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# Final Environmental Statement

## related to the operation of Braidwood Station, Units 1 and 2

Docket Nos. STN 50-456 and STN 50-457

Commonwealth Edison Company

U.S. Nuclear Regulatory Commission

Office of Nuclear Reactor Regulation

June 1984

NUCLEAR REGULATORY COMMISSION

Docket No. 50-456 OL Official Exh. No. 1
In the matter of Commonwealth Edison Co.

Staff ______ IDENTIFIED ✓
Applicant ______ RECEIVED ✓
Intervenor ✓ REJECTED ______
Cont'g Off'r ______
Contractor ______ DATE 3/11/86
Other ______ Witness ______
Reporter GLS

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PDR ADOCK 05000456
Q PDR

Table 5.11 Summary of environmental impacts and probabilities

| Probability of impact per reactor-yr | Persons exposed over 200 rems | Persons exposed over 25 rems | Early fatalities | Population exposure, millions of person-rems, 80-km (50-mi)/total | Latent* cancers, 80-km (50-mi)/total | Cost of offsite mitigating actions, $ millions |
|---|---|---|---|---|---|---|
| $10^{-4}$ | 0 | 0 | 0 | 0/<0.003 | 0/0 | < 5 |
| $10^{-5}$ | 0 | 0 | 0 | 0.35/0.81 | 71/220 | 7 |
| $5 \times 10^{-6}$ | 0 | 3,400 | 0 | 1.3/12 | 220/730 | 470 |
| $10^{-6}$ | 480 | 87,000 | 3 | 19/51 | 1,400/3,100 | 2,600 |
| $10^{-7}$ | 3,200 | 730,000 | 1,000 | 47/88 | 3,600/6,400 | 7,100 |
| $10^{-8}$ | 10,100 | 730,000 | 1,500 | 67/88 | 8,100/9,000 | 16,000 |
| Related figure | 5.9 | 5.9 | 5.11 | 5.10 | 5.12 | 5.13 |

*Includes cancers of all organs. Genetic effects would be approximately twice the number of latent cancers.

NOTE: Please refer to Section 5.9.4.5(7) for a discussion of uncertainties in risk estimates.

APPENDIX F

# CONSEQUENCE MODELING CONSIDERATIONS

## F.1 Evacuation Model

"Evacuation," used in the context of offsite emergency response in the event of substantial amount of radioactivity release to the atmosphere in a reactor accident, denotes an early and expeditious movement of people to avoid exposure to the passing radioactive cloud and/or to acute ground contamination in the wake of the cloud passage. It should be distinguished from "relocation," which denotes a postaccident response to reduce exposure from long-term ground contamination after plume passage. The Reactor Safety Study (RSS) (NUREG-75/014, formerly WASH-1400) consequence model contains provisions for incorporating radiological consequence reduction benefits of public evacuation. The benefits of a properly planned and expeditiously executed public evacuation would be manifested in a reduction of early health effects associated with early exposure; namely, in the number of cases of early fatality (see Section F.2) and acute radiation sickness that would require hospitalization. The evacuation model originally used in the RSS consequence model is described in WASH-1400 as well as in NUREG-0340 and NUREG/CR-2300. The evacuation model that has been used herein is a modified version of the RSS model (Sandia, 1978) and is, to a certain extent, site emergency planning oriented. The modified version is briefly outlined below.

The model uses a circular area with a specified radius (the 16-km (10-mi) plume exposure pathway emergency planning zone (EPZ)), with the reactor at the center It is assumed that people living within portions of this area would evacuate if an accident should occur involving imminent or actual release of significant quantities of radioactivity to the atmosphere.

