UTILIZING A VENTURI JET JUNK BASKET BHA TO CLEANOUT HORIZONTAL YESO PRODUCERS

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ABSTRACT

Utilizing a Venturi jet junk basket bottomhole assembly (BHA) with stick pipe has enabled Concho to successfully clean out a wellbore without the added cost of energized fluids and minimize the risk from getting stuck due to lost circulation. Well intervention and remediation is an essential step to ensure the maximum inflow volumes are being obtained and recovered volumes are matching the established production decline curves. Frac sand that migrates into the wellbore during production and scale precipitation can hinder the well's drawdown. One of the biggest challenges in being able to remove solids from the wellbore in the New Mexico Shelf Platform Yeso formation is low bottom-hole reservoir pressure. Traditional cleanout methods utilize forward or reverse circulation and the assistance of energized fluids. These methods require higher bottom-hole reservoir pressures than that which is found on the New Mexico Shelf. The inability to maintain circulation during traditional cleanout operations has resulted in unsuccessful jobs and diminished economic efficiencies for projects in recent years prior to the application of the Venturi tool. This document describes case histories and data compiled from results of workovers in 2015 and 2016. Overall, a total of 22 projects were successfully executed, providing an average incremental uplift of 35 barrels of oil per day.

INTRODUCTION

Over the past decade, the Permian basin has seen a paradigm shift in the way operators have developed their acreage. The industry took the technology proven in the Barnett and Marcellus Shale plays and applied those methods to drill and complete horizontal wellbores in the Permian. In the Southeastern New Mexico area of the Permian, operators have followed this trend and have transitioned from drilling vertical wells to horizontal wells in addition to modifying their completion strategies. Horizontal development on Concho's New Mexico Shelf Asset began in 2010 targeting the Paddock zone of the Yeso formation. Over the past 6 years, a total of 217 horizontal wells have been drilled in both the Paddock and Blinebry zones of the Yeso Formation. Typical horizontal lateral lengths vary from ¾ mile to 1-1/2 miles with TVD's ranging from 2,700'-6,000'. Wellbore geometry consists of either a 5-1/2" production string to TD or a 7" to 5-1/2" tapered string shown in figure 1. The typical Yeso horizontal model is 300-350 MBO and has an initial hyperbolic decline of 52-72% decline with a 6% exponential decline after 2-3 years of production (Mraz, 2015). While the total number of horizontal wells compared to existing vertical wells is less than 10%, the volume that they provide is 58% of the asset teams total oil production.

In the past, routine vertical well work included removing fill or excess frac sand from rathole or bottom section of the vertical well. Excess fill in vertical wellbores can block off perforations thus hampering production and creating downhole problems for production equipment. Likewise, horizontal wellbores require remedial well work but have a much longer perforated interval to cleanout. The presence of sand in the wellbore can cause enough of a production drop to require well intervention (Li,2008). COG hydraulic fracture treatments use cured resin coated sand to prevent the majority of proppant from reentering the wellbore after completion. However, as the stimulated reservoir pressure is depleted, closure pressure on the proppant can lead to sand migration into the lateral requiring remediation.

Since the Yeso is a carbonate reservoir, all producing zones have tendencies to precipitate scale. Water analysis generally show calcium sulfate, gypsum $CaSO_4(H_2O)_2$ and calcium carbonate, calcite $CaCO_3$. There are 5 -10 failures per year on the New Mexico Shelf that are caused by catastrophic scaling where production equipment is seized by scale that has precipitated. COG's chemical program combats scaling with the use of scale inhibitors during the hydraulic fracture treatment and while the well is on production. Fracturing fluid is treated "on-the-fly" during the job to minimize the chance of scale precipitation in the newly stimulated reservoir. Post-frac, the utilization of capillary string and continuous flush treatment yields positive results. However, the effectiveness of scale inhibitors in stimulation treatments can be short lived and surface chemical programs only offer protection to the production equipment, not the reservoir (Smith 2000). Being able to effectively cleanout horizontal wellbores of debris is critical to production not only on an individual well level but also on a field wide level, as more and more acreage is developed horizontally.

One of the most important decisions when considering wellbore stimulation and cleanout opportunities is well candidate selection. The best candidates must be performing below the area's type curve model, exhibit steep decline and have obvious inflow problems shown in figure 2. Downhole artificial lift design such as accurately sized gas separators and downhole capacities must be analyzed prior to any cleanout considerations. Consistently low fluid levels and noticeable production drops must be seen in order to justify incurred expenses. Poor candidate selection leads to poor cleanout results. Unsuccessful cleanout results often point back to candidate selection. Cleaning out wellbores that suffer from poor artificial lift design will not address the root cause affecting reduced production volumes.

