1948

NRR STAFF PRESENTATION TO THE ACRS

SUBJECT: Risk Analysis Results and Conclusions

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B/352

Risk Characterization

- Risk for each accident estimated based on frequency of fuel uncovery and SFP consequence estimates
- Fuel uncovery assumed to result in SFP fire (large release)
- Consequences assigned based on either early or late evacuation cases, depending on factors affecting EP
  - effectiveness of offsite notification
  - fission product release times relative to evacuation times
- Evacuation modeled as follows:

Event	Full EP	Relaxed EP
Seismic	Late	Late
Cask Drop	Early (for t > 4-5 h)	Early (for t > 10 h)
Boildown	Late	Late

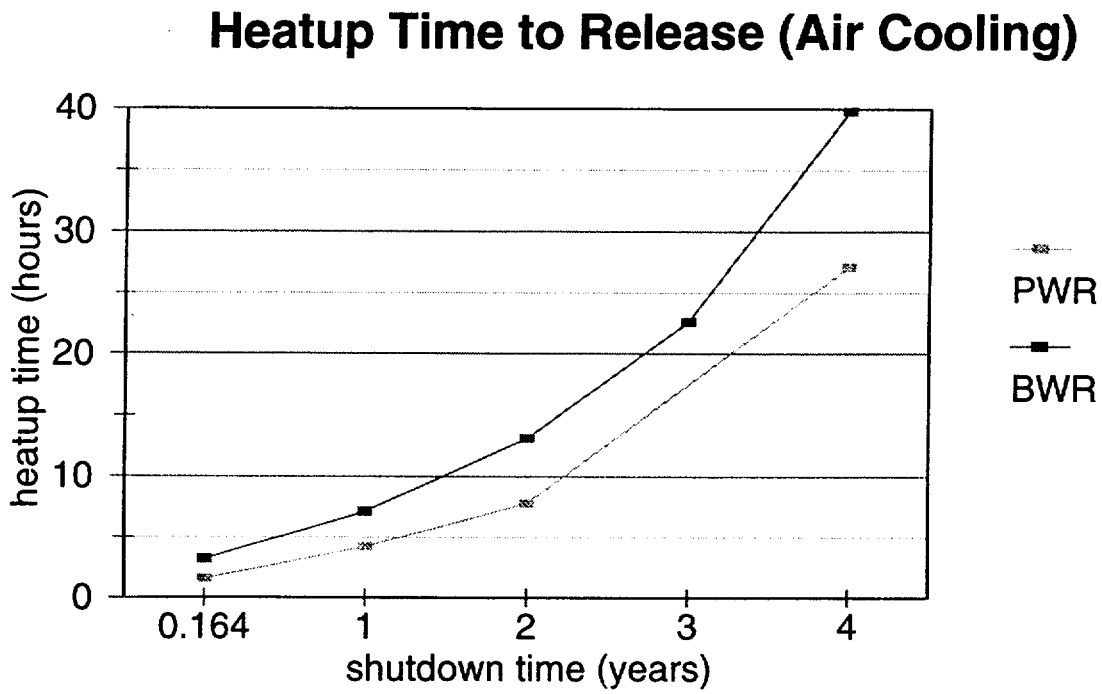

Figure 2.1 Heatup time from 30 °C to 900 °C

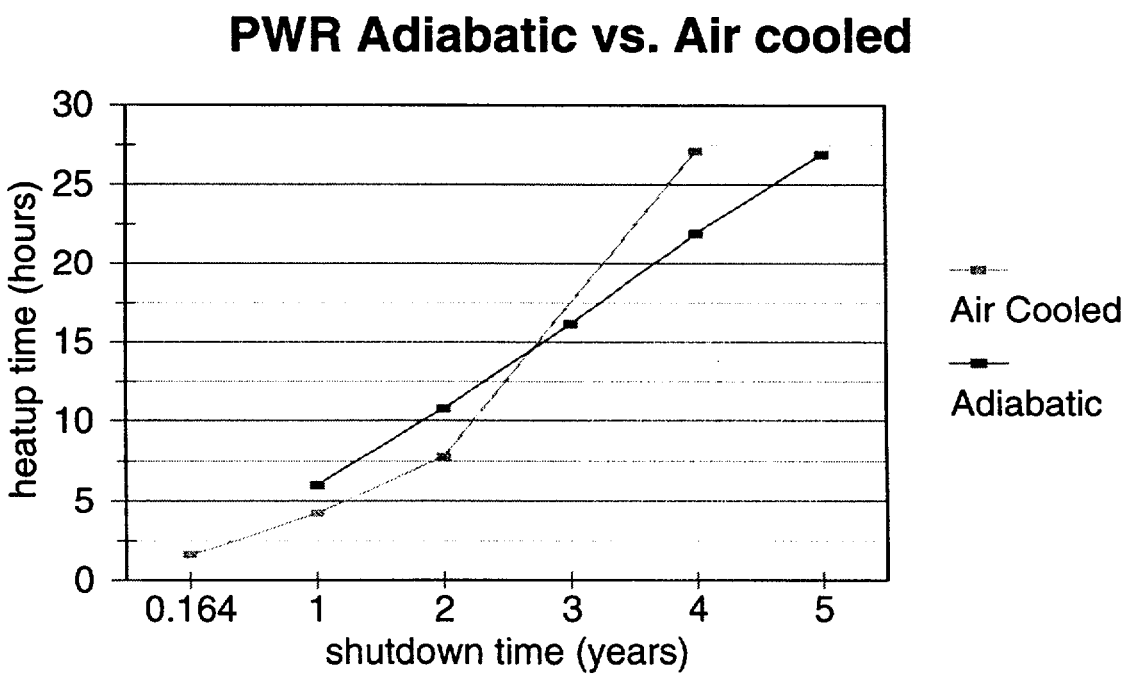

Figure 2.2 PWR heatup times for air cooling and adiabatic heatup.

Rationale for Evacuation Modeling

- **Seismic**
  - for ground motion corresponding to SFP failure, there would be extensive collateral damage within the emergency planning zone (electric power, structures, roads, bridges)
