Model Support for Performance Assessment

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Overview

- Background
- Principles and Practices
- Risk-informed Model Support
- Examples
- Conclusions

Key Messages

- Model support is arguably the most essential element of modeling.
- A variety of types of information can be used to provide model support.
- Modelers, by their nature, are biased to being overconfident.
- Natural and dynamic systems can be inherently difficult to predict.

Model Support

- At a minimum, should have elements of verification and validation:
  - Verification – Solving the equations right
  - Validation – Solving the right equations
- A variety of elements can be part of the model support process:
  - internal review (QA)
  - independent external review
  - documentation of verification efforts
  - multi-faceted confidence building effort: comparison to lab experiments, field experiments, analogs, etc.

The Need for Model Support

- Reliance on assumptions in PAs
- Inability to validate models
- Reduce uncertainty
- Provide confidence in modeling

Performance Assessment - Context

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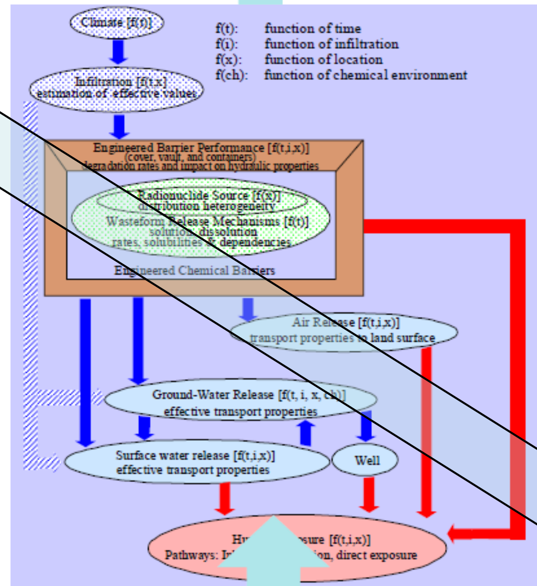
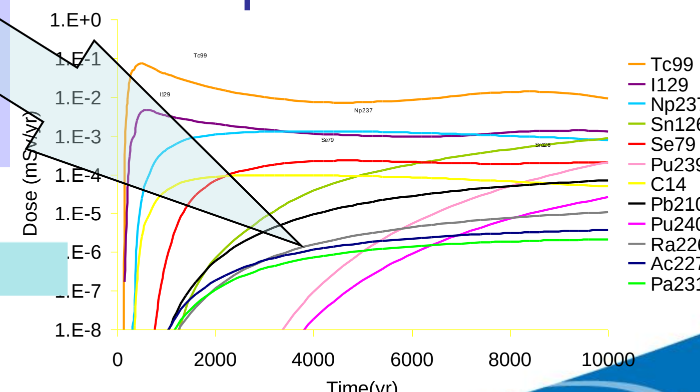
Real system

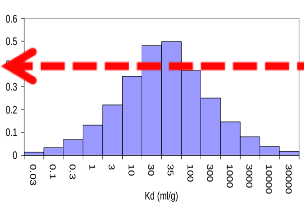


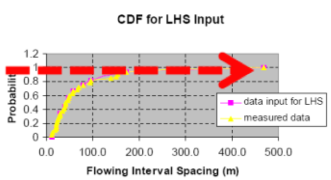
Mathematical model (abstraction)

Estimated future performance



Model Support





Performance Assessment Modeling

- Performance assessment process is iterative.
- Scope should err on the side of completeness initially.
- Models should be as simple as possible, but no simpler.
- Final model complexity should be commensurate with available supporting information.
- Model support activities can be used as a basis to add or reduce complexity.

Risk-Informed Model Support

- Use risk information to determine how much support is needed.
- Sensitivity, uncertainty, and barrier analyses should be considered.
- It is very important to identify features or systems that limit risk.

