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

# NUCLEAR WASTE TECHNICAL REVIEW BOARD
# PANEL ON HYDROGEOLOGY AND GEOCHEMISTRY
# FRACTURE FLOW AND TRANSPORT IN ARID REGIONS

## SUBJECT: PERFORMANCE ASSESSMENT PERSPECTIVE ON POTENTIAL SIGNIFICANCE OF LOCALIZED "FAST" FLOW PATHS ON WASTE ISOLATION AND CONTAINMENT AT YUCCA MOUNTAIN


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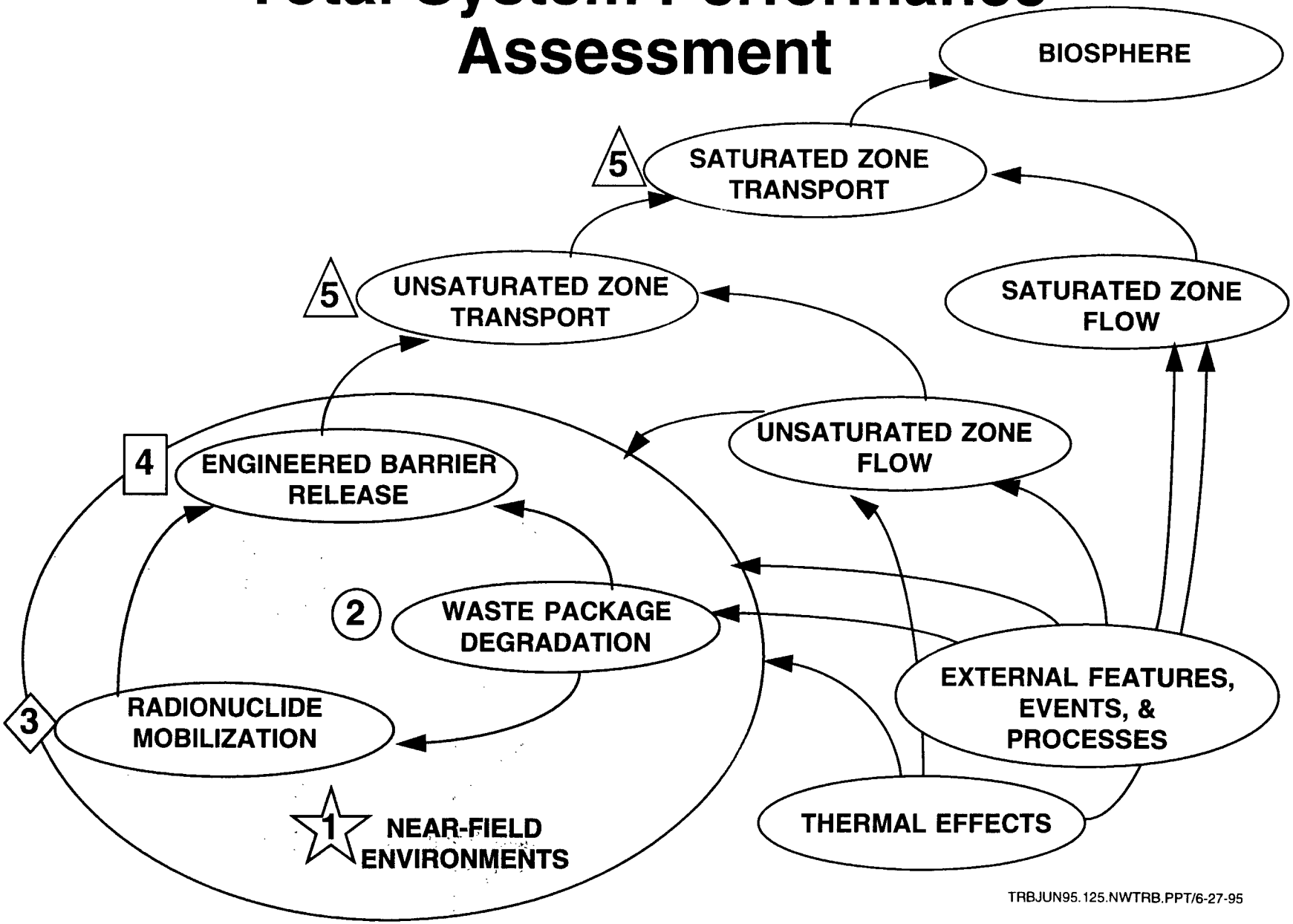
# Outline of Presentation

- Components of waste isolation and containment strategy
- Review of geosphere attributes in total system performance
- Potential significance of localized "fast" flow on
  - EBS performance
  - geosphere transport
- Incorporation of "fast" flow and transport in TSPA-1993 and Calico Hills Systems Study
- Plans for incorporating localized "fast" flow and transport in TSPA-1995
- Summary and conclusions

# Summary of Components of Total System Performance Assessment

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# Potential Significance of Localized "Fast" Flow on EBS Performance (Cont.)

