HPGL: The Critical Variables Affecting Your Maximum Outflow Potential

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ALRDC Gas Lift Workshop

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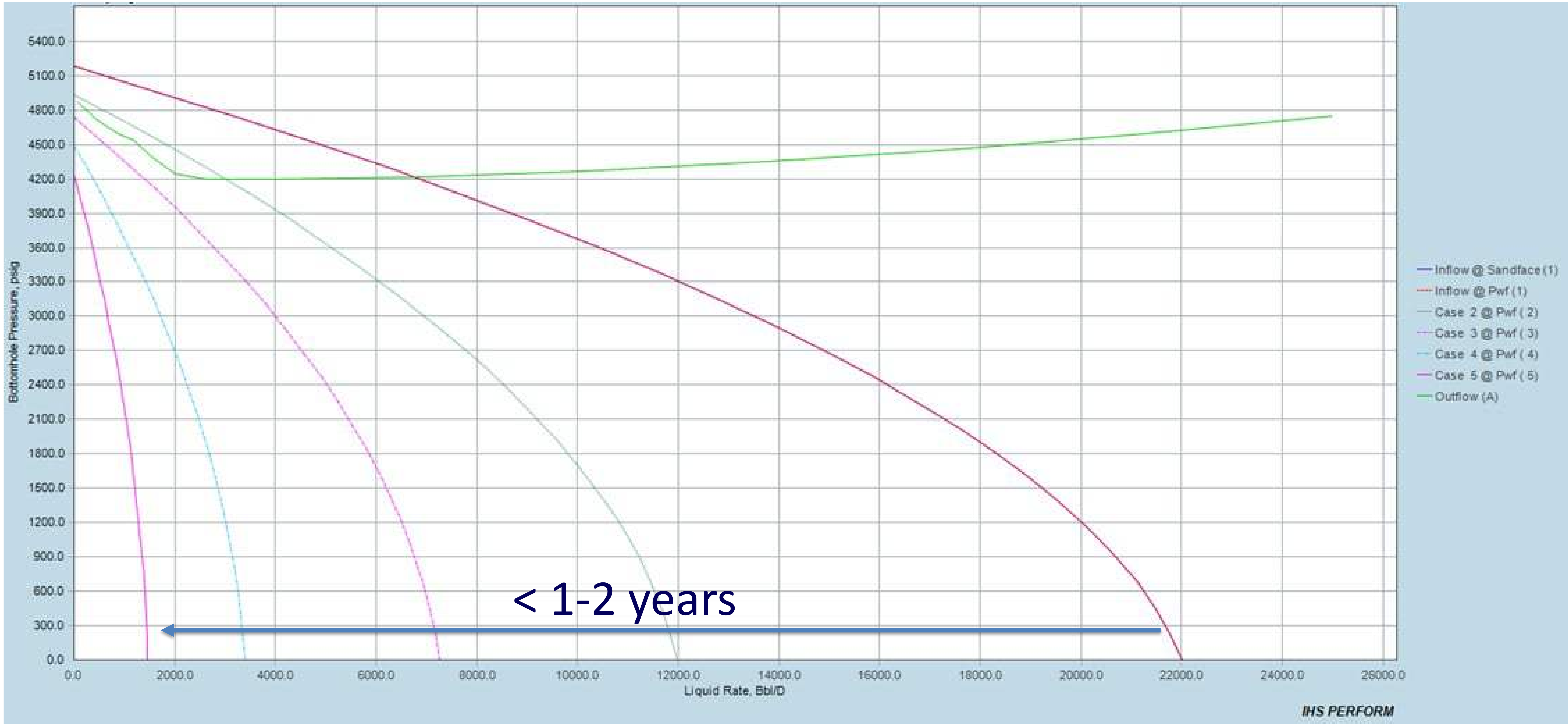
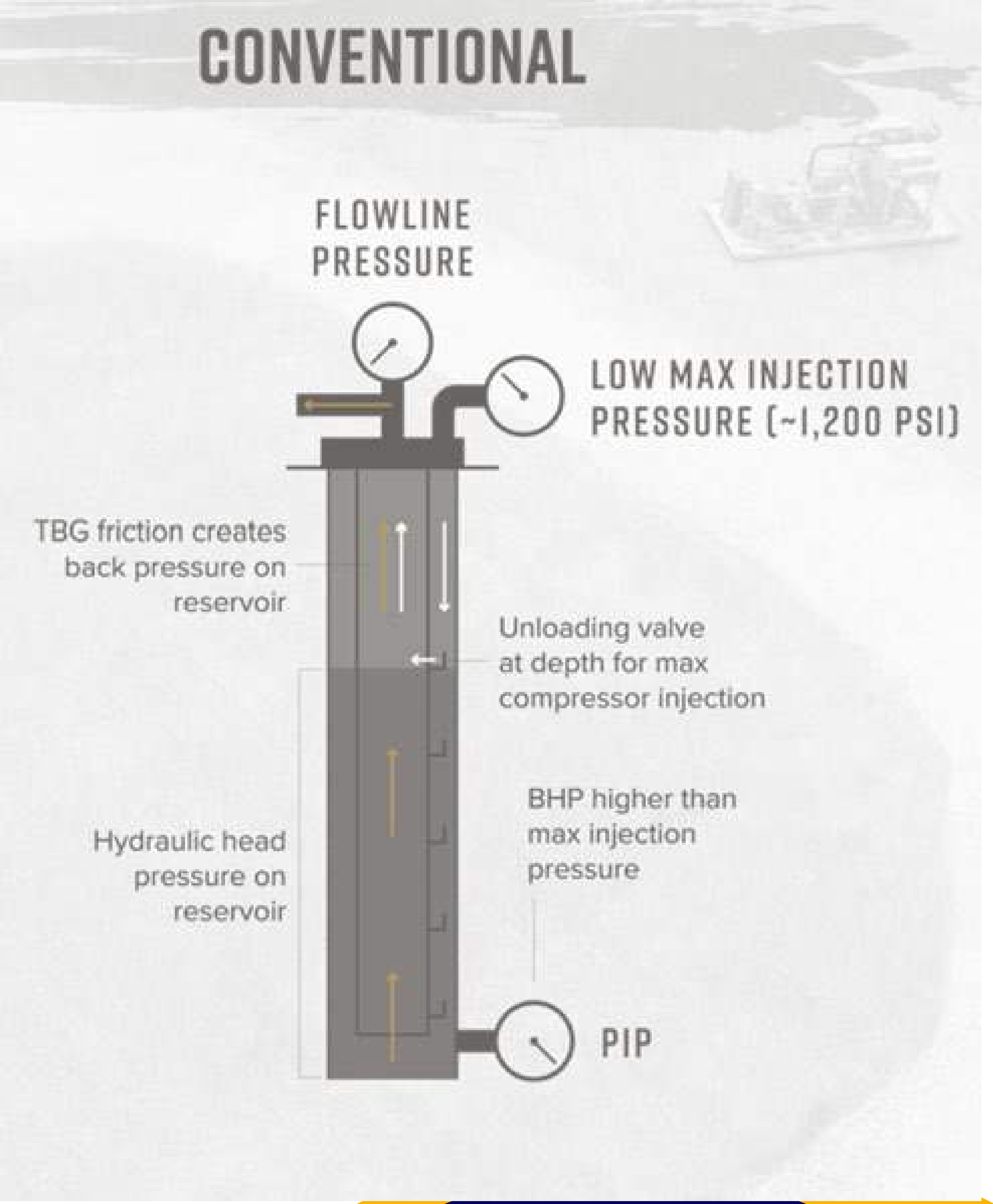
Agenda

