ACCELERATED DISTRIBUTION DEMONSTRATION SYSTEM enclosure in binder

REGULATORY INFORMATION DISTRIBUTION SYSTEM (RIDS)

ACCESSION NBR:8905260416 DOC.DATE: 89/05/17 NOTARIZED: NO DOCKET #
FACIL:
AUTH.NAME AUTHOR AFFILIATION
* Energy, Dept. of
RECIP.NAME RECIPIENT AFFILIATION

SUBJECT: "Performance Assessment Briefing," presented to Nuclear Waste Technical Review Board on 890516-17.

DISTRIBUTION CODE: NH03D COPIES RECEIVED:LTR 1 ENCL 1 SIZE: 425
TITLE: High Level Waste Tech Info re NNWSI Sites - General

NOTES:

	RECIPIENT ID CODE/NAME	COPIES LTTR	COPIES ENCL	RECIPIENT ID CODE/NAME	COPIES LTTR	COPIES ENCL
	RECIP Blanton	1	1			
INTERNAL:	ACNW	6	1	CENTRAL FILE 01	1	1
	NMSS/HLEN 4-H-3	1	1	NMSS/HLGP 4-H-3	1	0
	NMSS/HLPD 4-H-3	4	1	OGC/HDS2/HLW	1	1
	TLSS	1	1			
EXTERNAL:	*LPDR	3	3	CNWRA	1	1
	FORD BLDG HOY,A	1	1	NRC PDR	1	1

BLANTON

LIMITED DISTRIBUTION OF ENCLOSURES DUE TO SIZE

FULL TEXT ASCII SCAN

RIDS/ADDS

RIDS/ADDS

NOTE TO ALL "RIDS" RECIPIENTS: rec 6/8/89 6/9/89

PLEASE HELP US TO REDUCE WASTE! CONTACT THE DOCUMENT CONTROL DESK, ROOM P1-37 (EXT. 20079) TO ELIMINATE YOUR NAME FROM DISTRIBUTION LISTS FOR DOCUMENTS YOU DON'T NEED!

TOTAL NUMBER OF COPIES REQUIRED: LTTR 22 ENCL ~~22~~ 14

102

Bunting, J.O.

U.S. DEPARTMENT OF ENERGY

OCRWM

YUCCA MOUNTAIN

YUCCA MOUNTAIN PROJECT

PERFORMANCE ASSESSMENT BRIEFING

PRESENTED TO

NUCLEAR WASTE TECHNICAL REVIEW BOARD

MAY 16-17, 1989

UNITED STATES DEPARTMENT OF ENERGY
NEVADA OPERATIONS OFFICE/YUCCA MOUNTAIN PROJECT OFFICE

WM-11 NA03

U.S. DEPARTMENT OF ENERGY

OCRWM

YUCCA MOUNTAIN

YUCCA MOUNTAIN PROJECT

PERFORMANCE ASSESSMENT BRIEFING

PRESENTED TO

NUCLEAR WASTE TECHNICAL REVIEW BOARD

MAY 16-17, 1989

UNITED STATES DEPARTMENT OF ENERGY
NEVADA OPERATIONS OFFICE/YUCCA MOUNTAIN PROJECT OFFICE

AGENDA
NWTRB PERFORMANCE ASSESSMENT BRIEFING
MAY 16-17, 1989

MAY 16
OVERVIEW OF PERFORMANCE ASSESSMENT PROGRAM

10:00	INTRODUCTION AND WELCOME	DOE & NWTRB
10:30	OVERVIEW OF PERFORMANCE ASSESSMENT	ALEXANDER
11:00	FLOWDOWN OF REGULATORY REQUIREMENTS TO PERFORMANCE ASSESSMENT PROGRAM	RICKERTSEN
11:30	TECHNICAL INTEGRATION OF PERFORMANCE ASSESSMENT PROGRAM	GNIRK
12:00	LUNCH	

CURRENT STATUS AND DATA NEEDS FOR MAJOR PERFORMANCE ASSESSMENT AREAS

1:00	PERFORMANCE OF NATURAL BARRIERS	HOXIE
1:40	ENGINEERED BARRIER SYSTEM PERFORMANCE	VAN LUIK
2:20	BREAK	
2:30	POSTCLOSURE TOTAL SYSTEM PERFORMANCE ASSESSMENT	BINGHAM
3:10	PRECLOSURE SAFETY ASSESSMENT	MICHLEWICZ
3:40	REVIEW OF TOMORROW'S AGENDA & DISCUSSION	ALEXANDER
4:00	DISCUSSION PERIOD	

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

PRESENTATION TO THE NUCLEAR WASTE TECHNICAL REVIEW BOARD

SUBJECT: OVERVIEW OF PERFORMANCE ASSESSMENTS

PRESENTER: DR. DONALD H. ALEXANDER

PRESENTER'S TITLE AND ORGANIZATION: CHIEF
REGULATORY COMPLIANCE BRANCH
OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT

PRESENTER'S TELEPHONE NUMBER: (202) 586-4889

MAY 16-17, 1989

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

PRESENTATION TO THE NUCLEAR WASTE TECHNICAL REVIEW BOARD

SUBJECT: OVERVIEW OF PERFORMANCE ASSESSMENTS

PRESENTER: DR. DONALD H. ALEXANDER

PRESENTER'S TITLE AND ORGANIZATION: CHIEF
REGULATORY COMPLIANCE BRANCH
OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT

PRESENTER'S TELEPHONE NUMBER: (202) 586-4889

MAY 16-17, 1989

1. OBJECTIVES OF THE BRIEFING

2. DEFINITION OF PERFORMANCE ASSESSMENT

3. OBJECTIVES OF PERFORMANCE ASSESSMENT

4. REQUIRED PERFORMANCE ASSESSMENTS

5. MAJOR TECHNICAL CONCERNS

6. PERFORMANCE ASSESSMENT ACTIVITIES

OBJECTIVES OF THE BRIEFING

SESSION I: OVERVIEW

- ESTABLISH THE REGULATORY BASIS FOR THE PERFORMANCE ASSESSMENT PROGRAM
- REVIEW THE ROLE OF PERFORMANCE ASSESSMENT IN THE REDUCTION OF UNCERTAINTIES
- REVIEW THE APPROACH FOR THE TECHNICAL INTEGRATION OF PERFORMANCE ASSESSMENT ACTIVITIES
- REVIEW THE TIMING AND SEQUENCING OF PLANNED PERFORMANCE ASSESSMENT ACTIVITIES

SESSION II: SUMMARY OF MAJOR PERFORMANCE ASSESSMENT EFFORTS

- REVIEW PREVIOUS PERFORMANCE ASSESSMENT CALCULATIONS INCLUDING THOSE IN THE ENVIRONMENTAL ASSESSMENTS
- REVIEW DATA STATUS AND NEEDS
- IDENTIFY NEAR TERM ACTIVITIES

OBJECTIVES OF THE BRIEFING
DAY 2

SESSION III: INVESTIGATIVE APPROACH

- REVIEW APPROACH TO MODEL VALIDATION
- ESTABLISH ITERATIVE NATURE OF PERFORMANCE ASSESSMENT AND TESTING

SESSION IV: RECENT APPLICATIONS

- REVIEW OF PERFORMANCE ASSESSMENTS IN SUPPORT OF THE SCP
- REVIEW OF PERFORMANCE ASSESSMENTS IN THE COMPARATIVE SITE ANALYSIS
- REVIEW OF PERFORMANCE ASSESSMENTS CONDUCTED TO EVALUATE THE IMPACTS OF SITE CHARACTERIZATION ON LONG-TERM SITE PERFORMANCE

SESSION V: MODEL DEVELOPMENT

- PRESENT AN EXAMPLE OF PHYSICAL MODEL DEVELOPMENT
- PRESENT AN EXAMPLE OF SUBSYSTEM MODEL DEVELOPMENT

WHAT IS PERFORMANCE ASSESSMENT?

- PROCESS OF EVALUATING REPOSITORY SYSTEM, SUBSYSTEM, AND COMPONENT PERFORMANCE

- DEMONSTRATE COMPLIANCE WITH THE NUMERICAL CRITERIA OF THE REGULATIONS

- SUPPORT REPOSITORY DEVELOPMENT INCLUDING SITE CHARACTERIZATION AND DESIGN

OBJECTIVES OF PERFORMANCE ASSESSMENT

- EVALUATE SYSTEM AND SUBSYSTEM PERFORMANCE TO DEMONSTRATE COMPLIANCE WITH THE TECHNICAL CRITERIA OF 10 CFR PART 60 FOR THE LICENSE APPLICATION
- EVALUATE ENVIRONMENTAL IMPACTS FOR THE ENVIRONMENTAL IMPACT STATEMENT
- ASSESS SENSITIVITIES AND UNCERTAINTIES IN THE PERFORMANCE ASSESSMENT
- GUIDE DESIGN AND TESTING ACTIVITIES

REQUIRED PERFORMANCE ASSESSMENTS

- PRECLOSURE PERFORMANCE ASSESSMENTS
- POSTCLOSURE PERFORMANCE ASSESSMENTS
  - TOTAL SYSTEM PERFORMANCE ASSESSMENT
  - ENGINEERED BARRIER SYSTEM PERFORMANCE ASSESSMENT
  - NATURAL BARRIERS PERFORMANCE ASSESSMENT

NUCLEAR REGULATORY COMMISSION
10 CFR 60

Overall System Performance Objective

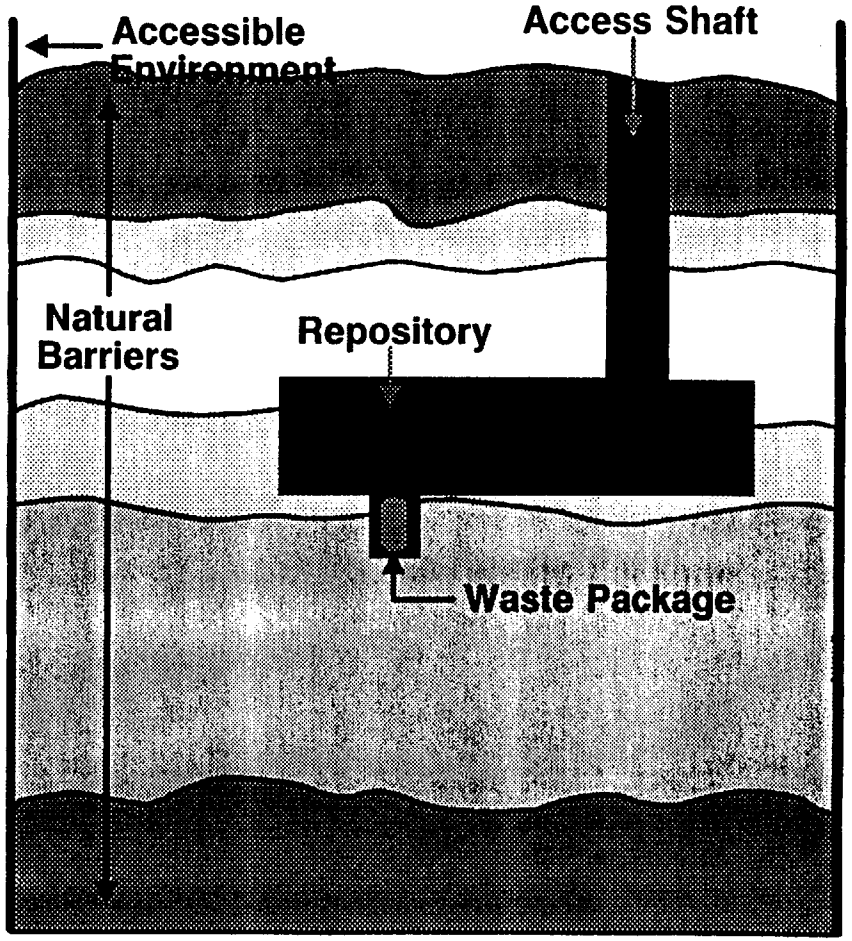
- Conformance with EPA Standard

Subsystem Performance Requirements

- Waste Package Lifetime
- Annual Radionuclide Release Rate
- Pre-Emplacement Ground-Water Travel Time

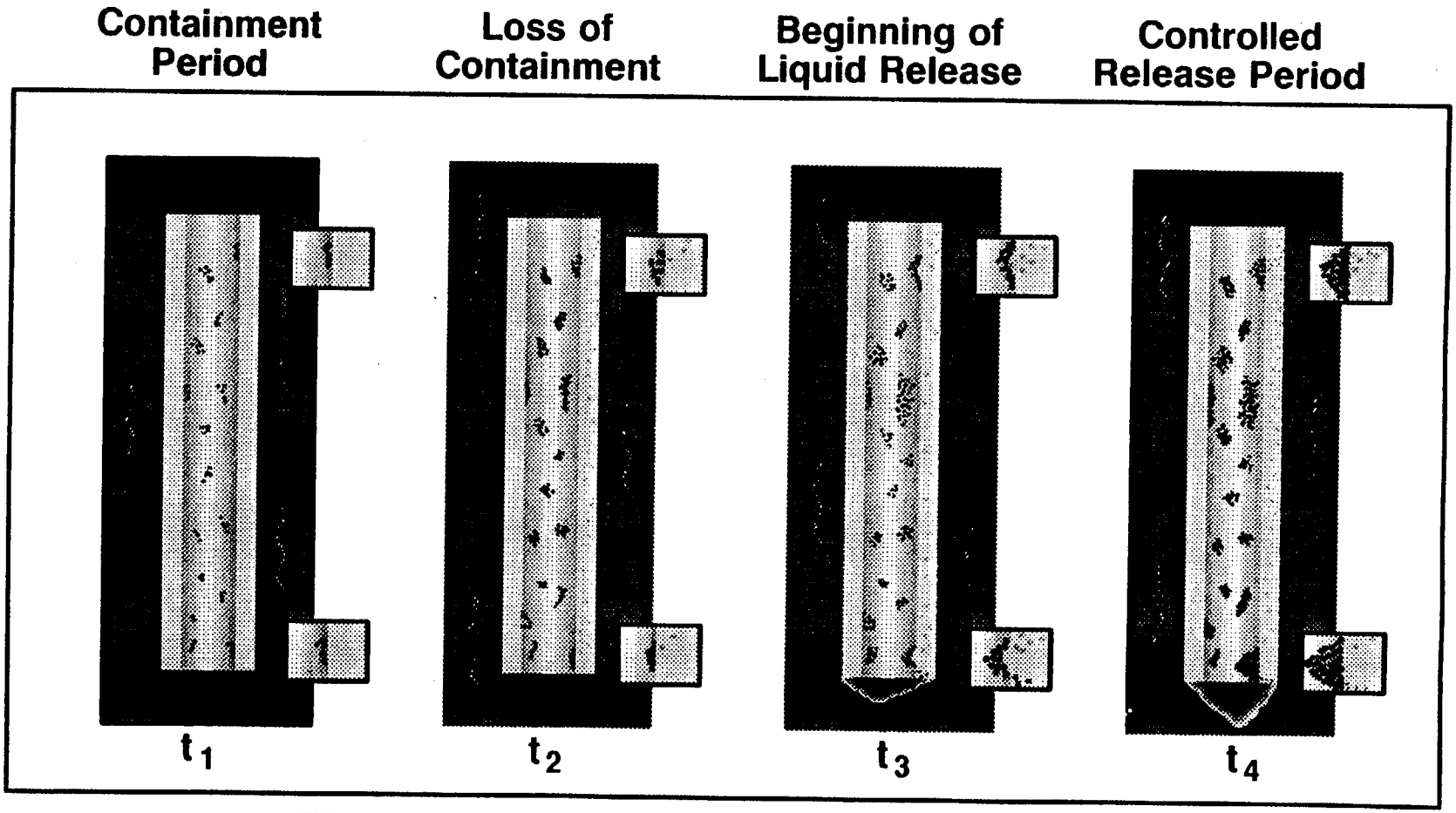
Siting Criteria

- Favorable Conditions
- Potentially Adverse Conditions



RW42387T.015

SCHEMATIC OF CONTAINER FUNCTIONS

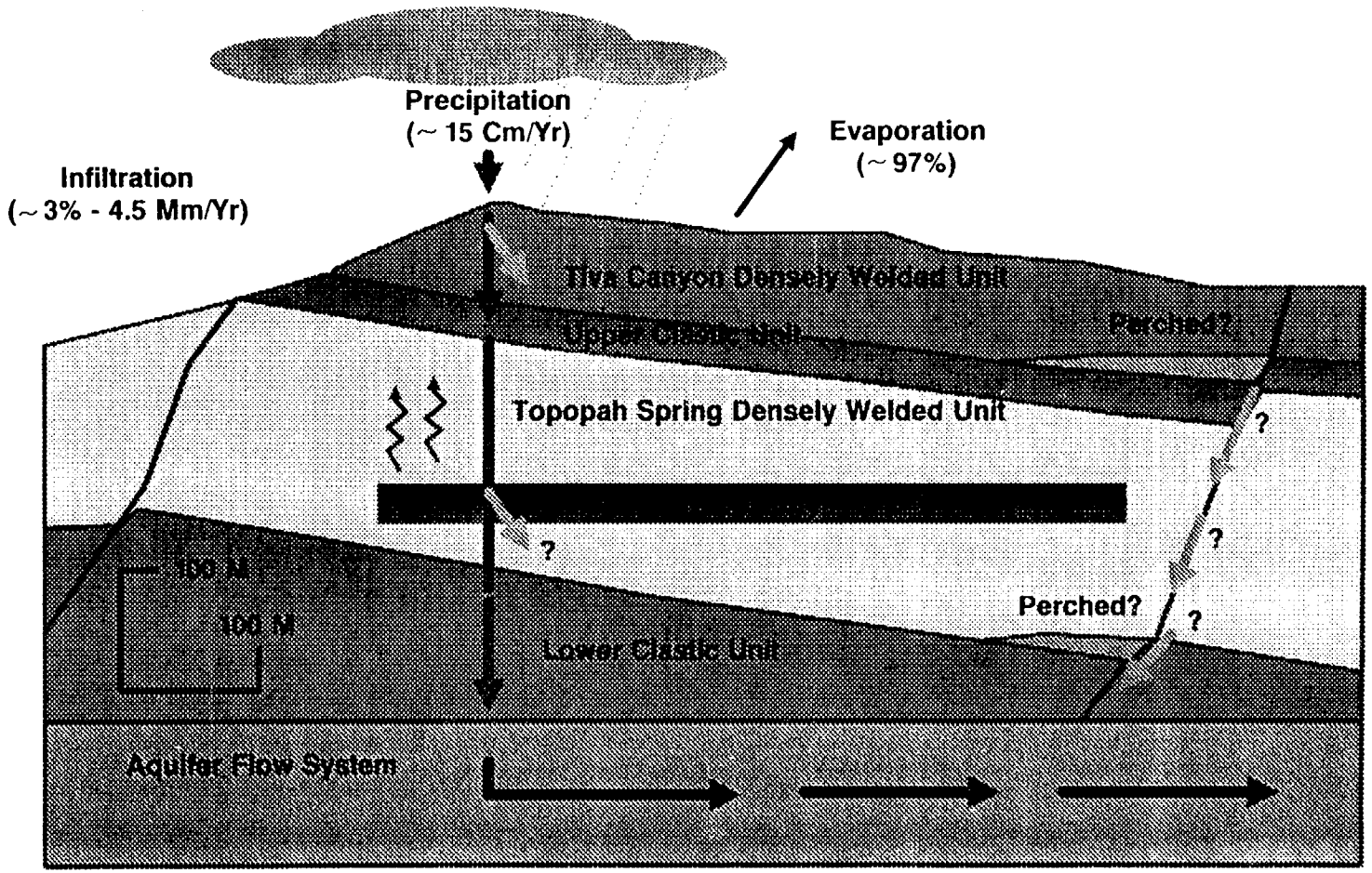


RW21675.006

UNSATURATED-ZONE SECTION
YUCCA MOUNTAIN

W

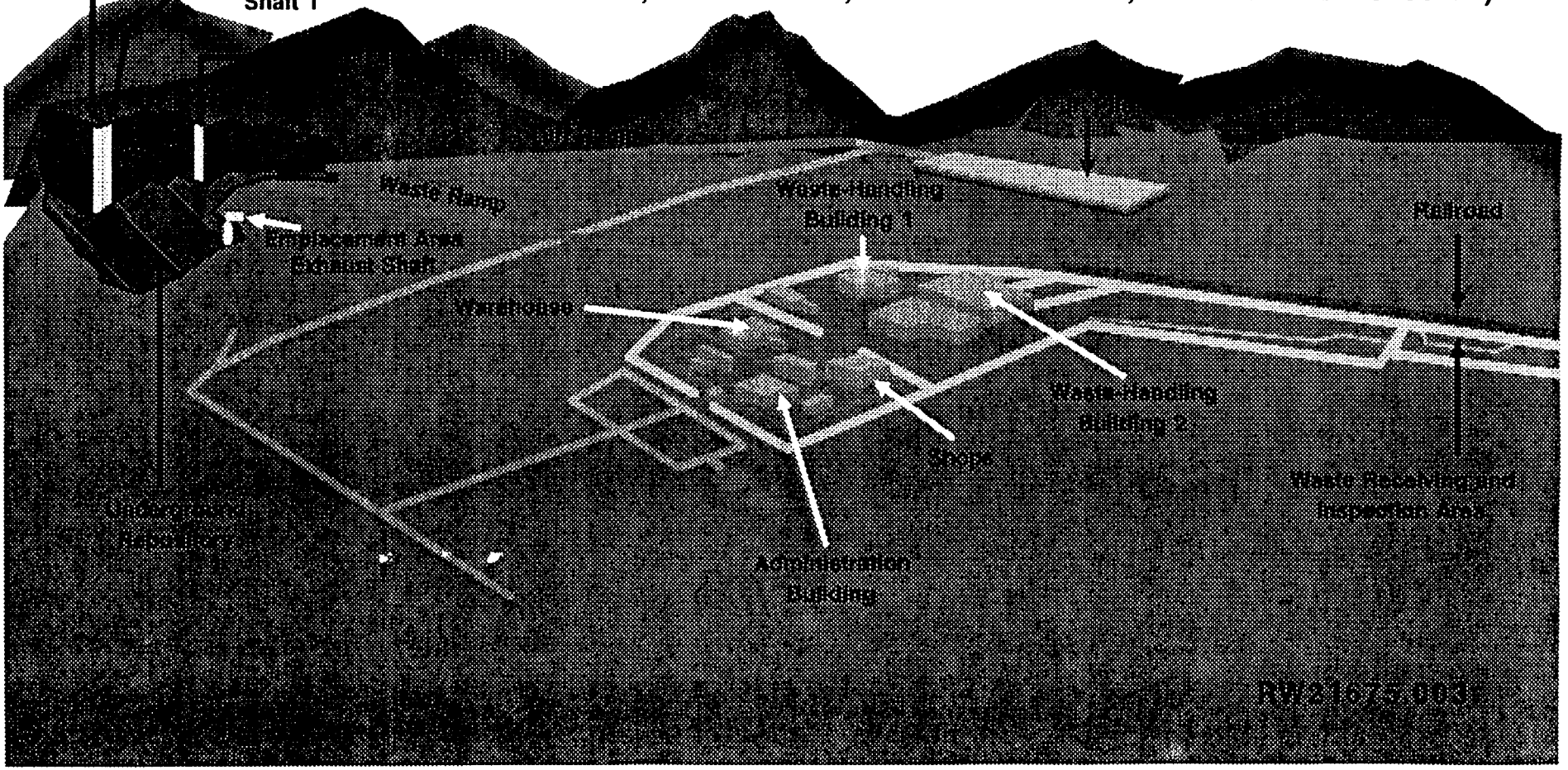
E



RW21675.002

PRECLOSURE REQUIREMENTS

Both the DOE and the NRC Require Radiation Protection for Workers and the General Public During Normal Operations and During Accidents; (10 CFR 60.111, 10 CFR 60.2, Proposed 10 CFR 20; DOE 5480.11, Draft DOE 5400.xx, and Draft DOE 6430.1A)



MAJOR TECHNICAL CONCERNS

- **INTEGRATION OF PERFORMANCE ASSESSMENT INTO TESTING PROGRAM TO EVALUATE ADEQUACY OF DATA**

- **UNCERTAINTIES IN SITE MODELS**
  - ALTERNATE CONCEPTUAL MODELS
  - SCENARIO SELECTION
  - VALIDITY OF PROCESS AND CONSITUTIVE MODELS (eg. FLOW MECHANISM IN UZ)
  - REPRESENTATIVENESS OF SITE DATA

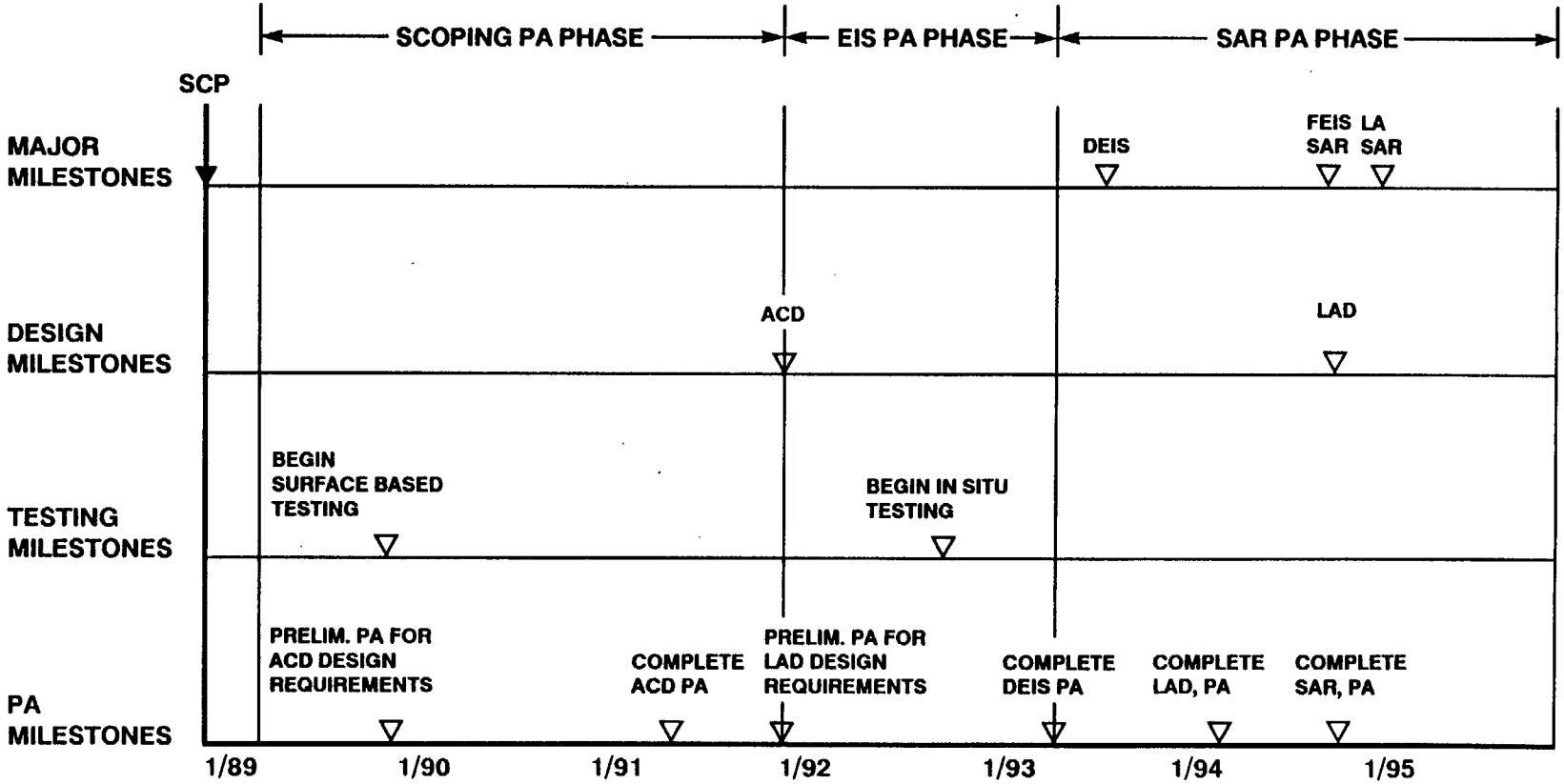
- **UNCERTAINTIES IN ENGINEERED BARRIER MODELS**
  - PHYSICAL MODEL FOR CONTAINER DEGRADATION AND FAILURE
  - MASS TRANSFER FROM WASTE PACKAGE IN UNSATURATED MEDIA

- **PRECLOSURE CONCERNS**
  - SEISMIC ENVIRONMENT
  - ACCIDENT SOURCE TERM

- **C-14 GASEOUS RELEASE IN THE UNSATURATED ZONE**

- **REGULATORY INTERPRETATION**
  - GROUND-WATER TRAVEL TIME
  - SUBSTANTIALLY COMPLETE CONTAINMENT
  - ANTICIPATED PROCESS AND EVENTS
  - DISTURBED ZONE EXTENT

PERFORMANCE ASSESSMENT TARGETS



MAJOR PHASES OF THE OCRWM PERFORMANCE ASSESMENT PROGRAM

12/88 10/89 10/90 10/91 10/92 10/93 1/95

..Complete SCP

.....DEIS Assessments

.....Complete PA Work Plans

.....Write DEIS.....Complete DEIS

.....Sensitivity Studies.....

