UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
WASHINGTON, D. C. 20555

September 19, 1997

The Honorable Shirley Ann Jackson
Chairman
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Dear Chairman Jackson:

SUBJECT: SITE-TO-SITE VARIATION IN RISK-BASED REGULATORY ACCEPTANCE CRITERIA FOR PLANT-SPECIFIC APPLICATION OF SAFETY GOALS

In the Staff Requirements Memorandum dated May 27, 1997, the Commission requested that the ACRS determine the change in core damage frequency (CDF) and large, early release frequency (LERF) from site-to-site when these lower-tier criteria are derived from the individual early fatality quantitative health objective (QHO). In response to this Commission request, during the 443rd and 444th meetings of the Advisory Committee on Reactor Safeguards, July 9-11 and September 3-5, 1997, we discussed the plant-specific application of NRC Safety Goals and derivation of subsidiary criteria. These criteria would be used in determining the acceptability of proposed changes to the licensing basis. During the discussions, we had the benefit of the documents referenced.

This report discusses the site variability in LERF as a risk-acceptance criterion derived from the individual early fatality QHO. The bases for the conclusions and recommendations in this report are provided in the attached studies. We addressed the CDF criterion in our April 11, 1997 report.

Variability in LERF Criteria Derived from the Safety Goal Individual Early Fatality QHO

In support of preparing our response to the Commission's request, an ACRS Senior Fellow performed a study (Attachment 1) to answer the following questions:

- Is there sufficient site-to-site variability in the site characteristics important to individual early fatality risk to warrant site-specific determination of lower level acceptance criteria - e.g., LERF?
- Can this range of variability be evaluated and bounded?

- Can generic criteria or site-specific criteria be determined using simplified approximate methods?

The range of variability in individual early fatality risk due to the site-to-site variations in the parameters important to individual early fatality risk, such as site-to-site population distribution, wind direction frequency distribution, exclusion zone size, and meteorology record, was evaluated for all U.S. plant sites and was found to be relatively small (a variation of a factor of 4).

This study has been independently reviewed, and although the reviewers had different opinions on some of the details of the analysis, all of the reviewers concurred with the overall conclusion on the magnitude of the variability. Since this variability is much less than the magnitude of uncertainties associated with the probabilistic risk assessment (PRA) calculation of the LERF, this study concluded that the site-to-site variability in individual early fatality risk is insufficient to warrant development of site-specific LERF criteria. Hence, a single LERF criterion can be determined on a generic basis. This is consistent with the approach used by the staff in the draft Regulatory Guide DG-1061, "An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Current Licensing Basis."

We believe that the information provided in the study can be used to bound the variability of site-specific LERFs.

Adequacy of Individual Risk Metric

In addition to the individual risk metric, DG-1061 contains deterministic considerations that include other risk parameters — one of which is "siting factors." A second study, which was performed by an ACRS Senior Fellow (Attachment 2), noted that one such siting factor, site population density, is a robust indicator of total (societal) early fatality risk. Consequently, we recommend that the consideration of siting factors, mentioned in DG-1061 only in passing, be given much greater visibility and prominence as part of the decision making process.

Conclusions and Recommendations

We have determined that there is insufficient site-to-site variability in the factors that influence individual early fatality risk to warrant site-specific differences in the LERF subsidiary criterion.

Large site-to-site variations in the population density result in large variations in total early fatality risk. We recommend that this robust indicator of societal risk be made more explicit and prominent in the criteria to be used in assessing plant-specific changes to the current licensing basis.

Sincerely,

R. L. Seale
Chairman

References:

1. Memorandum dated May 27, 1997, from John C. Hoyle, Secretary, NRC, to John T. Larkins, Executive Director, ACRS, Subject: Staff Requirements - Meeting with the ACRS, May 2, 1997, Commissioners' Conference Room.
2. Report dated November 18, 1996, from T. S. Kress, Chairman, ACRS, to Shirley Ann Jackson, Chairman, NRC, Subject: Plant-Specific Application of Safety Goals.
3. Report dated April 11, 1997, from R. L. Seale, Chairman, ACRS, to Shirley Ann Jackson, Chairman, NRC, Subject: Risk-Based Regulatory Acceptance Criteria for Plant Specific Application of Safety Goals.
4. U. S. Nuclear Regulatory Commission, NUREG/CR-2239, "Technical Guidance for Siting Criteria Development," Prepared by Sandia National Laboratories, December 1982.

Attachments:

1. Memorandum dated June 27, 1997, from R. Sherry, Senior ACRS Fellow to ACRS Members, Subject: Considerations for Plant-Specific, Site-Specific Application of Safety Goals and Definition of Subsidiary Criteria.
2. Memorandum dated June 11, 1997, from R. Sherry, Senior ACRS Fellow to ACRS Members, Subject: Consideration of Societal Risk in Plant-Specific, Site-Specific Application of Safety Goals and Definition of Subsidiary Criteria.

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June 27, 1997

MEMORANDUM TO: ACRS Members

FROM: Rick Sherry, Senior ACRS Fellow

SUBJECT: CONSIDERATIONS FOR PLANT-SPECIFIC, SITE-SPECIFIC APPLICATION OF SAFETY GOALS AND DEFINITION OF SUBSIDIARY CRITERIA

Background

In its November 18, 1996 report (ACRS-1996), the ACRS stated that "the safety goals and subsidiary objectives can and should be used to derive guidelines for plant-specific applications." In its April 11, 1997 report (ACRS-1997), the ACRS stated further that "Quantification of the LERF [large, early release frequency] at each site is needed to ensure the appropriateness of the choice of the LERF acceptance criterion proposed in draft Regulatory Guide DG-1061 and draft Standard Review Plan sections that support risk-informed, performance-based regulation."

In a Staff Requirements Memorandum dated April 15, 1997 (SRM-1997a), the Commission stated (referring to *Direction Setting Issue 12*), "The staff should develop objective standard(s) for the application of risk-informed, performance-based and risk-informed less prescriptive approaches to regulations on an expedited basis. Such standard(s) could be in the form of individual plant safety goals and subsidiary objective performance criteria as discussed in the issue paper."

In a staff requirements memorandum dated May 27, 1997 (SRM-1997b), the Commission "requested that the ACRS determine the change in the CDF and LERF from site to site, when these lower-tier criteria are derived from the prompt fatality quantitative health objectives." This memorandum addresses this request from the Commission.

Issues

To respond to this request, the following issues need to be addressed:

- Is there sufficient site-to-site variability to warrant site-specific determination of lower-level acceptance criteria — e.g., LERF criteria?

ATTACHMENT 1

- Can this range of variability be evaluated and can an appropriate bound be established on this variability?

- Can generic criteria or site-specific criteria (if required) be determined using simplified approximate methods?

This memorandum will address these issues.

Parameters Important to Early Fatality Risk

This section discusses those parameters that are (potentially) important to early fatality risk. These will be discussed in two categories. The first category includes those parameters that are determined by plant design/plant operations and that should be captured in a proper definition of the LERF. The second category includes those parameters that are determined by site characteristics.

The plant design/plant operations related parameters potentially important to early fatality risk:

- Source Term Characteristics

  - magnitude of the fission product release from containment (particularly the volatile I and Te groups)

  - release thermal energy and release height

- Timing Characteristics

  - timing of release (relative to the start of protective actions) — effective evacuation begins before the start of radionuclide release.

  - absolute time of release relative to reactor shutdown (for radionuclide decay considerations)

The site-related parameters potentially important to the early fatality risk are:

- sector population distribution

- wind direction frequency distribution

- variability due to site-to site variations in local meteorology

- size of exclusion boundary

This memorandum focuses on this second category of parameters.

Simplified Model for Individual Early Fatality Risk

A simple relationship between the individual early fatality frequency (IEFF) and the LERF has been defined (Sherry-1997) as:

$$IEFF = LERF \times EI \qquad \textit{Equation 1}$$

$$EI = \textit{Exposure Index} = \frac{\sum_{i=1}^{16} P_i \times F_i}{\sum_{i=1}^{16} P_i} \qquad \textit{Equation 2}$$

where: F_i = *the relative frequency wind blows toward sector i*
P_i = *population in sector i within one mile of the plant*

For site-specific analyses, it has been our practice to consider the EI as a site-specific constant. In this analysis, the EI is treated as a random variable, which represents the variability (across the spectrum of sites) of the site-related parameters important to early fatality risk. The EI can be represented as:

$$EI \equiv f(p,w,r,m)$$

where: p = *population distribution*
w = *the wind direction frequency distribution*
r = *minimum radius of the exclusion zone boundary*
m = *the local meteorology*

In the following analyses, we will construct the distribution for the EI. This will involve a three step process. First, we will determine the distribution resulting from site-to-site population and wind direction frequency variations. In the second step, we will add the variability from differences in exclusion zone boundary distances. Finally, we will add the variability from differences in the local meteorology.

Step 1: Variability in Population Distribution and Wind Direction Frequency

The exposure index for each nuclear plant site has been evaluated using the relationship shown in Equation 2. The wind direction frequencies for each plant site were taken from Appendix A of the Sandia Siting Study (NRC-1982) and are shown in Attachment 2. The population distribution around each plant was calculated using the SECPOP90 computer code.[1] The SECPOP90 code contains a database of 1990/1992 U.S. Census data. The SECPOP90 code requires the map coordinates of each plant; these were obtained from the geospatial data available on the NRC Wide World Web server. These coordinates are shown in Attachment 1.

The safety goal policy statement notes that the QHO for individual early fatalities should be evaluated for the "average individual ... locationally who resides within a mile of the plant site boundary." In NUREG-1150, "Severe Accident Risks: An Assessment for Five U.S. Nuclear Power Plants," the IEFF safety goal QHO was evaluated in the 1 mile annular ring with interior radius equal to the minimum distance to the (irregularly) shaped exclusion zone boundary. This interpretation of the evaluation region has been accepted for use in this study. Attachment 3 shows the minimum exclusion distances for each plant site (NRC-1982).

