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Particulate Matter Health Risk Assessment

for Selected Urban Areas

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Any analyses, interpretations, or conclusions presented in this report based on hospitalization and mortality data obtained from outside sources, are credited to the authors and not the institutions providing the raw data. Furthermore, Abt Associates expressly understands that the Michigan Health and Hospital Association has not performed an analysis of the hospitalization data obtained or warranted the accuracy of this information and, therefore, it cannot be held responsible in any manner for the outcome.

PREFACE TO DECEMBER 2005 EDITION

The purpose of this December 2005 revised edition is to include a number of technical corrections to the June 2005 final report. An errata sheet that lists the revisions made to the June 2005 report is included after the List of Figures.

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ERRATA

Corrections made to the Exhibits:

The baseline incidence rate for (non-accidental) mortality in Philadelphia was removed from Exhibit 5.3 (p. 56), because that health endpoint was not included for Philadelphia in the final analysis.

In Exhibits 7.1 (p. 84) and D.12 (p. D-15), corrections were made to the results for short-term exposure cardiovascular mortality (Mar (2003)) in Phoenix, AZ, using cutpoints of 10, 15, and 20 µg/m^3.

The 14 µg/m^3 annual and 65 µg/m^3 daily 98th percentile alternative set of standards was added to Exhibits E.3, E.11, E.19, and E.27. [This alternative set of standards was relevant only in Philadelphia.]

In Exhibit F.4, "Hospital Admissions" was changed to "Respiratory Symptoms"in the "Health Effects" column.

In Exhibit E.3, corrections were made in the right-most column of results (for cutpoint = 20 µg/m^3), beginning with the 14 µg/m^3 annual standard and 65 µg/m^3 98th percentile value daily standard.

PARTICULATE MATTER RISK ASSESSMENT FOR SELECTED URBAN AREAS

1. Introduction

As required by the Clean Air Act, the U.S. Environmental Protection Agency (EPA) periodically reviews the national ambient air quality standards (NAAQS) for particulate matter (PM). As a result of the last review of the PM NAAQS completed in 1997 (62 FR 38652, July 18, 1997), EPA added new standards for $PM_{2.5}$, referring to particles with a mean aerodynamic diameter less than or equal to 2.5 µm, in order to address concerns about the fine fraction of inhalable particles. The existing PM_{10} standards, referring to particles with a mean aerodynamic diameter less than or equal to 10 µm, were originally adopted in 1987. The U.S. Court of Appeals for the District of Columbia Circuit found "ample support" for EPA's decision to regulate coarse particle pollution, but vacated the Agency's 1997 revisions to the PM_{10} standards, concluding in part that PM_{10} is a "poorly matched indicator for coarse particle pollution" because it includes fine particles. (*American Trucking Association v. EPA*, 175 F. 3d 1027, 1053-55 (D.C. Cir. 1999). The 1987 PM_{10} standards remain in effect. The new primary (health-based) $PM_{2.5}$ standards included: an annual standard of 15 µg/m³, based on the 3-year average of annual arithmetic mean $PM_{2.5}$ concentrations from single or multiple community-oriented monitors; and a 24-hour standard of 65 µg/m³, based on the 3-year average of the 98th percentile of 24-hour $PM_{2.5}$ concentrations at each monitor in an area. These standards were based primarily on a large body of epidemiological evidence relating ambient PM concentrations to various adverse health effects.

As part of its last review, EPA's Office of Air Quality Planning and Standards (OAQPS) sponsored a risk assessment for two urban areas, Philadelphia County and Los Angeles County, to assess the risks associated with then-current PM levels and the effects of alternative PM standards on reducing estimated health risks attributable to PM (Abt Associates Inc., 1996; and Abt Associates Inc., 1997a,b. See also Deck et al., 2001 and Post et al., 2001 for published articles describing the risk assessment methodology used in the 1996-1997 analyses). Results were presented and discussed as part of the OAQPS Staff Paper (U.S. EPA, 1996b), that presented factors relevant to the evaluation of the then-current primary (health-based) NAAQS, as well as staff conclusions and recommendations of alternative standards for the EPA Administrator to consider.

The next periodic review of the PM NAAQS is now underway. EPA's final assessment of the available PM health effects literature is contained in the October 2004 final report, *Air Quality Criteria for Particulate Matter* (U.S. EPA, 2004) (hereafter 2004 PM CD). This final report underwent extensive review and comment by the Clean Air Scientific Advisory Committee's (CASAC) PM Review Panel and the general public. The 2004 PM CD includes an evaluation of the scientific evidence on the health effects of PM, including information on exposure, physiological mechanisms by which PM might damage human health, and an

evaluation of the epidemiological evidence including reported concentration-response (C-R) relationships.

At the time of the last PM CD (U.S. EPA, 1996a), a number of health studies indicated differences in health effects between fine and coarse fraction particles, and suggested that serious health effects, such as premature mortality, were more closely associated with fine fraction particles. The new studies, summarized in Chapter 8 of the 2004 PM CD continue to show associations between serious health effects, including premature mortality, and ambient $PM_{2.5}$ concentrations. In both the last and current PM NAAQS review, there were a greater number of studies assessing the relationship between PM_{10} and various health effects than any other PM indicator. In the past review, there were only a limited number of studies that assessed the relationship between ambient $PM_{2.5}$ and various health effects, and even fewer that assessed the relationship between ambient $PM_{10-2.5}$ and health effects. As shown in Exhibits C.1 through C.10 in Appendix C, for the current review there are significantly more studies available that address the relationship between ambient $PM_{2.5}$ levels and significant health effects, including increased mortality associated with short- and long-term exposures, increased hospital admissions, and increased respiratory symptoms. As discussed more fully in Sections 3 and 4, these new studies include single-city studies in a variety of locations across the United States and Canada, as well as some multi-city studies. The health effects evidence summarized in Chapter 8 of the 2004 PM CD also now includes a relatively smaller set of studies that assess the relationship between ambient $PM_{10-2.5}$ and various health effects.

An initial draft report, "Proposed Methodology for Particulate Matter Risk Analyses for Selected Urban Areas,"was submitted to the CASAC for review and was made available to the public in January 2002. In that draft report, we proposed to focus on assessing risk associated with $PM_{2.5}$ and, to the extent appropriate, $PM_{10-2.5}$.[1] We received both written public comments and comments made by members of the CASAC during and subsequent to an advisory teleconference review of this initial draft report. Among its comments, the CASAC suggested carrying out an additional health risk assessment employing PM_{10} as an indicator to complement the $PM_{2.5}$ risk assessment, since many health studies used PM_{10} as the indicator and PM_{10} air quality data are available (Hopke, 2002). Risks associated with PM_{10} ambient levels are likely to reflect the contribution of $PM_{2.5}$, $PM_{10-2.5}$, or some combination of both depending on the relative composition of PM in various urban areas within the United States and Canada.

Many time-series studies, especially those carried out in recent years, involved use of generalized additive models (GAMs). In late May 2002, EPA was informed by the Health Effects Institute (HEI) of a generally unappreciated aspect in the use of S-Plus statistical

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[1]Coarse particle concentrations have been measured directly using a dichotomous sampler or by subtraction of particles measured by a $PM_{2.5}$ sampler from those measured by a co-located PM_{10} sampler. This measurement is an indicator for the fraction of coarse-mode thoracic particles (i.e., those capable of penetrating to the tracheo-bronchial and the gas-exchange regions of the lung).

software often employed to fit these models. Using appropriate modifications of the default convergence criteria code in the S-Plus software and a correct approach to estimating the variance of estimators will change the estimated C-R functions and could change the results of tests of significance of estimates, although it is not possible to predict *a priori* how estimates and significance tests will change. Many but not all of the C-R functions that were originally estimated using the S-Plus software for fitting GAMs have since been re-estimated using revised methods. In May 2003, HEI published a special peer-reviewed panel report describing the issues involved and presenting the results of the re-analyzed studies (HEI, 2003). Among the panel's general conclusions was that:

> The impact of using more appropriate convergence criteria on the estimates of PM effect in the revised analyses varied greatly across the studies. In some studies, stricter convergence criteria had little impact, and in a few the impact was substantial. In no study were conclusions based on the original analyses changed in a meaningful way by the use of stricter criteria. Explanations for this variability considered by the Panel include the degree of temporal smoothing used in the original analyses, the number of smoothed terms in the models, and the degree of nonlinear collinearity (concurvity) among the smoothed terms. The relative importance of these and other explanations remains unclear. (p. iii)

A draft memorandum (Post, April 8, 2003) was made available to the CASAC and the public describing changes in the recommended methodology and scope for the $PM_{10-2.5}$ and PM_{10} risk assessments in light of the re-analyzed study results and the CASAC and public comments. In August 2003 a second draft report presented preliminary results from risk assessments for three PM indicators – $PM_{2.5}$, PM_{10}, and $PM_{10-2.5}$ – and provided a description of the methodology initially discussed in the January 2002 draft report, taking into account comments received from the CASAC and the public, as well as changes made in light of studies re-analyzed as a result of the S-Plus/GAM issue. The August 2003 draft report (Abt Associates Inc., 2003) presented assessments of the health risks associated with "as is" concentrations of each of the three PM indicators in excess of their policy relevant background (PRB) levels, as well as an assessment of the risk reductions associated with just meeting the current $PM_{2.5}$ standards. In January 2005, the precursor to the current final report (Abt Associates Inc., 2005) presented results based on air quality data and baseline incidence rates for mortality that were updated from those in the previous (August 2003) draft report.

The risk assessment described in this report focuses on the two PM indicators for which EPA now anticipates making decisions – $PM_{2.5}$ and $PM_{10-2.5}$. The report provides a description of the methodology used, taking into account comments received from the CASAC (Hopke, 2004; Henderson, May 2005) and the public on the August 2003 and January 2005 draft reports. The report also presents the assessments of the health risks associated with "as is" concentrations of $PM_{2.5}$ and $PM_{10-2.5}$ in excess of their PRB levels and various specified cutpoints, as well as an

assessment of the reduced health risks associated with just meeting the current and alternative standards for $PM_{2.5}$, and alternative standards for $PM_{10-2.5}$. In addition, in an appendix, we present an assessment of the health risks associated with "as is" concentrations of PM_{10} in excess of PRB levels. The risk assessment is based on the health effects evidence assessed in the 2004 PM CD, which includes the re-analyzed studies presented in the HEI special report (HEI, 2003).

The goals of the PM risk assessment are: (1) to provide estimates of the potential magnitude of mortality and morbidity associated with current $PM_{2.5}$ and $PM_{10-2.5}$ levels and with attaining the current suite of $PM_{2.5}$ NAAQS (as well as the reduced effects associated with attaining alternative $PM_{2.5}$ and $PM_{10-2.5}$ standards identified as part of this review) in specific urban areas,[2] (2) to develop a better understanding of the influence of various inputs and assumptions on the risk estimates (e.g., choice of PRB levels, and consideration of various cutpoints below which effects are assumed not to occur), and (3) to gain insights into the nature of the risks associated with exposures to ambient PM (e.g., patterns of reduced risks associated with meeting alternative annual and daily standards). As discussed in the June 2005 Staff Paper, *Review of the National Ambient Air Quality Standards for Particulate Matter: Policy Assessment of Scientific and Technical Information - OAQPS Staff Paper,* (U.S. EPA, 2005b) (hereafter 2005 PM SP), the risk assessment in this standards review must take into consideration significant uncertainties associated with the assessment, as discussed in Section 6 below.

As discussed in Chapter 9 of the 2004 PM CD (p. 9-79), "the new evidence from mechanistic studies suggesting plausible biological response pathways, and the extensive body of epidemiology evidence on associations between short- and long-term exposures to ambient thoracic particles (typically indexed by PM_{10}) and a range of health effects, supports the general conclusion that ambient thoracic particles, acting alone and/or in combination with gaseous co-pollutants, are likely causally related to cardiovascular and respiratory mortality and morbidity." The 2004 PM CD (p.9-79) also concludes that "a growing body of evidence both from epidemiological and toxicological studies also supports the general conclusion that $PM_{2.5}$ (or one or more $PM_{2.5}$ components), acting alone and/or in combination with gaseous co-pollutants are likely causally related to cardiovascular and respiratory mortality and morbidity." With respect to $PM_{10-2.5}$, the 2004 PM CD (pp.9-79 to 9-80) finds that there is "a much more limited body of evidence ... suggestive of associations between short-term (but not long-term) exposures to ambient coarse-fraction thoracic particles... and various mortality and morbidity effects observed at times in some locations." The 2004 PM CD (p.9-80) concludes that "the strength of the evidence varies across endpoints, with somewhat stronger evidence for coarse-fraction particle associations with morbidity (especially respiratory) endpoints than for mortality." The $PM_{2.5}$ risk assessment described in this draft report is premised on the assumptions that $PM_{2.5}$ is causally related to the mortality, morbidity, and symptomatic effects (alone and/or in

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[2]Risk estimates associated with current PM_{10} levels also have been included in an appendix to this report for those urban areas where $PM_{2.5}$ risks have been estimated to provide additional context.

combination with other pollutants) observed in the epidemiological studies and that $PM_{10-2.5}$ is causally related to the morbidity and symptomatic effects observed in the epidemiology studies. We recognize, as discussed in the PM CD (p.8-327), that "the apparent differences in $PM_{2.5}$ and/or $PM_{10-2.5}$ effect sizes across different regions should not be attributed merely to possible variations in measurement error or other statistical artifact(s). Some of these differences may reflect: real regional differences in particle composition or co-pollutant mix; differences in relative human exposures to ambient particles or other gaseous pollutants; sociodemographic differences (e.g., percent of infants or elderly in regional population); or other important, as of yet unidentified PM effect modifiers."

Given the availability of additional urban locations with recent and sufficient $PM_{2.5}$ and $PM_{10-2.5}$ air quality data, and additional health effect studies in various locations in different regions of the United States, and consistent with the advice of the CASAC, EPA expanded the scope of its PM risk assessment from the last review to several additional urban areas, consistent with the goals of the assessment. Philadelphia and Los Angeles Counties, which were the only areas included in the prior risk assessment, are included. As discussed in greater detail in Section 3, additional areas included for short- and/or long-term exposure mortality in the $PM_{2.5}$ risk assessment are as follows: Boston, Detroit, Phoenix, Pittsburgh, San Jose, Seattle, and St. Louis. In addition, increased hospital admissions associated with $PM_{2.5}$ were estimated for Detroit, Los Angeles, and Seattle, and increased respiratory symptoms were estimated for Boston and St. Louis. Inclusion of these additional areas allows EPA to explore potential geographic differences in risk estimates.

The $PM_{10-2.5}$ risk assessment is more limited because of the more limited air quality data (requiring co-located $PM_{2.5}$ and PM_{10} monitors) as well as the smaller number of studies and health effects for which there is sufficient evidence. While a few studies have reported positive statistically significant associations in some locations between $PM_{10-2.5}$ and non-accidental total mortality and cause-specific mortality (due to short-term exposure), the majority of studies investigating these relationships have not reported statistically significant results. Therefore, EPA does not believe the weight of the evidence supports including short-term exposure mortality in the quantitative $PM_{10-2.5}$ health risk assessment (see 2005 PM SP, Chapter 3) for further discussion of the evidence relating $PM_{10-2.5}$ and short-term exposure mortality). The areas included in the $PM_{10-2.5}$ risk assessment are Detroit and Seattle (where an association has been shown between $PM_{10-2.5}$ and hospital admissions) and St. Louis (where an association has been shown between $PM_{10-2.5}$ and respiratory symptoms).

The PM risk assessment has two parts. The first part considers health risks under "as is"[3] PM concentrations in the selected locations. The basic question addressed in the first part is of the following form:

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[3] "As is" PM concentrations are defined here as a recent year of air quality.

> *For a given human health endpoint (mortality, hospital admissions, etc.),*
> *what is the estimated annual incidence of the health endpoint that may*
> *be associated with "as is" PM concentrations in these locations?*

The second part of the risk assessment considers health risks if the current $PM_{2.5}$ standards (15 µg/m³ for the annual standard and 65 µg/m³ for the daily standard) or alternative $PM_{2.5}$ or $PM_{10-2.5}$ standards were just met in the selected locations. The basic question addressed in this part of the risk assessment is of the following form:

> *For a given human health endpoint (mortality, hospital admissions, etc.),*
> *what is the estimated annual incidence of the health endpoint that may*
> *be associated with the reduced PM concentrations that would be*
> *expected to result if the current or alternative sets of PM standards were*
> *just met?*

As described in more detail in Section 2.5 below, in both parts of the risk assessment only those PM levels in excess of specified "cutpoint" concentrations are considered. For health effects associated with short-term exposures to PM, the lowest of these cutpoints is the estimated PRB concentration for the location.[4]

The methods used to estimate risks associated with "as is" PM concentrations and PM concentrations that would be expected to result if the current or alternative sets of PM standards were just met in the selected urban areas in this risk assessment are similar to the methods used in the previous PM risk assessment. An overview of these methods is presented in Section 2. Section 3 discusses the selection of health endpoints and urban areas from a broader list of candidate health endpoints and locations to include in the risk assessment, as well as the selection of studies estimating C-R functions. Section 4 describes the approach to selecting and using C-R functions from the broader candidate pool of C-R functions available. Section 5 presents baseline health effects incidence rates (i.e., the health effects incidence rates associated with "as is" PM levels) for each of the assessment locations. Because the risk assessment was of necessity carried out with incomplete information, several assumptions were made at several points in the analysis process. These assumptions and the various sources of uncertainty in the analyses are discussed briefly in Section 2.6 and in greater detail in Section 6. The results of the

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[4] Consistent with the approach taken in the prior PM risk assessment, estimates of risks associated with PM concentrations above background are judged to be more relevant to policy decisions about the level of ambient air quality standards than estimates that include risks potentially attributable to uncontrollable background PM concentrations. Thus, risks are estimated only for concentrations exceeding "background" levels or above various higher cutpoints that reflect possible population thresholds, where "background" is defined as the PM concentrations that would be observed in the U.S. in the absence of anthropogenic, or man-made, emissions of primary PM and precursor emissions of volatile organic compounds, nitrogen oxides, sulfur dioxide, and ammonia in the U.S., Canada, and Mexico. Therefore, "background" for the purposes of the PM risk assessment includes PM from natural sources and transport of PM from sources outside of the U.S., Canada, and Mexico.

base case and sensitivity analyses for $PM_{2.5}$ from the first – recent air quality/"as is" – part of the risk assessment are discussed in Section 7, and the results of the base case and sensitivity analyses from the second part – just meeting the current and alternative standards – are discussed in Section 8. The results of the base case and sensitivity analyses for $PM_{10-2.5}$ from both parts of the risk assessment are discussed in Section 9. Appendix A discusses the air quality data used in the analyses. Appendix B describes an analysis of historical air quality data relevant to the choice of air quality adjustment procedures for simulating attainment of current and alternative $PM_{2.5}$ and $PM_{10-2.5}$ standards. Appendix C summarizes relevant study-specific information used to carry out the base case risk assessment and sensitivity analyses. Because the PM risk assessment covers $PM_{2.5}$ and $PM_{10-2.5}$ and a substantial number of urban locations, there are many exhibits of results. The results for both PM indicators are summarized in figures in Sections 7, 8, and 9. Most of the exhibits containing quantitative results are presented in the main body of the report for only one location (Detroit) for illustrative purposes. Results exhibits for $PM_{2.5}$ for the other locations are presented in Appendix D for base case and sensitivity analyses from the first – recent air quality/"as is" – part of the risk assessment , and Appendix E for base case and sensitivity analyses from the second – just meeting the current and alternative $PM_{2.5}$ standards – part of the risk assessment. All results exhibits for $PM_{10-2.5}$ for locations other than Detroit are presented in Appendix F. Finally, Appendix G presents the results of a PM_{10} "as is" air quality risk assessment for locations and health endpoints for which results are presented in the $PM_{2.5}$ risk assessment.

2. Overview of Methods

This section gives an overview of the methods used in the risk assessment. Section 2.1 presents the basic structure of the risk assessment, distinguishing between its two parts – i.e., risk associated with "as is" PM levels (defined as a recent year of air quality) and risks associated with just meeting the current and potential alternative PM standards – and identifying the basic information elements needed for the analyses. Section 2.2 discusses air quality inputs. Section 2.2.1 discusses the estimation of $PM_{2.5}$ and $PM_{10-2.5}$ PRB levels; Section 2.2.2 discusses the characterization of "as is" PM levels. Section 2.3 discusses the simulation of PM concentrations that just meet specified PM standards. A brief discussion of issues surrounding baseline incidence rates is given in Section 2.4. The calculation of health effects incidence and incidence reductions is described in Section 2.5. Section 2.6 gives an overview of the characterization of uncertainty and variability in the PM risk assessment. Finally, sensitivity analyses are discussed in Section 2.7.
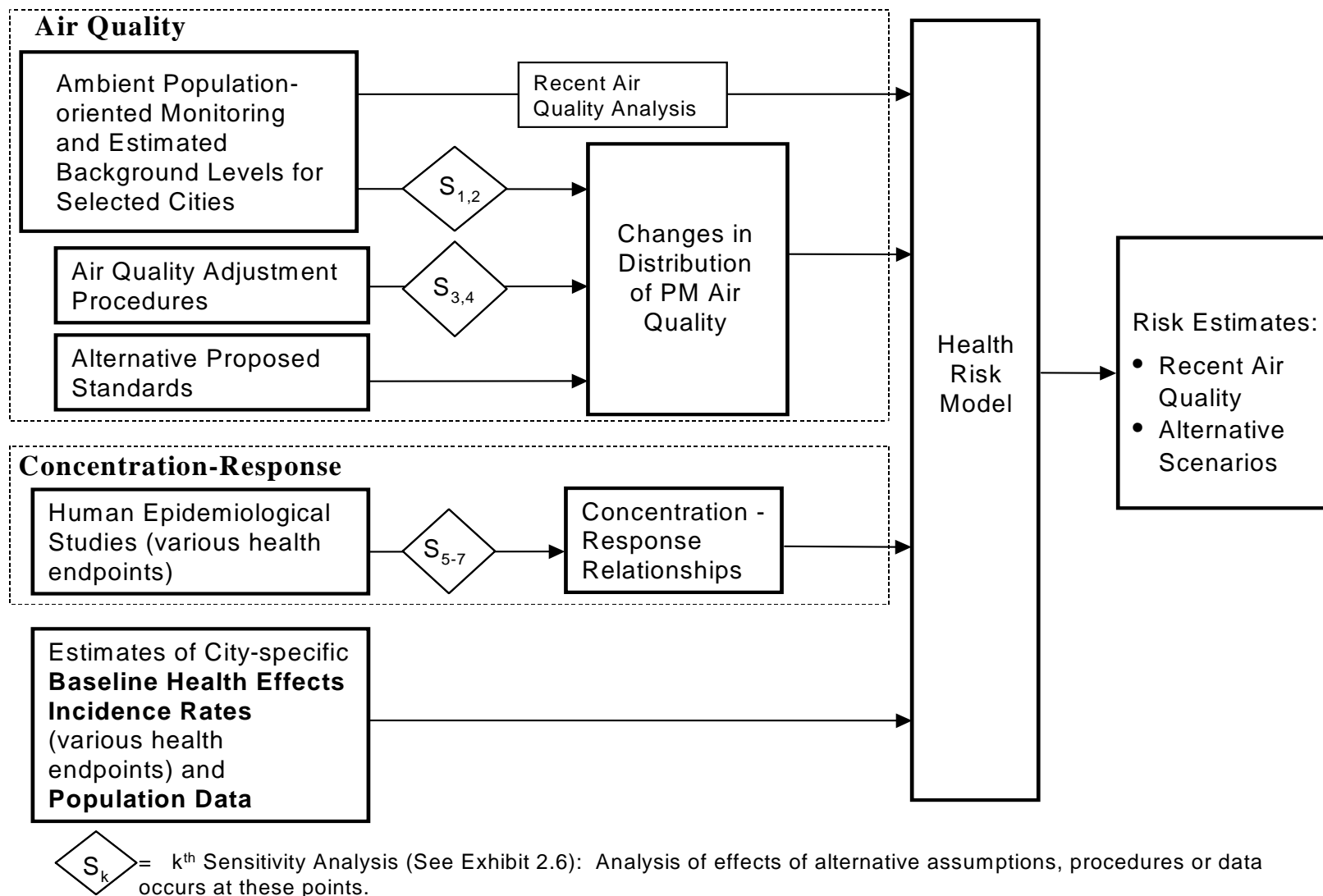
2.1 Basic structure of the risk assessment

The general approach used in both the prior and the current PM risk assessment relies upon C-R functions which have been estimated in epidemiological studies. Since these studies estimate C-R functions using ambient air quality data from fixed-site, population-oriented monitors, the appropriate application of these functions in a PM risk assessment similarly requires the use of ambient air quality data at fixed-site, population-oriented monitors. The general PM health risk model combines information about PM air quality for specific urban areas with C-R functions derived from epidemiological studies and baseline health incidence data for specific health endpoints and population estimates to derive estimates of the annual incidence of specified health effects attributable to ambient PM concentrations. The analyses are conducted for both "as is" air quality and for air quality simulated to reflect attainment of current and alternative PM ambient standards.

An overview of the major components of the risk assessment discussed in this report is presented in Exhibit 2.1. The points in the risk assessment at which sensitivity analyses were carried out are represented by diamonds. The sensitivity analyses (labeled in Exhibit 2.1 as s_k's) are described in Exhibit 2.6 below.

In the first part of the risk assessment, we estimate health effects incidence associated with "as is" PM levels. In the second part of the risk assessment, we estimate the reduced health effects incidence associated with those PM concentrations that would result if the current or alternative PM standards were just met in the assessment locations, as well as the percent reductions in incidence from incidence under the current standards (for $PM_{2.5}$) or "as is" concentrations (for $PM_{10-2.5}$). Both parts of the risk assessment consider only the incidence of health effects associated with PM concentrations in excess of specified cutpoint levels

Exhibit 2.1 Major Components of Particulate Matter Health Risk Analyses

Air Quality

- Ambient Population-oriented Monitoring and Estimated Background Levels for Selected Cities
- Recent Air Quality Analysis
- $S_{1,2}$
- Air Quality Adjustment Procedures
- $S_{3,4}$
- Alternative Proposed Standards
- Changes in Distribution of PM Air Quality

Concentration-Response

- Human Epidemiological Studies (various health endpoints)
- S_{5-7}
- Concentration - Response Relationships

- Estimates of City-specific **Baseline Health Effects Incidence Rates** (various health endpoints) and **Population Data**

Health Risk Model

Risk Estimates:
- Recent Air Quality
- Alternative Scenarios

S_k = kth Sensitivity Analysis (See Exhibit 2.6): Analysis of effects of alternative assumptions, procedures or data occurs at these points.

(see Section 2.5). Both parts may be viewed as assessing the change in incidence of the health effect associated with a change in PM concentrations from some upper levels to a specified (lower) cutpoint level. The important operational difference between the two parts is in the upper PM levels. In the first part, the upper PM levels are "as is" concentrations. In contrast, the upper PM levels in the second part of the risk assessment are the estimated PM levels that would occur when the current $PM_{2.5}$ or alternative $PM_{2.5}$ or $PM_{10-2.5}$ standards are just met in the assessment locations. The second part therefore requires that a method be developed to simulate just meeting the specified standards.
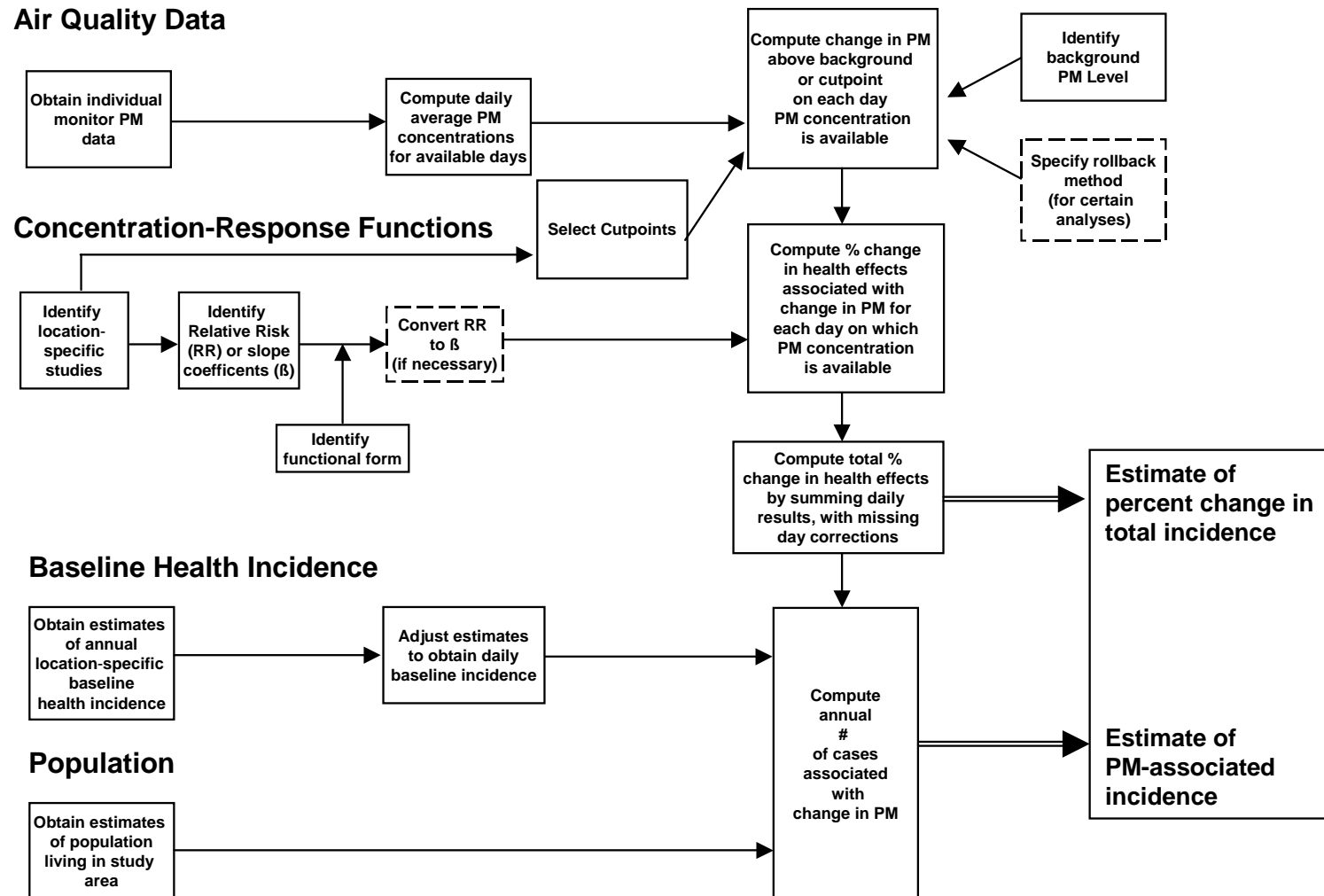
To estimate the change in the incidence of a given health effect resulting from a given change in ambient PM concentrations in an assessment location, the following analysis inputs are necessary:

- **Air quality information** including: (1) "as is" air quality data for PM from population-oriented monitors in the assessment location, (2) estimates of PRB PM concentrations appropriate to this location, and (3) a method for adjusting the "as is" data to reflect patterns of air quality change estimated to occur when the area just meets the specified standards. (These air quality inputs are discussed in more detail in Section 2.2).

- **Concentration-response function(s)** which provide an estimate of the relationship between the health endpoint of interest and PM concentrations (preferably derived in the assessment location, although functions estimated in other locations can be used at the cost of increased uncertainty -- see Section 6.1.3). For $PM_{2.5}$, C-R functions are available from epidemiological studies for both short- and long-term exposures. For $PM_{10-2.5}$, only short-term exposure studies are included in the risk assessment. (Section 2.5 describes the role of C-R functions in estimating health risks associated with PM).

- **Baseline health effects incidence rate and population**. The baseline incidence rate provides an estimate of the incidence rate (number of cases of the health effect per year, usually per 10,000 or 100,000 general population) in the assessment location corresponding to "as is" PM levels in that location. To derive the total baseline incidence per year, this rate must be multiplied by the corresponding population number (e.g., if the baseline incidence rate is number of cases per year per 100,000 population, it must be multiplied by the number of 100,000s in the population). (Section 2.4 summarizes considerations related to the baseline incidence rate and population data inputs to the risk assessment).
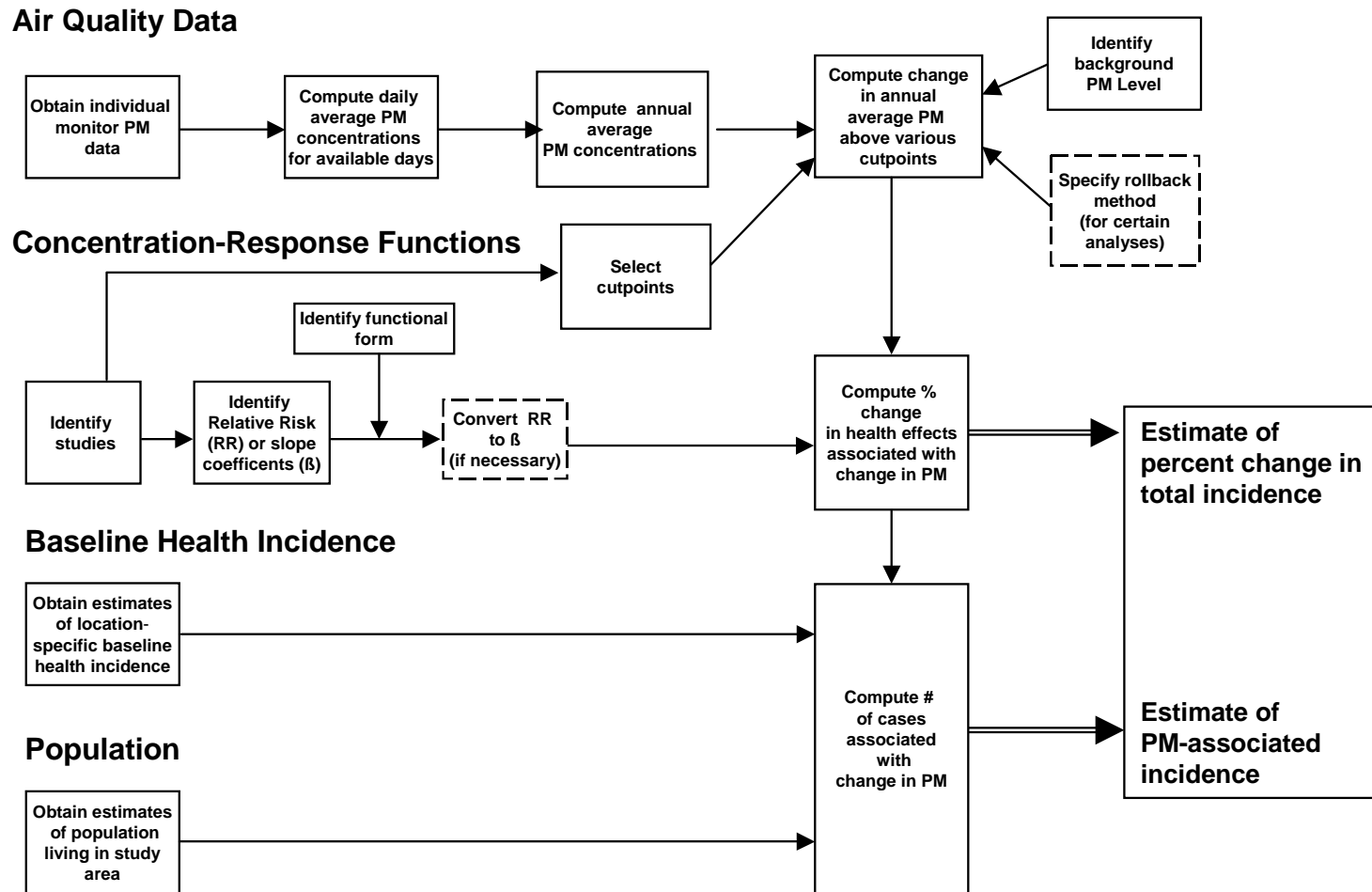
The risk assessment procedure described in more detail below is diagramed in Exhibit 2.2 for analyses based on short-term exposure studies and in Exhibit 2.3 for analyses based on long-term exposure studies.

Exhibit 2.2. Flow Diagram of Risk Analyses for Short-Term Exposure Studies

Air Quality Data

Obtain individual monitor PM data →
Compute daily average PM concentrations for available days →
Compute change in PM above background or cutpoint on each day PM concentration is available ←
Identify background PM Level

Specify rollback method (for certain analyses)

Concentration-Response Functions

Select Cutpoints

Identify location-specific studies →
Identify Relative Risk (RR) or slope coefficents (ß) →
Convert RR to ß (if necessary) →
Compute % change in health effects associated with change in PM for each day on which PM concentration is available

Identify functional form

Compute total % change in health effects by summing daily results, with missing day corrections →
Estimate of percent change in total incidence

Baseline Health Incidence

Obtain estimates of annual location-specific baseline health incidence →
Adjust estimates to obtain daily baseline incidence →
Compute annual # of cases associated with change in PM →
Estimate of PM-associated incidence

Population

Obtain estimates of population living in study area →

Exhibit 2.3. Flow Diagram of Risk Analyses for Long-Term Exposure Studies

Air Quality Data

Obtain individual monitor PM data → Compute daily average PM concentrations for available days → Compute annual average PM concentrations → Compute change in annual average PM above various cutpoints

Identify background PM Level → Compute change in annual average PM above various cutpoints

Specify rollback method (for certain analyses) → Compute change in annual average PM above various cutpoints

Concentration-Response Functions

Identify studies → Identify Relative Risk (RR) or slope coefficents (ß) → Convert RR to ß (if necessary) → Compute % change in health effects associated with change in PM

Identify functional form → Convert RR to ß (if necessary)

Select cutpoints → Compute change in annual average PM above various cutpoints

Compute change in annual average PM above various cutpoints → Compute % change in health effects associated with change in PM

Compute % change in health effects associated with change in PM → **Estimate of percent change in total incidence**

Baseline Health Incidence

Obtain estimates of location-specific baseline health incidence → Compute # of cases associated with change in PM

Population

Obtain estimates of population living in study area → Compute # of cases associated with change in PM

Compute # of cases associated with change in PM → **Estimate of PM-associated incidence**

2.2 Air quality inputs

2.2.1 Estimating policy relevant background PM levels

One of the cutpoint concentrations considered in the risk assessment for health endpoints associated with short-term exposure is the PRB level. Therefore estimates of PRB PM concentrations in the assessment locations are needed to calculate risk at "as is" concentrations in excess of PRB and for reduced risks associated with just meeting the current $PM_{2.5}$ ambient standards and just meeting alternative $PM_{2.5}$ and alternative $PM_{10-2.5}$ ambient standards.

Consistent with the prior PM CD, the 2004 PM CD estimates background annual average $PM_{2.5}$ concentrations to be in the range of 1 to 4 $\mu g/m^3$ in the Western United States and 2 to 5 $\mu g/m^3$ in the Eastern United States (p.3-82, p. 3-105). We use the midpoints of these ranges for the base case analysis. Thus PRB $PM_{2.5}$ concentrations in the base case analysis are estimated to be 3.5 $\mu g/m^3$ in Boston, Detroit, Philadelphia, Pittsburgh, and St. Louis; and 2.5 $\mu g/m^3$ in Los Angeles, Phoenix, San Jose, and Seattle. In sensitivity analyses, we examine the impact of assuming (1) a constant background set at the lower and upper end of the range of estimated background levels provided in the 2004 PM CD for the Eastern and Western United States, depending on the assessment location (see s_2 in Exhibit 2.1), and (2) varying daily $PM_{2.5}$ background, using distributions whose means are equal to the values used in the base case analysis and whose distributions are based on an analysis of $PM_{2.5}$ data from relatively remote sites with the sulfate component removed. (see s_1 in Exhibit 2.1). Section 7.2 provides a more detailed discussion of the sensitivity analyses performed, including the different daily background sensitivity analysis.

