Are All Those Bad Things They're Saying About Our Production Forecasts in Unconventionals True?

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Denver Chapter SPEE

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Do You Enjoy Reading These Headlines?

- **Fracking's Secret Problem – Oil Wells Aren't Producing as Much as Forecast**
  - *Wall Street Journal*, 2 January 2019
- **Shale Companies, Adding Ever More Wells, Threaten Future of U.S. Oil Boom**
  - *Wall Street Journal*, 3 March 2019
- **Shareholders Have No Love for Shale Companies**
  - Investors are down on fracking firms, even as the companies pump record volumes of oil and gas
  - *Wall Street Journal*, 13 August 2019

What's the Problem?

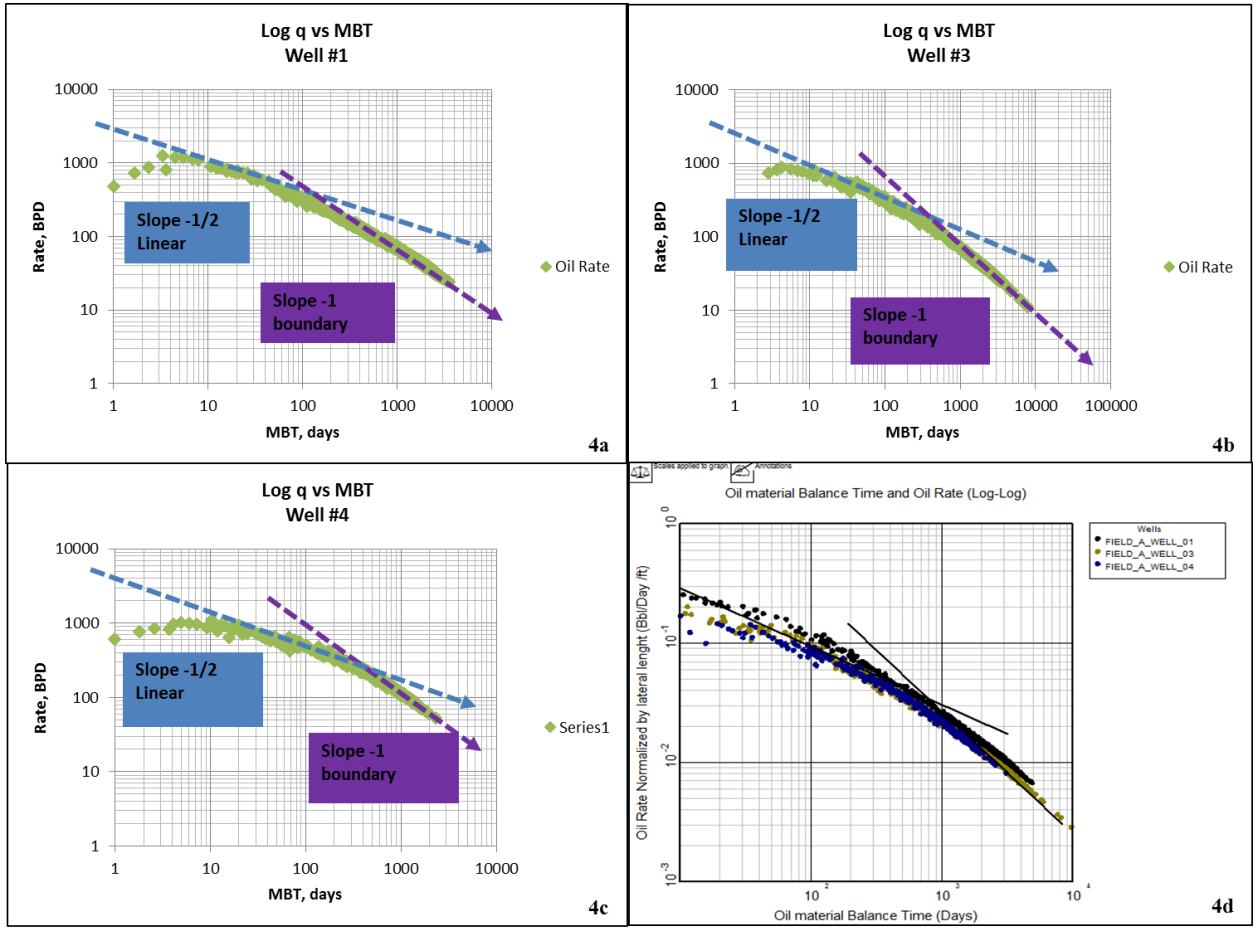
Major sources of discrepancies named in articles, studies

- Typical well production profiles ('type wells' or 'type curves'), based on averages of production profiles of existing wells, tend to be overly optimistic
- Forecasting procedures used with decline curves optimistic
  - Arps 'b' factors optimistic (too high) during early (transient) flow
  - "Terminal decline rates" too low
- "Parent, child" well relationships (particularly EURs in infill or closely spaced wells) improperly and optimistically forecasted
  - Wells generally interfered with one another more than forecasted

