UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	Docket Nos. 50-247-LR and 50-286-LR
ENTERGY NUCLEAR OPERATIONS, INC.	)	
(Indian Point Nuclear Generating Units 2 and 3)	)	September 21, 2009

APPLICANT'S ANSWER OPPOSING NEW YORK STATE'S MOTION FOR SUMMARY DISPOSITION ON CONTENTION NYS-16/16A (REGARDING USE OF ATMOS MODULE OF MACCS2 IN SAMA ANALYSES)

Pursuant to 10 C.F.R. § 2.1205(b), Entergy Nuclear Operations, Inc. ("Entergy") hereby responds to New York State's ("NYS") motion for partial summary disposition of Contention NYS-16/16A.[1] As admitted by the Atomic Safety and Licensing Board ("Board"), NYS-16/16A challenges the adequacy of Entergy's severe accident mitigation alternatives ("SAMA") analysis for Indian Point Nuclear Generating Units 2 and 3 ("IP2" and "IP3," collectively "Indian Point Energy Center" or "IPEC"). For the reasons that follow, NYS's motion should be denied.[2]

I. PRELIMINARY STATEMENT

As required by NRC regulations (10 C.F.R. Part 51), Entergy conducted a SAMA analysis for IPEC to determine if additional measures to mitigate severe accidents at the facility would be cost-effective. Consistent with regulatory guidance (NEI 05-01), Entergy performed that analysis using the MACCS2 computer code to calculate the "probability-weighted" cumulative dose and

[1] State of New York's Motion for Summary Disposition on Use of Straight Line Gaussian Air Dispersion Model for the Environmental Impact Analysis of Significant Radiological Accidents at Indian Point and NYS Contention 16/16A (Aug. 28, 2009) ("NYS Motion").

[2] This Answer is supported by the Joint Declaration of Kevin O'Kula and Grant Teagarden in Support of Entergy's Answer Opposing New York State's Motion for Summary Disposition on Contention NYS-16/16A (Sept. 18, 2009) ("Joint Declaration"). Also attached to this Answer, in accordance with 10 C.F.R. § 2.710(a), is a detailed statement of the material facts which Entergy believes are in dispute. *See* Entergy Nuclear Operations, Inc. Response to the State of New York's Statement of Material Facts Not in Dispute (Sept. 21, 2009).

economic impacts from a severe accident for a 50-mile radial region over a 30-year period. Integral to that model is the ATMOS module, which is used to predict atmospheric transport and dispersion of radionuclides released by a postulated severe accident. ATMOS, like the entire MACCS2 model, is designed to analyze scores of data points to assess risks based on *average* impacts to a 50-mile region over a 30-year period.

Although the NRC Staff reviewed and approved Entergy's SAMA analysis in its December 2008 Draft Supplemental Environmental Impact Statement ("DSEIS"), NYS suggests that the NRC Staff "admitted" that the ATMOS module is not suitable for analyzing the "complex terrain" around Indian Point, thus rendering the SAMA analysis "unreliable."[3] In light of ATMOS's supposed shortcomings, NYS contends that ATMOS *may* underestimate the cost of NYS's postulated worst-case scenario (and the corresponding benefit of unspecified mitigation measures) involving unique weather conditions directing a radiological plume to the highest-density population.[4]

Having focused on a worst-case scenario—a singular event that is incompatible with a SAMA analysis, which focuses on regional-and time-averaged impacts—NYS contends that ATMOS is not up to the SAMA task and should be replaced with air dispersion models that have been approved by the EPA for use in entirely different contexts that do *not* include SAMA analyses for nuclear plants.[5] NYS's Motion falls well short of providing the support needed to cast aside the ATMOS module and should be rejected for at least three independent reasons.

First, NYS ignores the scope of the contention as specifically admitted by the Board. In essence, NYS argues that Entergy somehow should replace ATMOS with an EPA-approved air dispersion model. That argument disregards the Board's ruling that "the issue of whether an 'EPA-

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[3] NYS Motion at 7-8, 13-14, 21.

[4] *See id.* at 9 ("The complex terrain features in the vicinity of Indian Point can result in channeling radiation from a hypothetical accident down the Hudson River and toward the largest and most concentrated population areas.")

[5] *See id.* at 23 (citing Egan Decl. ¶¶ 28-30) ("At least two readily available computer models could have been used in the SAMA analysis that would have reliably predicted air dispersion in the complex terrain of the Indian Point area.").

approved' air dispersion model must be used in the NRC Staff's analysis ... is outside the scope of NYS-16 and is also outside the scope of NYS-16-A."[6] Furthermore, because ATMOS is *integral* to the MACCS2 code, NYS's Motion constitutes a challenge to the use of MACCS2 itself—a challenge that has broad generic implications given long-standing NRC and industry acceptance of MACCS2 as an analytical tool for use in probabilistic risk assessments and SAMA analyses.

Second, NYS fails to demonstrate that modeling "variable terrain conditions" using a code other than ATMOS (assuming this were even feasible) would have a material effect on the results of the IPEC SAMA analyses (*i.e.*, result in identification of additional cost-beneficial SAMAs).[7] NYS's proffered expert, Dr. Bruce Egan, alleges that these supposed terrain conditions "could have" skewed the IPEC SAMA analysis, causing Entergy to underestimate the number of people exposed, and the magnitude of exposure, in a severe accident.[8] But he overestimates the effects varying terrain has on the IPEC SAMA analysis by ignoring the probabilistic and averaging aspects of a SAMA analysis.

Third, disputed material facts preclude disposition in NYS's favor. As demonstrated by Entergy's experts, Dr. Kevin O'Kula and Mr. Grant Teagarden, NYS's arguments lack a technical basis and are mistaken. Among other things, Entergy's experts show that: (1) ATMOS has not been "universally rejected" by the NRC and members of the relevant regulatory community; to the contrary, ATMOS remains an integral component of the state-of-the-art MACCS2 code; (2) the straight-line Gaussian plume model used in ATMOS is well suited for its intended purpose in NRC-required SAMA analyses; and (3) the EPA-approved models cited by NYS are not viable alternatives for ATMOS given the objectives of SAMA analysis and the structure of the MACCS2 code.

Accordingly, NYS's Motion should be denied.

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6 *Entergy Nuclear Operations, Inc.* (Indian Point Nuclear Generating Units 2 and 3), Order (Ruling on New York State's New and Amended Contentions) at 6 (June 16, 2009) (unpublished) ("June 16, 2009 Order").

7 NYS Motion at 13.

8 Declaration of Bruce A. Egan, Sc.D. ¶ 60 (Aug. 28, 2009) ("Egan Decl.").

II. FACTUAL BACKGROUND

A. Relevant Procedural History

1. Admission of NYS-16

This proceeding concerns Entergy's application, submitted to the NRC on April 23, 2007, to renew the operating licenses for IP2 and IP3 for 20 years beyond their current expiration dates. On November 30, 2007, NYS filed a petition to intervene in this proceeding.[9] NYS proffered NYS-16, in which it alleged that the air dispersion model used in Entergy's SAMA analyses for IP2 and IP3 "will not accurately predict the geographic dispersion of radionuclides released in a severe accident" and, therefore, "will not present an accurate estimate of the costs of human exposure."[10]

In particular, NYS-16 challenged Entergy's use of the MAACS2 code, which incorporates a straight-line Gaussian plume model, called ATMOS, to predict atmospheric transport and dispersion ("ATD") of radionuclides released by a postulated severe accident.[11] NYS claimed that ATMOS "does not account for changes in wind speed or direction during the simulation time period" or "incorporate differences in terrain that will affect the way in which the release will travel."[12] NYS further alleged that ATMOS is not as accurate as newer EPA-approved models (AERMOD, CALPUFF) used to show compliance with the Clean Air Act, and that the EPA has not authorized the use of a straight-line steady state Gaussian plume model beyond 50 kilometers (31 miles).[13]

On July 31, 2008, the Board admitted NYS-16, but identified three discrete issues for further proceedings:

> The Board *admits* NYS-16 to the extent that it challenges whether the population projections used by Entergy are underestimated. And also,

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9 *See* New York State Notice of Intention to Participate and Petition to Intervene (Nov. 30, 2007) at 163 ("NYS Petition").

10 NYS Petition at 163.

11 *Id.* at 165-66.

12 *Id.* at 166.

13 Unrelated to the specific claims made by NYS in its instant summary disposition motion, NYS also challenged Entergy's population projection for 2035, as used as an input to the IP2/IP3 SAMA analyses, on the basis that the U.S. Census estimate of the population of Manhattan in 2006 is larger than Entergy's 2035 projection.

> *within the framework of the bounding assumptions and conservative inputs used in MACCS2 SAMA analyses*, we admit NYS-16 to the extent that it challenges whether the ATMOS module in MACCS2 is being used beyond its range of validity—beyond 31 miles (50 kilometers)—and, whether use of MACCS2 with the ATMOS module leads to nonconservative geographical distribution of radioactive dose within a 50-mile radius of IPEC.[14]

2. *Admission of NYS-16A*

On December 22, 2008, the NRC Staff issued its DSEIS.[15] Thereafter, on February 27, 2009, NYS filed amended contention NYS-16A, alleging that the DSEIS "fails to address any of the issues raised" in NYS-16.[16] Drawing heavily from its original Petition, NYS asserted that the ATMOS module of MACCS2 is "flawed" and "inaccurate."[17] NYS further contended that the Staff will act in derogation of NEPA unless it prepares a SAMA analysis "based on a *remodeling* of the atmospheric dispersion of a release of radionuclides *using a more accurate EPA approved dispersion model*."[18]

On June 16, 2008, the Board admitted NYS-16A "to the degree that the Draft SEIS fails to address the issues raised by New York in NYS-16."[19] Importantly, the Board noted that NYS "will *not* be allowed to address arguments from the original NYS-16 that went beyond the limiting language of the admitted contention," and that "the issue of whether an 'EPA-approved' air dispersion model must be used in the NRC Staff's analysis . . . *is outside the scope of NYS-16 and is also outside the scope of NYS-16-A*."[20] NYS subsequently filed the instant Motion, in which it seeks summary disposition with respect to the broad issue of "whether ATMOS is a reliable air dispersion

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14 *Indian Point*, LBP-08-13, 68 NRC at 112 (emphasis added).

15 NUREG-1437, Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Supp. 38, Regarding Indian Point Nuclear Generating Unit Nos. 2 and 3, Draft Report for Comment (Dec. 22, 2008) ("DSEIS"), *available at* ADAMS Accession Nos. ML083540594, ML083540614.

16 State of New York Contentions Concerning NRC Staff's Draft Supplemental Environmental Impact Statement (Feb. 27, 2009).

17 *Id.* at 9-13.

18 *Id.* at 13 (emphasis added). As discussed below, this is ultimately the result NYS seeks via its Motion.

19 June 16, 2009 Order at 6.

20 *Id.* (emphasis added).

model for use in the MACCS2 SAMA analysis for Indian Point."[21] NYS, in effect, contends that ATMOS is not suitable for the IPEC SAMA analyses and should be replaced with an air dispersion model that has been approved by the EPA. Entergy herein opposes the NYS Motion.[22]

B. Regulatory Framework

NRC regulations in 10 C.F.R. Part 51 require, at the operating license renewal stage, that "[i]f the staff has not previously considered severe accident mitigation alternatives for the applicant's plant in an [EIS] or in an environmental assessment, a consideration of alternatives to mitigate severe accidents must be provided."[23] The NRC established this requirement despite the agency's generic finding in NUREG-1437 that "probability-weighted" consequences of impacts resulting from severe accidents would be small.[24] In reclassifying "severe accidents" as a Category 2 issue in its 1996 revisions to 10 C.F.R. Part 51, the Commission explained that:

> [T]he GEIS analysis of severe accident consequences and risk is adequate, and additional plant specific analysis of these impacts is not required. However, because the ongoing regulatory program related to severe accident mitigation (*i.e.*, IPE and IPEEE) has not been completed for all plants and consideration of severe accident mitigation alternatives has not been included in an EIS or supplemental EIS related to plant operations for all plants, a site-specific consideration of severe accident mitigation alternatives is required at license renewal for those plants for which this consideration has not been performed. The Commission expects that if these reviews identify any changes as being cost beneficial, such changes generally would be procedural and programmatic fixes,

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[21] NYS Motion at 25. In this regard, is not clear exactly what aspects of the *admitted* contention, as delimited by the Board in the "limiting language" of NYS-16/16A, NYS seeks to dismiss on summary grounds.

[22] The State served a copy of its Motion and supporting documents on Entergy counsel by mail on Friday, August 28, 2009, and served a Certificate of Service attesting to such service on August 29, 2009; service by mail thus appears to have been completed on August 29, 2009. *See* 10 C.F.R. § 2.302(c), 2.302(d)(1), and 2.305(d) and (f). The State also transmitted a copy of its Motion, Statement of Material Facts, and supporting exhibits by e-mail late on the evening of August 28, 2009, and it transmitted a certificate attesting to such service on August 31, 2009; the State's electronic service of its Motion, in its entirety, was thus complete on August 31. *See* 10 C.F.R. §§ 2.302(c), 2.302(d)(1) and 2.305(f). Accordingly, this Answer has been timely filed in accordance with 10 C.F.R. §§ 2.1205(b) and 2.306(b).

[23] 10 C.F.R. § 51.53(c)(3)(ii)(L); *Entergy Nuclear Generation Co. and Entergy Nuclear Operations, Inc.* (Pilgrim Nuclear Power Station), LBP-07-13, 66 NRC 131, 141 (2007) (petition for review pending with the Commission).

[24] *See* NUREG-1437, "Generic Environmental Impact Statement for License Renewal of Nuclear Plants," Vol. 1 (Final Report) at 5-115 (May 1996) ("GEIS").

> with any hardware changes being only minor in nature and few in number.[25]

Table B-1 in Appendix B to Part 51 implements the SAMA analysis requirement. It states:

> The *probability weighted* consequences of atmospheric releases, fallout onto open bodies of water, releases to ground water, and societal and economic impacts from severe accidents are small for all plants. *However, alternatives to mitigate severe accidents must be considered for all plants that have not considered such alternatives.*[26]

Accordingly, NRC regulations contemplate "the use of probabilistic (as opposed to deterministic) methodology."[27] SAMA analysis makes use of probabilistic safety assessment ("PSA")[28] and cost-benefit analysis techniques to identify and assess plant changes—*e.g.*, changes to hardware, procedures, or programs—that could significantly reduce the radiological risk from a severe accident by preventing substantial core damage or by limiting releases from containment in the event that substantial core damage occurs (*i.e.*, mitigating the impacts of a severe accident).[29]

The NRC and the industry have issued guidance to facilitate the preparation of SAMA analyses and the Staff's review thereof. In 2000, the NRC Staff issued Supplement 1 to Regulatory Guide 4.2 ("RG 4.2, Supp. 1"), providing guidance on the preparation of supplemental environmental

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25 Final Rule, Environmental Review for Renewal of Nuclear Power Plant Operating Licenses, 61 Fed. Reg. 28,467, 28,481 (June 5, 1996). As the Commission's 1996 GEIS-implementing amendments to Part 51 indicate, the NRC previously directed its licensees to perform an individual plant examination ("IPE") to assess plant vulnerabilities to internally initiated events, and a separate IPE for externally initiated events ("IPEEE"). As discussed in Generic Letter 88–20, "Individual Plant Examination for Severe Accident Vulnerabilities'' at 1 (Nov. 23, 1988), one of the goals this effort was to reduce the overall probabilities of core damage and fission product releases as necessary by modifying hardware and procedures to help prevent or mitigate severe accidents. In its 1996 rulemaking, the Commission stressed that plant-specific IPEs and IPEEEs "essentially constitute a broad search for severe accident mitigation alternatives." 61 Fed. Reg. at 28,481. The Commission thus observed that it is "unlikely that any site-specific consideration of severe accident mitigation alternatives for license renewal will identify major plant design changes or modifications that will prove to be cost-beneficial for reducing severe accident frequency or consequences." *Id.*

26 10 C.F.R. Part 51, Subpt. A, App. B, Table B-1 (emphasis added).

27 *Pilgrim*, LBP-07-13, 66 NRC 141. This approach in Part 51 is consistent with NRC policies concerning safety goals and risk assessment. In its Safety Goal Policy Statement, the Commission adopted the use of mean estimates for implementing the quantitative objectives of its safety goal policy. *See* Safety Goals for the Operation of Nuclear Power Plants; Policy Statement; Correction and Republication, 51 Fed. Reg. 30,028 (Aug. 21, 1986).

28 The terms PSA and PRA (probabilistic risk assessment) generally are used interchangeably within the nuclear industry. Joint Decl. ¶ 3.

29 Final Rule, Environmental Review for Renewal of Nuclear Power Plant Operating Licenses, 61 Fed. Reg. at 28,480-82; *Duke Energy Corp.* (McGuire Nuclear Station, Units 1 & 2; Catawba Nuclear Station, Units 1 & 2), CLI-02-17, 56 NRC 1, 5 (2002).

reports for license renewals, including the preparation of SAMA analyses. Since the issuance of RG 4.2 Supp. 1, the Nuclear Energy Institute ("NEI") has developed an industry template, NEI 05-01, Revision A, for completing SAMA analyses that "relies upon NUREG/BR-0184 regulatory analysis techniques, is a result of experience gained through past SAMA analyses, and incorporates insights gained from review of NRC evaluations of SAMA analyses and associated RAIs."[30] The NRC Staff has endorsed NEI 05-01, Revision A.[31]

Plant-specific PSAs are key components of an applicant's SAMA analysis.[32] NEI 05-01 instructs applicants to identify plant-specific SAMA candidates by reviewing dominant risk contributors in the Level 1 and Level 2 PSA models.[33] It further directs applicants to develop a Level 3 PSA model to "determine off-site dose and economic impacts of severe accidents based on Level 1 PSA results, Level 2 PSA results, *atmospheric transport*, mitigating actions, dose accumulation, early and latent health effects, and economic analyses."[34] NEI 05-01 indicates that the MACCS2 code may be used as an "analysis tool" to calculate the off-site consequences of a severe accident and provides guidance on the input data (*e.g.*, population, economic, nuclide release, emergency response, and meteorological data).[35]

30 NEI 05-01, Severe Accident Mitigation Alternatives Analysis, Guidance Document, Rev. A at i (Nov. 2005), *available at* ADAMS Accession No. ML060530203 ("NEI 05-01").

31 *See* Final License Renewal Interim Staff Guidance LR-ISG-2006-03: Staff Guidance for Preparing Severe Accident Mitigation Analyses' (Aug. 2007) ("LR-ISG-2006-03"). On July 31, 2009, the Staff issued a proposed revision to RG 4.2, Supp. 1, Draft Regulatory Guide DG-4015, Preparation of Environmental Reports for Nuclear Power Plant License Renewal Applications ("DG-4015"), *available at* ADAMS Accession No. ML091620409. Like LR-ISG-2006-03, the DG-4015 provides that applicants "should consider . . . the guidance provided in NEI 05-01." *Id.* at 48.

32 Joint Decl. ¶¶ 37-42. PSAs include three major phases. Level 1 PSA covers the period in time from the initiating event to the time of core damage. *Id.* ¶ 38. Level 2 PSA begins at core damage and follows the accident progression, with its output being the characterization of radioactive releases leaving containment. *Id.* ¶ 39. Level 3 PSA tracks these releases offsite and evaluates the offsite human health and environmental impacts from the releases, including emergency response (*e.g.*, evacuation). *Id.* ¶ 40..

33 NEI 05-01, at 23.

34 *Id.* at 13 (emphasis added).

35 *Id.*

C. <u>Overview of IPEC SAMA Analyses and the Role of MACCS2</u>[36]

A nuclear power plant SAMA analysis involves a cost-benefit evaluation, in which a baseline set of risks is quantified and then compared to a modified set of risks assuming a change to the plant or operating procedures is made.[37] The purpose of SAMA analysis is assist in understanding whether additional mitigative measures may be *cost-effective* for a facility, *based on regionally- and time-averaged quantities.*[38] The full SAMA evaluation is based on the numerical evaluation of severe accident risk impacts in four categories: (1) offsite radiological exposure cost, (2) offsite economic cost, (3) onsite radiological exposure cost, and (4) onsite economic cost.[39] MACCS2 provides results in terms of *offsite* population dose and *offsite* economic cost that are used to compute the offsite risk categories, *i.e.*, "PDR" and "OECR"[40]

The IP2 and IP3 SAMA analyses followed the NRC-approved guidance contained in NEI 05-01, and each evaluated a base case to provide *best-estimate* consequences for postulated events.[41] Entergy used version 1.13.1 of MACCS2 to perform Level 3 PSA models for IP2 and IP3 and calculate the offsite consequences (*i.e.*, the PDR and OECR).[42] MACCS2 is divided into three primary modules—ATMOS, EARLY, and CHRONC—and supports dispersion and transport on a radial-polar grid (16 compass sectors of 22.5° angular width and a 50-mile radius).[43] Plant-specific input to MACCS2 includes the source terms for each release category and the reactor core

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36 A more detailed discussion of the elements of a PSA and the SAMA process, the role of the MACCS2 consequence model (including ATMOS), and the IPEC SAMA analyses in particular, is provided in the Joint Declaration of Dr. O'Kula and Mr. Teagarden. *See* Joint Decl. ¶¶ 36-56; *see also* DSEIS, Section 5.2 and Appendix G.

37 Joint Decl. ¶ 36.

38 *Id.* ¶ 20, 81.

39 *Id.* ¶ 44.

40 *Id.*

41 *Id.* ¶¶ 43, 47.

42 *Id.* ¶ 46.

43 *Id.* ¶ 48.

radionuclide inventory, site-specific meteorological data, projected population distribution, emergency planning, and economic data.[44]

ATMOS performs all calculations pertaining to atmospheric transport, dispersion, and deposition of radioactive material, and to radioactive decay of that material both before and after its release into the atmosphere.[45] ATMOS calculates air and ground concentrations, plume size, and timing information for all plume segments as a function of downwind distance.[46] The results of the ATMOS calculations are stored for use by the other MACCS2 modules, EARLY and CHRONC.[47] The primary results developed and compiled by MACCS2 for use in the SAMA analysis are two values: (1) the 50-mile population dose and (2) the 50-mile economic impacts.[48] These two values represent the *mean cumulative impacts* from postulated severe accidents (*i.e.*, dose or economic costs) to all individuals and land in the 50-mile radial region occurring over a 30-year period.[49]

D. <u>The Widespread Acceptance and Use of the Straight-Line Gaussian Plume Model in ATMOS for PSA and SAMA Analyses</u>

MACCS2 and its precursor codes were developed by Sandia National Laboratory.[50] The straight-line Gaussian plume model implemented in MACCS2 by ATMOS has been an accepted analytical approach for atmospheric and transport ("ATD") analysis in the nuclear industry since nuclear plant severe accident risk analysis began over 30 years ago.[51] MACCS2 continues to be widely used for PSA and SAMA analyses in the U.S. and abroad, and for safety basis analysis in the DOE Complex.[52] ATMOS uses a straight-line Gaussian plume model in which released material is

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44 *Id.* ¶ 54.

45 *Id.* ¶ 49.

46 *Id.*

47 *Id.*

48 *Id.* ¶¶ 20, 55, 87.

49 *Id.* ¶ 20, 87.

