RYDER SCOTT

# 21st ANNUAL RESERVES CONFERENCE

SEPTEMBER 25, 2025

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Jennifer Fitzgerald is Vice President, Reserves Oil and Gas at Occidental Petroleum, overseeing SEC-compliant reserve estimates, audits, and internal reviews. With 24+ years in upstream E&P, she is recognized for ensuring the integrity of reserves reporting and promoting compliance, transparency, and continuous improvement.

An expert in SEC and SPE-PRMS reserves definitions, Jennifer co-authored SPEE Monograph 5 and serves as co-instructor for its Immersion course. She is past President of the SPEE International Executive Committee and active on the Annual Meeting Advance Planning and Reserves Definitions Committees.

A licensed Professional Engineer in Texas, she holds a B.S. in Chemical Engineering from the University of Illinois and completed UT Austin's "Women Who Mean Business" program.

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# MONOGRAPH 5: DON'T TURN A MOUSE INTO AN ELEPHANT

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**RYDER SCOTT CONFERENCE - HOUSTON**

**SEPTEMBER 25, 2025**

SPEE
SOCIETY OF PETROLEUM EVALUATION ENGINEERS

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# AGENDA

- The Long Road to Monograph 5
- Exploring the Purpose and Objectives
- Overview of Key Concepts
- Monograph 5 Momentum
- Closing Thoughts

# THE LONG ROAD

# SPEE MONOGRAPHS



***SPEE Monograph 3 - 2010***
***"Guidelines for the Practical Evaluation of Undeveloped Reserves in Resource Plays"***

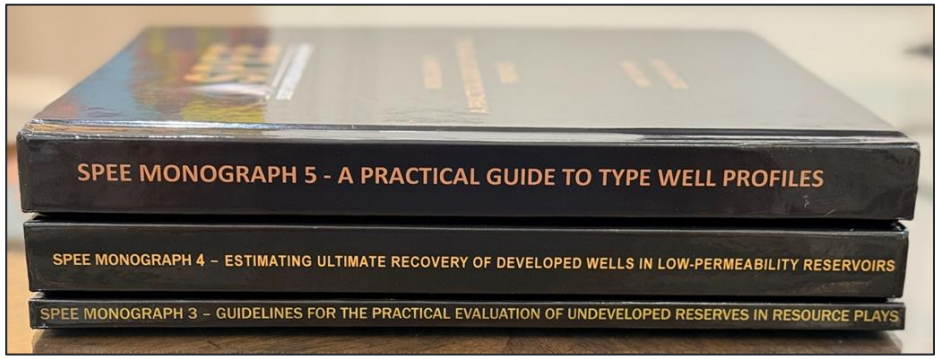
***Set forth methods for determining proved areas within a resource play, along with methods for estimating per-well reserves for undeveloped locations within those proved areas***

***SPEE Monograph 4 - 2016***
***"Estimating Ultimate Recovery of Developed Wells in Low-Permeability Reservoirs"***

***Presented and discussed several different methods of forecasting on a by-well basis***

***SPEE Monograph 5 – December 2024***
***"A Practical Guide to Type Well Profiles"***

***A recommended practices guideline for the evaluation engineer to perform type well analysis, as well as a guideline for assessing the reliability of type well profiles***

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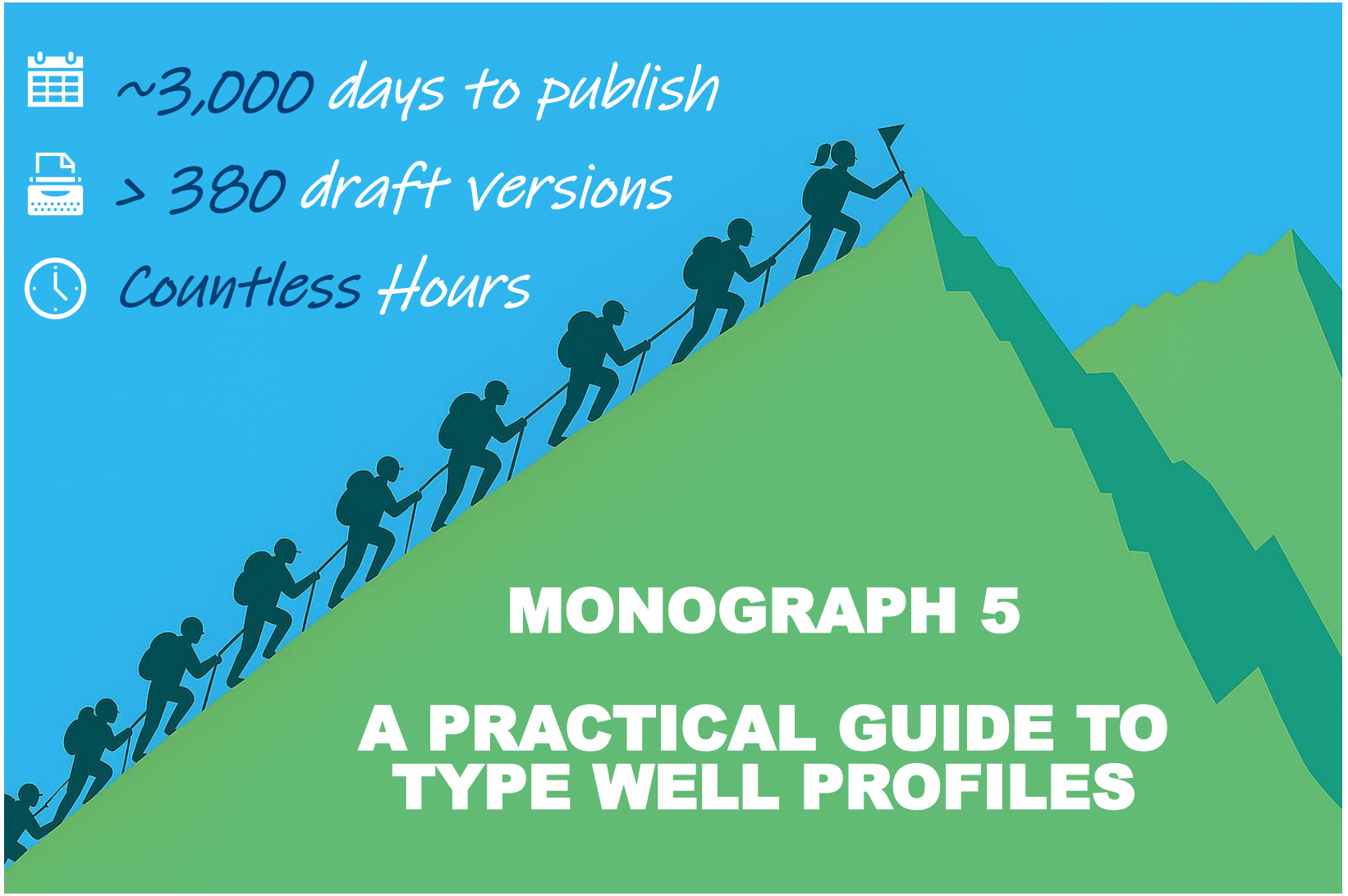
# THE LONG ROAD TO MONOGRAPH 5: TRIALS, TRIUMPHS, AND TENACITY