- Increases advective transport from waste package and through EBS
  - relative magnitude compared to diffusive release depends on
    - » magnitude of advective flux
    - » magnitude of effective diffusion coefficient
    - » percent of waste package area available for diffusive release

# Potential Significance of Localized "Fast" Flow on Geosphere Transport

- High advective velocities in "fast" flow paths
  - low travel times of unretarded species or limited matrix diffusion
- Dispersive effects depend on localized "fast" flow path heterogeneities
- Dilution effects depend on volumetric flow in "fast" flow networks intersecting waste packages

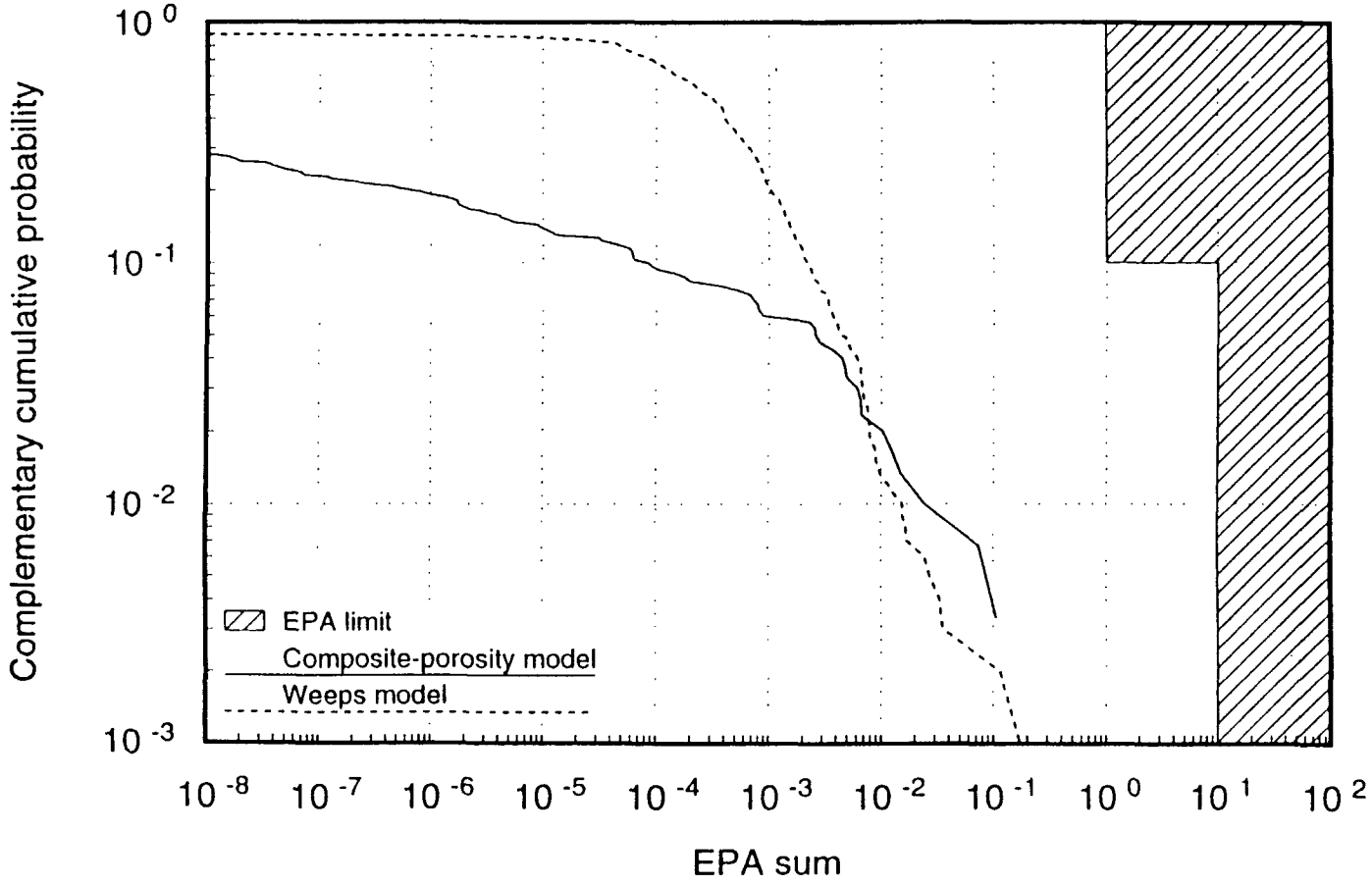
# Incorporating "Fast" Flow and Transport in TSPA-1993 and Calico Hills Systems Study: Synopsis of Results

