

The Society of Petroleum Evaluation Engineers SPEE Denver Chapter announces its October Luncheon Meeting.

(Members and Guests are cordially invited to attend.)

Wednesday, October 10, 2018

Gary J. Gonzenbach

Principal, CG Petroleum Consulting



Will be speaking on:

SPEE Monograph 5 Update on Type Well Profiles

LUNCHEON STARTS AT 11:30 A.M.

(A plated lunch will be served.)

PRESENTATION BEGINS AT NOON

The Denver Athletic Club

3rd Floor, Petroleum Room

1325 Glenarm Place (14th and Glenarm) Denver CO 80204

Parking flat rate \$7.00 on space available basis

Cost: \$25.00 per person online registration



**Sponsored in part by Quorum Software, creators of
Mosaic, a comprehensive software application for reserves management,
petroleum economics, and decline analysis www.quorumsoftware.com**

Please RSVP by Noon Monday, October 8, 2018

RSVP and simultaneously pay by credit card online at:

<https://secure.spee.org/civicrm/event/info?reset=1&id=195>

If the above link does not work, alternatively go to www.spee.org then select 'Local Chapters', then 'Denver', then 'Register Now'.

Abstract: *SPEE Monograph 5: A Practical Guide to Type Well Profiles* Type wells are one of the most critical tools used in reserve estimation for both conventional and unconventional plays. Yet to date, there are no concise or commonly accepted industry guidelines on the subject. The SPEE Monograph 5 committee has been hard at work exploring the differences in the way Type Well Profiles (aka "Type Curves") are constructed. The Monograph explores the appropriateness of those methods in different situations, and whether or not they adhere to basic reservoir flow principles. The Monograph also seeks understanding (by BOTH developers and consumers) as to the uncertainty of the developed profiles and clarity on the construction methods. This presentation is an update on the status of this project and its critical issues.

Speaker Bio.: **Mr. Gary Gonzenbach** is a registered Petroleum Reservoir Engineer with 30+ years' experience in the industry. His career experience includes acquisition and divestiture, software development, expert witness, third party evaluation reports, senior industry advisor, and unconventional basin studies concentrating in the Delaware, Permian, and Eagle Ford resource plays. Gary has served on panel discussions, has written technical papers on Standardized Reserve Reconciliations and is co-author of *SPEE Monograph 3 Guidelines for the Practical Evaluation of Undeveloped Reserves in Resource Plays*. More recently, Gary is a past president of the Society of Petroleum Evaluation Engineers. He has served many years at the local chapter level offices for both SPE and SPEE. He is the chairman of the SPEE Monograph 5 committee on Type Well Profiles, which will be publishing industry guidelines on Type Well Curve construction and uncertainty. Mr. Gonzenbach is the founder of CG Petroleum Consulting.



About SPEE: <http://www.spee.org> SPEE was formed in 1962 as a professional, non-profit organization bringing together specialists in the evaluation of petroleum and natural gas properties. SPEE continues today to be strongly committed to providing educational and other services to its members and to the oil and gas industry, and to promoting the profession of petroleum evaluation engineering.

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October 10, 2018
SPEE Denver , Colorado

Monograph 5: A Practical Guide to Type Well Profiles

Society of Petroleum Evaluation Engineers

Gary J. Gonzenbach: gary@cgpetroleum.com



SPEE Monograph 5 Committee Members

- Vitaliy Charkovskyy, Ryder Scott Company– Consultant
- Jorge Faz, Occidental Petroleum Corporation- E&P
- Jennifer Fitzgerald, Anadarko Petroleum Corp– E&P
- Randy Freeborn, 3esi Enersight – software
- David Fulford, Apache Corporation – E&P
- *Gary Gonzenbach, CG Petroleum Consulting, PLLC – Consultant
- Russell Hall, Russell K. Hall & Associates, Inc – Consultant
- Steve Hendrickson, Hendrickson Engineering – Consultant
- Dilhan Ilk, Degolyer and MacNaughton - Consultant
- Rick Krenek, Netherland, Sewell & Associates, Inc – Consultant
- John Lee, PHD , Texas A&M University, 3esi Enersight advisor – Academic
- Rod Sidle, 3esi Enersight advisor – Consultant
- John Wright, Wright Consulting Company – Consultant

SPEE Monograph 5 Committee - Disclaimer



Opinions are not final!



Audience

Consumers (Investors, Banks)

Producers (Consultants, E&P)

Software Vendors



Reaches Final Publication in 2020



Needs more non-public Data!!

Definition

Type Well Profiles (TWP)

method for constructing either (1) the "average well" performance or (2) the "average monthly" performance in a developmental program over time

Results can be directly applied to Cash Flow Analysis

Not

Type Well Curves

such as methods for analyzing pressure drawdown (flow) and buildup tests, diffusivity equation

Why Type Well Profiles?

- Forecasts of New Wells with Limited History
- Forecasts of Undrilled Wells
- Development Planning
- Unconventional and Conventional

What is the Committee trying to Accomplish?

- Establish **Practical** Industry Guidance
Adherence to Fluid Flow Principles
 - Methods of Construction
 - Public Data vs Proprietary Data
 - Fit for Purpose
 - Analogous Bin Selection
 - Survivor Bias
 - Scaling
 - Validation of Results
 - Communication of Uncertainty

Methodology



CREATE A **PRACTICAL**,
WORKING OUTLINE



PICK DIFFERENT AREAS AND
APPLY



SEE WHAT WORKS AND
RECORD OBSERVATIONS, ANY
CHANGES TO OUTLINE
METHODOLOGY



FEEDBACK AND SUGGESTIONS
FROM INDUSTRY PEERS
ALONG THE WAY



COORDINATE WITH OTHER
INDUSTRY GROUPS

Before you start

- What's the Purpose?
- Is it Multi-phase?
- Do you understand the geology?
- **Data, data, data !**
 - How will you bin?
 - How will you scale?
 - How will you accumulate and update data in the process?
 - Do you have enough samples?

