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EPA AN SAB REPORT: MULTI-MEDIA RISK ASSESSMENT FOR RADON

REVIEW OF UNCERTAINTY ANALYSIS OF RISKS ASSOCIATED WITH EXPOSURE TO RADON

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

July 9, 1993

OFFICE OF THE ADMINISTRATOR
SCIENCE ADVISORY BOARD

EPA-SAB-RAC-93-014

Honorable Carol M. Browner
Administrator
U.S. Environmental Protection Agency
401 M Street, S.W.
Washington, DC 20460

Re: Review of Uncertainty Analysis of Risks Associated with Exposure to Radon--"Chafee-Lautenberg Multi-media Risk Study"

Dear Ms. Browner:

The Science Advisory Board (SAB) is working with the Agency to reply to the so-called "Chafee-Lautenberg amendment" which is a part of the Agency's FY93 appropriation act. The Act calls for Agency generation and SAB review of a Study that addresses: (a) a multi-media risk assessment of radon gas; and (b) an assessment of the costs of mitigating those risks. As described in our recent commentary (EPA-SAB-EC-COM-93-003), the attached report is the first of three SAB reports that you will receive in connection with the Chafee-Lautenberg Study. This report addresses the risks posed by radon gas in various media (e.g., basements of homes and drinking water), with a focus on the Agency's quantitative uncertainty analysis associated with these risk estimates.

Specifically, this report is based upon the Radiation Advisory Committee's review of the EPA risk assessment study, *Uncertainty Analysis of Risks Associated with Exposure the Radon in Drinking Water* (January 29, 1993), related documents and public comment. The review was conducted at a public meeting February 17-19, 1993.

The Committee's charge was to review the adequacy of revisions of inhalation and ingestion risk from radon progeny and the adequacy of uncertainty analysis regarding risk assessment of water-borne radon, including health risk analysis and exposure analysis. In considering adequacy in the review, the Committee was mindful of concerns it had expressed in two earlier SAB reports about EPA documents on radon in drinking water which were transmitted to the Administrator in January, 1992.

Technical Observations

The Committee commends the EPA staff for having produced an excellent document that responds to previous SAB comments on uncertainty analysis and the exposure to radon gas at the point of use (e.g., showering). This response is all the more impressive given the constraint of tight deadlines imposed upon it by Congressional and Court mandates. Its quantitative analysis of uncertainties in the radon risk assessment represents a methodology that is essentially state-of-the-art and significantly enhances the scientific credibility of the EPA's decision-making basis. The Committee assumes that this reflects the EPA's recently stated commitment to a more rigorous approach to evaluating uncertainties in its risk analyses of radiological and other hazardous exposures in the future. However, the Committee continues to have concerns about the exposures and risks that could be associated with certain treatment options (e.g., granular activated carbon), once those options are selected.

Based on the current analysis, the risks associated with radon gas in homes from underground sources is considerably greater than the risks associated with the risks posed by radon gas in the drinking water supply. That smaller risk from radon gas in drinking water is composed of nearly equal contributions of the inhalation and ingestion pathways. The Committee notes, however, that the quantitative uncertainty analysis for the drinking water case does not cover some of the more important uncertainties. In particular, the Committee believes that the overall uncertainty regarding the ingestion risk estimate is substantially greater than would be inferred from the quantitative confidence interval.

Overall, the Committee finds that the EPA has adequately addressed most of the issues raised by the Committee in its earlier reports, either by incorporating the Committee's previously recommended changes into the new documents or by providing additional background documentation supporting the EPA's position. In the accompanying report the Committee makes a number of specific scientific comments and recommendations for additional improvements to the document. These deal with important issues such as uncertainties associated with an unpublished study on xenon that contributes significantly to the estimated internal doses from ingested radon-containing drinking water, the influence of smoking on lung cancer risks from radon, and, again, unsettled question of treatment technologies. These issues can generally be addressed by including clarifying statements. Further, the changes in most cases would not substantially change the document's estimates of central values for risks.

Policy Considerations

The comments below, to some extent, reach beyond the strictly technical issues examined by the Committee. However, the Committee feels that it was important that

the Agency have the benefits of these thoughts, also, as the decisionmaking process continues.

The Radiation Advisory Committee has long encouraged the use of integrated quantitative uncertainty analysis in a variety of EPA assessments. As noted above, the Committee is extremely pleased to see that the EPA has done such an analysis in this case. The Committee applauds EPA for its timely incorporation of a full quantitative uncertainty analysis for each pathway in its assessment and hopes that the use of quantitative uncertainty analysis will become a routine part of all EPA assessments, not only those associated with radiation risks. This information should be a valuable aid in guiding EPA in its consideration of possible regulatory strategies.

The Committee agrees with the Agency's Feb. 26, 1992 "risk characterization memo" that articulates the EPA policy of explicitly disclosing uncertainty in quantitative risk assessment. Screening risk assessments involve only point estimate calculations, and assumptions used to derive these estimates are generally biased on the conservative side and can be misleading in terms of indicating the need for regulatory action. In contrast, regulatory action must be based on realistic estimates of risk and these require a full disclosure of uncertainty. The disclosure of uncertainty enables the scientific reviewer, as well as the decisionmaker, to evaluate the degree of confidence that one should have in the risk assessment.

In its January 29, 1992, *Commentary: Reducing Risks from Radon; Drinking Water Criteria Documents* (EPA-SAB-RAC-COM-92-003), the Committee noted that the radon risk reduction situation reflects the fragmentation of environmental policy identified in *Reducing Risk* (EPA-SAB-EC-90-021). Therefore, the Committee suggested that the EPA focus its efforts on primary sources (e.g., radon in some home basements), rather than on secondary sources of risk, such as radon in drinking water, which is a very small contributor to radon risk, except in rare cases.

In summary, within the limitations of the data currently available, the EPA has now successfully prepared a scientifically credible multi-media risk assessment for regulatory decision-making on radon. The Committee's agreement with the principle of radiation protection optimization and in the concepts articulated in *Reducing Risk* lead it to note once again that radon in drinking water represents only a small fraction of radon exposure and risk compared to radon in indoor air from non-water sources. We acknowledge, however, that the relative emphasis given to various radon exposure reduction methods--whether for radon from water or non-water sources--is a policy choice for which scientific analysis is only one of many important inputs.

The Radiation Advisory Committee appreciates the opportunity to comment on the EPA's uncertainty analysis of risks associated with exposure to radon. We look

forward to receiving the EPA's response to the this report, particularly as it relates to our explicit recommendations.

Sincerely,

Raymond C. Loehr

Dr. Raymond C. Loehr
Chair, Executive Committee
Science Advisory Board

Genevieve M. Matanoski

Dr. Genevieve M. Matanoski
Chair, Radiation Advisory Committee
Science Advisory Board

NOTICE

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ABSTRACT

The Radiation Advisory Committee has reviewed the EPA's, "Uncertainty Analysis of Risks Associated with Exposure the Radon in Drinking Water " (January 29, 1993), related documents and public comment. The Committee reviewed the adequacy of the EPA's revisions of the risk assessment for both the ingestion and inhalation exposure pathways, and the adequacy of the associated uncertainty analysis has been examined. The Committee also considered the EPA's estimates of risks associated with radon exposures due to releases at drinking water treatment facilities. The Committee was mindful of its previously expressed concerns regarding the Agency's: (a) lack of quantitative uncertainty analyses; (b) failure to consider direct exposure to radon and its progeny released by showers; (c) lack of an assessment of risks associated with drinking water treatment; and (d) lack of consideration of potential occupational exposures and risk.

Overall the Committee finds that EPA has adequately addressed most of the issues raised in earlier reports from the Committee. The quantitative uncertainty analysis developed by the EPA represents a methodology that is state-of-the-art and significantly improves the scientific basis for the EPA's decision-making. The revised estimates for ingestion and inhalation risks due to radon in drinking water are scientifically acceptable. There is concern, however, that the uncertainties in the estimate of ingestion risk are larger than suggested by the quantitative uncertainty analysis. The Committee recommends that the EPA incorporate a qualitative discussion of known, but not quantified, uncertainties in its analyses and given the larger uncertainty bounds associated with the ingestion risk, that consideration be given to keeping the ingestion and inhalation risks separate in the EPA's deliberations on standards for radon in drinking water. The Committee also reiterated its previously stated concerns that the overall risks associated with radon in drinking water are small compared with the average radon exposures due to indoor air and that the drinking water risks be placed in context with other radon risks in the summary documents developed by the EPA.

The Committee's report also provides comments and recommendations regarding the adequacy of the analysis and the approaches taken. Among these was the recommendation that the EPA look at a range of water treatment technologies and include in the analyses risks due to occupational radiation exposures and potential waste disposal issues. Finally, the Committee also recommends that particular attention be given to the uncertainties associated with the variance and shape of the probability density functions used by the EPA to represent variability of exposures among individuals.

KEYWORDS: radon, drinking water, uncertainty, inhalation, ingestion

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* Although Dr. Makhijani attended the February 17-19 meeting, his participation in this review was limited.

**Mr. Voilleque was unable to attend the February 17-19, 1993 meeting where this review was conducted and has subsequently resigned from the Radiation Advisory Committee.

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1. EXECUTIVE SUMMARY

1.1 Background

In EPA's 1993 appropriation[1], Congress required EPA to, "conduct a risk assessment of radon considering: . . . the risk of adverse human health effects associated with exposure to various pathways of radon . . . . Such an evaluation shall consider the risks posed by the treatment and disposal of any wastes produced by water treatment." Congress also required that, "The Science Advisory Board shall review the Agency's study and submit a recommendation to the Administrator on its findings." This letter and the accompanying report set forth the Radiation Advisory Committee's findings and recommendations based on its review of the EPA risk assessment study, *Uncertainty Analysis of Risks Associated with Exposure the Radon in Drinking Water* (January 29, 1993), related documents and public comment. The EPA uncertainty analysis addressed four radon exposure pathways: inhalation indoors of radon from non-water sources, inhalation of radon outdoors, ingestion of waterborne radon, and inhalation of waterborne radon. The review was conducted at a public meeting February 17-19,1993.

