Benchmark for Hydraulic Fracturing Models
Case 2: Single Fracture in Layered Elastic Formations

MFrac Lite
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Summary of Equations

- Mass Conservation $$\int_0^t q(\tau)d\tau - V_f(t) - V_l(t) - V_{sp}(t) = 0$$
- Continuity equation $$\vec{\nabla}\cdot\vec{q} + 2q_L + \frac{\partial W}{\partial t} = 0$$
- Momentum Equation $$\vec{\nabla}P = -\frac{1}{2} f\rho\vec{q}^2 / w^3$$
- Width opening pressure elasticity $$W(x,z,t) = \Gamma_W(x,y,z,t)\frac{2(1-\nu)}{G} H_\xi \Delta P(x,0,t)$$
- Fracture Propagation Criteria $$K_I = K_{IC} \; or \; \sigma_I = \sigma_{IC}$$

References: SPE 19329 ; SPE 15240

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Numerical Methods Used

- The fracture propagation solution is obtained numerically by satisfying the aforementioned equations and the fracture propagation criteria.
- The equations are subsequently differentiated with respect to time and simplified by the transformations:

$$\alpha_\zeta = \frac{t}{\zeta(t)} \frac{d\zeta(t)}{dt} \quad \text{for } \zeta = L, A, W_w, H_w, \Delta\mathrm{P}, C$$

- Forming a set of equations in terms of the alpha parameters α_ζ
- The alpha parameter accounts for the time dependent gamma parameters, non-steady injection rates, and fluid rheology, spurt loss, etc.

References: SPE 19329 ; SPE 15240

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Assumptions

- Cased vertical well (4.5” 13.5#)
- Perf’d in the middle zone (8000-8001’)
  - 20 perfs @ 0.42in diameter

