FRACTURING PROCESS BOOSTS DEVONIAN PRODUCTIVITY

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ABSTRACT

The main purpose in the treatment of the Devonian formation is to successfully place the proppant strategically, allowing an increase in production while producing as little non-hydrocarbon fluid as possible. In the Roepke Field in west Texas (Crane County), an operator was entering his first newly drilled well in the area. Difficulties in the completion for an offset operator included high treating pressures resulting in shortened pump schedules and low fracture conductivity and length. Issues for this operator included proper log analysis, perforating schemes, well-bore mechanics, and the main stimulation treatment design. After discussions with the service company, an alternative method of fracture treatment was successfully tried and adopted to solve these problems. This method included designing the treatment with calculated rock properties in a 3-D fracturing model pumping a high permeability regain fracturing fluid via tubing which doubled as a temporary production string. This paper will detail how this problem was successfully addressed.

INTRODUCTION

Two aspects were recognized as problems with the completion methods in the Devonian formation within the Cowden Ranch lease of West Texas. First, the method of acidizing the formation and returning to fracture treat later made the treatment difficult resulting in low sand concentrations. Second, treating the well down casing meant the well would have to be killed before running production tubing which reduced the effectiveness of the treatments. A more effective completion method to place the proppant would enhance the recovery of the hydrocarbon production.

In 2001, the treatments for the offset wells on the Cowden Ranch lease stimulation process included an acid job, followed by the flowback up the tubing and formation testing, and the main treatment down the casing. There could be two stages to the well if separate zones were present . The process of fracturing the wells usually took about seven days. The acid job and cleanup could take from 2 to 3 days, including removing the tubing from the wellbore. The main stimulation treatment took 1 day to treat down the casing. Then the production tubing had to be run in the hole and the well pumped. The average time to production included day for perforating the zone, three days for acidizing, a day for the treatment, and 2 days for running tubing for production.

The improved process included calculating rock properties from an electronic Triple combo log including Delta Time Compressional, perforating the zones with a cluster of 4 shots per foot (spf), and by pumping the fracturing treatment using 15% hydrochloric acid and an enhanced guar based fracturing fluid (A newly developed premium LT 21). The treatment would break down the formation and stimulate the zone all in the same treatment. Then, the well could be flowed for up to 45 days up the 2 7/8 in. tubing without killing the well. This technique has decreased the cost of the completions and reduced the “days to sales” with equal or better initial and sustained daily oil & gas production. Figure 1 shows the reduced completion days and Figure 2 shows the first 45 days of production for the Cowden Ranch lease’s wells normalized to the start of each well’s date of first production.

GEOLOGY AND MINERALOGY

The Cowden Ranch lease is located approximately 7 miles west of Crane, Texas, in the Roepke (Upper Devonian) field, on the Central Basin Platform of the larger Permian Basin.

The field produces from Devonian Tripolytic Chert. The chert is encountered at an average depth of 6200 ft. The trapping mechanism is a combination structural and stratigraphic.

Porosity and permeability generally decrease with increased carbonate content in the Devonian. Fractures in the brittle chert matrix are locally important in some reservoirs [1]. This was apparent, in this particular area, where the low gamma ray reading stretches over a 200 ft interval while only approximately 50-60 ft has a relatively low bulk density reading (Figure 3), which is also associated with the lower photoelectric effect reading. This is an indication as to when the formation lithology changes, from the chert into a Limestone, the effective porosity decreases, demonstrating an area of no pay (Figure 4).

The Cowden lease targeted the Devonian cherts. Typically, the area included one interval of sands of interest with a net pay of 40 ft. The average porosity is 16% with a permeability of 0.25 to 0.5 md. Openhole logs depict gas by the crossover between the density and neutron readings. A clean sand is also indicated by gamma ray reading of less than 25. The virgin pore pressure (BHP) was between 1,500 and 2,000 psi.

Understanding the rock properties is a key component to any successful stimulation.

COMPLETION OF COWDEN TEST WELL 1

In 2001, the offset Cowden Test Well 1 was drilled**.** The upper Devonian chert was completed using the method of wireline perforating, acidizing the formation, and returning to the well for the fracture treatment.

