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UNITED STATES
NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING BOARD

In re:	Docket Nos. 50-247-LR; 50-286-LR
License Renewal Application Submitted by	ASLBP No. 07-858-03-LR-BD01
Entergy Nuclear Indian Point 2, LLC, Entergy Nuclear Indian Point 3, LLC, and Entergy Nuclear Operations, Inc.	DPR-26, DPR-64 December 16, 2011

REPORT OF
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IN SUPPORT OF
CONTENTION NYS-16/16A/16B ("NYS-16B")

Prepared for the State of New York
Office of the Attorney General

Population Estimates for Evaluation of Severe Accident Mitigation Alternatives

Summary of finding

The Severe Accident Mitigation Alternatives (SAMA) report produced by Enercon for Entergy in December 2009 contained analysis based in part upon estimates of population for the region within 50 miles of the Indian Point Energy Center (IPEC) site in Buchanan, New York. The population estimates used in the SAMA report are based on U.S. Census of Population data that are combined with estimates of resident population growth provided by the states and municipalities to provide estimates of the resident population expected for the region in 2035. To these estimates adjustments are made for "transient" (tourists and business travelers) population in the region.

The resulting population estimates, used in the SAMA analysis, are deficient in two respects. First, by working from a base of census data the report fails to take into consideration the "undercount" of minority population that has been well-documented and even accepted by the Census Bureau. Second, by focusing only on the resident and transient populations, the report is neglecting the substantial number of workers who commute into the region from areas farther than 50 miles from IPEC. If the appropriate adjustments are made for these factors, the estimated 2035 population in the region increases from 19,228,875 persons[1] to 20,456,285 persons. This is an increase of approximately 1.2 million persons (6.38%) over the estimates used in the SAMA evaluation.

Overview of Entergy's SAMA population estimates

Entergy's 2007 SAMA analysis and 2009 SAMA reanalysis rely upon several important variables including estimates of the population that could be at risk from a serious accident at IPEC during the period of proposed relicensed operations extending to 2035. Entergy's determination of this population is made via several steps that are outlined in the consultant's report[2] and can be summarized as follows:

1. Determine those counties that are, in whole or part, within 50 miles of IPEC. This is illustrated in figure 1 below, where the red dot indicates the location of IPEC, the red ring indicates a distance of 50 miles from the plant, and county boundaries are outlined in black.

2. For those counties that are not entirely within the 50 mile radius, determine the percentage of land area within the county that is within the 50 mile radius.

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[1] Obtained by taking the product of the share of the county within the 50 mile radius of IPEC and the estimated resident plus transient population in each county, and adding across all counties.
[2] *Site Specific MACCS2 Input Data for Indian Point Energy Center, Revision 1* prepared for Entergy Nuclear Northeast by Enercon Services, Inc., section 2.3, page 2-5, Dec. 2009.

3. Determine the population of each county from 2000 US Census data.

4. Making use of state and municipal projections of population changes, determine the expected population for each county in 2035.

5. Making use of state and local estimates of "transient" population (average person-visits per day; business travelers and tourists traveling to or through each county and staying temporarily within the county) estimate the ratio of "permanent" to "transient" population for each county in 2004 (this ratio is assumed to remain constant through the proposed relicensing period).

6. Assuming that population in each county is distributed uniformly over the county, estimate the county permanent resident population in 2035 that is at risk from a serious accident (within 50 miles of IPEC) by multiplying the estimated 2035 population in each county (determined in step 4) by the percentage of the county within 50 miles of IPEC (determined in step 2).

7. Estimate the 2035 transient population in each county by multiplying the estimated permanent resident population in 2035 (obtained in step 6) times the transient to permanent population ratio determined in step 5 and assumed to remain constant through 2035.

8. Add the estimated permanent and transient populations together to obtain estimated population for each county in 2035. These are presented in table 2.3 on page 2-5 of the SAMA evaluation report prepared by Entergy's consultant.

