January 3, 2011

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
Entergy Nuclear Generation Co. and	)	
Entergy Nuclear Operations, Inc.	)	Docket No. 50-293-LR
	)	
	)	ASLBP No. 06-848-02-LR
(Pilgrim Nuclear Power Station)	)	

NRC STAFF'S INITIAL STATEMENT OF POSITION ON REMANDED CONTENTION 3

INTRODUCTION

Pursuant to 10 C.F.R. §§ 2.1207(a)(1) and 2.337(g)(2) and the Atomic Safety and Licensing Board Panel's ("Board") September 23, 2010 Order,[1] the Staff of the U.S. Nuclear Regulatory Commission ("Staff") submits its initial written statement of position and written testimony with supporting affidavits on Pilgrim Watch's admitted contention, as remanded. Appended to this filing is the Staff testimony and certifications of Dr. Nathan E. Bixler, James V. Ramsdell, Jr., and Dr. S. Tina Ghosh, concerning Remanded Contention 3 and Staff's Exhibits NRC0000001 through NRC0000013 and JNT000001. For the reasons set forth below and in the testimony filed herewith, the Staff submits that a careful evaluation of Pilgrim Watch's ("PW') Remanded Contention 3 demonstrates that PW's challenge to the Entergy Nuclear Generation Co. and Entergy Nuclear Operations, Inc. (collectively, "Entergy") application for renewal of the Pilgrim operating license cannot be sustained.

[1] Order (Confirming Matters Addressed at September 15, 2010, Telephone Conference) September 23, 2010.

BACKGROUND

This matter arises from an application, filed by Entergy on January 25, 2006, to renew the operating license for the Pilgrim Nuclear Power Station ("Pilgrim") for an additional twenty-year period following the June 8, 2012 expiration date.[2] On May 25, 2006, PW filed a petition to intervene in this matter.[3] PW submitted five contentions for consideration by the Board. On October 16, 2006, the Board admitted two of those contentions.[4] As admitted, PW's Contention 3, concerning Severe Accident Mitigation Alternatives ("SAMA") analysis, reads:

> Applicant's SAMA analysis for the Pilgrim plant is deficient in that the input data concerning (1) evacuation times, (2) economic consequences, and (3) meteorological patterns are incorrect, resulting in incorrect conclusions about the costs versus benefits of possible mitigation alternatives, such that further analysis is called for.[5]

On May 17, 2007, Entergy moved for summary disposition of Contention 3.[6] On June 29, 2007, the Staff and PW filed their responses to Entergy's Motion.[7] On July 9, 2007,

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[2] *See* Letter from Michael Balduzzi, Entergy Nuclear Operations, to U.S. NRC, Re: License Renewal Application, (January 25, 2006) (Agencywide Documents and Access Management System ("ADAMS") Accession No. ML060300028).

[3] Request for Hearing and Petition to Intervene by Pilgrim Watch (May 25, 2006).

[4] *Entergy Nuclear Generation Co. and Entergy Nuclear Operations Inc.* (Pilgrim Nuclear Power Station), LBP-06-23, 64 NRC 257 (2006) ("Memorandum and Order on Contentions"). The second admitted contention, Contention 3, was disposed of by summary disposition granted on October 30, 2007. *See Entergy Nuclear Generation Co. and Entergy Nuclear Operations, Inc.* (Pilgrim Nuclear Power Station), LBP-07-13, 66 NRC 131 (2007).

[5] *Pilgrim*, LBP-06-23, 64 NRC at 341.

[6] Entergy's Motion for Summary Disposition of Pilgrim Watch Contention 3 ("Entergy's Motion") (May 17, 2007).

[7] NRC Staff Response to Entergy's Motion for Summary Disposition of Pilgrim Watch Contention 3 ("Staff Response") (June, 29, 2007); Pilgrim Watch's Answer Opposing Entergy's Motion for Summary Disposition of Pilgrim Watch Contention 3 ("PW's Opposition") (June 29, 2007).

PW filed a reply to the Staff's Response.[8] On October 30, 2007, the Board granted the motion for summary disposition of Contention 3, in LBP-07-13.[9]

On March 26, 2010, in response to PW's Petition for Review of, *inter alia*, the summary disposition of PW's Contention 3, the Commission issued a Memorandum and Order reversing in part, affirming in part, and remanding Contention 3, as limited by the Commission's Order, to the Board for further proceedings.[10] Specifically, the Commission remanded the meteorological patterns and air dispersion modeling issue.[11] The Commission allowed for the possibility that economic costs and evacuation timing might be affected by the issues.[12] As such, the Commission remanded the economic costs and evacuation timing issues, but only to the extent that the Board's findings on the meteorology and air dispersion modeling "materially call into question the relevant economic cost and evacuation timing conclusions in the Pilgrim SAMA analysis."[13] In remanding Contention 3, the Commission stated that "even assuming that the SAMA analysis does not entirely account for the sea breeze effect … if the sea breeze effect essentially is limited to lower population areas within 10 miles of the plant and occurs only on a

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[8] Pilgrim Watch's Answer to NRC Staff Response to Entergy's Motion For Summary Disposition Of Pilgrim Watch Contention 3 (July 9, 2007).

