U.S. DEPARTMENT OF ENERGY
OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT

NUCLEAR WASTE TECHNICAL REVIEW BOARD
FULL BOARD MEETING

SUBJECT: TSPA FOR YUCCA MOUNTAIN:
SANDIA NATIONAL LABORATORIES
SECOND ITERATION (TSPA-93)

PRESENTER: DR. HOLLY A. DOCKERY

PRESENTER'S TITLE AND ORGANIZATION:
MANAGER, YUCCA MOUNTAIN PERFORMANCE ASSESSMENTS
SANDIA NATIONAL LABORATORIES
ALBUQUERQUE, NEW MEXICO

PRESENTER'S TELEPHONE NUMBER: (505) 848-0730

ARLINGTON, VIRGINIA
JANUARY 12, 1994
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Approach

- Determine important processes and parameters from TSPA-91

- Incorporate design features and issues
  - Thermal loading studies
  - Multiple waste-package concepts

- Develop framework for assessing dose effects
Guiding Elements

- Site characterization prioritization
- Design requirements
- Regulation assessment
Important Processes and Parameters Identified from TSPA-91

- **Aqueous flow**
  - Composite porosity: percolation flux, source term
  - Weeps: fracture aperture, episodicity

- **Gaseous flow**: bulk permeability, retardation, source term

- **Direct releases**: probability of occurrence, source term
Elements in Sandia National Laboratories TSPA-93

Input Parameters
- Hydrogeologic and stratigraphic parameters
- Geochemistry
- Climate change/infiltration flux
- Waste Stream
- Emplacement and thermal configuration
- Radionuclide inventory
- Magma properties and constituents

Derived and Interpreted components
- Geostatistical stratigraphy
- Column locations
- Column stratigraphy

Supporting Calculations
- Saturated zone
- Flow and transport
- Gas flow

Abstracted Models
- Source term
- Repository layout
- Repository area

Results
- Dose
- Cumulative release
- Human intrusion
- Volcanism

TSPA93HD4.PM4.125.NWTRB/1-12-94
## Information Sources for Sandia National Laboratories TSPA-93

<table>
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<tr>
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Three-Dimensional Stratigraphy

- Repository
- TSw
- Vitrophyre
- CHn vitric
- CHn zeolitic
- BFw
- Water table

Elevation (m)

700. 750. 800. 850. 900. 950. 1000. 1050. 1100.

1 2 3 4 5 6 7 8
# Hydrogeologic Parameters

## Matrix Parameters

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## Fracture Parameters

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Percolation Flux Distributions

Complementary cumulative probability

Flux (mm/yr)

10^{-3} \rightarrow 10^{-1} \rightarrow 10^{0}

TSPA-1991 percolation
TSPA-1993 "dry" percolation
TSPA-1993 "wet" percolation
Saturated-Zone Contaminant Plume

Breakthrough for Selected Nodes at 5 km
(file psxxt3dT22b.out Aug 8) PHONE PASS

Potential Repository Location

TSPA93HD10.PM4.125.NWTRB/1-12-94
Geochemical Parameters

### Solubilities

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Thermal Loading

- Vertical-borehole Emplacement, 57 kW/acre
- In-drift Emplacement, 114 kW/acre
Magmatic Effects
CCDF: Composite-Porosity Model, 10,000 Years, 57 kW/Acre, Borehole Emplacement

Complementary cumulative probability

EPA sum

- EPA limit
- Total
- Gaseous (c-p)
- Aqueous (c-p)
- Human intrusion
- Volcanism (direct)
- Volcanism (indirect)
CCDF: Weeps Model, 10,000 Years, 57 kW/Acre, Borehole Emplacement
Cumulative Releases to the Accessible Environment: Composite-Porosity Model, 10,000 Years

Complementary cumulative probability

EPA limit
- 57 kW/acre, vertical emplacement
- 114 kW/acre, vertical emplacement
- 57 kW/acre, in-drift emplacement
- 114 kW/acre, in-drift emplacement
- TSPA-1991

