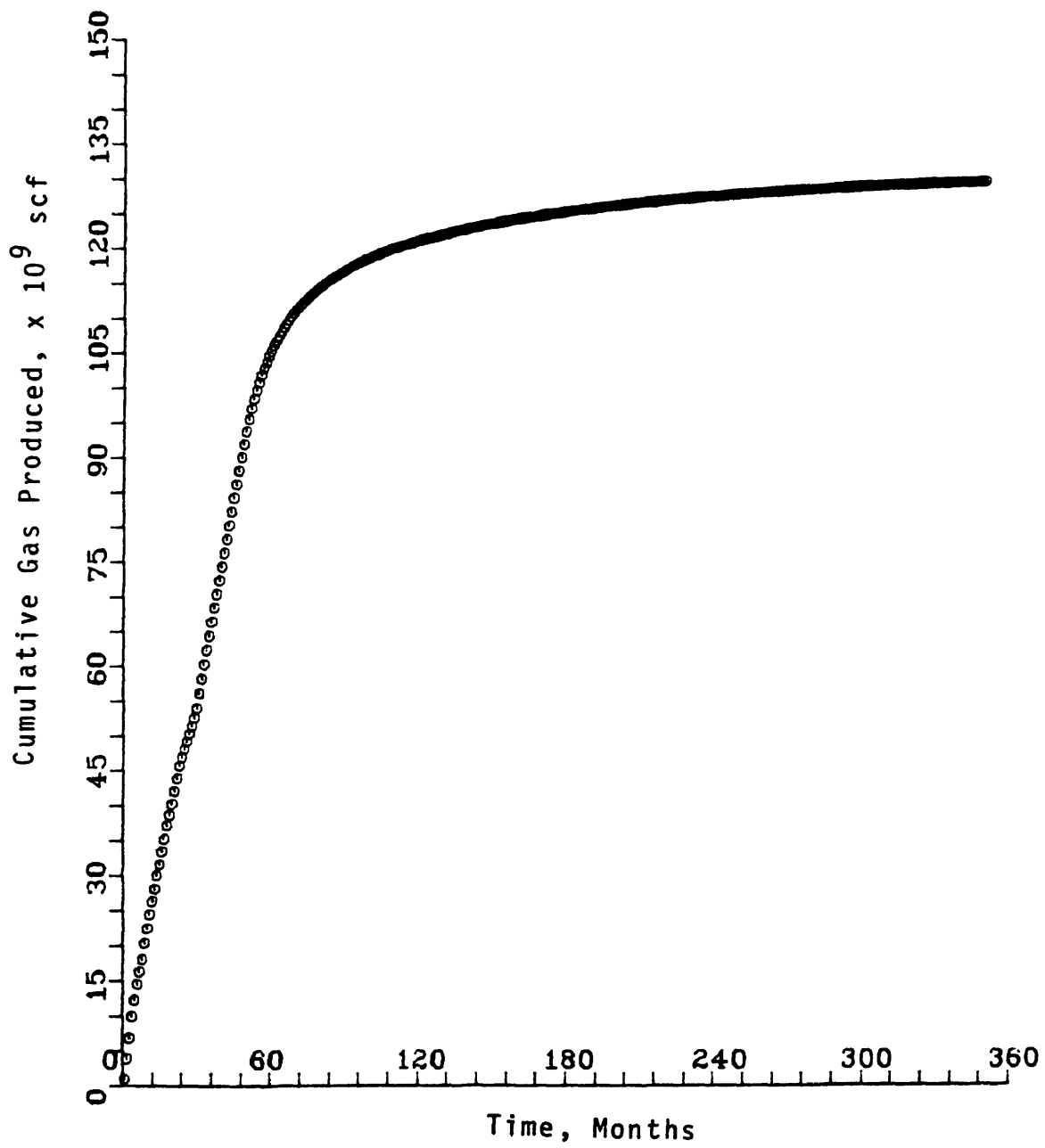


Figure 30. Gas Production Behavior for Prediction 2

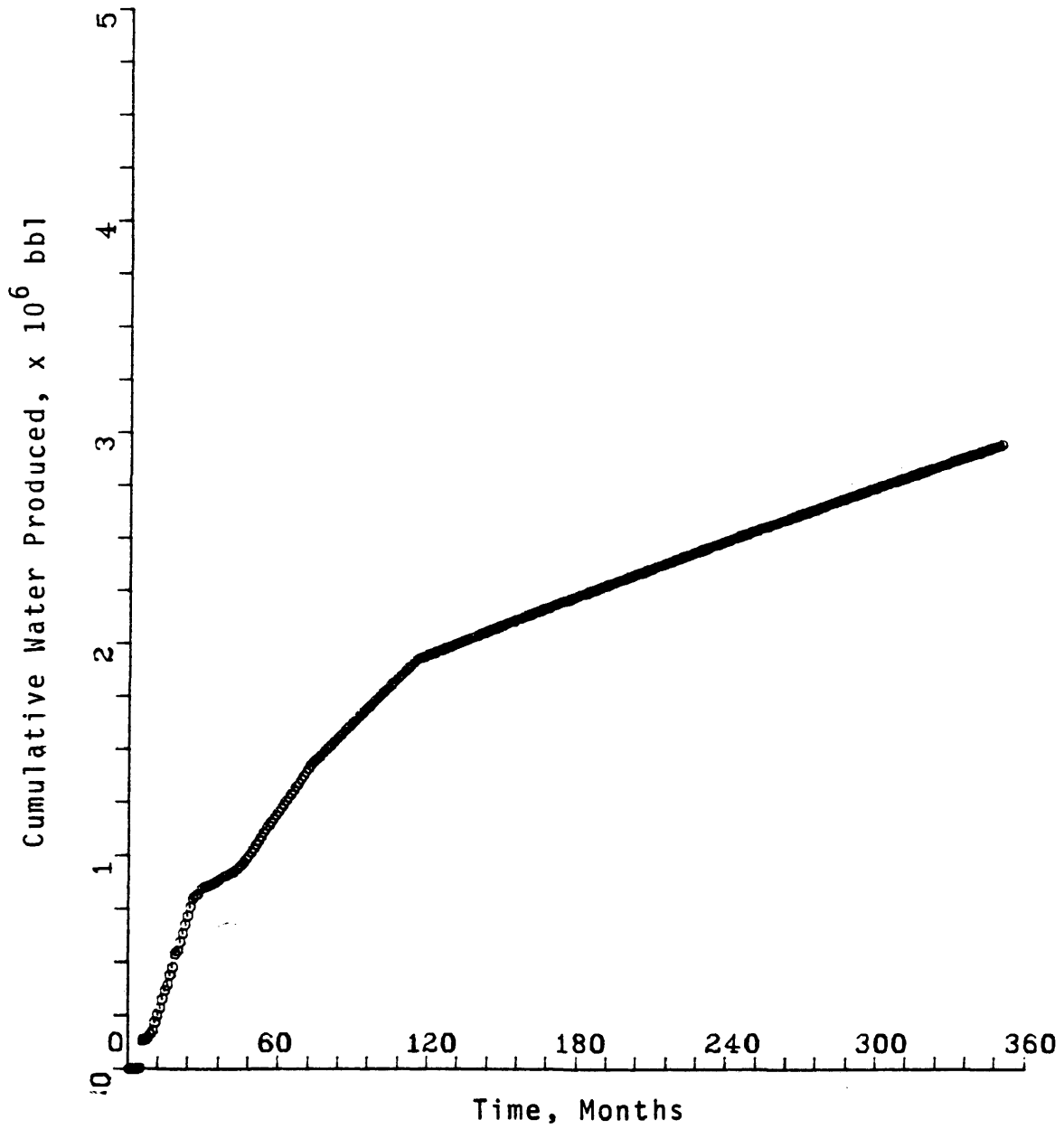


Figure 31. Water Production Behavior for Prediction 2

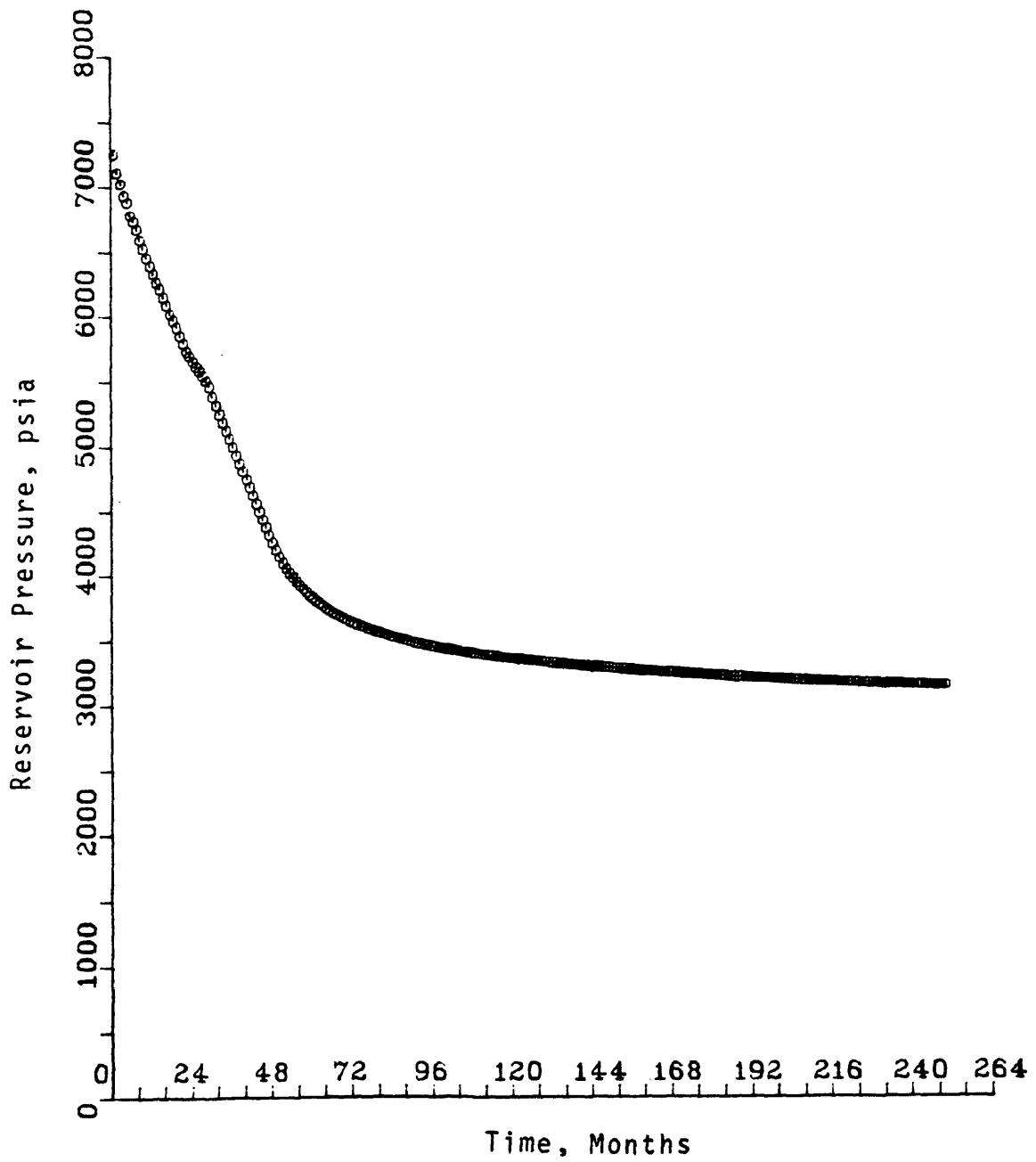


Figure 32. Pressure Behavior for Prediction 3

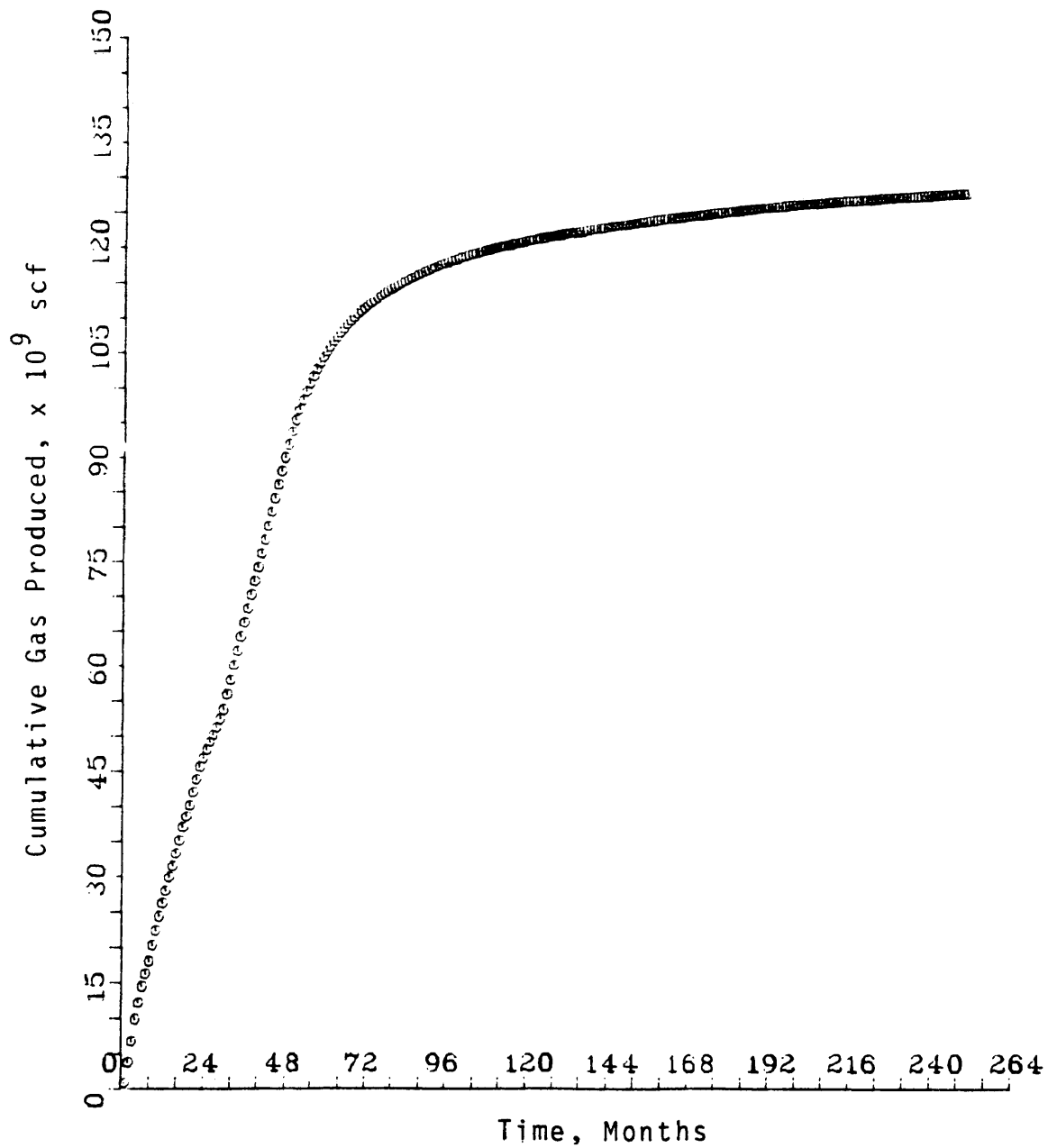


Figure 33. Gas Production Behavior for Prediction 3

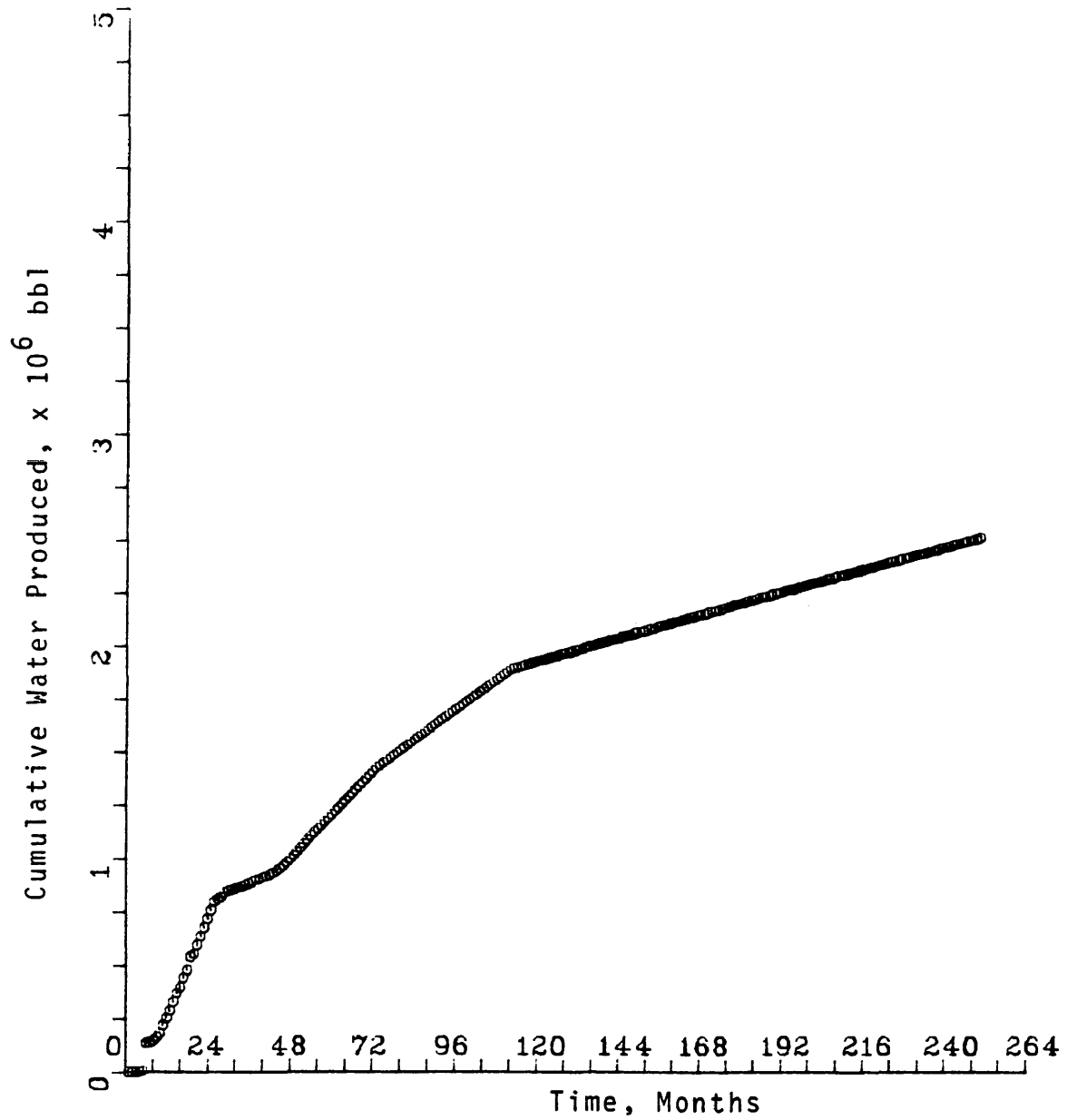


Figure 34. Water Production Behavior for Prediction 3

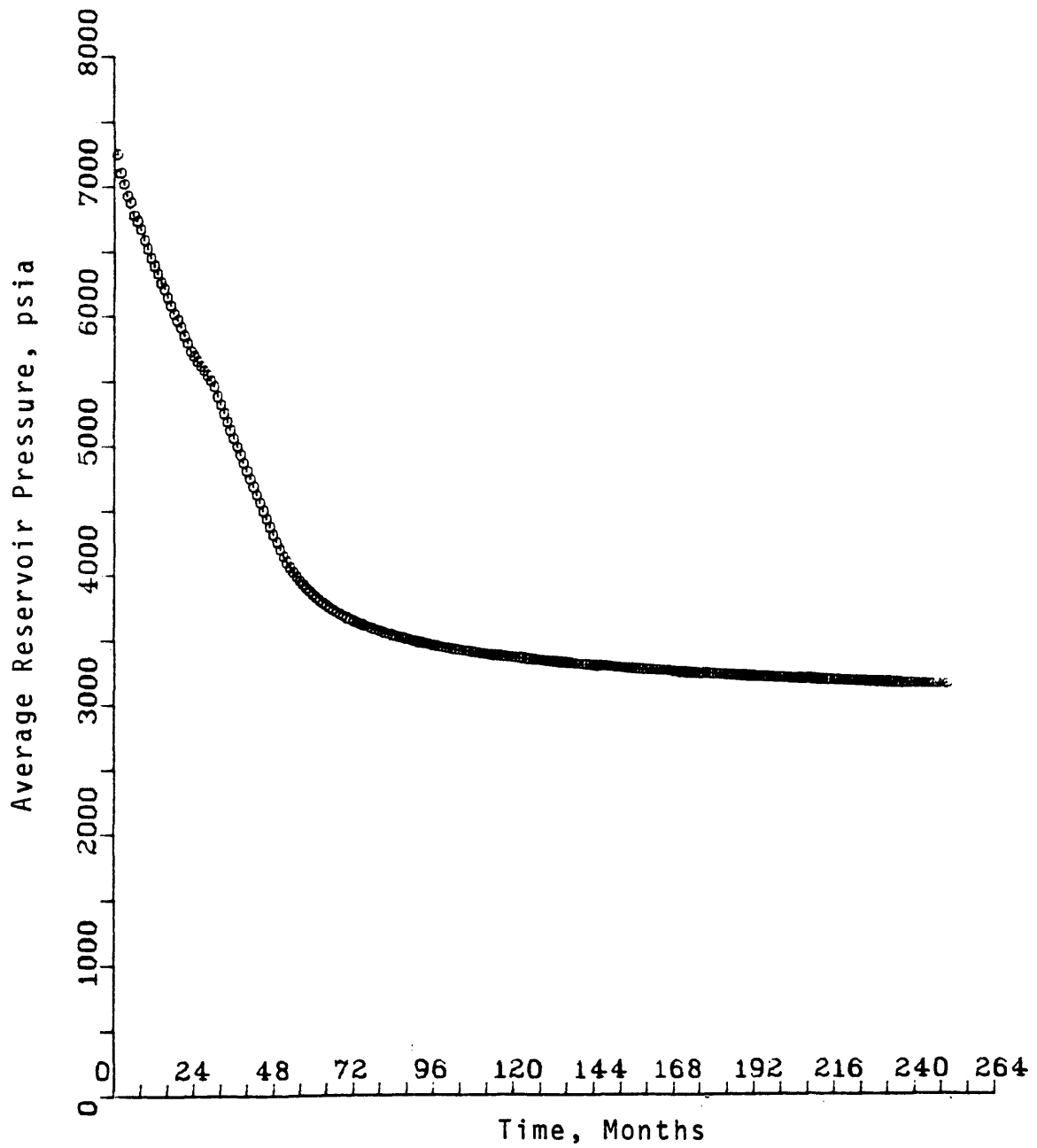


Figure 35. Pressure Behavior for Predication 4

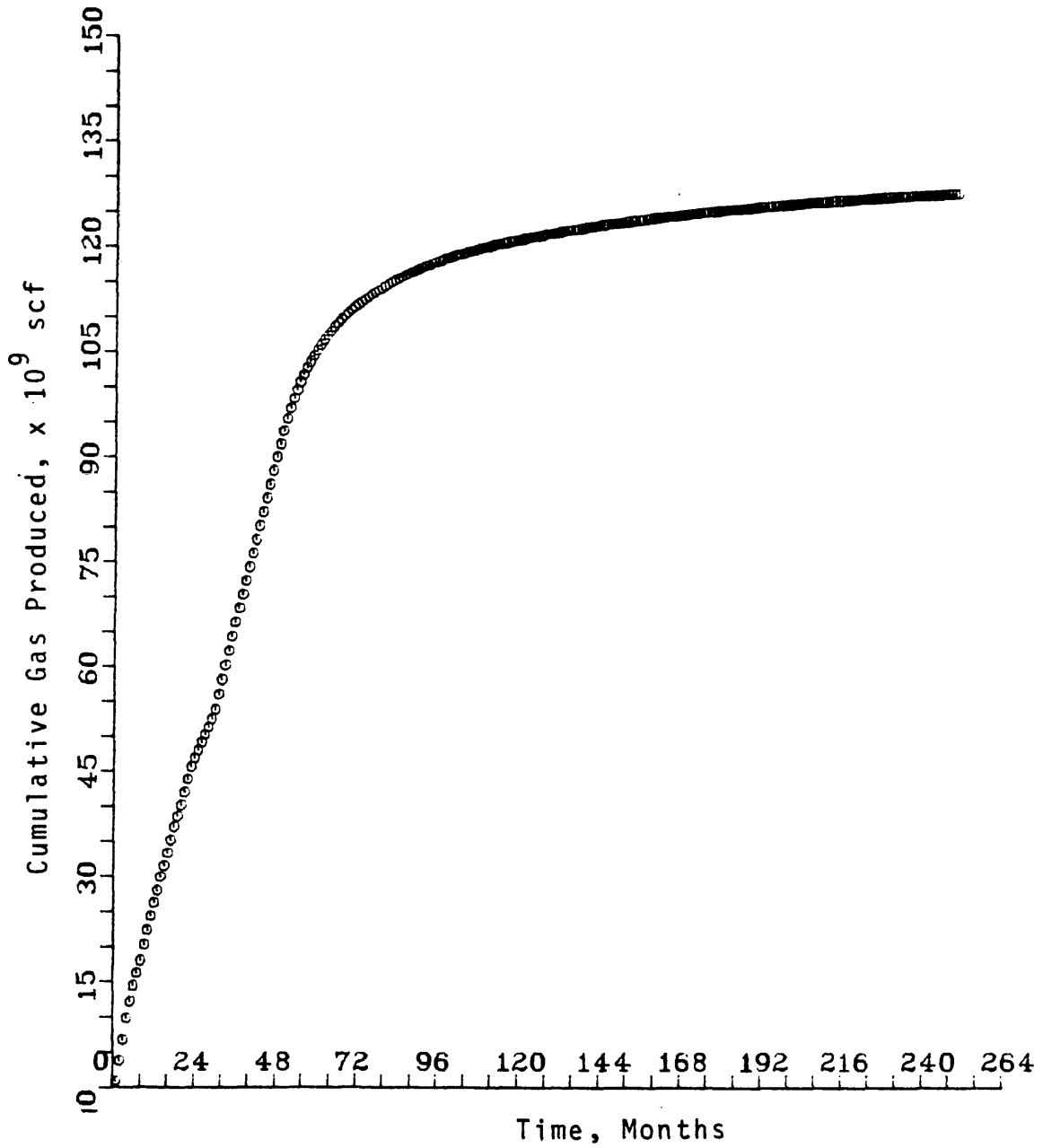


Figure 36. Gas Production Behavior for Prediction 4

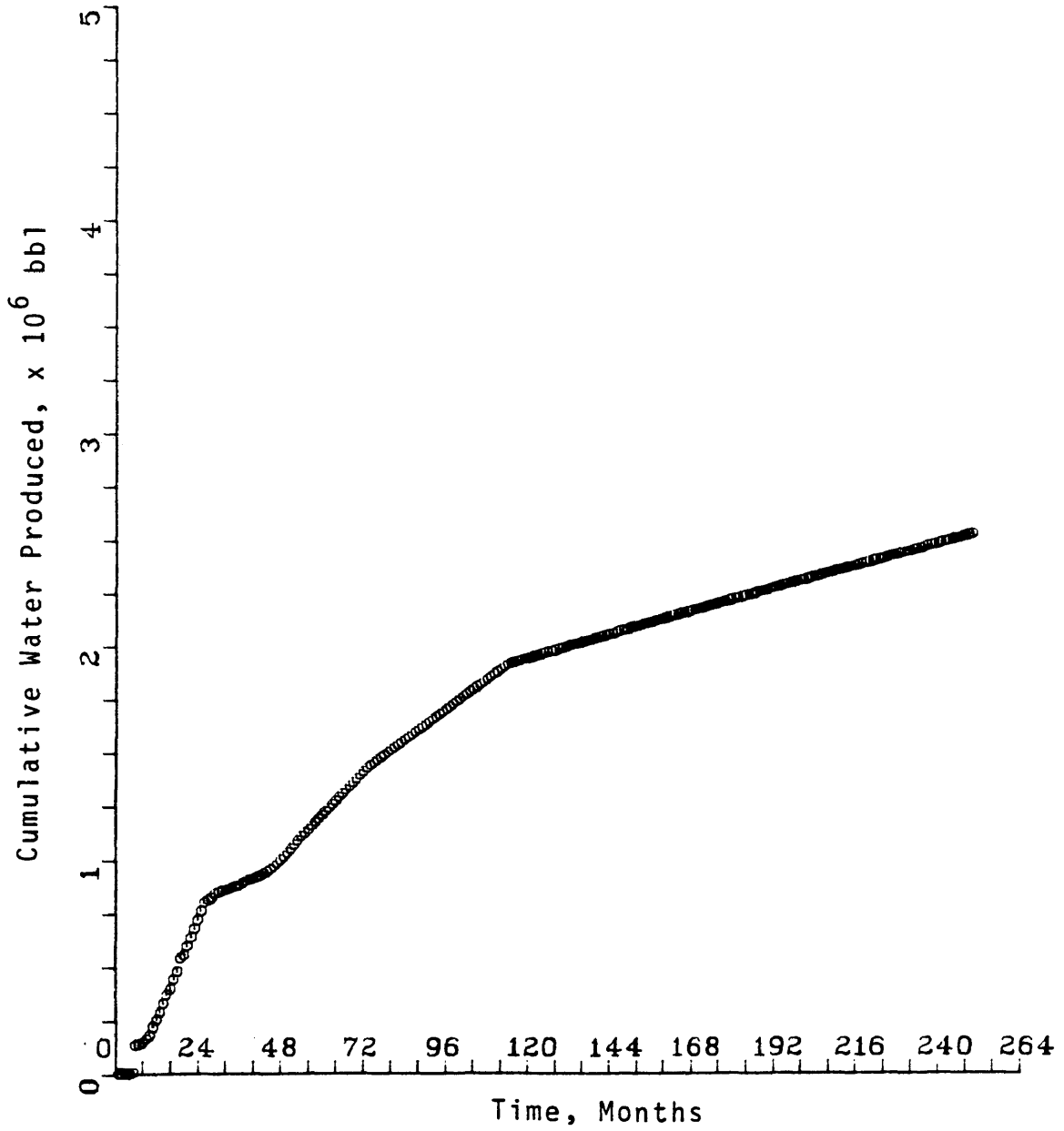


Figure 37. Water Production Behavior for Prediction 4

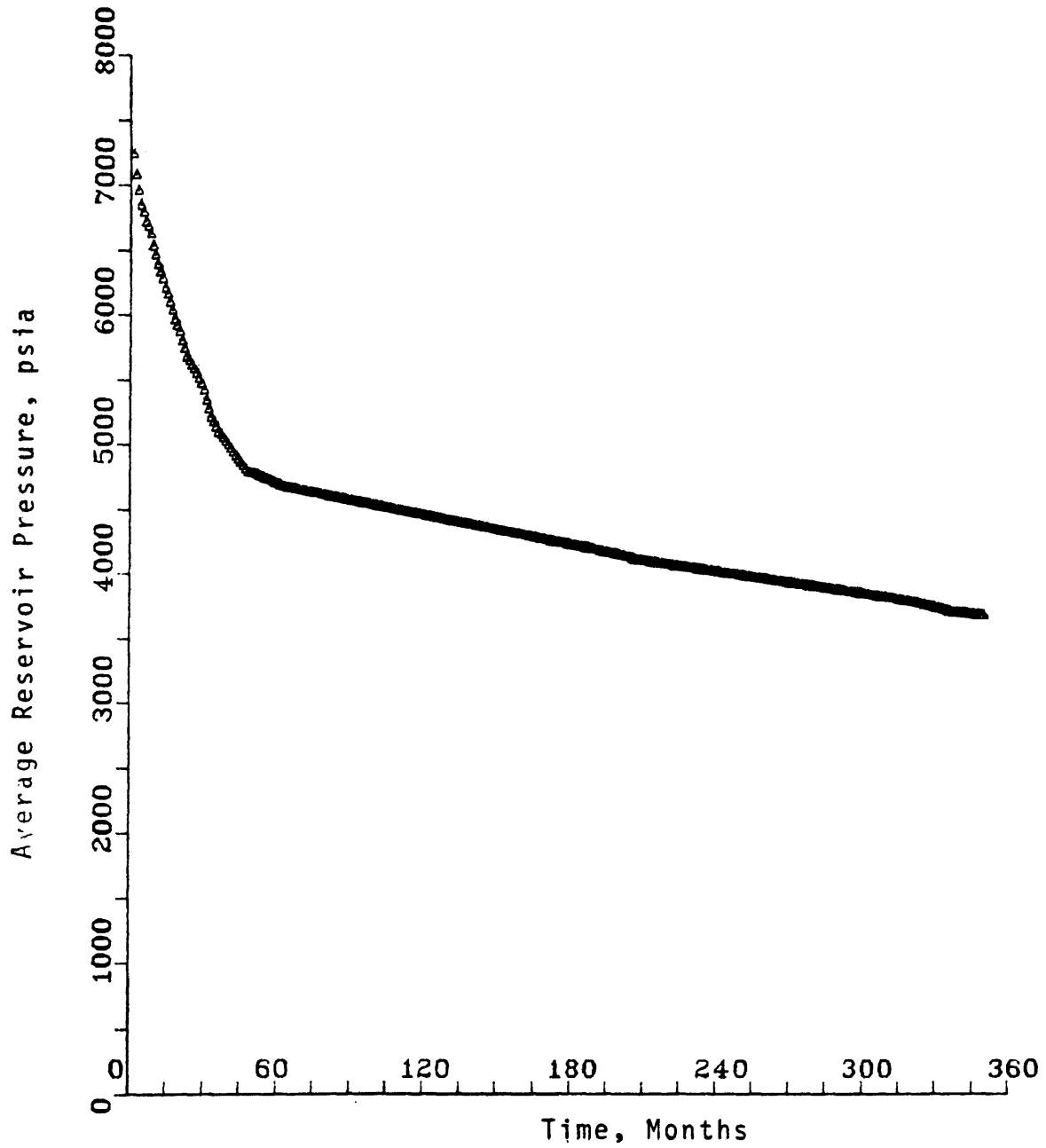


Figure 38. Pressure Behavior for Prediction 5

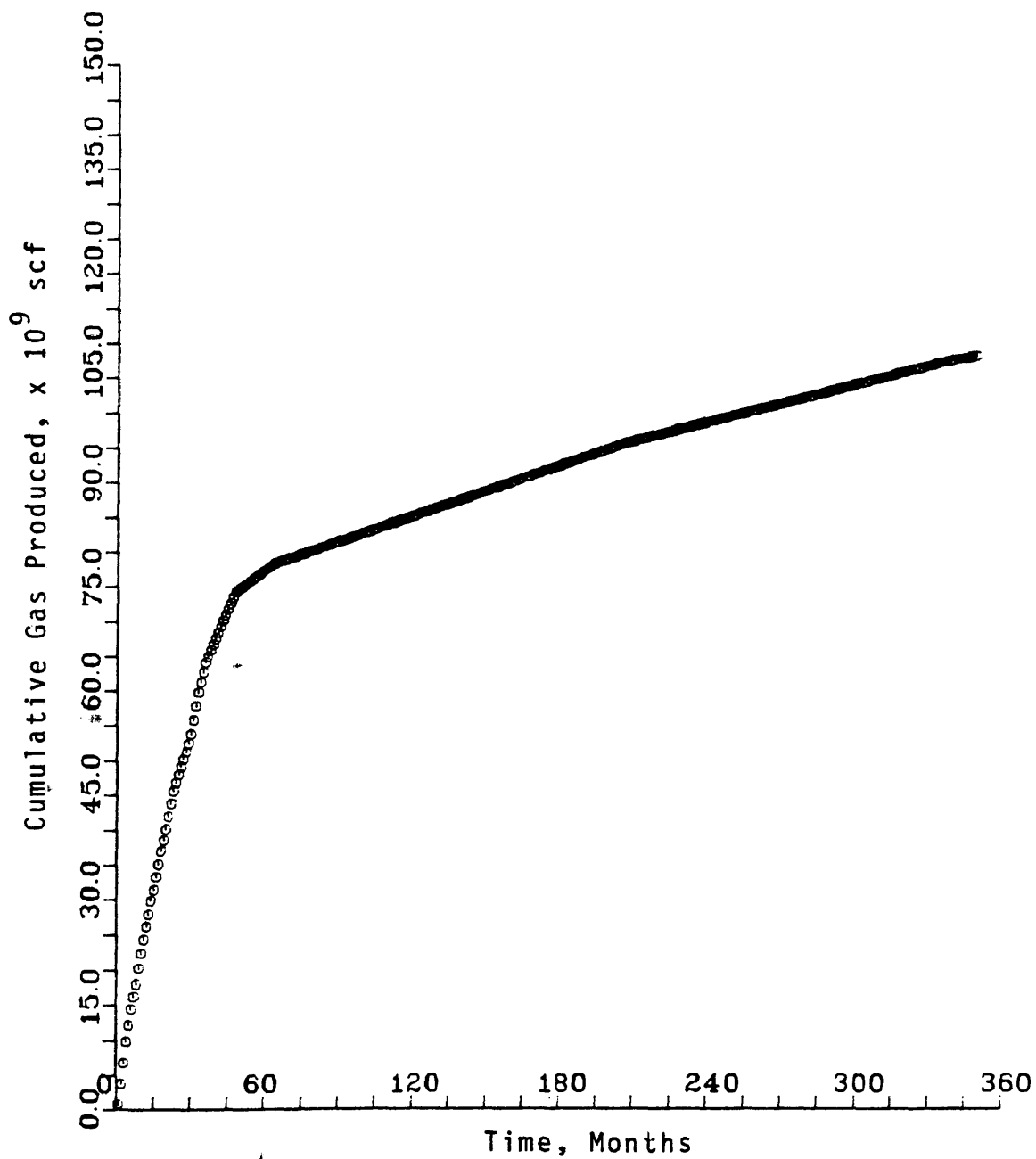


Figure 39. Gas Production Behavior for Prediction 5

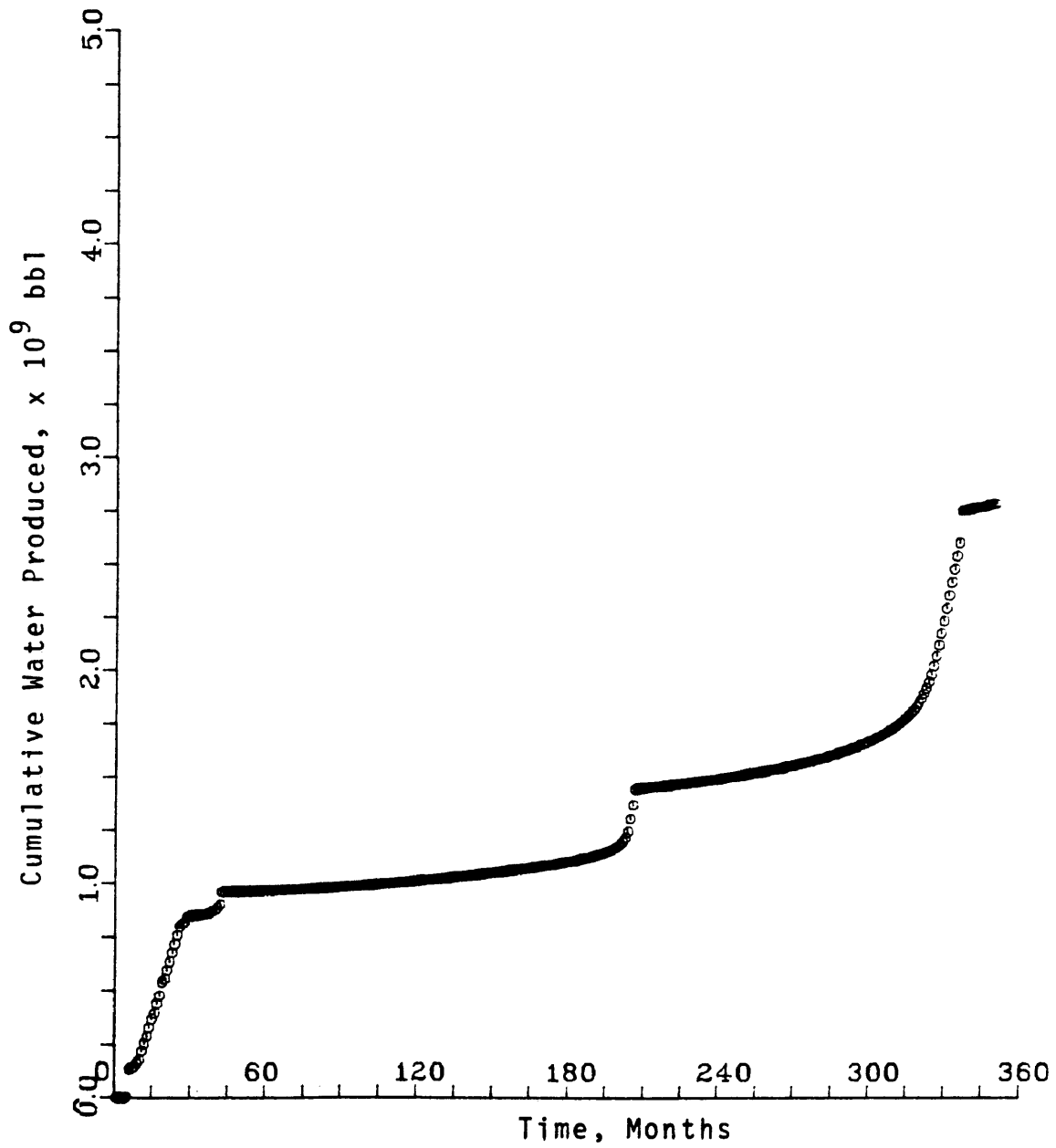


Figure 40. Water Production Behavior for Prediction 5

Table 1. Calculated Average Reservoir Pressure as a Function of Time

<u>Time/Days</u>	<u>Average Reservoir Pressure, psia</u>
30.08000	7251.212
60.16000	7093.150
90.24000	6961.711
120.3200	6834.616
150.4000	6761.545
180.4800	6680.732
210.5600	6646.146
240.6400	6606.046
270.7200	6538.377
300.8000	6483.072
330.8800	6421.919
360.9600	6365.389
391.0400	6311.310
421.1200	6243.808
451.2000	6198.473
481.2800	6139.603
511.3600	6081.013
541.4400	6017.577
571.5200	5973.355
601.6000	5928.577
631.6800	5864.528
661.7600	5807.274
691.8400	5747.792
721.9200	5719.945
752.0000	5688.422
782.0800	5660.519
812.1600	5631.947
842.2400	5603.710
872.3200	5564.724
902.4000	5519.556

Table 2. Value of (X) and (Y) Functions

$X, 10^3$	$Y, \times 10^{-9}$
2.804472	9.442305
3.172869	9.669654
3.673696	9.845552
4.017872	10.02534
4.390412	10.12484
4.632215	10.24942
4.951789	10.29791
5.157800	10.36862
5.224524	10.49955
5.274734	10.62302
5.310455	10.75326
5.355904	10.87146
5.390834	10.98737
5.413647	11.12667
5.465187	11.22728
5.479871	11.36443
5.517196	11.49613
5.547417	11.64318
5.591683	11.75505
5.617159	11.87739
5.641369	12.03586
5.682550	12.17787
5.715292	12.33421
5.759350	12.42372
5.778242	12.53376
5.805189	12.62659
5.826426	12.72217
5.848652	12.81436
5.868639	12.93055
5.895098	13.05623

TABLE 3 - PAST PERFORMANCE

TIME (DAYS)	RESERVOIR PRESSURE (PSI)	CUMULATIVE GAS PRODUCED (MM SCF)	CUMULATIVE WATER PRODUCED (M BBL)	CUMULATIVE WATER INFLUX (M BBL)	HEIGHT OF F-W-C (FT)
30.08000	7249.	838.03	0.00	86.94	0.16
60.16000	7087.	3751.14	0.00	493.47	0.91
