EPRI's Yucca Mountain TSPA, 'Phase 5'

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Outline

- Purpose of EPRI TSPAs
- Scope of 'Phase 5' report [November 2000]
- Model Components and Assumptions
- Base Case Results
- Identification of 'Barriers'
- DOE and EPRI conservatisms/optimisms
- Performance confirmation

Purpose of EPRI Yucca Mountain TSPAs

- Independent assessment of technical issues
  - Inform smart business decisions through third-party expert scientific insight
  - Provide input to utilities on regulatory and legislative issues
- Provide insight to outside review bodies such as TRB, ACNW

EPRI TSPA Scope - Scenarios Considered and not Considered

- Considered: “Normal release scenario”
  - Container degradation, waste dissolution, contaminant transport, biosphere
- Not considered:
  - Colloid-aided transport
  - Volcanism
  - Human intrusion

EPRI TSPA Model Components

- IMARC: Integrated Multiple Assumptions and Release Code
  - *Mostly* logic tree format (I.e., not Monte Carlo)
    - Container failure times are Monte Carlo simulations
  - 54 branches total
- IMARC 'shell'
  - Time steps
  - Most 'global' inputs
  - Liberal use of lookup tables
- Submodel Links
  - Source term
  - UZ/SZ transport

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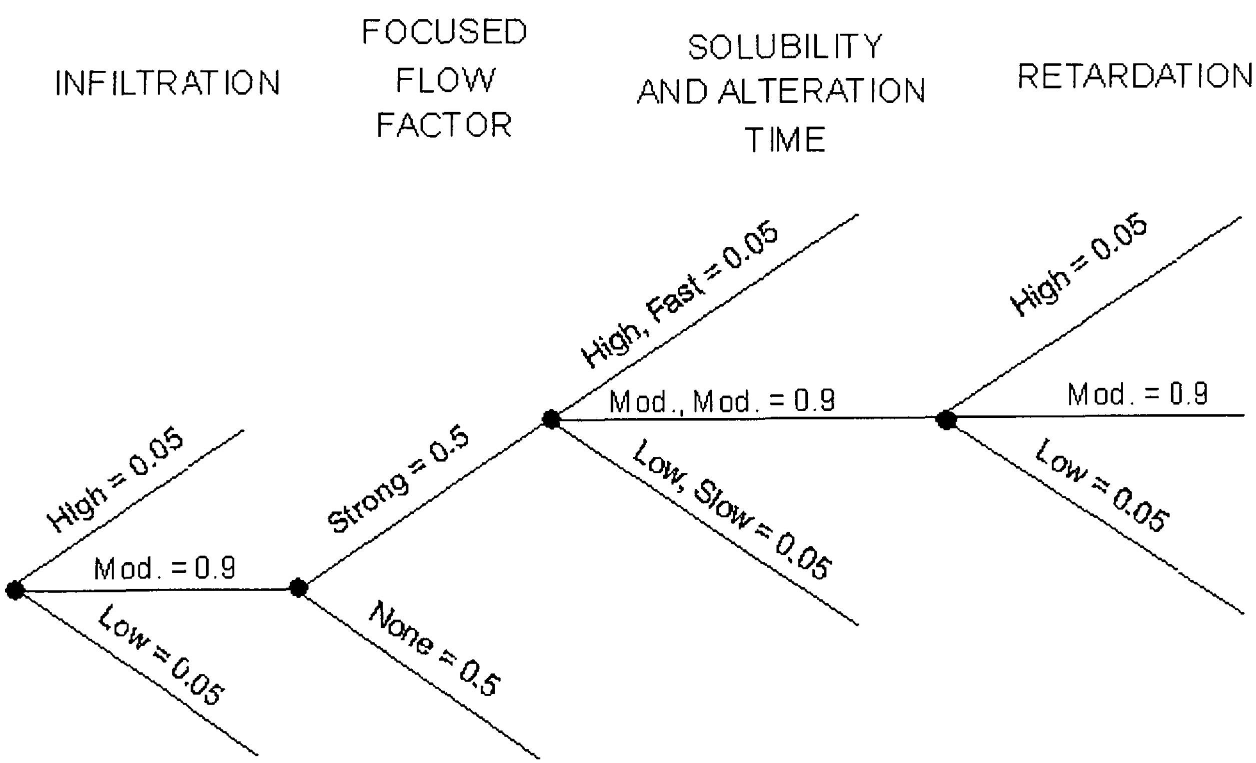
IMARC Logic Tree (54 branches)



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Net Infiltration

[Stuart Childs, Kennedy/Jenks]

- Based on three climate states [Austin Long, U. AZ]
- Infiltration assumed uniform over the entire repository footprint

