

The logo for Whitson, featuring the word "whitson" in a bold, lowercase, blue sans-serif font. It is positioned in the upper right quadrant of the slide, set against a white rectangular background that partially overlaps a dark blue header bar.

whitson

A background image of a city skyline with various skyscrapers under a blue sky with scattered white clouds. A large, dark blue diagonal shape cuts across the left side of the image, serving as a backdrop for the text.

whitson+

Nodal Analysis

Graham Helfrick

helfrick@whitson.com

Virtual Half-Day Course

Oct 2024



**Why does
this matter?**

Daily BHP all wells

Field Overview

Search Fields



ADD FIELD



Bakken

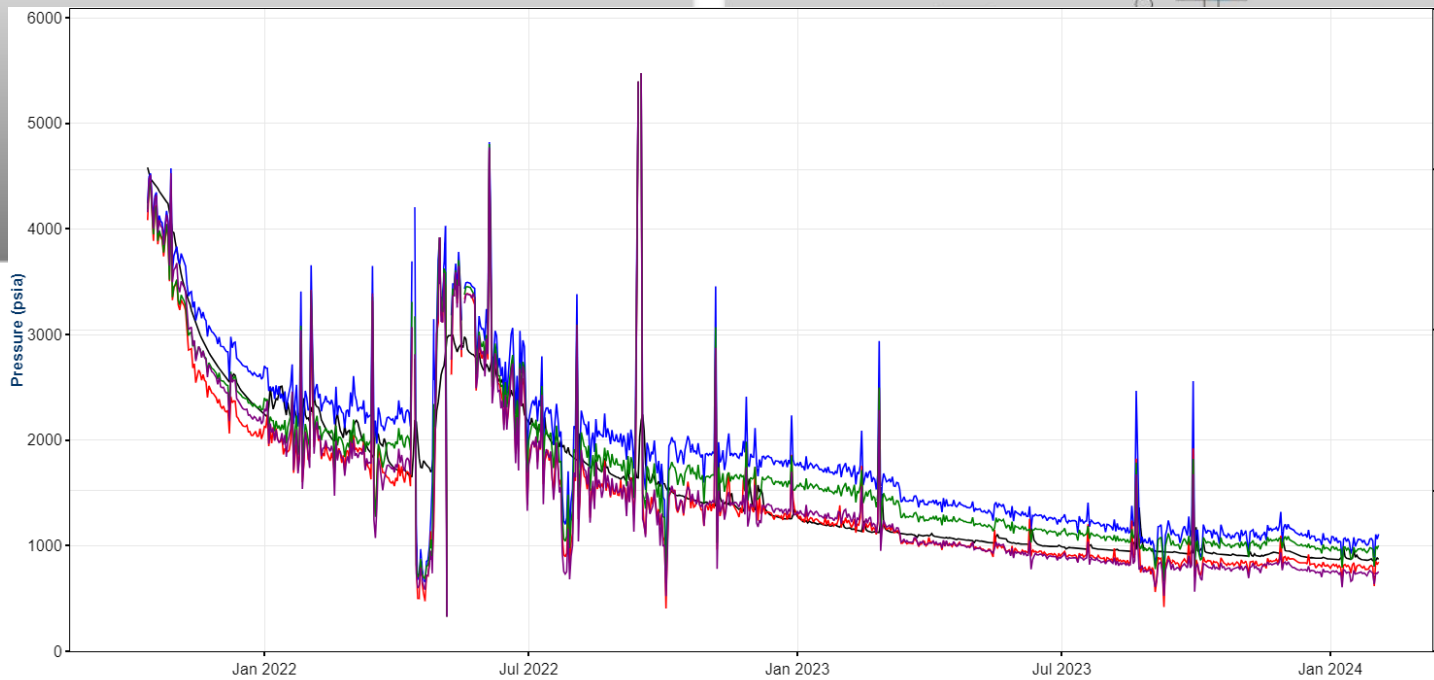
Company Wide
128 projects

API Test

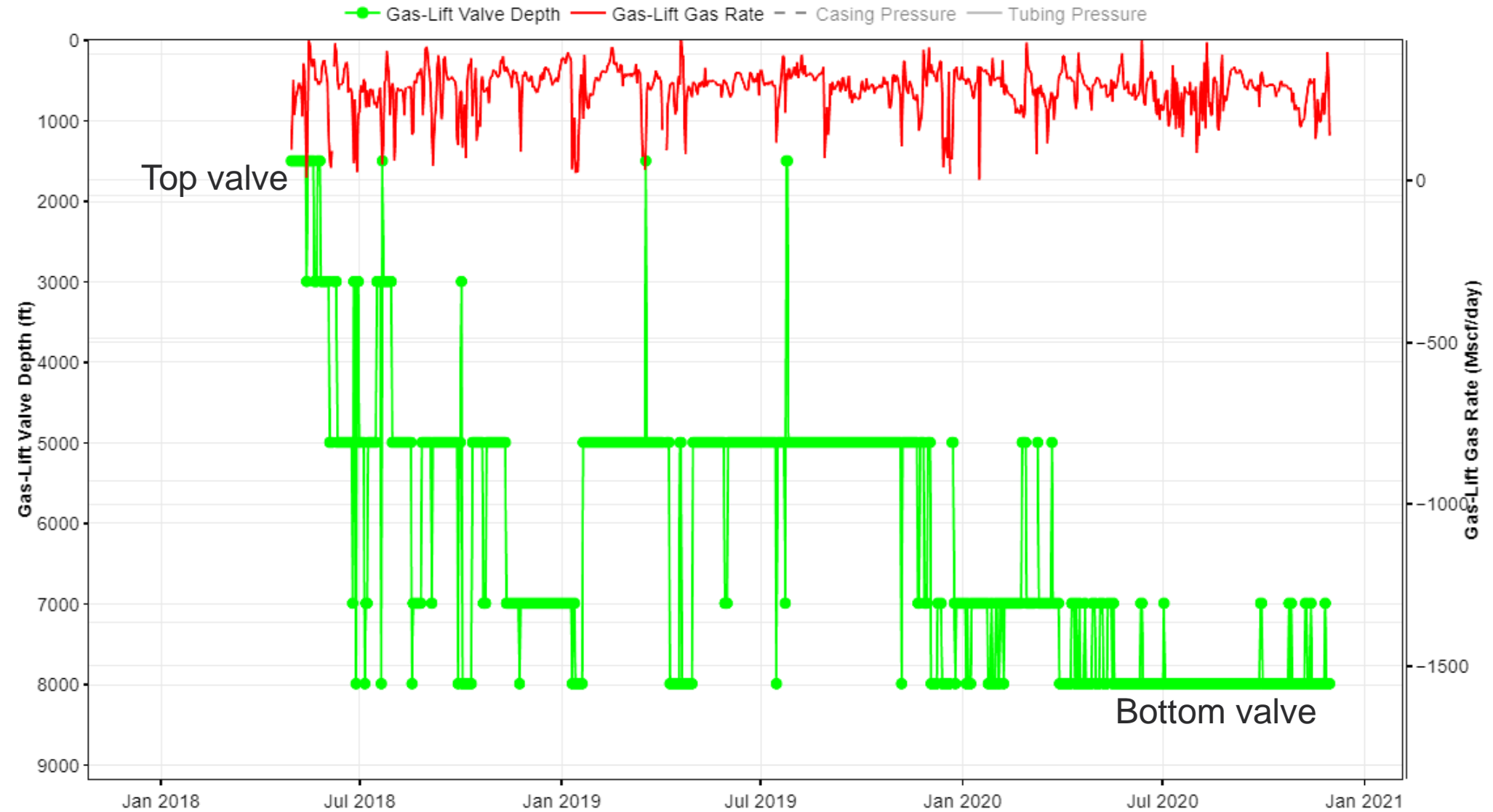
Company Wide
4 projects

Testing

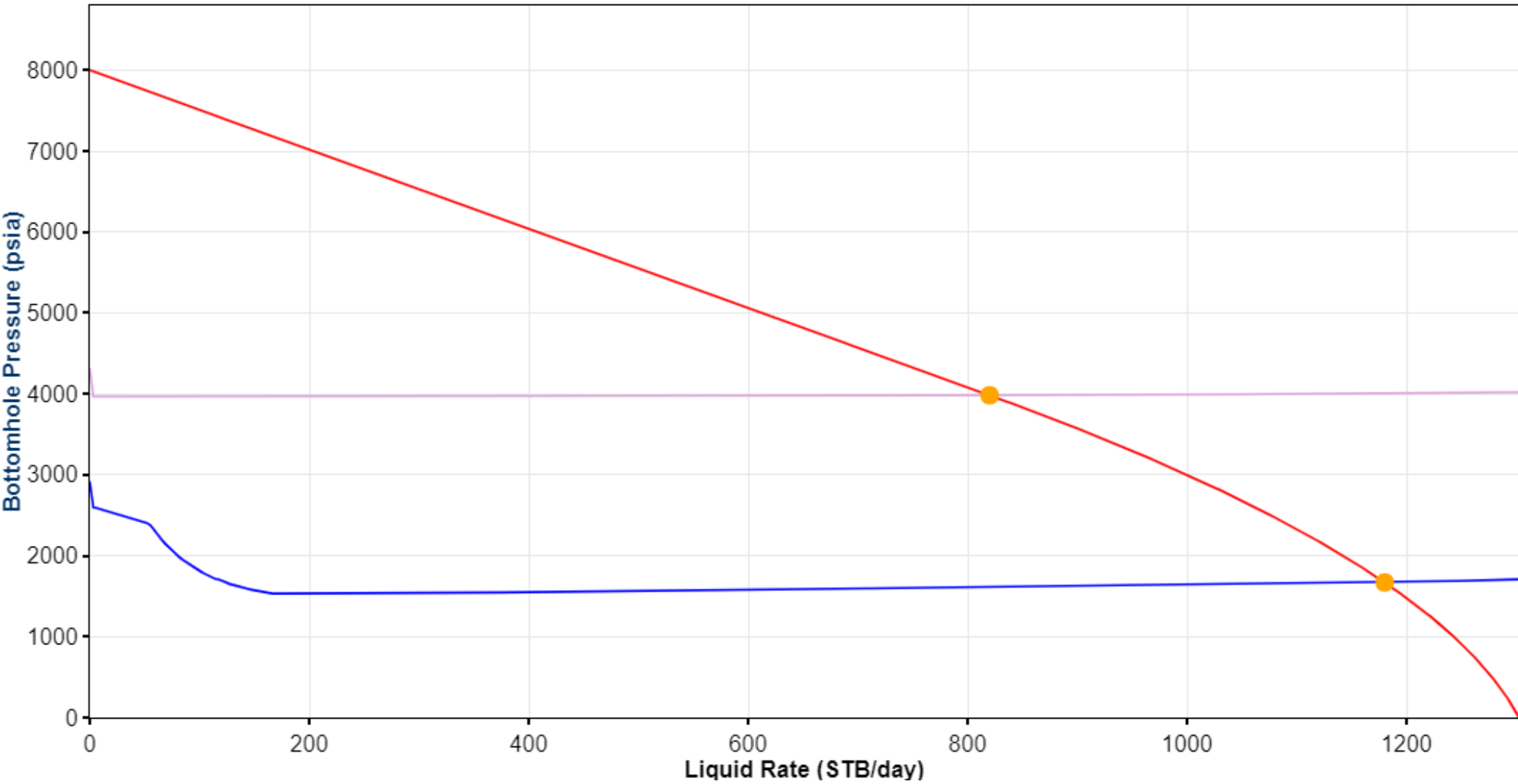
Private
2 projects



GL Injection Depth



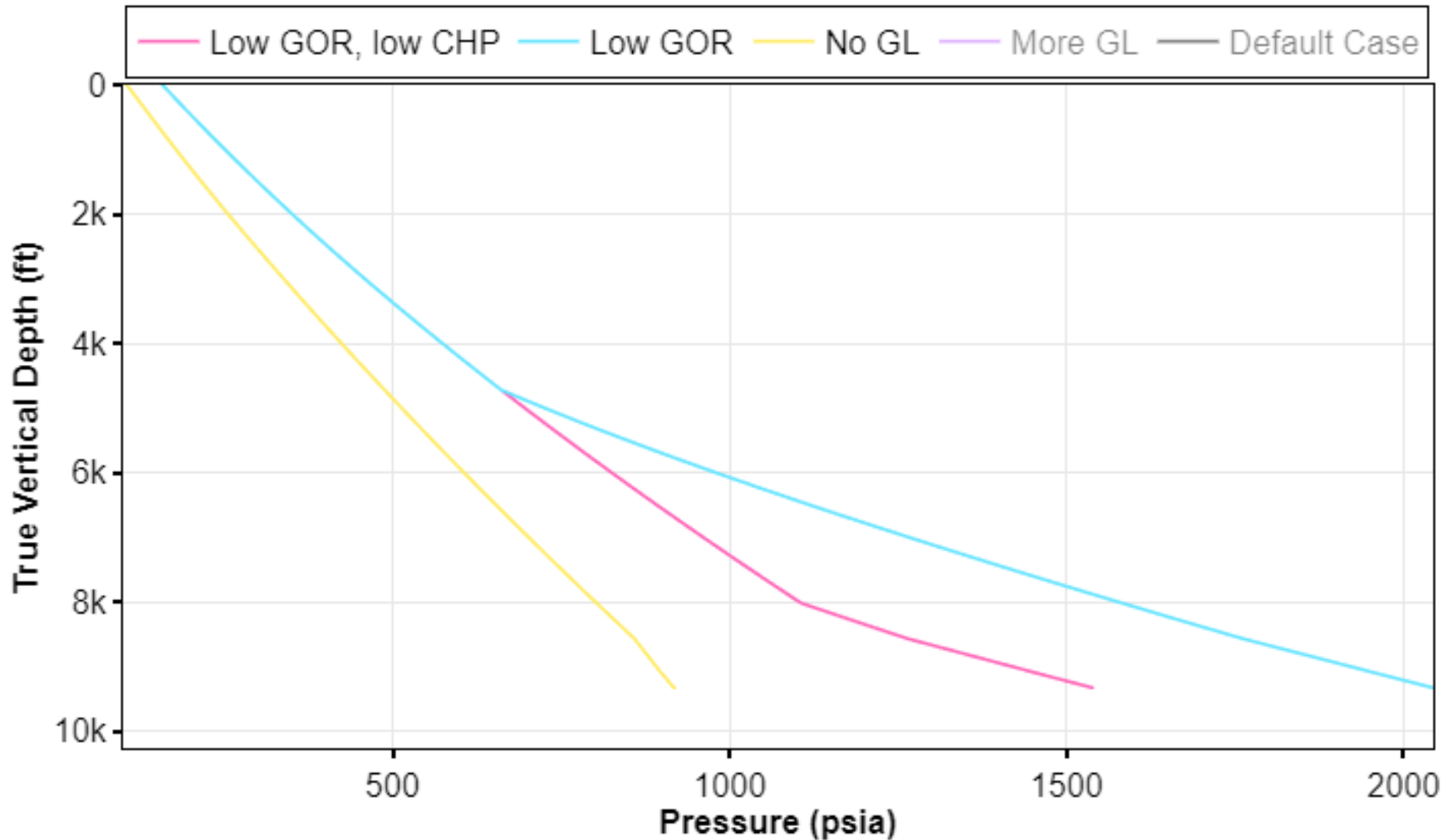
IPR/VLP



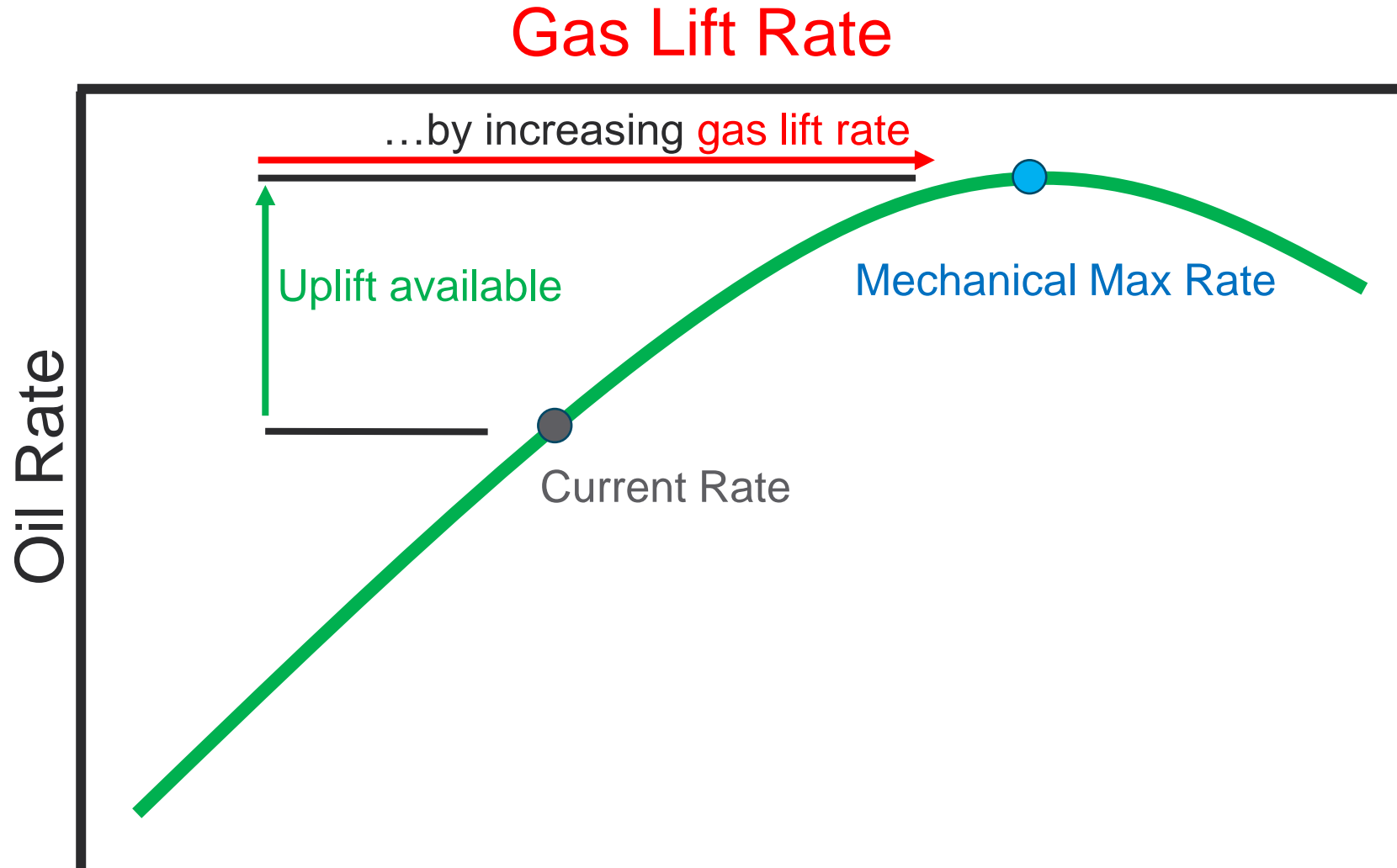
Gradient Calc

TEMPERATURE

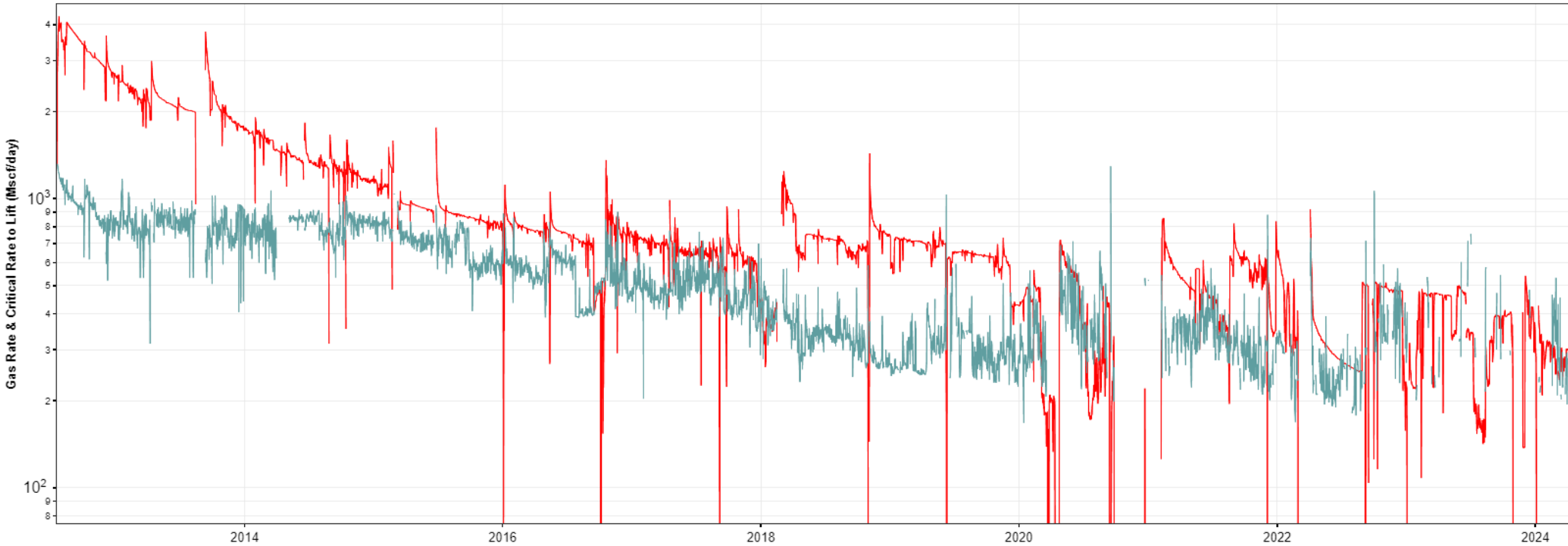
MD



Gas Lift Curve



Liquid Loading



Liquid Loading Dashboard

Field: Bakken
Project: example dry gas

Search Wells / UWIs

🔍
🔼
☰

RUN
DELETE
MOVE
COPY
EXPORT
GROUP
CREATE PSEUDO WELL
ADD WELL
MASS UPLOAD
ATTRIBUTES
RESULTS
EDIT ALL

<input type="checkbox"/>	Well Name	UWI	Scenario Count	Group
<input type="checkbox"/>	SPE-DATA-REPOSITORY-DATASET-1-WELL-12-LORIKEET	SPE-DATA-REPOSITORY-DATASET-1-WELL-12-LORIKEET	0	⋮
<input type="checkbox"/>	SPE-DATA-REPOSITORY-DATASET-1-WELL-13-MYNAH	SPE-DATA-REPOSITORY-DATASET-1-WELL-13-MYNAH	0	⋮
<input type="checkbox"/>	SPE-DATA-REPOSITORY-DATASET-1-WELL-14-PARTRIDGE	SPE-DATA-REPOSITORY-DATASET-1-WELL-14-PARTRIDGE	0	⋮
<input type="checkbox"/>	SPE-DATA-REPOSITORY-DATASET-1-WELL-15-CASSOWARY	SPE-DATA-REPOSITORY-DATASET-1-WELL-15-CASSOWARY	0	⋮
