7° CONGRESO IAPG Producción y Desarrollo de Reservas

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IAPG INSTITUTO ARGENTINO DEL PETROLEO Y DEL GAS

HELPING IMPROVE ASSET PRODUCTIVITY WITH NEAR-WELLBORE STIMULATION SOLUTIONS

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Andres Felipe Diaz, Halliburton andresfelipe.diaz@halliburton.com
Martin Schoener Scott, Halliburton martin.schoenerscott@halliburton.com
Federico Rios, Halliburton federico.rios@halliburton.com

- Overview
- Near-Wellbore Stimulation Techniques
- Cases in Colombia
- Conclusion

What is near-wellbore damage?

Near-wellbore damage has been a popular topic during the last many decades. Skin factor (S) is a measure of formation damage which is a hydrodynamic parameter characterizing additional resistance to flow of fluids in the near borehole zone of the reservoir, causing reduced production compared to the perfect ideal wells.

How do we remove or minimize near-wellbore damage?

The industry has adopted multiple stimulation scenarios for various well completion and formation characteristics. Some of these solutions are proprietary shaped charge designs, gun system designs, extreme overbalance, and dynamic underbalance, which can help reduce or eliminate the damaged zone that impacts asset productivity or well injectivity.

When does formation damage occur?

Formation damage may occur during the following operations:

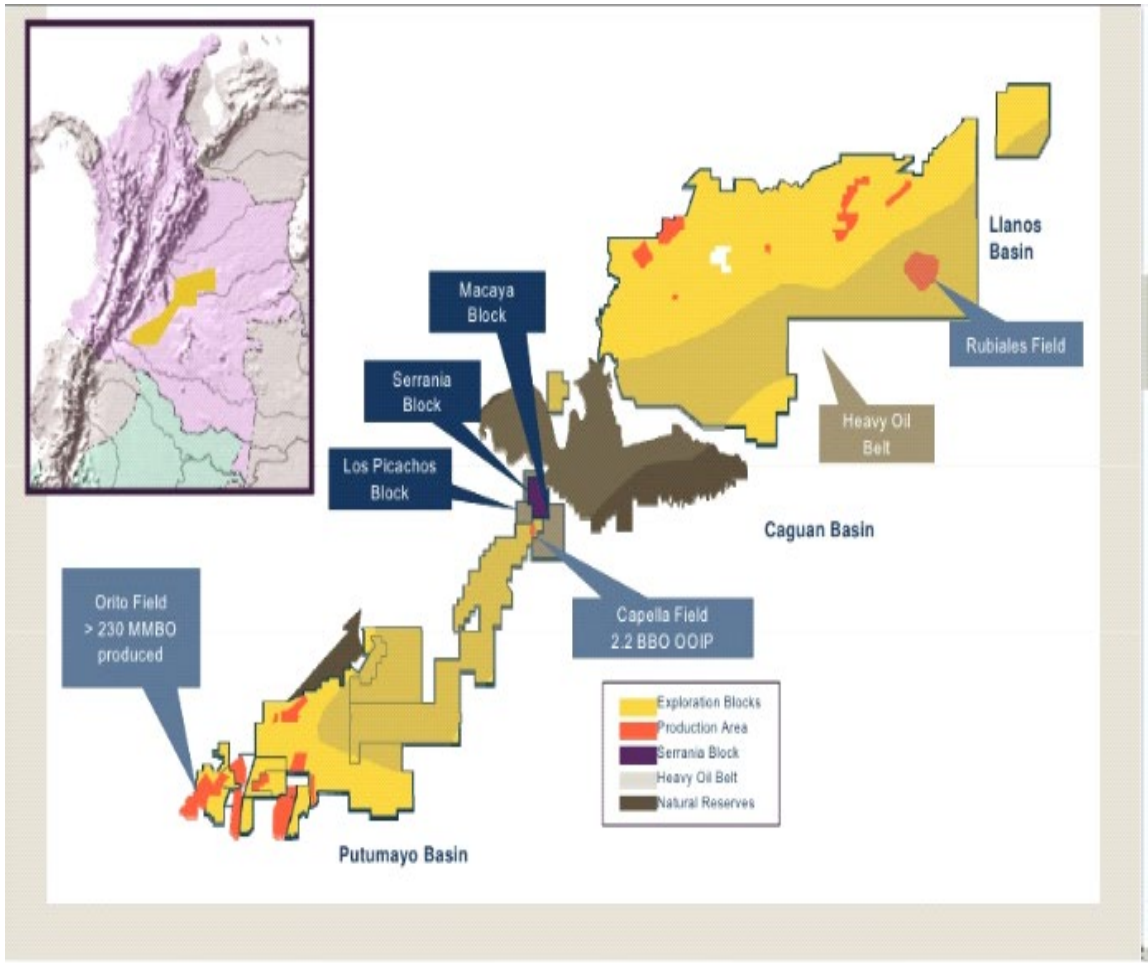
- Drilling
- Completion
- Workover
- Stimulation
- Production
- Water/Gas Injection