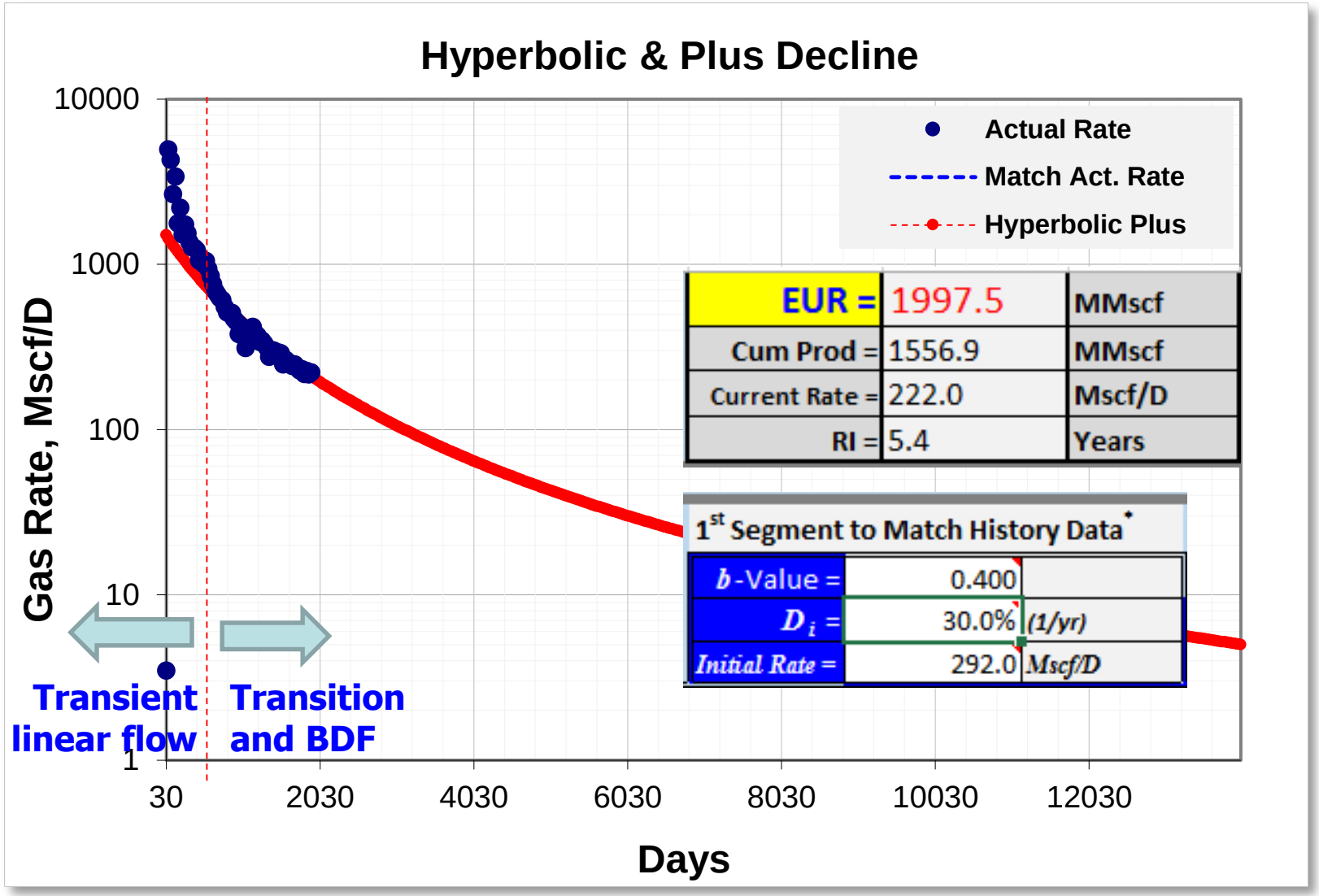
What Can We Do to Improve Decline Curve Forecasts?

