UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

COMMISSIONERS:

Stephen G. Burns, Chairman
Kristine L. Svinicki
William C. Ostendorff
Jeff Baran

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

CLI-16-07

<u>**MEMORANDUM AND ORDER**</u>

This proceeding concerns the application of Entergy Nuclear Operations, Inc. to renew

the operating licenses for the Indian Point Nuclear Generating Units 2 and 3. Following an

evidentiary hearing, the Atomic Safety and Licensing Board issued Partial Initial Decision

LBP-13-13, resolving nine contentions.[1] The State of New York petitioned for review of

LBP-13-13 to the extent that the decision resolved contention NYS-12C, an environmental

contention.[2] New York also petitioned for review of a subsequent Board order that declined to

reconsider LBP-13-13 or reopen the hearing record on NYS-12C.[3] Earlier this year, we granted

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[1] LBP-13-13, 78 NRC 246 (2013).

[2] *State of New York Petition for Review of Atomic Safety and Licensing Board Decision
LBP-13-13 with Respect to Consolidated Contention NYS-12C* (Feb. 14, 2014) (Petition).

[3] *State of New York Petition for Review of Atomic Safety and Licensing Board's April 1, 2014
Decision Denying the State's Motion to Reopen the Record and for Reconsideration of the*

review of New York's petitions for review and, given the complex technical arguments involving

NYS-12C, we directed the parties to provide further briefing on several questions.[4] Our decision

today is focused on the Board's resolution of NYS-12C.[5] As discussed below, we reverse

LBP-13-13 as it relates to NYS-12C and direct the Staff to supplement the Indian Point Severe

Accident Mitigation Alternatives (SAMA) analysis with sensitivity analyses.

I.   BACKGROUND

Below we describe briefly the purpose and nature of the SAMA analysis, New York's

arguments challenging the analysis, and the Board's decision.

A.   The Severe Accident Mitigation Alternatives Analysis

In NYS-12C, New York challenged the SAMA analysis for the Indian Point license

renewal application. A SAMA analysis is a mitigation analysis performed pursuant to the

National Environmental Policy Act (NEPA). NRC environmental regulations for license renewal

require a site-specific severe accident mitigation alternatives analysis if one was not previously

performed.[6]

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*Board's November 27, 2013 Partial Initial Decision Concerning Consolidated Contention
NYS-12C* (Apr. 28, 2014) (Petition for Review of April 1, 2014 Board Decision).

[4] *See* CLI-15-2, 81 NRC 213 (2015).

[5] We likewise took review of LBP-11-17 and LBP-10-13, both of which addressed Contention
NYS-35/36; we will address those appeals in a separate decision. We also received petitions
for review of LBP-13-13 insofar as the decision resolved two other contentions, NYS-8
(regarding transformers) and CW-EC-3A (regarding environmental justice). Our decision in
CLI-15-6 addressed those contentions. *See* CLI-15-6, 81 NRC 340 (2015).

[6] *See* 10 C.F.R. § 51.53(c)(3)(ii)(L). The NRC's Generic Environmental Impact Statement
(GEIS) for license renewal contains a generic analysis of the environmental impacts of severe
accidents. The GEIS analysis is bounding for all reactors, and therefore license renewal
applicants need not provide a site-specific analysis of severe accident environmental impacts.
The complete GEIS is included in the record as Exs. NYS00131A-I, "Generic Environmental
Impact Statement for License Renewal of Nuclear Plants," NUREG-1437 (May 1996). The
generic severe accident impacts analysis appears at *id.*, Vol. 1, Main Report, Final Report, at
5-12 to 5-116. The NRC issued a revised GEIS in June 2013, after the evidentiary hearing.

A SAMA analysis seeks to identify additional measures—hardware or procedures—that could be installed or implemented to reduce severe accident risk. The Staff's practice to date has been to conduct this NEPA mitigation analysis in the form of a quantitative cost-benefit analysis, comparing the benefits (e.g., averted accident risks) of specific mitigation measures against their implementation costs. The Staff's practice also has been to conduct the analysis as a probabilistic risk assessment, where the probabilities of different accident scenarios are taken into account. The SAMA analysis, therefore, is a probability-weighted assessment of the benefits of mitigation alternatives that may reduce risk by reducing the probability or consequences (or both) of potential severe accidents. These probability-weighted benefits are then compared with the implementation costs of the mitigation alternatives.

Of note, none of the mitigation alternatives evaluated in the SAMA analysis are measures the agency has deemed necessary for safety. They are supplemental to mitigation capabilities our safety regulations already require. As an ongoing matter, the NRC oversees the safety of reactor operations pursuant to the Atomic Energy Act of 1954, as amended, and may require licensees to implement new mitigation measures whenever warranted to assure adequate protection of public health and safety. The NEPA mitigation analysis conducted for license renewal helps to identify additional measures that may further reduce plant risk beyond that necessary for adequate protection of public health and safety.

Probabilistic risk assessment (PRA) is used in the SAMA analysis to calculate the probabilities and consequences of severe reactor accidents. PRA is carried out at three levels. The first is a probabilistic risk assessment of accident sequences that may lead to reactor core damage (Level 1 PRA). The second takes the output of the Level 1 PRA and examines accident progression leading to failure of the containment and release of radionuclides to the environment (Level 2 PRA). The third takes the results of the Level 2 PRA and goes on to estimate the potential offsite consequences (Level 3 PRA).

For the Level 3 portion of the SAMA analysis, the Staff has long used the MACCS2 computer code to calculate estimated offsite consequences (population doses and economic losses) for a spectrum of hypothetical severe reactor accidents modeled in the Level 1 and Level 2 PRA. In the case of Indian Point, for example, eight different categories of accidents or "bins" were modeled in the offsite consequence portion of the SAMA analysis, each representing a particular mix, amount, and timing of source term release.[7] For each designated accident category, the code models how the released radioactive material would be transported and dispersed in hypothetical severe reactor accidents occurring at any time over a year of potential weather scenarios (based on site-specific weather data for a representative year).

Typically, the SAMA analysis follows NRC cost-benefit analysis guidance documents.[8] Consequences are evaluated over a 50-mile radius area surrounding the nuclear power plant, divided into sixteen compass wind directions, and further divided into sequential rings reflecting incremental distances from the plant. For each accident scenario run, the MACCS2 code calculates the estimated concentration of the radioactive isotopes that would be deposited in each sector or "grid element" of the 50-mile radius map.[9] This mapping is run for all of the potential hourly weather that might occur over the course of a year. A representative year of site-specific hourly weather data (e.g., wind velocity and direction, atmospheric stability category, and precipitation intensity) are entered as inputs.

Data inputs for the offsite consequence analysis also include the population data for the 50-mile radius region (projected for the year 2035 for Indian Point), reactor core radionuclide

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[7] *See* Environmental Report, attached as Appendix E to License Application (Exs. ENT00015A-B), at E.1-93, E.3-87) (accident categories modeled with MACCS2 code ranged from NCF (no containment failure) to EARLY HIGH (early and high release)).

[8] *See* NUREG/BR-0058, Rev. 4, "Regulatory Analysis Guidelines" (Sept. 2004) (ML042820192); NUREG/BR-0184, "Regulatory Analysis Technical Evaluation Handbook" (Jan. 1997) (ML050190193).

[9] *See, e.g.*, Tr. at 1929-31.

inventory data, source term and release characteristics, and a large number of economic input data, including average county-wide farm wealth and non-farm wealth, population evacuation and relocation costs, depreciation costs for interdicted property, losses from banned agricultural products, and decontamination costs. Applying the population data, economic cost data, and other relevant inputs to the results of the plume modeling, the code calculates the estimated offsite costs (population dose and economic consequences) for the spectrum of accident scenarios evaluated. Population dose is converted to a monetary value through use of an NRC-recommended monetary conversion value (currently $2,000 per person/rem). All accident costs estimated in the analysis are probability-weighted, and therefore the frequencies of the various accident scenarios occurring (e.g., the particular combination of accident scenario, source term release, and weather) are factored into the analysis results.

We have emphasized that the SAMA analysis results are not based on either best-case or worst-case accident scenarios, but on "mean accident consequence values, averaged over the many hypothetical severe accident scenarios (with an additional uncertainty analysis also performed)."[10] More specifically, for each accident category evaluated, the SAMA analysis takes the mean annual consequences (mean total offsite dose and mean total offsite economic costs) over the examined 50-mile radius and multiplies these by the estimated frequency of the accident scenario occurring to obtain the population dose risk (PDR) and offsite economic cost risk (OECR), which the Board appropriately identified as the "key risk values of interest for determining potentially cost-beneficial SAMAs."[11] To identify those mitigation measures that may be cost-beneficial to implement, the SAMA cost-benefit analysis compares the cost of

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[10] *See*, *e.g.*, *Entergy Nuclear Generation Co. and Entergy Nuclear Operations, Inc.* (Pilgrim Nuclear Power Station), CLI-12-15, 75 NRC 704, 708 & n.12 (2012).

[11] *See* LBP-13-13, 78 NRC at 461; *Entergy Nuclear Generation Co. and Entergy Nuclear Operations, Inc.* (Pilgrim Nuclear Power Station), CLI-12-1, 75 NRC 39, 53-54 (2012).

implementing a new mitigation measure with its assessed potential to reduce severe accident

risk.

B.   Decontamination Modeling

Of particular interest in the Indian Point SAMA litigation are two inputs to the MACCS2

code: TIMDEC and CDNFRM. The TIMDEC input value defines the time required for

completing decontamination to a specified degree or level. The longer the TIMDEC, the longer

evacuated residents would remain away from their homes pending decontamination efforts and

the more dose decontamination workers would receive, both of which entail costs assessed in

the SAMA analysis. The CDNFRM input parameter defines the cost (on a per person basis) of

decontaminating non-farmland to a specified level. To obtain the cost of decontaminating non-

farmland areas, the code multiplies the specified CDNFRM parameter by the population residing

in the areas ("grid elements") requiring decontamination.[12]

Both decontamination time and decontamination cost are used in conjunction with

specified levels of decontamination called dose reduction factors (DSRFCT).[13]

Decontamination levels specify the effectiveness of the decontamination effort. A dose

reduction factor of 3, for example, means the population dose will be reduced by a factor of 3

(approximately 66%) compared to the radiological dose before cleanup. Similarly, a dose

reduction factor of 15 reflects a reduction in population dose by a factor of 15 (approximately

93%) compared to the dose before cleanup.[14] As the MACCS2 code user's guide describes,

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[12] *See* Ex. NYS000243, "Code Manual for MACCS2, User's Guide," NUREG/CR-6613, Vol. 1 (May 1998), at 7-9 to 7-11 (MACCS2 User's Guide). The decontamination costs relating to farmland are assessed on a per hectare basis and were not challenged in this proceeding.

[13] *Id.* at 7-9. Decontamination levels sometimes are referred to as decontamination factors (DF). *See id.* at 7-3. In this case, the Staff and New York often referred to the decontamination levels as decontamination factors.

