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FROM: L. G. Hulman, Chief
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SUBJECT: CONSEQUENCE CALCULATIONS FOR NUREG-0956

Attached is a description of the consequence calculations performed for NUREG-0956. The enclosure describes the input used, results obtained and some important sensitivities.

This work was the result of a team effort within the Accident Evaluation Branch, and significant contributions were made by Len Soffer, Larry Bell, Robert Buck, Mike McDonald, Gene Suh, and Karen Thornton. Contributions were also made by D. Cleary, Site Analysis Branch, and I. Spickler, Meteorology and Effluent Treatment Systems Branch. Modeling of emergency protective measures was coordinated with I&E.

We have also transmitted the input data for these calculations to Sandia Laboratories, to be used for the forthcoming 5 plant risk study (NUREG-1150), sponsored by Research.

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Enclosure: As stated

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Enclosure

CONSEQUENCE CALCULATIONS FOR NUREG-0956

Consequence Model and Inputs

Consequence calculations for the Surry plant were performed for four separate cases of accident frequencies and release categories using the CRAC2 computer code. This code represents an improved version of the consequence model (CRAC code) used in the Reactor Safety Study, WASH-1400, and is more fully described in References 1 and 2. To provide assurance that the code would yield results consistent with the CRAC code used in the Reactor Safety Study, sensitivity studies were done using both codes. These were found to give very similar results for 3 risk measures, mean early fatalities, mean latent cancer fatalities and interdicted land area.

While carrying out the calculations for the report and making use of the option of a non-evacuating portion of the population, a coding error was identified by Sandia Laboratories in several (early fatalities and early injuries) of the complementary cumulative distribution functions (CCDF). These quantities were corrected by hand tabulations and our contractor (ORNL) was requested to provide code corrections, after consultation with Sandia representatives.

Unlike the Reactor Safety Study, which used information based upon a composite of several sites, the calculations for this study used as much information specific to the Surry site as was available. The population distribution in the vicinity of the Surry site was used out to a distance of 350 miles from the reactor. This information was based upon the 1980 census residential plus estimated average daily transient population. A tabulation of this data is shown in Enclosure 1. The meteorological data used was hourly wind speed, stability class and precipitation data from the Shearon Harris site, located

in Wake County, North Carolina, since this data was not available for Surry in sufficient detail for use with the CRAC2 code. The Shearon Harris site was judged to be very similar to Surry in these parameters. The wind rose (see Enclosure 2), or, the probability of the wind blowing in each of the 16 compass directions used for the calculations, was provided by METB and made use of Surry meteorological data.

Parameters describing the emergency protective actions to be taken by the public to mitigate accident exposures are an important input to the code. These were revised from the values used in WASH-1400, where a key-hole shaped evacuation was assumed which extended for 5 miles in all directions and for 25 miles in the downwind directions. Consistent with resolution of severe accident issues between NRC and IDCOR (see Ref. 3), it has been agreed to assume that a small fraction of the population would not participate in evacuation. Five percent of the population within 10 miles was assumed not to evacuate, but carried on their normal activities for a period of 24 hours after a release. After this period, this population segment was assumed to be relocated to an area of no further radiation exposure. The remaining 95 percent of the population within 10 miles of the reactor was assumed to evacuate after being advised to do so. This group was assumed to delay for a one-hour period for activities such as preparation and mobilization, including gathering of belongings and assembling family members prior to movement. Their movement was modeled as an effective radial speed away from the reactor of 2.7 miles per hour. This accounts for time delays due to traffic congestion as well as the fact that the road network in the site vicinity does not lead radially away from the reactor. The delay prior to evacuation and the effective speed of movement were based upon analyses presented by the licensee (Ref. 4) for the "winter weekday" scenario. Variations in these assumptions are possible and are discussed below. Members of the population located beyond 10 miles were assumed to be relocated 12 hours after a release.

To obtain a distribution of consequences, the calculation were performed assuming the occurrence of an accident release at each of many "start" times. In order to choose start times, all the meteorological data for one year were

sorted into bins based upon meteorological characteristics they have in common. Start times were chosen from each bin randomly and the results weighed by the frequency of each bin.

It is also important to recognize that the CRAC2 code assumes that all radionuclides are released at a uniform rate over the time duration specified as input to the code. It has been recognized that this is an improper characterization, since BMI-2104 indicates that the noble gases and the more volatile species tend to be released relatively early, while the more refractory materials are released later. The CRAC2 code, however, does not have the capability of modeling such a time dependency for a given release. Some limited parametric calculations were made by varying the release duration and are discussed below. Research efforts, currently in progress, are expected to lead to a consequence model with time-dependent capability within the next several months.