Table 3-1. Relative Risk and Contributions of F-Tank Farm Barriers to Reducing Risk for Three Key Radionuclides (Tc, Pu, and Np)*

		Tc	Pu	Np	Notes
1	Total Barrier Performance Needed (Function of Inventory)†	6** (Type 1)	9 (Type IV, Tank 18)	6** (Type I)	Factor reduction in concentration needed to meet the §61.41 dose standard. The tank/type producing the highest dose for each key radionuclide is provided in ().
			Engineered System		
2a	Solubility Control	0**	2**	1 to 2**	Final solubility
2b		(9 to 11)¶	(9 to 11)¶	(5 to 6)	Initial solubility
3	Basemat Attenuation (Sorption)	<1	2^	2^	Very important for Pu and Np. Can compensate for solubility.
4	Near-Field Diffusion or Dispersion‡	2^	1^	1^	Additional reduction in concentration due to upward diffusion into tank grout, large cell size, or dispersion.
			Natural System		
5	Aquifer Dilution	1	1	1	Based on simple aquifer mixing model; comparison of concentrations between vadose zone and saturated zones; and between source and POC. Pu sorption can compensate for other barrier underperformance.
6	Sorption	<<1	1**	<<1	
7	Additional Dispersion to POC	1^	1^	1^	
8	Total Barrier Performance	5	8	6 to 7	Sum of rows 2a, 3-7.
9	Calculated Safety Margin	-1	-1	0 to 1	Difference Between Row 8 and Row 1.

*All values in the table are approximate (order of magnitude); values are only intended to provide relative information on the contributions of various barriers in DOE's FTF PA and are not expected to be exact. Many of the values for the various barriers were estimated based on tracking the concentrations of the three key radionuclides from the contaminated zone to the point of compliance in DOE's PORFLOW models for the tank/type listed in Row 1.

†The "total barrier performance needed" is calculated by assuming that the entire FTF tank inventory is located in the pore water of the contaminated zone. While virtually impossible, assuming that the total inventory is available to a potential receptor is necessary to provide a starting point from which to evaluate the contributions of various barriers to reducing risk and to gauge the relative residual risk associated with each key radionuclide listed based on inventory and groundwater pathway dose conversion factor (measure of risk) of each radionuclide. The contaminated zone is assumed to be one inch thick with a porosity of 0.27. For example, a value of "6" for Tc in the first row corresponds to a factor of 10^6 or 1,000,000, the factor by which the concentration in the waste zone needs to be reduced to produce a groundwater concentration at the point of compliance equivalent to 0.25 mSv/yr [25 mrem/yr] TEDE based on DOE biosphere modeling in the FTF PA.

‡Dispersion is used in a broad sense to describe diffusion, numerical, and physical dispersion in DOE's PA models. Because Tc is ultimately assumed to be highly soluble and mobile in DOE's PA model, almost all of the attenuation of Tc is due to dilution and dispersion. No solubility control is assumed for Tc upon transition to the final chemical state.

**Most Tractable

^Potentially Optimistic

Model Support Principles

- Multiple lines of evidence preferred
- Direct observations preferred
- Level of model support ~ risk significance
- Longer experience ~ less support
- Support encompass full range of future conditions

Multiple Lines of Evidence

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- Performance complex
- Variable initial conditions and boundary conditions
- Coupled processes
- Reduce errors
- Increase Confidence