<input type="checkbox"/>	SPE-DATA-REPOSITORY-DATASET-1-WELL-16-ORIOLE	SPE-DATA-REPOSITORY-DATASET-1-WELL-16-ORIOLE	0	⋮
<input type="checkbox"/>	SPE-DATA-REPOSITORY-DATASET-1-WELL-17-WARBLER	SPE-DATA-REPOSITORY-DATASET-1-WELL-17-WARBLER	0	⋮
<input type="checkbox"/>	SPE-DATA-REPOSITORY-DATASET-1-WELL-18-HARPY	SPE-DATA-REPOSITORY-DATASET-1-WELL-18-HARPY	0	⋮
<input type="checkbox"/>	SPE-DATA-REPOSITORY-DATASET-1-WELL-19-BEE-EATER	SPE-DATA-REPOSITORY-DATASET-1-WELL-19-BEE-EATER	0	⋮
<input type="checkbox"/>	SPE-DATA-REPOSITORY-DATASET-1-WELL-20-LOON	SPE-DATA-REPOSITORY-DATASET-1-WELL-20-LOON	0	⋮
<input type="checkbox"/>	SPE-DATA-REPOSITORY-DATASET-1-WELL-21-CUCKOO	SPE-DATA-REPOSITORY-DATASET-1-WELL-21-CUCKOO	0	⋮
<input type="checkbox"/>	SPE-DATA-REPOSITORY-DATASET-1-WELL-22-ROOSTER	SPE-DATA-REPOSITORY-DATASET-1-WELL-22-ROOSTER	0	⋮
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<input type="checkbox"/>	SPE-DATA-REPOSITORY-DATASET-1-WELL-25-STILT	SPE-DATA-REPOSITORY-DATASET-1-WELL-25-STILT	0	⋮
<input type="checkbox"/>	SPE-DATA-REPOSITORY-DATASET-1-WELL-26-AVOCET	SPE-DATA-REPOSITORY-DATASET-1-WELL-26-AVOCET	0	⋮

Rows per page: 200
1-15 of 15

**Why does
this matter?**

HOW FASCINATING

PLEASE, TELL ME MORE

General Information

- 3 hr Course
- Practical workflows and case studies
- Nodal Certificate:
https://manual.whitson.com/onboarding/certificate_nodal/
- BHP theory:
<https://youtu.be/PBOeWB365D0>



Support

- 2 minute response!
- General: support@whitson.com



Agenda

Course Agenda

Exercises in **whitson+**

- **Case 1: Gas Well**
 - BHPs
 - Liquid Loading
 - FMB
 - IPR/VLP
 - Compare
 - Compression
 - Large tubing
 - Small tubing

Course Agenda

Exercises in **whitson+**

- **Case 2: Oil Well, gas lift**
 - Gas Lift Valve Details
 - BHPs
 - Open Valve depth
 - FMB
 - IPR/VLP
 - Gradient
 - GL Curve

Gas Well

Open whitson+

Gas IPR/VLP

Gas IPR

Why?