50 *See* generally, *id.* ¶¶ 23-34.

51 *Id.* ¶¶ 21, 35, 96.

52 *Id.* ¶¶ 21, 31-34, 57, 63.

assumed to travel downwind in a straight line.[53] Large numbers of realizations (hundreds) are generally needed to perform PSA and SAMA analyses.[54] The Gaussian plume model was chosen for MACCS2 because it requires minimal computational effort and allows large numbers of realizations to be calculated.[55] In MACCS2 analyses, each weather trial is rotated through the 16 compass sectors (*i.e.*, 360 degrees) to accurately capture statistical variations associated with the population and wind direction distributions within the 50-mile analysis region.[56] Comparison of certain MACCS2 results to those generated by more advanced ATD models have shown that the Gaussian plume model used in ATMOS is acceptable for PSA-related applications such as SAMA analysis.[57]

E. <u>The Inapplicability of Other Plume Dispersion Models to SAMA Analysis</u>

MACCS2 is unique in its ability to model the many attributes of interest for reactor accident risk studies.[58] It is the only publicly available software package in the United States capable of meeting *all* of the analytical requirements of a SAMA analysis, including those tasks necessary to fully evaluate offsite consequences.[59] There are other "variable trajectory" ATD models that simulate a specific plume release event and model spatial variation of wind speed and direction in a region.[60] These models, however, are used for other regulatory purposes, such as evaluating compliance with EPA air quality standards for criteria pollutants (*e.g.*, AERMOD, CALPUFF).[61] Such models are not suitable for SAMA analysis, which requires an integrated process that evaluates a spectrum of radiological source terms and a sufficient number of weather sequences to achieve an

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53 *Id.* ¶¶ 25, 60; NYS Exh. 5 at 5.

54 *Id.* ¶¶ 58, 60; NYS Exh. 5 at 5.

55 *Id.*.

56 *Id.* ¶¶ 20, 48, 86.

57 *Id.* ¶¶ 67-75.

58 *Id.* ¶¶ 18, 20, 32, 58.

59 *Id.* ¶¶ 32, 58.

60 *Id.* ¶¶ 66, 91-94.

61 *Id.* ¶¶ 92-93.

adequate statistical basis on which to evaluate reasonable alternatives.[62] Moreover, because a user cannot elect another ATD option in MACCS2, these models are not interchangeable with ATMOS.[63]

III. CONTROLLING LEGAL STANDARDS

A. Legal Standards for Summary Disposition

The legal standards governing summary disposition of an admitted contention are set forth in Entergy's August 14, 2009 motion for summary disposition of contention NYS-8.[64] Entergy incorporates that discussion by reference here. In short, the Board may grant summary disposition when there is no genuine issue as to any material fact, such that the moving party is entitled to a decision as a matter of law.[65] The Board's resolution of a motion for summary disposition thus "requires a thorough examination of the potential *materiality* of the support offered by the Parties for their positions."[66] The determination as to materiality "is controlled by the governing law for the particular issue involved."[67] In the *Pilgrim* license renewal proceeding, the Board elaborated on the application of this standard in the specific context of a SAMA contention:

> For this Agency, as we see it, the inquiry becomes whether or not there is at issue any fact which can materially influence the determination the NRC (resting upon the technical evaluation by the Staff) must make; *i.e.*, in the case of [a contention] challenging SAMA analyses, *the determination rests on whether or not there are facts at issue which can affect whether or not a particular SAMA is cost-effective.*[68]

The governing law, as established by NEPA and the NRC regulations, is discussed further below.

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62 *Id.* ¶¶ 58, 94.

63 *Id.* ¶ 95.

64 *See* Applicant's Motion for Summary Disposition of Contention New York State Contention 8 (Electrical Transformers) at 15-17 (Aug. 14, 2009).

65 10 C.F.R. § 2.710(d)(2); *Carolina Power & Light Co.* (Shearon Harris Nuclear Power Plant), CLI-01-11, 53 NRC 370, 384 (2001).

66 *Pilgrim*, LBP-07-13, 66 NRC at 141 (emphasis added).

67 *Id.* at 140.

68 *Id.* (emphasis added).

B. Controlling NEPA Principles As Applicable to SAMA Analysis

As indicated above, SAMA analysis is mandated by 10 C.F.R. Part 51—the NRC's NEPA-implementing regulations—and thus is a NEPA-derived requirement. Accordingly, consideration of mitigation alternatives is governed by the NEPA "rule of reason." Under that standard, an EIS need contain only a "reasonably thorough discussion of the significant aspects of the *probable* environmental consequences" of a proposed action.[69]

In *Methow Valley*, the U.S. Supreme Court held that NEPA requires a "reasonably complete discussion of possible mitigation measures," but that there is no "substantive requirement that a complete mitigation plan be actually formulated and adopted."[70] As the *Methow Valley* Court further explained, NEPA is intended to "generate information and discussion on those consequences of greatest concern to the public and of greatest relevance to the agency's decision, rather than distorting the decisionmaking process by overemphasizing highly speculative harms."[71] As such, an agency need not consider wholly speculative impacts, even where the consequences could be severe.

The Commission has adhered closely to the principles of *Methow Valley* in NRC adjudicatory proceedings.[72] "Under NEPA, mitigation (and the SAMA issue is one of mitigation) need only be discussed in 'sufficient detail to ensure that environmental consequences [of the proposed project] have been fairly evaluated.'"[73] SAMA analyses, in other words, must be "bounded

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69 *Biological Diversity v. U.S. Forest Serv.*, 349 F.3d 1157, 1166 (9th Cir. 2003) (emphasis added).

70 *See Robertson v. Methow Valley Citizens Council*, 490 U.S. 332, 352 (1989). *See also Laguna Greenbelt, Inc. v. U.S. Dep't of Transp.*, 42 F.3d 517, 528 (9th Cir. 1994) ("NEPA does not require a fully developed plan that will mitigate all environmental harm before an agency can act; NEPA requires only that mitigation be discussed in sufficient detail to ensure that environmental consequences have been fully evaluated.") (citations omitted).

71 *Methow Valley*, 490 U.S. at 356.

72 *See, e.g.*, *Hydro Res., Inc*, (P.O. Box 777, Crownpoint, , N.M., LBP-04-23, 60 NRC 441, 447 (2004) (stating that the "'hard look' at environmental consequences mandated by NEPA is subject to a 'rule of reason,' meaning that the assessment need not include every environmental effect that could potentially result from the action, but rather may be limited to effects which are shown to have some likelihood of occurring."); *Private Fuel Storage* (Independent Spent Fuel Storage Installation), CLI-02-25, 56 NRC 340, 354 (2002) (rejecting consideration of worst-case scenarios because their consideration involves "the arduous and unproductive task of analyzing conceivable, but very speculative catastrophes" and diverts the agency's "limited resources" from more productive efforts).

73 *Duke Energy Corp.* (McGuire Nuclear Station, Units 1 and 2; Catawba Nuclear Station, Units 1 and 2), CLI-03-17, 58 NRC 419, 431(2003) (quoting *Methow*, 490 U.S. at 352).

by some notion of feasibility."[74] Therefore, while "any number of possible SAMAs may be theoretically conceivable, . . . many will prove far too costly compared to the reduction in risk that they might provide."[75] The Commission recently reiterated this crucial point:

> NRC adjudicatory hearings are not "EIS editing sessions." *The ultimate concern here is whether any additional SAMA should have been identified as potentially cost-beneficial*, not whether further analysis may refine the details in the SAMA NEPA analysis.[76]

Although NEPA requires that an EIS contain reasoned scientific explanations that are based on complete and accurate information, federal agencies have the discretion to determine how this mandate is met."[77] An agency "is entrusted with the responsibility of considering the various modes of scientific evaluation and theory and choosing the one appropriate for the given circumstances."[78] "The requisite 'hard look' does not require adherence to a particular analytic protocol."[79] Nor does it require that "the 'state of the art' of a scientific discipline be explicitly discussed in an EIS," particularly where such discussion would not enhance the agency's evaluation.[80] Rather, "[t]he specific methodology appropriate in a given circumstance will depend on the variable factors peculiar to that case."[81] Courts generally will not "second-guess" methodological choices made by an agency in its area of expertise.[82]

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74 *McGuire*, CLI-02-17, 56 NRC at 12 (quoting *Vermont Yankee Nuclear Power Corp. v. Natural Resources Defense Council, Inc.*, 435 U.S. 519, 551 (1978) (applying NEPA's rule of reason and rejecting proposed SAMA contention for failure to provide "any notion of cost").

75 *McGuire*, CLI-02-17, 56 NRC at 12.

76 *Entergy Nuclear Generation Co. and Entergy Nuclear Operations, Inc.* (Pilgrim Nuclear Power Station), CLI-09-11, 69 NRC __, slip op. at 6-7 (June 4, 2009).

77 *Sierra Club v. U.S. Dep't of Transp.*, 753 F.2d 120, 128 (D.C. Cir. 1985) (citing *Ethyl Corp. v. EPA*, 541 F.2d 1, 12 & n. 16 (D.C. Cir.), *cert. denied*, 426 U.S. 941 (1976)).

78 *Id.* at 129.

79 *Ass'n of Pub. Agency Customers, Inc. v. Bonneville Power Admin.*, 126 F.3d 1158, 1188 (9th Cir. 1997).

80 *Nat'l Indian Youth Council v. Andrus*, 501 F. Supp. 649, 668 (D.N.M. 1980) (citing 42 U.S.C. § 4332(2)(C)).

81 *Bonneville Power Admin.*, 126 F.3d at 1188. The Commission emphasized this point when it decided to require SAMA analysis as part of the 1996 Part 51 rulemaking. Specifically, it stated that it "does not intend to prescribe by rule the scope of an acceptable consideration of severe accident mitigation alternatives for license renewal nor does it intend to mandate consideration of alternatives identical to those evaluated previously." Final Rule, Environmental Review for Renewal of Nuclear Power Plant Operating Licenses, 61 Fed. Reg. at 28,481. The Commission noted that it "will review each severe accident mitigation consideration provided by a license renewal applicant on its

IV. ARGUMENT

A. NYS Seeks Relief That is Beyond the Scope of the Admitted Contention

NYS's objective is to compel Entergy and/or the Staff to undertake new SAMA analyses that deploy an EPA-approved, "variable trajectory" plume dispersion model in place of ATMOS. NYS's own statements evince this fact. For example, NYS states:

> What is clear is that Staff *cannot* do [a reliable SAMA analysis] for Indian Point by relying on the outdated and unreliable ATMOS model which cannot accommodate the complex terrain conditions at Indian Point which dominate the air flow patterns in this area.[83]

NYS further states that "[a]t least two readily available computer models could have been used in the SAMA analysis that would have reliably predicted air dispersion in the complex terrain of the Indian Point area."[84] Those two models are the EPA-approved AERMOD and CALPUFF models cited by NYS in its November 2007 Petition and by Dr. Egan in his original supporting declaration. In other words, the upshot of granting NYS's Motion would be the need for all new SAMA analyses deploying an EPA-approved plume dispersion model.

The relief sought by NYS, however, goes beyond the scope of the admitted contention. The Board admitted NYS-16 "within the framework of the bounding assumptions and conservative inputs used *in MACCS2 SAMA analyses*."[85] Furthermore, in admitting NYS-16A, the Board underscored the "limiting language" of the admitted contention and stated unequivocally that "the issue of

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merits and determine whether it constitutes a *reasonable* consideration of severe accident mitigation alternatives." (emphasis added). *Id.* at 28,481-82.

82 *See Marsh v. Oregon Natural Resources Council*, 490 U.S. 360, 376, 378 (1989) ("When specialists express conflicting views, an agency must have discretion to rely on the reasonable opinions of its own experts even if, ... a court may find contrary views more persuasive."); *Browning-Ferris Indus., Inc. v. Muszynski*, 899 F.2d 151, 160 (2d Cir. 1990) ("Courts should be particularly reluctant to second-guess agency choices involving scientific disputes that are in the agency's province of expertise."). *See also Salmon River Concerned Citizens v. Robertson*, 32 F.3d 1346, 1359 (9th Cir. 1994) (citation omitted) "NEPA does not require [that we] to decide whether an [EIS] is based on the best scientific methodology available, nor does NEPA require us to resolve disagreements among various scientists as to methodology"); City *of Carmel-By-The-Sea v. U.S. Dep't of Transportation*, 123 F.3d 1142, 1151 (9th Cir. 1997) (stating that NEPA does not require "unanimity of opinion, expert or otherwise").

83 NYS Motion at 24 (emphasis added).

84 *Id.* at 23.

85 *Indian Point*, LBP-08-13, 68 NRC at 112, 118 (emphasis added).

whether an 'EPA-approved' air dispersion model must be used in the NRC Staff's analysis ... is outside the scope of NYS-16 and is also outside the scope of NYS-16-A."[86] Accordingly, as a threshold legal matter, the Motion should be dismissed because the relief sought is not cognizable under the express terms of the admitted contention.[87]

B. NYS Fails to Show That Modeling "Variable Terrain Conditions" With A Different Plume Dispersion Code Will Materially Affect the Results of the IPEC SAMA Analyses

NYS's Motion also should be dismissed because it fails to address the "ultimate concern" posed by any admitted SAMA contention; *i.e.*, "whether any additional SAMA should have been identified as potentially cost-beneficial."[88] NYS has not shown that using an EPA-approved dispersion model would result in the identification of additional cost-beneficial SAMAs. Indeed, NYS and its expert demonstrate little, if any, understanding of how ATMOS performs its intended function, or how the results it provides are used in the broader context of a probabilistic SAMA analysis.[89] Indeed, with respect to this critical issue, Dr. Egan states only that:

> Because of these [alleged] deficiencies [in ATMOS], and because of the wide variations in population density within the 50 mile radius, the DSEIS's SAMA analysis *could have* grossly underestimated the number of people who would be exposed in a severe accident and the concentration of the doses they would receive. This would, in turn, underestimate the "cost" of a severe accident and thus the "benefit" of a proposed mitigation measure that would reduce the magnitude of the

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86 June 16, 2009 Order at 6.

87 NYS attempts to avoid this result by stating that the issue of "whether a new SAMA analysis for Indian Point using an appropriate model" must be performed is not "ripe for resolution at this time." NYS Motion at 8 n.3. NYS ascribes this lack of "ripeness" to the alleged failure of the NRC Staff to meet its discovery-related obligations relative to Contention NYS-16/16A. NYS alleges that the Staff "has turned over little discovery on this issue" and states that "[t]he full MACCS2 code has not been produced." *Id.* This argument is a red herring, insofar as NYS and its expert plainly assert any SAMA analysis performed using the ATMOS module—as opposed to the EPA-approved AERMOD or CALPUFF codes—is "unreliable." NYS Motion at 1, 8-9, 13, 21-22, 24; Egan Decl. ¶¶ 35, 37, 60.

88 *Pilgrim*, CLI-09-11, 69 NRC __, slip op. at 6-7.

89 NYS states that Dr. Egan "has extensive experience with the use of both the Gaussian plume model and more sophisticated models." NYS Motion at 7. However, neither Dr. Egan's declaration nor his resume suggests that he has significant (if any) experience using MACCS (including ATMOS) or performing SAMA analyses. In contrast, Dr. O'Kula has over 20 years of experience using the MACCS and MACCS2 computer codes and has taught MACCS2 training courses for the Department of Energy ("DOE") at Lawrence Livermore National Laboratory, Los Alamos National Laboratory, Idaho National Laboratory, the DOE Safety Basis Academy at Sandia National Laboratories ("Sandia"), and at DOE EFCOG Safety Analysis Workshops. Mr. Teagarden is Manager for Consequence Analysis for ERIN Engineering & Research, Inc. and also has substantial experience using MACCS2 and developing MACC2S models for commercial nuclear power plants in the United States. Joint Decl. ¶¶ 6, 14.

> initial release of the radiation from the plant or reduce the probability of the release occurring, or both.[90]

Such vague assertions, even if made by an alleged expert, are insufficient to support resolution of Contention NYS-16/16A in favor of NYS.[91]

As Entergy's experts explain, even specific worst-case weather conditions for a single type of release do not necessarily change a single consequence outcome with respect to a certain direction and for long-range distances.[92] Mitigating factors would tend to reduce the level of consequence.[93] For example, a radiological plume traveling in the direction of the highest population density would be subject to depletion by radioactive decay and dry deposition.[94] Further, wind direction persistence is not likely for the travel time needed before the front edge of the plume would arrive.[95]

More to the point, if a numerical change were to occur (*e.g.*, population dose change), then it would need to be *weighted by the frequency of time* that the worst-case meteorological condition occurs and for the direction chosen.[96] In the context of a *SAMA* analysis, the singular worst-case meteorological event in the worst high-population direction tends to be statistically negligible.[97]

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90 Egan Decl. ¶ 60 (emphasis added).

91 Notably, in the *Pilgrim* license renewal proceeding, the Board rejected a similarly vague and unsupported assertion by Dr. Egan in granting summary disposition of another SAMA contention:

> We note that for a fact to be material with regard to the SAMA analysis, it must be a fact which can reasonably be expected to impact the Staff's conclusion that any particular mitigation alternative may (or may not) be cost-effective. Mr. Egan's vague conclusory statement that the approach used in MACCS2 to modeling changing and uncertain meteorological patterns has caused the Applicant to draw *incorrect* cost-benefit conclusions fails entirely to address whether the errors he suggests are present would (or even could) cause the results to be less conservative or, in fact, to be nonconservative.

Pilgrim, LBP-07-13, 66 NRC at 152 n.22.

92 Joint Decl. ¶ 88

93 *Id.* ¶ 89.

94 *Id.*

95 *Id.* ATMOS takes these meteorological phenomena into account. Using meteorological data for wind speed, wind direction, atmospheric stability, accumulated precipitation, and atmospheric mixing heights, "ATMOS calculates air and ground concentrations, plume size, and timing information for all plume segments as a function of downwind distance." *Id.* ¶¶ 49, 54.

96 *Id.* ¶ 88.

97 *Id.*

Singular efforts, such as looking at worst-case conditions and resulting consequences (*e.g.*, a single high early release for one weather sequence in which the wind is directed towards a high population center) are not the appropriate point of reference in a SAMA study, which, consistent with NRC regulations, focuses on "probability-weighted" consequences.[98] Entergy's experts have thoroughly rebutted Dr. Egan's claim that the IPEC SAMA analyses "grossly underestimate" offsite radiological doses. Indeed, NYS essentially concedes that it has not shown that "any additional SAMA should have been identified as potentially cost-beneficial."[99]

C. Material Factual Disputes Regarding the Acceptability of the ATMOS Module for SAMA Analysis Plainly Defeat NYS's Motion for Summary Disposition

Summary disposition of admitted contentions is warranted for "those contentions that . . . are shown by undisputed facts to have nothing to commend them."[100] In their Joint Declaration, Dr. O'Kula and Mr. Teagarden fully controvert purportedly "undisputed" facts alleged by NYS and Dr. Egan. Therefore, summary disposition in favor of NYS is not warranted.

1. *Use of ATMOS or the Straight-Line Gaussian Plume Dispersion Model Has Not Been "Universally Rejected" by the Relevant Regulatory and Scientific Communities*

One of NYS's principal arguments, and a recurring theme in its Motion, is the notion that ATMOS, a straight-line Gaussian plume dispersion model, is "outdated" and "inherently unreliable."[101] This argument is spurious. As Entergy's experts explain, "[t]he straight-line Gaussian plume model implemented in MACCS2 by ATMOS has been an accepted analytical approach for ATD analyses in the nuclear industry since nuclear plant severe accident probabilistic risk analyses

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[98] *Id.* at ¶ 59 (citing 10 C.F.R. Part 51, Subpt. A, App. B, Table B-1).

[99] Specifically, in footnote 3 of its Motion, NYS states that "[o]nly when the full MACCS2 discovery is completed and analyzed by the State will the State be able to fully address the issue identified by the Commission in *Pilgrim*." NYS further states that this future "analysis may present *factual issues which must be resolved at the hearing*." NYS Motion at 8 n.3 (emphasis added). Regardless, Entergy's experts have rigorously rebutted NYS's claim that "there is already strong evidence" that the deficiencies in ATMOS alleged by NYS can "have a substantial impact on the calculated population at risk and the total exposure." *Id.*

[100] *Private Fuel Storage, L.L.C.* (Independent Spent Fuel Storage Installation), LBP-01-39, 54 NRC 497, 509 (2001)

[101] NYS Motion at 13, 24; Egan Decl. ¶¶ 37, 60.

began over 30 years ago."[102] In fact, MACCS2, of which ATMOS is an integral component, has been used by nearly all nuclear power plants in the U.S. to support PSAs and, more recently, SAMA analyses performed as part of license renewal.[103] It continues to be used extensively both in the United States and abroad for nuclear reactor and non-reactor safety analyses.[104] It is more accurate to say that, for purposes of the probabilistic safety analyses that underpin a SAMA evaluation, MACCS2 has been "universally accepted"—*not* "universally rejected" as NYS incorrectly claims.

NYS's related claim that the NRC—the principal sponsor of MACCS2—has "admitted" that "a model like ATMOS is unsuitable for the complex terrain at Indian Point" is groundless.[105] NYS relies, in principal part, on a single slide presentation presented by an NRC Staff member during a training workshop held during the April 2009 National Radiological Emergency Planning Conference.[106] It claims that this presentation is a "concession by NRC that a model like ATMOS is unsuitable for the complex terrain at Indian Point."[107]

The cited presentation was given by an NRC Staff member (Stephen F. LaVie, Senior Emergency Preparedness Specialist) as part of a "training workshop" on radiological dose assessment for personnel in the field of emergency planning. Although the presentation slides discuss various ATD models (including the Gaussian model and "advanced diffusion models)" and "terrain and building impacts" on modeling results, they do so in the context of *radiological dose*

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102 Joint Decl. ¶¶ 21.

103 *Id.* ¶¶ 57, 63. MACCS2 development efforts sponsored by the DOE and NRC continue to this day, as evidenced by the recent release of WinMACCS, a Windows-based interface and framework for performing consequence analyses. Joint Decl. ¶ 33. The new WinMACCS version of the MACCS2 code was sponsored by the NRC for use in its ongoing SOARCA project. *Id.* ¶¶ 9. WinMACCS maintains use of the straight-line Gaussian plume-based model used in the ATMOS module of MACCS2 and, thus, is clear evidence that the relevant regulatory and scientific communities do not view the ATMOS module as "antiquated and unreliable." *Id.* ¶¶ 34, 63.

104 *Id.* ¶ 63.

105 NYS Motion at 7, 14.

106 NYS Exh. 4, Stephen F. LaVie, Senior Emergency Preparedness Specialist, United States Nuclear Regulatory Commission, Power Point Presentation: What's in the Black Box Known as Emergency Dose Assessment?, prepared for the 2009 National Radiological Emergency Planning Conference Dose Assessment Workshop, Part 2, Dispersion, available at ADAMS Accession No. ML091050257.