90.24000	6967.	6698.98	0.00	1200.68	2.21
120.32000	6854.	9819.83	0.00	2045.17	3.78
150.40000	6800.	12170.93	2.48	2914.05	5.38
180.48000	6726.	14445.46	134.31	3721.55	6.63
210.56000	6689.	16202.93	137.52	4403.73	7.89
240.64000	6632.	17994.40	144.22	4950.70	9.08
270.72000	6540.	20269.53	161.96	5513.76	10.32
300.80000	6469.	22336.81	178.86	6113.10	11.64
330.88000	6398.	24359.09	218.61	6714.10	12.92
360.96000	6340.	26222.44	252.22	7316.72	14.21
391.04000	6286.	27968.68	286.25	7891.04	15.44
421.12000	6216.	29916.67	327.57	8449.79	16.63
451.20000	6170.	31477.19	367.18	8978.35	17.75
481.28000	6105.	33287.83	395.25	9484.52	18.85
511.36000	6042.	35094.19	440.08	10011.24	19.96
541.44000	5974.	37016.46	476.32	10553.76	21.13
571.52000	5927.	38534.67	539.28	11077.16	22.19
601.60000	5879.	40104.95	552.49	11564.12	23.28

TABLE 3 - (CONTINUED)

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TIME (DAYS)	RESERVOIR PRESSURE (PSI)	CUMULATIVE GAS PRODUCED (MM SCF)	CUMULATIVE WATER PRODUCED (M BBLS)	CUMULATIVE WATER INFLUX (M BBLS)	HEIGHT OF G-M-C (FT)
631.6800	5810.	41983.05	594.35	12066.35	24.37
661.7600	5749.	43768.25	634.85	12584.76	25.49
691.8400	5686.	45599.69	675.91	13103.02	26.62
721.9200	5657.	46810.37	716.41	13580.56	27.62
752.0000	5623.	48003.19	758.26	13992.88	28.50
782.0800	5591.	49079.61	798.37	14360.90	29.29
812.1600	5556.	50165.20	811.75	14685.40	30.04
842.2400	5522.	51223.73	818.92	14985.45	30.76
872.3200	5478.	52440.39	843.22	15296.89	31.46
902.4000	5430.	53809.69	849.54	15643.02	32.33

TABLE 4 - Prediction 1 When $Q_w/Q_g > 0$, shut well in

TIME (DAYS)	RESERVOIR PRESSURE (PSI)	CUMULATIVE GAS PRODUCED (MM SCF)	CUMULATIVE WATER PRODUCED (M BBL)	CUMULATIVE WATER INFLUX (M BBL)	HEIGHT OF U-W-C (FT)
10.08000	7249.	638.03	0.00	86.94	0.16
50.16000	7067.	3751.14	0.00	493.47	0.91
90.24000	6967.	6698.98	0.00	1200.68	2.21
120.3200	6854.	9819.83	0.00	2045.17	3.78
150.4000	6800.	12170.93	2.48	2914.05	5.38
180.4800	6726.	14445.46	134.31	3721.55	6.63
210.5600	6689.	16202.93	137.52	4403.73	7.89
240.6400	6632.	17994.40	144.22	4950.70	9.08
270.7200	6540.	20269.53	161.96	5513.76	10.32
300.8000	6469.	22336.81	178.86	6113.10	11.64
330.8800	6398.	24359.09	218.61	6714.10	12.92
360.9600	6340.	26222.44	252.22	7316.72	14.21
391.0400	6286.	27968.69	286.25	7891.04	15.44
421.1200	6216.	29916.67	327.57	8449.79	16.63
451.2000	6170.	31477.19	367.18	8978.35	17.75
481.2800	6105.	33287.83	395.25	9484.52	18.85
511.3600	6042.	35094.19	440.08	10011.24	19.96
541.4400	5974.	37016.46	476.32	10553.76	21.13
571.5200	5927.	38534.67	539.28	11077.16	22.19

TABLE 4 - (CONTINUED)