[9] *Pilgrim*, LBP-07-13, 66 NRC 131. Judge Young dissented from the Board's Order. *Id.* at 156.

[10] *Entergy Nuclear Generation Company and Entergy Nuclear Operations, Inc.* (Pilgrim Nuclear Power Station), CLI-10-11 ("Commission's Order"), 71 NRC ___ (March 26, 2010) (slip op. at 39).

[11] *Id.* at 26.

[12] *See id*. at 27.

[13] *Id*.

limited number of days per year, its overall impact on the SAMA cost benefit conclusions may be insignificant.[14]

After briefings by the parties, the Board set out the scope of the remanded contention, including specific issues for each party to address, in a September 23, 2010 Order.[15] The Board stated that Remanded Contention 3's"primary and threshold issue [is] *whether the meteorological modeling in the Pilgrim SAMA analysis is adequate and reasonable to satisfy NEPA, and whether accounting for the meteorological patterns/issues of concern to Pilgrim Watch could, on its own, credibly alter the Pilgrim SAMA analysis conclusions on which SAMAs are cost-beneficial to implement*."[16] Specifically, the Board asked the parties to address a series of related questions regarding the impact of the sea breeze effect[17] and hot spots[18] on the SAMA.[19] The Board stated:

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[14] *Id.* at 22.

[15] Order (Confirming Matters Addressed at September 15, 2010, Telephone Conference) September 23, 2010.

[16] *Id.* at 1.

[17] The sea breeze effect occurs because of differential heating between land and water surfaces, where air moving onshore off the ocean is heated by the landmass. Ramsdell Testimony at A7. This heated air rises due to its increased buoyancy and is eventually carried back out to ocean by winds blowing in the opposite direction of the onshore breeze. Ramsdell Testimony at A7. As this heated air mass passes back out over the ocean, it cools and decreases in elevation until it rejoins the onshore breeze at a location normally south of the original breeze. Ramsdell Testimony at A7. This southward movement of the air mass during the sea breeze is a normal characteristic of this phenomena in the northern hemisphere. Ramsdell Testimony at A7.

[18] The term "hot spot" is normally associated with area with increased radiation levels due to elevated contamination. For purposes of PW's contention, the term "hot spot" refers to the process where a plume moves over water, remains tightly concentrated over the water, and comes back on-shore after a change in the wind direction with higher concentrations of radionuclides than would be expected based physical characteristics.

[19] The Staff's responses to these questions are laid out Sections III.A and III.B, *infra*, and in the initial testimony of Dr. Nathan E. Bixler, Dr. S. Tina Ghosh, and Mr. James V. Ramsdell, Jr., which has (continued. . .)

1. Regarding the meteorological phenomena at issue in this remand hearing, describe in depth each of the following, with supporting data also provided, to the extent available:

a. The annual frequency of occurrence of the "sea breeze" effect and the "hot spot" effect, and the respective duration of each such occurrence;

b. The spatial and time-dependent pattern of wind and other meteorological phenomenological parameters associated with each such occurrence, or, if such data are not available, expert professional opinion for such parameters, and scientific literature references supporting those opinions;

c. The radioactive deposition distribution you would expect to occur from each such occurrence, assuming a normalized source term. If such depositions are not readily discernable or determinable, a computer model, such as those contained in ATMOS (excluding the straight line Gaussian plume portion) or another model selected by the relevant expert may be utilized to provide such information;

d. How that deposition would differ from that expected using a straight-line Gaussian plume model; and

e. The cost differential caused by the differences indicated in subsection d above (to be provided quantitatively if practicable, or if not, supported qualitative estimates may be provided).

