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 50-293-LR, 06-848-02-LR

PWA- Dr. Jan Beyea Declaration excerpts pertaining to meteorology (“hot spots”) and health from Report To The Massachusetts Attorney General On The Potential Consequences Of A Spent-Fuel-Pool Fire At The Pilgrim Or Vermont Yankee Nuclear Plant

UNITED STATES OF AMERICA
 NUCLEAR REGULATORY COMMISSION

Before The Atomic Safety And Licensing Board

In the Matter of
 Entergy Corporation
 Pilgrim Nuclear Power Station
 License Renewal Application

Docket # 50-293-LR

May 24, 2007

DECLARATION OF JAN BEYEA, Ph.D. IN SUPPORT OF PILGRIM WATCH’S RESPONSE OPPOSING ENTERGY’S MOTION FOR SUMMARY DISPOSITION OF PILGRIM WATCH CONTENTION 3

I, Jan Beyea prepared the attached Report to the Massachusetts Attorney General on the Consequences of the Potential Consequences of a Spent-Fuel Pool Fire at the Pilgrim Nuclear Power Station or Vermont Yankee Nuclear Plant, May 25, 2006.

Since the release of the report, I have come across no information or commentary by the applicant or any other person that would cause me to significantly change the report’s quantitative contents.¹

I declare that under penalty of perjury that the foregoing is true and correct.



 Jan Beyea

¹ In an alternate analysis, as reflected in Tables 4, 5, and 6 of the report, I made use of an updated cancer risk coefficient. I characterized the number used as “conservative.” Having now done an analysis that combines the new coefficients with the old, I would today characterize the number (a factor of 3 increase) as a “best” estimate. Quantitatively, I have reduced the number by 10%, which does not represent a significant change.

Report To The Massachusetts Attorney General On The Potential Consequences Of A Spent-Fuel-Pool Fire At The Pilgrim Or Vermont Yankee Nuclear Plant.

Jan Beyea, Ph.D., May 25, 2006, Consulting in the Public Interest, 53 Clinton Street
Lambertville, NJ 08530

Meteorology

I have not been able to incorporate new understanding of the flow of air over and around the New England Coastline that has been achieved in recent years. Still, this new knowledge should be taken into account in EISs for coastal facilities. Releases from Pilgrim headed initially out to sea will remain tightly concentrated due to reduced turbulence until winds blow the puffs back over land (Zagar et al.), (Angevine et al. 2006). This can lead to hot spots of radioactivity in unexpected locations (Angevine et al. 2004). Dismissing radioactivity blowing out to sea is inappropriate. Reduction of turbulence on transport from Pilgrim across the water to Boston should also be studied. Although incorporating such meteorological understanding into a PSA or equivalent at Pilgrim would not be likely to make more than a factor of two difference in risk, the change could bring more SAMAs into play and would be significant in an absolute sense, when combined with the increase arising from incorporation of new values of radiation dose conversion coefficients (discussed below). The program

CALPUFF (Scire et al. 2000) has the capability to account for reduced turbulence over ocean water and could be used in sensitivity studies to see how important the phenomenon is at Pilgrim.

New cancer risk coefficients There have been increases in the value of the cancer risk assigned to low doses of radiation that should be taken into account in EISs. These increases have been steady since 1972,⁶ which makes the original EISs out of date. In addition, there has been a marked increase in the value of the cancer mortality risk per unit of radiation at low doses (2-to-3 rem average) as a result of recent studies published on a) radiation workers (Cardis et al. 2005) and b) the Techa River cohort (Krestinina et al. 2005). Both studies give similar values for low dose, protracted exposure, namely about 1 cancer death per Sievert (100 rem).

Worker study: The average dose for the workers was 2-rem. The authors of this large, international study of radiation workers included major figures in the field of radiation studies. The authors state, "On the basis of these estimates, 1-2% of deaths from cancer among workers in this cohort may be attributable to radiation." Although it can be misleading to interpret epidemiologic data in this way (Beyea and Greenland 1999), because it implies to non-experts a single-cause model of cancer, there is no doubt that a 1-2% increase in cancer mortality for a worker population is unusually high.

Techa River Cohort: The results for the Techa River cohort are equally striking, showing a strong linear effect down to a few rads. The average dose was 3 rads. The authors, who once again include major figures in the field of radiation studies, state: "It is estimated that about 2.5% of the solid cancer deaths...are associated with the radiation exposure." As in the worker population, an increase in solid cancer deaths of 2.5% from a dose of 3 rads is extraordinarily high compared to past estimates.