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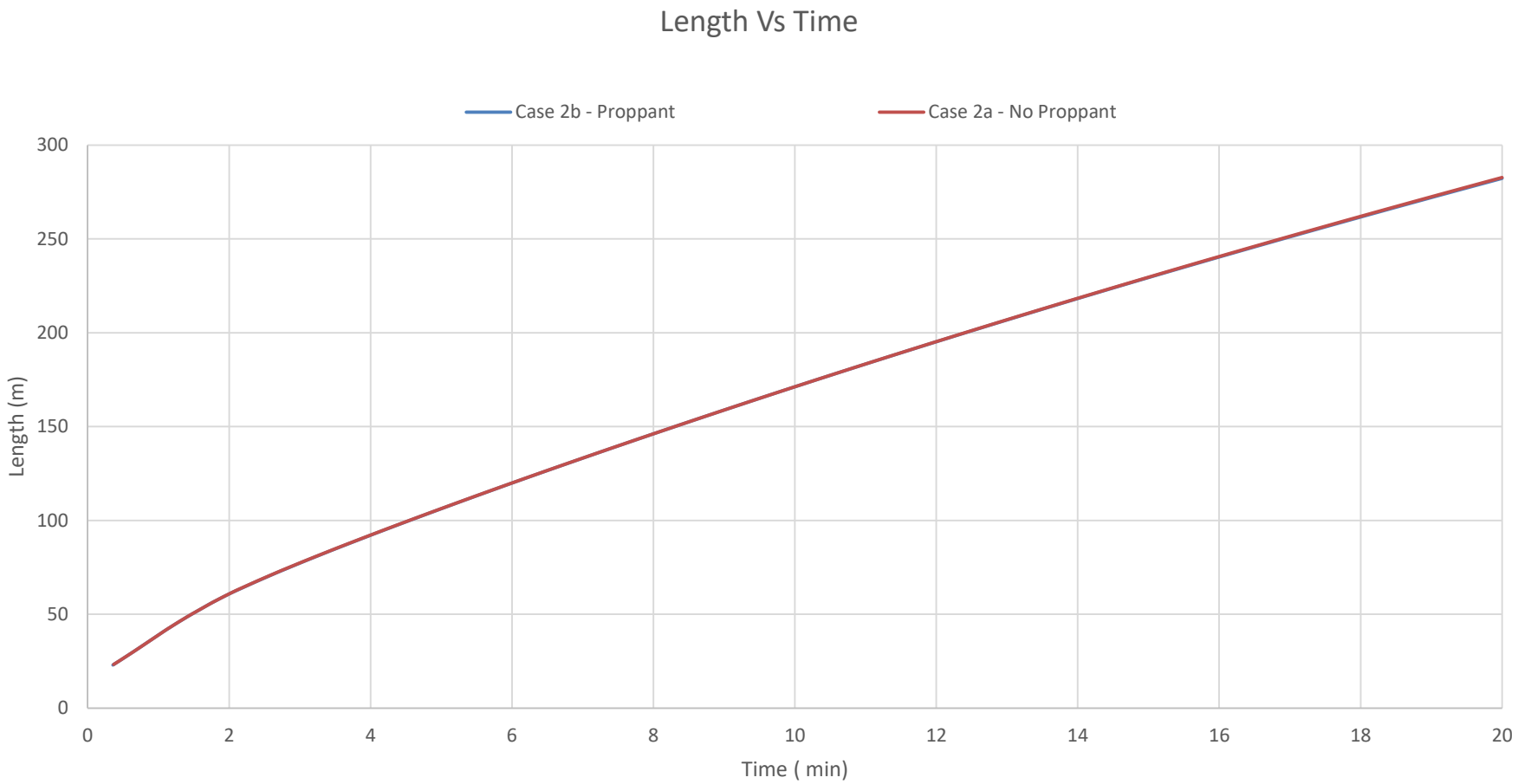
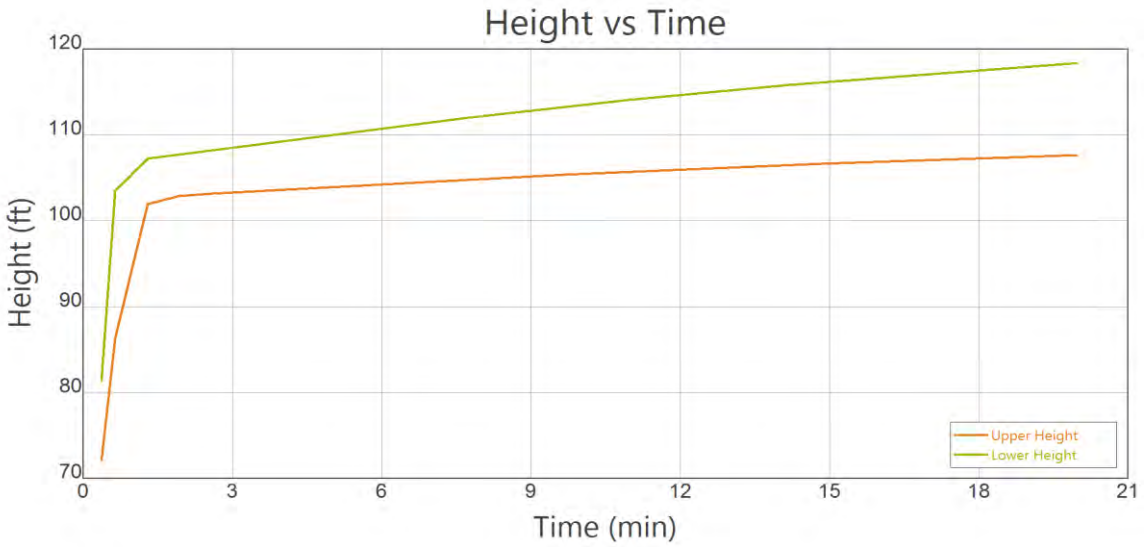
Results – Fracture Length Vs Time

