Gallagher, Carol

From: Mary Lampert [mary.lampert@comcast.net]
Sent: Tuesday, February 28, 2012 3:39 PM
To: Gallagher, Carol
Subject: Pilgrim Watch Comment SOARCA - Docket ID NRC 2012-0022
Attachments: 02.28.12 PW COMMENT SOARCA NRC 2012-0022.pdf

Good Afternoon:

Attached please find Pilgrim's Watch's Comment on SOARCA Draft Document, Docket ID NRC 2012-0022.
Please indicate receipt by return email and that it has been properly docketed.
If you have any difficulty opening, please call Mary Lampert at 781-934-0389.

Thank-you and enjoy your day.

Mary

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Template = ADM-013

E-RIDS= ADM-03
Add= P. Santiago (PAS2)
J. Barr (JXB7)

Pilgrim Watch

February 28, 2012

Cindy Bladley
Chief Rules, Announcements, Directives (RADB)
Office Administration
Mail Stop:TWB-05-B01M
U.S. NRC
Washington D.C. 20555-0001
Via E-Mail: Carol.Gallagher@nrc.gov

COMMENTS DOCKET ID NRC-2012-0022 STATE-OF-THE-ART-REACTOR CONSEQUENCE ANALSYES (SOARCA) REPORT DRAFT FOR COMMENT

Pilgrim Watch respectfully submits the following comments on the SOARCA January 2012 Draft (NRC 2012-0022). Essentially the Draft concludes (6.6) that:

> [W]hen successful mitigation is assumed, the MELCOR result indicate no core damage for all scenarios except the Surry STSBO.... (and) For the Surry STSBO with mitigation, the core is damaged; however containment failure is delayed an additional 41 hours compared to an unmitigated case. The mitigation measures (i.e., containment sprays) are effective in knocking down the airborne aerosols... (and) When scenarios were assumed to proceed unmitigated...MELCOR analyses indicated that the accidents progress more slowly and with smaller releases than the 1982 Siting Study.

In other words, Fukushima effectively did not happen; and although Peach Bottom is the exact same type of reactor as those in Japan (GE Mark I BWRs) the real world experiences there were not incorporated into the SOARCA.

We know from real world experience that both the probability of a severe accident is far greater and the consequences far more severe than what was modeled in the SOARCA. The draft's conclusions result from relying on outdated assumptions, using a flawed consequence analysis code (MACCS2), and effectively turning a blind eye to ongoing events in Japan.

I. PREMATURITY

It is premature for the NRC to issue the draft at this time when the lessons learned from Fukushima are admittedly not yet fully understood. This was made clear by Administrative Judge Ann Marshall Young in the Pilgrim license renewal adjudicatory proceeding:[1]

> The Commission in CLI-11-05 addressed the petitions of a number of parties to suspend, and take certain other actions with respect to, various nuclear power plant licensing proceedings (including Pilgrim) based on the March 2011 accident at the Fukushima Dai-ichi plant in Japan. The Commission declined to suspend the proceedings, finding among other things that "the mechanisms and consequences of the events at Fukushima [we]re not yet fully understood" and "the full picture of what happened at Fukushima was still far from clear" on September 9, 2011, thus warranting a conclusion that a request for analysis whether the Fukushima events constitute "new and significant information" under NEPA was then "premature"[2]... its prematurity analysis would reasonably seem also to be applicable in individual proceedings at this time. [Emphasis added]

The absurdity of issuing the SOARCA Draft at this time is magnified by the fact that one of the reactors reviewed, Peach Bottom, is the exact same design as those that failed so catastrophically at Fukushima – GE Mark I BWR's. Judge Young made the point in the Pilgrim LRA that,

> [I]t would indeed seem to be, and to be 'plain' and also self-evident that a severe accident involving the same type of reactor, even one occurring in a foreign country where earthquakes and tsunamis may be more likely, would need at least to be taken into account. [LBP-11-23, Young pg., 40]

And further in LBP-11-23 Memorandum and Order Denying Pilgrim Watch's Request for Hearing on New Contentions Relating to Fukushima, Administrative Judge Ann Marshall Young, *Concurring in Part and Dissenting in Part* (Sept. 8, 2011), pgs., 54-55 Judge Young concluded that:

> the Commission consider having the Staff look more closely – take a "hard look" – into the issues raised in these contentions, as well as any other issues arising out of the Fukushima Daiichi accident that relate particularly to Mark I BWR reactors,

[1] MEMORANDUM and ORDER (Denying Commonwealth of Massachusetts' Request for Stay, Motion for Waiver, and Request for Hearing on a New Contention Relating to Fukushima Accident), LBP-11-35, Nov 28, 2011, Administrative Judge Ann Marshall Young, Concurring in Results Only, at 1

2 Union Electric *Company d/b/a/ Ameren Missouri* (Callaway Plant, Unit 2) *et al.*, CLI-11-05, 74 NRC __ (Sept. 9, 2011).

> prior to any decision on the license renewal application, for the purpose of supplementing at least the SOARCA analysis part of the Pilgrim EIS, as appropriate based on new and significant information arising out of the accident at the Fukushima Daiichi nuclear power plant, as informed by existing information. I believe this would serve the interests of both public safety and public trust in the process the NRC utilizes for attending to such safety and environmental issues, which I find is particularly warranted given the seriousness of the Fukushima accident and the effect it has had on public perceptions of the safety of nuclear power – a public who must trust those responsible for regulating this very complex and important area of human enterprise, which can serve the public well, but can also threaten it in the event of accidents like that at Fukushima. Whatever the outcome of such an inquiry, in my view taking such a "hard look" would provide an important public service, in addition to satisfying relevant NEPA requirements.

Therefore, it is plain that until the lessons are learned from Fukushima (not simply speculated upon and glossed over, as here) it is premature to issue the Draft SOARCA.

II. SOARCA DRAFT - WHAT'S WRONG?

The SOARCA's main findings fall into three basic areas: how a reactor accident progresses; how existing systems and emergency measures can affect an accident's outcome; and how an accident would affect the public's health. The project's unrealistic preliminary findings include:

- Existing resources and procedures can stop an accident, slow it down or reduce its impact before it can affect the public;
- Even if accidents proceed uncontrolled, they take much longer to happen and release much less radioactive material than earlier analyses suggested; and
- The analyzed accidents would cause essentially zero immediate deaths and only a very, very small increase in the risk of long-term cancer deaths.

The SOARCA's findings result, in large measure, from the following:

- SOARCA's use of outdated and overly optimistic assumptions;
- Failure to include significant factors or variables in their SOARCA analyses; and
- Use of an outdated computer code, MACCS2 that significantly underestimates consequences.

A. ASSUMPTIONS - OUTDATED & OVERLY OPTIMISTIC

NRC's SOARCA is based on outdated and overly optimistic assumptions. Examples:

1. **Peach Bottom is a GE Mark I BWR, like 22 others in the U.S. It is a twin to the Fukushima reactors but somehow the SOARCA assumes that it, and by extension other Mark I's, will not succumb to the same design flaws as their sisters in Japan.** The Associated Press *Japan official faults nuke design, defends secrecy*, Yuri Kageyama, February 14, 2012 reported that Shunsuke Kondo, the head of the Japan Atomic Energy Commission said that the Fukushima reactor's design was faulty; it failed in crucial venting to relieve pressure and prevent explosions; and officials erroneously expected problems at a Japan plant to be like Three-Mile-Island with limited radiation leakage, our biggest mistake. The SOARC Draft repeats the same mistakes.

2. **The Draft assumes too low probability of a severe accident[3].** Post Fukushima Daiichi, it plainly is necessary to redo Peach Bottom's SOARCA analysis to take into account new and significant information learned from Fukushima regarding the probability of containment failure in the event of an accident and the concomitant probability of a significantly larger volume of off-site radiological releases. The NRC years ago recognized that "Mark I failure within the first few hours following core melt would appear rather likely;" a 90% likelihood of containment failure.[4] The events at Fukushima showed that there is an equally high likelihood that the supposed "fix," the DTV, will fail also[5].

