

**SYSTEMS PERSPECTIVES**  
**RELATIVE TO THE USE OF PSHA and PVHA**

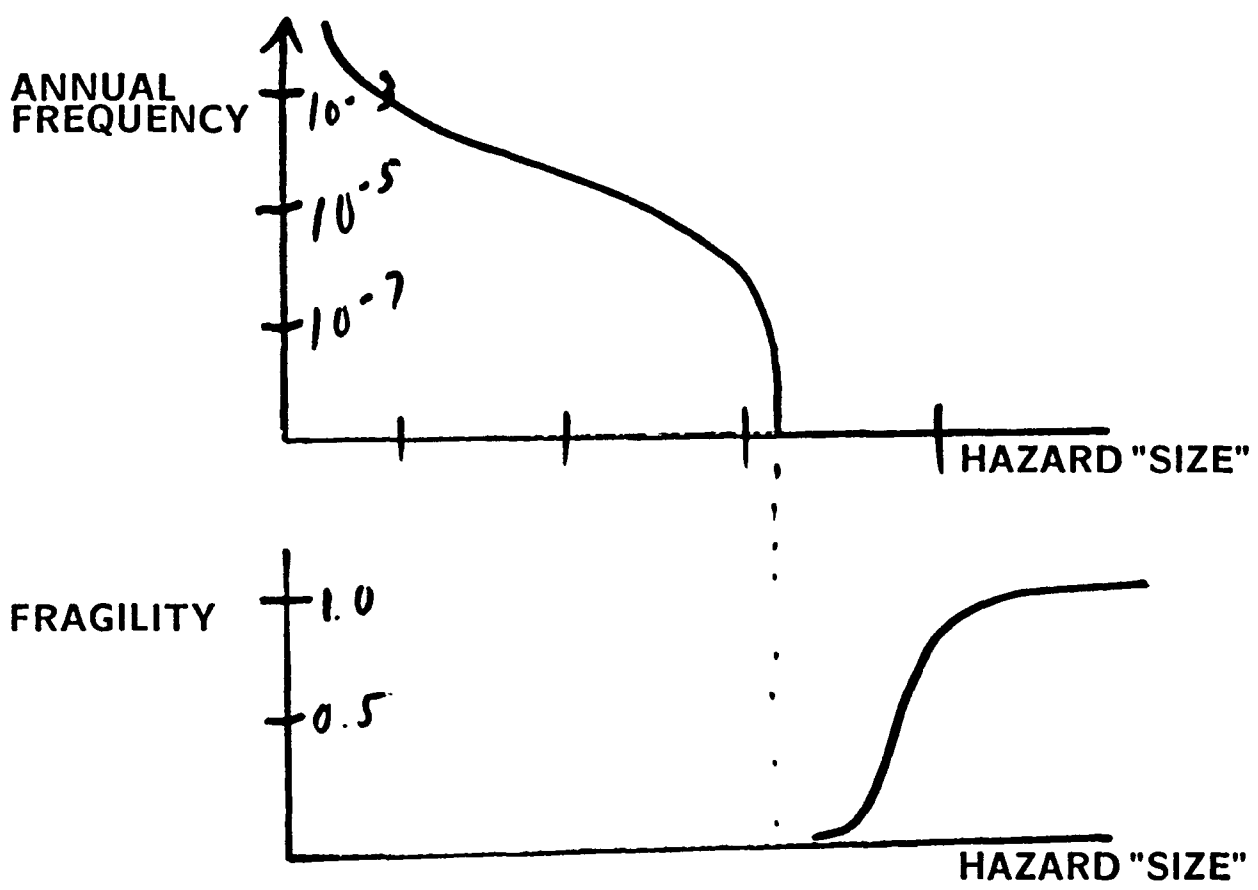
**ROBERT J. BUDNITZ**

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**2039 Shattuck Avenue, Suite 402**  
**Berkeley, California 94704 USA**

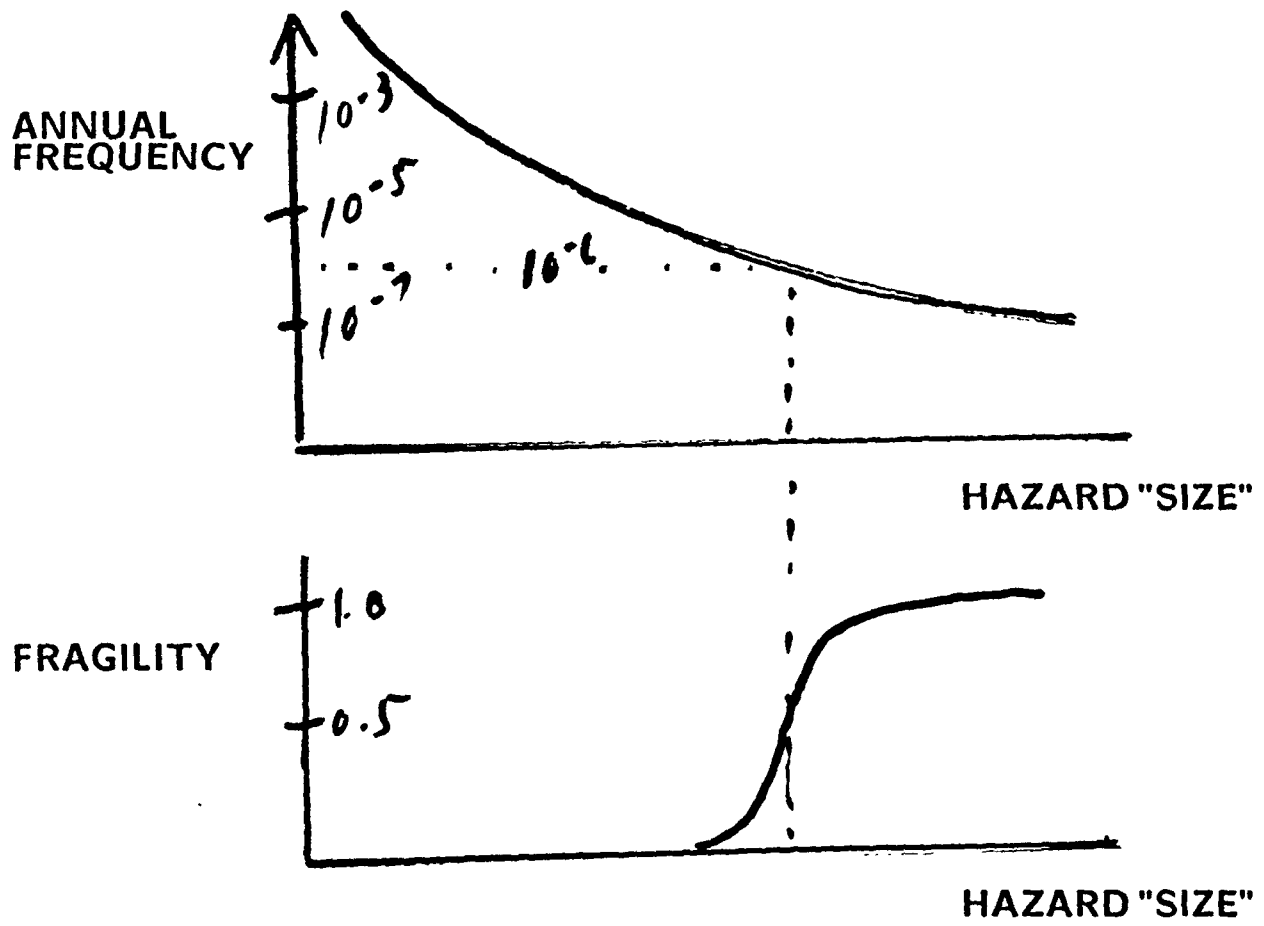
**Nuclear Waste Technical Review Board**  
**Structural Geology and Geoen지니어ing Panel Meeting**  
**Burlingame, California**

**March 8, 1993**

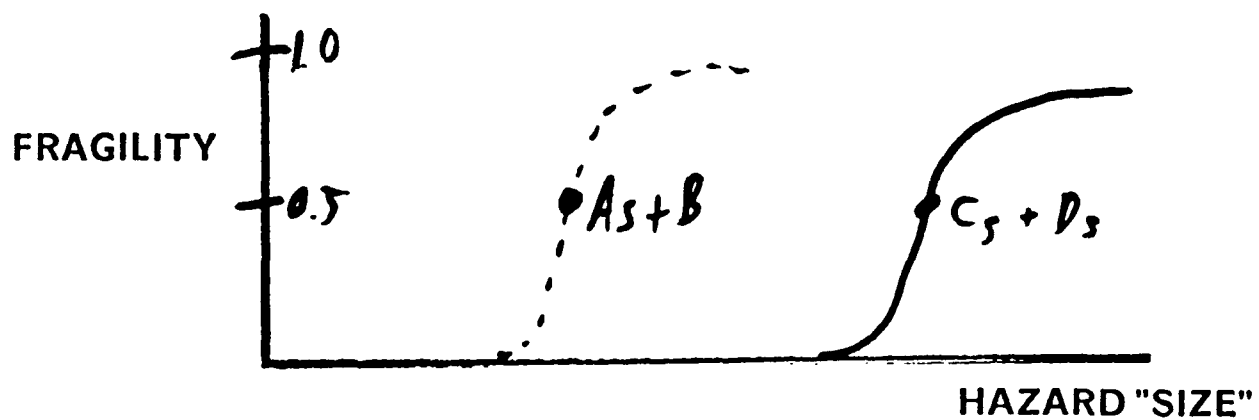
IF THE HAZARD CURVE HAS A "MAXIMUM HAZARD":



IF THE HAZARD CURVE HAS NO "MAXIMUM HAZARD":



HOW TO DEFINE "FRAGILITY" or "CAPACITY":



Assume here that B is a non-seismic failure.

