ADVANCED GAS AND SAND SEPARATION TECHNOLOGIES IMPROVE PERFORMANCE IN BAKKEN ROD PUMP WELLS

Bryan Weaver, ConocoPhillips
Don Crane, Endurance Lift Solutions

ABSTRACT

Across its many Bakken rod-pumped horizontal wells, ConocoPhillips repeatedly experienced insufficient pump fillage and lower-than-anticipated production volumes due to poor gas and sand separation. Unable to achieve the desired results after deploying a variety of different gas- and sand-mitigation techniques, ConocoPhillips partnered with Endurance Lift Solutions (ELS) to deploy the patented ELS Guardian separator in combination with the Triple Bypass tubing-anchor catcher.

This paper describes an extensive, 138-well project that resulted in significant gains in pump fillage and production volumes versus prior configurations. ConocoPhillips Senior Production Engineer Bryan Weaver—in collaboration with ELS Product Line Director Don Crane—will share before-and-after data, key lessons learned, and advancements in gas- and sand-separation technologies.

INTRODUCTION

As in the majority of unconventional basins, horizontal shale wells across the Bakken produce multiphase flow loaded with entrained gas and sand. This mix complicates artificial lift performance through every phase of production. As these wells mature, rising gas fractions and falling liquid volumes further increase the demands on lift equipment.

To keep production stable through these shifts, operators often cycle through multiple electric submersible pumps (ESPs) before turndown limits or failures force an eventual move to reciprocating rod lift (RRL). However, if RRL is introduced too early, the high liquids, high gas, sand load, and unstable flow typical of early-life wells can overwhelm the pump and surface equipment. In RRL systems, these conditions are known to undermine performance, accelerate failures, and drive costly workovers.

ConocoPhillips sought a more resilient RRL configuration as gas fractions rose and solids became harder to control. The Bakken team believed that pairing the Guardian separator with a Triple Bypass tubing anchor catcher (TAC) offered clear design advantages over their legacy BHA, and they initiated field trials to evaluate this configuration under real operating conditions. Early results demonstrated stronger gas and solids handling across a wide range of flow regimes. This performance increased ConocoPhillips's confidence that the system could support higher-rate, higher-gas applications. These outcomes ultimately showed that the Guardian-equipped BHA could enable earlier, more reliable transitions from ESP to RRL while maintaining stable pump performance.

The Guardian system introduces several design advantages relevant to Bakken conditions, including high-volume vented inlet geometry, dedicated flow paths for gas separation, and a 60-ft spacer section that cushions separated gas before it reaches the TAC. These features work together to reduce gas interference, limit sand-related disruptions, and support smoother, safer deployment through modular, fully assembled components.

ConocoPhillips conducted a multi-well test program across a diverse set of Bakken wells—some following RRL equipment failures, others transitioning proactively from ESP to rod lift. In the vast majority of cases, the Guardian-equipped BHAs delivered measurable improvements: stronger pump fillage, higher fluid and oil production, and early indications of extended equipment life. In keeping with ConocoPhillips's continuous-improvement culture, the team also reviewed wells that did not show measurable gains to better understand contributing operational or design factors. ConocoPhillips is still waiting to retrieve some of the poorer-performing BHAs, and those inspections will help determine the operational or design causes behind decreased or marginal performance.

This white paper summarizes the technical foundation of the Guardian system, presents detailed performance results from ConocoPhillips's Bakken test wells, and outlines broader operational and economic implications for operators seeking a more stable, efficient, and scalable rod-lift solution.

PROJECT BACKGROUND: INSIDE ConocoPhillips's BAKKEN ROD-LIFT

EVALUATION

ConocoPhillips manages a large, diverse portfolio of horizontal wells in the Bakken play. And even though each well behaves differently, they all face the same operating reality: high gas fractions, persistent sand, and shifting multiphase flow that becomes increasingly challenging as the wells mature. ConocoPhillips had relied on a traditional rod-lift BHA configuration for years, and it worked well enough when flow conditions were steady.

However, as gas volumes climbed and liquid rates fell, traditional RRL setups began to show their limits. These designs depend on spiral-based, centrifugal sand handling and a restricted gas flow path at the TAC, which can force the gas back into the pump. In addition, centrifugal separators often leave sand circulating longer, which can create an emulsion that carries solids into the pump.

ConocoPhillips typically transitioned wells off of ESP once rates declined into a manageable range for RRL, but that timing often meant the RRL system was taking over just as gas fractions were rising and solids became harder to control. It wasn't a flaw in the handoff, but it meant the traditional BHA was stepping in at the exact moment its design limitations created the most risk—when sand recirculation and gas interference were most likely to undermine pump performance. The result was predictable: pump fillage suffered and fluid production declined, creating economic bottlenecks during the transition from ESP to RRL. Failures and workovers also became more common, which compounded the operational impact. Those vulnerabilities carried real operational and financial consequences. Across a large well count, these interventions represented meaningful downtime and avoidable cost.

