Entergy Nuclear Operations, INC.

(Indian Point Nuclear Generating Units 2 and 3)

License Renewal Application

Attachment C

Excerpt from Draft Report, Consequence Study of a Beyond-Design-Basis Earthquake Affecting the Spent Fuel Pool for a U.S. Mark I Boiling Water Reactor
(ADAMS Accession No. ML13133A132)

June 24, 2012

the postulated conditions. The EPZ evacuation routes identified in the emergency plan indicate that evacuees west of the river would typically evacuate in a westerly or southerly direction, and evacuees east of the river would evacuate in a northerly or easterly direction. Thus, the loss of bridges and roads would have a minimal effect on the evacuation time. The other bridges and roadways that fail in the earthquake serve sparsely populated areas where alternative roads are available. Alternate routes out of the EPZ have more than sufficient capacity to support the evacuating population.

The seismic event is assumed to cause the loss of all onsite and offsite power within the EPZ, which can affect the response timing and actions of the public. Sirens would be sounded following the GE declaration, and because the reference plant will have a fully backed up siren system in 2013, it is assumed sirens sound for this analysis. The residents within the EPZ would have felt the earthquake, which effectively serves as the initial warning; however, the loss of power would affect the number of residents receiving instructions via emergency alert system messaging. It is expected that the residents use multiple methods of communication, such as cell phones, telephones, websites (where power is available), and direct interface to communicate the emergency message.

A review of the roadway network within the EPZ indicates that there are only a few traffic signals and that most intersections are controlled with stop signs. The loss of power would cause traffic signals to default to a four-way stop mode, which is less efficient than normal signalization. It is expected that emergency response personnel would respond to these intersections and direct traffic as indicated in the site evacuation time estimate. Therefore, the loss of signalization should have a limited impact on the evacuation. It is assumed that at distances beyond 20 miles, there is no loss of power and traffic signals, and emergency alert system messaging is not impacted.

7.1.5 Long-Term Protective Action Modeling

The long-term phase is the period following the seven-day emergency phase and is modeled for 50 years. The 50 year duration of the long-term phase has been chosen to provide a reasonable time period for calculating consequences from exposure for the average person. Exposure is mainly from external radiation from trace contaminants that remain after the land is decontaminated, or in lightly contaminated areas where no decontamination was required. However, internal exposures may also occur during this period, including inhalation of resuspended radionuclides and ingestion of food and water with trace contaminants. Depending on the relevant PAGs and the level of radiation, food and water below a certain limit could be considered adequately safe for ingestion, and lightly contaminated areas could be considered habitable.

A long-term cleanup policy for recovery after a severe accident does not currently exist. The actual decisions regarding how land would be recovered and populations relocated after an accident would be decided by a number of local, state, and federal jurisdictions and would most likely be based on a long-term cleanup strategy, which is currently being developed by the NRC, EPA, and other Federal agencies. Furthermore, a cleanup standard may not have an explicit dose level for cleanup. Instead, the cleanup strategy may give local jurisdictions the ability to develop localized cleanup goals after an accident, to allow for a number of factors that include sociopolitical, technical, and economic considerations. Three protective actions were modeled to occur for contaminated land during the long-term phase: interdiction, decontamination, and condemnation. As used in the MACCS2 model, interdiction and condemnation refer to the relocation of people from contaminated areas according to the habitability criterion. Interdiction

is defined in the MACCS2 model as temporary relocation during which the contamination levels are reduced by decontamination, natural weathering, and radioactive decay. Condemnation is defined in the MACCS2 model as a permanent relocation when contamination levels cannot be adequately reduced by decontamination, natural weathering, and radioactive decay.

Decontamination is modeled in a manner consistent with both NUREG-1150 and NUREG-1935. Two levels of decontamination (a decontamination factor of 3 and 15) are each assumed to take one year, but the cost of the higher decontamination factor (15) is assumed to be greater, reflecting the greater effort needed to achieve the higher level of decontamination. This study uses the values in NUREG/CR-7009 for the cost of decontamination. During the decontamination period, the land is temporarily interdicted (e.g. the population is temporarily relocated), and may be interdicted for an additional period to allow for radioactive decay and natural weathering to reduce contamination levels if needed to restore habitability. If land cannot be restored to habitability in 30 years, the MACCS2 model defines the land as condemned and residents are modeled to not return during the long-term phase. The MACCS2 models assume that decontamination will only take place if it is projected to make land habitable and if the value of the land is greater than the cost to decontaminate. If the level of contamination is too high, or if the cost of decontamination is projected to be higher than the land value, the individuals on that land are assumed to be permanently relocated. Because both the land values and the level of decontamination affect decisions on whether contaminated areas can be restored to habitability, they affect predicted long-term doses, health effects, and economic costs.