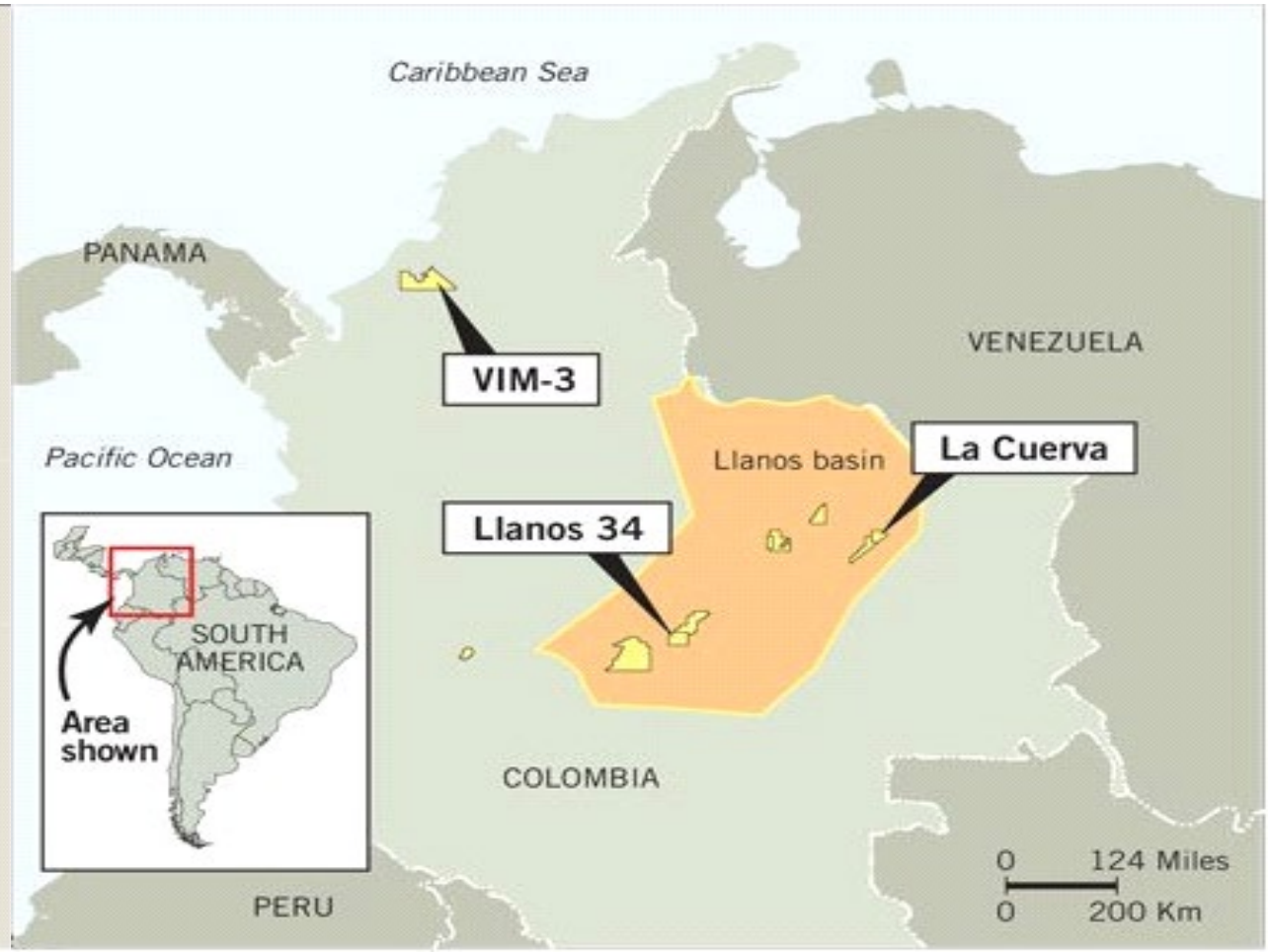
Although we do not have the ability to control reservoir rock properties, we have some degree of control over drilling, completion, and production operations.

What are some mechanisms of formation damage?

- Fines migration
- Clay swelling
- Induced particle plugging
- Asphaltene and sludge deposition
- Emulsion block
- Scale
- Bacteria
- Water block

Perforating past the near-wellbore damage can greatly increase wellbore productivity.





Caguán, Putumayo and Llanos Basins

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Near-Wellbore Stimulation Solutions Used

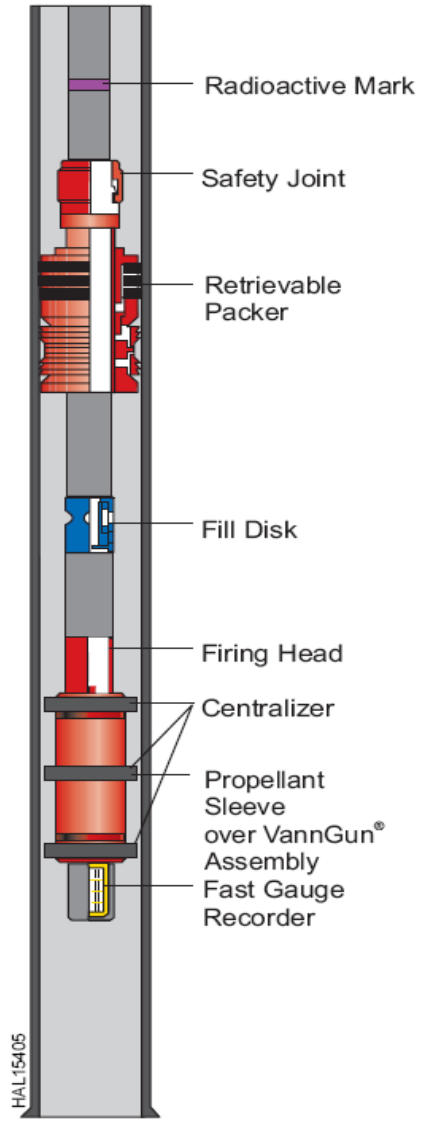
The first two cases presented used propellant-assisted perforating technology.

- The propellant material is potassium perchlorate, an oxidizer that burns rapidly, creating carbon dioxide gas.

The third case presented used dynamic underbalanced perforating technology.

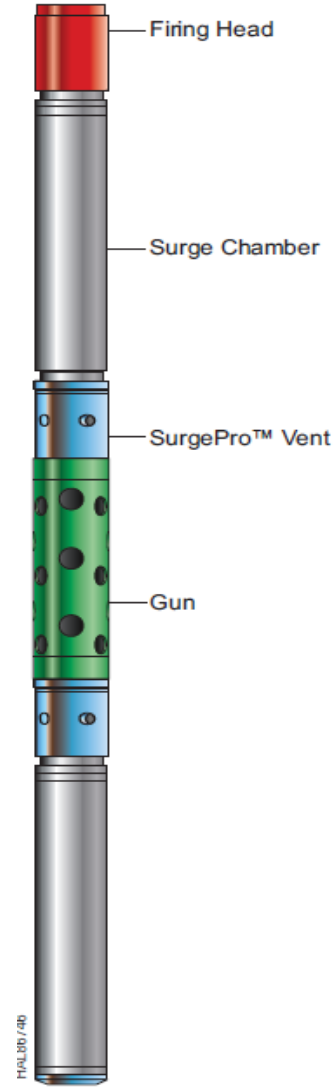
- The dynamic underbalance is achieved by using special fast-opening surge vents and atmospheric chamber assemblies.

