Stand-alone Thru-tubing Dynamic Underbalance Application to Improve Existing Well Productivity

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ASIA PACIFIC PERFORATING SYMPOSIUM

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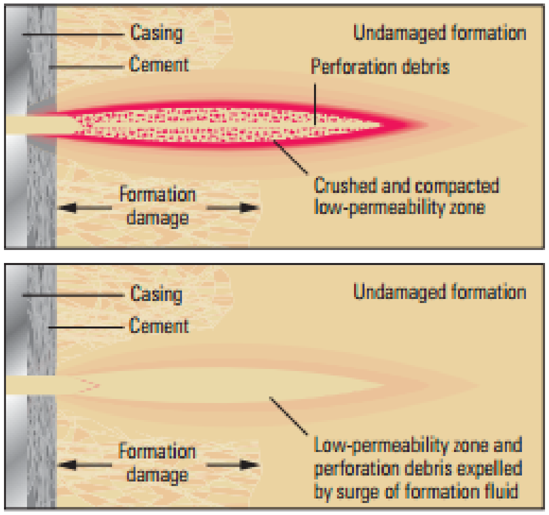
Agenda

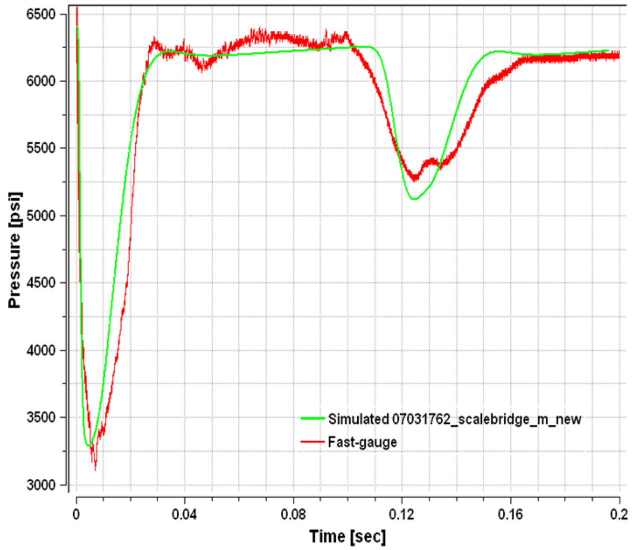
1. Technology Introduction
2. Candidate Screening
3. Well XS Implementation
4. Well YS Implementation
5. Conclusion

Technology Introduction

Stand-alone Thru-tubing Dynamic Underbalanced Application

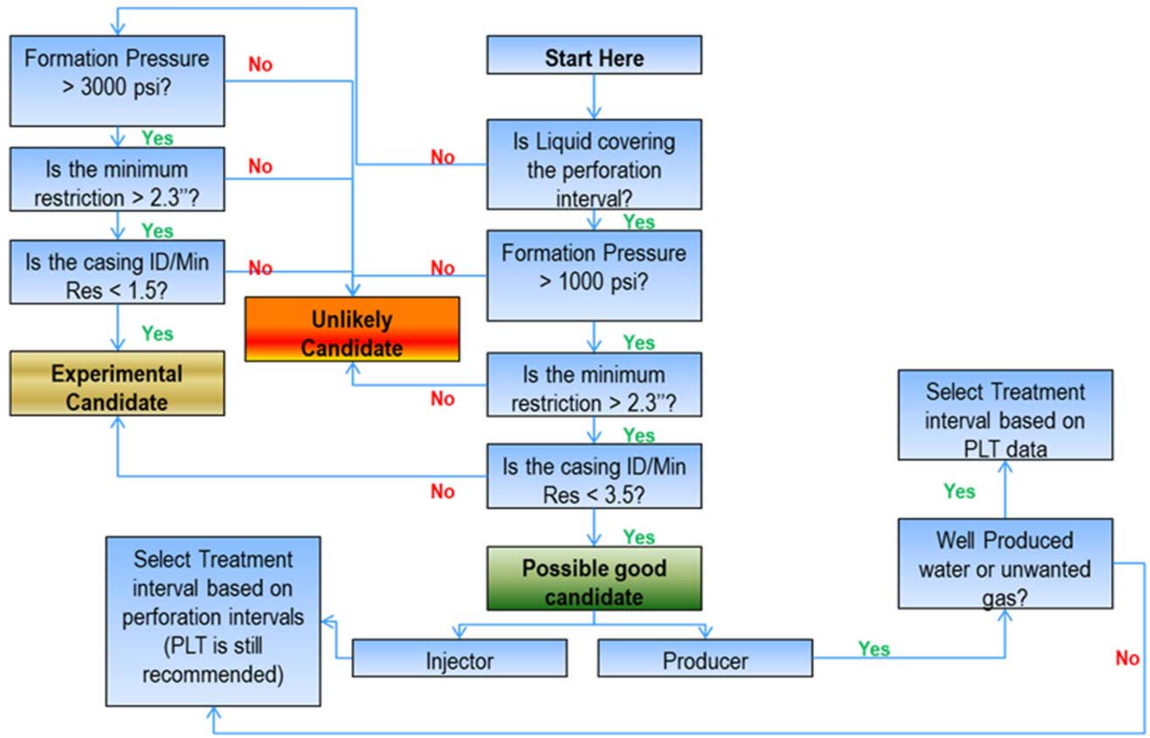
- An implosion chamber is placed across the interval to be treated, creating short-lived dynamic underbalance to clean perforation tunnels.





