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

NUCLEAR WASTE TECHNICAL REVIEW BOARD
FULL BOARD MEETING

SUBJECT: HUMAN INTRUSION, BASALTIC IGNEOUS ACTIVITY, AND COMBINING CCDFs

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DALLAS, TX
APRIL 7-8, 1992

Human Intrusion

- Investigated two scenarios from human intrusion event tree

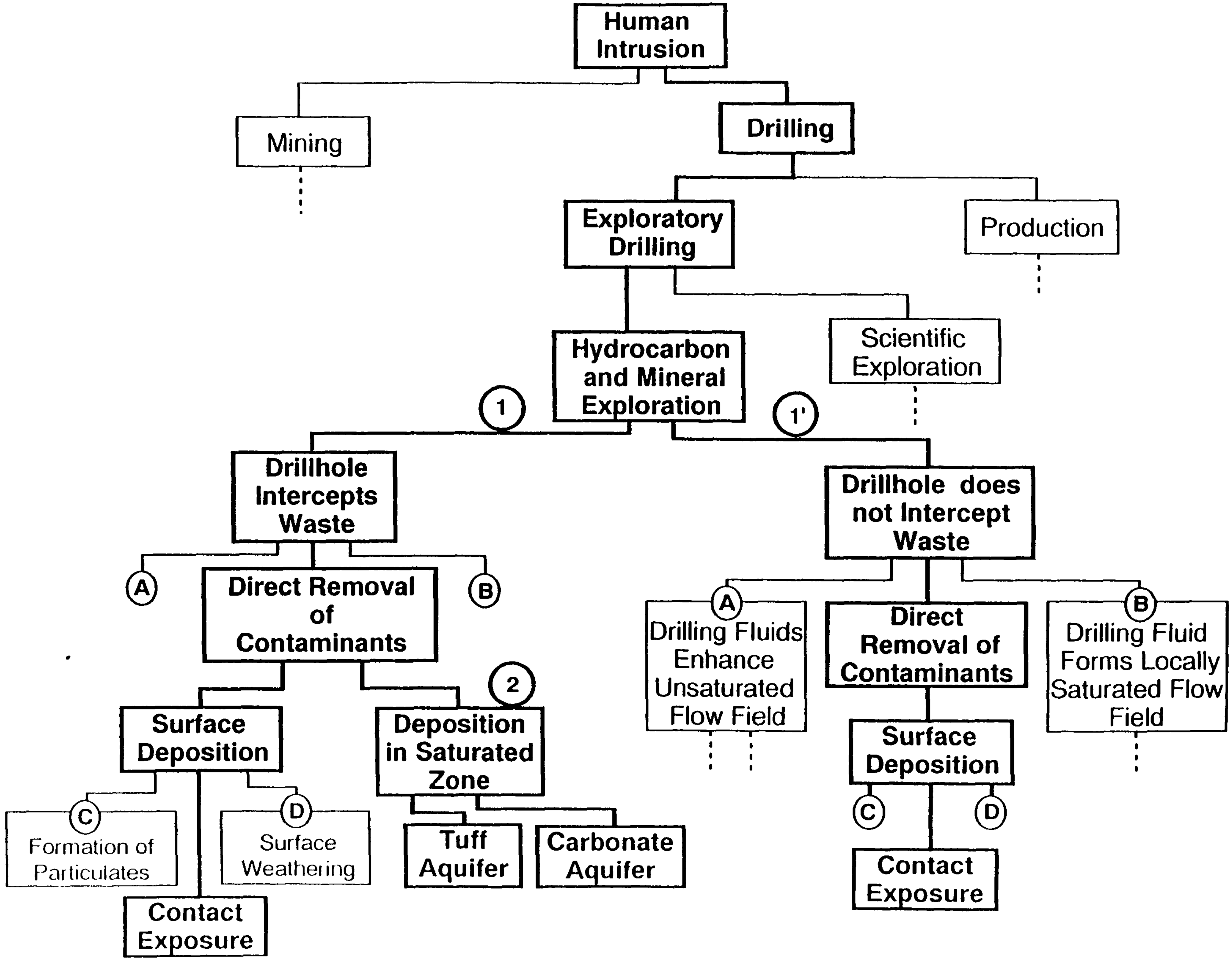
- Chose cases with presumed greatest consequences
  - Direct (mechanical) transport of waste
  - (Aqueous, gas transport in UZ slower)

- Processes modeled were abstracted
  - Modeled every FEP in path, but with simplifying assumptions

- Investigated two drilling-incident scenarios
  - Surface release
  - Release through saturated-zone transport

