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Enhanced Wellbore Gradient Modelling for CSG Wells

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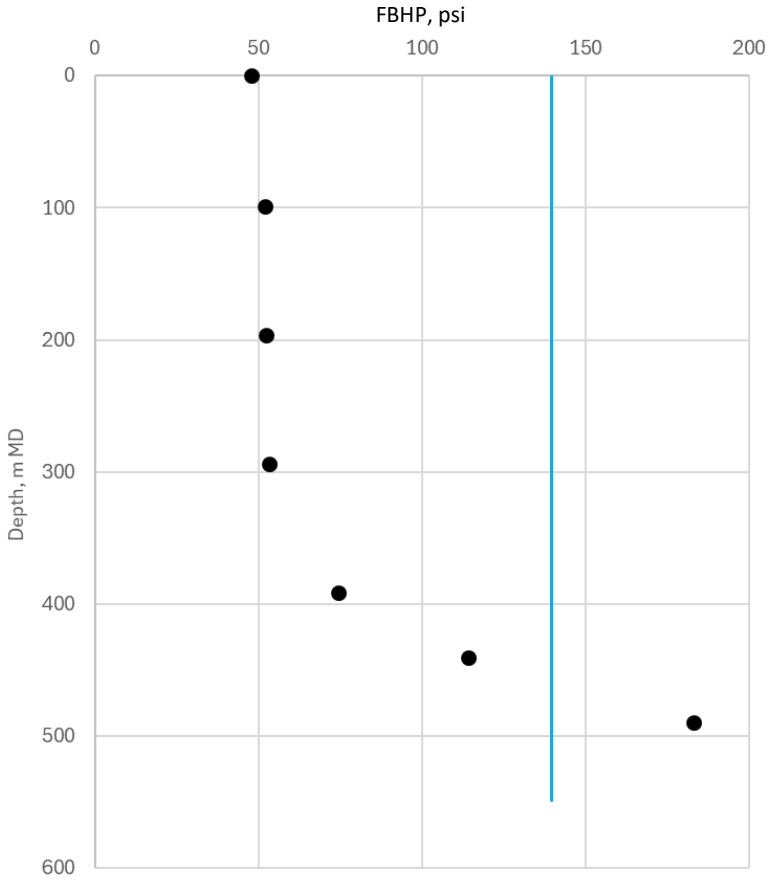
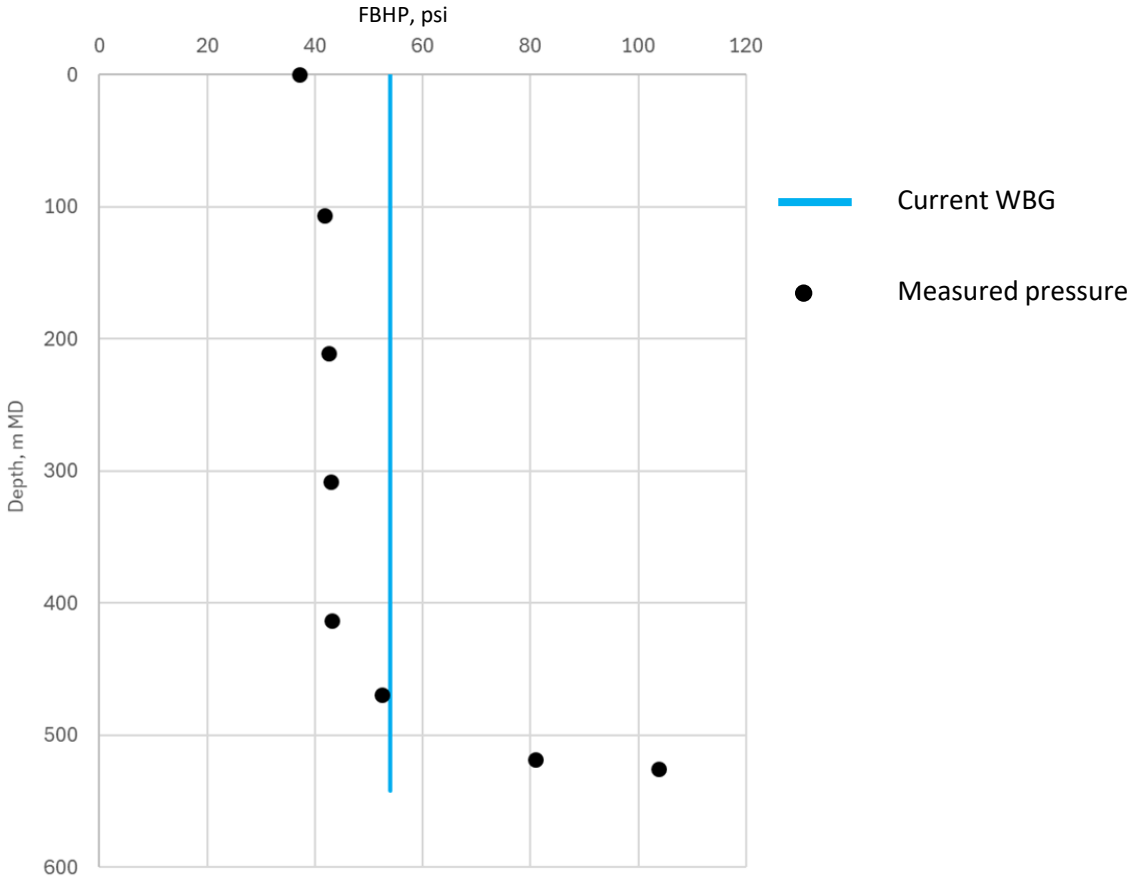
Flowing Wellbore Gradient (WBG) in a CSG Well