- CCDF of 10,000 year cumulative release
  - Composite porosity vs Weeps model
  - Composite porosity with increased fracture flow or reduced matrix diffusion
  - Composite porosity with increased fracture flow and reduced matrix diffusion

# Incorporating "Fast" Flow and Transport in TSPA-1993 and Calico Hills Systems Study: Synopsis of Results (Cont.)

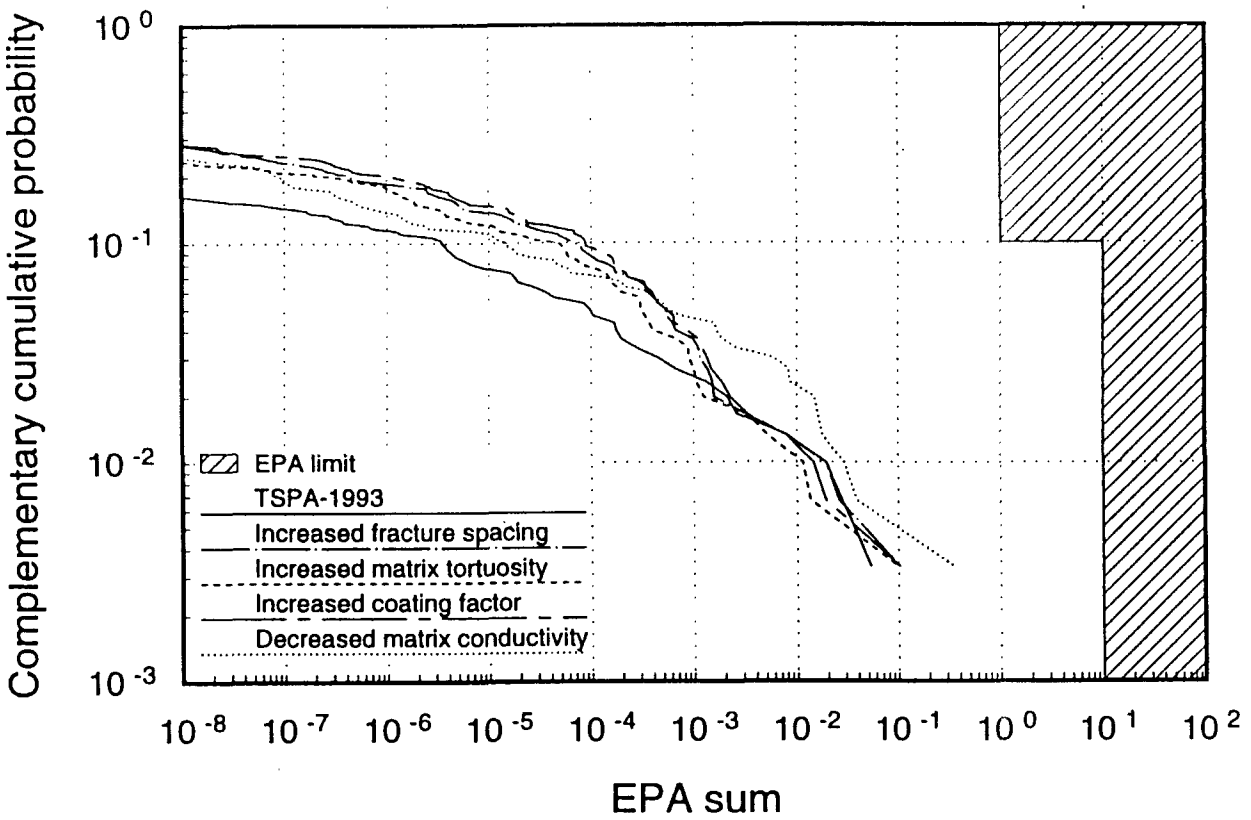
- CDF of 10,000 year peak individual dose
  - Composite porosity with increased fracture flow and reduced matrix diffusion
- CCDF of 1,000,000 year peak individual dose
  - Composite porosity vs Weeps model
  - Composite porosity with increased fracture flow and reduced matrix diffusion

