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

Performance Assessment - Natural System Modeling Long-Term Climate in Yucca Mountain Total System Performance Assessment

Presented to:
Nuclear Waste Technical Review Board

Presented by:
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YUCCA MOUNTAIN PROJECT

Outline

- **NWTRB Questions about Climate Model in TSPA**
- **Overview of TSPA-SR model for Long-term Climate (nominal case; extended model)**
- **Effects of the extended climate model on nominal case and peak dose, and igneous intrusion**
- **Effects of the extended climate model on sensitivity studies post-10,000 years**
- **Effects of the extended climate model on multiple barrier and defense-in-depth analyses**

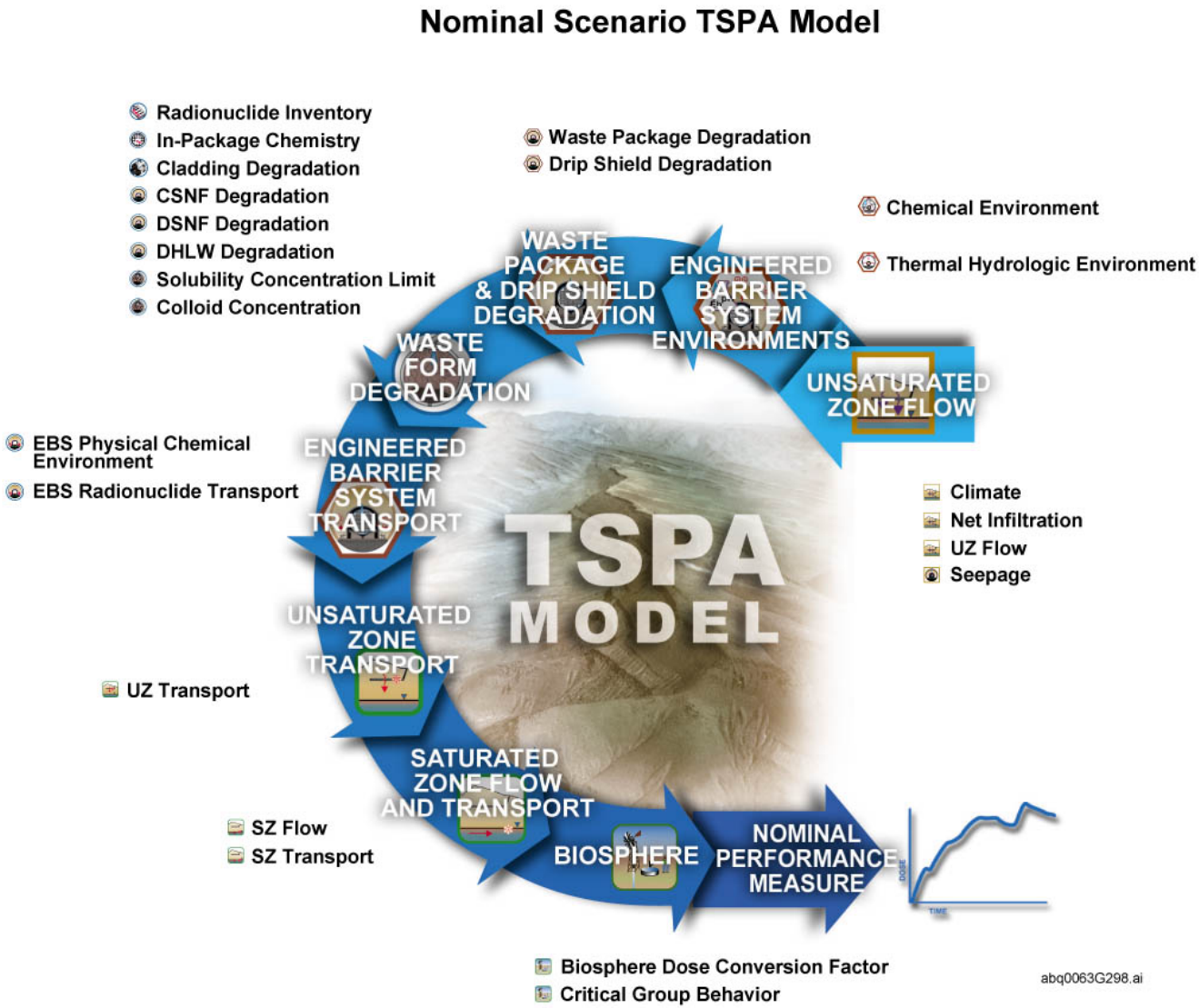
NWTRB Questions on Climate Modeling in TSPA