TIME (DAYS)	RESERVOIR PRESSURE (PSI)	CUMULATIVE GAS PRODUCED (MM SCF)	CUMULATIVE WATER PRODUCED (M BBL)	CUMULATIVE WATER INFLUX (M BBL)	HEIGHT OF C-W-C (FT)
601.6000	5879.	40104.95	552.49	11564.12	23.28
631.6800	5810.	41983.05	594.35	12066.35	24.37
661.7600	5749.	43768.25	634.85	12584.76	25.49
691.8400	5686.	45599.69	675.91	13103.02	26.62
721.9200	5657.	46810.37	716.41	13580.56	27.62
752.0000	5623.	48003.19	758.26	13992.88	28.50
782.0800	5591.	49079.61	798.37	14360.90	29.29
812.1600	5556.	50165.20	811.75	14685.40	30.04
842.2400	5522.	51223.73	818.92	14985.45	30.76
872.3200	5478.	52440.39	843.22	15296.89	31.48
902.4000	5430.	53809.69	849.54	15643.02	32.33
932.4800	5354.	55782.94	849.54	16063.06	33.41
962.5600	5237.	57756.19	849.54	16561.45	34.66
992.6400	5224.	59729.43	849.54	17093.25	36.00
1022.7200	5192.	61101.08	849.54	17594.58	37.20
1052.8000	5155.	62472.73	849.54	18034.25	38.28
1082.8800	5114.	63844.38	849.54	18437.15	39.29
1112.9600	5100.	64614.43	849.54	18760.54	40.07
1143.0400	5079.	65384.47	849.54	19006.88	40.68
1173.1200	5056.	66154.52	849.54	19230.60	41.25

TABLE 4 - (CONTINUED)

TIME (DAYS)	RESERVOIR PRESSURE (PSI)	CUMULATIVE GAS PRODUCED (MM SCF)	CUMULATIVE GAS PRODUCED (M BBL)	CUMULATIVE WATER INFLUX (M BBL)	WELLTOP OF U-M-C (FT)
1203.200	5032.	66924.57	849.54	19440.08	41.79
1233.280	5007.	67694.62	849.54	19641.50	42.31
1263.360	4983.	68464.67	849.54	19847.21	42.84
1293.440	4959.	69234.71	849.54	20058.09	43.39
1323.520	4935.	70004.76	849.54	20269.70	43.94
1353.600	4911.	70774.81	849.54	20480.72	44.49
1383.680	4887.	71544.86	849.54	20690.63	45.03
1413.760	4863.	72314.91	849.54	20899.95	45.58
1443.840	4839.	73084.95	849.54	21109.15	46.13
1473.920	4814.	73853.40	849.54	21269.95	46.49
1504.000	4843.	73421.85	849.54	21366.13	46.71
1534.080	4839.	73590.30	849.54	21433.51	46.87
1564.160	4834.	73758.75	849.54	21478.45	46.99
1594.240	4828.	73927.19	849.54	21512.84	47.09
1624.320	4822.	74095.64	849.54	21551.81	47.20
1654.400	4817.	74264.09	849.54	21597.47	47.32
1684.480	4812.	74432.54	849.54	21644.82	47.44
1714.560	4806.	74600.99	849.54	21691.93	47.57
1744.640	4801.	74769.43	849.54	21738.02	47.69
1774.720	4796.	74937.88	849.54	21783.45	47.81

TABLE 4 - (CONTINUED)

TIME (DAYS)	RESERVOIR PRESSURE (PSI)	CUMULATIVE GAS PRODUCED (MM SCF)	CUMULATIVE WATER PRODUCED (M BBL)	CUMULATIVE WATER FLOW (M BBL)	HEIGHT OF U-M-C (FT)
1804.800	4791.	75106.33	849.54	21828.89	47.93
1834.880	4785.	75274.78	849.54	21874.52	48.05
1864.960	4780.	75443.23	849.54	21920.24	48.17
1895.040	4775.	75611.67	849.54	21965.92	48.29
1925.120	4770.	75780.12	849.54	22011.55	48.41
1955.200	4765.	75948.57	849.54	22057.20	48.53
1985.280	4759.	76117.02	849.54	22102.83	48.66
2015.360	4754.	76285.47	849.54	22148.49	48.78
2045.440	4749.	76453.91	849.54	22194.19	48.90
2075.520	4744.	76622.36.	849.54	22239.91	49.01

TABLE 5 - Prediction 2 — When there is no limit on water production

TIME (DAYS)	RESERVOIR PRESSURE (PSI)	CUMULATIVE GAS PRODUCED (MM SCF)	CUMULATIVE WATER PRODUCED (M BBL)	CUMULATIVE WATER INFLUX (M BBL)	HEIGHT OF G-M-C (FT)
30.08000	7249.	838.03	0.00	86.94	0.16
60.16000	7087.	3751.14	0.00	493.47	0.91
90.24000	6967.	6698.98	0.00	1200.68	2.21
120.32000	6854.	9819.83	0.00	2045.17	3.78
150.40000	6800.	12170.93	2.48	2914.05	5.38
180.48000	6726.	14445.46	134.31	3721.55	6.63
210.56000	6689.	16202.93	137.52	4403.73	7.89
240.64000	6632.	17994.40	144.22	4950.70	9.08
270.72000	6540.	20269.53	161.96	5513.76	10.32
300.80000	6469.	22336.81	178.86	6113.10	11.64
330.88000	6398.	24359.09	218.61	6714.10	12.92
360.96000	6340.	26222.44	252.22	7316.72	14.21
391.04000	6286.	27968.66	286.25	7891.04	15.44
421.12000	6216.	29916.67	327.57	8449.79	16.63
451.20000	6170.	31477.19	367.18	8978.35	17.75
481.28000	6105.	33287.83	395.25	9484.52	18.85
511.36000	6042.	35094.19	440.08	10011.24	19.96
541.44000	5974.	37016.46	476.32	10553.76	21.13
571.52000	5927.	38534.67	539.28	11077.16	22.19

TABLE 5 - (CONTINUED)

TIME (DAYS)	RESERVOIR PRESSURE (PSI)	CUMULATIVE GAS PRODUCED (MM SCF)	CUMULATIVE WATER PRODUCED (M BBL)	CUMULATIVE WATER INFLUX (M BBL)	HEIGHT OF G-W-C (FT)
601.6000	5879.	40104.95	552.49	11564.12	23.28
631.6800	5810.	41983.05	594.35	12066.35	24.37
661.7600	5749.	43768.25	634.85	12584.76	25.49
691.8400	5686.	45599.69	675.91	13103.02	26.62
721.9200	5657.	46810.37	716.41	13580.56	27.62
752.0000	5623.	48003.19	758.26	13992.88	28.50
782.0800	5591.	49079.61	798.37	14360.90	29.29
812.1600	5556.	50165.20	811.75	14685.40	30.04
842.2400	5522.	51223.73	818.92	14985.45	30.76
872.3200	5478.	52440.39	843.22	15296.89	31.48
902.4000	5430.	53809.69	849.54	15643.02	32.33
932.4800	5345.	55957.35	854.07	16078.49	33.45
962.5600	5272.	58081.16	858.63	16610.51	34.78
992.6400	5205.	60179.66	863.25	17179.44	36.20
1022.720	5141.	62253.28	868.37	17768.55	37.66
1052.800	5079.	64302.85	874.02	18358.05	39.02
1082.880	5017.	66331.04	880.16	18929.97	40.33
1112.960	4954.	68331.92	887.34	19485.13	41.62
1143.040	4892.	70331.05	895.48	20032.32	42.89
1173.120	4831.	72305.73	904.50	20574.74	44.15

TABLE 5 - (CONTINUED)

TIME (DAYS)	RESERVOIR PRESSURE (PSI)	CUMULATIVE GAS PRODUCED (MM SCF)	CUMULATIVE WATER PRODUCED (M BBL)	CUMULATIVE WATER INFLUX (M BBL)	HEIGHT OF G-M-C (FT)
1203.200	4770.	74278.98	909.39	21113.65	45.43
1233.280	4709.	76252.23	915.04	21649.79	46.70
1263.360	4648.	78225.48	921.69	22183.74	47.98
1293.440	4585.	80198.73	929.51	22719.27	49.09
1323.520	4523.	82171.97	938.29	23257.93	50.22
1353.600	4461.	84145.22	948.56	23797.48	51.35
1383.680	4400.	86118.47	960.19	24337.13	52.48
1413.760	4339.	88091.72	973.08	24875.77	53.63
1443.840	4279.	90044.43	987.10	25410.87	54.77
1473.920	4222.	91936.62	1002.17	25936.99	55.90
1504.000	4166.	93773.00	1018.15	26449.77	57.01
1534.080	4114.	95540.72	1034.94	26946.46	58.10
1564.160	4068.	97133.48	1052.50	27416.40	59.26
1594.240	4028.	98547.49	1070.91	27847.97	60.31
1624.320	3993.	99807.98	1090.03	28238.05	61.26
1654.400	3961.	100946.26	1105.15	28587.24	62.12
1684.480	3931.	102000.50	1120.57	28900.50	62.90
1714.560	3902.	102980.11	1136.23	29185.74	63.62
1744.640	3876.	103892.94	1152.10	29449.16	64.29
1774.720	3851.	104745.57	1168.12	29694.79	64.92

TABLE 5 - (CONTINUED)

TIME (DAYS)	RESERVOIR PRESSURE (PSI)	CUMULATIVE GAS PRODUCED (MM SCF)	CUMULATIVE WATER PRODUCED (M BBL)	CUMULATIVE HEAT FLUX (MM BTU)	WEIGHT OF G-C (FT)
1804.800	3828.	105543.55	1184.29	29925.06	65.51
1834.880	3806.	106291.72	1200.58	30141.12	66.06
1864.960	3785.	106994.35	1216.98	30343.73	66.58
1895.040	3766.	107655.28	1233.46	30534.00	67.07
1925.120	3747.	108277.92	1250.01	30713.02	67.53
1955.200	3730.	108865.34	1266.62	30881.70	67.96
1985.280	3714.	109420.27	1283.28	31040.97	68.43
2015.360	3698.	109942.48	1300.01	31191.49	68.87
2045.440	3684.	110434.29	1316.80	31333.53	69.28
2075.520	3670.	110898.04	1333.65	31467.65	69.67
2105.600	3657.	111335.82	1350.54	31594.39	70.64
2135.680	3644.	111749.57	1367.48	31714.16	70.39
2165.760	3633.	112141.05	1384.44	31827.45	70.72
2195.840	3621.	112511.85	1401.43	31934.87	71.03
2225.920	3611.	112863.97	1413.29	32036.48	71.33
2256.000	3601.	113203.39	1425.15	32132.72	71.62
2286.080	3591.	113530.81	1437.01	32224.75	71.90
2316.160	3582.	113846.86	1448.88	32313.10	72.16
2346.240	3573.	114152.08	1460.74	32398.32	72.42
2376.320	3564.	114446.99	1472.61	32480.79	72.67

TABLE 5 - (CONTINUED)

TIME (DAYS)	RESERVOIR PRESSURE (PSI)	CUMULATIVE GAS PRODUCED (MM SCF)	CUMULATIVE WATER PRODUCED (M BBL)	CUMULATIVE WATER INFLOW (M BBL)	HEIGHT OF G-M-C (FT)
2406.400	3555.	114732.05	1484.47	32560.65	72.91
2436.480	3547.	115007.72	1496.33	32637.96	73.15
2466.560	3539.	115274.40	1508.18	32712.76	73.37
2496.640	3531.	115532.49	1520.03	32785.26	73.59
2526.720	3523.	115782.35	1531.88	32855.51	73.80
2556.800	3516.	116024.35	1543.71	32923.55	74.01
2586.880	3509.	116258.81	1555.54	32989.52	74.21
2616.960	3502.	116486.06	1567.36	33053.51	74.40
2647.040	3495.	116706.40	1579.17	33115.56	74.59
2677.120	3489.	116920.09	1590.98	33175.85	74.77
2707.200	3482.	117127.41	1602.77	33234.44	74.94
2737.280	3476.	117328.60	1614.55	33291.35	75.11
2767.360	3470.	117523.91	1626.32	33346.68	75.28
2797.440	3464.	117713.57	1638.09	33400.48	75.44
2827.520	3458.	117897.79	1649.84	33452.78	75.59
2857.600	3453.	118076.79	1661.57	33503.60	75.74
2887.680	3448.	118250.76	1673.30	33553.05	75.89
2917.760	3442.	118419.89	1685.02	33601.28	76.03
2947.840	3437.	118584.34	1696.72	33648.20	76.17
2977.920	3432.	118744.32	1708.41	33693.87	76.30

TABLE 5 - (CONTINUED)

TIME (DAYS)	RESERVOIR PRESSURE (PSI)	CUMULATIVE GAS PRODUCED (MM SCF)	CUMULATIVE WATER PRODUCED (M BBL)	CUMULATIVE WATER INFUX (M BBL)	HEIGHT OF CUM-C (FT)
3008.000	3427.	118899.95	1720.09	33738.42	76.43
3038.080	3423.	119051.41	1731.75	33781.87	76.56
3068.160	3418.	119198.82	1743.40	33824.23	76.69
3098.240	3413.	119342.35	1755.04	33865.53	76.81
3128.320	3409.	119482.12	1766.67	33905.86	76.92
3158.400	3405.	119618.27	1778.28	33945.15	77.03
3188.480	3401.	119750.92	1789.88	33983.44	77.14
3218.560	3396.	119880.20	1801.47	34020.83	77.25
3248.640	3392.	120006.21	1813.04	34057.39	77.36
3278.720	3389.	120129.06	1824.60	34093.06	77.46
3308.800	3385.	120248.86	1836.15	34127.93	77.56
3338.880	3381.	120365.71	1847.69	34162.03	77.65
3368.960	3377.	120479.70	1859.21	34195.36	77.75
3399.040	3374.	120590.92	1870.71	34227.94	77.84
3429.120	3370.	120699.47	1882.21	34259.79	77.92
3459.199	3367.	120805.43	1893.69	34291.01	78.01
3489.279	3364.	120906.06	1898.33	34320.98	78.12
3519.359	3361.	121011.30	1902.98	34349.59	78.23
3549.439	3358.	121112.21	1907.62	34377.34	78.34
3579.519	3355.	121211.80	1912.26	34404.31	78.44

TABLE 5 - (CONTINUED)

TIME (DAYS)	RESERVOIR PRESSURE (PSI)	CUMULATIVE GAS PRODUCED (MM SCF)	CUMULATIVE WATER PRODUCED (M BBL)	CUMULATIVE WATER INFLUX (M BBL)	HEIGHT OF U-M-C (FT)
3609.599	3352.	121310.11	1916.89	34430.81	78.54
3639.679	3349.	121407.16	1921.52	34457.03	78.64
3669.759	3346.	121502.97	1926.15	34482.98	78.74
3699.839	3343.	121597.57	1930.78	34508.63	78.83
3729.919	3340.	121690.98	1935.40	34533.98	78.93
3759.999	3337.	121783.21	1940.02	34559.04	79.03
3790.079	3335.	121874.28	1944.64	34583.76	79.12
3820.159	3332.	121964.22	1949.25	34608.21	79.21
3850.239	3329.	122053.04	1953.86	34632.34	79.30
3880.319	3326.	122140.77	1958.47	34656.14	79.39
3910.399	3324.	122227.42	1963.07	34679.69	79.48
3940.479	3321.	122313.02	1967.67	34702.94	79.57
3970.559	3319.	122397.57	1972.27	34726.00	79.66
4000.639	3316.	122481.09	1976.86	34748.96	79.75
4030.719	3313.	122563.59	1981.45	34771.79	79.83
4060.799	3311.	122645.08	1986.04	34794.44	79.92
4090.879	3308.	122725.60	1990.62	34816.80	80.00
4120.959	3306.	122805.14	1995.20	34838.98	80.08
4151.039	3303.	122883.73	1999.77	34860.91	80.17
4181.119	3301.	122961.37	2004.34	34882.60	80.25

TABLE 5 - (CONTINUED)

TIME (DAYS)	RESERVOIR PRESSURE (PSI)	CUMULATIVE GAS PRODUCED (MM SCF)	CUMULATIVE WATER PRODUCED (M BBL)	CUMULATIVE WATER INFLUX (M BBL)	HEIGHT OF OWC (FE)
4211.199	3299.	123038.09	2008.91	34904.01	80.33
4241.279	3296.	123113.90	2013.48	34925.13	80.41
4271.359	3294.	123188.82	2018.04	34946.00	80.48
4301.439	3291.	123262.86	2022.60	34966.66	80.56
4331.519	3289.	123336.03	2027.15	34987.10	80.64
4361.599	3287.	123408.35	2031.70	35007.33	80.71
4391.679	3285.	123479.83	2036.25	35027.34	80.79
4421.759	3282.	123550.48	2040.79	35047.12	80.86
4451.839	3280.	123620.32	2045.33	35066.65	80.93
4481.919	3278.	123689.37	2049.87	35085.94	81.01
4511.999	3276.	123757.62	2054.40	35105.08	81.08
4542.079	3274.	123825.10	2058.93	35124.03	81.15
4572.159	3272.	123891.81	2063.46	35142.69	81.22
4602.240	3270.	123957.77	2067.98	35161.18	81.28
4632.320	3268.	124023.00	2072.50	35179.50	81.35
4662.400	3266.	124087.49	2077.02	35197.57	81.42
4692.480	3264.	124151.27	2081.53	35215.45	81.49
4722.560	3262.	124214.34	2086.04	35233.17	81.55
4752.640	3260.	124276.71	2090.54	35250.69	81.62
4782.720	3258.	124338.40	2095.05	35268.00	81.68

TABLE 5 - (CONTINUED)

TIME (DAYS)	RESERVOIR PRESSURE (PSI)	CUMULATIVE GAS PRODUCED (MM SCF)	CUMULATIVE WATER PRODUCED (M BBL)	CUMULATIVE WATER INFLUX (M RBBL)	WEIGHT OF U-M-C (FT)
4812.800	3256.	124399.42	2099.54	35285.19	81.74
4842.880	3254.	124459.76	2104.04	35302.19	81.81
4872.960	3252.	124519.45	2108.53	35319.00	81.87
4903.040	3250.	124578.49	2113.02	35335.69	81.93
4933.120	3248.	124636.90	2117.50	35352.20	81.99
4963.200	3246.	124694.67	2121.98	35368.52	82.05
4993.280	3245.	124751.83	2126.46	35384.63	82.11
5023.360	3243.	124808.37	2130.94	35400.61	82.17
5053.440	3241.	124864.31	2135.41	35416.45	82.23
5083.520	3239.	124919.67	2139.88	35432.06	82.28
5113.600	3237.	124974.44	2144.34	35447.56	82.34
5143.680	3236.	125028.63	2148.80	35462.92	82.40
5173.760	3234.	125082.25	2153.26	35478.10	82.45
5203.840	3232.	125135.32	2157.71	35493.19	82.51
5233.920	3231.	125187.83	2162.16	35508.16	82.56
5264.000	3229.	125239.79	2166.61	35522.87	82.61
5294.080	3227.	125291.22	2171.05	35537.45	82.67
5324.160	3226.	125342.13	2175.50	35551.92	82.72
5354.240	3224.	125392.51	2179.93	35566.21	82.77
5384.320	3223.	125442.37	2184.37	35580.41	82.82

TABLE 5 - (CONTINUED)

TIME (DAYS)	RESERVOIR PRESSURE (PSI)	CUMULATIVE GAS PRODUCED (MM SCF)	CUMULATIVE WATER PRODUCED (M RBLS)	CUMULATIVE WATER INFLUX (M RBLS)	HEIGHT OF C-W-C (FT)
5414.400	3221.	125491.73	2188.80	35594.48	82.87
5444.480	3219.	125540.59	2193.23	35608.36	82.92
5474.560	3218.	125588.96	2197.65	35622.14	82.97
5504.640	3216.	125636.83	2202.07	35635.83	83.02
5534.720	3215.	125684.23	2206.49	35649.37	83.07
5564.800	3213.	125731.15	2210.91	35662.75	83.12
5594.880	3212.	125777.61	2215.32	35676.04	83.17
5624.960	3210.	125823.60	2219.73	35689.25	83.21
5655.040	3209.	125869.14	2224.13	35702.30	83.26
5685.120	3207.	125914.23	2228.53	35715.19	83.31
5715.200	3206.	125958.87	2232.93	35728.00	83.35
5745.280	3204.	126003.08	2237.33	35740.71	83.40
5775.360	3203.	126046.85	2241.72	35753.29	83.44
5805.440	3202.	126090.20	2246.11	35765.74	83.49
5835.520	3200.	126133.13	2250.50	35778.13	83.53
5865.600	3199.	126175.64	2254.88	35790.36	83.57
5895.680	3198.	126217.74	2259.26	35802.50	83.62
5925.760	3196.	126259.43	2263.64	35814.55	83.66
5955.840	3195.	126300.73	2268.01	35826.44	83.70
5985.920	3194.	126341.63	2272.38	35838.24	83.74

TABLE 5 - (CONTINUED)

TIME (DAYS)	RESERVOIR PRESSURE (PSI)	CUMULATIVE GAS PRODUCED (MM SCF)	CUMULATIVE WATER PRODUCTION (M RBLS)	CUMULATIVE WATER INFLUX (M RBLS)	HEIGHT OF GWC (FT)
6016.000	3192.	126382.14	2276.75	35849.98	83.79
6046.080	3191.	126422.27	2281.11	35861.58	83.83
6076.160	3190.	126462.02	2285.47	35873.06	83.87
6106.240	3188.	126501.40	2289.83	35884.47	83.91
6136.320	3187.	126540.40	2294.19	35895.78	83.95
6166.400	3186.	126579.04	2298.54	35906.98	83.98
6196.480	3185.	126617.33	2302.89	35918.12	84.02
6226.560	3183.	126655.25	2307.24	35929.17	84.06
6256.640	3182.	126692.82	2311.58	35940.08	84.10
6286.720	3181.	126730.04	2315.92	35950.91	84.14
6316.800	3180.	126766.92	2320.26	35961.67	84.17
6346.880	3178.	126803.47	2324.59	35972.30	84.21
6376.961	3177.	126839.68	2328.93	35982.85	84.25
6407.041	3176.	126875.55	2333.25	35993.37	84.28
6437.121	3175.	126911.11	2337.58	36003.75	84.31
6467.201	3174.	126946.34	2341.90	36014.06	84.36
6497.281	3173.	126981.25	2346.22	36024.28	84.39
6527.361	3171.	127015.84	2350.54	36034.41	84.42
6557.441	3170.	127050.13	2354.86	36044.44	84.46
6587.521	3169.	127084.11	2359.17	36054.45	84.49

TABLE 5 - (CONTINUED)

TIME (DAYS)	RESERVOIR PRESSURE (P.S.I.)	CUMULATIVE GAS PRODUCED (MM SCF)	CUMULATIVE WATER PRODUCED (M HBLD)	CUMULATIVE WATER INFLUX (M HBLD)	HEIGHT OF G-M-C (FT)
6617.601	3168.	127117.78	2363.48	36064.38	84.53
6647.681	3167.	127151.16	2367.78	36074.19	84.56
6677.761	3166.	127184.24	2372.08	36083.87	84.59
6707.841	3165.	127217.03	2376.38	36093.52	84.63
6737.921	3164.	127249.53	2380.68	36103.08	84.66
6768.001	3163.	127281.75	2384.98	36112.54	84.69
6798.081	3162.	127313.68	2389.27	36122.02	84.72
6828.161	3160.	127345.33	2393.56	36131.44	84.75
6858.241	3159.	127376.71	2397.84	36140.70	84.78
6888.321	3158.	127407.82	2402.13	36149.86	84.82
6918.401	3157.	127438.65	2406.41	36159.05	84.85
6948.481	3156.	127469.22	2410.69	36168.12	84.88
6978.561	3155.	127499.53	2414.96	36177.07	84.91
7008.641	3154.	127529.58	2419.23	36186.01	84.94
7038.721	3153.	127559.37	2423.50	36194.86	84.96
7068.801	3152.	127588.92	2427.77	36203.61	84.99
7098.881	3151.	127618.21	2432.03	36212.36	85.02
7128.961	3150.	127647.25	2436.30	36221.05	85.05
7159.041	3149.	127676.04	2440.55	36229.67	85.08
7189.121	3148.	127704.59	2444.81	36238.20	85.11

TABLE 5 - (CONTINUED)