  - radiological pre-planning would have marginal impact because of impairment by offsite damage

- **Cask Drop**
  - unambiguous indication of event; intact infrastructure for emergency response
  - Full EP: evacuation credited when > 4-5 hours delay time (1 year after shutdown and beyond)
  - Relaxed EP: evacuation credited when > 10 hours delay time (5 years after shutdown and beyond)

- **Boildown**
  - failure paths involve failure to acquire offsite resources to provide SFP makeup
  - failure to contact offsite authorities or implement effective response also expected for the same reasons

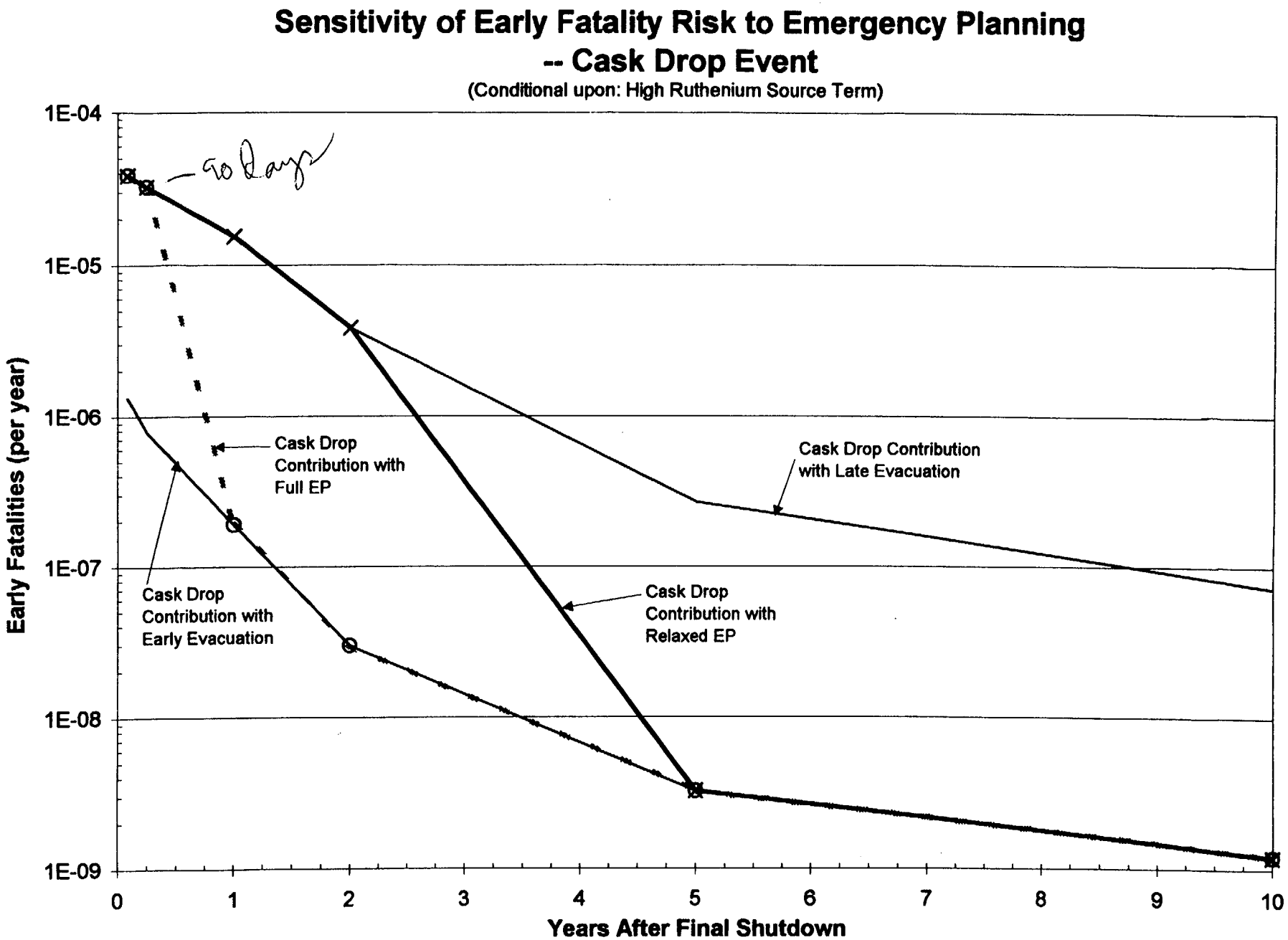
Sensitivity of Early Fatality Risk to Emergency Planning
-- Cask Drop Event
(Conditional upon: High Ruthenium Source Term)
Early Fatalities (per year)
1E-04
1E-05
1E-06
1E-07
1E-08
1E-09
0
1
2
3
4
5
6
7
8
9
10
Years After Final Shutdown
90 Days
Cask Drop Contribution with Full EP
Cask Drop Contribution with Late Evacuation
Cask Drop Contribution with Early Evacuation
Cask Drop Contribution with Relaxed EP