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[3] Commonwealth of Massachusetts (Thompson Report, June 1, 2011, at 17, Estimating Core Damage Probability: Post Fukushima) said that there are 5 core-damage events worldwide translated to a CDF of 3.4 E094 RY raising the CDF to 1 event per 2,900 reactor years.

[4] See memo from Steven Hanauer recommends that U.S. stop licensing reactors using pressure suppression system; September 25, 1972: memo from Joseph Hendrie (top safety official at AEC) agrees with recommendation but rejects it saying it "could well mean the end of nuclear power...": Pilgrim Watch's Petition For Review Of Memorandum And Order (Denying Pilgrim Watch's Requests For Hearing On New Contentions Relating To Fukushima Accident) Sept. 8, 2011 and previous filings available on N.R.C. EHD; and Commonwealth of Massachusetts' Contention Regarding New and Significant Information Revealed by the Fukushima Radiological Accident, 06.02.11 and subsequent filings also on EHD.

[5] See Pilgrim Watch's Petition for Review of Memorandum and Order (Denying Pilgrim Watch's Requests for Hearing on New Contentions Relating To Fukushima Accident) Sept. 8, 2011 (filed Sept., 23, 2011) and preceeding filings, NRC's EHD; and The Commonwealth of Massachusetts Contention Regarding New and Significant Information Revealed by Fukushima Radiological Incident, June 2, 2011, supporting declaration and subsequent filings, NRC's EHD, Pilgrim Docket.

3. The Draft assumes that the vents in Fukushima's U.S. twins will not fail to relieve pressure build up and prevent containment failure. According to SOARCA (pg., 96), it says that, "hydrogen leakage to the reactor building would not occur as a result of containment venting if the hardened vent is used, as assumed in the SOARCA models." (Emphasis added] "If" is a very big and important word. SOARCA's authors gloss over the fact that the only real tests of the DTV – Unit 1, Unit 2, and Unit 3 at Fukushima, March 2011 – all failed. Three out of three failures is not a good score. There is no reason to believe that the same reasons for failure there would not hold true here. At Fukushima, properly trained operators decided not to open the DTV when they should have because they feared the effects offsite of significant unfiltered releases; when the operators finally decided to open the DTV, they were unable to do so; and the failure of the DTV to vent led to containment failure/explosions that resulted in significant ongoing offsite consequences. The NRC Task Force agrees. [Section 4.2.2 and 4.2.3] There is no basis to assume, as the SOARCA does, that the vents in U.S. Mark I BWR's will operate as designed without important changes - making them passive and adding filters.

4. The SOARCA assumes that resources are available in the U.S. to mitigate a severe accident within 48-hours (unlike at Fukushima) and that tsunamis would not happen at either Peach Bottom or Surry. The assumption of sufficient resources for rapid mitigation is based on wishful thinking, not real world experience, and ignoring extreme natural events or acts of malice. Further, the NRC Task Force (July 2011) did not share SOARCA's over confidence. The Task Force recommended strengthening onsite emergency response capabilities such as EOPs, SAMGs, and EDMGs [Section 4.2.5] that clearly imply weakness with what is available today. Voluntary guidance cannot be properly evaluated by NRC.

5. The SOARCA assumes that emergency plans will work according to what is on paper-not real world experience. The SOARCA assumes a relatively small area of impact; however in Japan the NRC recommended that those within 50-miles evacuate. The SOARCA claims that ETE's show that folks will "get out of Dodge" in a timely manner. Citizens, for example, within Pilgrim's, Vermont Yankee's, Indian Point's, Seabrook's EPZs know otherwise.[6] For example, the KLD Evacuation Time Estimates that provide a basis for SOARCA's optimism ignore: peak

[6] See, for example James Lee Witt Associates' analysis Indian Points plan http://www.wittassociates.com/projects_NYdesc.html

traffic periods; do not assume shadow evacuation beyond 10 miles (although the SOARCA assumes out to 20 miles, still unrealistically short), assume a straight-line Gaussian plume that narrows the area within which it is assumed the population will evacuate. However in coastal locations, lake regions, river valleys and hilly terrain a variable trajectory model is required; in that case evacuations modeled will be necessary for a far larger area. Notification of the population rests largely on sirens. Sirens are outdoor notification system and cannot be heard inside over normal ambient noise in summer with air conditioning or at other times of the year at properties on large lots with, for example, landscaping and storm windows that buffer outside sound. The NRC Task Force clearly was not satisfied with the status quo otherwise they would not have recommended strengthening emergency preparedness [Section 4.3.1, 4.3.2]. The NRC has updated hostile action emergency planning but not completed other necessary upgrades.

6. **Japan has shown that SOARCA's assumptions of the probability of offsite consequences are wrong.** The SOARCA assumes that mitigation measures (i.e., containment sprays) are effective is knocking down airborne aerosols. (Draft 6.6, pg., 82) Dr. Frank von Hippel, for example, explained in a briefing to the NRC that,

> For accidents in which the damage is sufficient to open large pathways from the core to the containment, there will not be sufficient water available to trap the radioactive materials of concern, nor will the pathway be so torturous that a significant amount wills tick to surfaces before reaching the containment atmosphere. Similarly if the containment fails early enough, there will be insufficient time for aerosols to settle in the reactor building floor.[7]

7. **Risk coefficients are based on old health consequence studies** such as the Federal Guidance Report (FGR)-13 issued in April 2002 and not, as they should be, on the National Academies of Sciences (NAS) BEIR VII report, 2005. The flimsy excuse for ignoring NAS' most recent report is that the "SOARCA is waiting on EPA's review of BEIR VII." (Draft, pg., 62) SOARCA still is waiting a good <u>seven</u> years after the NAS report was issued.

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[7] Bulletin of Atomic Scientists: Containment of a Reactor Meltdown, Frank von Hippel, March 15, 2011, FN 16; also see Pilgrim Watch's Petition for Review of Memorandum and Order (Denying Pilgrim Watch's Requests for Hearing on New Contentions Relating To Fukushima Accident) Sept. 8, 2011 (filed Sept., 23, 2011) and preceeding filings, NRC's EHD ;and The Commonwealth of Massachusetts Contention Regarding New and Significant Information Revealed by Fukushima Radiological Incident, June 2, 2011, supporting declaration and subsequent filings, NRC's EHD, Pilgrim Docket

BEIR VII reported far greater sensitivity of certain population groups and at lower doses. First NAS concluded that there is no safe dose of radiation and cancer risk for women and children is much higher than for men.

- Women and Children Most at Risk: The National Academy reported that overall cancer mortality risks for females are 37.5 percent higher than for men, and the risks for all solid tumors (lung, breast, and prostate) are almost 50 percent higher. The differential risk for children is even greater. The same radiation in the first year of life for children produces three to four times the cancer risk as exposure between the ages of 20 and 50. Female infants have almost double the risk as male infants.
- Impact Offspring from Parents Exposure: While the report states there is no direct evidence of harm to human offspring from exposure of parents to radiation, the committee noted that such harm has been found in animal experiments and that there is "no reason to believe that humans would be immune to this sort of harm." This should be of concern to nuclear worker's families.
- Heart Disease and Stroke: The National Academy stated that No amount of radiation exposure is safe; and noted that relatively high levels of radiation exposure increase risk not only of cancer but also of heart disease and stroke.

SOARCA also ignored subsequent studies, not included in BEIR VII, that showed a marked increase in the value of cancer mortality risk per unit of radiation at low doses (2-3 rem average), as shown by recent studies published on radiation workers (Cardis et al. 2005[8]) and by the Techa River cohort (Krestina et al (2005[9]). Both studies give similar values for low dose, protracted exposure, namely (1) cancer death per Sievert (100 rem). According to the results of the study by Cardis et al. and use of the risk numbers derived from the Techa River cohort the SOARCA analyses needs to be redone.

