

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

**NUCLEAR WASTE TECHNICAL REVIEW BOARD
FULL BOARD MEETING**

**SUBJECT: TOTAL SYSTEM PERFORMANCE
ASSESSMENTS:
A CONTEXT FOR TSPA - 1995**

PRESENTER: ABRAHAM VAN LUIK

**PRESENTER'S TITLE
AND ORGANIZATION: TECHNICAL SYNTHESIS TEAM, TEAM LEADER
ASSISTANT MANAGER FOR SUITABILITY AND LICENSING
YUCCA MOUNTAIN SITE CHARACTERIZATION OFFICE
LAS VEGAS, NEVADA**

TELEPHONE NUMBER: (702) 794-7525

**ARLINGTON, VIRGINIA
OCTOBER 17-18, 1995**

Evolution of Performance Assessments Through Time

- **Modeling assumptions become less conservative, more representative**
- **Provide guidance regarding the significance of technical hypotheses related to site and design processes**
- **Improved calculation capability, including abstraction from available process models**

Previous Performance Assessments: A Context for TSPA - 1995

1983 NAS WISP Report

- **Limited groundwater flow may lead to substantial doses over very long times because of relatively low dilution potential**

Siegel & Chu 1983

- **Oxidizing conditions and low aquifer flow velocities result in increased solubilities for U and Np and violate draft standards**

Thompson et al. 1984

- **Flux ranges for the unsaturated zone from 0.2 to 17 mm/yr, and an expected value case at 5 mm/yr, compliance with draft standard**

Previous Performance Assessments: A Context for TSPA - 1995

Sinnock et al. 1984

- Compliance with draft standard at the saturated zone:
 - 10,000 years: 0.1 EPA Ratio;
 - 100,000 years: 0.2 EPA Ratio

EPA 1985

- Faulting, drilling, and volcanic event scenarios resulted in 10,000-year EPA cumulative release ratios significantly less than 1

McGuire et al. 1992 (EPRI)

- Calculated releases to the accessible environment dominated by ^{237}Np , ^{79}Se and ^{240}Pu . No violations of standard, even for gaseous ^{14}C releases.

Previous Performance Assessments: A Context for TSPA - 1995

Codell et al. 1992 (NRC)

- Fracture flow important; cases with flow at or below 2 mm/year infiltration rate did not violate standard
- Drilling not significant

Doctor et al. 1992 (DOE)

- ^{14}C gaseous release produced a negligible dose
- Population dose was 1.8×10^3 person-Sv (1.8×10^5 person-rem) over 10^6 years or 36 health effects
- Climate change added 14 health effects; volcanism added 0.3 to 131 health effects, depending on recurrence rate

Previous Performance Assessments: A Context for TSPA - 1995

**Barnard et al.1992 TSPA-91 (DOE)
Eslinger et al.1993**

- Individual dose results ranged from minuscule (gas pathways) to substantial (driller and post-drilling residential gardener scenarios)**
- Doses from aqueous pathways without fast paths zero for 10,000 years**
- Release risk from basaltic event insignificant**

EPA 1993

- Only lowest retardation estimates yielded doses for 10,000 years for TRU waste**

Previous Performance Assessments: A Context for TSPA - 1995

Duguid et al. 1994

- **>100,000 year doses are strongly related to the solubility of ^{237}Np**
- **1 m capillary barrier significantly reduced doses/cumulative releases at long time periods**

Previous Performance Assessments: A Context for TSPA - 1995

Andrews et al., 1994 TSPA-93 (DOE)

Wilson et al., 1994

- **10,000-year cumulative release performance:**
 - **Aqueous releases orders of magnitude below standard**
 - **^{14}C gaseous releases exceeded allowances for releases but not considered a health concern**
- **100,000-year cumulative release was dominated by ^{14}C and ^{99}Tc**
- **1,000,000-year peak doses were dominated by ^{237}Np**

Andrews et al., 1995 TSPA-95 (DOE)

- **Unsaturated and saturated zone hydrologic properties most important**
- **Capillary barrier and containment time also very important**

Summary

- **TSPA-95 provides insights, recommends specific activities for future work**
- **Although developed in parallel, resulting recommendations are consistent with Waste Isolation Strategy**