.....SAR Assessments.....

.....Benchmarking.....

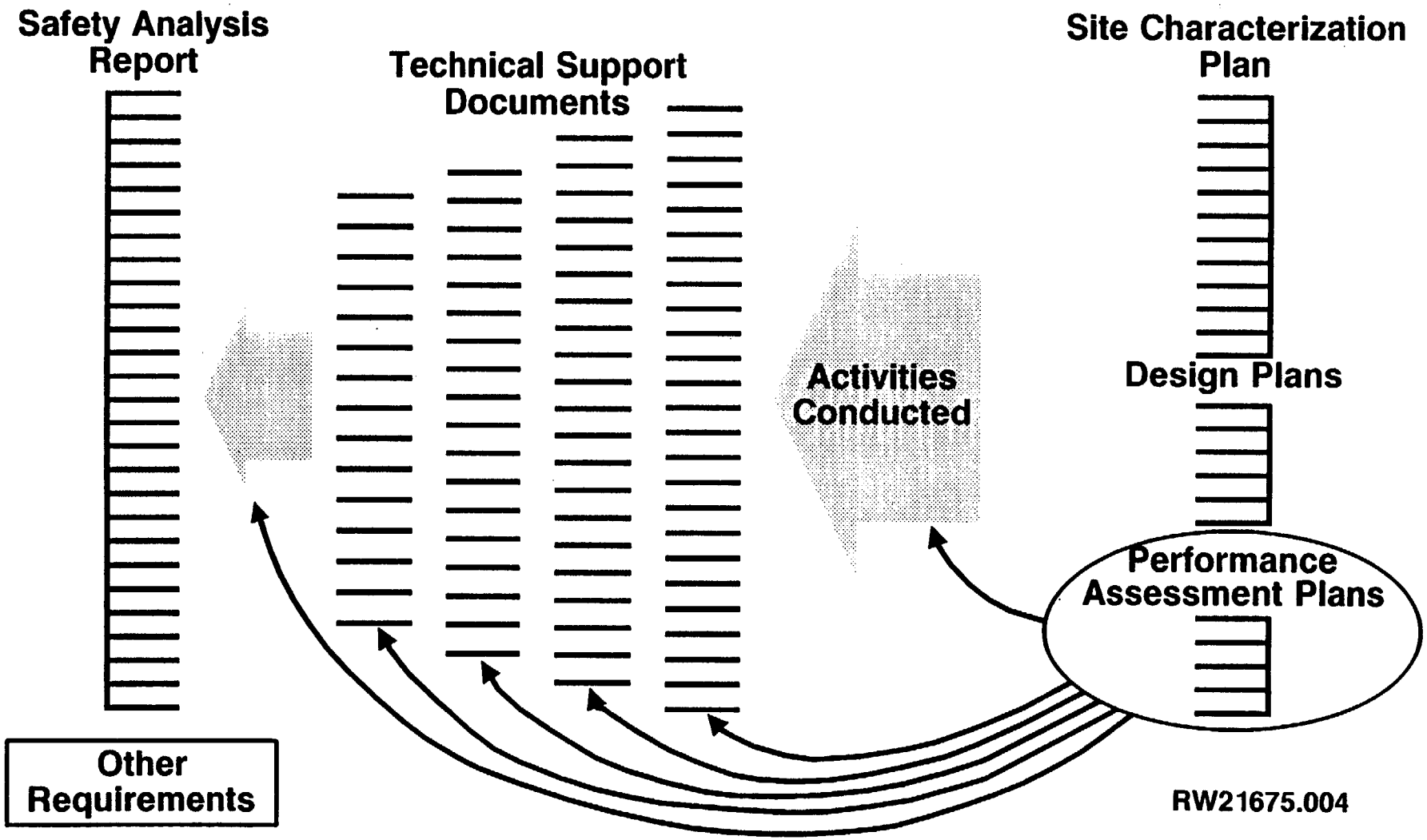
.....Write SAR.....Complete SAR

.....Verification/Validation.....

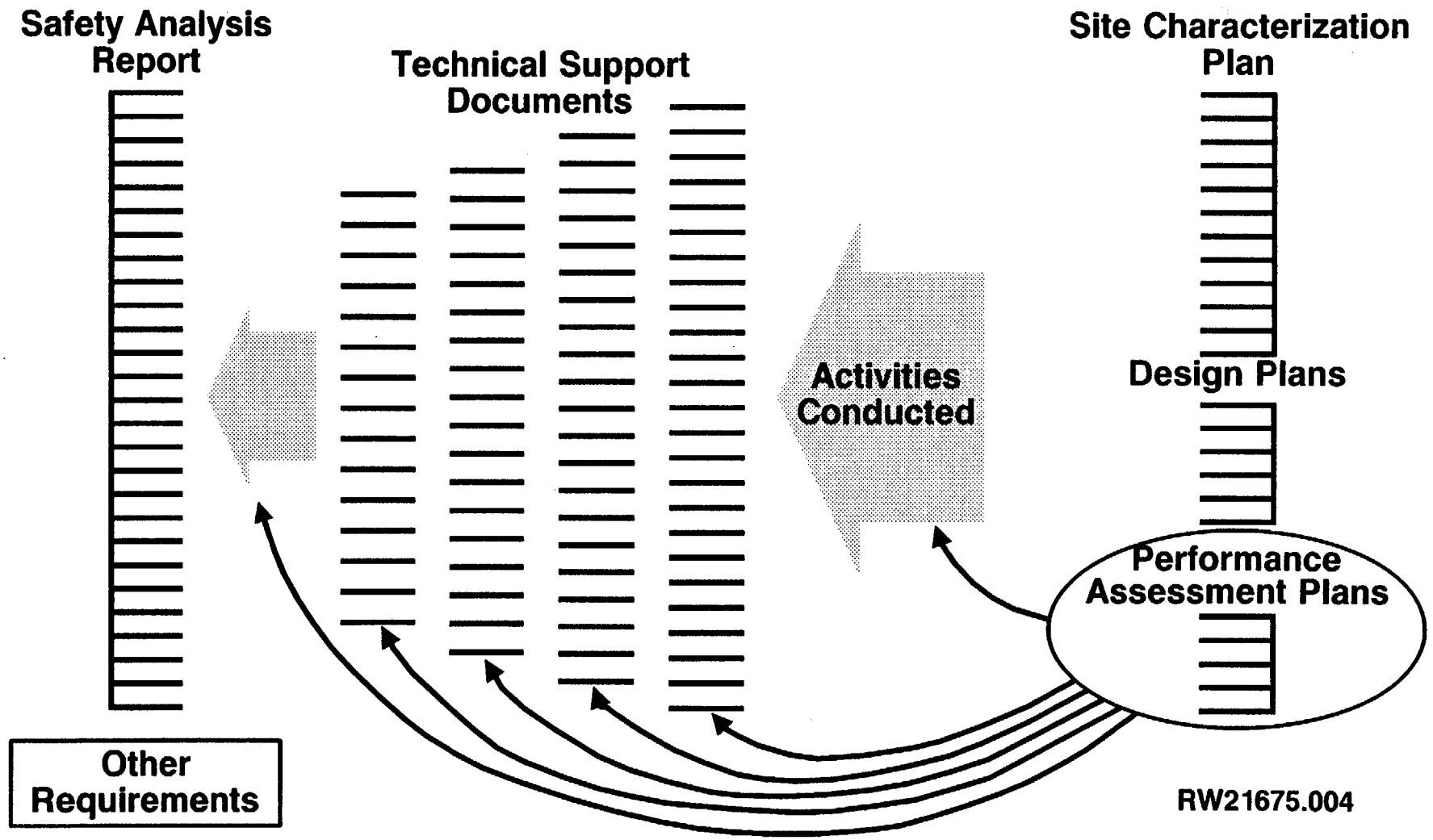
.....Code Selection.....

.....Code Documentation.....

PERFORMANCE ASSESSMENT CYCLES

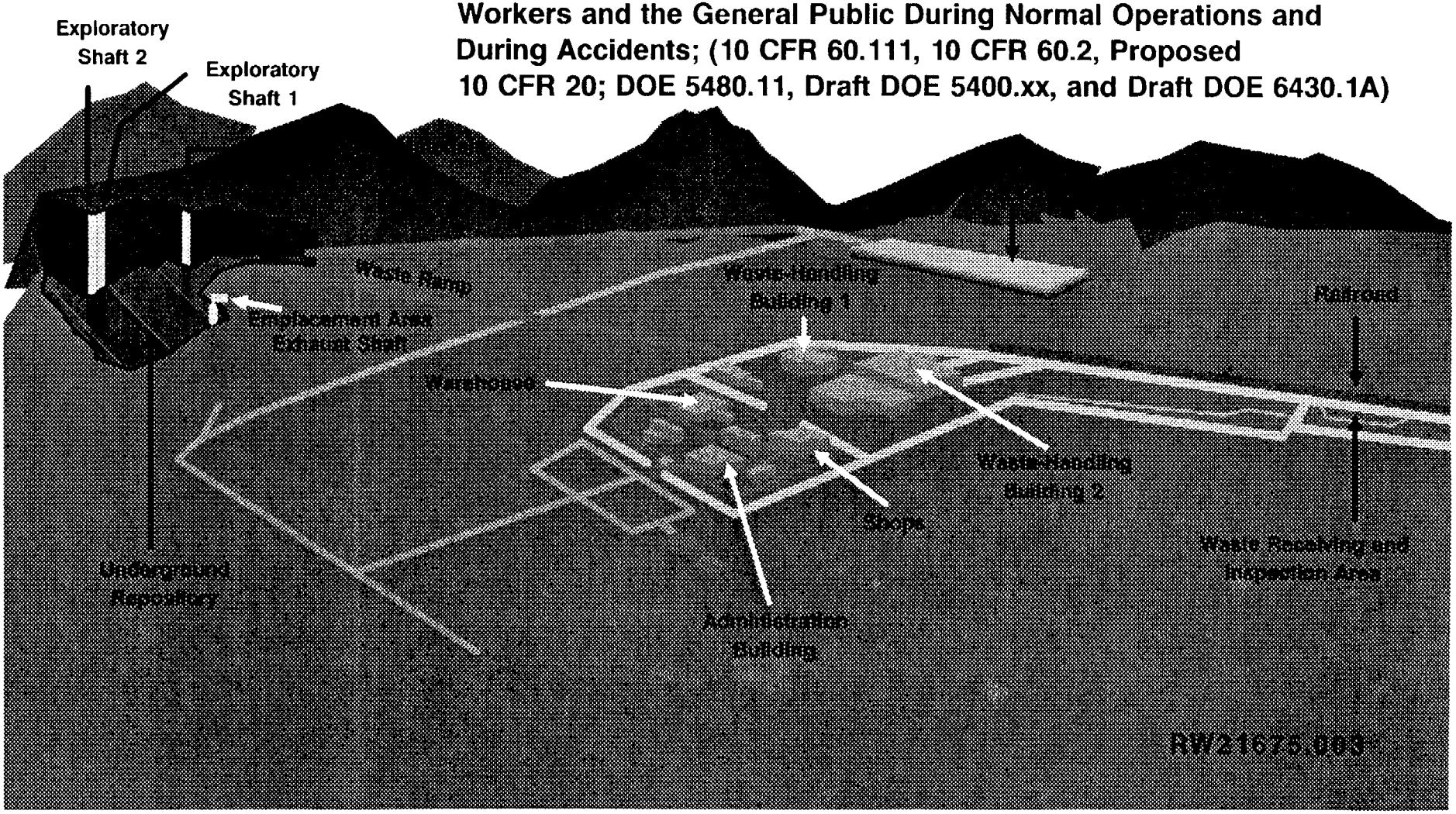


PERFORMANCE ASSESSMENT CYCLES

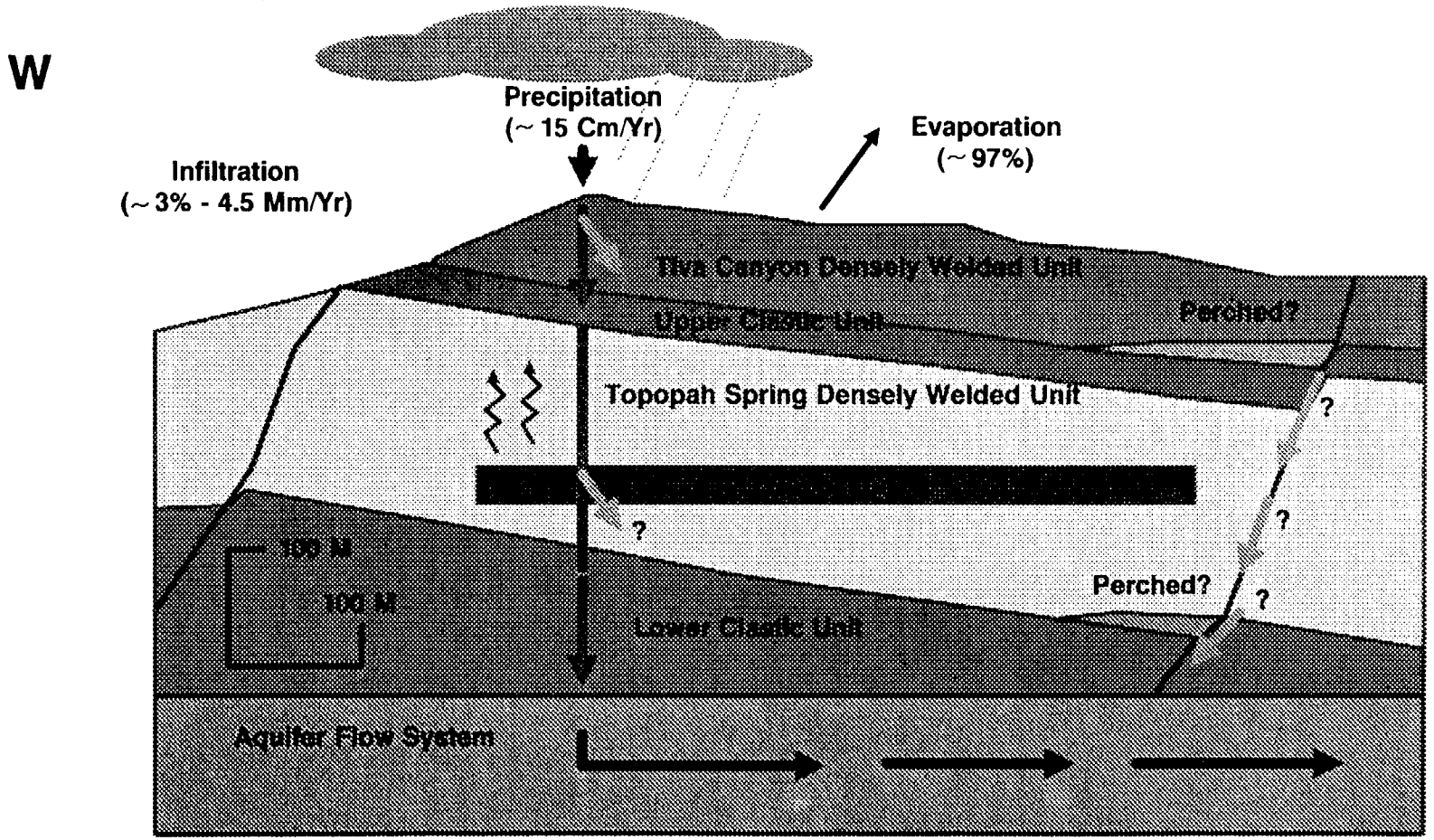


PRECLOSURE REQUIREMENTS

Both the DOE and the NRC Require Radiation Protection for Workers and the General Public During Normal Operations and During Accidents; (10 CFR 60.111, 10 CFR 60.2, Proposed 10 CFR 20; DOE 5480.11, Draft DOE 5400.xx, and Draft DOE 6430.1A)

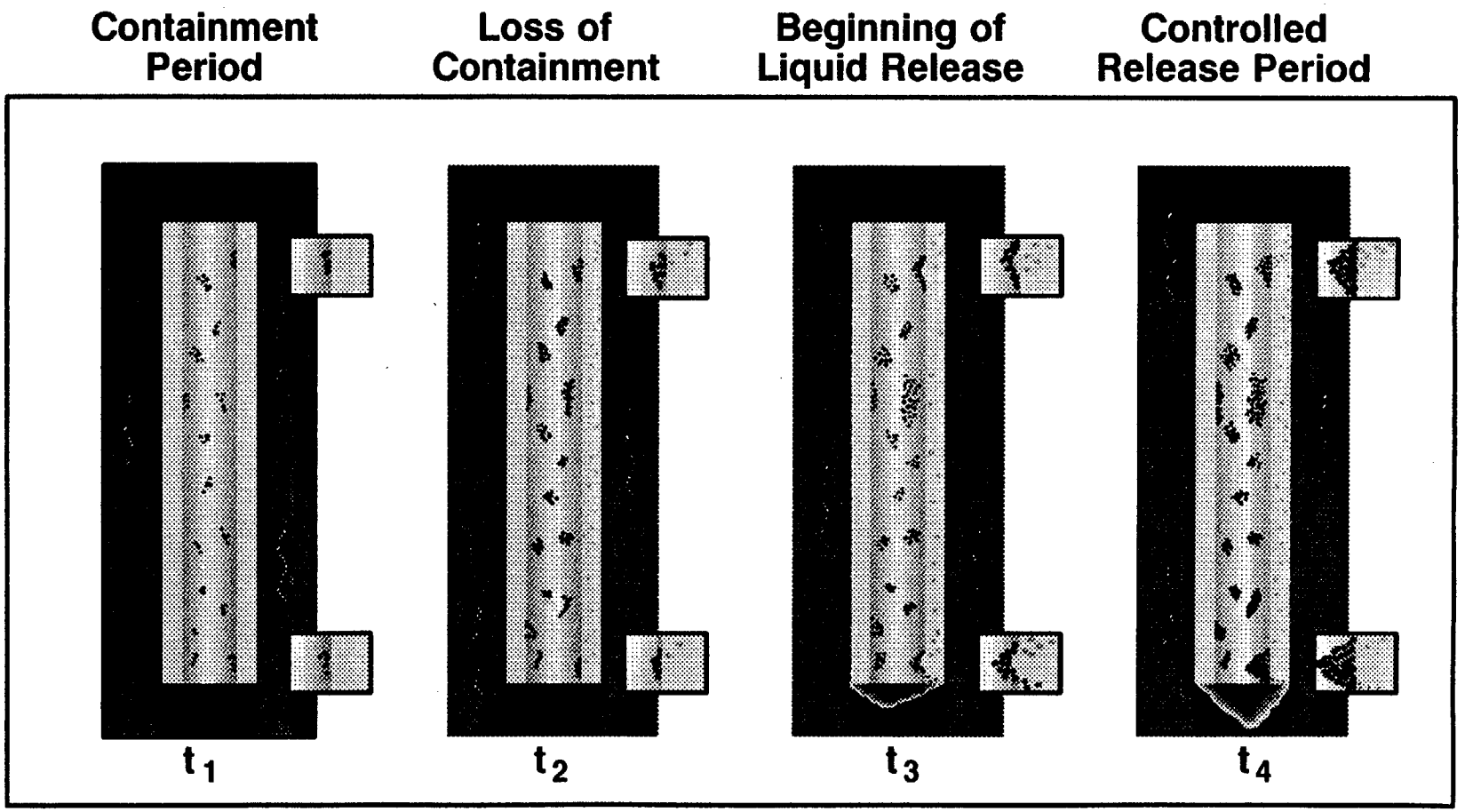


UNSATURATED-ZONE SECTION
YUCCA MOUNTAIN



RW21675.002

SCHEMATIC OF CONTAINER FUNCTIONS



RW21675.006

NUCLEAR REGULATORY COMMISSION
10 CFR 60

Overall System Performance Objective

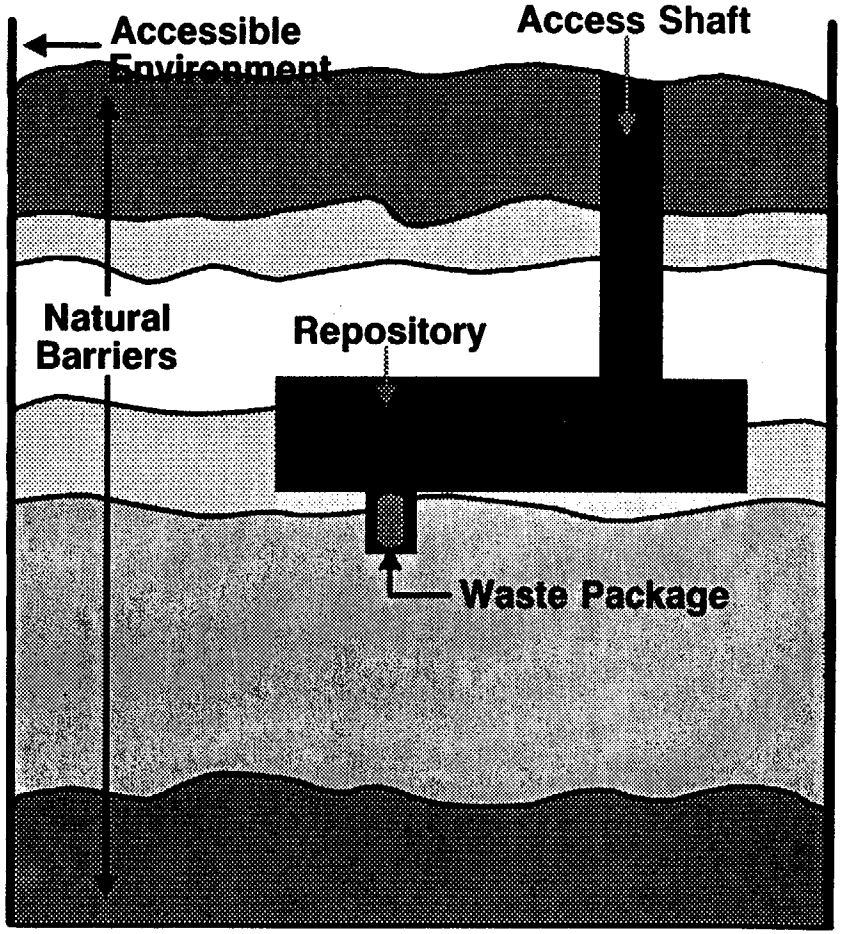
- Conformance with EPA Standard

Subsystem Performance Requirements

- Waste Package Lifetime
- Annual Radionuclide Release Rate
- Pre-Emplacement Ground-Water Travel Time

Siting Criteria

- Favorable Conditions
- Potentially Adverse Conditions



RW42387T.015

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

PRESENTATION TO THE NUCLEAR WASTE TECHNICAL REVIEW BOARD

SUBJECT: FLOWDOWN OF REGULATORY REQUIREMENTS TO THE PERFORMANCE ASSESSMENT PROGRAM

PRESENTER: DR. LARRY D. RICKERTSEN

PRESENTER'S TITLE AND ORGANIZATION: MANAGER, ISSUES RESOLUTION SECTION
WESTON TECHNICAL SUPPORT TEAM
OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT

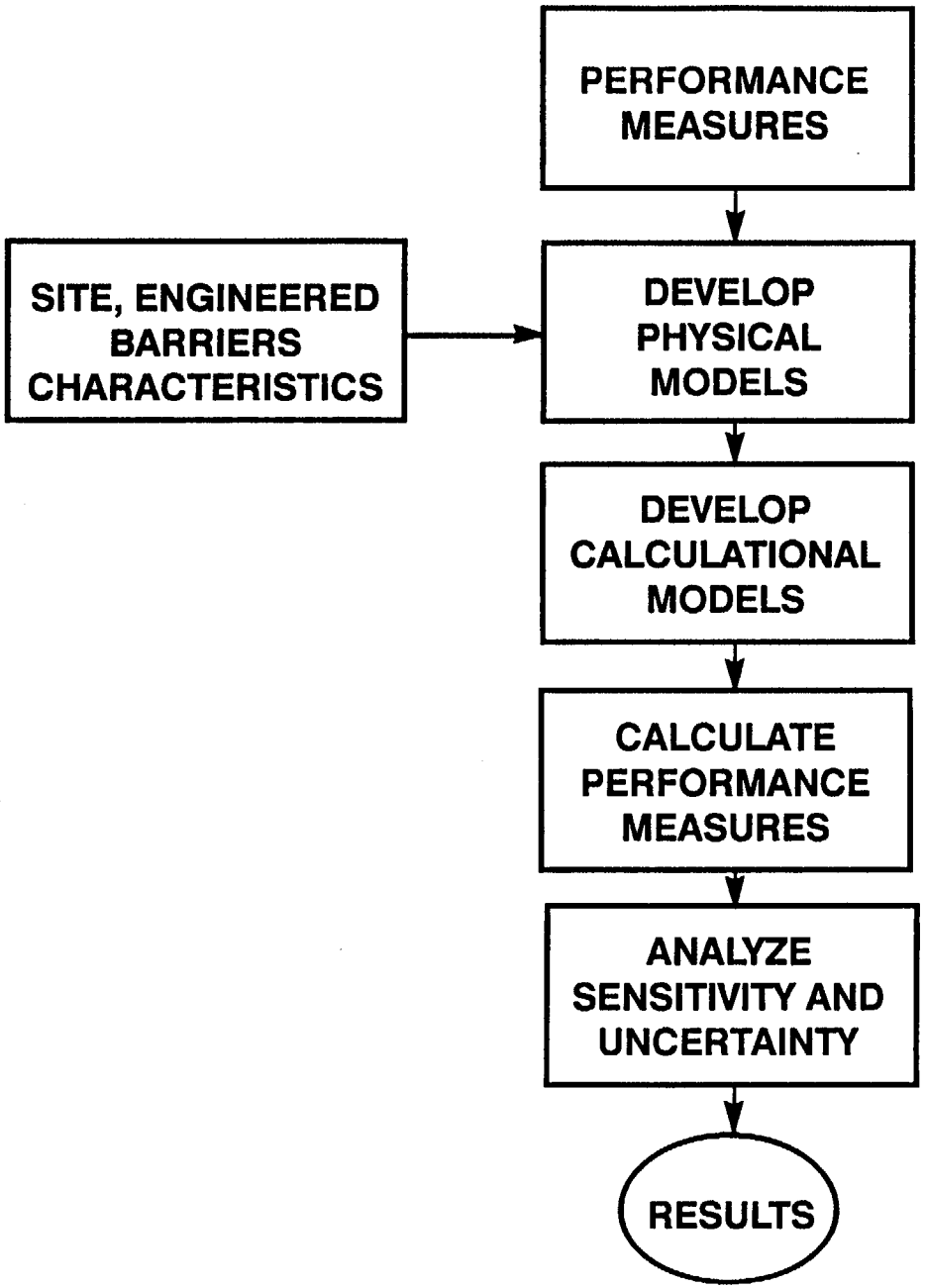
PRESENTER'S TELEPHONE NUMBER: (202) 646-6760

MAY 16-17, 1989

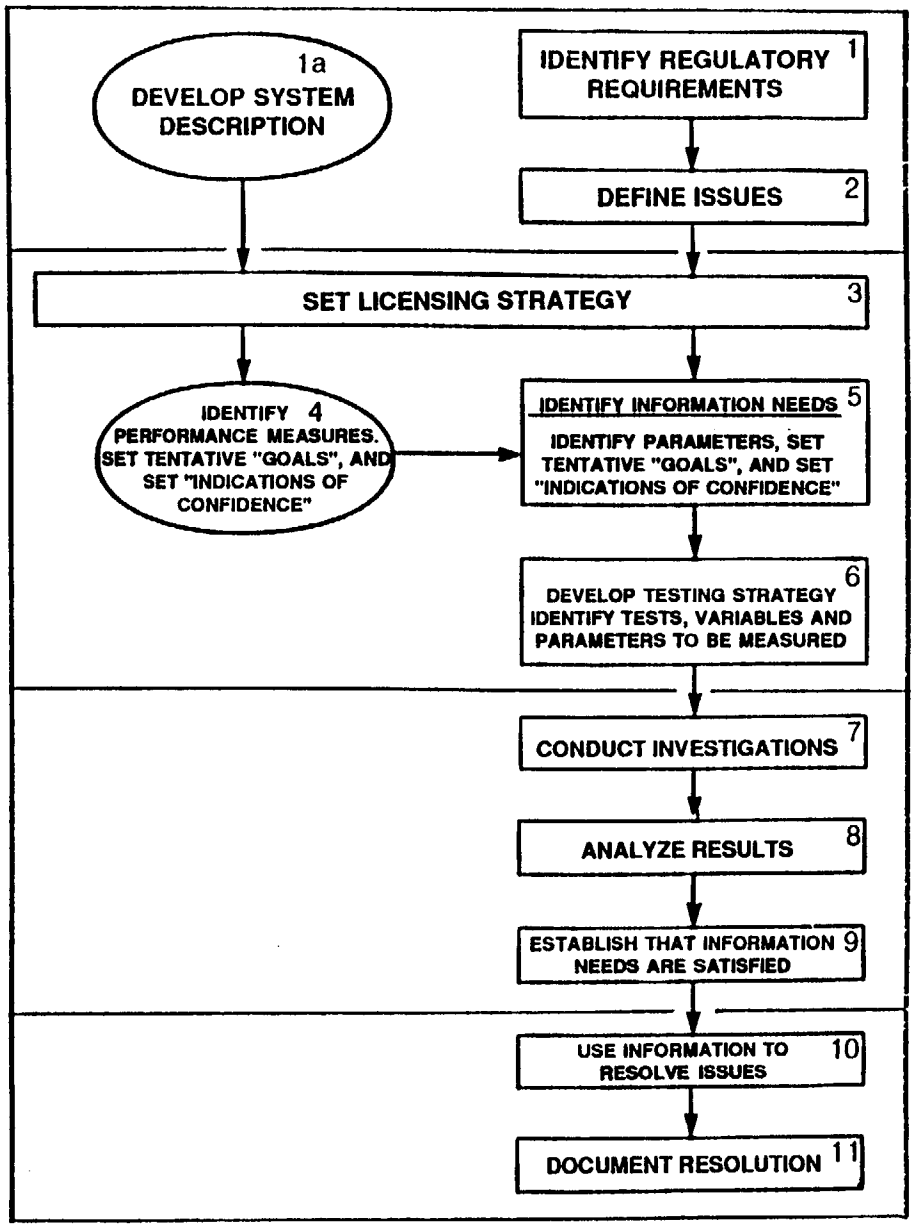
SCOPE OF PRESENTATION

- RELATION OF PERFORMANCE ASSESSMENT STRATEGY TO ISSUES RESOLUTION STRATEGY
- MEASURES OF PERFORMANCE TO BE EVALUATED
- ELEMENTS OF THE PERFORMANCE ASSESSMENT STRATEGY THAT FOLLOWS FROM THE PERFORMANCE OBJECTIVES OF 10 CFR PART 60

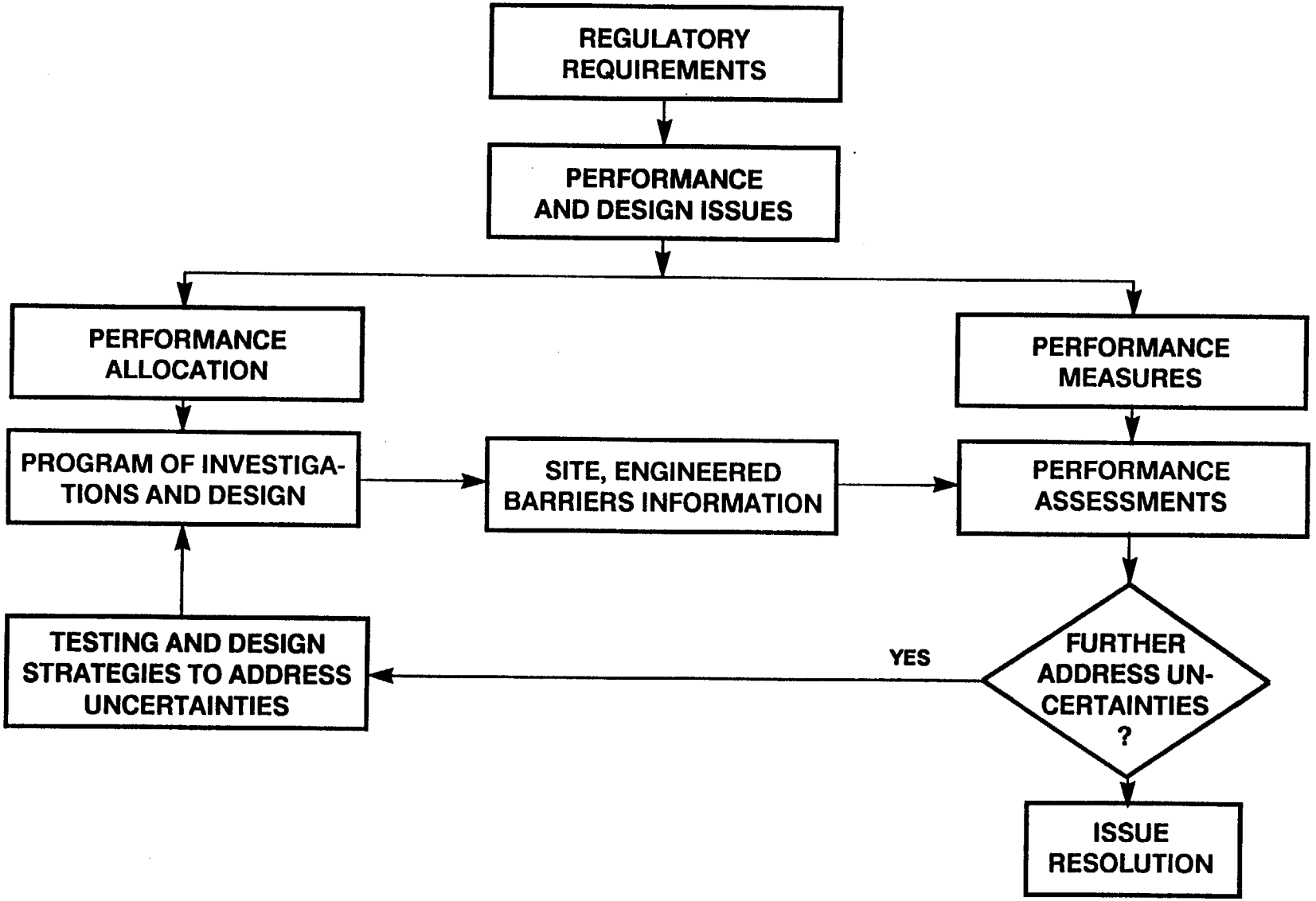
PERFORMANCE ASSESSMENT PROCESS



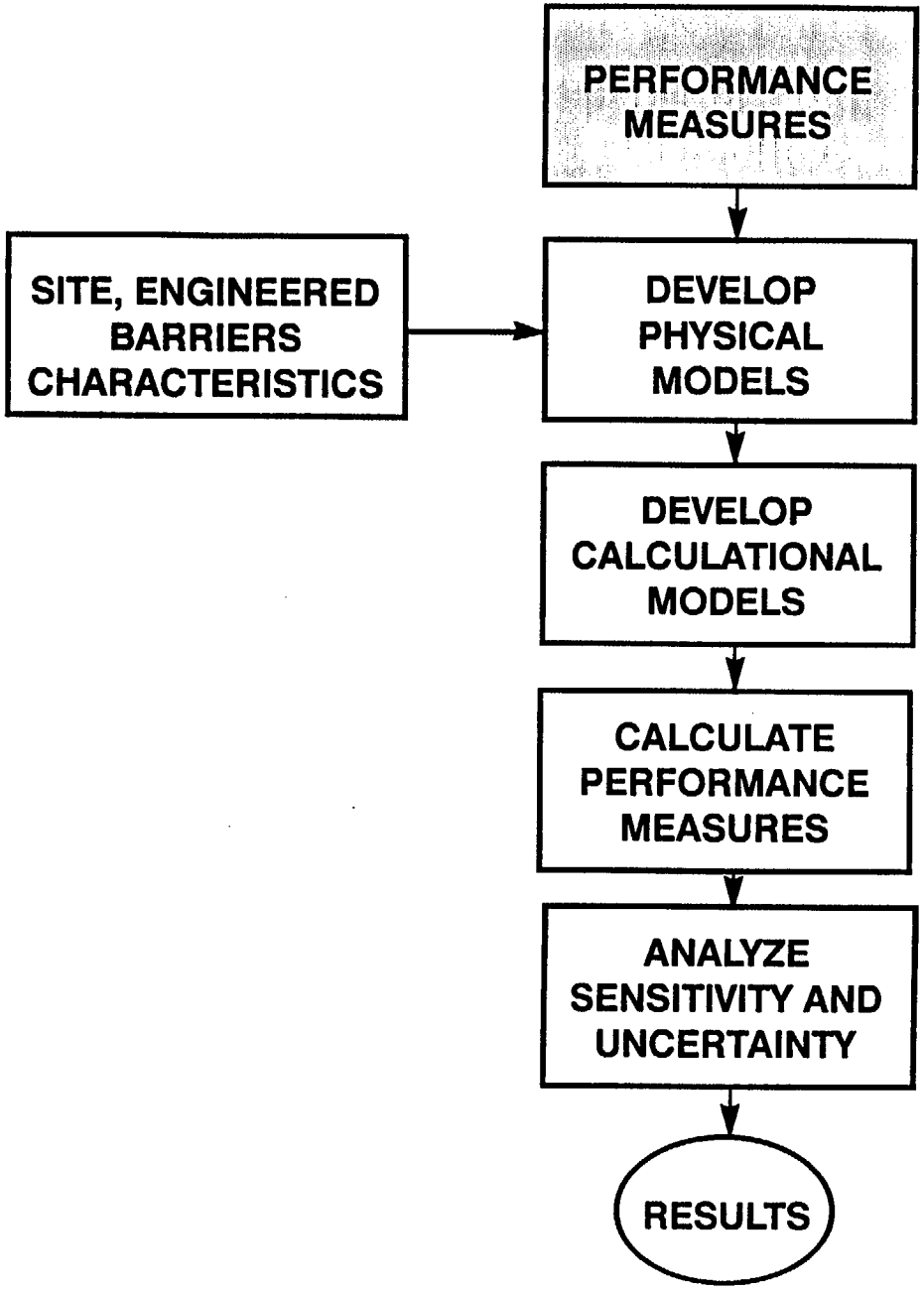
ISSUE RESOLUTION STRATEGY



FLOWDOWN OF REGULATORY REQUIREMENTS TO SITE INVESTIGATIONS, DESIGN, AND PERFORMANCE ASSESSMENT



PERFORMANCE ASSESSMENT PROCESS



PERFORMANCE ASSESSMENT OBJECTIVES DEFINE PERFORMANCE MEASURES

- EVALUATE SYSTEM AND SUBSYSTEM PERFORMANCE TO DEMONSTRATE COMPLIANCE WITH THE TECHNICAL CRITIERIA OF 10 CFR PART 60 FOR THE LICENSE APPLICATION
- EVALUATE ENVIRONMENTAL IMPACTS FOR THE ENVIRONMENTAL IMPACT STATEMENT
- ASSESS SENSITIVITIES AND UNCERTAINTIES IN THE PERFORMANCE ASSESSMENT
- GUIDE DESIGN AND TESTING ACTIVITIES

REQUIREMENTS FOR PRECLOSURE RADIOLOGICAL SAFETY 10 CFR 60.111

DOSES TO REPOSITORY WORKERS AND MEMBERS OF THE GENERAL PUBLIC FROM ROUTINE OPERATIONS MUST MEET CRITERIA SPECIFIED IN 10 CFR PART 20 AND 40 CFR PART 191, SUBPART A

NO CRITERIA FOR DOSES FROM ACCIDENTS BUT CRITERION FOR SYSTEMS, COMPONENTS AND STRUCTURES IMPORTANT TO SAFETY

REQUIREMENTS FOR POSTCLOSURE PERFORMANCE
10 CFR 60.112
40 CFR PART 191, SUBPART B (CURRENTLY IN REMAND)

CONTAINMENT FOR SIGNIFICANT PROCESSES AND EVENTS

PROBABILITY OF 10,000-YEAR CUMULATIVE RELEASE TO ACCESSIBLE ENVIRONMENT SHALL BE LESS THAN ONE CHANCE IN TEN OF EXCEEDING SPECIFIED LIMITS AND LESS THAN ONE CHANCE IN 1000 OF EXCEEDING TEN TIMES THESE LIMITS

INDIVIDUAL PROTECTION FOR UNDISTURBED PERFORMANCE

ANNUAL DOSE TO INDIVIDUALS LESS THAN SPECIFIED LIMITS FOR 1000 YEARS AFTER DISPOSAL

GROUND-WATER PROTECTION FOR UNDISTURBED PERFORMANCE

CONCENTRATIONS IN SPECIAL SOURCES OF GROUND WATER LESS THAN SPECIFIED LIMITS FOR 1000 YEARS AFTER DISPOSAL

REQUIREMENTS FOR NATURAL AND ENGINEERED BARIERS 10 CFR 60.113

CONTAINMENT OF HLW WITHIN WASTE PACKAGES WILL BE SUBSTANTIALLY COMPLETE FOR A PERIOD BETWEEN 300 AND 1000 YEARS AFTER PERMANENT CLOSURE FOR ANTICIPATED PROCESSES AND EVENTS

ANNUAL RELEASE OF ANY RADIONUCLIDE FROM THE EBS FOR ANTICIPATED PROCESSES AND EVENTS SHALL BE LESS THAN SPECIFIED LIMIT

PRE-WASTE-EMPLACEMENT GROUND-WATER TRAVEL TIME ALONG FASTEST PATH OF LIKELY RADIONUCLIDE TRAVEL FROM DISTURBED ZONE TO ACCESSIBLE ENVIRONMENT SHALL BE AT LEAST 1000 YEARS

REQUIREMENTS FOR FAVORABLE AND POTENTIALLY ADVERSE CONDITIONS 10 CFR 60.122

MUST EVALUATE EFFECT ON WASTE ISOLATION OF POTENTIALLY ADVERSE CONDITIONS THAT MAY BE PRESENT:

(1) POTENTIAL FOR FLOODING OF UNDERGROUND FACILITY
(2) FORESEEABLE HUMAN ACTIVITY THAT COULD AFFECT GROUND-WATER FLOW SYSTEM
(3) LARGE SURFACE WATER IMPOUNDMENTS THAT MAY BE ADVERSE
(4) STRUCTURAL DEFORMATION THAT MAY AFFECT REGIONAL GROUND-WATER SYSTEM
(5) CHANGES TO HYDROLOGIC CONDITIONS THAT COULD AFFECT RADIONUCLIDE MIGRATION
(6) CHANGES TO HYDROLOGIC CONDITIONS THAT COULD AFFECT EBS
(7) GEOCHEMICAL PROCESSES THAT COULD ADVERSELY AFFECT THE EBS

REQUIREMENTS FOR FAVORABLE AND POTENTIALLY ADVERSE CONDITIONS 10 CFR 60.122

(CONTINUED)

(8) GEOCHEMICAL PROCESSES THAT COULD ADVERSELY AFFECT WASTE ISOLATION

(9) GROUND-WATER CONDITIONS THAT ARE NOT REDUCING

(10) EVIDENCE OF DISSOLUTIONING

(11) STRUCTURAL DEFORMATION DURING QUATERNARY PERIOD

(12) EARTHQUAKES THAT COULD AFFECT THE SITE SIGNIFICANTLY

(13) INDICATION THAT FREQUENCY OR MAGNITUDE OF EARTHQUAKES MAY INCREASE

(14) MORE FREQUENT OCCURRENCE OF EARTHQUAKES AT SITE THAN IN REGION

(15) IGNEOUS ACTIVITY SINCE THE START OF THE QUATERNARY PERIOD

(16) EXTREME EROSION DURING QUATERNARY PERIOD

REQUIREMENTS FOR FAVORABLE AND POTENTIALLY ADVERSE CONDITIONS 10 CFR 60.122

(CONTINUED)

(17) PRESENCE OF NATURAL RESOURCES

(18) SUBSURFACE MINING AT THE SITE

(19) DRILLING AT THE SITE

(20) ROCK OR GROUND-WATER CONDITIONS REQUIRING COMPLEX ENGINEERING

(21) GEOCHEMICAL CONDITIONS THAT DO NOT PERMIT STABLE OPENINGS

(22) POTENTIAL FOR WATER TABLE RISE TO SATURATE THE UNDERGROUND FACILITY

(23) PERCHED WATER BODIES THAT MAY BE ADVERSE

(24) MOVEMENT OF GASEOUS RADIONUCLIDES THROUGH AIR-FILLED PORE SPACES

DESIGN CRITERIA
10 CFR 60.130-135

GENERAL DESIGN CRITERIA (60.131)

- LIMITS SPECIFIED IN 10 CFR PART 20 (10 CFR 60.111)
- STRUCTURES, SYSTEMS, COMPONENTS IMPORTANT TO SAFETY

ADDITIONAL DESIGN CRITERIA FOR SURFACE FACILITIES (60.132)

- REQUIREMENTS OF 10 CFR 60.111

ADDITIONAL DESIGN CRITERIA FOR THE UNDERGROUND FACILITY (60.133)

- CONTRIBUTE TO WASTE ISOLATION AND CONTAINMENT

DESIGN OF SEALS FOR SHAFTS AND BOREHOLES (60.134)

- DO NOT COMPROMISE ABILITY TO MEET PERFORMANCE OBJECTIVES
- DO NOT CREATE PREFERENTIAL PATHWAY

CRITERIA FOR THE WASTE PACKAGE (60.135)

- DO NOT COMPROMISE ABILITY TO MEET PERFORMANCE OBJECTIVES

ANALYSES REQUIRED FOR ENVIRONMENTAL IMPACT STATEMENT CEQ GUIDELINES

- ANALYSES DEFINED DURING SCOPING
- ENVIRONMENTAL IMPACTS (E.G., DOSE OR HEALTH EFFECTS)
- ANALYSIS OF LONG-TERM PERFORMANCE
- ANALYSIS OF ACCIDENTS AND DISRUPTIONS

SITE SUITABILITY ANALYSIS AND ANALYSES TO SUPPORT DESIGN AND TESTING PROGRAMS

ANALYSES FOCUS ON PERFORMANCE MEASURES OF 10 CFR PART 60

PERFORMANCE MEASURES

PRECLOSURE SAFETY

- DOSES TO WORKERS AND MEMBERS OF PUBLIC FROM ROUTINE OPERATIONS
- DOSES TO MEMBERS OF PUBLIC FROM ACCIDENTS

POSTCLOSURE TOTAL SYSTEM PERFORMANCE

- 10,000-YEAR CUMULATIVE RELEASE TO ACCESSIBLE ENVIRONMENT (CCDF)
- ANNUAL DOSE TO INDIVIDUALS
- CONCENTRATIONS IN SPECIAL SOURCES OF GROUND WATER

ENGINEERED BARRIERS PERFORMANCE

- TIME OF CONTAINMENT OF RADIOACTIVE MATERIAL IN WASTE PACKAGES
- RATE OF RELEASE OF FROM ENGINEERED BARRIER SYSTEM

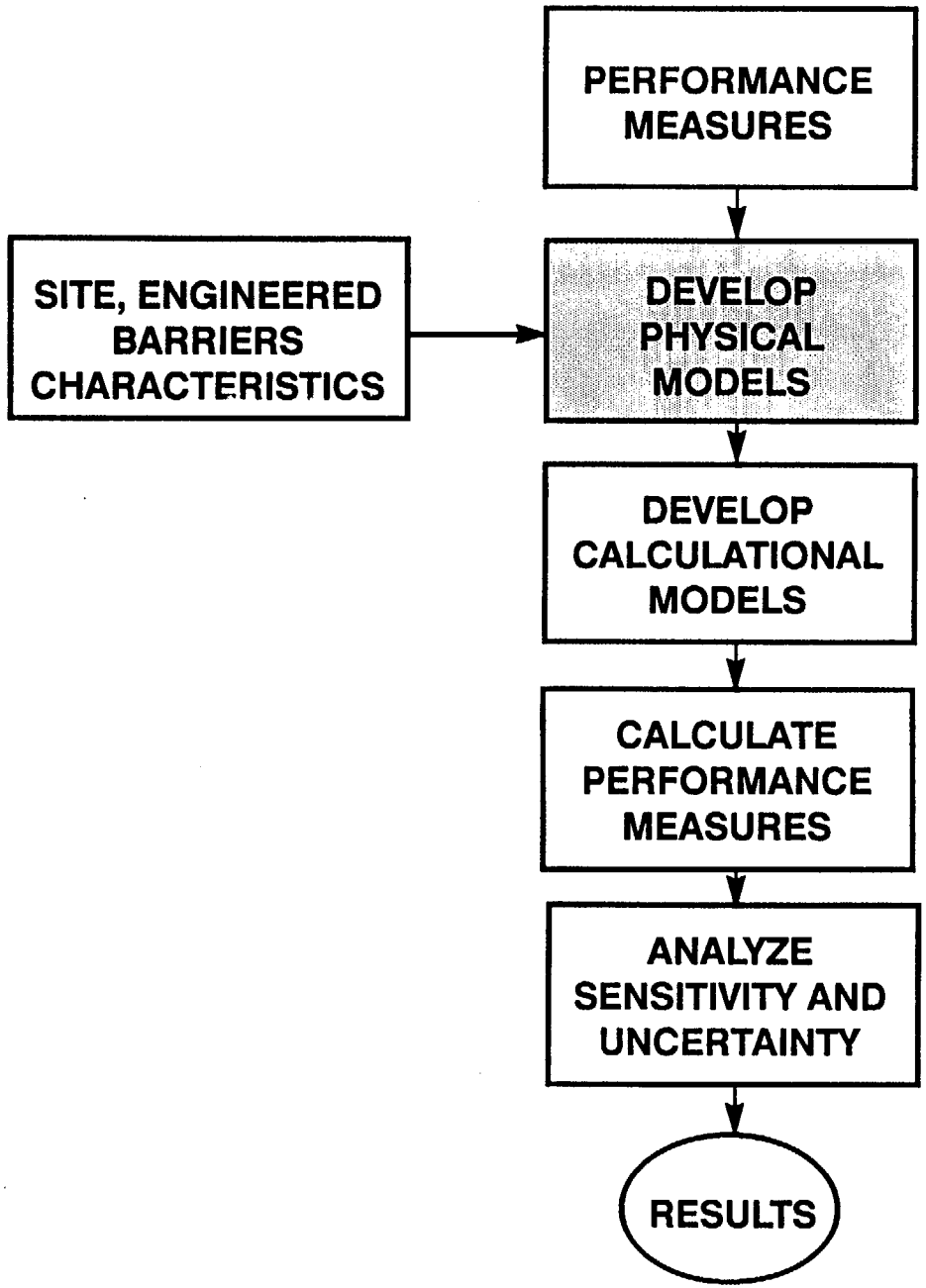
NATURAL BARRIERS PERFORMANCE

- PRE-WASTE-EMPLACEMENT GROUND-WATER TRAVEL TIME ALONG FASTEST PATH OF LIKELY RADIONUCLIDE TRAVEL FROM DISTURBED ZONE TO ACCESSIBLE ENVIRONMENT