The 2004 PM CD (p. 3-83) estimates background annual average $PM_{10-2.5}$ to be approximately ≤ 1 to 9 $\mu g/m^3$ in the East and ≤ 1 to 7 $\mu g/m^3$ in the West. We use 4.5 $\mu g/m^3$ as the estimated PRB for $PM_{10-2.5}$ in the base case analysis for the Eastern coarse risk assessment locations (i.e., Detroit, and St. Louis) and 3.5 $\mu g/m^3$ for Seattle. In a sensitivity analysis, we examine the impact of assuming a constant background set at the lower and upper end of the range of estimated background levels based on the 2004 PM CD (see s_2 in Exhibit 2.1).

2.2.2 Characterizing "as is" PM air quality

As discussed earlier, a major input to the PM risk assessment is ambient PM air quality data for each assessment location. In order to be consistent with the approach generally used in the epidemiological studies that estimated PM C-R functions, the *average* ambient PM concentration on each day for which measured data are available is deemed most appropriate for the risk assessment. Consistent with the approach used in the prior PM risk assessment, a composite monitor data set was created for each assessment location based on a composite of all monitors eligible for comparison with the annual standard with at least 11 observations per

quarter.[5] At the time of the prior PM risk assessment, there was no established $PM_{2.5}$ monitoring network and data sets from special studies conducted in Philadelphia and Los Angeles had to be used. There are now substantial $PM_{2.5}$ air quality data in EPA's Air Quality System (AQS) beginning with the year 1999. There were sufficient $PM_{2.5}$ data in AQS for the year 2003 for all of the assessment locations except Phoenix, for which we used year 2001 data.

For the $PM_{10-2.5}$ risk assessment there were sufficient data from co-located monitors in the year 2003 for Detroit, St. Louis, and Seattle.   As noted above, $PM_{10-2.5}$ air quality was calculated from $PM_{2.5}$ and PM_{10} concentrations at co-located monitors by subtracting the former from the latter. Because of measurement error, some of the $PM_{10-2.5}$ concentrations that were calculated were negative. In Detroit, 10.4 percent of the days (12 days) for which $PM_{10-2.5}$ concentrations were calculated were negative[6]; in St. Louis, 1.7 percent (1 day) of the days were negative. There were no negative $PM_{10-2.5}$ concentrations calculated in Seattle.

The negative $PM_{10-2.5}$ values in a location will result in a slightly lower calculated annual average $PM_{10-2.5}$ concentration in that location. However, annual averages were not used in the calculation of risks and risk reductions associated with $PM_{10-2.5}$ concentrations, because all C-R functions included in the $PM_{10-2.5}$ risk assessment are short-term (daily) C-R functions. In addition, because values below background concentration don't contribute to risks from anthropogenic (above background) PM, such values aren't considered in the PM risk assessment. Because negative values are below background concentration, they too are not considered.

Appendix A summarizes the $PM_{2.5}$ and $PM_{10-2.5}$ air quality data that were used in each of the assessment locations, including quarterly and annual counts, annual averages, and the 98th and 99th percentiles of the daily (24-hour) averages. Because the air quality data are not uniformly complete, annual averages were calculated as the average of quarterly averages to minimize the possible bias resulting from differential amounts of missing data in different quarters of the year.

2.3   Simulating PM levels that just meet specified PM standards

This section describes the methodology used to simulate ambient PM levels in an area upon just meeting specified PM standards. The form of the $PM_{2.5}$ standards promulgated in 1997 requires that the 3-year average (rounded to the nearest 0.1 $\mu g/m^3$) of the annual means *from single monitors or the average of multiple monitors* must be at or below the level of the annual

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[5] Based on a review of the monitoring sites included by State air pollution agencies in the classification/designation process for $PM_{2.5}$, which follow the guidance set forth in Part 58 of the CFR, 1 monitoring site in St. Louis and 1 monitoring site in Boston were excluded from consideration for the $PM_{2.5}$ risk assessment.

[6] Based on a review of the monitoring sites used in the Ito (2003) study in Detroit, we selected the two $PM_{10-2.5}$ sites that were closest to those used in the original health effects study.

standard and the 3-year average (rounded to the nearest 1 µg/m^3) of the ninety-eighth percentile values *at each monitor* cannot exceed the level of the daily standard. In determining attainment of the annual average standard, an area may choose to use either the spatially averaged concentrations across all population-oriented monitors, subject to meeting certain criteria detailed in Part 58 of the CFR, or it may use the highest 3-year average based on individual monitors. The most realistic simulation of just meeting both the annual and the daily PM$_{2.5}$ standards in a location would require changing the distribution of daily PM$_{2.5}$ concentrations at each monitor separately. This would require extensive analysis and assumptions about the nature of future control strategies that was considered beyond the scope of the previous risk assessment and is similarly considered beyond the scope of the current risk assessment.

Consistent with the approach used in the prior PM risk assessment, just meeting the current PM$_{2.5}$ standards was simulated by changing daily PM$_{2.5}$ concentrations at a "composite monitor," which represents the average of the monitors in a location. The PM$_{2.5}$ concentration at the composite monitor on a given day is defined as the average of the PM$_{2.5}$ concentrations of those monitors reporting on that day. The percent reduction of the PM$_{2.5}$ concentration at the composite monitor each day resulting from just meeting current and alternative standards is determined by the PM$_{2.5}$ annual and daily design values. The annual design value (in µg/m^3) was calculated as follows:

3. At each monitor, the annual average PM$_{2.5}$ concentration was calculated for each of the years 2001, 2002, and 2003, and these three annual average concentrations were then averaged.
4. The maximum of these monitor-specific 3-year averages of annual averages is the annual design value, denoted dv$_{annual}$;

The 98th (99th) percentile design value (in µg/m^3) was similarly calculated as follows:

5. At each monitor, the 98th (99th) percentile PM$_{2.5}$ concentration was calculated for each of the years 2001, 2002, and 2003, and these three 98th (99th) percentile concentrations were then averaged.
6. The maximum of these monitor-specific 3-year averages of 98th (99th) percentile concentrations is the daily 98th (99th) percentile design value, denoted dv$_{daily\ 98}$ (dv$_{daily\ 99}$).

Although the design values are based on monitor-specific values, the changes in PM$_{2.5}$ to simulate just meeting the specified standards are made at the composite monitor rather than at the individual monitors.

The method used to simulate just meeting alternative PM$_{2.5}$ or PM$_{10-2.5}$ standards was analogous to the method used to simulate just meeting the current PM$_{2.5}$ standards. Daily PM$_{2.5}$

or $PM_{10-2.5}$ concentrations were changed at a "composite monitor." The percent reduction of the $PM_{2.5}$ concentration at the composite monitor each day resulting from just meeting an alternative $PM_{2.5}$ standard is determined by the $PM_{2.5}$ annual and daily design values. Because only daily standards are being considered for $PM_{10-2.5}$, the percent reduction of the $PM_{10-2.5}$ concentration at the composite monitor each day resulting from just meeting an alternative $PM_{10-2.5}$ standard is determined by the daily design values for $PM_{10-2.5}$, which were calculated in the same way as the $PM_{2.5}$ daily design values. The annual, daily 98th percentile, and daily 99th percentile design values used in assessing the current and alternative standards for $PM_{2.5}$ are given in Exhibit 2.4. The daily 98th and 99th percentile design values used in assessing alternative standards for $PM_{10-2.5}$ are given in Exhibit 2.5.

Exhibit 2.4 EPA Design Values for Annual and 98th and 99th Percentile Daily $PM_{2.5}$ Standards*

Location	Annual	98th Percentile Daily	99th Percentile Daily
Boston	14.4	44	60
Detroit	19.5	44	48
Los Angeles	23.6	62	96
Philadelphia	16.4	51	89
Phoenix	11.5	35	41
Pittsburgh	21.2	63	70
St. Louis	17.5	42	46
San Jose	14.6	47	53
Seattle	11.1	41	48

*The calculation of design values is explained in Section 2.3 above. All design values are in $\mu g/m^3$. While the current daily standard is specified as a 98th percentile form, the 99th percentile form also is included to allow consideration of alternative standards with this alternative form.

Exhibit 2.5 EPA Design Values for 98th and 99th Percentile Daily PM$_{10\text{-}2.5}$ Standards*

Location	98th Percentile Daily	99th Percentile Daily
Detroit	70	77
St. Louis	33	47
Seattle	31	39

*The calculation of design values is explained in Section 2.3 above.   All design values are in μg/m^3.

There are many possible ways to create an alternative distribution of daily concentrations that just meets specified PM$_{2.5}$ (or PM$_{10\text{-}2.5}$) standards. The prior PM risk assessment used a proportional rollback of all PM concentrations exceeding the estimated background concentration for its base case estimates. This choice was based on analyses of historical PM$_{2.5}$ data which found that year-to-year reductions in PM$_{2.5}$ levels in a given location tended to be roughly proportional. That is, both high and low daily PM$_{2.5}$ levels decreased proportionally from one year to the next (see Abt Associates Inc., 1996, Section 8.2). This suggests that, in the absence of detailed air quality modeling, a reasonable method to simulate the PM$_{2.5}$ reductions that would result from just meeting a set of standards would be proportional rollbacks -- i.e., to decrease PM$_{2.5}$ levels on all days by the same percentage. Appendix B describes an analysis of historical air quality data for Philadelphia and Los Angeles which continues to support the hypothesis that changes in PM$_{2.5}$ levels that would result if a PM$_{2.5}$ standard were just met are reasonably modeled by using a proportional rollback approach. We recognize that the historic changes in PM$_{2.5}$ have not been the result of a PM$_{2.5}$ control strategy, but likely result from control programs for PM$_{10}$ and control programs for other pollutants (especially sulfur and nitrogen oxides). The pattern of changes that have occurred in the past, therefore, may not necessarily reflect the changes that will result from future efforts to attain PM$_{2.5}$ standards. However, it is interesting to note that reductions in ambient PM$_{2.5}$ concentrations are reasonably modeled by proportional rollbacks in both Philadelphia and Los Angeles, which likely had very different reductions in terms of types of emissions over this period.

Based on the above considerations, we simulated just meeting the current and alternative PM$_{2.5}$ standards by use of a proportional rollback procedure for the base case estimates. That is, average daily PM$_{2.5}$ concentrations at the composite monitor were reduced by the same percentage on all days. The PM$_{10\text{-}2.5}$ historical air quality data are substantially more sparse and are insufficient to support an analysis analogous to that carried out for PM$_{2.5}$. In the absence of a clearly preferable alternative, we used the same proportional rollback method to simulate just meeting alternative PM$_{10\text{-}2.5}$ standards. The uncertainty introduced by this approach in the absence of empirical evidence supporting it is discussed more fully in Section 6.

The percent reduction required to meet a standard (annual, ninety-eighth percentile daily or ninety-ninth percentile daily) was determined by comparing the design value for that standard with the level of the standard. Because pollution abatement methods are applied largely to anthropogenic sources of $PM_{2.5}$ and $PM_{10-2.5}$, rollbacks were applied only to $PM_{2.5}$ and $PM_{10-2.5}$ above estimated background levels. The percent reduction was determined by the controlling standard. For example, suppose both an annual and a ninety-eighth percentile daily $PM_{2.5}$ standard are being simulated. Suppose p_a is the percent reduction required to just meet the annual standard (i.e., the percent reduction of daily $PM_{2.5}$ above background necessary to get the annual design value down to the annual standard). Suppose p_d is the percent reduction required to just meet the ninety-eighth percentile daily standard (i.e., the percent reduction of daily $PM_{2.5}$ above background necessary to get the ninety-eighth percentile daily $PM_{2.5}$ design value down to the ninety-eighth percentile daily standard). If p_d is greater than p_a, then all daily average $PM_{2.5}$ concentrations above background are reduced by p_d percent. If p_a is greater than p_d, then all daily average $PM_{2.5}$ concentrations are reduced by p_a percent.

The method of rollbacks to meet a set of annual and daily PM standards is summarized as follows:

1. The percent by which the above-background portion of all daily PM concentrations (at the composite monitor) would have to be reduced to just meet the annual standard (denoted std_a) is

$$p_a = 1 - \frac{(std_a - b)}{(dv_{annual} - b)}$$

where b denotes background.

2. The percent by which the above-background portion of all daily PM concentrations (at the composite monitor) would have to be reduced to just meet the daily (e.g., 98th percentile) standard (denoted $std_{d\,98}$) is

$$p_{d98} = 1 - \frac{(std_{d98} - b)}{(dv_{daily98} - b)}$$
.

Let p_{max} = maximum of (maximum of p_a and $p_{d\,98}$) and zero.[7]

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[7] If the percent rollback necessary to just meet the annual standard and the percent rollback necessary to just meet the daily standard were both negative -- i.e., if both standards were already met -- then the percent rollback applied in the risk assessment was zero. That is, PM values were never increased.

3.   Then, if PM_o denotes the original PM value on a given day (at the composite monitor), the rolled back PM value on that day, denoted PM_{rb}, is

$$PM_{rb} = b + (PM_o - b) * (1 - p_{max})$$

Since an area could potentially use the spatial average of the population-oriented monitors to determine whether or not it met the annual average standard, the risk assessment report also presents the results of a sensitivity analysis for 3 urban areas based on the percent rollbacks that would have resulted from using this alternative approach (see Section 8).

As noted earlier, proportional rollback is only one of many possible ways to create an alternative distribution of daily concentrations to meet new $PM_{2.5}$ standards. One could, for example, reduce the high days by one percentage and the low days by another percentage, choosing the percentages so that the new distribution achieves the new standard. At the opposite end of the spectrum from proportional rollbacks, it is possible to meet a daily standard by "peak shaving." The peak shaving method would reduce all daily $PM_{2.5}$ concentrations above a certain concentration to that concentration (e.g., the standard) while leaving daily concentrations at or below this value unchanged. While a strict peak shaving method of attaining a standard is unrealistic, it is illustrative of the principal that patterns different from a proportional rollback might be observed in areas attempting to come into compliance with revised standards. Because the reduction method to attain a daily standard could have a significant impact on the risk assessment results, a sensitivity analysis was conducted using an alternative rollback method (see S_2 in Exhibit 2.1). As with the sensitivity analysis performed for the prior risk assessment, this sensitivity analysis used a rollback method in which the upper 10% of the $PM_{2.5}$ air quality distribution was rolled back to a greater extent than the remaining 90% of the distribution. In particular, the percentage by which the upper 10% of the $PM_{2.5}$ air quality distribution was rolled back was 1.6 times the percentage by which the rest of the distribution was rolled back. See Section 8 for a more detailed discussion of the alternative rollback sensitivity analysis.

2.4   Baseline health effects incidence data

As noted in Section 2.5 below, the form of C-R function most commonly used in epidemiological studies on PM, shown in equation (1), is log-linear. To estimate the change in incidence of a health endpoint associated with a given change in PM concentrations using this form of C-R function requires the baseline incidence rate of the health endpoint, that is, the number of cases per unit time (e.g., per year) in the location *before* a change in PM air quality (denoted y in equations 3 and 4).

Incidence rates express the occurrence of a disease or event (e.g., asthma episode, death, hospital admission) in a specific period of time, usually per year. Rates are expressed either as a value per population group (e.g., the number of cases in Philadelphia County) or a value per

number of people (e.g., the number of cases per 10,000 residents in Philadelphia County), and may be age and sex specific. Incidence rates vary among geographic areas due to differences in population characteristics (e.g, age distribution) and factors promoting illness (e.g., smoking, air pollution levels).

Incidence rates are available for mortality and for specific communicable diseases which state and local health departments are required to report to the federal government. In addition to the required federal reporting, many state and local health departments collect information on some additional endpoints. These most often are restricted to hospital admission or discharge diagnoses, which are collected to assist in planning medical services. None of the morbidity endpoints in the risk assessment are required to be reported to the federal government.

Although federal agencies collect incidence data on many of the endpoints covered in the PM risk assessment, their data are often available only at the national level, or at the regional or state level. One important exception is mortality rates, which are available at the county level. Because baseline incidence rates can vary from one location to another, location-specific baseline incidence information was obtained. Because hospital admission rates are available for some locations and not others, this was a consideration in the selection of locations for which to conduct the PM risk assessment. For respiratory symptom health endpoints, the only estimates of baseline incidence rates available are typically from the studies that estimated the C-R functions for those endpoints. However, because risk assessment locations for these endpoints were selected partly on the basis of where studies were carried out, baseline incidence rates reported in the studies should be appropriate to the risk assessment locations to which they are applied. A more detailed discussion of baseline health effects incidence data is presented in Section 5.

2.5   Calculating health effects incidence

2.5.1   General approach

The C-R functions used in the risk assessment are empirically estimated relations between average ambient concentrations of PM and the health endpoints of interest (e.g., short- and long-term exposure mortality or hospital admissions) reported by epidemiological studies for specific locales. This section describes the basic method used to estimate changes in the incidence of a health endpoint associated with changes in PM, using a "generic" C-R function of the most common functional form.

Although one epidemiological study estimated linear C-R functions and one estimated logistic functions, most of the studies used a method referred to as "Poisson regression" to

estimate exponential (or log-linear) C-R functions in which the natural logarithm of the health endpoint is a linear function of PM:[8]

$$y = B \, e^{\beta x} \quad , \tag{1}$$

where x is the ambient PM level, y is the incidence of the health endpoint of interest at PM level x, β is the coefficient of ambient PM concentration, and B is the incidence at x=0, i.e., when there is no ambient PM. The relationship between a specified ambient PM level, x_0, for example, and the incidence of a given health endpoint associated with that level (denoted as y_0) is then

$$y_0 = B \, e^{\beta x_0} \quad . \tag{2}$$

Because the log-linear form of C-R function (equation (1)) is by far the most common form, the discussion that follows assumes this form.

2.5.2 Short- and long-term exposure endpoints

C-R functions that use as input annual average PM levels (or some function of these) relate these to the annual incidence of the health endpoint. C-R functions that use as input daily average PM levels relate these to the daily incidence of the health endpoint. There are several variants of the short-term (daily) C-R function. Some C-R functions were estimated by using moving averages of ambient PM to predict daily health effects incidence. Such a function might, for example, relate the incidence of the health effect on day t to the average of PM concentrations on days t and (t-1). Some C-R functions consider the relationship between daily incidence and daily average PM lagged a certain number of days. For example, a study might estimate the C-R relationship between mortality on day t and average PM on day (t-1). The discussion below does not depend on any particular averaging time or lag time and assumes only that the measure of health effect incidence, y, is consistent with the measure of ambient PM concentration, x.

The difference in health effects incidence, $\Delta y = y_0 - y$, from y_0 to the baseline incidence rate, y, corresponding to a given difference in ambient PM levels, $\Delta x = x_0 - x$, can be derived by dividing equation (2) by equation (1), which yields:

$$\Delta y = y[e^{\beta \Delta x} - 1] \quad . \tag{3}$$

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[8] Poisson regression is essentially a linear regression of the natural logarithm of the dependent variable on the independent variable, but with an error structure that accounts for the particular type of heteroskedasticity that is believed to occur in health response data. What matters for the risk assessment, however, is simply the form of the estimated relation, as shown in equation (1).

Alternatively, the difference in health effects incidence can be calculated indirectly using relative risk. Relative risk (RR) is a measure commonly used by epidemiologists to characterize the comparative health effects associated with a particular air quality comparison. The risk of mortality at ambient PM level x_0 relative to the risk of mortality at ambient PM level x, for example, may be characterized by the ratio of the two mortality rates: the mortality rate among individuals when the ambient PM level is x_0 and the mortality rate among (otherwise identical) individuals when the ambient PM level is x. This is the RR for mortality associated with the difference between the two ambient PM levels, x_0 and x. Given a C-R function of the form shown in equation (1) and a particular difference in ambient PM levels, Δx, the RR associated with that difference in ambient PM, denoted as $RR_{\Delta x}$, is equal to $e^{\beta \Delta x}$. The difference in health effects incidence, Δy, corresponding to a given difference in ambient PM levels, Δx, can then be calculated based on this RR:

$$\Delta y = y(RR_{\Delta x} - 1) \ . \tag{4}$$

Equations (3) and (4) are simply alternative ways of expressing the relationship between a given difference in ambient PM levels, Δx, and the corresponding difference in health effects incidence, Δy. These equations are the key equations that combine air quality information, C-R information, and baseline health effects incidence information to estimate ambient PM health risk.

Given a C-R function and air quality data (ambient PM values) from an assessment location, then, the difference in the incidence of the health endpoint ($\Delta y = y_0 - y$) corresponding to a difference in ambient PM level of $\Delta x = x_0 - x$ can be determined. This can either be done with equation (3), using the coefficient, β, from a C-R function, or with equation (4), by first calculating the appropriate RR from the C-R function.

Because the estimated difference in health effect incidence, Δy, depends on the particular difference in PM concentrations, Δx, being considered, the choice of PM concentration difference considered is important. In the first part of the risk assessment, these differences in PM concentrations are differences between the current levels of PM ("as is" levels) and some alternative, lower level(s). In the second part, these differences in PM concentrations are differences between the levels under the current or alternative standards and some alternative, lower level(s). In both parts of the risk assessment, both $\Delta x = (x_0 - x)$ and $\Delta y = (y_0 - y)$, as defined in equation (3), are negative (or zero). We could have alternatively defined Δx to be positive (i.e., the change from a higher PM level to a lower one), in which case Δy would also have been positive, and the relationship between Δx and Δy would be slightly different from the relationship shown in equation (3). The results, however, would be the same.[9]

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[9] If Δx and Δy are defined to be negative, we interpret Δy as the number of cases of the health effect that would be avoided by reducing PM levels to lower levels; if Δx and Δy are defined to be positive, we interpret Δy as

Most daily time-series epidemiological studies estimated C-R functions in which the PM-related incidence on a given day depends only on same-day PM concentration or previous-day PM concentration (or some variant of those, such as a two-day average concentration). Such models necessarily assume that the longer pattern of PM levels preceding the PM concentration on a given day does not affect mortality on that day. To the extent that PM-related mortality on a given day is affected by PM concentrations over a longer period of time, then these models would be mis-specified, and this mis-specification would affect the predictions of daily incidence based on the model.

A few studies estimated distributed lag models, in which health effect incidence is a function of PM concentrations on several days – that is, the incidence of the health endpoint on day t is a function of the PM concentration on day t, day (t-1), day (t-2), and so forth. Such models can be reconfigured so that the sum of the coefficients of the different PM lags in the model can be used to predict the changes in incidence on several days. For example, corresponding to a change in PM on day t in a distributed lag model with 0-day, 1-day, and 2-day lags considered, the sum of the coefficients of the 0-day, 1-day, and 2-day lagged PM concentrations can be used to predict the sum of incidence changes on days t, (t+1) and (t+2).

The extent to which time-series studies using single-day PM concentrations may underestimate the relationship between short-term PM exposure and mortality is unknown; however, there is some evidence, based on analyses of PM_{10} data, that mortality on a given day is influenced by prior PM exposures up to more than a month before the date of death (Schwartz, 2000b). The extent to which short-term exposure studies (including those that consider distributed lags) may not capture the full impact of long-term exposures to PM is similarly not known. Currently, there is insufficient information to adequately adjust for the impact of longer-term exposure on mortality associated with $PM_{2.5}$ exposures, and this is an important uncertainty that should be kept in mind as one considers the results from the short-term exposure PM risk assessment.

2.5.3 Cutpoints and slope adjustment

For mortality and morbidity outcomes associated with short-term exposure to $PM_{2.5}$ and $PM_{10-2.5}$, the initial base case applies the linear or log-linear C-R functions from the epidemiological studies down to the estimated PRB concentration. Generally, the lowest measured concentrations in the short-term exposure studies were relatively near or below the estimated PRB levels such that little or no extrapolation of the C-R function is required beyond the range of data in the studies. Among the studies of mortality associated with long-term

the number of cases of the health effect that exist that are associated with PM levels at the higher level above the lower level. The number of cases is the same, however, in both cases.
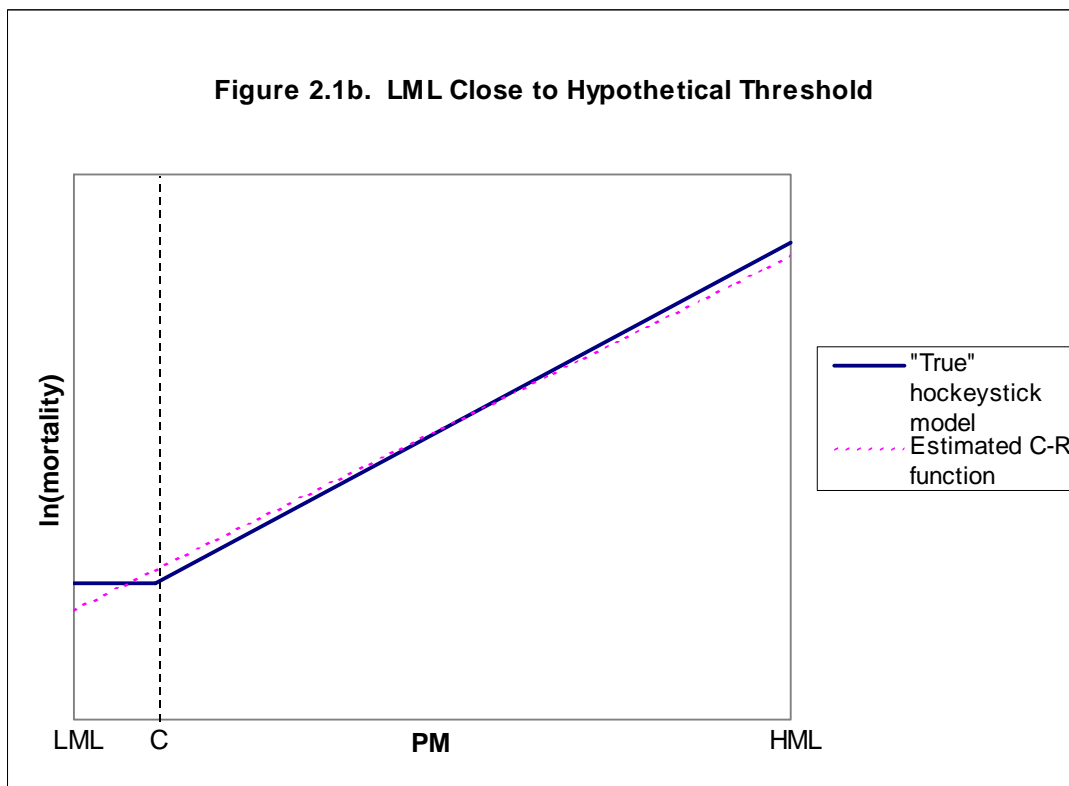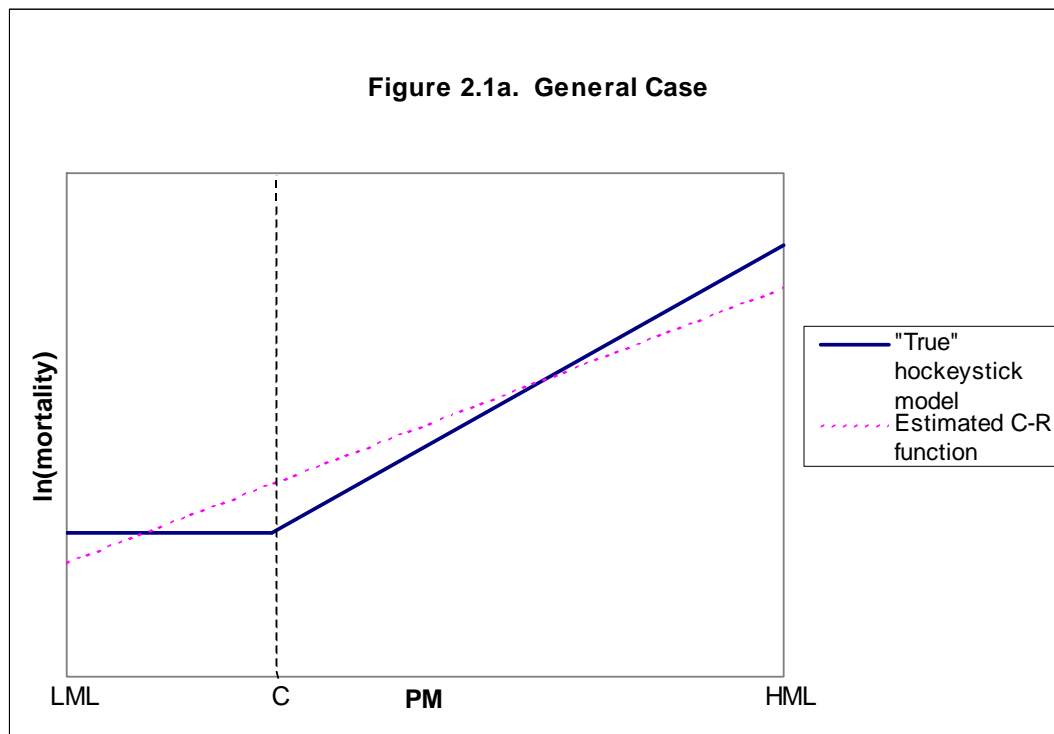
exposure to $PM_{2.5}$ that have been included in the risk assessment, the lowest measured long-term levels were in the range 7.5 to 11 $\mu g/m^3$. For mortality associated with long-term exposure to $PM_{2.5}$, the initial base case applies C-R functions down to 7.5 $\mu g/m^3$, which is the lowest of the lowest measured levels in these long-term studies. Going down to an estimated PRB level for short-term exposure studies and to 7.5 $\mu g/m^3$ for long-term studies provides a consistent framework which facilitates comparison of risk estimates across urban locations within each group of studies and avoids significant extrapolation beyond the range of concentrations included in these studies.

In addition to the initial base case models, we applied various alternative "cutpoint" models. While there are likely biological thresholds in individuals for specific health responses, the available epidemiological studies do not support or refute the existence of thresholds at the population level for either long-term or short-term PM exposures within the range of air quality observed in the studies. It may therefore be appropriate to consider health risks estimated not only with the reported linear or log-linear C-R functions, but also with modified functions that approximate non-linear, sigmoidal-shaped functions that would better reflect possible population thresholds. We approximated such sigmoidal functions by "hockeystick" functions based on the reported linear or log-linear functions. This approximation consisted of (1) imposing a cutpoint (i.e., an assumed threshold) on the original C-R function, that is intended to reflect an inflection point in a typical sigmoidal shaped function, below which there is little or no population response, and (2) adjusting the slope of the original C-R function above the cutpoint.

If the researchers in the original study fit a log-linear or a linear model through data that actually better support a sigmoidal or "hockeystick" form, the slope of the fitted curve would be smaller than the slope of the upward-sloping portion of the "true" hockeystick relationship, as shown in Figure 2.1a. The horizontal portion of the data below the cutpoint would essentially cause the estimated slope to be biased downward relative to the "true" slope of the upward-sloping portion of the hockeystick. The slope of the upward-sloping portion of the hockeystick model should therefore be adjusted upward (from the slope of the reported C-R function), as shown in Figure 2.1a. This rationale applies equally in the case of mortality associated with long- and short-term exposure to PM. In each case, under the threshold hypothesis a log-linear curve has been fit to data that are better characterized by a hockeystick model. In the case of a short-term exposure mortality or morbidity study, the curve represents the relationship between daily PM and daily mortality or morbidity; in the case of a long-term exposure mortality study, the curve represents the relationship between annual average PM and annual mortality. In both cases, however, if the "true" relationship looks like a hockeystick, then the log-linear curve fitted to the data would understate the impact of increases in PM (either daily, in the case of a short-term study, or annual average, in the case of a long-term study) on mortality or morbidity at PM levels above the cutpoint.

If the data used in a study do not extend down below the cutpoint or extend only slightly below it, then the extent of the downward bias of the reported PM coefficient will be minimal. This is the case, for example, when the cutpoint is 10 µg/m^3 or 12 µg/m^3 for long-term exposure mortality, given that the lowest measured PM$_{2.5}$ levels in the long-term exposure mortality studies were 7.5, 10, or 11 µg/m^3. In this case, the data in the study provided hardly any information about the relationship between PM$_{2.5}$ and mortality at levels below the cutpoints and would have biased an estimate of the slope of the upward-sloping portion of a hockeystick only minimally if at all, as illustrated in Figure 2.1b.

Figure 2.1. Relationship Between Estimated Log-Linear Concentration-Response Function and Hockeystick Model With Threshold C

Figure 2.1a. General Case

Figure 2.1b. LML Close to Hypothetical Threshold

We used a simple slope adjustment method based on the idea discussed above – that, if the data in the study were best described by a hockeystick model with a cutpoint at c, then the slope estimated in the study using a log-linear model would be approximately a weighted average of the two slopes of the hockeystick – namely, zero and the slope of the upward-sloping portion of the hockeystick.   If we let

- LML denote the lowest measured PM level in the study,
- c denote the cutpoint,
- HML denote the highest measured PM level in the study,
- β^{est} denote the slope (the PM coefficient) estimated in the study (using a log-linear model), and
- β^{T} denote the "true" slope of the upward-sloping portion of the hockeystick,

then, assuming the estimated coefficient reported by the study is (approximately) a weighted average of the slope below the cutpoint (0) and the slope above the cutpoint,

$$\beta^{est} = 0 * \frac{(c - LML)}{(HML - LML)} + \beta^{T} * \frac{(HML - c)}{(HML - LML)}$$

and, solving for β^{T},

$$\beta^{T} = \beta^{est} * \frac{(HML - LML)}{(HML - c)}$$

That is, the "true" slope of the upward-sloping portion of the hockeystick would be the slope estimated in the study (using a log-linear model rather than a hockeystick model) adjusted by the inverse of the proportion of the range of PM levels observed in the study that was above the cutpoint. Note that if the LML was below the estimated PRB (or if it was not available for the study), the estimated PRB was substituted for LML in the above equation. We believe that this slope adjustment method is a reasonable approach to estimating health effects under various assumed cutpoint models. A more definitive evaluation of the impact of alternative cutpoints and non-linear models is a subject that should be explored in further research.

A cutpoint of 20 $\mu g/m^3$ was selected as the highest value for base case scenarios for short-term exposure mortality for $PM_{2.5}$ and short-term exposure morbidity for $PM_{10-2.5}$. Two additional alternative cutpoints, 10 and 15 $\mu g/m^3$, also were selected to be included in base case scenarios for these short-term exposure health outcomes, so as to span the range between the initial cutpoint (i.e., estimated policy-relevant background) and the upper cutpoint value at roughly 5 $\mu g/m^3$ intervals.

For mortality associated with long-term exposure to $PM_{2.5}$, EPA staff selected 12 µg/m³ as the highest value for an alternative cutpoint based on the following two considerations: 1) the confidence intervals in the ACS extended study (Pope et al., 2002) begin to expand significantly starting around 12 to 13 µg/m³, indicating greater uncertainty about the shape of the reported C-R relationship at and below this level and 2) it is unlikely that the relationship is non-linear near the reported mean concentration levels in the long-term exposure studies (e.g., 14 µg/m³ in the ACS extended study). An additional alternative cutpoint of 10 µg/m³ is included, representing an approximate midpoint value between the cutpoints already selected.

2.5.4   Calculating incidence on an annual basis

The risk assessment estimated health effects incidence, and changes in incidence, on an annual basis. For mortality, both short-term and long-term exposure studies have reported estimated C-R functions. As noted above, most short-term exposure C-R functions estimated by daily time-series epidemiological studies relate daily mortality to same-day PM concentration or previous-day PM concentration (or some variant of those).

To estimate the *daily* health impacts of daily average ambient PM levels above background or above the levels necessary to just meet the current or alternative $PM_{2.5}$ standards (or alternative $PM_{10-2.5}$ standards), C-R functions from short-term exposure studies were used together with estimated changes in daily ambient PM concentrations to calculate the daily changes in the incidence of the health endpoint. (Alternative assumptions about the range of PM levels associated with health effects were explored in sensitivity analyses. Where a minimum concentration for effects (i.e., a cutpoint) was considered, reductions below this concentration did not contribute attributable cases to the calculation. Only reductions down to this concentration contributed attributable cases to the calculation.)

After daily changes in health effects were calculated, an annual change was calculated by summing the daily changes. However, there are some days for which no ambient PM concentration information was available. The predicted annual risks, based on those days for which air quality data are available, were adjusted to take into account the full year. If days with missing air quality data occur randomly or relatively uniformly throughout the year, a simple adjustment can be made to the health effect incidence estimate – the incidence estimate based on the set of days with air quality data can be multiplied by the ratio of the total number of days in the year to the number of days in the year for which direct observations were available, to generate an estimate of the total annual incidence of the health effect.[10] However, if the missing data are not uniformly distributed throughout the year, such a simple adjustment could lead to a biased estimate of the total annual incidence change. To reduce such possible bias, adjustments

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[10] This assumes that the distribution of PM concentrations on those days for which data are missing is essentially the same as the distribution on those days for which we have PM data.

were made on a quarterly basis. If Q_i is the total number of days in the ith quarter, and n_i is the number of days in the ith quarter for which there are air quality data, then the predicted incidence change in the ith quarter, based on those days for which there are air quality data, was multiplied by Q_i/n_i. The adjusted quarterly incidence changes were summed to derive an estimate of the annual incidence change.

Some short-term exposure C-R functions are based on average PM levels during several days. When such C-R functions were used, the air quality data were averaged for the same number of days. For example, a function based on two-day averages of PM was used in conjunction with two-day averages of PM in the assessment location to predict the incidence of the health effect in that location. In some cases, intervals of two or three consecutive days in a given location may be missing data, and so no multi-day average is available for use with multi-day C-R functions. These cases were treated by multi-day functions just as individual missing days were treated by single-day functions: they contributed no incidence change to the risk assessment, and incidence changes were adjusted for the days on which multi-day averages were missing.

C-R functions from long-term exposure studies (see Exhibit C.10) were used to assess the annual health impacts of changes in annual average ambient PM concentrations. Once again, to minimize the chance of bias due to differential amounts of missing data in different quarters of the year, quarterly averages were calculated based on the days in each quarter for which air quality data were available, and the "as is" annual average concentration was then calculated as an average of the four quarterly averages.

The mortality associated with long-term exposure is likely to include mortality related to short-term exposures as well as mortality related to longer-term exposures. As discussed previously, estimates of daily mortality based on the time-series studies also are likely influenced by prior PM exposures. Therefore, the estimated annual incidences of mortality calculated based on the short- and long-term exposure studies are not likely to be completely independent and should not be added together.

While we can characterize the statistical uncertainty surrounding the estimated PM coefficient in a reported C-R function, there are other sources of uncertainty about the C-R functions used in the risk assessment that are addressed via sensitivity analyses. The sources of uncertainty and how they are addressed in the risk assessment are discussed briefly below in Section 2.6 and in more detail in Section 6. Sensitivity analyses, which consider the impact of one assumption or source of uncertainty at a time, are listed in Section 2.7. Most of the sensitivity analyses, described more fully in Section 7, focus on mortality.

2.6   Characterizing uncertainty and variability

Any estimation of "as is" risk and reduced risks associated with just meeting specified PM standards should address both the variability and uncertainty that generally underlie such an analysis. Uncertainty refers to the lack of knowledge regarding the actual values of model input variables (parameter uncertainty) and of physical systems or relationships (model uncertainty – e.g., the shapes of C-R functions). The goal of the analyst is to reduce uncertainty to the maximum extent possible. Uncertainty can be reduced by improved measurement and improved model formulation.

Variability refers to the heterogeneity in a population or parameter. Even if there is no uncertainty surrounding inputs to the analysis, there may still be variability. For example, there may be variability among C-R functions describing the relationship between PM and mortality across urban areas. This variability does not imply uncertainty about the C-R function in any of the urban areas, but only that these C-R functions are different in the different locations, reflecting differences in the populations and/or the PM. In general, it is possible to have uncertainty but no variability (if, for instance, there is a single parameter whose value is uncertain) or variability but little or no uncertainty (for example, people's heights vary considerably but can be accurately measured with little uncertainty).