- Analyses included both base-case and sensitivity studies

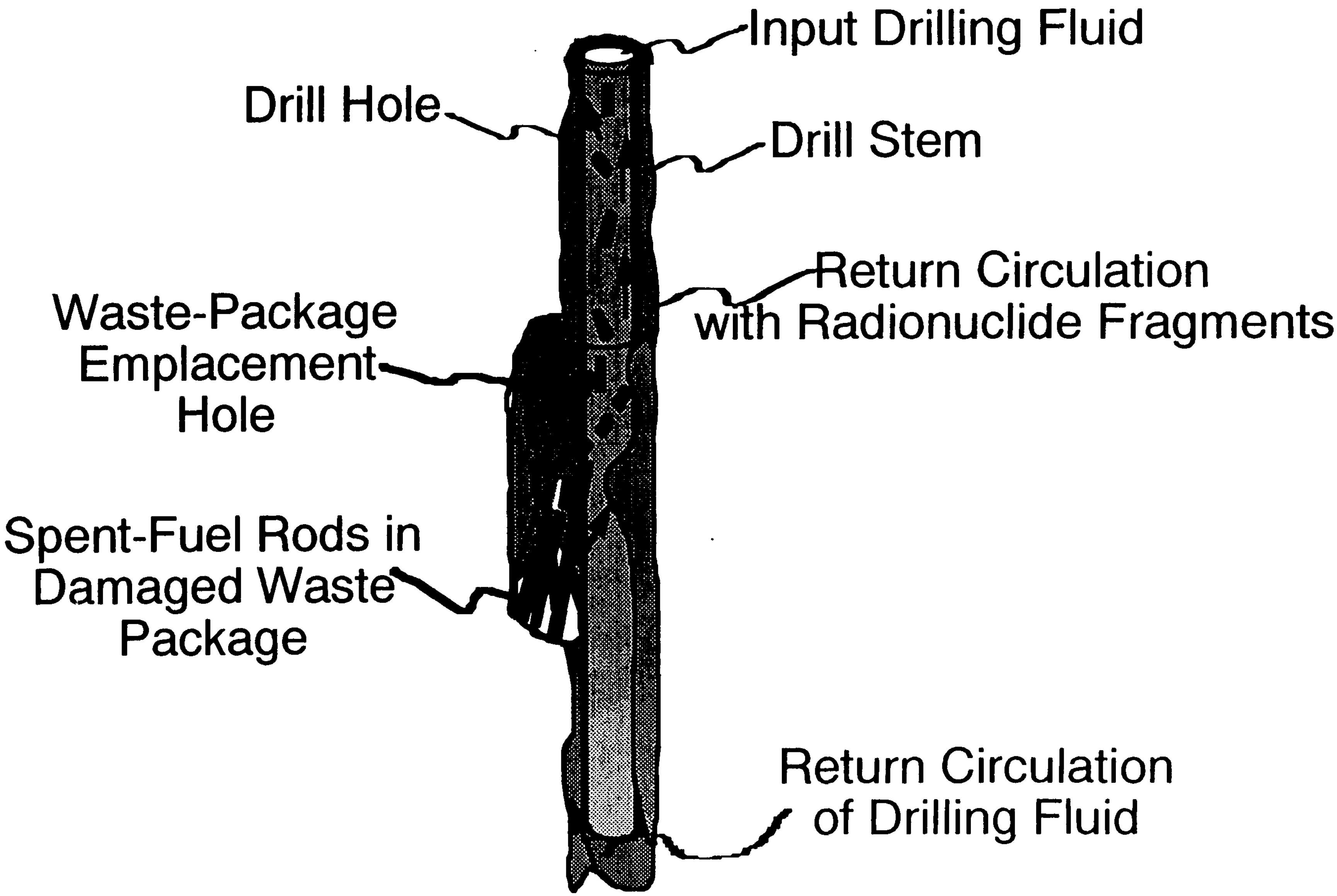
Human Intrusion Event Tree



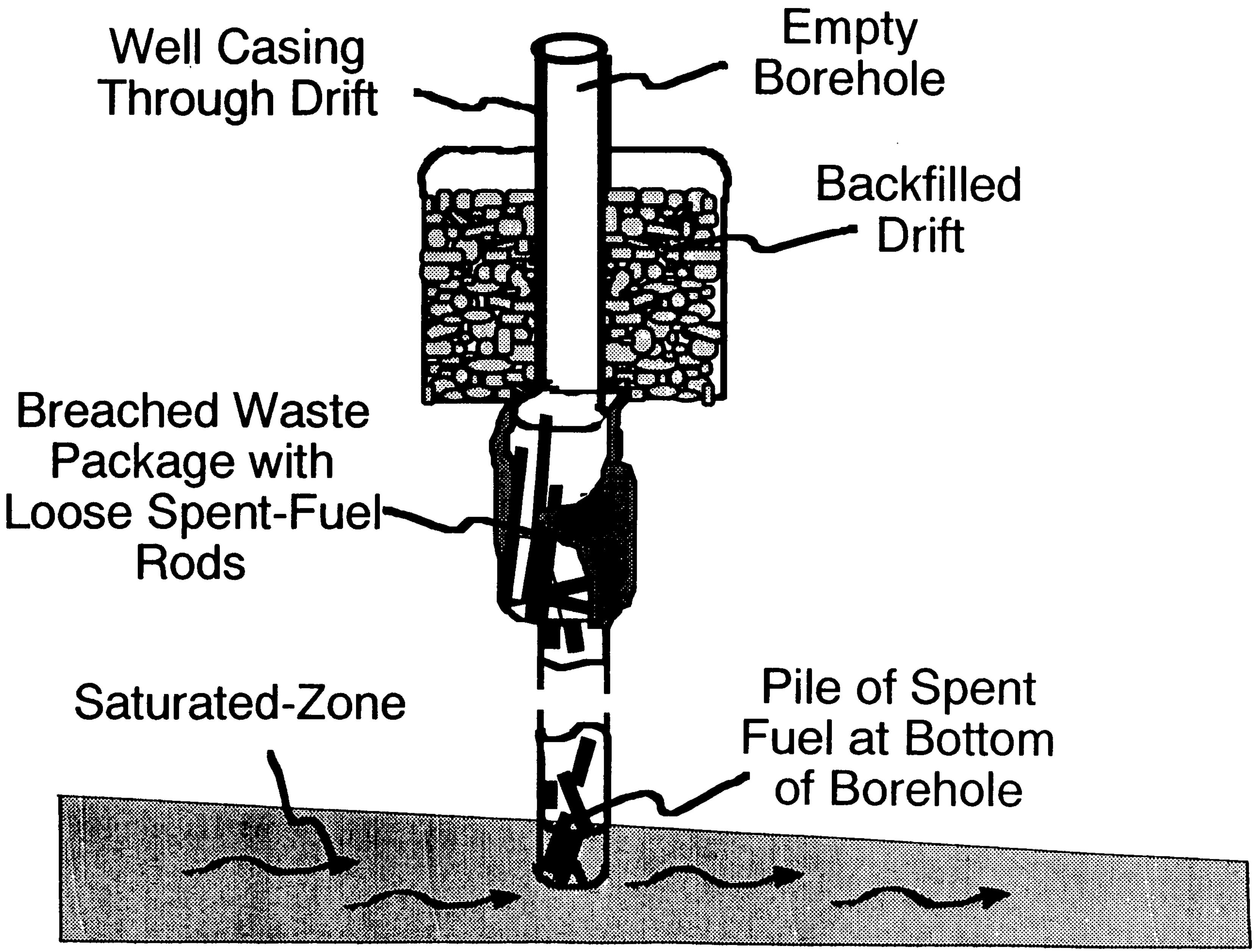
Assumptions--Conceptual

- Human intrusion occurs by 20th-century drilling practices
- Probability of drilling at site = 1.0
- Boreholes are drilled according to EPA drilling densities
- Probability of hit is based on geometry
- Transport is entirely mechanical
- Source term is primary determinant of release
- Direct hits and near misses contribute to releases
- Saturated-zone transport in tuff or carbonate aquifers