107 NYS Motion at 14.

assessment for emergency planning.[108] As Dr. O'Kula and Mr. Teagarden confirm, the presentation has "no relevance" to the use of the Gaussian plume model in SAMA cost-benefit applications."[109] Codes used for emergency planning purposes tend to focus on evaluation of a single release and its specific dispersion path for use in emergency planning decision making (*e.g.*, whether to evacuate a particular downwind population group).[110] SAMA analysis, in contrast, seeks to obtain "reasonable estimates of regionally-weighted consequences, such as population doses and economic costs."[111]

NYS's discussion of various other NRC/DOE documents and engineering texts (*see* NYS Exhibits 6-13) is similarly irrelevant and lends no support to the Motion.[112] The referenced documents do not indicate that there is scientific "consensus" that ATMOS is unsuitable for use in SAMA analyses.[113] In discussing most of these documents, Dr. Egan focuses on the ability of the straight-line Gaussian plume model to accommodate spatial and temporal variations *for purposes other than SAMA analysis*.[114] NYS's discussion of Regulatory Guide ("RG") 1.23 (Rev. 1, Mar. 2007) is illustrative. The portion of RG 1.23 on which NYS focuses (Section 7, "Special Considerations for Complex Terrain Sites") pertains to the implications of complex terrain for *protective action recommendations within the plume exposure emergency planning zone*.[115] However, it has no relevance to the use of MACCS2/ATMOS for SAMA cost-benefit applications.[116]

Similarly, Dr. Egan's reliance on the DOE document, *MACCS2 Computer Code, Application Guidance for Documented Safety Analysis* (NYS Exh. 10) also is misplaced. That document is a guidance document that points out features, strengths, and limitations of the straight-line Gaussian

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108 Joint Decl. ¶ 65.

109 *Id.*

110 *Id.* ¶ 66.

111 *Id.* ¶ 71.

112 *Id.* ¶ 76.

113 *Id.*

114 *Id.*

115 *Id.*

116 *Id.*

plume model as it applies to DOE safety basis dose calculations.[117] The DOE safety basis analysis is concerned with the dose to a single individual at a particular location, making the results more sensitive to the potential impacts of terrain variation than in a SAMA analysis.[118] Nonetheless, DOE endorses use of the Gaussian plume model for individual dose calculations.[119] In contrast, population or area-specific doses (rather than the dose to a specific individual) and offsite economic cost for the 50-mile analysis region are the metrics of interest in a SAMA analysis.[120]

2. *MACCS2 and ATMOS Are Well Suited for Their Intended Uses, Including Their Use in PSAs and PSA-Based SAMA Analyses*

Contrary to NYS's claim, MACCS2 continues to be widely used for nuclear reactor and nonreactor nuclear safety analysis, chiefly to support PSAs and cost-benefit studies (including SAMA analyses).[121] As noted above, this is due, in large part, to the computational efficiency of ATMOS, which lends itself to the statistical analysis required for severe accident risk.[122] MACCS2

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117 *Id.* ¶¶ 77-80.

118 *Id.* ¶¶ 79-80.

119 *Id.* ¶ 78 (citing DOE Standard DOE-STD-3009-94, Appendix A).

120 *Id.* ¶ 80.

121 *Id.* ¶ 57.

122 *Id.* ¶¶ 21, 58. One of NYS's exhibits (Exh. 5) underscores this important point. As stated therein:

> MACCS2 is the latest in a series of NRC-sponsored codes for estimating off-site consequences following a release of radioactive material into the environment.
>
> . . . .
>
> The atmospheric models in MACCS2 are relatively simple. Released material is assumed to travel downwind in a straight line. The concentration profiles in the crosswind and vertical dimensions are approximated as being Gaussian. *The Gaussian plume model was chosen for MACCS2 because it requires minimal computational effort and allows large numbers of realizations to be calculated.* These realizations represent uncertainty in weather data at the time of a hypothetical accident and uncertainty in other input parameters to represent degree of belief. *Large numbers of realizations (hundreds) are generally needed to perform PRA and sensitivity studies.*

Id. ¶ 60; NYS Exh. 5, NUREG/CR-6853, "Comparison of Average, Transport and Dispersion, Among a Gaussian, a Two-Dimensional, and a Three-Dimensional Model" United States Nuclear Regulatory Commission/Lawrence Livermore National Laboratory at 5 (Oct. 2004) (emphasis added), *available at* ADAMS Accession No. ML043240034.

is unique in its capability to perform the full suite of analytical tasks required by SAMA analysis in an integrated and efficient manner.[123]

In particular, "[a]n NRC-compliant SAMA analysis requires an integrated process that evaluates a spectrum of radiological source terms and a sufficient number of weather sequences to achieve an adequate statistical basis on which to evaluate reasonable alternatives."[124] Each simulation requires seven distinct steps.[125] After a specific source term is fully analyzed and the associated consequences are assessed at the mean, or average, level, another source term must be processed until the full set of accident release source terms is analyzed.[126] MACCS2, with its Gaussian plume model ATMOS, can meet the computational demands of calculating many kinds of consequence results, with the appropriate level of statistical sampling.[127]

Notably, MACCS2 has fared well when compared to more complex ATD models over regions of transport similar to the 50-mile region used for the IPEC SAMA analyses.[128] While long-distance and terrain- responsive models may provide more accurate projections of plume concentration and population dose at a given location, any such advantage is offset by increased data

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123 Joint Decl. ¶¶ 18, 20, 32, 58.

124 *Id.* ¶ 58.

125 *Id.* The seven required steps include: (1) characterizing and analyzing postulated, short-duration (tens of minutes to several hours) radiological releases; (2) modeling atmospheric transport and dispersion behavior of a radiological plume; (3) addressing radiological decay and other radioactivity characteristics that are radionuclide-specific and generally different from those of air toxics and particulate species; (4) implementing appropriate International Commission on Radiological Protection ("ICRP") or Federal Guidance Report ("FGR") metabolic and dosimetric models with associated data files such as dose conversion factors; (5) estimating economic and population dose consequences for short-term (hours to days) and long-term conditions (years); (6) performing a statistic sampling of consequence levels for mean (average), median, and other percentiles results, given uncertainties introduced by meteorology in a region; and (7) evaluating consequence changes with and without the effect of countermeasures (sheltering, evacuation, interdiction). *Id.*

126 *Id.*

127 *Id.* ¶ 59. In typical SAMA analyses more than 100 simulations are run of multiple source terms to be representative of the nuclear power plant in severe accident conditions, and to develop adequate statistics for SAMA purposes. *Id.* ¶ 58. The use of other specific-purpose air dispersion codes that invoked multiple-station data to model spatial variation of wind speed and direction, like the AERMOD and CALPUFF models advocated by Dr. Egan, is impractical in the context of a SAMA analysis, given the statistical sampling requirements and the amount of input data necessary to fully account for off-site exposure and economic costs. *Id.* ¶ 61.

128 *See* Joint Decl. ¶¶ 67-75.

demands, model/data uncertainty, and additional pre- and post-processing resource demands.[129] Dr. O'Kula and Mr. Teagarden discuss several key studies, and conclude that they demonstrate the fitness of the MACCS, with its straight-line Gaussian plume model, in providing reasonable estimates of regionally-weighted consequences (*e.g.*, population doses and economic costs).[130] They specifically refute Dr. Egan's mischaracterization of the 2004 Mollenkamp study, noting that the results of that study show reasonably good agreement between the one-dimensional (Gaussian) MACCS2 model and the three-dimensional (LODI) model.[131] This is particularly the case when "a risk metric is an area-weighted, time-integrated, and a long-range quantity, such as population dose or economic impact (the two metrics used in a SAMA analysis)."[132]

Thus, NYS's claim that MACCS2 or ATMOS has been rejected as "scientifically unreliable" has no basis in fact. Indeed, another Board recently reached the opposite conclusion, finding that MACCS2 provides an accepted, uniform approach to conducting SAMA analyses:

> [I]t is necessary for the Staff to take a uniform approach to its review of such analyses by license applicants and for performance of its own analyses, and it would be imprudent for the Staff to do otherwise without sound technical justification. Where, as here, these analyses are customarily prepared using the MACCS2 code, an*d where this code has been widely used and accepted as an appropriate tool in a large number of similar instances*, the Staff is fully justified in finding, after due consideration of the manner in which the code has been used, that analysis using this code is an acceptable method for performance of SAMA analysis.[133]

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129 *Id.* ¶ 67.

130 *Id.* ¶¶ 68-71.

131 *Id.* ¶¶ 72-74

132 *Id.* ¶ 75.

133 *Pilgrim*, LBP-07-13, 66 NRC at 142 (emphasis added).

3. *NYS Overstates, Without Any Technical or Factual Basis, the Alleged Effects of Large Populations and "Complex Terrain"*

NYS also fails to establish that (1) population size/distribution and (2) allegedly "complex terrain" in the vicinity of IPEC are likely to have a material effect on the outcome of IPEC SAMA analyses. With regard to the former, NYS states that "[b]ecause the population surrounding Indian Point is extremely large and because that population is not evenly distributed around the site, the direction of air dispersion from the site in the event of a severe accident can make a substantial difference in the number of people exposed and the total level of exposure."[134]

As Entergy's experts explain, however, many U.S. nuclear power plants have substantial populations in the 50-mile region analyzed for the purpose of SAMA, and nearly all nuclear plant sites would be characterized as having variations in population concentrations in this 50-mile analysis region.[135] They further explain that Dr. Egan has overstated the effects of "variations" in population on the outcome of the IPEC SAMA analyses given the probabilistic approach used in those analyses.[136] Using MACCS2, the IPEC SAMA analyses examined combinations of *representative* source terms, weather sequences, and exposed populations.[137] The weather sequences were separated by MACCS2 into 40 bins, which were then statistically sampled by MACCS2 to account for different meteorological conditions that might exist at the time of a release.[138] To address population and wind direction variations, each set of modeling results was rotated around the

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134 NYS Motion at 11.

135 Joint Decl. ¶¶ 20, 83.

136 Joint Decl. ¶¶ 85-87.

137 *Id.* ¶ 85.

138 *Id.* ¶¶ 52, 86. Because MACCS2 assesses the wind direction at each hourly interval as input, a typical MACCS2 data set is representative of the full spectrum of wind directions over an entire year. *Id.* ¶ 54. Thus, use of a full year of data accounts for seasonal and diurnal variations in weather conditions. *Id.* Also, in the case of IPEC, the annual data file was compiled by averaging five years of weather data to ensure that the data was representative over the long term. *Id.* The IPEC meteorological file contains actual site-specific weather data at hourly intervals for a full year (8760 hours of data), including wind speed, wind direction, atmospheric stability, and precipitation data. *Id.* These meteorological data were developed from on-site data sources. *Id.* Regional mixing height data were obtained from National Weather Service data stations. *Id.* Any allegation by NYS that the IPEC meteorological monitoring program is somehow inadequate for SAMA or other purposes is beyond the scope of this license renewal proceeding, as it is a current licensing basis issue.

16 compass directions and weighted by the wind rose probability to give a distribution of results for a specific source term.[139] The individual results were then statistically processed by MACCS2 to present mean results for population dose and cost for use in the SAMA analyses.[140] Thus, as the *Pilgrim* Board observed, "the effects of variations in wind speed and direction, meteorological patterns, and plume shape are fully encompassed by the stochastic/statistical methods used in the SAMA analysis."[141]

Dr. O'Kula and Mr. Teagarden also conclude, for similar reasons, that NYS has overstated the alleged effects of terrain variations on the IPEC SAMA analyses.[142] NYS and Dr. Egan contend that "[t]he terrain surrounding Indian Point is *complex* and creates *unique* variations in the movement of air" in the vicinity of the IPEC site and 50-mile analysis region, such as the "channeling [of] radiation from a hypothetical accident down the Hudson River and toward the largest and most concentrated population areas." In describing the terrain near IPEC as "complex," they cite the EPA definition of "complex terrain"—*i.e.*, "terrain exceeding the height of the stack being modeled."[143] NYS further notes that IPEC is located within two miles of mountains and bluffs ranging from 800 to over 1,000 feet in elevation; the site is located adjacent to a large river that may influence on air flow and dispersion of releases from the site; and the river is in a valley with steep sides.[144]

In response to NYS's claim of "unique" terrain-induced variations, Entergy's experts observe that applying the EPA definition of "complex terrain" cited by NYS, many, if not most, nuclear power plants would be classified as having complex terrain, especially when a moderate release

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[139] Joint Decl. ¶¶ 52, 86..

[140] *Id.*

[141] *Pilgrim*, LBP-07-13, 66 NRC at 146.

[142] Joint Decl. ¶¶ 20, 87.

[143] Egan Decl. ¶ 33; *see also* NYS Motion at 11 (citing 40 C.F.R. Part 51, Appendix W, § 4.1(b) and defining "complex terrain" as "any place where the area around the plant is higher than the top of the point from which the release will occur").

[144] NYS Motion at 12; Egan Decl. ¶¶ 31-34, 38-42.

height (*e.g.*, 30 meters) is considered.[145] More fundamentally, NYS provides no justification for applying the EPA definition of "complex terrain" (which is intended for different regulatory purposes) to a SAMA analysis that focuses on regionally- and time-averaged quantities.[146] Entergy's experts judge the terrain "variations" cited by Dr. Egan to have minimal impact on the IPEC SAMA analysis results (*e.g.*, no significant change to the 50-mile mean dose MACCS2 output value) given the large area analyzed, the use of a statistical analytical approach involving over 100 weather sequences, the rotation of the postulated releases through all 16 sectors to address population variation, and the use of cumulative regional mean values.[147]

4. *The "Variable Trajectory" Models Cited by NYS Are Not Viable Alternatives to ATMOS Given the Specific Purpose and Requirements of SAMA Analysis*

NYS erroneously claims that "[a]t least two readily available computer models [*i.e.*, AERMOD and CALPUFF] could have been used in the SAMA analysis that would have reliably predicted air dispersion in the complex terrain of the Indian Point area."[148] First, the AERMOD and CALPUFF models cited by NYS cannot perform the full suite of analytical tasks performed by MACCS2, which uses non-dispersion models (*e.g.*, economic impact) in addition to ATMOS to objectively support cost-benefit decision-making on potential plant modifications.[149] Indeed, AERMOD and CALPUFF are EPA-approved air quality models used for evaluating specific types of pollutants under the Clear Air Act.[150] Neither code has regulatory acceptance for PSA and SAMA

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145 *Id.* ¶¶ 20, 83-84. In SAMA analyses, releases are generally modeled to occur at a specific height somewhere between ground level (*i.e.*, postulated failure low in the containment) to the top of the reactor containment (i.e., postulated failure near the top of containment). *Id.* ¶ 84. NRC-approved guidance (NEI 05-01) suggests the use of a distance of approximately one half containment height. *Id.* The IPEC analyses followed this guidance and used a release height of 30 meters. *Id.*

146 *Id.* at ¶¶ 81-82, 85-87, 96.

147 Joint Decl. ¶ 87. The 50-mile radial region for which mean cumulative impacts (*i.e.*, dose or cost) to all individuals and land are probabilistically-estimated is a significant land analysis area of approximately 7,850 square miles (an area larger than the State of Connecticut). *Id.*

148 NYS Motion at 23.

149 Joint Decl. ¶ 94.

150 *Id.* ¶¶ 92-93.

analysis applications.[151] The EPA models were designed to meet different regulatory objectives (*i.e.*, not those of SAMA analysis), a fact NYS and its expert either fail to recognize or ignore. They have not supplanted the straight-line Gaussian plume approach for probabilistic assessments of severe accident risks.

Second, the ATMOS module of the MACCS2 code is not "interchangeable" with other ATD models, including AERMOD or CALPUFF.[152] The user cannot elect another ATD option in MACCS2.[153] A modification of this magnitude would involve major revisions to the MACCS2 code itself (*e.g.*, via FORTRAN programming changes), which Dr. Egan and Mr. Teagarden note is neither necessary nor feasible in the near term.[154] Furthermore, ATMOS already provides an established, accepted, and understood basis for conducting PSA studies and SAMA analyses.[155]

V. CONCLUSION

For the above reasons, the NYS Motion should be dismissed, particularly in view of the controlling NEPA and Part 51 principles set forth above. NYS has not met its legal burden in multiple respects. As a threshold matter, NYS ultimately argues that an EPA-approved air dispersion model must be used in the NRC Staff's analysis—an argument that the Board expressly excluded as outside the scope of NYS-16/16A.

In addition, NYS has failed to demonstrate that the use of an alternative dispersion model is even feasible or likely to yield materially different results within the *relevant* context of an NRC-required SAMA analysis. Entergy and the Staff have performed a "reasonable consideration of

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151 *Id.* ¶ 93.

152 *Id.* ¶ 95.

153 *Id.*

154 *Id.* Also, given that many sites would have "complex terrain" as defined by NYS in the 50-mile SAMA analysis region—such modifications, even if assumed to be necessary, would be a generic industry and NRC regulatory issue—not an IPEC-specific issue.

155 *Id.*

severe accident mitigation alternatives" using established analytical methods and tools. That is all that NEPA and NRC regulations require.

Finally, Entergy's experts have demonstrated that ATMOS is a proven, time-tested tool for use in SAMA analyses. NYS has provided no valid reason to conclude that MACCS2 (including ATMOS) is "scientifically unreliable" for its intended purposes, or to "second-guess" the NRC's acceptance of MACCS2 as an appropriate analysis tool. Indeed, the central premise of NYS's Motion—that ATMOS has been rejected by the NRC, DOE, and other members of the scientific or regulatory community—is wholly unsupported. Accordingly, NYS has not established the lack of genuine material dispute regarding the acceptability of ATMOS for use in SAMA analyses.

Respectfully submitted,

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Dated in Washington, D.C.
this 21st day of September 2009

DB1/63676467.1

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	Docket Nos. 50-247-OR and 50-286-LR
ENTERGY NUCLEAR OPERATIONS, INC.	)	ASLBP No. 07-858-03-LR-BD01
(Indian Point Nuclear Generating Units 2 and 3)	)	September 18, 2009

JOINT DECLARATION OF KEVIN O'KULA AND GRANT TEAGARDEN IN SUPPORT OF ENTERGY'S ANSWER OPPOSING NEW YORK STATE'S MOTION FOR SUMMARY DISPOSITION OF CONTENTION NYS-16/16A

Kevin R. O'Kula and Grant A. Teagarden state as follows under penalties of perjury:

I. PROFESSIONAL BACKGROUND

A. Kevin R. O'Kula

1. I, Kevin R. O'Kula, am an Advisory Engineer with Washington Safety Management Solutions ("WSMS") LLC. My professional and educational experience is summarized in the *curriculum vitae* attached as Exhibit 1 to this Declaration.

2. I earned my B.S. in Applied and Engineering Physics from Cornell University in 1975; my M.S. in Nuclear Engineering from the University of Wisconsin in 1977; and my Ph.D. in Nuclear Engineering from the University of Wisconsin in 1984.

3. I have nearly 27 years experience as a technical professional in the areas of accident and consequence analysis, source term evaluation, commercial and production reactor probabilistic safety assessment ("PSA")[1] and severe accident analysis.

4. I am a member of the American Nuclear Society ("ANS") and am currently serving on the writing committee for the *Standard for Radiological Accident Offsite Consequence Analysis*

1 The terms probabilistic safety assessment ("PSA") and probabilistic risk assessment ("PRA") generally are used interchangeably within the nuclear industry.

(Level 3 PRA) to Support Nuclear Installation Applications (ANSI/ANS-58.25). I also am a member of the Health Physics Society.

5. I am past chair of the ANS Nuclear Installations Safety Division ("NISD") and the Energy Facility Contractors Group ("EFCOG") Accident Analysis Subgroup. I was the Technical Program Chair for two ANS embedded topical meetings on Operating Nuclear Facility Safety (Washington, D.C., 2004) and the Safety and Technology of Nuclear Hydrogen Production, Control and Management (Boston, MA, 2007).

6. I have over 20 years experience using the MELCOR Accident Consequence Code System ("MACCS") and the MACCS2 Computer Codes. I also have taught MACCS2 training courses for the Department of Energy ("DOE") at Lawrence Livermore National Laboratory, Los Alamos National Laboratory, Idaho National Laboratory, the DOE Safety Basis Academy at Sandia National Laboratories ("Sandia"), and DOE EFCOG Safety Analysis Workshops.

7. I was the lead author of 2004 DOE Software Quality Assurance gap analysis and guidance reports on the use of MACCS2 for safety basis analysis (DOE, 2004a; DOE, 2004b).

8. In addition to MACCS2, I have experience with FUSCRAC (fusion dispersion and consequence code), UFOTRI (tritium dispersion and consequence code), and CONTAIN (in-plant severe accident modeling code) models. With respect to models used in the DOE Complex, I co-chaired a DOE Accident Phenomenology and Consequence evaluation program in the 1990s that evaluated applicable computer models for radiological dispersion and consequence analysis.

9. I currently serve as a member of the Review Committee for the Nuclear Regulatory Commission ("NRC") State-of-the-Art Reactor Consequence Analysis ("SOARCA") Program reviewing Sandia's program implementing more accurate models for severe accident and offsite consequence modeling. The SOARCA Program was initiated to develop more realistic evaluations of severe accident progression, radiological releases, and offsite consequences for dominant accident sequences using state-of-the-art modeling codes and methodologies, including WinMACCS (NRC,

2007a), a new Windows based interface and framework that includes MACCS2 for performing consequence analysis.

B. Grant A. Teagarden

10. I, Grant Teagarden, am the Manager for Consequence Analysis for ERIN Engineering & Research, Inc. My professional and educational experience is summarized in the *curriculum vitae* attached as Exhibit 2 to this Declaration.

11. I obtained my B.S. in Mechanical Engineering from University of Miami in 1990 and completed the Bettis Reactor Engineering School at the Bettis Atomic Power Laboratory as part of my training in the U.S. Navy nuclear program.

12. I have 12 years of experience in the nuclear field, with eight years as a manager and technical professional in the areas of PSA, source term analysis, consequence analysis, and nuclear power plant security risk assessment.

13. I am a member of the ANS and am currently serving on the writing committee for the *Standard for Radiological Accident Offsite Consequence Analysis (Level 3 PRA) to Support Nuclear Installation Applications* (ANSI/ANS-58.25).

14. I have substantial experience using the MACCS2 Computer Code and developing MACC2S models for commercial nuclear power plants in the U.S. I have developed or managed the development of MACCS2 models in support of Severe Accident Management Alternatives ("SAMA") analyses for eight existing nuclear plant sites. I also have developed similar analyses for three proposed new reactor sites and supported reactor vendor development of MACCS2 models for new plant designs.

II. OVERVIEW OF CONTENTION NYS-16/16A AND NYS MOTION

15. We are familiar with New York State ("NYS") Contention NYS-16/16A, which alleges that the ATMOS module of the MACCS2 computer code used in Entergy's SAMA analyses for Indian Point Units 2 and 3 ("IP2" and "IP3)[2] "will not accurately predict the geographic dispersion of radionuclides released in a severe accident" and, therefore, "will not present an accurate estimate of the costs of human exposure."[3] We understand that on July 31, 2008, the Atomic Safety and Licensing Board ("Board") admitted NYS-16 "to the extent that it challenges whether the population projections used by Entergy are underestimated" and "to the extent that it challenges whether the ATMOS module in MACCS2 is being used beyond its range of validity–beyond thirty-one miles (fifty kilometers)–and, whether use of MACCS2 with the ATMOS module leads to non-conservative geographical distribution of radioactive dose within a fifty-mile radius of IPEC."[4]

16. We further understand that on June 16, 2009, the Board admitted amended contention NYS-16A to the degree that the NRC Staff's December 2008 Draft Supplemental Environmental Impact Statement ("DSEIS") for IP2/IP3 license renewal does not address the issues raised by NYS-16, as previously admitted by the Board. The Board noted that the issue of whether an "EPA-approved" air dispersion model must be used in the NRC Staff's analysis. . . is outside the scope of NYS-16 and is also outside the scope of NYS-16A."[5]

17. We have reviewed the NYS's August 28, 2009 Motion for Summary Disposition relating to contention NYS-16/16A, including the Statement of Material Facts, the Declaration of

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2 IP2 and IP3 also are referred to herein collectively as the Indian Point Energy Center ("IPEC").

