UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
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OFFICE OF THE ADMINISTRATOR
SCIENCE ADVISORY BOARD

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

RE: Review of "The Benefits and Costs of the Clean Air Act, 1970 to 1990" by the Physical Effects Review Subcommittee (PERS) of the Advisory Council on Clean Air Compliance Analysis (ACCACA)

Dear Ms. Browner:

This letter report summarizes the major consensus conclusions drawn by the Physical Effects Review Subcommittee (PERS) of the Advisory Council on Clean Air Compliance Analysis (ACCACA, or "the Council") as a result of its analyses of the May 3, 1996 draft of the EPA document entitled "The Benefits and Costs of the Clean Air Act, 1970 to 1990", which is referred to hereafter in this letter as the "Document". The substance of this letter report was formulated at the PERS meeting in Alexandria, VA on June 4, 1996 and reported orally to the Council at its meeting in Alexandria on June 5 and 6, 1996. This report was reviewed and endorsed by PERS at a technical editing teleconference held by the PERS on July 30, 1996. Many more specific technical and editorial issues have been noted by members of the PERS, and these have been transmitted to EPA Staff. We trust that they will be given due consideration in the preparation of the final revisions of the Document.

Although the PERS members have reviewed and provided comments on all chapters in the Document, the consensus conclusions summarized herein are limited to our analyses of the chapters on health and welfare effects and the corresponding exposure-response relationships for which the PERS has specific expertise.

We are pleased to report that the authors have been very responsive to the critiques and suggestions provided by PERS following its earlier reviews of preliminary drafts. There are now much clearer statements of: a) what has been analyzed; b) the bases for the selection of data and models used in the analyses and of those effects either not analyzed or not monetized; c) the nature and extent of the uncertainties associated with the results reported; and d) what is known about the nature and extent of those effects of air pollution which cannot be adequately analyzed and/or monetized.

The only significant exception is the area of welfare effects, especially in terms of agricultural and forest productivity and ecological impacts. In these areas the literature reviews in the Document are largely limited to review papers and are not up-to-date. In particular, we suggest that the Staff utilize the up-to-date reviews and analyses in the recently completed Criteria Document and Staff Paper on Photochemical Oxidants in preparing the final draft. It provides sufficient data for the valuation of some damages to crops and forests. Inclusion of such analyses would help to balance the overall report.

The PERS's major concerns are focussed on the analyses and interpretations of the epidemiology data derived from the time-series (daily mortality) studies and the cross-sectional (annual mortality) studies for particulate matter (PM) and its closely associated co-pollutants such as sulfur dioxide (SO_2), nitrogen oxides (NO_x), and ozone (O_3). It has become clear in recent years that these pollutants, whether individually or collectively, are significantly associated with excess mortality, and that the associations generally are most closely and consistently related to the ambient air concentrations of thoracic particles (PM_{10}) and/or fine particles ($PM_{2.5}$). These pollutants have some common sources (e.g., combustion), and their concentrations tend to rise and fall together over large geographic regions. If PM exposure is not an independent causal factor for excess mortality, then it is at least a good surrogate measure of the exposure to the pollutant mixture. Therefore, for the kinds of aggregate analyses used in this Document, it is appropriate to use the PM effects coefficients from the epidemiological studies as surrogates for the exposure to the mixtures. It follows that it is inappropriate to also add separate SO_2 or O_3 effects estimates in addition to those for PM, since they would produce "double-counting" (unless they are included in the model simultaneously). In multiple-regression studies where separate coefficients for each pollutant were reported from separate models, the PM-only coefficient is the most practical one to use in this aggregate effects analysis, as it is the most consistently available. To the extent that other air pollutants have effects on mortality that do not correlate well with those of PM, then the reliance on PM as a surrogate for the effects of the mixture on mortality may understate the total impact of air pollution on mortality.

The majority of the PERS members concluded that the rationale for excluding annual mortality studies from the benefits summation was weak. One major reason for their omission may have been that the authors considered only the two recent prospective cohort studies [Harvard 6-cities (Dockery *et al.*, 1993) and the 151 communities in the American Cancer Society study (Pope *et al.*, 1995)]. By neglecting to cite earlier "ecological" studies (e.g., Ozkaynak and Thurston, 1987; Lipfert, 1984; Lave and Seskin, 1977) the Document suggested that only the two recent prospective cohort studies provided useful data on annual rates of mortality in relation to PM exposures. What the two cohort studies did show is that the association between ambient air pollution and mortality cannot be explained by confounding influences of smoking and other personal risk factors. Thus, the similar coefficients of response among the cohort and ecological studies indicate a consistent body of data implicating air pollution as a causal factor for variations in annual mortality rates.

The fact that excess mortality is significantly associated with ambient PM concentrations for both short-term and long-term exposures is important in terms of the credibility of each kind of exposure as a significant cause for adverse responses. If there were no evidence for excess annual mortality, then it would imply that the excess daily mortality was either due to very short-term advancement of mortality, or was an artifact of additional influential variables not considered in the analyses. Conversely, if there were no evidence for excess daily mortality on highly polluted days, the likelihood of chronic air pollution exposure being a causal factor for an excess of annual mortality would be reduced.