2. Regarding the radioactive contamination to be computed from the dispersion and deposition caused by the meteorological patterns at issue, describe in sufficient detail for scientific understanding the following:

a. How the source term to be used for each computation of radioactivity dispersion and deposition is determined (i.e., what is the frequency distribution of source terms used in SAMA analyses for the Pilgrim Plant and how is a particular source term selected to be assumed for each dispersion/deposition computation);

(. . .continued)

been filled simultaneously with the "NRC Staff's Initial Statement Of Position On Remanded Contention 3."

b. The degree of conservatism imbedded in that methodology, its sources, and the rationale for each source of conservatism;

c. The extent to which those conservatisms cause the resultant deposition to be conservative. Be as quantitative as is practicable, but qualitative discussions are acceptable where quantitative analysis is not practicable.[20]

For the reasons set forth below, the contention lacks merit.

DISCUSSION

I. Legal and Regulatory Requirements

The National Environmental Policy Act ("NEPA"), 42 U.S.C. § 4321 et seq., requires federal agencies, including the NRC, to take a hard look at the environmental impacts of their actions. NEPA does not mandate a specific outcome or a course of action including a decision to mitigate any potential impacts.[21] The NRC fulfills its requirements under NEPA, for renewal of operating licenses, through the Final Supplemental Environmental Impact Statement ("FSEIS").[22] The Commission stated that "there is no NEPA requirement to use the best scientific methodology, and NEPA 'should be construed in light of reason if it is not to demand' virtually infinite study and resources."[23] The Commission has cautioned that "[o]ur boards do

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[20] Order (Confirming Matters Addressed at September 15, 2010, Telephone Conference) at Appendix A (internal citations omitted).

[21] *See, e.g.*, *Baltimore Gas and Elec. Co. v. Nat. Res. Def. Council*, 462 U.S. 87, 97 (1983) (*quoting Kleppe v. Sierra Club*, 427 U.S. 390, 410 n.21 (1976)) (stating that NEPA requires "only that the agency take a 'hard look' at the environmental consequences before taking a major action); Sierra Club v. Army Corps of Engineers, 446 F.3d 808, 815 (2006) (same); *Louisiana Energy Services, L.P.* (Claiborne Enrichment Center), CLI-98-3, 47 NRC 77, 87-88 (1998) (same); *Hydro Resources, Inc.* (P.O. Box 777, Crownpoint, New Mexico 87313), LBP-06-19, 64 NRC 53, 63-64 (2006) (same); *see also Winter v. Nat. Res. Def. Council*, 129 S.Ct. 365, 376 (2008) (stating that "NEPA imposes only procedural requirements" and does not mandate any particular results).

[22] 10 C.F.R. § 51.2.

[23] CLI-10-11, at 37.

not sit to 'flyspeck' environmental documents or to add details or nuances. If the [EIS] on its face 'comes to grips with all important considerations' nothing more need be done."[24]

Here, the Commission's Order remanding Contention 3 explained that the issue for adjudication is "not whether there are 'plainly better' atmospheric dispersion models or whether the SAMA analysis can be refined further" but, whether "it looks genuinely plausible that inclusion of an additional factor or use of other assumptions or models may change the cost-benefit conclusions for the SAMA candidates evaluated."[25] The Commission went on to explain that mathematical precision is not required for evaluating PW's Remanded Contention 3.[26] The Commission concluded that "[u]ltimately, NEPA requires the NRC to provide a 'reasonable' mitigation alternatives analysis, containing 'reasonable' estimates, including where appropriate, full disclosures of any known shortcomings in available methodology, disclosure of incomplete or unavailable information and significant uncertainties, and reasoned evaluation of whether and to what extent these or other considerations credibly could or would alter the Pilgrim SAMA analysis conclusions …."[27] Thus, the Staff's FSEIS and the SAMA analysis satisfy the requirements of NEPA and the Board should enter a finding in favor of the Staff.

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[24] *Exelon Generation Co.*, LLC (Early Site Permit for Clinton ESP Site), CLI-05-29, 62 NRC 801, 811 (2005) (citing *Systems Energy Resources. Inc.* (Early Site Permit for Grand Gulf ESP Site), CLI-05-4, 61 NRC 10, 13 (2005) (footnote omitted)).

[25] *Entergy Nuclear Generation Company and Entergy Nuclear Operations, Inc.* (Pilgrim Nuclear Power Station), CLI-10-11 ("Commission's Order"), 71 NRC ___ (March 26, 2010) (slip op. at 39).

[26] *Id*.

[27] *Entergy Nuclear Generation Company and Entergy Nuclear Operations, Inc.* (Pilgrim Nuclear Power Station), CLI-10-22 ("Commission's Recusal Order"), 72 NRC ___ (Aug. 27, 2010) (slip op. at 9 – 10).

II. Staff's Witnesses

The attached testimony presents the opinions of a panel of three highly qualified witnesses as follows: (1) Dr. Nathan E. Bixler, a chemical engineer, (2) James V. Ramsdell, Jr., atmospheric scientist, and (3) Dr. Tina Ghosh, a nuclear engineer.

