OXY ZERO IN™

WHY WAS MY TYPE WELL PROFILE WRONG?

Jennifer Fitzgerald, Vice President Reserves - Oil & Gas
Occidental Petroleum Corporation

SPEE ANNUAL MEETING – NAPA, CA
JUNE, 2022

DISCLAIMER

The views and opinions expressed in this presentation are those of the author and do not necessarily reflect any policy or position of Occidental Petroleum Corporation.

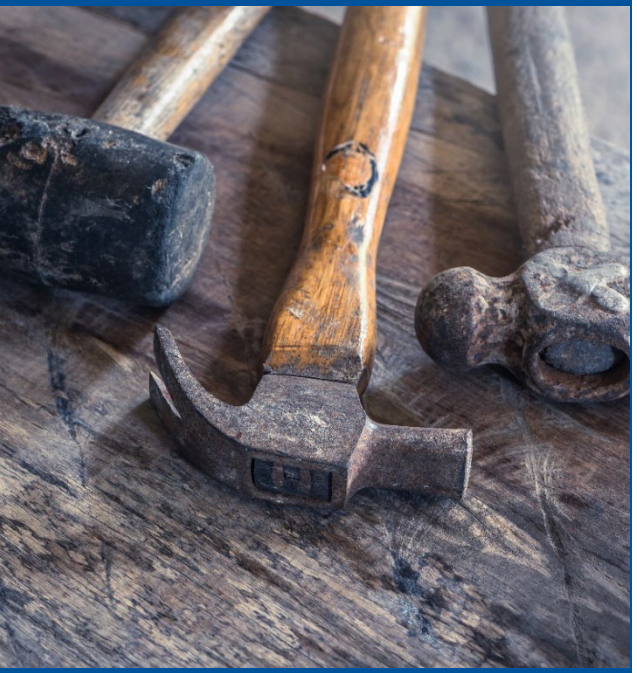
The slides in this presentation were prepared as visual references only. It is likely that key points delivered during the live presentation are not present as text on the slides. Questions regarding content should be directed to the author.

COMMITTEE MEMBERS

- Vitaliy Charkovskyy
- Jorge Faz
- Jennifer Fitzgerald*
- David Fulford
- Steve Hendrickson
- Dilhan Ilk
- Rick Krenek
- John Lee
- Rod Sidle
- John Wright

CHAIRPERSON

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.

TYPES OF BIAS

DEFINITION OF BIAS

Statistical Bias

- A systematic deviation in an estimated or modeled value when compared to the true value, generally as a result of the methodology used for data assembly and processing

Cognitive Bias

- The influence upon objective thinking that is caused by the tendency for an individual to perceive information through a filter of personal experience and professional judgment

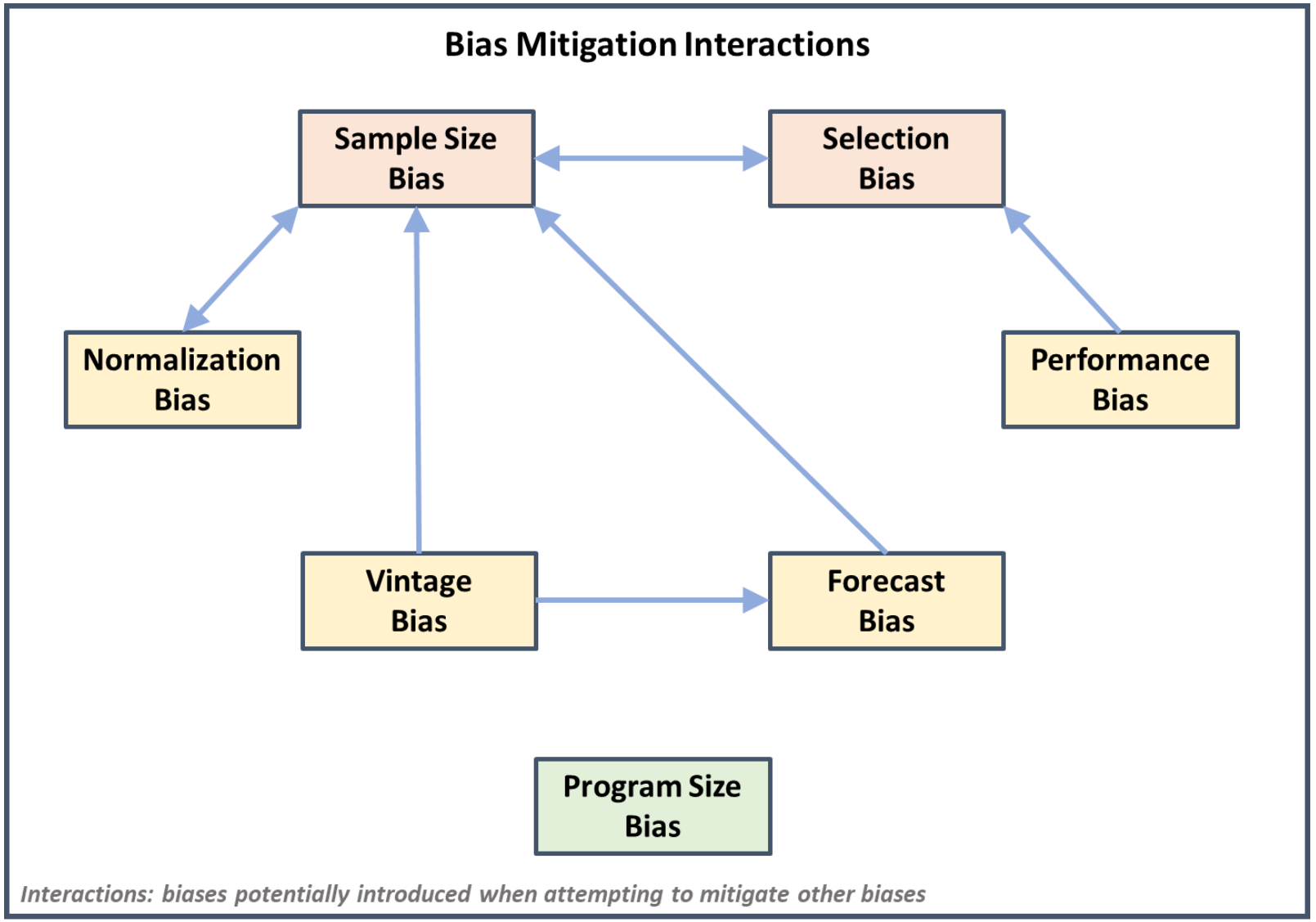
The ability to identify and mitigate the influence of various forms of negative bias is fundamentally important to the analysis. However, it is also important to understand when bias cannot be removed.