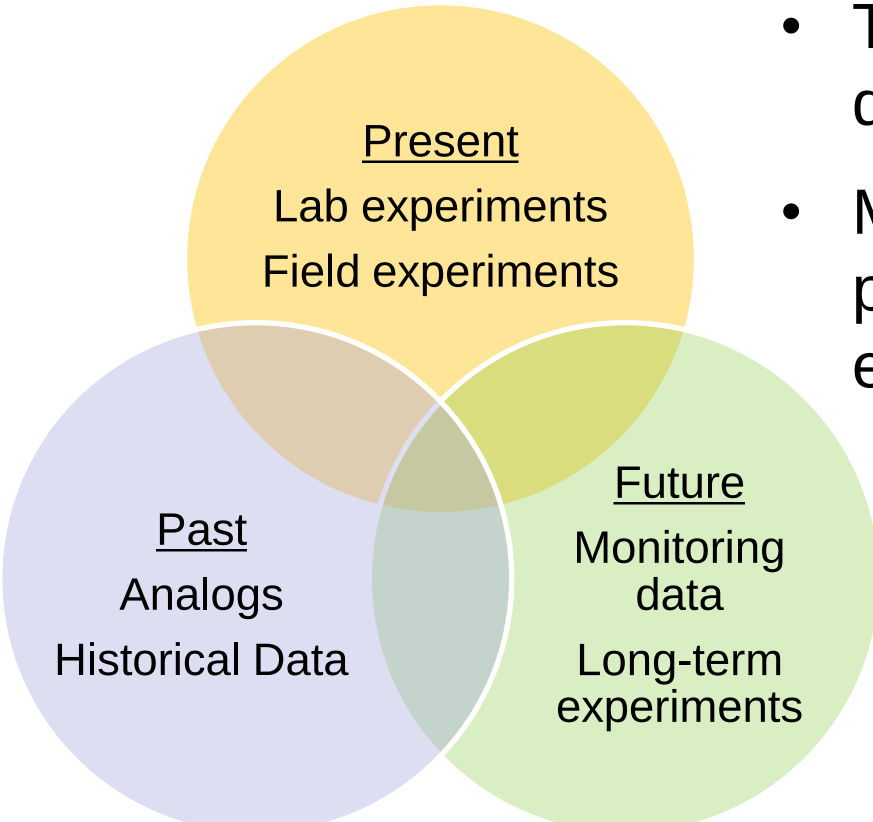
Direct

- Field experiments
- Monitoring data (PI's)

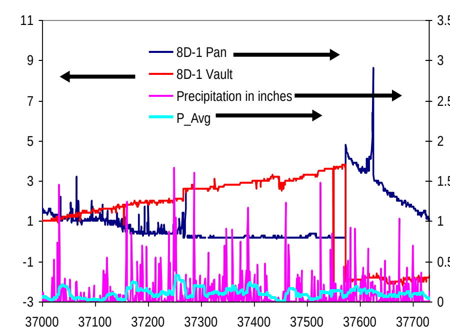
Indirect

- Accelerated laboratory experiments
- Natural analogs
- Expert judgment
- Alternative models
- Past experience