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[8] Elizabeth Cardis, "Risk of cancer risk after low doses of ionising radiation: retrospective cohort study in 15 countries." *British Medical Journal* (2005) 331:77. Available on line at: http://www.bioone.org/doi/abs/10.1667/RR1443.1?cookieSet=1&prevSearch=

[9] Krestinina LY, Preston DL, Ostroumova EV, Degteva MO, Ron E, Vyushkova OV, et al. 2005.Protracted radiation exposure and cancer mortality in the Techa River cohort. Radiation Research 164(5):602-611. Available on line at: http://www.bioone.org/doi/abs/10.1667/RR3452.1

Last the SOARCA looks simply at cancer mortality. Cancer incidence and the other many health effects from exposure to radiation in a severe radiological event (National Academy of Sciences, BEIR VII Report, 2005) must be considered; they were not. Neither did SOARCA appear to consider indirect health costs. Medical expenditures are only one component of the total economic burden of cancer. The indirect costs include losses in time and economic productivity and liability resulting from radiation health related illness and death.

8. Probabilistic Modeling: The limitations of probabilistic modeling were ignored.

a. The probability/likelihood of a severe accident used by the SOARCA was far too low; it ignored the real-world lessons from Fukushima.
b. By using probabilistic modeling and incorrect parameters in its SOARCA analysis the SOARCA downplays the likely consequences of a severe accident at Peach Bottom and Surry.
c. It is widely recognized that probabilistic modeling can underestimate the deaths, injuries, and economic impact likely from a severe accident. By multiplying high consequence values with low probability numbers, the consequence figures appear far less startling. For example a release that would cause 100,000 cancer fatalities would only appear to cause 1 cancer fatality per year if the associated probability of the release were 1/100,000 per year. Probability may be taken into consideration, but it must be taken with caution.
d. Kamiar Jamali's (DOE Project Manager for Code Manual for MACCS2) *Use of Risk Measures in Design and Licensing Future Reactors,*[10] explains that "PRA" uncertainties are <u>so large and so unknowable</u> that it is a huge mistake to use a single number coming from them for any decision regarding adequate protection. "Examples of these uncertainties include probabilistic quantification of single and common-cause hardware or software failures, occurrence of certain physical phenomena, human errors of omission and commission, magnitudes of source terms, radionuclide release and transport, <u>atmospheric dispersion</u>, biological effects of radiation, dose calculations, and many others." (Jamali, Pg., 935) (Emphasis added)
e. Probability analysis has other pitfalls. Human error is not considered in PRAs. PRAs project into the future and come up with some very small number that an accident scenario only is

[10] Appendix 3, Exhibit 14

likely to occur in so many hundreds-to-thousands of years. But no reactor has operated 45 or more years so actual experience is absent to base predictions. Uncertainty must be respected by making certain that appropriate and up-to-date methods and assumptions are used in the analysis. The SOARCA failed to do so.

B. SIGNIFICANT FACTORS OMITTED

The SOARCA analyses omitted significant factors that would increase the probability of a severe accident and consequences. For example:

1. **The SOARCA did not include aqueous discharges in its analysis thereby minimizing consequences[11].** Post Fukushima Daiichi, it plainly is necessary to redo the SOARCA analyses to take into account new and significant information learned from Fukushima regarding the probability of containment failure in the event of an accident and the concomitant probability of a significantly larger volume of off-site consequences due to the need for flooding the reactor (vessel, containment, pool) with huge amounts of water in a severe accident, as at Fukushima. This source of contamination would add to that resulting from aqueous transport and dispersion of radioactive materials through subsurface water, sediments, soils and groundwater, plus atmospheric fallout on the waters - resulting in <u>three sources of contamination in the waters</u>.

The MACCS2, that the SOARCA <u>chose</u> to use for its SOARCA, does not currently model and analyze aqueous transport and dispersion of radioactive materials; and there is no provision within the Severe Accident Mitigation Guidelines (SAMGs) for processing the water post accident, just as there was no discussion in NUREG/CR-5634. Lessons learned from Fukushima show that in a severe accident, enormous quantities of contaminated water are likely to enter water bodies (<u>adding</u> to the radioactive atmospheric fallout on the water and runoff) posing significant offsite consequences and costs, threatening the health of citizens and the ecosystem and damaging the economy. NRC recognized the need to include aqueous discharges in SECY-11-0089, July 7, 2011 and SECY-11-0089 Commission Voting Record, September 21, 2011.

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[11] Pilgrim Watch Request For Hearing On A New Contention Regarding Inadequacy Of Environmental Report, Post Fukushima, November 16, 2012; Pilgrim Watch's Petition For Review Of Memorandum And Order (Denying Pilgrim Watch's Request For Hearing On New Contention Relating To Fukushima Accident), LBP-12-01, January 1, 2012; available on NRC's EHD.

2. The SOARCA analyses did not include impacts on the spent fuel pools (SFPs) or acts of malice for either Peach Bottom or Surry[12]. (Draft, pg., 99) The Draft's rationale for excluding spent fuel pool releases alone or in conjunction with core releases is based upon pre-Fukushima theoretical, secret NRC studies; and what they admit as premature, conclusions from Fukushima. They ignore the BWR's vulnerability to a catastrophic fire from equipment failure, human error, and acts of malice.

Some Potential Modes of Attack on Civilian Nuclear Facilities

MODE OF ATTACK	CHARACTERISTICS	PRESENT DEFENSE
Commando-style by land	• Could involve heavy weapons/sophisticated tactics • Attack requiring substantial planning and resources	Alarms, fences, lightly-armed guards, with offsite backup
Commando-style by water	Could involve heavy weapons & sophisticated tactics Could target intake canal Attack may be planned to coordinate with a land attack	500 yard no entry zone – marked by buoys – simply, "no trespassing" signs Periodic Coast Guard surveillance by boat or plane
Land-vehicle bomb	• Readily obtainable • Highly destructive if detonated at target	Vehicle barriers at entry points to Protected Area
Anti-tank missile	• Readily obtainable • Highly destructive at point of impact	None if missile is launched from offsite
Commercial aircraft	• More difficult to obtain than pre-9/11 • Can destroy larger, softer targets	None
Explosive-laden smaller aircraft	• Readily attainable • Can destroy smaller, harder targets	None
10-kilotonne nuclear weapon	• Difficult to obtain • Assured destruction if detonated at target	None

[12] See Massachusetts Attorney General's Request for Hearing...May 25, 2006, Declarations Dr. Jan Beyea and Dr. Gordon Thomson and all subsequent filings, NRC's EHD; and The Commonwealth of Massachusetts Contention Regarding New and Significant Information Revealed by Fukushima Radiological Incident, June 2, 2011, supporting declaration and subsequent filings, NRC's EHD, Pilgrim Docket

The SOARCA ignores the findings of the NRC Task Force that recommend enhanced spent fuel pool make-up capability and instrumentation for the spent fuel pool [Section 4.2.4] If they had considered severe accidents that included spent fuel pools, the probability of an accident and offsite consequences would be greatly increased. For example, the Massachusetts Attorney General's experts[13] estimated the costs and latent cancers following releases of Cesium-137 from Pilgrim's spent fuel pool in a severe accident.