- Overview of gas lift methods being used today
- Overview of the critical variables affecting your outflow potential
- HPGL design case study and results
- Conclusions
- Discussion

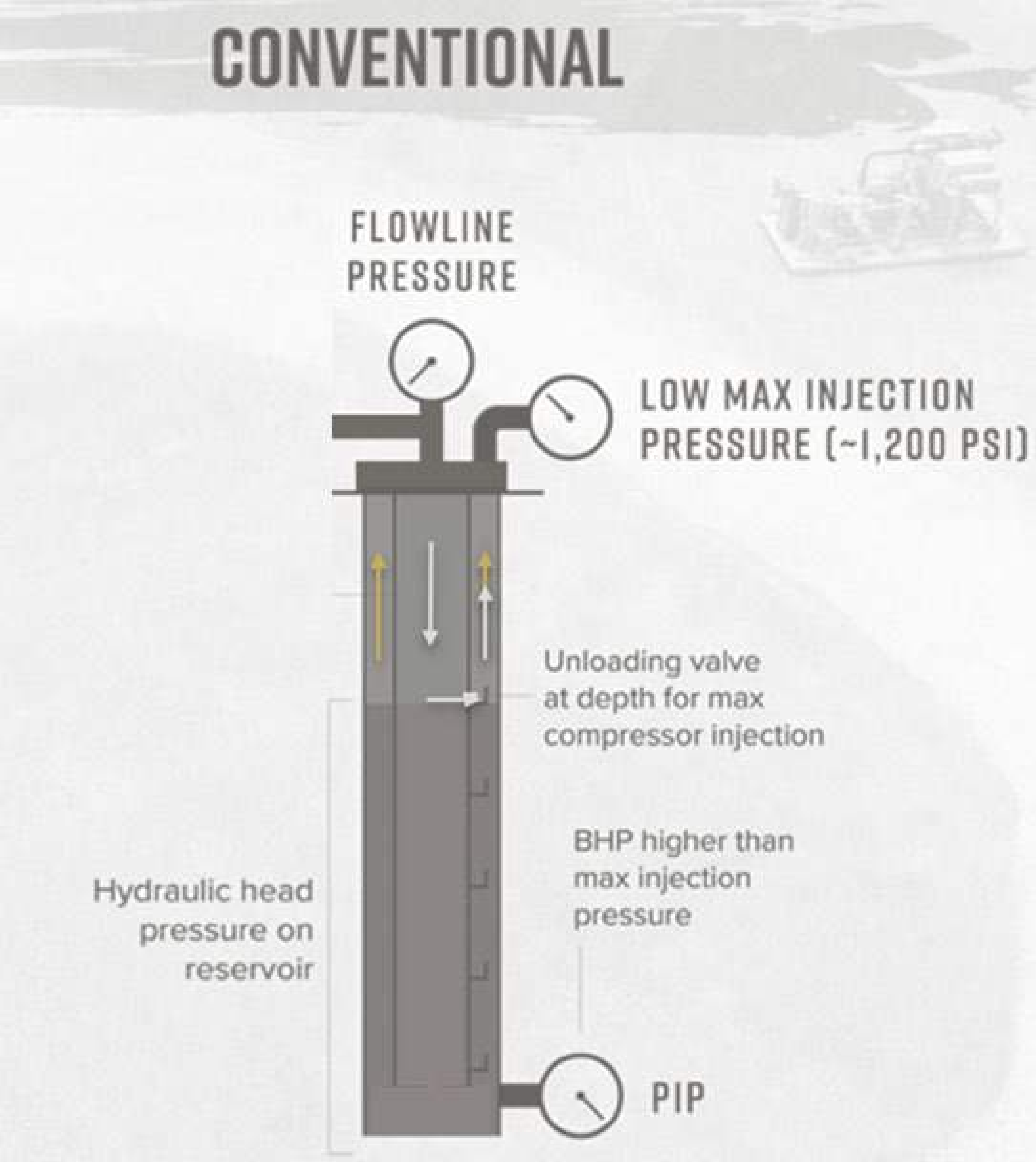


Bottomhole Pressure, psig
5400.0
5100.0
4800.0
4500.0
4200.0
3900.0
3600.0
3300.0
3000.0
2700.0
2400.0
2100.0
1800.0
1500.0
1200.0
900.0
600.0
300.0
0.0
0.0
2000.0
4000.0
6000.0
8000.0
10000.0
12000.0
14000.0
16000.0
18000.0
20000.0
22000.0
24000.0
26000.0
Liquid Rate, Bbl/D
IHS PERFORM
Inflow @ Sandface (1)
Inflow @ Pwf (1)
Case 2 @ Pwf (2)
Case 3 @ Pwf (3)
Case 4 @ Pwf (4)
Case 5 @ Pwf (5)
Outflow (A)
< 1-2 years



