Performance Assessment Demonstration: Source Term Model

Presentation to:
Panel on Risk & Performance Analysis
U.S. Nuclear Waste Technical Review Board

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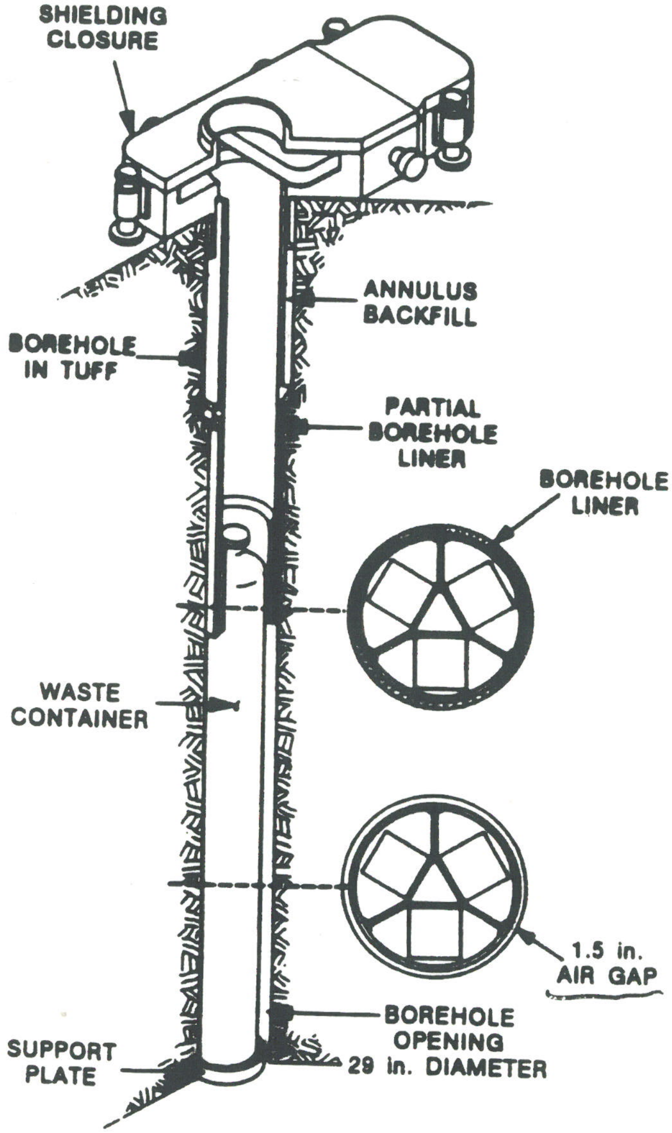
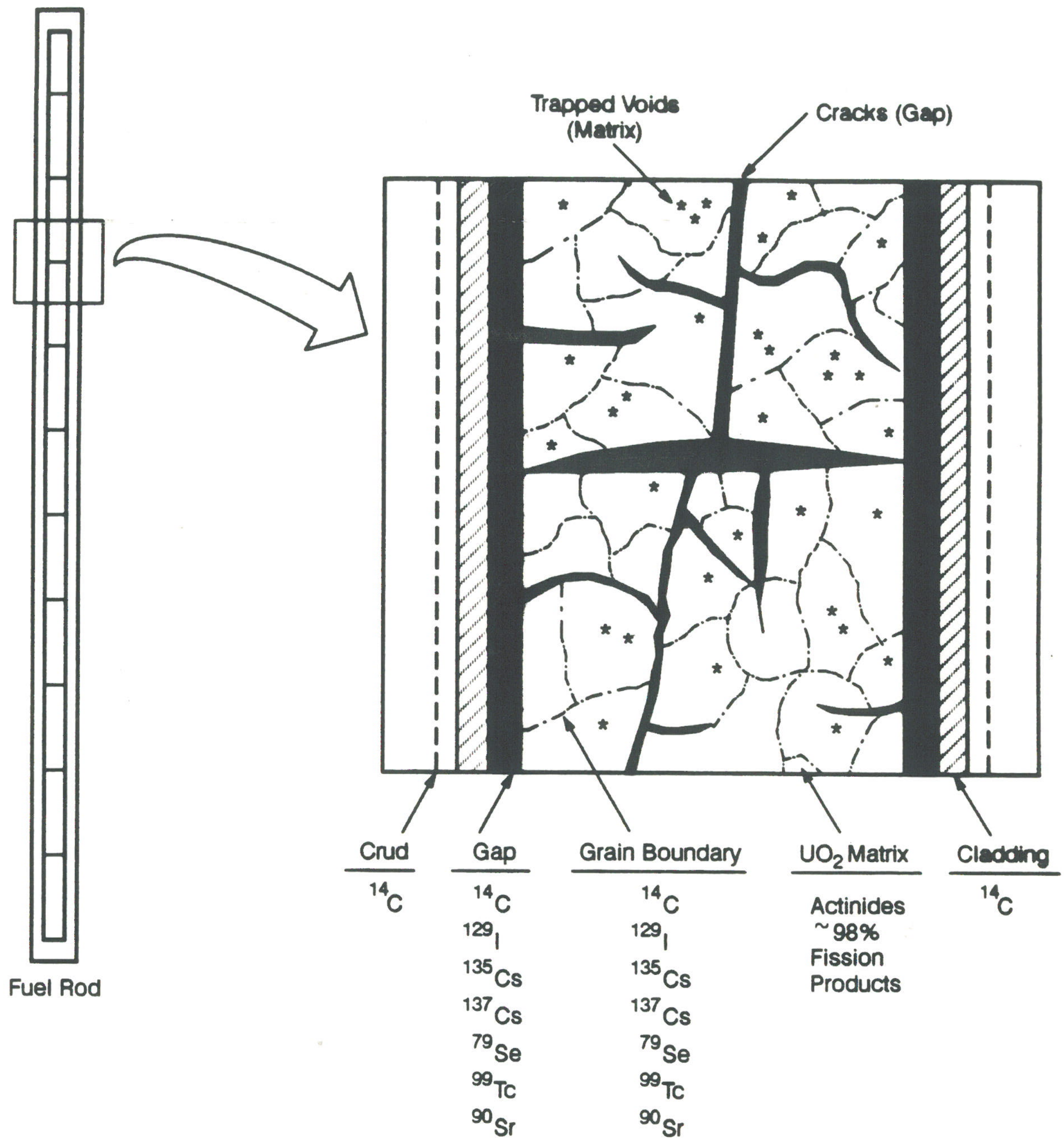