- ***1) What is the long term climate model and what is it based on? (S. Sharpe-gave basis)***
- ***2) What are the effects of the model (without assuming reduced neptunium solubility through secondary phases of uranium) on the nominal case, peak dose, and the igneous intrusion scenario?***
- ***3) What are the effects of this model on sensitivity studies and neutralization analyses carried out for periods longer than 10,000 years?***
- ***4) How does it affect conclusions about multiple barriers and defense in depth?***

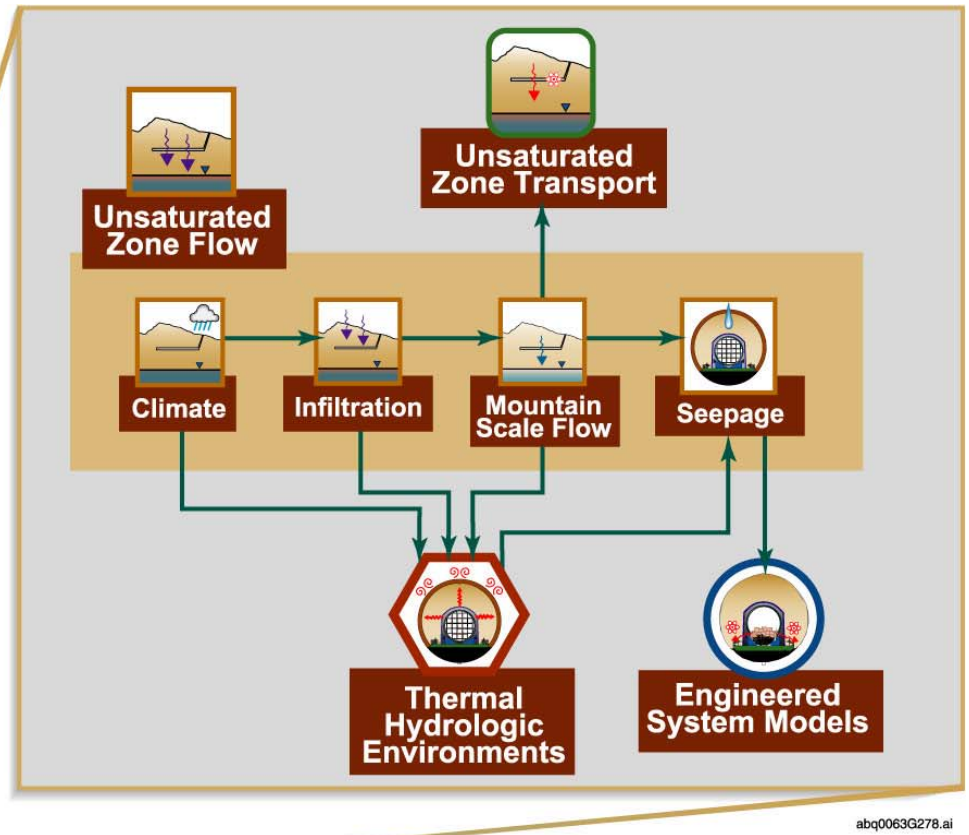
Long-term Climate Model Implemented in TSPA

- **Sharpe's extended climate model provides**
  - **climate state start/duration**
  - **precipitation range**
  - **temperature range**
- **TSPA implementation of extended climate model**
  - **reduces overall number of climate changes**
  - **utilizes a combined monsoon climate state instead of multiple discrete monsoon events**
  - **uses the start/duration as a fixed event (no uncertainty in start time or duration)**
  - **discretizes the precipitation range converted into infiltration into 3 infiltration cases (lo/med/hi)**