3 New York State Notice of Intention to Participate and Petition to Intervene (Nov. 30, 2007) at 163 ("NYS Petition").

4 *Entergy Nuclear Operations, Inc.* (Indian Point Nuclear Generating Units 2 and 3), LBP-08-13, 68 NRC 43, 112-13, 218 (2008).

5 *Entergy Nuclear Operations, Inc.* (Indian Point Nuclear Generating Units 2 and 3), Order (Ruling on New York State's New and Amended Contentions), slip op. at 4-7 (June 16, 2009).

Bruce A. Egan, and the exhibits attached thereto.[6] NYS and Dr. Egan allege that the IPEC SAMA analyses are not accurate because the straight-line Gaussian atmospheric transport and dispersion ("ATD") model used in MACCS2 and relied upon by Entergy and NRC Staff is "scientifically unreliable." NYS Motion at 1; Egan Decl. at ¶¶ 37, 60. Specifically, they contend that the ATMOS module used in MACCS2 is "unreliable" and cannot account for "variable terrain conditions," and that IPEC is located in "an area with complex terrain." NYS Motion at 6, 7, 13. As discussed below, those conclusions are erroneous.

III. OVERVIEW OF DECLARATION AND SUMMARY OF CONCLUSIONS

18. This Declaration shows that NYS's and Dr. Egan's criticisms of the ATMOS module of MACCS2 as applied to the IPEC SAMA analyses are unfounded and lack a technical basis. This Declaration also summarizes the purpose of and methodologies required for a SAMA analysis, and demonstrates that the MACCS2 code—including its integral ATMOS module—was specifically designed and developed for this type of analysis. As explained further below, to the best of our knowledge, MACCS2 is unique in its ability to perform all of the elements that are required for a SAMA analysis with the data that are typically available to the user of the code.

19. As summarized in NYS's Motion, NYS and Dr. Egan present four main arguments:

- Indian Point has a "substantial population and the differences in the concentration of population within 50 miles of Indian Point are such that an accurate calculation of the dispersion of airborne radiation following a hypothetical severe accident could result in a substantially different human exposure profile than the one produced by MACCS2 and relied upon in the DSEIS." NYS Motion at 9.
- "The terrain surrounding Indian Point is complex and creates unique variations in the movement of air in the vicinity of Indian Point and for as much as 50 miles beyond." *Id.*
- "NRC Staff, as well as independent experts, agree with Dr. Egan that a straight line Gaussian plume model like the ATMOS model used in MACCS2 cannot accurately

6 State of New York's Motion for Summary Disposition on Use of Straight Line Gaussian Air Dispersion Model for the Environmental Impact Analysis of Significant Radiological Accidents at Indian Point and NYS Contention 16/16A (Aug. 28, 2009) ("NYS Motion"); Declaration of Bruce A. Egan, Sc.D. (Aug. 28, 2009) ("Egan Decl."); Statement of Material Facts Not in Dispute (Aug. 28, 2009).

model the impact of these complex terrain features to calculate the movement of the plume of radiation from a hypothetical severe accident at Indian Point." *Id.* at 10.

- Alternative dispersion modeling codes "exist, of which NRC is aware, that could provide reliable air dispersion analysis for use in the Indian Point SAMA analysis." *Id.*

20. Based on our substantial familiarity and experience with the MACCS2 code, we conclude that NYS's and Dr. Egan's assertions reflect a misunderstanding of the purpose of a SAMA analysis and the role of the MACCS2 model (including the ATMOS module). Our response to NYS's arguments is summarized in the four points below, which are further elaborated in the remainder of this Declaration.

Point 1: NYS improperly focuses on a hypothetical worst-case scenario. SAMA analysis uses the sum of the *average* consequence results from a broad spectrum of possible releases and possible weather conditions across a 50-mile radial region. Indeed, many U.S. commercial nuclear plants have substantial populations in the 50-mile region analyzed for SAMA, and nearly all sites would be characterized as having variations in population concentrations in this 50-mile analysis region. To account for such population variations, MACCS2 includes a unique analytical feature—which was used in the IPEC SAMA analyses—whereby each weather trial of each radiological release plume is rotated through the 16 principal compass sectors (*i.e.*, 360 degrees) to accurately capture statistical variations associated with population distribution and the wind direction distributions.

Point 2: NYS and Dr. Egan mistakenly focus on terrain variations based upon EPA regulations that are *not* applicable to the SAMA analyses required by NRC in 10 C.F.R. Part 51. In any event, such terrain changes would have minimal or no impacts on the outcome of a SAMA analysis given the probabilistic approach that is used in SAMA analyses to obtain meaningful statistical results.

Point 3: The straight-line Gaussian plume model used by ATMOS is a time-tested model that is well suited for SAMA analysis. NYS's focus on movement of a single plume resulting from a hypothetical worse-case severe accident misunderstands the purpose of a SAMA analysis. SAMA analysis is concerned with statistical mean (*i.e.*, average) results for the 50-mile radial region associated with a broad spectrum of releases (from an intact containment case where only minimal leakage occurs to a large early release where significant health impacts can occur). Additionally, meteorological variation (*e.g.*, changes in wind speed and direction) is incorporated in the analysis using multiple years of actual site-specific data and sampling techniques as part of the development of the mean results. Use of a Gaussian plume model like ATMOS is well suited for analyses in which 160 weather trials are used with rotation to obtain statistically meaningful results. The primary results developed and compiled by MACCS2 for use in a SAMA analysis are two values: (1) the 50-mile population dose and (2) the 50-mile economic impacts. These two values represent the mean cumulative impacts from postulated severe accidents (*i.e.*, dose or economic costs) to all individuals and land in the 50-mile radial region occurring over a 30-year period. Because of the large areas involved, the need for statistically meaningful results, and the use of cumulative regional mean values, the terrain variations cited by NYS are generally expected to have minimal or no impacts on the results (*e.g.*, they would not significantly change the 50-mile mean dose value from MACCS2). Therefore, use of a Gaussian plume model is reasonable for this purpose. Comparisons of certain MACCS2 results to those generated by more sophisticated ATD models have shown that the Gaussian plume model used in ATMOS is acceptable for applications such as SAMA analysis.

Point 4: The alternative dispersion analysis codes recommended by NYS are designed for a different purpose that is not transferable to the SAMA context. Different regulatory objectives require different codes, and the MACCS2 code was specifically developed for probabilistic severe accident analyses like those performed for NRC-required SAMA analyses. A SAMA analysis is based on a current baseline PSA evaluation of the subject nuclear power plant, combined with certain other data (*e.g.*, projected population distribution, economic data, meteorological data). MACCS2 is the sole model used in the U.S. for this purpose. To our knowledge, neither CALPUFF nor AERMOD has been used in a PSA in the U.S. or abroad.

Moreover, in our professional opinion, it is not practical from an analytical or a mechanical standpoint to "incorporate" another plume dispersion model, such as CALPUFF or AERMOD, into MACCS2. The ATMOS module within MACCS2 is integral to the code; *i.e.*; MACCS2 is not designed to accept another type of dispersion modeling module. As such, we fundamentally disagree with NYS's assertion that "[a]t least two readily available computer models [*i.e.*, AERMOD and CALPUFF] could have been used in the SAMA analysis that would have reliably predicted air dispersion in the complex terrain of the Indian Point area." NYS Motion at 23; Egan Decl. ¶¶ 28-30.

21. In summary, given the purpose and analytical requirements of SAMA analysis, use of the MACCS2 code in the IPEC SAMA analyses is appropriate and consistent with standard, state-of-the-art industry practice. The straight-line Gaussian plume model implemented in MACCS2 by ATMOS has been an accepted analytical approach for ATD analyses in the nuclear industry since nuclear plant severe accident probabilistic risk analyses began over 30 years ago. The Gaussian plume model is a computationally efficient approach that lends itself to the robust statistical analyses needed for severe accident risk applications. Although more sophisticated ATD models have been developed to serve *other* purposes (*e.g.*, emergency planning), none has supplanted the Gaussian plume model for risk analysis focused on large regions and time-averaged risk metrics, such as those analyzed in the SAMA analyses performed as part of the NRC license renewal process.

22. Furthermore, NYS and Dr. Egan greatly overstate, without technical justification, the alleged effects of "variable terrain conditions" given the probabilistic nature of SAMA analysis. There are no alternative codes—including the EPA codes cited by NYS—that we would recommend for performance of a SAMA analysis.

IV. THE ORIGIN, DEVELOPMENT, AND PRINCIPAL APPLICATIONS OF THE MACCS2 COMPUTER CODE (INCLUDING ATMOS)

23. The MACCS2 code (and the included ATMOS module) was specifically developed to address the methodological requirements associated with PSAs of the type used in SAMA analyses. The following history of MACCS2 (summarized from the *MACCS2 User's Guide*, NUREG/CR-6613, Vol. 1, Section 1.1 (NRC, 1998)) begins with the development of CRAC (a predecessor code to MACCS2), and explains why, contrary to NYS's premise, MACCS2 continues to see widespread use as a state-of-the-art tool in PSA and SAMA analyses.

24. In 1975, the Reactor Safety Study ("RSS"), also known as WASH-1400 (NRC, 1975), was published to present an assessment of risk associated with potential accidents at commercial nuclear power plants. The RSS presented the first comprehensive PSA of hypothetical nuclear power plant accidents. The estimation of accident risks in the RSS required the consideration of both frequencies of accident occurrence as well as the resultant consequences.

25. As part of the RSS study, the Calculation of Reactor Accident Consequences ("CRAC") code was developed to calculate the health and economic consequences of accidental releases of radioactive material to the atmosphere. The CRAC code utilized a Gaussian plume model due to its greater computational efficiency, thereby facilitating multiple code runs for a given analysis. In 1982, Sandia released CRAC2, which incorporated major improvements to the original CRAC code in the areas of weather sequence sampling and emergency-response modeling.

26. In using CRAC2 for diverse applications such as the Sandia Siting Study (NRC, 1982), in which 91 approved reactor sites (including IPEC) were evaluated by Sandia for the NRC, it became apparent that the code did not offer sufficient flexibility for the performance of sensitivity studies and the evaluation of alternative parameter values for its models.

27. The MELCOR Accident Consequence Code System ("MACCS") was developed to address these issues by facilitating the performance of site-specific calculations, evaluation of

sensitivities and uncertainties, and the future incorporation of new phenomenological models. Many of the MACCS model parameter values are defined by the user to facilitate the performance of uncertainty and sensitivity analyses.

28. The MACCS code maintained use of the computationally-efficient straight-line Gaussian plume model in ATMOS, a computational module that is *integral* to the MACCS code.

29. The first version of MACCS released to the public, version 1.4, was first distributed by Sandia in 1987. MACCS was used for consequence analysis calculations in the study now commonly referred to as NUREG-1150 (NRC, 1990), in which the risk of severe accidents was assessed for five commercial nuclear plants in the United States.

30. In 1990, the NUREG-1150 PSA study significantly updated the understanding of severe accident risk posed by U.S. nuclear power plants. NUREG-1150 presents population dose results for a 50-mile radial region around each of five representative nuclear power plants, as well as population dose results for a broader region (*i.e.*, greater than 50 miles), that is typically referred to as the "entire region." The NUREG-1150 analyses continue to be used as benchmarks today for PSA in the U.S. commercial reactor industry.

31. MACCS experienced wide use within the U.S. and abroad for the evaluation of commercial power plant safety. Despite the code's original intended use for nuclear power plants, a sizable fraction of the code's users used it to assess the safety of DOE facilities. When the successive versions of MACCS were applied to DOE facilities, it became apparent that the set of included radionuclides selected for commercial reactor applications did not fully address certain DOE facilities. To address this issue, and to implement a number of other changes that would enhance the code's usefulness for all types of reactor and nonreactor nuclear facilities, MACCS2 was developed. MACCS2 provides an analysis tool for use in assessing potential accidents at a broad range of reactor and nonreactor nuclear facilities.

32. As discussed further below, the principal phenomena considered in MACCS2 are atmospheric transport, short-term and long-term mitigative actions (*e.g.*, sheltering in place, evacuation, relocation, land remediation), short-term and long term and exposure pathways (including ingestion dose, land remediation dose, and dose received from individuals living for decades on marginally contaminated land), deterministic and probabilistic health effects (*e.g.*, doses to individual organs, cancers), and economic costs. Among the U.S. consequence codes that are publicly available, MACCS2 is unique in its capability for modeling these many attributes of interest for reactor accident risk studies, including SAMA analyses.

33. Both DOE and the NRC have sponsored MACCS2 development efforts, which continue to this day, as evidenced by the recent release of WinMACCS, a Windows-based interface and computational framework for performing consequence analyses.

34. WinMACCS is integrated with an updated version of MACCS2. WinMACCS maintains use of the straight-line Gaussian plume model used in the ATMOS module of MACCS2.

35. In summary, the MACCS2 code used for the IPEC SAMA analysis benefits from a 30-year code use and development history for facilitating probabilistic safety analyses. The analysis examines the combinations of various important inputs to produce statistical results that are amenable for presentation in a risk context. To support such an analysis, a computationally efficient approach is required, such as that afforded by the Gaussian plume model used in ATMOS.

V. OVERVIEW OF THE IPEC SAMA ANALYSES AND THE ROLE OF MACCS2 (INCLUDING ATMOS) IN THOSE ANALYSES

36. A nuclear power plant SAMA analysis involves a cost-benefit evaluation, in which a baseline set of risks is quantified and then compared to a modified set of risks assuming a change to the plant or operating procedures is made. This section will summarize the elements of a PSA and the SAMA process, describe the role of the consequence model, describe the MACCS2 model (including ATMOS), and provide an overview of the IPEC SAMA analyses. A more detailed

summary of the IPEC SAMA analyses is contained in Section 5.2 and Appendix G of the NRC's DSEIS (Vols. 1 and 2, respectively) (NRC, 2008).

A. PSA as Context for SAMA Process Analysis

37. The basis for a SAMA analysis conducted for a U.S. nuclear power plant is a sequential, three-level PSA; *i.e.*, a comprehensive assessment of postulated accident sequences resulting in damage to the core and containment, radiological release, and their associated frequencies.

38. A Level 1 PSA consists of an analysis of plant design and operation focused on the accident sequences that could lead to a core melt, their basic causes, and their frequencies. The primary results of a Level 1 PSA are quantification of the Core Damage Frequency ("CDF") based on initiating event analysis, scenario development, system analyses, and human-factor evaluations.

39. A Level 2 PSA includes an analysis of the physical processes of the accident and the response of the containment, in addition to the analysis performed in a Level 1 PSA. Besides estimating the frequencies of core-melt sequences from the Level 1 analysis, the Level 2 PSA models determine radionuclide release frequency, severity, and timing based on the Level 1 PSA, containment performance, and accident progression analyses.

40. A Level 3 PSA analyzes the transport of radionuclides through the environment and assesses the public-health and economic consequences of the accident in addition to performing the tasks of a Level 2 PSA. Level 3 PSA models determine offsite dose and economic impacts of severe accidents based on Level 1 PSA results, Level 2 PSA results, atmospheric transport, mitigating actions, dose accumulation, early and latent health effects, and economic analyses.

41. An analysis of this scope (*i.e.*, a three-level PSA) provides an assessment of plant risk because it estimates both the consequences and the frequencies of various accident sequences. In a SAMA analysis, plant-specific SAMA candidates are identified by reviewing dominant risk contributors based on the full three-level PSA.

42. Thus, plant-specific PSAs are key components of a SAMA analysis. Full, three-level PSAs have been performed for Indian Point 2 and Indian Point 3 plants (NRC, 2008). As discussed below, these analyses are the principal bases for the IPEC SAMA evaluations.

B. Overview of the SAMA Analysis Methodology

43. The SAMA analyses for IP2 and IP3 follow NRC-approved guidance contained in NEI 05-01, *Severe Accident Mitigation Alternatives Analysis, Guidance Document,* Rev. A (Nov. 2005) (NEI, 2005). Broadly speaking, SAMA analysis includes quantification of the level of risk associated with potential reactor accidents using plant-specific PSA and other risk models; examination of the major risk contributors and identification of possible means (*i.e.*, SAMAs) of reducing that risk; estimation of the benefits and costs associated with specific SAMAs; and comparison of the costs and benefits of the identified SAMAs to determine whether the SAMA is cost-beneficial. NEI 05-01, Section 4.21 and Attachment E of the IPEC Environmental Report (Entergy, 2007) , and Appendix G to the NRC Staff's DSEIS (NRC, 2008) describe these steps in greater detail.

44. The full SAMA evaluation of a plant is based on the numerical evaluation of severe accident risk impacts in four categories: (1) offsite exposure cost, (2) offsite economic cost, (3) onsite exposure cost, and (4) onsite economic cost (NEI, 2005). MACCS2 provides results in terms of offsite population dose and offsite economic cost that are used to compute the offsite risk categories; *i.e.*, offsite population dose risk ("PDR") and offsite economic cost risk ("OECR"). The methodology for the overall approach is based on the NRC-accepted methods found in NUREG/BR-0184 (NRC, 1997). NUREG/BR-0184 also prescribes methods for determining onsite exposure and economic risks.

45. Technically-credible SAMA evaluations require the ability to "frequency-weight" the consequences, taking into account the frequency of a core damage condition, the conditional probability of a containment release, and the meteorological condition leading to a consequence

outcome. To use only one meteorological condition (*e.g.*, worst-case conditions) would bias the evaluation and potentially result in the recommended implementation of costly engineering safety features without a commensurate reduction in risk.

C. Description of the IPEC MACCS2 Consequence Model

46. The IPEC SAMA analyses rely on Level 3 PSA results to compare the costs of potential plant modifications with the risk averted benefits. Level 3 PSA models using version 1.13.1 of MACCS2 have been performed for both IP2 and IP3 (NRC, 2008). These models use detailed site-specific meteorological, population, and economic data. The PDR and OECR mean risk values are calculated by combining the MACCS2 calculated consequences and the release frequencies developed from the IP2 and IP3 PSAs.

47. The IP2 and IP3 SAMA analyses each evaluate a base case to provide best-estimate consequences for postulated events. Instead of considering various emergency planning scenarios, the base case conservatively assumes no evacuation. Offsite economic cost includes costs that could be incurred during the emergency response phase and costs that could be incurred through long-term protective actions and condemnation of property.

48. MACCS2 is divided into three primary modules—ATMOS, EARLY, and CHRONC—and supports dispersion and transport on a radial-polar grid (16 compass sectors of 22.5° angular width and a fifty-mile radius). MACCS2 includes input files for site meteorological data, dose conversion factors ("DCFs"), and site/population data to support an overall execution.

49. ATMOS performs all of the calculations pertaining to atmospheric transport, dispersion, and deposition, as well as the radioactive decay that occurs prior to release and while the material is in the atmosphere. The results of the ATMOS calculations are stored for use by EARLY and CHRONC. ATMOS calculates air and ground concentrations, plume size, and timing information for all plume segments as a function of downwind distance.

50. EARLY calculates consequences due to radiation exposure in the emergency phase (first seven days) from the time of release. The emergency phase begins, at each successive downwind distance point, when the first plume of the atmospheric release arrives. The duration of the emergency phase is specified by the user, and is set at seven days for the IPEC SAMA analyses. The exposure pathways considered during this period are cloudshine, groundshine, and resuspension inhalation. Mitigative actions that can be specified for the emergency phase include evacuation, sheltering, and dose-dependent relocation.

51. CHRONC calculates radiological conditions in each affected downwind segment, beginning at the end of the 7-day emergency period and extending to 30 years post-release. The exposure pathways considered during this period are those resulting from ground-deposited material, including groundshine, re-suspension inhalation, and food and water ingestion. A number of protective measures (*e.g.*, decontamination, temporary interdiction, and condemnation) can be modeled in the long-term phase to reduce doses to user-specified levels.

52. The IPEC MACCS2 analyses calculated results for eight source terms, each representing a release category defined by the Level 1 and 2 PSA (ranging from an intact containment case where only minimal leakage occurs to a large early release occurs). Each source term is released based on site-specific meteorology and transported in the direction that the wind is blowing for that weather trial, obtained from a year's worth of hourly data that are randomly selected from 40 weather bins. Four start times are selected from each of the 40 bins, thereby permitting analysis of 160 weather trials and yielding 160 separate modeling results. Each set of modeling results is rotated around the 16 compass directions and weighted by the wind rose probability to give a distribution of results for a specific source term. Point-value average or mean numerical consequence is the value selected for use in the overall SAMA analysis, and the MACCS2 analysis is repeated until all eight source terms are analyzed.

53. Figure 1 illustrates the data flow in the MACCS2 model through ATMOS, EARLY, and CHRONC, and the food ingestion model COMIDA (executed previously) (Bixler 2005).

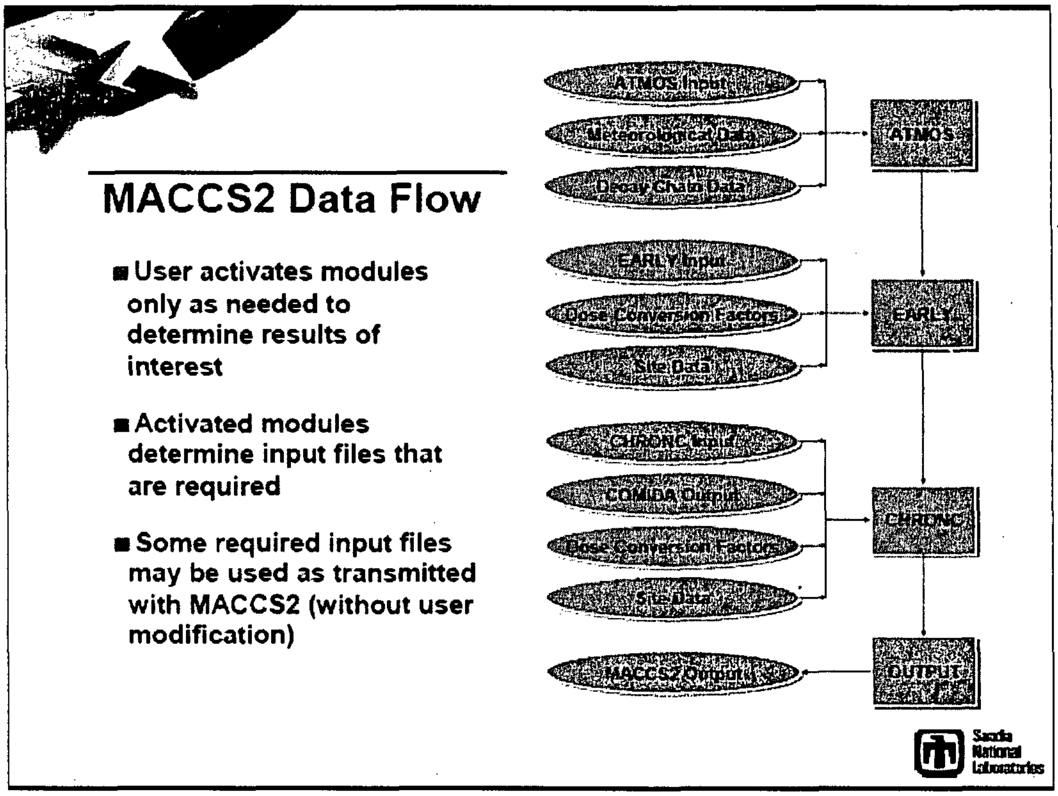

Figure 1. MACCS2 Three-Module Data Flow (from Bixler, 2005)

D. <u>Key Input Data for IPEC MACCS2 Analyses</u>

54. For a SAMA analysis, MACCS2 requires plant-specific source term information (radionuclide quantity, timing, and release characteristics (start time, duration, elevation and sensible heat for buoyancy effects) and meteorology. Regional data within a 50-mile radius of the plant are needed for population data, economic data, and emergency planning (especially within the Emergency Planning Zone, or "EPZ"). For IP2 and IP3, the input data for both plant-specific and regional categories complies with NRC-approved guidance (NEI, 2005). Key input data include:

- **Source term:** For IP2 and IP3, eight prototypic release categories were defined from the PSA and related analysis for use in the MACCS2 analysis.

