Data and Modeling for Predicting Radionuclide Transport

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Presentation to the
National Academy of Sciences
WIPP Review Panel

August 12-14, 1991
Idaho Falls, Idaho

Summary of Key Points

- K_d model is of questionable utility for WIPP
- Successfully demonstrated adsorption model for uranium
- Adsorption model can predict retardation given technically-feasible data describing radionuclides
- Field-scale chemical/transport model will provide sensitivity of retardation to:
  - heterogeneity,
  - water compositions,
  - and source term,

  as validated by integrated experiments

Outline

- Summary of Recent Culebra Characterization Work
- Relationship of Big Picture to Little Picture
- K_d Model and Available WIPP Culebra Data
- Adsorption Studies
- Solubility and Speciation Studies
- Integrated Chemical/Transport Model
- Conclusions

Major Characterization Work

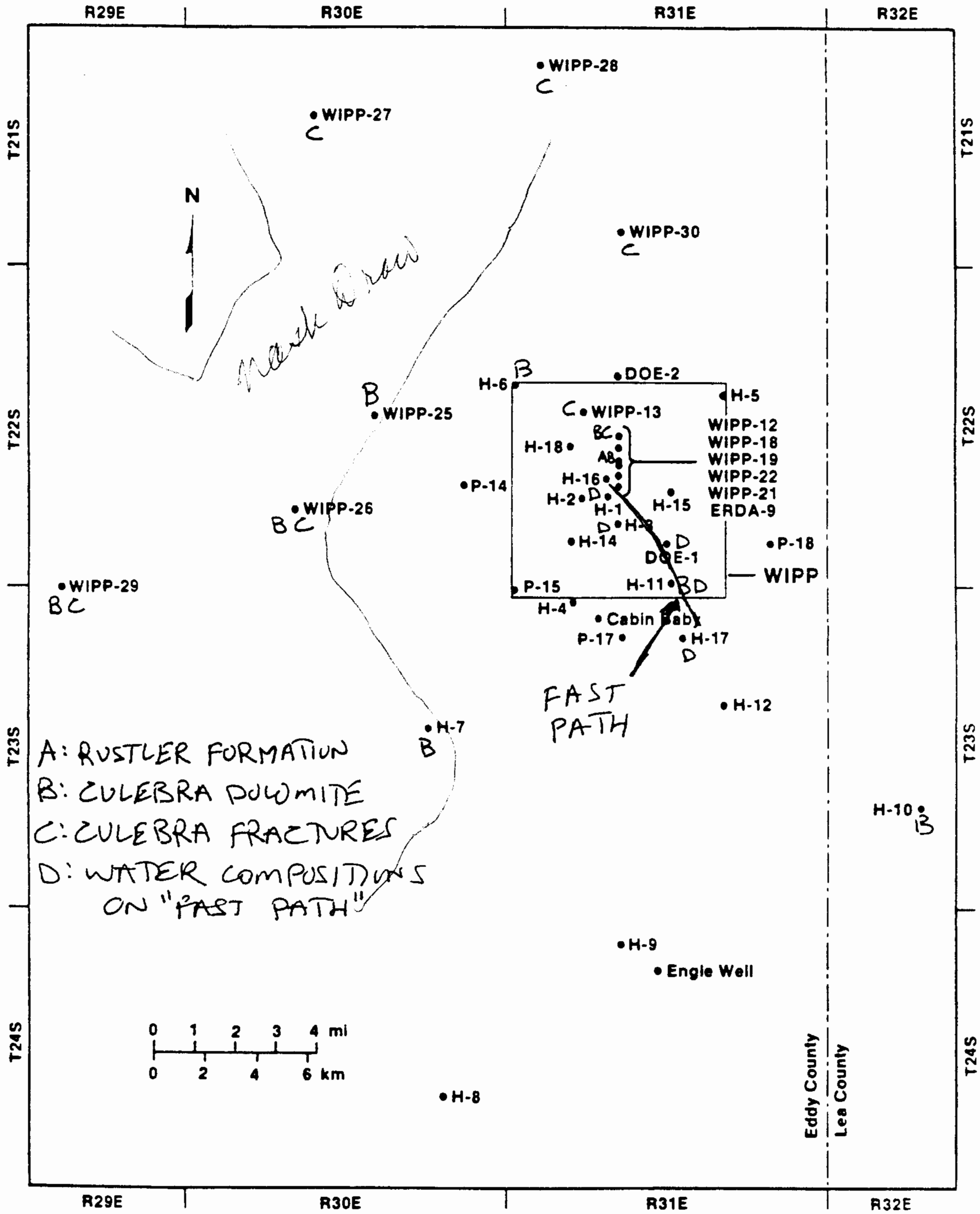
Rustler formation (SAND87-7036, T Sewards, K Keil) A
- mineral composition vs location and depth

Culebra dolomite member (SAND90-7008, T Sewards, K Keil) B
- contains dolomite, gypsum, calcite, corrensite

Culebra fracture surfaces (SAND90-7019, T Sewards) C
- horizontal fractures along clay seams

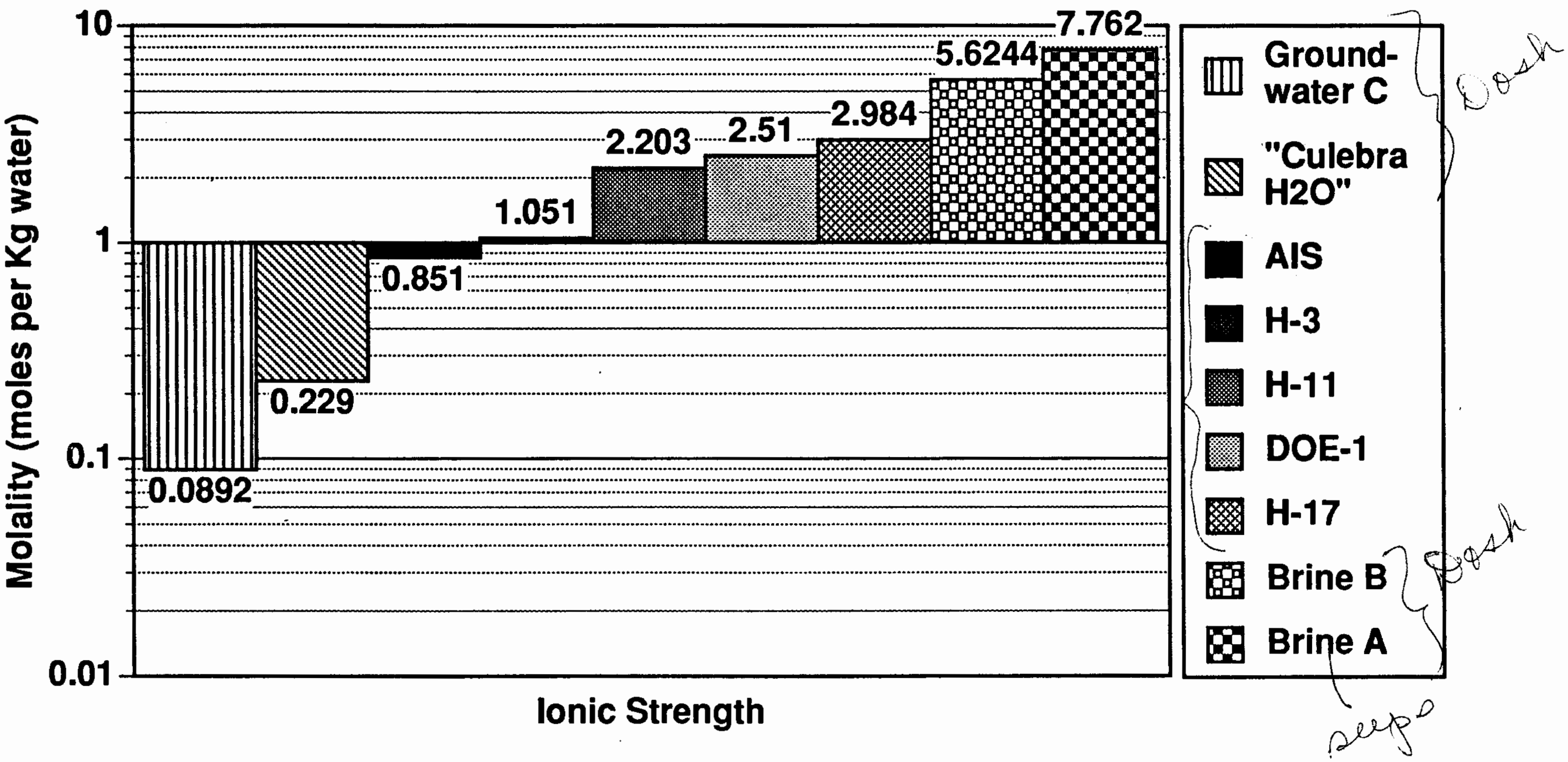
Water compositions along "fast path"
(SAND90-0418, 0419, Seigel) D
- Chemical interaction with other members necessary to describe water composition variation

Sample Locations for Characterization Reports



TRI-6342-19-1

Five Culebra Groundwaters and Four Simulants Used for Batch Kd Experiments Show Wide Variation in Ionic Strength



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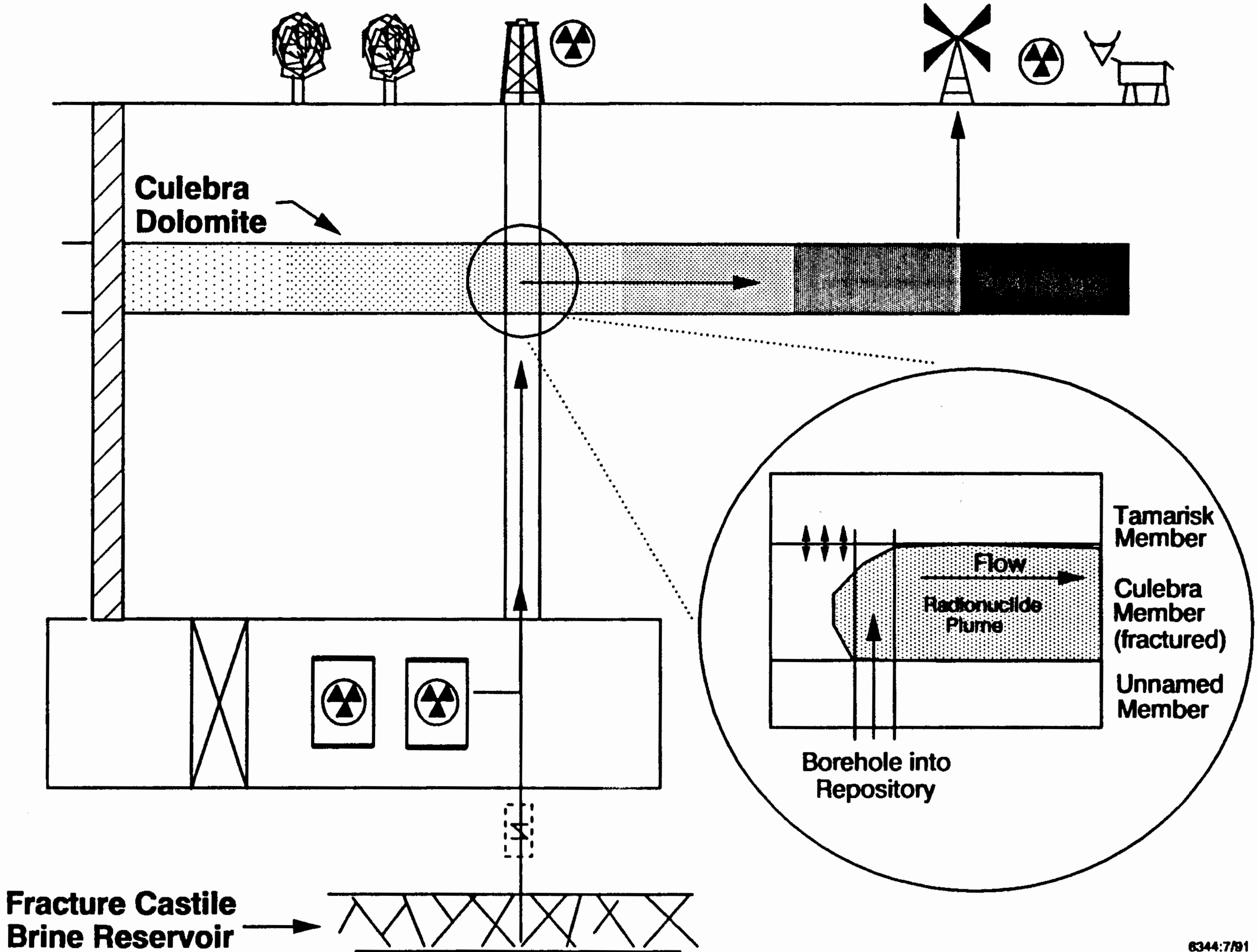
Demonstrate Strength of Chemical Barrier in Important PA Scenarios



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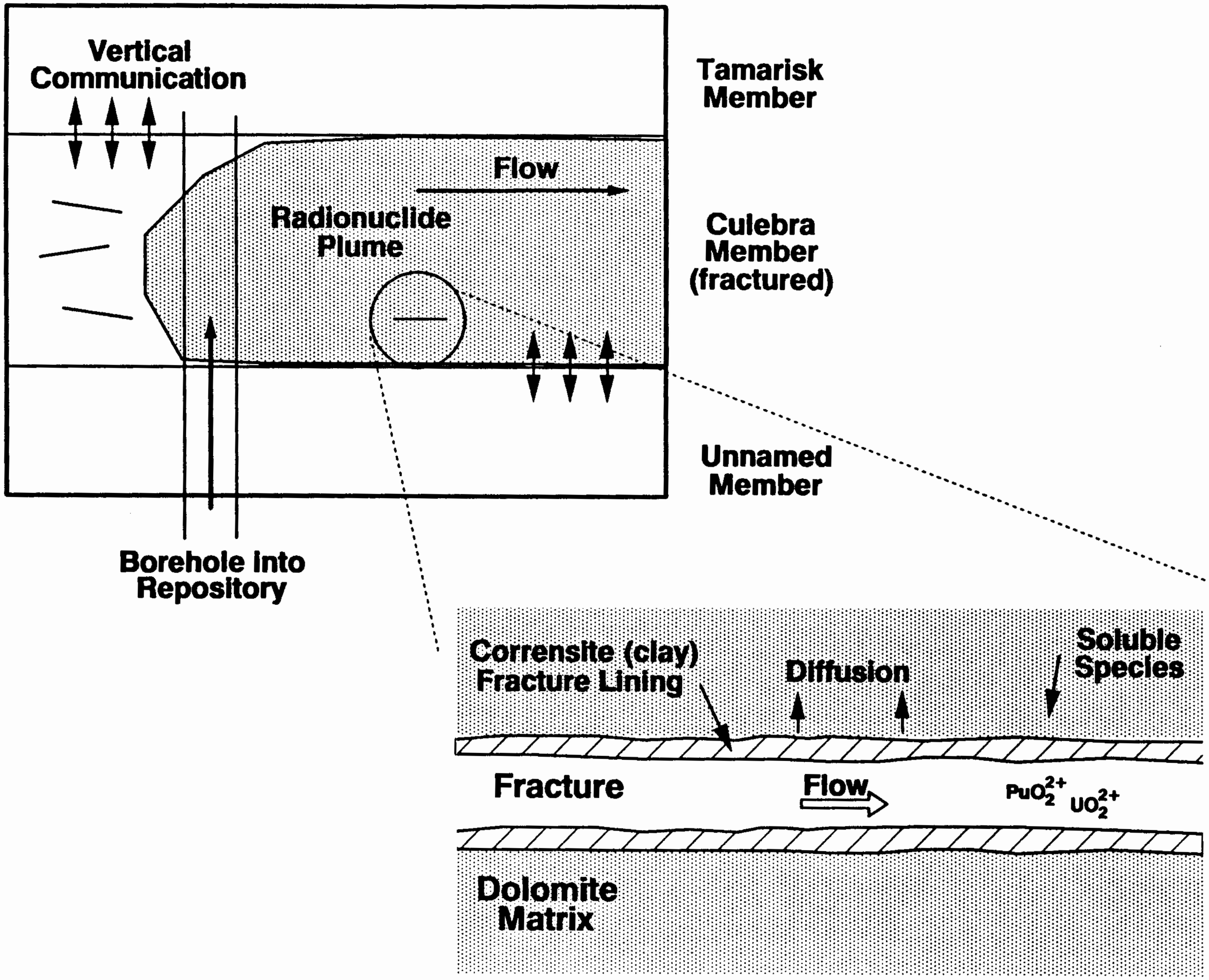
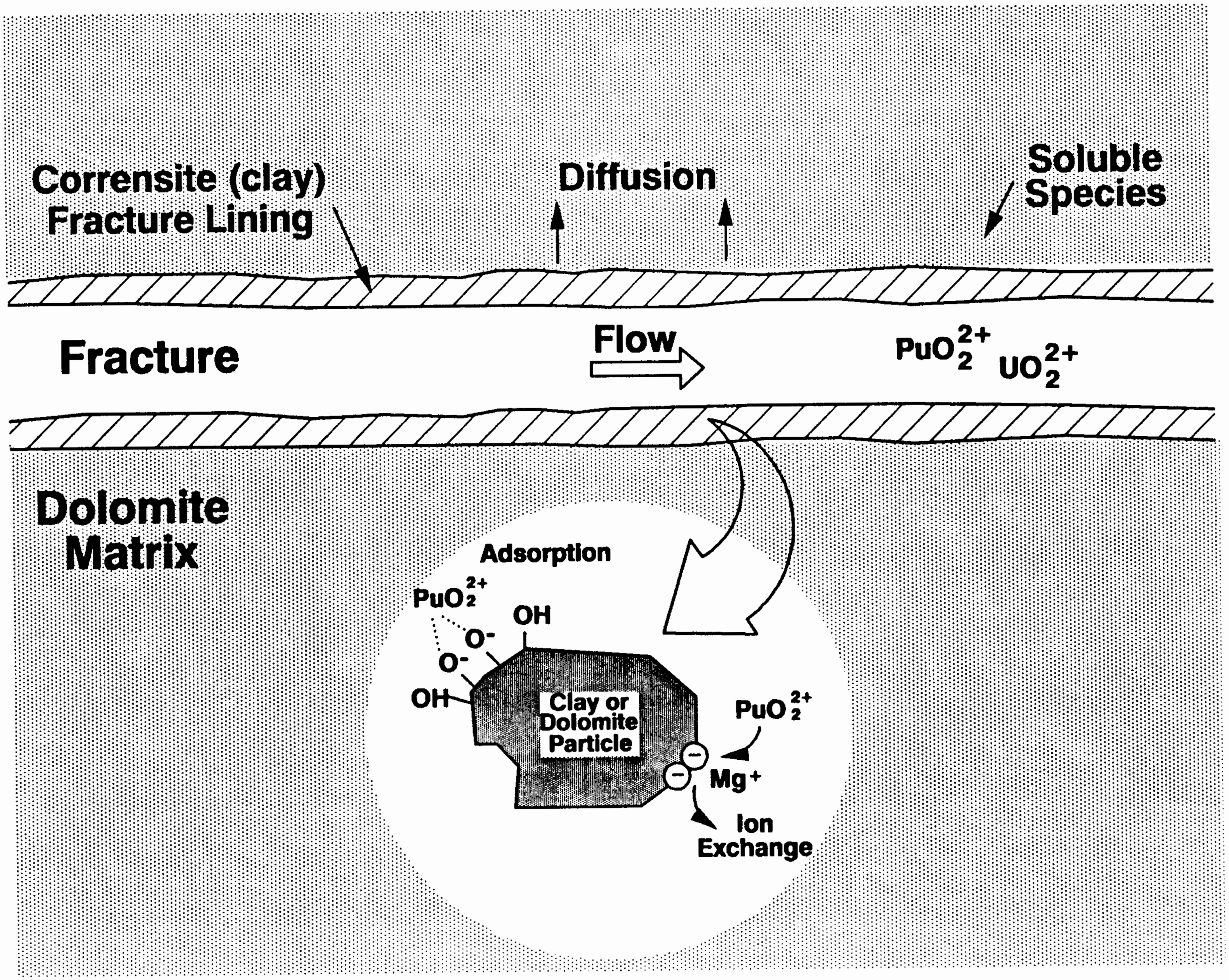
ChemBarr

Fracture/Matrix Transport in the Rustler



Mechanisms Causing Retardation in the Rock Matrix



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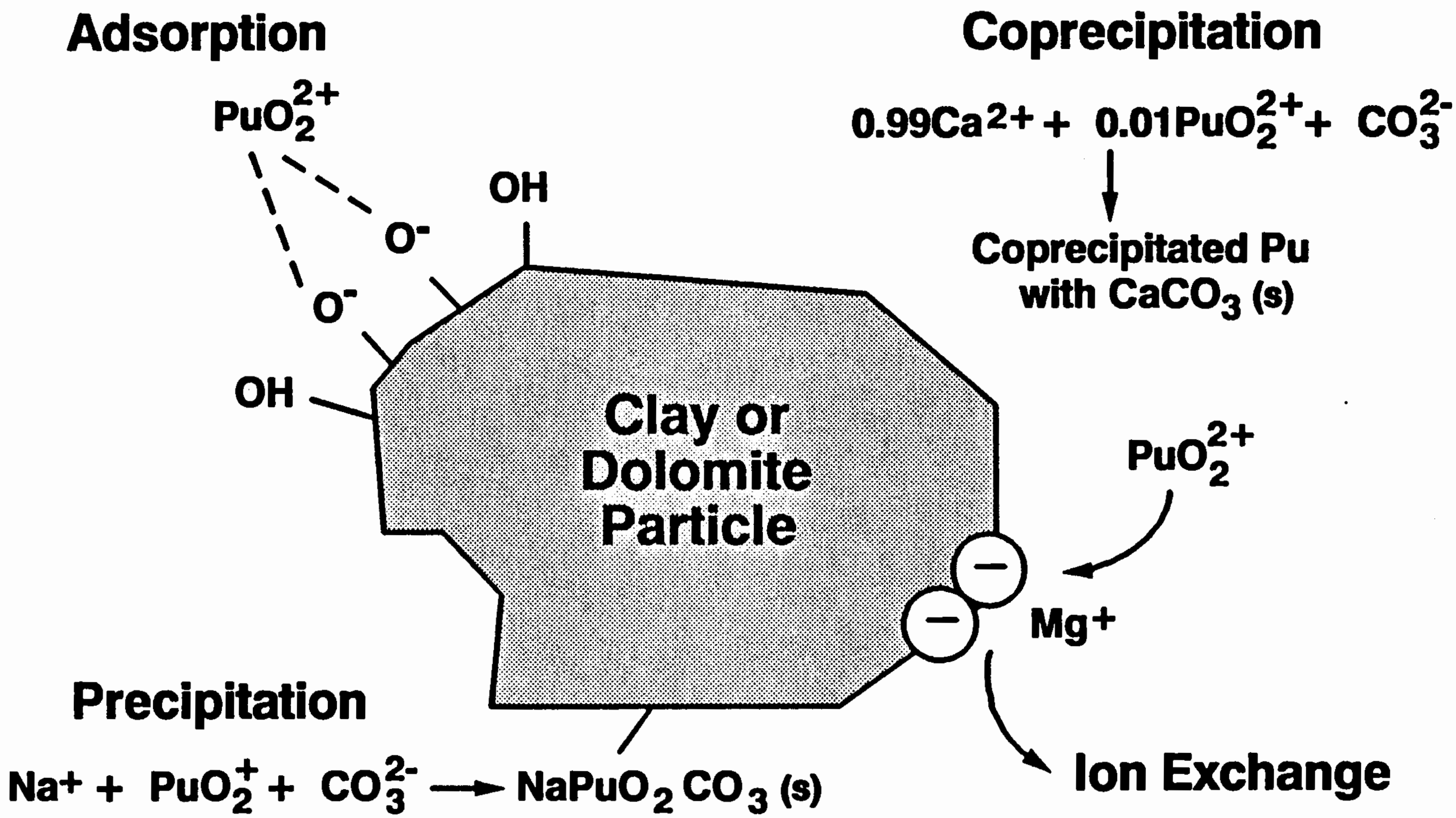
Chemical Phenomena Responsible for Retardation



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Particle

The K_d Sorption Model

- Assumes retardation is a linear function of K_d
- Approximate relationship for the Culebra

$$R = 1 + 10\,K_d$$

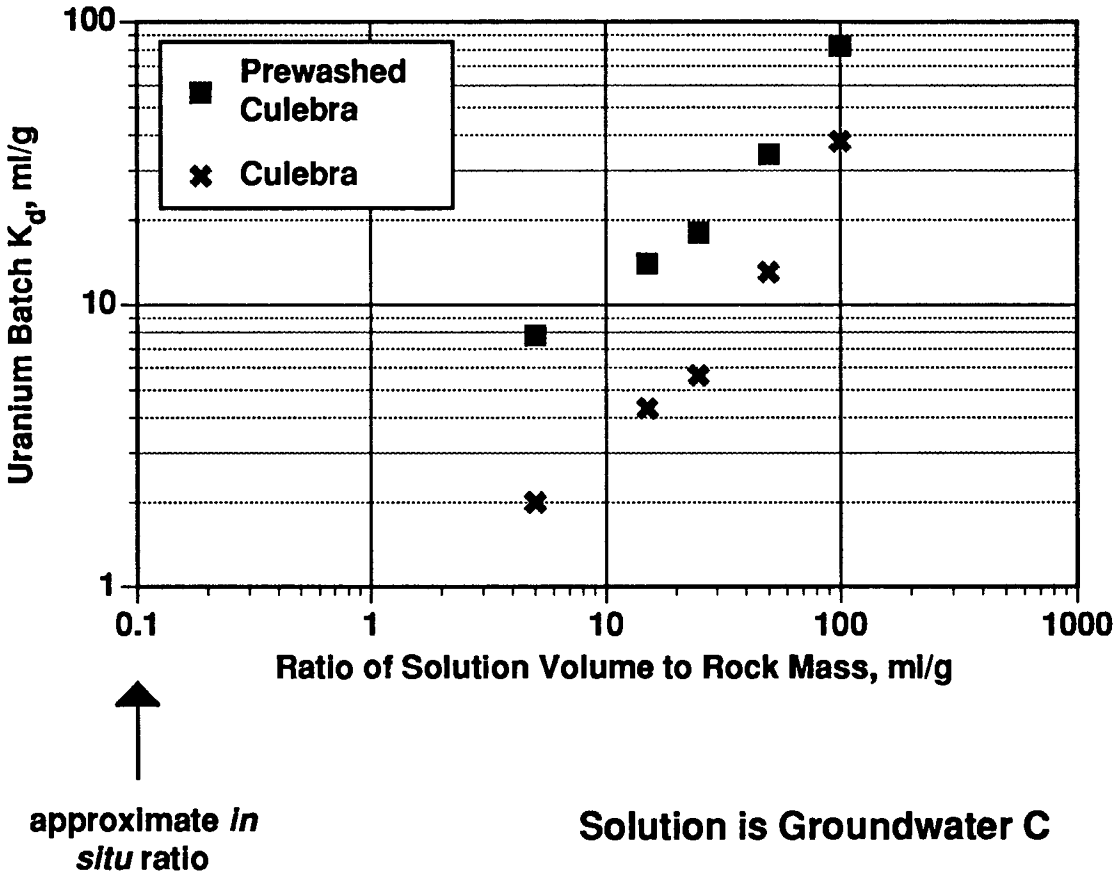
K_d in $\frac{ml}{g}$

Current Assumptions in WIPP Application of the K_d Sorption Model

- K_d is independent of
  - liquid to solid ratio used in batch experiments
  - Culebra substrate composition and sample preparation
  - solution composition

Batch Kd Data for Uranium Sorption Depend on Solution Volume to Rock Mass Ratio, and Pretreatment of Rock

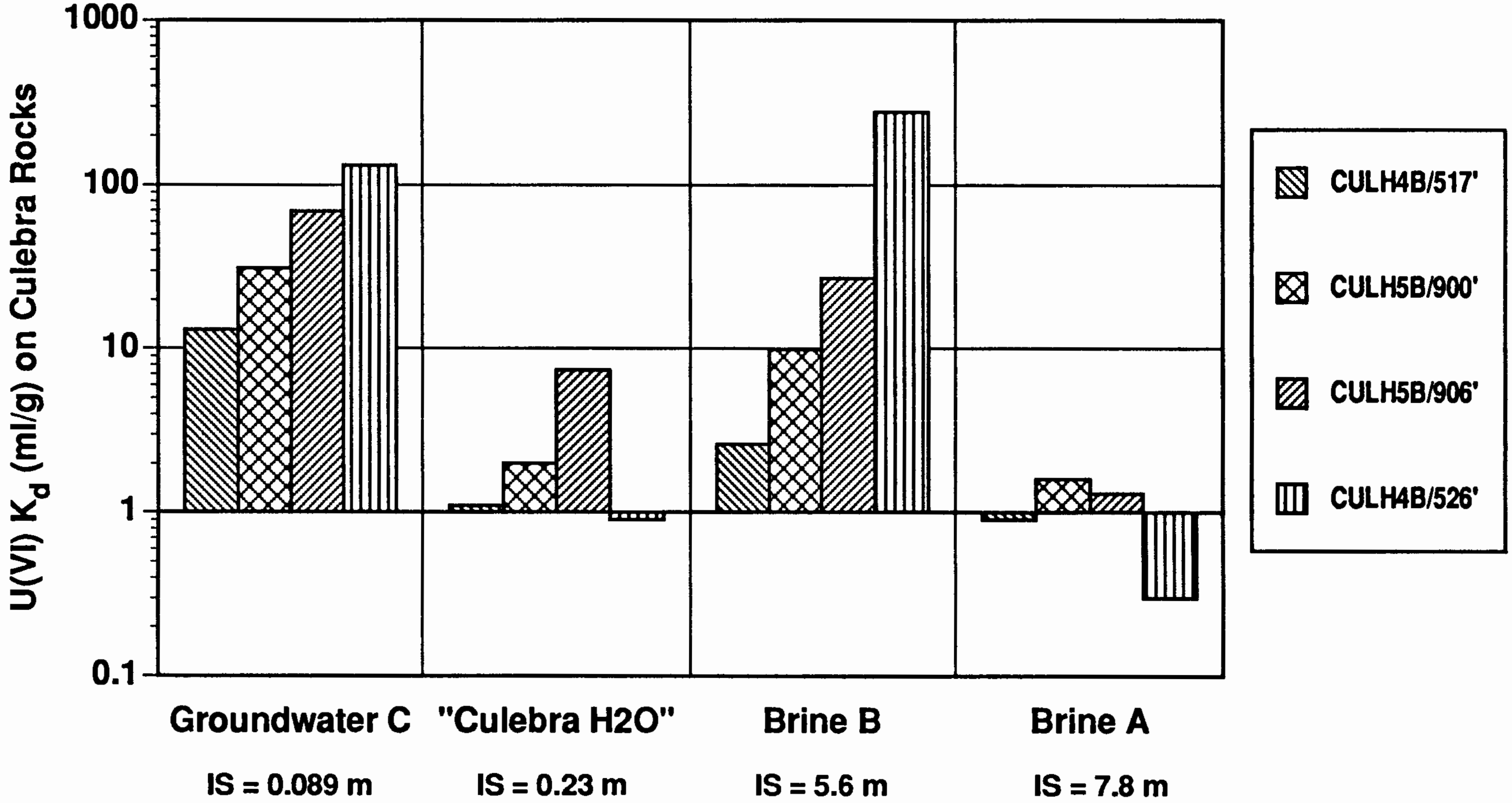
Data from SAND80-1595, R.G. Dosch; Figure from SAND91-1299, C.F. Novak



Solution is Groundwater C

Batch Kd Data for Uranium Depend on Water Composition and Culebra Rock Sample

Data from SAND80-1595, R.G. Dosch; Figure from SAND91-1299, C.F. Novak



Current Assumptions in WIPP Application of the K_d Sorption Model

- K_d is independent of
  - liquid to solid ratio used in batch experiments — CONTRADICTED BY DATA
  - Culebra substrate composition and sample preparation — CONTRADICTED BY DATA
  - solution composition — CONTRADICTED BY DATA

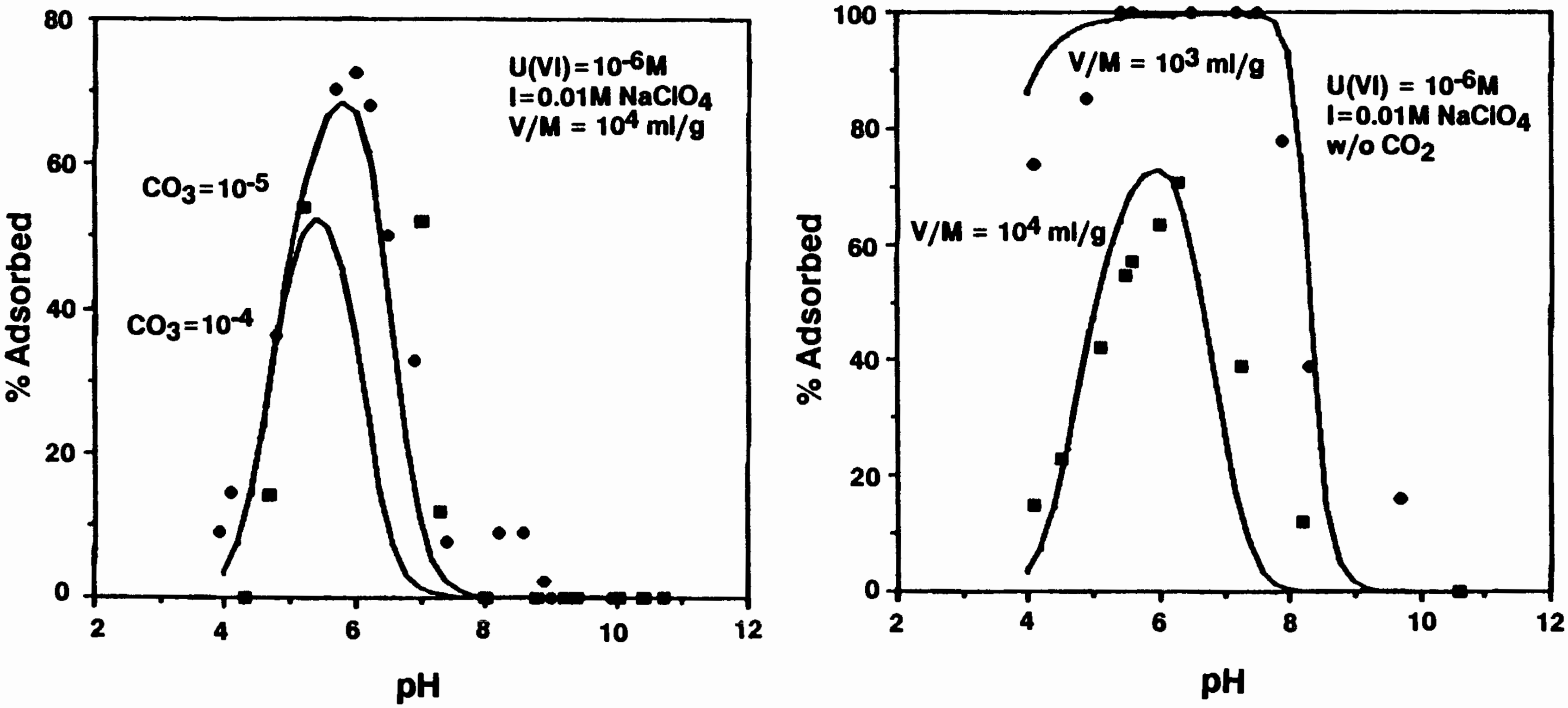
Total Number of Batch K_d Data Points on Culebra Rock

	Brine A	Brine B	Ground-water C	"Culebra H2O"	Brine B + Organics
U	8	8	28	8	
Am	0	3	3	4	~16
Np	0	2	2	0	
Eu	1	1	1	4	
Pu	0	10	2	4	~45

Model for Adsorption, General Framework

- Explicitly accounts for the chemical mechanism primarily responsible for retardation
- Predicts adsorption, and thus retardation, as a function of water and mineral chemistry
- Provides sensitivity to such parameters as:
  - liquid to solid ratio
  - substrate composition
- Ready for application, but data are needed

Model for UO_2^{2+} Adsorption on Corrensite
SAND90-7084, J. Leckie



Adsorption Data Measurement and Modeling
1. Work in Progress

Measure UO_2^{++} adsorption

- on corrensite as a function of concentrations of Na+, Ca++, K+, Mg++, Cl-, $SO_4^{=}$, $B(OH)_3^0$, and EDTA

- on corrensite for simulated WIPP Culebra waters

Validate UO_2^{++} adsorption model against measurements in WIPP Culebra waters

Adsorption Data Measurement and Modeling
2. Proposed Work

- **Measure UO_2^{++} adsorption on dolomite as function of water compositions**

- **Measure adsorption of important radionuclides on corrensite and dolomite as function of water compositions**

  - **important radionuclide include: Am, Cm, Pb, Np, Pu, Ra, Th, U**

for RCRA

Solubility and Speciation Studies
1. Solubility

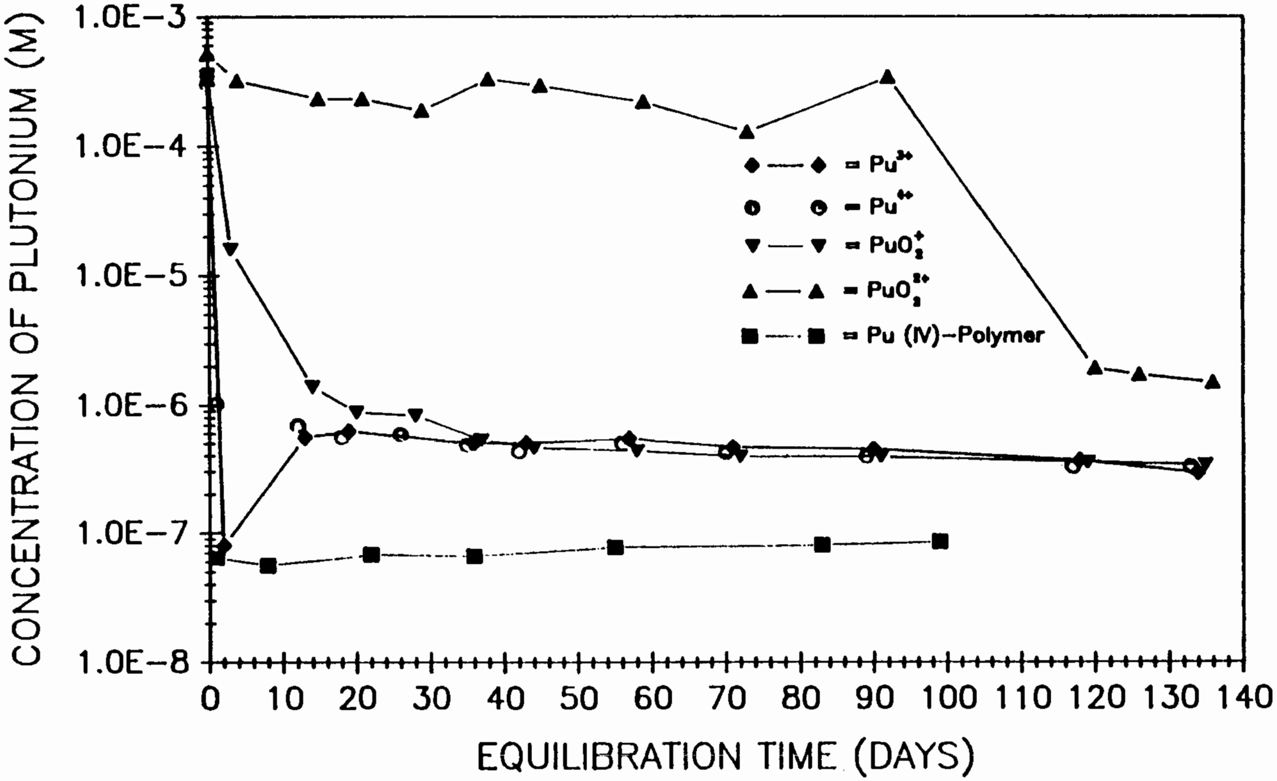
- **Empirical Studies**

- **Provide steady-state concentrations of radionuclides in Culebra waters**

- **Determine solubility-controlling minerals**

- **Provide steady-state redox states**
  - **a controlling factor for retardation**

APPROACH TO EQUILIBRIUM OF AlSinR (SYNTHETIC) WATER SOLUTIONS OF PLUTONIUM IN DIFFERENT OXIDATION STATES at pH 7.5 and 25 °C



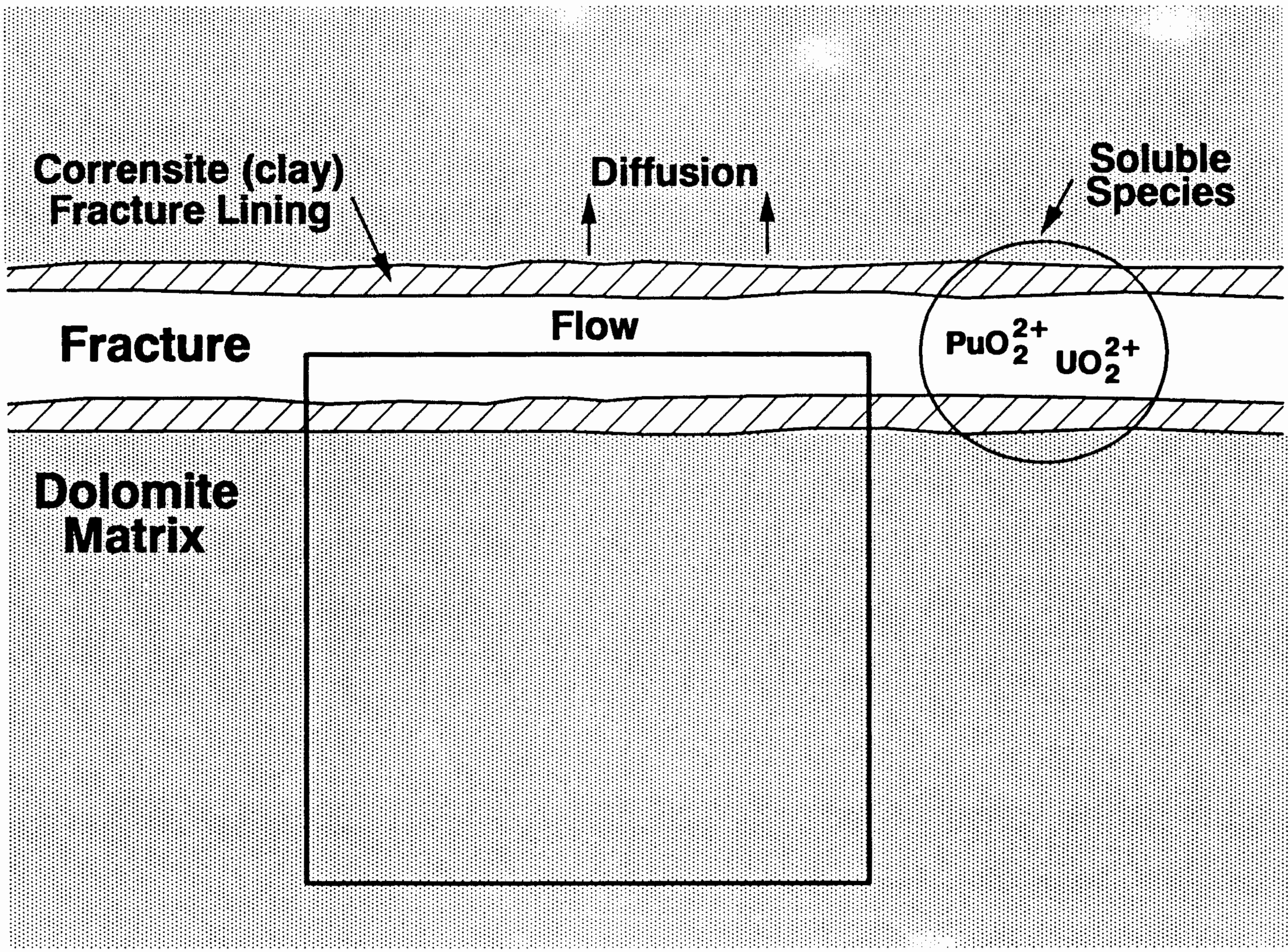
Solubility and Speciation Studies
2. Speciation