Significant atmospheric releases of radioactivity would in general be preceded by one or more hours of warning time (postulated as the time interval between the awareness of impending core melt and the beginning of the release of radioactivity from the containment building). For the purpose of calculation of radiological exposure, the model assumes that all people who live in a fan-shaped area (fanning out from the reactor) within the circular zone with the downwind direction as its median--that is, those people who would potentially be under the radioactive cloud that would develop following the release--would leave their residences after lapse of a specified amount of delay time* and then evacuate. The delay time is calculated from the beginning of the warning time and is recognized as the sum of the time required by the reactor operators to notify the responsible authorities; the time required by the authorities to interpret the data, decide to evacuate, and direct the people to evacuate; and the time required for the people to mobilize and get under way.

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*Assumed to be a constant value, 1 hour, that would be the same for all evacuees.

The model assumes that each evacuee would move radially outward* away from the reactor with an average effective speed** (obtained by dividing the zone radius by the average time taken to clear the zone after the delay time) over a fixed distance from the evacuee's starting point. This distance is selected to be 24 km (15 mi) (which is 8 km or 5 mi more than the 16-km (10-mi) plume exposure pathway EPZ radius). After reaching the end of the travel distance, the evacuee is assumed to receive no further radiation exposure.

The model incorporates a finite length of the radioactive cloud in the downwind direction that would be determined by the product of the duration over which the atmospheric release would take place and the average wind speed during the release. It is assumed that the front and the back of the cloud would move with an equal speed which would be the same as the prevailing wind speed; therefore, its length would remain constant at its initial value. At any time after the release, the concentration of radioactivity is assumed to be uniform over the length of the cloud. If the delay time were less than the warning time, then all evacuees would have a head start; that is, the cloud would be trailing behind the evacuees initially. On the other hand, if the delay time were more than the warning time, then, depending on initial locations of the evacuees, it is possible that (1) an evacuee would still have a head start, or (2) the cloud would be already overhead when an evacuee starts to leave, or (3) an evacuee would be initially trailing behind the cloud. However, this initial picture of cloud/people disposition would change as the evacuees travel, depending on the relative speed and positions between the cloud and people. The cloud and an evacuee might overtake one another one or more times before the evacuee would reach his/her destination. In the model, the radial position of an evacuating person, either stationary or in transit, is compared to the front and the back of the cloud as a function of time to determine a realistic period of exposure to airborne radionuclides. The model calculates the time periods during which people are exposed to radionuclides on the ground while they are stationary and while they are evacuating. Because radionuclides would be deposited continually from the cloud as it passed a given location, a person under the cloud would be exposed to ground contamination less concentrated than if the cloud had completely passed. To account for this, at least in part, the revised model assumes that persons are (1) exposed to the total ground contamination concentration that is calculated to exist after complete passage of the cloud, after they are completely passed by the cloud; (2) exposed to one-half the calculated concentration when anywhere under the cloud; and (3) not exposed when they are in front of the cloud. Different values of the shielding protection factors for exposures from airborne radioactivity and ground contamination have been used.

Results shown in Section 5.9.4.5 of the main body of this report for accidents involving significant release of radioactivity to the atmosphere were based on the assumption that all people within the 16-km (10-mi) plume exposure pathway EPZ would evacuate according to the evacuation scenario described above.

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*In the RSS consequence model, the radioactive cloud is assumed to travel radially outward only, spreading out as it moves away.

**Assumed to be a constant value, 1.1 mi (1.8 km) per hour, that would be the same for all evacuees.

Because sheltering can be a mitigative feature, it is not expected that detailed inclusion of any facility (see Section 5.9.4.5(2)) near a specific plant site, where not all persons would be quickly evacuated, would significantly alter the conclusions. For the delay time before evacuation, a value of 1 hour was used. The staff believes that such a value appropriately reflects the Commission's emergency planning requirements. The applicant has provided estimates of the time required to clear the 16-km (10-mi) zone.

From these estimates, the staff has conservatively estimated the effective evacuation speed to be 0.5 m per second (1.1 mph). It is realistic to expect that the authorities would aid and encourage evacuation at distances from the site where exposures above the threshold for causing early fatalities could be reached regardless of the EPZ distance. As an additional emergency measure for the Braidwood site, it was also assumed that all people beyond the evacuation distance who would be exposed to the contaminated ground would be relocated 12 hours after passage of the plume.

