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NRC's Development and Use of Performance Assessment

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Nuclear Waste Technical Review Board
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Outline

- Key Aspects in Development of a PA Model
- Scope/Level of Detail
- PA Development Process
- Challenges and Lessons Learned

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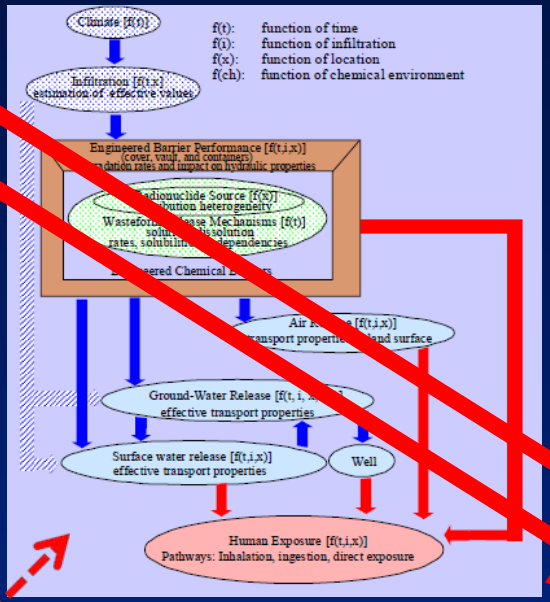
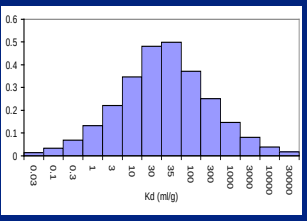
PA Example

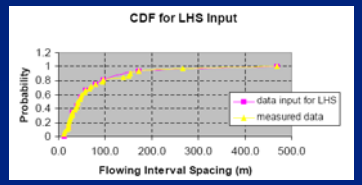
Real system

Mathematical model (abstraction)

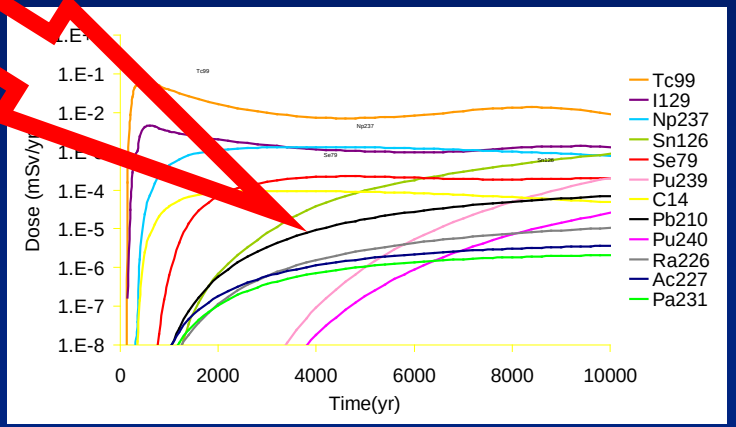


Model Support





Estimated future performance



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Key Aspects

- **Purpose**
  - Why do you need a PA model and what question(s) are you trying to answer?
- **Scope of the assessment (Conceptual)**
  - What to include – why and how (disruptive vs. nominal)
- **Modeling (Numerical)**
  - Complexity, system vs. process, data, model abstraction
- **Uncertainty**
  - Epistemic/aleatory, propagation, risk dilution
- **Model Support**

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Purpose (Decisions) – HLW Example

- **Site Recommendation**
  - ~20 years of site characterization
- **Construction Authorization**
  - ~10 years for license application preparation and regulatory review
- **License Approval (emplacement of waste)**
  - ~3-5 years of data collection during construction application preparation and regulatory review
- **Permanent Closure**
  - ~95 years of performance confirmation (continual learning) data

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Scope/Level of Detail

- **Features, events, and processes (FEPs) widely used**
  - Bottom up (FEP screening), top down (safety function), mix
- **May be iterative**
  - Expert judgment and external review important
- **Real world can be dynamic and complex**
- **One of the harder steps**

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Scope/Level of Detail – non-HLW Examples

Beatty

WIPP

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Model Development

- **Model development is iterative**
- **Modeling generally progresses from simple to complex**
- **Initially data may be sparse**
- **Designs may be evolving**

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Model Development - Initial

- **Scoping/screening – more simple models, limited data, large uncertainties**
- **Example - HLW site characterization and design**
  - general concepts and parameters
  - large uncertainties (limited data)
  - evolving design
  - limited availability of site- and design-specific models and parameters
  - limited detailed process level models

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Model Development - HLW (Purpose/Approach)

- **Demonstrate capability for conducting PA (NUREG-1327) - 1992**
  - integrated release standard
- **Include all steps of PA**
  - limited scenarios (e.g., gaseous release, drilling, pluvial conditions)
  - considered disruptive events (igneous activity, faulting)
  - sensitivity and uncertainty analyses
  - identify model improvements and data needs

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Model Development (Mid-stage)

- **Based on initial assessments make improvements**
  - enhance/modify models
  - collect new data
  - add or remove scenarios
  - modify the design

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Model Development - HLW

- **Model enhancements**
  - enhance flow model (e.g., more dimensions, temporal variability)
  - improve transport model (e.g., fracture matrix interaction)
  - include additional processes (e.g., thermal impact, include mechanistic models for waste package failure and water contacting the waste)
- **Data needs**
  - non-vertical flow, plutonium geochemistry, waste package corrosion, waste form behavior
  - igneous activity

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Uncertainty

- Including, evaluating, and understanding the impacts of uncertainties is essential
- NRC has learned many lessons (e.g., risk dilution, representativeness)
- In general, a small number of uncertainty parameters or alternate conceptual models drive the uncertainty in the overall results
  - These are not known a priori!