Well A



Well B



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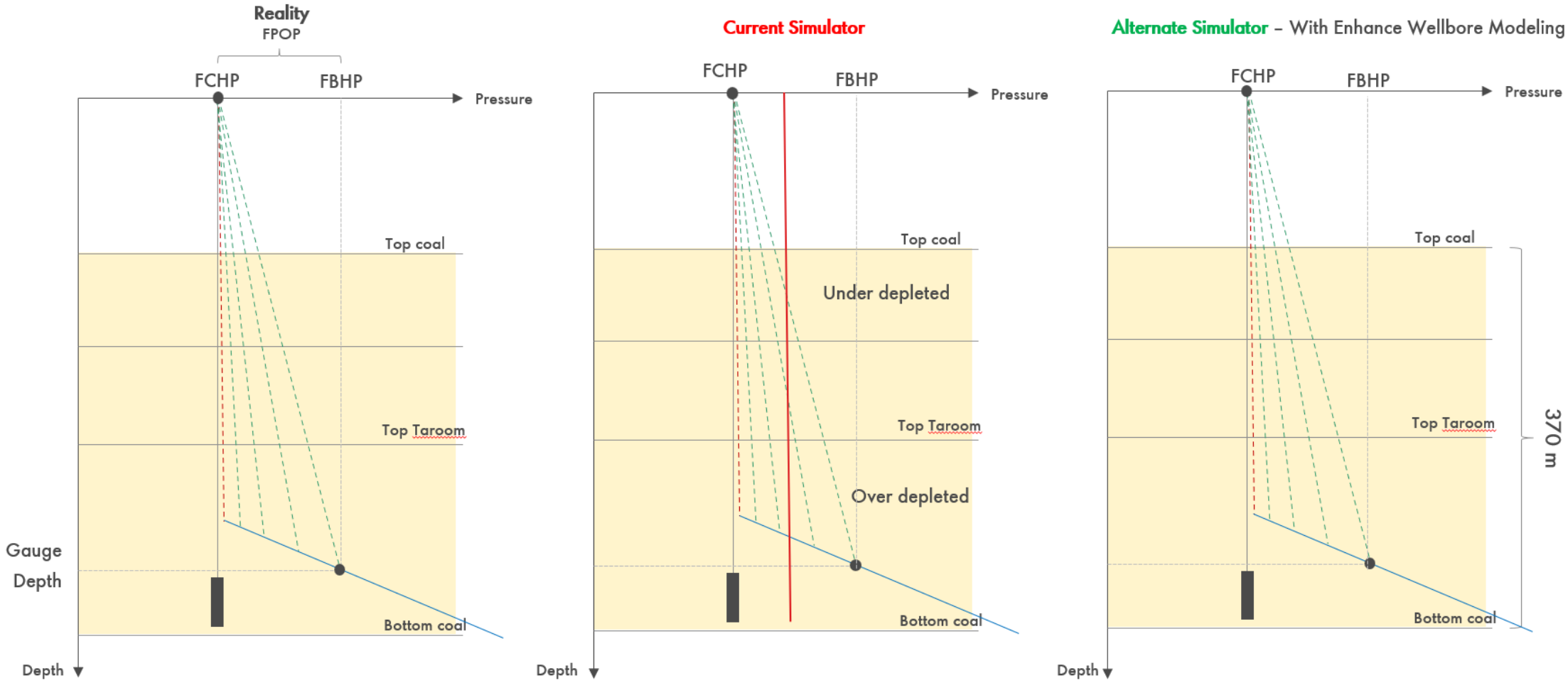
Problem Statement: Flowing Wellbore Gradient in a CSG Well