- Mechanistic Studies
- Provide species complexation in Culebra waters
  - a controlling factor for retardation
- Yields sensitivity of retardation to water composition
- Allows mechanistic extension of column/field retardation data to off-site transport path lengths

Integrated Chemical/Transport Model

- Incorporates submodels for chemistry responsible for retardation
- Validated against column experiments
- Aids in planning field-scale experiments and additional column experiments
- End result is retardation data for PA

Fracture/Matrix Integrated Chemical/Transport Model Domain



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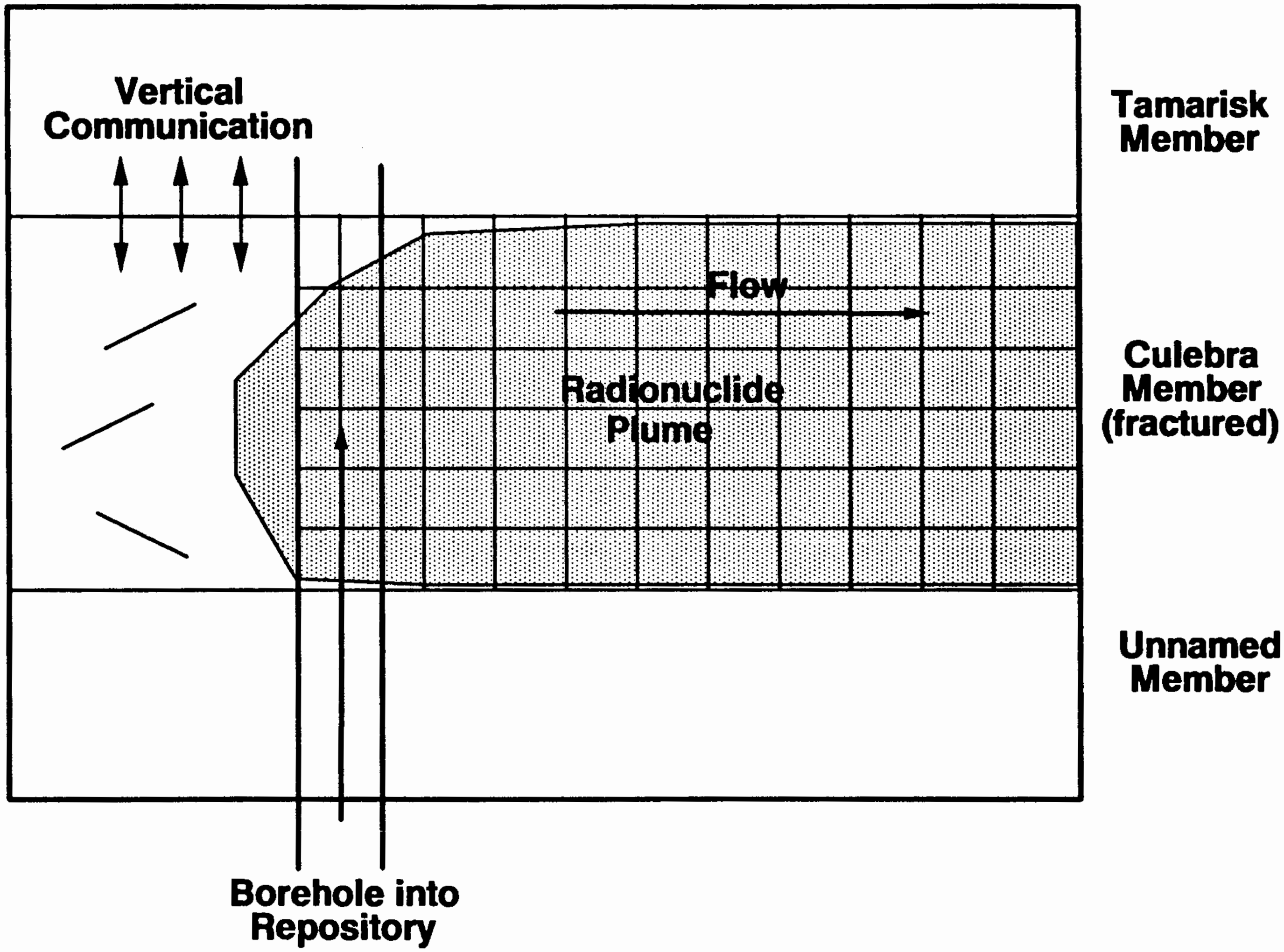
Schematic Assembly of Fracture/Matrix Transport Model for Field Scale Simulation



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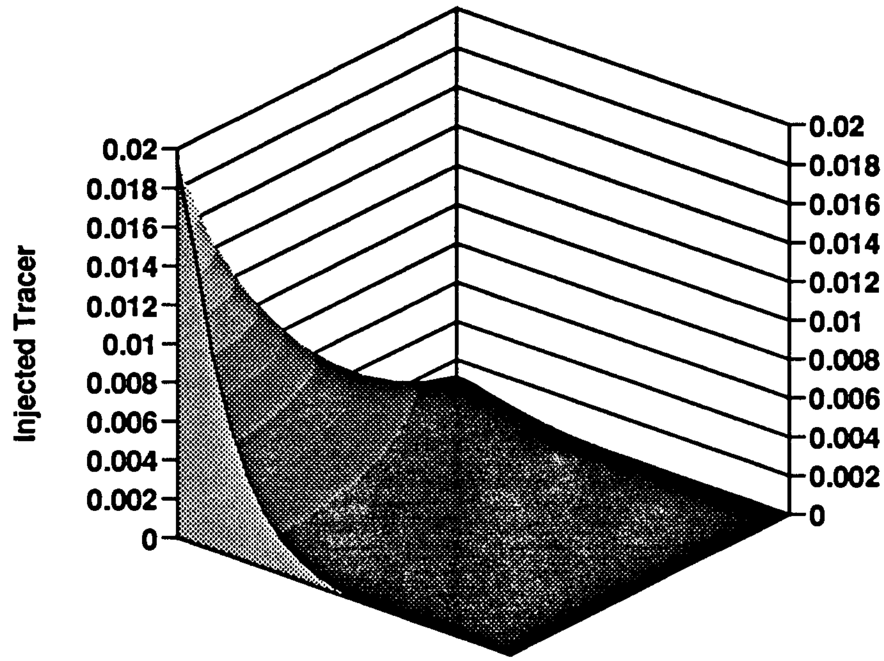
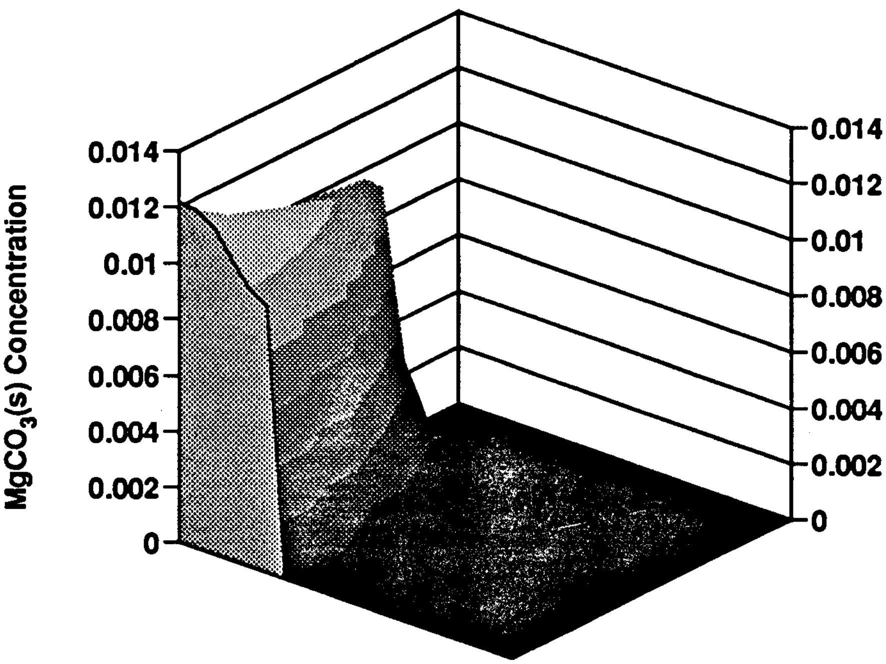
Schem-FM

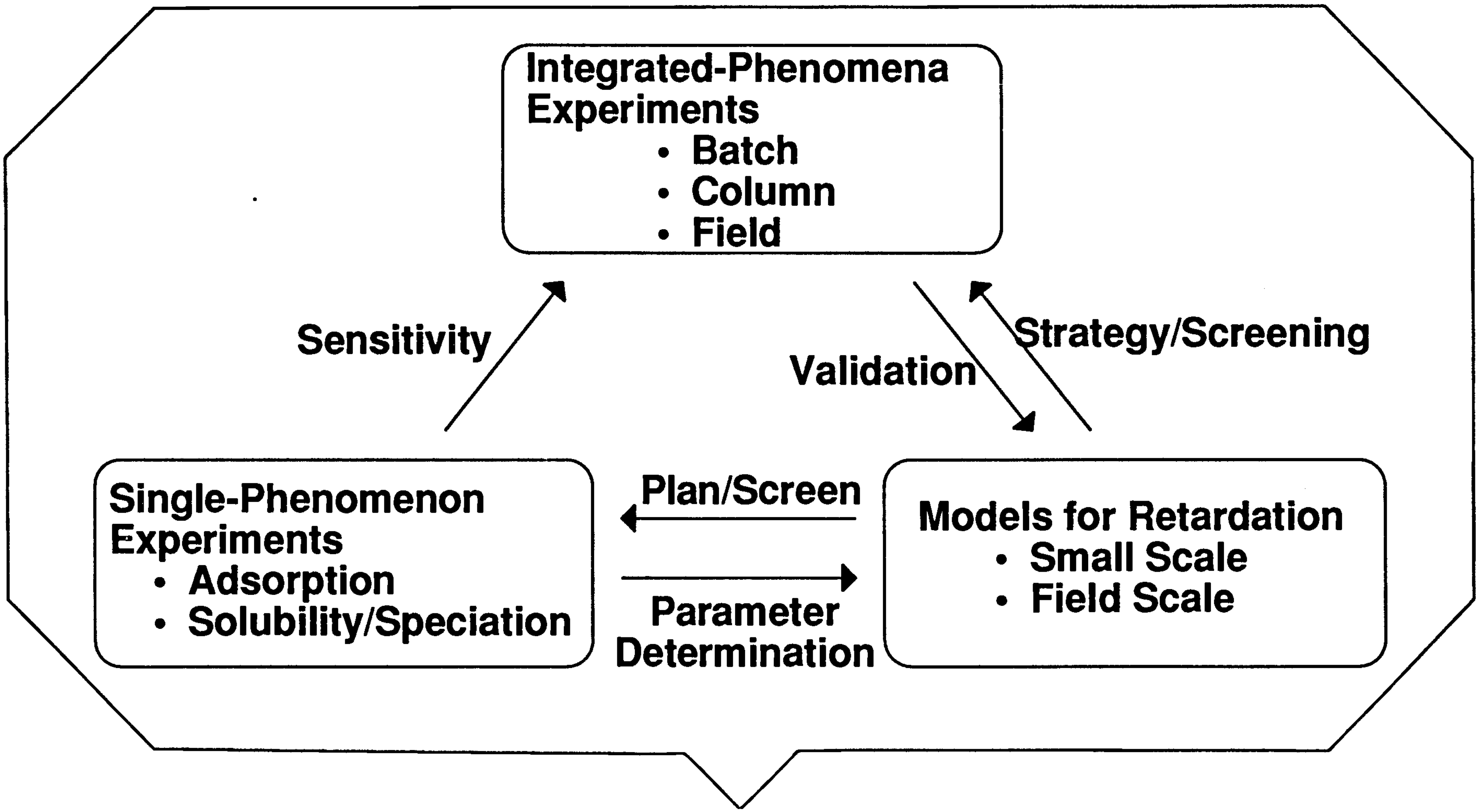
26

Example Results from Transport Model



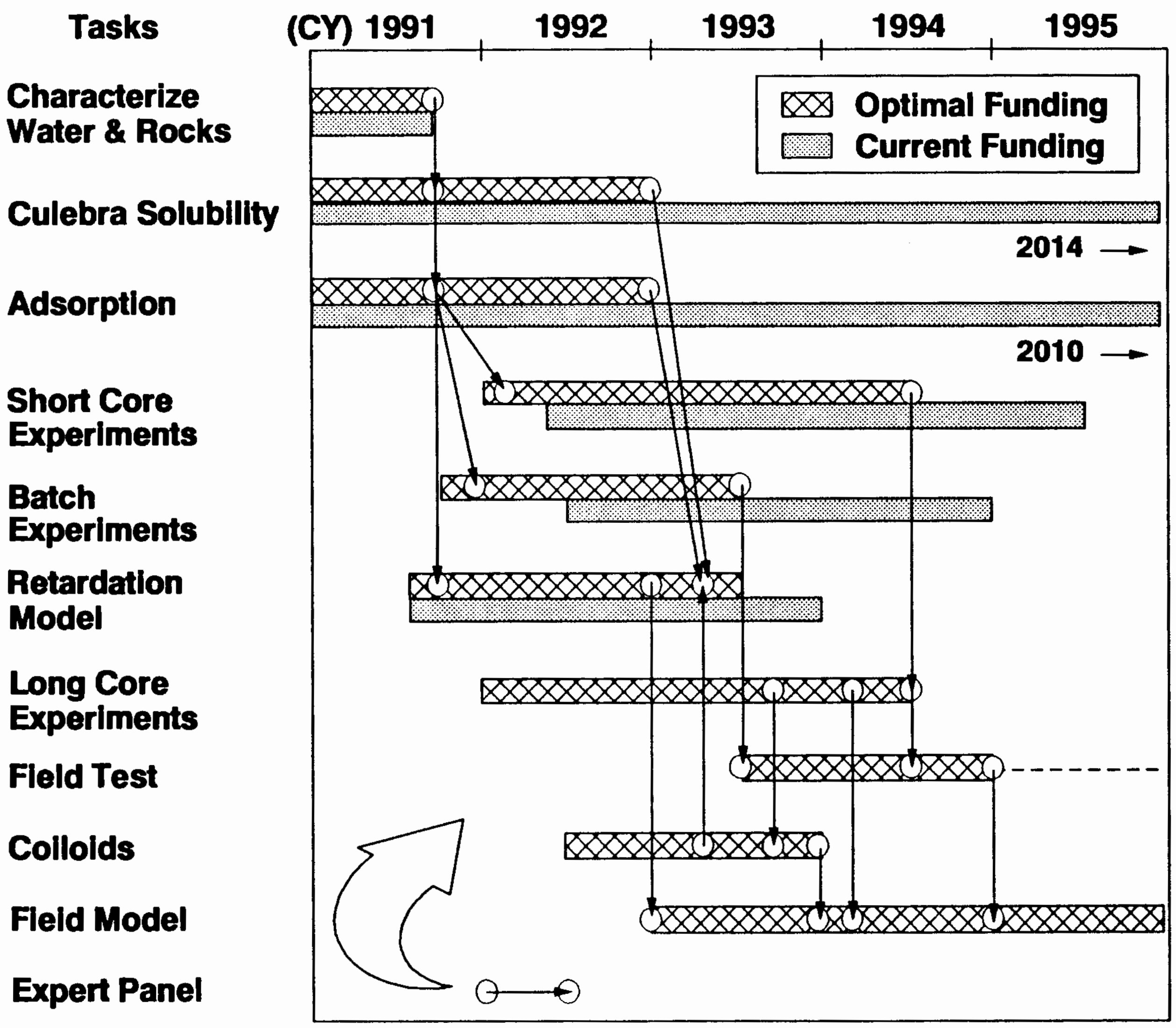


Summary of Approach to Predicting Retardation



Retardation Determination
Data to PA

Retardation Task Schedule



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RetFund3

Conclusions

- K_d model is of questionable utility for WIPP
- Successfully demonstrated adsorption model for uranium
- Complete uranium adsorption model can be applied with data currently being collected
- Data needed for modeling other radionuclides are unavailable but technically feasible
- Field-scale chemical/transport model will provide sensitivity of retardation to heterogeneity, water compositions, and source term, as validated by integrated experiments

Determining Retardation by Integrated-Phenomena Experiments

black box

F. Gelbard

Nuclear Waste Technology Department
Fluid Flow & Transport Division
Sandia National Laboratories

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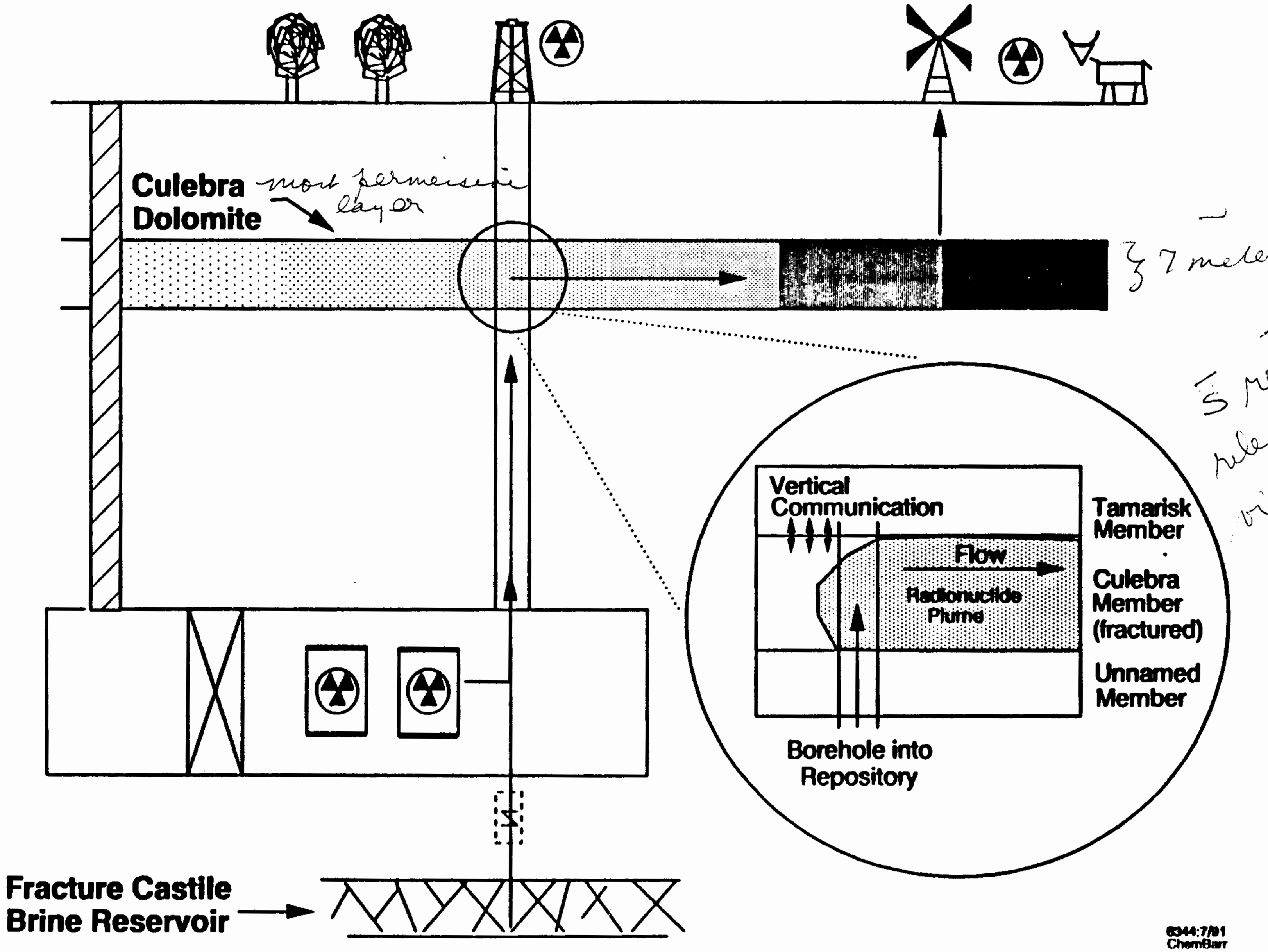
Summary

- Objective: Take credit for retardation by existing chemical barriers in Culebra
- Three integrated-phenomena experiments to demonstrate radionuclide retardation
  - Batch
  - Column
  - Field
- Batch Tests
  - Use crushed rock – powder
  - Provide data of limited use – Kd
- Column Tests
  - Use unaltered rock
  - Provide data on radionuclide retardation, scale, and analog retardation
- Field Tests
  - Potentially most informative
  - Definitely most expensive

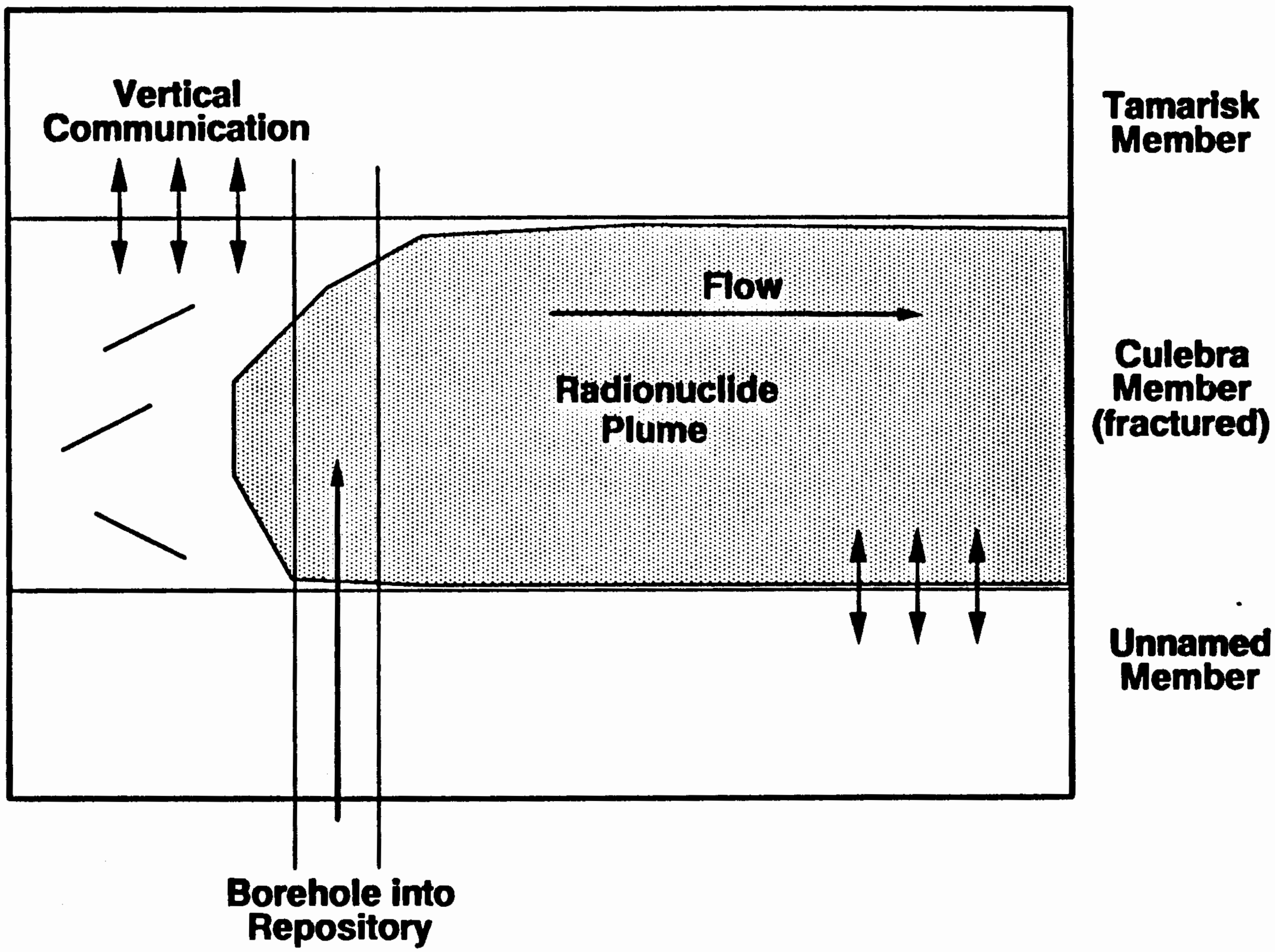
on retardation in
NMP/NMD

Demonstrate Strength of Chemical Barrier in Important PA Scenarios



retardation release would violate NMD/reg

Fracture/Matrix Transport in the Rustler



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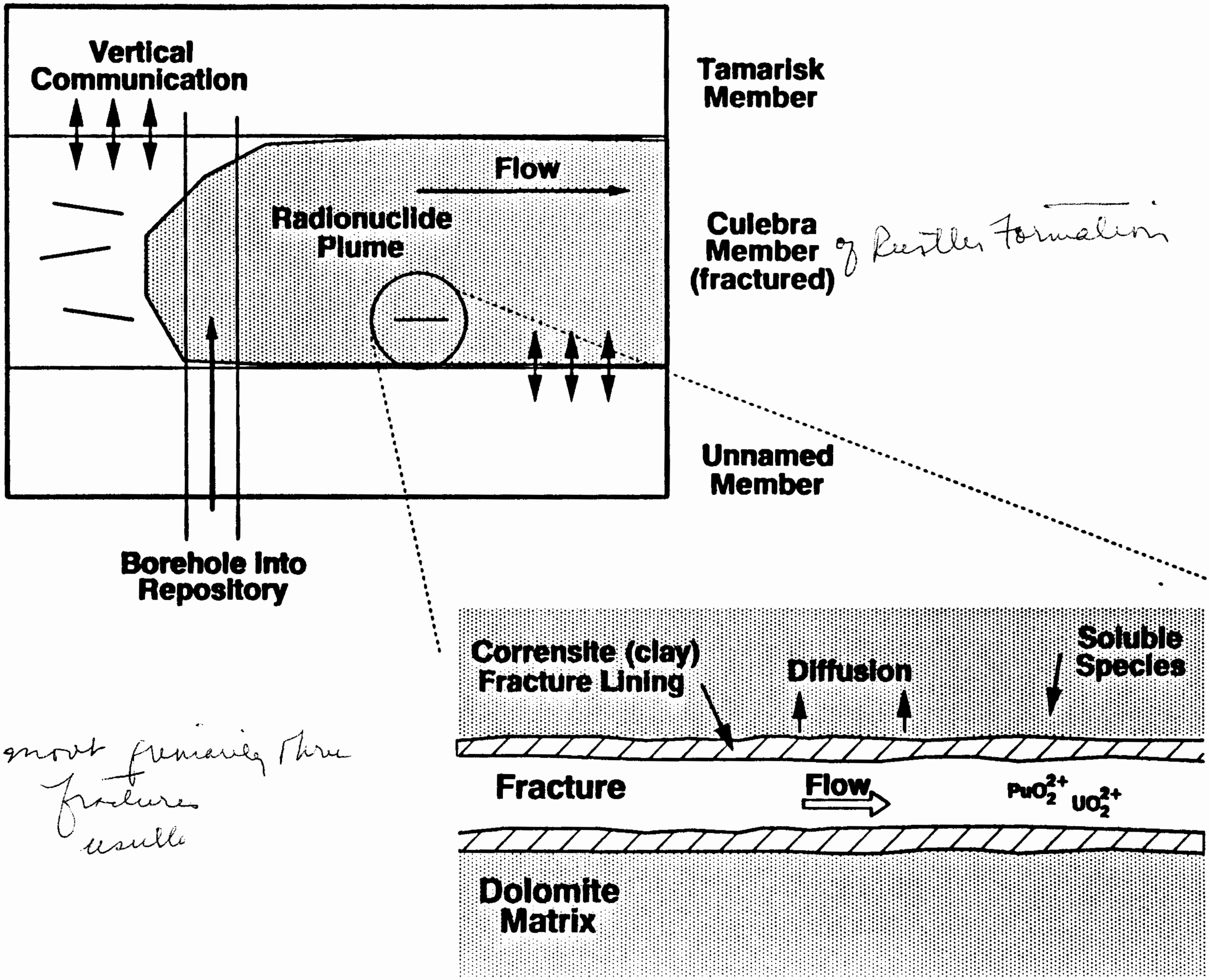
Fracmatx

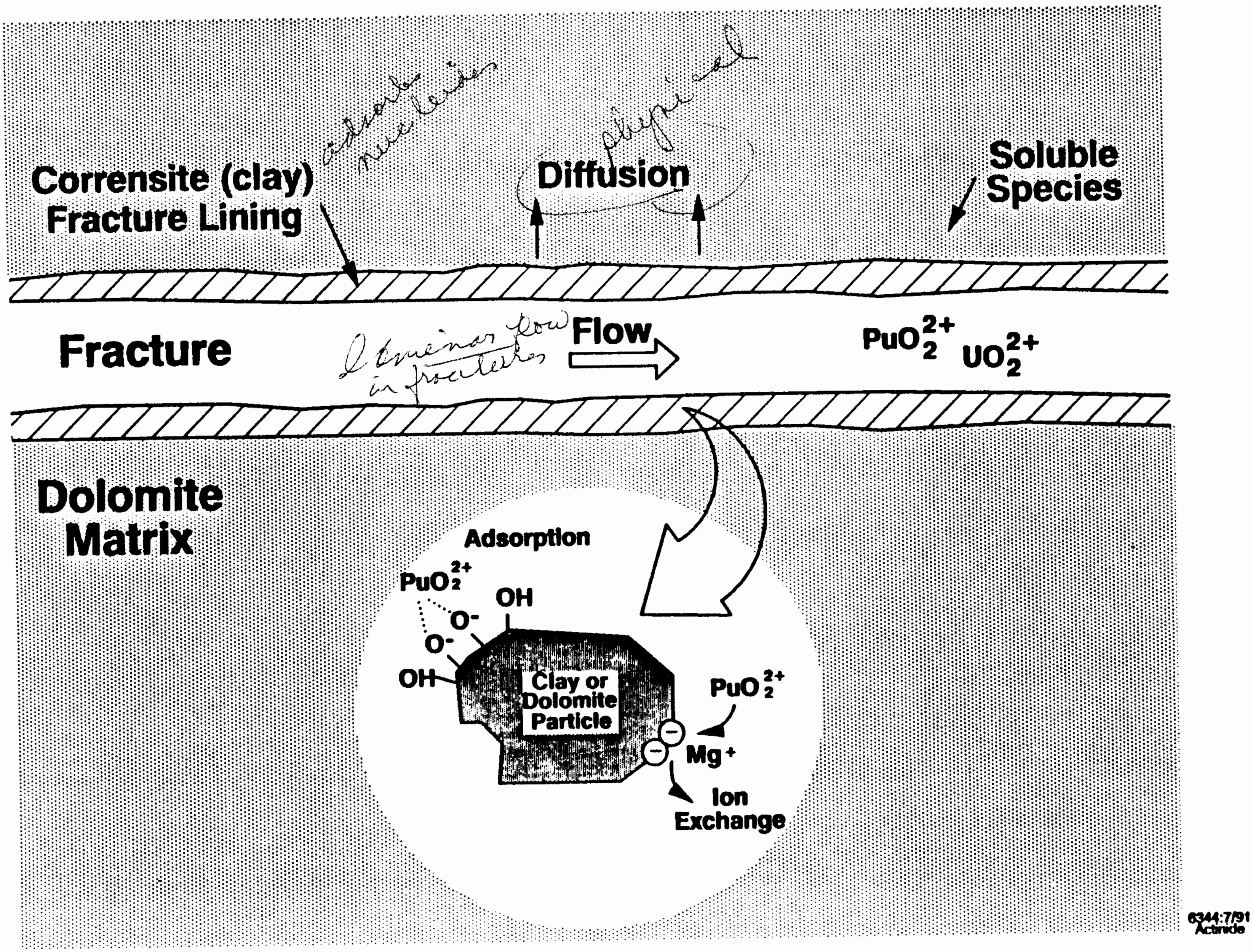
Fracture/Matrix Transport in the Rustler



most pumping thru fractures usually

6344:7/91
Fracture

Mechanisms Causing Retardation in the Rock Matrix



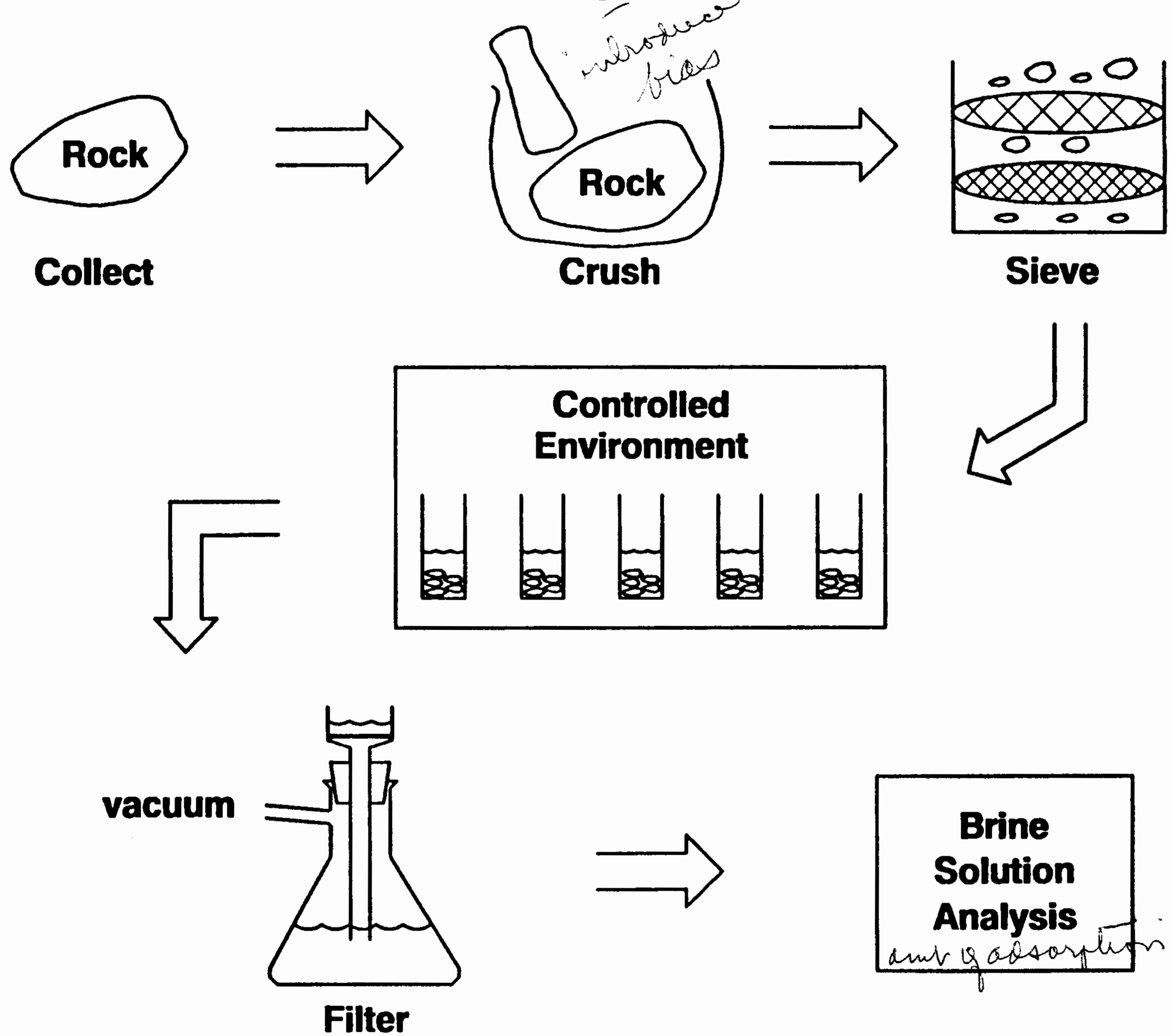
Retardation Processes That Influence Radionuclide Transport

more important than Kd for PA

$$R_i = \frac{\text{Velocity of Water}}{\text{Velocity or Radionuclide i}}$$

- Adsorption
- Ion exchange
- Physical retardation - diffusion
- Precipitation/Coprecipitation
- Colloid formation

Batch Experiments



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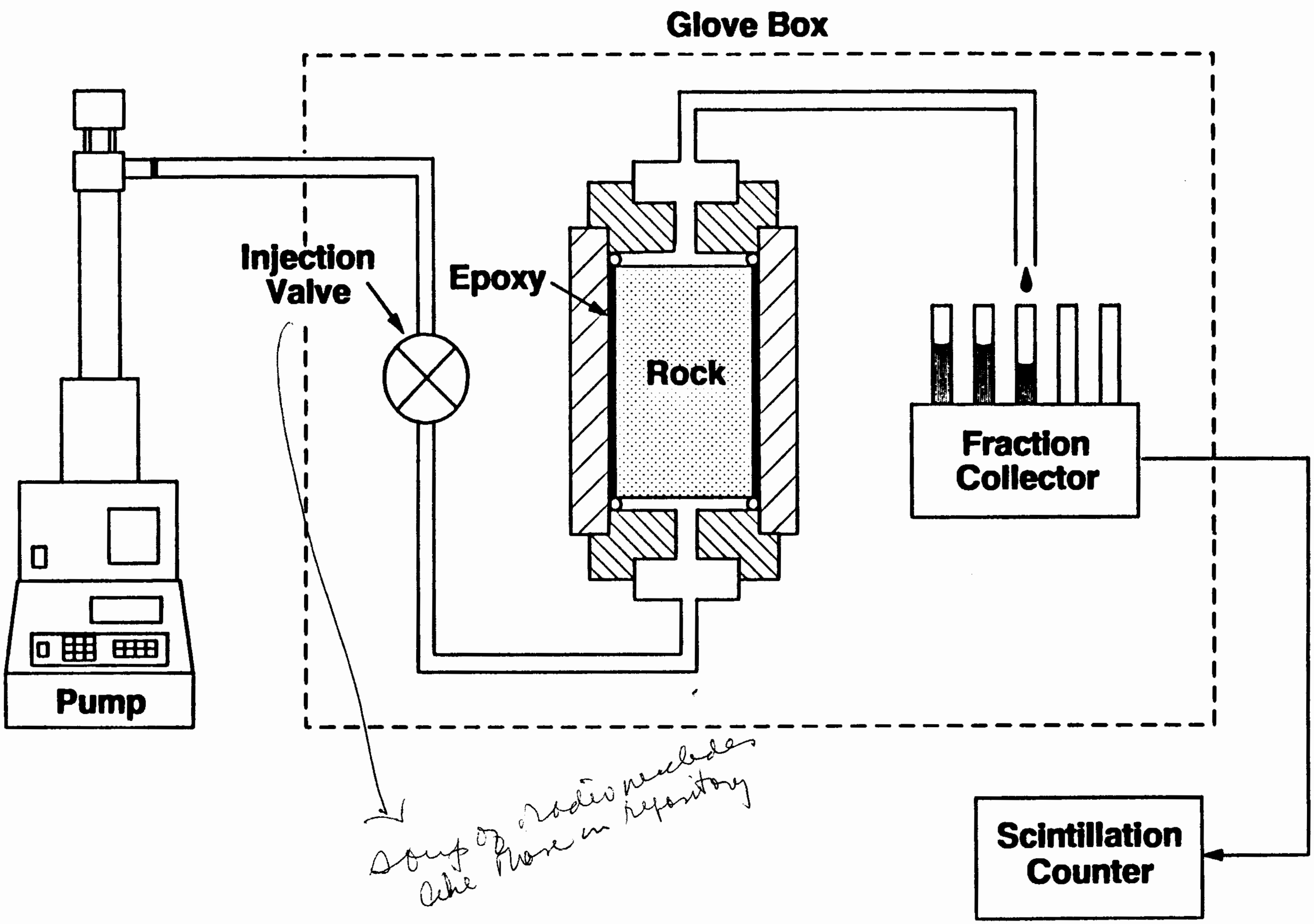
BatchEx