Back up

Study Type	Reference	Lesson(s) Learned
STUDIES ASSUMING A SATURATED ZONE REPOSITORY	A Study of the Isolation System for Geologic Disposal of Radioactive Wastes (National Academy of Sciences 1983)	The report observed that a repository in an environment with limited of groundwater flow may lead to substantial doses over very long times because of a relatively low dilution potential.
	A Simplified Analysis of a Hypothetical Repository in a Tuff Formation (Siegel & Chu 1983)	Under oxidizing conditions, there were some reasonably low aquifer flow velocities for which U and Np violated the draft standards because of increased solubilities.
STUDIES PERFORMED IN SUPPORT OF THE ENVIRONMENTAL ASSESSMENT	Preliminary Upper-Bound Consequence Analysis for a Waste Repository at Yucca Mountain, Nevada (Thompson et al. 1984)	With Darcy flux ranges for the unsaturated zone from 0.2 to 17 mm/a, and an expected value case at 5 mm/a, no case violated the draft EPA Standard (aqueous release only, to a 10 km boundary).
	Preliminary Bounds on the Expected Postclosure Performance of the Yucca Mountain Repository Site (Sinnock et al.1984)	Compliance with the Draft EPA Standard was calculated at the saturated zone. At 10,000-a, the result was a 0.1 EPA Ratio; at 100,000-a the result was an approximate 0.2 EPA Ratio.

Study Type	Reference	Lesson(s) Learned
CALCULATIONS SUPPORTING EPA STANDARDS	High-Level and Transuranic Rad. Wastes, Background Information for Final Rule (EPA 1985)	Faulting, drilling and volcanic event scenarios resulted in 10,000-a EPA cumulative release ratios of 3×10^{-3} , 4.4×10^{-4} , and 0.04, respectively, given occurrence frequency.
	High-Level and Transuranic Rad. Wastes, Background Information Document for Proposed Amendments (EPA 1993)	The 1993 calculations by the EPA were similar to the 1985 calculations, but a transuranic waste inventory was used. Only the lowest retardation estimates yielded potential doses within 10,000-a.
	Calculations In Support of Evaluating Potential Environmental Standards for Yucca Mountain (Duguid et al. 1994)	>100,000-a doses to an individual at the accessible environment are strongly related to the solubility of ^{237}Np . Effects of a 1.0 m capillary barrier significantly reduced doses and cumulative releases for >100,000-a by limiting radionuclide release to diffusive processes.
DEMONSTRATIONS OF TOTAL SYSTEM PERFORMANCE ASSESSMENT CAPABILITY	Phase 1 Demonstration of the NRC's Capability to Conduct a Performance Assessment for a High-Level Waste Repository (Codell et al. 1992)	Fracture flow was important, and cases with flow vectors at or below a 2 mm/a infiltration rate did not violate the EPA Standard. Drilling itself did not contribute significantly to the CCDF.
	An Example Postclosure Risk Assessment Using the Potential Yucca Mountain Site (Doctor et al. 1992) (DOE)	Gaseous release of ^{14}C produced a negligible dose. The population dose was 1.8×10^3 person-Sv (1.8×10^5 person-rem) over 106-a. This is about 36 health effects; climate change added 14 health effects, and volcanism added 0.3 to 131 health effects, depending on recurrence rate.
	Demonstration of a Risk-Based Approach to High-Level Waste Repository Evaluation, Phase 2 (McGuire et al. 1992) (EPRI)	Calculated releases to the accessible environment were dominated by ^{237}Np , ^{79}Se and ^{240}Pu . There were no violations of the EPA Standard, even for gaseous ^{14}C releases.

Study Type	Reference	Lesson(s) Learned
DOE's SERIES OF ITERATIVE TOTAL SYSTEM PERFORMANCE ASSESSMENTS	TSPA 1991: An Initial Total-System Performance Assessment [TSPA] for Yucca Mountain (Barnard et al.1992) and Preliminary Total-System Analysis of a Potential High-Level Nuclear Waste Repository at Yucca Mountain (Eslinger et al.1993)	Release risk from a single basaltic intrusive event was insignificant. Individual dose results ranged from minuscule for the gas pathways to substantial doses for the intrusive driller and post-drilling residential gardener scenarios. Doses resulting from the aqueous pathway were zero for 10,000 years for the cases calculated without fast ground- water travel-time pathways.
	Total-System Performance Assessment for Yucca Mountain - SNL Second Iteration (TSPA-1993) (Wilson et al., 1994) and Total-System Performance Assessment - 1993: An Evaluation of the Potential Yucca Mountain Repository (Andrews et al., 1994)	10,000 year cumulative release performance: (a) aqueous releases, meaning radionuclides carried by the downward flow of water, were many orders of magnitude below EPA allowances; (b) gaseous releases exceeded allowances for 14C in many cases (not a health and safety concern). 100,000 year cumulative release was dominated by 14C and 99Tc. 1,000,000 year peak doses were attributable to 237Np.
	Total-System Performance Assessment - 1995: An Evaluation of the Potential Yucca Mountain Repository (Andrews et al., 1995)	TSPA 1995 has just been completed and is the subject of most of the 18 October 1995 Nuclear Waste Technical Review Board meeting. Unsaturated and saturated zone hydrologic properties are again the more important determinants of long term system performance. The performance of the engineered system, however, is also a very important determinant of long term system performance.