ConocoPhillips also recognized that improved gas- and solids-handling in the BHA raised the production-rate ceiling for ESP-to-RRL conversions. This enabled transitions after the third and fourth ESP installations rather than waiting for further rate decline. However, traditional RRL systems couldn't handle the high liquids, high gas, sand load, and unstable flow typical of early-life wells—which is why ConocoPhillips historically delayed the transition and extended ESP deployment.

The ConocoPhillips team needed an alternate RRL solution that could manage gas and solids more effectively while reducing the frequency of failures. That search led them to evaluate the ELS Guardian BHA system. After initial exposure to the technology through industry events and peer recommendations, ConocoPhillips requested a detailed technical review and an on-site visit to ELS manufacturing facilities. The goal was straightforward: determine whether the Guardian separator and Triple Bypass TAC could create a more stable intake environment and sustain higher pump efficiency under Bakken conditions.

At the time of this report, ConocoPhillips has analyzed results from 91 Guardian-equipped wells. Of the original 138-well sample, 47 could not be directly compared in performance due to problematic well communications, meter-communication failures, or pump malfunctions. Several wells also had design differences that prevented a valid gas-separation evaluation—such as changes in pump size, pump set depth, or cases where Guardian was installed in a pumped-off condition.

The data show consistent improvements in pump fillage, more stable flow behavior, and higher production volumes across a wide range of operating conditions. These outcomes, combined with ConocoPhillips's commitment to continuous improvement, position the Guardian system as a more resilient and cost-effective path forward for RRL operations in the Bakken.

TECHNOLOGY OVERVIEW: GUARDIAN BHA SYSTEM

In unconventional shale wells, the pump sits at or near the heel, while all liquid, gas, and solids originate from the horizontal section below. With no natural separation occurring before the fluid reaches the pump, gas interference and sand recirculation become unavoidable. These effects intensify as wells mature and multiphase flow becomes more erratic.

To mitigate gas and sand incursion, traditional rod-lift BHAs often rely on centrifugal-style separation, a method borrowed from ESP applications. While effective in ESPs—where inflow is constant—centrifugal separation is poorly suited to RRL because rod-pump inflow slows or stops on every downstroke. This intermittent flow disrupts centrifugal action and often causes gas and solids to re-enter the pump.

Additionally, gas frequently accumulates around the TAC in traditional BHAs, creating backpressure that forces separated gas back down toward the separator intake. This undermines separation efficiency, reduces pump fillage, and increases the likelihood of gas-interference-related failures.

To address these downhole separation and flow-path limitations, the ELS Guardian BHA system incorporates a Guardian gas and sand separator and a Triple Bypass TAC. Supplemented with recommended spacer joints, these two components function as a unified system to create a more stable RRL intake environment compared to traditional rod-lift BHAs [Figure 1].

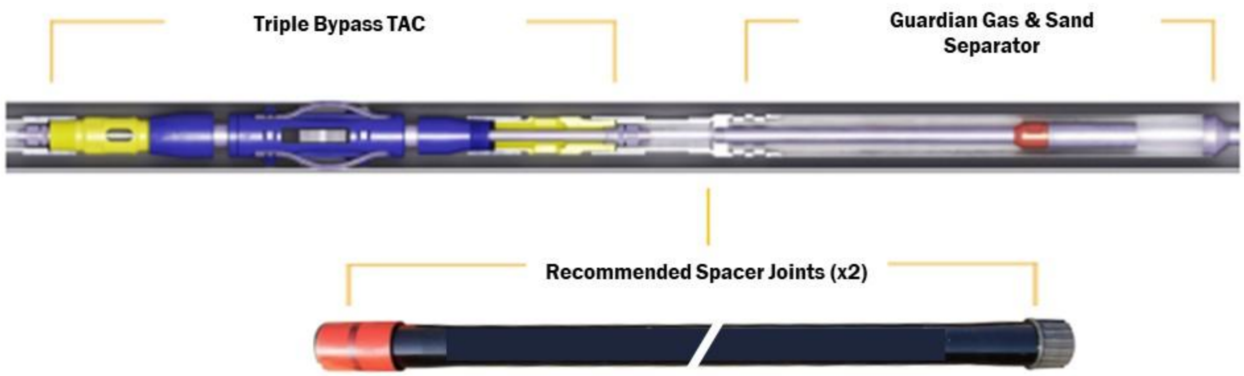

Figure 1 – Guardian BHA system components

In Guardian-equipped BHAs, production first enters the gas and sand separator, which uses inertial action to initiate controlled flow-area changes that slow, settle, and redirect gas and solids before they reach the pump. This inertial process results in a cleaner, more predictable inflow to the pump.

The vented gas then moves through the Triple Bypass TAC, which maintains an open flow path through multiple dedicated flow channels, enabling separated gas to move past the anchor without restriction instead of stacking above the separator. By preserving flow area and preventing gas accumulation, the Triple Bypass TAC helps maintain the stable intake conditions created by the separator.

