COILED TUBING FRACTURING SOLUTION FOR VERMEJO PARK RANCH

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ABSTRACT

Coiled tubing fracturing has been widely used as a method of stimulation for the coal seams on the Vermejo Park Ranch. The purpose of this paper is to compare associated cost, production results, and differences in methodology between coiled tubing fracturing and conventional fracturing. The comparisons will be drawn between a sampling of 90 wells completed on two different areas of the field.

Past stimulation (conventional fracturing) was done with stage work pumping down casing. This would affect 3 to 9 stages per well during pumping. Current stimulation being done on the Vermejo and Raton coal seams utilize coiled tubing (coiled tubing fracturing). The CT fracturing process increased the number of stimulation stages to 4 to 18 per well. This allows for a more accurate placement of proppant and a more effective stimulation of the producing zones in the well.

INTRODUCTION

The wells to be discussed in this paper are located in the Raton Basin of northern New Mexico. Historically, coal bed methane gas was a nuisance. It caused mining accidents and downtime. At first low methane prices made this low pressure gas undesirable. The first coal-bed methane wells drilled in the area were drilled to reduce gas in the coal mines of the area (Flores and Bader, 1999). Even after coal bed methane technology got its start in the late 1980's skepticism persisted until gas prices began increasing. Now we have the Black Warrior Basin, San Juan Basin, Powder River Basin, Raton Basin, etc. Following is a brief recent history of the Raton Basin and the Vermejo Park Ranch.

In 1973 the Pennzoil Company purchased Vermejo Park Ranch from the Gourley Estate and begins a wilderness management program. In 1982 the Pennzoil Company donates 100,000 acres to the U.S. Forest Service – the largest and most valuable donation of private land ever made to that agency. In 1989 Pennzoil begins its pilot project and the first CBM exploratory wells are drilled. During this same year Meridian also begins its CBM project in the Apache Canyon area of the Raton Basin. Evergreen Resources starts its Raton Basin drilling program in 1991. In September of 1996 Ted Turner acquired Vermejo Park Ranch from the Pennzoil Company. In May of 1999 PennzEnergy and Sonat E&P enter into a joint venture to develop the Ranch's coal bed methane assets. This area is currently being operated by El Paso Energy Raton, LLC.

GEOLOGY

The Raton Basin is bounded on the west by the Sangre De Cristo Mountains, on the northeast by the Apishapa arch in Colorado, and on the southeast by the Sierra Grande-Las Animas arch in New Mexico and Colorado (Johnson and Wood, 1956). General stratigraphy of the area has the deepest mapped sedimentary unit being the Pierre Shale which is overlain by the Trinidad Sandstone; both are Upper Cretaceous in age. The first of the coal bearing formations, the Vermejo formation, overlies the Trinidad sandstone and is Upper Cretaceous in age as well. The second coal bearing formation the Raton is Paleocene in age and is followed by the Poison Canyon formation also of Paleocene age. The Vermejo and Raton formations are commonly intruded by igneous dikes, sills, plugs, stocks, and laccoliths (Flores and Bader, 1999).

The Vermejo the deepest of the coal bearing and methane producing formations is primarily made up of fine to medium grained sandstone with mudstone, carbonaceous shale, and extensive thick coal seams throughout (Pillmore and Flores, 1987). The Vermejo formation was deposited in an active and abandoned delta plains environment (Flores and Bader, 1999).

The Vermejo coal is usually found in 2 ft. to 8 ft. strata from 1,900 ft – 2,300 ft. The Vermejo's coal is primarily a HiVol A to MedVol Abituminous coal with an average in-situ cu ft/ton range of 300 to 350 with highs of as much as 600 cu ftl ton in some areas.

The Raton formation the thicker of the coal bearing formations is divided into four main subgroups. In ascending order they are a basal conglomeratic interval, a lower coal rich interval, a fine grained sandstone interval, and an upper coal rich interval (Lee, 1917). The coal rich intervals are interbedded with fine grained sandstone, siltstone, and mudstone (Pillmore & Flores 1987). The depositional environment of the Raton formation includes fluvial channel, overbank-levee, crevasse splay, flood-plain lake, and low-lying and raised swamps (Strum, 1985). The coal was deposited in the low-lying and raised swamp environment.

The Raton coal is usually found in 2 ft. strata from surface to 1,800 ft. The Raton's coal is primarily a HiVol B to HiVol A bituminous coal with an average in-situ cu ftlton of 100.

Both the Vermejo and Raton coals average 20% ash content basin wide.