To simplify the analyses, the SECPOP90 code was set up to give the population distribution for three fixed radial rings (0-1 mile, 1-1.5 miles and 1.5-2 miles). Since the minimum exclusion radius of all but three plants is less than 1 mile, this range bracketed the evaluation distance (exclusion zone boundary + 1 mile) for most plants. For those plants with exclusion zones less than 1 mile, EIs were calculated for distances of 1, 1.5, and 2 miles from the plant and the EI at the exclusion zone boundary plus 1 mile was determined by interpolation. For the plants with exclusion zones greater than 1 mile, the EIs were calculated directly using the SECPOP90 code.

Table 1 shows the calculated EIs following step 1 for each plant. Figure 1 shows a histogram of the results. The statistics of the distribution are shown in Table 2. The mean and median values of the distribution are both approximately 0.61 and the 95th percentile value is 0.85, resulting in a ratio of the 95th percentile value to the mean value equal to 1.4.

Step 2: Variability Resulting From Differences in Site Boundary Radius

The radii of the minimum exclusion zone boundary range from a low of 0.17 mile to 1.33 miles, with a median value of 0.51 mile and a mean value of 0.56 miles. This range of differences potentially could have a significant effect on the site-to-site variability in individual early fatality frequency. In the Sandia siting study, a factor of $r^{-1.5}$ was used to represent the approximate decrease in risk with distance from the plant. Hence, for the range in exclusion zone boundary distances given above the potential site-to-site variation expressed as a risk ratio could be as much as:
In the above calculation the ratio is evaluated at the midpoint of the radial ring bounded on

[1] The potential for significant error in the population distribution close to the site exists due to the procedure for assigning population from the Census Block Data to the compass sectors and radial rings surrounding a plant. This potential uncertainty was not evaluated in this study.

$$Risk\ Ratio = \frac{\dfrac{1}{(0.17+0.5)^{1.5}}}{\dfrac{1}{(1.33+0.5)^{1.5}}} = 4.5$$

the inside by the exclusion zone minimum radius and on the outside by the exclusion zone minimum radius plus 1 mile. The potential variability due to differences in the exclusion zone boundary was evaluated by modifying the EI so that:

$$EI_r = \frac{\sum_{i=1}^{16} P_i \times F_i}{\sum_{i=1}^{16} P_i} \times \frac{1}{[1+(r-r_{med})]^{1.5}} \qquad \textit{Equation 3}$$

where: r = *the site-specific exclusion zone minimum radius*
r_{med} = *the median value of exclusion zone minimum radii*

The formulation of the second term in this equation is such that at the median value for the exclusion radii this term is equal to 1. For values of r less than the median value the term is greater than 1 and for values of r greater than the median radius, the value is less than 1.

The calculated values for the exposure index shown in equation 3 for each site are provided in Table 1 and a histogram of the results is shown in Figure 2. The statistics of the distribution are shown in Table 2. The distribution has a mean value of 0.062, a median value of 0.058, and a 95th percentile value of 0.114. The ratio of the 95th percentile value to the mean value is 1.8.

Step 3: Variability Resulting From Differences in Local Site Meteorology

In addition to the variability in early fatality risk resulting from differences in site population distribution, wind direction frequency, and size of the exclusion zone, the local meteorology also contributes to site-to-site variability. In the Sandia siting study a sensitivity analysis was performed to determine the site-to-site variability potentially arising from differences in the local meteorology. This analysis found that there was less than a factor of two difference in the mean number of early fatalities over a set of 29 weather records selected to represent the spectrum of meteorological conditions found within the continental United States. The analysis results were derived from CRAC code calculations using a defined source term, the population distribution, and wind direction frequency for a high population density site. In these calculations, only the weather record was modified from calculation to calculation.

A distribution of individual early fatalities was constructed to represent the potential variability in local meteorology and this distribution was then combined with the EI distribution determined from equation 2. The modified exposure index is shown in Equation 4.

$$EI_t = EI_r \times \epsilon_m \qquad \textit{Equation 4}$$

where: ϵ_m = *a random variable with unit median*

Random variable (RV) ε_m represents the variability resulting from site-to-site differences in the local meteorology. The distribution of ε_m was constructed so the RV has a median value of 1.0 and the shape of the distribution was selected to approximate the results from the Sandia siting study. The distribution was selected to be lognormal with a 90 percentile probability interval (95th/5th) equal to a factor of 2 (Error Factor = 1.41). The distribution on EI_t was then determined by Monte Carlo simulation, assuming EI_r and ε_m are independent.

The distribution for the exposure index in Equation 4 is shown in Figure 3. The statistics of the distribution are shown in Table 2. The distribution has a mean value of 0.063, a median value of 0.057 and a 95th percentile value of 0.126. The ratio of the 95th percentile value to the mean value is 2.0.

Procedure for Estimating Subsidiary LERF Criteria

An approach to deriving subsidiary LERF criteria from the safety goal QHO for individual early fatality risk is discussed below. We start with Equation 1 and recognize that this is generally not an exact equality. More accurately stated:

$$IEFF \propto LERF \times EI$$

or

$$IEFF = \frac{1}{C} \times LERF \times EI \qquad \textit{Equation 5}$$

where: C = *proportionality constant*

To determine the value of C we must first of all have a precise physical definition of LERF in terms of the characteristics described earlier in the section entitled "Parameters Important to Early Fatality Risk." With this definition in hand, the value of the constant C can be estimated using the (mean values for) LERF and IEFF from existing Level 3 probabilistic risk assessments (PRAs) such as NUREG-1150 and site-specific exposure index values from this study (or calculated using the same population distribution and wind direction frequency input information used in the PRAs for the consequence analyses).

Rearranging Equation 5 and substituting the value of the safety goal QHO for individual early fatality risk (QHO_{IEFF}) for the IEFF yields the following relationship for deriving the subsidiary LERF criteria ($LERF_c$):

$$LERF_c = C \times \frac{QHO_{IEFF}}{EI} \qquad \textit{Equation 6}$$

To account for variability in the site parameters important to individual early fatality risk, the constant C can be adjusted to bound the results for the population of sites. For example, on the basis of the results from this study indicating that the 95th percentile value of the EI was two times the mean value, the value of C could be reduced by a factor of 2 to bound this variability (at the 95th percentile level). This would result in a reduction in the LERF criteria by a factor of 2.

Conclusions and Recommendations

The range of variability due to site-to-site population distribution, wind direction frequency distribution, exclusion zone size, and meteorology record has been evaluated. The ratio of the 95th percentile value to the mean value of the exposure index (EI_i) is approximately 2.

Since this variability is much less than the magnitude of the other uncertainties associated with the (Level 1 and Level 2 PRA) calculation of the LERF, it is judged that there is insufficient site-to-site variability in individual early fatality risk to warrant development of site-specific subsidiary LERF criteria. Hence, a single lower-level (LERF) criterion can be determined on a generic basis.

The information provided on the variability of the individual early fatality risk resulting from site-related parameters can be used to develop an appropriate factor to bound the variability.

Derivation of a subsidiary LERF criterion, however, cannot proceed until a physical definition of the LERF is developed in terms of the parameters, important to early fatality risk, which have been identified above.

References

(ACRS-1996) "Plant-Specific Application of Safety Goals," Report to Shirley A. Jackson, Chairman, U.S. Nuclear Regulatory Commission from T. S. Kress, Chairman, Advisory Committee on Reactor Safeguards, November 18, 1996.

(ACRS-1997) "Risk-Based Regulatory Acceptance Criteria for Plant-Specific Application of Safety Goals," Report to Shirley A. Jackson, Chairman, U.S. Nuclear Regulatory Commission from R. L. Seale, Chairman, Advisory Committee on Reactor Safeguards, April 11, 1997.

(NRC-1982) Aldrich, D.C., et al, "Technical Guidance for Siting Criteria Development," NUREG/CR-2239, December, 1982.

(Sherry-1997) "Methodology for Estimating Offsite Early Fatality Risk in the Absence of a Level 3 PRA," Attachment 2 to (ACRS,1997)

(SRM-1997a) "Staff Requirement - COMSECY-96-01 - Risk-Informed, Performance-Based Regulation (DSI-12)," Memorandum to L. Joseph Callan, Executive Director for Operations, and Karen D. Cyr, General Counsel, from Annette L. Vietti-Cook, Acting Secretary, U.S. Nuclear Regulatory Commission, dated April 15, 1997.

(SRM-1997b) "Staff Requirement - Meeting with the Advisory Committee on Reactor Safeguards," Memorandum to John T. Larkins, Executive Director ACRS, from John Hoyle, Secretary, U.S. Nuclear Regulatory Commission, dated May 27, 1997.