OTHER PERFORMANCE MEASURES

- SURROGATE PERFORMANCE MEASURES WHEN DATA ARE INCOMPLETE
- VARIABLES IMPORTANT TO THE PERFORMANCE MEASURES

PERFORMANCE ASSESSMENT PROCESS

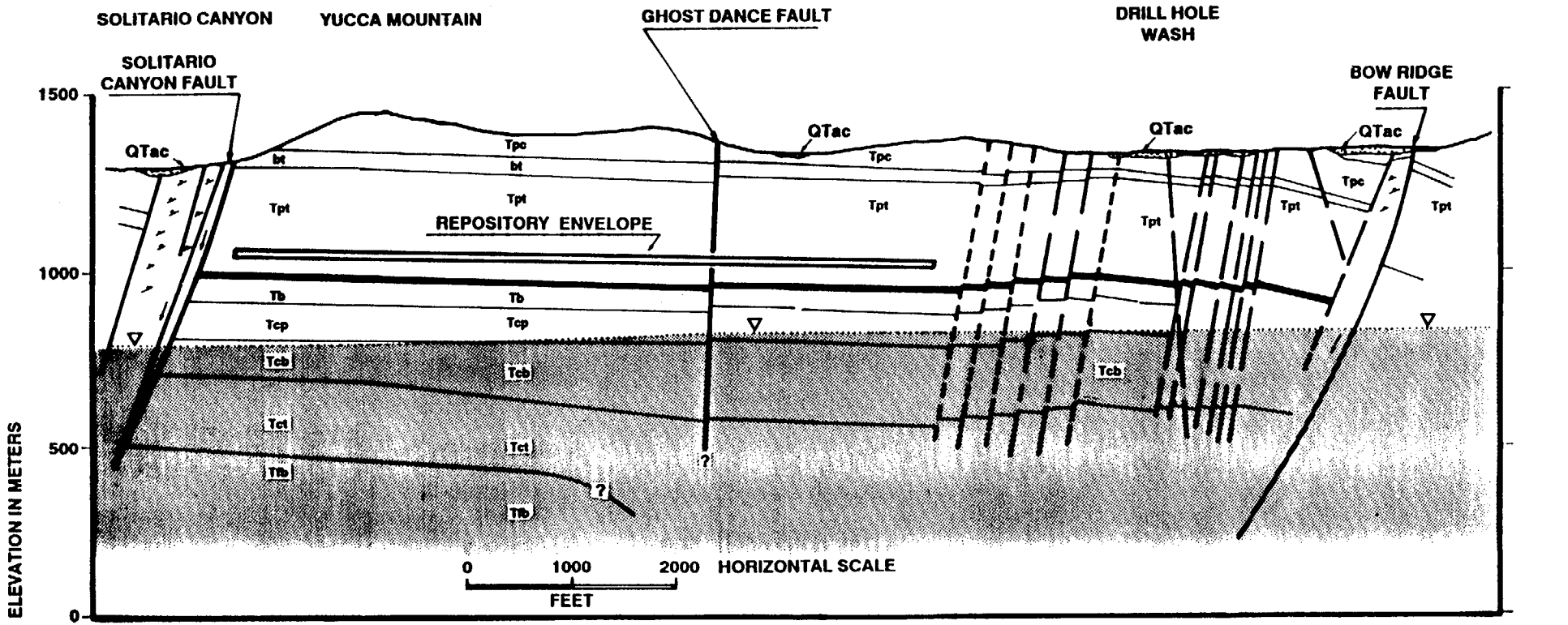


PHYSICAL MODELS

SITE CONCEPTUAL MODELS

SCENARIOS

PROCESS AND CONSTITUTIVE MODELS



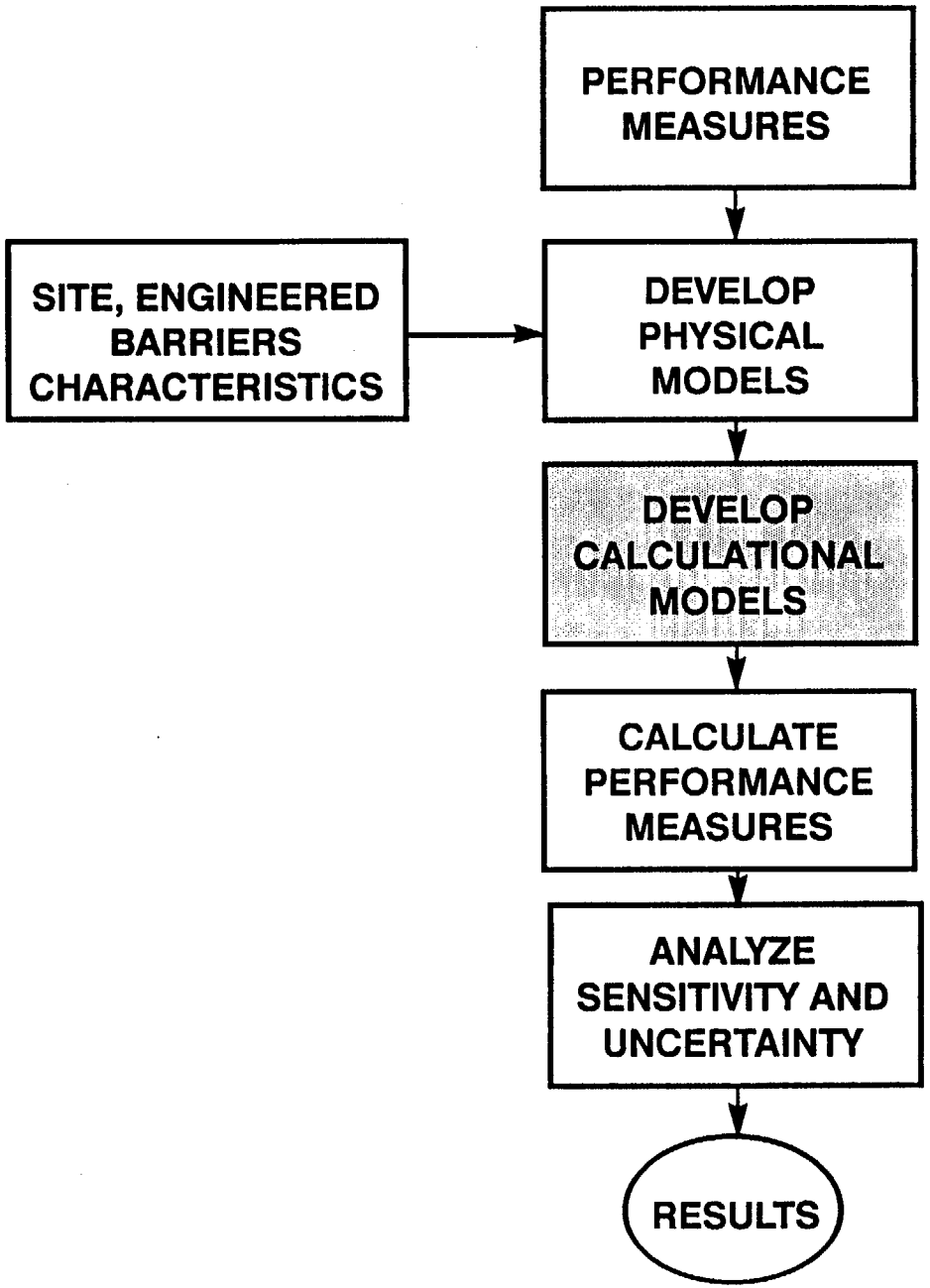
Tpc TIVA CANYON MEMBER
bt BEDDED TUFF
Tpt TOPOPAH SPRING MEMBER
Tb TUFFACEOUS BEDS OF CALICO HILLS
Tcp PROW PASS MEMBER
Tcb BULLFROG MEMBER
Tm TRAM MEMBER
Tfb FLOW BRECCIA
HIGHLY FAULTED AND BRECCIATED ZONE
QTac ALLUVIUM & COLLUVIUM
BASAL VITROPHYRE
? STRATIGRAPHY UNCERTAIN
WATER TABLE
ARROWS SHOW DIRECTION OF RELATIVE DISPLACEMENT

FAULTS WITH MINOR DIP-SLIP DISPLACEMENTS POSITIONS KNOWN OR CONCEALED AT SURFACE

FAULTS WITH MAJOR DIP-SLIP DISPLACEMENTS POSITIONS KNOWN OR CONCEALED AT SURFACE

UNMAPPED & INFERRED FAULTS WITH SMALL DISPLACEMENT

PERFORMANCE ASSESSMENT PROCESS



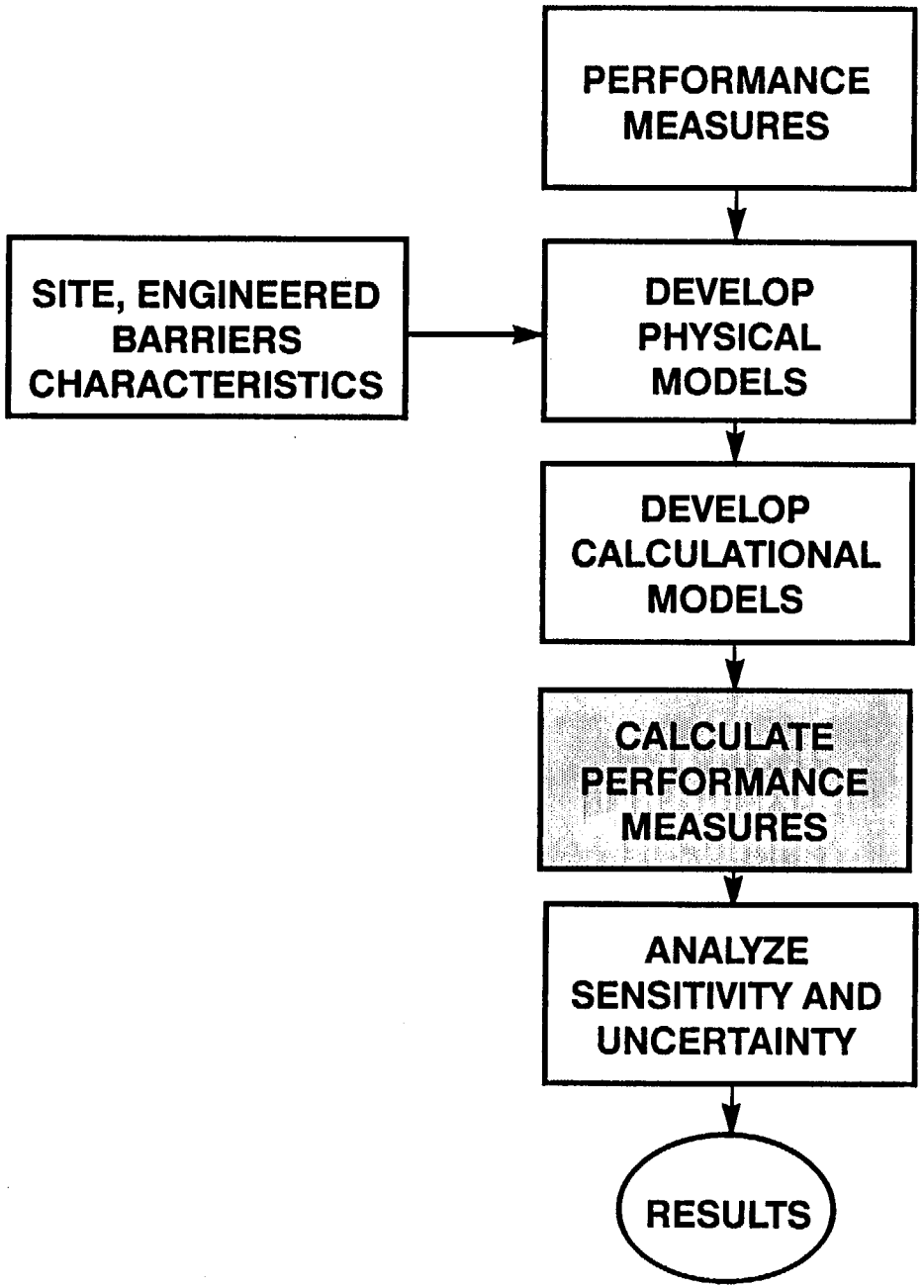
CALCULATIONAL MODELS

LEVEL I SIMPLIFIED SYSTEM AND SUBSYSTEM MODELS

LEVEL II INTEGRATED SYSTEM AND SUBSYSTEM MODELS
(MODELS TO CALCULATE PERFORMANCE MEASURES)

LEVEL III SUBMODELS FOR PROCESSES, COMPONENTS
(E.G., FLOW MODELS, THERMAL MODELS)

PERFORMANCE ASSESSMENT PROCESS



CALCULATIONS OF PERFORMANCE MEASURES

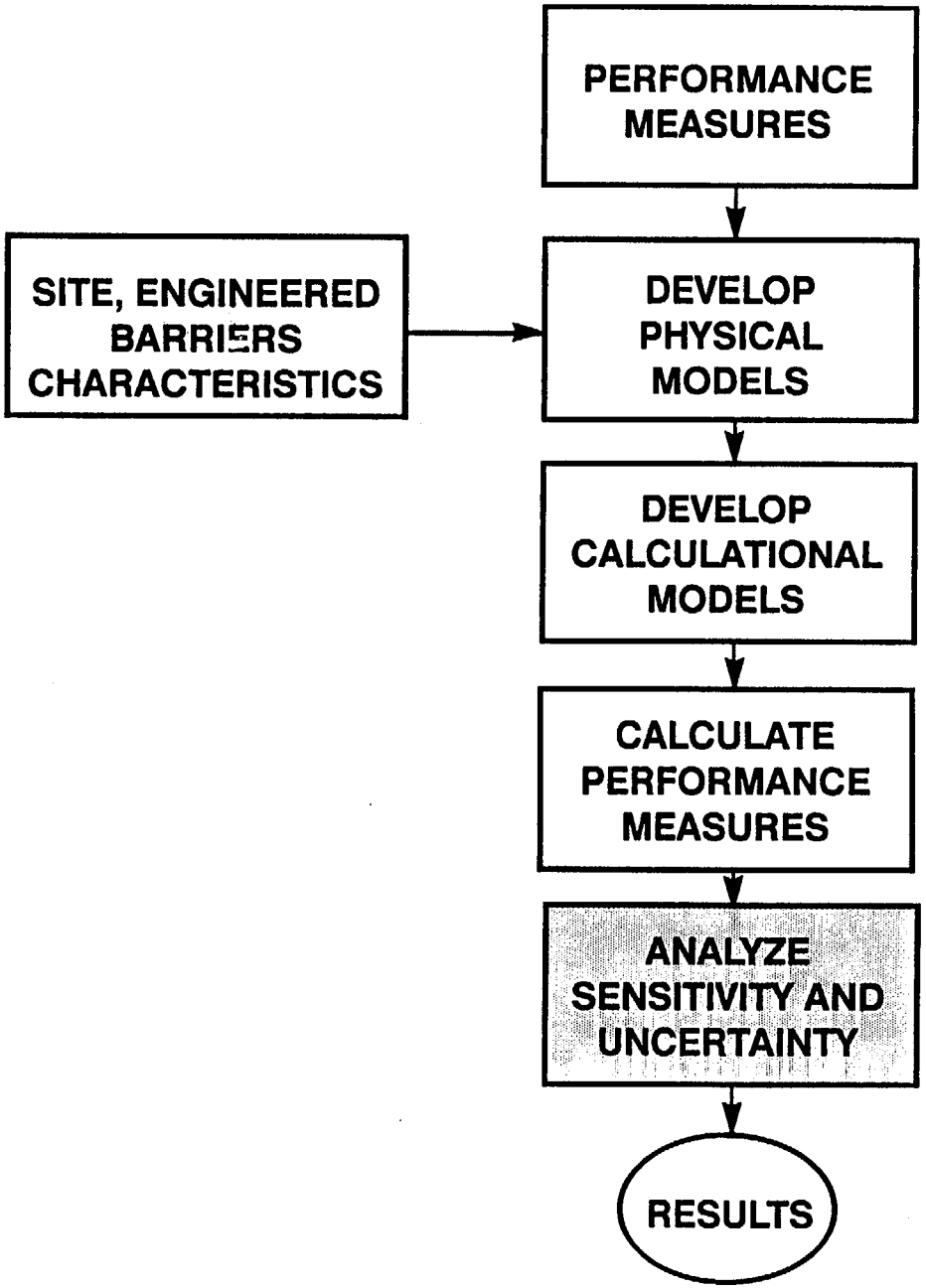
ONLY ONE ASPECT OF PERFORMANCE ASSESSMENT