Figure 3.7-5

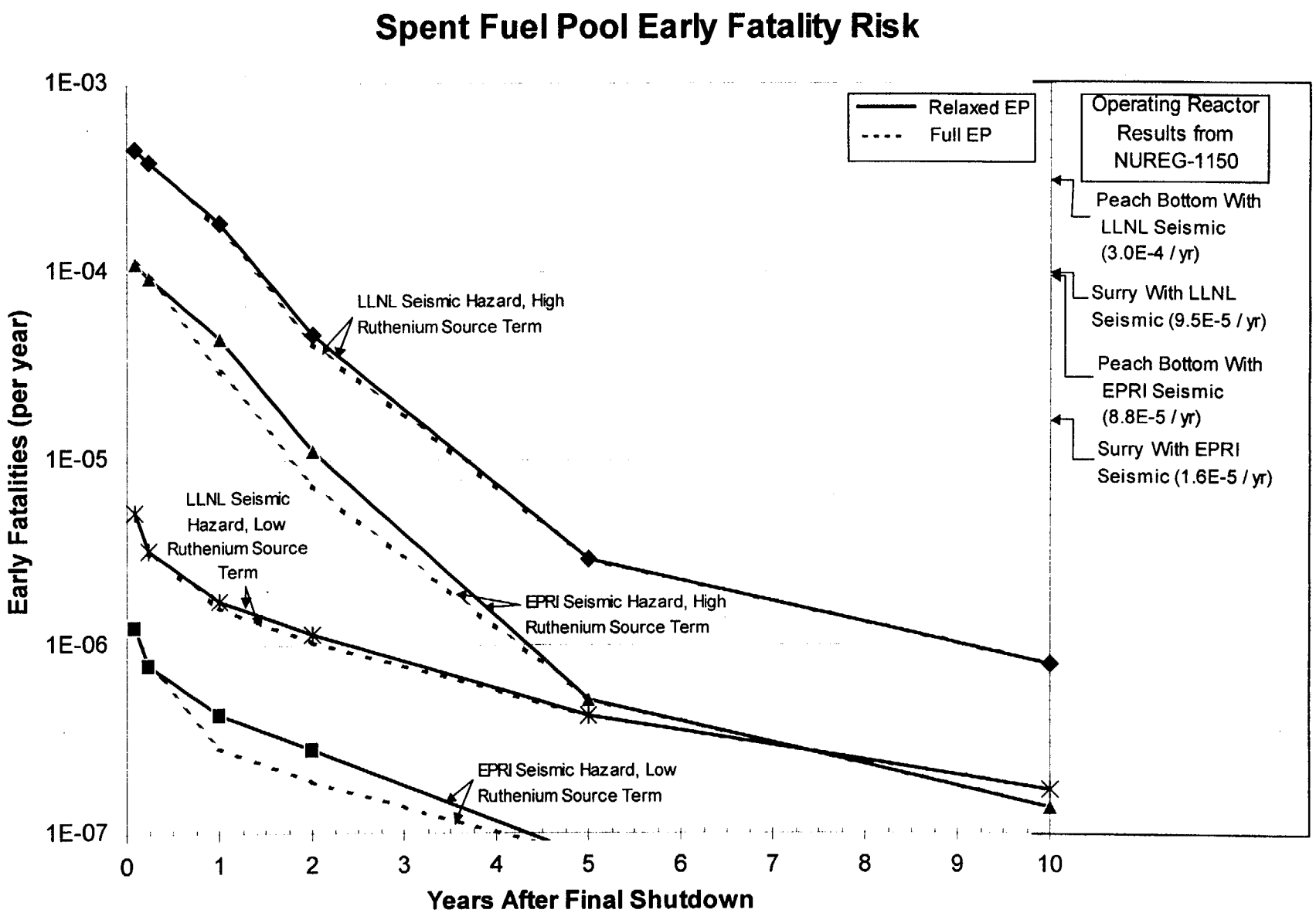
Spent Fuel Pool Early Fatality Risk
Early Fatalities (per year)
1E-03
1E-04
1E-05
1E-06
1E-07
0
1
2
3
4
5
6
7
8
9
10
Years After Final Shutdown
Relaxed EP
Full EP
Operating Reactor Results from NUREG-1150
Peach Bottom With LLNL Seismic (3.0E-4 / yr)
Surry With LLNL Seismic (9.5E-5 / yr)
Peach Bottom With EPRI Seismic (8.8E-5 / yr)
Surry With EPRI Seismic (1.6E-5 / yr)
LLNL Seismic Hazard, High Ruthenium Source Term
LLNL Seismic Hazard, Low Ruthenium Source Term
EPRI Seismic Hazard, High Ruthenium Source Term
EPRI Seismic Hazard, Low Ruthenium Source Term

