U.S. Department of Energy
Office of Civilian Radioactive Waste Management

Evaluation of Unquantified Uncertainties and Conservatism

Presented to:
Nuclear Waste Technical Review Board

Presented by:
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Objectives

- Review purpose and approaches to addressing unquantified uncertainties
- Summarize Supplemental Science and Performance Analyses (SSPA) activities to evaluate unquantified uncertainties
- Summarize system-level conclusions for the nominal case regarding the significance of unquantified uncertainties and conservatism
- Outline ongoing and future evaluations of uncertainty

Evaluation of Unquantified Uncertainties

- **Purpose:**
  - To evaluate the significance of uncertainties not quantified in Total System Performance Assessment for Site Recommendation (TSPA-SR) REV.00 ICN 01
  - To develop insights into the degree of conservatism or non-conservatism
  - To evaluate possible differences in uncertainties between different thermal operating modes of the repository
  - To develop guidance for the future treatment and management of uncertainties

Evaluation of Unquantified Uncertainties
(Continued)

- **Activities:**
  - Identification of important unquantified uncertainties
  - Interactive meetings with technical principal investigators to review the current models, their basis, more representative models, availability of data and need for judgment to characterize uncertainties
  - Development of more physically representative models
  - Quantification of uncertainties for new models, often taking advantage of updated data and/or analyses
  - TSPA calculations and sensitivity analyses using the supplemental model for nominal performance

Example of Uncertainty Treatment: Water Diversion of EBS

- **Evaporation of seepage contacting the drip shield (DS) and waste package (WP)**
  - **TSPA-SR Rev. 00 ICN 01: Evaporative reduction in the amount of water contacting DSs and WPs is ignored**
  - **Fraction of heat required to evaporate seepage treated as uncertain parameter**
    - **Two different distributions for the higher- and lower-temperature operating modes**
    - **Potentially reduces the amount of seepage available for transport through the Engineered Barrier System (EBS)**

Example of Uncertainty Treatment: Water Diversion of EBS

(Continued)

- **Condensation under the DS**
  - **TSPA-SR Rev. 00 ICN 01: No model for this process**
  - **If DS is cooler than invert, fraction of water evaporated from invert is assumed to condense and drip onto WP**
    - **Fraction is assumed to vary from zero to one**

Example of Uncertainty Treatment: Water Diversion of EBS

(Continued)

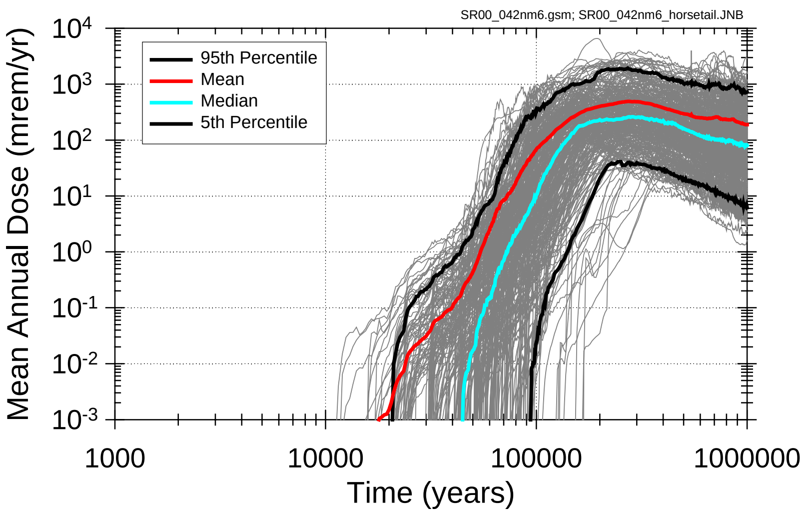
- **Geometrical constraints on flow through DSs and WPs**
  - **TSPA-SR Rev. 00 ICN 01: All seepage falls on the crown of the DS; fluid on DS or WP occurs at the same axial location as the breach; fraction flowing through equals patch length to DS length**
  - **Predictions of the type, number, and timing of breaches from the corrosion model defines time-dependent fluxes that flow through or are diverted**
  - **Droplets fall randomly on a drip shield and random fraction captured by breaches**

Example of Uncertainty Treatment: Water Diversion of EBS

(Continued)

- **Bathtub effect**
  - **TSPA-SR Rev. 00 ICN 01: Advective transport out of the WP is based on a flow-through model that is independent of the location of penetrations through the DS or WP**
  - **Model allows liquid to accumulate in WPs depending location of patches; water eventually released with breach bottom half**