Estimates of Costs and Latent Cancers Following Releases Of Cesium-137 from Pilgrim's Spent-Fuel Pool

	10% release C-137	100% release C-137
Cost (billions)	$105-$175 billion	$342-$488 Billion
Latent Cancers	8,000	24,000

3. The SOARCA did not include extreme natural events. Climate change has resulted in more extreme events across the country and increasingly severe events are predicted going forward. The draft says that:

> SOARCA does not include analysis of an extreme earthquake that directly results in a large breach of the RCS (large LOCA), a large breach of the containment, and an immediate loss of safety systems. Given the considerable uncertainties in the quantification of seismic loads and seismic fragilities, in particular the quantification of the size of a hole or the amount of leakage, more research is needed to perform a best estimate analysis. In addition, it would not be sufficient to perform a nuclear plant risk evaluation of this event without also assessing the concomitant nonnuclear risk associated with such a large earthquake. This assessment would have to include an analysis of the impact on public health of an extremely large earthquake—
> larger than that generally considered in residential or commercial construction codes—to provide the perspective on the relative risk posed by operation of the plant. (Draft, pgs., 15-16)

C. OUTDATED COMPUTER CODE-MACCS2

The SOARCA used the outdated MACCS2 computer code to analyze consequences and limited input data. The MACCS2 code is incapable of providing an accurate estimate of offsite

[13] 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, PhD.,May 2006

economic consequence. For example, David Chanin author of the code's FORTRAN testified that,

> If you want to discuss economic costs ... the 'cost model' of MACCS2 is not worth anyone's time. My sincere advice is to not waste anyone's time (and money) in trying to make any sense of it." (and) "I have spent many many hours pondering how MACCS2 could be used to calculate economic costs and concluded it was impossible."[14]

Major problems with the code include, for example:

1. **THE CODE IS NOT QUALITY ASSURED.**[15] The MACCS & MACCS2 codes were developed for research purposes not licensing purposes –for that reason they were not held to the QA requirements of NQA-a (American Society of Mechanical Engineering, QA Program Requirements for Nuclear Facilities, 1994). Rather they were developed using following the less rigorous QA guidelines of ANSI/ANS 10.4. [American Nuclear Standards Institute and American Nuclear Society, *Guidelines for the Verification and Validation of Scientific and Engineering Codes for the Nuclear Industry*, ANSI/ANS 10.4, La Grange Park, IL (1987).

Further the biggest reason for *not* using the MACCS2 economic cost model is that there is no written explanation of *exactly* how it works, and how it interacts with the long-term dose accumulation models

2. **DURATION RELEASES, LIMITED**[16]. The code limits the total duration of a radioactive release to no more than four (4) days, if the SOARCA chose to use four plumes occurring sequentially over a four day period.[17] However there is no evidence that the SOARCA chose that option and therefore limited its analysis to the maximum-allowed duration of 24 hours.[18] In any case either a 24-hour plume or a four-day plume is insufficient duration in light of lessons learned from Fukushima. The Fukushima crisis is ongoing and shows that releases can extend

[14] See Pilgrim Watch Finding of facts,Conclusions of Law, March 4, 2011, pg., 63 (Referencing PW A00004, Aug 23, 2006) NRC's EHD.
[15] Chanin, D.I. (2005), "The Development of MACCS2: Lessons Learned," [written for:] *EFCOG Safety Analysis Annual Workshop Proceedings*, Santa Fe, NM, April 29–May 5, 2005. Full text: the development of maccs2.pdf (154 KB), revised 12/17/2009. http://chaninconsulting.com/index.php?resume. (Attachment 5, Exhibit 4)
[16] Pilgrim Watch Request for Hearing on Pilgrim Watch Request for Hearing on Post Fukushima SAMA Contention, May 12, 2011; Pilgrim Watch's Petition For Review Of Memorandum And Order (Denying Pilgrim Watch's Requests For Hearing On New Contentions Relating To Fukushima Accident) Sept. 8, 2011(Sept 23, 2011), NRC's EHD
17 NUREG/CR-6613 Code Manual for MACCS2: Volume 1, User's Guide, 2-2
18 The MACCS2 uses a Gaussian plume model with Pasquill-Gifford dispersion parameters (Users code 5-1). Its equation is limited to plumes of 10 hour duration.

into many days, weeks, and months; a longer release will necessarily result in larger offsite consequences and costs.

3. **AQUEOUS RELEASES NOT MODELED:** The SOARCA did not include aqueous discharges in its analysis thereby minimizing consequences,[19] discussed above at 9. The MACCS2, that the SOARCA chose to use for its SOARCA, does not currently model and analyze aqueous transport and dispersion of radioactive materials; and there is no provision within the Severe Accident Mitigation Guidelines (SAMGs) for processing the water post accident, just as there was no discussion in NUREG/CR-5634. Lessons learned from Fukushima show that in a severe accident, enormous quantities of contaminated water are likely to enter water bodies (adding to the radioactive atmospheric fallout on the water and runoff) posing significant offsite consequences and costs, threatening the health of citizens and the ecosystem and damaging the economy. NRC recognized the need to include aqueous discharges in SECY-11-0089, July 7, 2011 and SECY-11-0089 Commission Voting Record, September 21, 2011.

4. **METEOROLOGICAL INPUTS**, (Draft, 5.1, 5.2): The SOARCA minimized the probable area of impact by: using one (1) year of hourly data from the licensee's onsite meteorological tower; assumed a straight line Gaussian plume, ignoring variability of wind flow that would increase the area of impact; and used the mean to average the data, instead of the 95%.

a. Single-Year data: One year of data is insufficient. "*The NRC staff considers 5 years of hourly observations to be representative of long-term trends at most sites,*" although "with sufficient justification [not presented here] of its representativeness, the minimum meteorological data set is one complete year (including all four seasons) of hourly observations." (NRC Regulatory Guide 1.194, 2003) Revised Chapter 4, *Meteorological Monitoring*, of Guide DOE/EH-0173T (PWA00021) says that the joint-frequency distribution and choices of meteorological conditions for the accident analyses should be based on a minimum of 5 years of

[19] Pilgrim Watch Request For Hearing On A New Contention Regarding Inadequacy Of Environmental Report, Post Fukushima, November 16, 2012; Pilgrim Watch's Petition For Review Of Memorandum And Order (Denying Pilgrim Watch's Request For Hearing On New Contention Relating To Fukushima Accident), LBP-12-01, January 1, 2012; available on NRC's EHD.

hourly-averaged data acquired by a meteorological program that meets the objectives and principles of ANSI/ANS-3.11-2000 and EPA-454/R-99-005.

b. Data from On-site Met Tower: The simple fact is that measurements from a single anemometer will not provide sufficient information to project how an accidental release of a hazardous material would travel. Basing wind direction on the single on-site meteorological tower data ignores shifting wind patterns away from the site including temporary stagnations, re-circulations, and wind flow reversals that produce a different plume trajectory.

Since the 1970s, the USNRC has historically documented all the advanced modeling technique concepts and potential need for multiple meteorological towers especially in coastal regions. NRC Regulatory Guide 123 (Safety Guide 23) On Site Meteorological Programs 1972, says that, "at some sites, due to complex flow patterns in non-uniform terrain, additional wind and temperature instrumentation and more comprehensive programs may be necessary."[Ibid., cited in Appendix 1]; and an EPA 2000 report, Meteorological Monitoring Guidance for Regulatory Model Applications, EPA-454/R-99-005, February 2000, Sec 3.4 points to the *need for multiple inland meteorological monitoring sites.* See also Raynor, G.S.P. Michael, and S. SethuRaman, 1979, Recommendations for Meteorological Measurement Programs and Atmospheric Diffusion Prediction Methods for Use at Coastal Nuclear Reactor Sites. NUREG/CR-0936

Therefore the Draft should have taken data from more locations over a longer period; and modified the MACCS2 code to account for the inability of the code used to account for site-specific conditions. "The user has total control over the results that will be produced." [1997 User Guide].

Further, Regulatory Guide 1.111 says that "The effectiveness of the meteorological input data in defining atmospheric transport and diffusion conditions is dependent on the representativeness of these data and the complexity of the topography in the site region; therefore a detailed discussion of the applicability of the model and input data should be provided." The plume segment model as has been applied here uses temporal but not spatial variations of meteorological conditions. Spatial variations would require the use of simultaneous meteorological data. Data from Peach Bottom and Surry did not use multiple station data in this context.

c. Straight-line Gaussian plume[20]: One fundamental defect in the SOARCA it its use of the MACCS2 code is that its meteorological inputs to that code are all based on the straight-line Gaussian plume model. (Draft, pg., 59) This model does not allow consideration of the fact that the winds for a given time period may be spatially varying. A variable plume model is appropriate for rectors near large bodies of water, river valleys and hilly terrain.

