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Reserves and Performance of Canyon Sand Gas Wells, 1970-1994

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Abstract

Two fields, Ozona (Canyon) and Sawyer (Canyon), with more than 4,000 total wells, contain the majority of wells in the Canyon Sand trend of Crockett, Edwards, Schleicher and Sutton Counties in Southwest Texas. Average ultimate recovery for the fields decreased from 1,100 MMCF/well for wells drilled in 1970 to 400 MMCF/well for wells drilled in 1985, then remarkably reversed the trend. Recently drilled wells (since 1991) are expected to recover an average 625 MMCF. Initial monthly production decreased from 15,000 mcf/month to 5,000 mcf/month in 1985 and then increased to the present 12,000 mcf/month. Average first year wellhead pressure continued to decrease throughout the 25 years studied to a present 1300 psig in Ozona and 700 psig in Sawyer. The data suggest that drainage interference began to be a factor in about 1985 in the more densely developed areas. Although the average well density was about 200 acres per well in 1985, the true density in areas of active infill drilling probably approached 120 acres per well. Present average density is 143 acres per well in Ozona Field and 131 acres per well in Sawyer Field, but many leases are developed on density of 80 acres or less.

Introduction

During the 1970's, the Canyon Sands of Crockett, Edwards, Schliecher and Sutton Counties, Texas became a significant source of new gas production (Figure 1). More than 4,000 productive wells have been completed in the Sawyer and Ozona Fields. Drilling activity since 1970 has varied, peaking in the mid to late 1970's and falling to a low in 1986 as gas demand from these fields fell.

As development of the trend proceeded and fields merged, the Texas Railroad Commission ordered a number of the adjacent fields reclassified into either Ozona (Canyon Sand) Field or Sawyer (Canyon) Field. The two fields now contain more than 65% of the wells in the entire 6,000 well Canyon Sand gas trend.

Sawyer (Canyon) Field was discovered in 1967 and produces gas from Pennsylvanian age deltaic or turbidite lenticular sands at about 5,200 to 6,500 feet. The field covers portions of Edwards, Schleicher and Sutton Counties, and contains some 2,200 active and abandoned wells. Ozona (Canyon Sand) Field is located almost entirely in Crockett County, west of the Sawyer Field, and trending deeper into the Val Verde Basin at about 6,500 to 7,500 ft. It was discovered in 1962, but, like Sawyer, was slow in development until the rise of air drilling in the early 1970's. Figures 2 and 3 show the development history of each field group.

Both fields produce dry gas with small amounts of water from tight sands of 8-10% porosity and less than .1 md permeability[1]. There is core evidence that 1-2 inch streaks of significantly greater permeability exist within the larger sand lenses and these may enable the sands to produce in economic quantities.

A study of estimated ultimate recovery, initial production rates, wellhead pressures, and well density was completed for each field. The study encompassed all 3,200 wells drilled since 1970 in the two Fields. The Ozona group of 1,270 wells included minor numbers in the adjacent fields of Ozona, NE (Canyon 7520), Ozona, North (Canyon), Ozona NW (Canyon) and Ozona, SW (Canyon, Lower). The Sawyer Field study of 1,950 wells included only those classified in Sawyer (Canyon) Field.

A Brief Summary of Methodology

Wells from each field group, Sawyer and Ozona, were divided into classes according to the year of first production. Detailed monthly production for each of the 3,200 wells in the study was obtained from a commercial production information service and divided into yearly vintages. Completion of this work resulted in 25 classes of wells for each of the two study groups, covering the years from 1970 to 1994.

Each class, representing just those wells completed in a single year, was then normalized. The normalizing process brought each well to the same starting date and produced a composite look at how the wells completed in a single year have behaved over time. This normalized composite or total of each vintage of wells was then divided by the monthly well count to produce an "average well" for each of the annual classes from the two field groups. Rate vs. time curves were plotted for use in projecting these average wells and determining the profile of the decline.