Figure 3.7-3

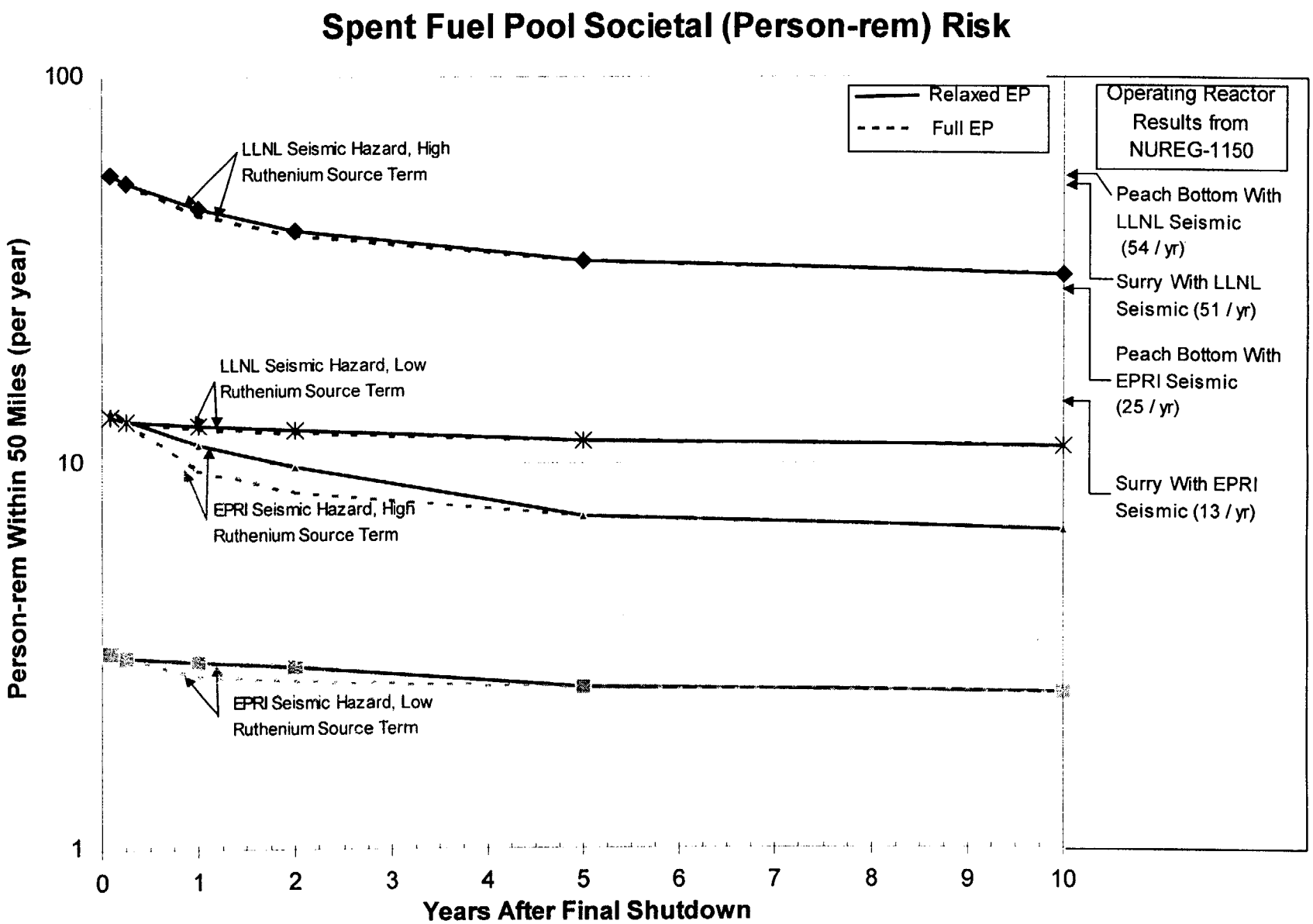
Spent Fuel Pool Societal (Person-rem) Risk
Person-rem Within 50 Miles (per year)
100
10
1
0
1
2
3
4
5
6
7
8
9
10
Years After Final Shutdown
Relaxed EP
Full EP
Operating Reactor Results from NUREG-1150
LLNL Seismic Hazard, High Ruthenium Source Term
LLNL Seismic Hazard, Low Ruthenium Source Term
EPRI Seismic Hazard, High Ruthenium Source Term
EPRI Seismic Hazard, Low Ruthenium Source Term
Peach Bottom With LLNL Seismic (54 / yr)
Surry With LLNL Seismic (51 / yr)
Peach Bottom With EPRI Seismic (25 / yr)
Surry With EPRI Seismic (13 / yr)