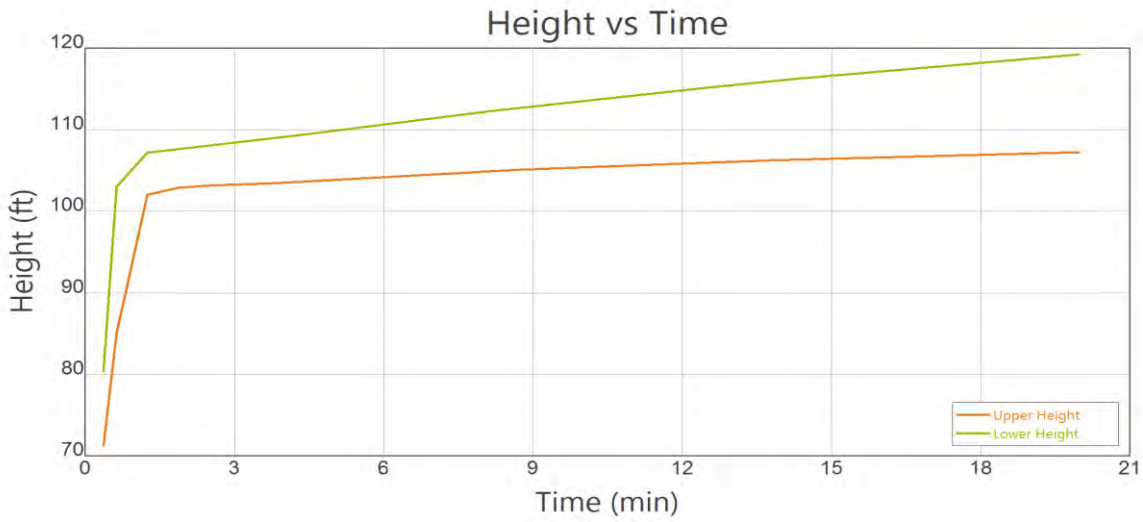


Results – Fracture Height Vs Time

Case 2a – No Proppant

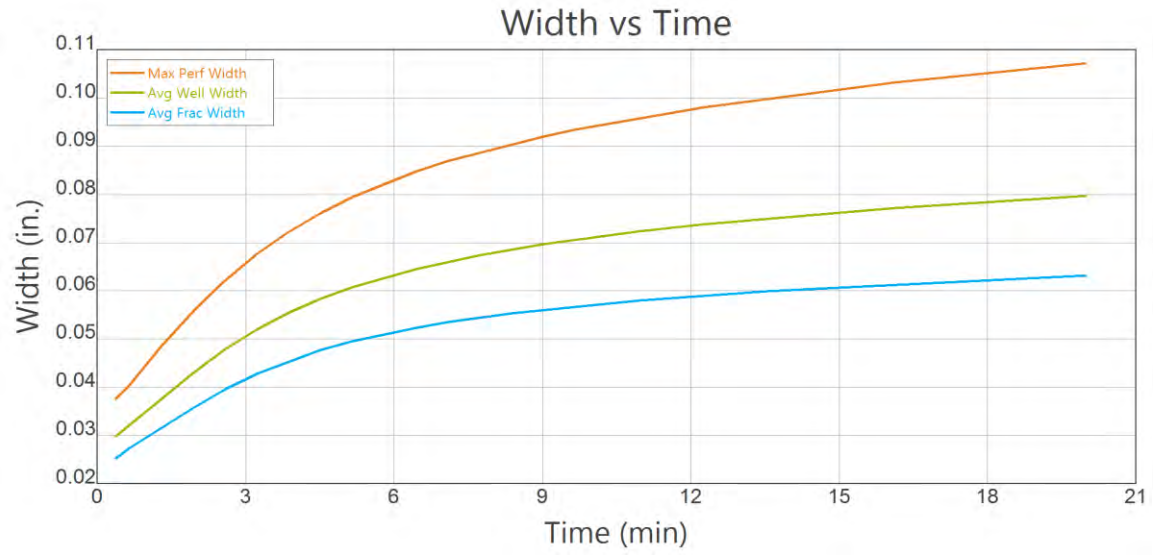


