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

July 30, 1993

OFFICE OF THE ADMINISTRATOR
SCIENCE ADVISORY BOARD

EPA-SAB-EC-LTR-93-010

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

Re: SAB Review of Multimedia Risk and Cost Assessment of Radon in Drinking Water

Dear Ms. Browner:

The EPA Science Advisory Board (SAB) is pleased to comment on the multimedia risk of exposure to radon and the cost of mitigation as required by Public Law 102-389 (the Chafee-Lautenberg Amendments to EPA's FY 1993 Appropriation Bill enacted October 6, 1992). The Chafee-Lautenberg Amendment states that "The Science Advisory Board shall review the Agency's study and submit its recommendation to the Administrator on its findings." The study report made available to the SAB is entitled "Multimedia Risk and Cost Assessment of Radon in Drinking Water".[1] This SAB report on the Agency's study, prepared by the Chafee-Lautenberg Study Review Committee of the SAB, complements previous detailed SAB comments transmitted to you on the uncertainty analysis of radon risks (July 9, 1993) and on costs of mitigation of risks from radon in water (July 30, 1993).

The issues of major concern in assessing risks of radon exposure and costs of mitigation may be grouped into four categories: a) population exposure profiles; b) risk estimation procedures; c) mitigation costs; and d) integration of these for regulatory decision making. The EPA study considered each of these issues and, in turn, they have been addressed by the SAB.

[1] *By way of background, the SAB early in 1993 began interactions with EPA, including receipt of background material on this study. However, the specific report reviewed by the Committee was not received until July 9, 1993, and thus, limited time was available to review and comment on the report because of the July 31, 1993 deadline for submission to Congress. Continuing to the present study report, there has been a steady improvement in the quality of the analyses conducted by EPA.*

A. Population exposure profiles

The Agency report estimates that 81 million people use water originating from community groundwater supplies with a population-weighted average radon activity of 246 picocuries per liter of water (pCi/L_{water}). The Agency report estimates that approximately 19 million people are served by water supplies with radon concentrations in excess of 300 pCi/L_{water}, the Maximum Concentration Level proposed by the Agency. It is the SAB's impression from information provided by public commenters, that the Agency's estimates of population exposure to radon in drinking water are rather uncertain and may seriously underestimate the number of community water systems impacted by the proposed drinking water standard. This uncertainty in exposure estimates ultimately impacts the costs of mitigation. There is clearly a need for more information and a better presentation of available data on the profile of population exposure to radon in drinking water, including the distribution of radon in drinking water exposures for communities of varying size.

B. Risk estimation procedures

The risk estimation procedures used by the Agency address both the risks from radon inhaled in air and ingested in water. The risk estimates from airborne radon with lung cancer as an endpoint are based on strong epidemiological evidence from studies of uranium miners, augmented by data on other underground miners, and supported by data from laboratory animal studies. However, there continues to be debate about the extrapolated lung cancer risk at lower levels of exposure. This issue may be clarified during the next several years when the results of several major epidemiological studies focusing on exposure to radon in homes become available. However, even though there is a potential risk at low levels of exposure to air borne radon, it must be recognized that the populations available for epidemiological studies are relatively small, the majority of residential exposures are not particularly high, and the postulated levels of risk are sufficiently low that epidemiological studies might well be unable to identify any increase in risk attributed to residential radon exposure if such a risk is present.

The situation is quite different for estimating the risks of ingested radon in drinking water. In this case, there is no direct epidemiological or laboratory animal evidence of cancer being caused by ingestion of radon in drinking water. Thus, the approach to estimation of cancer risk from radon in drinking water is more indirect than for radon in air. In the absence of direct evidence, it is not possible to exclude the possibility of zero risk from ingested radon.

The indirect risk estimation approach involves several steps. First, the dose to various tissues has been calculated from models for the distribution of radon in the body following ingestion of radon. The model calculation is based, in part, on organ distribution information from an unpublished study with radio-xenon (as a surrogate for radon, since both are noble gases) using human subjects. The meager data base results in uncertainty in estimating tissue doses from ingested radon in drinking water. This uncertainty could be reduced through further research. In the next step, the calculated doses have been used along with organ-specific risk estimates per unit dose, derived from data on the Japanese atomic bomb survivors, to calculate cancer risk to various organs. To a large extent, this involves an extrapolation from the very acute, high dose rate, gamma (low Linear Energy Transfer) exposure of the Atomic Bomb survivors to a very protracted, very low dose rate, alpha particle (high Linear Energy Transfer) exposure with ingested radon. The SAB is of the opinion that the estimates of risk from ingested radon have additional uncertainty due to possible differences in the distribution of dose, and resulting effects, from alpha particles from radon and progeny. However, it should be noted that even at the upper bound of the uncertainty analysis for ingested radon, for most situations the risk from radon ingested in drinking water is still much lower than the risk from airborne radon entering the house directly from the soil. Indeed, for many homes the risk from the radon in water is even lower than that from radon in the outdoor air.