Table 1 - Site Specific Exposure Indices (Step 1 and Step 2)

Site	Step 1	Step 2
	EI	EI_r
Arkansas 1,2	0.077	0.063
Beaver Valley 1,2	0.066	0.082
Big Rock Point	0.051	0.051
Browns Ferry 1,2,3	0.081	0.058
Braidwood 1,2	0.077	0.114
Brunswick 1,2	0.060	0.055
Byron 1,2	0.059	0.086
Callaway	0.098	0.078
Calvert Cliffs 1,2	0.040	0.030
Catawba 1,2	0.052	0.055
Clinton	0.086	0.075
Comanche Peak 1,2	0.043	0.027
D.C. Cook 1,2	0.061	0.075
Cooper	0.033	0.036
Crystal River 3	0.045	0.029
Davis-Besse	0.045	0.055
Diablo Canyon 1,2	0.063	0.063
Dresden 2,3	0.079	0.091
Duane Arnold	0.056	0.085
Farley 1,2	0.061	0.043
Fermi 2	0.035	0.032
Fitzpatrick	0.053	0.046
Fort Calhoun	0.079	0.130

Ginna	0.045	0.066
Grand Gulf	0.077	0.082
Hatch 1,2	0.062	0.043
Indian Point 2,3	0.078	0.134
Kewaunee	0.040	0.029
LaSalle 1,2	0.045	0.062
Limerick 1,2	0.071	0.076
Maine Yankee	0.056	0.069
McQuire 1,2	0.052	0.055
Millstone 1,2,3	0.081	0.113
Monticello	0.066	0.093
Nine Mile Point 1,2	0.055	0.031
North Anna 1,2	0.076	0.049
Oconee 1,2,3	0.072	0.040
Oyster Creek	0.082	0.129
Palisades	0.058	0.066
Palo Verde 1,2,3	0.052	0.048
Peach Bottom 2,3	0.047	0.047
Perry	0.055	0.050
Pilgrim	0.046	0.069
Point Beach 1,2	0.052	0.038
Praire Island 1,2	0.094	0.105
Quad Cities 1,2	0.068	0.109
Riverbend	0.065	0.060
H. B. Robinson	0.062	0.095
St. Lucie 1,2	0.042	0.024

Salem 1,2/Hope Creek	0.063	0.047
San Onofre 2,3	0.070	0.071
Seabrook	0.052	0.048
Sequoyah 1,2	0.022	0.028
Shearon Harris	0.062	0.025
South Texas 1,2	0.115	0.071
Summer	0.064	0.035
Surry 1,2	0.056	0.073
Susquehanna 1,2	0.062	0.081
Three Mile Island	0.066	0.081
Turkey Point 3,4	0.077	0.053
Vermont Yankee	0.040	0.075
Vogtle 1,2	0.063	0.049
Waterford 3	0.071	0.065
Watts Bar	0.042	0.030
WNP-2	0.063	0.028
Wolf Creek	0.055	0.040
Zion 1,2	0.039	0.036

Table 2 - Summary of Exposure Index Distribution Statistics

	Step 1	Step 2	Step 3
Statistic	EI	EI_r	EI_t
mean	.0609	.0623	.0633
median	.0611	.0582	.0570
5th percentile	.0394	.0282	.0249
95th percentile	.0849	.1136	.1260
97.5 percentile	-	-	.1423
standard deviation	.0166	.0273	.0314

cc: J. Larkins
R. Savio
S. Duraiswamy
A. Cronenberg
ACRS Senior Engineers

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Figure 1 - Exposure Indices - Step 1

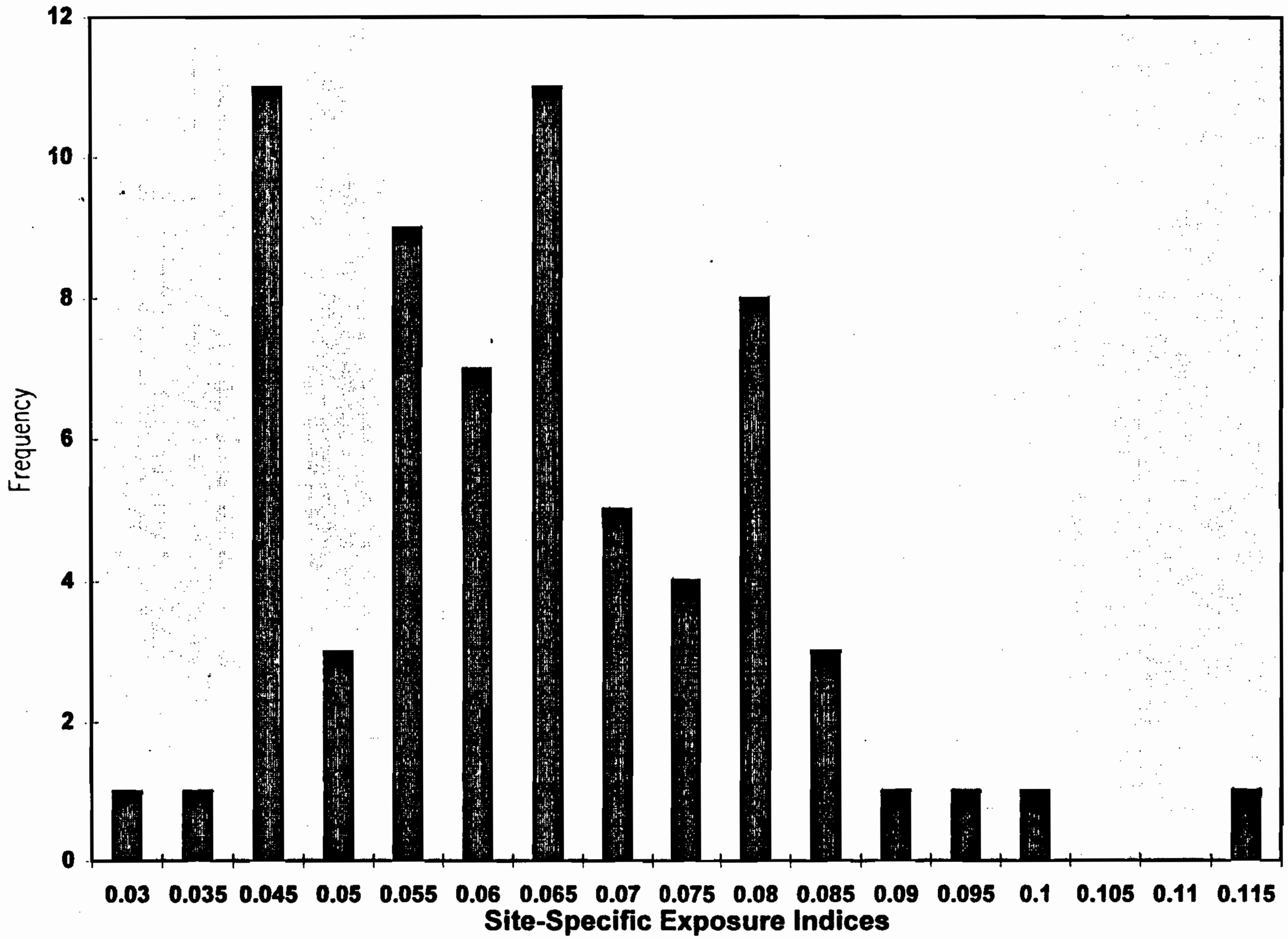


Figure 2 - Exposure Indices - Step 2

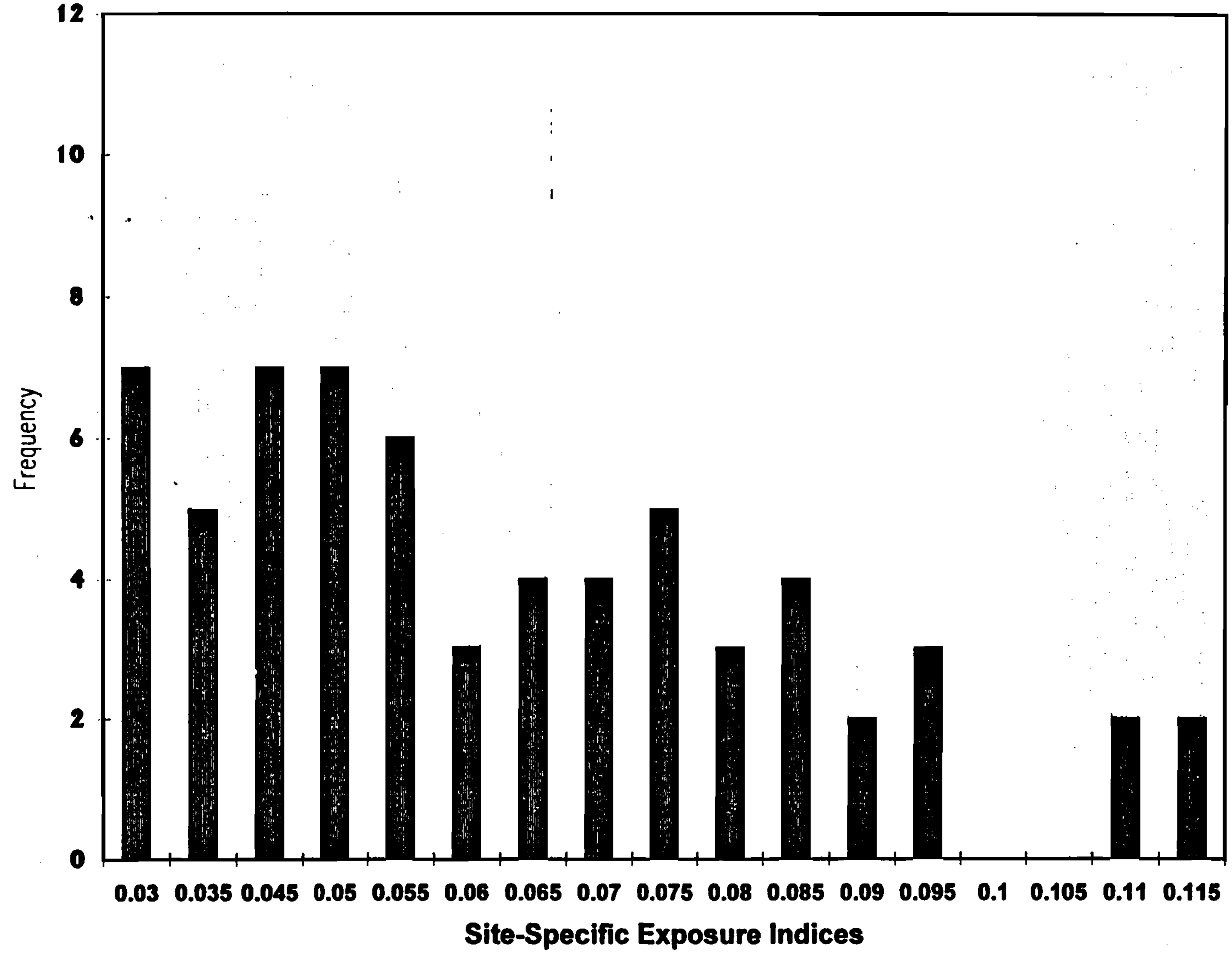
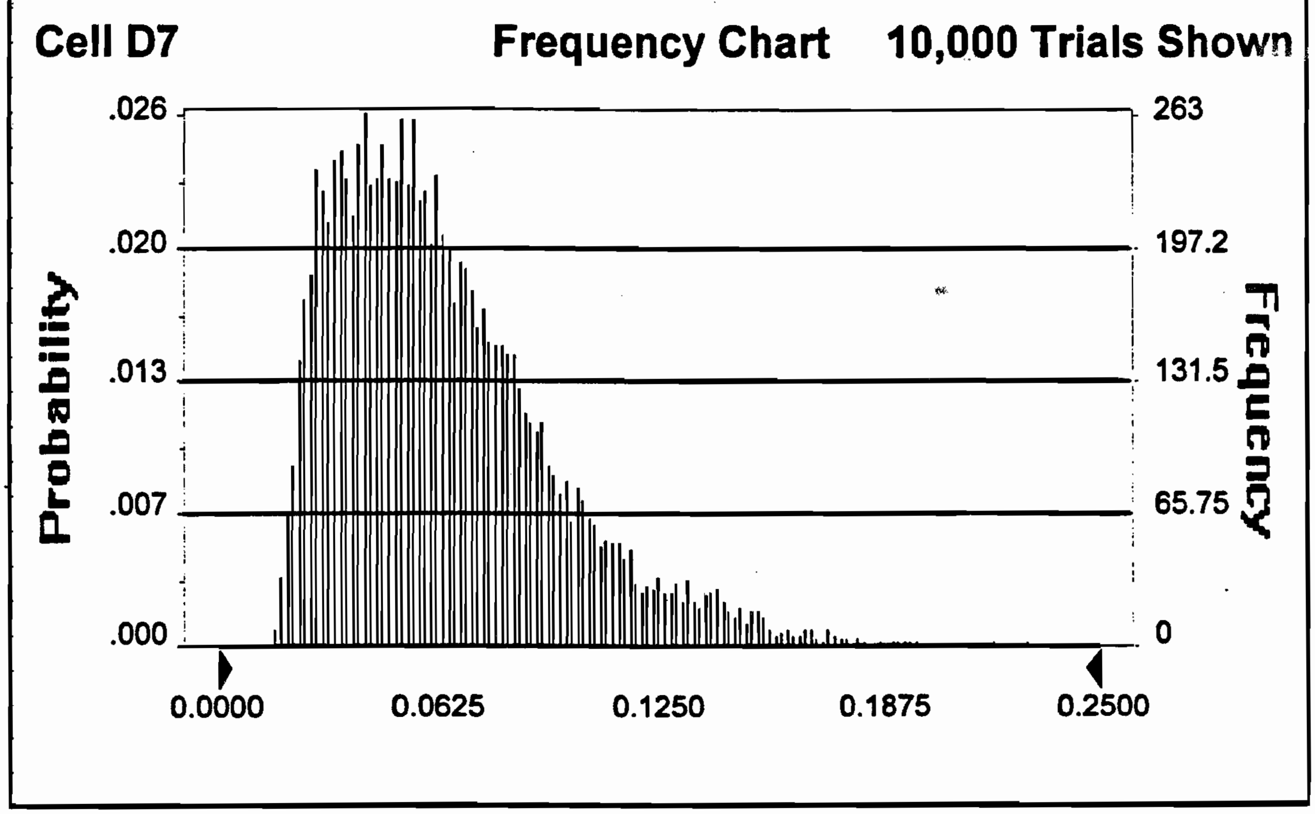