A modification of the RSS consequence model was used, which incorporates the assumption that if the calculated ground dose to the total marrow over a 7-day period were to exceed 200 rems, then this high dose rate would be detected by actual field measurements following plume passage, and people from these regions would be relocated immediately. For this situation the model limits the period of ground dose calculation to 24 hours; otherwise, the period of ground exposure is limited to 7 days for calculation of early dose.

Figure F.1 shows the early fatalities for (1) a pessimistic case for which no early evacuation is assumed and all persons are assumed to be exposed for the first 24 hours following plume passage and are then conditionally relocated on the basis of projected dose as described above and (2) a less pessimistic case, the same as (1) except relocation occurs 12 hours after plume passage.

The model has the same provision for calculation of the economic cost associated with implementation of evacuation as the original RSS model. For this purpose, the model assumes that for atmospheric releases of durations 3 hours or less, all people living within a circular area of 8-km (5-mi) radius centered at the reactor plus all people within a 45° angular sector within the plume exposure pathway EPZ and centered on the downwind direction will be evacuated and temporarily relocated. However, if the duration of release would exceed 3 hours, the cost of evacuation is based on the assumption that all people within the entire plume exposure pathway EPZ would be evacuated and temporarily relocated. For either of these situations, the cost of evacuation and relocation is assumed to be $225 (1980 dollars) per person, which includes cost of food and temporary sheltering for a period of 1 week.

## F.2 Early Health Effects Model

The medical advisors to the Reactor Safety Study (WASH-1400, Appendix IV, Section 9.2.2, and Appendix F) proposed three alternative dose-mortality relationships that can be used to estimate the number of early fatalities in an exposed population. These alternatives characterize different degrees of postexposure medical treatment, from "minimal" to "supportive" to "heroic"; they are more fully described in NUREG-0340. There is uncertainty associated with the mortality relationships (NUREG/CR-3185) and the availability and effectiveness of different classes of medical treatment (Andrulis, 1982).

