



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

EPA-SAB-RAC-LTR-92-003

January 9, 1992

Honorable William K. Reilly
Administrator
U.S. Environmental Protection Agency
401 M Street, SW
Washington, D.C. 20460

OFFICE OF
THE ADMINISTRATOR

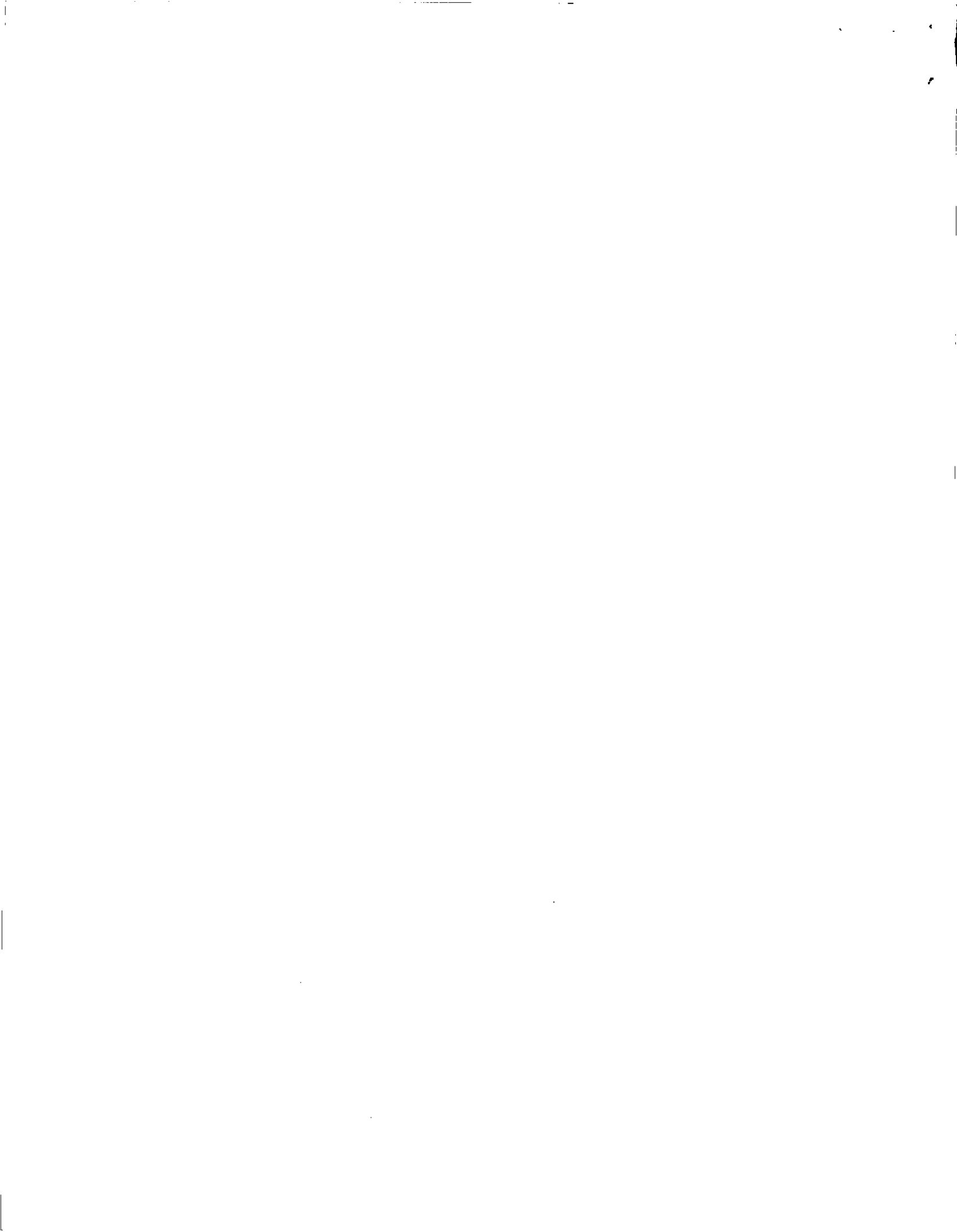
Re: Revised Radon Risk Estimates and Associated Uncertainties

Dear Mr. Reilly:

With this letter we are responding to the request of the Office of Radiation Programs (ORP) dated April 15, 1991 for review of two documents supporting the ORP reassessment of radon associated risks to the general population. This review is based on the documents entitled "EPA's National Residential Radon Survey Preliminary Results" and "Proposed Revisions in EPA Estimates of Radon-Risks and Associated Uncertainties." These documents were provided to the Radiation Advisory Committee in April, and the Committee was briefed on them by ORP staff at the committee meeting in Montgomery, Alabama, on May 20, 1991.