Avg density of produced fluids based WBG model leads to overestimation of drawdown in deeper coals and vica versa in the shallower coals

Enhanced Wellbore Model better represents dual phase flow in a well over its lifetime

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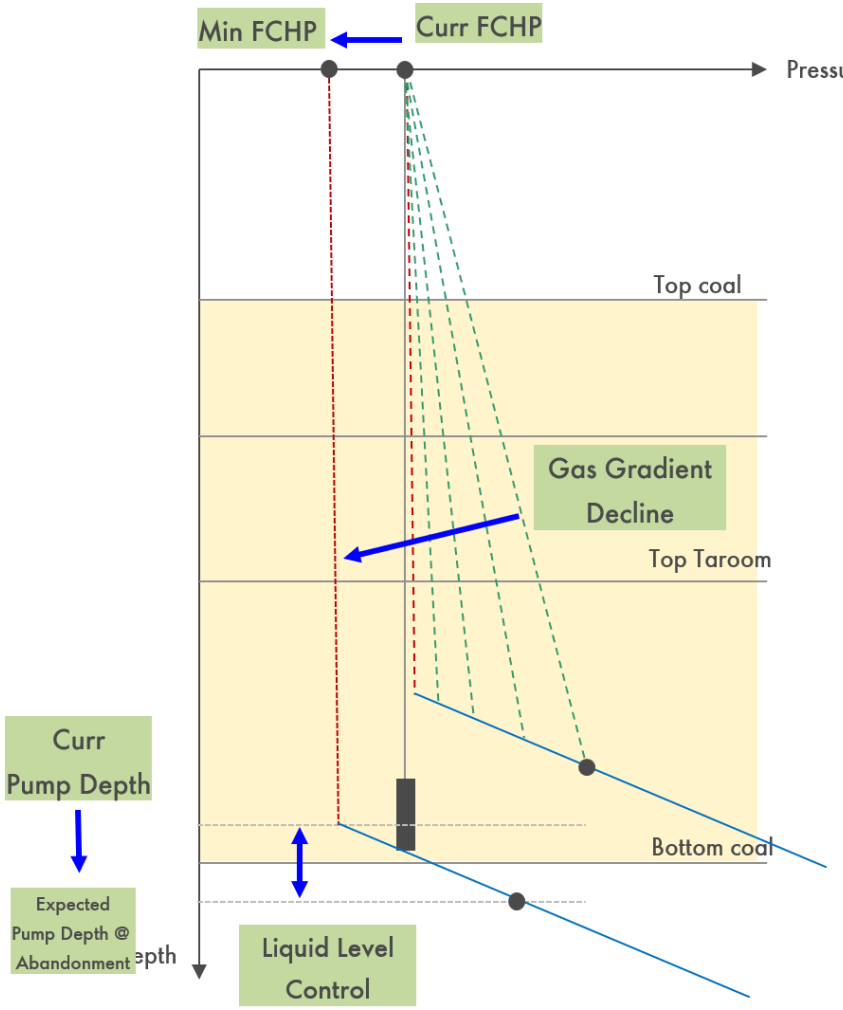
Methodology: Enhanced Wellbore Gradient Model in History



- Wellbore Gradient Control Model (workflow) was implemented using Python
- Historic wells are operated under reservoir voidage or gas rate control. Pump set depth changes due to workovers are accounted for
- Monthly well-level FCHP data is an input to the wellbore gradient control workflow
- The simulator adjusts FBHP at reference depth to match well-level gas guide rates.
- During FBHP updates, the workflow dynamically adjusts the mixed fluid gradient above the liquid level as well as liquid level height.
- With known near-wellbore permeability, reservoir engineers can track historical changes in liquid level and mixed gradient while honouring FCHP and guide rate constraints.