Column Experiments

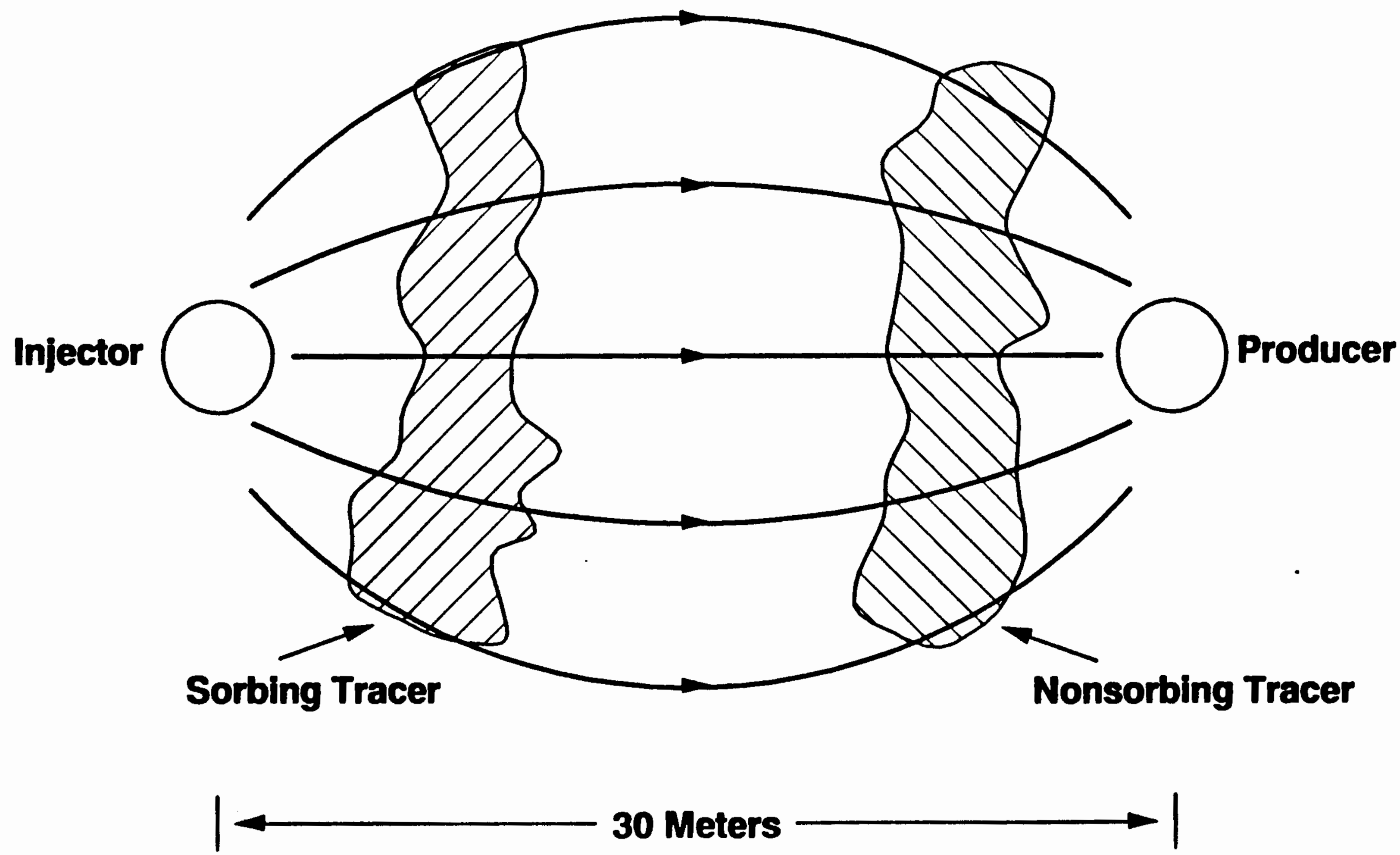


6344:6/91
Glovebox

Laboratory Measurements

	Batch	Short Column	Long Column
Length	NA	3-4 Inches	2-4 feet
Time	Weeks	Months	~1 year
Measurement	Solution concentration	Effluent concentration	Effluent concentration
Surfaces	Artificial	Actual	Actual
Fluid/Rock	Mismatched	Matched	Matched
Data	Maximum sorption	Flow and sorption	Flow, sorption, scale effects and concentration profile

Field Test



6345:7/91
FieldTst

Sorbing Field Test Background

- Part of C & C Agreement

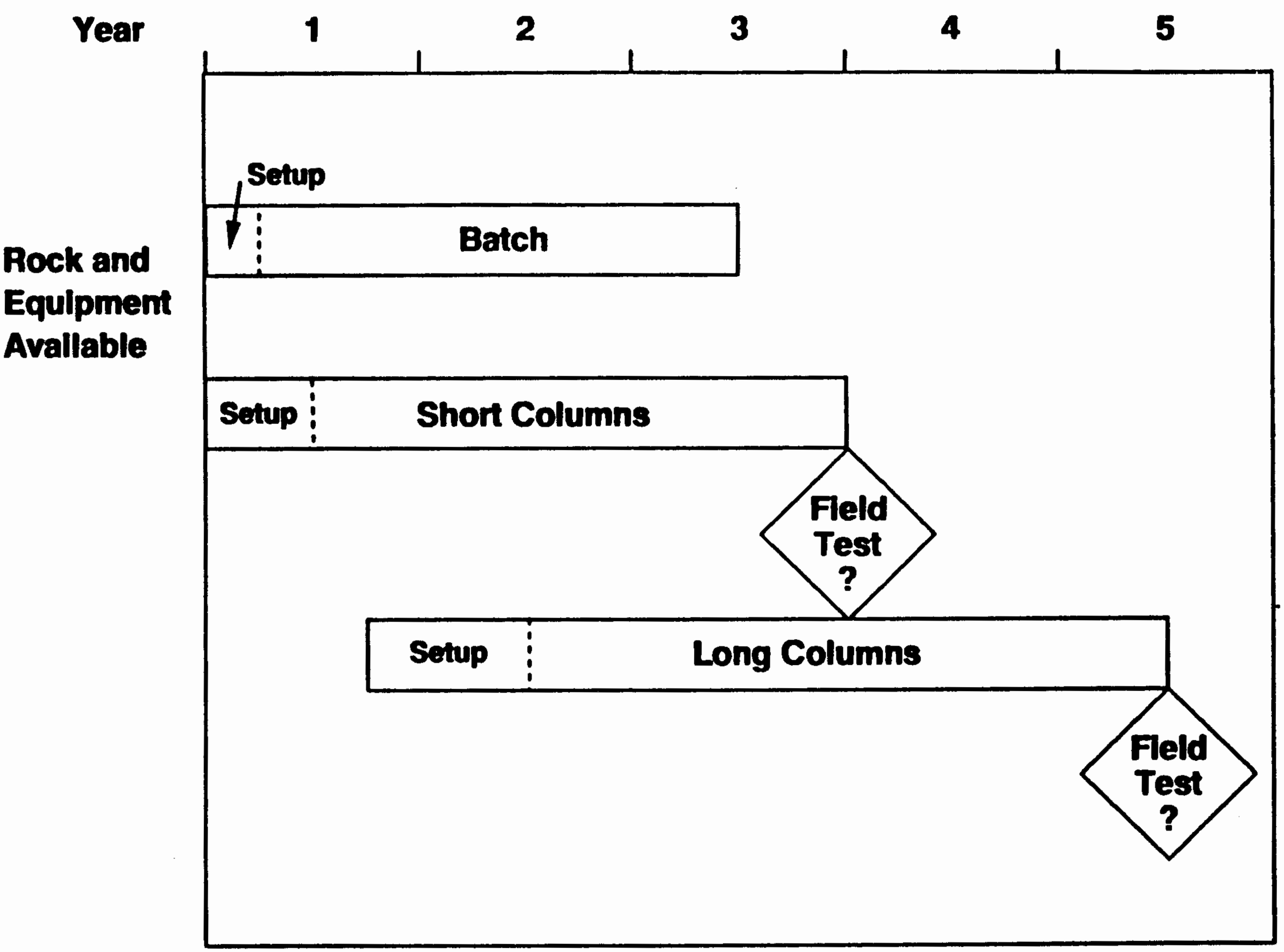
- Problems encountered (September 1986)
  - Scoping calculations needed first
  - Difficulty interpreting results
  - Tests at H-3 and/or H-11 begin late FY88 or FY89
  - Environment, cost, and time

- Preliminary design for a sorbing tracer test, SAND86-7177

Retardation Determination by Flow Tests

	Short Columns	Long Columns	Field
Length	3-4 inches	2-4 feet	100 feet
Time	Months	~1 year	2-5 years
Measurement	Radionuclide & analog effluent	Radionuclide & analog effluent	Analog effluent
Flow Path	Limited	Limited	Part of real world
Data	Flow and sorption	Flow, sorption, scale effects, concentration profile	Flow, sorption field scale & effects

Integrated-Phenomena Experiments Schedule



6345:8/91
Int-Phen

Conclusions

- Batch tests use crushed rock and provide limited information
- Column tests use unaltered rock and provide defensible retardation data on small scale
- Column tests on two scales can provide measure of scaling effects
- Column tests provide basis for analog field tests
- Field tests are potentially most informative but use analogs and are costly

CRITICAL EXPERIMENTS

and

TIME LINES

August 12, 1991

Wendell D. Weart

SNL

(1)
[EEG: dry bin concerns
room stability design work
at end of '91 expt s...
(Wendell) mtg with
SAR addendum
commitments re design concept
what design + when put new
design in ~~room~~ room ~~redesigned~~ redesigned
no waste before room redesigned
no room installed ~~at~~ at end of '91
(WP) room xs
SUIT]

(2)
[Waste characterization xs
schedule
RFP in October
low organics 2 rows 1 commin
high organics - flores
no method settle '92
bin 10 - combustible org
end of '91
sludges - system mid-'93
(18-24 mths after
arrival of first waste]

(3)
bin redesign for organics
[8 items from system checkout]
get this, thought done by end of month
ER + radiation contamination

Necessary Information Needs for 191 & RCRA PA

flow in *

- ■ Radionuclide Retardation Data in Culebra
- ■ Validation of Dual Porosity Flow Model
- ■ Salado Gas & Brine Flow Data
- ■ Marker Bed Data (Gas & Fluid Transport)
- Climate Variability Modeling
- 3-D non-Salado Modeling
- * Brine Reservoir Characteristics
- * Brine Chemistry Data
- * Culebra Geochemistry
- * Existing Site Characterization Data

→ Natural Barrier Description

- ■ Seal Effectiveness versus Time
- ■ Disturbed Rock Zone Permeability
  - pre-sealing permeability
  - fracture healing in halite
  - grout effectiveness
- ■ Shaft, Drift & Borehole Closure
- ■ Seal/Formation Interface Permeability
- Shaft, Drift & Borehole Seal Designs
- Seal Emplacement Feasibility
- Seal Material Evaluations (emplacement, longevity, compatibility)
- * Small Scale Seal Performance Test Data
- * Seal Design Concepts
- * Preliminary Seal Material Data (crushed salt, concrete formulations)

→ Develop Seal Designs & Models

marker bed 139 - flow of rooms

- ■ Gas Dissipation Data/Model
- ■ Backfill Permeability Data
- ■ Human Intrusion Scenarios
- 3-phase Room Model
- Salt Fracture/Rehealing Data
- * Waste & Backfill Compaction Data
- * Room Closure Model
- * Creep Model (including validation)
- * Creep Parameter Data

→ Develop Waste Panel Model

retardation, solubility, gas generation

- ■ Radionuclide Solubility/Leaching Data
- ■ Gas Generation Data (8/18)
- ■ RCRA VOC Inventory
- RCRA Non-gas Inventory
- Radionuclide Inventory
- Waste Materials Inventory

→ Develop Waste Interaction Model

■ critical need for performance assessment

* information need mostly satisfied

to PA →

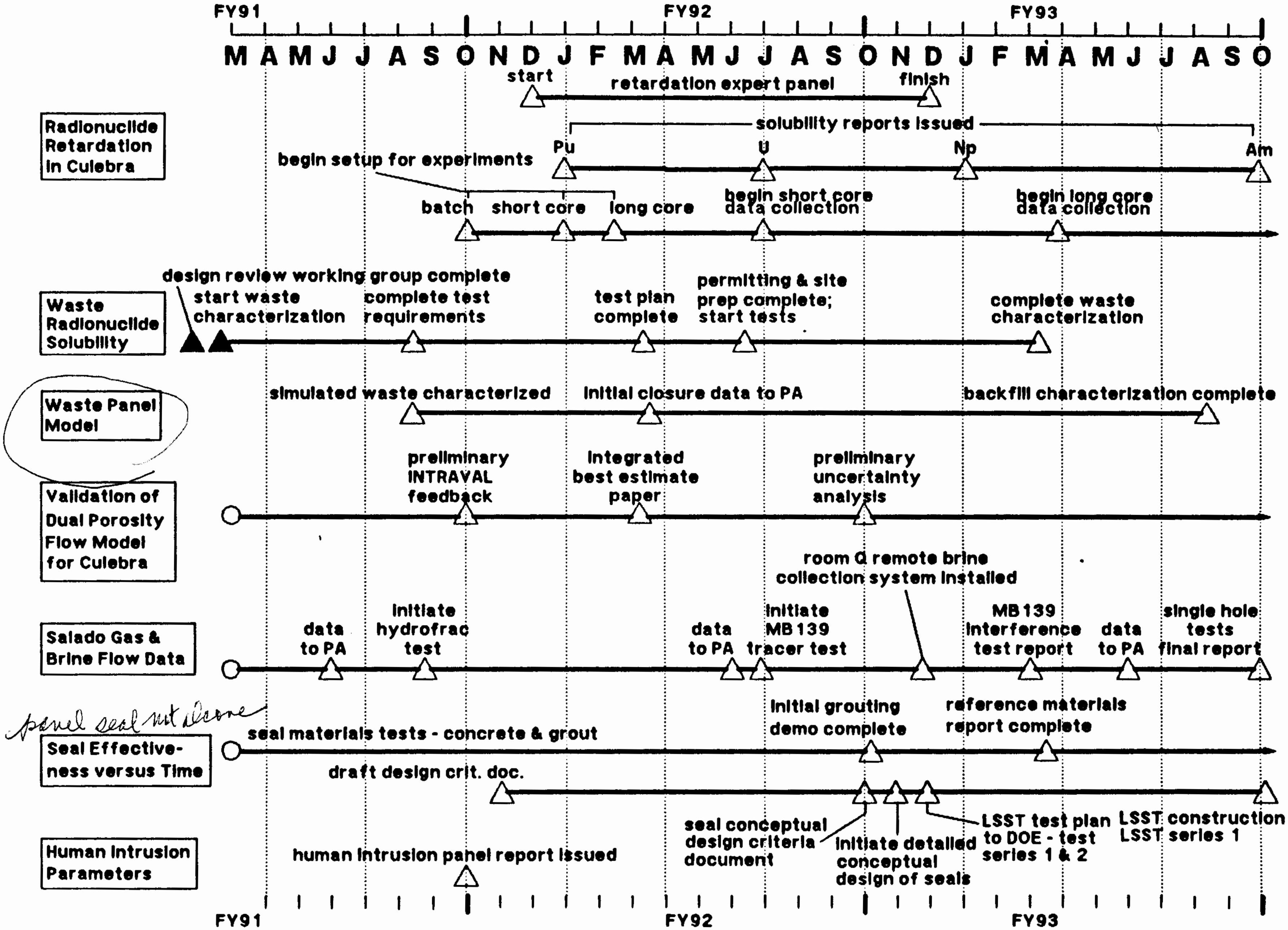
rarlp/8/9/91

Information Need	Activities Producing Information
Radionuclide Retardation in Culebra	Expert Panel & Laboratory Retardation Experiments
Waste Radionuclide Solubility	Lab Tests (surrogate & radioactive nuclides) Bench & Field Scale Tests (TRU wastes)
Waste Panel Model *	Laboratory/In-Situ Experiments/Analysis/Model Development
Validation of Dual Porosity Flow Model for Culebra	Analysis & Evaluation of Existing Data
Salado Gas & Brine Flow Data	Field Experiments/Analysis
Seal Effectiveness versus Time may require 200 years to get seal	Field & Laboratory Experiments/Modeling
Human Intrusion Parameters	Expert Panel on Human Intrusion

Figure 5. Relationship of Information Needs to Data Gathering Activities for Categories Having High PA Sensitivity

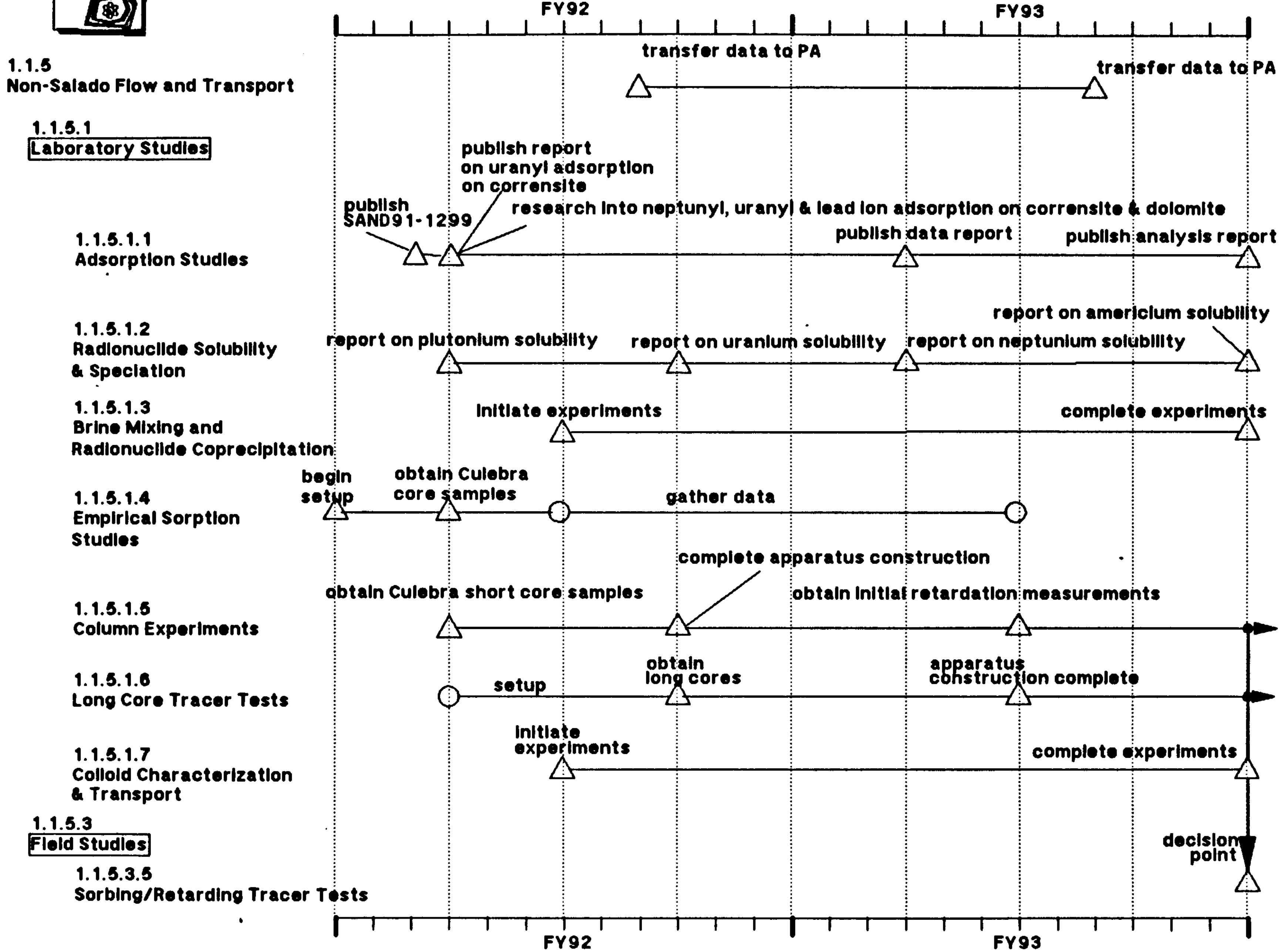
critest1/8/9/91

HIGHEST PRIORITY ACTIVITIES



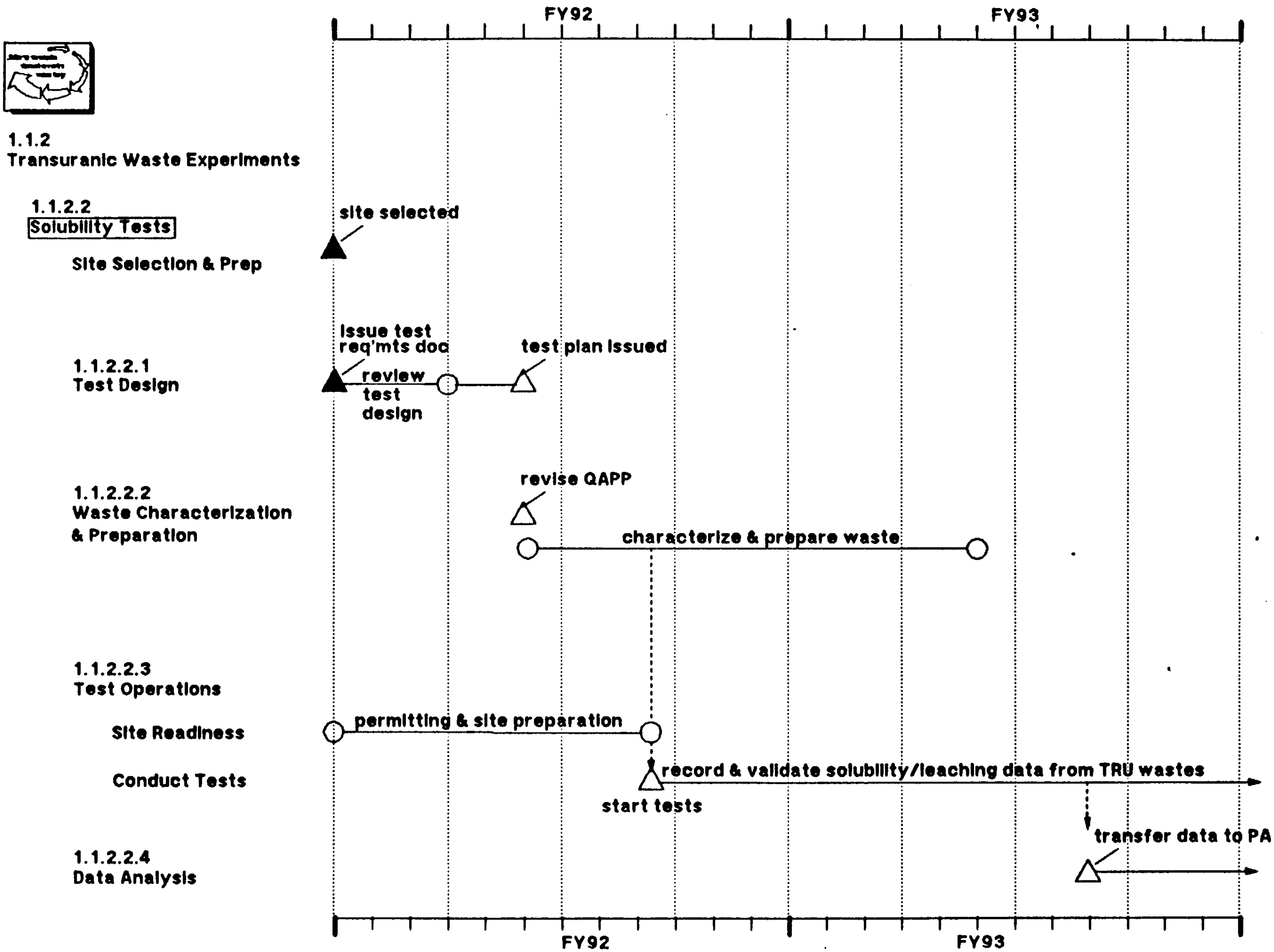
keysch/9/10/91

Working-Level Plan Example: Retardation Tests



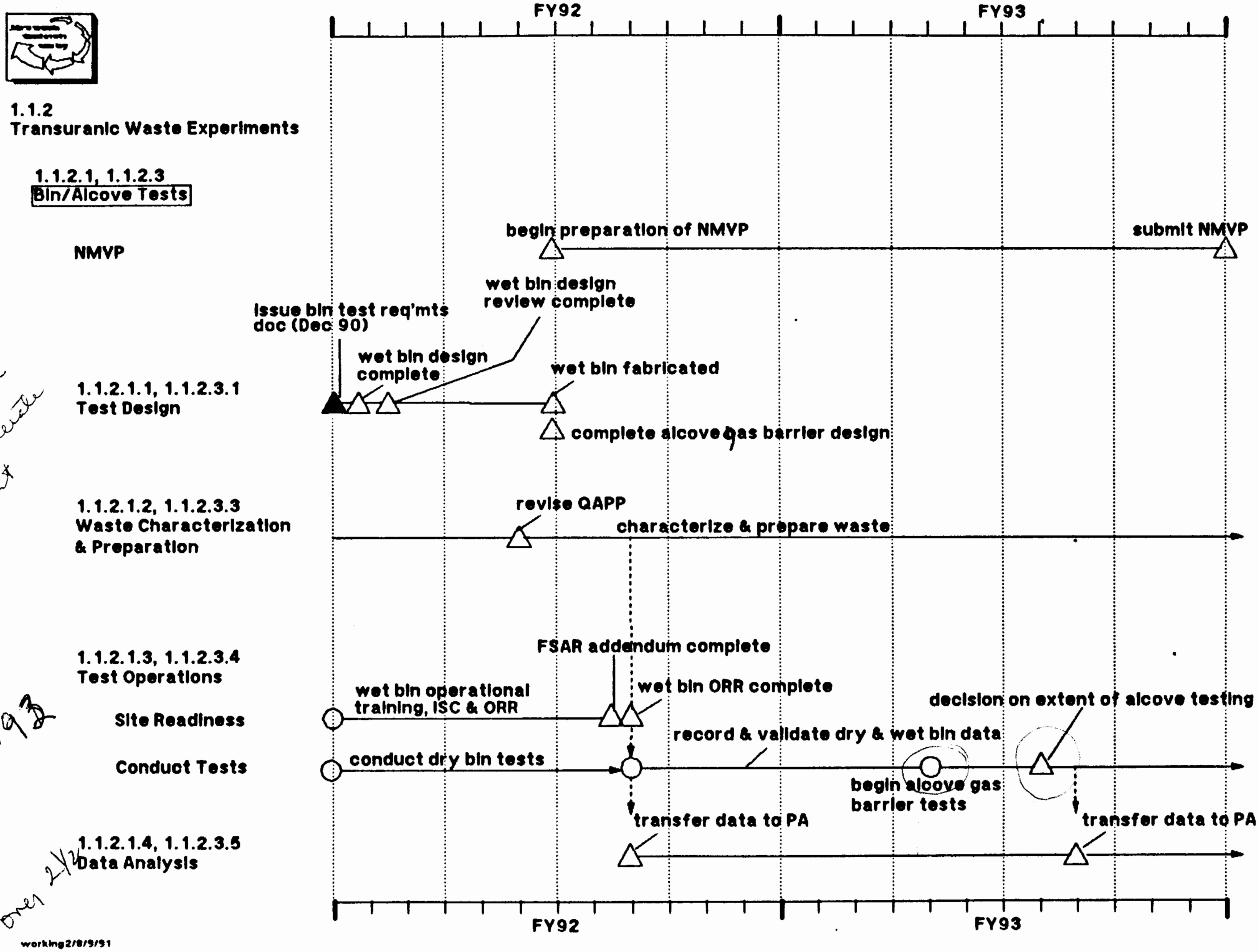
working 1/8/9/91

Working-Level Plan Example: Solubility Tests



working/8/9/91

Working-Level Plan Example: Bin/Alcove Tests



Performance Assessment Requirements for Bin Tests
40CFR191

- High gas generation rates lead to gas-dominated rooms
  - PA indicates less radioactive release for human intrusion scenarios
- Low gas generation may lead to brine saturated waste
  by Darcy flow
  - PA indicates more release for human intrusion
- Neither case leads to releases in 10,000 years without human intrusion
- Conclusion: Lower gas generation rates can lead to more severe waste room source term conditions

Performance Assessment Requirements for Bin Tests
40CFR268 (RCRA/ No Migration Determination)

- High gas generation rates will cause gases to migrate farther along interbeds
  - RCRA gases (VOCs) can be carried along with these gases toward RCRA boundary
- RCRA standard does <u>not</u> require consideration of human intrusion
- Conclusion: High gas generation rates can lead to a more severe waste room source term for VOC migration

What about metals in long term

VOC at health-based ... at marker bed * what is a reasonable source term

w2/8/4/91

Performance Assessment Requirements for Bin Tests
Conclusion

- Neither a high nor a low bounding assessment of gas generation rate is sufficient to assure the most severe long-term conditions for both WIPP standards since the bounds act in opposite directions
- Conclusion: Realistic values of TRU waste gas generation must be determined to adequately represent the waste room source term for both standards
- Bin tests are the most realistic simulation of repository/waste gas generation interactions and should be conducted to provide our best understanding of future waste room source term conditions

w3/8/8/91

Technical Concerns Often Raised Regarding Radioactive Tests at WIPP

Is gas generation really a major issue?

- **Performance Assessment to date has not addressed RCRA, an area where high gas generation increases concern for compliance**
- **Evaluation of both 40CFR191 and RCRA requires best estimates of gas; bounds are not sufficient**
- **Lack of knowledge on the gas generation issue will not be acceptable to the public**

gas gen + RCRA

metals???

Technical Concerns Often Raised Regarding Radioactive Tests at WIPP

Due to phasing of radioactive tests, experiments have been extended over a greater time interval

- **Experience to date supports need to start with least complex test**
- **High organic waste to be tested in fourth bin**; bin 10 highest organic
- **Wet bins will be conducted as soon as new design bin is available**
- **All bins will yield data in time to support PA**

solubility of retardation best means of showing compliance

dry sludges

Technical Concerns Often Raised Regarding Radioactive Tests at WIPP

Radioactive waste tests are commencing later than originally expected

- Wasteform complexity and regulatory & safety requirements do lengthen times
- Characterization will be required to ship waste to WIPP-- tests or not
- Bin tests will provide timely data to PA on present schedule

Test results will be difficult to interpret and extend to WIPP

- Test data will provide statistical knowledge of gas generation in WIPP
- Lab data will supplement bins for phenomenological interpretation
- Extensive test matrix will allow extrapolation to the WIPP repository

Technical Concerns Often Raised Regarding Radioactive Tests at WIPP

Solubility experiments have been removed from the WIPP bin tests

- DOE is committed to accelerating solubility experiments with TRU waste
- Other facilities are being actively considered to speed solubility tests
- New bin design to allow solubility testing at WIPP is being investigated

SUMMARY OF CRITICAL EXPERIMENTS

Retardation in the Culebra Aquifer

- Expert Panel Deliberations in Early 1992
- Laboratory Tests Accelerated

Solubility

- TRU Solubility Tests to Commence in Mid-'92

Bin Test

- Tests with Some High-Organic TRU Earlier in Program
- Redesign of Bins to Accelerate Wet Bin Testing into Mid-'92
- Decision on Alcoves in Early 1993 Based on Results of Bin Tests & Alcove Gas Barrier

Leak ck tanks
wet bin - strength
for flammability
or inert atmosphere
manifold system
circulation time
gasket & O_2 -
diffusion

Performance Assessment
Panel Modeling, Expert Elicitation, Status

D. R. Anderson and M. G. Marietta

Nuclear Waste Technology Department
Performance Assessment Division
Sandia National Laboratories

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Summary

Introduction - PA Schedules

PA Panel Modeling

- Assimilation of test program data and information into PA calculations
- Calculations still indicate zero release

  (CONDITIONAL ON 91 MODELS AND DISTRIBUTIONS)

  to the accessible environment (40 CFR 191, Subpart B) for undisturbed conditions
- Human intrusion calculations will be reported in December

Summary (Cont.)

PA expert panels

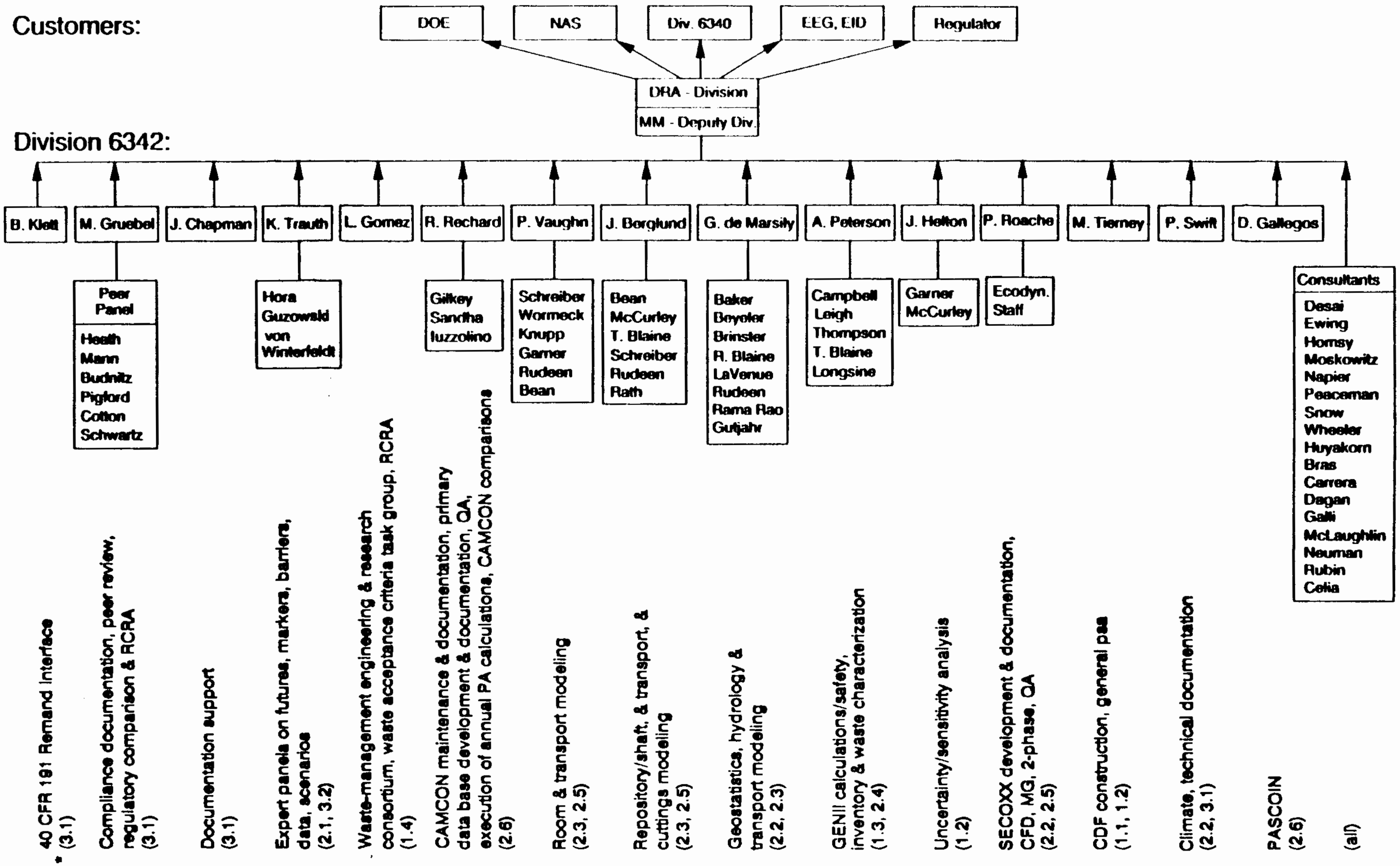
- Elicitation process, panel deliberations, and results for 1991 Preliminary Comparison

- Ranges and distributions for radionuclide concentrations (solubilities) in Salado brines

- Ranges and distributions for radionuclide distribution coefficients in Culebra brines

Discussion -

1.1.6 Performance Assessment Division Work Breakdown Structure Imbedded in Our Customer/Supplier Model



Suppliers: Divisions 6341, 43, 44, 45, 46
Element level of PWBS indicated by (x.x) is 1.1.6.x.x
* Division 6342 Program Plan numbers

Figure 2. Division 6342 Organization Chart

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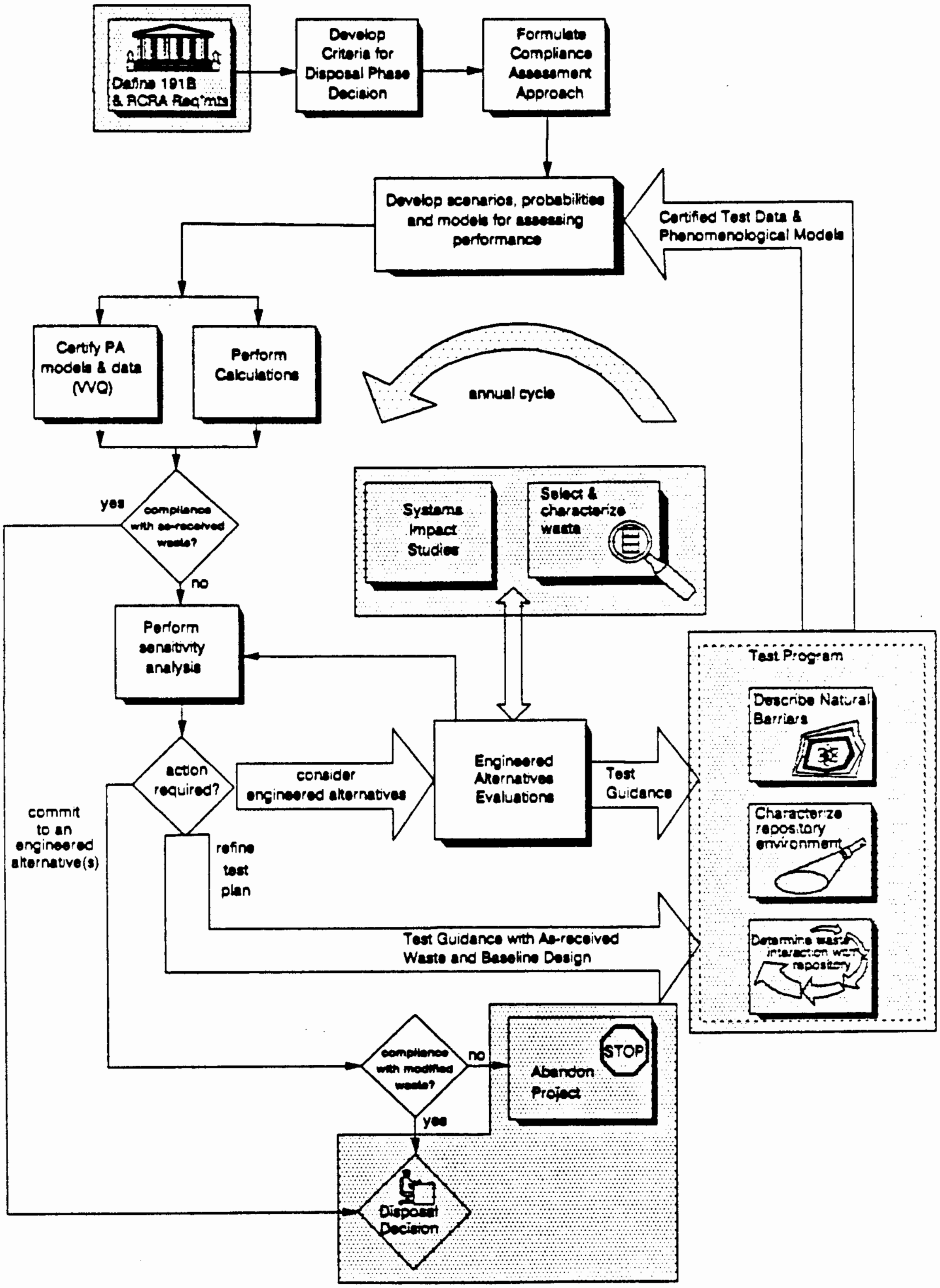


