PERFORMANCE ASSESSMENT

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U.S. DEPARTMENT OF ENERGY

PRESENTATION TO THE NUCLEAR WASTE TECHNICAL REVIEW BOARD

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OUTLINE OF PRESENTATION ON PERFORMANCE ASSESSMENT

- Requirements for Performance Assessment (PA)
- Major Milestones of PA
- PA Program Management
- Strategies for PA
- Technical Structure of PA
- Example of PA Calculation: Construction of a CCDF
- Example of PA Calculation: Waste Package System Sensitivity
- Example of PA Calculation: Ground Water Travel Time
- Summary: Technical Issues in PA

REQUIREMENTS FOR PERFORMANCE ASSESSMENT

(1) to predict the potential health, safety, and environmental effects of creating and using a nuclear waste repository as per applicable regulations (40 CFR Part 191, 10 CFR Part 60)

(2) to characterize these effects in terms of their magnitude and likelihood,

(3) to compare the characterization of these effects to standards of acceptability

(4) to guide site, laboratory and design activities, and

(5) to present the results of these analyses in a format useful to regulators, scientists, and the public.

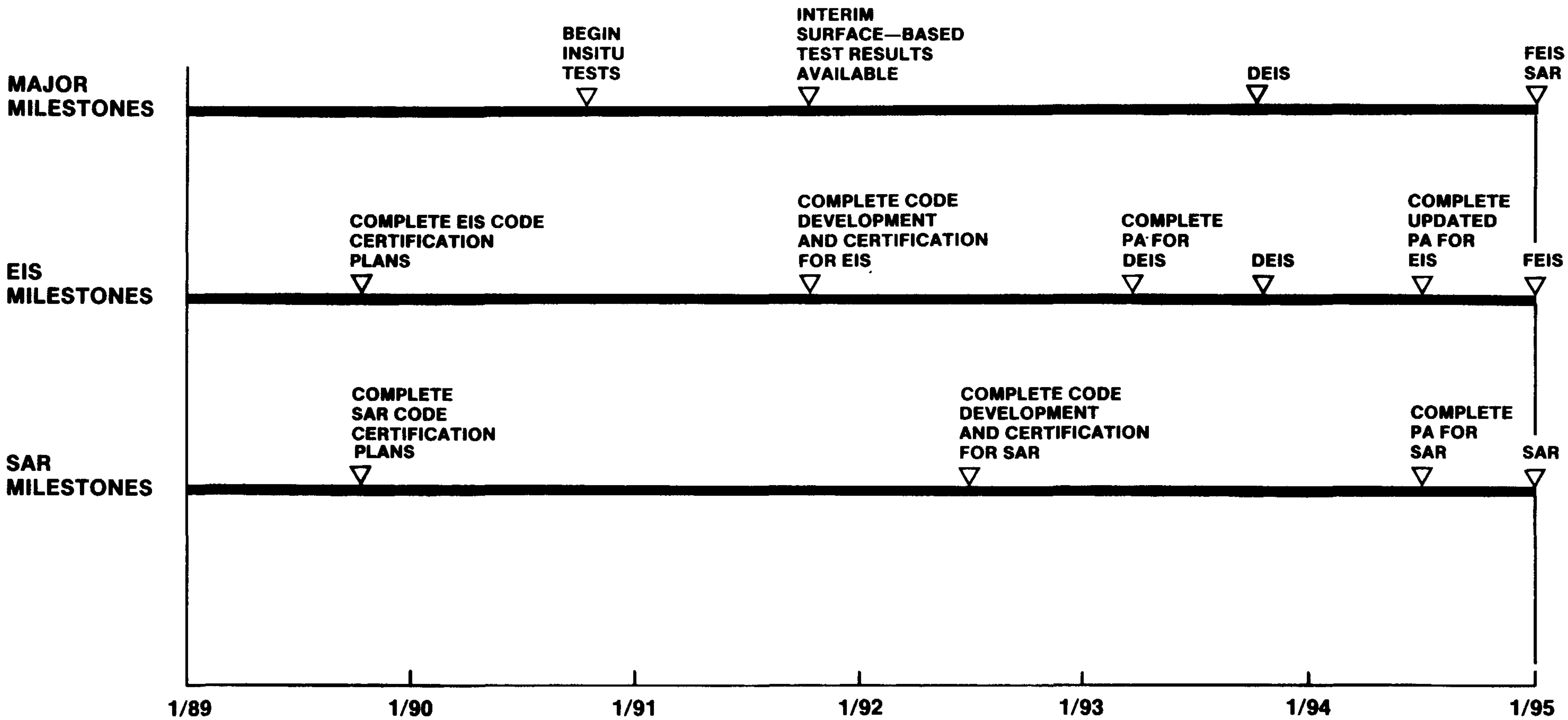
MAJOR MILESTONES
OF PERFORMANCE ASSESSMENT

- Major programmatic milestone documents were designated by Nuclear Waste Policy Act of 1982 (as amended) to include an Environmental Impact Statement (EIS) and a Licence Application [a Draft EIS (DEIS) is to be issued for public comment before a Final EIS (FEIS) is issued]