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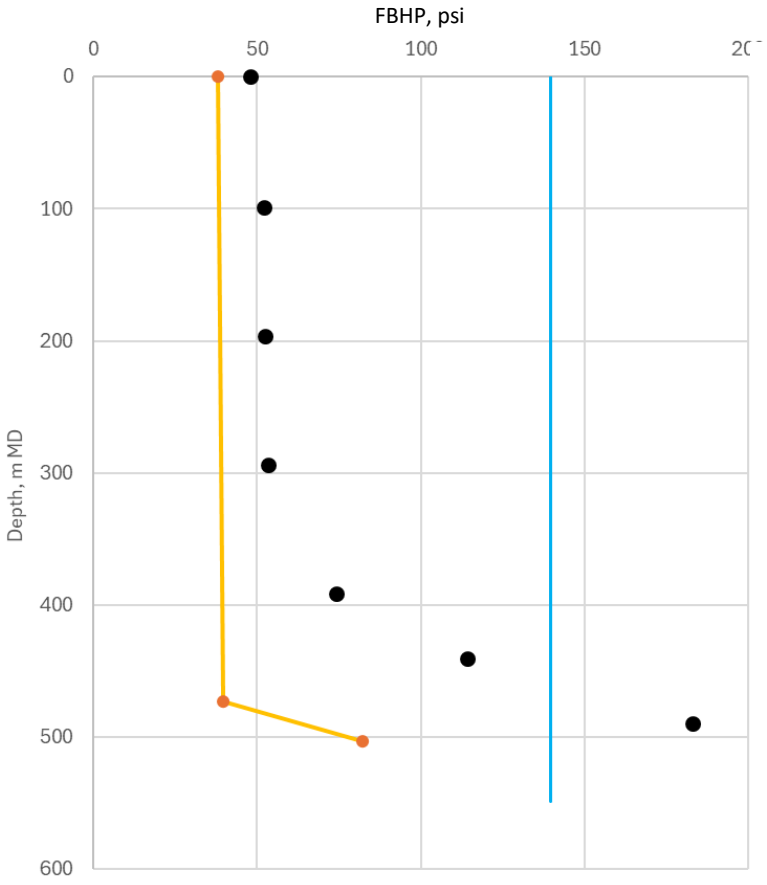
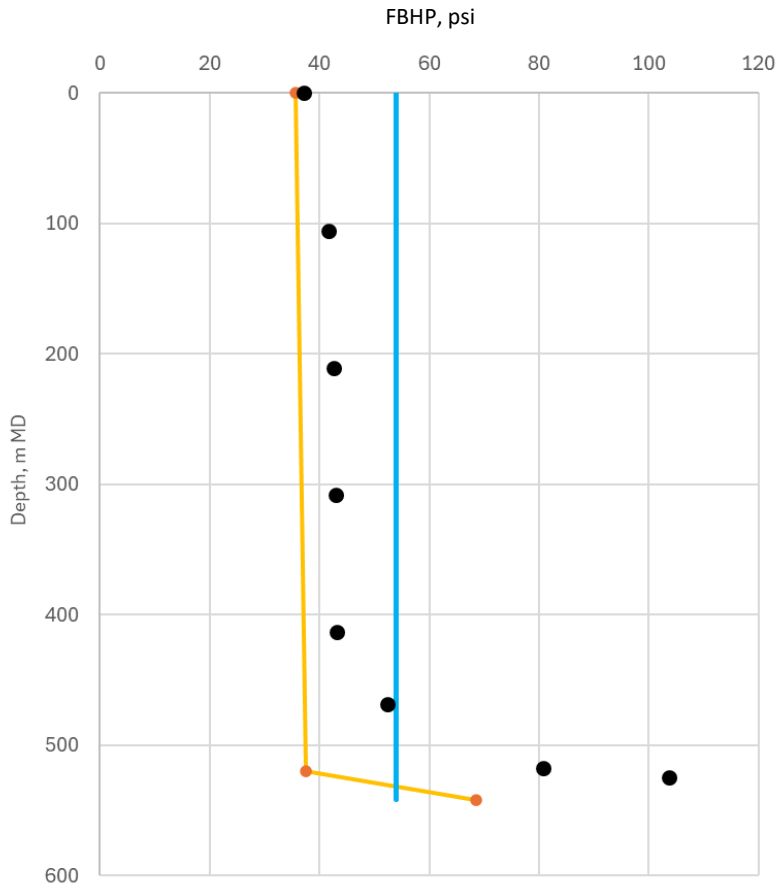
Benchmarking: Flowing Wellbore Gradient in a CSG Well

The enhanced WBG model provides improved benchmarking and more accurately captures dual-phase flow behaviour in wells