On the offset's first day, the Upper Devonian chert was wireline perforated. The next day, 2 3/8 in. tubing was run and the formation was acidized. During the acid job, 2,000 gal 15% hydrochloric acid (HCl) was spotted across the zone of interest. Once it was spotted in place, the annulus valve was closed and pump pressure was used to initiate a breakdown of the formation. The well was flowed back for 2 days to test the formation. The third day the tubing was pulled from the hole and the well head prepared for the main stimulation treatment. The main treatment included a 30 lb/Mgal cross-linked borate gel system for the fracturing fluid (Table 1). An enzyme breaker was utilized to help with breaking the fluid's initial viscosity and help recover the fluid. The treatment consisted of a 30 bbl/min rate with 25,000 lb of 16/30 Ottawa sand with the maximum sand concentration of 2 lb/gal. The fluid system also contained 2% potassium chloride (KCl) to help reduce swelling of the clays in the formation.

Upon completion of the zone, the well was flowed overnight to a tank until the well had no surface pressure or until the following day. Procedures then called for a pulling unit to run in the hole with the production tubing. The total time for the process could take 5 to 7 days before the production could begin up the tubing.

The Cowden Test Well 1 was put on sales with an average production rate of 50 BOPD and 50 Mcfpd. Several other Cowden wells were drilled and completed similarly with about a 50% chance of screen-out before all proppant was placed.

TRANSITION COMPLETIONS

In an effort to reduce the time and costs to sales and ensure treatments to completion, the thought process changed to a method of the acidizing the well and following with the main treatment. Also, the mesh of the sand would be changed for increased crush strength to 20/40 mesh resin coated sand, and the pumping rate was dropped to 20 bbl/min. A balance was needed between the pumping rate and the ability of successfully placing the treatment. This was achieved by the use of an enhanced fluid system capable of delivering a high viscosity yield with a high level of regained conductivity. Everything changed for the first well the new operator completed.

CURRENT COMPLETION METHOD

The Cowden Test Well 10 used a 2-day completion method, to increase the efficiency of the completion and reduce time to sales.

The first part of the method was to understand the rock and optimize the fracture treatment. Jobs were not being pumped to completion. The operator supplied las electronic log data to the service company who calculated rock properties such as young's modulus, poison's ratio, stresses, effective porosity, and permeability (Figure 4). The properties were entered into a 3-D fracture modeling program and the job was designed. Due to the results (Figure 5) of the 3-D modeling and in an effort to maintain a level of fracture confinement with the needed conductivity, changes included the fluid system, pumping rate, pad volume, proppant mesh and type, and the perforating scheme.

On the first day, the upper Devonian was wireline perforated and 2 7/8 in. tubing was run and the surface equipment prepared for fracturing. The next day, 2,300 gal of 15% iron control treated hydrochloric acid was pumped ahead of the 32,000 gal of a newly developed premium LT 21 frac fluid at 20 bbl/min carrying 32,000 lb of 20/40 curable resin-coated proppant down the tubing. The main treatment included a borate gel with an equivalent viscosity equal to a 30 lb/Mgal cross-linked borate gel system (Table 1). An enhanced enzyme breaker system was utilized to help with breaking the fluid for better regained conductivity in the formation. The treatment consisted of a 20 bbl/min rate with 32,000 lb of 20/40 curable resin coated sand with the maximum sand concentration of 3 lb/gal. The fluid system also contained 2% KCl to help reduce swelling of the clays in the formation.

The result was an increased flowing tubing pressure during the initial flowback before well died. Two of the three wells cleaned up by themselves, flowing up the tubing. They were produced for 30 and 45 days before workover crews entered the wellbore to pull the packer and re-run the tubing to begin pumping the well.

Additionally, the wells had no additional expenses for the time they flowed up the tubing. The reduced time to sales saved expenses and added revenue to the operator's bottom line.

A NEWLY DEVELOPED PREMIUM LT 21

The newly developed premium fracture fluid LT 21 has a reduced guar loading with equivalent viscosities of higher loadings (Figure 6) and has an enhanced breaker system for increased fracture conductivity.

The well will flow back more fluid in the recovery process reducing, the gel damage to the interval of interest. The system crosslink time can be delayed to reduce the viscosity, which will reduce the pipe friction as the treatment is pumped.

GENERAL COMPLETION PROCEDURE

The following is the current completion procedure.

Day 1

1. Rig up pulling unit.
2. Run a GR/CCL log and perforate upper Devonian.
3. Run in hole with 2 7/8 in. N80 tubing.
4. Prepare surface equipment for treatment.