- The License Application (LA) is to consist, in part, of a Safety Analysis Report (SAR) containing performance assessments

- PA will be used to support the Performance Confirmation activities specified by 10 CFR Part 60 related to the construction, operation and permanent-closure phases of the repository

PERFORMANCE ASSESSMENT (PA) MILESTONES FOR LICENSING



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PA PROGRAM MANAGEMENT

- A management structure is in place that oversees and integrates methodology development and certification (documentation, benchmarking and verification, validation), and the conduct of performance assessments

- The complexity and interdisciplinary nature of PA require that participants in the PA program include recognized experts at a number of facilities in a number of locations

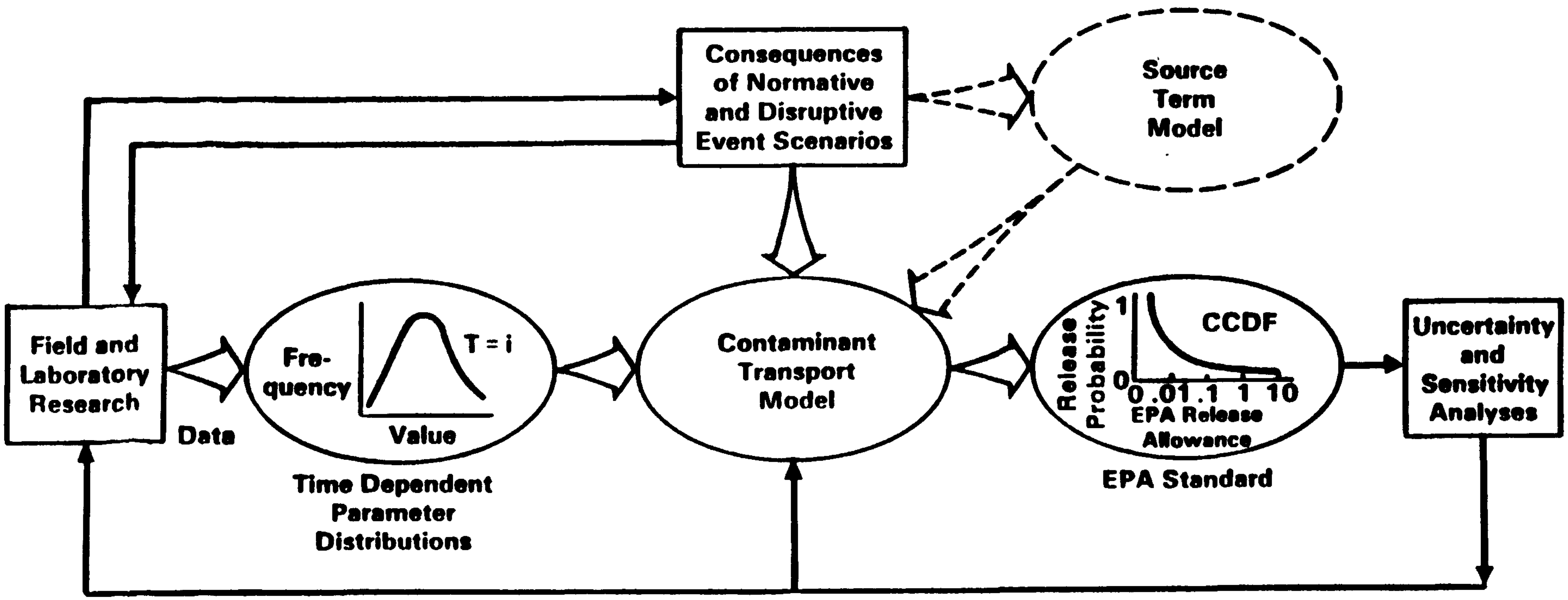
STRATEGIES FOR PA

1) **ADDRESSING THE EPA STANDARD (40 CFR Part 191) IN 10 CFR 60.112**

- 40 CFR Part 191 probabilistically specifies quantitative cumulative release limits for radionuclides through the geosphere to the accessible environment over 10,000 years

- A complementary cumulative distribution function (CCDF) of radionuclide releases, weighted by factors proportional to toxicity, is constrained at fixed points based on limiting population risk