Figure 4. Post-closure Performance Assessment

384-0

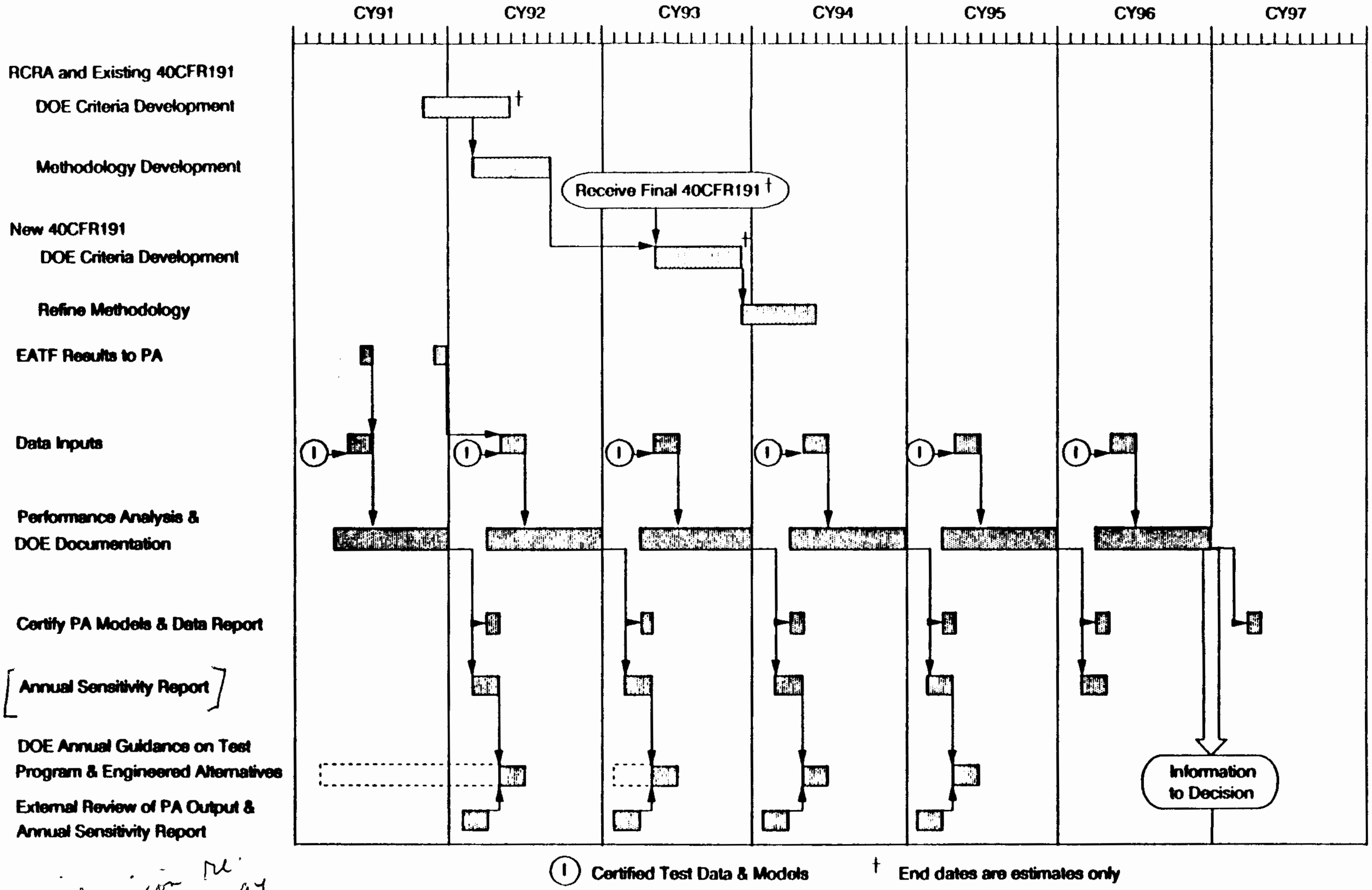
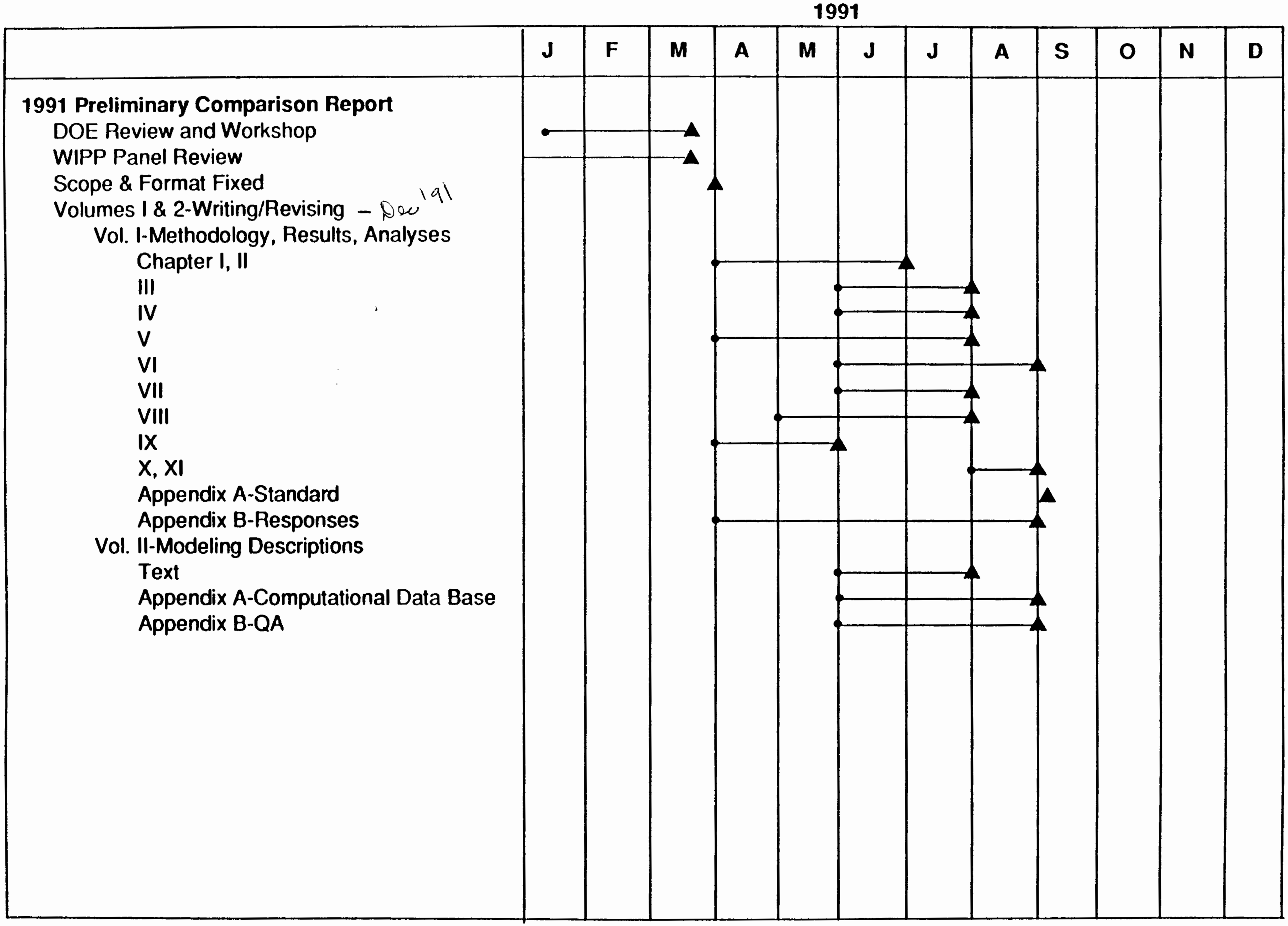


Fig. 5. Performance Assessment Time-Phased Activities

DOE - decision re: disposal in '97

385.0


1991
J
F
M
A
M
J
J
A
S
O
N
D
1991 Preliminary Comparison Report
DOE Review and Workshop
WIPP Panel Review
Scope & Format Fixed
Volumes I & 2-Writing/Revising – Dec '91
Vol. I-Methodology, Results, Analyses
Chapter I, II
III
IV
V
VI
VII
VIII
IX
X, XI
Appendix A-Standard
Appendix B-Responses
Vol. II-Modeling Descriptions
Text
Appendix A-Computational Data Base
Appendix B-QA

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1991	J	F	M	A	M	J	J	A	S	O	N	D
1991 Preliminary Comparison Report (continued)												
Volumes I & 2-Review/Revision/Production												
Deliver to PAPRP, DOE, SNL (9/13)									▲			
DOE Comments Due (10/1)										▲		
PAPRP Mtg. (10/7,8)										▲		
DOE Mtg. (10/15,16)										▲		
Respond to Comments, Revise Doc.										●—	—▲	
SNL 6330 Review											●—▲	
Prepare Pre-Publication Copy											●—▲	
Deliver to WIPP Panel (11/27)											▲	
Deliver to Print Shop (12/6)												▲
WIPP Panel Mtg. (12/?)												▲
Volume 3- Reference Data Base												
Writing/Revising			●—	—	—	—	—▲					
SNL Review								●—▲				
PreparePre-Publication Copy								●—	—▲			
Deliver Pre-Publication Copy to PAPRP (9/13)									▲			
Deliver to Print Shop (9/13)									▲			
PAPRP Mtg. (10/7,8)										▲		
Deliver Pre-Publication Copy to WIPP Panel (11/27)											▲	

Vol's 1-3 in December

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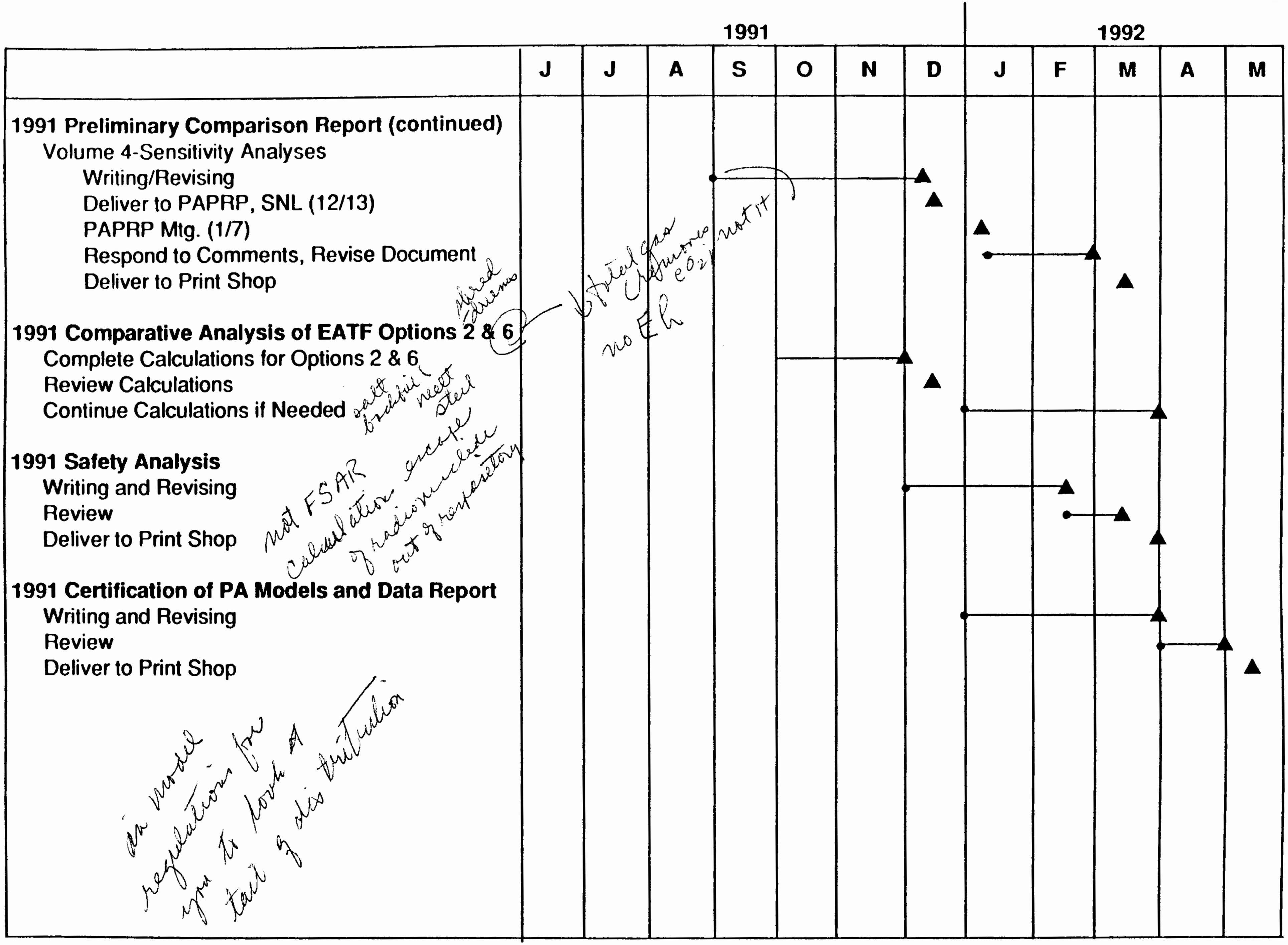
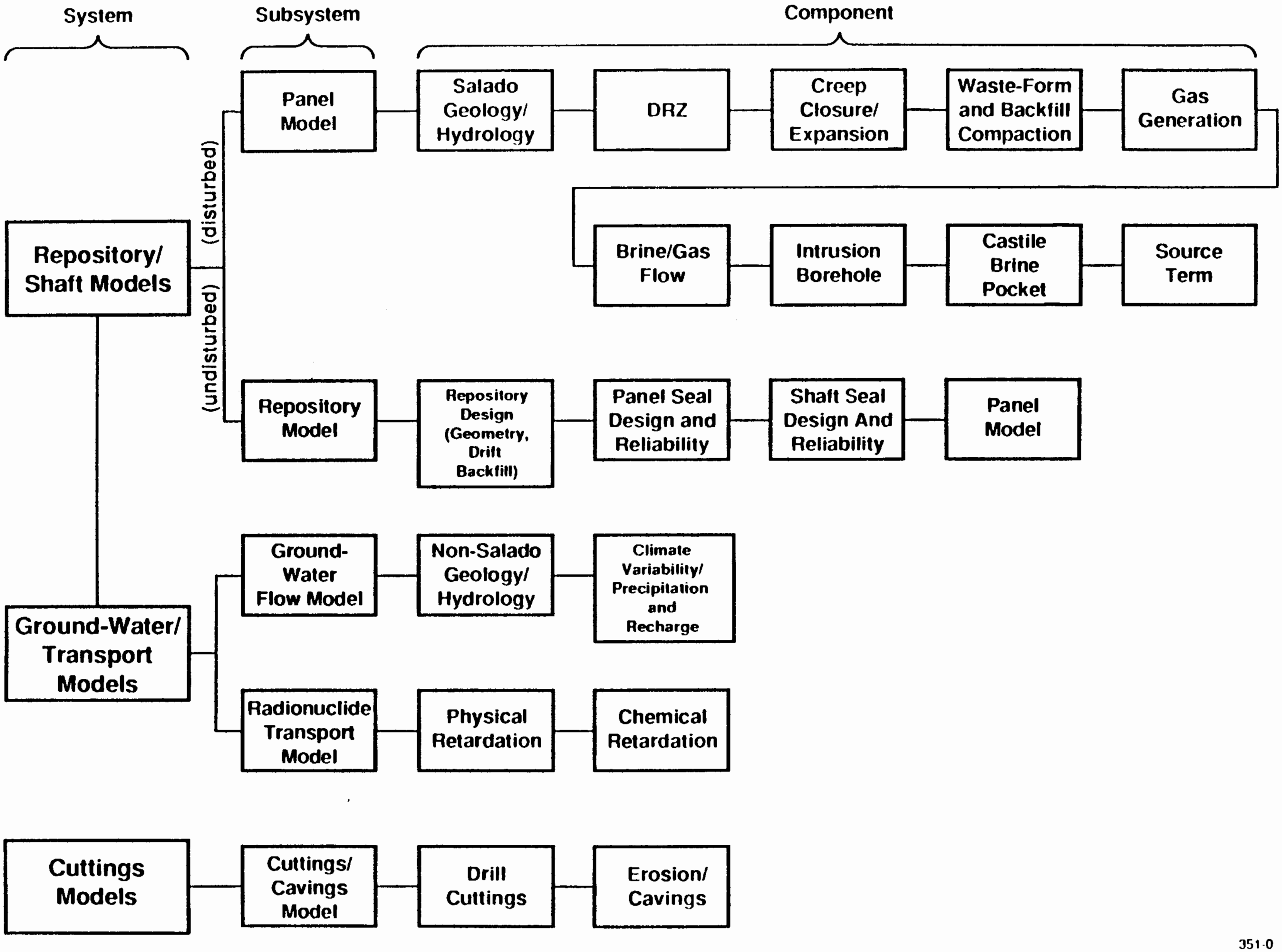

1991
1992
J J A S O N D J F M A M
1991 Preliminary Comparison Report (continued)
Volume 4-Sensitivity Analyses
Writing/Revising
Deliver to PAPRP, SNL (12/13)
PAPRP Mtg. (1/7)
Respond to Comments, Revise Document
Deliver to Print Shop
1991 Comparative Analysis of EATF Options 2 & 6
Complete Calculations for Options 2 & 6
Review Calculations
Continue Calculations if Needed
1991 Safety Analysis
Writing and Revising
Review
Deliver to Print Shop
1991 Certification of PA Models and Data Report
Writing and Revising
Review
Deliver to Print Shop


System
Subsystem
Component
Repository/ Shaft Models
(disturbed)
(undisturbed)
Panel Model
Salado Geology/ Hydrology
DRZ
Creep Closure/ Expansion
Waste-Form and Backfill Compaction
Gas Generation
Brine/Gas Flow
Intrusion Borehole
Castile Brine Pocket
Source Term
Repository Model
Repository Design (Geometry, Drift Backfill)
Panel Seal Design and Reliability
Shaft Seal Design And Reliability
Panel Model
Ground-Water/ Transport Models
Ground-Water Flow Model
Non-Salado Geology/ Hydrology
Climate Variability/ Precipitation and Recharge
Radionuclide Transport Model
Physical Retardation
Chemical Retardation
Cuttings Models
Cuttings/ Cavings Model
Drill Cuttings
Erosion/ Cavings
351-0

System Model: Repository/Shaft

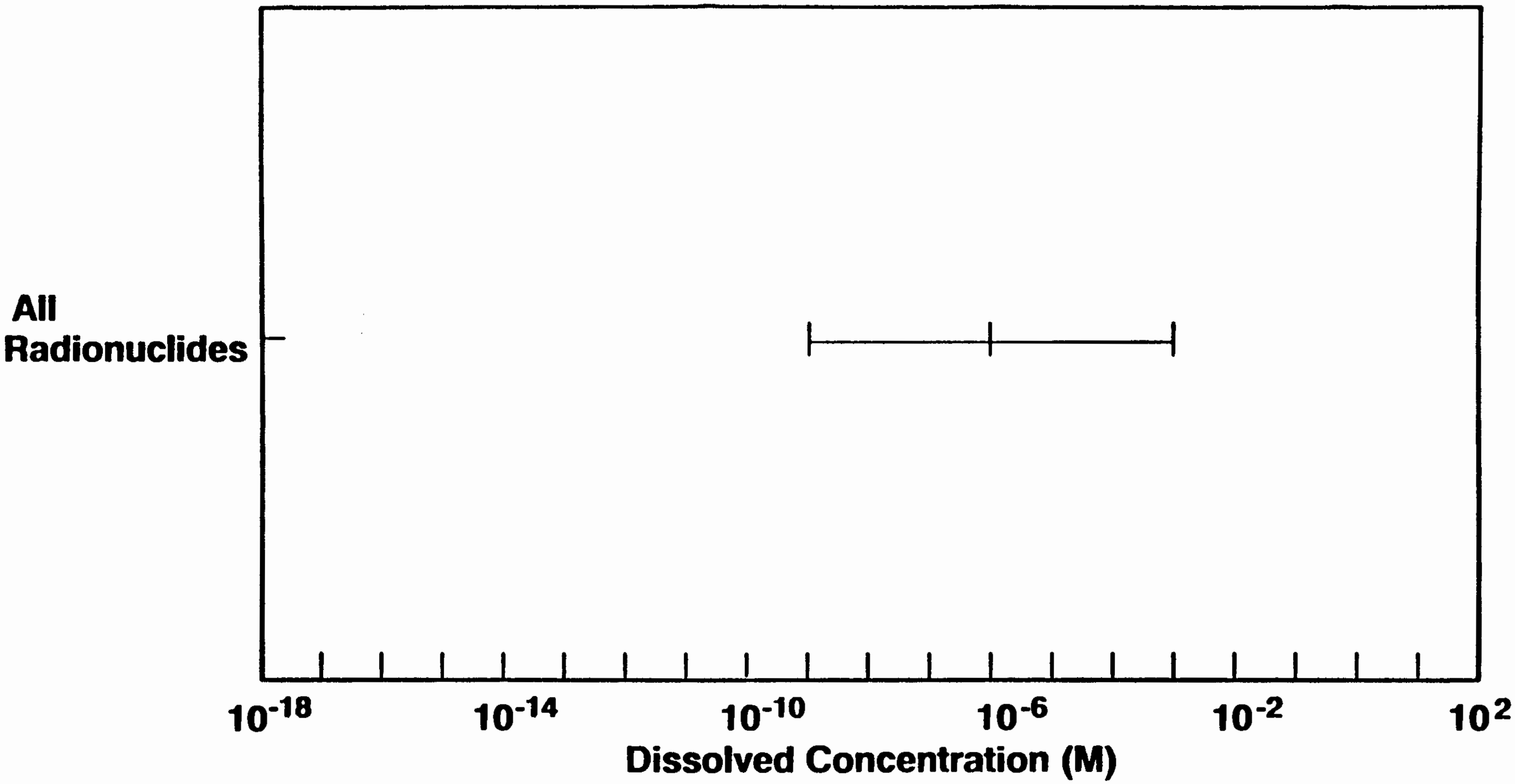
Sub-System Model: Panel

Component Model: Source Term

Process: Radionuclide Solubility
(Am, Np, Pb, Pu, Ra, Th, U)

Parameters:

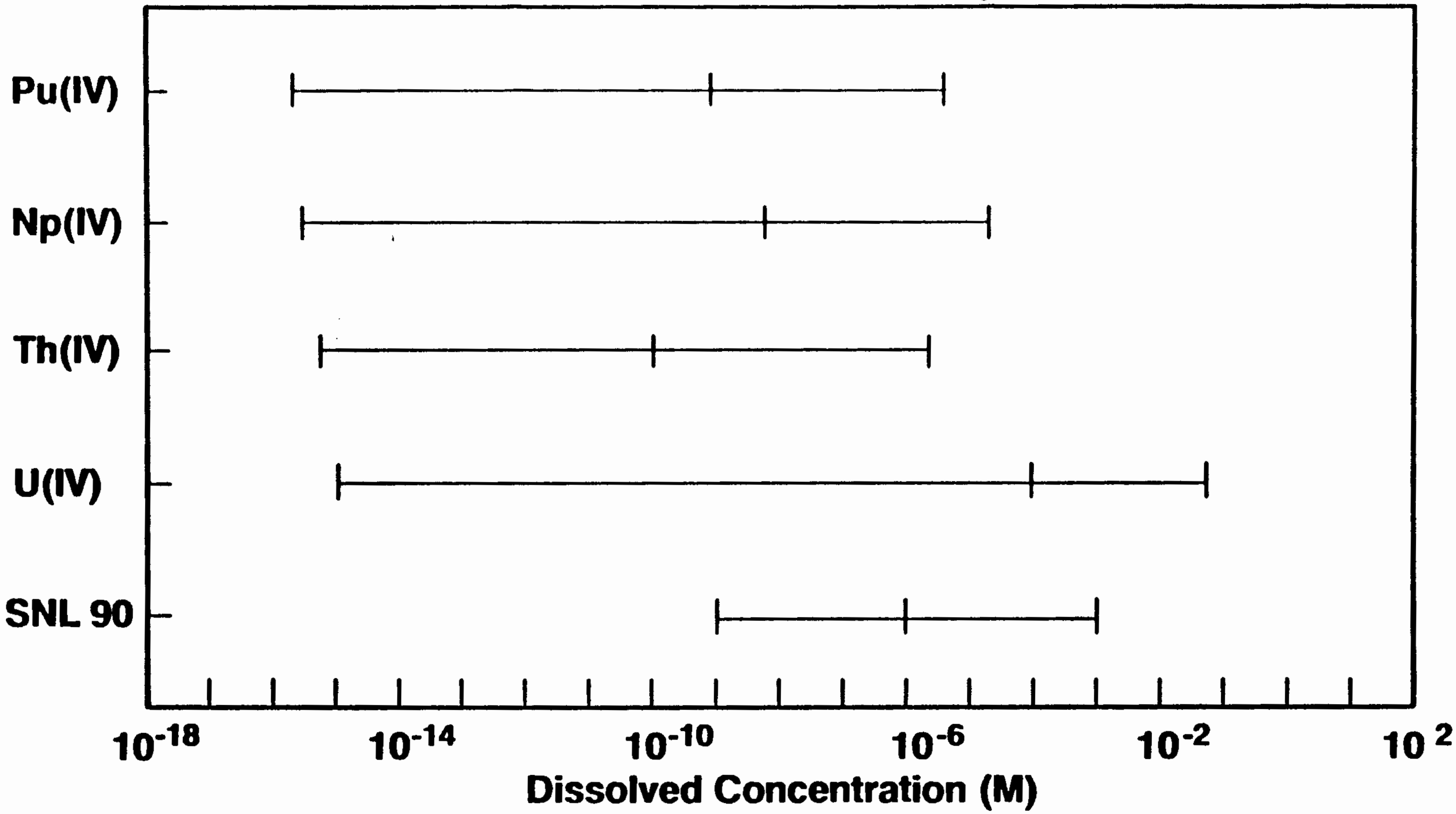
pH
Eh – solubility
Oxidation Potential
Carbonate Present
Chelating Agents
.
.
.



SNL 90 Estimate of Radionuclide Solubility

390-0

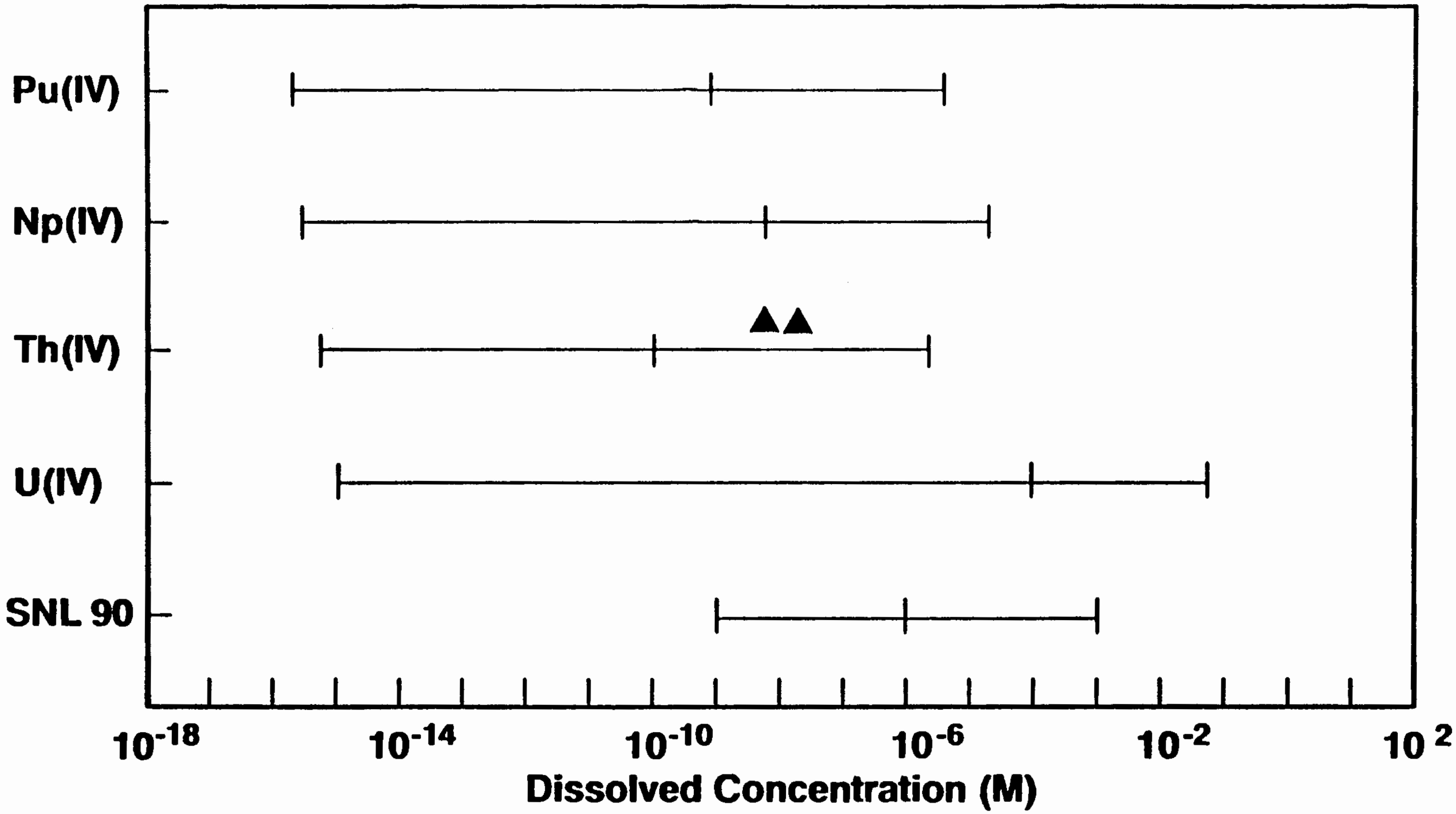
synthesized from lit
no info on Eh in brine



Expert Panel Estimates of Radionuclide Solubilities

391-0

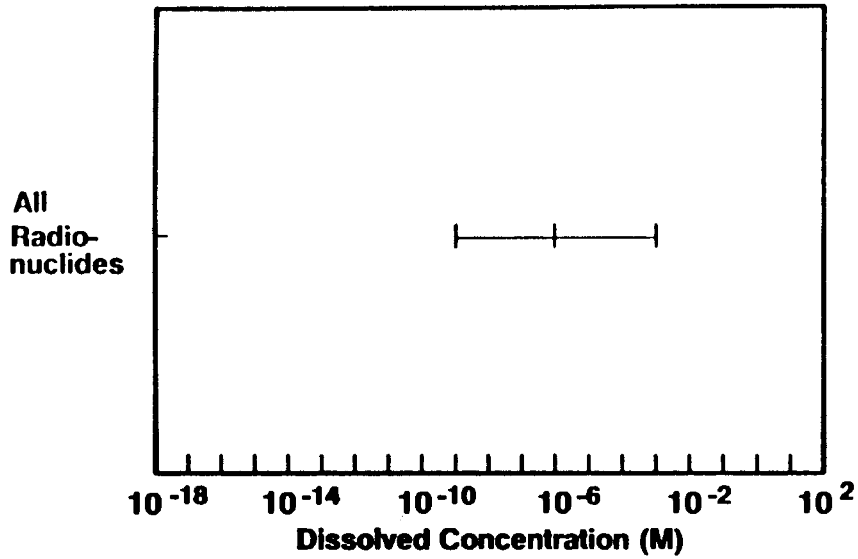
4-5 years to get data for the Eh assemblages



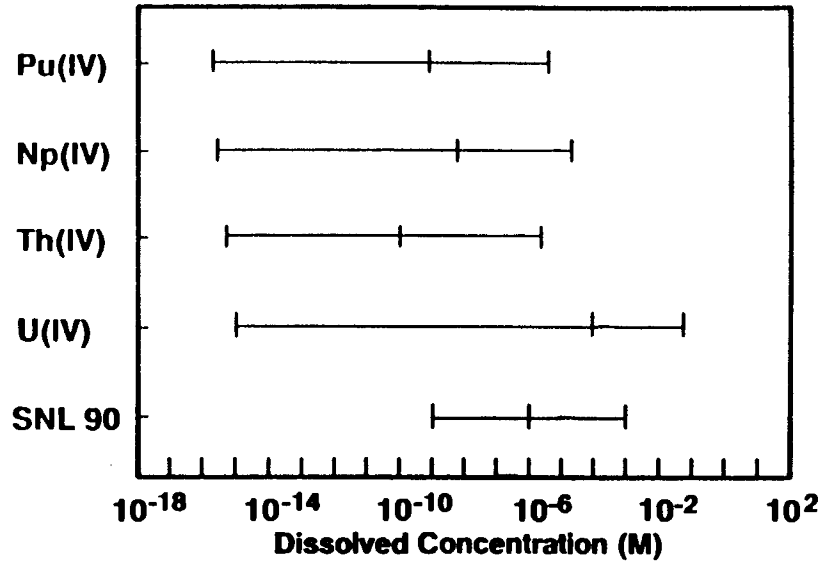
Measured Data For Radionuclide Solubilities

392-0

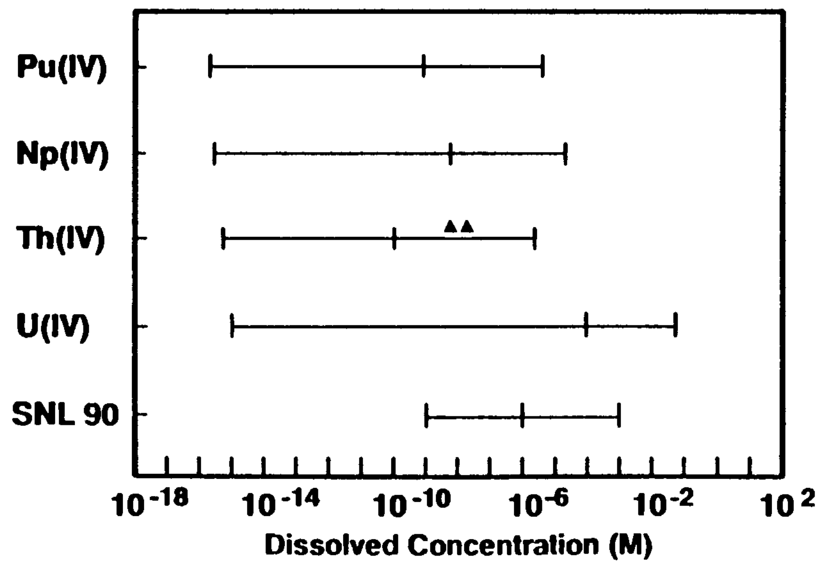
Compare to estimates



SNL 90 Estimate of Radionuclide Solubility



Expert Panel Estimates of Radionuclide Solubilities



Measured Data For Radionuclide Solubilities

SUMMARY

393 0

Summary

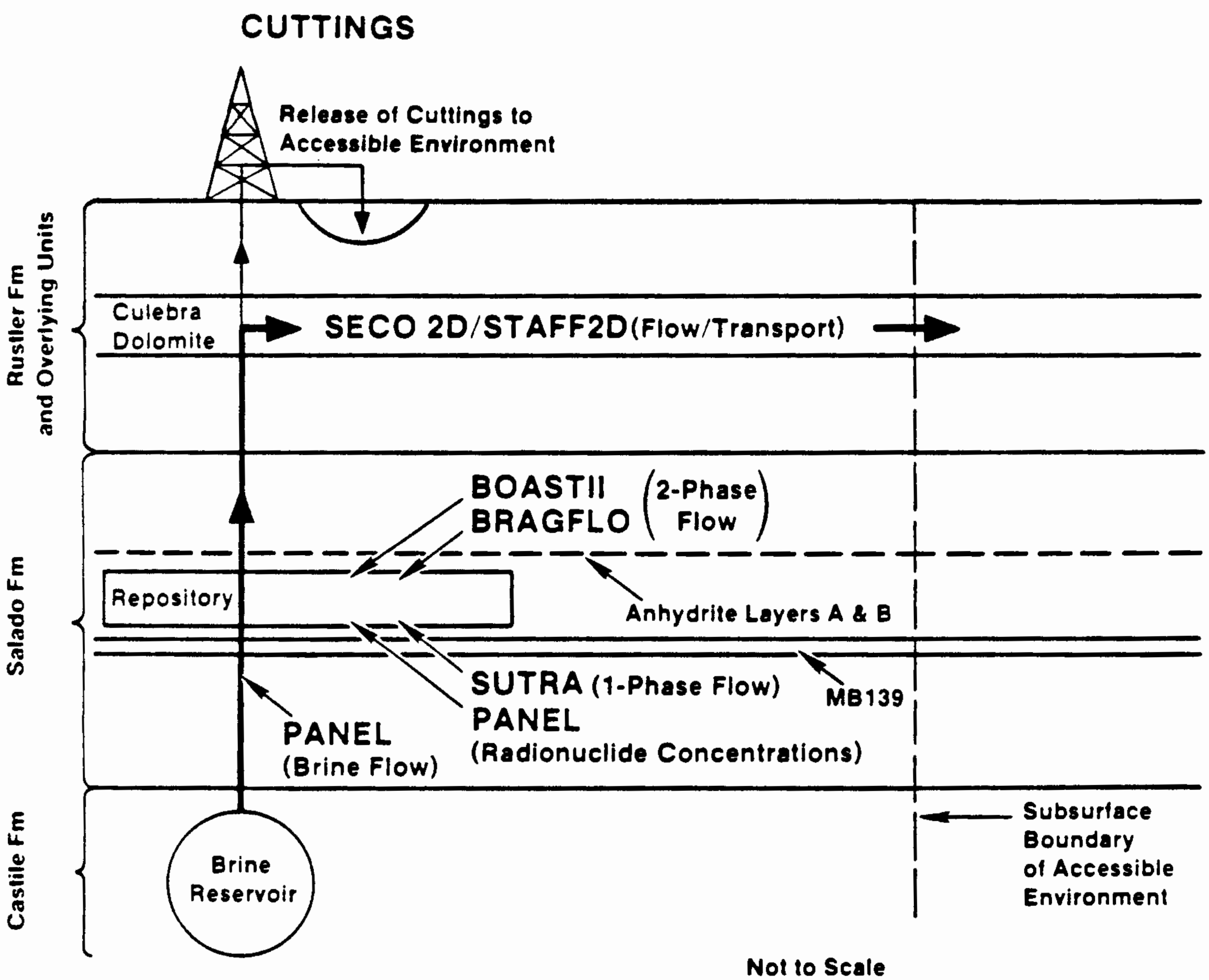
Introduction - PA Schedules

PA Panel Modeling

- Assimilation of test program data and information into PA calculations
- Calculations still indicate zero release

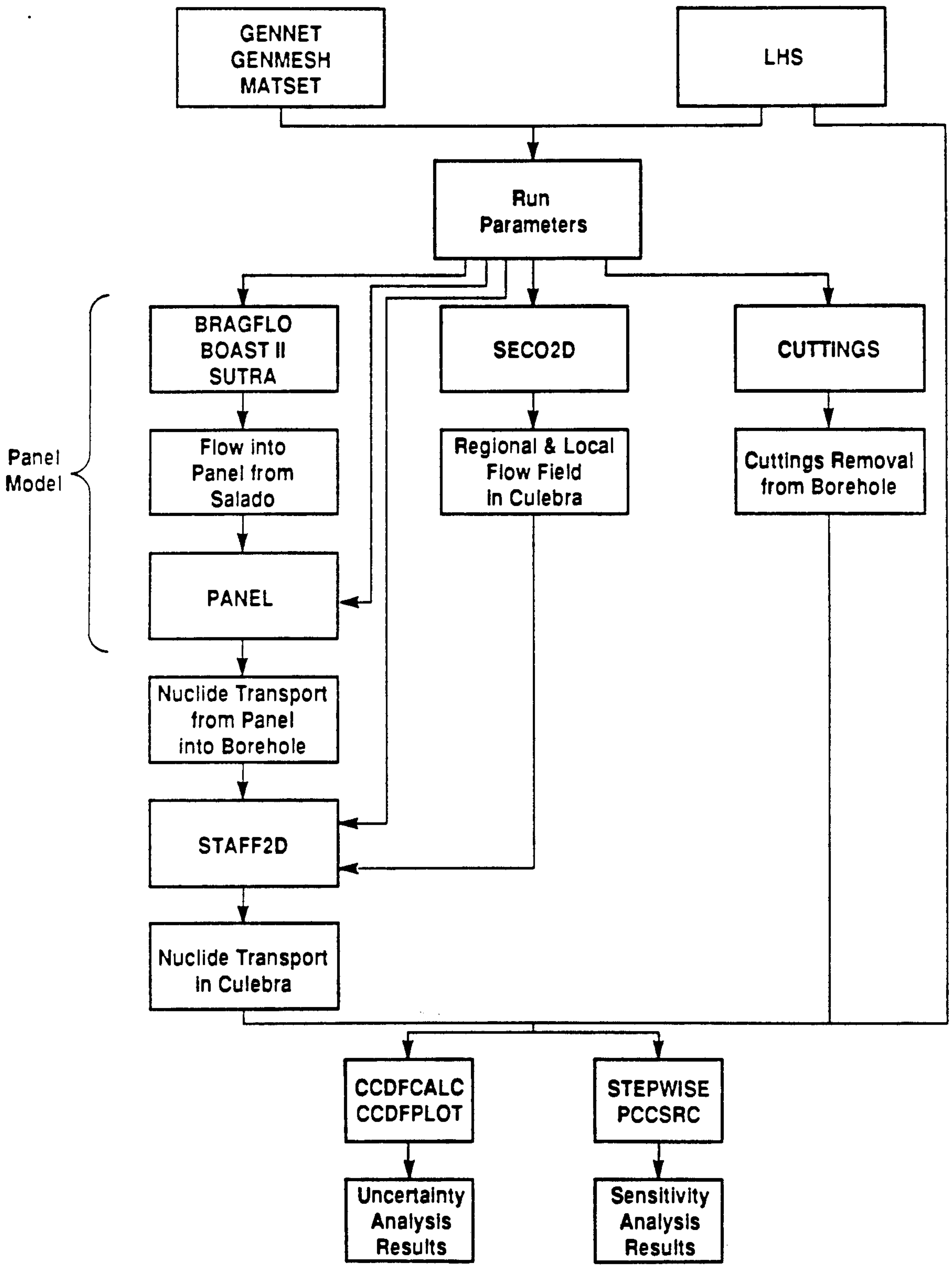
  (CONDITIONAL ON 91 MODELS AND DISTRIBUTIONS)

  to the accessible environment (40 CFR 191, Subpart B) for undisturbed conditions
- Human intrusion calculations will be reported in December