Further studies were done on average initial wellhead pressures from each vintage. Each class of wells was searched for pressures recorded in the year of first production. An average initial wellhead pressure was determined from the data obtained in this search of the individual well records.

Finally, the Gas Proration Schedule from the Texas Railroad Commission was used to determine the average proration unit size for Ozona and Sawyer Fields at five year intervals since 1970.

Estimated Ultimate Recovery

The average normalized rate vs. time curve for each well vintage was projected to an abandonment rate of 350 mcf per month. This remaining volume was added to the average cumulative production to determine an average estimated ultimate recovery (EUR).

Ozona Field. Figure 4 shows the EUR for Ozona Field group. Estimated ultimate recovery was at its highest in the early 1970's but relatively few wells were drilled during this period and the sample is influenced by a small number of very good wells. Average EUR during the early 1970's was about 1,200 MMCF per well, with a peak of 1,400 MMCF per well in the 1974 class. EUR declined for wells drilled over the next ten years to a low of about 400 MMCF per well in 1986. Surprisingly the trend then reversed, increasing to about 650 MMCF per well in 1990. A slight downward trend followed through 1994.

Sawyer Field. Figure 5 summarizes the EUR for this field. Only one well was recorded as being completed in Sawyer in the 1970 and 1971 well vintages. When drilling accelerated in 1972, the EUR was at its highest, 950 MMCF per well on average. EUR's declined until about 1980 when the average seems to have stabilized at about 600 MMCF per well.

Peak Monthly Production

The normalized rate vs. time curve for each well vintage was used to obtain the peak monthly rate of gas production. Usually this occurs in the first month of production but at times the second or third month is the highest level as wells clean up and produce back fracturing fluids. The data is influenced by the fact that the first month of recorded production may not be a full 30 or 31 days.

Ozona. The 1973 class of wells achieved the best early production rate of 18,000 mcf/month per well. Typical mid-1970's peak rates were in the 11,000 mcf per month range. A decline in initial production then developed until about 1986 when the same reversal of the trend shown in EUR occurred. The next 8 years have shown increasing initial productivity, so that recent wells have average peak rates higher than those in the mid- 1970's. See Figure 6.

Sawyer. Again, the 1970 and 1971 classes contain only one well each and do not produce any statistical distribution. Peak production declined from 15,000 mcf/month per well in the early 1970's to a low of 7,000 mcf per month in the mid 1980's. Productivity then increased to 14,000 mcf/month in 1990 before resuming a decline through 1994. Figure 7 shows the peak average monthly rate for each vintage of wells.

Initial Wellhead Pressures

Each class of wells was scanned for the average initial wellhead pressure (IWHP) found in wells drilled that year.

Ozona. Reported initial wellhead pressures as shown in Figure 8 rose from about 1,600 psig in the early 1970's to a peak of 1,940 psig in 1976. Initial pressures then declined to about 1,750 psig in 1985. After 1985, the rate of decline in IWHP appears to have increased. The present average IWHP is about 1,400 psig.

Sawyer. Figure 9 shows the history of average IWHP for Sawyer Field. These pressures were about 1,450 psig in the early 1970's, declining to a present average of only 700 psig. As in Ozona, it appears the decline rate in IWHP accelerated beginning in 1985.

Well Density

The Gas Proration Schedules published by the Texas Railroad Commission include data on proration unit size. The 1970, 1974, 1979, 1984, 1989 and 1994 schedules were reviewed for this study. The acreage assigned for proration purposes was totaled, then divided by the total number of wells in order to obtain the average unit size.

Ozona. Field rules were first adopted in 1965, three years after discovery. These were amended in 1974 to provide for 320 acre units with 160 acre optional units. Optional 80 acre units were approved in November, 1982.

The average proration unit size has decreased from 321 acres in 1970 to 143 acres per well in 1994 as shown in Figure 10.