The Committee's charge was to review the adequacy of revisions of inhalation and ingestion risk from radon progeny and the adequacy of uncertainty analysis regarding risk assessment of water-borne radon, including health risk analysis and exposure analysis. In considering adequacy in the review, the Committee was mindful of concerns it had expressed in reports about earlier EPA documents on radon in drinking water transmitted to the Administrator on January 9 and 29, 1992: (a) that uncertainties associated with the selection of particular models, specific parameters used in the models, and the final risk estimates were not adequately addressed in any of the documents; (b) that high exposure to radon from water at the point of use (e.g., a shower) had not been adequately addressed; (c) that regulation of radon in drinking water introduces risk from the disposal of treatment byproducts, tradeoffs which the EPA should consider more explicitly in its regulatory decision-making; and (d) that regulation and removal of radon in drinking water may result in occupational exposures.

[1] Departments of Veterans Affairs and Housing and Urban Development, and Independent Agencies Appropriation Act, 1993, PUB. L. 102-398, Section 519, 106 STAT 1618 (1992)

1.2 Technical Considerations

Regarding the Committee's charge and concerns (a) and (b) above, the Committee commends the EPA staff for producing an excellent document all the more impressive given the constraint of tight deadlines imposed upon it by Congressional and Court mandates. Its quantitative analysis of uncertainties in the radon risk assessment represents a methodology that is essentially state-of-the-art for a regulatory agency and significantly enhances the scientific credibility of the EPA's decision-making basis. The Committee assumes that this reflects the EPA's recently stated commitment to a more rigorous approach to evaluating uncertainties in its risk analyses of radiological and other hazardous exposures in the future. With respect to concerns (c) and (d) above, the Committee recommends that EPA re-examine its assumptions about which water treatment technologies will be used for radon removal. When EPA has determined the likely treatment options, then EPA should perform an uncertainty analysis for occupational exposure based on that distribution (including the uncertainty about how frequently the various options will be used). If granular activated carbon is among those treatment options, then EPA should broaden the uncertainty analysis to include the disposal of granular activated carbon.

With respect to the EPA's analysis, the risk assessment of radon in drinking water has been revised and an uncertainty analysis has been conducted using Monte Carlo simulation methods. The uncertainty analysis incorporates quantifiable uncertainties in exposure and toxicology, as well as true variation in exposure among individuals. EPA's mean estimate for the lifetime individual inhalation risk of lung cancer deaths per pCi/L of radon in drinking water is 3.6×10^{-7}, with a stated 90% confidence interval around the mean of 1.8×10^{-7} to 7.0×10^{-7}. The Agency's mean estimate for the lifetime individual ingestion risk of fatal cancers per pCi/L of radon in drinking water is 1.8×10^{-7} with a stated confidence interval around the mean of 6.9×10^{-8} to 6.4×10^{-7}. The Agency's nominal estimate for individual lifetime inhalation and ingestion risk per pCi/L for radon in drinking water are 3.0×10^{-7} and 3.5×10^{-7}, respectively. Therefore, for drinking water risks, the contributions of the inhalation and ingestion are almost equal.

The Committee notes, however, that the quantitative uncertainty analysis for the drinking water case does not cover *some of the more important uncertainties. In particular, the Radiation Advisory Committee believes that the stated uncertainty range for the ingestion risk is too small in comparison with that for inhalation, because the

ingestion risk estimate is based on two major factors: (a) an estimate of the distribution of radon to organs in the gastrointestinal tract, based on an unpublished study using xenon-133, and (b) the use of organ radiation risk factors that are based on high dose and high-dose rate exposures to low-LET radiation extrapolated to low dose and low-dose rates. These risk factors are then converted to high-LET radiation risks for alpha particles associated with radon and its progeny. The Committee recommends that EPA not only make this clear in its documents but also consider keeping the estimates or risks from inhalation and ingestion separate in its discussion of standards for radon in drinking water.

Overall, the Committee finds that the EPA has adequately addressed most of the issues raised by the Committee in its earlier reports, either by incorporating the Committee's previously recommended changes into the new documents or by providing additional background documentation supporting the EPA's position. The Committee makes the following scientific comments and recommendations for additional improvements to the document, but notes that these issues can generally be addressed by including clarifying statements and that the changes in most cases would not substantially change the document's estimates of central values for risks. (A more detailed discussion of each of the comments and recommendations can be found in the report section identified in parentheses.)

a) Recommendation Organ-specific doses used in the document for assessment of ingestion risks are based, in part, upon a single study of kinetics of xenon in humans, work that has not been published in the peer-reviewed literature. The cited study also did not include a mass balance determination. Consequently, the Committee recommends that the EPA carefully review this study to evaluate whether the uncertainties attributed to the results are adequately described. (3.1.1)

b) Comment With regard to assessment of inhalation risks associated with drinking water exposure (e.g., showering), the Committee believes that the EPA's uncertainty analysis is satisfactory and that, given the nature of the uncertainties, the transfer factor approach used in the document adequately accounts for risks arising from episodic shower exposures. (3.1.2)

c) Recommendation The Committee noted some minor inconsistencies between values in relevant documents and recommends that the EPA review its selection of parameter values (including ranges and their uncertainties) for each exposure pathway to ensure consistency with original data sources. (3.1.3)

d) Comment The Committee believes that the basic methods used to propagate uncertainty are acceptable. Proper consideration has been given to the possibility of covariance, and the Monte Carlo simulation methods are state-of-the-art. (3.2.1)

e) Recommendation The Committee recommends that particular attention be given to more completely addressing uncertainty about the variance and shape of the probability density functions (PDFs) that have been assumed by the EPA to represent variability in exposures among individuals. (3.2.2)

f) Recommendation The Committee recommends that the EPA include in its uncertainty analysis a qualitative discussion of known uncertainty variables which were not quantified in the uncertainty analysis. These include the issue of a linear dose rate response extending to low doses, the influence of smoking on increasing lung-cancer risks from radon, and the effect of population mobility on the distribution of risks. (3.2.3)

g) Recommendation In order to increase the scientific credibility of the results, the Committee recommends that EPA consider upgrading the uncertainty analysis for the risks associated with aeration for radon removal; however, the proposed revisions to the analysis will not change the conclusion that the risk for a maximally exposed individual attributable to radon released from a water treatment facility will be less than or equal to the average risk attributable to 300 pCi/L of radon in drinking water used in the home. (3.3.1)

h) Recommendation If EPA determines that granular activated carbon will be used for radon removal, the Committee urges EPA to thoroughly and completely analyze any potential risk and/or disposal problems related to

the use of granular activated carbon (GAC) for radon removal from drinking water

i) Recommendation EPA did not provide an analysis of occupational exposures as a result of water treatment for radon. The potential for such exposures appears to depend heavily upon the choice of water treatment technology, and the Committee recommends that such a comparative analysis be conducted for different technologies, such as aeration or granular activated carbon filtration, especially in view of waste disposal problems that may result from use of the latter technology. (3.3.3)

j) Recommendation The Committee recommends that the document include a summary of the results of the uncertainty analysis regarding the contribution of the various exposure pathways to the overall radon risk to individuals and to the general population. This summary should also highlight the major sources of uncertainty contributing to the total uncertainty in the risk estimate for each pathway. Such a discussion would provide the information necessary to factor uncertainties and variabilities into the cost-benefit analysis for the proposed regulation and to calculate a range for the estimates of cost/life saved. (3.4.1)

k) Recommendation The Committee recommends that the EPA extend its population risk assessment and uncertainty analysis to obtain an estimate of the lives that would be saved by the proposed maximum contaminant level, using the same assumptions as were used to calculate present-day risks but using for radon concentration a lognormal probability density function truncated at the maximum contaminant level. (3.4.2)

l) Recommendation The Committee urges the EPA to submit its risk analyses for publication in appropriate journals which would provide peer-review and recognition that the EPA's science is of high-quality and that it becomes part of the mainstream of scientific criticism, revision, and acceptance (or rejection). Publication will also assist in raising awareness within the scientific community to the risk issues associated with radon. (3.4.3)

1.3 Policy Considerations

The comments below, to some extent, reach beyond the strictly technical issues examined by the Committee. However, the Committee felt that it was important that the Agency have the benefits of these thoughts, also, as the decisionmaking process continues.

The Radiation Advisory Committee has long encouraged the use of integrated quantitative uncertainty analysis in a variety of EPA assessments. The Committee is extremely pleased to see that the EPA has done such analysis in this case. The Committee applauds EPA for its timely incorporation of a full quantitative uncertainty analysis for each pathway in its assessment and hopes that the use of quantitative uncertainty analysis will become a routine part of all EPA assessments, not only those associated with radiation risks. This information should be a valuable aid in guiding EPA in its consideration of possible regulatory strategies.

The Committee believes strongly that the explicit disclosure of uncertainty in quantitative risk assessment is necessary. Screening risk assessments involve only point estimate calculations, and assumptions used to derive these estimates are generally biased on the conservative side and can be misleading in terms of indicating the need for regulatory action.

Regulatory action must be based on realistic estimates of risk and these require a full disclosure of uncertainty. The disclosure of uncertainty enables the scientific reviewer, as well as the decision-maker, to evaluate the degree of confidence that one should have in the risk assessment. (deleted sentence redundant with end of previous paragraph)

In its January 29, 1992, *Commentary: Reducing Risks from Radon; Drinking Water Criteria Documents* (EPA-SAB-RAC-COM-92-003), the Committee noted that the radon risk reduction situation reflects the fragmentation of environmental policy identified in *Reducing Risk* (SAB-EC-90-021). Because radon in drinking water is a very small contributor to radon risk except in rare cases, the Committee suggested that the EPA focus its efforts on primary rather than secondary sources of risk. Within the limitations of the data currently available, the EPA has now successfully prepared a scientifically credible multi-media risk assessment for regulatory decision-making on radon. The Committee's agreement with the principle of radiation protection

optimization and in the concepts articulated in *Reducing Risk* lead it to note once again that radon in drinking water represents only a small fraction of radon exposure and risk compared to radon in indoor air from non-water sources. The emphasis on various radon exposure reduction methods--whether for radon from water or non-water sources--is a policy choice for which scientific analysis is only one of many important inputs.