Assume that  $A_s$ ,  $B_s$ , and  $C_s$  are seismic failures.

If  $B = 10^{-1}$ , then Failure =  $10^{-4}$ /year

If  $B = 10^{-2}$ , then Failure =  $10^{-5}$ /year

If  $B = 10^{-3}$ , then Failure =  $10^{-6}$ /year

"Fragility" is poorly defined  
when non-seismic failures are present

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culmotive distribution

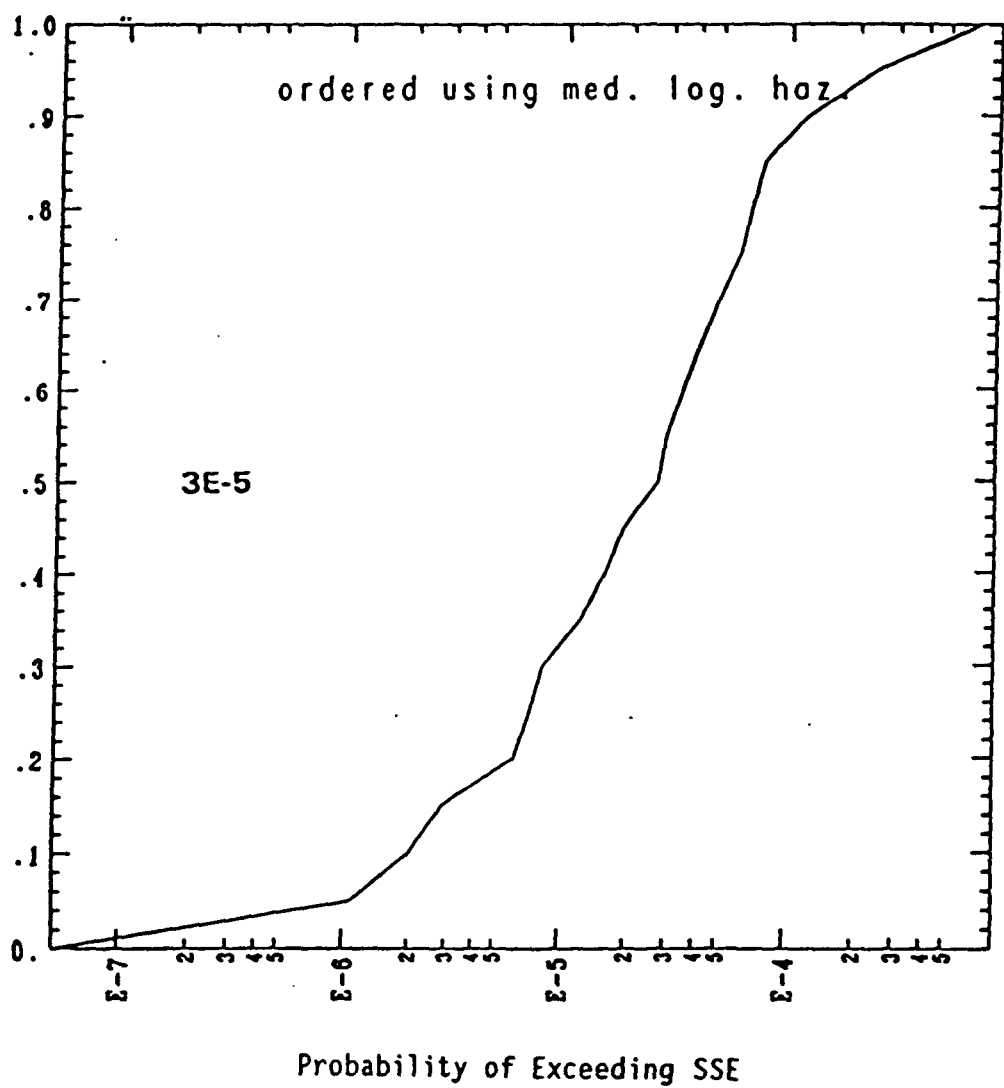


Figure B.4 Probability of Exceeding SSE Using Median EPRI Hazard Estimates

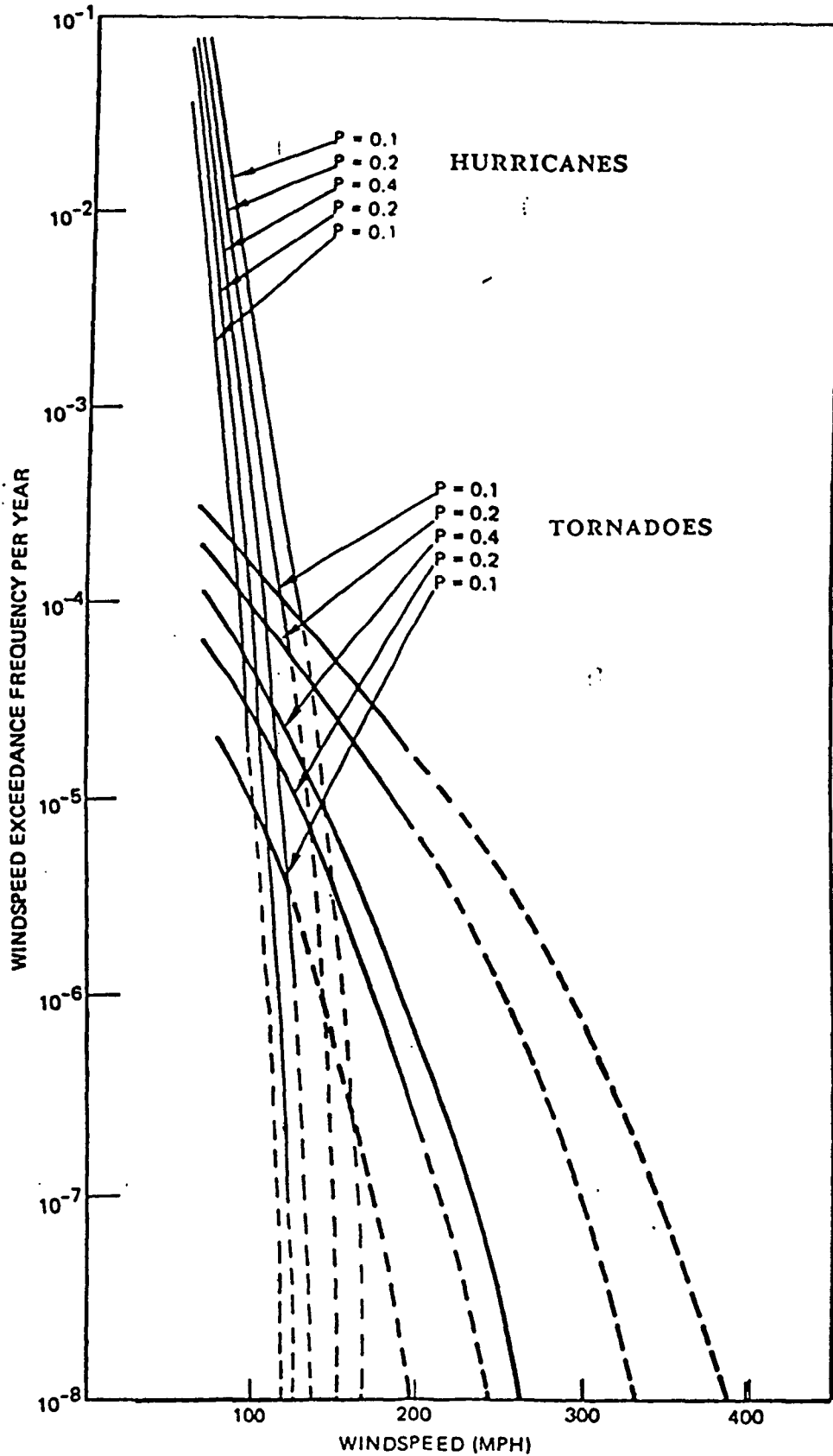


Figure 2.1 Typical wind hazard curve, for the Indian Point site (New York State, U.S.) and taken from the Indian Point PRA. The hurricane and tornado curves have been superimposed on this figure.