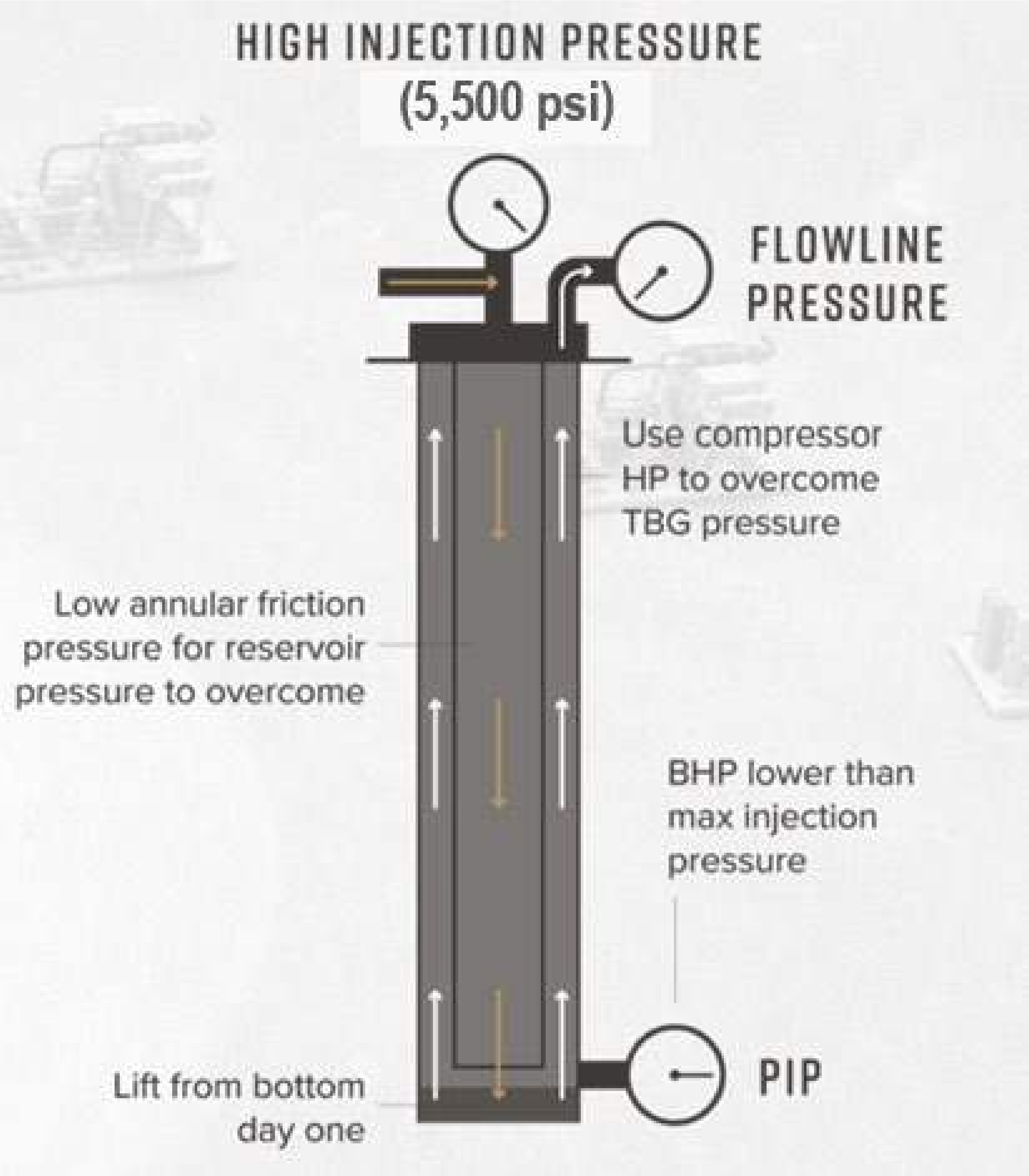
Tubing Flow

- Pros:
  - Excellent solids handling capabilities
  - Gas interference not an issue
  - Deviated wellbores not an issue
  - Flexible operating range
- Cons:
  - Susceptible to line pressure fluctuations
  - Maximum outflow limited by:
    - Hydraulics
    - Lift point
    - Injection Rate



Annular Flow

- Pros:
  - Excellent solids handling capabilities
  - Gas interference not an issue
  - Deviated wellbores not an issue
  - Flexible operating range
- Cons:
  - Susceptible to line pressure fluctuations
  - Maximum outflow limited by:
    - Hydraulics
    - Lift point
    - Injection Rate



HPGL

- Pros:
  - Excellent solids handling capabilities
  - Gas interference not an issue
  - Deviated wellbores not an issue
  - Flexible operating range
  - Complete control over drawdown
- Cons:
  - Susceptible to line pressure fluctuations

The Critical Variables

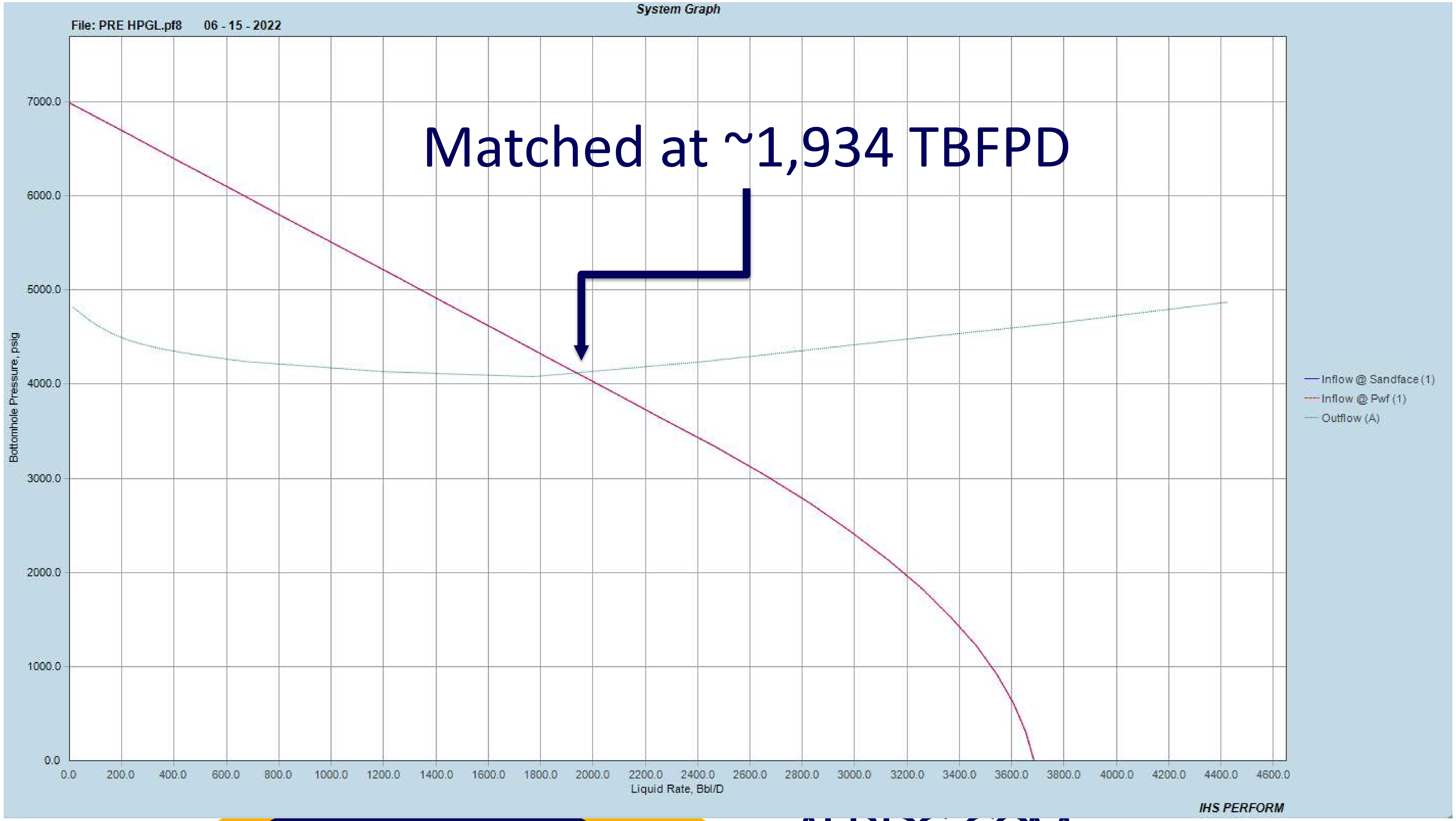
- Injection Rate
  - Unloading Phase
  - Critical Velocity Phase
- Flowing Wellhead Pressure
- Cross Sectional Flow Area
- Lift Point