# COMMITTEE MEMBERS

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Committee Vice-Chair – Richard Krenek

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# EXPLORING WHY

# TYPE WELL PROFILE WORKFLOW



## Construction

Determine TWP Construction Method

Prepare Central Tendency TWPs

Assess Uncertainty & Prepare Pxx TWPs

## Data Refinement

Identify Determinants of Performance

Analog Selection & Bias Consideration

Normalization

## Application & Documentation

Assess TWP Suitability

Apply TWPs

Prepare Documentation

## Identify

Purpose

Area of Interest

Data Integration

## Adapt & Validate

Adapt to Early Data

QA/QC

Hindcast & Update

# 3 FUNDAMENTAL TENETS OF MONOGRAPH 5



1. TWP's are rooted in the concept of analogy. If the wells selected for the TWP are not sufficiently analogous to those under consideration, the results will not be applicable.

2. Improper (or unfit for purpose) TWP construction can also lead to error-prone, if not outright misleading results, even if the underlying wells are good analogs.

3. TWPs calculated as the average of analogous wells are deterministic and only partially describe future outcomes amidst uncertainty. The nature and magnitude of that uncertainty must be understood, considered, and potentially quantified if the TWP is to be properly used to draw conclusions, make recommendations, and estimate reserves/resources.

# OVERVIEW OF KEY CONCEPTS

# INFLUENCE OF BIAS

***TWPs can be affected by statistical and cognitive biases***

***Cognitive bias is natural and impacts us all***

- Although it generally has a negative connotation, it can have both a positive and negative impact on an analysis
- Ability to identify and mitigate the influence of various forms of negative bias is fundamentally important to the analysis
- However, it is also important to understand when bias cannot be removed

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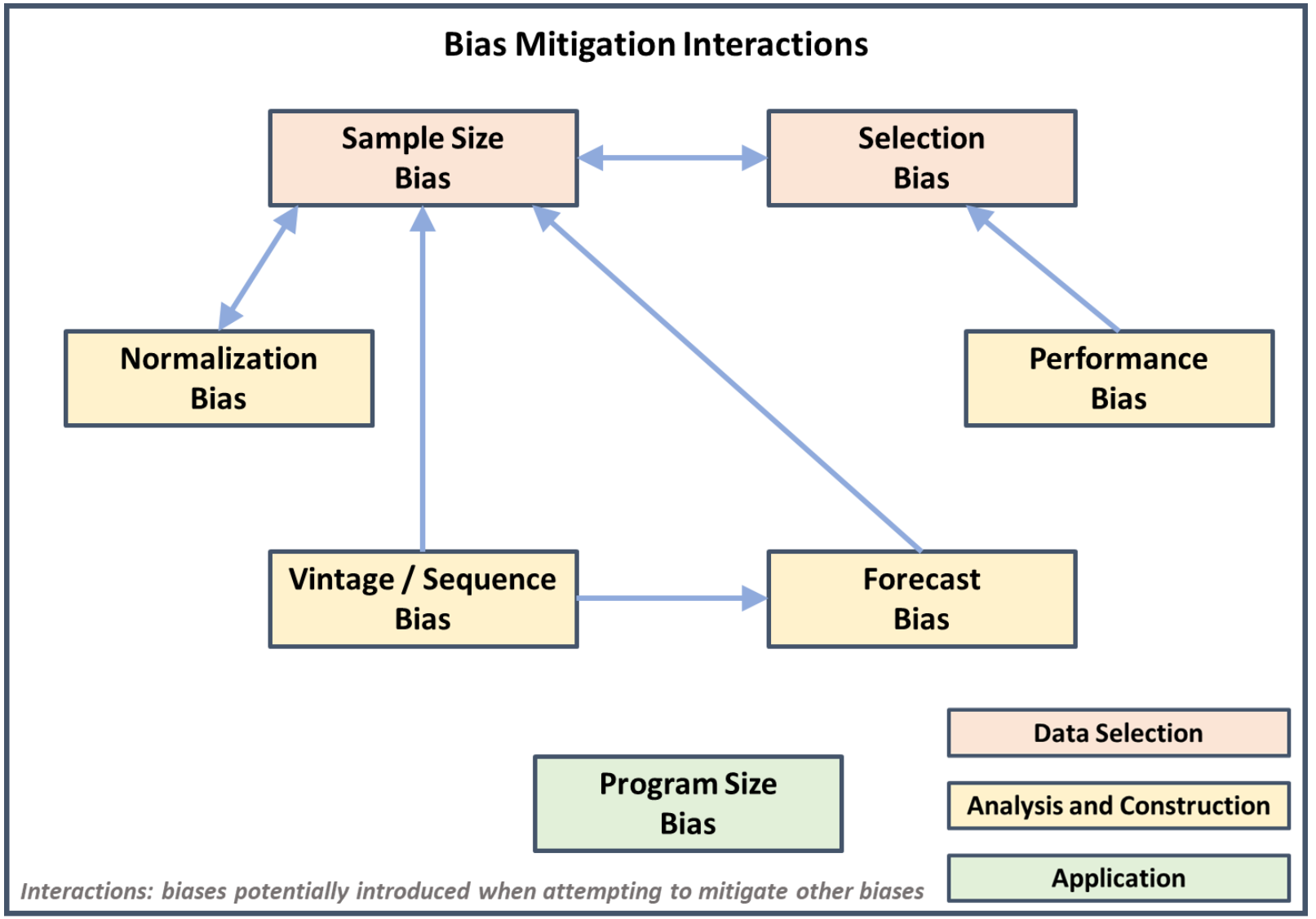
# BIAS MITIGATION INTERACTIONS