Dr. Bixler, a chemical engineer with a Doctorate in chemical engineering, is the Principal Investigator for Sandia on the code development for accident consequences including RADTRAD, MACCS2, WinMACCS, SECPOP2000, and MELMACCS, for the NRC. *See* NRC Staff Testimony of Nathan E. Bixler and S. Tina Ghosh Concerning the Impact of Alternative Meteorological Models on the Severe Accident Mitigation Alternatives Analysis ("Bixler/Ghosh Testimony") at A1a – A2a (January 3, 2010). Dr. Bixler has over twenty years of experience working with codes developed to model atmospheric transport for accident consequence analysis. *Id.* at A1a – A2a. Dr. Bixler's testimony will address the use of alternative atmospheric transport models on the SAMA analysis and why the MACCS2 code provides reliable results when modeling reactor accidents as part of a probabilistic risk assessment ("PRA") analysis. *Id.* at A4a.

Mr. James V. Ramsdell, a Senior Technical Researcher, primarily worked as an atmospheric scientist for 43 years at the Pacific Northwest National Laboratory. *See* NRC Staff Testimony of James V. Ramsdell, Jr., Concerning the Impact of Specific Meteorological Conditions on the Severe Accident Mitigation Alternatives Analysis ("Ramsdell Testimony") at A1 – A2. Mr. Ramsdell was the principle developer of RASCAL, the NRC's emergency response consequence assessment tool and the technical developer of many applied atmospheric dispersion models used for environmental review and licensing nuclear power plants. *Id.* Most recently, Mr. Ramsdell has been assisting the NRC in evaluating the meteorological and climatological reviews and the consequences of design basis and severe

accidents. *Id.* Mr. Ramsdell's testimony will address the impact of the sea breeze and hot spots on the SAMA analysis conclusions. *Id.* at A4.

Dr. Tina Ghosh, a nuclear engineer with a Doctorate in nuclear engineering, is the Senior Program Manager responsible for leading the NRC's research on state of the art reactor consequence analysis. Bixler/Ghosh Testimony at A1b – A2b. Previously, she was a Reactor Engineer for Division of Risk Analysis and primarily responsible for the review of SAMA analysis submitted as part of a plant's application for license renewal. *Id.* Prior to serving in the Division of Risk Assessment, she was primarily responsible for the risk assessment and performance evaluation for the high-level waste application submitted by the Department of Energy. *Id.* Dr. Ghosh's testimony along with Dr. Bixler's Testimony will address why the MACCS2 code provides reliable results when modeling reactor accidents as part of a PRA analysis. *Id.* at A4b.

III. The Concerns Raised by the PW's Remanded Contention 3 Lack Merit

The Staff's testimony presents its position that the concerns raised by PW's contention, as remanded by the Commission, lack merit because the use of additional meteorological data, alternative meteorological models, and accounting for the sea breeze effect and hot spots would not identify any new SAMAs as being potentially cost beneficial. Thus, the SAMA analysis for Pilgrim as discussed in the Staff's FSEIS is reasonable under NEPA.

A. The SAMA Analysis Is Reasonable

PW has argued that SAMA analysis submitted by Entergy and reflected in the Staff's FSEIS is unreasonable because other atmospheric transport models with higher fidelity would provide more accurate transportation and deposition rates for the 50 mile radius surrounding Pilgrim. PW asserts that by increasing the resolution of the atmospheric transport models additional SAMAs would become cost beneficial. PW's focus is too narrow because it is concerned only with how the atmospheric transport model projects the path of a plume for single set of weather data. If the purpose of the SAMA analysis was to make emergency planning and

response decisions based on path of the plume and its deposition rate under variable meteorological conditions, PW's focus might be an important consideration. But the purpose of a SAMA analysis is to identify particular mitigation measures that are potentially cost-beneficial given a particular accident, the likelihood of the accident, any characteristics of the accidental release, and the likely meteorological conditions that would be occurring at the time of the release. Bixler/Ghosh Testimony at A7 – A13, A16, A19 – A20. Thus, the important comparison is not to compare individual weather trials, as PW seems to suggest, but to compare all the weather trials performed for a single accident utilizing the ATMOS module to results produced by higher resolution models. Bixler/Ghosh Testimony at A34, A36 – A37, A40.