Case 2b- With 2ppa Proppant

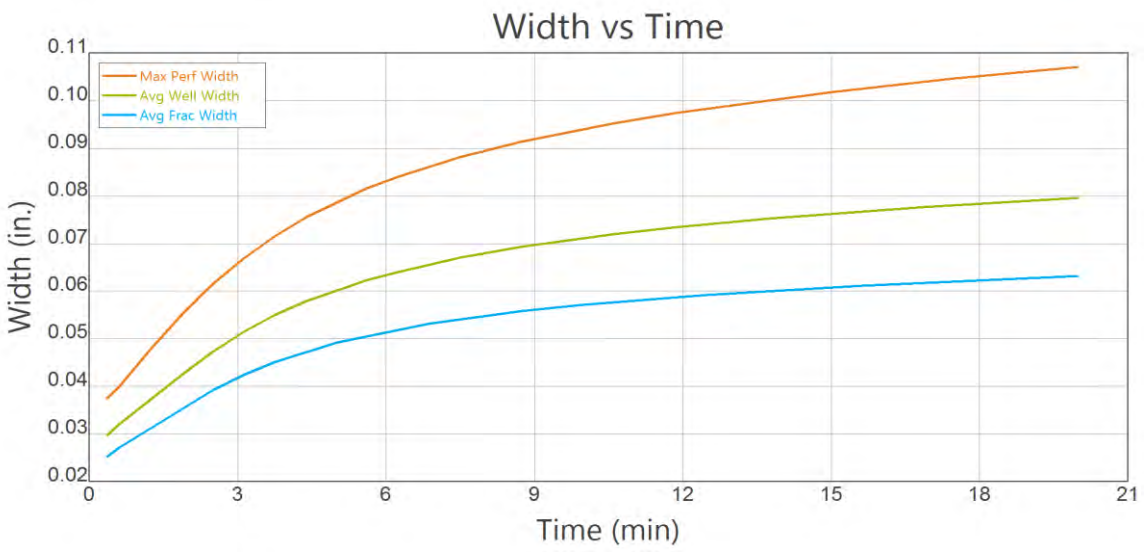


Results – Fracture Height Vs Time

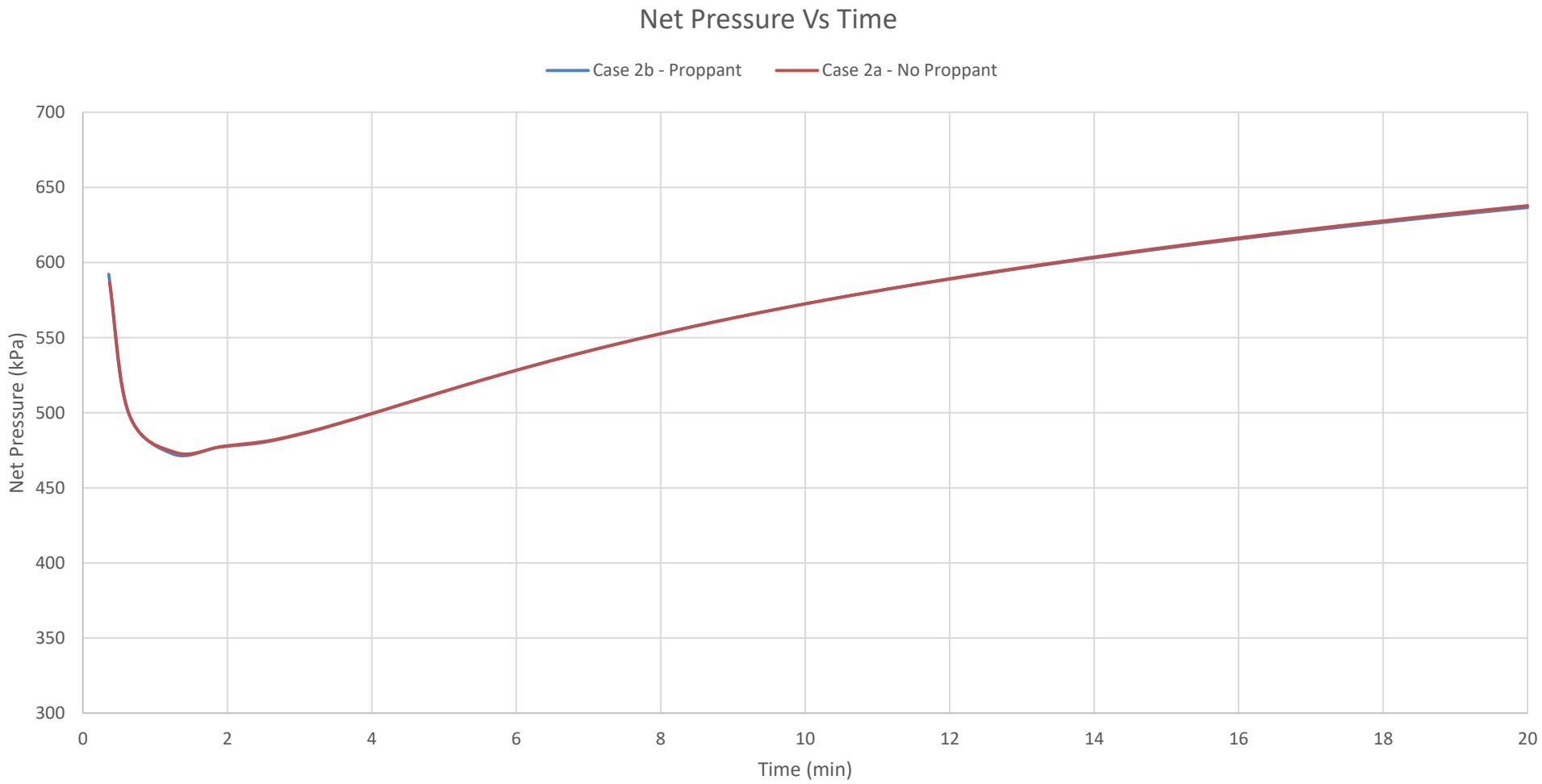
Case 2a – No Proppant