Candidate Screening Process

- Production profiles
- Open hole logs
- Well integrity reports
- Well intervention history
- Completion requirement
- Perforation designs
- Data acquisition (PTA, PLT, MIT, RST, etc.)



Basic candidate screening workflow for stand-alone thru-tubing dynamic underbalanced application

Candidate Selection Stages

First Stage Screening
186 Strings

- String status (active and idle)
- Screen out depleted idle status (reached economic limit)
- Screen PI and production history for active strings
- Screen out wells that have any future PE plan

Second Stage Screening
51 Strings

Completion Requirement:

- 2.3” < tubing ID/restriction < 3.5”.
- Direct access to perforation interval
- No permanent sand control (e.g. GP)

Subsurface Requirement:

- Static Res. Press > 1000 psi
- Perm > 50 mD

Candidate Selection Stages

Third Stage Screening
19 Strings

- Reservoir type (unconsolidated vs. consolidated)
- Rock UCS
- Sand tendency
- Critical drawdown pressure and water cut

Fourth Stage Screening
2 Strings

Technical gate approval – Full Candidate Analysis

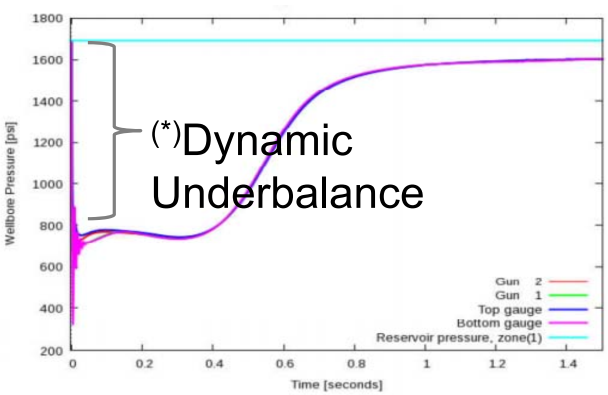
- Well & production history
- Subsurface evaluation (cross section, map, logs, fluid contacts)
- Reserves calculation (volumetric & DCA)
- Nodal analysis and perforation evaluation
- Economics
- Summary of job procedure

Well XS Implementation

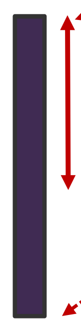
Well status: Well is depleting, reaching its economic limit (50 bopd)

Solution: Thru-tubing DUB pilot to stimulate upper layer. Lower risks due to low depleting production

Selective Treatment: Top 12 ft, ~ 900 psi DUB(*) applied in 2.5”, 30-ft chamber (20-ft loaded)