Surface Release Drilling Scenario



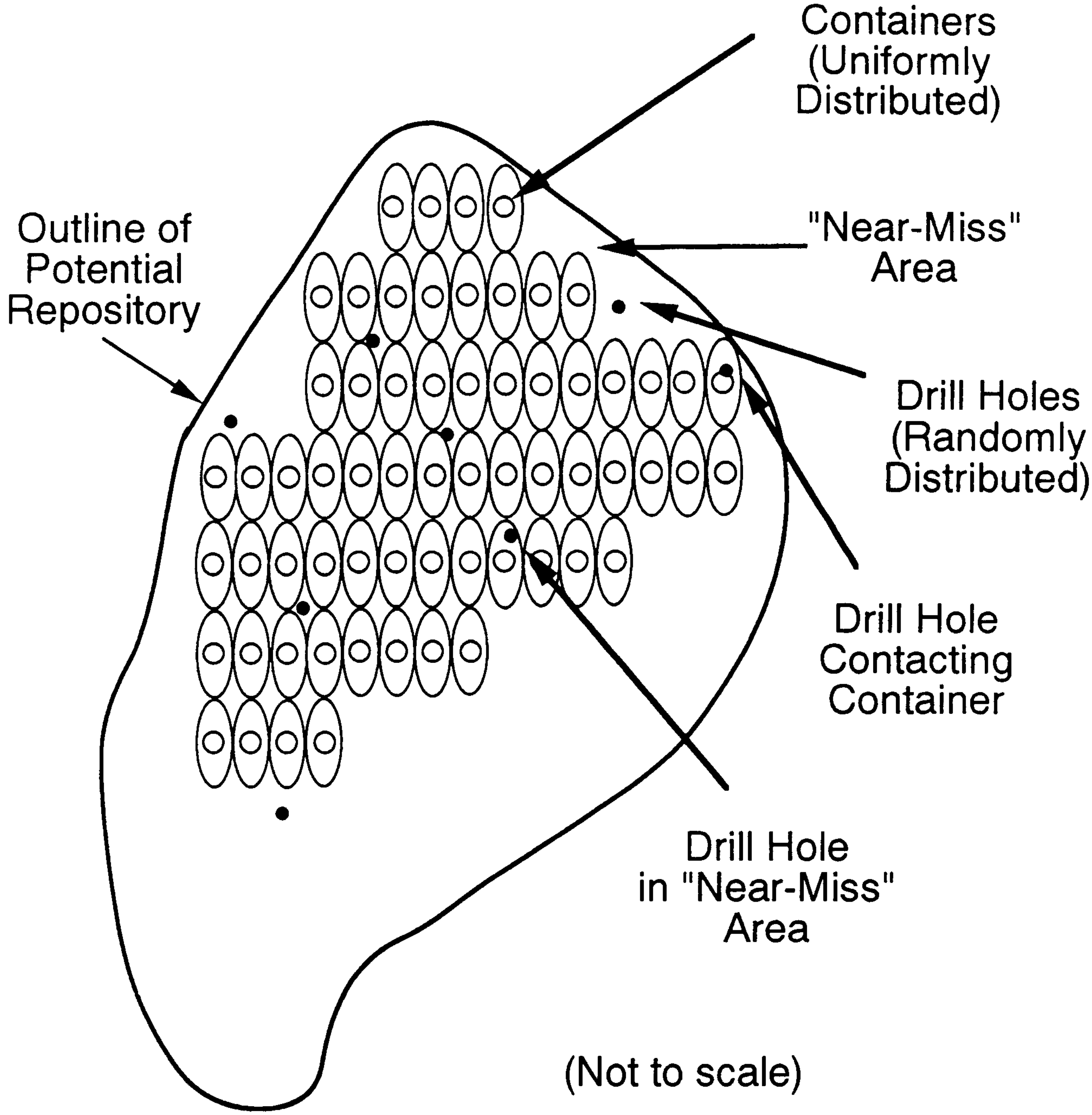
Saturated Zone Release Scenario



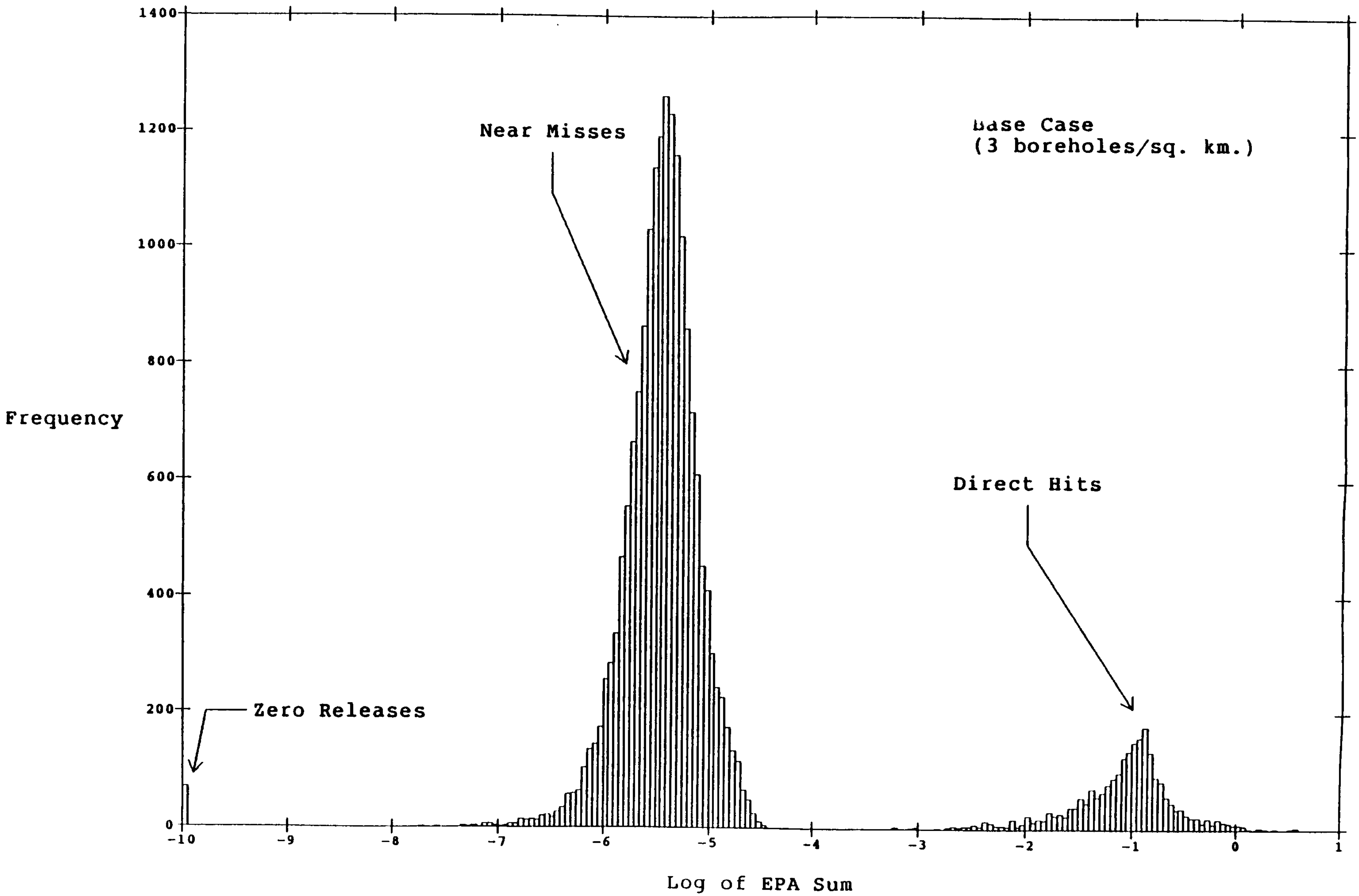
Assumptions--Process

- Waste is uniformly distributed in potential repository
- Up to entire waste package can be released
- Contaminated rock occurs due to diffusion from packages
  - Based on PACE-90 results
- Mechanical transport:
  - Waste is entrained in drilling mud to surface
  - Waste falls down drillhole to saturated zone
- Source term used limited number of radionuclides (inventory includes decay and ingrowth from chains)
- Aqueous transport in saturated zone influenced by velocity and retardation
- Time of occurrence of drilling randomly chosen

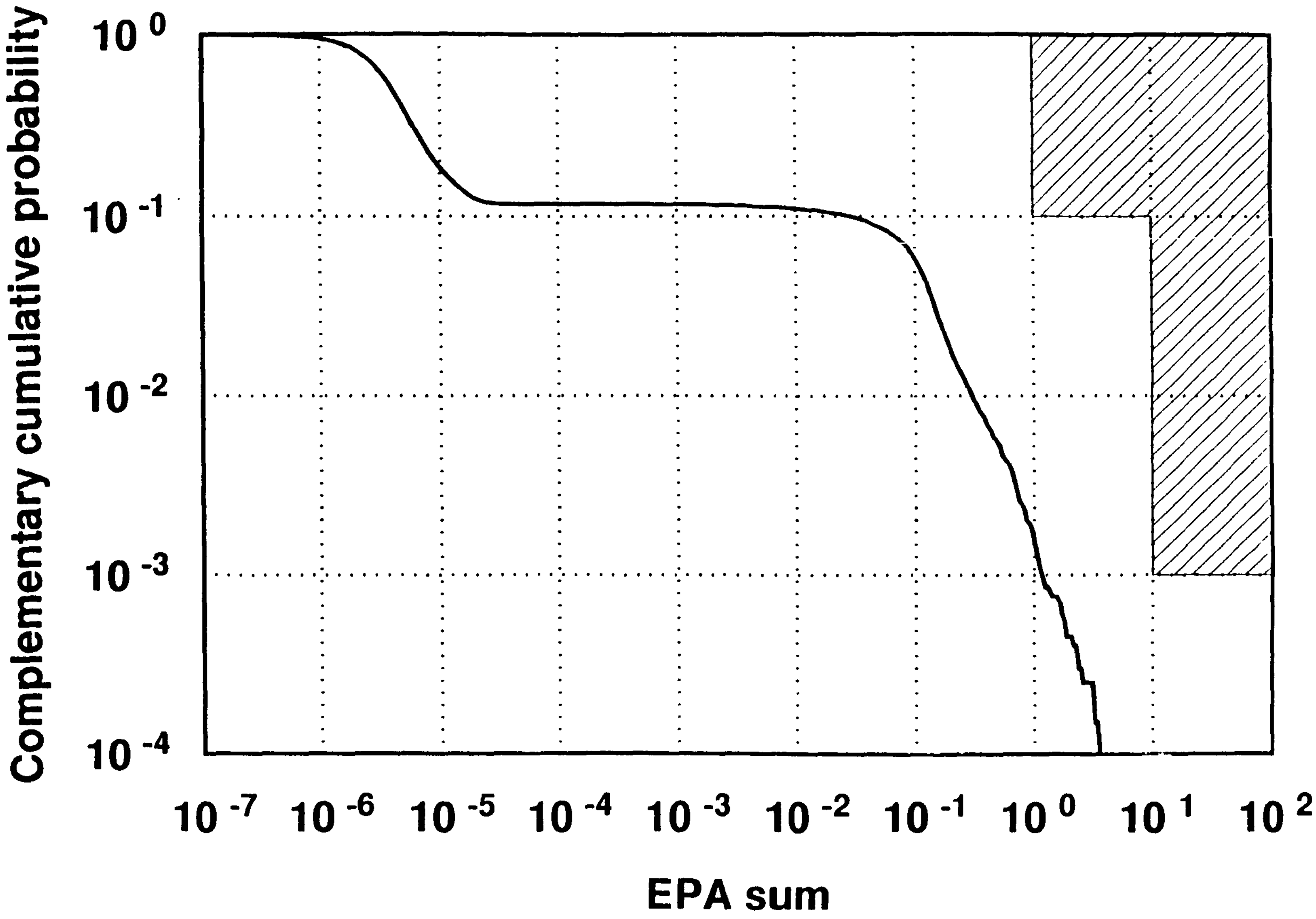
Distribution of Radionuclides in Repository