# ANALOG SELECTION



**Two competing goals:**

- Maximize analog well count to assure statistical significance - Requires more tolerance of variation with respect to key production determinants

*versus*

- Being highly selective of analog wells – Can result in a small analog well count

**Normalization is a potentially valuable method for increasing the analog well pool, allowing for inclusion of wells that would otherwise be rejected.**

# BEWARE OF TURNING A MOUSE INTO AN ELEPHANT

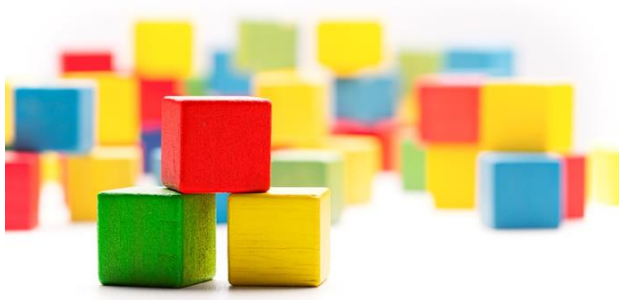
# UNDERSTANDING TWP UNCERTAINTY AND ERROR

*Analytical vs Stochastic Methods*

*Multi-Well Aggregation and Trumpet Plots*

*Sample vs Population*

*Standard Error of the Mean (SEM) and Standard Error (SE)*



*Uncertainty of the Mean*

*Aggregate Uncertainty*

*Forecast Uncertainty*

*Aggregate Z-scores ($Zxx_{AGGREGATE}$)*

*Analog Well Uncertainty Tradeoff*

*Aggregate Variances and Standard Deviations ($VAR_{\bar{x}}$ and $SD_{\bar{x}}$)*

*Aggregate Location and Scale Parameters ($\mu_{\bar{x}}$ and $\sigma_{\bar{x}}$) For Lognormal Distributions*

*Pxx TWPs and Translating Probability Levels*

# ELEMENTS OF OVERALL EUR UNCERTAINTY



$$VAR_{AGGREGATE} = \underbrace{VAR_{DWAWEUR}}_{\text{Simplified trumpet plot for multi-well aggregation}} + \underbrace{VAR_{AWSEM}}_{\text{Analog well count SEM}} + \underbrace{VAR_{DWCORR}}_{\text{Drilled well homogeneity relative to analogs}} + \underbrace{VAR_{AWFCST}}_{\text{EUR uncertainty associated with analog well forecast uncertainty}}$$

Aggregate EUR uncertainty for wells in a drilling program.

Can be visualized using trumpet plots

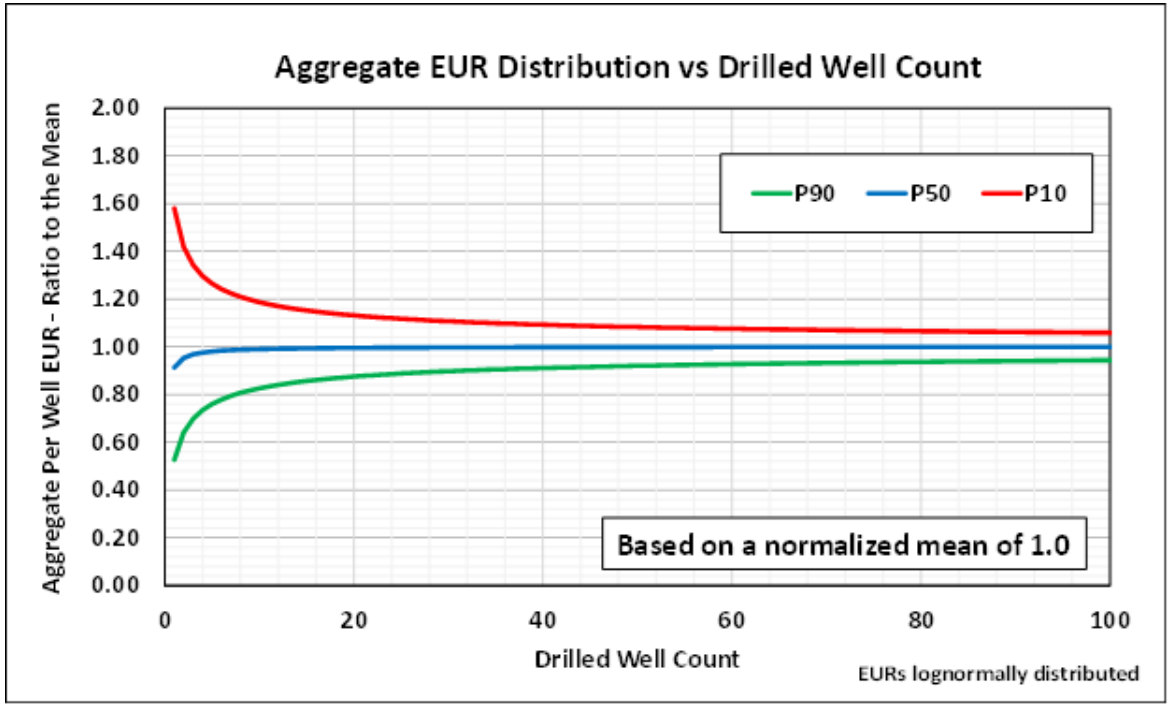
Analog well tradeoff quantity vs quality

High selectivity, low well count increases this component

High inclusivity, high well count increases this component

# SIMPLIFIED TRUMPET PLOT
# THE AGGREGATION EFFECT

- Common purpose of a trumpet plot is to illustrate the reduction in uncertainty with successive sampling
  - Underlying EUR distribution as the number of wells in a drilling program increases
- Key assumptions:
  - The mean and variance are known (i.e., no uncertainty of the mean)
  - Individual draws from the statistical distribution are fully independent