The current risk assessment incorporates some of the variability in key inputs to the analysis by using location-specific inputs (e.g., location-specific C-R functions, baseline incidence rates, and air quality data). Although spatial variability in these key inputs across all U.S. locations has not been fully characterized, variability across the selected locations is imbedded in the analysis by using, to the extent possible, inputs specific to each urban area. Temporal variability is more difficult to address, because the risk assessment focuses on some unspecified time in the future. To minimize the degree to which values of inputs to the analysis may be different from the values of those inputs at that unspecified time, we have used the most current inputs available – for example, year 2003 air quality data for most of the urban locations, and the most recent available mortality baseline incidence rates (from 2001). However, we have not tried to predict future changes in inputs (e.g., future population levels or possible changes in baseline incidence rates).

There are a number of important sources of uncertainty that were addressed where possible. The following are among the major sources of uncertainty in the risk assessment:

•   Uncertainties related to estimating the C-R functions, including the following:

    –   There is uncertainty about the extent to which the association between PM and the health endpoint actually reflects a causal relationship.

–   There is uncertainty surrounding estimates of PM coefficients in C-R functions used in the analyses.

–   There is uncertainty about the specification of the model (including the shape of the C-R relationship), particularly whether or not there are thresholds below which no response occurs.

–   There is uncertainty related to the transferability of PM C-R functions from study locations and time periods to the locations and time periods selected for the risk assessment.[11] A C-R function in a study location may not provide an accurate representation of the C-R relationship in the analysis location(s) and time periods because of

- variations in PM composition across cities or over time,
- the possible role of associated co-pollutants, which vary from location to location and over time, in influencing PM risk,
- variations in the relationship of total ambient exposure (both outdoor and ambient contributions to indoor exposure) to ambient monitoring in different locations (e.g, due to differences in air conditioning use in different regions of the U.S. or changes in usage over time),
- differences in population characteristics (e.g., the proportions of members of sensitive subpopulations) and population behavior patterns across locations or over time in the same location.

- Uncertainties related to the air quality adjustment procedure that was used to simulate just meeting the current PM standards, and uncertainties about estimated background concentrations for each location.

- Uncertainties associated with use of baseline health effects incidence information that is not specific to the analysis locations.[12]

The uncertainties from some of these sources -- in particular, the statistical uncertainty surrounding estimates of the PM coefficients in C-R functions -- were characterized quantitatively. It was possible, for example, to calculate confidence intervals around risk

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[11] The risk assessment locations were selected partly on the basis of where C-R functions were estimated, specifically to reduce this important source of uncertainty. Therefore, possible differences due to location is a source of uncertainty in the risk assessment only when C-R functions from multi-city studies or from another location are applied to a risk assessment location.

[12] Location-specific baseline incidence rates were obtainable for most health endpoints. The only health endpoints for which this was not the case are respiratory symptoms, for which baseline incidence rates were reported in the studies. For those studies carried out in a single location, this provides location-specific baseline incidence rates. For Schwartz and Neas (2000), the rates were based on six cities combined. Boston and St. Louis, the two assessment locations where these endpoints are evaluated, were two of the six cities.

estimates based on the uncertainty associated with the estimates of PM coefficients used in the risk assessment. These confidence intervals express the range within which the risks are likely to fall if the uncertainty surrounding PM coefficient estimates were the only uncertainty in the analysis. There are, of course, several other uncertainties in the risk assessment, as noted above. If there were sufficient information to quantitatively characterize these sources of uncertainty, they could be included in a Monte Carlo analysis to produce confidence intervals that more accurately reflect all sources of uncertainty.

We handled uncertainties in the risk assessment in several ways:

- Limitations and assumptions in estimating risks and risk reductions are clearly stated and explained.

- The uncertainty resulting from the statistical uncertainty associated with the estimate of the PM coefficient in a C-R function was characterized by confidence intervals around the corresponding point estimate of risk. As noted above, such a confidence interval expresses the range within which the true risk is likely to fall if the uncertainty surrounding the PM coefficient estimate were the only uncertainty in the analysis. It does not, for example, reflect the uncertainty concerning whether the PM coefficients in the study location and the assessment location are the same.[13]

- The uncertainty about possible population thresholds was addressed by applying "hockeystick" models, using various cutpoints, in addition to the original models estimated in the epidemiological literature.

- Sensitivity analyses were conducted to illustrate the effects of changing key default assumptions on the results of the assessment.

2.7   Summary of key assumptions and sensitivity analyses

In summary, the key assumptions on which the PM risk assessment is based include the following:

- The relationship between PM components examined and health endpoints is causal;
- The range of C-R models used in the risk assessment (including the original models and the models incorporating cutpoints) reasonably captures the possible range of functional relationships between PM and the health endpoints considered;
- Baseline incidence rates have not changed appreciably from those used in the risk assessment;

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[13] This is not an uncertainty, of course, if the C-R function has been estimated in the assessment location.

- Population sizes and age distributions have not changed appreciably from those used in the risk assessment;
- The distribution of PM concentrations on missing days is essentially the same as the distribution of PM concentrations on days for which we have PM data;
- The estimated background concentration for each component is appropriate for each urban area in the analysis;
- The background concentration for each component is essentially constant across the days in a year;
- A single year of air quality data is appropriate to characterize risks associated with as is and just meeting specified standards,
- Proportional rollback of concentrations over estimated background appropriately represents how standards would be just met;

Sensitivity analyses are used to illustrate the sensitivity of analysis results to different possible input values or to different assumptions or procedures that may affect these input values. Although a sensitivity analysis is not as comprehensive as an uncertainty analysis, selecting only a few possible alternative values of an input component rather than characterizing the entire distribution of these values, it is precisely the simplicity of a sensitivity analysis that makes it preferable for illustrating the impact on results of using different input component values. Exhibit 2.6 lists the sensitivity analyses that were conducted.

Exhibit 2.6 Sensitivity Analyses

Analysis Number (Exhibit 2.1)	PM Indicator	Component of the Risk assessment	Sensitivity Analysis
1	$PM_{2.5}$, $PM_{10-2.5}$	Air Quality	Sensitivity analyses of the effect of assuming different (constant) background PM levels
2	$PM_{2.5}$	Air Quality	Sensitivity analyses of the effect of assuming a constant background PM level versus a distribution of daily background levels
3	$PM_{2.5}$	Air Quality	Sensitivity analyses of the effect of just meeting the current and alternative annual $PM_{2.5}$ standards using the maximum versus the average of monitor-specific averages
4	$PM_{2.5}$	Air Quality	A sensitivity analysis of the effect of an alternative air quality adjustment procedure on the estimated risk reductions resulting from just meeting the current 24-hr and annual $PM_{2.5}$ standards
5	$PM_{2.5}$	Concentration-Response	A sensitivity analysis using an approach to estimate the possible impact of using a distributed lag C-R function
6	$PM_{2.5}$	Concentration-Response	A sensitivity analysis of the impact on mortality associated with long-term exposure of different assumptions about the role of historical air quality concentrations in contributing to the reported effects
7	$PM_{2.5}$	Concentration-Response	Sensitivity analysis of the impact on mortality associated with short-term exposure of using a multi-city C-R function compared to location-specific C-R functions from single-city studies

3.   Health Endpoints, Urban Areas, and Studies Selected

As discussed in the 2004 PM CD, a significant number of epidemiological studies examining a variety of health effects associated with ambient PM concentrations in various locations throughout the United States and Canada have been published since the prior NAAQS review. As a result of the availability of additional health effects studies and air quality information, EPA expanded the geographic scope of the PM risk assessment to include several additional urban areas beyond the two (Philadelphia and Los Angeles Counties) analyzed for the prior review, consistent with the goals of the assessment. The approaches that were used to select health endpoint categories, urban areas, and studies to include in the PM risk assessment are discussed below.

3.1   Health endpoints

OAQPS staff carefully reviewed the evidence evaluated in the 2004 PM CD (see Chapter 3 of the 2005 PM SP). Tables 8-A and 8-B in Appendices 8A and 8B of the 2004 PM CD summarize the available U.S. and Canadian short-term exposure studies that provide effect estimates for PM (i.e., $PM_{2.5}$, PM_{10}, and $PM_{10-2.5}$) for mortality and morbidity, respectively. Section 8.2.3 of the 2004 PM CD summarizes the available U.S. and Canadian studies that provide effect estimates for $PM_{2.5}$ and other PM indicators for long-term exposure. As discussed in the 2005 PM SP (Section 4.2.1), given the large number of endpoints and studies addressing PM effects, OAQPS included in the quantitative PM risk assessment only the more severe and better understood (in terms of health consequences) health endpoint categories. In addition, OAQPS included only those health endpoints for which the overall weight of the evidence from the collective body of studies supports the CD conclusion that there is likely to be a causal relationship or that the scientific evidence is sufficiently suggestive of a causal relationship that OAQPS staff judges the effects to be likely causal between PM and the effects category. Finally, OAQPS included only those categories for which there were studies that satisfy the study selection criteria (see Section 3.3 below).

For those health effect categories included, the risk assessment is predicated on the assumption that a causal relationship exists. As discussed in more detail in the 2004 PM CD (see Section 9.2.2), for the relationship between PM and various health outcomes

"...considering results from studies conducted both within and outside the U.S. and Canada, the epidemiological evidence is strong for associations between PM_{10} and $PM_{2.5}$ and mortality, especially for total and cardiovascular mortality. The magnitudes of the associations are relatively small, especially for the multi-city studies. However, there is a pattern of positive and often statistically significant associations across studies for cardiovascular and respiratory health outcomes, including mortality and hospitalization and medical visits for cardiovascular and respiratory diseases, with PM_{10} and $PM_{2.5}$. The few available $PM_{10-2.5}$ studies also provide

some evidence for associations between hospitalization for cardiovascular and respiratory diseases with $PM_{10-2.5}$. ... For $PM_{10-2.5}$, the evidence for association with mortality is more limited." (U.S. EPA, 2004, p.9-32)

With respect to the relationship between long-term exposure to $PM_{2.5}$ and increased mortality, the 2004 PM CD placed the greatest weight on the results of the ACS and Six Cities cohort studies and concluded that "the results of these studies, including the reanalyses results for the Six Cities and ACS studies and the results of the ACS study extension, provide substantial evidence for positive associations between long-term ambient (especially fine) PM exposure and mortality" (p.9-33). The 2004 PM CD (p. 9-34) finds no evidence for associations between long-term exposure to $PM_{10-2.5}$ and either morbidity or mortality health outcomes.

The 2004 PM CD(pp. 9-50 - 9-79) contains an extensive discussion considering both the extent to which the available epidemiological evidence shows associations in the same location with a range of logically linked health endpoints and the extent to which the available toxicological evidence and mechanistic information provides support for the plausibility of the observed epidemiological associations. Based on that review, the 2004 PM CD concludes that,

> "A growing body of evidence both from epidemiologic and toxicologic studies also supports the general conclusion that $PM_{2.5}$ (or one or more $PM_{2.5}$ components), acting alone and/or in combination with gaseous co-pollutants, are likely causally related to cardiovascular and respiratory mortality and morbidity. The strength of the evidence varies across such endpoints, with relatively stronger evidence of associations with cardiovascular than respiratory endpoints, potentially due to reduced statistical power where respiratory outcomes are seen less frequently than cardiovascular outcomes. In addition, mortality associations with long-term exposures to $PM_{2.5}$, in conjunction with evidence of associations with short-term exposures, provide strong evidence in support of a causal inference." (U.S. EPA, 2004, p. 9-79)

Based on its review of the evidence evaluated in the 2004 PM CD, OAQPS included in both the $PM_{2.5}$ and $PM_{10-2.5}$ risk assessments the following broad categories of health endpoints associated with short-term exposures:
- hospital admissions for cardiovascular and respiratory causes;[14] and
- respiratory symptoms not requiring hospitalization.

In addition, non-accidental, cardiovascular, and respiratory mortality due to short-term exposure, as well as total, cardiopulmonary, and lung cancer mortality due to long-term exposure are also

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[14] The category of emergency room visits was also considered, but there is evidence that baseline incidence rates vary considerably across locations, and location-specific rates were not available. Therefore this health effect was not included in the risk assessment.

included in the $PM_{2.5}$ risk assessment. Other effects reported to be associated with PM, such as decreased lung function and changes in heart rate variability, are discussed in the 2005 PM SP.

3.2   Urban areas

In the prior risk assessment the selection of urban areas to include was determined largely by the very limited availability of recent and sufficiently complete $PM_{2.5}$ ambient air quality data. For the current PM risk assessment, there was a significantly greater number of candidate locations in which epidemiological studies have reported C-R relationships and for which there are sufficient PM ambient air quality data. Recent evidence from the National Mortality and Morbidity Air Pollution Study (NMMAPS) (Samet et al., 2000) suggests there may be geographic variability in C-R relationships across many U.S. urban areas. In light of the evidence from NMMAPS, which examined C-R relationships across the 90 largest U.S. cities, we identified candidate areas for the PM risk assessment emphasizing geographically varied urban areas in the United States in which C-R relationships have been estimated.

An urban area in the United States was included in the PM risk assessment only if it satisfied the following criteria:

- It has sufficient air quality data for a recent year (1999 or later). A city was considered to have sufficient $PM_{2.5}$ air quality data if it had at least one $PM_{2.5}$ monitor at which there were at least 11 observations per quarter for a one year period and there were at least 122 observations per year (1 in 3 day monitoring). Sufficient air quality data for $PM_{10-2.5}$ was defined as a one year period with at least 11 daily values per quarter based on data from co-located PM_{10} and $PM_{2.5}$ monitors.[15]

- It is the same as or close to the location where at least one C-R function for one of the recommended health endpoints (see above) has been estimated by a study that satisfies the study selection criteria (see below).[16]

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[15] We excluded from consideration a few monitors sited in industrial areas that are intended to characterize local conditions near major point sources and which met the EPA criteria contained in Part 58 of the CFR for exclusion from consideration when evaluating whether an area meets the current annual average $PM_{2.5}$ standard .

[16] Urban locations for which C-R functions were estimated sometimes include several counties. (For example, in Klemm et al., 2000, the urban area labeled "Boston" consists of three counties: Middlesex, Norfolk, and Suffolk counties.) To the extent possible, in the PM risk assessment we tried to include the specific counties used in the urban location in the original epidemiological studies.

- For the hospital admission effects category, relatively recent area-specific baseline incidence data, specific to International Classification of Disease (ICD) codes, are available.[17]

3.2.1   Additional considerations: the $PM_{2.5}$ risk assessment

The largest data base for health effects associated with short-term (i.e., 24-hour) ambient $PM_{2.5}$ concentrations, in terms of number of studies in different locations, is for non-accidental total and cause-specific mortality. Therefore, OAQPS focused on selecting urban areas for the $PM_{2.5}$ risk assessment primarily on this health effect category supplemented by consideration of morbidity endpoints. We first reviewed the studies listed in Table 8-A of the 2004 PM CD that estimated C-R functions for short-term exposure mortality in U.S. locations and used measured $PM_{2.5}$ or $PM_{2.5}$ estimated by nephelometry as the air quality indicator. A candidate pool of sixteen urban areas in the U.S. was represented among those studies.

We next considered the precision of the effect estimates from those short-term exposure mortality studies identified in the first step.[18] In general, the relative precision of a study increases as the number of its observations increases. The number of observations depends not only on the number of days on which mortality counts were obtained, but also on the size of the mortality counts. The 2004 PM CD describes the use of the natural logarithm of the mortality-days (i.e., the natural log of the product of the number of study days and the average number of deaths per day) as a surrogate or indicator reflecting the relative weight of short-term exposure mortality epidemiological studies as an indicator of likely increasing precision for study effect estimates.   We considered only those urban areas in which studies with relatively greater precision were conducted – specifically, studies that have a natural log of mortality-days greater than or equal to 9.0 for total non-accidental mortality.[19] This criterion excluded 6 urban areas (Camden, NJ; Coachella Valley, CA; Elizabeth, NJ; Newark, NJ; Steubenville, OH; and Topeka, KS).

We next considered which of those study locations also have sufficient $PM_{2.5}$ monitoring data to support a $PM_{2.5}$ risk assessment. Using the completeness criterion defined above for $PM_{2.5}$, 2 additional areas (Knoxville, TN and Portage, WI) were excluded based on the air quality

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[17] The absence of hospital admissions baseline incidence data does not necessarily mean that we cannot use an urban area in the risk assessment, only that we cannot use it for the hospital admissions endpoint.

[18] Tolbert et al. (2000) was excluded from consideration because it presented only preliminary results, and the 2004 PM CD urged caution in interpreting these preliminary results.

[19] Most of the epidemiological studies reporting total non-accidental mortality also report on one or more cause specific mortality categories; in such studies the natural log of mortality days is often less than 9.0 because there are fewer deaths from a specific cause. We included the cause-specific mortality C-R relationships reported in such studies as long as the natural log of total mortality days was greater than or equal to 9.0.

data available in 2003, leaving eight cities in which epidemiological studies reported C-R relationships for $PM_{2.5}$ and mortality associated with short-term exposures and which had sufficient air quality data in a recent year.

The following urban areas satisfied the criteria of availability of C-R functions for short-term exposure mortality, study precision, and availability of sufficiently recent and complete air quality data to be included in the $PM_{2.5}$ risk assessment for short-term exposure mortality:

- Boston, MA
- Detroit, MI
- Los Angeles, CA
- Philadelphia, PA
- Phoenix, AZ
- Pittsburgh, PA
- San Jose, CA
- St. Louis, MO

Because baseline mortality incidence data are available at the county level, this was not a limiting factor in the selection of urban areas for any portion of the $PM_{2.5}$ risk assessment.

The long-term exposure C-R functions used in the $PM_{2.5}$ risk assessment are based on studies involving multiple cities across the United States, and the estimated C-R functions are based on differences in long-term averages observed across the various cities. The issue of matching a risk assessment location with the specific location in which a C-R function was estimated therefore does not arise for long-term exposure mortality in quite the way it does for short-term exposure mortality. We carried out the $PM_{2.5}$ risk assessment for long-term exposure mortality in all the urban locations listed above that are included in the $PM_{2.5}$ risk assessment.

Most of the urban locations in which C-R functions were estimated for health endpoints other than mortality are included in the set of locations available for mortality. A primary consideration in selecting urban locations for these other health endpoints, as with the $PM_{2.5}$ risk assessment for mortality, was that the assessment locations be the same as or close to the study locations where C-R functions were estimated. Second, studies with relatively greater precision were considered preferable. In addition, for the hospital admission effect category, we limited our selection of urban areas to those for which the necessary baseline incidence data were available.

3.2.2 Additional considerations: the $PM_{10-2.5}$ risk assessment

We wanted to include urban areas in the $PM_{10-2.5}$ risk assessment for which we were also conducting a $PM_{2.5}$ risk assessment, if there are epidemiological studies reporting associations for $PM_{10-2.5}$ in these locations. Because the $PM_{10-2.5}$ risk assessment requires air quality data for

PM_{10} and $PM_{2.5}$ at co-located monitors, the criterion of sufficient air quality data is significantly more limiting in the selection of urban areas for the $PM_{10-2.5}$ risk assessment than for the $PM_{2.5}$ risk assessment.

Based on these considerations, we included Detroit, Seattle, and St. Louis in the $PM_{10-2.5}$ risk assessment. While sufficient air quality data are also available for Los Angeles, the relevant epidemiological study used the S-Plus/GAM procedure but has not yet been re-analyzed.

3.3   Studies

A study that has estimated one or more C-R functions for a health endpoint in an urban location to be used for the $PM_{2.5}$ or $PM_{10-2.5}$ risk assessment had to satisfy the following criteria:

- It is an acceptable, published, peer-reviewed study that has been evaluated in the 2004 PM CD and judged adequate by EPA staff for purposes of inclusion in this risk assessment based on that evaluation.

- It directly measured PM using $PM_{2.5}$ or $PM_{10-2.5}$ as the indicator or for $PM_{2.5}$ was estimated using nephelometry data.[20]

- It either did not rely on GAMs using the S-Plus software to estimate C-R functions or has appropriately re-estimated them using revised methods.

3.4   A summary of health endpoints, urban areas, and studies selected

Based on applying the criteria and considerations discussed above, the health endpoints and the urban locations that were selected, as well as the studies that estimated the C-R functions used in the PM risk assessment are given in Exhibits 3.1 - 3.3 for $PM_{2.5}$, and Exhibit 3.4 for $PM_{10-2.5}$. More detailed information on the studies used is given in Appendix C.

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[20] Consistent with advice received from members of the CASAC PM Panel, we have included studies that used nephelometry to estimate $PM_{2.5}$ concentrations where gravimetric measurements were not available.

Exhibit 3.1 The PM$_{2.5}$ Risk Assessment: Mortality Associated with Short-Term Exposure				
Urban Location	Total (non-accidental)	Cardiovascular	Circulatory	Respiratory
Boston, MA	Schwartz et al. (1996)[A] *	Klemm et al. (2000)[B] – ischemic heart disease *		Klemm et al. (2000)[B] – COPD *, pneumonia *
Detroit, MI	Lippmann et al. (2000)[C]		Lippmann et al. (2000)[C]	Lippmann et al. (2000)[C]
Los Angeles, CA	Moolgavkar (2000a)[D]	Moolgavkar (2000a)[D]		
Philadelphia, PA		Lipfert et al. (2000) *		
Phoenix, AZ		Mar et al. (2000)[E]		
Pittsburgh, PA	Chock et al. (2000)			
San Jose, CA	Fairley (1999)[F]	Fairley (1999)[F]		Fairley (1999)[F]
St. Louis, MO	Schwartz et al. (1996)[A]	Klemm et al. (2000)[B] – ischemic heart disease *		Klemm et al. (2000)[B] – COPD *, pneumonia *

*Includes a multi-city or multi-county C-R function

[A] Reanalyzed in Schwartz (2003b)

[B] Reanalyzed in Klemm and Mason (2003)

[C] Reanalyzed in Ito (2003)

[D] Reanalyzed in Moolgavkar (2003)

[E] Reanalyzed in Mar et al. (2003)

[F] Reanalyzed in Fairley (2003)

Exhibit 3.2 The PM$_{2.5}$ Risk Assessment: Mortality Associated with Long-Term Exposure			
Urban Location	Total	Cardiopulmonary	Lung Cancer
Boston, MA	Krewski et al. (2000) – 6 cities Krewski et al. (2000) – ACS Pope et al. (2002) – ACS extended	Krewski et al. (2000) – 6 cities Krewski et al. (2000) – ACS Pope et al. (2002) – ACS extended	Pope et al. (2002) – ACS extended
Detroit, MI	Krewski et al. (2000) – ACS Pope et al. (2002) – ACS extended	Krewski et al. (2000) – ACS Pope et al. (2002) – ACS extended	Pope et al. (2002) – ACS extended
Los Angeles, CA	Krewski et al. (2000) – ACS Pope et al. (2002) – ACS extended	Krewski et al. (2000) – ACS Pope et al. (2002) – ACS extended	Pope et al. (2002) – ACS extended
Philadelphia, PA	Krewski et al. (2000) – ACS Pope et al. (2002) – ACS extended	Krewski et al. (2000) – ACS Pope et al. (2002) – ACS extended	Pope et al. (2002) – ACS extended
Phoenix, AZ	Krewski et al. (2000) – ACS Pope et al. (2002) – ACS extended	Krewski et al. (2000) – ACS Pope et al. (2002) – ACS extended	Pope et al. (2002) – ACS extended
Pittsburgh, PA	Krewski et al. (2000) – ACS Pope et al. (2002) – ACS extended	Krewski et al. (2000) – ACS Pope et al. (2002) – ACS extended	Pope et al. (2002) – ACS extended
San Jose, CA	Krewski et al. (2000) – ACS Pope et al. (2002) – ACS extended	Krewski et al. (2000) – ACS Pope et al. (2002) – ACS extended	Pope et al. (2002) – ACS extended
Seattle, WA	Krewski et al. (2000) – ACS Pope et al. (2002) – ACS extended	Krewski et al. (2000) – ACS Pope et al. (2002) – ACS extended	Pope et al. (2002) – ACS extended
St. Louis, MO	Krewski et al. (2000) – 6 cities Krewski et al. (2000) – ACS Pope et al. (2002) – ACS extended	Krewski et al. (2000) – 6 cities Krewski et al. (2000) – ACS Pope et al. (2002) – ACS extended	Pope et al. (2002) – ACS extended

Exhibit 3.3 The PM$_{2.5}$ Risk Assessment: Morbidity Associated with Short-Term Exposure			
Urban Location	**Cardiovascular Hospital Admissions**	**Respiratory Hospital Admissions**	**Respiratory Symptoms**
Boston, MA			Schwartz and Neas (2000) – cough, lower respiratory symptoms (LRS)
Detroit, MI	Lippmann et al. (2000)[A] – ischemic heart disease, congestive heart failure, dysrhythmias	Lippmann et al. (2000)[A] – pneumonia, COPD	
Los Angeles, CA	Moolgavkar (2000b)[B]	Moolgavkar (2000c)[B] – COPD	
Seattle, WA		Sheppard et al. (1999)[C] – asthma	
St. Louis, MO			Schwartz and Neas (2000) – cough, LRS

[A] Reanalyzed in Ito (2003)

[B] Reanalyzed in Moolgavkar (2003)

[C] Reanalyzed in Sheppard (2003)

Exhibit 3.4 The $PM_{10-2.5}$ Risk Assessment: Morbidity Associated with Short-Term Exposure			
Urban Location	**Cardiovascular Hospital Admissions**	**Respiratory Hospital Admissions**	**Respiratory Symptoms**
Detroit, MI	Lippmann et al. (2000)[A] – Congestive heart disease, Ischemic heart disease Dysrhythmias	Lippmann et al. (2000)[A] – Pneumonia, COPD	
Seattle, WA		Sheppard et al. (1999)[B] – asthma	
St. Louis, MO			Schwartz and Neas (2000) – LRS, cough

*Includes multi-city, regional, or national C-R function

[A] Reanalyzed in Ito (2003)

[B] Reanalyzed in Sheppard (2003)

4.   Selecting Concentration-Response Functions

For the most part, the selection of studies from which to draw C-R relationships for the PM risk assessment was determined by the choice of health endpoints to include in the analyses and by the process used to select the urban areas, discussed in the previous section. C-R functions from studies judged suitable for inclusion in the risk assessment were not excluded because of lack of statistical significance. As discussed in Section 3.2.1 above, one of the criteria for inclusion of studies in the risk assessment is that studies have enough sample size to provide a sufficient degree of precision. Effect estimates that are not statistically significant are used from studies judged suitable for inclusion in this assessment to avoid introducing bias into the estimates of the magnitude of the effects.

The C-R functions of interest for the PM risk assessment are from epidemiological studies investigating the relations between PM and a variety of health endpoints. Both single-pollutant, and where available, multi-pollutant C-R functions used in the PM risk assessment were obtained for the studies listed in Tables 8A and 8B in Appendices 8A and 8B of the 2004 PM CD that met the criteria discussed previously in Section 3. Some of these studies were used in the prior (1996) PM risk assessment (Abt Associates Inc, 1996).

Studies often report more than one estimated C-R function for the same location and health endpoint. Sometimes models including different sets of co-pollutants are estimated in a study; sometimes different lags are estimated. In some cases, two or more different studies estimated a C-R function for PM and the same health endpoint (this is the case, for example, with $PM_{2.5}$ and long-term exposure mortality).

4.1   Single and multi-city functions

All else being equal, a C-R function estimated in the assessment location is preferable to a function estimated elsewhere since it avoids uncertainties related to potential differences due to geographic location. That is why the urban areas selected for the PM risk assessment were those locations in which C-R functions have been estimated. There are several advantages, however, to using estimates from multi-city studies versus studies carried out in single cities. Multi-city studies are applicable to a variety of settings, since they estimate a central tendency across multiple locations. When they are estimating a single C-R function based on several cities, multi-city studies also tend to have more statistical power and provide effect estimates with relatively greater precision than single city studies due to larger sample sizes, reducing the uncertainty around the estimated coefficient. In addition, there is less likelihood of publication bias or exclusion of reporting of negative findings or findings that are not statistically significant with multi-city studies. Because single-city and multi-city studies have different advantages, if a single-city C-R function has been estimated in a risk assessment location and a multi-city study which includes that location is also available for the same health endpoint, the results from both were used for that location and reported in the base case risk assessment.

4.2   Single and multi-pollutant models

For several of the epidemiological studies from which C-R relationships for the PM risk assessment were obtained, C-R functions are reported both for the case where only PM levels were entered into the health effects model (i.e., single pollutant models) and where PM and one or more other measured gaseous co-pollutants (i.e., ozone, nitrogen dioxide, sulfur dioxide, carbon monoxide) were entered into the health effects model (i.e., multi-pollutant models). To the extent that any of the co-pollutants present in the ambient air may have contributed to the health effects attributed to PM in single pollutant models, risks attributed to PM might be overestimated where C-R functions are based on single pollutant models. However, the 2004 PM CD (p. 9-37) finds that associations for various PM indices with mortality or morbidity are robust to confounding by co-pollutants. As shown in figures 8-16 through 8-19 of the 2004 PM CD, effect estimates for PM_{10}, $PM_{2.5}$, and $PM_{10-2.5}$ were little changed in multi-pollutant models, as compared with single pollutant models. As stated in the 2005 PM SP (p. 3-46), "This indicates that effect estimates from single-pollutant models can be used to represent the magnitude of a concentration-response relationship, though there will remain uncertainty with regard to potential contributions from other pollutants."

The findings from NMMAPS, which characterized the effects of PM_{10} and each of the gaseous co-pollutants, alone and in combination, also are relevant to the potential role of gaseous pollutants in modifying the effects associated with $PM_{2.5}$. An important finding of the NMMAPS analyses was "the weak influence of gaseous co-pollutants on the PM_{10} effect size estimates" (2004 PM CD, p.8-35). The authors concluded that their finding "suggests that the effect of PM_{10} is robust to the inclusion of other pollutants" (Samet et al., 2000, p. 19).

For some of the gaseous co-pollutants, such as carbon monoxide, nitrogen dioxide, and sulfur dioxide, which tend to be highly correlated with ambient $PM_{2.5}$ concentrations in some cities, it is difficult to sort out whether these pollutants are exerting any independent effect from that attributed to $PM_{2.5}$. As discussed in the 2004 PM CD, inclusion of pollutants that are highly correlated with one another can lead to misleading conclusions in identifying a specific causal pollutant. When collinearity exists, inclusion of multiple pollutants in models often produces unstable and statistically insignificant effect estimates for both PM and the co-pollutants (U.S. EPA, 2004, p.8-339). The CD also notes, on the other hand, that omission of potentially-contributing pollutants may incorrectly attribute some of their independent effects to PM (U.S. EPA, 2004, p. 8-339) Given that single and multi-pollutant models each have both potential advantages and disadvantages, with neither type clearly preferable over the other in all cases, we report risk estimates based on both single and multi-pollutant models where both are available.

4.3　Single, multiple, and distributed lag functions

The question of lags and the problems of correctly specifying the lag structure in a model is discussed extensively in the 2004 PM CD (Section 8.4.4) and 2005 PM SP (Sections 3.6.5.1 and 4.3). The 2004 PM CD points out that

> In considering the results of models for a series of lag days, it is important to consider the pattern of results that is seen across the series of lag periods. If there is an apparent pattern of results across the different lags, ... then selecting the single-day lag with the largest effect from a series of positive associations is reasonable, although it is, in fact, likely to underestimate the overall effect size (since the largest single-lag day results do not fully capture the risk also distributed over adjacent or other days).(U.S. EPA 2004, p.8-270)

As discussed in the 2004 PM CD, a number of the $PM_{2.5}$ short-term exposure mortality studies reported stronger associations with shorter lags, with a pattern of results showing larger associations at the 0- and 1-day lag period that taper off with successive lag days for varying PM indicators. These included the following studies which are used in the $PM_{2.5}$ risk assessment presented in this report: Moolgavkar (2003) and Mar et al. (2000), reanalyzed in Mar et al. (2003). Several studies included in the $PM_{2.5}$ risk assessment used only 0- and 1-day lags in the analyses for $PM_{2.5}$ (for example, Schwartz et al., 1996; Lipfert et al., 2000; Klemm et al., 2000).

When a study reports several single lag models, unless the study authors identify a "best lag," we selected both 0- and 1-day lag models for mortality (both total and cause-specific) based on the assessment in the 2004 PM CD and Section 3.6.5.1 of the 2005 PM SP. Based on a review of the U.S. and Canadian studies reporting mortality effects associated with PM exposure, the 2004 PM CD states, "These studies reported stronger associations with shorter lags, with a pattern of results showing larger associations at the 0- and 1-day lag period that taper off with successive lag days for varying PM indicators ..." (p.8-273). For hospital admission endpoints, unless the author specified an optimal lag, we selected both 0- and 1-day lag models for cardiovascular admissions since the 2004 PM CD indicates that recent evidence from time series studies strongly suggests maximal effects at 0-day lag with some carryover to 1-day lag and little evidence for effects beyond 1-day for this health endpoint (2004 PM CD, p. 8-279). Since many of the time-series studies addressing COPD hospital admissions report effects at somewhat longer lags, we selected 0-, 1- and 2-day lag models (if all three were available) for this health endpoint category.

There is recent evidence (Schwartz, 2000b) that the relationship between PM and health effects may best be described by a distributed lag (i.e., the incidence of the health effect on day n is influenced by PM concentrations on day n, day n-1, day n-2 and so on). The 2004 PM CD makes the point that "if one chooses the most significant single-lag day only, and if more than one lag day shows positive (significant or otherwise) associations with mortality, then reporting

a RR for only one lag would also underestimate the pollution effects" (U.S. EPA 2004, p.8-279). Because of this, a distributed lag model is considered preferable to a single lag model where there is a consistent pattern of effects shown across several days. Unfortunately, distributed lag models have been estimated in only a few cases and only for PM_{10} (e.g., Schwartz, 2000b for PM_{10}). Consequently, we conducted a sensitivity analysis examining the potential impact of using a distributed lag approach for short-term exposure mortality associated with $PM_{2.5}$, based on the distributed lag analysis of PM_{10} and short-term exposure mortality by Schwartz (2000b). This sensitivity analysis has been included to provide a very rough sense of the possible underestimation of risk due to use of single-day lag models in this assessment.

4.4   Alternative approaches to estimating short-term exposure C-R functions

As noted in Sections 1 and 3, many studies that originally relied on GAMs using the S-Plus software to estimate short-term exposure C-R functions were subsequently reanalyzed. Many researchers used not just one but several alternative estimation approaches. In addition to GAMs with a more stringent convergence criterion, generalized linear model (GLM) approaches (with differing numbers of degrees of freedom, and different types of splines) were also used to reanalyze C-R functions. Thus, corresponding to a single log-linear C-R function with a single lag structure, there were often several different PM coefficients, each resulting from a different estimation approach.

Including all the alternative C-R functions in all the urban locations in the PM risk assessment would result in a prohibitively large set of results. Instead, for all urban locations, we included only GAM with a more stringent convergence criterion (denoted "GAM (stringent)"), to provide a consistent basis for comparison across studies and locations.[21] Although this approach does not address the issue of understated standard errors of coefficient estimates, this is probably not a significant drawback. The 2004 PM CD concludes that "the extent of downward bias in standard error reported in these data (a few percent to ~15%) also appears not to be very substantial, especially when compared to the range of standard errors across studies due to differences in population size and numbers of days available" (p. 9-35).

In those cases in which more than one lag model was estimated with each estimation approach, we followed the same procedure described in Section 4.3 above: where the best lag was identified by the study authors, we used this lag in the risk assessment. Where several lags were presented and the authors did not identify a best lag, we selected both 0- and 1-day lag models for mortality (both total and cause-specific), 0- and 1-day lag models for both cardiovascular and respiratory hospital admissions, and 0-, 1-, and 2-day lag models (if all three

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[21] In some cases (e.g., Moolgavkar, 2000a) two different versions of the "GAM (stringent)" approach were used – one with 30 degrees of freedom (df) and the other with 100 df. In those cases, we included only the version with 30 df in the base case results.

were available) for COPD hospital admissions, based on the discussion of lags in the 2005 PM SP.

In Los Angeles, Moolgavkar (2003) used several alternative estimation approaches and lag structures. We included a much wider array of models for this urban location in a sensitivity analysis for "as is" $PM_{2.5}$ concentrations in Section 7 (see Exhibit 7.11) to show the effects of different estimation approaches, for a given lag structure, and the effects of different lag structures, for a given estimation approach. First, for total non-accidental mortality, using the "GAM stringent" approach (with 30 degrees of freedom), we included the same lag models noted above. Next, we included all of the estimation approaches for each of the lag models listed above for the different endpoints: both 0- and 1-day lag models for mortality (both total and cause-specific); and 0- and 1-day lag models for both cardiovascular and respiratory hospital admissions. Given the inconsistent pattern observed for different lags for COPD mortality in this study, we did not include risk estimates for this endpoint in Los Angeles in either the base case or sensitivity analyses.

4.5   Long-term exposure mortality C-R functions

There are far fewer long-term exposure studies than short-term exposure studies cited in the 2004 PM CD. The available long-term exposure mortality C-R functions are all based on cohort studies, in which a cohort of individuals is followed over time. As discussed in the 2005 PM SP (Section 3.3.1.2), based on the evaluation contained in the 2004 PM CD and the OAQPS staff's assessment of the complete data base, two cohorts that have been studied are particularly relevant for the purposes of this risk assessment. One cohort, in six U.S. cities, was originally followed in a study referred to as the Six Cities study. The other cohort, of participants enrolled by American Cancer Society (ACS) volunteers, was composed of a much larger sample of individuals from many more cities. It was originally followed in a study referred to as the ACS study. There have been reanalyses of both the Six Cities study and the ACS study by Krewski et al. (2000), referred to here as Krewski et al. (2000) – Six Cities and Krewski et al. (2000) – ACS. Both of these reanalyses are included in the $PM_{2.5}$ risk assessment.

More recently, Pope et al. (2002) extended the follow-up period for the ACS cohort to sixteen years and published findings on the relationship of long-term exposure to $PM_{2.5}$ and all-cause mortality as well as cardiopulmonary and lung cancer mortality. As discussed more fully in Section 8.2.3.2.2 of the 2004 PM CD, the 2002 study has a number of advantages over previous analyses, including: doubling the follow-up time and tripling the number of deaths, expanding the ambient air pollution data to include two recent years of $PM_{2.5}$ data, improving the statistical adjustment for occupational exposure, incorporating data on dietary factors believed to be related to mortality, and using more recent developments in nonparametric spatial smoothing and random effects modeling. Recently, the Health Effects Subcommittee (HES) of the Science Advisory Board's (SAB) Clean Air Act Compliance Council indicated its preference that EPA use the results from this study rather than the results from the Krewski et al. (2000) ACS and/or

Six Cities analyses to represent base case estimates for long-term exposure mortality associated with $PM_{2.5}$ concentrations for the purposes of benefits analyses (SAB, 2004). Two periods of $PM_{2.5}$ measurements were considered in the ACS-extended study. The first, from 1979 through 1983, was the period considered in the original ACS study as well as in the Krewski reanalysis. The second was 1999-2000. The authors also report results based on an average of the two periods. The HES recommended that EPA use the results based on the average of the two periods from this study as representing the best estimates. The HES stated that this choice "may serve to reduce measurement error" (SAB, 2004). We therefore selected the corresponding C-R functions based on $PM_{2.5}$ measurements averaging the air quality data from the two periods to be included in the current $PM_{2.5}$ risk assessment. We note that the relative risks reported by Pope et al. (2002) corresponding to the earlier period (1979-1983) were somewhat smaller (RR = 1.04) than the relative risk reported for either the 1999-2000 or average of the two periods (RR = 1.06). We note also that in the ACS cohort, the strongest associations between $PM_{2.5}$ and mortality were among the less educated participants who form a relatively small portion of the total study cohort. If the education distribution were adjusted to reflect the education distribution in the general U.S. population, the summary effect estimate would increase.

