NRC INSIGHTS ON TREATMENT OF THE NATURAL SYSTEM IN TSPA-VA AND COMPARISONS WITH TPA 3.2

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NRC/DOE Technical Exchange on Total System Performance Assessment for Yucca Mountain

OBJECTIVES

- Outline Approaches Used by NRC and DOE (As Interpreted by NRC) to Develop Abstracted Models of the Natural System for Use in Performance Assessments

- Identify Significant Differences in DOE and NRC Modeling Approaches

- Present Limited Results Depicting the Difference in Repository Performance Estimates Using TSPA-VA "Abstracted Models" and "Parameters" in the TPA 3.2 Code

- Detailed Discussions: Groundwater Velocity in SZ
- (J. Winterle), Retardation in Alluvium (D. Turner), Dose Conversion Factors (P. LaPlante)

NATURAL SYSTEMS

- Infiltration and Deep Percolation
- Unsaturated Zone Flow and Transport
- Saturated Zone Flow and Transport
- Radionuclide Concentration Dilution Due to Well Pumping
- Biosphere and Dose Conversion Factors

INFILTRATION AND DEEP PERCOLATION

- Time Period Of Climate Change
  - TSPA-VA: Sample Range of 0 to 10,000 Years for Present Climate Followed by 80,000 to 100,000 Years of Long-term Average Climate
  - TPA 3.2: 10,000 Years of Present Climate (or Slightly Hotter/drier) Followed by 100,000 Year Wetter/cooler Sinusoidal Climate Cycle

- Average Areal Mean Infiltration at Start
  - TSPA-VA: 3.9 to 11 mm/yr, I=7.65 Mm/yr for 60%, 3×I for 10% and I/3 for 30%
  - TPA-3.2: 1-10 mm/yr Uniformly Sampled for All Sub-areas, 5.5 mm/yr Mean

INFILTRATION AND DEEP PERCOLATION

- Water Table Rise
  - TSAP-VA: 80 m for Long-term Average Climate, 120 m for Superpluvial
  - TPA 3.2: Not Accounted For

- Increased Precipitation at Glacial Max
  - TSPA-VA: Two Times Current for Pluvial, Three Times for Superpluvial
  - TPA 3.2: At Glacial Max 1.5 to 2.5 Times Current

- Change in Temperature at Glacial Maximum
  - TSPA-VA: 10 C Decrease (super pluvial; 6°C for LTA) T [illegible]
  - TPA 3.2: Uniform 5 to 10 C Decrease

INFILTRATION AND DEEP PERCOLATION

- Precipitation to Shallow Infiltration
  - TSPA-VA: Abstractions From Process-level Models of Water and Energy Balance, Including Runoff and Plant Transpiration
  - TPA 3.2: Abstractions From Process-level Models of Water and Energy Balance, Does Not Include Runoff/run-on or Plant Transpiration
- Shallow Infiltration to Deep Percolation
  - TSAP-VA: 3D Steady-state Model, 15 Deterministic Simulations
  - TPA 3.2: No Lateral Diversion, Deep Percolation Equals Sub-area Average Shallow Infiltration

UNSATURATED ZONE FLOW AND TRANSPORT

- Flow From Repository to Water Table
  - TSPA-VA: Detailed 3D Model That Suggests Significant Lateral Diversion
  - TPA 3.2: 1D Vertical Streamtubes for Each of the Seven Sub-areas, No Lateral Diversion
- Matrix Diffusion
  - TSPA-VA: Treated in Transport Model
  - TPA 3.2: Not Accounted for in Unsaturated Zone
- Retardation in Fractures
  - TSPA-VA: No Sorption
  - TPA 3.2: Not Modeled

UNSATURATED ZONE FLOW AND TRANSPORT

- Effects of Intervening Perched Zones
  - TSPA-VA: Low Permeability Region That Laterally Diverts Flow at Base of TSw
  - TPA 3.2: Not Considered

- Flow Model
  - TSPA-VA: Dual Permeability, for Base Case Steady-state Flow is Confined to Fractures
  - TPA 3.2: Fracture Flow When Flow Rate Exceeds Saturated K of the Matrix

- Treatment of Faults As Fast Paths
  - TSPA-VA: Accounted for in 3D Model
  - TPA 3.2: Not Modeled

UNSATURATED ZONE FLOW AND TRANSPORT

- Colloids
  - TSPA-VA: 1D Transport in Fractures with Colloid Partition Coefficient
  - TPA 3.2: Not Modeled