CONVENTIONAL FRACTURING COMPLETION SUMMARY

The well spacing on the Vermejo Ranch is contractually limited to 160 acres. Off the Ranch, operators normally use 80 acre spacing. All of El Paso's CBM wells on the Vermejo Park Ranch use 5-1/2" 15.5# or 17# casing from surface to TD as the production string. A multitude of different proppants have been and are still being used for completions in the coal. Currently El Paso is using 16/30 Brady proppant. In the past, operators in the area have used straight 20140 and 20/40 with 12120 proppant combinations. Other operators in the Raton Basin are using 20/40 resin coated proppants. Further experimentation with proppant concentrations is also being evaluated. Last year's program used 8,000 lbs of proppant per ft of coal with a maximum proppant concentration of 4 ppg. In 2002 the amount was increased to 10,000 lbs per ft of coal and a maximum proppant concentration of 6 ppg. Previously the majority of conventional treatments were 72 quality linear gel foams with some crosslinked foamed and non-foamed fluids used as well.

The conventional treatments consisted of 3-9 stages per well treated down casing. Perforating and bridge plugs were spotted between stages and the bridge plugs removed at the completion of the well.

COILED-TUBING FRACTURING COMPLETION SUMMARY

Coiled-tubing fracturing was introduced to the Raton basin as a method to isolate the individual coal stringers and effectively and efficiently stimulate them. Prior to the wells completed in the Raton basin the vast majority of the coil-tubing fracturing completions had been done in Canada. The work in Canada proved the process and developed coiled tubing fracturing into an efficient way to place proppant into bounded porosity stringers.

Coiled-tubing fracturing is a system that allows the user to stimulate multiple zones individually in a short period of time. The system begins with the perforation of all intervals to be completed. These are selected so as to minimize the potential for communication between perforation sets. Individual perforation intervals are isolated using a compression set packer and modified cup with blast joints in between, thereby eliminating the need for separate plug and perforating runs. These tools are run on Coiled tubing which allows the user to move the tools across each zone of interest and stimulate at the rates, pressures and volumes desired. An additional benefit of utilizing coil tubing, and, essentially, the reason the technology works, is the ability to "snub" by definition. Tools are moved while pressure is on the tubing/casing; pressure across the packer element is dispersed by way of an internal equalizing valve. The primary advantage of using a coiled-tubing fracturing system is that an accurate placement technique is coupled with the ability to tailor the stimulation treatment design for each porosity unit or section of pay straddled.

Zones in the area have been fracture stimulated with a variety of fluids: 30# linear gel with Nitrogen foam, 25# borate crosslinked fluid, and 20# borate crosslinked fluid. The average number of stages per well was 8 with a range of 4-18 stages. Jobs were pumped at an average rate of 8 bpm and designed sand volume was based on 10,000 lbs per net ft of coal.

RESULTS

The wells on the Vermejo Park ranch are broken up into separate pods. This paper deals with the work performed in the A and E pods. These pods are selected by reservoir parameters and geologic boundaries (Fig 1). In the **A** pod a total of 58 wells were completed 24 of the wells were stimulated by coiled tubing fracturing (Fig 2). In the E pod 32 wells total were completed, 19 of them were stimulated with the coiled tubing fracturing process (Fig 3). The following results are a comparison between the conventionally stimulated wells and the wells stimulated with coiled tubing fracturing. Comparisons will be drawn on the percentage of pay effectively stimulated, completion costs, and production trends.

The first comparison to be made between conventional and coiled tubing stimulation is the percentage of pay being effectively stimulated by each method. The 'net pay stimulated' values are derived by taking into account the amount of sand pumped into the zone and the number of coal seams being stimulated per stage. From tracer logs we were able to deduce that only about 2/3rd's of the perforated coals were being propped with sand. Since not every job was traced we developed a system for estimating the effective net pay stimulated. First, any zone that did not take in at least 1,000 lbs of proppant per ft of pay was considered not effectively stimulated and, therefore, was removed. The entire interval was considered effectively stimulated if there was only one coal seam in the stage and the required volume of proppant was placed. When there was more than one coal seam in the stage we would take the total net coal footage and multiply it by 0.66 (2/3rd's). This number was based off of our best estimates from radioactive tracer logs. In the **A** pod the conventional treatments showed a percentage net pay stimulated of 61% the coiled tubing treatments showed 71% of the net pay was stimulated (Fig 4). In the E pod conventional stimulation was 59% versus 81% (Fig 6). These numbers show an increase of at least 10% and as much as 22% more net pay being stimulated per well across the field (Table 1).