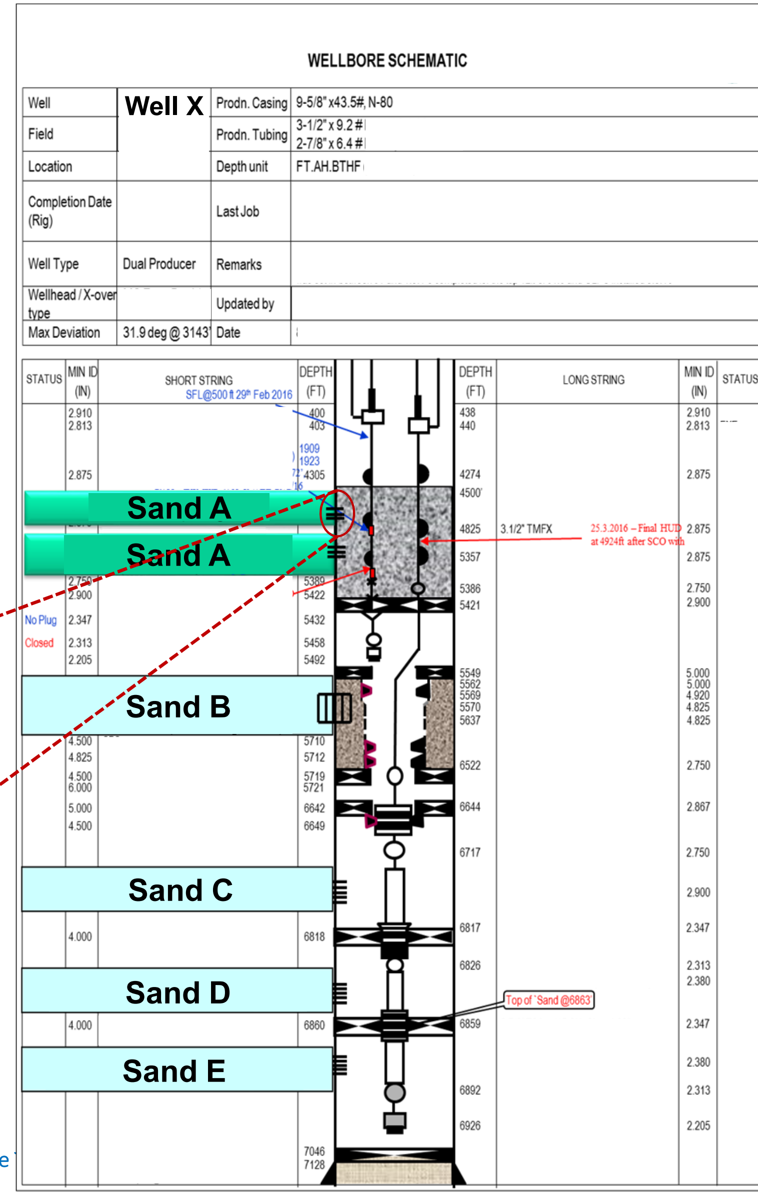


4788 Ft MDKB



DUB treatment (12 ft)

4808 Ft MDKB

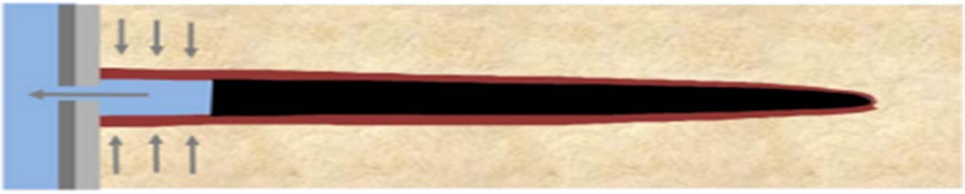


Stand-alone

WELL XS (Sand A) Implementation

Reverse Perforation Evaluation (Before Thru-tubing DUB)

- Current effective perforation tunnels length show **only ~30%** of the total tunnel length are contributing to flow.



Perforating System(s)

Perf #	Loaded Length (ft)	Phasing Angle (deg)	Shot Density (spf)	Eff Shot Density (spf)	Clean Length Lc/L	Form Pen Avg (in)	Form Dia Avg (in)	EH Dia Avg (in)
1	20.0	0 (360)	8.00	8.00	0.28	2.47 *	0.26	0.10

* Rock-based Model: Based on lab experiments in rocks with UCS up to 18k psi under downhole conditions