- Identify flow regimes, treat each separately with its own unique Arps “b-factor” or equivalent
- Be more realistic about decline rate at which early transient flow regime ends, some interference between fractures begins

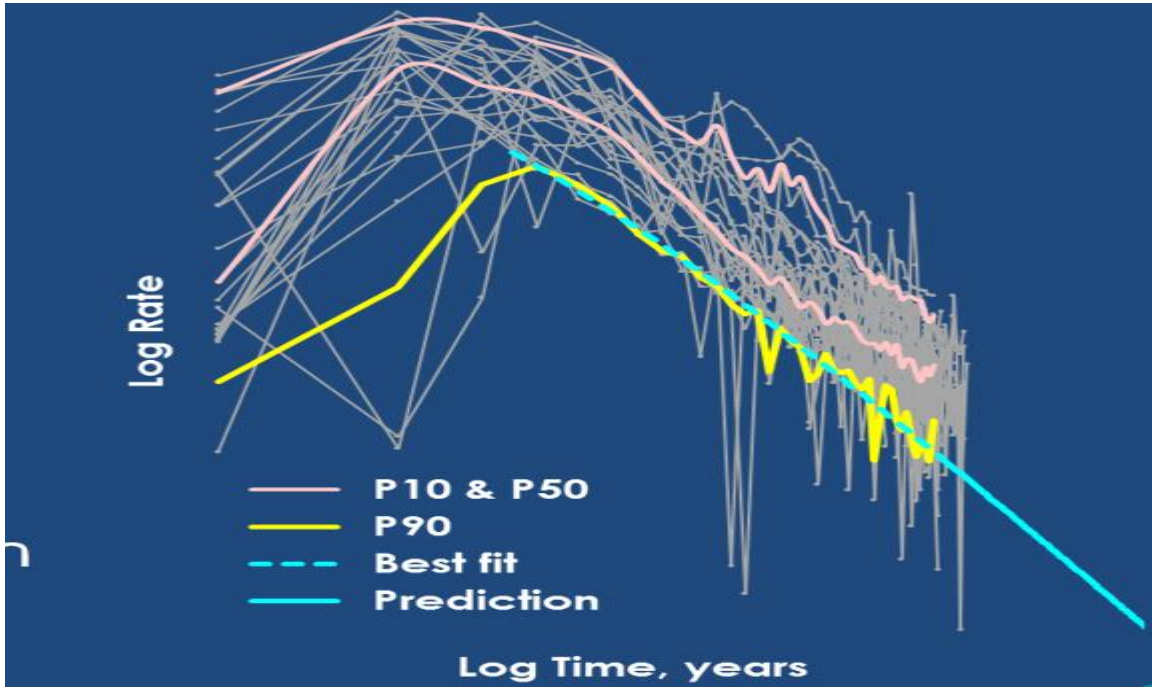
Diagnostic Plots Good Way to Identify Flow Regimes (Examples from Bakken)



Arps Hyperbolic Model Fitted with BDF Data Only for Forecasting



And What's the Problem with Type Well Construction? Don't We Just Average Production Profiles?