Figure 3.7-4

Risk Conclusions

- For the first 1 to 2 years, the early fatality risk for a SFP fire is low, but comparable to that for a severe accident in an operating reactor. At 5 years following shutdown, the early fatality risk for SFP accidents is approximately two orders of magnitude lower than for a reactor accident

- Societal risk for a SFP fire is also comparable to that for a severe accident in an operating reactor, but does not exhibit a substantial reduction with time due to the slower decay of fission products and the interdiction modeling assumptions that drive long term doses

- Changes to EP requirements affect only the cask drop accident, and do not substantially impact either the total risk or the margin between SFP risk and operating reactor risk due to the low frequency of cask drop accidents

Risk Conclusions (continued)

- Use of the low ruthenium source term reduces early fatality risk by about a factor of 100 (relative to the high ruthenium source term) within the first 1 to 2 years, and by about a factor of 10 at 5 years and beyond

- With the low ruthenium source term, the early fatality risk for SFP accidents is about an order of magnitude lower than the corresponding values for a reactor accident shortly following shutdown, and about two orders of magnitude lower at 2 years following shutdown

- With the low ruthenium source term, the societal risk for SFP accidents is also about an order of magnitude lower than the corresponding values for a reactor accident shortly following shutdown, but does not exhibit a substantial reduction with time due to the slower decay of fission products and the interdiction modeling assumptions

- The above observations are valid regardless of whether seismic event frequencies are based on the LLNL or the EPRI seismic hazard study.

Comparisons to the Safety Goals

- Both the Individual Early Fatality Risk and the Individual Latent Cancer Fatality Risk for a SFP accident are about one to two orders of magnitude lower than the Commission's Safety Goal, depending on assumptions regarding the SFP accident source term and seismic hazard
  - At upper end (LLNL seismic hazard estimates and high ruthenium source term) the risks are somewhat lower than the corresponding risks for reactor accidents, and about a decade lower than the Safety Goal
  - At lower end (EPRI seismic hazard estimates and low ruthenium source term) the risks are lower than those for reactor accidents, and about 2 decades lower than the Safety Goal

- The Individual Early Fatality Risk for a SFP accident decreases with time, and is about a factor of 5 lower at 5 years following shutdown (relative to the value at 30 days)

- The Individual Latent Cancer Fatality Risk is not substantially reduced with time due to the slower decay of fission products and the interdiction modeling assumptions that drive long term doses

- Changes to EP requirements, as modeled, do not substantially impact the margin between SFP risk and the Safety Goals due to the low frequency of events for which EP would be effective