***These conditions will rarely exist in practice***

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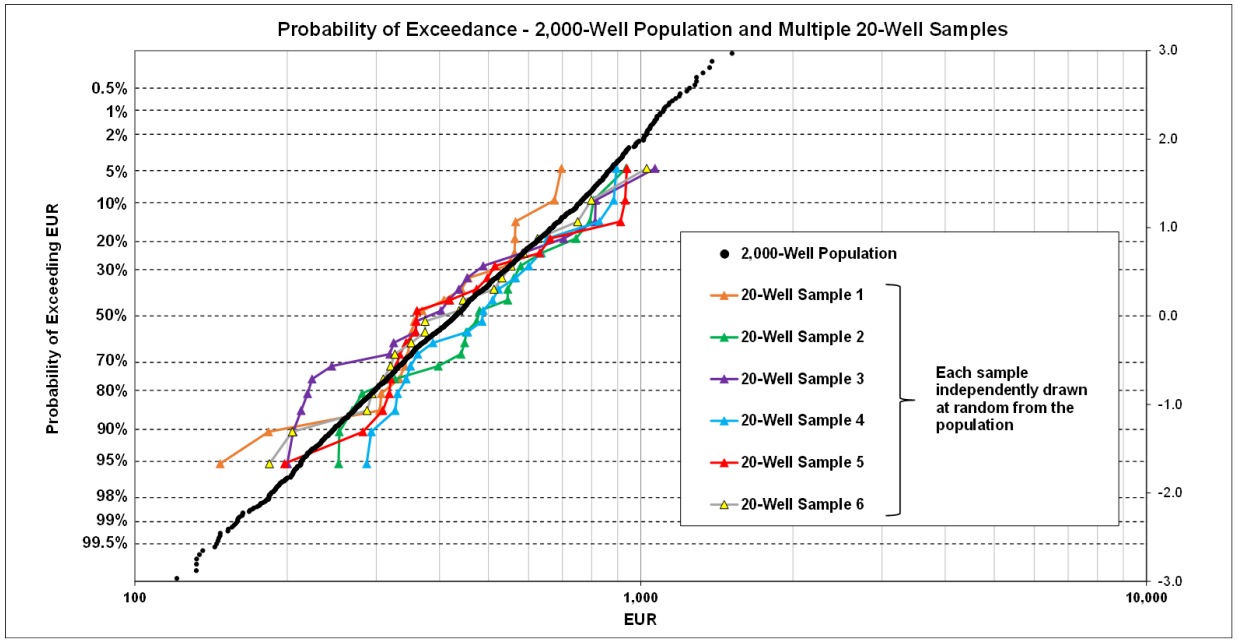
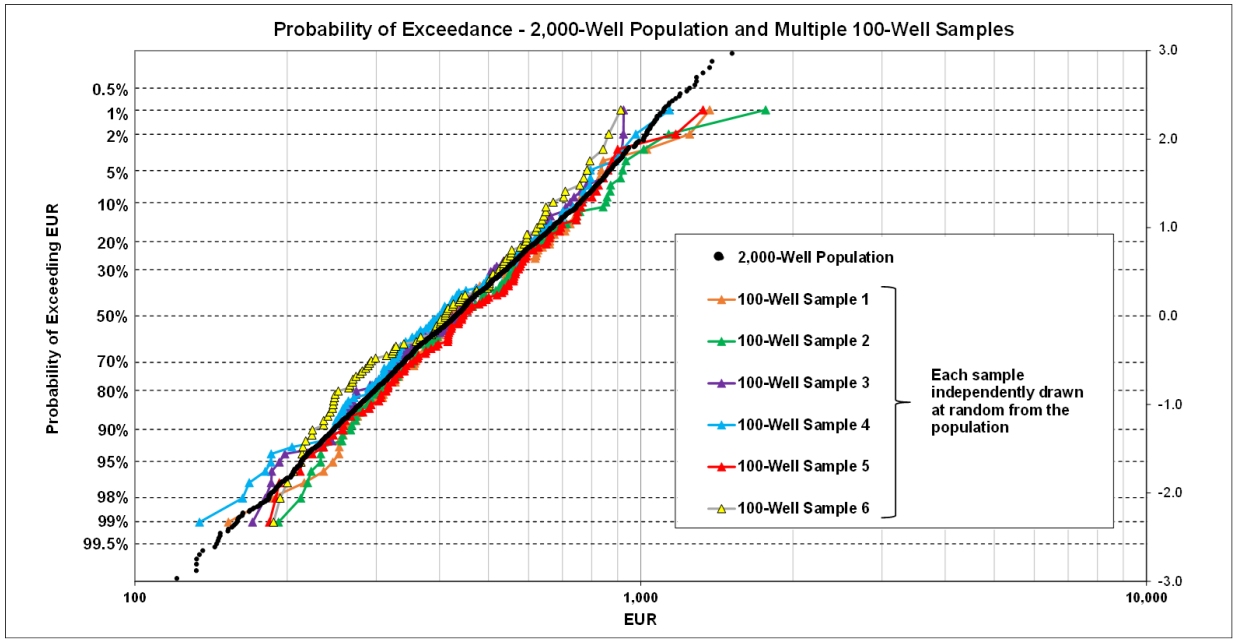
# IMPORTANCE OF ANALOG WELL SAMPLE SIZE