Results

Calculations were performed for four different cases for the Surry plant. These were: Case I - WASH-1400 Smoothed Release Categories PWR1 through PWR7 using WASH-1400 release values (see Table 1); Case II - WASH-1400 Unsmoothed Release Categories PWR1 through PWR7 using WASH-1400 release values (see Table 2); Case III - BMI-2104 fission product release insights (see Tables 3 and 4); and Case IV - BMI-2104 fission product release and containment insights. The release fractions for Cases III and IV were the same; Case IV made use of different bin probabilities (see Table 5).

Results of the consequence calculations are presented for two measures of health risk to the public: early fatalities and latent cancer (including thyroid cancer) fatalities. These represent only two of the many potential impacts of severe accident releases, but were chosen because they display two important measures of accident consequences. These measures can be used to form a perspective on accident risk, as well as to compare changes in fission product release and transport and containment behavior of the present work against those of the Reactor Safety Study. For more complete discussions of accident impacts, the reader is referred to recent Environmental Impact

Statements (EIS) (see Reference 5), issued by the NRC staff, and to the Reactor Safety Study (Reference 6).

The results summarizing the consequence calculations are shown in Tables 6 and 7. Table 6 shows the mean or average results for early and latent fatalities for each of the 4 cases discussed above. The values are given in terms of their probabilities of occurrence, per reactor-year, and are the average values for any given year of reactor operation. Table 7 shows the mean or average consequence, conditional upon the occurrence of a core-melt (the average values that can be expected to result, assuming that a core-melt has occurred). There is a large variation in the possible outcomes, or consequences, for a given core-melt. This variation is due not only to large differences in the magnitude and timing of radioactivity release, but also to differences in meteorological dispersion and wind direction. Differences in emergency response by the population will also affect these results. The mean results represent the average of all the accident consequences over variations not only in accident sequences, but meteorology and wind direction as well. To present a perspective of the range of these consequences, the distribution of these outcomes have been presented as a Complementary Cumulative Distribution Function (CCDF). This presents information on the probability that a consequence equal to or greater than a given magnitude will occur. Figures 1 and 2 present the CCDF's for early fatalities and latent cancer fatalities respectively, for the 4 cases evaluated. It should be noted that the peak values, or highest magnitude values, shown on each CCDF curve, result from the greatest release coupled with the most adverse meteorology. The peak value is typically 3 to 5 orders of magnitude less probable than more typical values for such events. In addition, the uncertainty involved in estimating peak values is significantly greater than for more typical values because, among other factors, the reproducibility of the meteorological data becomes questionable for very unusual situations that may be observed only a few hours in each year.

From Tables 6 and 7, it can be seen that mean early fatalities are about an order of magnitude less for Case IV, vs. the unsmoothed insights of WASH-1400 in Case II. Mean latent cancer fatalities are about a factor of 4 less for the same two cases, respectively. It is of special note that the CCDF's for

early fatalities show that the peak values for Cases III and IV are predicted to be reduced about two orders of magnitude below those for Case II.

Sensitivities in Emergency Protective Measure

Two sensitivities in results to changes in emergency protective measures were explored. The first examined the change in consequences that would occur assuming that 100% of the population participated in evacuation (at the licensee analysis evacuation speed of 2.7 miles per hour). A second variation also assumed 100% participation in evacuation, but at a faster evacuation speed of 6.5 miles per hour. The mean conditional consequences for Cases II, III and IV for these variations are shown in Tables 8 and 9. These tables also show the conditional expected early injuries as well as early fatalities and latent cancer fatalities.

Comparison of Tables 8 and 9 with the results shown in Table 7 indicates that the assumption that a portion or fraction of the population does not participate in evacuation has a significant effect upon estimated early health effects. For the WASH-1400 unsmoothed results (Case II), early fatalities are reduced by about a factor of three in going from a 95% to a 100% participation. For the BMI-2104 cases (cases III and IV), early fatalities are predicted to be completely eliminated for the 100% evacuation case. In contrast, increasing the evacuation speed from 2.7 to 6.5 miles per hour appears to have no significant effect on the consequences. The reader is cautioned, however, because of the limited data that one cannot infer that evacuation speed has no effect upon consequences. It is also clear from inspection of Tables 7, 8 and 9 that latent cancer fatalities do not appear to be significantly affected by changes in evacuation participation or evacuation speed.

Sensitivities in Release Timing

A number of the sequences have releases extending over a period of many hours. Reference 7 (BMI-2104) has indicated that not all of the radioactivity is released uniformly in time, and that the noble gases and volatile fission products are released early while the more refractory fission products are released significantly later. A precise treatment of the time dependency of

these releases is not possible with the CRAC2 code, which has the limitation that all releases must be uniform over the time duration specified. Also, releases longer than 10 hours in duration cannot be modeled.