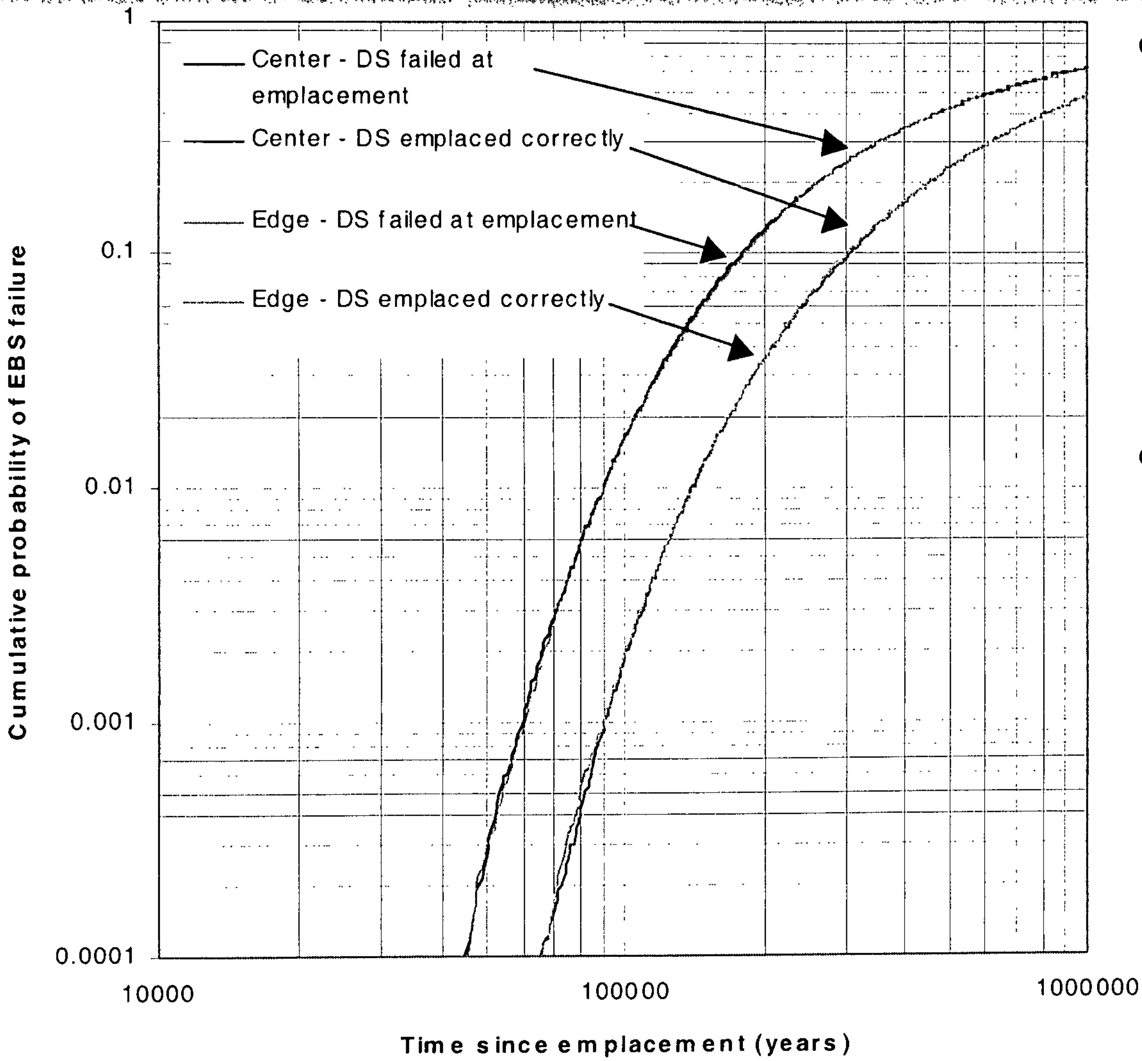
  -Infiltration rates [mm/yr]:

	Low	Moderate	High
Greenhouse:	1.9	11.3	19.2
Interglacial:	1.11	7.2	9.6
Full glacial maximum:	6.8	19.6	35.4

Focused Flow Factor
[Ben Ross, Disposal Safety]

- Based on March 2000 AMR: "Abstraction of Drift Seepage"
- Zero focusing: percolation rate = net infiltration rate repository-wide
- Focusing factor of 22: 4.5% of the repository gets 22 times the area-average infiltration rate

Drip Shield/Waste Package Combined Failure Distribution
[Dave Shoesmith (UWO), John Massari (CNS)]



- Drip Shield degradation
  - General corrosion, HIC
  - 14 failed at emplacement
- Container degradation
  - Aqueous corrosion at T<120C
  - Localized corrosion above 100C
  - SCC only on outer lid weld

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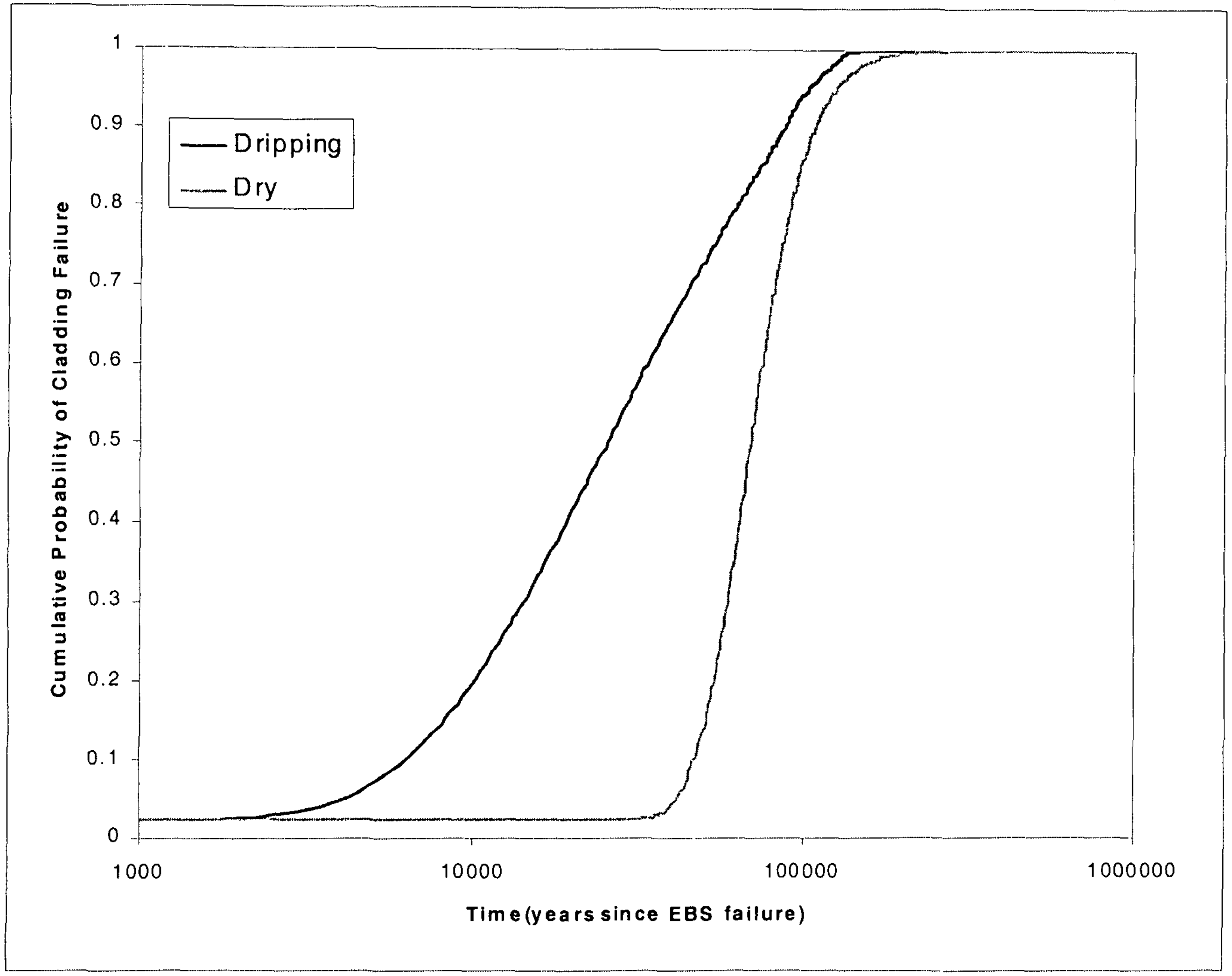
Fuel Rod Cladding Failure Distribution
[Shoesmith and Massari]