Day 2

1. Rig up the fracturing equipment.
2. Treat the interval.
3. Flowback the well overnight to tank.

Day 45

1. Rig up the pulling unit.
2. Kill the well with 2% KCl water if necessary.
3. POOH with tubing and packer and re-run the tubing.
4. Place the well on pump.

IMPROVEMENTS AND BENEFITS

These following elements are essential to the success of the current completion method:

A. Immediate flowback of all fractured zones.

B. Increased fracturing fluid efficiency and recovery yielded an increased flowing tubing pressure.

C. Reduced time for well completion; a duration of 2 days instead of 7 to 14 days.

CONCLUSIONS

The completion method reduced the completion time and costs by $35,000 (Figure 7) for the Devonian chert formation on the Cowden lease by decreasing the total completion time.

Fracture treatments were 100% completed as designed.

Stand alone initial production lasted for 45 days with equal or better productivity (Figure 8 & Figure 9).

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NOMENCLATURE

Mcfpd	=	thousand cubic feet per day
spf	=	shots per foot
bbl/min	=	barrels per minute
lb/gal	=	pounds per gallon

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Table 1
Typical Devonian Frac Sequence

Stage	Volume	Fluid	Conc.	Proppant
1 - Acid Spearhead	2,300 Gal	15% NEFE Acid		
2 - Spacer	2,000 Gal	Water Frac G - R (21)		
3 - Shut-In				
4 – Pad	3,500 Gal	A newly developed premium frac system		
5 – Pad	13,500 Gal	A newly developed premium frac system	0.50 lbm/gal	100 Mesh, SSA-2
6 - Proppant Laden Fluid	3,500 Gal	A newly developed premium frac system	1 lbm/gal	20/40 Resin Coated Sand
7 - Proppant Laden Fluid	3,500 Gal	A newly developed premium frac system	2 lbm/gal	20/40 Resin Coated Sand
8 - Proppant Laden Fluid	5,000 Gal	A newly developed premium frac system	2.50 lbm/gal	20/40 Resin Coated Sand
9 - Proppant Laden Fluid	3,000 Gal	A newly developed premium frac system	3 lbm/gal	20/40 Resin Coated Sand
10 – Flush	1,500 Gal	Water Frac G - R (21)		