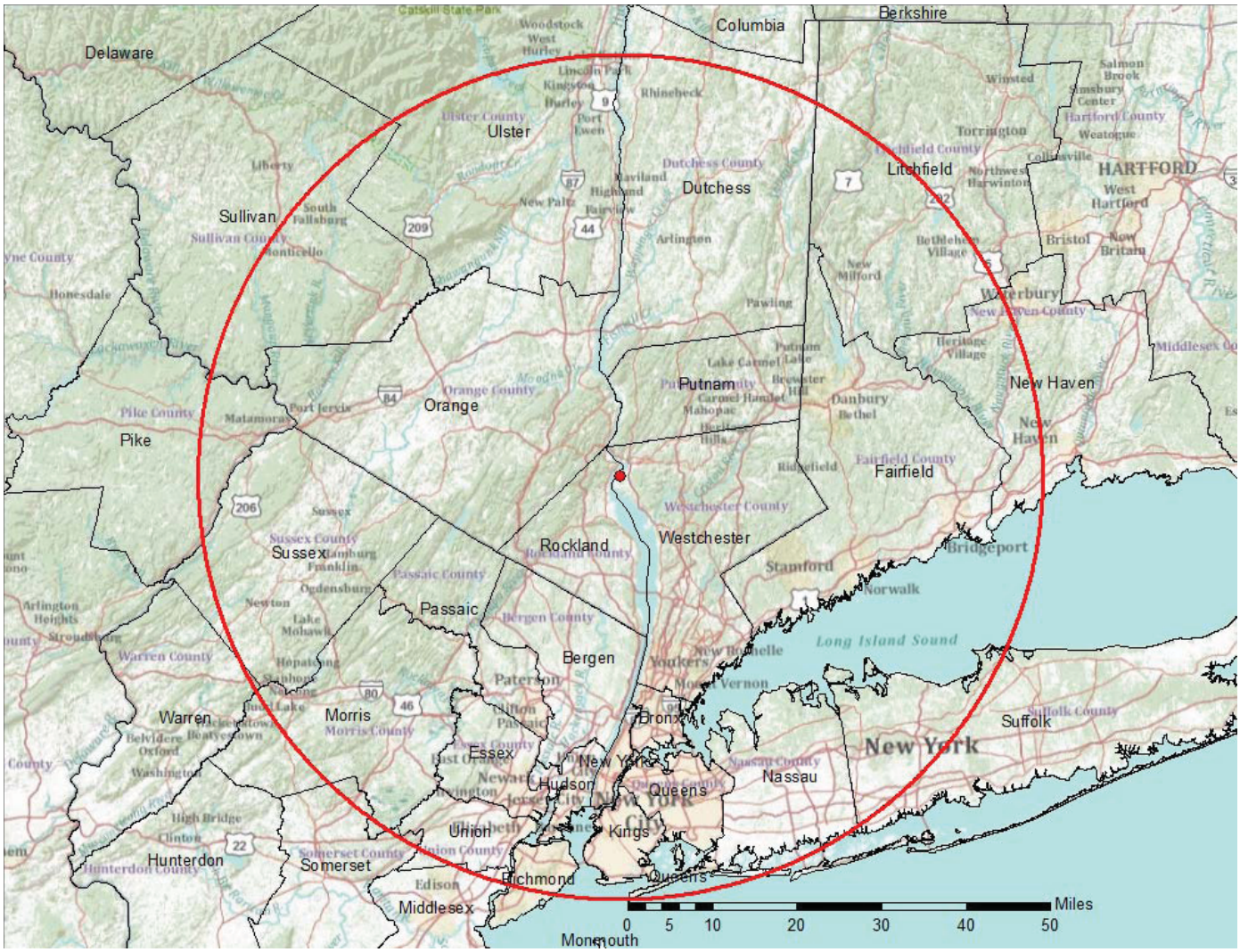

Figure 1: Region within 50 miles of IPEC

Through this procedure, Entergy's consultants obtained an estimate of the 2035 resident population within 50 miles of IPEC (shown in column 3 of Table 1 below) for each county, providing an estimated population of 18,879,657 persons residing within 50 miles of IPEC, plus an adjustment for the transient tourist and business traveler population of 349,218 persons within this area[3], bringing the total to 19,288,875 persons. Next, Entergy transferred the total population from source areas (county) to target areas (spatial elements, i.e. wind direction and buffer distance) by converting county population to a density measure and multiplying this density by the area that a county has in a given spatial element. This

[3] These estimates are presented in *Site Specific MACCS2 Input Data for Indian Point Energy Center, Revision 1* prepared for Entergy Nuclear Northeast by Enercon Services, Inc., section 2.3, page 2-5, Dec. 2009.

calculation produced a total population of 19,228,712 persons[4], which was then used as a central input into the MACCS2 model to complete Entergy's SAMA analysis.