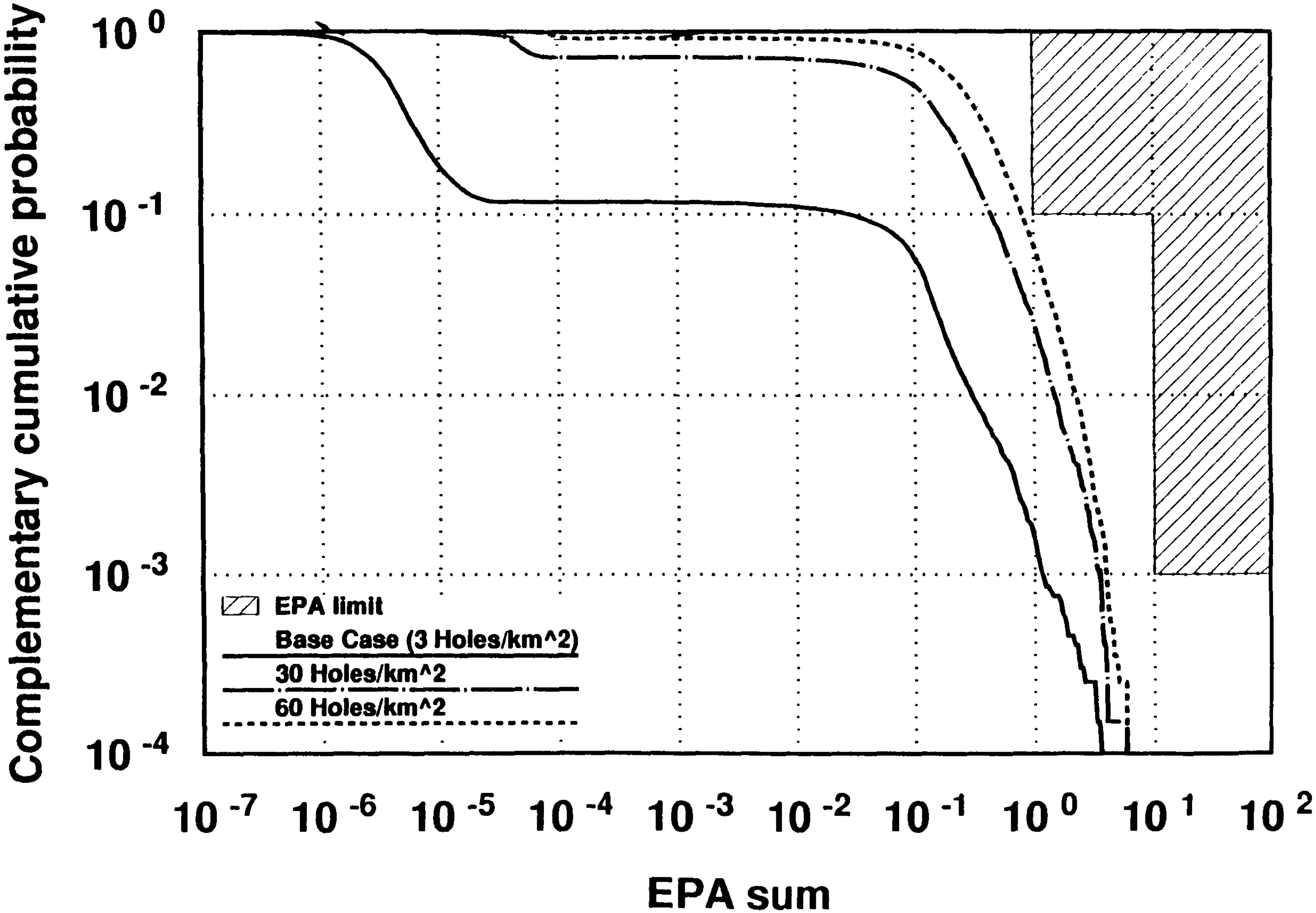
Distribution of Surface Releases



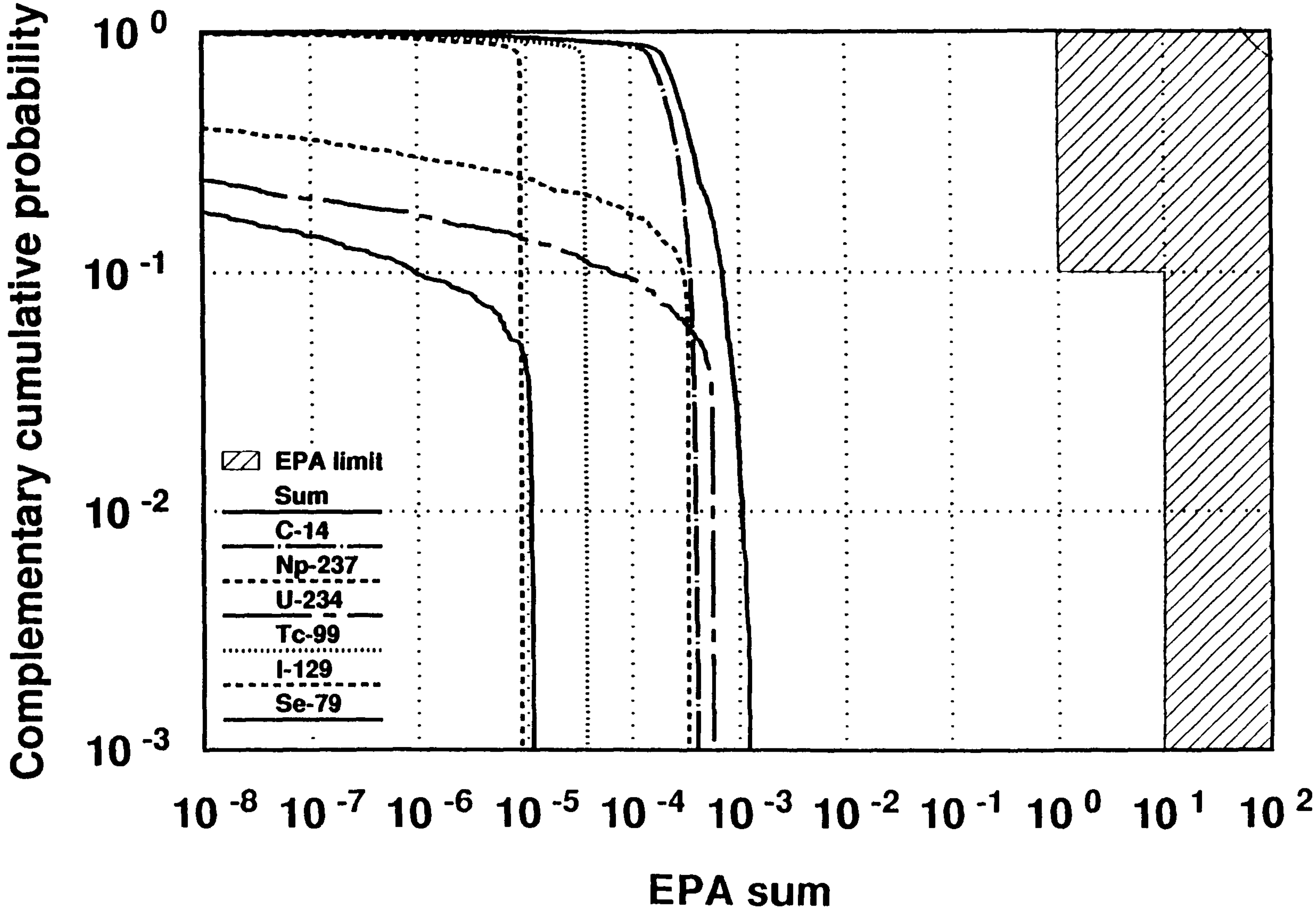
Conditional Probability Distribution for Surface Releases due to Drilling



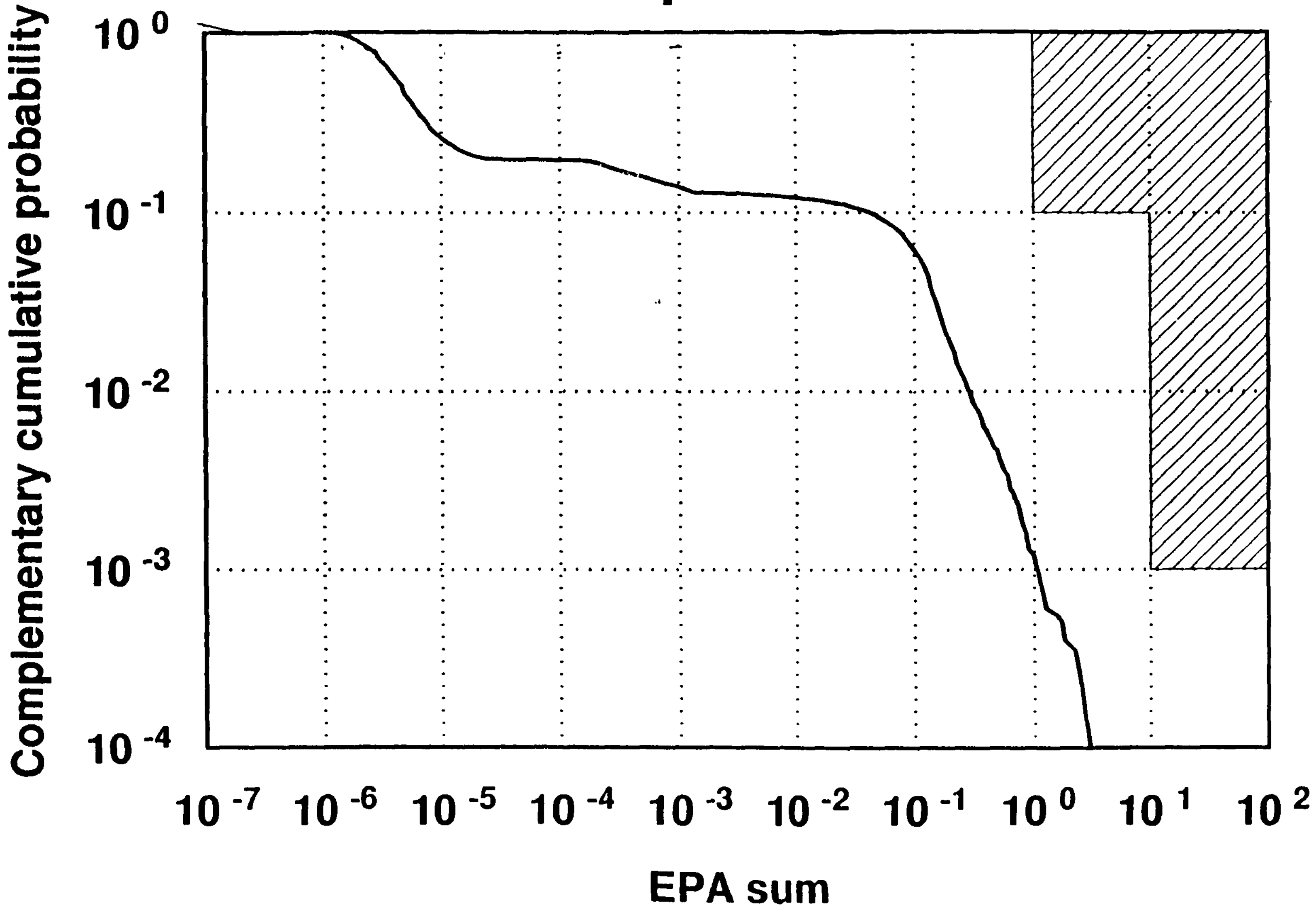
Effect of Increasing the Number of Boreholes Drilled over 10,000 Years



Aqueous Releases from Tuff Aquifer Due to Human-Intrusion Drilling



Overall Conditional CCDF for Three Drilling Scenarios--Surface, Tuff-Aquifer, Carbonate-Aquifer Releases