Some very limited parametric calculations were undertaken to gain insight into the possible effect of these limitations. The sequence AB-β for the Surry plant was analyzed at the end of 4 hours and at the end of the sequence which was modeled as lasting 10 hours. The plume characteristics and release fractions are shown in Table 10. Consequence calculations were made for these two sequences and the mean values of early fatalities and total latent cancers are shown in Table 11. The results indicate that both early effects, such as early fatalities and latent health effects, are affected by judgments made regarding the release duration. Where the noble gases are released early, it appears to be non-conservative from the standpoint of estimation of early health effects, to model the release as a long-duration event where the same quantity of noble gases are released over 10 hours rather than 4 hours. For estimation of latent effects, on the other hand, it is important to model the entire release over its full duration.

Uncertainties

Some understanding of the uncertainties is necessary for a fuller appreciation of the results. A good discussion of uncertainties in this regard is given in Reference 5. This points out that major contributors to uncertainty are the probability of occurrence of the accident sequences, quantity and chemical form of the radioactivity released, atmospheric dispersion modeling and other errors of completeness in modeling. Other areas of uncertainty include estimation of health effects resulting from radiation exposure. A major purpose of NUREG-0956 is to reduce the uncertainty in the quantity and timing of radioactivity released. However, the uncertainty in the remaining factors exists.

TABLE 1 SUMMARY OF RELEASE CATEGORIES REPRESENTING HYPOTHETICAL ACCIDENTS

Release Category	Probability (reactor-yr^{-1})	Time of Release (hr)	Duration of Release (hr)	Warning Time for Evacuation (hr)	Elevation of Release (meters)[g]	Energy Release (10^6 Btu/hr)	Fraction of Core Inventory Released[a]							
							Xe-Kr	Organic I[b]	I[b]	Cs-Rb	Te-Sb	Ba-Sr	Ru[c]	La[d]
PWR 1	9×10^{-7}[e]	2.5	0.5	1.0	25	20 and 520[e]	0.9	6×10^{-3}	0.7	0.4	0.4	0.05	0.4	3×10^{-3}
PWR 2	8×10^{-6}	2.5	0.5	1.0	0	170	0.9	7×10^{-3}	0.7	0.5	0.3	0.06	0.02	4×10^{-3}
PWR 3	$4 \times 10^{-[illegible]}$	5.0	1.5	2.0	0	6	0.8	6×10^{-3}	0.2	0.2	0.3	0.02	0.03	3×10^{-3}
PWR 4	5×10^{-7}	2.0	3.0	2.0	0	1	0.6	2×10^{-3}	0.09	0.04	0.03	5×10^{-3}	3×10^{-3}	4×10^{-4}
PWR 5	7×10^{-7}	2.0	4.0	1.0	0	0.3	0.3	2×10^{-3}	0.03	9×10^{-3}	5×10^{-3}	1×10^{-3}	6×10^{-4}	7×10^{-5}
PWR 6	6×10^{-6}	12.0	10.0	1.0	0	N/A	0.3	2×10^{-3}	8×10^{-4}	8×10^{-4}	1×10^{-3}	9×10^{-5}	7×10^{-5}	1×10^{-5}
PWR 7	4×10^{-5}	10.0	10.0	1.0	0	N/A	6×10^{-3}	2×10^{-5}	2×10^{-5}	1×10^{-5}	2×10^{-5}	1×10^{-6}	1×10^{-6}	2×10^{-7}
PWR 8	4×10^{-5}	0.5	0.5	N/A[f]	0	N/A	$2 \times 10^{-[illegible]}$	5×10^{-6}	1×10^{-4}	5×10^{-4}	1×10^{-6}	1×10^{-8}	0	0
PWR 9	4×10^{-4}	0.5	0.5	N/A	0	N/A	3×10^{-6}	7×10^{-9}	1×10^{-7}	6×10^{-7}	1×10^{-9}	1×10^{-11}	0	0
BWR 1	1×10^{-6}	2.0	0.5	1.5	25	130	1.0	7×10^{-3}	0.40	0.40	0.70	0.05	0.5	5×10^{-3}
BWR 2	6×10^{-6}	30.0	3.0	2.0	0	30	1.0	7×10^{-3}	0.90	0.50	0.30	0.10	0.03	4×10^{-3}
BWR 3	2×10^{-5}	30.0	3.0	2.0	25	20	1.0	7×10^{-3}	0.10	0.10	0.30	0.01	0.02	[illegible] $\times 10^{-3}$
BWR 4	2×10^{-6}	5.0	2.0	2.0	25	N/A	0.6	7×10^{-4}	8×10^{-4}	5×10^{-3}	4×10^{-3}	6×10^{-4}	$6 \times 10^{-[illegible]}$	[illegible] 10^{-4}
BWR 5	1×10^{-4}	3.5	5.0	N/A	150	N/A	5×10^{-4}	2×10^{-9}	6×10^{-11}	4×10^{-9}	8×10^{-12}	8×10^{-14}	0	