VERTICAL EMPLACEMENT

Air gap



Location of Radionuclides in Spent Fuel and Potential Releases of C-14
(Apted, el. al., 1989)

Release of Dissolved Radionuclides Depends on:

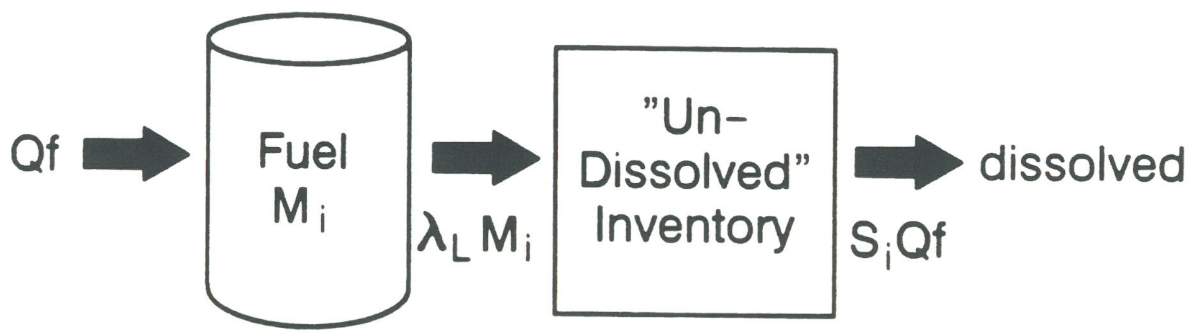
- Water getting into and out of canister
- Dissolution of fuel
- Solubility of released radionuclides
- Formation of colloids (esp. plutonium)