SPECIFIC TYPES OF BIAS

- Selection Bias
- Sample Size Bias
- Forecast Bias
- Normalization Bias

- Program Size Bias
- Survivor Bias
  - Vintage Bias
  - Performance Bias

BIAS MITIGATION INTERACTIONS



Data Selection

Analysis and Construction

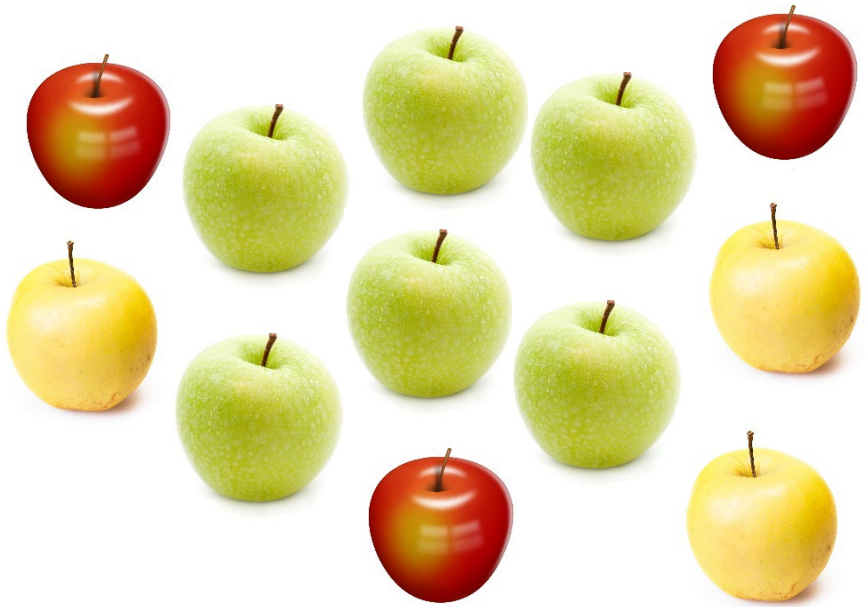
Application

SAMPLE SIZE BIAS - SITUATIONS

Sample Size Bias can occur when:

1) **An insufficient availability of analog wells is coupled with heterogeneity of production performance among those analog wells**

2) **The evaluator values quality of analogs over quantity of analogs**



SAMPLE SIZE BIAS - MITIGATION

Primary Mitigation

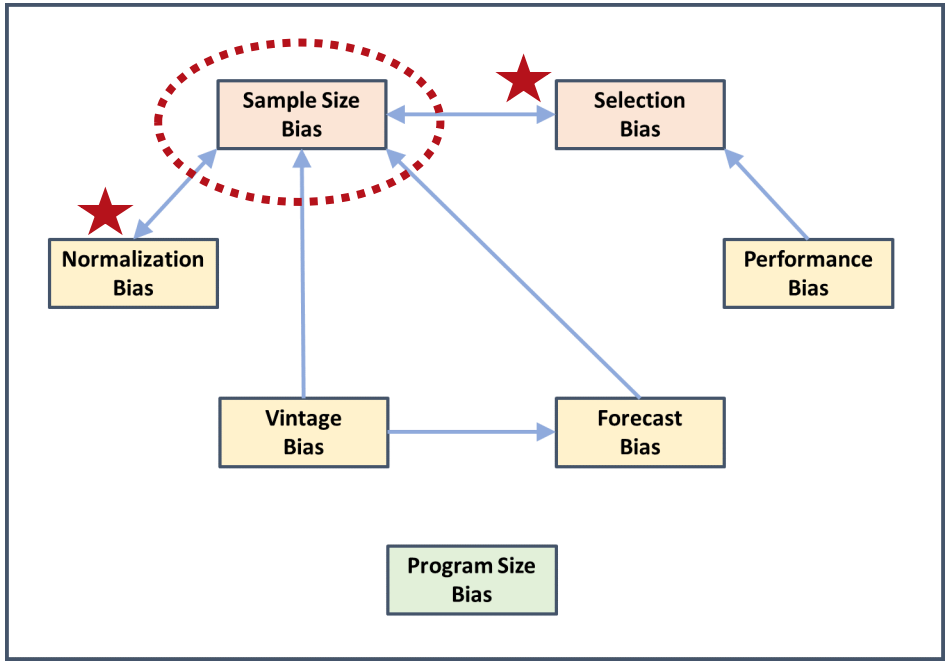
- Increase count of wells in the analog group by using normalization/scaling techniques
- **Could lead to Normalization Bias**

Alternative Mitigation

- Increase count of wells in the analog group, by accepting more variation in analog wells
- **Could lead to Selection Bias**

Alternatively,

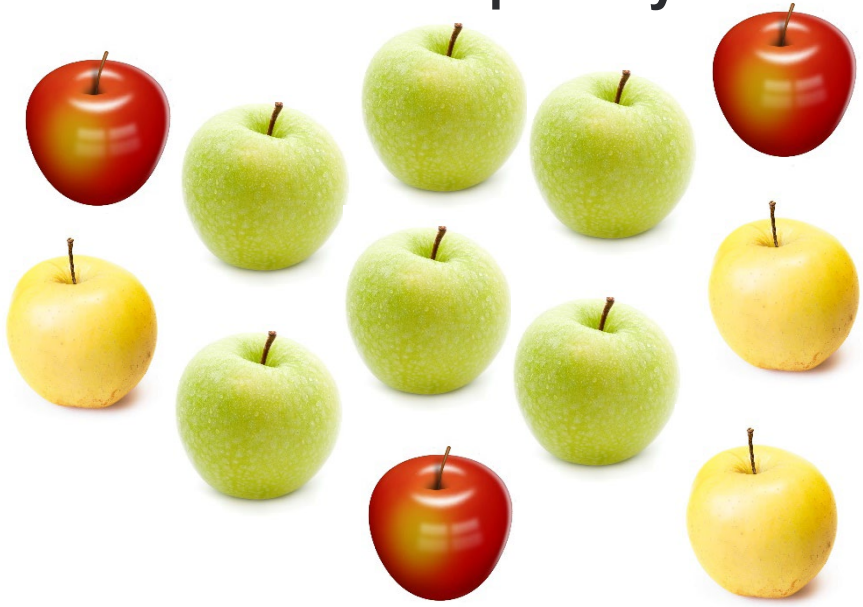
- Accept an inadequate number of analogs but recognize the additional uncertainty about the mean is imparted by an insufficient sample size, which will increase as the heterogeneity of underlying wells increases.