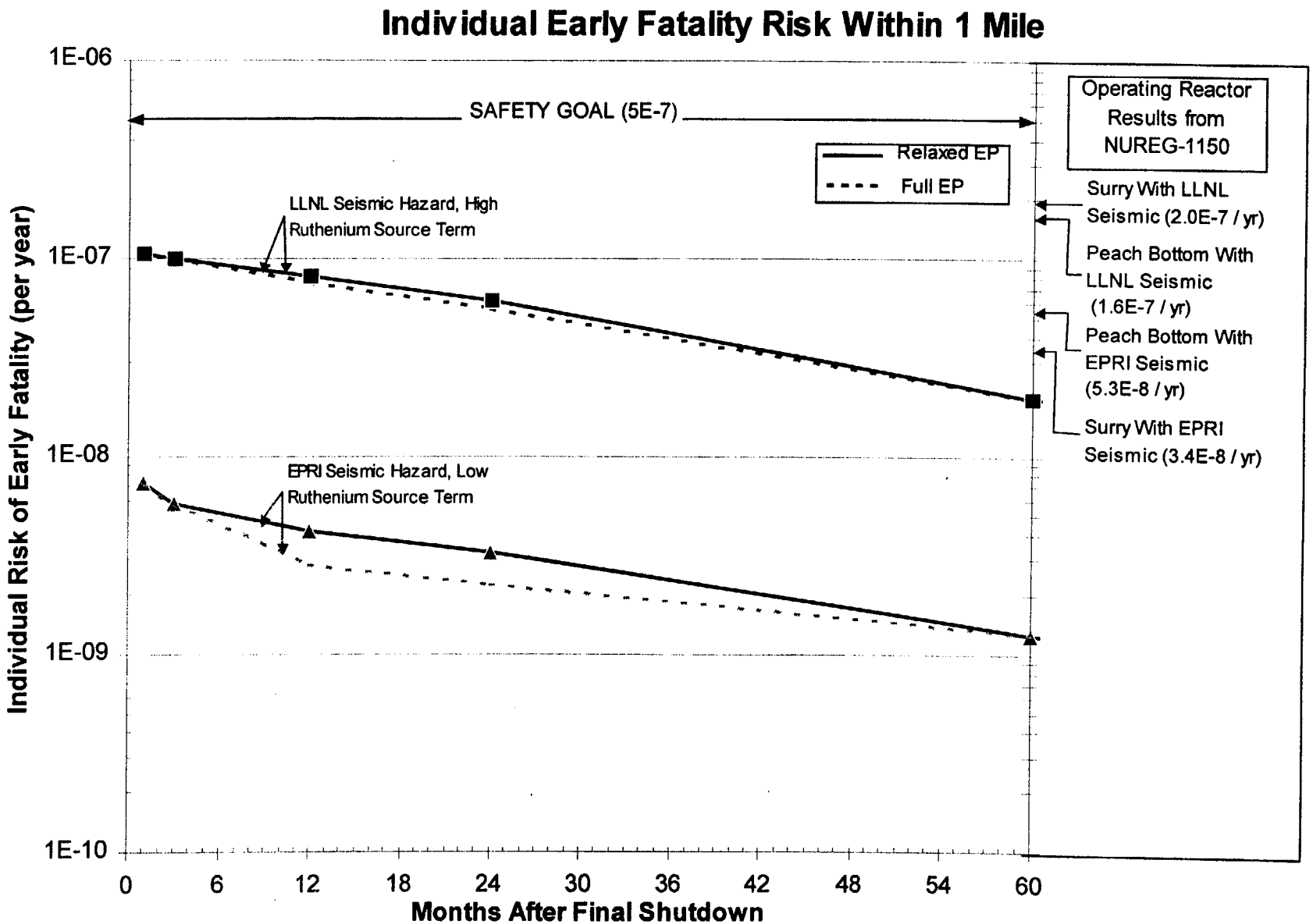
Individual Early Fatality Risk Within 1 Mile
1E-06
1E-07
1E-08
1E-09
1E-10
Individual Risk of Early Fatality (per year)
SAFETY GOAL (5E-7)
Relaxed EP
Full EP
Operating Reactor Results from NUREG-1150
LLNL Seismic Hazard, High Ruthenium Source Term
EPRI Seismic Hazard, Low Ruthenium Source Term
Surry With LLNL Seismic (2.0E-7 / yr)
Peach Bottom With LLNL Seismic (1.6E-7 / yr)
Peach Bottom With EPRI Seismic (5.3E-8 / yr)
Surry With EPRI Seismic (3.4E-8 / yr)
0
6
12
18
24
30
36
42
48
54
60
Months After Final Shutdown