(a) Background on the isotope groups and release mechanisms is presented in Appendix VII.
(b) Organic iodine is combined with elemental iodines in the calculations. Any error is negligible since its release fraction is relatively small for all large release categories.
(c) Includes Ru, Rh, Co, Mo, Tc.
(d) Includes Y, La, Zr, Nb, Ce, Pr, Nd, Np, Pu, Am, Cm.
(e) Accident sequences within PWR 1 category have two distinct energy releases that affect consequences. PWR 1 category is subdivided into PWR 1A with a probability of 4×10^{-7} per reactor-year and 20×10^6 Btu/hr and PWR 1B with a probability of 5×10^{-7} per reactor-year and 520×10^6 Btu/hr.
(f) Not applicable.
(g) A 10 meter elevation is used in place of zero representing the mid-point of a potential containment break. Any impact on the results would be slight and conservative.

Table 2 Unsmoothed frequencies for PWR Reactor Safety Study release categories

Sequence Type	Release Category 1	2	3	4	5	6	7
Large LOCA	2.5×10^{-10}	1.6×10^{-10}	4.9×10^{-8}	1×10^{-4}	7×10^{-9}	1.3×10^{-9}	3×10^{-6}
Small LOCA(S_1)	7×10^{-10}	5.6×10^{-10}	1.2×10^{-7}	1×10^{-11}	1.1×10^{-8}	2.7×10^{-9}	6×10^{-6}
Small LOCA(S_2)	2.2×10^{-8}	1.6×10^{-9}	2.3×10^{-6}	1×10^{-12}	3×10^{-8}	2.9×10^{-8}	1.5×10^{-5}
Vessel Rupture	2×10^{-12}	4.1×10^{-11}	1×10^{-9}	0	0	0	1×10^{-7}
V	0	4×10^{-6}	0	0	0	0	0
Transient	3×10^{-8}	2.7×10^{-6}	1×10^{-7}	0	6×10^{-10}	6×10^{-7}	1×10^{-5}
Total	5.3×10^{-8}	6.7×10^{-6}	2.6×10^{-6}	$2.1\times10^{-1}1$	4.9×10^{-8}	6.3×10^{-7}	3.4×10^{-5}

Table 3 Source term bins for the Surry plant

Bin	Time of Release	Duration	Warning Time	Elevation	Energy of Release (cal/sec)	1	2	3	4	5	6	7
1	2.5	10	.5	10	1.4×10^{5}	1.0	7.5×10^{-2}	5.8×10^{-2}	5.5×10^{-2}	1.0×10^{-2}	1.3×10^{-3}	1.7×10^{-4}
2	1.5	1	.5	10	1.4×10^{5}	1.0	7.5×10^{-2}	5.8×10^{-2}	4.2×10^{-2}	5.1×10^{-3}	1.3×10^{-3}	1.4×10^{-5}
3	2.5	3	.5	10	7.7×10^{5}	1.0	5.1×10^{-3}	1.1×10^{-4}	1.1×10^{-2}	3.2×10^{-2}	1.1×10^{-3}	9.4×10^{-4}
4	2.5	1	.5	10	4.8×10^{4}	1.0	5.0×10^{-3}	4.8×10^{-5}	2.5×10^{-5}	6.8×10^{-4}	2.6×10^{-4}	1.3×10^{-6}
5	12	10	2	10	1.4×10^{5}	1.0	3.9×10^{-1}	3.8×10^{-1}	2.0×10^{-1}	8.6×10^{-2}	1.2×10^{-2}	1.7×10^{-4}
6	2	10	0	10	1.4×10^{4}	1.0	2.7×10^{-2}	1.3×10^{-2}	1.2×10^{-1}	6.2×10^{-2}	1.6×10^{-3}	2.6×10^{-4}
7	1	10	0	10	0	1.0	5.3×10^{-3}	2.6×10^{-4}	1.8×10^{-4}	1.8×10^{-4}	2.7×10^{-5}	5.8×10^{-7}
8	8	1	6	10	4.8×10^{4}	1.0	5.0×10^{-3}	$<1 \times 10^{-9}$	1.5×10^{-3}	1.2×10^{-5}	4.3×10^{-8}	2.1×10^{-8}
9	12	1	10	10	7.8×10^{4}	1.0	7.8×10^{-3}	3.9×10^{-4}	8.5×10^{-2}	1.8×10^{-2}	3.3×10^{-6}	8.1×10^{-5}
10	2.5	10	.5	10	1.4×10^{4}	1.0	6.9×10^{-3}	1.1×10^{-3}	1.3×10^{-2}	5.8×10^{-3}	1.7×10^{-4}	2.4×10^{-5}
11	1	2	.8	0	2.4×10^{5}	1.0	8.4×10^{-2}	7.3×10^{-2}	2.5×10^{-2}	2.2×10^{-2}	4.5×10^{-3}	1.1×10^{-3}
12	1	2	.8	0	2.4×10^{5}	1.0	4.1×10^{-1}	4.0×10^{-1}	1.2×10^{-1}	1.3×10^{-1}	2.7×10^{-2}	6.4×10^{-3}
13	24	1	22	0	0	1.0	0	0	0	0	0	0
14	24	1	22	10	0	3×10^{-2}	1.5×10^{-4}	0	0	0	0	0
15						negligible						