Well A



Well B



Measured FBHP

Current WBG

Enhanced WBG*

* Match will be further improved with history matching

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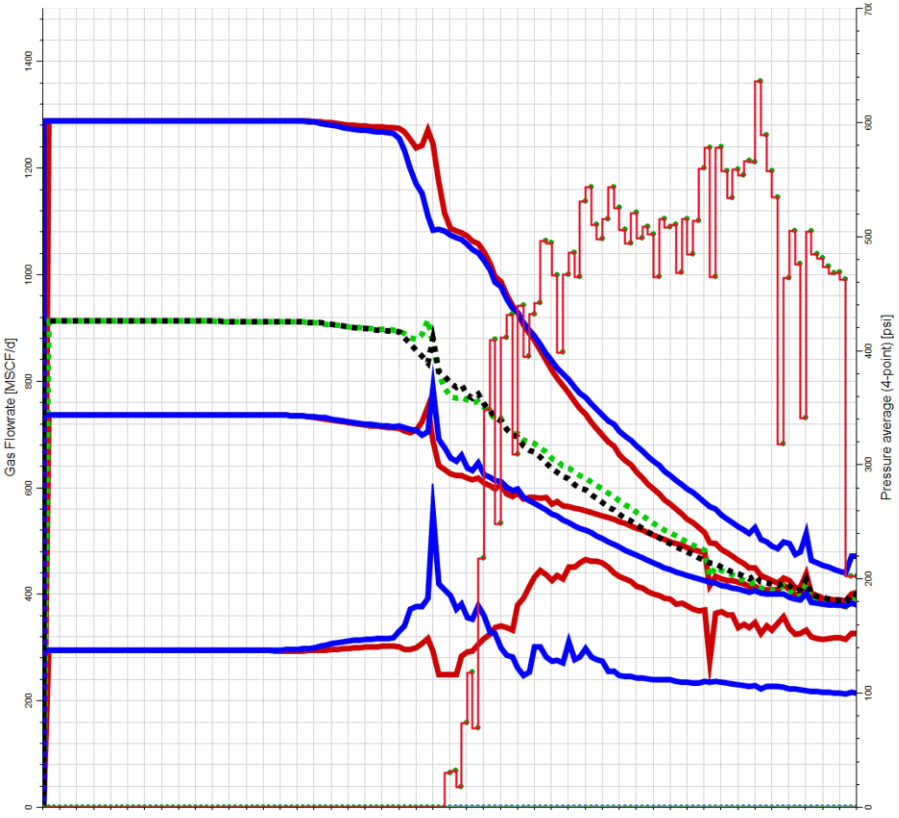
Enhanced Wellbore Gradient (WBG) Model in History