CHALLENGES WITH WELLBORE REMEDIATION ON THE NEW MEXICO SHELF

Whether the solids are scale or sand, the ability to clean out the lateral conventionally hinges on the bottomhole reservoir pressure (BHP). Traditional horizontal cleanout procedures consist of attempting to establish circulation using forward or reverse circulation. However, once past the first several perforation clusters, the well will begin to lose BHP or go on a vacuum and the ability to circulate the well will be lost. If circulation can not be established with fresh water, adding compressed air or nitrogen to the fluid would be the next option. The goal is to lighten the gradient of the fluid in the wellbore and near wellbore enough to enable fluids and debris to travel back to surface via the tubing (Li,2008). In pressure depleted wells, the majority of the energized fluids would travel through the perforations and into the formation similar to the initial results with fresh water. Occasionally, circulation can be maintained temporarily but once a modest amount of solids are removed, circulation is lost through the newly remediated perforations. This process is very time consuming and costly. At this point, the decision must be made to either "dry drill" without circulation or abandon cleanout operations. Dry drilling is an inherently risky operation. Dry drilling is forward circulating without returns to surface up the annulus. Lack of circulation around the workstring creates a situation where debris can pile up and stick the pipe in the cased hole causing major mechanical issues. Because of these challenges, cleanouts using conventional methods on the Shelf are almost impossible.

APPLICATION OF VENTURI JETTING TOOL

The utilization of the Venturi jet junk basket has allowed us to bypass nearly all challenges associated with low pressure wellbore remediation. The opportunity to apply the Venturi jet junk basket BHA began in 2015 to clean out multiple horizontal wells. The original tool has patents that date back to the 1950's. Prior to its application in 2015, COG had only used the tool once with decent success for drilling out completion plugs. The earlier applications first began as a tool to clean out debris via coiled tubing; they have since evolved by increasing the size of the cavity and conveying the tool on stick pipe. Due to the larger ID of stick pipe and higher tensile strengths, volumes of debris that can be retrieved in one run have increased. The basic downhole setup of the BHA is composed of a bit, bit sub, flapper valve, 2 -7/8" P-110 tubing joint, flapper, 30-80 jts of 2 -7/8" P-110 tubing for cavity, strainer nipple/ screen, Venturi tool, and the rest of the 2 -7/8" P-110 workstring with PH-6 connections as shown in figure 3. The total number of cavity joints is adjusted based on the material found in the cavity after the first trip. Larger debris such as plugs or bands may require less joints of cavity than sand or scale. The jetting tool BHA is accompanied by a reverse unit, reverse pit and a swivel. Fresh water is then pumped down the tubing at a rate of 1-2 bpm at a pressure of 500 psi at the reverse unit. The fluid is then diverted outside the tubing to the casing annulus where a pressure sink is generated inside the cavity and fluids begin traveling towards the low pressured zone below the Venturi tool, see figure 4. The strainer nipple prevents large pieces of debris from traveling to the Venturi sub and plugging the jets (Li,2011). Pumping operations begins once the bit tags on solids while tripping in hole. Revolutions of 40 RPMs at the swivel and approximately 2500 ft.lbs torque are typical while cleaning out solids. Pumping fluid down the tubing and rotating the bit are always done simultaneously. Once the obstruction is removed the operator can rig down the swivel and continue tripping in hole to tag up on the next solids bridge.

During operations with the tool, a typical rate of penetration (ROP) of 15' per minute is common when the cavity is completely empty. As the cavity begins to fill with solids the ROP will taper to 2' per minute. At this juncture it is time to trip out of hole (TOOH) and clean out the cavity joints. Typically with sand, you can expect to see 50-60% of the cavity joints filled with solids. Sand is easier to cleanout than scale due to the grain size distribution. COG's proppant sand selection has monomodal particle distribution while scale has a multimodal particle distribution. This affects the ability for the bit to vacuum the solids without the particles sticking together in clumps. Proppant also has a higher bulk density than calcium sulfate scale which may explain why the majority of the sand material stays in the cavity and does not migrate to the screen at the end of the cavity section. Scale tends to plug the bit or pack off the screen which will require the operator to TOOH earlier than compared to sand and with fewer materials in the cavity. Scale remediation requires more trips than sand with this tool. The attached photo in figure 5 is an example of what can happen to the tool when pumping operations continue after ROPs have diminished and the cavity has been filled with solids. This resulted in material cutting the Venturi jets and damaging the tool. Despite this set back, this ensured that the Venturi tool was generating enough of a pressure drop to warrant fluid flow through the bit and into the cavity joints.

A wellbore treatment is designed based on the material found in the cavity. If scale is discovered, acid and if necessary gypsum scale converter is spotted throughout the lateral after the bit is able to reach plugback. Due to the ineffectiveness of hydrochloric acid HCl on gypsum scale, being able to classify the scale is critical to dissolve scale that has precipitated in the near wellbore. Calcium sulfate can severely impair the formations permeability and is a root cause of reservoir influx problems (Al-khaldi, 2011). Scale converter requires 48 hour to convert the calcium sulfate to glauberite, $Na_2Ca(SO_4)_2$. Once the calcium sulfate has been converted to acid soluble glauberite, acid is spotted in the same locations to completely dissolve all the scale in the wellbore or near wellbore. If solids are not found in the lateral, an acid stimulation is still necessary to treat near wellbore restrictions that could be present in the formation due to the acid soluble scale. Gypsums converter is usually not pumped unless calcium sulfate is found in the cavity.

