MEMORANDUM FOR: Robert E. Browning, Director
Division of High-Level Waste Management

THRU: Ronald L. Ballard, Chief
Geosciences and Systems Performance Branch, HLWM

John L. Linehan, Director
Repository Licensing and Quality Assurance
Project Directorate, HLWM

Joseph O. Bunting, Chief
Engineering Branch, HLWM

FROM: Philip S. Justus, Section Leader
Geology-Geophysics Section
Geosciences and Systems Performance Branch, HLWM

SUBJECT: TRIP REPORT: NUCLEAR WASTE TECHNICAL REVIEW BOARD TECHNICAL INFORMATION EXCHANGE ON SEISMIC HAZARDS, LAS VEGAS, NV, 12 APRIL 1990

Title: Structural Geology and Geoengineering Panel Technical Information Exchange on Seismic Hazards

Date/Place: 12 April 1990, Las Vegas, NV

Purpose: Division of HLWM to participate in TRB/DOE/St of NV/NRC Technical Information Exchange hosted by the TRB.

Objectives:

1) Brief the TRB on "Nuclear Regulatory Commission's Approach on Regulatory Guidance for Seismic Hazards Assessment."

2) Participate in roundtable dialogue with TRB and DOE on Seismic Hazards.

Agenda: See Enclosure 1, as amended at the meeting

Attendees: See Enclosure 2.

Division of HLWM staff in attendance:

John Linehan	Abou-Bakr Ibrahim
Joseph Bunting	Michael Blackford
Philip Justus	Keith McConnell
Dinesh Gupta	Paul Prestholt
King Stablein	Donald Chery, Jr.
John Gilray	

9007120167 900706
PDR WASTE
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Center staff in attendance:

John Russell	Russ Purcell
Gerry Stirewalt	Richard Galster
Michael Miklas	Steve Young
English Pearcy	Larry McKague

Scope: DOE made six presentations as follows (Enclosures 3a-f):

a) DOE Position on NRC Regulatory Guidance
b) Summary of Probabilistic Seismic Hazard Evaluations
c) Seismicity and Tectonic Models
d) Summary of Seismic Design Cost-Benefit Assessment
e) Proposed Approach for Developing the Seismic Design Basis for Repository Components Important to Safety
f) Summary of DOE Position

NRC made the following presentation (Enclosure 3g):

g) Nuclear Regulatory Commission's Approach on Regulatory Guidance for Seismic Hazards Assessment.

State of Nevada made a presentation on characteristics of historic earthquakes and surface faulting (no handout available).

Results: The objectives of the Information Exchange were fulfilled as follows:

1) P. Justus briefed the TRB (see Enclosure 3g)
2) NRC staff (Ibrahim, Blackford, Justus) participated in roundtable discussions; other NRC attendees participated appropriately from the audience.

Benefits: The following benefits and significant information was derived from the Information Exchange:

1) NRC provided the status of its current positions with regard to DOE's seismic hazards program:

a) On DOE's Site Characterization Plan. NRC's Site Characterization Analysis comments on the cumulative slip earthquake and magnitude 5.5 cutoff remain unresolved; review of SCP found no significant concerns about seismic hazard investigations methods; seismic hazard evaluation investigation and analyses must address 60.21 (c)(1)(i), 60.122(c)(12,13,14), 60.131(b)(1), 40 CFR 191.13.

b) On probabilistic hazard analysis. A deterministic seismic hazard evaluation, supplemented by a probabilistic seismic hazard analysis is an acceptable approach to fulfilling NRC and EPA requirements.

c) On use of Appendix A, 10 CFR 100. Staff reiterated that Part 60 does not require the use of Appendix A, and the staff does not require the use of Appendix A in repository siting or design. The staff considers that certain generic seismic hazard investigation methods and concepts that are enumerated in Appendix A can, with modification, be applied acceptably to the repository program. Staff is developing a Seismic Hazard Investigation Methods Technical Position to this effect.

d) On non-prescriptive nature of Part 60. DOE has the responsibility of identifying the seismic hazard, developing design bases and providing rationale necessary for NRC to evaluate the License Application in light of Part 60 requirements.

e) PSHA. The staff is developing a Technical Position on what are attributes of an acceptable method of performing a probabilistic seismic hazard analysis. Currently, it is considering two examples which appear to have the acceptable attributes, the LLNL and EPRI methods developed for nuclear power plant PSHAs.

2. DOE presented updated versions of its approaches to identifying and analysing seismic hazards at Yucca Mtn. (see Enclosures 3a-f). DOE's presentation on cost-benefit analysis for seismic design of surface facilities concluded that there is a certain reinforcement and thickness of concrete walls required for shielding purposes, and therefore seismic design up to .6g is not likely to affect the cost of the surface facilities. Staff are reviewing the assumptions of the cost-benefit study (see Enclosure 3d).

3. State of Nevada presented an updated version of its studies of the nature and rates of significant seismogenic faults in Nevada.

/S/

Philip S. Justus, Section Leader
Geology-Geophysics Section
Geosciences and Systems Performance Branch
Division of High-Level Waste Management

Enclosures: See Jacket
1. Agenda, as amended
2. List of Attendees
3. DOE Briefing Packages, a-f, as stated above
   NRC Briefing Package, g, as stated above

cc: J. Youngblood
R. Ballard

DISTRIBUTION

Central Files	HLGP r/f	NMSS r/f
RBrowning, HLWM	BJYoungblood, HLWM	JBunting, HLEN
RBallard, HLGP	JLinehan, HLPD	PJustus, HLGP
AIbrahim, HLGP	MBlackford, HLGP	DGupta, HLEN

OFC :	HLGP	: HLGP	: HLGP	: HLEN	: HLPD	: HLEN	: HLGP
NAME:	PJustus/cj	: AIbrahim	: MBlackford	: DGupta	: JLinehan	: JBunting	: RBallard
Date:	6/20/90	: 6/29/90	: 6/20/90	: 6/20/90	: 6/ /90	: 6/27/90	: 7/ 6/90

UNITED STATES
NUCLEAR WASTE TECHNICAL REVIEW BOARD
1111 18th Street, N.W., Suite 801
Washington, D.C. 20036

ENCLOSURE 1

Received w/Ltr Dated 7/6/90

Structural Geology and Geoengineering Panel

Technical Information Exchange on Seismic Hazards

Bordeaux Room, Flamingo Hilton
Las Vegas, NV

April 12, 1990

Morning, Thursday, April 12 1990

8:30 a.m.	Department of Energy's (DOE's) position on Appendix A and other potential Nuclear regulatory Commission (NRC) regulatory guidance Jeffrey K. Kimball, DOE (1)
9:15 a.m.	Summary of probabilistic assessments conducted to date Richard Lee, Science Applications International Corp, (SAIC) Terry Grant, SAIC (2)
10:15 a.m.	BREAK
10:30 a.m.	SEISMICITY & TECTONIC MODELS ~~History of the DOE's design development~~ ~~Richard Lee, SAIC~~ T.A. Grant (3)
10:45 a.m.	SUMMARY OF SEISMIC DESIGN COST-BENEFIT ASSESSMENT A. Haljian (4) ~~Proposed DOE approach for developing seismic design basis~~ ~~Jerry Frazier, SAIC~~
12:00 noon	LUNCH

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Telephone: 202-254-4792 Fax: 202-254-4803

Afternoon, Thursday, April 12, 1990

1:30 p.m.	PROPOSED APPROACH SEISMIC DESIGN BASIS (5) ~~Summary of seismic design cost benefit assessment~~ Jerry A. Frazier SUMMARY OF DOE POSITION J. Kimball (6)
2:15 p.m.	Nuclear Regulatory Commission's (NRC) approach on regulatory guidance for seismic hazards assessment Philip S. Justus, NRC (7) Mirdad E. Blackford Abu-Bakr Ibrahim
3:00 p.m.	BREAK
3:15 p.m.	Open Discussion
4:30 p.m.	Adjourn

1 of 4

SG+6 Panel Technical Exchange

NUCLEAR WASTE TECHNICAL REVIEW BOARD

DATE April 12, 1990

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NAME	ORGANIZATION	STREET	CITY, STATE	ZIP	PHONE
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TERRY GRANT	SAIC	101 CONVENTION CNTR DR	LAS VEGAS NV	89109	702-794-7647
Jerry King	SAIC	101 Convention Center Dr.	Las Vegas, NV	89109	702-794-7648
Michael Voegele	SAIC	" "	"	"	702-794-763
J.A De Mastry	Fl Power & Lt Co	Box 14000	Juno Beach Fl	33408	407-694-361
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• Donald L. Cheryl	NRC	MS WFO 4H3	Washington DC	20555	(301) 492-39
Ray Wallace	US Geological Survey	410 National Ctr	Reston, VA	22092	(703) 648-500
DAVID TILLSON	NEVADA	530 11th AVE	SALT LAKE, UT	84103	(801) 363-40
Craig deFolo	NV. Bureau of Mines & Geology	Univ. of Nevada - Reno	Reno, Nevada	89557	(702) 784-6691
Ardyth Simmons	DOE/YMP	101 Convention Ctr,	Las Vegas, NV	89109	(702 794-7998

ENCLOSURE 2

2) of 4

SG+G Panel Technical Exchange

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DATE April 12, 1990

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• Paul Prestholt	NRC	1050 Flamingo Rd.	Las Vegas, Nv.	89119	FTS 598-6125
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Rich Schweickert	Univ Nevada Reno		Reno NV	89557	702-784-69
A.C. Douglas	City of Las Vegas	400 E. Stewart St.	Las Vegas, NV	89[illegible]	702-799-6866
J.D. Gibson	Sandia Nat Labs	B.5800	Albuquerque NM	87185	505-844-8923
DC Dobson	DOE/NMD	Box 98518 Las	Las Vegas	89109	702-794-7946
T.F. Bullard	Geomatrix Consultants	One Market Plaza Spear Tow 717	San Francisco	94105	415-957-9557
G.L. Shideler	USGS	Denver Fed. Center, MS-913	Denver	80401	FTS: 776-12
• Michael Blackford	USNRC/DHLWM	MS 4H-3	Washington DC	20555	FTS 492-0524
• Edward O'Donnell	NRC/RES	NLS-260	Wash DC	20555	492-388
• Jake Philip	NRC/RES	NLS-260	Wash. DC	20555	FTS 49238
Bob Shaw	EPRI	3412 Hillview Ave.	Palo Alto, CA	94303	415 855 2026

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Richard W. Galster	Consultant CNWRA	18233-13th N.W.	Seattle, WA	98177	206-542-258
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Ken Fox Jr.	U.S.G.S.	Denver Rd Center MS 913	Denver CO	80401	303-236-0213
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English C. Pearcy	CNWRA - SwRI	6220 Culebra Rd	San Antonio, TX	78228	512-522-55
Stephen R. Henry	CNWRA - SwRI	" "	" "	"	512-522-524
Robert L. Terrell	DOE	1000 INDEPENDENCE AVE, SW	WASHINGTON DC	20585	586-6850
Vinod Murayi	Brookhaven Nat'l Lab	Bldg. 130	Upton, NY	11973	516-282-203
Eugene Smith	UNLV	Las Vegas	Las Vegas, NV	89154	702-739-326
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Jim Faulds	UNLV	Las Vegas	NV	89154	702-739-3
John Gilray	NRC	1050 E. Flamingo Las Vegas	Las Vegas NV	-	702-388-612
Dennis Bechtel	Clark Co, NV	225 Bridger Ave, Clark County	Las Vegas, NV	89155	702-455-418
Asa Hadsian	Bechtel	12440 Imperial Hwy	Norwalk, CA.	90650	213-807-245
Tom Issacs					

(4) of 4

SG&G Panel Technical Exchange

NUCLEAR WASTE TECHNICAL REVIEW BOARD

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• JOHN LINEHAN	NRC	" "	"	"	301-492-85
CARL JOHNSON	NEVADA	CAPITOL COMPLEX	CARSON CITY NV	89701	702 885-374
Jean Younker	SAIC	101 Convent Dr	Las Vegas NV	89109	702 794 7650
• A.K. Ibrahim	URE	4-H-3	Washington DC	20555	301-492-052
R.E. JACKSON	WESTON (DOE-HQ)	L'ENFANT PLAZA, SW.	WASHINGTON DC.	20024	202-646-66
- Charles (Rus) Purcell	Consultant/SRI	3344 California St	Costa Mesa CA	92626	8714-545-3174
- Michael P. Miklos, Jr.	Center for Nuclear Waste Regulatory Analysis	6220 CULEBRA	SAN ANTONIO, TX	78228	512-522-5207
- G. STIEFENALT	" " " " "	1275 J. Davis Hwy	ARLINGTON, VA		(703) 979-9129
- LARRY McKAGUE	CONSULTANT / CNWRA	2642 COTTE VIDA	PLEASANTON, CA	94566	(415) 846-96
BOB YOUNGBLOOD	Brookhaven	Bldg 130	Upton, NY 11973	11973	(516) 282-236
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CARL STEPP	EPRI	3412 HILL VIEW AVE	Palo Alto, Ca	94303	415-855-210
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MAX Blanchard	DOE/YMPO	Las Vegas		89109	(702) 794-79

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

PRESENTATION TO THE NUCLEAR WASTE TECHNICAL REVIEW BOARD

SUBJECT: DOE POSITION ON NRC REGULATORY GUIDANCE

PRESENTER: JEFFREY K. KIMBALL

PRESENTER'S TITLE AND ORGANIZATION: ACTING CHIEF, SITING AND GEOSCIENCES BRANCH
U.S. DEPARTMENT OF ENERGY
OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT

PRESENTER'S TELEPHONE NUMBER: (202) 586-1063

APRIL 12, 1990

ENCLOSURE 3a

AGENDA

NWTRB TECHNICAL EXCHANGE
SEISMIC HAZARDS
LAS VEGAS, NEVADA
APRIL 12, 1990

8:30	DOE POSITION ON APPENDIX A AND OTHER POTENTIAL NRC REGULATORY GUIDANCE	J. KIMBALL, DOE/HQ
9:15	SEISMIC GEOLOGY AND TECTONIC MODELS APPLIED TO PROBABILISTIC ASSESSMENTS	T. GRANT, SAIC
10:00	SUMMARY OF PROBABILISTIC ASSESSMENTS CONDUCTED TO DATE	R. LEE, SAIC
10:45	BREAK	
11:05	SUMMARY OF SEISMIC DESIGN COST-BENEFIT ASSESSMENT	A. HADJIAN, BECHTEL

AGENDA

(CONTINUED)

12:00	LUNCH	
1:30	PROPOSED DOE APPROACH FOR DEVELOPING SEISMIC DESIGN BASIS	G. FRAZIER, SAIC
2:15	SUMMARY OF DOE POSITION	J. KIMBALL, DOE/HQ
2:30	NRC APPROACH ON REGULATORY GUIDANCE FOR SEISMIC HAZARDS ASSESSMENT	P. JUSTUS, NRC
3:15	BREAK	
3:30	OPEN DISCUSSION	
4:30	ADJOURN	

OVERVIEW

- WHAT PARTS OF REGULATIONS PERTAIN TO SEISMICITY AND TECTONICS?
- WHY ARE WE CONCERNED ABOUT EARTHQUAKES AT YUCCA MOUNTAIN?
- WHAT GUIDANCE HAS NRC PROVIDED?
  - TECTONIC MODELS
  - SEISMIC HAZARD
  - PROBABILISTIC SEISMIC HAZARD ANALYSIS (IN PREPARATION)
- DOE COMMENTS AND CONCERNS ON APPENDIX A

PARTS OF REGULATIONS THAT PERTAIN TO PRECLOSURE SEISMIC DESIGN

10 CFR 60.131(b)(1)PRECLOSURE DESIGN

"THE STRUCTURES, SYSTEMS, AND COMPONENTS IMPORTANT TO SAFETY SHALL BE DESIGNED SO THAT NATURAL PHENOMENA AND ENVIRONMENTAL CONDITIONS ANTICIPATED AT THE GEOLOGIC REPOSITORY OPERATIONS AREA WILL NOT INTERFERE WITH NECESSARY SAFETY FUNCTIONS."

10 CFR 960.5-2-11 PRECLOSURE TECTONICS GUIDELINES

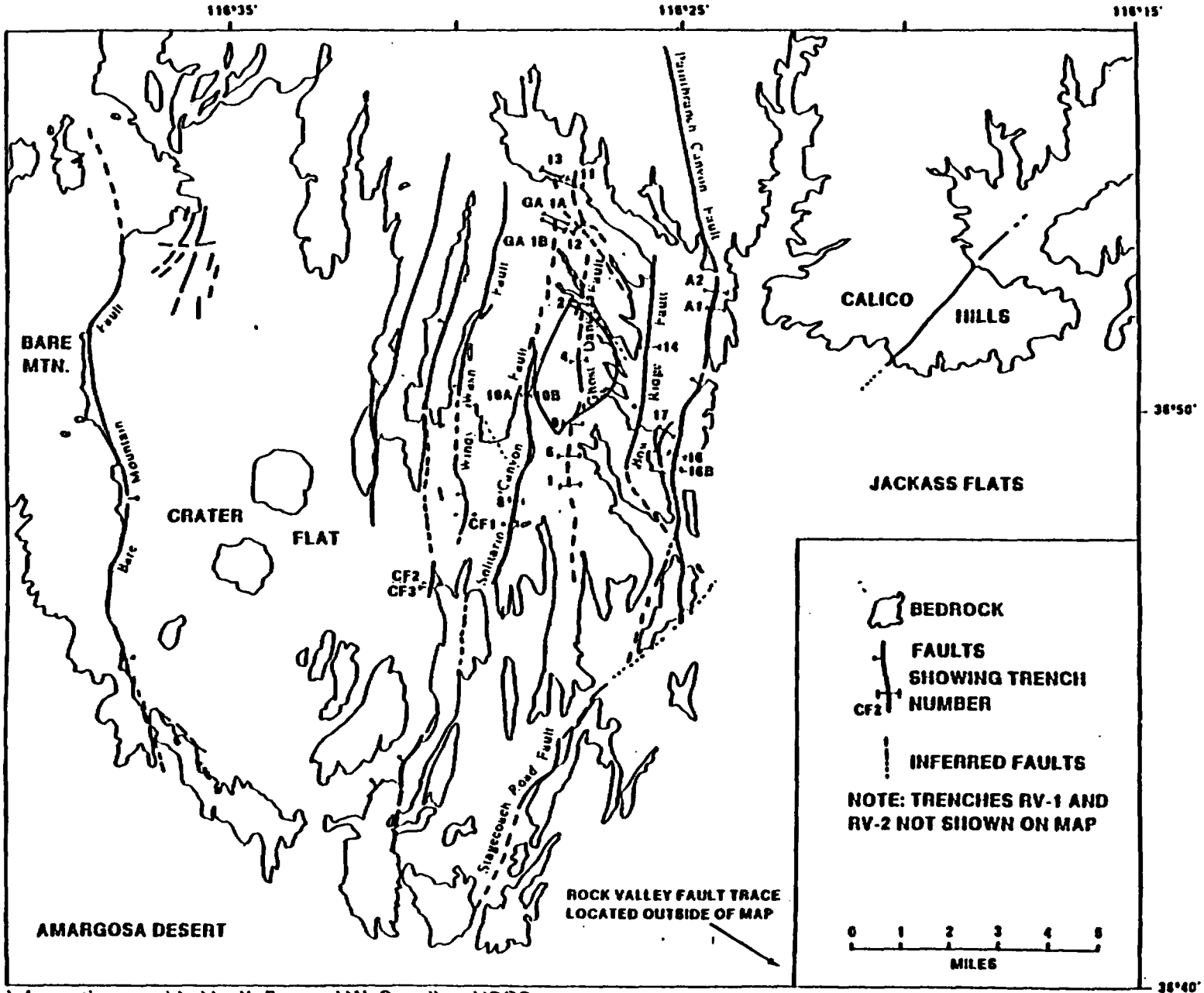
THIS GUIDELINE ENSURES THAT THE SITE IS IN A GEOLOGIC SETTING IN WHICH ANY PROJECTED EFFECTS OF EXPECTED TECTONIC PHENOMENA OR IGNEOUS ACTIVITY WILL BE SUCH THAT REPOSITORY SITING, CONSTRUCTION, OPERATION AND CLOSURE ARE TECHNICALLY FEASIBLE ON THE BASIS OF REASONABLY AVAILABLE TECHNOLOGY AND THE ASSOCIATED COSTS ARE REASONABLE

DURING PRECLOSURE WHAT ARE THE POTENTIAL EFFECTS OF AN EARTHQUAKE?

VIBRATORY GROUND MOTION AND FAULTING

- WASTE HANDLING FACILITIES
  - STRUCTURAL AND EQUIPMENT DAMAGE LEADING TO CRUSHED FUEL, WHICH COULD LEAD TO RELEASES
  - HOW LIKELY IS THIS DAMAGE?
- UNDERGROUND
  - STRUCTURAL DAMAGE LEADING TO WASTE PACKAGE DAMAGE, WHICH COULD LEAD TO RELEASES
  - HOW LIKELY IS THIS DAMAGE?

FAULTS IN THE REPOSITORY AREA



Information provided by K. Fox and W. Swadley, USGS.

0216-0023DS 2/20/87

PARTS OF REGULATIONS THAT PERTAIN TO POSTCLOSURE SEISMIC DESIGN

10 CFR 60.122 FAVORABLE AND POTENTIALLY ADVERSE CONDITIONS

TOGETHER WITH THE ENGINEERED BARRIERS SYSTEM, THE FAVORABLE AND POTENTIALLY ADVERSE CONDITIONS PRESENT MUST BE ADEQUATELY INVESTIGATED TO PROVIDE REASONABLE ASSURANCE THAT THESE CONDITIONS DO NOT SIGNIFICANTLY AFFECT THE ABILITY OF THE REPOSITORY TO ISOLATE WASTE

10 CFR 960.4-2-7 POSTCLOSURE TECTONICS GUIDELINES

"THE SITE SHALL BE LOCATED IN A GEOLOGIC SETTING WHERE FUTURE TECTONIC PROCESSES OR EVENTS WILL NOT BE LIKELY TO LEAD TO RADIONUCLIDE RELEASES GREATER THAN THOSE ALLOWABLE UNDER REQUIREMENTS SPECIFIED IN (40 CFR 191)."

DURING THE POSTCLOSURE WHAT ARE THE POTENTIAL EFFECTS OF AN EARTHQUAKE?

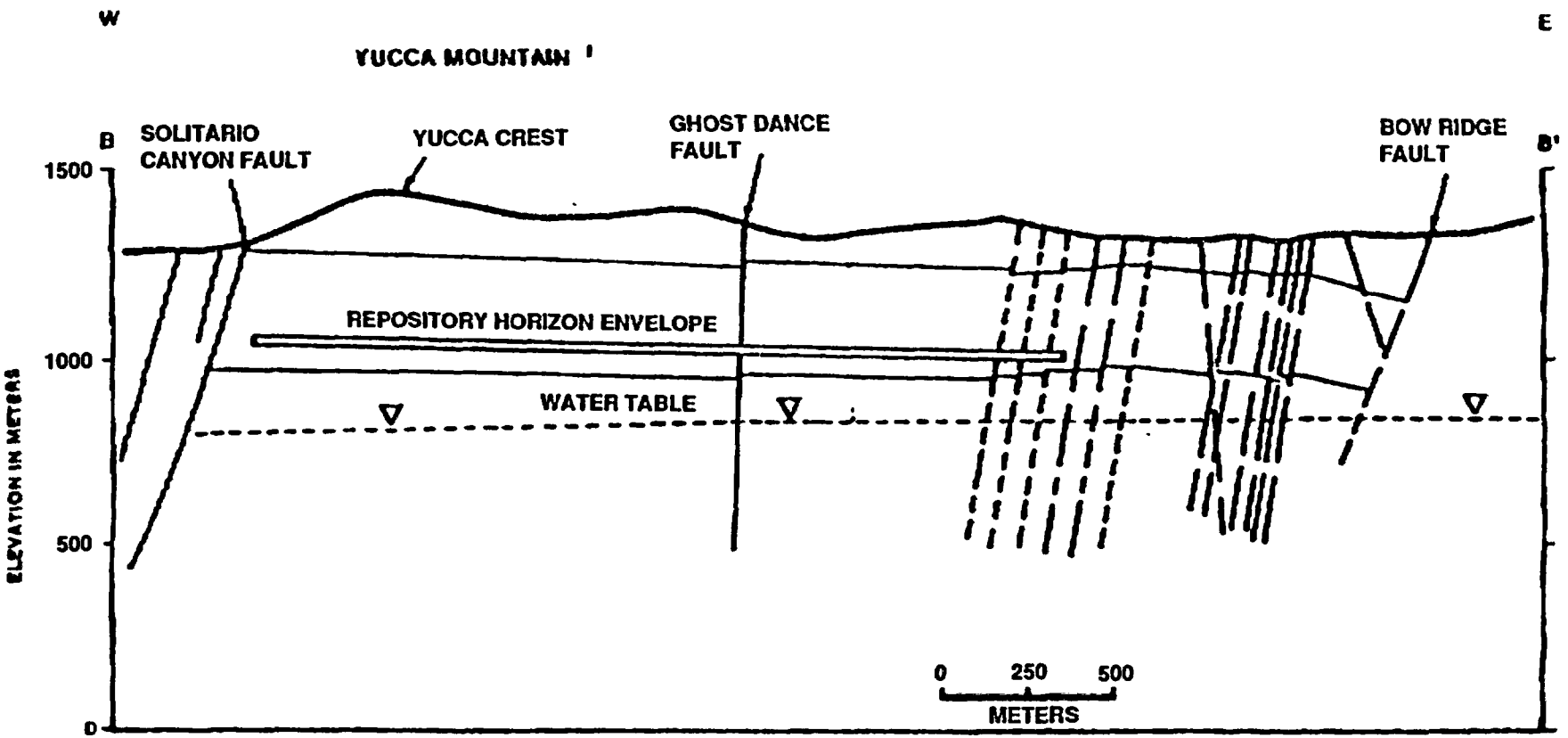
- VIBRATORY GROUND MOTION CONCERNS
  - DAMAGE TO WASTE PACKAGES
  - STRAIN LEADS TO RISE IN WATER TABLE
- FAULTING CONCERNS
  - FAULT SHEARS WASTE PACKAGE
  - OFFSET LEADS TO:
    * PERCHED WATER
    * RISE IN WATER TABLE
    * CHANGE IN ROCK PROPERTIES LEADING TO FLOW CHANGES

stability

- NOTE: TO UNDERSTAND THE CONSEQUENCES, ONE MUST UNDERSTAND THE LINK BETWEEN EARTHQUAKES AND HYDROLOGY

seals?

EAST-WEST CROSS-SECTION OF YUCCA MOUNTAIN SITE SHOWING POSSIBLE LOCATION OF THE UNDERGROUND REPOSITORY ENVELOPE



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

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

UNMAPPED AND INFERRED FAULTS WITH SMALL DISPLACEMENT.