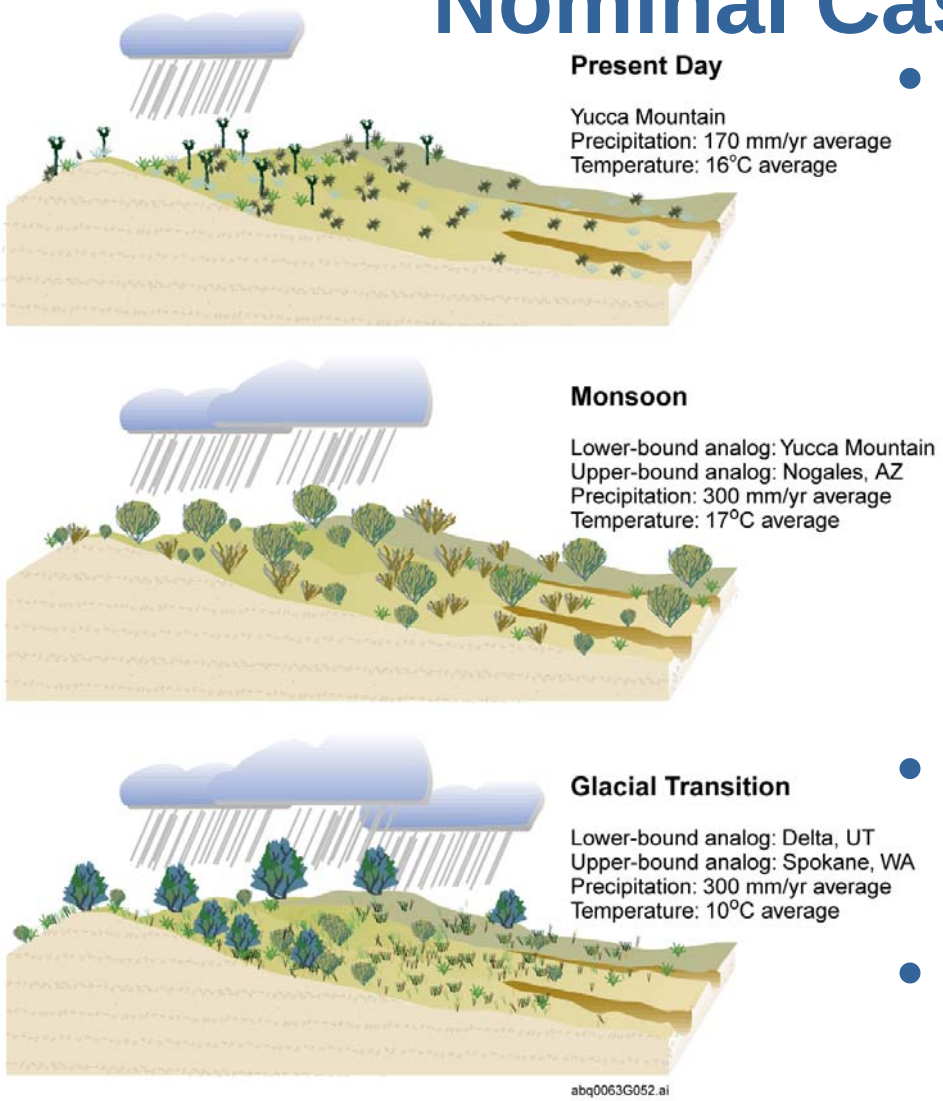
Nominal TSPA Components



Unsaturated Zone Flow Components



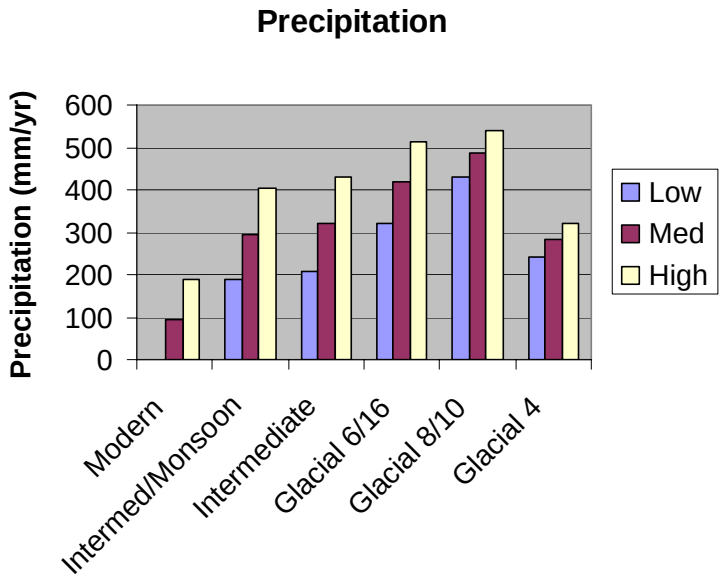
TSPA-SR Rev 00, ICN 01
Nominal Case Climate

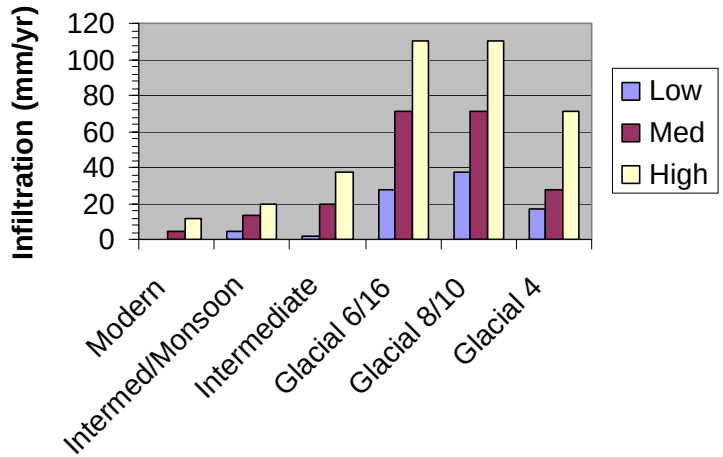


- **Three climate states modeled**
  - **"Interglacial (Modern)" climate for first 600 years**
  - **Wetter and warmer "intermediate/monsoon" climate for 600–2,000 years**
  - **Wetter and cooler "intermediate" climate for 2,000–10,000 years**