BEST PRACTICES

Operational success and rig time can be greatly affected by bit selection. An initial vendor recommendation was a fixed badger bit; however, we have found the best success using a blade bit with rounded edges for sand. This bit provides better penetration than a badger or rock bit and does not get plugged as easily. In scale, the blade bit took too large of a bite and dug too deep into the fill material. The sealed bearing mill-tooth roller cone bit worked best for this application. Particle size of the material being cleaned is pivotal and dictates whether the project can be completed in a few trips or a dozen. Thus far, all clean outs on the New Mexico Shelf have been inside of the 5-1/2" OD casing in the lateral. All

Venturi style BHA tools used on the Shelf have had higher tensile strengths than their equivalent PH-6 connections. This ensures the tool is not the weakest member in the string if the tool could become stuck. The larger 3-1/2” tool is designed to run in 5-1/2” OD casing applications and the smaller 3-1/16” tool is primarily designed for 4-1/2” or 4” liner applications. Both tools have PH-6 connections and are the same length. See table 1 for technical specifications.

RESULTS

Since 2013, a total of 36 cleanout attempts have been performed by the New Mexico Shelf Asset team, as shown in figure 6. This data includes wells both on sucker rod lift and electric submersible pump (ESP). Prior to 2015, the tool had only been used once to drill out frac plugs as previously stated. The increase of cleanouts executed in 2015 and 2016 was directly related to the positive results obtained in production and decrease in project cost compared to previous years without the Venturi tool. Post project production data was obtained by taking allocated production data 60 days before and 60 days after the completion of the project. The 2015-2016 average sustained uplift per well was 35 barrels of oil per day (BOPD).The 2013-2014 average sustained uplift per well of 11 BOPD, that did not utilize the Venturi tool, is shown in figure 7. Comparing total project cost on average, per well, in each year, is shown in figure 8. A 33% reduction in project cost is noted immediately upon employing the Venturi tool for projects executed in 2015. An additional 25% decrease in project cost is shown in 2016 as efficiencies improved and more jobs were executed. The amount of time spent on each project increased as well. Figure 9 shows average days with workstring per well in each year. The 2015-2016 workovers averaged 4.5 days per wells vs. the 2013-2014 workovers that averaged 2 days per well. As stated previously, conventional cleanout methods would involve pumping fresh water or energized fluids down the tubing or annulus in an attempt to maintain or regain circulation. In nearly all cases, circulation was lost once the first few perforations or half of the lateral was cleaned out. Efforts to get circulation would cease by the second or third day and the entire cleanout could be abandoned altogether due to the increased risk of getting stuck while dry drilling. The ability to maintain ROP and RPMs while using the Venturi tool mitigated risk of getting stuck and allowed COG to increase the total lateral length that was remediated. Figure 10 shows all 22 well’s normalized allocated oil production before and after cleanouts. The overall average of all the projects combined is shown in figure 11. Of the 22 projects selected, 5 consisted of wells that were making below 5 bopd. Post cleanout, nearly all of the cases show allocated volumes at or above 15 bopd by day 60. The overall increase in average incremental uplift of 35 BOPD and decreased cost of $83,000 per project has allowed more candidates to be remediated, and decreased the loss of reserves due to sand and scale.

CONCLUSIONS

- Forward or reverse circulation should always be attempted first due to higher ROPs than the Venturi tool when circulation can be maintained.
- Venturi Jet Junk Basket is an effective BHA to clean out sand, scale, junk, and debris from a wellbore that cannot be circulated by conventional means.
- The tool reduces the cost of cleanouts for low BHP wells that are shallow and water supply is not a problem.
- The tool works excellent for cleaning out sand, trash, plugs or bands from a lateral.
- The tool performs fair when cleaning out scale due to small particles plugging up the screen, check valves or bit.
- The candidates must be pumped off and free of artificial lift design flaws prior to operations.
- It is not ideal for wellbores sensitive to hydrostatic pressure on the formation.
- Reduced average project cleanout cost by $32,000 per well and more efficiently cleaned the lateral.

- Project economics improved from a 14 month pay out at 10 bopd incremental uplift to a 3 month pay out at 35 bopd incremental uplift.

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Technical Specifications

Maximum O.D.	*Maximum I.D.*	*Tensile Strength (STD Service)*	*Torque Strength*	*Length*	*Number of Nozzles*	*Nozzle I.D.*
3.063"	*N/A*	*220,000*	*>3800*	*56.37"*	*4*	*.187"*
3.500"	*N/A*	*348,000*	*>4500*	*62.65"*	*4*	*.187"*