All cases required the use of a dynamic wellbore simulator to accurately model and help predict the effects of pressure transients during the perforating event.



StimGun™ Tool

Cases 1 and 2



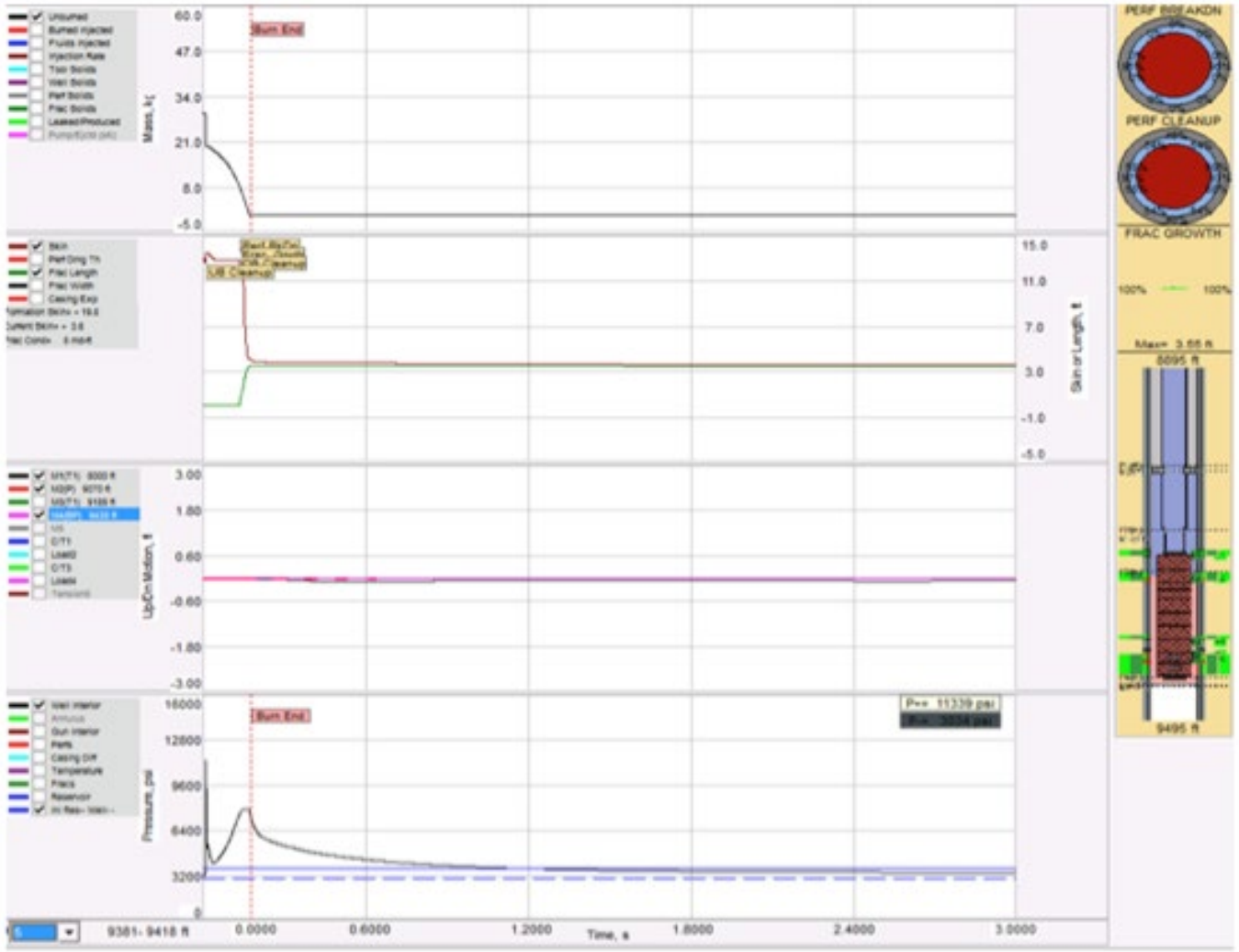
SurgePro™ Assembly

Case 3

Case 1: Injector Well Using Extreme Overbalance Perforating – Propellant-Assisted Perforating

- Well was drilled and completed in the Caguan-Putumayo basin in 1988.
- Field was evaluated and left inactive for 14 years.
- During the early 2000s, the well was produced from two sands with unstable rates.
- During 2016, the well was converted to an injector with unsatisfactory results.
- Finally, during 2018, the well was reperforated using a propellant-induced overbalanced stimulation technique.
- Results were positive—1,500 to 1,800 B/D injection rates—and shortly thereafter, an acid treatment increased injection rates to 8,000 B/D.

Case 1: Injector Well Using Extreme Overbalance Perforating – Propellant-Assisted Perforating



Formation Characteristic

- Depth TVD: 9000 to 9500ft
- Porosity: 15 to 18%
- Permeability: 150 to 220 mD
- Formation Pressure: 3600 to 3700 psi
- Unconfined Compressive Strength: 10000 to 15000 psi

Software Results

- Propellant coverage: 42%
- Initial skin: +20.4
- Final skin: +3.6
- Fracture length: 3.55 ft
- No *alert flags*
- Pressure generated: 7,884 psi