Such high risk coefficients imply that background radiation itself must increase cancer mortality by 3-5%.⁷ (It has long been known that background radon concentrations may well increase lung cancer rates by 10% or more (Lubin et al. 1995), (Darby et al. 2005).) Critics of studies like those by

⁶ For instance, there was a large increase in the risk coefficients estimated between the 1980 BEIR III report and the 1990 BEIR V report. See Table 4-4 of (National Research Council 1990), where the lifetime risk estimates increased by a factor of 4.6-19, depending on the risk model.

⁷ Assuming 0.1 rem per year background, which ignores the "equivalent" dose to the lung from radon. It is more difficult to compare rates of lung cancer, because the interaction of smoking and radiation has been found to lie between a linear and relative model. Therefore, such interactions must be taken into account, before drawing conclusions about area-wide differences, or lack of differences, in lung cancer rates.

Cardis et al. and by Krestinina et al. argue that such big effects, if they were real, should show up in cancer statistics in places like Colorado, where background radiation is high, when compared to areas of the country where background radiation is lower. However, crude statistical analysis that does not adjust for covariates at an individual level is unlikely to be very reliable (Lubin 1998). Also, there is an issue of the confounding effect of hypoxia (Weinberg et al. 1987). Hypoxia also varies with altitude.

Because the average dose in these two new studies is so low and so close to background radiation dose, there is no way to escape the linear non-threshold model. Even were a hypothetical hormesis effect to lead to a minimum risk at background levels (5 rem lifetime dose), the risk has to rise again after another 2-3 rem dose, based on the studies by Cardis et al. and Krestinina et al.

Could the increased risk numbers be due to a systematic underestimate or underreporting of doses? Random errors in doses would tend, in most cases, to reduce the strength of associations (Carroll et al. 1998), (Thomas et al. 1993). On the other hand, if dose errors were not random, but were proportionately underestimated or proportionately underreported in the worker studies and the Techa River cohort, then the risk coefficients could be inflated. For this to happen in both studies would be a coincidence. And in the radiation worker study, the results for Hanford do not support the missing-dose hypothesis, even though we know the neutron doses were likely underreported at Hanford (CohenAssociates 2005). In fact, the cancer risk numbers at Hanford were lower than average, not higher (Cardis et al. 2005). Finally, should the Techa River cohort dose estimates be too low that would mean that modern dose reconstruction techniques are underestimating doses, suggesting that other modern dose estimation techniques, such as those used in MACCS2 (Chanin and Young 1997), the standard NRC consequence code, could well be too low. In that case, an upward adjustment of doses would be required, if the risk coefficients were kept the same. Certainly, from a public health point of view, the arguments are strong for making use of the new risk coefficients, one way or another, with programs like MACCS2 and other consequence codes.

Recent press reports around the anniversary of the Chernobyl accident seemed to suggest that effects of radiation doses were lower than expected. Not at all. The "new" estimates of 4,000 projected fatalities were merely a re-interpretation of a study from the 1990s. No longer were 5,000 projected cancers outside the most highly contaminated regions counted. Also, another 7,000 cancers projected to occur in Europe were not noted by the press (Cardis et al. 2006). A summary of all of these estimates can be found in (Cardis et al. 2006). Were the new risk coefficients discussed earlier applied to the population dose estimates, the projected numbers of fatalities from the Chernobyl releases would

given much attention in the radiation protection community until now.¹⁰ This is not the time for *pro forma* treatment of licensing applications. Whereas it would be unreasonable to require an applicant to redo analysis after every new paper is published in the scientific literature, the increase at low doses is very dramatic in this case. It represents a 5-fold increase over the risk estimated in BEIR VII (NRC 2005). Based on information in (Little 1998), it appears to represent a factor of 10 over the standard value used in the MACCS2 computer code, which is the code on which the applicants' analyses are based. With such a high reported increase, public health considerations have to take precedence over applicant convenience. The paper by Cardis et al., at the very minimum, demands that a thorough analysis be made of mitigation and alternatives to spent-fuel pool storage.

For example, application of the new risk coefficients would drive the risk of spent-fuel-pool accidents during decommissioning (without even considering terrorist threats) above the NRC's safety goal. See Figures ES-1, ES-2 of (Collins and Hubbard 2001).