[14] *Id.* at 7-11.

the "objective of decontamination is to reduce projected doses below the long-term dose criterion in a cost-effective manner."[15] Each decontamination level modeled in the code "represents an alternative strategy" for reducing population dose.[16]

The more heavily contaminated an area, the greater the decontamination effectiveness will need to be to reduce the projected radiological doses to a habitable level. Areas that are less contaminated may only require decontamination to achieve a DSRFCT of 3 to reduce population doses enough for the population to return, while more heavily contaminated areas may require decontamination to a DSRFCT of 15 or more to reduce doses sufficiently to achieve the specified habitability criterion. Several factors may bear on the effectiveness of decontamination, including the radionuclides to be removed, the type of material being cleaned, the methods used, and weather conditions.

In the code modeling, each decontamination effectiveness level is assigned an associated decontamination time and an associated cost. Higher decontamination levels typically are assigned a higher decontamination cost, under the assumption that it will cost more to achieve a greater degree of cleanup. The code user can specify up to three decontamination levels (ranging from 1 to 100) for each accident category analyzed. The Indian Point analysis used two decontamination levels (dose reduction factors): 3 and 15, for all of the accident categories analyzed, as has been the Staff's practice for SAMA analyses. We assume those levels below.

In a nutshell, the modeling of decontamination costs involves the following steps. The code—by its atmospheric transport and dispersion module—will first model the deposition of radionuclides over the 50-mile radius map, depicting concentrations of the different isotopes.

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[15] *Id.* at 7-9.

[16] *Id.*

Based on the radionuclide concentrations shown, the modeling will show which grid sectors, if any, may be uninhabitable following the particular kinds of accidents analyzed.[17] If there are uninhabitable sectors, a progressive series of events are modeled. The code will next model, for example, what areas if any would be habitable after the lighter decontamination effort of 3 has reduced population dose by approximately 66%. If the lightest decontamination effort is insufficient, the code will go on to model what areas would be habitable following the next decontamination level—here level 15, where 93% of the dose is reduced.

Where even the heaviest decontamination effort specified would be insufficient to reduce doses enough to allow residents to return, the code can model an interdiction period, during which residents and businesses remain gone and the processes of decay and weathering act to reduce dose. If modeling shows that property in an area would not return to a habitable dose level even within a maximum interdiction period of 30 years, or, if decontamination and interdiction would be more expensive than outright property condemnation, then the code will assume that the property is condemned and will assess a cost for the total loss of the property.

C.   Decontamination Time and Cost Inputs Used in the Indian Point SAMA Analysis

The Indian Point SAMA analysis assumes that to clean up a non-farmland area to a decontamination level of 3 will require an average of 60 days at a per person cost of $5,184.[18] To achieve the higher decontamination level of 15, the analysis assumes an average decontamination time of 120 days at a per person cost of $13,824.[19] It is undisputed that these time and cost values were consistent with values used in the NRC-sponsored severe accident study NUREG-1150, "Severe Accident Risks: An Assessment for Five U.S. Nuclear Power

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[17] The code user specifies the habitability criterion (e.g., the Environmental Protection Agency's standard of 2 rem the first year, 0.5 rem for years 2 through 5).

[18] *See* LBP-13-13, 78 NRC at 459-60.

[19] *Id.*

Plants," published in 1990.[20] NUREG-1150 assessed the risks of severe accidents at nuclear

power plants by performing probabilistic risk analyses for five plants of varying reactor and

containment designs (Surry, Zion, Sequoyah, Peach Bottom, and Grand Gulf).

NUREG-1150 assumed the decontamination times of 60 and 120 days, respectively, for

the lighter (DSRFCT of 3) and heavier (DSRFCT of 15) decontamination efforts modeled. For

non-farmland decontamination cost, NUREG-1150 assumed values of $3,000 per person and

$8,000 per person, respectively, to achieve a DSRFCT of 3 and a DSRFCT of 15. For the

SAMA analysis, Entergy adjusted these decontamination cost values to account for changes in

the Consumer Price Index (CPI) from 1986 (during the time of NUREG-1150's drafting) to 2005,

when Entergy prepared its Environmental Report.[21]

D.   New York's Challenge to Decontamination-Related Inputs

The Board's decision in LBP-13-13 outlines the procedural history of NYS-12C, which

we do not repeat here.[22] As litigated, NYS-12C read as follows:

> Entergy's severe accident mitigation alternatives (SAMA) for Indian Point 2 and 3
> does not accurately reflect decontamination and clean up costs associated with a
> severe accident in the New York Metropolitan Area and, therefore, Entergy's
> SAMA Analysis underestimates the cost of a severe accident in violation of
> 10 C.F.R. § 51.53(c)(3)(ii)(L).[23]

New York argued that the Indian Point SAMA analysis underestimated the economic

costs of a severe reactor accident at Indian Point by underestimating the costs of

decontamination. New York presented one expert witness, Dr. François Lemay. Dr. Lemay

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[20] See, e.g., id. at 460, 463, 469; Tr. at 1951; Ex. NYS00252A-C, "Severe Accident Risks: An Assessment for Five U.S. Nuclear Power Plants," NUREG-1150 (Dec. 1990) (NUREG-1150).

[21] See LBP-13-13, 78 NRC at 463; Tr. at 1951.

[22] See LBP-13-13, 78 NRC at 450-51. The Board's decision also provides a detailed summary of key hearing exhibits and witness testimony. See id. at 454-65.

[23] Id. at 450.

argued that the SAMA analysis inappropriately used generic input values taken from a Sample Problem in the MACCS2 Code User's Guide. He stated that the User's Guide contains fourteen sample problems intended for testing whether the code is properly installed, and that the Indian Point SAMA analysis adopts "all but three of the MACCS2 input values related to decontamination" from Sample Problem A, only adjusting "those inputs for inflation" from 1986-based dollars to 2005-based dollars.[24] He stated—and no party disputes—that Sample Problem A "incorporates site-specific data for the Surry" reactor site in Virginia, data that was used in the NUREG-1150 severe accident study.[25]

Dr. Lemay testified that the generic values adopted from NUREG-1150 were unrealistic, "given current known decontamination data and the complexities of an urban to hyper-urban area such as that surrounding" Indian Point.[26] He pointed to the accidents at Chernobyl and Fukushima as examples of the complex and time-consuming nature of large-scale decontamination following a severe reactor accident.[27] Dr. Lemay claimed that the decontamination times assumed in the Indian Point SAMA analysis are "unreasonable and have not been justified with supportive evidence."[28] He further argued that the underlying factual basis for the non-farm decontamination cost parameters used in NUREG-1150 and adopted for the Indian Point SAMA analysis comes from a document that "does not appear to exist in a

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[24] *See* Ex. NYS000241, *Pre-Filed Written Testimony of Dr. Francois J. Lemay Regarding Consolidated NYS-12C* (Dec. 21, 2011), at 21-22 (New York Testimony).

[25] *Id.* As Entergy's experts described, "Entergy relied on Sample Problem A [input] values insofar as those values are based on, and coincide with, the relevant values in NUREG-1150"; Entergy "updated those input values using the CPI ratio for 1986 to 2005." Ex. ENT000450, *Testimony of Entergy Witnesses Lori Potts, Kevin O'Kula, and Grant Teagarden on Consolidated Contention NYS-12C* (Mar. 30, 2012), at 59-60 (Entergy Testimony).

[26] *See* LBP-13-13, 78 NRC at 462.

[27] *Id.*; Ex. NYS000241, New York Testimony, at 52-54.

[28] Ex. NYS000241, New York Testimony, at 54.

published form" and is unavailable for review, and therefore is "not a reliable source upon which experts . . . would base any findings."[29]

Dr. Lemay stated that International Safety Research, Inc. (ISR) performed a sensitivity analysis to determine the MACCS2 code offsite consequence inputs most likely to have an impact on the Indian Point SAMA analysis's offsite economic cost risk.[30] Based on ISR's analysis, Dr. Lemay testified that "decontamination costs are the dominant factor in the . . . remediation costs following a severe accident," and that the "most sensitive input parameters related to decontamination costs include [the] decontamination factor, non-farm decontamination cost, and decontamination time."[31] Dr. Lemay claimed that the SAMA analysis underestimates the total economic costs of a severe accident at Indian Point "largely due to Entergy's use of costs and times for decontamination" that are unrealistic for the site.[32]

Dr. Lemay also claimed that where "there is very little data on actual severe reactor accidents in a hyper-urban area such as NYC, research must be done" to determine an appropriate range of input values.[33] He stated that ISR developed a methodology and used four different approaches to calculate a reasonable range of input values for the Indian Point analysis "by extrapolating data from other types of nuclear accidents, field radiological decontamination work, and actual decontamination experiments."[34] Dr. Lemay claimed that the

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[29] Ex. NYS000420, *Pre-Filed Written Rebuttal Testimony of Dr. François J. Lemay Regarding Consolidated Contention NYS-12C* (June 29, 2012), at 24 (New York Rebuttal Testimony).

[30] Ex. NYS000241, New York Testimony, at 23-27; LBP-13-13, 78 NRC at 462 n.1504. Dr. Lemay is a Vice President of ISR.

[31] Ex. NYS000241, New York Testimony, at 27.

[32] *Id.* at 9-10.

[33] *Id.* at 20.

[34] *Id.*

ISR report's alternative ranges of input values were not "intended to be an alternative SAMA

analysis" for Indian Point, but reflected a comparative "benchmarking" exercise to assess the

reasonableness of the decontamination cost inputs used in the SAMA analysis by comparing

them to "values calculated from data produced by other analysts in the field."[35] Dr. Lemay

stated that under all four methodology approaches the results showed much higher per person

decontamination cost values than those used in the Indian Point analysis.[36]

As to decontamination time, Dr. Lemay testified that based on decontamination plans

and reports from Fukushima, a "minimum TIMDEC of 1 year is justifiable by the recent reports"

for light decontamination, and a "minimum TIMDEC of 2 years for heavy decontamination is also

reasonable," while upper bound maximum decontamination times for light and heavy

decontamination could be 15 years and 30 years, respectively.[37] Dr. Lemay claimed that an

"average" time value for severe accident decontamination would fall "somewhere between"

these proposed minimum and maximum time values.[38]

In response to New York, Staff experts testified that NYS-12C did not raise any "valid

issues that would materially impact the Indian Point" SAMA analysis.[39] Dr. Nathan Bixler of

Sandia National Laboratories claimed that Dr. Lemay's methodology and estimated

decontamination costs for Indian Point "tend to be biased toward the worst accident scenarios

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[35] Ex. NYS000420, New York Rebuttal Testimony, at 5-6.

[36] *See* Ex. NYS000241, New York Testimony, at 31-51; Ex. NYS000430, "Revisions to Tables in ISR Report 13014-01-01" (June 29, 2012), at Table 13 (New York Revised Tables).

[37] *See* Ex. NYS000420, New York Rebuttal Testimony, at 48-51.

[38] *Id.* at 51.