300 Realizations of Million-Year Annual Dose Histories for Nominal Performance



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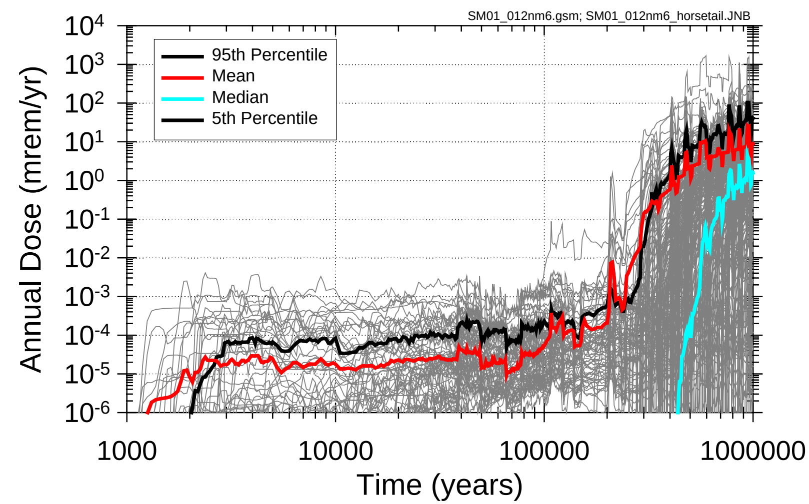

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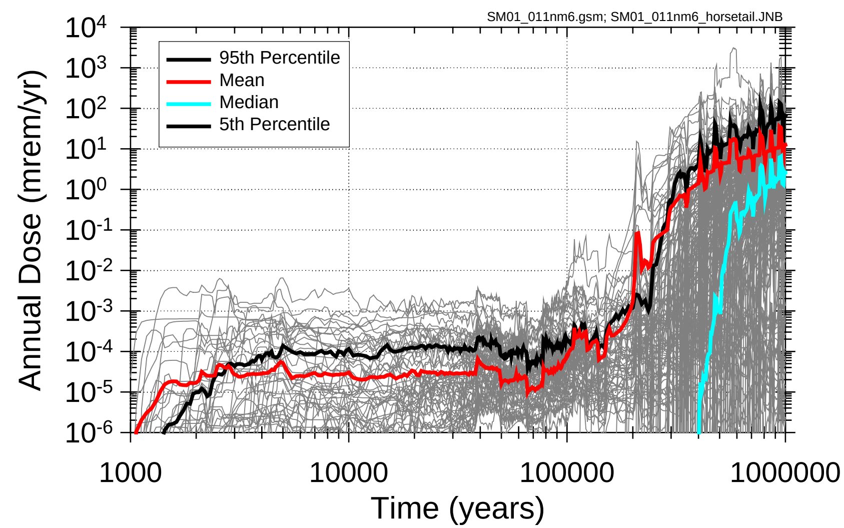
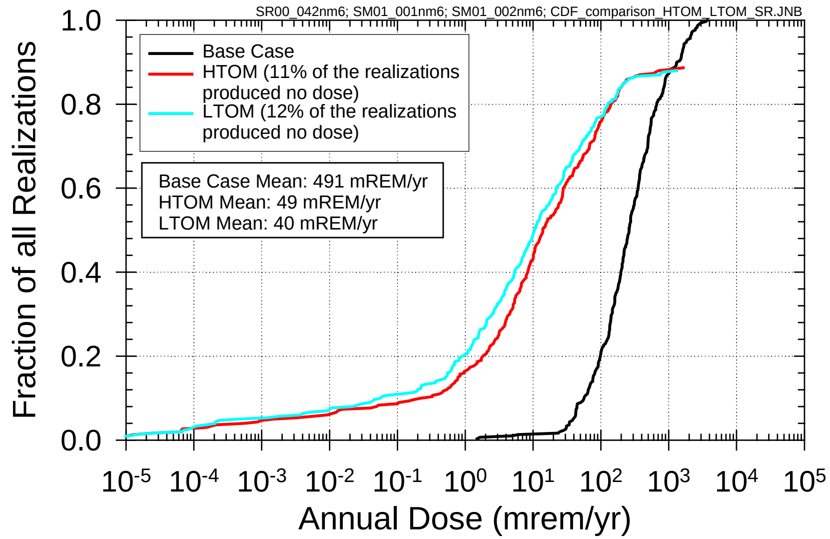