Gas IPR



Gas IPR



Gas IPR

- Simplified deliverability (under 2,500psi res pres)

$$q_g = C \left(p_R^2 - p_{wf}^2 \right)^n$$

Gas rate

Flow coefficient

Res Pres

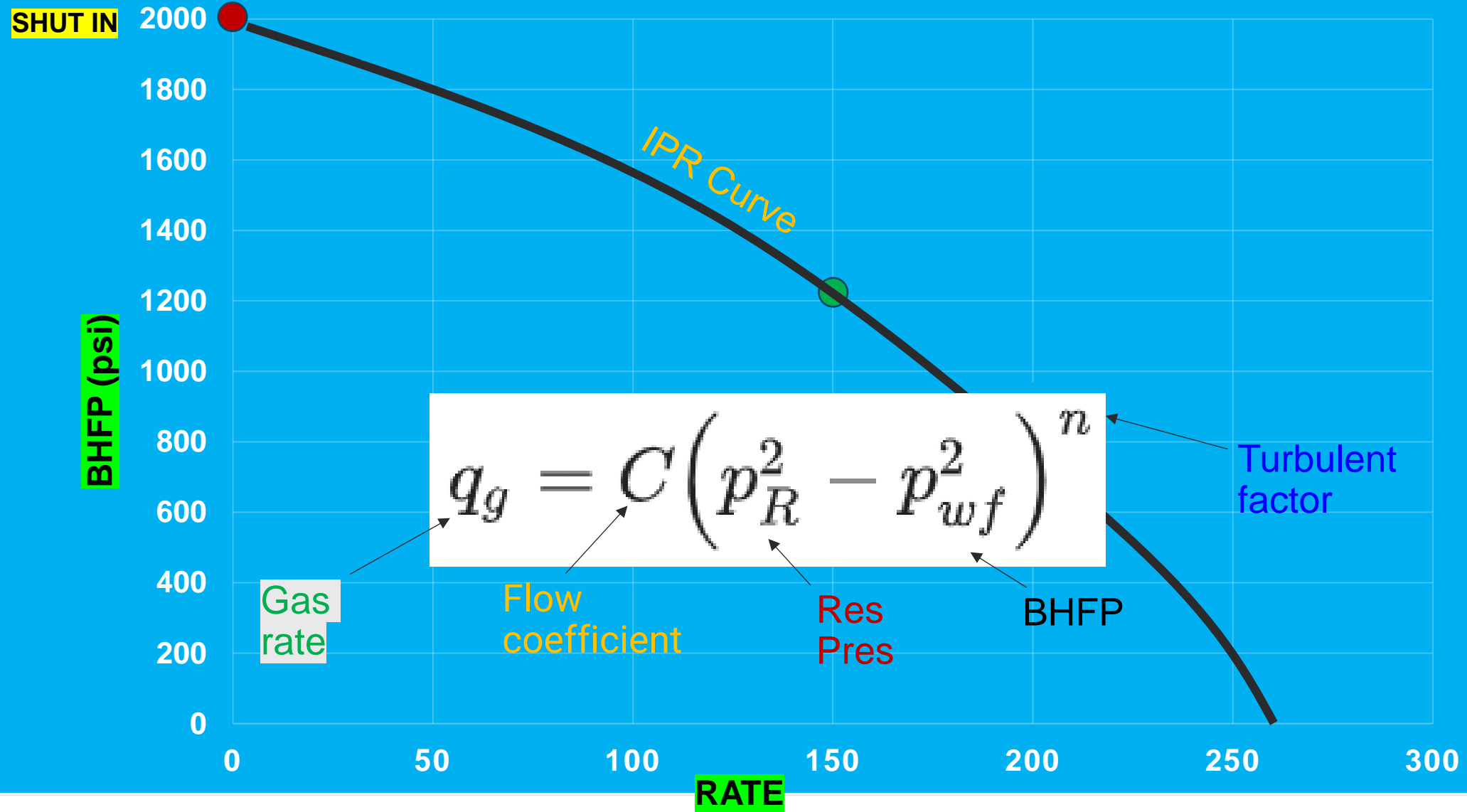
BHFP

Turbulent factor

The diagram shows the equation $q_g = C (p_R^2 - p_{wf}^2)^n$. Arrows point from text labels to the corresponding variables in the equation: 'Gas rate' points to q_g , 'Flow coefficient' points to C , 'Res Pres' points to p_R^2 , 'BHFP' points to p_{wf}^2 , and 'Turbulent factor' points to the exponent n .

Gas IPR

BHFP VS RATE



Gas IPR

- Simplified deliverability (under 2,500psi res pres)

$$q_g = C \left(p_R^2 - p_{wf}^2 \right)^n$$

Gas rate

Flow coefficient

Res Pres

BHFP

Turbulent factor

- Over 2,500psi. Pseudo pressure applied.

$$q_g = C \left(p_p(p_R) - p_p(p_{wf}) \right)^n$$

Gas rate

Flow coefficient

Pseudopressure

Res Pres

Pseudopressure

BHFP

Turbulent factor

Oil Well

Open whitson+

Oil IPR

Why?