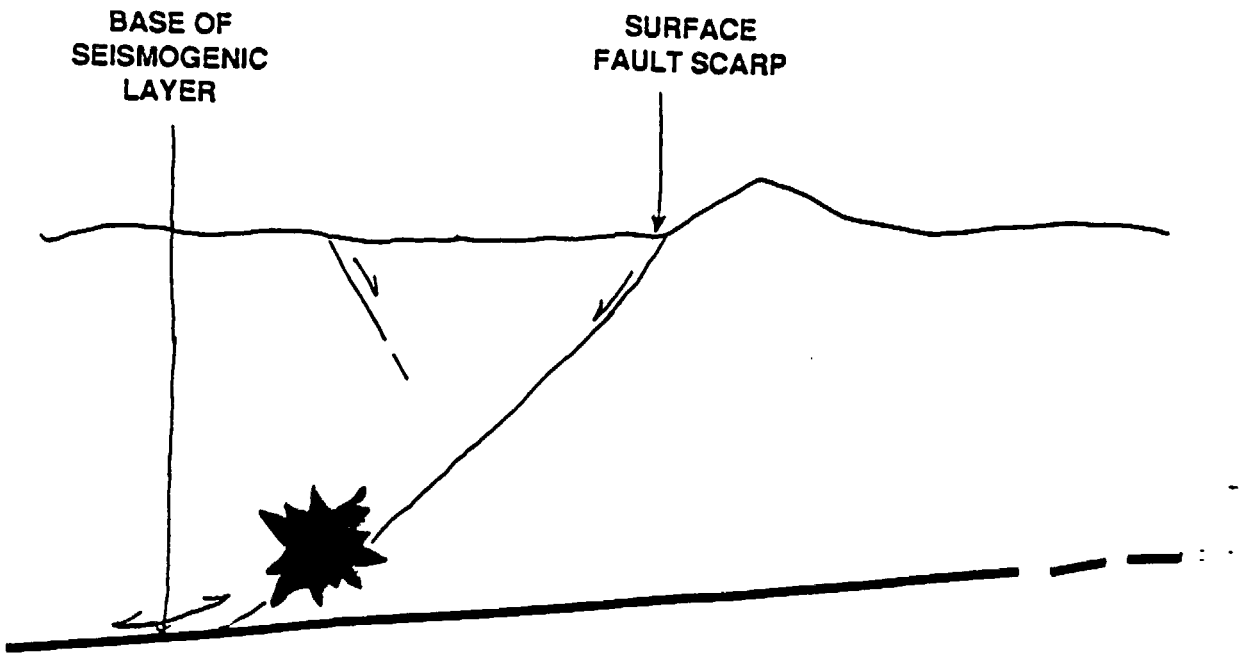
NWDOEP5P.A27/4-12-90

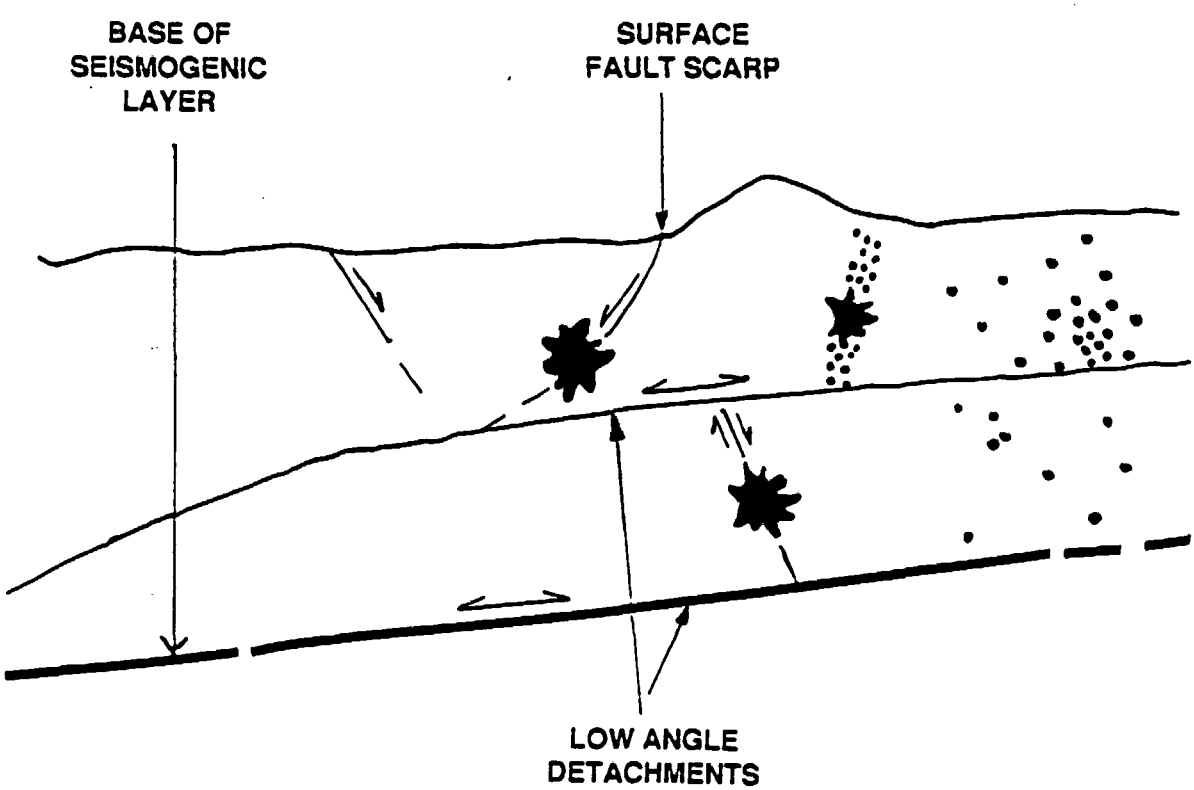
PARTS OF REGULATIONS THAT PERTAIN TO TECTONIC MODELS

10 CFR 60.21 (c)(ii)(F) MODELS

EXPLAIN THE MEASURES USED TO SUPPORT THE MODELS THAT WILL BE USED TO PREDICT FUTURE CONDITIONS. CHANGES IN THE GEOLOGIC SETTING SHALL BE SUPPORTED BY USING METHODS SUCH AS FIELD TESTS, IN SITU TESTS, LABORATORY TESTS, MONITORING DATA, AND NATURAL ANALOG STUDIES

EFFECTS OF DIFFERENT MODELS ON SEISMIC HAZARD EVALUATION





NRC DRAFT TECHNICAL POSITION ON TECTONIC MODELS IN THE ASSESSMENT OF PERFORMANCE OF HIGH-LEVEL RADIOACTIVE WASTE REPOSITORIES

- JUNE 19, 1989 — DRAFT TECHNICAL POSITION ISSUED
- SEPTEMBER 20, 1989 — LETTER (APPEL TO LINEHAN) EXPRESSED DOE CONCERN TO NRC
  - THE LEVEL OF CONSERVATISM DOES NOT REPRESENT REGULATORY REQUIREMENTS AND MAY BE TECHNICALLY UNATTAINABLE. IN THE TECHNICAL POSITION, MODELS ARE USED TO BOUND CONDITIONS
  - THE ROLES OF UNCERTAINTY AND PROBABILISTIC TECHNIQUES ARE NOT CLEARLY DEFINED
  - NO CRITERIA FOR DEVELOPING ACCEPTABLE TECTONIC MODELS ARE PROVIDED

NRC DRAFT TECHNICAL POSITION ON TECTONIC MODELS IN THE ASSESSMENT OF PERFORMANCE OF HIGH-LEVEL RADIOACTIVE WASTE REPOSITORIES

(CONTINUED)

- SEPTEMBER 26, 1989 DOE/NRC TECHNICAL EXCHANGE
  - THE SEPTEMBER 20 LETTER WAS DISCUSSED
  - TOPICS SUCH AS THE USE OF PROBABILISTIC TECHNIQUES TO EVALUATE TECTONIC MODELS, THE USE OF TECTONIC MODELS TO INTEGRATE DATA, AND THE TYPES OF DATA TO BE CONSIDERED IN TECTONIC MODEL DEVELOPMENT WERE DISCUSSED

THE ROLE OF TECTONIC MODELS IN THE YUCCA MOUNTAIN PROJECT

- DATA INTEGRATION
- FRAMEWORK FOR THE SITE
- SCENARIOS
- DIFFERENT TECTONIC MODELS PROVIDE DIFFERENT SOURCES AND MAGNITUDES FOR EARTHQUAKES, BUT COULD RESULT IN PRODUCING SIMILAR SEISMIC HAZARDS

NRC DRAFT TECHNICAL POSITION ON METHODS OF EVALUATING THE SEISMIC HAZARD AT A GEOLIGIC REPOSITORY

- AUGUST 24, 1989 DRAFT TECHNICAL POSITION ISSUED
- SEPTEMBER 20, 1989 & NOVEMBER 3, 1989 DOE CONCERNS EXPRESSED TO NRC
  - TERMINOLOGY AND CONCEPTS IN APPENDIX A ARE OUT-OF-DATE AND DIFFICULT TO INTERPRET
  - NRC HAS PREVIOUSLY RECOGNIZED THE NEED TO REVISE APPENDIX A
  - APPENDIX A DOES NOT TAKE INTO ACCOUNT THE DIFFERENCES BETWEEN A NUCLEAR POWER REACTOR AND A NUCLEAR WASTE REPOSITORY, WASTE HANDLING FACILITY, UNDERGROUND FACILITY, AND POSTCLOSURE TIME FRAME

NRC DRAFT TECHNICAL POSITION ON METHODS OF EVALUATING THE SEISMIC HAZARD AT A GEOLIGIC REPOSITORY

(CONTINUED)

- DECEMBER 19-20, 1989 DOE/NRC TECHNICAL EXCHANGE
  - NRC INTENDED DOE TO USE THE INVESTIGATIVE GUIDANCE AND NOT THE SEISMIC HAZARD PROCEDURES IN APPENDIX A
- FEBRUARY 27, 1990 DOE CONCERNS EXPRESSED TO NRC
  - SCP PLANS FOR ACQUIRING AND ANALYZING DATA ARE ADEQUATE AND NO ADDITIONAL REGULATORY GUIDANCE IS NEEDED (FOR INVESTIGATION TECHNIQUE)
  - DOE SUGGESTS TECHNICAL POSITION BE RECAST AS "ACCEPTABLE CRITERIA"
- NRC PLANS TO PUBLISH A DRAFT GENERIC TECHNICAL POSITION ON PROBABILISTIC SEISMIC HAZARD ANALYSIS IN THE NEAR FUTURE

APPENDIX A SHORTCOMINGS

- CONTAINS CONTENTIOUS TERMINOLOGY
  - "GREATEST MAGNITUDE," "MAXIMUM DISPLACEMENT," "MAXIMUM VIBRATORY GROUND MOTION," AND "UNCERTAINTY" HAVE PROVEN TO BE DIFFICULT TO DEFINE
- IS BASED ON PROFESSIONAL PRACTICE IN THE 1960'S AND EARLY 1970'S AND NO LONGER REFLECTS CURRENT STATE-OF-THE-ART PRACTICE

APPENDIX A SHORTCOMINGS

(CONTINUED)

- DOES NOT ACCOUNT FOR FAULTS HAVING DIFFERENT RECURRENCE INTERVALS. FOR EXAMPLE, A PLATE BOUNDARY FAULT SUCH AS THE SAN ANDREAS IS ASSESSED IN THE SAME MANNER AS A LESS ACTIVE FAULT WITH A LONG RECURRENCE INTERVAL SUCH AS THE BARE MOUNTAIN FAULT

- DOES NOT EXPLICITLY ALLOW THE USE OF PROBABILISTIC TECHNIQUES TO JUDGE DESIGN BASIS GROUND MOTION

- DOES NOT RECOGNIZE THAT FACILITIES MAY HAVE DIFFERENT RISK PROFILES

DOE'S APPROACH TO DEFINING SEISMIC DESIGN BASES

WE AGREE

EARLY AGREEMENT ON SEISMIC DESIGN STRATEGY AVOIDS CONTENTIOUS ISSUES, COSTLY LITIGATION AND LICENSING DELAYS BASED ON TERMINOLOGY IN APPENDIX A (FOR EXAMPLE THE DIABLO CANYON, SAN ONOFRE AND SEABROOK REACTOR REVIEWS)

- USES STATE-OF-THE-ART SEISMIC HAZARD ASSESSMENT TECHNIQUES
- EXPLICITLY CONSIDERS PROBABILISTIC HAZARD ESTIMATES AND PALEOSEISMIC RECURRENCE/SLIP RATE ESTIMATES AND ESTABLISHES A BASIS FOR CONCLUSIONS
- USES PROBABILISTIC TECHNIQUES WHICH ARE WIDELY ACCEPTED BY INDUSTRY (PRA), USGS, AND THE SCIENTIFIC COMMUNITY IN GENERAL

DOE'S APPROACH TO DEFINING SEISMIC DESIGN BASES

(CONTINUED)

- DEFINES GROUND MOTION DETERMINISTICALLY WITH EXPLICIT CONSIDERATION OF RECURRENCE INTERVALS

- RESULTS IN PROBABILITIES OF DESIGN BASIS GROUND MOTION THAT ARE AS CONSERVATIVE AS THOSE CALCULATED FOR REACTORS. HOWEVER, LIKELIHOODS OF PRECLOSURE RELEASES FROM SURFACE FACILITIES DUE TO EARTHQUAKES MAY BE MUCH LOWER THAN RELEASES FROM REACTORS

SUMMARY

- 10 CFR 60 LEAVES THE APPLICANT TO DEVELOP AND JUSTIFY A SEISMIC DESIGN BASIS THAT ENSURES SAFE FACILITY DESIGNS
- DOE RECOGNIZES THE SHORTCOMINGS OF APPLYING APPENDIX A PROCEDURE TO THE DETERMINATION OF SEISMIC DESIGN BASIS
- DOE IS DEVELOPING APPROACHES THAT INCORPORATE PROBABILISTIC AND DETERMINISTIC METHODS AND CONSIDER THE RISK POSED BY THE FACILITIES AND THE CONSEQUENCES OF THEIR FAILURE
- CONTINUING INTERACTIONS WITH THE NRC ARE IMPORTANT AS THE DOE METHODOLOGY IS REFINED AND USED TO DEVELOP A SEISMIC DESIGN BASIS

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

PRESENTATION TO THE NUCLEAR WASTE TECHNICAL REVIEW BOARD

SUBJECT: SUMMARY OF PROBABILISTIC SEISMIC HAZARD EVALUATIONS

PRESENTER: RICHARD LEE

PRESENTER'S TITLE AND ORGANIZATION: SEISMOLOGIST
SCIENCE APPLICATIONS INTERNATIONAL CORPORATION

PRESENTER'S TELEPHONE NUMBER: (702) 794-7134

APRIL 12, 1990

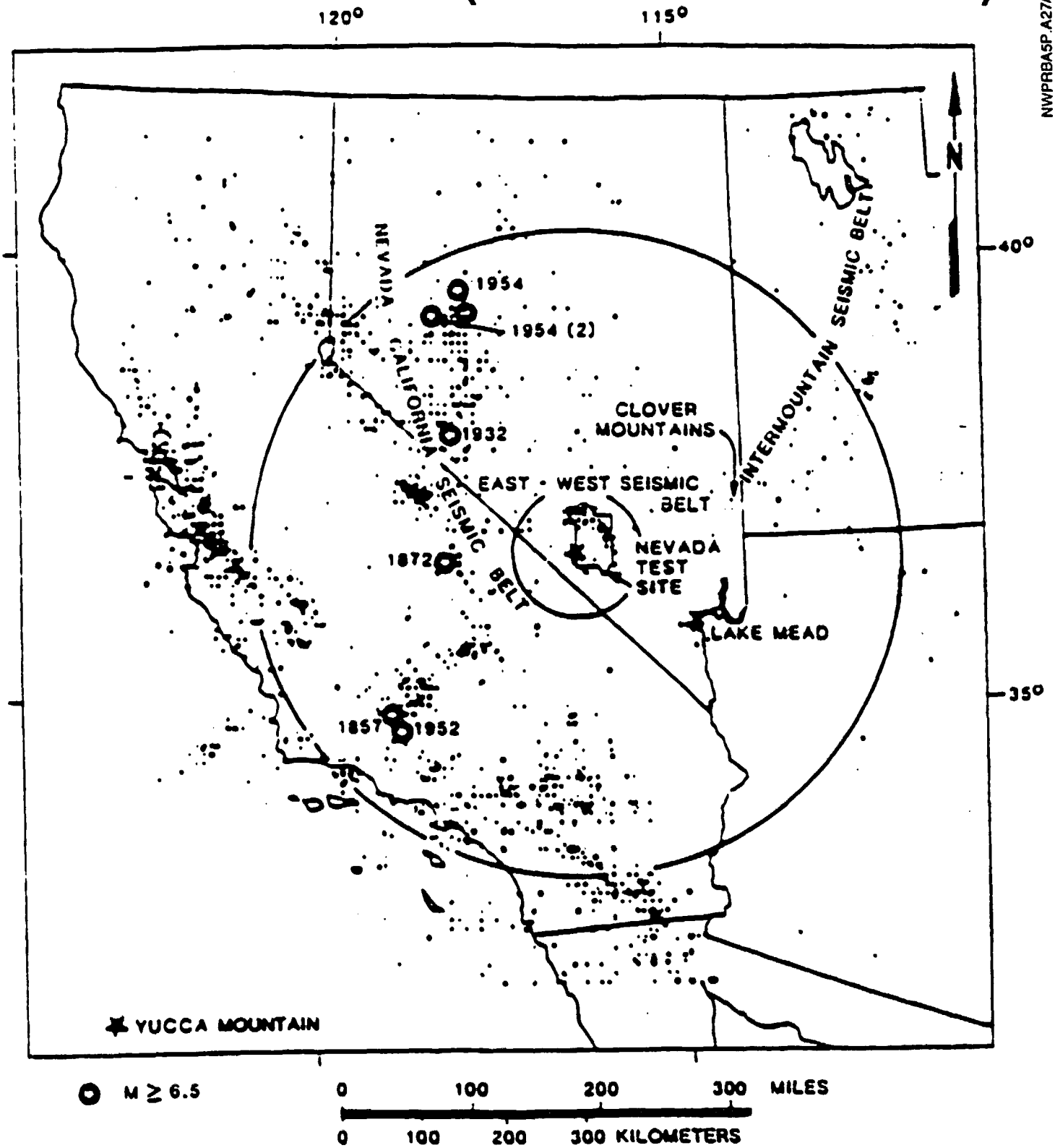
ENCLOSURE 3b

YUCCA MOUNTAIN PROBABILISTIC SEISMIC HAZARD EVALUATIONS

- THIS PRESENTATION SUMMARIZES PRELIMINARY PROBABILISTIC HAZARD ASSESSMENTS CONDUCTED IN SUPPORT OF THE YUCCA MOUNTAIN PROGRAM (ROGERS et al., 1977; PERKINS et al., 1987; URS/BLUME 1986; and URS/BLUME 1987)

- HAZARD RESULTS CAN BE APPLIED DIRECTLY TO SUPPORT A DESIGN BASIS OR INDIRECTLY TO ASSESS THE CONSERVATISM OF AN ALTERNATIVE DESIGN BASIS SUCH AS THE 10,000 YEAR CUMULATIVE SLIP EARTHQUAKE

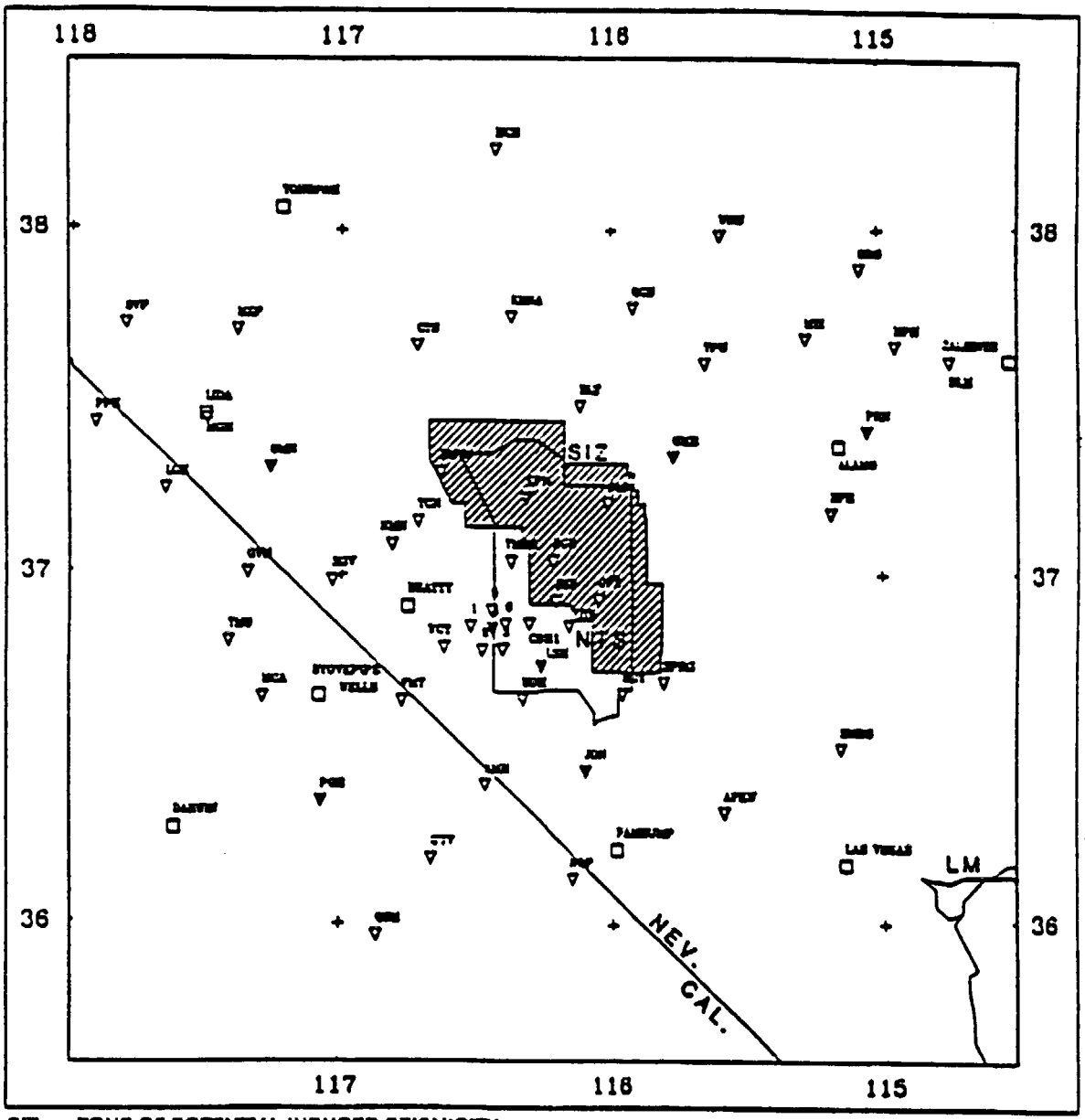
SEISMICITY OF SOUTHWESTERN UNITED STATES (1769 THROUGH 1978)



NWPRBA5P.A27/4-12-90

SOUTHERN GREAT BASIN SEISMOGRAPH STATIONS

NWPRBA5P.A27/4-12-90



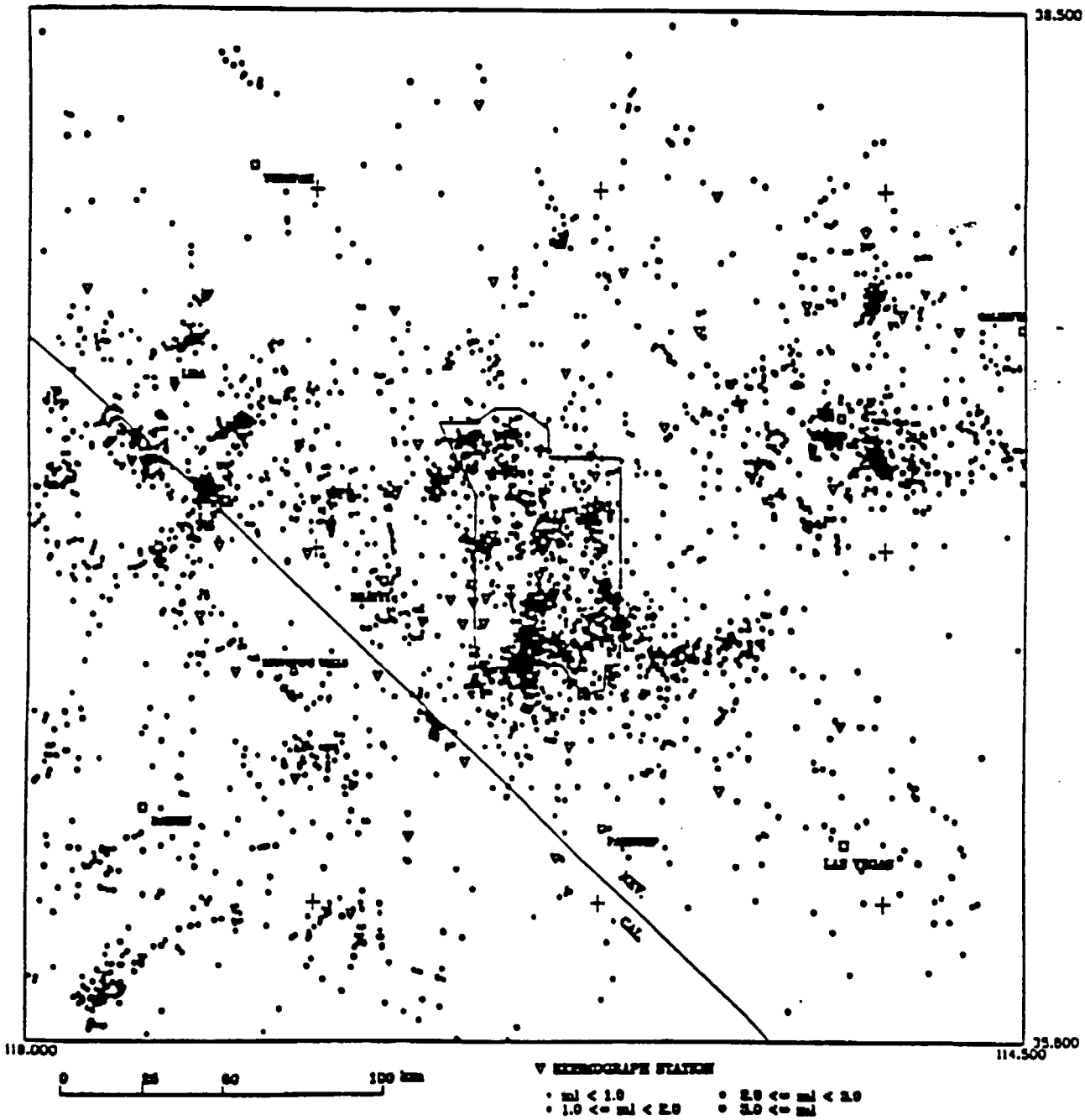
SIZ - ZONE OF POTENTIAL INDUCED SEISMICITY;
NTS - NEVADA TEST SITE;
LM - LAKE MEAD
▼ - HORIZONTAL COMPONENT SEISMOMETERS

0 20 40 60 80 100 KILOMETERS

SEISMICITY IN THE SOUTHERN GREAT BASIN

AUGUST 1, 1978 THROUGH DECEMBER 31, 1986

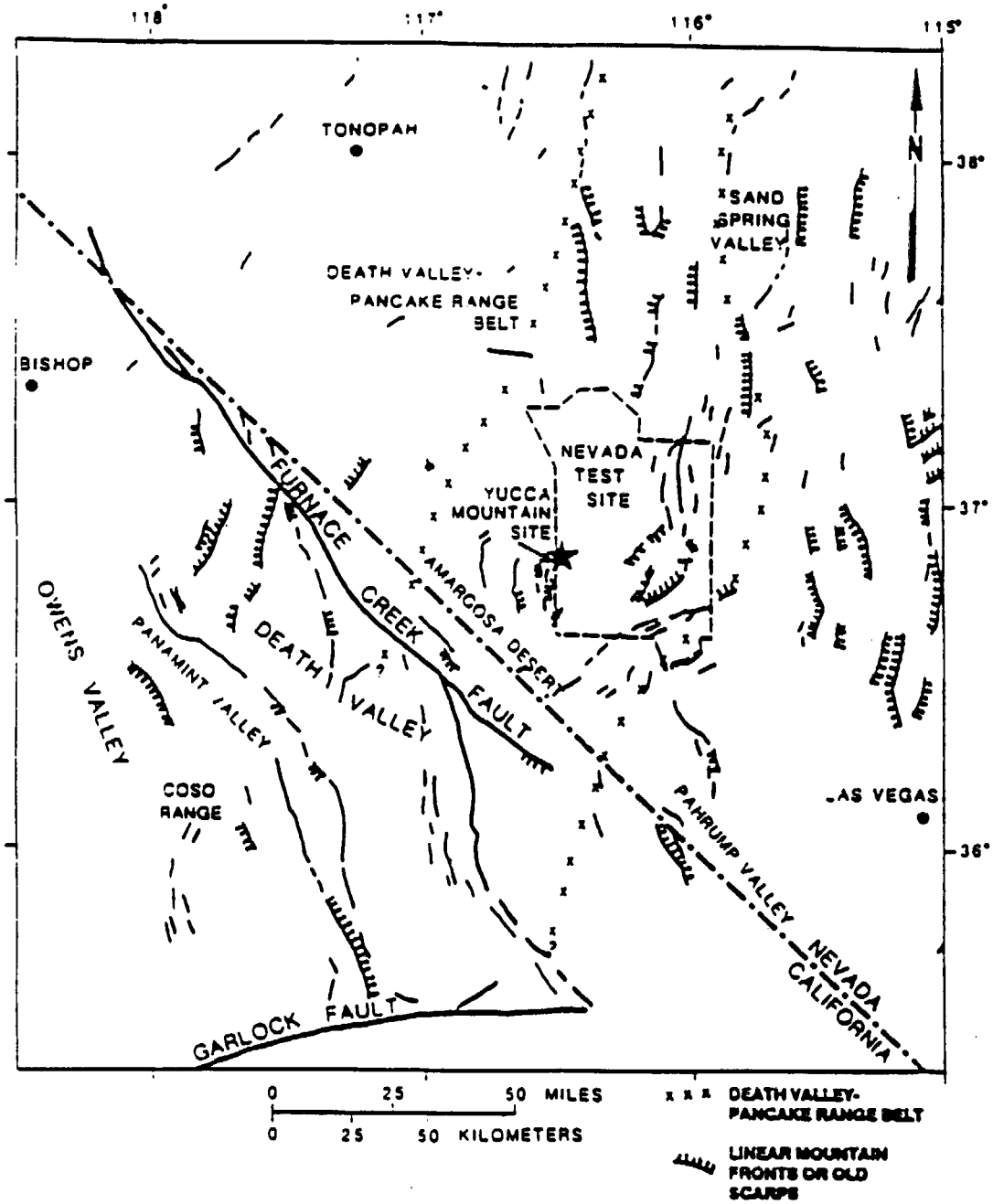
NWPRBASP.A27/4-12-90



LATE PLIOCENE AND QUATERNARY FAULTS IN THE NEVADA TEST SITE REGION AND THEIR RELATIONS TO THE DEATH VALLEY-PANCAKE RANGE BELT

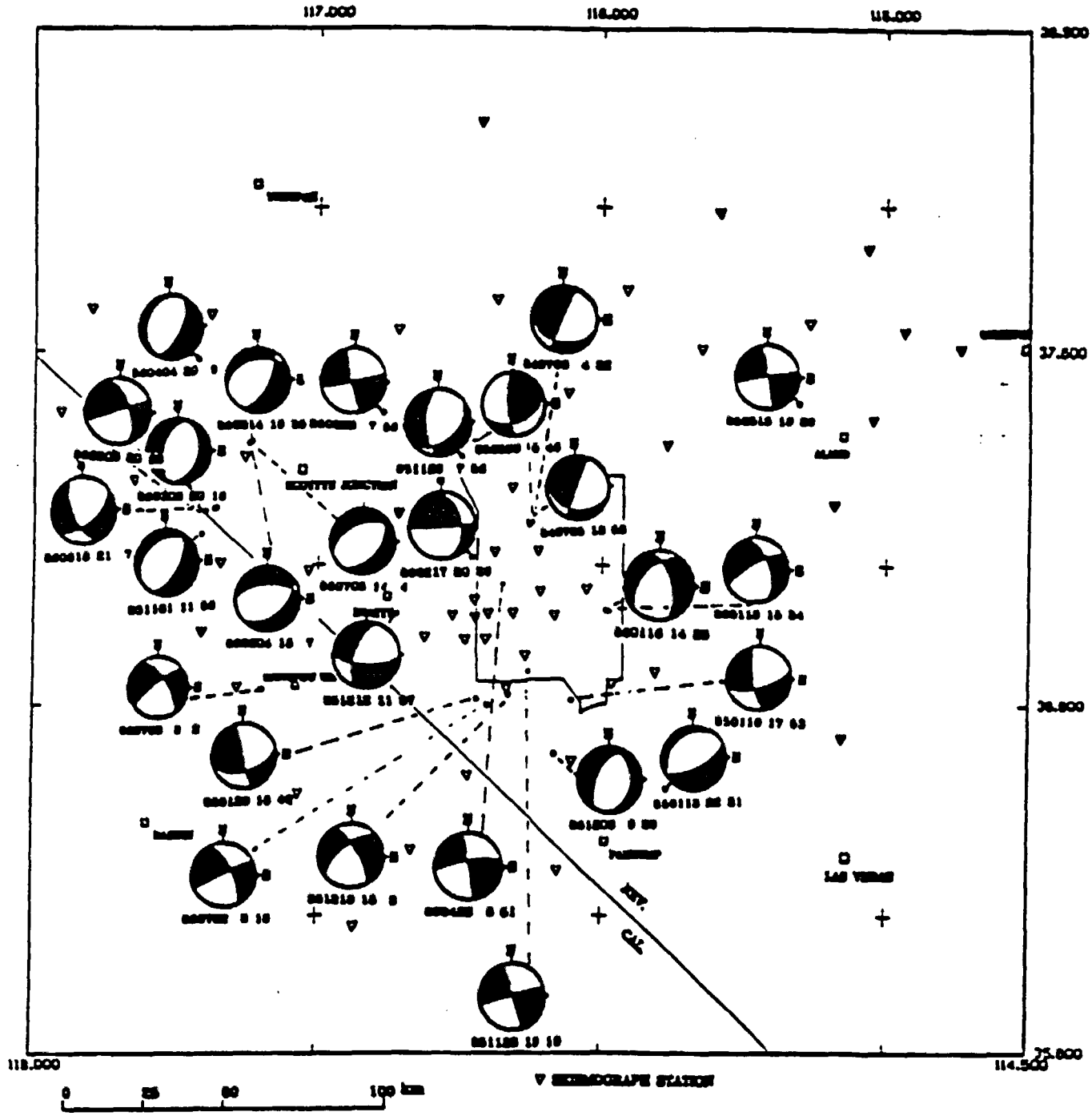
NWPRBA5P.A27/4-12-90

DECEMBER 1988



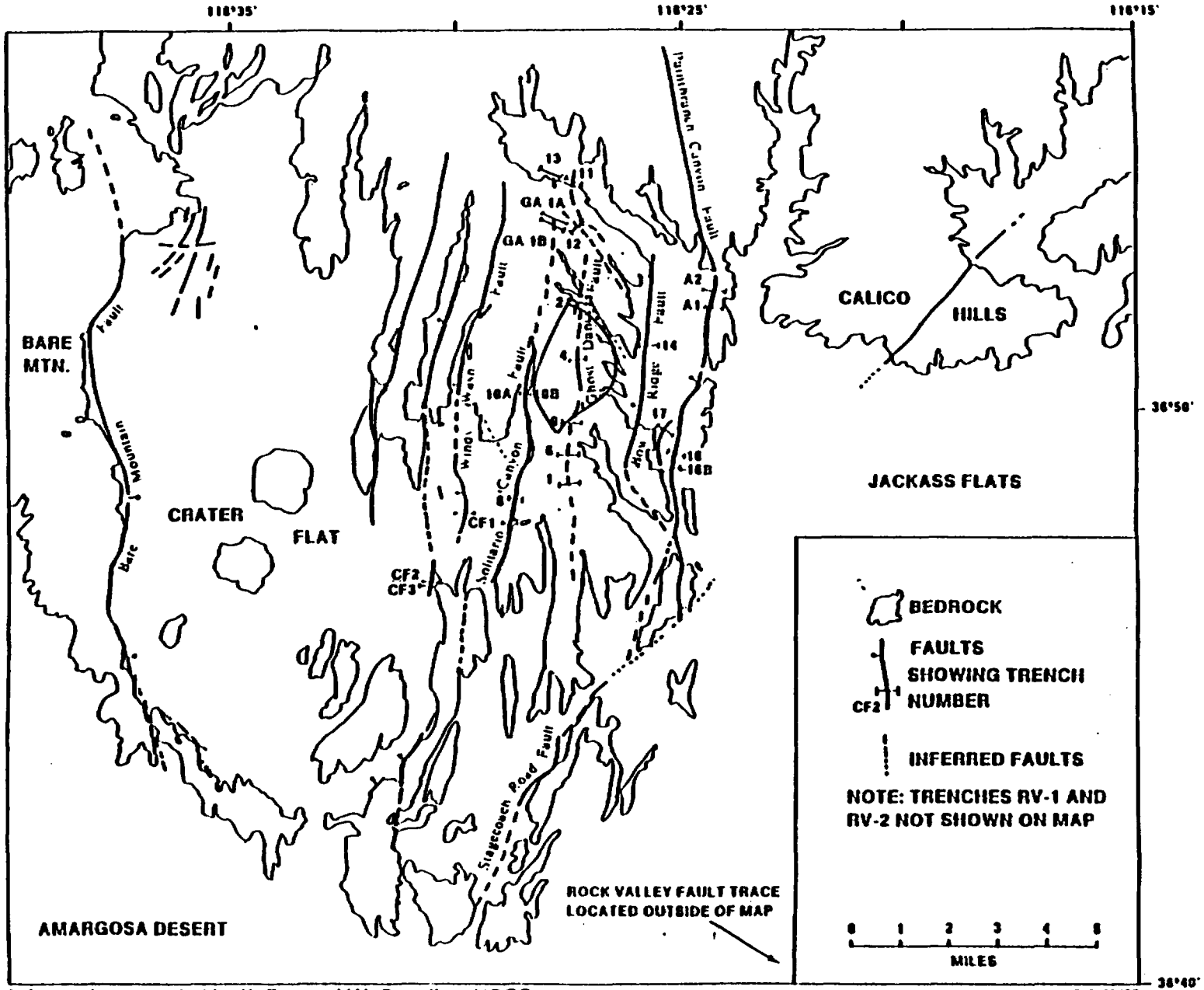
TWENTY-SEVEN FOCAL MECHANISMS FOR SOUTHERN GREAT BASIN EARTHQUAKES

NWPRBA5P A27/4-12-90



NOTE: FOCAL MECHANISMS PLOTTED AS EQUAL-AREA PROJECTIONS OF GREAT CIRCLES ON THE LOWER HEMISPHERE; TENSION (T) AXES BISECT THE *BLACKENED* QUADRANTS. (FROM HARMSEN AND ROGERS, -1987)

FAULTS IN THE REPOSITORY AREA



Information provided by K. Fox and W. Swadley, USGS.