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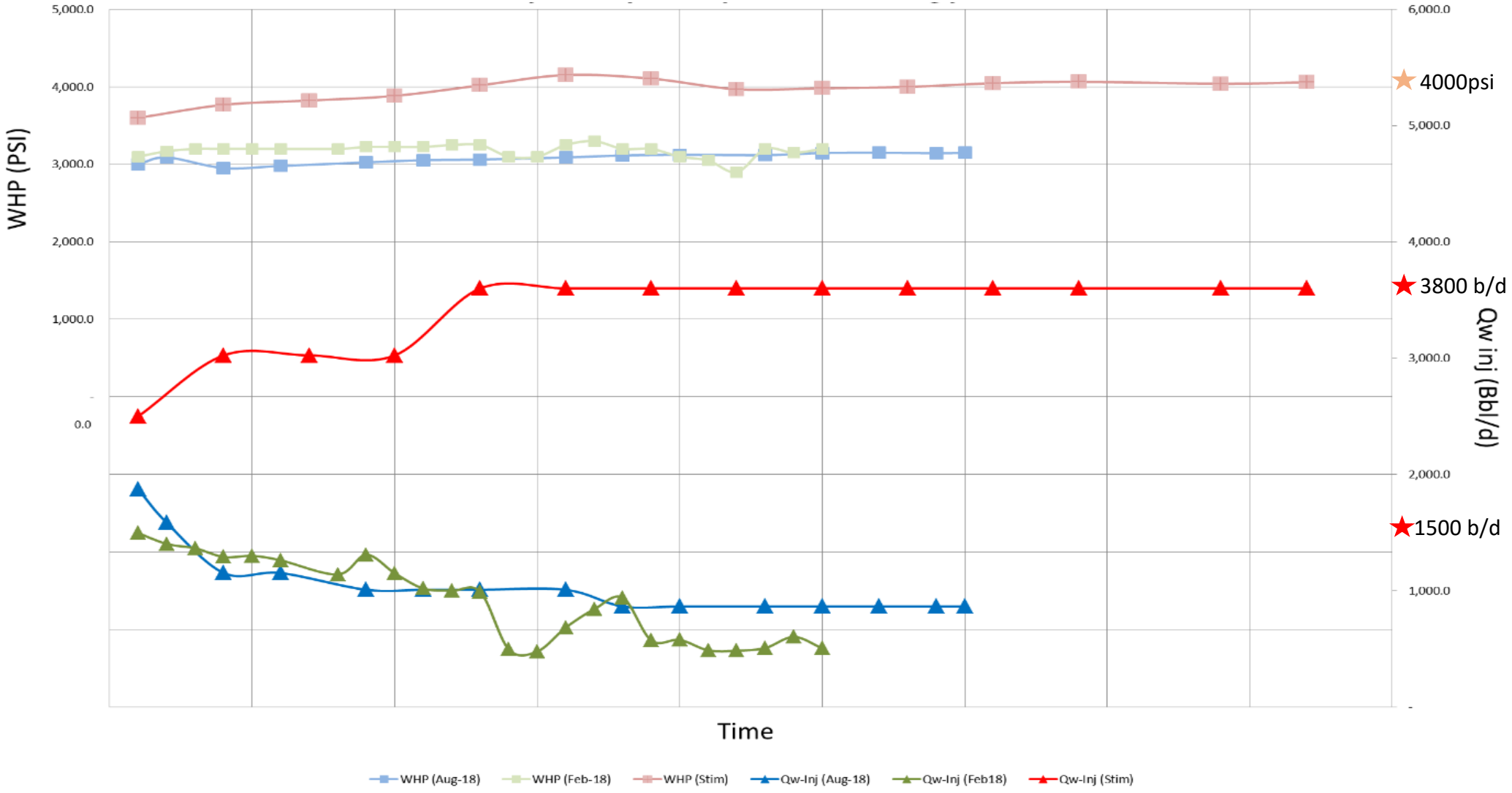
Case 1: Injector Well Using Extreme Overbalance Perforating – Propellant-Assisted Perforating



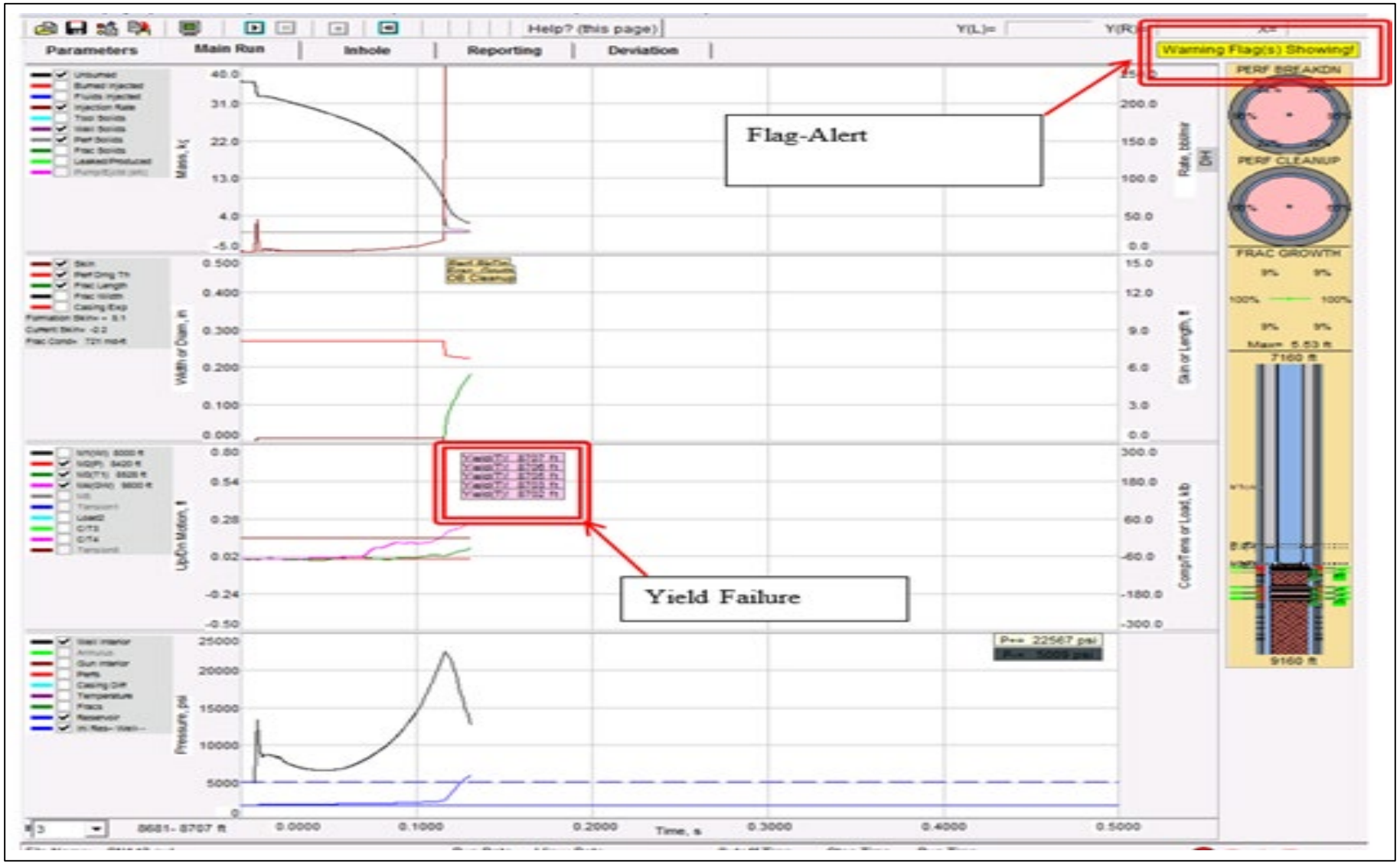
Increase from 1,500 to 3,800 B/D at 4,000 psi

