UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

In the Matter of	)	
	)	
Philadelphia Electric Company	)	Docket Nos. 50-352
	)	50-353
(Limerick Generating Station Units 1 and 2)	)	
	)	

APPLICANT'S RESPONSES TO INFORMATION REQUESTS OF THE CITY OF PHILADELPHIA TO THE PHILADELPHIA ELECTRIC COMPANY

DISCOVERY 26
FEBRUARY 16, 1984

REQUEST NO. 1.

The maximum concentration of radioactive isotopes in the Schuylkill River following a severe accident at distances of:

a) 20 miles downstream (river distance)
b) 30 miles downstream (river distance)
c) 40 miles downstream (river distance)
d) at the Schuylkill River's junction with the Delaware River.

RESPONSE

Philadelphia Electric Company does not have the specific information requested.

However, in response (designated Discovery 26, Item 1a) to NRC staff question E240.21, a comparison to NUREG-0440, Liquid Pathway Generic Study (designated Discovery 26, Item 1b), which considers the direct pathway, is presented. The conclusion of that comparison was that the consequences for the Limerick site were comparable to the river site results in NUREG-0440. This comparison assumed that containment base mat melt thru would occur given a core melt as was assumed in NUREG-0440 at page vi, first full paragraph. This assumption is conservative for the Limerick containment design as shown in the Limerick Generating Station Probabilistic Risk Assessment at page 1-20 item 8 and Response to Question PRA H.08(c) at pages Q-156i through Q-156l (designated Discovery 26 Item 1c). Therefore, the direct contamination category is not a significant contributor to risk. Generic information available on the indirect contamination by way of cloud

deposition is contained in "Contamination of Surface Water Bodies after Reactor Accidents by the Erosion of Atmospherically Deposited Radionuclides" by J. C. Helton, A. B. Muller, and A. Bayer, Health Physics, to be published (designated Discovery 26, Item 1d) which arrives at the conclusion that indirect contamination is not a major risk contributor.

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REQUEST NO. 2

What the worst case analysis showed for deposition of radioactive elements at a distance of 30 miles from the site, not averaged over all wind directions. Please specify a) the key assumptions in the worst case analysis, b) which radioactive isotopes would be deposited out, and c) what the concentrations (of the radioactive isotopes) would be in terms of pico curies per square meter.

RESPONSE

Philadelphia Electric Company does not have the requested information. CRAC2 provides only Cs-137 for ground concentrations and the output option to provide these results in curies per square meter was not selected (see NUREG/CR-2326, Discovery 26 Item 2a, at figure III-2). The precise distance of 30 miles would have to have been made a midpoint of a spatial interval to produce the specific result for 30 miles. If the available option in CRAC2 had been selected, results for Cs-137 would have been output at the midpoint of each spatial interval for each weather sequence sampled.

However, the CRAC2 code and data sets used for SARA are available and the code could be modified to provide an option to output the deposited ground concentrations at the midpoint of each spatial interval for each isotope, similar to the existing CRAC2 option for air concentrations shown in Figure III-5 of NUREG/CR-2326 (Discovery 26 Item 2a). The spatial intervals could be changed to make 30 miles a spatial interval midpoint. CRAC2 could then be run for all the SARA

source terms and for each of the weather sequences sampled by the code. The worst case at the distance of 30 miles could be determined by inspection of the output. In order to put the results in probabilistic perspective a routine would be written to present the results for each source term as Conditional Complementary Cumulative Distribution Functions (CCCDFs) of deposited concentration for the important isotopes at 30 miles. On these curves the worst case would appear at the tail of the CCCDF curve. These curves would then be used to develop a Complementary Cumulative Distribution Function (CCDF) by weighing the CCCDF's by the source term frequencies. This curve would provide frequency concentration information in a form consistent with SARA and in a probabilistic perspective that would aid interpretation. The analysis could be performed for approximately $8,000 to $10,000 and could be completed in two to three weeks.