Sawyer. The original Field rules adopted in 1967 provided for 640 acre gas units. Later the units were allowed optional 320 acre development (1972), and shortly afterward, 160 acre optional density (1973). An application filed in June, 1980 was approved, allowing optional 80 acre units. Due to numerous applications for smaller units, the Commission called a July, 1993 hearing and approved 320 acre units with 40 acre optional density.

Figure 11 shows how average proration unit size has decreased since 1970. In 1994, the average proration unit size was 132 acres.

Decline Curve Profiles

The normalized rate vs. time curves provide a look at how the decline profiles have changed over the last 25 years. And the recent curves give an indication of what type of profile should be used in projecting future wells, at least in the near term.

Ozona. Early wells in this field showed hyperbolic behavior for about 2-3 years then generally exponential decline thereafter. Figure 12 shows the average normalized decline curves for six selected years from 1970 to 1993. Final decline rates are in the 7-10% range. By the mid to late 1980's the profiles changed to a much more hyperbolic shape. The 1988, 1990 and 1993 curves represent typical behavior for the recent wells and should be used in forecasting additional drilling. These profiles typically show a hyperbolic factor of 1.35, a starting rate of 12,500 mcf/month declining initially at 60% per year, and a final decline of 8% per year.

Sawyer. Figure 13 gives examples of average decline profiles for the Sawyer Field since 1972. Wells in this field typically had hyperbolic behavior for longer periods than Ozona, although the final declines are not much different - in the 7-10% range. The 1988, 1989 and 1993 profiles provide good examples of typical recent drilling. A reasonable profile is a hyperbolic factor of 1.35, an initial decline of 50% from 10,000 mcf/month, and a final decline of 8%.

Discussion

Both Sawyer Field and the Ozona Field group (which included a few minor adjacent fields) show a decrease in ultimate gas recovery until about 1985. Afterward, EUR's either increased in the case of Ozona or remained flat as in Sawyer. Peak production rate, which correlates to EUR, showed an even more dramatic reversal, especially in Ozona. Since additional drilling through this period was largely infill development on closer spacing, it seems likely the reversal was a result of stimulation technology instead of finding better reservoirs. Contacts with the major service companies yielded little definitive information on this subject, but the reversal seems to correlate with the introduction of borate crosslinked fracturing fluids into the Southwest Texas region. It is also likely that frac size increased during this same period.

The decline in initial wellhead pressure appeared to accelerate in both fields in about 1985. The proration unit size in 1985 had decreased to an average of about 200 acres per well. The data imply that drainage interference may have become a more important limiting factor in ultimate recovery as average well density fell below 200 acres per well. This is not to say that *economic* recovery of the available gas was not enhanced by accelerating the rate of drainage, or that local areas did not require additional development. But the average IWHP appears to be more affected by drilling density after 1985.

Remember that an operator is not likely to realize the averages unless he drills enough wells to benefit from the statistics. Dennis Beliveau, in his excellent review of horizontal wells[2], points out that for log-normal distributions, "... the typical error associated with any individual well estimate is at least ± 50%!" Beliveau further points out that although a multi-well program would *tend* toward the mean values, it is significantly more likely that an individual well will be *below* the average - a statistical fact of log-normal distributions. EUR and initial rates are certainly log-normally distributed in Sawyer and Ozona. Enough wells need to be drilled to find those exceptional ones in order to realize the average.

The highly variable nature of the Canyon Sand reservoirs will result in areas that are sufficiently drained by 160 acre spacing and others that require denser drilling to accomplish adequate drainage.

Conclusions

1. A multi-well development program in Ozona Field should result in an average reserve of 645 MMCF per well.

2. The typical decline profile of Ozona wells is expected to be 12,500 mcf/month (410 mcfpd) initially, declining at 60% with a hyperbolic factor of 1.35 and a final decline of 8%. (See Figure 14 for the 1990 profile).