0216-0023DS 2/20/87

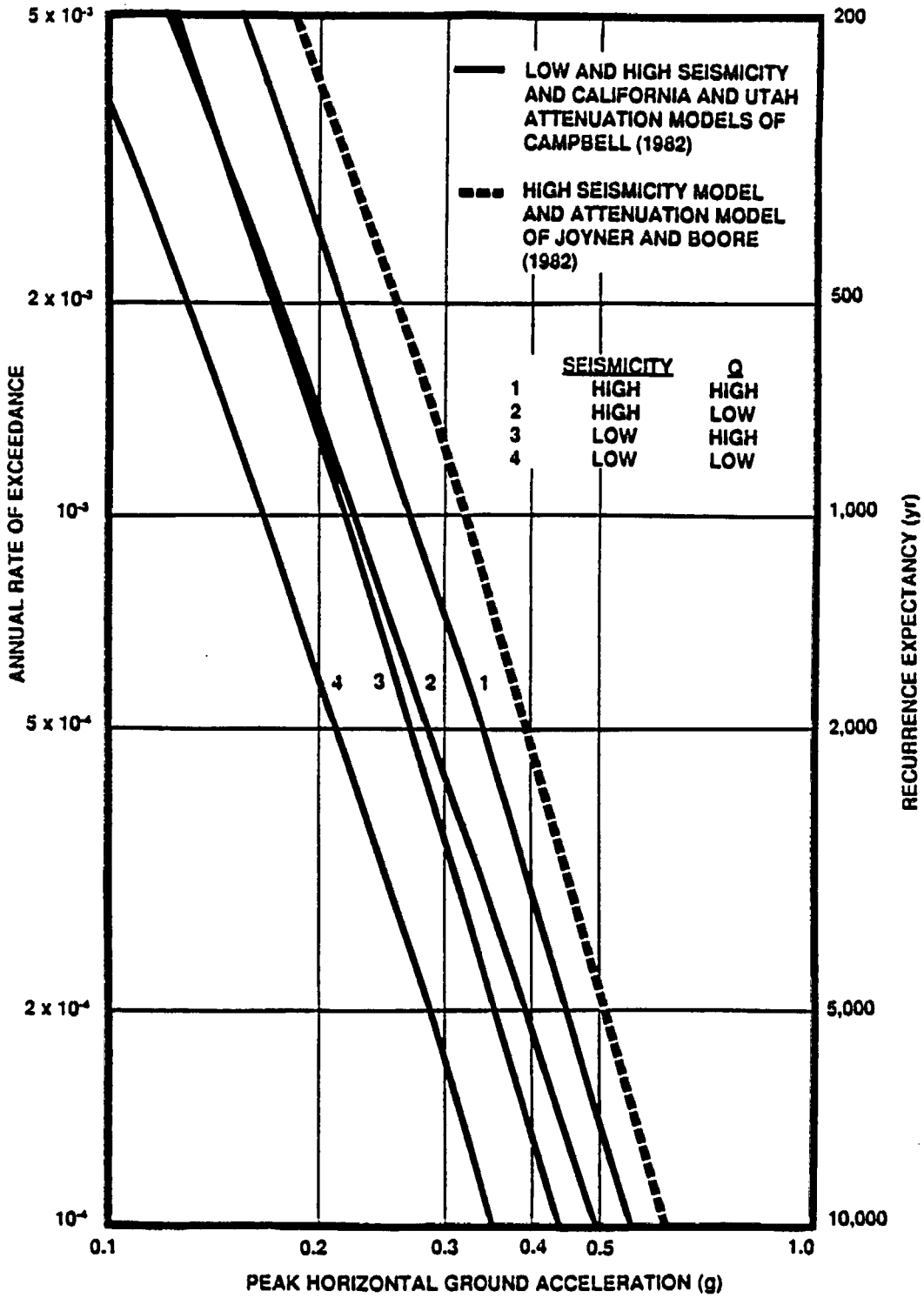
IN SUPPORT OF YUCCA MOUNTAIN SEISMIC HAZARD EVALUATIONS, SEVERAL DIFFERENT AND EVOLVING SEISMIC SOURCE MODELS HAVE BEEN DEVELOPED OWING TO BASIN AND RANGE COMPLEXITY:

- COMPLEX TECTONICS IN VICINITY OF YUCCA MOUNTAIN
- LOW RATES OF DEFORMATION IN THE SOUTHERN BASIN AND RANGE, RESULTING IN HISTORIC SEISMICITY THAT MAY NOT RELIABLY INDICATE LONG-TERM ACTIVITY RATES
- HISTORIC SEISMICITY THAT IS NOT WELL CORRELATED WITH MAPPED FAULTS
- AN EARTHQUAKE CATALOG CONTAMINATED BY INDUCED SEISMICITY
- AN ABUNDANCE OF LATE CENOZOIC FAULTS IN THE SITE VICINITY

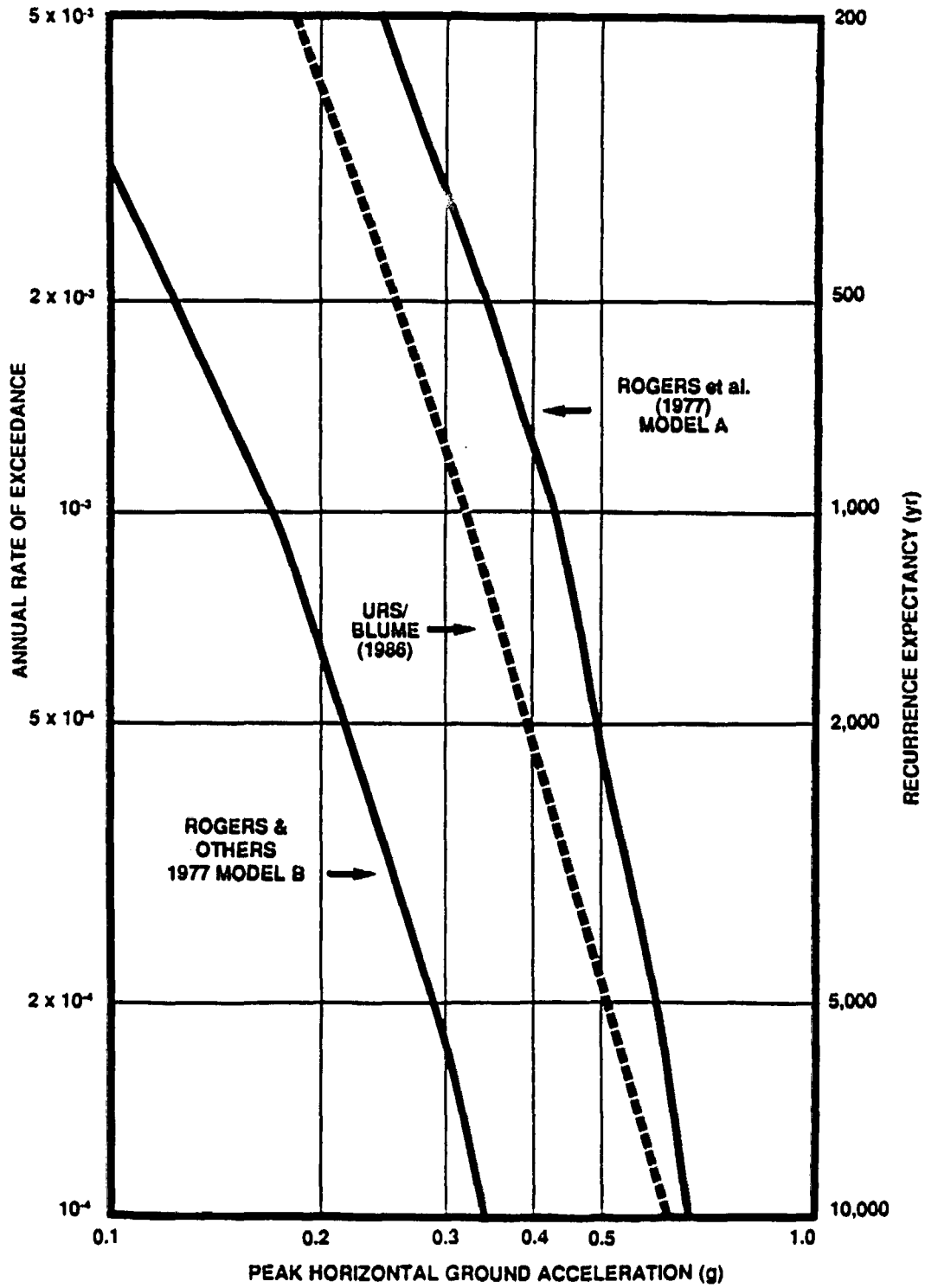
SEISMIC HAZARD EVALUATIONS USING AREALLY DISTRIBUTED SEISMICITY

- TWO EVALUATIONS:
  - ROGERS et al. (1977), MODELS A AND B
  - URS/BLUME (1986), SENSITIVITY STUDY (PRELIMINARY SEISMIC DESIGN BASIS)
- MODELS DIFFER BY HOW HISTORICAL SEISMICITY CATALOGS ARE AVERAGED IN TIME AND SPACE (SEISMOGENIC ZONATION; USE OF POST-1962 EARTHQUAKE CATALOG FOR THE NTS VICINITY)
- MODELS ARE ILLUSTRATIVE OF ESTIMATED HAZARD SENSITIVITIES TO:
  - SEISMOGENIC ZONATION
  - GROUND MOTION ATTENUATION
  - UNE CONTAMINATION OF EARTHQUAKE CATALOG

URS/BLUME (1986) EARTHQUAKE HAZARD



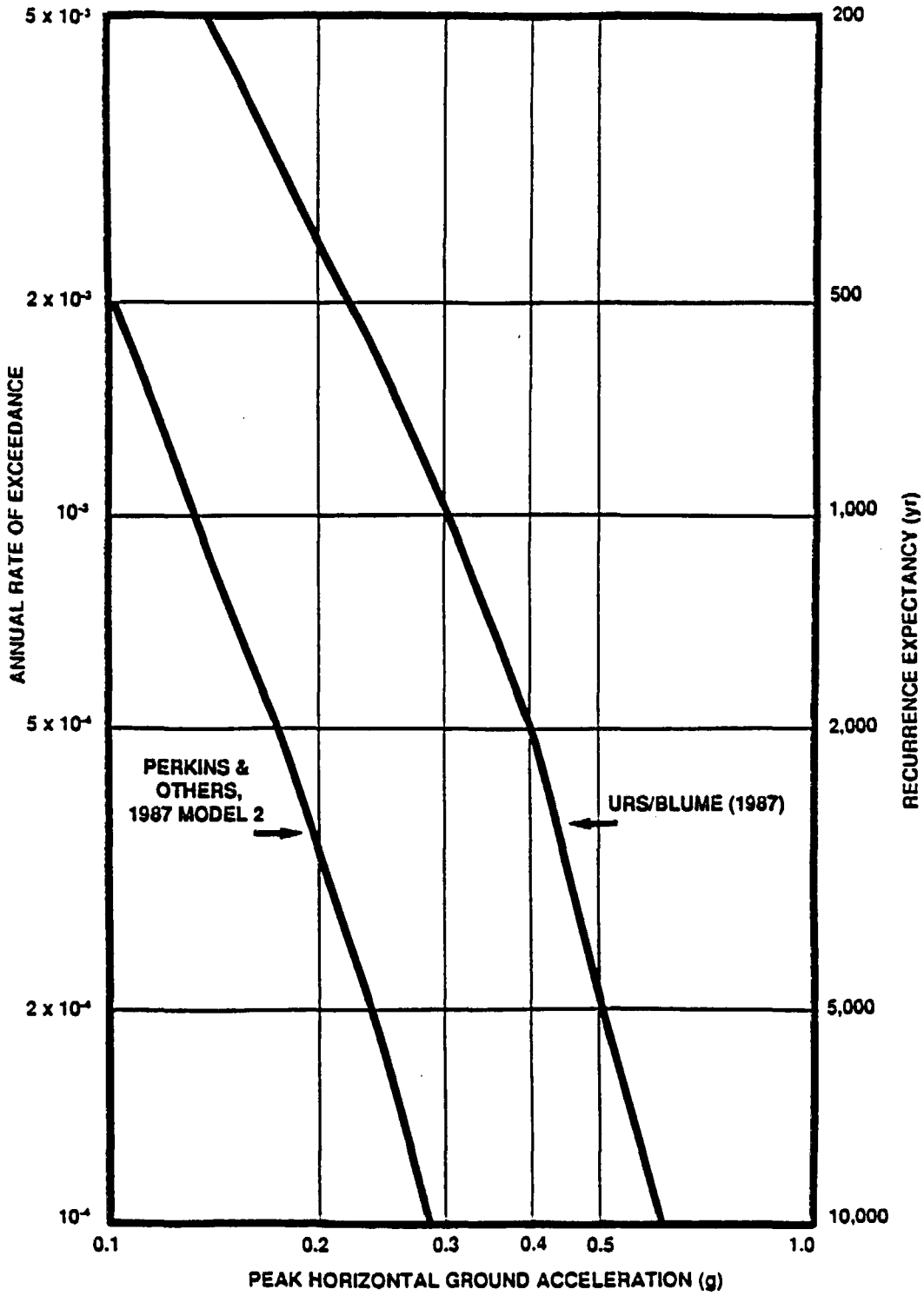
COMPARISON OF HAZARD RESULTS OF ROGERS et al. (1977) AND PREFERRED URS/BLUME (1986) MODEL



SEISMIC HAZARD EVALUATIONS USING FAULT SOURCES

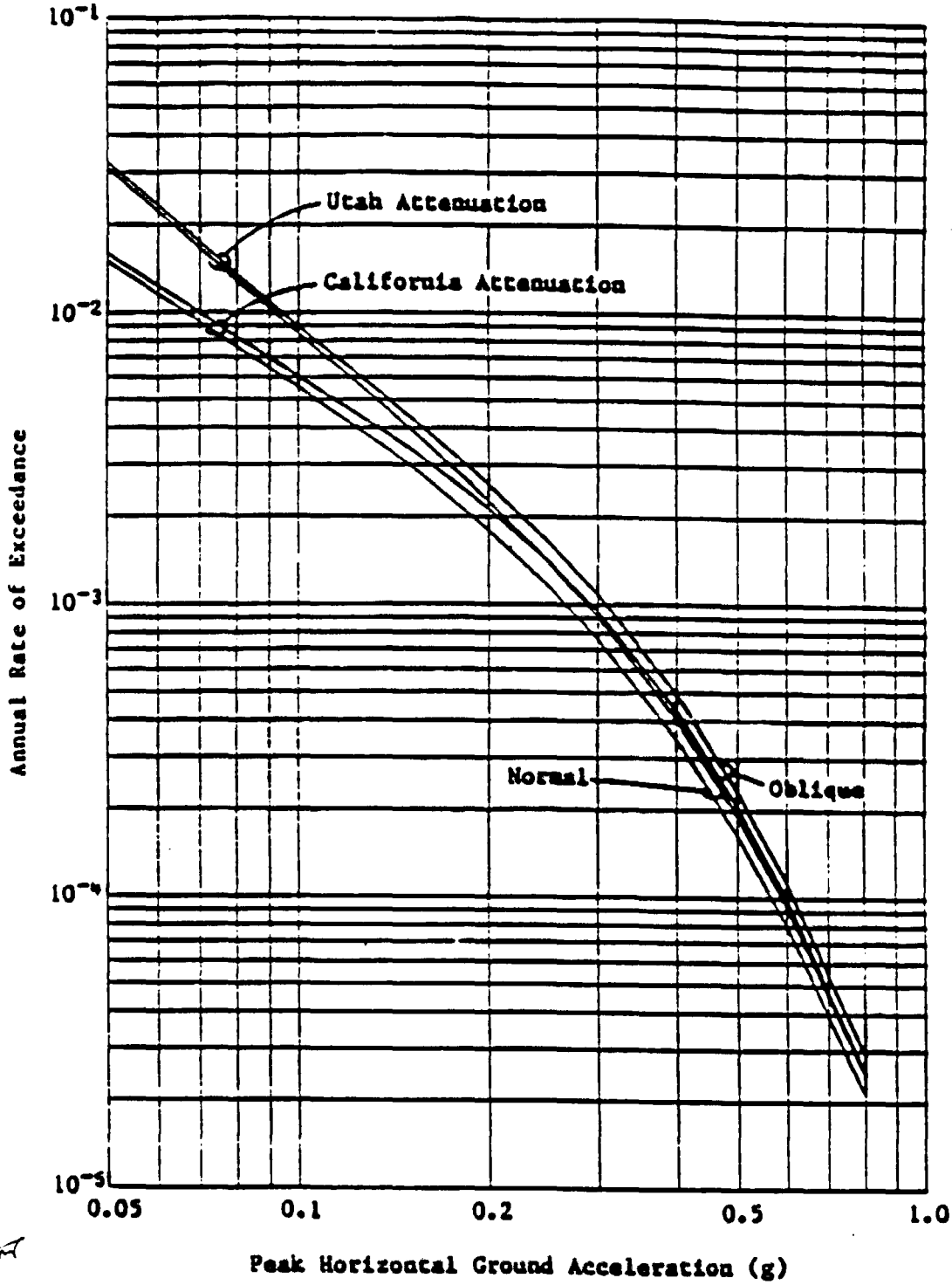
- TWO EVALUATIONS:
  - PERKINS et al. (1987), PREFERRED MODEL 2
  - URS/BLUME (1987), PARAMETER STUDY
- BOTH MODELS USE FAULT AND AREA SEISMIC SOURCES, AND TOTAL SEISMICITY IS CONSTRAINED BY THE PRE-1963 EARTHQUAKE CATALOG
- PERKINS CONSTRAINS FAULT-RELATED SEISMICITY BY PARTITIONING RATES OF HISTORIC SEISMICITY AMONG FAULTS
  - USES FAULT MAP REPORTED IN ROGERS et al. (1983)
- BLUME MODELS USE FAULTS IN IMMEDIATE SITE VICINITY (PRELIMINARY GEOLOGIC MAP BY SCOTT AND BONK, 1984)
  - FAULT-RELATED ACTIVITY BASED ON GEOLOGIC DEFORMATION (HYPOTHETICAL RELATIONSHIP BETWEEN FAULT LENGTH AND SLIP-RATE)
  - SENSITIVITY STUDIES WERE CONDUCTED FOR SLIP-RATE, STYLE OF FAULTING, GROUND MOTION ATTENUATION AND HAZARD COMPOSITION

COMPARISON OF HAZARD RESULTS OF PERKINS et al. (1987) AND URS/BLUME (1987)



EFFECT ON PGA EXCEEDANCE RATES OF WHOLE-PATH SEISMIC ABSORPTION

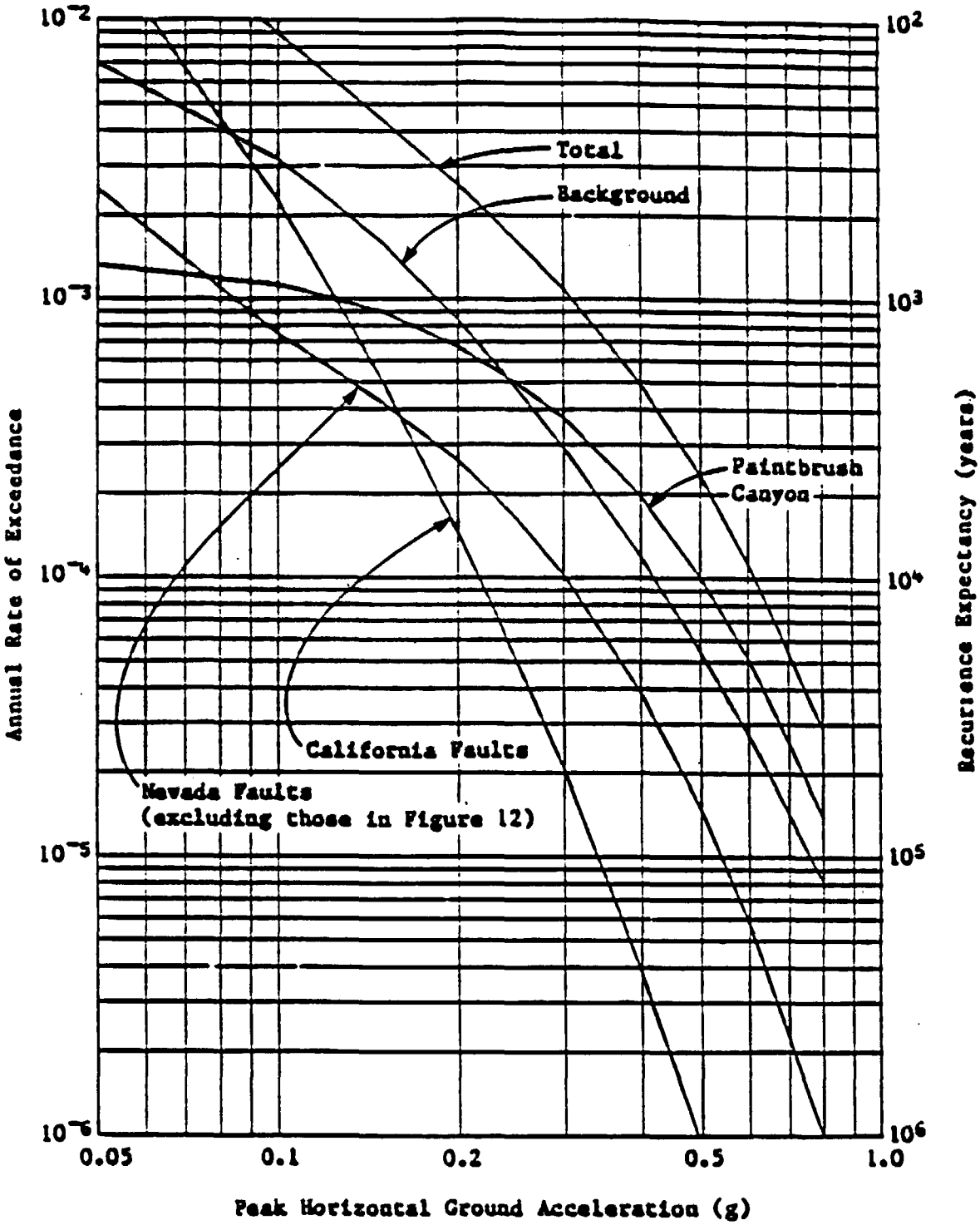
(URS/BLUME, 1987)



slip rate change but not attenuation

COMPOSITION OF PGA EXCEEDANCE RATES

(URS/BLUME, 1987)



BASED ON VERY PRELIMINARY HAZARD EVALUATIONS, WE CAN CONCLUDE THAT:

- PEAK HORIZONTAL GROUND ACCELERATIONS OF 0.3g TO 0.6g APPEAR TO HAVE ANNUAL PROBABILITIES IN THE RANGE OF 10^{-3} TO 10^{-4}
- THE PRESENCE OF UNEs AND AFTERSHOCKS IN THE EARTHQUAKE CATALOG SIGNIFICANTLY INCREASES THE APPARENT RATE OF SEISMICITY, AND INCREASES ESTIMATED GROUND MOTION HAZARD

BASED ON VERY PRELIMINARY HAZARD EVALUATIONS, WE CAN CONCLUDE THAT:

(CONTINUED)

- THE PRESENCE OF NEARBY AND RELATIVELY ACTIVE FAULTS IN THE YUCCA MOUNTAIN VICINITY (SUCH AS THE PAINTBRUSH CANYON FAULT) TEND TO DOMINATE THE SEISMIC HAZARD ESTIMATED FOR THE NEARBY LOCATIONS, AND THEIR PRESENCE WOULD APPEAR TO DECREASE THE NECESSARY CONFIDENCE IN CHARACTERIZATION OF MORE DISTANT SEISMIC SOURCES

- ALTHOUGH HISTORIC SEISMICITY WILL REMAIN A CONSIDERATION FOR PRECLOSURE DESIGN, A RELIABLE PROBABILISTIC HAZARD EVALUATION WILL DEPEND ON THE SUCCESSFUL RECOVERY OF PALEOSEISMIC DATA IN THE YUCCA MOUNTAIN VICINITY

SIGNIFICANT IMPROVEMENTS IN PROBABILISTIC HAZARD CONFIDENCE CAN BE MADE BY:

(1) DETERMINING THE QUATERNARY RATES OF DEFORMATION ON FAULTS IN THE SITE VICINITY

(2) EVALUATION OF POTENTIAL SITE EFFECTS AT YUCCA MOUNTAIN AND MIDWAY VALLEY

(3) CLEANSING THE EARTHQUAKE CATALOG OF NTS UNEs AND AFTERSHOCKS

(4) CORRECTING THE SOUTHERN GREAT BASIN (SGB) SEISMICITY CATALOG USING APPROPRIATE CRUSTAL ANELASTIC ATTENUATION

(5) DETERMINING THE APPLICABILITY OF THRUST AND STRIKE-SLIP GROUND MOTION ATTENUATION FUNCTIONS TO A NORMAL FAULTING ENVIRONMENT (SEISMOTECTONIC MODELS)