To further optimize gas separation, spacer joints can create an extended open area where separated gas can slow down, coalesce, and stabilize before reaching the TAC. This spacing—approximately 60 ft between the separator exhaust and the TAC intake—reduces the velocity and concentration of gas arriving at the TAC's natural pinch point and helps prevent the effects of high-volume gas surges. As a result, the TAC receives a calmer, more uniform flow pattern that improves overall system performance.

Together, these components of the Guardian BHA operate as a coordinated system to manage gas, solids, and flow restrictions in the order they occur downhole [Figure 2]. By creating a stable, low-interference intake environment, the system improves pump efficiency, increases fluid production, reduces gas interference and extends equipment life.

ConocoPhillips FIELD TRIAL: SCOPE AND EQUIPMENT

After assessing the Guardian BHA system's design and operating principles, ConocoPhillips initiated a structured field trial to evaluate performance across a range of Bakken wells.

Trial Equipment

The majority of the trial sample consisted of direct comparisons between these BHA configurations in the same wells:

- Guardian gas and sand separators paired with Triple Bypass TACs
- Legacy separators paired with non-Triple Bypass TACs

Modular System Development

Discussions with ELS focused on the modular application of the Guardian separator and Triple Bypass TAC components to optimize system performance across varying well conditions. This modularity enabled the team to make incremental design changes, including the addition of spacer joints, without wholesale changes to the BHA.

Spacer-Joint Design Philosophy

The team's decision to introduce spacer joints between the separator exhaust windows and the tubing anchor's lower bypass nipple was based on two primary theoretical considerations:

1. *Slug Mitigation Through Annular Volume:*
   The spacer joints add annular volume that dampens gas slugging effects common in gassy wells, reducing transient gas interference at the pump intake.

2. *Improved Flow-By Geometry:*
   Increasing the distance between the separator and the tubing anchor improves gas-bypass flow by stabilizing gas movement in the annulus before it reaches the anchor. The Triple Bypass TAC contributes an additional benefit by providing an internal, low-restriction path for gas to flow through the anchor. This ability to prevent gas stacking at the TAC is especially valuable in applications where external flow-by area is limited by the anchor's restrictive geometry.

Data from the 91 sample wells confirmed that adding spacer joints improved pump fillage and production compared to installs that did not incorporate spacer joints [Table 1].

Table 1 – Guardian BHA performance comparison: No Spacer Joints Used vs. Spacer Joints Used

		Pump Fillage		Production				Delta			% Change		
	# of Wells	Pre - Avg. Fillage (%)	Post - Avg Fillage (%)	Pre-Total Fluid (BPD)	Post Total Fluid (BPD)	Pre- Gas (MCFD)	Post Gas (MCFD)	dFillage	dFluid	dGas	pFillage	pFluid	pGas
No Spacer-Joints Used	38	85	93	141	165	217	312	8	23	95	9.8%	16.6%	43.9%
Spacer - Joints Used	53	83	95	101	148	228	316	11	47	89	13.7%	46.5%	38.9%
Total	91	84	94	118	155	223	314	10	37	91	12.0%	31.4%	40.9%

Recognizing the operational and production improvements gained by adding spacers, ConocoPhillips now uses two spacer joints as the standard configuration in most RRL installations. The team has trialed configurations using up to four spacer joints, but they have not yet conducted controlled comparisons within the same well to isolate the effects of additional spacer count.

Spacer-joint deployment is primarily limited by pump set depth. In wells with low fluid levels, further lowering the pump to accommodate spacer joints may not be operationally feasible. Future trials may include deploying the BHA deeper in the wellbore, to expand the operational range of wells where the pump's set depth is constrained by fluid level—as well as to improve gas handling in pumping-in-curve applications.

Corrosion Control and Metallurgy

The team identified corrosion control as a critical requirement for spacer-joint deployment. Maintaining spacer-joint integrity is critical, because even a small hole would create a low-pressure ingress point that enables gas to enter directly into the pump and compromise the entire gas-handling system.

Recommended material includes IPC or boronized spacer joints. Due to cost and availability, ConocoPhillips deployed legacy inventory of inspected boronized spacer joints for these field trials. Corrosion performance continues to be monitored during BHA retrieval.

