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

NUCLEAR WASTE TECHNICAL REVIEW BOARD FULL BOARD MEETING

SUBJECT: TSPA AQUEOUS AND GASEOUS RELEASE CALCULATIONS

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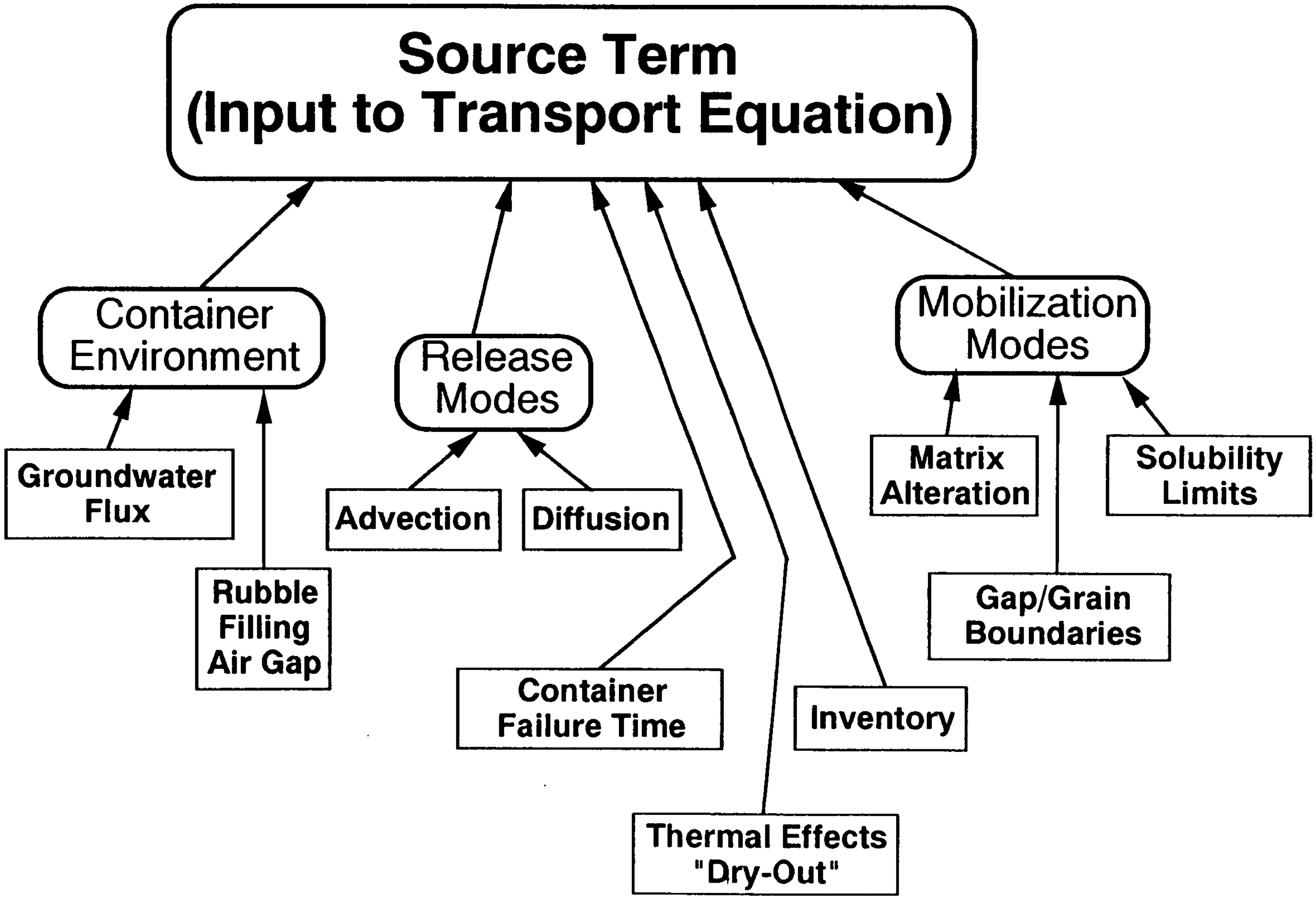
DALLAS, TX
APRIL 7-8, 1992

Outline

- Source term
- Ground-water flow and transport
- Gas flow and transport
- Results

Factors Included in the Source Term



Radionuclides Included in Calculations

Alteration-limited: ^{14}C, ^{79}Se, ^{99}Tc, ^{129}I, ^{135}Cs

Solubility-limited: ^{126}Sn, ^{234}U, ^{237}Np, ^{239}Pu, ^{243}Am

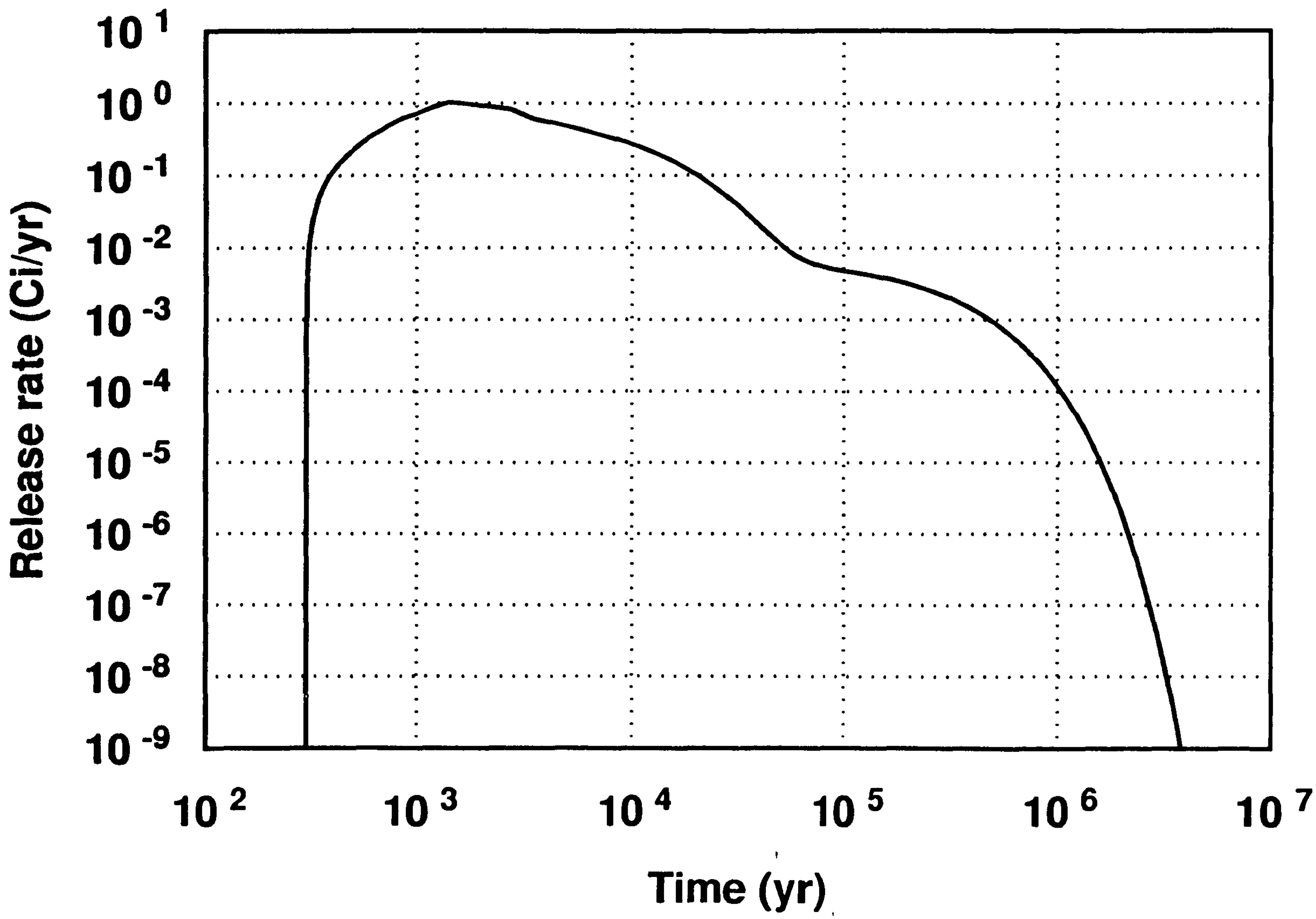
Assumed 60% PWR, 40% BWR spent fuel

Release Modes In Source Model

3 release types:
- advection
- diffusion
- advection + diffusion

3 mobilization types:
- prompt release (gap/grain boundaries)
- matrix alteration
- dissolution

^{135}Cs Release Rate
Showing Three Release Modes



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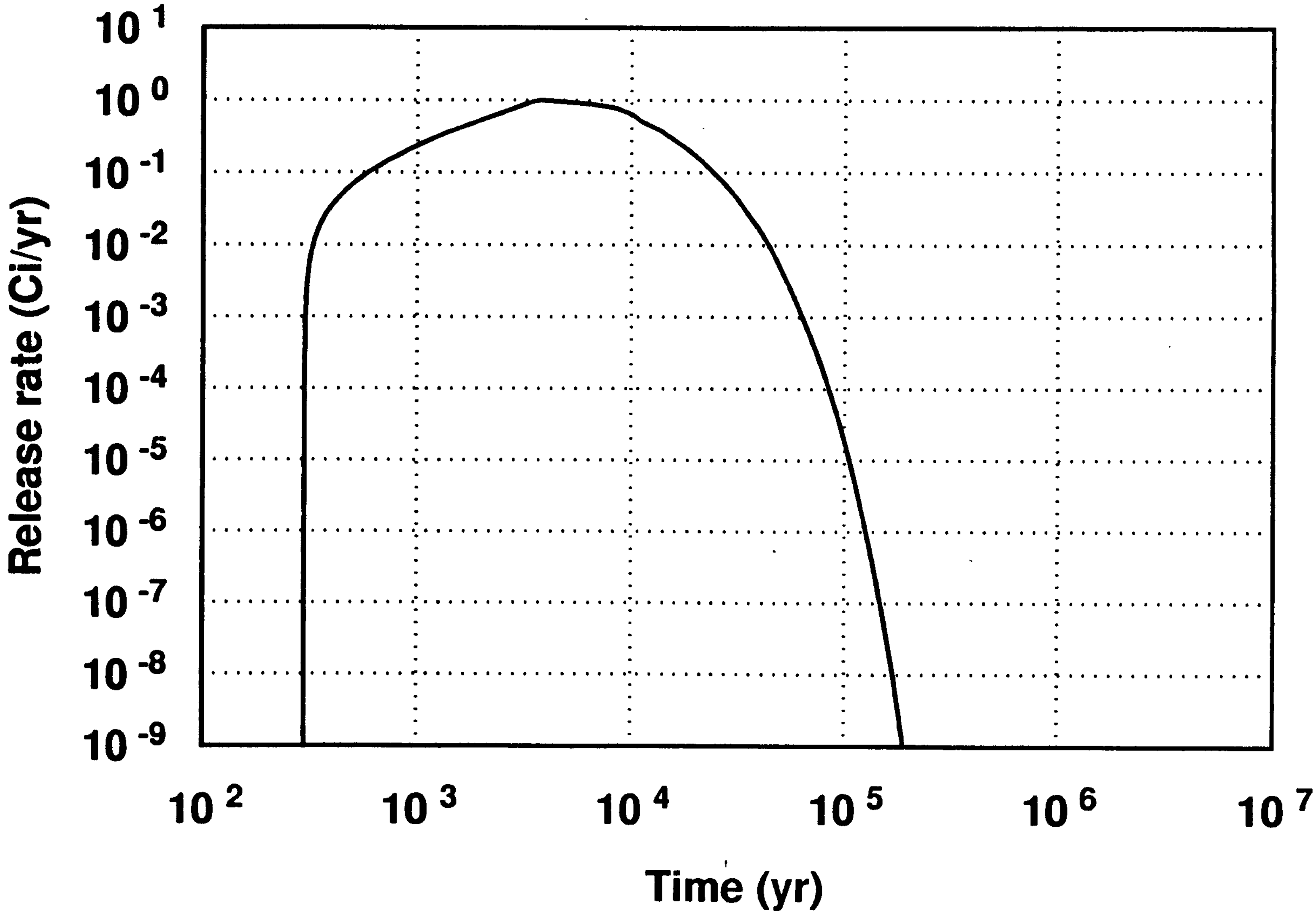
^{135}Cs Release Rate
Using Average Values for Input Parameters