- 2.44% initial cladding failures
- General corrosion (not specifically driven by F^-)
- Localized corrosion considered unlikely

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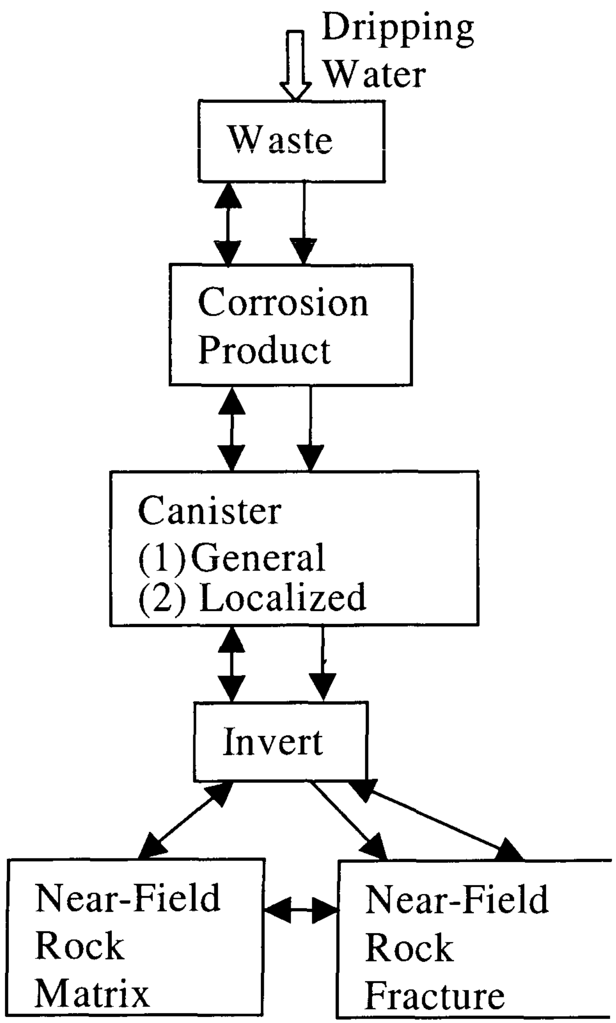
Source Term General Approach
[Wei Zhou; Mike Stenhouse, Monitor Scientific]



↕: diffusion

↓: advection

- Compartments are assumed well connected
- Advection directly into local flowing fracture
- 100% of waste form in failed cladding assumed exposed

UZ/SZ Flow and Transport Model
[Frank Schwartz, OSU; Ed Sudicky, U. Waterloo]

- UZ:
  - 1-D, dual K continuum
  - Simplified vertical columns

- SZ:
  - 3-D, dual porosity, dual permeability
  - SZ thickness: 200 meters
  - Vertical dispersion significant

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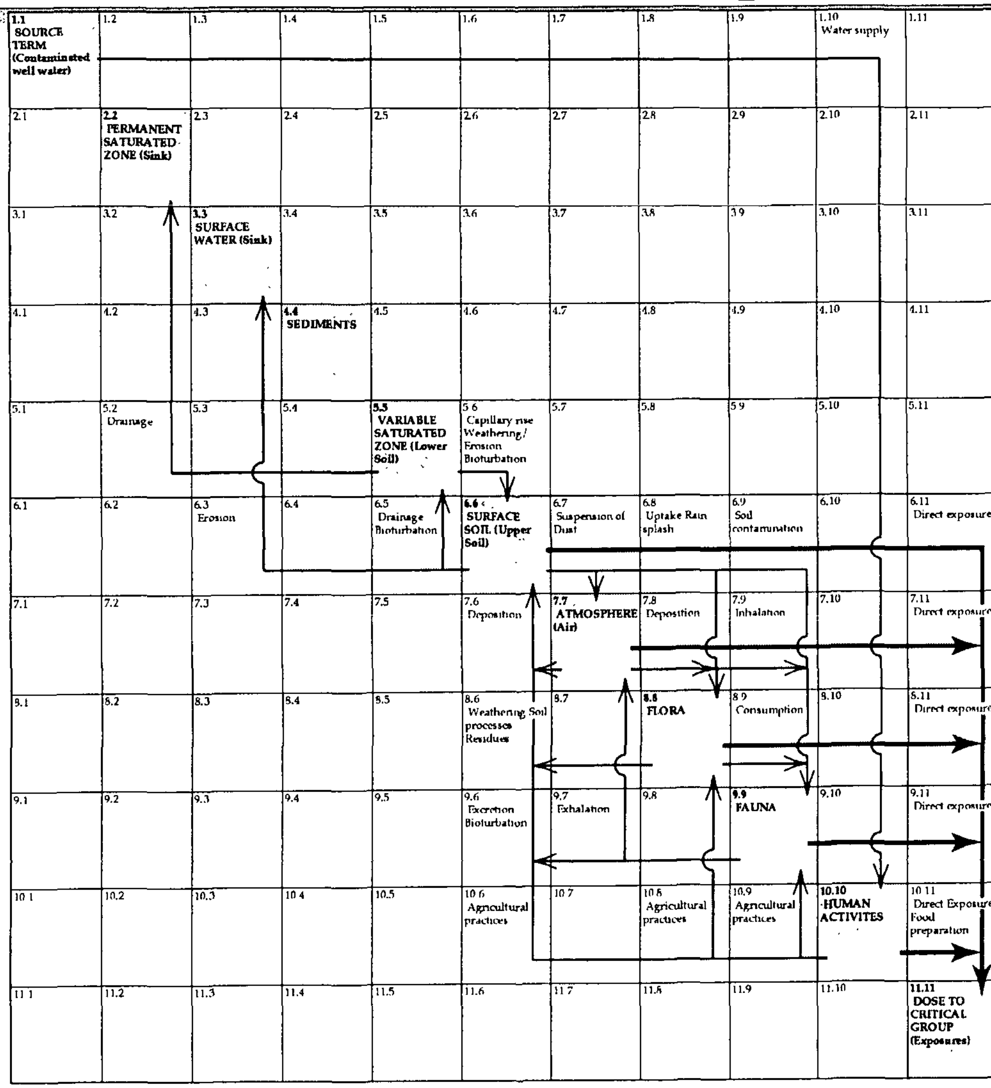
Biosphere Dose Conversion Factors Conceptual Model
[Smith et al., QuantiSci, Ltd.]