[39] *See* Ex. NRC000041, *NRC Staff Testimony of Nathan E. Bixler, S. Tina Ghosh, Joseph A. Jones, and Donald G. Harrison Concerning NYS' Contentions NYS 12/16* (Mar. 30, 2012), at 12-14 (Staff Testimony).

and for the worst environmental conditions."[40] The Staff and Entergy criticized as over-conservative or otherwise inappropriate assumptions made in all four of the modeling approaches used in the ISR report to estimate decontamination cost values for the Indian Point area.[41] The Staff's experts stated that "Dr. Lemay's suggested clean-up times are skewed to the worst case severe accident scenarios under some of the worst case conditions for implementing a clean-up and cannot represent the multitude of clean-up scenarios modeled in a SAMA analysis."[42]

The Staff and Entergy explained that they chose the same decontamination time parameters and same (unescalated) non-farm decontamination cost parameters that had been used in the NUREG-1150 severe accident study.[43] Entergy described NUREG-1150 as a seminal study that "greatly enhanced the understanding of risk at nuclear power plants," was used to support the NRC's Generic Environmental Impact Statement for license renewal, and along with its supporting technical documentation in NUREG/CR-4551, "continue[s] to be used as appropriate benchmarks today for PRA in the U.S. commercial power reactor industry."[44]

Entergy also highlighted the "peer review quality of the work" involved with the NUREG-1150 study.[45] Entergy called the "use of the NUREG-1150/Sample Problem A values at issue here . . . standard for Level 3 PRA studies (including SAMA analyses) performed in the U.S."[46]

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[40] *Id.* at 31.

[41] *See id.* at 69-88.

[42] *Id.* at 90.

[43] *See* Tr. at 2241, 2247, 2249, 2250.

[44] *See* Ex. ENT000450, Entergy Testimony, at 22.

[45] *See* Tr. at 2034; 2369-71; Ex. ENT000450, Entergy Testimony, at 13.

[46] Ex. ENT000450, Entergy Testimony, at 61.

In short, Entergy claimed that these are "values with a well-established technical pedigree that is widely recognized and accepted by the PRA community" and that "warrants their continued use in NRC-related PRA/SAMA analysis applications."[47]

E. Board's Decision in LBP-13-13

The Board's decision focused on the TIMDEC and CDNFRM input parameters because Dr. Lemay had stressed that they were the most significant of the challenged inputs and indeed were the "crux of the matter."[48] The Board found the TIMDEC and CDNFRM values "reasonable and appropriate for Indian Point," satisfying the requirements of NEPA.[49] The Board also found the SAMA analysis reasonably site-specific, given that the non-farm decontamination cost parameter is applied on a per capita basis, an approach the Board found reasonably accounted for the "site-specific high population density of New York City and the correspondingly high density of buildings."[50]

In addressing the reasonableness of the decontamination time inputs, the Board traced the "genesis" of the 60-day and 120-day decontamination time values to a 1984 report, NUREG/CR-3673, "Economic Risks of Nuclear Power Reactor Accidents," issued by Sandia National Laboratories.[51] As the Board described, NUREG/CR-3673 estimated that it would take an average of "90 days with approximately 46,000 workers" to "restore habitability to an area after the most severe type of reactor accident."[52] The Board went on to explain that, based on

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[47] *Id.* at 13, 61.

[48] Tr. at 2054-55; LBP-13-13, 78 NRC at 459, 462 n.1504.

[49] LBP-13-13, 78 NRC at 465.

[50] *Id.* at 467.

[51] *Id.* at 469; *see also* Tr. at 2241-46; Ex. NRC000058, "Economic Risks of Nuclear Power Reactor Accidents," Sandia National Laboratories, NUREG/CR-3673 (May 1984).

[52] LBP-13-13, 78 NRC at 469; *see also* Ex. NRC000058, NUREG/CR-3673, at 6-25. The category of accident referenced was an "SST1" accident, described as a "severe core-melt

this 90-day estimate, the NUREG-1150 study "adopted 60 days and 120 days . . . as the

average times to be expected to achieve dose reduction factors of 3 and 15, respectively, when

examining a wide spectrum of severe accident scenarios."[53]

Concluding that "the NRC has examined decontamination times for more than 37 years"

and "the origin of the 90-day decontamination time (and the related 60-day and 120-day values)

is known and reviewable and based upon an average over a wide spectrum of severe accident

scenarios," the Board found it appropriate for the SAMA analysis to have used the "60-day and

120-day average decontamination time values from NUREG-1150."[54] The Board stressed that

the SAMA analysis is not intended to "model a single radiological release event under specific

conditions at a single moment in time," but to "estimate annual average impacts for the entire

50-mile radius study area."[55] Citing to Staff testimony, the Board found the time values

reasonable "given the need to develop a decontamination time representative of all possible

severe accident scenarios."[56] The Board did not address New York's arguments on

decontamination times at Fukushima, but it found inappropriate New York's example of

decontamination times from the Chernobyl accident because Chernobyl represented "a single

scenario of an extreme case," and "[i]f it were possible to use it along with case/scenario-

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accident which results in a rapid, large release of radioactive material to the environment," and a "release of approximately 100% of the reactor core inventory of noble gases and ~50% of the volatile radionuclides in a very short time period." *See* Ex. NRC000058, NUREG/CR-3673, at 2-7.

[53] LBP-13-13, 78 NRC at 469.

[54] *Id.* at 469-70.

[55] *Id.* at 470 (quotation omitted).

[56] *Id.*

specific [decontamination times] its inclusion in the SAMA analysis would require weighting it by its low probability of occurrence."[57]

The Board also found reasonable the non-farm decontamination cost (CDNFRM) parameters, although the underlying "source" of those values was unavailable for review.[58] The Board described how the CDNFRM values used in NUREG-1150 ($3,000/person for decontamination level of 3 and $8,000/person for decontamination level of 15) stem from decontamination cost estimates provided in NUREG/CR-3673, the same 1984 economic risk study referenced in support of the decontamination time inputs.[59] In turn, NUREG/CR-3673's cost estimates were "taken from a detailed review of decontamination effectiveness and costs performed at Sandia National Laboratories."[60] The Board specified that this review was an "unpublished report by Robert Ostmeyer and Gene Runkle" (Os84 or the Ostmeyer Report). [61] None of the parties were able to locate Os84.

Citing to Staff and Entergy expert testimony, the Board stated that the CDNFRM parameters used in NUREG-1150 are "standard for SAMA analyses," "all prior NRC license renewal applicants have used these same values (as appropriately escalated) in their SAMA analyses," and "the key economic inputs were vetted before their inclusion in NUREG-1150."[62] The Board concluded that the economic input parameters were "reviewed and a best estimate

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[57] *Id.* at 469.

[58] *Id.* at 471.

[59] *Id.* at 472; *see also* Ex. NRC000058, NUREG/CR-3673, at 4-15, 4-17 to 4-19.

[60] LBP-13-13, 78 NRC at 472 (quoting Ex. NRC000058, NUREG/CR-3673, at 4-15).

[61] *Id*. The full citation to the review is "Ostmeyer, R.M., and G.E. Runkle, 'An Assessment of Decontamination Costs and Effectiveness for Accident Radiological Releases,' Albuquerque, N.M.: Sandia National Laboratories, to be published." *See* Ex. NRC000058, NUREG/CR-3673, at 8-8 (referencing "Os84").

[62] LBP-13-13, 78 NRC at 471.

was recommended during the NUREG-1150 peer review process," and the Staff was "justified in relying on the secondary peer reviews of the economic cost variables."[63] The Board moreover stressed that Entergy and Staff witnesses had testified that they also specifically had considered and deemed appropriate use of the NUREG-1150 values in the Indian Point SAMA analysis.[64] Noting that not "all uncertainties" needed to be resolved in a NEPA analysis, and highlighting the "level of review of NUREG-1150 and its predecessor documents," the Board found the CDNFRM values reasonable.[65]

II.   ANALYSIS

In CLI-15-2, we granted review of the Board's decision as to NYS-12C, and directed the parties to provide additional briefing on specific questions.[66] While typically we decline to second-guess the Board on its fact-specific conclusions, here the decision contains obvious material factual errors and could be misleading, warranting clarification.[67] We find that the SAMA analysis and the Board's decision insufficiently address uncertainty in the Indian Point CDNFRM and TIMDEC inputs—uncertainty shown by New York to have a potential to affect the SAMA analysis cost-benefit conclusions. We conclude, as a NEPA matter, that the analysis should be buttressed by additional sensitivity analysis.

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[63] *Id.* at 473.

[64] *Id.*

[65] *Id.* at 474.

[66] We also allowed the State of Connecticut to file an *amicus* brief in response to our questions, which it did. *Connecticut's Response to the Commission's Memorandum and Order of February 18, 2015 (CLI-15-2), Regarding Contention NYS-12C* (Mar. 30, 2015). We have reviewed Connecticut's brief. Those claims that fell within the scope of this proceeding are encompassed by our decision. *See also Amicus Brief of the Attorney General of* Connecticut (Feb. 14, 2014).

[67] *See, e.g.*, *Dominion Nuclear Connecticut, Inc.* (Millstone Power Station, Unit 3), CLI-02-22, 56 NRC 213, 222 (2002); *see also* 10 C.F.R. § 2.341(b)(4).

This decision involved a balancing of considerations. As the Board noted, not all uncertainties need be resolved. Further, there is no requirement in NEPA or our SAMA rule for the Staff to perform a detailed three-level PRA analysis for the license renewal SAMA analysis, although that is how the Staff by longstanding practice and guidance has conducted the analysis. Having performed such an analysis, however, the Staff's choice of input values is subject to challenge under NEPA standards.

We long have emphasized that the SAMA analysis computer modeling involves thousands of code inputs, and that it will always "be possible to conceive of yet another" alternative input "that could have been used, and in fact "many different inputs and approaches may all be reasonable choices" for the analysis.[68] That the analysis can be performed with more conservative inputs, therefore, does not render it deficient. NEPA is satisfied so long as the analysis that *was* done is reasonable. "[W]here appropriate, full disclosures of any known shortcomings in available methodology, disclosure of any incomplete or unavailable information and significant uncertainties, and a reasoned evaluation of whether and to what extent these . . . considerations credibly could or would alter" the SAMA analysis conclusions should be provided.[69]

Although we are mindful of and reiterate our frequent admonition against needless agency effort merely to "fine-tune a NEPA mitigation analysis,"[70] here we conclude that NEPA's information-disclosure purpose was not satisfied. New York's concerns about the TIMDEC and CDNFRM input values were not meaningfully addressed in the final supplemental environmental impact statement (FSEIS) or the Board's decision. Our conclusions follow.

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[68] *Pilgrim*, CLI-12-1, 75 NRC at 57.

[69] *Pilgrim*, CLI-10-22, 72 NRC at 202, 208-09.

[70] *See Pilgrim*, CLI-12-1, 75 NRC at 57.

A.   Input Values and the Spectrum of Modeled Releases

First, on the issue of decontamination time (the TIMDEC input), the Board erroneously refers to an "*input requirement* of the MACCS2 code for a single average decontamination time as an input value"—a single time "which is representative of all possible severe accident scenarios."[71] The Board incorrectly emphasized a need for the "selected TIMDEC values" to "represent all the modeled severe accidents including ones that require little decontamination."[72] Yet as we earlier described, the MACCS2 code by design permits a user to select up to three different decontamination times—linked to up to three different decontamination effectiveness levels—for each of the modeled accident releases or "bins."

Simply put, there is no code requirement to use the same decontamination times for the entire spectrum of modeled accident categories, from least to most severe. The Staff's longstanding practice has been to use the same two decontamination levels (3 and 15) with the same two respective decontamination times (60 days and 120 days) and apply these inputs to all of the modeled accident scenarios, but the option exists to select longer decontamination times (up to 365 days) for the accident categories that depict higher source term releases. Decontamination times longer than the 60-day and 120-day values—up to one year—readily could have been applied to the larger accident categories modeled.[73] In short, the Board erred in concluding that the decontamination time inputs had to represent an "average over all the modeled severe accidents."[74]

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[71] *See* LBP-13-13, 78 NRC at 470 (emphasis added).