TIME (DAYS)	RESERVOIR PRESSURE (PSI)	CUMULATIVE GAS PRODUCED (MM SCF)	CUMULATIVE GAS PRODUCED AT 8000 PSIA (MM SCF)	CUMULATIVE GAS PRODUCED AT 8000 PSIA (MM SCF)	CUMULATIVE WATER INFLUX (M RBBL)	HEIGHT OF G-M-C (FT)
7219.201	3147.	127732.91	2449.06	2449.06	36246.68	85.14
7249.281	3146.	127760.98	2453.32	2453.32	36255.10	85.16
7279.361	3146.	127788.83	2457.56	2457.56	36263.46	85.19
7309.441	3145.	127816.44	2461.81	2461.81	36271.73	85.22
7339.521	3144.	127843.82	2466.05	2466.05	36279.95	85.24
7369.601	3143.	127870.97	2470.29	2470.29	36288.14	85.27
7399.681	3142.	127897.91	2474.53	2474.53	36296.24	85.30
7429.761	3141.	127924.62	2478.77	2478.77	36304.27	85.32
7459.841	3140.	127951.11	2483.00	2483.00	36312.30	85.35
7489.921	3139.	127977.38	2487.23	2487.23	36320.31	85.37
7520.001	3138.	128003.43	2491.46	2491.46	36328.22	85.40
7550.081	3137.	128029.28	2495.68	2495.68	36336.05	85.42
7580.161	3136.	128054.92	2499.91	2499.91	36343.77	85.45
7610.241	3136.	128080.35	2504.13	2504.13	36351.45	85.47
7640.321	3135.	128105.58	2508.34	2508.34	36359.10	85.50
7670.401	3134.	128130.61	2512.56	2512.56	36366.69	85.52
7700.481	3133.	128155.43	2516.77	2516.77	36374.22	85.54
7730.561	3132.	128180.06	2520.98	2520.98	36381.72	85.57
7760.641	3131.	128204.49	2525.19	2525.19	36389.22	85.59
7790.721	3130.	128228.73	2529.39	2529.39	36396.67	85.62

TABLE 5 - (CONTINUED)

TIME (DAYS)	RESERVOIR PRESSURE (PSI)	CUMULATIVE GAS PRODUCED (MM SCF)	CUMULATIVE WATER PRODUCED (M RBBL)	CUMULATIVE WATER INFLOW (M RBBL)	HEIGHT OF G-N-C (FT)
7820.801	3130.	128252.77	2533.60	36404.02	85.64
7850.881	3129.	128276.63	2537.80	36411.26	85.66
7880.961	3128.	128300.30	2541.99	36418.47	85.68
7911.041	3127.	128323.79	2546.19	36425.69	85.71
7941.121	3126.	128347.09	2550.38	36432.82	85.73
7971.201	3126.	128370.21	2554.57	36439.94	85.75
8001.281	3125.	128393.15	2558.76	36447.04	85.77
8031.361	3124.	128415.91	2562.94	36454.01	85.79
8061.441	3123.	128438.50	2567.13	36460.97	85.81
8091.521	3122.	128460.92	2571.31	36467.91	85.83
8121.602	3122.	128483.16	2575.49	36474.73	85.85
8151.682	3121.	128505.23	2579.66	36481.51	85.88
8181.762	3120.	128527.14	2583.84	36488.30	85.90
8211.842	3119.	128548.88	2588.01	36495.08	85.92
8241.922	3119.	128570.45	2592.18	36501.77	85.94
8272.001	3118.	128591.87	2596.34	36508.42	85.96
8302.081	3117.	128613.11	2600.51	36515.04	85.98
8332.161	3116.	128634.21	2604.67	36521.63	86.00
8362.241	3116.	128655.13	2608.83	36528.19	86.02
8392.321	3115.	128675.91	2612.98	36534.67	86.04

TABLE 5 - (CONTINUED)

TIME (DAYS)	RESERVIOR PRESSURE (PSI)	CUMULATIVE GAS PRODUCED (MM SCF)	CUMULATIVE WATER PRODUCED (M RBLS)	CUMULATIVE WATER INFLUX (M RBLS)	HEIGHT OF U-M-C (FT)
8422.401	3114.	128696.53	2617.14	36541.09	86.05
8452.481	3113.	128717.00	2621.29	36547.47	86.07
8482.561	3113.	128737.32	2625.44	36553.81	86.09
8512.641	3112.	128757.49	2629.59	36560.13	86.11
8542.721	3111.	128777.50	2633.74	36566.45	86.13
8572.801	3111.	128797.37	2637.88	36572.73	86.15
8602.881	3110.	128817.10	2642.02	36578.93	86.17
8632.961	3109.	128836.68	2646.16	36585.09	86.18
8663.041	3108.	128856.13	2650.30	36591.21	86.20
8693.121	3108.	128875.43	2654.43	36597.29	86.22
8723.201	3107.	128894.59	2658.56	36603.37	86.24
8753.281	3106.	128913.61	2662.69	36609.41	86.25
8783.361	3106.	128932.49	2666.82	36615.37	86.27
8813.441	3105.	128951.25	2670.94	36621.28	86.29
8843.521	3104.	128969.87	2675.07	36627.15	86.30
8873.601	3104.	128988.36	2679.19	36633.00	86.32
8903.681	3103.	129006.71	2683.31	36638.84	86.34
8933.760	3102.	129024.94	2687.42	36644.67	86.35
8963.840	3102.	129043.04	2691.54	36650.51	86.37
8993.920	3101.	129061.01	2695.65	36656.25	86.39

TABLE 5 - (CONTINUED)

TIME (DAYS)	RESERVOIR PRESSURE (PSI)	CUMULATIVE GAS PRODUCED (MM SCF)	CUMULATIVE WATER PRODUCED (M BBL)	CUMULATIVE WATER INFLUX (M BBL)	HEIGHT OF CWC (FT)
9024.000	3100.	129078.86	2699.76	36661.94	86.40
9054.080	3100.	129096.58	2703.87	36667.64	86.42
9084.160	3099.	129114.17	2707.97	36673.28	86.43
9114.240	3099.	129131.65	2712.08	36678.89	86.45
9144.320	3098.	129149.00	2716.18	36684.50	86.46
9174.400	3097.	129166.24	2720.28	36690.06	86.48
9204.480	3097.	129183.35	2724.38	36695.53	86.49
9234.560	3096.	129200.35	2728.47	36701.01	86.51
9264.640	3095.	129217.24	2732.56	36706.47	86.52
9294.720	3095.	129234.00	2736.65	36711.92	86.54
9324.800	3094.	129250.65	2740.74	36717.33	86.55
9354.880	3094.	129267.20	2744.83	36722.69	86.57
9384.960	3093.	129283.63	2748.91	36727.99	86.58
9415.040	3092.	129299.95	2753.00	36733.26	86.60
9445.120	3092.	129316.16	2757.08	36738.54	86.61
9475.200	3091.	129332.26	2761.15	36743.84	86.62
9505.280	3091.	129348.25	2765.23	36749.07	86.64
9535.360	3090.	129364.14	2769.30	36754.27	86.65
9565.440	3089.	129379.92	2773.38	36759.43	86.66
9595.520	3089.	129395.61	2777.45	36764.56	86.68

TABLE 5 - (CONTINUED)

TIME (DAYS)	RESERVOIR PRESSURE (PSI)	CUMULATIVE GAS PRODUCED (MM SCF)	CUMULATIVE WATER PRODUCED (M BBL)	CUMULATIVE WATER INFLUX (M BBL)	HEIGHT OF G-M-C (ft)
9625.599	3088.	129411.18	2781.51	36769.66	86.69
9655.679	3088.	129426.65	2785.58	36774.72	86.71
9685.759	3087.	129442.03	2789.64	36779.80	86.72
9715.839	3087.	129457.30	2793.71	36784.84	86.73
9745.919	3086.	129472.47	2797.77	36789.81	86.74
9775.999	3085.	129487.55	2801.82	36794.79	86.76
9806.079	3085.	129502.53	2805.88	36799.76	86.77
9836.159	3084.	129517.41	2809.93	36804.68	86.78
9866.239	3084.	129532.19	2813.99	36809.59	86.79
9896.319	3083.	129546.88	2818.03	36814.48	86.81
9926.399	3083.	129561.48	2822.08	36819.30	86.82
9956.479	3082.	129575.99	2826.13	36824.09	86.83
9986.559	3082.	129590.41	2830.17	36828.91	86.84
10016.64	3081.	129604.73	2834.21	36833.73	86.86
10046.72	3080.	129618.96	2838.25	36838.48	86.87
10076.80	3080.	129633.10	2842.29	36843.19	86.88
10106.88	3079.	129647.16	2846.33	36847.91	86.89
10136.96	3079.	129661.13	2850.36	36852.57	86.90
10167.04	3078.	129675.01	2854.39	36857.22	86.91
10197.12	3078.	129688.81	2858.42	36861.85	86.92

TABLE 5 - (CONTINUED)

TIME (DAYS)	RESERVOIR PRESSURE (PSI)	CUMULATIVE GAS PRODUCED (MM SCF)	CUMULATIVE WATER PRODUCED (M BBL)	CUMULATIVE WATER INFLUX (M BBL)	HEIGHT OF G-M-C (FT)
10227.20	3077.	129702.52	2862.45	36066.48	86.94
10257.28	3077.	129716.14	2866.48	36871.10	86.95
10287.36	3076.	129729.68	2870.50	36875.68	86.96
10317.44	3076.	129743.14	2874.52	36880.18	86.97
10347.52	3075.	129756.52	2878.55	36884.73	86.98
10377.60	3075.	129769.82	2882.56	36889.29	86.99
10407.68	3074.	129783.03	2886.58	36893.77	87.00
10437.76	3074.	129796.17	2890.60	36898.22	87.01
10467.84	3073.	129809.23	2894.61	36902.66	87.02
10497.92	3073.	129822.21	2898.62	36907.05	87.03
10528.00	3072.	129835.11	2902.63	36911.43	87.04

TABLE 6 - Prediction 3 ——— When $Q_w/Q_g > .002$ shut well in

TIME (DAYS)	RESERVOIR PRESSURE (PSI)	CUMULATIVE GAS PRODUCED (MM SCF)	CUMULATIVE WATER PRODUCED (M BBLS)	CUMULATIVE WATER INFLUX (M BBLS)	HEIGHT OF G-W-C (FT)
30.08000	7249.	838.03	0.00	86.94	0.16
60.16000	7087.	3751.14	0.00	493.47	0.91
90.24000	6967.	6698.98	0.00	1200.68	2.21
120.3200	6854.	9619.83	0.00	2045.17	3.78
150.4000	6800.	12170.93	2.48	2914.05	5.38
180.4800	6726.	14445.46	134.31	3721.55	6.63
210.5600	6689.	16202.93	137.52	4403.73	7.89
240.6400	6632.	17994.40	144.22	4950.70	9.08
270.7200	6540.	20269.53	161.96	5513.76	10.32
300.8000	6469.	22336.81	178.86	6113.10	11.64
330.8800	6398.	24359.09	218.61	6714.10	12.92
360.9600	6340.	26222.44	252.22	7316.72	14.21
391.0400	6286.	27968.68	286.25	7891.04	15.44
421.1200	6216.	29916.67	327.57	8449.79	16.63
451.2000	6170.	31477.19	367.18	8978.35	17.75
481.2800	6105.	33287.83	395.25	9484.52	18.85
511.3600	6042.	35094.19	440.08	10011.24	19.96
541.4400	5974.	37016.46	476.32	10553.76	21.13
571.5200	5927.	38534.67	539.28	11077.16	22.19

TABLE 6 - (CONTINUED)

TIME (DAYS)	RESERVOIR PRESSURE (PSI)	CUMULATIVE GAS PRODUCED (MM SCF)	CUMULATIVE WATER PRODUCED (M BBLS)	CUMULATIVE WATER INFLOW (M BBLS)	HEIGHT OF U-W-C (FT)
601.6000	5879.	40104.95	552.49	11564.12	23.28
631.6800	5810.	41983.05	594.35	12066.35	24.37
661.7600	5749.	43768.25	634.85	12584.76	25.49
691.8400	5686.	45599.69	675.91	13103.02	26.62
721.9200	5657.	46810.37	716.41	13580.56	27.62
752.0000	5623.	48003.19	758.26	13992.88	28.50
782.0800	5591.	49079.61	798.37	14360.90	29.29
812.1600	5556.	50165.20	811.75	14685.40	30.04
842.2400	5522.	51223.73	818.92	14985.45	30.76
872.3200	5478.	52440.39	843.22	15296.89	31.48
902.4000	5430.	53809.69	849.54	15643.02	32.33
932.4800	5345.	55957.35	854.07	16078.49	33.45
962.5600	5272.	58081.16	858.63	16610.51	34.78
992.6400	5205.	60179.66	863.25	17179.44	36.20
1022.7200	5141.	62253.28	868.37	17768.55	37.66
1052.8000	5079.	64302.85	874.02	18358.05	39.02
1082.8800	5017.	66331.04	880.16	18929.97	40.33
1112.9600	4951.	68339.92	887.34	19485.13	41.62
1143.0400	4892.	70331.05	895.48	20032.32	42.89
1173.1200	4831.	72304.30	899.57	20573.99	44.16

TABLE 6 - (CONTINUED)

TIME (DAYS)	RESERVOIR PRESSURE (PSI)	CUMULATIVE GAS PRODUCED (MM SCF)	CUMULATIVE WATER PRODUCED (M RBBL)	CUMULATIVE WATER INFLOW (M RBBL)	HEIGHT OF C-M-C (FT)
1203.200	4770.	74277.55	904.47	21111.93	45.43
1233.280	4709.	76250.80	910.12	21647.71	46.71
1263.360	4648.	78224.04	916.78	22181.35	47.99
1293.440	4586.	80197.29	924.60	22716.78	49.10
1323.520	4524.	82170.54	933.39	23255.62	50.22
1353.600	4462.	84143.79	943.67	23795.17	51.35
1383.680	4400.	86117.04	955.31	24334.93	52.49
1413.760	4339.	88090.29	968.21	24873.63	53.63
1443.840	4279.	90042.96	982.24	25408.67	54.78
1473.920	4222.	91935.13	997.31	25934.69	55.91
1504.000	4167.	93771.48	1013.30	26447.46	57.02
1534.080	4114.	95539.23	1030.10	26944.10	58.11
1564.160	4068.	97131.76	1047.67	27414.08	59.26
1594.240	4028.	98545.56	1066.09	27845.58	60.31
1624.320	3993.	99805.86	1085.22	28235.71	61.26
1654.400	3961.	100944.10	1100.34	28584.88	62.12
1684.480	3931.	101998.26	1115.77	28898.22	62.90
1714.560	3903.	102977.79	1131.44	29183.47	63.62
1744.640	3876.	103890.55	1147.31	29446.82	64.29
1774.720	3851.	104743.09	1163.34	29692.53	64.92

TABLE 6 - (CONTINUED)

TIME (DAYS)	RESERVOIR PRESSURE (PSI)	CUMULATIVE GAS PRODUCED (MM SCF)	CUMULATIVE WATER PRODUCED (M RBLS)	CUMULATIVE WATER INFLOW (M RBLS)	HEIGHT OF UIC (FT)
1804.800	3828.	105540.98	1179.51	29922.83	65.51
1834.860	3806.	106289.07	1195.81	30138.80	66.06
1864.960	3785.	106991.64	1212.21	30341.38	66.58
1895.040	3766.	107652.50	1228.69	30531.62	67.07
1925.120	3748.	108275.07	1245.25	30710.61	67.53
1955.200	3730.	108862.39	1261.87	30879.36	67.97
1985.280	3714.	109417.22	1278.53	31038.69	68.43
2015.360	3698.	109939.33	1295.27	31189.16	68.87
2045.440	3684.	110431.03	1312.07	31331.18	69.28
2075.520	3670.	110894.68	1328.92	31465.22	69.67
2105.600	3657.	111332.37	1345.83	31591.90	70.04
2135.680	3645.	111746.02	1362.77	31711.68	70.39
2165.760	3633.	112137.41	1379.74	31824.97	70.72
2195.840	3622.	112508.12	1396.74	31932.32	71.03
2225.920	3611.	112860.25	1408.59	32033.85	71.33
2256.000	3601.	113199.66	1420.46	32130.12	71.62
2286.080	3592.	113527.06	1432.32	32222.19	71.90
2316.160	3582.	113843.00	1444.19	32310.57	72.17
2346.240	3573.	114146.29	1456.06	32395.75	72.43
2376.320	3564.	114443.19	1467.93	32478.21	72.68

TABLE 6 - (CONTINUED)

TIME (DAYS)	RESERVOIR PRESSURE (PSI)	CUMULATIVE GAS PRODUCED (MM SCF)	CUMULATIVE WATER PRODUCED (M BBLS)	CUMULATIVE WATER INFLUX (M RBLS)	HEIGHT OF C-M-C (FT)
2406.400	3555.	114728.23	1479.80	32558.12	72.92
2436.480	3547.	115003.86	1491.66	32635.45	73.15
2466.560	3539.	115270.52	1503.52	32710.27	73.38
2496.640	3531.	115528.58	1515.38	32782.72	73.60
2526.720	3524.	115778.43	1527.22	32852.93	73.81
2556.800	3516.	116020.40	1539.06	32921.03	74.01
2586.880	3509.	116254.83	1550.90	32987.01	74.21
2616.960	3502.	116482.05	1562.72	33050.97	74.40
2647.040	3495.	116702.36	1574.54	33113.04	74.59
2677.120	3489.	116916.02	1586.34	33173.37	74.77
2707.200	3482.	117123.30	1598.14	33231.97	74.95
2737.280	3476.	117324.46	1609.93	33288.89	75.12
2767.360	3470.	117519.73	1621.70	33344.19	75.28
2797.440	3464.	117709.36	1633.47	33397.93	75.44
2827.520	3459.	117893.56	1645.22	33450.23	75.60
2857.600	3453.	118072.52	1656.96	33501.08	75.75
2887.680	3448.	118246.46	1668.70	33550.55	75.89
2917.760	3443.	118415.56	1680.41	33598.72	76.04
2947.840	3437.	118579.99	1692.12	33645.61	76.17
2977.920	3432.	118739.93	1703.82	33691.35	76.31

TABLE 6 - (CONTINUED)

TIME (DAYS)	RESERVOIR PRESSURE (PSI)	CUMULATIVE GAS PRODUCED (MM SCF)	CUMULATIVE WATER PRODUCED (M RBBL)	CUMULATIVE WATER INFLUX (M RBBL)	HEIGHT OF C-M-C (FT)
3008.000	3428.	118895.53	1715.50	33735.91	76.44
3038.060	3423.	119046.96	1727.17	33779.29	76.56
3068.160	3418.	119194.36	1738.82	33821.59	76.69
3098.240	3414.	119337.87	1750.47	33862.84	76.81
3128.320	3409.	119477.64	1762.10	33903.06	76.92
3158.400	3405.	119613.78	1773.71	33942.38	77.04
3188.480	3401.	119746.41	1785.32	33980.78	77.15
3218.560	3397.	119875.66	1796.91	34018.25	77.25
3248.640	3393.	120001.63	1808.49	34054.84	77.36
3278.720	3389.	120124.46	1820.05	34090.54	77.46
3308.800	3385.	120244.22	1831.60	34125.40	77.56
3338.880	3381.	120361.04	1843.14	34159.48	77.65
3368.960	3378.	120475.00	1854.67	34192.80	77.75
3399.040	3374.	120586.19	1866.18	34225.39	77.84
3429.120	3371.	120692.30	1870.84	34256.53	77.94
3459.199	3368.	120797.12	1875.49	34286.06	78.04
3489.279	3365.	120900.64	1880.15	34314.59	78.14
3519.359	3362.	121002.81	1884.80	34342.28	78.25
3549.439	3359.	121103.64	1889.44	34369.41	78.35
3579.519	3356.	121203.17	1894.09	34396.21	78.45

TABLE 6 - (CONTINUED)

TIME (DAYS)	RESERVOIR PRESSURE (PSI)	CUMULATIVE GAS PRODUCED (MM SCF)	CUMULATIVE WATER PRODUCED (M BBLS)	CUMULATIVE WATER INFLOW (M BBLS)	HEIGHT OF G-M-C (FT)
3609.599	3353.	121301.43	1898.73	34422.81	78.56
3639.679	3350.	121399.42	1903.37	34449.12	78.66
3669.759	3347.	121494.17	1908.00	34475.11	78.75
3699.839	3344.	121588.71	1912.63	34500.75	78.85
3729.919	3341.	121682.06	1917.26	34526.04	78.95
3759.999	3338.	121774.23	1921.89	34551.06	79.04
3790.079	3335.	121865.25	1926.51	34575.76	79.14
3820.159	3333.	121955.14	1931.13	34600.15	79.23
3850.239	3330.	122043.91	1935.75	34624.29	79.32
3880.319	3327.	122131.58	1940.36	34648.19	79.41
3910.399	3325.	122218.18	1944.97	34671.75	79.50
3940.479	3322.	122303.72	1949.57	34695.02	79.59
3970.559	3319.	122388.21	1954.18	34718.06	79.68
4000.639	3317.	122471.67	1958.78	34740.94	79.76
4030.719	3314.	122554.11	1963.37	34763.73	79.85
4060.799	3312.	122635.55	1967.96	34786.33	79.93
4090.879	3309.	122716.01	1972.55	34808.76	80.02
4120.959	3307.	122795.49	1977.14	34830.93	80.10
4151.039	3304.	122874.03	1981.72	34852.79	80.18
4181.119	3302.	122951.62	1986.30	34874.44	80.26

TABLE 6 - (CONTINUED)

TIME (DAY)	RESERVOIR PRESSURE (PSI)	CUMULATIVE WATER PRODUCED (MM BBL)	CUMULATIVE GAS PRODUCED (MM SCF)	CUMULATIVE WATER PRODUCED (MM BBL)	CUMULATIVE WATER FLUX (MM BBL)	HEIGHT OF C-W-C (FT)
4211.199	3299.	123028.29	1990.87	1990.87	34895.85	80.34
4241.279	3297.	123104.04	1995.44	1995.44	34916.95	80.42
4271.359	3295.	123178.92	2000.01	2000.01	34937.78	80.50
4301.439	3292.	123252.91	2004.58	2004.58	34958.44	80.58
4331.519	3290.	123326.03	2009.14	2009.14	34978.86	80.65
4361.599	3288.	123398.30	2013.69	2013.69	34999.07	80.73
4391.679	3286.	123469.73	2018.25	2018.25	35019.07	80.80
4421.759	3283.	123540.34	2022.80	2022.80	35038.85	80.88
4451.839	3281.	123610.13	2027.34	2027.34	35058.38	80.95
4481.919	3279.	123679.13	2031.89	2031.89	35077.68	81.02
4511.999	3277.	123747.33	2036.42	2036.42	35096.02	81.09
4542.079	3275.	123814.76	2040.96	2040.96	35115.77	81.16
4572.159	3273.	123881.42	2045.49	2045.49	35134.42	81.23
4602.240	3271.	123947.34	2050.02	2050.02	35152.91	81.30
4632.320	3269.	124012.51	2054.55	2054.55	35171.24	81.37
4662.400	3267.	124076.96	2059.07	2059.07	35189.30	81.43
4692.480	3265.	124140.69	2063.59	2063.59	35207.18	81.50
4722.560	3263.	124203.71	2068.10	2068.10	35224.91	81.57
4752.640	3261.	124266.03	2072.61	2072.61	35242.43	81.63
4782.720	3259.	124327.67	2077.12	2077.12	35259.73	81.69

TABLE 6 - (CONTINUED)

TIME (DAY)	RESPIRATOR PRESSURE (PSI)	CUMULATIVE GAS PRODUCED (CCM SCF)	CUMULATIVE WATER PRODUCED (GAL RBLS)	CUMULATIVE METHANE FLOW (M ³ RBLS)	WEIGHT OF GASES (LB)
4812.800	3257.	124388.64	2081.63	35276.92	81.76
4842.880	3255.	124448.93	2086.13	35293.93	81.82
4872.960	3253.	124508.57	2090.62	35310.73	81.88
4903.040	3251.	124567.57	2095.12	35327.37	81.94
4933.120	3249.	124625.92	2099.61	35343.87	82.00
4963.200	3247.	124683.65	2104.10	35360.21	82.06
4993.280	3246.	124740.76	2108.58	35376.32	82.12
5023.360	3244.	124797.26	2113.06	35392.27	82.18
5053.440	3242.	124853.16	2117.54	35408.05	82.24
5083.520	3240.	124908.47	2122.01	35423.67	82.30
5113.600	3238.	124963.19	2126.48	35439.15	82.35
5143.680	3237.	125017.34	2130.95	35454.47	82.41
5173.760	3235.	125070.93	2135.41	35469.68	82.46
5203.840	3233.	125123.95	2139.87	35484.73	82.52
5233.920	3232.	125176.42	2144.33	35499.63	82.57
5264.000	3230.	125228.34	2148.78	35514.40	82.63
5294.080	3228.	125279.73	2153.24	35529.04	82.68
5324.160	3227.	125330.59	2157.68	35543.55	82.73
5354.240	3225.	125380.92	2162.13	35557.89	82.78
5384.320	3224.	125430.74	2166.57	35572.09	82.84

TABLE 6 - (CONTINUED)