Case 2: Production Well Using Extreme Overbalance Perforating – Propellant-Assisted Perforating

- Well was a high-angle well (80°) drilled and completed in the Llanos basin during in 2012.
- By 2014, the well had 843 ft of perforations producing 184 B/D of oil with a bottomhole flowing pressure (Pwf) of 1,231 psi and a skin damage of +27.
- During 2015, the well was perforated using tubing-conveyed perforating guns and only 50% of open interval was selected to be treated with propellant.
- Results obtained were an astonishing 130% increase in production, which drove the technology implementation to an additional 80 wells in the field.

Case 2: Production Well Using Extreme Overbalance Perforating – Propellant-Assisted Perforating

First Iteration Failed



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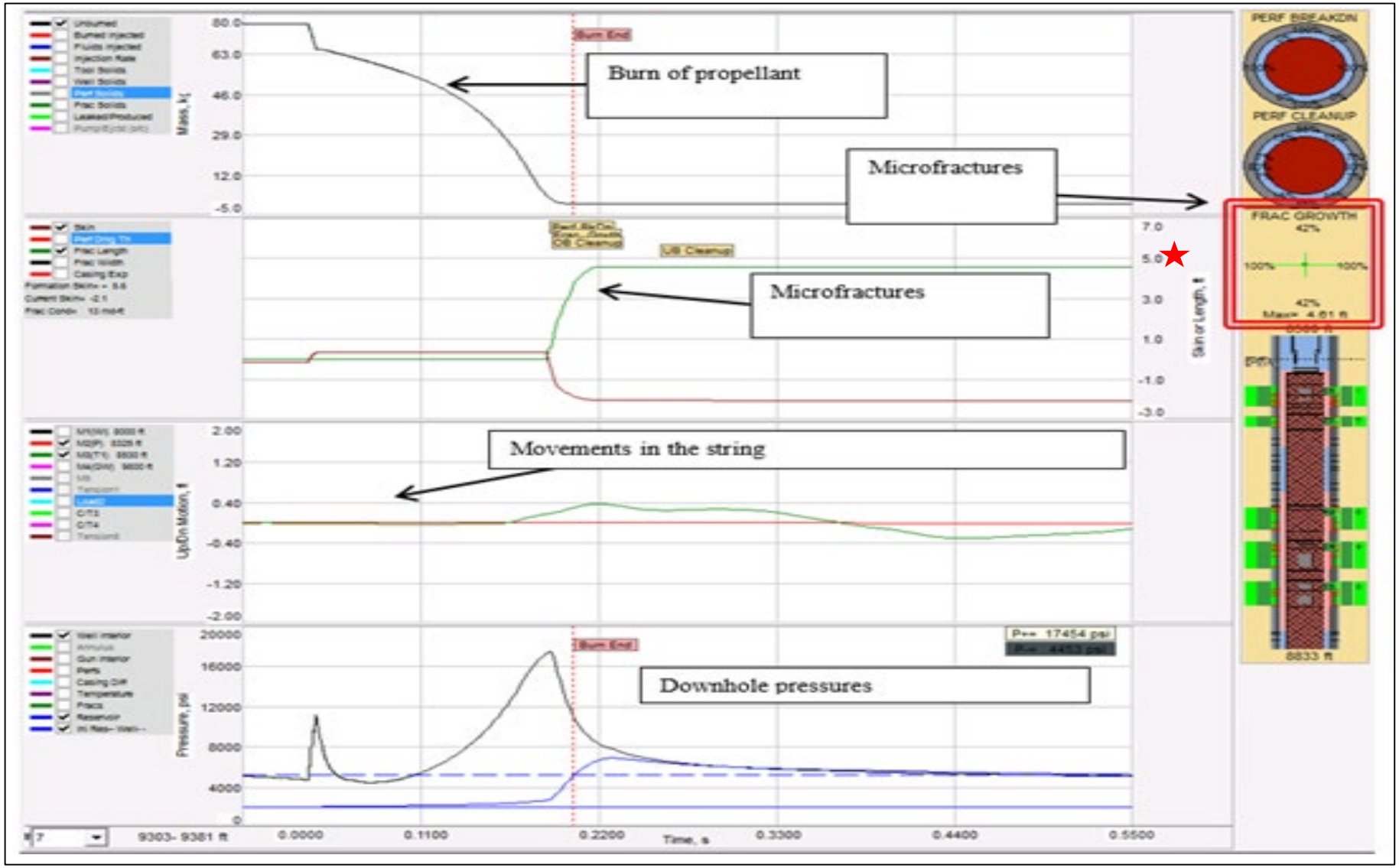
Simulation with 80% coverage of propellant compared to perforating guns

Case 2: Production Well Using Extreme Overbalance Perforating – Propellant-Assisted Perforating