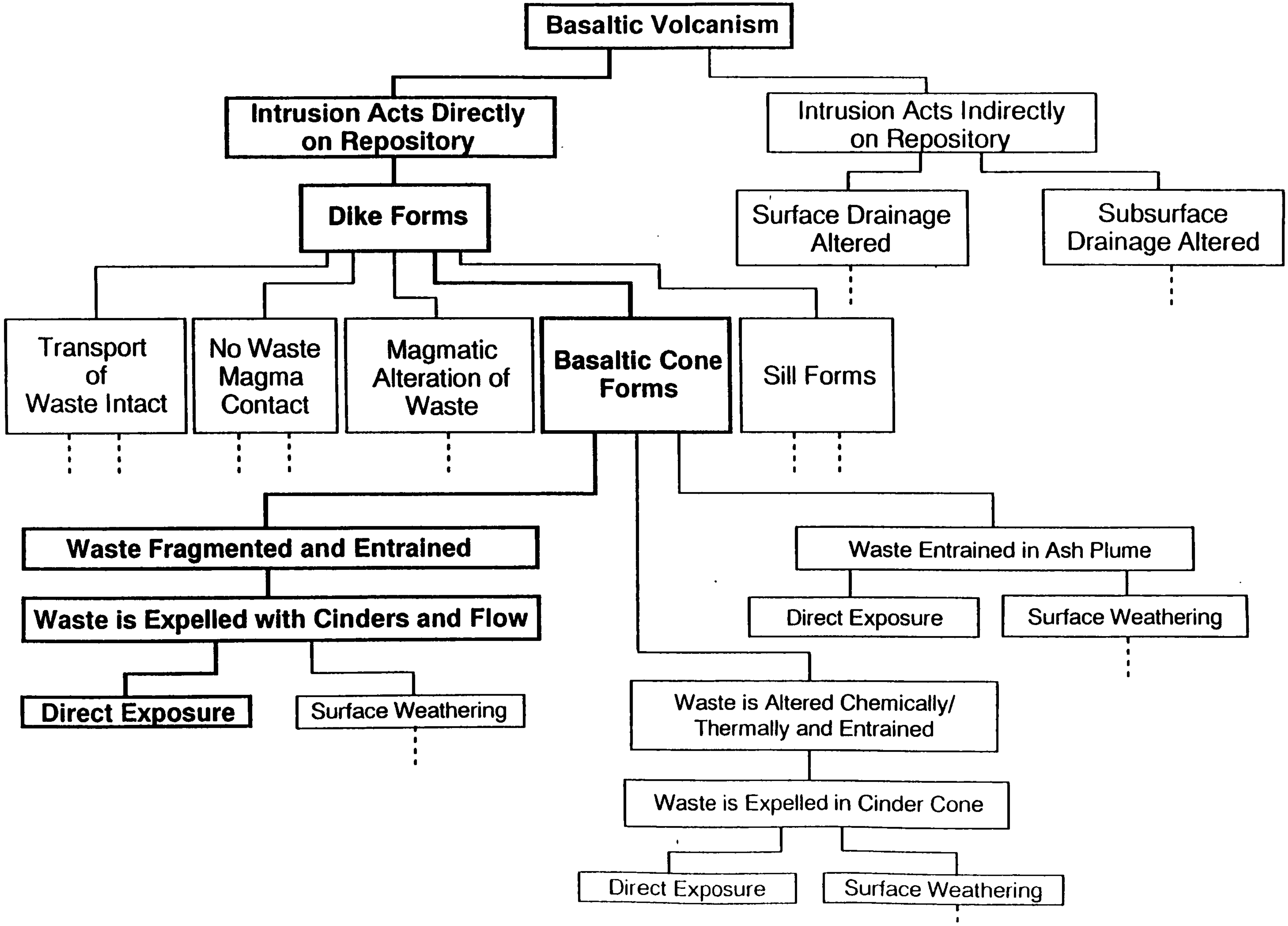
Conclusions

- Using these models, releases from human intrusion are below EPA limit
- Drilling density must be increased greatly before releases approach EPA limit
- Near misses do not come close to exceeding the EPA limit
- Surface releases appear to be independent of site characteristics
- Including the probability of drilling at the Yucca Mountain site will reduce the probabilities of releases further
- Aqueous releases are highly dependent on estimates of ground-water velocity and retardation
- Using more detailed models may not improve estimates

Basaltic Igneous Activity

- Investigated one scenario from event tree
  - Investigated direct basaltic-dike intrusion into repository, followed by the release at the surface via volcanism
  - Other senarios may actually have greater consequences
- Used abstracted models
  - Relied on prior analyses for model and parameters
  - Developed 2 simple models for the process
- Analyses included both base-case and sensitivity studies

Basaltic Igneous Activity Event Tree



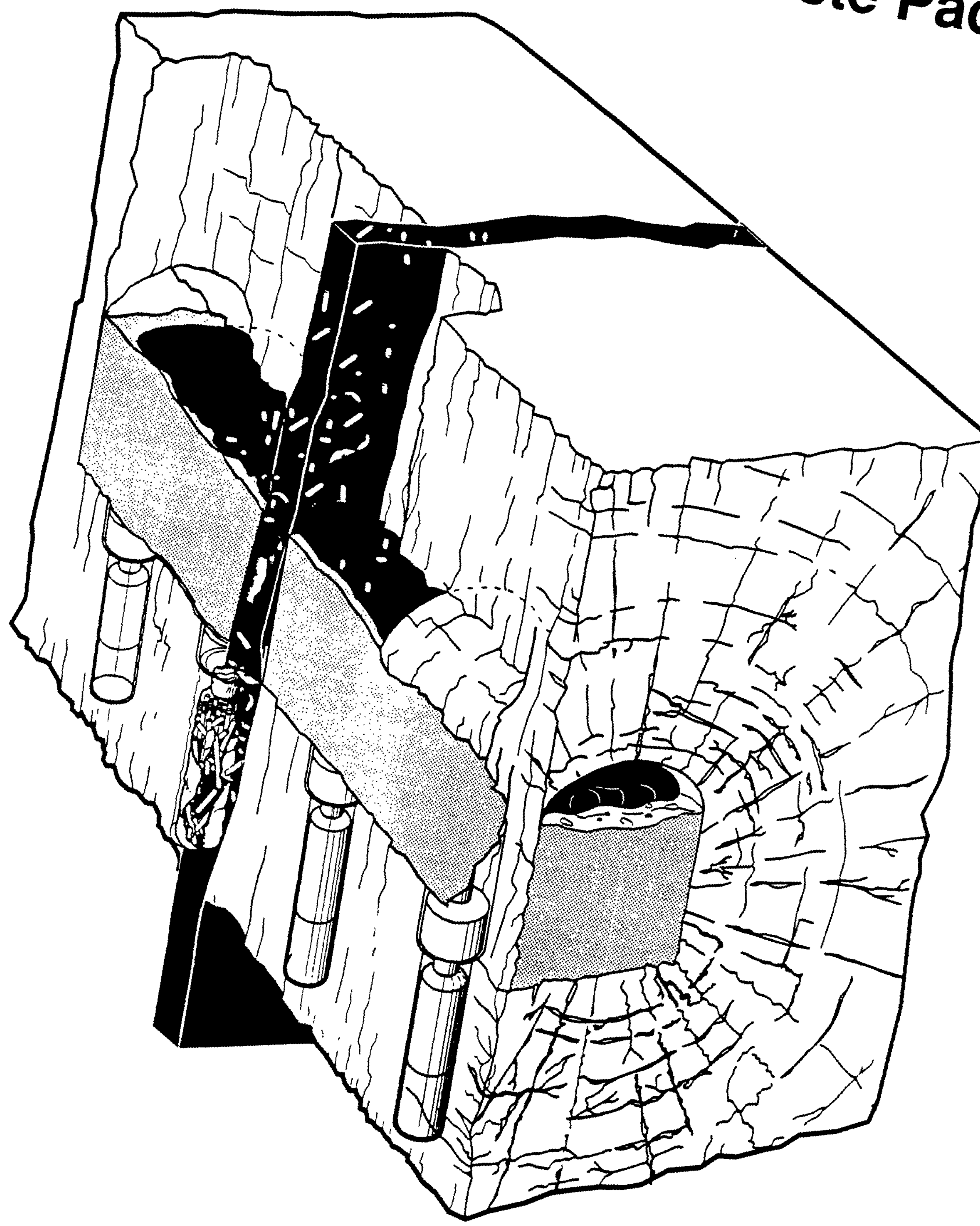
Conceptual-Model Assumptions

- Basaltic dike acts directly on waste packages
  - Dike passes directly through repository
  - Intrusion continues to surface

- Waste is fragmented and entrained in dike by thermo-mechanical effects

- Fragments are erupted as part of cinder cone or lava sheet at surface
  - Entrained radionuclides are released at surface
  - Waste is not encapsulated in lava

Interaction of Dike with Waste Package



Process Assumptions

- **Amount of waste entrained is linearly related to volume of intersection of dike and repository**
  - Geometric model of interaction
  - Field observations of volcanic activity