In its May 8, 1992 *Commentary on Harmonizing Chemical and Radiation Risk Reduction Strategies* (EPA-SAB-RAC-COM-92-007), the Committee brought to the EPA's attention the need for a more coherent policy for making risk reduction decisions with respect to radiation and chemical exposures. The control of radon in drinking water presents a situation where a radiological contaminant being regulated by a paradigm developed for chemicals, yet radon in drinking water represents only a small fraction of radon exposure. The Committee appreciates the EPA's difficulty in establishing a coherent risk reduction strategy under the variety of statutes governing EPA and acknowledges that harmonization does not necessarily imply identical treatment. However, the Committee urges the EPA to explain clearly why the risks from radiation (in this case radon in indoor air) and chemicals (in this case radon in drinking water) are treated differently under specified conditions and in specified exposure settings. The Committee urges EPA, the Congress and the public to carefully consider how chemical and radiation risks are being regulated in this case.

2. INTRODUCTION

2.1 Relevant Prior SAB Reports

For many years the Radiation Advisory Committee and other SAB committees have urged the incorporation of quantitative uncertainty analysis into EPA assessments to explicitly disclose the extent of confidence that one should have in the results of these assessments and to identify areas where the acquisition of additional information could lead to substantial improvements in the estimation of risks and uncertainties. In its recent multi-media radon risk assessment study entitled, *Uncertainty Analysis of Risks Associated with Exposure the Radon in Drinking Water* (January 29, 1993) the EPA has implemented most of the SAB's recommendations in a scientifically credible manner. A brief chronology of relevant SAB reports can be found in Appendix A.

2.2 Procedural History of this Review

This review resulted from the Chaffee-Lautenberg amendment. (A copy of the complete language can be found in Appendix B.) More formally known as the Departments of Veterans Affairs and Housing and Urban Development, and Independent Agencies Appropriation Act 1993, PUB. L. 102-398, Section 519, 106 STAT 1618 (1992), the amendment was also published in the U.S. Congressional Record and appears as Attachment 1 to this report. Regarding this review, Congress required EPA to,

> *conduct a risk assessment of radon considering: (A) the risk of adverse human health effects associated with exposure to various pathways of radon; (B) the costs of controlling or mitigating exposure to radon; and (C) the costs for radon control or mitigation experienced by households and communities, including the costs experienced by small communities as the result of such regulations. Such an evaluation shall consider the risks posed by the treatment or disposal of any wastes produced by water treatment. The Science Advisory Board shall review the Agency's study and submit a recommendation to the Administrator on its findings.*

This report by the SAB's Radiation Advisory Committee is a review of EPA's work in response to (A). The SAB's Drinking Water Committee is reviewing the

Agency's work in response to (B) and (C) and is generating a separate SAB report. In addition, a subcommittee of the SAB Executive Committee will generate a third SAB report that reviews the Agency's "synthesis document" that is being generated by EPA for submission to the Congress.

At publicly announced conference call meetings November 30, December 2, December 3, and December 17, 1992, the Radiation Advisory Committee together with members of the Drinking Water Committee, Environmental Engineering Committee, and Indoor Air Quality Committee provided a consultation to the EPA staff. The consultation was on EPA's outline for a multi-media radon risk assessment and on the parameters and uncertainty analysis for the assessment. The SAB has developed the consultation as a mechanism to advise the EPA on technical issues that should be considered in the development of regulations, guidelines, or technical guidance before the EPA has taken a position. Consultations differ from other SAB activities in that no report is generated by the SAB and no response from the EPA is required.

The review of "Uncertainty Analysis of Risks Associated with Exposure to Radon in Drinking Water " (January 29, 1993), related documents and public comment was conducted at a February 17-19, 1993 publicly announced meeting of the Radiation Advisory Committee. The first draft of this report was made available to the EPA and the public on February 19. Written comments were received from the EPA and the public subsequent to the meeting. The Committee held non-public writing sessions by conference call to revise the draft prior to its submittal to the Executive Committee.

The Committee's charge was to review the adequacy of revisions of inhalation and ingestion risk from radon progeny and the adequacy of uncertainty analysis regarding risk assessment of water-borne radon, including health risk analysis and exposure analysis. In considering adequacy in the review, the Committee was mindful of concerns it had expressed in reports about earlier EPA documents on radon in drinking water transmitted to the Administrator on January 9 and 29, 1992: (a) that uncertainties associated with the selection of particular models, specific parameters used in the models, and the final risk estimates were not adequately addressed in any of the documents; (b) that high exposure to radon from water at the point of use (e.g., a shower) had not been adequately addressed; (c) that regulation of radon in drinking water introduces risk from the disposal of treatment byproducts, tradeoffs which the

EPA should consider more explicitly in its regulatory decision-making; and (d) that regulation and removal of radon in drinking water may result in occupational exposures.

3. FINDINGS AND DETAILED DISCUSSION

3.1 Adequacy of Revisions to Ingestion and Inhalation Risk Estimates

3.1.1 Are revisions of ingestion risk estimates for waterborne radon and its progeny adequate?

Recommendation Organ-specific doses used in the document for assessment of ingestion risks are based, in part, upon a single study of kinetics of xenon in humans, work that has not been published in the peer-reviewed literature. The cited study also did not include a mass balance determination. Consequently, the Committee recommends that the EPA carefully review this study to evaluate whether the uncertainties attributed to the results are adequately described.

Discussion. Revisions of ingestion risk resulted from modifications of gastrointestinal (GI) and lung dosimetry and from the use of revised organ-specific risk coefficients, particularly that for the stomach. The revised ingestion risk is greater than the previous estimate (EPA, 1991) by a factor of 2.3. The Committee has reviewed these revised risk coefficients. The Committee's primary concern is that radon retention times in organs are based upon a single study of kinetics of xenon in humans (Correia et al., 1987), work that has not been published in the peer-reviewed literature. The xenon study also did not include a mass balance determination. Consequently, the Committee recommends that the EPA carefully review this study to evaluate whether the uncertainties attributed to the results are adequately described. Other factors in the EPA's biological model that are difficult to verify are the assumptions that a diffusion gradient exists in the GI tract and that lead-214 and subsequent decay products are removed from the GI tract before decaying and do not contribute to dose. The implications of these assumptions have been considered in the uncertainty analysis, and in this case also the Committee recommends the EPA carefully review these factors to evaluate whether the uncertainties are adequately described. Many of these uncertainties are difficult to quantify because alternative formulations and parameter values have not been proposed. EPA has adequately captured the apparent quantifiable uncertainties in the ingestion risk estimates and has propagated them properly, in the opinion of the Committee. However, the quantitative uncertainty bounds may give rise to a false sense of the overall reliability of the ingestion risk estimates. Qualitative uncertainties about the formulation of the exposure models and the applicability of high-dose, high-dose-rate, low-LET risk

coefficients to the low-dose, low-dose-rate, high-LET exposure conditions present with ingestion of radon in drinking water are substantial. An expanded discussion of the implication of these qualitative uncertainties is important to EPA's consideration of regulations for radon in drinking water.

3.1.2 Are revisions of inhalation risk estimates for waterborne radon and its progeny adequate?

Comment With regard to assessment of inhalation risks, the Committee believes that the EPA's uncertainty analysis is satisfactory and that, given the nature of the uncertainties, the transfer factor approach used in the document adequately accounts for risks arising from episodic shower exposures.

Discussion. The analysis of inhalation risk from radon in water has two components. The first considers exposures from radon released from general water use within a house. The EPA applied a general transfer factor that describes radon release from water indoors. The factor used had a value of 1 in 10,000 (i.e., 10,000 pCi/L in water yields an average indoor air concentration of 1 pCi/L), which is consistent with values used and published by others. In order to investigate whether exposures to radon from releases in showers represent a significant episodic peak exposure not captured by an average transfer factor approach, the EPA used a multicompartment model, based on one developed by McKone (1987). Because the analysis of shower exposures required that radon progeny ingrowth and decay be accounted for, the model specifically recognized the differences between radon and radon progeny exposures. The multicompartment model yielded results that were somewhat higher for radon but somewhat lower for radon progeny when compared with the analysis based on use of an average transfer factor.

The Radiation Advisory Committee believes, first, that the EPA's analysis, incorporating an uncertainty analysis, is satisfactory and, second, that given the nature of the uncertainties, the EPA's conclusion that episodic shower exposures are adequately accounted for by a transfer factor approach is also satisfactory.

3.1.3 Discrepancies in Numerical Values: Are EPA's choices for risk parameters and the uncertainties adequately defended?

Recommendation The Committee noted some minor inconsistencies between values in relevant documents and recommends that the EPA review its selection of parameter values (including ranges and their uncertainties) for each exposure pathway to ensure consistency with original data sources.

Discussion. Some examples of discrepancies follow.

3.1.3.1 Estimates of risk due to inhalation of indoor air

In general, the estimated central value for the annual number of lung cancer cases and the corresponding upper and lower bounds appear to be in the same range in the present assessment as in the previous assessment. However, the lack of consistency in the risk factor used is troubling. The summary information presented in Table 6-2 of the EPA document (EPA, 1993) does not appear to be entirely consistent with the parameter values used previously. The Committee recommends that the previous values be used throughout or that clarification of the differences be made in the document.