Second Iteration Success



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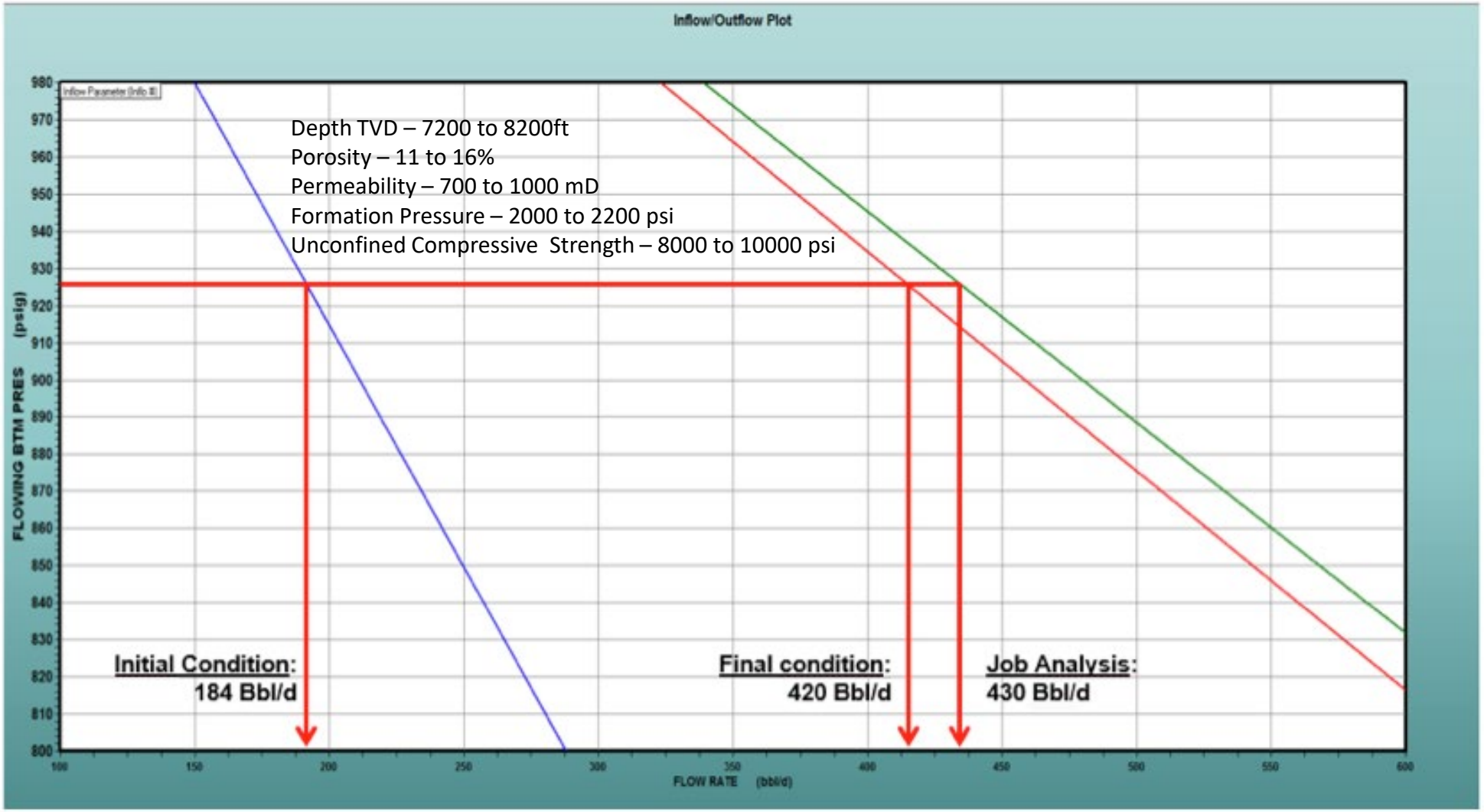
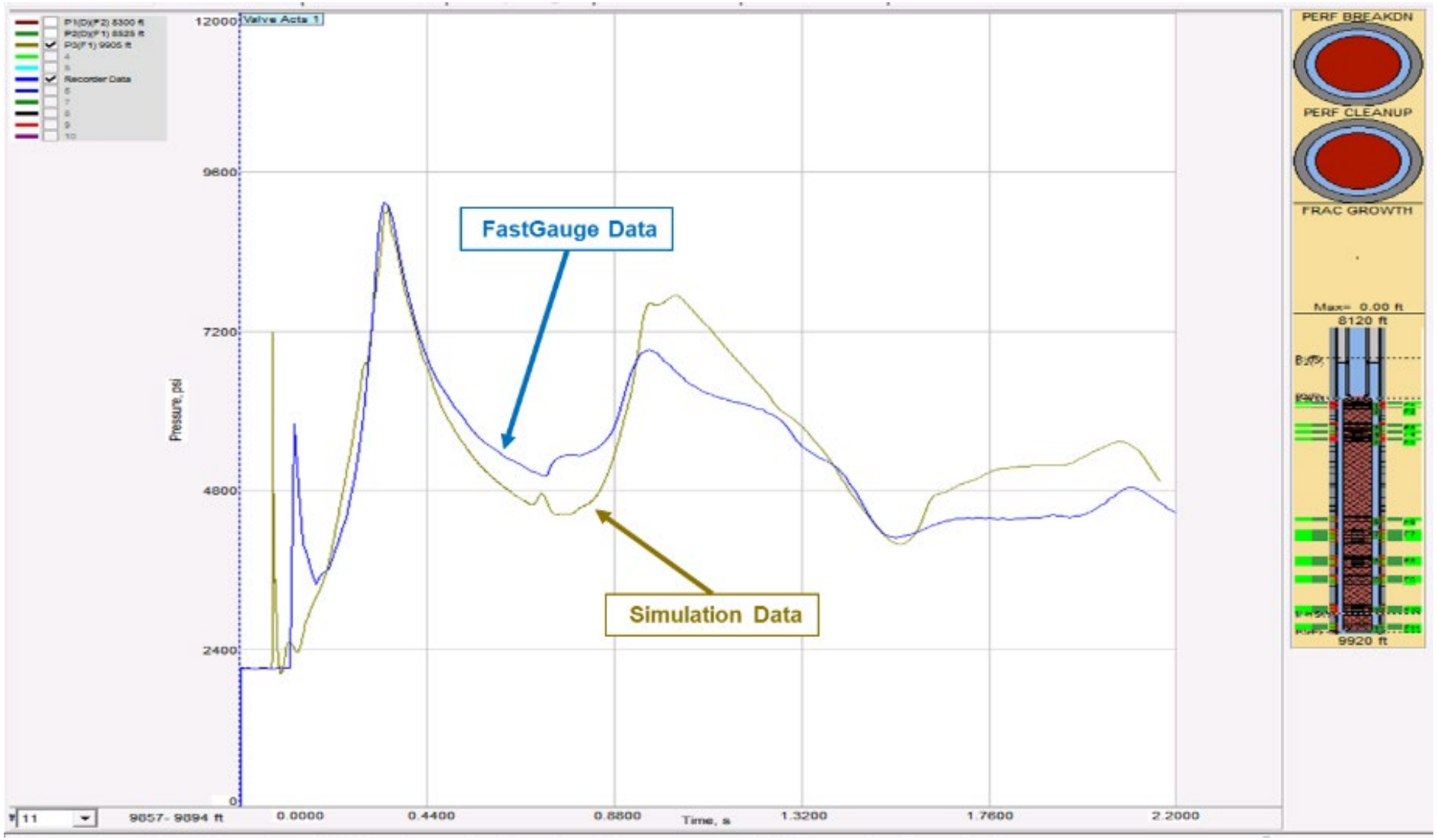
Final shockwave simulation with 50% ratio of propellant compared to perforating guns