Design Exercise

- Area: Delaware Basin
- Scope: Maximize Production
- Reservoir Pressure = 7000 psig
- Reservoir Temp. = 175 deg F
- Oil API = 45
- SG Gas = 0.77
- WC = 76%
- Water SG = 1.02
- Flowing Wellhead Pressure = 225 psig
- Producing GLR = 289 scf/bbl
- Total Fluid Per Day (TFPD) = 1,934
- Casing: 5-1/2" 23# set at 22,000 MD (11,850' TVD)
- Tubing: 2-7/8" 6.5# set at 11,200 MD (11,175' TVD)
- Free flowing up tubing

Design Process

1. Perform base case history match by:
    a. If FBHP data available, match hydraulic correlation (Hagedorn & Brown, Ansari, Beggs & Brill, etc)
    b. If FBHP not present, use Hagedorn & Brown to match FBHP
2. Run sensitivities for each critical variable
    a. Lift point
    b. Cross section flow area
    c. Injection rate
    d. Flowing wellhead pressure
3. Put it all together to demonstrate maximum outflow potential



System Graph
File: PRE HPGL.pf8 06 - 15 - 2022
Matched at ~1,934 TBFPD
Bottomhole Pressure, psig
7000.0
6000.0
5000.0
4000.0
3000.0
2000.0
1000.0
0.0
0.0 200.0 400.0 600.0 800.0 1000.0 1200.0 1400.0 1600.0 1800.0 2000.0 2200.0 2400.0 2600.0 2800.0 3000.0 3200.0 3400.0 3600.0 3800.0 4000.0 4200.0 4400.0 4600.0
Liquid Rate, Bbl/D
Inflow @ Sandface (1)
Inflow @ Pwf (1)
Outflow (A)
IHS PERFORM

Step 1: Compare lift point depth based on compressor max allowable discharge pressure (MADP) using the following equation

$$Dv = \frac{Pko - Pwh}{\text{gls}}$$

Source: PEH Vol. III

where:

Dv = top valve depth (ft)

Pko = surface kick off pressure (psig)

Pku = surface pressure (psig)

gls = static kill fluid gradient (psi/ft)