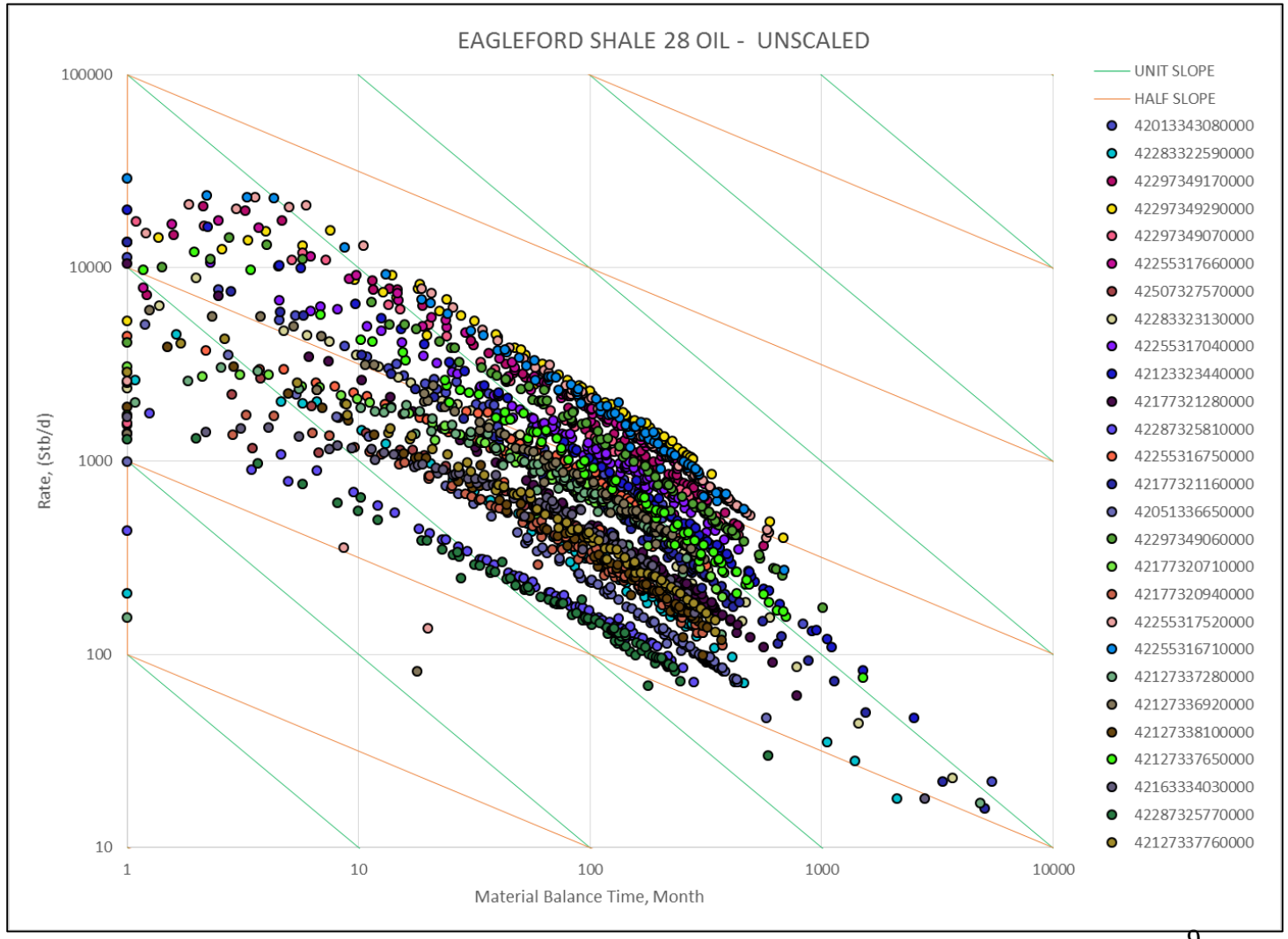


R. Freeborn, SPE Distinguished Lecture 2016-2017

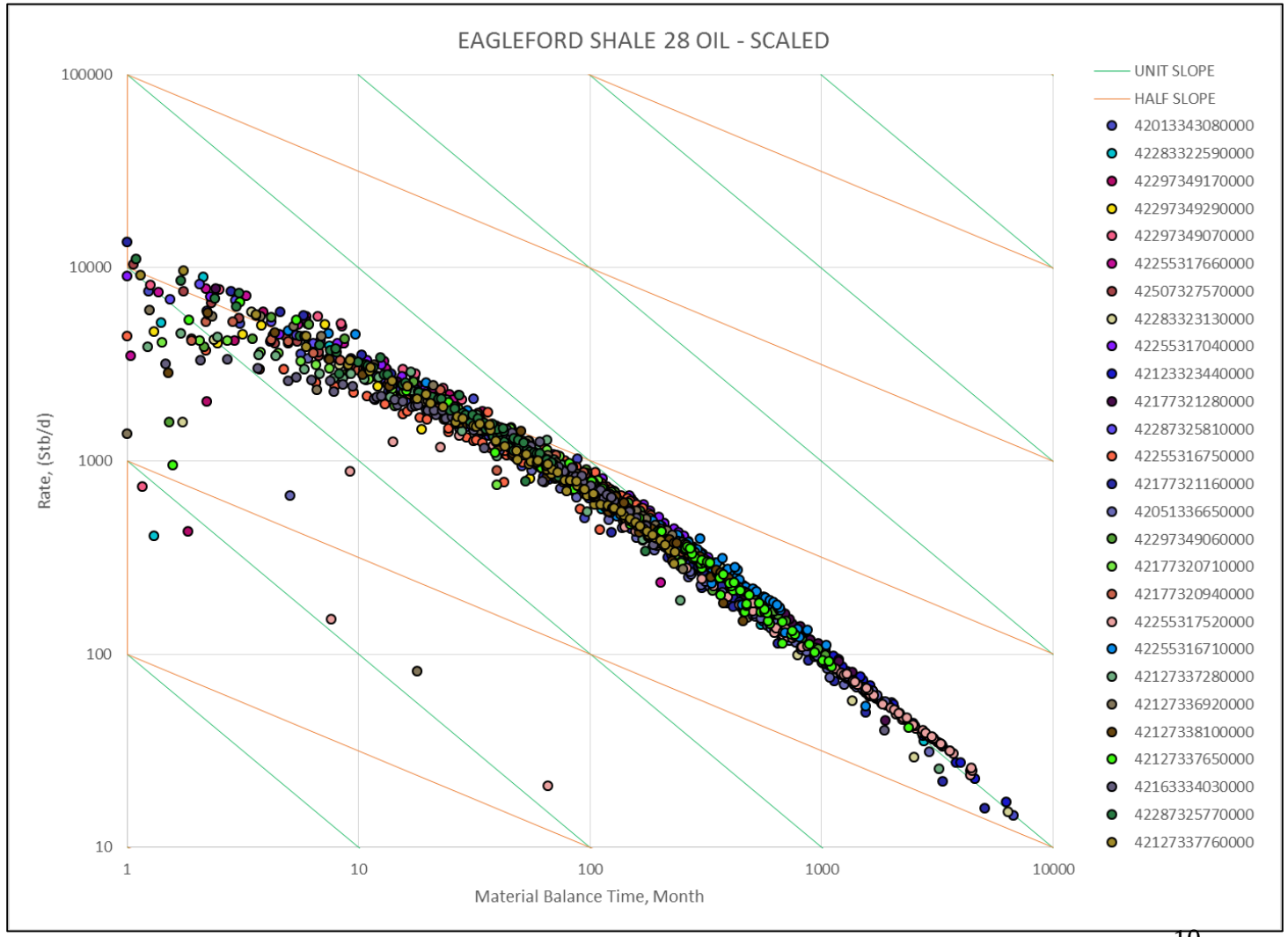
It's Not That Simple: We Can Improve Type Well Construction