- Compartment model (AMBER)
  - Thin arrows: nuclide migration processes
  - Thick arrows: exposure pathways

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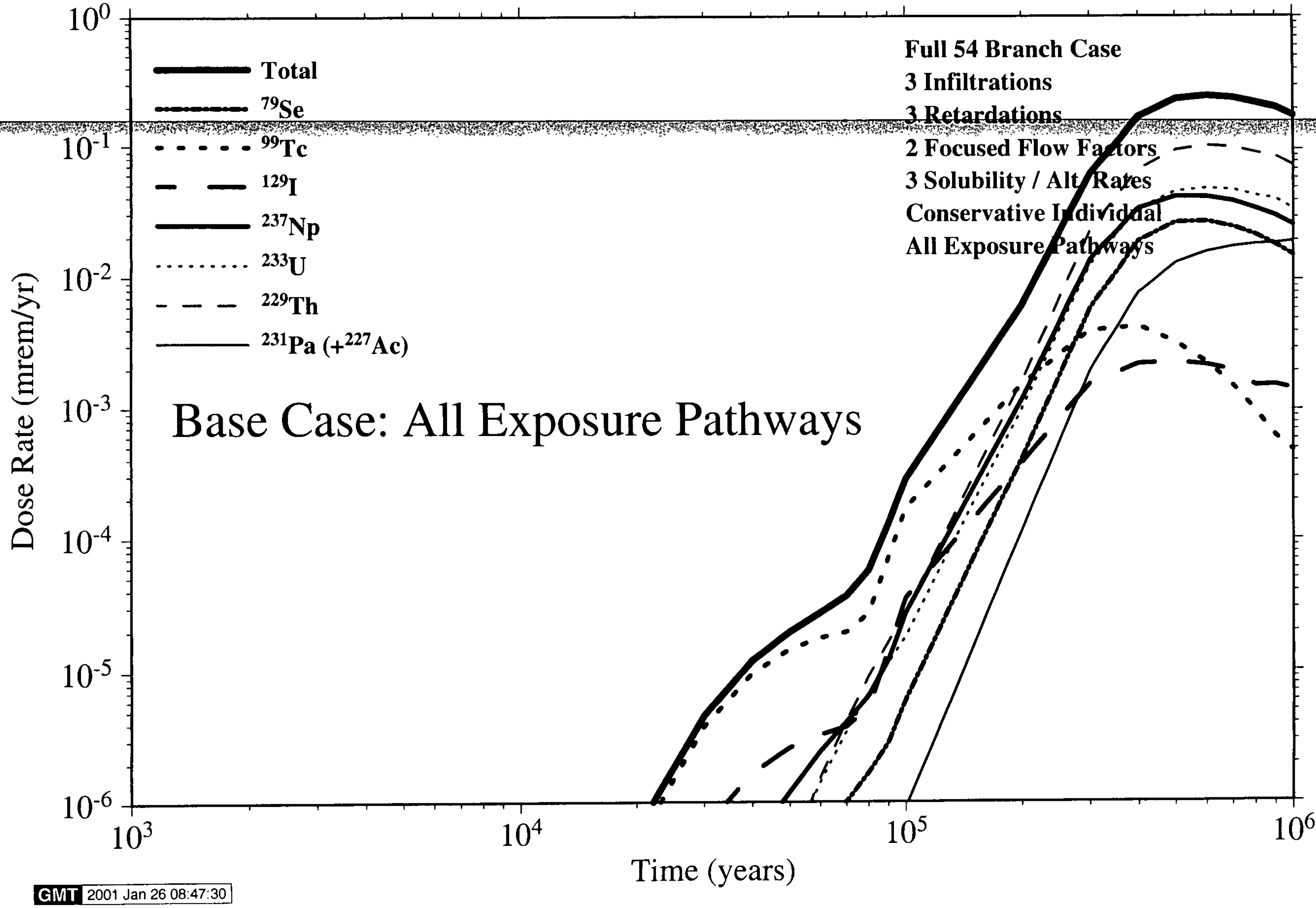
ANNUAL DOSE VS. TIME