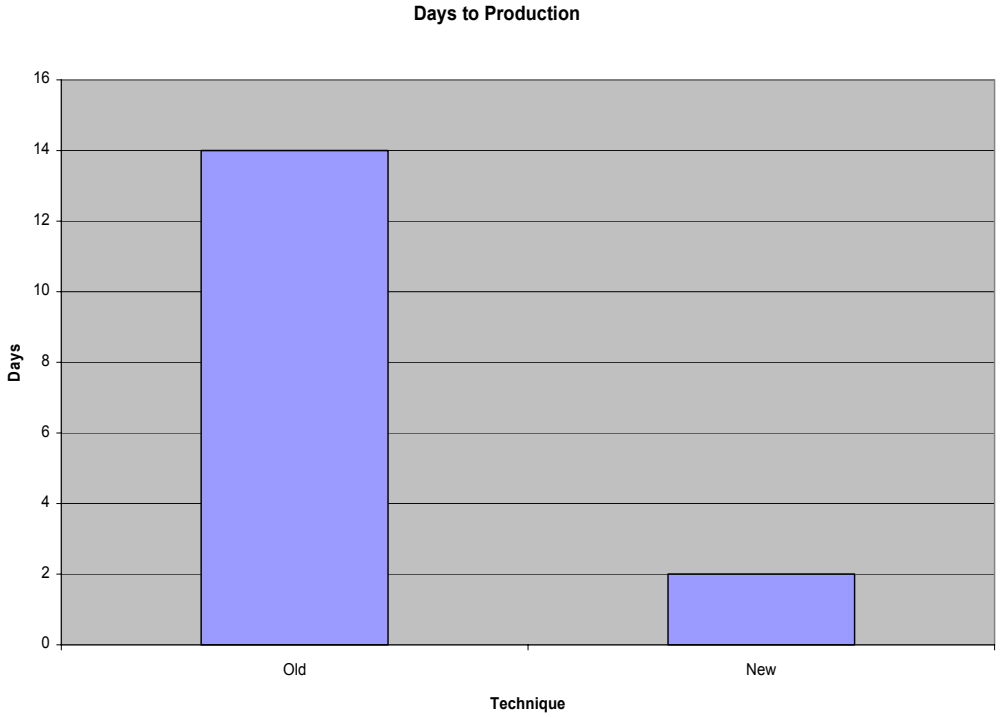

Figure 1 - Days to Production

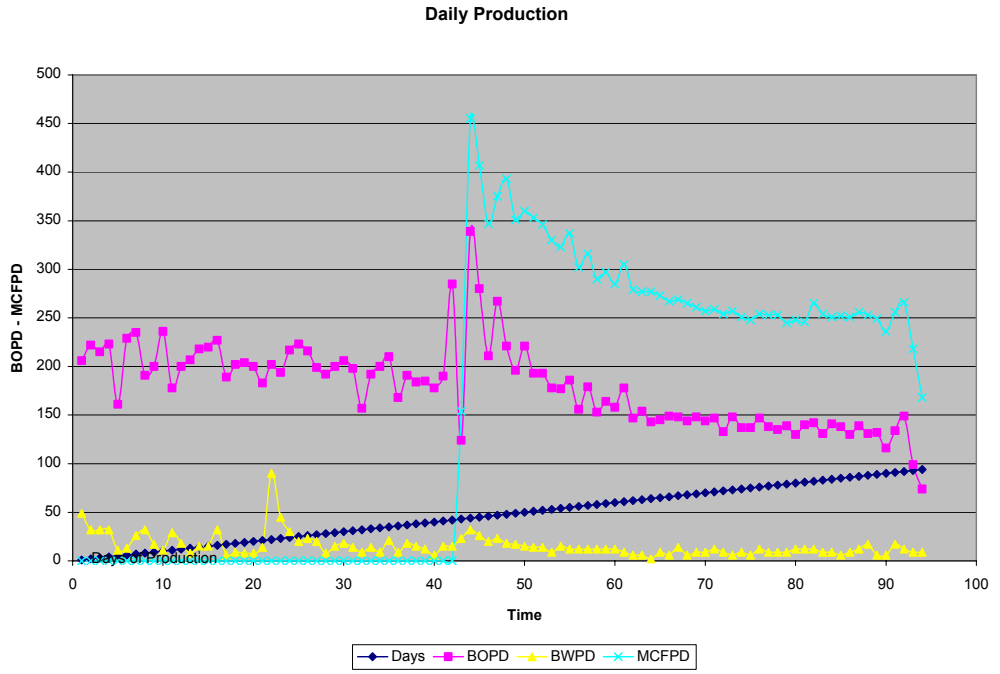

Figure 2 - Daily Production for 45 Days