Release of Dissolved Radionuclides

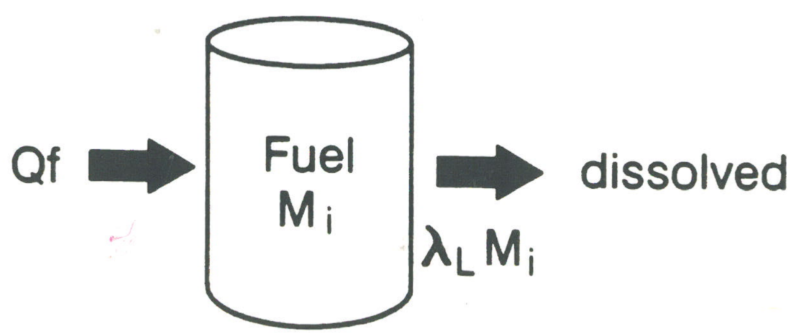
Rate of UO_2 Dissolution

$$\lambda_L = \frac{QfS_u}{M_{ou}}$$

Low-Solubility Radionuclides



High-Solubility Radionuclides



Significant Parameters for Source Term Model

Waste Package Lifetime

- Non-mechanistic
- Assumed normal distribution
  mean = 550 years,
  0.001 fractile = 100 years
  0.999 fractile = 1000 years

Solubility of Fuel Matrix

- Based on conservative range of data on uranium solubility
- Uniformly distributed
  0.0001 to 0.001 gms/ml

Significant Parameters for Source Term Model (Cont.)

<u>Fraction of water contacting waste</u>

- Exposed cross-section = 0.0008
- Most canisters probably dry
- Diversion of flow to some canisters
- Thermally driven circulation
- Assumed uniform distribution 0.002 to 0.01

<u>Radionuclide Solubilities</u>

- Typical of previous DOE studies of YMP

Performance Assessment Demonstration: Sensitivity and Uncertainty Analyses

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Sensitivity and Uncertainty Analyses