Table 4 Assignment of Reactor Safety Study frequencies to BMI-2104-based source term bins

Bin	Reactor Safety Study Sequences and Frequencies
1	$2x10^{-6}$ (TMLB'δ) $5.3x10^{-8}$ (all PWR1) = $\underline{2.1x10^{-6}}$
2	
3	$\underline{3.4x10^{-7}}$ (all α in PWR3)
4	
5	$1x10^{-8}$ (AFδ) $9x10^{-9}$ (AGδ) $3x10^{-8}$ (S_1Fδ) $3x10^{-8}$ (S_1Gδ) $1x10^{-7}$ (S_2Fδ) $9x10^{-8}$ (S_2Gδ) = $\underline{2.7x10^{-7}}$
6	
7	$4x10^{-9}$ (ADβ) $3x10^{-9}$ (AHβ) $5x10^{-9}$ (S_1Hβ) $6x10^{-9}$ (S_1Dβ) $2x10^{-8}$ (S_2Dβ) $1x10^{-8}$ (S_2Hβ) $3x10^{-10}$ (TMLβ) $3x10^{-10}$ (TKQβ) = $\underline{4.9x10^{-8}}$
8	
9	$7x10^{-7}$ (TMLB'γ)
10	
11	
12	$\underline{4x10^{-6}}$ (V)
13	$\underline{6.3x10^{-7}}$ (all PWR6)
14	$\underline{3.4x10^{-5}}$ (all PWR7)
15	$\underline{2x10^{-6}}$ (S_2C)

Table 5 Core melt frequencies for BMI-2104-based source term bins with containment reevaluation

Bin	Frequency
1	4.1×10^{-8}
2	2.4×10^{-7}
3	3.1×10^{-8}
4	[illegible].1 $\times 10^{-7}$
5	2.7×10^{-7}
6	6.6×10^{-9}
7	6.8×10^{-8}
8	2.7×10^{-6}
9	6.6×10^{-6}
10	7.5×10^{-7}
11	3×10^{-6}
12	1×10^{-6}
13	3×10^{-7}
14	8.5×10^{-6}
15	2×10^{-5}

Table 6 Surry results - absolute probabilities

		Mean per reactor year
Case I -	WASH-1400 Smoothed	Mean per reactor year
	Early Fatalities	$6.4x10^{-5}$
	Latent Cancer Fatalities	$2.2x10^{-2}$
Case II -	WASH-1400 ~~Unsmoothed~~	Mean per reactor year
	Early Fatalities	$4.0x10^{-5}$
	Latent Cancer Fatalities	$1.6x10^{-2}$
Case III -	BMI-2104-Based Source Terms*	Mean per reactor year
	Early Fatalities	$1.1x10^{-5}$
	Latent Cancer Fatalities	$6.7x10^{-3}$
Case IV -	Containment Reevaluation*	Mean per reactor year
	Early Fatalities	$3.1x10^{-6}$
	Latent Cancer Fatalities	$3.4x10^{-3}$

*Using WASH-1400 core-melt probabilities.

Table 7 Surry results -- conditional on core melt*

Case I	-	<u>WASH-1400 Smoothed</u>	<u>Mean</u>
		Early Fatalities	1.1
		Latent Cancer Fatalities	360.
Case II	-	<u>WASH-1400 Unsmoothed</u>	<u>Mean</u>
		Early Fatalities	0.9
		Latent Cancer Fatalities	350.
Case III	-	<u>BMI-2104-Based Source Terms**</u>	<u>Mean</u>
		Early Fatalities	0.25
		Latent Cancer Fatalities	150.
Case IV	-	<u>Containment Reevaluation**</u>	<u>Mean</u>
		Early Fatalities	0.07
		Latent Cancer Fatalities	77.

*Probability of core melt for Case I = 6.0×10^{-5}
Probability of core melt for Case II = 4.4×10^{-5}
Probability of core melt for Case III = 4.4×10^{-5}
Probability of core melt for Case IV = 4.4×10^{-5}
**Using WASH-1400 core-melt probabilities.