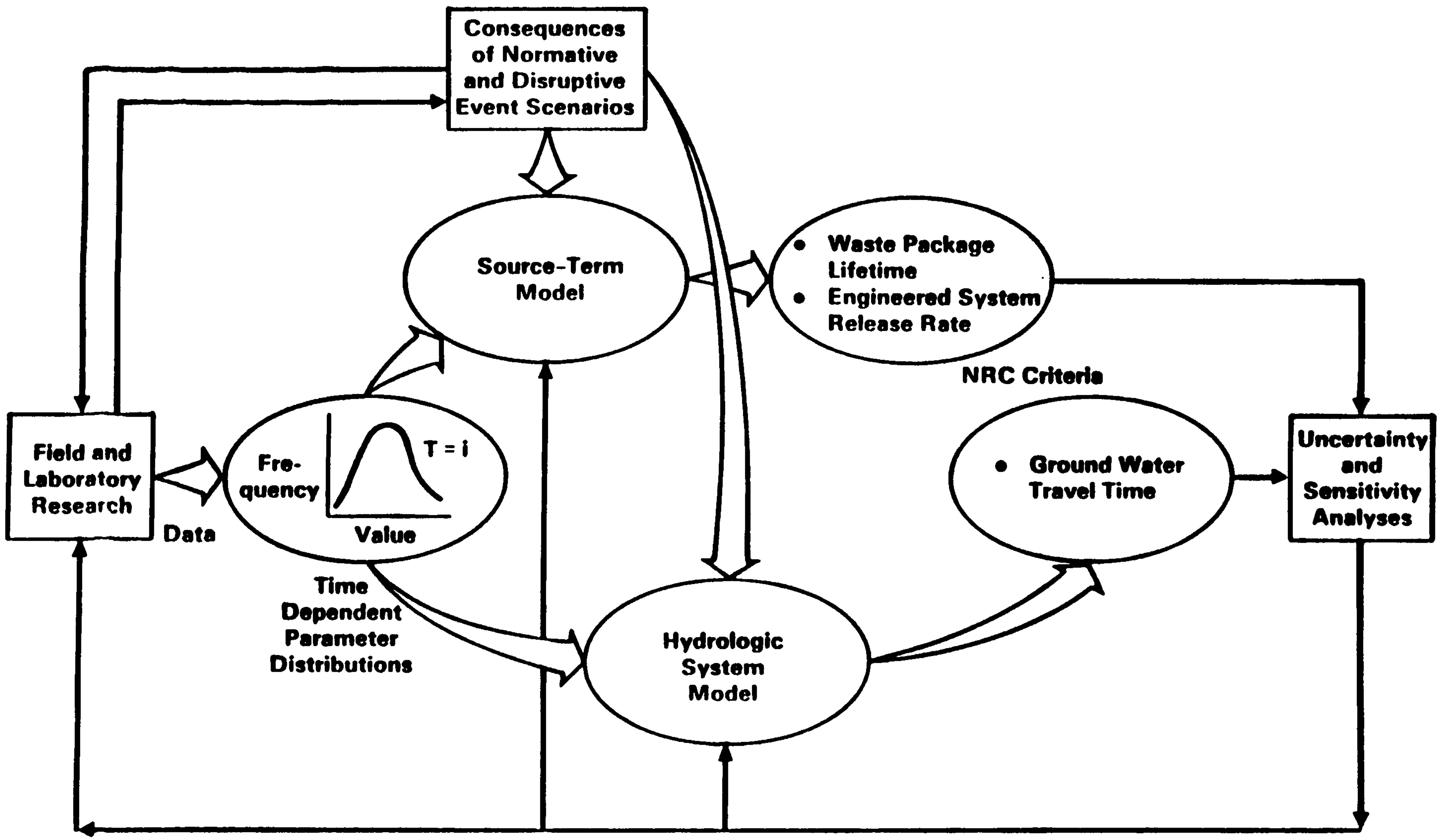
- In addition, maximally exposed individual dose and radionuclide concentrations in certain types of groundwaters are limited for 1,000 years after permanent closure of the repository


Consequences of Normative and Disruptive Event Scenarios
Source Term Model
Field and Laboratory Research
Data
Fre-quency
T = i
Value
Time Dependent Parameter Distributions
Contaminant Transport Model
Release Probability
1
0
CCDF
0 .01 .1 1 10
EPA Release Allowance
EPA Standard
Uncertainty and Sensitivity Analyses

STRATEGIES FOR PA

2) ADDRESSING THE QUANTITATIVE REQUIREMENTS OF 10 CFR 60.113

- 10 CFR 60.113 specifies a minimum time period during which containment within the waste-package system must be substantially complete
- Maximum rates of radionuclide releases from the engineered barrier system after the containment period are also specified
- In addition, a minimum pre-emplacement ground water travel time from the disturbed rock zone to the accessible environment is specified


Consequences of Normative and Disruptive Event Scenarios
Source-Term Model
• Waste Package Lifetime
• Engineered System Release Rate
NRC Criteria
Field and Laboratory Research
Data
Fre-quency
T = i
Value
Time Dependent Parameter Distributions
• Ground Water Travel Time
Uncertainty and Sensitivity Analyses
Hydrologic System Model

TECHNICAL STRUCTURE OF PA

There are various levels of detail in the modeling that is done under the auspices of the PA program because the PA program serves multiple needs:

- At the highest level of detail, experimental and exploratory work are used to create mechanistic models for processes, as practicable

- At the lowest level of detail the total system model, based to a large extent on subsystem and process models, are used to address the probabilistic system standard of 60.112

- At an intermediate level of detail, subsystem models, based to a large extent on process models, are used to address engineering and design needs and are to be used to address the subsystem performance requirements of 60.113