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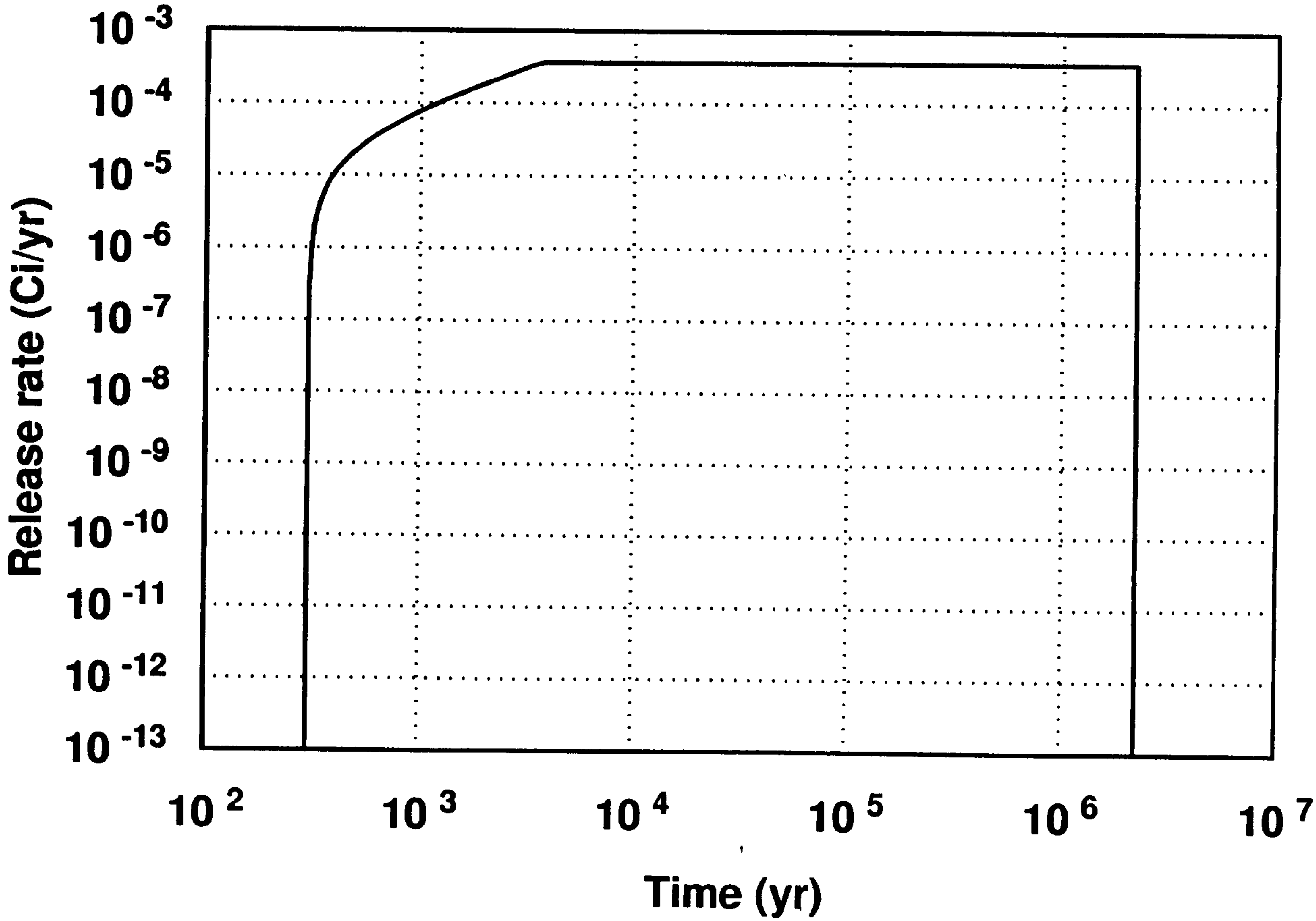
^{234}U Release Rate
Using Average Values for Imput Parameters



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Source-Model Simplifications

- After container failure, the container and cladding are neglected as barriers to releases

- Releases for each radionuclide are represented as a superposition of several, modes, with each mode having a simple functional form.

- Probability distributions were developed for only some of the source parameters, so the full uncertainty is not represented

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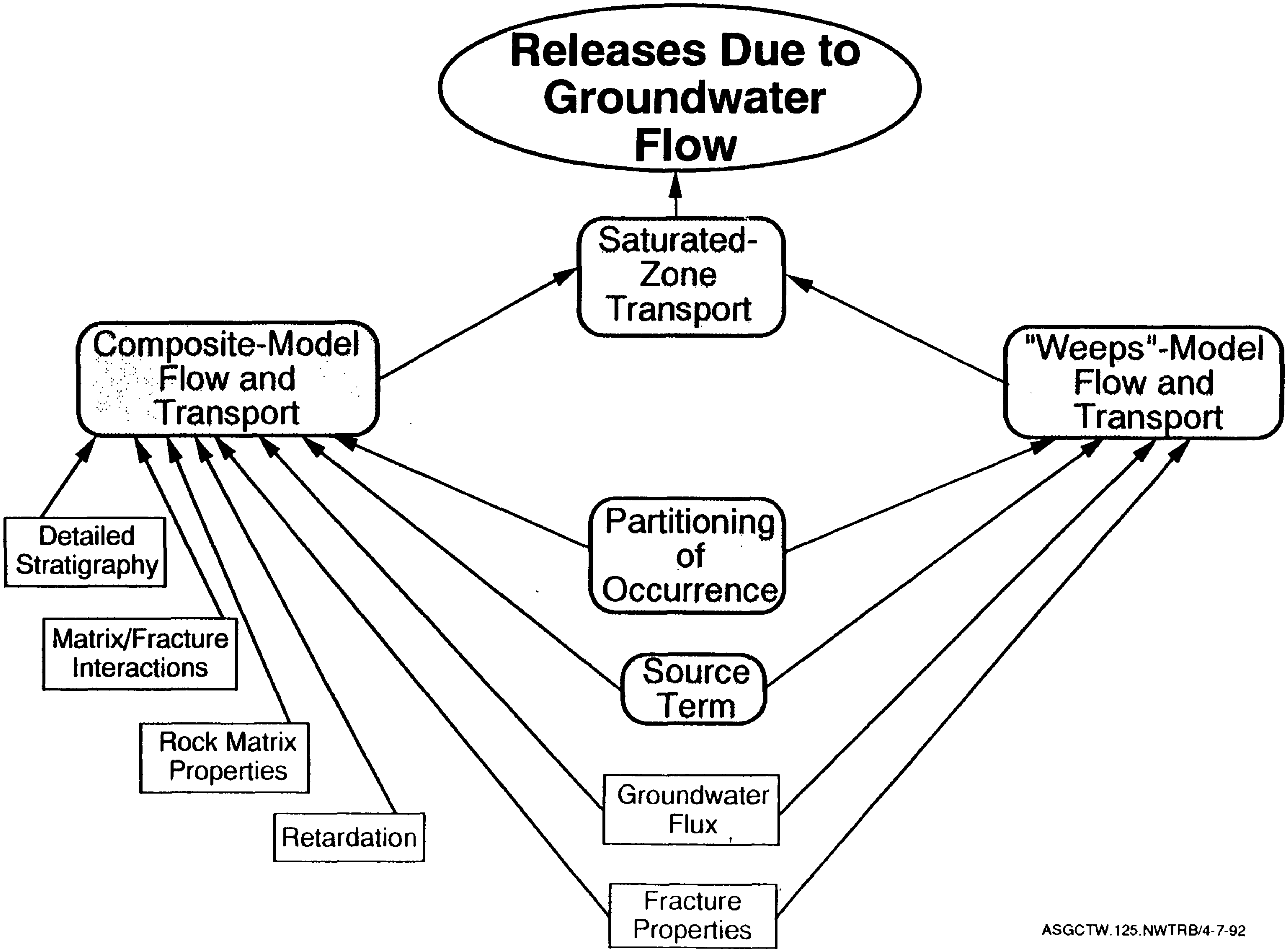
Factors Included in the Ground-water Flow Problem