- Good practices
  - Place wells with similar decline characteristics into "bins"
    - Maximizing number of wells in bins helps ensure sufficient sample size
  - Scaling to common reference conditions can reduce number of bins – and can avoid mixing "apples and oranges"
  - Avoid survivor bias
    - Maintain original well count to end of type well construction
    - Forecast production to common end of history for wells with short production histories

Example Oil Wells from Eagleford Shale

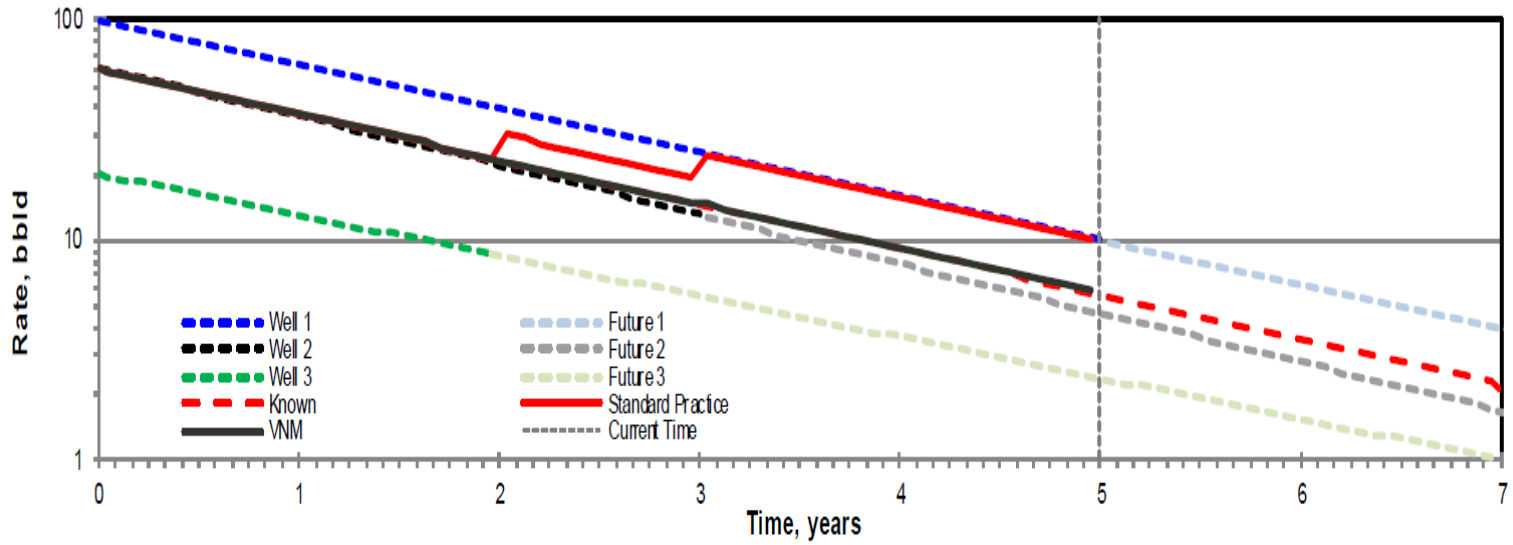