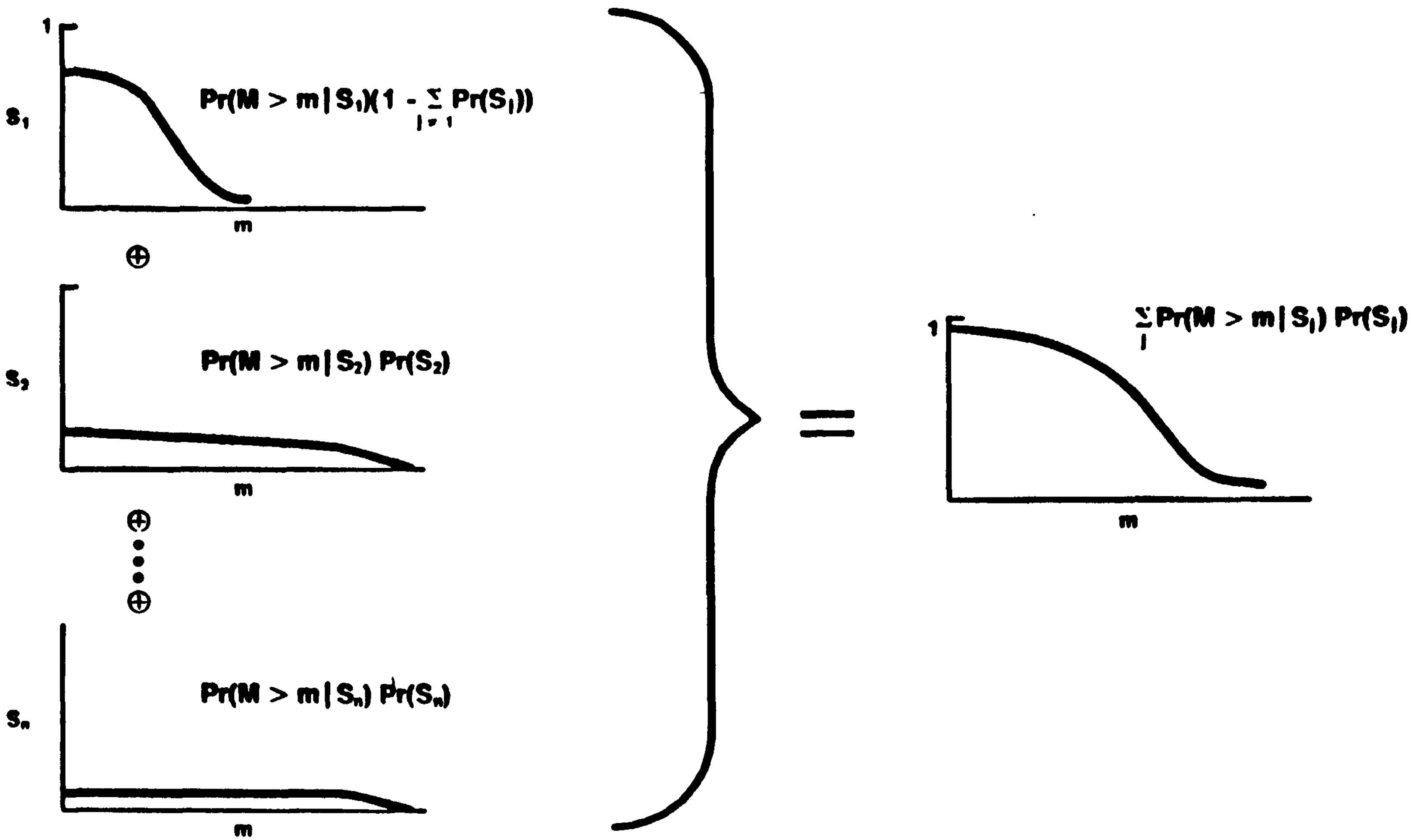
EXAMPLE OF PA CALCULATION
CONSTRUCTION OF A CCDF (10 CFR 60.112)

- For each scenario, release results from contributing models are summed to create a curve showing normalized releases

- Scenario-specific ($S_{1...n}$) releases are plotted in terms of increasing probability (Pr) versus increasing releases (performance-measure M)

- Scenario CCDF's are then combined to produce an overall CCDF that can be compared with the 60.112 standard