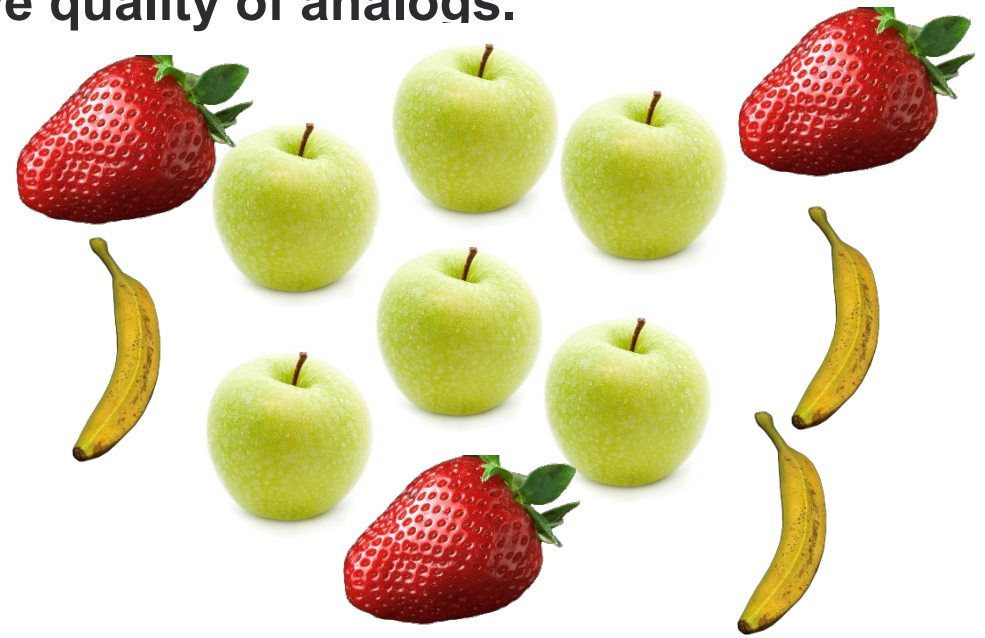


SELECTION BIAS - SITUATIONS

Selection Bias can occur when:

1) **Insufficient geologic, fluid, or drilling / completion data regarding potential analog wells such as could occur when using public data for selecting analogs (TWP Prep step)**
2) **Unexpected differences in geology, reservoir fluids, or drilling / completion designs relative to prediction (TWP Application step)**
3) **The evaluator values quantity of analogs above quality of analogs.**





SELECTION BIAS - MITIGATION

Primary Mitigation

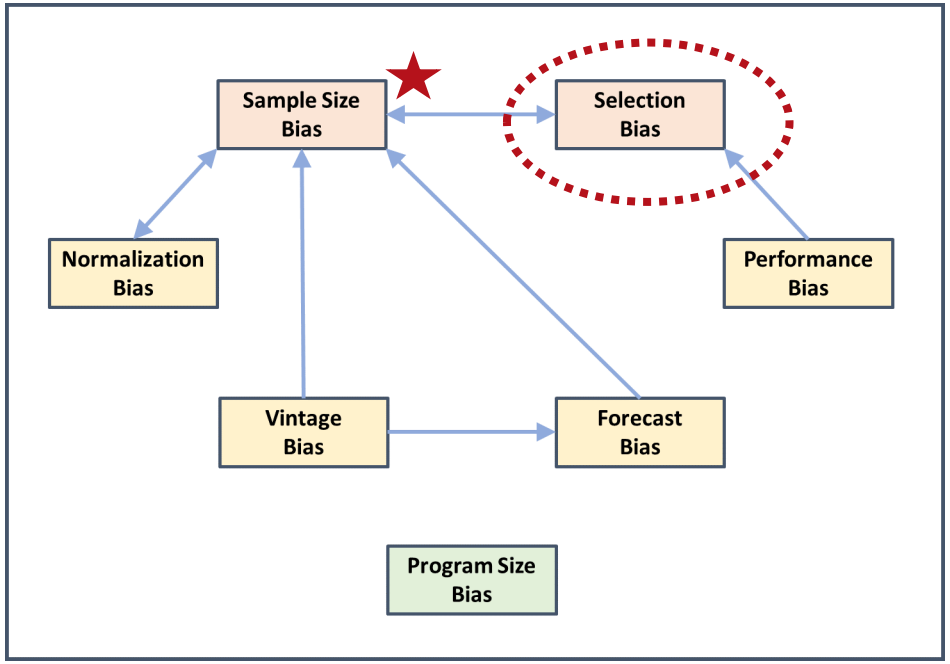
- Utilize as much data and information as are available to assure chosen analogs are fit for purpose with respect to Geology, reservoir fluids, and drilling / completion design
- **Attempts to over mitigate Selection Bias can lead to Sample Size Bias**

Alternative Mitigation

- When sufficient geologic, fluid, or drilling / completion data is not available, utilize proxy indicators such as completion date, operator, and proximity to bin the wells prior to analog selection
- **Attempts to over mitigate Selection Bias can lead to Sample Size Bias**

