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

Scope/Content/Summary/Results of SSPA Volume 2 - Performance Analyses

Presented to:
Nuclear Waste Technical Review Board

Presented by:
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YUCCA MOUNTAIN PROJECT

Outline

- **Describe purpose, scope, and content of the Supplemental Science and Performance Analyses (SSPA) Report Volume (Vol.) 2**
- **Describe relationship between SSPA Vol. 1 and SSPA Vol. 2**
- **Provide context for interpretation of SSPA performance assessment results**
- **Summarize SSPA Vol. 2 performance assessment results**
  - **Technical basis for SSPA analyses and details of results described in later presentations**

Purpose of SSPA Volume 2

- **SSPA Vol. 2 documents analyses that provide insight into the effects on Total System Performance Assessment (TSPA) of three types of information not addressed in TSPA-SR Rev. 00 ICN 01 (December 2001)**
  - **Uncertainties that were not fully quantified in TSPA-SR Rev. 00 ICN 01**
    - **e.g., conservative assumptions for models, fixed parameter values or distributions, simplifications**
  - **Additional scientific information developed since TSPA-SR Rev. 00 ICN 01**
    - **e.g., updated corrosion model**
  - **Effects of alternative thermal operating conditions, considering other information and quantified uncertainties**

Alternative Thermal Operating Conditions

- **Effects of alternative thermal conditions examined in SSPA by evaluating two repository operating modes**
  - **High-temperature operating mode (HTOM), nearly the same as the design assumptions in the TSPA-SR base case**
  - **Low-temperature operating mode (LTOM), chosen to keep waste package (WP) temperatures below 85°C**

Types of Analyses Contained in Vol. 2

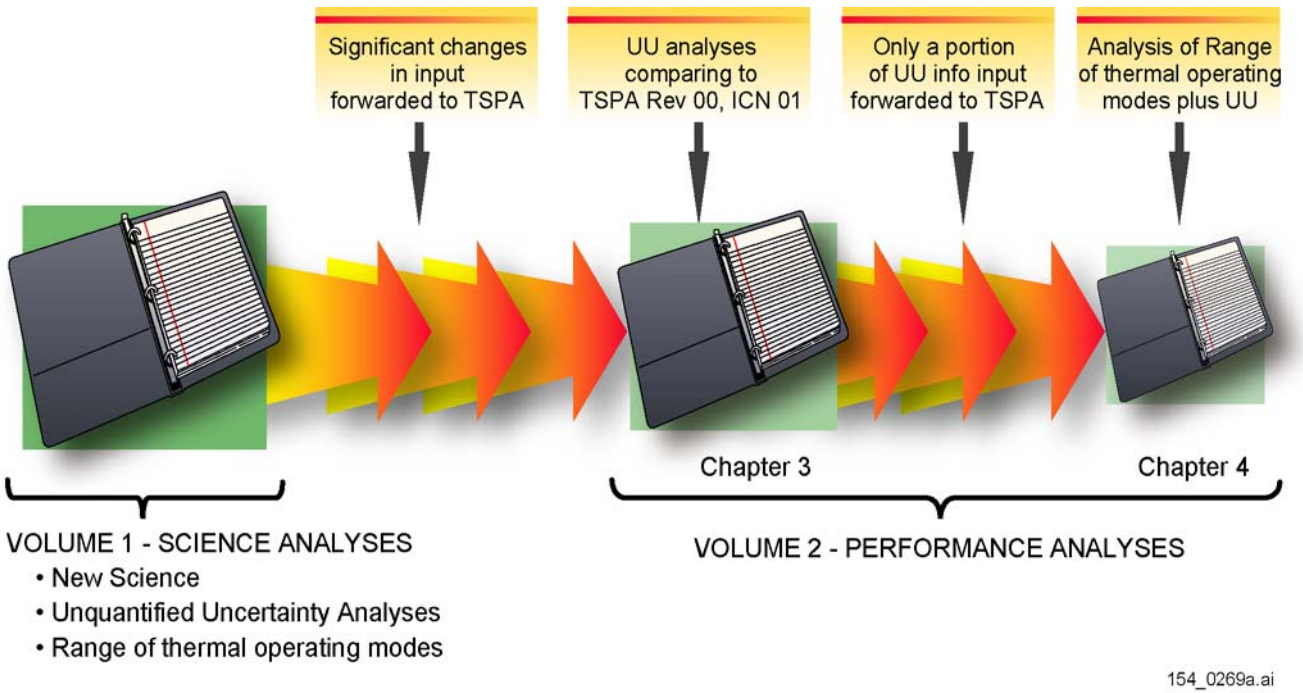
- **Sensitivity analyses using the TSPA-SR Rev. 00 ICN 01 models to examine individual components**
  - **“one-off” analyses, in which all models and parameters are identical to those used in TSPA-SR Rev. 00 ICN 01 except those characterizing the component in question**
  - **Used to examine effects of unquantified uncertainty and new information**
  - **Results are directly comparable to TSPA-SR Rev. 00 ICN 01 at both system and sub-system level**
    - **Differences show what performance would have been if only the component in question had been changed**
  - **“one-off” results do not provide insight into the coupled effects of uncertainty in multiple components**