CALCULATION OF OVERALL CCDF FROM SCENARIO CCDFs



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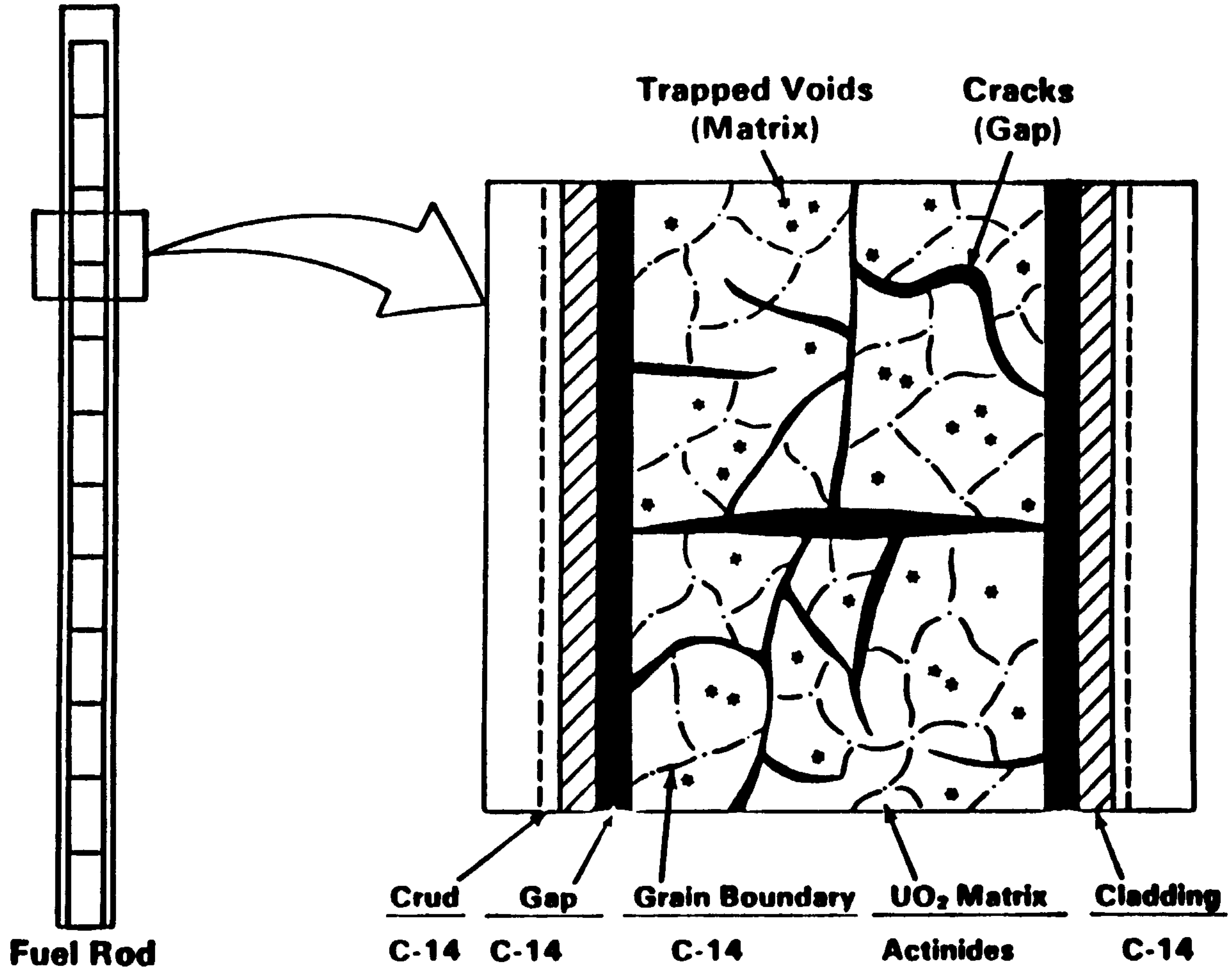
EXAMPLE OF PA CALCULATION
WASTE PACKAGE SYSTEM SENSITIVITY (10 CFR 60.113)

- Spent nuclear fuel is a heterogeneous waste form, with different parts contributing to the total release at different rates

- Gap and grain-boundary element releases are sensitive to container-failure assumptions (point-failure versus distributed failure)

- Matrix element release rates are sensitive to matrix-stability assumptions (stable: release congruent with matrix dissolution rate; unstable: release as a function of individual element solubilities)

Schematic of Spent Nuclear Fuel



Crud	Gap	Grain Boundary	UO_2 Matrix	Cladding
C-14	C-14	C-14	Actinides	C-14
	I-129	I-129	~98% Fission Products	
	Cs-135	Cs-135		
	Cs-137	Cs-137		
	Se-79	Se-79		
	Tc-99	Tc-99		
	Sr-90	Sr-90		