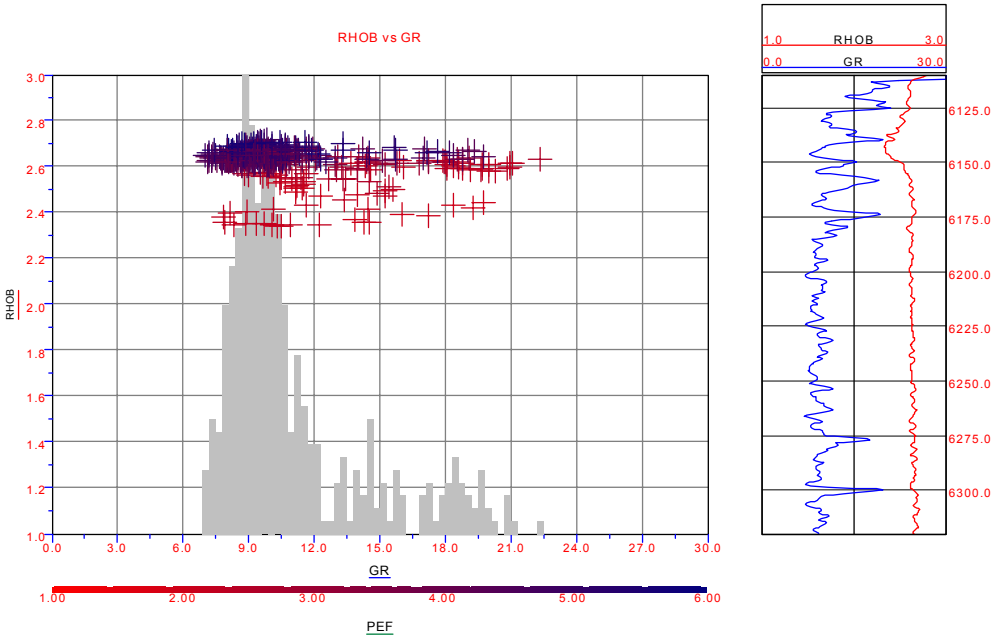

Figure 3 - Cross Plot Gamma Ray vs. Bulk Density vs. Photoelectric Effect

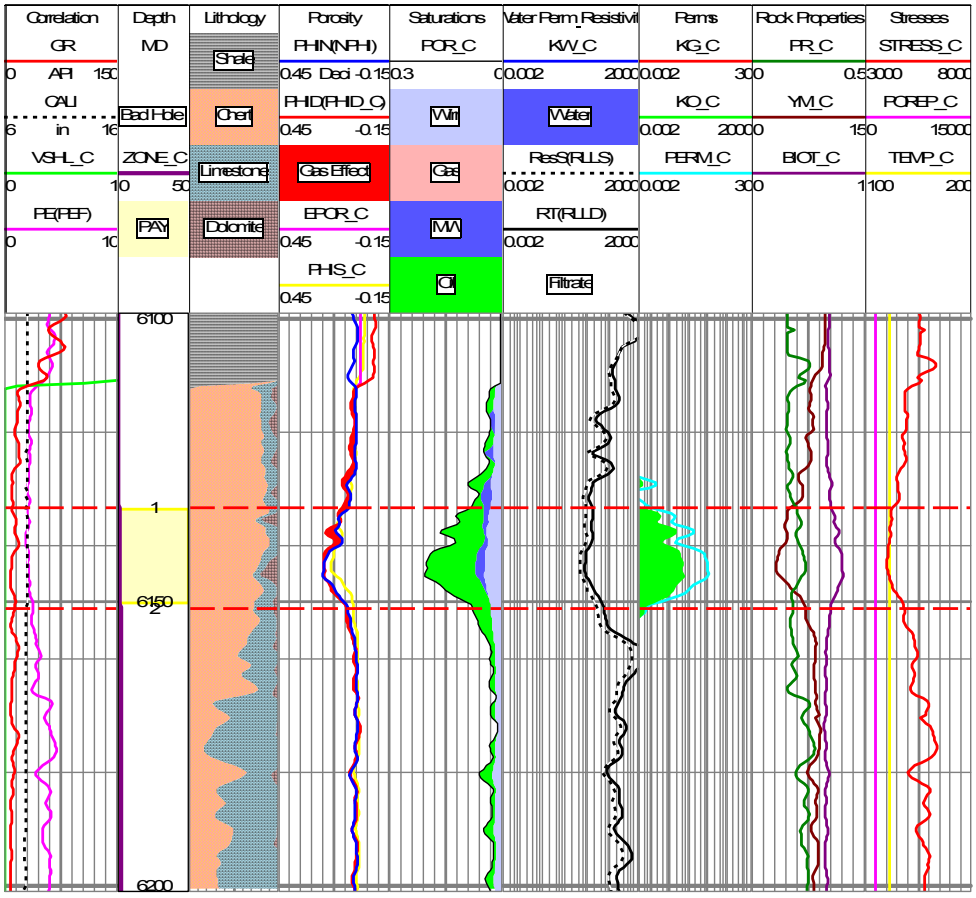