The next point of comparison are the total completion costs associated with the stimulation treatment which include the cement bond log, perforating, frac job, and after frac clean out costs. For the **A** pod the associated costs with performing conventional treatments averaged $125,507 per well versus $95,464 per well for coiled tubing stimulation (Fig 5). For the E pod the conventional treatments averaged $112,127 per well compared to $149,735 per well for the coiled tubing stimulations (Fig 7). On average across the field the coiled tubing completion costs were $2,920 per well less than the conventional completions (Table 1).

The **A** Pod gives us a unique look at the differences in production from one year to the next and from different completion types. During the previous year's program all of the wells in the **A** Pod were conventionally completed. In 2002 there is a 2:1 ratio between the numbers of Coil Tubing completed jobs and conventionally completed jobs. From the **A** Pod production graph (Fig 8) you can see that there is a difference in the way that the wells were being brought on production from one year to the next. In 2001 the wells were cleaned up as quickly as possible in order to unload the completion fluid and bring the wells online. In 2002 the wells were brought on more gradually to help reduce sand flow back and coal fines migration. The most encouraging trend that can be derived from the A Pod production is the way that the production curve of the Coil Tubing jobs begins to increase during the last 45 days of production for the 2002 wells. This trend is due to the final 17 coil tubing completed wells being brought online. While 45 days of production is still very early *to* predict how the wells will ultimately produce, it is an encouraging trend. But, the most significant information to note is that the Coil Tubing completed wells, which averaged 17.61 net ft of coal per well, are producing more gas per ft of pay than the conventionally completed wells, which averaged twice as much net pay per well than the Coil Tubing completed wells. This says a lot toward how effectively Coil Tubing fracturing can complete the net pay in a well versus conventional methods.

The E Pod gives us another look at the differences in production. There is the same number of wells completed in this Pod during the two project years. Also, the wells have almost identical net footage of pay with less than a 1 ft difference between years. In 2001 only 4 of the 16 wells were completed using Coil Tubing while in 2002 15 of the 16 wells were completed with Coil Tubing. As shown on the E Pod graph (Fig 9) the 2002 wells have come on line much better than their 2001 counterparts. Even with the change in how the 2002 wells were brought on line the initial production numbers are considerably better than the 2001 wells. Again, with only 3 months of production available for the 2002 wells it is still too early to tell how the wells will ultimately produce but, the initial trend is encouraging.

FUTURE DEVELOPMENTS

On going completion procedures include coiled tubing fracturing as the primary form of stimulation in the area, along with continued evaluation of different completion types in specific areas of the Ranch, and changes in proppant selection. There are plans to use temperature probes as a means of determining where the producing zones are and when, during the life of the well, do the different zones begin to contribute. As in the past, data will continuously be collected and evaluated in order to optimize the completions. There will be continued monitoring of the production data which will help in future decisions of completion types and help to identify production trends in the different areas of the Vermejo Park Ranch. There have been and will continue to be changes in the completions procedures in order to optimize the process and achieve the greatest economic gain.

CONCLUSIONS

The coiled tubing fracturing program was considered to be a success for the Vermejo Park Ranch project from an economic and operations standpoint. We were able to lower overall completion costs an average of $2,920 per well while at the same time being able to effectively stimulate a greater percentage of pay, 10 to 22 percent more net pay per well.

With the experiences gained from the work performed at the Ranch we were also able to increase our efficiency with the Coil Tubing Fracturing process and finish the project ahead of time. Towards the end of the project we were able to consistently finish 6 to 7 stages per day. Also, while much of the production data for 2002 was limited at the time of this paper, the early numbers are looking favorable for the Coiled Tubing completions. It is important to note that Coiled Tubing Fracturing is not just a local technology that was effective on the Vermejo Park Ranch but a new technology that can, and has been, effectively used to stimulate bounded formations in other areas as well.

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Table 1
Cost Summary for **Pod** A & E

Pod A

	CBL	Perforating	Perf Costs/Net Pay	Frac	Total Frac(CBL Perf Frac)	TFCwCO	Clean Out Costs	Frac/Net Pay	Total Frac/Net Pay	TFCwCO/Net Pay	Frac/Net Pay Slim	Total Frac/Net Pay Stim	TFCwCO/Net Pay Stim	Frac/lb of Sand	Total Frac/lb of Sand	TFCwCO/lb of Sand	Net Pay
Conventional Stimulation	'$2,337 91	$8,38598	$25534	$101,555 92	$117,059 79	$125,507 15'	$9,68921	$3,15326	$3485 39	$3,795 70	$5,02813	$5,480 02	$6013 79	$0 46	$0 51	$0 56	109[illegible]
Coiled Tubing Stimulation	$1,500 00	$3,500 00	$218 15'	$7805900	$84,99683	$95,46401	$4,400 29	$4,42266	$4,71211	$4,94383	$6,96494	$6,76787	$6,93520	$0 60	$0 63	$0 67	41[illegible]