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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.

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Lessons Learned

- Performance Assessment useful even when data and design are in initial stages of development
- Iterative development is expected – assists integration of data collection and model/parameter enhancements
- Detailed analyses outside of performance assessment useful to informing and assisting model development

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Lessons Learned (cont.)

- Sensitivity and uncertainty analyses were conducted with every version of the PA model
- Given decades of development computer tools will evolve (Fortran – Goldsim)
- Flexibility to incorporate alternative approaches and scenarios - recognition that performance assessment will be used throughout facility development (e.g., performance confirmation)

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Independent Modeling

- Continued evaluation and improvement
- Promotes technical discussions with experts
- Informed by data
- Enhances staff capabilities to review licensee models

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Thank you for your Attention!

Questions?

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Backup Slides

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Performance Assessment Improvements and Analyses

- **NUREG-1464 (1995)**
  - More mechanistic source term model, inclusion of seismicity and magmatic scenarios, dose capability
  - Executive module
- **NUREG-1746 (2001)**
  - Secondary mineral formation on spent fuel dissolution, correlation between sampled sorption parameters for similar species
  - Mechanical failure of waste package due to seismically induced rockfall

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Performance Assessment Improvements and Analyses (cont.)

- **CNWRA 2002-05 (2004)**
  - Finer spatial discretization of repository, inclusion of drip shield, alternative waste package failure mode for igneous scenario, variable flow paths in alluvium, stylized human intrusion scenario
  - Evaluation of barrier capabilities, consideration of 100,000-year time period
- **NUREG-1762 (2005)**
  - Integrated Issue Resolution Status Report
  - Key technical issues

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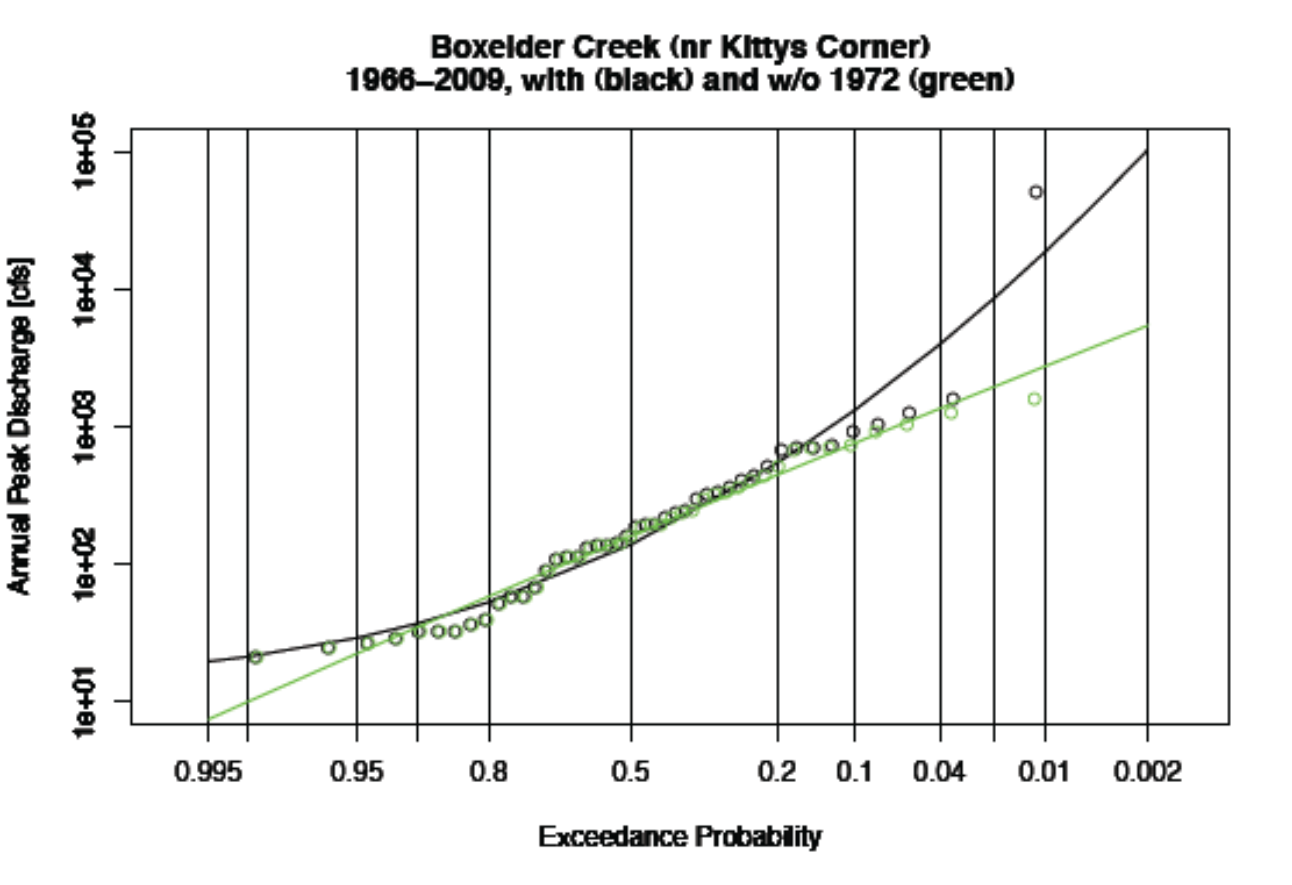
Model Support - Example



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