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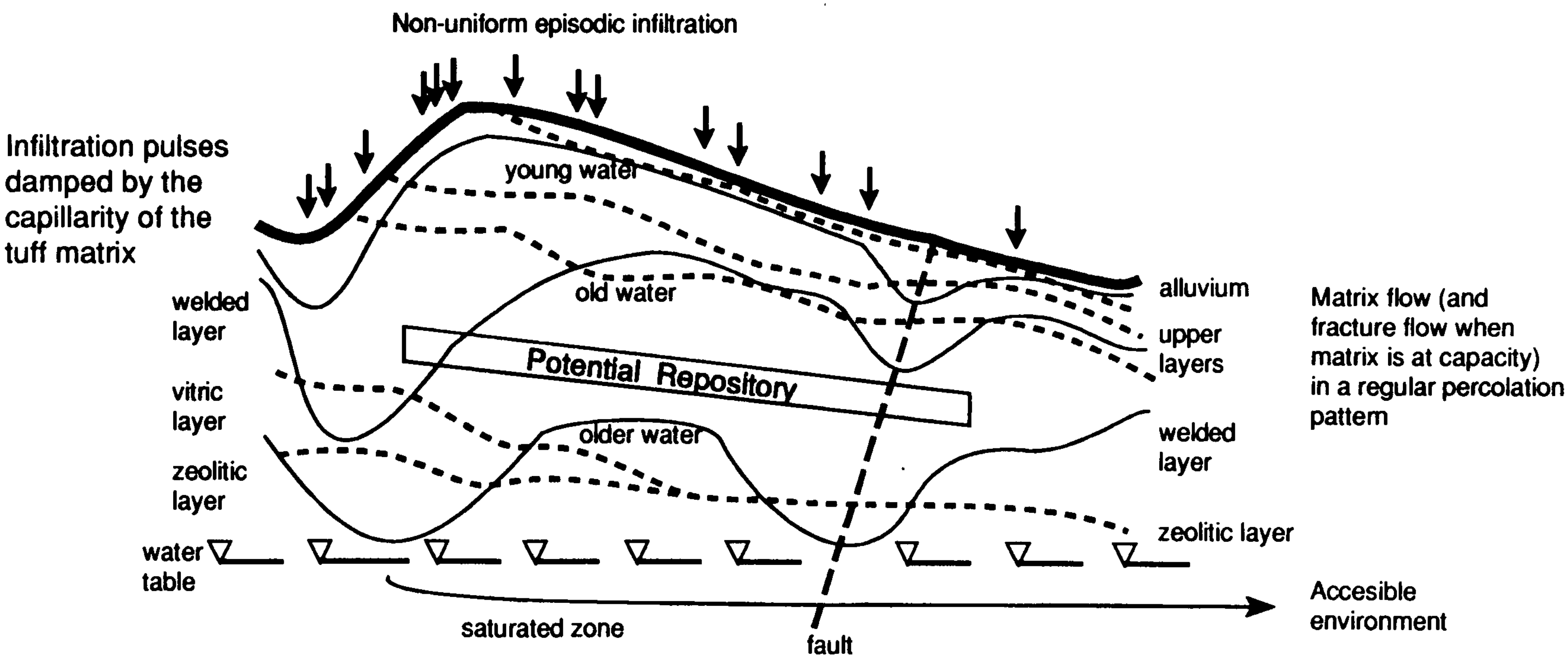
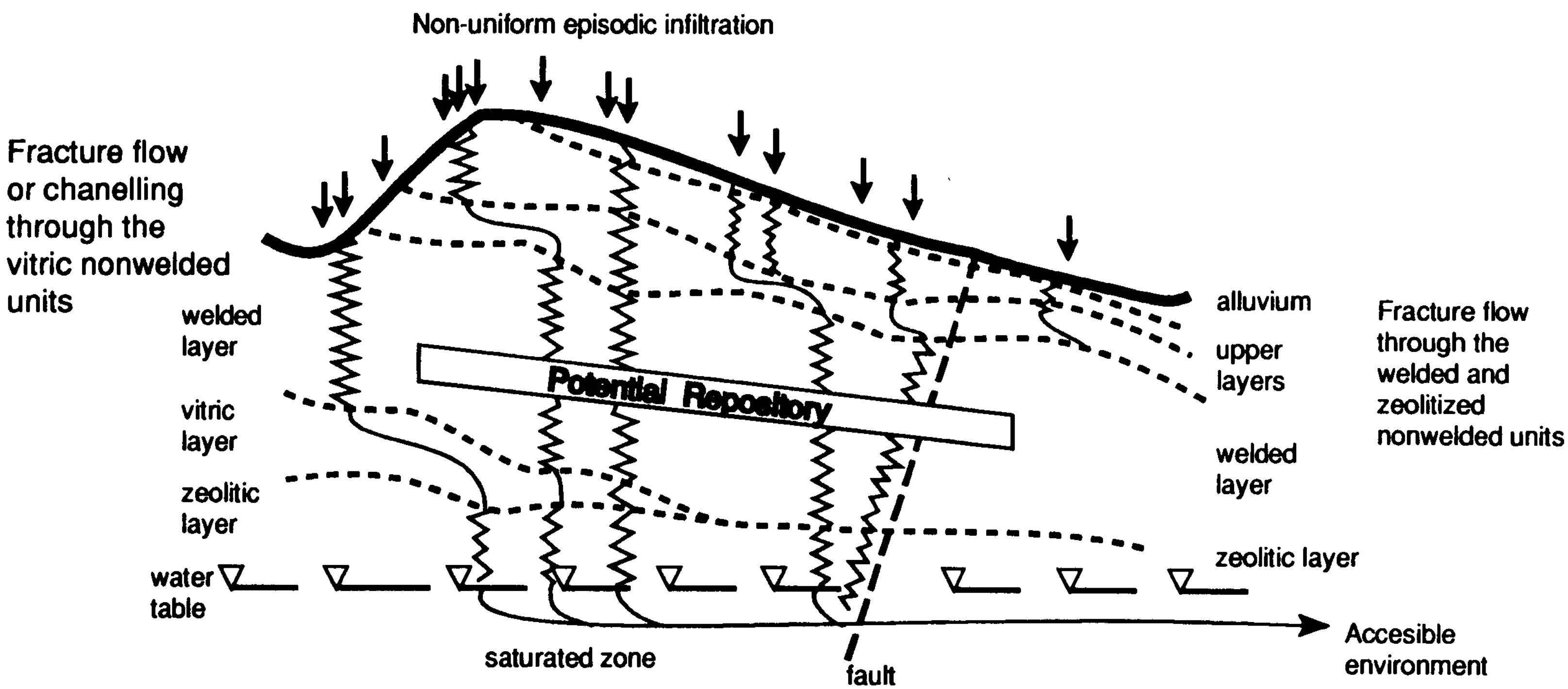
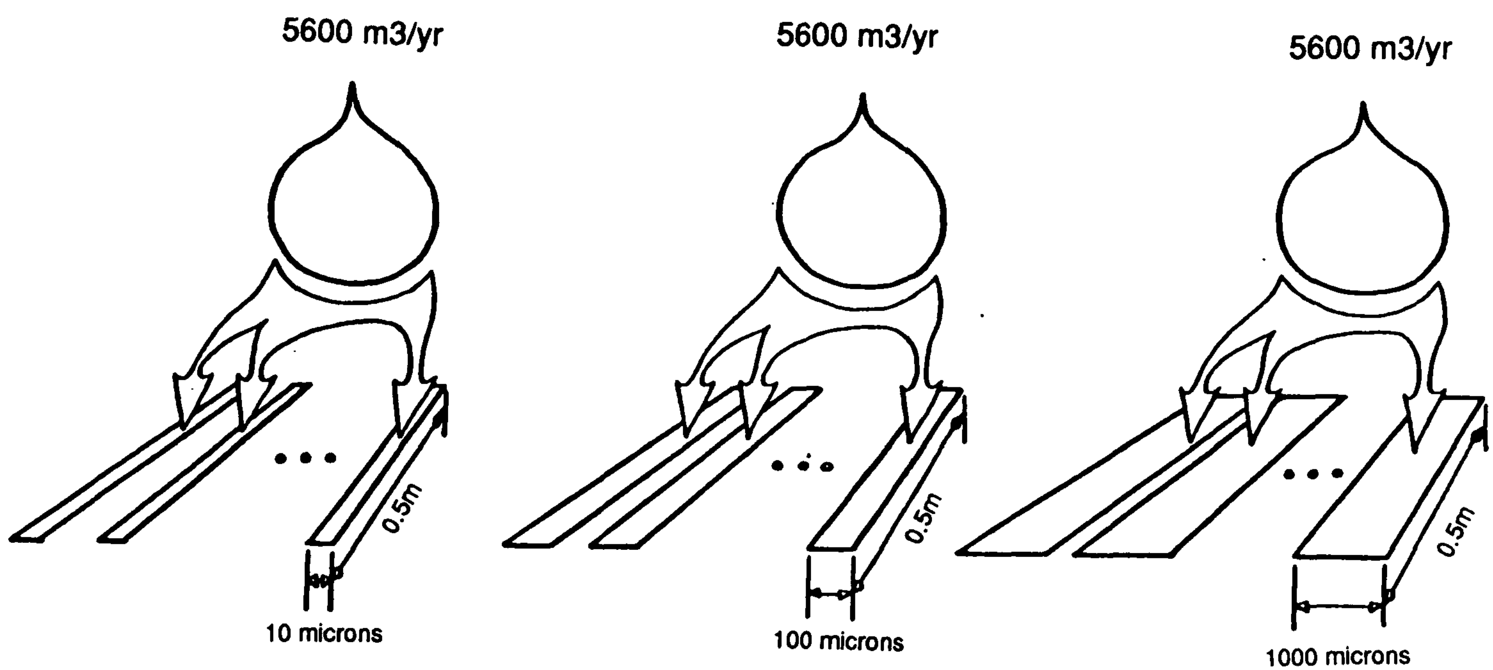
Composite-Porosity Model of Ground-water Flow



Weeps Model of Ground-water Flow



How Many Flowing Fractures Does it Take for $5600 m^3/yr$ of Water?

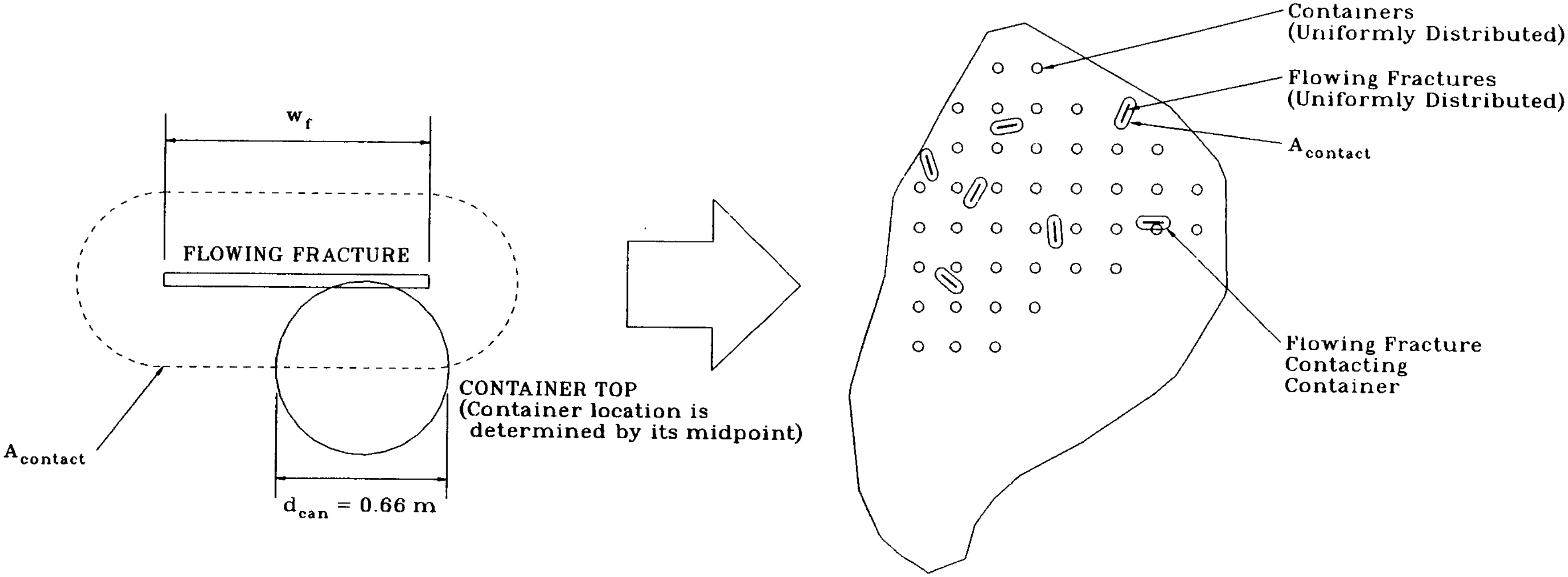


4,600,000
10-micron fractures

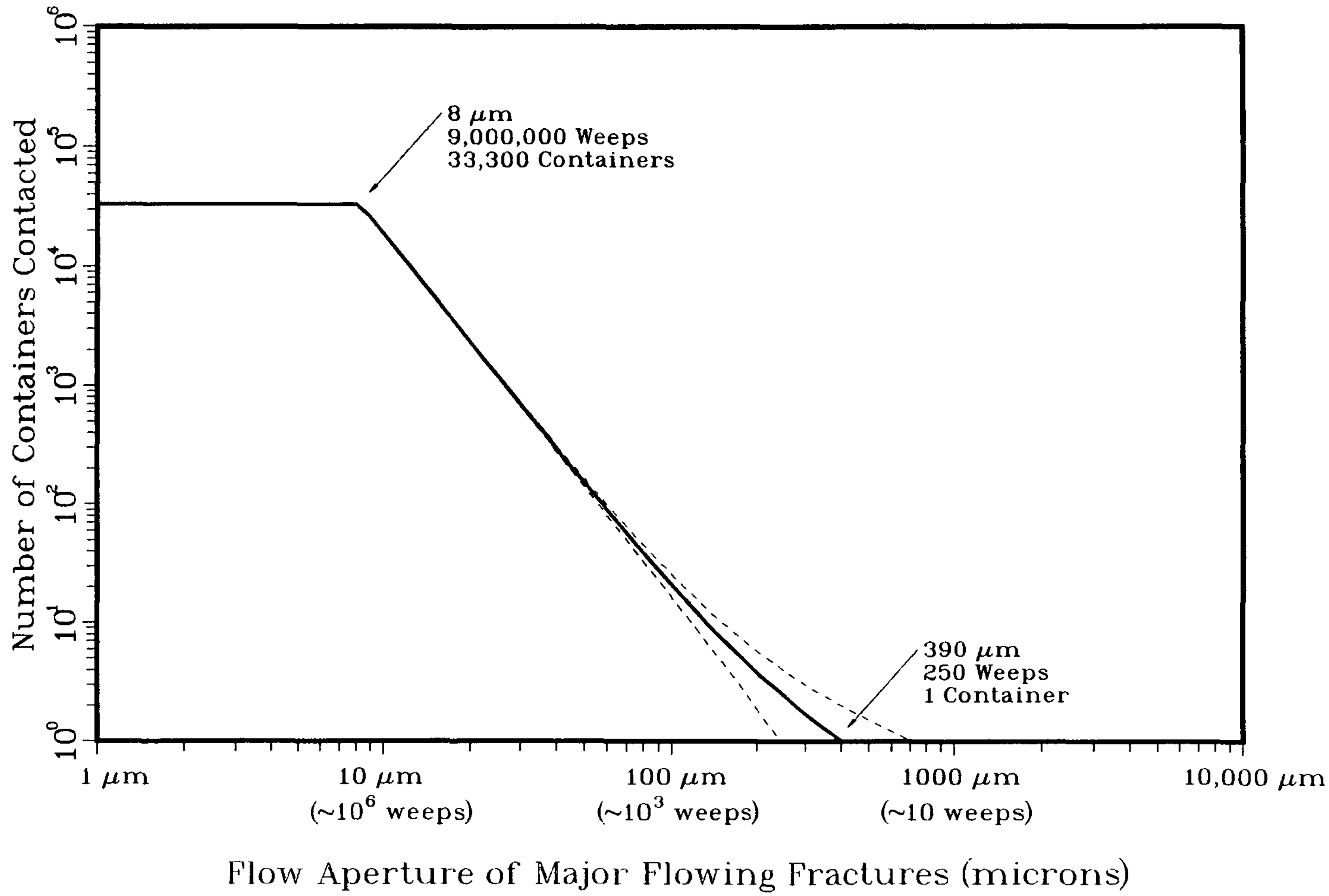
5,200
100-micron fractures

55
1000-micron fractures

How Many of the Flowing Fractures Contact Waste Containers?