Standard MADP = 1200 psig

$$Dv = \frac{1,200 - 225}{0.433 * 1.02}$$

$Dv =$ 2,207' TVD

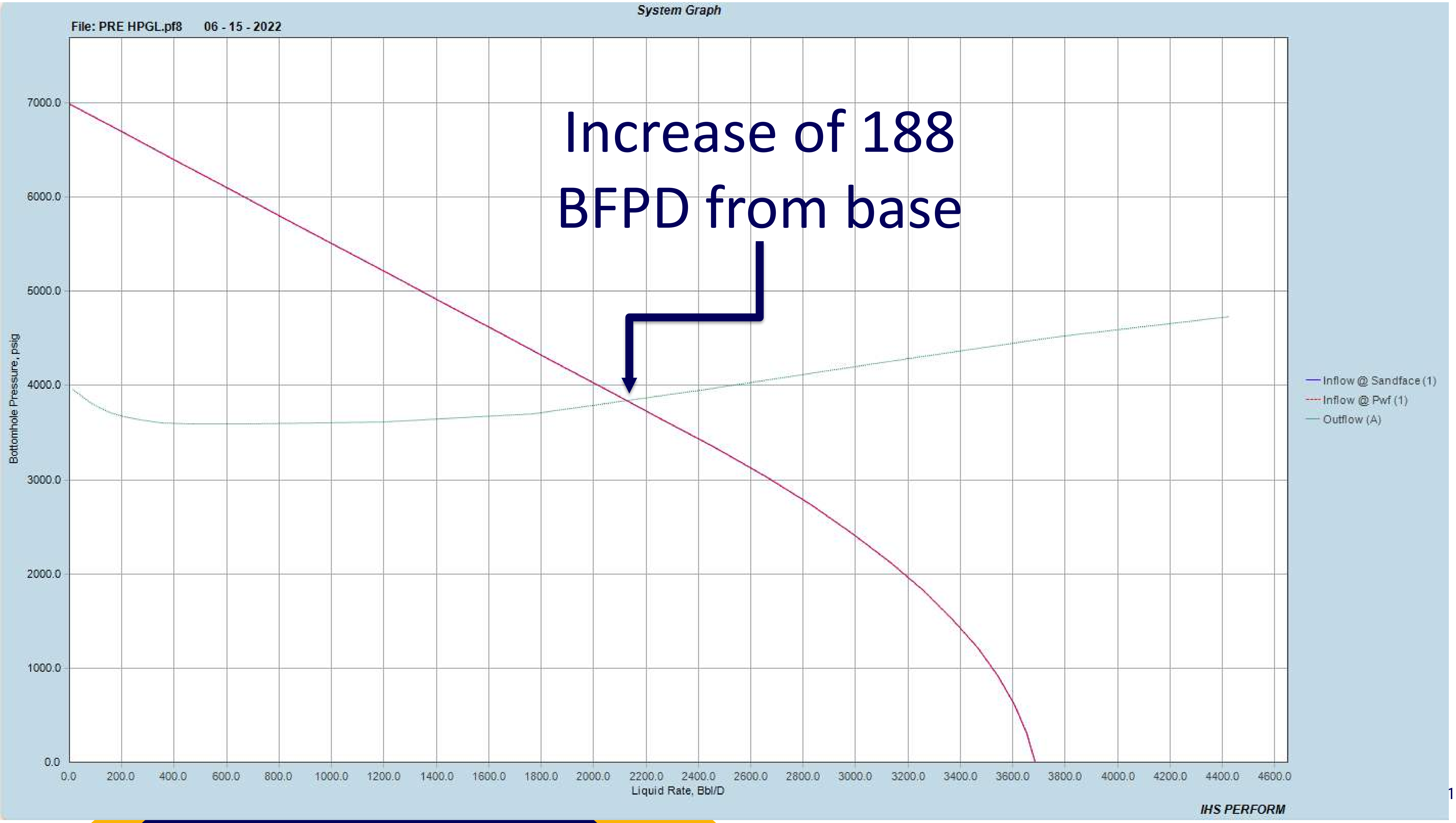
HPGL MADP = 5,500 psig

$$Dv = \frac{5500 - 225}{0.433 * 1.02}$$

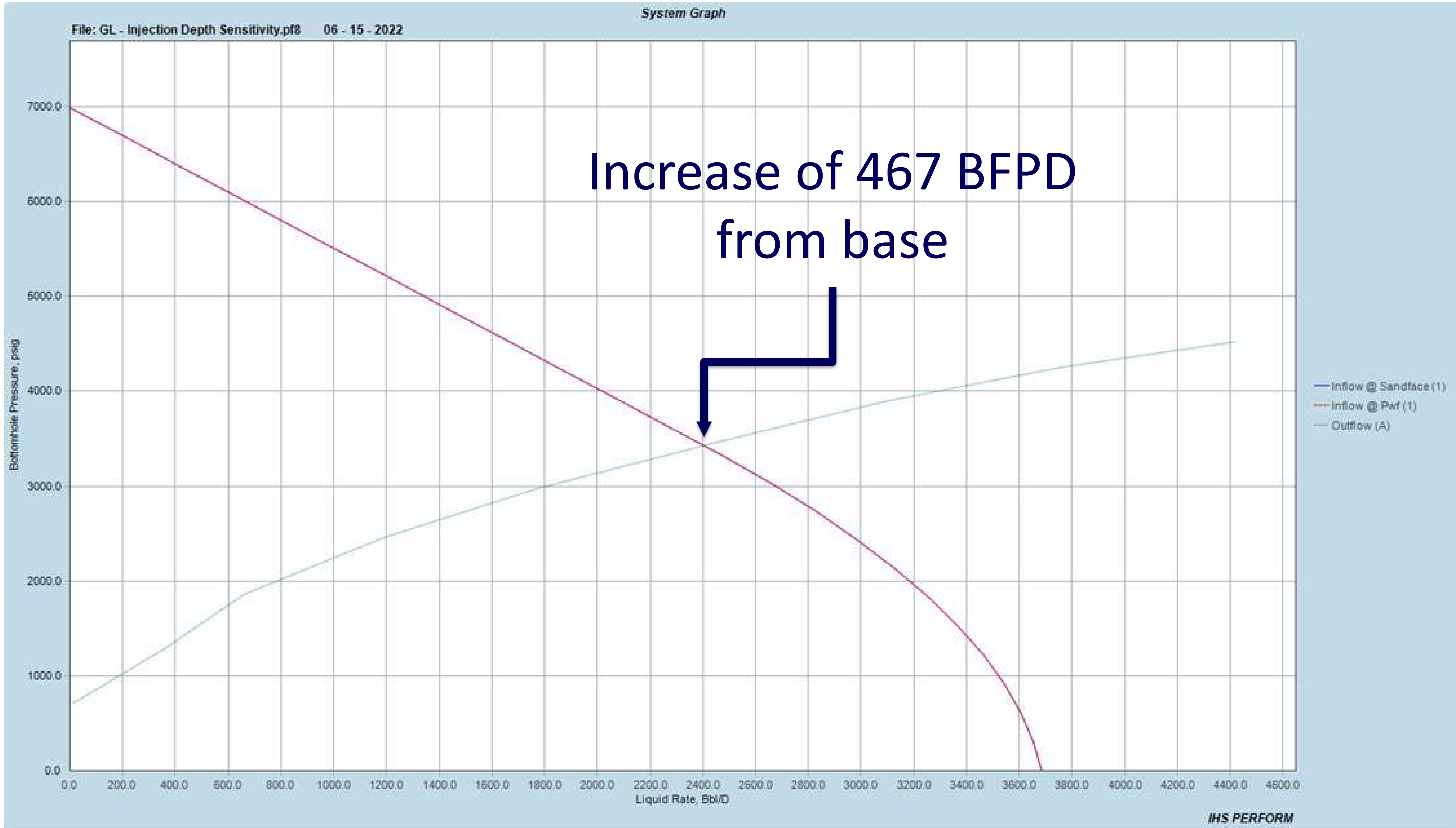
$Dv =$ 11,943' TVD

Initial injection rate = 600 mcfd

Standard Compression



HPGL Compression



Step 2: Compare varying cross sectional flow areas

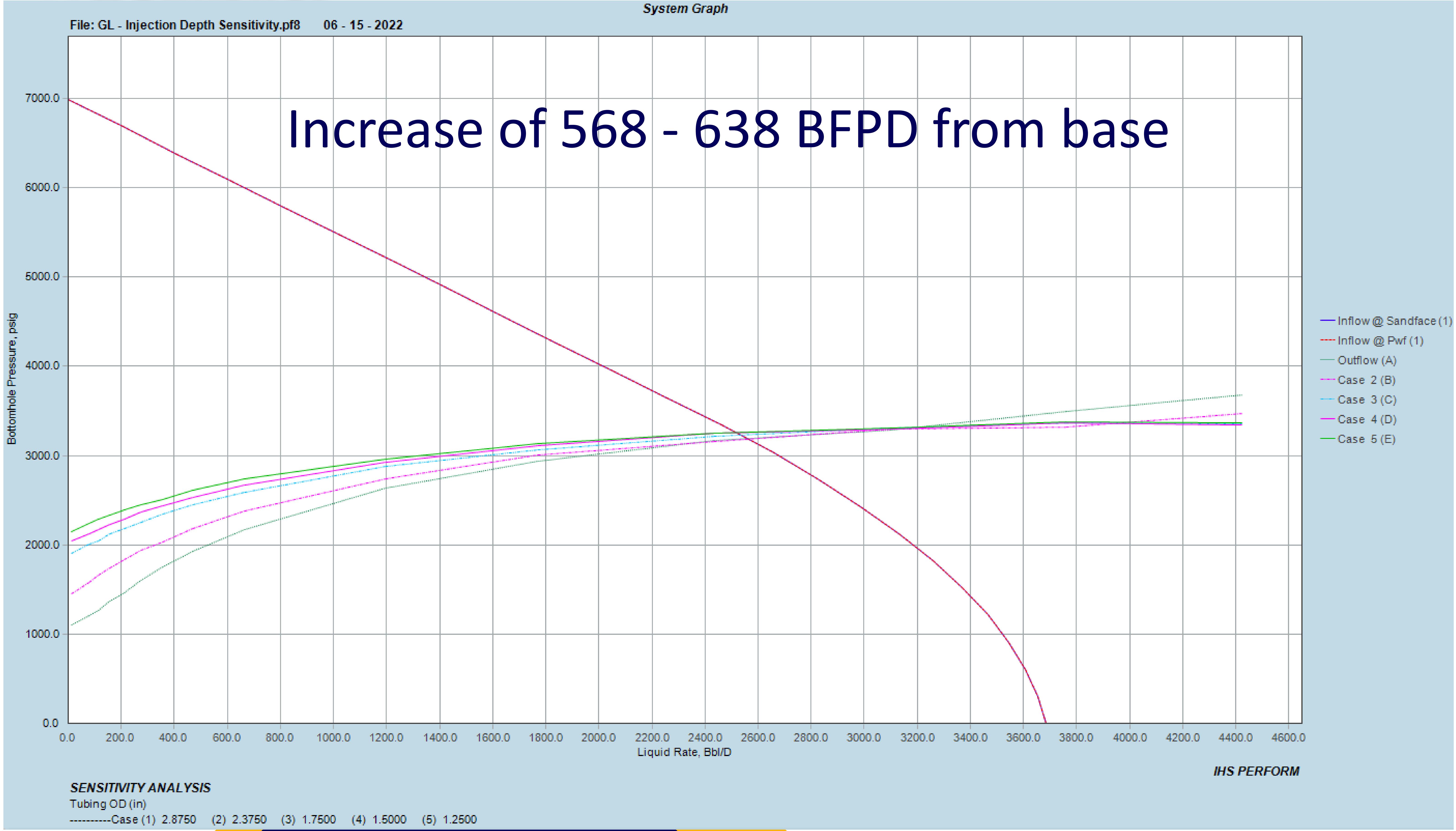
Flow Path	Equiv. ID (in)	Area (in^2)
2-3/8" 4.7# Tubing	1.995	3.13
2-7/8" 6.5# Tubing	2.441	4.68