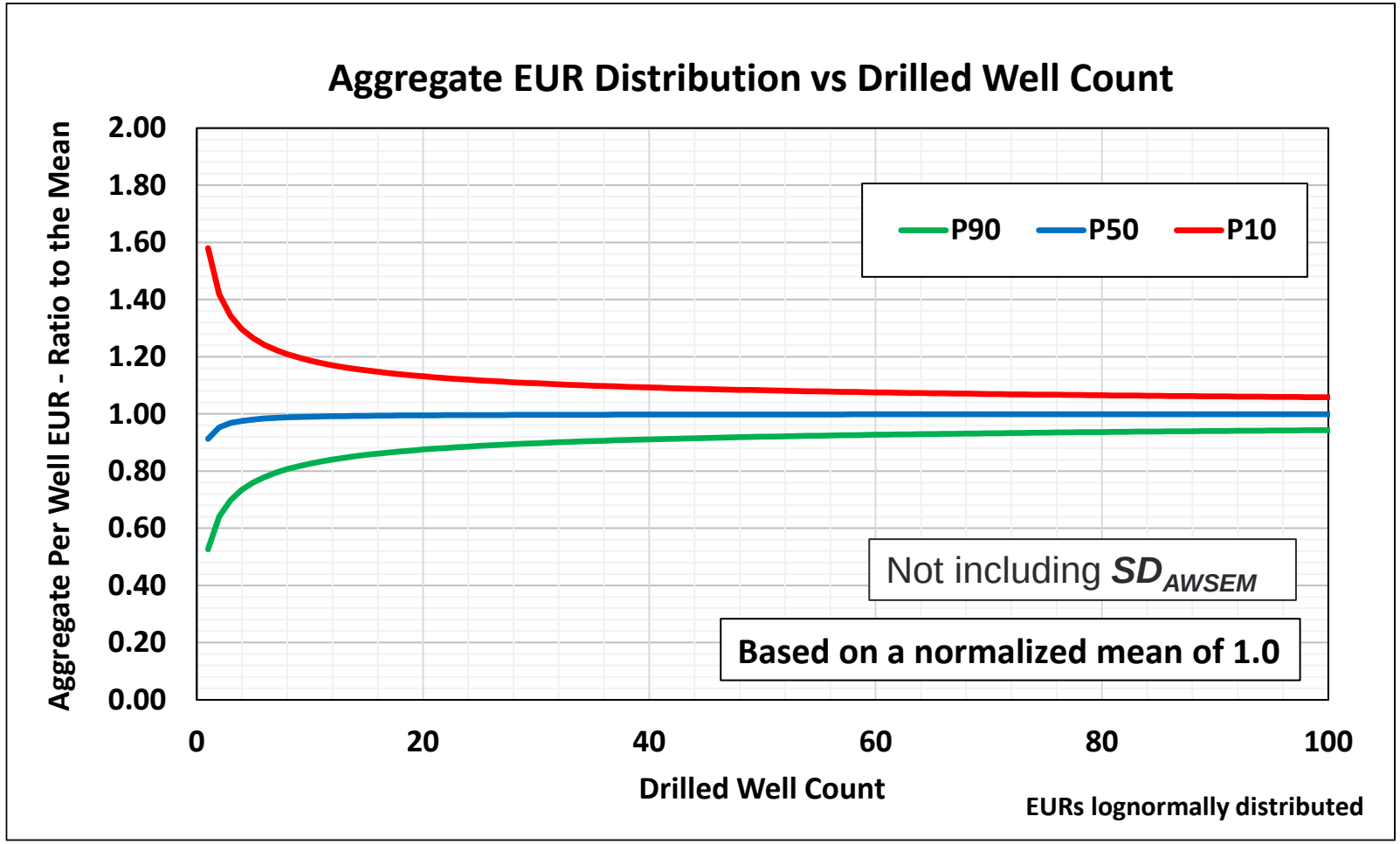

**Illustrates uncertainty of the mean as related to sample size**

- Larger samples predict/estimate the mean:
  - With more precision (lower range of means)
  - With more accuracy (closer to continuous distribution mean)

# IMPACT OF AW SEM ON UNCERTAINTY EXAMPLE

Not including $SD_{AWSEM}$

Equivalent to inclusion of $SD_{AWSEM}$ for an infinite number of analog wells




Analog well ***P10/P90 EUR ratio*** = 3.0

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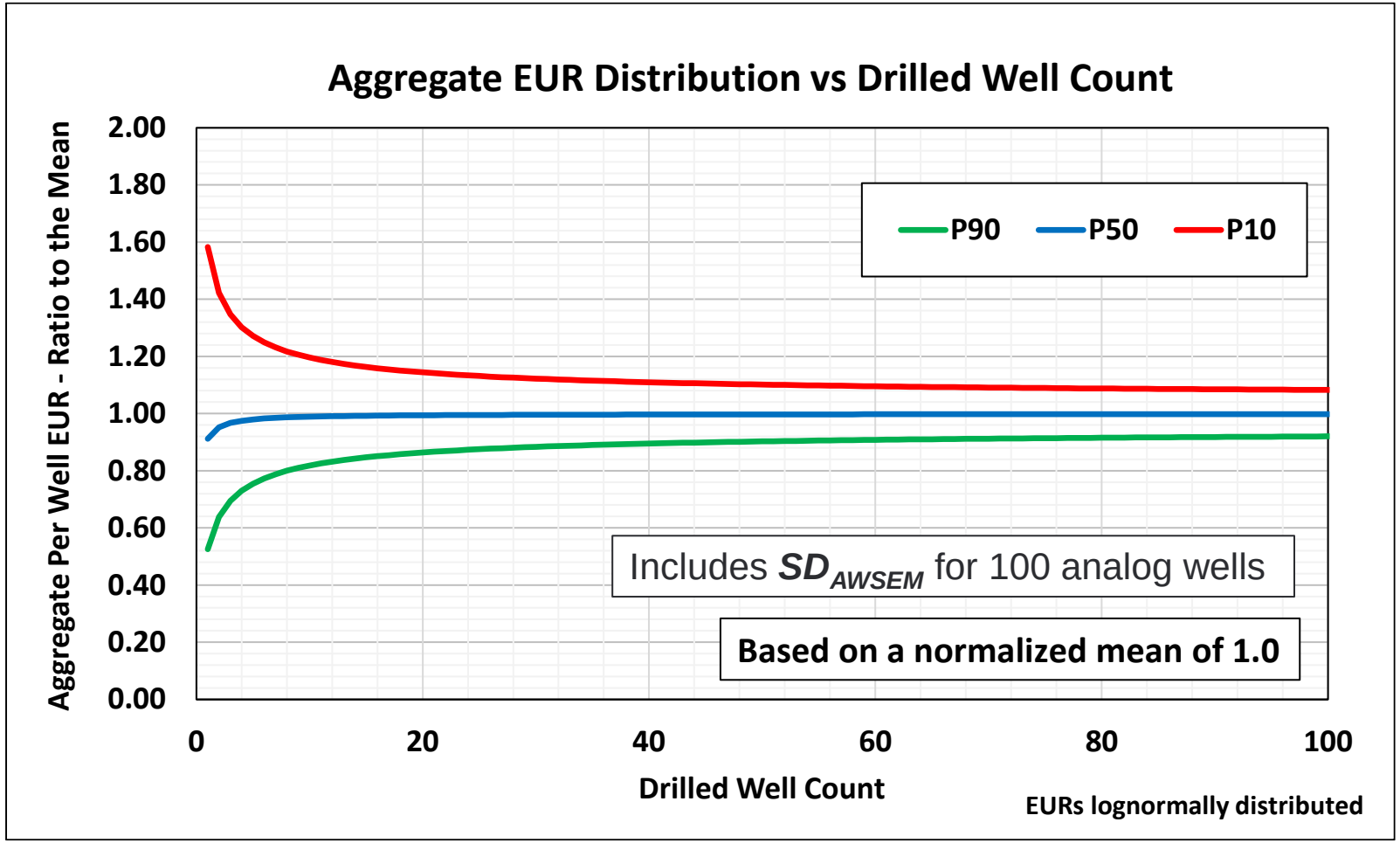
# IMPACT OF AW SEM ON UNCERTAINTY EXAMPLE