3.1.3.2 Estimates of risk associated with inhalation of outdoor air

Although the total risk associated with inhalation of radon and its progeny in outdoor air is small compared with that attributable to inhalation of radon and its progeny in indoor air, the estimated lung cancer risks due to outdoor radon/radon progeny exposures are, in fact, larger than those estimated to arise from radon in drinking water. Hence, it is important that the uncertainties in the risk assessment for the outdoor pathway be assessed in a manner consistent with that used for the indoor (drinking water) pathway. Examples of points of concern follow:

a) There are inconsistencies in the inhalation risk factors used and in their uncertainties. For example, the text (at p. 6-2) states that one would expect the unattached fraction to be lower outdoors than indoors, which is consistent with the few measurements that have been made. However, this reduction -- which would reduce the dose conversion factor -- is not reflected in the geometric mean chosen for this value, nor is the

geometric standard deviation (GSD) increased to capture this uncertainty.

b) The average outdoor radon concentration used in the calculations presented (0.3 pCi/L) does not appear to be consistent with the UNSCEAR (1988) observation that a population-weighted average value is about 0.14 pCi/L. In fact, the UNSCEAR value falls outside the stated credibility interval of 0.19 to 4.6 pCi/L. A GSD of 1.3 is clearly much too small for a concentration as uncertain as this.

c) Similarly, relatively few measurements are available to assess the average equilibrium factor for outdoor exposure settings. Although the observed values fall in a small range, the GSD of 1.05 implies greater accuracy in the value chosen (0.8) than is warranted.

d) Time spent outdoors is estimated to be 7.5%, on average. The variability in this factor is much larger than a GSD of 1.1 would imply.

3.1.3.3 Estimates of risks and uncertainties associated with water ingestion

The variability assumed for the amount of direct tap water consumed appears to be biased high, at least as reflected in the analyses presented on pp. 5-26+.

3.2 Adequacy of Quantitative Uncertainty Analyses Regarding Risk Assessment

Are quantitative uncertainty analyses regarding risk assessment of water-borne radon, including health risk analysis and exposure analysis, adequate? At the suggestion of the EPA staff, this question has been broken down into three subparts:

3.2.1 Are the basic methods used to propagate uncertainty acceptable?

Comment The Committee believes that the basic methods used to propagate uncertainty are acceptable. Proper consideration has been given to the possibility of covariance, and the Monte Carlo simulation methods are state-of-the-art.

Discussion. In making this determination, the Committee considered the following:

a) The EPA acknowledged uncertainty in each step of the calculation.
b) The EPA identified the sources of that uncertainty.
c) The EPA examined uncertainty about best estimate values and about best estimate distributions whereby the distributions represent variability in exposures and risk among individuals.
d) This latter approach whereby uncertainty is expressed about a best estimate distribution of exposures is the current state-of-the -art in uncertainty analyses.
e) The EPA distinguished between variability and uncertainty, which past analyses have not always done.
f) Perhaps most important, the EPA has also shown what the most dominant sources of uncertainty are in the calculation. In the case of the multi-media exposures to radon, the dominant source of uncertainty is associated with the uncertainty of translating an exposure to radon to an estimate of health risk. This risk conversion factor will probably be the parameter which is most difficult to estimate accurately.
g) Nevertheless, the uncertainty associated with the dose to risk conversion for radon, although it is the dominant contributor to overall uncertainty, is still much less than the uncertainty associated with other carcinogens that EPA regulates.

3.2.2 Are the probability density functions (PDFs) selected to describe Type A and Type B uncertainty of each variable reasonable?

Recommendation The Committee recommends that particular attention be given to more completely addressing uncertainty about the variance and shape of the probability density functions (PDFs) that have been assumed by the EPA to represent variability in exposures among individuals.

Discussion. The Committee believes that the general treatment of the PDFs used by the EPA in its uncertainty analysis is adequate, subject to the points made below. The EPA analysis considers two types of uncertainty. First, it recognizes that different individuals living in an area with the same level of radon in water will have different exposures, and therefore risks, as a result of differences in household

characteristics, water consumption rates, and other factors. The uncertainty due to stochastic variability in the lifetime exposure per individual in the U.S. population (Type A uncertainty) differs from uncertainty attributable to limitations in our knowledge about the quantities (mean, variance and shape) that describe the true distribution of individual lifetime exposures (Type B uncertainty). This latter uncertainty also reflects limitations that influence the average risk per individual.

While the Committee notes that the EPA analysis has not completely recognized these distinctions, it believes that the EPA has captured the most important features of quantitative uncertainty analysis and has adequately documented its choice of PDFs used in its analysis for describing uncertainty about the true value of risk for the average individual.

3.2.3 Are there any important terms or assumptions that have not been adequately evaluated?

Recommendation The Committee recommends that the EPA include in its uncertainty analysis a qualitative discussion of known uncertainty variables which were not quantified in the uncertainty analysis. These include the issue of a linear dose rate response extending to low doses, the influence of smoking on increasing lung-cancer risks from radon, and the effect of population mobility on the distribution of risks.

Discussion. The EPA is well aware that other model and parameter uncertainties may be important but are difficult to quantify given current state of knowledge. Many of these are mentioned in its draft documents, such as the issue of a linear dose response extending to low doses. Another issue that the Committee would like to see discussed qualitatively in the document is the influence of smoking on increasing lung-cancer risks from radon. The risk coefficient for airborne radon is an average value that underestimates the risk to smokers and overestimates it for nonsmokers. The average risk value thus depends implicitly upon assumptions about the nature of the relationship between lung cancer risk factors of smoking and radon exposure, and on the fraction of smokers in the population.

The EPA assessment of radon in water is designed to apply to people whose water supplies have the same radon content for their entire 70-year lifetimes. The Committee recognizes that this design assumption is consistent with EPA policy to

promulgate an MCL for radon that is protective for those people who might live out their lives in a water service area with radon at the maximum contaminant level. The Committee notes, however, that the mobility of the population implies that not every person currently living in an area with especially high or especially low radon levels in water will remain there. The distribution of radon exposures and risks therefore will not be the same as if every person remained in the same area for a lifetime. In general, fewer people will have very high or very low exposures and risks and more will have intermediate levels of risk than under the no-mobility assumption. The effect of mobility on overall population risk (cancers per year in the United States arising from radon in drinking water), in contrast, will likely be negligible because most people moving from a high radon area to a low one will be replaced by people moving in the other direction, except for any effect of net population migration within the country.

3.3 Adequacy of Characterization of Risks from Water Treatment Facilities

3.3.1 Has the EPA adequately characterized the risks introduced by radon that would be released by aeration from water treatment facilities?

Recommendation In order to increase the scientific credibility of the results, the Committee recommends that EPA consider upgrading the uncertainty analysis for the risks associated with aeration for radon removal; however, the proposed revisions to the analysis will not change the conclusion that the risk for a maximally exposed individual attributable to radon released from a water treatment facility will be no more than the average risk attributable to 300pCi/L of radon in drinking water used in the home.

Discussion. The EPA has proposed air-stripping as Best Available Technology (BAT) for achieving the proposed radon standard for drinking water where current levels exceed the proposed standard. Recognizing that this technique would discharge much of the waterborne radon to the atmosphere, the EPA analyzed the risks of such discharges in terms of the risks to a maximally exposed individual (MEI) living near the treatment facilities. The EPA also projected the population risk or annual cancer incidence assuming that each water supplier exceeding the proposed standard were to use air-stripping at a single location in order to bring itself into compliance with the proposed standard (EPA, 1988; 1989).

The EPA reasoned that if the individual and population risks from the treatment facilities were small relative to the risks avoided by applying the proposed standard, then a comparative risk tradeoff would favor implementation of the standard. To ensure that this comparison would not favor the proposed standard solely through differences in assessment methods, the EPA estimated the risks attributable to water treatment by using two radiation risk models, AIRDOSE and MINEDOSE. Although the Committee has reservations about the degree of validation of these models, the MINEDOSE model is thought to provide conservative risk estimates. In the assessment of risk from water treatment, the EPA also made assumptions that were the same as or more conservative than those used for assessing the risks of radon in water used in the home. Specifically, the individual risks were calculated for an MEI who was defined as exposed to the highest concentrations for the longest possible time from discharges under worst-case meteorological conditions. The Committee concurs that the set of assumptions chosen was generally quite conservative.

The MEI risks presented to the Committee ranged up to 8×10^{-4}, or about 4 times the nominal value for the risk of 300 pCi/L radon in drinking water. However, this was a single value derived from largely unrealistic assumptions, and more typical MEI risks appear to be much lower, generally falling at or below the risk due to exposure to radon in drinking water at 300 pCi/L.

The EPA also projected population risk using AIRDOSE and estimated total cancer death rate of approximately 0.1/yr, a value that is considerably less than the reduction of 80 cancer deaths/yr estimated to be achieved by implementing the proposed standard.

The EPA conducted a semiquantitative uncertainty analysis of the MEI risk calculation and concluded that upper bound risks would remain in the vicinity of 1×10^{-4}, given the conservative nature of the nominal values. The uncertainty analysis was less rigorous and more subjective than that for the risks of radon in drinking water. Although more rigor is unlikely to change the conclusion, improvement of the uncertainty analysis would improve the scientific credibility of the results.

3.3.2 Has the EPA adequately characterized the risks introduced by radon that would be released from other types of water treatment facilities?

Recommendation If EPA determines that granular actived carbon will be used for radon removal, the Committee urges EPA to thoroughly and completely analyze any potential risk and/or disposal problems related to the use of granular activated carbon (GAC) for radon removal from drinking water

Discussion Another technology for radon removal from drinking water is Granular-Activated-Charcoal (GAC). Although GAC has not been designated a best available treatment (BAT) for radon removal, in a draft technical memorandum from the Office of Water (dated January 1993 and circulated to the RAC on February 18, 1993), EPA discussed various issues related to the use of this technology which mentioned radioactivity accumulation in the GAC (mostly lead-210). However, while the memorandum mentioned the issue of GAC building up levels of radioactivity such that the residuals would require disposal at a low-level-radioactive-waste (or naturally occurring radioactive material waste) repository, the memorandum was without sufficient data or analysis for the Committee to evaluate this possibility and the implications of this problem.

The Committee urges EPA to thoroughly and completely analyze any potential risk and/or disposal problems related to the use of GAC for radon removal from drinking water.