The 1997 User Guide for MACCS2, SAND 97-0594[21] says: "The atmospheric model included in the code does not model the impact of terrain effects on atmospheric dispersion." Most important, EPA's November 2005 Modeling Guideline (Appendix A to Appendix W) lists EPA's "preferred models" and the use of straight line Gaussian plume model, called ATMOS, is not listed. Sections 6.1 and 6.2.3 discuss that the Gaussian model is not capable of modeling beyond 50 km (32 miles) and the basis for EPA to recommend CALPUFF, a non - straight line model.[22]

Further the MACCS2 Guidance Report, June 2004,[23] is even clearer that SOARCA's inputs to the code do not account for variations resulting from *site-specific* conditions such as those present at Peach Bottom or Surry. (1) The "code does not model dispersion close to the source (less than 100 meters from the source);" thereby ignoring resuspension of contamination blowing offsite. (2) The code "should be applied with caution at distances greater than ten to fifteen miles, especially if meteorological conditions are likely to be different from those at the source of release." (3) "Gaussian models are inherently flat-earth models, and perform best over regions where there is minimal variation in terrain."

d. The Affected Area: SOARCA's choice of a straight-line Gaussian plume rather than a variable trajectory model drastically reduced, to a wedge, the size of the area that might potentially be impacted by a release. Also, as shown above, the SOARCA assumed a "small" accident; it did not consider the potential of the by far largest, and perhaps also the most likely, potential radiological release – from the spent fuel pool. The use of a variable trajectory model, rather than the straight-line Gaussian plume, would have significantly increased the area

[20] Pilgrim Watch Findings of Fact Conclusions of Law SAMA Remand, March 4, 2011; available NRC Electronic Hearing Docket

[21] Chanin, D.I., and M.L. Young, Code Manual for MACCS2:Volume 1, User's Guide, SAND97-0594 Sandia National Laboratories, Albuquerque, NM, (1997)

[22] http://www.epa.gov/scram001/guidance/guide/appw_05.pdf

[23] MACCS2 Guidance Report June 2004 Final Report page 3-8:3.2 Phenomenological Regimes of Applicability, Exhibit 21

potentially affected by a released radioactive plume, and thus would also greatly increase the size of the affected population and property, and the economic effect.

5. **METRICS, SOARCA USED THE MEAN INSTEAD 95th PERCENTIAL** (Draft 5.8, pg., 66): For each plant damage state, the MACCS2 code is run over a meteorological data set to produce a set of consequence results. For each consequence endpoint, the values corresponding to various statistical parameters of the resulting data set (mean, 95th percentile etc) are provided. It is then necessary for the user to determine which statistical parameter should be used as input into the SAMA analysis: e.g., the mean, the median or the 95th percentile. Once this input parameter is chosen, then the population dose-risks and off-site economic dose risks can be calculated, summed and compared to the costs of mitigative measures. The choice of statistical input parameter determines the level of protection which mitigative measures would be expected to provide. A choice of 95th percentile, for example, means that mitigative measures would be considered cost-beneficial if they were no more expensive than the value of the averted risk to the public from a severe accident for 95 percent of the meteorological conditions expected to occur over the course of a year. In contrast, use of the mean consequences would imply that measures would be cost-beneficial if they were no more expensive than the (significantly lower) value of the averted risk to the public for an accident occurring under average meteorological conditions. This is analogous to the situation of a homeowner who is considering whether to spend the money to install windows to protect against a 20-year storm or just an average storm. Thus the outcome of the SAMA analysis is functionally dependent on the choice of statistical input parameter[24].

6. **CLEANUP/DECONTAMINATION COSTS:** Cleanup costs are the "Elephant in the Room." Proper assessment of clean-up costs would result in major offsite consequences/costs and profoundly change the analysis.

[24] PW SAMA Remand, Declaration Of Edwin S. Lyman, Ph.D., Regarding The Mechanics Of Computing Mean Consequences In SAMA Analyses, Nov 22, 2010, NRC ADAMS Accession No. ML 103340326

The SOARCA used the MACCS2 for its analysis and one of the main reasons for *not* using the MACCS2 economic cost model is that there is no written explanation of *exactly* how it works and how it interacts with the long-term dose accumulation models.

a. Decontamination Factor (DF-15): The SOARCA used the values from NUREG-1150 to provide the basis for decontamination parameters, which consist of two levels of decontamination, just as in NUREG-1150. (Draft, pg., 63) Hence it appears that the SOARCA assumes that a DF of 15 can be achieved for less than 10% of the property value being remediated, which seems to be based on a total misuse of 1960s data on recovery from nuclear explosions, discussed in the *Site Restoration* Study[25], pgs., 2-9:

> Prior to the 1986 Chernobyl accident, reactor accident risk assessments in the U.S. and Europe relied heavily on the economic cost model of WASH-1400, in which the decontamination of residential property was modeled as achieving a DF of 20 in urban areas at a minimal cost, that is, one-tenth of the value of the affected property.
>
> The use of a DF of 20 in WASH-1400 was apparently based on contemporary guidance documents for anticipated recovery actions following nuclear explosions of warfare. Nuclear explosions produce fallout with large particles and high mass loadings on surfaces. The DF of 20 was widely used in planning documents addressing such events. Furthermore, data presented within WASH-1400 give strong weight to this supposition in its presentation of decontamination data for mass loadings of 5 and 25 g/ft^2 (WASH-1400, Appendix 6, pgs., K-23 through K-32).
>
> The WASH-1400 model now appears to have been unduly optimistic in the broad application of a DF of 20 to large-scale urban areas, when, according to Cowan and Meinhold (1969), in their discussion of the importance of pre-planning for the post-attack recovery of vital **selected** facilities such as power plants, water works, medical installations, and transportation systems,
>
> Radiation levels inside of selected structures can be reduced by a factor of 5. Radiation levels outdoors in selected areas can be reduced by a factor of 20.
>
> These results can be achieved without excessive exposure to individuals carrying out the decontamination.

Data on recovery from nuclear explosions, publicly available since the 1960s, were misinterpreted which led to long-standing underestimates of the potential economic costs of severe reactor accidents. Basically, the DF=20 of WASH-1400 (revised to DF=15 for NUREG-

[25] Chanin, D.; Murfin, W. (1996). *Site Restoration: Estimation of Attributable Costs from Plutonium-Dispersal Accidents*, SAND96-0957, DE9601166, Sandia National Laboratories

1150 used here) was based on early 1960s civil defense planning recovery from nuclear war. The DF=20 (likewise DF-15) was based on cost estimates for sweeping up *visible* weapon fallout, which is mostly "dirt" from soil and structures vaporized in the blast which condenses to solid as it falls to the ground. The layer of fallout to be cleaned up has only small amounts of radioactive materials mixed with other materials. When the bomb fallout reaches the ground or other structures almost all the fallout particles will be resting on other particles, with only the bottom layer of particles being in contact with the substrate. It is that "stacking" of particles upon particles in a layer of dirt that could be swept up with brooms or vacuums which is what made those simple and cheap decontamination methods so effective. This is in sharp contrast to the deposition of aerosol particles from a plume released from a severe reactor accident where the deposited particles would not constitute a "layer," they would be invisible, and could not be picked up with brooms, shovels, and pails

b. Hosing Buildings/Plowing under Fields: The MACCS2 Decontamination Plan is described in part in the Code Manual for MACCS2: Volume I, User's Guide (NUREG/CR-6613, Vol. 1) Prepared by D. Chanin and M.I. Young, May 1998. Section 7.5 Decontamination Plan describes some of the assumptions. It says at 7-10 that, "Many decontamination processes (e.g., plowing, fire hosing) reduce ground shine and resuspension doses by washing surface contamination down into the ground. Since these processes may not move contamination out of the root zone, the WASH-1400 based economic cost model of MACCS2 assumes that farmland decontamination reduces direct exposure doses to farmers without reducing uptake of radioactivity by root systems. Thus decontamination of farmland does not reduce the ingestion doses produced by the consumption of crops that are contaminated by root uptake." Hosing buildings simply washes the contamination into the ground, sewers that cannot be cleaned, and eventually into groundwater. Runoff from use of these "cleanup" methods will add to the volume of aqueous discharges in nearby waters.