1. PW's Preferred Models Are Not Reliable for Predicting Economic Consequences for a SAMA Analysis

PW's narrow focus on increasing the resolution of the atmospheric transport model fails to account for any lost resolution resulting from their preferred models, AERMOD and CALPUFF. The models advanced by PW fail to accurately model radioactive decay. Both models ignore or simplify radioactive decay by substituting a single half-life instead of accounting for the widely varying half-lives that would be present during any accidental release. Bixler/Ghosh Testimony at A27, A34, A36. For AERMOD, the consequences of an accident would be grossly over-estimated because radioactive decay is not modeled. The failure to account for the decay of the released radionuclides forces the consequence analysis to treat these sources of dose to personnel and contamination as constants. Bixler/Ghosh Testimony at A27, A34, A36. As a result of this inaccuracy, all persons exposed to the plume, involved in the decontamination, and returned to their homes or places of work would be projected to receive excess dose. Bixler/Ghosh Testimony at A27, A34. This excess dose could potentially be significantly higher than the dose that would actually occur given the initial concentration of released radionuclides. *Id*. The economic consequences of an accident would also be

significantly higher than could be justified based on the released radionuclides. *Id*. Similar to the increased dose, AERMOD's oversimplification would also inflate the expected clean-up costs for an accident. Many of the radionuclides released during an accident have relatively short half-lives.[28] Bixler/Ghosh Testimony at A27, A36. Because of the short half-life, substantial decay would be expected to occur prior to entering the clean-up phase of the accident. Thus, less clean-up would be required and fewer costs would be imposed by the accident. *Id*. AERMOD, alternatively, would force clean-up based on the radionuclides released without accounting for their decay into stable isotopes. *See id*.

CALPUFF's use of a single half-life to represent the entire population of radionuclides would also introduce significant errors into its determination of consequences, although whether those errors would cause an over-estimate or under-estimate of the consequences would depend significantly on the half-life that is selected. *Id*. For example, if an average half-life for the radionuclides was selected, the calculated concentration of long-lived radionuclides would decrease significantly faster than the actual concentration of those radionuclides.[29] *Id*. Even though the radionuclides with the longest half-lives would not be expected to appreciably decay during the clean-up phase of a severe accident, their impact on the consequences based on their contribution to dose and clean-up would be unjustifiably minimized by the use of a single half-life for all radionuclides released during an accident. *Id*.

Both AERMOD and CALPUFF are unable to model daughter ingrowth resulting from the radioactive decay. Bixler/Ghosh Testimony at A27, A34 – A36. Daughter ingrowth describes

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[28] For the purpose of this case, a short half-life would be on the order of the emergency phase or less.

[29] A long lived radionuclide here would be any radionuclide with a longer half-life. *See* Bixler/Ghosh Testimony at A27. The most pronounced effect would be on radionuclides with half-lives greatly exceeding the average half-life used. *See id.*

the process whereby a radionuclide decays into another isotope that is also unstable and will also undergo radioactive decay. Bixler/Ghosh Testimony at A27. Failing to properly model daughter ingrowth may also lead to underestimates in the projected consequences of an accident. *Id.* Some of the daughters represent more dose risk than the isotopes initially released during an accident due to their particular biological pathways and decay methods.

2. The ATMOS Module has Demonstrated Good Performance in a SAMA Analysis

The performance of the ATMOS module of the MACCS2 code has been quantitatively compared to codes like CALPUFF and AERMOD under SAMA conditions.[30] Bixler/Ghosh Testimony at A37; Ramsdell Testimony at A29. The study compared the performance of the ATMOS module to RASCAL, RATCHET, and LODI atmospheric transport models. RASCAL and RATCHET are Gaussian puff models similar to CALPUFF's model.[31] RASCAL and RATCHET are NRC atmospheric transport codes used for emergency planning and decision-making processes in the event of an actual accident. Bixler/Ghosh Testimony at A40; Ramsdell Testimony at A27. LODI is Lagrangian mechanics atmospheric transport model, which allows for free motion in all directions. Bixler/Ghosh Testimony at A31. After comparing the performance of each model over multiple distances including the 50 mile radius used for SAMA analysis, the ATMOS module was shown to outperform the higher resolution Gaussian puff models RASCAL and RATCHET. Bixler/Ghosh Testimony at A38 – A40; Ramsdell Testimony at A30. Dr. Bixler and Mr. Ramsdell were authors of the study comparing the ATMOS module

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[30] NUREG-6853, "Comparison of Average Transport and Dispersion Among a Gaussian, a Two-Dimensional, and a Three-Dimensional Model," Ex. JNT000001 (2004).

[31] Bixler/Ghosh Testimony at A40; Ramsdell Testimony at A27. AERMOD is a Gaussian plume model with some additional features like terrain following. Ramsdell Testimony at A25 – A26.

to these higher fidelity codes. In their expert opinions, they conclude that the results of the comparison study are applicable to Pilgrim.[32] Bixler/Ghosh Testimony at A41.