Perf #	Eff Skin	PI * (STB/day /psi)	Flow * Rate (STB/day)
1	15.84	0.99	512.4

Formation

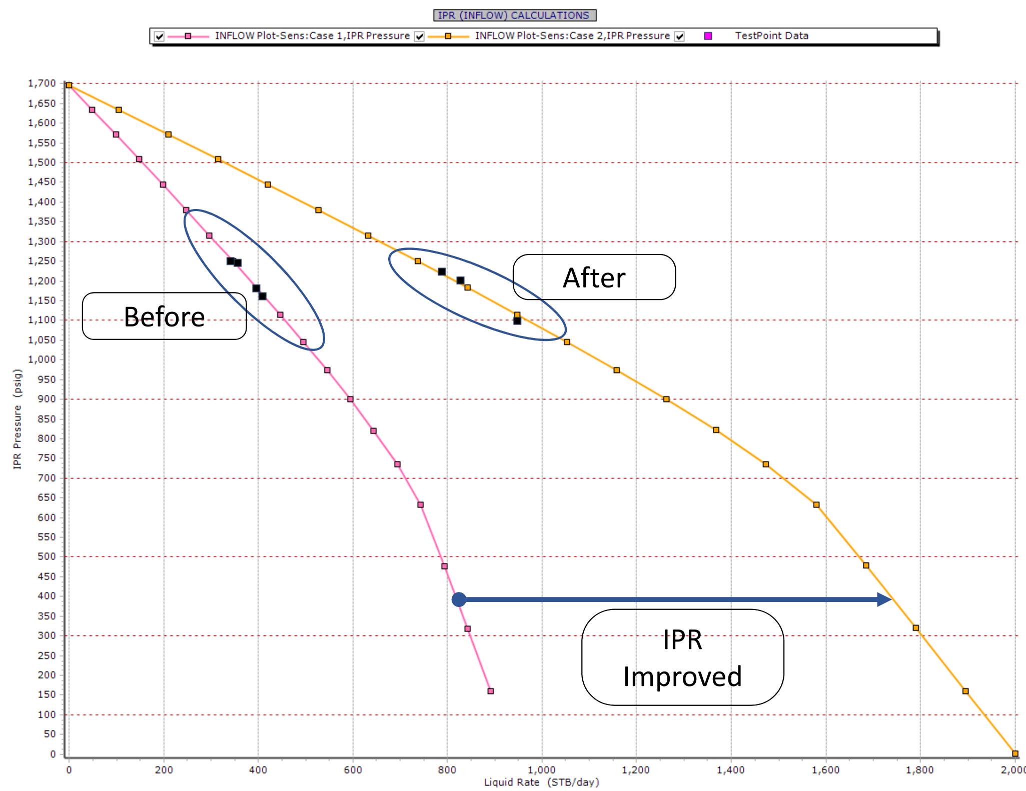
kh:	377.00	md
kh/kv:	10.00	
Bulk Density:	2.24	g/cm3
Rock UCS:	2947	psi
Vertical Stress:	4479	psi
Pore Pressure:	1696	psi
kd/k:	0.65	
Well Damage:	8	in

WELL XS (Sand A) Implementation

Thru-tubing DUB Results

Well XS	Before	After
Gross Rate (blpd)	410	828
Oil Rate (bopd)	82	166
WC (%)	80	80
Productivity Index (STBD/psi)	0.8	1.7
UEC ($/bbl)	**9.65**	

Instantaneous Gain
~80 bopd

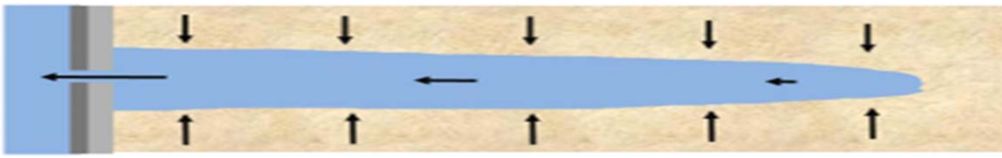


PI doubled from 0.8 to 1.7 STBD/psi

WELL XS (Sand A) Implementation

Reverse Perforation Evaluation (After Thru-tubing DUB)

- The new effective perforation tunnels show **100%** of the total tunnel length are **contributing to flow**

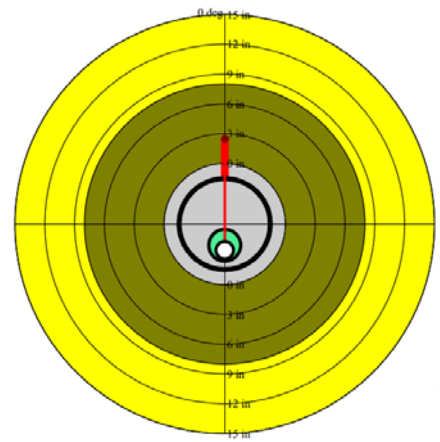


Perforating System(s)