Two other PM cohort studies that are discussed in the 2004 PM CD are not included in the PM risk assessment. The Adventist Health Study of Smog (AHSMOG) followed 6,338 non-smoking non-Hispanic white Seventh day Adventist residents of California. The other study, the EPRI-Washington University Veteran's study, followed a cohort of 26,000 middle-aged male veterans who were, at the time of recruitment, mildly to moderately hypertensive and having a very high percentage of prior smoking. The 2004 PM CD presents a comparison of the study designs and results (see Section 8.2.3.2.5) and concludes:

> In considering the results of these studies together, statistically significant associations are reported between fine particles and mortality in the ACS and Six Cities analyses, inconsistent but generally positive associations with PM were reported in the AHSMOG analyses, and distinctly inconsistent results were reported in the VA study. Based on several factors, the larger study population in the ACS study, the larger air quality data set in the Six Cities study, the more generally representative study populations used in the Six Cities and ACS studies, and the fact that these studies have undergone extensive reanalyses – the greatest weight should be placed on the results of the ACS and Six Cities cohort studies in assessing relationships between long-term PM exposure and mortality.(U.S. EPA 2004, pp.8-120 to 8-121)

Based on this assessment, for purposes of the quantitative risk assessment, only the results of the ACS and Six Cities cohort studies have been included. The Veteran's study, which did not find any positive associations between indicators of long-term exposures to PM, and the Seventh Day Adventist study, which reported some positive but not statistically significant associations for males with long-term exposure to $PM_{2.5}$ are discussed in greater detail in the 2004 PM CD and the 2005 PM SP.

4.6   Summary

To summarize, the basic approach to selecting C-R functions was as follows:

- if a single-city C-R function has been estimated in a risk assessment location and a multi-city study on the same health endpoint which includes that location is also available, risk and risk reduction estimates based on both are reported in the base case analysis; and

- if both single-pollutant and multi-pollutant C-R functions are available, risk and risk reduction estimates based on both are reported;

- based on the evaluation of the issue of selecting appropriate lags in the 2005 PM SP, if only single lag models were available, we selected both 0- and 1-day lag models for mortality (both total and cause-specific), 0- and 1-day lag models for both cardiovascular and respiratory hospital admissions, and 0-, 1-, and 2-day lag models (if all three were available) for COPD hospital admissions, where there was a consistent pattern across these lags. If the study authors did identify a best lag, however, we focused on the lag they identified as best.

- For short-term exposure studies that were reanalyzed in light of the GAM/S-Plus issue, if more than one alternative estimation approach was used, we selected the GAM approach with a more stringent convergence criterion; if more than one lag model was estimated, we followed the procedure we used for all studies, described above.

- For one city (Los Angeles), we included alternative approaches to estimating the C-R function (e.g., use of GLM) in combination with the preferred lags discussed above to illustrate the effects of these alternative model specifications on the risk estimates.

- For long-term exposure mortality, the most recently published C-R functions are used in the $PM_{2.5}$ risk assessment. Two of these are based on reanalyses of original cohort data; one (Pope et al., 2002) is an extension of the original study.

5.   Baseline Health Effects Incidence Rates

Most of the epidemiology studies used in the PM risk assessment directly estimate the percentage change in incidence (i.e., the RR), rather than the absolute number of cases for an endpoint. To estimate the annual number of PM-associated cases using these studies, it is necessary to know the annual baseline incidence, that is, the annual number of cases in a location *before* a change in PM air quality.

Incidence rates express the occurrence of a disease or event (e.g., asthma episode, hospital admission, premature death) in a specific period of time, usually per year. Rates are expressed either as a value per population group (e.g., the number of cases in Philadelphia County) or a value per number of people (e.g., number of cases per 10,000 residents), and may be age and sex specific. Incidence rates vary among geographic areas due to differences in population characteristics (e.g, age distribution) and factors promoting illness (e.g., smoking, air pollution levels).[22]   The sizes of the populations in the assessment locations that are relevant to the risk assessment (i.e., the populations for which the PM C-R functions are estimated and to which the baseline incidences refer) are given in Exhibits 5.1 and 5.2 for the $PM_{2.5}$ and $PM_{10-2.5}$ risk assessments, respectively.

Incidence rates are available for mortality (death rates) and for specific communicable diseases which state and local health departments are required to report to the federal government. None of the morbidity endpoints included in the risk assessment are required to be reported to the federal government. In addition to the required federal reporting, many state and local health departments collect information on some additional endpoints. These most often are restricted to hospital admission or discharge diagnoses, which are collected to assist in planning medical services. Data may also be collected for particular studies of health issues of concern.

Although federal agencies collect incidence data on many of the endpoints included in the risk assessment, their data are often available only at the national level (national averages), or at the regional or state level. We contacted state and local health departments and hospital planning commissions to obtain location-specific rates of cause-specific hospital admissions.

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[22] Incidence rates also vary within a geographic area due to the same factors; however, statistics regarding within-city variations are rarely available and are not necessary for this analysis.

Exhibit 5.1 Relevant Population Sizes for PM$_{2.5}$ Risk Assessment Locations

City	Population[a]							
	Total	Ages 7-14	Ages ≥25	Ages ≥30	Ages <65	Ages ≥ 65	Ages <75	Ages ≥75
Boston[1]	2,806,000	283,000 (10%)	1,903,000 (68%)	1,673,000 (60%)	---		---	---
Detroit[2]	2,061,000		---	1,153,000 (56%)	---	249,000 (12%)	---	---
Los Angeles[3]	9,519,000		---	5,092,000 (53%)	---	927,000 (10%)	---	---
Philadelphia[4]	1,518,000		---	852,000 (56%)	---	---	---	---
Phoenix[5]	3,072,000		---	1,684,000 (55%)	---	359,000 (12%)	---	---
Pittsburg[6]	1,281,666		---	814,000 (64%)	---	---	1,166,000 (91%)	116,000 (9%)
San Jose[7]	1,683,000		---	965,000 (57%)	---	---	---	---
Seattle[8]	1,737,000		---	1,044,000 (60%)	1,555,000 (90%)	---	---	---
St. Louis[9]	2,518,000	307,000 (12%)	1,637,000 (65%)	1,475,000 (59%)	---	---	---	---

[a] Total population and age-specific population estimates taken from the CDC Wonder website are based on 2000 U.S. Census data. See
http://factfinder.census.gov/. Populations are rounded to the nearest thousand. The urban areas given in this exhibit are those considered in the studies used in
the PM$_{2.5}$ risk assessment. The percentages in parentheses indicate the percentage of the total population in the specific age category.

[1] Middlesex, Norfolk, and Suffolk Counties.   [2] Wayne County.   [3] Los Angeles County.   [4] Philadelphia County.

[5] Maricopa County.   [6] Allegheny County.   [7] Santa Clara County.   [8] King County.

[9] St. Louis, Franklin, Jefferson, St. Charles, Clinton (IL), Madison (IL), Monroe (IL), and St. Clair (IL) Counties and St. Louis City.

Exhibit 5.2 Relevant Population Sizes for PM$_{10\text{-}2.5}$ Risk Assessment Locations

City	Population[a]			
	Total	Ages 7-14	Ages ≥ 65	Ages <65
Detroit[1]	2,061,000	---	249,000 (12%)	---
Seattle[2]	1,737,000	---	---	1,555,000 (90%)
St. Louis[3]	2,518,000	307,000 (12%)	---	---

[a] Total population and age-specific population estimates are based on 2000 U.S. Census data. See http://factfinder.census.gov/. Populations are rounded to the nearest thousand. The urban areas given in this exhibit are those considered in the studies used in the PM$_{10\text{-}2.5}$ risk assessment. The percentages in parentheses indicate the percentage of the total population in the specific age category.
[1] Wayne County.
[2] King County.
[3] St. Louis, Franklin, Jefferson, St. Charles, Clinton (IL), Madison (IL), Monroe (IL), and St. Clair (IL) Counties and St. Louis City.

We obtained estimates of location-specific baseline mortality rates for each of the PM$_{2.5}$ risk assessment locations for 2001 from CDC Wonder, an interface for public health data dissemination from the Centers for Disease Control (CDC).[23] The mortality rates are derived from U.S. death records and U.S. Census Bureau post-censal population estimates, and are reported in Exhibit 5.3 per 100,000 general population. In all cases, the incidence rates listed correspond to the ages of the populations studied in the relevant epidemiology studies (e.g., individuals over 65 years of age). National rates are provided for 2001 from CDC Wonder for comparison. The epidemiological studies used in the risk assessment reported causes of mortality using the ninth revision of the International Classification of Diseases (ICD-9) codes. However, the tenth revision has since come out, and baseline mortality incidence rates for 2001 shown in Exhibit 5.3 use ICD-10 codes. The groupings of ICD-9 codes used in the epidemiological studies and the corresponding ICD-10 codes used to calculate year 2001 baseline incidence rates is given in Exhibit 5.4.

Baseline incidence rates for both cardiovascular and respiratory hospital admissions were obtained for those locations in which hospital admissions C-R functions were estimated: Detroit, Los Angeles, and Seattle. Year 2000 hospitalization data were obtained for Wayne County (Detroit) from the Michigan Health and Hospital Association. Year 1999 hospitalization data were obtained for Los Angeles County from California's Office of Statewide Health Planning and Development – Health Care Information Resource Center. Finally, year 2000 hospitalization data were obtained for King County (Seattle) from the State of Washington

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[23] See http://wonder.cdc.gov/.

Department of Health, Center for Health Statistics, Office of Hospital and Patient Data Systems. These data are presented in Exhibits 5.5 and 5.6. The data from these counties are actually annual hospital discharge data, which are used as a proxy for hospital admissions. Hospital discharges are issued to all people who are admitted to the hospital, including those who die in the hospital. By using the annual discharge rate, we assume that the admissions at the end of the year (e.g. 2000) that carry over to the beginning of the next year (e.g. 2001), and are therefore not included in the discharge data are offset by the admissions in the previous year (e.g. 1999) that carry over to the beginning of the current year (e.g. 2000).

For respiratory symptoms the only available estimates of baseline incidence rates are from the studies that estimated the C-R functions for those endpoints. Schwartz and Neas (2000) is the only respiratory symptom study included in the PM risk assessment. This study estimated multi-city C-R functions using six cities, including Boston and St. Louis. The baseline incidence rates in this study are likewise based on all six cities combined. The C-R functions and the baseline incidence rates (for lower respiratory symptoms and cough) were used in Boston and St. Louis.

Exhibit 5.3 Baseline Mortality Rates for 2001 for PM$_{2.5}$ Risk Assessment Locations*

Health Effect	Boston[1]	Detroit[2]	Los Angeles[3]	Philadelphia[4]	Phoenix[5]	Pittsburgh[6]	San Jose[7]	St. Louis[8]	Seattle[9]	National Average
Mortality[a]:										
A. Mortality Rates Used in Risk Analysis for Short-Term Exposure Studies[b] (deaths per 100,000 general population/year)										
Non-accidental (all ages): ICD-9 codes < 800	776	916	581	---	---	---	494	869	---	791
Non-accidental (75+): ICD-9 codes < 800	---	---	---	---	---	761	---	---	---	469
Non-accidental (<75): ICD-9 codes < 800	---	---	---	---	---	399	---	---	---	322
Cardiovascular (all ages): ICD-9 codes: 390-459	---	416	---	---	---	---	206	---	---	328
Cardiovascular (all ages): ICD-9 codes: 390-448	---	---	---	418	---	---	---	---	---	324
Cardiovascular (65+): ICD-9 codes: 390-448	---	---	---	---	211	---	---	---	---	273
Cardiovascular (all ages): ICD-9 codes: 390-429	---	---	207	---	---	---	---	---	---	252
Ischemic Heart Disease (all ages): ICD-9 codes: 410-414	122	---	---	---	---	---	---	206	---	152
Respiratory (all ages): ICD-9 codes: 11, 35, 472-519, 710.0, 710.2, 710.4	---	---	---	---	---	---	51	---	---	80

Health Effect	Boston[1]	Detroit[2]	Los Angeles[3]	Philadelphia[4]	Phoenix[5]	Pittsburgh[6]	San Jose[7]	St. Louis[8]	Seattle[9]	National Average
Ischemic Heart Disease (all ages): ICD-9 codes: 410-414	122	---	---	---	---	---	---	206	---	152
Respiratory (all ages): ICD-9 codes: 11, 35, 472-519, 710.0, 710.2, 710.4	---	---	---	---	---	---	51	---	---	80
Respiratory (all ages): ICD-9 codes: 460-519	---	72	---	---	---	---	---	---	---	79
COPD without Asthma (all ages): ICD-9 codes: 490-492, 494-496	36	---	---	---	---	---	---	39	---	42
COPD with Asthma (all ages): ICD-9 codes: 490-496	---	---	30	---	---	---	---	---	---	43
Pneumonia (all ages): ICD-9 codes: 480-487	26	---	---	---	---	---	---	27	---	22
B. Mortality Rates Used in Risk Analysis for Long-term Exposure Studies[b] (deaths per 100,000 general population/year)										
Total mortality (25+): ICD-9 codes: all	803	---	---	---	---	---	---	905	---	822

Health Effect	Boston[1]	Detroit[2]	Los Angeles[3]	Philadelphia[4]	Phoenix[5]	Pittsburgh[6]	San Jose[7]	St. Louis[8]	Seattle[9]	National Average
Total mortality (30+): ICD-9 codes: all	797	937	591	1100	676	1189	499	897	637	814
Cardiopulmonary Mortality (25+): ICD-9 codes: 400-440, 485-495	297	---	---	---	---	---	---	391	---	341
Cardiopulmonary Mortality (30+): ICD-9 codes: 401-440, 460-519	347	468	313	489	313	573	247	439	287	391
Lung Cancer Mortality (30+): ICD-9 code: 162	55	64	33	72	42	78	30	61	44	55

*The epidemiological studies used in the risk assessment reported causes of mortality using the ninth revision of the International Classification of Diseases (ICD-9) codes. However, the tenth revision has since come out, and baseline mortality incidence rates for 2001 shown in this exhibit use ICD-10 codes. The groupings of ICD-9 codes used in the epidemiological studies and the corresponding ICD-10 codes used to calculate year 2001 baseline incidence rates is given in Exhibit 5.4.

[a] Mortality figures were obtained from CDC Wonder for 2001. See http://wonder.cdc.gov/.

[b] Mortality rates are presented only for the locations in which the C-R functions were estimated. All incidence rates are rounded to the nearest unit. Mortality rates for St. Louis may be slightly underestimated because some of the mortality counts in the smaller counties were reported as missing in CDC Wonder.

[1] Middlesex, Norfolk, and Suffolk Counties.   [2] Wayne County.   [3] Los Angeles County.   [4] Philadelphia County.

[5] Maricopa County.   [6] Allegheny County.   [7] Santa Clara County.

[8] St. Louis, Franklin, Jefferson, St. Charles, Clinton (IL), Madison (IL), Monroe (IL), and St. Clair (IL) Counties and St. Louis City.

[9] King County.

Exhibit 5.4 ICD-9 Codes used in Epidemiological Studies and Corresponding ICD-10 Codes

Causes of Death	ICD-9 Codes	ICD-10 Codes
A. Causes of Death used in Short-Term Exposure Studies		
Non-accidental	<800	A00-R99
Cardiovascular	390-459	G45.0-G45.2, G45.4,G45.9, G54.0, G90.3, G93.6, G93.8, G95.1, I00-I13.9, I20.0-I22.9, I24.1-I64, I67.0-I87.9, I89.0-I95.9, I99, K66.1, K92.2, M21.9, M30.0-M31.9, R00.1, R00.8, R01.2, R58
Cardiovascular	390-448	G45.0-G45.2, G45.4-G45.9, G54.0, G93.6, G93.8, G95.1, I00-I13.9, I20.0-I22.9, I24.1-I64, I67.0-I78.9, M21.9, M30.0-M31.9, R00.1, R00.8, R01.2
Cardiovascular	390-429	I00-I13.9, I20.0-I22.9, I24.1-I51.9, I71.9, M21.9, R00.1, R00.8, R01.2
Ischemic Heart Disease	410-414	I20.0-I22.9, I23.6, I24.0-I24.9, I25.1-I25.9, M21.9
Respiratory	11, 35, 472-519, 710.0, 710.2, 710.4	A16.2, A16.4, A16.9, A46, A48.1, B05.2, B90.9, J65, J02.9, J03.9, J05.0, J10.0-J16.8, J18.0-J18.9, J20.9, J30.0-J32.9, J33.9-J34.1, J34.3-J39.8, J40-J64, J66.0-J94.9, J98.0-J98.9, M32.0-M32.9, M35.0, M33.2, P28.8, R09.1
Respiratory	460-519	J00-J01.9, J02.8-J02.9, J03.8-J64, J66.0-J94.9, J98.0-J98.9, P28.8, R06.5, R09.1
COPD without Asthma	490-492, 494-496	J20.9, J40-J44.9, J47, J67.0-J67.9, J98.0
COPD with Asthma	490-496	J20.9, J40-J47, J67.0-J67.9 J98.0
Pneumonia	480-487	A48.1, B05.2, J10.0-J18.9, J99.8
B. Health Effects used in Long-term Exposure Studies		
Total Mortality	all	all

Causes of Death	ICD-9 Codes	ICD-10 Codes
Cardiopulmonary Mortality	400-440, 485-495	G45.0-G45.2, G45.4-G45.9, G93.6, G93.8, G95.1, I10-170.9, I72.9, M21.9, R00.1, R00.8, R01.2, J10.0-J11.8, J18.0, J18.2-J18.9, J20.9, J40-J43.9, J44.1-J44.8, J45.0-J47, J67.0-J67.9, J98.0
Cardiopulmonary Mortality	401-440, 460-519	G45.0-G45.2, G45.4-G45.9, G93.6, G93.8, G95.1, I10-170.9, I72.9, M21.9, R00.1, R00.8, R01.2, A48.1, B05.2, J00-J01.9, J02.8-J02.9, J03.8-J64, J66.0-J94.9, J98.0-J98.9, P28.8, R06.5, R09.1
Lung Cancer Mortality	162	C33-C34.9, C39.8, C45.7

Exhibit 5.5 Baseline Hospitalization Rates for PM$_{2.5}$ Risk Assessment Locations [a]

Health Effect	Detroit[1]	Los Angeles[2]	Seattle[3]
Hospital Admissions (per 100,000 general population/year)			
Pneumonia admissions (65 and over): ICD codes 480-486	250	---	---
COPD and asthma admissions (all ages): ICD codes 490-496	---	318	---
COPD and asthma admissions (65 and over): ICD codes 490-496	192	---	---
Asthma (<65): ICD code 493	---	---	92
Cardiovascular admissions (65 and over): ICD codes: 390-429	---	728	---
Ischemic heart disease (65 and over): ICD codes 410-414	487	---	---
Dysrhythmias (65 and over): ICD code 427	161	---	---
Congestive heart failure (65 and over): ICD code 428	341	---	---

[a] Hospitalization rates are presented only for the locations in which the C-R functions were estimated.   For each location, the number of discharges was divided by the location's population from the 2000 U.S. Census estimates to obtain rates. All incidence rates are rounded to the nearest unit.

1. Wayne County. Year 2000 hospitalization data were obtained from the Michigan Health and Hospital Association.

2. Los Angeles County. Year 1999 hospitalization data were obtained from California's Office of Statewide Health Planning and Development – Health Care Information Resource Center.

3. King County. Year 2000 hospitalization data were obtained from the State of Washington Department of Health, Center for Health Statistics, Office of Hospital and Patient Data Systems.

Exhibit 5.6 Baseline Hospitalization Rates for PM$_{10-2.5}$ Risk Assessment Locations [a]

Health Effect	Detroit[1]	Seattle[2]
Hospital Admissions (per 100,000 general population/year)		
Pneumonia admissions (65 and over): ICD codes 480-486	250	---
COPD with asthma (65 and over): ICD codes 490-496	192	---
Asthma (<65): ICD code 493	---	92
Ischemic heart disease (65 and over): ICD codes 410-414	487	---
Dysrhythmias (65 and over): ICD code 427	161	---
Congestive heart failure (65 and over): ICD code 428	341	---

[a] Hospitalization rates are presented only for the locations in which the C-R functions were estimated. For each location, the number of discharges was divided by the location's population from the 2000 U.S. Census estimates to obtain rates. All incidence rates are rounded to the nearest unit.

1. Wayne County. Year 2000 hospitalization data were obtained from the Michigan Health and Hospital Association.

2. King County. Year 2000 hospitalization data were obtained from the State of Washington Department of Health, Center for Health Statistics, Office of Hospital and Patient Data Systems.

6.   Sources of Uncertainty and Variability

The PM health risk models that were used in the risk assessment combined information about PM for specific urban areas to derive estimates of the annual incidence of specified health effects associated with "as is" PM concentrations and the reduction in incidence that would result upon just meeting the current $PM_{2.5}$ standards in those areas. The three main inputs to such analyses -- air quality information, C-R information, and baseline incidence and population information -- all vary from one time and location to another time and location. In addition, there are uncertainties associated with each of these three main inputs to the health risk assessment.

We were able to obtain air quality information for many, but not all days in the year for each assessment location. Some uncertainty surrounding the results of the analyses therefore arises from the incompleteness of the air quality data. Even if the air quality data were complete, there is always some degree of measurement error with any monitoring data, including that of PM. We also recognize that for any given assessment location there is year to year variability in the distribution of daily PM ambient concentrations and annual average concentrations. The current health risk assessment focuses on a single year and does not incorporate year-to-year variability, except in its use of design values which were based on the most recent three-year period available. Annual risk estimates in an area just meeting a set of standards would be expected to vary from year to year. If PM levels in the most recent year are the lowest of the three most recent years in a location, applying a design value based on the most recent three-year period available will result in greater reductions in risk and lower remaining risk than would be the case if the design value were based only on the single most recent year.

We were able to obtain baseline incidence rates specific to each assessment location (specifically, for all counties included in each assessment location). However, the available information was not specific to the exact analysis period, although it was possible to obtain baseline incidence rates from quite recent years (e.g., mortality rates were obtained for 2001). The risk assessment also does not reflect any year-to-year variability that may exist in baseline incidence rates. These factors result in some additional uncertainty surrounding the results of the risk assessment, although this uncertainty component is likely to be small.

Finally, even if the input values were from the same times and locations as the analysis periods and locations, they are only *estimates*, and therefore have statistical uncertainty, including sampling error, surrounding them. The specific sources of uncertainty in the PM risk assessment are described in detail below and are summarized in Exhibit 6.1.

Exhibit 6.1 Key Uncertainties in the Risk Assessment

Uncertainty	Comments
Causality	Statistical association does not prove causation. However, the risk assessment considers only health endpoints for which the overall weight of the evidence supports the assumption that $PM_{2.5}$ is likely causally related or, for $PM_{10-2.5}$ that the evidence is suggestive of a causal relationship.
Empirically estimated C-R relations	Because C-R functions are empirically estimated, there is uncertainty surrounding these estimates. Omitted confounding variables could cause bias in the estimated PM coefficients. However, including potential confounding variables that are highly correlated with one another can lead to unstable estimators. Both single- and multi-pollutant models were used where available.
Functional form of C-R relation	Statistical significance of coefficients in an estimated C-R function does not necessarily mean that the mathematical form of the function is the best model of the true C-R relation. Several "hockeystick" models, using various alternative cutpoints, were applied alongside the original log-linear or linear models to assess the risks under a range of models incorporating different potential population thresholds.
Lag structure of C-R relation	There is some evidence that a distributed lag might be the most appropriate model for PM effects associated with short-term exposures. Most studies, however, included only one lag in their models. Omitted lags could cause downward bias in the predicted incidence associated with a given reduction in PM concentrations. A sensitivity analysis using an approach to estimate the possible impact of using a distributed lag C-R function was carried out.
Transferability of C-R relations	C-R functions may not provide an adequate representation of the C-R relationship in times and places other than those in which they were estimated. For example, populations in the analysis locations may have more or fewer members of sensitive subgroups than locations in which functions were derived, which would introduce additional uncertainty related to the use of a given C-R function in the analysis location. However, in the majority of cases, the risk assessment relies on C-R functions estimated from studies conducted in the same location.

Uncertainty	Comments
Extrapolation of C-R relations beyond the range of observed PM data	A C-R relationship estimated by an epidemiological study may not be valid at concentrations outside the range of concentrations observed during the study. To partially address this problem, in the initial base case (1) risks associated with long-term exposures were not calculated for $PM_{2.5}$ levels below 7.5 $\mu g/m^3$, which is the lowest of the lowest measured levels in the long-term exposure studies; and (2) risks associated with short-term exposures were not calculated for $PM_{2.5}$ levels below PRB, which was generally close to or above the lowest measured levels in the short-term exposure studies.
Truncation of risk estimates at the lowest PM concentration observed in a study	As noted above, mortality associated with long-term exposures to $PM_{2.5}$ was not calculated for $PM_{2.5}$ levels below 7.5 $\mu g/m^3$, the lowest of the lowest measured levels in the long-term exposure studies. If there is any positive relationship between $PM_{2.5}$ and mortality below this level, this procedure will understate the $PM_{2.5}$ impact. (This is less of an issue for risks associated with short-term exposures, since the lowest measured levels in the short-term exposure studies were generally close to or below the PRB.)
Adequacy of PM characterization	Only size differentiated particle mass per unit volume has been explicitly considered, and not, for example, chemical composition. However, in the majority of cases, the risk assessment relies on C-R functions estimated from studies conducted in the same location as the assessment location. Therefore differences in PM between the study location in which a C-R function was estimated and the assessment location to which it is applied are, in general, minimal (arising only from possible temporal changes).
Accuracy of PM mass measurement	Possible differences in measurement error, losses of particular components, and measurement method between the assessment locations and the study locations would be expected to add uncertainty to quantitative estimates of risk.
Adequacy of ambient PM monitors as surrogate for population exposure	Possible differences in how the spatial variation in ambient $PM_{2.5}$ levels across each urban area are characterized in the original epidemiological studies compared to the more recent ambient $PM_{2.5}$ data used to characterize current air quality would contribute to uncertainty in the health risk estimates. This would be expected to add even more uncertainty in the case of the $PM_{10-2.5}$ risk assessment where greater spatial variability in ambient monitoring data within an urban area has been observed.

Uncertainty	Comments
Adjustment of air quality distributions to simulate just meeting current $PM_{2.5}$ standards or alternative $PM_{2.5}$ or $PM_{10-2.5}$ standards	The pattern and extent of daily reductions in $PM_{2.5}$ concentrations that would result if current or alternative $PM_{2.5}$ standards were just met is not known. Although the assumption that $PM_{2.5}$ concentrations would be reduced by the same percentage on all days appears reasonable given the patterns observed based on historical data, there remains uncertainty about the shape of the air quality distribution of daily levels upon just meeting alternative $PM_{2.5}$ standards which will depend on future air quality control strategies. There is much greater uncertainty about the use of a proportional air quality adjustment procedure to simulate the daily distribution of ambient $PM_{10-2.5}$ concentrations upon just meeting alternative $PM_{10-2.5}$ standards due to the lack of sufficient $PM_{10-2.5}$ air quality data over time to evaluate the reasonableness of this assumption.
Background PM concentrations	The calculation of PM risk associated with "as is" air quality and of risk reductions that would result if current standards were just met requires as inputs the background PM concentrations in each of the assessment locations. Background concentrations were estimated for the eastern and western regions of the country, but not specifically for the assessment locations. In addition, a constant value is used for the estimated background, which does not take into account seasonal or daily variability in background concentrations. Sensitivity analyses were conducted, however, exploring the impact of assuming both a constant background level at the lower and upper end of the ranges estimated in the 2004 PM CD for $PM_{2.5}$ and $PM_{10-2.5}$ and of allowing daily $PM_{2.5}$ background levels to vary day by day.
Baseline health effects data	Data on baseline incidence is uncertain for a variety of reasons. For example, location- and age-group-specific baseline rates may not be available in all cases. Baseline incidence may change over time for reasons unrelated to PM.

Although the PM risk assessment considered mortality as well as several morbidity health effects, not all health effects which may result from PM exposure were included. Only those for which there was sufficient epidemiological evidence from studies which met the study selection criteria (see Section 3) were included in the risk assessment. Other possible health effects reported to be associated with short- and/or long-term exposures to PM are considered qualitatively in the 2005 PM SP. Thus, the PM risk assessment does not represent all of the health risks associated with PM exposures.

In addition, we limited application of a C-R function to only that portion of the population on which estimation of the function was based. For example, lower respiratory symptoms were examined in Schwartz and Neas (2000) for children ages 7-14. It is likely that the effect of PM on lower respiratory symptoms does not begin at age 7 and end at age 14; however, data are not available to estimate the number of cases avoided for other age groups. Therefore, a substantial number of potentially avoided health effects were likely not captured in this analysis.

6.1 Concentration-response functions

The C-R function is a key element of the PM risk assessment. The quality of the risk assessment depends, in part, on (1) whether the C-R functions used in the risk assessment are good estimates of the relationship between the population health response and ambient PM concentration in the study locations, (2) how applicable these functions are to the analysis periods and locations, and (3) the extent to which these relationships apply beyond the range of the PM concentrations from which they were estimated. These issues are discussed in the subsections below.

6.1.1 Uncertainty associated with the appropriate model form

The relationship between a health endpoint and PM can be characterized in terms of the form of the function describing the relationship – e.g., linear, log-linear, or logistic – and the value of the PM coefficient in that function. Although most epidemiological studies estimated PM coefficients in log-linear models, there is still substantial uncertainty about the correct functional form of the relationship between PM and various health endpoints – especially at the low end of the range of PM values, where data are generally too sparse to discern possible thresholds. While there are likely biological thresholds in individuals for specific health responses, the available epidemiological studies do not support or refute the existence of thresholds at the population level for either long-term or short-term PM exposures within the range of air quality observed in the studies. We addressed this uncertainty by assessing risks based on several "cutpoint" models that were designed to approximate non-linear, sigmoidal-shaped functions that would better reflect possible population thresholds, as described more fully in Section 2.5.3.

It should also be noted that there is increasing uncertainty surrounding risks associated with progressively lower PM levels approaching the lowest measured levels and with progressively higher levels approaching the highest measured levels. This increased uncertainty is not reflected in the confidence intervals for the risk estimates presented in this report, which are based on the standard errors for the PM coefficient in the log linear or linear C-R models reported in the published studies and do not vary by concentration level. As illustrated in a series of figures included in Pope et al. (2002) (Figure 3-4 in the 2005 PM SP), when nonparametric smoothed C-R relationships are plotted, there are increasingly wider pointwise confidence intervals, reflecting the smaller amount of data available, at the lower and upper ends of the range of measured PM concentrations.

6.1.2 Uncertainty associated with the estimated concentration-response functions in the study locations

The uncertainty associated with an estimate of the PM coefficient in a C-R function reported by a study depends on the sample size and the study design. The 2004 PM CD has evaluated the substantial body of PM epidemiological studies. In general, critical considerations in evaluating the design of an epidemiological study include the adequacy of the measurement of ambient PM, the adequacy of the health effects incidence data, and the consideration of potentially important health determinants and potential confounders and effect modifiers such as:

- other pollutants;
- exposure to other health risks, such as smoking and occupational exposure; and
- demographic characteristics, including age, sex, socioeconomic status, and access to medical care.

The selection of studies included in the PM risk assessment was guided by the evaluations in the 2004 PM CD. One of the criteria for selecting studies addresses the adequacy of the measurement of ambient PM. This criterion was that PM was directly measured using $PM_{2.5}$ or, for $PM_{10-2.5}$, $PM_{2.5}$ and PM_{10} at co-located monitors, as the indicator or, for $PM_{2.5}$, was estimated using nephelometry data where direct $PM_{2.5}$ measurement data were not available. This criterion was designed to minimize error in the estimated PM coefficients in the C-R functions used in the risk assessment.

To the extent that a study did not address all relevant factors (i.e., all factors that affect the health endpoint), there is uncertainty associated with the C-R function estimated in that study, beyond that reflected in the confidence interval. It may result in either over- or underestimates of risk associated with ambient PM concentrations in the location in which the study was carried out. Techniques for addressing the problem of confounding factors and other study design issues have improved over the years, however, and the epidemiological studies currently available for use in the PM risk assessment provide a higher level of confidence in study quality than ever before.

When a study is conducted in a single location, the problem of possible confounding co-pollutants may be particularly difficult, if co-pollutants are highly correlated in the study location. Single-pollutant models, which omit co-pollutants, may produce overestimates of the PM effect, if some of the effects of other pollutants (omitted from the model) are falsely attributed to PM. With regard to gaseous co-pollutants as potential confounders in short-term exposure studies, a new multi-city study (NMMAPS; Samet et al., 2000; Dominici et al., 2003) has evaluated the effects of PM_{10} alone and in combination with each of the monitored gaseous co-pollutants across the 90 largest U.S. cities and reported that associations found between PM_{10} and mortality were not confounded by the presence of the gaseous co-pollutants (2004 PM CD, p. 9-36). It is likely that this is true for $PM_{2.5}$ as well, although there is no equivalent $PM_{2.5}$ study like the NMMAPS. Statistical estimates of a PM effect based on a multi-pollutant model can be more uncertain, and even statistically insignificant, if the co-pollutants included in the model are highly correlated with PM. This means that, although the expected value of the estimated PM coefficient is correct, the estimate based on any particular sample may be too low or too high. As a result of these considerations, we report risk estimates based on both single-pollutant and multi-pollutant models, when both are reported by a study.

With respect to the $PM_{10-2.5}$ health risk assessment, the locations used in the risk assessment are not representative of urban areas in the U.S. that experience the most significant 24-hour peak $PM_{10-2.5}$ concentrations, and thus, observations about relative risk reductions associated with alternative standards may not be as relevant to the areas expected to have the greatest health risks associated with elevated ambient $PM_{10-2.5}$ levels. In considering the $PM_{10-2.5}$ risk estimates it also is important to recognize that there is a much smaller health effects database from which to obtain the C-R relationships used in this portion of the risk assessment, compared to that available for $PM_{2.5}$ and, thus, there is significantly greater uncertainty associated with the $PM_{10-2.5}$ risk estimates.

6.1.3 Applicability of concentration-response functions in different locations

As described in Section 3, risk assessment locations were selected on the basis of where C-R functions have been estimated, to avoid the uncertainties associated with applying a C-R function estimated in one location to another location. However, multi-county, multi-city, and/or regional C-R functions were also applied to any risk assessment location contained in the set of locations used to estimate the C-R function. The accuracy of the results based on a multi-location C-R function rests in part on how well this multi-location C-R function represents the relationship between ambient PM and the given population health response in the individual cities involved in the study.

The relationship between ambient PM concentration and the incidence of a given health endpoint in the population (the population health response) depends on (1) the relationship between ambient PM concentration and personal exposure to ambient-generated PM and (2) the

relationship between personal exposure to ambient-generated PM and the population health response. Both of these are likely to vary to some degree from one location to another.

The relationship between ambient PM concentration and personal exposure to ambient-generated PM will depend on patterns of behavior, such as the amount of time spent outdoors, as well as on factors affecting the extent to which ambient-generated PM infiltrates into indoor environments. The relationship between personal exposure to ambient-generated PM and the population health response will depend on both the composition of the PM and on the composition of the population exposed to it.

The composition of PM (e.g., the chemical constituents of the PM) is known to differ from one location to another. As discussed in the 2004 PM CD (see Section 8.2.2.4), growing evidence indicates that there are numerous potentially toxic PM components and some components may act in combination.

Exposed populations also differ from one location to another in characteristics that are likely to affect their susceptibility to PM air pollution. For instance, people with pre-existing conditions such as chronic bronchitis are probably more susceptible to the adverse effects of exposure to PM, and populations vary from one location to another in the prevalence of specific diseases. Also, some age groups may be more susceptible than others, and population age distributions also vary from one location to another. Closely matching populations observed in studies to the populations of the assessment locations is not possible for many characteristics (for example, smoking status, workplace exposure, socioeconomic status, and the prevalence of highly susceptible subgroups).

Other pollutants may also play a role in either causing or modifying health effects, either independently or in combination with PM (see Section 8.1.3.2 in the 2004 PM CD). Inter-locational differences in these pollutants could also induce differences in the C-R relationship between one location and another.

In summary, the C-R relationship is most likely not the same everywhere. Even if the relationship between personal exposure to ambient-generated PM and population health response were the same everywhere, the relationship between ambient concentrations and personal exposure to ambient-generated PM differs among locations. Similarly, even if the relationship between ambient concentrations and personal exposure to ambient-generated PM were the same everywhere, the relationship between personal exposure to ambient-generated PM and population health response may differ among locations. In either case, the C-R relationship would differ.

6.1.4 Extrapolation beyond observed air quality levels

Although a C-R function describes the relationship between ambient PM and a given health endpoint for all possible PM levels (potentially down to zero), the estimation of a C-R function is based on real ambient PM values that are limited to the range of PM concentrations in the location in which the study was conducted. Thus, uncertainty in the shape of the estimated C-R function increases considerably outside the range of PM concentrations observed in the study.

In its initial base case analysis, the PM risk assessment assumes that the estimated C-R functions adequately represent the true C-R relationship down to PRB PM levels in the assessment locations, in the case of short-term exposures, and down to 7.5 $\mu g/m^3$ in the case of long-term exposures. Because we are interested in the effects of anthropogenic PM, this is not a problem for estimating short-term exposures. For long-term exposures, however, while this procedure avoids extrapolating C-R functions below the lowest of the lowest measured levels in the long-term exposure studies, it will tend to understate the impact of long-term exposures to $PM_{2.5}$ if there is actually a C-R relationship below 7.5 $\mu g/m^3$.

The C-R relationship may also be less certain towards the upper end of the concentration range being considered in a risk assessment, particularly if the PM concentrations in the assessment location exceed the PM concentrations observed in the study location. Even though it may be reasonable to model the C-R relationship as log-linear over the ranges of PM concentrations typically observed in epidemiological studies, it may not be log-linear over the entire range of PM levels at the locations considered in the PM risk assessment.[24]

6.2   The air quality data

6.2.1   Use of PM as the indicator

PM is often measured in units of mass per unit volume, and typically reported in micrograms per cubic meter ($\mu g/m^3$). The PM risk assessment used PM size classes – $PM_{2.5}$ and $PM_{10-2.5}$ – and the chemical composition of PM was not considered explicitly (as it was not in most of the epidemiological studies used in these analyses). As summarized in Chapter 9 of the 2004 PM CD, recent studies provide new evidence for health effects associations with many different PM components. Recognizing that ambient PM exposure has been associated with increases in numerous health indices, the evidence is still too limited to allow identification of

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[24] Although most of the C-R functions reported in the published studies are log-linear, they are practically linear. It is still unlikely, however, that a linear function is appropriate over a very wide range of PM concentrations. Although the base case analyses include alternative non-linear C-R functions developed using a hockey-stick model approach, as discussed in Section 2.5.3, these models do not address possible non-linearity at the high end of the PM range. This is unlikely to be a problem, however, when assessing remaining risks when alternative, more stringent standards are just met.

which PM components or sources might be more toxic than others, and growing evidence indicates that there are numerous potentially toxic PM components and some components may act in combination (see 2004 PM CD, Section 8.2.2.4). It is possible that PM risks may differ from one area to another with differing PM composition, but this potential source of uncertainty cannot be tested in this risk assessment. However, because the risk assessment primarily uses C-R functions estimated from studies conducted in the same location as the analysis location, the C-R functions already capture to some extent the potential impact of differential composition. To the extent that composition differentially affects toxicity and if future control strategies alter the composition in an area, then this introduces an additional uncertainty into the risk estimates associated with just meeting the current or any alternative PM standards.

6.2.2 Adequacy of PM air quality data

The method of averaging data from monitors across a metropolitan area in the risk assessment is similar to the methods used to characterize ambient air quality in most of the epidemiology studies. Ideally, the measurement of average daily ambient PM concentrations in the study location is unbiased. In this case, unbiased risk predictions in the assessment location depend, in part, on an unbiased measurement of average daily ambient PM concentrations in the assessment location as well. If, however, the measurement of average daily ambient PM concentrations in the study location is biased, unbiased risk predictions in the assessment location are still possible if the measurement of average daily ambient PM concentrations in the assessment location incorporates the same bias as exists in the study location measurements. Because this is not known, however, the errors in the PM measurements in the assessment locations are a source of uncertainty in the risk assessment.