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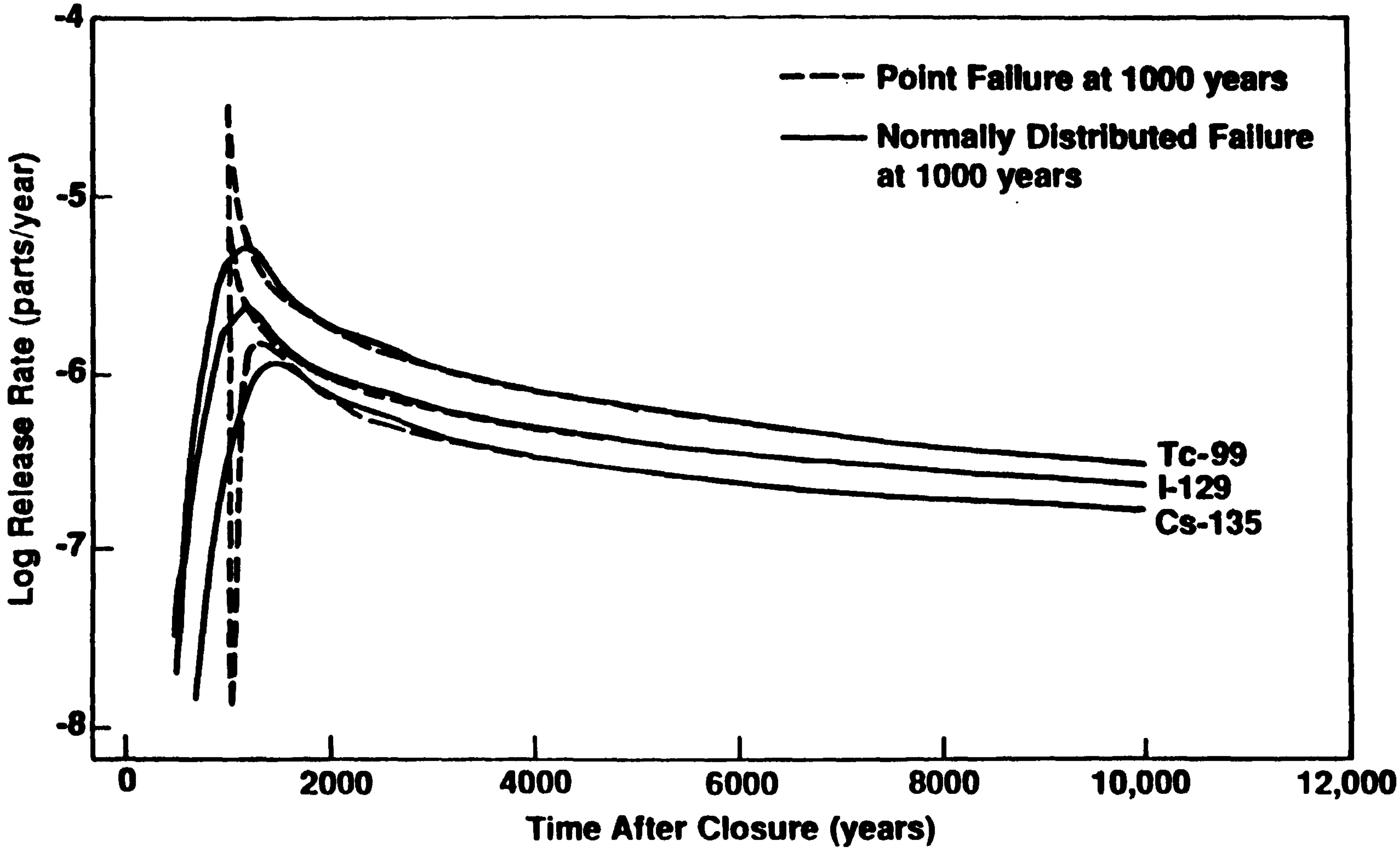
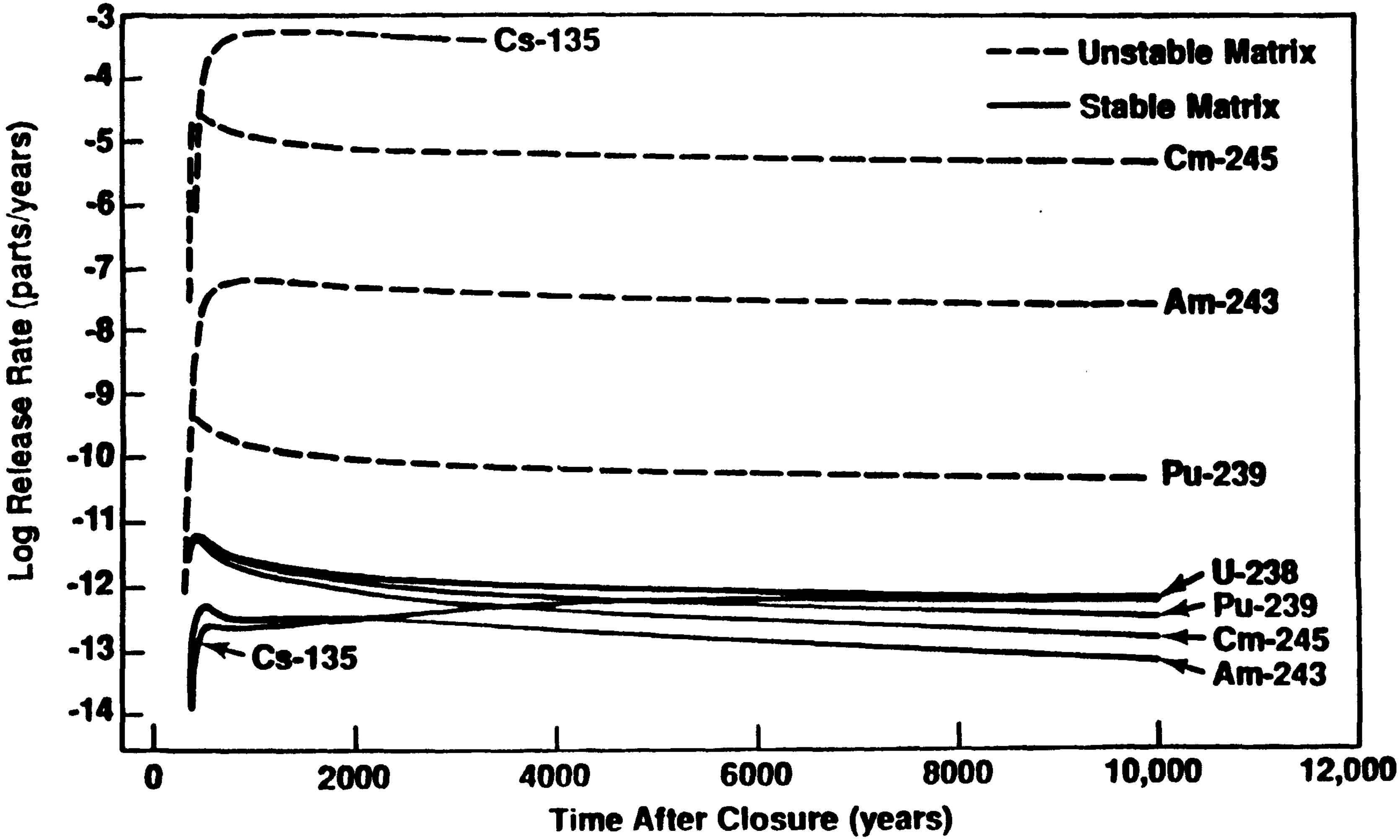
Effect of Distributed Containment Failures on EBS Release