[72] *Id.*

[73] The code as designed allows the user to select TIMDEC values up to 365 days. *See* Ex. NYS000243, MACCS2 User's Guide, at 7-10. Values longer than a year would require code revision.

[74] LBP-13-13, 78 NRC at 470.

Much of the testimony in this case indeed revolves around the subject of "averages" and "averaging," a topic warranting clarification. SAMA analysis results necessarily will reflect an averaging of sorts because for each modeled accident category the analysis estimates the mean consequences over the 50-mile radius area and multiplies those consequences by the mean estimated frequency of the accident scenario occurring to calculate the accident risk.[75] This frequency-weighting is performed *after* the calculation of consequences (population doses and economic costs). The frequency-weighted results for the separate modeled accident categories are then added together to compute the total risk. By this process the analysis will take into account and appropriately weight the very low probabilities of the most severe categories. Choosing larger TIMDEC or CDNFRM values (where appropriate) for the larger releases does not improperly skew the analysis to more extreme scenarios because the lower frequencies of the large releases will be factored in, as Dr. Lemay testified.[76]

Decontamination time and cost inputs, therefore, should reflect reasonable estimates for the level of decontamination effectiveness specified and for the releases that are modeled. There is no requirement for the Staff to use a "universal set of average" TIMDEC and CDNFRM inputs for modeled scenarios ranging from no containment failure to scenarios involving radiological releases comparable to or exceeding that of the Fukushima accident.[77] Instead, the

[75] Accident frequency for each release scenario modeled is determined in the earlier Level 1 and Level 2 PRA analyses, whose results feed into the Level 3 offsite consequence portion of the analysis. *See* Tr. at 2194.

[76] *See id*. at 1937 (inputs "should be best estimate appropriate for the release category we're trying to simulate"), 2178-79, 2186 ("decontamination time ideally should change with the release category to make sure that we use reasonable assumptions").

[77] *See NRC Staff's Response to the Commission's Memorandum and Order of February 18, 2015 (CLI-15-2), Regarding Contention NYS-12* (Mar. 30, 2015), at 29 (Staff Response to Commission Questions). Judge McDade posed an appropriate question: "At one . . . end of the spectrum say you have a Three Mile Island-type of severe accident, at the other end of the spectrum you have a Chernobyl-type severe accident, and how, if at all, are the differences between those factored into these numbers, or into the SAMA analysis generally." *See* Tr. at

appropriate consideration is whether the value used with each modeled release reflects a reasonable estimate of the average decontamination time or cost that would be associated *with that release* (and decontamination level).

Further, New York presented evidence that while the most severe releases modeled in the Indian Point analysis have the lowest probabilities of occurring, the estimated consequences from these releases drive most of the overall offsite economic cost risk calculated in the Indian Point analysis. In other words, while the estimated frequencies of these most severe releases are quite low, the cost and time inputs assigned to them have a potential to affect the analysis results because it is the large economic consequences of the larger release categories that contribute the most to the offsite economic cost risk portion of the analysis.[78]

The Staff argues that because the Indian Point SAMA analysis "modeled severe accidents with *larger* releases than Fukushima," New York's "actual complaint appears to be that severe accidents should have been accorded greater weight in the SAMA analysis."[79] But New York did not challenge the frequency-weighting of the large releases. It challenged the choice of the inputs (i.e., the 120-day TIMDEC for heavy decontamination) applied to those larger, low-probability releases. New York argued that unless the TIMDEC (and CDNFRM) inputs used with the larger releases reflect reasonable estimates *for those release scenarios* the overall calculated consequences may be skewed too low.[80] The Board's decision did not reach

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1978 (McDade, J.). The answer, as we discuss here, is that different input values can be applied to the different accident categories modeled.

[78] *See, e.g.*, Petition at 28-29; Tr. at 2179-80, 2196.

[79] *See NRC Staff's Answer to "State of New York Petition for Review of Atomic Safety and Licensing Board Decision LBP-13-13 with Respect to Consolidated Contention NYS-12C"* (Apr. 28, 2014), at 20 (Staff Answer to New York Petition).

[80] *See* Tr. at 2196 ("we can't average the time it takes to decontaminate a trivial or benign accident with the time it takes to decontaminate these more severe accidents"); Ex. NYS000420, New York Rebuttal Testimony, at 15-16 ("[t]he suggestion by NRC Staff that is acceptable to average input parameters over all release categories is wrong."); Petition at 30

this claim because the Board incorrectly assumed that only one set of inputs must be used with all modeled releases.

Whether using larger TIMDEC (and CDNFRM) values with the larger releases modeled actually would affect the results of the Indian Point analysis and if so, to what degree, cannot be discerned from the current case record. The Staff suggests that there would be no "substantial differences" once the low frequencies of such releases are factored in.[81] We find, however, that New York provided sufficient evidence of a potential for a material effect on the Indian Point cost-benefit results if larger values were used for the larger releases.

B.   Evidence on the Input Values

We turn next to the evidence on the TIMDEC inputs used in the analysis: 60 days for light decontamination (effectiveness level 3) and 120 days for heavy decontamination (effectiveness level 15). Both were used in the NUREG-1150 severe accident study. As the Board described, Staff witnesses testified that these inputs are based on a 90-day "mean" decontamination time estimate described in the 1984 report on economic risks of reactor accidents, NUREG/CR-3673.[82] That report estimated consequences from an "SST1 accident," a category of severe accident defined as resulting in a "release of approximately 100% of the reactor core inventory of noble gases and ~50% of the volatile radionuclides in a very short time period."[83] The relevant passage from NUREG/CR-3673 reads as follows:

(citing Tr. at 2179-80); *State of New York Reply in Support of Petition for Review of Atomic Safety and Licensing Board's November 27, 2013 Partial Initial Decision Concerning Consolidated Contention NYS-12C* (May 22, 2014), at 10 (New York Reply in Support of Petition) ("[u]sing a small TIMDEC value for the severe accident scenarios involving larger releases artificially minimizes the accident costs flowing from those scenarios").

[81] *See* Staff Response to Commission Questions at 30.

[82] LBP-13-13, 78 NRC at 469.

[83] *See* Ex. NRC000058, NUREG/CR-3673, at 2-7.

A total of ~11,000 man-years of effort is involved in the decontamination program to reduce population exposure from the accident. Based on a mean time to completion of 90 days for the decontamination efforts, this program would require a work force of ~46,000 men . . . . However, manpower limitations may force an extended period for completion of the offsite decontamination program after large releases of radioactive material.[84]

Stressing that the "origin of the 90-day decontamination time" is "known and reviewable" and "based upon an average over a wide spectrum of severe accident scenarios," the Board found it "reasonable for Entergy to have adopted the 60-day and 120-day average decontamination time values from NUREG-1150 for dose reduction factors of 3 and 15, respectively."[85] But NUREG/CR-3673 does not identify the underlying data and reasoning—the factual underpinning—for this key 90-day estimate.[86] Nor did the Staff or Entergy describe the basis of the 90-day time estimate. Contrary to the Board's conclusion, the actual origin of the 90-day estimate was never presented or explained.

Citing to Staff testimony, the Board went on to stress that a "1990 report (i.e., NUREG/CR-4551)," which was a companion document to the NUREG-1150 study, "reviewed the MACCS2 input parameters used in NUREG-1150, *including TIMDEC*, and again concluded that an 'average cleanup was expected to take 90 days . . . for this most severe type of reactor accident."[87] But the Board failed to identify any part of NUREG/CR-4551 that describes a

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[84] *Id.* at 6-25.

[85] LBP-13-13, 78 NRC at 469-70. Entergy's experts testified that the 60-day and 120-day periods selected for NUREG-1150 essentially reflected lower and upper bound sensitivity cases for the 90-day average decontamination period described in NUREG/CR-3673. *See, e.g.*, Ex. ENT000450, Entergy Testimony, at 85-86; Tr. at 2242-43.

[86] The source of the 90-day estimate may be the earlier-referenced Ostmeyer Report, given that NUREG/CR-3673 also contains estimates of decontamination labor costs and manpower needs that were taken from the Ostmeyer Report, and these labor and manpower estimates bear a relationship to decontamination time. *See* Ex. NRC000058, NUREG/CR-3673, at 4-19.

[87] LBP-13-13, 78 NRC at 470 (emphasis added); Ex. NYS000248, "Evaluation of Severe Accident Risks: Quantification of Major Input Parameters," NUREG/CR-4551, SAND86-1309, Vol. 2, Rev. 1, Part 7 (Dec. 1990) (NUREG/CR-4551).

confirmation of the 90-day decontamination estimate or that reviewed the TIMDEC inputs used in NUREG-1150.

NUREG/CR-4551's introduction states that it contains a review of "*most* input parameters" used in the offsite consequence analysis of NUREG-1150, and further, that for "each parameter reviewed, a best estimate value and an uncertainty range were estimated."[88] Neither the Staff nor Entergy, however, identified any section of NUREG/CR-4551 that reviews or explains the TIMDEC (or CDNFRM) values. We also could not locate any such review. Apparently, NUREG/CR-4551 merely lists NUREG/CR-3673 among its references.[89] And Dr. Lemay stressed that he had found "no description" in NUREG/CR-4551 of how the TIMDEC or CDNFRM values were derived.[90] We therefore agree with New York that it was a factual error for the Board to have relied on NUREG/CR-4551 as support for the TIMDEC values.[91]

Regarding the non-farmland decontamination cost values (CDNFRM), the Board similarly found that the Staff was "justified in relying on the secondary peer reviews of the economic cost variables."[92] The Board again relied on NUREG/CR-4551, quoting its introduction as evidence that the CDNFRM values specifically were "reviewed and a best estimate was recommended during the NUREG-1150 peer review process."[93] Again, however, while NUREG/CR-4551 explains most of the MACCS input parameters selected for the NUREG-1150 study, no evidence was presented of a review or vetting of the CDNFRM inputs.

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[88] Ex. NYS000248, NUREG/CR-4551, at 1-1 (emphasis added).

[89] *See id.* at 5-9 to 5-10.

[90] *See* Tr. at 2005; *see also* Ex. NYS000420, New York Rebuttal Testimony, at 21.

[91] *See* Petition at 20.

[92] LBP-13-13, 78 NRC at 472.

[93] *Id.*

We know from the case record that the challenged CDNFRM and TIMDEC input values were taken from NUREG-1150, and that in turn the NUREG-1150 values were based on estimates reported in the earlier study, NUREG/CR-3673. Yet none of the parties were able to describe the underlying foundation for these values. The difficulty here is not only that old documents such as the referenced Ostmeyer Report were never located, but that no witness could provide the technical basis—e.g., the assumptions made and data considered—for key economic inputs selected for this cost-benefit analysis.[94]

Repeatedly, the Staff and Entergy rely on the estimates and related reasoning contained in NUREG/CR-3673.[95] That reliance is why the missing underlying assumptions for NUREG/CR-3673 are relevant. In support of the CDNFRM values, for example, Mr. O'Kula testified that the NUREG/CR-3673 decontamination cost estimates incorporated a "multitude of possible [decontamination] methods . . . and have been weighted to account for residential, commercial and industrial and public use land areas [based] on national average statistics."[96] But as Judge Kennedy remarked, this "open[s] up the question" of "what type of land use was used in this study."[97] The Staff and Entergy experts did not describe what "average statistics"

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[94] The Board stated that NUREG/CR-3673 was not "necessarily an unreliable source," given that the authors "had access to the Ostmeyer report when they prepared" it and that "Dr. Ostmeyer provided technical assistance and advice during the preparation of NUREG/CR-3673." *See* LBP-13-13, 78 NRC at 472-73. But this tells us only that the NUREG/CR-3673 authors understood the Ostmeyer Report conclusions. It does not shed light on the basis for those conclusions or their continued applicability to the Indian Point analysis today.