RESULTS AND DISCUSSION

Positive Performance Trends

Overall trial results have been positive, though variability exists across wells [Table 2]. Average observed performance improvements across evaluated wells include:

- Stabilization and improvement of pump fillage – 12%
- Increased total fluid uplift – 31% (including outlier wells with reduced uplift and others with up to fivefold increases)
- Significant increases in produced gas rates – 41%

Table 2 - Guardian BHA performance observed for wells evaluated

		Pump Fillage		Production				Delta			% Change		
	# of Wells	Pre - Avg. Fillage (%)	Post - Avg Fillage (%)	Pre-Total Fluid (BPD)	Post Total Fluid (BPD)	Pre- Gas (MCFD)	Post Gas (MCFD)	dFillage	dFluid	dGas	pFillage	pFluid	pGas
No Triple Bypass & No Spacer Join Used	2	89	96	50	50	0	0	7	0	0	7.9%	0.0%	0.0%
Sub-Total	2	89	96	50	50	0	0	7	0	0	7.9%	0.0%	0.0%
Triple Bypass & No Spacer Join Used	36	85	93	144	168	223	321	8	24	98	9.9%	16.8%	43.8%
Triple Bypass & Spacer - Joints Used	53	83	95	101	148	228	316	11	47	89	13.7%	46.5%	38.9%
Sub-Total	89	84	94	119	156	226	318	10	38	92	12.1%	31.6%	40.9%
Total	91	84	94	118	155	223	314	10	37	91	12.0%	31.4%	40.9%

Other observed benefits include higher average strokes per minute and reduced pump cycling (Figures 3a and 3b, Figures 4a and 4b, Figures 5a and 5b). Beyond current production metrics, ongoing monitoring evaluates potential long-term benefits associated with improved fillage, including reduced tubing wear, lower buckling risk, and decreased shock loading caused by abrupt plunger speed changes during gas-interference events.

Additional Monitoring Areas

The team is also evaluating sand-separation performance. Comparative analysis is ongoing between wells equipped with conventional, centrifugal-style sand separators and those using the Guardian separator’s velocity-driven mechanism. Metrics of interest include stuck-pump frequency and solids-related failures.

Negative Observations and Limitations

The team identified several limitations and negative observations during the trial:

- *Performance Degradation Over Time:*
  Multiple wells exhibited strong initial performance followed by gradual degradation. However, this behavior is often associated with workover fluid introduced during repairs, which temporarily improves fillage before the well reverts to its pre-repair performance.

- *Unverified Root Causes:*
  Because the wells exhibiting degradation have not yet been pulled, it remains unclear whether the observed issues are driven by well conditions, equipment integrity, or pump performance. In collaboration with the ELS team, ConocoPhillips plans to evaluate these wells when the BHAs are retrieved.

- *Lack of Improvement or Worsened Performance:*
  Some installations showed no improvement or worsened gas interference [Table 3]. Current working theories include:
  - Adverse impacts from changing anchor geometry (slimline vs. quarter-turn)
  - Solids-transport behavior influenced by pressure changes within the Guardian and TBP system
  - Pump spacing or mechanical configuration issues
  - Dynamic well conditions, including increased drawdown

Table 3 – Wells with no improvement or worsened gas interference

	Pump Fillage		Production				Delta			% Change		
Well	Pre - Avg. Fillage (%)	Post - Avg Fillage (%)	Pre-Total Fluid (BPD)	Post Total Fluid (BPD)	Pre- Gas (MCFD)	Post Gas (MCFD)	dFillage	dFluid	dGas	pFillage	pFluid	pGas
Well 4	90	90	350	250	350	300	0	-100	-50	0%	-29%	-14%
Well 10	80	100	100	100	140	120	20	0	-20	25%	0%	-14%
Well 11	90	80	150	125	100	50	-10	-25	-50	-11%	-17%	-50%
Well 54	86	70	60	40	160	60	-16	-20	-100	-19%	-33%	-63%
Well 58	80	95	70	80	250	200	15	10	-50	19%	14%	-20%
Well 102	95	95	180	280	500	90	0	50	-410	0%	56%	-82%
Well 90	100	95	50	60	100	160	-5	10	60	-5%	20%	60%
Well 47	95	95	75	100	450	350	0	25	-100	0%	33%	-22%
Well 72	80	95	175	300	320	300	15	125	-20	19%	71%	-6%
Well 41	77	100	0	0	400	200	23	-	-200	30%	-	-50%
Average	87	92	121	134	277	183	4	8	-94	5%	10%	-34%

CONCLUSION

Field trials using the Guardian gas and sand separator paired with the Triple Bypass tubing anchor demonstrate meaningful potential to improve gas handling and stabilize RRL performance. Through the deployment of nearly 400 Guardian systems, we've learned that proper anchor selection, adequate flow-by geometry, and optimized spacer-joint configurations deliver the most consistent benefits.

While results have been generally favorable, variability underscores the need for well-specific design—including careful consideration of anchor geometry, spacer-joint count, and solids management. Additionally, sand mitigation technologies should be considered in rod pump design.

Continued monitoring, retrieval inspections, and controlled comparisons remain essential for ongoing efforts to refine application guidelines—as well as to fully quantify long-term reliability and performance impacts.