WIPP PA Consequence Modeling

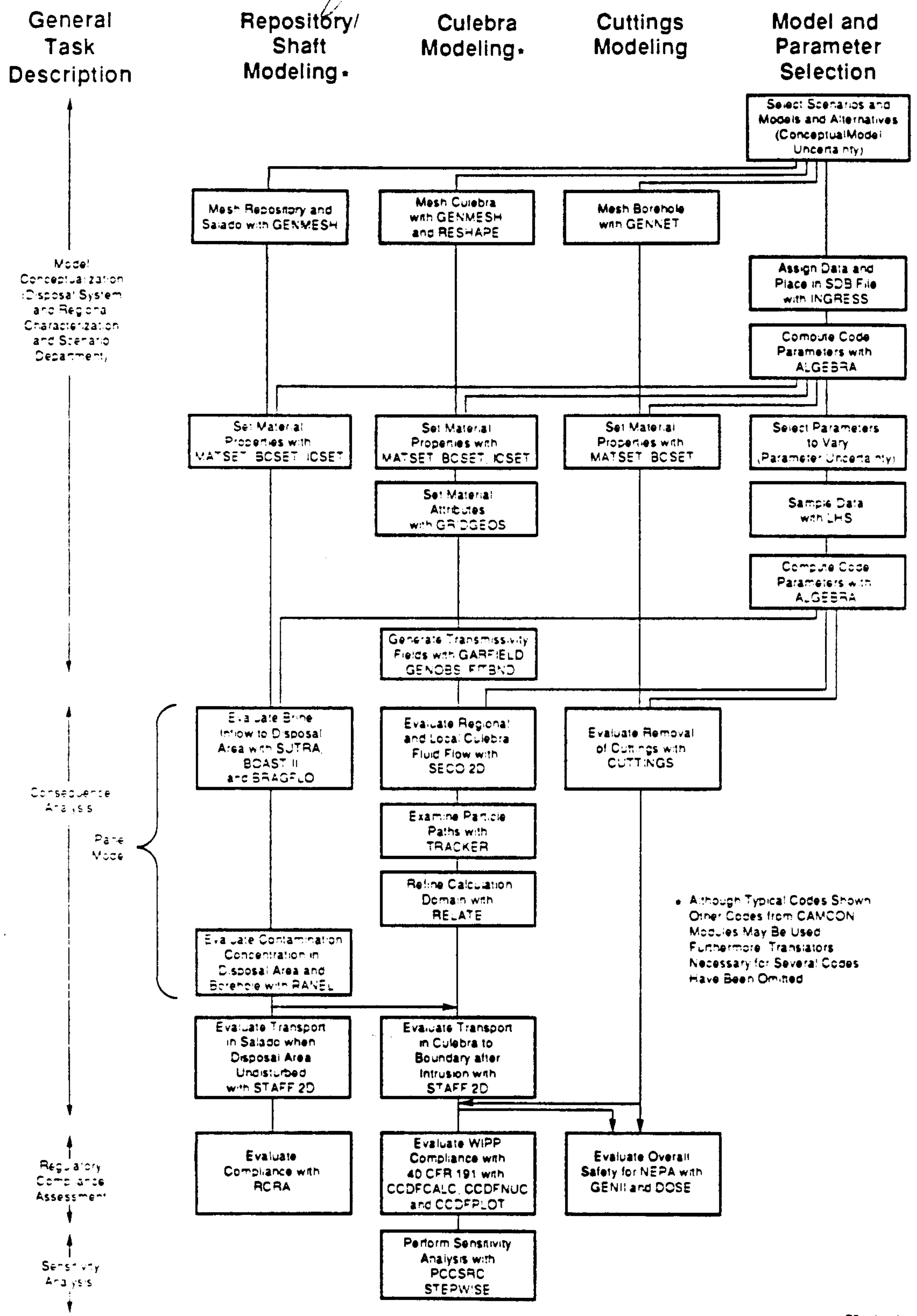
346-0



Diagrammatic Representation of Example Analysis

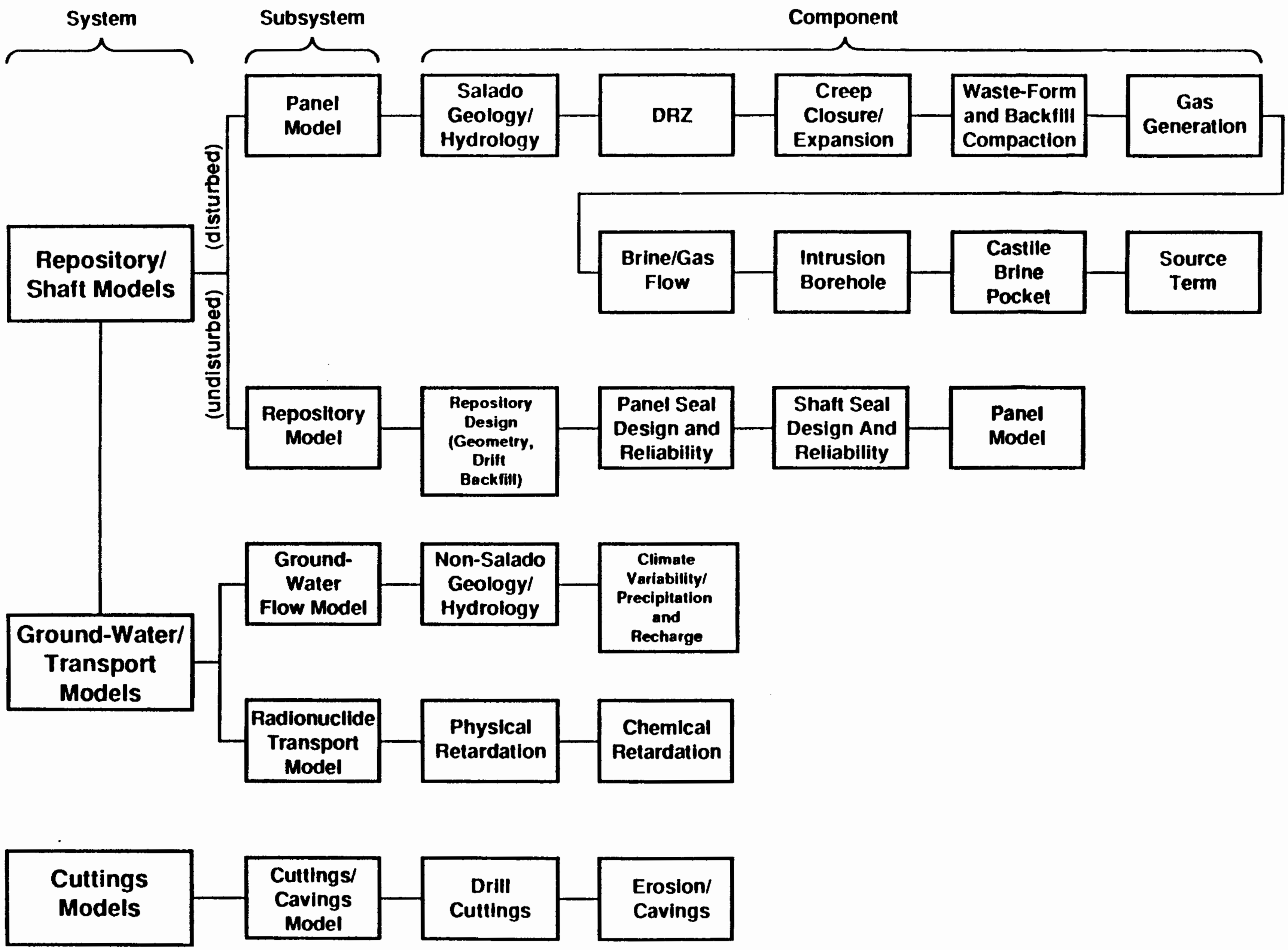
347-0

CAMCON report + where panel model fits in

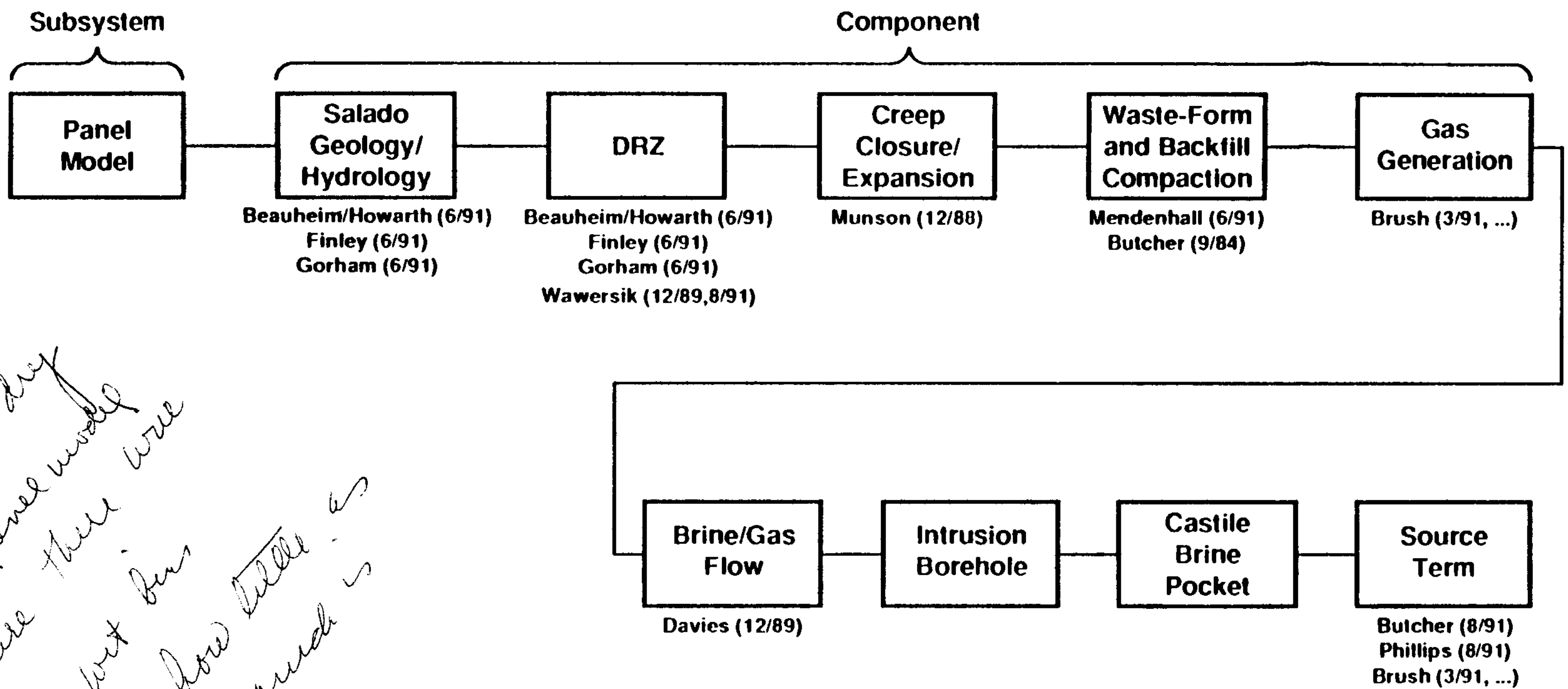


TRI 6342 56 1

394-0


System
Subsystem
Component
Repository/ Shaft Models
(disturbed)
(undisturbed)
Panel Model
Salado Geology/ Hydrology
DRZ
Creep Closure/ Expansion
Waste-Form and Backfill Compaction
Gas Generation
Brine/Gas Flow
Intrusion Borehole
Castile Brine Pocket
Source Term
Repository Model
Repository Design (Geometry, Drift Backfill)
Panel Seal Design and Reliability
Shaft Seal Design And Reliability
Panel Model
Ground-Water/ Transport Models
Ground-Water Flow Model
Non-Salado Geology/ Hydrology
Climate Variability/ Precipitation and Recharge
Radionuclide Transport Model
Physical Retardation
Chemical Retardation
Cuttings Models
Cuttings/ Cavings Model
Drill Cuttings
Erosion/ Cavings

351-0


Subsystem
Component
Panel Model
Salado Geology/ Hydrology
Beauheim/Howarth (6/91)
Finley (6/91)
Gorham (6/91)
DRZ
Beauheim/Howarth (6/91)
Finley (6/91)
Gorham (6/91)
Wawersik (12/89,8/91)
Creep Closure/ Expansion
Munson (12/88)
Waste-Form and Backfill Compaction
Mendenhall (6/91)
Butcher (9/84)
Gas Generation
Brush (3/91, ...)
Brine/Gas Flow
Davies (12/89)
Intrusion Borehole
Castile Brine Pocket
Source Term
Butcher (8/91)
Phillips (8/91)
Brush (3/91, ...)

350-0

Data Flow for 91 PA Panel Model

Components: Salado Geology/Hydrology and DRZ

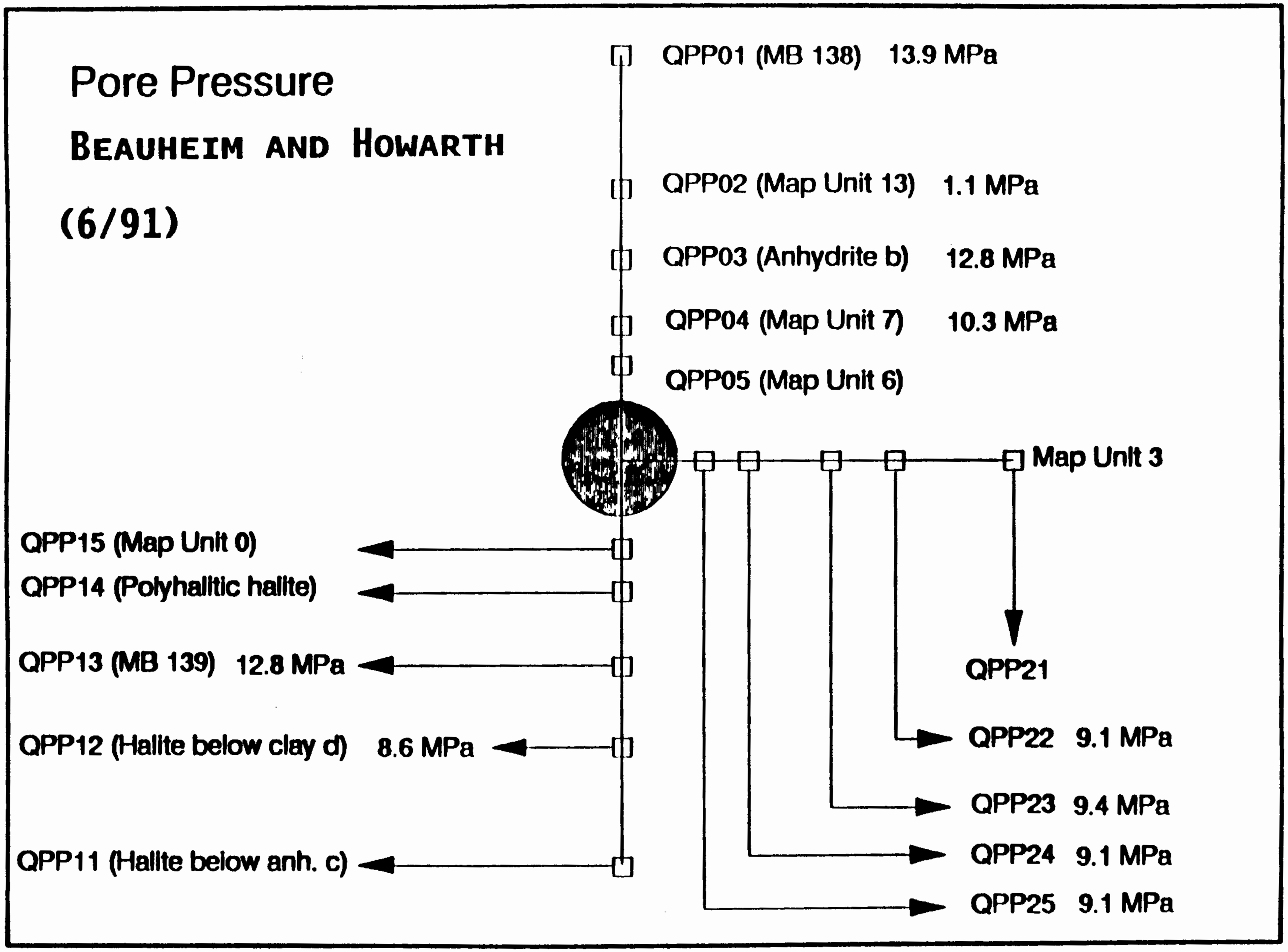
Gorham (6/91), Beauheim and Howarth (6/91), Beauheim (3/90), Finley (6/91)
Fluid Flow and Transport Division

Intact and DRZ Halite and Anhydrite
Pore Pressure
Permeability
Diffusivity

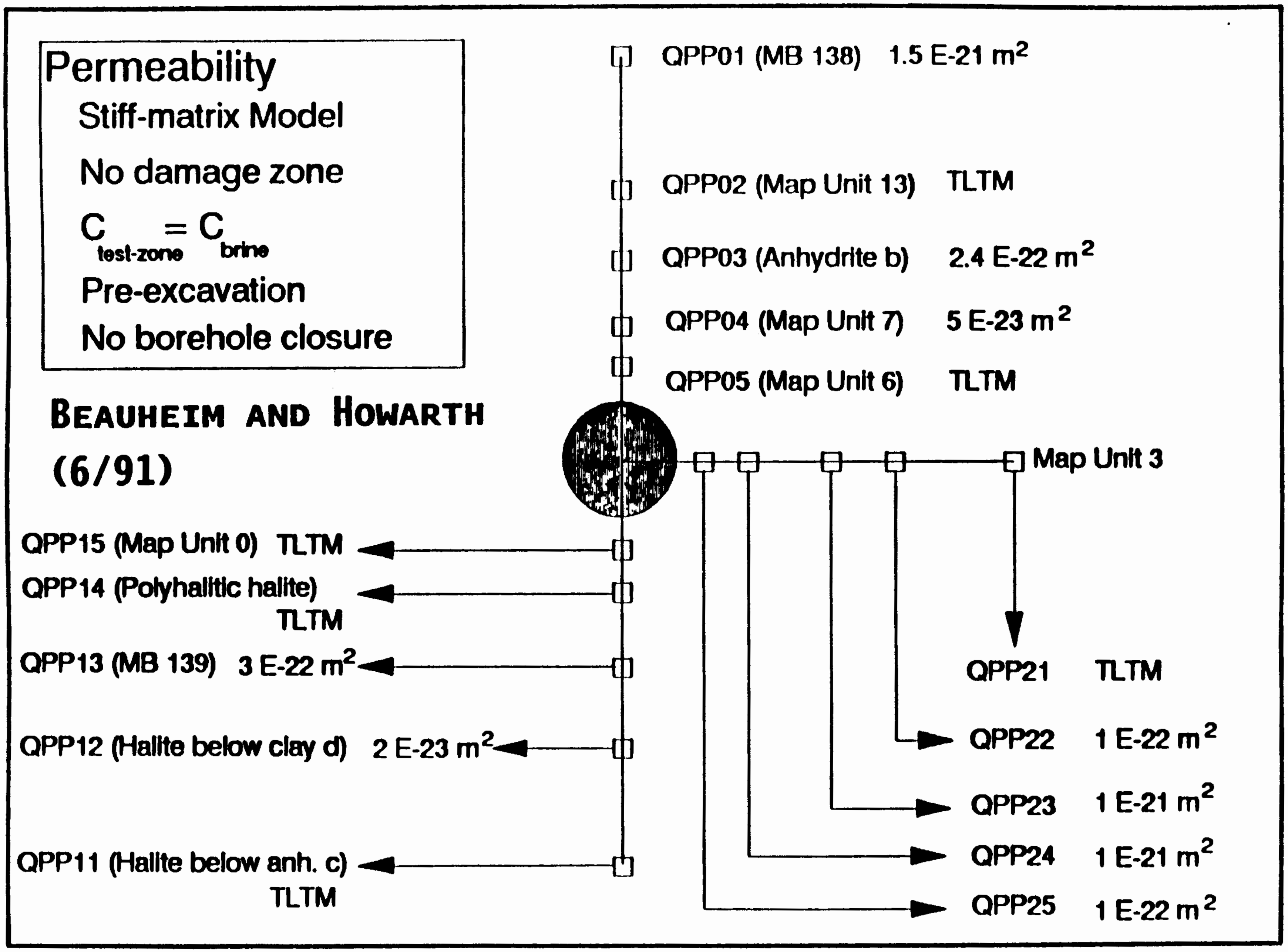
Wawersik (8/91,12/89)
Geomechanics Division

Fracturing

395-0


Pore Pressure
BEAUHEIM AND HOWARTH
(6/91)
QPP01 (MB 138) 13.9 MPa
QPP02 (Map Unit 13) 1.1 MPa
QPP03 (Anhydrite b) 12.8 MPa
QPP04 (Map Unit 7) 10.3 MPa
QPP05 (Map Unit 6)
Map Unit 3
QPP15 (Map Unit 0)
QPP14 (Polyhalitic halite)
QPP13 (MB 139) 12.8 MPa
QPP12 (Halite below clay d) 8.6 MPa
QPP11 (Halite below anh. c)
QPP21
QPP22 9.1 MPa
QPP23 9.4 MPa
QPP24 9.1 MPa
QPP25 9.1 MPa

395-0


Permeability
Stiff-matrix Model
No damage zone
C test-zone = C brine
Pre-excavation
No borehole closure
BEAUHEIM AND HOWARTH
(6/91)
QPP01 (MB 138) 1.5 E-21 m2
QPP02 (Map Unit 13) TLTM
QPP03 (Anhydrite b) 2.4 E-22 m2
QPP04 (Map Unit 7) 5 E-23 m2
QPP05 (Map Unit 6) TLTM
Map Unit 3
QPP15 (Map Unit 0) TLTM
QPP14 (Polyhalitic halite)
TLTM
QPP13 (MB 139) 3 E-22 m2
QPP12 (Halite below clay d) 2 E-23 m2
QPP11 (Halite below anh. c)
TLTM
QPP21 TLTM
QPP22 1 E-22 m2
QPP23 1 E-21 m2
QPP24 1 E-21 m2
QPP25 1 E-22 m2

396 0

Beauheim and Howarth (6/91)
Summary Of Permeability Testing Results

1. Halite permeability is typically < 10^{-20} m^2. Anhydrite permeability is typically between 10^{-19} and 10^{-18} m^2.

2. Halites containing no clay show no permeability (limit of resolution is approximately 10^{-23} m^2) or apparent pore pressure.

3. Pore pressures approaching lithostatic pressure are observed in anhydrites far from excavations.

4. Pore pressures decrease with increasing proximity to excavations.

5. Uncertainty in the specific storage of halite results in significant uncertainty in permeability, potential flow volumes, and the radius of influence of the tests.

6. Constant-pressure flow tests can help resolve uncertainty in specific storage.

397-0

Conclusions
Beauheim and Howarth (6/91)

1. A simple Darcy flow model is adequate to explain all anhydrite tests and about half of the halite tests. The remainder of the halite tests show no apparent permeability.

2. Hydraulic properties are different between strata, and also exhibit lateral heterogeneity within individual strata.

3. Within the DRZ around the excavations, pore pressures are lower and permeabilities are higher than in the far field. Specific storage is probably also higher within the DRZ. We cannot as yet define the boundaries of the DRZ, or the exact nature or mechanics of the changes that occur within the DRZ.

4. No evidence has been observed to date of two-phase flow under undisturbed (far-field) pressures. Two-phase flow does appear to occur in anhydrite interbeds close to excavations where significant depressurization has occurred.

398-0

Data Flow for 91 PA Panel Model, Cont.

Component: Creep Closure/Expansion

Munson (12/88)
Repository Isolation Division

Elastic Constants
Creep Constituitive Model Constants

Data Flow for 91 PA Panel Model, Cont.

Component: Waste-Form and Backfill Compaction

Mendenhall (6/91) and Butcher (9/89)
Disposal Room Systems Division

Waste-Form (as received for 91 PA)
Porosity and Permeability

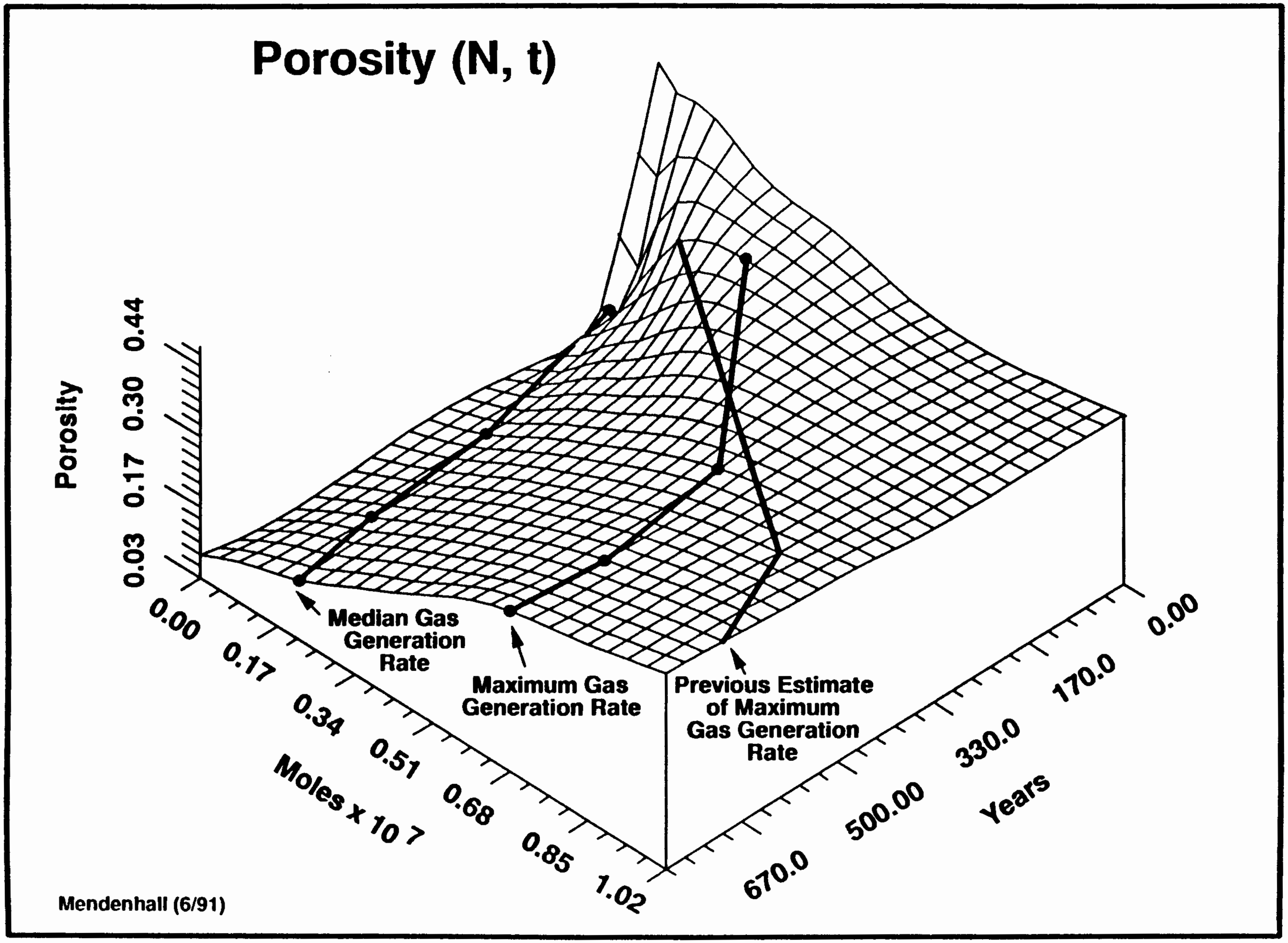
Peterson (IDB 90, IT)
Performance Assessment Division

Material Inventory (volumes and masses of metals, cellulosics, organics, and sludges)

Approaches for Capturing the Disposal Room Model into Performance Assessment

- Three phase flow models
- Simplified closure descriptions (IT type EATF models)
- Path dependent porosity surfaces

Mendenhall (6/91)


Porosity (N, t)
Porosity
0.03
0.17
0.30
0.44
0.00
0.17
0.34
0.51
0.68
0.85
1.02
Moles x 10 7
Median Gas Generation Rate
Maximum Gas Generation Rate
Previous Estimate of Maximum Gas Generation Rate
670.0
500.00
330.0
170.0
0.00
Years
Mendenhall (6/91)

Summary
Mendenhall (6/91)

- A Disposal Room Model has been developed that takes into account:
  - -- Salt creep
  - -- Backfill
  - -- Waste
  - -- Gas generation
  - -- Preexisting cracks
  - -- Preliminary study of geomechanical and saturated fluid flow
- The Model has been exercised with various test problems and the results of these test problems presented.
- Work is progressing to develop approaches that incorporate the results of the Disposal Room Model into the Performance Appraisal process.
- Work that still needs to be done includes:
  - -- Panel scale modeling
  - -- Human intrusion
  - -- Complete coupled geomechanical-fluid flow models
  - -- Crack opening in an isolated or edge room

402.0

Data Flow for 91 PA Panel Model, Cont.

Component: Gas Generation

Brush (3/91,12/90,12/89,12/88)
Disposal Room Systems Division
Gas Generation Rates

Peterson (IDB 90, IT)
Performance Assessment Division
Material Inventory (volumes and masses of metals, cellulosics, organics, and sludges)

Data Flow for 91 PA Panel Model, Cont.

Component: Brine/Gas Flow

Davies (12/89)
Fluid Flow and Transport Division

Threshold Pressure
Residual Saturation
Brooks and Corey Exponent
Capillary Pressure
Relative Permeability

Data Flow for 91 PA Panel Model, Cont.

Component: Source Term

Phillips and Butcher (8/91)
Brush (3/91 ...)
Disposal Room Systems Division

Radionuclide Solubility (expert panel)

Peterson (IDB 90, IT)
Performance Assessment Division
Radionuclide and RCRA Inventory

Modeling Guidance for 91 PA Panel Model

Davies (12/89,9/90)
Fluid Flow and Transport Division
Code: ECLIPSE

Webb
Fluid Flow and Transport Division
Code: TOUGH

Mendenhall and Butcher (6/91, 9/89)
Disposal Room Systems Division
Weatherby (12/89)
Engineering and Structural Mechanics Division
Code: SANCHO

Davies (9/90) Summary Observations - Fixed "Inundated" Gas Generation Rates

- Gas release through interbeds causes significant reduction in peak room pressure and in gas energy stored in disposal room.
- Peak room pressure is sensitive to degree of room closure and to interbed intrinsic permeability; peak room pressures range from approximately 12 1/2 to 24 1/2 MPa.
- Stored gas energy is also sensitive to room-closure state, however, the impact is opposite in character to that of peak room pressure.

Davies (9/90)
Summary Observations - Fixed "Inundated" Gas Generation Rates (cont.)

- Once gas penetrates an interbed, lateral migration occurs relatively efficiently.

  Within the first several tens of meters, gas pressure within the interbed tracks gas pressure in the room quite closely.

- If gas pressures exceed lithostatic, a likely response will be dilatation and/or extension of preexisting, near-horizontal fractures within the interbeds.

  The magnitude of interbed permeability (fracture aperture) increase required to maintain room pressure $\leq$ 15 MPa is small.

Davies (9/90)
Summary Observations - Variable Gas Generation Rates

- All simulations (fixed and variable rate) suggest that much of the room remains highly unsaturated due to limited brine inflow.

- Simulations in which gas generation rates vary as a function of local saturation conditions produce significant differences in system response than are produced by fixed rate simulations.

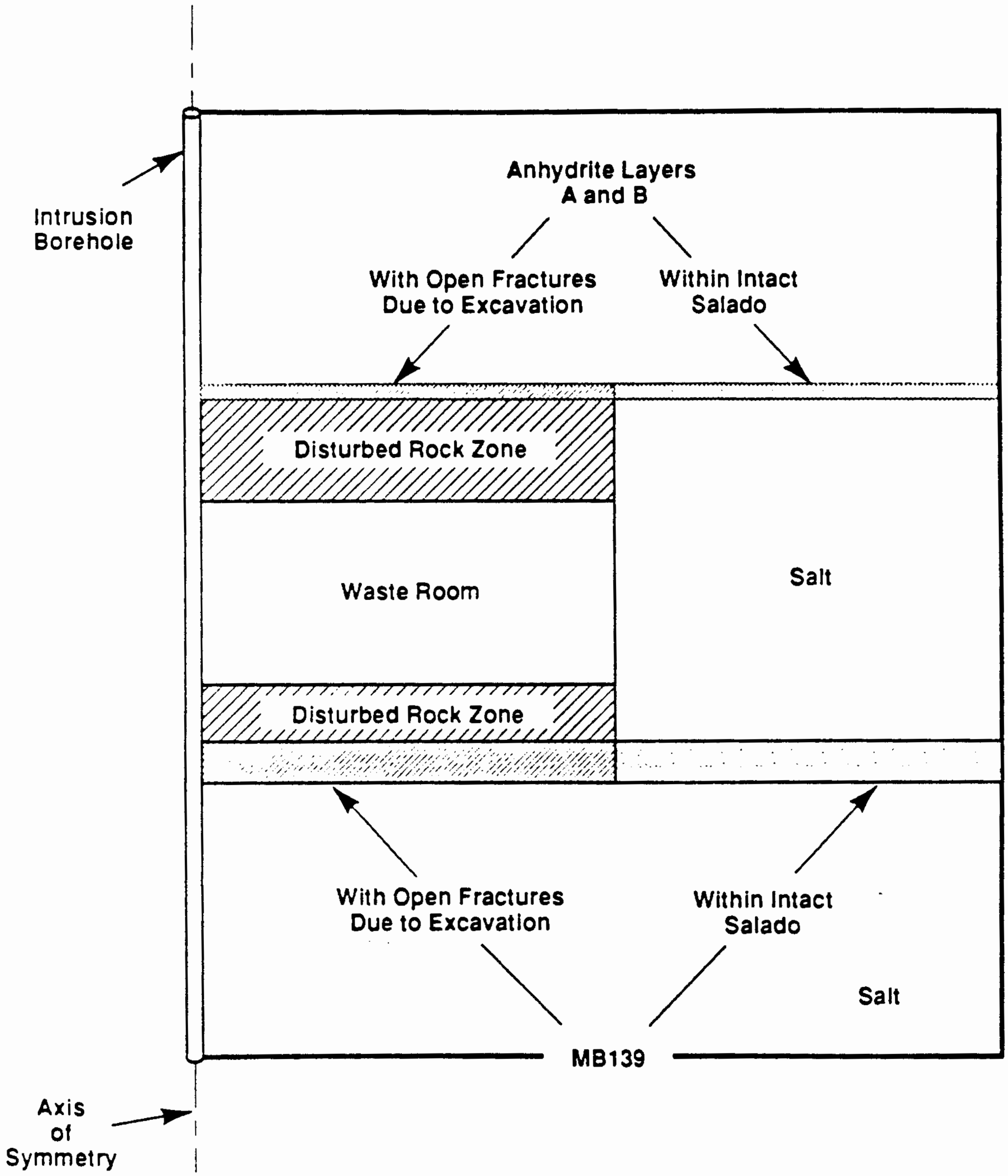
- Peak room pressures are lower than in comparable fixed rate simulations by as much as 10 MPa; peak pressures range from approximately 13 1/2 to 15 1/2 MPa.

Davies (9/90)
Summary Observations - Variable Gas Generation Rates (cont.)

- Peak room pressure is much less sensitive to interbed permeability and room-closure state than in comparable fixed rate simulations.

- Unlike the fixed rate simulations, the variable rate simulations produce lower peak pressures in the fully consolidated room-closure state than are produced in the intermediate room-closure state simulations

  This occurs because gas generation in the variable rate simulations is closely tied to brine availability, and less brine enters the fully consolidated room due to more rapid pressurization.



SUTRA Geologic/Waste Panel Model.

429-0

91 Panel Model (BRAGFLO)

Two dimensional cylindrical geometry

Materials - Culebra, Salado (halite, anhydrite, MB139, DRZ), Waste, HI borehole fill, Castile

No-flow boundaries

Two-phase (brine and gas) Darcy flow

Brooks-Corey relative permeabilities and capillary pressure

Dissolved gas

91 Panel Model (BRAGFLO), Cont.

Saturation dependent corrosion and biodegradation rates

Brine and iron consumption during corrosion

Cellulose consumption during biodegradation

Fully implicit and coupled (handles HI)

Time invariant room porosity for 91 only

Rock and fluid compressibilities

91 Panel Model (BRAGFLO), Cont.

Anisotropic permeabilities

Gravity effects

Benchmarked against BOAST, TOUGH, and ECLIPSE

Based on three-phase compositional petroleum model (TSRS) used for enhanced oil recovery and tar sands

PANEL/calculates radionuclide concentration up to solubility limit or inventory limit and radionuclide flux into HI borehole

6344, Webb

Benchmark Test Problems

ECLIPSE, TOUGH, BOAST, and BRAGFLO

BENCHMARK #2

Conditions:

<u>Room</u>	<u>Salado</u>
P = 0.1 MPa	11 MPa
ϕ = 1.0	0.01
k = 10^{-11} m^2	10^{-18} m^2

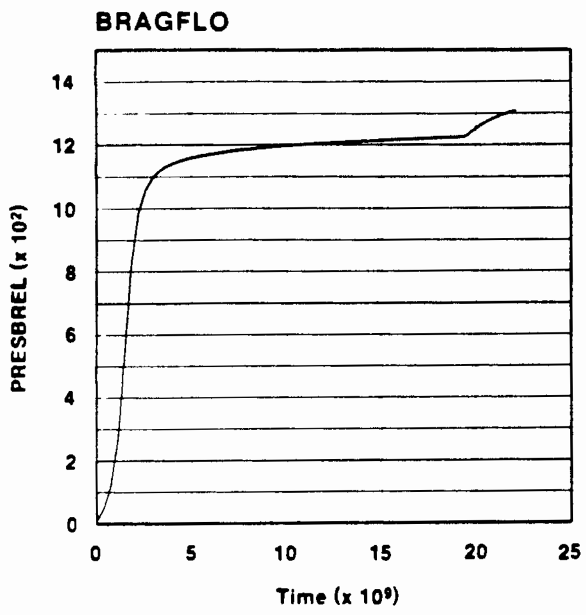
Gas Generation: 2 x 10^{-7} $kg/sec/m^3$

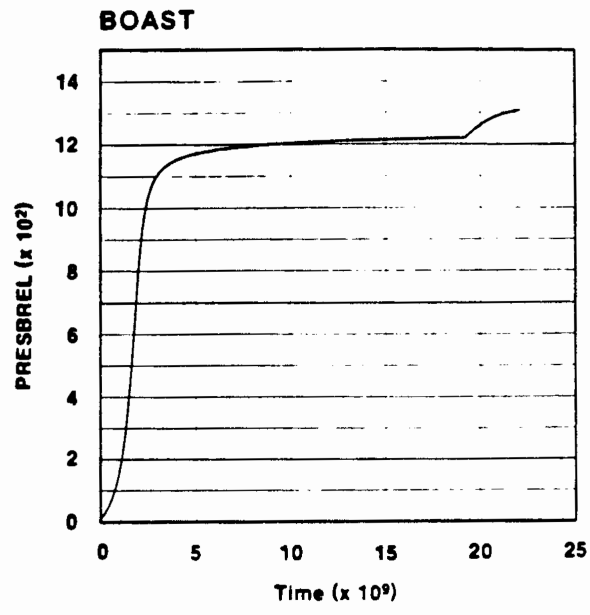
Simulate 700 yr

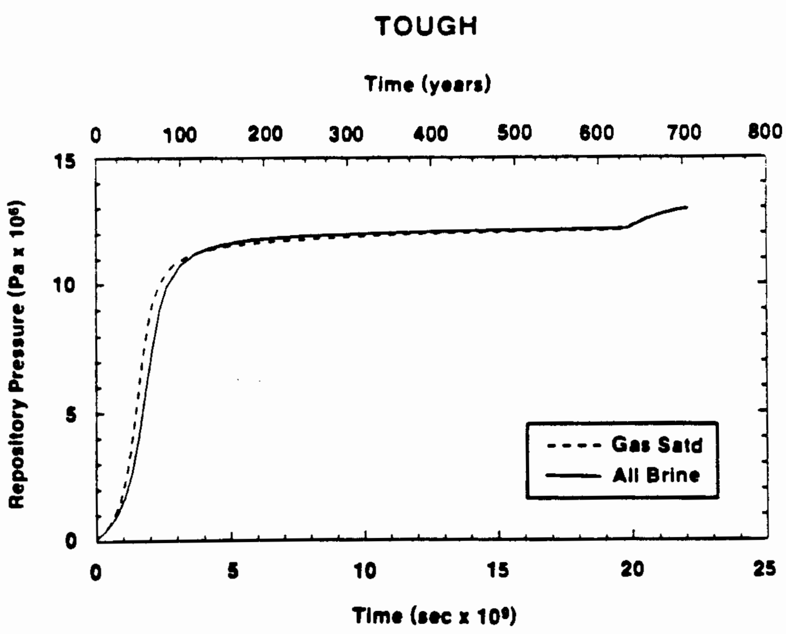
Fluids: Air, Water

Fluid Compressibility
Dissolved Gas
Brooks-Corey Relative Permeability

Benchmark #2







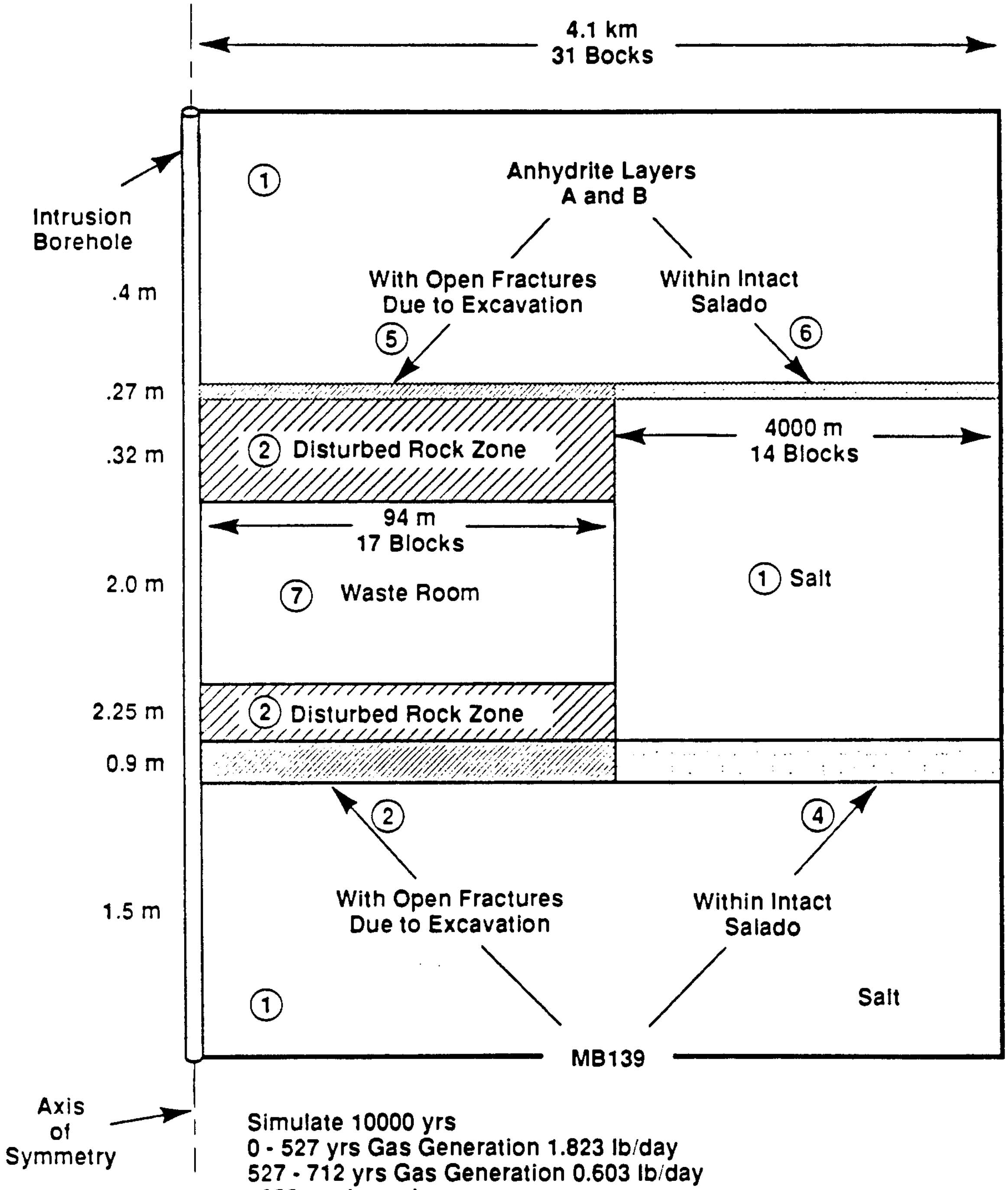
340-0

BENCHMARK #3

Material	Index	λ^*	MPa $P_{Threshold}$	S_{or}	S_{gr}	m² k_x	m² k_y	ϕ
Salado	1	0.7	23.0	0.2	0.2	1.0×10^{-21}	1.0×10^{-21}	0.01
Salado-DRZ	2	0.7	2.0×10^{-3}	0.2	0.2	1.0×10^{-21}	1.0×10^{-17}	0.01
MB30-DRZ	3	0.7	2.0×10^{-3}	0.2	0.2	1.0×10^{-18}	1.0×10^{-17}	0.10
MB30	4	0.7	2.0×10^{-3}	0.2	0.2	1.0×10^{-18}	1.0×10^{-18}	0.01
Anhydrite-DRZ	5	0.7	2.0×10^{-3}	0.2	0.2	1.0×10^{-18}	1.0×10^{-17}	0.10
Anhydrite	6	0.7	0.3	0.2	0.2	1.0×10^{-18}	1.0×10^{-18}	0.01
Waste	7	2.89	2.0×10^{-3}	0.276	0.02	1.0×10^{-15}	1.0×10^{-15}	0.08