(6) CONSIDERATION OF ALTERNATE EARTHQUAKE RECURRENCE MODELS

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

PRESENTATION TO THE NUCLEAR WASTE TECHNICAL REVIEW BOARD

SUBJECT: SEISMICITY AND TECTONIC MODELS

PRESENTER: TERRY A. GRANT

PRESENTER'S TITLE AND ORGANIZATION: GEOLOGIST
SCIENCE APPLICATIONS INTERNATIONAL CORPORATION

PRESENTER'S TELEPHONE NUMBER: (702) 794-7647

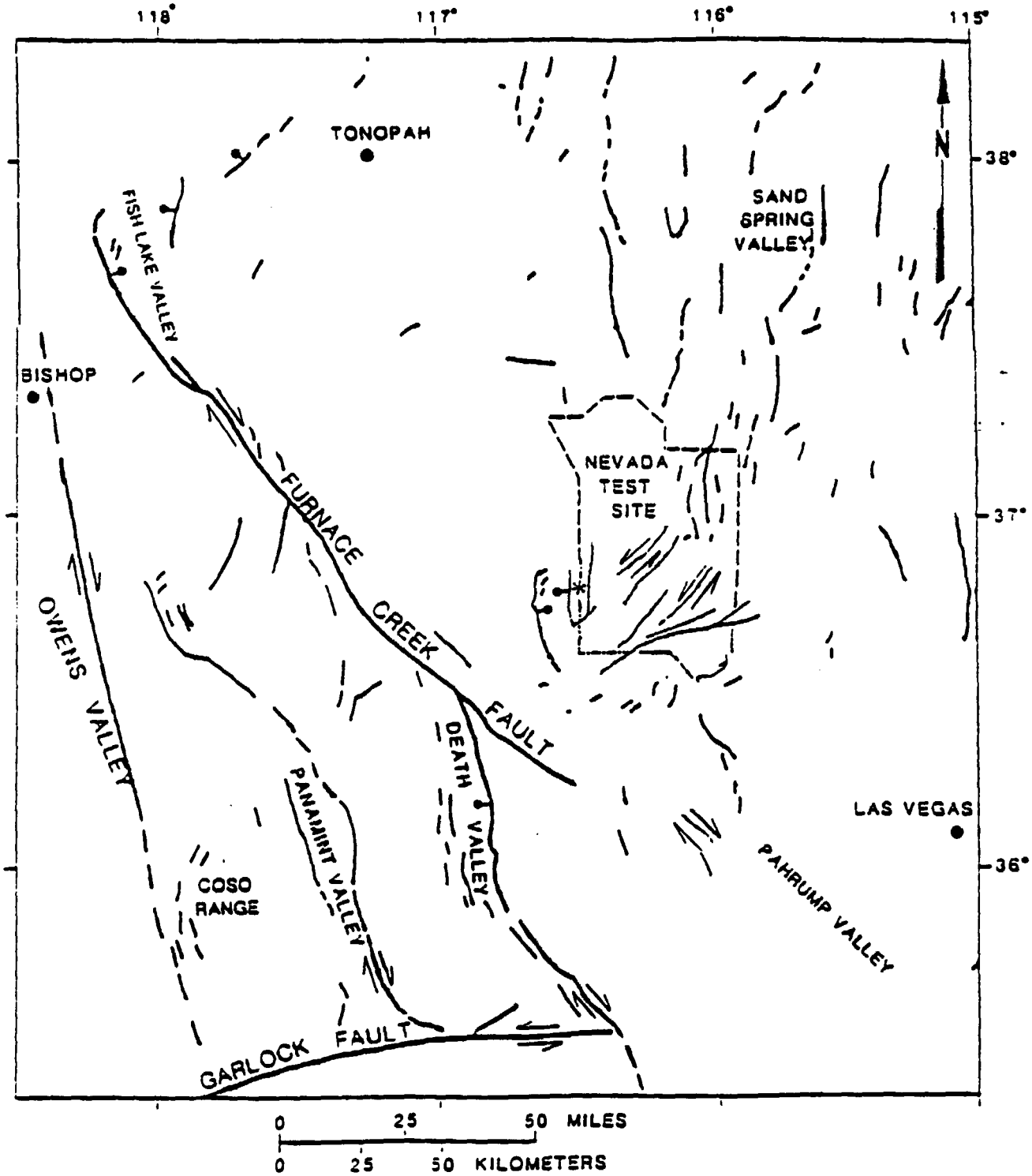
APRIL 12, 1990

ENCLOSURE 3c

SEISMIC GEOLOGY AND TECTONIC MODELS

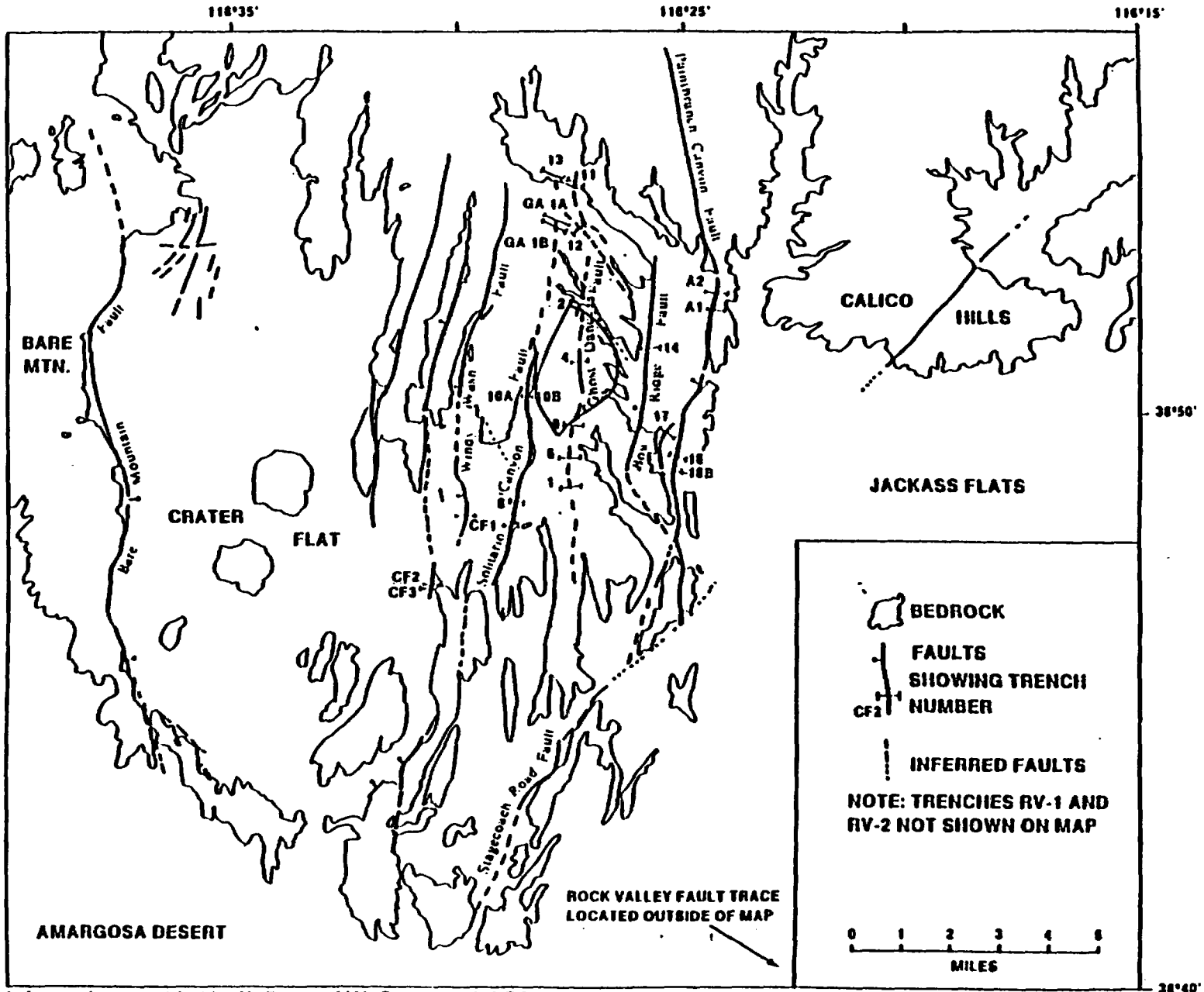
- PALEOSEISMICITY AND QUATERNARY FAULTING IN THE SITE AREA
- DATA UNCERTAINTIES AND FAULTING IN THE REPOSITORY BLOCK
- TECTONIC MODELS FOR BASIN-AND-RANGE FAULTING
- APPLICATION OF TECTONIC MODELS TO SITE CHARACTERIZATION

SIGNIFICANT FAULTS IN THE NTS REGION



* LOCATION OF REPOSITORY

FAULTS IN THE REPOSITORY AREA

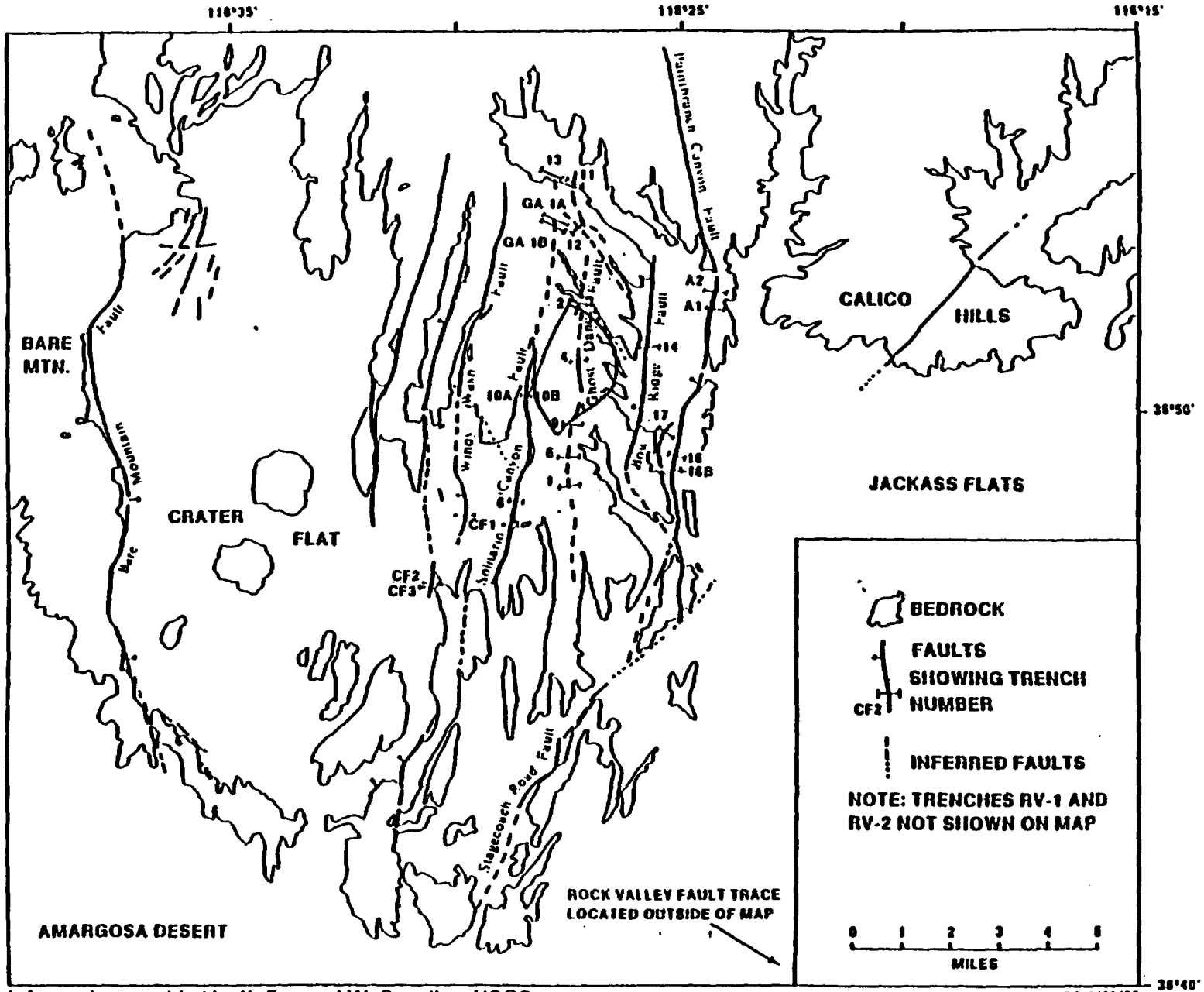


Information provided by K. Fox and W. Swadley, USGS.

6216-0023DS 2/20/87

PHOTOGRAPH OF BARE MOUNTAIN FAULT

FAULTS IN THE REPOSITORY AREA



Information provided by K. Fox and W. Swadley, USGS.

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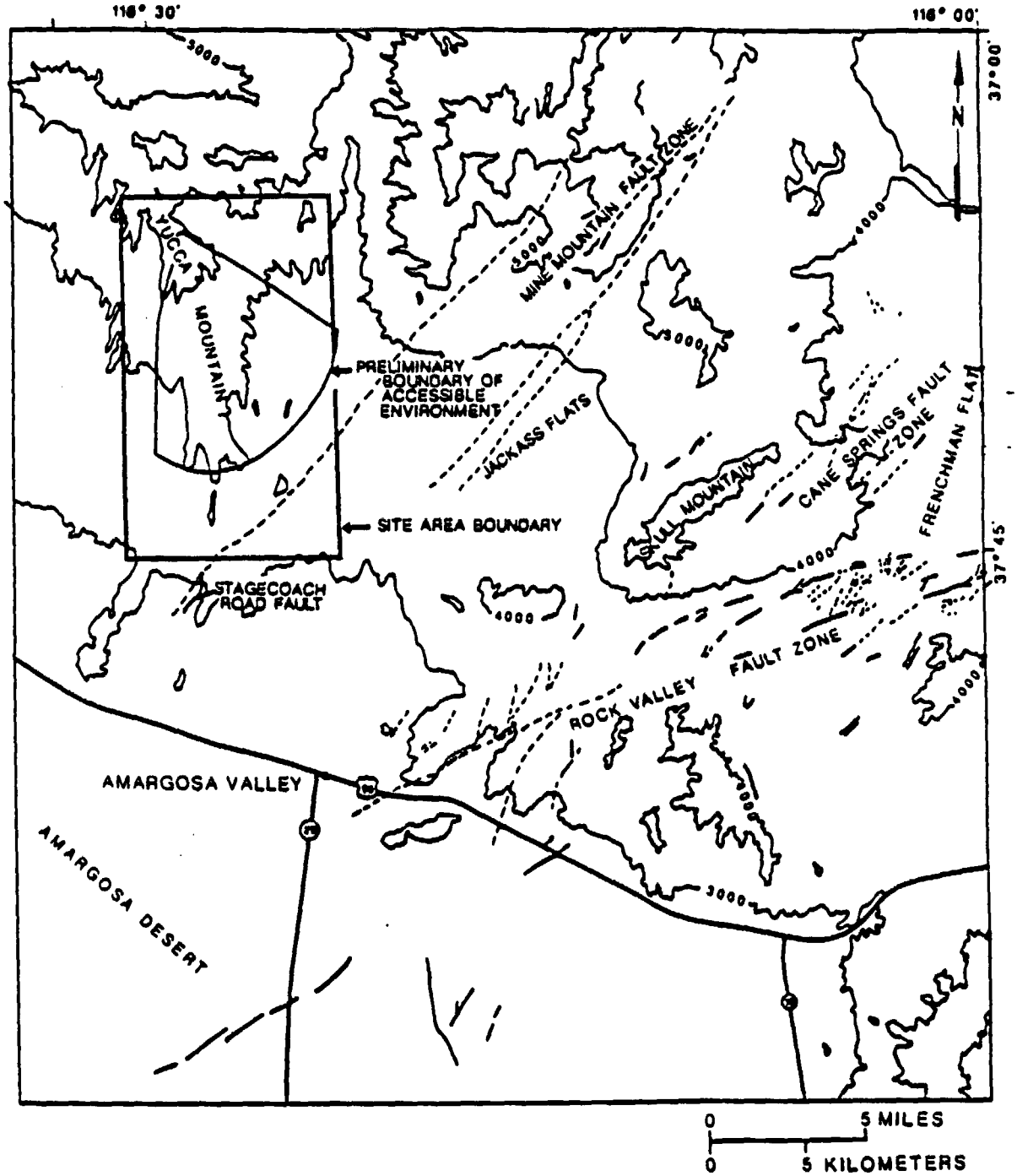
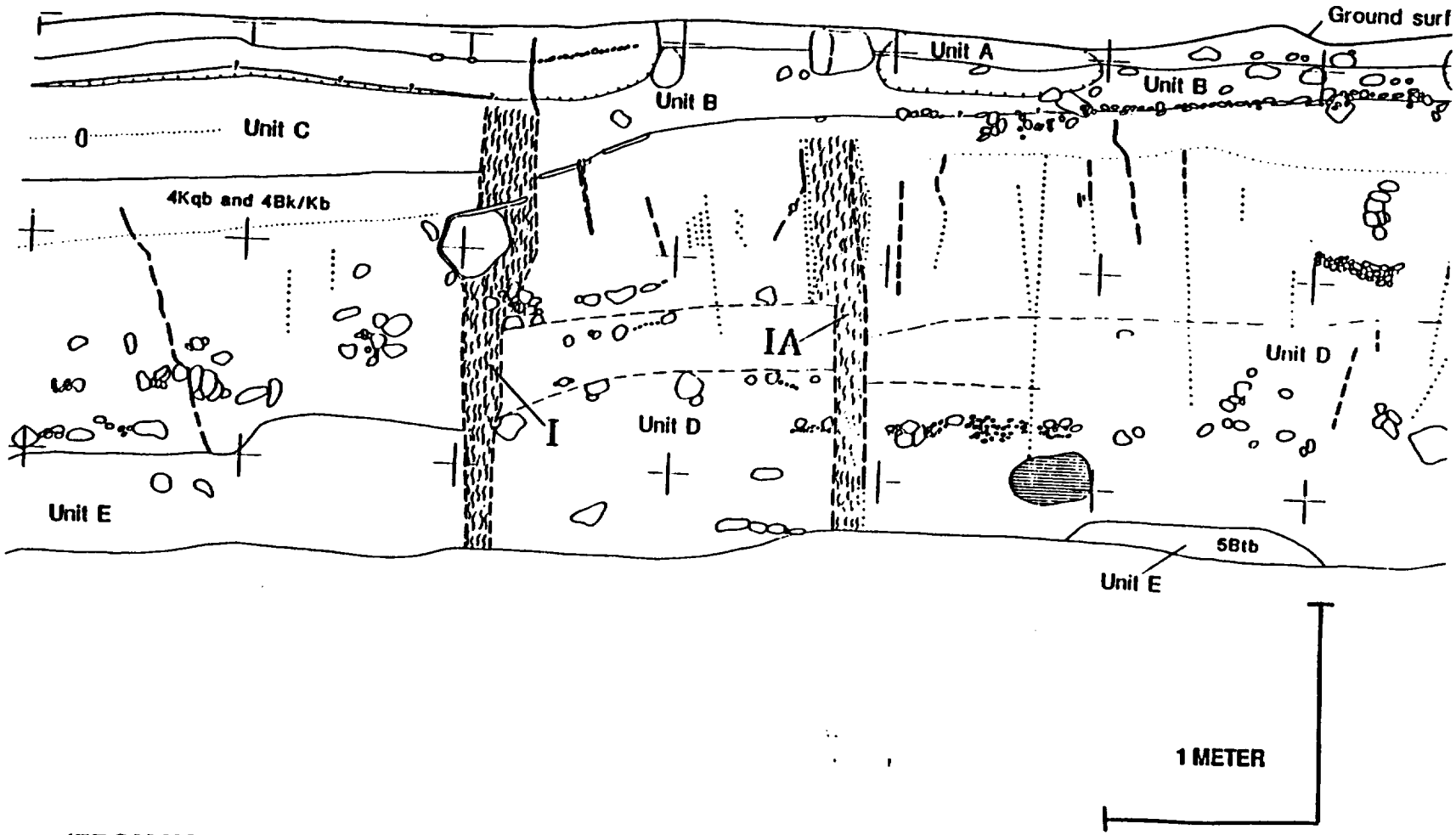
PHOTOGRAPH OF WINDY WASH TRENCH

LOCATION OF NORTHEAST-TRENDING LEFT-LATERAL FAULTS



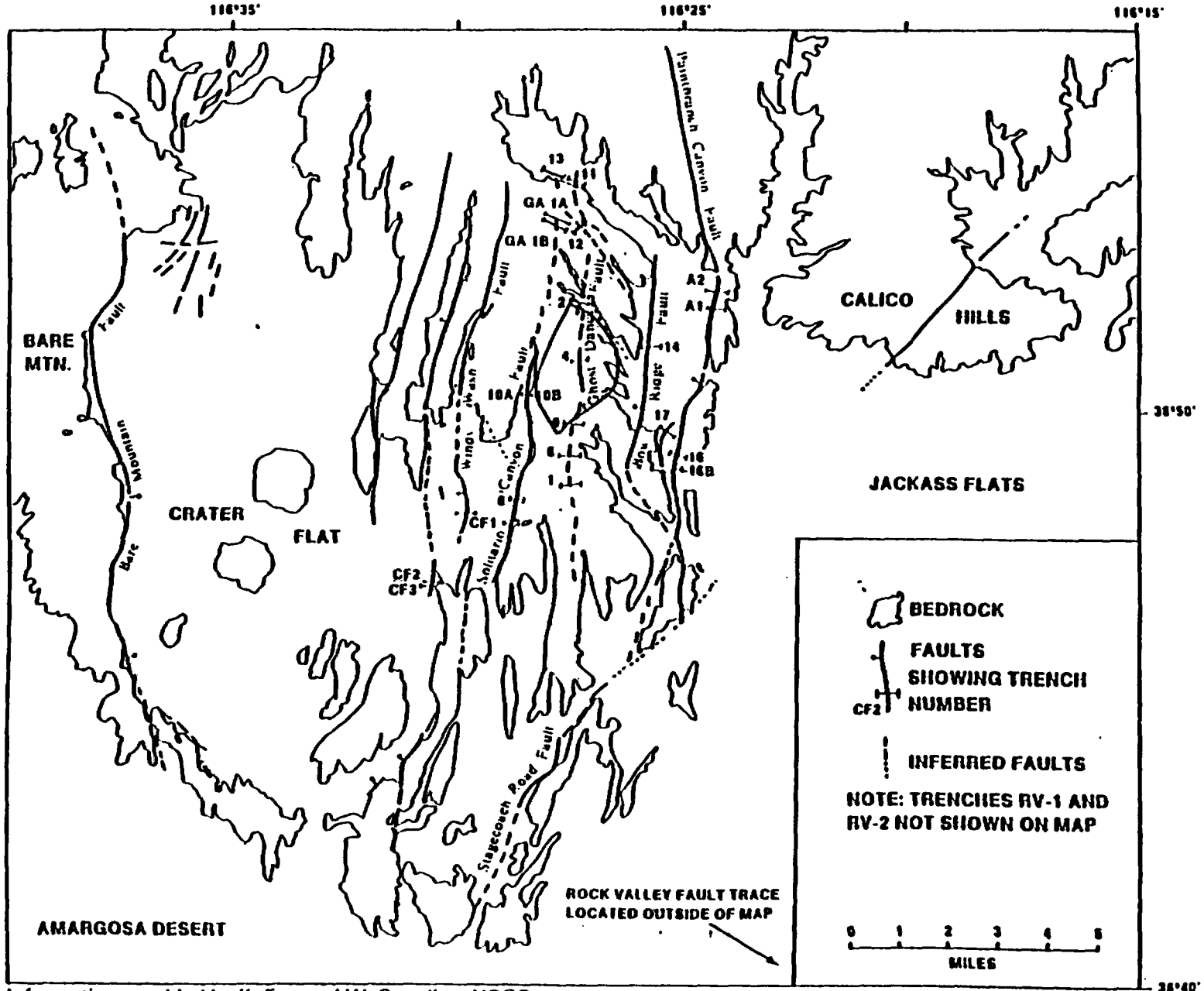
PART OF LOG FOR ROCK VALLEY TRENCH 2-EAST WALL



(FROM YOUNT ET AL, 1987)

NWSGEO5P.A27/4-12-90

FAULTS IN THE REPOSITORY AREA



Information provided by K. Fox and W. Swadley, USGS.

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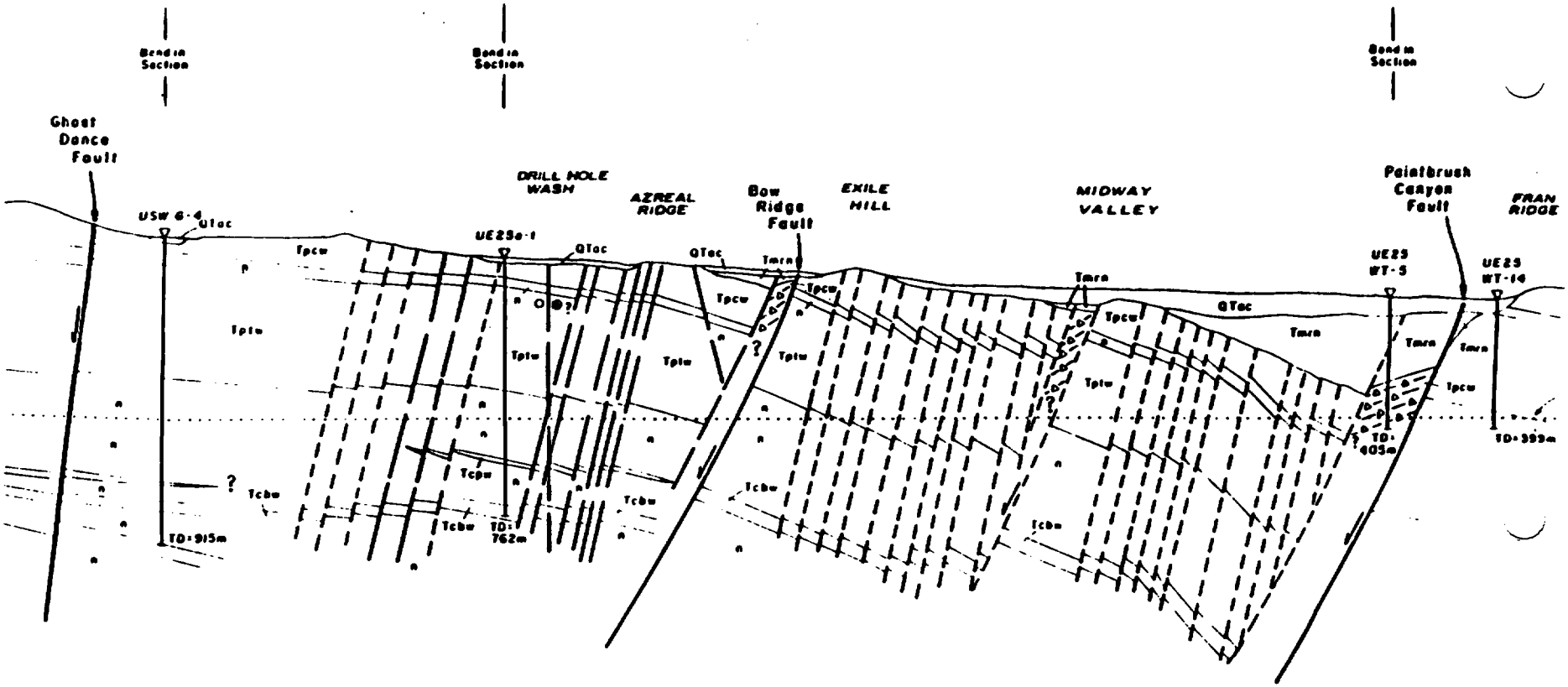
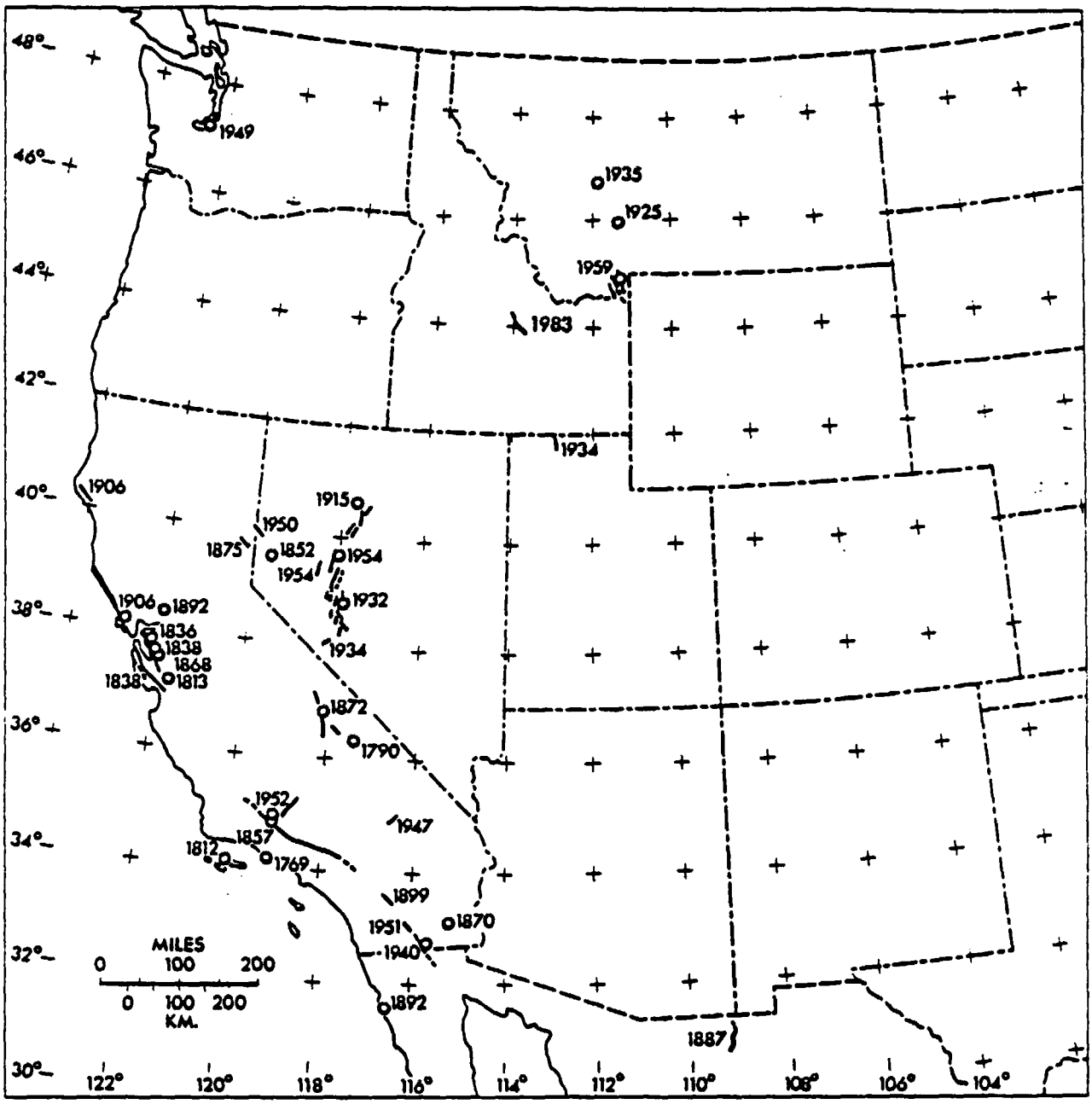
CROSS SECTION ACROSS MIDWAY VALLEY



(FROM SCOTT AND BONK, 1984)

NWSGEO5P.A27/4-12-90

HISTORIC FAULTING IN THE WESTERN U.S.