Dose from Highest Concentration at AE



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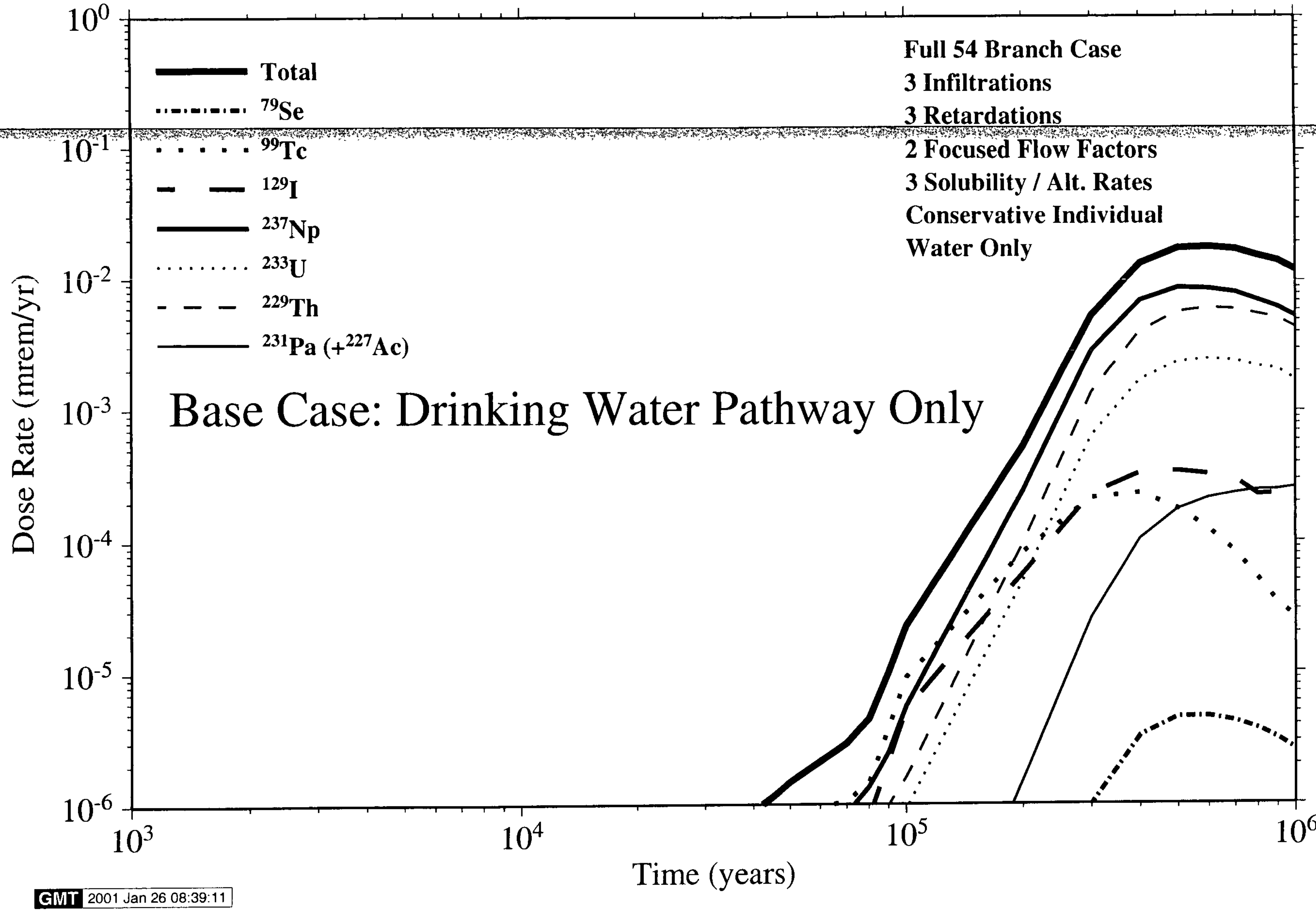
ANNUAL DOSE VS. TIME

Dose from Highest Concentration at AE



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Barrier Importance Analyses

- Purpose
  - Assign "value" to various components of Yucca Mountain System
  - Motivation: "Defense-in-depth"
    - Are all eggs in one (or two) basket(s)?
  - Provide insight on important Features, Events, and Processes (FEPs)
  - EPRI uses a "Hazard Index" approach
    - Variant of 'full neutralization'

"Hazard Index" Approach to Identifying Potential Barriers

- Begin by eliminating ALL barriers

- Add potential barriers one-by-one

- Amount 'Hazard Index' (dose rate) is reduced indicates potential barrier importance

Starting Point - Highest "Imaginable" Dose

- All 70,000 MTU of spent fuel dissolved in 0.6 m^3 water
- One individual drinks it in one year
- Starting total Hazard Index, HI_{tot} ~10^{17} [mrem/yr]
- Why start so unrealistically?
  - ***All*** FEPs can be evaluated quantitatively
    - Basic engineering decisions (e.g. repository layout)