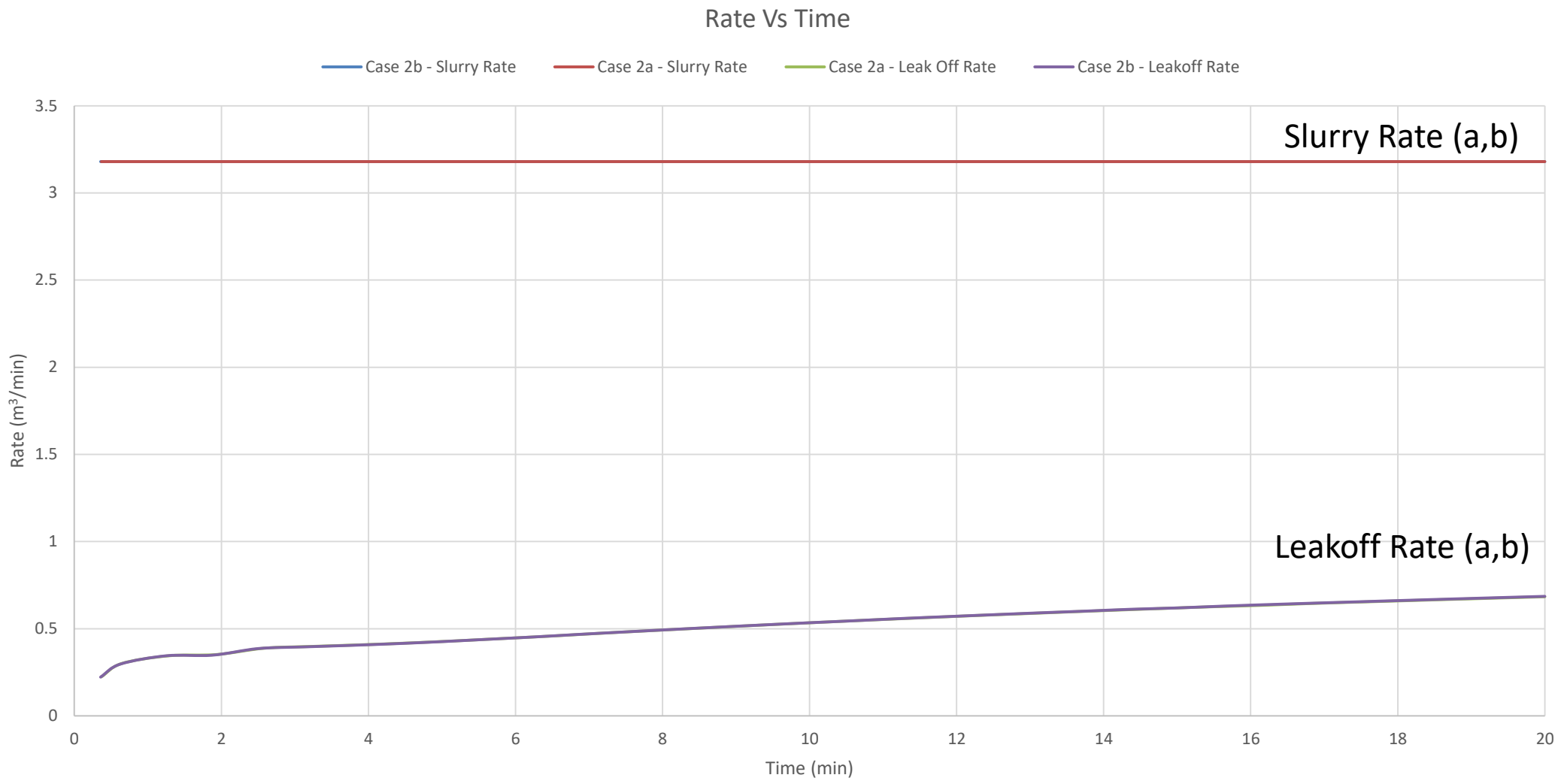
Case 2b- With 2ppa Proppant



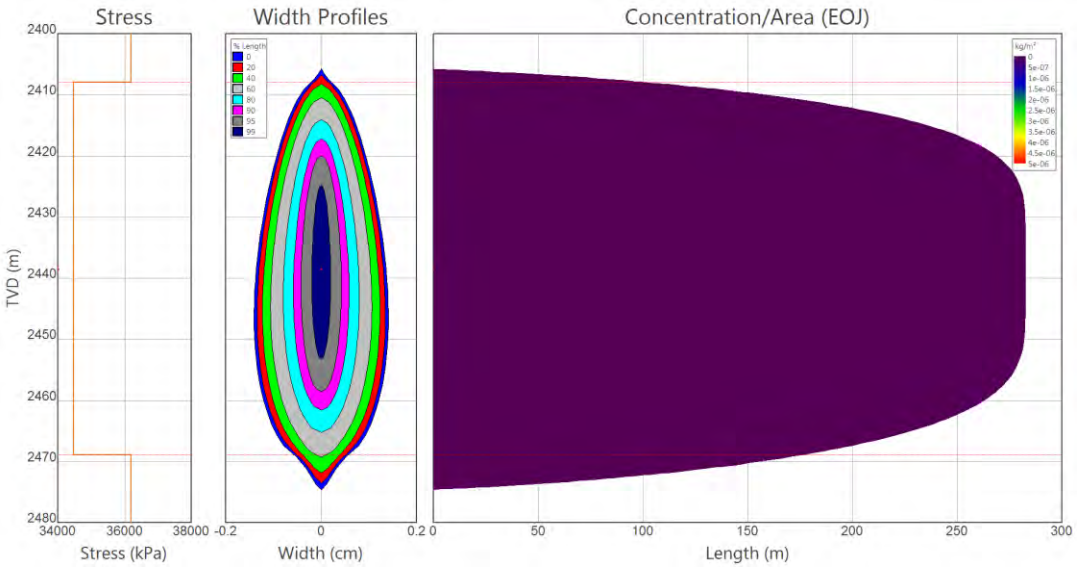
Results – Net Pressure Vs. Time