Figure 3 - Exposure Index - Step 3



Attachment 1 - Site Coordinates

Site	Location	State	Latitude	Longitude
ARKANSAS NUCLEAR	RUSSELLVILLE	AR	351336	931351
BEAVER VALLEY	SHIPPINGPORT	PA	403719	802602
BIG ROCK POINT	CHARLEVOIX	MI	452133	851141
BRAIDWOOD	BRACEVILLE	IL	411437	881344
BROWNS FERRY	DECATUR	AL	344215	870707
BRUNSWICK	SOUTHPORT	NC	335730	780038
BYRON	BYRON	IL	420430	891655
CALLAWAY	FULTON	MO	384530	914654
CALVERT CLIFFS	LUSBY	MD	382605	762631
CATAWBA	YORK	SC	350305	810410
CLINTON	CLINTON	IL	401019	885003
COMANCHE PEAK	GLEN ROSE	TX	321752	974706
COOK	BRIDGMAN	MI	415834	863359
COOPER STATION	BROWNSVILLE	NE	402143	953828
CRYSTAL RIVER	CRYSTAL RIVER	FL	285726	824156
DAVIS-BESSE	OAK HARBOR	OH	413550	830511
DIABLO CANYON	AVILA BEACH	CA	351242	1205116
DRESDEN	MORRIS	IL	412323	881616
DUANE ARNOLD	PALO	IA	420602	914638
FARLEY	ASHFORD	AL	311322	850645
FERMI	NEWPORT	MI	415748	831531
FITZPATRICK	LYCOMING	NY	433126	762354
FORT CALHOUN	FORT CALHOUN	NE	413115	960436
GINNA	ONTARIO	NY	431690	771832
GRAND GULF	PORT GIBSON	MS	320027	910253
HADDAM NECK	HARTFORD	CT	412855	722957
HARRIS	RALEIGH	NC	353800	785722
HATCH	BAXLEY	GA	315603	822040
HOPE CREEK	HANCOCKS BRIDGE	NJ	392804	753217
HUMBOLDT BAY	SAN FRANCISCO	CA	404431	12412 0

INDIAN POINT	BUCHANAN	NY	411617	735709
KEWAUNEE	KEWAUNEE	WI	442035	873210
LASALLE	MARSEILLES	IL	411438	884015
LIMERICK	PHILADELPHIA	PA	401312	753524
MAINE YANKEE	WISCASSET	ME	435702	694146
MCGUIRE	CORNELIUS	NC	352556	805654
MILLSTONE	WATERFORD	CT	411831	721005
MONTICELLO	MONTICELLO	MN	452000	935054
NINE MILE POINT	LYCOMING	NY	433120	762436
NORTH ANNA	RICHMOND	VA	380339	774726
OCONEE	SENECA	SC	344730	825355
OYSTER CREEK	FORKED RIVER	NJ	394851	741223
PALISADES	COVERT	MI	421920	861855
PALO VERDE	WINTERSBURG	AZ	332323	1125143
PEACH BOTTOM	PHILADELPHIA	PA	394532	761609
PERRY	PERRY	OH	414804	810836
PILGRIM	PLYMOUTH	MA	415640	703446
POINT BEACH	TWO RIVERS	WI	441651	873210
PRAIRIE ISLAND STATION	WELCH	MN	443710	923759
QUAD CITIES	CORDOVA	IL	414334	901836
RANCHO SECO	HERALD	CA	382046	1210708
RIVER BEND STATION	ST FRANCISVILLE	LA	304526	911954
ROBINSON	HARTSVILLE	SC	342419	800931
SALEM	HANCOCKS BRIDGE	NJ	392746	753209
SAN ONOFRE	SAN CLEMENTE	CA	332213	1173325
SEABROOK	MANCHESTER	NH	425353	705105
SEQUOYAH	SODDY-DAISY	TN	351324	850516
SOUTH TEXAS PROJECT	WADSWORTH	TX	284742	960253
ST LUCIE	JENSEN BEACH	FL	272055	801447
SUMMER	JENKINSVILLE,	SC	341745	811913
SURRY	SURRY	VA	370956	764154
SUSQUEHANNA	ALLENTOWN	PA	410530	760855

THREE MILE ISLAND	MIDDLETOWN	PA	400911	764330
TURKEY POINT	MIAMI	FL	252606	801953
VERMONT YANKEE	VERNON	VT	424649	723057
VOGTLE	WAYNESBORO	GA	330831	814553
WATERFORD	KILLONA	LA	295942	902816
WATTS BAR	SPRING CITY	TN	353610	844725
WNP	RICHLAND	WA	462817	1191959
WOLF CREEK STATION	BURLINGTON	KS	381420	954120
ZION	ZION	IL	422644	874808

Attachment 2

Site Wind Rose Data - from NUREG/CR-2239

Table A.4-1 Site Wind Rose Data

Probability of Wind Blowing Towards Sector

Station	N S	NNE SSW	NE SW	ENE WSW	E W	ESE WNW	SE NW	SSE NNW
Allens Creek		10 m			8/1/1972 - 7/31/1973			
	.121 .107	.073 .075	.043 .062	.024 .050	.022 .046	.021 .055	.027 .101	.069 .104
Arkansas 1, 2		190 ft			6/69 - 5/70			
	.103 .025	.074 .015	.052 .037	.074 .056	.126 .098	.087 .077	.053 .057	.021 .042
Bailly		[illegible] ft			12/4/51 - 12/3/57			
	.064 .064	.105 .068	.095 .069	.086 .063	.069 .038	.056 .028	.040 .053	.038 .066
Beaver Valley 1, 2		150 ft			9/15/69 - 9/5/70			
	.087 .055	.078 .023	.051 .021	.041 .023	.083 .040	.137 .059	.123 .067	.050 .064
Bellefonte 1		54 ft			1971			
	.064 .069	.075 .066	.092 .031	.082 .040	.071 .037	.067 .053	.060 .064	.076 .053
Big Rock Point		250 ft			2/61 - 2/63			
	.112 .056	.075 .039	.071 .034	.081 .046	.099 .088	.058 .037	.057 .037	.065 .045
Black Fox		33 ft			12/73 - 11/74			
	.180 .067	.055 .064	.026 .056	.026 .045	.022 .034	.030 .046	.051 .079	.059 .160
Braidwood 1		30 ft			11/1/73 - 10/31/74			
	.105 .052	.113 .048	.077 .048	.065 .045	.061 .043	.070 .044	.065 .056	.045 .063
Browns Ferry 1, 2, 3		300 ft			2/11/67 - 12/31/68			
	.072 .052	.066 .067	.058 .056	.058 .038	.052 .032	.067 .072	.055 .101	.054 .099
Brunswick 1, 2		350 ft			9/25/70 - 1/5/73			
	.055 .059	.077 .065	.145 .084	.088 .078	.053 .053	.037 .044	.036 .047	.041 .038
Byron 1		30 ft			6/11/73 - 5/31/74			
	.097 .053	.089 .037	.081 .048	.065 .058	.075 .049	.063 .044	.076 .039	.057 .069
Calloway		10 m			5/4/73 - 5/4/74			
	.126 .051	.096 .040	.074 .026	.043 .028	.058 .036	.070 .046	.058 .083	.050 .116
Calvert Cliff 1, 2		33 ft						
	.116 .084	.089 .050	.070 .038	.045 .024	.064 .035	.061 .028	.103 .028	.078 .082
Catawba 1		30 ft			6/30/71 - 6/30/72			
	.023 .075	.056 .079	.207 .179	.087 .060	.043 .033	.024 .025	.026 .040	.026 .017
Cherokee		30 ft			9/11/73 - 9/11/74			
	.036 .064	.048 .059	.124 .075	.104 .055	.094 .029	.081 .022	.114 .036	.059 .019
Clinton		10 m			8/72 - 6/73			
	.104 .070	.093 .068	.086 .071	.054 .056	.042 .054	.041 .038	.042 .049	.052 .067
Commanche Peak		10 m			3/12/72 - 3/14/76			
	.151 .060	.084 .040	.041 .029	.025 .025	.034 .032	.029 .068	.067 .105	.076 .149