DETERMINISTIC vs PROBABILISTIC ANALYSIS

CONSERVATIVE ANALYSIS

BOUNDING ANALYSIS

PERFORMANCE ASSESSMENT PROCESS



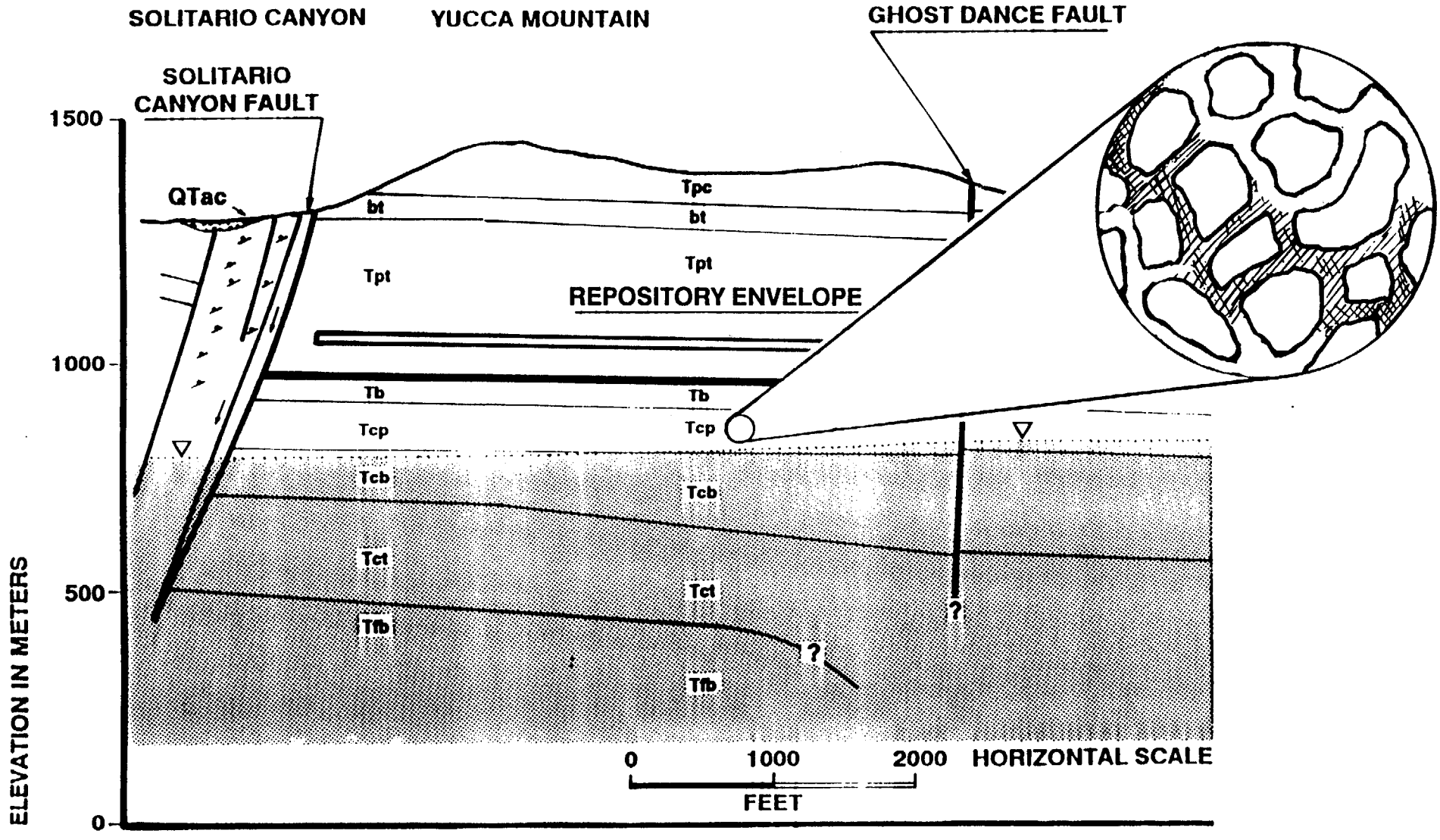
TYPES OF UNCERTAINTIES

UNCERTAINTIES IN PHYSICAL MODELS

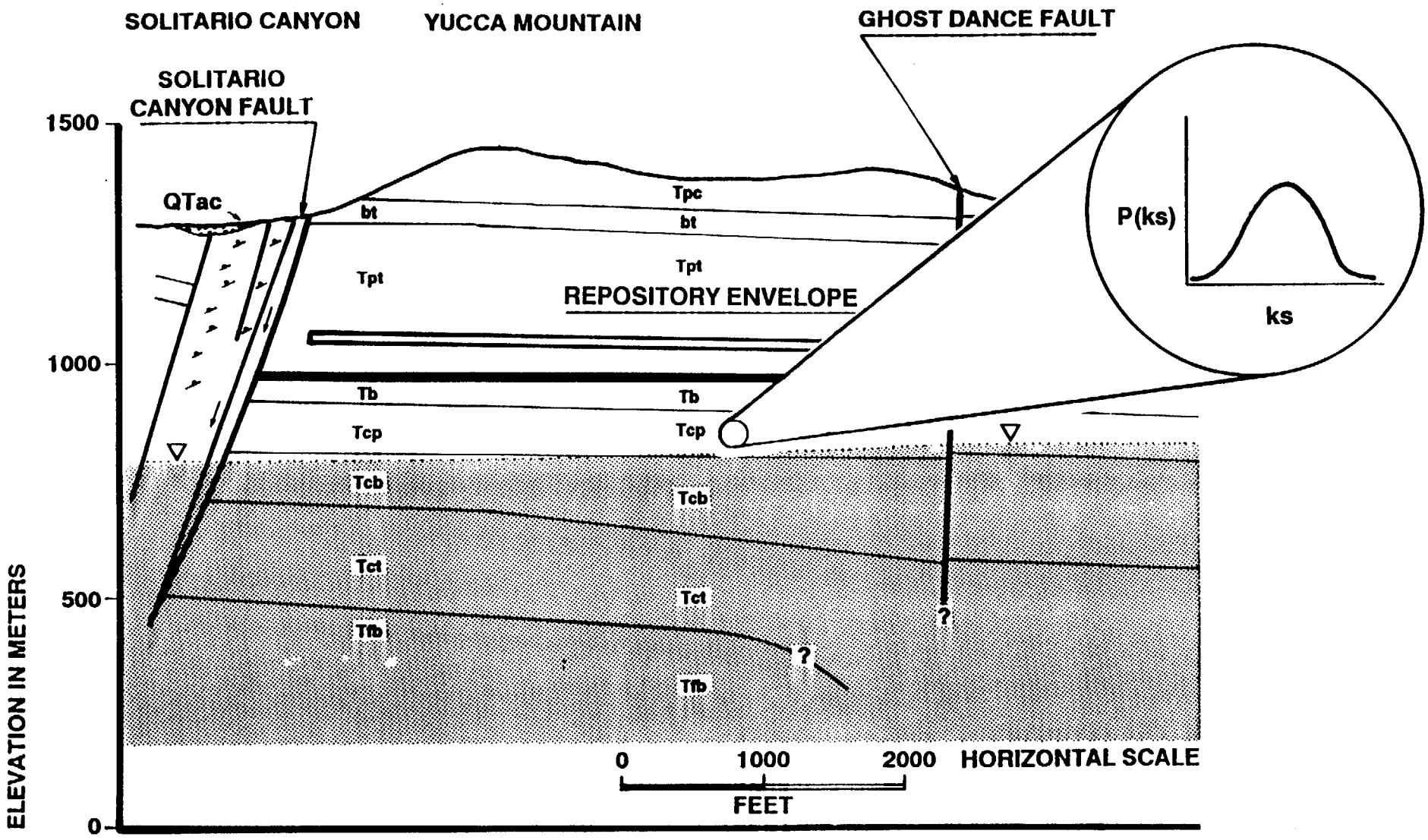
PARAMETER UNCERTAINTY

UNCERTAINTY DUE TO EXTRAPOLATION OF MODELS

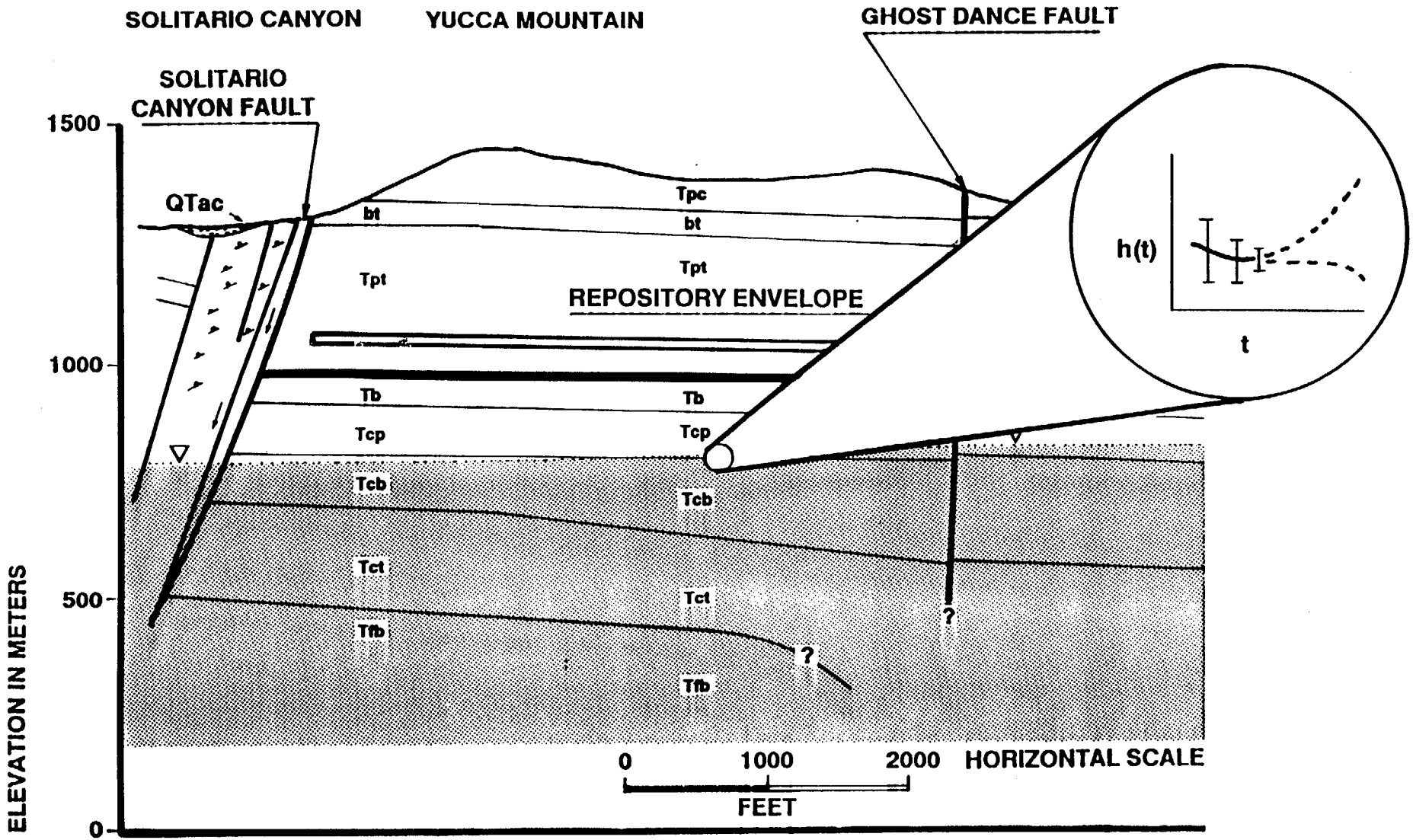
UNCERTAINTIES DUE TO UNANTICIPATED PROCESSES OR EVENTS



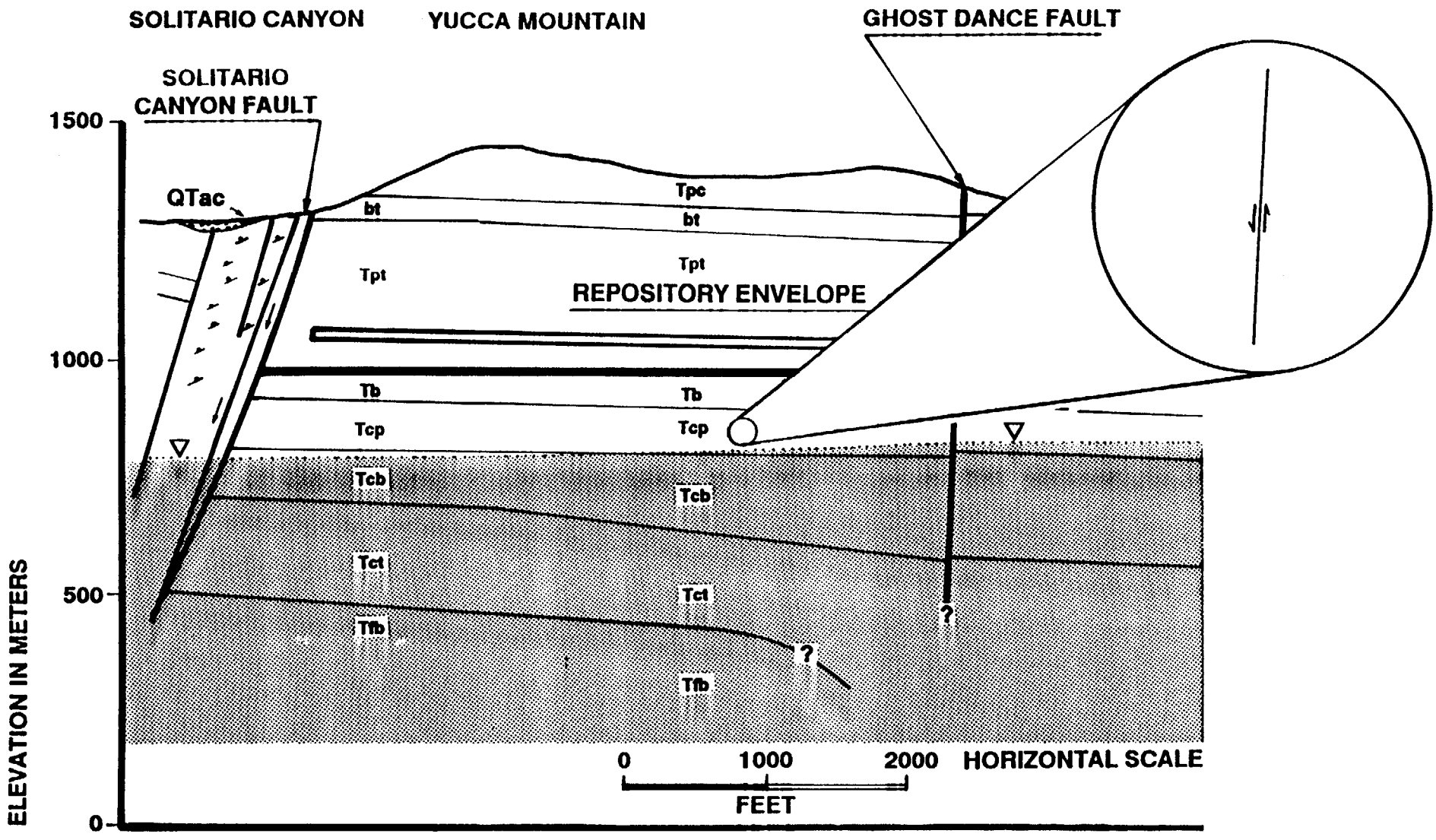
UNCERTAINTY IN MODEL OF FLOW PROCESS



UNCERTAINTY IN PARAMETERS



UNCERTAINTY IN EXTRAPOLATION OF MODELS



UNCERTAINTY DUE TO UNANTICIPATED EVENTS

ADDRESSING UNCERTAINTIES

MODIFY PERFORMANCE ASSESSMENTS TO ADDRESS UNCERTAINTIES

- CONSERVATIVE ANALYSES
- BOUNDING ANALYSES
- SCENARIO ANALYSIS TO ADDRESS UNANTICIPATED PROCESSES AND EVENTS
- SENSITIVITY AND UNCERTAINTY ANALYSIS

ADDITIONAL TESTING TO REDUCE UNCERTAINTIES

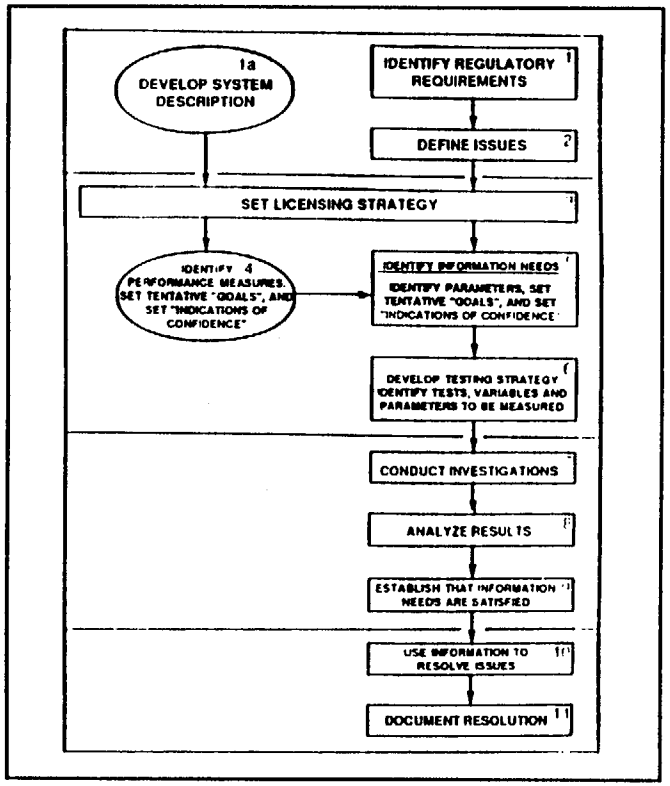
- SITE CHARACTERIZATION AND ENGINEERED BARRIERS TESTING
- MODEL VALIDATION
- PERFORMANCE CONFIRMATION

MODIFY DESIGN TO MITIGATE UNCERTAINTIES

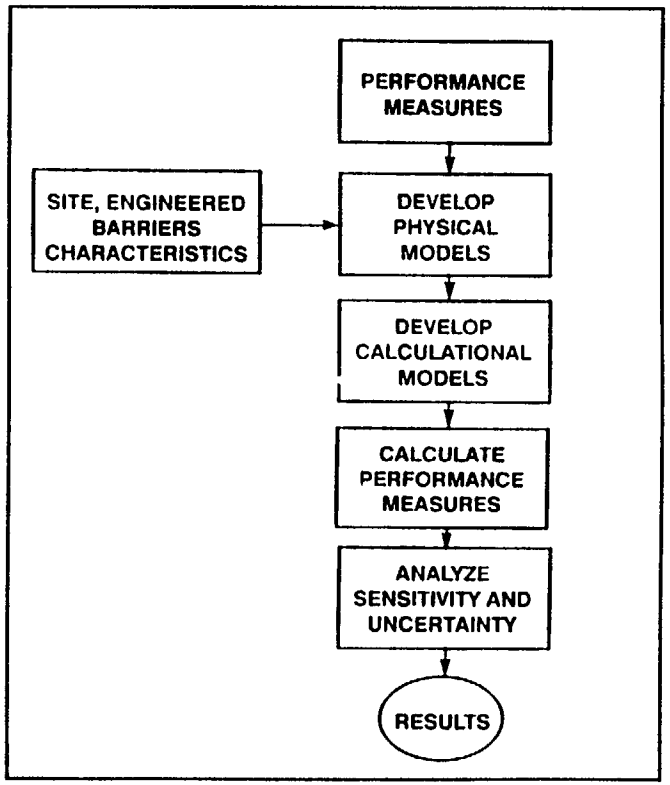
- MULTIPLE BARRIERS
- DESIGN MARGIN

STRATEGY AND IMPLEMENTATION

SITE CHARACTERIZATION PLAN
STUDY PLANS



PERFORMANCE ASSESSMENT
STRATEGY PLAN (PASP)
IMPLEMENTATION PLAN (PAIP)



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

PRESENTATION TO THE NUCLEAR WASTE TECHNICAL REVIEW BOARD

SUBJECT: TECHNICAL INTEGRATION OF PERFORMANCE ASSESSMENT PROGRAM

PRESENTER: DR. PAUL GNIRK

PRESENTER'S TITLE AND ORGANIZATION: PRINCIPAL CONSULTANT
RE/SPEC INC.

PRESENTER'S TELEPHONE NUMBER: (505) 293-2000

MAY 16-17, 1989

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

PRESENTATION TO THE NUCLEAR WASTE TECHNICAL REVIEW BOARD

SUBJECT: TECHNICAL INTEGRATION OF PERFORMANCE ASSESSMENT PROGRAM

PRESENTER: DR. PAUL GNIRK

PRESENTER'S TITLE AND ORGANIZATION: PRINCIPAL CONSULTANT
RE/SPEC INC.

PRESENTER'S TELEPHONE NUMBER: (505) 293-2000

MAY 16-17, 1989

SCOPE

THIS PRESENTATION WILL ADDRESS:

- PURPOSE
- ORGANIZATION
- FUNCTION
- ACTIVITIES IN RELATION TO GENERAL PROGRAM

OF THE PERFORMANCE ASSESSMENT INTEGRATION EFFORT

PURPOSE

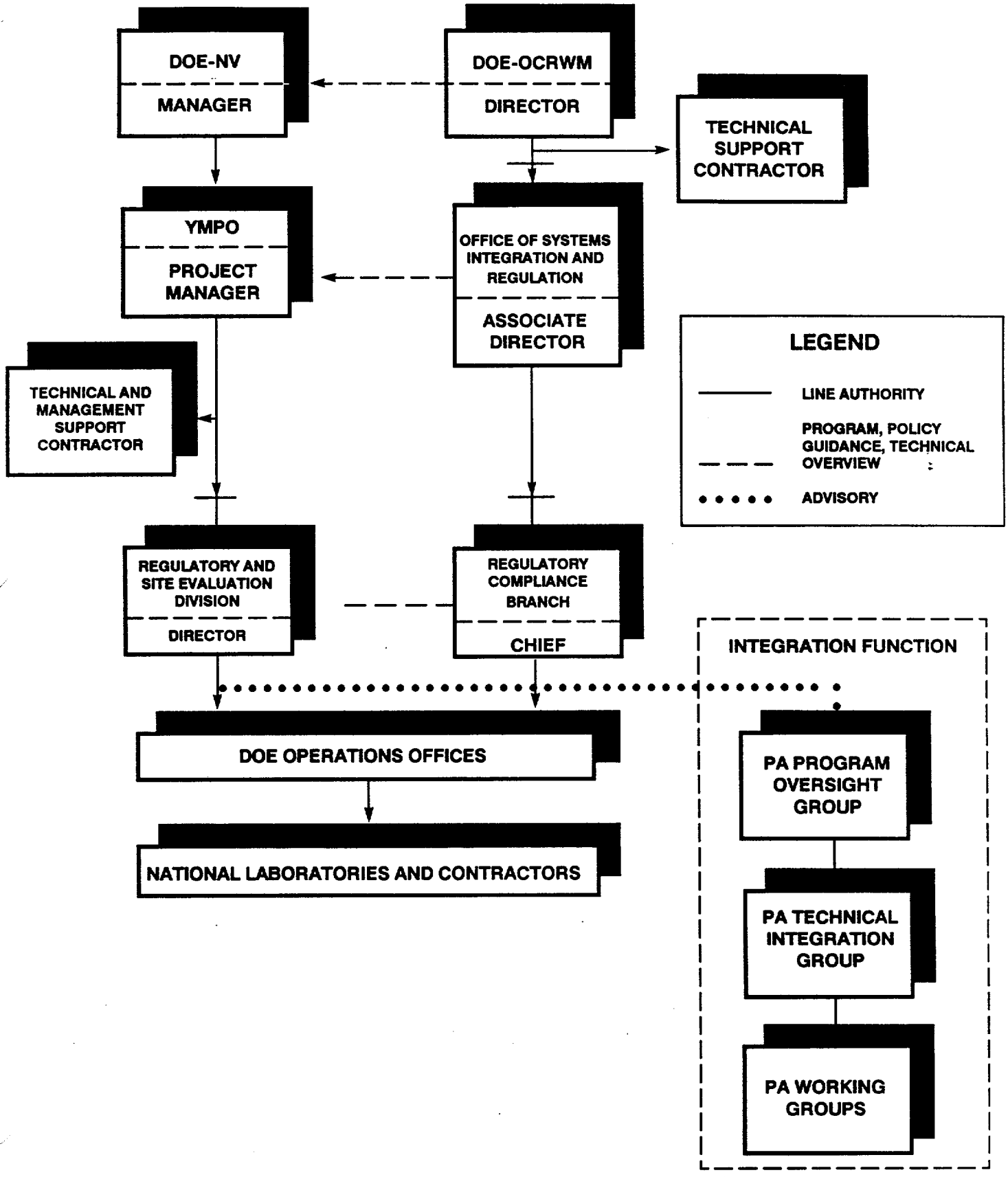
THE PURPOSE OF THE PA INTEGRATION FUNCTION IS TO COORDINATE AND GUIDE THE VARIOUS PERFORMANCE-ASSESSMENT ACTIVITIES UNDERTAKEN BY THE DOE-HQ PARTICIPANTS AND THE DOE-YMP PARTICIPANTS TO ENSURE THAT:

- **THE CAPABILITY (METHODOLOGY, TOOLS, EXPERTISE) WILL EXIST TO CONDUCT THE ASSESSMENTS REQUIRED TO SUPPORT PREPARATION OF THE SAFETY ANALYSIS REPORT (SAR) AND THE ENVIRONMENTAL IMPACT STATEMENT (EIS) WHEN REQUIRED BY THE SCHEDULE**

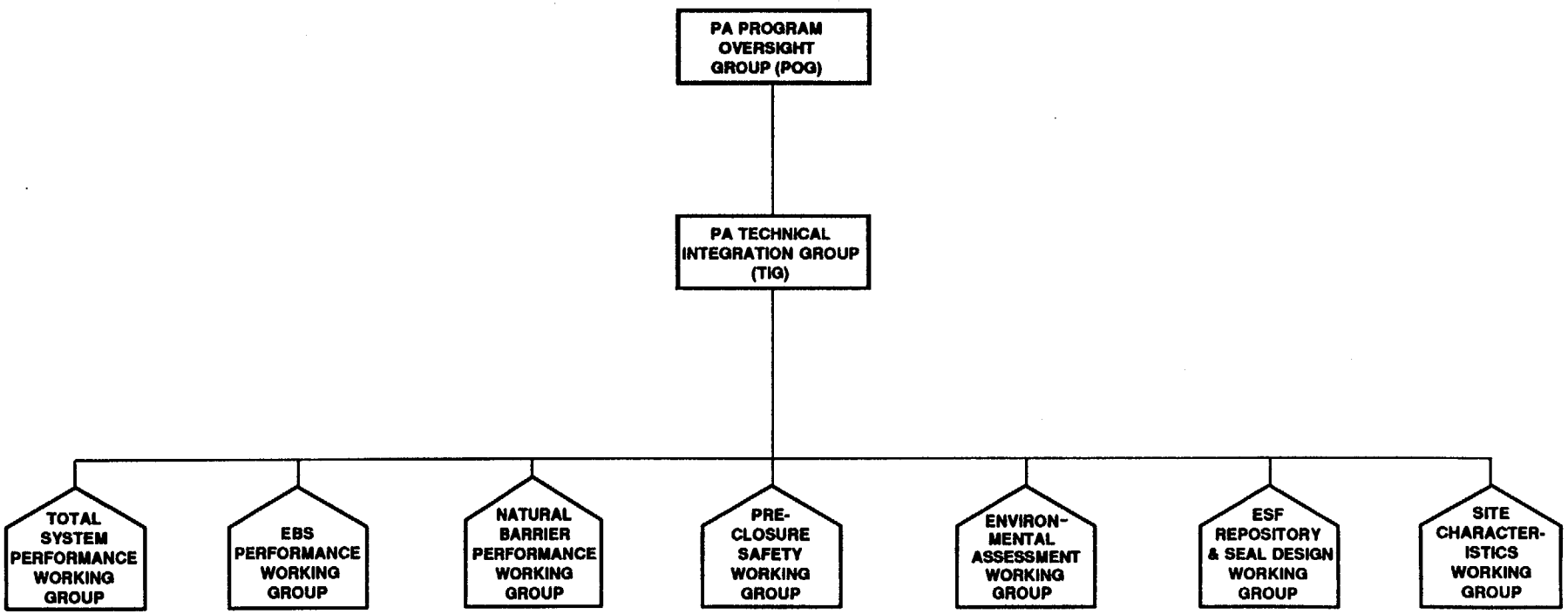
- **A SEPARATE CAPABILITY WILL EXIST TO REVIEW THESE ASSESSMENTS**

- **THE CAPABILITY EXISTS TO CONDUCT ASSESSMENTS IN SUPPORT OF SITE CHARACTERIZATION AND REPOSITORY DESIGN**

MANAGEMENT/INTEGRATION STRUCTURE



PERFORMANCE ASSESSMENT INTEGRATION STRUCTURE



PA INTEGRATION PARTICIPANTS

PROGRAM OVERSIGHT GROUP

D. ALEXANDER, DOE/HQ
M. BLANCHARD, DOE-NV/YMP

TECHNICAL INTEGRATION GROUP

P. GNIRK, RE/SPEC
L. RICKERTSEN, WESTON
J. YOUNKER, SAIC

WORKING GROUPS

TOTAL SYSTEM PERFORMANCE

A. VAN LUIK, PNL
H. AHAGEN, DOE-NV/YMP
F. BINGHAM, SNL

ENGINEERED BARRIER PERFORMANCE

S. GOMBERG, DOE/HQ
M. CLONINGER, DOE-NV/YMP
M. APTED, PNL
U. PARK, SAIC

NATURAL BARRIER PERFORMANCE

A. BINDOKAS, DOE-CH/RTP
D. HOXIE, USGS
C. TSANG, LBL

PRECLOSURE SAFETY

D. MICHLEWICZ, WESTON
N. MORLEY, DOE-NV/YMP
R. SANDOVAL, SNL

ESF, REPOSITORY AND SEALS DESIGN

H. PERRY, SAIC
V. MONTENYOHL, WESTON

ENVIRONMENTAL ASSESSMENT

J. FRIEDMAN, SRA

SITE CHARACTERISTICS

K. KRUPKA, PNL
C. VOSS, PNL

PRINCIPAL NEAR-TERM INTEGRATION ROLE
(FY-1989 AND EARLY FY-1990)

- ONGOING REVIEW OF THE PA PROGRAM

- PREPARATION OF:
  - PERFORMANCE ASSESSMENT MANAGEMENT PLAN (PAMP)
  - PERFORMANCE ASSESSMENT STRATEGY PLAN (PASP)
  - PERFORMANCE ASSESSMENT IMPLEMENTATION PLAN (PAIP)

- GUIDE METHODOLOGY DEVELOPMENT FOR:
  - MODEL VALIDATION/CODE CERTIFICATION
  - IDENTIFYING AND SCREENING PRECLOSURE INITIATING EVENTS
  - DETERMINATION OF THE EXTENT OF THE DISTURBED ZONE
  - EVALUATION OF TOTAL SYSTEM AND WASTE PACKAGE PERFORMANCE AND GROUND-WATER TRAVEL TIME
  - ASSESSMENT OF POSTCLOSURE ASSESSMENT REQUIREMENTS FOR DEIS

PRINCIPAL NEAR-TERM INTEGRATION ROLE

(CONTINUED)

- GUIDE MODEL/CODE DEVELOPMENT, INCLUDING DOCUMENTATION AND BENCHMARKING
- COORDINATE AND MONITOR "TEST PROBLEMS" FOR PRELIMINARY PA OF YUCCA MOUNTAIN
  - COORDINATION OF CAPABILITIES AND WORKING INTERFACES
  - IDENTIFICATION OF KEY ASSUMPTIONS AND CRITICAL DATA/MODEL NEEDS

LONGER-TERM INTEGRATION ROLE

FY 1990 - 1991 TIMEFRAME

- COORDINATE MODEL VALIDATION AND CODE CERTIFICATION ACTIVITIES
- ESTABLISH METHODOLOGIES FOR SAR AND DEIS ASSESSMENTS
- PRELIMINARY IDENTIFICATION, SCREENING, AND QUANTIFICATION OF DISRUPTIVE PROCESS AND EVENTS FOR POSTCLOSURE SAR AND DEIS ASSESSMENTS
- "CALCULATIONAL EXERCISES" FOR PRELIMINARY PA OF YUCCA MOUNTAIN
  - EXPECTED SITE AND REPOSITORY CONDITIONS
  - IMPACTS OF DISRUPTIVE PROCESS AND EVENTS

FY 1992 TIMEFRAME

- CONDUCT ASSESSMENTS TO SUPPORT PREPARATION OF DEIS

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

PRESENTATION TO THE NUCLEAR WASTE TECHNICAL REVIEW BOARD

SUBJECT: PERFORMANCE OF NATURAL BARRIERS

PRESENTER: DR. DWIGHT HOXIE

PRESENTER'S TITLE AND ORGANIZATION:
HYDROLOGIST
YUCCA MOUNTAIN PROJECT
U.S. GEOLOGICAL SURVEY

PRESENTER'S TELEPHONE NUMBER: (303) 236-5019

MAY 16-17, 1989

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

PRESENTATION TO THE NUCLEAR WASTE TECHNICAL REVIEW BOARD

SUBJECT: PERFORMANCE OF NATURAL BARRIERS

PRESENTER: DR. DWIGHT HOXIE

PRESENTER'S TITLE AND ORGANIZATION: HYDROLOGIST
YUCCA MOUNTAIN PROJECT
U.S. GEOLOGICAL SURVEY

PRESENTER'S TELEPHONE NUMBER: (303) 236-5019

MAY 16-17, 1989

SCOPE OF PRESENTATION

- REGULATORY REQUIREMENTS FOR THE NATURAL BARRIERS: THE GROUND-WATER TRAVEL TIME (GWTT)
- INFORMATION NEEDS FOR GWTT CALCULATIONS
- GWTT CALCULATIONS FOR THE ENVIRONMENTAL ASSESSMENT
- UNSATURATED-ZONE HYDROGEOLOGIC SYSTEM: CONCEPTS AND UNCERTAINTIES
- ADDITIONAL INFORMATION NEEDS
- CURRENT AND FUTURE ACTIVITIES