* Brooks-Corey Equation for Relative Permeability

Benchmark #3



Simulate 10000 yrs
0 - 527 yrs Gas Generation 1.823 lb/day
527 - 712 yrs Gas Generation 0.603 lb/day
1200 yrs Intrusion

418-0

Modeling Guidance for 91 PA Panel Model

Performance Assessment Division

Codes: NORIA, SUTRA, STAFF2D, BOAST, BRAGFLO

Performance Assessment

Undisturbed Scenario Calculations

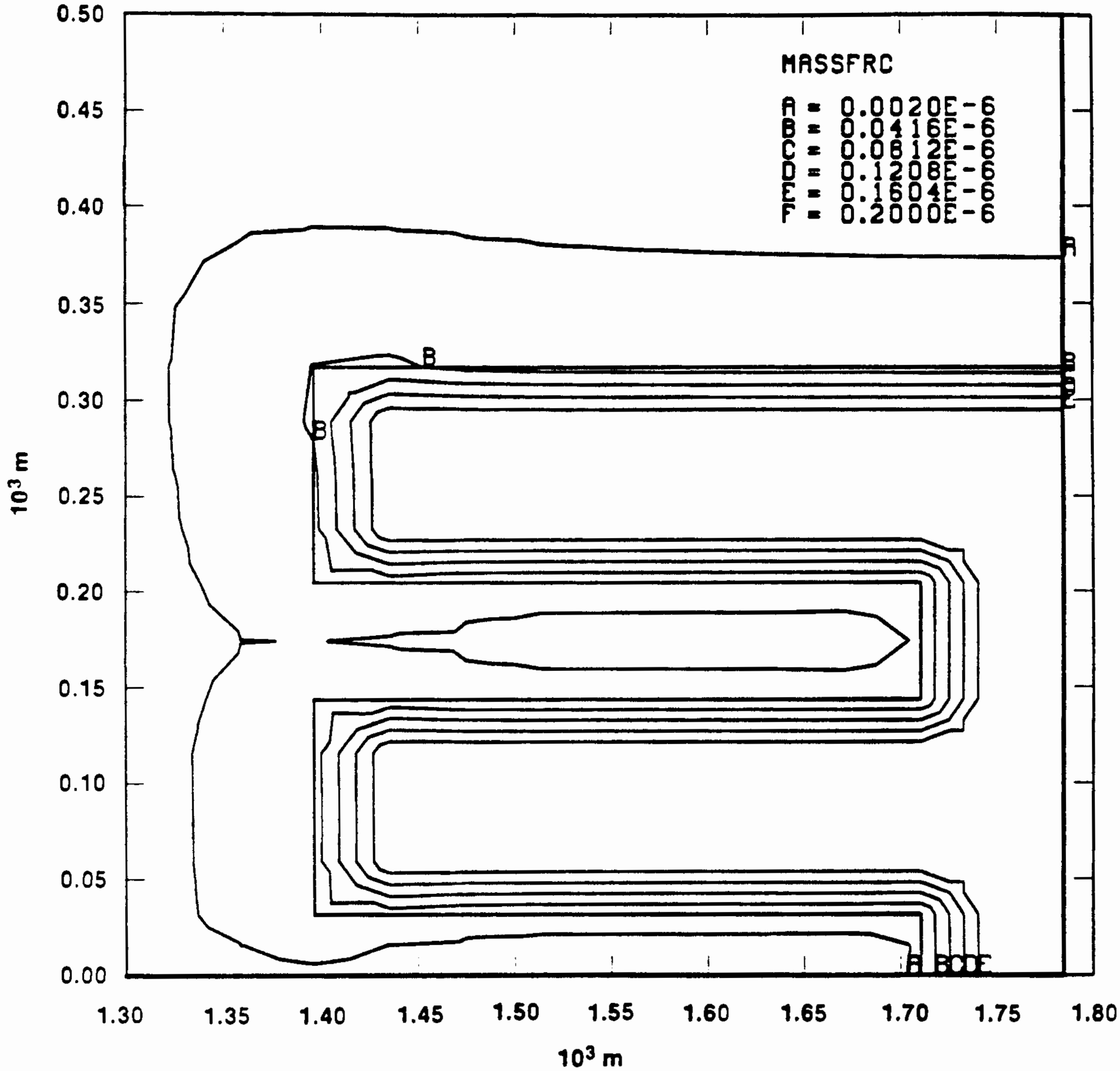
- Brine Transport

- Radionuclide Transport

Human Intrusion Scenario Calculations

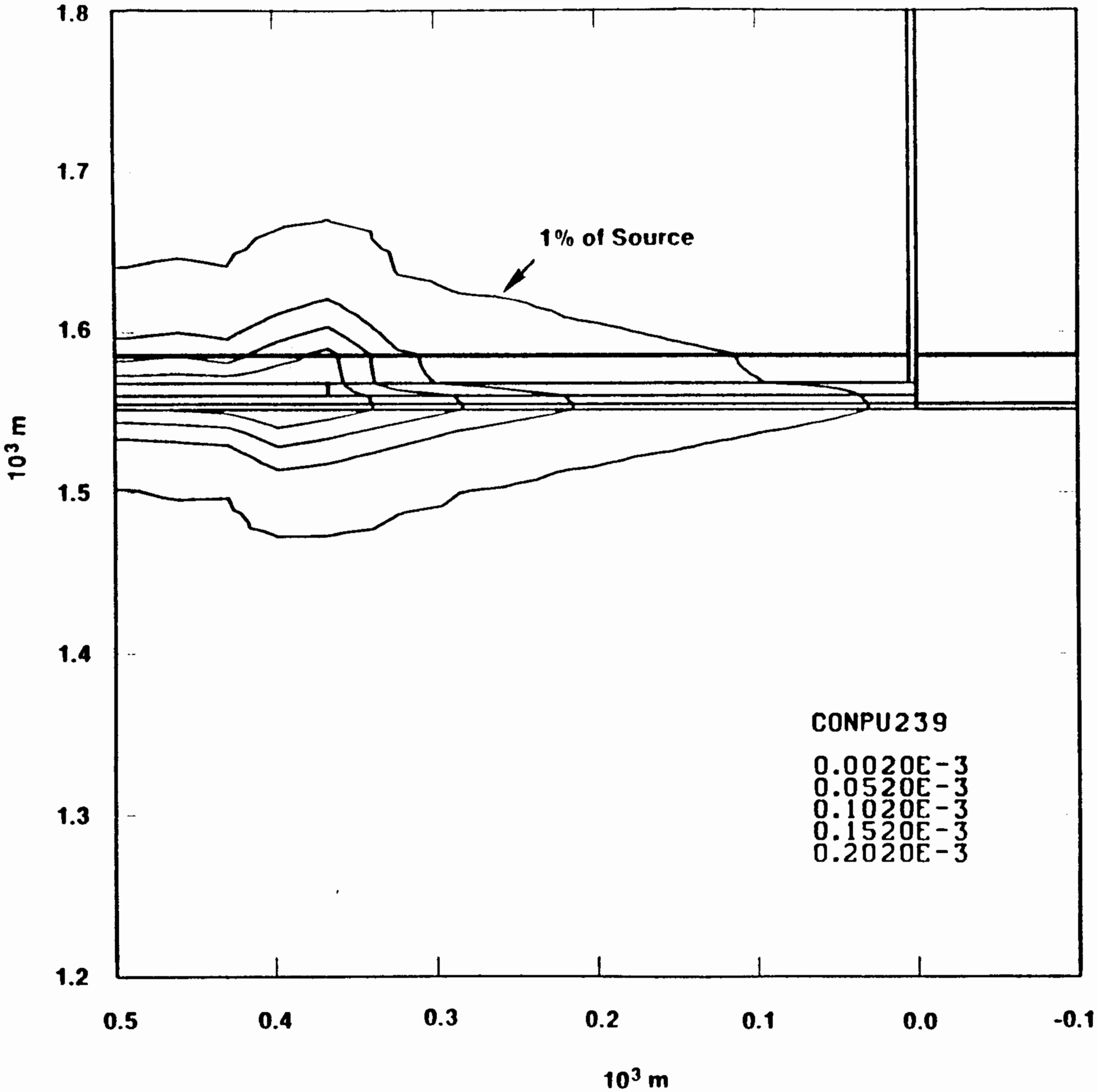
-- To Be Reported in December --

Undisturbed Conditions: Solute Mass Fraction at 10,000 Years in MB139 Below Panels



341-0

Undisturbed Conditions: Solute Concentrations at 10,000 Years



342-0

Undisturbed Conditions

Including Waste-Generated Gas Effects

Assuming No Fracturing Occurs

(CONDITIONAL on 91 MODELS and DISTRIBUTIONS)

Zero Releases in 10,000 Years

Compliance with Individual Protection

For 91 Calculations, Only HI Scenarios Contribute to CCDF for Containment

(Same as 89 and 90 Calculations)

421-0

Expert Panels for Parameter Elicitation

Expert Panel on Radionuclide Source Term

Composition

- All external experts

Results

- Ranges and distributions of the concentrations of radionuclides in brines in the rooms and drifts
  - Am, Cm, Np, Pu, Th, U, Ra, Pb

Expert Panel on Radionuclide Source Term (cont.)

Selection of panelists

- Nominations
  - Initial nominees from several outside sources
  - Additional nominations from all those contacted

- Selection criteria

- Selection committee
  - Dr. Ross Heath, University of Washington (oceanography)
  - Dr. Detlof von Winterfeldt, University of Southern California (decision analysis)

Expert Panel on Radionuclide Source Term

Name	Organization	Discipline
Carol Bruton	Lawrence Livermore National Laboratory	Geochemistry
I-Ming Chou	U.S. Geological Survey	Geochemistry
David Hobart	Los Alamos National Laboratory	Actinide Chemistry
Frank Millero	University of Miami, Rosenstiel School School of Marine & Atmospheric Science	Physical Chemistry

Expert Panel on Radionuclide Source Term (cont.)

Results

- Organized themselves into a team to utilize different areas of expertise.
- Established a strategy for developing probability distributions for radionuclide concentrations due to dissolved material.
  - With little data, the strategy was based on
    - basic solubility principles
    - experimental data where available
    - considering the effect of variable conditions
    - judgement based on experience
  - The concentrations are theoretical values which may be higher than what could exist at the WIPP given the inventory.

Expert Panel on Radionuclide Source Term (cont.)

Results

- **Were not able to develop probability distributions for radionuclide concentrations due to suspended material.**

- **Correlations between radionuclides**
  - **Possibly between Am (III) and Cm (III)**
    Np (IV) and Pu (IV)

chelates } outside range
colloids }

Radionuclide Source-Term Expert-Panel Assessment of Concentrations

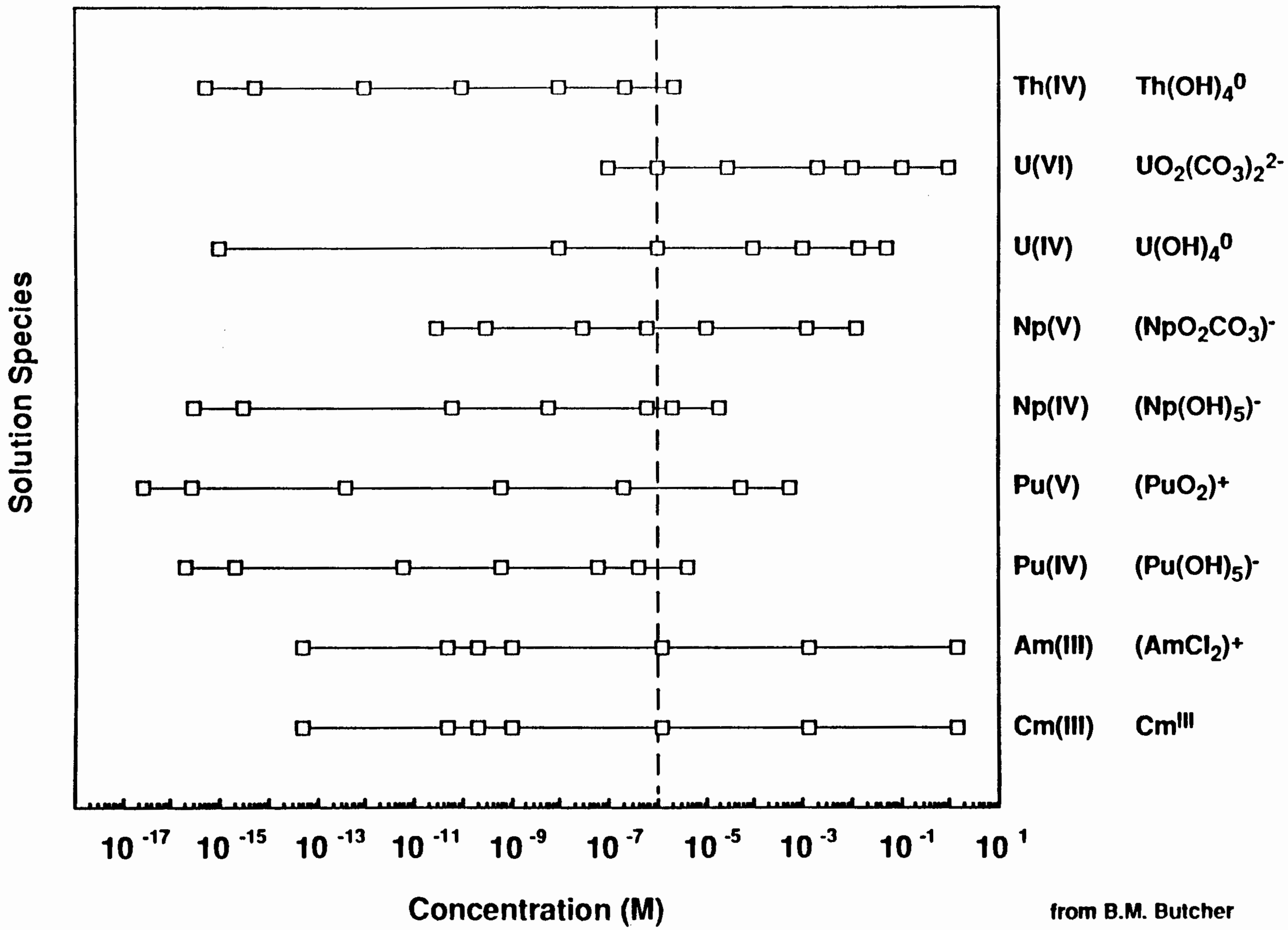
Element	Solution Species	Solid Species Maximum and Minimum	Condition	Cumulative Probabilities of Concentrations (M) 0.0	0.10	0.25	0.50	0.75	0.90	1.00
Pb(II)	$PbCl_4^{2-}$	$PbCO_3$	Carbonate Present	1.0×10^{-9}	1.0×10^{-5}	1.0×10^{-4}	8.0×10^{-3}	4.4×10^{-2}	6.2×10^{-2}	8.0×10^{-2}
		$PbCl_2$	Carbonate Absent	0.01	0.10	1.0	1.64	2.5	6.0	10.0
Ra(II)	Ra^{2+}	$RaSO_4$ and (Ra/Ca)SO_4	Sulfate Present	1.0×10^{-11}	1.0×10^{-10}	1.0×10^{-9}	1.0×10^{-8}	1.0×10^{-7}	2.0×10^{-7}	1.0×10^{-6}
		$RaCO_3$ and (Ra/Ca)CO_3	Carbonate Present	1.6×10^{-9}	1.6×10^{-8}	1.6×10^{-7}	1.6×10^{-6}	1.6×10^{-5}	1.6×10^{-1}	1.0
		$RaCl_2 \cdot 2H_2O$	Carbonate and Sulfate Absent	2.0	4.0	8.6	11.0	14.5	17.2	18.0
Th(IV)	$Th(OH)_4^0$	$Th(OH)_4$ ThO_2		5.5×10^{-16}	5.5×10^{-15}	1.0×10^{-12}	1.0×10^{-10}	1.0×10^{-8}	2.2×10^{-7}	2.2×10^{-6}
U(VI)	$UO_2(CO_3)_2$-	$UO_3 \cdot 2H_2O$ UO_2		1.0×10^{-7}	1.0×10^{-6}	3.0×10^{-5}	2.0×10^{-3}	1.0×10^{-2}	0.1	1.0
U(IV)	$U(OH)_4 0$	UO_2 (amorphous) U_3O_8		1.0×10^{-15}	1.0×10^{-8}	1.0×10^{-6}	1.0×10^{-4}	1.0×10^{-3}	1.4×10^{-2}	5.0×10^{-2}

228-1

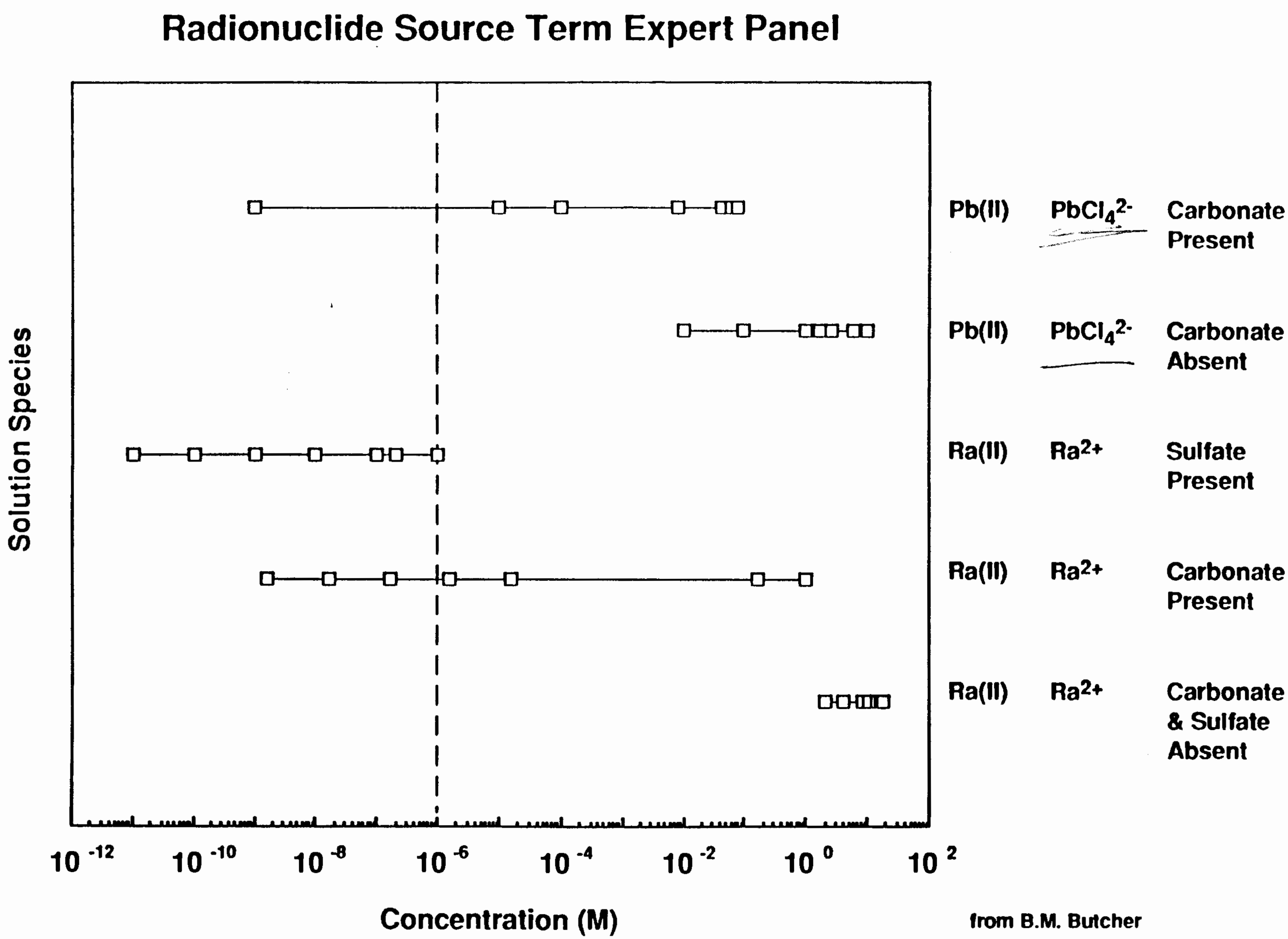
Radionuclide Source-Term Expert-Panel Assessment of Concentrations (Concluded)

Element	Solution Species	Solid Species Maximum and Minimum	Condition	Cumulative Probabilities of Concentrations (M) 0.0	0.10	0.25	0.50	0.75	0.90	1.00
Np(V)	$(NpO_2CO_3)^-$	$NpO_2(OH)$ (amorphous) $NaNpO_2CO_3 \cdot 3.5H_2O$		3.0×10^{-11}	3.0×10^{-10}	3.0×10^{-8}	6.0×10^{-7}	1.0×10^{-5}	1.2×10^{-3}	1.2×10^{-2}
Np(IV)	$(Np(OH)_5)^-$	$Np(OH)_4$ NpO_2		3.0×10^{-16}	3.0×10^{-15}	6.0×10^{-11}	6.0×10^{-9}	6.0×10^{-7}	2.0×10^{-6}	2.0×10^{-5}
Pu(V)	$(PuO_2)^+$	$Pu(OH)_4$ PuO_2		2.5×10^{-17}	2.5×10^{-16}	4.0×10^{-13}	6.0×10^{-10}	2.0×10^{-7}	5.5×10^{-5}	5.5×10^{-4}
Pu(IV)	$(Pu(OH)_5)^-$	$Pu(OH)_4$ PuO_2		2.0×10^{-16}	2.0×10^{-15}	6.0×10^{-12}	6.0×10^{-10}	6.0×10^{-8}	4.0×10^{-7}	4.0×10^{-6}
Am(III)	$(AmCl_2)^+$	$Am(OH)_3$ $AmOHCO_3$		5.0×10^{-14}	5.0×10^{-11}	2.0×10^{-10}	1.0×10^{-9}	1.2×10^{-6}	1.4×10^{-3}	1.4
Cm(III)	Cm^{III}	$Cm(OH)_3$ CmO_2		5.0×10^{-14}	5.0×10^{-11}	2.0×10^{-10}	1.0×10^{-9}	1.2×10^{-6}	1.4×10^{-3}	1.4

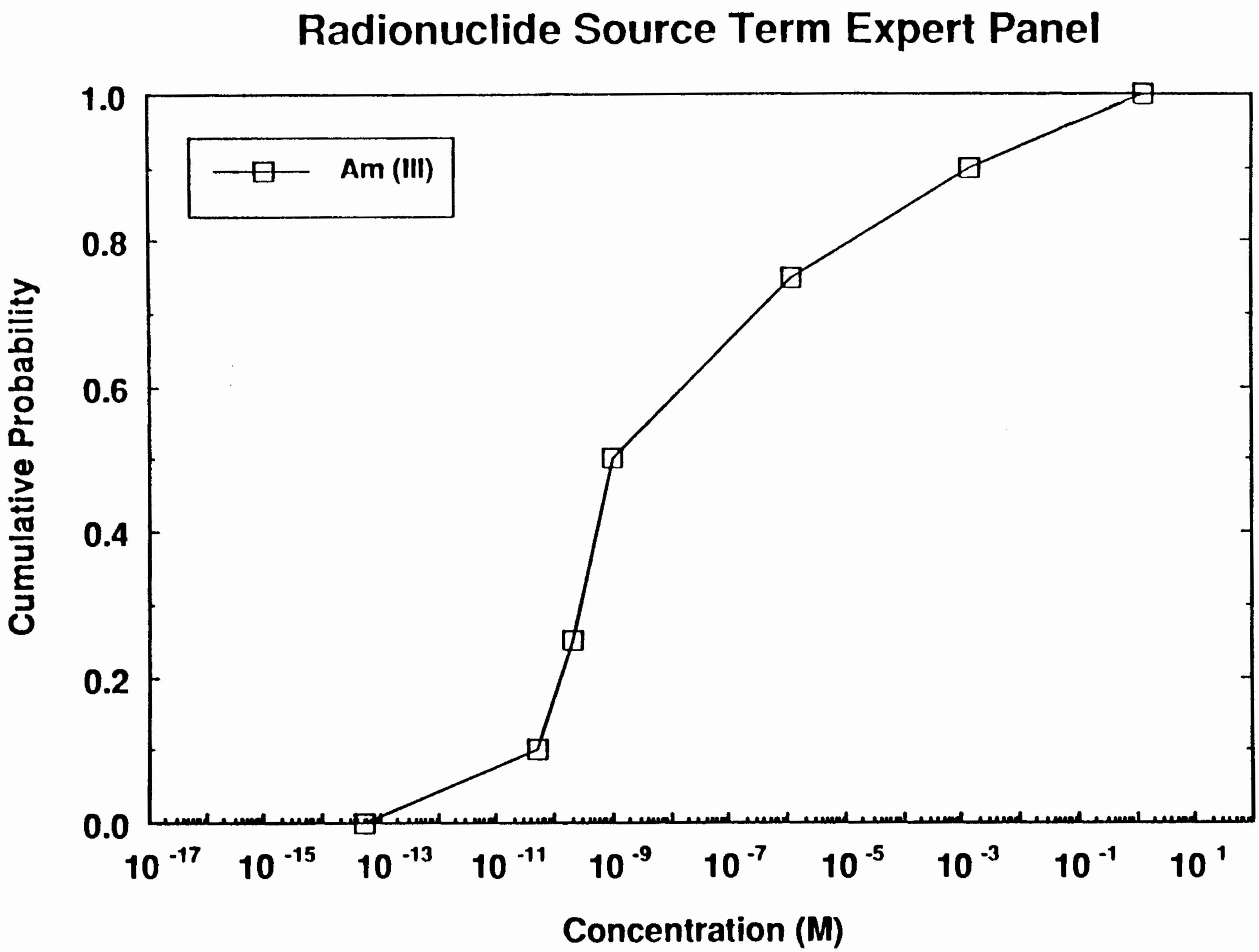
Radionuclide Source Term Expert Panel



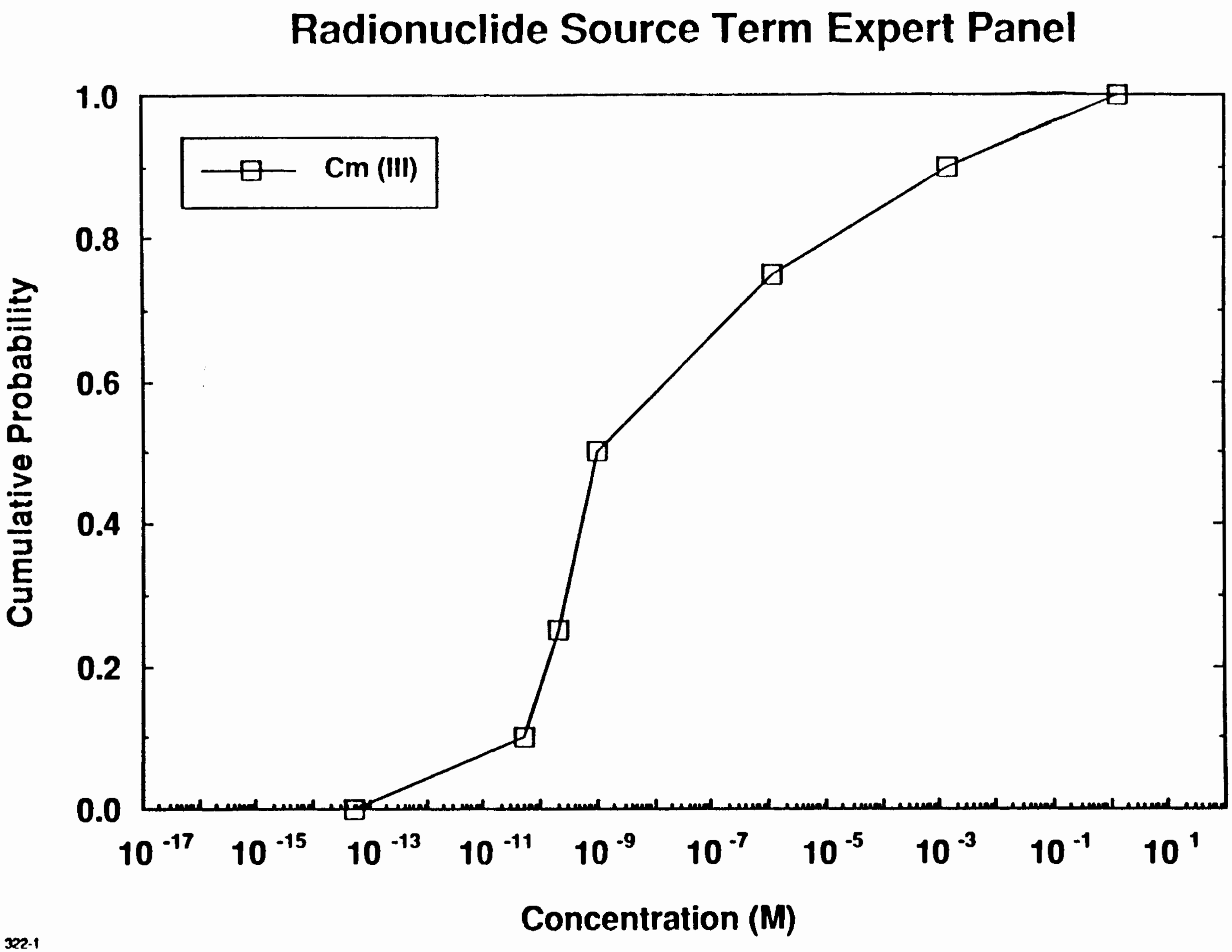
309-1 The blocks represent, from left to right, the 0.00, 0.10, 0.25, 0.50, 0.75, 0.90 and 1.00 fractiles

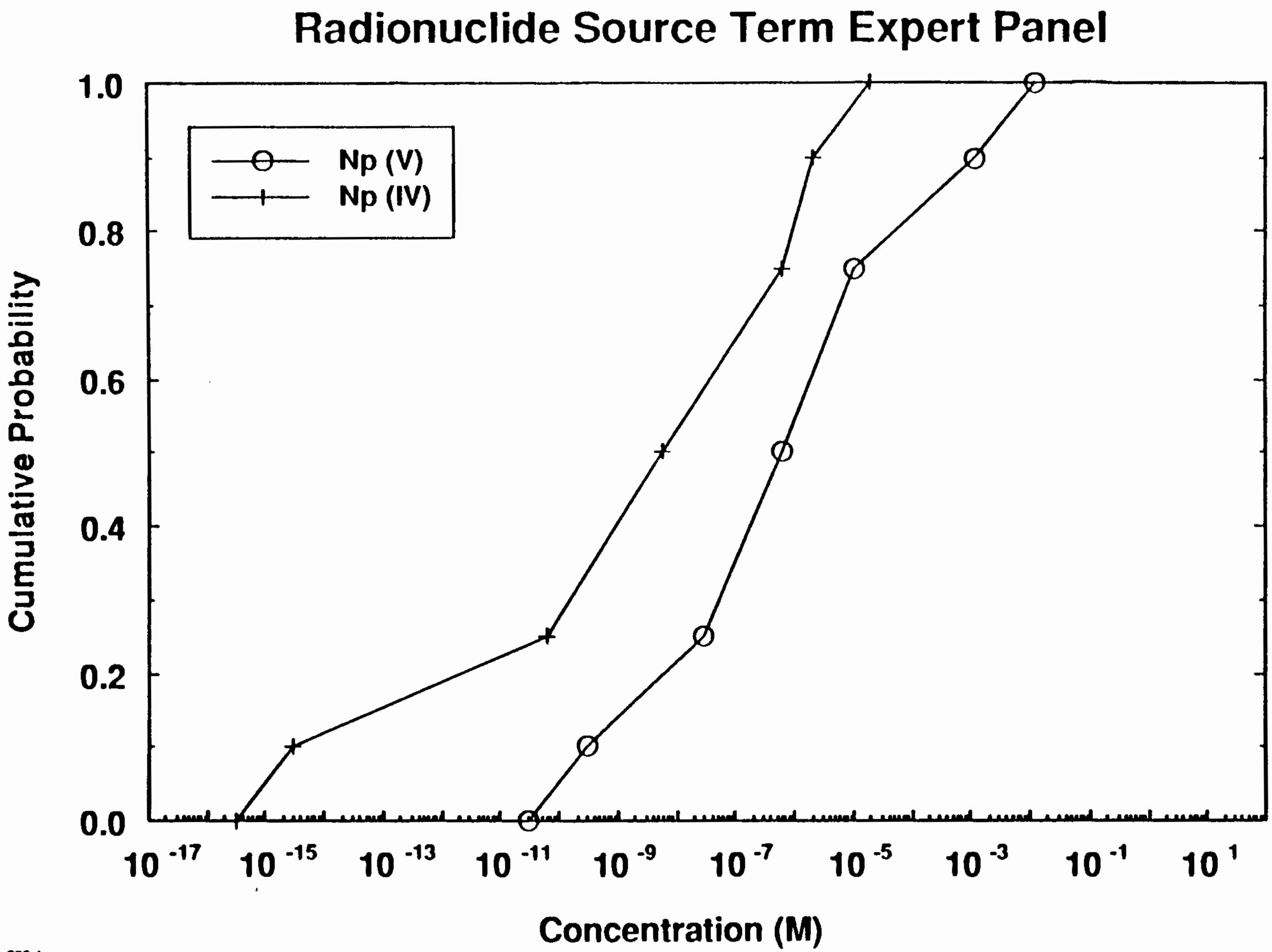


310-0 The blocks represent, from left to right, the 0.00, 0.10, 0.25, 0.50, 0.75, 0.90 and 1.00 fractiles

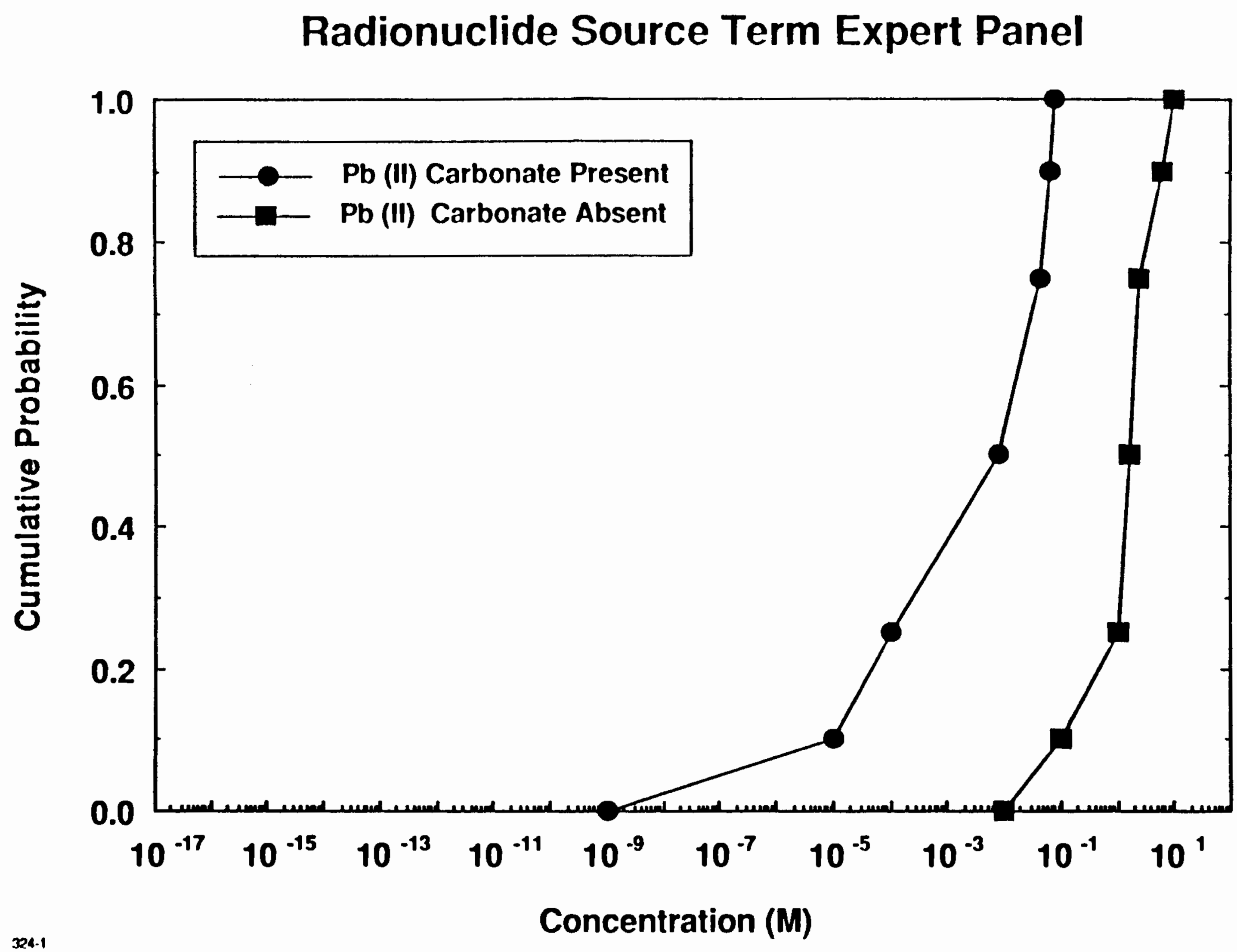

Radionuclide Source Term Expert Panel
Am (III)
Cumulative Probability
1.0
0.8
0.6
0.4
0.2
0.0
10 -17
10 -15
10 -13
10 -11
10 -9
10 -7
10 -5
10 -3
10 -1
10 1
Concentration (M)

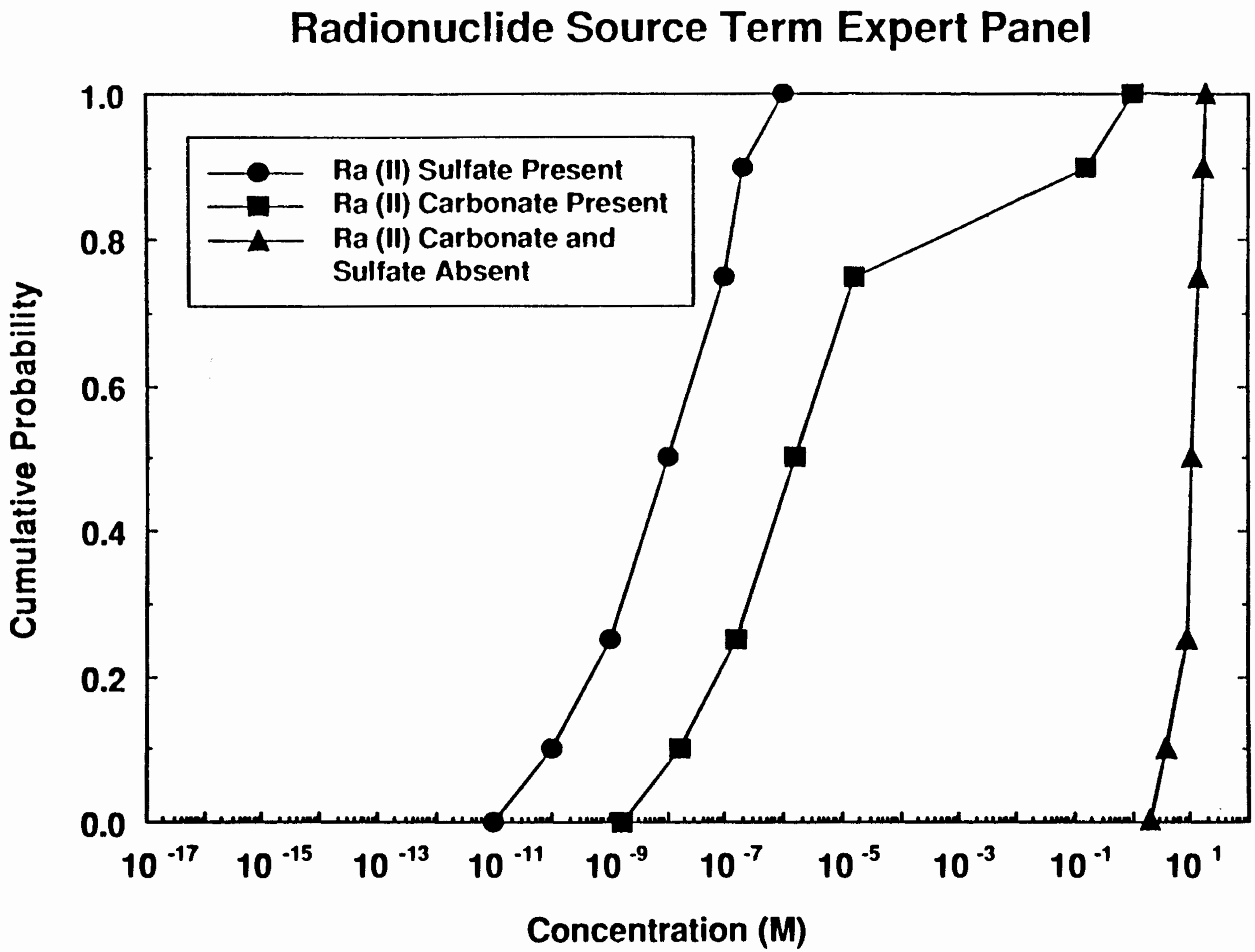
320-1


Radionuclide Source Term Expert Panel
Cm (III)
Cumulative Probability
1.0
0.8
0.6
0.4
0.2
0.0
10 -17
10 -15
10 -13
10 -11
10 -9
10 -7
10 -5
10 -3
10 -1
10 1
Concentration (M)
322-1