These documents represent an important step forward by the Agency in assessing the health risks of exposure to radon and its decay products, in reviewing and utilizing the recent scientific results and deliberations on issues affecting the dose and risk, and in attempting to quantify the attendant uncertainties. The National Residential Radon Survey is a success story, since it represents the first significant nationwide survey of an indoor air pollutant with a firm statistical basis for its design and implementation. The original design of this survey was brought to the Board for review in October 1987 [SAB-RAC-88-002]. The Agency adopted many of the suggestions made by the Board, and has provided periodic status reports on its progress. The initial analyses have been completed. It appears the survey will provide a wealth of important data on annual average radon concentrations and on housing stock characteristics.

In its letter of transmittal, ORP requested that the Board address seven issues. These questions and the Board responses are detailed below. Overall, the Board has found that the methods and analyses used by the Agency for the assessment of radon risk are generally appropriate. The nationwide average of radon concentrations in U.S. homes, based on the National Residential Radon Survey, represents the best available data. The Agency's proposed adjustment of the exposure/dose relationship between miners and the general population, obtained from the recent EPA-sponsored National Research Council report,



"Comparative Dosimetry of Radon in Miners and Homes," (National Academy Press, Washington, DC, 1991) is appropriate as is the proposed value for the residential radon equilibrium fraction. The average home occupancy factor is reasonable and the Agency's method for deriving an estimate of uncertainty associated with the number of annual radon-related lung cancers is deemed acceptable.

The Board has some reservations and comments regarding the dose-response model used for the estimation of overall risk. Notwithstanding the SAB's earlier recommendation [SAB-RAC-88-042] that an average of the relative risk models presented in the National Research Council's 1990 report, "Health Effects of Radon and Other Internally Deposited Alpha-Emitters--BEIR IV," and in the International Commission on Radiological Protection report ICRP-50 be used for making this estimate, the sole use of the BEIR IV model is now recommended with no adjustment for a potential increased risk for individuals exposed as children and young adults. ORP staff concurs with this recommendation. The effect of implementing this recommendation would be to lower the central estimate of the overall risk. The possible variation of risk with age at exposure could be incorporated in the uncertainty analysis.

The Agency's estimate of overall U.S. risk of lung cancer from radon exposure is calculated for the total population consisting of both smokers and non-smokers. Since smokers are significantly more sensitive to the effects of radon exposure than are non-smokers and former smokers, the Board recommends that the Agency review periodically the national lung cancer estimates in view of changes in smoking habits as well as changes in the underlying lung cancer incidence rate. Detailed discussion of the various issues is provided below.

- a. Is the methodology which will be used to derive the nationwide average of radon concentrations in U.S. homes appropriate?

Yes. The Board had previously reviewed and provided input to the design for the National Residential Radon Survey. Based on the preliminary results, the Survey appears to have met its original objectives. The initial survey result of use to the task of estimating the nationwide risks associated with radon exposure is the average radon concentration in U.S. homes. Since data were collected from multiple locations in each house, four methods of describing the average radon concentration for a particular house were presented. The Board feels that the method selected by ORP, that of averaging overall frequently occupied levels, is a reasonable approach.



- b. Given the finding to date of higher risk to atomic bomb survivors exposed as children, is it prudent for EPA to continue to follow the previous SAB advice to average the risk estimates from BEIR IV and ICRP 50 to reflect a potential higher risk to children?

No. The earlier Science Advisory Board advice [SAB-RAC-88-042] should be revised at this time. The Radiation Advisory Committee (RAC) unanimously recommends that the Agency now use only the BEIR IV Model for its risk assessment for residential exposure to radon. This recommendation differs from the Committee's previous advice to average the estimates based on the BEIR IV and the ICRP 50 models. This current recommendation is based on the following rationale:

1. The earlier recommendation that projections of the BEIR IV model be averaged with those of ICRP 50 was based, in part, on the assumption by the International Commission on Radiological Protection (ICRP) committee that radon exposures of children and young adults below 20 years of age may produce a greater risk for cancer of the lung than do exposures of adults. This assumption was based largely on earlier (1950-1978) Life Span Study data on lung cancer from whole-body exposure to low-LET radiation from the atomic bomb explosions in Hiroshima and Nagasaki as reported by Kato and Schull (1982). However, the subsequently published (1990) National Research Council report, "Health Effects of Exposure to Low Levels of Ionizing Radiation--BEIR V," using Life Span Study data through 1985 concluded that there was no dependence on age at exposure for lung cancer.