**NPPs: ACTUAL CASES:**

**NRC Safety Goal =  $10^{-6}$ /year (large radiological release)**

<b><u>HAZARD</u></b>	<b><u>DESIGN LEVEL</u></b>	<b><u>TYPICAL PRA OUTCOMES</u></b>
Earthquakes	$10^{-3}$ to $10^{-6}$ /year	$10^{-5}$ to $10^{-6}$ /year
High Winds	about $10^{-7}$ /year	$10^{-7}$ or better
Flooding (poorer sites)	$\leq 10^{-3}$ /year	$10^{-6}$ or better
Internal Fires	about $10^{-3}$ /year (some damage)	$10^{-5}$ to $10^{-6}$ /year

**LOTS OF EXPERT JUDGMENT IS INVOLVED  
IN ALL OF THESE PRA NUMERICAL "RESULTS" !**

**BUT: NPP LICENSING IS NOT PROBABILISTIC !**

**TRADITIONAL = DETERMINISTIC" APPROACH:**

**RELY ON:**

**1) Design Basis Events:**

**Safe Shutdown Earthquake**

**Probable Maximum Flood**

**Design Basis Windspeeds**

**etc.**

**2) Standards, Codes, etc. ----- > Rely on  
Code Margins**

**3) Design Rules, etc.**



**IN TODAY'S NPP LICENSING:**

**PRA has no specific role**

**FOR FUTURE ADVANCED NPPs:**

**PRA is to be used as a "check"**

**IN ALL REACTOR-LICENSING CASES:**

**Acceptability -----> Expert Judgment Heavily Relied On**

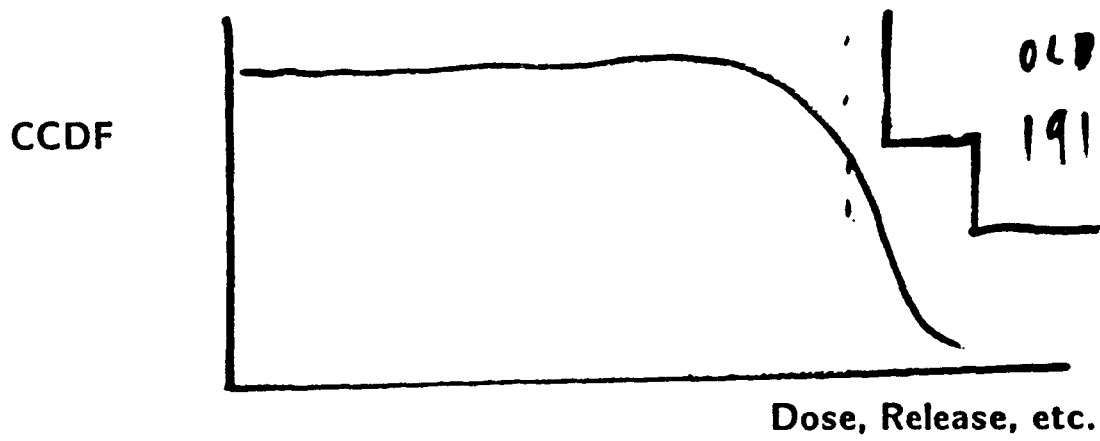
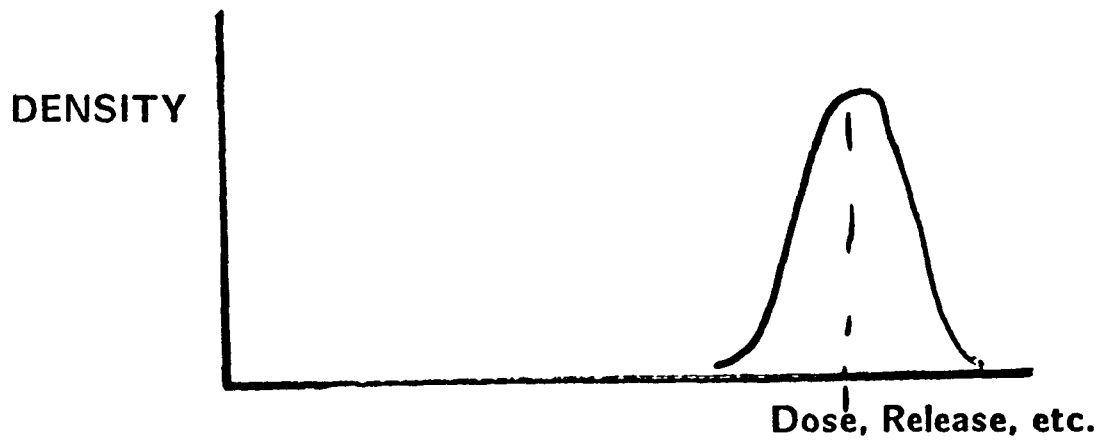
**YUCCA MOUNTAIN SITUATION:**

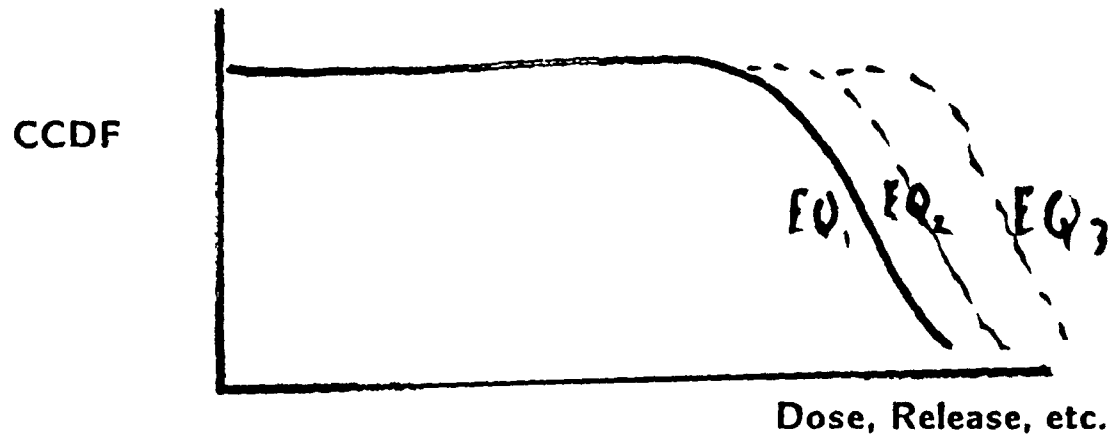
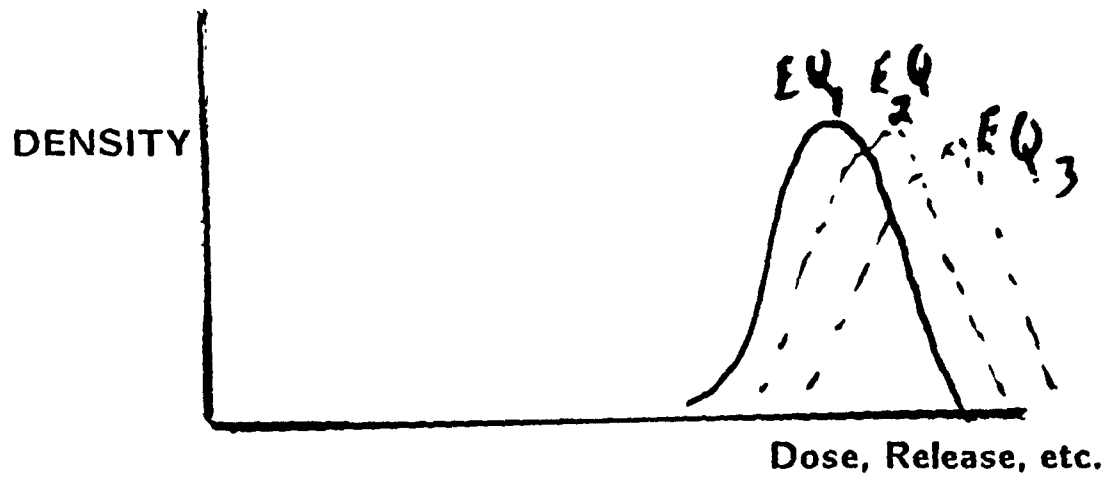
**STANDARDS:** (no idea what the standards will be like)

**I WILL POSTULATE:**

- 1) Performance-Based Standards
- 2) Probabilistic
- 3) Inevitably ---- Heavy Reliance on Expert Judgment !