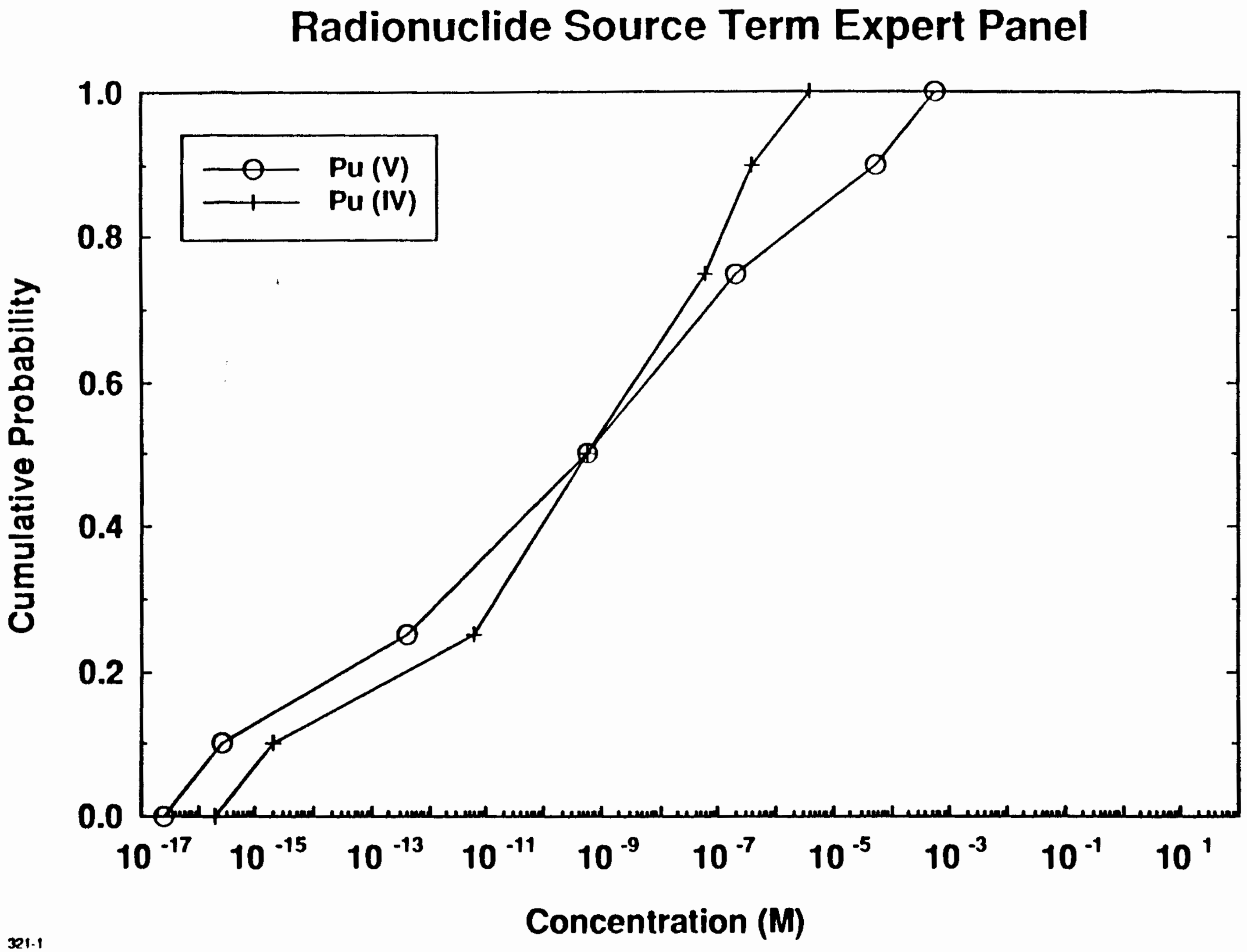

Radionuclide Source Term Expert Panel
Np (V)
Np (IV)
Cumulative Probability
1.0
0.8
0.6
0.4
0.2
0.0
10 -17
10 -15
10 -13
10 -11
10 -9
10 -7
10 -5
10 -3
10 -1
10 1
Concentration (M)

323-1

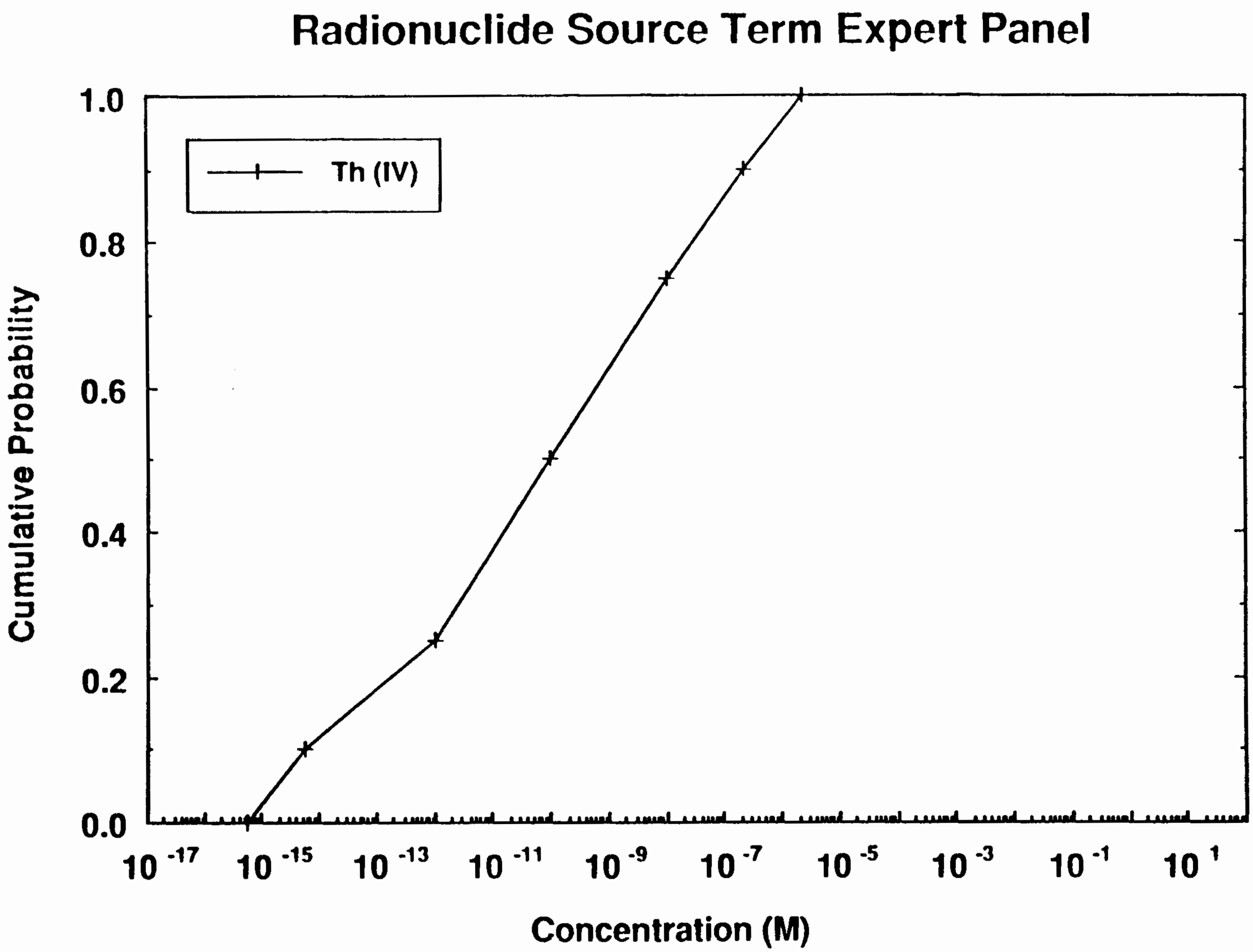

Radionuclide Source Term Expert Panel
Pb (II) Carbonate Present
Pb (II) Carbonate Absent
Cumulative Probability
1.0
0.8
0.6
0.4
0.2
0.0
10 -17
10 -15
10 -13
10 -11
10 -9
10 -7
10 -5
10 -3
10 -1
10 1
Concentration (M)
324-1


Radionuclide Source Term Expert Panel
1.0
0.8
0.6
0.4
0.2
0.0
Cumulative Probability
Ra (II) Sulfate Present
Ra (II) Carbonate Present
Ra (II) Carbonate and
Sulfate Absent
10 -17
10 -15
10 -13
10 -11
10 -9
10 -7
10 -5
10 -3
10 -1
10 1
Concentration (M)

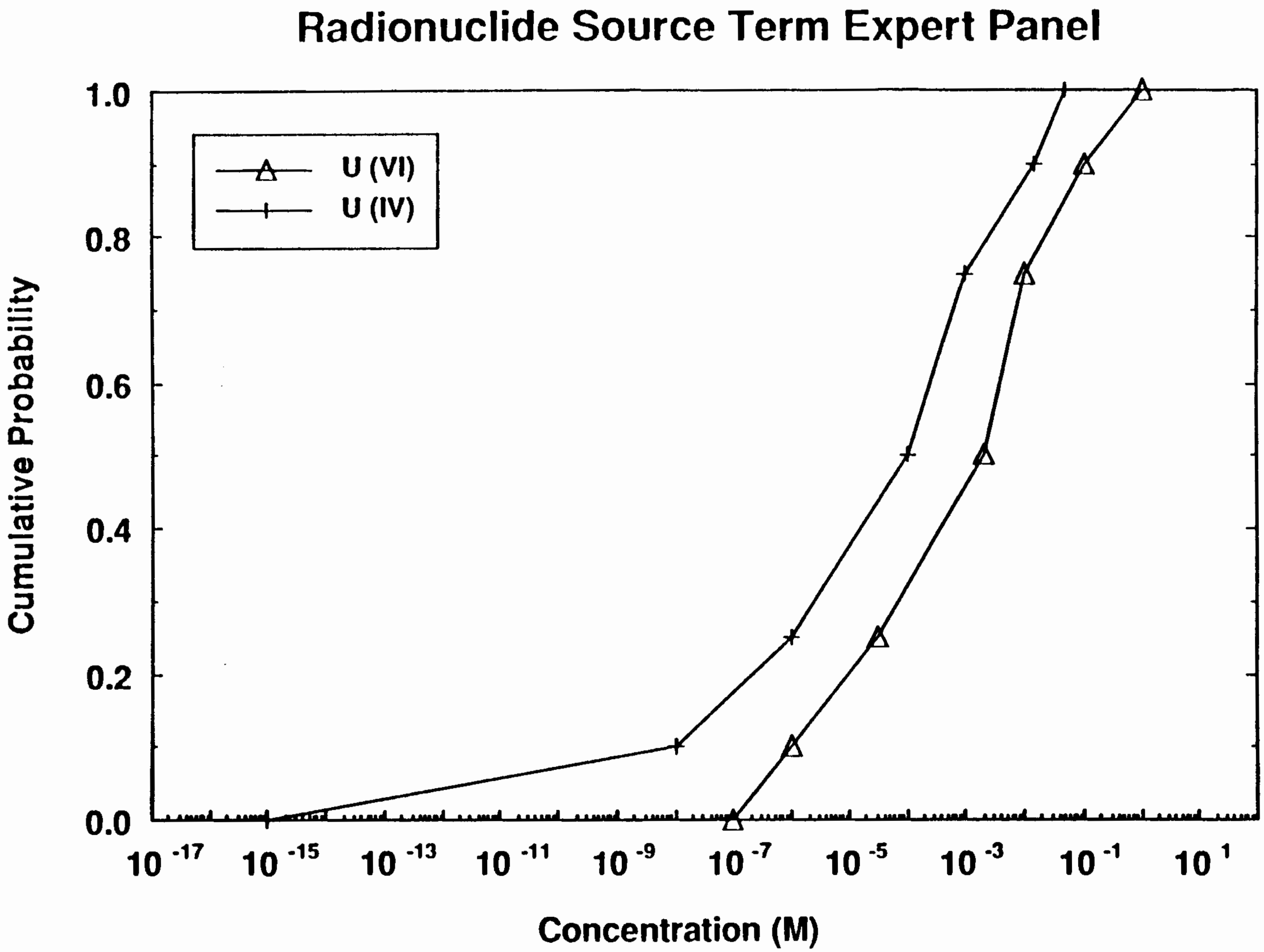
325-1


Radionuclide Source Term Expert Panel
Pu (V)
Pu (IV)
Cumulative Probability
1.0
0.8
0.6
0.4
0.2
0.0
10 -17
10 -15
10 -13
10 -11
10 -9
10 -7
10 -5
10 -3
10 -1
10 1
Concentration (M)

321-1


Radionuclide Source Term Expert Panel
Th (IV)
Cumulative Probability
1.0
0.8
0.6
0.4
0.2
0.0
10 -17
10 -15
10 -13
10 -11
10 -9
10 -7
10 -5
10 -3
10 -1
10 1
Concentration (M)

326-1


Radionuclide Source Term Expert Panel
U (VI)
U (IV)
Cumulative Probability
1.0
0.8
0.6
0.4
0.2
0.0
10 -17
10 -15
10 -13
10 -11
10 -9
10 -7
10 -5
10 -3
10 -1
10 1
Concentration (M)

327-1

Expert Panel on Radionuclide Source Term (cont.)

Strategy for Developing Probability Distributions

- Given the room conditions, what oxidation states are possible?
- For each oxidation state of each element, what compounds will have the highest and lowest solubility?
- Estimate the mode of the concentrations for both the highest and lowest solubilities. These numbers were often used as the 0.10 and 0.90 fractiles.
- Establish the lower and upper endpoints (0.00 and 1.00 fractiles) by considering how changes in the room chemistry (e.g., pH) could impact the concentrations.

Expert Panel on Radionuclide Source Term (cont.)

Strategy for Developing Probability Distributions

- Where possible, concentration data from a well (J-13) at the Nevada Yucca Mountain site, corrected for ionic strength, was used as the 0.50 fractile.
- The 0.25 and 0.75 fractiles were established based on which speciation was believed to be more likely.
- For lead and radium, the above procedure was repeated, not for different oxidation states but for the presence of compounds that change the controlling species, and therefore the solubility.

Expert Panel on Radionuclide Retardation in the Culebra

Composition

- All Sandia experts

Results

- Ranges and distributions of distribution coefficients, Kd
  - Dolomite matrix
  - Clay in fractures

  - Transport fluid dominated by Castile brine
  - Transport fluid dominated by Culebra water

  - Am, Cm, Np, Pu, Th, U, Ra, Pb

Expert Panel on Radionuclide Retardation in the Culebra (cont.)

Sandia Personnel

Robert Dosch

Craig Novak

Malcom Siegel

Expert Panel on Radionuclide Retardation in the Culebra (cont.)

1st meeting (April 12, 1991)

- Issue statement

2nd meeting (April 23, 1991)

- Issue statement

3rd meeting (May 29-30, 1991)

- Expert judgement training
- Discussion of approaches/cases
- Elicitation sessions

Expert Panel on Radionuclide Retardation in the Culebra (cont.)

Results

- Experts elicited separately
- Interpretation of existing data
- One set of results not used in 1991 calculations
  - Different information provided
- Some estimates incomplete
  - Insufficient data
- Minimum estimates
  - Expert #1: ranged from 0, to 0.1, 10, and 1000
  - Expert #2: always zero

Expert Panel on Radionuclide Retardation in the Culebra

Results (cont.)

- Impact of dolomite matrix vs. clay in fractures on K_d
  - Expert #1: K_d (fractures) > K_d (matrix)
    - 2 or 4 orders of magnitude for the 0.00 fractile and 1 order of magnitude for the 1.00 fractile
    - Am, Cm, Np, Pu
  - Expert #1: K_d (fractures) < K_d (matrix)
    - No difference for the 0.00 fractiles and 3 orders of magnitude for the 1.00 fractile
    - Ra

Expert Panel on Radionuclide Retardation in the Culebra

Results (cont.)

- Expert #1: Th and Pb not reported, U incomplete
- Expert #2: K_d (fractures) > K_d (matrix)
  - 1 order of magnitude
  - Am, Cm, Np, Pb, Pu, Ra, Th, U

- Impact of Culebra brine vs. Salado brine as dominant transport fluid on K_d
  - Expert #1: K_d (Culebra) = K_d (Salado)
    - Within the same type of rock
    - Am, Cm, Np, Pu, Ra
  - Expert #1: K_d (Culebra) > K_d (Salado)
    - Dolomite matrix
    - More than 1 order of magnitude
    - U

Expert Panel on Radionuclide Retardation in the Culebra

Results (cont.)

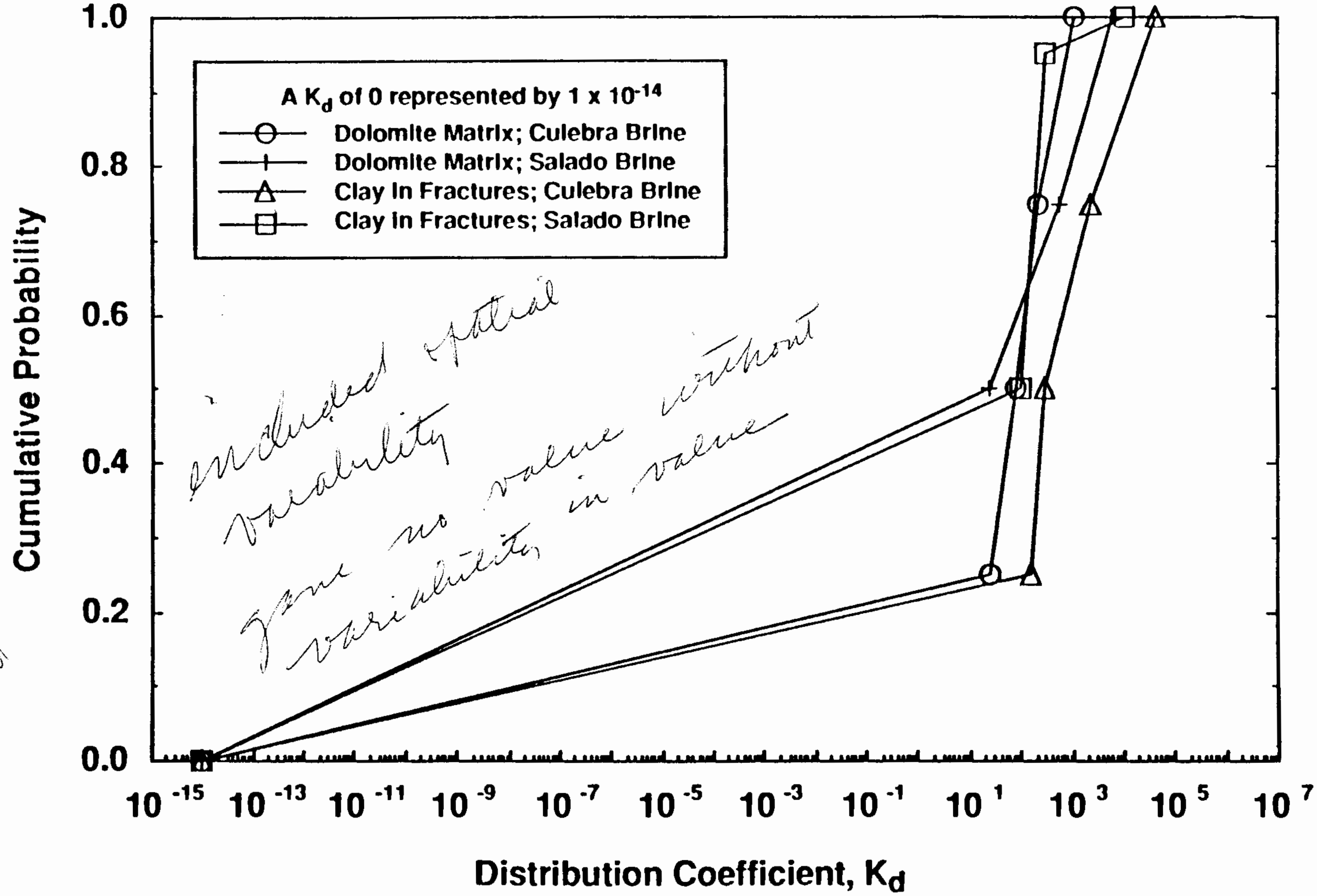
- Expert #1: Th and Pb not reported

- Expert #2: K_d (Culebra) = K_d (Salado)
  -- Within the same type of rock
  -- Pb, Ra, Th

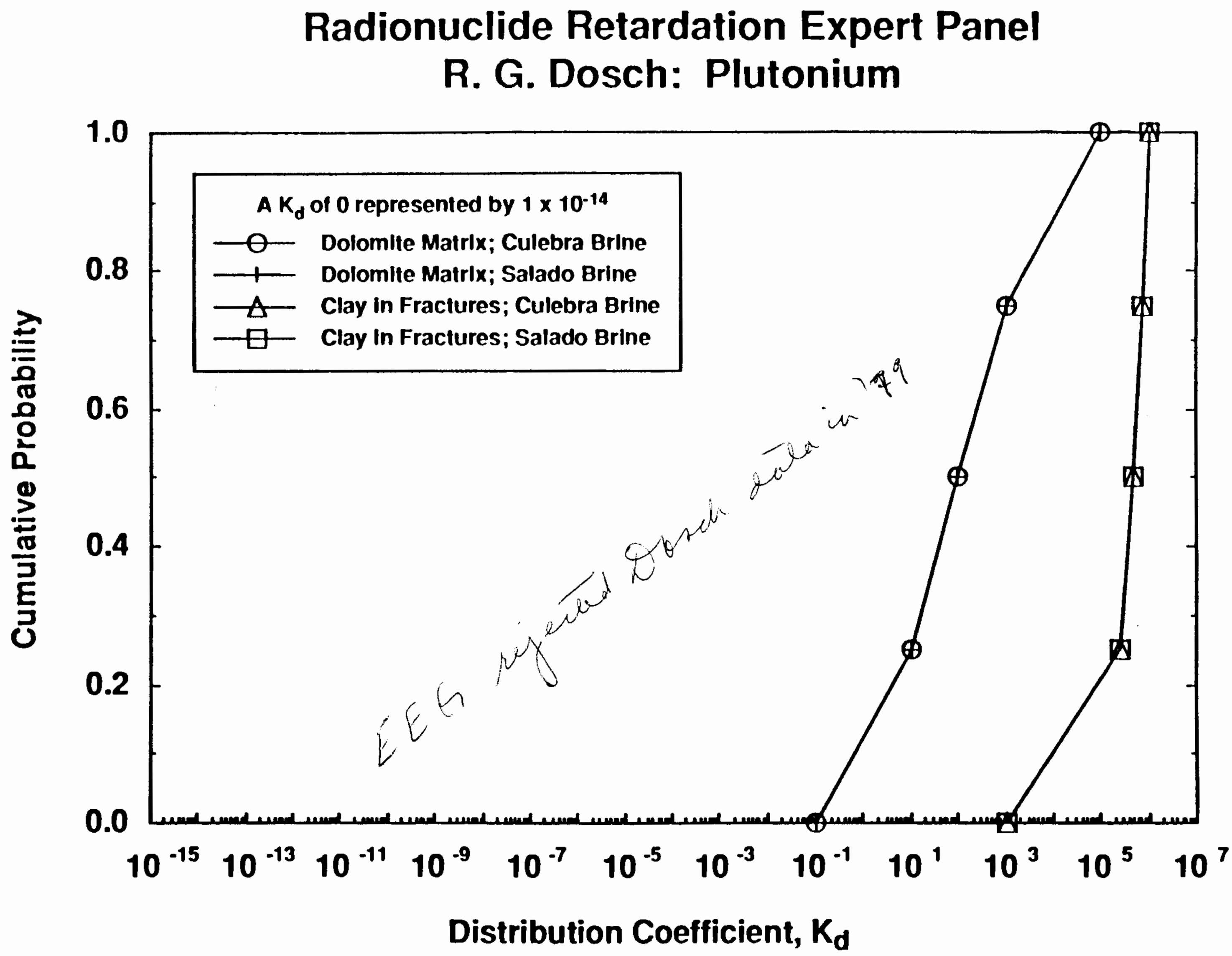
- Expert #2: K_d (Culebra) > K_d (Salado)
  -- 1 order of magnitude for the 0.25 fractile to no difference for the 1.00 fractile
  -- Am, Cm, Pu,

- Expert #2: K_d (Culebra) < K_d (Salado)
  -- Factor of 4
  -- Np, U

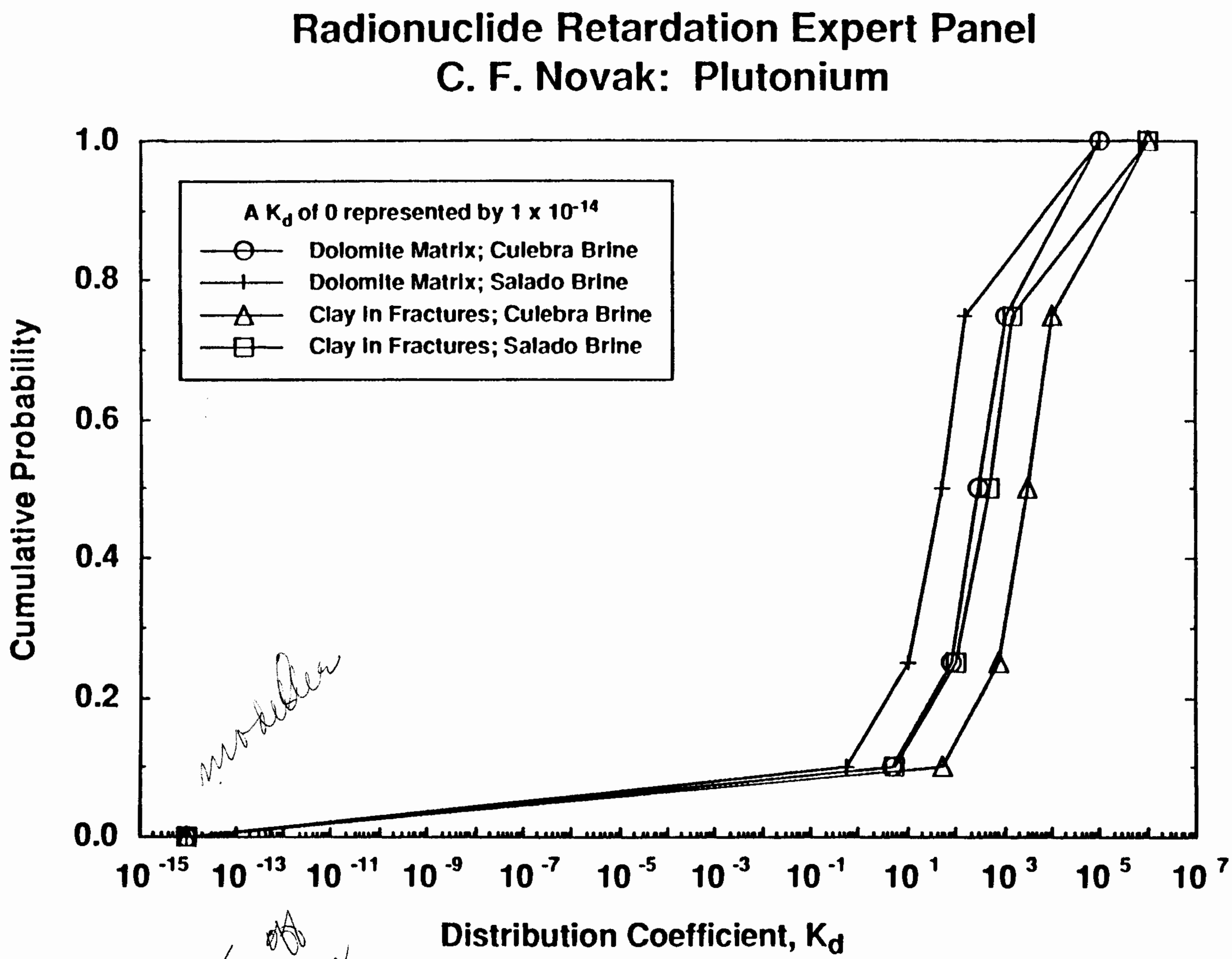
Radionuclide Retardation Expert Panel
M.D. Siegel: Plutonium



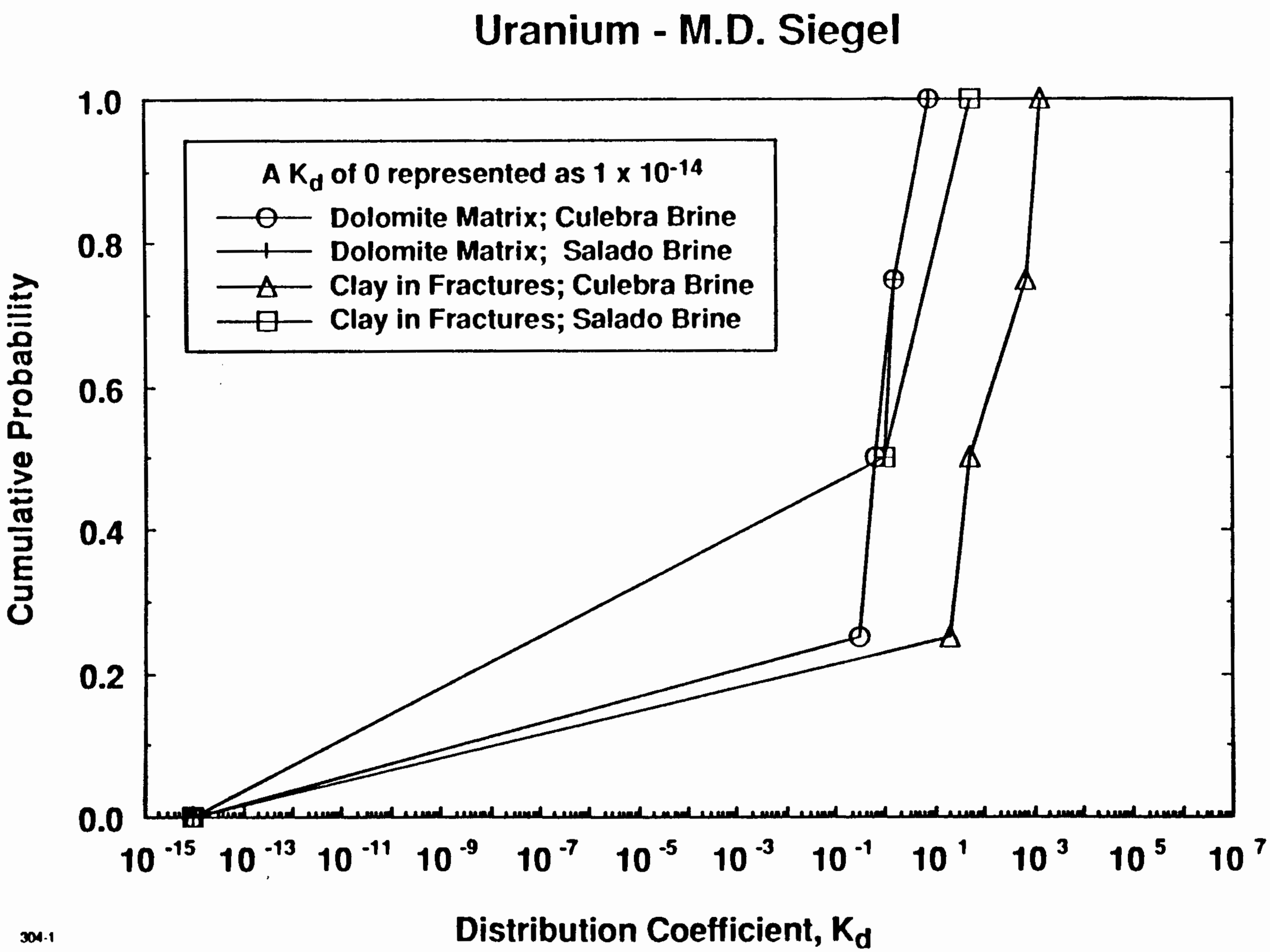
332-1

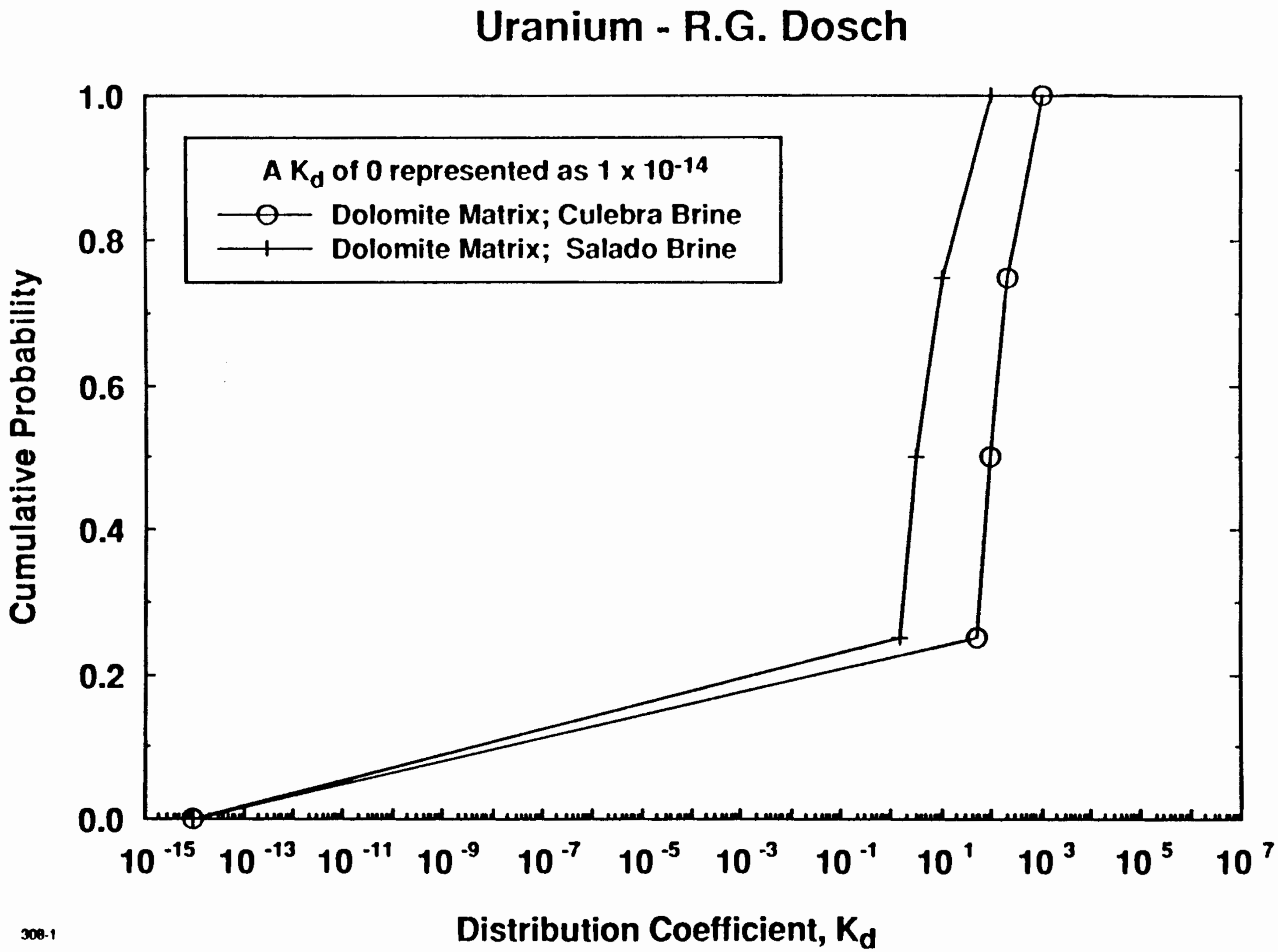

Radionuclide Retardation Expert Panel
R. G. Dosch: Plutonium
A K_d of 0 represented by 1 x 10^{-14}
Dolomite Matrix; Culebra Brine
Dolomite Matrix; Salado Brine
Clay in Fractures; Culebra Brine
Clay in Fractures; Salado Brine
Cumulative Probability
1.0
0.8
0.6
0.4
0.2
0.0
10^{-15}
10^{-13}
10^{-11}
10^{-9}
10^{-7}
10^{-5}
10^{-3}
10^{-1}
10^{1}
10^{3}
10^{5}
10^{7}
Distribution Coefficient, K_d
EEG rejected Dosch data in '79

337-1

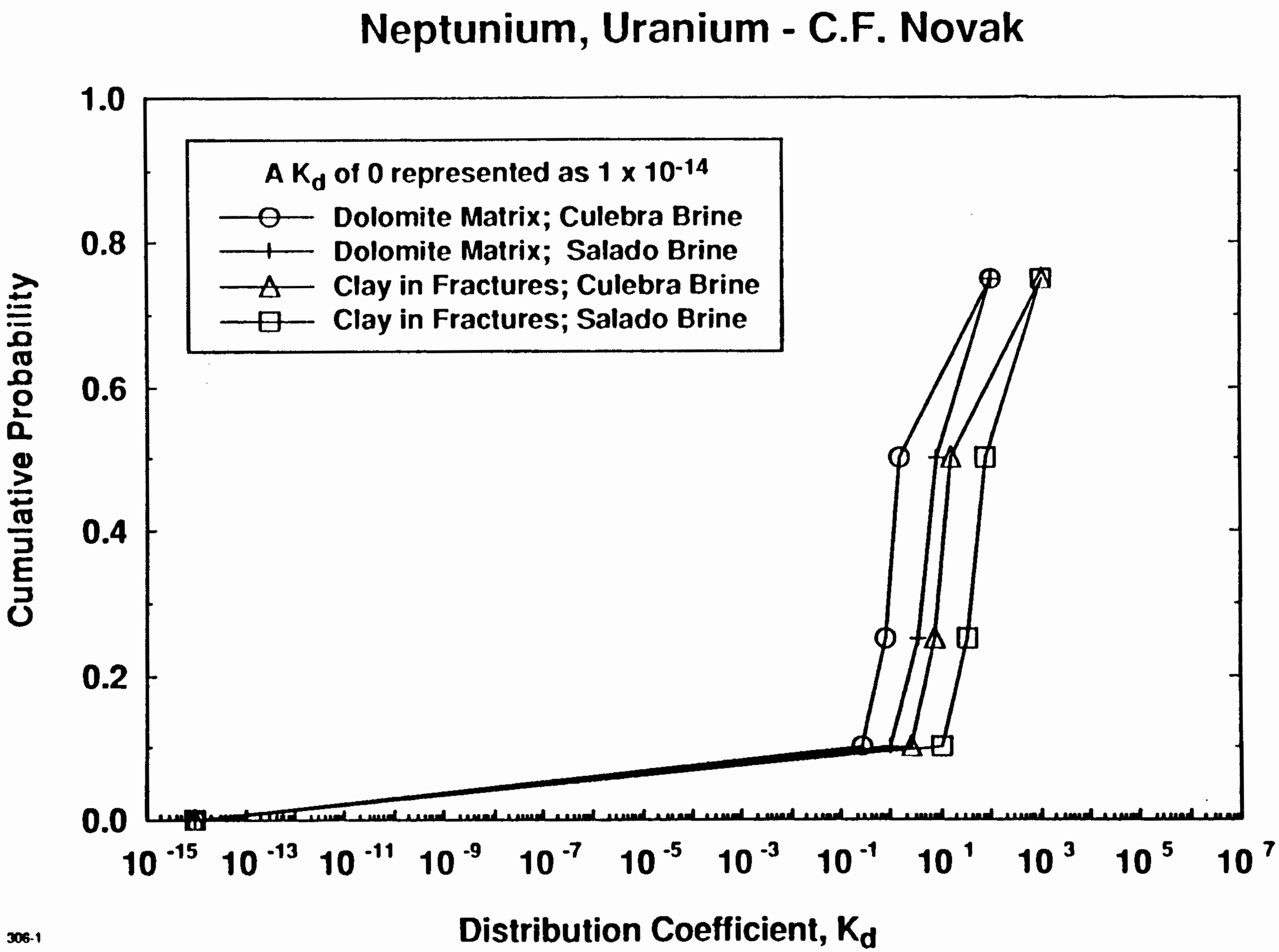

Radionuclide Retardation Expert Panel
C. F. Novak: Plutonium
A K_d of 0 represented by 1×10^{-14}
Dolomite Matrix; Culebra Brine
Dolomite Matrix; Salado Brine
Clay in Fractures; Culebra Brine
Clay in Fractures; Salado Brine
Cumulative Probability
1.0
0.8
0.6
0.4
0.2
0.0
10^{-15} 10^{-13} 10^{-11} 10^{-9} 10^{-7} 10^{-5} 10^{-3} 10^{-1} 10^{1} 10^{3} 10^{5} 10^{7}
Distribution Coefficient, K_d

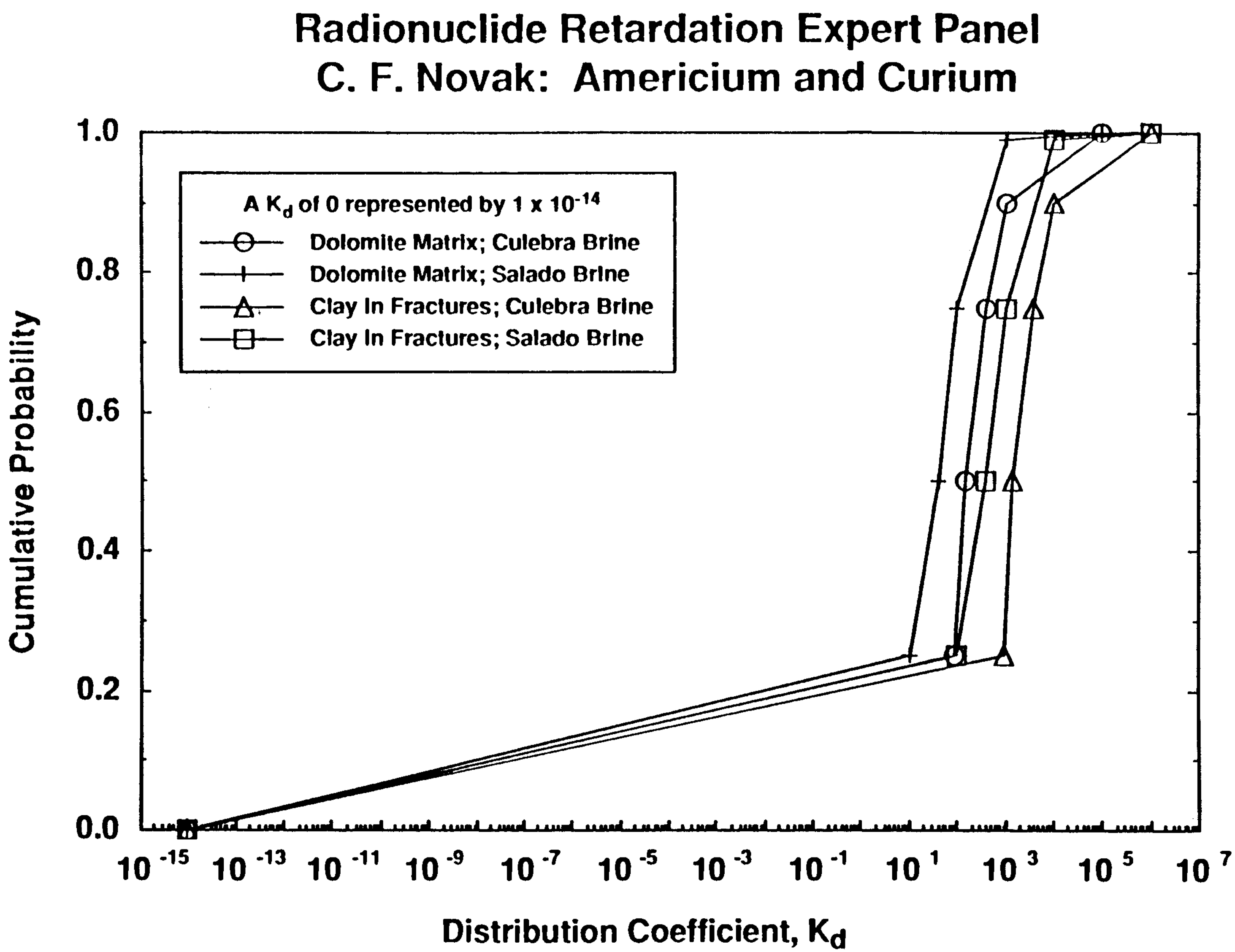
333-1


Uranium - M.D. Siegel
A K_d of 0 represented as 1×10^{-14}
Dolomite Matrix; Culebra Brine
Dolomite Matrix; Salado Brine
Clay in Fractures; Culebra Brine
Clay in Fractures; Salado Brine
Cumulative Probability
1.0
0.8
0.6
0.4
0.2
0.0
10^{-15} 10^{-13} 10^{-11} 10^{-9} 10^{-7} 10^{-5} 10^{-3} 10^{-1} 10^{1} 10^{3} 10^{5} 10^{7}
Distribution Coefficient, K_d
304-1