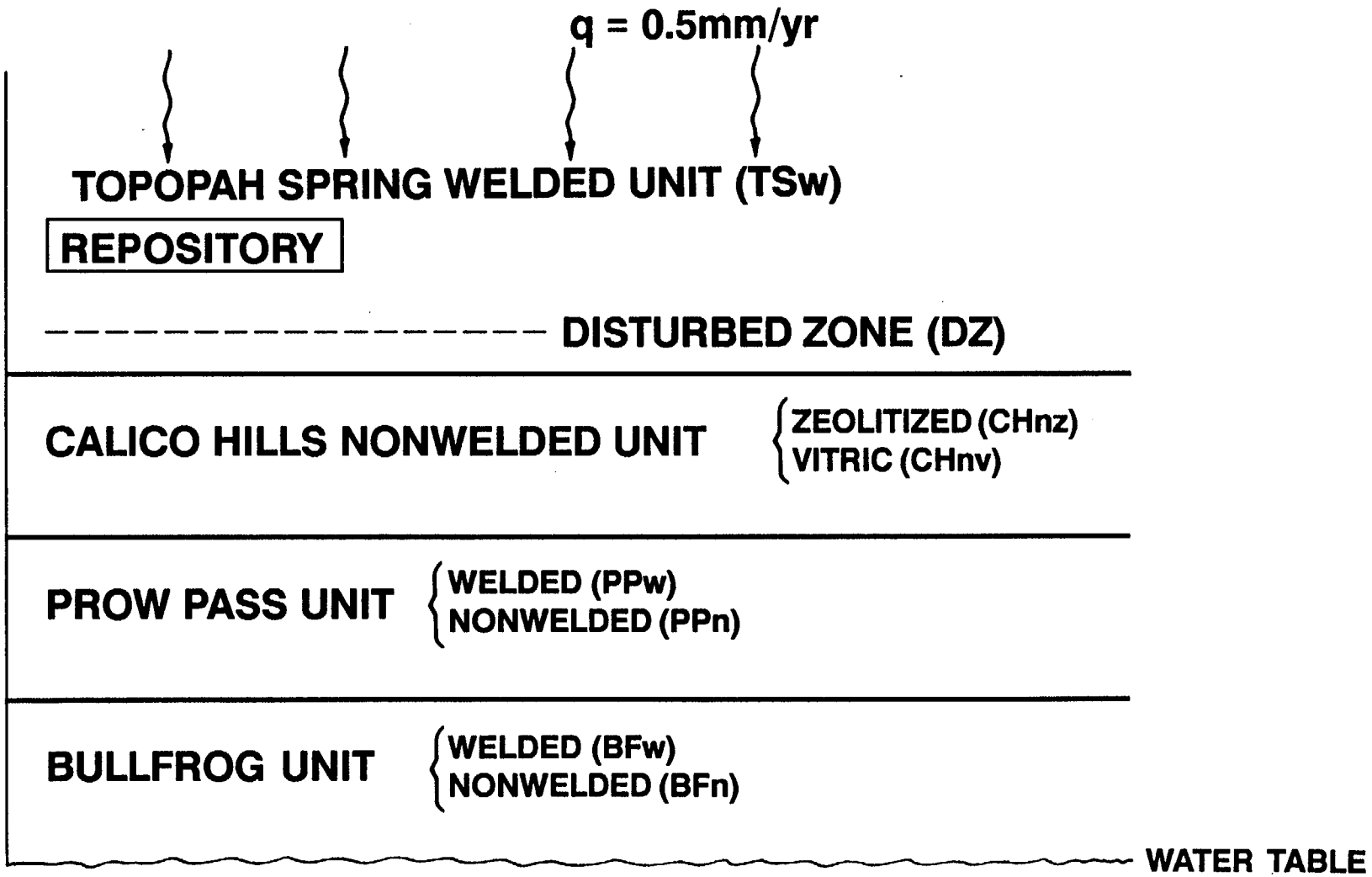
10 CFR PART 60.113(a)(2)

" THE GEOLOGIC REPOSITORY SHALL BE LOCATED SO THAT PRE-WASTE-EMPLACEMENT GROUNDWATER TRAVEL TIME ALONG THE FASTEST PATH OF LIKELY RADIONUCLIDE TRAVEL FROM DISTURBED ZONE TO THE ACCESSIBLE ENVIRONMENT SHALL BE AT LEAST 1,000 YEARS OR SUCH OTHER TRAVEL TIME AS MAY BE APPROVED OR SPECIFIED BY THE COMMISSION"

INFORMATION NEEDED TO EVALUATE GROUND-WATER TRAVEL TIME

- CHARACTERISTICS OF THE GROUND-WATER FLOW SYSTEM
  - GEOLOGIC FRAMEWORK
  - INITIAL AND BOUNDARY CONDITIONS
  - HYDROLOGIC AND OTHER PHYSICAL PROCESSES
- CALCULATIONAL MODELS
- EXTENT OF DISTURBED ZONE
- PATHS OF LIKELY RADIONUCLIDE TRAVEL
- EVALUATION OF GROUND-WATER TRAVEL TIME

CONCEPTUAL MODEL USED FOR THE ENVIRONMENTAL ASSESSMENT (EA) GWTT CALCULATIONS

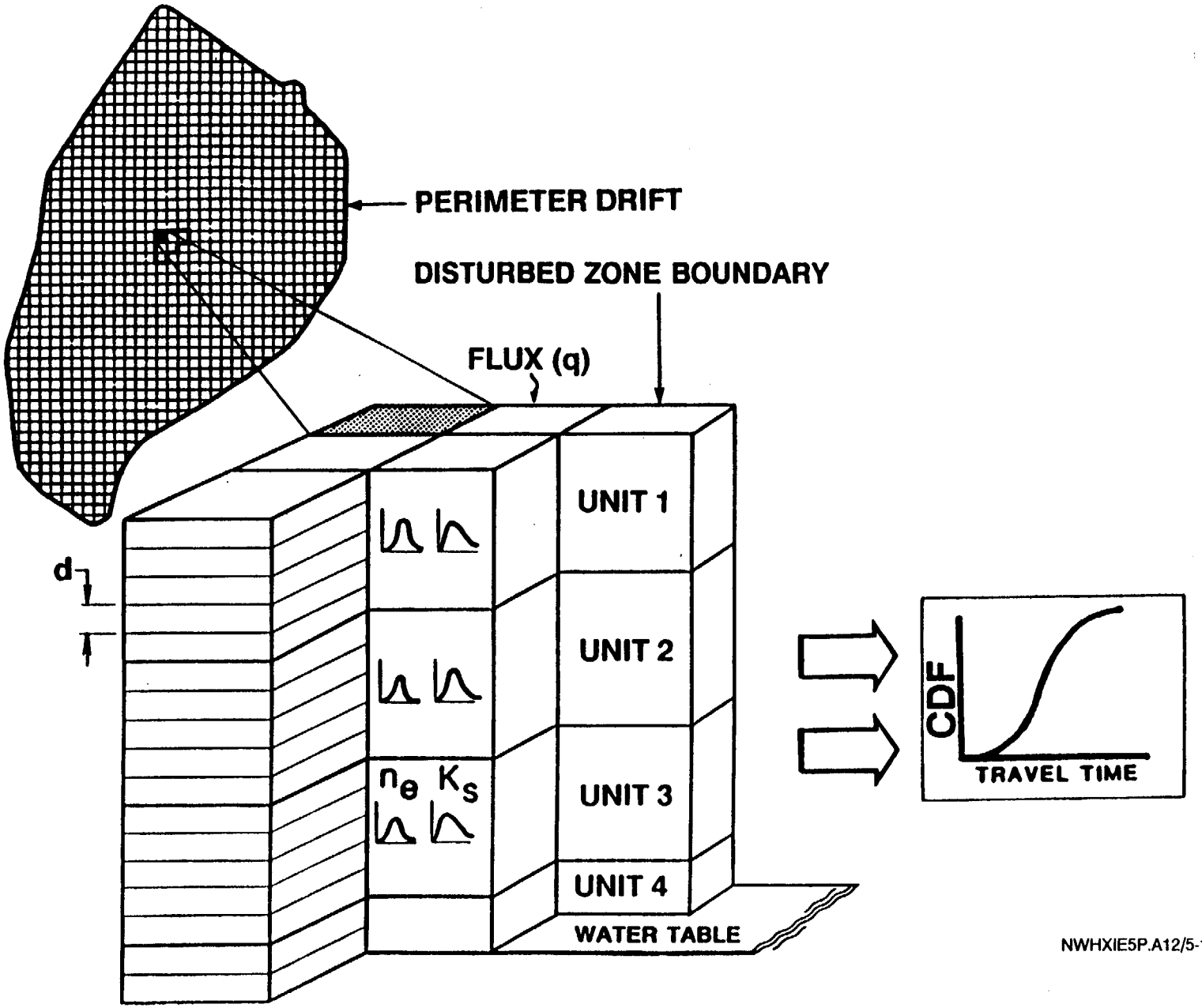


GWTT CALCULATIONS FOR THE EA

THE PRINCIPAL ASSUMPTIONS:

- UNIT VERTICAL HYDRAULIC GRADIENT
- LIQUID-WATER FLUX q IS VERTICAL AND IS CONSTANT IN SPACE AND TIME
- EFFECTIVE MATRIX HYDRAULIC CONDUCTIVITY K = q
- SATURATED HYDRAULIC CONDUCTIVITY (K_{sat}) AND EFFECTIVE POROSITY (n_e) ARE RANDOM VARIABLES
- WATER FLOW IN FRACTURES DOMINATES IF $q \geq 0.95 \cdot K_{sat}$
- BASE OF DISTURBED ZONE (DZ) IS 50m BELOW REPOSITORY MIDPLANE

APPROACH TO GROUNDWATER TRAVEL TIME CALCULATION FOR THE ENVIRONMENTAL ASSESSMENT



GWTT T_i FOR COLUMN i CONSISTING OF N_i ELEMENTS OF THICKNESS d

$$Ti = \sum_{I=1}^{N_i} \frac{d}{V_i}$$

WHERE THE SEEPAGE VELOCITY V_i IS GIVEN BY

- **FOR THE ROCK MATRIX**

$$V_i = \frac{q}{n_e}\left(\frac{K_{sat}}{q}\right)^{\frac{1}{E}}$$

$$n_e = n(1 - S_r)$$

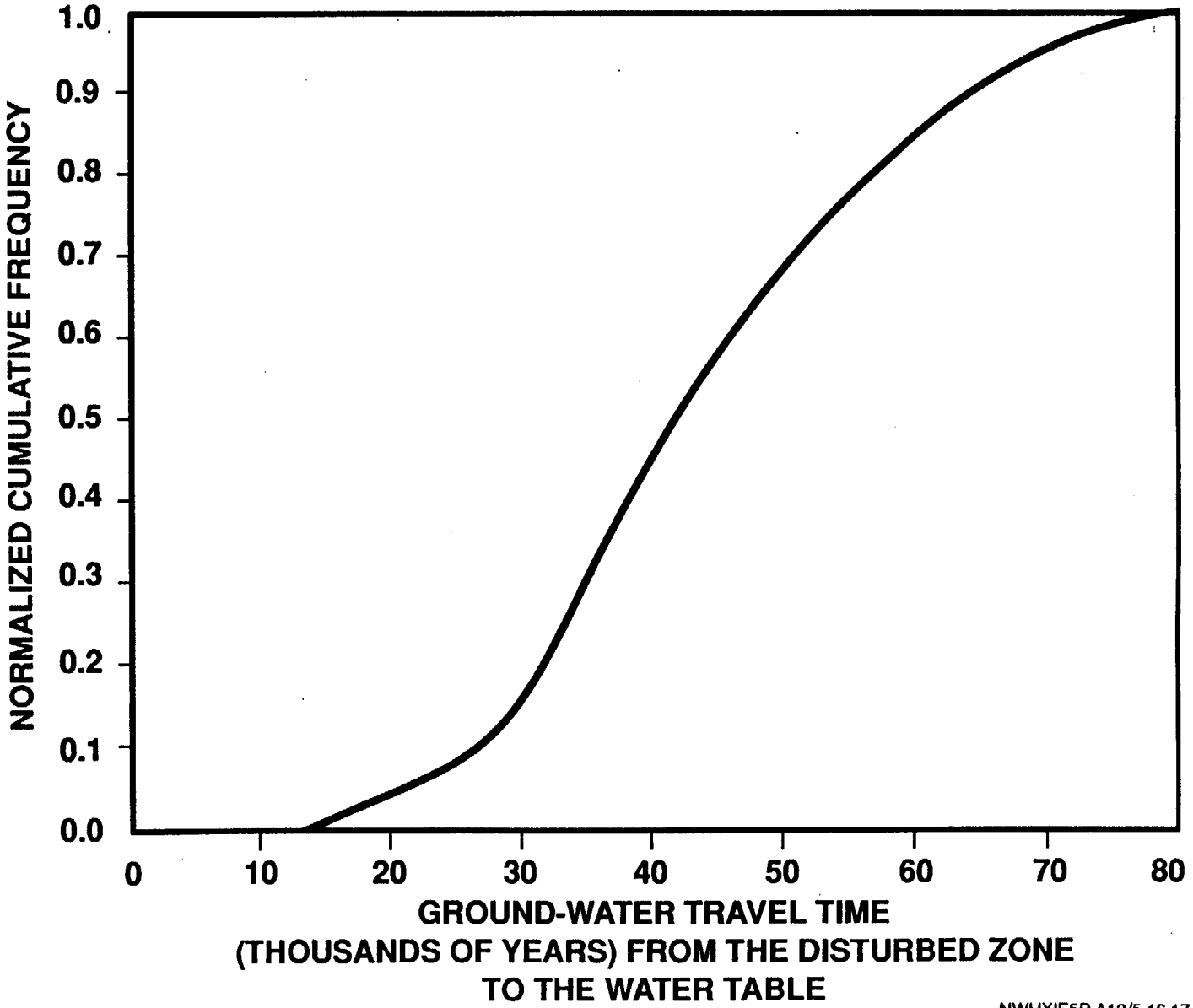
- **FOR THE FRACTURES**

$$V_i = (q - K_{sat}) \times 10^4 \quad \text{IF } q \geq 0.95 \cdot K_{sat}$$

HYDROLOGIC-PROPERTY DATA FOR THE EA GWTT CALCULATIONS

HYDRO-GEOLOGIC UNIT / PROPERTY	TSw	CHnv	CRATER FLAT TUFF				
			CHnz	PPw	PPn	BFw	BFn
MAXIMUM THICKNESS OF UNIT BETWEEN DZ AND THE WATER TABLE (m)	72	135	133	44	122	91	55
K_{sat} (mm/yr)	0.7	107	0.5	88	22	118	22
N_e	0.11	0.32	0.27	0.24	0.25	0.22	0.25
ε	5.9	4.2	7.0	4.0	5.2	4.6	5.2

GWTT CALCULATIONS FOR THE EA

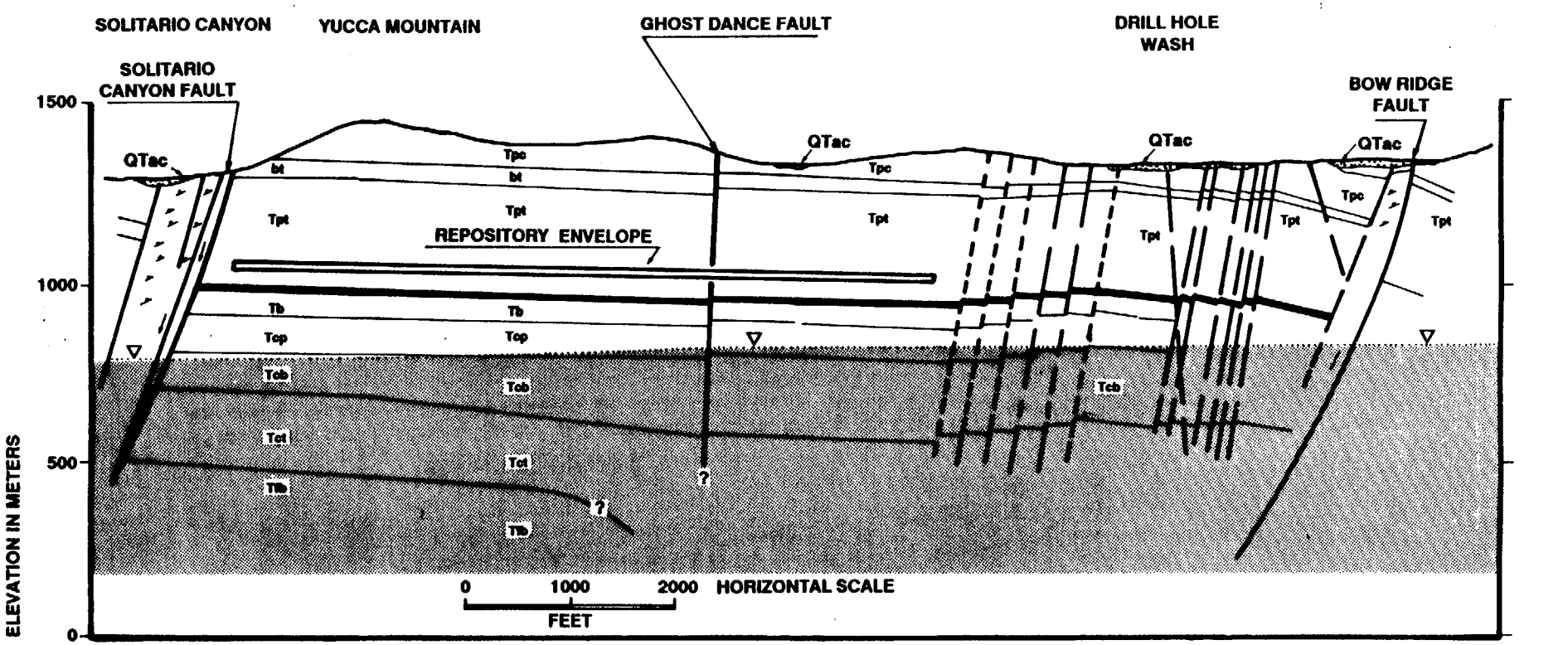


COMPONENTS OF A CONCEPTUAL MODEL FOR A HYDROLOGIC SYSTEM

- GEOLOGIC FRAMEWORK
- INITIAL AND BOUNDARY CONDITIONS
- HYDROLOGIC AND OTHER PHYSICAL PROCESSES

GEOLOGIC FRAMEWORK

- **STRUCTURAL FEATURES**
  - FAULTS
  - FOLDS
  - FRACTURES
- **HYDROGEOLOGIC UNITS**
  - HIGHLY FRACTURED WELDED TUFFS
  - SPARSELY FRACTURED NONWELDED TUFFS



Tpc TIVA CANYON MEMBER

bt BEDDED TUFF

Tpt TOPOPAH SPRING MEMBER

Tb TUFFACEOUS BEDS OF CALICO HILLS

Tcp PROW PASS MEMBER

Tcb BULLFROG MEMBER

Tm TRAM MEMBER

Tlb FLOW BRECCIA

HIGHLY FAULTED AND BRECCIATED ZONE

QTac ALLUVIUM & COLLUVIUM

BASAL VITROPHYRE

? STRATIGRAPHY UNCERTAIN

▽ WATER TABLE

ARROWS SHOW DIRECTION OF RELATIVE DISPLACEMENT

FAULTS WITH MINOR DIP-SLIP DISPLACEMENTS POSITIONS KNOWN OR CONCEALED AT SURFACE

FAULTS WITH MAJOR DIP-SLIP DISPLACEMENTS POSITIONS KNOWN OR CONCEALED AT SURFACE

UNMAPPED & INFERRED FAULTS WITH SMALL DISPLACEMENT

LOWER BOUNDARY CONDITION: THE WATER-TABLE CONFIGURATION

- **DEFINITION: SURFACE IN SPACE ON WHICH LIQUID-WATER PRESSURE IS ZERO (ATMOSPHERE)**
- **VARIABLE IN SPACE**
- **VARIABLE IN TIME**

UPPER BOUNDARY CONDITION: LAND-SURFACE NET INFILTRATION

- PAST → PALEOCLIMATOLOGY
- PRESENT
  - → MEAN PRECIPITATION ~ 150 mm/yr
  - → POTENTIAL EVAPOTRANSPIRATION ~1600 mm/yr
  - → NET INFILTRATION 1 mm/yr
- FUTURE → CLIMATE CHANGE

LATERAL BOUNDARY CONDITIONS

- MUST ENCLOSE ALL POINTS IN SPACE FROM WHICH HYDROLOGIC-RELATED EFFECTS CAN PROPAGATE TO REPOSITORY SITE
- VARIABLE IN SPACE AND TIME
- WORKING HYPOTHESIS: DEFINED BY THE FAULT SYSTEMS SURROUNDING THE REPOSITORY BLOCK

HYDROLOGIC PROCESSES: AIR AND WATER-VAPOR FLOW

- TOTAL MOISTURE BALANCE = LIQUID WATER + WATER VAPOR
- WATER-VAPOR DIFFUSION
- WATER-VAPOR ADVECTION DUE TO BULK FLOW OF AIR

NOTATION

$\vec{r}$ **POSITION VECTOR IN SPACE** $\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$ (L)

S_f **SATURATION OF FLUID** f

$K(\vec{r})$ **INTRINSIC PERMEABILITY OF POROUS MEDIUM** (L^2)

$k_R(S_f)$ **RELATIVE PERMEABILITY OF FLUID** f

ρ_f **MASS DENSITY OF FLUID** f (M/L^3)

μ_f **VISCOSITY OF FLUID** f (M/LT)

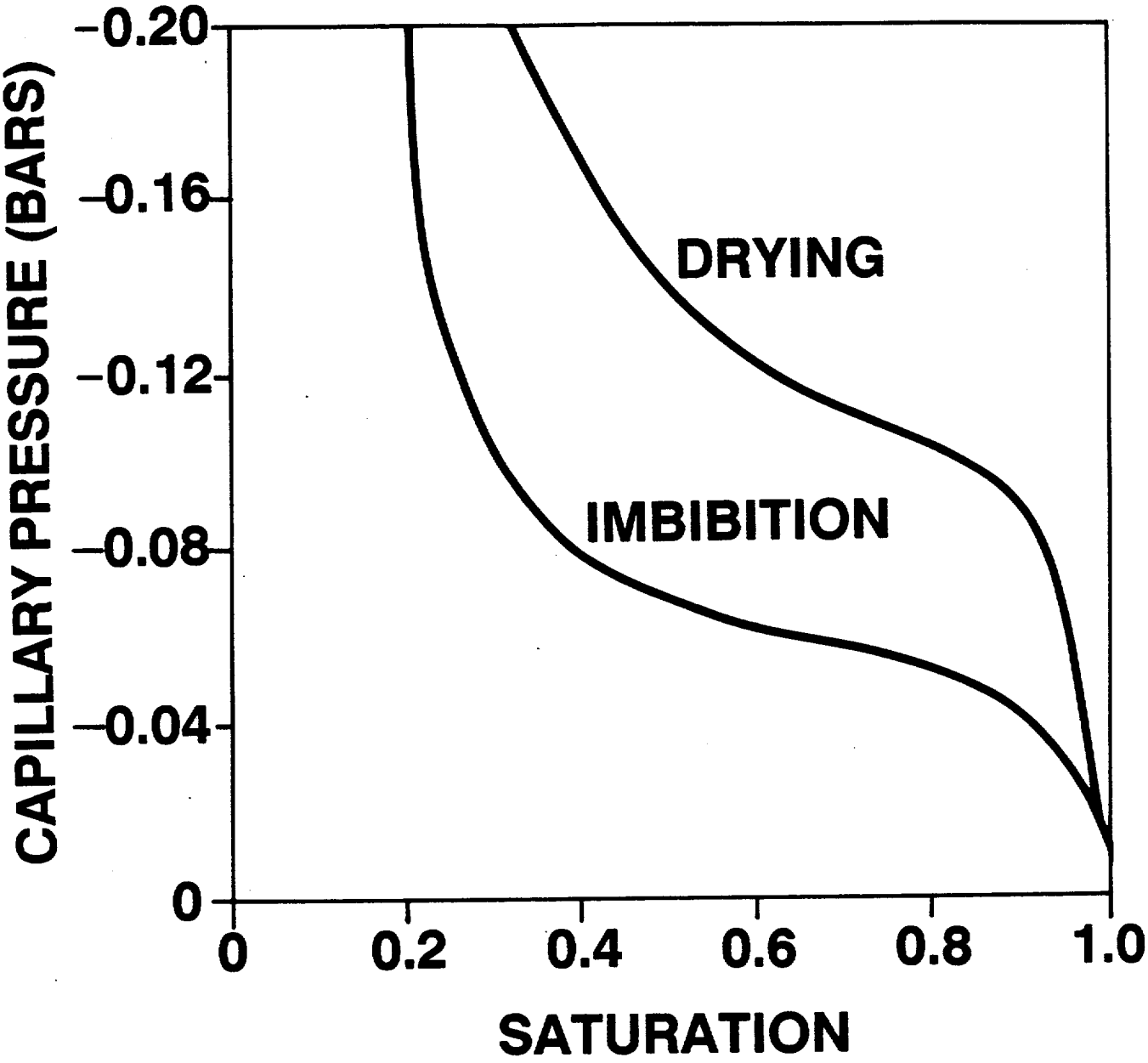
P_f **PORE PRESSURE OF FLUID** f (M/LT^2)

g **ACCELERATION OF GRAVITY** (L/T^2)

F_f **VECTOR VOLUMETRIC FLUX OF FLUID** f (L/T)

DARCY'S LAW II

$$F_f(r) = -\frac{k(r)k_R[S_f(r)]\rho_f}{\mu_f}\,\mathrm{Grad}\left(\frac{P_f(S_f)}{\rho_f} + gz\right)$$



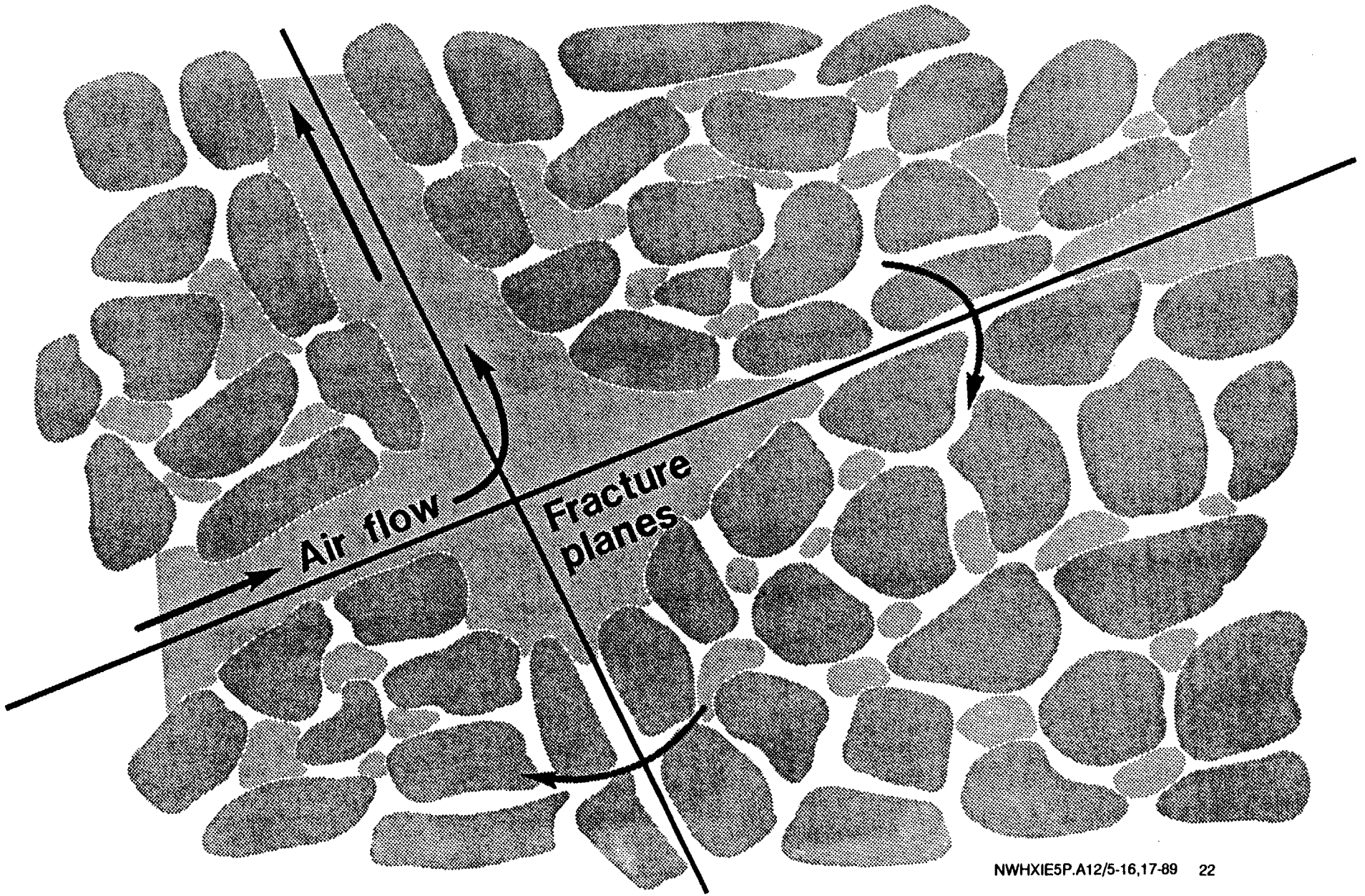
CAPILLARY PRESSURE AS A FUNCTION OF LIQUID-WATER VOLUMETRIC SATURATION (DEL MONTE SAND)

HYDRAULICS OF UNSATURATED FRACTURES

FLOW BARRIERS OR CONDUITS ?