Figure 3.7-7

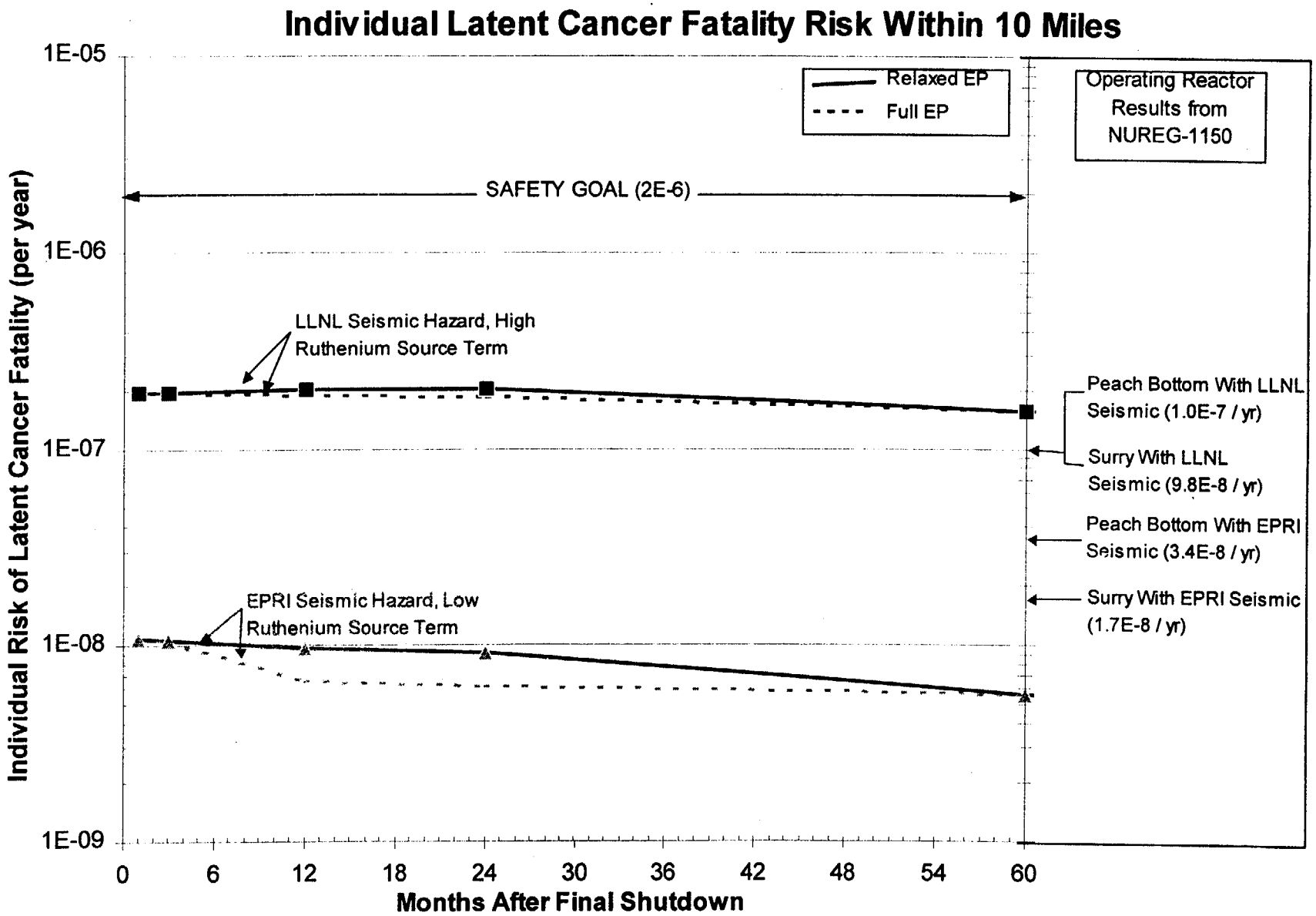
Individual Latent Cancer Fatality Risk Within 10 Miles
Relaxed EP
Full EP
Operating Reactor Results from NUREG-1150
SAFETY GOAL (2E-6)
LLNL Seismic Hazard, High Ruthenium Source Term
EPRI Seismic Hazard, Low Ruthenium Source Term
Peach Bottom With LLNL Seismic (1.0E-7 / yr)
Surry With LLNL Seismic (9.8E-8 / yr)
Peach Bottom With EPRI Seismic (3.4E-8 / yr)
Surry With EPRI Seismic (1.7E-8 / yr)
Individual Risk of Latent Cancer Fatality (per year)
1E-05
1E-06
1E-07
1E-08
1E-09
0
6
12
18
24
30
36
42
48
54
60
Months After Final Shutdown

Figure 3.7-8

Comparison to RG 1.174 Principles
1. Small Increases in Risk

- A SFP facility that conforms with IDCs and SDAs would meet the QHOs by one to two orders of magnitude shortly after shutdown, and with greater margins at later times
- Risk increases associated with EP relaxations are small, even under optimistic assumptions regarding the value of EP in seismic events, and the QHOs continue to be met with margin
- Continued conformance with IDCs and SDAs provides reasonable assurance that the SFP risk and risk increases associated with regulatory changes would remain small

for worst case / consequence for Surry

Table 4 - Comparison of Risk Increase with RG 1.174 Guideline (at one year)

Risk Measure	Risk Increase Due to EP Relaxation (per year)		RG 1.174 Guideline Risk Increase (per year)
	Baseline [1]	Seismic Sensitivity [2]	
Early Fatalities	1.5×10^{-5}	1.6×10^{-4}	2.5×10^{-4}
Population Dose	1.6	17.6	11
Individual Early Fatality Risk	6.6×10^{-9}	7.3×10^{-8}	8.7×10^{-8}
Individual Latent Cancer Fatality Risk	1.6×10^{-8}	1.8×10^{-7}	6.9×10^{-8}

10% QA

<10%

<10%

1 - Assumes no effective evacuation in seismic events, regardless of pre-planning