The use of the ATMOS module and the MACCS2 code is reasonable for conducting a SAMA analysis because it has been shown to provide more reliable results in comparative studies with alternative atmospheric transport models similar to those suggested by PW, the conclusions of the comparative studies are applicable to Pilgrim, and the alternative atmospheric transport models suggested by PW have significant flaws in their treatment of the decay of radionuclides and daughter ingrowth models making them unreasonable for use in a SAMA analysis. Bixler/Ghosh Testimony at A6.

B. The Limited and Localized Effects like the Sea Breeze Will Not Alter the Conclusions of the SAMA Analysis

PW has argued that the sea breeze effect and hot spots that could be experienced at Pilgrim would alter the conclusions of the SAMA analysis.[33] The sea breeze effect and hot spots are rare occurrences with a small geographical impact over the entire modeled area. Ramsdell Testimony at A14, A42 – A45. In addition, and under either phenomenon, the sea breeze effect or hot spots, the consequences are limited because the plume will tend to travel in a clockwise rotation[34] before coming back onto shore. Ramsdell Testimony at AA14, A48. This rotation moves the plume away from the densest population centers further minimizing any impact on the consequence analysis. *Id*.

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[32] The impact of the sea breeze effect and hot spots are discussed in detail in Section III.B, *infra.*

[33] The term “hot spot” is normally associated with area with increased radiation levels due to elevated contamination. For purposes of PW’s contention, the term “hot spot” refers to the process where a plume moves over water, remains tightly concentrated over the water, and comes back on-shore after a change in the wind direction with higher concentrations of radionuclides than would be expected based physical characteristics.

[34] This clockwise rotation tends to move the plume east and south of Pilgrim.

1. The Sea Breeze Effect Cannot Alter the SAMA Analysis Conclusions

The sea breeze effect is a local wind pattern resulting from differential heating of land and water surfaces.[35] Ramsdell Testimony at A7. The sea breeze effect has minimal impact on the SAMA analysis conclusions because it occurs only during a limited time of the year and the MACCS2 code both over- and under-estimates the economic consequences. Ramsdell Testimony at A8, A14. The over- and under-estimate of the economic consequences are of nearly equal magnitudes and off-setting, such that the overall impact of the sea breeze effect is unlikely to affect the overall conclusions of the SAMA analysis. Ramsdell Testimony at A14.

A recent graduate thesis on the meteorological patterns analyzed ten years of meteorology data from Logan Airport in Boston, Massachusetts.[36] Ramsdell Testimony at A8. Based on the data in the Thorp study and on the meteorological data available for Pilgrim, the normal prevalence and timing of the sea breeze is discernable. Ramsdell Testimony at A8. On average, the conditions necessary for the sea breeze effect (i.e., weak synoptic regime[37] and warm land mass) only occurred on 88 days per year. Ramsdell Testimony at A8. Even though 88 days per year had conditions conducive to the sea breeze effect, only 31 days per year

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[35] For purposes of this discussion, the terms “sea breeze effect” and “sea breeze event” are used somewhat interchangeably to describe a particular meteorological phenomenon associated with coast lines. The sea breeze effect occurs because of differential heating between land and water surfaces, where air moving onshore off the ocean is heated by the landmass. Ramsdell Testimony at A7. This heated air rises due to its increased buoyancy and is eventually carried back out to ocean by winds blowing in the opposite direction of the onshore breeze. Ramsdell Testimony at A7. As this heated air mass passes back out over the ocean, it cools and decreases in elevation until it rejoins the onshore breeze at a location normally south of the original breeze. Ramsdell Testimony at A7. This southward movement of the air mass during the sea breeze is a normal characteristic of this phenomena in the northern hemisphere. Ramsdell Testimony at A7.

[36] Jennifer E. Thorp, “The Eastern Massachusetts Sea Breeze Study,” (“Thorp Study”) (May 2009) Ex. NRC0000010 (unpublished).

[37] A weak synoptic regime refers to a meteorological pattern with no well-defined pressure systems affecting the overall air flow.