Oil IPR

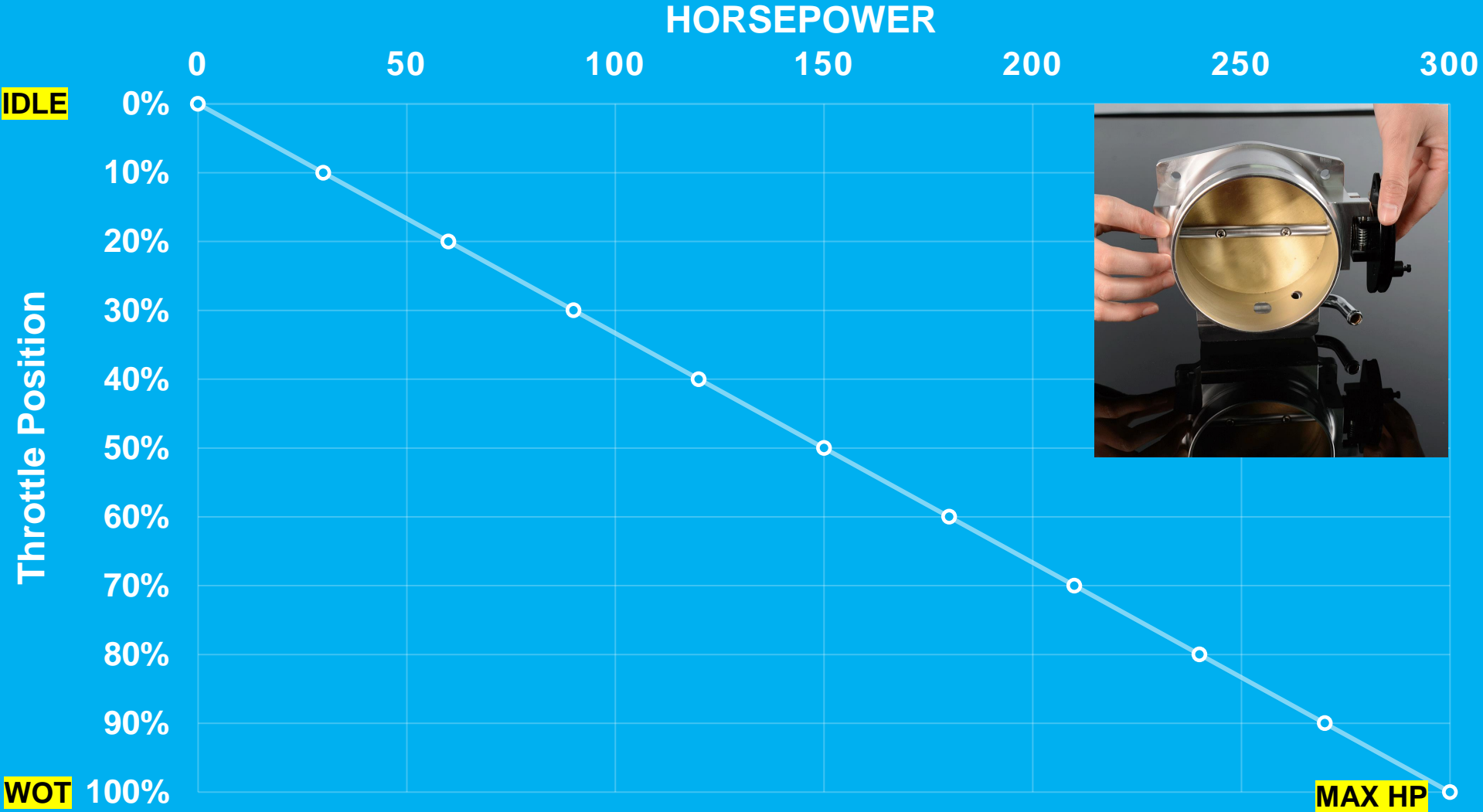


Oil IPR



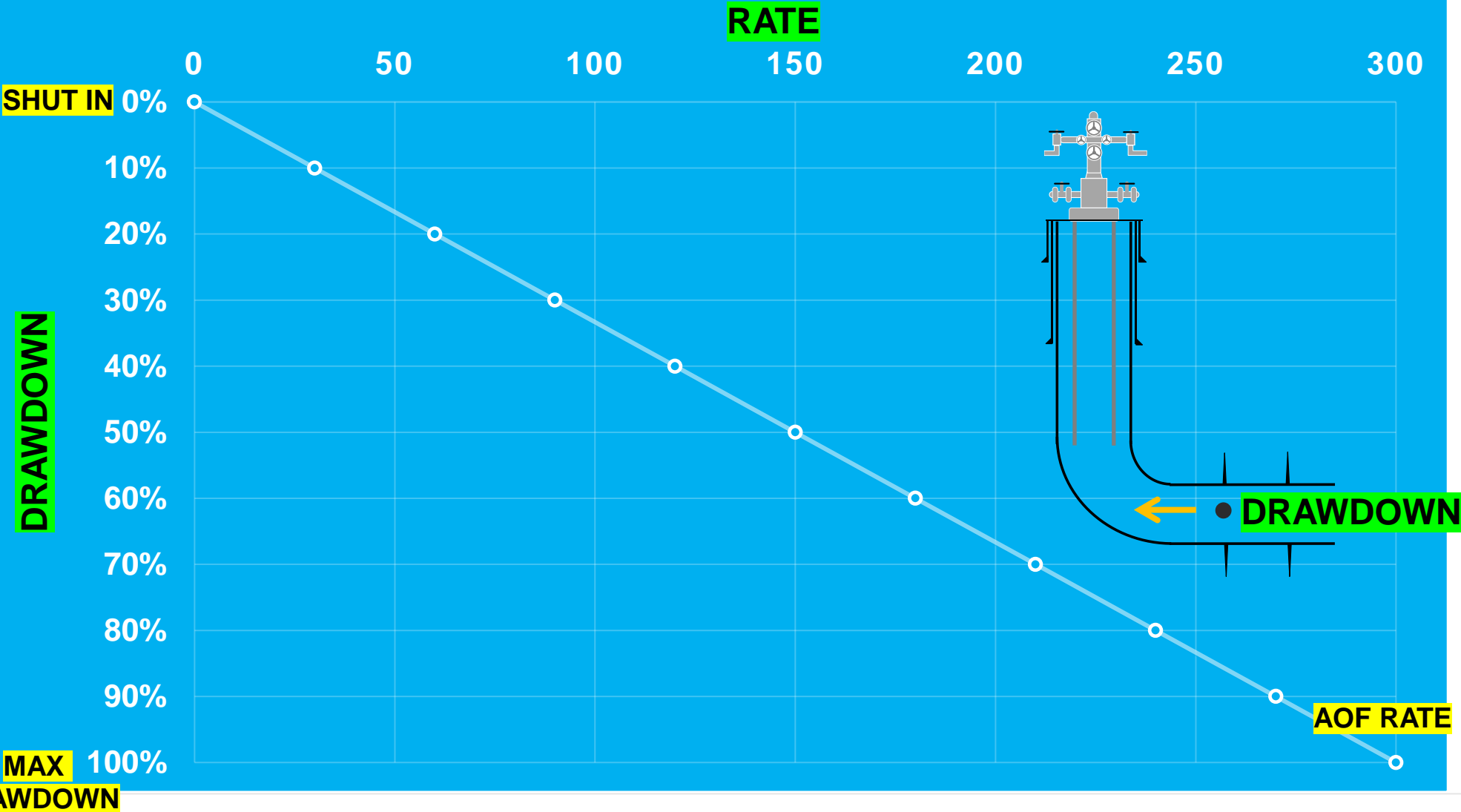
Oil IPR

THROTTLE POSITION VS HORSEPOWER



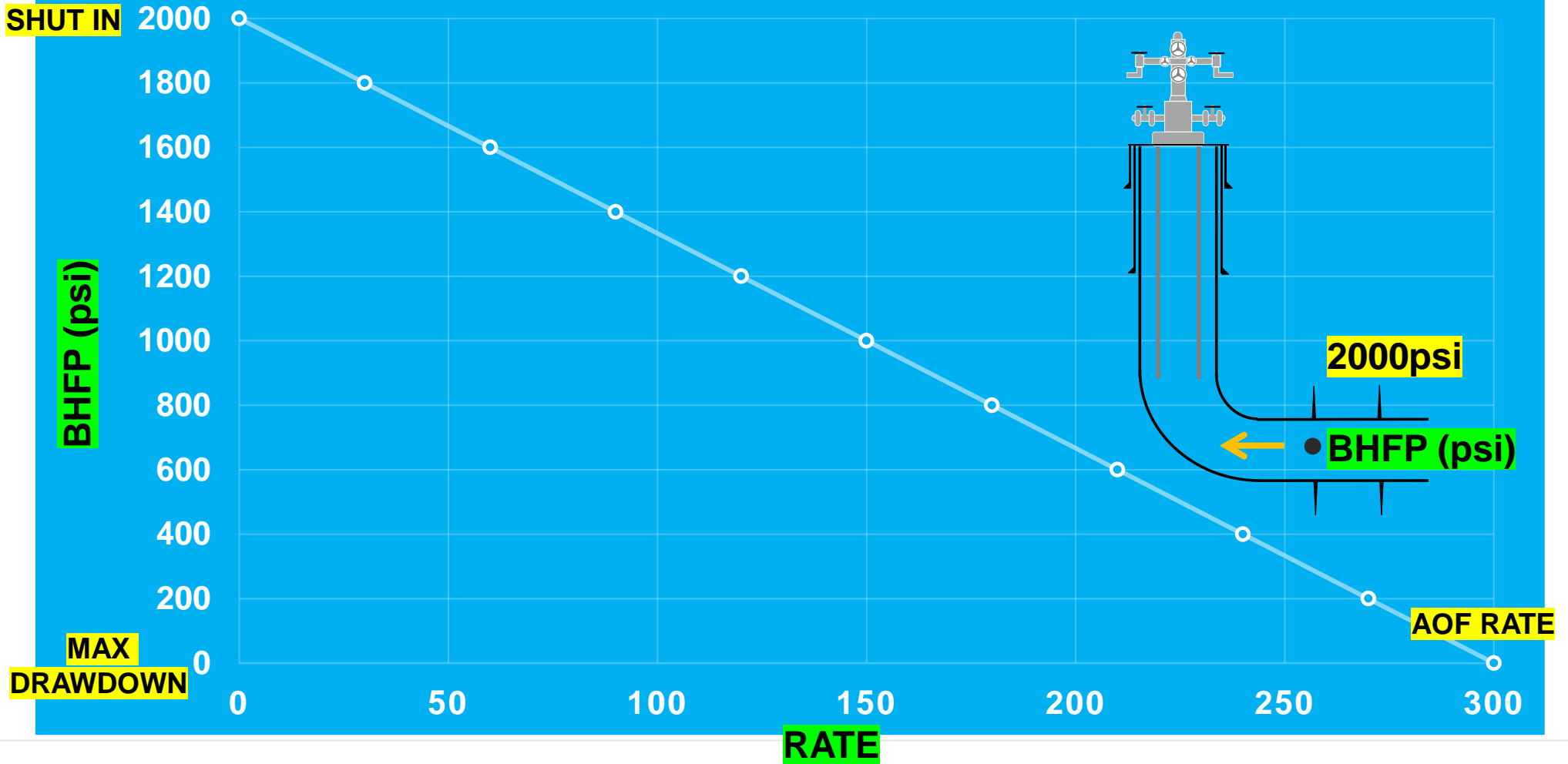
Oil IPR

DRAWDOWN VS RATE



Oil IPR

BHFP VS RATE



Oil IPR

- Above the bubble point

$$q_o = J(p_R - p_{wf})$$

Oil rate

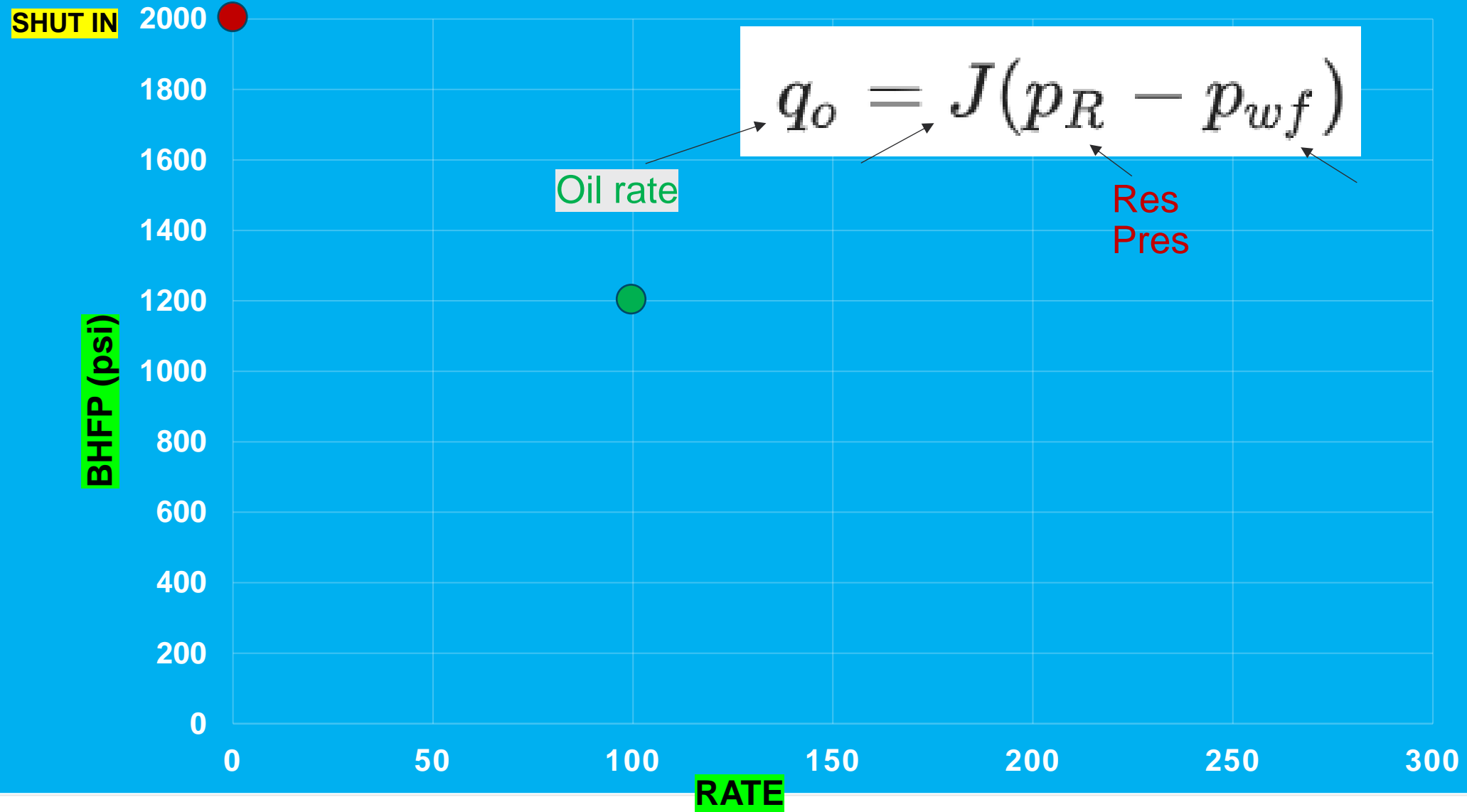
Productivity Index

Res Pres

BHFP

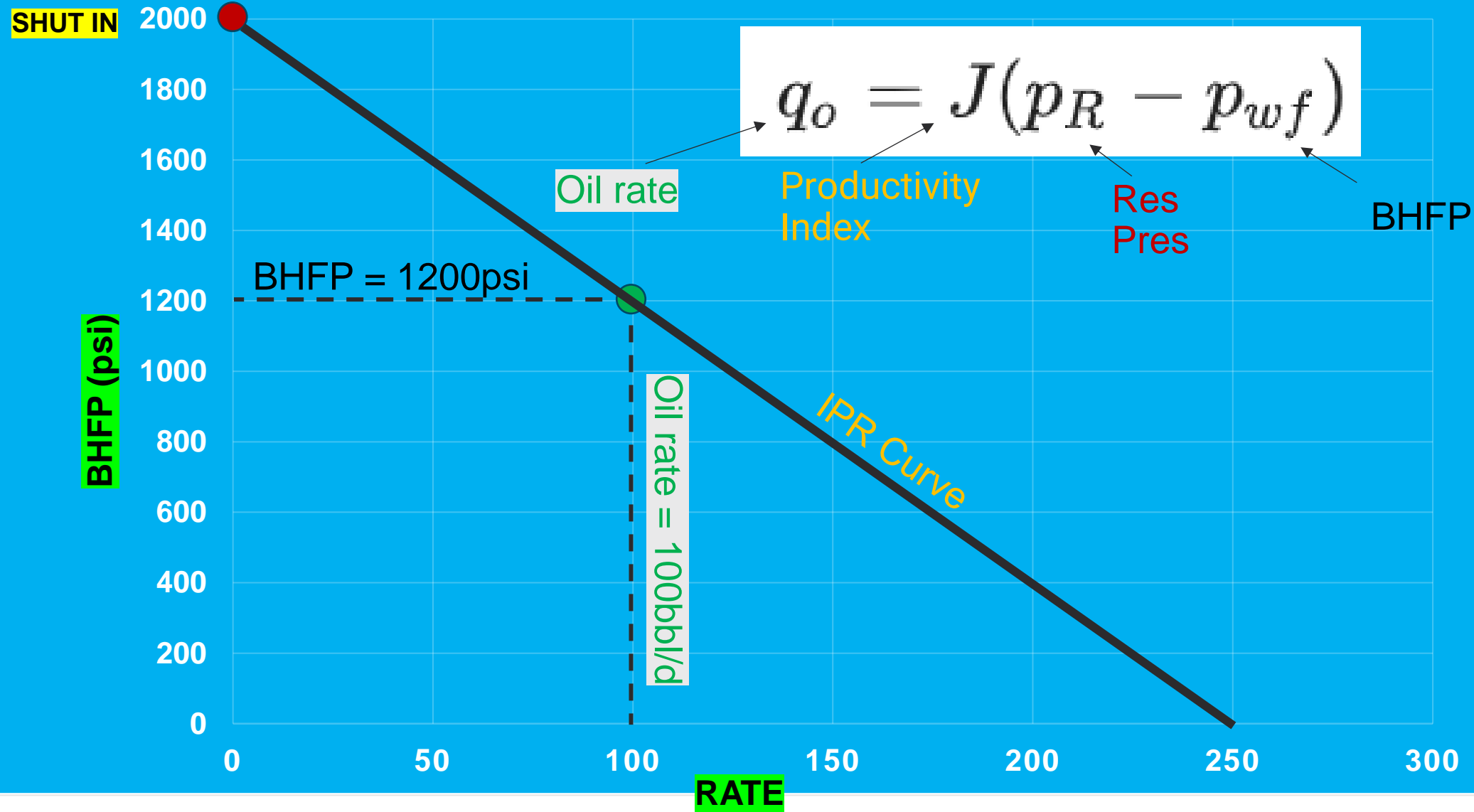
Oil IPR – Above BP

BHFP VS RATE



Oil IPR – Above BP

BHFP VS RATE



Oil IPR

○ Above the bubble point

$$q_o = J(p_R - p_{wf})$$

Oil rate (green) points to q_o . Productivity Index (yellow) points to J . Res Pres (red) points to p_R . BHFP (blue) points to p_{wf} .

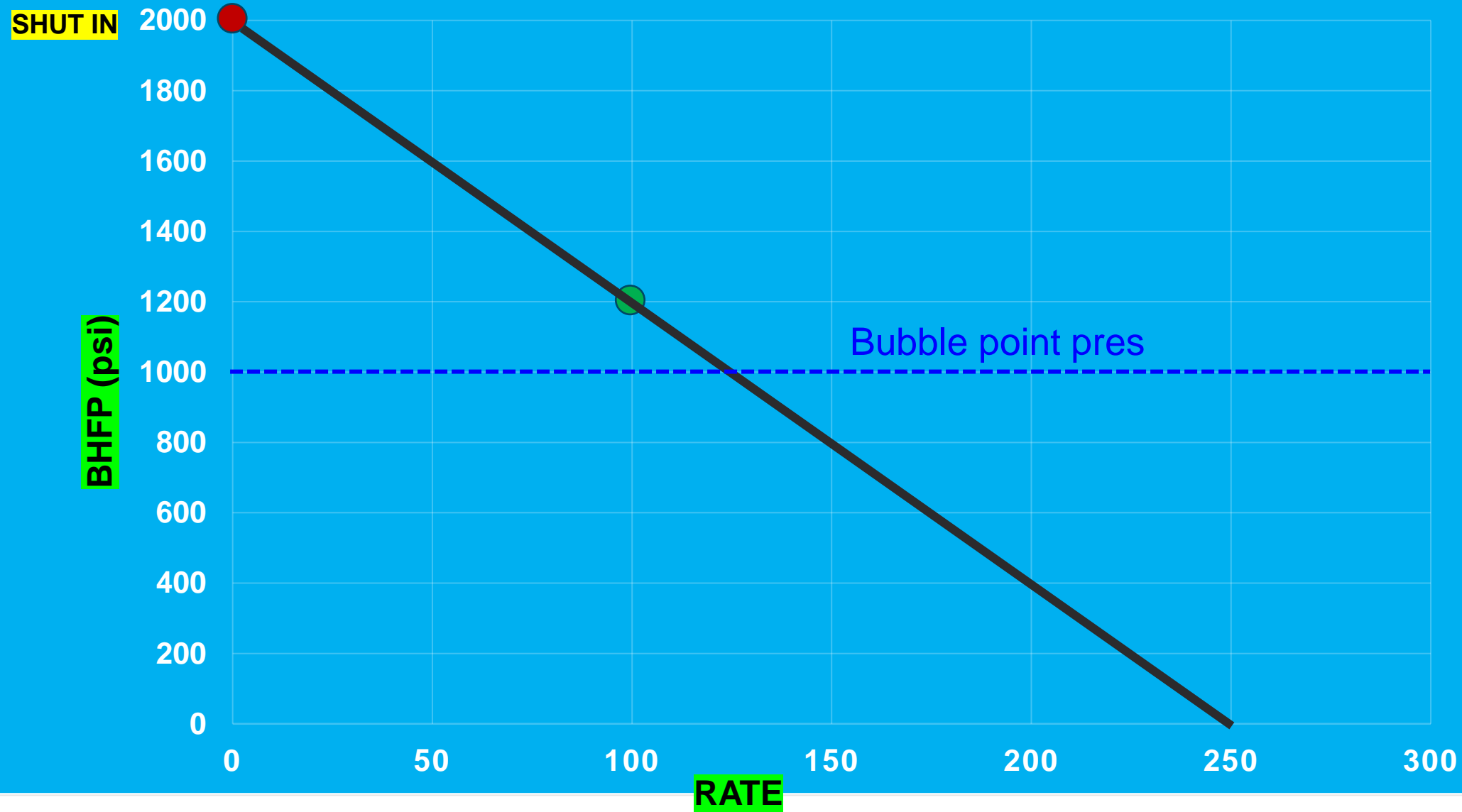
○ Below the bubble point

$$q_o = J(p_R - p_b) + \left(\frac{J}{2p_b} \right) (p_b^2 - p_{wf}^2)$$

Oil rate (green) points to q_o . Productivity Index (yellow) points to J . Res Pres (red) points to p_R . Bubble point pres (blue) points to p_b . Bubble point pres (blue) points to $2p_b$. Bubble point pres (blue) points to p_b^2 . BHFP (blue) points to p_{wf}^2 .