The draft Document analyzed exposure-response relationships for both acute and chronic mortality, but recommended that only the acute mortality coefficients be used for the summary benefits calculations. The PERS recommends that both the acute and chronic mortality benefits of the pollution reductions attributable to the Clean Air Act (CAA) (1970-1990) be fully presented and discussed in the revised Document. The discussion should include a summary of the major uncertainties of both types of studies and provide a balanced discussion of the advantages and limitations of each kind of analysis for an unbiased cost accounting.

The daily mortality analyses have some advantages as evidence of PM-associated excess mortality. They are not complicated by unknown intercommunity differences in ethnicity, lifestyle, housing density, socio-economic factors, climate, etc. that may confound the interpretation of the annual mortality. Also, more individual studies are available and more comprehensive analyses and reviews have been performed for this data set, including those in the recently completed PM Criteria Document. Thus, daily mortality should continue to be a significant element in the analysis of benefits of the CAA.

With respect to the treatment of the daily mortality data in the Document, the PERS offers the following comments and recommendations:

a) Expand listing of time-series analyses to other studies having the statistical power to detect small relative risks. In other words, do not omit good quality studies that failed to report statistically significant associations between daily mortality and PM concentrations;

b) List only the effects associated with PM concentration, on the basis that PM is representing the pollution mixture;

c) Do not characterize the range of mortality coefficients based on the single highest and single lowest reported positive coefficients. If high and low estimates are to be reported, they should be based on the confidence

intervals of the distribution of the PM coefficients from the individual studies, such as, for example, those at 2 standard deviations from the mean.

The daily mortality analyses have the disadvantage that the extent of prematurity of mortality cannot be accurately determined or inferred from the available literature. Thus, as discussed in the June 1996 Letter Report of the Council, it is difficult to assign monetary values to the reductions in daily mortality attributable to the reduced pollution.

By contrast, the annual mortality can more readily be expressed in terms of reduced lifespan, providing a basis for the monetary valuation of the estimated life extension. On the other hand, the annual mortality studies have some limitations that do not affect the daily mortality studies to the same degree. These include:

a) Assigning the appropriate period of exposure to the coefficient of response. If the relevant exposure extends over a decade or more, then a coefficient determined on the basis of current or recent years' exposure could be inflated when pollution levels have decreased markedly.

b) Insufficient or inappropriate adjustment for confounding factors affecting long-term mortality rates. There may be differences among communities in diet, exercise, ethnicity, climate, industrial effluents, etc. which could affect longevity. Such intercommunity differences are much less likely to affect the results of time-series studies of daily changes in the same community.

Despite these concerns, cross-sectional (annual) mortality rate studies have consistently shown evidence for excess mortality in relation to indices of fine airborne particles (sulfates and $PM_{2.5}$), as discussed previously. In completing the analyses of annual mortality, we recommend that EPA Staff use a somewhat different approach than that used for the daily mortality studies, where we recommended using a mid-value and statistically based upper and lower bounds based on the results of the numerous valid studies. For annual mortality, we recommend that the benefits analysis should be based primarily on the Pope *et al.* (1995) study results for the following reasons:

a) It is based on a much larger population (> 500,000) and many more communities (151 vs. 6) than the other prospective fine particle cohort study (Dockery *et al.*, 1993).

b) Its results are consistent with the results of Dockery *et al.* (1993), which reported even larger mortality responses, but only in six cities.

c) Its results are consistent with ecological population studies of annual mortality based on 1960 and 1970 census data (e.g., Lave and Seskin, 1977), 1970 census data (Lipfert, 1984) and 1980 census data (Ozkaynak

and Thurston, 1987). These ecological studies could not account for individual risk factors, such as smoking and occupational exposures, which are now known to have only modest influences based on the recent analyses from the prospective cohort studies of Dockery *et al.* (1993) and Pope *et al.* (1995).

A specific issue associated with the annual mortality study of Pope *et al.* (1995) is that the mortality rates were determined by relating mortality associated with long-term pollutant exposures using ambient air data for approximately 15 years prior to death. If mortality is also related to exposures earlier in life, when fine particle pollution levels could have been 50-100% higher, then the calculated coefficient may overestimate the effect. On the other hand, Pope *et al.* (1995) noted that their population was largely composed of middle class Caucasians who have lower mortality rates and possibly lower exposures to pollution than poorer minority populations. Their study may therefore have yielded lower coefficients of response than those appropriate for minority populations, or for the population as a whole. In any case, as noted previously, the assumption is made that the fine particle associations with annual mortality represent the overall responses to community air pollution as a complex mixture rather than to the particulate mass components alone.