Table 8 - Surry Results
Conditional on Core-Melt
100% Participation in Evacuation at 2.7 Miles/Hour

Case II WASH-1400 Unsmoothed

	Mean
early fatalities	0.27
early injuries	146.
latent cancer fatalities	330.

Case III - BMI-2104 Fission Product Release Insights

	Mean
early fatalities	0.
early injuries	27.
latent cancer fatalities	150.

Case IV - BMI-2104 Insights Plus Containment Re-evaluation

	Mean
early fatalities	0.
early injuries	7.8
latent cancer fatalities	78.

Table 9 - Surry Results
Conditional on Core-Melt
100% Participation in Evacuation at 6.5 Miles/Hour

Case II - WASH-1400 Unsmoothed

	Mean
early fatalities	0.27
early injuries	145
latent cancer fatalities	370.

Case III - BMI-2104 Fission Product Release Insights

	Mean
early fatalities	0.
early injuries	27.
latent cancer fatalities	150.

Case IV - BMI-2104 Insights Plus Containment Re-evaluation

	Mean
early fatalities	0.
early injuries	7.8
latent cancer fatalities	77.

Table 10

Release Fractions vs. Timing

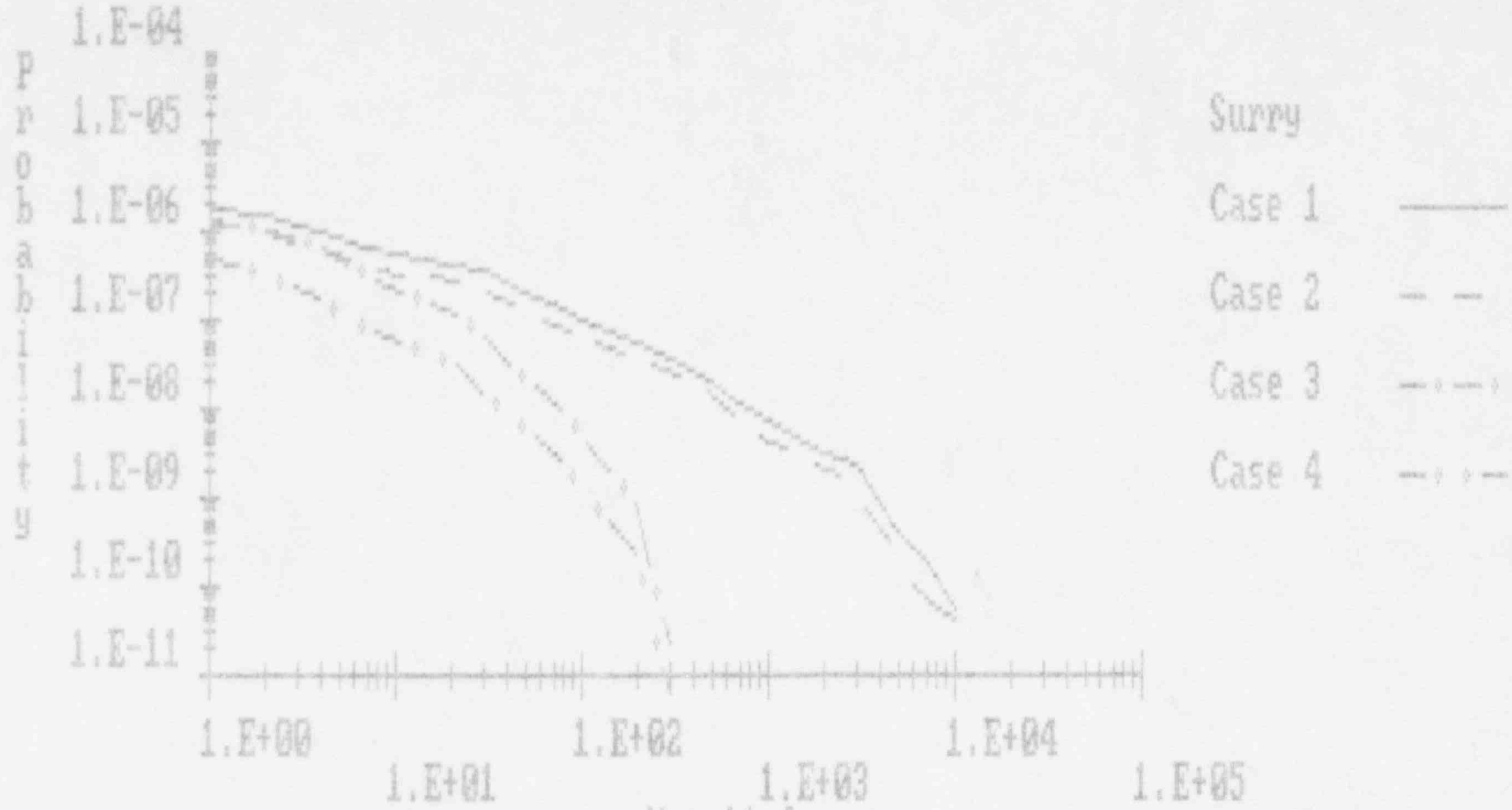
Sequence AB-β (Surry)