Case 2: Production Well Using Extreme Overbalance Perforating – Propellant-Assisted Perforating



Comparative inflow performance relationship for Well B

Case 2: Production Well Using Extreme Overbalance Perforating – Propellant-Assisted Perforating



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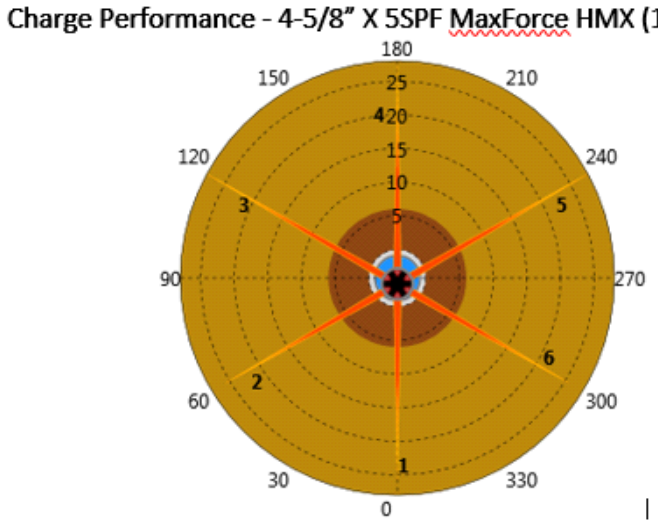
Match FastGauge data with simulation data

Case 3: Producer Well Using Dynamic Underbalance Perforating

- Well was drilled and completed in the Llanos basin during 2016.
- Well had permeability close to a Darcy and an approximately 5,000-psi unconfined compressive strength (UCS).
- Well was initially perforated at 12 shots per foot (spf) using big hole charges to maximize flow areas and then later reperforated at 5 spf using deep-penetrating charges to bypass near-wellbore damage with a resulting skin of +12.53 and 308 B/D.
- Solution chosen was a dynamic underbalance wireline conveyed perforating gun system. With this, the well increased production to 631 B/D and a skin of +6.31. Because of the positive results, this technique was used in more than 15 additional wells.

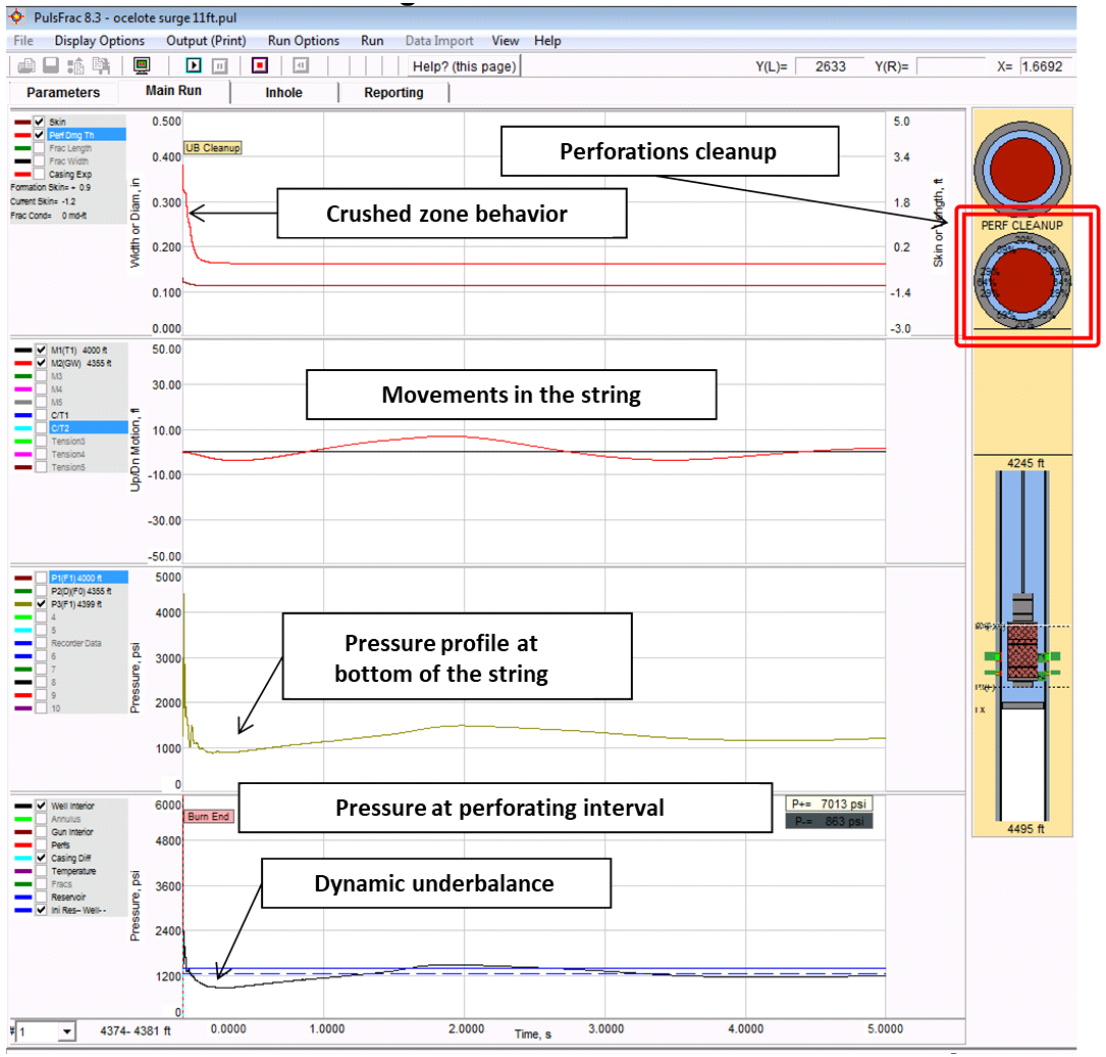
Case 3: Producer Well Using Dynamic Underbalance Perforating



