Indian Point Nuclear Generating Units 2 and 3
Docket Nos. 50-247/ 50-286-LR

NRC Staff's Response in Opposition to State of New York's Motion for Partial Summary Disposition of NYS Contention 16/16A

Exhibit 2

October 13, 2009

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

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

AFFIDAVIT OF ROBERT L. PALLA CONCERNING THE STATE OF NEW YORK'S MOTION FOR PARTIAL SUMMARY DISPOSITION OF NYS CONTENTION 16/16A

I, Robert L. Palla, do hereby state as follows:

1. I am employed as a senior reactor engineer in the Office of Nuclear Reactor Regulation of the United States Nuclear Regulatory Commission ("NRC" or "Commission"). I am responsible for technical evaluations of license applications and policy issues in the areas of severe accident progression and phenomena, containment performance, offsite consequences, and risk management. I have been conducting such evaluations at NRC since 1981, including the evaluations of Severe Accident Mitigation Alternatives ("SAMAs") for over 40 plants in support of initial plant licensing, advanced reactor design certification, and operating reactor license renewal. A statement of my professional qualifications is attached as Exhibit ("Ex.") B.

2. This affidavit is written to provide general information concerning the performance of a SAMA analysis and the role served by meteorological modeling in a SAMA analysis.

3. A Severe Accident Mitigation Alternative is an additional feature or action which might be implemented at a nuclear power plant in order to further reduce the risk to the public associated with a severe reactor accident at the plant. NUREG/CR-1437,

Volume 1, Generic Environmental Impact Statement for License Renewal of Nuclear Plants, at 5-106 (attached as Ex. C); Nuclear Power Plant Accident Considerations Under the National Environmental Policy Act of 1969, 45 Fed. Reg. 40,101 and 40,103 (June 13, 1980).

4. A SAMA analysis is a systematic process that is used to identify, rank, and screen potential SAMAs, taking into account the estimated benefits associated with any risk reduction (generally expressed in terms of averted dollar cost) and the estimated implementation costs of each SAMA. NUREG-1555, Supplement 1, Revision 1, Environmental Standard Review Plan ("ESRP"), at 5.2-4 – 2-6 (attached as Ex. D).

5. The scope of the potential SAMAs that could be considered in a SAMA analysis includes changes to plant hardware, plant procedures, and operator training programs. Nuclear Energy Institute, Severe Accident Mitigation Alternatives (SAMA) Analysis Guidance Document ("NEI-05-01") at 23 (2005) (attached as Ex. E). The scope of potential SAMAs also includes SAMAs that reduce the likelihood of damage to the reactor core and SAMAs that reduce the likelihood or magnitude of releases from the reactor containment building. ESRP at 5.2-1.

6. The scope of the severe accidents considered in a SAMA analysis includes the full scope of reactor accidents that are important to plant risk, to the extent that such information is available. NEI 05-01, Ex. E, at 5. This would generally include internally-initiated events such as loss of coolant accidents, and externally-initiated accidents such as seismic events. ESRP, Ex. D, at 5.2-5; NEI 05-01, Ex. E, at 4 – 11.

<u>Information Utilized to Support the SAMA Analysis</u>

7. Ideally, a full-scope, plant-specific probabilistic risk assessment ("PRA") study would be available to support the SAMA evaluation. This would include a Level 1, Level 2, and Level 3 analysis, with consideration of both internally- and externally-initiated core damage events, as well as low-power and shutdown modes of operation.

NRC Regulatory Guide 1.174, An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis ("RG 1.174"), Rev. 1, at 15 (2002) (attached as Ex. F).

8. A Level 1 PRA analysis provides identification and quantification of the sequences of events leading to the onset of core damage. NRC Fact Sheet, Probabilistic Risk Assessment ("PRA Fact Sheet"), (October 2007) (attached as Ex. G); American Society of Mechanical Engineers, Addenda to ASME/ANS RA-S—2008, Standard for Level 1/Large Early Release Frequency Probabilistic Risk Assessment for Nuclear Power Plant Applications, at 14 (2009) (attached as Ex. H); NUREG/CR-2300, Volume 1, PRA Procedures Guide, at 2-18 (attached as Ex. I). A Level 2 PRA analysis provides an assessment of containment response and a characterization of the releases to the environment. PRA Fact Sheet; PRA Procedures Guide, Ex. G, at 2-19. A Level 3 PRA analysis provides an assessment of the offsite consequences and risks to the public associated with releases to the environment. *Id.* at 2-20. The MACCS2 code (with its associated Gaussian plume model) is a key element of a Level 3 PRA analysis; it is not part of either the Level 1 or Level 2 analysis.