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REQUEST NO. 3

Information requested in (2)(b) and (c), at 20, 30 and 40 miles for the sectors in which Philadelphia is situated (Please prorate for any sectors in which Philadelphia is partially situated).

RESPONSE

Philadelphia Electric Company does not have the requested information (See Response to Request No. 2).

The information could be generated in the same runs described in the response to Request No. 2 with the additional specification of 20 and 40 miles as spatial interval midpoints.

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REQUEST NO. 4

a) What percentage of people (and absolute numbers) that are evacuating from the 10 mile EPZ sectors in the direction of Philadelphia are assumed to go toward Philadelphia.
b) Please explain any other assumptions used for these people including but not necessarily limited to evacuation rate(s) and sheltering.

RESPONSE

The SARA analysis, which used year 2000 projected population and the CRAC2 computer code, assumed 100% of the population within the EPZ evacuated with various delay times. The number of people from zero to 10 miles in the "ESE" and "SE" sectors, as shown on SARA Table 10-2, when totaled, is 33,149. The "E" sector is not included because the area within the City of Philadelphia boundaries which is in this sector is less than 10% of the area of that sector between 30 and 35 miles. In the CRAC2 computer code these individuals are assumed to evacuate radially within the sectors to a distance of 20 miles at which time they cease to accumulate dose. Assumptions dealing with the evacuated populace are provided in SARA 10.1.6.1.1 through 10.1.6.1.4.

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REQUEST NO. 5

Whether you are aware of the experience around TMI that people who were not asked to evacuate did so anyway, i.e., the "shadow phenomenon?" What allowance, if any, for that is incorporated in the health effects analysis.

RESPONSE

While Philadelphia Electric Company is aware of the "shadow phenomenon", it was not modeled in SARA. The consequence model used, CRAC2, does not permit the modeling of such detailed effects. If people who were not asked to evacuate were to do so this could well reduce the consequences because they would accumulate a smaller radiation dose than if they were to stay. A countervailing effect might be that they would interfere with and slow down planned evacuees. Overall, the two effects would tend to balance out and other considerations affecting evacuating and non-evacuating populations would be more significant (e.g., delay before evacuation and effective shielding).

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REQUEST NO. 6

For any CRAC runs done for bad weather, please specify a) how these assumptions were different and b) the incremental differential in results.

RESPONSE

While no CRAC runs were performed to attempt to explicitly analyze the effects of bad weather, the data base for the Sandia generic model is derived from US evacuation experience. Included are a rain case, a fog case, and a snow case [see Reactor Safety Study (designated Discovery 26, Item 6a) Table VI J-1]. Hence, bad weather is included in the evacuation model which was applied in SARA.

No specific analysis was performed beyond the use of this model. However, to estimate the effect of explicitly considering bad weather, it could be assumed that 4% of the time (SARA, page 10-11) the evacuation is adversely affected by bad weather to such an extent that the assumptions for evacuation speeds for the seismic evacuation case are appropriate (3 hours delay and 1 mph evacuation speed). In this case, an estimate of the effect of this change may be made. First, attention should be called to two typographical errors in Table 10-12 of SARA: under the column identified "internal" the value for VRH20 should be 2.7-5 and the Total should be 4.9-5. Next, the seismic contribution for C4% and VRH20 from Table 10-12 should in turn be divided by the

corresponding point estimate seismic frequencies from Table 12-8 and then multiplied by the point estimate internal frequencies from Table 12-8. These results should then be multiplied by 0.04 and summed. The result of 3.0×10^{-6} may then be compared to the sum of VRH20 and C4δ from Table 10-12, using the corrected value above, of 3.7×10^{-5}. This shows that the explicit inclusion of slowing of evacuation due to bad weather, in addition to that included in the model data base, would only have a small (less than 10% increase) effect on the results.

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REQUEST NO. 7

a) A description of the different breathing rates, if any, assumed in the analyses.
b) What the differences were in results as a function of breathing rate assumptions.