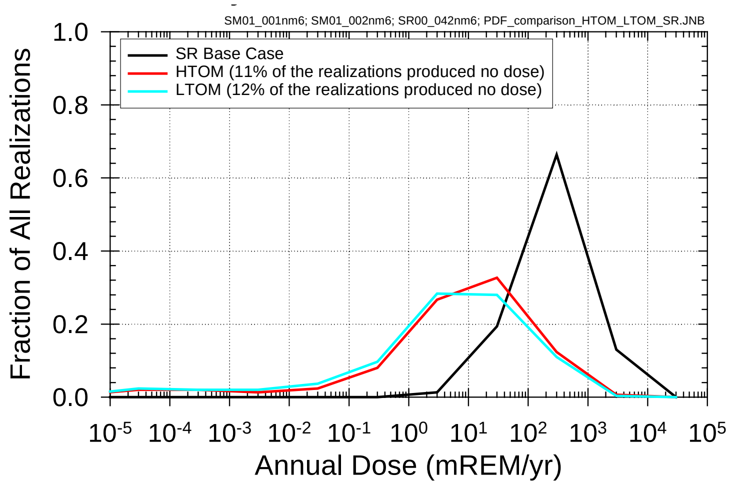
Doses at Particular Times: Peak dose

- Peak dose occurs at about 275,00 yrs for base; about 1,000,000 yrs for supplemental model
- Median (50th percentile) and mean doses for supplemental model are about one order of magnitude less than base case
- Additional quantified uncertainties and updated models lead to a reduction in the peak dose at this time, but also a broader spread in the range of dose rates
- Differences due primarily to revised solubility models, which have lower mean solubility and broader range of uncertainty

Preliminary
Dose Rate CDF, at Time When Mean Peaks

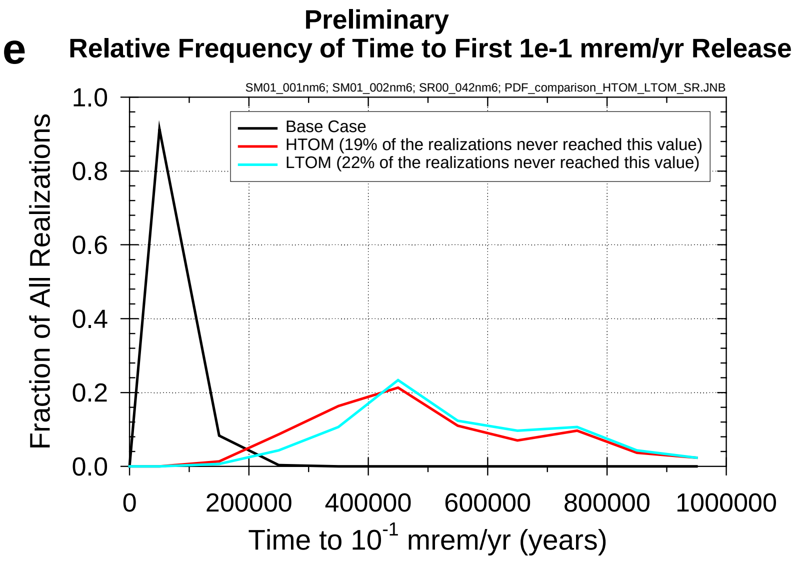


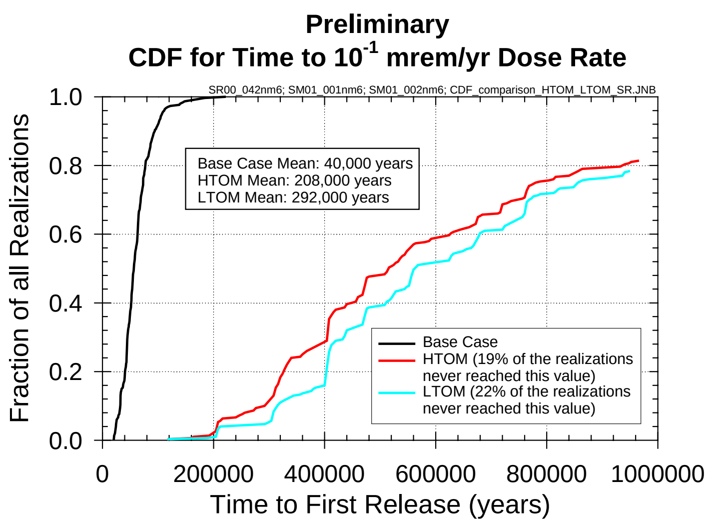
Preliminary
Relative Dose History, at the Time When the Mean Dose Peaks
For 1,000,000 year simulations, 300 Realizations