Quantitative damage estimates for releases from Pilgrim and Vermont Yankee, assuming cancer risk coefficients are increased to accommodate the new epidemiologic studies:

This section presents a subset of consequence estimates for hypothetical releases of Cesium-137 from spent-fuel pools at Pilgrim and Vermont Yankee, assuming a 3-fold increase in cancer risk coefficients to conservatively account for the latest studies on radiation risk at low dose. To account for some weighting of other studies, I have chosen a value lower than the factor of 5-to-10 increase that is suggested by the study of (Cardis et al. 2005).¹¹

As with earlier Tables, estimates are presented for economic costs and latent cancers. Variance in the estimates are not considered for the contention phase. See the Table footnotes and Appendix I for details. Political, psychological, and social impacts of hypothetical releases are not considered, although they could obviously be significant. As stated earlier, there appears to exist a "radiation syndrome" that affects a subset of exposed populations, causing debilitating psychiatric symptoms (Vyner 1983). Psychological effects of radiation disasters are expected to be most serious for children (CEH 2003).

climb much higher.

The confusion over the Chernobyl numbers appears to be traceable to a typo in a highly publicized IAEA report (Forum 2005) that relied on a WHO report for its cancer numbers (WHO 2005). The WHO report stated that the "Expert Group" concluded that there may be up to 4 000 additional cancer deaths among the three *highest* exposed groups over their lifetime (emphasis added). This was translated in the IAEA report to, "The total number of people that could have died or could die in the future due to Chornobyl originated exposure over the lifetime of emergency workers and residents of *most* contaminated areas is estimated to be around 4 000." (Emphasis added.) In fact, in my view, the last clause should have referred to "residents of *the* most contaminated areas..."⁸

Impact of new cancer risks. As a result of these two radiation studies, all probabilistic safety analyses prepared prior to them need to be revisited. These new studies should change the threshold for adoption of severe accident mitigation alternatives (SAMA). For instance, the current Environmental Report for Pilgrim assigns a value of \$2,000 per person rem in deciding whether a proposed SAMA is cost effective. According to the results of the study by Cardis et al., \$2,000 per rem implies a valuation of \$200,000 per cancer death before discounting, which is way to low.⁹ The same low valuation of life would arise from use of the risk numbers derived from the Techa River cohort (Krestinina et al. 2005). As a result, the SAMA analyses prepared for the Pilgrim and Vermont Yankee facilities need to be redone, even without inclusion of spent-fuel-pool fires as a risk to be addressed. Presumably, a number of additional SAMAs that were previously rejected by the applicant's methodology will now become cost effective. In addition to affecting the existing SAMA calculations, the new cancer risk coefficients make the consideration in an EIS of mitigation measures for spent-fuel-pool fires especially important.

In addition to providing motivation for a reanalysis of past PSAs and SAMA thresholds, the results of these new epidemiologic studies throw into doubt the entire basis of the NRC culture, which maintains that the linear non-threshold theory (LNT) is conservative, providing a margin of safety. Although it has always been known that the dose-response at doses below the 25-rad average dose of the Atomic Bomb survivors could be supralinear, as opposed to sublinear, the possibility has not been

⁸ Note that the IAEA stands by its original wording, not accepting it as a typo. Personal Communication, 2006, D. Kinley, IAEA public information, Vienna.

⁹ \$50,000 net present value for a cancer death occurring 20 years from now, based on the 7% per year discount rate assumed in the Pilgrim Environmental Report, which leads to a factor of 4 reduction in present value for a cancer induced 20 years from now.

Table 5. Cost estimates for a release of ~100% of spent-fuel-pool inventory of Cs-137 assuming a three-fold increase in cancer risk coefficient (billions of dollars)

Category	Pilgrim	Vermont Yankee	Comment
Direct costs ^{a)}	283	353	
Indirect administrative costs ^{b)}	283	353	
Loss in property values adjacent to treated areas ^{c)}	16-162	17-172	
Costs associated with cleanup or demolition of downtown business and commercial districts, heavy industrial areas, or high-rise apartment buildings ^{d)}	??	??	Particularly important for Pilgrim, with its proximity to Boston
Costs due to delays in implementing remediation and deconstruction ^{d)}	??	???	
Total	> 582-728	> 723-878	

a) As estimated from computations with MACCS2 at comparable sites with the parameters given in (Beyea et al. 2004a). An increase in the cancer risk numbers is mathematically equivalent to an increase in release magnitude, which is how the numbers in the Table were computed. Figures reduced by 1/3rd to account for wind rose effects.

b) Based on Chanin and Murfin. "We believe . . . that it might be reasonable to double the cost estimates provided [here] in order to account for indirect costs." (Chanin and Murfin 1996), p. 6-3. The factor might not be as great in the current case, however, because of economies of scale. We assume that litigation costs offset the economies of scale.

c) Assumed to be at least as great as the figures calculated in Table 2, where the cancer risk coefficient was left unchanged. Although not included in this total for the contention phase, loss in property value upon sale by government of remediated property should be included here. MACCS2 assumes no such loss.

d) We have not attempted an estimate for this category in the contention phase.