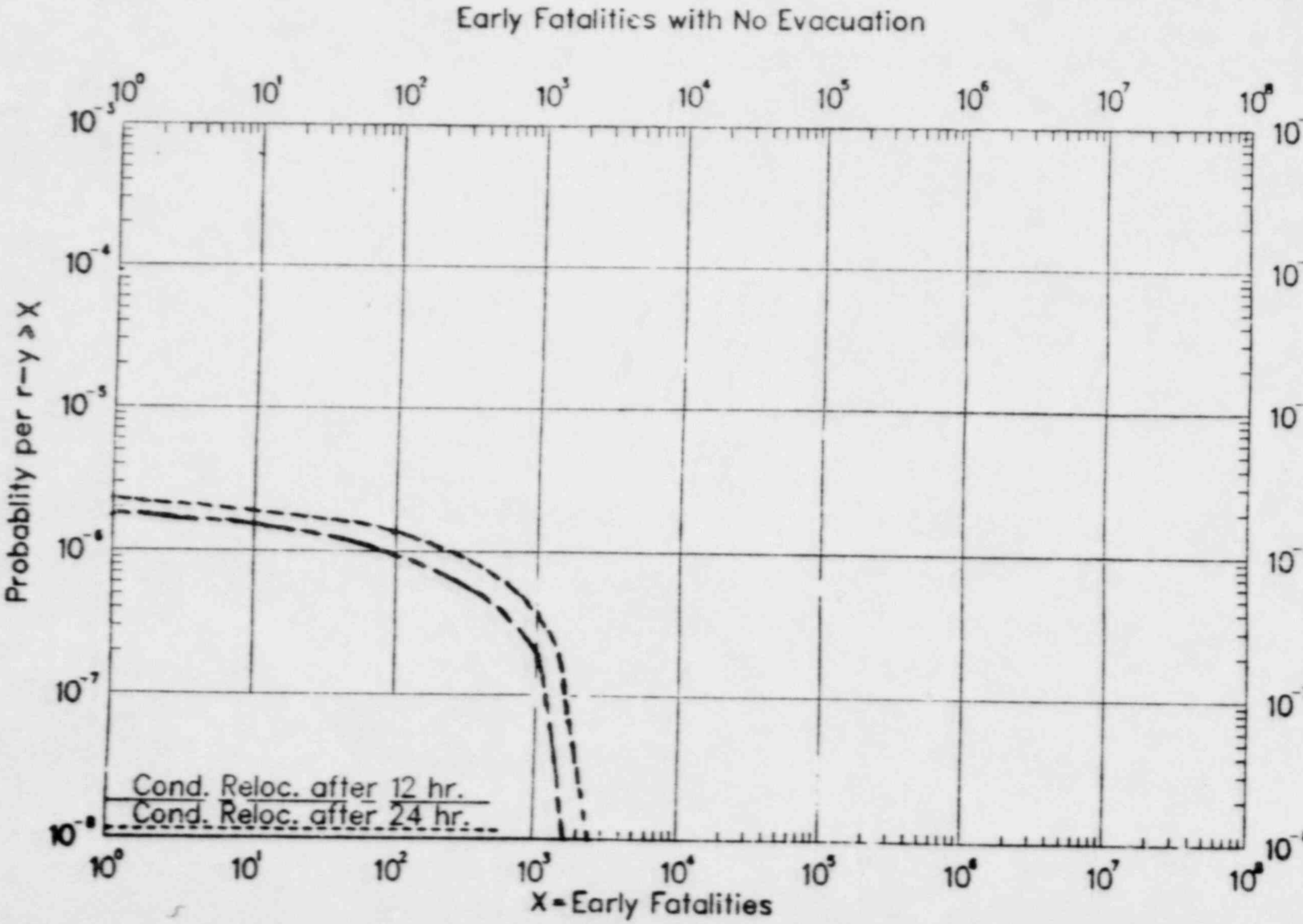


**Figure F.1** Sensitivity of early fatalities to evacuation characteristics (See Section 5.9.4.5(7) for a discussion of uncertainties in risk estimates. See also footnote in section entitled "Dose and Health Impacts of Atmospheric Releases" for help in interpreting this figure.)

The calculated estimates of the early fatality risks presented in Section 5.9.4.5(3) of the main body of this report and in Section F.1 of this appendix used the dose-mortality relationship that is based on the supportive treatment alternative. This implies the availability of medical care facilities and services that are designed for radiation victims exposed in excess of 170 rems, the approximate level above which the medical advisors to the Reactor Safety Study recommended more than minimum medical care to reduce early fatality risks. At the extreme low-probability end of the spectrum (i.e., at the 3 chances in 100 million per reactor-year level), the number of persons involved might exceed the capacity of facilities that provide the best such services, in which case the number of early fatalities might have been underestimated. However, this number may not have been greatly underestimated, because the hospitals now in the United States are likely to be able to supply considerably better care to radiation victims than the medical care that the sometimes assumed minimal medical treatment relationship is based on. Further, a major reactor accident at Braidwood would certainly cause a mobilization of the best available medical services with a high national priority to save the lives of radiation victims. Therefore, the staff expects that the mortality risks would be less than those indicated by the RSS description of minimal treatment (and much less, of course, for those who will be given the type of treatment defined as "supportive"). For these reasons, the staff has concluded that the early fatality risk estimates are bounded by the range of uncertainties discussed in Section 5.9.4.5(7).

## F.3 References

Andrulis Research Corp., Task 5 letter report from Dr. D. A. Elliot to A. Chu, NRC Project Officer, on Technical Assistance Contract No. NRC-03-82-128, December 13, 1982.

Sandia Laboratories, "A Model of Public Evacuation for Atmospheric Radiological Releases," SAND 78-0092, June 1978.

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---, NUREG/CR-3185, "Critical Review of the Reactor Safety Study Radiological Health Effects Model," March 1983.