3.3.3 Occupational Exposures

Recommendation EPA did not provide an analysis of occupational exposures as a result of water treatment for radon. The potential for such exposures appears to depend heavily upon the choice of water treatment technology, and the Committee recommends that such a comparative analysis be conducted for different technologies, such as aeration or granular activated carbon filtration, especially in view of waste disposal problems that may result from use of the latter technology.

Discussion. The EPA did not provide an analysis of potential radiation exposures to workers in water treatment or ancillary facilities. The RAC notes that in the case of aeration techniques, proper ventilation of the water treatment facility

should result in little increase in radon concentrations and exposures to personnel. There should be no other significant sources of radiation due to such treatment. However, the EPA has not ruled out treatment by other means, including granular activated carbon filtration (GAC), in which case build-up of radon progeny in the bed can result in an increased radiation field near the beds. Furthermore, the handling and disposal of GAC beds containing radionuclides has not been analyzed nor, in fact, have provisions been made for such disposal in the event it is necessary. In order to provide a complete risk analysis, the Committee believes that the EPA needs to consider the possibility of worker exposures either to radiation or to chemicals (such as those used as biocides in aeration facilities) resulting from some water treatment technologies.

3.4 Other Scientific Issues

3.4.1 Recommended extensions of the risk and uncertainty analysis and publication of results in peer-reviewed journals

Recommendation The Committee recommends that the document include a summary of the results of the uncertainty analysis regarding the contribution of the various exposure pathways to the overall radon risk to individuals and to the general population. This summary should also highlight the major sources of uncertainty contributing to the total uncertainty in the risk estimate for each pathway. Such a discussion would provide the information necessary to factor uncertainties and variabilities into the cost-benefit analysis for the proposed regulation and to calculate a range for the estimates of cost/life saved. (3.4.1)

Discussion. One aspect that was lacking in the reviewed document was a summary and interpretation of the uncertainty analysis for radon in drinking water. The Committee has studied the results presented by the EPA and offers the following interpretation.

3.4.1.1 Individual risks

The following table lists the unit risks attributable to drinking water by inhalation and ingestion pathways, including the 90% confidence interval around the median, the upper-bound 95th percentile, and the lower-bound 5th percentile for risk.

Table 1. Unit Risk Boundaries for Exposure to Radon in Drinking Water
(Fatal cancers/person/year per pCi/L)

	5th percentile Lower Bound	5th percentile Median	Median	95th percentile Median	95th Percentile Upper Bound
Inhalation	1.6×10^{-10}	1.1×10^{-9}	2.7×10^{-9}	6.3×10^{-9}	4.2×10^{-8}
Ingestion	1.2×10^{-10}	3.7×10^{-10}	1.7×10^{-9}	6.5×10^{-9}	2.0×10^{-8}

The nominal unit risk in the proposed rule is 9.4×10^{-9} fatal cancers/person/year per pCi/L. This nominal risk can be compared to the median inhalation and ingestion risks from radon in drinking water shown in Table 1. The nominal risk is larger than the median inhalation risk by a factor of 3.5 and is larger than the ingestion median risk by a factor of 5.5. Therefore, the combined unit risk from inhalation and ingestion exposure will be <3.5, and well within the range encompassed by the 90% confidence interval of risk about the median. The same comment applies to the nominal unit risk presented in Chapter 3 of the reviewed document.

3.4.1.2 Population risks

The estimates of cancer fatalities due to exposure of radon in drinking water are based upon 81 million people being exposed. This number was presented to the Committee during a briefing on 2/17/93, and comes from a preliminary contractor report on occurrence of radon in drinking water (Wade Miller, 1992). That report is being reviewed by the EEC of the SAB. Any changes in that estimate will affect the results presented below.

Table 2. Cancer Fatalities per Year due to Exposure to Radon

Exposure Pathway	5th Percentile Median	Median	95th Percentile Median	Upper Bound
Inhalation due to Water Treatment	—	—	—	< 1
Inhalation from Drinking Water	48	105	233	—
Ingestion from Drinking Water	19	53	166	—
Inhalation from Outdoor Air	280	657	1,500	—
Inhalation from Indoor Air	6,790	14,410	30,950	—

The estimated lung cancer deaths attributable to inhalation exposure to radon in drinking water range from 48 to 233 per year. The estimated fatal cancer cases attributable to ingestion exposure to radon in drinking water range from 19 to 166 per year. Therefore, estimated total fatal cancer cases attributable to waterborne radon will be about a quarter of the risks associated with exposure to radon in outdoor air, and about one percent of the risks associated with exposure to radon in indoor air and of the total risks attributable to exposure to radon by all pathways. These calculations also indicate that population risks from exposure to radon in drinking water are similar to or higher than those normally addressed by regulation of chemical pollutants in drinking water. Although the risk attributable to inhalation and ingestion of radon in drinking water were apportioned equal weight in the calculation of the nominal value in Chapter 3, the weight obtained as a result of the uncertainty analysis is approximately two-thirds for inhalation and one-third for ingestion. This last set of values is similar to those presented in the Proposed Rule (EPA, 1991).

3.4.2 Estimate of Lives Saved

Recommendation The Committee recommends that the EPA extend its population risk assessment and uncertainty analysis to obtain an estimate of the lives that would be saved by the proposed maximum contaminant level, using for radon concentration the same assumptions as were used to calculate present-day risks but using a lognormal probability density function truncated at the maximum contaminant level.

Discussion. The Committee could not carry out an analysis of the estimated number of lives that would be saved by the Proposed MCL of 300 pCi/L because no uncertainty analysis was done on the number of cancer fatalities projected for the rule in place. The Committee recommends that a population risk assessment and uncertainty analysis be carried out, using the same assumptions as were used to calculate present-day risks but using for radon concentration a lognormal PDF truncated at the proposed MCL. An uncertainty for the tolerance in the measurement of radon as described in the section regarding monitoring of the Proposed Rule should also be factored into this uncertainty analysis. From these calculations, one would obtain a 90% confidence interval for the cancer fatalities that would remain with enforcement of the proposed MCL, and the difference between the values in Table 2 and those calculated with the truncated PDF would yield a range of lives saved. This analysis would then allow the persons conducting the cost-benefit analysis to factor

these uncertainties and variabilities into their calculations, leading to a range of costs per life saved. The Committee believes that this extension to the EPA's uncertainty analysis would enhance the usefulness of the document reviewed.

3.4.3 Peer Review and Publication

Recommendation The Committee urges the EPA to submit its risk analyses for publication in appropriate journals which would provide peer-review and recognition that the EPA's science is of high-quality and that it becomes part of the mainstream of scientific criticism, revision, and acceptance (or rejection). Publication will also assist in raising awareness within the scientific community to the risk issues associated with radon.

Discussion. The Committee believes that overall, the use of the peer-reviewed literature as both a source of data and information and also as a method of disseminating the EPA's own scientific work is an important means by which the EPA and the public can be assured that the best science is being used or produced. In this particular case, the estimate of the ingestion risk due to radon in drinking water rests heavily upon data and analyses that have not been published and therefore have not been broadly circulated within the scientific community. Reliance upon such results should be done with considerable caution.

Although publication in peer-reviewed journals does not, by itself, assure infallibility, it is the only generally recognized means by which scientific work gets accepted by members of the scientific community. In seeking to improve the quality and the scientific acceptability of its science, the EPA should encourage its scientists to submit their work for peer-reviewed publication. The work and methodologies presented here mark an important advance in the risk and uncertainty analyses undertaken by the EPA and are certainly worthy of such publication.

4. POLICY CONSIDERATIONS

4.1 The Importance of Quantitative Uncertainty Analysis

The Radiation Advisory Committee has long encouraged the use of integrated quantitative uncertainty analysis in a variety of EPA assessments. The Committee is extremely pleased to see that the EPA has done such analysis in this case . The Committee applauds EPA for its timely incorporation of a full quantitative uncertainty analysis for each pathway in its assessment and hopes that the use of quantitative uncertainty analysis will become a routine part of all EPA assessments, not only those associated with radiation risks. This information should be a valuable aid in guiding EPA in its consideration of possible regulatory strategies.

The Committee believes strongly that the explicit disclosure of uncertainty in quantitative risk assessment is necessary any time the assessment is taken beyond a screening calculation. Screening risk assessments typically involve only point estimate calculations. The assumptions used to derive these point estimates are generally biased on the conservative side to ensure that the true risk to individuals will not be underestimated. Screening calculations are thus useful for identifying situations that are clearly below regulatory risk levels of concern. They can be grossly misleading in terms of indicating the need for regulatory action.

The need for regulatory action must be based on more realistic estimates of risk. Realistic risk estimating, however, requires a full disclosure of uncertainty. The disclosure of uncertainty enables the scientific reviewer, as well as the decision-maker, to evaluate the degree of confidence that one should have in the risk assessment. The confidence in the risk assessment should be a major factor in determining strategies for regulatory action.

Large uncertainty in the risk estimate, although undesirable, may not be critical if the confidence intervals about the risk estimate indicate that risks are clearly below regulatory levels of concern. On the other hand, when these confidence intervals overlap the regulatory levels of concern, consideration should be given to acquiring additional information to reduce the uncertainty in the risk estimate by focusing research on the factors that dominate the uncertainty. The dominant factors controlling the overall uncertainty are readily identified through a sensitivity analysis conducted as an integral part of quantitative uncertainty analysis. Acquiring additional

data to reduce the uncertainty in the risk estimate is especially important when the cost of regulation is high. Ultimately, the explicit disclosure in the risk estimate should be factored into analyses of the cost-effectiveness of risk reduction as well as in setting priorities for the allocation of regulatory resources for reducing risk.