Focus Area 1

Permian Basin

(Howard Co)

- **Analogous Data Sets** are difficult to find
 - Multiple Benches (Wolfcamp A)
 - Completion differences
 - Small data sets
- **Multiphase, primarily oil**
- **Flow Regime Information** is limited
 - No frac spacing information
 - No perm information
 - No daily data
 - Limited pressure data
 - Very short linear flow period
 - Most data exists in BIF (Boundary Influenced Flow)
 - Some BDF (Boundary Dominated Flow)
- **Validation of Results**
 - Not enough history to hindcast

Focus Area 2 Barnet Shale (Johnson Co)

- **Dry Gas Window** (Lower Barnett)
 - Large Data Set
 - Single Phase
- **Historical Data**
 - Publicly available Monthly data, no daily
 - Assumed Constant Pressure
 - Oldest wells drilled in 2007
 - Field wide event that changed performance
- **Established Diagnostic Techniques**
 - Long period of linear flow
 - Short Transient period
 - Boundary Dominated Flow, maybe
- **Straightforward Validation**
 - Enough history to validate results with hindcasting

Other Focus Areas

Montney

Niobrara
(Codell)

TWP Construction 1

Iterative Selection

- **Well selection (bins)**
 - Geologic area, formation, permeability, height
 - Well type, lateral length, spacing between clusters, landing depth, number of stages
 - Multi-phase, flow regime
 - Vintage, Proppant, Frac Fluids
 - Months of history, interference, allocated data
- **Forecast Focus and surrounding wells**
 - *First pass can be normalized forecast of sum if needed for familiarity*
 - Individual well forecasted to Technical EUR
 - Eliminate Survivor Bias
- **Verification**
 - Examine P10/P90 ratios, EUR Distribution
 - Look for Outliers and why
 - Spatial analysis
 - Sample Size
- **Rinse and Repeat**
 - Re-bin

TWP Construction 2

Application

- **Scaling**
 - Lateral length, kH, proppant
- **Fitness Metrics**
 - Discounted Volume
- **Uncertainty**
 - Probability of Outcome
 - Commerciality
 - Success / Fail decision tree
- **Communication of purpose**

Type Well Profiles - Fluid Flow Principles

Flow Regime Theory

*from Monograph 4,
describing multi-fractured
horz wells*

- **Transient Linear Flow**
• (until fracture interference, $b=2$)
- **Boundary Influenced Flow**
• (BDF of Stimulated Reservoir Volume $b < 1$, Linear beyond SRV $b=2$)
- **Boundary Dominated Flow**
($b < 1$)

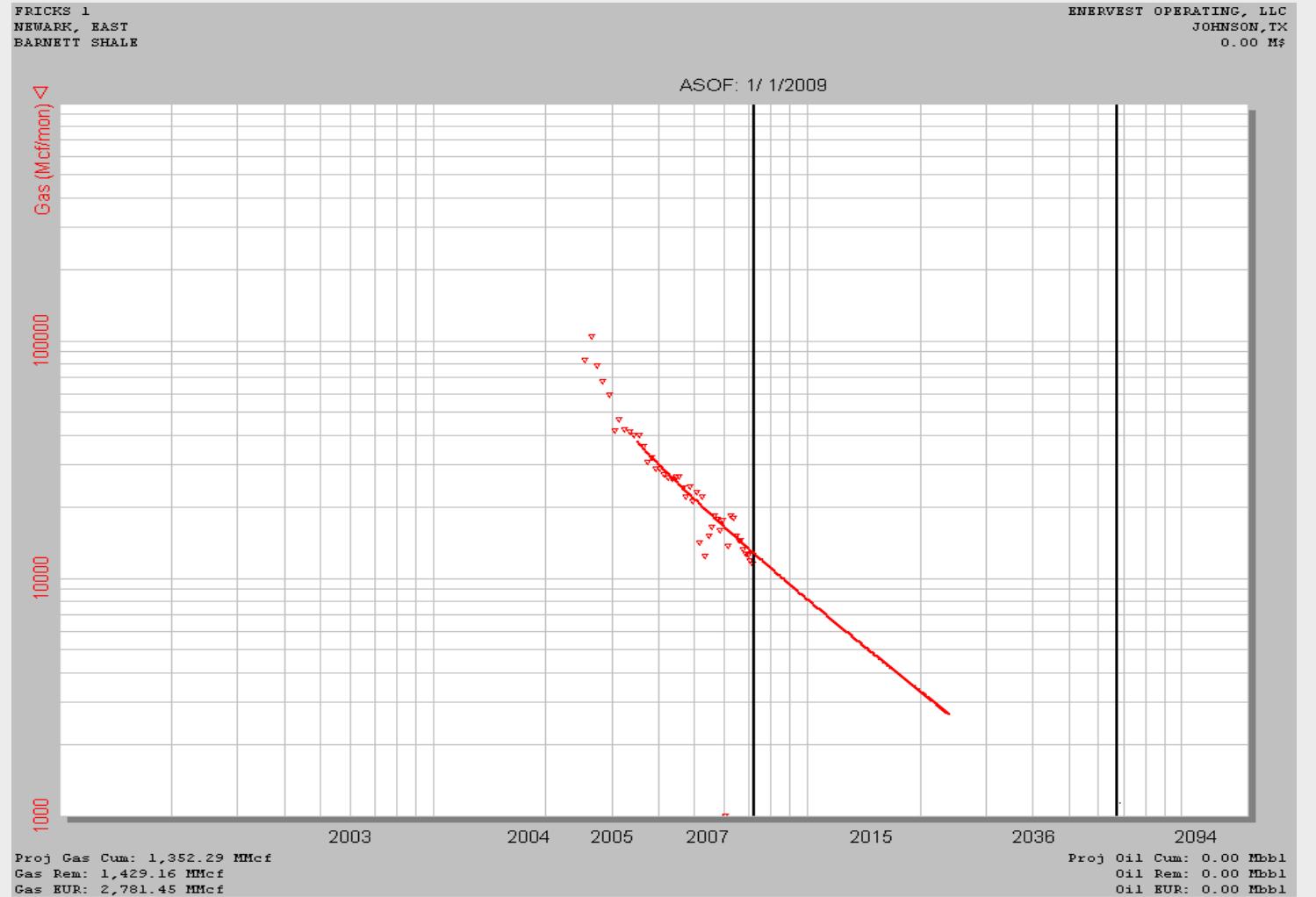
Goals:

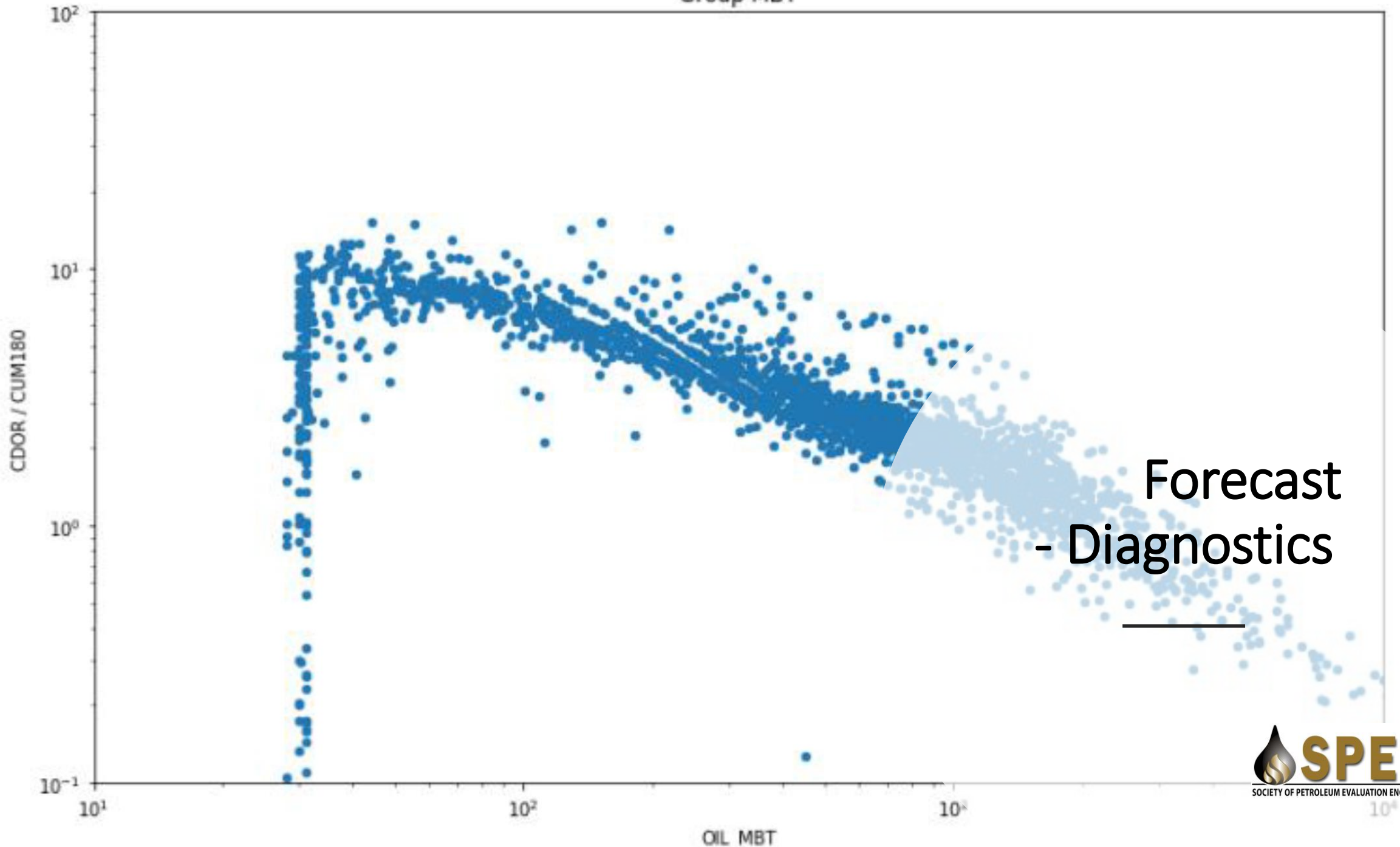
- **Establish Start of Boundary Influenced Flow**
- **Establish Decline rate and B**

Flow Regime Identification

- Diagnostic Methods
 - Pressure normalized $\text{Log}(q)$ versus $\text{Log}(\text{MBT})$ sometimes effective
 - Absence of Daily Data makes it difficult to pick unique half-slope and unity slope solutions
 - Absence of Pressure data for rate normalization can make for misleading interpretation
 - $\text{Log}(q)$ versus $\text{Log}(t)$ Plots
 - assumes constant pressure, single phase
 - Workable with monthly data
 - GOR change method in multi-phase environment (based on some observations):
 - During Linear flow, if Flowing pressure is constant, GOR is constant
 - GOR starts to increase under Boundary Influenced Flow

Flow Regime Identification Log(q) versus Log(t)





Forecast
- Diagnostics

Practical Decline Models

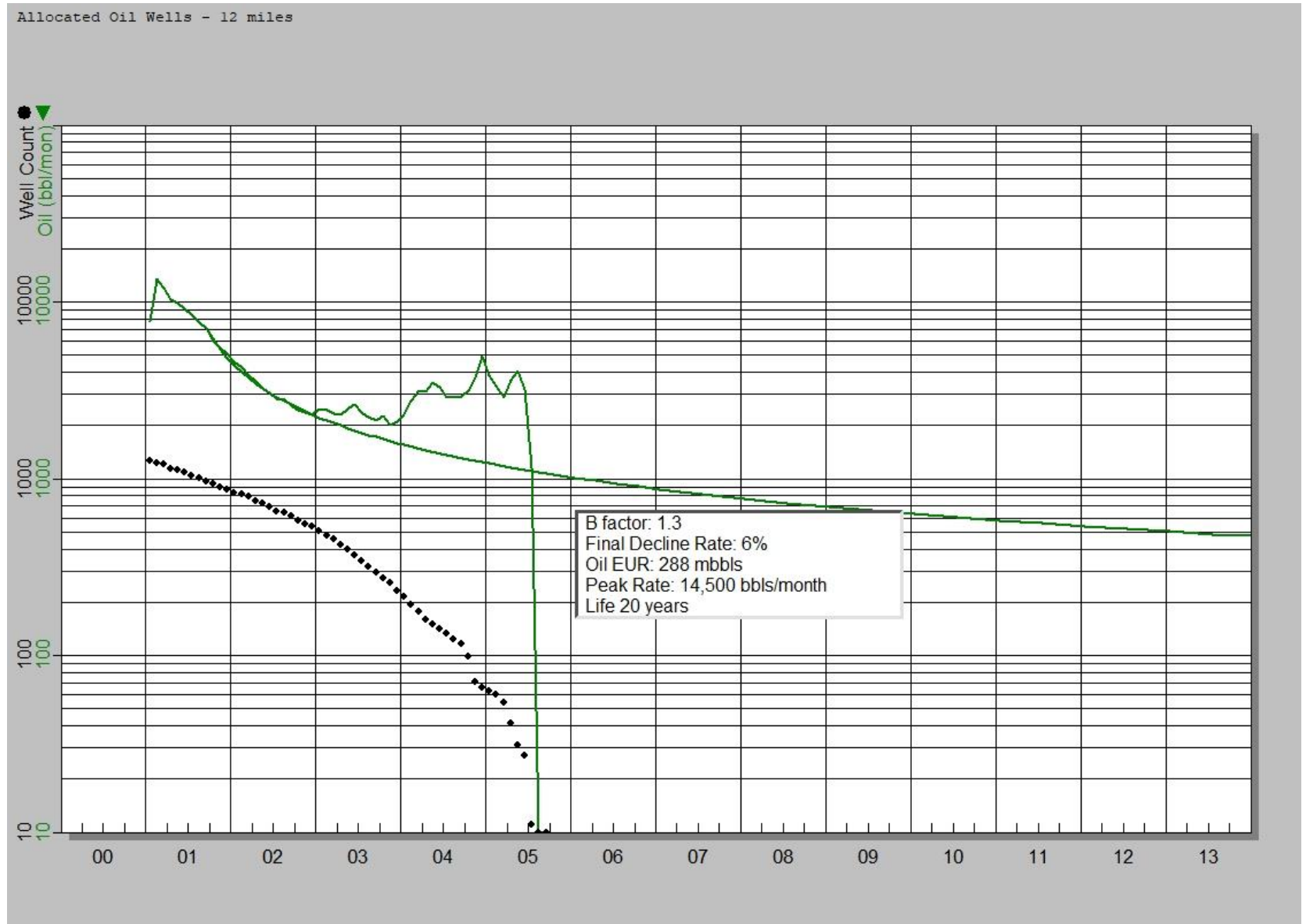
- **Single Segment Arps** – *intended for BDF only, difficult or impossible to fit multiple flow regimes and usually overstates reserves*
- **Two Segment Arps** – *Linear & BIF, or BIF and BDF flow regimes*
 - Two different B Factors
 - Need to determine end of Linear Flow
- **Three Segment Arps** – *Linear, BIF, and BDF flow*
 - Three different B Factors
 - Determination of the end of Linear flow
 - Determination of the end of Boundary Influenced flow