Deficiencies in Entergy's SAMA population estimates

While there are some concerns that could be expressed about the growth rates assumed or the methods for predicting the transient population[5], there are two clear and unambiguous deficiencies in the SAMA population estimates that require further adjustment. First, an adjustment is required to compensate for the census "undercount" of population. Second, an adjustment is needed to account for the daily flow of commuter traffic from outside of the 50 mile zone to employment locations within the 50 mile radius of IPEC. I turn to these deficiencies and provide quantitative estimates of the required adjustments below.

(1) Failure to consider census undercount

Since at least the 1990s, there has been a clear understanding that the census of population conducted by the U.S. Census Bureau is subject to a systematic undercount.[6] This arises for a variety of reasons, but demographers and other scholars who have studied the problem have noted that the undercount is most severe for Black males and non-white Latino males, and in general, is higher for the non-white population than for persons who classify themselves as white. This has led to the hypothesis that these population subgroups may be less willing to cooperate with postal census forms or to make themselves known to census enumerators. Areas with particularly high minority populations may be particularly subject to census undercount.

Fortunately, the Census Bureau and other government agencies have recognized this problem and several studies have been undertaken that report estimates of the magnitude of the

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[4] This figure is 163 persons fewer than the result that is obtained by taking the product of the share of the county within 50 miles of IPEC reported in Table 1.1 of Entergy's *Site Specific MACCS2 Input Data for Indian Point Energy Center, Revision 1* report and the population projection for 2035 county population reported in Table 2.1 adjusted by the transient:permanent ratio presented in Table 2.2, which is equivalent to the methodology described at the beginning of section 2.4 of the report. This discrepancy could be due to rounding error in Entergy's reporting of the permanent:transient ratios or the percent of each county within the 50 mile radius of IPEC (or both). The discrepancy is 0.00085% of the population estimated by Entergy, and does not affect the central findings of this report.

[5] For example, linear regression was used for resident and transient population forecasting in 25 of the 28 counties, while polynomial regression was used for New York, Rockland, and Westchester counties in New York. Neither Entergy nor Enercon has given an explanation with the details of how these regressions were made, therefore, I was unable to check the accuracy of the regressions.

[6] J. Gregory Robinson, Bashir Ahmed, Prithwis Das Gupta and Karen A. Woodrow, "Estimation of Population Coverage in the 1990 United States Census Based on Demographic Analysis," *Journal of the American Statistical Association*, Vol. 88, No. 423 (Sep., 1993), pp. 1061-1071.

undercount.[7] Estimates have been made of the percentage of the entire population that was missed in census tabulations[8], the percentage of the entire population of individual states that was missed[9], and the percentage of various ethnic groups[10] that was missed by census enumerators.

Making adjustment for the undercounted population is important if we are to have the most accurate possible measure of the population that could be at risk in the event of a severe accident at IPEC. Fortunately, this adjustment is a relatively straightforward one. The U.S. Census Monitoring Board report[11] provides estimated undercount rates for the states in the region surrounding IPEC that range from 0.52% to 4.49%. Averaging the rates for various subgroups and rounding to the nearest percent gives 3% as a reasonable average percentage undercount. Assuming no undercount of the white population and applying this 3% undercount rate to the 2000 census figures for non-white population results in an overall estimated undercount of 1.11% in the IPEC region, slightly less than the 1.18% undercount estimated for the entire US.