4.2 The Relative Risk of Radon in Drinking Water

In its January 29, 1992, *Commentary: Reducing Risks from Radon; Drinking Water Criteria Documents* (EPA-SAB-RAC-COM-92-003), the Committee noted that the radon risk reduction situation reflects the fragmentation of environmental policy identified in *Reducing Risk* (SAB-EC-90-021). Because radon in drinking water is a very small contributor to radon risk except in rare cases, the Committee suggested that the EPA focus its efforts on primary rather than secondary sources of risk. Within the limitations of the data currently available, the EPA has now successfully prepared a scientifically credible multi-media risk assessment for regulatory decision-making on radon. The Committee's agreement with the principle of radiation protection optimization and in the concepts articulated in *Reducing Risk* lead it to note once again that radon in drinking water represents only a small fraction of radon exposure and risk compared to radon in indoor air from non-water sources. The emphasis on various radon exposure reduction methods--whether for radon from water or non-water sources--is a policy choice for which scientific analysis is only one of many important inputs.

4.3 Harmonizing

In its May 8, 1992 *Commentary on Harmonizing Chemical and Radiation Risk Reduction Strategies* (EPA-SAB-RAC-COM-92-007), the Committee brought to the EPA's attention the need for a more coherent policy for making risk reduction decisions with respect to radiation and chemical exposures. The control of radon in drinking water presents a situation where a radiological contaminant being regulated by a paradigm developed for chemicals yet radon in drinking water represents only a small fraction of radon exposure. The Committee appreciates the EPA's difficulty in establishing a coherent risk reduction strategy under the variety of statutes governing EPA and acknowledges that harmonization does not necessarily imply identical treatment. However, the Committee urges the EPA to explain clearly why the risks from radiation (in this case radon in indoor air) and chemicals (in this case radon in drinking water) are treated differently under specified conditions and in specified

exposure settings. The Committee urges EPA, the Congress and the public to carefully consider how chemical and radiation risks are being treated in this case.

5. REFERENCES

5.1 Documents Received by the Radiation Advisory Committee During this Review

A. DOCUMENTS RECEIVED BEFORE THE FEBRUARY 17-19 PUBLIC MEETING

Documents Provided by EPA

1. Departments of Veterans Affairs and Housing and Urban Development, and Independent Agencies Appropriation Act, 1993, PUB. L. 102-398, Section 519, 106 STAT 1618 (1992)

2. Draft 2 "Uncertainty Analysis of Risk Associated with Exposure to Radon in Drinking Water" prepared by U.S. EPA Office of Science and Technology, Office of Radiation and Indoor Air, Office of Ground Water and Drinking Water, and Office of Policy Planning and Evaluation, January 29, 1993

3. Proposed Revisions in EPA Estimates of Radon Risks and Associated Uncertainties

4. An Analysis of the Uncertainties in Estimates of Radon-Induced Lung Caner by Jerome S. Puskin in Risk Analysis Volume 12, Number 2. 1992

5. Response to SAB Radon Comments

6. Preliminary Risk Assessment for Radon Emissions from Drinking Water Treatment Facilities, a memorandum from Warren D. Peters and Christopher B. Nelson to Stephen W. Clark, June 28, 1988

7. An Analysis of Potential Radon Emissions from Water Treatment Plants Using the MINEDOSE Code, a memorandum from Parc. J. Parrotta to Greg Helms, November 22, 1989

8. Proposed Methodology for Estimating Radiogenic Cancer Risks (no author or date given)

9. Cancer Fatalities from Waterborne Radon (Rn-222) by Douglas J. Crawford-Brown in Risk Analysis, Volume 11, Number 1, 1991

Public Comment

10. Letter re: National Primary Drinking Water Regulations: Radionuclides (Radon) [WH-FRL 3956-4] from John H. Sullivan of the American Water Works Association to Honorable Carol Browner, Administrator of the Environmental Protection Agency, January 26, 1993. There were 27 Appendices to this letter.

    1. EPA Technical Support Document for the 1992 Citizen's Guide to Radon, EPA 400-R-92-011 (May 1992)
    2. "Harmonizing Chemical and Radiation Risk-Reduction Strategies - A Science Advisory Board Commentary,"(May 18,1992)
    3. Letter from SAB Chairman Raymond Loehr to EPA Administrator William Reilly Re: "Radionuclides in Drinking Water" (EPA-SAB-RAC-91-XXX) (September 1991)
    4. "An SAB Report: Radionuclides in Drinking Water" (EPA-SAB-RAC-91-009) (December 1991)
    5. Letter from SAB Chairman Raymond Loehr to EPA Administrator William Reilly Re: "Reducing Risks from Radon; Drinking Water Criteria Documents," (EPA-SAB-RAC-COM-92-003) (January 29, 1992)
    6. Letter from SAB Chairman Raymond Loehr to EPA Administrator William Reilly Re: "Status of EPA Radionuclides Model" (EPA-SAB-RAC-COM-92-001) (January 9, 1992)
    7. SAB, "Review of the office of Drinking Water's Assessment of Radionuclides in Drinking Water and Four Draft Criteria Documents" (July 1987)
    8. Letter from SAB Chairman Raymond Loehr to EPA Administrator William Reilly Re: "Review of Draft Criteria Documents for Radionuclides in Drinking Water" (EPA-SAB-RAC-92-0009) (January 9, 1992)
    9. Letter from SAB Chairman Raymond Loehr to EPA Administrator William Reilly Re: "Revised Radon Risk Estimates and Associated Uncertainties" (EPA-

SAB-RAC-LTR-92-003) (January 9, 1992)

10. Puskin, Jerome, "An Analysis of the Uncertainties in Estimates of Radon-Induced Lung Cancer," Risk Analysis, Vol. 12, No. 2, p. 277 (1992)
11. SENES Consultants Limited Memorandum Re: "Exposure and Risk from Radon Released in Showers" (December 3, 1992)
12. Fensterheim, Robert, Stolwijk, Jan, "Critique of Hess and Bernhardt Radon Shower Exposure Study,"(1992)
13. Testimony of Jonathan M. Samet before the Subcommittee on Transportation and Hazardous Materials, House Energy and Commerce Committee (June 3, 1992)
14. Neuberger, John S., "Residential Radon Exposure and Lung Cancer: An Overview of Published Studies," Cancer Detection and Prevention, Vol.15, Issue 6, (1991) 435-443
15. Neuberger, John S., et al., "Residential Radon Exposure and Lung Cancer: Evidence of an Inverse Association in Washington State," Journal of Environmental Health, Nov/Dec. 1992, 23-25

16. "Proposed Guideline for Radon-222 in Drinking Water," prepared by SENES Consultants Limited for Health Protection Branch, Health and Welfare Canada (March 1992)
17. Draft of SAB Radiation Advisory Committee Comments on EPA's "Suggested Guidelines for the Disposal of Drinking Water Treatment Wastes Containing Naturally-Occurring Radionuclides" (July 6, 1992)
18. Testimony of Dr. Jill Lipoti on HR 3258, the "Radon Awareness and Disclosure Act of 199111 before the House Subcommittee on Transportation and Hazardous Materials (June 3, 1992)
19. Factor Analysis for Differences Between EPA and RCG Compliance Cost Estimates
20. Table Comparing Compliance Costs for A Radon MCL of 300 pci/l; Letter to Editor and Response in American Water Works Association Journal
21. Comments of the State of Idaho Department of Water Resources (May 18, 1992)
22. Letter from Dr. Alvin Young, Chairman of Committee on Interagency Radiation Research and Policy coordination, to Dr. Donald Henderson, Office of Science and Technology Policy (May 21, 1992)
23. Testimony of Dr. Jan Stolwijk before the House Subcommittee on Transportation and Hazardous Materials (June 3, 1992)
24. Valentine, Richard, "Radon and Radium From Distribution System and Filter Media Deposits/" AWWA Water Quality Technology conference, Toronto (1992). 24
25. Comments of the State of New York Department Health to EPA (February 12, 1992)
26. "Evaluation of the Impact of a Radon-222 MCL on Small Water Systems," by John E. Reanier, Alabama Rural Water Association (May 10, 1992)
27. Comments of the Association of State Drinking Water Administrators (November 19, 1991)

11. Letter to Administrator Browner and three SAB Chairs from Bill Mills, Steve Hall, and Tom Levy of the Alliance for Radon Reduction, February 2, 1993

B. DOCUMENTS RECEIVED AT THE FEBRUARY 17-19 PUBLIC MEETING

Documents Provided by EPA

1. Draft Summary (no date or author given, appears to be a draft summary for the "Uncertainty Analysis of Risk Associated with Exposure to Radon in Drinking Water"

2. Overheads: Briefing for SAB on Multimedia Risk Assessment of Human Exposure to Radon, Office of Science and Technology, Office of Radiation and Indoor Air, Office of Policy, Planning, and Evaluation, Office of Ground Water and Drinking Water.