- Dispersion
  - TSPA-VA: Mean Dispersion Length of 20 m over 300 m Thickness
  - TPA 3.2: Longitudinal Dispersion Equal to 10% of Path Length

- Sorption on Rock Matrix
  - TSPA-VA: Kd Approach
  - TPA 3.2: Kd Approach

SATURATED ZONE FLOW AND TRANSPORT

- Darcy Flux
  - TSPA-VA: 2.3 m/yr Long-Term Average in Streamtubes
  - TPA 3.2: Varies Among and Along Streamtubes (Typical Value 0.3 m/yr)

- Treatment of Alluvium
  - TSPA-VA: 10% of Realizations Have no Alluvium in Streamtubes. for 90% That do, Sampled Length Varies From 0 to 6 km
  - TPA 3.2: Varies with Streamtubes (8-12 km). Fixed for All Realizations

- Alluvium Porosity
  - TSPA-VA: Mean of 0.25, Standard Deviation Truncated Normal is 0.075
  - TPA 3.2: Uniform from 0.1 to 0.15

SATURATED ZONE FLOW AND TRANSPORT

- Tuff Porosity
  - TSPA-VA: 1×10^{-5}, 0.02, 0.23 Log-triangular
  - TPA 3.2: 0.001 to 0.01 Log-uniform

- Longitudinal Dispersion
  - TSPA-VA: Mean 2.0, Standard Deviation 0.753, Log-normal
  - TPA 3.2: 0.01 Fraction of Path length for Tuff, 0.1 Fraction of Path Length in Alluvium

- Retardation for Important Nuclides
  - TSPA-VA: Np237, K_d 5-15 mL/g, Uniform; I129 K_d =0; Tc99 K_d =0
  - TPA 3.2: Np237, K_d 1-3900 mL/g, Log-normal; I129, K_d 0-0.23 mL/g, Log-uniform; Tc99, K_d 0-1.7 mL/g, Log-uniform. (Actually Use Rds)

BOREHOLE DILUTION AND TRANSVERSE DISPERSION

- Borehole Dilution
  - TSPA-VA: Not Accounted For.
  - TPA 3.2: Pumping at Receptor Location Uniform From 6,200,000 to 18,000,000 m^3 per Year

- Transverse Dispersion
  - TSPA-VA: Accounted for by Dilution Factor, 1-100 Uniformly Distributed
  - TPA 3.2: Not Accounted For

BOREHOLE DILUTION AND TRANSVERSE DISPERSION

- Equivalence Between TSPA-VA Dilution Factor and TPA 3.2 Borehole Dilution Effect Achieved by Using Pumping Rates (In TPA 3.2) from 146,300 to 14,630,000 m^3 per Year.
  - TSPA-VA: 146,300 m^3 per Year Flows Through Repository Footprint and SZ. Multiply this Flow Rate by the Dilution Factor (1,100) to Obtain Equivalent Dilution Volume.

- For TSPA-VA Radionuclide Concentrations Are Added. This Approach Does Not Conserve Mass, but Would be Conservative From the Standpoint of Safety.