Example Oil Wells from Eagleford Shale



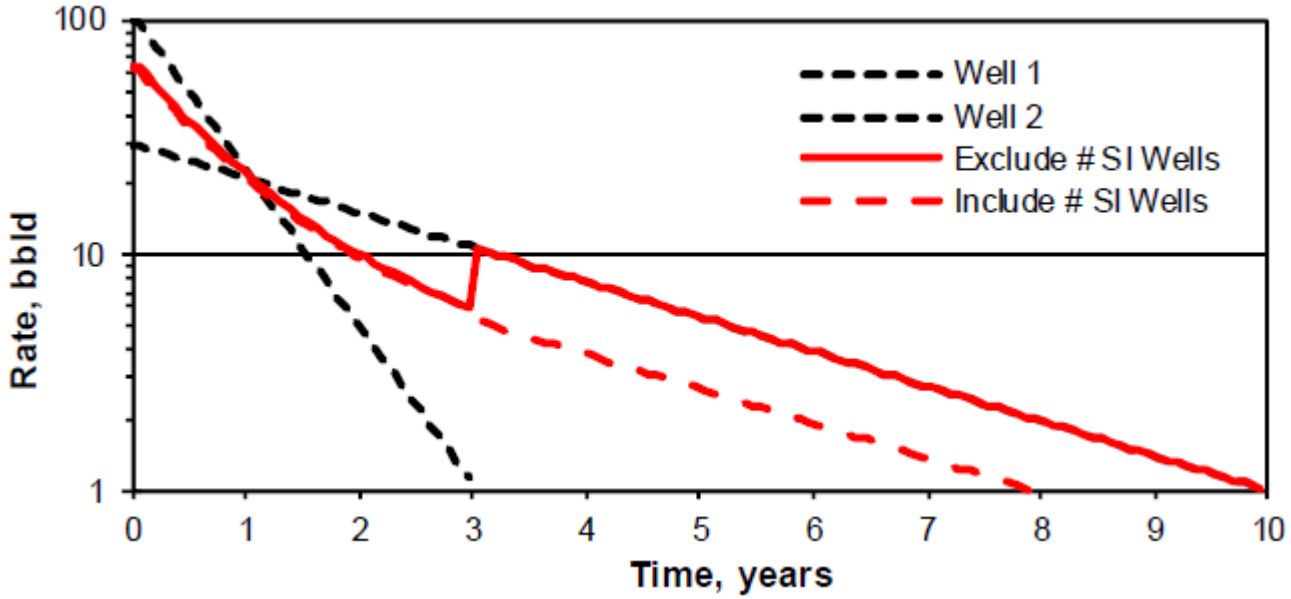
Include Forecasts for Wells with Short Histories? Why?

- Excluding forecasts for wells with short histories ensures bias in type well (***Survivor bias*** – SPE 158867)



What? Include Abandoned Wells in Well Count with Zero Rate?

- Failure to include abandoned wells with zero rate ensures upward bias in type well (SPE 162631 - *survivor bias*)



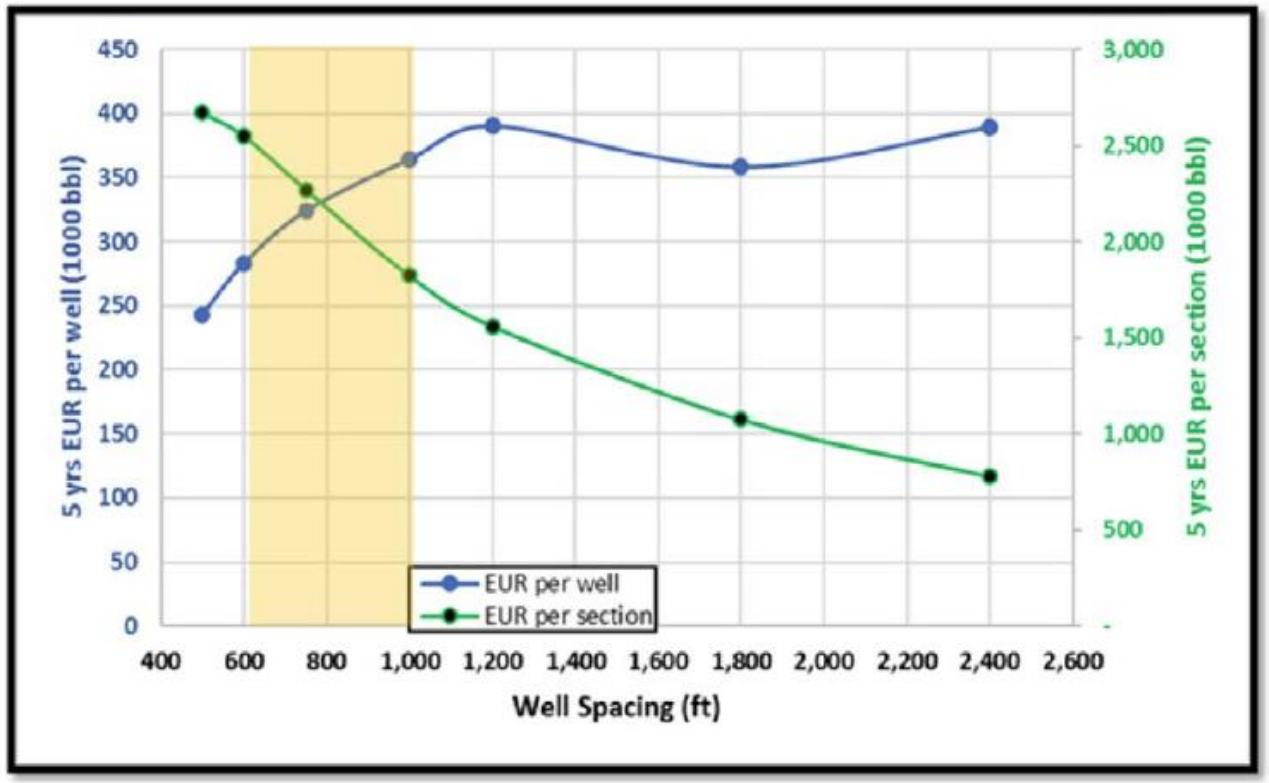
How Can We Model Interference Properly?