Table A.4-1 Site Wind Rose Data (cont)

Probability of Wind Blowing Towards Sector

Station	N S	NNE SSW	NE SW	ENE WSW	E W	ESE WNW	SE NW	SSE NNW
Cook DC 1, 2		200 ft				1967		
	.091	.105	.055	.045	.056	.069	.057	.062
	.078	.042	.042	.050	.040	.063	.072	.073
Cooper		318 ft				3/70 - 2/71		
	.116	.117	.079	.037	.030	.041	.060	.100
	.094	.061	.025	.031	.027	.034	.058	.090
Crystal River		33 ft				1/1/75 - 12/31/75		
	.043	.048	.051	.048	.082	.057	.043	.030
	.062	.047	.098	.121	.111	.064	.061	.034
Davis-BE 1		35 ft				8/4/74 - 8/3/75		
	.064	.116	.130	.102	.081	.039	.053	.037
	.030	.039	.058	.057	.077	.041	.038	.039
Diablo Canyon 1, 2		250 ft				10/69 - 9/70		
	.031	.012	.014	.015	.026	.045	.363	.128
	.059	.029	.055	.017	.014	.015	.103	.075
Dresden 2, 3		300 ft						
	.088	.090	.096	.067	.101	.085	.080	.056
	.049	.031	.039	.033	.036	.033	.060	.055
Duane Arnold		165 ft				1971		
	.129	.073	.053	.036	.051	.062	.083	.095
	.075	.040	.032	.034	.039	.060	.061	.076
Farley 1, 2		33 ft						
	.073	.070	.064	.044	.044	.045	.067	.090
	.097	.083	.086	.062	.044	.035	.040	.056
Fermi 2						9/1/73 - 8/31/74		
	.041	.088	.089	.102	.083	.086	.063	.047
	.026	.025	.059	.063	.069	.050	.058	.058
Fitzpatrick		200 ft				1963 - 1964		
	.087	.059	.102	.132	.115	.056	.053	.035
	.040	.047	.033	.014	.018	.037	.101	.068
Forked River		400 ft				2/66 - 2/67		
	.075	.096	.087	.068	.087	.093	.075	.063
	.044	.037	.052	.055	.039	.040	.047	.040
Fort Calhoun		40 ft				10/68 - 9/70		
	.093	.059	.034	.021	.042	.079	.113	.098
	.071	.018	.017	.022	.028	.064	.115	.126
Fort St. Vrain		205 ft				1967 - 1968		
	.063	.069	.076	.057	.040	.029	.035	.039
	.164	.085	.076	.064	.058	.043	.051	.049
Ginna R.E.		50 ft				1966 - 1967		
	.090	.081	.102	.097	.112	.101	.079	.044
	.030	.032	.031	.038	.045	.036	.030	.052
Grand Gulf 1						1951 - 1960		
	.101	.074	.062	.043	.036	.043	.070	.064
	.065	.060	.061	.040	.040	.044	.080	.117
Haddam Neck		129 ft				1963		
	.048	.046	.043	.038	.070	.160	.265	.052
	.013	.006	.009	.013	.035	.092	.055	.055
Hartsville		33 ft				2/1/73 - 1/31/74		
	.045	.058	.048	.056	.051	.034	.044	.025
	.045	.113	.175	.063	.050	.074	.069	.051

Table A.4-1 Site Wind Rose Data (cont)

Probability of Wind Blowing Towards Sector

Station	N S	NNE SSW	NE SW	ENE WSW	E W	ESE WNW	SE NW	SSE NNW
Hatch, E.I. 1, 2		150 ft				6/1/70 - 8/31/74		
	.055	.069	.082	.073	.075	.077	.072	.049
	.040	.038	.051	.047	.081	.068	.057	.044
Indian Point 2, 3		100 ft				1/1/71 - 12/31/71		
	.076	.055	.038	.039	.053	.079	.077	.070
	.124	.135	.066	.027	.019	.019	.041	.063
Kewaunee		180 ft				8/31/68 - 3/25/70		
	.082	.090	.064	.075	.094	.117	.082	.080
	.066	.055	.042	.030	.022	.023	.028	.050
LaSalle 1, 2		300 ft						
	.088	.090	.096	.067	.101	.085	.080	.056
	.049	.031	.039	.033	.036	.033	.060	.055
La Crosse		350 ft				1968 - 1970		
	.194	.139	.084	.018	.051	.026	.076	.062
	.125	.101	.048	.011	.022	.010	.026	.033
Limerick 1		270 ft				1/72 - 12/74		
	.071	.068	.052	.051	.090	.150	.109	.059
	.054	.039	.035	.046	.0670	.040	.037	.040
Marble Hill		33 ft				1/74 - 12/74		
	.058	.141	.124	.074	.062	.060	.044	.037
	.045	.044	.063	.060	.047	.030	.030	.041
Me Yankee		149 ft				7/67 - 6/68		
	.118	.124	.082	.041	.041	.055	.088	.089
	.075	.068	.064	.030	.024	.027	.031	.044
McGuire 1, 2		130 ft				10/17/70 - 10/16/71		
	.070	.090	.122	.062	.054	.042	.042	.040
	.057	.068	.113	.078	.056	.037	.038	.030
Midland 2						1962 - 1966		
	.060	.082	.123	.106	.124	.066	.064	.051
	.045	.046	.061	.043	.045	.024	.028	.032
Millstone 1, 2		152 ft				8/65 - 9/67		
	.038	.060	.076	.170	.078	.070	.078	.073
	.066	.060	.036	.035	.058	.035	.025	.041
Monticello		140 ft				2/9/67 - 2/10/68		
	.089	.091	.063	.055	.030	.089	.104	.119
	.036	.041	.029	.051	.031	.055	.052	.065
Nine M. Pt. 1, 2		204 ft				1963 - 1964		
	.082	.060	.104	.131	.118	.059	.054	.037
	.041	.048	.034	.013	.018	.037	.097	.069
North Anna 1, 2, 3		150 ft				9/16/71 - 9/15/72		
	.141	.095	.058	.047	.055	.047	.074	.084
	.100	.048	.044	.035	.041	.035	.042	.054
Oconee 1, 2, 3						6/19/68 - 6/19/69		
	.021	.036	.075	.051	.062	.043	.061	.081
	.174	.084	.100	.058	.060	.038	.036	.019
Oyster Creek		400 ft				2/66 - 2/67		
	.075	.096	.087	068	.087	.093	.075	.063
	.044	.037	.052	.055	.039	.040	.047	.040
Palisade		55 ft				9/67 - 8/68		
	.204	.113	.027	.030	.058	.046	.072	.081
	.080	.033	.013	.012	.052	.038	.049	.093

Table A.4-1 Site Wind Rose Data (cont)

Probability of Wind Blowing Towards Sector

Station	N S	NNE SSW	NE SW	ENE WSW	E W	ESE WNW	SE NW	SSE [a] NNW
Palo Verde 1		200 ft				8/13/73 - 8/13/74		
	.055 .048	.073 .059	.144 .068	.082 .048	.068 .073	.047 .059	.052 .056	.035 .041
Peach Bottom 2, 3		320 ft				8/67 - 7/69		
	.085 .060	.064 .043	.046 .031	.052 .032	.069 .034	.095 .046	.125 .054	.109 .064
Pebble Springs		30 ft				1/74 - 12/74		
	.017 .012	.039 .019	.075 .050	.201 .055	.313 .035	.094 .028	.021 .020	.009 .014
Perkins		30 ft				10/12/73 - 10/11/74		
	.036 .068	.067 .066	.125 .104	.066 .067	.058 .063	.047 .037	.064 .044	.053 .034
Perry 1		200 ft				5/1/72 - 4/30/73		
	.105 .045	.095 .030	.082 .057	.084 .045	.081 .048	.054 .037	.057 .054	.042 .073
Phipps Bend		33 ft				2/1/74 - 1/31/75		
	.037 .054	.054 .110	.107 .112	.106 .045	.053 .020	.071 .018	.053 .021	.120 .019
Pilgrim 1		72 ft						
	.051 .051	.185 .038	.118 .042	.085 .035	.094 .048	.060 .031	.053 .033	.046 .030
Point Beach 1, 2		150 ft				4/67 - 4/68		
	.088 .096	.122 .070	.087 .055	.048 .022	.081 .020	.097 .018	.075 .031	.056 .036
Prairie 1, 2		140 ft				6/1/71 - 5/31/72		
	.065 .046	.031 .023	.025 .019	.031 .019	.073 .055	.102 .108	.125 .134	.065 .080
Quad Cities 1, 2		400 ft				4/68 - 9/69		
	.072 .068	.128 .051	.090 .042	.049 .028	.045 .037	.069 .033	.083 .075	.067 .063
Rancho Seco		50 ft				1967 - 1969		
	.066 .049	.073 .034	.069 .029	.107 .021	.114 .029	.078 .039	.100 .057	.074 .062
Riverbend 1		135 ft				10/1/72 - 9/30/73		
	.057 .069	.058 .066	.048 .066	.048 .060	.054 .076	.048 .082	.061 .072	.066 .067
H. B. Robinson 2		120 ft				4/14/67 - 4/19/68		
	.045 .141	.074 .114	.072 .095	.081 .050	.071 .040	.037 .035	.036 .038	.043 .029
Saint Lucie 1		50 ft				11/1/72 - 12/31/72		
	.062 .045	.056 .038	.063 .070	.046 .088	.030 .121	.041 .093	.053 .098	.029 .067
Salem 1, 2		300 ft				6/69 - 5/71		
	.067 .062	.062 .046	.060 .049	.056 .037	.073 .028	.095 .023	.132 .042	.094 .074
San Onofre		10 m				1/25/73 - 1/24/76		
	.066 .034	.061 .111	.054 .134	.065 .028	.088 .016	.109 .022	.060 .049	.031 .070
Seabrook 1		30 ft				11/71 - 10/72		
	.030 .039	.040 .024	.069 .033	.079 .046	.110 .038	.167 .041	.145 .043	.049 .037