Types of Analyses Contained in Vol. 2
(Continued)

- **Supplemental TSPA analyses for the SSPA**
  - **Full system-level analysis incorporating**
    - **Major uncertainties identified in unquantified uncertainty work**
    - **Important updates from new information**
    - **Alternative thermal operating modes (high and low temperature)**
  - **System-level results show overall effect of quantified uncertainties and new information on performance of representative high and low-temperature designs**
- **Later presentations will provide detail of model changes, system and subsystem results**

Relationship of SSPA Vol. 1 and Vol. 2

- **Vol. 1 provides technical bases for analyses documented in Vol. 2**
- **“One-off” sensitivity analyses in Vol. 2 and guidance from Vol. 1 determine the content of the supplemental TSPA model**



Outline of SSPA Vol. 2

- Introduction
- Methods and Approach
- Sensitivity Analyses
  - 3.1 System-Level Evaluation--Nominal Scenario
  - 3.2 Subsystem-Level Evaluations--Nominal Scenario
  - 3.3 Evaluations of Disruptive Performance
- Supplemental Total System Performance Assessment Model
  - 4.1 System-Level Evaluations--Nominal Scenario
  - 4.2 Subsystem-Level Evaluations--Nominal Scenario
  - 4.3 System-Level Evaluation of Igneous Disruption
- Summary and Conclusions

Summary List of SSPA Vol. 2 Analyses

New Analyses Reported in SSPA Vol. 2	TSPA Sensitivity Analysis	Included in Supplemental TSPA Model
Post-10,000 Year Climate Model	X	X
Infiltration for post-10,000 yr Climate Model	X	X
Flow-focussing within heterogeneous permeability field; episodic seepage	X	X
Thermal effects on seepage	X	X
Multiscale thermal-hydrologic model, including effects of rock dryout		X
Thermal property sets		X
Composition of liquid and gas entering drift	X	X
Evolution of in-drift chemical environment	X	X
Condensation under drip shields	X	
Evaporation of seepage	X	X
Effect of breached drip shields or waste package on seepage	X	X
Waste package release flow geometry (flow-through, bathtub)	X	
Aging and phase stability effects on A-22	X	
Uncertainty in weld stress state following mitigation	X	X
Weld defects	X	X
Early failure due to improper heat treatment	X	X

Summary List of SSPA Vol. 2 Analyses

(Continued)

New Analyses Reported in SSPA Vol. 2	TSPA Sensitivity Analysis	Included in Supplemental TSPA Model
General corrosion rate of A-22: Temperature dependency	X	X
General corrosion rate of A-22: uncertainty/variability partition	X	X
Stress threshold for initiation of stress corrosion cracking	X	X
Probability of non-detection of manufacturing defects	X	X
Number of defects	X	X
Distribution of crack growth exponent (repassivation slope)	X	X
Effect of HLW glass degradation rate and steel degradation rate on in-package chemistry	X	X
Effect of initial perforations, creep rupture, stress corrosion cracking, localized corrosion, seismic failure, rock overburden failure, and unzipping velocity on cladding degradation	X	X
Solubility of neptunium, thorium, plutonium, and technetium	X	X
Colloid mass concentrations	X	
Diffusion inside waste package	X	X
Sorption inside waste package	X	X
Sorption in invert	X	X
Diffusion through invert	X	X
Effect of drift shadow zone - advection/diffusion splitting	X	X
Groundwater specific discharge uncertainty	X	
Effective diffusion coefficient in volcanic tuffs	X	