3-1/2" 9.3# Tubing	2.992	7.03
2-7/8" x 5-1/2" 20# Annulus	3.816	11.44
2-3/8" x 5-1/2" 20# Annulus	4.146	13.50
1-5/8" x 5-1/2" 20# Annulus	4.493	15.85
1-1/4" x 5-1/2" 20# Annulus	4.612	16.71

$P_1^2 - P_2^2 =$ … $Q^2(SG)$

Simpli… id Flow … n

(*Sourc… e III*)

Increase of 568 - 638 BFPD from base



Step 3: Compare varying injection rates

$$P_1^2 - P_2^2 = 25.2\frac{Q^2 f Z T S L}{d^5}$$

Simplified Gas Equation
(*Source: PEH Volume III*)

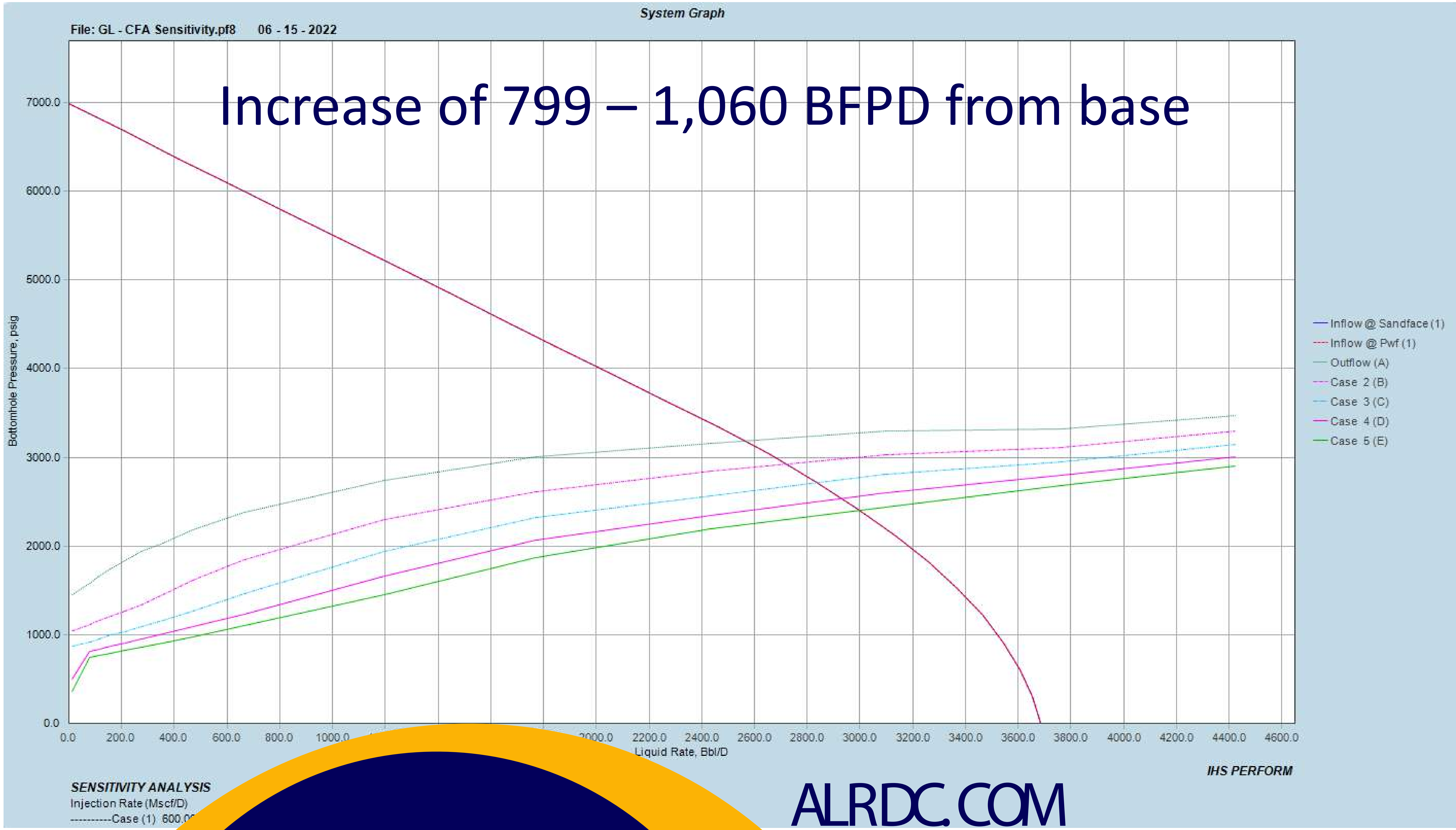
$$\Delta_P = \frac{(11.5 \times 10^6) f L Q^2 (SG)}{d^5}$$