A report on lung cancer in Chinese tin miners exposed to radon gas (published in *Cancer Research*, January 1, 1990, by Jay H. Lubin, You-lin Qiao, et. al.) also failed to show a dependence on age at exposure for individuals less than 13 years of age. The recent (1991) National Research Council analysis "Comparative Dosimetry of Radon in Mines and Homes" states that "although the K-factors [the ratio of the exposure-to-dose relationship in homes to that of mines] for children and infants were somewhat greater than those for adults, none of the values was above unity." The K-factor values of 0.7 for adults and 0.8 for children do not support the greater risk to children assumed in the ICRP 50 model.

2. The BEIR IV model is based on four reasonably well-documented cohorts of underground miners and represents the consensus of a National Academy of Sciences/National Research Council Committee of well-established and qualified scientists.

3. The BEIR IV model incorporates a decrease in lung cancer risk with time after exposure, a phenomenon that was also accounted for in the 1984 NCRP model and which has been further demonstrated in epidemiological studies published subsequent to the BEIR IV report. The ICRP 50 model does not incorporate this decrease in risk with time after exposure.



- c. Is the EPA proposed adjustment of the exposure-dose relationship between miners and persons in the general population, based on the 1991 NAS report, appropriate?

Yes, the adjustment of the risk coefficient using a K-factor of 0.7 to account for the estimated lower bronchial dose per unit exposure in homes compared with that in mines is appropriate. The Board notes that recent data on nasal deposition of ultra-fine aerosols suggest that the K-factor may decrease to about 0.6.

- d. Is the proposed EPA value for the residential radon equilibrium ratio reasonable?

The Agency's evaluation and selection from the available data set of the value of 0.5 is reasonable. The uncertainty range of 0.35-0.55 is appropriate. This value of the equilibrium factor may turn out to be lower as further data are collected from U.S. homes.

- e. Is the proposed occupancy factor reasonable in view of available data?

Yes, the Agency has selected a value of 75%, with an associated uncertainty range of 65 to 80%.

- f. Is EPA's method for deriving an estimate of uncertainty associated with the number of annual radon-related lung cancer deaths appropriate?

Yes, although the Board does recommend that, because smoking has a significant effect on risk, the Agency attempt to incorporate smoking into the uncertainty analysis. The uncertainty analysis conducted by the Agency begins with a central estimate of lung cancer deaths based on the BEIR IV risk model and the results of the residential radon survey. Following an approach utilized by The National Institutes of Health for quantifiable uncertainties, the uncertainty ranges were distributed log-normally without correlations and the log-transformed variances were then added. The quantified uncertainties included the variability in risk coefficients derived from different cohorts, uncertainty about the decrease in relative risk following cessation of exposure, and uncertainty about the relationship between exposure and risk in homes versus that in underground mines. The quantified uncertainties about exposure included the statistical reliability of the



survey, uncertainty about the equilibrium factor, and uncertainty about the percent of time people spend in their residences. Variables not treated quantitatively include estimates of exposure in mines, the effect of exposure rate on risk and the effects of smoking status and gender. The knowledge base about these uncertainties is not well developed.

- g. Is EPA's methodology for deriving the central estimate and range of radon-related lung cancer deaths in the U.S. population appropriate?

As has been discussed in addressing the earlier questions, the Board has found the methods and data to be appropriate, with the exception of the dose-risk methodology. The Board now recommends the sole use of the BEIR IV model for this purpose. This model has already served as the basis for the uncertainty analysis presented by ORP. Although alternative methods or assumptions could lead to different central estimates, in general these differences are not large compared with the range of the uncertainty. The present analysis, with the use of the single BEIR IV model, will yield a solid, well-documented and defensible central estimate of the radon-related lung cancer deaths in the U.S. and the probable range of uncertainties. The possible variation of risk with age may also be addressed in the uncertainty analysis.

General Recommendations:

ORP has identified and utilized most of the recent data or assessments on the factors influencing the risk assessment, including the K-factor and the equilibrium factor. As pointed out briefly in the discussion of these individual issues, both are topics of (or their values are influenced by) current research.