# CCDF of 10,000 year Normalized Cumulative Release:
## Composite porosity vs Weeps model



# CCDF of 10,000 year Normalized Cumulative Release:

## Composite porosity with increased fracture flow or reduced matrix diffusion



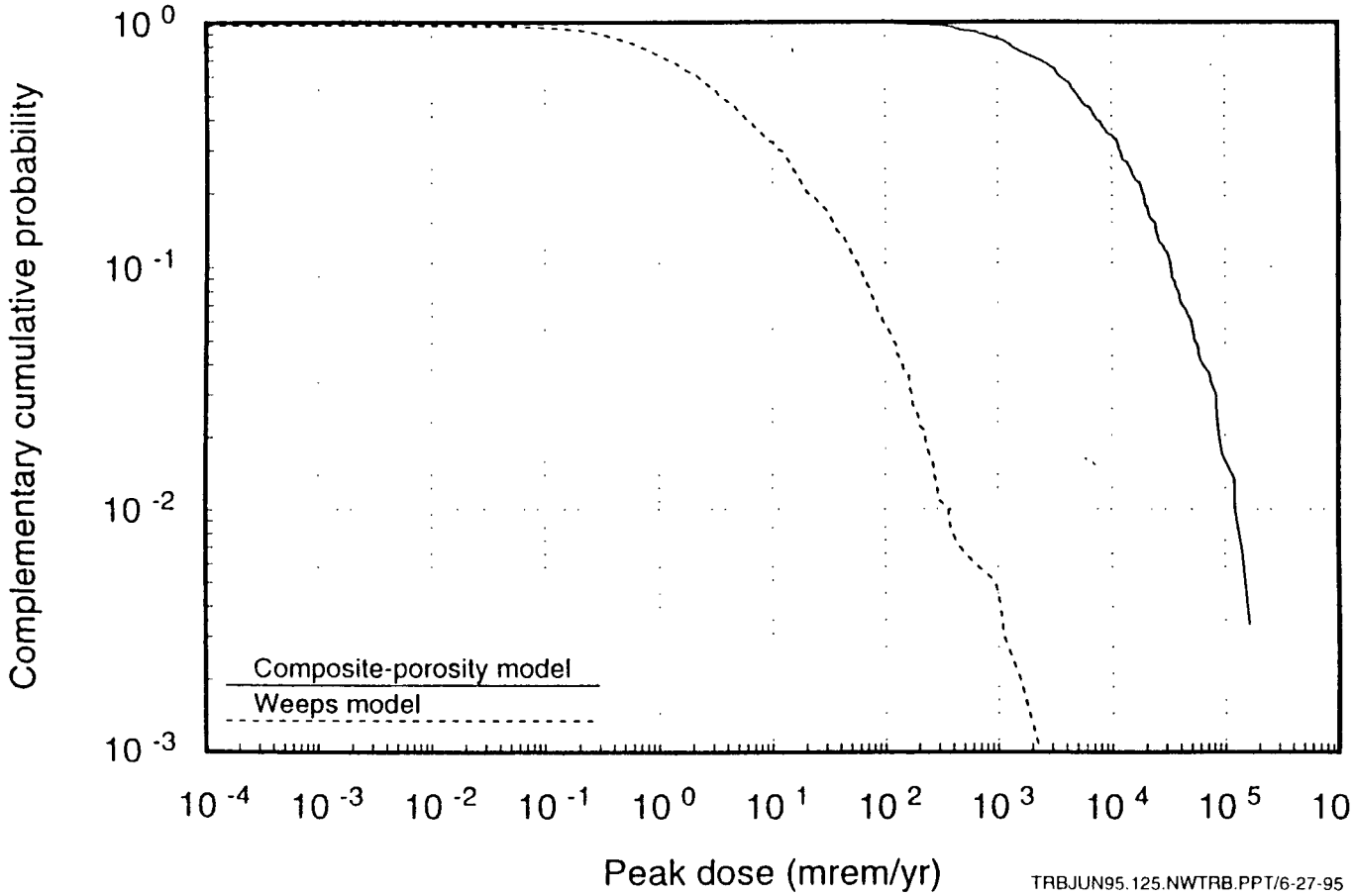
# Review of Geosphere Attributes in Total System Performance Assessment

- Ambient environment provides favorable conditions that are consistent with possible engineered barrier system (EBS) designs
- Natural barrier for radionuclide transport for those radionuclides released from EBS
- Natural mixing/dispersion/dilution of those radionuclides released from EBS