Pod E

CBL	Perforating	Perf Costs/Net Pay	Frac	Total Frac(CBL Perf,Frac)	TFCwCO	Clean Out Costs	Frac/Net Pay	Total Frac/Net Pay	TFCwCO/Net Pay	Frac/Net Pay Slim	Total Frac/Net Pay Stim	TFCwCO/Net Pay Stim	Frac/lb of Sand	Total Frac/lb of Sand	TFCwCO/lb of Sand	Net Pay

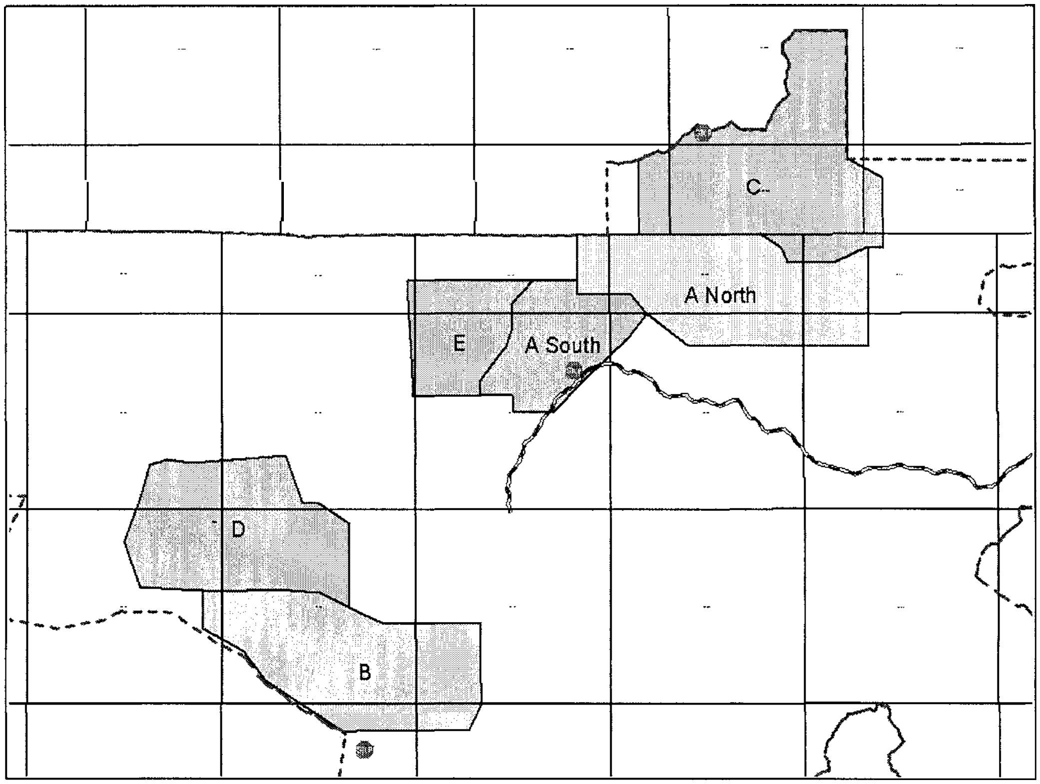

Figure 1 – Map of Vermejo Park Ranch Showing Pod Locations

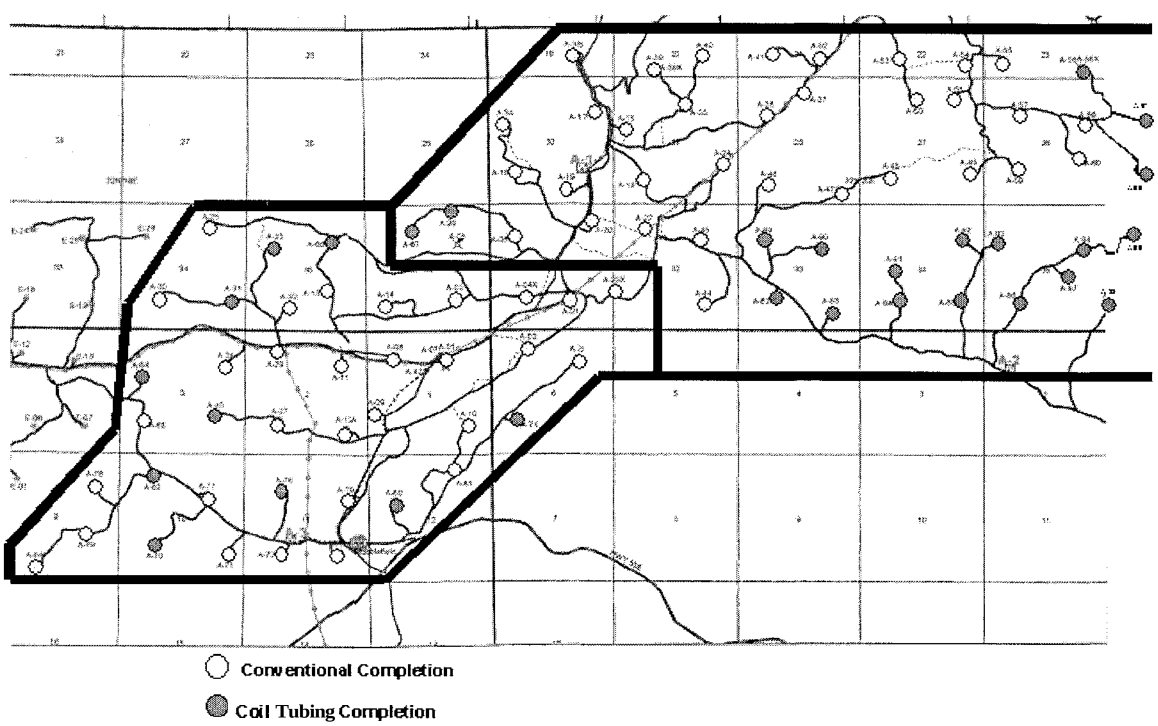

Figure 2 – Map of Pod A Showing Well Locations and Completion Types