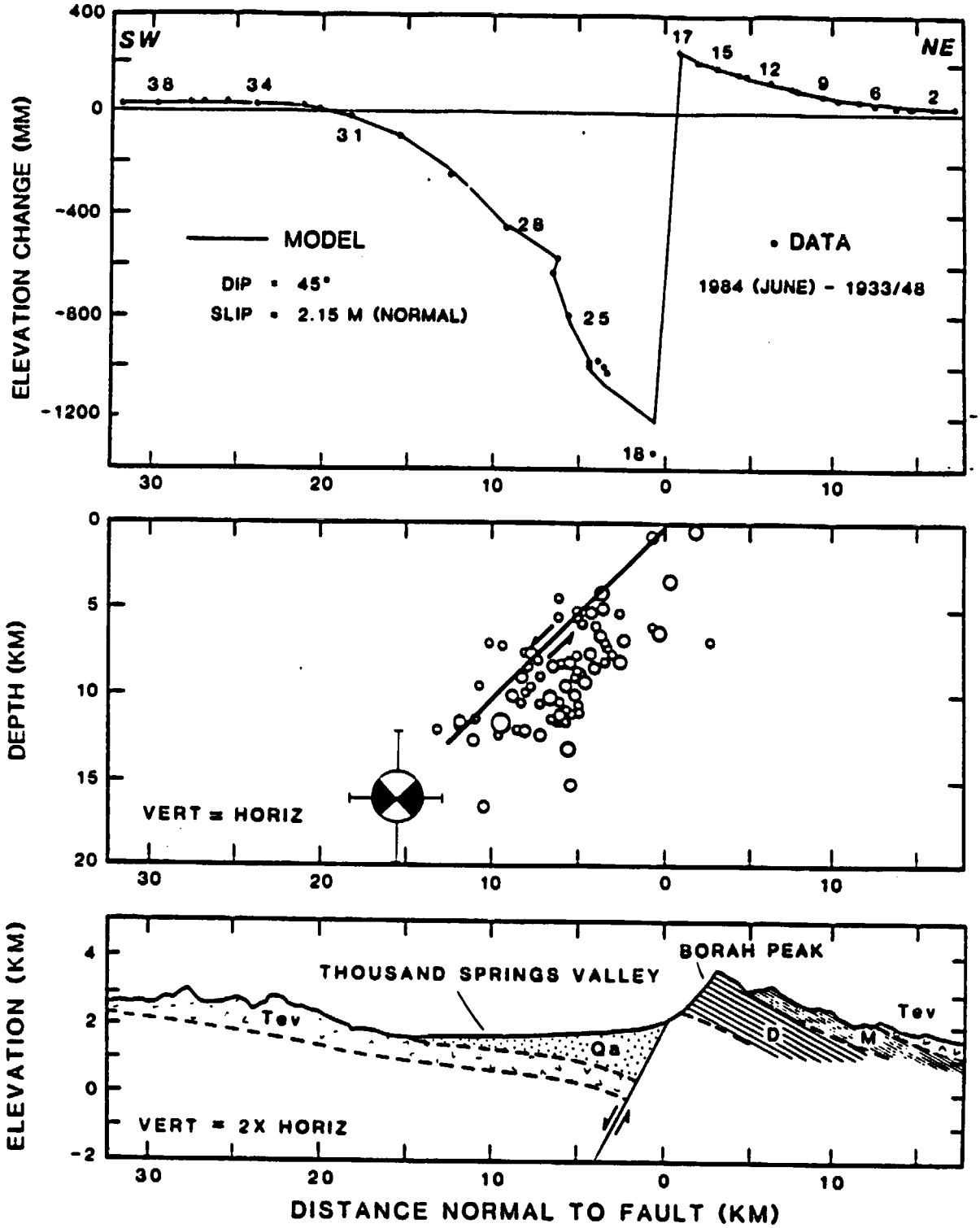


(FROM THOMPSON, 1985)

o SIGNIFICANT EARTHQUAKE

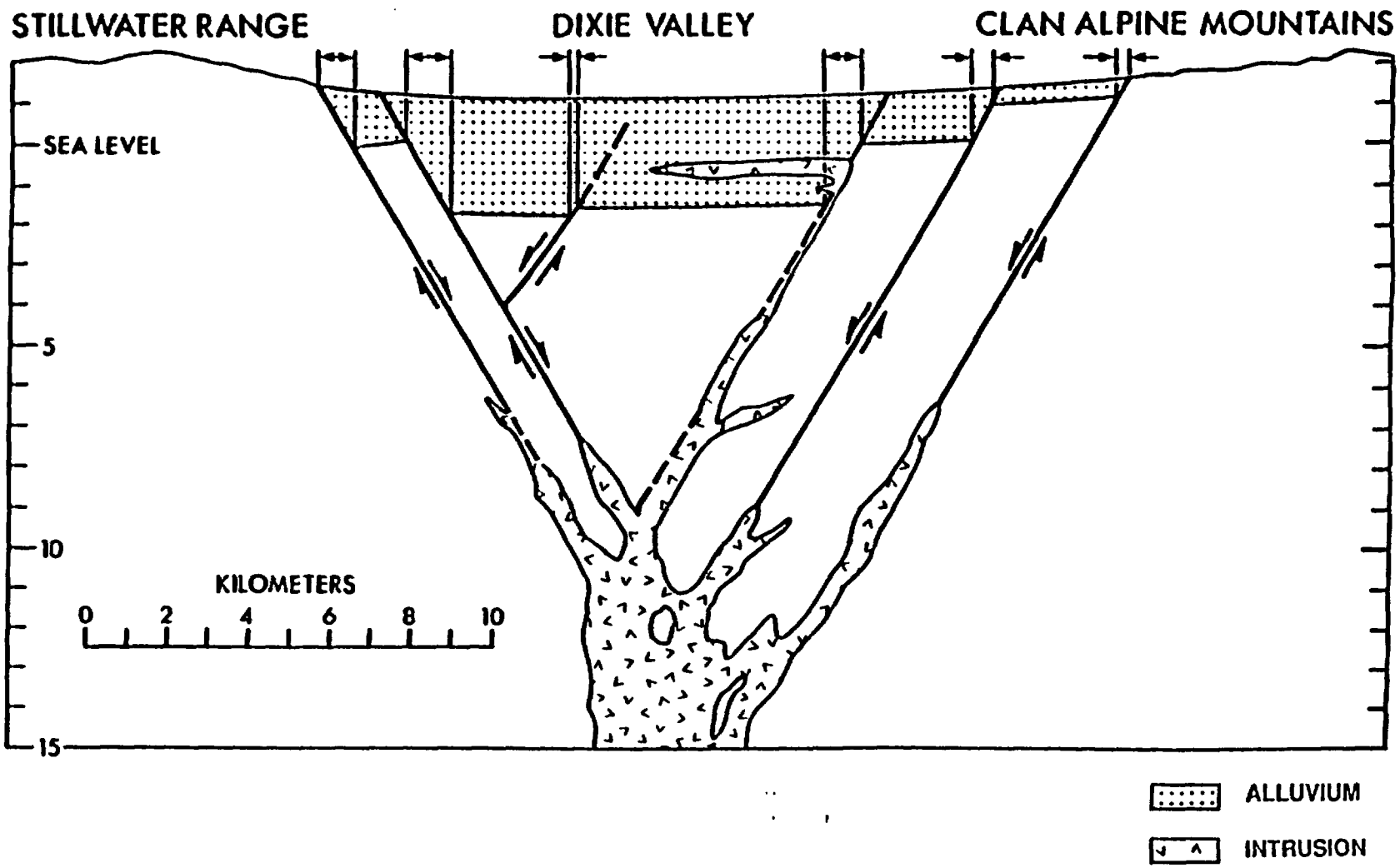
SIGNIFICANT SURFACE FAULTING ASSOCIATED WITH THE EARTHQUAKE

GEODETIC AND AFTERSHOCK DATA FROM THE BORAH PEAK EARTHQUAKE



(FROM STEIN AND BARRIENTOS, 1985)

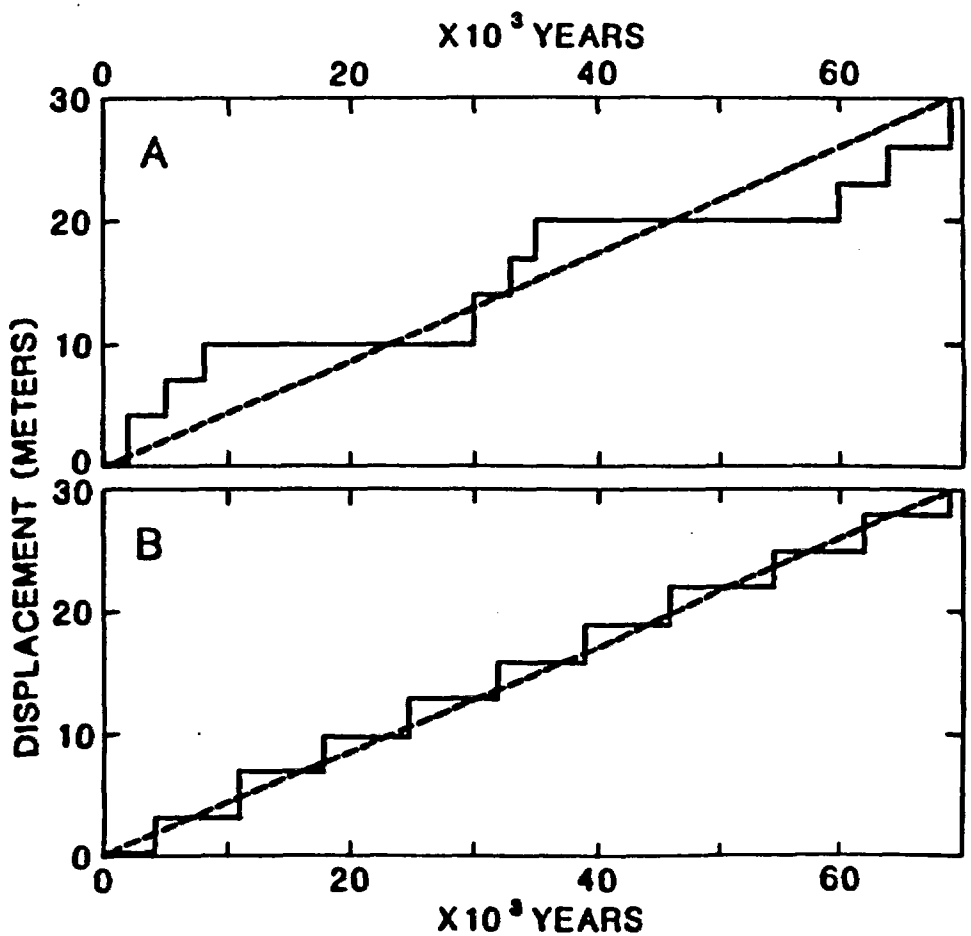
HYPOTHETICAL CROSS SECTION ACROSS DIXIE VALLEY



(FROM THOMPSON, 1985)

NWSGEO5P.A27/4-12-90

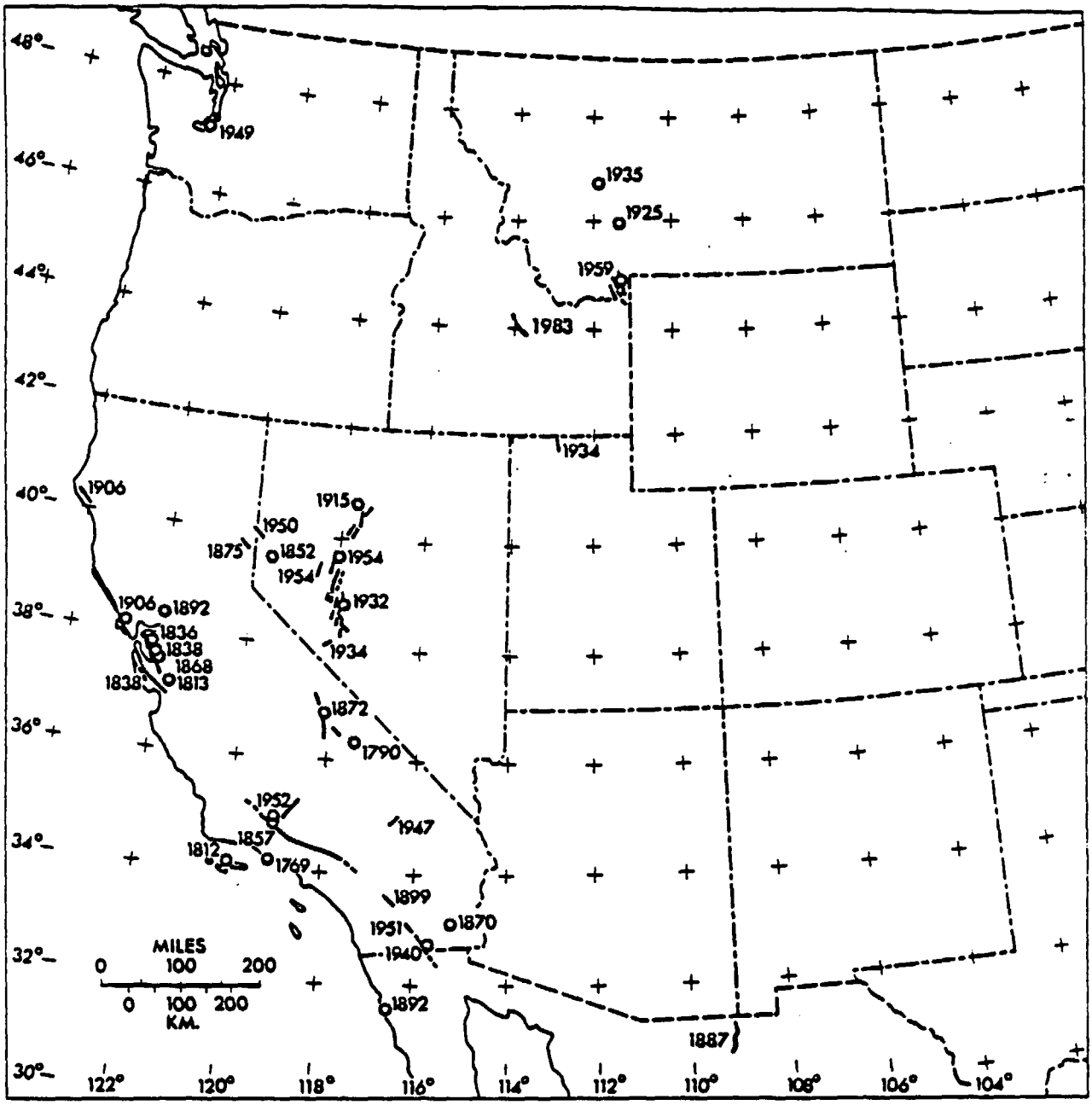
DIAGRAMMATIC FAULT-DISPLACEMENT TIME HISTORIES FOR GREAT BASIN PROVINCE



(FROM WALLACE, 1985)

NWSGEO5P.A27/4-12-90

HISTORIC FAULTING IN THE WESTERN U.S.

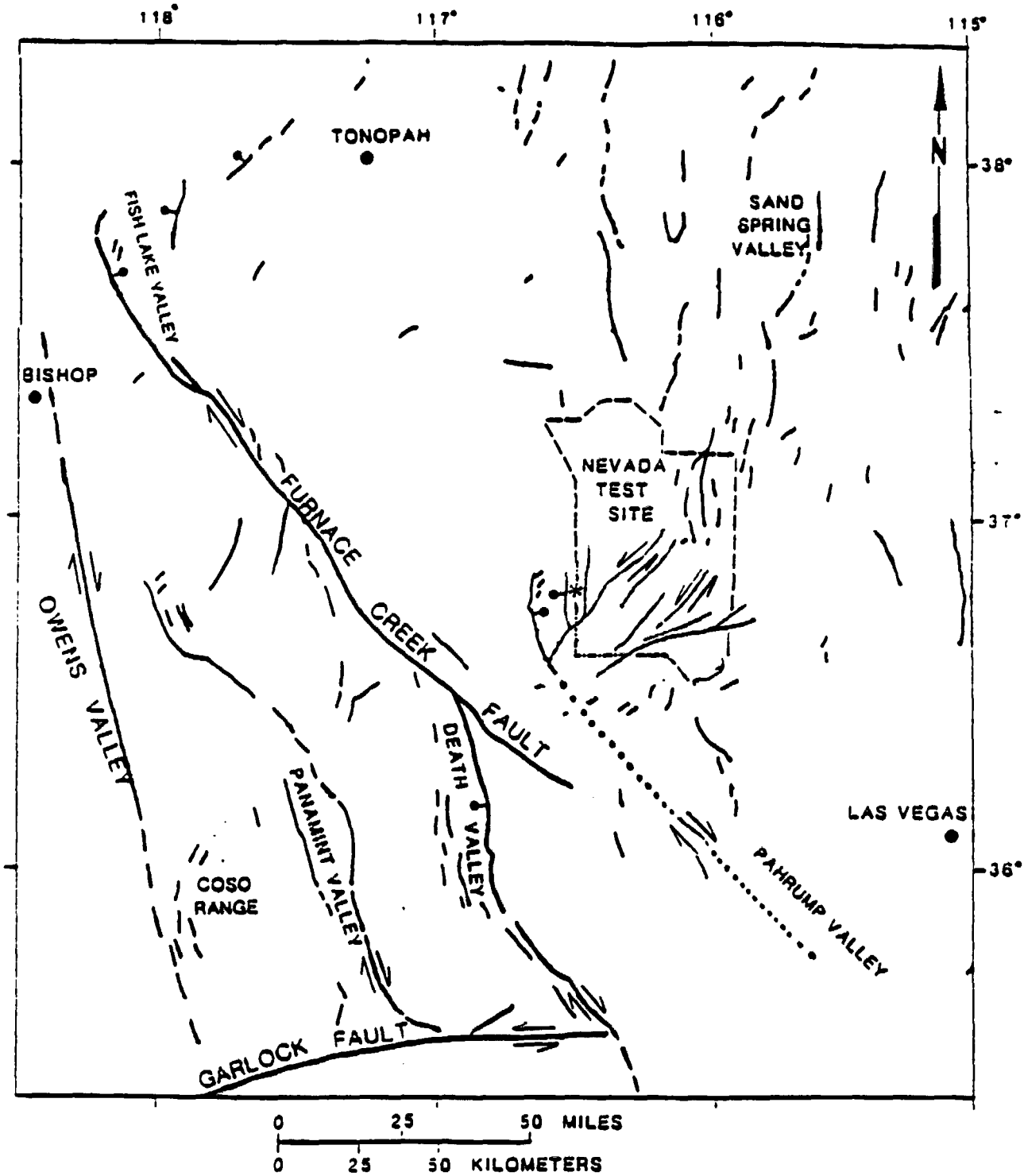


(FROM THOMPSON, 1985)

o SIGNIFICANT EARTHQUAKE

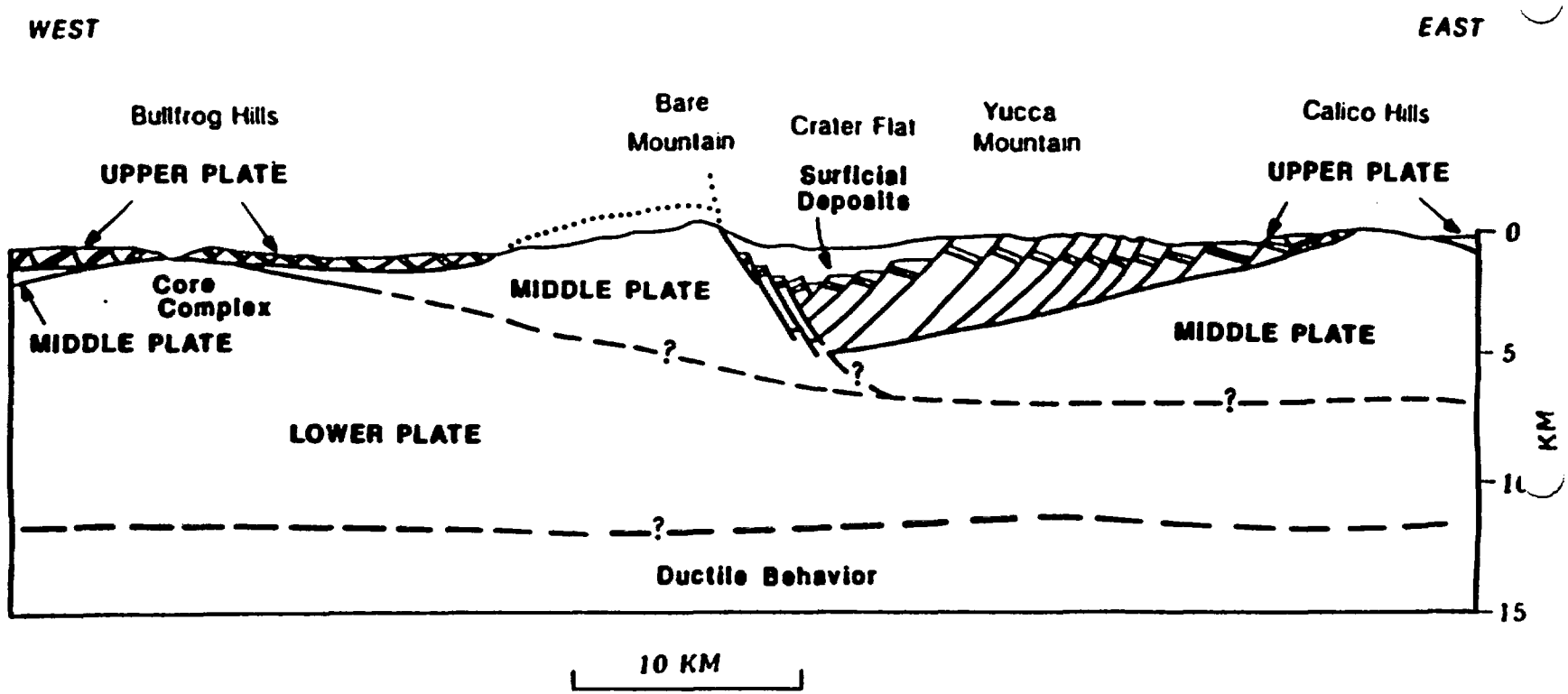
— SIGNIFICANT SURFACE FAULTING ASSOCIATED WITH THE EARTHQUAKE

A HYPOTHETICAL STRIKE-SLIP MODEL FOR THE REGION



* LOCATION OF REPOSITORY

A DETACHMENT FAULT MODEL FOR THE AREA



(FROM R.B. SCOTT)

NWSGEO5P.A27/4-12-90

APPLICATION OF TECTONIC MODELS TO SITE CHARACTERIZATION

SURFACE FAULT RUPTURE	NEED FOR SITE STUDIES (TRENCHING AND RELATED STUDIES). TECTONIC OR FAULTING MODELS DO NOT INFLUENCE CHARACTERIZATION METHOD (EXCEPT FOR NEED TO RECOGNIZE POSSIBILITY OF STRIKE-SLIP FAULTING)
GROUND-MOTION EVALUATION	RANGE OF MODELS INDICATES NEED FOR: - DATA ON DOWN-DIP GEOMETRY OF FAULTS IN YUCCA MOUNTAIN-CRATER FLAT AREA - DATA ON LENGTH AND INTERCONNECTIONS OF SIGNIFICANT FAULTS - ADDITIONAL DATA ON SLIP RATE, RECURRENCE INTERVAL, INCREMENTAL DISPLACEMENT, AND EVENT TIMING ON NORTH-TRENDING FAULTS. SLIP NEEDS TO BE DETERMINED FOR BOTH STRIKE-SLIP AND DIP-SLIP COMPONENTS

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

PRESENTATION TO THE NUCLEAR WASTE TECHNICAL REVIEW BOARD

SUBJECT: SUMMARY OF SEISMIC DESIGN COST-BENEFIT ASSESSMENT

PRESENTER: ASADOUR H. HADJIAN

PRESENTER'S TITLE AND ORGANIZATION: BECHTEL FELLOW AND PRINCIPAL ENGINEER
BECHTEL CORPORATION

PRESENTER'S TELEPHONE NUMBER: (213) 801-2454

APRIL 12, 1990

ENCLOSURE 3a

SANDIA REPORT

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Yucca Mountain Project

Preliminary Seismic Design Cost-Benefit Assessment of the Tuff Repository Waste-Handling Facilities

C. V. Subramanian, N. Abrahamson, A. H. Hadjian, L. J. Jardine,
J. B. Kemp, O. K. Kiciman, C. W. Ma, J. King, W. Andrews,
R. P. Kennedy

Prepared by
Sandia National Laboratories
Albuquerque, New Mexico 87185 and Livermore, California 94550
for the United States Department of Energy
under Contract DE-AC04-76DP00789

PRELIMINARY SEISMIC DESIGN COST-BENEFIT ASSESSMENT OF THE TUFF REPOSITORY WASTE-HANDLING FACILITIES

by

C. V. Subramanian
Sandia National Laboratories

N. Abrahamson, A. H. Hadjian, L. J. Jardin
J. B. Kemp, O. K. Kiciman, and C. W. Ma
Bechtel National, Inc.

J. King, W. Andrews
Science Applications International Corporation

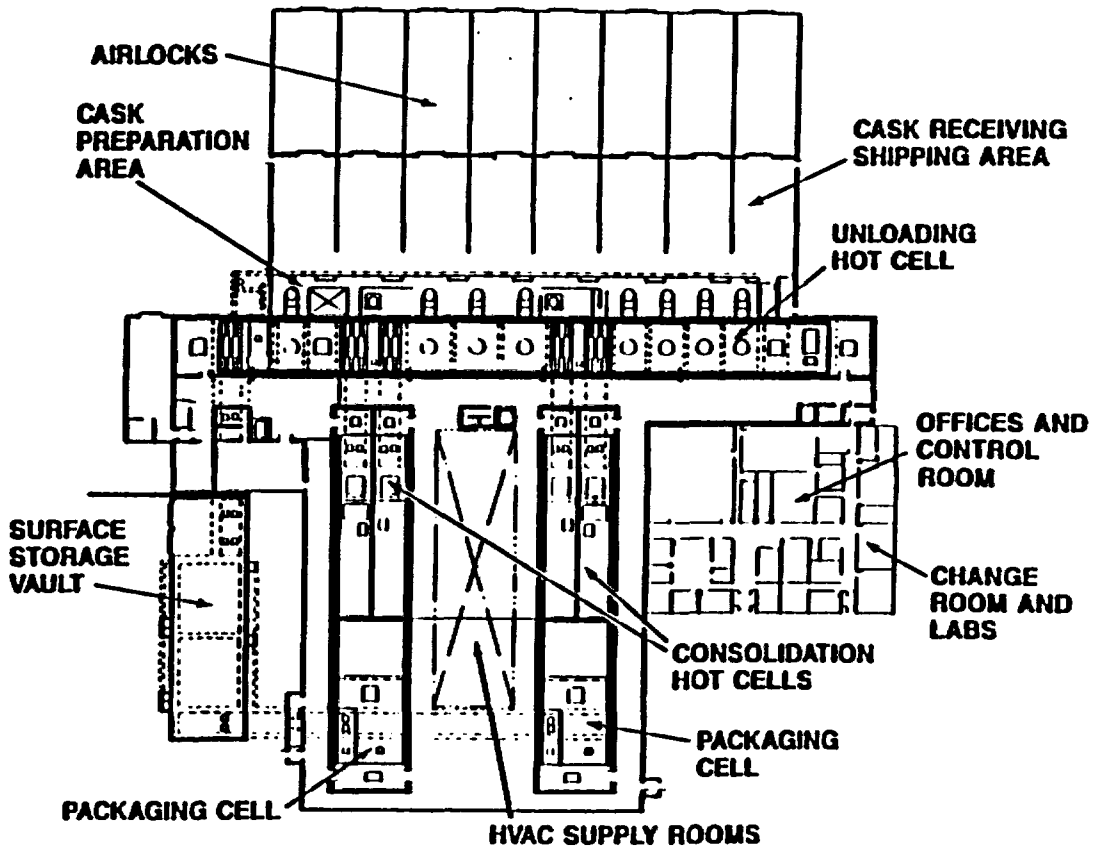
and

R. P. Kennedy
Structural Mechanics Consulting, Inc.

COORDINATION WORKSHOPS

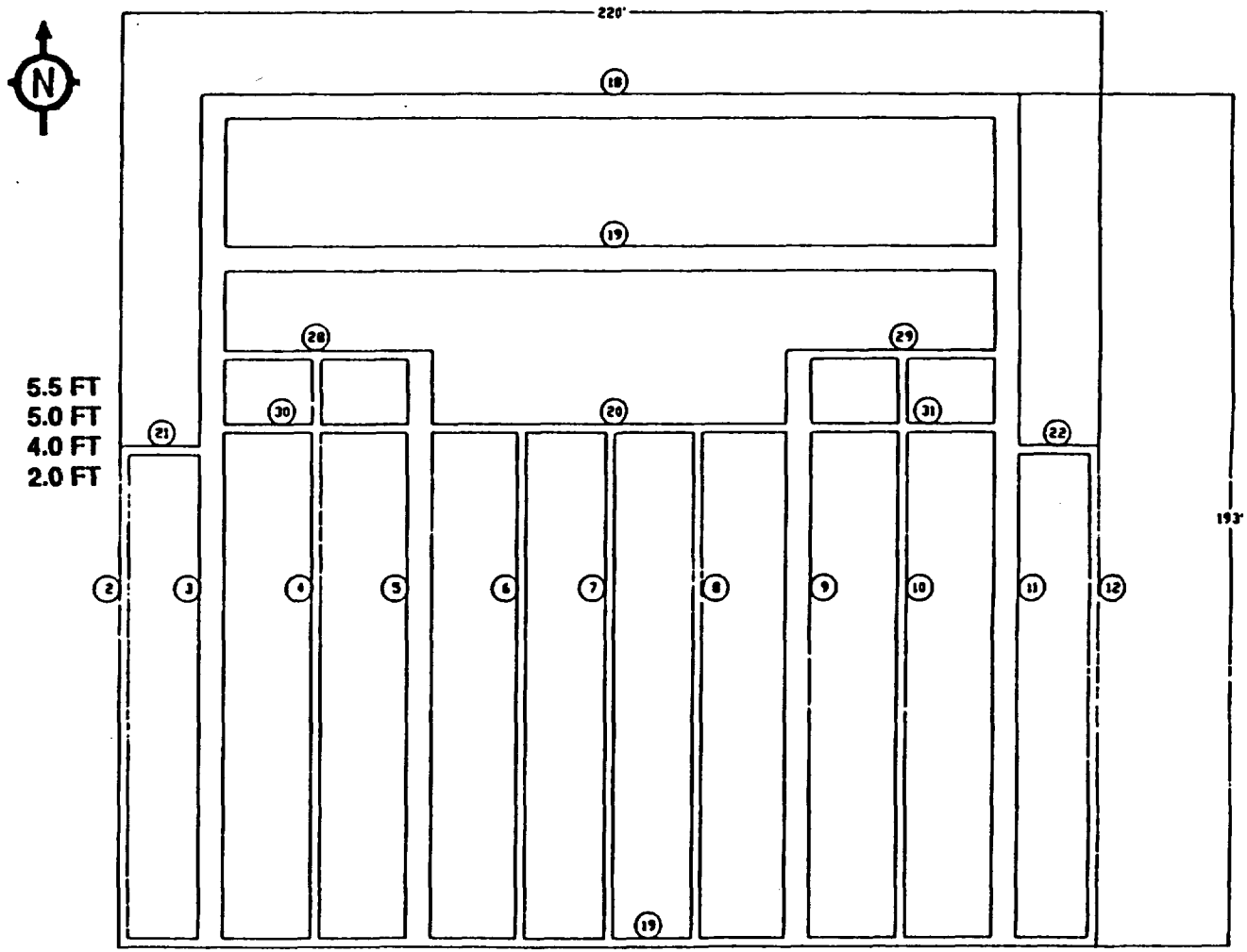
APRIL 4-5, 1988	LAS VEGAS, NEVADA
APRIL 26-27, 1988	NORWALK, CALIFORNIA
MAY 17-18, 1988	SAN FRANCISCO, CALIFORNIA

WHB-2: SCP-CDR CONFIGURATION



SHEAR WALLS OF THE CENTRAL MODULE OF THE WHB-2 AT THE THIRD-FLOOR LEVEL (ELEVATION 18 TO 40 FT)