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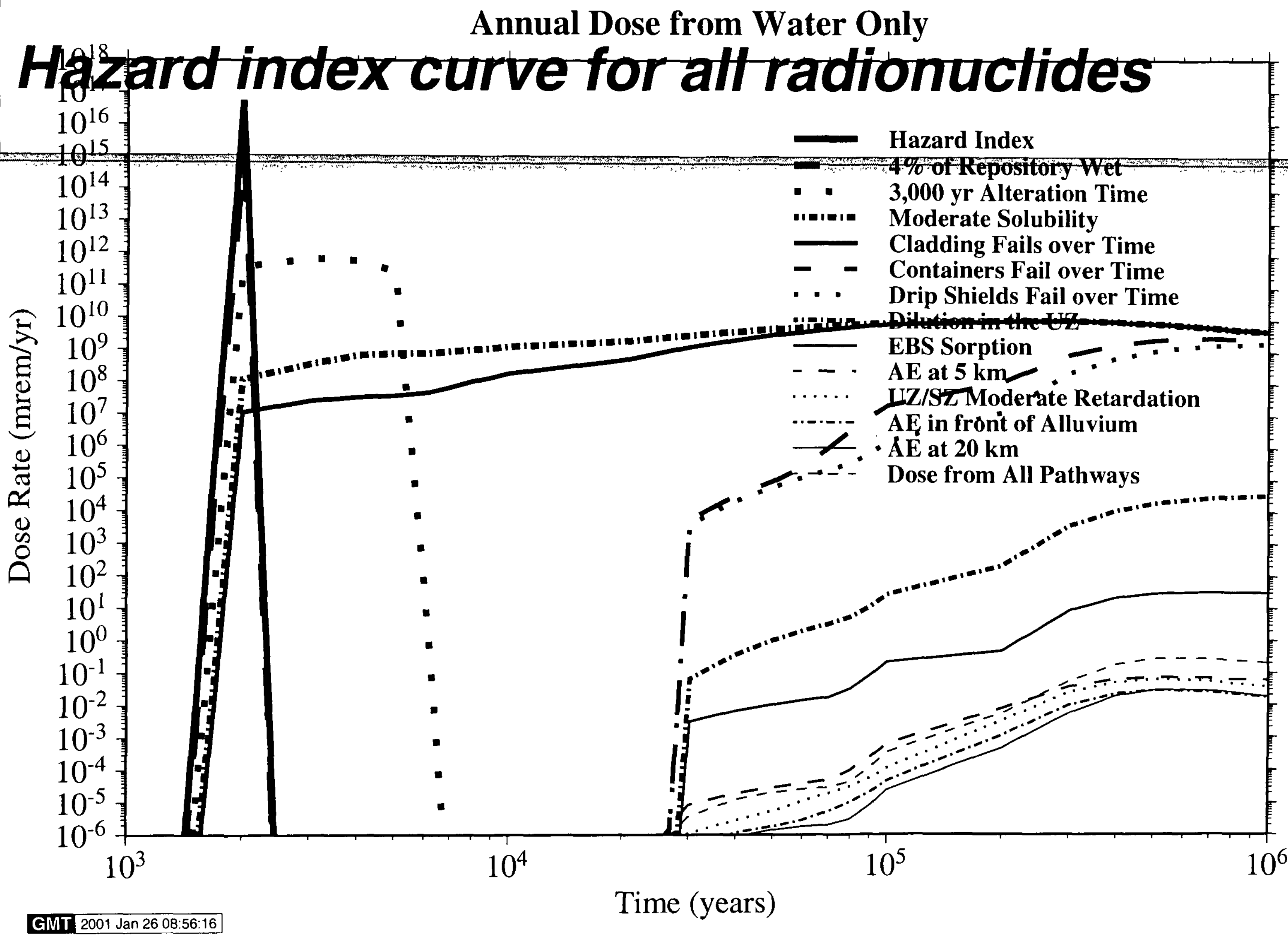
13 FEPs Added One-by-One

- 4% of Repository Wet
- 3,000 year Alteration Time
- Moderate Solubility
- Cladding Fails Over Time
- Containers Fail Over Time
- Drip Shield Fails Over Time
- Dilution in the UZ
- EBS Sorption
- Accessible Environment (AE) at 5 km
- UZ/SZ Moderate Retardation
- AE in Front of Alluvium
- AE at 20 km
- Dose from All Pathways

TOTAL HAZARD REDUCTION

Hazard index curve for all radionuclides



Hazard Reduction Factors

Hazard Reduction	Time of Peak [yr]	Barrier	"Engineered" or "Natural"?
$10^{\sim 1}$	2000	4% of repository wet	both
10^{3}	3000	3,000 year alteration time	both
10^{2}	200,000	Moderate solubility	natural
10^{0-1}	200,000	Cladding fails over time	engineered
$10^{\sim 1}$	600,000	Containers fail over time	engineered
$10^{\sim 0}$	700,000	Drip shields fail over time	engineered
$10^{\sim 5}$	700,000	Dilution in the UZ	both
10^{3}	700,000	EBS sorption	mostly engineered
10^{2}	500,000	AE at 5 km	natural
$10^{0.5}$	600,000	UZ/SZ moderate retardation	natural
$10^{\sim 0.5}$	600,000	AE in front of alluvium	natural
$10^{\sim 0}$	600,000	AE at 20 km	natural
$10^{\sim 18}$		*Total Hazard Reduction*	
10^{5-14}		*Hazard reduction due to "engineered" features*	
10^{5-14}		*Hazard reduction due to "natural" features*	
10^{-1}		Hazard "reduction" (i.e., increase) due to all pathways	

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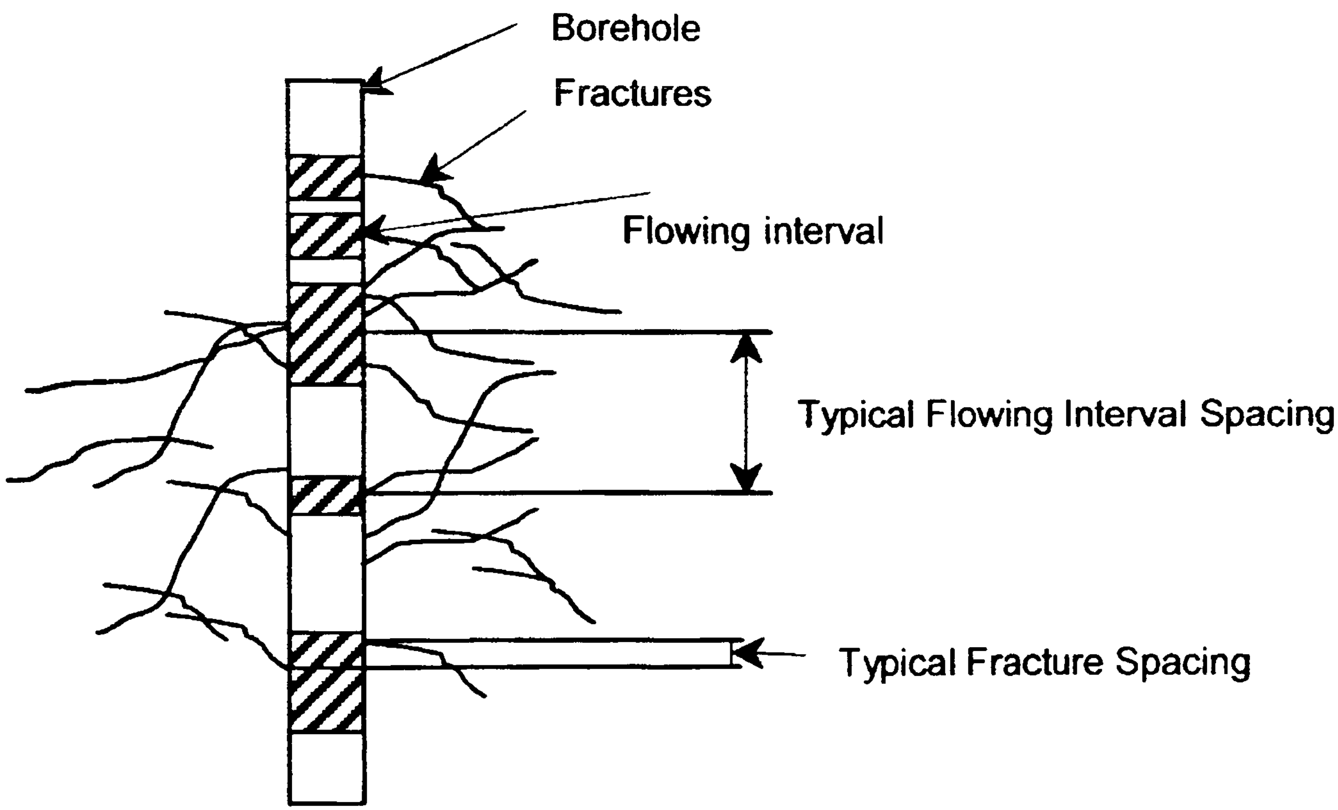
EPRI Analysis of Conservatisms and Optimisms in the DOE Models

