Exhibit No. ENT000013
Pilgrim LR Proceeding
50-293-LR, 06-848-02-LR

ENT –Rebuttal Meteorological Testimony

February 1, 2011

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION,

Before the Atomic Safety and Licensing Board Panel

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

Rebuttal Testimony of Dr. Kevin R. O'Kula and Dr. Steven R. Hanna on
Meteorological Matters Pertaining to Pilgrim Watch Contention 3

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Q1: Have you reviewed the document filed by Pilgrim Watch, entitled "Pilgrim Watch SAMA Remand Prefiled Testimony," which is Pilgrim Watch's statement of position ("PW Statement" or "Statement") and the exhibits thereto?

A1. (KRO, SRH) Yes.

Q2: Dr. Hanna, are you familiar with Pilgrim Watch's claims regarding "hot-spots?" and its reliance on the Angevine et al. (2006) paper entitled "Modeling of the Coastal Boundary Layer and Pollutant Transport in New England" (Exhibit PWA00006) for those claims?

A2. (SRH) Yes.

Q3: At Page 30 of its Statement, Pilgrim Watch states that the conclusions in the Angevine et al. (2006) paper related to ozone transport are applicable to radionuclide transport. Do you agree with this assertion?

A3. (SRH) I do not agree with Pilgrim Watch's assertion. Pilgrim Watch fails to appreciate and understand the differences in the basic physics of transport and dispersion for a point-source release, such as from the Pilgrim stack, and that for a broad ozone plume.[1] There are many differences in behavior of a broad regional

[1] Ozone is a regional air quality problem mainly because its precursors (nitrogen oxides and volatile organic compounds) are emitted over a broad area by a wide range of sources, e.g., traffic, power plants (oil. coal and natural gas-fired), industrial processes, gas stations and so on. Ozone is not directly emitted but is produced over time as a result of chemical reactions among the precursors that have been directly emitted. Ozone episodes in the Eastern U.S. occur during the hottest days of summer with persistent high-pressure systems. For Northern New England, the ozone episodes are usually associated with general wind flow from the southwest, when the source areas from Richmond,

ozone polluted air mass, such as that evaluated by Angevine et al. (2006), and a single plume emitted from a point source evaluated in a SAMA analysis.

The plume from a point source will initially disperse rapidly in both the lateral and vertical directions, causing large decreases in ground level concentrations (see ENT000001 at A84). Even after the plume disperses vertically so that it fills the mixing layer, it will still significantly disperse in the lateral direction. In contrast, the basic physics and chemistry of an ozone plume will result in the plume being 100 to 200 miles wide by the time it reaches the Eastern Massachusetts coast. The plume (better referred to as a regional polluted air mass) has nearly uniform ozone concentration, with no more than a factor of two difference, in a lateral direction for at least 100 miles in either direction and for hundreds of miles upwind. This plume or polluted air mass has already "filled up" the mixing layer. Even though the broad ozone plume is dispersing at its sides at the normal rate, this is insufficient to cause much of a decrease in concentration over the wide area.[2]

Thus, the physics and chemistry principles that apply for the ozone plumes studied in Angevine et al. (2006) are inapplicable for point source plumes, such as those considered in a SAMA analysis. As noted in my testimony (ENT000001 at A85), even under very stable atmospheric conditions, there is sufficient turbulence occurring overwater to cause a plume from an industrial stack to rapidly disperse such that maximum plume centerline ground level concentrations will decrease by a factor of about 10 to 30 for each factor of ten increase in distance.

Virginia to Boston, Massachusetts are "lined up" and maximize the emissions within the broad regional plume. For hot conditions and winds from the southwest, the broad ozone air mass is going to be transported out to sea at the eastern Massachusetts coast. The ozone air mass is likely to be at least 100 to 200 mi wide at this point. For severe episodes, the ozone-polluted air mass covers most of the eastern U.S.

[2] There is another fundamental difference between the behavior of an ozone plume and a nuclear power plant radiological plume. Near a major point source of nitrogen oxides, such as within a fossil-fired power plant plume or in a busy city street canyon, ozone concentrations are reduced due to removal by chemical reactions involving ozone and nitrogen oxides. The ozone concentrations increase again only after at least 10 to 20 miles of travel downwind of the major nitrogen oxide sources, when other slower chemical reactions lead to ozone formation.

Q4: Are there any other reasons why the Angevine et al. (2006) study is not applicable here?

A4. (SRH) Yes. The Angevine et al. (2006) study of ozone episodes was focused on just five days of hot summertime conditions in 2002 when two separate ozone episodes occurred in New England (PWA00006 at 139). Thus, although the article is broadly titled "Modeling of the Coastal Boundary Layer and Pollutant Transport in New England," Angevine et al. (2006) do not discuss the general aspects of pollutant transport in New England, nor do they study a large number of representative days in the year. All of the statements in the Angevine et al. (2006) study need to be understood in view of this narrow focus of their study.[3] Pilgrim Watch uses the limited conclusions from Angevine et al. (2006), based on a few days of hot conditions in the summer, to extrapolate conclusions about atmospheric stability and plume dispersion for an entire year. The Angevine et al. (2006) study simply does not address calculating long-term annual consequences over a 50-mile radius region to support a SAMA cost-benefit analysis.