Oil IPR – Above BP

BHFP VS RATE



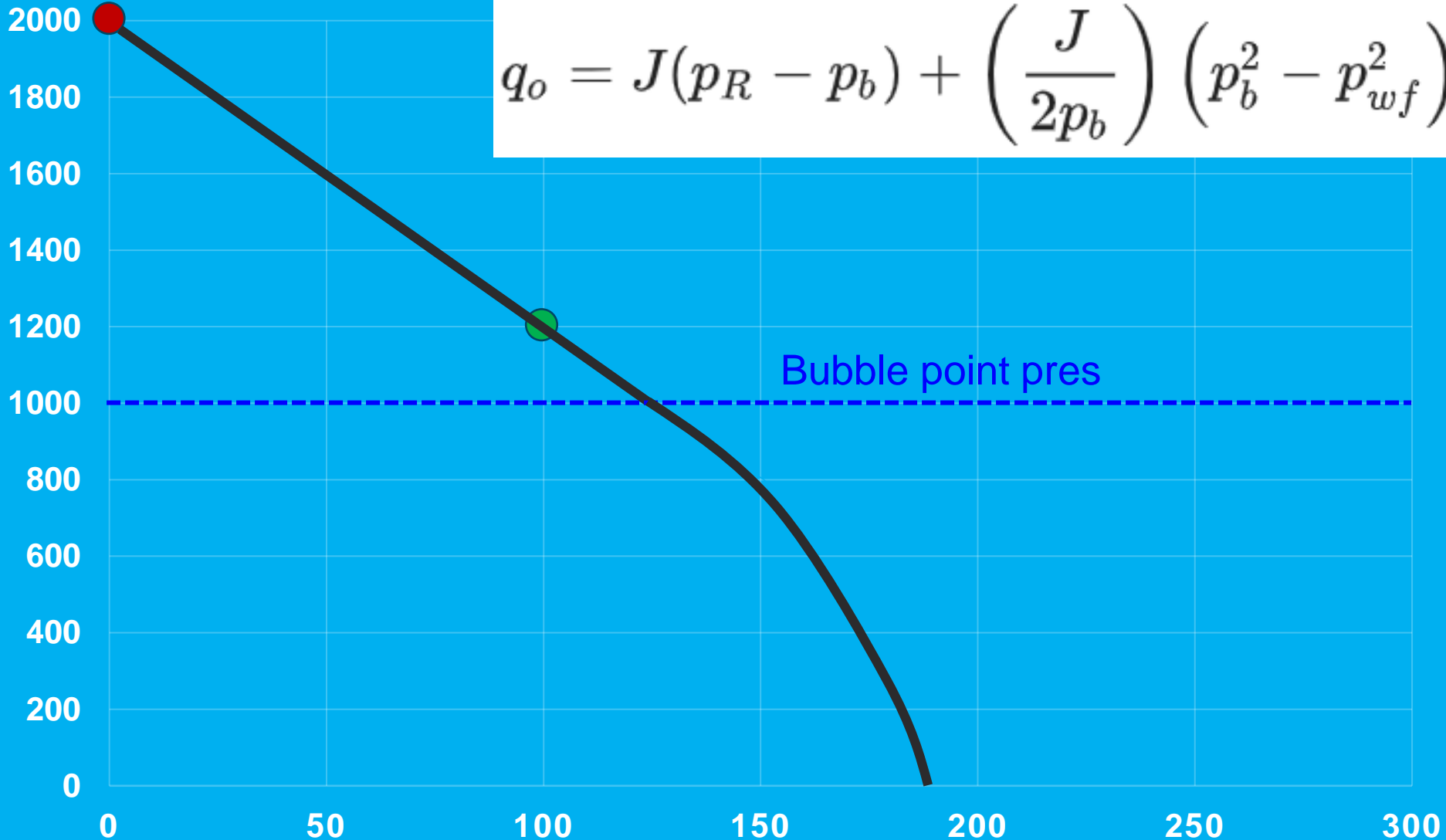
Oil IPR – Below BP

BHFP VS RATE

$$q_o = J(p_R - p_b) + \left(\frac{J}{2p_b} \right) (p_b^2 - p_{wf}^2)$$

SHUT IN

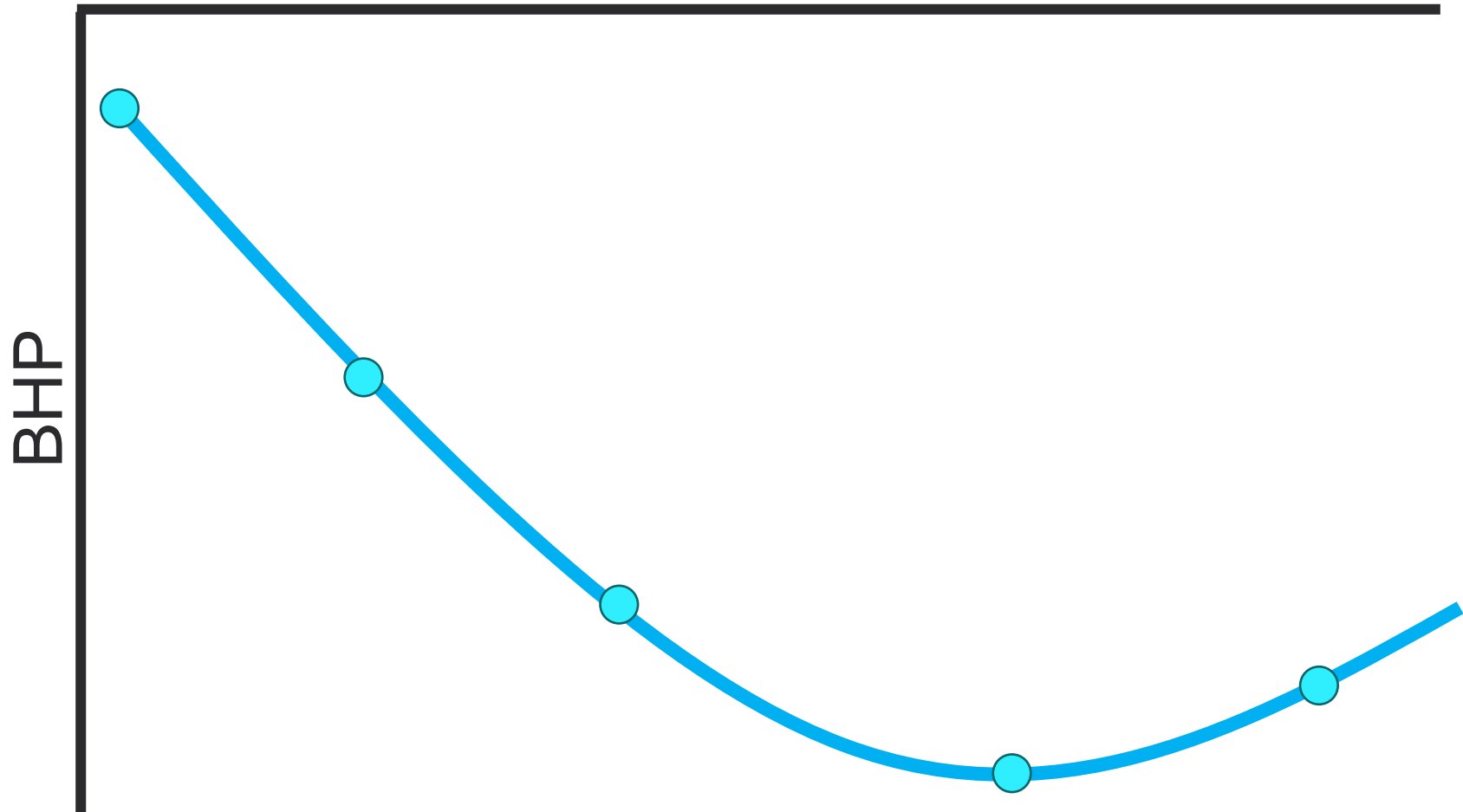
BHFP (psi)