[95] *See, e.g.*, Ex. ENT000450, Entergy Testimony, at 57, 84-85, 87-88; Ex. NRC000041, Staff Testimony, at 90; Tr. at 2014.

[96] *See* Tr. at 2244 (referencing Ex. NRC000058, NUREG/CR-3673, at 4-17).

[97] Tr. at 2245 (Kennedy, J.). As New York states, the "geographic location . . . or [the] size of the area" considered are not known. *See State of New York Response to Commission Order CLI-15-2 Requesting Further Briefing on Contention NYS-12C Concerning Site-Specific Severe Accident Mitigation Alternatives* (Mar. 30, 2015), at 7 n.27 (New York Response to Commission Questions).

were used, what decontamination methods were considered, or how the weighting was done. In short, we do not know how the specific per person cost parameters were derived, although these are the parameter values (only adjusted for inflation) that were multiplied by the Indian Point area's site-specific population to obtain decontamination cost estimates for the SAMA analysis.

Moreover, quite apart from the fact that NUREG/CR-3673 relies on a study (Os84) that has not been located, NUREG/CR-3673 itself highlights the uncertainty in its conclusions:

> The cost and effectiveness estimates for decontamination contain large uncertainties, and results of future experimentation with decontamination techniques should be used to update models for decontamination.[98]

Large uncertainties were said to exist because the decontamination cost conclusions were based on experimental data and "little data" was considered "directly applicable" to the "small particle sizes" and "soluble materials which are anticipated in releases from most severe [light-water reactor] accidents."[99]

Nonetheless, Staff and Entergy experts—who include MACCS2 code modeling experts—offered their professional opinion that the challenged inputs are reasonable for this analysis.[100] Much of their testimony is rooted in confidence in NUREG-1150 and peer reviews of that study. For example, Mr. O'Kula asserted confidence in the "nature and breadth and depth of the work that was done" for NUREG-1150, and what he described as an "unprecedented" level of review of the study.[101] Entergy experts also testified that the input values had been "judged appropriate" and "sufficiently applicable to each of the [five] sites"

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[98] Ex. NRC000059, NUREG/CR-3673, at 4-15.

[99] *Id.*

[100] *See* Tr. at 2037, 2039, 2274.

[101] *See id.* at 2371-72, 2034.

evaluated in NUREG-1150, which included a site located near a large urban city—the (now

decommissioned) Zion plant, located approximately 37 miles from Chicago.[102] The Staff stated

that it has been examining decontamination times for 37 years.[103] And Entergy repeatedly

referred to the "well-established pedigree" of these inputs.[104]

While we do not discount their expertise, neither Staff nor Entergy experts provided any

documented review or analysis (independent or internal), from the time of NUREG-1150 or

more recently, that examines, reassesses, or otherwise explains the underlying basis for these

parameters. It is possible that the NUREG-1150 peer reviews or other secondary reviews may

have thoroughly vetted the TIMDEC and CDNFRM inputs, but we lack record evidence of such

vetting.[105] Neither the Staff nor Entergy put into evidence any portions of the NUREG-1150

peer reviews or other reviews of NUREG-1150 that they referenced.[106] We cannot make factual

determinations based on items never introduced for review into the case record or otherwise

confirmed.[107]

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[102] *See id.* at 1951-53, 2246.

[103] *See, e.g.*, Ex. NRC000041, Staff Testimony, at 89.

[104] *See, e.g.*, Ex. ENT000450, Entergy Testimony, at 13, 72; *see also* Tr. at 2054, 2286.

[105] NEPA does not require peer-reviewed analyses, but here it is the Staff and Entergy that reference the NUREG-1150 peer reviews as a basis for their confidence in the challenged values. The limited information presented in the record directly pertaining to reviews of the decontamination costs portion of NUREG-1150 were comments critical of a draft version of the study. *See, e.g.*, Petition at 37; Tr. at 2024-26.

[106] Tr. at 2375-76 (Board inquiring whether any reviews were submitted as exhibits). We do not mean to minimize the significance of the NUREG-1150 study and its continued relevance to PRA-based analyses today. Our focus is only on two inputs, as specifically challenged in this proceeding, taken from the offsite consequence portion of NUREG-1150, an extensive three-level PRA study involving thousands of inputs.

[107] Because the derivation of the values was not explained in NUREG-1150 or its companion document, NUREG/CR-4551, Dr. Lemay suggested that the challenged values are "a very specific part of the economic cost assessment" that "was not peer reviewed." *See, e.g.*, Tr. at 2175.

Moreover, NUREG-1150's final version did not discuss economic losses due to severe accidents and was not a cost-benefit analysis.[108] NUREG-1150's overall focus was on doses and health effects of severe accidents to determine whether the plants studied met the NRC's safety goals. Economic costs were calculated in the individual plant studies to determine whether individuals could return to their homes or would stay relocated (and their property condemned)—factors relevant to assessing long-term population doses and health risks for comparison to the NRC's safety goals. In contrast to NUREG-1150, the Indian Point SAMA analysis is a cost-benefit analysis, where a primary focus is economic costs given the need to compare the avoided costs of accidents with the implementation costs of risk reduction strategies.

The Staff and Entergy also cite to the NRC's SOARCA (State-of-the-Art Reactor Consequence Analysis) study, published in 2012, as evidence and confirmation that the TIMDEC and CDNFRM values are reasonable for the SAMA analysis.[109] Mr. O'Kula explained that while the SOARCA study was not a SAMA analysis or a PRA analysis, the "model had to be set up and run as if it [were] a SAMA-type analysis" to show "when to bring populations back onsite to their residences in terms of cleanup criteria."[110] SOARCA analysts adopted the NUREG-1150 decontamination times (60 and 120 days) and base decontamination costs ($3,000/person and $8,000/person) for decontamination levels of 3 and 15, respectively.[111]

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[108] *See, e.g.*, *id*. at 2035.

[109] *See, e.g.*, *Applicant's Answer Opposing the State of New York's Petition for Review of the Board's Partial Initial Decision (LBP-13-13)* (Apr. 28, 2014), at 37-38 & n. 213 (Entergy Answer to New York Petition); Tr. at 2241, 2274, 2374-75.

[110] *See* Tr. at 2373.

[111] *See id*.

But a recent report describing the SOARCA study's parameter selection makes clear

that these decontamination-related parameters "were not reviewed for SOARCA because

SOARCA did not calculate economic consequences."[112] As was the case with NUREG-1150,

the SOARCA "cost decisions were only used to support the habitability decisions in the

model."[113] MACCS code users therefore are directed to "review the basis and applicability of

the decontamination and cost parameters for site-specific analyses."[114] As New York claims,

SOARCA's limited use of the TIMDEC and CDNFRM values "does not represent a vetting of

those values."[115]

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[112] "*See* "MACCS Best Practices as Applied in the State-of-the-Art Reactor Consequence
Analyses (SOARCA) Project," NUREG/CR-7009, Sandia National Laboratories, Bixler, N.,
Jones, J., Osborn, D., Weber, S., § 4.7, at 4-43 (Aug. 2014) (ML14234A148). NUREG/CR-7009
is publicly available but post-dates the Board's decision. The document was not material to our
decision, but helps to make clear the limited purposes behind the use of the decontamination
cost-related values in the SOARCA study.

[113] *Id.*

[114] *Id.*

[115] *See State of New York Reply to Entergy's and NRC Staff's Responses to Commission Order
CLI-15-2 Requesting Further Briefing on Contention NYS-12C Concerning Site-Specific Severe
Accident Mitigation Alternatives* (Apr. 29, 2015), at 5-6 (New York Reply Brief Re: Commission
Questions). While it was not entered into the record, we further note that the SOARCA peer
review addressed the "[a]ssumptions and input data associated with decontamination and
cleanup of economic assets." *See* "Summary Report: Peer Review of the State-of-the-Art
Reactor Consequence Analyses (SOARCA) Project," Sandia National Laboratories (May 2012),
at 47 (ML121250032). Although these were found "acceptable for achieving the overall goals of
the SOARCA project," the peer reviewer—one of Entergy's experts in this case—stated that "the
approach taken for decontamination in the mid-to late eighties isn't consistent with a state-of-
the-art analysis." *See id.* The SOARCA peer review was published several months before the
hearing and authored by one of the Staff's experts in this case. Although the peer reviewer's
comment is not directed to a NEPA analysis and does not suggest that use of the inputs is
unacceptable, it reflects a consideration of the NUREG-1150 decontamination-related input
values in a recent peer review—and a core Staff and Entergy argument before the Board and
before us is that peer review vetting confirmed the reliability of the values. *See, e.g.*, Entergy
Answer to Petition at 26. We note, additionally, that while the SAMA analysis need not be state-
of-the-art it is a cost-benefit analysis, which the SOARCA study was not.

The Board also refers to evidence of "Entergy technical reviewers [who] considered the applicability of the NUREG-1150 values and concluded that they were reasonable values" for the Indian Point analysis specifically.[116] The Board cited to the testimony of Entergy expert Ms. Potts and referenced an Entergy response to a Staff Request for Additional Information (RAI), said to "describe[] the bases" for the Entergy SAMA analysis reviewers' conclusions regarding why the NUREG-1150 inputs are appropriate for Indian Point.[117] The RAI response, however, describes the CDNFRM input, without more, as a "NUREG/CR-4551 default value[]" that was scaled to a current dollar value.[118] Neither the RAI response nor the cited pages of Ms. Potts's testimony reveal additional considerations beyond that of a practice to use default CDNFRM values escalated for inflation.[119] We have emphasized that an "expert opinion that merely states a conclusion . . . without providing a reasoned basis or explanation for that conclusion is inadequate because it deprives the Board of the ability to make the necessary, reflective assessment of the opinion."[120]

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[116] LBP-13-13, 78 NRC at 473.

[117] *Id.* at 473 n.1584; *see also* Entergy Answer to New York Petition at 25.

[118] *See* Ex. ENT000460, NL-08-028, letter from Fred Dacimo, Vice President, Entergy, to NRC, "Reply to Request for Additional Information Regarding License Renewal Application—Severe Accident Mitigation Alternatives Analysis, Attach. 1 at 37-38 (Feb. 5, 2008); *see also* Tr. at 2325-27.

[119] *See* Tr. at 2067-70. At the hearing, Ms. Potts stated that the reviewers "looked to see if [the CDNFRM value] passes the smell test," but did not indicate what factors were considered in making that determination. *See id*. at 2068. Mr. Teagarden added that the CDNFRM values are "judged to have applicability across . . . reactor plants and sites, and now I need to escalate them appropriately [to current dollar values] for my site-specific analysis." *See id*. at 2069.