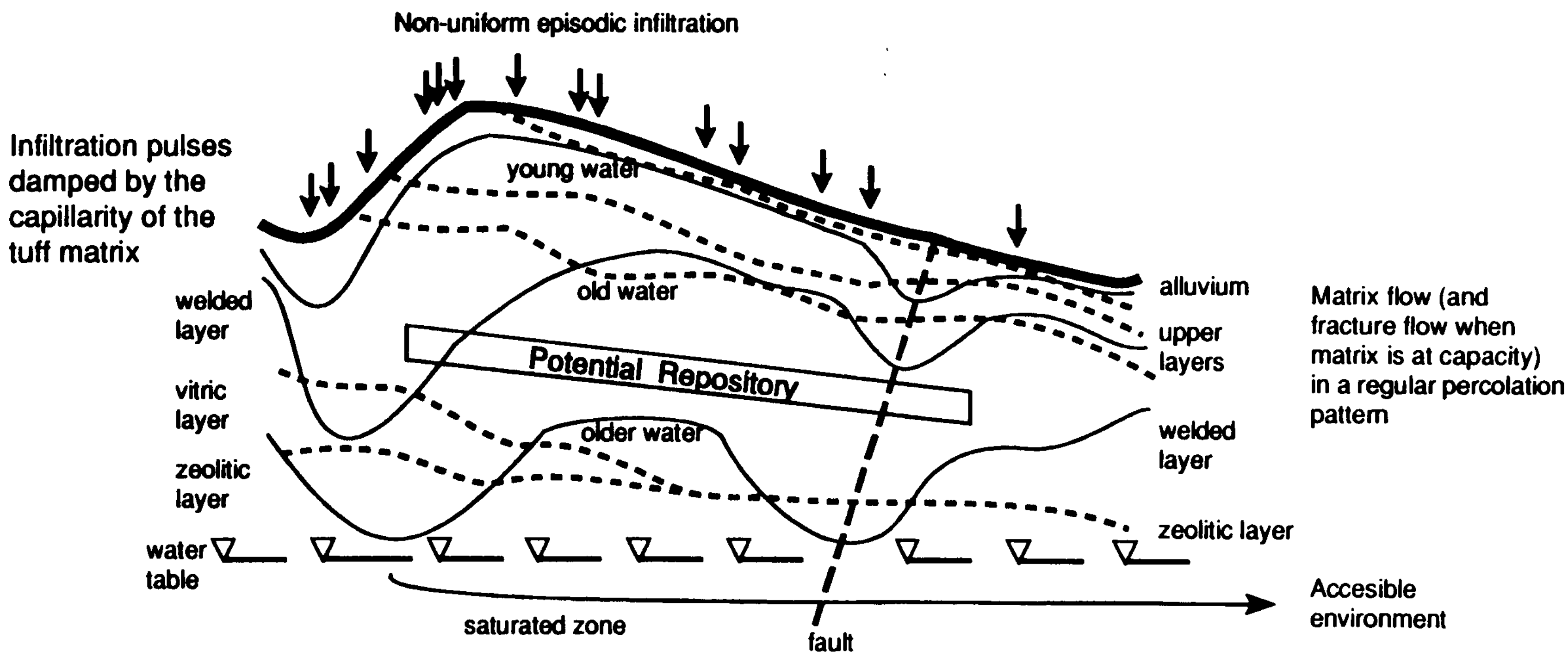
Flow Aperture vs Contacted Containers
Average Case



Weeps-Model Simplifications

- Major flowing fractures are all the same size
- No matrix/fracture interaction (flow/transport only in fractures)
- Unsaturated-zone travel time neglected
- Only waste containers fail as contacted by a flowing fracture

Composite-Porosity Model of Ground-water Flow



Profile Through USW H-5, USW G-4, and UE-25a#1

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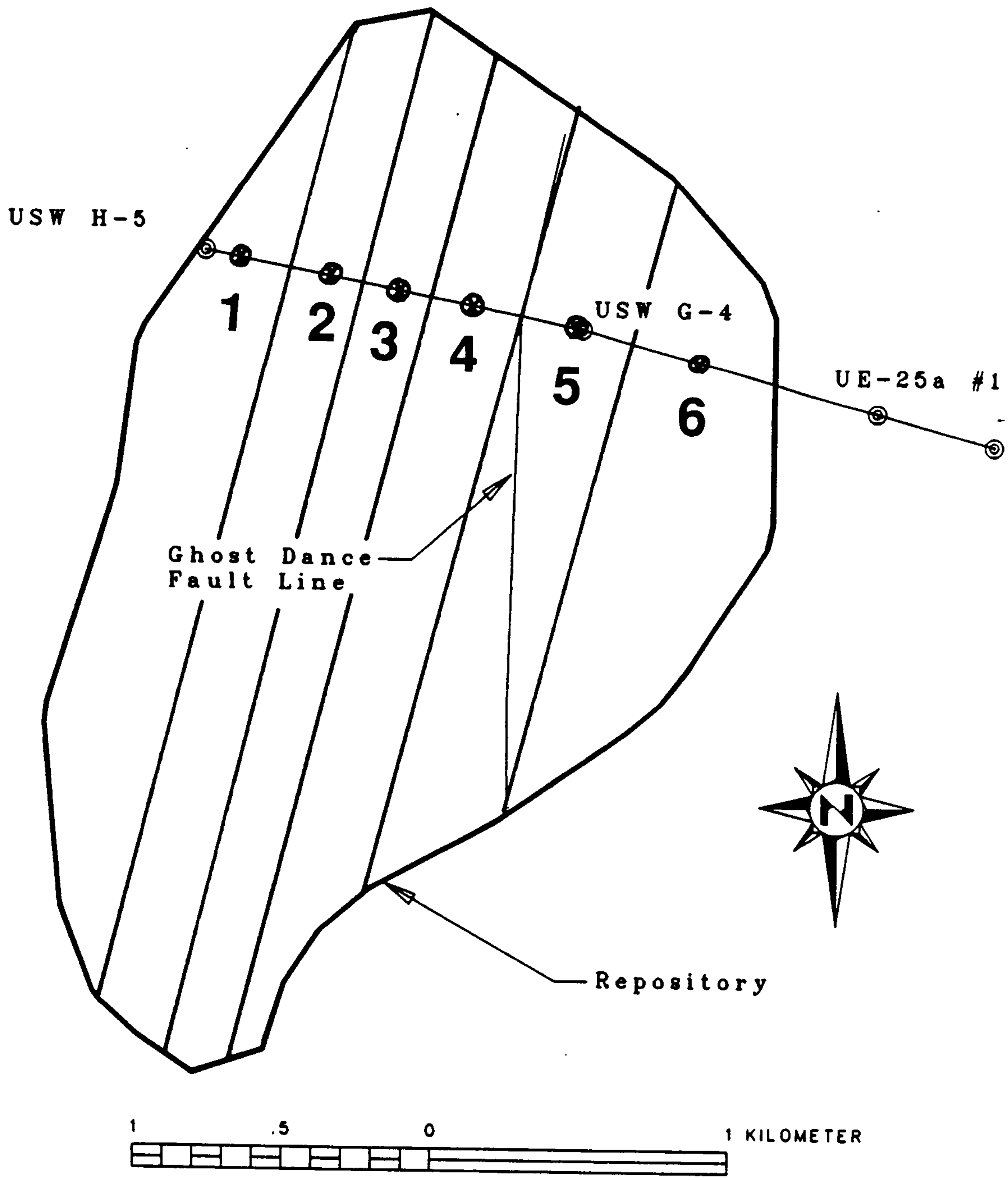
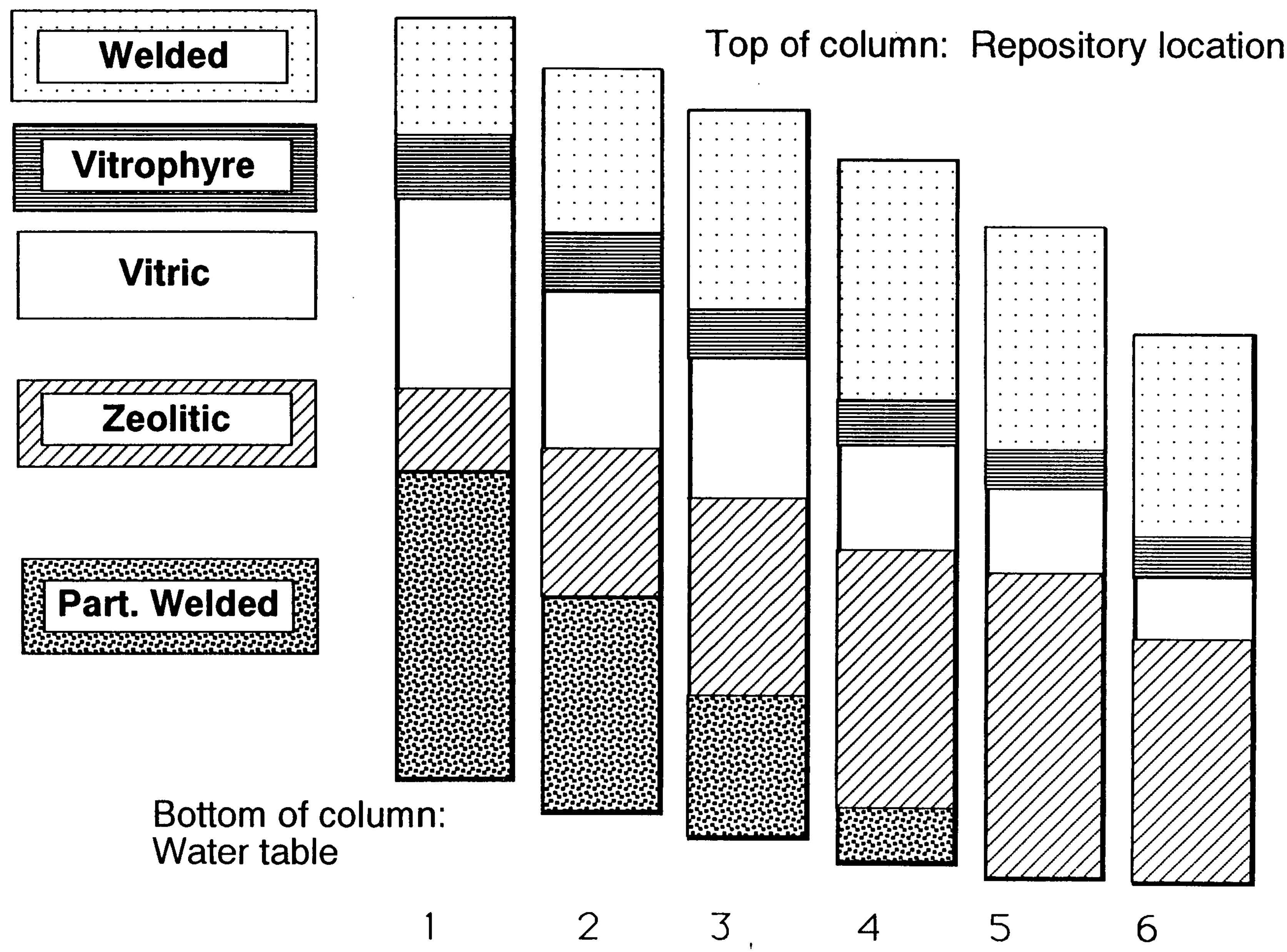




Welded
Vitrophyre
Vitric
Zeolitic
Part. Welded
Top of column: Repository location
Bottom of column:
Water table
1
2
3
4
5
6