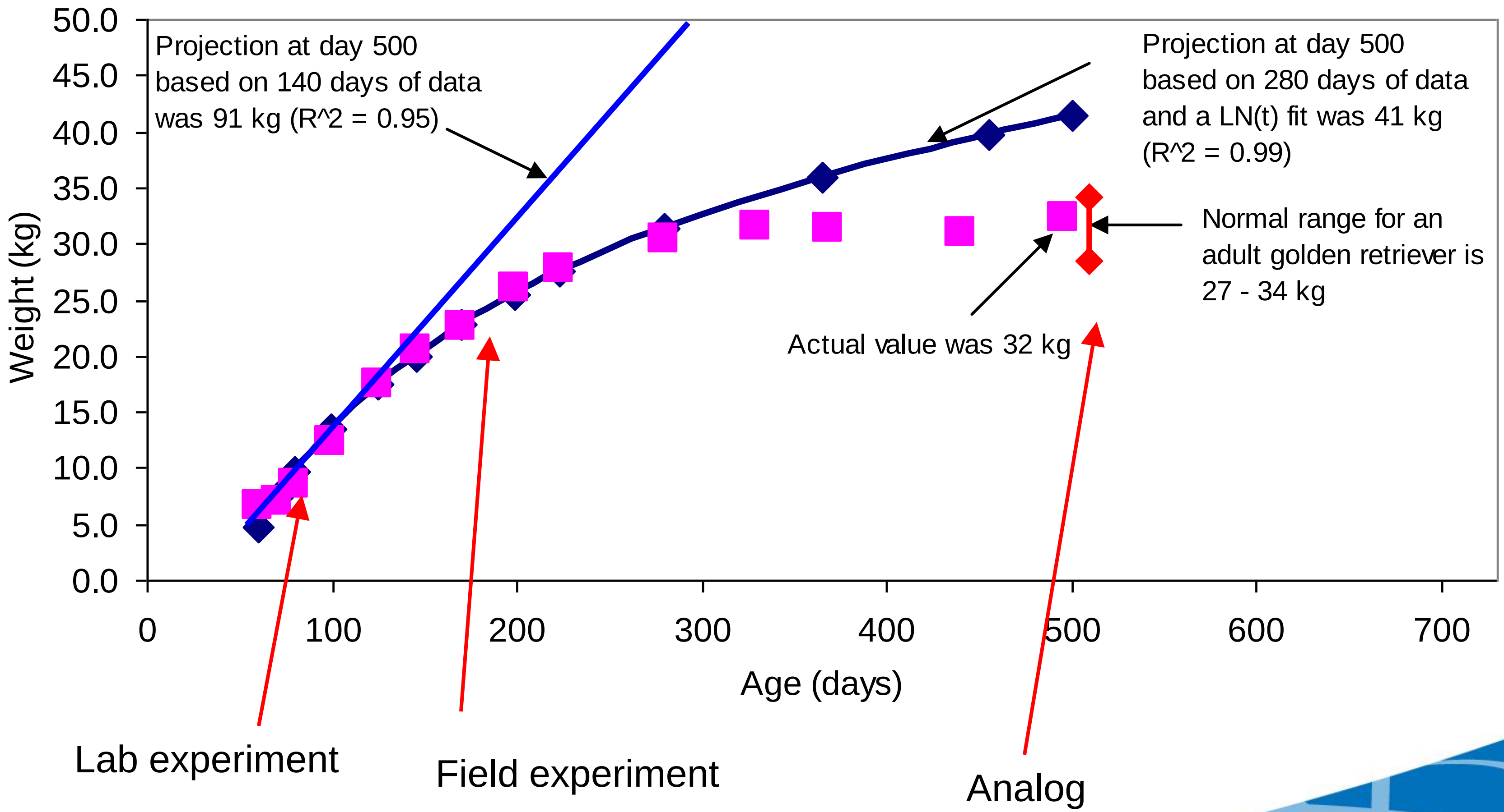
Range of Support



- The real world can be highly dynamic.
- Model support should be provided for the full range of expected future conditions.



Example: Dog Growth Rate



Correlation ≠ Causation

Example: Model Support/ Engineered Barriers

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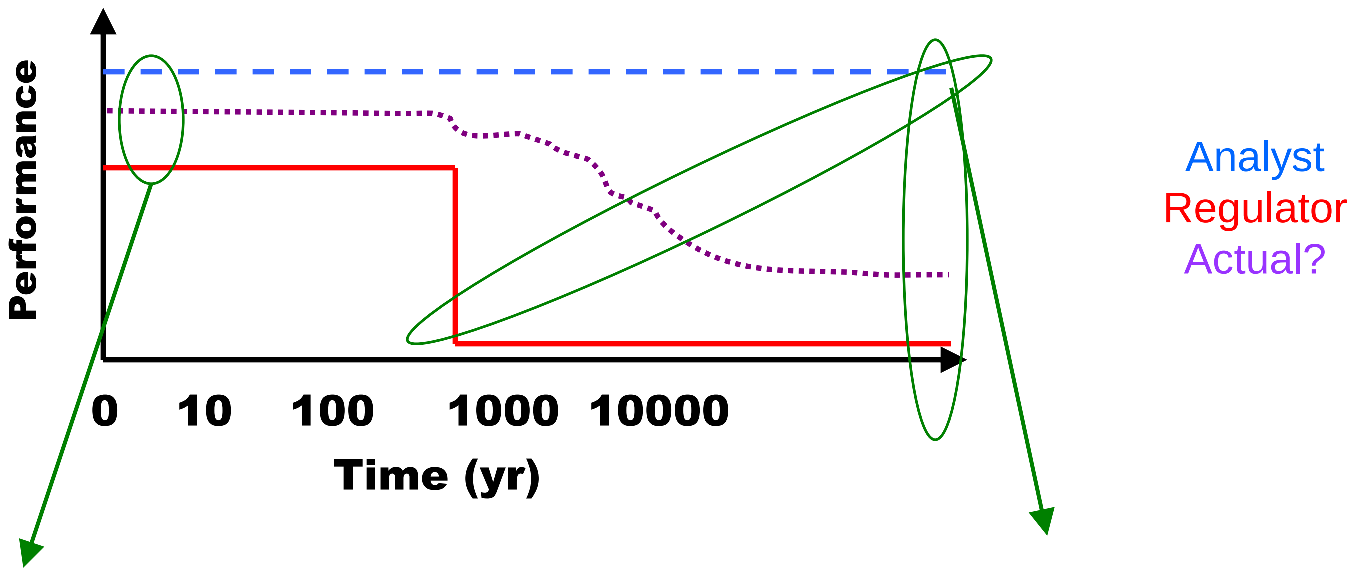
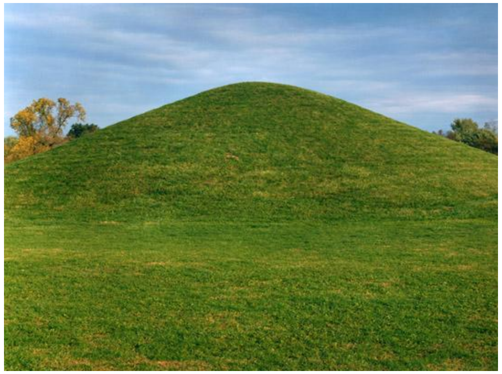