**Survivor
Bias** - *declining
well count, no
individual
forecast*

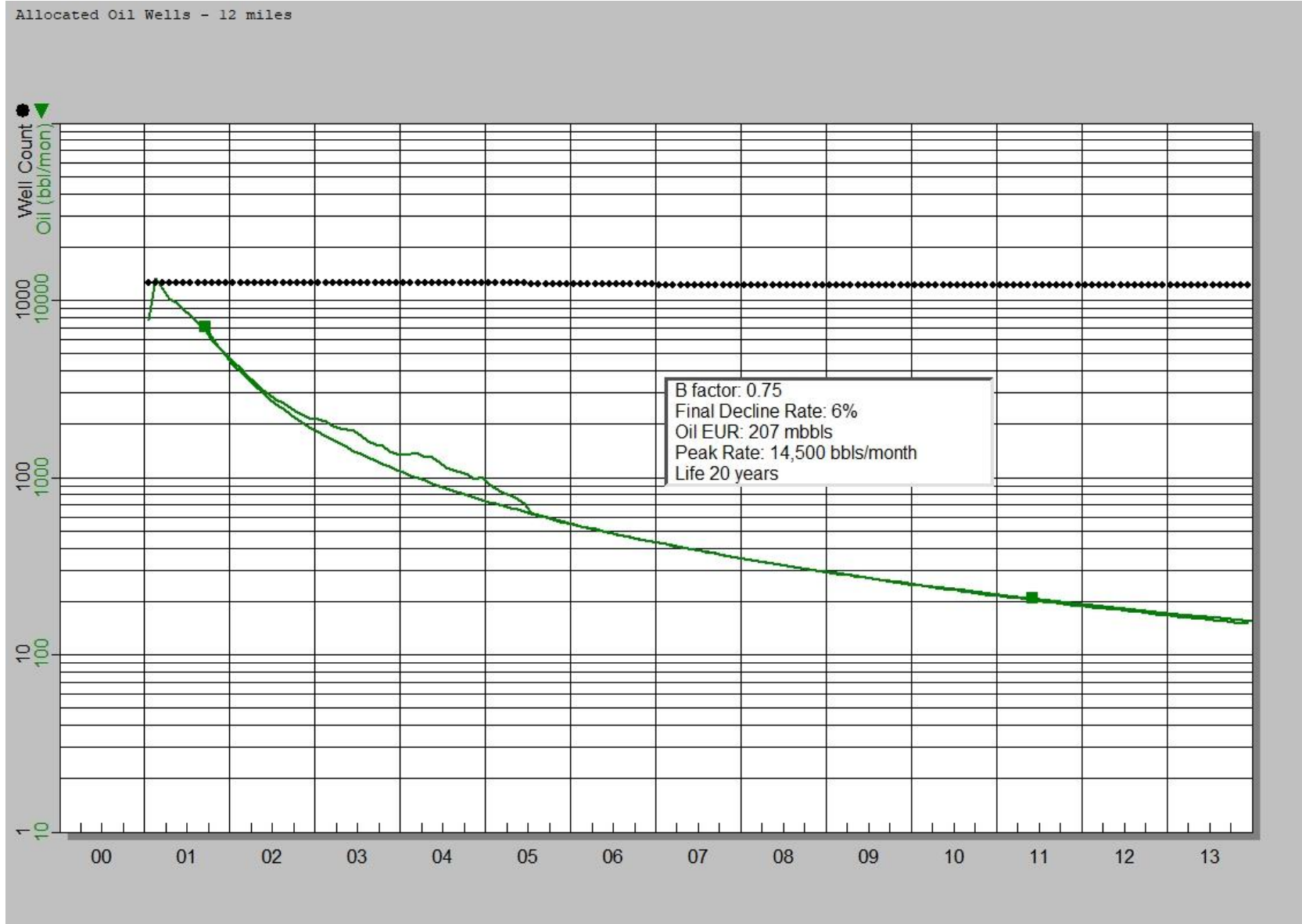
Tendency to bias towards the longest surviving wells when averaging production

- Forecast all wells individually first
- Separate TWP by Vintage if you see a performance trend
- Divide by a constant well count (even as wells go off-line)