3. Overheads: Risk Assessment for Radon Emissions from Drinking Water Treatment Facilities, EPA Office of Radiation and Indoor Air, February 17, 1993

4. Overheads: Cancer Risks Associated with Radon in Drinking Water--Uncertainty and Variability Analysis

5. "Review of Risk Assessments of Radon Emissions from Drinking Water Treatment Facilities" from Christopher Nelson ORIA to Mark Parrotta ODW

6. Radon Documents for SAB Review, a memorandum from Nancy Chiu of OST/OW to William F. Raub, Science Advisor

7. Draft Technical Memorandum: Problems with the Use of GAC for Radon Removal, printed date is January 1993 (handwritten date is 2/11)

Public Comment

8. Review of Technical Justification of Assumptions and Methods Used by the Environmental Protection Agency for Estimating Risks Avoided by Implementing MCLs for Radionuclides by S.C. Morris, M.D. Rosw, S. Holtzman, and A.F. Meinhold and Brookhaven National Laboratory, November, 1992

9. Letter from Edward J. Schmidt to Comments Clerk-Radionuclides, Subject Comments on National Primary Drinking Water Regulations: Radionuclides

Proposed Rule, 40CFR Parts 141 & 142, Thursday, July 18, 1991, September 30, 1991

10. Letter to James R. Elder from Raymond F. Pelletier, Office of Environmental Guidance, U.S. Department of Energy, January 27, 1993

C. DOCUMENTS RECEIVED SUBSEQUENT TO THE FEBRUARY 17-19 PUBLIC MEETING

Documents Provided by EPA

1. One-page note to Kathleen Conway from Jan Auerbach, February 23, 1993

2. Note to Kathleen Conway, RAC DFO from Nancy Chui OGWDW, faxed to the Radiation Advisory Committee, March 10, 1993

Public Comment

3. Letter to the SAB Radiation Advisory Committee from Frederick W. Pontius of the American Water Works Association, February 24. This letter had seven enclosures:
    a. Lognormal Distributions for Water Intake by Children and Adults, by Ann M. Roseberry and David. E. Burmaster in Risk Analysis, Volume 12, Number 1, 1992
    b. Distribution and Expected Time of R e sidence for U.S. Households by Milton Israeli and Christopher B. Nelson in Risk Analysis, Volume 12, Number 1, 1992
    c. Review of Risk Estimates for Inhalation of Radon Progeny by Miners: Presentation by the Atomic Energy Control Board of Canada (ACB) before the ICRP Main Commission, printed date is November 1992, there is also a stamped date of February 12, 1993
    d. A Cohort Study in Southern China of Tin Miners Exposed to Radon and Radon Decay Products by Xuan Xiang-Zhen, Jay. H. Lubin, and others in Health Physics, Volume 62, Number 10, pages 120-131, February 1993

e. Contribution of Waterborne Radon to Home Air Quality, prepared by Arun K. Deb of Roy F., Eston, Inc. for the AWWA Research Foundation, undated

f. Final Report: Risk and Uncertainty Analysis for Radon in Drinking Water prepared by Douglas J. Crawford Brown for the American Water Works Association.

g. Proposed Guideline for Radon-222 in Drinking Water prepared by SENES Consultants Limited for the Health Protection Branch of Health and Welfare Canada, March 1992

4. Letter to the Radiation Advisory Committee from Douglas Crawford-Brown of the University of North Carolina, March 2, 1993

5. Letter to Dr. Genevieve Matanoski from Bill Mills, Steve Hall and Tom Levy of the Alliance for Radon Reduction, March 11, 1993

6. Letter to Dr. Genevieve Matanoski from Robert J. Fensterheim, consultant to the Alliance for Radon Reduction, March 16, 1993

7. Fax from Robert J. Fensterheim referencing Brown-Senate Letter and Naomi Harley Study, March 16, 1993. This fax included both a March 11, 1993 letter from nine senators to Administrator Carol M. Browner and A Biokinetic Model for the Distribution of Rn-22 Gas in the Body Following Ingestion by Naomi H. Harley and Edith S. Robbins, March 12, 1993

8. Letter to Dr. Vern Ray, Chairman of the Radon Engineering Cost Subcommittee from Stephen Hall of the Association of California Water Agencies, March 22, 1993

5.2 Science Advisory Board Reports of Potential Interest

1. Report of the Scientific Basis of EPA's Proposed National Emission Standards for Hazardous Air Pollutants for Radionuclides: A report of the Subcommittee on Risk Assessment for Radionuclides, August 1984 (There is no report number because this report was produced before the SAB developed a report numbering system.)

2. Radionuclides in Drinking Water (SAB-RAC-87-035)
3. Effective Dose Equivalent Concept (SAB-RAC-88-026)
4. Radon Risk Estimates (SAB-RAC-88-042)
5. Radionuclides NESHAP (SAB-RAC-89-003)
6. EEC Mathematical Models Resolution (SAB-EEC-89-01)
7. Radionuclides NESHAP (SAB-RAC-89-024)
8. Radon Risks (SAB-RAC-91-LTR-001)
9. Status of EPA Radionuclide Models (EPA-SAB-RAC-COM-92-00)
10. Revised Radon Risk Estimates and Associated Uncertainties (EPA-SAB-RAC-LTR-92-003)
11. Criteria Documents for Radionuclides in Drinking Water (EPA-SAB-RAC-92-009)
12. Reducing Risks from Radon/Drinking Water Criteria Documents (EPA-SAB-RAC-COM-003)
13. Harmonizing Chemical and Radiation Risks (EPA-SAB-RAC-COM-92-007)
14. Drinking Water Treatment Wastes Containing NORM (EPA-SAB-RAC-LTR-92-018)
15. Radon in Water: Consultation (EPA-SAB-RAC-CON-92-002)

5.3 Literature cited

Correia JA, Weise SB, Callahan RJ, Strauss HW, 1987. The kinetics of ingested Rn-222 in humans determined from measurements with Xe-133. Massachusetts General Hospital, Boston MA, unpublished report Prepared for Health Effects Research Laboratory, U.S. EPA, Report No. EPA/600/1-87/013.

Crawford-Brown DJ, 1991. Cancer fatalities from waterborne radon (Rn-222). Risk Anal. 11:135-143.

EPA, 1988. "Preliminary Risk Assessment for Radon Emissions from Drinking Water Facilities," memorandum from Warren Peters and Christopher Nelson to Stephen Clark, June 28, 1988.

EPA, 1989. "An Analysis of Potential radon Emissions from Water Treatment Plants using the MINEDOSE Code," memorandum from Marc Parrotta to Greg Helms, November 22, 1989.

EPA, 1991. "Notice of Proposed Rulemaking for Radionuclides in Drinking Water"

EPA, 1989. "Draft 2 "Uncertainty Analysis of Risk Associated with Exposure to Radon in Drinking Water" prepared by U.S. EPA Office of Science and Technology, Office of Radiation and Indoor Air, Office of Ground Water and Drinking Water, and Office of Policy Planning and Evaluation, January 29, 1993

McKone, TE, 1987. Human exposure to volatile organic compounds in household tap water: the indoor inhalation pathway. Environ. Sci. Technol. 21:1194-1201

UNSCEAR, Sources, Effects and Risks of Ionizing Radiation, United Nations Scientific Committee on the Effects of Atomic Radiation, United Nations: New York, 1988, p.64.

Wade Miller Associates, 1992, Draft addendum to the occurence and exposure assessments for radon, radium-226, radium-228, uranium, and gross alpha particle activity in public drinking water supples. EPA contract No. 68-CO-0069 September 30, 1992.

APPENDIX A: Brief Chronology of Relevant SAB Reports

In 1984 a specialized ad hoc Subcommittee of the Science Advisory Board reviewed the scientific basis for EPA's proposed national emissions standards for hazardous air pollutants for radionuclides. That report led to the formation of the Radiation Advisory Committee to "review risk assessments for radiation standards" . The report also stated,"A scientifically defensible risk assessment for radionuclides should address at least five major elements. These include 1) identification of the significant . . . sources; 2) a description of the movement . . from a source . . . to people; 3) calculation of doses; 4) estimation of . . . health effects, and 5) incorporation of estimates of uncertainty into elements 1-4. . . ." The routine incorporation of uncertainty analysis into risk assessments has been a recurring theme in Radiation Advisory Committee reports.

In the summer of 1986, the Drinking Water Subcommittee of the Radiation Advisory Committee reviewed the Office of Drinking Water's Assessment of Radionuclides in Drinking Water and Four Draft Criteria Documents, (SAB-RAC-87-035). This Subcommittee did not explicitly address uncertainty analysis. While recommending some improvements in science and presentation, the Subcommittee concluded, "that the Office of Drinking Water has developed scientifically comprehensive assessment documents." This report was transmitted to the Administrator July 27, 1987.

In 1988 and 1989 reviews of revisions to the scientific basis for the radionuclides NESHAP, the Radiation Advisory Committee again raised concerns about quantitative uncertainty analysis. The cover letter of the November 10, 1988 report (SAB-RAC-89-003) highlighted three findings for serious attention by the EPA, including, "To date, EPA's treatment of modeling uncertainties has been qualitative rather than quantitative although state-of-the-art methods for estimating uncertainty are available." The June 30, 1989 report (SAB-RAC-89-024) noted in the cover letter (p.2), " . . . the Radiation Advisory Committee and the Science Advisory Board has repeatedly urged the use of best estimates and ranges in the specifications of risk, and a detailed explanation of the uncertainties in the estimates themselves."

On January 13, 1989, the SAB transmitted to the Administrator the Environmental Engineering Committee's Resolution on the Use of Mathematical

Models by EPA for Regulatory Assessment and Decision-Making (EPA-SAB-EEC-89-012). The Committee (p.1) had reviewed "a number of integrated environmental modeling studies" and "noted a number of problems" including, "a lack of studies quantifying the uncertainties associated with model predictions, and concurrently, the potential misuse of particular uncertainty analysis techniques." The resolution's fourth recommendation (p.3) was, "Sensitivity and uncertainty analysis of environmental models and their predictions should be performed to provide decision-makers with an understanding of the level of confidence in model results, and to identify key areas for future study."

In the summer of 1990, the Radionuclides in Drinking Water Subcommittee of the Radiation Advisory Committee reviewed draft criteria documents for radionuclides in drinking water, including those for uranium, radium, radon, and a combined document on beta particles and gamma emitters. The Subcommittee found that, "The overall quality of the four draft criteria documents was not good. . . . recommendations from a 1987 Science Advisory Board report on its review of the standards for radionuclides in drinking water (SAB-RAC-87-035) had not been addressed. Nor did the new criteria documents address recommendations from other available SAB reports that are directly relevant (such as SAB-RAC-88-026 and SAB-EEC-89-012). . . . Uncertainties associated with the selection of particular models, specific parameters used in the models, and the final risk estimates are not adequately addressed in any of the documents." Although the review was conducted in 1990 and draft reports circulated at that time, this SAB report was not transmitted to the Administrator until January 9, 1992. (EPA-SAB-RAC-92-009)

In the summer and fall of 1991, the Radiation Advisory Committee received revised criteria documents and declined to review them. It did, however, produce a commentary which noted (p.4) that, "Although each criteria document now includes a chapter discussing uncertainty, the content of the chapters is very qualitative and is not the rigorous technical analysis envisioned by the Committee." In its section on policy considerations, the Committee also noted (p.3) that, "radon in drinking water is a very small contributor to radon risk except in rare cases and the Committee suggests the EPA focus its efforts on primary rather than secondary sources of risk." This commentary was transmitted to the Administrator January 29, 1992 (EPA-SAB-RAC-COM-92-003)

The January 9 and 29, 1992 reports also contained other advice relevant to the scientific assessment of the risk of radon in drinking water. Additionally, the January 29, 1992 report provided policy-related comments on radon in light of the SAB report, Reducing Risk. A May 8, 1992 Radiation Advisory Committee commentary, "Harmonizing Chemical and Radiation Risk Reduction Strategies," described chemical and radiation risk reductions paradigms, discussed the difficulties of applying a paradigm developed for one type of contaminant to the other, and recommended harmonization.