Laboratory experiments
Field experiments
Observations – working systems
Monitoring

Analogs
Accelerated experiments
Expert elicitation
Comparison to other models

Model Support - Natural Analogs

- Data for very long term
- Confirmation bias
- Unknown exposure conditions (past, current, future)




Photos – Terry Johnson (NRC)

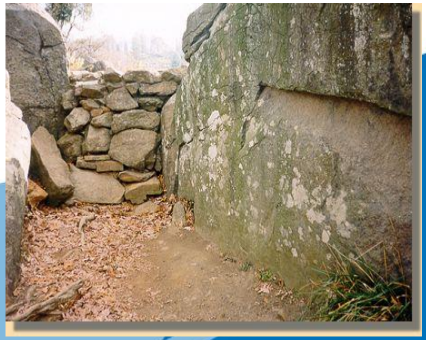
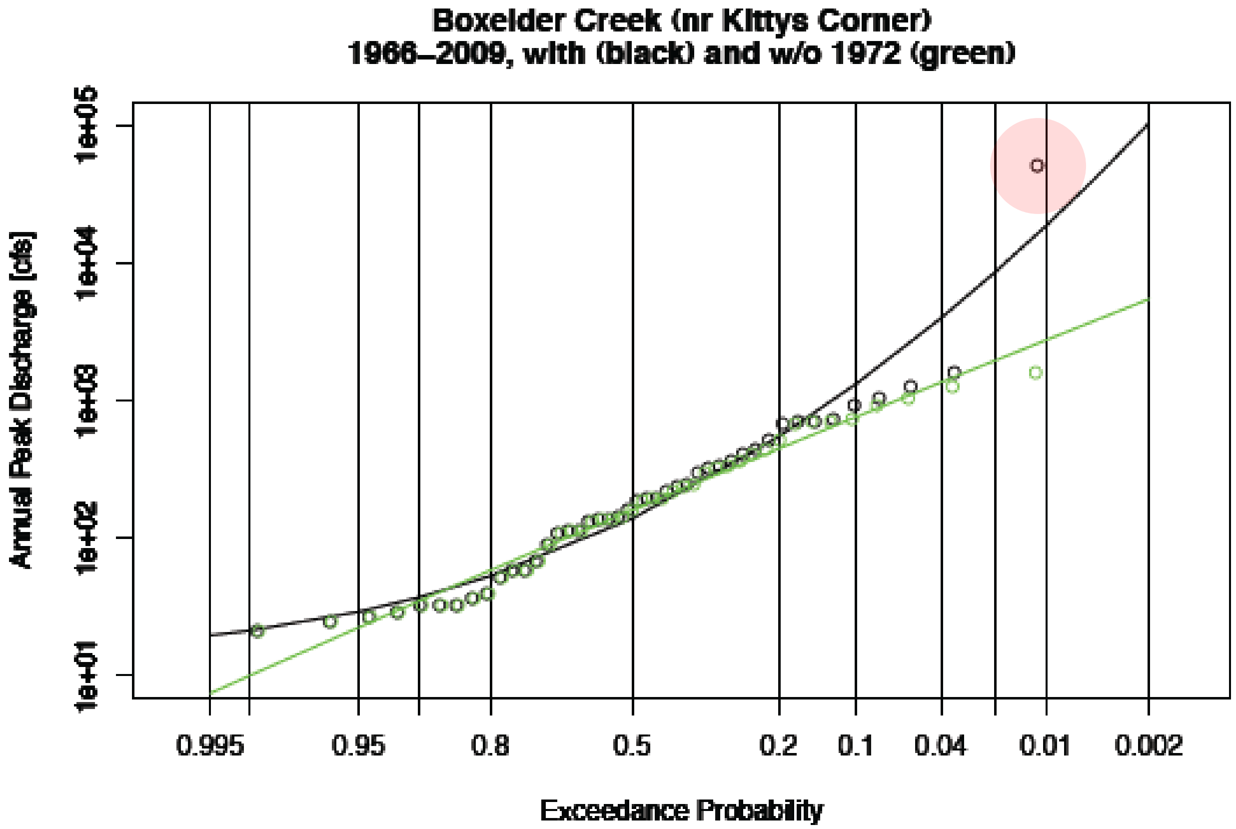