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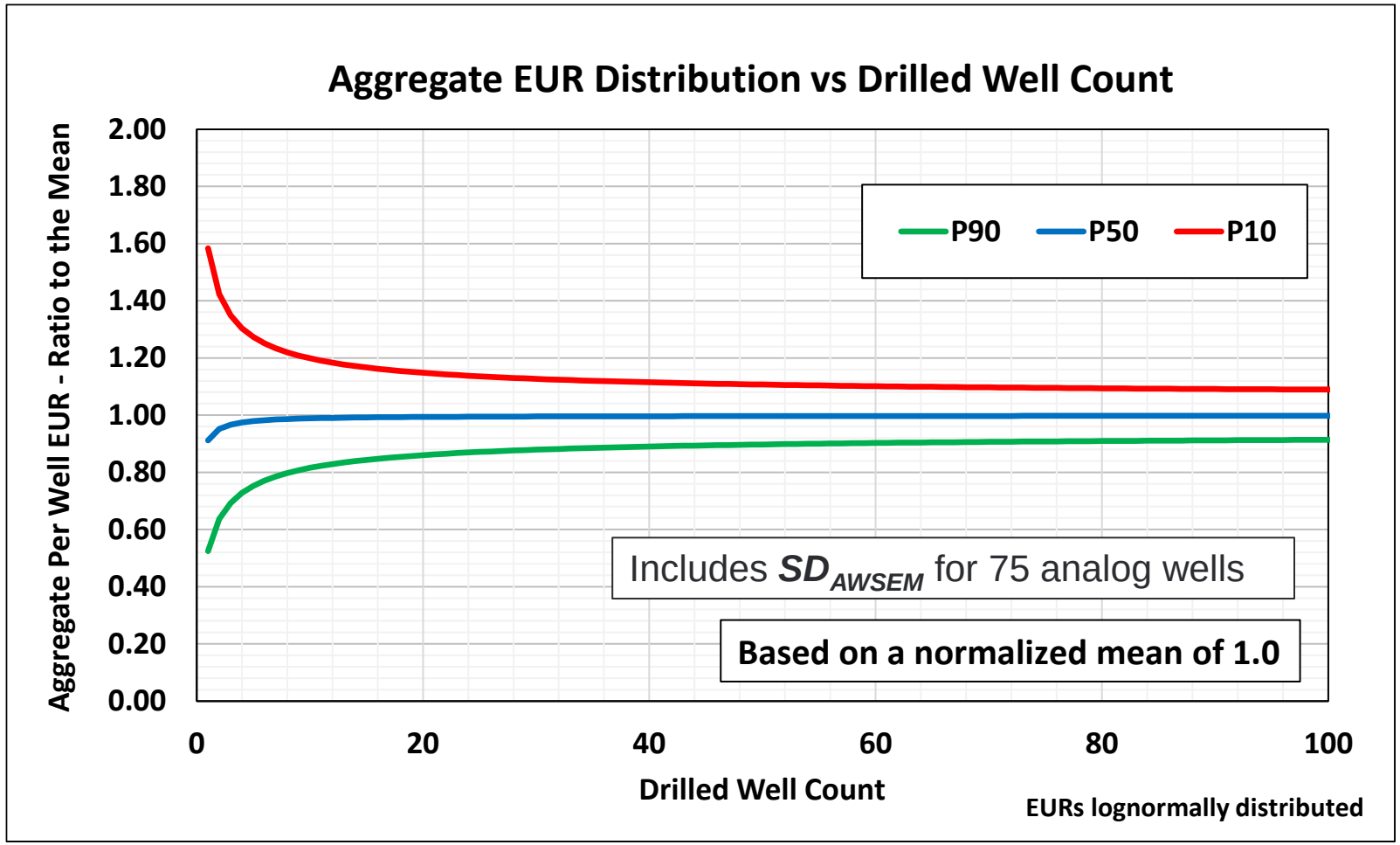


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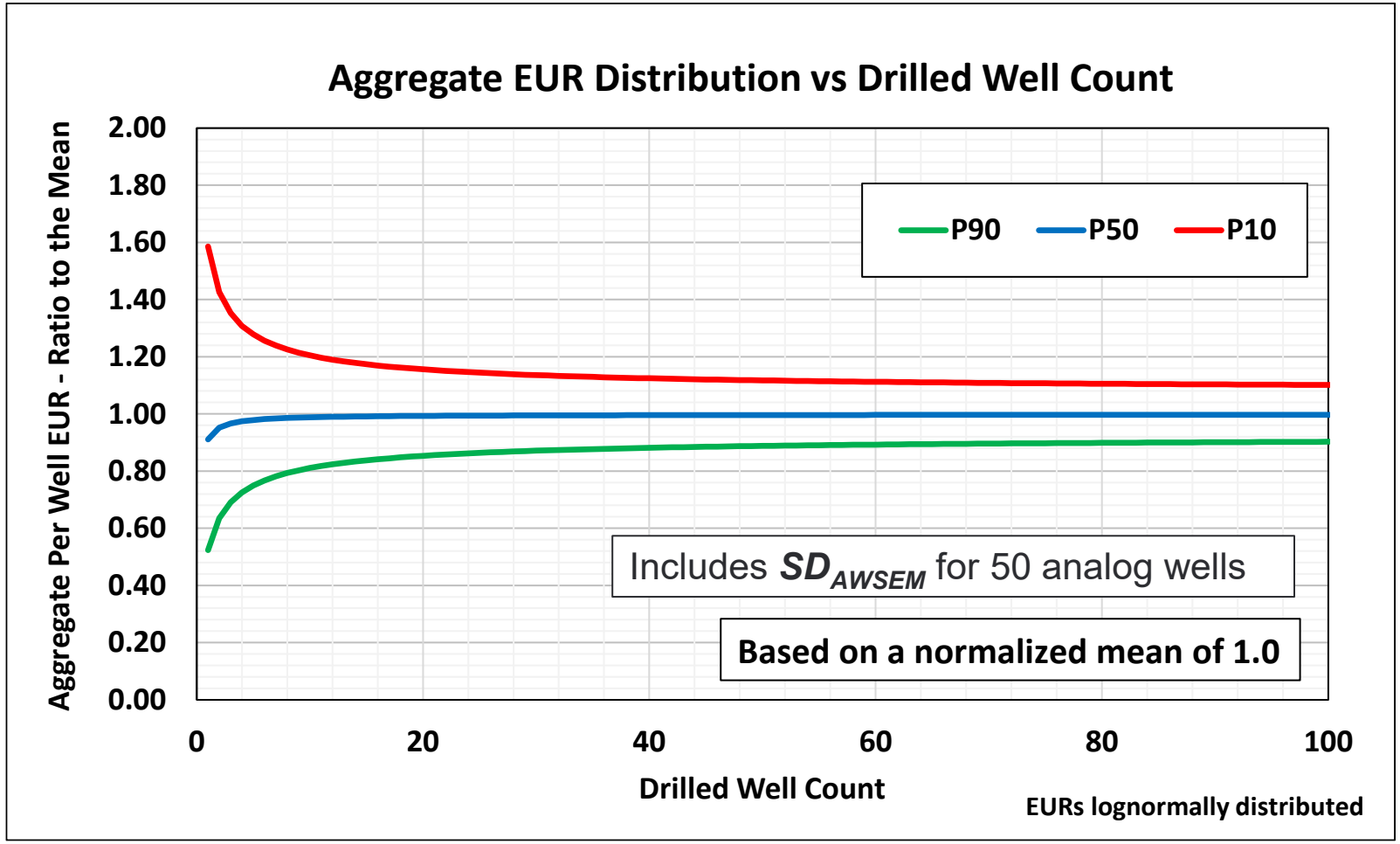