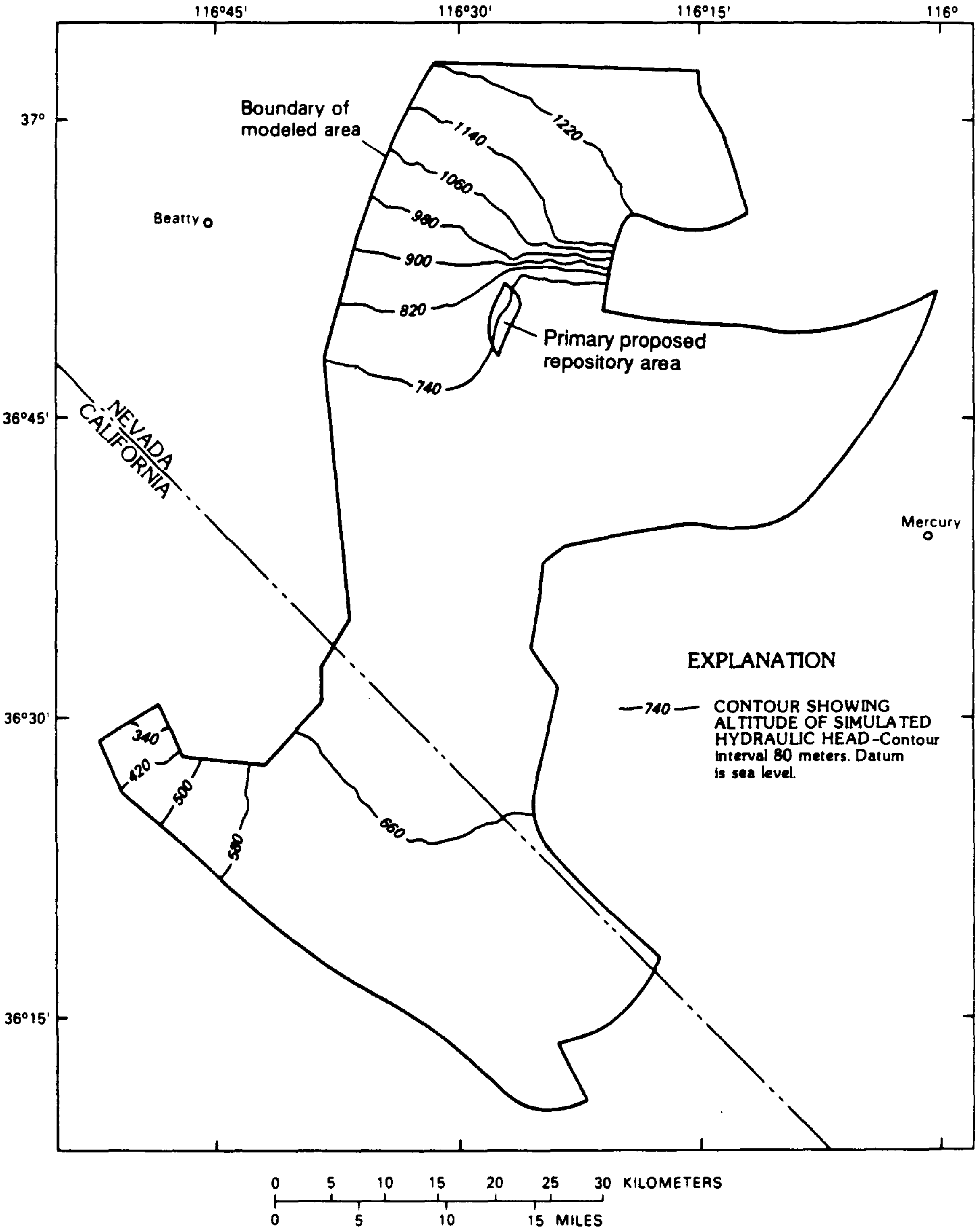
Probability distributions for K_d (ml/g)

Element (rock type)	Distribution type	Distribution parameters
Selenium (devitrified)	uniform	0 to 5
Selenium (zeolitic)	beta	min. 5, max. 21, mean 10, std. dev. 3
Selenium (vitric)	uniform	0 to 4
Technetium	constant	0
Tin	constant	100
Iodine	constant	0
Cesium (devitrified)	beta	min. 20, max. 100, mean 50, std. dev. 10
Cesium (zeolitic)	beta	min. 0, max. 6000, mean 2000, std. dev. 500
Cesium (vitric)	beta	min. 20, max. 100, mean 50, std. dev. 10
Uranium (devitrified)	uniform	0 to 5
Uranium (zeolitic)	beta	min. 5, max. 21, mean 10, std. dev. 3
Uranium (vitric)	uniform	0 to 4
Neptunium (devitrified)	exponential	mean 2
Neptunium (zeolitic)	exponential	mean 4
Neptunium (vitric)	exponential	mean 0.5
Plutonium	constant	100
Americium	constant	100

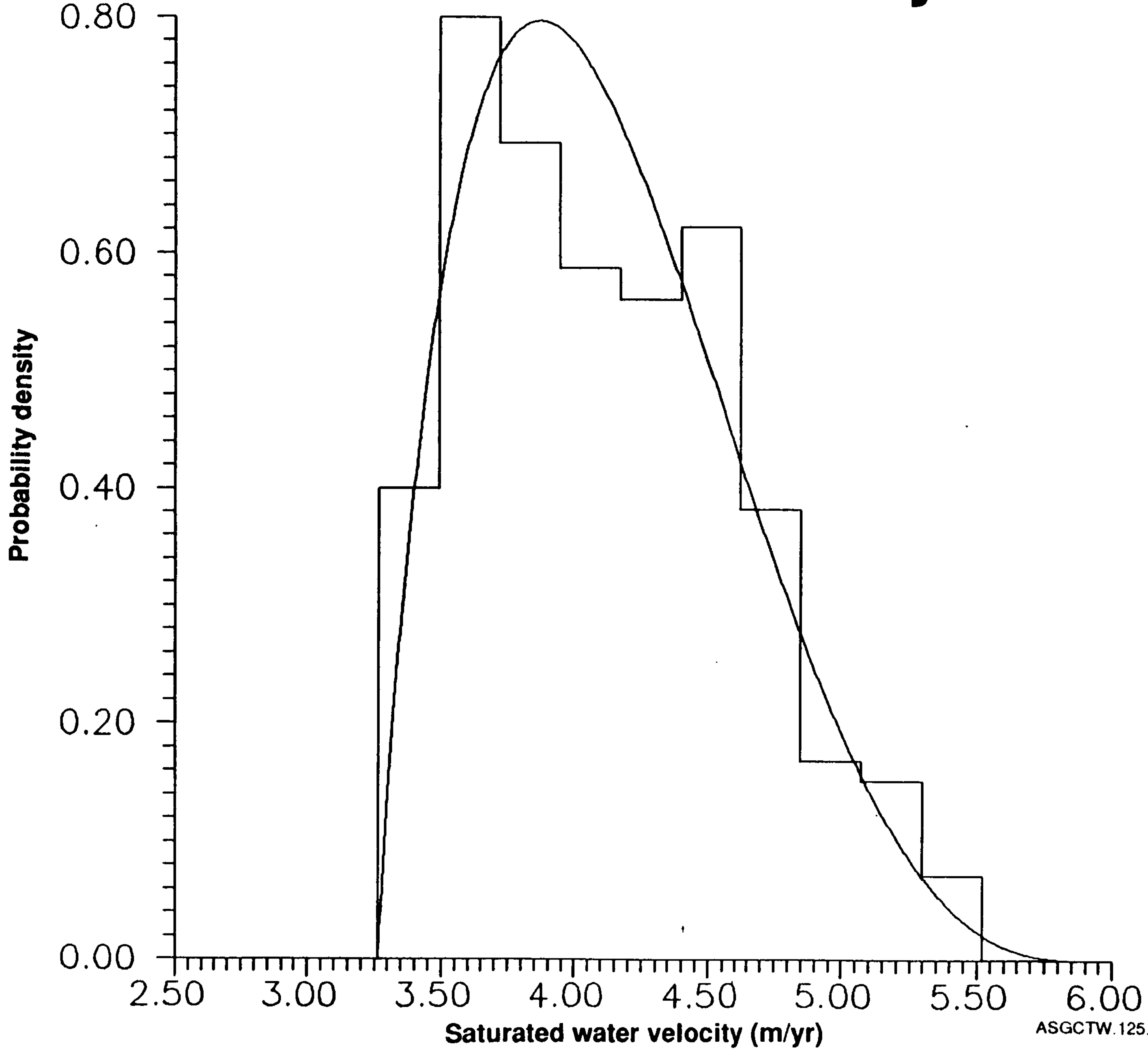
Composite-Porosity Model Simplifications

- Strong matrix/fracture coupling
- Isothermal
- Steady-state water flow
- One-dimensional, vertical flow and transport
- Retardation represented by K_d

Czarnecki and Waddell Model of Saturated Zone



Effective Saturated-Zone Velocity Distribution



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Saturated-Zone Simplifications

- Properties of tuff and carbonate aquifers lumped together
- Strong matrix/fracture coupling
- Based on a single realization of the saturated zone, so parameter variability and uncertainty not fully represented

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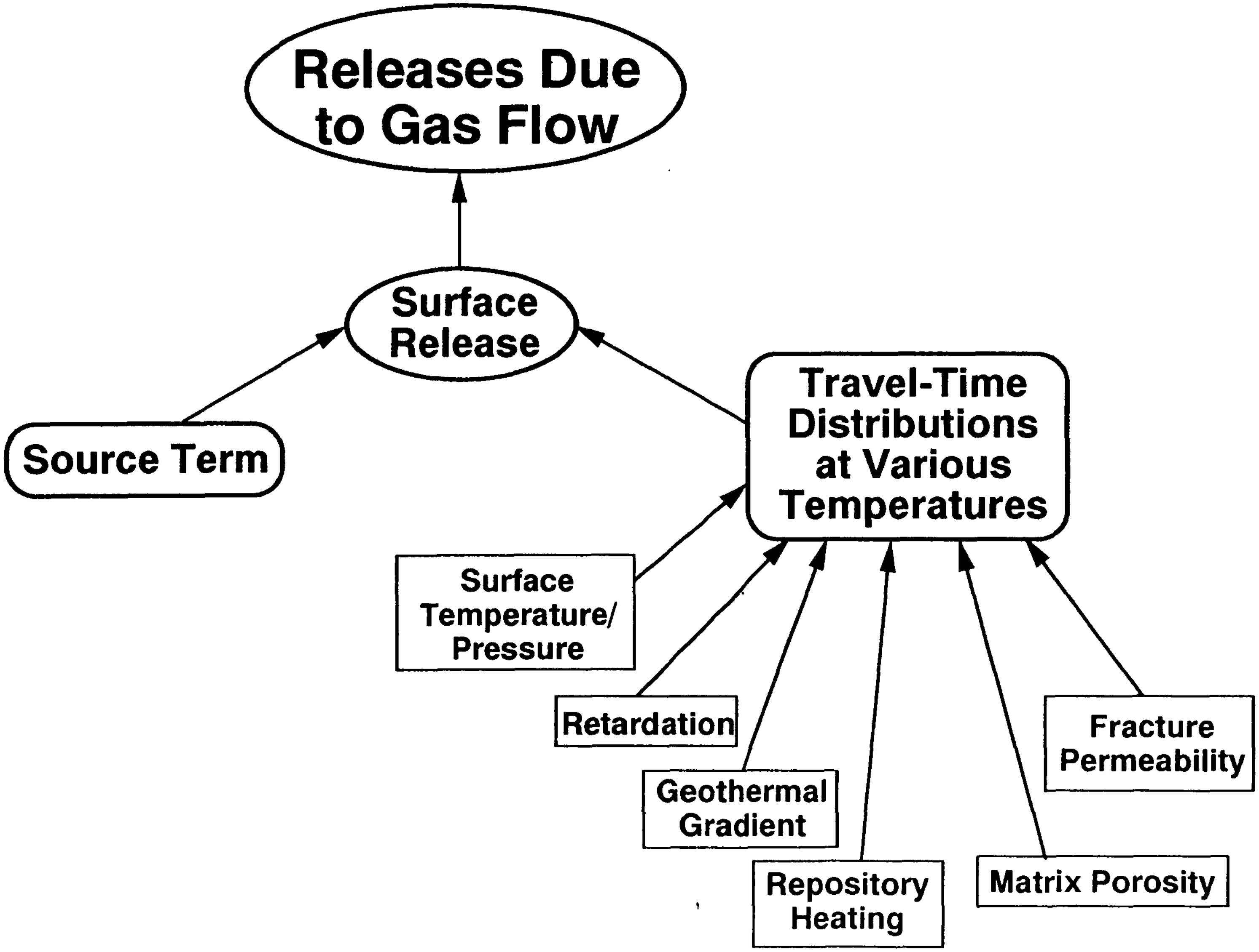
Factors Included in the Gas Flow Problem