Purpose

Determine sensitivity of model output to parameter variations

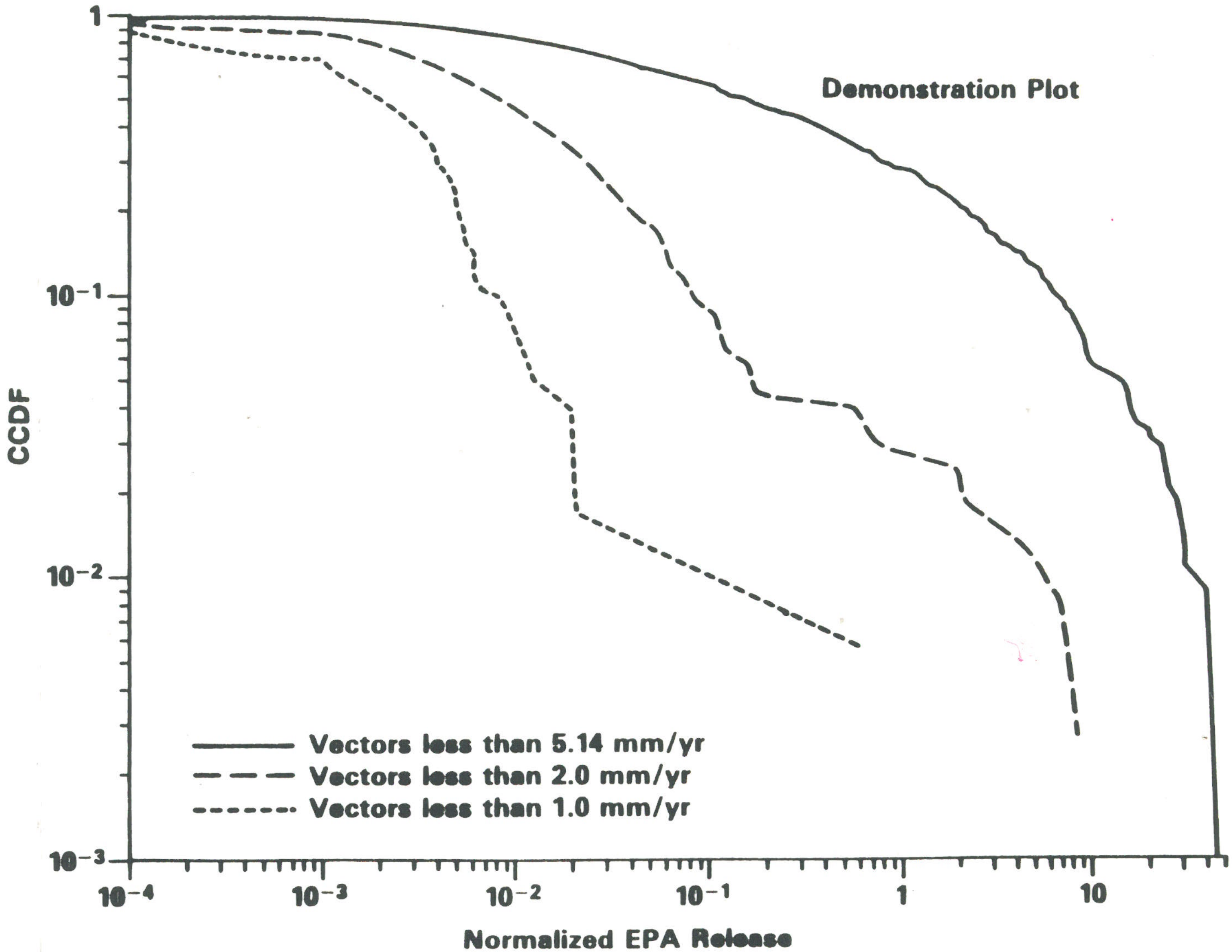
Demonstrations of:

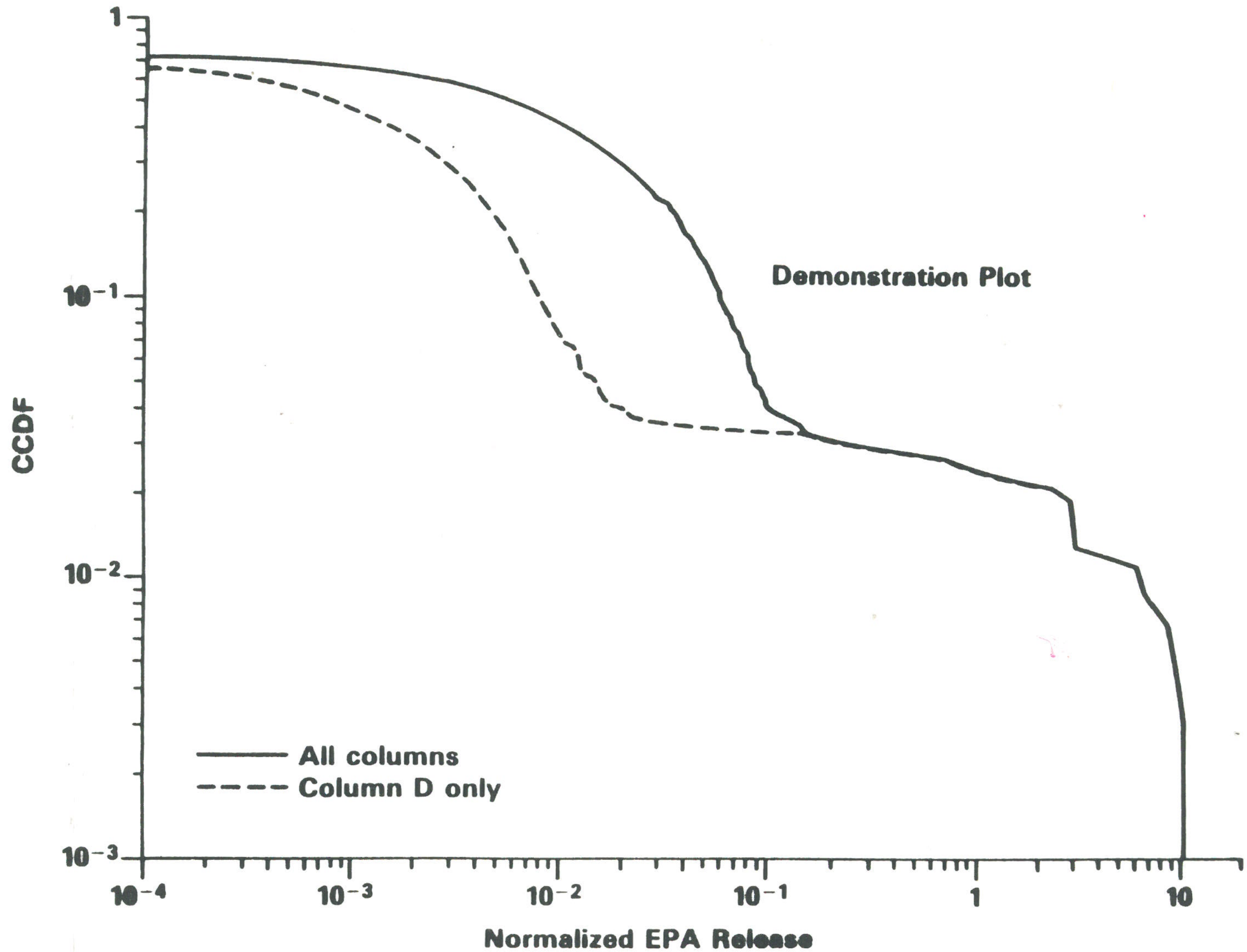
Ceteris paribus method - change one variable at a time to see effect on CCDF