Table 1 – Venturi jetting tool BHA technical specifications

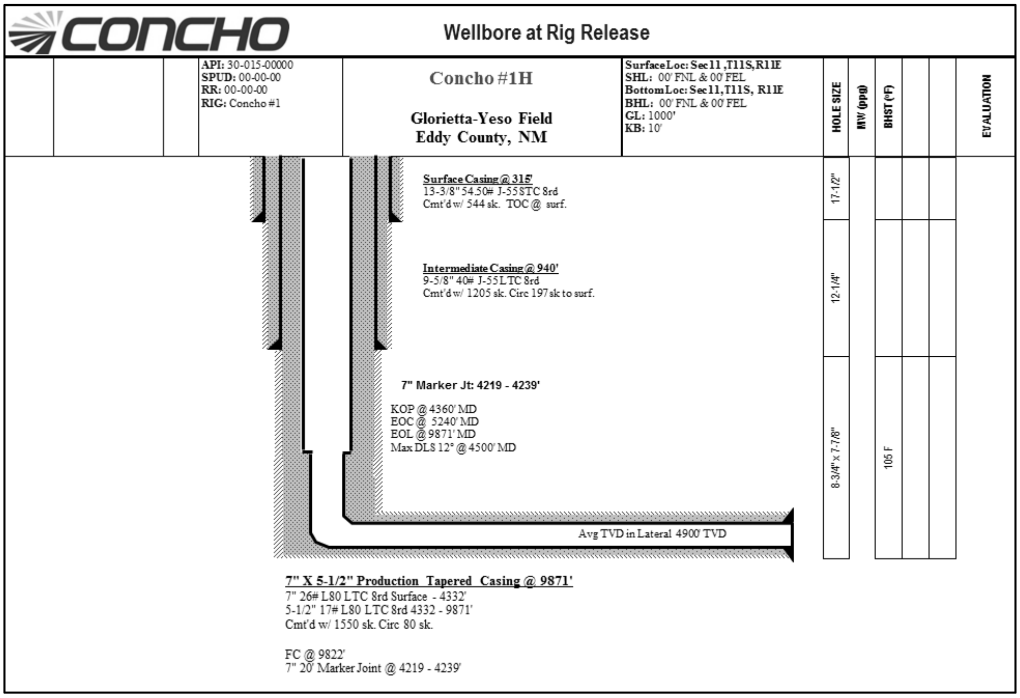

Figure 1 - Yeso wellbore diagram

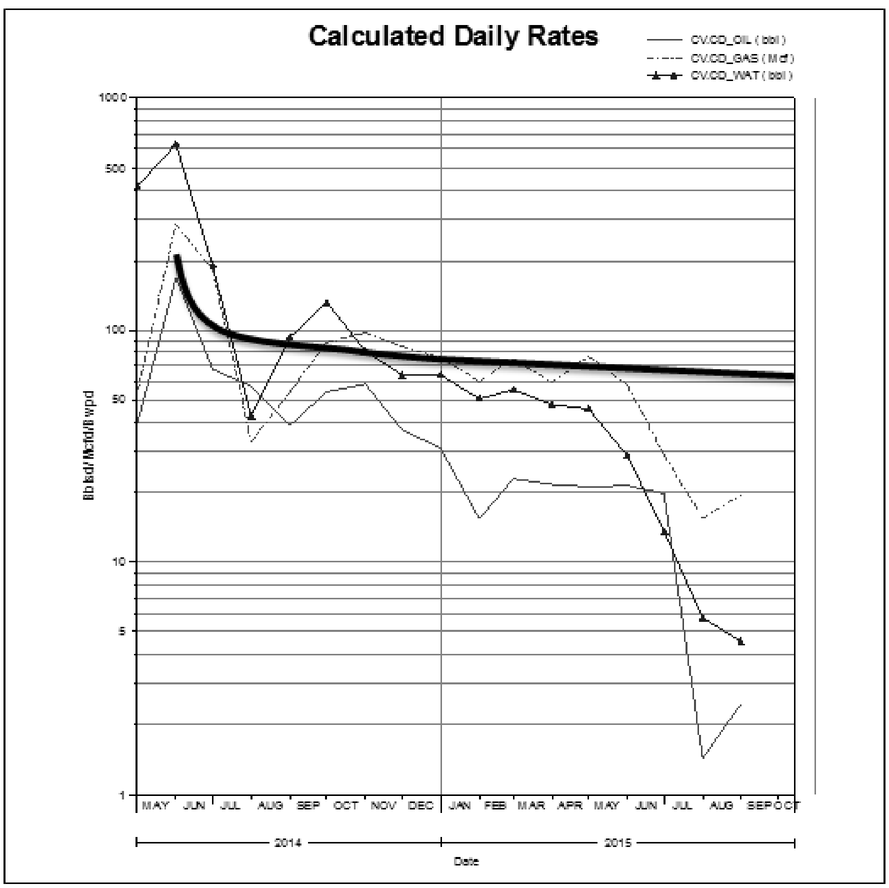

Figure 2 –Daily allocated production with oil, water, gas and oil forecast type curve overlaid