RATE

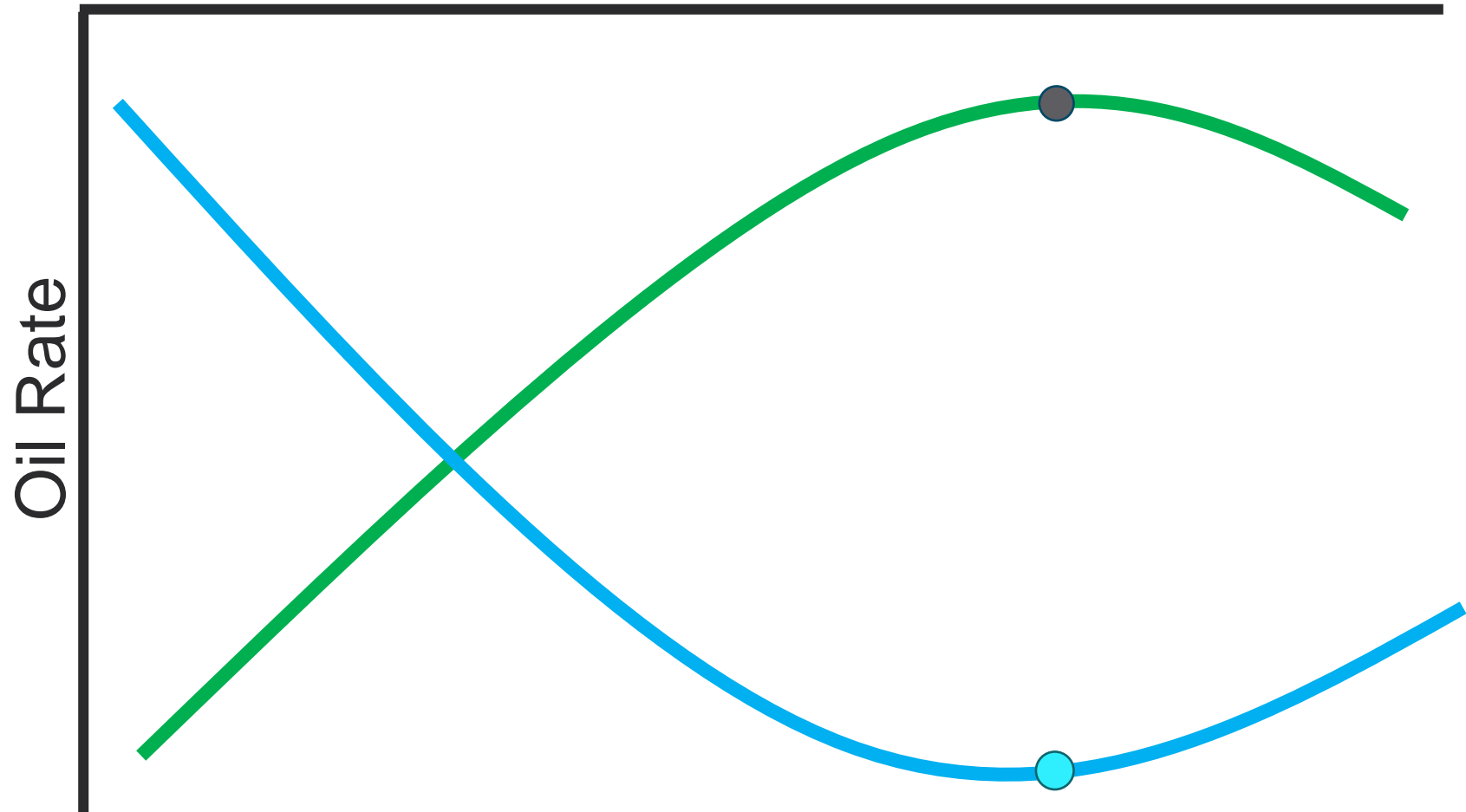
Gas Lift Curve

Gas Lift Rate

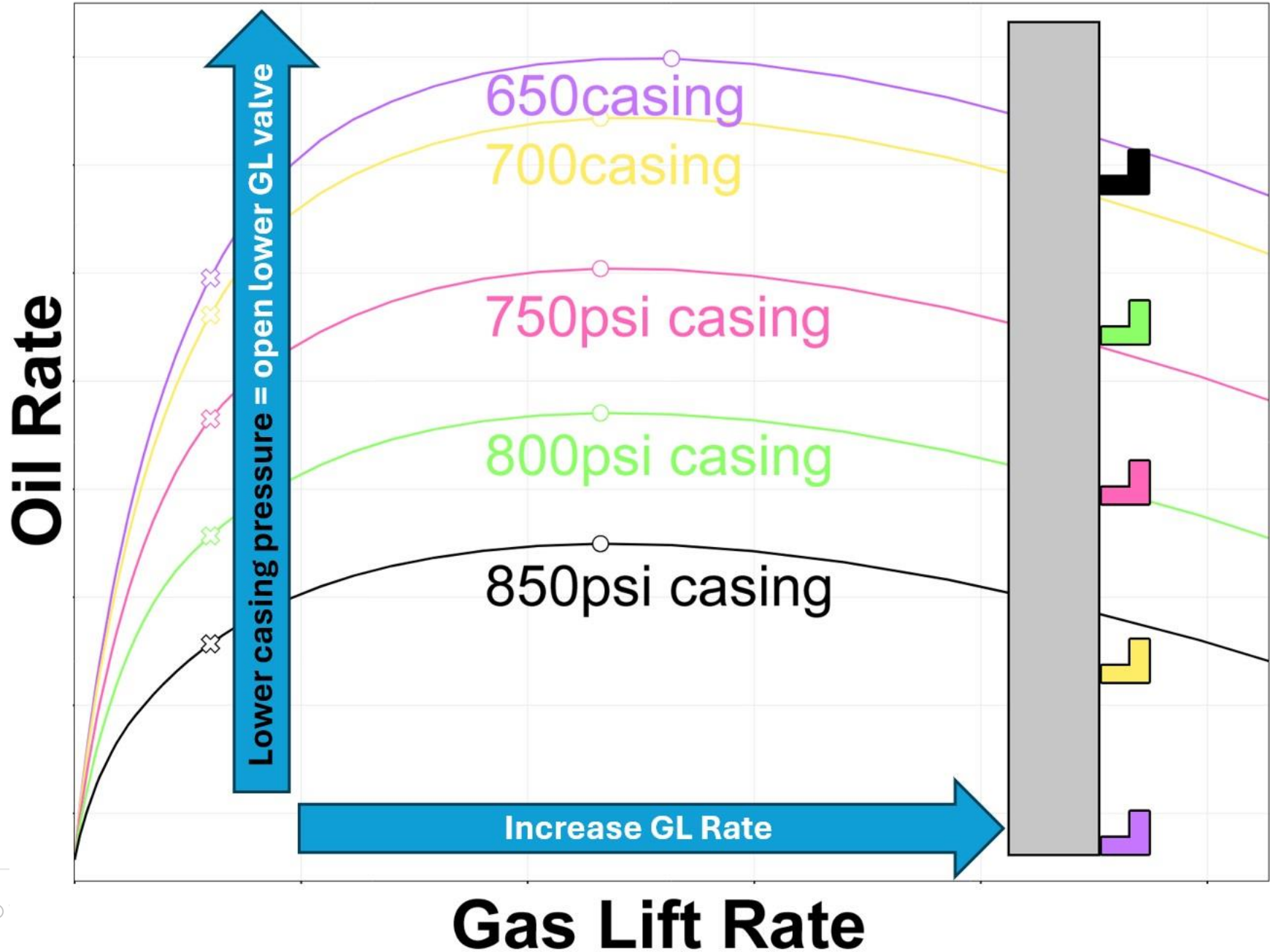


Gas Lift Curve

Gas Lift Rate



whitson⁺ Gas Lift Curve



Future Dev

Liquid Loading Dashboard

Field: Bakken
Project: example dry gas

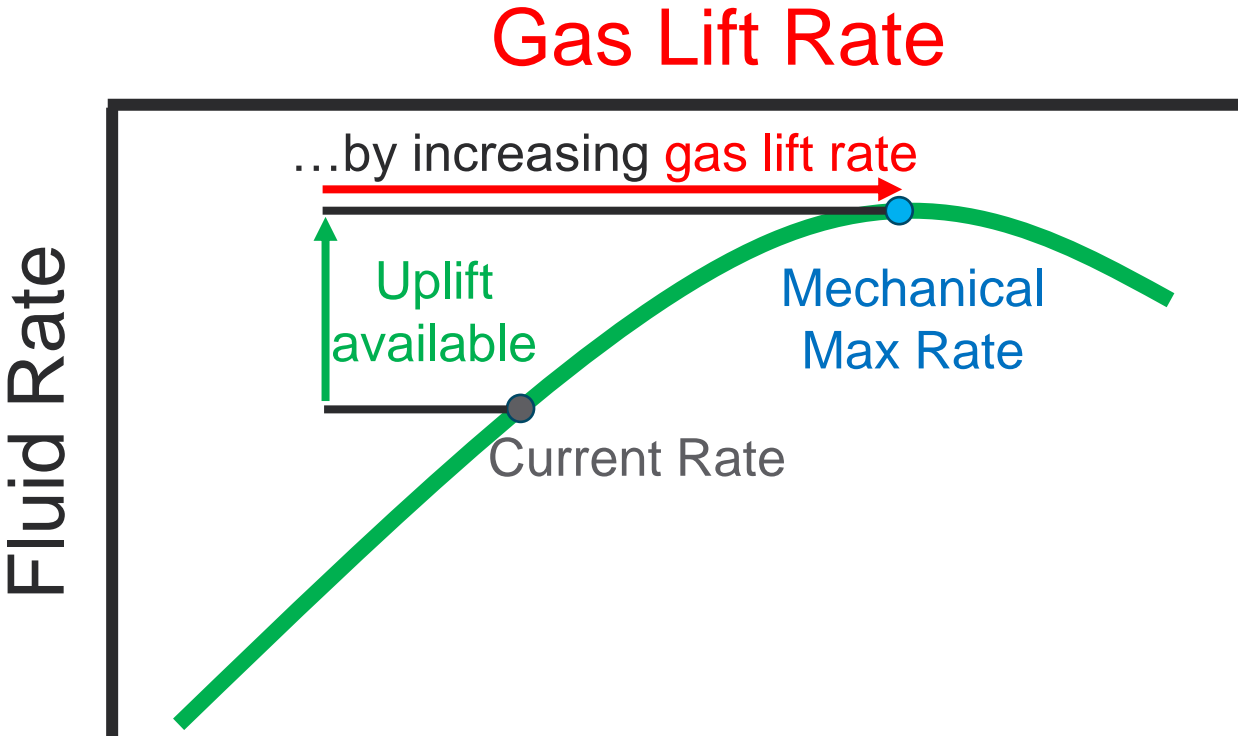
Search Wells / UWIs

RUN
DELETE
MOVE
COPY
EXPORT
GROUP
CREATE PSEUDO WELL
ADD WELL
MASS UPLOAD
ATTRIBUTES
RESULTS
EDIT ALL

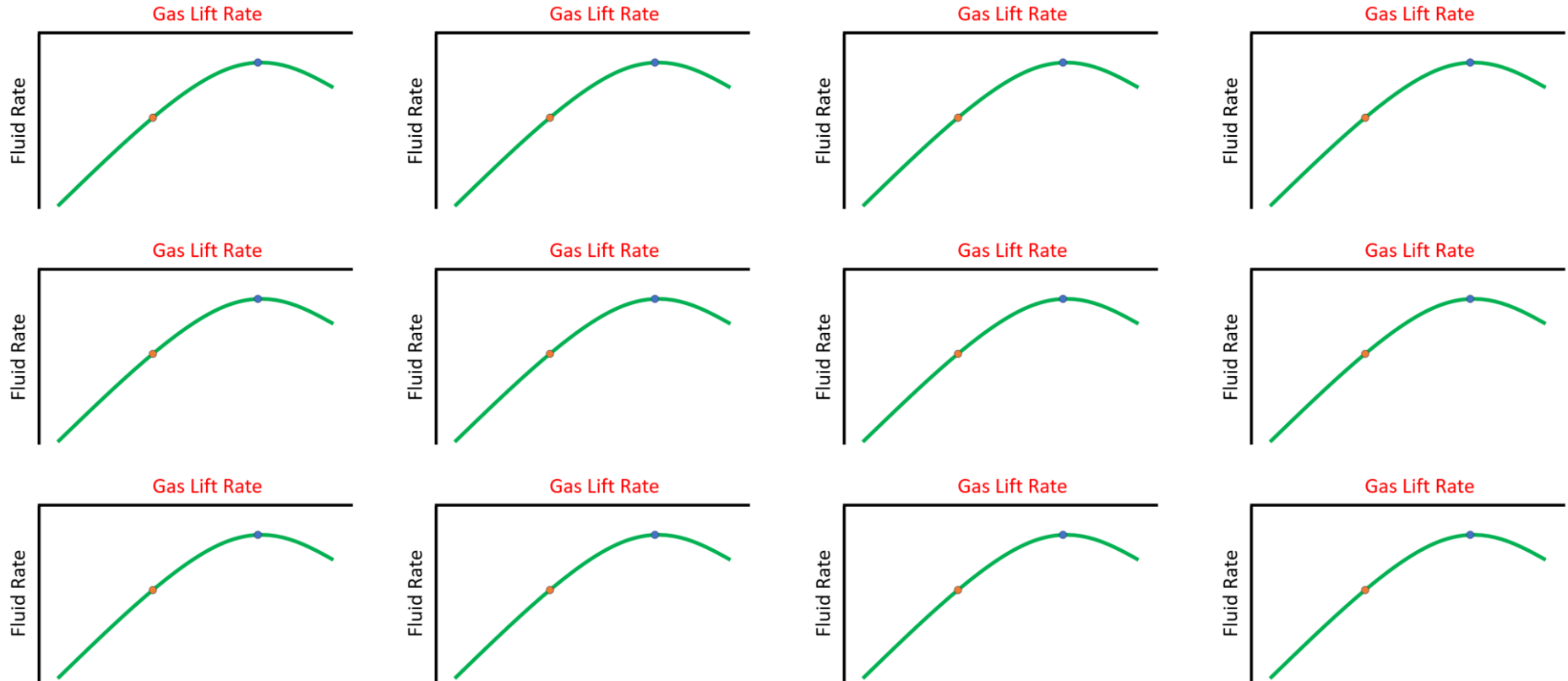
<input type="checkbox"/>	Well Name	UWI	Scenario Count	Group
<input type="checkbox"/>	SPE-DATA-REPOSITORY-DATASET-1-WELL-12-LORIKEET	SPE-DATA-REPOSITORY-DATASET-1-WELL-12-LORIKEET	0	⋮
<input type="checkbox"/>	SPE-DATA-REPOSITORY-DATASET-1-WELL-13-MYNAH	SPE-DATA-REPOSITORY-DATASET-1-WELL-13-MYNAH	0	⋮
<input type="checkbox"/>	SPE-DATA-REPOSITORY-DATASET-1-WELL-14-PARTRIDGE	SPE-DATA-REPOSITORY-DATASET-1-WELL-14-PARTRIDGE	0	⋮
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<input type="checkbox"/>	SPE-DATA-REPOSITORY-DATASET-1-WELL-17-WARBLER	SPE-DATA-REPOSITORY-DATASET-1-WELL-17-WARBLER	0	⋮
<input type="checkbox"/>	SPE-DATA-REPOSITORY-DATASET-1-WELL-18-HARPY	SPE-DATA-REPOSITORY-DATASET-1-WELL-18-HARPY	0	⋮
<input type="checkbox"/>	SPE-DATA-REPOSITORY-DATASET-1-WELL-19-BEE-EATER	SPE-DATA-REPOSITORY-DATASET-1-WELL-19-BEE-EATER	0	⋮
<input type="checkbox"/>	SPE-DATA-REPOSITORY-DATASET-1-WELL-20-LOON	SPE-DATA-REPOSITORY-DATASET-1-WELL-20-LOON	0	⋮
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<input type="checkbox"/>	SPE-DATA-REPOSITORY-DATASET-1-WELL-26-AVOCET	SPE-DATA-REPOSITORY-DATASET-1-WELL-26-AVOCET	0	⋮