TIME (DAY)	RESURFICE PRESSURE (PSI)	CUMULATIVE GAS PRODUCED (MM SCF)	CUMULATIVE WATER PRODUCED (M RBLS)	CUMULATIVE WATER FLOK (M RBLS)	HEIGHT OF G-M-C (FT)
5414.400	3222.	125480.05	2171.00	35586.14	82.49
5444.480	3220.	125528.86	2175.44	35600.05	82.94
5474.560	3219.	125577.18	2179.87	35613.83	82.99
5504.640	3217.	125625.01	2184.30	35627.49	83.04
5534.720	3216.	125672.36	2188.72	35641.02	83.08
5564.800	3214.	125719.23	2193.14	35654.44	83.13
5594.880	3213.	125765.64	2197.56	35667.73	83.16
5624.960	3211.	125811.59	2201.97	35680.85	83.23
5655.040	3210.	125857.08	2206.38	35693.88	83.27
5685.120	3208.	125902.12	2210.79	35706.83	83.32
5715.200	3207.	125946.72	2215.20	35719.65	83.37
5745.280	3206.	125990.88	2219.60	35732.30	83.41
5775.360	3204.	126034.61	2224.00	35744.85	83.46
5805.440	3203.	126077.92	2228.39	35757.33	83.50
5835.520	3201.	126120.80	2232.79	35769.66	83.54
5865.600	3200.	126163.27	2237.17	35781.92	83.59
5895.680	3199.	126205.32	2241.56	35794.04	83.63
5925.760	3197.	126246.98	2245.94	35806.02	83.67
5955.840	3196.	126288.24	2250.32	35817.92	83.71
5985.920	3195.	126329.10	2254.70	35829.72	83.76

TABLE 6 - (CONTINUED)

TIME (DAY)	RESISTIVE PRESSURE (PSI)	CUMULATIVE GAS PRODUCED (MM SCF)	CUMULATIVE WATER PRODUCED (M RBLS)	CUMULATIVE WATER INFLUX (M RBLS)	WEIGHT OF G-M-C (KT)
6016.000	3193.	126369.58	2259.07	35841.40	83.80
6046.080	3192.	126409.67	2263.45	35853.03	83.84
6076.160	3191.	126449.37	2267.81	35864.57	83.88
6106.240	3189.	126488.71	2272.18	35875.97	83.92
6136.320	3188.	126527.67	2276.54	35887.28	83.96
6166.400	3187.	126566.27	2280.90	35898.44	84.00
6196.480	3186.	126604.52	2285.25	35909.50	84.03
6226.560	3184.	126642.41	2289.61	35920.50	84.07
6256.640	3183.	126679.95	2293.96	35931.37	84.11
6286.720	3182.	126717.14	2298.30	35942.16	84.15
6316.800	3181.	126753.99	2302.65	35952.92	84.19
6346.880	3179.	126790.50	2306.99	35963.64	84.22
6376.961	3178.	126826.67	2311.33	35974.24	84.26
6407.041	3177.	126862.51	2315.66	35984.71	84.29
6437.121	3176.	126898.03	2319.99	35995.07	84.33
6467.201	3175.	126933.23	2324.32	36005.36	84.37
6497.281	3174.	126968.11	2328.65	36015.59	84.40
6527.361	3172.	127002.67	2332.97	36025.71	84.43
6557.441	3171.	127036.92	2337.29	36035.78	84.47
6587.521	3170.	127070.86	2341.61	36045.81	84.50

TABLE 6 - (CONTINUED)

TIME (DAY)	RESERVOIR PRESSURE (PSI)	CUMULATIVE GAS PRODUCED (MM SCF)	CUMULATIVE WATER PRODUCED (M BBL)	CUMULATIVE WATER FLOX (M BBL)	WEIGHT OF COLUMN (FT)
6617.601	3169.	127104.50	2345.92	36055.70	84.54
6647.681	3168.	127137.85	2350.24	36065.53	84.57
6677.761	3167.	127170.89	2354.54	36075.27	84.60
6707.841	3166.	127203.64	2358.85	36084.89	84.64
6737.921	3165.	127236.11	2363.15	36094.46	84.67
6768.001	3164.	127268.29	2367.45	36103.98	84.70
6798.081	3163.	127300.18	2371.75	36113.42	84.73
6828.161	3161.	127331.80	2376.05	36122.79	84.76
6858.241	3160.	127363.14	2380.34	36132.06	84.79
6888.321	3159.	127394.21	2384.63	36141.22	84.83
6918.401	3158.	127425.02	2388.92	36150.35	84.86
6948.481	3157.	127455.55	2393.20	36159.41	84.89
6978.561	3156.	127485.83	2397.48	36168.39	84.92
7008.641	3155.	127515.85	2401.76	36177.33	84.95
7038.721	3154.	127545.60	2406.04	36186.20	84.97
7068.801	3153.	127575.11	2410.31	36194.97	85.00
7098.881	3152.	127604.37	2414.58	36203.68	85.03
7128.961	3151.	127633.37	2418.85	36212.40	85.06
7159.041	3150.	127662.13	2423.11	36221.02	85.09
7189.121	3149.	127690.65	2427.37	36229.50	85.12

TABLE 6 - (CONTINUED)

TIME (DAY)	FLIGHT LEVEL (PSI)	CUMULATIVE GAS PRODUCED (MM SCF)	CUMULATIVE WATER PRODUCED (M RB19)	CUMULATIVE WATER INFLOW (M RB19)	WEIGHT (F.C.-G)
7219.201	3148.	127718.93	2431.63	36237.96	85.14
7249.281	3147.	127746.98	2435.89	36246.38	85.17
7279.361	3147.	127774.79	2440.15	36254.71	85.20
7309.441	3146.	127802.37	2444.40	36262.97	85.23
7339.521	3145.	127829.72	2448.65	36271.20	85.25
7369.601	3144.	127856.84	2452.89	36279.43	85.28
7399.681	3143.	127883.74	2457.14	36287.56	85.31
7429.761	3142.	127910.42	2461.38	36295.56	85.33
7459.841	3141.	127936.88	2465.62	36303.54	85.36
7489.921	3140.	127963.13	2469.85	36311.51	85.38
7520.001	3139.	127989.15	2474.09	36319.43	85.41

TABLE 7 - Prediction 4 — When $Q_w/Q_g > .004$ shut well in

TIME (DAYS)	RESERVOIR PRESSURE (PSI)	CUMULATIVE GAS PRODUCED (MM SCF)	CUMULATIVE WATER PRODUCED (M BBLS)	CUMULATIVE WATER INFLUX (M BBLS)	HEIGHT OF C-M-C (FT)
30.08000	7249.	838.03	0.00	86.94	0.16
60.16000	7087.	3751.14	0.00	493.47	0.91
90.24000	6967.	6698.98	0.00	1200.68	2.21
120.32000	6854.	9619.83	0.00	2045.17	3.78
150.40000	6800.	12170.93	2.48	2914.05	5.38
180.48000	6726.	14445.46	134.31	3721.55	6.63
210.56000	6689.	16202.93	137.52	4403.73	7.89
240.64000	6632.	17904.40	144.22	4950.70	9.04
270.72000	6540.	20269.53	161.96	5513.76	10.32
300.80000	6469.	22336.81	178.86	6113.10	11.64
330.88000	6398.	24359.09	214.61	6714.10	12.92
360.96000	6340.	26222.44	252.22	7316.72	14.21
391.04000	6286.	27968.68	286.25	7891.04	15.44
421.12000	6216.	29916.67	327.57	8449.79	16.63
451.20000	6170.	31477.19	367.18	8978.35	17.75
481.28000	6105.	33287.83	395.25	9484.52	18.85
511.36000	6042.	35094.19	440.08	10011.24	19.96
541.44000	5974.	37016.46	476.32	10553.76	21.13
571.52000	5927.	38534.67	539.28	11077.16	22.19

TABLE 7 (CONTINUED)

TIME (DAYS)	RESERVOIR PRESSURE (PSI)	CUMULATIVE GAS PRODUCED (MM SCF)	CUMULATIVE WATER PRODUCED (M BBW)	CUMULATIVE WATER FLOX (M BBW)	HEIGHT OF FLY-C (FT)
601.6000	5879.	40104.95	552.49	11564.12	23.28
631.6800	5810.	41983.05	594.35	12066.35	24.37
661.7600	5749.	43768.25	634.85	12584.76	25.49
691.8400	5686.	45599.69	675.91	13103.02	26.62
721.9200	5627.	46810.37	716.41	13580.56	27.62
752.0000	5623.	48003.19	758.26	13992.88	28.50
782.0800	5591.	49079.61	798.37	14360.90	29.29
812.1600	5556.	50165.20	811.75	14685.40	30.04
842.2400	5522.	51223.73	818.92	14985.45	30.76
872.3200	5476.	52440.39	843.22	15296.89	31.48
902.4000	5430.	53809.69	849.54	15643.02	32.33
932.4800	5345.	55957.35	854.07	16070.49	33.45
962.5600	5272.	58081.16	858.63	16610.51	34.78
992.6400	5205.	60179.66	863.25	17179.44	36.20
1022.720	5141.	62253.28	868.37	17768.55	37.66
1052.800	5079.	64302.85	874.02	18358.05	39.02
1082.880	5017.	66331.04	880.16	18929.97	40.33
1112.960	4954.	68339.92	887.34	19485.13	41.62
1143.040	4892.	70331.05	895.48	20032.32	42.89
1173.120	4831.	72305.73	904.50	20574.74	44.15

TABLE 7 (CONTINUED)

TIME (DAYS)	RESERVOIR PRESSURE (PSI)	CUMULATIVE GAS PRODUCED (MM SCF)	CUMULATIVE WATER PRODUCED (M RB10)	CUMULATIVE WATER INFLUX (M RB10)	HEIGHT OF U-M-C (FE)
1203.200	4770.	74278.98	909.39	21113.65	45.43
1233.280	4709.	76252.23	915.04	21649.79	46.70
1263.360	4648.	78225.48	921.69	22183.74	47.98
1293.440	4585.	80198.73	929.51	22719.27	49.09
1323.520	4523.	82171.97	938.29	23257.93	50.22
1353.600	4461.	84145.22	948.56	23797.48	51.35
1383.680	4400.	86118.47	960.19	24337.13	52.48
1413.760	4339.	88091.72	973.08	24875.77	53.63
1443.840	4279.	90044.43	987.10	25410.87	54.77
1473.920	4222.	91936.62	1002.17	25936.99	55.90
1504.000	4166.	93773.00	1018.15	26449.77	57.01
1534.080	4114.	95540.72	1034.94	26946.46	58.10
1564.160	4068.	97133.48	1052.50	27416.40	59.26
1594.240	4028.	98547.49	1070.91	27847.97	60.31
1624.320	3993.	99807.98	1090.03	28238.05	61.26
1654.400	3961.	100946.26	1105.15	28587.24	62.12
1684.480	3931.	102000.50	1120.57	28900.50	62.90
1714.560	3902.	102980.11	1136.23	29185.74	63.62
1744.640	3876.	103892.94	1152.10	29449.16	64.29
1774.720	3851.	104745.57	1168.12	29694.79	64.92

TABLE 7 (CONTINUED)

TIME (DAYS)	RESERVOIR PRESSURE (PSI)	CUMULATIVE GAS PRODUCED (MM SCF)	CUMULATIVE WATER PRODUCED (M RBLS)	CUMULATIVE WATER FLUX (M RBLS)	HEIGHT OF C-M-C (FE)
1804.800	3828.	105543.55	1184.29	29925.06	65.51
1834.880	3806.	106291.72	1200.58	30141.12	66.06
1864.960	3785.	106994.35	1216.98	30343.73	66.58
1895.040	3766.	107655.28	1233.46	30534.00	67.07
1925.120	3747.	108277.92	1250.01	30713.02	67.53
1955.200	3730.	108865.34	1266.62	30881.70	67.96
1985.280	3714.	109420.27	1283.28	31040.97	68.43
2015.360	3698.	109942.48	1300.01	31191.49	68.87
2045.440	3684.	110434.29	1316.80	31333.53	69.28
2075.520	3670.	110898.04	1333.65	31467.65	69.67
2105.600	3657.	111335.82	1350.54	31594.39	70.04
2135.680	3644.	111749.57	1367.48	31714.16	70.35
2165.760	3633.	112141.05	1384.44	31827.45	70.72
2195.840	3621.	112511.85	1401.43	31934.87	71.03
2225.920	3611.	112863.97	1413.29	32036.48	71.33
2256.000	3601.	113203.39	1425.15	32132.72	71.62
2286.080	3591.	113530.81	1437.01	32224.75	71.90
2316.160	3582.	113846.86	1448.88	32313.10	72.16
2346.240	3573.	114152.08	1460.74	32398.32	72.42
2376.320	3564.	114446.99	1472.61	32480.79	72.67

TABLE 7 (CONTINUED)

TIME (DAYS)	RESERVOIR PRESSURE (PSI)	CUMULATIVE GAS PRODUCED (MM SCF)	CUMULATIVE WATER PRODUCED (M BBL)	CUMULATIVE WATER INFLUX (M BBL)	WEIGHT OF LIFT (FT)
2406.400	3555.	114732.05	1484.47	32560.65	72.91
2436.480	3547.	115007.72	1496.33	32637.96	73.15
2466.560	3539.	115274.40	1508.18	32712.76	73.37
2496.640	3531.	115532.49	1520.03	32785.26	73.59
2526.720	3523.	115782.35	1531.88	32855.51	73.80
2556.800	3516.	116024.35	1543.71	32923.55	74.01
2586.880	3509.	116258.81	1555.54	32989.52	74.21
2616.960	3502.	116486.06	1567.36	33053.51	74.40
2647.040	3495.	116706.40	1579.17	33115.56	74.59
2677.120	3489.	116920.09	1590.98	33175.85	74.77
2707.200	3482.	117127.41	1602.77	33234.44	74.94
2737.280	3476.	117328.60	1614.55	33291.35	75.11
2767.360	3470.	117523.91	1626.32	33346.68	75.28
2797.440	3464.	117713.57	1638.09	33400.48	75.44
2827.520	3458.	117897.79	1649.84	33452.78	75.59
2857.600	3453.	118076.79	1661.57	33503.60	75.74
2887.680	3448.	118250.76	1673.30	33553.05	75.89
2917.760	3442.	118419.89	1685.02	33601.28	76.03
2947.840	3437.	118584.34	1696.72	33648.20	76.17
2977.920	3432.	118744.32	1708.41	33693.87	76.30

TABLE 7 (CONTINUED)

TIME (DAYS)	RESTRICTOR PRESSURE (PSI)	CUMULATIVE GAS PRODUCED (MM SCF)	CUMULATIVE WATER PRODUCED (M RBLS)	CUMULATIVE WATER INFILUX (M RBLS)	WEIGHT OF GUM-C (LT)
3008.000	3427.	118899.95	1720.09	33738.42	76.43
3038.080	3423.	119051.41	1731.75	33781.87	76.56
3068.160	3418.	119198.82	1743.40	33824.23	76.69
3098.240	3413.	119342.35	1755.04	33865.53	76.81
3128.320	3409.	119482.12	1766.67	33905.86	76.92
3158.400	3405.	119618.27	1778.28	33945.15	77.03
3188.480	3401.	119750.92	1789.88	33983.44	77.14
3218.560	3396.	119880.20	1801.47	34020.83	77.25
3248.640	3392.	120006.21	1813.04	34057.39	77.36
3278.720	3389.	120129.06	1824.60	34093.06	77.46
3308.800	3385.	120248.86	1836.15	34127.93	77.56
3338.880	3381.	120365.71	1847.69	34162.03	77.65
3368.960	3377.	120479.70	1859.21	34195.36	77.75
3399.040	3374.	120590.92	1870.71	34227.94	77.84
3429.120	3370.	120699.47	1882.21	34259.79	77.92
3459.199	3367.	120804.33	1886.86	34290.35	78.02
3489.279	3364.	120907.89	1891.51	34319.41	78.13
3519.359	3361.	121010.08	1896.15	34347.52	78.24
3549.439	3358.	121110.94	1900.80	34374.89	78.34
3579.519	3355.	121210.49	1905.44	34401.69	78.45

TABLE 7 (CONTINUED)

TIME (DAYS)	RESERVOIR PRESSURE (PSI)	CUMULATIVE GAS PRODUCED (MM SCF)	CUMULATIVE WATER PRODUCED (M BBL)	CUMULATIVE WATER INFLUX (M BBL)	HEIGHT OF G-M-C (FT)
3609.599	3352.	121308.77	1910.08	34428.20	78.55
3639.679	3349.	121405.77	1914.71	34454.53	78.65
3669.759	3346.	121501.55	1919.34	34480.53	78.75
3699.839	3343.	121596.11	1923.97	34506.15	78.84
3729.919	3340.	121689.47	1928.59	34531.43	78.94
3759.999	3338.	121781.67	1933.21	34556.49	79.03
3790.079	3335.	121872.70	1937.83	34581.19	79.13
3820.159	3332.	121962.61	1942.45	34605.59	79.22
3850.239	3329.	122051.40	1947.06	34629.76	79.31
3880.319	3327.	122139.09	1951.67	34653.62	79.40
3910.399	3324.	122225.70	1956.28	34677.15	79.49
3940.479	3321.	122311.26	1960.88	34700.40	79.58
3970.559	3319.	122395.77	1965.48	34723.47	79.67
4000.639	3316.	122479.25	1970.07	34746.41	79.75
4030.719	3314.	122561.71	1974.66	34769.19	79.84
4060.799	3311.	122643.18	1979.25	34791.81	79.92
4090.879	3309.	122723.65	1983.84	34814.25	80.01
4120.959	3306.	122803.16	1988.42	34836.41	80.09
4151.039	3304.	122881.71	1993.00	34858.30	80.17
4181.119	3301.	122959.32	1997.57	34879.93	80.25

TABLE 7 (CONTINUED)

TIME (DAY)	RESPIRATOR PRESSURE (PSI)	CUMULATIVE GAS PRODUCED (MM SCF)	CUMULATIVE WATER PRODUCED (M RBLS)	CUMULATIVE WATER INFLOW (M RBLS)	HEIGHT OF C-W-C (FT)
4211.199	3299.	123036.01	2002.14	34901.30	80.33
4241.279	3296.	123111.79	2006.71	34922.46	80.41
4271.359	3294.	123186.67	2011.27	34943.41	80.49
4301.439	3292.	123260.67	2015.83	34964.03	80.57
4331.519	3290.	123333.82	2020.39	34984.43	80.64
4361.599	3287.	123406.11	2024.94	35004.63	80.72
4391.679	3285.	123477.56	2029.49	35024.59	80.79
4421.759	3283.	123548.18	2034.04	35044.33	80.87
4451.839	3281.	123617.99	2038.58	35063.90	80.94
4481.919	3278.	123687.00	2043.12	35083.27	81.01
4511.999	3276.	123755.23	2047.65	35102.36	81.08
4542.079	3274.	123822.68	2052.18	35121.25	81.15
4572.159	3272.	123889.36	2056.71	35139.96	81.22
4602.240	3270.	123955.29	2061.24	35158.45	81.29
4632.320	3268.	124020.49	2065.76	35176.73	81.36
4662.400	3266.	124084.96	2070.28	35194.80	81.43
4692.480	3264.	124148.71	2074.79	35212.68	81.49
4722.560	3262.	124211.75	2079.30	35230.39	81.56
4752.640	3260.	124274.09	2083.81	35247.95	81.62
4782.720	3258.	124335.75	2088.31	35265.33	81.69

TABLE 7 (CONTINUED)

TIME (DAY)	RESERVOIR PRESSURE (PSI)	CUMULATIVE GAS PRODUCED (MM SCF)	CUMULATIVE WATER PRODUCED (M RBLS)	CUMULATIVE WATER INFLOW (M RBLS)	HEIGHT OF U-W-C (FT)
4812.800	3256.	124396.73	2092.81	35282.46	81.75
4842.880	3254.	124457.05	2097.31	35299.46	81.81
4872.960	3252.	124516.71	2101.81	35316.25	81.87
4903.040	3250.	124575.73	2106.30	35332.86	81.94
4933.120	3249.	124634.11	2110.78	35349.34	82.00
4963.200	3247.	124691.86	2115.27	35365.63	82.06
4993.280	3245.	124748.99	2119.75	35381.82	82.12
5023.360	3243.	124805.51	2124.22	35397.84	82.17
5053.440	3241.	124861.42	2128.70	35413.67	82.23
5083.520	3240.	124916.75	2133.17	35429.29	82.29
5113.600	3238.	124971.49	2137.63	35444.79	82.35
5143.680	3236.	125025.65	2142.09	35460.18	82.40
5173.760	3234.	125079.25	2146.55	35475.33	82.46
5203.840	3233.	125132.29	2151.01	35490.36	82.51
5233.920	3231.	125184.77	2155.46	35505.31	82.57
5264.000	3229.	125236.71	2159.91	35520.04	82.62
5294.080	3228.	125288.12	2164.36	35534.61	82.67
5324.160	3226.	125339.00	2168.80	35549.05	82.72
5354.240	3224.	125389.36	2173.24	35563.33	82.78
5384.320	3223.	125439.20	2177.68	35577.52	82.83

TABLE 7 (CONTINUED)

TIME (AV)	RESERVOIR PRESSURE (PSI)	CUMULATIVE GAS PRODUCED (MM SCF)	CUMULATIVE WATER PRODUCED (M BBL)	CUMULATIVE WATER FLOOK (M BBL)	HEIGHT OF G-W-C (FT)
5414.400	3221.	125488.54	2182.11	35591.57	82.88
5444.480	3220.	125537.38	2186.54	35605.49	82.93
5474.560	3218.	125585.72	2190.97	35619.29	82.98
5504.640	3217.	125633.57	2195.39	35632.96	83.03
5534.720	3215.	125680.95	2199.81	35646.49	83.08
5564.800	3214.	125727.85	2204.23	35659.91	83.12
5594.880	3212.	125774.28	2208.64	35673.20	83.17
5624.960	3211.	125820.25	2213.06	35686.37	83.22
5655.040	3209.	125865.76	2217.46	35699.42	83.27
5685.120	3208.	125910.83	2221.87	35712.31	83.31
5715.200	3206.	125955.45	2226.27	35725.09	83.36
5745.280	3205.	125999.63	2230.67	35737.80	83.40
5775.360	3203.	126043.38	2235.06	35750.37	83.45
5805.440	3202.	126086.71	2239.45	35762.82	83.49
5835.520	3201.	126129.62	2243.84	35775.21	83.54
5865.600	3199.	126172.11	2248.23	35787.44	83.58
5895.680	3198.	126214.19	2252.61	35799.59	83.62
5925.760	3197.	126255.86	2256.99	35811.63	83.66
5955.840	3195.	126297.13	2261.36	35823.52	83.71
5985.920	3194.	126338.02	2265.74	35835.32	83.75

TABLE 7 (CONTINUED)

TIME (DAY)	RESIDUAL PRESSURE (PSI)	CUMULATIVE GAS PRODUCED (MM SCF)	CUMULATIVE WATER PRODUCED (M BBL)	CUMULATIVE WATER INFLUX (M BBL)	HEIGHT OF C-M-C (FT)
6016.000	3193.	126378.51	2270.11	35847.06	83.79
6046.080	3191.	126418.61	2274.47	35858.66	83.83
6076.160	3190.	126458.35	2278.84	35870.09	83.87
6106.240	3189.	126497.71	2283.20	35881.48	83.91
6136.320	3187.	126536.69	2287.56	35892.77	83.95
6166.400	3186.	126575.32	2291.91	35903.95	83.99
6196.480	3185.	126613.58	2296.26	35915.08	84.03
6226.560	3184.	126651.49	2300.61	35926.13	84.07
6256.640	3182.	126689.04	2304.96	35937.09	84.10
6286.720	3181.	126726.25	2309.30	35947.94	84.14
6316.800	3180.	126763.11	2313.64	35958.68	84.18
6346.880	3179.	126799.64	2317.98	35969.30	84.22
6376.961	3178.	126835.83	2322.31	35979.89	84.25
6407.041	3176.	126871.68	2326.64	35990.41	84.29
6437.121	3175.	126907.22	2330.97	36000.80	84.32
6467.201	3174.	126942.42	2335.29	36011.13	84.36
6497.281	3173.	126977.32	2339.62	36021.32	84.39
6527.361	3172.	127011.90	2343.94	36031.41	84.43
6557.441	3171.	127046.17	2348.25	36041.43	84.46
6587.521	3169.	127080.13	2352.57	36051.37	84.50