Pressure Drop for Liquid Flow General Equation
(*Source: PEH Volume III*)

Typical Gas SG of 0.7 to 0.9

Typical H2O SG of 1.02 to 1.1

Increase of 799 – 1,060 BFPD from base



Step 4: Compare varying FWHP

- Gas Lift is a naturally flowing Process
- Common choke points
  - WH valves/chokes
  - Flowback iron/equipment
  - Facility operating pressure
  - Orifice valves

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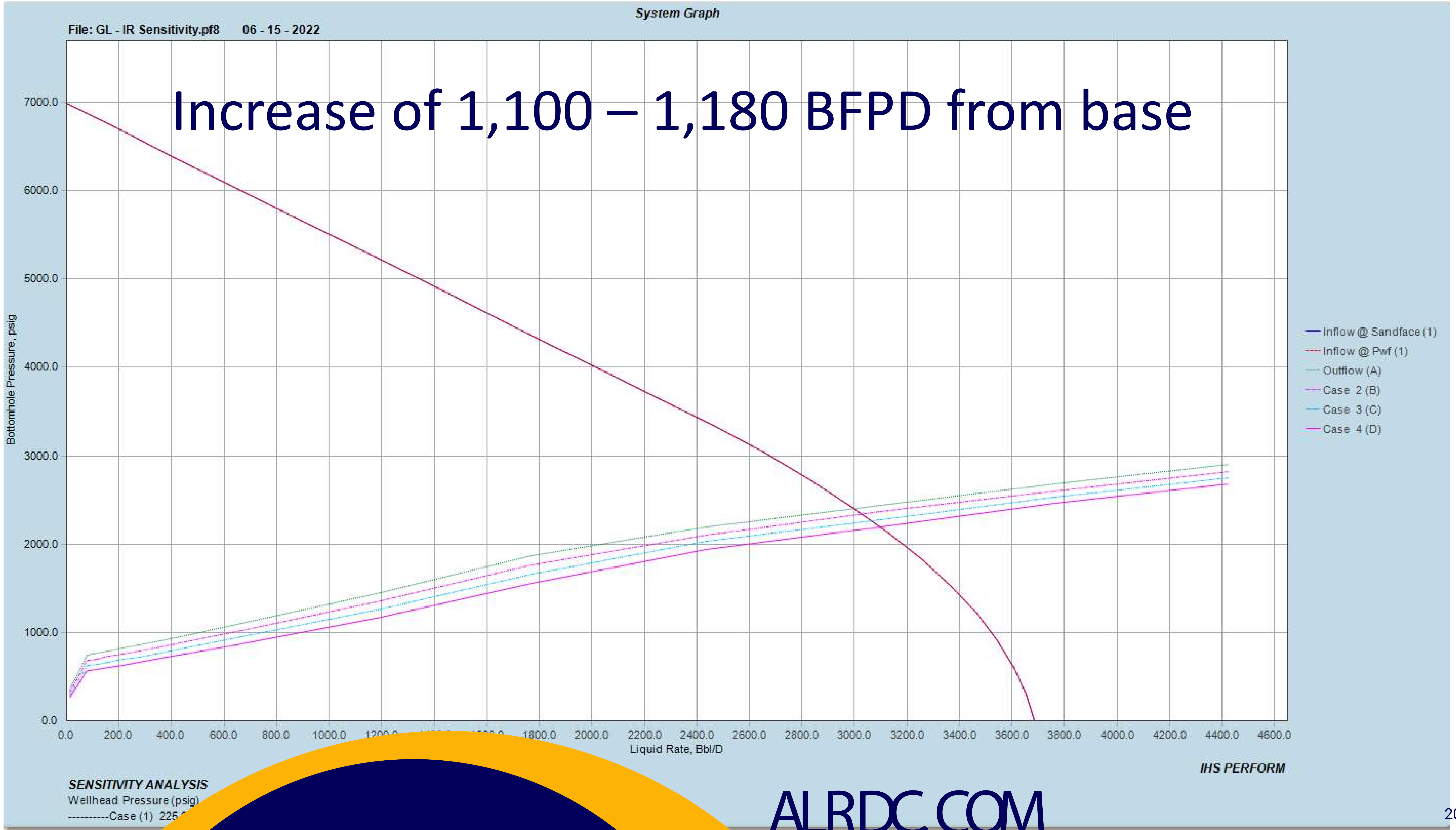
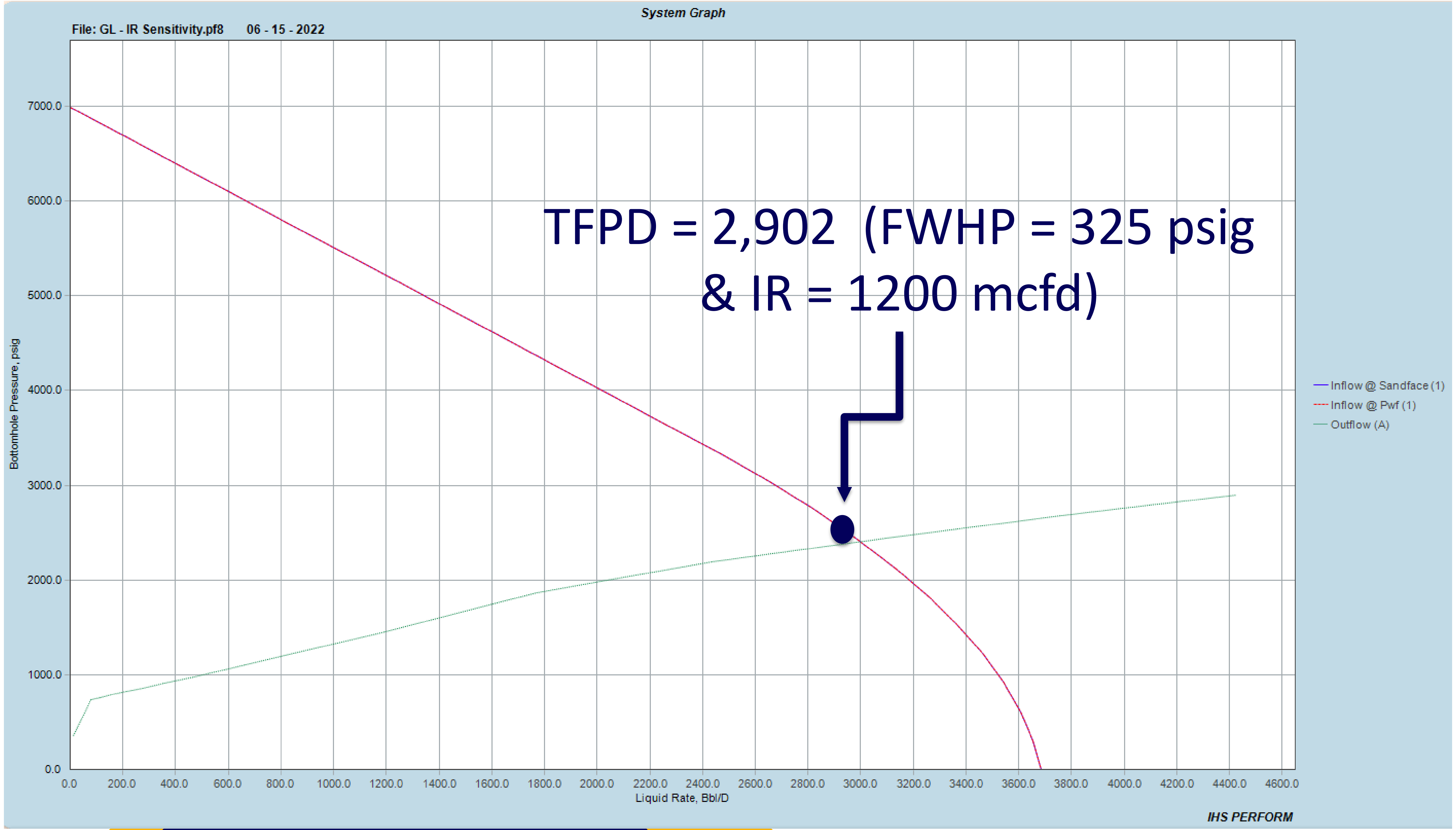
Increase of 1,100 – 1,180 BFPD from base