Well A: Gas rate and Coal Seam Level Reservoir Pressure

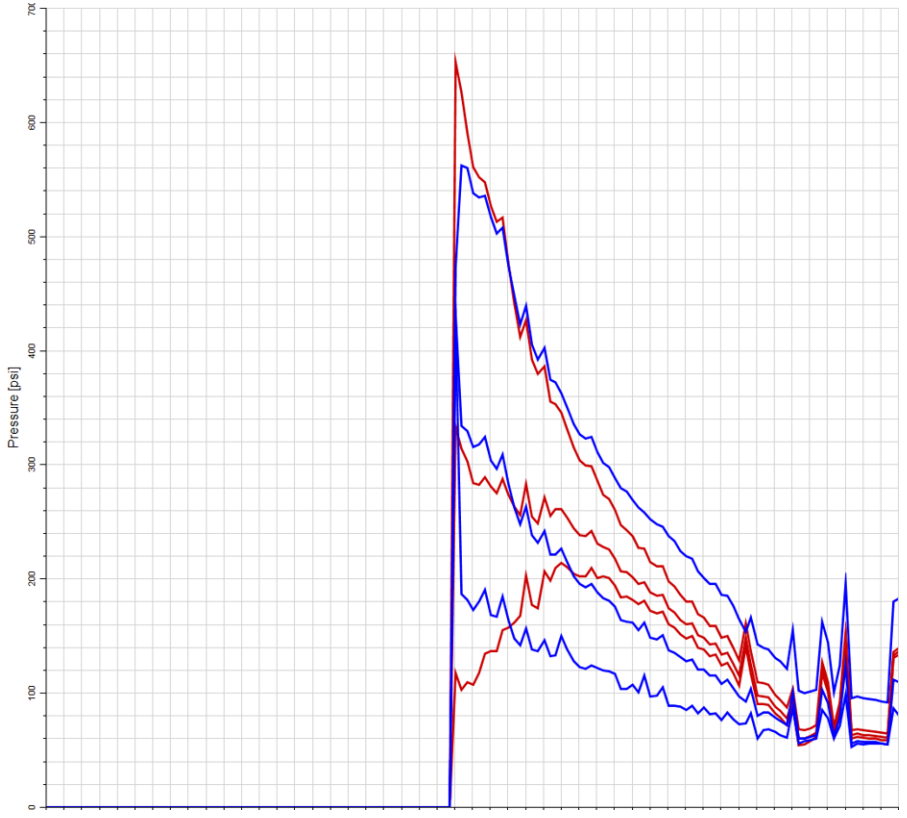


Old WBG Model

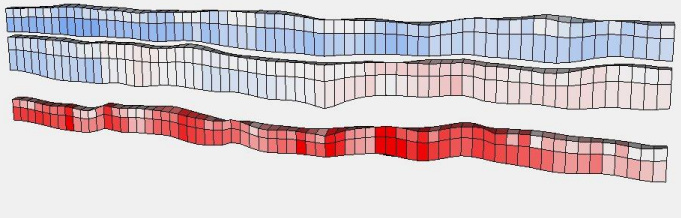
Advanced WBG Model

Reported Avg for the Well

Well A: Coal Seam Level FBHP



Zonal Pressure Difference @end of history (EOH)



Higher

Lower

At the EOH Shallower Coals are observed to be under-depleted with the deeper coals over depleted in the old WBG Model

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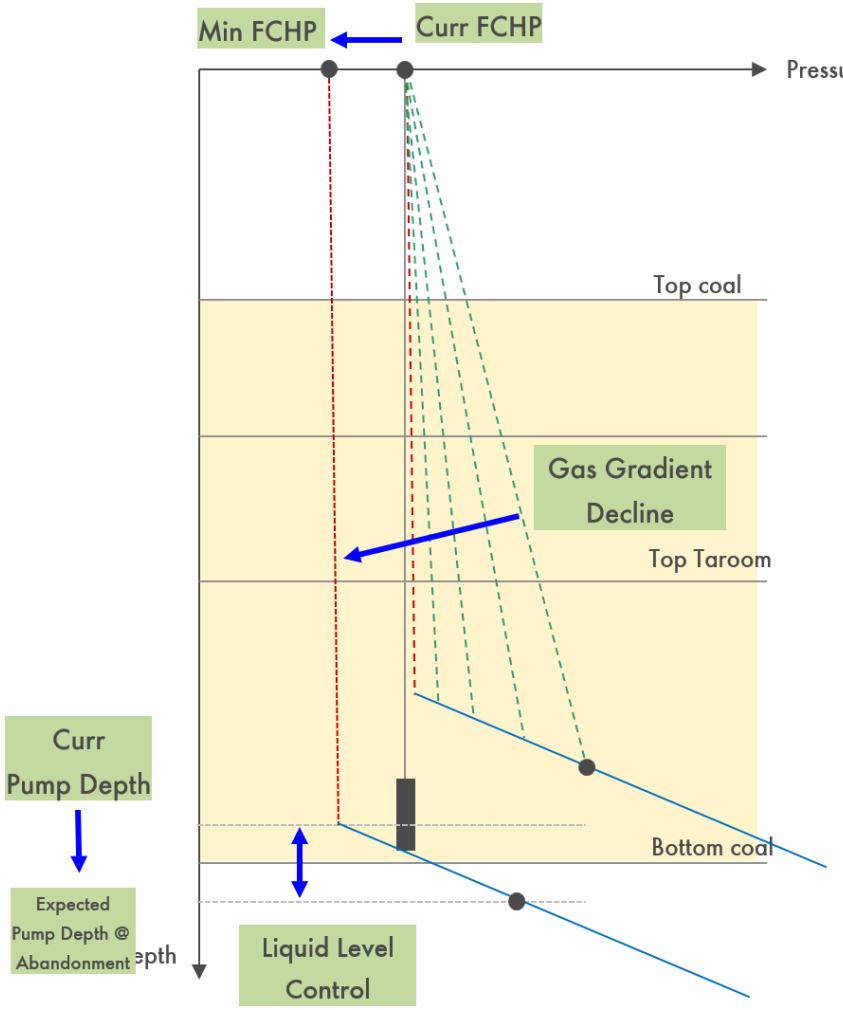
Enhanced Wellbore Gradient Model in Forecast