# Potential Significance of Localized "Fast" Flow on EBS Performance

- Depends on spatial distribution of localized "fast" flow paths
- Depends on efficiency of any designed in-drift capillary barrier
- Increases percent of waste form in contact with liquid water

# CCDF of 1,000,000 year Peak Dose to Maximally Exposed Individual:
## Composite porosity vs Weeps model

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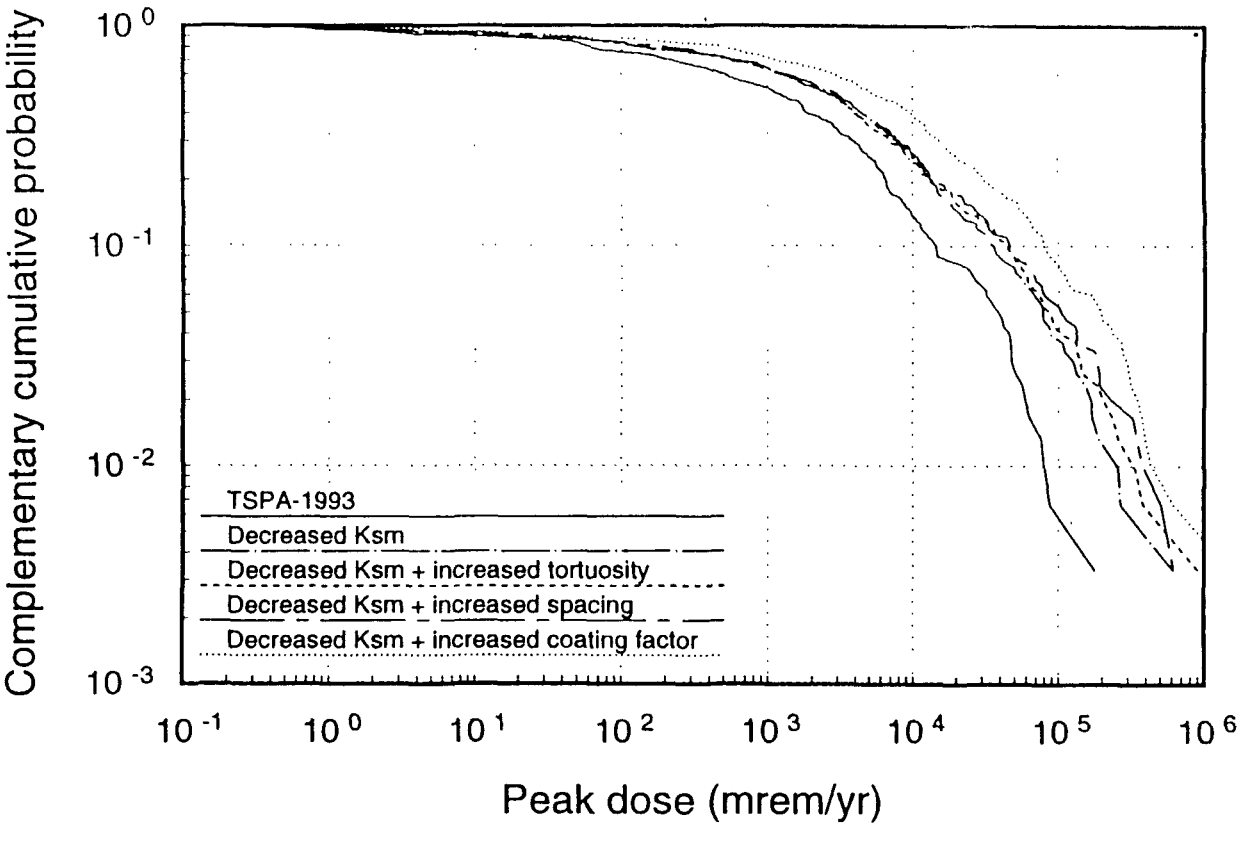
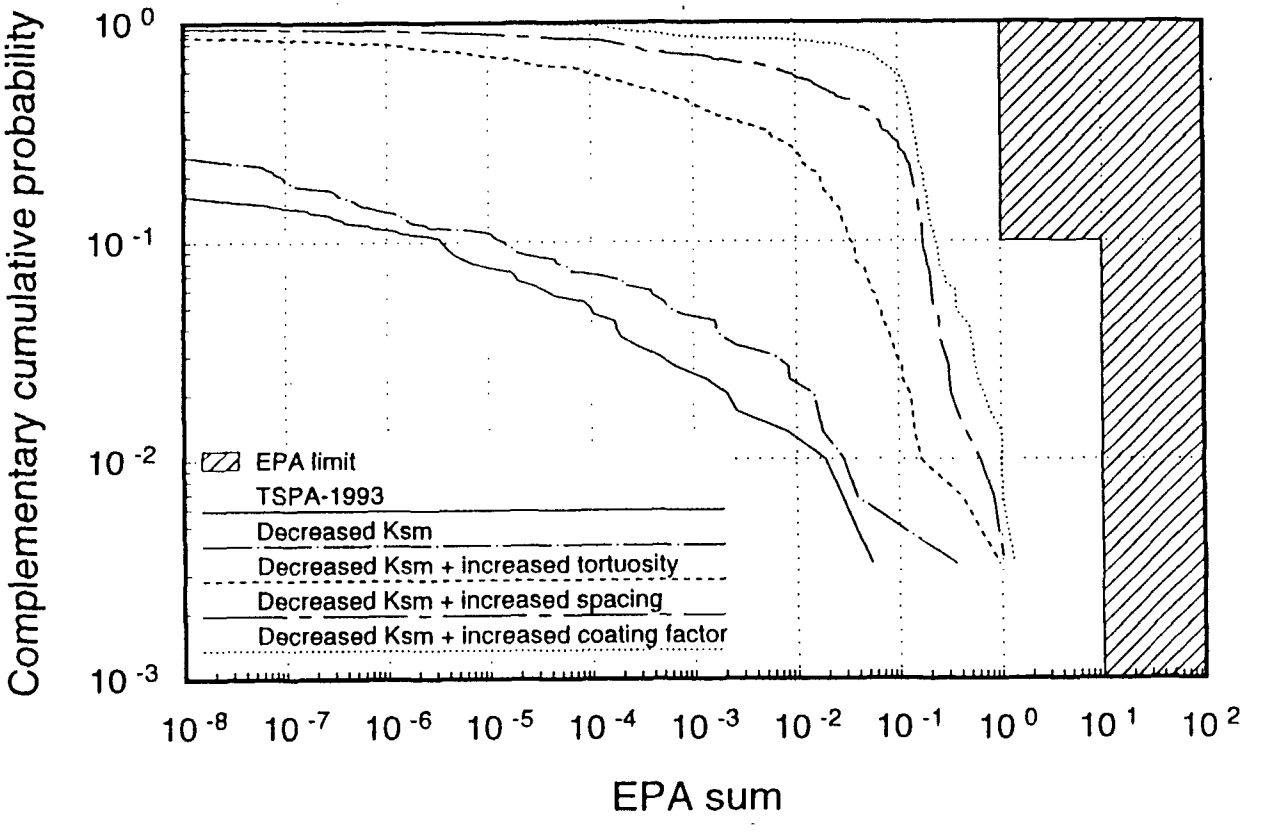
# CCDF of 1,000,000 year Peak Dose to Maximally Exposed Individual:

## Composite porosity with increased fracture flow and reduced matrix diffusion



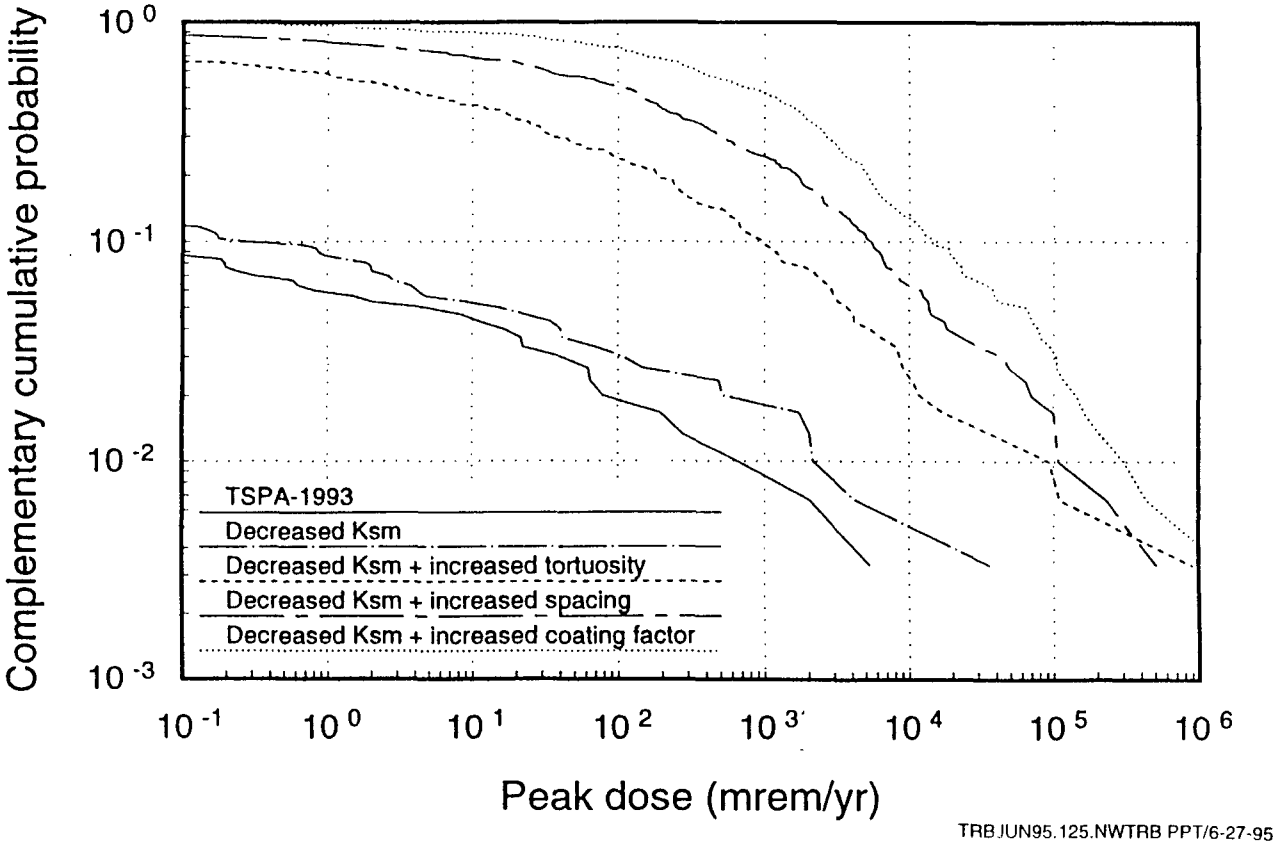
# CCDF of 10,000 year Normalized Cumulative Release:

## Composite porosity with increased fracture flow and reduced matrix diffusion



# CCDF of 10,000 year Peak Dose to Maximally Exposed Individual:

## Composite porosity with increased fracture flow and reduced matrix diffusion



# Plans for Incorporating Localized "Fast" Flow into TSPA-1995

- Include uncertainty in ambient infiltration rate
- Allow spatial variability in average percolation flux
  - bimodal to reflect conceptual uncertainty (spatial averaging vs spatial variability)
  - unimodal to encompass entire infiltration distribution

# Plans for Incorporating Localized "Fast" Flow into TSPA-1995
(Cont.)

- Magnitude of localized percolation flux determined at each waste package
  - assume log-normal variability in local percolation flux
- Localized flux intersecting drifts distributed between matrix and seeps
  - depends on saturated matrix conductivity of TSw