[120] *See, e.g.*, *USEC, Inc.* (American Centrifuge Plant), CLI-06-10, 63 NRC 451, 472 (2006). We note, additionally, that Entergy's expert, Mr. Teagarden, described the non-farm decontamination per person cost value of $13,824 for heavy decontamination as equating to approximately a cost of "some $41,000" to decontaminate a "household of three," $55,000 for a "household of four," and for "an apartment building housing 200 people, . . . $2.7 million to cover decontamination costs for that and nearby spaces." *See* Tr. at 2040; *see also id.* at 2122. But he did not provide corroborative evidence that these are reasonable decontamination cost estimates for these types of buildings, whether speaking generally or in the specific context

C.   Other Evidence Regarding CDNFRM Values Not Addressed by the Board

The Board left unaddressed other Staff or Entergy arguments made in support of the

CDNFRM values. These claims merit acknowledgement, although we conclude that they are

insufficient to serve as a basis on which to find the CDNFRM values reasonable for the Indian

Point SAMA analysis.

The Staff argues, for example, that "New York's own expert confirmed the

reasonableness of the [SAMA analysis] selected inputs through his independent analysis."[121] In

effect, the Staff claims that if Dr. Lemay's assumptions are altered to the degree that the Staff

considers appropriate, his results become comparable or even conservative compared to the

values used in the Indian Point analysis. More specifically, and as we earlier described, Dr.

Lemay used four different approaches (designated A, B, C, and D) to calculate alternate ranges

of CDNFRM values for Indian Point. In Dr. Lemay's view, the "most appropriate method in [the]

whole set of data" that he used was a decontamination cost methodology from the United

Kingdom called CONDO, which focuses on reactor accident cleanup and which he used in his

Approach "C."[122] As pertinent here, Staff and Entergy experts testified that when they

considered Dr. Lemay's CONDO-related methodology in light of qualifications or corrections that

they considered necessary, Dr. Lemay's analyses indeed served to confirm the reasonableness

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relevant here: namely, achieving a 93% reduction in public dose in an average of 120 days. Similarly, Mr. Jones (whose resume indicates decontamination experience) testified for the Staff that he did not have any "cesium-related characterization or cost-data" from his decontamination work experience, which was performed for the Department of Energy. *See id.* at 2100-01.

[121] *See* Staff Answer to New York Petition at 26; *see also id.* at 34-35.

[122] *See* Tr. at 2108; *see also id.* at 2110-11, 2151-52. Based on the CONDO methodology, Dr. Lemay's suggested input values for CDNFRM range from $15,422 to $23,952 per person for light decontamination (level 3), and from $71,255 to $112,856 per person for heavy decontamination (level 15).

of the Indian Point analyses.[123] The Staff therefore argues that "New York's own analysis, as

corrected, suggests that the values selected by Entergy, accepted by the Staff, and approved by

the Board in LBP-13-13 are conservative."[124]

We need not, however, parse the extensive, highly technical, and contentious testimony

on New York's alternate methodologies and proposed alternate ranges of CDNFRM inputs.

Much of the hearing was diverted to an inquiry over the soundness of New York's methods and

assumptions—none of which the Board addressed in its decision. As the Board ultimately

stated in LBP-13-13, "New York was not required to develop reasonable alternative CDNFRM

values."[125]

More importantly, it should not be necessary—nor would it be sufficient—to rely on

"informal" and "rough" consideration of New York's CONDO methodology-based results to find

the Indian Point CDNFRM values reasonable.[126] Here, neither the Staff nor Entergy offered any

updated examination of decontamination costs or benchmarking analyses of their own. And Dr.

Lemay stressed that while he made his analyses available for the Staff's and Entergy's review,

he was not afforded the same opportunity to review and challenge the underlying technical

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[123] *See* Staff Answer to Petition at 25 n.111, 26, 29-31. More specifically, Mr. Jones testified that once he removed various multipliers and factors Dr. Lemay's analysis had applied, the result was a CDNFRM value of $16,778 for heavy decontamination, which came "reasonably close to" the value used in the Indian Point SAMA analysis ($13,824). *See* Ex. NRC000041, Staff Testimony, at 82-83; *see also* Tr. at 2251-52.

[124] *See* Staff Answer to New York Petition at 35.

[125] LBP-13-13, 78 NRC at 473.

[126] Mr. O'Kula explained, for example, that he took a "quick glance" and an "informal look" at Dr. Lemay's spreadsheets for the CONDO-based analyses, and after reducing various multipliers that Dr. Lemay had used to account for particular numbers of surfaces to be decontaminated, the results "became much like those applied in the Entergy SAMA analysis." *See* Tr. at 2365-66; *see also* Staff Response to Commission Questions at 22 ("after applying very rough and basic corrections to Dr. Lemay's analysis the Staff's experts concluded that New York's analysis supported the selected input variables").

basis and assumptions for the CDNFRM values because these were not made available.[127]

The Staff, moreover, discounted the CONDO methodology cost-estimation values, stating that

they "cannot be technically substantiated."[128] Given the record as a whole, informal

extrapolations from New York's alternate analyses, without more, are not a sufficient ground on

which to find the SAMA analysis reasonable.

The Board also did not address a cost comparison described in the FSEIS as lending

support for the CDNFRM values. The Staff in the FSEIS states that it requested the Sandia

National Laboratories to compare the non-farmland decontamination cost values used in the

Indian Point analysis with "decontamination cost factors derived from" a 1996 study of site

restoration costs for a plutonium-dispersal accident in Albuquerque, New Mexico.[129] In using

this weapons-related cleanup study (referenced as the Site Restoration Study), Sandia made

various assumptions including that the heavy decontamination level (dose reduction factor 15)

considered in the SAMA analysis would be most comparable to the Site Restoration Study's

analysis of "moderate plutonium" decontamination.[130] Applying the Site Restoration Study's

estimated cost for cleanup of "moderate plutonium" contamination to the population of New York

City, Sandia derived an estimated non-farmland decontamination cost value of $14,900 per

person.[131] The FSEIS noted that this value is comparable to the CDNFRM value assumed in

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[127] *See, e.g.*, Tr. at 2134, 2138, 2042.

[128] *See* Ex. NYS000041, Staff Testimony, at 88.

[129] *See* Ex. NYS000133I, "Generic Environmental Impact Statement for License Renewal of Nuclear Plants: Regarding Indian Point Nuclear Generating Unit Nos. 2 and 3, NUREG-1437, Supp. 38, Vol. 3, Final Report, app. G, at G-23 (Dec. 2010) (FSEIS) (referencing Ex. NYS000249, "Site Restoration: Estimation of Attributable Costs from Plutonium Dispersal Accidents," SAND96-0957, Chanin, D., and Murfin, W. (May 1996)).

[130] Ex. NYS000133I, FSEIS, at G-23 to G-24.

[131] *Id.* at G-24.

the SAMA analysis for heavy decontamination ($13,824 per person for decontamination level of 15).[132] The FSEIS additionally noted that the calculated value was not scaled to 2005 dollars, in which case the per capita cost would be greater, but "within a factor of about 2" (e.g., the scaled value could be twice the estimated $14,900 or approximately $30,000 per person).

In CLI-15-2, we asked the parties to address the extent to which the cost comparison substantiates the non-farm decontamination cost parameters used in the Indian Point analysis, particularly given that the FSEIS also describes the Site Restoration report as "not relevant" to reactor accident cleanup.[133] In its response, the Staff maintains that "weapons accidents do not provide a good analogue for estimating decontamination costs or times."[134] The Staff explains that it "tr[ied] to adjust the costs for a weapons accident to a reactor accident" in order to respond to comments received on the Draft SEIS, and that the "roughly comparable costs determined by this alternative method reinforced the Staff's conclusion that the costs used by Entergy were reasonable."[135] Entergy stresses that the 1996 Site Restoration Report "has no direct relevance" to the Indian Point SAMA analysis.[136] And for its part, New York disputes the assumptions that the Staff made in using the Site Restoration Study.[137]

Neither the Staff nor Entergy principally relies on the cost comparison and both further state that the Site Restoration Study is not relevant or reliable as a tool for estimating reactor

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[132] *Id.*

[133] *Id.* at G-23.

[134] *See* Staff Response to Commission Questions at 37 & n.226.

[135] *Id.* at 39-40.

[136] *See Entergy Nuclear Operations, Inc., Initial Brief in Response to Commission Questions in CLI-15-2 Concerning Contention NYS-12C* (Mar. 30, 2015), at 37-38.

[137] *See* New York Response to Commission Questions at 37; New York Reply Brief Re: Commission Questions at 17.

accident decontamination costs for the Indian Point analysis. Therefore, while intimating no opinion on the merits of the cost comparison, we find only that we have insufficient basis to conclude that the cost comparison confirms the Indian Point CDNFRM values.

D.   Conclusions on the TIMDEC and CDNFRM values

Stepping back from the details, we reach the following conclusions. First, the Board's decision relies on several significant factual errors, both relating to SAMA analysis computer modeling and to the content of the evidence presented. Second, while the evidence does not establish that the Indian Point SAMA analysis non-farm decontamination costs are unduly low or wrong,[138] it reveals potentially significant uncertainties in the non-farm land and property decontamination cost and the decontamination time input values. The Staff and Entergy could not explain the underlying technical basis for these values. And they presented no updated analysis that revisited and confirmed the values in light of any more recent decontamination data. Given the passage of time, it is not surprising that the individuals most acquainted with the work that produced these cost and time estimates may no longer be available to explain their analyses, but unfortunately none of the parties could provide a documented description outlining the technical foundation of the estimates (e.g., the experiments, data, size of area, or other factors considered).[139]

In this circumstance, running sensitivity analyses for the TIMDEC and CDNFRM values is appropriate. Sensitivity analyses are a common method of addressing uncertainty in specific inputs used in PRA analyses and as such they are a common practice in SAMA analyses.

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[138] Merely because New York's analyses resulted in higher values did not show that the Staff's values were unreasonable. New York's own estimated ranges of values varied widely depending on which of the four different approaches and information sources were used; the entire range of estimated CDNFRM values based on approach "A" was much higher than the entire range obtained with approach "C."

[139] *See, e.g.*, Tr. at 2006-09 (paper trail "end of the line" is NUREG/CR-3673); 2026 ("unable to trace the origin" of decontamination costs).

Sensitivity analyses help demonstrate whether and to what extent variations in an uncertain input value might affect the overall cost-benefit conclusions. Indeed, the MACCS2 code was designed to accommodate sensitivity analyses, and Entergy already has performed sensitivity analyses for other input values in the Indian Point analysis.[140] And recently, the SAMA analyses performed and accepted for the Byron and the Braidwood facilities' license renewal reviews included sensitivity analyses for the CDNFRM, TIMDEC, and other generic economic input values.[141]

The NEPA record in this case is not yet closed. The Staff is in the process of supplementing the Indian Point FSEIS in regard to other matters.[142] We therefore direct the Staff to supplement the SAMA analysis with sensitivity analyses for the CDNFRM and TIMDEC values. We leave up to the Staff to determine (if it so chooses) whether there are particular ranges of input values that it considers appropriate to use. In any event, however, the Staff at a minimum should include sensitivity runs for the maximum allowable values in the code—one year (365 days) for the TIMDEC values, at least (but not limited to) the four most severe

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[140] *See* Ex. NYS000243, MACCS2 User's Guide, at 1-2 (MACCS code is intended to facilitate the "evaluation of sensitives and uncertainties"); Tr. at 2078-79, 2039 (regarding sensitivity analysis for tourism and lost business); New York Response to Commission Questions at 16 (regarding sensitivity analysis relating to population).