3. A multi-well infill drilling program in the Sawyer Field should result in average reserves of 600 MMCF per well.

4. The typical Sawyer well will produce initially at 10,000 mcf/month (330 mcfpd), and will begin declining at a rate of 50% per year with a hyperbolic factor of about 1.35, and a final decline of about 8%. (See Figure 15 for the 1989 profile).

Conversion Factors

1 mcf (thousand cubic feet)=28.317 m^3
1 MMCF (million cubit feet)=28,317 m^3
1 acre=4,046 m^2
1 psig=6895 pascal

Appendix
References

1. Trabelsi, Ali: "Canyon Sand - SW Texas Example of a Low Permeability Gas Reservoir," *Oil & Gas Journal* (May 9, 1994) 83.

2. Beliveau, Dennis: "Heterogeneity, Geostatistics, Horizontal Wells, and Blackjack Poker," *JPT* (December 1995) 1068, SPE paper 30745.

3. Pferdehirt, D.J., Brown, J.E., and Rucker, L.R.: "New Stimulation Techniques Improved Canyon Sand Gas Production: A Case Study," paper SPE 20133, presented at the 1990 Permian Basin Oil and Gas Recovery Conference, Midland, Texas, March, 1990.

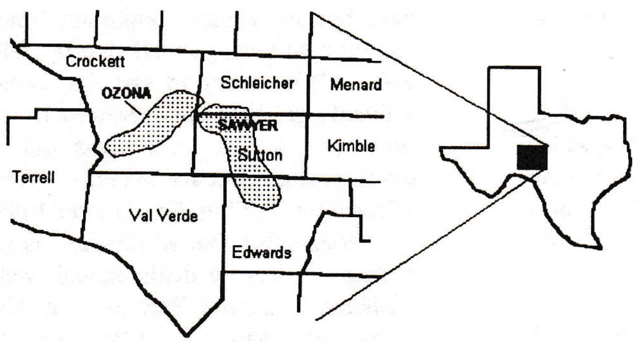

Figure 1 - Area of study

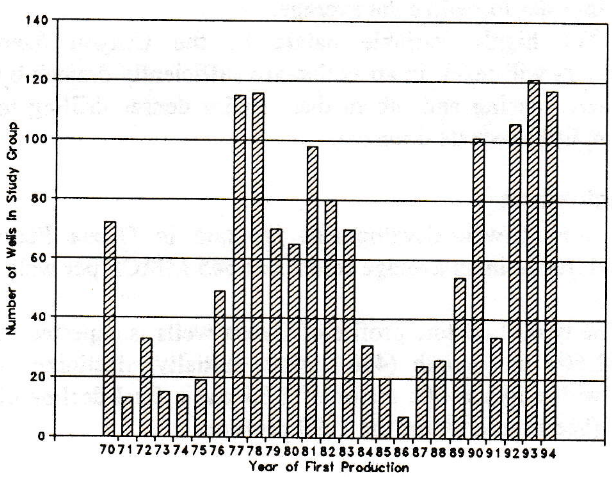

Figure 2 -Ozona Field Well Vintages.