In summation, the annual mortality studies are important for several reasons. These include:

a) The excess mortality estimates are greater than that of the annual sum of daily mortality from the more numerous time-series mortality studies, suggesting that excess daily mortality during pollution episodes is not largely balanced by deficits in daily mortality during cleaner days that follow.

b) The annual mortality estimates can be expressed in terms of duration of life-shortening as well as number of excess deaths. This provides an alternate means for determining the benefits of pollution controls that may be more easily interpreted by risk assessors, risk managers, and the public.

c) Chronic cardiopulmonary damage produced by long-term pollution exposure can account for both reduced lifespan and predisposing individuals to be at special risk for excess daily mortality during the stress associated with peak pollution episodes.

Thus, the document should not have omitted the estimates of mortality based on the annual studies from its summary tabulations. These estimates differ from those based on the time-series studies, both in terms of their nature (number and quality of life-years saved) and their implications for assigning monetary values to them. Thus, they should be presented as separate ledger entries from those for daily mortality, and

no combined mortality estimate should be presented. It should be made clear that combining them would be double-counting, since excess daily mortality is one component of excess annual mortality. Presenting them separately provides the reader with alternative, plausible means of judging the extent of the benefits of the estimated reductions in mortality attributable to the control activities resulting from the Clean Air Act between 1970 and 1990.

The quantitation of the mortality associated with lead (Pb) is based on a different kind of analysis from either the time-series (daily) or chronic (annual) mortality studies of populations, and it is appropriate to tabulate its impact on mortality separately. It is based on epidemiological studies showing statistically significant associations between blood lead (PbB) and blood pressure, combined with the well-established association between blood pressure and mortality rates. Thus, the PERS recommends separate discussions and tabular summation for: a) the excess daily mortality associated with the non-Pb criteria pollutants, using daily PM concentration as the surrogate index; b) the excess annual mortality associated with the non-Pb criteria pollutants, using annual average PM concentration as the surrogate index; and c) the excess annual mortality associated with Pb exposure attributable to air emission, as indexed by population averages of PbB.

The benefits analyses for the morbidity associated with exposure to lead (Pb) also have uncertainties. However, those for Pb have a much clearer mechanistic basis for the underlying biological responses that supports the extensive and generally consistent epidemiological data base. The control of exposure to Pb is clearly one of the great success stories of the CAA as well as being the best documented success, and this is reflected in the thorough and well described benefits analysis in the Document.

Regarding the estimates of morbidity effects for the other criteria pollutants, the PERS was most concerned about the treatment of chronic bronchitis, especially the staff decision not to include the number of cases of chronic bronchitis avoided in its summaries of quantified effects in Chapter 5 and Appendix D. The question of what monetary value to assign to the reduction in the incidence of this endpoint is separate from the question of the reliability of the statistical evidence linking PM to increases in the incidence of chronic bronchitis. We understand that the former question will be addressed by the Council. But whether or not a monetary value is assigned to this effect, the estimated number of cases avoided should be included as a quantified health effect.

With regard to the other morbidity effects listed and evaluated for exposure-response relationships, the PERS concludes that the Document provides as thorough, careful and complete a summation as the available literature permits. We hope the Council's report will emphasize the severe limitations imposed on these analyses by the paucity of relevant data, especially the lack of sufficient scientific information and/or economic tools to monetize ecological benefits. We hope EPA and the Congress will

mobilize the resources needed to generate the data to mount more thorough and satisfactory analyses of costs and benefits of air pollution controls in future projects of this kind.

Sincerely,

Morton Lippmann

Dr. Morton Lippmann, Chair
Physical Effects Review Subcommittee (PERS)

Dr. Richard Schmalensee, Chair
Advisory Council on Clean Air Act
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NOTICE

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ABSTRACT

The Physical Effects Review Subcommittee (PERS) of the Advisory Council on Clean Air Compliance Analysis (ACCACA, or the Council) of the Science Advisory Board (SAB) reviewed the Agency's May 3, 1996 draft Report to Congress entitled *"The Benefits and Costs of the Clean Air Act, 1970-1990."* The Agency was responsive to the PERS critiques of preliminary drafts, with exceptions being agricultural and forest productivity and ecological impacts. In these areas, the Agency's draft document is still not up-to-date.

For PM-associated excess daily mortality, the PERS noted that it is difficult to assign monetary values to the reductions to mortality. By contrast, the annual mortality can more readily be expressed in terms of reduced lifespan, providing a firmer basis for the monetary valuation. The Agency should not have omitted the estimates of annual mortality studies from its summary tabulations, and estimates of annual mortality should be presented as a separate ledger item from the daily mortality. Combining these estimates would be double-counting, since excess daily mortality is one component of excess annual mortality. The PERS also recommended a separate discussion for lead mortality. The control of exposure to lead is a success story, and this is reflected in the thorough and well described benefits analysis in the Agency's draft document.

With the exception of the treatment of chronic bronchitis, the estimates of the morbidity effects of the criteria pollutants evaluated for exposure-response relationships in the Agency's draft document has provided a thorough, careful and complete an evaluation and summation as the available literature permits.

Key Words: Air Pollutants, Clean Air Act, Cost-Benefit Analysis, Economic Valuation, Mortality Effects, Morbidity Effects, Physical Effects of Air Pollutants, Valuation Methodologies

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