YUCCA MOUNTAIN:  
(explain how Performance Assessment works)



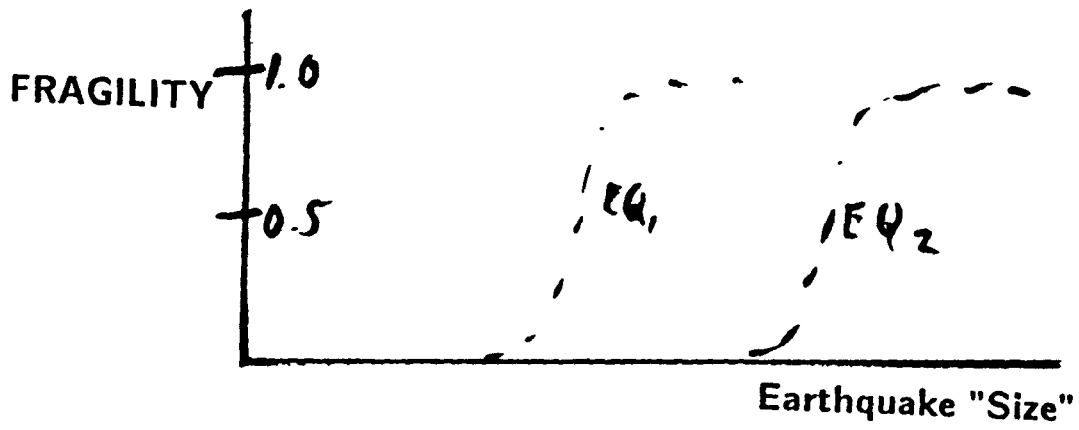
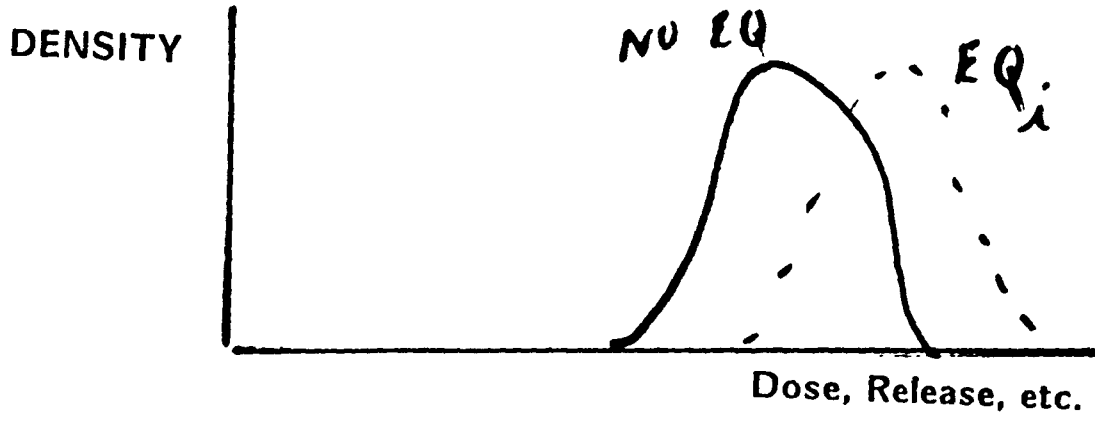
YUCCA MOUNTAIN:

EQ<sub>1</sub> = No earthquake

EQ<sub>2</sub> = 10<sup>-3</sup>/year earthquake

EQ<sub>3</sub> = 10<sup>-5</sup>/year earthquake

WE DEFINITELY NEED A SEISMIC PA!



**RUN EACH EQ<sub>i</sub> SEPARATELY?**

**DO A WEIGHTED SUM?**

**If EQ<sub>1</sub> = 10<sup>-3</sup>/year, expect 10**

**in 10,000 years**

**If EQ<sub>3</sub> = 10<sup>-5</sup>/year, expect 1/10**

**in 10,000 years**

**MEANING of SEISMIC "CAPACITY" ?**

**Fuzzy !**

**IS ANYONE DOING THESE SEISMIC-"CAPACITY" ANALYZES?**

**DESIGN FOR LARGEST EQ in 10,000 or 100,000 YEARS?**

**DESIGN FOR SOME "RISK" INDEX FROM EARTHQUAKES?**

**DESIGN TIED TO A PERFORMANCE ASSESSMENT?**

**or**

**DESIGN INDEPENDENT OF PERFORMANCE ASSESSMENT INSIGHTS?**

**WHAT CAN BE "CONTROLLED" IN THE DESIGN?**

ROBERT BUDNITZ'S  
SLIDES  
AND  
THE NOODLING ON 'EM

8 MARCH 1994

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*Future Resources Associates, Inc.*

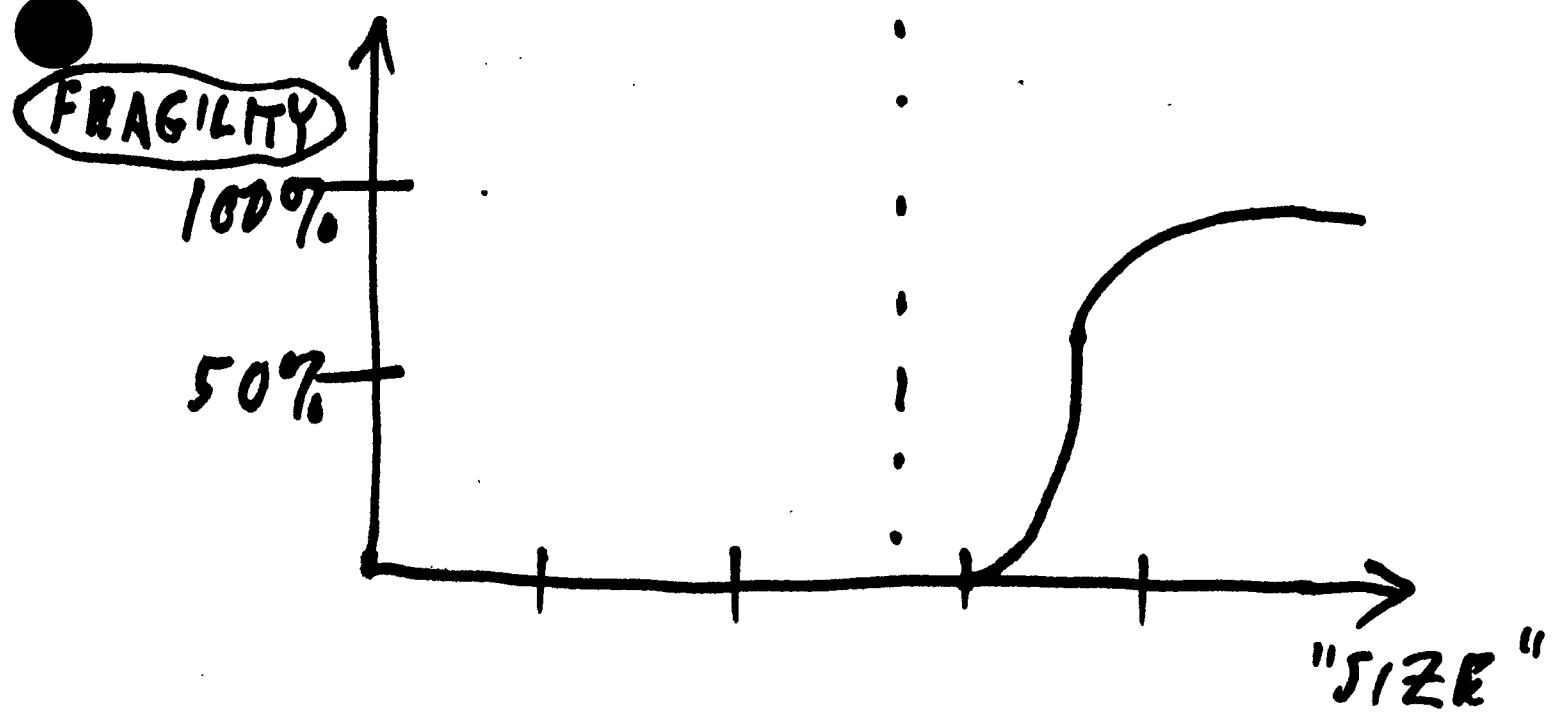
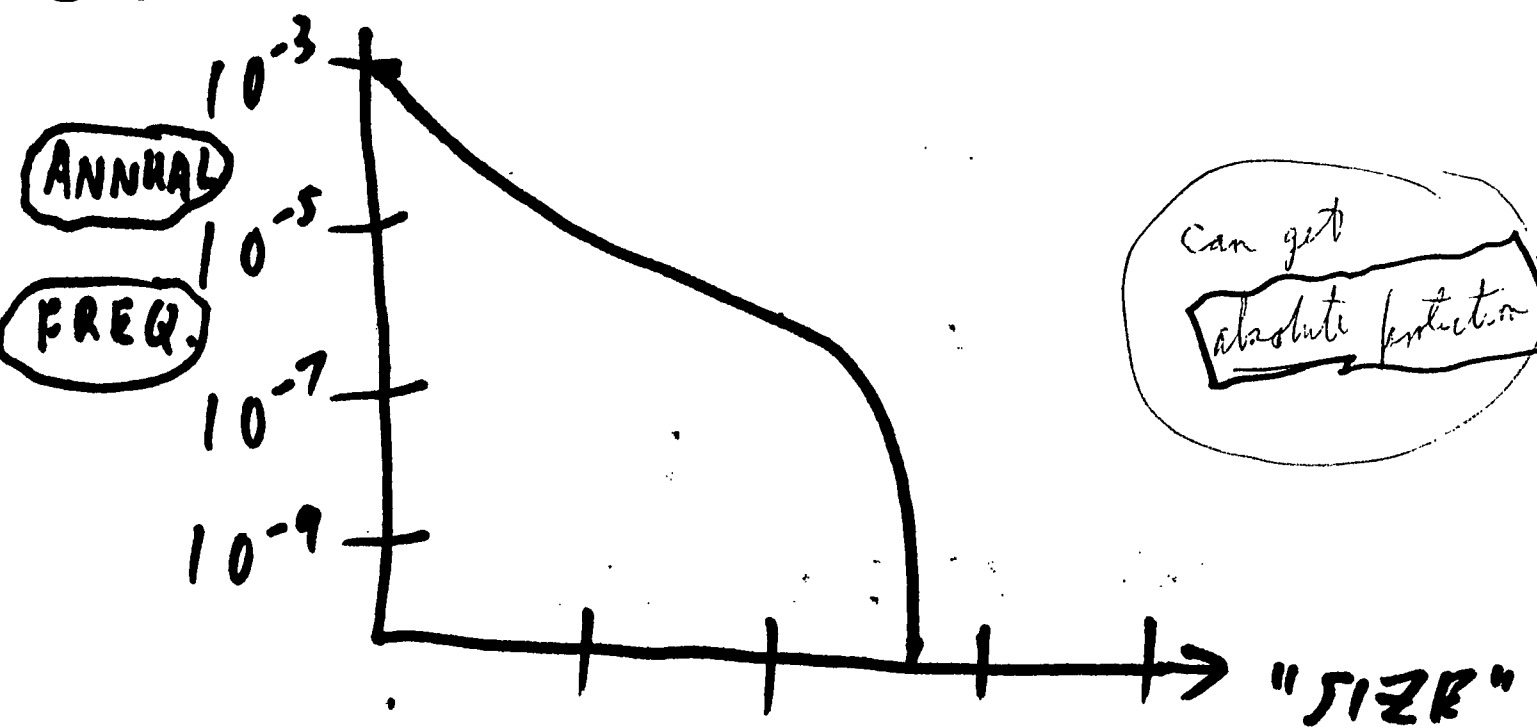
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ROBERT J. BUDNITZ, Ph.D.  
President