Alternatively,

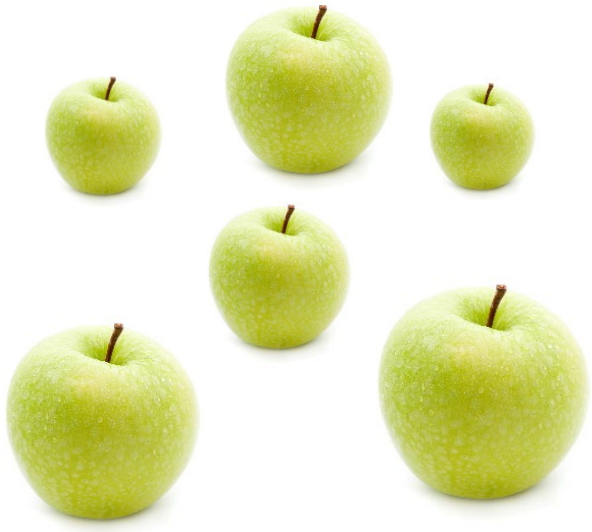
- Accept that using analog wells as a proxy for forecasting performance of other wells inherently imparts some level of uncertainty of the mean and that this uncertainty can be reduced with more complete information



NORMALIZATION BIAS - SITUATIONS

Normalization Bias can occur when:

1) **Normalization / scaling is applied to analog well production prior to preparation of a TWP. Potential issues increase as the amount of normalization / scaling increases**
   - **As the mix of wells becomes more heterogeneous in terms of parameters to normalize**



NORMALIZATION BIAS - MITIGATION

Primary Mitigation

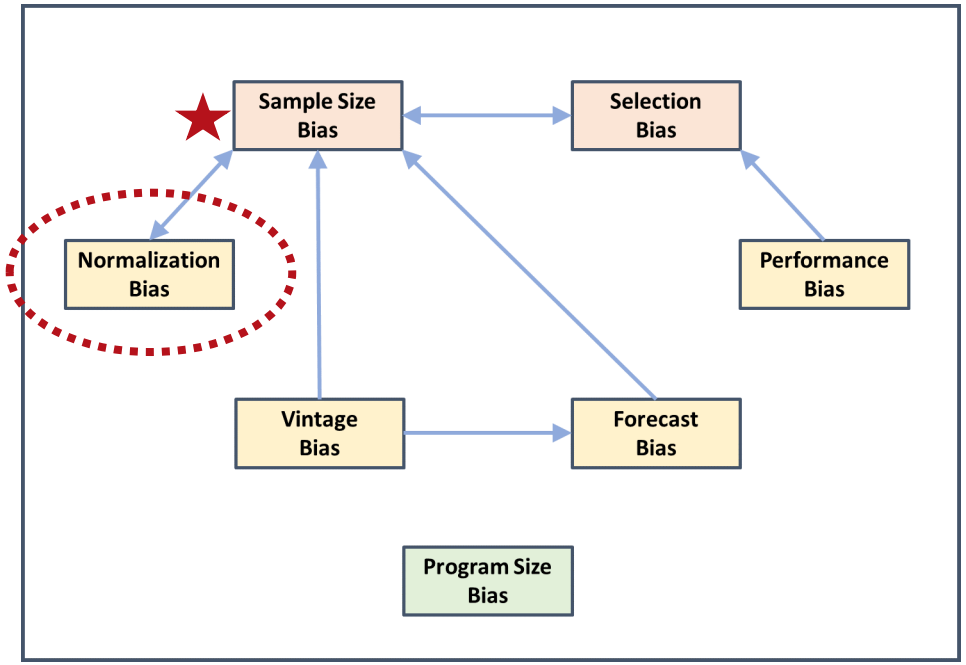
- Sufficiently bin in order to utilize analog wells where no normalization / scaling is necessary
- **May introduce Sample Size Bias through insufficient Sample size**

Alternative Mitigation

- Use binning to incorporate analog wells with minimal variation in normalizable parameters, such that minimal normalization / scaling is necessary. Use technically sound normalization methodologies.
- **May introduce Sample Size Bias through insufficient Sample size. Even with minimal normalization, recognize that some Normalization Bias may remain.**

Alternatively,

- When the pool of potential analogs is insufficient such that a significant amount of normalization / scaling is required, recognize that additional uncertainty about the mean exists. In particular, the uncertainty will increase when the heterogeneity of underlying wells increases.



VINTAGE BIAS - SITUATIONS

Vintage Bias can occur when:

1) **Incorporating analogs of various ages (i.e., vintages) into a single TWP**

VINTAGE BIAS - MITIGATION

Primary Mitigation

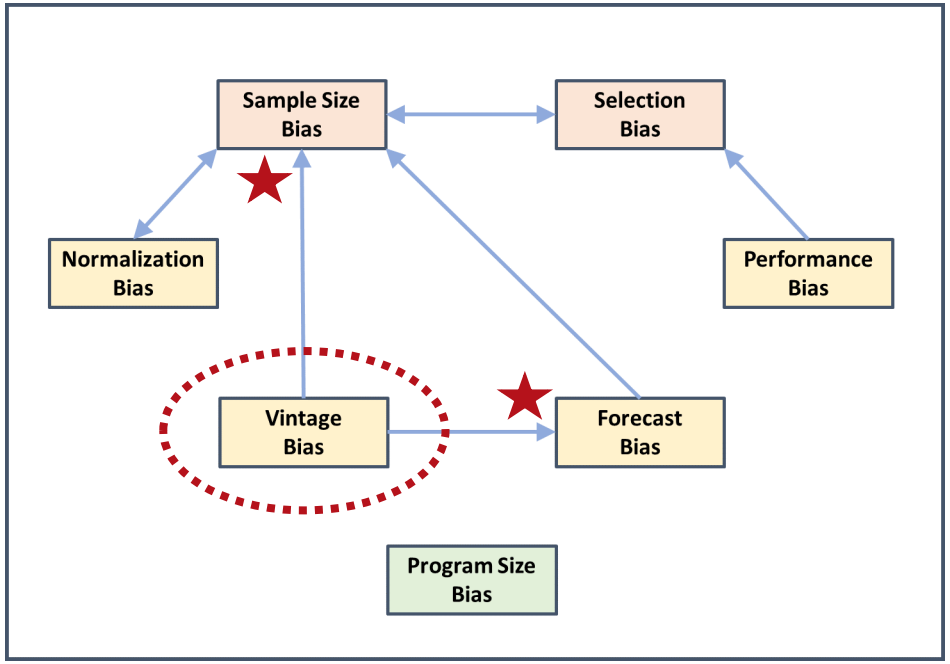
- Project each analog well before preparing a TWP
- **Could lead to Forecast Bias**