- In prediction mode, well is on FBHP control, but this FBHP is calculated based on the EWBG model inputs using Python logic
- Engineer can manually or using automated logic modify 4 parameters:
  - Flowing Casing Head Pressure
  - Depth of the pump
  - Liquid level above pump
  - Mixed fluid gradient above liquid level
- All these parameters will affect FBHP at the reference depth, and hence produced gas rate
- Ability to control these 4 parameters in prediction allows to explicitly model well interventions, such as liquid level optimization, deep setting of the pump, or installation of the well head compression

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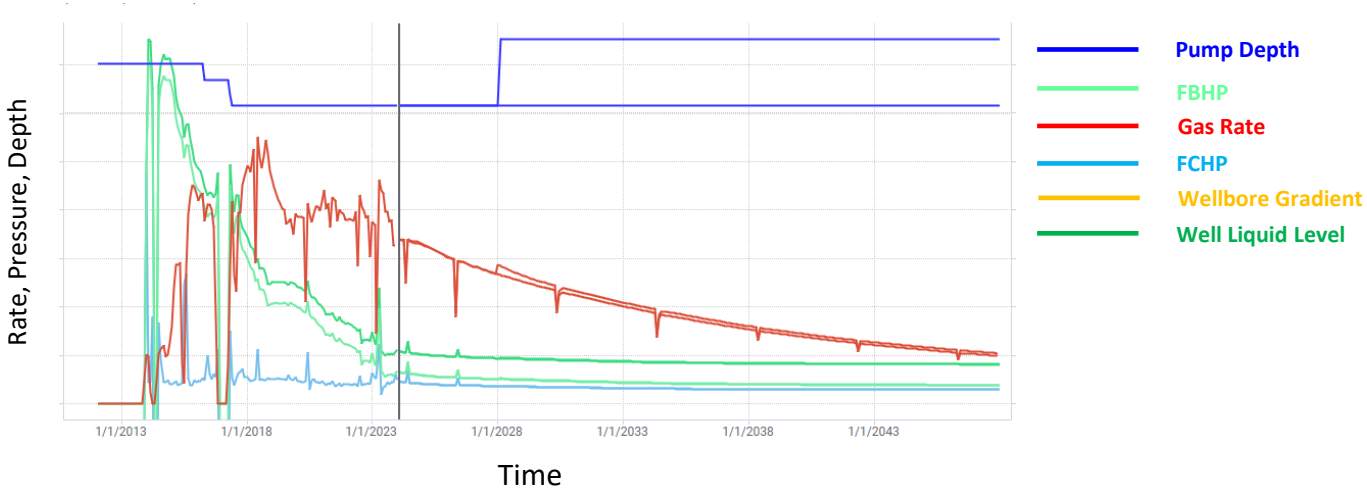
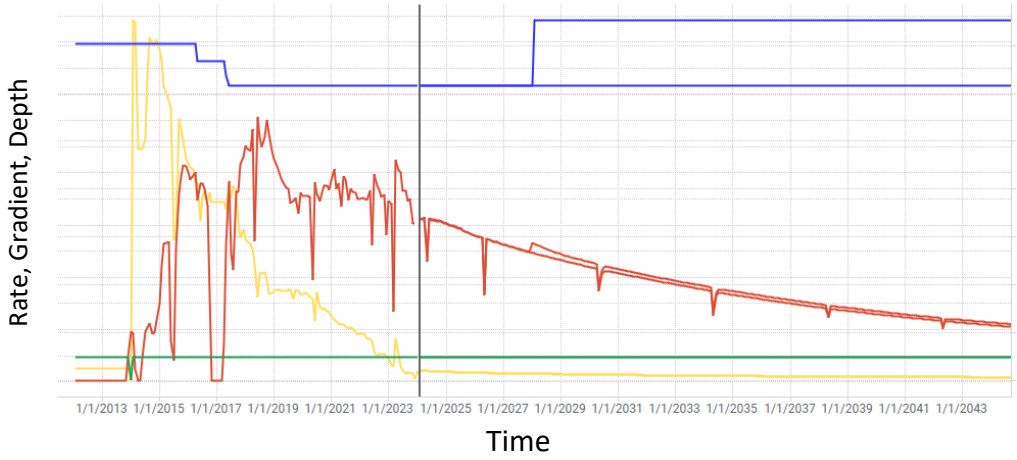
Enhanced Wellbore Gradient Model in Forecast: Pump Deep set





- Deep Setting of the pump is modelled explicitly by lowering the pump depth
- This increases drawdown on the deepest coals, without affecting shallow coals
- Well availability impact of the deeper pump is also modelled explicitly