- Some interference required to properly drain reservoir
- With no interference, some areas left undrained
- Proper well spacing, fracture length determined by economic analysis
- Modeling with calibrated (history-matched) reservoir simulation good basis for economic analysis
- Infill drilling after long-duration production of parent well leads to frac hits and poor recovery (fractures go to depleted areas rather than undrained areas)

Schlumberger Study in Delaware Basin Provides Insight into Interference

- Study results presented in SPE 191799
- Geomechanical model, dynamic (flow) reservoir simulation coupled
- Fracture patterns for parent, child wells determined
  - Prior to production from parent well
  - After various durations of production from parent well
- Spacing between parent, child wells varied

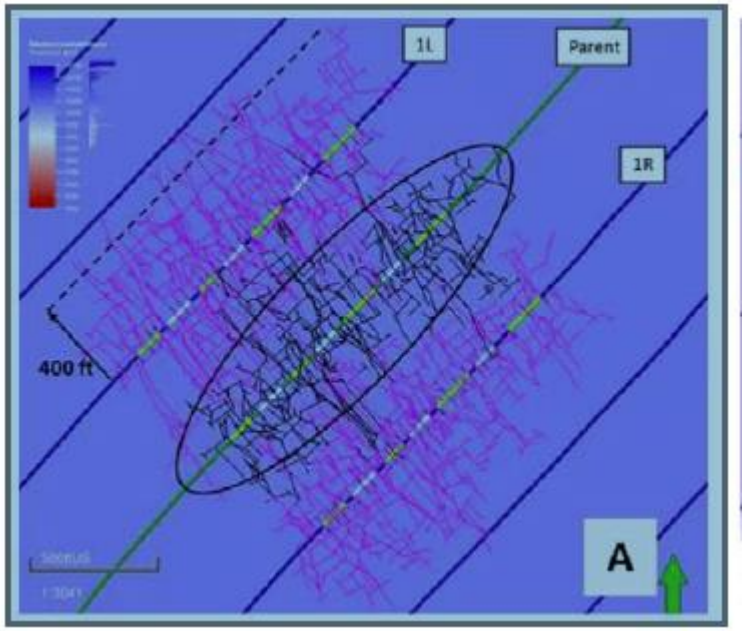
Wider Spacing Increases per Well EUR, But Decreases EUR per Section