EPA sum
Peak Individual Doses from Drinking Water: Composite-Porosity Model, 1,000,000 Years

Complementary cumulative probability

Peak dose (mrem/yr)

57 kW/acre, vertical emplacement
114 kW/acre, vertical emplacement
57 kW/acre, in-drift emplacement
114 kW/acre, in-drift emplacement
Conclusions from Sandia National Laboratories TSPA-93

• For the composite-porosity model:
  - CCDFs are dominated by gaseous releases
  - Aqueous releases similar for all emplacement configurations and slightly lower than TSPA-91
  - Highest sensitivity still to percolation flux
  - Human intrusion and volcanism not major contributors to release

• For the weeps model:
  - Human intrusion and aqueous and gaseous flow all contribute significantly to the CCDF
  - More sensitivity to thermal load
  - Sensitive parameters include container lifetime; number; episodicity and size of weeps, retardation in saturated zone
Conclusions from Sandia National Laboratories TSPA-93 (Continued)

- Waste-package model:
  - Waste-package failure strongly dependent on coupled processes
  - Little differentiation seen in corrosion-resistance of various designs
  - Larger containers show poorer performance for weeps and human intrusion models

- Little difference in releases observed for two thermal loads (may be due to simplifications and conservative assumptions)

- Improved saturated zone representation shows much structure in contaminant plumes not seen in 2D models
Limitations

- Exclusion of barrier effects from cladding may be very conservative
- Near-field geochemistry not explicitly modeled
- No diffusive releases from waste package
- Abstraction of hydrothermal properties may be too simplistic
- Waste-form alteration resulting from interaction with magmatic constituents not included in model
Guidance for Site Characterization

- Obtain information to help differentiate among possible flow models
  - Evidence of weeps
  - Size, connectivity, frequency, duration of flow in weeps

- Refine understanding of gas flow and retardation

- Characterize percolation flux
  Need a lot more info

- Characterize saturated zone flow, dilution, and unsaturated zone coupling

- Expand understanding where simplifications may have masked importance:
  - Colloids
  - Matrix/fracture coupling
  - Temporal persistence of flow paths
Guidance for Site Characterization
(Continued)

Increased data completeness

- Obtain more information on southern and western portions of potential repository area

- Determine scaling properties

- Obtain more information on spatial correlations and cross-correlations

- Investigate Ue25a#1 saturated hydraulic conductivities

- Obtain information on hydraulic characterization of unsaturated zone fractures and rock matrix
Guidance for Site Characterization
(Continued)

For near field:

• Perform integrated testing on waste package for water contact under saturated and unsaturated conditions

• Investigate near-field coupled thermal-mechanical-hydrologic-geochemical processes

• Characterize the interaction of natural and man-made components

• Obtain much more information on container corrosion and waste-form alteration processes
Guidance for Design

- Characterize thermal and hydraulic properties of any potential backfill materials
- Examine true benefits of horizontal vs. vertical emplacement
- Pursue emplacement design to minimize water contact
- Evaluate the possible enhanced performance from cladding and the contribution of the waste-package temperature to cladding failure
- Evaluate feasibility of maintaining long-term reducing environment (to reduce Np solubility)
Issues of Interest to Regulation Assessment

• Dose calculations require more information:
  - Saturated zone information must be more detailed
  - Characterization of a larger area may be necessary
  - Additional information must be gathered on the biosphere
  - For very long time-periods, radionuclide travel time not important to peak dose

• Longer time periods introduce even more uncertainty
Future TSPA Work

• Maintain effort to:
  - Work on larger suite of scenarios
  - Validate TSPA abstractions
  - Update parameter distributions and process models with new information
  - Study effects of heterogeneity

• Perform additional detailed modeling and abstraction for hydrothermal effects

• Develop models for coupled effects in the near field and on the waste package and waste form

• Improve aqueous and gaseous modeling capability by incorporating information on fracture/matrix coupling, parameter scaling, climate change, hydrothermal effects, etc.