As stated in our testimony (ENT000001 at A88 and A108), a SAMA analysis evaluates an entire year of meteorological data and therefore includes the slightly enhanced overwater dispersion during some days in the winter as well as the slightly reduced overwater dispersion during some days in the summer. There are many days of extreme instability and very large mixing during the winter, when cold air is transported over warm ocean water, which counter balances the five hot summer days studied by Angevine et al. (2006). Over a year, the effects of more stability in the mid-summer overwater boundary layer are balanced by the effects of less stability in the winter.

[3] For example, Angevine et al. (2006) at 143 say, "The boundary layer over the water by contrast is *always* stable …" However, the boundary layer over water is not *always* stable, particularly during the cold winter months. Rather, the boundary layer over water for the five 2002 summer days of ozone episodes that the authors chose to study was *always* stable, at least in most of the areas where they operated their meteorological instruments..

Q5: Have you reviewed Pilgrim Watch's criticism of the Molenkamp et al. (2004) study (Exhibit JNT000001) made at pages 46-47 of its Statement?

A5. (SRH, KRO) Yes.

Q6: Do you agree with Pilgrim Watch's assertion that the Study was performed for areas that "are not in the least comparable to the PNPS site" and "tells little or nothing about what a [model] comparison made in Plymouth, Massachusetts would show?"

A6. (SRH, KRO) No, we disagree. At the outset, Pilgrim Watch's claim is based on its misreading of the Molenkamp et al. (2004) study. For its claim, Pilgrim Watch quotes and relies on (Statement at 46-47) that portion of the study which explains the criteria that were considered in making a final selection of the study's site. These are the criteria that were used in searching for sites with extensive long-term meteorological observations for use in carrying out the model comparisons as well as topography and other surface property variability that could affect local wind speed and direction. Contrary to Pilgrim Watch's assertions in its Statement, these criteria are not conclusions. In fact, in making the site selection, Molenkamp et al. (2004) conclude that "the last two criteria were only partially satisfied, but there was sufficient variability for the purpose of this study" (JNT000001 at 3).

(SRH) Furthermore, it is my professional opinion that the Molenkamp et al. (2004) study and its conclusions are valid and applicable here because the Molenkamp et al. (2004) study site and the Pilgrim SAMA domain are reasonably comparable. My opinion is based on my review of the wind variability and topography of the Molenkamp et al. (2004) study area and my professional experience in analyzing weather data for the general region in which the Molenkamp et al. (2004) study area is located.

Q7: Please describe your review and experience on which you base your opinion.

A7. (SRH) First, I reviewed the observations provided in the Molenkamp et al. (2004) report on wind variability for the study area. Specifically, I reviewed the wind roses provided in Section 9 of the Molenkamp et al. (2004) study for six sites within the study area. The variability shown by these six wind roses is approximately the same

as the variability of the wind roses analyzed in my CALMET Report for weather sites in the Pilgrim SAMA domain.[4]

The wind variability shown by the Molenkamp et al. (2004) study wind roses are confirmed by my own extensive experience in analyzing weather data for the Southern Great Plains (SGP) geographic domain used in their study. This is the same geographic domain that I analyzed for a recent journal article.[5] A key finding in my paper (Hanna et al., 2010)) is that there is significant wind variability in the SGP, even though it is located in the Kansas and Oklahoma central plains. My research determined that the typical model errors at specific locations and for specific hours are the same magnitude here as in many other test sites, including many in mountainous and coastal domains. The similarity of the wind variations found at the SGP with those of other geographic domains, including coastal domains such as the Pilgrim SAMA domain, leads to the conclusion that the Molenkamp et al. (2004) study is an appropriate comparison of transport and dispersion models for the Pilgrim SAMA domain and that the study reflects meteorological variations in time and space representative of those expected at Pilgrim.

Second, I reviewed topographical maps for different areas of the Southern Great Plains domain.[6] For example, I looked at the Lamont, OK area, where the Department of Energy's "Central Facility" (the primary meteorological observation site for the SGP) is located. The town is near a river with two tributary streams on either side of town. In a 4 by 4 mile area around the town, the vegetation is mostly farm fields but the stream channel banks and the adjacent slopes are wooded. The terrain is "gently rolling" with stream cuts of depth about 20 feet or so. The terrain slopes up and down with differences of 25 or 50 feet. Another example is Claremont,

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[4] Analysis of Annual Wind Roses and Precipitation within about 50 Miles of the Pilgrim Nuclear Power Station, and Use of CALMET to Calculate the Annual Distribution of Trajectories from the Pilgrim Station," Dec. 2010 (" Report") (Exhibit ENT000004).