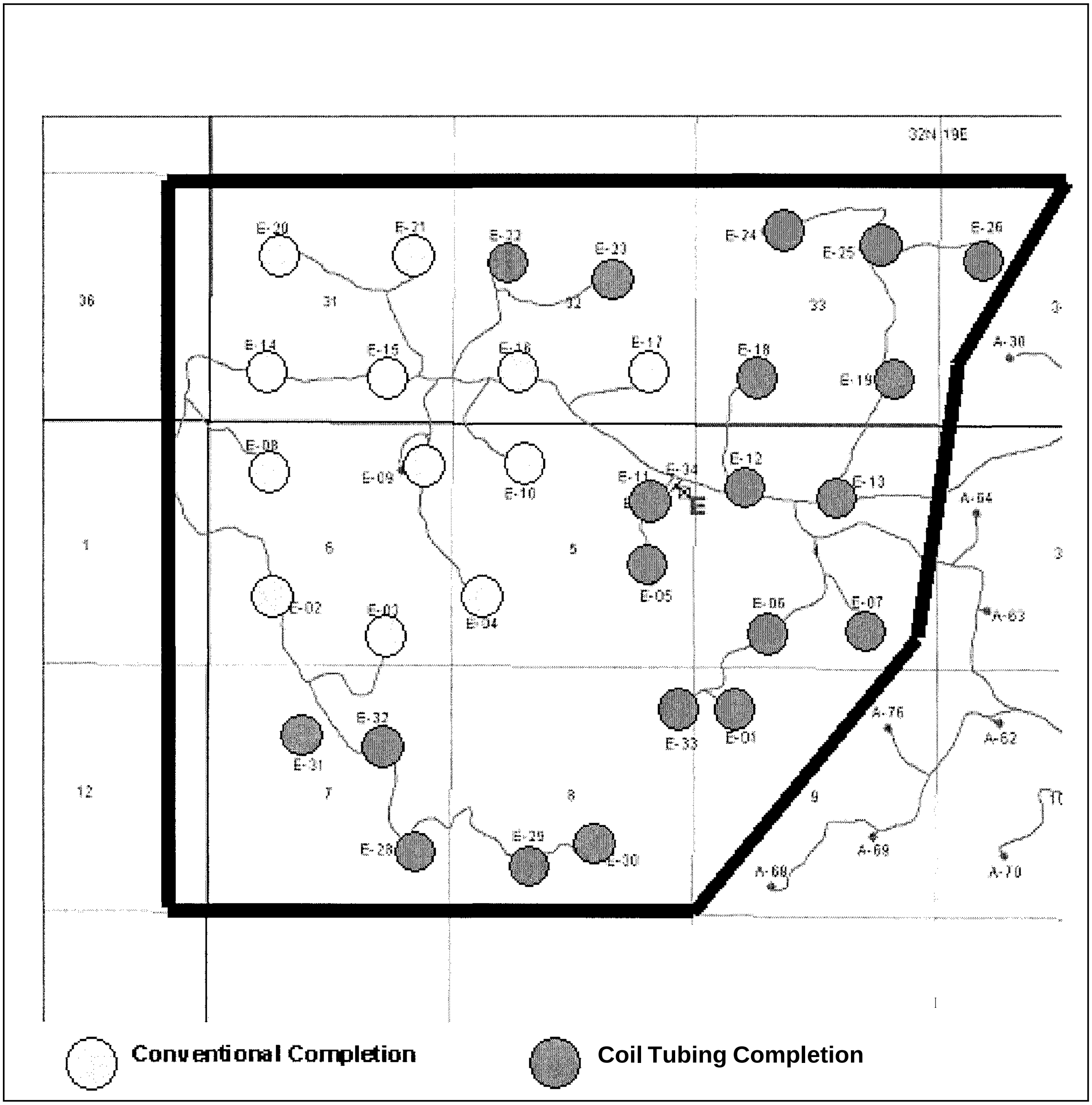

Figure 3 – Map of E Pod Showing Well Locations and Completion Type

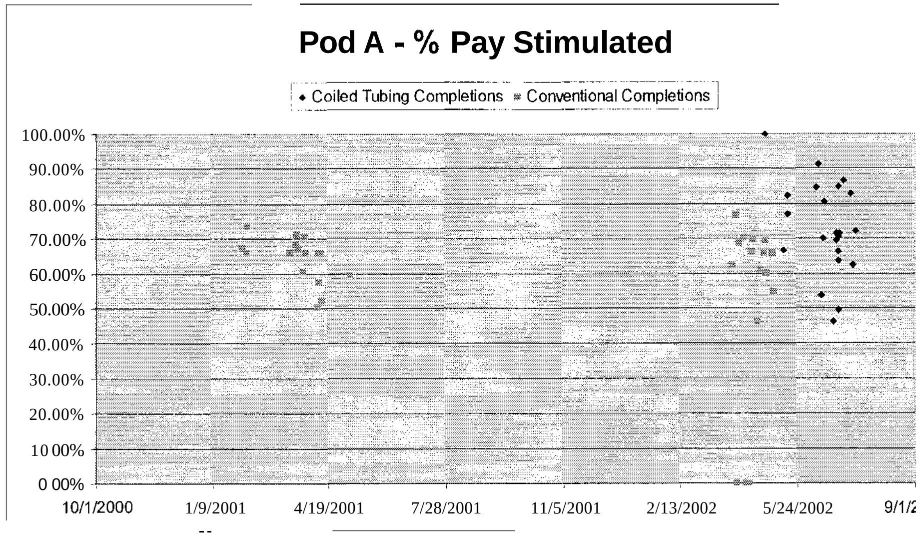

Figure 4 – Graph – Pod A % Net Pay Stimulated