The Agency's estimate of overall U.S. risk of lung cancer from radon exposure is calculated for the total population consisting of both smokers and non-smokers. It is well-established that smokers are significantly more sensitive to the effects of radon exposure than are non-smokers and former smokers. As noted in the ORP discussion of uncertainties, since the dose-risk estimate is based on a relative risk model, changes in the underlying cancer incidence rate, including the results of changes in smoking habits, will cause changes in the number of lung cancer deaths attributable to radon. The Board recommends that the Agency review these cancer risk estimates and the underlying data periodically to update the estimates. The Board believes the current methodology and the reliance on BEIR IV are sufficiently robust, so that these reassessments would primarily need to focus on updating the various factors.



We appreciate the opportunity to review this issue and are ready to provide review comments on any significant revisions to the subject documents. We look forward to your response on the major points we have raised.

Sincerely,



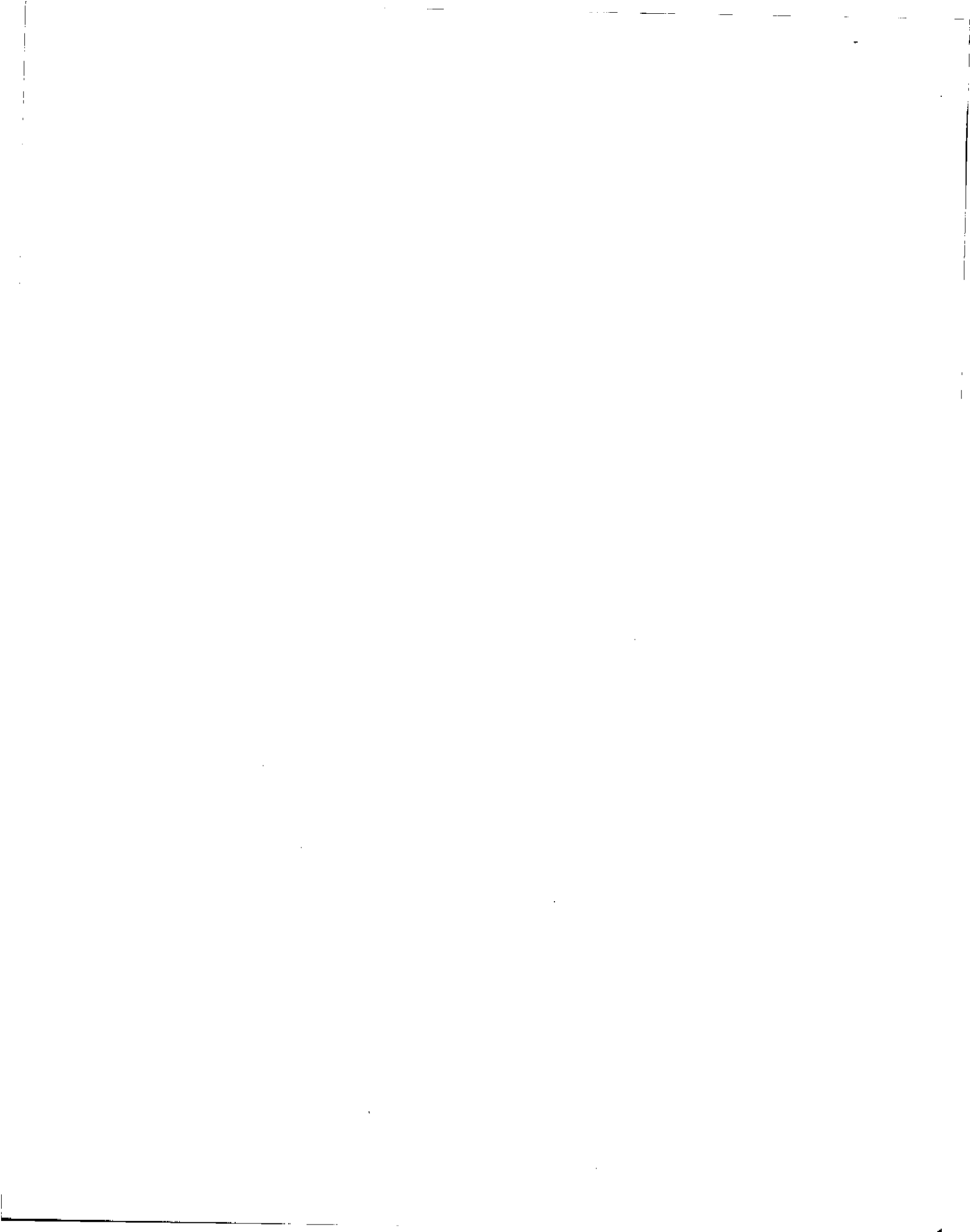
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cc: Assistant Administrators
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