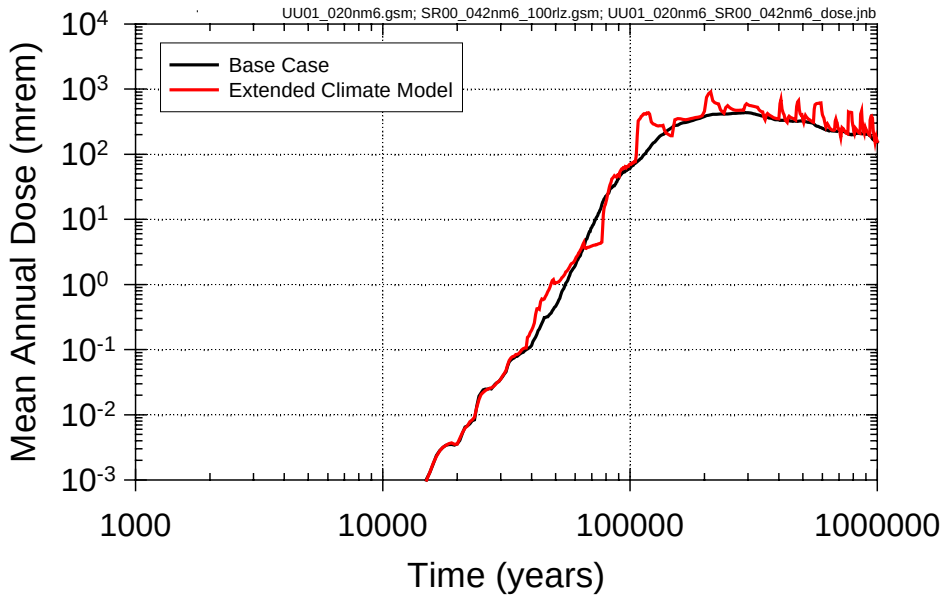
Summary List of SSPA Vol. 2 Analyses

(Continued)

New Analyses Reported in SSPA Vol. 2	TSPA Sensitivity Analysis	Included in Supplemental TSPA Model
Flowing interval spacing	X	
Flowing interval (fracture) porosity, enhanced matrix diffusion case	X	
Effective porosity in the alluvium	X	
Correlation of the effective diffusion coefficient with matrix porosity	X	
Bulk density of the alluvium	X	X
Retardation for radionuclides irreversibly sorbed on colloids in the alluvium	X	
No matrix diffusion in volcanic tuffs case	X	
Presence or absence of alluvium	X	
Sorption coefficient in alluvium for I, Tc	X	X
Sorption coefficient in alluvium for Np, U	X	
Sorption coefficient for Np in volcanic tuffs	X	
Kc model for groundwater colloid concentrations Pu, Am	X	
BDCF's for groundwater and igneous releases	X	X
Probability of dike intersection of repository for 70,000 MTHM, no backfill, design		X
Contribution to release of Zones 1 and 2	X	
Sensitivity to waste particle size distribution	X	
New wind speed data	X	X
Volcanism inputs for Supplemental TSPA Model		X

Results of One-Off Analyses

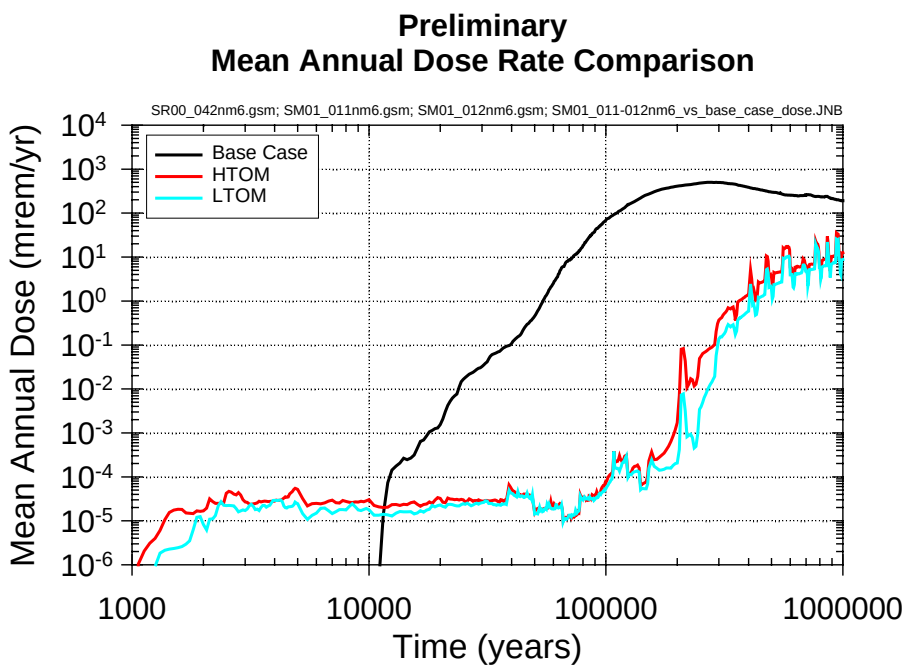
- **One-off results are presented as comparisons of mean annual dose and relevant subsystem measures to TSPA-SR Rev. 00 ICN 01 results**
- **Full distributions of results are available**
- **Additional detail provided in later presentations**