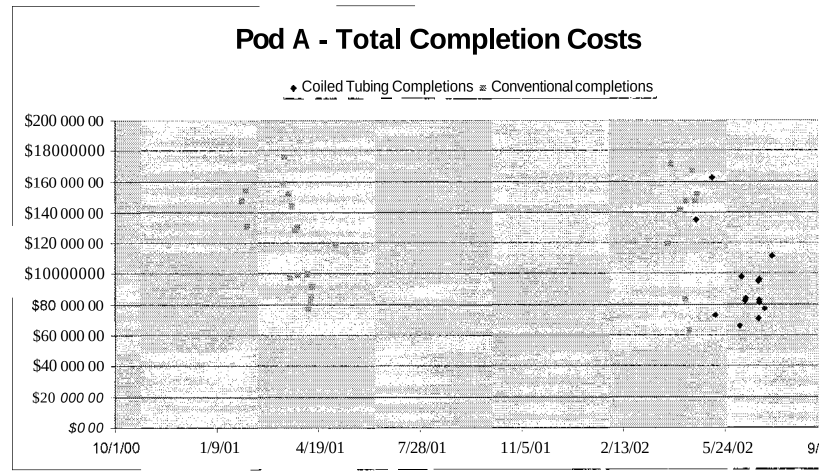

Figure 5 – Graph - Pod A Total Completion Costs

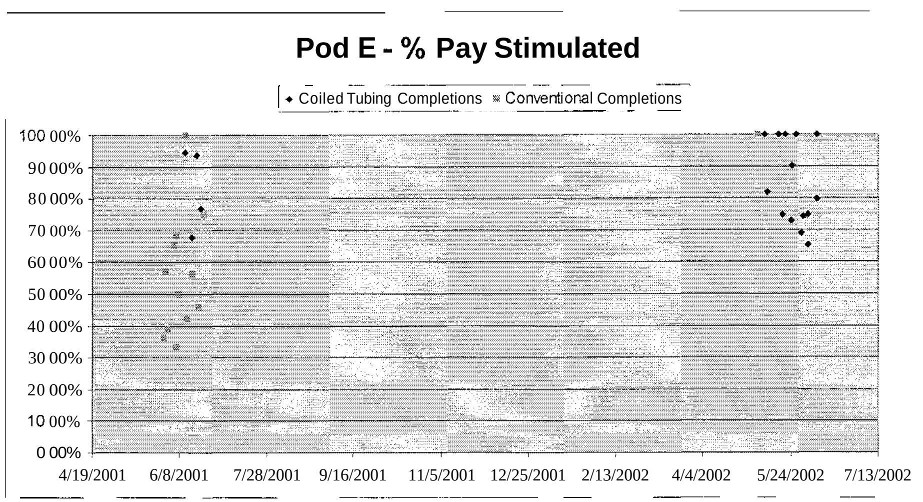

Figure 6 – Graph – Pod E% Net Pay Stimulated

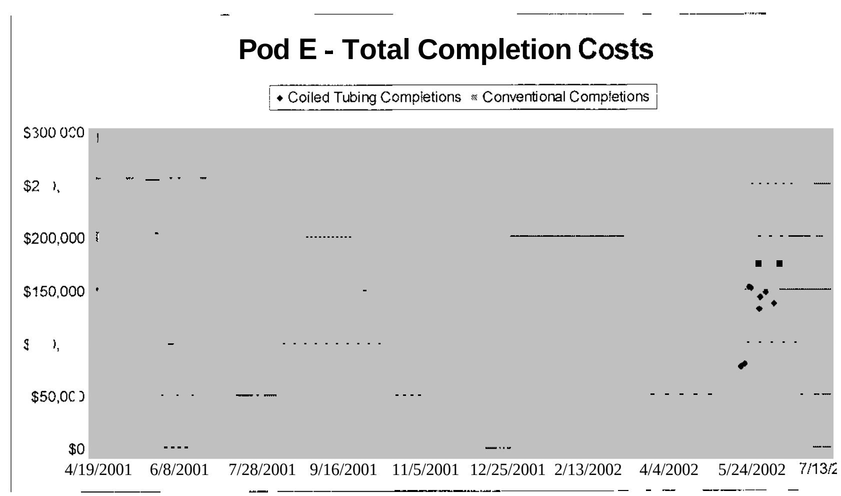