Perf #	Loaded Length (ft)	Phasing Angle (deg)	Shot Density (spf)	Eff Shot Density (spf)	Clean Length Lc/L	Form Pen Avg (in)	Form Dia Avg (in)	EH Dia Avg (in)
1	20.0	0 (360)	8.00	8.00	1.00	2.47 *	0.26	0.10

* Rock-based Model: Based on lab experiments in rocks with UCS up to 18k psi under downhole conditions

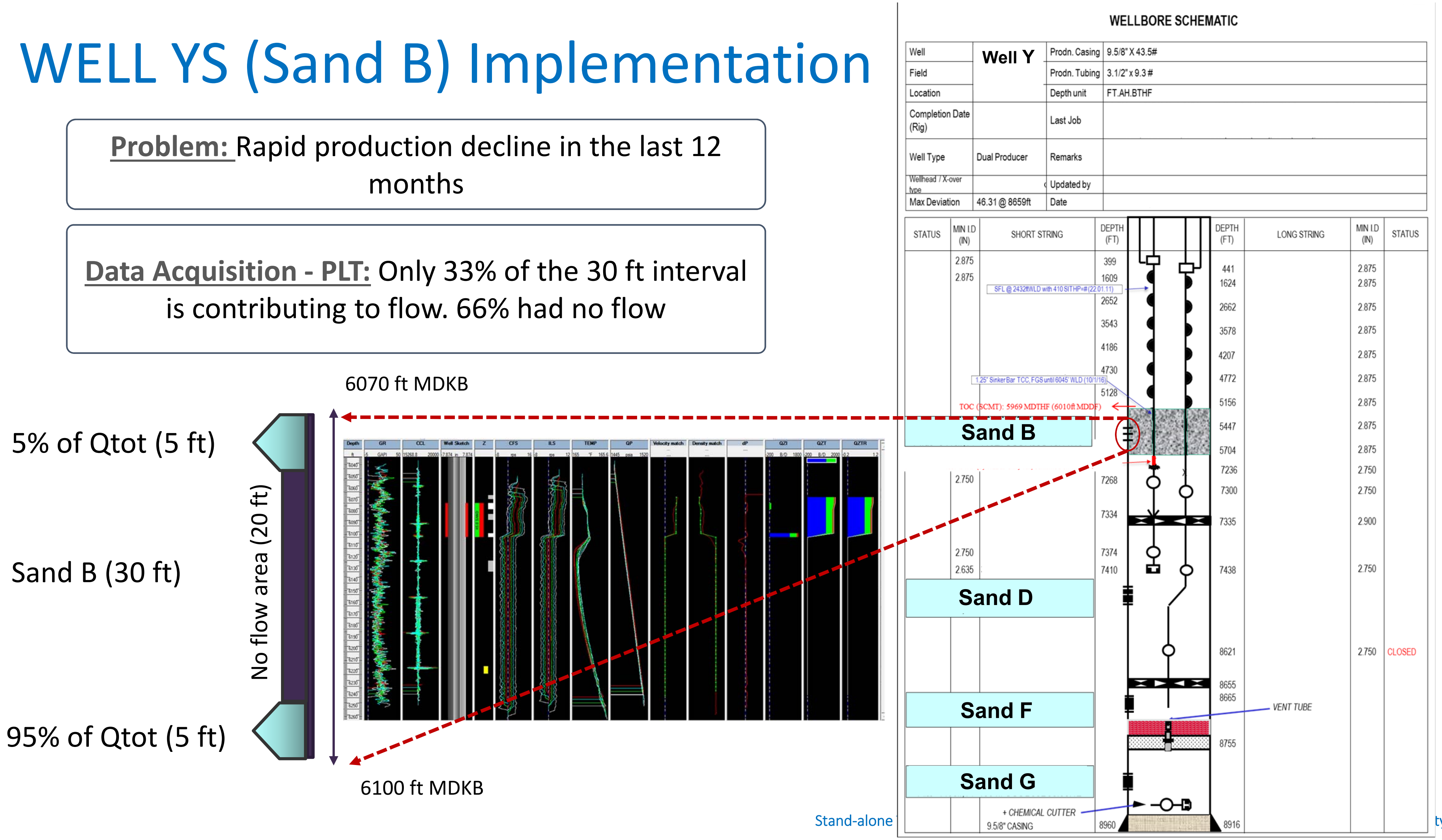
Perf #	Eff Skin	PI * (STB/day /psi)	Flow * Rate (STB/day)
1	7.47	1.62	805.5