Another consideration regarding "plowing" and "fire hosing," is that CERLA, EPA and local authorities would not allow use of those methods. Fire hosing and plowing do not decontaminate, it simply moves the contamination from one place to another – only to reappear again later in groundwater, resuspended into the air, or in food. Therefore cleanup will take far longer and be more expensive than assumed; and its success (defined as returning to pre-accident status) unlikely.

Also apparently missing from consideration is that forests, wetlands and shorelines cannot realistically be cleaned-up and decontaminated- demonstrated at Fukushima. Additionally, urban areas will be considerably more expensive and time consuming to decontaminate and clean than rural areas.

c. **Waste Disposal Ignored**: SOARCA's cost model ignored radioactive waste disposal. In a weapon's event, the waste could be shipped to Utah or to the Nevada Test Site. The Greater-than- Class C waste expected in a reactor accident would not have a repository likely available to receive such a large quantity of material in the foreseeable future. Also, the costs incurred for safeguarding the wastes and preventing their being re-suspended or entering the groundwater or runoff (adding to the volume of aqueous discharges) was not accounted for in the model. Even optimistically assuming a repository becoming available, (Utah's site is approximately one-square mile) it seems unlikely that there would be a sufficient quantity of transport containers and communities not objecting to the hazardous materials going over their roads and through their communities.

Lessons Learned at Fukushima starkly show that waste disposal in the real world will dramatically increase costs in a severe accident in the U.S. For example:

Japan's new crisis: radioactive waste disposal , Mari Yamaguchi , Business Week, November 4, 2011

> Goshi Hosono, the country's nuclear crisis minister, said Friday that Japan has yet to come up with a comprehensive plan for how to dispose of the irradiated waste that has been accumulating since the March 11 earthquake and tsunami. Japan could be stuck with up to 45 million cubic meters of radioactive waste in Fukushima and several nearby prefectures (states), according to the environment ministry. Cleaning up the area and compensating residents is expected to cost trillions of yen (tens of billions of dollars). Hot spots of highly localized radiation have been reported hundreds of kilometers away

Fukushima Cleanup Bill $14B Over 30 Years, Bloomberg, *Jacob Adelman - Nov 3, 2011*

> Contaminated material from Japan's wrecked Fukushima nuclear plant will be collected over 30 years and stored at a secure site at a cost of 1.1 trillion yen ($14 billion), according to the country's environment ministry.

Certain areas around the plant, which continues to emit radiation, may be uninhabitable for at least two decades, according to a government estimate in August.

Asia-Pacific: ***Mainichi Daily News*** - Municipalities increasingly unwilling to accept quake debris 11.03.11

"Even if all of the municipalities that are now considering accepting debris do accept it, it would not lead to the disposal of all the debris that the devastated areas want to get rid of," a ministry official said.

Radioactive soil can fill 23 Tokyo Domes, Five prefectures' nuclear burden a hot potato no one wants to catch, Setsuko Kamiya, Japan Times, September 29, 2011

Radioactive soil and vegetation that must be removed in Fukushima and four adjacent prefectures could reach up to 28.79 million cu. meters, equal to filling the Tokyo Dome 23 times, according to a recent Environment Ministry estimate.

But finding a disposal or temporary storage site will be a tall order.

The estimate covers soil and dead leaves mainly from areas with radiation levels of more than 5 millisieverts per year in the prefectures of Fukushima, Miyagi, Yamagata, Tochigi and Ibaraki, whose data were used to mete out the rough figures.

In Fukushima, home of the nuclear plant leaking all the radiation, about 17.5 percent of the prefecture is contaminated to that level.

The estimate was submitted Tuesday to a 12-member expert panel working out decontamination plans. The panel assumed that 5 cm of topsoil should be removed from contaminated areas, including pinpoint decontamination efforts in certain locations with radiation of 1 to 5 millisieverts per year.

The government is hammering out details on plans to remove and store the soil and leaves. But finding a location to temporarily store such a huge amount of radioactive materials will be an extremely sensitive and politically difficult task for the central government.

Breaking down the total, contaminated soil from residential areas was estimated at 1.02 million cu. meters, farm land at 17.43 million cu. meters and forests at 8.76 million cu. meters, the Environment Ministry said.

A single facility capable of housing the entire 28.79 million cu. meters of soil would have to be 1 sq. km in area and 30 meters deep. But if the central government decides on multiple facilities, negotiations would have to be completed with numerous local governments.

> The location for a temporary facility is still undecided, but the government is reportedly considering Fukushima Prefecture.

Contaminated soil can amount to 29 million cubic meters, Denki Shimbun, Sep. 30, 2011 estimated that the amount of soil contaminated from Fukushima could be as much as 29 million cubic meters (38 million cubic yards) that if placed on a football field, including the end zones, would make a pile 6,000 feet high or over a mile.

Reuters in May estimated that the cleanup would take 10-20 years, cost $100 Billion dollars, require 10,000 nuclear cleanup workers, decontamination of a 100,000 square mile area, and produce 100,000 gallons of waste. They made note of the facts that: "Japan doesn't have robust shipping plans for nuclear waste and will have to develop them as the need comes to transport and figure out how and where to bury, burn or ship the waste; Japan has no storage capability currently to contain the highly radioactive core and SFP debris.[26]"

In the meantime absent an acceptable storage facility for the waste, public health and the environment are impacted that will result in increased offsite costs. The same would happen here. Today, Massachusetts for example has no place to ship its low-level radioactive waste.

Japan faces costly, unprecedented radiation cleanup,[27] Yoko Kubota,TOKYO, Thu Aug 25, 2011 8:25am EDT

> Another major headache is where to store the radioactive waste like dirt and water generated from cleanup work.
>
> The amount of radioactive waste from decontamination is likely to be tens of millions of tonnes and the government in the long run plans to build an underground disposal facility to store this, though when and where is unclear.

d. **US Department of Homeland Security commissioned studies** for the economic consequences of a Rad/Nuc attack. Much more deposition would occur in reactor accident, magnifying consequences and costs, but there are important lessons to be learned from these studies. Barbara Reichmuth's study, Economic Consequences of a Rad/Nuc attack: Cleanup