<u>Process for Identifying and Evaluating Potential SAMAs</u>

9. In performing a SAMA analysis, a systematic process is used to identify, rank, and screen potential SAMAs for a specific nuclear power reactor. This process can be characterized as consisting of the following 4 major steps: (1) estimate the level of risk associated with potential reactor accidents, including identifying and characterizing the leading contributors to core damage frequency and offsite population dose; (2) examine the major risk contributors and identify possible SAMAs for reducing these contributors; (3) for each SAMA, estimate (a) the approximate reduction in risk (in terms of core damage frequency ("CDF"), population dose, and economic cost risk), (b) the dollar value of the reduction in risk (considering averted public exposure, averted

offsite property damage, averted occupation exposure and averted onsite costs), and (c) the SAMA implementation cost; and (4) compare the costs and benefits for each SAMA, including assessing the impact of key uncertainties on the factors identified above via bounding assumptions and sensitivity analyses, screening out SAMAs that would not be cost-beneficial even when uncertainties are considered, and performing more detailed cost-benefit analysis for remaining SAMAs to determine whether they warrant implementation.

10. A SAMA analysis provides a process for methodically screening potential improvements that might be implemented to reduce risk, and ultimately dispositioning the SAMAs based on both probabilistic and deterministic considerations. ESRP, Ex. D, at 5.1.1-5 – 1-6. The methodology and repeatability of a SAMA analysis is more important to developing usable conclusions regarding the potential effects of implementing any particular SAMA than the selection of a particular meteorological model.

Role of PRA in the License Renewal SAMA Evaluation Process

11. Probability and consequence information is used in a SAMA analysis performed for license renewal purposes, in considering potential alternatives and determining whether any potential alternative warrants implementation. ESRP, Ex. D, at 5.2-5; NEI 05-01, Ex. E, at 23 and 27 – 28.

12. In Step 1 of a SAMA analysis (as described above), the results of the Level 1 and Level 3 PRA are used to characterize the level of risk associated with potential reactor accidents. ESRP, Ex. D, at 5.2-5. The level of risk is typically expressed in terms of the CDF, the annual population dose (person-rem per year), and the major accident sequence and containment release modes contributing to these risk metrics. *Id.* Although the results of the Level 3 PRA are used to derive the risk metrics, this information is not used in Step 1 to either identify or assess potential SAMAs.

Rather, the evaluation of potential SAMAs is carried out as part of Steps 2 and 3 of the SAMA analysis. *Id.*

13. In Step 2 of the SAMA analysis, a set of SAMAs are identified. The results and insights from the plant-specific PRA study provide an important means of identifying potential SAMAs. This includes the results of PRA "importance analyses," which rank the initiating events, equipment failures, and operator actions that have the greatest impact on CDF and large early release frequency for the plant. These importance analyses are based on the Level 1 and Level 2 PRA and are not impacted by the Level 3 analysis or the atmospheric transport and dispersion (ATD) model. Other sources for identifying potential SAMAs are considered as well, including SAMA analyses performed for other operating plants that have submitted license renewal applications.

14. In Step 3 of the SAMA analysis, the potential SAMAs are further assessed and screened based on a number of considerations. In determining whether an alternative should be implemented, a cost-benefit analysis is performed using a methodology consistent with the NRC Regulatory Analysis Technical Evaluation Handbook (NUREG/BR-0184). This analysis identifies and estimates the relevant values and impacts of each candidate SAMA, and provides a structured approach for balancing benefits and costs in determining whether implementation is justified. NUREG/BR-0184, Regulatory Analysis Technical Evaluation Handbook, Final Report ("Regulatory Analysis Handbook"), at 5.20 – 5.49 (attached as Ex. J), NEI 05-01, Ex. E, at 27 – 29.

15. Within Step 3 of the SAMA analysis, the Level 1 PRA is used to evaluate the reduction in CDF that would be associated with implementation of each SAMA; the Level 2 PRA is used to evaluate the impact of each SAMA on containment release characteristics (for example, a shift in release characteristics from an un-scrubbed

release to a scrubbed release that might be associated with implementation of a filtered containment vent); and the Level 3 PRA results are used to evaluate the impact of the change in release characteristics (e.g., revised frequencies and magnitudes of release) on offsite consequence metrics, specifically, population dose and offsite economic impacts. NEI 05-01, Ex. E, at 16 – 22 and 28. An applicant's use of a PRA in this manner is an essential and widely accepted part of the cost-benefit methodology and has been used at a variety of nuclear plants with varied topography and meteorological conditions. Regulatory Analysis Handbook, Ex. J, at 5.22 – 5.49.