Future Work

Future efforts will focus on:

- Controlled evaluation of spacer-joint count and associated performance impacts within the same well
- Retrieval-based inspection of degraded-performance installations
- Expanded analysis of sand-separation performance
- Failure-rate tracking of tubing-hole events to validate reduced rod-buckling risk resulting from improved fillage and cycling
- Development of standardized criteria to optimize anchor and spacer-joint selection

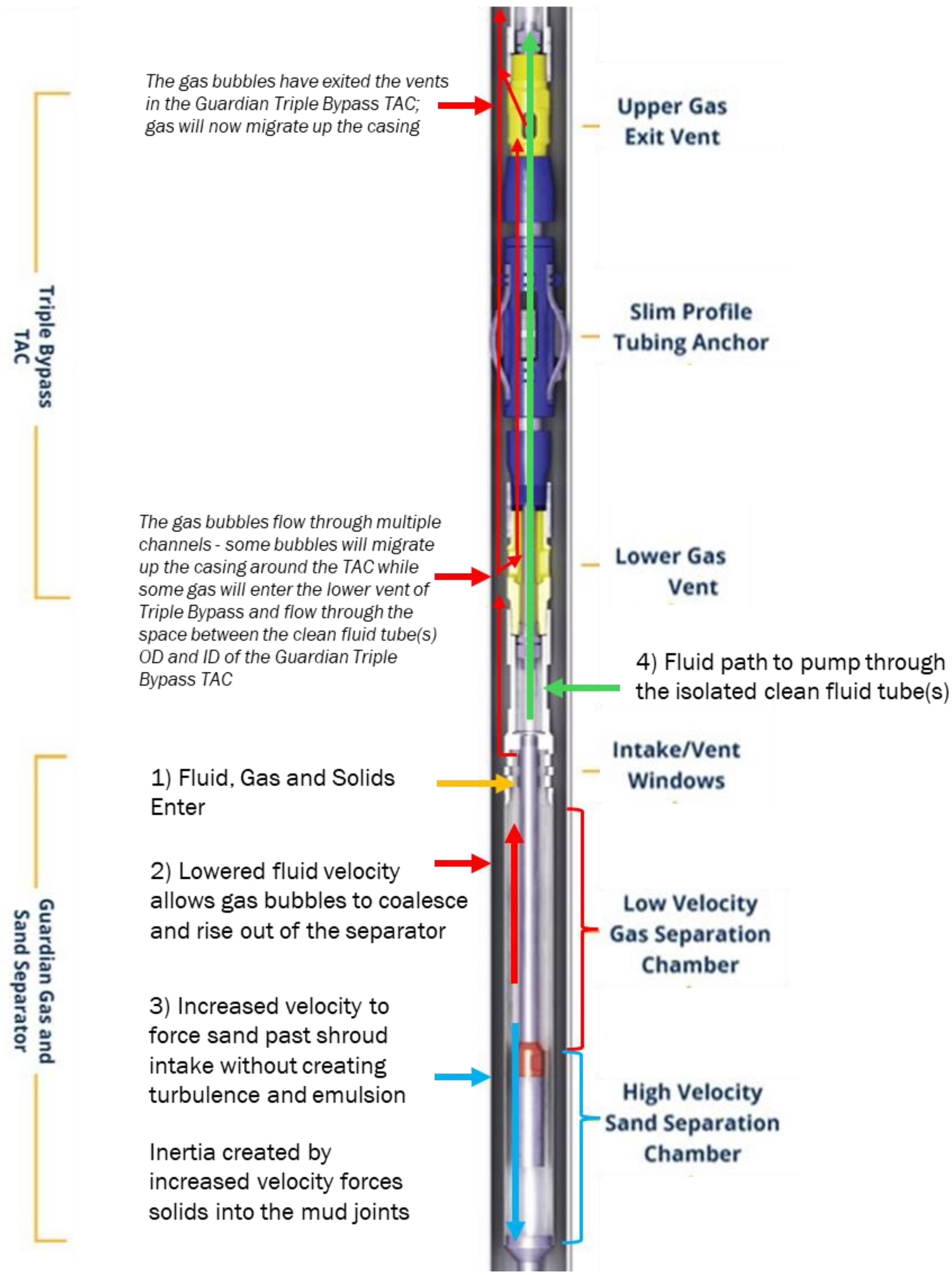

Figure 2 – Guardian BHA System – separation of fluid (1) into gas (2), sand (3) and clean fluid (4)