Survivor
Bias - declining
well count, no
individual
forecast



Survivor Bias - constant well count, individual forecasts

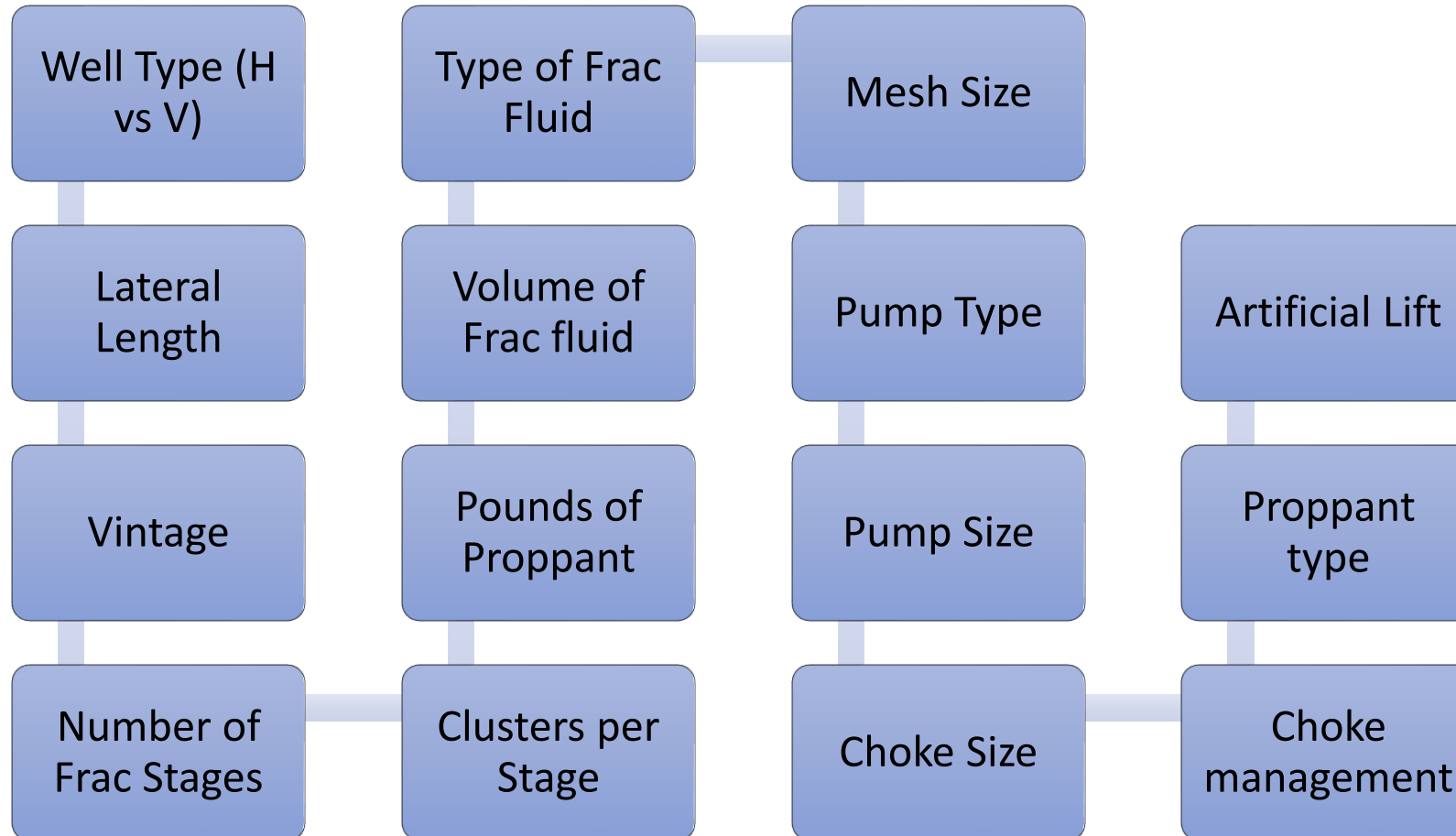


Binning

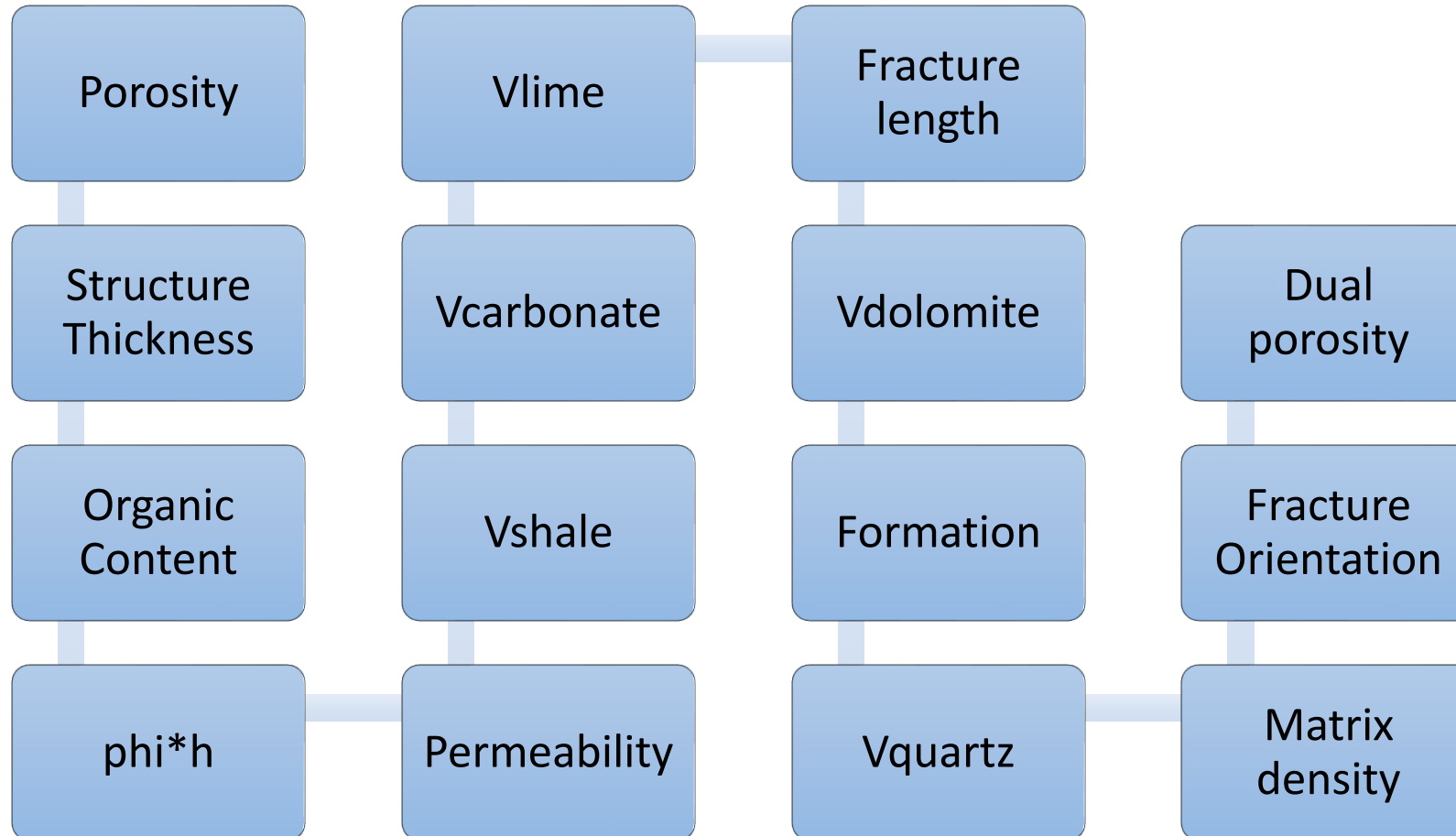
Grouping wells into analogous categories so that a TWP is meaningful and predictive, while keeping the number of samples per bin statistically meaningful