As discussed in the 2005 PM SP (see Section 5.4.4.1), the uncertainty related to exposure measurement error in epidemiologic studies linking health effects to $PM_{10-2.5}$ is potentially quite large, and this contributes to much larger uncertainty surrounding the $PM_{10-2.5}$ risk estimates included in this report. For example, as discussed in the 2005 PM SP (p. 5-64),

> in looking specifically at the Detroit study the staff notes that the $PM_{10-2.5}$ air quality values were based on air quality monitors located in Windsor, Canada. The study authors determined that the air quality values from these monitors were generally well correlated with air quality values monitored in Detroit, where the hospital admissions data were gathered, and thus concluded that these monitors were appropriate for use in exploring the association between $PM_{10-2.5}$ air quality and hospital admissions in Detroit. Staff has observed, however, that the $PM_{10-2.5}$ levels reported in this study are significantly lower than the $PM_{10-2.5}$ levels measured at some of the Detroit monitors in 2003 – an annual mean level of 13.3 µg/m^3 is reported in the study, based on 1992 to 1994 data, as compared to an average annual mean level of 21.7 µg/m^3 measured at two urban-center monitors in 2003 (which is used as the basis for the risk assessment).

As discussed in Section 5.4.4.1 of the 2005 PM SP, OAQPS staff's evaluation comparing Windsor and Detroit monitoring data has shown that in recent years the Windsor monitors used in this study typically have recorded $PM_{10-2.5}$ levels that are generally less than half the levels recorded at urban-center Detroit monitors. OAQPS staff have concluded that the association observed in the Detroit study likely reflects population exposure levels that may be appreciably higher in the central city area than those reported in that study (2005 PM SP, p. 5-65). Thus, there are concerns that the current $PM_{10-2.5}$ levels measured at ambient monitoring sites in recent years may be quite different from the levels used to characterize exposure in the original $PM_{10-2.5}$ epidemiologic studies based on monitoring sites in different locations, thus possibly over- or underestimating population risk levels.

PM air quality data were not available for all days of the year chosen for the risk assessment in many of the assessment locations.[25] The change in the incidence of a health effect over the course of the year corresponding to a given change in daily PM levels is calculated based on the assumption that PM levels on those days with PM data are representative of levels on those days without PM data (see Section 2.6 for an explanation of the method of extrapolating changes in health effects incidence to an entire year). If there are seasonal differences in average PM levels and in monitoring frequencies, a simple annual adjustment for missing data could result in a biased estimate of total annual incidence change. To minimize the presence of bias due to an uneven distribution of missing data throughout the year, incidence changes in different quarters of the year were scaled separately, and the scaled quarterly results were added.

Because the PM data in each assessment location were limited to a specific year (usually 2003), the results of the risk assessment are generalizable to the present only to the extent that ambient PM levels in the available data are similar to current ambient PM levels in those locations. A substantial difference between PM levels in the year used in the risk assessment and current PM levels could imply a substantial difference in predicted incidences of health effects. This is not expected to be a large problem for the $PM_{2.5}$ risk assessment, however, because adequate $PM_{2.5}$ monitoring data were available for all but one of the assessment locations in the year 2003, which is quite recent; $PM_{2.5}$ monitoring data were available in 2001 for Phoenix, AZ.

6.2.3 Simulation of reductions in $PM_{2.5}$ and $PM_{10-2.5}$ concentrations to just meet the current and alternative standards

The pattern of daily $PM_{2.5}$ concentrations that would result if the current $PM_{2.5}$ standards were just met in any of the assessment locations is, of course, not known. The assumption that

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[25] $PM_{2.5}$ monitor data were available for all days in the year for two of the locations in the $PM_{2.5}$ risk assessment, and almost complete data were available for most of the other locations; monitor data were substantially more sparse, however, for $PM_{10-2.5}$.

$PM_{2.5}$ concentrations will be reduced by the same percentage on all days is believed to be a reasonable approximation based on an evaluation of how $PM_{2.5}$ concentration distributions have changed historically in some areas (see Appendix B). There is, however, some uncertainty surrounding the predicted daily changes in $PM_{2.5}$ concentrations that would result if the current or alternative standards were just met, and consequently there is some uncertainty surrounding the associated daily changes in population health response. With respect to the $PM_{10-2.5}$ health risk estimates, there is much greater uncertainty about the reasonableness of the use of proportional rollback to simulate attainment of alternative $PM_{10-2.5}$ daily standards in any urban area due to the limited availability of $PM_{10-2.5}$ air quality data over time. This is one of several factors that contributes to the greater uncertainty associated with the $PM_{10-2.5}$ risk estimates.

As noted above, the current health risk assessment focuses on a single year and does not incorporate year-to-year variability, except in its use of design values which were based on the most recent three-year period available. If PM levels in the most recent year are the lowest of the three most recent years in a location, applying a design value based on the most recent three-year period available will result in a greater percent reduction in PM and greater reductions in risk and lower remaining risk than would be the case if the design value were based only on the single most recent year.

6.3   Baseline health effects incidence rates

Most of the C-R functions used in the PM risk assessment are log-linear (see equations 1 through 3 in Section 2.5).[26] Given this functional form, the percent change in incidence of a health effect corresponding to a change in PM depends only on the *change* in PM levels (and not the actual value of either the initial or final PM concentration). This percent change is multiplied by a baseline incidence in order to determine the change in health effects incidence, as shown in equation (3-1) in Section 2.5:

$$\Delta y = y[e^{\beta \Delta x} - 1] . \qquad\qquad (3\text{-}1)$$

in which $e^{\beta \Delta x}$ is the RR, and $[e^{\beta \Delta x} - 1]$ is the percent change associated with a change in PM of Δx. If there has been an increase in PM (i.e., if Δx positive), then the RR will be greater than 1.0. If, for example, the RR associated with a change in PM of Δx is 1.05, then the percent change in incidence of the health effect is 0.05 (5%). The change in incidence of the health effect associated with a change in PM of Δx is, then, 5 percent of the baseline incidence, y. Predicted changes in incidence therefore depend on the baseline incidence of the health effect.

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[26] The exceptions to this are Lipfert et al. (2000), which reports linear C-R functions for cardiovascular mortality, and Schwartz and Neas (2000), which reports logistic functions for respiratory symptoms.

6.3.1 Quality of incidence data

County-specific incidence data were available for mortality for all counties. We have also obtained hospital admissions baseline incidence data for all the urban areas for which we have hospital admissions C-R functions for one or more of the PM indicators (Detroit, Los Angeles, and Seattle). This is clearly preferable to using non-local data, such as national incidence rates. As with any health statistics, however, misclassification of disease, errors in coding, and difficulties in correctly assigning residence location are potential problems. These same potential sources of error are present in most epidemiological studies. In most cases, the reporting institutions and agencies utilize standard forms and codes for reporting, and quality control is monitored.

Data on hospital admissions are actually hospital discharge data rather than admissions data. Because of this, the date associated with a given hospital stay is the date of discharge rather than the date of admissions. Therefore, there may be some hospital admissions in an assessment location in the year of interest (e.g., 2000) that are not included in the baseline incidence rate, if the date of discharge was after the year ended, even though the date of admissions was within the year. Similarly, there may be some hospital admissions that preceded the year of interest that are included in the baseline incidence rate because the date of discharge was within the year of interest. This is a very minor problem, however, partly because the percentage of such cases is likely to be very small, and partly because the error at the beginning of the year (i.e., admissions that should not have been included but were) will largely cancel the error at the end of the year (i.e., admissions that should have been included but were not).

Another minor uncertainty surrounding the hospital admissions baseline incidence rates arises from the fact that these rates are based on the reporting of hospitals within each of the assessment counties. Hospitals report the numbers of ICD code-specific discharges in a given year. If people from outside the county use these hospitals, and/or if residents of the county use hospitals outside the county, these rates will not accurately reflect the numbers of county residents who were admitted to the hospital for specific illnesses during the year, the rates that are required for the risk assessment. Once again, however, this is likely to be a very minor problem because the health conditions studied tend to be acute events that require immediate hospitalization, rather than planned hospital stays.

Incidence rates for respiratory symptoms were obtained from the study reporting the C-R functions for those endpoints (Schwartz and Neas, 2000). Schwartz and Neas (2000) considered six cities, and the baseline incidence rates reported in that study were based on all six locations combined. Therefore there is some uncertainty associated with applying it to the individual locations (Boston and St. Louis) that are in both the study and the PM risk assessment. In addition, because this study is a reanalysis of data collected earlier, changes in baseline incidence rates over time could have introduced additional uncertainty into the analysis.

Regardless of the data source, if actual incidence rates are higher than the incidence rates used, risks will be underestimated. If incidence rates are lower than the incidence rates used, then risks will be overestimated.

Both morbidity and mortality rates change over time for various reasons. One of the most important of these is that population age distributions change over time. The old and the extremely young are more susceptible to many health problems than is the population as a whole. The most recent available data were used in the risk assessment. However, the average age of the population in many locations will increase as post-World War II children age. Consequently, the baseline incidence rates for some endpoints may rise, resulting in an increase in the number of cases attributable to any given level of PM pollution. Alternatively, areas which experience rapid in-migration, as is currently occurring in the South and West, may tend to have a decreasing mean population age and corresponding changes in incidence rates and risk. Temporal changes in incidence are relevant to both morbidity and mortality endpoints. However, the most recent available data were used in all cases, so temporal changes are not expected to be a large source of uncertainty.

6.3.2 Lack of daily health effects incidence rates

Both ambient PM levels and the daily health effects incidence rates corresponding to ambient PM levels vary somewhat from day to day. Those analyses based on C-R functions estimated by short-term exposure studies calculate daily changes in incidence and sum them over the days of the year to predict an annual change in health effect incidence. However, only annual baseline incidence rates are available. Average daily baseline incidence rates, necessary for short-term daily C-R functions, were calculated by dividing the annual rate by the number of days in the year for which the baseline incidence rates were obtained.[27] To the extent that PM affects health, however, actual incidence rates would be expected to be somewhat higher than average on days with high PM concentrations; using an average daily incidence rate would therefore result in underestimating the changes in incidence on such days. Similarly, actual incidence rates would be expected to be somewhat lower than average on days with low PM concentrations; using an average daily incidence rate would therefore result in overestimating the changes in incidence on low PM days. Both effects would be expected to be small, however, and should largely cancel one another out.

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[27] This is 365, unless the baseline incidence data were obtained from the year 2000, which is a leap year, and therefore has 366 days.

7. Assessment of the Health Risks Associated with "As Is" PM$_{2.5}$ Concentrations in Excess of Specified Levels

7.1 Base case analysis
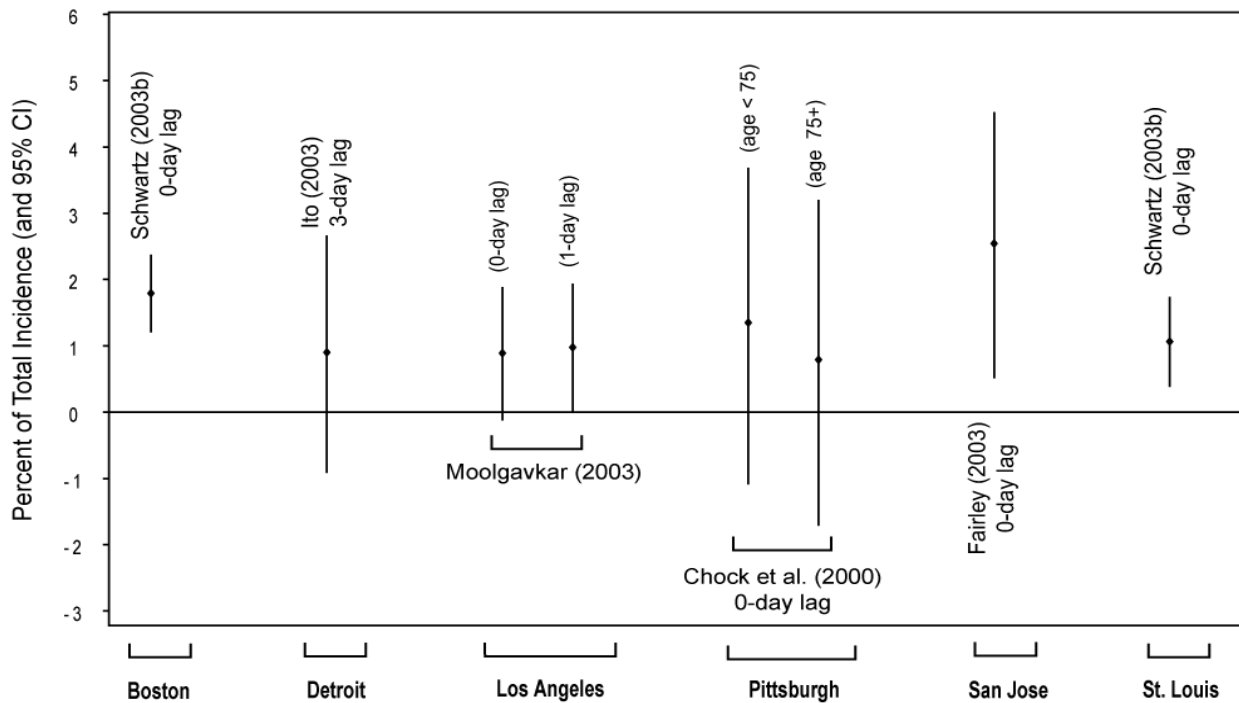
The results of the first part of the risk assessment, assessing the health risks associated with "as is" PM$_{2.5}$ concentrations (representing levels measured in 2003 for most of the assessment locations) in excess of various cutpoints, are summarized across urban areas in figures and, for mortality associated with short-term and long-term exposures, in Exhibits 7.1 and 7.2, respectively. The percent of total incidence that is PM$_{2.5}$-related is shown in Figures 7.1a through 7.6a; the incidence per 100,000 general population is shown in Figures 7.1b through 7.6b.

Although we carried out the base case analysis in each of the assessment locations, to reduce the number of exhibits in this section of the report, we selected one location (Detroit) to include here for illustrative purposes. Exhibit 7.3 shows results in Detroit for health endpoints associated with short-term exposure to "as is" PM$_{2.5}$ concentrations in excess of the estimated PRB concentration, and for mortality associated with long-term exposure to "as is" PM$_{2.5}$ concentrations in excess of 7.5 µg/m^3 (see Section 2.5). Exhibit 7.4 shows results in Detroit for mortality associated with short-term and long-term exposures to PM$_{2.5}$ in excess of each of the specified cutpoint concentrations (see Section 2.5). Results for the other locations corresponding to those shown for Detroit in Exhibits 7.3 and 7.4 are shown in Appendix D, in Exhibits D.1 through D.8 and D.9 through D.16, respectively.
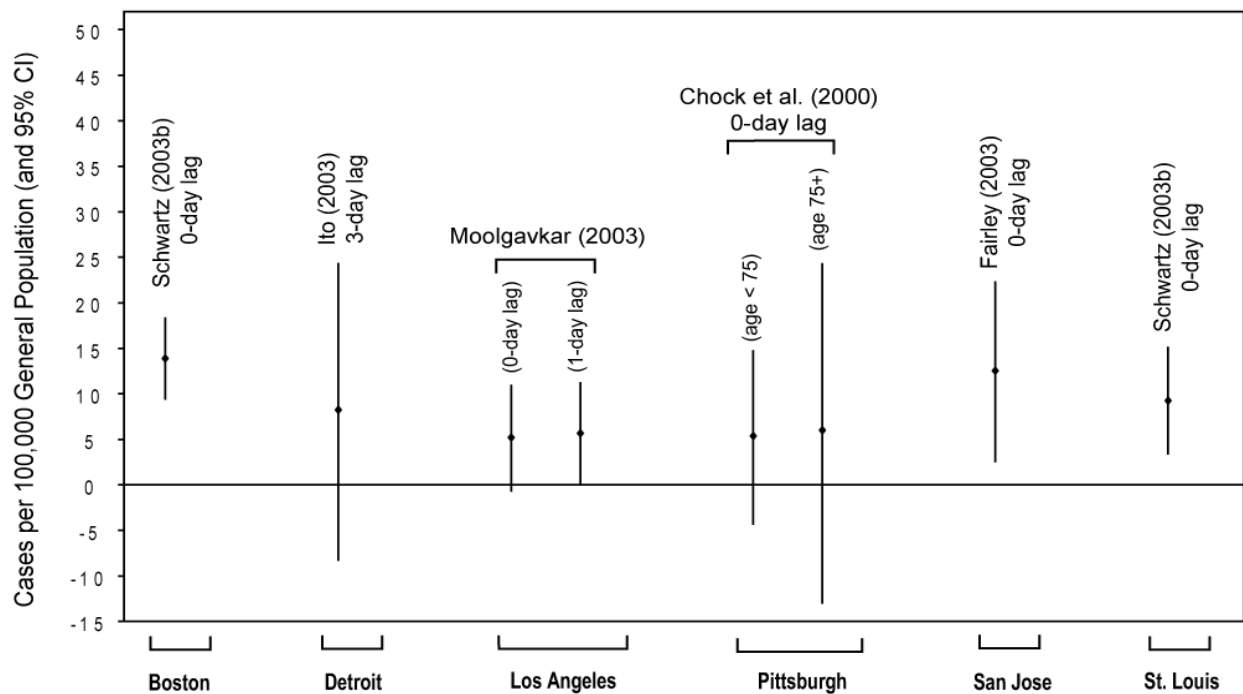
The central tendency estimates in all of the figures and in Exhibits 7.3 and D.1 through D.8 are based on the PM$_{2.5}$ coefficients estimated in the studies, and the ranges are based on the 95 percent confidence intervals (CIs) around those estimates. In Exhibits 7.4 and D.9 through D.16, for results based on cutpoints in excess of the initial base case levels (PRB and 7.5 µg/m^3 for health endpoints associated with short-term and long-term exposures, respectively) the central tendency estimates and 95 percent CIs are based on the adjusted PM$_{2.5}$ coefficients estimated in the studies, as described in Section 2.5.3.

In all portions of the risk assessment, all estimated incidences were rounded to the nearest whole number, except respiratory symptoms, which were rounded to the nearest 100. All percentages were rounded to one decimal place. These rounding conventions are not intended to imply confidence in that level of precision, but rather to avoid the confusion that can result when a greater amount of rounding is used (for example, when the central tendency estimate rounds to the same number as the lower and/or upper bound of the 95 percent confidence interval).
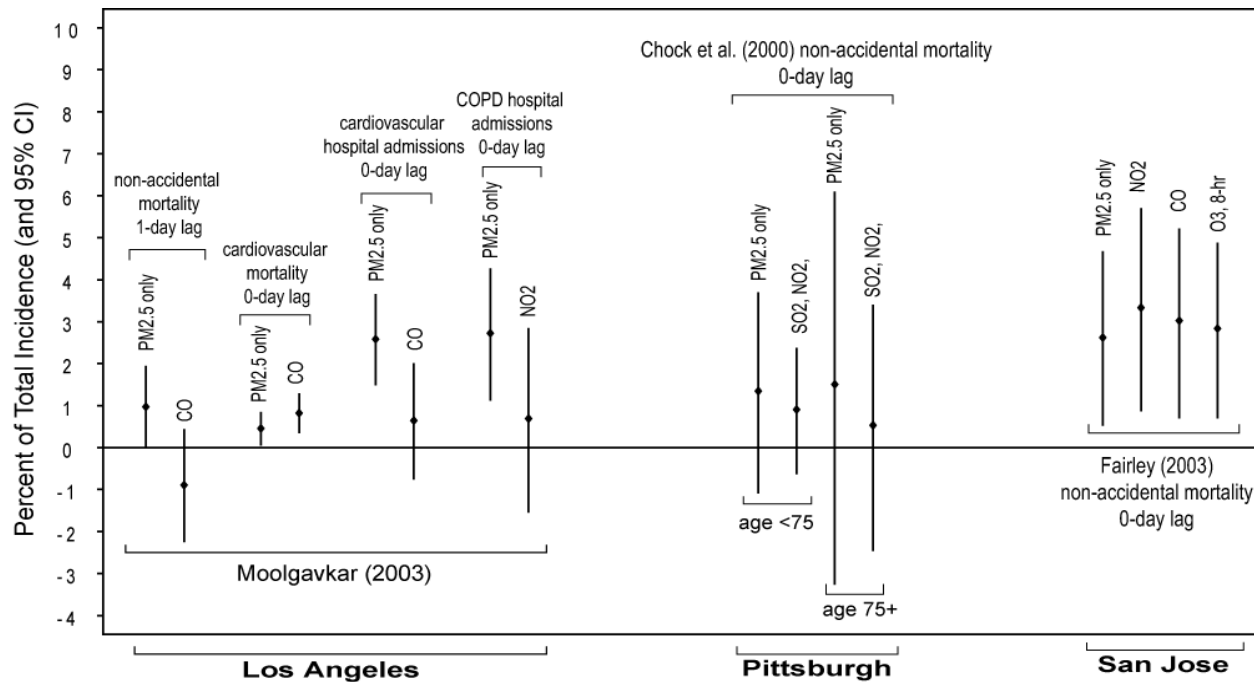
Figure 7.1a. Estimated Annual Percent of Total (Non-Accidental) Mortality Associated with Short-Term Exposure to PM$_{2.5}$ Above Background: Single-Pollutant, Single-City Models
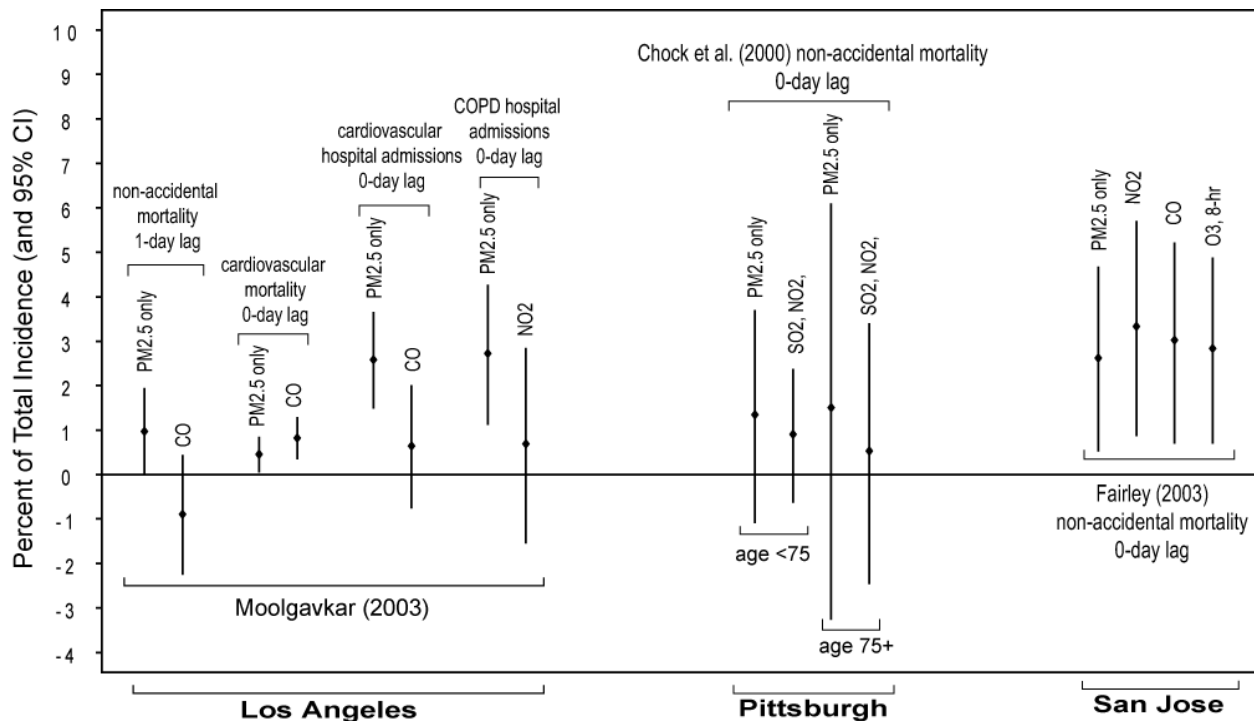
Figure 7.1b. Estimated Annual Cases of Total (Non-Accidental) Mortality per 100,000 General Population Associated with Short-Term Exposure to PM$_{2.5}$ Above Background: Single-Pollutant, Single-City Models
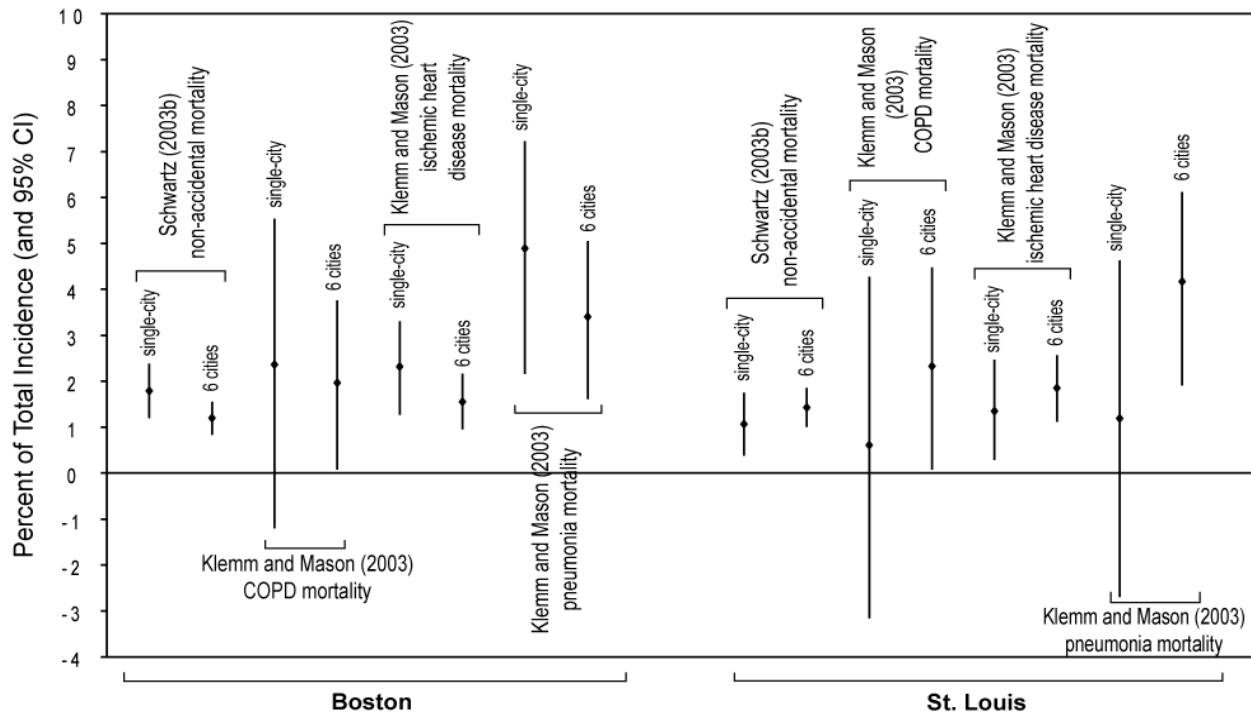
Figure 7.2a. Estimated Annual Percent of Health Effects Associated with Short-Term Exposure to PM$_{2.5}$ Above Background: Results Based on Single-Pollutant versus Multi-Pollutant Models
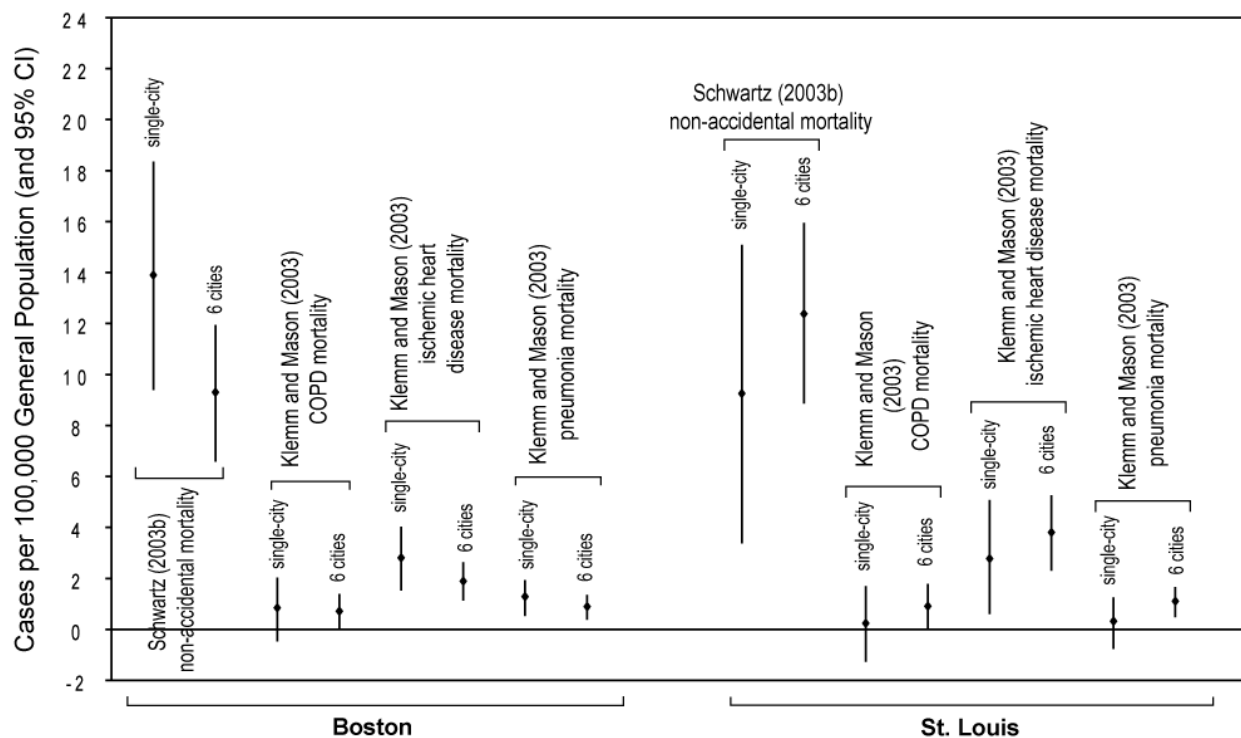
Figure 7.2b. Estimated Annual Cases of Health Effects per 100,000 General Population Associated with Short-Term Exposure to PM$_{2.5}$ Above Background: Results Based on Single-Pollutant versus Multi-Pollutant Models
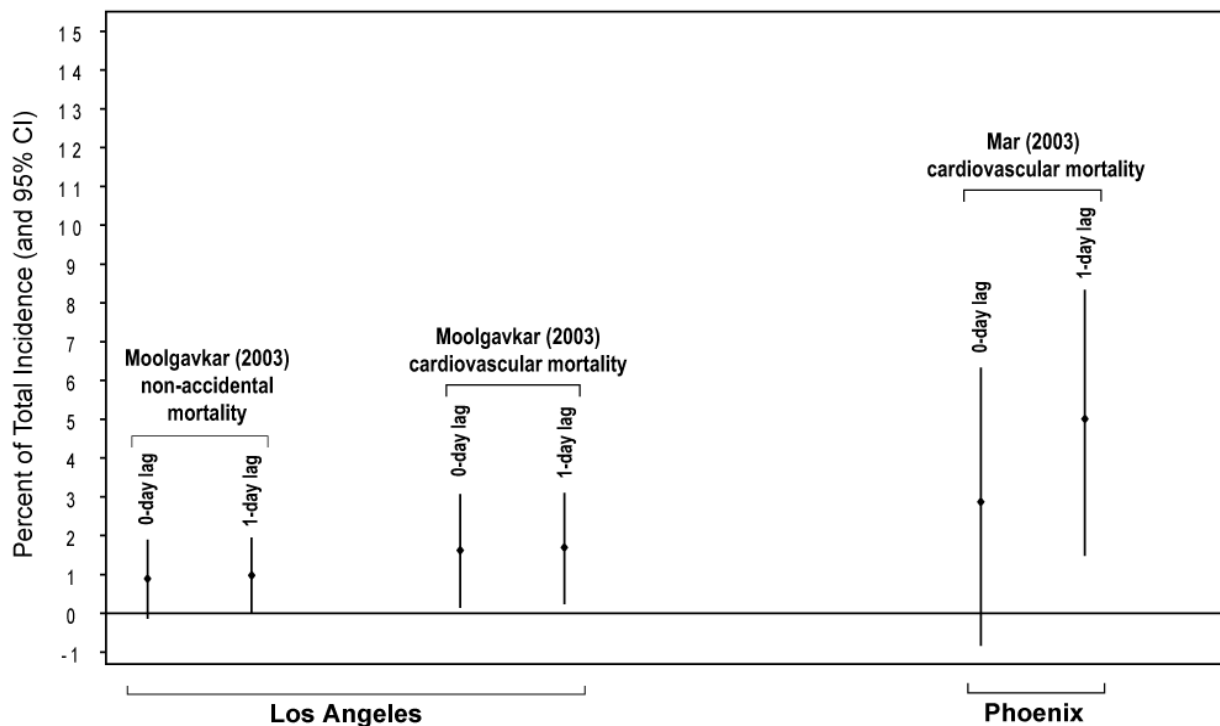
Figure 7.3a. Estimated Annual Percent of Health Effects Associated with Short-Term Exposure to PM$_{2.5}$ Above Background: Results Based on Single-City versus Multi-City Models
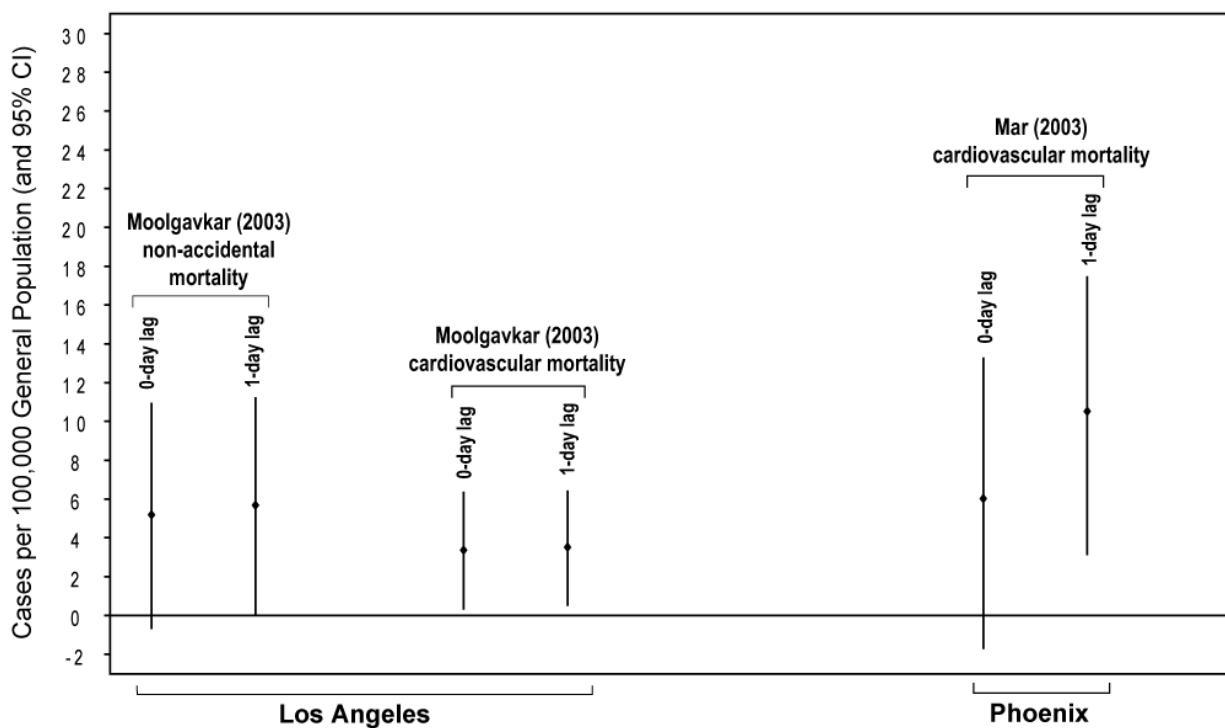
Figure 7.3b. Estimated Annual Cases of Health Effects per 100,000 General Population Associated with Short-Term Exposure to PM$_{2.5}$ Above Background: Results Based on Single-City versus Multi-City Models
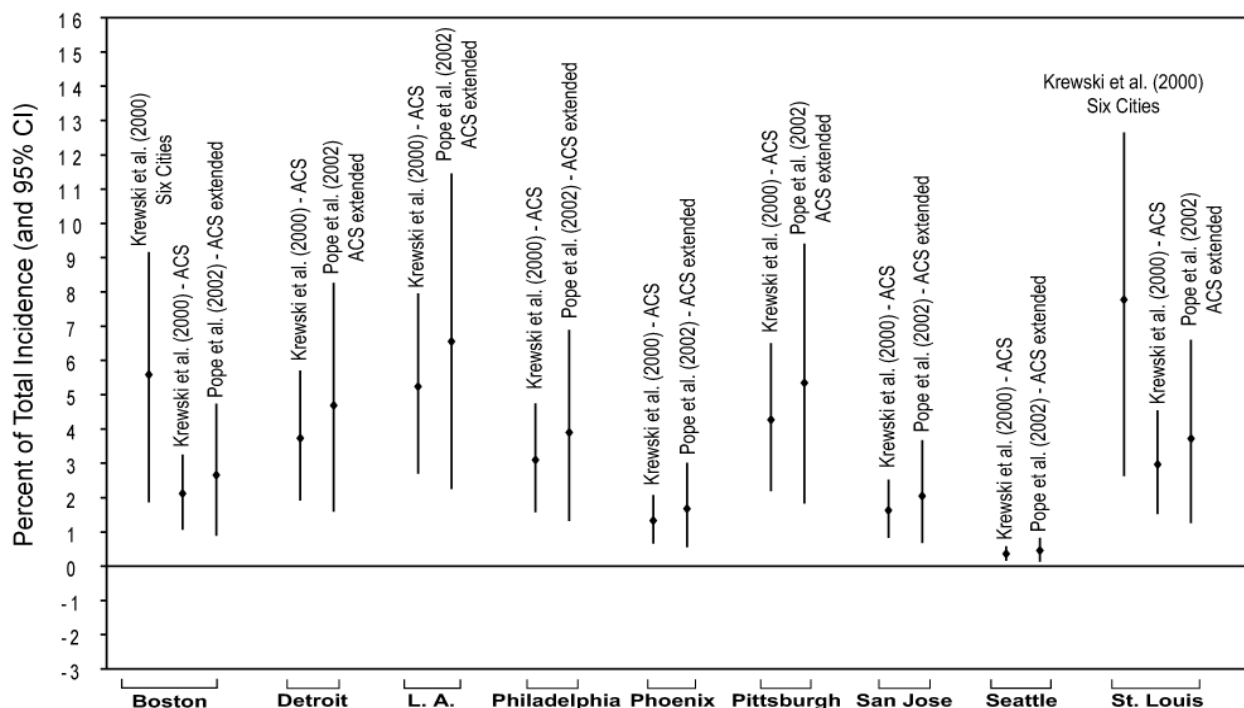
Figure 7.4a. Estimated Annual Percent of Mortality Associated with Short-Term Exposure to PM$_{2.5}$ Above Background: Effect of Different Lag Models
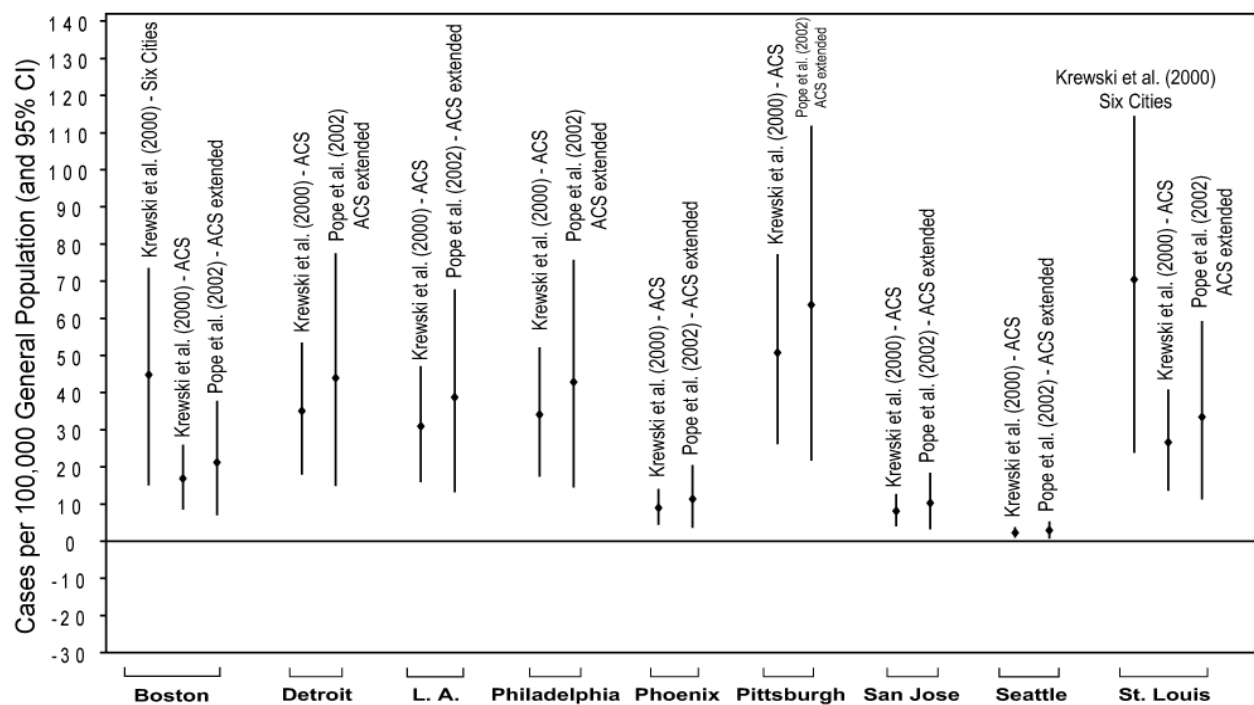
Figure 7.4b. Estimated Annual Cases of Mortality per 100,000 General Population Associated with Short-Term Exposure to PM$_{2.5}$ Above Background: Effect of Different Lag Models