[141] *See* "Generic Environmental Impact Statement for License Renewal of Nuclear Plants: Regarding Braidwood Station, Units 1 and 2," NUREG-1437, Supp. 55, Final Report, app. F, at F-18 to F-20 (Nov. 2015) (ML15314A814) (citing Braidwood Station Environmental Report, SAMA Analysis, Rev. 2, app. F, at F-340); "Generic Environmental Impact Statement for License Renewal of Nuclear Plants: Regarding Byron Station, Units 1 and 2, NUREG-1437," Supp. 54, Final Report, app. F, at F-20 (July 2015) (ML1516A263) (citing Byron Station Environmental Report, SAMA Analysis, Rev. 2, app. F, at F-292)).

[142] The Staff issued a draft second supplement (Volume 5) to the FSEIS in December 2015, and expects to issue a final supplement in September 2016. *See NRC Staff's 50th Status Report in Response to the Atomic Safety and Licensing Board's Order of February 16, 2012* (Apr. 1, 2016), at 3.

accident categories modeled; and $100,000 for the CDNFRM values for heavy

decontamination, at least (but not limited to) the four most severe accident categories modeled.

Running the analysis to the maximum values allowed will provide a better understanding

of whether and to what extent uncertainty in these challenged values may alter the SAMA

analysis cost-benefit conclusions. Use of a $100,000 CDNFRM value for heavy

decontamination falls within New York's suggested range of CDNFRM values for the Indian

Point analysis: $71,255 to $112,856 for heavy decontamination, based on Dr. Lemay's

Approach "C" using the CONDO cost-estimating methodology (which Dr. Lemay described as

the "most appropriate" of his analyses) and which was calculated taking into account his

conclusions regarding the types of buildings and building density in the 50-mile radius area for

Indian Point.[143] A $100,000 CDNFRM value may prove to be over-conservative, but in a NEPA

analysis that seeks to identify *potentially* cost-beneficial mitigation alternatives,[144] it is not

inappropriate, where the basis for a given input value is uncertain, to err on the side of

conservative values when conducting a sensitivity analysis for that input.[145]

As to decontamination time, New York claims that the SAMA analysis "should at a

minimum account for the possibility of decontamination times of one year."[146] Given that it is

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[143] *See* Ex. NYS000430, New York Revised Tables, at tbl. 11; Tr. at 2108, 2111, 2137-38, 2150.

[144] *See generally* Ex. NYS000133I, FSEIS, app. G.

[145] Entergy does argue that "simple" (or "independent") sensitivity analyses would not be "appropriate," reasoning that TIMDEC, CDNFRM, and the decontamination factors are interrelated. Entergy Response to Commission Questions at 25. We do not deny that these inputs are interrelated, and our decision does not preclude the Staff from considering interrelationship of inputs when choosing values for the sensitivity analyses or from discussing the topic within the FSEIS supplement. In any event, with no sufficient explanation in the record for how the TIMDEC and CDNFRM values were derived, the record leaves us similarly uncertain as to the impacts of these interrelationships. The sensitivity analyses we are requiring here are intended to inform our understanding of how material these uncertainties are to the SAMA analysis conclusions.

[146] *See* New York Response to Commission Questions at 30.

undisputed that three out of the eight release categories modeled in the Indian Point analysis reflect cesium releases relatively comparable to (or greater than) those experienced at Fukushima, we agree with New York that it is inappropriate to discount altogether the example of the Fukushima accident as an irrelevant "extreme" or "worst case" scenario, as the Staff and Entergy argue.[147] While we may not yet have a full understanding of what aspects of the Fukushima decontamination experience might be applicable to NRC severe accident analyses including (as relevant here) environmental analyses, the Fukushima experience highlights the potential need for extended decontamination periods following a severe accident with offsite consequences. At least in regard to the more severe releases modeled in the Indian Point analysis, a sensitivity analysis using a TIMDEC value of one year is reasonable.

Current code limitations do not permit the use of TIMDEC values longer than one year (nor of CDNFRM values greater than $100,000 per person). And here we agree with the Staff and Entergy that revising the code to accept TIMDEC and CDNFRM values outside of the currently allowed ranges would require a complex effort, necessitating expert validation and verification, including testing by independent laboratories.[148] As discussed below, NEPA does not require such an effort here.

Much of the evidence presented in this case, including much of New York's own evidence, relates to experimental data or to decontamination cost data from incidents or accidents that may have limited relevance.[149] Dr. Lemay's own testimony from late 2011

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[147] *See* Petition at 24; Staff Answer to New York Petition at 19; Entergy Answer to New York Petition at 32.

[148] Staff Response to Commission Questions at 33; *see also* Staff Answer to New York Petition at 18; Ex. ENT000450, Entergy Testimony, at 15, 74-76.

[149] *See* Ex. NYS000241, New York Testimony, at 20 (alternate decontamination cost values based on "extrapolating data from other types of nuclear accidents, field radiological work," and experiments).

stressed how "very little data" existed at the time on decontamination following "an actual severe reactor accident" in an urban environment.[150] Recent real-world data emerging from the Fukushima accident will provide significantly more relevant modern-day sources for assessing the decontamination times and costs of a severe reactor accident with offsite consequences. The accident involved cesium releases on the order of those modeled in the Indian Point SAMA analysis, for example, and an extensive cleanup effort remains under way. Data based on in-the-field decontamination work ultimately will allow for the review and updating, where warranted, of decontamination cost-related estimates that historically may have been based on experimental data or on smaller-scale radiological accident cleanup.[151]

Notably, as testimony in this case described, the CDNFRM and TIMDEC values are inter-connected, and they additionally relate to the decontamination effectiveness level, and to other input values in the SAMA analysis. A number of complex considerations would be involved in properly selecting alternate CDNFRM and TIMDEC values (or ranges of values) for a SAMA analysis.[152] Conclusions would need to be reached, for example, on the effectiveness

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[150] *Id.*

[151] In an unrelated context, the NRC Staff recently informed us that "Research efforts are underway to evaluate newly emerging information from the Fukushima accident recovery experience, and in particular develop MACCS decontamination plan input parameters based on Fukushima." *See* Draft Regulatory Basis for Containment Protection and Release Reduction for Mark I and Mark II Boiling Water Reactors (10 CFR Part 50) (May 2015) at 84, enclosure to "Evaluation of the Containment Protection and Release Reduction For Mark I and Mark II Boiling Water Reactors Rulemaking Activities (10 CFR Part 50) (RIN-3150-AJ26)," Commission Paper SECY-15-0085 (June 18, 2015) (ML15042A218) (package). The specific input parameters under review "include the costs to decontaminate, the dose reductions achieved [e.g., dose reduction factors or decontamination levels], and the times required to perform decontamination." *See id.* at 85. In short, the TIMDEC and CDNFRM values litigated in this case are now under review by the Staff. Such a review likely will require an extended time to complete, as we note above.

[152] *See, e.g.*, Tr. at 2201-03, 2247 ("cost is linked to the time, which is linked to the dose reduction factor"), 2273 (if decontamination time is "long enough, it could be that just radioactive decay and weathering would have gotten you below the habitability level, and you wouldn't need to decontaminate" an area); Staff Answer to Petition at 17-18.

of different decontamination strategies on different kinds of materials, and on the costs and time

scales necessary to achieve the different levels of decontamination effectiveness. Sufficient

data would need to be gathered and analyzed to reach such conclusions, including data on the

sizes of areas cleaned, workforce and resource needs, decontamination methods used, and

even waste disposal considerations.

An EIS, however, is not a "research document reflecting the frontiers of scientific

methodology, studies, and data."[153] And NEPA does not require the NRC to stop and await

internationally-based research and potential code modifications that could take years to

complete. Otherwise the NEPA process would effectively "become unending," particularly given

the NRC's frequent long-term research to improve severe accident consequence modeling.[154]

NEPA requires only a "reasonably complete" mitigation analysis.[155] Our decision mandating

sensitivity analyses to the full extent of the code strikes a reasonable balance between

disclosure of uncertainties (and their potential to affect the cost-benefit results) and what we

reasonably can conclude and apply to the Indian Point analysis today.[156]

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[153] *See Entergy Nuclear Generation Co. and Entergy Nuclear Operations, Inc.* (Pilgrim Nuclear Power Station), CLI-10-11, 71 NRC 287, 315 (2010) (citing *Town of Winthrop v. FAA*, 535 F.3d 1, 11-13 (1st Cir. 2008)).

[154] *See Massachusetts v. NRC*, 708 F.3d 63, 82 (1st Cir. 2013).

[155] *See Citizens Against Burlington Inc. v. Busey,* 938 F.2d 190, 206 (D.C. Cir. 1991); *see also Pilgrim*, CLI-10-22, 72 NRC at 208-09 & n.40.

[156] Moreover, we have generically determined, based on probability-weighted consequences, that the environmental impacts from severe accidents at plants operating under renewed licenses are expected to be "small"—our lowest impact category. *See* 10 C.F.R. pt. 51, subpt. A, app. B, tbl. B-1 (codifying license renewal GEIS finding on environmental impacts of postulated severe accidents). Under basic NEPA principles, it is reasonable to tailor the degree of mitigation analyses to the significance of the impact to be mitigated. *See* 10 C.F.R. § 51.45(b)(2) ("Impacts shall be discussed in proportion to their significance."); 40 C.F.R. § 1502.2 (same).

III.   ADDITIONAL CHALLENGES TO LBP-13-13

A.   Other Challenged Input Values

New York also argues that the Board erred in limiting its consideration only to the

TIMDEC and CDNFRM inputs, when New York had also challenged other economic input

values in the analysis.[157] New York refers to the following five other economic input values:

POPCST, VALWNF, DSRATE, FRNFIM, and DPRATE.

The Board focused its decision only on the decontamination time and non-farm

decontamination cost values because Dr. Lemay testified that "CDNFRM and TIMDEC were the

most important ones, and the *rest had minimal impact* on the calculation of the offsite economic

cost."[158] Values with only a minimal effect on the offsite economic cost risk are not likely to

change the SAMA cost-benefit analysis conclusions, especially considering that economic cost

risk is only one portion of the offsite risk analysis, the other major portion being population dose

risk. As to the DSRATE, DPRATE, and FRNFIM values, Dr. Lemay stated that using the

alternate values that he considered more appropriate would have a "negligible" overall effect on

the offsite economic cost risk.[159]

In regard to VALWNF, which represents a per capita value of non-farm wealth, Dr.

Lemay characterized his proposed change to scale up the SAMA analysis values from 1997

dollars to 2004 dollars a "minor correction" and agreed with the Board that it did not warrant

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[157] Petition at 58.

[158] Tr. at 2054-55 (emphasis added); LBP-13-13, 78 NRC at 459.