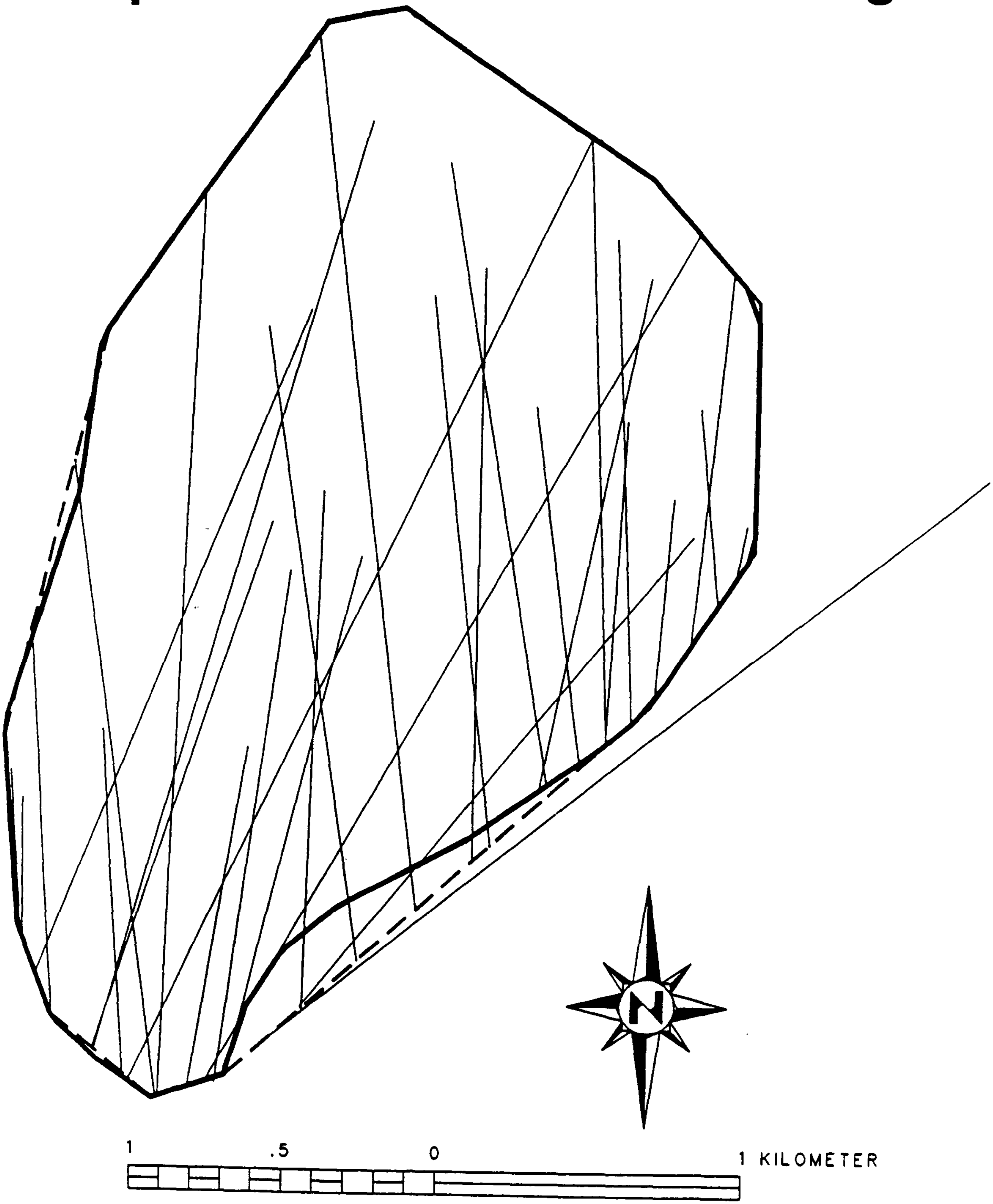
- **Ranges for parameters (dike width, wall-rock fraction entrained, etc) elicited from Valentine (LANL)**

- **Probability of occurrence taken from Crowe's work (LANL)**

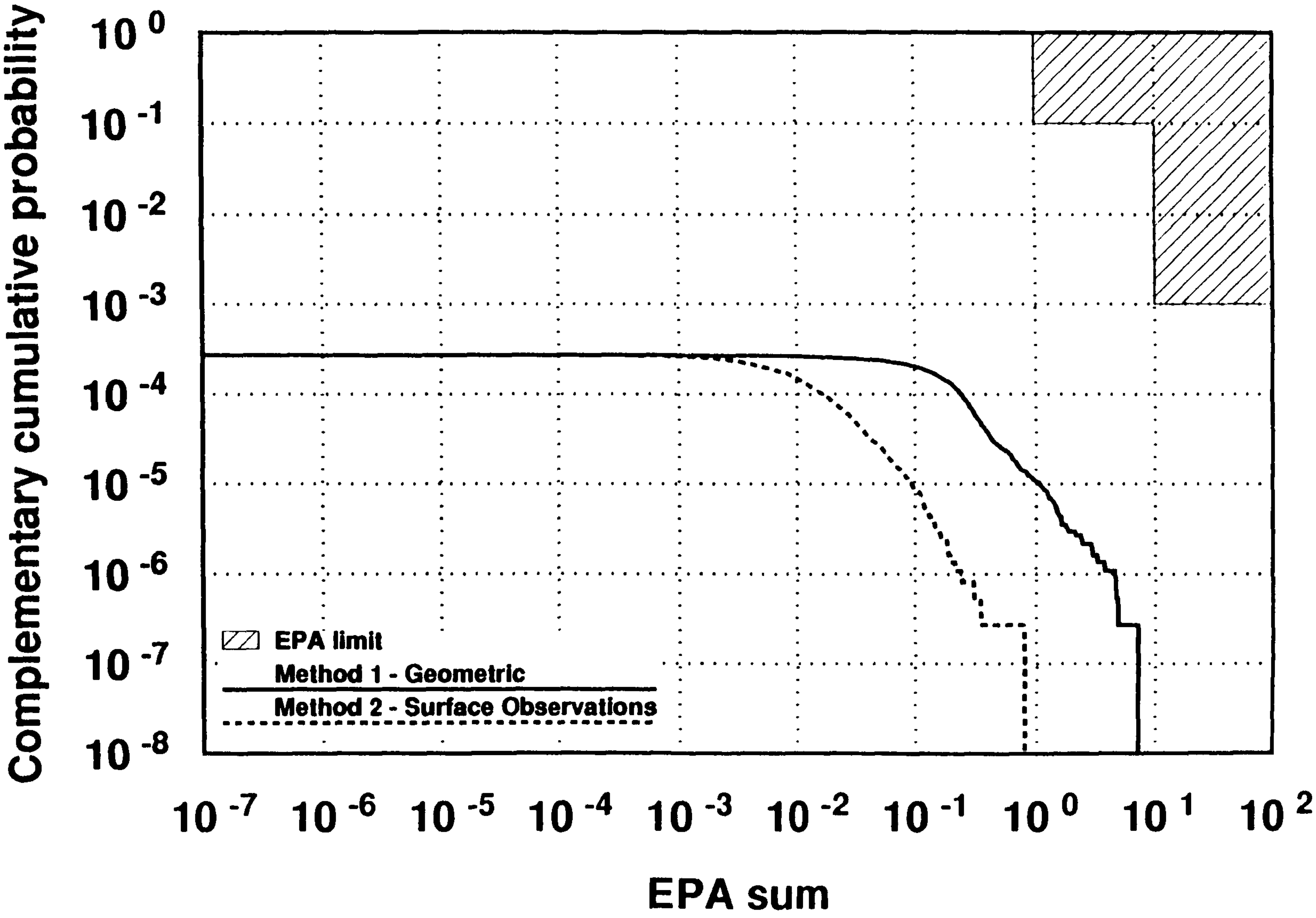
- **Because of low probability, conditional CCDF for consequences was calculated first**
  - Used Monte Carlo simulations for dike-waste interaction
  - Final CCDFs calculated from conditional CCDFs and probabilities

- **Sensitivity studies investigated reasonable parameter variations**

Examples of Dike Trends and Lengths



Comparison of Two Models for Surface Release due to Basaltic Igneous Activity into Repository



Conclusions

- Direct releases are below EPA limit
  - Models used conservative assumptions about transport processes
  - No cases were found from sensitivity studies with much larger releases
- Releases from basaltic igneous activity do not contribute significantly to this estimate of total-system releases
- Future igneous-activity analyses should concentrate on indirect effects (e.g., changes in ground-water-flow patterns)

Combining CCDFs

- Two methods for generating an overall CCDF:

1) Single Monte Carlo simulation with ALL important FEPs included

2) Identify scenario classes
   - Mutually exclusive and exhaustive
   - Calculate conditional CCDFs
   - Calculate final CCDF by weighting components

- TSPA used a modification of method 2
  - Identify specific scenarios and calculate conditional CCDFs
  - Combine CCDFs by various techniques
  - Combined CCDF is still conditional