Rows per page: 200 1-15 of 15 < >

Gas Lift Curve

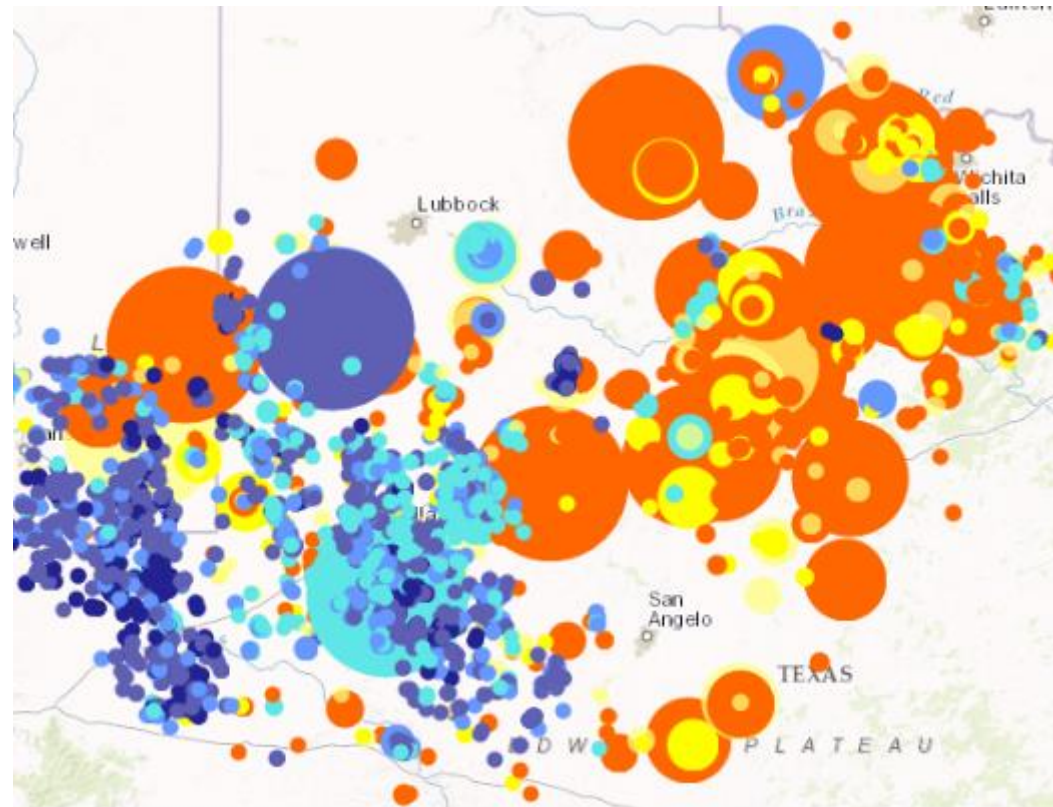


All Wells



Rank Uplift from Gas Lift

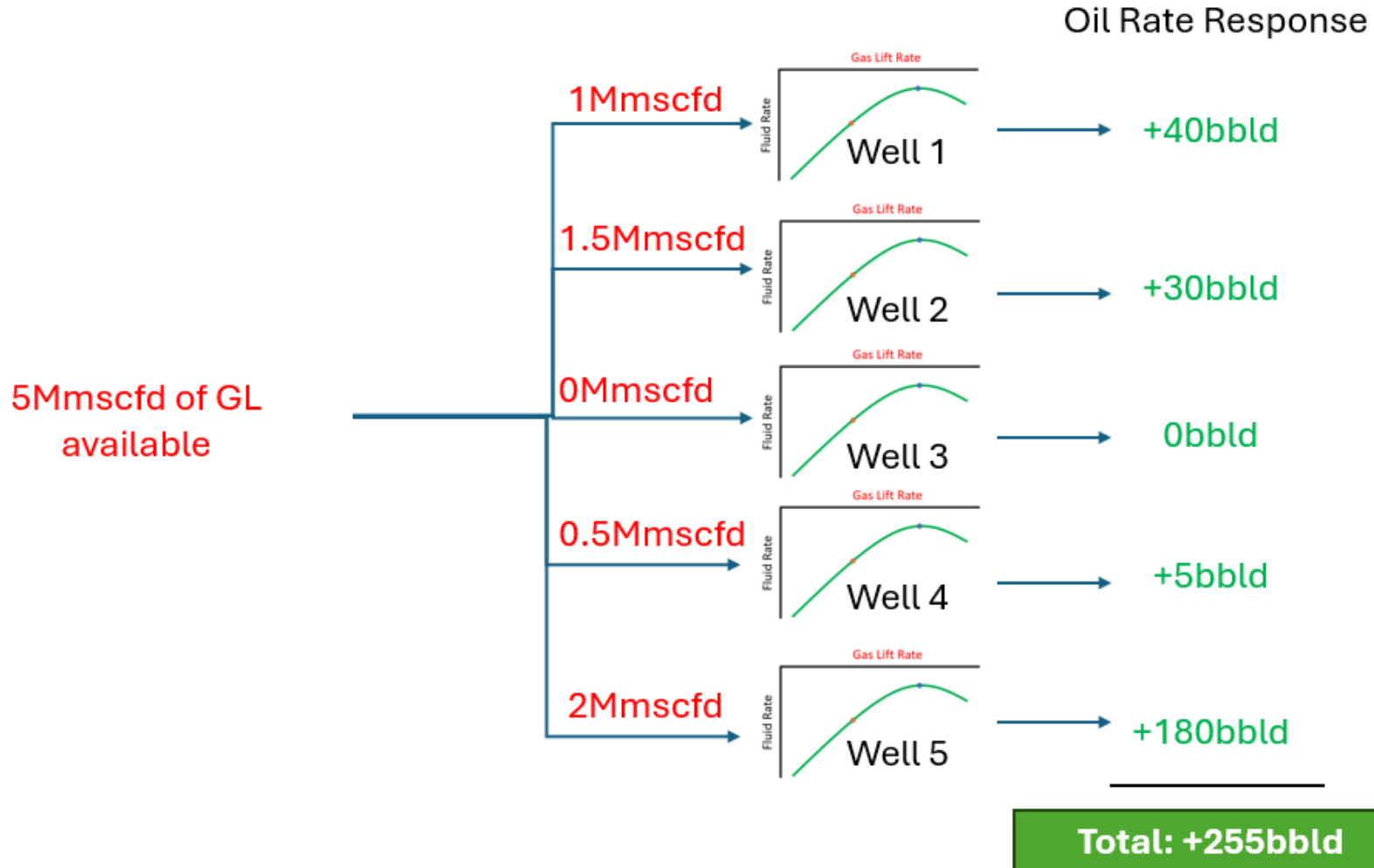
Well Name	Uplift Available (bbl/d)
Well 3	587
Well 9	579
Well 5	568
Well 6	555
Well 18	529
Well 4	526
Well 12	501
Well 25	433
Well 19	431
Well 16	427
Well 10	418
Well 13	396
Well 24	351
Well 20	324
Well 22	245
Well 11	225
Well 15	222
Well 23	213
Well 2	187
Well 14	179
Well 27	171
Well 17	166
Well 26	163
Well 7	149
Well 21	127
Well 8	104
Well 1	86



GL Distribution

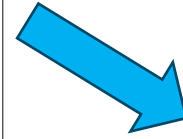
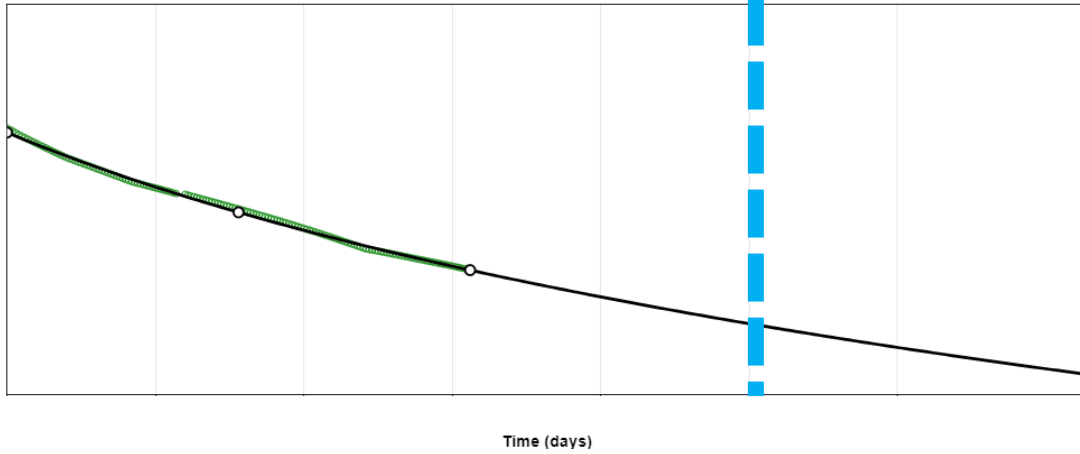
Distributing Gas Lift – “Smart method”

Automatically allocating GL rates to maximize liquid response

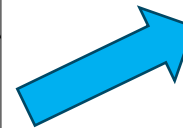
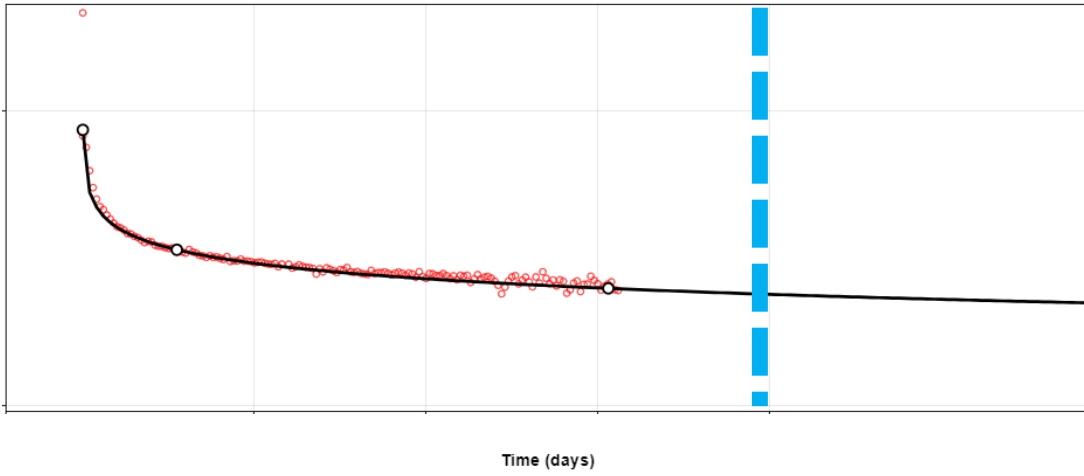