- **Population data**: The total population within a 50-mile radius of IPEC was estimated for the year 2035 for each spatial element by combining total resident population projections with transient populations.

- **Economic data**: Each spatial element was assigned to an economic region on a county-specific basis. County level economic data were obtained from the United States Census of Agriculture for 2002.

- **Meteorological data**: The MACCS2 model requires meteorological data for wind speed, wind direction, atmospheric stability, accumulated precipitation, and atmospheric mixing heights. The IPEC MACCS2 meteorological file contains these weather data at hourly intervals for a full year (8760 hours of data) and is thus representative of the full spectrum of wind directions over an entire year. The required data were obtained from the IPEC meteorological monitoring system and regional National Weather Service stations (*i.e.*, regional mixing height). For the IPEC SAMA analyses, the annual data file was compiled by averaging five recent years of weather data to ensure that the data were representative over the long term. The five-year data included 43,848 (two leap years) consecutive hourly values of wind speed, wind direction, precipitation, and temperature recorded at the IPEC meteorological tower from January 2000 to December 2004.

- **Emergency planning**: The IPEC SAMA base case assumes that no evacuation occurs.

E. Principal Outputs of IPEC MACCS2 Analyses

55. The SAMA analysis evaluates a base case to provide best-estimate consequences for postulated internal events. The PDR was estimated by summing over all releases the product of mean population dose and frequency for each accidental release (Entergy, 2007). Similarly, OECR was estimated by summing over all releases the product of the mean offsite economic cost and frequency for each postulated accidental release (Entergy, 2007).

56. The base case was compared to several sensitivity analyses in the IPEC Environmental Report to assess the importance of key inputs and assumptions (Entergy, 2007). Each candidate SAMA was evaluated with base case and sensitivity case assumptions and compared to cost of implementation to determine whether it is cost-beneficial (Entergy, 2007). The cost-beneficial SAMAs are specifically identified in Appendix G of the DSEIS (pp. G-30 to G-31) (NRC, The methodology used by Entergy for the IPEC SAMA analyses is consistent with prior NRC-approved SAMA analyses and NRC-approved regulatory guidance.

VI. RESPONSE TO NYS'S AND DR. EGAN'S CRITICISMS OF MACCS2/ATMOS

A. MACCS2 and Its Integral ATMOS Module Are Scientifically Reliable and Well Accepted for Use in PSA-Related Applications, Including SAMA Analysis

57. As discussed above, the MACCS2 code was developed by Sandia and is a mature atmospheric release consequence model for PSA and related applications. The current version 1.13 and its predecessor, 1.12 have been used for most SAMA analyses prepared in the U.S. since 10 C.F.R. § 51.53(c)(3)(ii)(L) was promulgated. MACCS2 continues to have a large international user community for nuclear reactor and nonreactor safety analysis, chiefly to support PSAs and cost-benefit studies (including SAMA analyses), but also for safety basis analysis in the DOE Complex.

58. MACCS2 is the only U.S. publicly available software package capable of meeting *all* of the requirements of a SAMA analysis, including those tasks necessary to support a full evaluation of offsite consequences. An NRC-compliant SAMA analysis requires an integrated process that evaluates a spectrum of radiological source terms and a sufficient number of weather sequences to achieve an adequate statistical basis on which to evaluate reasonable alternatives. Thus, in typical SAMA analyses more than 100 simulations are run of multiple source terms to be representative of the nuclear power plant in severe accident conditions, and to develop adequate statistics for SAMA purposes. Each simulation requires:

1. Characterizing and analyzing postulated, short-duration (tens of minutes to several hours) radiological releases;
2. Modeling atmospheric transport and dispersion behavior of a radiological plume;
3. Addressing radiological decay and other radioactivity characteristics that are radionuclide-specific and generally different from those of air toxics and particulate species;
4. Implementing appropriate International Commission on Radiological Protection ("ICRP") or Federal Guidance Report ("FGR") metabolic and dosimetric models with associated data files such as dose conversion factors;
5. Estimating economic and population dose consequences for short-term (hours to days) and long-term conditions (years);

6. Performing a statistic sampling of consequence levels for mean (average), median, and other percentiles results, given uncertainties introduced by meteorology in a region; and

7. Evaluating consequence changes with and without the effect of countermeasures (sheltering, evacuation, interdiction).

Once a specific source term is fully analyzed and the associated consequences are assessed at the mean, or average, level, another source term must be processed until the full set of accident release source terms is analyzed.

59. Thus, singular efforts, such as looking at worst-case conditions and resulting consequences (*e.g.*, a single high early release for one weather sequence in which the wind is directed towards a high population center) are not the appropriate point of reference in a SAMA study, which, consistent with NRC regulations, focuses on "probability-weighted" consequences. 10 C.F.R. Part 51, Subpt. A, App. B, Table B-1. The MACCS2 code (with its Gaussian plume model, ATMOS), can meet the computational demands of calculating many kinds of consequence results, with the appropriate level of statistical sampling—a key requirement of SAMA analysis.

60. NUREG/CR-6853 (Mollenkamp, 2004), which is attached as Exhibit 5 to Dr. Egan's own declaration, highlights this important fact:

> MACCS2 is the latest in a series of NRC-sponsored codes for estimating off-site consequences following a release of radioactive material into the environment. . . . The atmospheric models in MACCS2 are relatively simple. Released material is assumed to travel downwind in a straight line. The concentration profiles in the crosswind and vertical dimensions are approximated as being Gaussian. *The Gaussian plume model was chosen for MACCS2 because it requires minimal computational effort and allows large numbers of realizations to be calculated.* These realizations represent uncertainty in weather data at the time of a hypothetical accident and uncertainty in other input parameters to represent degree of belief. *Large numbers of realizations (hundreds) are generally needed to perform PRA and sensitivity studies.* (Emphasis added)

61. Although there are other computer codes that model spatial variation of wind speed and direction in a region (*e.g.*, mesoscale Lagrangian puff models), their use would be impractical for

SAMA analysis given the statistical sampling requirements and the amount of input data necessary to fully account for offsite exposure and economic costs.

B. The Straight-Line Gaussian ATD Model Has Not Been "Rejected" by the NRC or Other Members of the Relevant Scientific and Regulatory Communities

62. We strongly disagree with NYS's and Dr. Egan's position that the straight-line Gaussian plume model used in ATMOS has been rejected as "antiquated and unreliable" by the NRC or other members of the pertinent scientific and regulatory communities. To the contrary, the straight-line Gaussian plume model remains the "workhorse" approach for PSA-related applications due, in large part, to its computational efficiency.

63. MACCS2 *continues* to have a large U.S. and international user community for nuclear reactor and nonreactor safety analysis, chiefly to support PSAs and cost-benefit studies (including SAMAs) as well as for safety basis analysis in the DOE Complex. As noted above, the NRC and Sandia have maintained the Gaussian plume approach in the ATMOS module for the new WinMACCS code version. MACCS2, including ATMOS, thus remains a state-of-the-art tool for PSA analysis and related studies, such as SAMA analysis

64. NYS and Dr. Egan suggest that a recent NRC Staff presentation at the National Radiological Emergency Planning Conference constitutes a "concession by NRC that a model like ATMOS is unsuitable for the complex terrain at Indian Point." Our review of this presentation and related conference materials confirms that the presentation was given by an NRC Staff member (Stephen F. LaVie, Senior Emergency Preparedness Specialist) as part of a "training workshop" on radiological dose assessment for personnel in the field of emergency planning.

65. Although the presentation slides included by NYS as Exhibit 4 discuss various ATD models, including the Gaussian model and "advanced diffusion models," as well as "terrain and building impacts" on modeling results, they do so in the context of *radiological dose assessment for emergency planning purposes.* The presentation, in our opinion, has no relevance to the use of the

Gaussian plume model in SAMA cost/benefit applications (for which hundreds of weather sequences are used, applied in a statistical sampling model, and combined to the associated frequencies to obtain representative sets of PSA-based radiological source terms).

66. Different dispersion analysis codes, not surprisingly, have been developed for different regulatory purposes. Codes used for emergency planning purposes tend to be oriented towards evaluation of a single release and its specific dispersion path for use in emergency planning decision making (*e.g.*, whether to evacuate a particular downwind population group). In contrast, dispersion analysis in support of SAMA is concerned with the probabilistically-determined mean results (*i.e.*, dose and economic cost) for a 50-mile region. For SAMA analyses, terrain variation is generally expected in the 50-mile region and typically is judged not to significantly impact the mean results (which are compiled from hundreds of results).

67. It is noteworthy that comparisons of MACCS2 with more complex computer models have proven favorable and support use of MACCS2 in PSA and SAMA applications, where long distances (tens of kilometers) are considered with varying terrain. While long-distance and terrain-responsive models may provide more accurate projections of plume concentration and population dose at a given location, any such advantage is offset by increased data demands, model/data uncertainty, and additional pre- and post-processing resource demands. Code comparisons involving Gaussian plume models have been reported, several of which are discussed below:

68. **Idaho National Laboratory testing in the early 1980s:** Measurements at Idaho National Laboratory in 1981 with release of a non-radioactive tracer (SF_6) and comparison to three different computer models demonstrated wide variability (Gregory and Harper, 1999). The three models were (a) a simple straight-line Gaussian plume model, (b) a Gaussian-puff trajectory model with wind-shift, and (c) a more sophisticated wind field/terrain sensitive model. In this study, the Gaussian model was *more conservative* than (1) the actual maximum dose and isopleths as measured

by field equipment, and (2) the maximum dose isopleths predicted by the more complex wind field/terrain sensitive code.

69. **<u>CRAC2 estimates with radioactivity measured downwind from Chernobyl</u>**: Susnik (1996) used a predecessor of MACCS2 (CRAC2, with virtually the same ATD model) to estimate Cs-137 and I-131 contamination of areas in Slovenia from the radioactive release at Chernobyl. Persistent weather was assumed and the source term was estimated. The distance for plume travel in this case was approximately 800 miles. Notably, there were appreciable terrain variations between the Ukraine source of release and the area of interest. Nonetheless, the ratio of the CRAC2 estimated contamination levels to actual measured contamination levels was 0.90 to 1.18 for the two radionuclides considered.

70. **<u>Comparison of one-, two- and three-dimensional codes for a short-term release simulation</u>**: A comparison of several codes of varying complexity was performed for a hypothetical point source release (Mollenkamp, 2004). This study compared MACCS2 to a fully three-dimensional code (LODI) that can account for terrain changes and spatial variability of weather, at a series of one-mile wide arcs at various distances downwind over a distance of 100 miles. The results showed reasonably good agreement between MACCS2 and the three-dimensional (LODI) model, with the MACCS2 code varying by 21% higher to about 22% lower for average deposition as a function of distance from the postulated point source release.

71. The Gregory and Harper (1999) and Mollenkamp (2004) studies demonstrate the fitness of the straight-line Gaussian plume model and the ability of MACCS2 to provide reasonable estimates of regionally-weighted consequences, such as population doses and economic costs.

72. In his declaration, Dr. Egan mischaracterizes the Mollenkamp (2004) study in several respects, particularly as it relates to the ability of MACCS2 to estimate regional dose consequences for purposes of a SAMA analysis. First, terrain variations for the Mollenkamp test grid are not unlike those noted for Indian Point, with elevations ranging from approximately 500 feet (153m)

above sea level to nearly 2,500 feet (760m) above sea level across the approximately 250 mile square test grid. Thus, the variation in elevation across the test grid is nearly 2000 feet, and the study noted that the test grid includes "several river valleys and other irregularities in the terrain." For modeling purposes, a release height of 50 meters above ground level was utilized in the study. Using the EPA definition for "complex terrain" (*i.e.*, terrain height exceeds the release height) as proposed by NYS and Dr. Egan, this test site would be characterized as complex terrain, and the results provide a reasonable indication of MACCS2 ability to address terrain variation. Also, the test grid was subject to localized meteorological phenomena, such as frequent low-level nocturnal jets and occasional severe storms. These conditions would affect the transport and diffusion of a plume in a manner similar to terrain changes along the region of plume travel.

73. Second, SAMA analysis considers finite-duration release events (*i.e.*, postulated accident releases) and involves comparisons at the *average, or mean level of consequence* for population dose and offsite economic cost. A meteorological file of a representative year of data is the basis for development of an average. The Mollenkamp postulated release also was for a finite duration (0.5 h), using a selected year of meteorological data for a single observation point for MACCS2 and multiple points on the grid for the three-dimensional code (LODI). In this regard, Mollenkamp (2004) provides useful insight into the ability of MACCS2 to provide time- and regionally-weighted estimates of dose consequences.

74. Third, the differences between the MACCS2 ATMOS model and the more sophisticated LODI (Lagrangian trajectory) model varied depending on the distance and whether a "depositing" species (land contamination) or "non-depositing" species (air concentration) was being predicted. A comparison of the arc-averaged *exposures* for non-depositing and depositing species reported in Mollenkamp (2004) for distances of 10, 20, 50 and 100 miles shows reasonably good agreement between the one-dimensional (Gaussian) MACCS2 model and the three-dimensional (LODI) model, with the MACCS2 code varying by 58% higher to about 36% lower as a function of

distance for non-depositing species, and 41% higher to 19% lower for depositing species. The arc average *deposition*, a key parameter leading to both population dose and economic impacts in a SAMA study, shows very good agreement between MACCS2 and the three-dimensional code, varying by 21% higher to 22% lower. The authors of Mollenkamp (2004) deemed this level of agreement "gratifying."

75. The comparisons of a straight-line Gaussian plume model and MACCS2 (or the precursor CRAC2 code) with more complex codes show that, while more detailed ATD physics models theoretically could provide a more accurate answer for certain specific conditions, user interpretation as well as data and model uncertainties can lead to approximately equivalent results. This situation is more likely to arise when a risk metric is an area-weighted, time-integrated, and a long-range quantity, such as population dose or economic impact (the two metrics used in a SAMA analysis).

76. The other exhibits cited by Dr. Egan (Exhibits 6 through 13) do not indicate that there is scientific "consensus" that ATMOS is unsuitable for use in SAMA analyses. In discussing most of these documents, Dr. Egan focuses on the ability of the straight-line Gaussian plume model to accommodate spatial and temporal variations *for purposes other than SAMA analysis*. For example, the section of Regulatory Guide 1.23 (NRC, 2007b) on which Dr. Egan focuses (Section 7, "Special Considerations for Complex Terrain Sites") discusses the implications of complex terrain for *protective action recommendations within the plume exposure emergency planning zone*. As such, it has no relevance to the use of MACCS2 in SAMA analyses. Similarly, even in those documents that note the potential limitations of the straight-line Gaussian plume model, such a notation does not equate to a rejection of the model for use in locations where terrain is varied. The notation simply serves to alert the analyst to consider the potential of terrain impacts in a particular analysis.

77. In this regard, Dr. Egan's reliance on the DOE document, *MACCS2 Computer Code, Application Guidance for Documented Safety Analysis* (NYS Exh. 10) is similarly misplaced. That

DOE guidance document identifies features, strengths, and limitations of the straight-line Gaussian plume model as applied in DOE Documented Safety Analysis ("DSA") dose calculations.

78. The requirement of DSA dose calculations is to provide "bounding" rather than "best estimate" assessments for postulated short-term accident releases. Nonetheless, DOE Standard DOE-STD-3009-94, Appendix A endorses the Gaussian plume model for individual dose calculations.

79. The focus of the DSA for DOE applications is the individual dose (total effective dose equivalent, or TEDE) to a single, hypothetical public receptor (*i.e.*, maximally exposed offsite individual, or MOI) located at the closest DOE site boundary throughout the *short-term phase* after the release (*e.g.*, no shelter or evacuation is assumed).

80. Because the DOE safety basis analysis is concerned with the dose to a single individual at a particular location, the results are more sensitive to the potential impacts of terrain variation than are the results of a SAMA analysis. In contrast, population or area-specific doses (rather than the dose to a specific individual) and offsite economic cost for the 50-mile analysis region are the metrics of interest in a SAMA analysis. Further, although both short-term and long-term phases after the radiological release are calculated, the long-term dose impacts dominate the numerical results. Therefore, in a SAMA analysis, terrain impacts are significantly less important.

81. In summary, the purpose of SAMA analysis is to assist in understanding whether additional mitigative measures may be cost-effective for a facility, based on regionally- and time-averaged quantities. This application is different from providing a basis for the appropriate near real-time protective action recommendation for a specific emergency situation.

C. **<u>NYS Provides No Valid Technical Basis for the Alleged Effects of Large Populations and Variable Terrain Conditions on the IPEC SAMA Analyses</u>**

82. Based upon our review, we conclude that Dr. Egan has significantly overestimated the potential impacts of varying terrain on the IPEC SAMA analyses. As discussed further below,

Dr. Egan fails to recognize, or at least account for, the probabilistic nature of SAMA analysis, as conducted using the MACCS2 computer code.

83. As an initial matter, many U.S. commercial nuclear plants have substantial populations in the 50-mile region considered in the SAMA analysis, and nearly all nuclear plant sites would be characterized as having variations in population concentrations within the 50-mile analysis region. Moreover, many U.S. commercial nuclear plants have terrain variations in the 50-mile region analyzed for SAMA purposes that would be classified as "complex terrain" under the EPA definition cited by Dr. Egan. As Dr. Egan states: "For purposes of categorizing appropriate air dispersion models for regulatory applications, EPA defines complex terrain as 'terrain exceeding the height of the stack being modeled.'" Egan Decl. at ¶ 33 (quoting 40 C.F.R. Part 51: Appendix W, *Guideline on Air Quality Models*).

84. It is improper, however to apply the EPA definition of "complex terrain" to an NRC-required SAMA analysis. In SAMA analyses, releases are generally modeled to occur at a specific height somewhere between ground level (*i.e.*, postulated failure low in the containment) to the top of the reactor containment (*i.e.*, postulated failure near the top of containment). NRC-approved guidance (NEI 05-01) suggests the use of a distance of approximately one half containment height. The IPEC analyses followed this guidance and used a release height of 30 meters.

85. In our opinion, the "variations" in population and terrain cited by NYS would have minimal or no impact on the outcome of the IPEC SAMA analyses given the probabilistic approach properly used in those and other SAMA analyses, as described above. Specifically, using MACCS2, the IPEC SAMA analyses examined numerous combinations of representative source terms, weather sequences, and exposed populations.

86. As discussed in paragraph 52 above, each source term is released based on site-specific meteorology and transported in the direction that the wind is blowing for that weather trial. To address population and wind direction variations, each set of modeling results is then rotated

around the 16 compass directions and weighted by the wind rose probability to give a distribution of results for a specific source term. The individual results are then statistically processed by MACCS2 to present mean (average) results for population dose and economic cost.

87. In summary, SAMA analysis is concerned with statistical mean results for the 50-mile radial region as a whole for a broad spectrum of releases. The key results developed and compiled by MACCS2 for use in the SAMA cost benefit analysis are two values: the 50-mile population dose and the 50-mile economic impacts. These two values represent the mean cumulative impacts (*i.e.*, dose or cost) to all individuals and land in the 50-mile radial region. This 50-mile radial region is a significant land analysis area of approximately 7,850 square miles—an area larger than the State of Connecticut. Given the large area involved, the conduct of statistical analyses involving over 100 weather sequences, the rotation of the release through all 16 sectors to address population variation, and the use of cumulative regional mean values, we further conclude that the "variable terrain conditions" cited by NYS would have no significant impacts on the results.

88. Even if specific worst-case weather conditions for a single type of release were taken into account (which is not necessary for SAMA analysis), they would not necessarily change a single consequence outcome with respect to a certain direction and for long-range distances. For example, if a numerical change were to occur (*e.g.*, population dose change), then it would need to be weighted by the frequency of time that the worst-case meteorological condition occurs and for the direction chosen. In other words, in the context of SAMA analysis, the singular worst-case meteorological event in the worst high-population direction tends to be statistically negligible.

89. Furthermore, certain mitigating factors would tend to offset the level of consequence. For example, a radiological plume postulated to travel in the direction of the highest population density (*e.g.*, south towards NYC) would be subject to the following processes or conditions:

- **Deposition**: For the majority of radiological species, deposition would deplete the plume. This phenomenon is an effective concentration depletion mechanism and is more effective with surface cover such as forests and irregular terrain, and depletes the plume as a function of plume travel.

- **Persistence of wind direction and low wind speed:** Low wind speeds on the order of 1 to 2 miles per hour would be needed to sustain a plume in a given direction (e.g., towards a distant population center). Higher wind speeds could transport the plume to a distant population center faster, but also would tend to dilute the plume more readily. The travel distance from Buchanan to the north border of New York City is approximately 24 miles (38.6 km). This would require over a 10-hour travel time for a low wind speed condition (less than 2 mph) in the same direction.

- **Decay:** The travel time to reach a major population center is such that depletion would occur due to decay for some of the short-lived radionuclides.

Thus, in addition to misunderstanding the probabilistic nature of SAMA analysis, several atmospheric transport and dispersion, and radiological phenomena are ignored that would tend to mitigate offsite dose consequences, particularly at larger distances from the IPEC site.

90. For the foregoing reasons, we disagree with NYS's and Dr. Egan's suggestion that "variable" or "complex" terrain features have caused Entergy to "grossly underestimate" the offsite population dose risk in SAMA analyses.

D. <u>The EPA Models Cited by NYS Are Not Viable "Alternatives" to ATMOS</u>

91. NYS and Dr. Egan mistakenly suggest that the EPA-approved models AERMOD and CALPUFF could have been used in the IPEC SAMA analyses to "reliably predict[] air dispersion in the complex terrain of the Indian Point area." NYS Motion at 23; *see also* Egan Decl. at ¶¶ 28-30.