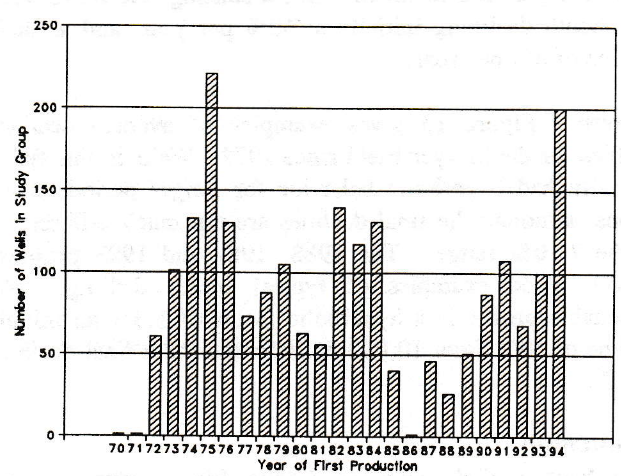

Figure 3 - Sawyer Field Well Vintages

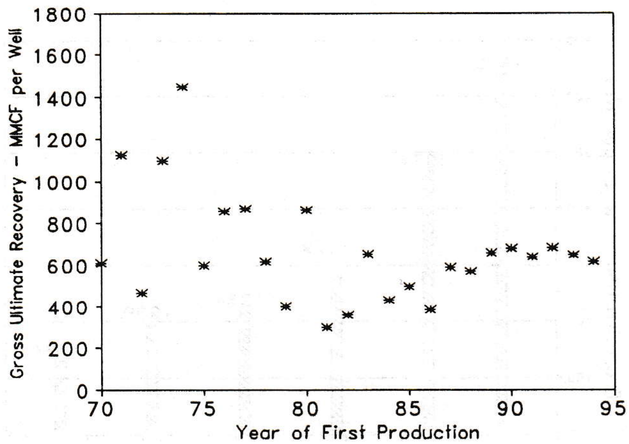

Figure 4 - Ozona Field Average EUR per Well

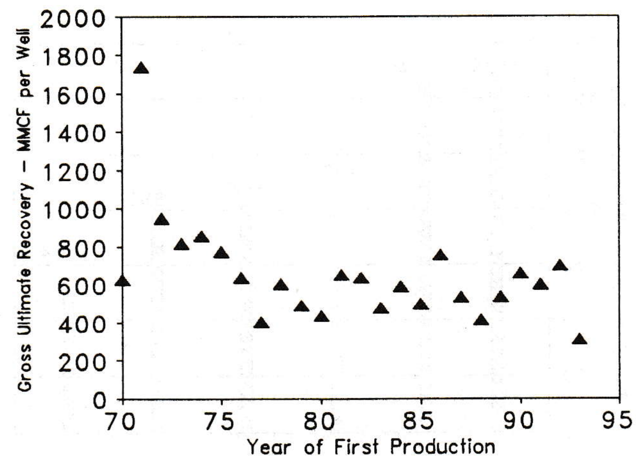

Figure 5 - Sawyer Field Average EUR per Well

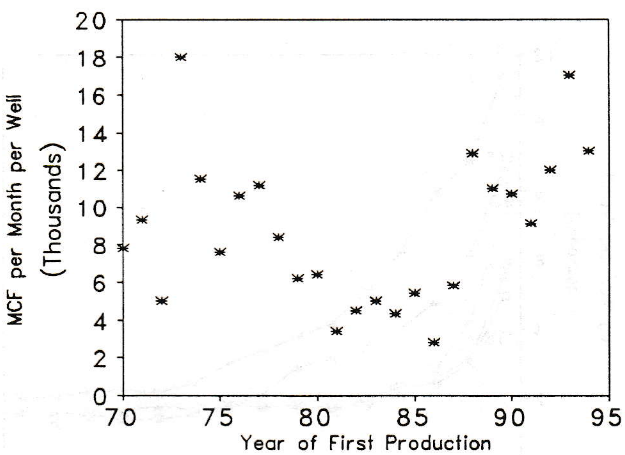