- Multi-variate
 - Separate into regions of significant differences
- Correlate
 - Variables which show definite influence on performance results
- Anomalies may shed most light on differentiators

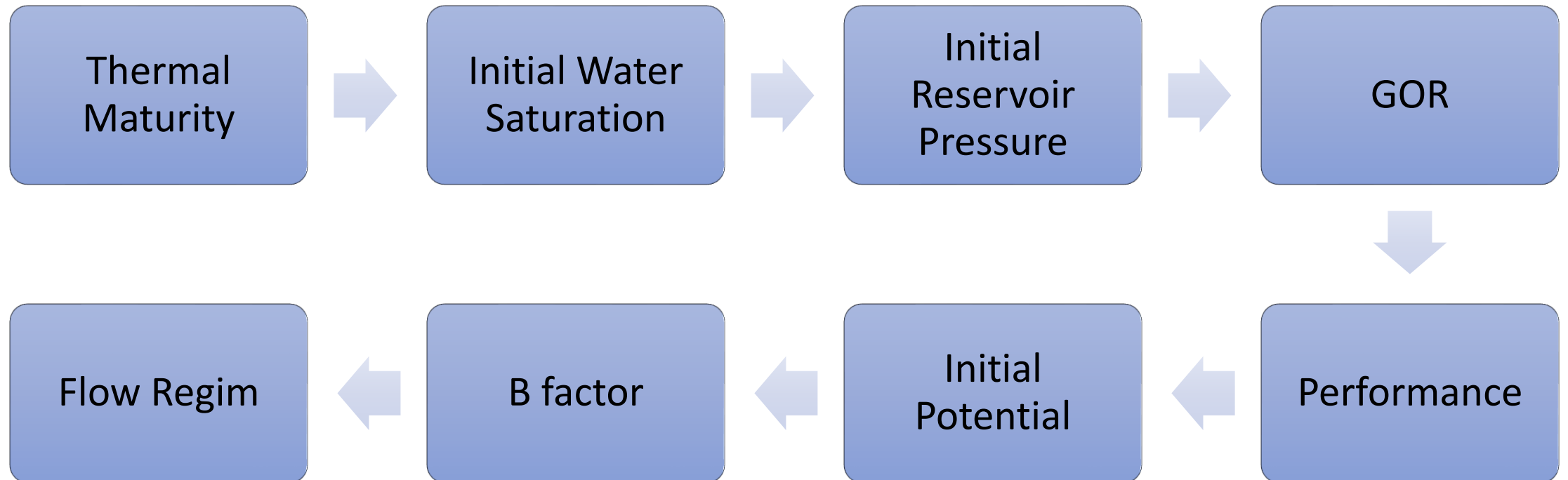
Binning – Completion Differences



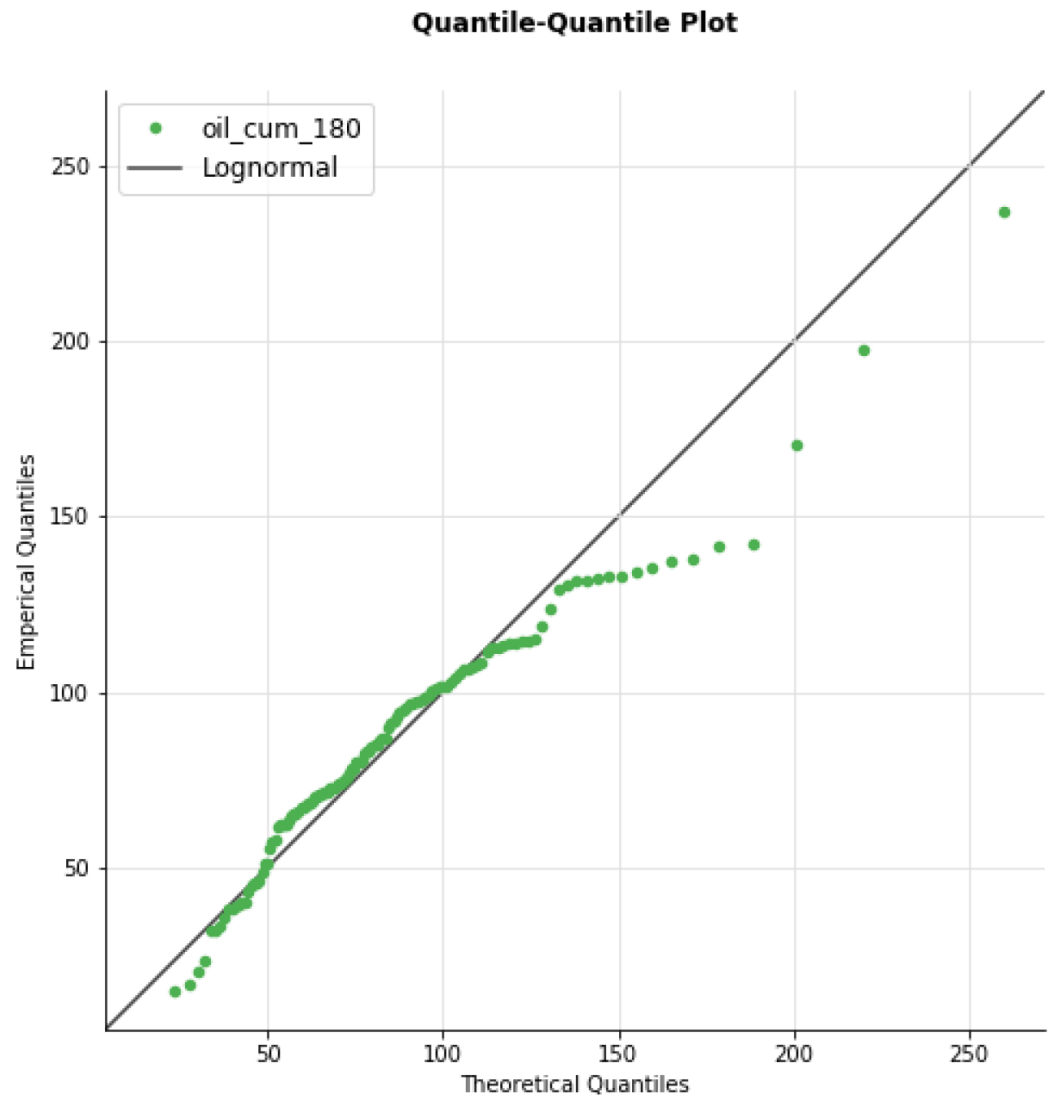
Binning – Geologic Differences



Binning – Reservoir Differences

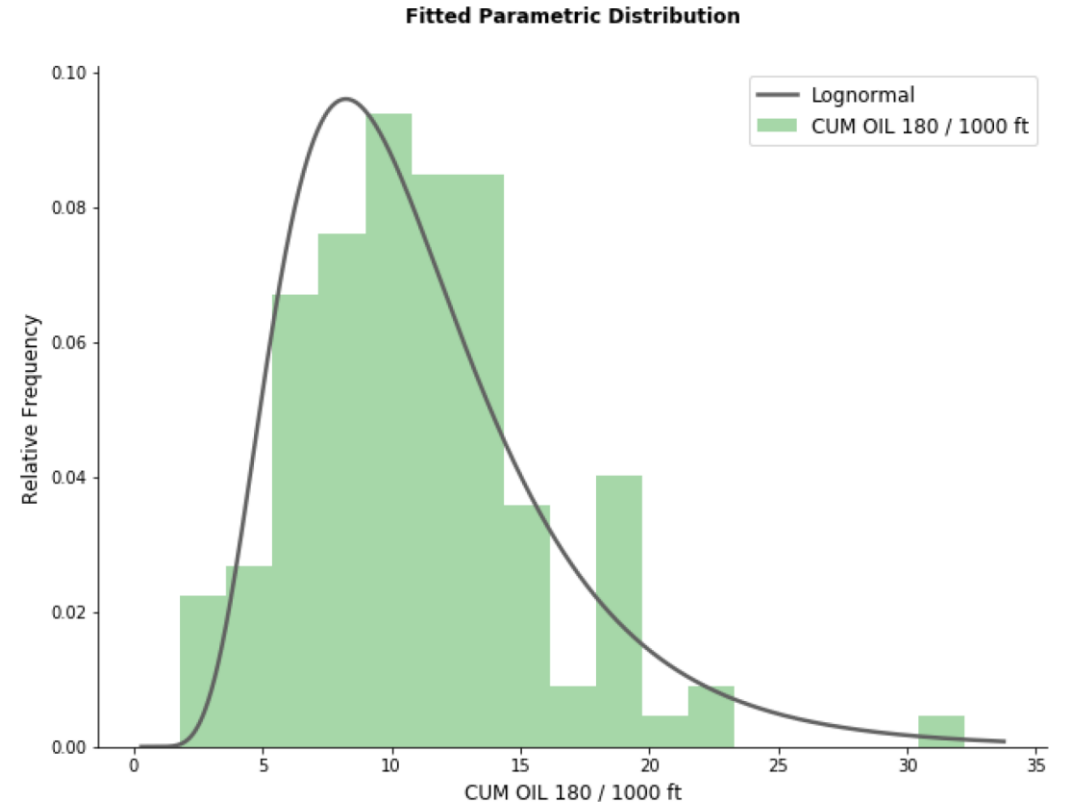


Bins - Distribution

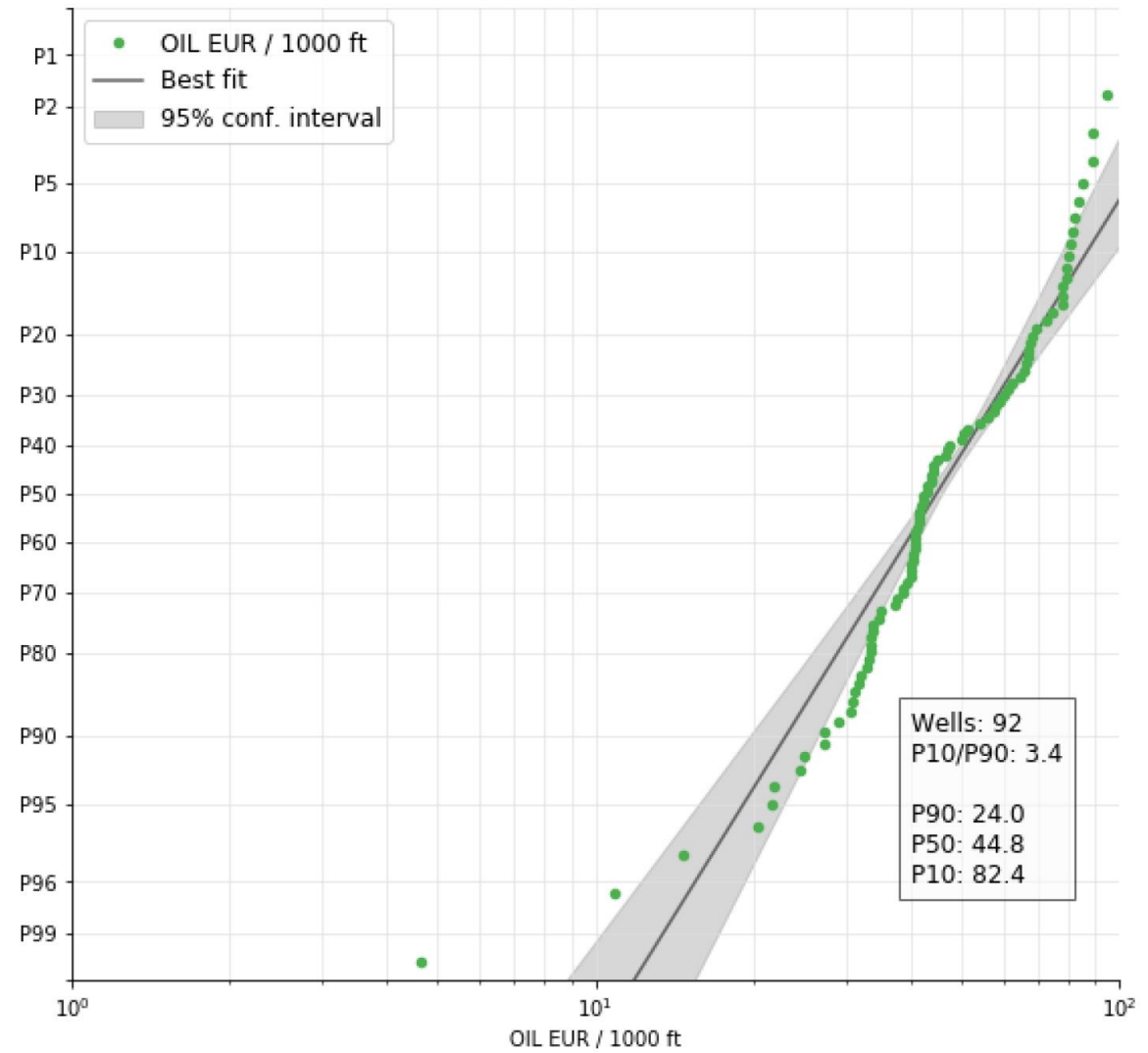


Bins - Distribution

Simple scaling to a lateral length



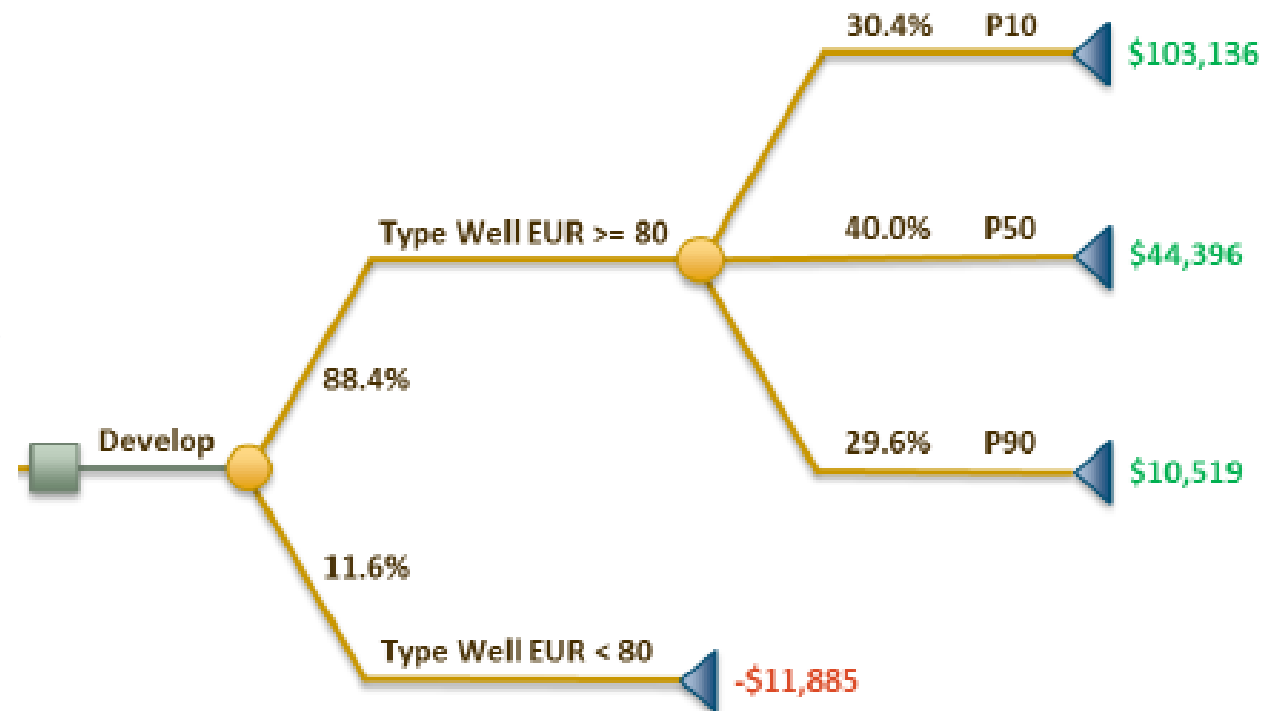
Bins
- EUR / 1000'
Probit