Regression method - for the entire sampled space, perform multiple linear regression to determine sensitivity

Average contribution to cumulative EPA release by radionuclide over all vectors

Nexus between NRC subsystem requirements and cumulative EPA release


Demonstration Plot
CCDF
1
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
10
Normalized EPA Release
Vectors less than 5.14 mm/yr
Vectors less than 2.0 mm/yr
Vectors less than 1.0 mm/yr


1
10^-1
10^-2
10^-3
CCDF
Demonstration Plot
All columns
Column D only
10^-4
10^-3
10^-2
10^-1
1
10
Normalized EPA Release

CCDF for Pluvial Scenario

- Pluvial scenario doubles upper limit of infiltration and shortens distance to water table
- Shows high sensitivity to infiltration and shorter path
- Less relative contribution from column D

REGRESSION OF YMP RESULTS

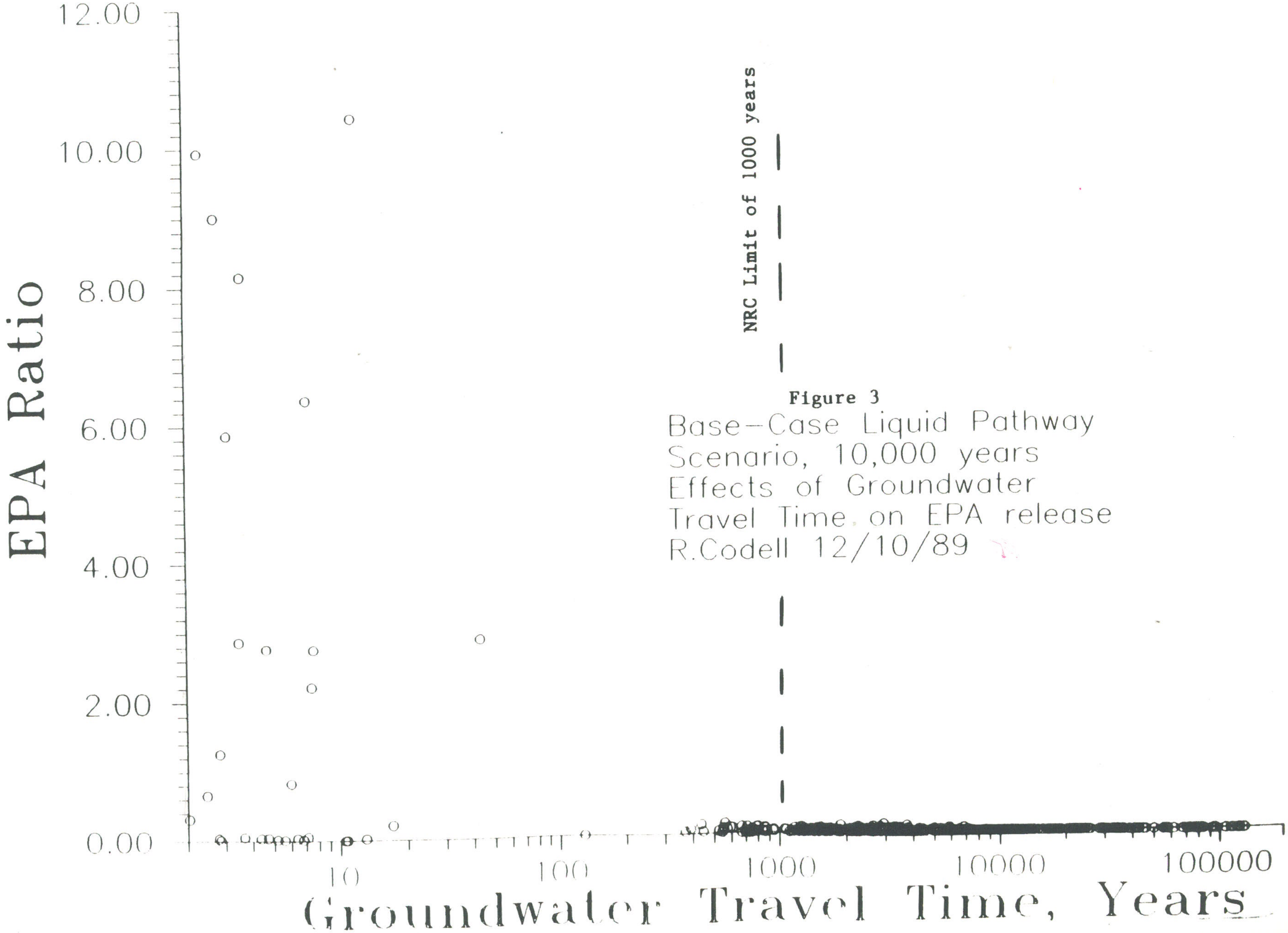
Raw Data Sensitivity Coefficients

Variable	Base Case 10,000 yr	Base Case 100,000 yr
W.P. Lifetime	-0.045	-0.049
Solubility of UO	0.09	0.13
Infiltration Rate	0.10	0.31
Contact Fraction	--	0.18
Mean log ksat TSw	--	-0.11
Mean log ksat CHnz	-0.14	-0.22
Rd Plutonium	--	0.23
Correlation Length	0.11	--

AVERAGE IMPORTANCE BY RADIONUCLIDE

- Pu-239 and Pu-240 are largest contributors in general
- C-14, Am-241, and I-129 less important
- Results reflect fracture flow
- C-14, I-129, and Tc-99 may be relatively important for no fracture flow

Relationship between EPA Compliance (40CFR191) and NRC Subsystem Requirements (10CFR60)



12.00
10.00
8.00
6.00
4.00
2.00
0.00
EPA Ratio
NRC Limit of 1000 years
Figure 3
Base-Case Liquid Pathway
Scenario, 10,000 years
Effects of Groundwater
Travel Time on EPA release
R.Codell 12/10/89
10
100
1000
10000
100000
Groundwater Travel Time, Years