TPA CALCULATIONS WITH TSPA-VA DATA

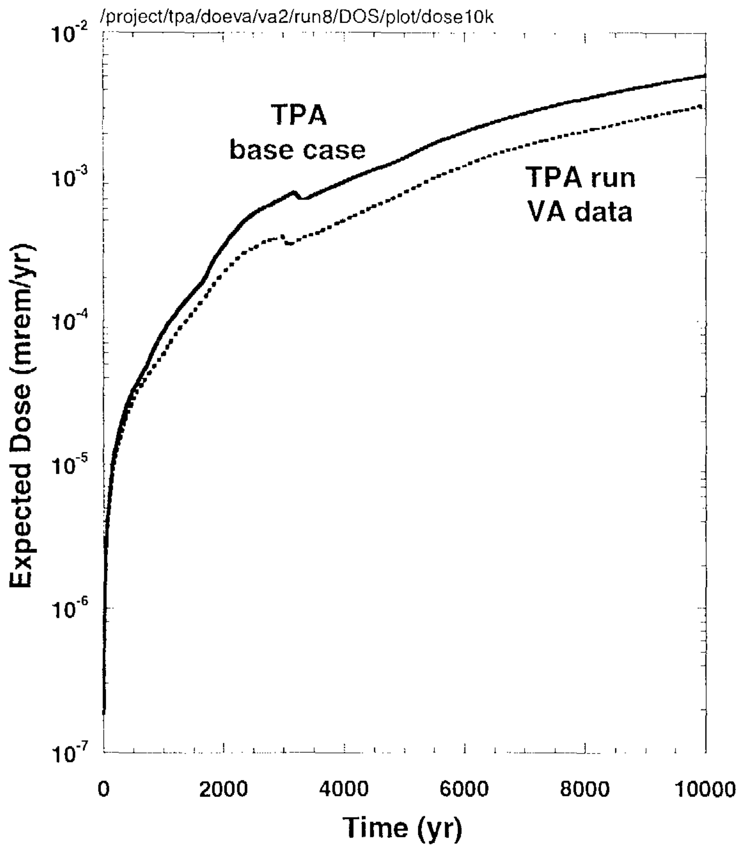
SZFT Transport

Parameter	TPA 3.2	TSPA-VA
Alluvium R_d for Np	Log-normal: 1.0, 3.9×10^3	Log-normal: 8.7×10, 2.6×10^2
Alluvium R_d for I	Log-uniform: 1.0, 4.0	Constant: 1.0
Alluvium R_d for Tc	Log-uniform: 1.0, 30.0	Constant: 1.0
Fracture Porosity Saturated Tuff	Log-uniform: 1×10^{-3}, 1×10^{-2}	Log-triangular 1×10^{-5}, 2×10^{-2}, 2.3×10^{-1}
Porosity of Saturated Alluvium	Uniform: 1×10^{-1}, 1.5×10^{-1}	Truncated Normal: 0.25, 0.075

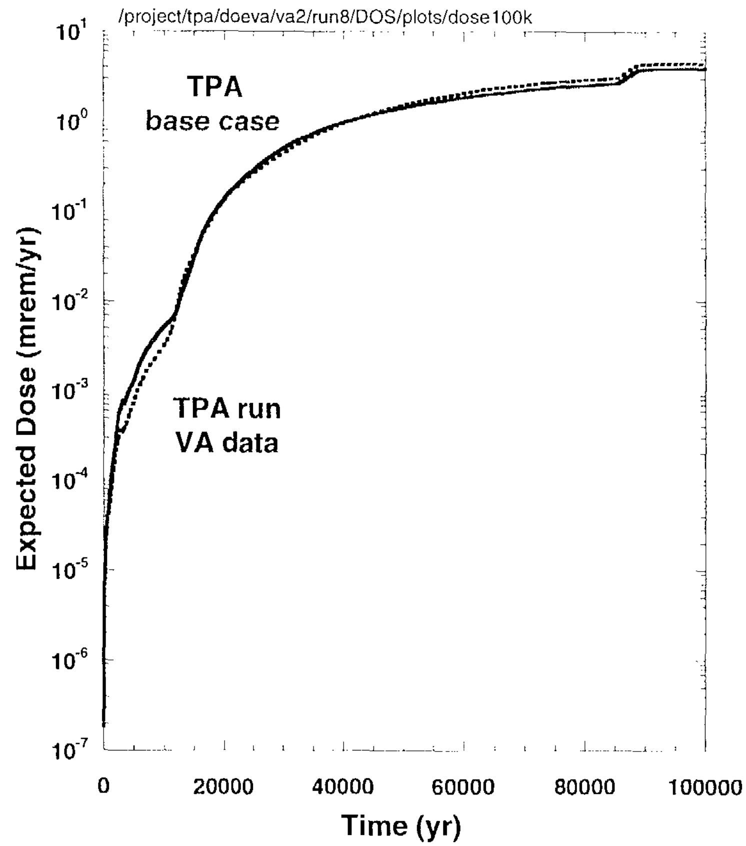
Dilution

Parameter	TPA 3.2	TSPA-VA
Well Pumping Rate for Farming Receptor Group Located Greater than 20 km from YM (Gal/day)	Uniform: 4.5×10^6, 1.3×10^7 (6.2×10^6, 1.8×10^7 m^3/yr)	Log-uniform: 1.07×10^5, 1.07×10^7 (1.46×10^5, 1.46×10^7 m^3/yr)