TABLE 7 (CONTINUED)

TIME (DAY)	RESYNCHRON PRESSURE (PSI)	CUMULATIVE GAS PRODUCED (MM SCF)	CUMULATIVE WATER PRODUCED (M RBIS)	CUMULATIVE WATER INFLOW (M RBIS)	HEIGHT OF C-M-C (FT)
6617.601	3168.	127113.79	2356.88	36061.27	84.53
6647.681	3167.	127147.15	2361.18	36071.10	84.56
6677.761	3166.	127180.22	2365.49	36080.84	84.60
6707.841	3165.	127212.99	2369.79	36090.52	84.63
6737.921	3164.	127245.47	2374.09	36100.12	84.66
6768.001	3163.	127277.67	2378.39	36109.57	84.69
6798.081	3162.	127309.58	2382.68	36118.98	84.73
6828.161	3161.	127341.22	2386.97	36128.36	84.76
6858.241	3160.	127372.58	2391.26	36137.62	84.79
6888.321	3159.	127403.68	2395.55	36146.83	84.82
6918.401	3158.	127434.50	2399.83	36156.01	84.85
6948.481	3157.	127465.05	2404.11	36165.10	84.88
6978.561	3156.	127495.34	2408.39	36174.10	84.91
7008.641	3155.	127525.37	2412.66	36183.00	84.94
7038.721	3154.	127555.15	2416.93	36191.85	84.97
7068.801	3153.	127584.67	2421.20	36200.64	85.00
7098.881	3152.	127613.95	2425.47	36209.40	85.03
7128.961	3151.	127642.97	2429.73	36218.06	85.06
7159.041	3150.	127671.75	2434.00	36226.67	85.08
7189.121	3149.	127700.28	2438.25	36235.24	85.11

TABLE 7 (CONTINUED)

TIME (DAY)	RESIDUAL PRESSURE (PSI)	CUMULATIVE GAS PRODUCED (MM SCF)	CUMULATIVE WATER PRODUCED (M RB/D)	CUMULATIVE WATER FLUX (M RB/D)	WEIGHT OF G-C (FT)
7219.201	3149.	127726.58	2442.51	36243.67	85.14
7249.281	3147.	127756.64	2446.76	36252.04	85.17
7279.361	3146.	127784.47	2451.01	36260.37	85.19
7309.441	3145.	127812.06	2455.26	36268.65	85.22
7339.521	3144.	127839.43	2459.51	36276.92	85.25
7369.601	3143.	127866.57	2463.75	36285.09	85.27
7399.681	3142.	127893.48	2467.99	36293.22	85.30
7429.761	3141.	127920.17	2472.23	36301.30	85.33
7459.841	3140.	127946.65	2476.46	36309.25	85.35
7489.921	3140.	127972.91	2480.69	36317.13	85.38
7520.001	3139.	127998.96	2484.92	36325.01	85.40

TABLE 8 - Prediction 5 ~~---~~ When $Q_w/Q_g > 0$, set gas rate at 1×10^6 Scf/day

TIME (DAYS)	RESERVOIR PRESSURE (PSI)	CUMULATIVE GAS PRODUCED (MM SCF)	CUMULATIVE WATER PRODUCED (M BBL)	CUMULATIVE WATER INFLUX (M BBL)	HEIGHT OF GWC (FT)
30.6800	7249.	838.03	0.00	86.94	0.16
60.1600	7087.	3751.14	0.00	493.47	0.91
90.2400	6967.	6698.98	0.00	1200.68	2.21
120.3200	6854.	9819.83	0.00	2045.17	3.78
150.4000	6800.	12170.93	2.48	2914.05	5.38
180.4800	6726.	14445.46	134.31	3721.55	6.63
210.5600	6689.	16202.93	137.52	4403.73	7.89
240.6400	6632.	17994.40	144.22	4950.70	9.08
270.7200	6540.	20269.53	161.96	5513.76	10.32
300.8000	6469.	22336.81	178.86	6113.10	11.64
330.8800	6396.	24359.09	218.61	6714.10	12.92
360.9600	6340.	26222.44	252.22	7316.72	14.21
391.0400	6286.	27968.66	286.25	7891.04	15.44
421.1200	6216.	29916.67	327.57	8449.79	16.63
451.2000	6170.	31477.19	367.18	8978.35	17.75
481.2800	6105.	33287.83	395.25	9484.52	18.85
511.3600	6042.	35094.19	440.08	10011.24	19.96
541.4400	5974.	37016.46	476.32	10553.76	21.13
571.5200	5927.	38534.67	539.28	11077.16	22.19

TABLE 8 - (CONTINUED)

TIME (DAYS)	RESERVOIR PRESSURE (PSI)	CUMULATIVE GAS PRODUCED (MM SCF)	CUMULATIVE WATER PRODUCED (M RBLS)	CUMULATIVE WATER FLUX (M RBLS)	HEIGHT OF C-M-C (FT)
601.6000	5874.	40104.95	552.49	11564.12	23.28
631.6800	5810.	41983.05	594.35	12066.35	24.37
661.7600	5749.	43768.25	634.85	12584.76	25.49
691.8400	5686.	45599.59	675.91	13103.02	26.62
721.9200	5627.	46410.37	716.41	13580.56	27.62
752.0000	5563.	46203.19	758.26	13992.88	28.50
782.0800	5501.	49079.61	798.37	14360.90	29.29
812.1600	5556.	50165.20	811.75	14685.40	30.04
842.2400	5522.	51223.73	818.92	14985.45	30.76
872.3200	5478.	52440.39	843.22	15296.89	31.48
902.4000	5430.	53809.69	849.54	15643.02	32.33
932.4800	5353.	55813.02	850.32	16065.69	33.42
962.5600	5285.	57816.35	851.23	16570.19	34.69
992.6400	5220.	59819.67	852.32	17109.63	36.03
1022.7200	5186.	61251.48	853.71	17622.46	37.27
1052.8000	5146.	62683.29	855.48	18077.45	38.35
1082.8800	5104.	64115.10	857.74	18496.89	39.30
1112.9600	5086.	64975.39	860.68	18840.34	40.05
1143.0400	5062.	65835.67	864.46	19110.60	40.66
1173.1200	5036.	66695.96	869.30	19359.74	41.22

TABLE 8 - (CONTINUED)

TIME (DAYS)	RESERVOIR PRESSURE (PSI)	CUMULATIVE GAS PRODUCED (MM SCF)	CUMULATIVE WATER PRODUCED (M BBL)	CUMULATIVE WATER INFLUX (M BBL)	HEIGHT OF OIL-C (FT)
1253.200	5008.	67556.25	875.76	19595.97	41.76
1233.230	4980.	68416.54	885.16	19825.29	42.29
1263.360	4952.	69276.83	901.60	20060.15	42.81
1293.440	4921.	70137.11	963.25	20307.21	43.27
1323.520	4897.	70967.32	963.47	20552.97	43.84
1353.600	4872.	71797.53	963.72	20788.15	44.39
1383.680	4846.	72627.74	963.98	21018.90	44.94
1413.760	4820.	73457.95	964.26	21245.42	45.48
1443.840	4795.	74288.15	964.56	21468.81	46.02
1473.920	4796.	74546.84	964.88	21646.72	46.38
1504.000	4792.	74805.53	965.21	21764.78	46.64
1534.080	4785.	75064.22	965.57	21855.90	46.85
1564.160	4777.	75322.91	965.93	21925.81	47.01
1594.240	4768.	75581.59	966.30	21985.52	47.16
1624.320	4760.	75840.28	966.68	22049.28	47.32
1654.400	4752.	76098.97	967.07	22119.22	47.49
1684.480	4744.	76357.66	967.46	22190.85	47.66
1714.560	4736.	76616.35	967.87	22262.28	47.83
1744.640	4728.	76875.03	968.28	22332.80	48.00
1774.720	4720.	77133.72	968.70	22402.66	48.18

TABLE 8 - (CONTINUED)

TIME (DAYS)	RESERVOIR PRESSURE (PSI)	CUMULATIVE GAS PRODUCED (MM SCF)	CUMULATIVE DATA PRODUCED (MM BBL)	CUMULATIVE WATER FLUX (MM BBL)	HEIGHT OF O-W-C (FT)
1804.800	4712.	77392.41	969.13	22472.52	48.35
1834.880	4704.	77651.10	969.57	22542.53	48.53
1864.960	4696.	77909.79	970.01	22612.58	48.70
1895.040	4688.	78168.47	970.46	22682.68	48.88
1925.120	4680.	78427.16	970.92	22752.67	49.05
1955.200	4678.	78547.48	971.40	22811.76	49.18
1985.280	4676.	78667.80	971.90	22856.17	49.29
2015.360	4672.	78789.12	972.42	22893.89	49.38
2045.440	4568.	78909.44	972.95	22926.49	49.46
2075.520	4664.	79028.76	973.50	22956.62	49.53
2105.600	4661.	79149.08	974.05	22987.68	49.61
2135.680	4657.	79269.40	974.63	23020.29	49.69
2165.760	4653.	79389.72	975.21	23053.30	49.78
2195.840	4649.	79510.04	975.81	23086.31	49.86
2225.920	4646.	79630.36	976.42	23119.31	49.94
2256.000	4642.	79750.68	977.04	23152.34	50.02
2286.080	4638.	79871.00	977.67	23185.53	50.10
2316.160	4634.	79991.32	978.32	23218.80	50.19
2346.240	4630.	80111.64	978.98	23252.14	50.27
2376.320	4626.	80231.96	979.66	23285.59	50.35

TABLE 8 - (CONTINUED)

TIME (DAYS)	RESERVIUM PRESSURE (PSI)	CUMULATIVE GAS PRODUCED (MM SCF)	CUMULATIVE WATER PRODUCED (M RBBL)	CUMULATIVE WATER FLUX (M RBBL/D)	HEIGHT OF C-M-C (FT)
2406.400	4623.	80352.28	980.35	23318.98	50.43
2436.480	4619.	80472.60	981.05	23352.33	50.52
2466.560	4615.	80592.92	981.76	23385.78	50.60
2496.640	4611.	80713.24	982.48	23419.16	50.68
2526.720	4607.	80833.56	983.22	23452.43	50.77
2556.800	4604.	80953.88	983.97	23485.73	50.85
2586.880	4600.	81074.20	984.74	23519.12	50.93
2616.960	4596.	81194.52	985.51	23552.44	51.01
2647.040	4592.	81314.84	986.30	23585.78	51.10
2677.120	4588.	81435.16	987.10	23619.23	51.18
2707.200	4584.	81555.48	987.91	23652.61	51.26
2737.280	4581.	81675.80	988.73	23685.88	51.35
2767.360	4577.	81796.12	989.57	23719.18	51.43
2797.440	4573.	81916.44	990.42	23752.56	51.51
2827.520	4569.	82036.76	991.28	23785.89	51.59
2857.600	4565.	82157.08	992.15	23819.23	51.68
2887.680	4562.	82277.40	993.03	23852.58	51.76
2917.760	4558.	82397.72	993.92	23885.92	51.84
2947.840	4554.	82518.04	994.83	23919.23	51.93
2977.920	4550.	82638.36	995.75	23952.55	52.01

TABLE 8 - (CONTINUED)

TIME (DAYS)	RESERVOIR PRESSURE (PSI)	CUMULATIVE GAS PRODUCED (MM SCF)	CUMULATIVE GAT (M BBL)	CUMULATIVE WATER INFLUX (M BBL)	HEIGHT OF C-M-C (FT)
3008.000	4546.	82758.68	996.68	23985.86	52.07
3038.080	4542.	82879.00	997.62	24019.18	52.17
3068.160	4539.	82999.32	998.57	24052.49	52.26
3098.240	4535.	83119.64	999.53	24085.71	52.34
3128.320	4531.	83239.96	1000.51	24118.98	52.42
3158.400	4527.	83360.28	1001.49	24152.35	52.51
3188.480	4523.	83480.60	1002.49	24185.67	52.59
3218.560	4520.	83600.92	1003.50	24218.92	52.67
3248.640	4516.	83721.24	1004.52	24252.22	52.76
3278.720	4512.	83841.56	1005.55	24285.51	52.84
3308.800	4508.	83961.88	1006.59	24318.79	52.92
3338.880	4504.	84082.20	1007.64	24352.09	53.01
3368.960	4501.	84202.52	1008.70	24385.31	53.09
3399.040	4497.	84322.84	1009.77	24418.57	53.17
3429.120	4493.	84443.16	1010.86	24451.84	53.26
3459.199	4489.	84563.48	1011.95	24485.12	53.34
3489.279	4485.	84683.80	1013.05	24518.42	53.42
3519.359	4482.	84804.12	1014.17	24551.64	53.51
3549.439	4478.	84924.44	1015.29	24584.81	53.59
3579.519	4474.	85044.76	1016.43	24618.03	53.67

TABLE 8 - (CONTINUED)

TIME (DAYS)	RESERVOIR PRESSURE (PSI)	CUMULATIVE CYCLES PRODUCED (M SCF)	CUMULATIVE CYCLES PRODUCED (M BOB)	CUMULATIVE WATER INFLUX (M BOB)	HEIGHT OF C-M-C (FT)
3609.599	4470.	85165.08	1017.57	24651.27	53.76
3639.679	4466.	85285.40	1018.73	24684.53	53.84
3669.759	4462.	85405.72	1019.89	24717.82	53.92
3699.839	4459.	85526.04	1021.07	24751.04	54.01
3729.919	4455.	85646.36	1022.26	24784.21	54.09
3759.999	4451.	85766.68	1023.45	24817.34	54.17
3790.079	4447.	85887.00	1024.66	24850.53	54.26
3820.159	4443.	86007.32	1025.87	24883.74	54.34
3850.239	4440.	86127.64	1027.10	24917.00	54.42
3880.319	4436.	86247.96	1028.33	24950.30	54.51
3910.399	4432.	86368.28	1029.57	24983.52	54.59
3940.479	4428.	86488.60	1030.83	25016.69	54.67
3970.559	4424.	86608.92	1032.09	25049.82	54.76
4000.639	4421.	86729.24	1033.36	25082.91	54.84
4030.719	4417.	86849.56	1034.65	25115.98	54.92
4060.799	4413.	86969.88	1035.94	25149.15	55.01
4090.879	4409.	87090.20	1037.24	25182.36	55.09
4120.959	4405.	87210.52	1038.56	25215.53	55.17
4151.039	4402.	87330.84	1039.88	25248.68	55.26
4181.119	4398.	87451.16	1041.22	25281.81	55.34

TABLE 8 - (CONTINUED)

TIME (DAY)	RESERVOIR PRESSURE (PSI)	CUMULATIVE GAS PRODUCED (MM SCF)	CUMULATIVE OIL PRODUCED (M RBBL)	CUMULATIVE WATER INFLUX (M RBBL)	HEIGHT OF U-M-C (FT)
4211.199	4394.	87571.48	1042.57	25314.99	55.43
4241.279	4390.	87691.80	1043.92	25348.21	55.51
4271.359	4387.	87812.12	1045.29	25381.37	55.59
4301.439	4383.	87932.44	1046.67	25414.53	55.68
4331.519	4379.	88052.76	1048.06	25447.65	55.76
4361.599	4375.	88173.08	1049.45	25480.74	55.85
4391.679	4371.	88293.40	1050.86	25513.82	55.93
4421.759	4368.	88413.72	1052.28	25546.89	56.01
4451.839	4364.	88534.04	1053.71	25579.96	56.10
4481.919	4360.	88654.36	1055.15	25613.03	56.18
4511.999	4356.	88774.68	1056.60	25646.10	56.26
4542.079	4352.	88895.00	1058.06	25679.18	56.35
4572.159	4349.	89015.32	1059.53	25712.25	56.43
4602.240	4345.	89135.64	1061.01	25745.32	56.52
4632.320	4341.	89255.96	1062.50	25778.39	56.60
4662.400	4337.	89376.28	1064.00	25811.46	56.68
4692.480	4333.	89496.60	1065.52	25844.53	56.77
4722.560	4330.	89616.92	1067.04	25877.61	56.85
4752.640	4326.	89737.24	1068.57	25910.68	56.94
4782.720	4322.	89857.56	1070.11	25943.75	57.02

TABLE 8 - (CONTINUED)

TIME (DAYS)	RESERVOIR PRESSURE (PSI)	CUMULATIVE GAS PRODUCED (MM SCF)	CUMULATIVE DATA PRODUCED (M BBLS)	CUMULATIVE WATER INJECTION (M BBLS)	HEIGHT OF OIL-C (FT)
4812.600	4318.	89977.68	1071.66	25976.82	57.11
4842.880	4315.	90098.20	1073.22	26009.89	57.19
4872.960	4311.	90218.52	1074.79	26042.87	57.27
4903.040	4307.	90338.84	1076.38	26075.80	57.36
4933.120	4303.	90459.16	1077.97	26108.78	57.44
4963.200	4299.	90579.48	1079.57	26141.77	57.53
4993.280	4296.	90699.80	1081.18	26174.79	57.61
5023.360	4292.	90820.12	1082.80	26207.84	57.69
5053.440	4288.	90940.44	1084.44	26240.82	57.78
5083.520	4284.	91060.76	1086.08	26273.74	57.86
5113.600	4281.	91181.08	1087.75	26306.72	57.95
5143.680	4277.	91301.40	1089.45	26339.72	58.03
5173.760	4273.	91421.72	1091.19	26372.73	58.12
5203.840	4269.	91542.04	1092.97	26405.78	58.20
5233.920	4265.	91662.36	1094.79	26438.86	58.29
5264.000	4262.	91782.68	1096.66	26471.93	58.37
5294.080	4258.	91903.00	1098.57	26504.91	58.45
5324.160	4254.	92023.32	1100.53	26537.93	58.54
5354.240	4250.	92143.64	1102.55	26570.96	58.62
5384.320	4246.	92263.96	1104.62	26603.99	58.71

TABLE 8 - (CONTINUED)

TIME (DAYS)	RESERVOIR PRESSURE (PSI)	CUMULATIVE GAS PRODUCED (MM SCF)	CUMULATIVE WATER PRODUCED (M BBL)	CUMULATIVE WATER INFLOW (M BBL)	HEIGHT OF CWC (FT)
5414.400	4243.	92384.28	1106.75	26637.04	58.79
5444.480	4239.	92504.60	1108.94	26670.12	58.88
5474.560	4235.	92624.92	1111.20	26703.28	58.96
5504.640	4231.	92745.24	1113.54	26736.40	59.04
5534.720	4228.	92865.56	1115.96	26769.52	59.13
5564.800	4224.	92985.88	1118.48	26802.63	59.21
5594.880	4220.	93106.20	1121.09	26835.72	59.30
5624.960	4216.	93226.52	1123.80	26868.88	59.38
5655.040	4212.	93346.84	1126.63	26902.19	59.46
5685.120	4209.	93467.16	1129.59	26935.50	59.55
5715.200	4205.	93587.48	1132.69	26968.75	59.63
5745.280	4201.	93707.80	1135.95	27002.05	59.71
5775.360	4197.	93828.12	1139.38	27035.44	59.80
5805.440	4193.	93948.44	1143.01	27068.86	59.88
5835.520	4189.	94068.76	1146.87	27102.43	59.96
5865.600	4185.	94189.08	1150.98	27136.12	60.06
5895.680	4182.	94309.40	1155.46	27169.86	60.17
5925.760	4178.	94429.72	1160.44	27203.74	60.28
5955.840	4174.	94550.04	1166.07	27237.69	60.38
5985.920	4170.	94670.36	1172.55	27271.86	60.49

TABLE 8 - (CONTINUED)

TIME (DAYS)	RESERVOIR PRESSURE (PSI)	CUMULATIVE GAS PRODUCED (MM SCF)	CUMULATIVE WATER PRODUCED (M BBL)	CUMULATIVE WATER IN/LUX (M BBL)	WEIGHT OF G-M-C (FT)
6016.000	4166.	94790.68	1180.23	27306.46	60.59
6046.080	4162.	94911.00	1189.68	27341.50	60.70
6076.160	4157.	95031.32	1202.00	27377.22	60.79
6106.240	4153.	95151.64	1219.58	27414.12	60.88
6136.320	4147.	95271.96	1248.89	27453.33	60.94
6166.400	4140.	95392.28	1308.79	27498.06	60.94
6196.480	4134.	95512.60	1373.29	27548.92	60.95
6226.560	4126.	95632.92	1448.78	27604.41	61.03
6256.640	4125.	95723.16	1449.97	27653.53	61.09
6286.720	4123.	95813.40	1451.18	27690.42	61.21
6316.800	4121.	95903.64	1452.39	27721.02	61.31
6346.880	4118.	95993.88	1453.63	27746.23	61.39
6376.961	4115.	96084.12	1454.88	27768.50	61.47
6407.041	4112.	96174.36	1456.14	27791.30	61.56
6437.121	4110.	96264.60	1457.41	27815.41	61.64
6467.201	4107.	96354.84	1458.70	27839.97	61.73
6497.281	4104.	96445.08	1460.00	27864.60	61.81
6527.361	4101.	96535.32	1461.31	27889.08	61.90
6557.441	4098.	96625.56	1462.64	27913.44	61.98
6587.521	4096.	96715.80	1463.99	27937.85	62.07

TABLE 8 - (CONTINUED)

TIME (DAY)	RESERVOIR PRESSURE (PSI)	CUMULATIVE GAS PRODUCED (MM SCF)	CUMULATIVE WATER PRODUCED (M BBL)	CUMULATIVE WATER INFLUX (M BBL)	HEIGHT OF G-M-C (FT)
6617.601	4093.	96806.04	1465.35	27962.31	62.16
6647.681	4090.	96896.28	1466.73	27986.72	62.24
6677.761	4087.	96986.52	1468.12	28011.12	62.33
6707.841	4084.	97076.76	1469.52	28035.49	62.41
6737.921	4082.	97167.00	1470.95	28059.83	62.50
6768.001	4079.	97257.24	1472.39	28084.15	62.58
6798.081	4076.	97347.48	1473.84	28108.56	62.67
6828.161	4073.	97437.72	1475.31	28133.02	62.76
6858.241	4070.	97527.96	1476.80	28157.43	62.84
6888.321	4068.	97618.20	1478.31	28181.83	62.93
6918.401	4065.	97708.44	1479.83	28206.20	63.01
6948.481	4062.	97798.68	1481.37	28230.54	63.10
6978.561	4059.	97888.92	1482.93	28254.95	63.19
7008.641	4056.	97979.16	1484.51	28279.41	63.27
7038.721	4054.	98069.40	1486.11	28303.82	63.36
7068.801	4051.	98159.64	1487.73	28328.22	63.44
7098.881	4048.	98249.88	1489.36	28352.60	63.53
7128.961	4045.	98340.12	1491.02	28376.93	63.62
7159.041	4042.	98430.36	1492.70	28401.34	63.70
7189.121	4040.	98520.60	1494.39	28425.81	63.79

TABLE 8 - (CONTINUED)

TIME (DAYS)	REBERY OF PRESSURE (PSF)	CUMULATIVE GAS PRODUCED (MM SCF)	CUMULATIVE WATER PRODUCED (M BBLS)	CUMULATIVE WATER INFLOW (M BBLS)	HEIGHT OF U-W-C (FT)
7219.201	4037.	98610.84	1496.11	28450.22	63.87
7249.281	4034.	98701.08	1497.85	28474.61	63.96
7279.361	4031.	98791.32	1499.61	28499.08	64.05
7309.441	4029.	98881.56	1501.40	28523.56	64.13
7339.521	4026.	98971.80	1503.20	28547.97	64.22
7369.601	4023.	99062.04	1505.03	28572.37	64.30
7399.681	4020.	99152.28	1506.89	28596.75	64.39
7429.761	4017.	99242.52	1508.76	28621.18	64.47
7459.841	4015.	99332.76	1510.67	28645.64	64.56
7489.921	4012.	99423.00	1512.59	28670.05	64.65
7520.001	4009.	99513.24	1514.55	28694.54	64.73
7550.081	4006.	99603.48	1516.53	28719.06	64.82
7580.161	4003.	99693.72	1518.53	28743.49	64.90
7610.241	4001.	99783.96	1520.57	28767.88	64.99
7640.321	3998.	99874.20	1522.63	28792.35	65.08
7670.401	3995.	99964.44	1524.72	28816.83	65.16
7700.481	3992.	100054.68	1526.84	28841.34	65.25
7730.561	3989.	100144.92	1528.99	28865.88	65.33
7760.641	3987.	100235.16	1531.17	28890.35	65.42
7790.721	3984.	100325.40	1533.38	28914.86	65.51