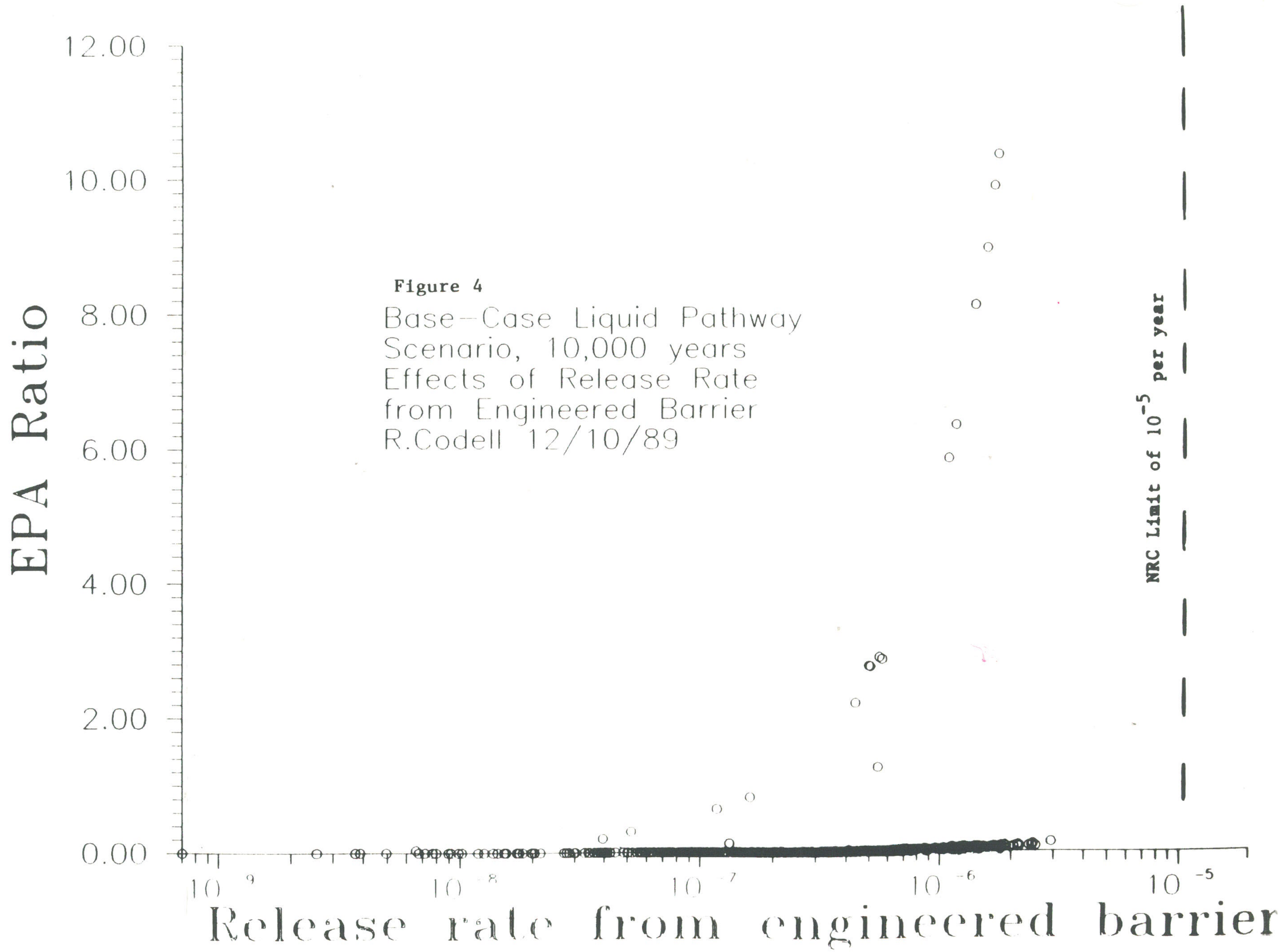


Figure 4
Base-Case Liquid Pathway
Scenario, 10,000 years
Effects of Release Rate
from Engineered Barrier
R.Codell 12/10/89
EPA Ratio
12.00
10.00
8.00
6.00
4.00
2.00
0.00
10 -9
10 -8
10 -7
10 -6
10 -5
Release rate from engineered barrier
NRC Limit of 10^-5 per year