Effect of Stability of Waste Form Matrix on Release (Point Failure at 300 Years)



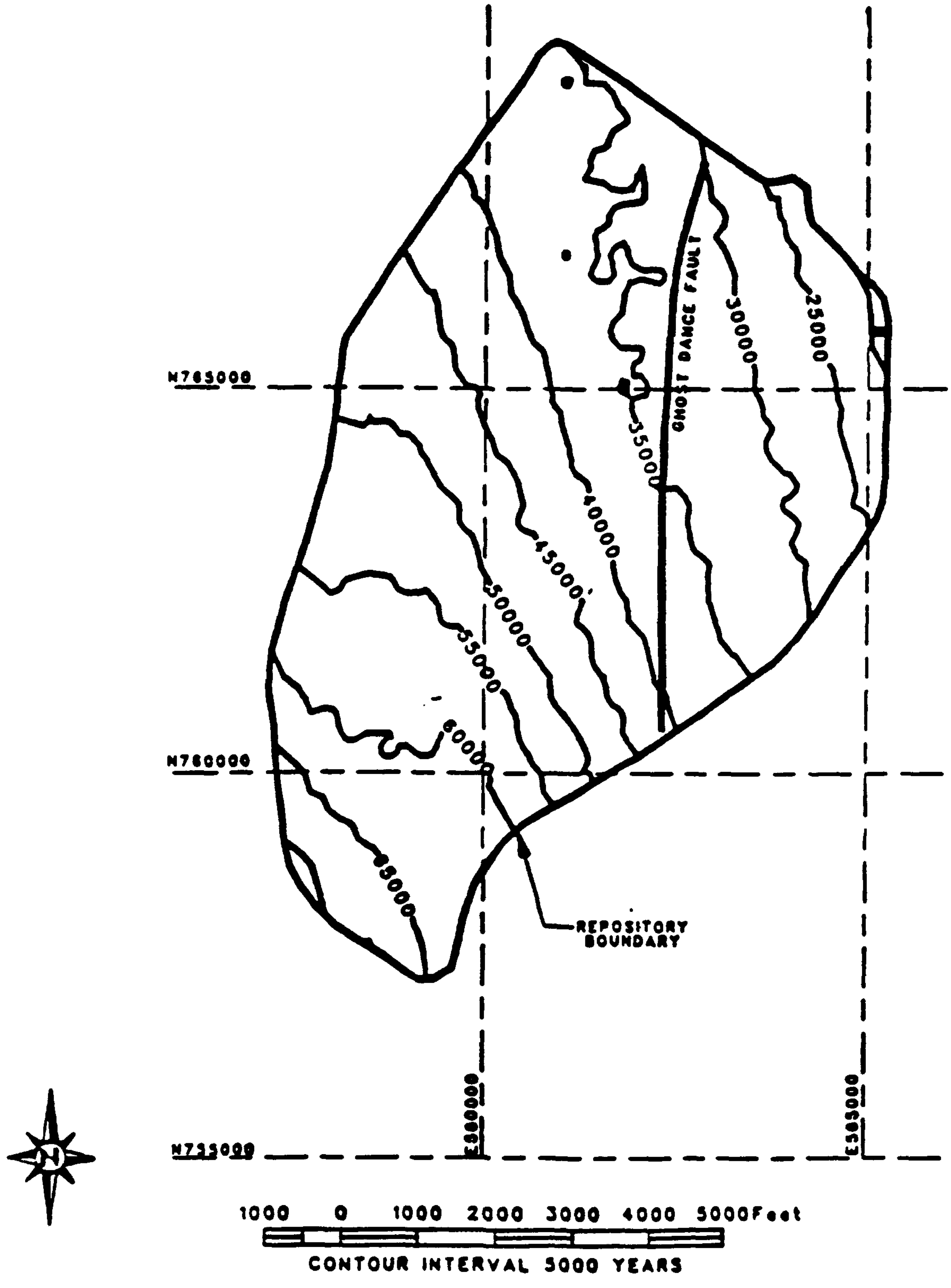
EXAMPLE OF PA CALCULATION
GROUND WATER TRAVEL TIME (10 CFR 60.113)