- **Beyond 10,000 years assume that "intermediate" climate continues**
- **Weather records from analog sites used to define upper and lower bounds of climate**

Effect of Extended Climate Model on Net Infiltration

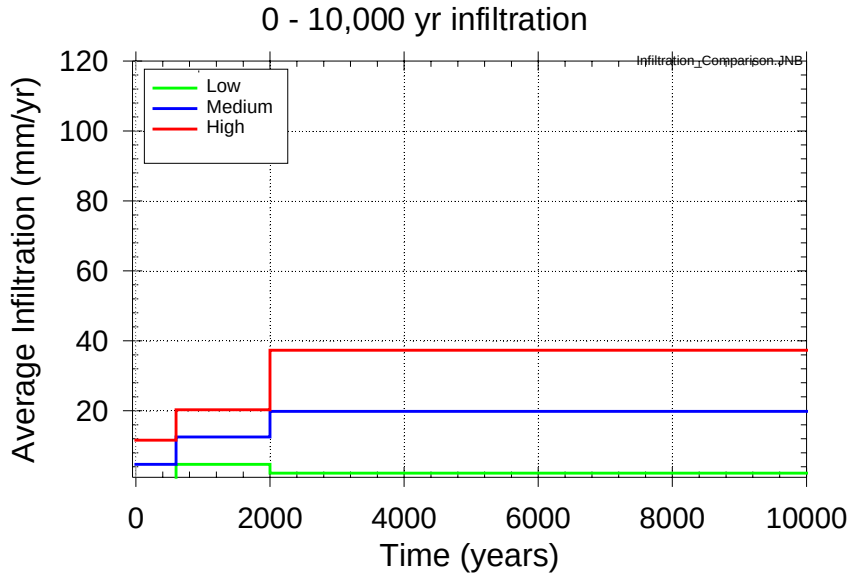
- **Each climate state has a range of precipitation values (low, medium and high)**
- **Each climate state has a range of infiltration values (low, medium, high)**
- **These values are based on extended climate information from analog sites**