16. In Step 4 of the SAMA analysis, the costs and benefits of each SAMA are compared, the impact of key uncertainties are assessed, and SAMAs are screened and/or further assessed based on probabilistic and deterministic considerations. ESRP, Ex. D, at 5.2-5. The results of the Level 3 PRA are not an explicit consideration in this step, although the sensitivity of the Level 3 PRA (including population dose and offsite economic costs) to alternative assumptions is assessed. *Id.* This could include the sensitivity of results to alternative assumptions regarding meteorology data, release characteristics, and evacuation assumptions. *Id.*; NEI 05-01, Ex. E, at 30-32.

<u>Elements of the Cost-Benefit Analysis Impacted by the MACCS2 Calculation</u>

17. The economic costs of a severe accident can be divided into 4 major cost factors. These involve the costs associated with: (1) offsite public exposure, (2) offsite property damage, (3) occupational exposure during cleanup, and (4) onsite costs, including cleanup and decontamination costs and replacement power costs. Regulatory Analysis Handbook, Ex. J, at 5.22, 5.29, 5.37, and 5.40; NEI, Ex. E, 05-01 at 16-22. The dollar benefit associated with implementing a candidate SAMA is determined by assessing the degree to which the SAMA would reduce or avert each of these cost factors. NEI 05-01, Ex. E, at 28.

18. The Level 3 PRA, and in particular a PRA utilizing the MACCS2 code, is used to calculate several but not all of these cost factors. NEI 05-01, Ex. E, at 16-17. Specifically, population dose output values from the MACCS2 analyses are used to calculate Averted Public Exposure ("APE") costs; similarly, offsite economic cost output values from the MACCS2 analyses are used to calculate Averted Offsite Property Damage Costs ("AOC"). *See* Joint Sandia Declaration, Ex. 3, at ¶ 20. These two costs, combined, would account for about 70% of the cost of a severe accident at a nuclear reactor in a high-population area, like at the Indian Point site. Other economic costs are computed based on generic regulatory guidance and would not be impacted by changes in the dispersion model; such costs include Averted Occupational Exposure ("AOE"), Averted Cleanup Costs ("ACC") and Averted Replacement Power Costs ("ARPC").

Guidance on the Conduct of SAMA Evaluations and the Use of Offsite Consequence Codes

19. NRC regulations do not stipulate how the analysis of severe accident mitigation alternatives must be carried out; however, guidance is provided in various documents, including: NUREG-1555, Supplement 1, *Environmental Standard Review Plan*, Section 5.1.1, Severe Accident Mitigation Alternatives; NUREG/BR-0184, *Regulatory Analysis Technical Evaluation Handbook*, Section 5.7.5, Offsite Property; and NEI 05-01, *Severe Accident Mitigation Alternatives (SAMA) Analysis Guidance Document*, Section 3.4, Level 3 PSA Model.

20. The NRC Staff has used and is continuing to use the MACCS2 code for offsite consequence analyses for nuclear reactors, including reactor sites with more significant terrain variation than is found at Indian Point. *See* Frequently Asked Questions About State-of-the-Art Reactor Consequence Analysis (SOARCA), http://www.nrc.gov/about-nrc/regulatory/research/soar/faqs.html. The Staff's use of the

MACCS2 code for such purposes has been accepted by in every license renewal application that has been approved to date.

21. No other program is publicly available that offers all of the capabilities of the MACCS2 code. *See* NUREG/CR-6613, Volume 1, Code Manual for MACCS2, User's Guide ("MACCS2 User Guide"), at iii (1998) (attached as Ex. K). The MACCS2 code capabilities include modeling of multiple release scenarios; multiple weather conditions; emergency response actions (shelter, evacuate, relocate); fission product transport, deposition, and resuspension; multiple exposure pathways (cloudshine, groundshine, inhalation, and ingestion); and economic impacts.

<u>The Role of MACCS2 and Atmospheric Transport and Dispersion Modeling in SAMA Analysis</u>

22. The principal phenomena considered in the MACCS2 code are atmospheric transport and dispersion under time-variant meteorology, accident scenarios and releases, the range of short- and long-term mitigative actions, multiple exposure pathways, deterministic and stochastic health effects, and economic costs. Thus, ATD modeling, although important, is only one of many areas modeled in the MACCS2 code. MACCS2 User Guide, Ex. K, at 1-2. Variations in atmospheric transportation dispersion ("ATD") modeling effects, unless extremely divergent from the model used, would thus have only a limited effect on the overall SAMA analysis performed with the MACCS2 code.

23. ATD models do not calculate radiological or economic consequences of a release. *See* Joint Sandia Declaration, Ex. 1, at ¶ 17. Although ATD models, such as AERMOD or CALPUFF, may estimate ambient air concentrations and deposition rates of particles at places of interest, they cannot calculate the radiological and economic consequences of a severe reactor accident. *Id.* The use of such ATD models, in place

of ATMOS, would not take the place of a SAMA analysis, but would only vary one component of that analysis.