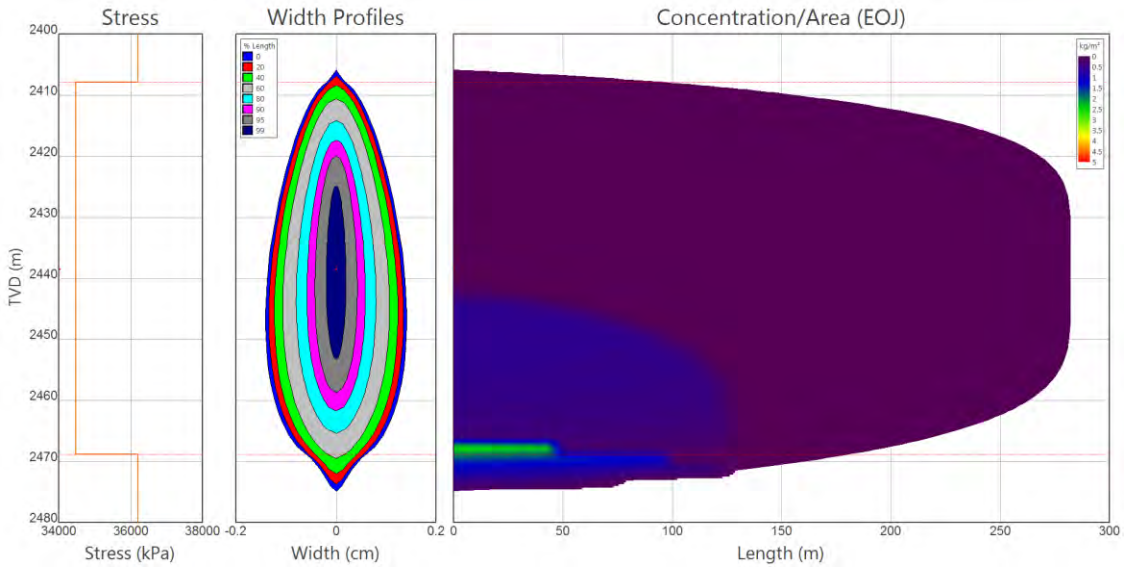
Results – Leakoff Rate Vs. Time



Results – Proppant Distribution



Case 2a – No Proppant