SHIELDING WALL/CEILING	5.5 FT
BASEMENT	5.0 FT
TRANSFER TUNNEL WALLS	4.0 FT
ALL OTHER WALLS/FLOORS	2.0 FT



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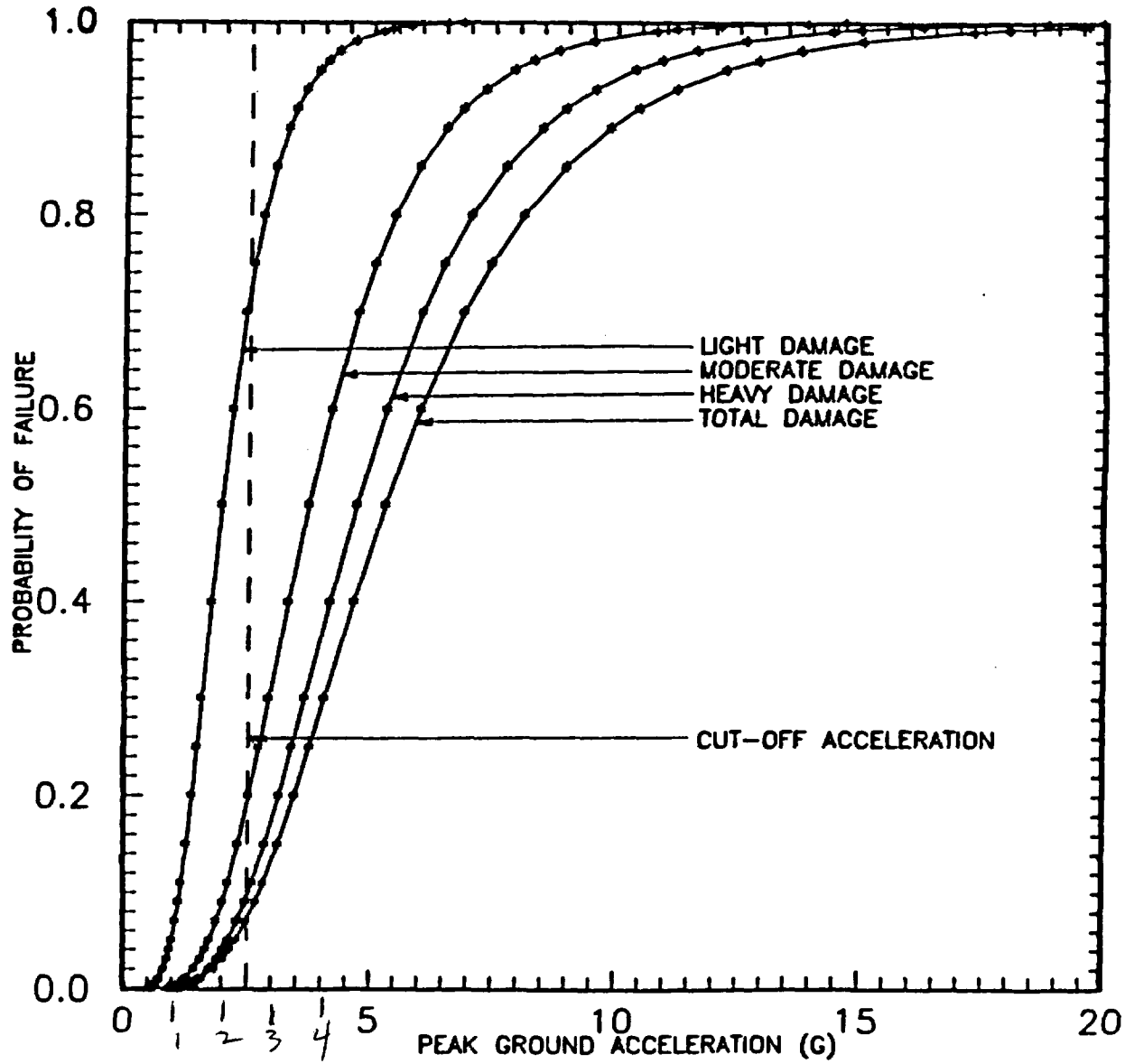
QUANTITATIVE DEFINITION OF SHEAR WALL DAMAGE

DAMAGE STATE	DRIFT (%)	CONCRETE PROJECTILES CREATED (in.)	NUMBER OF CONCRETE PIECES PER 1,000 FT²	DIAGONAL CRACKS		
				SPACING (ft)	LENGTH	WIDTH (in.)
LIGHT	0.1-0.2	NONE	0	3	FULL	0.02
MODERATE	0.4	6x6x3	3	3	FULL	0.05
HEAVY	0.7	6x6x6	30	3	FULL	0.12
TOTAL	1.5	6x6x6 24x24x3	60 20	3	FULL	0.24

FRAGILITY CURVES FOR THE AVERAGE WALL, 0.4g DESIGN



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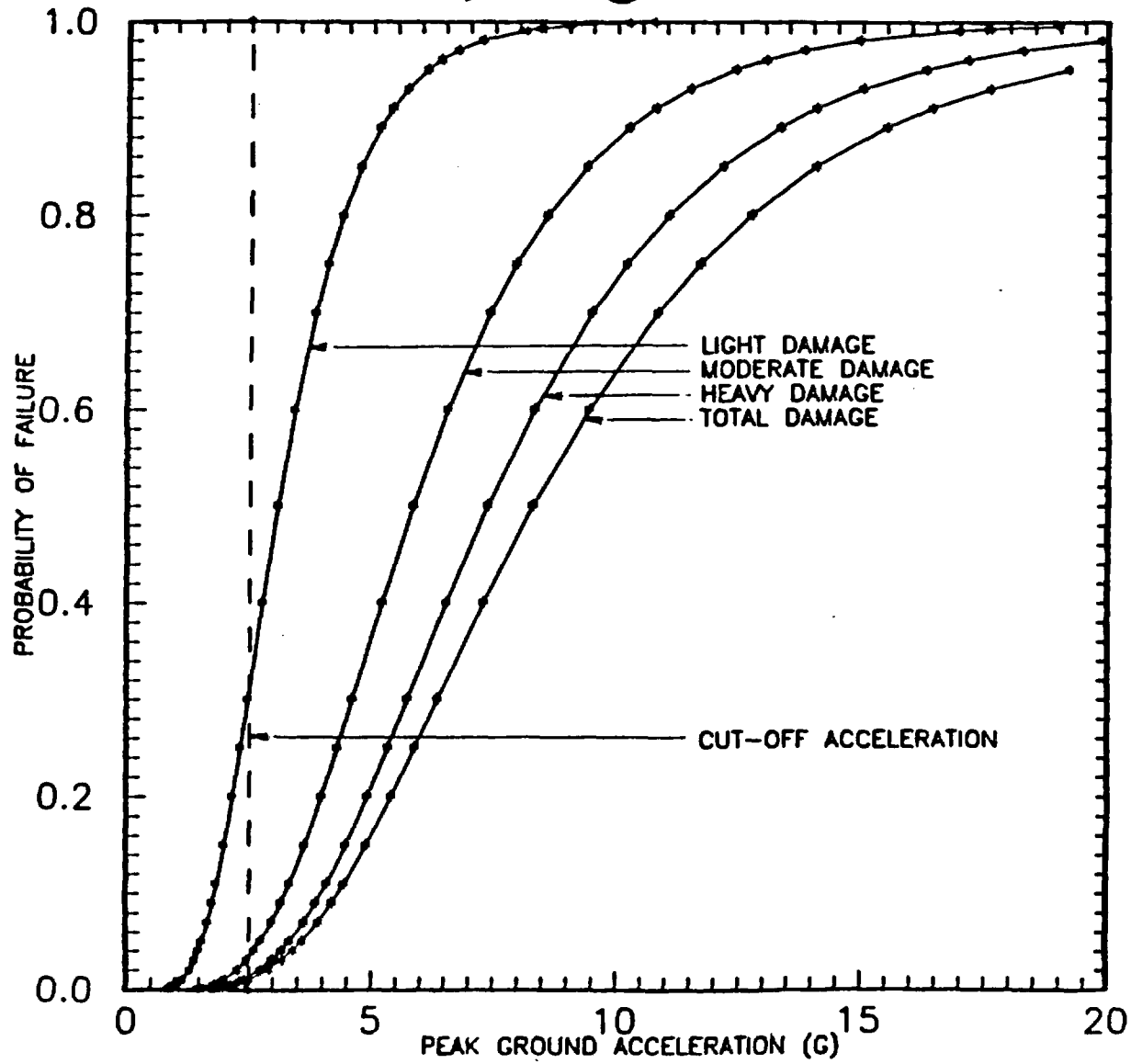
FRAGILITY CURVES FOR THE AVERAGE WALL, 1.0g DESIGN



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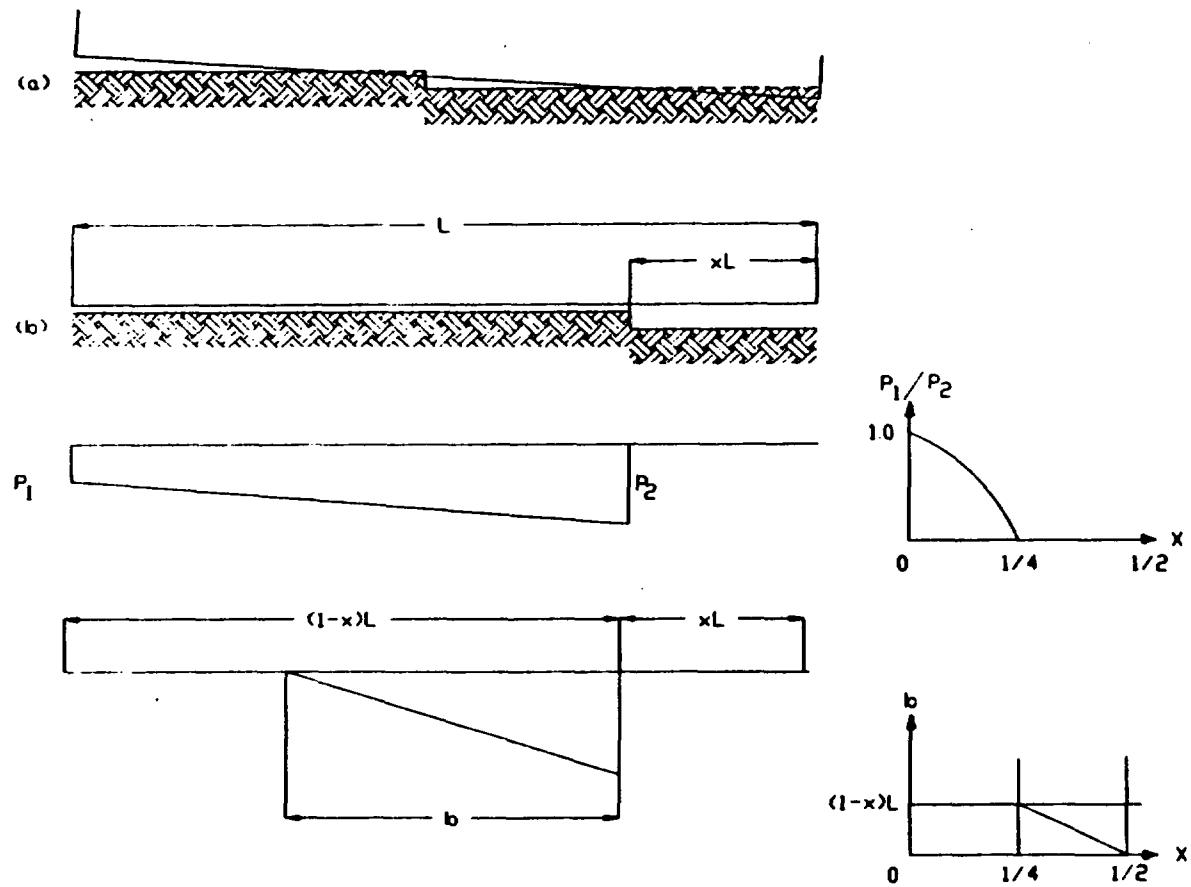
INHERENT RUGGEDNESS

PROBABILITY OF ACHIEVING DAMAGE STATE - AVERAGE WALL

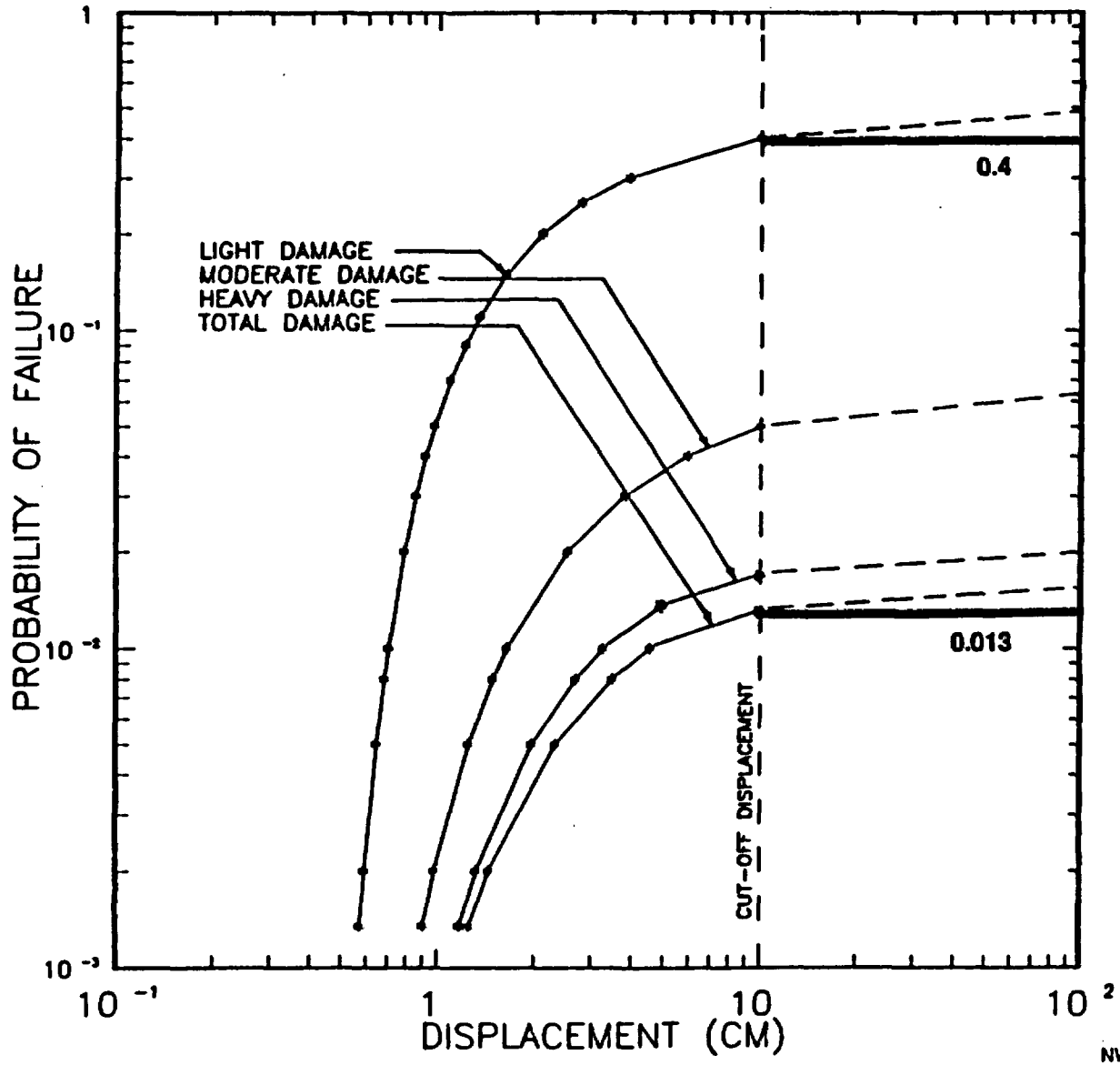
	0.8g EVENT ANNUAL PROBABILITY OF EXCEEDANCE ~ 3×10^{-5}		2.5g EVENT ANNUAL PROBABILITY OF EXCEEDANCE ~ 10^{-9}	
	DESIGN LEVEL		DESIGN LEVEL	
	0.4g	0.8g	0.4g	0.8g
LIGHT DAMAGE	0.017	0.002	0.75	0.46
TOTAL DAMAGE	0.001	0.0001	0.072	0.017

SPECTRUM OF FAULT DISPLACEMENT LOCATIONS:
(a) TILT OR (b) OVERHANG



P_1 and P_2 are subgrade reactions.

FAULT DISPLACEMENT FRAGILITY CURVES FOR THE TILTED BUILDING MODE, 0.4g DESIGN



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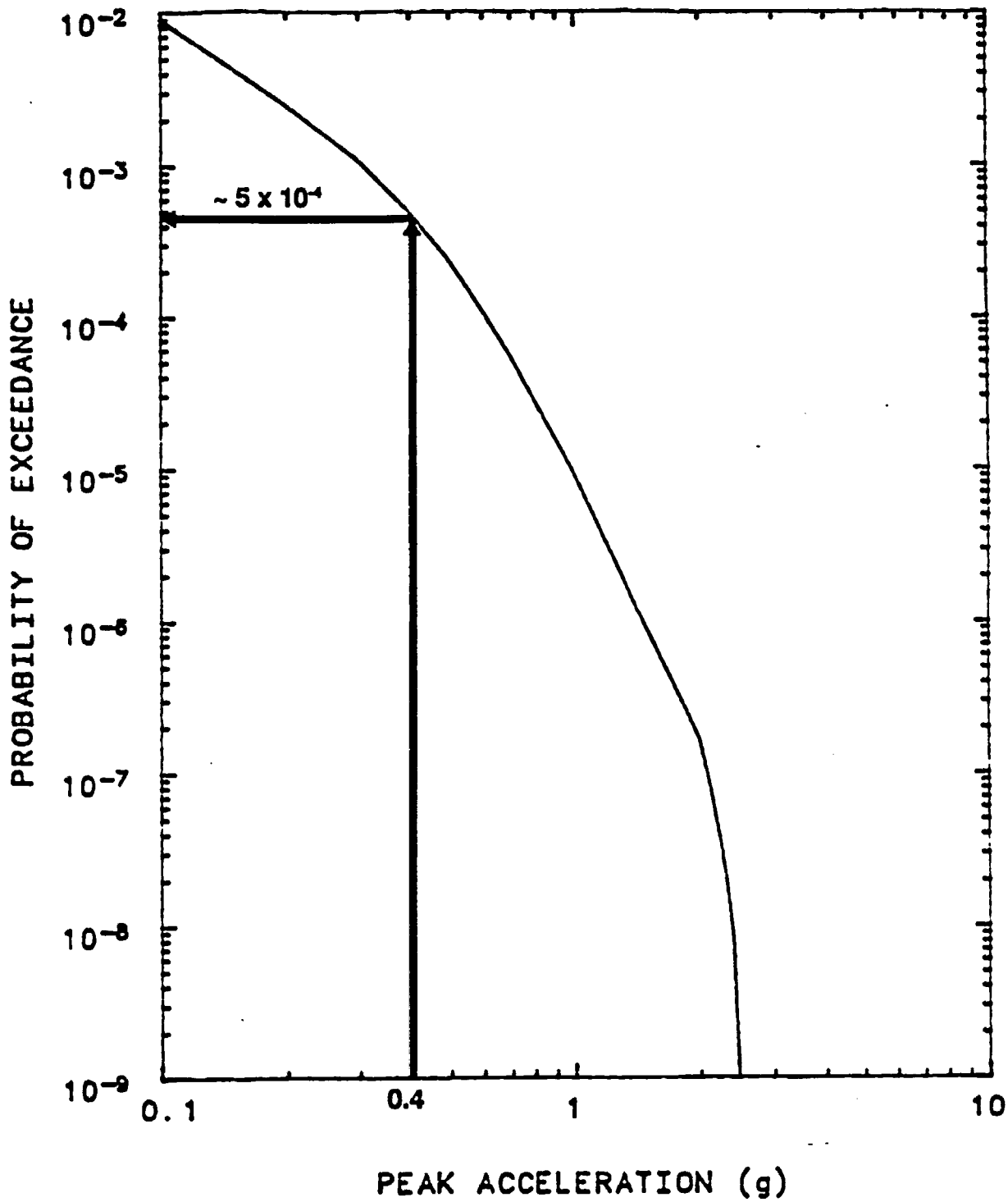
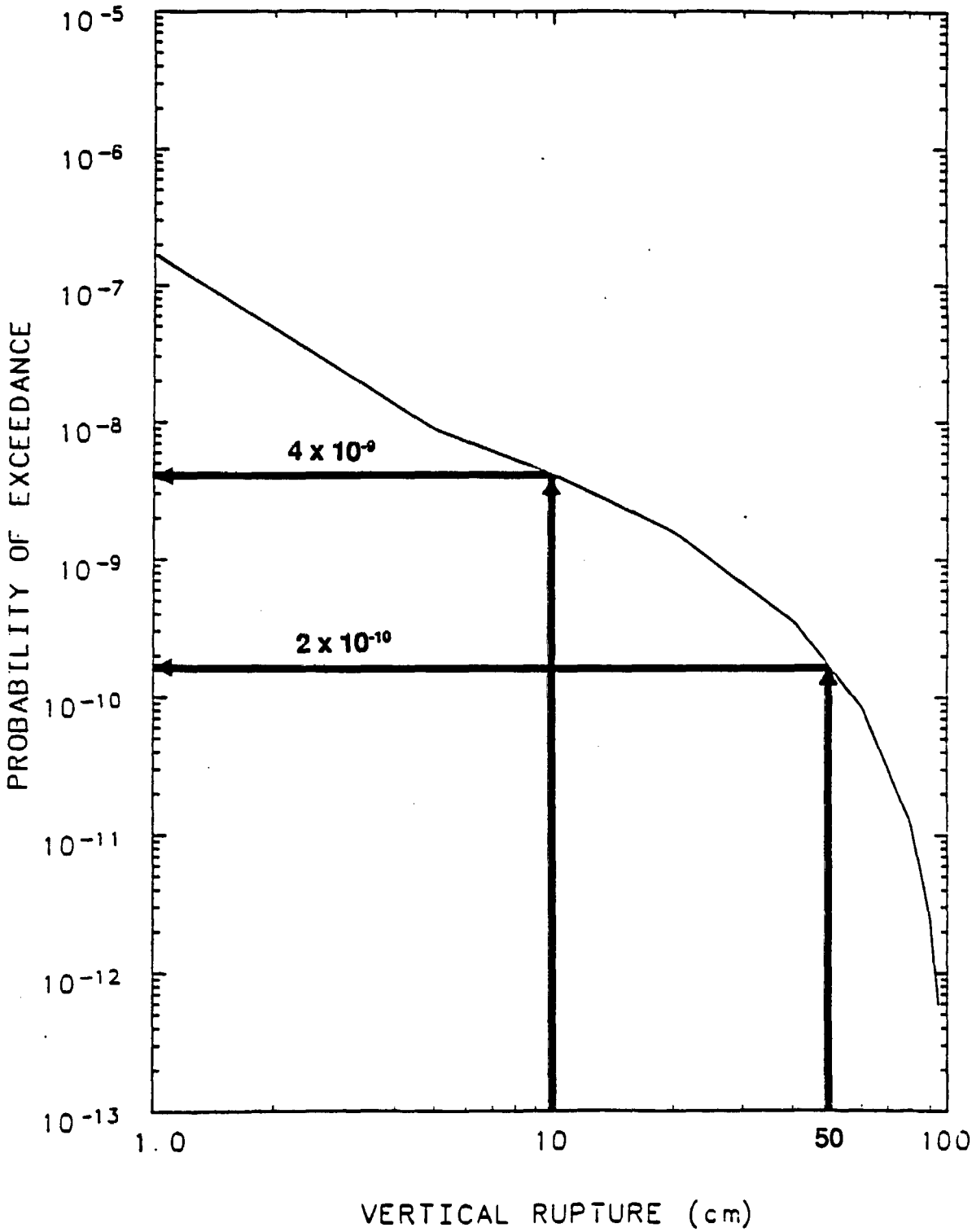
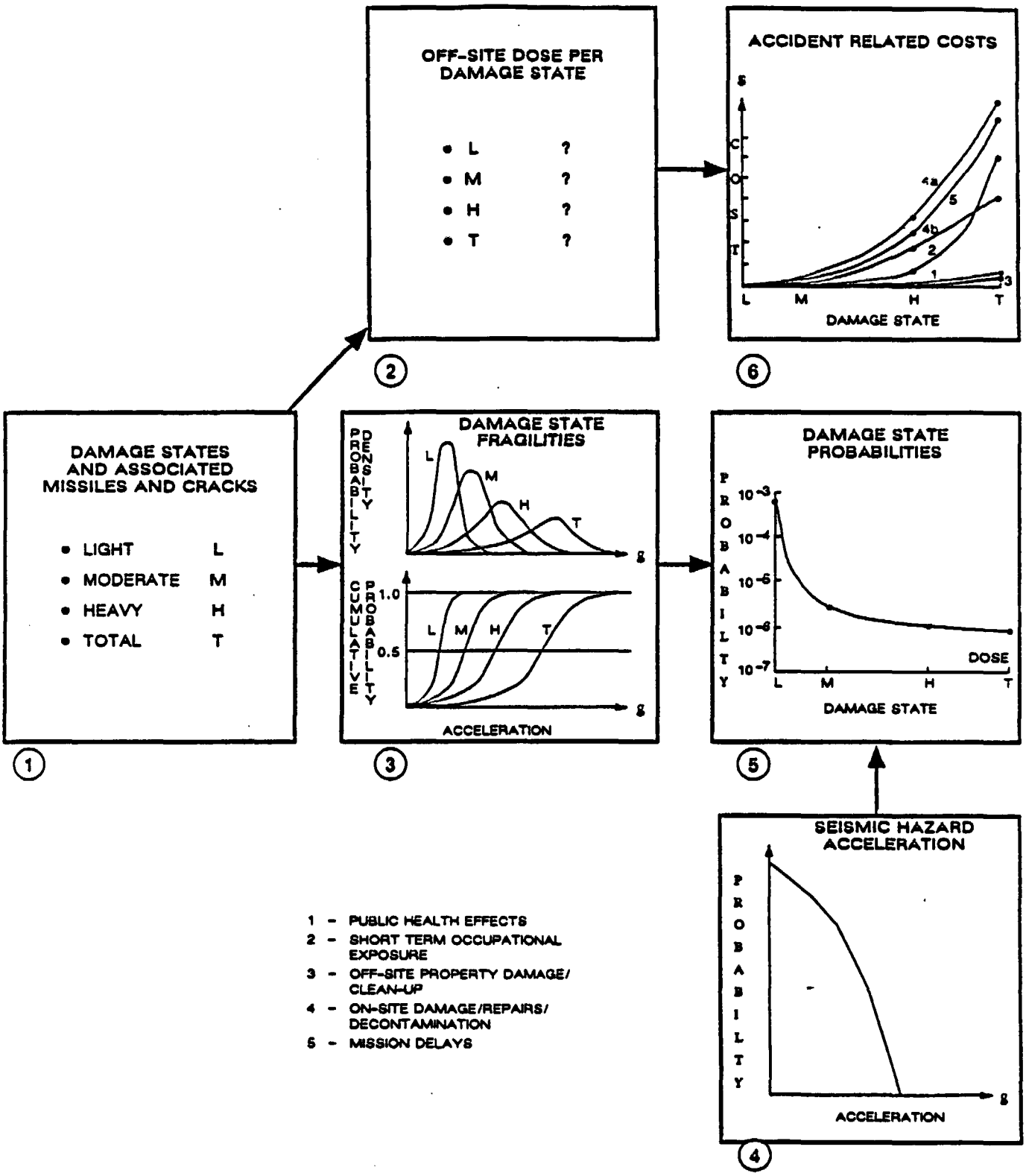
RECALCULATED HORIZONTAL GROUND ACCELERATION SEISMIC HAZARD CURVE FOR THE YUCCA MOUNTAIN SITE BASED ON URS/BLUME STANDARD OBLIQUE SEISMICITY MODEL AND THE CAMPBELL ATTENUATION MODEL



GROUND RUPTURE HAZARD CURVE FOR THE YUCCA MOUNTAIN SITE



FLOW CHART FOR CALCULATING DAMAGE STATES

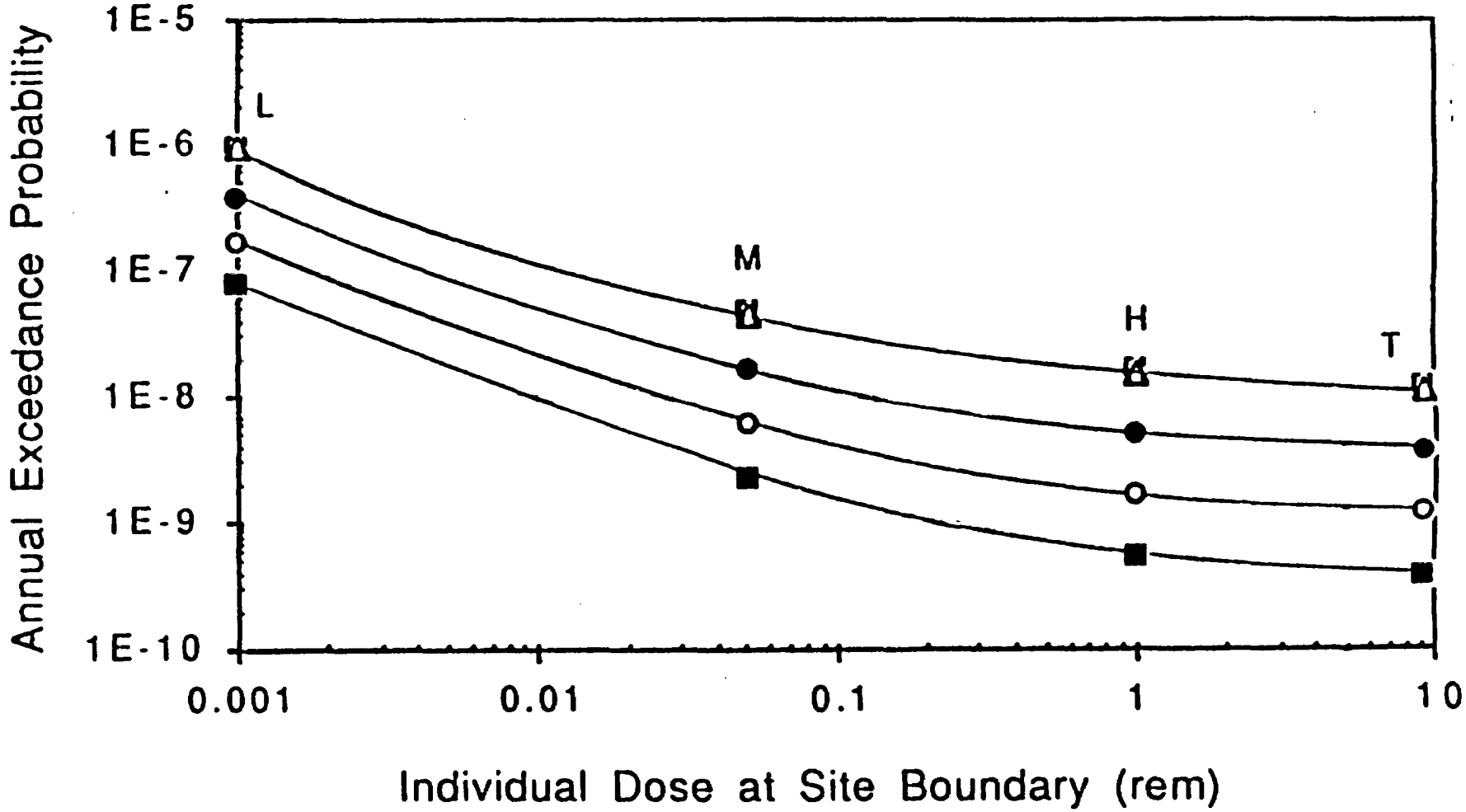


OFFSITE MAXIMUM INDIVIDUAL DOSE AND POPULATION DOSE

DAMAGE STATE	MAXIMUM(a) INDIVIDUAL DOSE(REM)	POPULATION(b) DOSE (MAN-REM)	PROBABILITY OF EXCEEDANCE OF DAMAGE STATES(c)
LIGHT	0	0	1.0×10^{-6}
MODERATE	5×10^{-2}	5×10^{1}	4.8×10^{-8}
HEAVY	1.0	1.0×10^{3}	1.6×10^{-8}
TOTAL	9	9×10^{3}	1.2×10^{-8}