92. AERMOD and CALPUFF are EPA-recognized models identified in 40 CFR Part 51, Revision to the Guideline on Air Quality Models: Adoption of a Preferred General Purpose (Flat and Complex Terrain) Dispersion Model and Other Revisions; Final Rule (Nov. 9, 2005), for assessing pollutant levels and air quality issues under the Clean Air Act.

93. AERMOD and CALPUFF, therefore, are air quality models used for evaluating specific types of pollutants under the Clear Air Act and related EPA regulations. They do not have regulatory acceptance for PSA and SAMA analysis applications.

94. These EPA models cannot perform the full suite of analytical tasks performed by MACCS2, which uses *non-dispersion* models (*e.g.*, economic impacts) *in addition to* ATMOS. The use of a "variable trajectory" model such as AERMOD or CALPUFF to simulate a specific plume release event would provide little value in a SAMA analysis, where the focus is evaluating mean (average) consequence levels over a 50-mile region. Furthermore, it is impractical to employ multiple weather station data for SAMA cost-benefit analyses, where, as noted above, more than 100 hundred weather trials are needed to provide statistically valid consequence results.

95. Moreover, the ATMOS module of MACCS2 is not "interchangeable" with other ATD models such as AERMOD or CALPUFF. The user cannot elect another transport and dispersion option in MACCS2. A modification of this magnitude would require major revisions to the MACCS2 code (*e.g.*, via FORTRAN programming changes that are in the sphere of code programmers, not MACCS2 users). Accordingly, implementation of a variable trajectory plume model in the SAMA context is not feasible in the near-term, nor judged necessary. ATMOS, the current model for performing ATD analysis in MACCS2, provides an established, accepted, and understood basis for conducting PSA studies and SAMA analyses.

VII. CONCLUSIONS

96. It is our expert opinion that NYS's and Dr. Egan's criticisms of the use of MACCS2 for the IPEC SAMA analyses lack merit and fail to distinguish between dispersion analysis conducted for SAMA analyses and dispersion analysis conducted for other purposes, such as emergency planning or Clean Air Act compliance. The following key points are summarized.

- The straight-line Gaussian plume model implemented in MACCS2 by ATMOS has been an accepted analytical approach for atmospheric transport and dispersion (ATD) analysis in the nuclear industry since nuclear plant severe accident risk analysis began over 30 years ago. It continues to be widely used for PSA and SAMA analyses in the U.S. and abroad.

- The Gaussian plume model is a computationally efficient approach that lends itself to the robust statistical analyses needed for severe accident risk and cost-benefit analysis. Although more sophisticated ATD models have been developed to serve other purposes, none is a suitable substitute for the Gaussian plume model for risk analysis focused on large regions and cumulative, time-averaged quantities, such as those analyzed in the SAMA analyses.

- In MACCS2 analyses, each weather trial is rotated through the 16 compass sectors (*i.e.*, 360 degrees) to accurately capture statistical variations associated with population and the wind direction distributions.

- Because of the large land areas involved, the need for statistically meaningful results, and the use of cumulative regional mean values, the population and terrain variations cited by NYS are expected to have minimal or no impacts on the results (*e.g.*, they would not significantly change the 50-mile dose MACCS2 output mean value). Therefore, use of a Gaussian straight-line plume model is considered reasonable for this purpose.

- Comparison of certain MACCS2 results to those generated by more sophisticated ATD models have shown that the Gaussian plume model used in ATMOS is acceptable for PSA and PSA-related applications such as SAMA analysis.

- The ATMOS module of MACCS2 in integral to the code, and MACCS2 is not designed to accept other dispersion modules. There are no alternative codes that we would recommend for performance of a SAMA analysis.

In accordance with 28 U.S.C. § 1746, I declare under penalty of perjury that the foregoing is true and correct.

Executed on September 18, 2009.

Kevin R. O'Kula

In accordance with 28 U.S.C. § 1746, I declare under penalty of perjury that the foregoing is true and correct.

Executed on September 18, 2009.

Grant A. Teagarden

In accordance with 28 U.S.C. § 1746, I declare under penalty of perjury that the foregoing is true and correct.

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Grant G. Teagarden

Grant A. Teagarden

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<u>EXHIBIT 1</u>

CURRICULUM VITAE OF KEVIN R. O'KULA

KEVIN R. O'KULA

Key Areas:

- **Computer Model Verification and Validation**
- **Accident and Consequence Analysis for Design Basis Accident Support**
- **Regulatory Standard & Guidance Development**
- **New Reactor Design Accident Analysis and PRA Support**
- **Severe Accident and Quantitative Risk Analysis (QRA)**
- **Level 2/3 Probabilistic Risk Assessment (PRA**
- **MACCS2 Code Applications**
- **Level 3 PRA Standard Development**

Professional Summary:

Dr. O'Kula has nearly 27 years experience as a manager and technical professional in the areas of accident and consequence analysis, source term evaluation, commercial and production reactor probabilistic risk assessment (PRA) and severe accident analysis, safety software quality assurance (SQA), safety analysis standard and guidance development, computer code evaluation and verification, risk management, hydrogen safety, reactor materials dosimetry, shielding, and tritium safety applications. He is a member of the American Nuclear Society (ANS) Standard working group ANS 58.25 on Level 3 Probabilistic Safety Assessment, and is a member of the MELCOR Accident Consequence Code System, Version 2 (MACCS2) Review Committee for the Nuclear Regulatory Commission's (NRC's) State-of-the-Art Reactor Consequence Analysis (SOARCA) Program. Dr. O'Kula was part of the Department of Energy (DOE) team writing DOE G 414.1-4, *Safety Software Guide*. He coordinated technical support for the DOE Office of Environment, Safety, and Health (EH) in addressing Defense Nuclear Facilities Safety Board (DNFSB) Recommendation 2002-1 on Software Quality Assurance (SQA), and was a consultant to DOE/EH-31 Office of Quality Assurance for disposition of SQA issues.

Dr. O'Kula was a member of the Partner, Assess, Innovate, and Sustain (PAIS) Safety Case team for the Sellafield Site in the United Kingdom in the early 2009 period. The PAIS teams were used to identify and begin implementation of improvement opportunities in nuclear safety and related areas. Recommendations were documented in comprehensive reports to the site's Nuclear Management Partners consortium in March 2009.

He is supporting, or has supported, Atomic Safety Licensing Board (ASLB) relicensing issue resolution for several commercial plants including Indian Point, Prairie Island, and Pilgrim Nuclear Power Station, on severe accident mitigation alternatives (SAMA) analysis. He was also part of the accident analysis and PRA/severe accident teams supporting the Design Certification Document for the US Advanced Pressure Water Reactor (APWR) a joint effort with Washington Division and Mitsubishi Heavy Industries (MHI). He has provided similar support for an alternative reactor technology, the Pebble Bed Modular Reactor (PBMR).

Dr. O'Kula is coordinating WSMS support to the Quantitative Risk Analysis (QRA) for evaluation of hydrogen events in a waste vitrification plant design. This support includes fault tree and human factors areas, and is providing input to DOE response on the use of risk assessment methodologies as part of the DNFSB Recommendation 2009-1 activities. He led work in reviewing EIS food pathway consequence analysis performed on assumed accident conditions from the Mixed Oxide Fuel Fabrication Facility (MFFF), sited at the Savannah River Site. This project compared and evaluated the impacts calculated from three computer models, including MACCS2, GENII, and UFOTRI.

He is past chair of the American Nuclear Society (ANS) Nuclear Installations Safety Division (NISD), and the Energy Facility Contractors Group (EFCOG) Accident Analysis Subgroup. He currently chairs the Nuclear Hydrogen Production Technical Group under the ANS's Environmental Sciences Division, and a newly establishing EFOCG Hydrogen Safety Interest Group. He was the Technical Program Chair for two ANS embedded topical meetings on Operating Nuclear Facility Safety (Washington, D.C., 2004) and the Safety and Technology of Nuclear Hydrogen Production, Control and Management (Boston, MA, 2007).

Dr. O'Kula was PRA group manager for K Reactor at the time of restart in the early 1990s. He led a successful effort demonstrating Savannah River Site (SRS) K-Reactor siting compliance to 10 CFR 100, and tritium facility compliance with SEN-35-91.

He was the project leader for independent Verification and Validation (V&V) of urban dispersion software for the Defense Threat Reduction Agency (DTRA) and is the current V&V project manager for the evaluation of several chemical/biological software tools for the U.S. Army Test and Evaluation Command (ATEC) and Chemical-Biological Program (Dugway Proving Ground (Utah) and Edgewood Chemical/Biological Center in Maryland.

Education:

Ph.D., Nuclear Engineering, University of Wisconsin, 1984
MS, Nuclear Engineering, University of Wisconsin, 1977
BS, Applied and Engineering Physics, Cornell University, 1975

Training:

Conduct of Operations (CONOPS), 1994
Harvard School of Public Health, Atmospheric Science and Radioactivity Releases, 1995
Consequence Assessment, (Savannah River Site, 1995)
U.S. DOE Risk Assessment Workshop (Augusta, GA, 1996)
MELCOR Accident Computer Code System (MACCS) 2 Computer Code, 1997, 2005
MCNPX Training Class (ANS Meeting, 1999)

Clearance:

Active DOE "Q"

Professional Experience:

Washington Safety Management Solutions **1997 to Present**
Advisory Engineer and Senior Fellow Advisor

Dr. O'Kula provided support to DOE/EH-31 for addressing SQA issues for safety analysis software. He was a contributor to DOE G 414.1-4, *Safety Software Guide* on SQA practices, procedures, and programs. As a member of the MACCS2 Review Panel, he recommends practices to Sandia National Laboratories (SNL) and the NRC regarding the 3-year State-of-the-Art Reactor Consequence Analysis (SOARCA) Program. Dr. O'Kula is also part of the Level 3 PRA Standard working group charged with developing an ANSI/ANS standard for Level 3 PRA analysis. He participated in a team that conducted an SQA gap analysis on the bioassay code [Integrated Modules for Bioassay Analysis (IMBA)] based on DOE G 414.1-4 requirements. He identified safety analysis codes that were designated as DOE "toolbox" codes, and oversaw production of the first documents (QA criteria and application plan, code guidance reports, and gap analysis) for six accident analysis codes designated for the DOE Safety Software Toolbox.

He also was instrumental in providing leadership for completion of work packages for recent commercial projects. In the first, he teamed with Entergy on MACCS2 code applications and issue resolution in the Severe Accident Mitigation Alternatives (SAMA) analysis area for the Pilgrim Nuclear Power Station. In the second, he was part of tritium environmental release analysis team that supported evaluation of tritium control and management areas for the Braidwood plant. A third effort developed an initial SAMDA document for the Mitsubishi Heavy Industries (MHI) US-APWR (1610 MW_e evolutionary PWR), as well as complete a control room habitability study for postulated toxic chemical gas releases.

Dr. O'Kula was part of a Washington Group team that developed a Design Control Document (DCD) for the MHI US-APWR using input information from MHI. He was Chapter lead on Chapter 15 (Transient and Accident Analysis), and later transitioned to severe accident evaluation and documentation support to Chapter 19 (PRA and Severe Accidents). He currently is the Chapter 19 lead for PRA and Severe Accident for COLA development for the Pebble Bed Modular Reactor (PBMR).

He developed the outline, coordinated contributors, and assembled the first draft of the DOE *Accident Analysis Guidebook*, a reference guide for hazard, accident, and risk analysis of nuclear and chemical facilities operated in the DOE Complex. He is also the primary author and coordinator for the *Accident Analysis Application Guide* for the Oak Ridge contractor. Dr. O'Kula also developed a one-day course and exam for the guide, which he later presented to the Oak Ridge, Paducah, and Portsmouth staff.

Dr. O'Kula also led an independent V&V review for the DTRA of the U.K.-developed Urban Dispersion Model (UDM) software for predicting chemical and biological plume dispersion in city environments, and is leading projects to verify and validate chemical/biological simulation suite software applications for the Dugway Proving Ground (Utah), and the Edgewood Chemical Biological Center (ECBC) in Maryland.

Managing Member, Consequence Analysis

Dr. O'Kula was responsible for the consequence analysis associated with accident analysis sections of Documented Safety Analysis (DSA) reports and other safety basis documents for SRS, Oak Ridge, and other DOE nuclear facilities. He also developed the methodology and identified appropriate computer models for this purpose. Additionally, Dr. O'Kula developed training to enhance consistency and standardize analyses in the consequence analysis area. He was project manager for environmental assessment support to SRS on a transportation safety analysis using the RADTRAN code.

Dr. O'Kula coordinated development of a DOE Accident Analysis Guidebook involving over 10 sites and organizations. He also led the effort to produce Computer Model Recommendations for source term (fire, spill, and explosion), in-facility transport, and dispersion/consequence (radiological and chemical) areas.

Westinghouse Savannah River Company **1989 to 1997**
Group Manager

Dr. O'Kula managed consequence analyses associated with accident analysis sections of DSA reports and other safety basis documents. He also developed the associated methodologies and identified appropriate computer models. He was a member of the management team supporting Criticality Safety Evaluation preparation assisting Safe Sites of Colorado and the dispositioning of final criticality safety issues for the decommissioning and decontamination of nuclear facilities at the Rocky Flats Environmental Technology Site.

In a teaming arrangement with Science Applications International Corporation, Dr. O'Kula initiated discussions that led to development of an emergency management enhancement tool to better predict likely source terms. Applied to a Savannah River nuclear facility (K Reactor) and to the British Advanced Gas-Cooled Reactors (AGRs) (for the United Kingdom's Nuclear Installation Inspectorate). Model was knowledge-based, and required development of an Accident Progression Event Tree (APET) for the facility in question.

Dr. O'Kula managed the completion of the SRS K Reactor PRA program. He was the lead for development of the K Reactor Source Term Predictor Model and assisted with the core technology lay-up program to preserve competencies in reactor safety. He coordinated a 25-person group responsible for K Reactor probabilistic and deterministic dose analyses, and led the examination of reduced power cases at project termination. He developed risk and dose management applications to cost-effectively prioritize facility modifications.

Dr. O'Kula interfaced with DOE Independent and Senior Review teams to finalize study acceptance, and transitioned the risk assessment team to risk management functions for nuclear and waste processing facilities. In addition, he successfully prepared a 10 CFR 100 Siting white paper to resolve issues raised by the DNFSB, and teamed with DOE/HQ legal support to document resolutions. He led the development of a position paper demonstrating SRS Replacement Tritium Facility compliance with DOE Safety Policy (SEN-35-91).

Staff Engineer

Dr. O'Kula led an analytical team quantifying the tritium source term during a Loss of River Water design basis accident. He evaluated airborne tritium levels with multi-cell CONTAIN model, interfaced with a multidisciplinary team to resolve Operational Readiness Review concerns, developed an SRS-specific methodology for applying MACCS as a tool for Level 3 PRA Applications, and applied CONTAIN code for K Reactor source term analysis.

E.I. du Pont de Nemours & Company **1982 to 1989**
Principal Engineer, Research Engineer

Dr. O'Kula performed risk analysis duties for the Savannah River Laboratory (SRL) Risk Analysis Group, after earlier conducting research activities for the Reactor Materials and Reactor Physics Groups. He performed initial planning for offsite irradiation of test specimens to evaluate remaining reactor lifetime for Savannah River reactor components.

Westinghouse Electric Corporation **1975**
Summer Student, Reactor Licensing
Monroeville, PA

American Electric Power Corporation **1973 to 1974**
Co-op Student, Reactor Physics and Reactor Licensing
New York, NY

Long Island Lighting Company **1972**
Summer Intern
Riverhead, NY

Partial List of Publications (2000-2008):

K. R. O'Kula, D. C. Thoman, J. Lowrie, and A. Keller, *Perspectives on DOE Consequence Inputs for Accident Analysis Applications*, American Nuclear Society 2008 Winter Meeting and Nuclear Technology Expo, November 9-13, 2008 (Reno, NV).

K. R. O'Kula, F. J. Mogolesko, K-J Hong, and Paul Gaukler, *Severe Accident Mitigation Alternative Analysis Insights Using the MACCS2 Code*, American Nuclear Society 2008 Probabilistic Safety Assessment (PSA) Topical Meeting, September 7-11, 2008 (Knoxville, TN).

K. R. O'Kula and D. C. Thoman, *Modeling Atmospheric Releases of Tritium from Nuclear Installations*, American Nuclear Society Embedded Topical Meeting on the Safety and Technology of Nuclear Hydrogen Production, Control and Management, June 24-28, 2007 (Boston, MA).

K. R. O'Kula and D. C. Thoman, *Analytical Evaluation of Surface Roughness Length at a Large DOE Site (U)*, American Nuclear Society Winter Meeting, November 12-16, 2006 (Albuquerque, NM).

K. R. O'Kula and D. Sparkman, *Safety Software Guide Perspectives for the Design of New Nuclear Facilities (U),* Winter Meeting of the American Nuclear Society, November 13 – 17, 2005 (Washington, D.C.).

K. R. O'Kula and R. Lagdon, *Progress in Addressing DNFSB Recommendation 2002-1 Issues: Improving Accident Analysis Software Applications*, Fifteenth Annual Energy Facility Contractors Group Safety Analysis Workshop, April 30 – May 5, 2005, Los Alamos, NM (2005).

K. R. O'Kula and Tony Eng, *A "Toolbox" Equivalent Process for Safety Analysis Software*, Fourteenth Annual Energy Facility Contractors Group Safety Analysis Workshop, May 1-6, 2004, Pleasanton, CA (2004).

K. R. O'Kula, D. C. Thoman, J. A. Spear, R. L. Geddes, *Assessing Consequences Due to Hypothetical Accident Releases from New Plutonium Facilities (U)*, American Nuclear Society Embedded Topical Meeting on Operating Nuclear Facility Safety, November 14 – 18, 2004 (Washington, D.C.).

K. O'Kula and J. Hansen, *Implementation of Methodology for Final Hazard Categorization of a DOE Nuclear Facility (U)*, Annual Meeting of the American Nuclear Society, June 13-17, 2004, (Pittsburgh, PA).

K. R. O'Kula and Tony Eng, *A "Toolbox" Equivalent Process for Safety Analysis Software*, Fourteenth Annual Energy Facility Contractors Group Safety Analysis Workshop, May 1-6, 2004, Pleasanton, CA (2004).

K. R. O'Kula, et al., *Evaluation of Current Computer Models Applied in the DOE Complex for SAR Analysis of Radiological Dispersion & Consequences*, WSRC-TR-96-0126, Westinghouse Savannah River Company (2003).

K. R. O'Kula, et al., *Evaluation of Current Computer Models Applied in the DOE Complex for SAR Analysis of Radiological Dispersion & Consequences*, WSRC-TR-96-0126, Rev. 3, Westinghouse Savannah River Company (2002).

K. R. O'Kula, *A DOE Computer Code Toolbox: Issues and Opportunities*, Eleventh Annual EFCOG Workshop, also 2001 Annual Meeting of the American Nuclear Society, Milwaukee, WI (2001).

Publications (1988-1999):

Dr. O'Kula authored or co-authored more than 20 publications between 1988 and 1999. Details are available upon request.

Professional Societies and Standards Committees

- American Nuclear Society
- Health Physics Society
- Level 3 ANS PRA Standard Committee 58.25

EXHIBIT 2

CURRICULUM VITAE OF GRANT A. TEAGARDEN

Grant Teagarden

Manager
Consequence Analysis

AREAS OF EXPERTISE

- ***Level 3 PRA (MACCS)***
- ***Fire PRA***
- ***Security Risk Assessment***
- ***Level 2 PRA (MAAP)***
- ***Internal Flooding***
- ***Data Analysis***

EDUCATION

B.S. Mechanical Engineering, University of Miami, Florida

Bettis Nuclear Reactor Engineering School, Bettis Atomic Power Laboratory, Pennsylvania

SECURITY CLEARANCE

Secret

Safeguards

U.S. Citizen

WORK EXPERIENCE SUMMARY

Mr. Teagarden has over eleven years experience in the nuclear field, including four years as a Naval Reactors Engineer in the U.S. Navy. He has experience in Level 3 PRA consequence analysis, Fire PRA, plant security risk assessment, PRA updates, data and common cause failure analysis, integrated leak rate test extension evaluations, and internal flood updates.

WORK EXPERIENCE

Mr. Teagarden holds a Bachelor of Science degree in Mechanical Engineering from the University of Miami, Florida. He is responsible for Level 3 PRA consequence analysis and for providing support in the area of PRA model analysis. The following are some of his recent activities:

- Developed Level 3 PRA models (MACCS2) for Salem (2008), Hope Creek (2008), Diablo Canyon (2008), Progress Energy Levy County Site (2008), Harris Advanced Reactor Site (2007), General Electric's ABWR (2007) and ESBWR (2006, 2005), TMI (2006), Prairie Island (2006), Oyster Creek (2004), Exelon Early Site Permit (2004), Palisades (2004), and Monticello (2004)
- Developed quasi-site specific Level 3 PRA models (MACCS2) for every operating U.S. commercial nuclear power plant site in support of industry security assessments (2005)
- Member of ANS Level 3 PRA Standard Writing Committee
- Supported Fire PRA updates to NUREG/CR-6850 for LaSalle (2008), Clinton (2007) and Hatch (2007)
- Supported Aircraft Impact Analysis for MHI US-APWR (2008)
- Co-authored development of Risk Analysis and Management for Critical Asset Protection (RAMCAP) methodology for nuclear power plants in support of EPRI, ASME, and the U.S. Department of Homeland Security (DHS) and supports its implementation for NEI at all U.S. nuclear power plants (2007, 2006, 2005)
- Developed RAMCAP methodology for spent nuclear fuel dry storage and transportation in support of EPRI, ASME, and DHS, and supports its implementation for NEI (2007, 2006, 2005)
- Co-authored report for EPRI for identifying potential mitigation strategies for beyond design basis conditions (2005)
- Participated in the development of NEI industry guidance to resolve security related open issues related to large fires and explosions (i.e., B.5.b) at all U.S. nuclear power plants (2006, 2005)
- Authored Vulnerability Assessment Methodology for EPRI and NEI use for security threat analysis (2003)
- Co-authored report for EPRI for identification of mitigation strategies for scenarios involving loss of intake structure and offsite power (2004)
- Co-authored reports for EPRI and NEI use for operational response to beyond design basis security threats (2003)

PROFESSIONAL ORGANIZATIONS

American Nuclear Society

- Authored Explosive Threat Guidelines for EPRI and NEI use in response to NRC Interim Compensatory Measures (2002)
- Served as analyst for Integrated Leak Rate Test (ILRT) extension evaluations for Clinton (2006), Columbia (2004), Dresden (2003) and Quad Cities (2002)
- Served as analyst for Hope Creek and Quad Cities PRA Updates performing the common cause failure analysis and revisions to all the System Notebooks (2002)
- Served as analyst for NASA Space Shuttle PRA performing common cause failure analysis (2002)
- Performed pipe rupture and flooding analysis for Internal Flood updates for Hope Creek (2003), Dresden (2001), and Oyster Creek (2001)
- Performed system analysis and pipe rupture evaluation for Limerick ISLOCA analysis (2001)
- Converted Fault Tree and Event Tree computer models from RISKMAN to CAFTA for Fermi 2 Level II analysis (2001)
- Served as analyst for Initiating Events evaluation for Limerick (2001)

Prior to working for ERIN Engineering, Mr. Teagarden worked four years as a Naval Reactors Engineer in the U.S. Navy for the Department of Energy. He was principally involved in refueling operations, providing technical support and oversight for the nuclear refueling of the eight reactors on the USS Enterprise Aircraft Carrier. Mr. Teagarden's responsibilities included oversight of reactor disassembly, spent fuel removal and shipout, and reactor reassembly.