(8.5%) experienced an actual sea breeze event.[38] Ramsdell Testimony at A8. Of the 31 days per year with a sea breeze event, seven (7) days per year had marginal sea breeze events. Ramsdell Testimony at A8. A marginal sea breeze event is normally characterized as lasting less than two (2) hours, interrupted by calm or light and variable winds, or with no clear start or stop. Ramsdell Testimony at A8. The ATMOS module of the MACCS2 code will tend to overestimate and underestimate the consequences of an accident during a single weather trial when the accident occurs just prior to beginning or ending of the sea breeze. Ramsdell Testimony at A14. For accidents occurring just prior to the beginning of the sea breeze, the MACCS2 code is likely to overestimate the consequences because the ATMOS module would use an onshore wind direction for an accident even though the wind will shift out to sea during the accident. Ramsdell Testimony at A14. Similarly, the MACCS2 code would tend to underestimate the consequences for accident beginning just before sea breeze effect stops because it will use the prevalent wind direction out to sea even though wind will shift back to an onshore flow. Ramsdell Testimony at A14.

Based on the Thorp Study, the onset of the sea breeze effect normally occurs at about 10:00 a.m. and lasts for approximately 8 hours. Ramsdell Testimony at A8, A14. During a sea breeze event, the likelihood that an accidental release would occur and MACCS2 would underestimate the consequences is 42%. Ramsdell Testimony at A14. Similarly, the likelihood that MACCS2 would overestimate the consequences during a sea breeze event is about 33%. Ramsdell Testimony at A14. Over an entire year, including conditions conducive to the sea

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[38] A sea breeze effect and sea breeze event need to be distinguished from a “sea breeze.” The reference to the sea breeze effect and sea breeze event are to particular localized wind patterns with low elevation onshore flows coupled to higher elevation offshore flows, which should not be confused with a wind originating from off-shore.

breeze effect, the MACCS2 code would overestimate the consequences of an accident about 2.8% of the time and underestimate the consequences 3.5%. Ramsdell Testimony at A14. Since these errors will offset, the resulting net error is approximately 0.7%. *See* Ramsdell Testimony at A14. For the next SAMA to become cost beneficial, the off-site economic consequences would need to double.[39] Ramsdell Testimony at A16.

The Thorp Study utilized information for Logan Airport, which should have a stronger and more common sea breeze effect than would be experienced at Pilgrim, because of the locations and shapes of each coastline. Ramsdell Testimony at A36. The Pilgrim site is not ideally located for the sea breeze effect. Ramsdell Testimony at A9. Whereas, Logan Airport is located along a slightly curved coast line that has no other coast lines oriented in different directions to interfere with sea breeze circulation. Ramsdell Testimony at A9. Pilgrim is located further south than Logan on the Massachusetts coast line and closer to Cape Cod. Ramsdell Testimony at A9. Pilgrim's location along the western coastline helping to form the Cape Cod Bay along with southern and eastern coast lines for the bay tend to minimize the strength and prevalence of any sea breeze events at Pilgrim. Each coast line would try to establish circulation patterns that due to their orientations would interfere with each other. Ramsdell Testimony at A9. Whereas, near Logan, the coastlines North and South help to reinforce the sea breeze event. Ramsdell Testimony at A9. Thus, the sea breeze effect at Pilgrim would be less prevalent and weaker than near the Logan airport. Ramsdell Testimony at A9.

Even though there is minor net percentage of time when the MACSS2 code is likely to under-estimate the consequences of an accident during the entire year because of the sea

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[39] Doubling the off-site economic consequences would represent a 100% increase over the original SAMA analysis.

breeze effect, the actual impact on the consequences of an accident during the sea breeze is small due to the prevalent circulation patterns. Ramsdell Testimony at A14. Based on Pilgrim's location and its meteorological conditions, the wind circulation pattern will primarily rotate in clockwise direction such that any plume moving off-shore will tend to return onshore south of its origination point. Ramsdell Testimony at A14. During an accidental release at Pilgrim with a sea breeze event, the plume would be initially carried off-shore and to the south. Ramsdell Testimony at A14. Thus, the plume would be moving away from the densest population centers located west and north of Pilgrim. Ramsdell Testimony at A14. As such, any impact on the economic consequences would be minimized in comparison to a sea breeze effect that carried the plume towards a more densely populated area. Ramsdell Testimony at A14.

Finally, sea breeze events are geographically localized. Ramsdell Testimony at A7, A48. The onshore portion of the sea breeze event only penetrates 10 to 25 miles inland, spends significant periods of time over water, and follows the coast line south. Ramsdell Testimony at A8. As such, the impact of a sea breeze event is unlikely to alter the economic consequences calculated for each accident under all of the conceivable weather events for the entire 50 mile radius surrounding Pilgrim.

Thus, the sea breeze effect is unlikely to alter the conclusions of the SAMA analysis because it is a rare occurrence over the course of a year, has a limited impact over the modeled geography for consequence analysis, and the MACCS2 code's Gaussian plume model treatment of the sea breeze effect causes only small off-setting errors where consequences are both over-estimated and under-estimated. Ramsdell Testimony at A14.