- Conservatisms
  - Source term diffusion model
  - Volcanism consequences
  - Unsaturated Zone transport (FEHM particle tracker needs correcting)
  - *Saturated Zone transport*
- Optimisms
  - 70% heat removal by ventilation (?)
  - Choice between temperature and RH conservatism/optimism
- EPRI satisfied overall DOE assessment is conservative

Concept of a SZ "Flowing Interval"



- "Flowing Interval" spacing: ~20m
- Typical fracture spacing within the flowing interval: <1m

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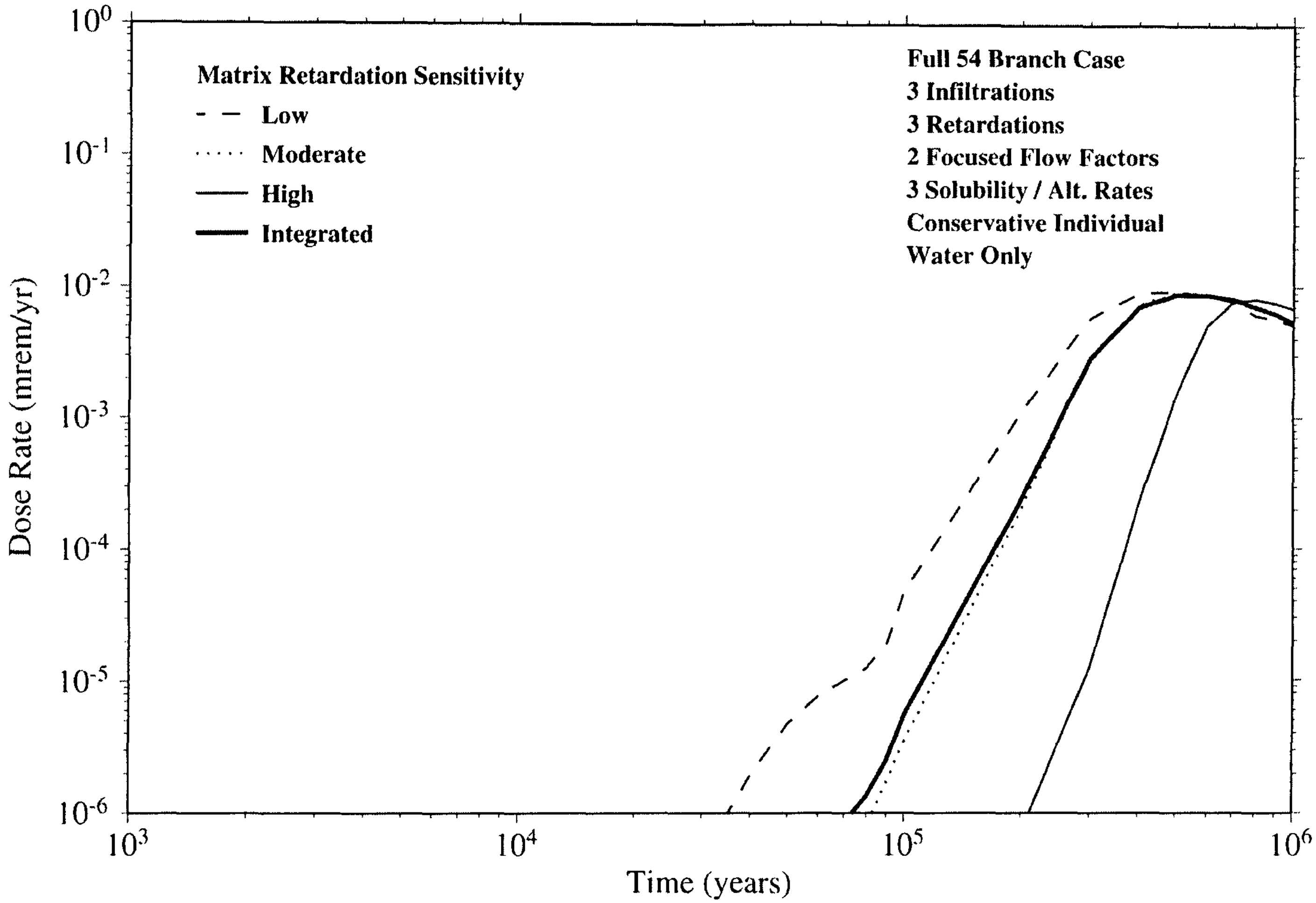
Sensitivity of Np-237 Drinking Water Dose Rate to SZ Sorption