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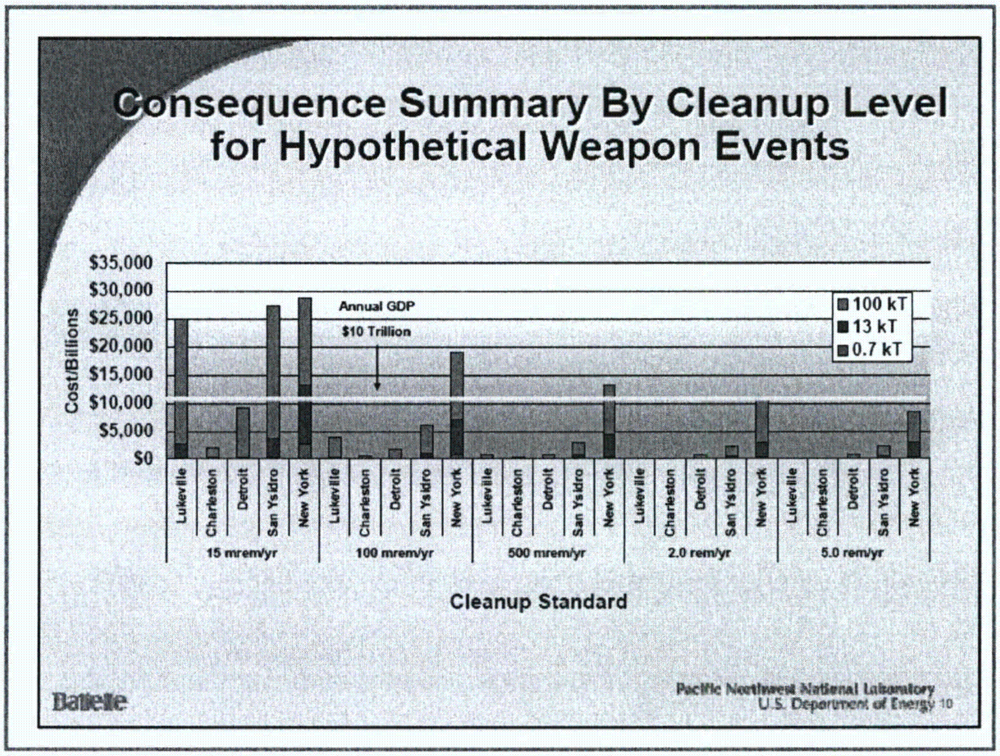
26 The Enormity Of Decontaminating Japan And Decommissioning Fukushima, Fukushima Project, Reuters, May 17, 2011 (Hyperlink)

27 Japan faces costly, unprecedented radiation cleanup27, http://www.reuters.com/article/2011/08/25/us-japan-nuclear-decontamination-idUSTRE77O3LI20110825, Yoko Kubota,TOKYO | Thu Aug 25, 2011 8:25am EDT

Standards Significantly Affect Cost, 2005,[28] Table 1 Summary Unit Costs for D &D (Decontamination and Decommissioning) Building Replacement and Evacuation Costs provides estimates for different types of areas from farm or range land to high density urban areas. Reichmuth's study also points out that the economic consequences of a Rad/Nuc event are highly dependent on cleanup standards: "Cleanup costs generally increase dramatically for standards more stringent than 500 mrem/yr."



(Source: Battelle Study - Locations range from a small rural community to densely populated NYC)

A similar study was done by Robert Luna, *Survey of Costs Arising from Potential Radionuclide Scattering Events,*.[29] concluded that, "...the expenditures needed to recover from a successful attack using an RDD type device ...are likely to be significant from the standpoint of resources available to local or state governments Even a device that contaminates an area of a

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[28] Economic Consequences of a Rad/Nuc attack: Cleanup Standards Significantly Affect Cost Barbara Reichmuth, Steve Short, Tom Wood, Fred Rutz, Debbie Swartz, Pacific Northwest National laboratory, 2005

[29] Survey of Costs Arising From Potential Radionuclide Scattering Events, Robert Luna, Sandia National laboratories, WM2008 Conference, February 24-28, 2008, Phoenix AZ

few hundred acres (a square kilometer) to a level that requires modest remediation is likely to produce costs ranging from $10M to $300M or more depending on the intensity of commercialization, population density, and details of land use in the area." (Luna, Pg., 6)

Currently the NRC and EPA have not agreed on a cleanup standard.[30] The potential standard appears to range from 15 mrem/yr to 5 rem/yr. The General Accounting Office (GAO) reports that the current EPA and NRC cleanup standards differ and these differences have implications for both the pace and ultimate cost of cleanup.[31] SOARCA should use the EPA (15 mrem/yr) standard in determining clean-up costs; it did not.

In place of the outdated decontamination costs figure in the MACCS2 code, the SOARCA analysis should have incorporated the analytical framework contained in the 1996 Sandia National Laboratories report concerning site restoration costs,[32] as well as Luna's and Reichmuth's methodology and studies examining Chernobyl and Fukushima.

7. **HEALTH COSTS**: The SOARCA minimized health costs by using a too low value of life and choosing to rely on outdated dose response research.

a. Value of Life: Health costs are an important part of economic consequences. SOARCA's "life lost" value is too low. U.S. agencies other than NRC place a value on human life of between $5 million and $ 9 million. NRC despite the Office of Management and Budget's warning that it would be difficult to justify a value below $5 million- has continued to value human life at $3 million since 1995.[33] Bringing the valuation in line with other agencies today would have a major effect on assessing consequences in a severe accident.

b. The population dose conversion factor of $2000/person-rem appears to have been used by SOARCA to estimate the cost of the health effects generated by radiation exposure. It is based on a deeply flawed analysis and seriously underestimates the cost of the health consequences of severe accidents.

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[30] See INSIDE EPA; please see report and supporting documents at: http://environmentalnewsstand.com/Environmental-NewsStand-General/Public-Content/agencies-struggle-to-craft-offsite-cleanup-plan-for-nuclear-power-accidents/menu-id-608.html

[31] GAO, "Radiation Standards Scientific Basis Inconclusive, and EPA and NRC Disagreement Continues," June 2004

[32] Site Restoration: Estimation of Attributable Costs from Plutonium-Dispersal Accidents, SAND96-0957, David Chanin, Walt Murfin, UC-502, (May 1996)

33 Appelbaum, B. 2011. A life's value: It may depend on the agency, NYT, Feb 17.

The SOARCA underestimates the population-dose related costs of a severe accident by relying inappropriately on a $2000/person-rem conversion factor. The use of the conversion factor is inappropriate because it (i) does not take into account the significant loss of life associated with early fatalities from acute radiation exposure that could result from some of the severe accident scenarios, that SOARCA refused to consider; and (ii) underestimates the generation of stochastic health effects by failing to take into account the fact that some members of the public exposed to radiation after a severe accident will receive doses above the threshold level for application of a dose- and dose-rate reduction effectiveness factor (DDREF).

The $2000/person-rem conversion factor is intended to represent the cost associated with the harm caused by radiation exposure with respect to the causation of "stochastic health effects," that is, fatal cancers, nonfatal cancers, and hereditary effects.[34] The value was derived by NRC staff by dividing the Staff's estimate for the value of a statistical life, $3 million (presumably in 1995 dollars, the year the analysis was published) by a risk coefficient for stochastic health effects from low-level radiation of 7×10^{-4}/person-rem, as recommended in Publication No. 60 of the International Commission on Radiological Protection (ICRP). (This risk coefficient includes nonfatal stochastic health effects in addition to fatal cancers.) But the use of this conversion factor in the analysis is inappropriate in two key respects and underestimates the health-related costs associated with severe accidents.

First, the $2000/person-rem conversion factor is specifically intended to represent only stochastic health effects (e.g. cancer), and not deterministic health effects "including early fatalities which could result from very high doses to particular individuals."[35] However, for some of the potential severe accident scenarios, we estimate that large numbers of early fatalities could occur representing a significant fraction of the total number of projected fatalities, both early and latent. This is consistent with the findings of the Generic Environmental Impact Statement for License Renewal of Nuclear Plants (NUREG-1437).[36] Therefore, it is inappropriate to use a conversion factor that does not include deterministic effects.

[34] U.S. Nuclear Regulatory Commission, Office of Nuclear Regulatory Research, "Reassessment of NRC's Dollar Per Person-Rem Conversion Factor Policy," NUREG-1530, 1995, p. 12
[35] U.S. NRC (1995), op cit., p. 1.
[36] U.S. NRC, Generic Environmental Impact Statement for License Renewal of Nuclear Plants, NUREG-1437, Vol. 1, May 1996, Table 5.5.

According to NRC's guidance, "the NRC believes that regulatory issues involving deterministic effects and/or early fatalities would be very rare, and can be addressed on a case-specific basis, as the need arises."[37] Post Fukushima, GE Mark I BWR's in particular, are instances where the need arises.