WELL YS (Sand B) Implementation

Problem: Rapid production decline in the last 12 months

Data Acquisition - PLT: Only 33% of the 30 ft interval is contributing to flow. 66% had no flow

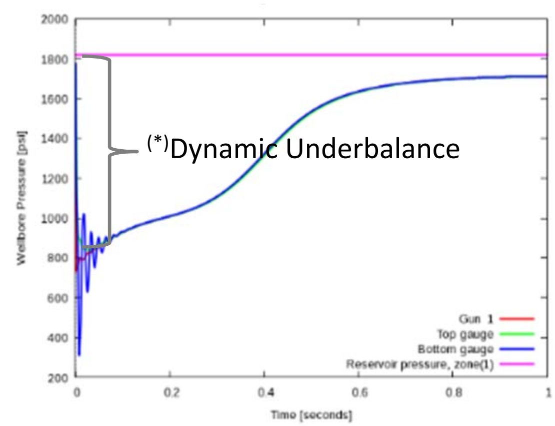


Stand-alone

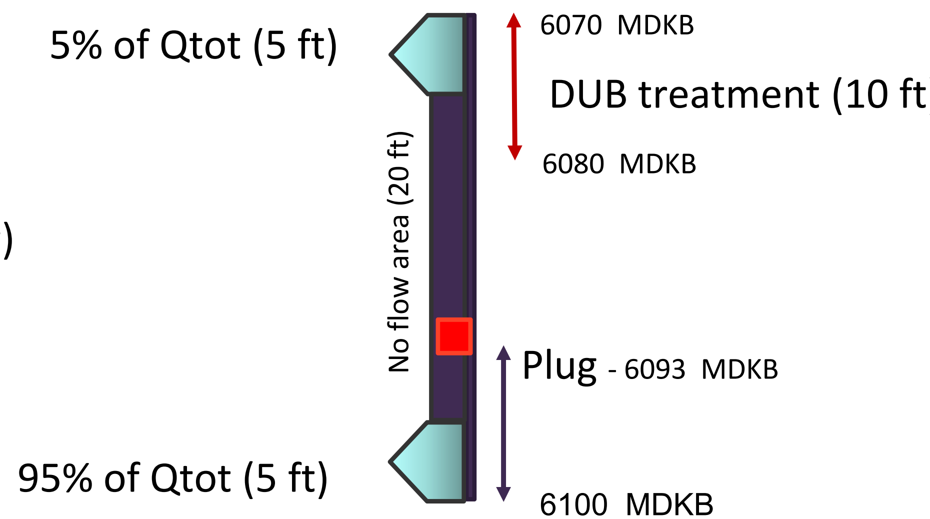
WELL YS (Sand B) Implementation

Solution – Selective Thru-tubing DUB Treatment:

- A nippleless plug was installed to isolate lower zone
- Treat top 10 ft, ~ 1000 psi DUB(*) applied in 2.5”, 30-ft chamber (20 ft loaded)



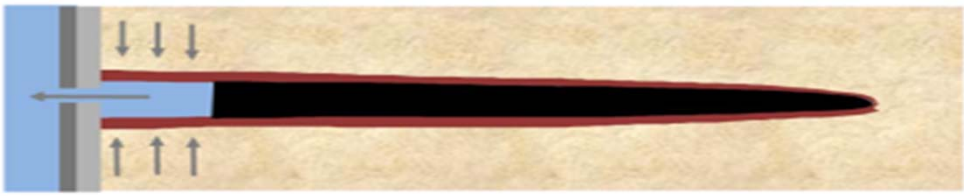
Debris analysis:
73% formation sand
(good tunnel cleaning)



WELL YS (Sand B) Implementation

Reverse Perforation Evaluation (After Thru-tubing DUB)

- Current effective perforation tunnels show only **32%** of the total tunnel length are contributing to flow



Perforating System(s)

Perf #	Loaded Length (ft)	Phasing Angle (deg)	Shot Density (spf)	Clean Length Lc/L	Form Pen Avg (in)	Form Dia Avg (in)
1	5.0	0 (360)	8.00	0.32	5.79 *	0.31

* Rock-based Model: Based on lab experiments in rocks with UCS up to 18k psi under downhole conditions

Perf #	Eff Skin	Perf Skin	PI * (STB/day /psi)	Flow * Rate (STB/day)
1	21.94	21.95	0.19	57.1