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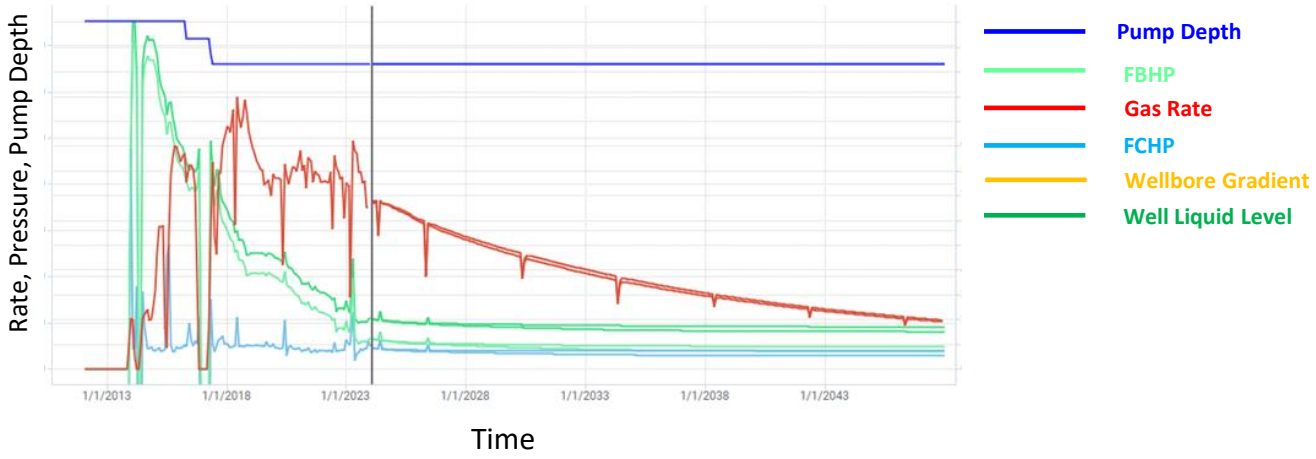
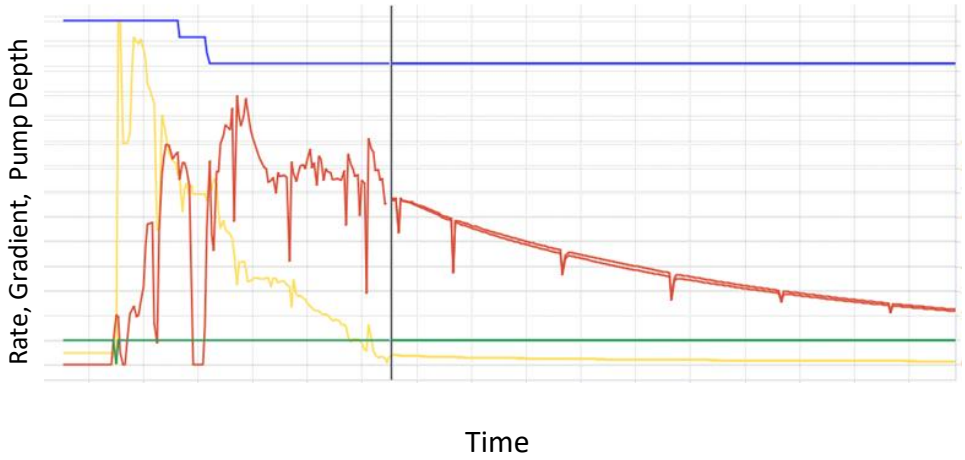
Enhanced Wellbore Gradient Model in Forecast: Compressor Curves





- As gas rates decline over a well's life, compressors can operate at lower inlet pressures, reducing FCHP and backpressure on coal seams.
- The Enhanced wellbore model explicitly captures these dynamics, enabling more accurate simulation of pressure behaviour and its impact on reservoir performance and ultimate recovery of the field.

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Conclusions

1. As the Surat Basin CSG assets mature and approach end-of-field life, accurately modelling backpressure on coal seams at varying depths becomes increasingly critical.
2. The enhanced wellbore gradient model allows for dynamic control of wellhead pressure, pump depth, water column height, and the expected mixed gradient, all tailored to actual operating conditions.
3. This eliminates the need for proxy abandonment FBHP values currently used in late-life simulations, enabling more realistic dual-phase flow representation, improved reservoir management, and more accurate estimation of recoverable volumes.
4. By leveraging advanced reservoir simulation technologies and Python-based automation, the QGC Subsurface Team is well-positioned to make confident, data-driven decisions in managing complex field development and late-life production strategies.

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