Scaling – Tradeoff versus Bin Size

- Scaling
 - Establish Correlations
 - IP versus Lateral Length
 - EUR versus Lateral Length
 - Note Decline rate and Q_i are both changing
 - Note that EUR per foot decreases with increasing length
- Possible new techniques on scaling to curve shape using permeability and calculated fracture half-length

Commerciality – Risky Probability of Success



*SPE 179996 -(David S. Fulford) – Unconventional Risk and Uncertainty:
Show Me What Success Looks Like

Uncertainty



Sources of Uncertainty

Uncertainty of the Individual Forecasts

clean data

sufficient history

Is Sample set “truly” analogous

Is Sample set large enough for high statistical confidence



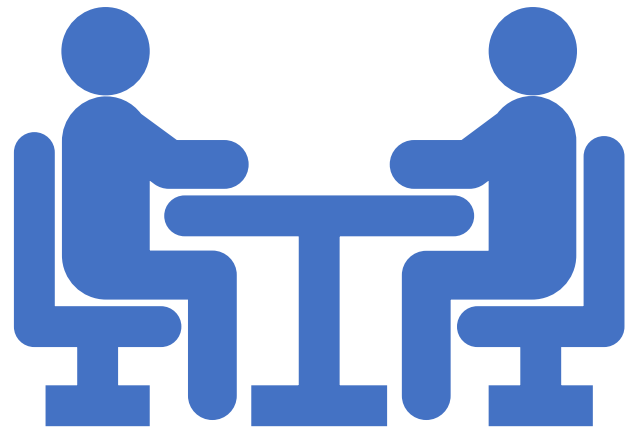
Clarity of Purpose

Analogy of input area wells to intended use area

For single well or developmental program



The level of Uncertainty does not preclude the use of a TWP or not, what is important is that the Level of Uncertainty is adequately communicated from the producer to the consumer.



Closing

Monograph 5 is a work in progress. If you would like to contribute comments, suggestions, ideas, or data, please contact me at

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Thank you!