Figure 7.5a. Estimated Annual Percent of Mortality Associated with Long-Term Exposure to PM$_{2.5}$ Above 7.5 µg/m³: Single-Pollutant Models
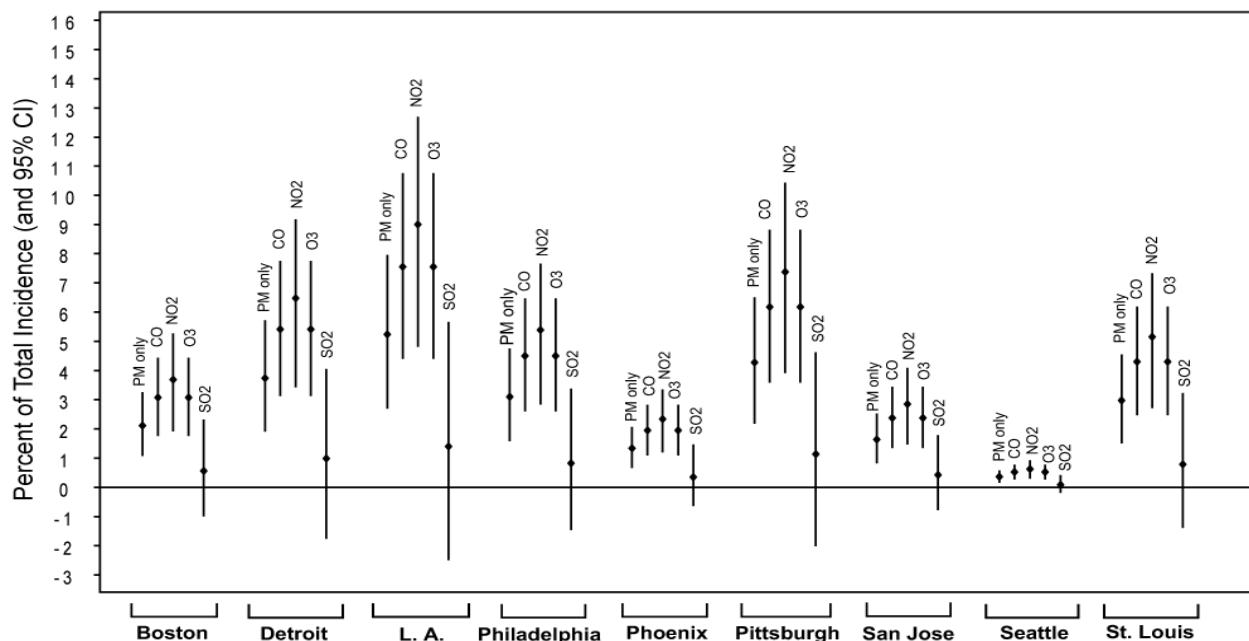
Figure 7.5b. Estimated Annual Cases of Mortality per 100,000 General Population Associated with Long-Term Exposure to PM$_{2.5}$ Above 7.5 µg/m³: Single-Pollutant Models
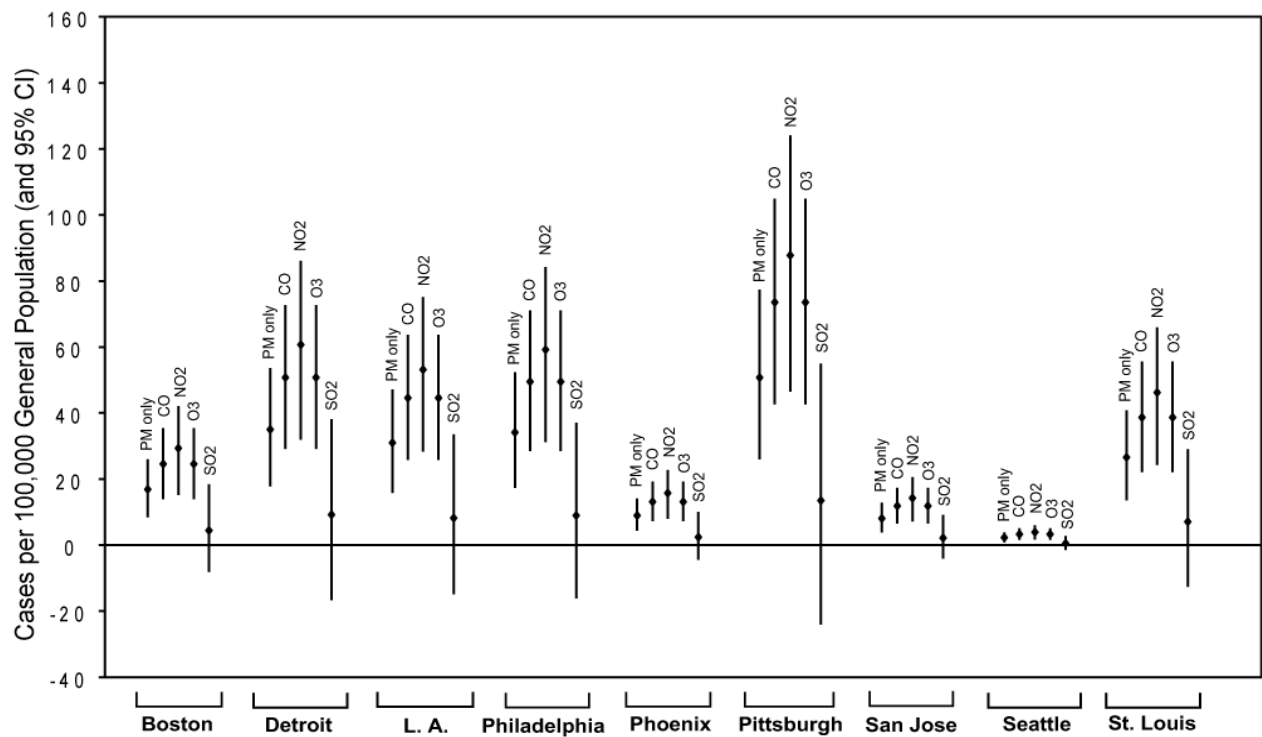
Figure 7.6a. Estimated Annual Percent of Mortality Associated with Long-Term Exposure to PM$_{2.5}$ Above 7.5 µg/m^3: Single-Pollutant and Multi-Pollutant Models*

Figure 7.6b. Estimated Annual Cases of Mortality per 100,000 General Population Associated with Long-Term Exposure to PM$_{2.5}$ Above 7.5 µg/m^3: Single-Pollutant and Multi-Pollutant Models*

*Based on Krewski et al. (2000) – ACS

Exhibit 7.1. Estimated Annual Mortality Associated with Short-Term Exposure to "As Is" PM$_{2.5}$ Concentrations, Assuming Various Cutpoint Levels*

Urban Area	Study	Type	Ages	Lag	Incidence Associated with PM2.5 Assuming Various Cutpoint Levels (95% Confidence Interval) / Incidence per 100,000 General Population (95% Confidence Interval) / Percent of Total Incidence (95% Confidence Interval)			
					Policy Relevant Background** =2.5 or 3.5 µg/m3	Cutpoint*** =10 µg/m3	Cutpoint*** =15 µg/m3	Cutpoint*** =20 µg/m3
Boston	Schwartz (2003b) [reanalysis of Schwartz et al. (1996)]	Non-accidental	all	mean of lag 0 & 1 day	390 (265 - 514)	173 (118 - 228)	82 (56 - 109)	41 (28 - 53)
					14 (9 - 18)	6 (4 - 8)	3 (2 - 4)	1 (1 - 2)
					1.8% (1.2% - 2.4%)	0.8% (0.5% - 1.1%)	0.4% (0.3% - 0.5%)	0.2% (0.1% - 0.2%)
Detroit	Ito (2003) [reanalysis of Lippmann et al. (2000)]	Non-accidental	all	3 day	170 (-170 - 501)	99 (-99 - 293)	62 (-62 - 184)	37 (-38 - 110)
					8 (-8 - 24)	5 (-5 - 14)	3 (-3 - 9)	2 (-2 - 5)
					0.9% (-0.9% - 2.7%)	0.5% (-0.5% - 1.6%)	0.3% (-0.3% - 1.0%)	0.2% (-0.2% - 0.6%)
Los Angeles	Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Non-accidental	all	0 day	494 (-62 - 1038)	308 (-38 - 647)	212 (-26 - 445)	146 (-18 - 306)
					5 (-1 - 11)	3 (0 - 7)	2 (0 - 5)	2 (0 - 3)
					0.9% (-0.1% - 1.9%)	0.6% (-0.1% - 1.2%)	0.4% (-0.1% - 0.8%)	0.3% (0.0% - 0.6%)
Philadelphia	Lipfert et al. (2000) -- 7 counties	Cardiovascular	all	1 day	412 (197 - 628)	231 (110 - 352)	141 (67 - 215)	83 (40 - 127)
					27 (13 - 41)	15 (7 - 23)	9 (4 - 14)	5 (3 - 8)
					2.5% (1.2% - 3.9%)	1.4% (0.7% - 2.2%)	0.9% (0.4% - 1.3%)	0.5% (0.2% - 0.8%)
Phoenix	Mar (2003) [reanalysis of Mar (2000)]	Cardiovascular	65+	1 day	323 (97 - 536)	115 (35 - 190)	67 (21 - 109)	43 (13 - 69)
					11 (3 - 17)	4 (1 - 6)	2 (1 - 4)	1 (0 - 2)
					5.0% (1.5% - 8.3%)	1.8% (0.5% - 2.9%)	1.0% (0.3% - 1.7%)	0.7% (0.2% - 1.1%)
Pittsburgh	Chock et al. (2000)	Non-accidental	75+	0 day	77 (-166 - 311)	48 (-103 - 193)	31 (-67 - 125)	20 (-43 - 80)
					6 (-13 - 24)	4 (-8 - 15)	2 (-5 - 10)	2 (-3 - 6)
					0.8% (-1.7% - 3.2%)	0.5% (-1.1% - 2.0%)	0.3% (-0.7% - 1.3%)	0.2% (-0.4% - 0.8%)
San Jose	Fairley (2003) [reanalysis of Fairley (1999)]	Non-accidental	all	0 day	218 (45 - 387)	80 (17 - 141)	44 (9 - 77)	28 (6 - 50)
					13 (3 - 23)	5 (1 - 8)	3 (1 - 5)	2 (0 - 3)
					2.6% (0.5% - 4.7%)	1.0% (0.2% - 1.7%)	0.5% (0.1% - 0.9%)	0.3% (0.1% - 0.6%)
St. Louis	Schwartz (2003b) [reanalysis of Schwartz et al. (1996)]	Non-accidental	all	mean of lag 0 & 1 day	233 (86 - 379)	114 (42 - 185)	55 (20 - 89)	23 (8 - 38)
					9 (3 - 15)	5 (2 - 7)	2 (1 - 4)	1 (0 - 1)
					1.1% (0.4% - 1.7%)	0.5% (0.2% - 0.8%)	0.3% (0.1% - 0.4%)	0.1% (0.0% - 0.2%)

*All results are for single pollutant, non-accidental mortality models, unless otherwise specified.

**Policy relevant background is 2.5 µg/m3 in the West (Los Angeles, Phoenix, and San Jose) and 3.5 µg/m3 in the East (Boston, Detroit, Philadelphia, Pittsburgh, and St. Louis).

***For the cutpoints above policy relevant background, the slope of the C-R function has been modified based on a simple hockeystick model (see discussion in section 2.5).

Exhibit 7.2. Estimated Annual Mortality Associated with Long-Term Exposure to "As Is" PM$_{2.5}$ Concentrations, Assuming Various Cutpoint Levels*

Urban Areas	Incidence Associated with PM2.5 Assuming Various Cutpoint Levels (95% Confidence Interval) Incidence per 100,000 General Population (95% Confidence Interval) Percent of Total Incidence (95% Confidence Interval)		
	Cutpoint** = 7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
Boston	594 (204 - 1053)	309 (106 - 551)	20 (7 - 36)
	21 (7 - 38)	11 (4 - 20)	1 (0 - 1)
	2.7% (0.9% - 4.7%)	1.4% (0.5% - 2.5%)	0.1% (0.0% - 0.2%)
Detroit	906 (313 - 1592)	713 (245 - 1259)	519 (178 - 920)
	44 (15 - 77)	35 (12 - 61)	25 (9 - 45)
	4.7% (1.6% - 8.2%)	3.7% (1.3% - 6.5%)	2.7% (0.9% - 4.8%)
Los Angeles	3684 (1280 - 6426)	3267 (1132 - 5715)	2846 (984 - 4994)
	39 (13 - 68)	34 (12 - 60)	30 (10 - 52)
	6.6% (2.3% - 11.4%)	5.8% (2.0% - 10.2%)	5.1% (1.8% - 8.9%)
Philadelphia	650 (224 - 1146)	466 (160 - 825)	280 (96 - 497)
	43 (15 - 76)	31 (11 - 54)	18 (6 - 33)
	3.9% (1.3% - 6.9%)	2.8% (1.0% - 4.9%)	1.7% (0.6% - 3.0%)
Phoenix	349 (119 - 620)	55 (19 - 98)	0 (0 - 0)
	11 (4 - 20)	2 (1 - 3)	0 (0 - 0)
	1.7% (0.6% - 3.0%)	0.3% (0.1% - 0.5%)	0.0% (0.0% - 0.0%)
Pittsburgh	816 (282 - 1430)	678 (234 - 1193)	539 (185 - 951)
	64 (22 - 112)	53 (18 - 93)	42 (14 - 74)
	5.4% (1.9% - 9.4%)	4.5% (1.5% - 7.8%)	3.5% (1.2% - 6.2%)
San Jose	172 (59 - 306)	58 (20 - 104)	0 (0 - 0)
	10 (4 - 18)	3 (1 - 6)	0 (0 - 0)
	2.1% (0.7% - 3.6%)	0.7% (0.2% - 1.2%)	0.0% (0.0% - 0.0%)
Seattle	50 (17 - 89)	0 (0 - 0)	0 (0 - 0)
	3 (1 - 5)	0 (0 - 0)	0 (0 - 0)
	0.5% (0.2% - 0.8%)	0.0% (0.0% - 0.0%)	0.0% (0.0% - 0.0%)
St. Louis	842 (290 - 1486)	587 (201 - 1041)	330 (113 - 587)
	33 (12 - 59)	23 (8 - 41)	13 (4 - 23)
	3.7% (1.3% - 6.6%)	2.6% (0.9% - 4.6%)	1.5% (0.5% - 2.6%)

*Based on Pope et al. (2002) -- ACS extended, all cause mortality among adults age 30 and older.

**For the cutpoints above policy relevant background, the slope of the C-R function has been modified based on a simple hockeystick model (see discussion in section 2.5).

Exhibit 7.3. Estimated Annual Health Risks Associated with "As Is" PM$_{2.5}$ Concentrations

Detroit, MI, 2003

Health Effects*	Study	Type	Ages	Lag	Other Pollutants in Model	Health Effects Associated with PM2.5 Above Specified Levels**		
						Incidence	Incidence per 100,000 General Population	Percent of Total Incidence
Short-Term Exposure Mortality	**Single Pollutant Models (Total Mortality)**							
	Ito (2003) [reanalysis of Lippmann et al. (2000)]	Non-accidental	all	3 day		170 (-170 - 501)	8 (-8 - 24)	0.9% (-0.9% - 2.7%)
	Single Pollutant Models (Cause-Specific Mortality)							
	Ito (2003) [reanalysis of Lippmann et al. (2000)]	Circulatory	all	1 day		91 (-139 - 311)	4 (-7 - 15)	1.1% (-1.6% - 3.6%)
	Ito (2003) [reanalysis of Lippmann et al. (2000)]	Respiratory	all	0 day		16 (-83 - 106)	1 (-4 - 5)	1.1% (-5.6% - 7.1%)
Long-Term Exposure Mortality	**Single Pollutant Models**							
	Krewski et al. (2000) - ACS	All cause	30+			722 (375 - 1098)	35 (18 - 53)	3.7% (1.9% - 5.7%)
	Krewski et al. (2000) - ACS	Cardiopulmonary	30+			721 (469 - 990)	35 (23 - 48)	7.5% (4.9% - 10.3%)
	Pope et al. (2002) - ACS extended	All cause	30+			906 (313 - 1592)	44 (15 - 77)	4.7% (1.6% - 8.2%)
	Pope et al. (2002) - ACS extended	Cardiopulmonary	30+			661 (232 - 1110)	32 (11 - 54)	6.9% (2.4% - 11.5%)
	Pope et al. (2002) - ACS extended	Lung cancer	30+			135 (42 - 207)	7 (2 - 10)	10.2% (3.2% - 15.7%)
	Multi-Pollutant Models							
	Krewski et al. (2000) - ACS	All cause	30+		CO	1046 (609 - 1492)	51 (30 - 72)	5.4% (3.2% - 7.7%)
	Krewski et al. (2000) - ACS	All cause	30+		NO2	1250 (666 - 1767)	61 (32 - 86)	6.5% (3.5% - 9.2%)
	Krewski et al. (2000) - ACS	All cause	30+		O3	1046 (609 - 1492)	51 (30 - 72)	5.4% (3.2% - 7.7%)
	Krewski et al. (2000) - ACS	All cause	30+		SO2	191 (-336 - 778)	9 (-16 - 38)	1.0% (-1.7% - 4.0%)

Health Effects*	Study	Type	Ages	Lag	Other Pollutants in Model	Health Effects Associated with PM2.5 Above Specified Levels**		
						Incidence	Incidence per 100,000 General Population	Percent of Total Incidence
Single Pollutant Models								
Hospital Admissions	Ito (2003) [reanalysis of Lippmann et al. (2000)]	Pneumonia	65+	1 day		241 (46 - 425)	12 (2 - 21)	4.7% (0.9% - 8.3%)
	Ito (2003) [reanalysis of Lippmann et al. (2000)]	COPD	65+	3 day		56 (-143 - 241)	3 (-7 - 12)	1.4% (-3.6% - 6.1%)
	Ito (2003) [reanalysis of Lippmann et al. (2000)]	Ischemic heart disease	65+	2 day		173 (-101 - 439)	8 (-5 - 21)	1.7% (-1.0% - 4.4%)
	Ito (2003) [reanalysis of Lippmann et al. (2000)]	Congestive heart failure	65+	1 day		256 (47 - 457)	12 (2 - 22)	3.7% (0.7% - 6.5%)
	Ito (2003) [reanalysis of Lippmann et al. (2000)]	Dysrhythmias	65+	1 day		50 (-114 - 201)	2 (-6 - 10)	1.5% (-3.5% - 6.1%)

*Health effects are associated with short-term exposure to PM2.5 unless otherwise specified.

**For the short-term exposure studies, incidence was quantified down to the estimated policy relevant background level of 3.5 µg/m3 . For the long-term exposure studies, incidence was quantified down to 7.5 ug/m3, which was the lowest of the lowest measured levels in the long-term exposure studies. Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Note: Numbers in parentheses are 95% confidence intervals based on statistical uncertainty surrounding the PM2.5 coefficient.

Exhibit 7.4. Estimated Annual Mortality Associated with Short-Term and Long-Term Exposure to "As Is" PM₂.₅ Concentrations, Assuming Various Cutpoint Levels*

Detroit, MI, 2003

Health Effects	Study	Type	Ages	Lag	Other Pollutants in Model	Incidence Associated with PM2.5 Assuming Various Cutpoint Levels** (95% Confidence Interval) Percent of Total Incidence (95% Confidence Interval)			
						Policy Relevant Background =3.5 µg/m3	Cutpoint =10 µg/m3	Cutpoint =15 µg/m3	Cutpoint =20 µg/m3
Short-Term Exposure Mortality	Single Pollutant Models (Total Mortality)								
	Ito (2003) [reanalysis of Lippmann et al. (2000)]	Non-accidental	all	3 day		170 (-170 - 501) 0.9% (-0.9% - 2.7%)	99 (-99 - 293) 0.5% (-0.5% - 1.6%)	62 (-62 - 184) 0.3% (-0.3% - 1.0%)	37 (-38 - 110) 0.2% (-0.2% - 0.6%)
Long-Term Exposure Mortality						Cutpoint = 7.5 µg/m3	Cutpoint =10 µg/m3	Cutpoint =12 µg/m3	
	Single Pollutant Models								
	Krewski et al. (2000) - ACS	All cause	30+			722 (375 - 1098) 3.7% (1.9% - 5.7%)	551 (285 - 839) 2.9% (1.5% - 4.3%)	388 (201 - 593) 2.0% (1.0% - 3.1%)	
	Pope et al. (2002) - ACS extended	All cause	30+			906 (313 - 1592) 4.7% (1.6% - 8.2%)	713 (245 - 1259) 3.7% (1.3% - 6.5%)	519 (178 - 920) 2.7% (0.9% - 4.8%)	
	Multi-Pollutant Models								
	Krewski et al. (2000) - ACS	All cause	30+		CO	1046 (609 - 1492) 5.4% (3.2% - 7.7%)	799 (464 - 1143) 4.1% (2.4% - 5.9%)	564 (327 - 810) 2.9% (1.7% - 4.2%)	
	Krewski et al. (2000) - ACS	All cause	30+		NO2	1250 (666 - 1767) 6.5% (3.5% - 9.2%)	956 (508 - 1356) 5.0% (2.6% - 7.0%)	676 (358 - 962) 3.5% (1.9% - 5.0%)	
	Krewski et al. (2000) - ACS	All cause	30+		O3	1046 (609 - 1492) 5.4% (3.2% - 7.7%)	799 (464 - 1143) 4.1% (2.4% - 5.9%)	564 (327 - 810) 2.9% (1.7% - 4.2%)	
	Krewski et al. (2000) - ACS	All cause	30+		SO2	191 (-336 - 778) 1.0% (-1.7% - 4.0%)	145 (-255 - 593) 0.8% (-1.3% - 3.1%)	102 (-178 - 418) 0.5% (-0.9% - 2.2%)	

*For the short-term exposure studies, incidence was quantified down to policy relevant background level of 3.5 µg/m3, as well as down to each of the alternative cutpoints. For the long-term exposure studies, incidence was quantified down to 7.5 µg/m3, the lowest of the lowest measured levels in the long-term exposure studies, as well as down to each of the alternative cutpoints. For the cutpoints above policy relevant background, the slope of the C-R function has been modified based on a simple hockeystick model (see discussion in section 2.5).

**Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

As discussed in Chapter 3, assessment locations were chosen in part on the basis of whether an acceptable C-R function had been reported for that location. As a result, risks were estimated in a given assessment location only for those health endpoints for which there is at least one acceptable C-R function reported for that location. The set of health effects shown in Exhibits 7.3 and 7.4 and Exhibits D.1 through D.16 therefore varies from one location to another. For example, mortality associated with short-term and long-term exposure to $PM_{2.5}$ and respiratory symptoms are included in Exhibit D.1 for Boston, but hospital admissions are not included because there was no study that met the selection criteria that reports a C-R function for hospital admissions reported in the $PM_{2.5}$ epidemiological literature for Boston evaluated in the 2004 PM CD. For total non-accidental mortality associated with short-term exposure to $PM_{2.5}$, Figure 7.1 displays estimates for only six of the nine risk assessment locations because acceptable C-R functions for this health outcome were not available for the other three locations.

There is substantial uncertainty surrounding all estimates of incidence associated with "as is" $PM_{2.5}$ concentrations in any location. We tried to minimize the extent of this uncertainty by avoiding the application of a C-R function estimated in one location to another location as much as possible. As discussed in Section 6, however, there are other sources of uncertainty. The uncertainty surrounding risk estimates resulting from the statistical uncertainty of the $PM_{2.5}$ coefficients in the C-R functions used is characterized by ninety-five percent confidence intervals around incidence estimates and estimates of the percent of total incidence that $PM_{2.5}$-related incidence comprises. In some cases, the lower bound of a confidence interval falls below zero. This does not imply that additional exposure to PM has a beneficial effect, but only that the estimated $PM_{2.5}$ coefficient in the C-R function was not statistically significantly different from zero. Lack of statistical significance could mean that there is no relationship between $PM_{2.5}$ and the health endpoint or it could mean that there wasn't sufficient statistical power to detect a relationship that exists.

Figure 7.2 shows estimated mortality and morbidity effects associated with short-term exposure to $PM_{2.5}$ based on C-R functions in which $PM_{2.5}$ was the only pollutant in the model versus C-R functions in which there was at least one additional pollutant included. There was no consistent pattern. For example, in Los Angeles the addition of CO to the model substantially decreased the $PM_{2.5}$ effect estimates for non-accidental mortality, cardiovascular hospital admissions, and COPD hospital admissions but increased the $PM_{2.5}$ effect estimate for cardiovascular mortality. In Pittsburgh and San Jose, the addition of single co-pollutants or a combination of co-pollutants only had a modest impact on the $PM_{2.5}$ effect estimates.

Figure 7.3 compares single vs. multi-city models. Only two assessment locations (Boston and St. Louis) had available PM coefficients based on both single and multi-city models, from the Six Cities study. In all cases, the confidence intervals for the estimates from the multi-city model were tighter than those for the single-city model estimates. In most, but not all cases, the central estimates for the single vs. multi-city models did not vary greatly.

Figure 7.4 shows the effect of different lag structures in the C-R function. Based on the discussion of selection of lags earlier in this report (see Section 4.3), estimates are shown for alternative lags dependent on the type of health endpoint. For non-accidental mortality in Los Angeles there is little difference in effect estimates considering lags ranging from 0 to 2 days and also little difference in effect estimates for cardiovascular mortality in this same location between 0-day and 1-day lags. For cardiovascular mortality in Phoenix the effect estimate from a 1-day lag model is larger than that from a 0-day lag model. However, this is insufficient evidence upon which to base any general conclusion about the lag structure between $PM_{2.5}$ and this health endpoint.

As would be expected, there were substantial differences across cities, at least in part reflecting differences in air quality and populations exposed. For example, using Pope et al. (2002) – ACS extended, 6.6 percent of premature mortality was associated with long-term exposure to $PM_{2.5}$ in excess of background levels in Los Angeles, which has the highest $PM_{2.5}$ levels among the assessment locations; in contrast, using the same study, only 2.0 percent of premature mortality was associated with long-term exposure to $PM_{2.5}$ in excess of background levels in San Jose, which has much lower levels of $PM_{2.5}$. The corresponding incidences of premature mortality using that same study (about 3,700 cases in Los Angeles versus about 170 cases in San Jose) reflect not only differences in $PM_{2.5}$ levels in the two locations but also differences in population size (Los Angeles has a population of over 9.5 million whereas San Jose's population is only about 1.7 million). However, a comparison of the rates per 100,000 general population – 39 in Los Angeles versus only 10 in San Jose – adjusts for this difference in population sizes, reflecting only the differences in levels of $PM_{2.5}$ in the two locations (see Appendix D).

The incidence and the percent of total incidence of long-term exposure mortality was generally greater, and sometimes substantially greater than that of short-term exposure mortality in most assessment locations. This varied significantly, however, from one location to another (and may have depended on the particular short-term exposure mortality studies used in the different locations). For example, in Los Angeles, 0.9 percent of short-term exposure non-accidental mortality was associated with "as is" $PM_{2.5}$ concentrations in excess of background (Moolgavkar (2003) [using the GAM (stringent) model with 30 df and 0-day lag]) compared with anywhere from 5.2 percent (Krewski et al., 2000 - ACS) to 6.6 percent (Pope et al., 2002 – ACS extended) of long-term exposure mortality. In San Jose, however, 2.6 percent of short-term exposure non-accidental mortality was associated with "as is" $PM_{2.5}$ concentrations in excess of background (Fairley, 2003) [0-day lag, single pollutant model], compared with 1.6 percent (Krewski et al., 2000 – ACS) to 2.1 percent (Pope et al., 2002 – ACS extended) of long-term exposure total mortality cases.

Figure 7.6 shows the effect of having only $PM_{2.5}$ in the model (single pollutant model) vs. having other pollutants in the model as well (multi-pollutant model), using the effect estimates for long-term exposure mortality based on Krewski et al. (2000) - ACS study. The bars labeled

"PM only" represent the effect on mortality associated with $PM_{2.5}$ exposures estimated by a model in which $PM_{2.5}$ is the only pollutant in the model. The bars labeled with other pollutants (e.g., CO, NO_2, SO_2) represent the effect on mortality associated with $PM_{2.5}$ exposures estimated when other pollutants are also included in the health effects model. The $PM_{2.5}$ effect estimates are generally increased with the addition of CO, NO_2, or O_3 in two-pollutant models and are substantially decreased with the addition of SO_2 in such models.

7.2   Sensitivity analyses

Several sensitivity analyses were carried out to assess the sensitivity of the results of the first ("as is") part of the risk assessment to various assumptions underlying the analyses. In general, we carried out each sensitivity analysis listed for $PM_{2.5}$ in each of the assessment locations (see Exhibit 2.6). However, to reduce the number of exhibits in this section of the report, we selected one location (Detroit) to include here for illustrative purposes. Exhibits of the results of location-specific sensitivity analyses that are not presented here are given in Appendix D. To reduce the quantity of numbers reported, with the exception of the sensitivity analysis of alternative constant background concentrations we focused the $PM_{2.5}$ sensitivity analyses on total (or non-accidental) mortality. The sensitivity analyses in this section and the exhibits presenting their results are summarized in Exhibit 7.5. The results of the sensitivity analyses for Detroit are shown in Exhibits 7.6 through 7.9.

In addition to the sensitivity analyses carried out in all locations included in the $PM_{2.5}$ risk assessment, we carried out two sensitivity analyses in single locations. In 2002, natural fires in Quebec, Canada resulted in several days of exceptionally high levels of PM in the Northeastern United States. Exhibit 7.10 shows the impact of these "exceptional event episodes" on air quality in Boston, MA in 2002, and Exhibit 7.11 shows the impact on the estimated annual health risks associated with "as is" $PM_{2.5}$ concentrations.

Finally, using Moolgavkar (2003), we examined the effect of different model specifications on estimated annual health risks associated with "as is" $PM_{2.5}$ concentrations in Los Angeles. The results are shown in Exhibits 7.12a (for mortality) and 7.12b (for morbidity).

Exhibit 7.5 Summary of Sensitivity Analyses Associated with the "As Is" Part of the Risk Assessment for PM$_{2.5}$

Sensitivity Analysis*	Applied to	Exhibit
Estimated annual health risks associated with "as is" PM$_{2.5}$ concentrations above background, using three different background levels	all health endpoints	Exhibit 7.6 Exhibits D.17 - D.24
Estimated annual health risks associated with "as is" PM concentrations with adjustments for the estimated increases in incidence if distributed lag models had been estimated	mortality associated with short-term exposure	Exhibit 7.7 Exhibits D.25 - D.29
The effect of assumptions about historical air quality on estimates associated with "as is" PM$_{2.5}$ concentrations	mortality associated with long-term exposure	Exhibit 7.8 Exhibits D.30 - D.37
Estimated annual health risks associated with "as is" PM$_{2.5}$ concentrations using a constant background level versus different daily background levels	non-accidental mortality associated with short-term exposure - Detroit, and St. Louis	Exhibit 7.9
The effect of exceptional event days on estimated annual health risks associated with "as is" PM$_{2.5}$ concentrations – Boston, MA, 2002	mortality and respiratory symptoms associated with short-term exposure – Boston only	Exhibits 7.10 and 7.11
Estimated annual health risks associated with short-term exposures, using alternative model specifications – Los Angeles only	health risks associated with short-term exposures - Los Angles only	Exhibit 7.12

*Sensitivity analyses presented in this section are for Detroit, MI, unless otherwise stated.

Exhibit 7.6. Sensitivity Analysis: Estimated Annual Health Risks Associated with Short-Term Exposure to "As Is" PM$_{2.5}$ Concentrations, Using Different Estimates of Policy Relevant Background Level
Detroit, MI, 2003

Health Effects	Study	Type	Ages	Lag	Other Pollutants in Model	Health Effects Associated with PM2.5 Above Policy Relevant Background of: *					
						2 ug/m3		3.5 ug/m3		5 ug/m3	
						Incidence	Percent of Total Incidence	Incidence	Percent of Total Incidence	Incidence	Percent of Total Incidence
Short-Term Exposure Mortality						Single Pollutant Models (Total Mortality)					
	Ito (2003) [reanalysis of Lippmann et al. (2000)]	Non-accidental	all	3 day		190 (-191 - 562)	1.0% (-1.0% - 3.0%)	170 (-170 - 501)	0.9% (-0.9% - 2.7%)	150 (-150 - 442)	0.8% (-0.8% - 2.3%)
						Single Pollutant Models (Cause-Specific Mortality)					
	Ito (2003) [reanalysis of Lippmann et al. (2000)]	Circulatory	all	1 day		102 (-156 - 349)	1.2% (-1.8% - 4.1%)	91 (-139 - 311)	1.1% (-1.6% - 3.6%)	80 (-123 - 274)	0.9% (-1.4% - 3.2%)
	Ito (2003) [reanalysis of Lippmann et al. (2000)]	Respiratory	all	0 day		18 (-94 - 119)	1.2% (-6.3% - 8.0%)	16 (-83 - 106)	1.1% (-5.6% - 7.1%)	14 (-73 - 94)	1.0% (-4.9% - 6.3%)
Hospital Admissions						Single Pollutant Models					
	Ito (2003) [reanalysis of Lippmann et al. (2000)]	Pneumonia	65+	1 day		270 (52 - 476)	5.3% (1.0% - 9.3%)	241 (46 - 425)	4.7% (0.9% - 8.3%)	212 (41 - 376)	4.1% (0.8% - 7.3%)
	Ito (2003) [reanalysis of Lippmann et al. (2000)]	COPD	65+	3 day		63 (-160 - 270)	1.6% (-4.1% - 6.8%)	56 (-143 - 241)	1.4% (-3.6% - 6.1%)	49 (-126 - 213)	1.3% (-3.2% - 5.4%)
	Ito (2003) [reanalysis of Lippmann et al. (2000)]	Ischemic heart disease	65+	2 day		194 (-113 - 492)	1.9% (-1.1% - 4.9%)	173 (-101 - 439)	1.7% (-1.0% - 4.4%)	153 (-89 - 387)	1.5% (-0.9% - 3.9%)
	Ito (2003) [reanalysis of Lippmann et al. (2000)]	Congestive heart failure	65+	1 day		287 (53 - 511)	4.1% (0.8% - 7.3%)	256 (47 - 457)	3.7% (0.7% - 6.5%)	226 (41 - 403)	3.2% (0.6% - 5.8%)
	Ito (2003) [reanalysis of Lippmann et al. (2000)]	Dysrhythmias	65+	1 day		56 (-128 - 225)	1.7% (-3.9% - 6.8%)	50 (-114 - 201)	1.5% (-3.5% - 6.1%)	44 (-100 - 177)	1.3% (-3.0% - 5.4%)

*Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.
Note: Numbers in parentheses are 95% confidence intervals based on statistical uncertainty surrounding the PM2.5 coefficient.

**Exhibit 7.7. Sensitivity Analysis: Estimated Annual Mortality Associated with Short-Term Exposure to
"As Is" PM_{2.5} Concentrations, With Adjustments for the Estimated Increases in Incidence if Distributed Lag Models
Had Been Estimated
Detroit, MI, 2003**

Health Effects	Study	Type	Ages	Lag	Other Pollutants in Model	Health Effects Associated with PM2.5 Above Policy Relevant Background*			
						Single Lag		Adjusted for Distributed Lag	
						Incidence	Percent of Total Incidence	Incidence	Percent of Total Incidence
Short-Term Exposure Mortality	Single Pollutant Models (Total Mortality)								
	Ito (2003) [reanalysis of Lippmann et al. (2000)]	Non-accidental	all	3 day		170 (-170 - 501)	0.9% (-0.9% - 2.7%)	334 (-339 - 971)	1.8% (-1.8% - 5.2%)

*Health effects incidence was quantified down to estimated policy relevant background level of 3.5 ug/m3. Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Note: Numbers in parentheses are 95% confidence intervals based on statistical uncertainty surrounding the PM2.5 coefficient.

Exhibit 7.8. Sensitivity Analysis: The Effect of Assumptions About Historical Air Quality on Estimates of Mortality Associated with Long-Term Exposure to "As Is" PM$_{2.5}$ Concentrations
Detroit, MI, 2003

Health Effects	Study	Type	Ages	Other Pollutants in Model	Percent of Total Incidence*		
					Base Case: Assuming AQ as Reported	Assuming relevant AQ 50% higher	Assuming relevant AQ twice as high
Long-Term Exposure Mortality	Single Pollutant Models						
	Krewski et al. (2000) - ACS	All cause	30+		3.7% (1.9% - 5.7%)	2.5% (1.3% - 3.8%)	1.9% (1.0% - 2.9%)
	Krewski et al. (2000) - ACS	Cardiopulmonary	30+		7.5% (4.9% - 10.3%)	5.1% (3.3% - 7.0%)	3.8% (2.5% - 5.3%)
	Pope et al. (2002) - ACS extended	All cause	30+		4.7% (1.6% - 8.2%)	3.2% (1.1% - 5.6%)	2.4% (0.8% - 4.2%)
	Pope et al. (2002) - ACS extended	Cardiopulmonary	30+		6.9% (2.4% - 11.5%)	4.6% (1.6% - 7.8%)	3.5% (1.2% - 5.9%)
	Pope et al. (2002) - ACS extended	Lung cancer	30+		10.2% (3.2% - 15.7%)	7.0% (2.1% - 10.8%)	5.3% (1.6% - 8.2%)
	Multi-Pollutant Models						
	Krewski et al. (2000) - ACS	All cause	30+	CO	5.4% (3.2% - 7.7%)	3.6% (2.1% - 5.2%)	2.8% (1.6% - 3.9%)
	Krewski et al. (2000) - ACS	All cause	30+	NO2	6.5% (3.5% - 9.2%)	4.4% (2.3% - 6.2%)	3.3% (1.7% - 4.7%)
	Krewski et al. (2000) - ACS	All cause	30+	O3	5.4% (3.2% - 7.7%)	3.6% (2.1% - 5.2%)	2.8% (1.6% - 3.9%)
	Krewski et al. (2000) - ACS	All cause	30+	SO2	1.0% (-1.7% - 4.0%)	0.7% (-1.2% - 2.7%)	0.5% (-0.9% - 2.0%)

* For the long-term exposure studies, health effects incidence was quantified down to 7.5 ug/m3, which was the lowest of the lowest measured levels in the long-term exposure studies. Percents are rounded to the nearest tenth.

Note: Numbers in parentheses are 95% confidence intervals based on statistical uncertainty surrounding the PM2.5 coefficient.