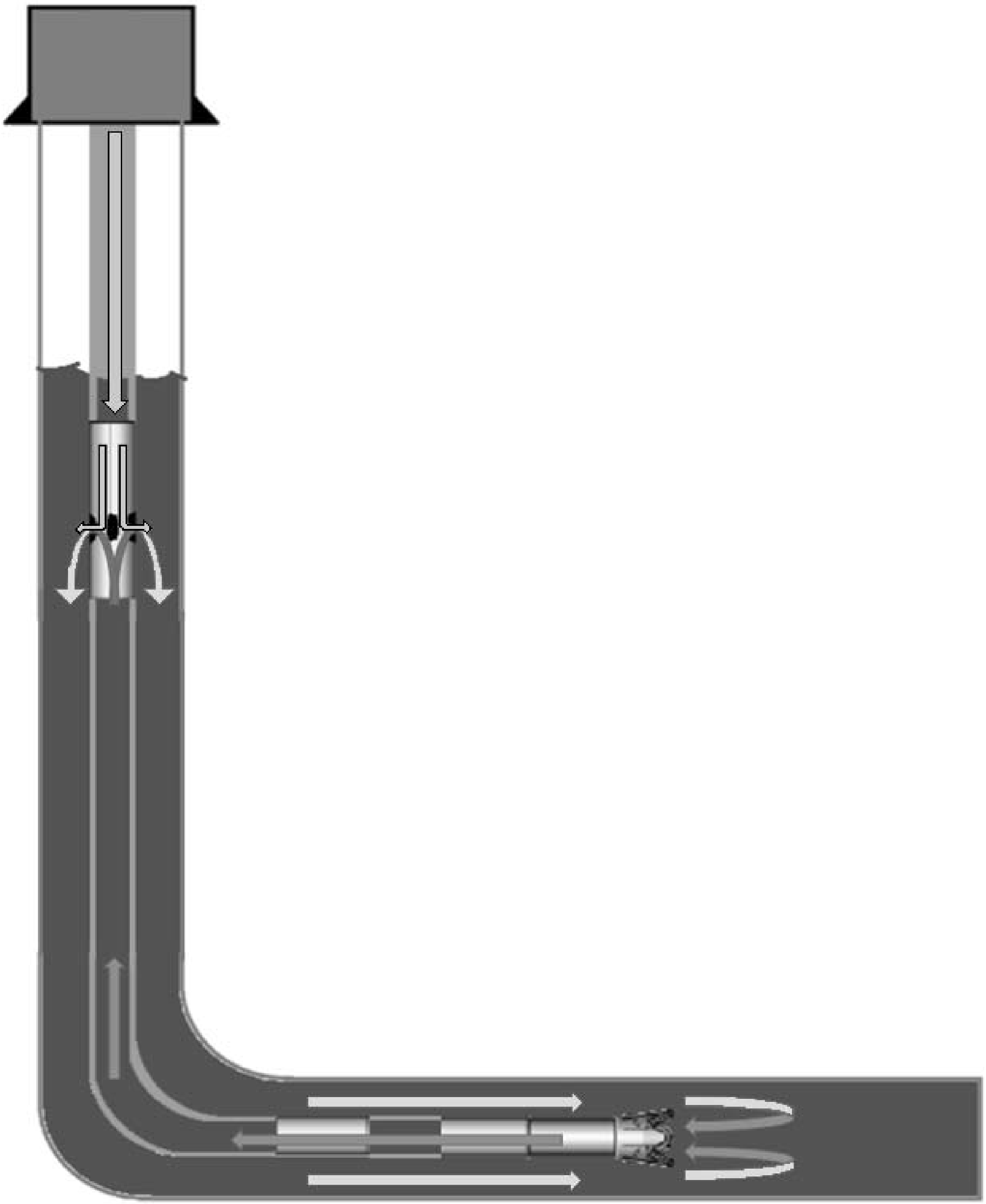

Figure 3- Basic downhole setup of the Venturi BHA and fluid flow path

Figure 4 – Venturi Jetting Tool Cutout, power fluid pumped down tubing from surface out venturi jets, low pressure drop is generated inside the basket cavity