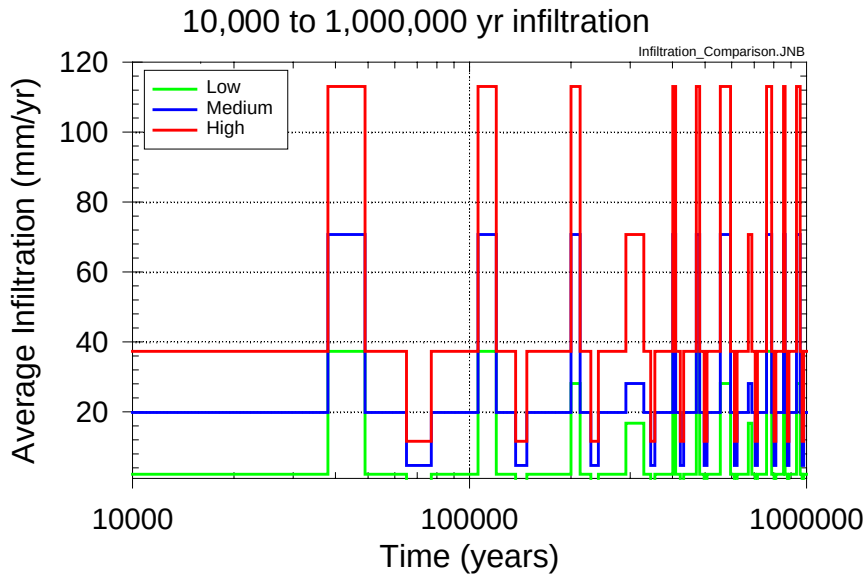




Extended Climate States

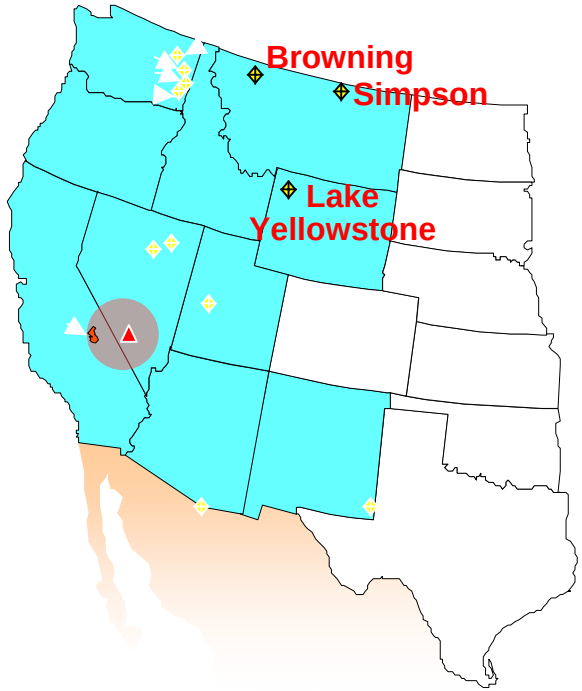
- **Multiple climate states**
  - **Interglacial (same as present-day climate)**
  - **Intermediate**
  - **Intermediate/Monsoon**
  - **Glacial (3 types of glacial states)**
- **45 climate changes in sequence from 10,000 to 1,000,000 years**
- **Low, medium, high infiltration for each climate state**