Ross, Amter, and Lu Model of Gas Flow

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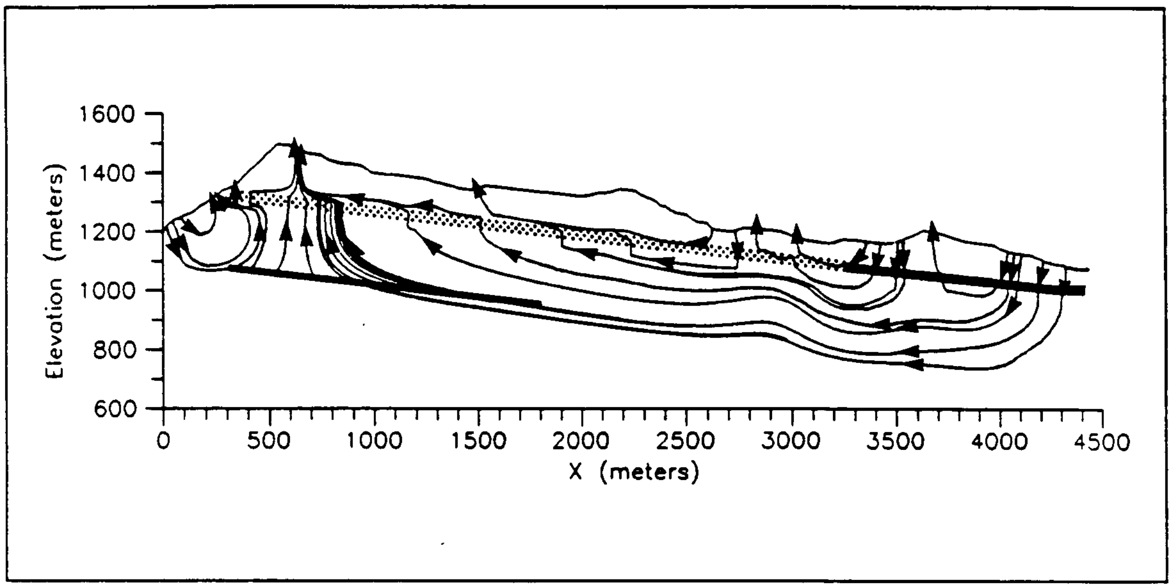
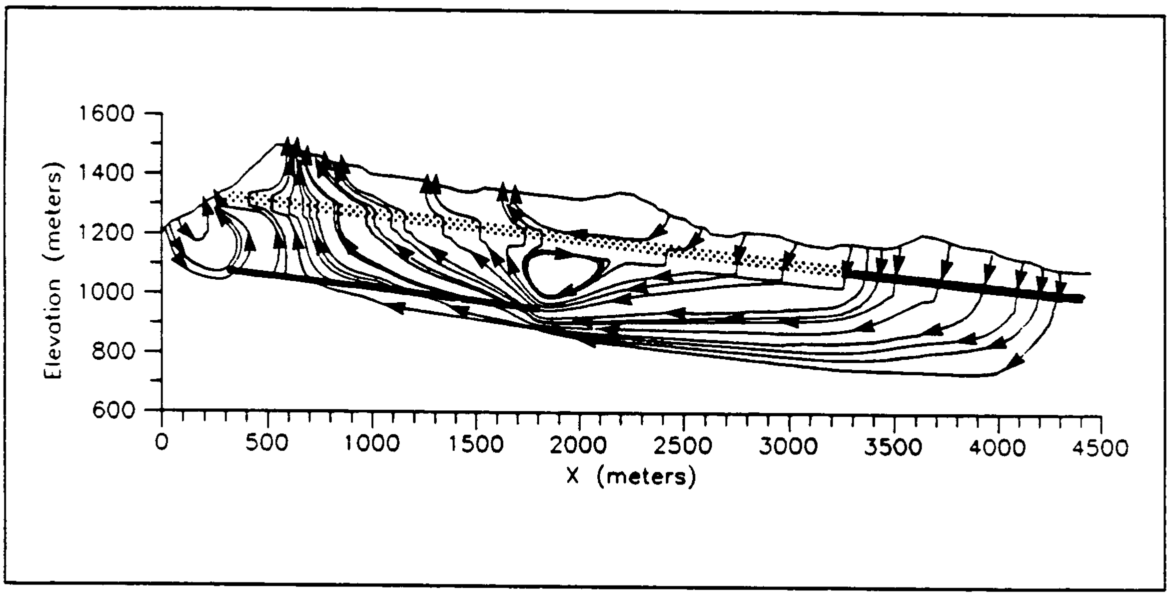
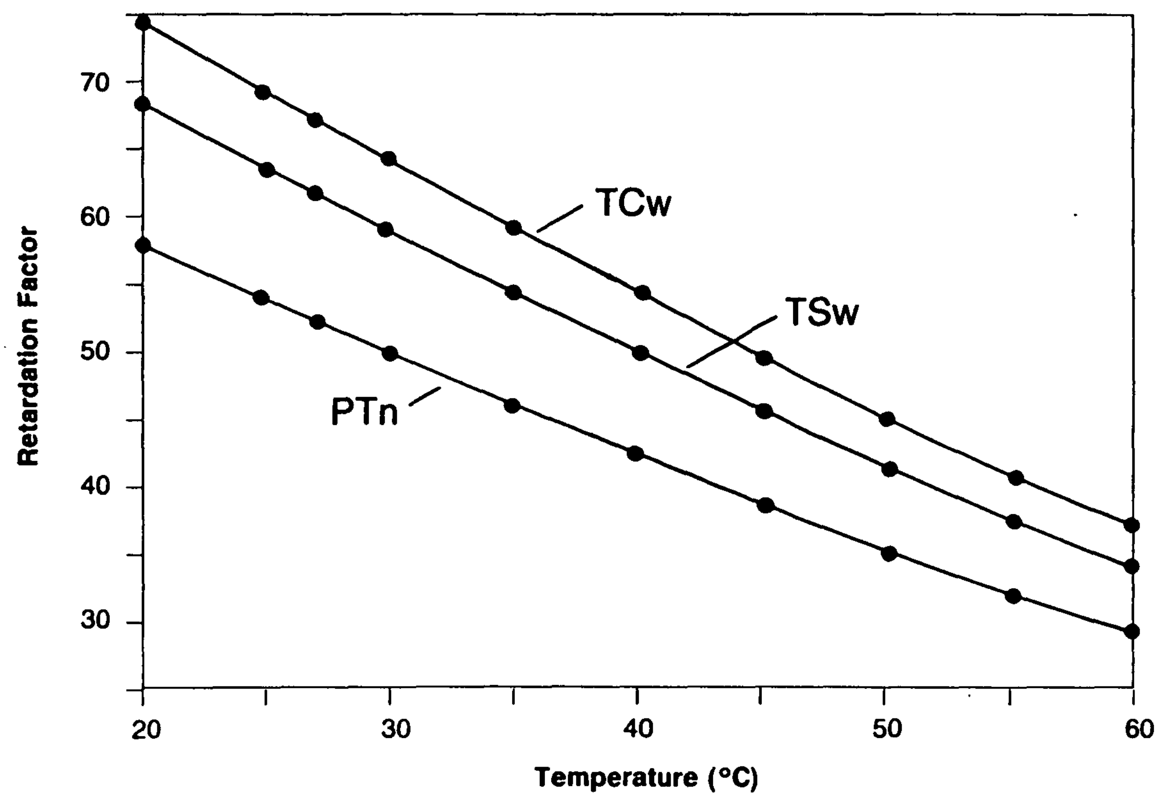


Path lines with ambient temperature, permeability contrast between welded and nonwelded tuffs 100x (10x in faulted area). (cross section N760000)

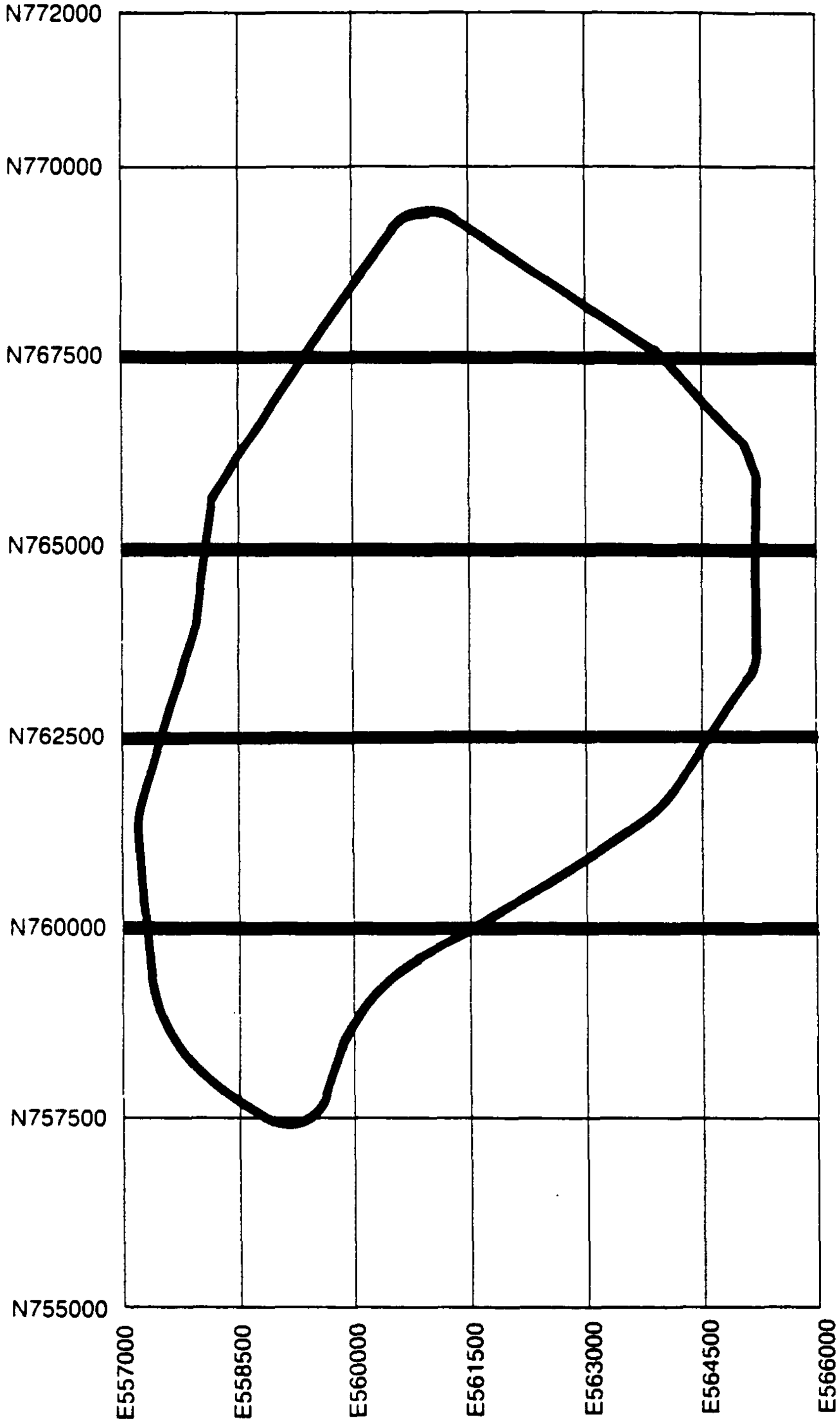


Path lines with the repository heated to 330 K, permeability contrast between welded and nonwelded tuffs 100x (10x in faulted area). (cross section N760000)

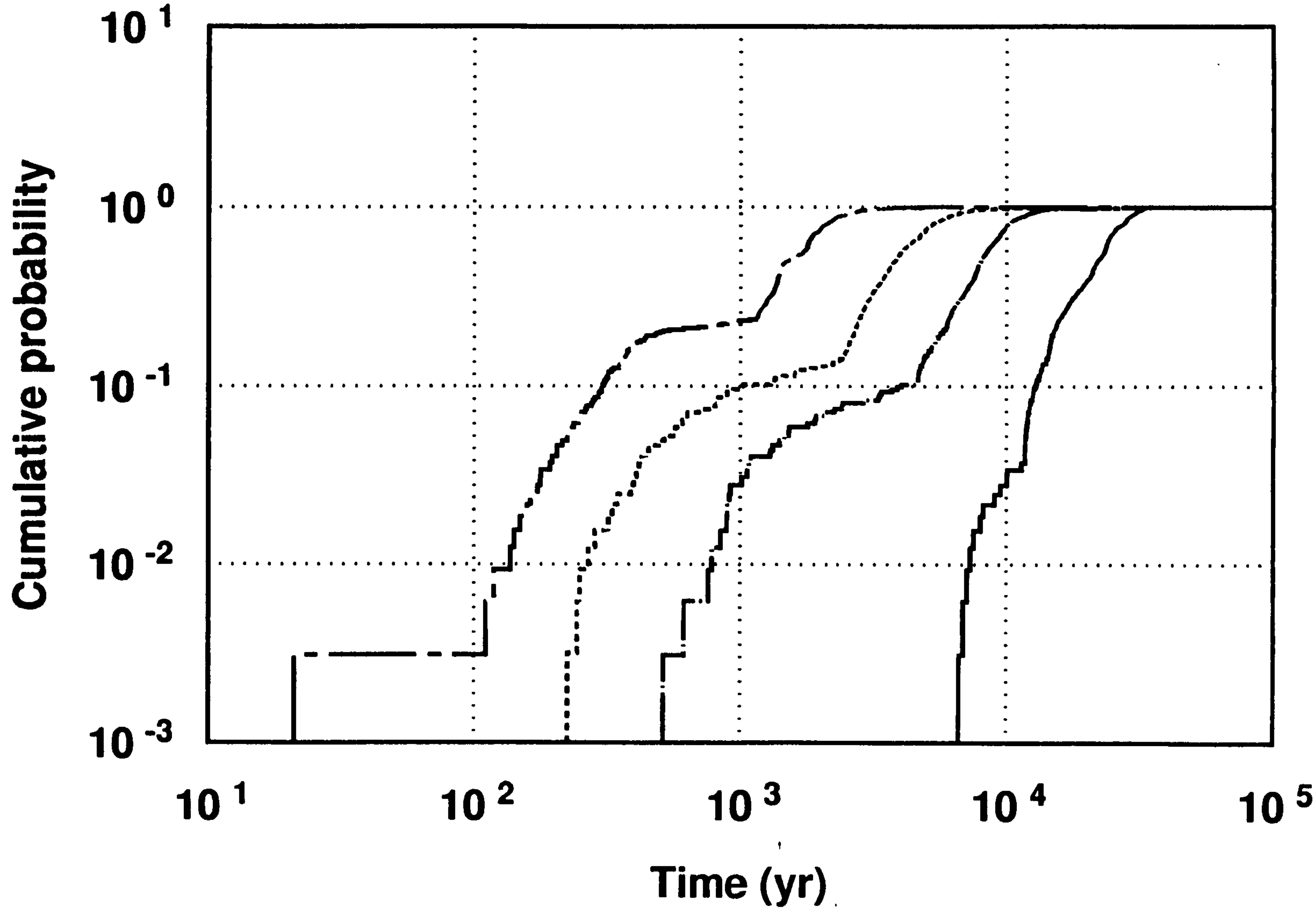
Carbon Retardation Factors for Gaseous Transport