In general, the growth rate of minority populations is somewhat faster than the growth rate of the population as a whole, but I conservatively assume that the growth rate from 2000 to 2035 for the uncounted minority population will be the same as that for the population as a whole in each county. Applying this growth rate and taking the share of land area in each county that is within 50 miles of IPEC (equivalent to assuming that the undercounted population in each county is uniformly distributed over the county) as the share of required county adjustment provides the adjustment for census undercount for each county provided in column 5 of Table 1 below.

(2) Failure to take into account commuter population

An additional deficiency in the SAMA report population estimates relates to the number of persons who would be present within 50 miles of IPEC during a substantial portion of the day, not because they permanently reside there, nor because they are transient overnight visitors to the area, but because they commute to workplaces that are within the area. Because such workers are part of the population potentially at risk from a severe accident, it is important to include them in the estimate of population in the area.

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[7] *See*, in particular, U.S. Census Monitoring Board, *Presidential Members Final Report to Congress,* Sep. 1, 2001, available online at http://govinfo.library.unt.edu/cmb/cmbp/reports/final_report/FinalReport.pdf and J. Gregory Robinson, *ESCAP II: Demographic Analysis Results*, Executive Steering Committee for A.C.E. Policy II Report No. 1, Oct. 13, 2001, and other references cited therein.
[8] About 1.18% for the entire U.S. in the 2000 Census, *ibid* p. 31, Table 3.
[9] About 0.97% for Connecticut, 1.15 percent for New Jersey and 1.09 percent for New York, *ibid* Appendix A, pp. 48, 69 and 72.
[10] *Ibid.*
[11] *Ibid.*

In order to estimate the number of commuters, I use data on county-to-county commuter flows in 2000 made available by the Census Bureau.[12] These data provide, for every county in the US, the estimated number of commuters coming into the county each day from any other individual county in the US. Thus these data can tell us how many commuters can be expected to come to workplaces within a 50 mile radius of IPEC from residential locations outside of this radius. Using these data, I estimated the total commuter flow into the area within 50 miles of IPEC by the following procedure:

1. For every county that is 100 percent within the 50 mile boundary:

    a. Take 100 percent of the average daily commuter flows into that county that come from counties that are completely outside of the 50 mile boundary.

    b. Take (100-S) percent of the average daily commuter flows into that county that come from counties that have S percent of their area within the 50 mile boundary.

2. For every county that is partially within the 50 mile boundary, where P percent is the percentage of land area in the county located within 50 miles of IPEC:

    a. Take P percent of the average daily commuter flows into that county that come from counties that are completely outside the 50 mile boundary.

    b. Take P×(100-S) percent of the average daily commuter flows into that county that come from counties that have S percent of their area within the 50 mile boundary.

Just as using the shares of land area within 50 miles of IPEC to adjust resident, transient, and undercounted population in each county was equivalent to assuming population in each county is uniformly distributed over the entire county, the steps outlined above add the assumption that employment locations are also distributed uniformly over the entire land area of each county.

Thus, for example, if a county has 25 percent of its land area within 50 miles of IPEC and 100 commuters come into that county from a county that is entirely outside of the 50 mile radius, we count 25 commuters as being present within the area that is being evaluated for SAMA (the other 75 are known to work in the county, but are assumed to be employed outside of the 50 mile radius). If 200 commuters come into this same county from a different county that has 50 percent of its area within 50 miles of IPEC, then 100 of those commuters are counted as already residing within the 50 mile boundary (and thus they are already counted under the resident population total) and the other 100 are counted as persons coming from outside the 50 mile area. Of these, 25 are counted as having employment within the area evaluated

[12] U.S. Census Bureau, *County-to-County Worker Flow Files* available at http://www.census.gov/population/www/cen2000/commuting/index.html.

for SAMA and the other 75 are counted as having employment farther than 50 miles from IPEC.

This procedure provides estimates of the commuter population in 2000 into that portion of each county that is within 50 miles of IPEC. Taking the county population growth rates from 2000 to 2035 used in the original report as a conservative estimate of growth in county employment, we apply those growth rates to total commuter population for each county to obtain the estimates provided in column 6 of Table 1.