Effects of long-term climate change model shown as an example

Supplemental TSPA Model Results Nominal Performance

- **Million-year dose histories for SSPA analyses for high-temperature and low-temperature operating modes (HTOM and LTOM)**
- **Mean annual dose histories compared to mean annual dose from TSPA-SR Rev. 00 ICN 01**

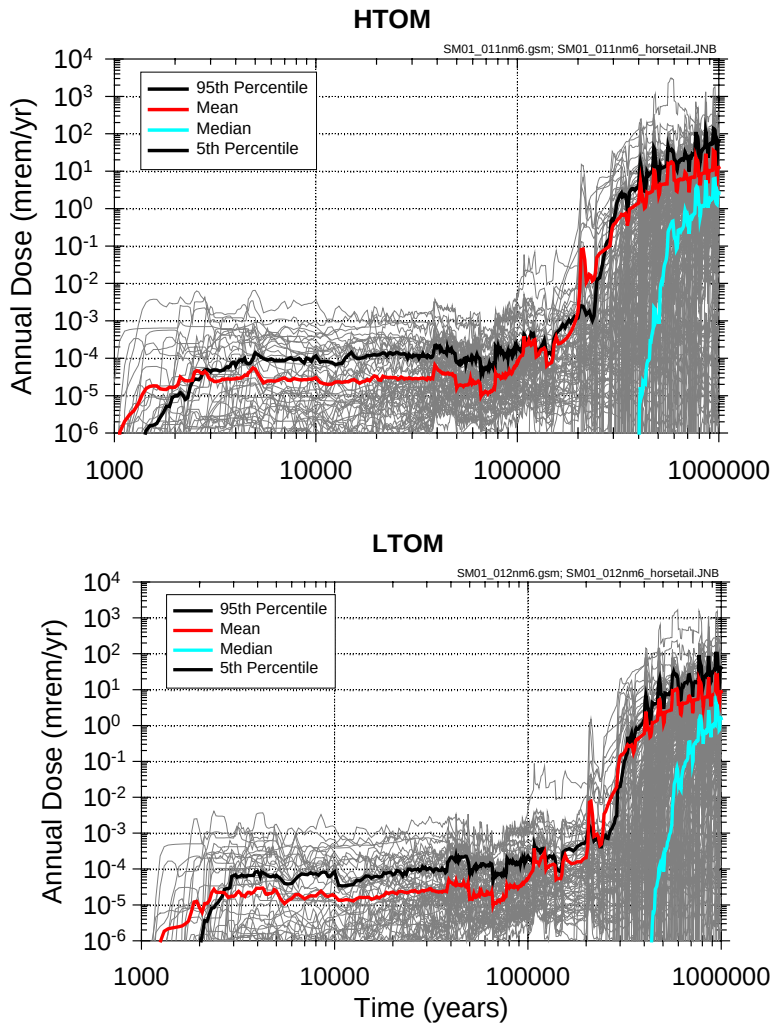


First-order observations from SSPA results
Some early WP failures cause small doses before 10k yr
Slower WP corrosion delays main rise in dose
Lower solubilities lower peak dose
Thermal effects are small at the system level

Supplemental TSPA Model Results Nominal Performance

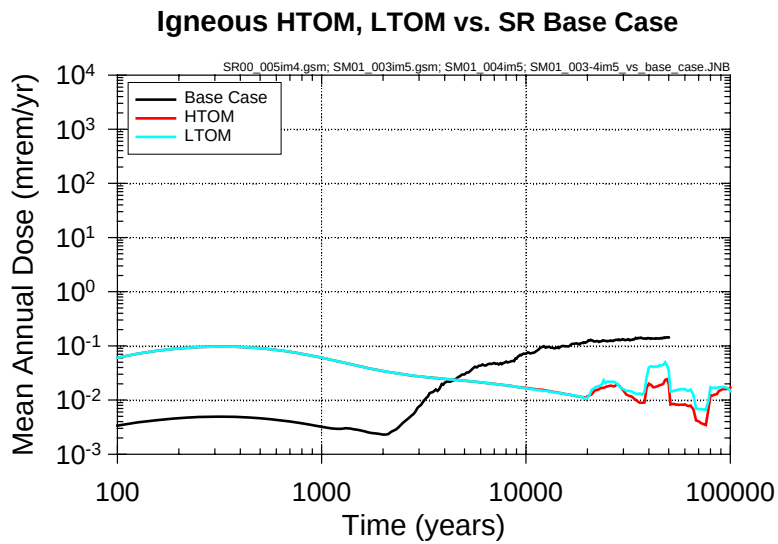
(Continued)