Gas Flow Simulated for Four 2-D Cross Sections



^{14}C Travel-Time Distributions
87 C, 57 C, 42 C, 27 C



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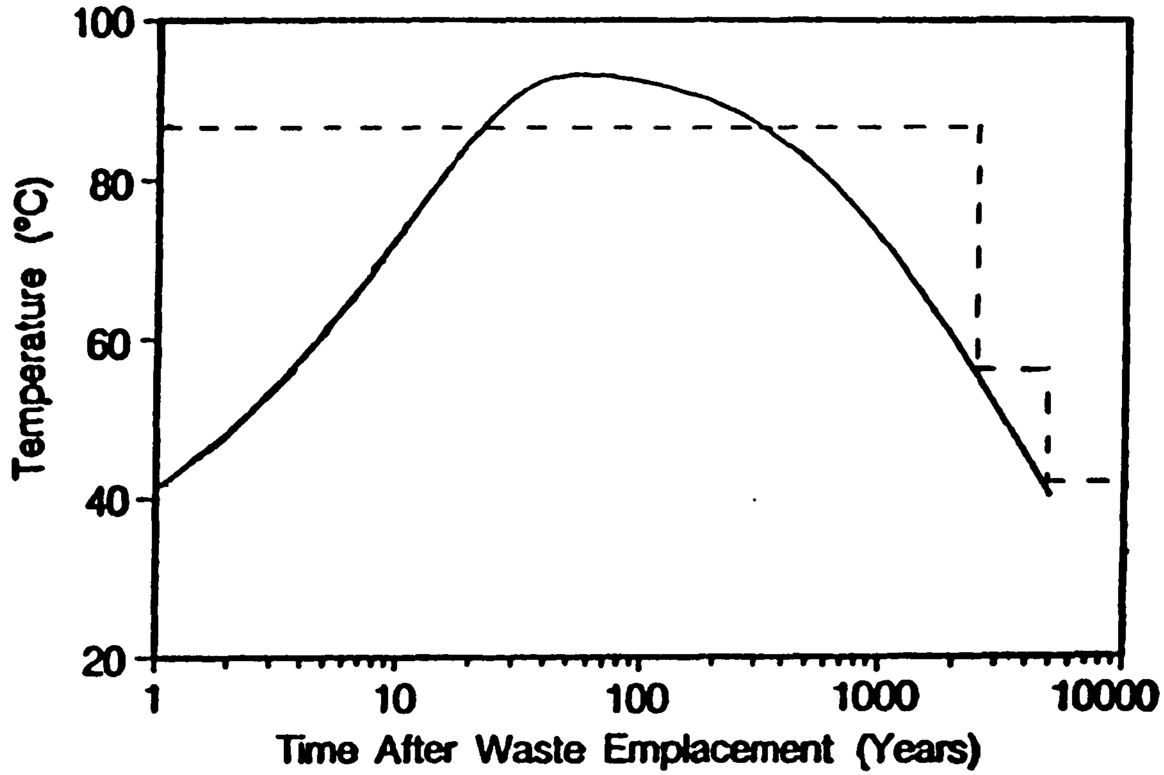
Tsang and Pruess Model of Repository Temperature



Gas-Flow-Model Simplifications

- Gas permeability high enough that transport is advection-dominated
- Gas flow decoupled from water flow
- Travel-time distributions calculated for steady-state conditions
- Temperature always exaggerated (except possibly at early times)
- Carbon geochemistry simplified

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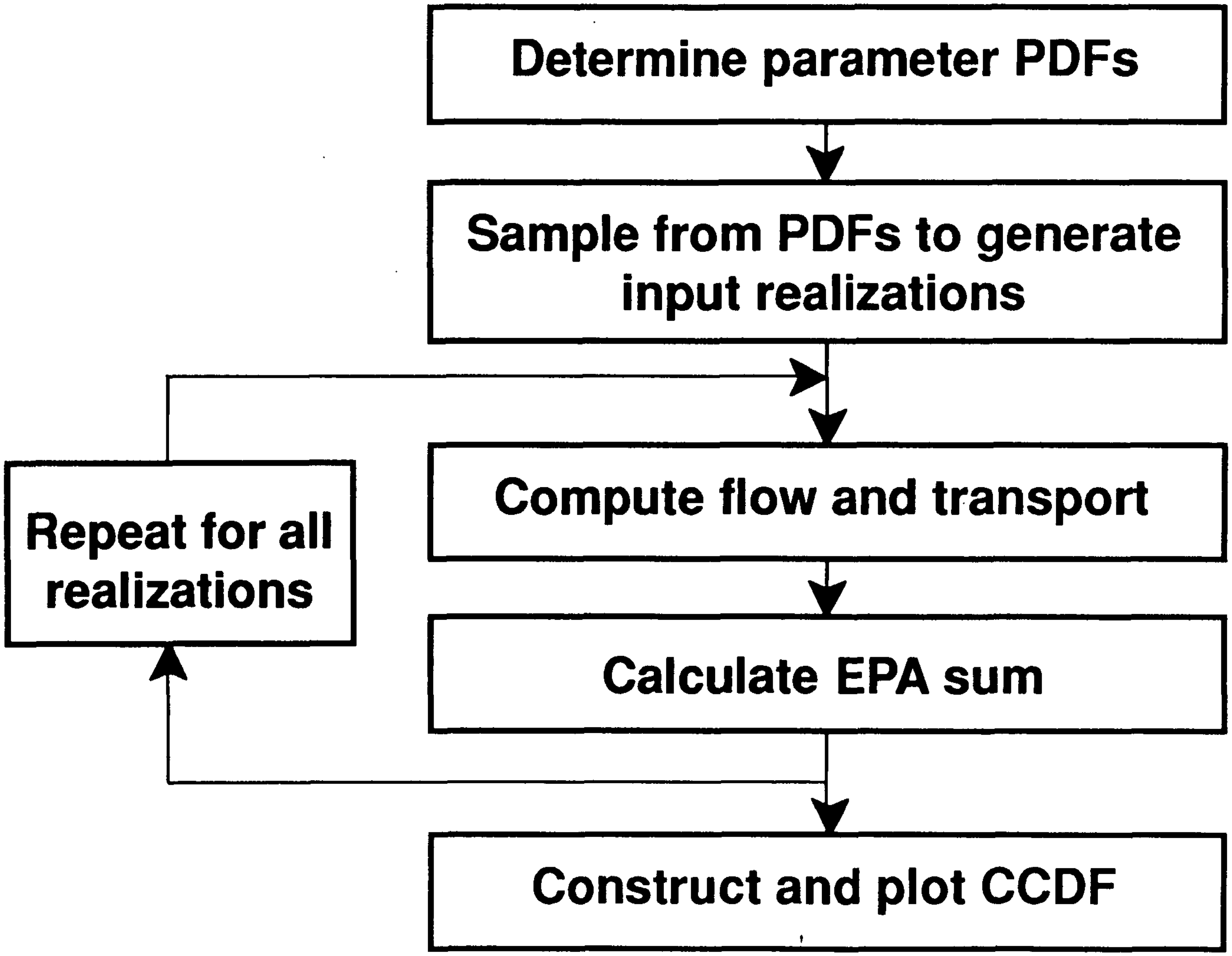
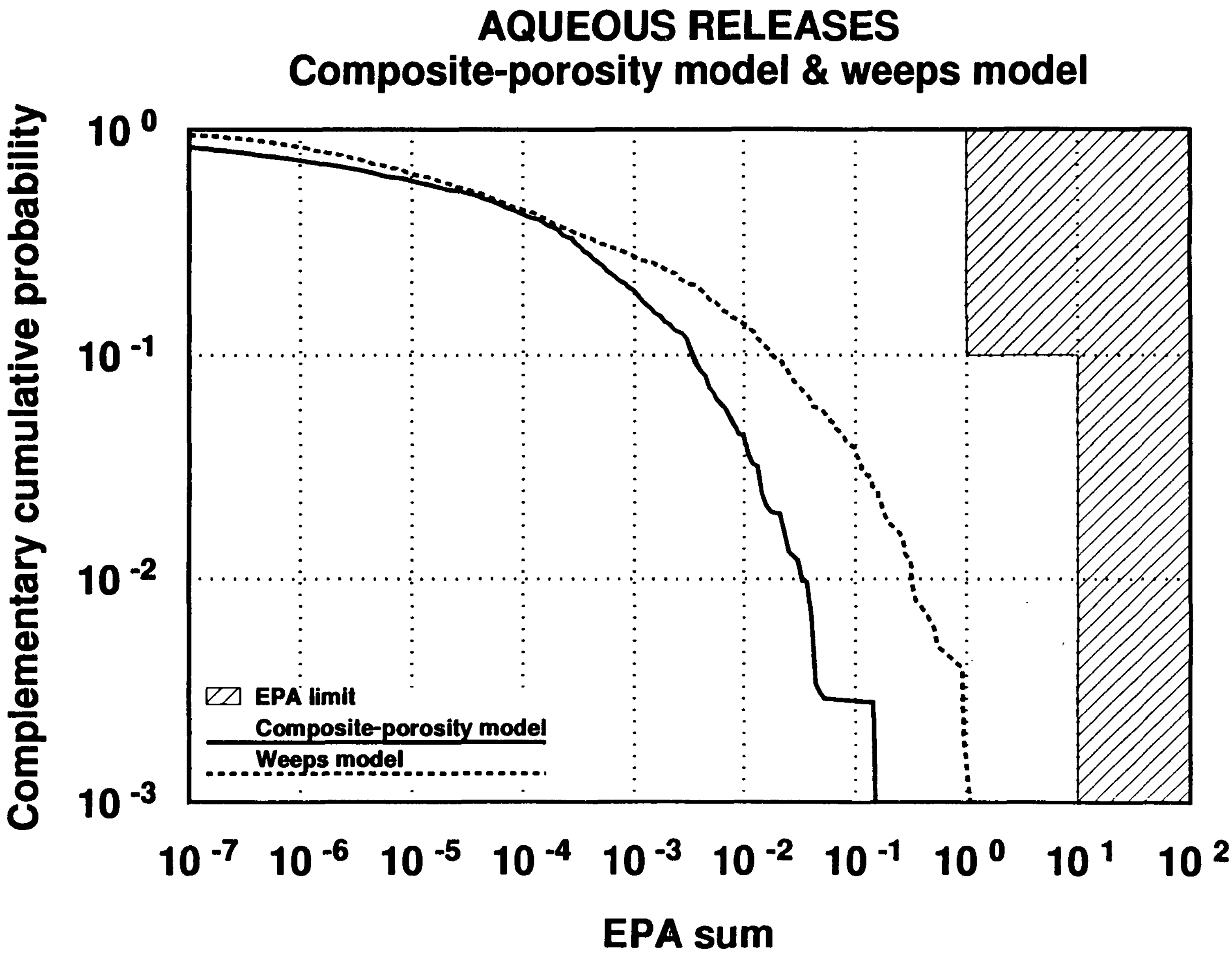
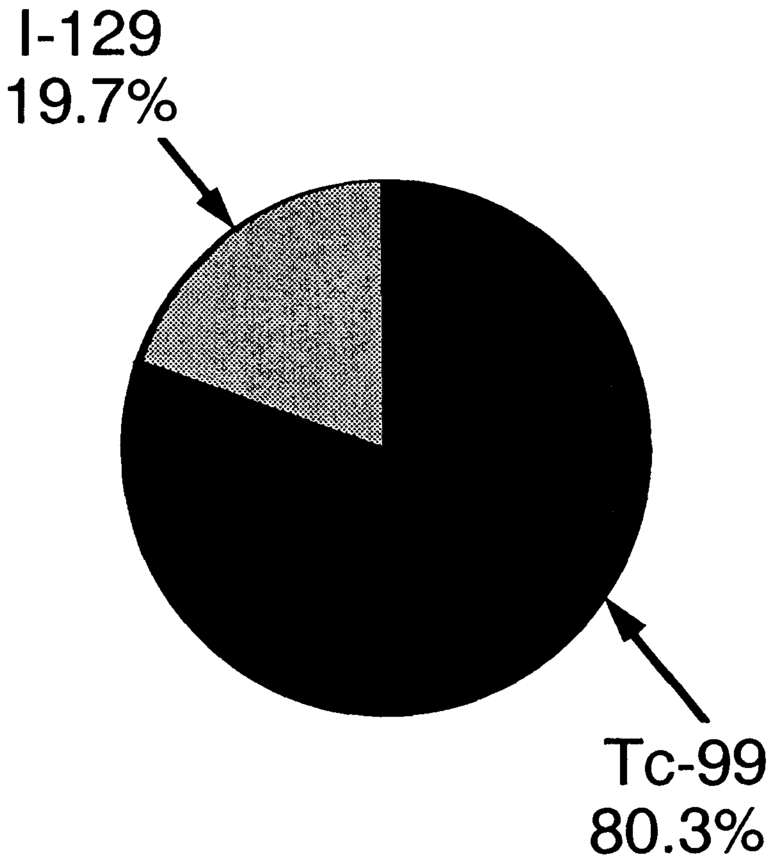
Monte Carlo Simulation