Figure 4 - LAS Log Calculations and Rock Properties

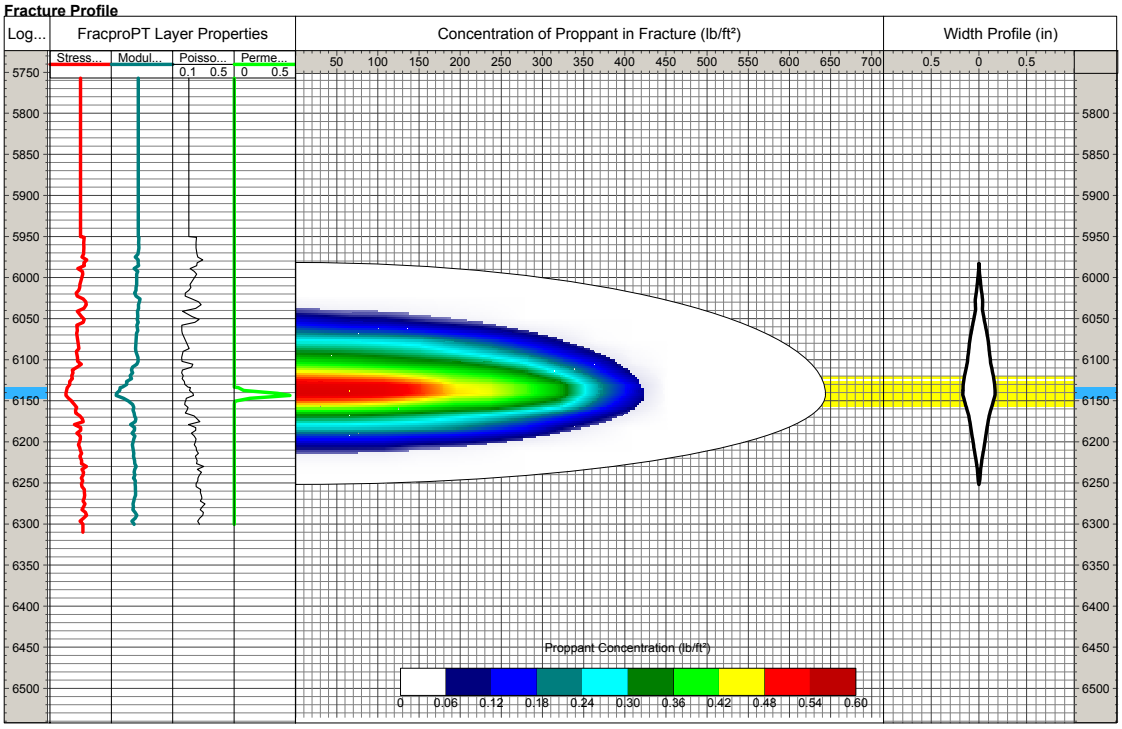

Figure 5 - 3-D Fracture Model

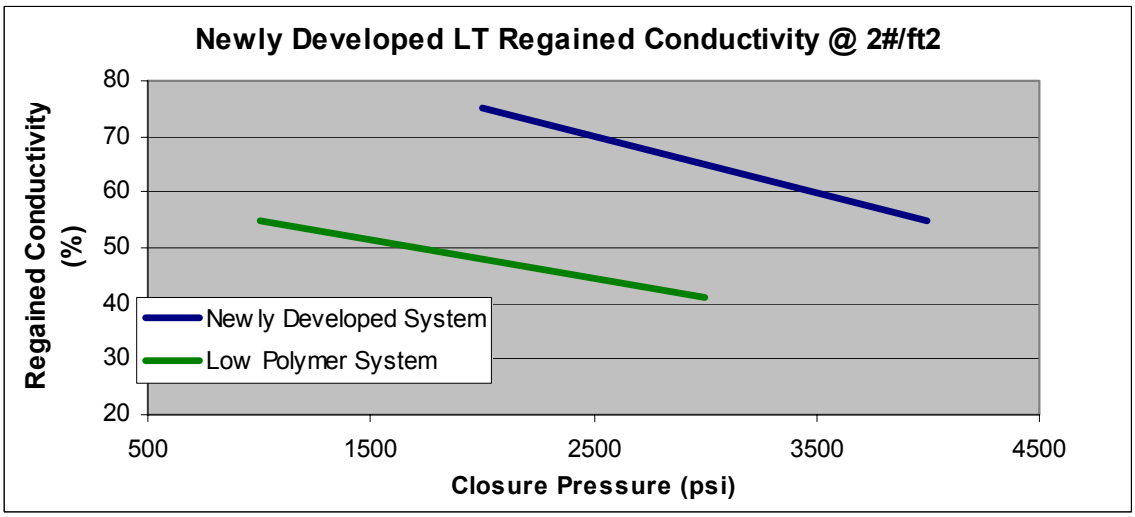