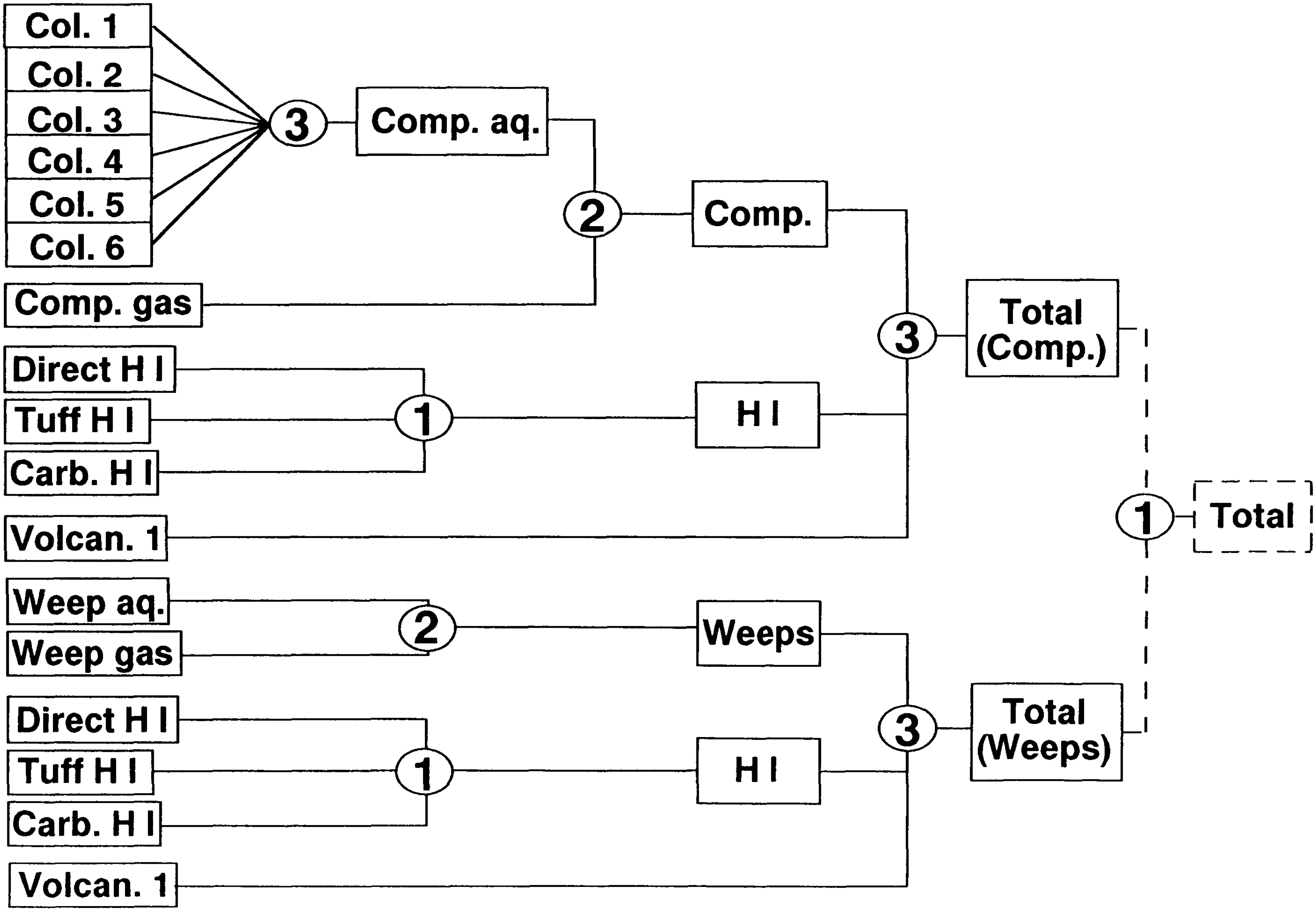
Methods of Combining CCDFs

1) Weighted Sum--used for mutually exclusive scenarios
   - e.g., human intrusion cases

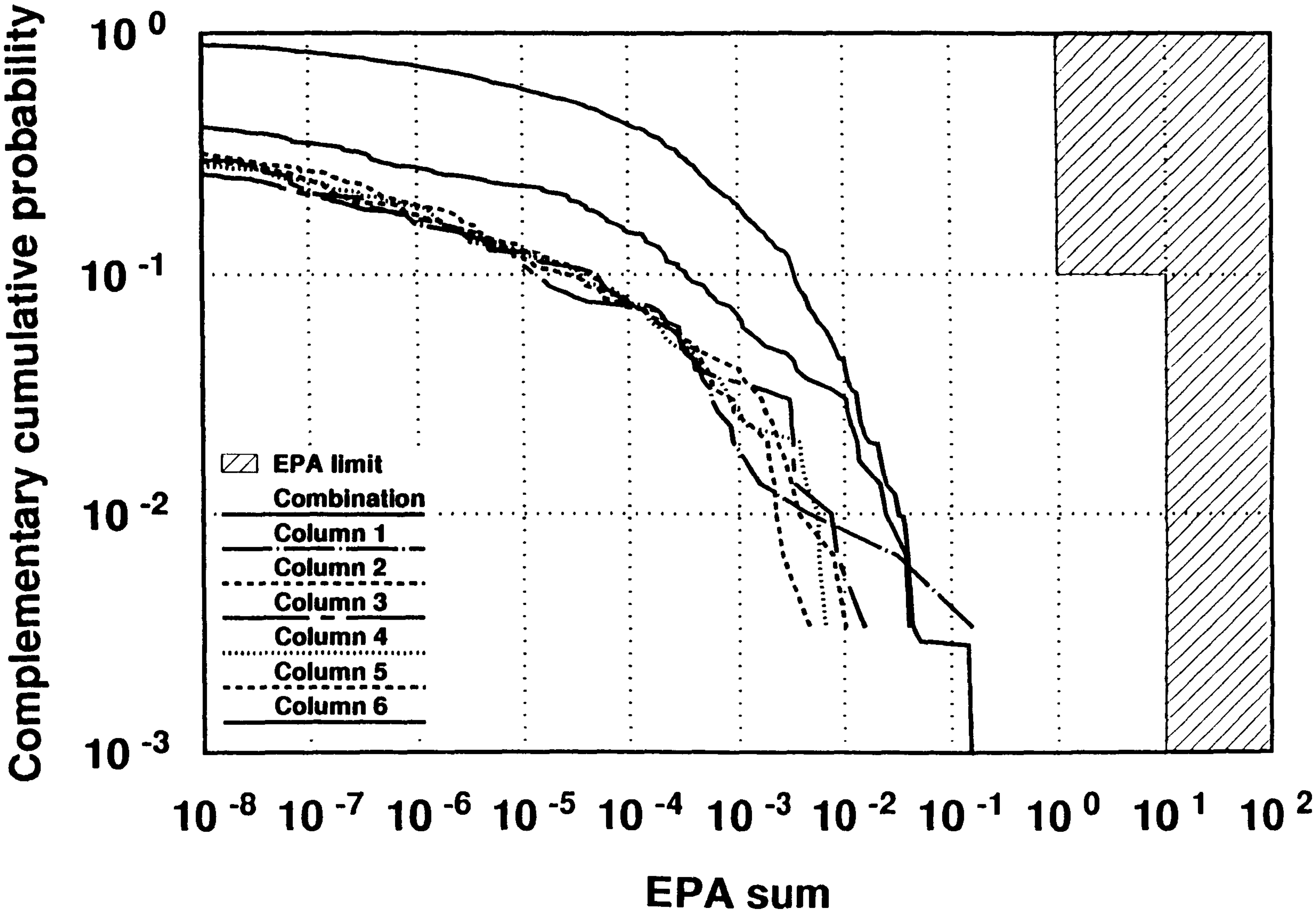
2) "Horizontal Addition"--done as an expedient for not calculating CCDFs with correlations
   - e.g., aqueous and gaseous cases
   - Associates high releases from one case with high releases from the other case
   - This technique is probably appropriate when one parameter is dominant for both processes

3) Probablilistic sum--used for completely independent scenarios
   - e.g., 6 UZ columns modeled by Total System Analyzer
   - Combine by randomly drawing EPA sums from each simulation