The available information on exposure and risk have been generally integrated under a scientifically satisfactory framework by the Agency as evidenced in the Agency's multimedia risk assessment for radon (EPA-SAB-RAC-93-014, July, 1993). However, the uncertainties noted earlier in this report are carried forward into most of the integrated analyses. However, the differences of opinion, especially with regard to the extent of the exposed population, with interested parties are not reflected in the Agency report or in the integrated analyses.

The risk estimates are illustrated in Figures 1 and 2. The population risk estimates for airborne radon indoors are the most certain, with the nominal estimate of 13,600 lung cancer deaths per year (range of 6740 to 30,600 lung cancer deaths) from exposure to indoor air[2]. Less than one percent of this lung cancer risk is attributable to radon reaching homes via water. In contrast, exposure to radon in outdoor air is estimated to produce 520 lung cancer deaths per year (range of 280 to 1500 lung cancer deaths)[3]. And finally it is estimated that ingestion of radon in water is estimated to cause 46 cancers per year (range of 11 to 212 cancers per year)[4]. This latter estimate is the most uncertain of all the estimates made. Airborne radon arising from water is estimated to result in 113 lung cancers per year (range of 40 to 408 lung cancers per year)[5] which are included in the estimate presented above for indoor residential air. These risk estimates for radon can be placed in perspective by comparison with an estimate of approximately 30,000 cancer deaths per year from all exposures to naturally occurring radiation, including approximately 13,600 deaths from inhaled radon and approximately 2,500 cancers estimated for naturally occurring radio-potassium in the human body.

C. Mitigation costs

The costs of mitigation of radon in the water and indoor air are also uncertain. Part of the uncertainty for mitigation costs of radon in water relates to differences of opinion between the Agency staff and interested parties over the cost of mitigation systems. For example, the Agency staff estimates capital costs for mitigation of radon in water at less than $2 billion, while interested parties have estimates of capital costs in excess of $10 billion. Similar differences exist for recurring maintenance and operating costs. The other part of the uncertainty for mitigation costs of radon in water relates to the representativeness of the data base on the occurrence of radon in groundwater used by the Agency. These data

[2] Report to the United States Congress on Radionuclides in Drinking Water: Multimedia Risk and Cost Assessment of Radon in Drinking Water. Prepared for PL 102-389. Office of Water, US Environmental Protection Agency. July 9, 1993. page 3-2.

[3] *Ibid, p. 3-3.*

[4] *Ibid, Table 7-3 beta model estimates.*

[5] Ibid, Table 7-3.

are the source for estimates of the number and size of communities that would require radon mitigation depending on the level of the MCL finally selected for regulation. In contrast to the potential mandated regulation of radon in water, mitigation of radon in indoor air involves voluntary actions by homeowners. Total cost estimates of the latter are highly uncertain because the extent and cost of testing for radon in homes and the extent of voluntary participation in mitigation action in affected homes are unknown.

The SAB is of the opinion that the mitigation cost uncertainties for radon in drinking water could be reduced by the EPA working with interested parties to resolve issues related to the occurrence of radon in community systems of various sizes, the cost of the various process treatment operations and processes for various system sizes, and the frequency of the need for disinfection after aeration. This may require reopening the comment period for this rulemaking. The SAB recommends that EPA, if necessary, request from the Court and Congress sufficient time to do this work to reduce uncertainties in the cost estimates and the cost per cancer avoided. The public interest will be served if the Agency carries out activities over several years which provide a better basis for deciding how to most effectively mitigate risks from radon exposure in drinking water.

D. Integration for regulatory decision-making

Because of uncertainties in both risk estimates and costs of mitigation there is substantial uncertainty in the cost per cancer death avoided. This uncertainty is especially large for mitigation of cancers related to ingestion of water. However, even with this uncertainty, it is clear that the cost per lung cancer avoided from mitigation of indoor air radon is substantially less than the cost per cancer death avoided due to mitigation of exposure from radon in drinking water. This difference appears to be at least a factor of 4 ($3.2 million per cancer death related to drinking water and $0.7 million per cancer death related to airborne radon) and may be substantially larger. The highest costs may be those associated with mitigation of risks for radon in water for the smallest communities.

In summary, the SAB notes the extent of the uncertainties in the population exposure profiles, the risk estimates for ingested radon in drinking water and the costs of mitigation. In view of these large uncertainties for risk estimates for ingested radon in drinking water and knowledge of the substantially greater risks associated with airborne radon indoors and outdoors directly from soil, the SAB advises that EPA consider various options for mitigating radon cancer risks. The options all include continuing the Agency's efforts to encourage voluntary actions to reduce indoor air radon in view of the cost effectiveness of this approach for reducing risks.