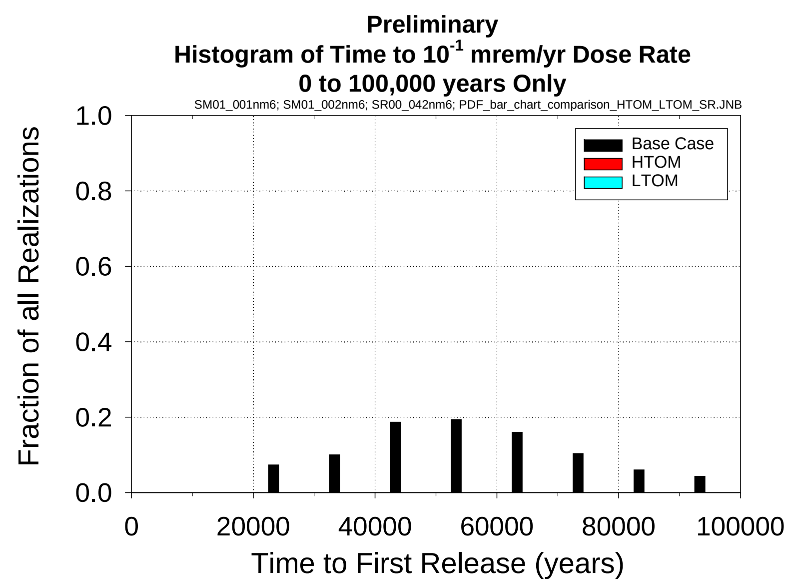


Time to Particular Doses: 0.1 mrem/yr

- About one order of magnitude difference in time to reach 0.1 mrem/yr between base case and supplemental model at 50th percentile
- Broadening in timing due to additional quantified uncertainties
- Related to removal of conservatisms, particularly in WP and solubility models
- Delay in reaching dose by lower temperature operating mode; due to temperature dependence in general corrosion rate







Conclusions Regarding Uncertainties and Conservatism at System Level

- **Supplemental model shows significantly wider ranges of doses at a given time and times to reach given doses**
  - **Represented quantitatively by the distribution of realizations at particular dose rates and particular times**
  - **Broader range is a result of the additional uncertainties and updated models that have been incorporated into the supplemental model**
  - **Simplified or "bounding" models have been replaced with more physically representative models that include quantified uncertainties in their parameters**
  - **Examples are WP degradation modes, diffusive pathways in WP, Np solubility, and saturated zone (SZ) transport**
  - **The low temperature and high temperature operating modes show similar effects of incorporation of uncertainties**

Conclusions Regarding Uncertainties and Conservatism at System Level
(Continued)

- **After the first 10,000 yrs, the base case model appears to be conservative with respect to the supplemental model:**
  - **The magnitude of the dose is less for the supplemental model and it occurs later in time**
  - **Mean estimates provide insight into the magnitude of the conservatism**
    - **At 30,000 years, the difference between the mean estimates of dose rate is about three orders of magnitude, and at time of peak mean dose the difference is about one order of magnitude**

Conclusions Regarding Uncertainties and Conservatism at System Level

(Continued)

    - The mean delay in reaching 0.1 mrem/yr in the supplemental model is about 200,000 years, and in reaching 10 mrem/yr is over 400,000 years
  - At higher doses and later times, low temperature operating mode appears to show lower and delayed doses
- During the period prior to 10,000 years, the base case model appears to be slightly non-conservative with respect to the supplemental model
  - Base case model results in no dose and the supplemental model results in finite, but very low, dose (about 0.00006 mrem/yr)

Ongoing and Future Work Related to Uncertainties

- **TSPA calculations and sensitivity analyses**
  - **Further comparison of performance probability distributions at particular doses and particular times**
  - **Further analysis of intermediate performance measures (e.g., residence time in the unsaturated zone, EBS, SZ) from the SSPA supplemental TSPA**
  - **Conditional assessments with barriers removed**
- **Further evaluations of significance and conservatism**
  - **Identification of contributors, and magnitude of contribution, to uncertainties at particular doses and times**
  - **Judgments regarding potential for future changes, robustness**

Ongoing and Future Work Related to Uncertainties

(Continued)

- Communication of uncertainties
  - Development of approaches to communicate and illustrate significance of uncertainties
  - Communication with decision-makers and public on significance of uncertainties in performance analyses
- Development of guidance for future uncertainty treatment
  - Consideration of lessons-learned from uncertainty review
  - Consistent with licensing strategy, provide guidance on:
    - Instances where uncertainties should be quantified and where they should be bounded
    - Definitions of "bounds" and approaches to their development

Ongoing and Future Work Related to Uncertainties
(Continued)

- Approaches to quantifying uncertainties with specific examples provided
- Probabilistic and statistical tools for developing probability distributions
- Guidance for the documentation of uncertainty characterization

– Outline approaches to uncertainty communication and management