Figure 6 - Ozona Peak Monthly Production

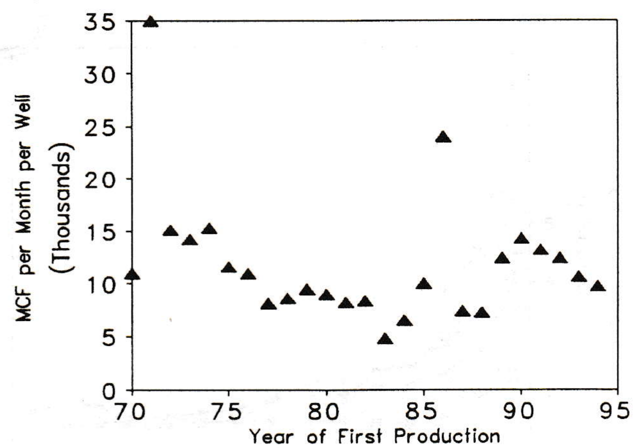

Figure 7 - Sawyer Peak Monthly Production

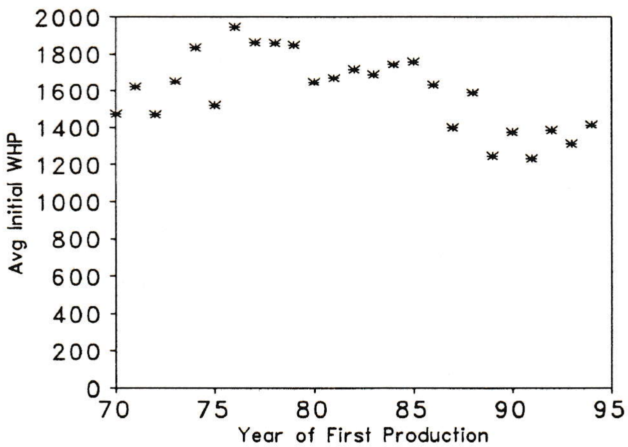

Figure 8 - Ozona Average Initial Wellhead Pressure

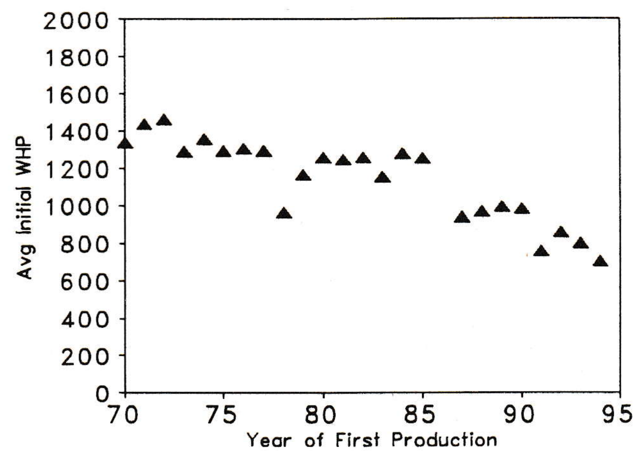

Figure 9 - Sawyer Average Initial Wellhead Pressure