Average Expected Values Versus Worst Case, Single Weather Samples

24. In a SAMA analysis, the MACCS2 code is used to determine the expected consequences of a severe accident -- recognizing that the actual accident could be any one of the many accidents (commonly referred to as release categories) that are modeled in the PRA, and that such an accident could occur at any time during the life of the plant. NUREG/CR-6853, Comparison of Average Transport and Dispersion Among a Gaussian, a Two-Dimensional, and a Three-Dimensional Model, at 5 – 8 (2004) (Attached as Ex. L). This consideration requires that, within the SAMA calculation, the applicant must conduct a large number of weather samples or trials using site-specific data that are representative of the range of weather conditions that could exist at the actual time of the release. *Id.* The actual weather conditions that may exist at the time of an accident cannot be known in advance, so a probabilistic assessment of such conditions is performed.

25. Furthermore, the consequence parameters calculated by the MACCS2 code (e.g., short term and long term health effects and economic impacts) are much broader than the factors calculated by stand-alone ATD models.

26. The ATMOS module which is incorporated in the MACCS2 code atmospheric dispersion model has been criticized. Such criticisms are misplaced, in that only average or expected values of the metrics of interest are needed for SAMA purposes; a simplified ATD model, which averages the metrics of interest using numerous weather sequences on a one-by-one basis, compensates for the loss of structure or directional changes in the plume that occurs away from the point of release. The use of average or mean results in regulatory decision making is consistent with guidance provided in NRC regulatory guides as well as the Commission's policy

statement on use of PRA methods in nuclear regulatory activities, RG 1.174, Ex. F, at 21-22; Use of Probabilistic Risk Assessment Methods in Nuclear Regulatory Activities; Final Policy Statement, 60 Fed. Reg. 42622, 42629 (Aug. 16, 1995).

Consideration of Uncertainties in the SAMA Analysis

27. Consistent with the use of risk methods in other regulatory applications, a SAMA analysis is based on best estimate (mean value) risk estimates, but considers the potential impact of uncertainties on the results of the evaluation, i.e., whether additional SAMAs could be cost-beneficial given the uncertainties. ESRP, Ex. D, at 5.2.-5; NEI 05-01, Ex. E, at 30. In reaching a final decision regarding implementation of a SAMA, the Staff considers the margin between the estimated costs and benefits for the SAMA, together with the conservatism inherent in these estimates, and judges whether the margins and conservatism would cover any uncertainties. ESRP, Ex. D, at 5.2.-5; NEI 05-01, Ex. E, at 30.

28. Uncertainties in SAMA analyses derive from several sources, including uncertainties in CDF estimates, offsite consequence estimates, the estimated risk reduction for each candidate SAMA, and the estimated implementation costs for each SAMA. ESRP, Ex. D, at 5.2.-5; NEI 05-01, Ex. E, at 30; Regulatory Analysis Handbook, Ex. J, at 5.3 - 5.8. The impacts of uncertainties in some of these factors is offset by conservatively estimating the factors. NEI 05-01, Ex. E, at 30.

29. Uncertainties in the SAMA analysis are typically addressed through: (1) the use of conservative assumptions in the cost-benefit analysis (e.g., underestimating SAMA implementation costs by neglecting certain cost factors, or overestimating SAMA benefits by assuming the SAMA completely eliminates the sequences/failures it is intended to address), (2) the conduct of sensitivity analyses to explore the impact of alternative models or assumptions on SAMA results (e.g., differences in meteorology or the elevation of the fission product release), and (3) an assessment of the impact on

SAMA results if the benefits were based on the 95th percentile CDF rather than the mean CDF. NEI 05-01, Ex. E, at 30.

30. Although certain terrain features may be present at or near the Indian Point site, such as River Valley Palisades, these features are not unique to the IP site and are present at other sites where MACCS2 has been utilized successfully in performing SAMA analyses. Based on my review of NYS' New York State's Motion for Summary Disposition of Portions of NYS Contention 16/16A, and its supporting documentation, I am satisfied that inclusion of these topographic features in the MACCS2 analysis would not result in a material difference in the outcome of the Indian Point SAMA analysis. Further, I am satisfied that use of the MACCS2 code, including the ATMOS module incorporated therein, is appropriate for purposes of conducting a SAMA analysis for the Indian Point license renewal application.

Robert L Palla

Robert L. Palla

CIRCE E. MARTIN
NOTARY PUBLIC
MONTGOMERY CO., MD

Sworn and subscribed to

Before me this 13 th day of October, 2009.

My Commission expires March 1 2011

CIRCE E. MARTIN
NOTARY PUBLIC STATE OF MARYLAND
My Commission Expires March 1st 2011