Alternative Mitigation

- Bin wells by vintage and prepare separate history-only TWPs
- **May lead to multiple TWPs each with Sample Size Bias through insufficient Sample size**

Alternatively,

- Although it is not recommended, use a history-only TWP consisting of analog wells selected without regard to vintage, but consider the TWP data suspect after a point in normalized time where a material number of analog wells has dropped out due to vintage (i.e., the TWP is suspect past a 25% reduction in contributing well count)



FORECAST BIAS - SITUATIONS

Forecast Bias can occur when projecting analog wells prior to preparing a TWP:

1) **Lack of information, which dictates that the potential for uncertainty is higher for newer wells and lower for more mature wells**

2) **Potential for systematic error resulting from evaluator judgment**

FORECAST BIAS - MITIGATION

Primary Mitigation

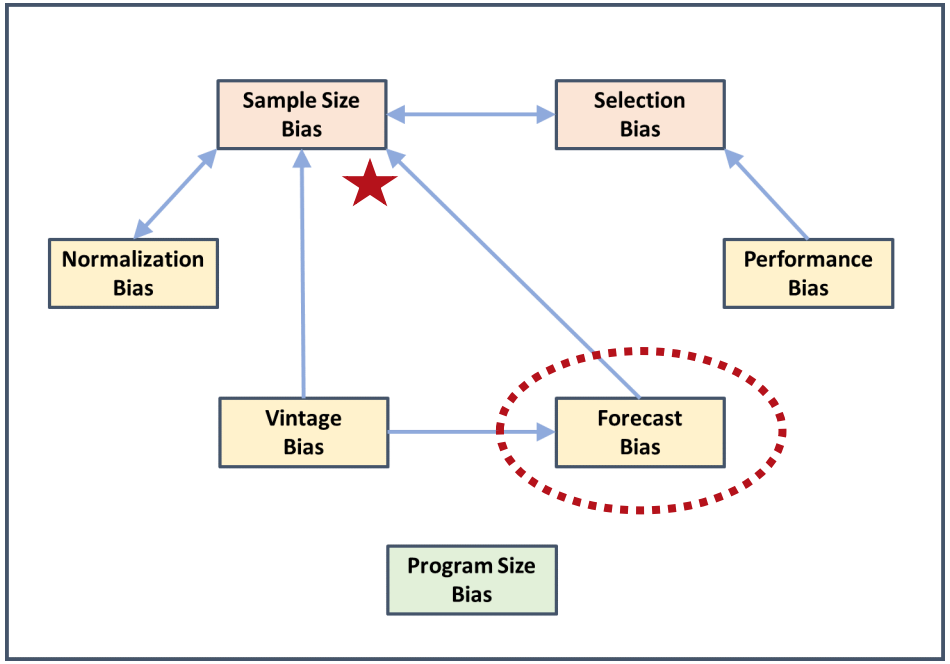
- Prepare history-only TWPs, but only after binning data into analog groups with similar vintages (to avoid Vintage Bias)
- **May introduce Sample Size Bias through insufficient Sample size**

Alternative Mitigation

- Prepare one TWP using history + forecast and a second TWP using history only then cross check. Investigate and reconcile any material differences.
- **Must consider (1) that a range of uncertainty exists in every projection, and the potential for (2) systematic bias might have been incorporated into projections.**

Alternatively,

- Prepare a single TWP using history + forecast but consider the TWP result suspect after a point in normalized time where a material number of analog wells is being represented by projection, not history

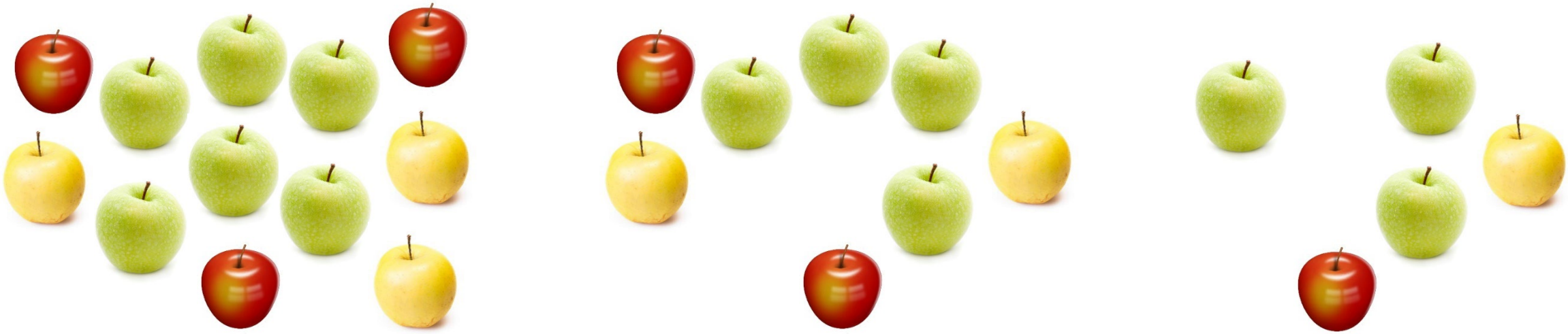


PERFORMANCE BIAS - SITUATIONS

Performance Bias can occur when:

1) **Including analog wells with producing lives less than the well's vintage would imply (i.e., when including wells that have been shut-in because of poor performance)**

2) **Allowing the well count divisor to decrease commensurate with the well's shut-in date when preparing the TWP**