- **300 TSPA realizations shown for HTOM and LTOM, with 95th, 50th, and 5th percentiles and the mean annual dose**



Supplemental TSPA Model Results Igneous Disruption

- **100,000 year dose histories for SSPA analyses for high-temperature and low-temperature operating modes (HTOM and LTOM)**
- **Mean probability-weighted annual dose histories compared to 50,000-year mean annual dose from TSPA-SR Rev. 00 ICN 01**

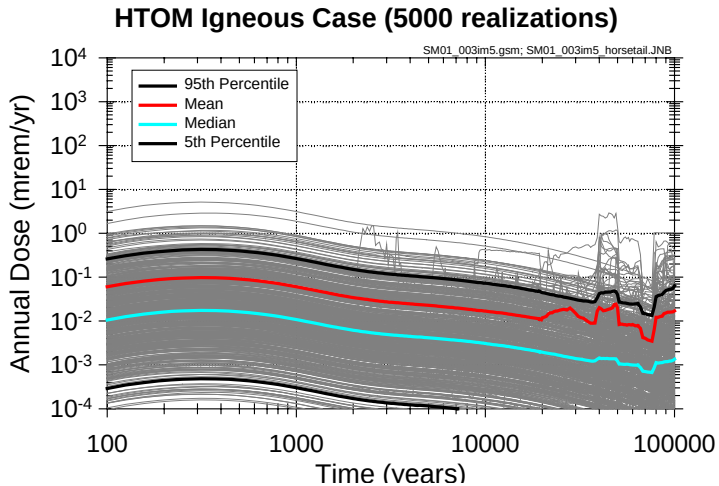


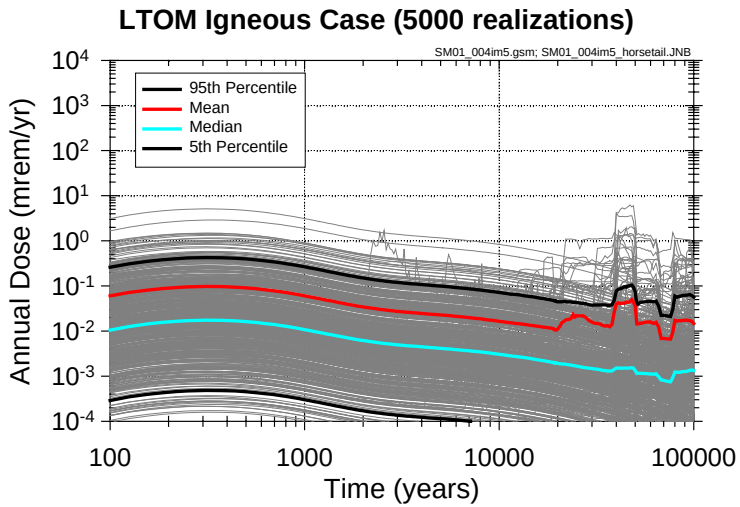
First-order observations from SSPA results
Eruptive doses increase by ~20x, dominate for >10 kyr changes in probability, BDCFs, wind speed, # of packages damaged
Intrusive groundwater doses peak with 38 kyr climate change
Overall peak probability-weighted dose is similar to base case, but dominant pathway shifts from groundwater to eruptive ashfall

Supplemental TSPA Model Results Igneous Disruption

(Continued)

- **500 of the 5000 TSPA realizations shown for HTOM and LTOM, with 95th, 50th, and 5th percentiles and the mean annual dose**





Summary

- **SSPA Vol. 2 contains**
  - **One-off analyses, component-by-component, comparing effects on the TSPA-SR Rev. 00 ICN 01 model of new information and quantified uncertainties**
  - **A supplemental TSPA using updated models to evaluate and compare performance of a high-temperature operating mode (HTOM) and a low-temperature operating mode (LTOM)**
- **Detailed discussions in later presentations will cover**
  - **Quantification of uncertainties and new information, component-by-component**
  - **Alternative thermal operating modes**
  - **Integration of new information into the supplemental TSPA model**
  - **Detailed results of the supplemental TSPA model**
  - **What the uncertainty analyses tell us**