Shot	Orientation (deg)	Clearance (in)	Formation Penetration (in)	EHD (in)
1	0	0	25.1	0.33
2	60	0.34	25.09	0.33
3	120	1.22	27.37	0.3
4	180	1.74	27.15	0.25
5	240	1.22	27.37	0.3
6	300	0.34	25.09	0.33

Charge Information	
Charge Type	MaxForce
Powder	HMX
Part Number	102054947
Phase Angle	60 deg
Bank Angle	60 deg
API Target Strength	5513 psi

Gun Information	
Gun Size	4.625 in
Gun Position	Eccentered
SPF	5 SPF
Shot Pattern	Spiral
Rotation	0 deg
Clearance	0 in



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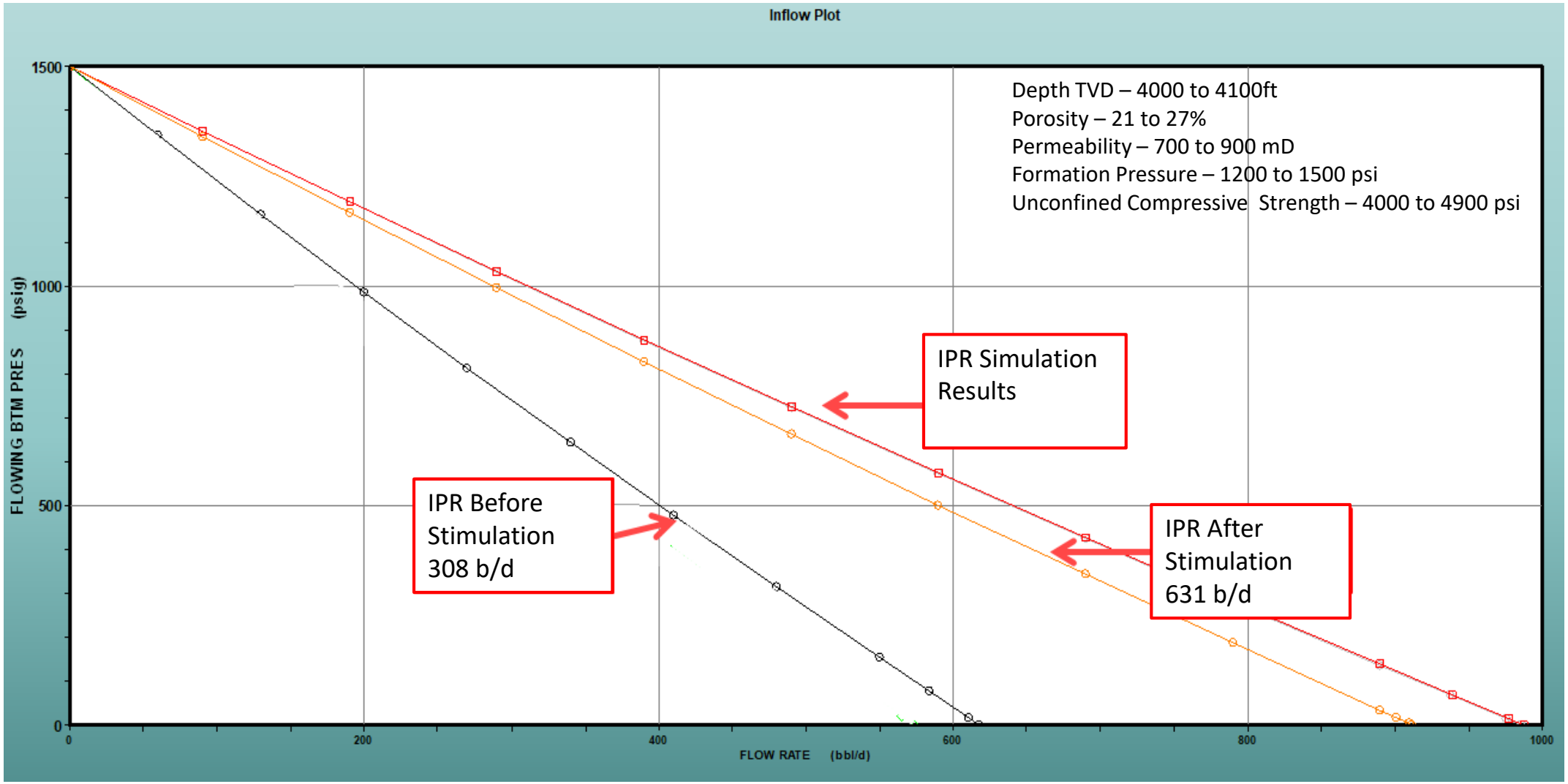
Simulations of charge penetration and dynamic underbalance perforating events

Case 3: Producer Well Using Dynamic Underbalance Perforating



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Comparative inflow performance relationship for Well C

Conclusions

Planning and executing on a well thought-out design of service helps overcome the challenges and achieve vital success.

Using a near-wellbore stimulation techniques made it possible to:

- Help improve well production and injection rates by reducing skin damage caused by fluid invasion and perforation crushed zone
- Reduce cost of workover operations by eliminating the need for matrix acidification
- Reduce water production by not fracturing into water/oil contact

THANK YOU