Figure 5- Sand erosion on the tool from jets once the cavity has been filled

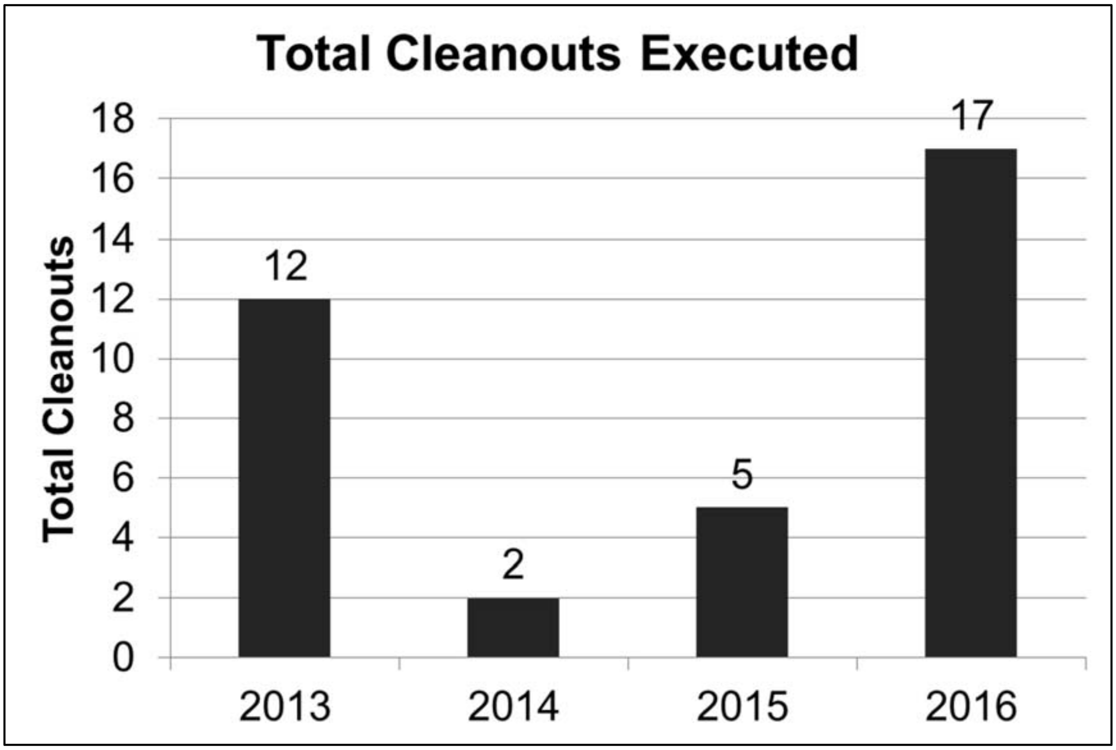

Figure 6 – Total cleanouts executed per year

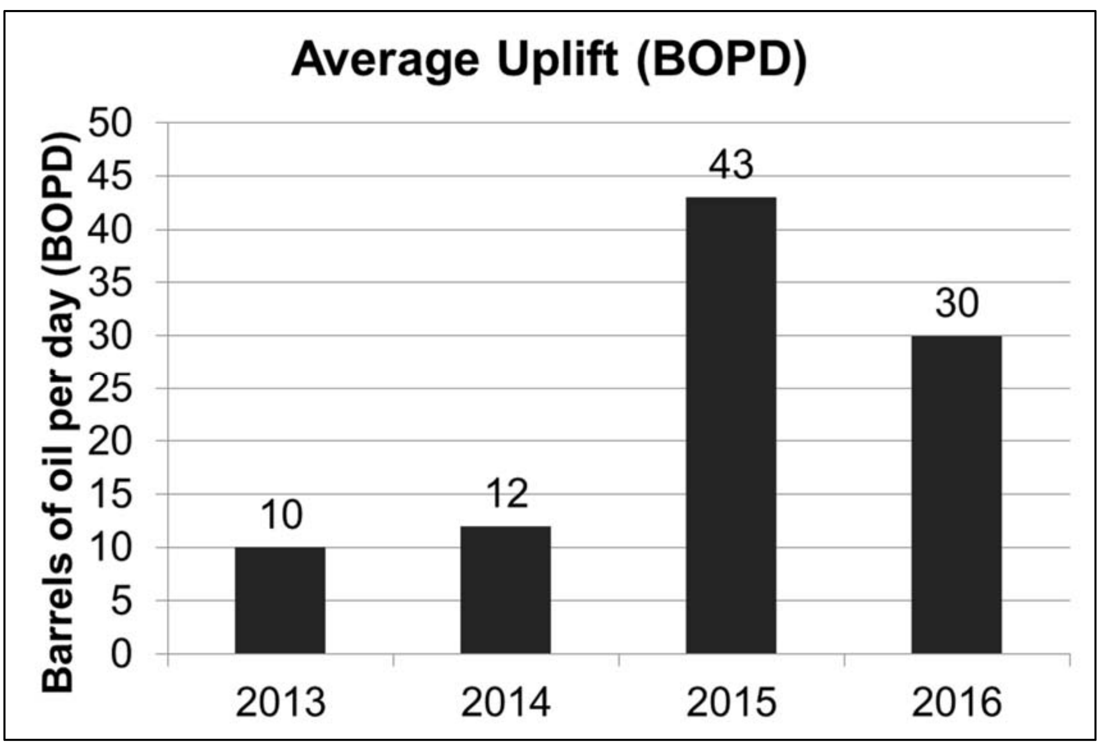

Figure 7 – Average sustained uplift per well in each year