2 - Assumes maximum effectiveness of emergency planning (i.e., early evacuation) when EP requirements are maintained, and minimum effectiveness (i.e., late evacuation) when EP requirements are relaxed

Comparison to RG 1.174 Principles
2. Defense-in-Depth

- Remaining EP requirements, together with the substantial amount of time available for emergency response will provide a sufficient level of defense-in-depth for SFP accidents

- In the large seismic events that dominate SFP risk, current EP would be of marginal value due to extensive collateral damage offsite. Accordingly, relaxations in EP requirements are not expected to substantially alter the outcome from such a large seismic event

- In those sequences in which current EP would be effective, such as cask drop accidents, a comparable level of protection should continue to be provided though remaining requirements for on-site EP and the capability to implement offsite protective actions on an ad hoc basis.

Comparison to RG 1.174 Principles
3. Safety Margins

- A SFP facility that conforms with IDCs and SDAs would meet the QHOs by one to two orders of magnitude shortly after shutdown, and with greater margins at later times

- A SFP facility maintained at or below the recommended PPG would continue to meet the QHOs for even the most severe source term.

- The estimated risk increases associated with the EP relaxations are well below the values developed from the RG 1.174 LERF criteria (by about a factor of 10)

- Even under optimistic assumptions regarding the value of EP in seismic events, the change in risk associated with EP relaxations is relatively small
  - increases in early fatalities and individual early fatality risk remain below the maximum allowable for each risk measure
  - population dose and individual latent cancer fatality risk are about a factor of two higher than the allowable value inferred from RG 1.174, however, the increase in individual latent cancer risk represents less than 10 percent of the QHO

Comparison to RG 1.174 Principles
4. Monitoring Program

- The following monitoring should continue following decommissioning in order to assure SFP risk remains low:
  - Performance and reliability monitoring of the SFP systems, heat removal, AC power and inventory should be carried out similar to the provisions of the maintenance rule (10 CFR 50.65)
  - The current monitoring programs identified in licensee's responses to Generic Letter 96-04 with respect to monitoring of the Boraflex absorber material should be maintained by decommissioning plants until all fuel is removed from the SFP (SDA #7)
  - Heavy load activities and load paths should be monitored and controlled by the licensee (IDC # 1)
  - Licensees should continue to provide a level of onsite capabilities to assure prompt notification of offsite authorities, characterization of potential releases, development of protective action recommendations and communication with the public. These capabilities should be monitored by holding periodic onsite exercises and drills
- Continued compliance with the maintenance rule, the IDCs, and the SDAs, together with remaining requirements related to onsite EP provides a reasonable level of monitoring of SFP safety

Pool Performance Guideline (PPG)

- PPG provides threshold for controlling risk from decommissioning plant SFP

- PPG of 1E-5/y proposed in February 2000 report was reassessed in view of SFP source term issues

- Based on further evaluation, PPG of 1E-5/y is appropriate -- by maintaining fuel uncovery frequency less than PPG:
  - zirconium fires remain unlikely
  - risk will continue to meet Commission's Safety Goals
  - small increases in risk may be permitted

- Plants that conform with Industry Decommissioning Commitments (IDCs) and Staff Decommissioning Assumptions (SDAs) will have SFP accident frequencies consistent with reference plant analysis and meet PPG (with exception of high seismic sites)

- Plants that do not meet IDCs and SDAs (including high seismic sites) would need to demonstrate compliance with PPG on plant-specific basis

Comparison of Spent Fuel Pool Accident Risk One Year After Shutdown with Quantitative Health Objectives (QHOs)

Case	QHO for Individual Risk of Prompt Fatality					QHO for Societal Risk of Latent Cancer Fatality				
	Ind. Early Fatality Risk (per event)	PPG (events per year)	Prob of Early Fatality (per year)	QHO (per year)	% of QHO	Ind. Latent C. Fatality Risk (per event)	PPG (events per year)	Prob of Latent C. Fatality (per year)	QHO (per year)	% of QHO
Low Ruthenium Source Term, Early Evacuation	5.44E-4	1E-5	5.44E-9	5E-7	1	9.09E-4	1E-5	9.09E-9	2E-6	<1
Low Ruthenium Source Term, Late Evacuation	7.13E-3	1E-5	7.13E-8	5E-7	14	1.68E-2	1E-5	1.68E-7	2E-6	8
High Ruthenium Source Term, Early Evacuation	1.50E-3	1E-5	1.50E-8	5E-7	3	4.33E-3	1E-5	4.33E-8	2E-6	2
High Ruthenium Source Term, Late Evacuation	3.46E-2	1E-5	3.46E-7	5E-7	69	8.49E-2	1E-5	8.49E-7	2E-6	42
Worst Source Term in App. 4A, Late Evacuation	3.66E-2	1E-5	3.66E-7	5E-7	73	5.16E-2	1E-5	5.16E-7	2E-6	26