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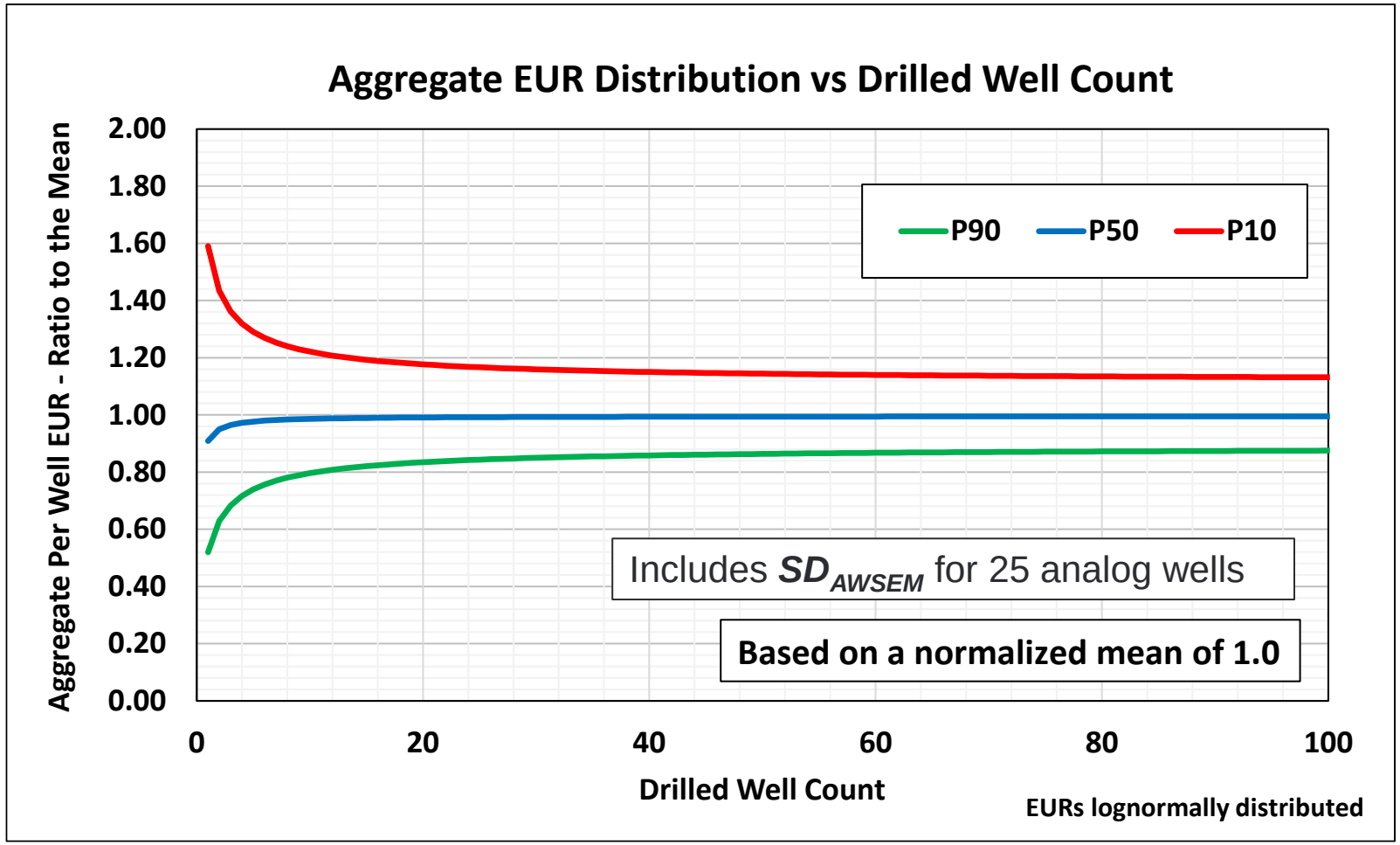