Table A.4-1 Site Wind Rose Data (cont)

Probability of Wind Blowing Towards Sector

Station	N S	NNE SSW	NE SW	ENE WSW	E W	ESE WNW	SE NW	SSE NNW
Sequoyah 1, 2		33 ft				4/21/71 - 3/31/72		
	.066 . 58	.151 .169	.161 .116	.48 .026	.024 .011	.024 .008	.035 .013	.070 .019
Shearon Harris		10 m				1/76 - 12/76		
	.079 .083	.107 .067	.098 .063	.079 .047	.053 .033	.054 .031	.057 .035	.062 .053
Skagit		10 m						
	.014 .037	.011 .021	.021 .041	.037 .028	.128 .109	.109 .058	.085 .039	.062 .020
Shoreham		150 ft				10/1/73 - 9/30/74		
	.060 .050	.129 .045	.095 .049	.050 .043	.079 .032	.103 .028	.094 .036	.066 .041
South Texas		33 ft				7/20/73 - 7/20/74		
	.148 .075	.046 .078	.029 .080	.018 .047	.015 .053	.014 .059	.020 .137	.037 .153
Virgin C. Summer		202 ft				1975		
	.068 .029	.090 .042	.118 .080	.087 .070	.064 .059	.046 .041	.055 .052	.043 .056
Surry St 1, 2		150 ft				11/67 - 12/69		
	.064 .072	.082 .051	.082 .046	.062 .045	.059 .057	.061 .052	.087 .055	.081 .043
Susquehanna 1						1956 - 1960		
	.037 .046	.070 .039	.125 .049	.126 .054	.044 .040	.059 .062	.100 .031	.090 .029
Three Mile Island		100 ft				4/71 - 3/72		
	.054 .040	.045 .027	.054 .036	.059 .057	.091 .085	.092 .082	.091 .062	.070 .057
Trojan		30 ft				9/1/71 - 8/31/72		
	.203 .172	.070 .054	.026 .016	.013 .006	.022 .007	.037 .009	.070 .046	.132 .120
Turkey Point 1, 2		30 ft				1969		
	.038 .035	.041 .028	.047 .048	.027 .100	.027 .136	.047 .135	.051 .100	.077 .062
Vermont Yankee 1		140 ft				8/67 - 7/68		
	.072 .070	.027 .025	.018 .017	.023 .019	.069 .024	.086 .066	.117 .085	.196 .086
Vogtle		30 ft				12/73 - 12/74		
	.064 .043	.062 .043	.074 .072	.079 .065	.084 .069	.075 .060	.056 .063	.031 .060
Waterford 3		30 ft				5/72 - 4/73		
	.042 .046	.053 .092	.045 .088	.047 .059	.049 .029	.056 .100	.064 .083	.072 .077
Watts Bar 1, 2		300 ft				7/1/73 - 6/30/75		
	.033 .053	.109 .106	.183 .132	.089 .059	.040 .041	.031 .019	.035 .014	.037 .019
WPPS 1, 4		33 ft				4/74 - 3/75		
	.100 .164	.082 .045	.063 .036	.052 .031	.061 .022	.099 .026	.107 .040	.085 .075
WPPS 2		33 ft				4/74 - 3/75		
	.100 .164	.082 .045	.063 .036	.052 .031	.061 .022	.099 .026	.107 .040	.085 .075

Table A.4-1 Site Wind Rose Data (cont)

Probability of Wind Blowing Towards Sector

Station	N S	NNE SSW	NE SW	ENE WSW	E W	ESE WNW	SE NW	SSE NNW
WPPS 3, 5		60 m				5/73 - 4/74		
	.071 .014	.098 .019	.124 .062	.170 .074	.125 .047	.031 .052	.015 .050	.010 .027
Wolf Creek		10 m				6/1/73 - 5/31/75		
	.080 .164	.100 .058	.040 .039	.024 .035	.030 .039	.041 .046	.064 .061	.069 .111
Yankee Rowe		30 ft				10/71 - 9/72		
	.101 .086	.080 .064	.052 .065	.037 .063	.039 .047	.041 .036	.072 .052	.086 .081
Yellow Creek		33 ft				7/1/74 - 6/30/75		
	.142 .037	.097 .070	.049 .049	.039 .019	.040 .021	.050 .046	.057 .060	.087 .130
Zimmer 1		30 ft				3/1/72 - 2/28/74		
	.108 .062	.066 .031	.068 .027	.056 .023	.051 .030	.059 .054	.047 .127	.062 .129
Zion		35 ft				1970		
	.071 .046	.078 .059	.079 .037	.113 .039	.069 .035	.076 .035	.046 .060	.071 .096

Attachment 3

Site Minimum Exclusion Zone Distances - from NUREG/CR-2239

TABLE D.2-1

EXCLUSION DISTANCES (MILES) FOR 91 REACTOR SITES

	SITE	EX. DIST.
1	ALLENS CREEK	0.82
2	ARKANSAS 1 + 2	0.65
3	BAILLY S	0.12
4	BEAVER VALLEY 1 + 2	0.38
5	BELLEFONTE 1	0.57
6	BIG ROCK POINT	0.51
7	BLACK FOX	0.53
8	BRAIDWOOD 1	0.28
9	BROWNS FERRY 1, 2, + 3	0.76
10	BRUNSWICK 1 + 2	0.57
11	BYRON 1	0.29
12	CALLAWAY	0.68
13	CALVERT CLIFF 1 + 2	0.71
14	CATAWBA 1	0.47
15	CHEROKEE	0.37
16	CLINTON	0.61
17	COMMANCHE PEAK	0.87
18	COOK DC 1 + 2	0.38
19	COOPER S	0.46
20	CRYSTAL RIVER	0.83
21	DAVIS-BE 1	0.39
22	DIABLO CANYON 1 + 2	0.50
23	DRESDEN 2 + 3	0.42
24	DUANE ARNOLD	0.27
25	FARLEY 1 + 2	0.78
26	FERMI 2	0.57
27	FITZPATRICK	0.61
28	FORKED RIVER 1	0.38
29	FORT CALHOUN	0.23
30	FORT ST VRAIN	0.37
31	R. E. GINNA	0.28
32	GRAND GULF 1	0.47
33	HADDEM NECK	0.33
34	HARTSVILLE	0.76
35	HATCH, E.I. 1 + 2	0.78
36	INDIAN PT 2 + 3	0.21
37	KEWAUNEE	0.75
38	LASALLE 1 + 2	0.32
39	LA CROSSE	0.21
40	LIMERICK 1	0.47
41	MARBLE HILL	0.42
42	ME YANKEE	0.38
43	MCGUIRE 1 + 2	0.47
44	MIDLAND 2	0.31
45	MILLSTONE 1 + 2	0.31

TABLE D.2-1 (cont'd)

	SITE	EX. DIST.
46	MONTICELLO	0.30
47	NINE M. PT. 1 + 2	0.97
48	NORTH ANNA 1, 2, + 3	0.84
49	OCONEE 1, 2 + 3	1.00
50	OYSTER CREEK	0.25
51	PALISADE	0.42
52	PALO VERDE 1	0.56
53	PEACH BOTTOM 2 + 3	0.51
54	PEBBLE SPRINGS	0.49
55	PERKINS	0.37
56	PERRY 1	0.57
57	PHIPPS BEND	0.47
58	PILGRIM 1	0.27
59	POINT BEACH 1 + 2	0.75
60	PRAIRIE 1 + 2	0.44
61	QUAD CITIES 1 + 2	0.24
62	RANCHO SECO	0.40
63	RIVERBEND 1	0.57
64	H. B. ROBINSON 2	0.26
65	SAINT LUCIE 1	0.97
66	SALEM 1 + 2	0.72
67	SAN ONOFRE	0.50
68	SEABROOK 1	0.57
69	SEQUOYAH 1 + 2	0.36
70	SHEARON HARRIS	1.33
71	SHOREHAM	0.19
72	SKAGIT	0.38
73	SOUTH TEXAS	0.89
74	VIRGIL C. SUMMER	1.01
75	SURRY ST 1 + 2	0.35
76	SUSQUEHANNA 1	0.35
77	THREE MILE ISLAND	0.38
78	TROJAN	0.41
79	TURKEY POINT 1 + 2	0.79
80	VERMONT YANKEE 1	0.17
81	VOGTLE	0.68
82	WATERFORD 3	0.57
83	WATTS BAR 1 + 2	0.75
84	WPPSS1+4	1.21
85	WPPSS 3 + 5	0.81
86	WPPSS 2	1.21
87	WOLF CREEK	0.75
88	YANKEE ROWE	0.59
89	YELLOW CREEK	0.43
90	ZIMMER 1	0.24
91	ZION	0.57

UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
WASHINGTON, D. C. 20555

June 11, 1997

MEMORANDUM TO: ACRS Members

FROM: Rick Sherry, Senior ACRS Fellow

SUBJECT: CONSIDERATIONS OF SOCIETAL RISK IN PLANT-SPECIFIC, SITE-SPECIFIC APPLICATION OF SAFETY GOALS AND DEFINITION OF SUBSIDIARY CRITERIA

Background

In its November 18, 1996 report (ACRS-1996), the ACRS stated that "the safety goals and subsidiary objectives can and should be used to derive guidelines for plant-specific applications." In its April 11, 1997 report (ACRS-1997), the ACRS stated further that "Quantification of the LERF [large, early release frequency] at each site is needed to ensure the appropriateness of the choice of the LERF acceptance criterion proposed in draft Regulatory Guide DG-1061 and draft Standard Review Plan sections that support risk-informed, performance-based regulation."