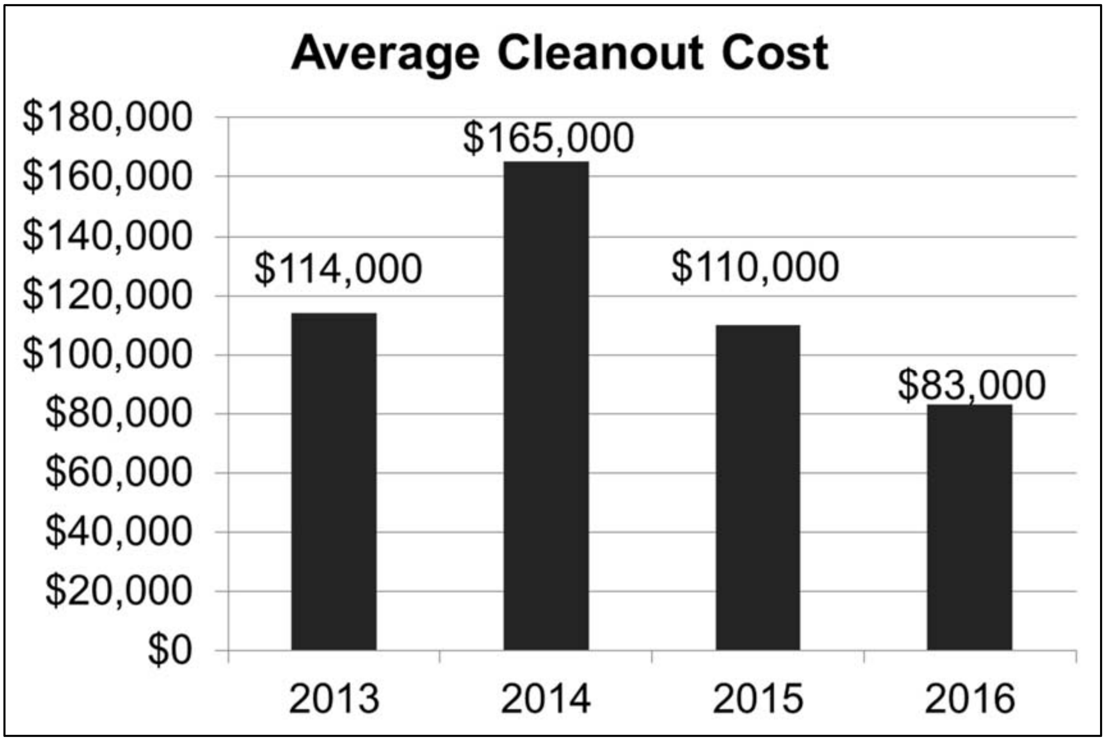

Figure 8- Average cleanout cost per well per year

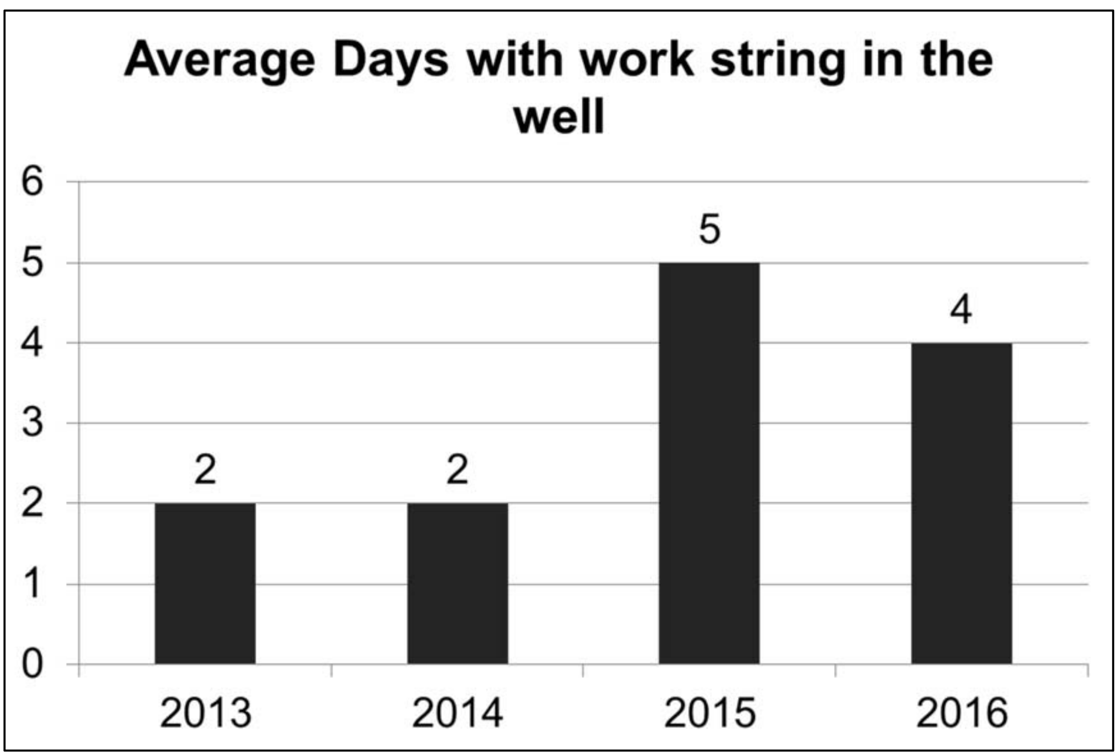

Figure 9- Average days with workstring in the well increasing as we are able to cleanout more lateral without resorting to dry drilling