TPA 3.2 RUN WITH TSPA-VA UZ FLOW AND TRANSPORT

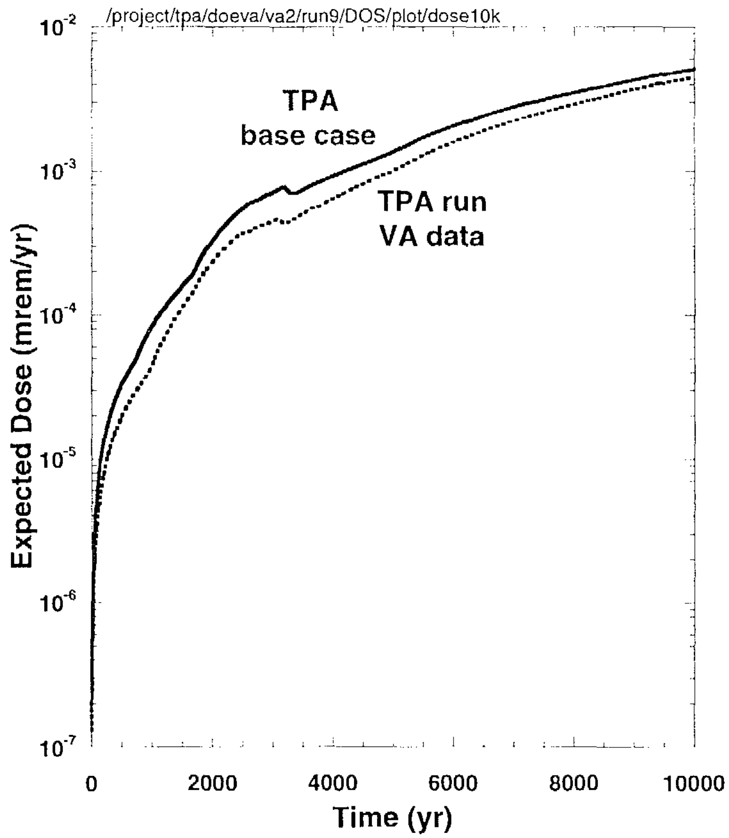


10,000 years

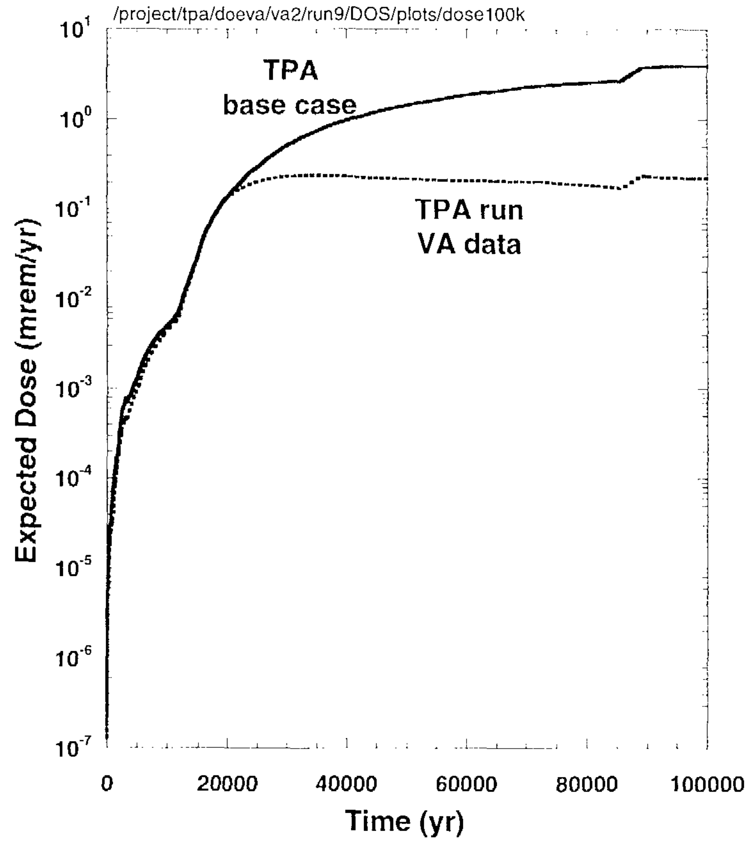


100,000 years

TPA 3.2 RUN WITH TSPA-VA SZ FLOW AND TRANSPORT

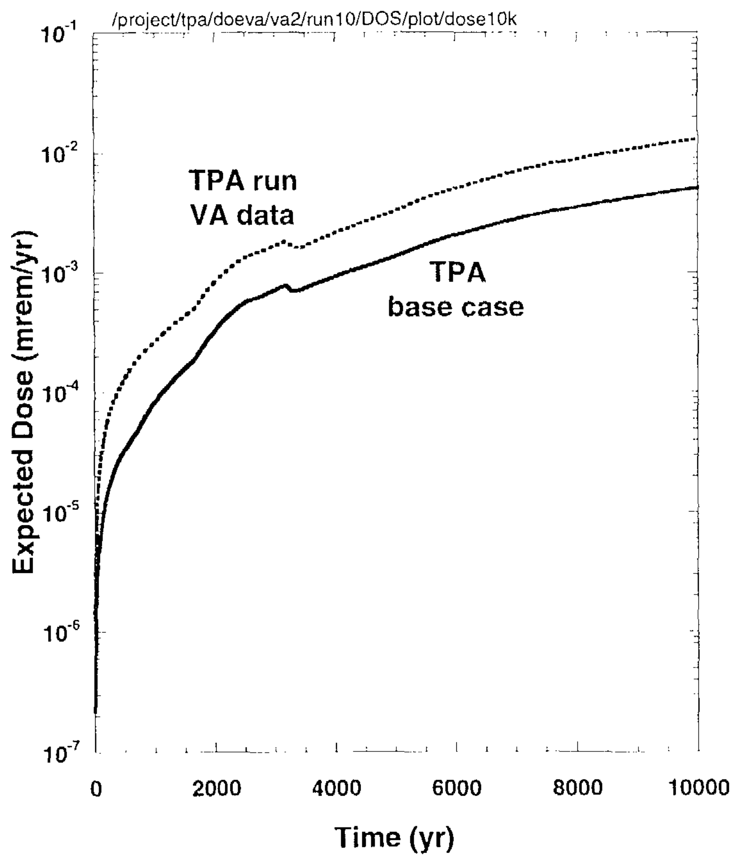


10,000 years



100,000 years

TPA 3.2 RUN WITH TSPA-VA DILUTION



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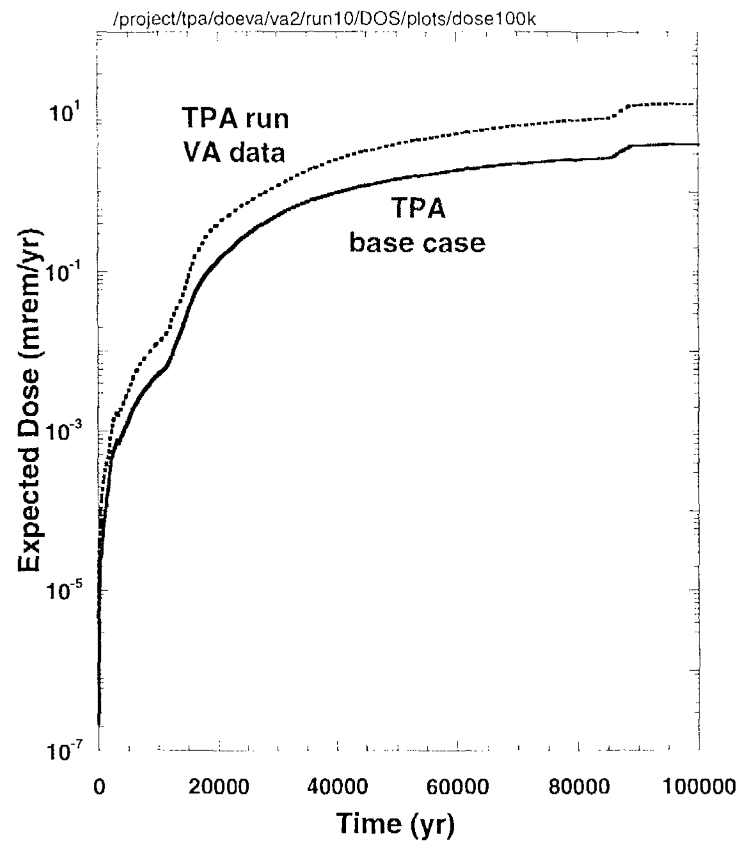

100,000 years

SUMMARY AND CONCLUSIONS

- No Apparent Major Performance-Affecting Difference in Infiltration/Deep Percolation

- Unsaturated Zone Flow and Transport Modeling Approaches Differ. Greater Presence of CHnv in TSPA-VA may Attenuate Release. Matrix Diffusion Does Not Appear to Affect Performance.

- Although TSPA-VA SZ Darcy Velocities are Generally Greater, Use of Higher Effective Porosity Leads to Longer Transport Times Than TPA 3.2

- Smaller Overall Values for Dilution in TSPA-VA Appear to Produce Higher Average Doses than TPA 3.2