With regard to water, as one option the Agency could promulgate a standard at 300 pCi/L_{water} as has been proposed. However, in doing so it must be recognized that this involves selecting a risk reduction strategy for radon that is the most costly in terms of costs per cancer death avoided; i.e., more than four times the cost of cancer risk avoidance for airborne radon indoors. Alternatively, as another option a standard might be set at some higher level such as 1000 to 3000 pCi/L_{water}, to initiate mitigation of the highest potential risks. For example, setting a water standard at 3000 pCi/L_{water} would result in water contributing no more radon to indoor air than is present in outdoor air. (Keep in mind that the radon in outdoor air arises by natural processes from soil gas and there is no way to alter the outdoor radon levels.) At the same time it would be appropriate to intensify research on radon ingestion and radon mitigation, data gathering on radon occurrence for all media, and dialogue with interested parties. These actions would serve to reduce the uncertainties in the risk estimates, the costs of mitigation, and, ultimately, the estimates of cost per cancer avoided. We cannot emphasize too strongly the SAB view that a relative risk orientation should be applied to the decision making process. Comparative analysis of uncertainties on the risks of various exposure scenarios and mitigation approaches should be developed and provided to the risk managers.

The SAB strongly supports the use of a relative risk reduction orientation as an important consideration in making risk reduction decisions on all sources of risk, including those attributable to radon. Other important considerations include legislative authorities, environmental equity, economics, and the like. In short, the relative risk approach calls for giving the highest priority to mitigating the largest sources of risks first, especially when the cost-effectiveness of risk reduction of such sources is high. The SAB recognizes that the large number of laws under which EPA operates makes it difficult to implement a relative risk reduction strategy uniformly across the Agency. Radon is an excellent example of the problem with radon in drinking water governed under one statute (Safe Drinking Water Act) while radon in indoor air is not currently subject to regulation under a specific statute. The SAB strongly encourages the Agency and the Congress to work together to consider changes in existing statutes that would permit implementation of relative risk reduction strategies in a more efficient and effective manner.

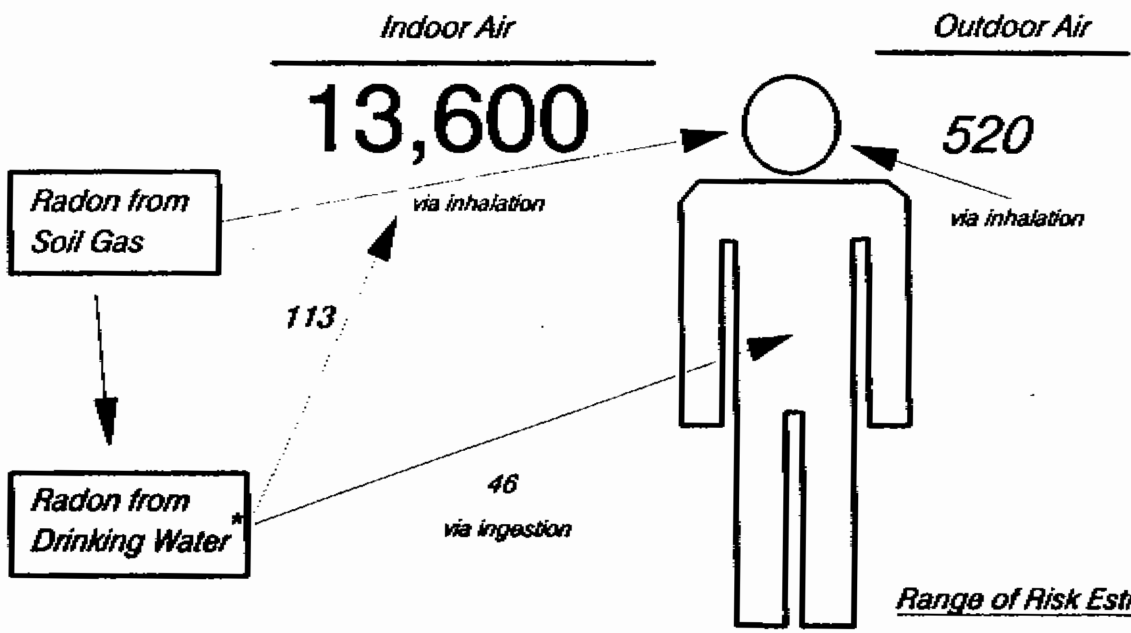
The SAB appreciates this opportunity to advise you and the Congress on this important matter, and we look forward to receiving a response on these suggestions.