- LATERAL FLOW ACROSS FRACTURES
- LONGITUDINAL FLOW WITHIN FRACTURES

Flow in Unsaturated Fractures



THE SITE-CHARACTERIZATION PROGRAM (PRE-WASTE EMPLACEMENT)

- **DATA ACQUISITION**
  - EXPLORATORY-SHAFT FACILITY
  - SURFACE-BASED BOREHOLES
- **HYDROLOGIC-PROPERTY DATA**
  - ROCK MATRIX: n, Ksat, CHARACTERISTIC RELATIONS
  - FRACTURES: DISCRETE, NETWORKS, OVERLAPPING CONTINUA
  - FAULTS: DISCRETE BARRIERS OR CONDUITS
- **HYPOTHESIS TESTING: ALTERNATIVE CONCEPTUAL MODELS**
- **UNCERTAINTY ANALYSES**
  - SENSITIVITY STUDIES: IMPORTANCE OF PROPERTIES
  - CLASSICAL STATISTICS: PROBABILITY DISTRIBUTION FUNCTIONS
  - GEOSTATISTICS: SPATIAL CORRELATION AND HETEROGENEITY
- **NUMERCIAL MODELING**
  - LIQUID-WATER STORAGE AND FLOW
  - CONVECTIVE AIR FLOW IN FRACTURE SYSTEMS
  - ADVECTIVE WATER-VAPOR TRANSPORT
  - GEOTHERMAL HEAT FLOW

CURRENT ACTIVITIES (FY89)

- COMPILE BEST AVAILABLE DATA FOR THE SITE
- PERFORM CLASSICAL AND GEOSTATISTICAL ANALYSES OF THESE DATA
- ASSEMBLE A SET OF APPROPRIATE HYDROLOGIC NUMERICAL MODELS

FUTURE ACTIVITIES (FY90)

- REPEAT GWTT CALCULATIONS USING
  - BEST AVAILABLE DATA
  - BEST AVAILABLE MODELING TECHNIQUES

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

PRESENTATION TO THE NUCLEAR WASTE TECHNICAL REVIEW BOARD

SUBJECT: ENGINEERED BARRIER SYSTEM PERFORMANCE

PRESENTER: DR. ABRAHAM E. VAN LUIK

PRESENTER'S TITLE AND ORGANIZATION: STAFF SCIENTIST, PACIFIC NORTHWEST LABORATORY

PRESENTER'S TELEPHONE NUMBER: (202) 646-5207

MAY 16-17, 1989

SCOPE OF PRESENTATION

- **DESCRIPTION OF THE WASTE PACKAGE/ENGINEERED BARRIER SYSTEM**

- **THE ENVIRONMENTAL ASSESSMENT'S (EA) ENGINEERED BARRIER SYSTEM PERFORMANCE EVALUATION**

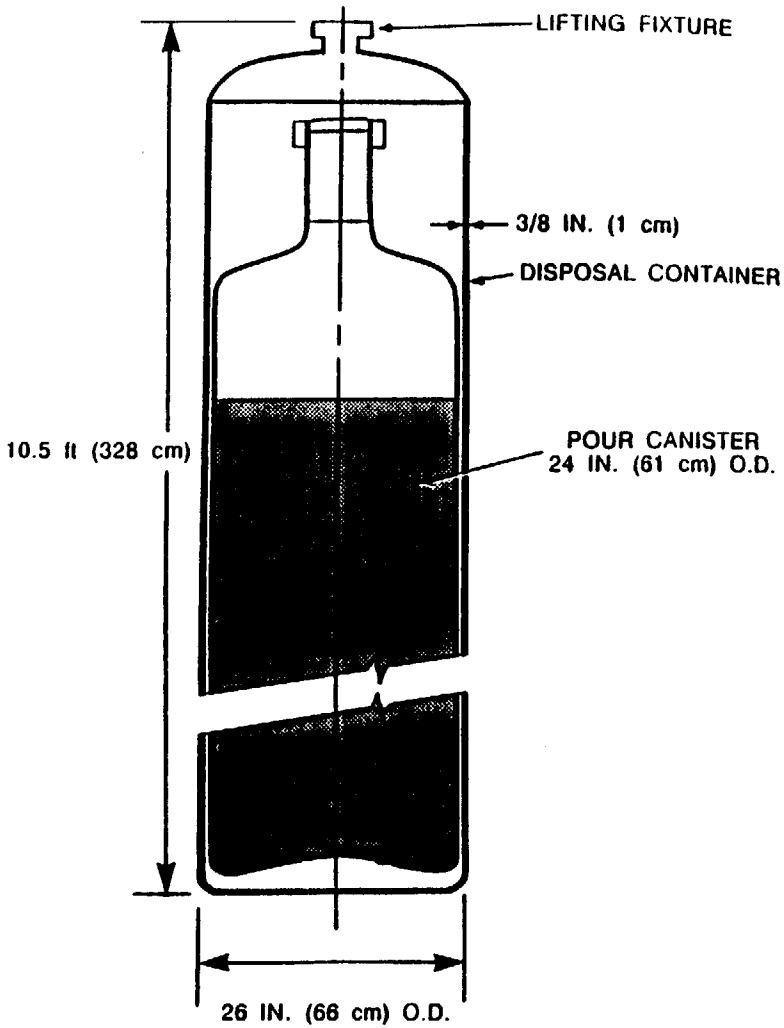
- **THE SITE CHARACTERIZATION PLAN'S (SCP) ENGINEERED BARRIER SYSTEM PERFORMANCE ASSESSMENT PROGRAM**

ENGINEERED BARRIER SYSTEM DEFINITIONS

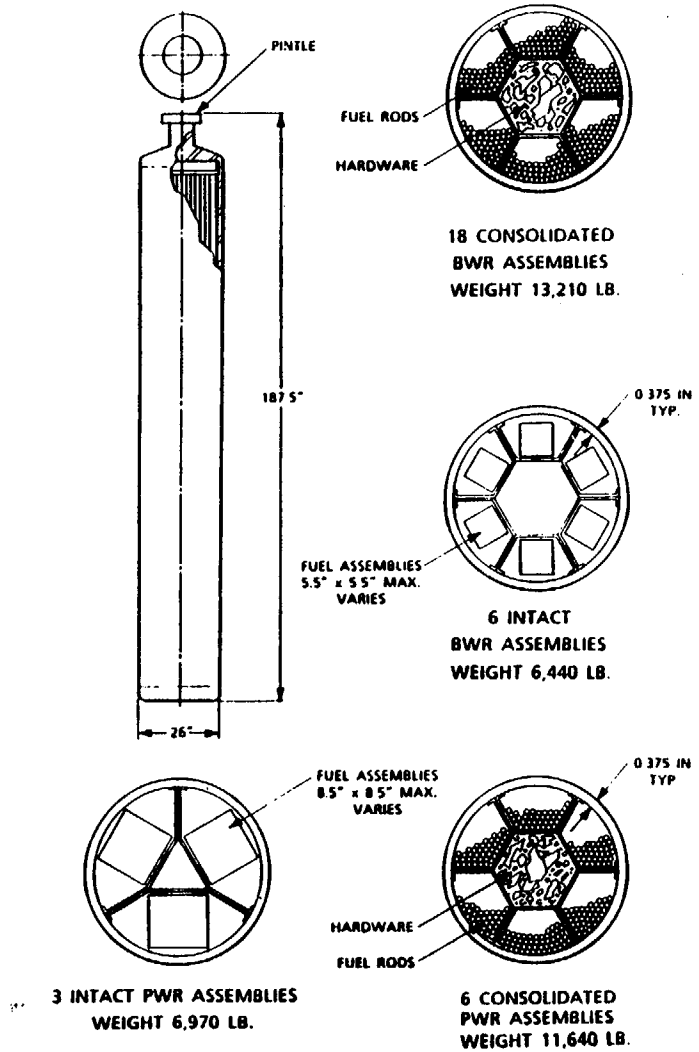
- **ENGINEERED BARRIER SYSTEM (EBS):**
  - **WASTE PACKAGES**
  - **THE UNDERGROUND FACILITY**
- **THE EDGE OF THE EBS IS THE EDGE OF THE EXCAVATION**

CONCEPTUAL WASTE PACKAGE DESIGNS FOR HIGH-LEVEL WASTE AND SPENT NUCLEAR FUEL

HIGH-LEVEL WASTE CONTAINER

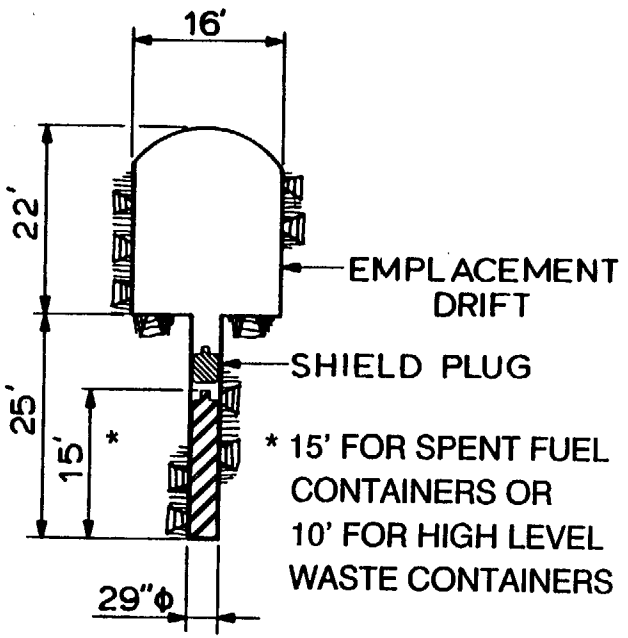


SPENT NUCLEAR FUEL CONTAINER

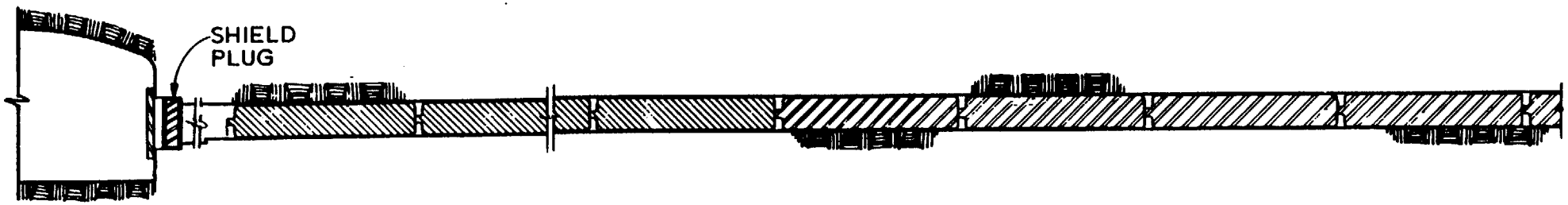


DETAIL OF WASTE PACKAGE EMPLACEMENT OPTIONS

VERTICAL EMPLACEMENT



HORIZONTAL EMPLACEMENT



8 DUMMY CONTAINERS

EITHER 14 SPENT FUEL OR 18 HIGH LEVEL WASTE CONTAINERS

SCOPE OF PRESENTATION

- DESCRIPTION OF THE WASTE PACKAGE/ENGINEERED BARRIER SYSTEM

- THE ENVIRONMENTAL ASSESSMENT'S (EA) ENGINEERED BARRIER SYSTEM PERFORMANCE EVALUATION

- THE SITE CHARACTERIZATION PLAN'S (SCP) ENGINEERED BARRIER SYSTEM PERFORMANCE ASSESSMENT PROGRAM

THE ENVIRONMENTAL ASSESSMENT RELEASE RATE CALCULATION FOR A FAILED SPENT FUEL CONTAINER

$$\dot{M} = FAS$$

$\dot{M}$ - MASS LOSS FROM CONTAINER

F - FLUX OF WATER [5×10^{-4} m^3/m^2-yr]

A - CONTAINER AREA NORMAL TO THE FLUX [0.33 m^2]

S - SOLUBILITY LIMIT OF WASTE MATRIX [5×10^{-2} kg/m^3]

$$\dot{M} = 5 \times 10^{-4} \frac{m}{yr} \cdot 0.33 m^2 \cdot 5 \times 10^{-2} \frac{kg}{m^3} = 8.3 \times 10^{-6} \frac{kg}{yr}$$

$$\text{FRACTIONAL RELEASE RATE: } \frac{\dot{M}}{3.3 \times 10^3 \text{ kg}} = 2.5 \times 10^{-9}/yr$$

ASSUMPTIONS AND LIMITATIONS OF THE ENVIRONMENTAL ASSESSMENT EBS PERFORMANCE CALCULATION

- **SCENARIO**
  - NO RELEASE OCCURS IF NO LIQUID WATER CONTACTED THE WASTE PACKAGE
  - A BOUNDING FLUX RATE OVER AN EFFECTIVE AREA CONTACTED EACH WASTE PACKAGE
  - CONCEPTUAL HYDROLOGIC MODELS ARE NEEDED TO DEFINE THE FLUX AND THE AMOUNT OF LIQUID WATER THAT MAY CONTACT A WASTE PACKAGE
  - GASEOUS RELEASES MAY NEED TO BE MODELED EVEN IF NO LIQUID WATER CONTACTS A WASTE PACKAGE

ASSUMPTIONS AND LIMITATIONS OF ENVIRONMENTAL ASSESSMENT'S EBS PERFORMANCE CALCULATION

(CONTINUED)

- **CONTAINER DEGRADATION**
  - SINGLE FAILURE TIME USED FOR ALL CONTAINERS (3,000 YEARS)
  - FAILURE TIME ESTIMATE BASED ON EXPERIMENTAL RESULTS FOR ONE CONTAINER METAL AND ONE FAILURE MODE
  - ENVIRONMENTS NEED TO BE DEFINED
  - DEGRADATION MODES FOR REFERENCE AND ALTERNATE METALS NEED TO BE DEFINED FOR ENVIRONMENTS
  - DEGRADATION RATES NEED TO BE DEFINED
  - CONTAINMENT FAILURE TIMES NEED TO BE MODELED

ASSUMPTIONS AND LIMITATIONS OF ENVIRONMENTAL ASSESSMENT EBS PERFORMANCE CALCULATION

(CONTINUED)

- **RELEASE RATE**
  - A CONGRUENT DISSOLUTION RATE WAS USED
  - OTHER RELEASE PROCESSES NEGLECTED
  - DISSOLUTION RATE BASED ON UNCERTAIN UO_2 SOLUBILITY LIMIT
  - CONTINUOUS HYDROLOGIC PATHWAY ASSUMED
  - ELEVATED TEMPERATURE AND RADIATION FLUX NEGLECTED (ARTIFACT OF 3,000 YEAR CONTAINMENT TIME)

SCOPE OF PRESENTATION

- DESCRIPTION OF THE WASTE PACKAGE/ENGINEERED BARRIER SYSTEM

- THE ENVIRONMENTAL ASSESSMENT'S (EA) ENGINEERED BARRIER SYSTEM PERFORMANCE EVALUATION

- THE SITE CHARACTERIZATION PLAN'S (SCP) ENGINEERED BARRIER SYSTEM PERFORMANCE ASSESSMENT PROGRAM

THE SITE CHARACTERIZATION PROGRAM

A. PERFORMANCE ISSUES

- ISSUE 1.4, CONTAINMENT
- ISSUE 1.5, RELEASE RATE

B. INFORMATION NEEDS

- SITE CHARACTERISTICS
- WASTE PACKAGE ENVIRONMENTS
- MATERIALS PROPERTIES AND BEHAVIORS

C. STUDIES

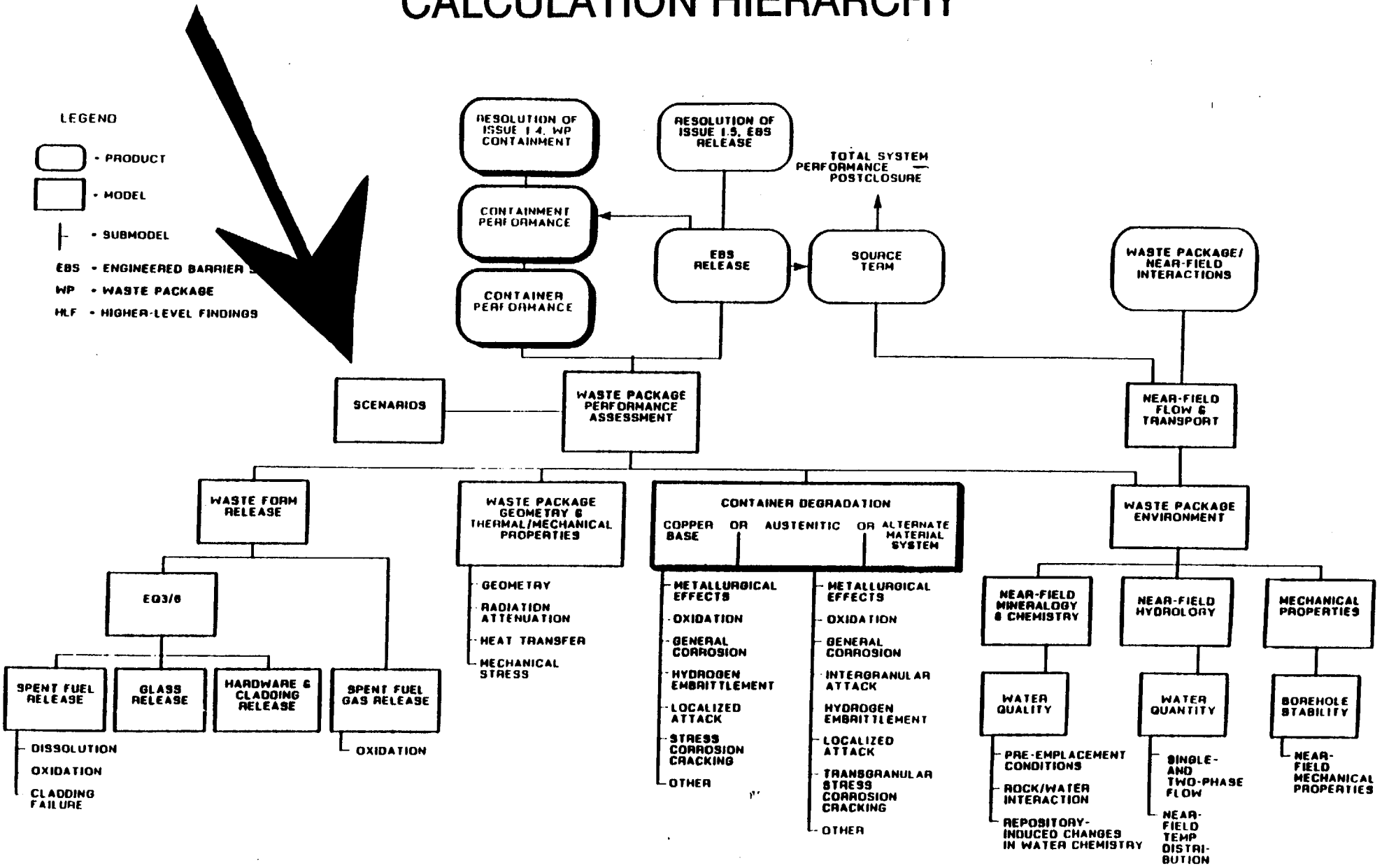
- IN SITU AND LABORATORY TESTING
- MODEL DEVELOPMENT AND TESTING
- PERFORMANCE AND UNCERTAINTY ANALYSES

SITE CHARACTERIZATION PLAN
PERFORMANCE CALCULATION HIERARCHY

- **PARTITIONS THE MODELING CONTRIBUTIONS INTO MANAGEABLE MODELING UNITS**
  - **MODELING UNITS ARE, AT MECHANISTIC/PROCESS LEVELS, LINKED TO SITE AND LABORATORY DATA COLLECTING PROGRAMS**
  - **ITERATIVE PROCESS USING DATA TO TEST THE MODEL, THEN USING UNCERTAINTY AND SENSITIVITY ANALYSES TO DEFINE FURTHER DATA-GATHERING PRIORITIES, FOCUSES EFFORT ON REDUCTION OF UNCERTAINTIES**

ENGINEERED BARRIER SYSTEM PERFORMANCE

CALCULATION HIERARCHY

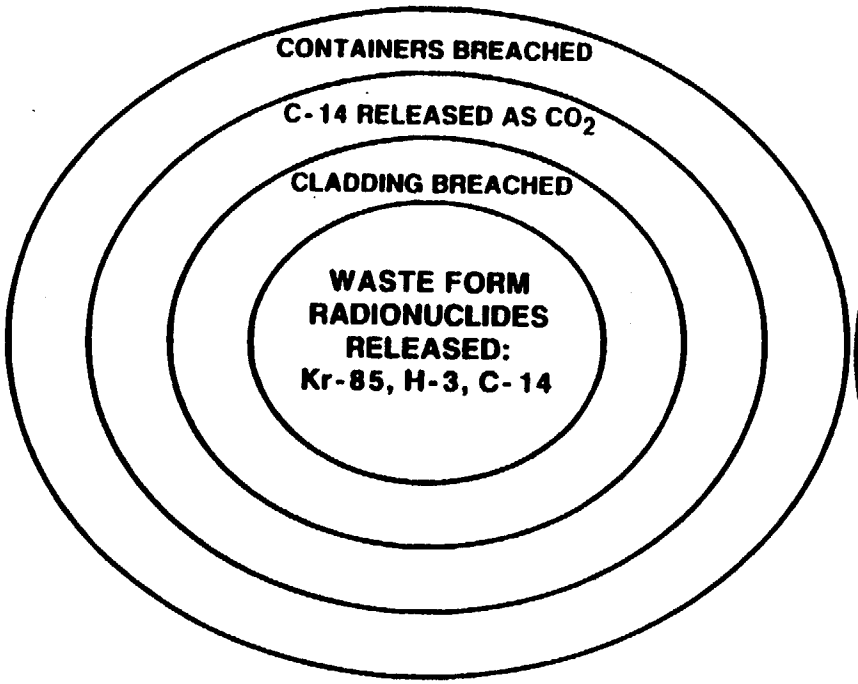


WASTE PACKAGE FAILURE SCENARIOS: "WET" AND "DRY"