Revised population estimates

Adding the populations in columns 3 through 6, in Table 1 below, together provides an improved estimate of the total population in the portion of each county located within 50 miles of IPEC. This improved estimate of 20,456,285 persons is 6.38 percent larger than both the 2035 projected population of 19,228,875 (county total), presented in the consultant's report, and 19,228,712 (spatial element total), used in Entergy's SAMA analyses.

Using a model to forecast future costs is inherently difficult and obtaining accurate results from these forecasts requires the most accurate inputs possible to this model. For this reason, it is important to correct this discrepancy because population forecasts are a critical input to the MACCS2 model used to evaluate the risk and expected economic consequences of a severe accident taking place at IPEC. As noted in Chanin, et al.[13], "MACCS2 is used to estimate the radiological doses, health effects, and economic consequences that could result from postulated accidental releases of radioactive materials to the atmosphere." The outputs of this model are therefore essential in understanding and planning for the potential risks and expected damages associated with a severe accident at IPEC. The use and accuracy of such models is only as good as the quality of the information that is provided for analysis. The model requires input of a specific allowable contamination level following an accident, and "[i]f contamination levels exceed a user-specified criterion, mitigative actions can be triggered to limit radiation exposures. If mitigative actions are triggered, the economic costs of these actions are calculated and can be reported. . . . Mitigative actions that can be specified for the emergency phase include evacuation, sheltering, and dose-dependent relocation.[14]"

Several of the mitigative actions that are analyzed by the model have costs that are directly related to the population that would be affected. If the inputs to the model include population estimates that are too low, then the estimates of economic damages and costs associated with a severe accident may also be too small. For this reason it is imperative that this error be corrected.

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[13] D. Chanin, M.L. Young, J. Randall and K. Jamali, *Code Manual for MACCS2: Volume 1, User's Guide*, NUREG/CR-6613
SAND97-0594, May 1998.
[14] *Ibid*, pp. 2-1, 2-2.

Table 1: Estimates of 2035 Population within 50 Miles of IPEC

County	Pct within 50 mi.	Resident Pop	Transient Pop	Undercount	Commuters	Total Pop
Fairfield	100.0	918,600	14,228	5,701	52,388	990,917
Litchfield	41.5	90,183	1,397	114	20,633	112,328
New Haven	32.9	294,904	4,568	1,823	85,165	386,459
Bergen	100.0	1,089,428	25,448	7,056	30,893	1,152,826
Essex	100.0	868,715	20,292	14,474	62,809	966,290
Hudson	100.0	690,981	16,140	9,208	30,913	747,242
Middlesex	1.8	18,963	443	180	7,739	27,325
Morris	80.8	527,786	12,328	2,026	83,176	625,317
Passaic	100.0	553,404	12,926	6,255	12,135	584,721
Somerset	4.5	21,156	494	131	9,169	30,950
Sussex	93.9	204,652	4,780	262	9,762	219,456
Union	92.9	548,682	12,816	5,369	69,446	636,315
Warren	0.5	780	18	1	256	1,056
Bronx	100.0	1,634,750	22,930	34,396	6,683	1,698,759
Dutchess	88.9	283,939	6,809	1,392	18,957	311,096
Kings	100.0	2,618,418	36,727	46,188	34,740	2,736,073
Nassau	97.9	1,225,359	29,384	7,610	78,710	1,341,063
New York	100.0	1,570,657	22,031	21,506	154,793	1,768,987
Orange	100.0	445,234	10,676	2,177	14,410	472,498
Putnam	100.0	120,738	2,895	222	1,251	125,106
Queens	100.0	3,024,717	42,426	50,742	47,269	3,165,154
Richmond	65.4	433,496	6,080	2,914	37,816	480,305
Rockland	100.0	278,799	6,685	1,931	1,779	289,195
Suffolk	21.3	317,533	7,614	1,467	87,491	414,106
Sullivan	36.3	34,142	819	150	6,724	41,835
Ulster	58.1	129,363	3,102	430	19,466	152,360
Westchester	100.0	914,934	21,939	7,865	8,702	953,440
Pike	18.7	19,343	3,222	40	2,503	25,108
Total		**18,879,657**	**349,218**	**231,632**	**995,778**	**20,456,285**

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