Sincerely ~~yours~~,

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

Roger O. McClellan
Dr. Roger O. McClellan
Chair, Chafee-Lautenberg Study Review Committee

Figure 1. Estimated Annual Cancer Risk From Exposure to Radon (in Cancer Deaths/Year)



** Risk potentially impacted by Drinking Water Standard*

Range of Risk Estimates Shown in Figure:

13,600 (6740 - 30,600)

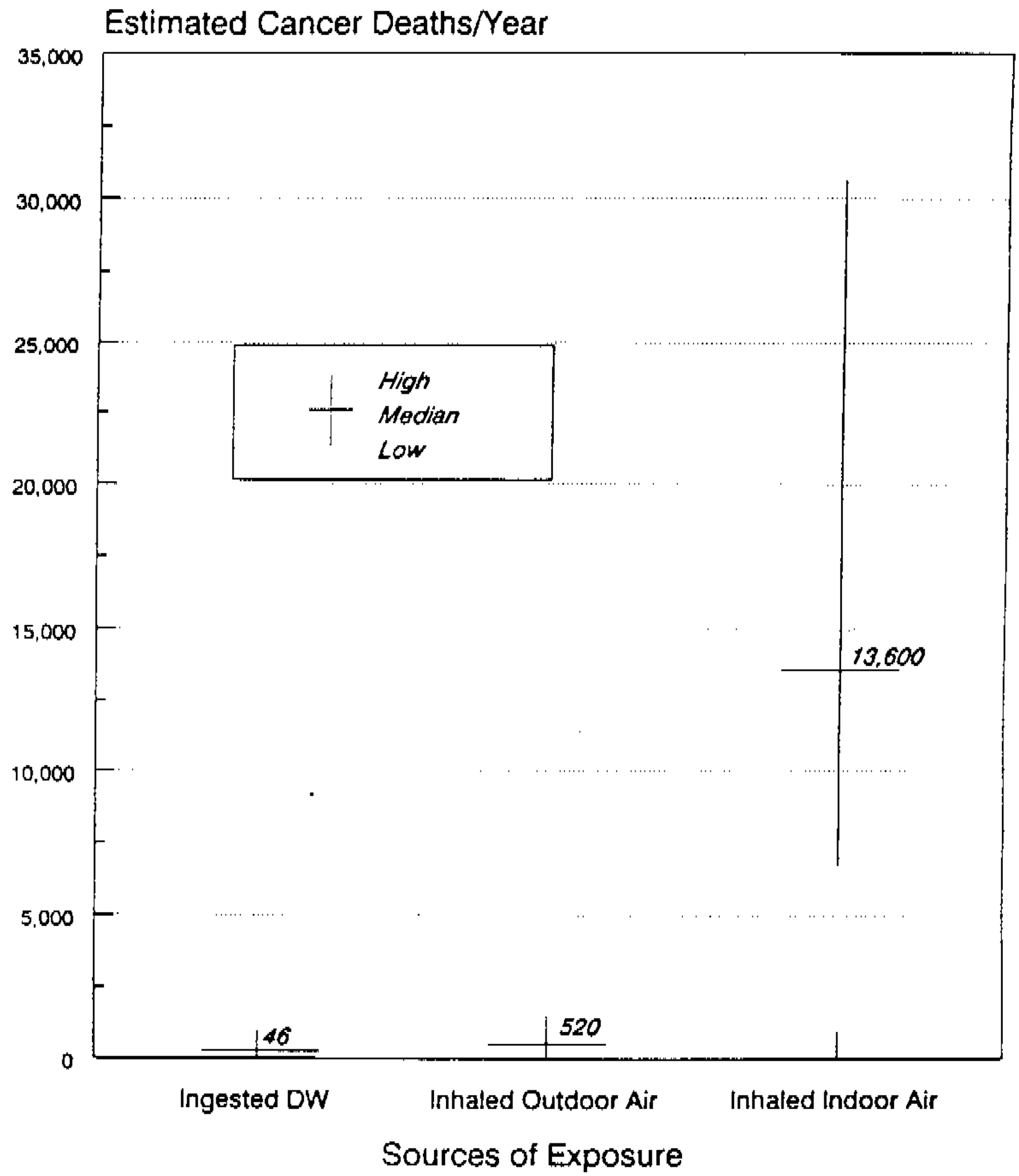
520 (280 - 1500)

*113 (40 - 408)**

*46 (11 - 203)**

DATA SOURCE: "Report to Congress on Radionuclides in Drinking Water: Multimedia Risk and Cost Assessment of Radon in Drinking Water Office of Water, July 9, 1993.

Figure 2. Estimated Annual Deaths From Exposure to Radon (in Cancer Deaths/Year)



Source: "Report to the U.S. Congress on Radionuclides in Drinking Water: Multimedia Risk and Cost Assessment of Radon in Drinking Water", Office of Water, US EPA July 9, 1993.

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