In the winter and spring of 1992, the Committee conducted a review of the EPA's, "Suggested Guidelines for the Disposal of Drinking Water Treatment wastes Containing Naturally-Occurring Radionuclides" dated July 1990. The Committee found that such guidelines were needed because of the potential radiation doses to treatment plant workers and the public. However, the 1990 guidelines did not fully assess the magnitude of risk from exposure to treatment wastes, nor did the document specify whether the radiation exposures to workers should be considered as occupational exposures or viewed against dose limits for the general public, a decision which will have considerable bearing on any final guidelines. This letter report was transmitted to the Administrator September 30, 1992 (EPA-SAB-RAC-LTR-92-018).

APPENDIX B: Chaffee-Lautenberg Language from the Congressional Record

cipients to further science, technology development, education, and other purposes

Resolved, That the House recede from its disagreement to the amendment of the Senate numbered 246 to the aforesaid bill, and concur therein with an amendment as follows:

In lieu of the matter proposed by said amendment, insert:

Chapter X of title XI of the Dire Emergency Supplemental Appropriations Act, 1992, Including Disaster Assistance to Meet the Present Emergencies Arising from the Consequences of Hurricane Andrew, Typhoon Omar, Hurricane Iniki, and Other Natural Disasters, and Additional Assistance to Distressed Communities (H.R. 5620) is amended by (1) striking the matter under the heading "Disaster relief" and insert in lieu thereof: "For necessary expenses in carrying out the Robert T. Stafford Disaster Relief and Emergency Assistance Act, as amended, $2,893,000,000, of which not to exceed $50,000,000 may be transferred to the 'Disaster Assistance Direct Loan Program' account for administrative expenses and subsidies for direct loans provided under section 417 of such Act, and of which $143,000,000 shall be available only to the extent an official budget request, for a specific dollar amount, that includes designation of the entire amount of the request as an emergency requirement as defined in the Balanced Budget and Emergency Deficit Control Act of 1985, is transmitted by the President to the Congress, to remain available until expended: Provided, That the entire amount is designated by Congress as an emergency requirement pursuant to section 251(b)(2)(D)(i) of the Balanced Budget and Emergency Deficit Control Act of 1985, as amended." and (2) striking the matter under the heading "Disaster assistance direct loan program account" and insert in lieu thereof: "The limitation on direct loans for the 'Disaster assistance direct loan program account' is increased, within existing funds, by $230,000,000 to not to exceed $258,000,000: Provided further, That not to exceed $54,000,000 is available for direct loan obligations provided to eligible applicants or to States under section 319 of the Robert T. Stafford Disaster Assistance and Emergency Relief Act, as amended: Provided further, That not to exceed $200,000,000 is available for community disaster loans to local governments under section 417 of the Robert T. Stafford Disaster Assistance and Emergency Relief Act, as amended: Provided further, That any unused portion of the direct loan limitation shall be available until September 30, 1993: Provided further, That the entire amount is designated by Congress as an emergency requirement pursuant to section 251(b)(2)(D)(i) of the Balanced Budget and Emergency Deficit Control Act of 1985, as amended.".

Resolved, That the House recede from its disagreement to the amendment of the Senate numbered 247 to the aforesaid bill, and concur therein with an amendment as follows:

In lieu of the sum proposed by said amendment, insert:

$160,409,000: Provided further, That up to $1,000,000 of the funds appropriated under this heading may be transferred to and merged with sums appropriated for "Office of Inspector General"

Resolved, That the House recede from its disagreement to the amendment of the Senate numbered 249 to the aforesaid bill, and concur therein with an amendment as follows:

In lieu of the sum proposed by said amendment, insert: *$253,243,000*

Resolved, That the House recede from its disagreement to the amendment of the Senate numbered 254 to the aforesaid bill, and concur therein with an amendment as follows:

Restore the matter stricken by said amendment, amended to read as follows:

(1) six workyears for the Office of the Director, (2) 22 workyears for the Office of General Counsel.

Resolved, That the House recede from its disagreement to the amendment of the Senate numbered 258 to the aforesaid bill, and concur therein with an amendment as follows:

In lieu of the matter proposed by said amendment, insert:

Notwithstanding any other provision of this or any other Act with respect to any fiscal year, the Hazardous Materials Branch of the Office of Technological Hazards, and all funds and staff years provided to it by this Act, shall be transferred from the State and Local Programs and Support Directorate to the United States Fire Administration within 90 days of the enactment of this Act.

Resolved, That the House recede from its disagreement to the amendment of the Senate numbered 260 to the aforesaid bill, and concur therein with an amendment as follows:

In lieu of the matter proposed by said amendment, insert:

The Director of the Federal Emergency Management Agency shall undertake a review of the agency's organizational structure and, within 180 days of enactment of this Act, submit to the appropriate committees of the Congress a reorganization plan which reflects changing mission requirements and priorities. The review shall include an assessment of the National Preparedness Directorate and examine potential alternatives to meet that directorate's principal objectives while increasing overall agency efficiency.

Resolved, That the House recede from its disagreement to the amendment of the Senate numbered 277 to the aforesaid bill, and concur therein with an amendment as follows:

In lieu of the matter inserted by said amendment, insert:

The Mission Simulator and Training Facility, Building Number 5, of the National Aeronautics and Space Administration, located at the Johnson Space Center in Houston, Texas, is hereafter named and designated the "Jake Garn Mission Simulator and Training Facility". Any reference in a law, rule, map, regulation, document, record, or other paper of the United States to such facility shall be held to be a reference to the "Jake Garn Mission Simulator and Training Facility".

Resolved, That the house recede from its disagreement to the amendment of the Senate numbered 303 to the aforesaid bill, and concur therein with an amendment as follows:

In lieu of the matter proposed by said amendment, insert:

SEC. 591 SAFE DRINKING WATER ACT IMPLEMENTATION.—

(a) Safe Drinking Water Act Report.—The Administrator of the Environmental Protection Agency shall report to the Congress within nine months of the date of enactment of this section recommendations concerning the reauthorization of the Safe Drinking Water Act. Such report shall address—

(1) the adverse health effects associated with contaminants in drinking water and the public health and other benefits that may be realized by removing such contaminants;

(2) the process for identifying contaminants in drinking water and selecting contaminants for control;

(3) schedules for the development of regulations and compliance with drinking water standards;

(4) the financial and technical capacity of drinking water systems to implement monitoring requirements associated with regulated and unregulated contaminants and options to facilitate implementation of such requirements, with special emphasis on small communities;

(5) the financial and technical capacity of drinking water systems to install treatment facilities needed to assure compliance with drinking water standards and options to facilitate compliance with such standards, with special emphasis on small communities;

(6) the financial and technical capacity of States to implement the drinking water program, including options for increasing funding of State programs; and

(7) innovative and alternative methods to increase the financial and technical capacity of drinking water systems and the States to assure effective implementation of such Act.

(b) MORATORIUM AND REPORT ON RADIONUCLIDES IN DRINKING WATER.—(1) The Administrator of the Environmental Protection Agency shall conduct a risk assessment of radon considering: (A) the risk of adverse human health effects associated with exposure to various pathways of radon; (B) the costs of controlling or mitigating exposure to radon; and (C) the costs for radon control or mitigation experienced by households and communities, including the costs experienced by small communities as the result of such regulation. Such an evaluation shall consider the risks posed by the treatment or disposal of any wastes produced by water treatment. The Science Advisory Board shall review the Agency's study and submit a recommendation to the Administrator on its findings. The Administrator shall report the Administrator's findings and the Science Advisory Board recommendation to the Senate Committee on Environment and Public Works and the House Committee on Energy and Commerce. Not later than July 31, 1993, the Administrator shall publish the Administrator's study and risk assessment and the Science Advisory Board recommendation.

(2) The Administrator is directed, if additional time is required to establish the radon standard, to seek an extension of the deadline contained in the judicially-imposed consent decree for promulgation of the radon standard to a date not later than October 1, 1993.

(c) Small System Monitoring Cost Reduction.—With respect to monitoring requirements for organic chemicals, pesticides, PCBs, or unregulated contaminants promulgated in January 1991 (known as the Phase II rule), the Administrator or a primacy State may modify such requirements to provide that any drinking water system serving a population of less than 3300 persons shall not be required to conduct additional quarterly monitoring for a specific contaminant or contaminants prior to October 1, 1993, if monitoring for any one quarter conducted after the date of enactment of this subsection and prior to October 1, 1993 for any such contaminant or contaminants fails to detect the presence of such contaminant or contaminants in the water supplied by the drinking water system.

The PRESIDING OFFICER. The clerk will report the amendment.

The legislative clerk read as follows:

Resolved, That the House recede from its disagreement to the amendment of the Senate numbered 242 to the aforesaid bill, and concur therein with an amendment as follows:

In lieu of the matter proposed by said amendment, insert: ": *Provided*, That the Council on Environmental Quality and Office of Environmental Quality shall reimburse other agencies for not less than one-half of the personnel compensation costs of individuals detailed to it.".

Mr. METZENBAUM. Mr. President, I rise on behalf of Senator WIRTH to address myself to this amendment, which I very strongly support. Senator WIRTH is unable to be with us at this late

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