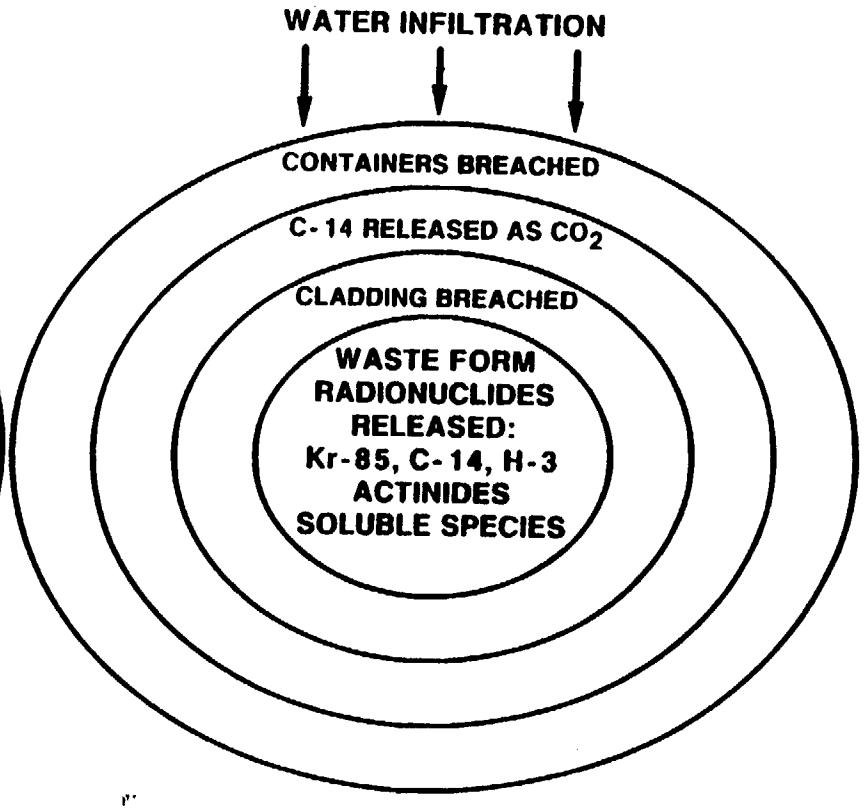
- THE EXPECTED CASE IS THE "DRY" CASE; LIQUID WATER WILL NOT CONTACT THE WASTE PACKAGE:
  - UNSATURATED NEAR FIELD ROCK
  - LIKELIHOOD THAT MATRIX FLOW PREDOMINATES
  - WASTE PACKAGE TEMPERATURE EXCEEDS AMBIENT
  - ENGINEERED AIR GAP BREAKS HYDROLOGIC CONTINUITY
- AN UNEXPECTED BUT CREDIBLE CASE IS THE "WET" CASE; THE AIR GAP HAS FAILED, OR THERE IS LIQUID WATER DRIPPING ONTO A WASTE PACKAGE

DRY AND WET CASE RELEASE SCENARIOS

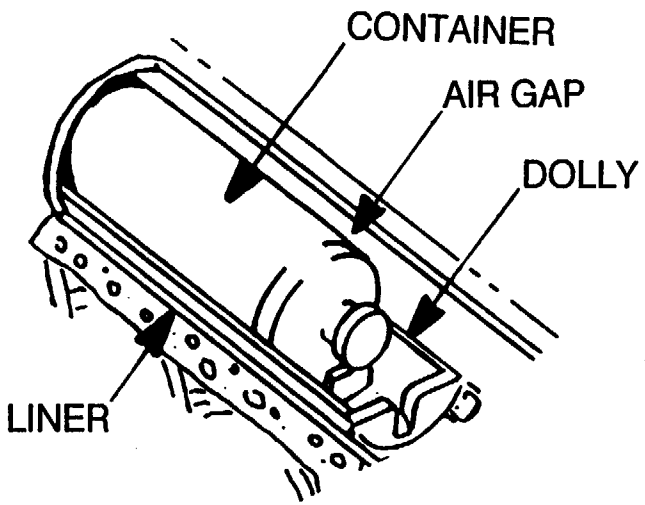
NO LIQUID WATER CONTACTS WASTE PACKAGE (EXPECTED CASE)

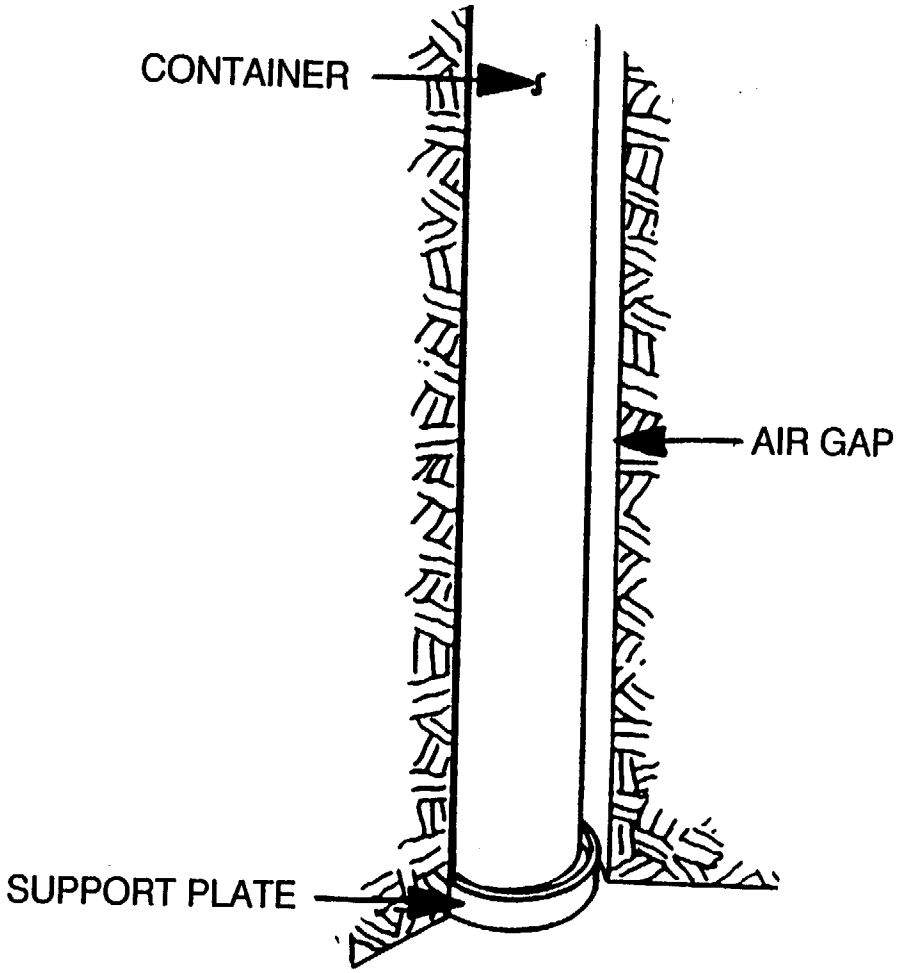


SOME LIQUID WATER CONTACTS WASTE PACKAGE



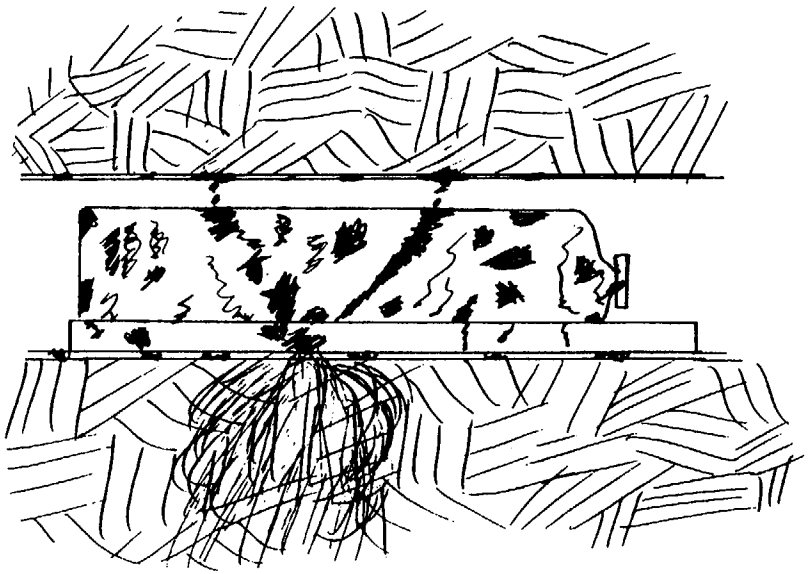
THE AIR GAP IN WASTE PACKAGE EMPLACEMENT: ENHANCING PERFORMANCE BY BREAKING HYDROLOGIC CONTINUITY



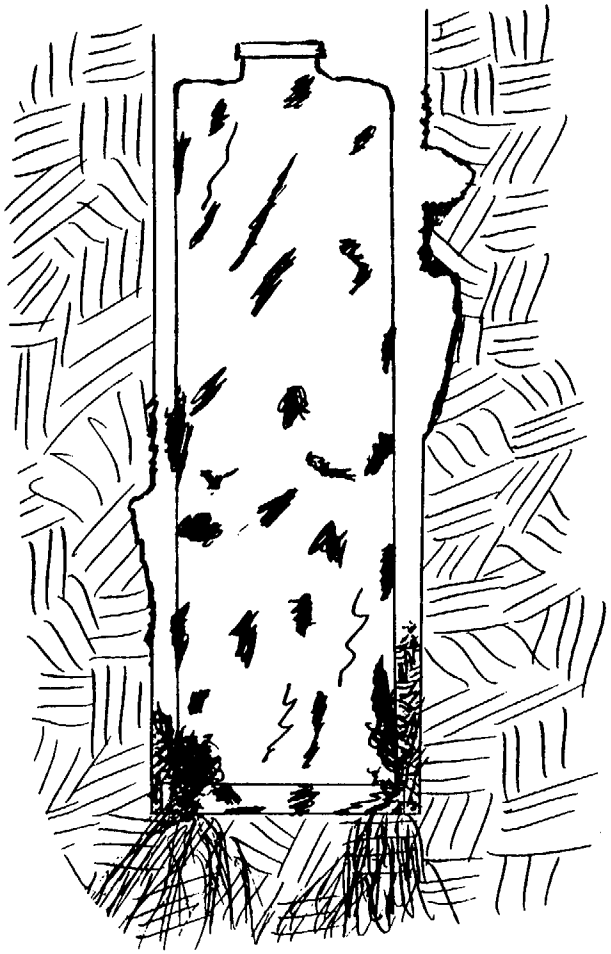


TWO FAILED AIR GAP SCENARIOS

DRIPPING WATER

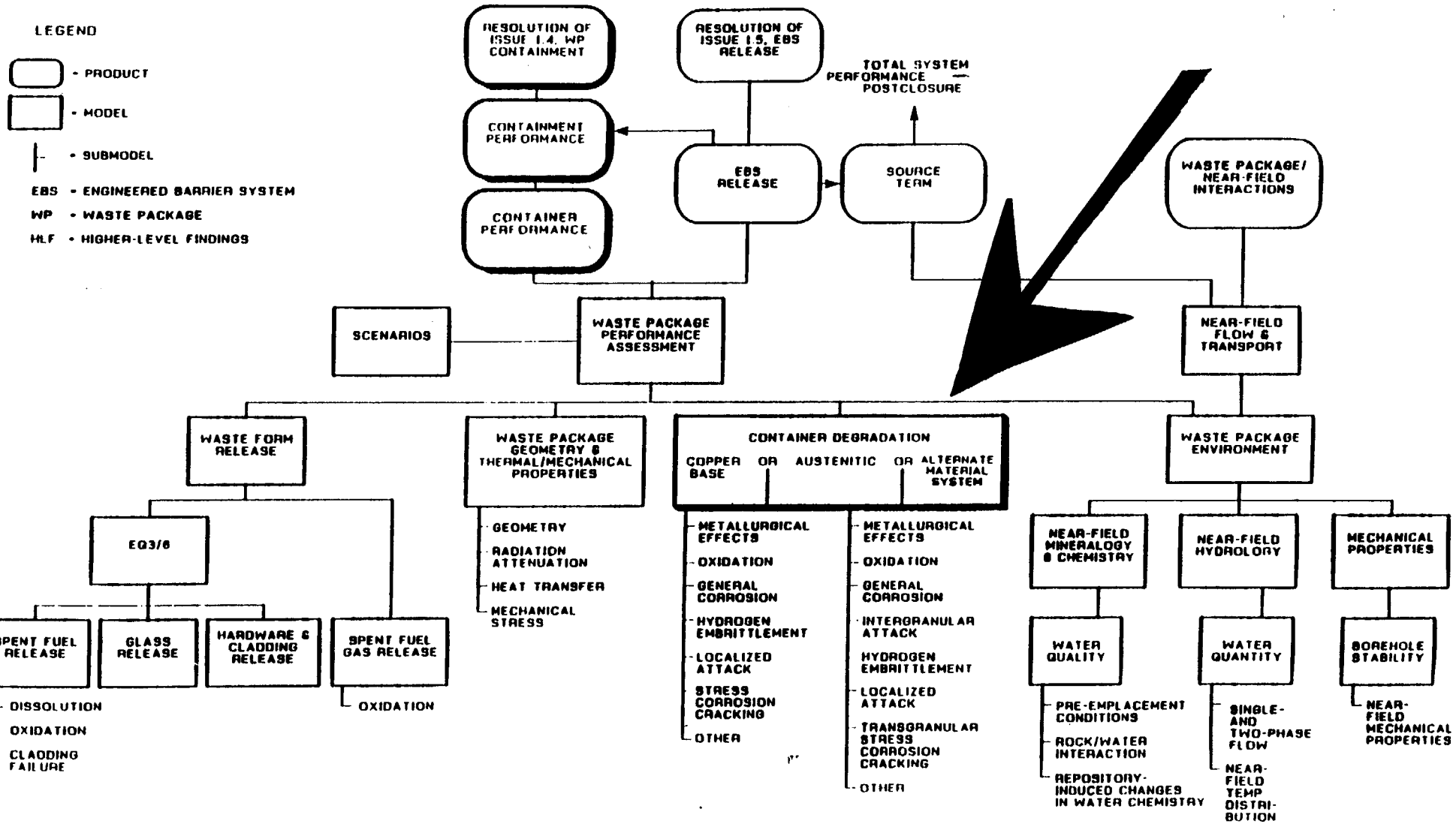


COMPROMISED AIR GAP



ENGINEERED BARRIER SYSTEM PERFORMANCE

CALCULATION HIERARCHY

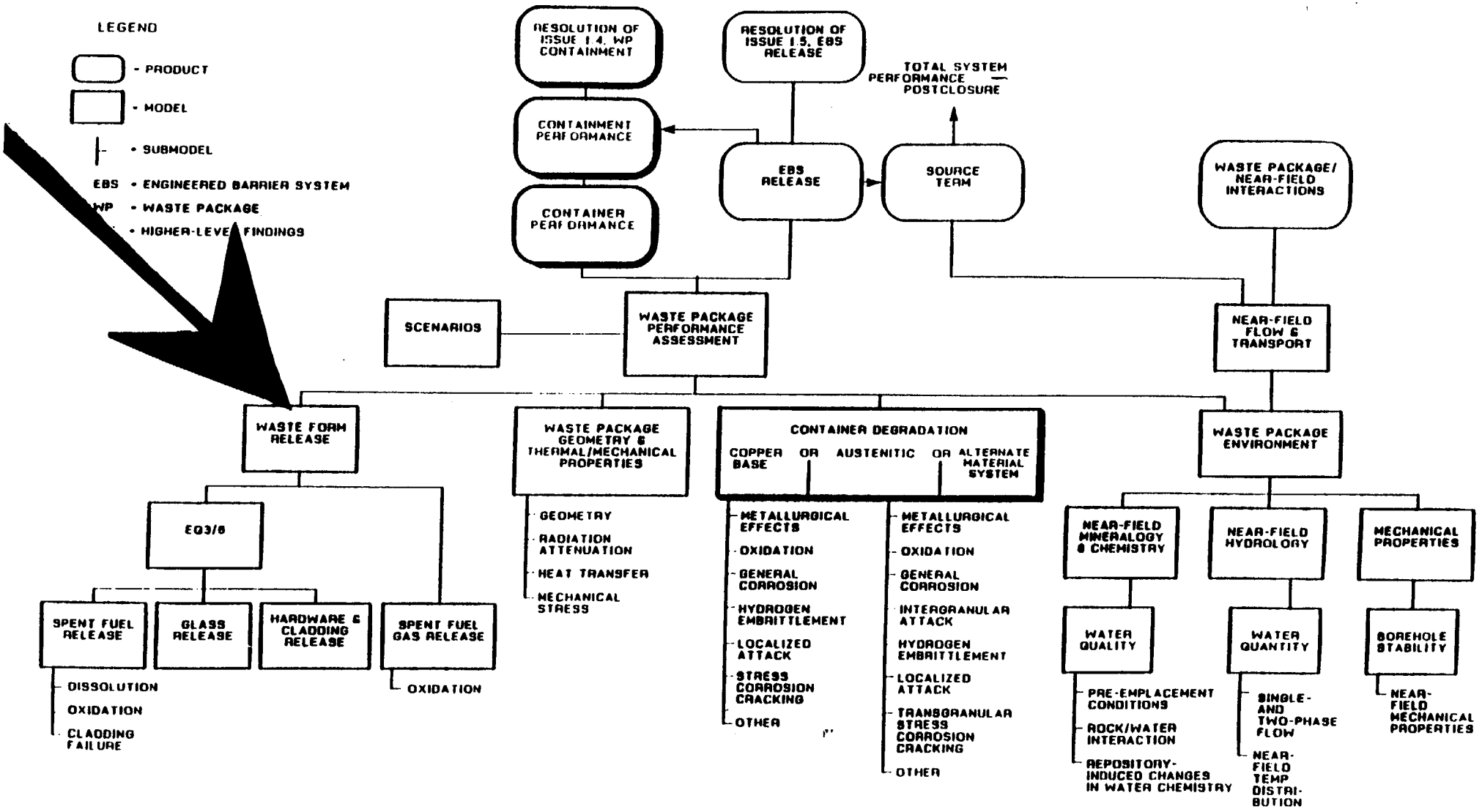


CONTAINER DEGRADATION MODELING PROGRAM

- **SYSTEMATIC LABORATORY TESTING**
  - IDENTIFY DEGRADATION MODES
  - IDENTIFY PHENOMENOLOGY
  - DEVELOP PARAMETRIC DEPENDENCIES (OCCURRENCES AND RATES)
  - IDENTIFY MECHANISMS
- **CONTAINER DEGRADATION MODELING**
  - DEVELOP PRELIMINARY MODELS
  - DEFINE TESTS OF MODELS, CONSIDER ALTERNATE MODELS
  - COMPARE PREDICTIONS TO EXPERIMENTS AND REFINE MODELS
- **WASTE PACKAGE SYSTEM MODELING**
  - COMBINE MODE-SPECIFIC MODELS INTO ONE MODEL FOR ALL MODES
  - PREDICT BEHAVIOR UNDER RANGE(S) OF REPOSITORY CONDITIONS
  - PERFORM SENSITIVITY AND UNCERTAINTY ANALYSIS

ENGINEERED BARRIER SYSTEM PERFORMANCE

CALCULATION HIERARCHY



LIQUID PATHWAY RELEASE MODELING

- RAPID RELEASE IS ASSUMED FOR SPENT FUEL GAP AND GRAIN-BOUNDARY RADIONUCLIDE INVENTORIES (A FEW PERCENT OF TOTAL)

- RADIONUCLIDE-SPECIFIC RELEASE MAY BE CALCULATED AS A FUNCTION OF:
  - RADIONUCLIDE CONCENTRATION AT WASTE FORM SURFACE
  - MASS FRACTION IN WASTE FORM
  - FORWARD RATE OF MATRIX DISSOLUTION
  - RADIONUCLIDE RETARDATION
  - FLUX OF GROUNDWATER
  - OTHER FACTORS (RATES OF ALTERATION PHASE FORMATION, COLLOID FORMATION, AND CLADDING DEGRADATION)

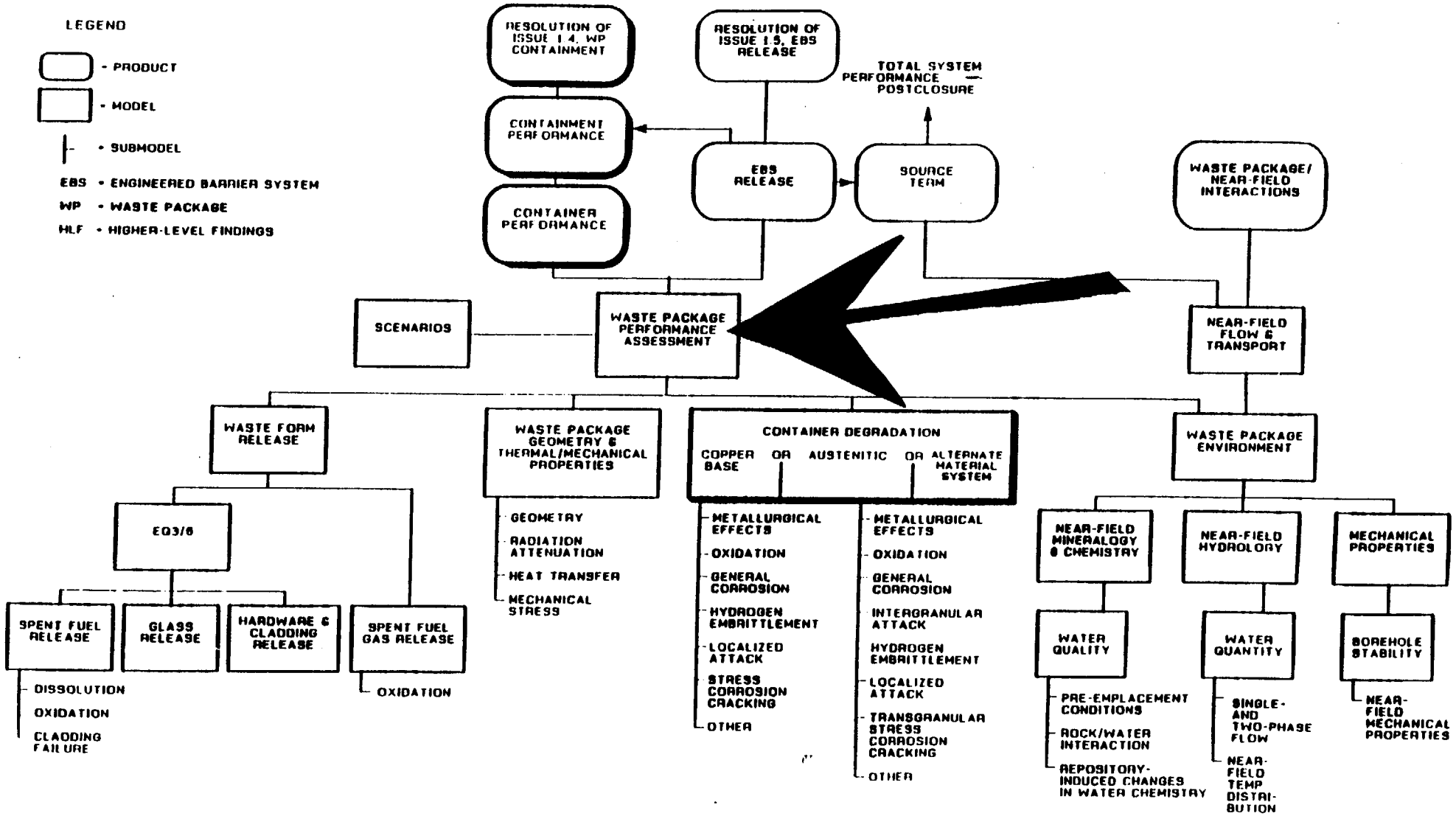
- IF GROUNDWATER FLUX IS VERY LOW, DIFFUSION-CONTROLLED FLUX MAY BE CALCULATED AS A FUNCTION OF:
  - RADIONUCLIDE CONCENTRATION AT WASTE FORM SURFACE
  - POROSITY
  - RADIONUCLIDE DIFFUSION COEFFICIENT
  - RADIONUCLIDE RETARDATION

GAS PATHWAY RELEASE MODELING

- **THE RADIONUCLIDE GAS FRACTION MAY BE CALCULATED AS A FUNCTION OF:**
  - **INITIAL GAS INVENTORY**
  - **RADIONUCLIDE GAS PRODUCTION RATE (e.g. $^{14}CO_2$)**
  - **GAS ADVECTION VELOCITY**
  - **RADIONUCLIDE GAS PARTITIONING INTO GROUNDWATER**
  - **GAS-FILLED POROSITY/TORTUOSITY**
  - **DIFFUSION COEFFICIENT**
  - **APERTURE OF CONTAINER/CLADDING FAILURE**
- **THE PRODUCTION RATE OF A GASEOUS RADIONUCLIDE MAY BE CALCULATED AS A FUNCTION OF:**
  - **CONTAINER FAILURE RATE**
  - **RADIONUCLIDE VOLATILITY**
  - **CLADDING DEGRADATION RATE**

ENGINEERED BARRIER SYSTEM PERFORMANCE

CALCULATION HIERARCHY



WASTE PACKAGE PERFORMANCE ASSESSMENT PROGRAM

- **WASTE PACKAGE ENVIRONMENTS**
  - SUBMODELS
  - CALCULATIONAL MODELS
  - CALCULATION OF CONDITIONS
- **CONTAINER DEGRADATION**
  - DEGRADATION MODES
  - INITIATING CONDITIONS AND PROCESS RATES
  - PROJECTION OF FAILURE RATES

WASTE PACKAGE PERFORMANCE ASSESSMENT PROGRAM

(CONTINUED)

- **ENGINEERED BARRIER SYSTEM RELEASE RATE**
  - SUBMODELS
  - MASS TRANSFER MODELS
  - CALCULATION OF RELEASE PERFORMANCE
- **INPUT TO TOTAL SYSTEM PERFORMANCE**
  - DISRUPTIVE PROCESS AND EVENT SUBMODELS
  - SIMPLIFIED ENGINEERED BARRIER SYSTEM MODEL
  - CALCULATION OF TIME-DEPENDENT CONCENTRATIONS AT HOST-ROCK/EBS INTERFACE

ENGINEERED BARRIER SYSTEM PERFORMANCE MODELING HIERARCHY

- **SYSTEM LEVEL MODELING:**

  eg: PANDORA (DETERMINISTIC); AREST (PROBABILISTIC)

- **PROCESS MODELING**

  eg: ORIGEN2 (WASTE RADIONUCLIDE CONTENT, HEAT AND RADIATION OUTPUT); ADINAT (CONDUCTIVE AND CONVECTIVE HEAT AND MASS TRANSFER); EQ3/EQ6 (SPECIATION/SOLUBILITY AND REACTION PATHS); SPECTROM 31 (ROCK STRESS AND FRACTURE ALTERATIONS)

- **MECHANISTIC MODELING**

  eg: CONTAINER FAILURE MODE MODELS AND WASTE FORM DEGRADATION MODELS AT THE MECHANISTIC LEVEL OF DETAIL, IF POSSIBLE

ENGINEERED BARRIER PERFORMANCE ASSESSMENT ACTIVITIES FOR FY 1989-90

- **BENCHMARKING**
  - USING PROBLEM SETS CURRENTLY BEING DEFINED
  - USING A PRELIMINARY ANALYSIS COMPLETED IN FY 1988
  - AREST/SYVAC-VAULT COMPARISON
- **SENSITIVITY AND UNCERTAINTY ANALYSES TO HELP GUIDE TESTING**
- **MODEL DEVELOPMENT**
- **PRELIMINARY ANALYSIS OF GLASS WASTE FORM PERFORMANCE**