In a Staff Requirements Memorandum dated April 15, 1997 (SRM-1997), the Commission stated (referring to *Direction Setting Issue 12*), "The staff should develop objective standard(s) for the application of risk-informed, performance-based and risk-informed less prescriptive approaches to regulations on an expedited basis. Such standard(s) could be in the form of individual plant safety goals and subsidiary objective performance criteria as discussed in the issue paper."

Issue

An important issue that arises when considering application of the safety goals on a plant-specific, site-specific basis is whether individual risk alone is adequate for characterizing risk or should other risk metrics, such as societal risk, be considered in assessing risk-informed regulatory applications?

ATTACHMENT 2

Discussion

The two quantitative health objectives (QHOs) delineated in the NRC Safety Goal policy statement (NRC-1986) are both stated in terms of individual risk. Because of this formulation of the QHOs, and as pointed out many years ago by the ACRS (ACRS-1983), "Larger societal risks are permitted for the nuclear power plant which has the larger surrounding population...." The ACRS has proposed in the past that a societal risk goal be applied to early fatalities (ACRS-1980). Recently, other countries have developed nuclear power plant quantitative safety criteria that explicitly include societal as well as individual risk (Versteeg-1992).

Contained in the NRC Safety Goal Policy Statement are separate views of Commissioner Bernthal, which include the following:

> The absence of such explicit population density considerations in the Commission's 0.1 percent goals for offsite consequences deserves careful thought. Is it reasonable that Zion and Palo Verde, for example, be assigned the same 'standard person' risk, even though they pose considerably different risks for the U.S. population as a whole? As they stand these 0.1 percent goals do not explicitly include population density considerations.

Although it may have been acceptable to neglect explicit considerations of societal risk in the safety goals when the goals were to be used in a generic fashion to assess the risk of the population of plants as a whole, it is less clear that this is acceptable when the goals are used to assess the acceptability of proposed changes on a plant-specific basis.

The Sandia siting study (NRC-1981) indicates that total (as opposed to individual) early fatality risk is very sensitive to site population distribution and that the mean number of early fatalities is determined by the average density of the exposed population. In the Sandia siting study, there was a difference of three orders of magnitude in the calculated mean number of early fatalities among 91 sites using the same source term, same emergency response, same wind rose, and same meteorological record. The only difference in this analysis was the use of a site-specific population distribution. On the bases of 1970 census data, the population density within five miles of the plant among the 91 sites examined had the following characteristics:

Median	- 40 people per square mile
90th Percentile	- 190 people per square mile
Maximum	- 790 people per square mile

Figure 1 shows the calculated number of early fatality results from this study.

Benchmark calculations were performed for the "Task Force on Interim Operation of Indian Point" (NRC-1980) to assess the impact of population density on offsite consequences. For these calculations, four high-density sites (Zion, Indian Point, Limerick, and Fermi), one average-density site (Palisades) and one low-density site (Diablo Canyon) were selected. A standard plant was then located at each site, identical weather sequences and emergency responses were assumed, and wind-rose weighted 1970 population distributions for each site were utilized. This analyses allowed the comparison of the calculated total early fatality risk for each site. Figure 2 summarizes the results of this comparison in the form of complementary cumulative distribution functions (CCDFs) for total early fatality risk. This figure shows that the three sites with the highest population density have similar risk profiles and are substantially above the risk curves for the "average" site and for low-population-density sites. On Table 1 these curves have been reduced to single values showing the expected consequences (number of early fatalities per year). From this table, it is observed that the total early fatality risk is an order of magnitude greater for the three highest population density plants than for the "average" plant and more than two orders of magnitude greater than for a low-population-density plant.

Table 1
Expected Annual Consequences

Site	Early Fatality Risk
Indian Point	6.1×10^{-3}
Zion	4.7×10^{-3}
Limerick	3.5×10^{-3}
Fermi	9.2×10^{-4}
Palisades	2.9×10^{-4}
Diablo Canyon	1.6×10^{-5}

Figure 3 shows the distribution of population densities within one-mile wide annular rings within five miles of each nuclear plant (population densities projected for the year 2000) (NRC-1979). This figure indicates that the population densities for the top 10 percent of nuclear plant sites exceed the median site population by approximately one order of magnitude. These results indicate that if all plants were to exactly meet the individual early fatality risk QHO then the top 10 percent of the plants would contribute the majority of the societal risk.

These results suggest that a number of the high-population-density sites may have an order of magnitude or larger societal risk than the median site. For plants at these sites, it is not clear that a risk metric that only considers individual risk is adequate. Consequently, the Committee may wish to consider whether societal risk should be considered in applying the safety goals on a plant-specific, site-specific basis.

Strawman Approach

One possible approach for addressing societal risk impacts for high-population-density sites that would not result in the need for revisiting the definition of the safety goals and could be implemented using the approach delineated in draft Regulatory Guide DG-1061 (NRC-1997) is discussed below.

For the very high-population-density sites, the QHOs for individual early fatality risk and individual latent cancer fatality risk could be reduced from their nominal values by a "population density reduction factor" to compensate for the increased societal risks associated with the high-population-density sites. On the basis of the results presented above, a reduction of approximately a factor of 10 in the individual early fatality QHO would be required for the highest population density sites to assure that the societal early fatality risk for these sites would not exceed the societal risk for an "average" site. The reduced QHO could then also be used to calculate a site-specific LERF. However, for these sites, it seems prudent to require a full Level 2/Level 3 probabilistic risk assessment and direct comparison with the (reduced) QHOs because of the large societal risk potential. The use of the simplified containment analyses procedures contained in Appendix B to draft Regulatory Guide DG-1061 and use of a LERF as surrogate for the QHOs may not be appropriate. The core damage frequency (CDF) could probably remain at $1x10^{-4}$ since this value for the CDF has been demonstrated in NUREG-1150 to result in an individual early fatality risk that is substantially below the safety goal QHOs.