TABLE 8 - (CONTINUED)

TIME (DAYS)	TEMPERATURE PRESSURE (PSI)	CUMULATIVE GAS PRODUCED (MM SCF)	CUMULATIVE WATER PRODUCED (M RBLS)	CUMULATIVE FLUX (M RBLS)	WEIGHT OF G-M-C (LB)
7820.801	3981.	100415.64	1535.63	28939.38	65.59
7850.881	3978.	100505.88	1537.91	28963.81	65.68
7880.961	3975.	100596.12	1540.22	28988.30	65.76
7911.041	3972.	100686.36	1542.57	29012.82	65.85
7941.121	3970.	100776.60	1544.95	29037.34	65.94
7971.201	3967.	100866.84	1547.38	29061.88	66.02
8001.281	3964.	100957.08	1549.84	29086.44	66.11
8031.361	3961.	101047.32	1552.33	29111.00	66.19
8061.441	3958.	101137.56	1554.87	29135.56	66.28
8091.521	3956.	101227.80	1557.45	29160.12	66.36
8121.602	3953.	101318.04	1560.08	29184.69	66.45
8151.682	3950.	101408.28	1562.75	29209.34	66.54
8181.762	3947.	101498.52	1565.46	29233.95	66.62
8211.842	3944.	101588.76	1568.22	29258.55	66.71
8241.922	3942.	101679.00	1571.03	29283.15	66.79
8272.001	3939.	101769.24	1573.89	29307.73	66.88
8302.081	3936.	101859.48	1576.80	29332.39	66.96
8332.161	3933.	101949.72	1579.76	29357.09	67.05
8362.241	3930.	102039.96	1582.78	29381.75	67.14
8392.321	3927.	102130.20	1585.86	29406.39	67.22

TABLE 8 - (CONTINUED)

TIME (DAYS)	RESERVOIR PRESSURE (PSI)	CUMULATIVE GAS PRODUCED (MM SCF)	CUMULATIVE WATER PRODUCED (M BBL)	CUMULATIVE WATER INFLUX (M BBL)	HEIGHT OF U-M-C (FT)
8422.401	3925.	102220.44	1589.00	29431.10	67.31
8452.481	3922.	102310.68	1592.20	29455.82	67.39
8482.561	3919.	102400.92	1595.47	29480.57	67.48
8512.641	3916.	102491.16	1598.80	29505.36	67.56
8542.721	3913.	102581.40	1602.20	29530.16	67.65
8572.801	3910.	102671.64	1605.68	29554.96	67.73
8602.881	3907.	102761.88	1609.23	29579.77	67.82
8632.961	3905.	102852.12	1612.87	29604.57	67.90
8663.041	3902.	102942.36	1616.58	29629.37	67.99
8693.121	3899.	103032.60	1620.39	29654.27	68.07
8723.201	3896.	103122.84	1624.29	29679.22	68.16
8753.281	3893.	103213.08	1628.28	29704.12	68.24
8783.361	3890.	103303.32	1632.38	29729.10	68.33
8813.441	3887.	103393.56	1636.58	29754.10	68.41
8843.521	3885.	103483.80	1640.90	29779.11	68.50
8873.601	3882.	103574.04	1645.34	29804.14	68.58
8903.681	3879.	103664.28	1649.90	29829.19	68.66
8933.760	3876.	103754.52	1654.61	29854.33	68.75
8963.840	3873.	103844.76	1659.45	29879.52	68.83
8993.920	3870.	103935.00	1664.45	29904.75	68.91

TABLE 8 - (CONTINUED)

TIME (DAYS)	RESERVOIR PRESSURE (PSI)	CUMULATIVE GAS PRODUCED (MM SCF)	CUMULATIVE WATER PRODUCED (M BBLS)	CUMULATIVE WATER INFLUX (M BBLS)	HEIGHT OF G-M-C (FT)
9024.000	3867.	104025.24	1669.62	29930.02	69.00
9054.080	3864.	104115.48	1674.97	29955.31	69.08
9084.160	3861.	104205.72	1680.50	29980.70	69.16
9114.240	3859.	104295.96	1686.24	30006.13	69.25
9144.320	3856.	104386.20	1692.21	30031.61	69.33
9174.400	3853.	104476.44	1698.42	30057.22	69.41
9204.480	3850.	104566.68	1704.90	30082.90	69.49
9234.560	3847.	104656.92	1711.67	30108.62	69.57
9264.640	3844.	104747.16	1718.76	30134.47	69.65
9294.720	3841.	104837.40	1726.21	30160.48	69.73
9324.800	3838.	104927.64	1734.06	30186.59	69.81
9354.880	3835.	105017.88	1742.36	30212.78	69.89
9384.960	3832.	105108.12	1751.16	30239.12	69.97
9415.040	3829.	105198.36	1760.53	30265.62	70.05
9445.120	3825.	105288.60	1770.55	30292.31	70.12
9475.200	3822.	105378.84	1781.33	30319.22	70.20
9505.280	3819.	105469.08	1793.00	30346.37	70.27
9535.360	3816.	105559.32	1805.70	30373.87	70.34
9565.440	3813.	105649.56	1819.64	30401.65	70.41
9595.520	3809.	105739.80	1835.07	30429.82	70.48

TABLE 8 - (CONTINUED)

TIME (DAYS)	RESERVOIR PRESSURE (PSI)	CUMULATIVE GAS PRODUCED (MM SCF)	CUMULATIVE GAS PRODUCED (MM BBLS)	CUMULATIVE WATER INFLUX (MM BBLS)	HEIGHT OF U-W-C (FT)
9625.599	3806.	105830.04	1852.31	30458.60	70.55
9655.679	3802.	105920.28	1871.82	30488.02	70.61
9685.759	3799.	106010.52	1894.14	30518.14	70.66
9715.839	3795.	106100.76	1919.95	30549.20	70.72
9745.919	3791.	106191.00	1950.07	30581.48	70.76
9775.999	3787.	106281.24	1985.44	30615.15	70.79
9806.079	3782.	106371.48	2026.54	30650.47	70.82
9836.159	3778.	106461.72	2073.36	30687.78	70.84
9866.239	3773.	106551.96	2125.28	30726.99	70.85
9896.319	3768.	106642.20	2180.62	30767.88	70.86
9926.399	3763.	106732.44	2238.59	30810.13	70.86
9956.479	3758.	106822.68	2298.01	30853.28	70.86
9986.559	3753.	106912.92	2358.60	30897.12	70.86
10016.64	3747.	107003.16	2420.11	30941.31	70.86
10046.72	3742.	107093.40	2481.68	30985.68	70.87
10076.80	3737.	107183.64	2543.78	31030.24	70.87
10106.88	3732.	107273.88	2606.06	31074.79	70.95
10136.96	3722.	107364.12	2757.83	31127.62	71.03
10167.04	3722.	107424.28	2760.04	31176.10	71.11
10197.12	3721.	107484.44	2762.28	31208.19	71.19

TABLE 8 - (CONTINUED)

TIME (DAYS)	RESERVOIR PRESSURE (PSI)	CUMULATIVE GAS PRODUCED (MM SCF)	CUMULATIVE OIL PRODUCED (M BBL)	CUMULATIVE WATER INFLUX (M BBL)	HEIGHT OF O-W-C (FT)
10227.20	3720.	107544.60	2764.54	31233.80	71.27
10257.28	3718.	107604.76	2766.83	31253.15	71.35
10287.36	3716.	107664.92	2769.15	31267.41	71.43
10317.44	3714.	107725.08	2771.50	31281.34	71.51
10347.52	3713.	107785.24	2773.88	31296.98	71.59
10377.60	3711.	107845.40	2776.28	31313.25	71.67
10407.68	3709.	107905.56	2778.72	31329.69	71.75
10437.76	3707.	107965.72	2781.19	31346.03	71.83
10467.84	3705.	108025.88	2783.70	31362.19	71.91
10497.92	3703.	108086.04	2786.23	31378.35	71.99
10528.00	3701.	108146.20	2788.81	31394.55	72.07

TABLE 9

THE DATA USED TO DETERMINE VALUES OF C_p

Well No.	Flow Rate scf/day	h_g , ft	Bottom Hole Flowing Pressure psia	Reservoir Pressure psia
1	13.55×10^6	54	6944	7250
2	11.6×10^6	12	6909	7250
3	4.8×10^6	39	6900	7250
4	13.2×10^6	25	6876	7250
5	14.3×10^6	39	6963	7250

TABLE 10
CALCULATED SPECIFIC PRODUCING CAPACITY

<u>Well No.</u>	<u>C_p, scf/D/psi² - ft</u>
1	.0578
2	.20
3	.0247
4	.10
5	.0897

TABLE 11
VERTICAL DISTRIBUTION OF PRODUCING CAPACITY

<u>Interval</u>	<u>Specific Producing Capacity scf/D/psi² - ft</u>	<u>Cumulative Specific Producing Capacity scf/D/psi² - ft</u>	<u>Fraction of Total Specific Producing Capacity scf/D/psi² - ft</u>
A	.6358	.6358	1.0
B	1.0325	1.6683	.943
C	2.475	4.1433	.851
D	4.17	8.3133	.6295
E	.495	8.8083	.2566
F	.59	9.3983	.212
G	.688	10.0863	.1596
H	.33	10.4163	.098
I	.7657	11.1820	.0684

TABLE 12

DATA FOR CALCULATING FUTURE PRODUCTION RATES

<u>Well No.</u>	<u>Contract Flow Rate, scf/D x 10⁶</u>	<u>Minimum Bottom Hole Flowing Pressure, P_{min}, psia</u>
1	20.0	2290
2	5.6	2937
3	7.0	2243
4	20.0	2248
5	20.0	2243

APPENDIX A

INPUT DATA

1. Rock and Fluid Properties:

- a. Aquifer permeability (K), this obtained from core data as follows:

Well No. 1	K	= 290 md
Well No. 2	K	= 310 md
Well No. 3	K	= 200 md
Well No. 4	K	= 300 md
Well No. 5	K	= 300 md

$280 = \bar{K}$

- Water permeability Kw generated in the invaded zone $ie S_w = .772$ = 123 md
- b. Porosity (ϕ) from log = .26
- c. Water viscosity μ_w = .8
- d. Gas specific gravity G, depends on the amount of condensate produced and the average value is = .77
- e. Formation compressibility (C_f) is = 6×10^{-6} psi⁻¹
- f. Connate water compressibility (C_w) = 4×10^{-6} psi⁻¹
- g. Connate water saturation S_w from log = .30
- h. Residual gas saturation S_{gr} , calculated = .228
- i. Gas compressibility factor (Z) has been calculated as a function of P_r and T_r using ZFAC subroutine.

- j. Gas viscosity (μ_g) has been calculated as a function of reservoir temperature, reservoir pressure and gas gravity using VISGAS subroutine.

2. Reservoir and Aquifer Conditions:

- a. Reservoir thickness (H) = 50 ft
- b. Shape factor (ψ) = 1
- c. Initial reservoir pressure (P_i),
calculated = 7300 psi
- d. Relative size of the aquifer ($\frac{r_a}{r_g}$),
calculated = 2.39
- e. Initial gas in-place (G_i),
calculated = 220×10^9 scf
- f. Production rate (variable)
- g. Reservoir temperature (T) and this
varies with depth = 640 $^{\circ}$ R
- h. Reference temperature (T_s) = 520 $^{\circ}$ R
- i. Reference pressure (P_s) = 14.7 psi

APPENDIX B

PROGRAM No. 1

D = INSIDE DIAMETER OF THE TUBE - INCH
 EPS = RELATIVE ROUGHNESS
 X = DEPTH INCREMENT - FT
 AP = CROSS SECTIONAL AREA OF THE TUBE - FT
 GS = GAS GRAVITY FROM SEPARATOR
 R = GAS/OIL RATIO
 R1 = OIL/GAS RATIO
 P = WELL HEAD PRESSURE - PSIA
 QG = GAS PRODUCTION RATE - MSCF/DAY
 QC = CONDENSATE PRODUCTION RATE - B/DAY
 QW = WATER PRODUCTION RATE - B/DAY
 WM = MOLECULAR WEIGHT OF CONDENSATE
 API = GRAVITY OF CONDENSATE
 GC = SPEC. GRAVITY OF CONDENSATE
 QGT1 = CONDENSATE EQUIVALENT TO GAS - SCF/DAY
 QGT2 = GAS FLOW RATE AND CONDENSATE FLOW RATE AS A GAS
 G1 = SPEC. GRAVITY OF GAS AND CONDENSATE
 QGEW = WATER EQUIVALENT TO GAS - SCF/DAY
 W1 = VOLUME OF GAS AND VOLUME OF WATER
 W2 = WEIGHT OF GAS PRODUCED -LB
 W3 = WEIGHT OF WATER PRODUCED - LB
 G = SPEC. GRAVITY OF MIXTURE (WATER AND GAS)
 T = TEMPERATURE - R
 PR = REDUCE PRESSURE
 TR = REDUCE TEMPERATURE
 Z = COMPRESSIBILITY FACTOR
 PF = BOTTOM HOLE FLOWING PRESSURE - PSIA
 PCA = CALCULATED PRESSURE AT ASSUMED DP
 UW = WATER VISCOSITY - CP
 QL = WATER FLOW RATE - FT³/SEC
 QG1 = GAS FLOW RATE SCF/SEC
 QT = TOTAL FLOW RATE FT³/SEC
 DL = DENSITY OF LIQUID - LB/FT³
 DG = DENSITY OF GAS - LB/FT³
 VT = TOTAL VELOCITY - FT/SEC
 RN = REYNOLD NUMBER
 VB1 = BUBBLE RISE VELOCITY - FT/SEC
 CNB = BUBBLE REYNOLD NUMBER
 TT = LIQUID DISTRIBUTION COEFFICIENT
 DA = AVERAGE FLOWING DENSITY - LB/FT³
 TF = WALL FRICTION-LOSS TERM
 DPC = CALCULATED PRESSURE DROP

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C.....PROGRAM NO. ONE
C.....THIS PROGRAM CALCULATES THE BOTTOM
C.....HOLE PRESSURE AT DIFFERENTE FLOW RATES
C.....AND DIFFERENT WELL HEAD PRESSURE
C.....IT CAN CALCULATE THE PRESSURE
C.....WHEN THERE IS ASINGLE PHASE AND TWOPHASE
C.....FLOW , DEPENDING ON GAS GRAVITY
C.....BECAUSE AS THE AMOUNT OF WATER INCREASE
C.....THE FLOW BECOMES TWO PHASE
C.....WELL NO 1:6080.
DIMEVSION PS(100),P(45),QG(45),QC(45),QGT(45)
1,R(45),API(45),WM(45),GC(45),G(45),B(100),
2A(100),H(100),S(100),F(100),QGT1(45)
DIMEVSION QGEW(45),QW(45),G1(45),QGT2(45),R1(45)
DIMEVSION P1(100),QL(45),QG1(45),QT(45)
D=2.441
EPS=.0006
DEPTH=9600.0
X=DEPTH/100.
DD=D/12.
AP=(3./4.)*DD**2.
GS=.583
DO 10 I=1,35
READ(8,3)QG(I),QC(I),QW(I),API(I),R1(I),P(I)
R(I)=10.E6/R1(I)
P1(I)=P(I)
WM(I)=6084./((API(I)-5.9)
GC(I)=141.5/(131.5+API(I))
QGT1(I)=QC(I)*13300.*GC(I)/WM(I)
QGT2(I)=QGT1(I)+QG(I)
G1(I)=(R(I)*GS+4591.*GC(I))/(P(I)+1123.)
QGEW(I)=7390.*QW(I)
QGT(I)=QGT2(I)+QGEW(I)
W1=QGT2(I)+5.6148*QW(I)
W2=(QGT2(I)*G1(I)*28.97)/379.0
W3=350.*QW(I)
G(I)=(W2+W3)/(W1*.0764)
C.....CHECK ON GAS GRAVITY
IF(G(I).GT.1.) GO TO 40
DO 20 J=1,100,1
C=100.*FLOAT(J)
T=520.+C/100.
CALL PSEUDO (P(I),G(I),T,PR,TR)
CALL ZFAC (PR,TR,Z,NN)
CALL VISCAS (T,P(I),Z,G(I),VISC)
B(J)=QGT(I)**-.065*D**-.058*G(I)**-.065
F(J)=30.9208E-03*B(J)/VISC**-.065
H(J)=D**5./(G(I)*T*Z*F(J)*X)
S(J)=.3375*G(I)*X/(T*Z)
A(J)=S(J)/(2.7163**S(J)-1.)
PS(J)=SQRT((QGT(I)**2.+4.E10*A(J)*H(J)*2.7183**S(J)
1*P(I)**2.)/(4.E10*A(J)*H(J)))
P(I)=PS(J)
20 CONTINUE
PF=PS(100)
WRITE(4,30)PF,QGT2(I),SS1
30 FORMAT(2X,3(3X,F12.2))
3 FORMAT(6G)
GO TO 10
40 CONTINUE

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C>.....TWO PHASE PROGRAM
DO 50 K=1,100,1
  KK=1
  L=1
  DIV=1.0
  DEL=2.0
  DP=50.
C.....ITERATION ON DP
DO 60 M=1,10
  C=FLOAT(K)
  T=520.+X*C/100.
  PCA=PI(K-1)+DP/2.
  UW=1.-.0053*C
  CALL PSEUDO (PCA,G1(I),T,PR,TR)
  CALL ZFAC (PR,TR,Z,NN)
  QL(I)=6.49E-05*QW(I)
  QG1(I)=3.27E-07*QGT2(I)*Z*T/PCA
  QT(I)=QL(I)+QG1(I)
  WL=4.0509E-03*QW(I)
  WG=QG1(I)/379.*G1(I)*28.97
  WT=WL+WG
  DL=WL/QL(I)
  DG=WG/QG1(I)
  VT=QT(I)/AP
  RN=1488.*DL*DD*VT/UW
  VB1=.5*SQRT(32.2*DD)
C.....ITERATION ON VB1
DO 70 J=1,10
  CNB=1488.*DL*DD*VB1/UW
  IF((CNB.GT.3000.).AND.(CNB.LT.8000.)) GO TO 11
  GO TO 12
11  VB1=(.35+8.74E-06*RN)*SQRT(32.2*DD)
  VB=.5*VB1+SQRT(VB1**2.+(13.59*UW/(DL*SQRT(DD))))
  GO TO 15
12  IF(CNB.LE.3000.) GO TO 13
  GO TO 14
13  VB=(.546+8.74E-06*RN)*SQRT(32.2*DD)
  GO TO 15
14  IF(CNB.GE.8000.) GO TO 16
16  VB=(.35+8.74E-06*RN)*SQRT(32.2*DD)
15  IF(ABS(VB-VB1).LT..001) GO TO 17
  VB1=VB
70  CONTINUE
17  CONTINUE
  IF(VT.LT.10.) GO TO 18
  TT=((.045*ALOG10(UW))/(DD**.799))-.709-
  1.162*ALOG10(VT)-.888*ALOG10(DD)
  GO TO 21
18  TT=((.013*ALOG10(UW))/(DD**1.38))-.681+
  2.232*ALOG10(VT)-.428*ALOG10(DD)
  T1=-.065*VT
21  CONTINUE
C.....
CALL FRICT (RN,EPS,D,F1)
DA=(WT+DL*VB*AP)/(QT(I)+VB*AP)+TT*DL
T2=-(VB*AP*(1.-DA/DL))/(QT(I)+VB*AP)
IF((VT.LT.10.).AND.(TT.LT.T1)) GO TO 19
GO TO 22
19  TT=T1

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22      GO TO 23
      IF((VT.GT.10.).AND.(TT.LT.T2)) GO TO 24
      GO TO 25
24      TT=T2
23      DA=(WT+DL*VB*AP)/(QT(I)+VB*AP)+TT*DL
25      CONTINUE
      TF1=F1*DL*VT**2./(64.4*DD)
      TF2=((QL(I)+VB*AP)/(QT(I)+VB*AP))+TT
      TF=TF1*TF2
      H1=WT*QG1(I)/(4637.*AP**2.*PCA)
      DPC=((DA+TF)/(144.*(1.-H1)))*X
      PN=P1(K-1)+DPC
      IF(ABS(PN-PCA).LT..001) GO TO 51
      IF(PN-PCA)49,51,52
C.....METHOD OF CONVERGENCE
49      CMUL=-1.0
      KK=2
      IF(L.GT.1) GO TO 53
      GO TO 55
53      DIV=DIV*2.
55      DP=DP+CMUL*DEL/DIV
      GO TO 60
52      CMUL=1.
      L=2
      IF(KK.GT.1) GO TO 53
      GO TO 55
60      CONTINUE
51      P1(K)=PN
50      CONTINUE
      PF=P1(100)
      WRITE(4,30)PF,QGT2(I)
10     CONTINUE
      END

```

C.....PROGRAM NO. 2
QJ=GAS FLOW RATE FOR WELL J ,SCF/D
PWJ=BOTTOM HOOLE PRESSURE FOR WELL J ,PSI
PJJ=AVERAG PRESSURE FOR WELL J ,PSI
PRA=AVERAGE RESERVOIR PRESSURE ,PSI
DVJ=DRAINAGE VOLUME FOR WELL J ,FT**3
HJ=THINESS OF WELL J ,FT
PO=POROSITY
RWJ=RADIUS OF WELL J ,FT
REJ=RADIUS OF DRAINAGE OF WELL J ,FT**3
T=FORMATION TEMPT. R
TS=STANDARED TEMPT.R
PS=STANDARED PRESSURE ,PSI
CKJ=PERMEABILITY OF WELL J ,MD
PRJ=REDUCED PRESSURE
TRJ=REDUCED TEMPT.
ZJ=COMPRESSILITY FACTOR
VISGJ=GAS VISCOSITY ,CP
VC=TOTAL DRAINAGE VOLUME CALCULATED , FT**3
VT=TOTAL DRAINAGE VOLUME MEASURED FOM ISOPACH MAP , FT**3
G=SPECIFIC GRAVITY OF THE GAS
RI=INCREMENTAL DISTANCE FROM BORE HOLE TO REJ , FT

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C.....PROGRAM NO. 2
C.....THIS PROGRAM IS TO CALCULATE THE
C.....AVERAGE RESERVIOR PRESSURE,
C.....USING DRAINAGE VOLUME CONCEPT FOR
C.....EACH WELL BY ASSUMING (PE)AND
C.....COMPARING THE TOTAL DRAINAGE VOLUME CALCULATED
C.....WITH THAT MEASURED FROM ISOPACH MAP

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C.....DIMENSION Q1(25),Q2(25),Q3(25),Q4(25),Q5(25)
1PW1(25),PW2(25),PW3(25),PW4(25),PW5(25),PE(25),
2PZ(25),PRA(25),A1(25),A2(25),A3(25),A4(25),
3A5(25),DV1(25),DV2(25),DV3(25),DV4(25),DV5(25),VC(25)
4,SUM1(0/100),SUM2(0/100),SUM3(0/100),SUM4(0/100)
5,SUM5(0/100),F1(0/100),F2(0/100),F3(0/100),F4(0/100)
6,F5(0/100),R1(0/100),R2(0/100),R3(0/100),R4(0/100)
7R5(0/100),PJ1(0/100),PJ2(0/100),PJ3(0/100),PJ4(0/100),
8PJ5(0/100)

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C.....(INPUT DATA).....

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DATA PD,TS,PS /,26,640.,520.,14.7 /
DATA H1,H2,H3,H4,H5 /60.,60.,43.,62.,71. /
DATA CK1,CK2,CK3,CK4,CK5 /290.,310.,200.,290.,280. /

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```

G=.77
D1=6.184
D3=4.276
RW1=D1/24.
RW2=RW1
RW4=RW1
RW5=RW1
RW3=D3/24.
VT=588.E5
C1=3.14159*PO*H1*RW1**2.
C2=3.14159*PO*H2*RW2**2.
C4=3.14159*PO*H4*RW4**2.
C3=3.14159*PO*H3*RW3**2.
C5=3.14159*PO*H5*RW5**2.

```

```

DO 10 I=1,21
READ(58,1)Q1(I),Q2(I),Q3(I),Q4(I),Q5(I)
READ(59,1)PW1(I),PW2(I),PW3(I),PW4(I),PW5(I)
PE(I)=PW3(I)+50.
Q1(I)=Q1(I)*1.E6
Q2(I)=Q2(I)*1.E6
Q3(I)=Q3(I)*1.E6
Q4(I)=Q4(I)*1.E6
Q5(I)=Q5(I)*1.E6

```

```

C.....CALL PETROLEUM SUBROUTINE.....