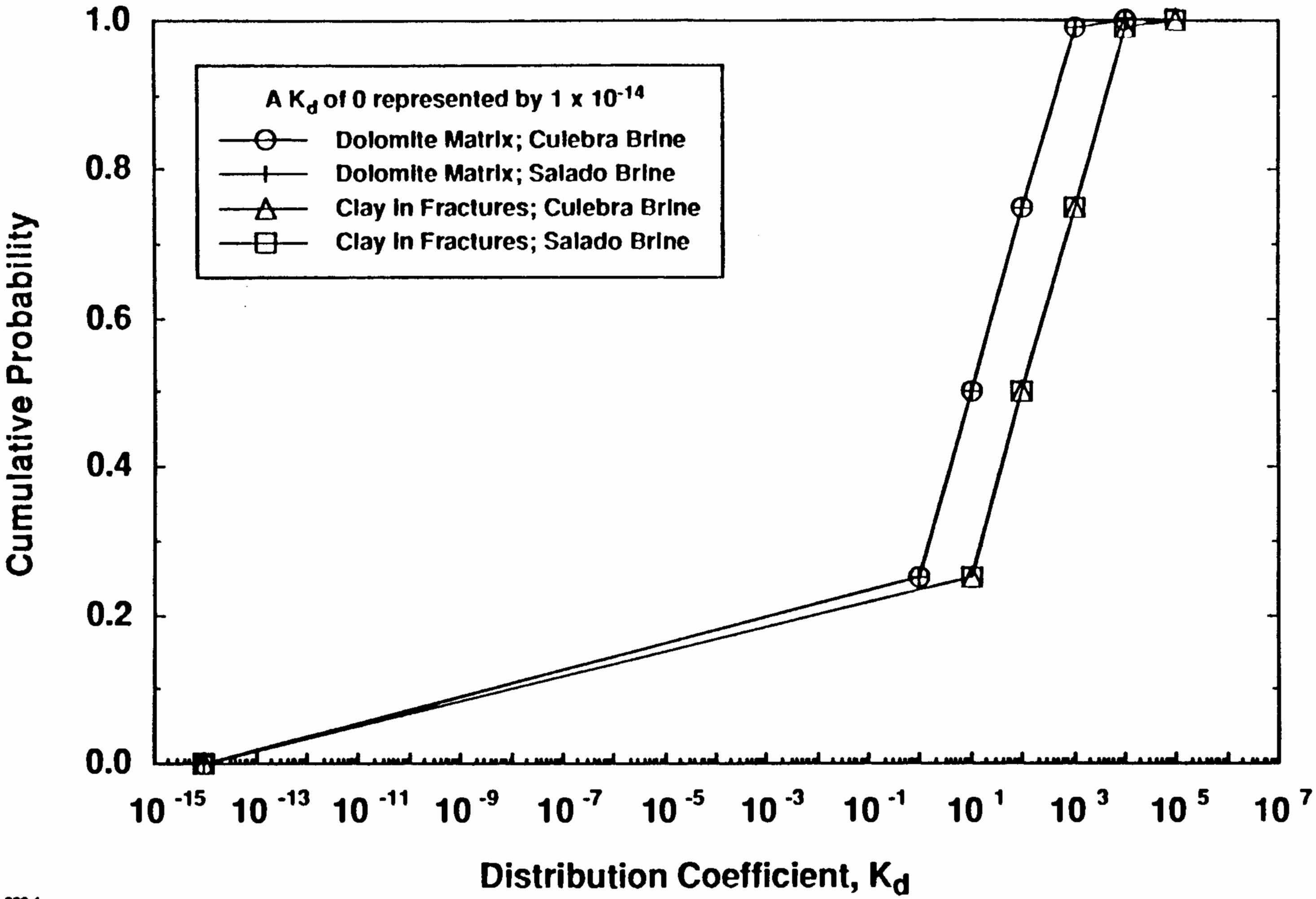
Uranium - R.G. Dosch
A Kd of 0 represented as 1 x 10-14
Dolomite Matrix; Culebra Brine
Dolomite Matrix; Salado Brine
Cumulative Probability
1.0
0.8
0.6
0.4
0.2
0.0
10 -15
10 -13
10 -11
10 -9
10 -7
10 -5
10 -3
10 -1
10 1
10 3
10 5
10 7
Distribution Coefficient, Kd
308-1


Neptunium, Uranium - C.F. Novak
A Kd of 0 represented as 1 x 10-14
Dolomite Matrix; Culebra Brine
Dolomite Matrix; Salado Brine
Clay in Fractures; Culebra Brine
Clay in Fractures; Salado Brine
Cumulative Probability
1.0
0.8
0.6
0.4
0.2
0.0
10 -15
10 -13
10 -11
10 -9
10 -7
10 -5
10 -3
10 -1
10 1
10 3
10 5
10 7
Distribution Coefficient, Kd
306-1

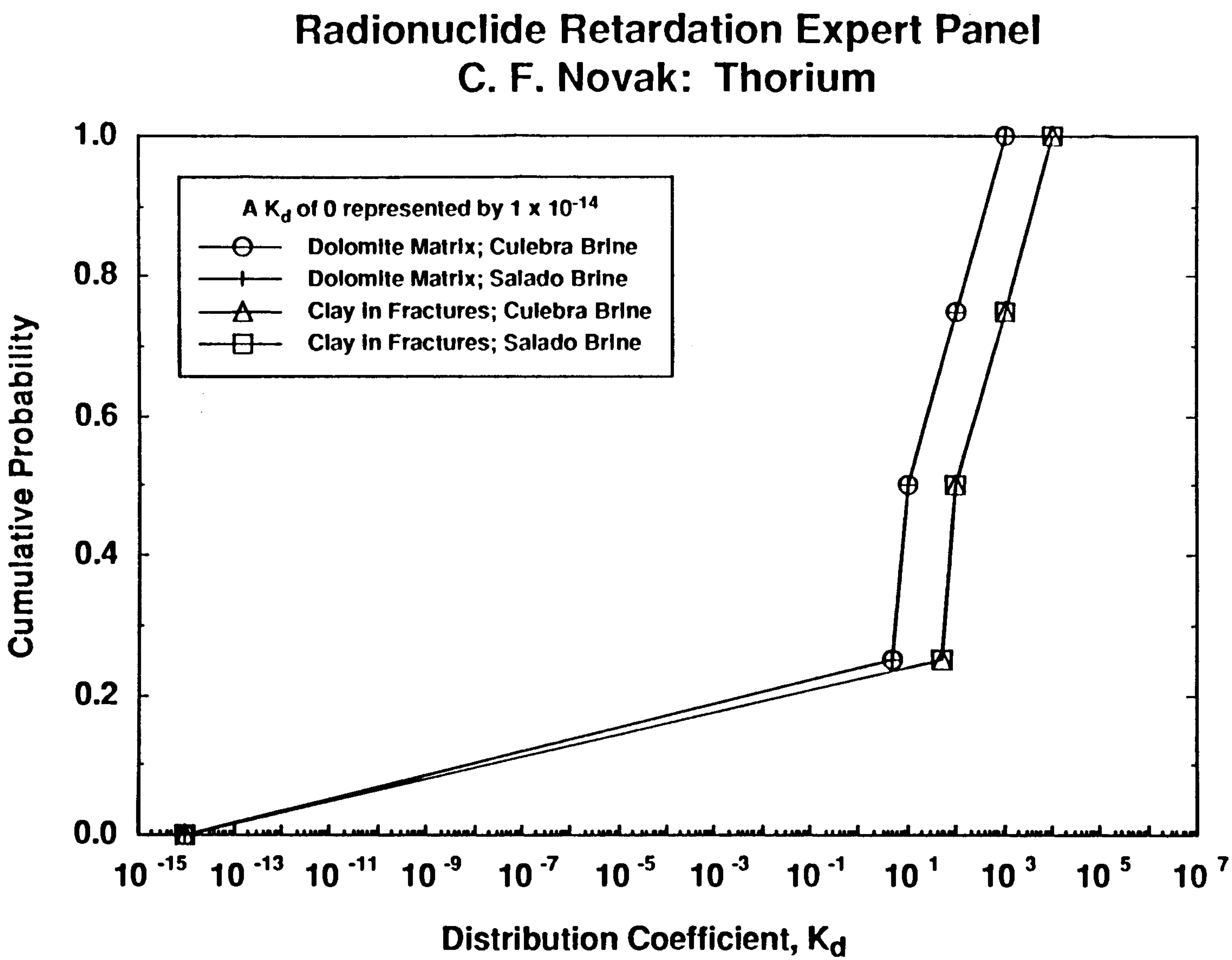

Radionuclide Retardation Expert Panel
C. F. Novak: Americium and Curium
A K$_d$ of 0 represented by 1 x 10^{-14}
Dolomite Matrix; Culebra Brine
Dolomite Matrix; Salado Brine
Clay In Fractures; Culebra Brine
Clay In Fractures; Salado Brine
Cumulative Probability
1.0
0.8
0.6
0.4
0.2
0.0
10 -15
10 -13
10 -11
10 -9
10 -7
10 -5
10 -3
10 -1
10 1
10 3
10 5
10 7
Distribution Coefficient, K$_d$

335-1

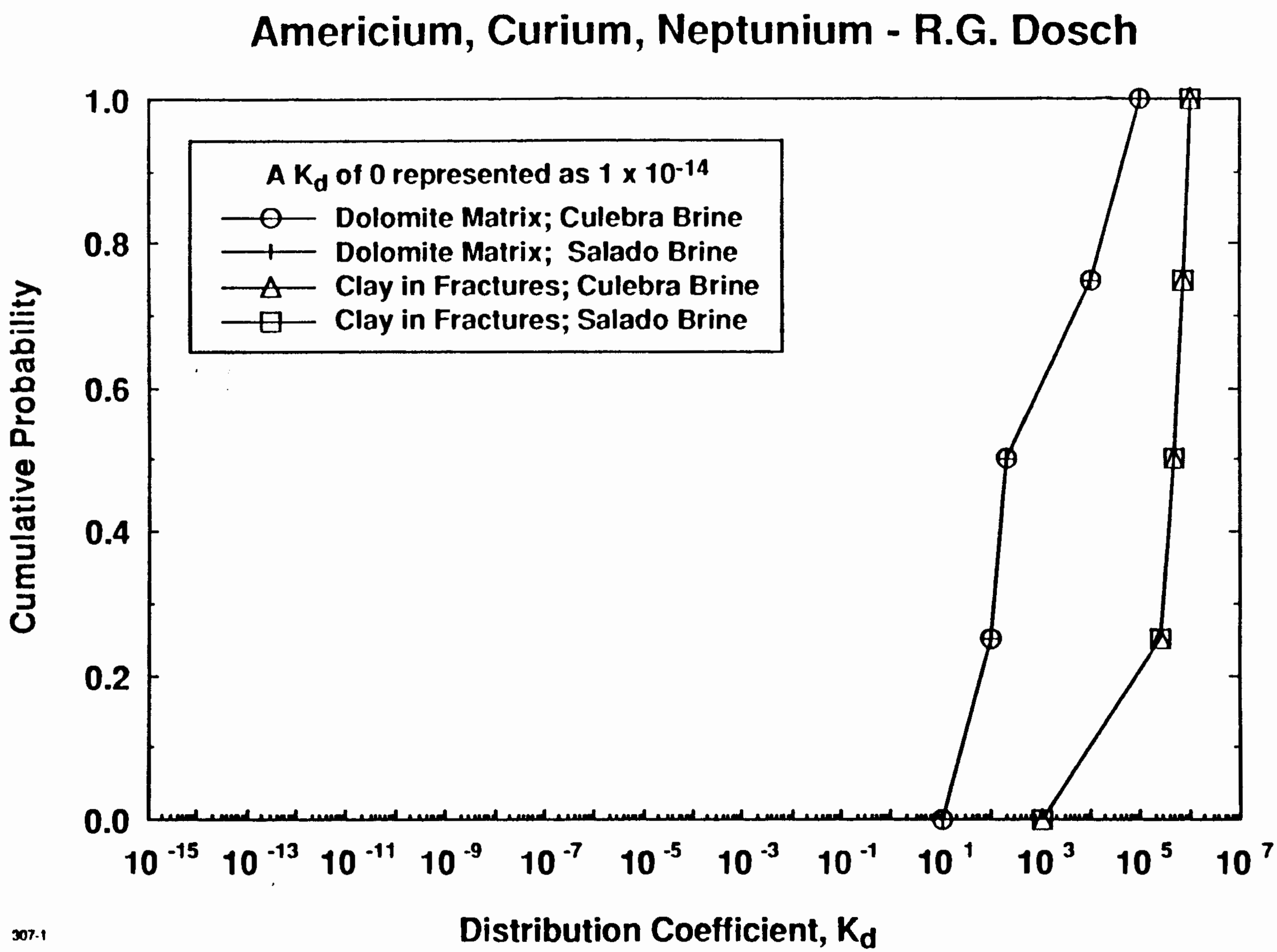
Radionuclide Retardation Expert Panel
C. F. Novak: Radium and Lead

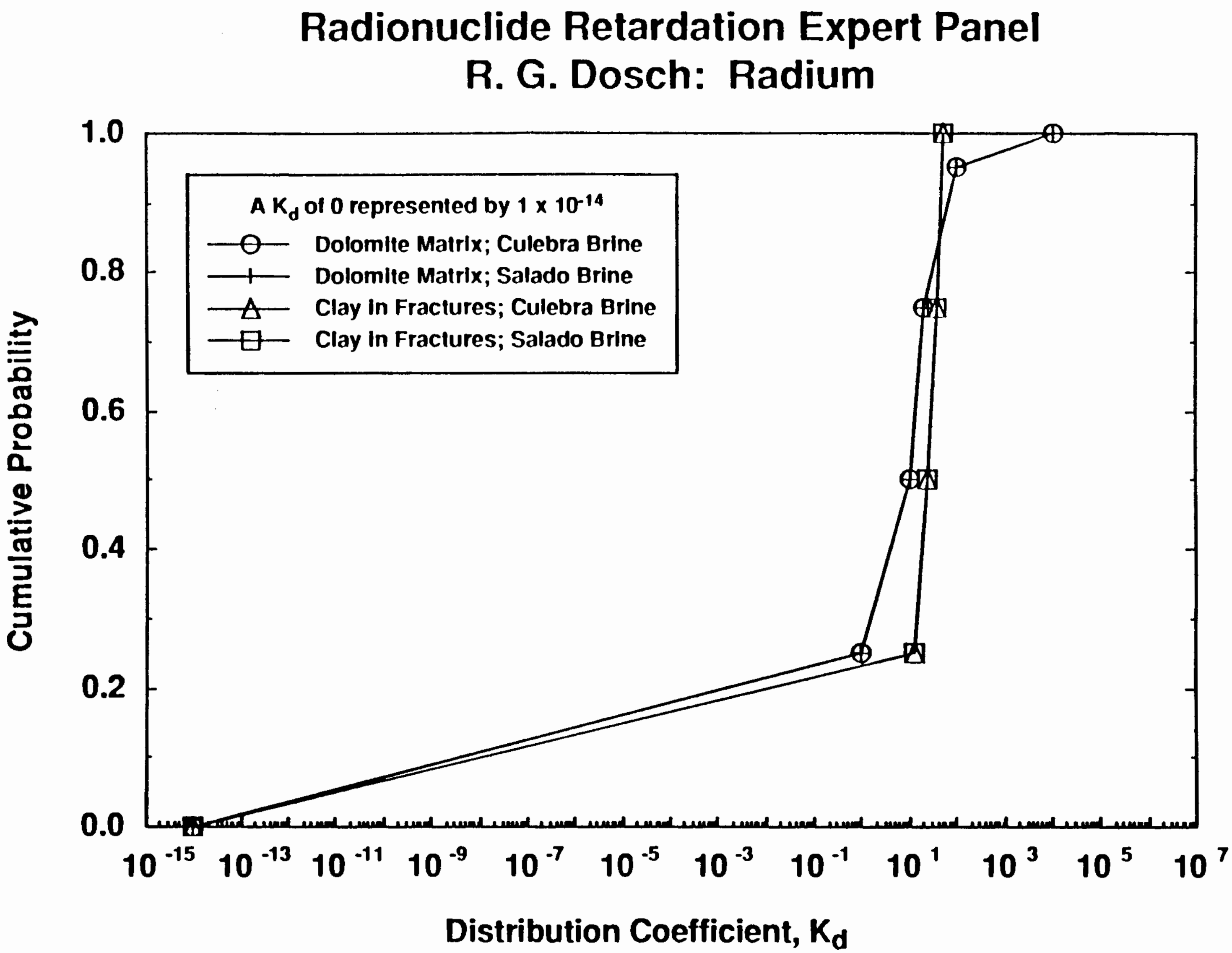


336-1


Radionuclide Retardation Expert Panel
C. F. Novak: Thorium
A K_d of 0 represented by 1 x 10^{-14}
Dolomite Matrix; Culebra Brine
Dolomite Matrix; Salado Brine
Clay in Fractures; Culebra Brine
Clay in Fractures; Salado Brine
Cumulative Probability
1.0
0.8
0.6
0.4
0.2
0.0
10^{-15} 10^{-13} 10^{-11} 10^{-9} 10^{-7} 10^{-5} 10^{-3} 10^{-1} 10^{1} 10^{3} 10^{5} 10^{7}
Distribution Coefficient, K_d

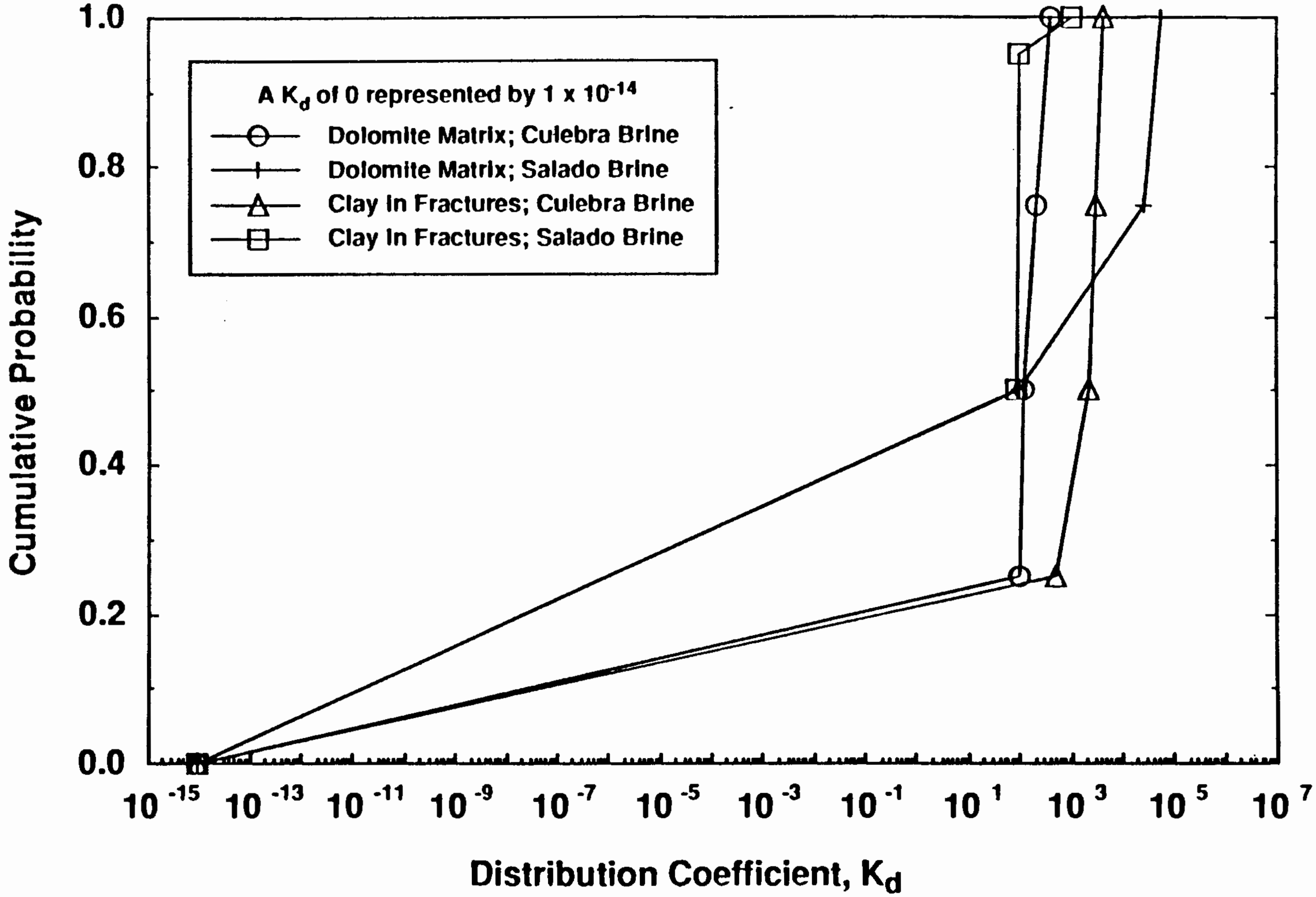
334-1


Americium, Curium, Neptunium - R.G. Dosch
A Kd of 0 represented as 1 x 10-14
Dolomite Matrix; Culebra Brine
Dolomite Matrix; Salado Brine
Clay in Fractures; Culebra Brine
Clay in Fractures; Salado Brine
Cumulative Probability
1.0
0.8
0.6
0.4
0.2
0.0
10 -15
10 -13
10 -11
10 -9
10 -7
10 -5
10 -3
10 -1
10 1
10 3
10 5
10 7
Distribution Coefficient, Kd
307-1


Radionuclide Retardation Expert Panel
R. G. Dosch: Radium
A Kd of 0 represented by 1 x 10-14
Dolomite Matrix; Culebra Brine
Dolomite Matrix; Salado Brine
Clay in Fractures; Culebra Brine
Clay in Fractures; Salado Brine
Cumulative Probability
1.0
0.8
0.6
0.4
0.2
0.0
10 -15
10 -13
10 -11
10 -9
10 -7
10 -5
10 -3
10 -1
10 1
10 3
10 5
10 7
Distribution Coefficient, Kd

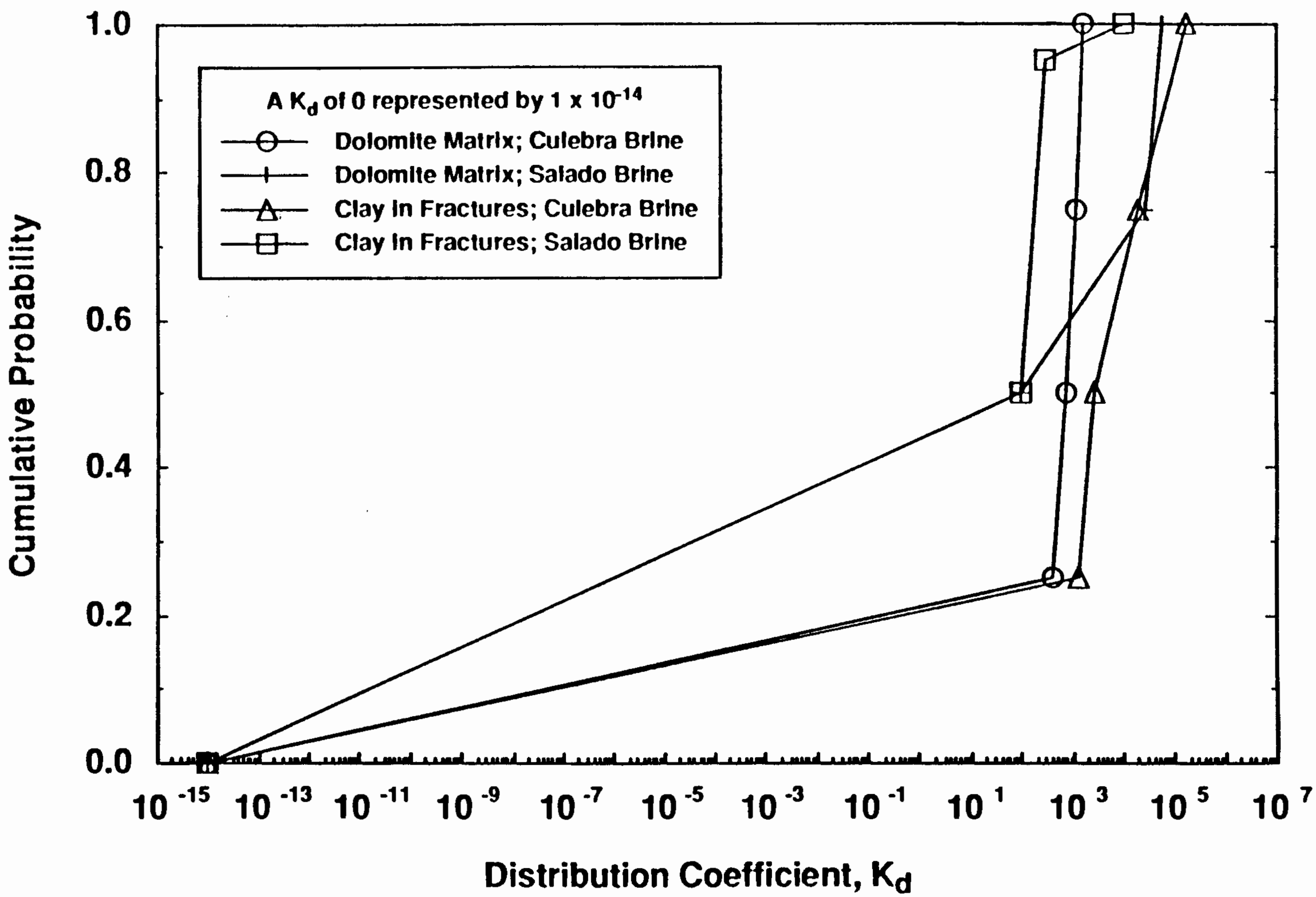
338-1

Radionuclide Retardation Expert Panel
M.D. Siegel: Americium

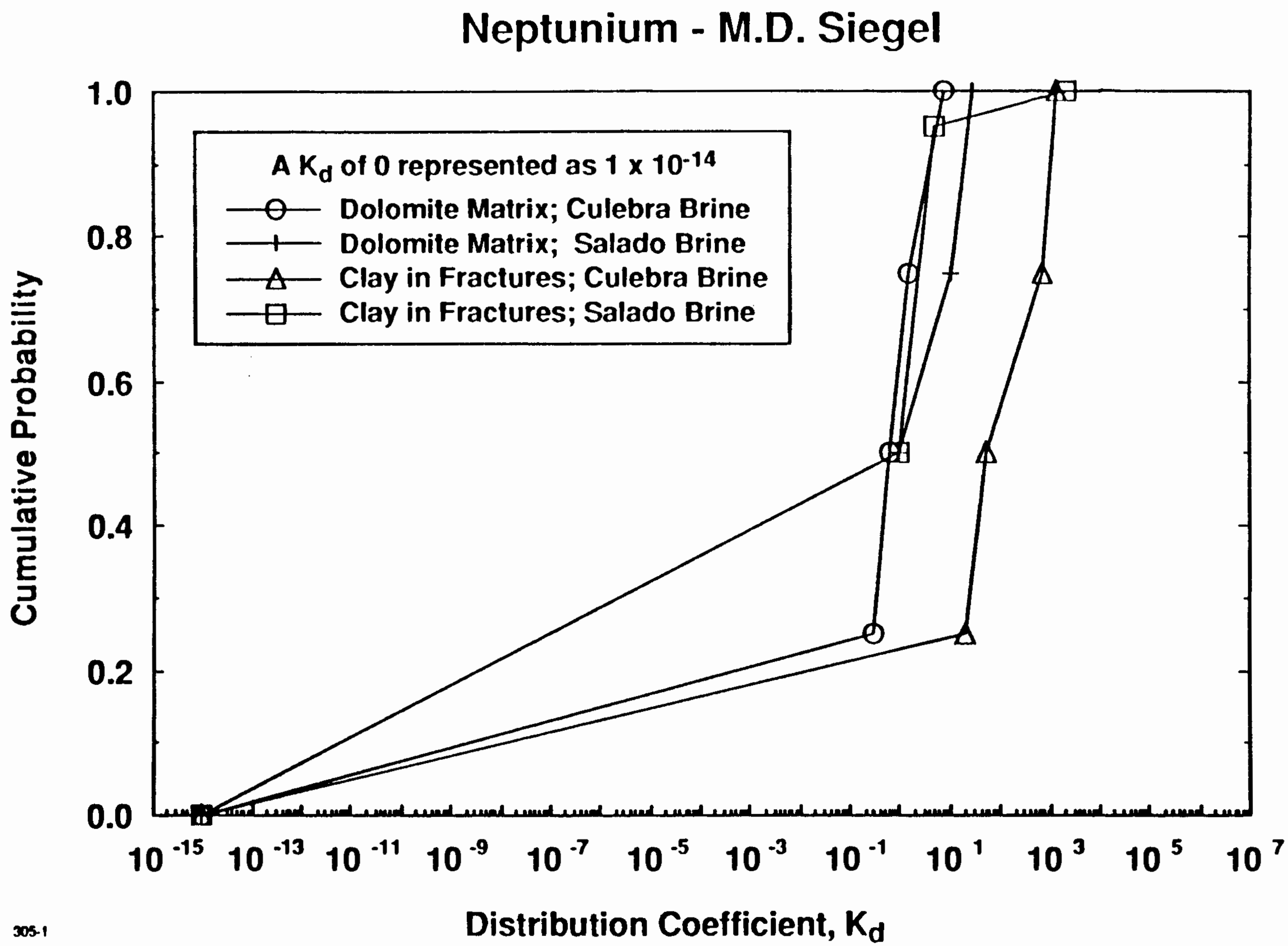


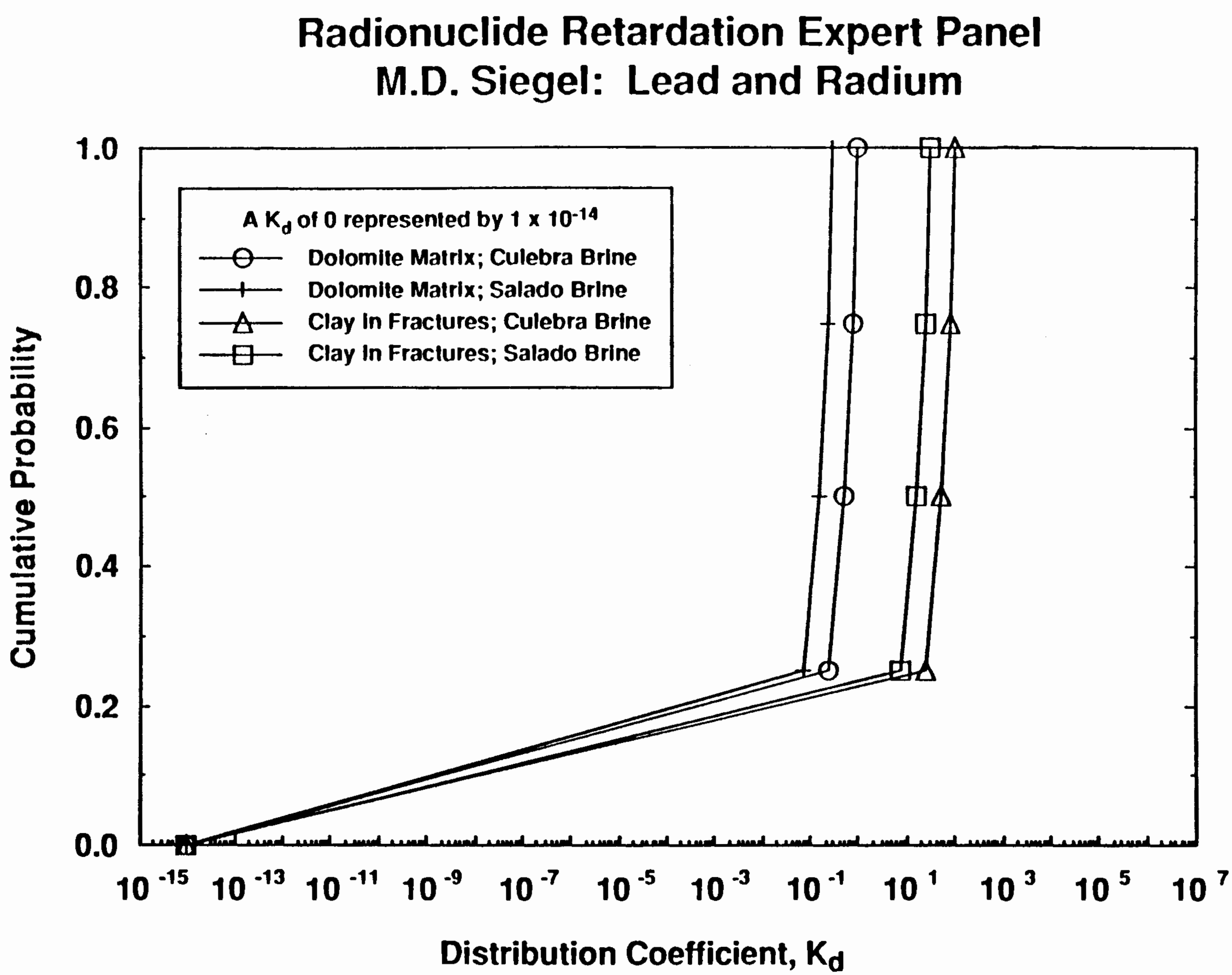
328-1

Radionuclide Retardation Expert Panel
M.D. Siegel: Curium



331-1

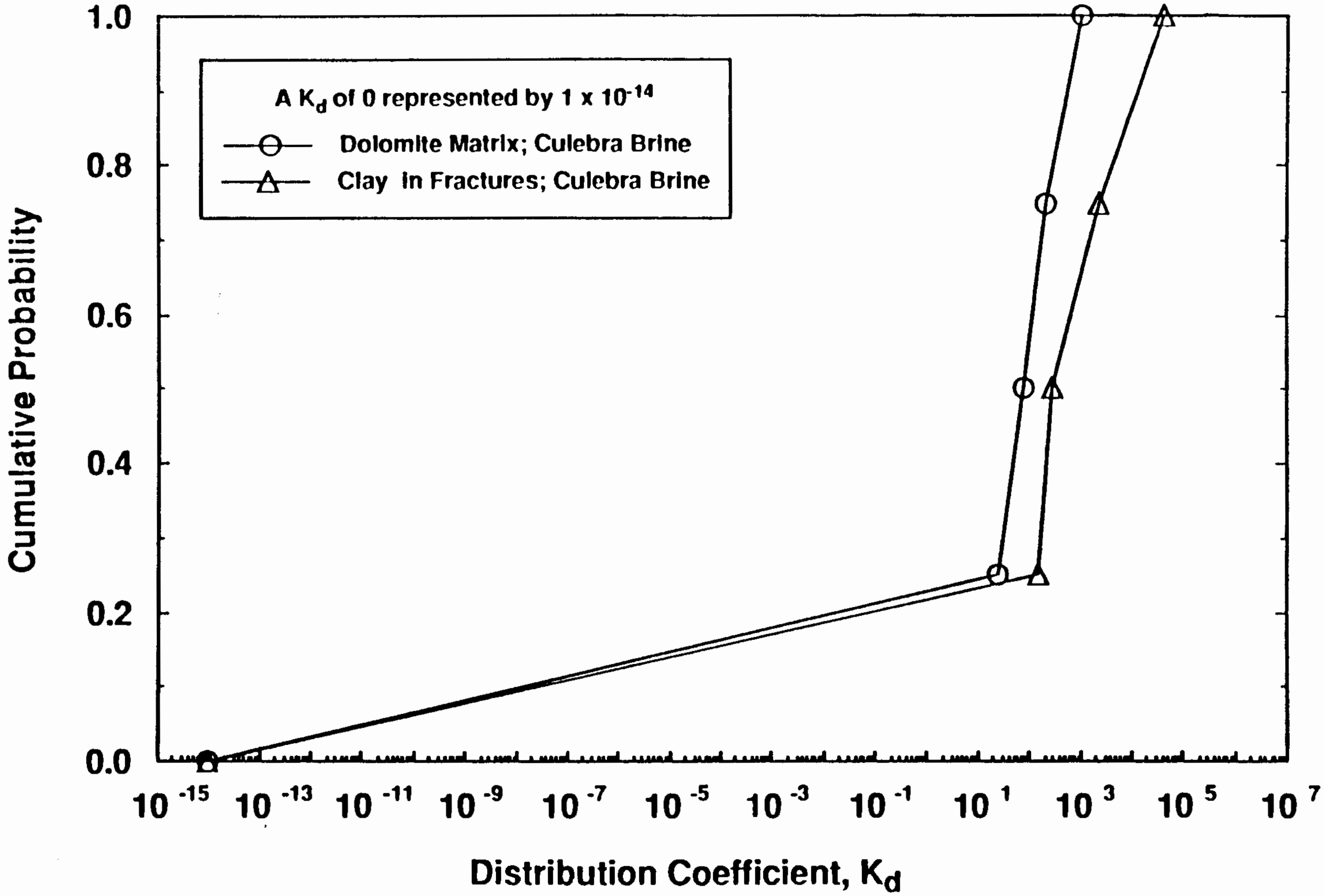

Neptunium - M.D. Siegel
A Kd of 0 represented as 1 x 10-14
Dolomite Matrix; Culebra Brine
Dolomite Matrix; Salado Brine
Clay in Fractures; Culebra Brine
Clay in Fractures; Salado Brine
Cumulative Probability
1.0
0.8
0.6
0.4
0.2
0.0
10 -15
10 -13
10 -11
10 -9
10 -7
10 -5
10 -3
10 -1
10 1
10 3
10 5
10 7
Distribution Coefficient, Kd
305-1



Radionuclide Retardation Expert Panel
M.D. Siegel: Lead and Radium
A K_d of 0 represented by 1 x 10^-14
Dolomite Matrix; Culebra Brine
Dolomite Matrix; Salado Brine
Clay in Fractures; Culebra Brine
Clay in Fractures; Salado Brine
Cumulative Probability
0.0
0.2
0.4
0.6
0.8
1.0
10 -15
10 -13
10 -11
10 -9
10 -7
10 -5
10 -3
10 -1
10 1
10 3
10 5
10 7
Distribution Coefficient, Kd

329-1

Radionuclide Retardation Expert Panel
M.D. Siegel: Thorium



330-1

Expert Panels for Parameter Elicitation

Expert Panel on Radionuclide Retardation in the Culebra, Proposed for FY 1992

Composition

- All external experts

Results

- Evaluate existing data base
  - Can it justify minimum estimates of distribution coefficients
- Provide minimum estimates, if possible
  - Am, Cm, Np, Pu, Th, U, Ra, Pb
- Review proposed research plan
  - Can the plan help verify the minimum estimates
  - Necessary modifications

Expert Panel on Radionuclide Retardation in the Culebra, Proposed for FY 1992 (cont.)

Selection of panelists

- Nominations
  - Initial nominees from Sandia staff, review groups, intervener groups, public agencies, and literature
  - Additional nominations from all those contacted

- Selection criteria

- Selection committee
  - Taken from the pool of nominees
  - Removed from consideration as nominees

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Expert Panel on Radionuclide Retardation in the Culebra, Proposed for FY 1992 (cont.)

1st meeting

- Issue statement
- Background presentations
- Expert judgment training

Between meetings

- Develop approach for determining minimum values for the coefficients
- Review proposed experimental plan
- Prepare draft text explaining approach

2nd meeting

- Discussion of approaches
  - Analyzing/interpreting existing data
  - Outlining necessary research
- Elicitation sessions
- Discussion between panel and Division 6344 regarding modifications to proposed experimental plan

Expert Panel on Radionuclide Retardation in the Culebra, Proposed for FY 1992 (cont.)

After meeting

- Final text explaining K_d estimates and the reasoning behind the modifications to the experimental plan

Expert Panel Summary

Human Intrusion -

- Expert panel on future societies: Document in preparation
- Expert panel on markers: Restart October 1
- Expert panel on barriers to HI: Begin FY92

Radionuclide Source Term and Transport -

- Source term panel (external) : Elicitation complete and document in preparation
- Retardation (Culebra) panel (internal): Elicitation complete and document in preparation
- Retardation (Culebra) panel (external): Proposed for FY92

Expert Panel Summary, Cont.

Geostatistics Working Group -

- Conditional Simulations of T fields using present CAMCON module completed for 91 Assessment
- Automated SWIFT II/GRASP II calibration/conditional-simulation approach using pilot point method to be used for 92 assessment available by 3/92
- T field comparison study to be completed by 3/92

Future Panels -

- Will depend on results of 91 Sensitivity Analysis and project priorities

425.0