Fig ure 7 – Graph – Pod E Total Completion Costs

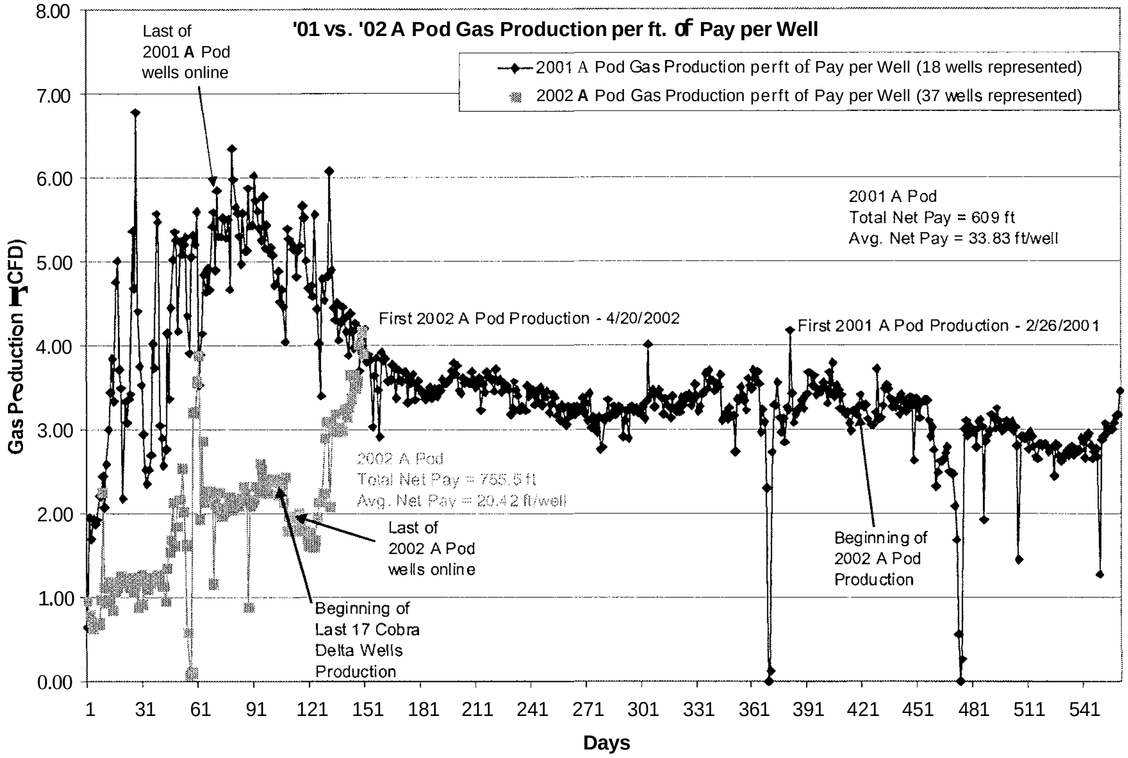

Figure 8 - Graph – Pod A Production Comparison

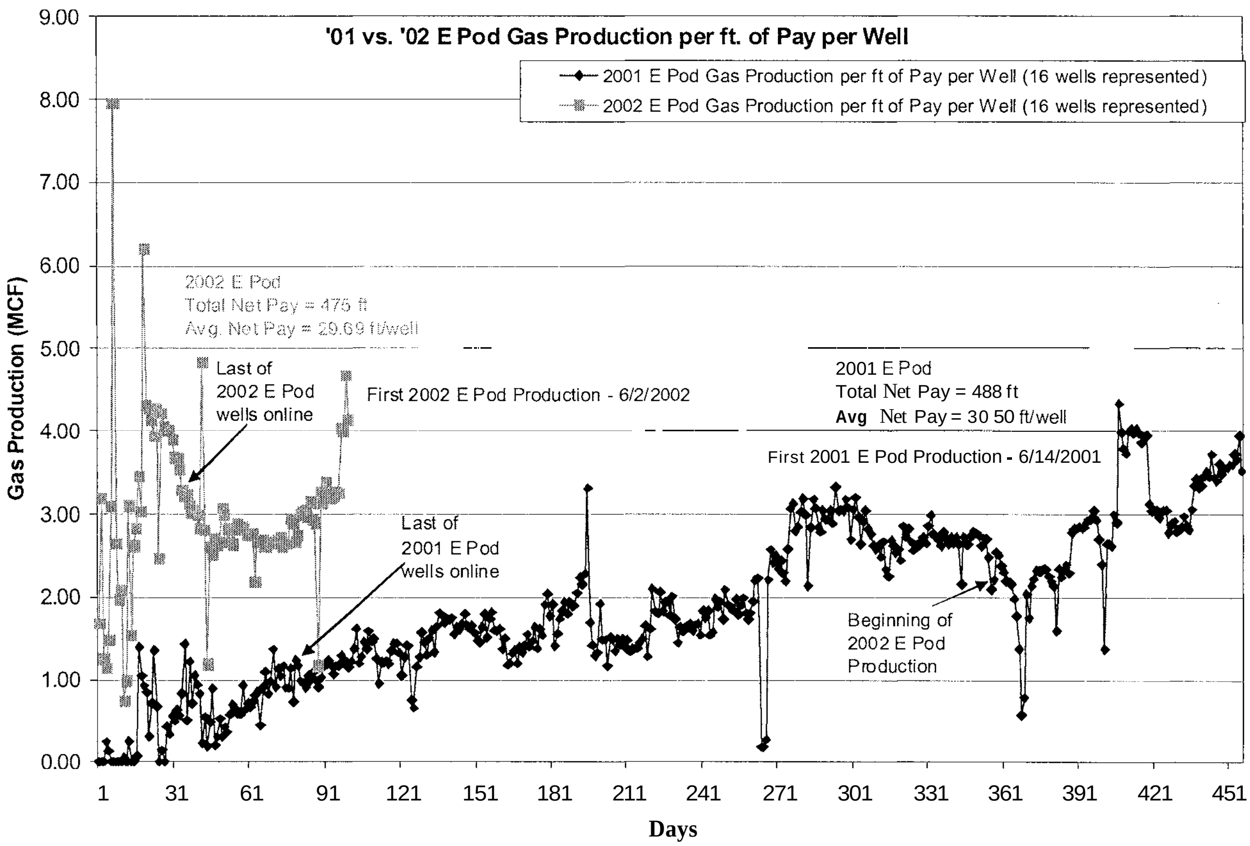

Figure 9 – Graph – Pod E Production Comparison