Site-specific values are used to determine long-term habitability, whereas farmability is defined to be consistent with NUREG-1150. For habitability, most states adhere to EPA guidelines that allow a dose of 2 rem in the first year and 500 mrem each year thereafter. However, consistent with the location of the reference plant, the analysis includes the State of Pennsylvania position using a habitability criterion of 500 mrem per year beginning in the first year, which is the value that is used for this study. For consistency and practicality reasons, the same standard for estimating habitability is applied to all affected areas in this study. The values used to define farmability were taken from NUREG-1150. During the year of the accident, the allowable committed dose equivalent from consumption of dairy products to an organ or tissue is 2.5 rem (7.5 rem for the thyroid), as well as an additional dose of 2.5 rem (7.5 rem for the thyroid) for all other foods. In subsequent years, the maximum allowable dose to the organ or tissue from all foods, including dairy products, is 500 mrem (1.5 rem for the thyroid). Agricultural lands projected to be contaminated to such an extent that agricultural products would exceed these levels are defined to be unfarmable, and the crops growing on these lands at the time of the accident are assumed to be disposed. No farming is allowed until the farmability criterion is satisfied.

7.2 Offsite Consequence Results

Several consequence metrics have been selected to characterize the impacts resulting from a severe spent fuel pool accident. Individual risk of early and latent cancer fatality, as well as societal risk of latent cancer fatalities, are measures of the radiological health impact of the accident and consistent with NRC's safety goals (NRC, 1986). In this study, collective dose is used as a surrogate for the societal impact of latent cancer fatalities. In addition, certain metrics that would influence the values considered by the NRC in regulatory analysis and documented in NUREG/BR-0058, such as measures of offsite property damages, the number of displaced individuals (either temporarily or permanently), and the extent over which such actions may be needed, are also presented. These metrics provide a benchmark for understanding the nature

and extent of a severe spent fuel pool accident. These measures are subject to considerable uncertainty, as the details of how long-term protective actions would be carried out would have a significant effect on the actual values reported herein.

All results presented in this section are conditional upon a pool leak following a specified severe (0.71g peak ground acceleration) seismic event on the SFP at the reference plant. In the event of a pool leak following a severe seismic event, a number of potential outcomes could occur, depending upon when in the operating cycle the event occurred, the severity of the leak, and whether effective mitigation (in the form of either makeup water or pool sprays) was able to be successfully deployed prior to the beginning of the release. Staff has evaluated the likelihood of these different conditions. The relative likelihood of a seismic event during a particular operating cycle phase is simply proportional to the duration of the phase. The relative likelihood of significantly different leak rates is discussed in Section 4. Because these probabilities can be quantified with a reasonable degree of certainty, the offsite consequence results are weighted by the relative likelihood of these factors to yield an average over the different operating cycle phases and leak rates.

In contrast, the likelihood of successful deployment of 10 CFR 50.45(hh)(2) mitigation has not been quantified. NRC staff judgment is that the likelihood of successful mitigation can in many cases be high, but that it is affected by a number of factors that are difficult to quantify (see Section 5.3). Related to this, a human reliability assessment (HRA) is provided in Section 8. Although the HRA does not provide a quantitative value required to determine the overall likelihood of mitigation, it does provide significant insights into the likelihood of mitigation during this seismic event for certain damage states. To quantify the overall likelihood of successful mitigation, a PRA type analysis would be required. For this reason, the results of the study are presented as a range of mitigation effects related to successfully deployed mitigation and mitigation that is unsuccessful for 3 days.

This analysis examines the relative effects of a low-density and a high-density fuel loading configuration. Therefore, results are reported for two configurations, those being a high-density loading case with a 1x4 loading pattern and for a low-density loading case with a mixture of 1x4 and checkerboard loading patterns, as portrayed in Figure 44 through Figure 48.

In this chapter, the results for each selected metric are discussed for each loading configuration (high-density and low-density). In addition, the factors that affect the results and how those results vary with dose truncation assumptions and with distance are discussed. To the extent possible, the relationship between the results presented here and the results obtained in previous studies is discussed.