[5] Hanna SR, Reen B, Hendrick E, Santos L, Stauffer D, Deng AJ, McQueen J, Tsidulko M, Janjic Z, Jovic D, Sykes RI, 2010: Comparison of observed, MM5 and WRF-NMM model-simulated, and HPAC-assumed boundary-layer meteorological variables for three days during the IHOP field experiment. *Bound.-Layer Meteorol*. 134, 285-306. The research required the use of several of the same meteorological data sites used by Molenkamp et al. (2004).

[6] High resolution topographical maps of the SGP domain are available at www.mytopo.com and www.topoquest.com.

OK area, just north of Tulsa, OK where the hills are slightly higher. There are 100 to 200 foot variations across a 4 mile by 4 mile area. Finally, I reviewed the Walnut River watershed in Kansas, the subject of a journal article by LeMone et al. (2000), who reviewed meteorological measurements for a portion of the same geographic domain used in the Molenkamp et al. (2004) study.[7] The Walnut River maps show plus and minus 100 foot terrain variations across the river's drainage basin (approximately 2400 square miles), with two or three hills and valleys in any one mile.

This review of the on-line topographical maps confirms my own visits to several locations in the SGP domain which, although generally classified as a plain, contains many areas with rolling terrain, hills, and river and stream valleys. The 50 to 100 foot plus and minus hills and the stream channels, plus the forested areas interspersed in the farm fields, cause significant variations in observed wind flows, as confirmed by LeMone et al. (2000) and Hanna et al. (2010).

Q8: What do you conclude from your review and professional experience?

A8. (SRH) Having been both places, I conclude that (1) the terrain in the SGP is similar to that in eastern Massachusetts (with the exception of occasional significant hills in Massachusetts such as Pine Hill near the Pilgrim Station and Blue Hill farther north both discussed in ENT000001 at A107 and A109), and (2) the wind variability exhibited for the SGP is comparable to the wind variability for the Pilgrim SAMA domain. Thus, the Molenkamp et al. (2004) study and its conclusions are fully valid and applicable for the Pilgrim SAMA domain.

(SRH, KRO) Finally, we should note that, as discussed in our Testimony (ENT000001at A113), the CALMET wind trajectory analysis takes into account the complexities caused by terrain and coastline and shows that their impacts on annual wind field patterns are minimal and do not alter the outcome of the SAMA analysis.

[7] LeMone, M.A. et al., 2000: Land-atmospheric interaction research, early results, and opportunities in the Walnut River Watershed in Southeast Kansas: CASES and ABLE. Bull. Am. Meteorol. Soc. 81, 757-779.

Q9: Are you familiar with Pilgrim Watch's assertion at page 21 of its Statement that "Entergy failed to properly account for …precipitation, moisture, fog…" and that (quoting PWA00011) a "drizzly, foggy day" may be a worst case scenario?

A9. (KRO, SRH) Yes.

Q10: Do you agree with Pilgrim Watch's assertion?

A10. (SRH, KRO) No. As we explained in our testimony, precipitation is accounted for in MACCS2. See ENT000001 at A32. Whether the precipitation is rain or a light drizzle, the weather binning process takes the precipitation into account (see ENT000001 at A36) as long as it is reported in the official log at the Plymouth Municipal Airport. Also, as pointed out in the Report (ENT000004) and our testimony (ENT000001 at A71 and A72), the precipitation collected from Plymouth Municipal Airport is representative for the Pilgrim 50-mile SAMA domain. Furthermore, if there is fog with no recorded drizzle, the winds and stability conditions associated with the fog measured at the Pilgrim Station will be used in the MACCS2 SAMA runs. Thus, contrary to Pilgrim Watch's claim, MACCS2 does properly account for precipitation, moisture and fog.

(SRH) In addition, a weather condition with an advection fog is not a worst-case dispersion scenario as speculated by Pilgrim Watch. Meteorologists define two major of causes for fogs: 1) radiative fogs caused by surface cooling at night in low spots, which occur with light winds and clear skies, and 2) advective fogs caused by saturated air blown by the wind. Advective fogs are often associated with periods with light precipitation. Either type of fog could occur over the land or over the water. The statement from PWA00011 cited in the PW Statement refers to advective fog. Notably, the vertical temperature gradient in a fog layer is usually nearly-neutral, implying that inversions and hence strong stabilities are unlikely in a fog. Thus, an advection fog marked by nearly-neutral stabilities and moderate winds is not a worst-case dispersion scenario as speculated by Pilgrim Watch.

(KRO, SRH) Moreover, as discussed in ENT000001, SAMA analyses are not focused on speculative worst-case scenarios. The SAMA analysis is based on one

year’s worth of meteorological data to predict the annual probabilistic expected consequences over the 50-mile radius SAMA domain.

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AFFIDAVIT OF KEVIN R. O'KULA

I, Kevin R. O'Kula, do hereby declare under penalty of perjury that my statements in the foregoing testimony are true and correct to the best of my knowledge and belief.

Executed in Accord with 10 CFR 2.304(d)

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AFFIDAVIT OF STEVEN R. HANNA

I, Steven R. Hanna, do hereby declare under penalty of perjury that my statements in the foregoing testimony are true and correct to the best of my knowledge and belief.

Executed in Accord with 10 CFR 2.304(d)

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