- For this example, the ground water travel time calculation is to cover matrix-controlled flow over a distance from 50 m below the repository to the water table

- Results of deterministic, simple-geometry calculations of travel times reflect the stratigraphy of the site

- More complex stochastic calculations, accounting for the variance in hydrologic properties in each stratigraphic unit, result in probabilistic travel time calculations

SPARTAN CALCULATIONS
(SIMPLE GEOMETRY, SIMPLE PROCESS)



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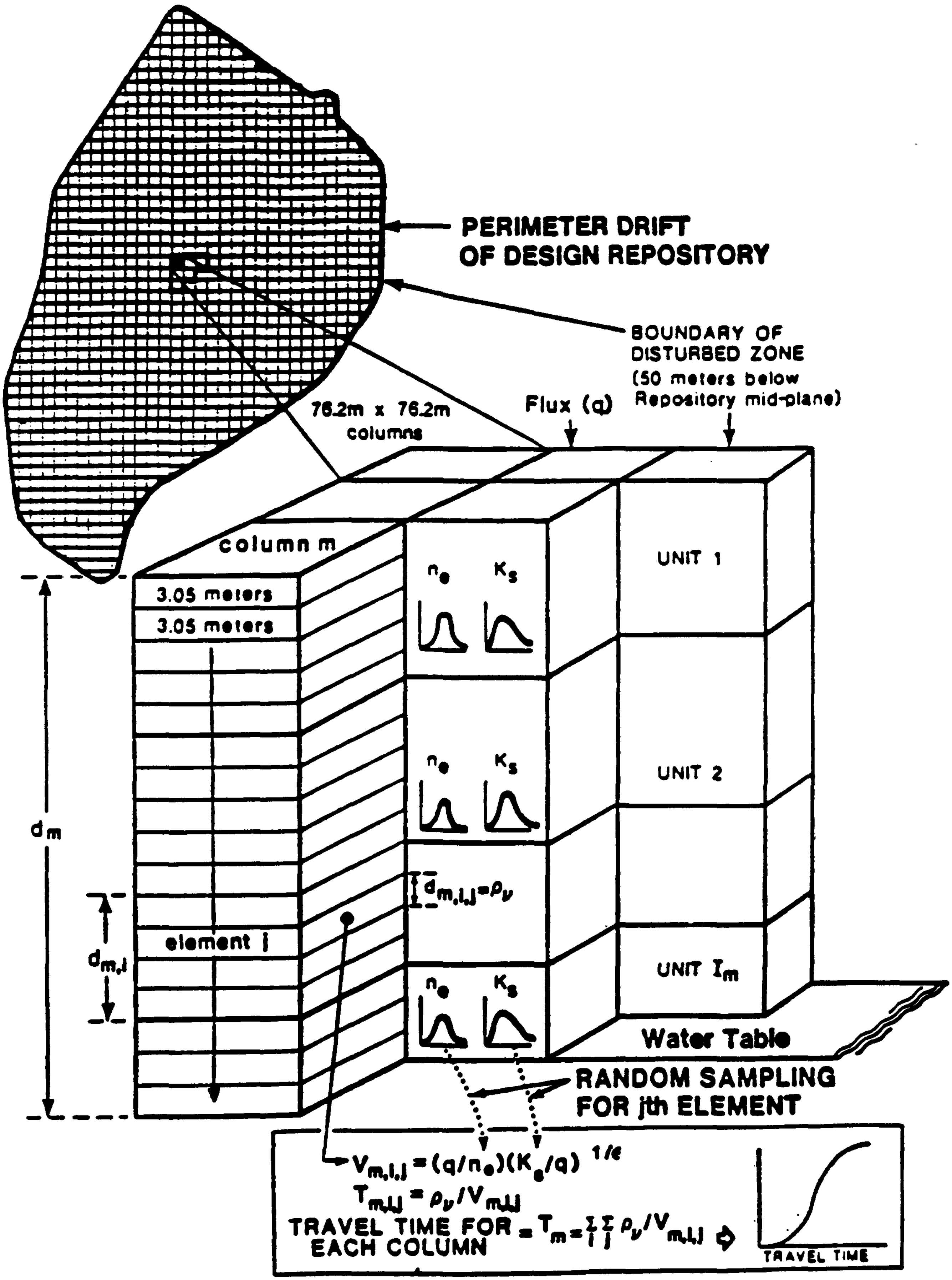
SPARTAN-GW CALCULATIONS (COMPLEX GEOMETRY, SIMPLE PROCESS)



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SUMMARY: TECHNICAL ISSUES IN PA

10 CFR 60.112

- Selection of scenarios for the construction of the CCDF
- The treatment of human interference scenarios

10 CFR 60.113(a)(1)

- The approach to waste package corrosion modeling and testing
- The approach to evaluating engineered barrier system performance

10 CFR 60.113(a)(2)

- Determining the extent of the disturbed zone
- The approach to evaluating ground water travel time