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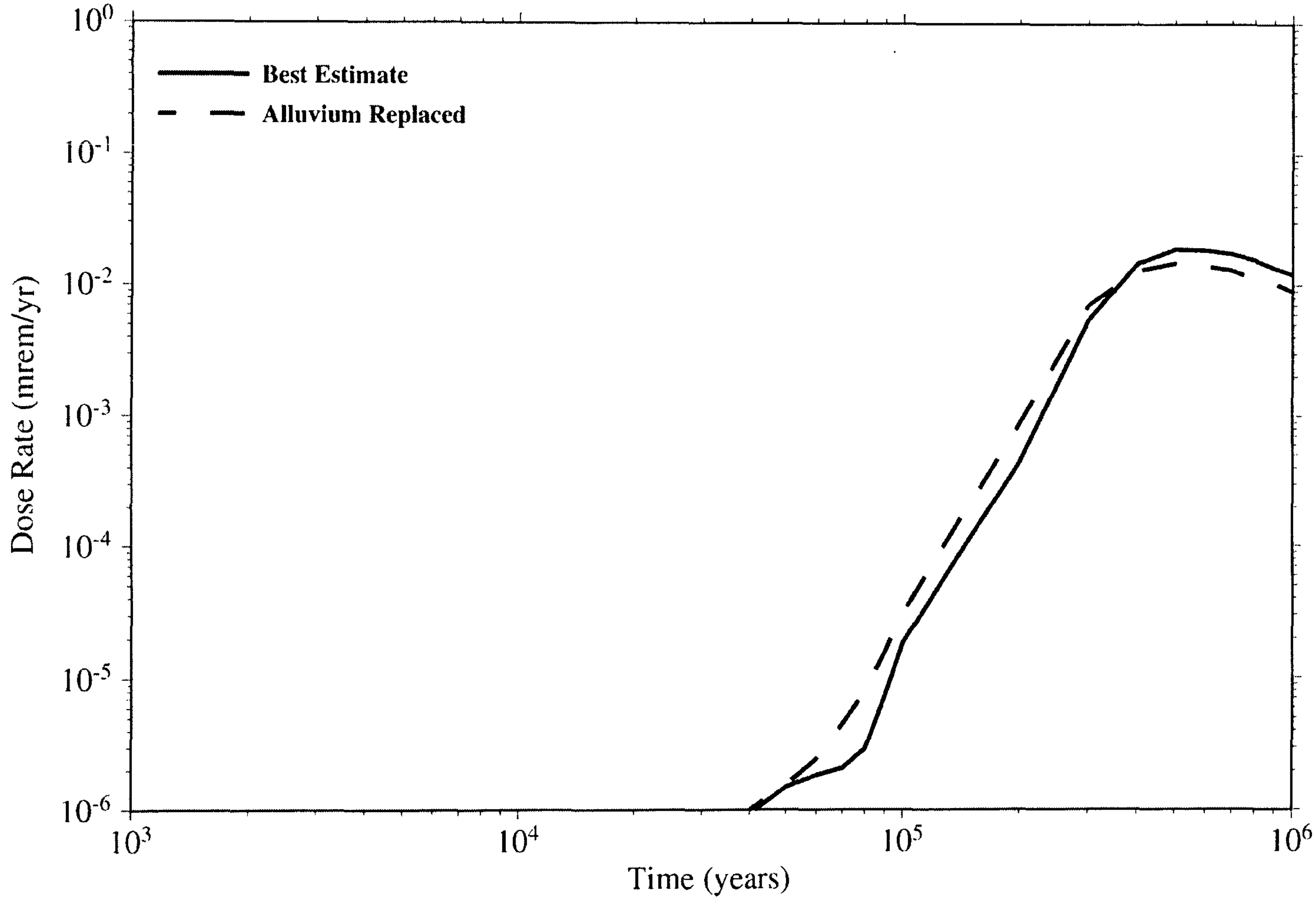
Impact of Eliminating Alluvium



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Is it Necessary to Assess all Uncertainties?

- No
  - Many parameters we treat as fixed are truly unimportant to performance
    - Therefore, not worth the effort
  - Other, more important, fixed parameters could, during SR analyses, be investigated using expert judgment (non-Q OK)
    - ‘Conservative’ versus ‘best estimate’ to provide some insight on potential degree of conservatism
- EPRI encourages current M&O effort led by Coppersmith

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Is TSPA an Appropriate Decision-Making Tool?

- **Yes**
  - Comprehensive and quantitative measure of the degree of public health protection
  - TSPA now based on many years of experience
  - Multiple practitioners arrive at consistent results
  - Most TSPA submodels are based on solid data
    - Years of R&D data incorporated directly or indirectly
  - Multiple lines of evidence built-in to TSPA
    - Many submodels already employ natural analog information
  - Performance confirmation will further bolster TSPA

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Role of Performance Confirmation (and other Long-Term R&D) Activities

- Performance confirmation (and other long-term R&D) activity definition important for SR- not just for licensing
  - Helps provide clarity when managing many important uncertainties
  - Performance confirmation is an opportunity to improve understanding and bolster the safety case
  - SR decision makers can use long-term R&D plans, along with current knowledge

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EPRI Two-Year Program to Clarify the Role of Performance Confirmation in SR/LA

- November 2000: 'Interim report' issued
  - Review of performance confirmation issues
    - What constitutes an appropriate performance confirmation activity
      - Has to be able to truly 'confirm' long-term performance
      - Has to have clearly defined goals and stopping criteria
    - Review of current DOE performance confirmation plan (May 2000)
      - Generally sound, but needs improvement
  - Other long-term R&D can provide bases for model improvements
    - Relaxing conservatisms could lead to a more efficient repository design

EPRI Performance Confirmation Plans for 2001

- External review of and recommendations for appropriate performance confirmation and other important long-term R&D activities (to help establish consensus)
- 'Bottom out' details of one or two performance confirmation activities
  - More detailed test plan
  - Supporting models to show how ~50-year data can be extrapolated to 10,000+ years
  - Definition of 'error bar(s)'
  - Will choose container degradation
  - May also investigate larger-scale thermal testing
- Planned completion is mid 2001

Conclusions

- DOE's TSPA is conservative
- Repository performance is bolstered by a diverse range of multiple barriers
- Efforts to quantify uncertainties should be risk-informed
- TSPA is an appropriate tool for repository decision-making
- Performance confirmation should play an important role in repository decision-making