Case 2b- With 2ppa Proppant

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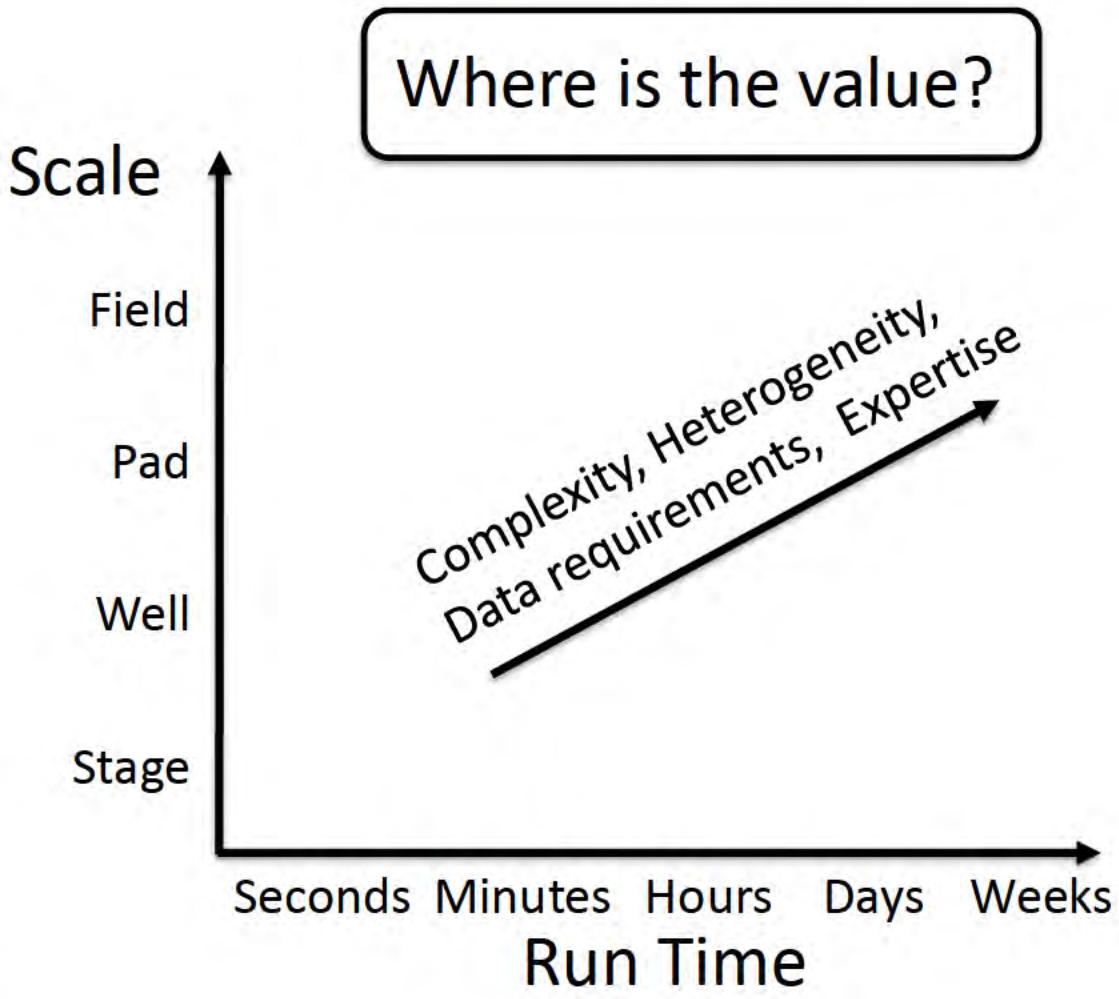
HF Modeling Value & Complexity Spectrum