```

```

CALL PSEUDO(PW1(I),G,T,PR1,TR1)
CALL PSEUDO(PW2(I),G,T,PR2,TR2)
CALL PSEUDO(PW3(I),G,T,PR3,TR3)
CALL PSEUDO(PW4(I),G,T,PR4,TR4)
CALL PSEUDO(PW5(I),G,T,PR5,TR5)
CALL ZFAC(PR1,TR1,Z1,NN)
CALL ZFAC(PR2,TR2,Z2,NN)
CALL ZFAC(PR3,TR3,Z3,NN)
CALL ZFAC(PR4,TR4,Z4,NN)
CALL ZFAC(PR5,TR5,Z5,NN)
CALL VISGAS(T,PW1(I),Z1,G,VISG1)
CALL VISGAS(T,PW2(I),Z2,G,VISG2)
CALL VISGAS(T,PW3(I),Z3,G,VISG3)
CALL VISGAS(T,PW4(I),Z4,G,VISG4)

```

```

CALL VISGAS(T,PW5(I),Z5,G,VISG5)
C.....A1(I)=.00708*5.615*H1*CK1*TS/(T*VISG1*Z1*PS)
A2(I)=.00708*5.615*H2*CK2*TS/(T*VISG2*Z2*PS)
A3(I)=.00708*5.615*H3*CK3*TS/(T*VISG3*Z3*PS)
A4(I)=.00708*5.615*H4*CK4*TS/(T*VISG4*Z4*PS)
A5(I)=.00708*5.615*H5*CK5*TS/(T*VISG5*Z5*PS)
C.....ITERATION METHOD TO FIND THE
C.....DRAINAGE VOLUME FOR EACH WELL
DO 20 J=1,2000
DV1(I)=EXP((A1(I)*(PE(I)**2.-PW1(I)**2.))+Q1(I)*
1ALOG(C1)+Q1(I))/Q1(I))
DV2(I)=EXP((A2(I)*(PE(I)**2.-PW2(I)**2.))+Q2(I)*
1ALOG(C2)+Q2(I))/Q2(I))
IF(DV2(I).LT.1.)DV2(I)=1.
DV3(I)=EXP((A3(I)*(PE(I)**2.-PW3(I)**2.))+Q3(I)*
1ALOG(C3)+Q3(I))/Q3(I))
IF(DV3(I).LT.1.)DV3(I)=1.
DV4(I)=EXP((A4(I)*(PE(I)**2.-PW4(I)**2.))+Q4(I)*
1ALOG(C4)+Q4(I))/Q4(I))
DV5(I)=EXP((A5(I)*(PE(I)**2.-PW5(I)**2.))+Q5(I)*
1ALOG(C5)+Q5(I))/Q5(I))
C.....TOTAL DRAINAGE VOLUME CALCULATED
VC(I)=DV1(I)+DV2(I)+DV3(I)+DV4(I)+DV5(I)
IF(ABS(VC(I)-VT).LT.1.E6)GO TO 30
IF(VC(I)-VT)31,30,32
31 PE(I)=PE(I)+.1
CO TO 20
32 PE(I)=PE(I)-.1
20 CONTINUE
C.....CALCULATION THE AVERAGE RESERVOIR PRESSURE
30 RE1=SQRT((DV1(I)/(3.14159*PO*H1))
RE2=SQRT((DV2(I)/(3.14159*PO*H2))
RE3=SQRT((DV3(I)/(3.14159*PO*H3))
RE4=SQRT((DV4(I)/(3.14159*PO*H4))
RE5=SQRT((DV5(I)/(3.14159*PO*H5))
RR1(O)=RW1
RR2(O)=RW2
RR3(O)=RW3
RR4(O)=RW4
RR5(O)=RW5
FR1(O)=2.*RW1*PW1(I)
FR2(O)=2.*RW2*PW2(I)
FR3(O)=2.*RW3*PW3(I)
FR4(O)=2.*RW4*PW4(I)
FR5(O)=2.*RW5*PW5(I)
DO 40 K=1,100
Y=FLOAT(K)
R1(K)=RE1/100.*Y
R2(K)=RE2/100.*Y
R3(K)=RE3/100.*Y
R4(K)=RE4/100.*Y
R5(K)=RE5/100.*Y
W1=ALOGG(R1(K)/RW1)/ALOGG(RE1/RW1)
W2=ALOGG(R2(K)/RW2)/ALOGG(RE2/RW2)
W3=ALOGG(R3(K)/RW3)/ALOGG(RE3/RW3)
W4=ALOGG(R4(K)/RW4)/ALOGG(RE4/RW4)
W5=ALOGG(R5(K)/RW5)/ALOGG(RE5/RW5)
F1(K)=2.*R1(K)*SQRT(PW1(I)**2.+(PE(I)**2.-PW1(I)**2.)*W1)
F2(K)=2.*R2(K)*SQRT(PW2(I)**2.+(PE(I)**2.-PW2(I)**2.)*W2)

```

```

F3(K)=2.*R3(K)*SQRT(PW3(I)**2.+(PE(I)**2.-PW3(I)**2.)*W3)
F4(K)=2.*R4(K)*SQRT(PW4(I)**2.+(PE(I)**2.-PW4(I)**2.)*W4)
F5(K)=2.*R5(K)*SQRT(PW5(I)**2.+(PE(I)**2.-PW5(I)**2.)*W5)
SUM1(K)=SUM1(K-1)+(F1(K-1)+F1(K))*(R1(K)-R1(K-1))/2.
SUM2(K)=SUM2(K-1)+(F2(K-1)+F2(K))*(R2(K)-R2(K-1))/2.
SUM3(K)=SUM3(K-1)+(F3(K-1)+F3(K))*(R3(K)-R3(K-1))/2.
SUM4(K)=SUM4(K-1)+(F4(K-1)+F4(K))*(R4(K)-R4(K-1))/2.
SUM5(K)=SUM5(K-1)+(F5(K-1)+F5(K))*(R5(K)-R5(K-1))/2.
40 CONTINUE
PJ1(I)=SUM1(100)/(RE1**2.-RW1**2.)
PJ2(I)=SUM2(100)/(RE2**2.-RW2**2.)
PJ3(I)=SUM3(100)/(RE3**2.-RW3**2.)
PJ4(I)=SUM4(100)/(RE4**2.-RW4**2.)
PJ5(I)=SUM5(100)/(RE5**2.-RW5**2.)
PRA(I)=(PJ1(I)*DV1(I)+PJ2(I)*DV2(I)+PJ3(I)*DV3(I)
1+PJ4(I)*DV4(I)+PJ5(I)*DV5(I))/VC(I)
WRITE(4,4)PRA(I)
4
1
10 FORMAT(G)
FORMAT(5G)
CONTINUE
END

```

PROGRAM NO:3

QC=CONTRACT FLOW RATE OF THE WELL, SCF/D
 QG=GAS FLOW RATE OF THE WELL, SCF/D
 QW=WATER FLOW RATE OF THE WELL BBL/D
 PM=MINIMUM SALE PRESSURE =(BOTTOM HOLE PRESSURE
 WHEN THE WELL HEAD PRESSURE =975.0 PSI, AT QC
 CP=PRODUCING CAPACITY OF THE WELL =SCF/D/PSI**2/FT.PERF.
 H1,2,...=PERFORATED FT. FOR THE WELL ABOVE GAS WATER CON.
 X1,2,...=THE DISTANCE FROM ZERO G-W-C TO THE
 BOTTOM OF PERFORATION OF EACH WELL ,FT
 PI=INITIAL RES. PRESSURE ,PSI
 GI=INITIAL GAS INPLACE ,SCF
 T=FORMATION TEMPT. R
 TA=STANDARD TEMPT. R
 PA=STANDARD PRESSURE , PSI
 GP=CUMULATIVE GAS PRODUCED , SCF
 WP=CUMULATIVE WATER PRODUCED ,BBL
 CW=WATER COMPRESSIBILITY ,PSI**-1
 CF=FORMATION COMPRESSIBILITY , PSI**-1
 SW=IRREDUCIBLE WATER SATURATION
 SGR=RESIDUAL GAS SATURATION
 WEM=WATER INFUX FROM MATERIAL BALANCE EQ. BBL
 WEU=WATER INFUX FROM UNSTEADY STATE EQ. BBL
 B=WATER INFUX CONSTANT
 TIM=TIME , DAY
 G=GAS GRAVITY
 PO=POROSITY
 CKG=GAS PERMEABILITY ,MD
 CKW=WATER PERMEABILITY ,MD
 VISG=GAS VISCOSITY ,CP
 UW=WATER VISCOSITY ,CP
 BG=GAS FORMATION VOL.FACTOR -CF/SCF
 HW=HEIGHT OF G-W-C ,FT
 POI=PORE VOLUME INVADED. FT**3

```

C.....PROGRAM NO. 3.
C.....THIS PROGRAM USED FOR PREDICTION PURPOSE,
C.....THE IDEA IS TO CALCULATE WATER INFLUX FROM
C.....MATERIAL BALANCE EQ. AND WATER INFLUX FROM
C.....SUBROUTION WATRAD. (THIS SUBROUTION USE THE
C.....UNSTEADY STATE EQ. TO CALCULATE WATER
C.....INFLUX) AND THEN COMPER THE TOW VALUES
C.....DIMENSION P(0/250),PC(0/250),GP(0/250),WP(0/250),PS(0/250),
1,WEM(0/250),WEU(0/250),X(0/250),HW(0/250),POI(0/250),TIM(0/250)
2,DEL1(0/250),DEL2(0/250),DEL3(0/250),DEL4(0/250),DEL5(0/250)
3,HI(0/250),H2(0/250),H3(0/250),H4(0/250),H5(0/250)
5,CUG(0/250),CUC(0/250),CWP(0/250),DEL55(0/250)
6,QCC(0/250),QCC(0/250),GP1(0/250)
7,BG(0/250),DVW(0/250),SUM(0/250),HWG(0/250),POG(0/250)
C.....
C.....INPUT DATA.....
C.....DATA QC1, QC2, QC3, QC4, QC5 /20.E6, 5.6E6, 7.0E6, 20.E6, 20.E6/
DATA PM1, PM2, PM3, PM4, PM5 /2290., 2937., 2243., 2448., 2243./
DATA CP1, CP2, CP3, CP4, CP5 /0.0578, .2, .0247, .1, .0897/
DATA PI, GI /7300., 220.E9 /
DATA X1, X2, X3, X4, X5 /35., 49., 4., 46., 39./
DATA T, TA, PA /640., 520., 14.7/
DATA CW, CF, SW, SGR, BW /4.E-6, 6.E-6, .3, .228, 1./
DATA CKG, CKW, CKGI, PO, H, UW /300., 123., 300., .26, 50., .8/
C.....
C.....DATA FOR PAST PERFORMANCE.....
C.....DO 90 I=1, 30
90 READ(18, 22)CUG(I), CUC(I), CWP(I)
22 FORMAT(3G)
C.....NUMBER OF FEET PERFORATED ABOVE G-W-C FOR EACH WELL
H1(0)=54.
H2(0)=12.
H3(0)=39.
H4(0)=25.
H5(0)=39.
C.....INITIALIZATION.....
X(0)=0.0
HW(0)=0.0
POI(0)=0.0
DEL1(0)=0.0
DEL2(0)=0.0
DEL3(0)=0.0
DEL4(0)=0.0
DEL5(0)=0.0
GP(0)=0.0
WP(0)=0.0
SUM(0)=0.0
C.....
WEU(0)=0.0
TD=30.08
G=.77
QMAX=2.624
CE=CW+CF
A=TA/(T*PA)
P(0)=PI
PS(0)=PI
P2=P(0)
C.....CALL PETROLEUM SUBROUTION.....
CALL PSEUDO(P(0), G, T, PR, TR)
CALL ZFAC(PR, TR, ZI, NN)

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CALL VISGAS(T,P(0),ZI,G,VISGI)
BGI=.02829*ZI*T/P(0)
RG=(GI*BGI/PO/H/3.14159/(1.-SW))**.5
B=1.119*PO*CE*RG*RG*H
DET=6.323E-3*CKW/PO/UW/CE/RG/RG
TIM(0)=0.0
DO 10 I=1,250
10  TIM(I)=TIM(I-1)+30.08
CONTINUE
DO 60 K=1,250
I=K
50  P4=(P1+P2)/2.
CALL PSEUDO(P4,G,T,PR,TR)
CALL ZFAC(PR,TR,Z,NN)
CALL VISGAS(T,P4,Z,G,VISG)
BG(K)=.02829*Z*T/P4
BG(0)=BGI
C.....CALCULATING GAS FLOW RATE FOR EACH WELL
C=VISG*BG(K)*CKG/(VISGI*BGI*CKGI)
IF(K.LT.31) GO TO 70
QG1=CP1*H1(K-1)*C*(P4**2.-PM1**2.)
IF(QG1.GT.QC1) QG1=QC1
QG2=CP2*H2(K-1)*C*(P4**2.-PM2**2.)
IF(QG2.GT.QC2) QG2=QC2
QG3=CP3*H3(K-1)*C*(P4**2.-PM3**2.)
IF(QG3.GT.QC3) QG3=QC3
QG4=CP4*H4(K-1)*C*(P4**2.-PM4**2.)
IF(QG4.GT.QC4) QG4=QC4
QG5=CP5*H5(K-1)*C*(P4**2.-PM5**2.)
IF(QG5.GT.QC5) QG5=QC5
C.....CALCULATING WATER FLOW RATE FOR EACH WELL.....
C.....
C1=CKW*BW*VISGI*Z*T*PA/(5.615*UW*TA*CKGI)
QW1=CP1*DEL1(K-1)*C1*(P4-PM1)
QW2=CP2*DEL2(K-1)*C1*(P4-PM2)
QW3=CP3*DEL3(K-1)*C1*(P4-PM3)
QW4=CP4*DEL4(K-1)*C1*(P4-PM4)
QW5=CP5*DEL5(K-1)*C1*(P4-PM5)
C.....HOW DO YOU WANT THE PRODUCTION FROM EACH WELL,
C.....(THIS MEANS WHEN DO YOU WANT SHUT THE WELL)
1  IF(QG1-0.0)1,1,2
   QW1=0.0
   GO TO 3
2  D1=QW1/QG1
   IF(D1-0.004)3,4,4
4  QW1=0.0
   QG1=0.0
3  IF(QG2-0.0)5,5,6
5  QW2=0.0
   GO TO 7
6  D2=QW2/QG2
   IF(D2-0.004)7,8,8
8  QW2=0.0
   QG2=0.0
7  IF(QG3-0.0)9,9,11
9  QW3=0.0
   GO TO 12
11 D3=QW3/QG3
   IF(D3-0.004)12,13,13

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13      QW3=0.0
      QG3=0.0
12      IF(QG4-0.0)14,14,15
14      QW4=0.0
      GO TO 16
15      D4=QW4/QG4
      IF(D4-0.004)16,17,17
17      QW4=0.0
      QG4=0.0
16      IF(QG5-0.0)18,18,19
18      QW5=0.0
      GO TO 20
19      D5=QW5/QG5
      IF(D5-0.004)20,21,21
21      QW5=0.0
      QG5=0.0
20      BBB=0.0
C.....CALCULATING CUMULATIVE GAS AND CUMULATIVE WATER.....
      GP(K)=(QG1+QG2+QG3+QG4+QG5)*TD
      WP(K)=(QW1+QW2+QW3+QW4+QW5)*TD
      GP(K)=GP(K-1)+GP(K)
      WP(K)=WP(K-1)+WP(K)
      GO TO 80
C.....PAST PERFORMACE CALCULATIONS
70      WE=6084./(.47.-5.9)
      GRC=141.5/(131.5+47.)
      QCC(K)=QCC(K-1)+CUC(K)*133000.*GRC/WE
      QCG(K)=QCG(K-1)+CUG(K)
      GP(K)=QCC(K)+QCG(K)
      WP(K)=WP(K-1)+CWP(K)
C.....THE MATERIAL BALANCE EQUATION.....
80      CC1=GP(K)*Z/P4+A*5.615*WP(K)*BW
      CC2=GI*(Z/P4-ZI/P(0))
      CC3=GI*ZI/P(0)/(1.-SW)*(CW*SW+CF)*(P(0)-P4)
      WEM(K)=(CC1-CC2-CC3)/(A*5.615)
      KI=K+1
      PS(K)=P4
      KK=K
C.....SUBROUTION WATRAD.....
      CALL WATRAD(DET, KK, QMAX, TIM, PS, KI, W)
      WEU(K)=W*B
C.....METHOD OF CONVERGANCE.....
      IF(ABS(WEM(K)-WEU(K)).LT.500.) GO TO 40
      IF(WEM(K).GT.WEU(K)) GO TO 30
      P1=P4
      P4=(P1+P2)/2.
      GO TO 50
30      P2=P4
      P4=(P1+P2)/2.
      GO TO50
C.....
40      PC(K)=P4
C.....CALCULATING WATER INVADED ZONE.....
      SUM(K)=SUM(K-1)+DVW(K-1)*SGR/BG(K-1)
      E1=(WEU(K)-WEU(K-1))*5.615
      E2=(WP(K)-WP(K-1))*5.615
      E3=SUM(K)*(BG(K)-BG(K-1))
      DVW(K)=(E1-E2+E3)/(1.-SW-SGR)
      POI(K)=POI(K-1)+DVW(K)
C.....CALCULATING HEIGHT OF G-W-C.....

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REWIND 19
DO 110 M=1,16
110 READ(19,120)POG(M),HWG(M)
120 FORMAT(2G)
DO 111M=1,16
IF (ABS(POG(M)-POI(K)).LT.10.E-4) GO TO 140
IF (ABS(POG(M+1)-POI(K)).LT.10.E-4) GO TO 150
IF (PCI(K).GT.POG(M).AND.POI(K).LT.POG(M+1)) GO TO 130
111 CONTINUE
130 HW(K)=HWG(M)+(HWG(M+1)-HWG(M))*(POI(K)-
1POG(M))/(POG(M+1)-POG(M))
GO TO 160
140 HW(K)=HWG(M)
GO TO 160
150 HW(K)=HWG(M+1)
160 CONTINUE
IF(HW(K).LT.0.0) HW(K)=0.0
C .....
C .....CALCULATING THE NUMBER OF FEET PERFORATED BELOW G-W-C .....
C .....
DEL1(K)=HW(K)-X1
DEL2(K)=HW(K)-X2
DEL3(K)=HW(K)-X3
DEL4(K)=HW(K)-X4
DEL5(K)=HW(K)-X5
IF(DEL1(K).LT.0.0) DEL1(K)=0.0
IF(DEL2(K).LT.0.0) DEL2(K)=0.0
IF(DEL3(K).LT.0.0) DEL3(K)=0.0
IF(DEL4(K).LT.0.0) DEL4(K)=0.0
IF(DEL5(K).LT.0.0) DEL5(K)=0.0
C .....CALCULATING THE NUMBER OF PERFORATED FEET REMAINING
C .....
ABOVE G-W-C FOR EACH WELL
H1(K)=H1(0)-DEL1(K)
H2(K)=H2(0)-DEL2(K)
H3(K)=H3(0)-DEL3(K)
H4(K)=H4(0)-DEL4(K)
H5(K)=H5(0)-DEL5(K)
IF(H1(K).LT.0.0) H1(K)=0.0
IF(H2(K).LT.0.0) H2(K)=0.0
IF(H3(K).LT.0.0) H3(K)=0.0
IF(H4(K).LT.0.0) H4(K)=0.0
IF(H5(K).LT.0.0) H5(K)=0.0
C .....THE OUTPUT.....
PP=PC(K)/1.0
GGP=GP(K)/1.E6
WWP=WP(K)/1000.
WEE=WEU(K)/1000.
HWW=HW(K)/1.0
WRITE(6,57)
57 FORMAT(40)
WRITE(6,56)TIM(I),PP,GGP,WWP,WEE,HWW
56 FORMAT(2X,G,6X,F6.0,6X,F11.2,6X,F9.2,6X,F5.2)
C WRITE(6,55)TIM(K),PC(K),GP(K),WP(K),WEU(K),HW(K)
SS2=GP(K)/1.E9
SS1=WP(K)/1.E6
TIM(I)=TIM(P)/30.08
WRITE(27,100)TIM(I),SS2
WRITE(25,100)TIM(I),SS1
WRITE(26,100)TIM(I),PC(K)
100 FORMAT(2X,2G)
55 FORMAT(2X,6(3X,G))
P1=0.0
P2=P(0)
60 CONTINUE
STOP
END

```

CSM Program Library
Pseudo reduced Properties

REFERENCE NUMBER: PE:SR002.F4

TITLE: PSEUDO.F4

AUTHOR: J d wright

DATE: 29-OCT-74

SOURCE LANGUAGE: FORTRAN-40

DESCRIPTION: this subroutine calculates the pseudo reduced pressure and pseudo reduced temperature of a mixture of natural gases. the acceptable range of gas gravity is .55 to 1.2

CALL PSEUDO(P,G,TRANK,PR,TR)

P = INPUT: pressure, psia
G = INPUT: gas gravity (air = 1)
TRANK = INPUT: temperature, deg rankine
PR = OUTPUT: pseudo reduced pressure
TR = OUTPUT: pseudo reduced temperature

SUBPROGRAMS USED: none

REFERENCES: amur, bass, and whiting, page 259 - misc gases

CSM Program Library
z-factor subroutine

REFERENCE NUMBER: FE:SR001.F4.JIW

TITLE: ZFAC.F4

AUTHOR: J d wright

DATE: 29-OCT-74

SOURCE LANGUAGE: FORTRAN-40

DESCRIPTION: this subroutine calculates the compressibility factor of a mixture of natural gases. the method is a table lookup and interpolation on a table of 400 z-factors. 4-point lagrange interpolation is used on pseudo reduced pressure and either 4-point lagrange or linear interpolation is used on reduced temperature.

the limits on reduced pressure are zero to 15. the limits on reduced temperature are 1.05 to 3.00.

CALL ZFAC(PR,TR,Z,NTIME)

PR = INPUT: pseudo reduced pressure
TR = INPUT: pseudo reduced temperature
Z = OUTPUT: z-factor. set to zero if PR or TR out of range.
NTIME = INPUT: call to rtime can be disabled by supplying a negative number for ntime when the subroutine is called. this will save quite a bit of time since two calls to rtime are made in zfac.
OUTPUT: cpu time of this call to zfac in millisec. usually should be disabled as shown above.

SUBPROGRAMS USED: lagrange interpolation subroutine

REFERENCES: gray and simms, oil and gas journal, July 20, 1959, vol 57, no 30

CSM Program Library
water influx subroutine

REFERENCE NUMBER: PE:SR009.FOR.JDW

TITLE: WATRAD.FOR

AUTHOR: J d wright

DATE: 10-DEC-74

SOURCE LANGUAGE: FORTRAN-10

DESCRIPTION: this subroutine calculates water influx based on curves fitted to the tables presented by van everdinger and hurst. this routine follows the unsteady state curve until the q -sub- td calculated is greater than the q_{tdmax} specified in the call statement. this has the effect of ignoring the transition from unsteady state to pseudo steady state flow. the user must provide an array of time and an array of the corresponding pressures dimensioned from zero to whatever the maximum number of time steps is.

CALL WATRAD(DELTD,~~K~~,QTDMAX,TIME,P,~~K~~,WFLUX)

DELTD = INPUT: delta dimensionless time
~~K~~ = INPUT: time of interest. you want to solve for the cumulative water influx at this time. (this is the location of the time of interest in the time array.) remember that the initial time and pressure are stored in the zero location in the time and P arrays.
 QTDMAX = INPUT: for finite reservoirs this is the maximum q -sub- td that they can provide. for an infinite reservoir set q_{tdmax} to zero or a negative number.
 TIME = INPUT: an array (from 0 to ~~k~~) containing the various times.
 P = INPUT: an array (from 0 to ~~k~~) containing the various pressures corresponding to the above times.
~~K~~ = INPUT: the size of the time and P arrays.
 WFLUX = OUTPUT: the summation of q -sub- td times delta τ from time=0 to time=~~n~~. must be multiplied by 'b' (the water influx coefficient) to get cumulative water influx at time ~~n~~.

SUBPROGRAMS USED: none

REFERENCES: craft and hawkins, page 221.
 van everdinger, timmerman, and mcMahon, 'application of the material balance equation to a partial water drive reservoir', petroleum transactions, aime, vol 198, 1953, page 51.

REFERENCES

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