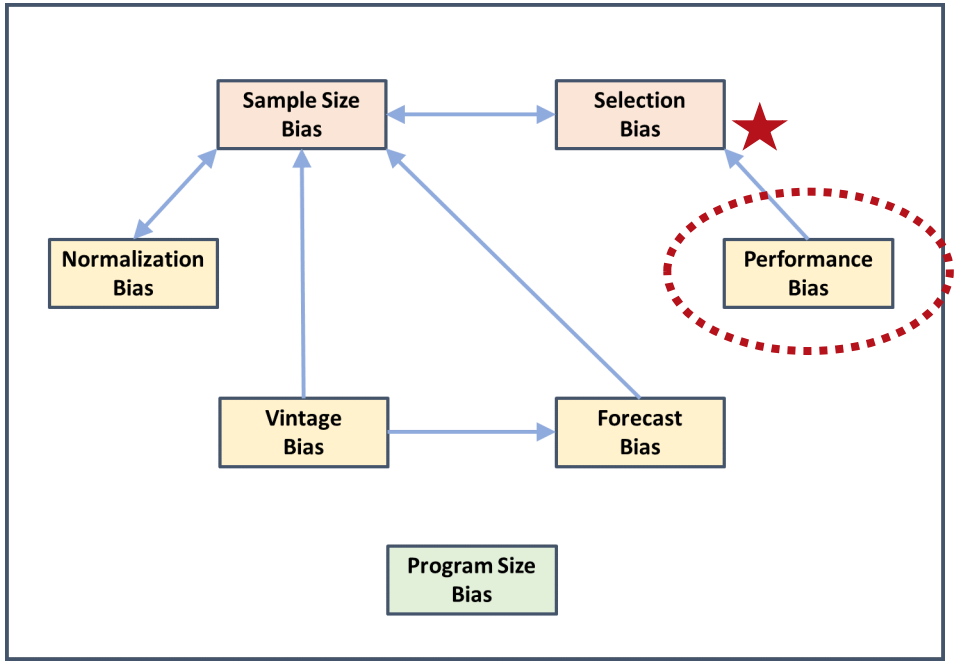
PERFORMANCE BIAS - MITIGATION

Primary Mitigation

- When including such wells as analogs, and when using a production averaging method of TWP construction, it is a recommended practice that well counts must not be decreased after shut-in. An alternative way of describing this recommended practice is that zero production must be included for that well after shut-in for TWP production averaging.

Alternative Mitigation

- Not generally recommended, eliminate such well(s) from the analog pool
- **Not recommended if well is an analog in all respects but for poor performance, as this will likely impart Selection Bias resulting in a TWP that overstates expected performance.**
- **Wells should not be excluded from an analog pool merely because they don't perform like we expect or hope.**



PROGRAM SIZE BIAS - SITUATIONS

Program Size Bias can occur when:

1) **A TWP is used to predict the average outcome for a small number of wells (separate from and regardless of the number of wells included as analogs)**

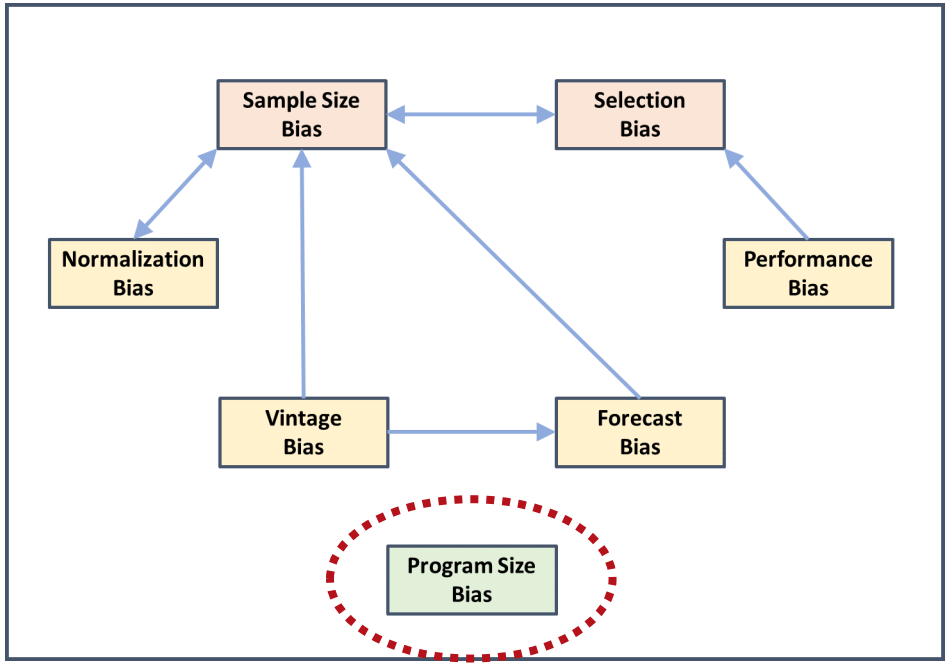
PROGRAM SIZE BIAS - MITIGATION

Primary Mitigation

- Consider use of a non central tendency TWP (i.e., P90 or something between P90 and P50/mean), if a high certainty TWP estimate is desired
- **Mitigation techniques for Program Size Bias do not lead to additional forms of bias**