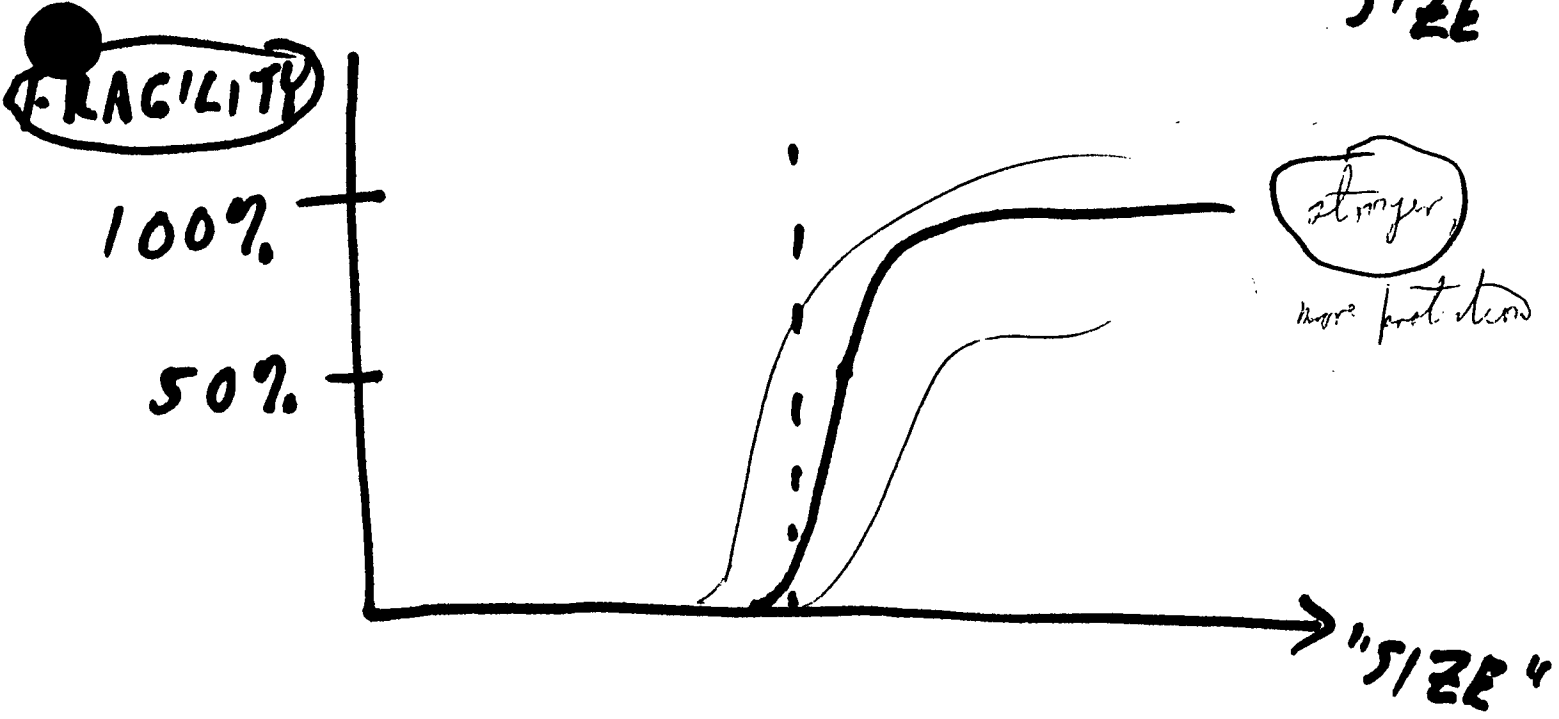
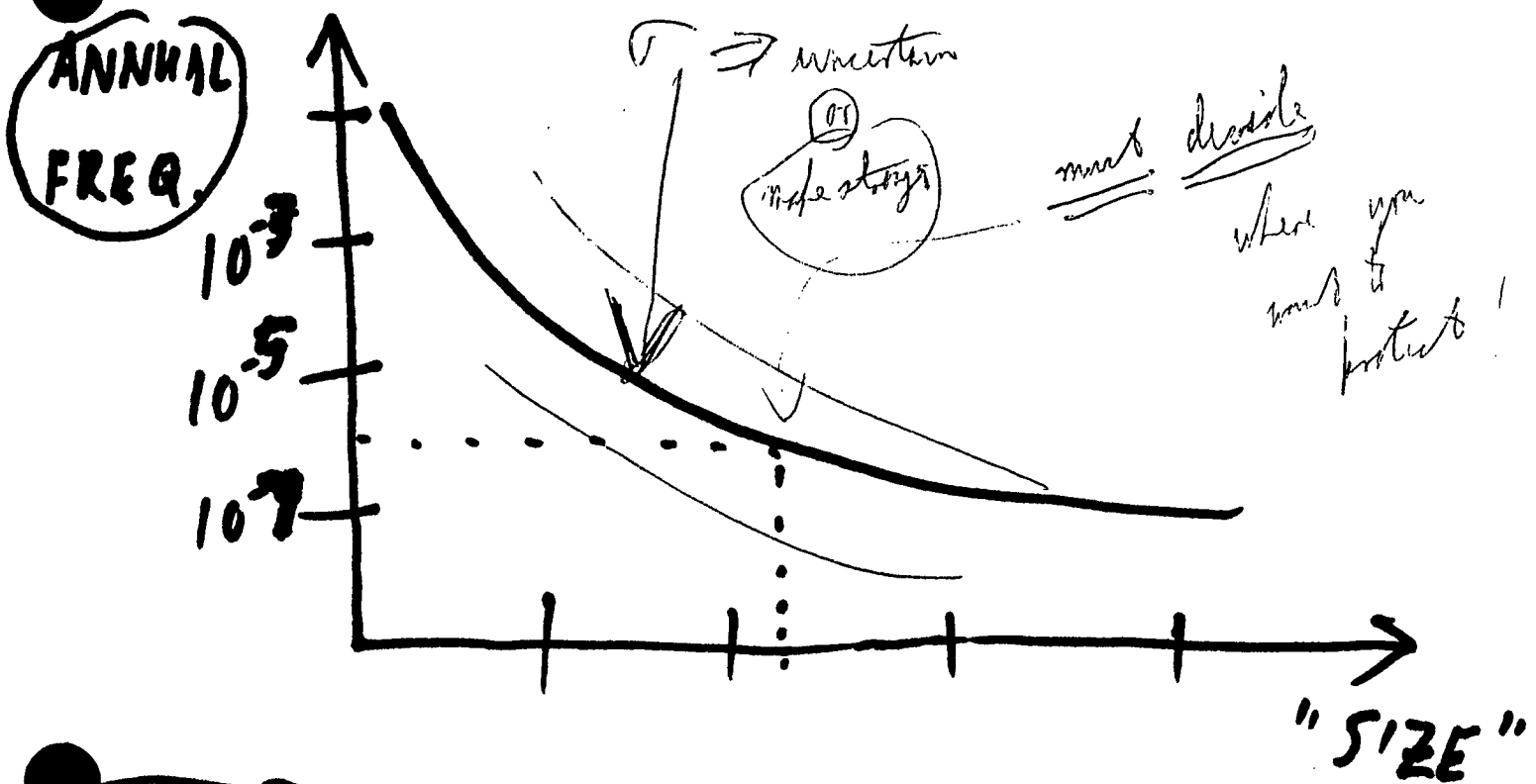
2039 Shattuck Ave Suite 402 Berkeley, CA 94704  
Tel: 510-644-2700 Fax: 510-644-1117