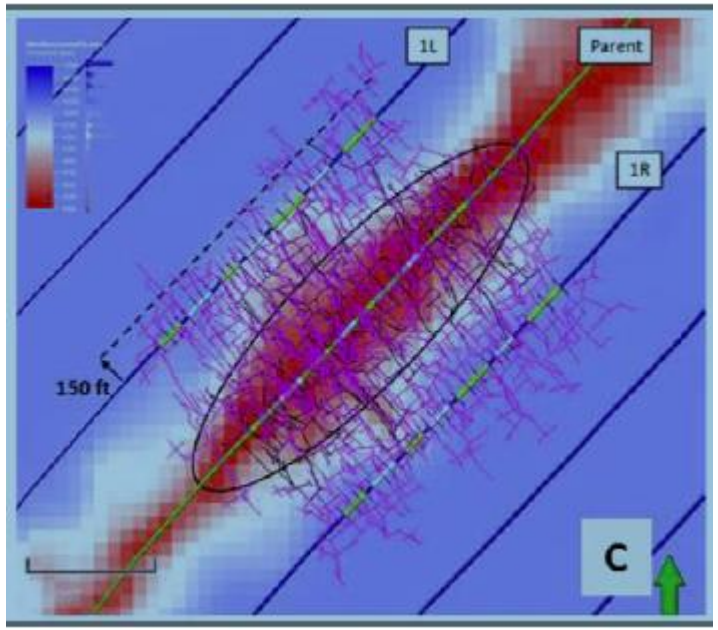
- SPE 191799

Delay in Fracturing Child Well Reduces Drainage Area and Recovery

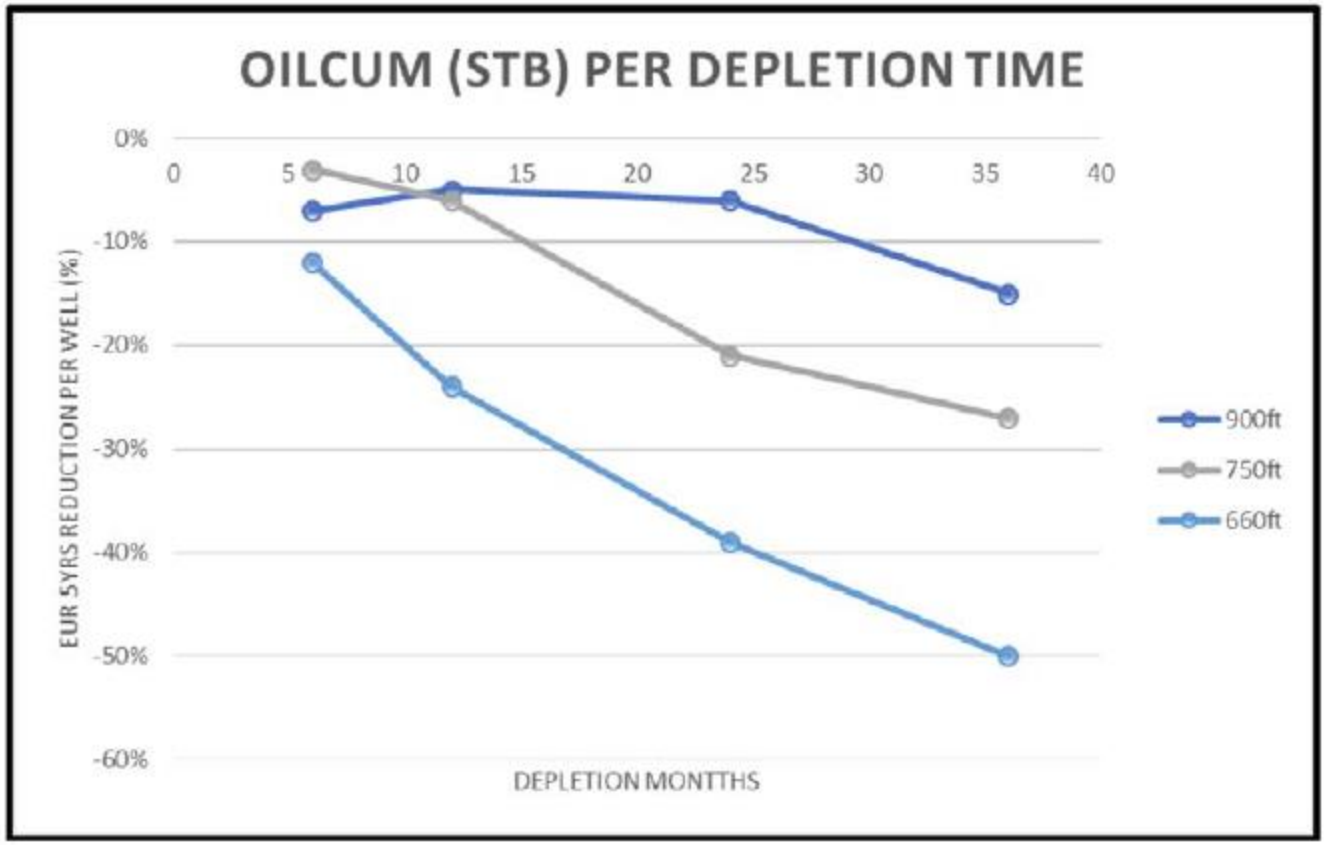
Fracture pattern with no prior production from parent



Fracture pattern with one year of production prior to fracturing child



Longer Production Duration in Parent Well, Closer Well Spacing Reduce Cumulative Oil



Major Conclusions from SLB Study

- Parent-well depletion impacts fracture geometry and future production of child wells
- Wells closer to parent more affected because hydraulic fractures grow preferentially toward adjacent depleted areas
  - At larger well spacing, little impact observed because of limited interference between wells
- Duration of production from parent well strongly affects EUR of child well; limited production duration best choice

Implications of SLB Study

- Tools are available to predict effects of interference between wells at various well spacing, fracture design
- We need to select optimal well spacing in advance, and avoid infilling
- Avoiding interference (almost) completely not good practice, results in relatively lower recovery efficiency
  - Optimal well spacing, fracture design should be based on economic analysis
- Pre-drilling analyses of spacing may be particularly good investments

Summary of Possible Ways to Improve Production Forecasts

- Improve DCA workflow
  - Identify flow regimes, model each separately
  - Include final BDF regime as basis for forecasting (small *b*)
- Improve type well construction workflow
  - Become familiar with good practices – only scratched surface
  - Watch for developments, detail in forthcoming SPEE Monograph 5
- Try to determine optimal well spacing with modeling, validate with production data, base on economic analysis

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