RESPONSE

The breathing rates assumed in SARA are documented in SARA at 10.1.6.4. The breathing rate given is $2.66 \times 10^{-4} m^3 s^{-1}$ on page 10-13 and is the same as that which was used in the Reactor Safety Study (Discovery 26, Item 6a) and documented in the PRA Procedures Guide (Discovery 26, Item 7a) at page 9-34.

The precise value or range of values chosen for the breathing rate is a relatively unimportant input to the calculations. Based upon a preliminary scoping execution of CRAC2 for the source term VRH20 (Discovery 26, Item 7b) the breathing rate was simply doubled to $5.32 \times 10^{-4} m^3 s^{-1}$. This assumption is equivalent to assuming that the entire population out to 500 miles was breathing at an average rate indicative of 16 hours of heavy work and 8 hours of resting. The whole-body manrem increased by 15%, latent cancer fatalities increased 37%, and early fatalities increased 40%. These results would indicate that even a conservative doubling of the breathing rate would not have a large effect on public risk. SARA has indicated that other uncertainties, such as variations in source terms, are much more significant.

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REQUEST NO. 8

a) Whether a constant value for cancer per radiation dose was assumed.
b) If not, what values were assumed for different dose levels.

RESPONSE

A constant value for cancer induction was not assumed and the values used are in SARA section 10.1.7. Sensitivity analysis results for a constant value are shown in Figure 10-26 and discussed in section 10.3.3.1 of SARA.

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REQUEST NO. 9

a) Describe the bases and assumptions for rapid relocation in the "sheltering zone" used in the analyses.
b) State whether any studies or texts were relied upon and provide, if any (Or a reference if voluminous).
c) Specify particular assumptions, if different, for the 10-25 mile area that cover the sectors in the direction toward Philadelphia.

RESPONSE

a) The discussion of and basis for rapid relocation are given in SARA at page 10-11.

b) No additional studies or texts were relied upon.

c) The sectors towards Philadelphia were treated in SARA with the same assumptions as other sectors.

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REQUEST NO. 10

Was any attempt made to analyze the environmental impact of human errors of commission during an accident or transient mitigation. If yes, please describe efforts and provide any available written documentation. If no, explain in light of the historic record of this as contributor to accidents.

RESPONSE

Yes, a state of the art analysis of human errors of commission was included in the event trees and fault trees developed for the LGS-PRA and used in SARA. Examples of the PRA treatment of errors of commission generally are grouped into the following areas:

1. Explicit evaluation of operator error - common mode miscalibration of instruments, improper valve line up, and common mode maintenance errors and miscalibration of setpoints leading to failure to depressurize the reactor.

2. Implicit inclusion in the failure rate data base - diesel generator common mode failure rates and valve failures due to maintenance errors such as improper installation of valve seals.

3. Initiating event probabilities - operator errors causing scrams contribute to the initiating event frequencies used in the PRA.

Specific instances of inclusion of operator errors of commission occur throughout the PRA "Quantification of Event Tree Functions".

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REQUEST NO. 11

a) What assumptions were made as to percentage of population that would evacuate within the ten mile EPZ. Provide bases for the assumption.

RESPONSE

The percentage of population assumed to evacuate was 100%. The basis for this assumption is provided in SARA at page 10-10.

A rough estimate can be provided of the likely increase in the public risk of early fatality if it is assumed that a 5% fraction of the population does not evacuate. The basis for 5% as the fraction of nonparticipating people is that, in actual evacuations, Civil Defense Personnel observed this fraction ["A Model of Public Evacuation for Atmospheric Radiological Releases" by D. C. Aldrich et. al., SAND78-0092, (1978) at page 13 (designated Discovery 26, Item 11a)]. From SARA, Table 10-12, the accident sequences C4δ and VRH20 contribute significantly to the point-estimate public risk of early fatality. (2.3×10^{-4} per year out of 3.3×10^{-4} per year). Two additional CRAC2 runs (designated Discovery 26, Items 11b and 11c respectively), one each for VRH20 and C4δ were performed which assumed a delay time of 24 hours and subsequent evacuation at a high speed (sufficient speed to ensure that the incremental radiation dose accumulated during evacuation is small compared to that accumulated during the delay time). The areas under the conditional CCDFs so