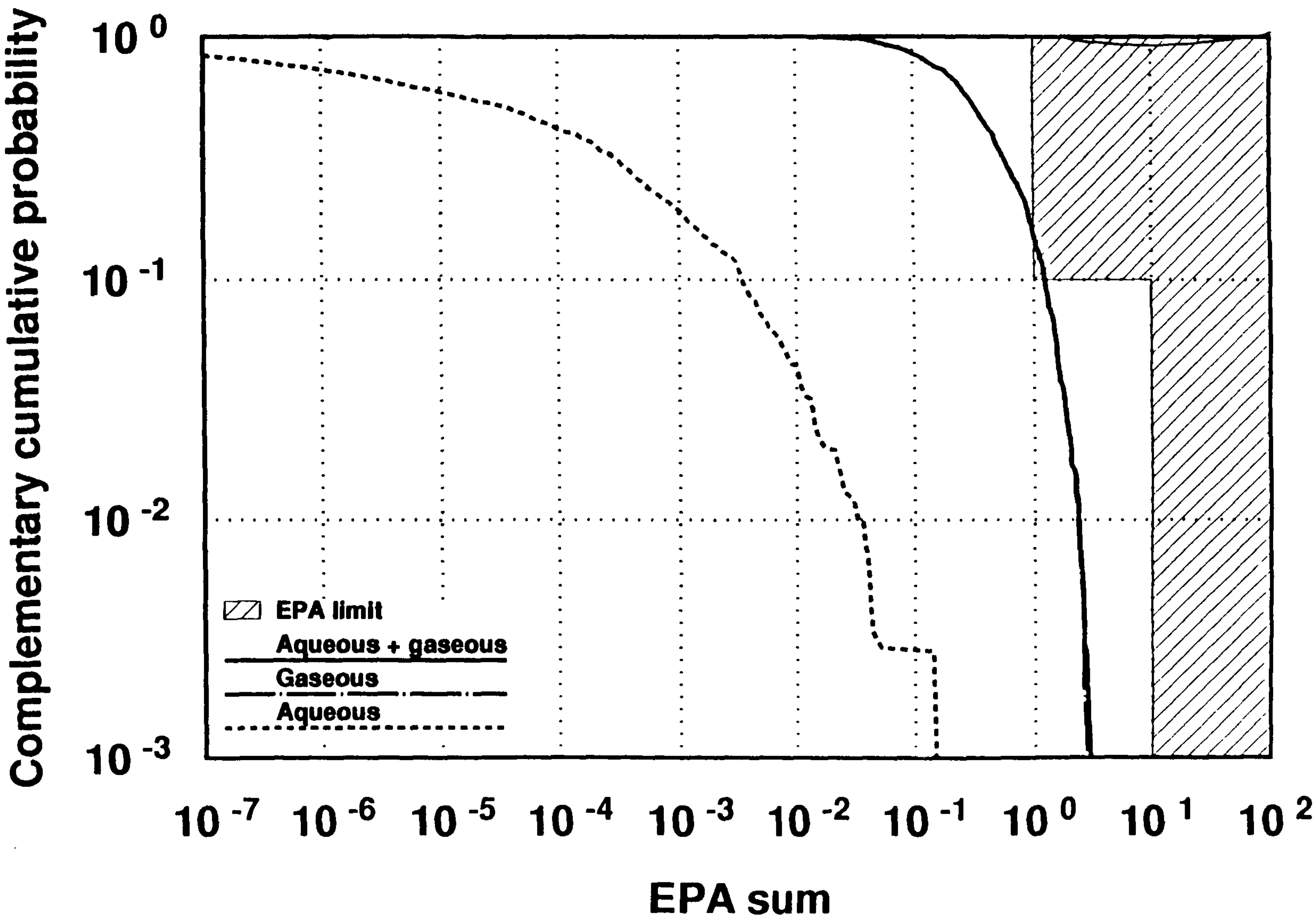
Methods of Combining CCDFs



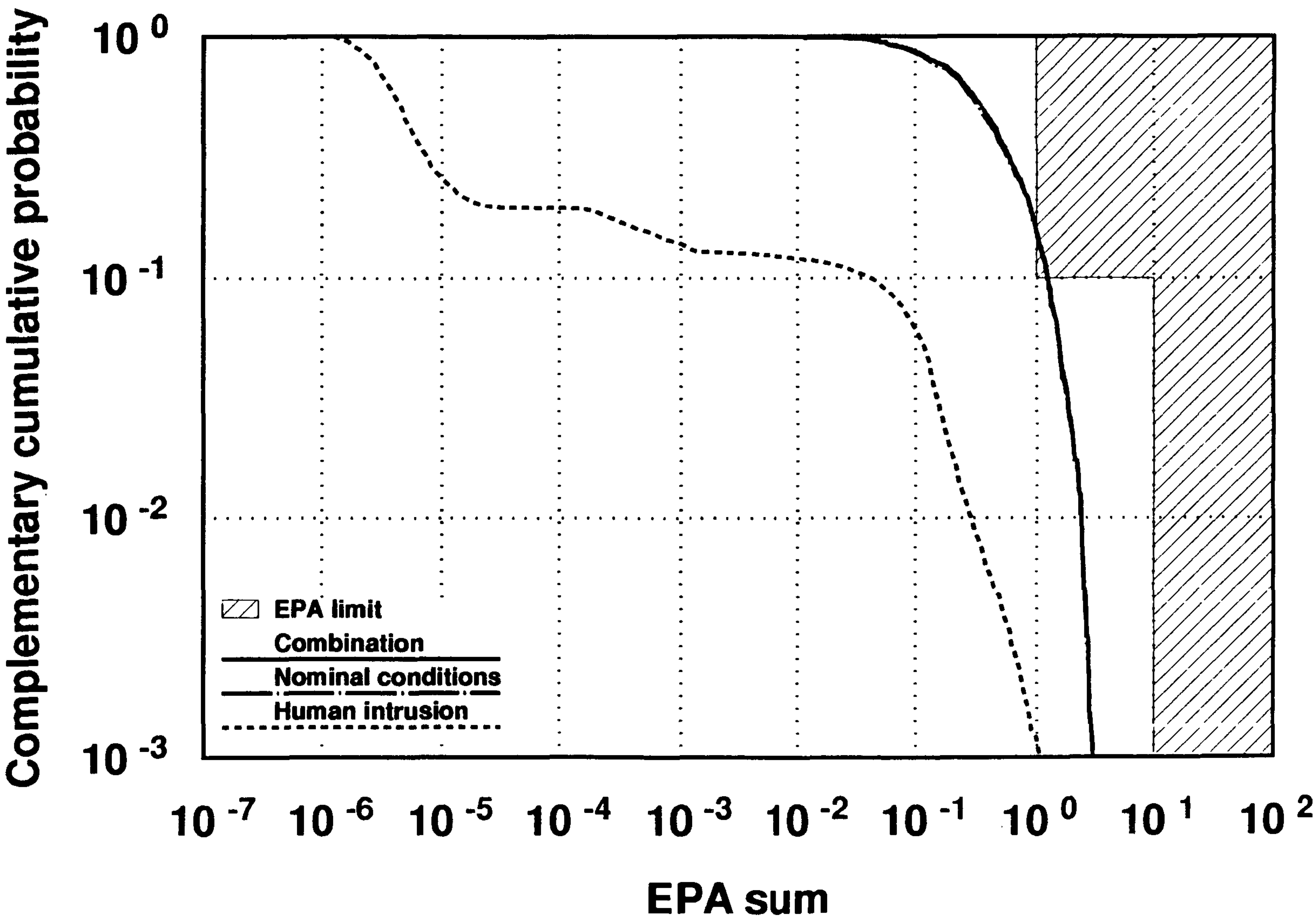
Aqueous Releases, Composite-Porosity Model Six Columns and Combination



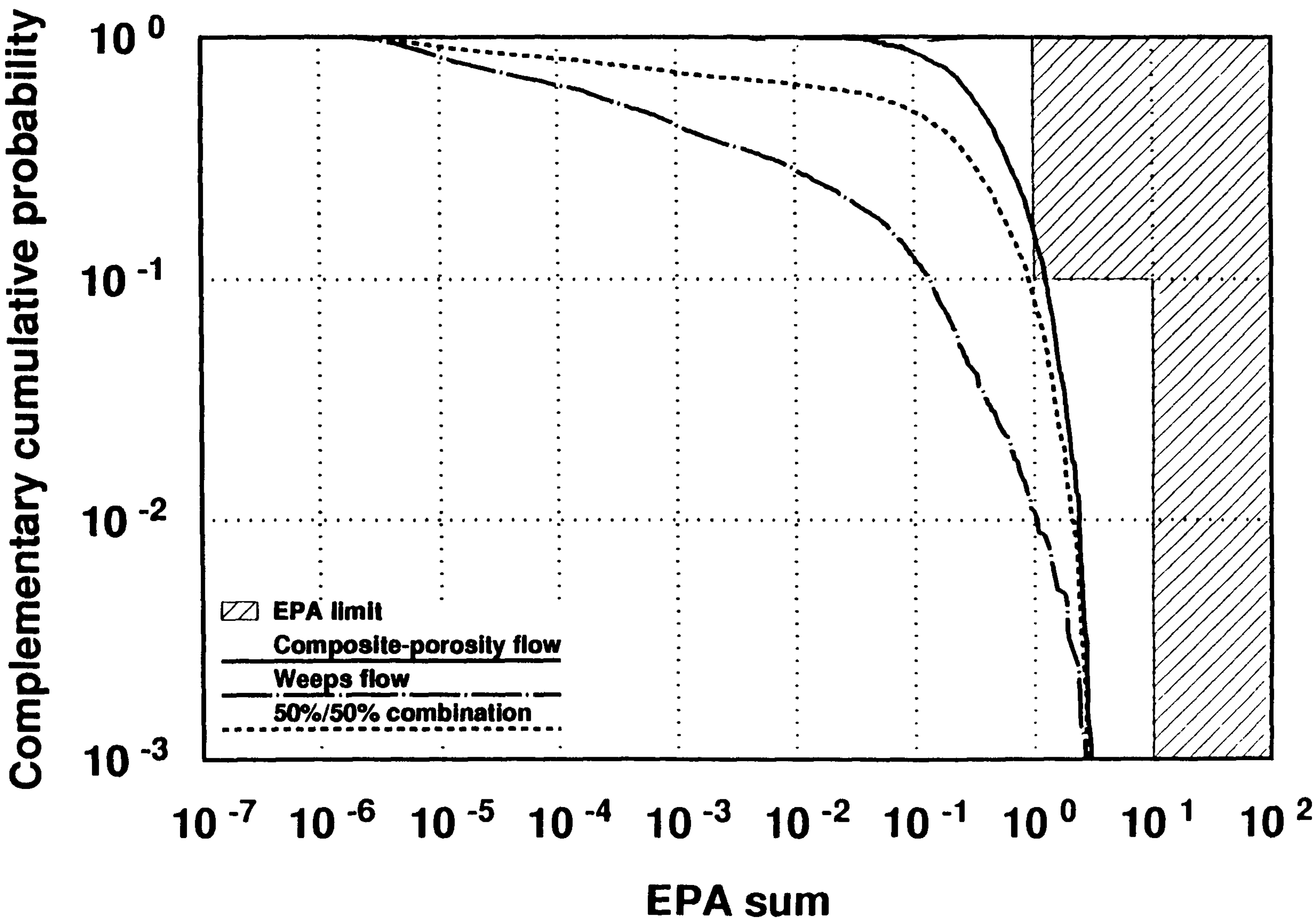
Combined Conditional CCDF for Gaseous and Aqueous (Composite-Porosity Model) Releases



Overall Conditional CCDF, Assuming Composite-Porosity Aqueous Transport



Overall Conditional CCDF, with Three Weightings of Composite-Porosity and Weeps Models



Summary of SNL's TSPA Analyses

- An analysis using abstracted models and data structures has been completed
  - Results of modeling are consistent with SNL's understanding of the process from more detailed modeling
  - Conditional CCDFs for four scenarios have been combined into an overall conditional CCDF