Step 5: Putting it all together

Putting It All Together			
Case	**Action**	**TBFPD**	**Inc. Uplift (BFPD)**
Base	Free Flowing up 2-7/8" tbg	1,937	
Inj. Depth	HPGL. Inj. Depth @ 11,580' MD	2,401	464
CFA	AGL with inj. down 2-3/8" tbg	2,511	110
Inj. Rate	Increase inj. Rate	2,997	486
FWPH	Decrease FWHP	3,037 - 3,087	40 - 100
Total Uplift Potential Relative to Base Case			1,100 - 1,180

Step 5: Putting it all together



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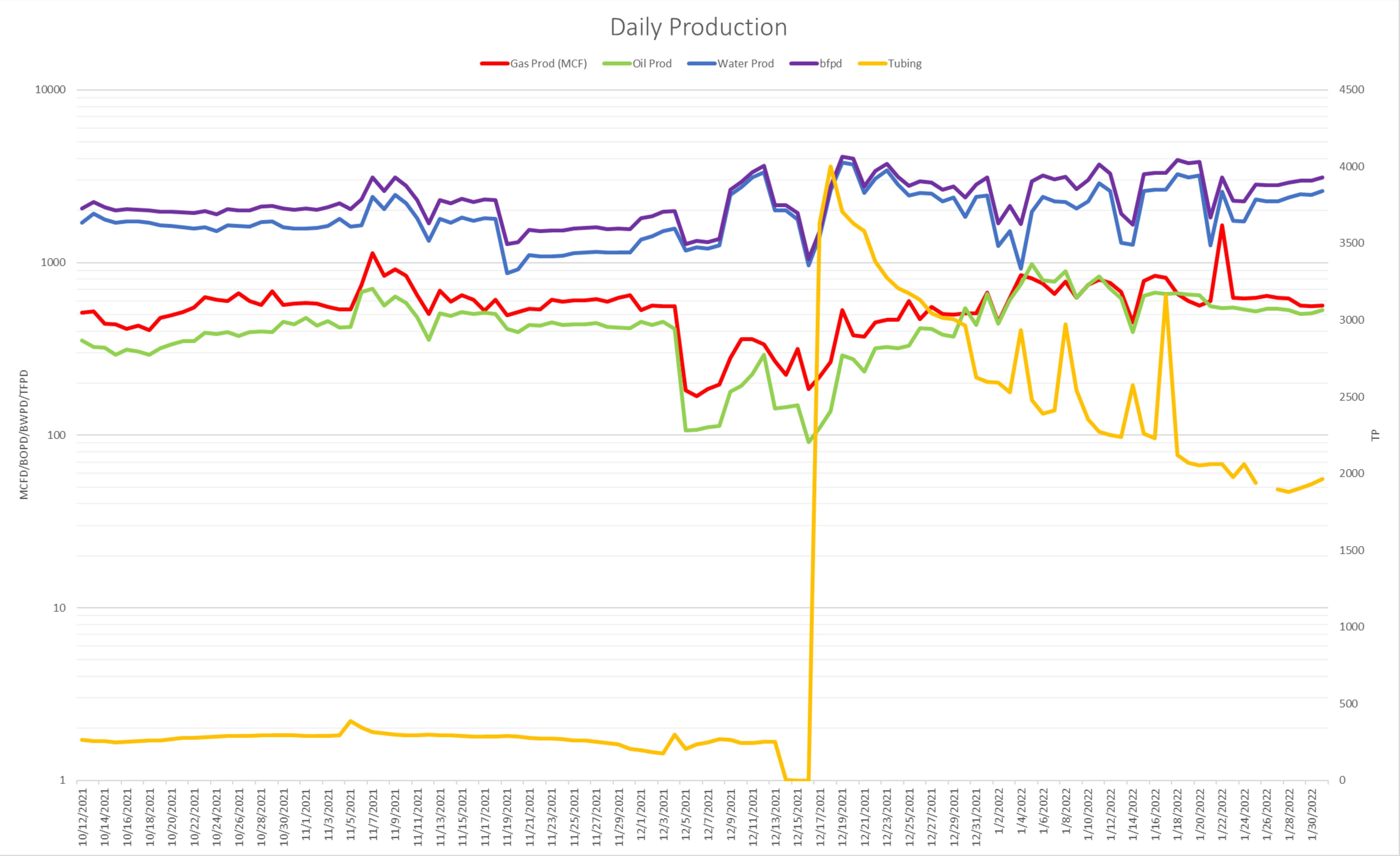

Conclusions

- Understanding the effect each critical variable has on your outflow potential is critical to maximizing production.

- The model demonstrated significant uplift potential by installing HPGL.

- HPGL gives you complete control over your drawdown potential, you just have to do your homework.

- Operator saw an uplift of 968 BFPD (~50% increase in TFPD)

Thanks to ALRDC for allowing us to present: HPGL - The Critical Variables Affecting your Outflow Potential

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