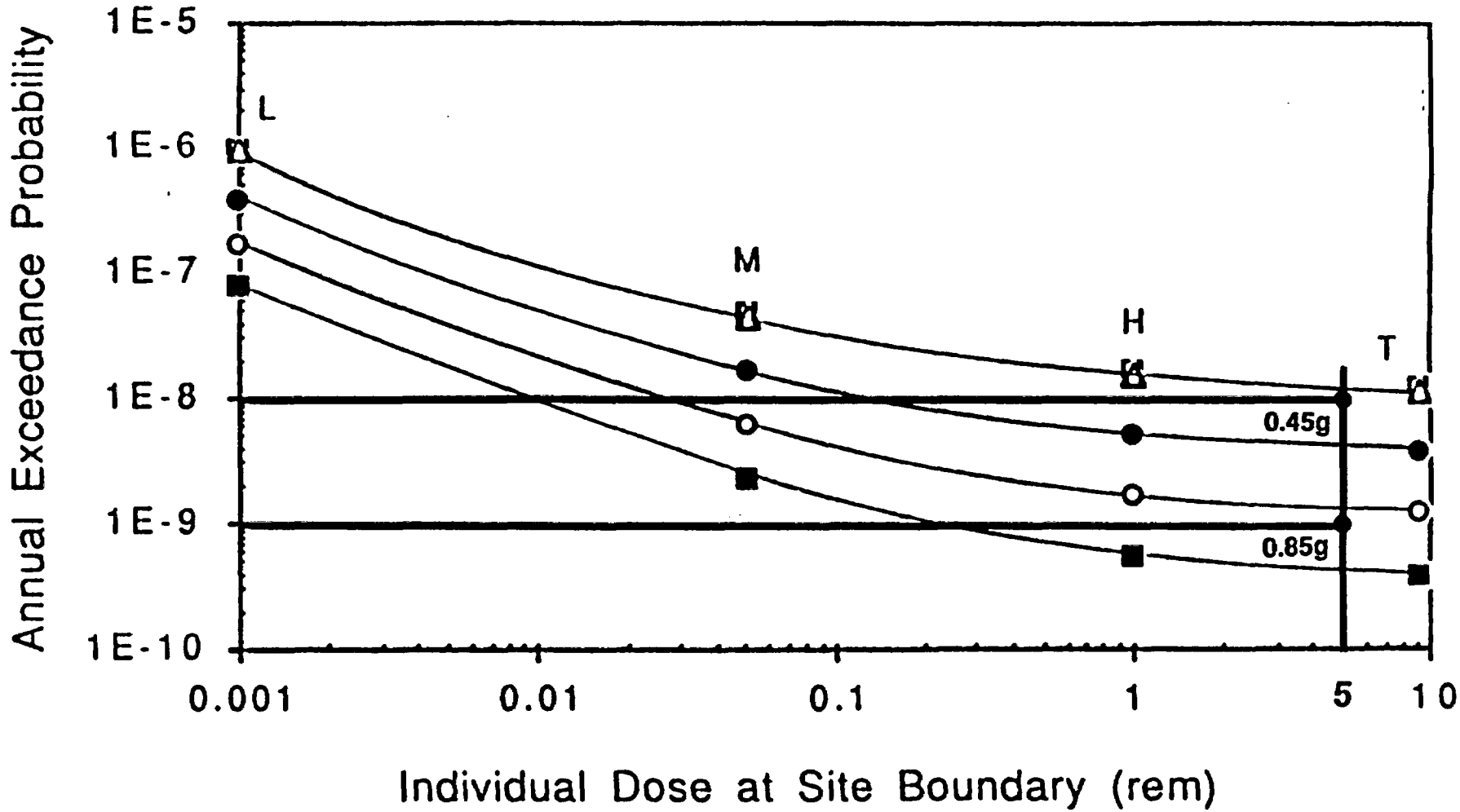
NOTES:
A. THE INDIVIDUAL IS ASSUMED TO BE AT THE SITE BOUNDARY, i.e., 5 km FROM THE REPOSITORY
B. AN EQUIVALENT POPULATION OF 1,000 PEOPLE IS ASSUMED TO BE AT THE SITE BOUNDARY
C. PROBABILITY OF EXCEEDANCE IS BASED ON 0.4g

PROBABILITY OF RELEASE FOR ALL DESIGNS



□ 0.2g Design Δ 0.4g Design ● 0.6g Design ○ 0.8g Design ■ 1.0g Design

PROBABILITY OF RELEASE FOR ALL DESIGNS



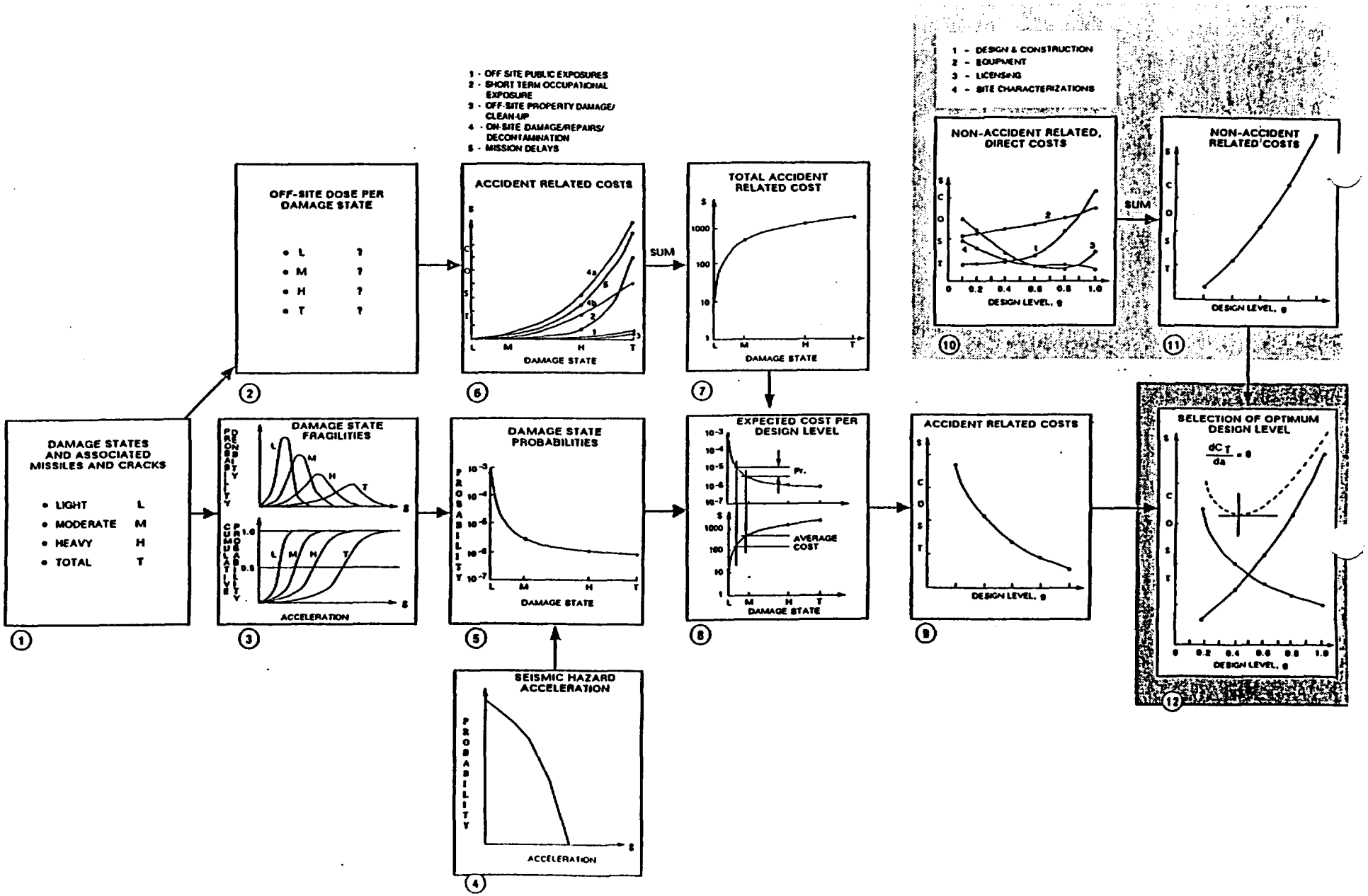
□ 0.2g Design Δ 0.4g Design ● 0.6g Design o 0.8g Design ■ 1.0g Design

WORKER DOSE FOR MODERATE, HEAVY, AND TOTAL STRUCTURAL DAMAGE OF THE UNLOADING HOT CELL

CASE	DOSE PER WORKER, REM		TOTAL OCCUPATIONAL EXPOSURE (MAN-REM)(c)	PROBABILITY OF EXCEEDANCE(d)
	WHB-2(a)	ADMINISTRATION(b)		
LIGHT	-	-	-	1×10^{-6}
MODERATE	9.1	3.6	4.5×10^{2}	4.8×10^{-8}
HEAVY	3.5×10^{2}	1.4×10^{2}	1.8×10^{4}	1.6×10^{-8}
TOTAL	7.7×10^{3}	3.1×10^{3}	3.8×10^{5}	1.2×10^{-8}

A. EXPOSURE FOR 10 MINUTES, ADJACENT ROOM 300' x 29' x 40', INSTANTANEOUS MIXING
B. EXPOSURE FOR 30 MINUTES, GROUND RELEASE, WIND SPEED OF 3 M/SSEC, DISTANCE OF 100 M, 50 YEAR COMMITMENT AND INHALATION DOSE
C. TOTAL DOSE RECEIVED BY 10 WORKERS IN WHB-2 AND 100 WORKERS IN ADMINISTRATION BUILDING
D. PROBABILITY OF EXCEEDANCE IS BASED ON 0.4g

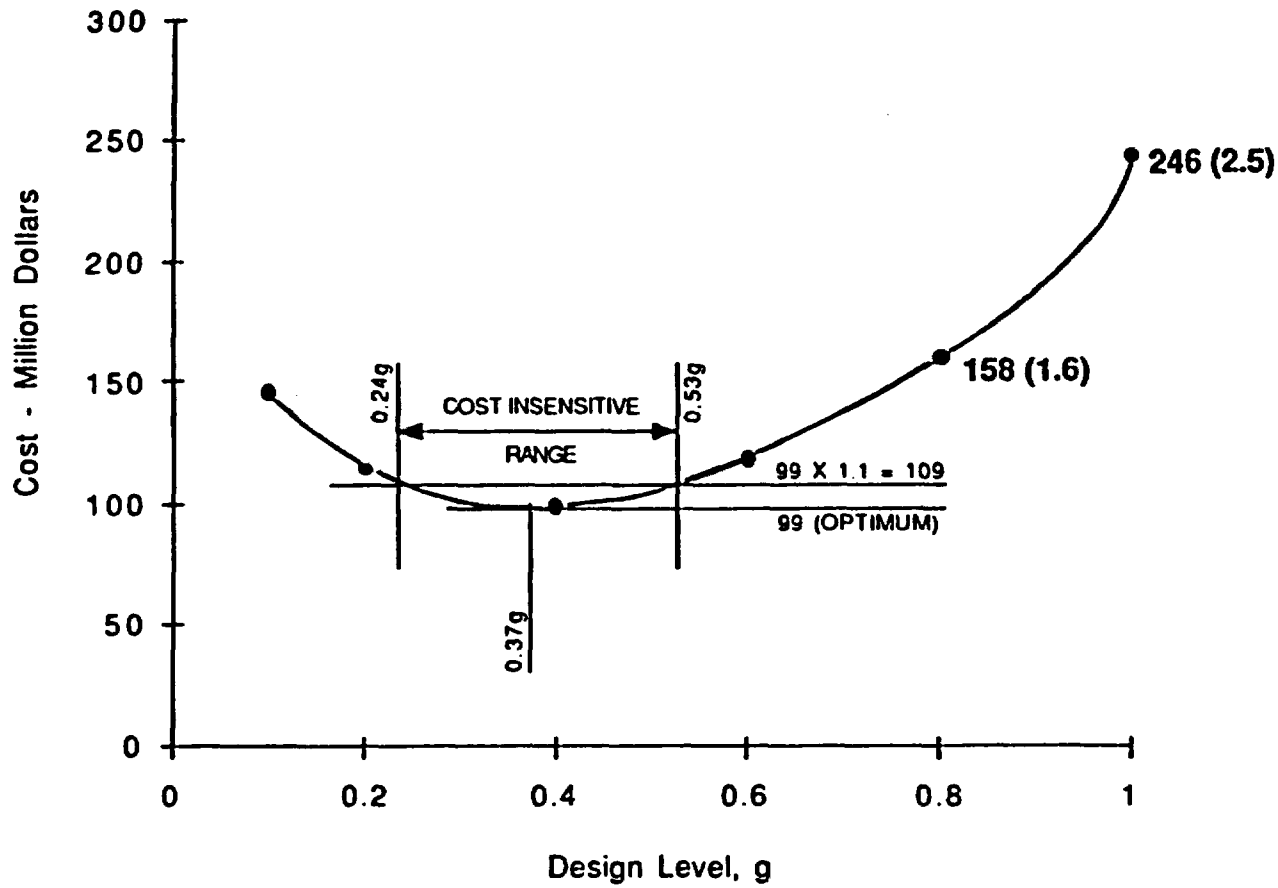
STEPS TO OBTAINING THE OPTIMUM DESIGN LEVEL



COST-BENEFIT STUDY METHODOLOGY

- TWO MAJOR ELEMENTS OF COSTS ARE:
  - ACCIDENT RELATED
  - NON-ACCIDENT RELATED
- ATTRIBUTES CONSIDERED FOR NON-ACCIDENT RELATED COSTS
  - SITE CHARACTERIZATION
  - DESIGN
  - CONSTRUCTION
  - MAINTENANCE
  - LICENSING
  - DELAYS (POLITICAL) } NOT QUANTIFIED
  - PRECEDENCE } NOT QUANTIFIED
- ESTIMATION IS DIRECT AND HENCE RELATIVELY SIMPLE

TOTAL NONACCIDENT-RELATED COSTS AS A FUNCTION OF DESIGN ACCELERATION



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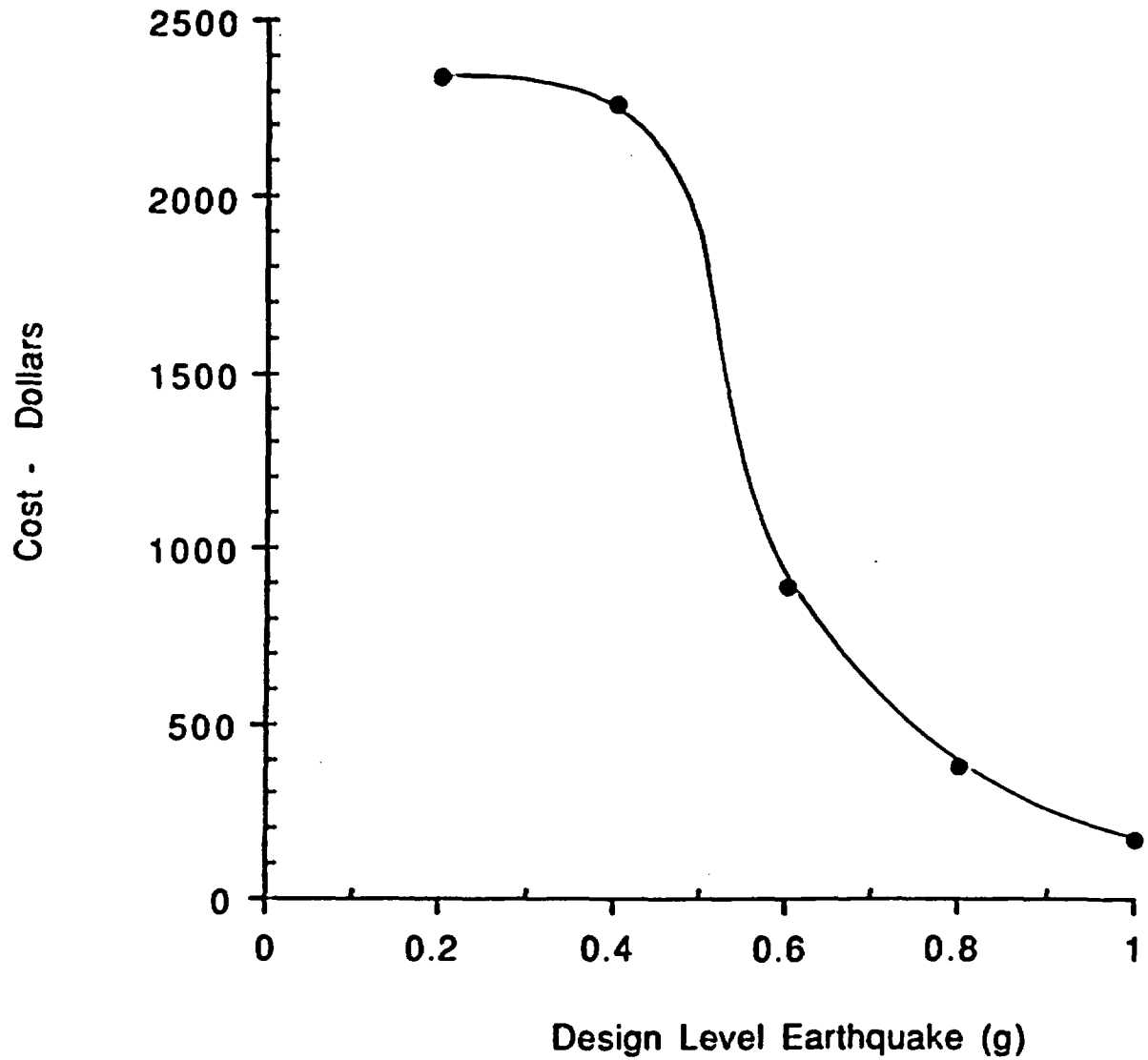
COST-BENEFIT STUDY METHODOLOGY

(CONTINUED)

- ACCIDENT RELATED COSTS
  - ASSOCIATED WITH PROBABILITIES OF EARTHQUAKE OCCURRENCES AND SYSTEM, STRUCTURE AND COMPONENT FAILURES
  - ATTRIBUTES CONSIDERED ARE
    - * PUBLIC HEALTH EFFECTS
    - * OCCUPATIONAL EXPOSURE
    - * OFF-SITE PROPERTY DAMAGE
    - * ON-SITE DAMAGE
    - * MISSION DELAYS
  - MORE DIFFICULT TO QUANTIFY
  - ANNUALIZED COSTS
  - HAVE LARGE BAND OF UNCERTAINTY

PROBABLE COST OF ACCIDENT AS A FUNCTION OF THE SEISMIC DESIGN LEVEL



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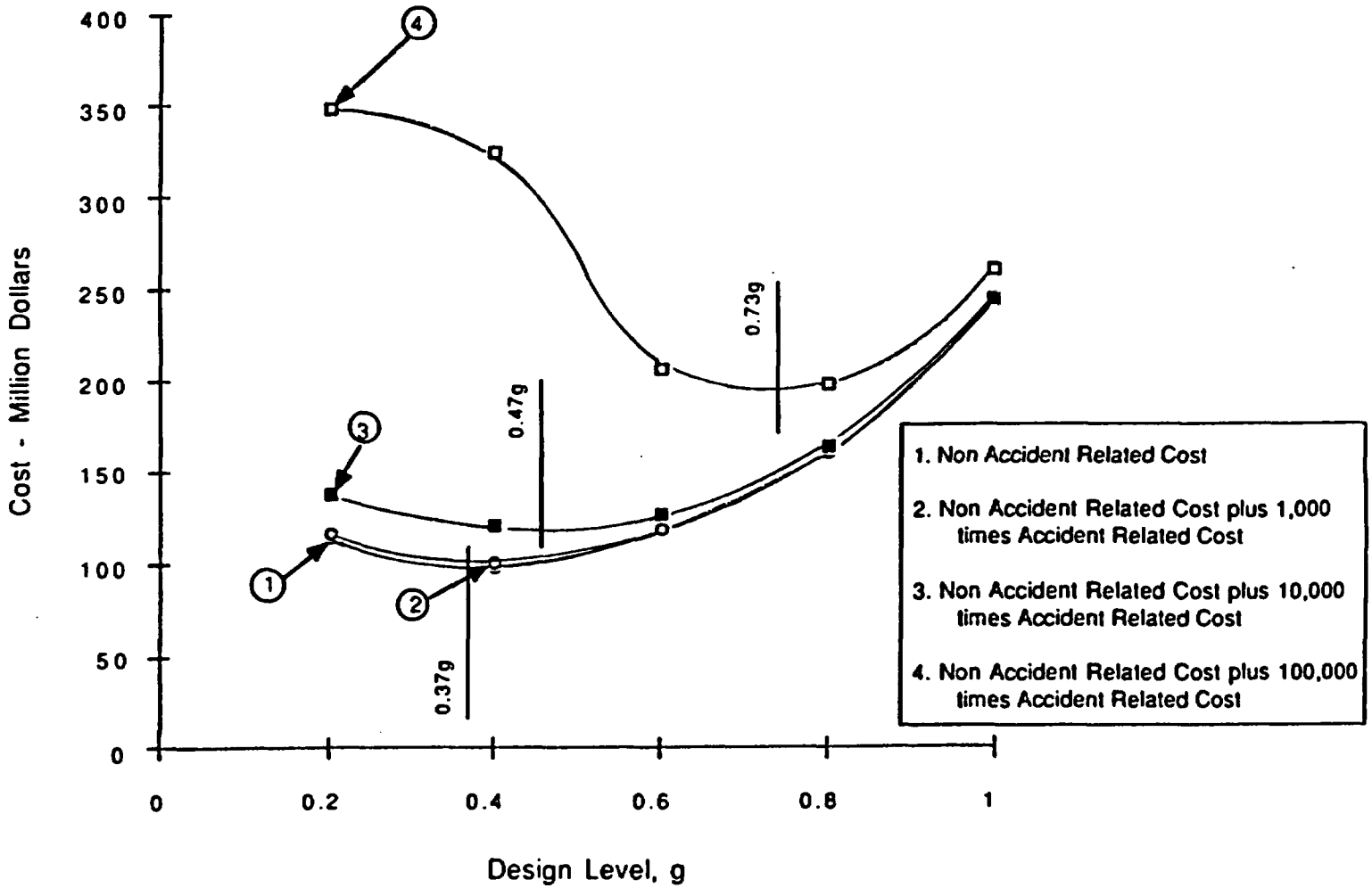
SENSITIVITY EVALUATION OF ACCIDENT-RELATED COSTS



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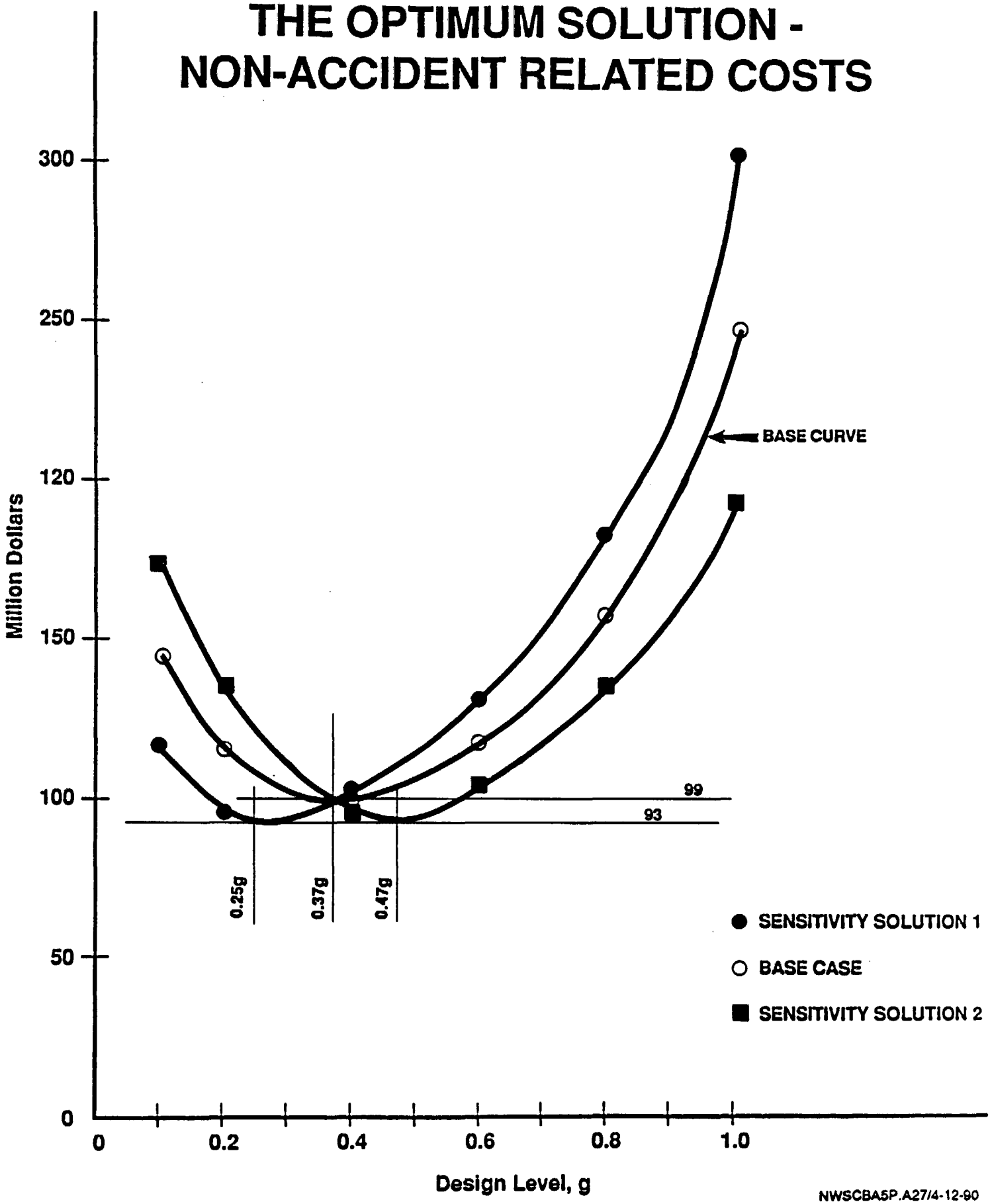
SENSITIVITY EVALUATION OF THE OPTIMUM SOLUTION - NON-ACCIDENT RELATED COSTS



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HIGH CONFIDENCE (95% NON-EXCEEDANCE PROBABILITY) ADJUSTMENT FACTORS BASED ON PRIOR EXPERIENCE AND JUDGEMENT

MEAN ANNUAL PROBABILITY ESTIMATES FOR	FACTOR
EXCEEDING A GROUND MOTION ABOVE 1.0g	5-10
REACHING DAMAGE STATES	10-20
ACCIDENT RELATED DOSE CONSEQUENCES	100

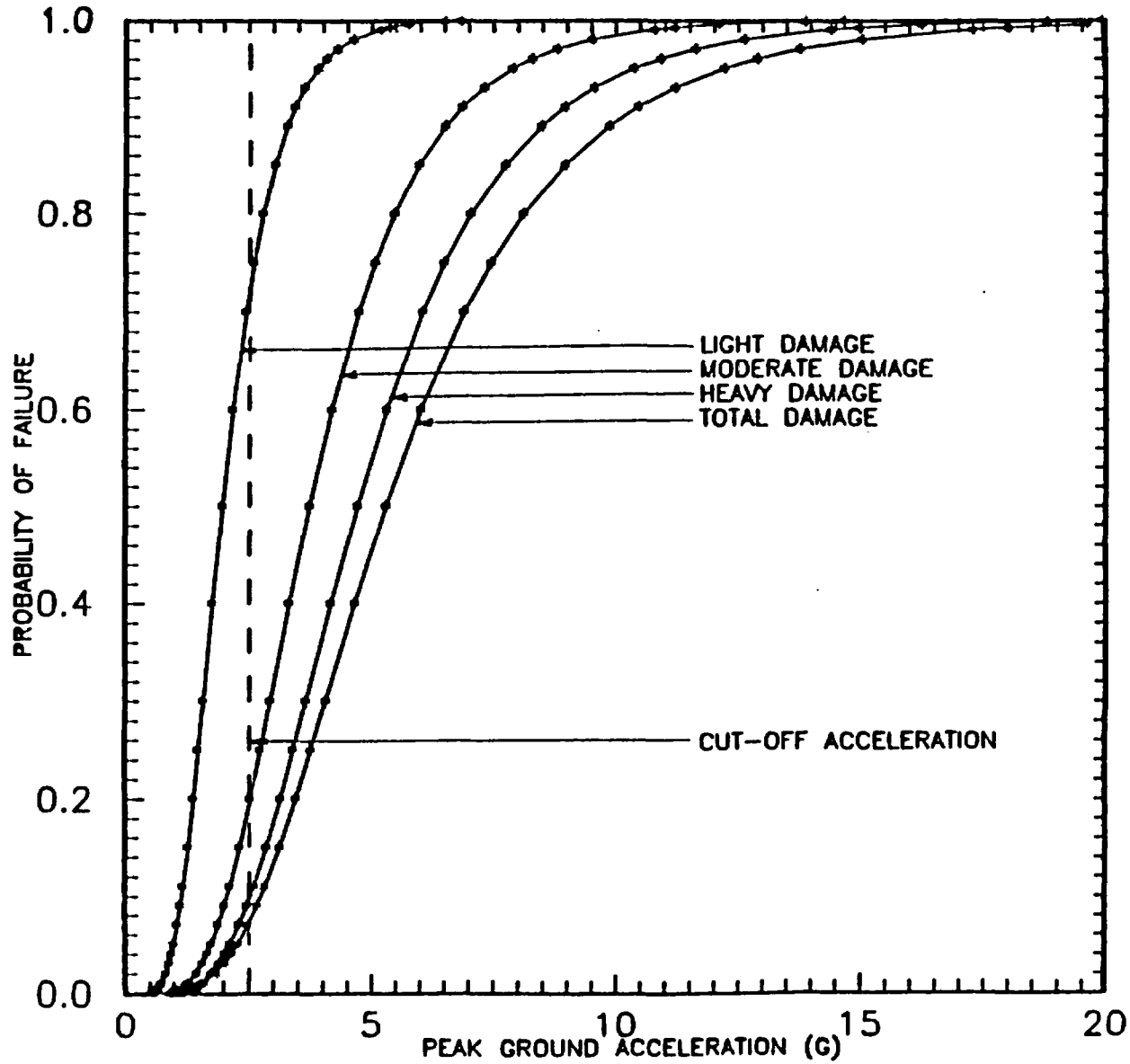
CONSEQUENCES OF BEYOND DESIGN EVENTS

- INCREASED LEVEL OF DAMAGE
- INCREASED DOSE TO INDIVIDUAL AND POPULATION

FOR THE 0.4g DESIGN

	50% PROBABILITY OF DAMAGE REQUIRES PGA OF	AVERAGE RATIO, OVER ALL PROBABILITIES, OF PGA: OTHER DAMAGE TO LIGHT DAMAGE
LIGHT DAMAGE	1.9g	1.0
MODERATE DAMAGE	3.7g	1.9
HEAVY DAMAGE	4.6g	2.4
TOTAL DAMAGE	5.2g	2.7

FRAGILITY CURVES FOR THE AVERAGE WALL, 0.4g DESIGN



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CONCLUSIONS

- CONSIDERING:
  - SEISMIC HAZARD (ACCELERATION AND DISPLACEMENT)
  - DAMAGE STATE PROBABILITIES
  - BOUNDARY AND ON-SITE DOSE RELEASES
  - COST CONSIDERATIONS AND THEIR UNCERTAINTIES
- IT IS CONCLUDED THAT:
  - THE WHB-2 IS AN INHERENTLY RUGGED FACILITY
  - SITE BOUNDARY INDIVIDUAL DOSE OF 5 REMS HAS AN EXCEEDANCE PROBABILITY OF LESS THAN 10^{-8} PER YEAR

CONCLUSIONS

(CONTINUED)

- IT IS CONCLUDED THAT:
  - THE COST OF THE FACILITY IS INSENSITIVE TO DESIGNS UP TO 0.6g
  - ACCIDENT RELATED COSTS ARE RELATIVELY SMALL
  - THE FACILITY CAN SAFELY ACCOMODATE SMALL FAULT DISPLACEMENT (10-20 cm)
  - THE FACILITY POSES A LOW SEISMIC RISK AND A 0.4g DESIGN BASIS IS ADEQUATE

3e

(5)

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

PRESENTATION TO THE NUCLEAR WASTE TECHNICAL REVIEW BOARD

SUBJECT: PROPOSED APPROACH FOR DEVELOPING THE SEISMIC DESIGN BASIS FOR REPOSITORY COMPONENTS IMPORTANT TO SAFETY

PRESENTER: GERALD A. FRAZIER

PRESENTER'S TITLE AND ORGANIZATION: SENIOR SEISMOLOGIST
SCIENCE APPLICATIONS INTERNATIONAL CORPORATION

PRESENTER'S TELEPHONE NUMBER: (702) 794-7624

APRIL 12, 1990

ENCLOSURE 3e

INTRODUCTION TO THE DOE APPROACH

METHODOLOGIES ARE BEING FORMULATED FOR DEVELOPING THE SEISMIC DESIGN BASIS FOR REPOSITORY COMPONENTS IMPORTANT TO SAFETY. THE PLAN IS TO USE:

- PROBABILISTIC APPROACHES TO GUIDE THE METHODOLOGIES AND TO CHECK ADEQUACY
- DETERMINISTIC APPROACHES TO ANCHOR QUANTITATIVE PARAMETERS IN THE DESIGN BASIS
- MAXIMUM CREDIBLE EARTHQUAKES TO ASSESS PERFORMANCE AND SITE SUITABILITY, AND TO ENSURE PUBLIC SAFETY

SUMMARY ASSESSMENTS

- PRACTICAL, RELIABLE, AND SUFFICIENT METHODS ARE PROPOSED FOR ENSURING SAFE PERFORMANCE (CONFINEMENT OF CONTAMINANTS) DURING PRECLOSURE OPERATIONS FROM CREDIBLE EARTHQUAKE AND MINIMAL DISRUPTION TO OPERATIONS FROM REASONABLY LIKELY EARTHQUAKES

- POSTCLOSURE PERFORMANCES IS MORE DIFFICULT TO ASSESS BECAUSE OF UNCERTAIN EARTHQUAKE EFFECTS ON GEOHYDROLOGY

HISTORY OF DOE DEVELOPMENT OF SEISMIC DESIGN BASIS

- EARLY SEISMIC DESIGN INPUT NEEDED TO SUPPORT CONCEPTUAL DESIGN
  - SOURCE - M=6.8 BARE MOUNTAIN FAULT AT DISTANCE = 14Km
  - RESULTS - PEAK GROUND ACCELERATION = 0.4g
  - REFERENCE - ROGERS, PERKINS, McKEOWN, 1977, BSSA, pp 1587-1606; USGS-OFR-84-792; SCP SECTION 1.4.2
- ADDITIONAL CONSIDERATIONS RECOMMENDED BY SAIC WORKSHOPS ON "TECTONIC STABILITY AND EXPECTED GROUND MOTION AT YUCCA MOUNTAIN", 1985
- PROBABILISTIC GROUND MOTION ASSESSMENTS BY URS-BLUME 1986, SAND 85-7104; AND PERKINS, THENHAUS, HANSON, AND ALGERMISSEN, USGS-OFR-87-199
- CURRENT METHODOLOGY FIRST INTRODUCED IN CONSULTATION DRAFT-SCP, 1988

SCP AND SCP-CDR SEISMIC CONSIDERATIONS PERTINENT TO DESIGN

"THIS VALUE (0.4g VIBRATORY GROUND MOTION) MAY BE REVISED AS A RESULT OF ONGOING STUDIES, PARTICULARLY THE CHARACTERIZATION OF FAULTS IN THE IMMEDIATE VICINITY OF THE SITE, FOR USE IN FUTURE DESIGN ANALYSIS (SCP SECTION 6.1.2.7, PAGE 6-70)."