Formation

Rock Type:	Sandstone	
Porosity:	21.8	%
Horizontal Permeability:	220.00	md
Vertical Permeability:	22.00	md
kd/k:	0.25	
Wellbore Damage:	8	in

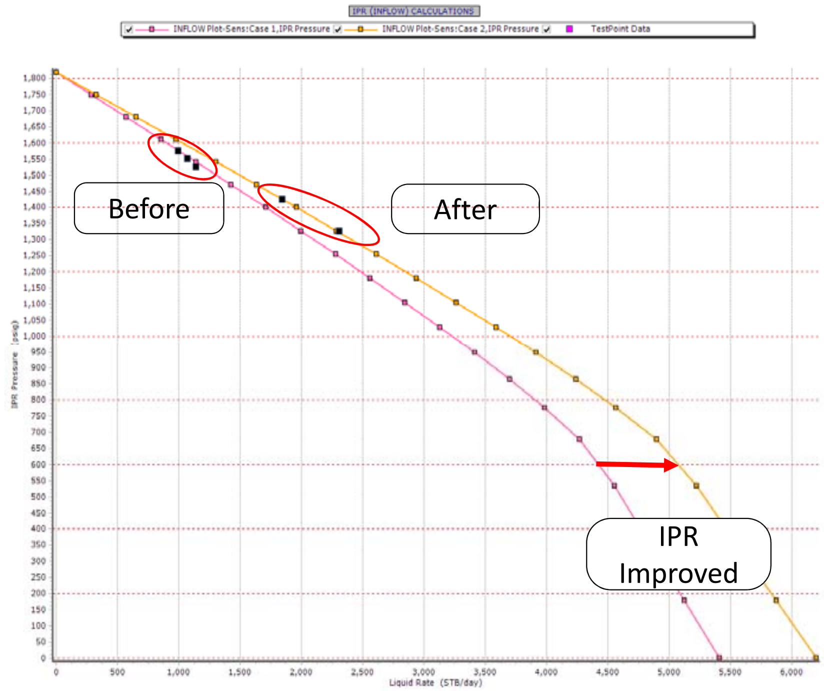
WELL YS (Sand B) Implementation

Thru-tubing DUB Results

Well YS	Before	After
Gross Rate (bfpd)	1145	2307
Oil Rate (bopd)	344	449
WC (%)	70	80
Prod Index (STBD/psi)	4.1	4.7
UEC ($/bbl)	**8.66**	

Instantaneous Gain

~100 bopd

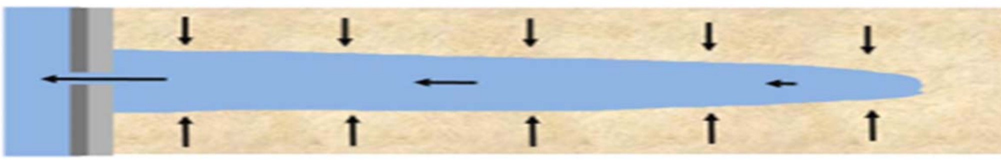


PI increased from 4.1 to 4.7. GLVC was conducted to optimize lifting due to increased WC

WELL YS (Sand B) Implementation

Reverse Perforation Evaluation (After Thru-tubing DUB)

- Result: **Additional 3 ft** of perf interval is now contributing to flow (total 8 ft) with the effective perforation tunnels length **100%**



Perforating System(s)

Perf #	Loaded Length (ft)	Phasing Angle (deg)	Shot Density (spf)	Clean Length Lc/L	Form Pen Avg (in)	Form Dia Avg (in)
1	8.0	0 (360)	8.00	1.00	5.79 *	0.31

* Rock-based Model: Based on lab experiments in rocks with UCS up to 18k psi under downhole conditions

Perf #	Eff Skin	Perf Skin	PI * (STB/day /psi)	Flow * Rate (STB/day)
1	11.17	10.76	0.52	254.8

Well Ys	Oil Rate (bopd)	Perf Int (ft)	PI (stbd/psi)
Before	57	5	0.15
After	254	8	0.52
Increment	197	3	0.37

Conclusion

1. Instantaneous gain: 180 bopd from thru-tubing DUB application
2. Cost optimization (~9 USD/bbl)
3. New technology introduction in Field S
4. Increased perforation efficiency
5. Studies of impact of watercut increase and sand production are needed

QUESTIONS?
THANK YOU!

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