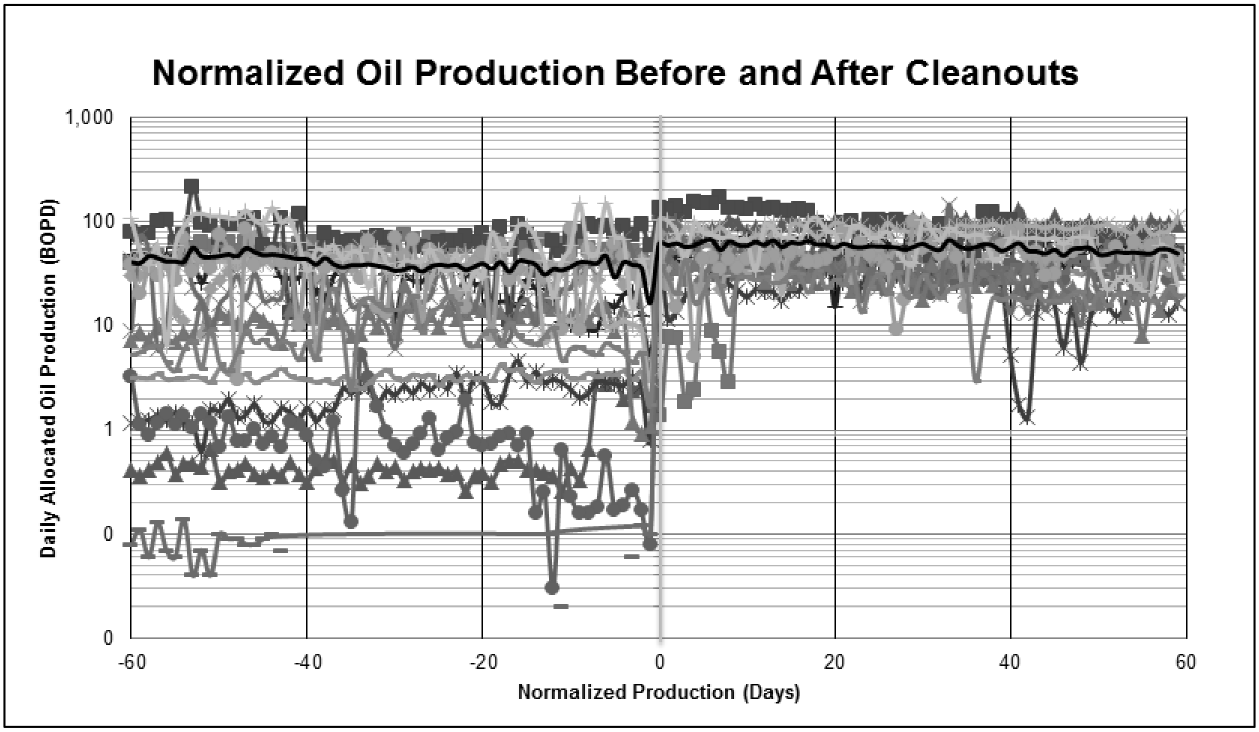

Figure 10- Normalized oil production before and after for all 22 projects

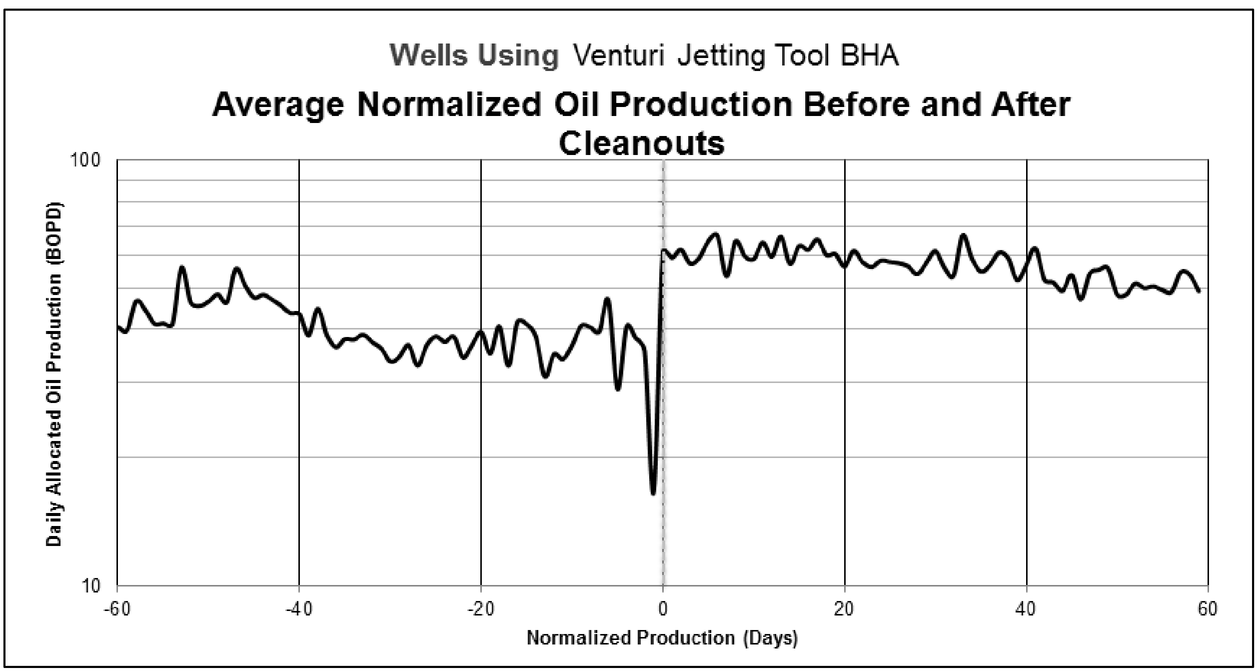

Figure 11- Overall average normalized oil production before and after