Time Assumption	Release Time (hrs)	Rel. Duration (hrs)	Warning Time (hrs)	Energy of Rel. (10^6 BTU/hr)	Release Fractions Xe, Kr	I	Cs	Te	Ba	Ru	La
End of 4 hrs	0.5	3.5	0.2	0.2	0.9	8.1E-2	8E-2	3.4E-2	5.1E-2	2.5E-3	4.3E-3
Total Duration	0.5	10.	0.2	0.2	0.9	8.7E-2	8.7E-2	6.6E-2	7.6E-2	2.9E-3	7.5E-3

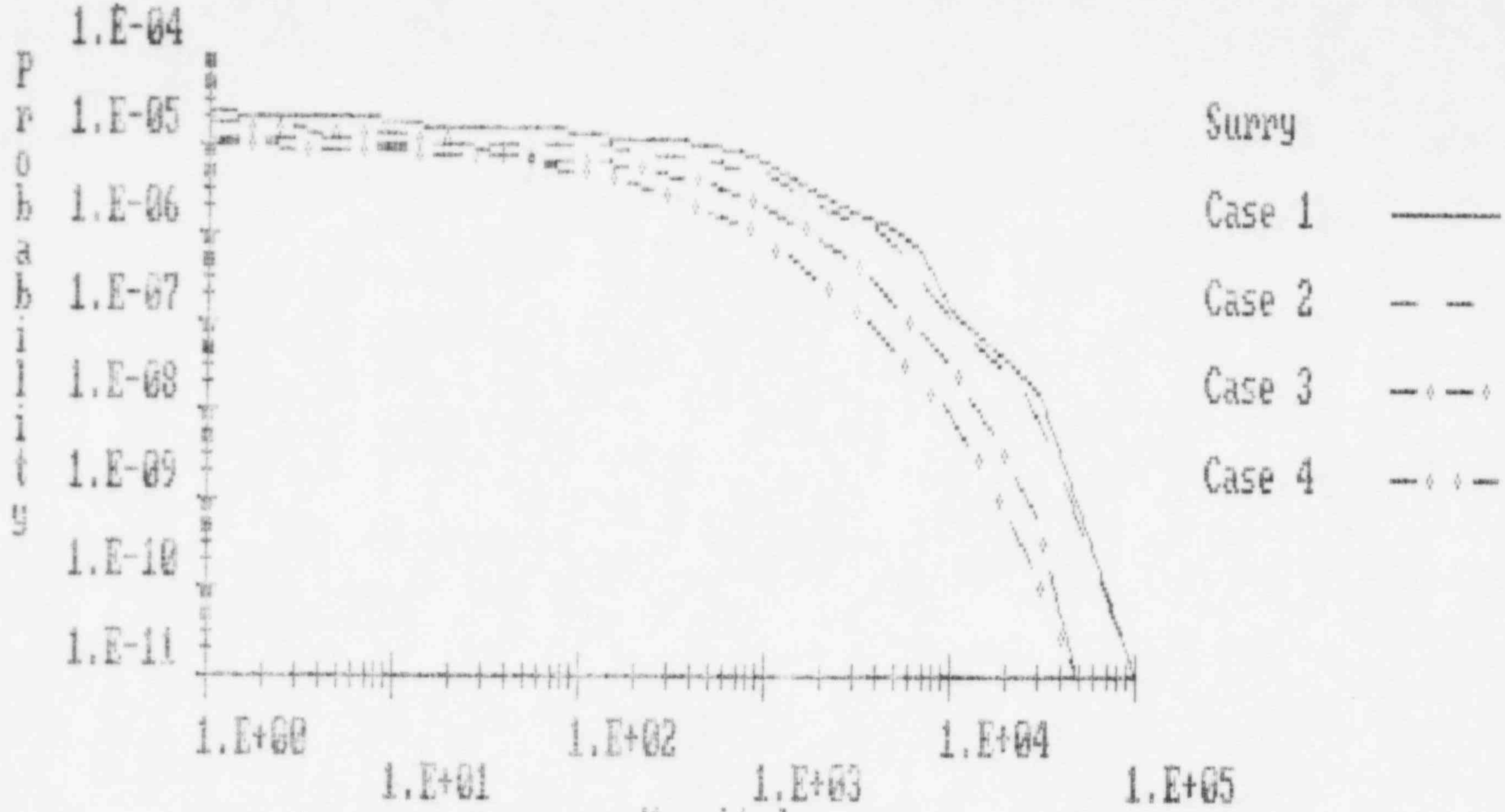
Table 11

Conditional Results - Sequence Duration

	Mean
AB-β (4 hours)	
early fatalities	2.2×10^{-2}
latent cancer fatalities	280.
AB-β (Total)	
early fatalities	0.
latent cancer fatalities	436.