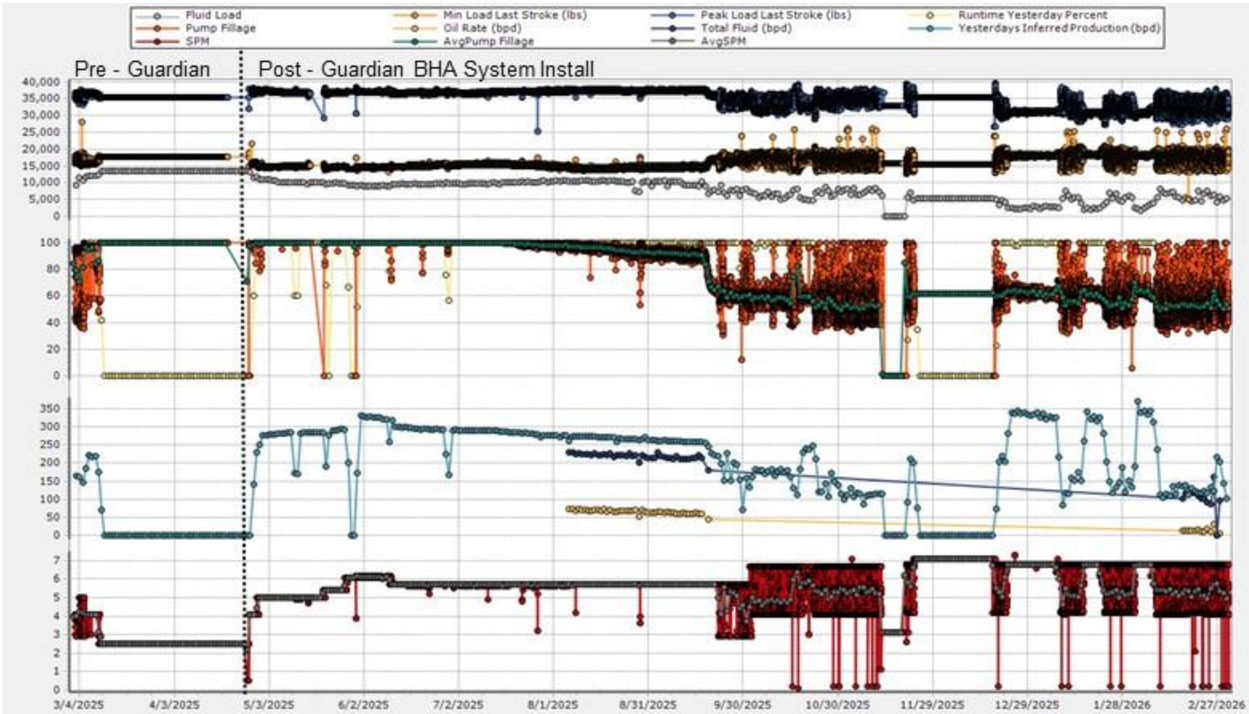

Figure 3a – Well 29 Performance observed – 33% improvement in average pump fillage

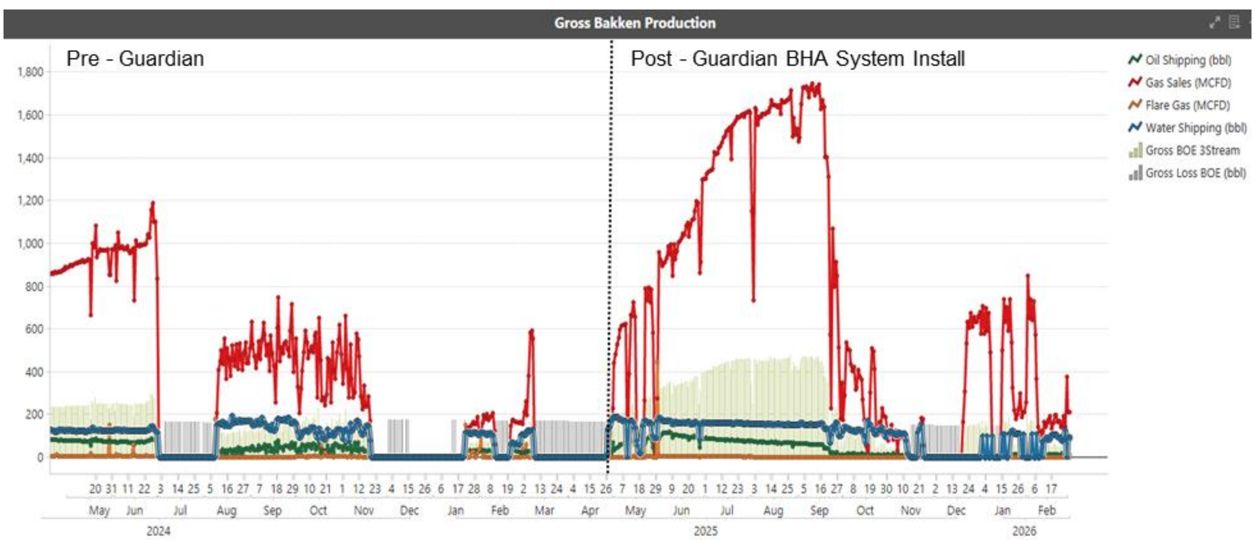

Figure 3b – Well 29 Production Improvements – 31% average fluid production increase, 233% average gas production increase