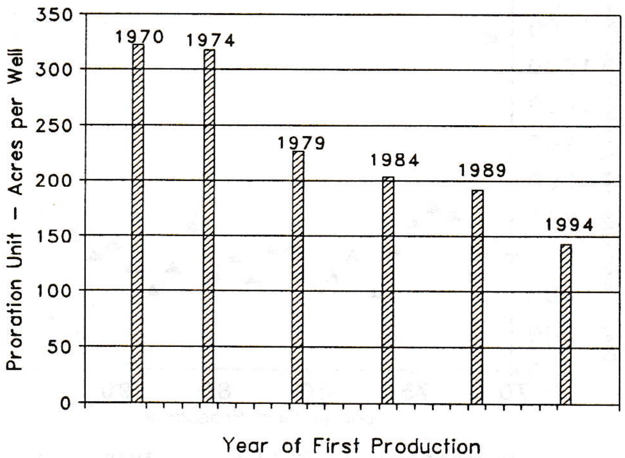

Figure 10 - Ozona Field Average Proration Unit Size

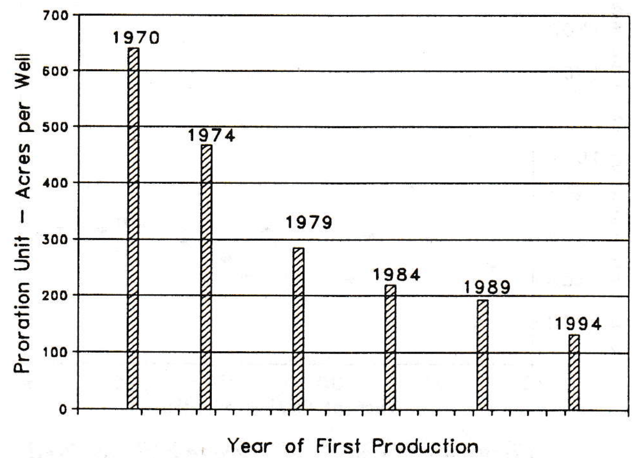

Figure 11 - Sawyer Field Average Proration Unit Size

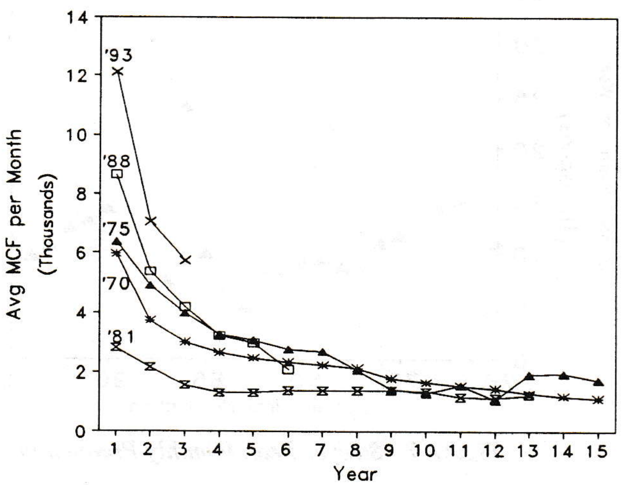

Figure 12 - Ozona Average Decline Curves