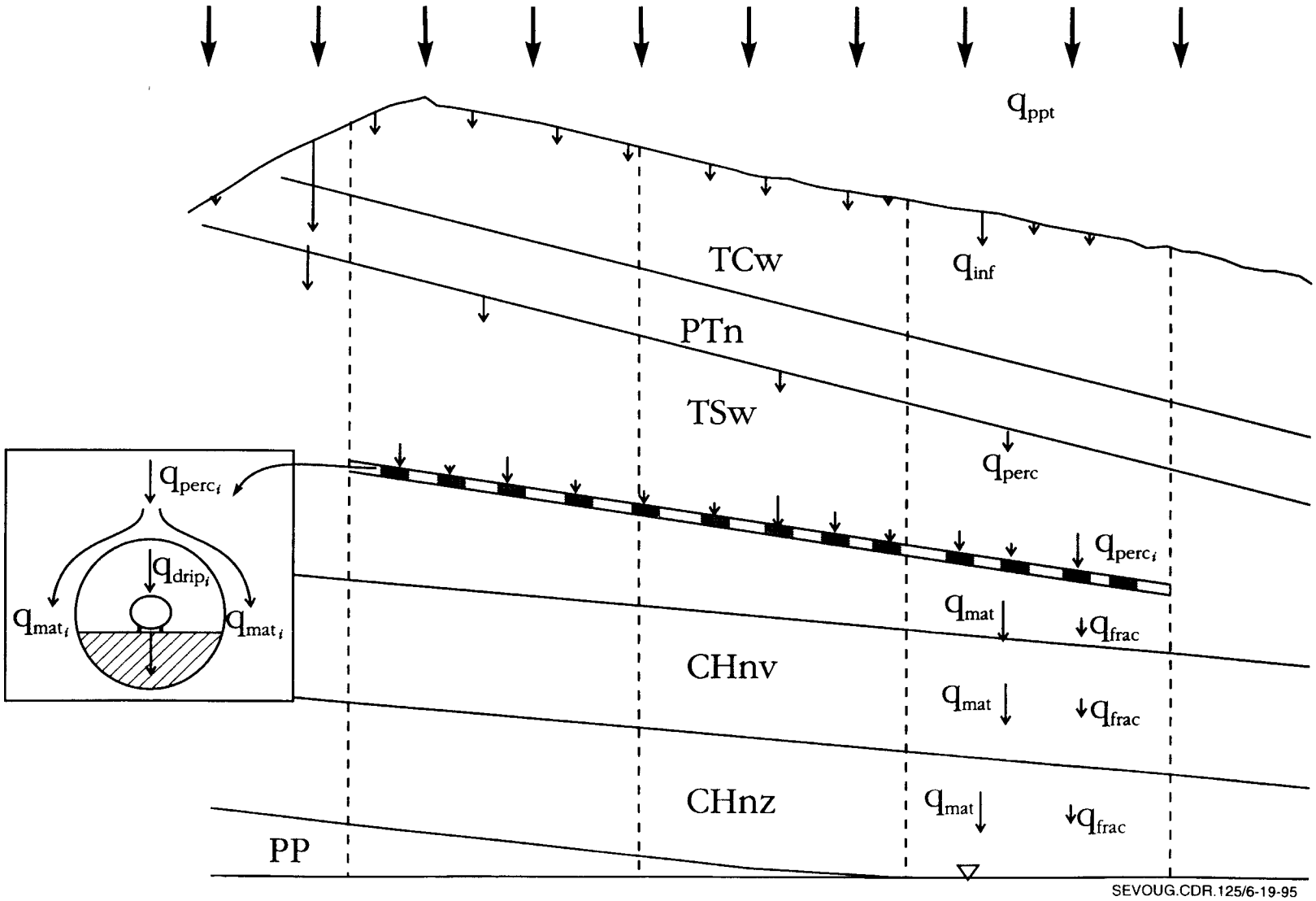
# Plans for Incorporating Localized "Fast" Flow into TSPA-1995
(cont)

- Waste packages with localized flow assumed to have both advective and diffusive releases once the package and cladding have been breached and liquid water in contact with waste form
  - waste packages with no localized flow have only diffusive releases (diffusion a function of saturation)

# Plans for Incorporating Localized "Fast" Flow into TSPA-1995
(cont)

- Range of "matrix" and "fast" flow path percolation fluxes based on process model results for each hydrostratigraphic unit
  - uncertainty due to property uncertainty and value of "matrix" saturation for "fast" flow initiation

# Schematic Depiction of Distribution of Infiltration into Fracture and Matrix Percolation Flux Components (TSPA-1995)



# Distribution of Infiltration into Fracture and Matrix Percolation Flux Components (TSPA-1995)

| | | |
|---|---|---|
| $q_{ppt}$ | = precipitation rate | varies in time - long-term climate change |
| $q_{inf}$ | = infiltration rate (Flint et al.) | varies in space and is uncertain |
| $q_{perc}$ | = percolation flux (Bodvarsson, Kwicklis et al.) | averaging of infiltration rates is uncertain |
| $q_{perc_i}$ | = local percolation flux (Chesnut et al.) | varies in space; variability assumed log normal ($\sigma \log q_{perc}$=1.0) |
| $q_{drip_i}$ | = local seepage flux into drift | varies in space variability caused by $q_{perc}$ variability and variability in saturated matrix conductivity of TSw |
| $q_{mat}$ | = matrix percolation flux | varies between hydrologic units and is uncertain; variability caused by variability in characteristic curves; uncertainty caused by satiated matrix saturation |
| $q_{frac}$ | = fracture percolation flux | |

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# Summary and Conclusions

- Recent confirmation of potential for "fast" flow paths necessitates incorporation into TSPA analyses
- Expect the natural percolation flux distribution and presence/absence of seeps to be variable and uncertain

# Summary and Conclusions
(Cont.)

- TSPA-1993 and Calico Hills Systems Study evaluated sensitivity to localized "fast" flow
  - potential positive effects (limited waste contacted)
  - potential negative effects depend on flux distribution and transport properties
- TSPA-1995 will continue sensitivity analyses using more representative EBS environments and variability in localized "fast" flow