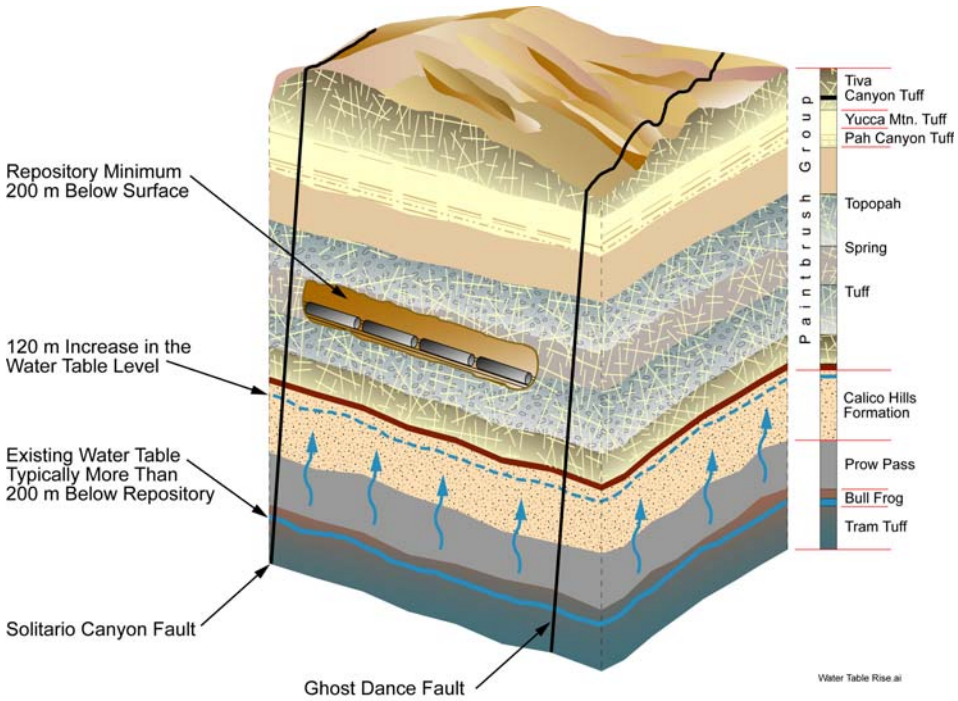
Extended Climate Infiltration Calculations

- **Precipitation and temperature from analog locations utilized to develop new infiltration maps for TSPA model**
- **Ratio of infiltration to precipitation ranges from 6.1% to 21% for the 4 new infiltration maps (0.2% to 8.5% in nominal case)**



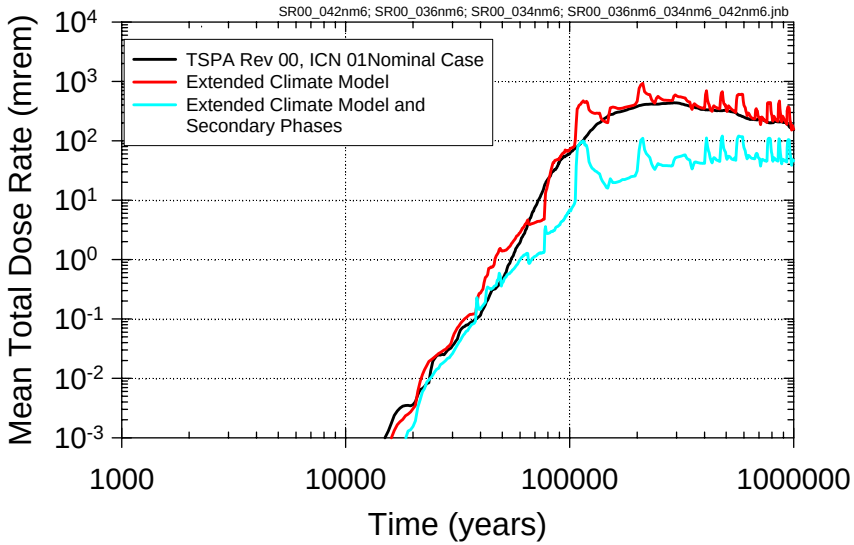
Extended Climate UZ/SZ

- **Four new UZ flow fields, corresponding to the four new infiltration maps**
- **Water table elevation increased by 120 m for wetter future climates (all except interglacial)**
- **SZ Flux multipliers:**
  - **~5 for glacial stage 4**
  - **~20 for glacial stages 8/10 and 6/16**