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	Docket Nos. 50-247-LR and 50-286-LR
ENTERGY NUCLEAR OPERATIONS, INC.	)	ASLBP No. 07-858-03-LR-BD01
(Indian Point Nuclear Generating Units 2 and 3	)	September 21, 2009

ENTERGY NUCLEAR OPERATIONS, INC. RESPONSE TO THE STATE OF NEW YORK'S STATEMENT OF MATERIAL FACTS NOT IN DISPUTE

Pursuant to 10 C.F.R. §§ 2.1205(b) and 2.710(b), Entergy Nuclear Operations, Inc. ("Entergy") respectfully submits this response to the State of New York's Statement of Material Facts Not in Dispute that it filed in support of Contention NYS-16/16-A. Entergy sets forth its statement-by-statement response to NYS's assertions in correspondingly numbered paragraphs.[1]

A. Entergy's Response to NYS's Purported Undisputed Material Facts

1. The Indian Point Nuclear Power Station (the "Indian Point Station") is located in the Village of Buchanan in the northwest corner of Westchester County on the eastern bank of the Hudson River. Draft Supplemental Environmental Impact Statement, Draft NUREG-1437, Supplement 38 ("DSEIS") at § 2.1, p. 2-1.

Response Undisputed as to the general location of the Indian Point Nuclear Power Station.

2. The Indian Point reactors and spent fuel pools are approximately 24 miles north of the New York City line, and approximately 37 miles north of Wall Street, in lower Manhattan. *Id.*

[1] The evidence cited by Entergy in this response is set forth in the accompanying Joint Declaration of Kevin O'Kula and Grant Teagarden in Support of Entergy's Answer Opposing New York State's Motion for Summary Disposition of Contention NYS-16/16A. ("Joint Decl.").

Response Disputed to the extent that DSEIS Section 2.1 does not provide a distance from Indian Point to Wall Street.

3. The station is approximately three miles southwest of Peekskill, with a population of 22,441; five miles northeast of Haverstraw, with a population of 33,811; 16 miles southeast of Newburgh, with a population of 31,400; 17 miles northwest of White Plains, with a population of 52,802 and approximately 18 miles southwest of Brewster, New York. It is also 23 miles northwest of Greenwich, Connecticut; 37 miles west of Bridgeport, Connecticut and 37-39 miles north northeast of Jersey City and Newark, New Jersey. *Id.*

Response Undisputed as to the general location of the Indian Point Nuclear Power Station and distance to surrounding towns and cities. Disputed to the extent that Paragraph 3 refers to specific distances and populations not referenced in Section 2.1 of the DSEIS.

4. Portions of four counties - Westchester, Rockland, Orange, and Putnam - fall within the inner 10-mile Emergency Planning Zone, and significant population centers in New York, Connecticut, and New Jersey lie within the 50 mile Emergency Planning Zone. The U.S. Census Bureau estimated that New York City, located approximately 24 miles south of plant, had a population of 8,214,426 in 2006. *Id.*

Response Undisputed as to the distance to and estimated population of New York City; that the 50-mile radius from the Indian Point Nuclear Power Station includes parts of New York, Connecticut, and New Jersey; and that portions of the four cited counties are within the 10-mile plume exposure pathway Emergency Planning Zone ("EPZ").

5. More than 17 million people live within 50 miles of the Indian Point power reactors and spent fuel pools. *See* DSEIS at Figure 2-1; p.2-3. Indian Point also has the highest surrounding population within 50 miles of any operating nuclear power plant in the Nation. April 17, 1973 Atomic Energy Commission Report Population Distribution Around Nuclear Power Plant Sites, Appendix B, Figures 2 & 4, PDR Fiche No. 8111120800.

Response Undisputed as to the estimated population living within 50 miles of the Indian Point Nuclear Power Station. Disputed to the extent that paragraph 5 compares the current population surrounding Indian Point to other operating reactor sites based on a 1973 Atomic Energy Commission Report.

6. The Indian Point Station is on a point of land in the Hudson River valley that protrudes into the Hudson River as the river bends west. DSEIS at § 2.2.5.1, p.2-33. The region surrounding the Indian Point site has undulating terrain with many peaks and valleys. DSEIS at § 2.1.

Response Undisputed as to the general location of the Indian Point Nuclear Power Station on the Hudson River and as to the general description of the surrounding terrain.

7. On the west side of the Hudson River one mile north of the station, is Dunderberg Mountain. *Id.* This mountain rises to a height of 1,086 feet above sea level at a distance of approximately 2.5 miles from the station. *Id.*

Response Undisputed as the general location and height of Dundenberg Mountain.

8. North of the Indian Point Station, the eastern bank of the river is formed by high grounds reaching an elevation of 800 feet; to the west across the river, the Timp Mountains reach an elevation of 844 feet. *Id.*

Response Undisputed as the general description of the Hudson River north of the Indian Point Nuclear Power Station. Disputed as to the fact that the Timp Mountains reach an elevation of 846, not 844 feet. DSEIS at pg. 2-2.

9. Releases from the station may come from near ground level sources or from stack vents with heights up to 334 feet and within 1-2 miles of high terrain features on the opposite side of the Hudson River, such as Dunderberg and the Timp Mountains, that rise well above the facility and well above the top of the 122 meter meteorological tower located onsite. *See* Declaration of Dr. Bruce Egan, sworn to August 28, 2009 ("Egan Decl."), ¶ 32; DSEIS § 2.1.1, p.2-2.

Response Disputed to the extent that the referenced section of the DSEIS does not refer to or contain information regarding sources or heights of station releases used in the SAMA analysis. For SAMA analysis purposes, releases are generally modeled to occur at a specific height somewhere in the range of the ground level (in view of a failure low in the containment) to the top of the reactor containment (in view of a failure near the top of containment). NRC-approved industry SAMA guidance (NEI 05-01) suggests the use of a distance of approximately one half containment height. The IPEC SAMA analysis followed this guidance and uses a release height of 30 meters. Joint Decl. at ¶ 84.

10. The DSEIS relies on the MACCS2 computer code output to calculate the economic cost of a hypothetical severe accident at Indian Point. DSEIS at § 5.2.2, p. 5-2.

Response Disputed as incomplete. Entergy's assessment of SAMAs for IP2 and IP3 was based on the most recent IP2 and IP3 PSAs, a plant-specific offsite consequence analysis performed using MACCS2 computer code, and insights from the IP2 and IP3 individual plant examination and individual plant examination of external events. DSEIS at § 5.2.2, p. 5-5; Joint Decl. at ¶ 42. Additionally, MACCS2 is only used to compute off-site economic costs. SAMA also includes on-site related costs which are not based on MACCS2. Joint Decl. at ¶ 44.

11. In order to carry out the MACCS2 analysis it is necessary to calculate the dispersion of airborne radiation following the hypothetical severe accident. United States Department of Energy Office of Environment, Safety and Health, MACCS2 Computer Code Application Guidance for Documented Safety Analysis: Final Report (June 2004) at 4-1 ("MACCS2 Guidance") (annexed to the Egan Declaration as Exhibit 10).

Response Undisputed as to the fact that the ATMOS module of the MACCS2 code models dispersion, transport, deposition, and radioactive decay of airborne radiation following hypothetical severe accidents. Joint Decl. at ¶ 49. Disputed to the extent that Paragraph 11 implies the cited Department of Energy reference applies to NRC-required SAMA analyses, including those performed for IP2 and IP3. Joint Decl. at ¶ 77-80.

12. Atmospheric dispersion modeling is the field of predicting the fate and consequences of releases of contaminants into the atmosphere. *See* Egan Decl. at ¶ 18.

Response Undisputed as a broad, general description of atmospheric dispersion modeling, but disputed as to the word "fate," which is ambiguous and undefined. Disputed as to the relevance of such a general description to the IP2 and IP3 SAMA analysis.

13. Dispersion models are routinely used for determining compliance with ambient air quality standards by state and federal agencies, for assessing the incremental changes in air quality levels associated with the permitting of new facilities and for health risk assessments for nuclear energy facilities. *Id.*

Response Disputed to the extent that Paragraph 13 implies that unidentified air dispersion models that may be used by state and federal agencies to determine compliance with ambient air quality standards are relevant to the IP2 or IP3 SAMA analysis. Different dispersion analysis codes have been developed over the years with different purposes in mind, including evaluating air quality for the EPA. The MACCS2 code, including the ATMOS module, was specifically developed for probabilistic severe accident analyses such as those performed for the IP2 and IP3 SAMA analysis. Additionally, it is disputed as incomplete because dispersion models also are used to develop economic estimates as is required for a SAMA analysis. Joint Decl. at ¶¶ 20, 23, 44-45, 55, 66, 96.

14. Dispersion models use meteorological and emission rate information as inputs to mathematical algorithms that simulate the transport and dispersion of air pollutants. *Id.*

Response Undisputed as a broad, general description of atmospheric dispersion modeling. Disputed to the extent this assertion suggests such a general description is sufficient to describe the purpose and design of a SAMA analysis as required for IP2 and IP3.

15. Dispersion models estimate the ambient air concentrations, deposition rates of particles to ground surfaces at all places of interest and for different averaging times. Models can include chemical or nuclear atmospheric transformation algorithms to estimate dosages to exposed populations. *Id.*

Response Undisputed as a broad, general description of atmospheric dispersion modeling. Disputed to the extent this assertion suggests such a general description is sufficient to describe the purpose and design of a SAMA analysis as required for IP2 and IP3.

16. The precision required for the model to determine air dispersion of the pollutant of interest depends upon the precision required in the result. Egan Decl. at ¶ 19.

Response Disputed because "precision" and "result" are undefined and therefore ambiguous. Further disputed to the extent that Paragraph 16 implies that a particular level of precision is required for the IP2 and IP3 SAMA analysis. The SAMA analysis is performed as an integrated process evaluating a spectrum of radiological source terms and more than hundred weather sequences to achieve a sufficient statistical basis on which to evaluate overall risk and reasonable alternatives for a broad spectrum of releases. Joint Decl. at ¶ 58.

17. Where the purpose of the air dispersion model is to predict the actual exposure of individuals in the path of the pollutant plume in order to assign a monetary cost to the full extent of the potential health risk, and then to quantify in monetary terms the cost savings that can be achieved by mitigating that exposure, the air dispersion model must have a high degree of accuracy to avoid either understating or overstating the economic costs and benefits involved. Egan Decl. at ¶ 25.

Response Disputed because "actual exposure" and "high degree of accuracy" are undefined and therefore ambiguous. Furthermore, disputed to the extent that Paragraph 17 implies that a particular level of accuracy is required for the IP2 and IP3 SAMA analysis. As noted previously, the SAMA analysis is specifically performed to achieve a sufficient statistical basis on which to evaluate overall risk and "reasonable" alternatives (as required by NEPA) for a broad spectrum of releases. *See* Environmental Review for Renewal of Nuclear Power Plant Operating Licenses, 61 Fed. Reg. at 28,481. Singular efforts, looking at worst-case conditions and resulting consequences, are not the appropriate point of reference in a SAMA study. Joint Decl. at ¶¶ 58-59.

18. The need for accuracy in the predictive model is particularly important where the number of individuals who could be exposed to the pollutant, the level of such exposures and the duration of such exposures is greatly impacted by the actual path the pollutant plume follows once it is released from the source. Egan Decl. at ¶ 26.

Response Disputed to the extent that Paragraph 18 implies that a particular level of accuracy is required for the IP2 and IP3 SAMA analysis or that the IP2 and IP3 SAMA analysis must model a particular pollutant path. Nearly all nuclear plant sites have variations in population concentrations in the 50-mile analysis region. Because of such variations, the MACCS2 code includes a unique analytical feature (used in the IP2 and IP3 SAMA analysis) by which each weather trial of each radiological release plume is rotated through the 16 compass sectors (*i.e.*, 360 degrees) in order to appropriately capture statistical variations associated with population distribution. Joint Decl. at ¶¶ 20, 86.

19. The need for accuracy in the predictive model is also particularly important where the economic cost of mitigation measures and the economic benefits of mitigation measurements are fairly close, such as within a factor of 2 of each other. Egan Decl. at ¶ 27.

Response Disputed to the extent that Paragraph 19 implies that a particular level of accuracy is required for the IP2 and IP3 SAMA analysis and to the characterization of the SAMA results as "fairly close." Disputed because SAMA also includes the consideration of on-site costs in the cost-benefit decision making. Furthermore, SAMA addresses uncertainty for each SAMA candidate as part of the cost benefit decision making. Joint Decl. at ¶¶ 43-44; DSEIS, Vol. App. G, Section G.6.

20. MACCS2, as relied upon the DSEIS, relies on an air dispersion model to calculate the dispersion of airborne radiation following the hypothetical severe accident. MACCS2 Guidance, Egan Decl., Ex. 10.

Response Undisputed as a general description of the ATMOS module within the MACCS2 code.

21. The model used by MACCS2 as applied to the Indian Point site and relied upon in the DSEIS is called ATMOS. *See* Answer Of Entergy Nuclear Operations, Inc. Opposing New York State Notice Of Intention To Participate and Petition to Intervene (Jan. 22, 2008), at 110; MACCS2 Guidance, Egan Decl., Ex. 10.

Response Undisputed

22. ATMOS is a steady-state straight line Gaussian plume model which assumes that any emissions from the Indian Point Station are imbedded in an air mass having a single wind speed that flows for each period of simulation in a single straight line direction. Egan Decl. at ¶ 35. The atmospheric stability classification is also assumed to be constant over that time period. *Id.* Thus each simulation will result in a prediction that the pollutants will theoretically travel in a straight line to infinity or to the limits of the computational domain, regardless of topographical features that might render such a trajectory impossible. *Id.*

Response Disputed as incomplete because the straight-line assumption is based on a statistical mean, which is consistent with the purpose of a SAMA analysis, and it is otherwise impossible to model and accurately identify infinite singular events. Joint Decl. at ¶ 59.

23. The concentrations of contaminants within the plume are assumed to have a maximum value along the plume centerline and to fall off in a bell shaped, Gaussian distribution curve with distance away from the plume centerline. Egan Decl. at ¶ 35.

Response Undisputed as a general description of Gaussian distribution where a "normal distribution" is described as bell shaped.

24. High terrain in the potential path of the plume introduces several complicating factors into dispersion analyses:

a. The presence of high terrain distorts and changes the directions of approaching winds as the flow cannot pass through the terrain.

b. The distortion of the flow direction materially changes the downwind destination of pollutant material emitted into the airflow and also, for elevated emissions, changes the proximity of contaminants to the ground surface increasing the ground level concentrations.

c. The presence of valley sidewalls together with radiational cooling will cause drainage flows that further distort air flow directions.

d. High terrain may degrade the reliability of a single meteorological station of being representative of the transport wind speed and direction needed by the model, especially for longer distance transport calculations, because wind directions measured near the surface will vary with location. The effect is most pronounced during lighter wind and stable atmospheric conditions that occur at night.

Egan Decl. at ¶¶ 20, 21, 23.

Response Disputed to the extent that Paragraph 24 implies that terrain in the vicinity of Indian Point causes the IP2 and IP3 SAMA analysis to be unreliable or insufficient for its intended purpose, and to the extent that it implies that the Indian Point site meteorological station is insufficient for its intended purpose. While terrain variations have the potential to impact the dispersion associated with any specific release (which may be important for other analytical purposes), the SAMA analysis is concerned with statistical mean results for the 50-mile radius region associated with a broad spectrum of releases because it is otherwise impossible to accurately predict "distortions," "material changes" or other behavior of singular events of infinite variables for purposes of a SAMA analysis. Additionally, meteorological variation (*e.g.*, wind speed and direction) is incorporated in the SAMA analysis using multiple years of data and sampling techniques as part of the development of the mean results. Because of the large areas involved, required statistical analytical approach, and use of cumulative regional mean values, terrain variations generally have no significant impacts on the 50-mile dose output mean value. Joint Decl. at ¶¶ 85-88.

25. For the Indian Point site, from a meteorological air flow perspective, the presence of the river, nearby terrain features and non-homogeneous ground surface features all affect the overall air flow patterns, which in turn affect the rates of vertical and horizontal mixing of any pollutants released from the plant. Egan Decl. at ¶ 38.

Response Disputed. See Response to Paragraph 24 above.

26. For the Indian Point site, the presence of high terrain features that rise above the height of the meteorological towers at the Indian Point station means that the wind speeds and directions measured on the towers are unlikely to be representative of the larger scale flow patterns that carry contaminants from the plant to the surrounding areas. Egan Decl. at ¶ 39.

Response Disputed. See Response to Paragraph 24 above.

27. For the Indian Point site, in the case of terrain features across the river, the flow will either turn and pass along the side or rise over the feature depending upon atmospheric stability conditions. Thus, air pollution imbedded in the air flow will not take the straight line trajectory across the valley that would be predicted by ATMOS using data from the Indian Point meteorological tower. *Id.*

Response Disputed. See Response to Paragraph 24 above.

28. The Indian Point Station is located in a turning part of the Hudson River. *See* United States Department of the Interior Geological Survey maps, annexed to the Egan Declaration at Exhibit 3; *see also* Egan Decl. ¶ 34.

Response Undisputed

29. The high terrain of Dunderberg Mountain to the west distorts and turns winds which might be measured to be from the east at the anemometer at the primary tower location. Egan Decl. ¶ 34.

Response Disputed. See Response to Paragraph 24 above.

30. Under overall light wind conditions, even though the Hudson is still tidal at the Indian Point location, the net average downstream movement of the river water and the effects of drainage induced airflows will favor movement of air above and near the river surface to be down river. *Id.*

Response Disputed. See Response to Paragraph 24 above.

31. For the Indian Point site, under the more stable atmospheric conditions associated with greater ground level impacts, the plume is likely to be turned down the overall river valley, as it cannot pass through the terrain. Egan Decl. ¶ 39.

Response Disputed. See Response to Paragraph 24 above.

32. A second effect of mountainous terrain occurs for sources, like Indian Point, located in river valleys because of the presence of the valley side walls on creating drainage flows. Egan Decl. ¶ 40.

Response Disputed. See Response to Paragraph 24 above.

33. For the Indian Point site, at night when the earth's surface cools by radiation, the air in contact with the surface cools and being heavier than other air at that elevation, flows, under the forces of gravity, down the valley slopes toward the base of the valley. In the absence of other influences, the pooling of the heavier air at the low point of the valley cross section, causes that air to then tend to flow down river following the valley contours. *Id.*

Response Disputed. See Response to Paragraph 24 above.

34. For the Indian Point site, the presence of high terrain causes increased turbulence generated by the air having to flow close to the surface of terrain features and the mixing also associated with the thermal flows generated by the radiational heating and cooling. Egan Decl. at ¶¶ 39, 40.

Response Disputed. See Response to Paragraph 24 above.

35. ATMOS, as implemented in the DSEIS SAMA analysis, did not account for the variations created by the Indian Point terrain as set forth in paragraphs 23-33, *supra*. Egan Decl. ¶ 37.

Response Disputed. See Response to Paragraph 24 above.

36. For over three decades atmospheric scientists and meteorologists have been identifying problems in the use of models similar to ATMOS for complex terrain settings like Indian Point. *See* Steven R. Hanna, Gary A. Briggs, Rayford P. Hosker, Jr., National Oceanic and Atmospheric Administration, Atmospheric Turbulence and Diffusion Laboratory, *Handbook on Atmospheric Diffusion* (1982) (excerpt annexed to the Egan Declaration as Exhibit 11); Egan Dec. ¶ 59.

Response Disputed to the extent that paragraph 36 implies that criticism of certain undefined dispersion models suggests that the ATMOS model is deficient or has been rejected by knowledgeable experts. The MACCS2 code, including the integral ATMOS module, is a mature model for Probabilistic Safety Assessment (PSAs) and related applications. The MACCS2 code including ATMOS has been used—and is still being used—by nearly all nuclear power plants in the U.S. to support PSAs and also license renewal. MACCS2 currently has a large U.S. and international user community for nuclear reactor and nonreactor safety analysis. The MACCS2 code is the only publicly available software package in the U.S. currently capable of fulfilling all of the tasks necessary to support the full offsite consequence process in a SAMA analysis. For purposes of analyses such as SAMA, the Gaussian plume modeling approach has been routinely implemented by practitioners in this field to assess patterns involving terrain changes of the magnitude discussed in the NYS motion. Joint Decl. at ¶ 57. Further disputed to the extent that NYS characterizes Indian Point as having a unique "complex terrain pattern" inasmuch as many if not most U.S. commercial nuclear plants have terrain variations in the 50 mile region analyzed for SAMA that would be classified as "complex terrain" as defined by NY in its Motion for Summary Disposition. Joint Decl. at ¶ 83.

37. Different air dispersion models can be used depending upon the application and regulatory requirements. For example, EPA recommends simple screening models (EPA, SCREEN3, or CT SCREEN) that are structured to provide conservative concentration estimates for simple pass or fail determinations. Egan Decl. ¶ 24. If the estimates fail the test, *i.e.*, if the concentrations are too high for regulatory purposes, the modeler would have an option of using a more refined model and more appropriate meteorological input data in further analyses. *Id.*

Response Undisputed to the extent that different air dispersion analysis codes have been developed through the years with different purposes in mind. Joint Decl. at ¶ 66. Disputed to the extent that Paragraph 37 implies that EPA air dispersion models could or should be used for the IP2 and IP3 SAMA analysis, and that EPA's actions with regard to screening models are relevant to the IP2 and IP3 SAMA analysis. The MACCS2 code is the only publicly available software package in the U.S. currently capable of fulfilling all of the tasks necessary to support the full offsite consequence process in a SAMA analysis. The ATMOS module is integral to the MACCS2 code and the user has no option of choosing a different dispersion modeling module. Joint Decl. at ¶¶ 58, 95.

38. Even these screening models must be appropriate for the terrain in which the source is located. SCREEN3 is appropriate for sources located in flat terrain. CTSCREEN is appropriate for complex terrain. *Id.*

Response See Response to Paragraph 37 above.

39. Where the goal is to ascertain the total amount of a pollutant to which a population would be exposed in the event of a release and the population density varies depending upon the direction and distance the plume takes following the release, screening technologies would be

inappropriate because they could not provide a reliable upper limit exposure value without artificially assuming that all the released pollution reached the areas of highest population. Egan Decl. ¶ 24.

Response See Response to Paragraph 37 above.

40. Generally, the selection of a dispersion model depends critically upon the complexity of the meteorology and terrain influencing a release from a source, and at what downwind distances the concentration projections are needed. In flat terrain settings, homogeneous surface characteristics (*e.g.*, surface roughness, albedo and Bowen ratio) and relatively evenly distributed populations of interest the simple straight-line Gaussian plume model algorithm is often appropriate. Egan Decl. ¶ 28.