Exhibit 7.9. Sensitivity Analysis: Estimated Annual Mortality Associated with Short-Term Exposure to "As Is" PM$_{2.5}$ Concentrations, Using a Constant Policy Relevant Background Level Versus Different Daily Policy Relevant Background Levels Detroit, MI, 2003

Health Effects	Study	Type	Ages	Lag	Other Pollutants in Model	Health Effects Associated with PM2.5 Above Background*			
						Constant Background Level		Different Daily Background Levels	
						Incidence	Percent of Total Incidence	Incidence	Percent of Total Incidence
Short-Term Exposure Mortality	Single Pollutant Models (Total Mortality)								
	Ito (2003) [reanalysis of Lippmann et al. (2000)]	Non-accidental	all	3 day		170 (-170 - 501)	0.9% (-0.9% - 2.7%)	153 (-153 - 451)	0.8% (-0.8% - 2.4%)

*Health effects incidence was quantified down to estimated policy relevant background level of 3.5 ug/m3. Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Note: Numbers in parentheses are 95% confidence intervals based on statistical uncertainty surrounding the PM2.5 coefficient.

Exhibit 7.10. Comparison of PM$_{2.5}$ Concentrations in Boston, MA in 2002 With and Without Monitor-Days Flagged as "Exceptional/Natural Event Episodes"

Monitor:	250170008881011		250210007881011		250250042881011		250250043881011		composite	
	Including All Days	Excluding Exceptional Event Days	Including All Days	Excluding Exceptional Event Days	Including All Days	Excluding Exceptional Event Days	Including All Days	Excluding Exceptional Event Days	Including All Days	Excluding Exceptional Event Days
number of monitor days	103	102	118	117	264	261	86	85	299	296
mean ($\mu g/m^3$)	10.8	10.3	12.2	11.7	11.4	11.1	13.9	13.3	11.5	11.2
75th percentile ($\mu g/m^3$)	12.5	12.3	15.5	14.8	14.0	13.7	17.5	17.4	14.3	14.2
90th percentile ($\mu g/m^3$)	21.1	20.8	23.0	22.6	21.2	20.4	25.1	24.4	21.2	20.4
95th percentile ($\mu g/m^3$)	27.5	23.8	27.7	26.2	24.9	23.8	27.1	26.4	25.2	24.0
98th percentile ($\mu g/m^3$)	29.2	28.5	48.1	33.8	33.0	26.4	29.8	28.2	33.0	27.4
maximum value ($\mu g/m^3$)	65.1	30.6	66.9	66.9	59	52.4	63.1	29.8	63.1	51.2
number of days above 30 $\mu g/m^3$	2	1	5	4	6	4	1	0	6	4
number of days above 50 $\mu g/m^3$	1	0	2	1	3	2	1	0	2	1

Exhibit 7.11. Sensitivity Analysis: The Effect of Exceptional Event Days on Estimated Annual Health Risks Associated with "As Is" PM$_{2.5}$ Concentrations

Boston, MA, 2002

Health Effects*	Study	Type	Ages	Lag	Other Pollutants in Model	Health Effects Associated with PM-2.5 Above Policy Relevant Background: Including All Days		Health Effects Associated with PM-2.5 Above Policy Relevant Background: Excluding Exceptional Event Days	
						Incidence**	Percent of Total Incidence**	Incidence**	Percent of Total Incidence**
Short-Term Exposure Mortality	Single Pollutant Models (Total Mortality)								
	Schwartz (2003b) [reanalysis of Schwartz et al. (1996)]	Non-accidental	all	mean of lag 0 & 1		356 (242 - 469)	1.6% (1.1% - 2.2%)	345 (235 - 455)	1.6% (1.1% - 2.1%)
	Schwartz (2003b) [reanalysis of Schwartz et al. (1996)] -- 6 cities	Non-accidental	all	mean of lag 0 & 1		238 (170 - 305)	1.1% (0.8% - 1.4%)	231 (165 - 296)	1.1% (0.8% - 1.4%)
	Single Pollutant Models (Cause-Specific Mortality)								
	Klemm and Mason (2003) [reanalysis of Klemm et al. (2000)]	COPD	all	0 day		22 (-11 - 51)	2.2% (-1.1% - 5.1%)	22 (-10 - 50)	2.1% (-1.0% - 4.9%)
	Klemm and Mason (2003) [reanalysis of Klemm et al. (2000)]	Ischemic heart disease	all	0 day		72 (40 - 102)	2.1% (1.2% - 3.0%)	70 (39 - 99)	2.0% (1.2% - 2.9%)
	Klemm and Mason (2003) [reanalysis of Klemm et al. (2000)]	Pneumonia	all	0 day		33 (15 - 49)	4.4% (2.0% - 6.6%)	32 (14 - 47)	4.3% (2.0% - 6.4%)
	Klemm and Mason (2003) [reanalysis of Klemm et al. (2000)] -- 6 cities	COPD	all	0 day		18 (1 - 35)	1.8% (0.1% - 3.4%)	18 (1 - 34)	1.8% (0.1% - 3.3%)
	Klemm and Mason (2003) [reanalysis of Klemm et al. (2000)] -- 6 cities	Ischemic heart disease	all	0 day		48 (30 - 67)	1.4% (0.9% - 2.0%)	47 (29 - 65)	1.4% (0.9% - 1.9%)
	Klemm and Mason (2003) [reanalysis of Klemm et al. (2000)] -- 6 cities	Pneumonia	all	0 day		23 (11 - 34)	3.2% (1.5% - 4.7%)	22 (11 - 33)	3.1% (1.5% - 4.5%)
Long-Term Exposure Mortality	Single Pollutant Models								
	Krewski et al. (2000) - Six Cities	All cause	25+			121 (40 - 202)	0.5% (0.2% - 0.9%)	56 (19 - 93)	0.3% (0.1% - 0.4%)
	Krewski et al. (2000) - ACS	All cause	30+			148 (76 - 227)	0.7% (0.3% - 1.0%)	124 (64 - 190)	0.6% (0.3% - 0.9%)
	Krewski et al. (2000) - Six Cities	Cardiopulmonary	25+			61 (20 - 100)	0.7% (0.2% - 1.2%)	28 (9 - 46)	0.3% (0.1% - 0.6%)
	Krewski et al. (2000) - ACS	Cardiopulmonary	30+			131 (84 - 182)	1.3% (0.9% - 1.9%)	110 (71 - 152)	1.1% (0.7% - 1.6%)
	Pope et al. (2002) - ACS extended	All cause	30+			507 (173 - 899)	2.3% (0.8% - 4.0%)	477 (163 - 847)	2.1% (0.7% - 3.8%)
	Pope et al. (2002) - ACS extended	Cardiopulmonary	30+			324 (112 - 552)	3.3% (1.2% - 5.7%)	305 (106 - 520)	3.1% (1.1% - 5.3%)
	Pope et al. (2002) - ACS extended	Lung cancer	30+			77 (24 - 120)	5.0% (1.5% - 7.8%)	73 (22 - 114)	4.7% (1.4% - 7.4%)

Health Effects*	Study	Type	Ages	Lag	Other Pollutants in Model	Health Effects Associated with PM-2.5 Above Policy Relevant Background: Including All Days		Health Effects Associated with PM-2.5 Above Policy Relevant Background: Excluding Exceptional Event Days	
						Incidence**	Percent of Total Incidence**	Incidence**	Percent of Total Incidence**
						Multi-Pollutant Models			
	Krewski et al. (2000) - ACS	All cause	30+		CO	216 (124 - 311)	1.0% (0.6% - 1.4%)	181 (104 - 260)	0.8% (0.5% - 1.2%)
	Krewski et al. (2000) - ACS	All cause	30+		NO2	259 (136 - 370)	1.2% (0.6% - 1.7%)	217 (114 - 310)	1.0% (0.5% - 1.4%)
	Krewski et al. (2000) - ACS	All cause	30+		O3	216 (124 - 311)	1.0% (0.6% - 1.4%)	181 (104 - 260)	0.8% (0.5% - 1.2%)
	Krewski et al. (2000) - ACS	All cause	30+		SO2	39 (-67 - 159)	0.2% (-0.3% - 0.7%)	32 (-56 - 134)	0.1% (-0.3% - 0.6%)
Respiratory Symptoms*						**Single Pollutant Models**			
	Schwartz and Neas (2000) -- 6 cities	Lower respiratory symptoms	7-14	1 day		7800 (3900 - 14700)	15.0% (7.6% - 28.4%)	7400 (3800 - 14300)	14.2% (7.2% - 27.5%)
	Schwartz and Neas (2000) -- 6 cities	Cough	7-14	0 day		12500 (-900 - 24100)	8.3% (-0.6% - 15.9%)	11800 (-900 - 22900)	7.8% (-0.6% - 15.1%)
						Multi-Pollutant Models			
	Schwartz and Neas (2000) -- 6 cities	Lower respiratory symptoms	7-14	1 day	PM10-2.5	7100 (2300 - 14600)	13.6% (4.3% - 28.0%)	6700 (2100 - 14100)	12.9% (4.1% - 27.1%)
	Schwartz and Neas (2000) -- 6 cities	Cough	7-14	0 day	PM10-2.5	6000 (-10100 - 18800)	3.9% (-6.7% - 12.4%)	5600 (-9400 - 17800)	3.7% (-6.2% - 11.7%)

*Health effects are associated with short-term exposure to PM2.5 unless otherwise specified.
**For the short-term exposure studies, incidence was quantified down to the estimated policy relevant background level of 3.5 µg/m3 . For the long-term exposure studies, incidence was quantified down to 7.5 ug/m3, which was the lowest of the lowest measured levels in the long-term exposure studies. Incidences are rounded to the nearest whole number, except for respiratory symptoms, which are rounded to the nearest 100; percents are rounded to the nearest tenth.
***The C-R functions for lower respiratory symptoms and cough were calculated for the summer period April 1 through August 31.
Note 1: Numbers in parentheses are 95% confidence intervals based on statistical uncertainty surrounding the PM2.5 coefficient.
Note 2: Multi-city short-term exposure C-R functions were applied only to urban areas included among the cities used to estimate the function.

Exhibit 7.12a. Sensitivity Analysis: Estimated Annual Mortality Associated with Short-Term Exposure to "As Is" PM$_{2.5}$ Concentrations, Using Alternative Model Specifications

Los Angeles, CA, 2003

Health Effects	Study	Type	Ages	Model	Lag	Other Pollutants in Model	Health Effects Associated with PM2.5 Above Policy Relevant Background*	
							Incidence	Percent of Total Incidence
Single Pollutant Models (Total Mortality)								
Short-Term Exposure Mortality	Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Non-accidental	all	log-linear, GAM (stringent), 30 df	0 day		494 (-62 - 1038)	0.9% (-0.1% - 1.9%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Non-accidental	all	log-linear, GAM (stringent), 30 df	1 day		540 (2 - 1067)	1.0% (0.0% - 1.9%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Non-accidental	all	log-linear, GAM (stringent), 30 df	0 day		494 (-62 - 1038)	0.9% (-0.1% - 1.9%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Non-accidental	all	log-linear, GLM, 30 df	0 day		367 (-314 - 1030)	0.7% (-0.6% - 1.9%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Non-accidental	all	log-linear, GAM (stringent), 100 df	0 day		294 (-208 - 786)	0.5% (-0.4% - 1.4%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Non-accidental	all	log-linear, GLM, 100 df	0 day		275 (-395 - 929)	0.5% (-0.7% - 1.7%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Non-accidental	all	log-linear, GAM (stringent), 30 df	1 day		540 (2 - 1067)	1.0% (0.0% - 1.9%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Non-accidental	all	log-linear, GLM, 30 df	1 day		503 (-154 - 1145)	0.9% (-0.3% - 2.1%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Non-accidental	all	log-linear, GAM (stringent), 100 df	1 day		92 (-427 - 601)	0.2% (-0.8% - 1.1%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Non-accidental	all	log-linear, GLM, 100 df	1 day		-9 (-928 - 879)	0.0% (-1.7% - 1.6%)

Health Effects	Study	Type	Ages	Model	Lag	Other Pollutants in Model	Health Effects Associated with PM2.5 Above Policy Relevant Background*	
							Incidence	Percent of Total Incidence
Single Pollutant Models (Cause-Specific Mortality)								
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Cardiovascular	all	log-linear, GAM (stringent), 30 df	0 day		321 (33 - 601)	1.6% (0.2% - 3.1%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Cardiovascular	all	log-linear, GAM (stringent), 100 df	0 day		315 (47 - 575)	1.6% (0.2% - 2.9%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Cardiovascular	all	log-linear, GLM, 100 df	0 day		315 (-5 - 624)	1.6% (0.0% - 3.2%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Cardiovascular	all	log-linear, GAM (stringent), 30 df	1 day		334 (52 - 608)	1.7% (0.3% - 3.1%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Cardiovascular	all	log-linear, GAM (stringent), 100 df	1 day		260 (-10 - 523)	1.3% (-0.1% - 2.7%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Cardiovascular	all	log-linear, GLM, 100 df	1 day		225 (-105 - 543)	1.1% (-0.5% - 2.8%)
Multi-Pollutant Models (Total Mortality)								
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Non-accidental	all	log-linear, GAM (stringent), 30 df	1 day	CO	-492 (-1235 - 232)	-0.9% (-2.2% - 0.4%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Non-accidental	all	log-linear, GAM (stringent), 100 df	1 day	CO	-305 (-984 - 356)	-0.6% (-1.8% - 0.6%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Non-accidental	all	log-linear, GLM, 100 df	1 day	CO	-305 (-1100 - 466)	-0.6% (-2.0% - 0.8%)
Multi-Pollutant Models (Cause-Specific Mortality)								
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Cardiovascular	all	log-linear, GAM (stringent), 100 df	0 day	CO	572 (249 - 884)	2.9% (1.3% - 4.5%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Cardiovascular	all	log-linear, GLM, 100 df	0 day	CO	603 (223 - 969)	3.1% (1.1% - 4.9%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Cardiovascular	all	log-linear, GAM (stringent), 100 df	1 day	CO	296 (-40 - 620)	1.5% (-0.2% - 3.1%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Cardiovascular	all	log-linear, GLM, 100 df	1 day	CO	296 (-113 - 687)	1.5% (-0.6% - 3.5%)

*Health effects incidence was quantified down to estimated policy relevant background level of 2.5 ug/m3. Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Note: Numbers in parentheses are 95% confidence intervals based on statistical uncertainty surrounding the PM2.5 coefficient.

Exhibit 7.12b. Sensitivity Analysis: Estimated Annual Morbidity Associated with Short-Term Exposure to "As Is" PM$_{2.5}$ Concentrations, Using Alternative Model Specifications

Los Angeles, CA, 2003

Health Effects	Study	Type	Ages	Model	Lag	Other Pollutants in Model	Health Effects Associated with PM2.5 Above Policy Relevant Background*	
							Incidence	Percent of Total Incidence
Hospital Admissions				**Single Pollutant Models**				
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000b)]	Cardiovascular	65+	log-linear, GAM (stringent), 30 df	0 day		1787 (1042 - 2516)	2.6% (1.5% - 3.6%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000b)]	Cardiovascular	65+	log-linear, GAM (stringent), 100 df	0 day		1319 (583 - 2039)	1.9% (0.8% - 2.9%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000b)]	Cardiovascular	65+	log-linear, GLM, 100 df	0 day		1431 (521 - 2315)	2.1% (0.8% - 3.3%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000b)]	Cardiovascular	65+	log-linear, GAM (stringent), 30 df	1 day		1576 (795 - 2339)	2.3% (1.2% - 3.4%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000b)]	Cardiovascular	65+	log-linear, GAM (stringent), 100 df	1 day		1285 (537 - 2017)	1.9% (0.8% - 2.9%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000b)]	Cardiovascular	65+	log-linear, GLM, 100 df	1 day		1364 (447 - 2255)	2.0% (0.7% - 3.3%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000c)]	COPD+	all	log-linear, GAM (stringent), 30 df	0 day		824 (346 - 1286)	2.7% (1.1% - 4.3%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000c)]	COPD+	all	log-linear, GAM (stringent), 100 df	0 day		683 (262 - 1092)	2.3% (0.9% - 3.6%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000c)]	COPD+	all	log-linear, GLM, 100 df	0 day		737 (210 - 1244)	2.4% (0.7% - 4.1%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000c)]	COPD+	all	log-linear, GAM (stringent), 30 df	1 day		591 (115 - 1050)	2.0% (0.4% - 3.5%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000c)]	COPD+	all	log-linear, GAM (stringent), 100 df	1 day		374 (-54 - 790)	1.2% (-0.2% - 2.6%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000c)]	COPD+	all	log-linear, GLM, 100 df	1 day		384 (-136 - 885)	1.3% (-0.5% - 2.9%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000c)]	COPD+	all	log-linear, GAM (stringent), 30 df	2 day		911 (417 - 1387)	3.0% (1.4% - 4.6%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000c)]	COPD+	all	log-linear, GAM (stringent), 100 df	2 day		566 (110 - 1008)	1.9% (0.4% - 3.3%)

Health Effects	Study	Type	Ages	Model	Lag	Other Pollutants in Model	Health Effects Associated with PM2.5 Above Policy Relevant Background*	
							Incidence	Percent of Total Incidence
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000c)]	COPD+	all	log-linear, GLM, 100 df	2 day		512 (-56 - 1059)	1.7% (-0.2% - 3.5%)
	Multi-Pollutant Models							
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000b)]	Cardiovascular	65+	log-linear, GAM (stringent), 100 df	0 day	CO	448 (-512 - 1380)	0.7% (-0.7% - 2.0%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000b)]	Cardiovascular	65+	log-linear, GLM, 100 df	0 day	CO	664 (-473 - 1763)	1.0% (-0.7% - 2.5%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000b)]	Cardiovascular	65+	log-linear, GAM (stringent), 100 df	1 day	CO	276 (-755 - 1276)	0.4% (-1.1% - 1.8%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000b)]	Cardiovascular	65+	log-linear, GLM, 100 df	1 day	CO	310 (-874 - 1453)	0.5% (-1.3% - 2.1%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000c)]	COPD+	all	log-linear, GAM (stringent), 100 df	0 day	NO2	210 (-464 - 855)	0.7% (-1.5% - 2.8%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000c)]	COPD+	all	log-linear, GAM (stringent), 100 df	1 day	NO2	-20 (-833 - 750)	-0.1% (-2.8% - 2.5%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000c)]	COPD+	all	log-linear, GAM (stringent), 100 df	2 day	NO2	176 (-524 - 842)	0.6% (-1.7% - 2.8%)

*Health effects incidence was quantified down to estimated policy relevant background level of 2.5 ug/m3. Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Note: Numbers in parentheses are 95% confidence intervals based on statistical uncertainty surrounding the PM2.5 coefficient.

The first sensitivity analysis, shown in Exhibit 7.6, examines the effect of alternative assumptions about PRB concentration on the estimated effect of short-term exposures to $PM_{2.5}$ concentrations above background in Detroit. The results for the other assessment locations are shown in Appendix D. In many cases, changing the assumed background concentration had a noticeable effect. For example, changing from the midpoint estimate of 3.5 µg/m^3 for $PM_{2.5}$ background in the Eastern U.S. to the lower end of the range for $PM_{2.5}$ background (2 µg/m^3) increased the estimated percent of total incidence that is $PM_{2.5}$-related using Schwartz (2003b) in Boston by about 17 percent (from 1.8 percent to 2.1 percent). Similarly, changing from the midpoint estimate to the upper end of the range for $PM_{2.5}$ (5 µg/m^3) decreased the percent of total incidence that is $PM_{2.5}$-related using that same study by about 17 percent (from 1.8 percent to 1.5 percent). Because all three background levels in both the East and the West are lower than 7.5 µg/m^3, the initial base case cutpoint used for the long-term exposure mortality studies, changing background levels had no effect on the risk estimates based on these studies. Therefore only health effects associated with short-term exposures were included in this sensitivity analysis.

The second sensitivity analysis attempts to estimate how different the results would be if the C-R functions used had been distributed lag models rather than single lag models, using the results of a study by Schwartz (2000b). Schwartz (2000b) estimated constrained and unconstrained distributed lag C-R functions for PM_{10} and daily deaths of persons 65 years and older in 10 U.S. cities. Using an unconstrained distributed lag model, he estimated a 1.29% increase in mortality associated with an increase of 10 µg/m^3 PM_{10}. Using a constrained model (which assumed that the effect all occurs in one day) he estimated a 0.65% increase associated with a 10 µg/m^3 increase in PM_{10} (see Schwartz, 2000b, Table 3). The PM_{10} coefficient corresponding to the constrained model result is 0.00065. The PM_{10} coefficient corresponding to the unconstrained model (i.e., the value that a single lag coefficient would have to be to result in a relative risk of 1.013) is 0.00128. The ratio of those coefficients is 1.98. That is, a distributed lag model predicted the same relative risk that a single lag model would have predicted if the coefficient were 1.98 times what it was estimated to be. To simulate what the results might have been had a distributed lag model been estimated instead of a single lag model, we multiplied the $PM_{2.5}$ coefficients for total mortality by 1.98. The results are shown for Detroit in Exhibit 7.7 (and for the other urban areas in Exhibits D.25 - D.29 in Appendix D). As would be expected, the results are almost double using the distributed lag approximation.

An important source of uncertainty in applying the long-term exposure studies in a risk assessment is what the relevant period of exposure is and the extent, if any, of a lag period between exposure and effects. If air quality was historically 50 percent higher than the levels measured in the long-term exposure mortality studies, and if the historical air quality levels were the relevant levels, then the $PM_{2.5}$ coefficients that would have been estimated using the historical $PM_{2.5}$ levels would have been two-thirds (=1/1.5) the coefficients that were actually estimated in the studies. Similarly, if air quality was historically twice the levels measured in the long-term exposure mortality studies, and if the historical air quality levels were the relevant levels, then the $PM_{2.5}$ coefficients that would have been estimated using the historical $PM_{2.5}$

levels would have been half (=1/2.0) the coefficients that were actually estimated in the studies. The impact of varying assumptions about historical air quality on estimates of long-term exposure mortality associated with "as is" $PM_{2.5}$ concentrations is shown for Detroit in Exhibit 7.8 (and for the other urban areas in exhibits D.30 - D37 in Appendix D).

The impact of using different daily background $PM_{2.5}$ concentrations (versus a constant background concentration) on the estimates of risk associated with "as is" $PM_{2.5}$ concentrations in excess of background was assessed in Detroit and St. Louis. Daily background values were generated first assuming no correlation between the anthropogenic portion of "as is" concentrations and background concentrations, and then assuming a moderate correlation of 0.4. The method of generating daily background concentrations is described in detail in Langstaff (2004). Using different daily background $PM_{2.5}$ concentrations had only a minimal effect on the estimates of risk reduction. The estimated percent of total non-accidental mortality associated with short-term exposure to $PM_{2.5}$ in excess of background levels in Detroit decreased from 0.9 percent (170 cases) to 0.8 percent (153 cases) when different daily background concentrations (assuming zero correlation with the anthropogenic portion of "as is" concentrations) were substituted for a constant PRB (Exhibit 7.9). The changes in percent of total non-accidental mortality in St. Louis (assuming a 0.4 correlation of background and anthropogenic concentrations) were not sufficiently large to be detected when results were rounded to one decimal place. The results for St. Louis are therefore not shown.

As noted earlier, a sensitivity analysis was conducted examining the impact on PM risk estimates of a large natural fire that occurred in July 2002 in Quebec that resulted in unusually high $PM_{2.5}$ concentrations being reported at ambient monitors in the northeastern portions of the U.S. The exclusion of "exceptional event episodes" in Boston in 2002 resulted in three fewer days at the composite monitor (296 vs. 299 days with composite monitor values), a decrease in the maximum $PM_{2.5}$ value from 63.1 to 51.2 $\mu g/m^3$, and a decrease in the annual average $PM_{2.5}$ concentration from 11.5 to 11.2 $\mu g/m^3$ (see Exhibit 7.10). The corresponding decreases in mortality associated with short-term exposure to $PM_{2.5}$ were quite modest (see Exhibit 7.11). The incidence of PM-related non-accidental mortality estimated using Schwartz (2003b), for example, decreased from 356 to 345; the corresponding change in the estimated percent of total incidence was not sufficiently large to be detected when results were rounded to one decimal place. Decreases in long-term exposure mortality were somewhat larger. The incidence of PM-related mortality estimated using Pope et al. (2002) – ACS extended decreased from 507 to 477; the estimated percent of total incidence decreased from 2.3 percent to 2.1 percent.

The impact of using different model specifications and C-R functions with different lag structures on mortality and morbidity risks in Los Angeles is shown in Exhibits 7.12a and 7.12b, respectively. As noted in Section 1 above, many time-series studies which reported log-linear C-R functions based on generalized additive models (GAMs) estimated using the S-Plus software had to re-estimate those C-R functions using appropriate modifications of the default convergence criteria code. In re-estimating C-R functions for $PM_{2.5}$ and mortality and morbidity

in Los Angeles, Moolgavkar (2003) presented three different model specifications – GAMs with more stringent convergence criteria with 30 degrees of freedom (df) and with 100 df, as well as a generalized linear model (GLM) with 100 df. Results are shown based on each of these model specifications in combination with both 0-day and 1-day lags for all health endpoints, and with a 2-day lag in addition for hospital admissions for COPD.

Estimated mortality and morbidity risks varied substantially with model specification and lag structure, although there was no obvious pattern across all health endpoints. GLM estimates were generally higher than GAM estimates with the same number of df for both cardiovascular and COPD hospital admissions, but lower for non-accidental and cardiovascular mortality. Not surprisingly, increasing the df generally lowered the estimated incidence. The highest non-accidental mortality risk estimate (540 PM-related deaths associated with "as is"$PM_{2.5}$ concentrations, or 1.0 percent of total incidence) was produced by the GAM with 30 df and a 1-day lag, and the lowest (-9 PM-related deaths, or 0.0 percent of total incidence) was produced by the GLM with 100 df and a 1-day lag. Cardiovascular mortality exhibited the same pattern as non-accidental mortality across model specifications and lag structures. For cardiovascular hospital admissions, PM-related incidence estimates ranged from 1787 (2.6 percent of total incidence) produced by the GAM with 30 df and a 0-day lag to 1285 (1.9 percent of total incidence) produced by the GAM with 100 df and a 1-day lag. For COPD hospital admissions, PM-related incidence estimates ranged from 911 (3.0 percent of total incidence) produced by the GAM with 30 df and a 2-day lag to 374 (1.2 percent of total incidence) produced by the GAM with 100 df and a 1-day lag.

8. Assessment of the Reduced Health Risks Associated with Just Meeting the Current and Alternative PM$_{2.5}$ Standards

8.1 Base case analysis

The second part of the risk assessment estimates the reduced risks that would result if the current PM$_{2.5}$ standards or alternative PM$_{2.5}$ standards were just met in the assessment locations. (Note that the current standards are already met in Boston, Phoenix, San Jose, and Seattle based on 2001 - 2003 air quality data.) In addition to the current set of standards, annual standards of 15, 14, 13, and 12 µg/m^3 were each combined with ninety-eighth percentile daily standards of 40, 35, 30, and 25 µg/m^3, and ninety-ninth percentile daily standards at the same levels. In addition, an annual standard of 15 µg/m^3 was combined with a ninety-ninth percentile daily standard of 65 µg/m^3. Among those locations that did not meet the current PM$_{2.5}$ standards based on 2001 - 2003 air quality data (Detroit, Los Angeles, Philadelphia, Pittsburgh, and St. Louis), there was no difference in the percent rollback required to just meet any of the alternative annual standards (14, 13, and 12 µg/m^3) in combination with the current ninety-eighth percentile daily standard of 65 µg/m^3 versus the percent rollback required to just meet any of these annual standards in combination with the more stringent ninety-eighth percentile daily standard of 40 µg/m^3 – except in Philadelphia, where just meeting the 14 µg/m^3 annual standard combined with the ninety-eighth percentile daily standard of 40 µg/m^3 requires a 23.2% rollback compared with an 18.6% rollback necessary to just meet the 14 µg/m^3 annual standard combined with the ninety-eighth percentile daily standard of 65 µg/m^3. Because of this, the 14 µg/m^3 annual standard was combined with the ninety-eighth percentile daily standard of 65 µg/m^3 only in Philadelphia. The combinations of annual and daily standards used in the PM$_{2.5}$ risk assessment are summarized in Exhibit 8.1.[28]

Exhibit 8.1 Alternative Sets of PM$_{2.5}$ Standards Considered in the PM$_{2.5}$ Risk Assessment*

Annual Standard	98th Percentile Daily Standard					99th Percentile Daily Standard				
	65	40	35	30	25	65	40	35	30	25
15	x**	x	x	x	x	x	x	x	x	x
14	x***	x	x	x	x		x	x	x	x
13		x	x	x	x		x	x	x	x
12		x	x	x	x		x	x	x	x

*All standards are in µg/m^3.
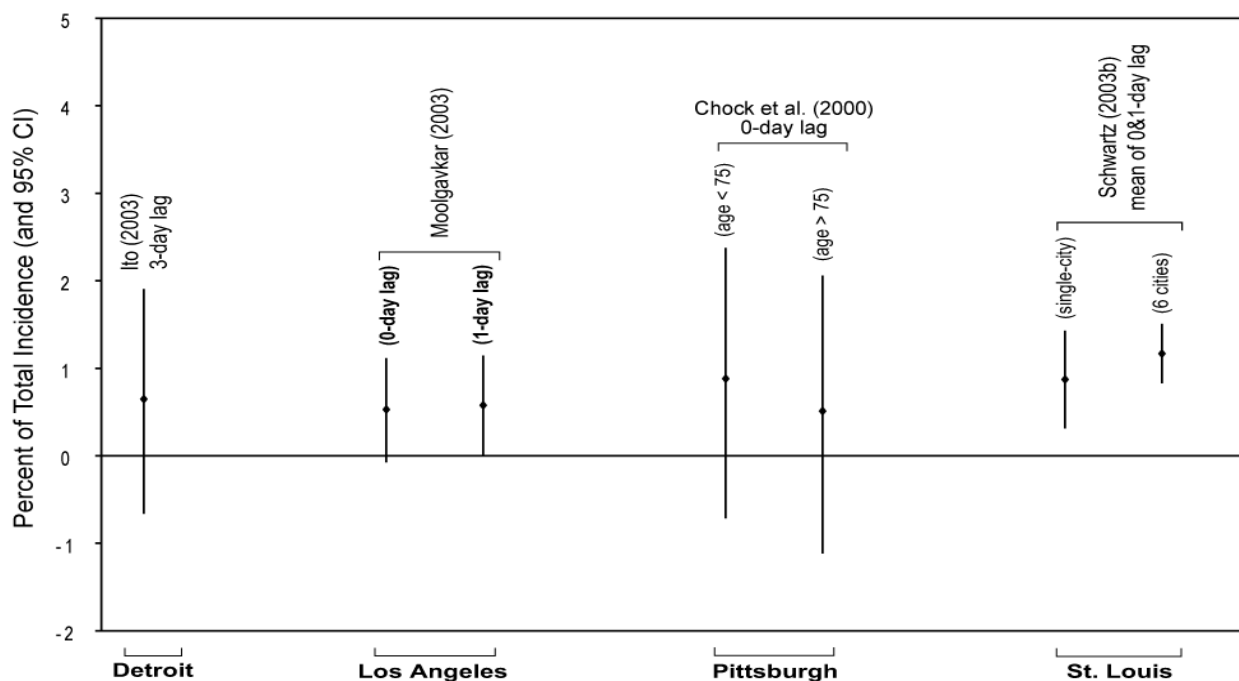
**Current standards.

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[28] See Chapter 5 of U.S. EPA(2005a) for a discussion of the rationale for selecting these alternative standards.
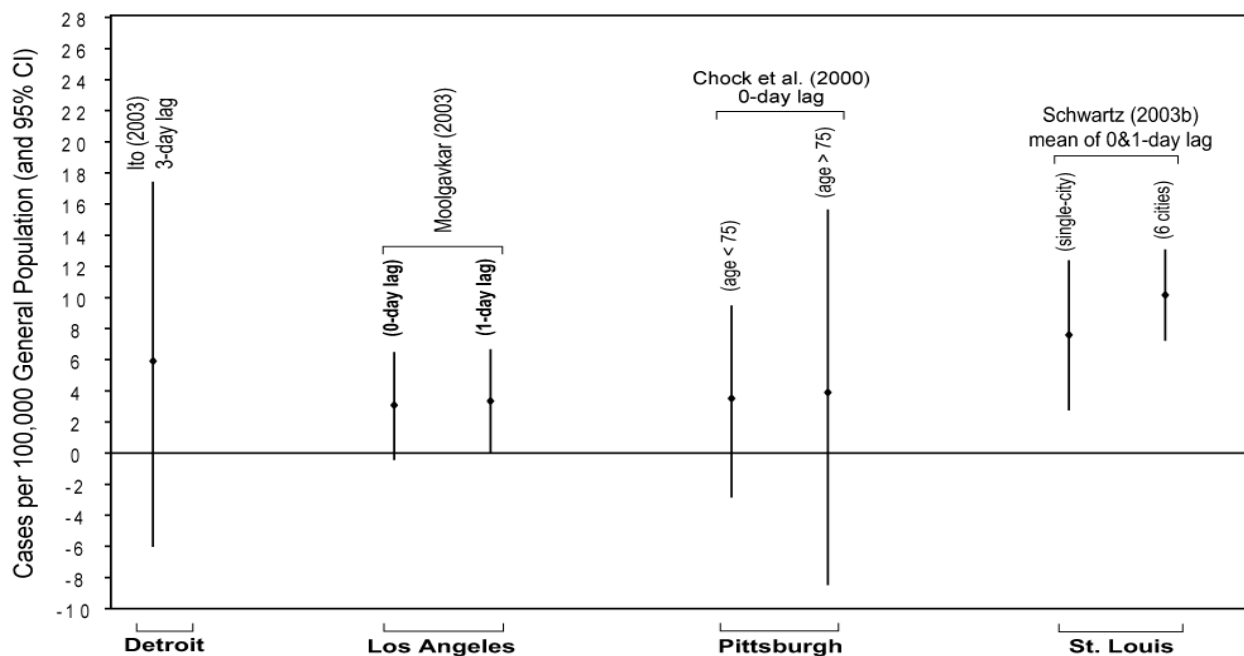
***Only in Philadelphia.

       Estimated annual mortality associated with short-term and long-term exposure to $PM_{2.5}$ when the current standards are just met, assuming various cutpoints, are shown for all locations in Figures 8.1a and b and 8.2a and b, respectively, and in Exhibits 8.2 and 8.3, respectively. Estimated annual incidence, as well as the percent reduction from incidence under the current standards, of short-term exposure mortality, and all-cause, cardiovascular, and lung cancer mortality associated with long-term exposure to $PM_{2.5}$, when alternative standards are just met, assuming various cutpoint levels, are given for Detroit in Exhibits 8.4, 8.5, 8.6, and 8.7, respectively. The corresponding exhibits for the other locations are given in Exhibits E.1 - E.36 of Appendix E.
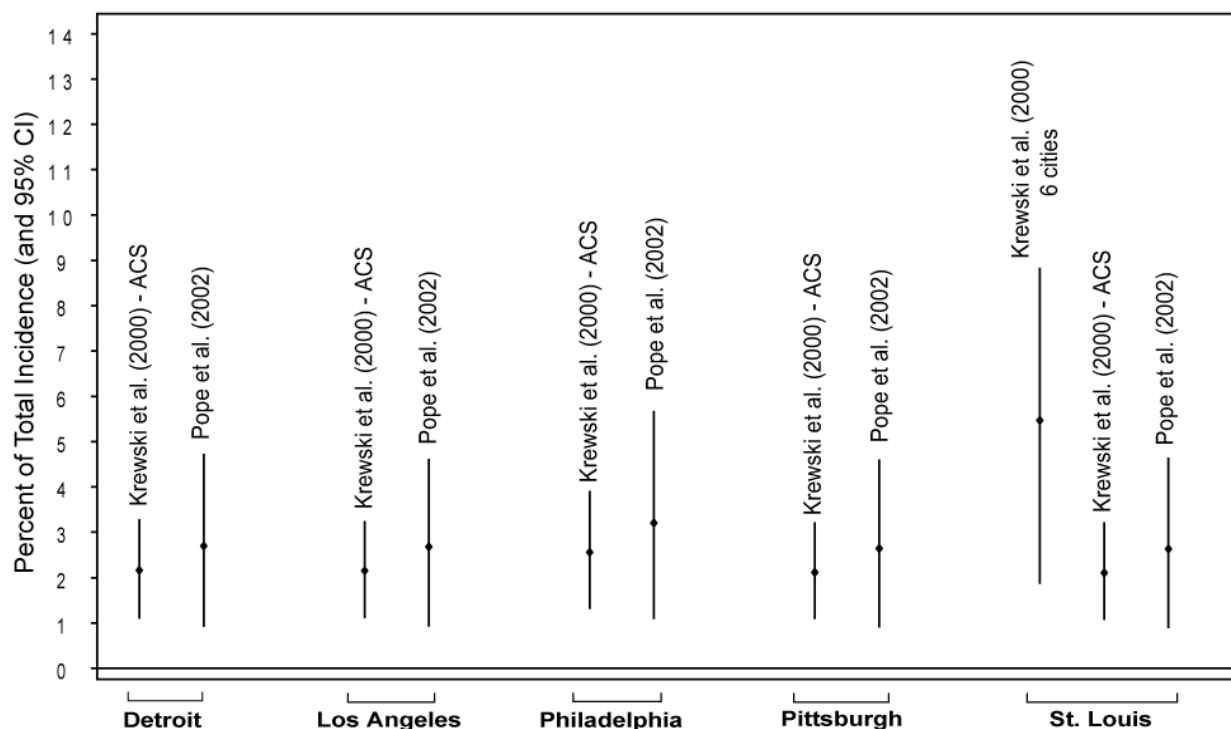
Figure 8.1a. Estimated Annual Percent of Non-accidental Mortality Associated with Short-Term Exposure to PM$_{2.5}$ Above Background When the Current Annual Standard of 15 µg/m^3 and the Current Daily Standard of 65 µg/m^3 Are Just Met
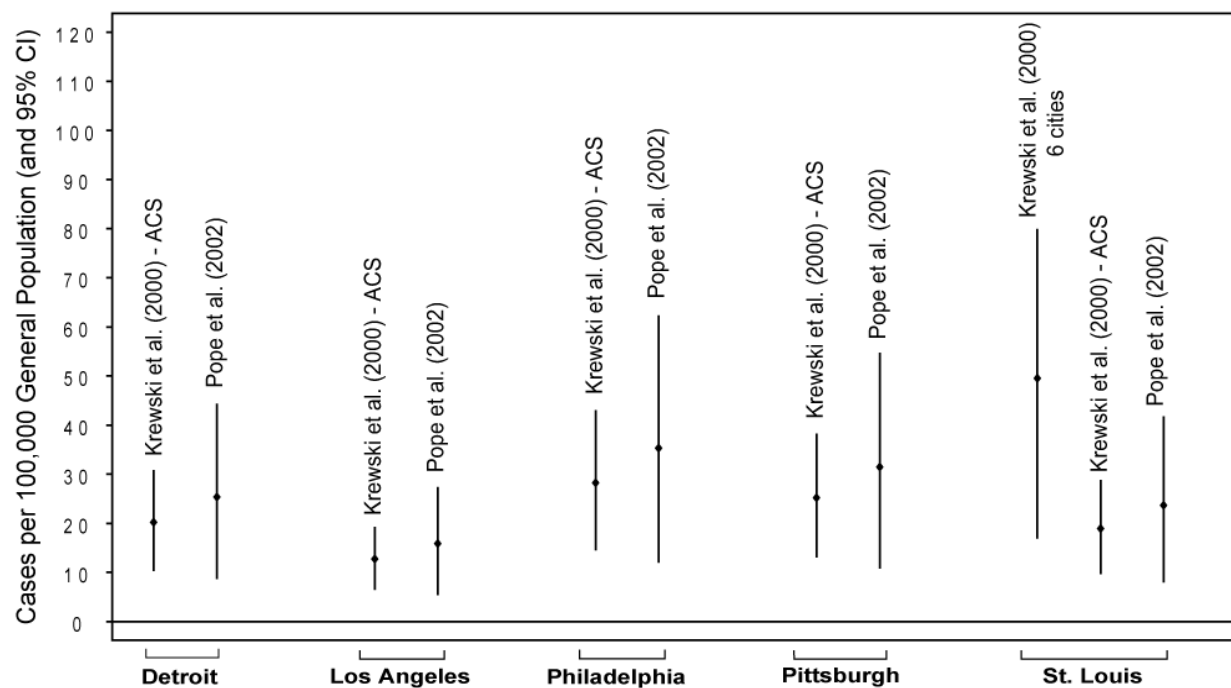
Figure 8.1b. Estimated Annual Cases of Non-accidental Mortality per 100,000 General Population Associated with Short-Term Exposure to PM$_{2.5}$ Above Background When the Current Annual Standard of 15 µg/m^3 and the Current Daily Standard of 65 µg/m^3 Are Just Met

Figure 8.2a. Estimated Annual Percent of Mortality Associated with Long-Term Exposure to PM$_{2.5}$ Above 7.5 µg/m³ When the Current Annual Standard of 15 µg/m³ and the Current Daily Standard of 65 µg/m³ Are Just Met

Figure 8.2b. Estimated Annual Cases of Mortality per 100,000 General Population Associated with Long-Term Exposure to PM$_{2.5}$ Above 7.5 µg/m³ When the Current Annual Standard of 15 µg/m³ and the Current Daily Standard of 65 µg/m³ Are Just Met

Exhibit 8.2. Estimated Annual Mortality Associated with Short-Term Exposure to PM$_{2.5}$ When the Current Annual Standard of 15 µg/m3 and the Current Daily Standard of 65 µg/m3 Are Just Met, Assuming Various Cutpoint Levels*

Urban Area	Study	Type	Ages	Lag	Incidence Associated with PM2.5 Assuming Various Cutpoint Levels (95% Confidence Interval) / Incidence per 100,000 General Population (95% Confidence Interval) / Percent of Total Incidence (95% Confidence Interval)			
					Policy Relevant Background** =2.5 or 3.5 µg/m3	Cutpoint*** =10 µg/m3	Cutpoint*** =15 µg/m3	Cutpoint*** =20 µg/m3
Detroit	Ito (2003) [reanalysis of Lippmann et al. (2000)]	Non-accidental	all	3 day	122 (-123 - 358)	54 (-55 - 159)	26 (-27 - 77)	12 (-12 - 35)
					6 (-6 - 17)	3 (-3 - 8)	1 (-1 - 4)	1 (-1 - 2)
					0.7% (-0.7% - 1.9%)	0.3% (-0.3% - 0.8%)	0.1% (-0.1% - 0.4%)	0.1% (-0.1% - 0.2%)
Los Angeles	Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Non-accidental	all	0 day	292 (-37 - 612)	115 (-14 - 240)	58 (-7 - 121)	29 (-4 - 61)
					3 (0 - 6)	1 (0 - 3)	1 (0 - 1)	0 (0 - 1)
					0.5% (-0.1% - 1.1%)	0.2% (0.0% - 0.4%)	0.1% (0.0% - 0.2%)	0.1% (0.0% - 0.1%)
Philadelphia	Lipfert et al. (2000) -- 7 counties	Cardiovascular	all	1 day	367 (175 - 560)	189 (90 - 288)	106 (51 - 162)	57 (27 - 87)
					24 (12 - 37)	12 (6 - 19)	7 (3 - 11)	4 (2 - 6)
					5.8% (2.8% - 8.8%)	3.0% (1.4% - 4.5%)	1.7% (0.8% - 2.6%)	0.9% (0.4% - 1.4%)
Pittsburgh	Chock et al. (2000)	Non-accidental	75+	0 day	50 (-108 - 200)	22 (-48 - 87)	10 (-23 - 41)	5 (-11 - 18)
					4 (-8 - 16)	2 (-4 - 7)	1 (-2 - 3)	0 (-1 - 1)
					0.5% (-1.1% - 2.1%)	0.2% (-0.5% - 0.9%)	0.1% (-0.2% - 0.4%)	0.1% (-0.1% - 0.2%)
St. Louis	Schwartz (2003b) [reanalysis of Schwartz et al. (1996)]	Non-accidental	all	mean of lag 0 & 1 day	191 (70 - 311)	75 (28 - 122)	29 (11 - 46)	9 (3 - 14)
					8 (3 - 12)	3 (1 - 5)	1 (0 - 2)	0 (0 - 1)
					0.9% (0.3% - 1.4%)	0.3% (0.1% - 0.6%)	0.1% (0.1% - 0.2%)	0.0% (0.0% - 0.1%)

*All results are for single pollutant, non-accidental mortality models, unless otherwise specified.