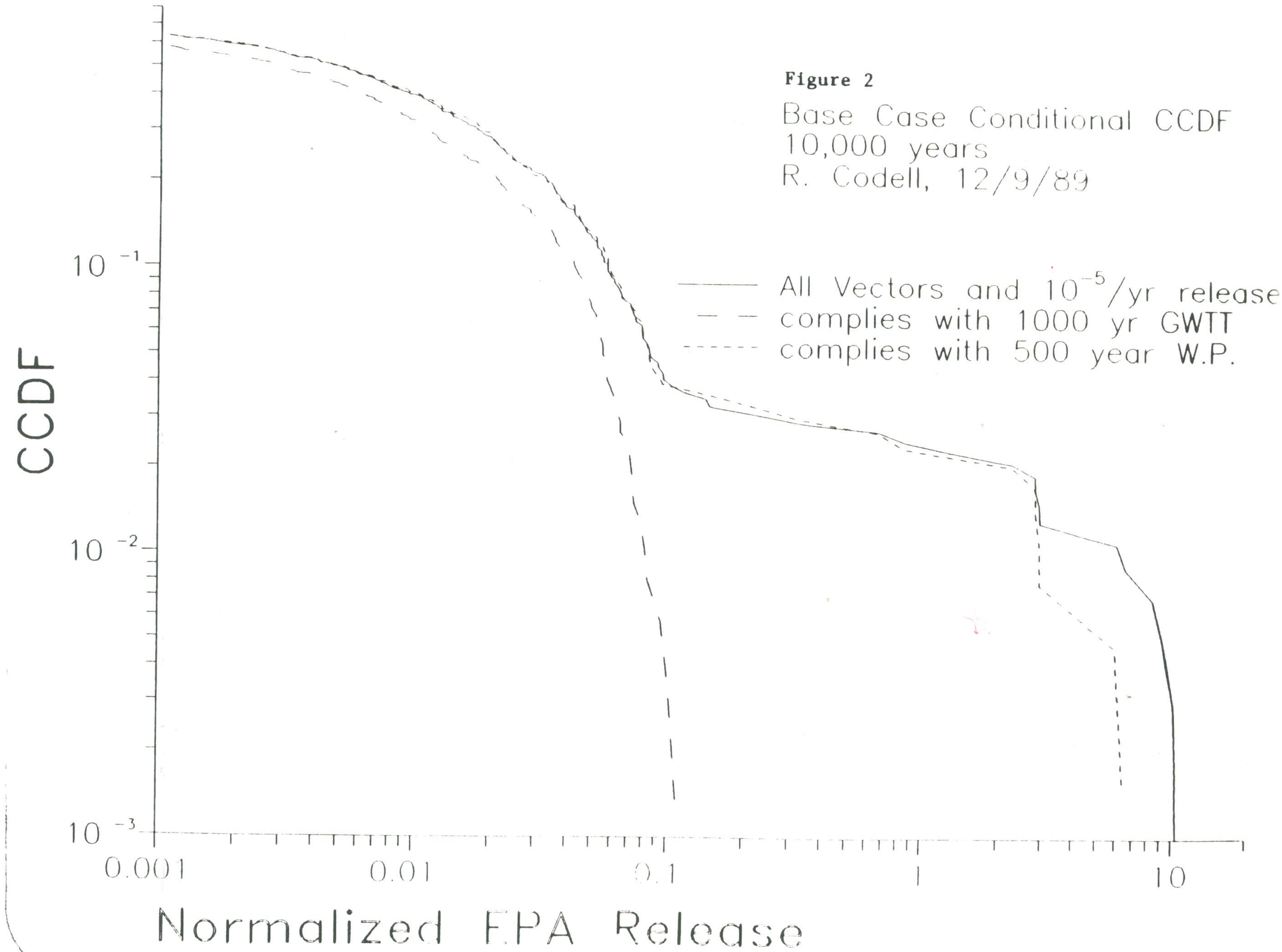


Figure 2

Base Case Conditional CCDF
10,000 years
R. Codell, 12/9/89