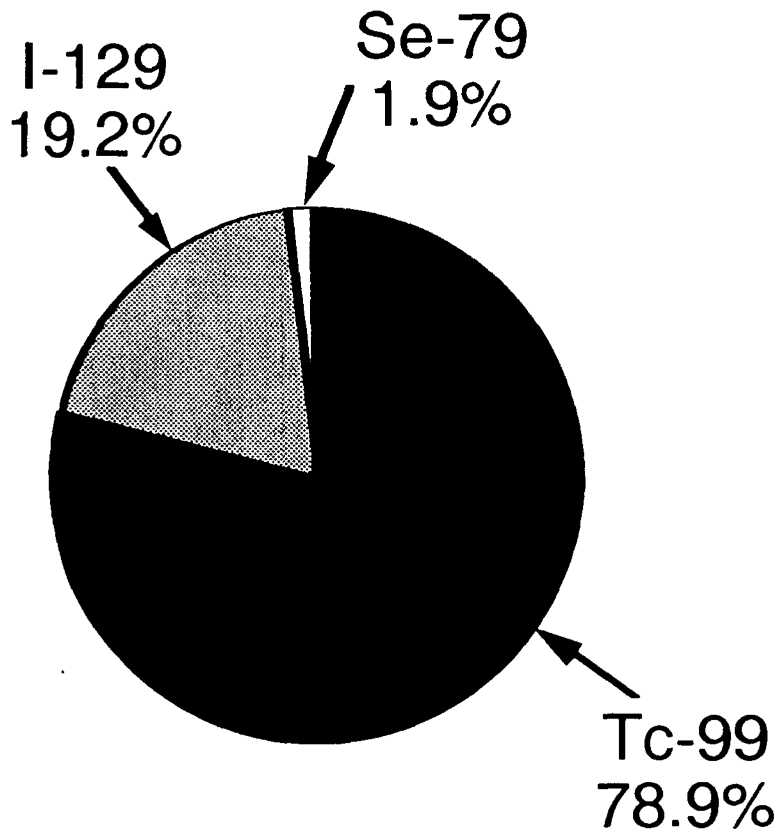


AQUEOUS RELEASES
Composite-porosity model & weeps model
Complementary cumulative probability
10 0
10 -1
10 -2
10 -3
EPA limit
Composite-porosity model
Weeps model
10 -7
10 -6
10 -5
10 -4
10 -3
10 -2
10 -1
10 0
10 1
10 2
EPA sum

Aqueous Releases

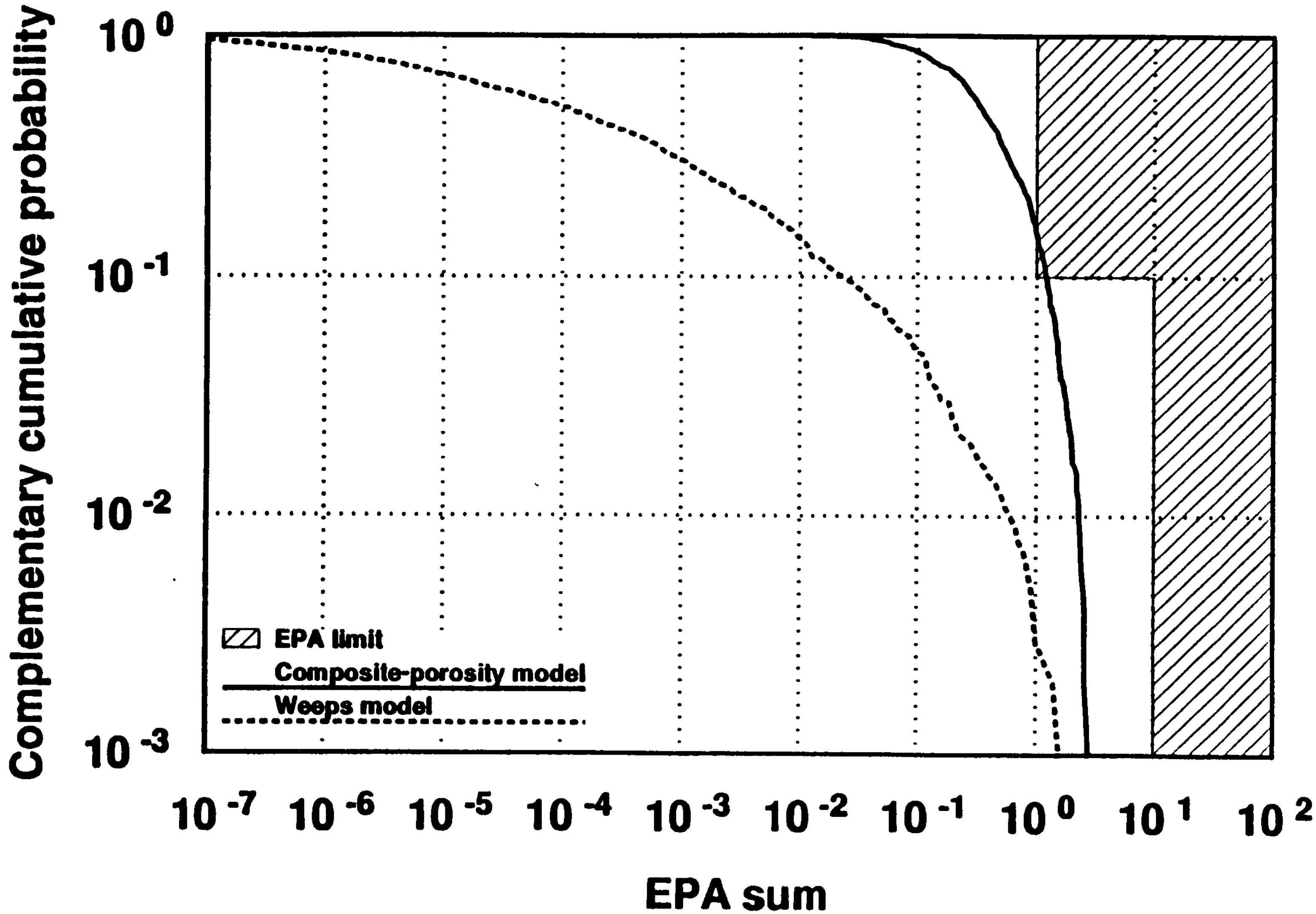


Composite Flow Model

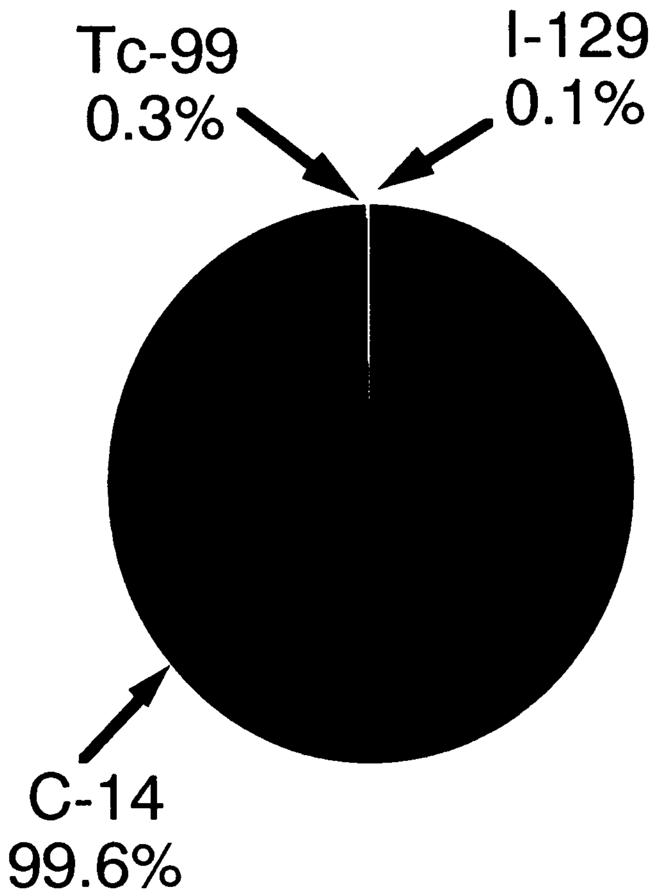


Weeps Flow Model

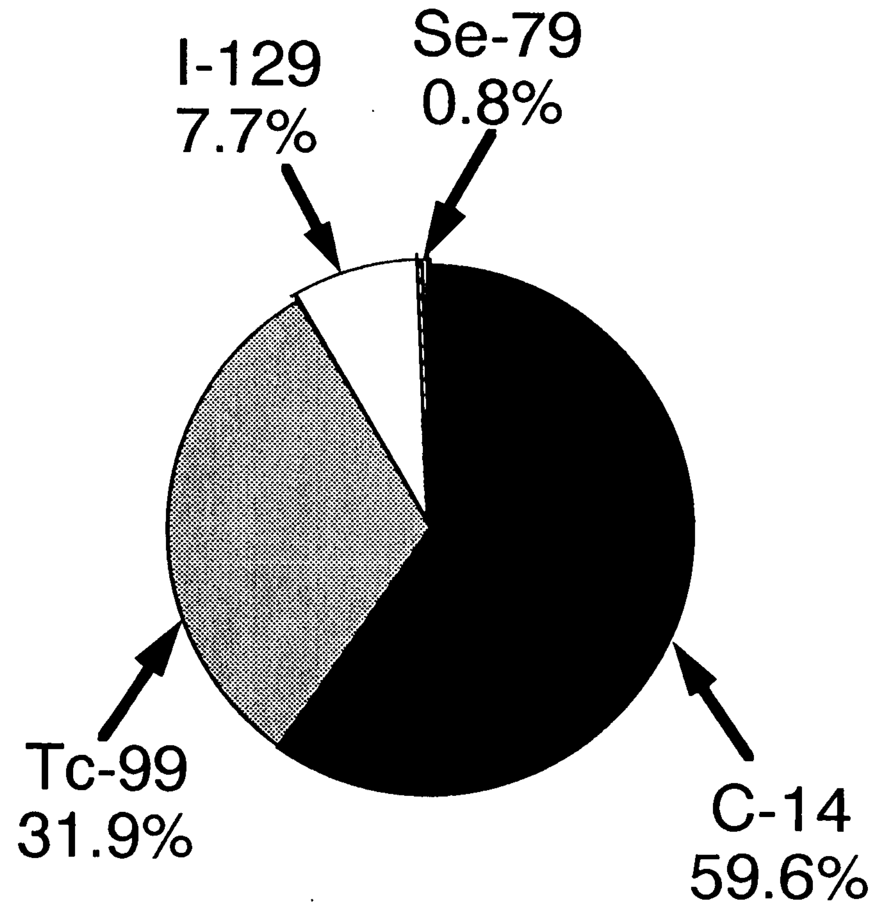
GASEOUS RELEASES
Composite-porosity model & weeps model



Aqueous and Gaseous Releases



Composite Flow Model



Weeps Flow Model

Conclusions

- Our abstract/detailed approach is workable
- Preliminary modeling shows gaseous ^{14}C releases to be the largest contributor to the total-system CCDF
- Preliminary modeling shows localized fracture flow to produce lower releases than uniform matrix/fracture flow (because fewer waste containers are affected)