Figure 6 - A Newly Developed Premium Fracturing Fluid

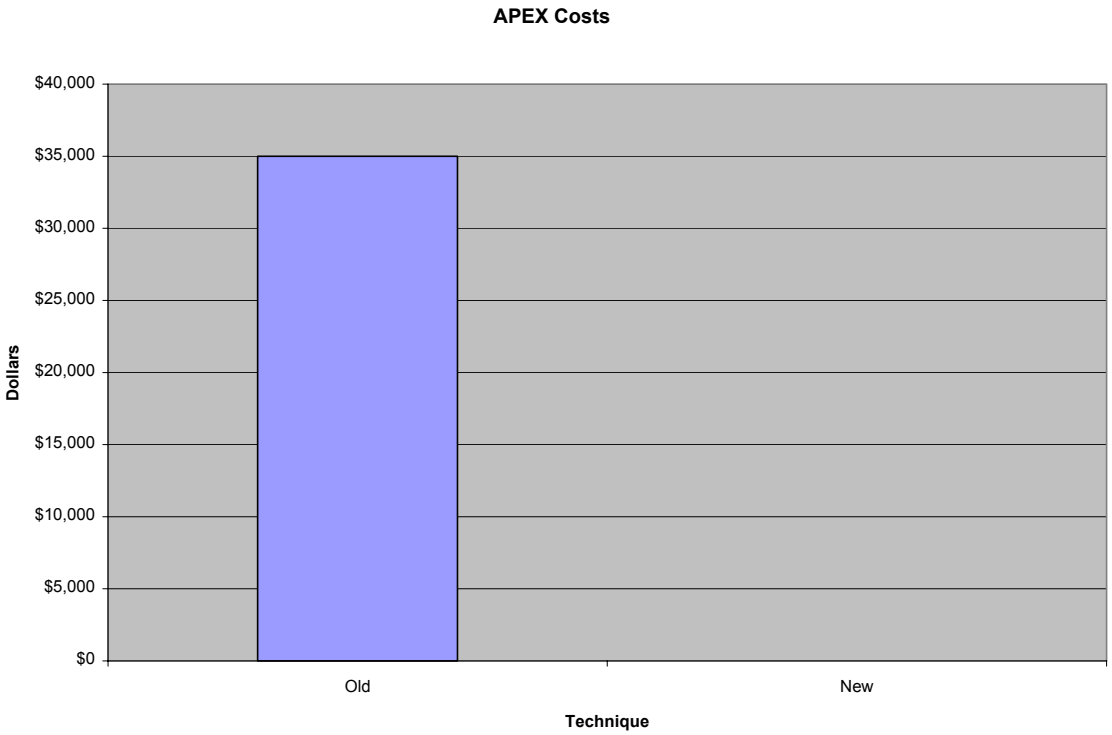

Figure 7 - Differential Costs Per Well