Table 3.1 Examples of Surviving Native American Mounds

Mound	Location	Approximate Age (years)
Grave Creek Mounds	Moundsville, WV	2500
Hopewell Culture Mounds	Chillicothe, OH	2000
Cahokia Mounds	Collinsville, IL	1000
Poverty Point Mounds	Epps, LA	3500
Watson Break Mounds	Monroe, LA	5500

NUREG 1757 Vol2, Section 3.5

Model Support – Flood Example



Tim Cohn USGS – The Value of Paleoflood Information When Estimating Flood Risk (8/23/11)

Model Support – Erosion

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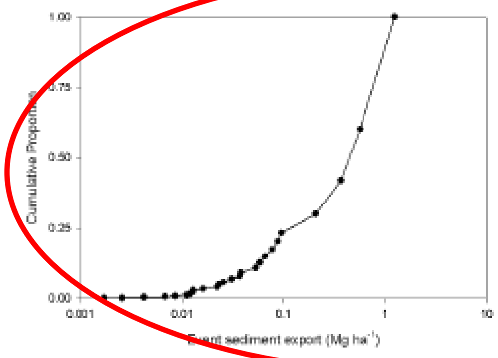
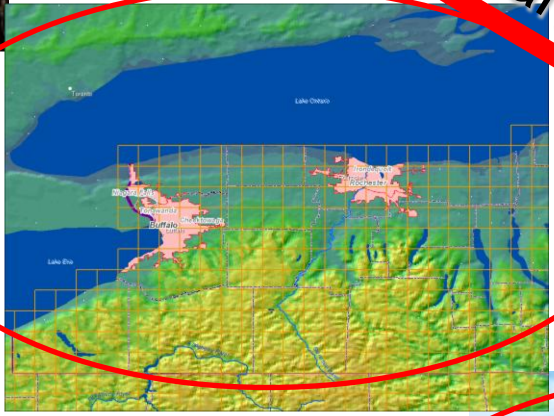
Model Complexity
>>
Model Support!

Complexity and Effort



Comparison of features
Mass balance (watershed)



GIS based analysis
Model comparisons
Analogs

Long-term field experiments
Isotopic studies

Limitations of Model Support Activities

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- Laboratory experiments
  - Are laboratory conditions representative of field conditions?
  - How do you interpret and apply results (e.g., spatial and temporal scaling)?
- Historical data
  - Is the dataset biased (e.g., Pantheon)?
  - Historical record may be limited relative to period of performance
  - Is the historical record a reasonable proxy for future conditions?
  - Limited observations of extreme events
- Expert Elicitation
  - Conflicts of interest
  - Diversity of expert panel
  - Aggregation of disparate opinions
  - Potential introduction of additional uncertainty
  - Defensibility of expert judgements (see NUREG 1563)
- Natural Analogs

Conclusions

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- Following basic principles for model support will increase acceptance of performance assessment modeling.
- Model support is essential to successful decision making.