[159] Ex. NYS000241, New York Testimony, at 61-62. DSRATE defines the expected rate of return from land, buildings, equipment, etc. DPRATE defines the property depreciation rate (from lack of habitation and maintenance), and FRNFIM defines the fraction of non-farm wealth due to improvements. *See* LBP-13-13, 78 NRC at 459. The values for these cost categories also were taken from the "Sample Problem A" values outlined in the MACCS2 code user's guide and taken from the NUREG-1150 study. *See id.* at 459 & n.1479.

much examination at the hearing.[160] According to Dr. Lemay's analysis, the proposed

adjustment would increase the final offsite economic cost risk by approximately 18%, not a

major revision in light of such an extensive NEPA analysis.[161] Nonetheless, given that in this

decision we remand the SAMA analysis for sensitivity analyses, the Staff should consider taking

the opportunity to examine the sensitivity of this input by scaling up the VALWNF dollar values,

if appropriate.

The last additional economic input value that New York references is POPCST, which is

defined as the per capita cost of temporary or permanent relocation of population and

businesses in a region rendered uninhabitable during the modeled "long-term phase" period.[162]

As described in the MACCS2 code user's guide, the value should be derived in a fashion that

"takes account of both personal and corporate income losses for a transitional period as well as

moving expenses."[163] The parties here agreed that moving expenses would not contribute

much to the value given that most of the belongings of relocated individuals would be

contaminated and therefore would not be moved.[164] Apart from moving expenses, the rest (and

most) of the value represents an average "personal income per day" multiplied by a "number of

days of lost wages" considered appropriate.[165]

Dr. Bixler, for the Staff, described the POPCST value as a "one-time relocation cost," to

"account for [wage] losses" that would be incurred until "for example, . . . a new job" were

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[160] *See* Tr. at 2212.

[161] *See* Ex. NYS000241, New York Testimony, at 58-59.

[162] *See* LBP-13-13, 78 NRC at 459. In the Indian Point SAMA analysis, the "long-term phase" begins following an initial seven-day "emergency phase" and extends 30 years.

[163] *See* Ex. NYS000243, MACCS2 User's Guide, at 7-14.

[164] *See* Ex. NYS000241, New York Testimony, at 60; Tr. at 1974, 2213.

[165] *See* Tr. at 2213.

found.[166] The POPCST value used in the SAMA analysis is $8,640 per person. It is derived

from a NUREG-1150 value of $5,000 per person, escalated by use of the Consumer Price Index

to $8,640.[167] The value reflects a "per capita lost income of $61.70/person-day" and an

estimated unemployment period of 140 days (or 20 weeks).[168] The value is not intended to

reflect a "permanent loss of salary," but was described by Entergy expert Mr. Teagarden as a

"disruption cost" that "reflects primarily a transition period of some loss of income for a period of

time."[169] Staff expert Mr. Jones stated the POPCST value is applied per person for anyone

relocated, regardless of age or whether employed, and therefore would reflect a cost of "just

over $40,000" for a family of five.[170]

New York's proposed higher range of POPCST values is based on the view that while

"New York State unemployment benefits normally last 26 weeks (182 days)," unemployment

benefits "extended to 93 weeks (651 days)" during the 2008 economic crisis.[171] New York's

proposed range of POPCST values—$10,640 to $49,857 per person—are based on a minimum

of 140 days to a maximum of 651 days of unemployment benefits, and Dr. Lemay agreed an

average value within that proposed range would be approximately $25,000 per person.[172] New

York's proposed larger POPCST value is essentially an argument for a more conservative

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[166] *See id.* at 1972-73.

[167] *See* Ex. ENT000450, Entergy Testimony, at 125 (citing description of value in NUREG/CR-4551). NUREG/CR-4551 explains how the NUREG-1150 value of $5,000 was derived. It is mostly based on a $14,600 per capita income value from 1986, and the assumption of 140 days of lost wages. *See id.*; Ex. NYS00248, NUREG/CR-4551, at 5-3.

[168] *See* Ex. ENT000450, Entergy Testimony, at 125; Tr. at 1975, 2213.

[169] Tr. at 1979.

[170] *Id.* at 1972.

[171] See Ex. NYS000241, New York Testimony, at 60; Tr. at 2213-14.

[172] Tr. at 2213-14.

unemployment benefits timeframe given that an "extended benefit" was provided "following the crash in 2008."[173] New York does not show that the 140-day value used in the analysis is unreasonable or otherwise in error. In short, the Board's failure to address these input values at most amounts to harmless error.

B.   Decontamination Levels

New York's appeal additionally challenges the decontamination levels assumed in the Indian Point analysis. New York claims that Dr. Lemay's benchmarking analysis calculations, "for the purposes of comparison . . . used the same decontamination factors as Entergy" (3 and 15), but that "Entergy's values are likely unrealistic."[174] New York argues that "real world experience demonstrates that decontamination of an entire building to a level greater than 10, i.e., 90%, may not be possible or realistic" at all to achieve.[175] But the Staff and Entergy provided evidence (including by Mr. Jones, who has decontamination work experience) that decontamination to a level of 15 potentially may be achievable with current decontamination technologies.[176] In the future, data from Fukushima will bring a greater understanding of decontamination methods and their effectiveness for different kinds of materials, and help to verify (or refute) these effectiveness assumptions, but we find that adequate evidence exists in the record for the values used.

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[173] *Id.* at 2214.

[174] Petition at 50.

[175] *Id.*

[176] *See, e.g.*, Ex. NRC000041, Staff Testimony, at 43-44; Ex. ENT000450, Entergy Testimony, at 71.

C.   **Other Costs the SAMA Analysis Do Not Consider**

New York also argues that the Board's decision failed to recognize that the MACCS2 code does not account for "all of the costs associated with a severe accident."[177] New York further claims that there is "no requirement, regulatory or otherwise, that the MACCS2 code be used in a SAMA analysis."[178] The NRC, however, has never represented that the SAMA analysis encompasses "the entirety of the environmental impacts that could realistically be associated with a severe reactor accident."[179] Nor is the SAMA analysis intended to serve as the severe accident environmental impacts analysis for Indian Point, as we earlier stressed. The generic bounding environmental impacts analysis contained in the NRC's License Renewal GEIS applies to Indian Point.

As a mitigation analysis, the SAMA cost-benefit analysis need not include every potential accident impact and cost conceivable. It is well known that the SAMA analysis does not include various categories of costs, including for example, hospitalization or other medical costs (the analysis instead assesses costs based on radiological dose the population receives), loss of tax revenues, deployment of the National Guard, and litigation expenses. NEPA requirements are "tempered by a practical rule of reason."[180]

Further, New York's arguments raise claims beyond the scope of the admitted contention. The Board admitted the contention "to the extent that it challenged the reasonableness of the "cost data for decontamination and clean up used in MACCS2."[181] And

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[177] *See* Petition at 51.

[178] *Id.*

[179] *See id.* at 52.

[180] *See Pilgrim*, CLI-10-22, 72 NRC at 208 (citation omitted).

[181] *See* LBP-13-13, 78 NRC at 451.

as to use of the code, Dr. Lemay stressed that "use of the MACCS2 code is not in question,"

and "it's the right tool for doing this job."[182]

IV.   NEW YORK'S PETITION FOR REVIEW OF APRIL 1, 2014 DECISION

We also have before us New York's petition for review of the Board's April 1 decision.[183]

New York sought to have the Board reopen the record on NYS-12C and reconsider its decision

in LBP-13-13 based on the Staff having used a 365-day decontamination time (for both light and

heavy decontamination levels) in a spent fuel pool consequence study that was issued in

2013.[184] New York claimed that the Staff's use of the 365-day period contradicted the Staff's

testimony regarding a standard and ongoing practice of using the 60-day and 120-day

decontamination time values. The Board denied New York's motion, concluding that New

York's claims likely would not have led the Board to reach a materially different result.[185]

In seeking our review, New York's petition calls the Board's April 1, 2014 order

"inextricably linked to, and part of, the Partial Initial Decision."[186] Among other claims, New York

argues that the Board overlooked New York's evidence that using a "365 day TIMDEC for the

four most severe accidents Entergy modeled (while maintaining Entergy's values for all other

parameters) would almost double the offsite economic cost risk."[187] While we granted review of

both related Board decisions, we need not reach the various arguments on the Board's April 1,

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[182] *See* Tr. at 2175.

[183] *See* Petition for Review of April 1, 2014 Board Decision.

[184] *See State of New York Motion to Reopen the Record and for Reconsideration on Contention NYS-12C* (Dec. 7, 2013).

[185] *See* Order (Denying New York's Motion to Reopen the Record; Setting Deadline for New or Amended Contention) (Apr. 1, 2014) (ML14091A319) (unpublished), at 3.

[186] Petition for Review of April 1, 2014 Board Decision at 12.

[187] *See id.* at 16.

2014 decision. Our decision already encompasses New York's principal arguments on the

TIMDEC values, which New York reiterates in its second petition for review.[188] Here, it is

undisputed that the Staff used a 365-day TIMDEC value in the spent fuel pool consequence

study. That fact is not material to our conclusions relating to the Board's decision in LBP-13-13.

Reopening the record on Contention NYS-12C is unwarranted given the conclusions we reach

today.

In conclude with two comments. First, our decision today is not about flyspecking. It is

instead about responding with appropriate scrutiny and reasoned explanations to "opposing

views,"[189] which includes being able to explain and make available underlying assumptions in

our environmental analyses. Second, while the sensitivity analyses we direct the Staff to

provide may identify additional potentially cost-beneficial mitigation measures, these would be

additional *alternatives* for consideration to further reduce risk. NEPA does not require that a

"mitigation plan be actually formulated and adopted."[190] NEPA seeks to "guarantee process,"

not any "specific outcomes."[191]

V.   CONCLUSION

With respect to Contention NYS-12C, we *reverse* the Board's decision in LBP-13-13 in

regard to the TIMDEC and CDNFRM input values, and direct the Staff to run sensitivity

analyses for those values, as indicated. New York's petition for review of the Board's April 1,

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[188] *See id.* at 5-8.

[189] *See* 10 C.F.R. § 51.91(b).

[190] *Robertson v. Methow Valley*, 490 U.S. 332, 352 (1989).

[191] *Massachusetts v. NRC*, 708 F.3d at 78. NEPA does not, for example, require agencies or third parties to effect mitigation measures. *See, e.g.*, *Theodore Roosevelt Conservation P'ship v. Salazar*, 616 F.3d 497, 503 (D.C. Cir. 2010) (quoting *Citizens Against Burlington*, 938 F.2d at 206).

2014 decision is *denied.* Our decision today becomes part of, and serves to supplement, the

environmental record of decision for this matter.[192]

       IT IS SO ORDERED.[193]

                           For the Commission

NRC SEAL   **/RA/**

                          _____

                          Annette L. Vietti-Cook
                          Secretary of the Commission

Dated at Rockville, Maryland,
this 4th day of May, 2016.

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[192] *See, e.g., Louisiana Energy Services, L.P.* (National Enrichment Facility), CLI-06-15, 63 NRC 687, 707 n.91 (2006).

[193] Chairman Burns did not participate in this matter.

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

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

CERTIFICATE OF SERVICE

I hereby certify that copies of the foregoing **COMMISSION MEMORANDUM AND ORDER (CLI-16-07)** have been served upon the following persons by Electronic Information Exchange.

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[Original signed by Herald M. Speiser   ]
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Dated at Rockville, Maryland
this 4th day of May, 2016