- Modeling
  - Reduction of reality to the essential components
  - Not more and not less
  - If in doubt, make educated decision (aka. modelers choice)
- Choice of Model
  - The right tool for the job
  - Which model do I need?
  - What do I need to model?
- Purpose of stimulation modeling?
  - What answer can a model provide?
  - What answer do we need from a model?

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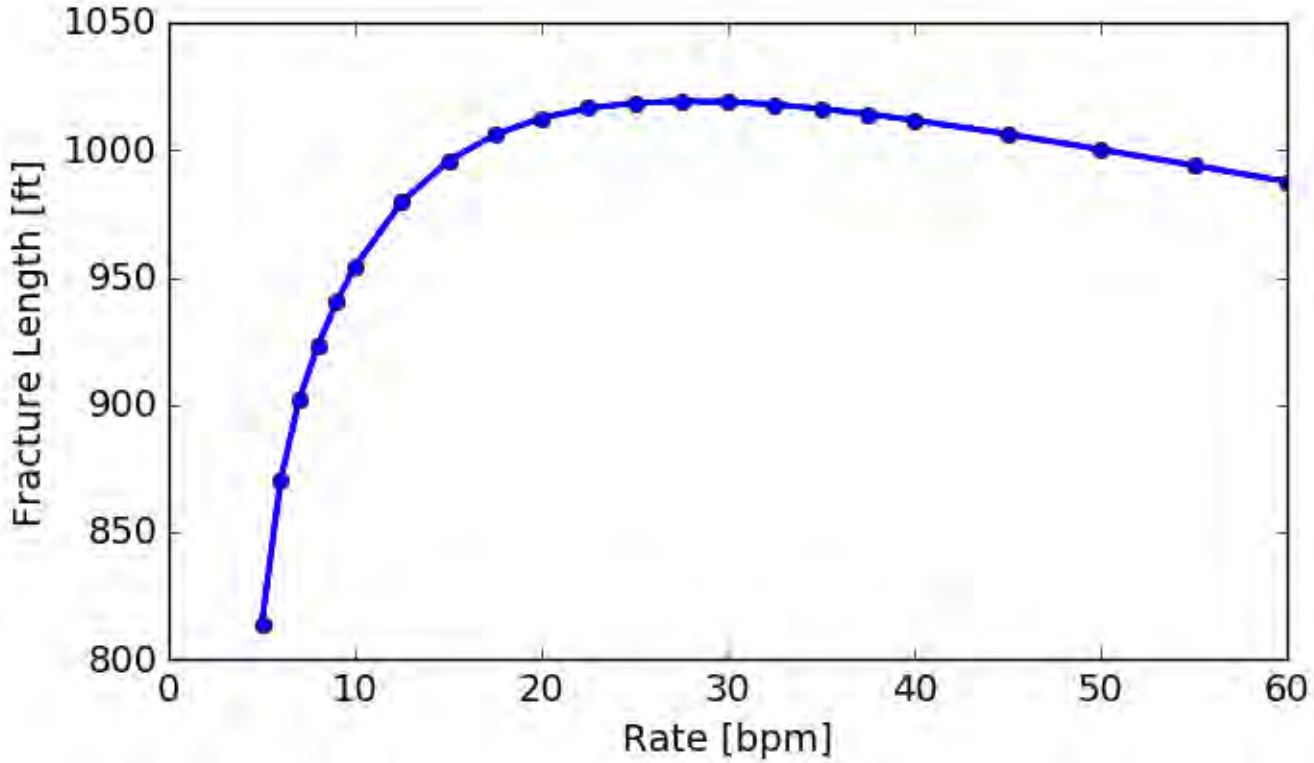
Extra Slide – Optimization with MFrac Engine

- Decoupled MFrac Engine allows for quick optimization studies
  - e.g., answer *What is the optimum rate to maximize fracture length?* in under 30 seconds!



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