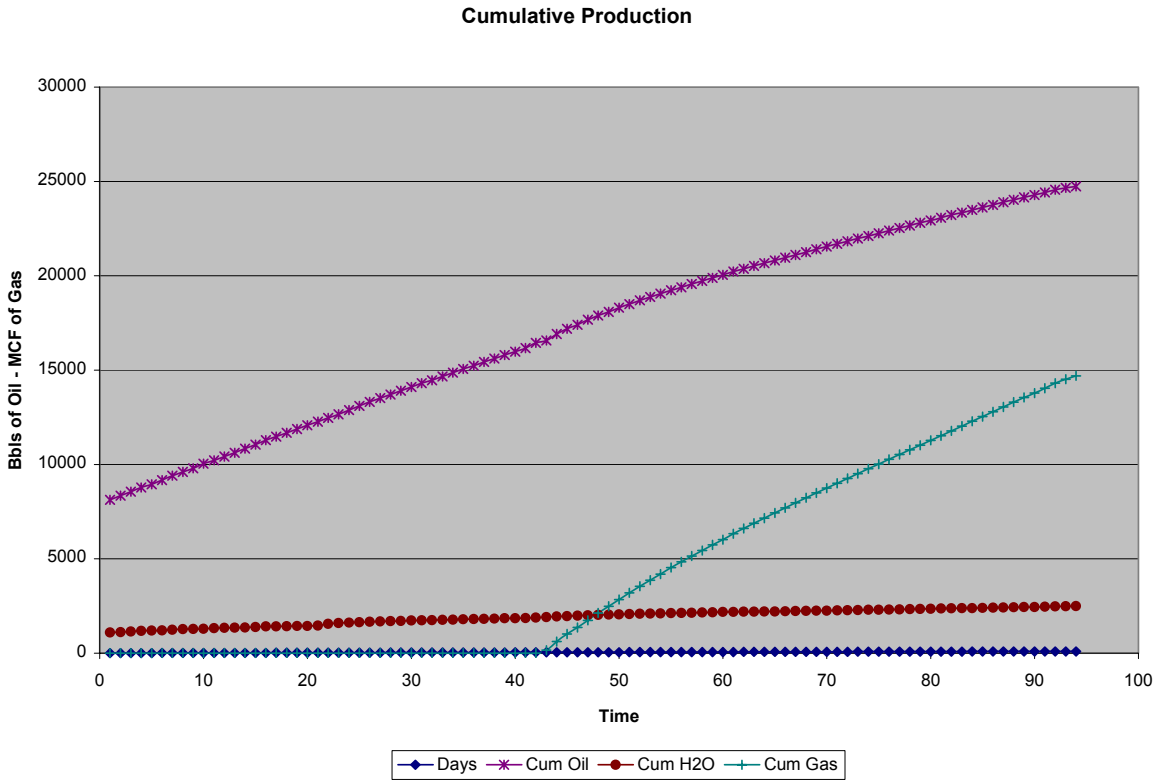

Figure 8 - Cumulative 45 Days of Production

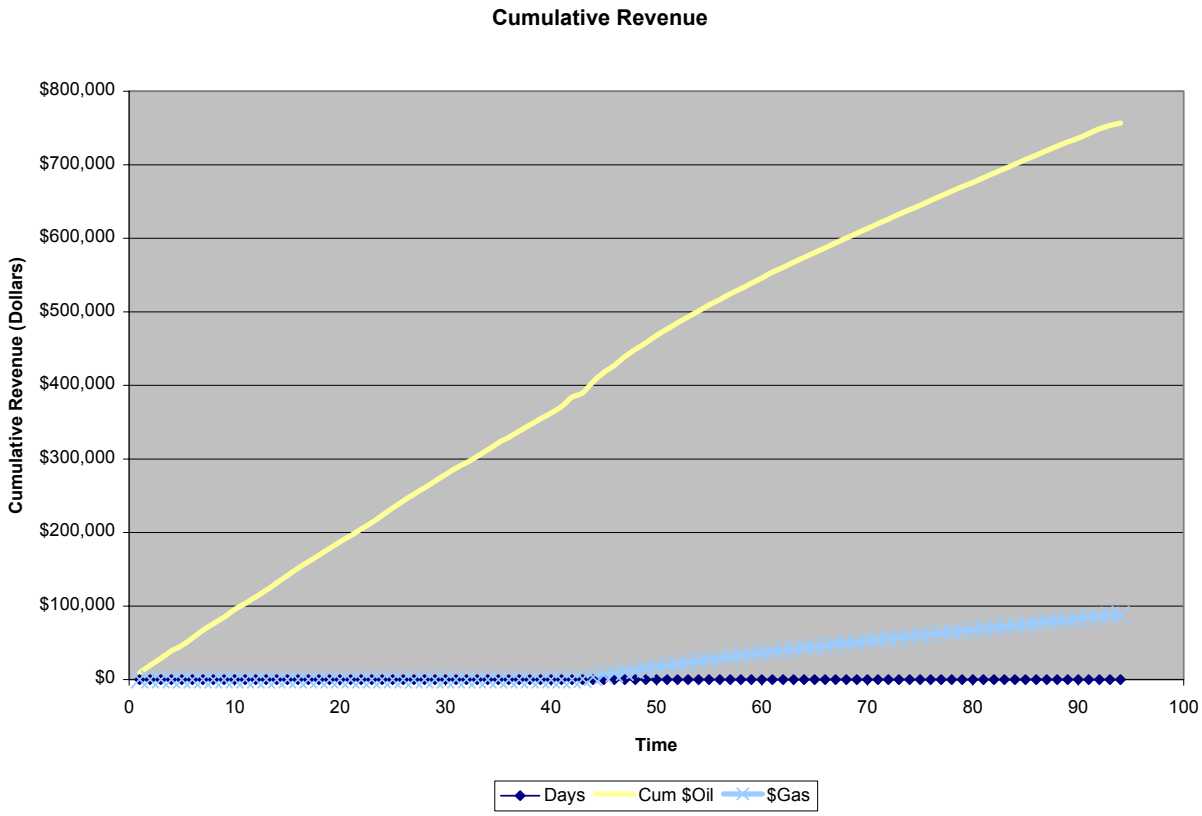

Figure 9 - Cumulative Additional Production Revenue