# IF "MAXIMUM HAZARD"

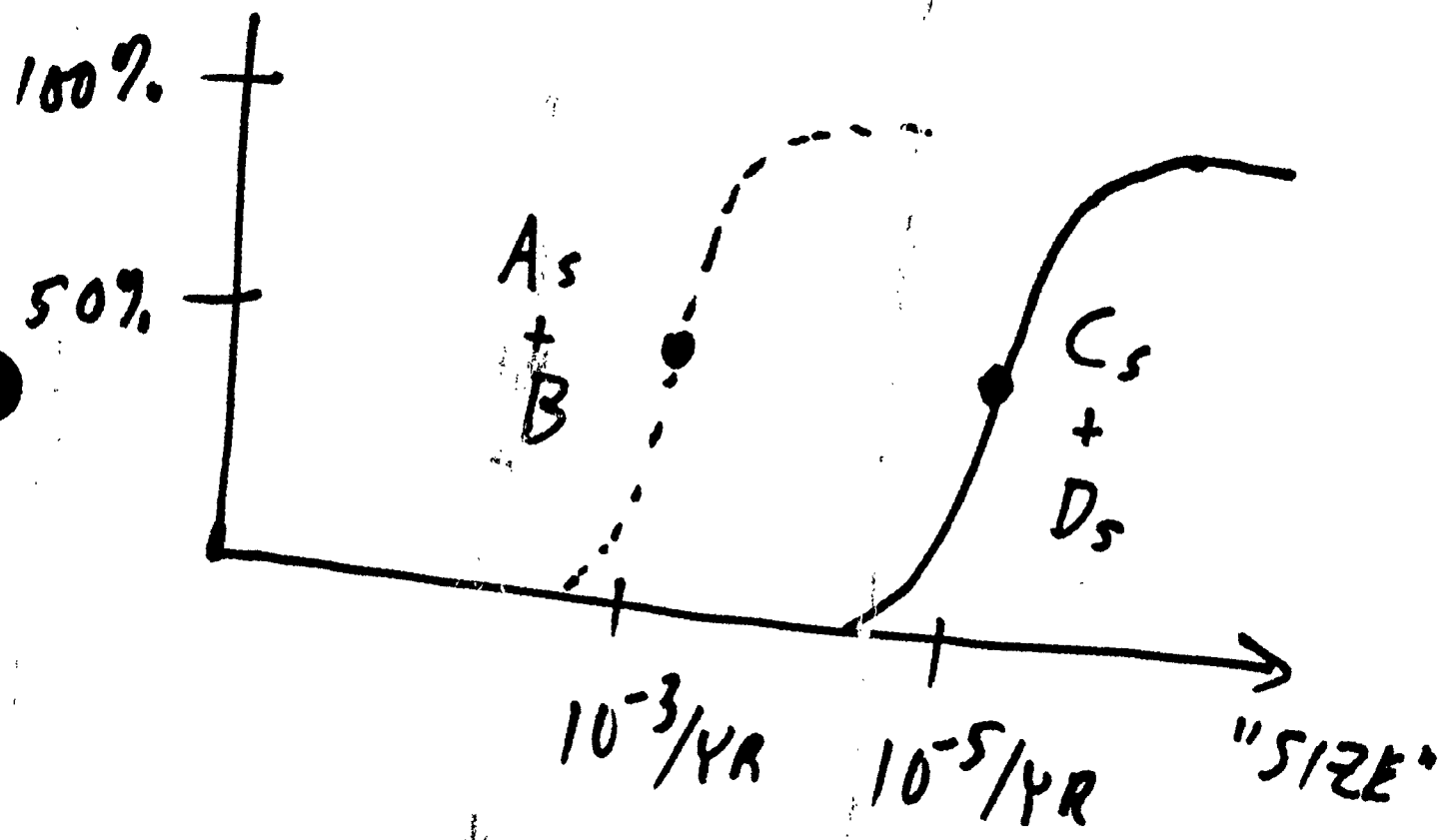


# IF NO "MAXIMUM HAZARD"



CITR PLUGS,  
HIGH + DRY

HOW TO DEFINE "FRAGILITY"  
OR "CAPACITY" ?



- IF  $B = 10^{-1}$ , FAILURE =  $10^{-4}/\text{YR}$
- IF  $B = 10^{-2}$ , FAILURE =  $10^{-5}/\text{YR}$
- IF  $B = 10^{-3}$ , FAILURE =  $10^{-6}/\text{YR}$

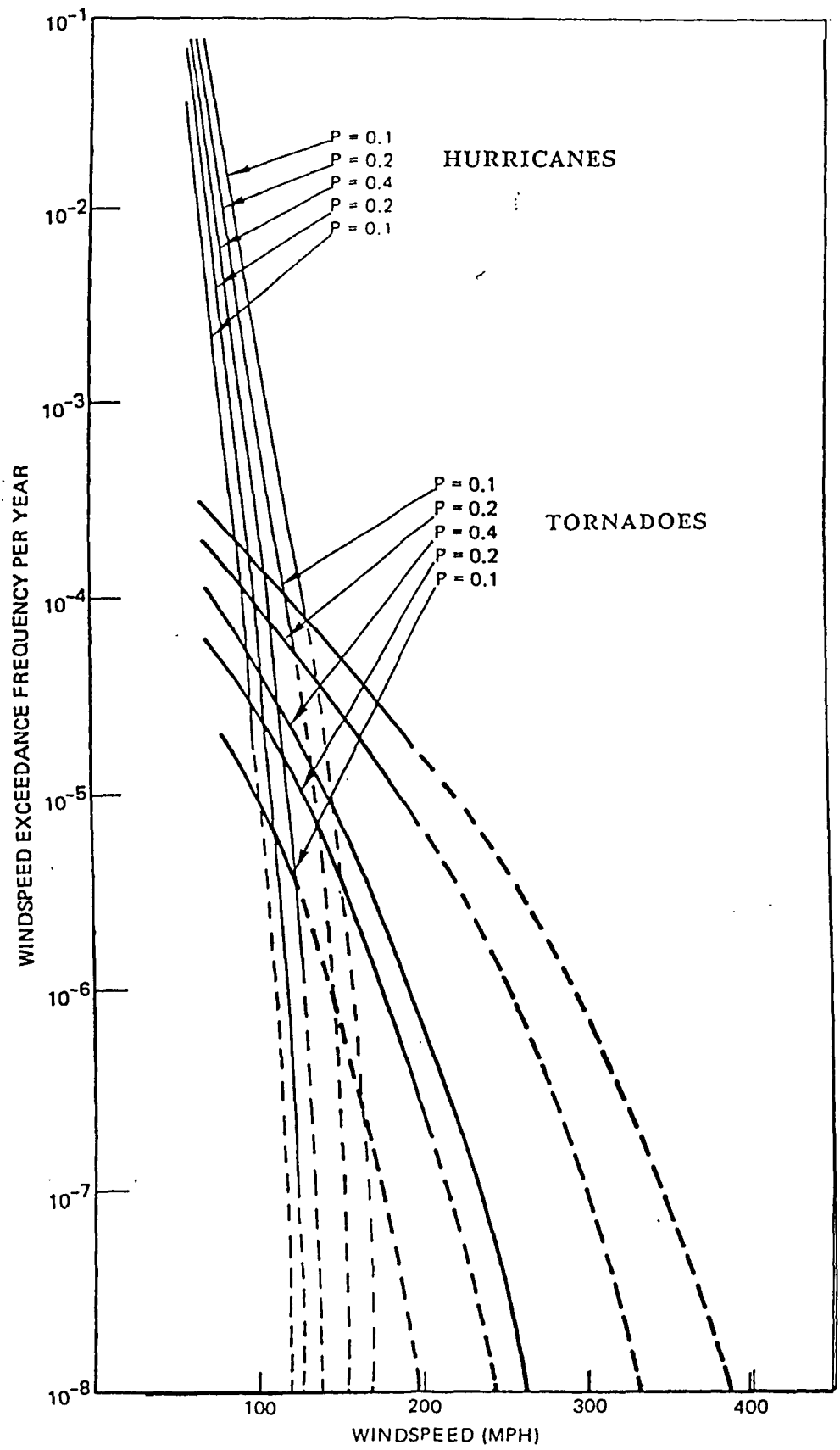


Figure 2.1

Typical wind hazard curve, for the Indian Point site (New York State, U.S.) and taken from the Indian Point PRA. The hurricane and tornado curves have been superimposed on this figure.