Alternatively,

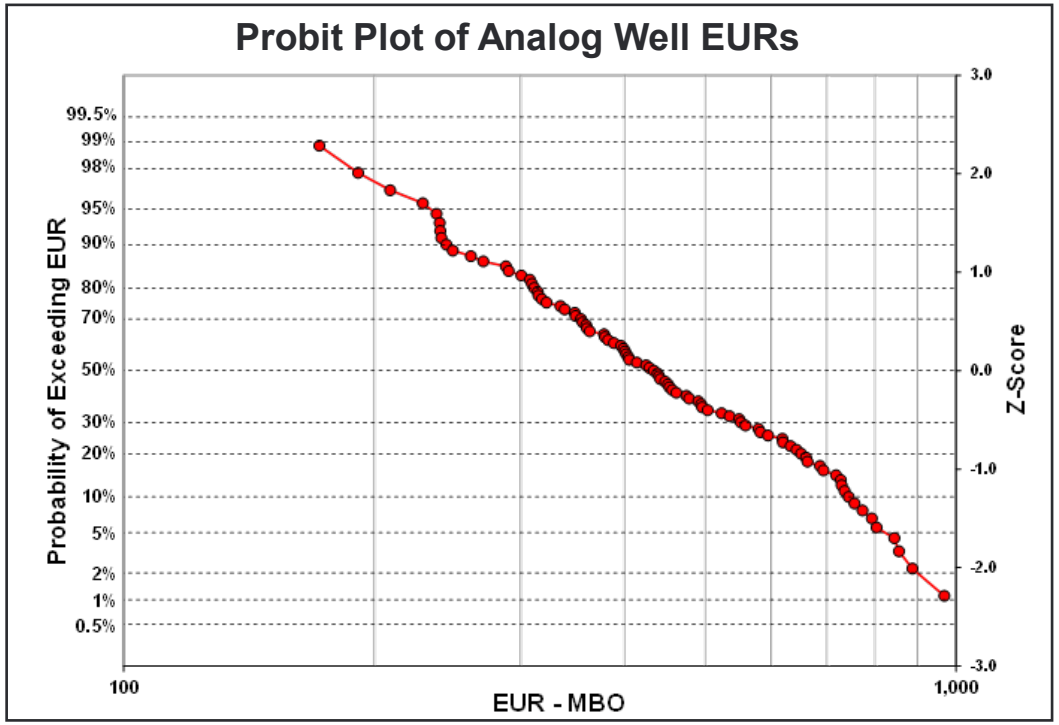
- When using a TWP to forecast performance for a small number of wells, accept that the well count is insufficient
  - For the TWP to accurately reflect the central tendency of the aggregate outcome
  - For the performance statistics of the underlying analog wells to accurately reflect the distribution of performance among the wells to which the TWP is applied



ELEMENTS OF UNCERTAINTY

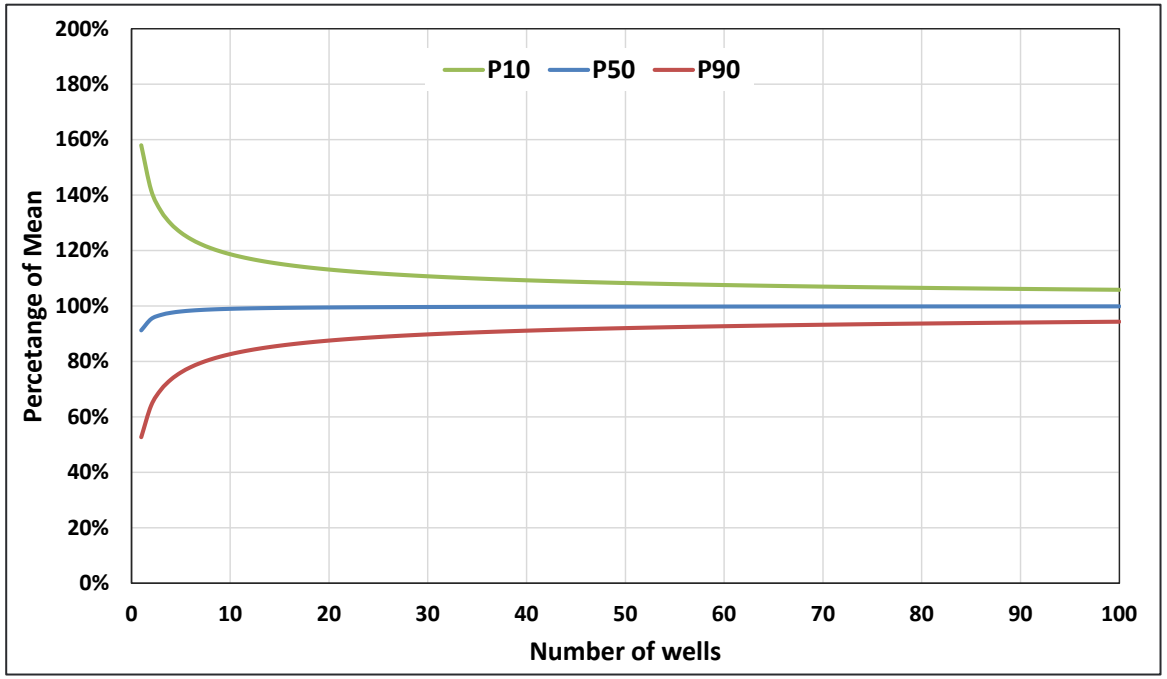
MISCONCEPTIONS OF UNCERTAINTY FOR A SINGLE DRILLED WELL

- Given an identified EUR distribution for a group of analog wells, and given any single well drilled, one might expect:
  - That no reasonable certainty exists that the single well EUR will match the central tendency of the analog well EUR distribution
  - That the performance of that single well will fall anywhere within the analog well EUR distribution
- In reality, the uncertainty distribution is potentially greater, in part because of:
  - Uncertainty imposed based on analog well count
  - Uncertainty imposed by analog well EUR projections