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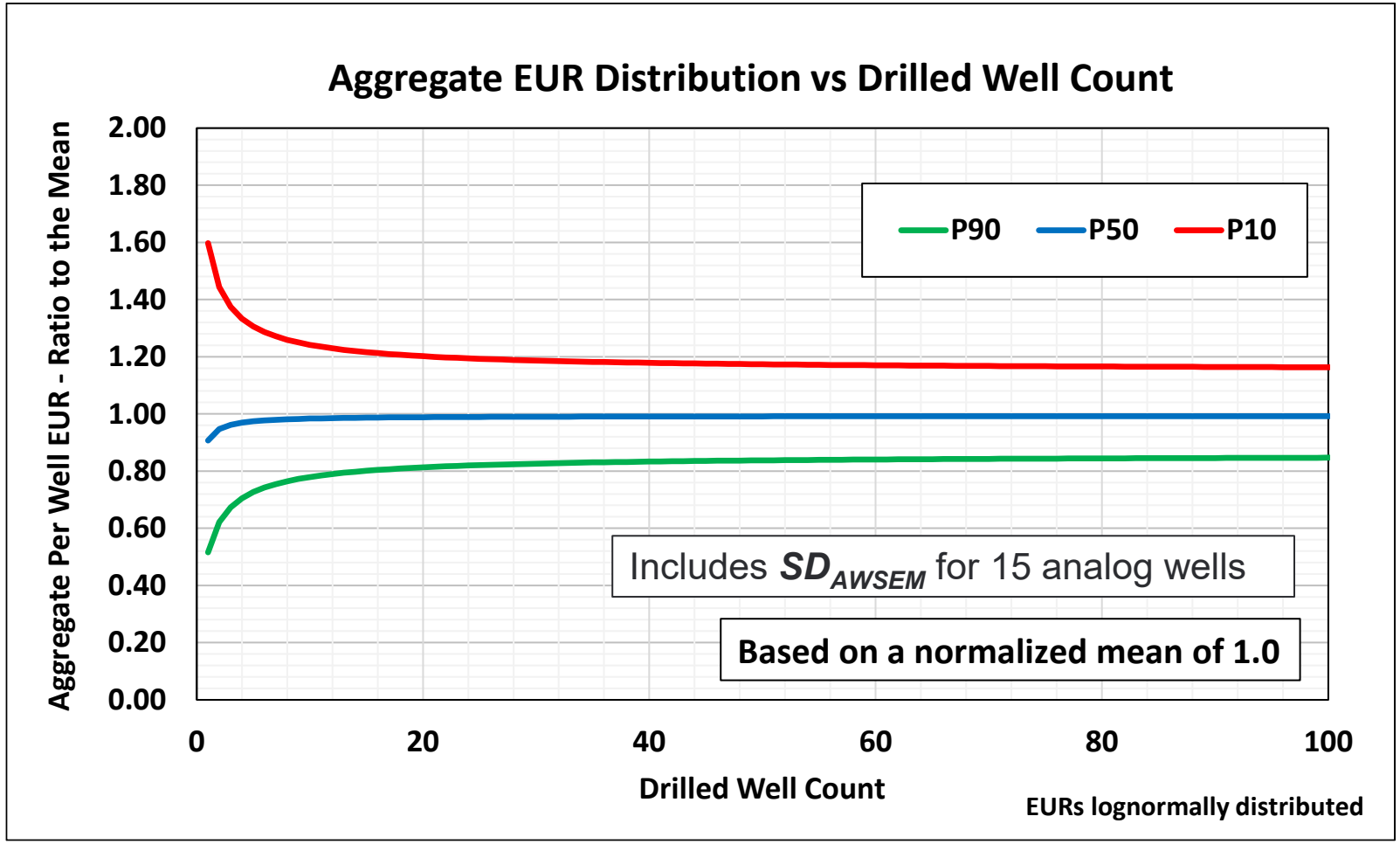


Analog well ***P10/P90 EUR ratio*** = 3.0

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# UNCERTAINTY CONSIDERATIONS



- Fully assessing TWP uncertainty is a complex task
- Some uncertainties are difficult to identify and thus impossible to quantify
- Inability to quantify all uncertainties should not preclude investigating those uncertainties that can be quantified
- The TWP generation and application workflow should include consideration of identifiable and material uncertainties
- Monograph 5 includes a comprehensive process to calculate key elements of TWP uncertainty


- It is recognized that not all evaluators will choose to perform the calculations set out in Monograph 5. What is most important is that their potential existence is understood

**Regardless of the prudence of the evaluator and the soundness of the methodology used in TWP construction and use, the result will contain some level of uncertainty of the mean**

# MONOGRAPH 5 MOMENTUM

# MONOGRAPH 5 MOMENTUM

**Monograph 5 Publication**

- Published the week of Christmas 2024
- Available in both electronic and hardcover printed versions
- Within first 7 months, sold nearly 700 copies

**Two-Day Immersion Training**

- Less than 3 months from the date of publication
- Conducted 7 courses in 5 short months, training 170 evaluators
- Comprehensive review of concepts and workflows
- Participants engage in several examples using a series of provided spreadsheets

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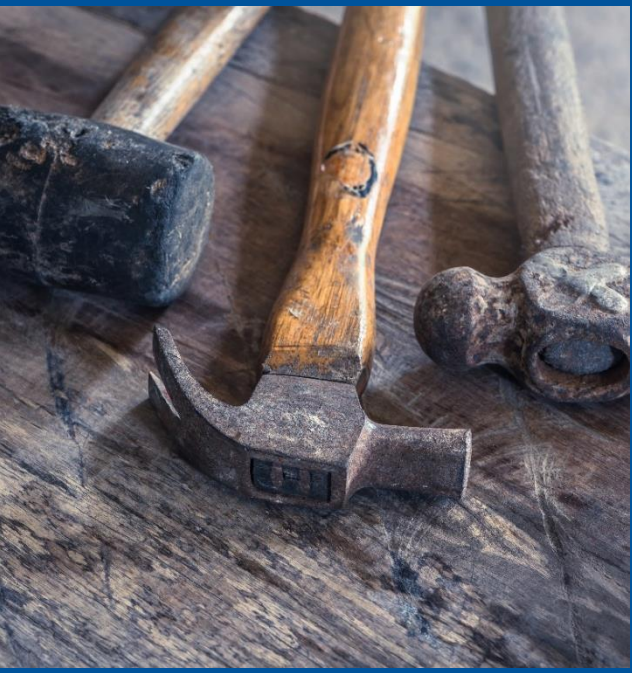
# IMMERSION TRAINING



- Emphasizes important material, concepts and skills
- Addresses different learning styles
- Enhances critical and creative thinking
- Builds confidence through conversations
- Creates a sense of community

# FINDING THE RIGHT TOOL IN THE TOOLBOX



*The purpose of this monograph is to be a recommended practices guideline for the evaluation engineer to perform type well analysis, focusing first on public or easily obtained data, and then enhancing the reliability by supplementing detailed or proprietary data as necessary. The monograph gives due consideration to the "fit for purpose" confidence level to be achieved. Secondly, this monograph serves as a guideline for assessing the reliability of type well profiles.*

# CLOSING THOUGHTS

# LET'S KEEP THE CONVERSATION GOING



- Created Monograph 5 Training Alumni email list to stay connected
  - Share updates and improved workflows
  - Promote idea and experience exchange
  - Platform for questions and feedback to instructors and SPEE
- Second-Level Aggregation
  - Monograph 5 handles uncertainty at the TWP level, but field-level evaluations with multiple TWPs add complexity
  - Developed a validated, spreadsheet-based solution for this second-level aggregation
  - Enhanced tools and workflows will be shared shortly

# QUESTIONS

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**https://SPEE.org**