Effect of Extended Climate on Dose (question #2)

- **Mean dose rates for this case (multiple realization case) are jagged due to the inclusion of 45 additional climate states and flushing in the UZ from water table rise**
- **Mean peak dose rate increases by approximately a factor of 2 at ~250,000 years**

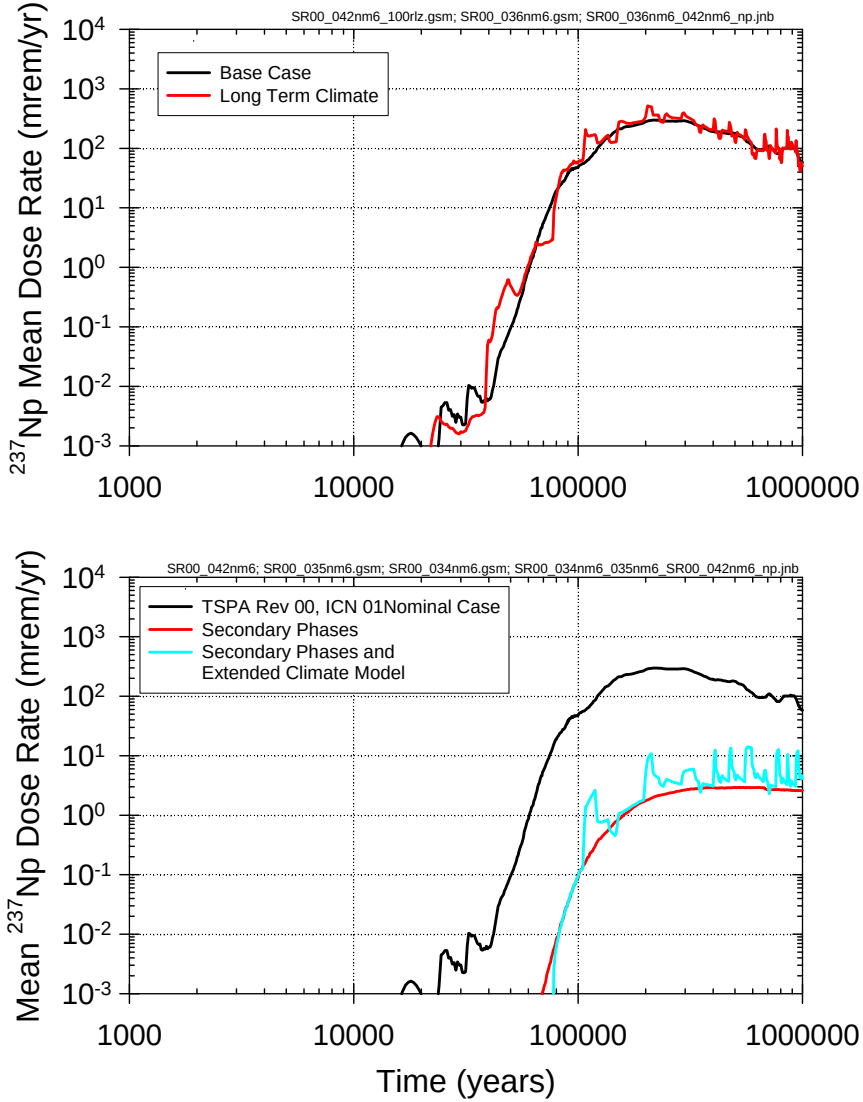


- **No extra dilution is accounted for in SZ model**
- **Glacial climate state at ~40,000 yrs has little affect because doses controlled by diffusive release of Tc, not advective release of Np**