REGULATIONS

- 10 CFR 60 REQUIRES THAT STRUCTURES, SYSTEMS AND COMPONENTS IMPORTANT TO SAFETY BE DESIGNED SO THAT ANTICIPATED NATURAL PHENOMENA WILL NOT INTERFERE WITH SAFETY FUNCTIONS

- PART 60 DOES <u>NOT</u> SPECIFY DETAILED PROCEDURES FOR DEVELOPING A SEISMIC DESIGN BASIS, UNLIKE REGULATIONS GOVERNING NUCLEAR POWER PLANT SITING (10 CFR 100, APPENDIX A)

THE APPLICATION INTENT PROVIDES USEFUL GUIDANCE

IN THE EVENT OF A LOCAL EARTHQUAKE, THE SEISMIC DESIGN BASIS IS TO ENSURE:

- SAFE REPOSITORY OPERATIONS
- MINIMAL DISRUPTION TO OPERATIONS

HENCE, THE METHODOLOGY MUST INCORPORATE ASSESSMENTS OF:

- LOCAL EARTHQUAKE HAZARDS, i.e., FAULTING, GROUND DEFORMATION, AND GROUND SHAKING
- POTENTIAL EFFECTS ON REPOSITORY COMPONENTS

THE PRECLOSURE CONCERN IS FOR COMPONENTS IMPORTANT TO SAFETY

THE SEISMIC DESIGN BASIS IS PRIMARILY NEEDED FOR SITING AND DESIGN OF THE SURFACE WASTE HANDLING FACILITIES

SEISMIC DESIGN BASIS: REQUIREMENTS AND OBJECTIVES

- SUFFICIENCY → CONSERVATISM
- RELIABILITY → ROBUSTNESS
- PRACTICALITY → EFFECTIVENESS

SUFFICIENCY: REQUIREMENTS

THE SEISMIC DESIGN BASIS MUST:

- PROTECT PUBLIC HEALTH AND SAFETY IN THE EVENT OF ANY CREDIBLE EARTHQUAKE
- PROTECT SAFETY FUNCTIONS WITH MINIMAL DISRUPTION TO OPERATIONS FOR EVENTS MORE LIKELY THAN ONE CHANCE IN TEN PER FACILITY/COMPONENT LIFETIME

RELIABILITY: OBJECTIVES

TO THE DEGREE POSSIBLE, THE SEISMIC DESIGN BASIS METHODOLOGY MUST:

- PRODUCE UNAMBIGUOUS RESULTS FROM OBSERVABLE EARTH PARAMETERS
- PRODUCE ROBUST RESULTS THAT CAN BE INVARIANT TO MINOR REFINEMENTS IN PERCEPTION OF SEISMIC HAZARDS
- INCORPORATE THE BEST ATTRIBUTES OF PREVIOUS METHODOLOGIES

PRACTICALITY: OBJECTIVES

THE SEISMIC DESIGN BASIS MUST:

- PROVIDE A SIMPLIFIED REPRESENTATION OF COMPLEX SEISMIC-INDUCED EFFECTS TO BE ACCOMMODATED BY REPOSITORY COMPONENTS (THE DESIGN BASIS NEED NOT BE PHYSICALLY REALIZABLE)

- INCLUDE CONSIDERATIONS OF CONSEQUENCES OF POTENTIAL FAILURES AND CONSEQUENCES OF IMPLEMENTING DIFFERENT DESIGN LEVELS (ANY SYSTEM CAN BE MADE SAFER, BUT CONSEQUENCES OF INCREASED PROTECTION EVENTUALLY OUTWEIGH THE BENEFITS)

SITE-SPECIFIC CONSIDERATIONS FOR SEISMIC DESIGN OF SURFACE FACILITIES

- THE WASTE HANDLING FACILITIES ARE INHERENTLY RUGGED AND HAVE RESERVE MARGINS FOR CONFINING CONTAMINANTS
- CHARACTERISTIC LOCAL EARTHQUAKES APPEAR TO OCCUR INFREQUENTLY WITH AVERAGE RETURN PERIODS OF TENS OF THOUSANDS OF YEARS
- INTENSE GROUND SHAKING AT YUCCA MOUNTAIN PROBABLY RESULTS MOSTLY FROM MODERATE, LOCAL EARTHQUAKES ($M<7$)
- USE OF A LARGE (OR MAXIMUM) MAGNITUDE EARTHQUAKE IN THE SEISMIC DESIGN BASIS OF SURFACE FACILITIES CANNOT BE JUSTIFIED IN TERMS OF SAFETY BENEFITS

ALTERNATE APPROACHES FOR ESTABLISHING DESIGN BASIS GROUND SHAKING FOR THE SURFACE FACILITIES

- SPECIFY AN AVERAGE RETURN PERIOD (e.g., 10^3 YEARS) FOR GROUND MOTIONS, AND USE PROBABILISTIC METHODS FOR ESTABLISHING CONSERVATIVE DESIGN BASIS GROUND MOTION AMPLITUDES

- SPECIFY A TIME PERIOD (e.g., 10^4 YEARS) OF AVERAGE CUMULATIVE FAULTING DEFORMATIONS TO BE USED FOR ESTABLISHING DESIGN BASIS EARTHQUAKE MAGNITUDE(S) AND GROUND MOTION AMPLITUDES

PROPOSED METHOD FOR DETERMINING DESIGN BASIS EARTHQUAKE: CUMULATIVE SLIP EARTHQUAKE (CSE)

<u>DEFINITION OF CSE</u> - A HYPOTHETICAL EARTHQUAKE THAT WOULD PRODUCE FAULT DISPLACEMENT EQUAL TO THE AVERAGE QUATERNARY DISPLACEMENT RATE ACCUMULATED OVER A SPECIFIED PERIOD OF TIME (e.g., 10^4 YEARS)

CSE MAGNITUDE CONSTRAINT:

- M_{MIN} (SURFACE RUPTURE)$<M_{CSE}<M_{MAX}$ (QUATERNARY)

CSE METHODOLOGY

1. SPECIFY CSE TIME INTERVAL > 10 x FACILITY LIFE

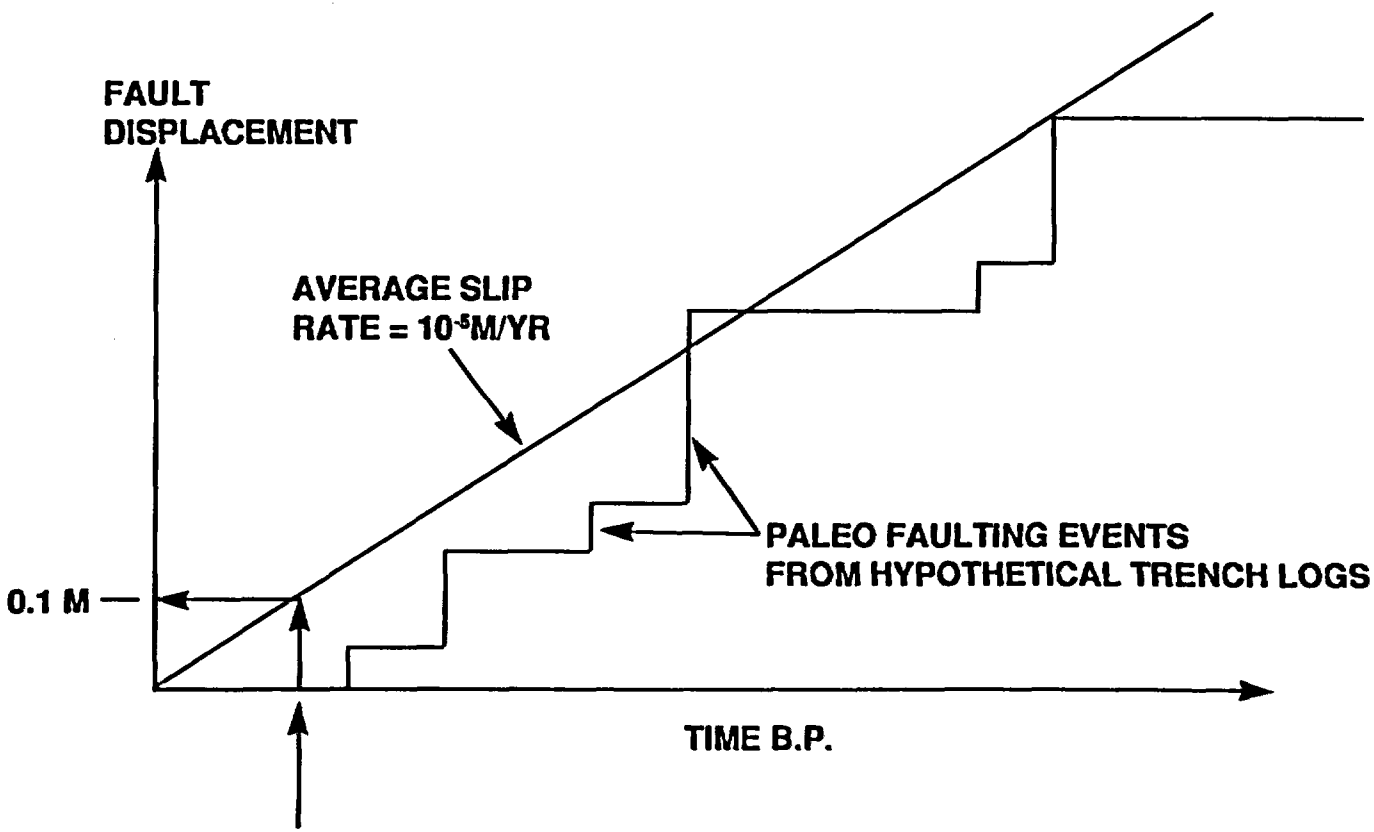
2. DETERMINE M_{CSE} FOR LOCAL AND POTENTIALLY CONTROLLING DISTANT FAULTS

3. ESTIMATE MEDIAN GROUND MOTIONS AT FACILITY SITE FOR EACH M_{CSE}

4. SET DESIGN BASIS MOTIONS = ENVELOPE OF MEDIAN GROUND MOTION ESTIMATES

5. CHECK THAT DESIGN BASIS REQUIREMENTS AND OBJECTIVES ARE SATISFIED

HYPOTHETICAL EXAMPLE OF 10^4 YR CSE



10^4 YEARS SELECTED FOR PRECLOSURE DESIGN BASIS

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HYPOTHETICAL EXAMPLE OF 10^4 YR CSE

- AVERAGE LATE QUATERNARY SLIP RATE = 10^{-5}M/YR
- AVERAGE FAULT SLIP = 10^4 YR x 10^{-5} M/YR = 0.1M
- MAXIMUM FAULT SLIP ~ 3 x AVERAGE = 0.3M
- MAGNITUDE OF 10^4 YR CSE ~ 6.5
- MEDIAN NEAR-FIELD PEAK ACCELERATION ~ 0.5g
- PROBABILITY OF EXCEEDING 0.5g APPEARS TO BE BETWEEN 10^{-3} AND 10^{-4}/YR

ATTRIBUTES OF 10^4 YR CSE METHODOLOGY FOR SEISMIC DESIGN BASIS OF WASTE HANDLING FACILITIES

- SUFFICIENCY
  - STRONG MOTION ACCELERATIONS IN THE NEAR-FIELD TEND TO SATURATE WITH INCREASING EARTHQUAKE MAGNITUDE FOR $M > 6.5$
  - EXPECTED PROBABILITY OF EXCEEDANCE = 10^{-3} TO 10^{-4}/YR = RANGE TYPICAL OF NPP DESIGNS
  - LARGE RESERVE MARGINS EXPECTED BECAUSE OF 5-FT-THICK CONCRETE WALLS FOR SHIELDING AND ABSENCE OF HIGH-ENERGY MECHANISMS FOR DISPERSING CONTAMINANTS

NWDSDB5P.A27/4-12-90

ATTRIBUTES OF 10^4 YR CSE METHODOLOGY FOR SEISMIC DESIGN BASIS OF WASTE HANDLING FACILITIES

(CONTINUED)

- RELIABILITY
  - POTENTIAL AMBIGUITY IS REDUCED BY EARLY SPECIFICATION OF CSE RETURN PERIOD
  - INVESTIGATIONS CAN CONCENTRATE ON FEW LOCAL FAULTS THAT DOMINATE RESULTS
  - CONSERVATIVE SLIP RATES CAN COMPENSATE FOR REMAINING UNCERTAINTIES
  - NEAR-FIELD GROUND MOTION PREDICTIONS MOST RELIABLE FOR MEDIAN EXPECTATIONS OF EARTHQUAKES WITH $M<7$

PROPOSED SEISMIC DESIGN BASIS FOR PRECLOSURE WASTE HANDLING FACILITIES (LIFE ~ 10^2YR)

AVERAGE RETURN PERIOD (YR)	TYPE OF SEISMIC HAZARD	OBJECTIVES	DESIGN/PERFOR-MANCE APPROACH
10^3	GROUND SHAKING	SAFETY & MIN. DISRUPTION TO OPERATIONS	DESIGN FOR 10^4 YR CSE (OR 10^3 YR MOTIONS)
10^4	GROUND DISPLACE-MENT	SAFETY & MIN. DISRUPTION TO OPERATIONS	SITE TO AVOID DISPLACEMENTS > 5 cm
MAX DURING QUATERNARY	ALL	CONFINE HAZARDS	ASSESS PERFORMANCE & VERIFY (OR IMPLEMENT ADDITIONAL) SAFEGUARDS

SUMMARY ASSESSMENTS

- PRACTICAL, RELIABLE, AND SUFFICIENT METHODS ARE PROPOSED FOR ENSURING SAFE PERFORMANCE (CONFINEMENT OF CONTAMINANTS) DURING PRECLOSURE OPERATIONS FROM CREDIBLE EARTHQUAKE AND MINIMAL DISRUPTION TO OPERATIONS FROM REASONABLY LIKELY EARTHQUAKES

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

PRESENTATION TO THE NUCLEAR WASTE TECHNICAL REVIEW BOARD

SUBJECT: SUMMARY OF DOE POSITION

PRESENTER: JEFFREY K. KIMBALL

PRESENTER'S TITLE AND ORGANIZATION: ACTING CHIEF, SITING AND GEOSCIENCES BRANCH
U.S. DEPARTMENT OF ENERGY
OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT

PRESENTER'S TELEPHONE NUMBER: (202) 586-1063

APRIL 12, 1990

ENCLOSURE 3f.

SUMMARY OF DOE POSITION

- DOE RECOGNIZES THE IMPORTANCE OF RESOLVING SEISMIC HAZARD ISSUES EARLY
- THE SEISMIC HAZARD PROCEDURES IN APPENDIX A ARE OUT-OF-DATE AND INAPPROPRIATE FOR A GEOLOGIC REPOSITORY WHICH, UNLIKE A NUCLEAR REACTOR, IS A PASSIVE SYSTEM
- DOE IS DEVELOPING A SEISMIC HAZARD APPROACH THAT INCORPORATES PROBABILISTIC AND DETERMINISTIC METHODOLOGIES
- BASED ON A COST-BENEFIT ANALYSIS, THE CURRENT DESIGN OF 0.4g IS APPROPRIATE
- CONTINUING INTERACTIONS WITH THE NRC ARE IMPORTANT AS THE DOE APPROACH TO RESOLVING SEISMIC HAZARD ISSUES IS REFINED

(7)

NRC'S APPROACH ON REGULATORY GUIDANCE FOR SEISMIC HAZARDS ASSESSMENT

TRB Technical Exchange on Seismic Hazards, Las Vegas, NV
April 12, 1990

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Office of Nuclear Material Safety and Safeguards

ENCLOSURE 3g(1)

NRC's Approach...Seismic Hazards Assessment

- DOE/NRC INTERACTIONS ON SEISMIC HAZARD
- SCA CONCERNS ON GROUND MOTION
- SEISMIC HAZARD INVESTIGATIONS TP
- PROBABILISTIC SEISMIC HAZARD ANALYSIS
- SUMMARY STATEMENTS

DOE/NRC INTERACTIONS ON SEISMIC HAZARD

• Technical Exchange on Draft Seismic Hazards Technical Position	Dec 19-20, 1989
• Meeting on SCA Concerns	Aug 30-31, 1989
• USGS Seismic Monitoring Program	Feb 29-Mar 3, 1989
• Seismotectonics Technical Meeting	Sep 22-23, 1987
• Generic Seismo-Tectonics Meeting	Dec 3-4, 1985
• Seismic/Geologic Design Criteria for Waste Repository	Jan 25, 1978

NRC's Approach...Seismic Hazards Assessment

SCA CONCERNS

GROUND MOTION

1. 10,000-Year Cumulative Slip Earthquake:

   The 10,000-Year cumulative slip earthquake methodology appears to imply an assumed fixed recurrence interval of 10,000 years (SCA Comment 66).

2. Comprehensive Earthquake Data:

   The cut-off of 5.5 magnitude for earthquake data may not provide data sufficient for site characterization (SCA Comment 67).

NRC's Approach...Seismic Hazards Assessment

EXPECTED OUTPUT FROM DOE

To provide an adequate understanding of the seismic hazard at the site...

a deterministic seismic hazard evaluation, supplemented by a probabilistic seismic hazard analysis, should be performed.

NRC's Approach...Seismic Hazards Assessment

BASIS FOR TECHNICAL POSITION ON SEISMIC HAZARD INVESTIGATIONS

Describe site, subsurface conditions and subsurface conditions outside controlled area that are relevant (60.21(c)(1)(i))

PAC. Repeat of historical earthquakes that could significantly affect site (60.122(c)(12)

PAC. Indication that either frequency or magnitude of earthquakes may increase (c)(13)

PAC. More frequent or higher magnitude earthquakes than typical of area of geologic setting (c)(14)

PAC = Potentially Adverse Conditions

REGULATORY REQUIREMENTS TECTONICS

Logic for Evaluating Potentially Adverse Condition 60.122(c)(12)

"Earthquakes which have occurred historically that if they were to be repeated could affect the site significantly."

If Historical Seismic Activity is Repeated

TO SHOW

That Repeat of Historical Seisjmic Activity Does Not Compromise Ability of Repository to Meet Performance Objectives Relating to Waste Isolation

DOE MUST (NRC TO EVALUATE)

Adequately Investigate Repeat of Historical Seismic Activity, Including Extent to Which Condition May be Present and still be Undetected Taking Into Account Resolution of Investigations

AND

Adequately Evaluate the Effect of Repeat of Historical Seismic Activity Using Analyses and Assumptions Not Likely to Underestimate Its' Effect

AND

Show Repeat of Historical Seismic Activity Does Not Signiicantly Affect Ability of Repository to Meet Performance Objectives

OR

Show Effect of Repeat of Historical Seismic Activity is Compensated by Favorable Characteristics

OR

Show Effects of Repeat of Historical Seismic Activity Can Be Remedied

NRC's Approach...Seismic Hazards Assessment

SEISMIC HAZARD INVESTIGATIONS TECHNICAL POSITION

Summary

- The position addresses investigations for faulting, vibratory ground motion, and site geomechanical properties and conditions for both the surface and the underground facility

- The methods of investigation are appropriate for: determining design basis earthquake, use as input to probabilistics, assessing pre- and post-closure seismic and faulting hazard

BASIS FOR GUIDANCE ON PROBABILISTIC SEISMIC HAZARD ANALYSIS 10 CFR 60.131(b)(1)

"Structures, systems, and components important to safety in the geologic repository area be designed so that natural phenomena do not interfere with their safety functions."

BASIS FOR GUIDANCE ON PROBABILISTIC SEISMIC HAZARD ANALYSIS

EPA standard states that whenever practicable, demonstration of compliance shall be accomplished by assembling all results of performance assessments into a Complementary Cumulative Distribution Function (CCDF)

PROBABILISTIC SEISMIC HAZARD ANALYSIS

When addressing the Seismic Hazard, the following attributes should be considered:

- The rationale for the choice of specific models, parameters and procedures used in the analysis, and

- Quantification of the uncertainties in the results

NRC SUMMARY STATEMENTS

- SCA Comments on 10,000-year CSE and Magnitude 5.5 cutoff are unresolved
- Review of SCP found no significant concerns about Seismic Hazard Investigations Methods
- Seismic Hazard Investigations and Analyses Must Address 60.21(c)(1)(i), 60.122(c)(12,13,14), 60.131(b)(1), 40 CFR 191.13
- A deterministic seismic hazard evaluation, supplemented by a probabilistic seismic hazard analysis is an acceptable approach to fulfilling NRC and EPA requirements
- DOE has the responsibility of identifying the seismic hazard, developing design bases and providing rationale necessary for NRC to evaluate the License Application in light of 10 CFR Part 60 Requirements

SUPPLEMENTARY VUGRAPHS

GROUND MOTION CONCERN #1: 10,000 -YEAR CUMULATIVE SLIP EARTHQUAKE

Key Observations

- The 10,000-year recurrence interval selected to characterize the cumulative displacement for the 10,000-year CSE, appears to be the minimum recurrence interval for the region

- Use of a 10,000-year recurrence interval will result in a minimum cumulative displacement, which results in a minimum magnitude

- The description of the 10,000-year CSE presented in Section 8.3.1.17.1.2 does not appear to clearly address recurrence

GROUND MOTION CONCERN #1: 10,000-YEAR CUMULATIVE SLIP EARTHQUAKE (Continued)

Recommendations

- Give special emphasis to recurrence-rate estimate studies
- Assure that site-characterization activities will permit comparison of the 10,000-year CSE methodology with alternative methodologies

GROUND MOTION CONCERN #2: COMPREHENSIVE EARTHQUAKE DATA

Key Observations

- Earthquake parameters listed under Activity 8.3.1.7.4.1.1 that are needed for earthquake characerization will only be compiled for the larger ($m \geq 5.5$) earthquakes

- Based on the 5.5 magnitude cut-off, it is unlikely that enough earthquake parameters will be compiled for Yucca Mountain

GROUND MOTION CONCERN #2: COMPREHENSIVE EARTHQUAKE DATA (continued)

Recommendations

Analyze earthquake data that are reasonable and practical without regard to a magnitude distinction

BASIS FOR TECHNICAL POSITION ON SEISMIC HAZARD INVESTIGATIONS

60.21(c)(1)(i):

" 60.21(c) The Safety Analysis Report shall include:
(1) A description . . . of the site at which the proposed geologic repository operations area is to be located with appropriate attention to those features of the site that might affect geologic repository operations area design and performance. The description of the site shall identify the location of the geologic repository operations area with respect to the boundary of the accessible environment.
(i) The description of the site shall also include . . . information regarding subsurface conditions. This description shall, in all cases, include such information with respect to the controlled area. In addition, where subsurface conditions outside the controlled area may affect isolation within the controlled area, the description shall include such information with respect to subsurface conditions outside the controlled area to extent such information is relevant and material..."

POTENTIALLY ADVERSE SEISMIC HAZARD CONDITIONS

60.122(c):

(12) Earthquakes which have occurred historically that if they were to be repeated could affect the site significantly.

(13) Indications, based on correlations of earthquakes with tectonic processes and features, that either the frequency of occurrence or magnitude of earthquakes may increase.

(14) More frequent occurrence of earthquakes or earthquakes of higher magnitude than is typical of the area in which the geologic setting is located.

BASIS FOR GUIDANCE ON PROBABILISTIC SEISMIC HAZARD ANALYSIS 40 CFR 191.13 EPA STANDARD

"Disposal Systems for spent fuel, high-level, or trans-uranic radioactive waste shall be designed to provide reasonable expectation, based upon performance assessment, for 10,000 years after the disposal, from all significant processes and events that may affect the disposal system, shall:

a. Have a likelihood of less than one chance in 10 of exceeding the quantities calculated according to table 1; and
b. Have a likelihood of less than one chance in 1,000 in exceeding ten times the quantities calcualted according to table 1."

PROBABILISTIC SEISMIC HAZARD ANALYSIS

Summary of Guidance

- Develop Seismic Source Zones and Alternative Source Zone Models
- Estimate the Rate of Earthquake Occurrence
- Develop Attenuation Models Appropriate for the Site
- Perform Uncertainty Analysis for the Seismic Source Zones, the Maximum Earthquake Magnitude, and the Ground Motion Attenuation Model
- Perform Sensitivity Analysis on the Model Input's Parameters
- Generate Seismic Hazard Curves with their Uncertainty

SYSTEM ENGINEERING APPROACH
GOALS

- Adequate Guidance to Receive Complete and Sufficient License Application - Three Year Statutory Decision
- Ensure Staff Capability for Comprehensive and Timely License Application Review
- Establish Record that will Support the License Decision

ENCLOSURE 3g(2)

ENCLOSURE 3g(2)

SUMMARY OF STATEMENTS MADE AT
NUCLEAR WASTE TECHNICAL REVIEW BOARD
TECHNICAL INFORMATION EXCHANGE ON SEISMIC HAZARDS
BY PHILIP JUSTUS
12 APRIL, 1990

Mr. Chairman, Members of the Board, Ladies and Gentlemen,

NRC's role in this pre-licensing consultation phase of the HLW program is to identify information needed for licensing and to reduce sources of uncertainty.

The NRC approach to fulfilling its role is to conduct independent reviews of regulatory and technical concerns and to provide guidance to DOE to effect resolution of the concerns.

DOE is required to identify and describe the seismic hazards at a site. NRC expects DOE to take a reasonably conservative approach to identifying and describing the seismic hazard. The characterization of seismogenic features is not complete, the historical and instrumental records of seismic activity are limited, the approximate 100-year pre-closure period of performance and the 10,000 year post-closure period is fairly long and earthquake disruption-scenarios have not been established.

The NRC staff's review of the SCP pointed out two seismic concerns where DOE did not appear to be conservative:

- 10,000 yr CSE
- Mag 5.5 cut-off

DOE has agreed to resolve these concerns. No significant concerns about seismic hazard investigation methods were found in the SCP review.

The staff position on what are acceptable ways for DOE to obtain seismic hazard information needed for licensing is that a deterministic seismic hazard evaluation, supplemented by a PSHA is an acceptable approach to meeting NRC and EPA requirements.

It should be clear now, that Appendix A to Part 100, is not required by NRC to meet any Part 60 requirement. With regard to Appendix A the staff's position is that methods of investigation like those in Appendix A, with modification, are appropriate for addressing investigations of seismic hazard at a geologic repository.

The Appendix A methods of investigation that can be modified for repository seismic hazard investigations are appropriate for determining the design basis earthquake, for use as input to probabilistic methods, and for assessing pre-and post-closure seismic hazard.

PSHA methods must be used to demonstrate compliance with EPA requirements. The attributes of an acceptable PSHA include: documentation of the rationale for choosing seismic source zone models, of parameters and procedures used in the analysis, and quantification of uncertainties in the results. At least two existing PSHA methodologies exist that have these attributes, one by LLNL, the other by EPRI. The staff intends to issue a draft TP stating their acceptability.

10 CFR 60 does not specify the manner in which seismic hazards are to be investigated or analyzed. DOE has the responsibility of identifying the seismic hazards, developing seismic design bases, and providing rationale necessary for NRC staff to evaluate the license application.

[This summary is to accompany the NRC Briefing package of Vu-graphs]

NRC Form 8–C
(4–79)
NRCM 0240

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