2. Hot Spots Would Not Alter the SAMA Analysis Conclusions

Similar to the sea breeze effect, hot spots[40] are unlikely to alter the SAMA analysis conclusions because they rarely form and have a limited geographical effect on economic consequences. Ramsdell Testimony at A47. In order for hot spots to form, specific accident scenarios and meteorological conditions must be present. Ramsdell Testimony at A41. Hot spots are most likely to manifest under accidental releases at elevation (i.e. not near the ground) with a precipitation event (e.g. rain or snow) following the release. Ramsdell Testimony at A41.

Hot spot formation has a localized effect on the economic consequences of a particular accident. Ramsdell Testimony at A48. First, the concentrated plume travels over a small subset of the 50 mile radius modeled for the SAMA analysis. *See* Ramsdell Testimony at A48. This small subset bounds any potential increase in economic consequences resulting from a hot spot. Ramsdell Testimony at A48. The potential increase in economic consequences is limited to the difference in dose modeled by ATMOS to the dose resulting from the slightly elevated concentrations of radionuclides and the small increase in contamination clean-up costs. *See* Ramsdell Testimony at A48. As discussed above, the circulation patterns for Pilgrim tend to rotate clockwise. Ramsdell Testimony at A7. Thus any plume being carried out over Cape Cod Bay would tend to move to the south and east. Ramsdell Testimony at A7. This normal rotation would then bring any plume back onshore south of Pilgrim in areas with lower population

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[40] The term “hot spot” is more traditionally utilized to describe a region in a radiation/contamination area where the level of radiation/contamination is significantly greater than in neighboring regions in the area. Ramsdell Testimony at A38 – A39. In the present case, the term “hot spot” seems to be describing a particular atmospheric transport phenomenon where an accident plume initially proceeds over a body of water while remaining more tightly grouped than it if it had travelled over land and then proceeds back over land with increased dose and deposition rates. Ramsdell Testimony at A39.

densities and economic development than areas to the west and north of Pilgrim. Ramsdell Testimony at A7. Thus, any increase would be mitigated by the lower total dose resulting from the lower population density. Ramsdell Testimony at A48. This localized impact on economic consequences would not be sufficient on its own to conclude that the SAMA analysis' conclusions would be altered. Ramsdell Testimony at A7, A48.

Although hot spots are not as well studied as the sea breeze effect, the likelihood of a hot spot forming may be estimated based on the annual meteorological conditions measured at Pilgrim. Ramsdell Testimony at A41 – A43. Based on the climatological records for the area surrounding Pilgrim, hot spots only occur on average for 10% to 20% of the modeled accidental releases.[41] Ramsdell Testimony at A42. Accounting for the particular type of event describe by PW, an additional 10% of the modeled releases might exhibit a hot spot. Ramsdell Testimony at A43. However, even when the conditions conducive to forming a hot spot are present, each hot spot may not actually result in an under-estimate of the economic consequences. *See* Ramsdell Testimony at A44 – A45. For example, economic consequences in excess of those calculated by the MACCS2 code require that the plume pass back over land before depleting its radionuclides. Thus, plumes traveling over the bay but experiencing precipitation prior to returning over land may actually over-estimate the consequences because many of the radionuclides would have deposited in the bay. Radionuclides deposited in the bay by the plume would result in greatly reduced dose and clean-up costs. Even though the economic consequences of hot spots may be underestimated by the MACCS2 code under certain limited circumstances, the MACCS2 code will also overestimate the consequences under conditions

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[41] The 10% to 20% excludes the type of event postulated by PW, which requires a plume to be carried out into the bay before returning over land. *See* Ramsdell Testimony at A42 – A43.

where precipitation results in excess deposition over the bay. Ramsdell Testimony at A47 – A48.

Thus, hot spots are unlikely to alter the conclusions of the SAMA analysis because they are relatively rare occurrences, have a limited impact over the modeled geography, and result in off-setting errors that will cause the MACCS2 code to both overestimate and underestimate the economic consequences. Ramsdell Testimony at A48.

CONCLUSION

For the reasons discussed above, the use of additional meteorological input data, alternative meteorological models, which would include additional meteorological input data, and accounting for the sea breeze effect and hot spots would not result result in the identification of an additional cost-beneficial SAMA. As such, the SAMA analysis performed for Pilgrim using the MACCS2 code is reasonable and satisfies the NRC's requirements under NEPA. Thus, the Board should enter a finding in favor of the applicant.

Respectfully submitted,

/Electronically signed/
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Dated at Rockville, Maryland
this 3rd day of January, 2011