Future IPR

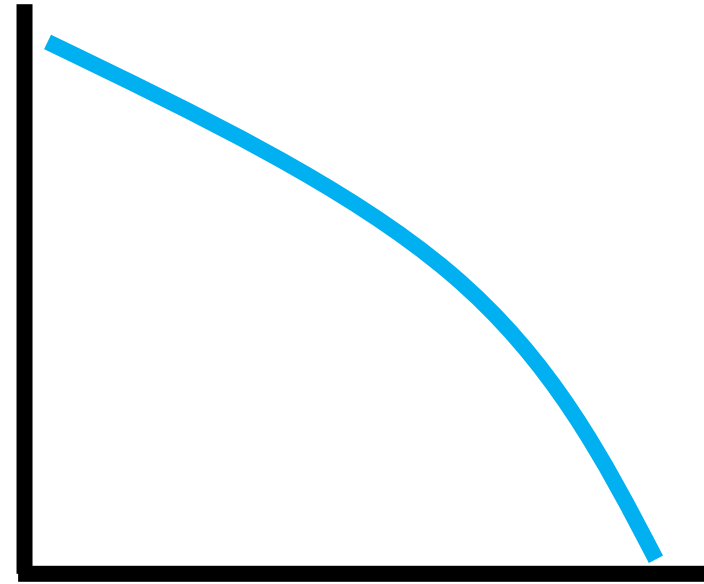
P Ave



C value

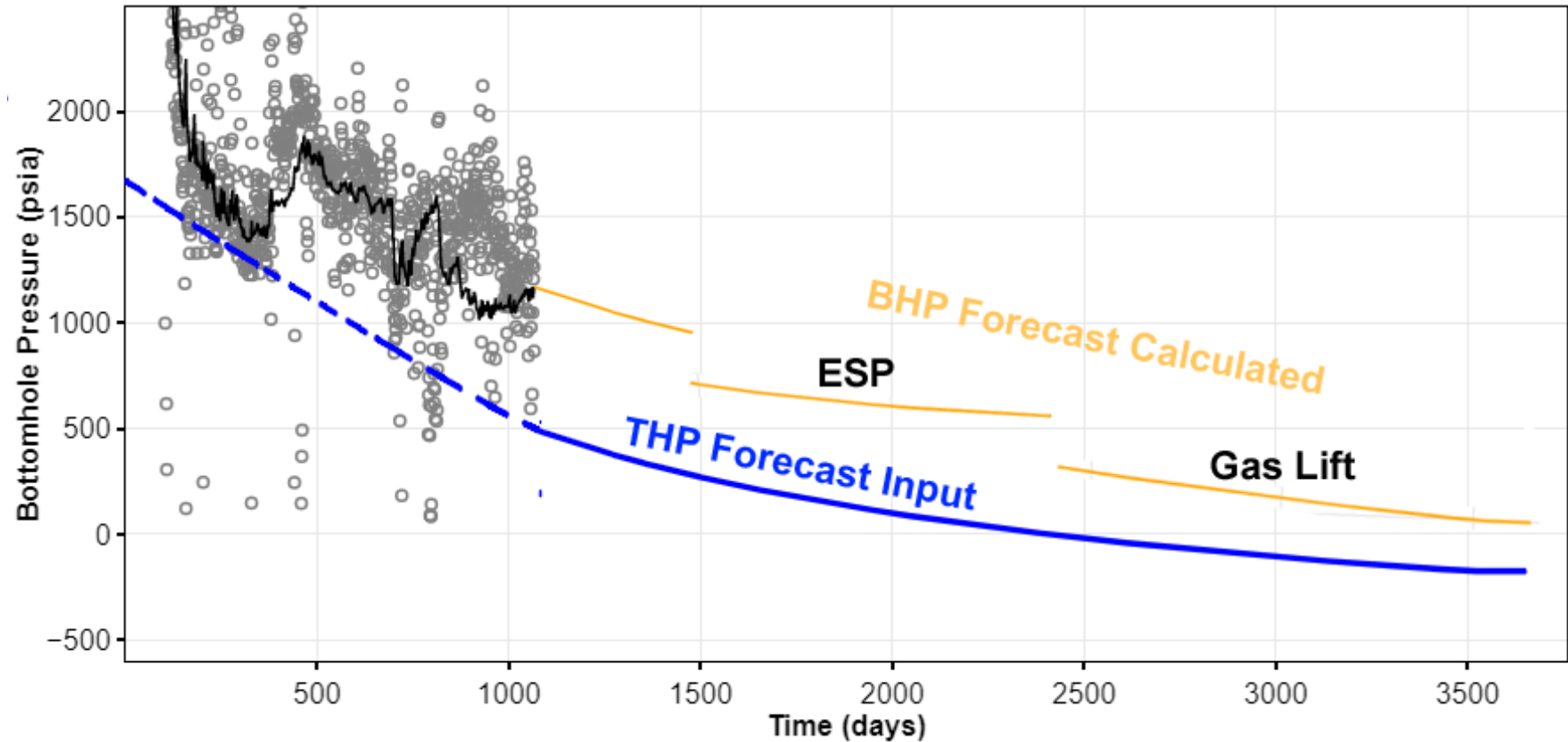


BHP

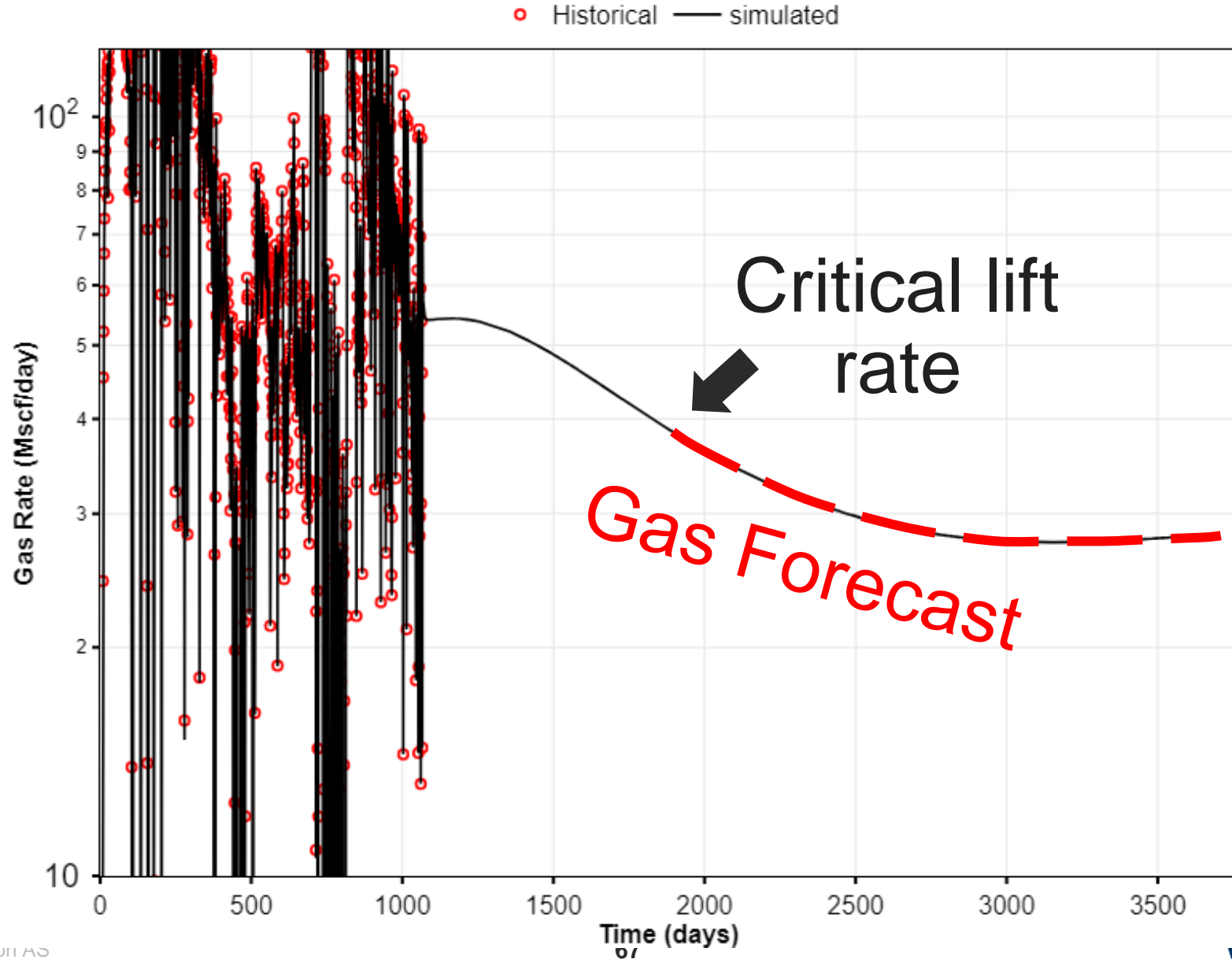


Rate

Artificial Lift Life Cycle



Liquid Loading Timeline



Resources





Resources

- This recording will be sent out
- BHP theory: <https://youtu.be/PBOeWB365D0>
- Support: support@whitson.com
- whitson manual:
 - BHP: <https://manual.whitson.com/modules/well-performance/bottomhole-pressure-calculations/>
 - Nodal: <https://manual.whitson.com/modules/well-performance/nodal-analysis/>
- Webpage: <https://whitson.com/>
- Follow us on LinkedIn <https://www.linkedin.com/company/whitson/>

Resources



Resources

-  **BHP automation in whitson+**
Mark Watson, Diamondback
<https://youtu.be/NHyU4Tz3RbY?t=2440>
-  **BHP automation in whitson+**
Wade Baustian, Camino
<https://youtu.be/NHyU4Tz3RbY?t=1274>
-  **Nodal in whitson+**
Jon Pratt, Devon Energy
<https://youtu.be/NHyU4Tz3RbY?t=5190>
-  **To ESP, or not ESP – That's the Question**
Brock Robertson, Marathon
<https://youtu.be/el1iPv9G1cQ?t=4941>

Case Studies



Fluid Mapping in Duvernay

Jaron van Dijken, CPG

https://youtu.be/i4tS_0kX7qQ?t=4350



How to interpret MFMB

Leslie Thompson, whitson

https://youtu.be/i4tS_0kX7qQ?t=7618



Numerical RTA on 100 wells

Brian Collins, 89 Energy

https://youtu.be/i4tS_0kX7qQ?t=9152



Transitional Flow in Duvernay

Jaron van Dijken, CPG

<https://youtu.be/sdHPbR9eAr!t=4866>



Nodal in whitson*

Jon Pratt, Devon Energy

<https://youtu.be/NHyU4Tz3RbY?t=5190>



Numerical RTA & Well Spacing

Braden Bowie, Apache

https://youtu.be/i4tS_0kX7qQ?t=10610



Check this before Numerical RTA

Mathias Carlsen, whitson

<https://youtu.be/h0YbsKRldU8>



Multiphase FMB in the Bakken

Jason Billings, Whiting

<https://youtu.be/U0q5QB8yHw?t=8563>



BHP automation in whitson*

Wade Baustian, Camino

<https://youtu.be/NHyU4Tz3RbY?t=1274>



RTA in the Bakken

Gaurav Sharma, CPG

<https://youtu.be/NHyU4Tz3RbY?t=7800>



MFMB to Evaluate Refracs

Steven Young, Devon

https://youtu.be/1HW6_kIRyX8?t=2414



Probabilistics in whitson*

Tyler Micheli, Tap Rock

<https://youtu.be/U0q5QB8yHw?t=12055>



Estimates of p_i from flowback data

Steve Jones, Consultant

<https://youtu.be/U0q5QB8yHw?t=12968>



BHP automation in whitson*

Mark Watson, Diamondback

<https://youtu.be/NHyU4Tz3RbY?t=2440>



Multiphase FMB for well-groups

Leslie Thompson, Coterra

<https://youtu.be/NHyU4Tz3RbY?t=9594>



Numerical RTA in Anadarko

Ruth Hulme, Ovintiv

<https://youtu.be/sdHPbR9eAr!t=2306>



To ESP, or not ESP – That's the Question

Brock Robertson, Marathon

<https://youtu.be/el1iPv9G1cQ?t=4941>



Utilizing RTA in Asset Acquisitions

Brian Permian, WNR

<https://youtu.be/sdHPbR9eAr!t=3710>



Gas lift in whitson*

Graham Helfrick, whitson

<https://youtu.be/NHyU4Tz3RbY?t=3707>



Quick nodal in whitson*

Graham Helfrick, whitson

https://youtu.be/T6NO5wN76_U



Well Interference: DQI

Mouin Almasoodi, Devon

https://youtu.be/1HW6_kIRyX8?t=5100



Filtering & Grouping in whitson*

Mohamad Dahouk, whitson

https://youtu.be/1HW6_kIRyX8?t=7067



Choke Management IP Analysis

Jorge Garcia, EQT

https://youtu.be/1HW6_kIRyX8?t=1332



whitson* API 1.01: Auto Connect your Data

Jason Hu, whitson

https://youtu.be/1HW6_kIRyX8?t=10465



Recovery Factor: CGR/WGR vs p_{wf}

Narayan Nair, Coterra

https://youtu.be/1HW6_kIRyX8?t=8885

whitCon 2023



Fluid Modeling for Underground Hydrogen Storage

Markus Hays Nielsen, whitson
<https://youtu.be/MB6sSoAoM0w?si=dUa8kpdX01kJ4PVw&t=9>



DCA & Type Well Workflow

Jason Billings, Civitas
https://youtu.be/MB6sSoAoM0w?si=SO29OkBueiLk_auT&t=1028



Operationalizing Reservoir Insights using whitson+

Jeffrey van Wageningen, Formentera
<https://youtu.be/MB6sSoAoM0w?si=W34mh6gNlCqKg6WX&t=4165>



Centralized Gas Lift Compression Optimization Workflow

Jon Pratt, Devon
<https://youtu.be/MB6sSoAoM0w?si=MIMSe7BXqDHC48xM&t=5370>



What's New? Multi-well Nodal Analysis

Graham Helfrick, whitson
<https://youtu.be/MB6sSoAoM0w?si=AMqwpV-XcaWiBIO4&t=6622>



Measurements, Models, and Innovation – Increasing Oil Recovery in the Bakken

Craig Cipolla, HESS
<https://youtu.be/MB6sSoAoM0w?si=NEVPnUEHI5Z6ISCj&t=7888>



Converting RTA Half-Lengths to Actual Non-Uniform SRV Half-Lengths

Vivek Muralidharan, Oxy
<https://youtu.be/MB6sSoAoM0w?si=e9AcddbsxLq4GKy6&t=9377>



Use of Build-Ups in RTA

Danish Tarar, Continental Resources
<https://youtu.be/MB6sSoAoM0w?si=N3nXmLEconfFc9fy&t=10919>



Permian Case Study: DCA & Multiphase FMB Workflow

Neil Longenbaugh, Coterra
<https://youtu.be/MB6sSoAoM0w?si=QPCoNNn9FiFkDBJE&t=11720>



Case Study: RTA in the Midland Basin

Adam Block, Ovintiv
<https://youtu.be/MB6sSoAoM0w?si=zsPuSflIFB0UlwOA&t=12364>



Scalable Estimation of initial Pressure from Early Flow Data

Sam Shoun, Callon Petroleum
<https://youtu.be/L1eqWc5zazc?si=6Xo8pnNdhycozTzG&t=148>



CumPI and Numerical RTA: A simple Method for Well Performance Analysis

Carlos Miranda, HESS
<https://youtu.be/L1eqWc5zazc?si=8JJytctdwbJqvteu&t=17067>



Multiphase FMB for Well-Groups

Leslie Thompson, whitson
<https://youtu.be/L1eqWc5zazc?si=5q4HOIRalCluqg-T&t=25770>



How NOT to CPG

Donovan Armistead, Devon
<https://youtu.be/L1eqWc5zazc?si=E6PJNpxg7uGNdUa3&t=3650>



Multi-well Numerical Models in whitson+

Stian Mydland, whitson
<https://youtu.be/L1eqWc5zazc?si=nMjH5rtfZT41tbRj&t=48610>



Numerical RTA on 100+ wells in the Anadarko Basin

Brian Collins, 89 Energy
https://youtu.be/L1eqWc5zazc?si=LtjFKfpZvHsGQ_4O&t=57062



Evaluating 20+ Refracs in the Eagle Ford with Multiphase FMB

Steven Young, Devon
<https://youtu.be/L1eqWc5zazc?si=yPyLq4qcrzYGRPr2&t=68827>



Seeking Delta: Fractional, Numerical RTA on 269 wells in the Midland Basin

Braden Bowie, Apache
https://youtu.be/L1eqWc5zazc?si=i_-CCqF01HWDhxt6k&t=781900



Oil Well Interpretation 1

Alejandro Lerza, Chevron
<https://youtu.be/L1eqWc5zazc?si=f4aNg4nwO8QFQdBr&t=10400>



Oil Well Interpretation 2

Rohit Sinha, Marathon
<https://youtu.be/L1eqWc5zazc?si=6jWn6FJeefCnSpK1&t=10767>



Oil Well Interpretation 3

Amy Studdert, Murphy
<https://youtu.be/L1eqWc5zazc?si=4lsSZYaL3tWajaPm&t=11312>



Gas Well Interpretation 1

Ryan Jicha, Pioneer
https://youtu.be/L1eqWc5zazc?si=8M9_ZteoYmCAWINs&t=11842



Gas Well Interpretation 2

Brian Periman, Crescent E
https://youtu.be/L1eqWc5zazc?si=a_irtEKWyc_iEX83&t=12412
<https://youtu.be/S8V0kvTdVFg?si=BmXaXlr77SsYw6qq>



Gas Well Interpretation 3

Jorge Garcia (EQT)
https://youtu.be/S8V0kvTdVFg?si=_0i4xHYru4kR3xOt&t=24500

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Using whitson+ to Identify Exploration Opportunities

Scott Grant, Suede Energy

<https://youtu.be/il49AJug1x0?si=x5q3nQWe1AE67QR&t=1528>



EOS PVT Mapping in the Montney

Rashid Sohail, Ovintiv

<https://youtu.be/il49AJug1x0?si=2K6yYpc8rz1BJwCM&t=3068>



Multi-layer PVT Initializations

John Yeo, Birchcliff

https://youtu.be/il49AJug1x0?si=Tv48_Ak0tHHpDKgw&t=4198



Integrated RTA Workflow in the Bakken

Gaurav Sharma, CPG

<https://youtu.be/il49AJug1x0?si=I9Ua3M0QMuo7LO1E&t=5581>



A Montney Pad Case Study: Late Time Interference Challenge

Raj Kumar, Whitecap

<https://youtu.be/il49AJug1x0?si=JyNmoBOt26fFkl-c&t=7404>



Transitional Flow – How far can you go?

Jaron van Dijken, CPG

https://youtu.be/il49AJug1x0?si=V6fxa0RxIYb9DNp_&t=8703



Next Generation Workflows: What we've done, where we're going

William Hutchison, Ovintiv
Angela Dang Atkinson, Ovintiv

<https://youtu.be/il49AJug1x0?si=p-BcpHZtL2XXqyV6&t=10145>



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The company was founded by Dr. Curtis Hays Whitson in 1988 and is a Norwegian corporation located in Trondheim, Norway, with local presence in USA, Middle East, India and Indonesia.

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