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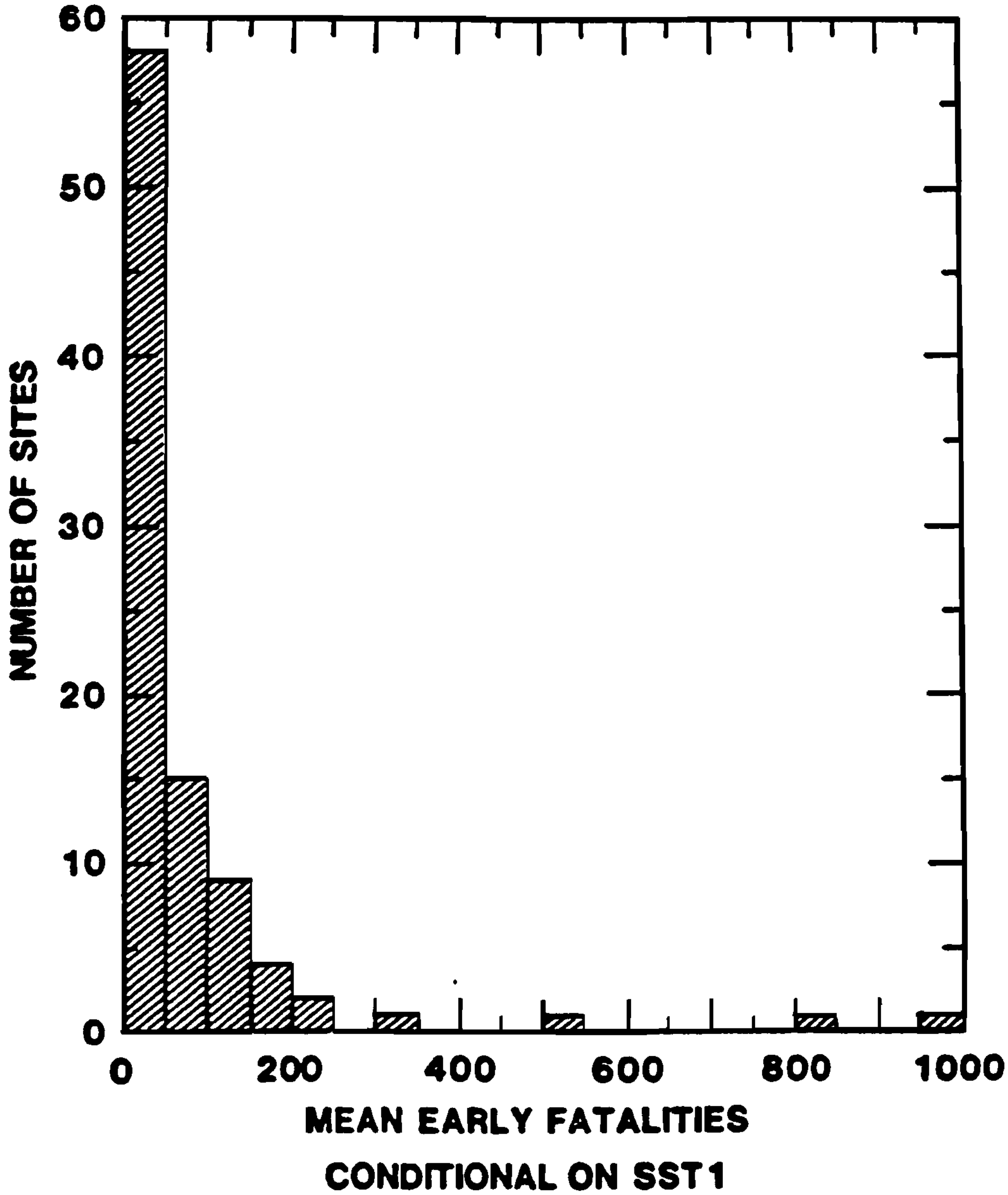
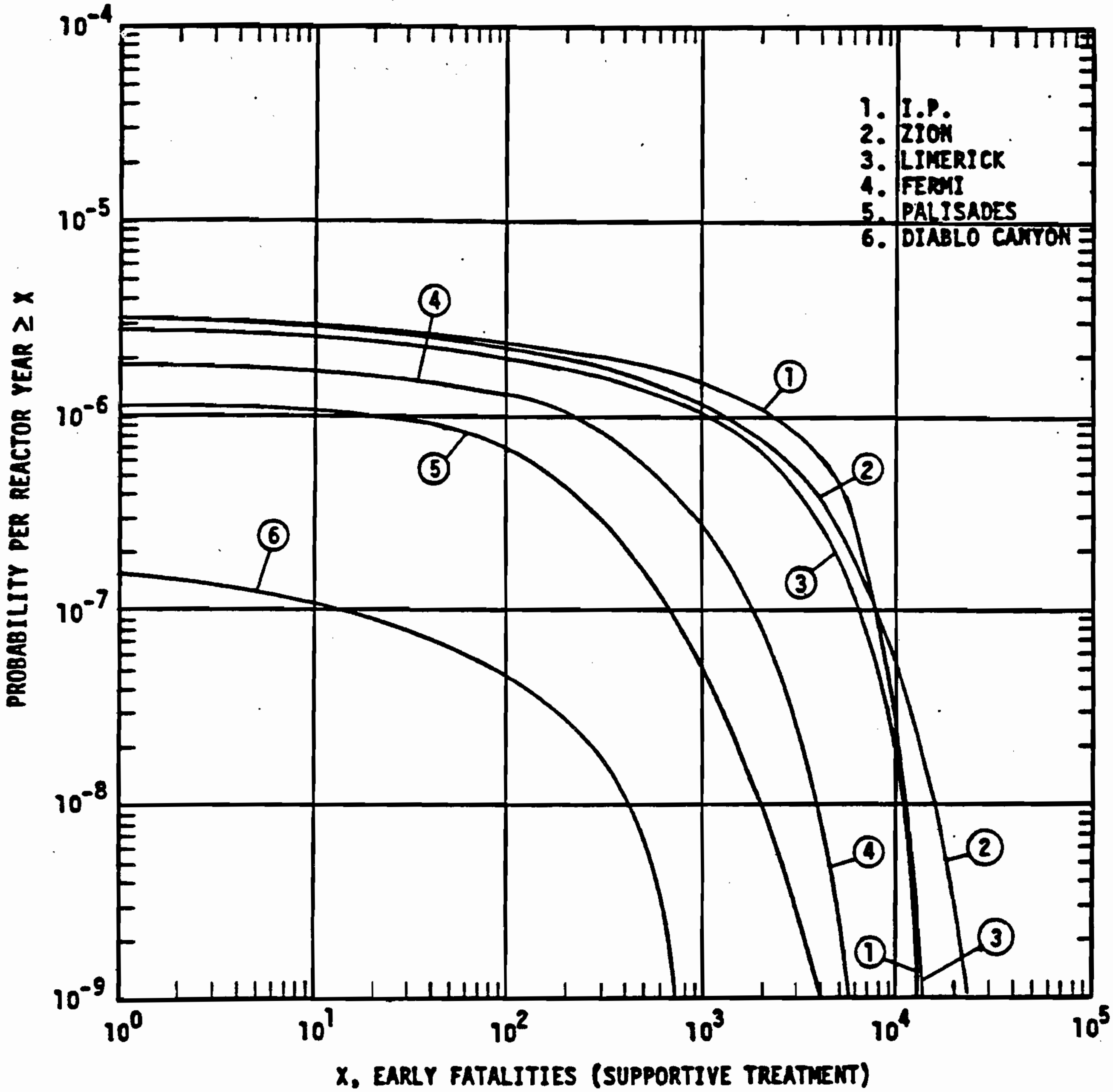


Figure 1 Histogram of Mean Early Fatalities for 91 Sites, Conditional on an SST1 release. Assumptions: 1120 MWe reactor, a representative meteorological record, and Summary Evacuation.

FIGURE 2 EARLY FATALITY RISK FOR DIFFERENT SITES



NOTE: THERE ARE LARGE UNCERTAINTIES WITH THE ABSOLUTE VALUES PRESENTED IN THIS FIGURE

ASSUMPTIONS: 1) SURRY DESIGN.
2) I.P. UNIT 3 POWER LEVEL (3025 MWT).
3) WITHIN 10 MILES - ENTIRE CLOUD EXPOSURE + 4 HOURS GROUND EXPOSURE NO SHIELDING
BEYOND 10 MILES - ENTIRE CLOUD EXPOSURE + 7 DAY GROUND EXPOSURE SHIELDING BASED ON NORMAL ACTIVITY.
4) WIND ROSE WEIGHTED 1970 CENSUS POPULATION DISTRIBUTION.
5) IDENTICAL 91 WEATHER SEQUENCES FOR ALL SITES.

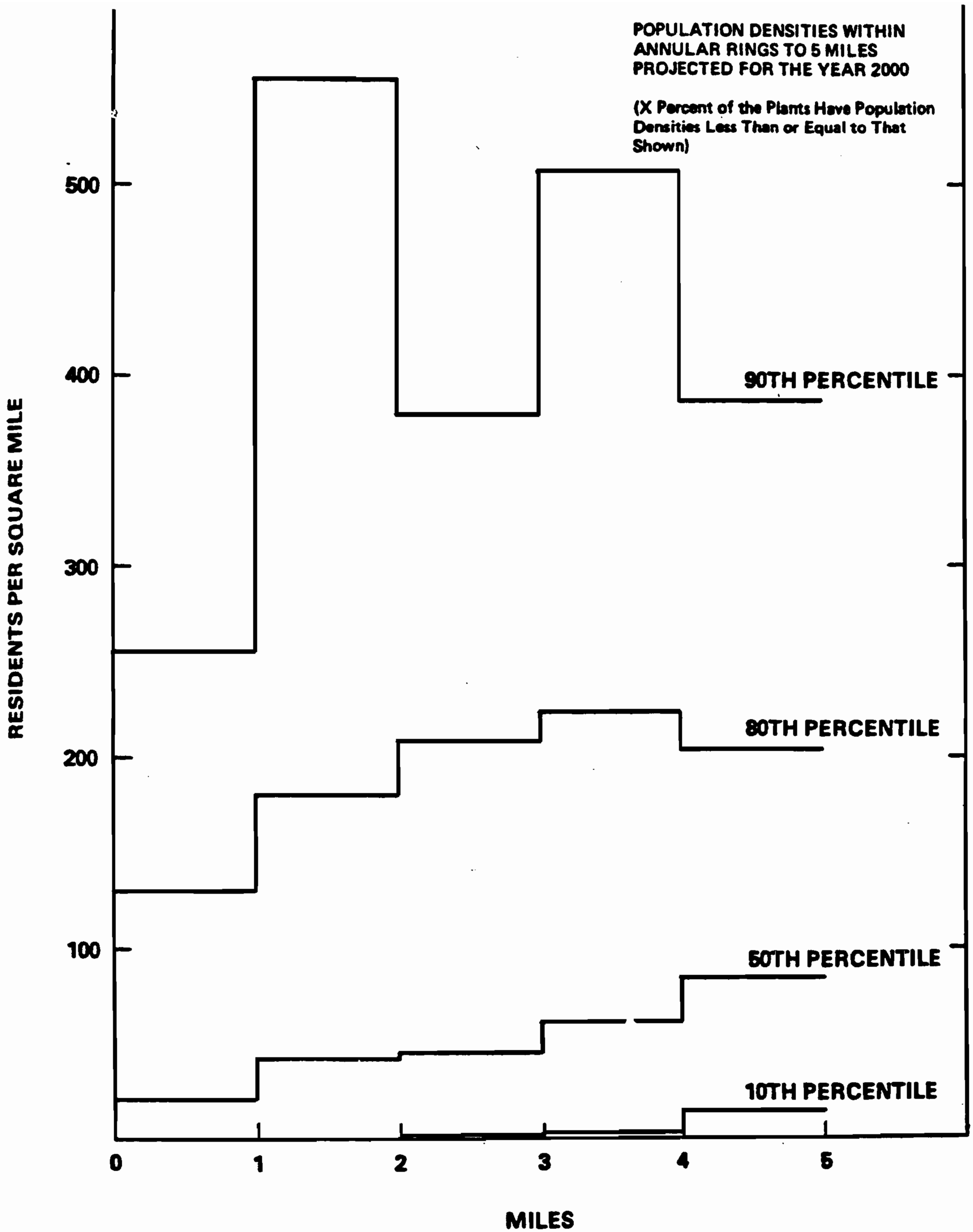

POPULATION DENSITIES WITHIN ANNULAR RINGS TO 5 MILES PROJECTED FOR THE YEAR 2000
(X Percent of the Plants Have Population Densities Less Than or Equal to That Shown)
90TH PERCENTILE
80TH PERCENTILE
50TH PERCENTILE
10TH PERCENTILE
RESIDENTS PER SQUARE MILE
500
400
300
200
100
0
1
2
3
4
5
MILES

FIGURE 3

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This compilation contains 67 ACRS reports submitted to the Commission, or to the Executive Director for Operations, during calendar year 1997 It also includes a report to the Congress on the NRC Safety Research Program All reports have been made available to the public through the NRC Public Document Room, the U S Library of Congress, and the Internet at http //www nrc gov/ACRSACNW. The reports are categorized by the most appropriate generic subject area and by chronological order within the subject area

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