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cumulative distribution

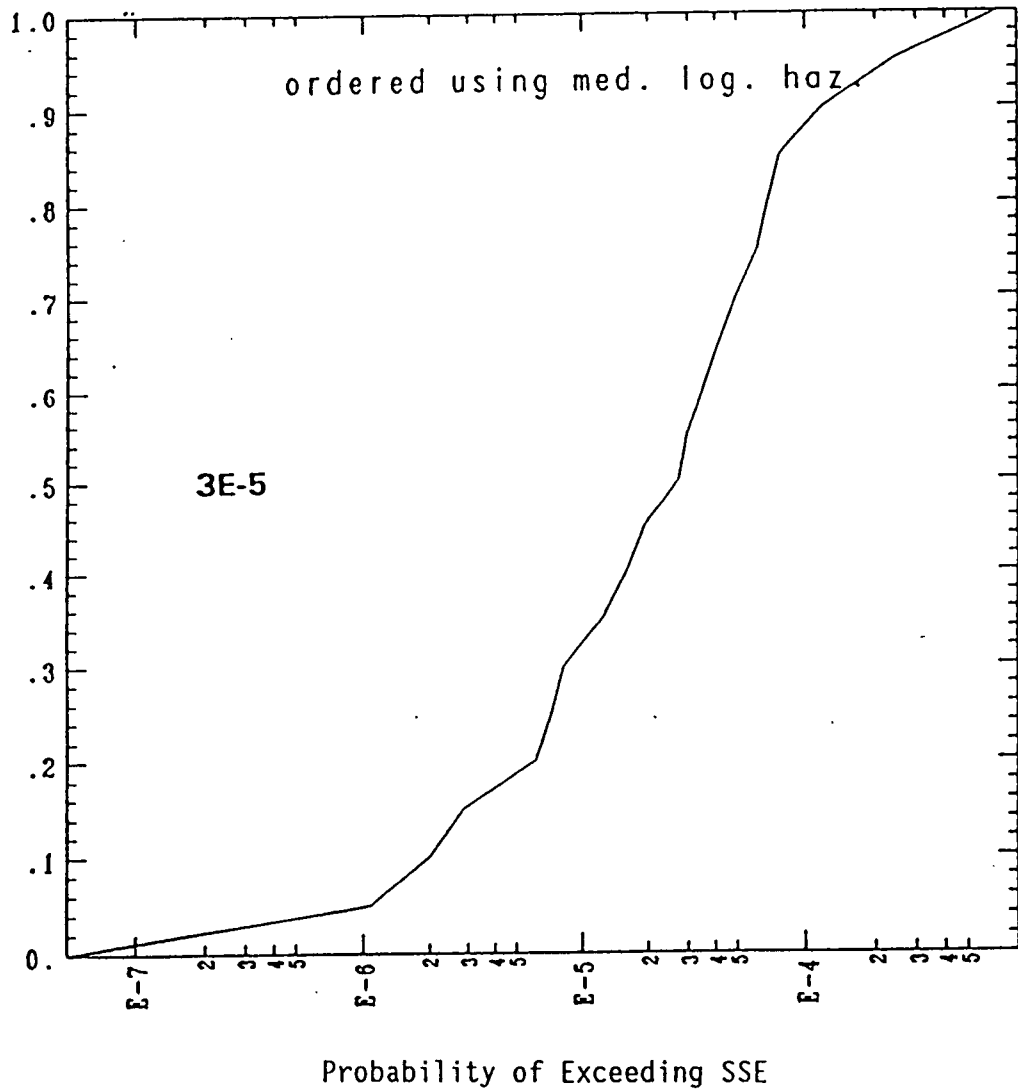


Figure B.4 Probability of Exceeding SSE Using Median EPRI Hazard Estimates

# ● NPPs: ACTUAL CASES

GOAL  $\approx 10^{-6}$ /YR LARGE RELEASE

<u>HAZARD</u>	<u>DESIGN</u>	<u>OUTCOME (PRA)</u>
EQ	$10^{-3} - 10^{-6}$	$10^{-5} - 10^{-6}$
WINDS	$10^{-7}$	$10^{-7}$ (OR BETTER)
FLOODS	$\leq 10^{-3}$	$10^{-6}$ (OR BETTER)
INTERNAL FIRES	$\sim 10^{-3}$ SOME DAMAGE	$10^{-5} - 10^{-6}$

↑  
LOTS OF EXPERT J'MENT

BUT: NPP LICENSING  
IS NOT PROBABILISTIC!

DON'T TRUST IT!

"TRADITIONAL" = "DETERMINISTIC"  
APPROACH

① DESIGN BASIS { EQ  
WIND  
FLOOD

STANDARD  
PROJECT  
FLOOD

② STANDARDS,  
CODES,  
DESIGN RULES

-----> RELY ON  
"MARGINS"

● TODAY'S NPPS:

PRA HAS NO SPECIFIC  
ROLE

FUTURE NPPS:

● PRA USED AS A "CHECK"

DESIGN STAGE

≠ CDF/LARGE RELEASE

ACCEPTABILITY

→ EXPERT  
JUDGMENT



Y. MTN:

STANDARDS? (NO IDEA)

A BIT DISINGENUOUS

POSTULATE:

① PERFORMANCE-BASED

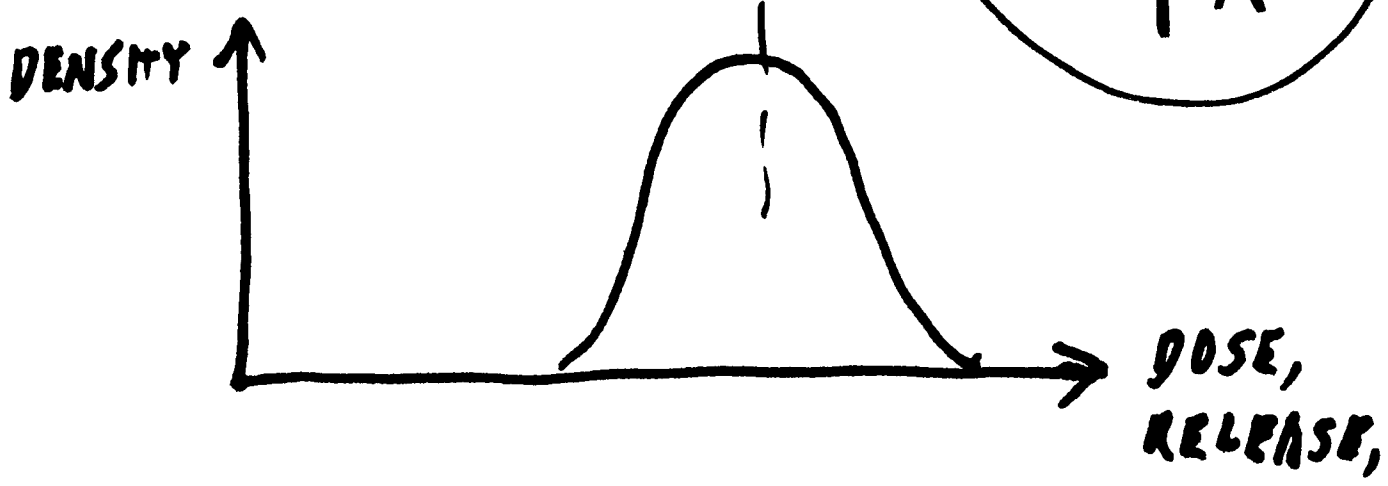
② PROBABILISTIC

③ INEVITABLY ...

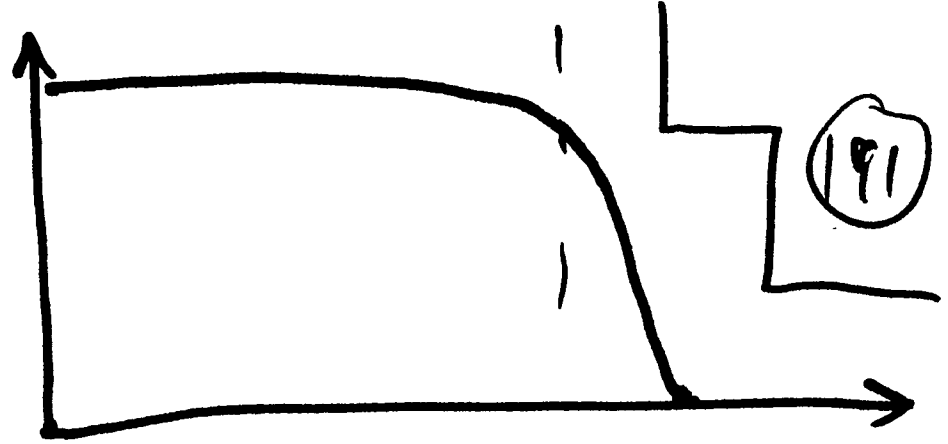
EXPERT JUDGMENTS!