Response Disputed to the extent Paragraph 40 implies that use of the ATMOS module in the MACCS2 code is inappropriate or insufficient for the terrain surrounding Indian Point for purposes of SAMA analysis. For purposes of analyses such as SAMA, the Gaussian plume modeling approach has been adopted routinely by practitioners in this field for terrain changes of the magnitude discussed in the NYS motion. Furthermore, the MACCS2 code is the only publicly available software package in the U.S. currently capable of fulfilling all of the tasks necessary to support the full offsite consequence process in a SAMA analysis. Joint Decl. at ¶¶ 57-58.

41. The Industrial Source Complex (ISC3ST) model (a Gaussian plume model) was used for such permitting applications by EPA until it was replaced in 2005 by AERMOD. United States Environmental Protection Agency (2005) *Appendix W to Part 51 – Guideline on Air Quality Models*, 40 CFR Ch. I (11-9-05 Edition) at 68218-68261; Egan Decl. ¶ 28.

Response Disputed to the extent that Paragraph 41 implies that EPA air dispersion models could or should be used for the IP2 and IP3 SAMA analysis, and that EPA's actions with regard to ISC3ST or other air quality models are relevant to the IP2 and IP3 SAMA analysis. The ATMOS module is integral to the MACCS2 code, and the user has no option of choosing a different dispersion modeling module. Joint Decl. at ¶ 95.

42. The ISC3ST model was not deemed suitable for calculating concentrations on terrain elevations above the height of the source. This limitation was the reason that EPA sought the development of models appropriate for complex terrain settings. Egan Decl. ¶ 28.

Response Disputed. See response to Paragraph 41 above. Furthermore, NYS identifies no support for inferring EPA's purported rationale for seeking alternative models, and EPA's reasoning is, in any event, irrelevant to this NRC proceeding. Joint Decl. at ¶¶ 93-94.

43. After the CTMD project, sources located in complex terrain (defined by EPA as terrain that exceeded the height of the release) were required to use complex terrain screening models or refined models such as CTDM-PLUS. *See* 40 C.F.R. Part 51, Appendix W: Guideline on Air Quality Models at 18453; Egan Decl. ¶ 28.

Response Disputed to the extent that Paragraph 43 implies that EPA air dispersion models could or should be used for the IP2 and IP3 SAMA analysis, and that EPA's actions with regard to CTDM-PLUS or other air quality models are relevant to the IP2 and IP3 SAMA analysis. Joint Decl. at ¶¶ 93-94.

44. The adoption of AERMOD as a refined model for both simple (flat) and complex terrain settings obviated the need for separate refined dispersion models. United States Environmental Protection Agency (2005) *Appendix W to Part 51 – Guideline on Air Quality Models*, 40 C.F.R. Ch. I (Nov. 9, 2005) (70 Fed. Reg. 68218 (Nov. 9, 2005)); 40 C.F.R. Part 51, Appendix W: Guideline on Air Quality Models; Egan Decl. ¶ 28.

Response Disputed to the extent that Paragraph 44 implies that EPA air dispersion models could or should be used for the IP2 and IP3 SAMA analysis, and that EPA's actions with regard to AERMOD or other air quality models are relevant to the IP2 and IP3 SAMA analysis. Joint Decl. at ¶¶ 93-94. Furthermore, disputed to the extent NYS purports to characterize the relative advantages of AERMOD without discussing corresponding limitations or the context in which it is being applied.

45. AERMOD was developed for applications within 50 Km (about 31 Miles) of a source. Egan Decl. ¶ 29.

Response Disputed. See response to Paragraph 44 above.

46. AERMOD was developed after more than a decade of efforts of many researchers to incorporate the greatly advanced understanding of boundary layer meteorology into the dispersion algorithms that were available when the Gaussian plume model was parameterized by Pasquill and Gifford. Egan Decl. ¶ 29; *see also* Egan Decl., Ex. 2 (Declaration of Dr. Bruce Egan in Support of the State of New York's Petition to Intervene (Nov. 27, 2007), at ¶¶ 22 – 26 (discussing boundary layer meteorology).

Response Disputed. See response to Paragraph 44 above.

47. The AERMOD model was subjected to extensive statistical model evaluations in a variety of terrain settings. Egan Decl. ¶ 29. These efforts showed that AERMOD represented a major improvement over the ISC3ST and other models. *Id.*

Response Disputed. See response to Paragraph 44 above.

48. The CALPUFF model is appropriate for simulating transport and dispersion in wind fields that change with space and time. Egan Decl. ¶ 30. It is often coupled to CALMET, a model that computes the needed wind and dispersion fields from meteorological data. *Id.*

Response Disputed to the extent that Paragraph 48 implies that EPA air dispersion models including CALPUFF or CALMET could or should be used for the IP2 and IP3 SAMA analysis, and that EPA's actions with regard to CALPUFF or other air quality models are relevant to the IP2 and IP3 SAMA analysis. Joint Decl. at ¶¶ 93-94. Furthermore, disputed to the extent NYS purports to characterize the relative advantages of CALPUFF or other models without discussing corresponding limitations or the context in which the model is being applied.

49. CALPUFF may also be coupled to a full mesoscale meteorological flow model such as MM5. *Id.* CALPUFF also has benefited from advances in the parameterization of wind fields and turbulent dispersion over the past four decades. *Id.*

Response Disputed. See response to Paragraph 48 above.

50. CALPUFF is routinely used in both simple and complex terrain settings to estimate ambient air concentrations at distances beyond the recommended 50 kilometer upper limit of AERMOD. *Id.* The air flow fields used by CALPUFF generally use data from more than one meteorological station in order to estimate concentrations at large distances from a source. *Id.*

Response Disputed. See response to Paragraph 48 above.

51. The NRC, in Part 2 of a 2009 Presentation to the National Radiological Emergency Planning Conference ("NRC 2009 Presentation"), concluded that straight-line Gaussian plume models cannot accurately predict dispersion in a complex terrain such as the Indian Point site and are therefore scientifically defective for that purpose. *See* Stephen F. LaVie, Sr. Emergency Preparedness Specialist, United States Nuclear Regulatory Commission, Power Point Presentation: *What's in the Black Box Known as Emergency Dose Assessment?* Prepared for the 2009 National Radiological Emergency Planning Conference (relevant excerpt annexed to the Egan Declaration as Exhibit 3; the full presentation is available at ML091050226, ML091050257, and ML091050269 (page references used here refer to the portion attached, Part 2, ML091050257)).

Response Disputed to the extent that Paragraph 51 implies that the referenced presentation on Emergency Planning represents the views of the NRC or served as a policy statement or interpretative guidance of the agency. Further disputed that the referenced presentation has any relevance to the SAMA analysis conducted for IP2 and IP3, and disputed that the characterization of NRC's conclusions with regard to straight-line Gaussian plume models used in SAMA analyses. Review of that presentation and related conference materials indicates that the presentation was given as part of a "training workshop" on radiological dose assessment for personnel in the field of emergency planning—not risk analysis. Joint Decl. at ¶¶ 64-65. For purposes of severe accident risk analysis, the Gaussian plume model remains the nationally-accepted approach in the industry due to its computational efficiency, which is needed to support the development of statistically significant input combinations required to present results in a risk context. Joint Decl. at ¶¶ 62-63.

52. The NRC in its 2009 Presentation, states that the "most limiting aspect" of the basic Gaussian Model, is its "inability to evaluate spatial and temporal differences in model inputs." NRC 2009 Presentation, Slide 28. Because ATMOS is non-spatial, it cannot account for the effect of terrain on the trajectory of the plume - that is, the plume is assumed to travel in a straight line regardless of the surrounding terrain. Therefore, it cannot, for example, "'curve' a plume around mountains or follow a river valley." NRC 2009 Presentation, Slide 33.

Response See Paragraph 51 above. Also disputed to the extent that Paragraph 52 implies that the referenced 2009 NRC presentation discussed the ATMOS module – it did not.

53. The NRC 2009 Presentation also acknowledges the "gravity sink" phenomenon that could cause the plume to travel down river towards New York City from a valley site such as Indian Point. Egan Decl. ¶ 45. As Slide 46 explains, the air in a valley is not heated directly by the sun but by heat convection from the earth. *Id.*; NRC 2009 Presentation, Slide 46. At night the earth cools and because higher elevations cool faster, cool air flows toward warmer air in the valley. This flow is described by the NRC as "gravity drainage," and in the absence of other meteorological influences (such as high wind speeds), the drainage will tend to flow down river. *Id.*

Response Disputed. See response to paragraph 51.

54. In its introduction to a discussion of advanced air dispersion models, the NRC 2009 Presentation summed up the Gaussian model's inability to project dispersion in a complex terrain:

> In many Gaussian models, terrain height is addressed only in determining the effective plume height.
>
> The impact of terrain on plume transport is not addressed.

Straight-line models can not "curve" a plume around mountains or follow a river valley. NRC 2009 Presentation, Slide 33.

Response Disputed. See response to Paragraph 51 above.

55. The NRC 2009 Presentation discussed the methods of more advanced models that can address terrain impact on plume transport, including models in which emissions from a source are released as a series of puffs, each of which can be carried separately by the wind. NRC 2009 Presentation Slides 35, 36.

Response Disputed. See response to Paragraph 51 above. Also disputed to the extent that Paragraph 55 implies that other, unnamed air dispersion models that may be used for Emergency Planning or other purposes are relevant to IP2 and IP3 SAMA analysis. Joint Decl. at ¶ 65.

56. Lawrence Livermore National Laboratory conducted a study apparently intended to compare the results of using a Gaussian, a two-dimensional and a three-dimensional model. *See Comparison of Average Transport and Dispersion Among a Gaussian, A Two-Dimensional and a Three-Dimensional Model*, Lawrence Livermore National Laboratory (Oct. 2004) ("Livermore Report"), annexed to the Egan Declaration at Exhibit 5.

Response Undisputed.

57. The study did not compare the results for a discrete event such as a postulated severe accident. *Id.*

Response Disputed as incomplete because the release, although short in duration (30 minutes), was significant and provides insights relative to severe accident releases. Joint Decl. at ¶¶ 70-75.

58. The study did not compare the computer generated results with actual measurements to see how close any of the models came to predicting reality. *Id.*

Response Undisputed.

59. The study was conducted in terrain that was fairly homogenous with little vertical variations and no major valleys, mountains or rivers. *Id.*

Response Disputed as incomplete because while terrain effects were minimal for this site, the test grid was subject to localized meteorological phenomena, such as frequent low-level nocturnal jets and occasional severe storms. These conditions would affect the transport and diffusion of a plume in a manner similar to terrain changes along the path of travel. Joint Decl. at ¶ 72.

60. The study found the results of the ATMOS model when compared to the most sophisticated of the models used - the LODI model - produced average differences of as much as a factor of two: "All of the arc average and the great majority of the arc-sector average exposures and depositions are within a factor of two when comparing MACCS2 to the state-of-the- art model, LODI." *Id.* at 72.

Response Disputed to the extent NYS characterizes the LODI model as the "most sophisticated" without discussing the purpose for which the model was designed, its specific strengths and weaknesses, or the context in which it is applied. Further disputed to the extent that it is implied that a factor of two is viewed as unacceptably disparate. The study results were judged to show good agreement between the MACCS2 code and the three dimensional model. Joint Decl. at ¶ 74.

61. The authors included a strong caveat cautioning about the use of simple straight line Gaussian models in complex terrain. *See id.* at 72 ("this study was performed in an area with smooth or favorable terrain and persistent winds although with structure in the form of low-level nocturnal jets and severe storms. In regions with complex terrain, particularly if the surface wind direction changes with height, caution should be used.")

Response Disputed as to the characterization of the cited study including a "strong caveat." Although terrain effects were minimal for this site, the test grid was subject to localized meteorological phenomena, such as frequent low-level nocturnal jets and occasional severe storms. These conditions would affect the transport and diffusion of a plume in a manner similar to terrain changes along the path of travel. Joint Decl. at ¶ 72.

62. In March 1996, the NRC issued RTM-96, Response Technical Manual, which contains "simple methods for estimating the possible consequences of different kinds of radiological accidents." T. McKenna, J. Trefethen, K. Gant (ORNL), J. Jolicoeur, G. Kuzo, G. Athey, United States Nuclear Regulatory Commission, Incident Response Division, Office for Analysis and Evaluation of Operational Data, RTM-96: Response Technical Manual (NUREG/BR-0150, Vol. 1, Rev. 4) (Mar. 1996)(annexed to the Egan Declaration as Exhibit 7). In the glossary of that document, the NRC's definition of "Gaussian plume dispersion model" states that such models have important limitations, including the inability to "deal well with complex terrain." *Id.*

Response Disputed to the extent it fails to distinguish between dispersion analysis for emergency planning purposes and risk assessment. Joint Decl. at ¶¶ 20, 96. Further disputed as incomplete because NYS fails to discuss the corresponding benefits of the model, the model's intended purpose and the context in which it is applied.

63. In December 2005, as part of a cooperative program between the governments of United States and Russia to improve the safety of nuclear power plants designed and built by the former Soviet Union, the NRC issued a Procedures Guide for a Probabilistic Risk Assessment, related to a Russian Nuclear Power Station. United States Nuclear Regulatory Commission/Brookhaven National Laboratory, NUREG/CR-6572, Rev. 1, Kalinin VVER-1000 Nuclear Power Station Unit 1 PRA: Procedure Guides for a Probabilistic Risk Assessment (Dec. 2005) (ML060450618). The Guide, prepared by the Brookhaven National Laboratory and NRC staff, explained that atmospheric transport of released material is carried out assuming Gaussian plume dispersion, which is "generally valid for flat terrain." *Id.* at 3-114. However, the Guide

contained the caveat that in "specific cases of plant location, such as, for example, a mountainous area or a valley, more detailed dispersion models may have to be considered." *Id.*; Egan Decl. at ¶ 55.

<u>Response</u> Disputed to the extent that it is implied that the terrain in the vicinity of Indian Point causes the IP2 and IP3 SAMA analysis to be unreliable or insufficient for its intended purpose. Joint Declaration at ¶¶ 76, 87. Further disputed to the extent that the referenced Guide does not reject use of the straight-line Gaussian plume model for locations where terrain is varied. Joint Decl. at ¶ 76. Further disputed to the extent that many if not most U.S. commercial nuclear plants have terrain variations in the 50 mile region analyzed for SAMA that would be classified as "complex terrain" as defined by NY in its Motion for Summary Disposition. Joint Decl. at ¶ 83.

64. The U.S. Department of Energy ("DOE") has also acknowledged problems with the ATMOS simple straight line Gaussian plume model in the MACCS2 Code when used in complex terrain. For example, the Radiation Safety Information Computational Center ("RSICC") of DOE's Oak Ridge National Laboratory has a summary description of the MACCS2 Code in its Code Package CCC-652. *See* RSICC Code Package CCC-652, *MACCS2 Ver. 1.13.1: MELCOR Accident Consequence Code System for the Calculation of the Health and Economic Consequences of Accidental Atmospheric Radiological Releases* (Abstract dated May 1997, revised June 1998, March 2004, June 2005)(annexed to the Egan Declaration as Exhibit 9). Under the heading "Restrictions or Limitations," the RSICC unequivocally states that "the atmospheric model included in the code does not model the impact of terrain effects on atmospheric dispersion." *Id.* (emphasis added).

<u>Response</u> Disputed as to the characterization of "problems" and disputed as incomplete; Entergy respectfully refers the Board to the document for a complete account of DOE's assessment. Further disputed to the extent that it implies that DOE recommends against the use of MACCS2 for purposes similar to SAMA analysis. DOE safety basis analysis differs from SAMA analysis. DOE safety basis analysis is concerned with the dose to a single individual at a particular location, and therefore the results are more sensitive to the potential impacts of terrain variation than for probabilistic analysis performed for SAMA. Nonetheless, DOE Standard DOE-STD-3009-94, Appendix A endorses the Gaussian plume model for individual dose calculations. Joint Decl. at ¶¶ 77-80.

65. In June 2004, the U.S. Department of Energy's Office of Environment, Safety and Health issued a final report entitled MACCS2 Computer Code, Application Guidance for Documented Safety Analysis. United States Department of Energy Office of Environment, Safety and Health, *MACCS2 Computer Code Application Guidance for Documented Safety Analysis: Final Report* (June 2004)(annexed to the Egan Declaration as Exhibit 10). In Table 2-1, Summary Description of MACCS2 Code Software, under the heading Restrictions or Limitations, the Guidance also states "the atmospheric model included in the Code does not model the impact of terrain effects on atmospheric dispersion nor can it accept more than one weather spatial location." *Id.* at 2-5. Table 6-1, entitled "Limitations of Gaussian Plume Model in MACCS2 and MACCS," describes the "terrain sensitivity" of the Gaussian plume model as "flat earth" to "gently rolling" and instructs that "complicated terrain over the region of transport may require Lagrangian particle or other models." *Id.* at 6-1.

Response Disputed. See Response to Paragraph 64 above.

66. More recently, the NRC revised their Regulatory Guide 1.23, Meteorological Monitoring Programs for Nuclear Power Plants. *See* United States Regulatory Commission, Regulatory Guide 1.23, Meterological Monitoring Plan for Nuclear Power Plants (Rev. 1, Mar. 2007) (annexed to the Egan Declaration as Exhibit 13). Regulatory Guide 1.23 recognizes the important relationship between meteorological measurements and atmospheric dispersion modeling. *See id.*, Introduction at 3:

> Thus, each nuclear power plant has multiple needs for an onsite program to measure and document basic meteorological information. These data may be used to develop atmospheric transport and diffusion parameters that with *appropriate* atmospheric dispersion models, may be used to estimate potential radiation doses to the public resulting from actual routine or accidental releases of radioactive materials to the

> atmosphere or to evaluate the potential dose to the public and control room as a result of hypothetical reactor accidents....This regulatory guide describes a suitable onsite program to provide meteorological data to estimate these impacts."

(emphasis added).

Response Undisputed as to the fact that RG 1.23 has been recently revised and includes the quoted section, but disputed as incomplete. Entergy respectfully refers the Board to the document for a complete account of the authors' assessment. Disputed as to the relevance of RG 1.23 to the SAMA analysis and to the extent that Paragraph 66 implies that additional meteorological monitoring or instrumentation is required for the SAMA analysis. Joint Decl. at ¶ 76. IP2 and IP3 are in full compliance with applicable meteorological monitoring regulations and requirements.

67. Regulatory Guide 1.23 also states that the program should be capable of providing the meteorological information needed to make several assessments including: "a realistic assessment by both the applicant and the regulatory staff of the potential dispersion of radioactive materials from, and the radiological consequences of, a spectrum of accidents to aid in evaluating the environmental risk posed by a nuclear power plant in accordance with Subpart A to 10 CFR Part 51." *Id.* at 5. On page 11, the section entitled *Special Considerations for Complex Terrain Sites* states that the program "should provide an adequate basis for atmospheric transport and diffusion estimates ... [within 8 kilometers (5 miles) in each downwind sector]" (brackets in original) and mentions special "complex flow patterns in nonuniform terrain" and "circulation for a hill-valley complex or a site near a large body of water." *Id.* at 11. The Regulatory Guide also states that "[t]he plant's operational meteorological monitoring program should provide an adequate basis for atmospheric transport estimates within the plume exposure emergency planning zone [i.e., within approximately 16 kilometers (10 miles)]." *Id.*

Response Undisputed as to the cited contents of RG 1.23. Disputed as to the relevance of RG 1.23 to the SAMA analysis and to the extent that Paragraph 67 implies that additional meteorological monitoring or instrumentation is required for the SAMA analysis. IP2 and IP3 are in full compliance with applicable meteorological monitoring regulations and requirements. Furthermore, disputed for the reasons set forth in response to paragraph 66.

68. The inability of a simple Gaussian plume model to accurately predict air transport and dispersion in complex terrains is discussed in a textbook for a college-level introductory course in environmental science and engineering. In listing the assumptions that are made to develop a simple straight line Gaussian plume model, the textbook warns that:

> The equation is to be used over relatively flat, homogeneous terrain. It should not be used routinely in coastal or mountainous areas, in any area where building profiles are highly irregular, or where the plume travels over warm bare soil and then over colder snow or ice-covered surfaces.

ENVIRONMENTAL SCIENCE AND ENGINEERING, J. Glynn Henry & Gary W. Heinke (Prentice- Hall 1989) at 528.

Response Disputed as an incomplete quote from the cited reference. Entergy respectfully refers the Board to the cited source for a complete account of the authors' discussion. Disputed as to the relevance of that reference to the IP2 and IP3 SAMA analysis. Also disputed to the extent that Paragraph 68 implies that terrain in the vicinity of Indian Point causes the IP2 and IP3 SAMA analysis to be unreliable or insufficient for its intended purpose. Although terrain variations have the potential to impact the dispersion associated with any specific release (which may be important for other analytical purposes), the SAMA analysis is concerned with statistical mean results for the 50-mile radius region associated with a broad spectrum of releases. To support such a multifaceted analysis, a computationally efficient approach is required, such as that afforded by a Gaussian plume model. Joint Decl. at ¶¶ 21, 28, 35, 58-61.

B. **Entergy's Statement of Material Facts As to Which It Contends There is a Material Issue to Be Heard.**

1. Whether Entergy conducted the SAMA analysis for IP2 and IP3 in accordance with established NRC and industry guidance.

2. Whether Entergy reasonably relied upon the ATMOS module for conducting the SAMA analysis at Indian Point.

3. Whether the MACCS2 and incorporated ATMOS module reasonably account for variations in population and terrain surrounding Indian Point to conduct a SAMA analysis.

4. Whether the MACCS2 and incorporated ATMOS module reasonably estimate for purposes of a SAMA analysis the number of people who would be exposed, and the concentration of doses they would receive, in case of a severe accident at Indian Point.

5. Whether the domestic nuclear industry continues to routinely employ and accept the ATMOS module for SAMA analyses.

6. Whether the NRC has deemed ATMOS unreliable or unsuitable for the SAMA analysis at Indian Point or other domestic power reactors.

7. Whether it is reasonable or practicable to incorporate any plume dispersion module other than ATMOS into MACSS2 for the SAMA analysis for Indian Point.

8. Whether NYS has demonstrated that modeling variable terrain conditions like those at Indian Point using a code other than ATMOS would have any material effect on the SAMA analysis by identifying additional cost-beneficial SAMAs.

Respectfully submitted,

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OPERATIONS, INC.

Dated in Washington, D.C.
this 21st day of September 2009

DB1/63676827.1

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	Docket Nos. 50-247-LR and
	)	50-286-LR
ENTERGY NUCLEAR OPERATIONS, INC.	)	
	)	
(Indian Point Nuclear Generating Units 2 and 3)	)	
	)	September 21, 2009

CERTIFICATE OF SERVICE

I hereby certify that copies of (1) "Applicant's Answer Opposing New York State's Motion for Summary Disposition of Contention NYS-16/16A (Regarding Use of ATMOS Module of MACCS2 in SAMA Analyses)," dated September 21, 2009; (2) "Joint Declaration of Kevin O'Kula and Grant Teagarden in Support of Entergy's Answer Opposing New York State's Motion for Summary Disposition of Contention NYS-16/16A," dated September 18, 2009; (3) supporting Exhibits 1 and 2; and (4) "Entergy Nuclear Operations, Inc. Response to the State of New York's Statement of Materials Facts Not in Dispute;" dated September 21, 2009 were served this 21st day of September, 2009 upon the persons listed below, by first class mail and by e-mail as shown below.

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