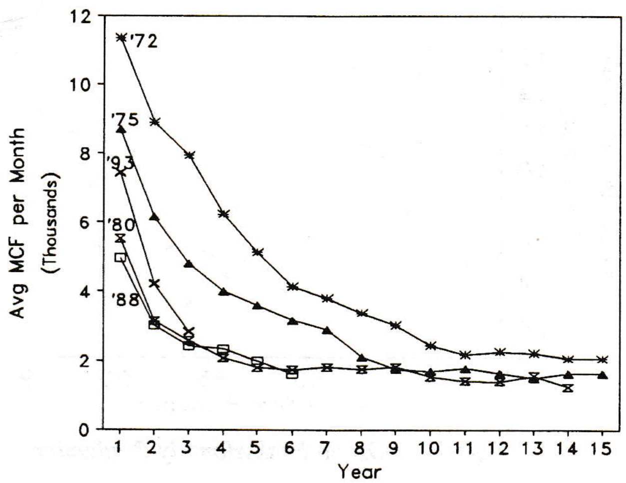

Figure 13 - Sawyer Average Decline Curves

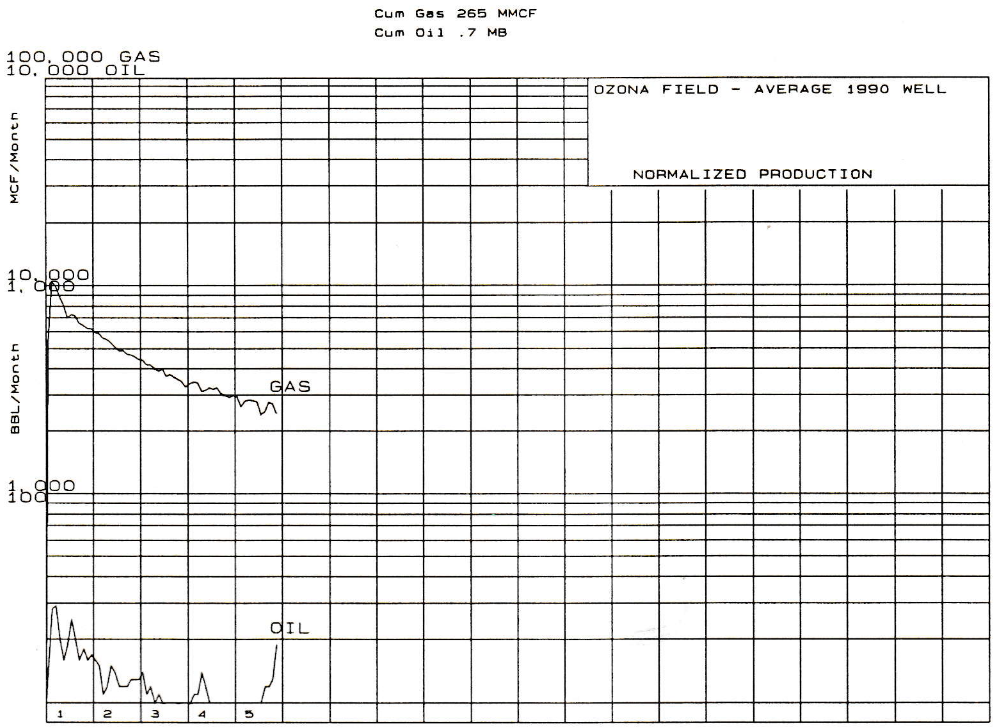

Figure 14 - Typical Recent Ozona Field Rate vs. Time Curve

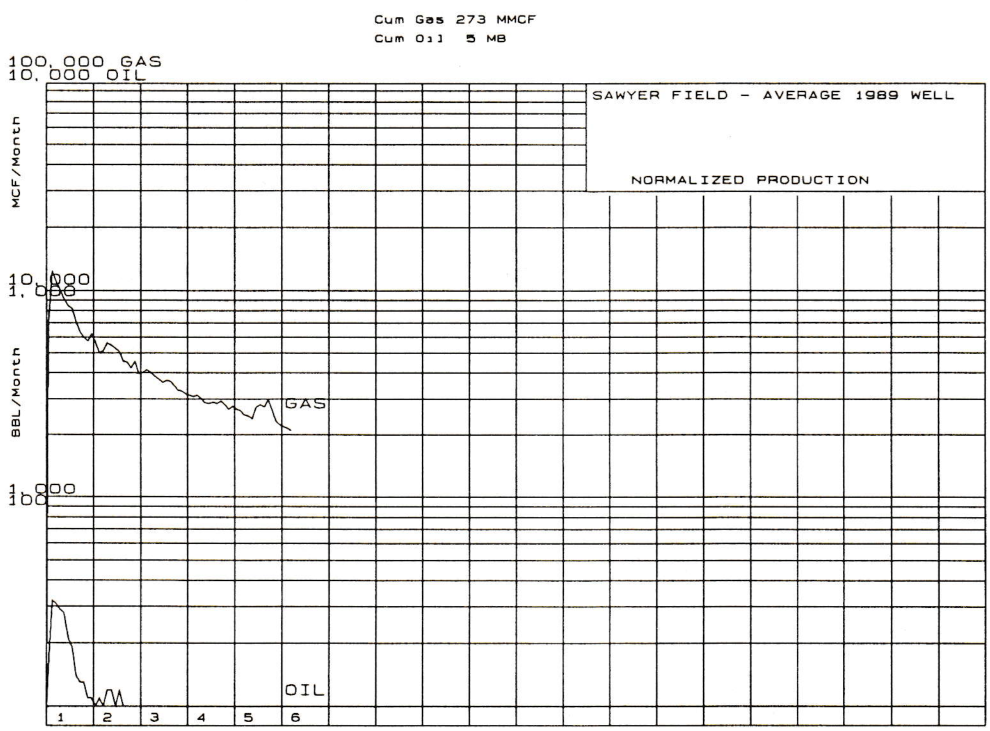

Figure 15 - Typical Recent Sawyer Field Rate vs. Time Curve