Y. MTN:

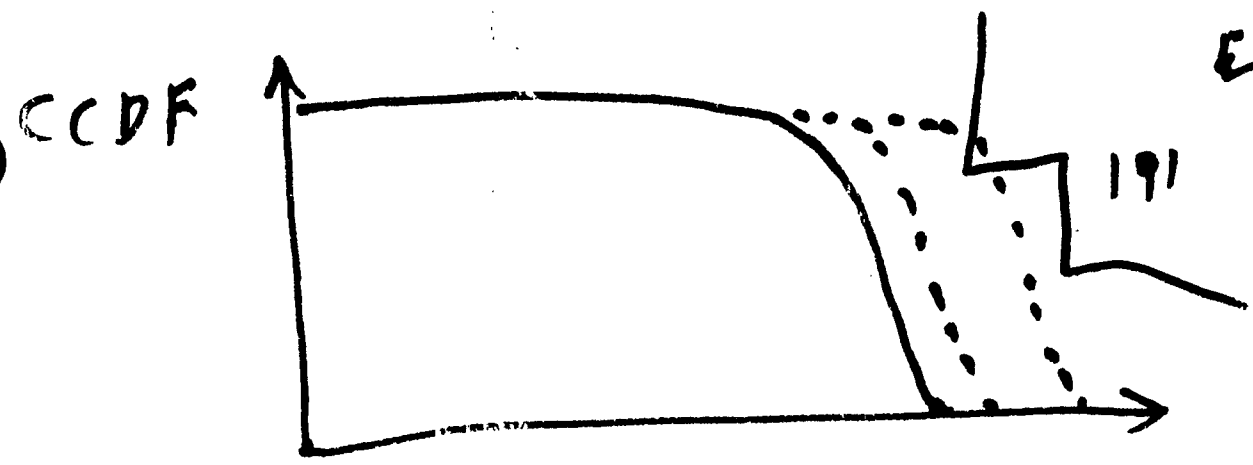
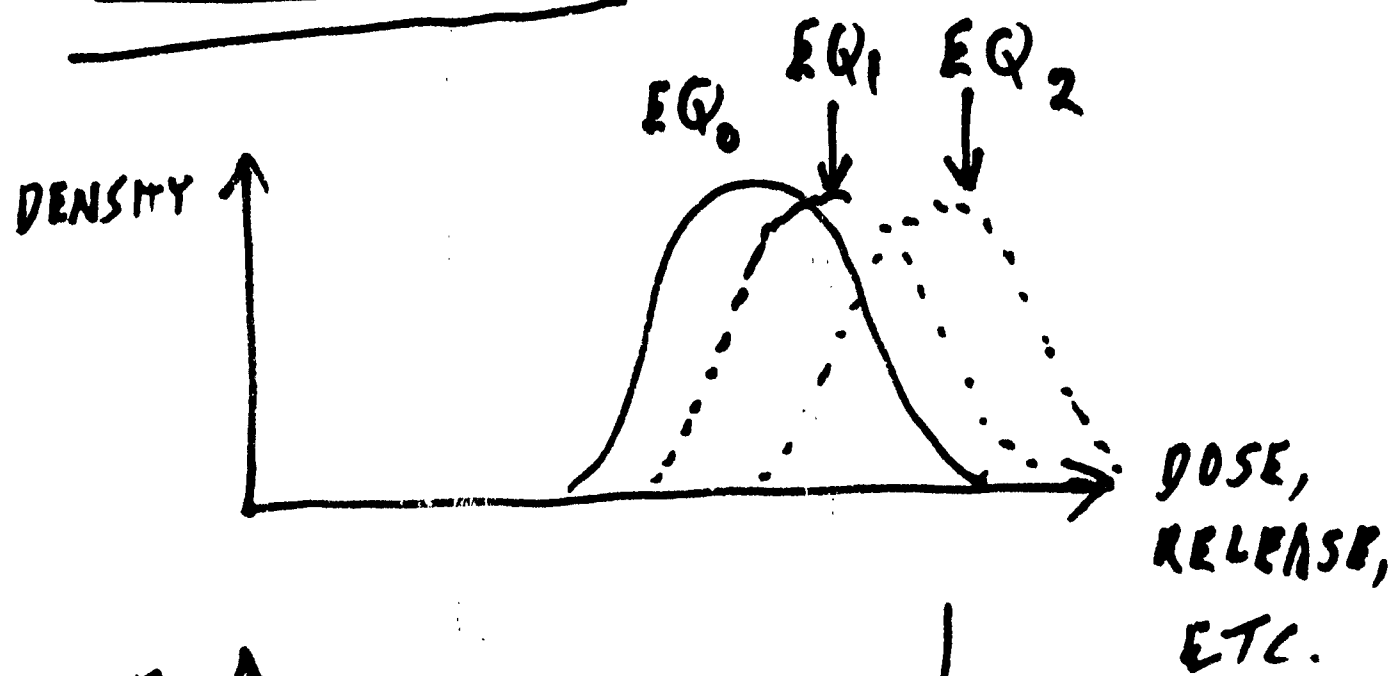
EXPLAIN  
PA



CCDF



# Y. MTN:

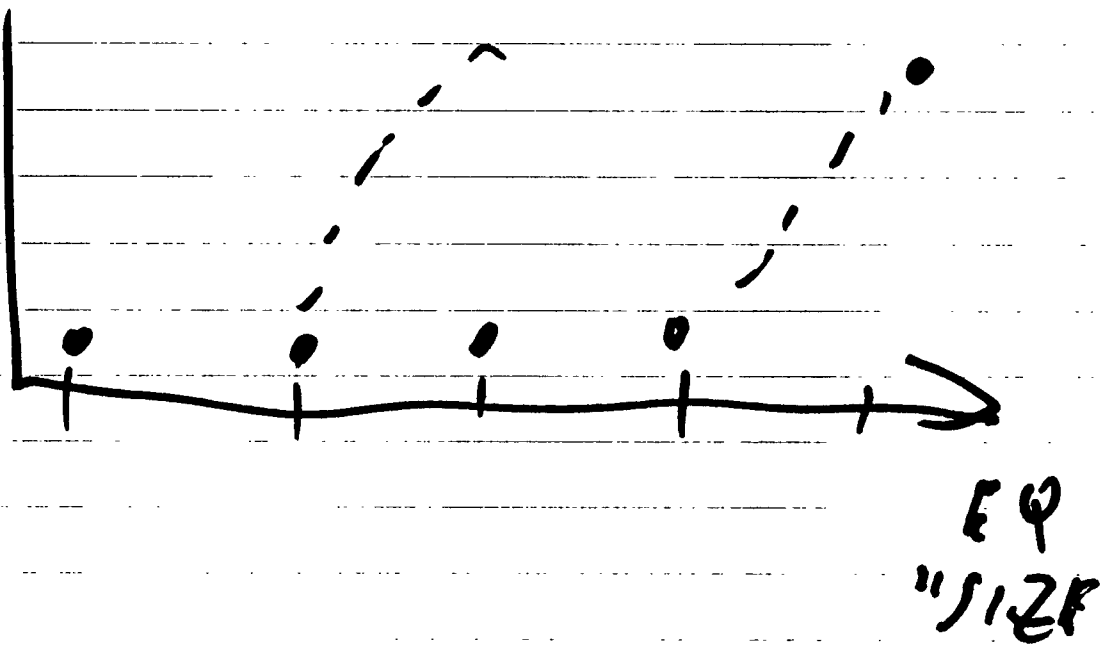
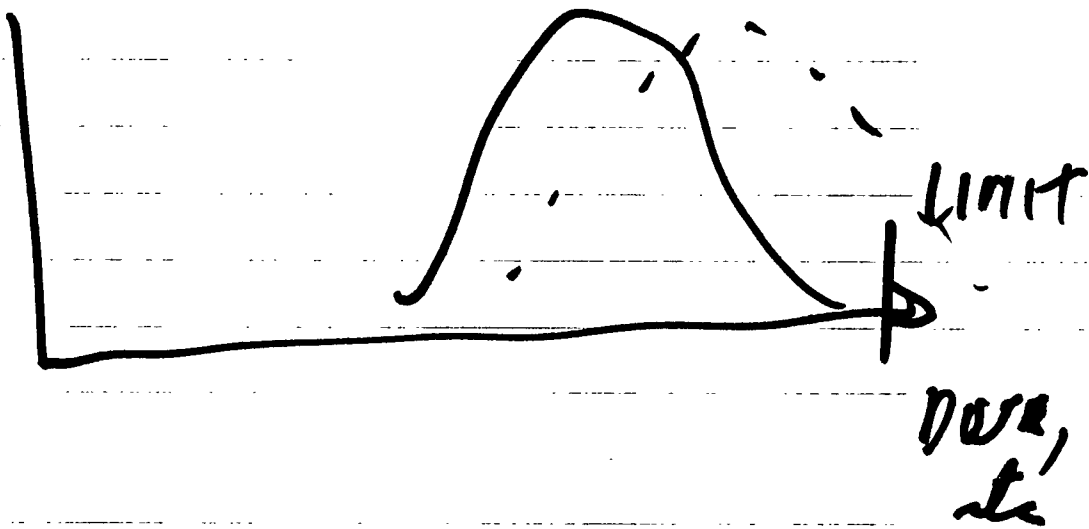


- EQ<sub>0</sub> = NO EQ
- EQ<sub>1</sub> = 10<sup>-3</sup>/YEAR
- EQ<sub>2</sub> = 10<sup>-5</sup>/YEAR

?

WE NEED A

SEISMIC PA!



● RUN EACH EQ<sub>i</sub> SEPARATELY? 13

WEIGHTED SUM?

IF EQ<sub>1</sub> =  $10^{-3}$ /YR, EXPECT 10  
IN 10,000  
YRS

● IF EQ<sub>3</sub> =  $10^{-5}$ /YR, EXPECT 1/10  
IN 10,000  
YRS

MEANING OF "CAPACITY"?

FUZZY

● IS ANYONE DOING  
THESE ANALYSES?

● DESIGN FOR LARGEST EQ  
 IN 10,000 OR 100,000  
 YEARS ?

10<sup>-4</sup> over  
 10<sup>-6</sup> 1/100

100 IN ?  
 σ ?  
 MEAN ?

DESIGN FOR SOME "RISK"  
 INDEX ?

DESIGN TIED TO PA ?  
 (OR)  
 DESIGN INDEPENDENT OF PA ?

WHAT CAN BE  
 "CONTROLLED"  
 IN THE DESIGN ?