Second, the \$2000/person-rem factor, as derived by NRC, also underestimates the total cost of the latent cancer fatalities that would result from a given population dose because it assumes that all exposed persons receive dose commitments below the threshold at which the dose and dose-rate reduction factor (DDREF) (typically a factor of 2) should be applied. However, for certain severe accident scenarios, we believe that considerable numbers of people would receive doses high enough so that the DDREF should not be applied.[38] This means, essentially, that for those individuals, a one-rem dose would be worth "more" because it would be more effective at cancer induction than for individuals receiving doses below the threshold. To illustrate, if a group of 1000 people receive doses of 30 rem each over a short period of time (population dose 30,000 person-rem), 30 latent cancer fatalities would be expected, associated with a cost of \$90 million, using NRC's estimate of \$3 million per statistical life and a cancer risk coefficient of $1x10^{-3}$/person-rem. If a group of 100,000 people received doses of 0.3 rem each (also a population dose of 30,000 person-rem) a DDREF of 2 would be applied, and only 15 latent cancer fatalities would be expected, at a cost of \$45 million. Thus a single cost conversion factor, based on a DDREF of 2, is not appropriate when some members of an exposed population receive doses for which a DDREF would not be applied.

A better way to evaluate the cost equivalent of the health consequences resulting from a severe accident is simply to sum the total number of early fatalities and latent cancer fatalities, as computed by the MACCS2 code, and multiply by a readjusted value of life figure (> \$3 million figure). Again, we do not believe it is reasonable to distinguish between the loss of a "statistical" life and the loss of a "deterministic" life when calculating the cost of health effects.

Cancer incidence and the other many health effects from exposure to radiation in a severe radiological event (National Academy of Sciences, BEIR VII Report, 2005) should have been considered; they were not. Neither did the SOARCA consider indirect costs. Medical

[37] U.S. NRC, "Reassessment of NRC's Dollar Per Person-Rem Conversion Factor Policy (1995), op cit., p. 13.
[38] The default value of the DDREF threshold is 20 rem in the MACCS2 code input

expenditures only are one component of the total economic burden of cancer. The indirect costs include losses in time and economic productivity and liability resulting from radiation health related illness and death.

Last, if correct evacuation times and assumptions regarding evacuation had been used, the analysis would show far fewer will evacuate in a timely manner, increasing health-related costs.

Example: The following comment submitted by Peter Crane (NRC Counsel for Special Projects, retired Co-facilitator, Thyroid Cancer Survivors' Association support group, Seattle, Washington) Feb 2012) to the SOARCA, underscores the point.

> [T]he most significant observable health effect of the 1986 Chernobyl disaster has been some 7,000 thyroid cancers, almost all among persons who were young children or in the womb at the time of the accident. Only an extremely small percentage of these have died, or are likely to die, of the disease. If the example of Chernobyl carries over to Fukushima, and there is no reason to doubt that it will, we will see the first Fukushima-related thyroid cancers turning up in Japanese children in another four years or so.
>
> Common sense tells us that diseases do not have to be fatal to have a profound impact on the quality of life. (For example, blindness, deafness, and disfiguring acne are not in themselves fatal, and the death rate from malaria, if my reference sources are correct, is only about 1 in 300.) Anyone who doubts that thyroid cancer creates lifelong burdens need only follow the commendable example of Commissioner Apostolakis, who came to the October 2011 annual conference of the Thyroid Cancer Survivors' Association to gather data for himself, by meeting with small groups of patients.
>
> For those unfamiliar with the disease, some explanation may be in order. Thyroid cancer is not like those cancers for which, once a given number of years have passed without a recurrence, the patient is pronounced cured and no further medical attention is needed. Thyroid cancer patients are usually treated by removal of the thyroid gland, often coupled with radiation treatment to destroy any residual thyroid tissue. Accordingly, they are patients for life, requiring daily medication, without which they will die of hypothyroidism. They also require regular monitoring, since there is no date at which it can be said with assurance that the disease will not recur.
>
> Many patients find it easy to achieve the correct dosage of thyroid hormone and resume a reasonably normal life, but many others never succeed in doing so. Experiences are highly individual. Because the thyroid gland controls metabolism, and has both physical and psychological effects, imbalance can be extremely destructive to the quality of life. To give just one example, in 1986, a sitting U.S.

Senator, John East of North Carolina, committed suicide, leaving a note that blamed his doctors for failing to properly treat his hypothyroidism.

To offer an analogy, when we compute the human cost to American forces of the war in Iraq, it goes without saying that we tally not only the 4,400+ troops killed in the line of duty, but also the 31,000+ who were wounded but survived, sometimes with lasting disabilities. To do otherwise would produce a distorted and highly misleading result. Surely the same reasoning applies to those harmed by a nuclear catastrophe. If the SOARCA considers only the latent cancer fatalities from a major nuclear accident, when the non-fatal but nevertheless serious cancers may outnumber the cancer fatalities by 20 or 100 to 1, it will mean a choice to look only at the tip of the tip of the iceberg, as though everything below that point did not exist. The NRC should revise the SOARCA accordingly.

8. **EMERGENCY RESPONSE MODELING, Draft 5.3:** In response to the Fukushima disaster, the NRC advised Americans living in Japan to evacuate out to 50-miles from the site. However, SOARCA assumed evacuation only to 10-miles beyond the EPZ where they assumed that evacuees would receive no further dose. (Draft, pg., 54) The real-world accidents in Japan at Peach Bottom's twins showed otherwise. In the U.S. we have a 50-mile ingestion zone; however contaminated food and water has spread much further than 50 miles. The SOARCA analyses do not treat the ingestion of contaminated food and water reasoning that abundant alternatives are available in the U.S. (Draft, pg., 61) Again Japan has shown otherwise.

SOARCA's emergency planning assumptions are overly optimistic; they minimize risk by assuming a larger percentage of the population will be able to get out of harm's way in a timely manner. Examples: (a) The SOARCA assumed that if the population moved 10 miles beyond the evacuation zone that they would be exposed to no further dose. Post Fukushima, there is no basis for that assumption. (b) Shadow evacuation was considered only out to 20 miles from the site; and only 20% of the population from 10-20 miles would choose to evacuate, based on a pre-Fukushima telephone survey. Post-Fukushima, the public is likely to react differently then NRC assumed from earlier telephone samples from a small population group. (c) The licensee's ETE's were used to estimate evacuation times. If they KLD did the estimates then the ETE did not take into consideration variables that would slow evacuation in reality: an extensive shadow evacuation; evacuation time estimates during inclement weather coinciding with high traffic periods such as commuter traffic, traffic during peak commute times, holidays, summer beach/holiday traffic; notification delay due to fact that notification is largely based on sirens that cannot be heard in doors above normal ambient noise with windows closed or air conditioning systems operating.

9. **ECONOMIC COSTS:** Under decontamination costs, SOARCA lists the costs of farm and non-farm decontamination and the value of farm and nonfarm wealth. However nowhere is there a discussion of the loss of, and costs to remediate the economic infrastructure that make business, tourism and other economic activity possible.

Economic infrastructure is the basic physical and organizational structures needed for the operation of a society or enterprise, or the services and facilities necessary for an economy to function. The term typically, and as used by PW, refers to the technical structures that support a society, such as roads, water supply, sewers, power grids telecommunications, and so forth. Viewed functionally, infrastructure *facilitates* the production of goods and services; for example, roads enable the transport of raw materials to a factory, and also for the distribution of finished products to markets. Also, the term may also include basic social services such as schools and hospitals.

The SOARCA appears to ignore the indirect economic effects or the "multiplier effects." For example, depending on the business done inside the building contaminated, the regional and national economy could be negatively impacted. A resulting decrease in the area's real estate prices, tourism, and commercial transactions could have long-term negative effects on the region's economy.

Respectfully submitted,

(Electroncially signed)

Mary Lampert
Pilgrim Watch, Director
148 Washington Street
Duxbury, MA 02332
Tel 781-934-0389
Email: mary.lampert@comcast.net
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