Acute Fatalities



Latent Cancer Fatilities

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3. Memo from Z. Rosztoczy to T. Speis, "Minutes of the NRC/IDCOR Meeting on April 30, 1985", dated June 21, 1985.

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5. Final Environmental Statement - related to operation of Limerick Generating Station, Units 1 & 2, NUREG-0974, U. S. Nuclear Regulatory Commission, April 1984.

6. Reactor Safety Study, WASH-1400 (NUREG-75/014), U. S. Nuclear Regulatory Commission, October 1975.

7. J. A. Gieseke, et.al. "Radionuclide Release under Specific LWR Accident Conditions", BMI-2104, Vols. I-VI, Battelle Columbus Laboratories, July 1984.

For [illegible] population [illegible] to AEB

Surry 1980 POPULATION

SECTOR DIR / MILES	1.3 - 11.3 N	11.3 - 33.8 NNE	33.8 - 56.3 NE	56.3 - 78.8 ENE	78.8 - 101.3 E	101.3 - 123.8 ESE	123.8 - 146.3 SE	146.3 - 168.8 SSE
0-1	0	0	0	0	0	0	0	0
1-2	0	3	0	0	0	0	0	0
2-3	0	0	0	0	0	0	0	0
3-4	0	0	0	0	0	0	0	0
4-5	39	98	49	15	0	10	0	20
5-10	21295	5089	2512	2196	14590	25358	0	390
10-20	1309	826	6686	6902	18407	82787	54661	7512
20-30	3846	4733	4126	1529	391	181,212	123358	17694
30-40	4226	7753	1553	596	2123	78860	344249	21036
40-50	4488	5557	0	7880	1544	61539	48201	5428
50-60	10666	5598	998	8123	0	0	5100	5145
60-70	7498	4459	5939	3874	0	0	3530	30075
70-85	48754	7810	21608	0	0	0	2875	5991
85-100	61441	7126	36501	0	0	0	3952	4074
100-150	3369243	220305	209738	30962	0	0	13408	19295
150-200	1282124	858879	277024	0	0	0	0	6156
200-350	2927455	19562776	295909	0	0	0	0	0
~~350-500~~								

Note: Population includes 1980 residential and estimated average daily transient population.

SAB
12/11/84

SURRY

SECTOR DEG. / MILES	168.8 - 191.3	191.3 - 213.8	213.8 - 236.3	236.3 - 258.8	258.8 - 281.3	281.3 - 303.8	303.8 - 326.3	326.3 - 348.8
	S	SSW	SW	WSW	W	WNW	NW	NNW
0-1	0	0	0	0	0	0	0	0
1-2	40	0	3	3	0	0	0	0
2-3	56	36	54	11	0	0	0	0
3-4	17	9	19	82	66	0	0	83
4-5	71	138	84	54	172	72	1264	63
5-10	915	141	483	343	98	98	1893	7643
10-20	2662	984	2005	1126	980	697	2168	7328
20-30	9095	4207	2611	2675	2894	3083	3577	5069
30-40	10635	14321	2714	2221	70949	37370	7526	2151
40-50	5294	5067	5283	3907	27421	202648	112866	8121
50-60	6930	12782	11364	4627	4633	177699	96727	1921
60-70	11966	18256	14822	7529	5437	13523	13867	10220
70-85	17299	13958	39425	14579	19845	14719	20039	33381
85-100	20020	3[illegible]740	24739	22400	23925	16205	16352	82423
100-150	127675	328073	569730	290881	165914	223045	192116	930567
150-200	41187	235889	402489	736679	464804	79260	74064	494260
200-350	120696	382899	1760812	2902122	1613509	1464637	4303655	1193646
350-500								

Surry Wind Rose (Ref. PAVAN run 10/11/78)
10 m level 3/3/74-4/30/76

OVERALL WIND DIRECTION* FREQUENCY

WIND DIRECTION:	N	NNE	NE	ENE	E	ESE	SE	SSE
FREQUENCY:	6.4	3.7	3.4	3.4	5.3	5.8	6.0	5.9

WIND DIRECTION:	S	SSW	SW	WSW	W	WNW	NW	NNW
FREQUENCY:	8.1	11.7	11.5	5.4	5.0	5.1	6.2	7.1

For use in CRAC1 analysis for Surry along with the Shearon Harris wind speed, stability and precipitation data in CRAC1 format.

* Wind Direction From (i.e. N indicates wind blowing from N to S)