obtained were summed and multiplied by 0.05 and then multiplied by the sum of the point estimate frequencies for VRH20 and C4T from Table 12-8. The result was 5.1×10^{-5} per reactor year. The total contribution to public risk of C4T and VRH20 would then be $5.1 \times 10^{-5} + 0.95 \times 2.3 \times 10^{-4} = 2.7 \times 10^{-4}$ per reactor year. The increase in public risk is 19%. This scoping calculation shows that including a nonevacuating fraction of the population would not be expected to increase the public risk by a large amount, and that other uncertainties discussed in SARA, such as variations in source term, are much more significant.

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REQUEST NO. 12

It is noted that PECo's SARA analysis assumed normal behavior beyond ten miles for twelve hours then evacuation.

For PECo Only:

a) What evacuation times were assumed?

b) If any sensitivity analyses were done with other assumptions, please describe the assumptions and the results.

RESPONSE

a) The evacuation of the populace beyond 10 miles is "rapid relocation which is discussed in SARA at page 10-11. Rapid Relocation assumes the instantaneous cessation of dose accumulation.

b) In the preparation of SARA and subsequent to its submittal a number of CRAC2 cases were run to specifically evaluate the sensitivity of the results to the assumptions on behavior of the population beyond 10 miles. Except for the cases discussed below no analysis or evaluation of these CRAC2 cases has been made.

1) Results for sheltering in basements for 24 hours followed by Rapid Relocation are provided in SARA Tables G-4 and G-24.

2) A series of CRAC2 cases were run as a result of discussions with the City of Philadelphia showing the effect of a 48 hours delay in relocation with

"normal activity" during the 48 hours on the population of the City of Philadelphia. A summary of the results of this is provided on the following page:

Chance Per Reactor Year That Various Radiological Effects Will Occur in Philadelphia If No Counter-measures are Taken for 48 Hours

	Internal	Seismic	Total
Chance that there will be one or more early fatality in the City of Philadelphia	One in 5 billion	One in 1.5 billion	One in 1.1 billion
Chance that there will be one or more persons in Philadelphia requiring hospital treatment (bone marrow dose more than 200 rem)	One in 4 billion	One in 1.4 billion	One in 1 billion
Chance that there will be one or more persons in Philadelphia with whole body dose in excess of 25 rem	One in 125 million	One in 80 million	One in 50 millon
Chance that there will be one or more persons in Philadelphia with whole body dose in excess of 5 rem	One in 10 million	One in 12 million	One in 5 million

A number of additional CRAC2 runs were made which included changes in the assumptions on behavior of people beyond 10 miles along with other changes so that the impact of the individual changes cannot be separated. An example of this is the CRAC2 runs, referred to in Response to Request No. 11 above (Discovery 26, Items 11b and 11c), for no evacuation of 5% of the population which also included no relocation (until 24 hours) of the population from 10 to 25 miles.

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COMMONWEALTH OF PENNSYLVANIA :

ss.

COUNTY OF PHILADELPHIA :

V. S. Boyer, being first sworn, deposes and states:

That he is Senior Vice President of Philadelphia Electric Company, the Applicant herein; that he has read the foregoing Applicant's Responses to Information Requests of the City of Philadelphia to the Philadelphia Electric Company and knows the contents thereof; and that the statements and matters set forth therein are true and correct to the best of his knowledge, information and belief.

V. S. Boyer
Senior Vice President

Subscribed and sworn to
before me this 16th day
of February, 1984.

Patricia D. Scholl
Notary Public

PATRICIA D. SCHOLL
Notary Public, Philadelphia, Philadelphia Co.
My Commission Expires February 10, 1986