MISCONCEPTIONS OF THE AGGREGATION EFFECT

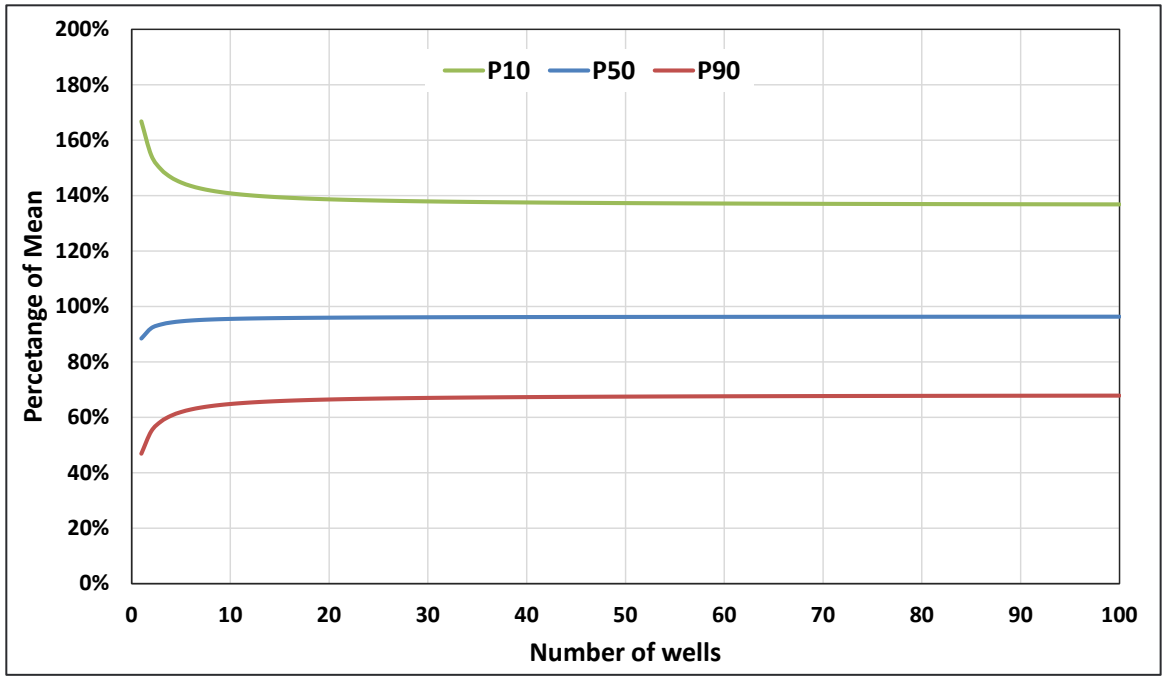
- Common purpose of a trumpet plot is to illustrate the reduction in uncertainty with successive sampling
  - Underlying EUR distribution as the number of wells in a drilling program increases
- Key assumptions:
  - The mean and variance are known (i.e., no uncertainty of the mean)
  - Individual draws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



SOURCES OF UNCERTAINTY

- TWP tends to be single deterministic representation of a potential outcome amidst both uncertainty and natural variability

- Primary elements of uncertainty:
  - Drilling program size
  - Correlation among applied wells
  - Uncertainty based on analog well count
  - Uncertainty of EURs of underlying analog wells



- Incorporating one or more elements of uncertainty, leads to much less aggregation effect

MORE TO COME…

- TWP analysis and selection should be underpinned by consideration of all identifiable uncertainties
- Quantitative assessment of uncertainty can be complex and difficult to fully represent
- Monograph 5 will include a comprehensive process to calculate uncertainty
- Inability to quantify all uncertainties should not preclude representing those uncertainties that can be quantified
- Comprehensive efforts to quantify uncertainty, may still fall short due to unidentified uncertainties

CONCLUSIONS

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

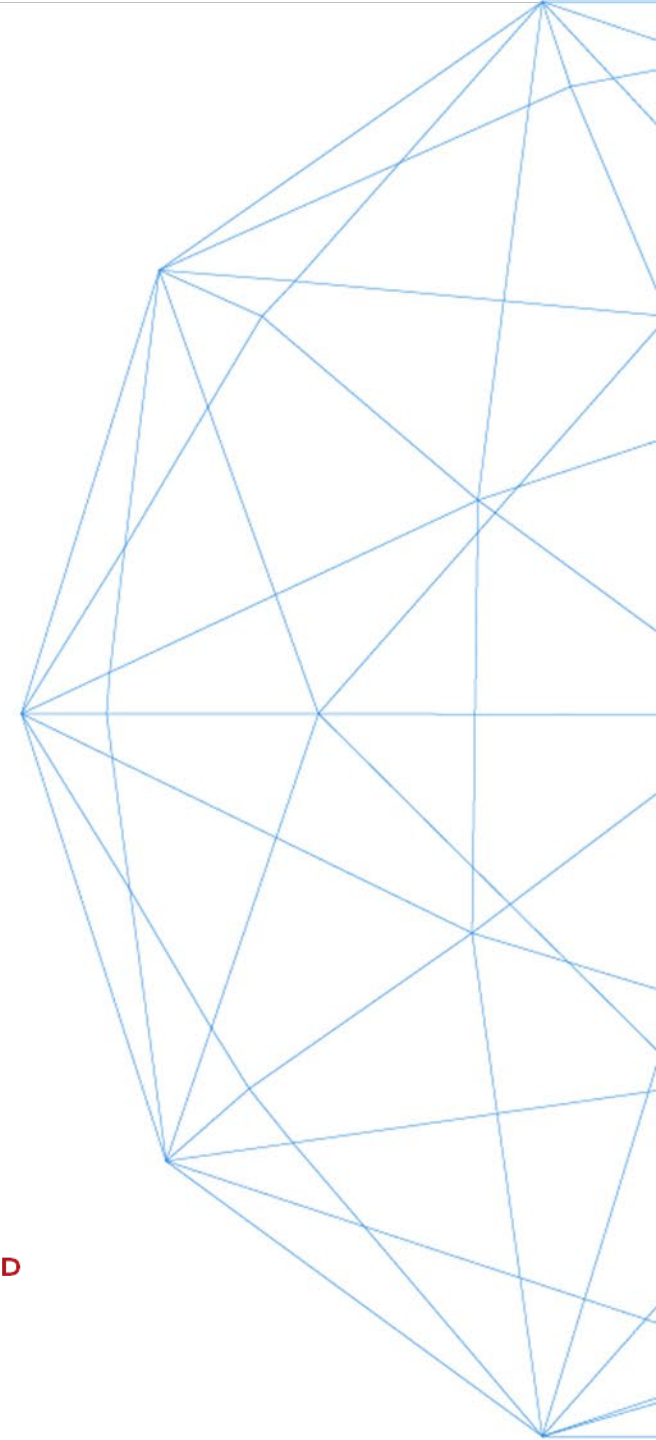
Uncertainty cannot be eliminated, even when drilling large programs

- By not accounting for elements of uncertainty, the evaluator is likely to overestimate the low-side outcome and underestimate the high-side outcome

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

Jennifer Fitzgerald, Monograph 5 Chairperson
Jennifer_Fitzgerald@Oxy.com

https://SPEE.org



LEAD WITH PASSION • OUTPERFORM EXPECTATIONS
DELIVER RESULTS RESPONSIBLY • UNLEASH OPPORTUNITIES • COMMIT TO GOOD