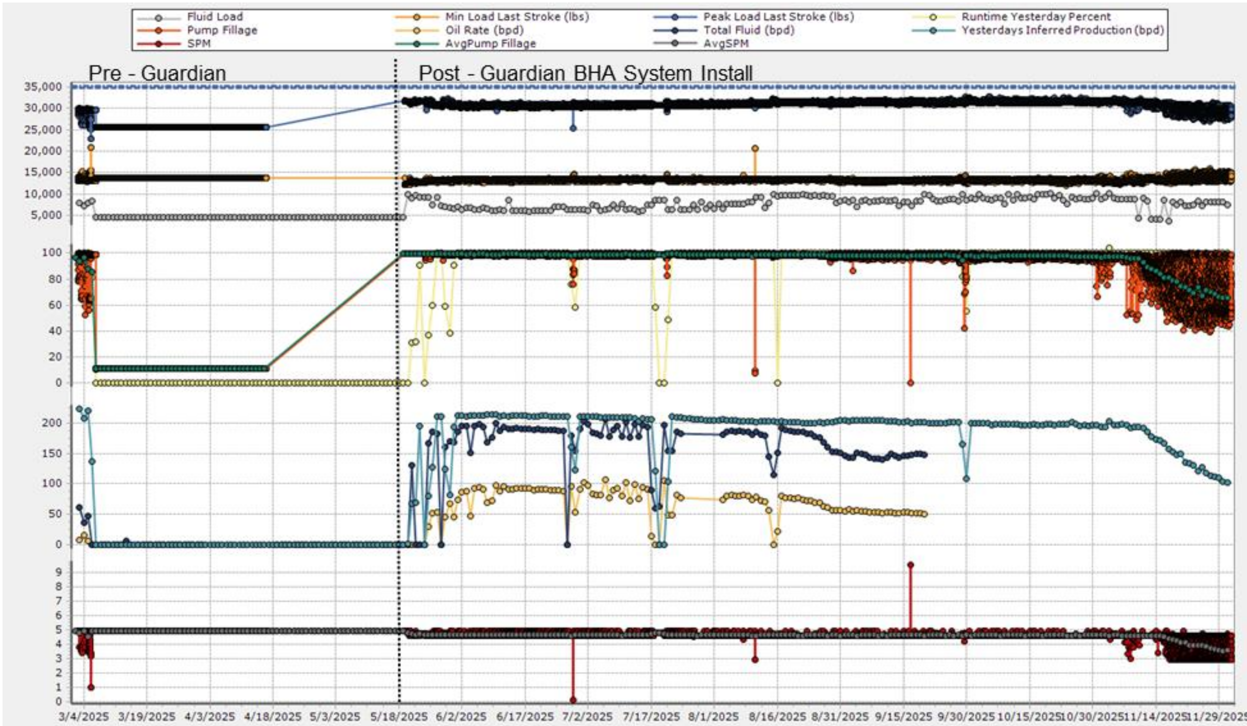

Figure 4a – Well 32 Performance observed – 11% improvement in average pump fillage

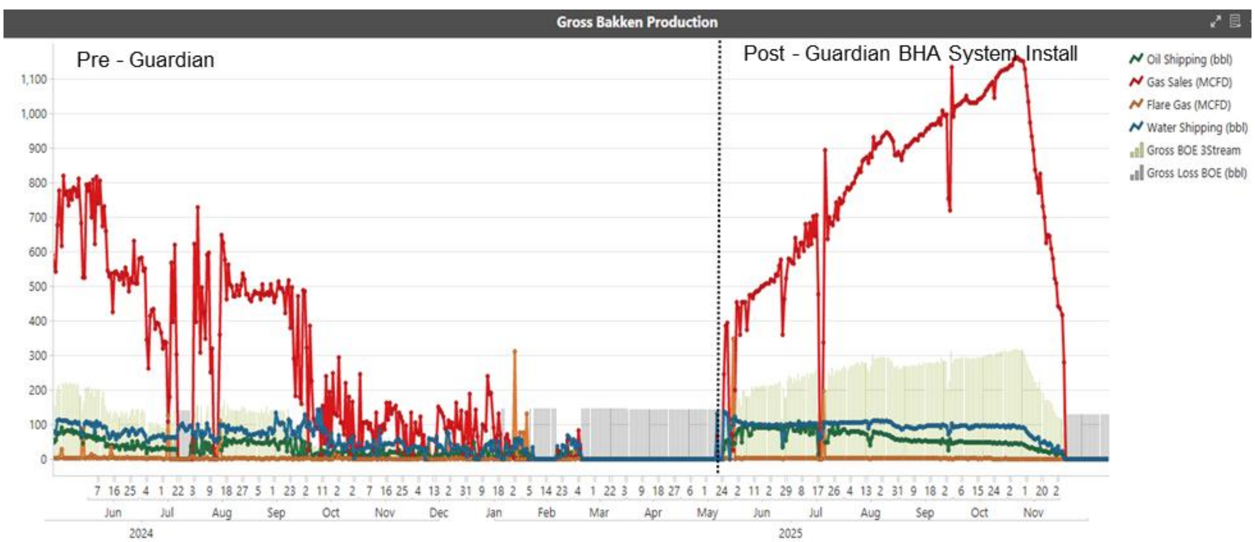

Figure 4b – Well 32 Production Improvements – 200% average fluid production increase, 233% average gas production increase