Np Dose for Extended Climate Model

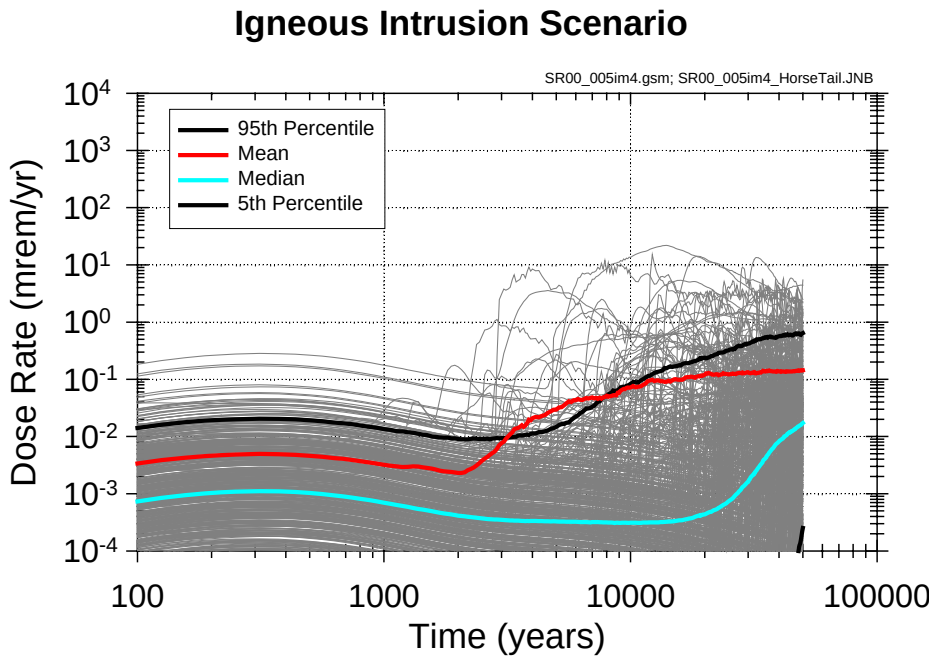
- **Mean Np dose rate shows similar trends as total dose rate with extended climate**
- **Reduction in actinide solubility to account for secondary phases significantly reduces "solubility-limited" doses**

Extended Climate Model without Reduced Solubility: ^{237}Np



Effect of Extended Climate on Igneous Intrusion Scenario (question #2)

- **No additional analyses have been conducted for this scenario**
- **Igneous analyses for TSPA-SR were conducted for 50,000 year time period**
- **First significant climate change after 10,000 years is at ~40,000 years**
- **This is expected to increase the dose at that time, but not to affect the combined dose which is dominated by the nominal dose rate**



- **These doses are weighted by the probability of occurrence of the igneous event (conditional doses were presented in the January Board Meeting)**

Effect of Extended Climate on Sensitivity Analyses Post 10K yrs (question #3)

- **No additional analyses have been conducted specifically to address this question**
- **After supplemental TSPA-SR model is completed, additional sensitivity analyses will be conducted for this model**
- **However, such analyses are not expected to change the conclusions, as the relative significance of seepage and advective releases from the EBS were evaluated in TSPA-SR, Rev 00.**

Effect of Extended Climate on Barrier Importance Analyses (question #4)

- **No additional analyses have been conducted specifically to address this question**
- **After supplemental TSPA-SR model is completed, additional analyses are planned**
- **Incorporation of the extended climate into the existing barrier importance analyses is expected to increase the peak dose, but not change the relative importance of barriers**

Summary

- **TSPA-SR Rev 00, ICN 01 nominal case climate assumes constant climate beyond 10,000 years**
- **Extended climate model developed with 4 climate states (interglacial, intermediate/monsoon, intermediate, and glacial (3 types of glacial cycles))**
- **Implemented in TSPA as 45 different climate periods with range of infiltration but fixed time**
- **Incorporating the extended climate model results in peak dose increases by a factor of 2 at late time**
- **Additional sensitivity and barrier importance analyses have not been completed utilizing the extended climate model**