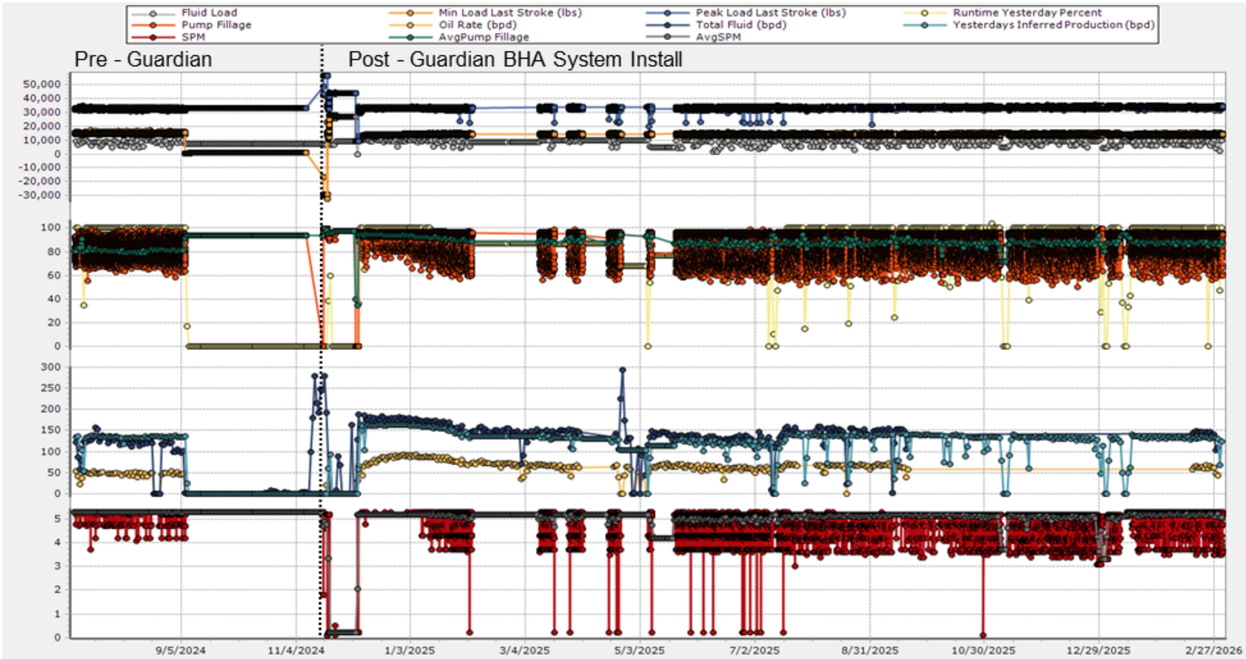

Figure 5a – Well 2 Performance observed – 8% improvement in average pump fillage

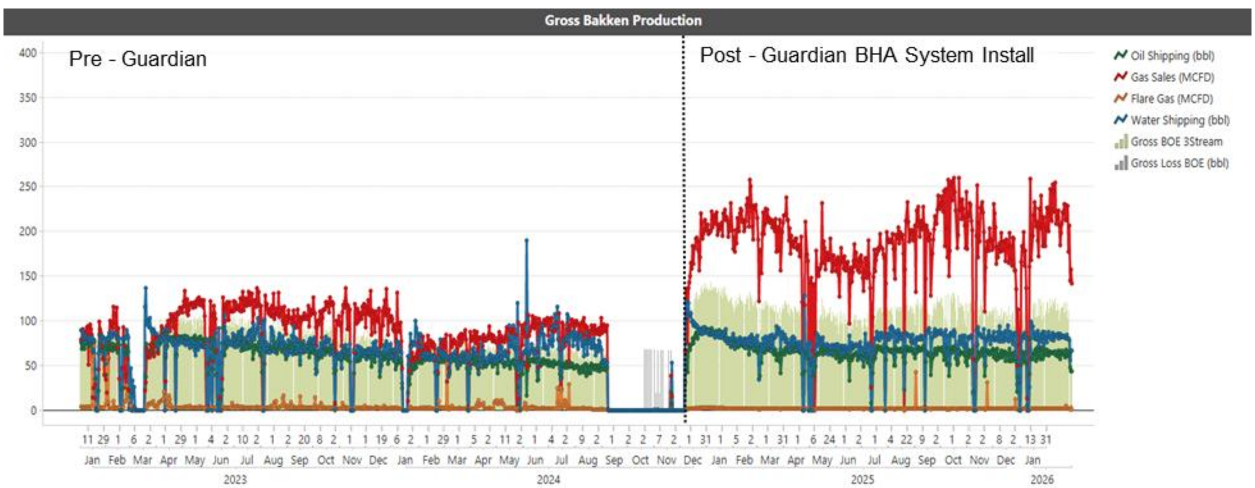

Figure 5b – Well 2 Production Improvements – 27% average fluid production increase, 60% average gas production increase