**Policy relevant background is 2.5 µg/m3 in the West (Los Angeles) and 3.5 µg/m3 in the East (Detroit, Philadelphia, Pittsburgh, and St. Louis).

***For the cutpoints above policy relevant background, the slope of the C-R function has been modified based on a simple hockeystick model (see discussion in section 2.5).

Exhibit 8.3. Estimated Annual Mortality Associated with Long-Term Exposure to PM$_{2.5}$ When the Current Annual Standard of 15 μg/m3 and the Current Daily Standard of 65 μg/m3 Are Just Met, Assuming Various Cutpoint Levels*

Urban Areas	Incidence Associated with PM2.5 Assuming Various Cutpoint Levels (95% Confidence Interval) Incidence per 100,000 General Population (95% Confidence Interval) Percent of Total Incidence (95% Confidence Interval)		
	Cutpoint** = 7.5 μg/m3	Cutpoint** =10 μg/m3	Cutpoint** =12 μg/m3
Detroit	522 (181 - 910)	282 (98 - 494)	41 (14 - 72)
	25 (9 - 44)	14 (5 - 24)	2 (1 - 3)
	2.7% (0.9% - 4.7%)	1.5% (0.5% - 2.6%)	0.2% (0.1% - 0.4%)
Los Angeles	1507 (531 - 2587)	823 (290 - 1415)	138 (48 - 237)
	16 (6 - 27)	9 (3 - 15)	1 (1 - 2)
	2.7% (0.9% - 4.6%)	1.5% (0.5% - 2.5%)	0.2% (0.1% - 0.4%)
Philadelphia	536 (185 - 943)	338 (116 - 597)	137 (47 - 244)
	35 (12 - 62)	22 (8 - 39)	9 (3 - 16)
	3.2% (1.1% - 5.7%)	2.0% (0.7% - 3.6%)	0.8% (0.3% - 1.5%)
Pittsburgh	403 (141 - 699)	215 (75 - 373)	25 (9 - 43)
	31 (11 - 55)	17 (6 - 29)	2 (1 - 3)
	2.7% (0.9% - 4.6%)	1.4% (0.5% - 2.5%)	0.2% (0.1% - 0.3%)
St. Louis	596 (206 - 1047)	311 (107 - 548)	23 (8 - 40)
	24 (8 - 42)	12 (4 - 22)	1 (0 - 2)
	2.6% (0.9% - 4.6%)	1.4% (0.5% - 2.4%)	0.1% (0.0% - 0.2%)

*Based on Pope et al. (2002) -- ACS extended, all cause mortality among adults age 30 and older.

**For the cutpoints above policy relevant background, the slope of the C-R function has been modified based on a simple hockeystick model (see discussion in section 2.5).

Exhibit 8.4. Estimated Annual Mortality Associated with Short-Term Exposure to PM$_{2.5}$ When Alternative Standards Are Just Met, Assuming Various Cutpoint Levels*
Detroit, MI, 2003

Alternative Standards		Incidence Associated with PM2.5			
		(95% Confidence Interval)			
		Percent Reduction in Incidence from Current Standards			
Annual (µg/m3)	Daily (µg/m3)	Policy Relevant Background =3.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =15 µg/m3	Cutpoint** =20 µg/m3
15	65, 98th percentile value***	122 (-123 - 358) 0.0%	54 (-55 - 159) 0.0%	26 (-27 - 77) 0.0%	12 (-12 - 35) 0.0%
15	40, 98th percentile value	122 (-123 - 358) 0.0%	54 (-55 - 159) 0.0%	26 (-27 - 77) 0.0%	12 (-12 - 35) 0.0%
15	35, 98th percentile value	122 (-123 - 358) 0.0%	54 (-55 - 159) 0.0%	26 (-27 - 77) 0.0%	12 (-12 - 35) 0.0%
15	30, 98th percentile value	111 (-112 - 325) 9.0%	45 (-45 - 131) 16.7%	20 (-20 - 58) 23.1%	8 (-9 - 24) 33.3%
15	25, 98th percentile value	90 (-91 - 263) 26.2%	28 (-29 - 82) 48.1%	10 (-10 - 28) 61.5%	3 (-4 - 10) 75.0%
15	65, 99th percentile value	122 (-123 - 358) 0.0%	54 (-55 - 159) 0.0%	26 (-27 - 77) 0.0%	12 (-12 - 35) 0.0%
15	40, 99th percentile value	122 (-123 - 358) 0.0%	54 (-55 - 159) 0.0%	26 (-27 - 77) 0.0%	12 (-12 - 35) 0.0%
15	35, 99th percentile value	120 (-121 - 352) 1.6%	53 (-53 - 154) 1.9%	25 (-26 - 74) 3.8%	11 (-12 - 33) 8.3%
15	30, 99th percentile value	101 (-102 - 296) 17.2%	37 (-37 - 107) 31.5%	15 (-15 - 42) 42.3%	6 (-6 - 16) 50.0%

Alternative Standards		Incidence Associated with PM2.5			
		(95% Confidence Interval)			
		Percent Reduction in Incidence from Current Standards			
Annual (µg/m3)	Daily (µg/m3)	Policy Relevant Background =3.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =15 µg/m3	Cutpoint** =20 µg/m3
15	25, 99th percentile value	82 (-83 - 239) 32.8%	22 (-23 - 65) 59.3%	7 (-7 - 19) 73.1%	2 (-2 - 6) 83.3%
14	40, 98th percentile value	111 (-112 - 326) 9.0%	45 (-46 - 132) 16.7%	20 (-20 - 58) 23.1%	8 (-9 - 24) 33.3%
14	35, 98th percentile value	111 (-112 - 326) 9.0%	45 (-46 - 132) 16.7%	20 (-20 - 58) 23.1%	8 (-9 - 24) 33.3%
14	30, 98th percentile value	111 (-112 - 325) 9.0%	45 (-45 - 131) 16.7%	20 (-20 - 58) 23.1%	8 (-9 - 24) 33.3%
14	25, 98th percentile value	90 (-91 - 263) 26.2%	28 (-29 - 82) 48.1%	10 (-10 - 28) 61.5%	3 (-4 - 10) 75.0%
14	40, 99th percentile value	111 (-112 - 326) 9.0%	45 (-46 - 132) 16.7%	20 (-20 - 58) 23.1%	8 (-9 - 24) 33.3%
14	35, 99th percentile value	111 (-112 - 326) 9.0%	45 (-46 - 132) 16.7%	20 (-20 - 58) 23.1%	8 (-9 - 24) 33.3%
14	30, 99th percentile value	101 (-102 - 296) 17.2%	37 (-37 - 107) 31.5%	15 (-15 - 42) 42.3%	6 (-6 - 16) 50.0%
14	25, 99th percentile value	82 (-83 - 239) 32.8%	22 (-23 - 65) 59.3%	7 (-7 - 19) 73.1%	2 (-2 - 6) 83.3%
13	40, 98th percentile value	101 (-101 - 295) 17.2%	36 (-37 - 106) 33.3%	14 (-15 - 42) 46.2%	6 (-6 - 16) 50.0%
13	35, 98th percentile value	101 (-101 - 295) 17.2%	36 (-37 - 106) 33.3%	14 (-15 - 42) 46.2%	6 (-6 - 16) 50.0%

Alternative Standards		Incidence Associated with PM2.5			
		(95% Confidence Interval)			
		Percent Reduction in Incidence from Current Standards			
Annual (µg/m3)	Daily (µg/m3)	Policy Relevant Background =3.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =15 µg/m3	Cutpoint** =20 µg/m3
13	30, 98th percentile value	101 (-101 - 295) 17.2%	36 (-37 - 106) 33.3%	14 (-15 - 42) 46.2%	6 (-6 - 16) 50.0%
13	25, 98th percentile value	90 (-91 - 263) 26.2%	28 (-29 - 82) 48.1%	10 (-10 - 28) 61.5%	3 (-4 - 10) 75.0%
13	40, 99th percentile value	101 (-101 - 295) 17.2%	36 (-37 - 106) 33.3%	14 (-15 - 42) 46.2%	6 (-6 - 16) 50.0%
13	35, 99th percentile value	101 (-101 - 295) 17.2%	36 (-37 - 106) 33.3%	14 (-15 - 42) 46.2%	6 (-6 - 16) 50.0%
13	30, 99th percentile value	101 (-101 - 295) 17.2%	36 (-37 - 106) 33.3%	14 (-15 - 42) 46.2%	6 (-6 - 16) 50.0%
13	25, 99th percentile value	82 (-83 - 239) 32.8%	22 (-23 - 65) 59.3%	7 (-7 - 19) 73.1%	2 (-2 - 6) 83.3%
12	40, 98th percentile value	90 (-91 - 264) 26.2%	28 (-29 - 82) 48.1%	10 (-10 - 28) 61.5%	3 (-4 - 10) 75.0%
12	35, 98th percentile value	90 (-91 - 264) 26.2%	28 (-29 - 82) 48.1%	10 (-10 - 28) 61.5%	3 (-4 - 10) 75.0%
12	30, 98th percentile value	90 (-91 - 264) 26.2%	28 (-29 - 82) 48.1%	10 (-10 - 28) 61.5%	3 (-4 - 10) 75.0%
12	25, 98th percentile value	90 (-91 - 263) 26.2%	28 (-29 - 82) 48.1%	10 (-10 - 28) 61.5%	3 (-4 - 10) 75.0%
12	40, 99th percentile value	90 (-91 - 264) 26.2%	28 (-29 - 82) 48.1%	10 (-10 - 28) 61.5%	3 (-4 - 10) 75.0%

Alternative Standards		Incidence Associated with PM2.5 (95% Confidence Interval)			
		Percent Reduction in Incidence from Current Standards			
Annual (µg/m3)	Daily (µg/m3)	Policy Relevant Background =3.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =15 µg/m3	Cutpoint** =20 µg/m3
12	35, 99th percentile value	90 (-91 - 264) 26.2%	28 (-29 - 82) 48.1%	10 (-10 - 28) 61.5%	3 (-4 - 10) 75.0%
12	30, 99th percentile value	90 (-91 - 264) 26.2%	28 (-29 - 82) 48.1%	10 (-10 - 28) 61.5%	3 (-4 - 10) 75.0%
12	25, 99th percentile value	82 (-83 - 239) 32.8%	22 (-23 - 65) 59.3%	7 (-7 - 19) 73.1%	2 (-2 - 6) 83.3%

*This analysis used a C-R function from Ito (2003).

**For the cutpoints above policy relevant background, the slope of the C-R function has been modified based on a simple hockeystick model (see discussion in section 2.5).

***Current standards.

Note: Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Exhibit 8.5. Estimated Annual Mortality Associated with Long-Term Exposure to PM$_{2.5}$ When Alternative Standards Are Just Met, Assuming Various Cutpoint Levels*
Detroit, MI, 2003

Alternative Standards		Incidence Associated with PM2.5 (95% Confidence Interval)		
		Percent Reduction in Incidence from Current Standards		
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
15	65, 98th percentile value***	522 (181 - 910) 0.0%	282 (98 - 494) 0.0%	41 (14 - 72) 0.0%
15	40, 98th percentile value	522 (181 - 910) 0.0%	282 (98 - 494) 0.0%	41 (14 - 72) 0.0%
15	35, 98th percentile value	522 (181 - 910) 0.0%	282 (98 - 494) 0.0%	41 (14 - 72) 0.0%
15	30, 98th percentile value	435 (151 - 757) 16.7%	185 (64 - 323) 34.4%	0 (0 - 0) 100.0%
15	25, 98th percentile value	270 (94 - 468) 48.3%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	65, 99th percentile value	522 (181 - 910) 0.0%	282 (98 - 494) 0.0%	41 (14 - 72) 0.0%
15	40, 99th percentile value	522 (181 - 910) 0.0%	282 (98 - 494) 0.0%	41 (14 - 72) 0.0%
15	35, 99th percentile value	507 (176 - 884) 2.9%	266 (92 - 465) 5.7%	23 (8 - 40) 43.9%
15	30, 99th percentile value	356 (124 - 619) 31.8%	97 (34 - 168) 65.6%	0 (0 - 0) 100.0%

Alternative Standards		Incidence Associated with PM2.5 (95% Confidence Interval)		
		Percent Reduction in Incidence from Current Standards		
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
15	25, 99th percentile value	207 (72 - 358) 60.3%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	40, 98th percentile value	438 (152 - 762) 16.1%	188 (65 - 328) 33.3%	0 (0 - 0) 100.0%
14	35, 98th percentile value	438 (152 - 762) 16.1%	188 (65 - 328) 33.3%	0 (0 - 0) 100.0%
14	30, 98th percentile value	435 (151 - 757) 16.7%	185 (64 - 323) 34.4%	0 (0 - 0) 100.0%
14	25, 98th percentile value	270 (94 - 468) 48.3%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	40, 99th percentile value	438 (152 - 762) 16.1%	188 (65 - 328) 33.3%	0 (0 - 0) 100.0%
14	35, 99th percentile value	438 (152 - 762) 16.1%	188 (65 - 328) 33.3%	0 (0 - 0) 100.0%
14	30, 99th percentile value	356 (124 - 619) 31.8%	97 (34 - 168) 65.6%	0 (0 - 0) 100.0%
14	25, 99th percentile value	207 (72 - 358) 60.3%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	40, 98th percentile value	354 (123 - 615) 32.2%	94 (33 - 164) 66.7%	0 (0 - 0) 100.0%
13	35, 98th percentile value	354 (123 - 615) 32.2%	94 (33 - 164) 66.7%	0 (0 - 0) 100.0%

Alternative Standards		Incidence Associated with PM2.5 (95% Confidence Interval)		
		Percent Reduction in Incidence from Current Standards		
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
13	30, 98th percentile value	354 (123 - 615) 32.2%	94 (33 - 164) 66.7%	0 (0 - 0) 100.0%
13	25, 98th percentile value	270 (94 - 468) 48.3%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	40, 99th percentile value	354 (123 - 615) 32.2%	94 (33 - 164) 66.7%	0 (0 - 0) 100.0%
13	35, 99th percentile value	354 (123 - 615) 32.2%	94 (33 - 164) 66.7%	0 (0 - 0) 100.0%
13	30, 99th percentile value	354 (123 - 615) 32.2%	94 (33 - 164) 66.7%	0 (0 - 0) 100.0%
13	25, 99th percentile value	207 (72 - 358) 60.3%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	40, 98th percentile value	271 (94 - 469) 48.1%	0 (0 - 1) 100.0%	0 (0 - 0) 100.0%
12	35, 98th percentile value	271 (94 - 469) 48.1%	0 (0 - 1) 100.0%	0 (0 - 0) 100.0%
12	30, 98th percentile value	271 (94 - 469) 48.1%	0 (0 - 1) 100.0%	0 (0 - 0) 100.0%
12	25, 98th percentile value	270 (94 - 468) 48.3%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	40, 99th percentile value	271 (94 - 469) 48.1%	0 (0 - 1) 100.0%	0 (0 - 0) 100.0%

Alternative Standards		Incidence Associated with PM2.5 (95% Confidence Interval)		
		Percent Reduction in Incidence from Current Standards		
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
12	35, 99th percentile value	271 (94 - 469) 48.1%	0 (0 - 1) 100.0%	0 (0 - 0) 100.0%
12	30, 99th percentile value	271 (94 - 469) 48.1%	0 (0 - 1) 100.0%	0 (0 - 0) 100.0%
12	25, 99th percentile value	207 (72 - 358) 60.3%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%

*This analysis used a C-R function from Pope et al. (2002) -- ACS extended.

**For the cutpoints above 7.5 µg/m3, the slope of the C-R function has been modified based on a simple hockeystick model (see discussion in section 2.5).

***Current standards.

Note: Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Exhibit 8.6. Estimated Annual Cardiopulmonary Mortality Associated with Long-Term Exposure to PM$_{2.5}$ When Alternative Standards Are Just Met, Assuming Various Cutpoint Levels* Detroit, MI, 2003

Alternative Standards		Incidence Associated with PM2.5		
		(95% Confidence Interval)		
		Percent Reduction in Incidence from Current Standards		
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
15	65, 98th percentile value***	379 (134 - 630) 0.0%	205 (73 - 343) 0.0%	30 (11 - 50) 0.0%
15	40, 98th percentile value	379 (134 - 630) 0.0%	205 (73 - 343) 0.0%	30 (11 - 50) 0.0%
15	35, 98th percentile value	379 (134 - 630) 0.0%	205 (73 - 343) 0.0%	30 (11 - 50) 0.0%
15	30, 98th percentile value	316 (112 - 523) 16.6%	134 (48 - 224) 34.6%	0 (0 - 0) 100.0%
15	25, 98th percentile value	195 (70 - 322) 48.5%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	65, 99th percentile value	379 (134 - 630) 0.0%	205 (73 - 343) 0.0%	30 (11 - 50) 0.0%
15	40, 99th percentile value	379 (134 - 630) 0.0%	205 (73 - 343) 0.0%	30 (11 - 50) 0.0%
15	35, 99th percentile value	368 (131 - 612) 2.9%	193 (68 - 323) 5.9%	17 (6 - 28) 43.3%
15	30, 99th percentile value	258 (92 - 427) 31.9%	70 (25 - 116) 65.9%	0 (0 - 0) 100.0%

Alternative Standards		Incidence Associated with PM2.5 (95% Confidence Interval)		
		Percent Reduction in Incidence from Current Standards		
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
15	25, 99th percentile value	149 (53 - 246) 60.7%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	40, 98th percentile value	318 (113 - 526) 16.1%	137 (48 - 227) 33.2%	0 (0 - 0) 100.0%
14	35, 98th percentile value	318 (113 - 526) 16.1%	137 (48 - 227) 33.2%	0 (0 - 0) 100.0%
14	30, 98th percentile value	316 (112 - 523) 16.6%	134 (48 - 224) 34.6%	0 (0 - 0) 100.0%
14	25, 98th percentile value	195 (70 - 322) 48.5%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	40, 99th percentile value	318 (113 - 526) 16.1%	137 (48 - 227) 33.2%	0 (0 - 0) 100.0%
14	35, 99th percentile value	318 (113 - 526) 16.1%	137 (48 - 227) 33.2%	0 (0 - 0) 100.0%
14	30, 99th percentile value	258 (92 - 427) 31.9%	70 (25 - 116) 65.9%	0 (0 - 0) 100.0%
14	25, 99th percentile value	149 (53 - 246) 60.7%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	40, 98th percentile value	256 (91 - 424) 32.5%	68 (24 - 113) 66.8%	0 (0 - 0) 100.0%
13	35, 98th percentile value	256 (91 - 424) 32.5%	68 (24 - 113) 66.8%	0 (0 - 0) 100.0%

Alternative Standards		Incidence Associated with PM2.5 (95% Confidence Interval)		
		Percent Reduction in Incidence from Current Standards		
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
13	30, 98th percentile value	256 (91 - 424) 32.5%	68 (24 - 113) 66.8%	0 (0 - 0) 100.0%
13	25, 98th percentile value	195 (70 - 322) 48.5%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	40, 99th percentile value	256 (91 - 424) 32.5%	68 (24 - 113) 66.8%	0 (0 - 0) 100.0%
13	35, 99th percentile value	256 (91 - 424) 32.5%	68 (24 - 113) 66.8%	0 (0 - 0) 100.0%
13	30, 99th percentile value	256 (91 - 424) 32.5%	68 (24 - 113) 66.8%	0 (0 - 0) 100.0%
13	25, 99th percentile value	149 (53 - 246) 60.7%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	40, 98th percentile value	196 (70 - 323) 48.3%	0 (0 - 1) 100.0%	0 (0 - 0) 100.0%
12	35, 98th percentile value	196 (70 - 323) 48.3%	0 (0 - 1) 100.0%	0 (0 - 0) 100.0%
12	30, 98th percentile value	196 (70 - 323) 48.3%	0 (0 - 1) 100.0%	0 (0 - 0) 100.0%
12	25, 98th percentile value	195 (70 - 322) 48.5%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	40, 99th percentile value	196 (70 - 323) 48.3%	0 (0 - 1) 100.0%	0 (0 - 0) 100.0%

Alternative Standards		Incidence Associated with PM2.5 (95% Confidence Interval)		
		Percent Reduction in Incidence from Current Standards		
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
12	35, 99th percentile value	196 (70 - 323) 48.3%	0 (0 - 1) 100.0%	0 (0 - 0) 100.0%
12	30, 99th percentile value	196 (70 - 323) 48.3%	0 (0 - 1) 100.0%	0 (0 - 0) 100.0%
12	25, 99th percentile value	149 (53 - 246) 60.7%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%

*This analysis used a C-R function from Pope et al. (2002) -- ACS extended.

**For the cutpoints above 7.5 µg/m3, the slope of the C-R function has been modified based on a simple hockeystick model (see discussion in section 2.5).

***Current standards.

Note: Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Exhibit 8.7. Estimated Annual Lung Cancer Mortality Associated with Long-Term Exposure to PM$_{2.5}$ When Alternative Standards Are Just Met, Assuming Various Cutpoint Levels*
Detroit, MI, 2003

Alternative Standards		Incidence Associated with PM2.5		
		(95% Confidence Interval)		
		Percent Reduction in Incidence from Current Standards		
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
15	65, 98th percentile value***	77 (24 - 116) 0.0%	42 (13 - 64) 0.0%	6 (2 - 9) 0.0%
15	40, 98th percentile value	77 (24 - 116) 0.0%	42 (13 - 64) 0.0%	6 (2 - 9) 0.0%
15	35, 98th percentile value	77 (24 - 116) 0.0%	42 (13 - 64) 0.0%	6 (2 - 9) 0.0%
15	30, 98th percentile value	64 (20 - 96) 16.9%	27 (9 - 41) 35.7%	0 (0 - 0) 100.0%
15	25, 98th percentile value	39 (13 - 59) 49.4%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	65, 99th percentile value	77 (24 - 116) 0.0%	42 (13 - 64) 0.0%	6 (2 - 9) 0.0%
15	40, 99th percentile value	77 (24 - 116) 0.0%	42 (13 - 64) 0.0%	6 (2 - 9) 0.0%
15	35, 99th percentile value	75 (24 - 113) 2.6%	39 (12 - 60) 7.1%	3 (1 - 5) 50.0%
15	30, 99th percentile value	52 (17 - 79) 32.5%	14 (5 - 21) 66.7%	0 (0 - 0) 100.0%

Alternative Standards		Incidence Associated with PM2.5 (95% Confidence Interval)		
		Percent Reduction in Incidence from Current Standards		
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
15	25, 99th percentile value	30 (10 - 45) 61.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	40, 98th percentile value	64 (20 - 97) 16.9%	28 (9 - 42) 33.3%	0 (0 - 0) 100.0%
14	35, 98th percentile value	64 (20 - 97) 16.9%	28 (9 - 42) 33.3%	0 (0 - 0) 100.0%
14	30, 98th percentile value	64 (20 - 96) 16.9%	27 (9 - 41) 35.7%	0 (0 - 0) 100.0%
14	25, 98th percentile value	39 (13 - 59) 49.4%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	40, 99th percentile value	64 (20 - 97) 16.9%	28 (9 - 42) 33.3%	0 (0 - 0) 100.0%
14	35, 99th percentile value	64 (20 - 97) 16.9%	28 (9 - 42) 33.3%	0 (0 - 0) 100.0%
14	30, 99th percentile value	52 (17 - 79) 32.5%	14 (5 - 21) 66.7%	0 (0 - 0) 100.0%
14	25, 99th percentile value	30 (10 - 45) 61.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	40, 98th percentile value	52 (17 - 78) 32.5%	14 (4 - 21) 66.7%	0 (0 - 0) 100.0%
13	35, 98th percentile value	52 (17 - 78) 32.5%	14 (4 - 21) 66.7%	0 (0 - 0) 100.0%

Alternative Standards		Incidence Associated with PM2.5 (95% Confidence Interval)		
		Percent Reduction in Incidence from Current Standards		
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
13	30, 98th percentile value	52 (17 - 78) 32.5%	14 (4 - 21) 66.7%	0 (0 - 0) 100.0%
13	25, 98th percentile value	39 (13 - 59) 49.4%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	40, 99th percentile value	52 (17 - 78) 32.5%	14 (4 - 21) 66.7%	0 (0 - 0) 100.0%
13	35, 99th percentile value	52 (17 - 78) 32.5%	14 (4 - 21) 66.7%	0 (0 - 0) 100.0%
13	30, 99th percentile value	52 (17 - 78) 32.5%	14 (4 - 21) 66.7%	0 (0 - 0) 100.0%
13	25, 99th percentile value	30 (10 - 45) 61.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	40, 98th percentile value	40 (13 - 59) 48.1%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	35, 98th percentile value	40 (13 - 59) 48.1%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	30, 98th percentile value	40 (13 - 59) 48.1%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	25, 98th percentile value	39 (13 - 59) 49.4%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	40, 99th percentile value	40 (13 - 59) 48.1%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%

Alternative Standards		Incidence Associated with PM2.5 (95% Confidence Interval)		
		Percent Reduction in Incidence from Current Standards		
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
12	35, 99th percentile value	40 (13 - 59) 48.1%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	30, 99th percentile value	40 (13 - 59) 48.1%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	25, 99th percentile value	30 (10 - 45) 61.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%

*This analysis used a C-R function from Pope et al. (2002) -- ACS extended.

**For the cutpoints above 7.5 µg/m3, the slope of the C-R function has been modified based on a simple hockeystick model (see discussion in section 2.5).

***Current standards.

Note: Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

8.2   Sensitivity analyses

Several sensitivity analyses were carried out to assess the sensitivity of the results of the second (just meeting the current and alternative standards) part of the risk assessment to various assumptions underlying the analyses. In general, we carried out each sensitivity analysis listed for $PM_{2.5}$ in each of the assessment locations (see Exhibit 2.6). However, to reduce the number of exhibits in this section of the report, as in the first part of the risk assessment we selected one location (Detroit) to include here for illustrative purposes. Exhibits of the results of location-specific sensitivity analyses that are not presented here are given in Appendix E. To reduce the quantity of numbers reported, we focused the $PM_{2.5}$ sensitivity analyses on total (or non-accidental) mortality. The sensitivity analyses in this section and the exhibits presenting their results are summarized in Exhibit 8.8.

Exhibit 8.8 Summary of Sensitivity Analyses Associated with the Second Part of the Risk Assessment for $PM_{2.5}$ (Just meeting the Current and Alternative $PM_{2.5}$ Standards)

Sensitivity Analysis*	Applied to	Exhibit
Effect of alternative rollback method on estimated annual reductions in mortality associated with just meeting the current standards	mortality associated with short- and long-term exposure	Exhibit 8.9 Exhibits E.33 - E.36
Effect of using different, location-specific C-R functions vs. the same C-R function in all urban areas on estimated mortality associated with just meeting the current standards	mortality associated with short-term exposure	Exhibit 8.10
Effect of using design values based on the maximum vs. the spatial average of monitor-specific averages on estimates of mortality associated with exposure to $PM_{2.5}$ concentrations when current standards are just met.	mortality associated with short- and long-term exposure	Exhibits 8.11 - 8.13; Exhibits E.37 - E.40

*Sensitivity analyses presented in this section are for Detroit, MI, unless otherwise stated.

8.2.1   The effect of alternative rollback methods

The plausibility of proportional rollbacks to simulate the pattern by which daily $PM_{2.5}$ concentrations would change if an urban area just met the current $PM_{2.5}$ standards is discussed briefly in Section 2.4 and in more detail in Appendix B. Although an examination of the evidence suggests that proportional rollbacks are a reasonable way to simulate the change in daily $PM_{2.5}$ concentrations, there are other patterns of changes that are also plausible. We examined one such pattern, in which the highest $PM_{2.5}$ concentrations are reduced more than the

rest of the PM$_{2.5}$ concentrations. In particular, in this sensitivity analysis, we hypothesized that the top 10 percent of the distribution of PM$_{2.5}$ concentrations is reduced by 1.6 times as much as the lower 90 percent of concentrations. We examined the effects of this hypothesis on incidence reductions that would result from meeting the annual standard because it was the controlling standard in all five study areas that do not meet the current PM$_{2.5}$ standards based on 2001 - 2003 air quality data.

To meet the annual standard, the annual average must not exceed the annual standard of 15 µg/m^3. If

- p_a denotes the percent rollback necessary to just meet the annual standard if all days are rolled back the same proportion,
- aa denotes the annual average
- b denotes background level,
- $a_{0.9}$ denotes the average of the lower 90 percent of concentrations,
- $a_{0.1}$ denotes the average of the upper 10 percent of concentrations,
- and x denotes the percent rollback that would be applied to the lower 90 percent of the distribution of concentrations, if 1.6x is the percent rollback applied to the upper 10 percent of the concentrations, so that the resulting rolled back annual average just attains the annual standard, then

$$x = p_a * (aa - b) / (0.9 * (a_{0.9} - b) + 0.1 * 1.6 * (a_{0.1} - b)).$$

The results of this sensitivity analysis are shown for Detroit in Exhibit 8.9. The results for the other assessment locations that do not meet the current standards are shown in Appendix E. The results are based on the controlling standard, which, in all cases, is the annual standard of 15 µg/m^3. In general, this alternative hypothetical adjustment procedure, which reduces the highest days more than the rest of the distribution, shows only a small difference (less than 1%) in the percent change in PM-associated incidence. In Detroit, for example, there is no difference in the estimated percent change in mortality associated with short-term exposure to PM$_{2.5}$ between the two alternative air quality adjustment scenarios used to adjust "as is" levels to just meet the current PM$_{2.5}$ standards (see Exhibit 8.9). For mortality associated with long-term exposure to PM$_{2.5}$, the estimated reduction in PM-associated incidence in Detroit corresponding to reducing "as is" levels to just meet current PM$_{2.5}$ standards, using Pope et al. (2002) – ACS extended, was 42.4% for the proportional rollback scenario vs. 42.5% for the rollback involving greater reductions of the top 10% of the PM$_{2.5}$ daily concentrations (see Exhibit 8.9).

Exhibit 8.9. Sensitivity Analysis: Estimated Annual Reductions of Short-Term and Long-Term Exposure Mortality Associated with Rolling Back PM$_{2.5}$ Concentrations to Just Meet the Current Annual Standard of 15 ug/m^3 and the Current Daily Standard of 65 ug/m^3 Using an Alternative Rollback Method
Detroit, MI, 2003

Health Effects	Study	Type	Ages	Lag	Other Pollutants in Model	Annual and Daily Standards	Percent Change in PM-Associated Incidence*		Portion of Proportional Rollback Incidence Reduction Achieved by Alternative Rollback Method
							All PM concentrations rolled back equally	Percent rollback of upper 10% of AQ distribution = 1.6 x percent rollback of lower 90% of AQ distribution	
Short-Term Exposure Mortality	Single Pollutant Models (Total Mortality)								
	Ito (2003) [reanalysis of Lippmann et al. (2000)]	Non-accidental	all	3 day		15 ug/m3 annual 65 ug/m3 daily	28.3% 0.0%	28.3% 0.0%	100.0% --
Long-Term Exposure Mortality	Single Pollutant Models								
	Krewski et al. (2000) - ACS	All cause	30+			15 ug/m3 annual 65 ug/m3 daily	42.2% 0.0%	42.4% 0.0%	100.5% --
	Pope et al. (2002) - ACS extended	All cause	30+			15 ug/m3 annual 65 ug/m3 daily	42.4% 0.0%	42.5% 0.0%	100.2% --
	Multi-Pollutant Models								
	Krewski et al. (2000) - ACS	All cause	30+		CO	15 ug/m3 annual 65 ug/m3 daily	42.5% 0.0%	42.6% 0.0%	100.2% --
	Krewski et al. (2000) - ACS	All cause	30+		NO2	15 ug/m3 annual 65 ug/m3 daily	42.6% 0.0%	42.7% 0.0%	100.2% --
	Krewski et al. (2000) - ACS	All cause	30+		O3	15 ug/m3 annual 65 ug/m3 daily	42.5% 0.0%	42.6% 0.0%	100.2% --
	Krewski et al. (2000) - ACS	All cause	30+		SO2	15 ug/m3 annual 65 ug/m3 daily	41.9% 0.0%	42.0% 0.0%	100.2% --

*For the short-term exposure studies, health effects incidence was quantified down to estimated policy relevant background level of 3.5 ug/m3. For the long-term exposure studies, health effects incidence was quantified down to 7.5 ug/m3, which was the lowest of the lowest measured levels in the long-term exposure studies. Percents are rounded to the nearest tenth.

Note: Only those C-R functions for which rollbacks are predicted to result in a positive number of cases avoided are included.

8.2.2 The effect of using different, location-specific C-R functions vs. a single C-R function in all locations

Differences in results across locations may be due to a number of factors, including differences in air quality, baseline incidence rates, population, and C-R functions. The extent to which differences in results are due to the last factor can be assessed by comparing results across urban areas when different, location-specific C-R functions are used versus using a single C-R function everywhere. Exhibit 8.10 shows this comparison for mortality associated with short-term exposure to $PM_{2.5}$, using a multi-city C-R function estimated in Schwartz (2003).

As would be expected, given the generally larger $PM_{2.5}$ coefficient estimated in Schwartz (2003), the estimated incidence and deaths per 100,000 general population are somewhat larger in four of the five locations when the multi-city C-R function estimated in Schwartz (2003) is used. The range of risk estimates across the five locations also narrows considerably when the same C-R function is used in all five locations. For example, deaths per 100,000 general population range from 3 to 24 when the separate single-city C-R functions are used, whereas the range is from 8 to 14 when a single multi-city C-R function is used everywhere. While there are a number of reasons why risk estimates in the different cities would be expected to differ, some of the observed differences are probably a result of differences in study design and model specifications. This sensitivity analysis suggests that the actual differences in risks across different locations may be somewhat less than might be suggested by a comparison of the results based on the location-specific C-R functions.

Exhibit 8.10. **Estimated Annual Mortality Associated with Short-Term Exposure to PM$_{2.5}$ When the Current Annual Standard of 15 µg/m3 and the Current Daily Standard of 65 µg/m3 Are Just Met, Assuming Various Cutpoint Levels***

Urban Area	Study	Type	Ages	Lag	Incidence Associated with PM2.5 Assuming Various Cutpoint Levels (95% Confidence Interval) / Incidence per 100,000 General Population (95% Confidence Interval) / Percent of Total Incidence (95% Confidence Interval)			
					Policy Relevant Background** =2.5 or 3.5 µg/m3	Cutpoint*** =10 µg/m3	Cutpoint*** =15 µg/m3	Cutpoint*** =20 µg/m3
Detroit	Ito (2003) [reanalysis of Lippmann et al. (2000)]	Non-accidental	all	3 day	122 (-123 - 358)	54 (-55 - 159)	26 (-27 - 77)	12 (-12 - 35)
					6 (-6 - 17)	3 (-3 - 8)	1 (-1 - 4)	1 (-1 - 2)
					0.7% (-0.7% - 1.9%)	0.3% (-0.3% - 0.8%)	0.1% (-0.1% - 0.4%)	0.1% (-0.1% - 0.2%)
	Schwartz (2003b) [reanalysis of Schwartz et al. (1996)]	Non-accidental	all	mean of lag 0 & 1 day	224 (160 - 286)	87 (62 - 111)	34 (25 - 44)	15 (11 - 19)
					11 (8 - 14)	4 (3 - 5)	2 (1 - 2)	1 (1 - 1)
					1.2% (0.9% - 1.5%)	0.5% (0.3% - 0.6%)	0.2% (0.1% - 0.2%)	0.1% (0.1% - 0.1%)
Los Angeles	Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Non-accidental	all	0 day	292 (-37 - 612)	115 (-14 - 240)	58 (-7 - 121)	29 (-4 - 61)
					3 (0 - 6)	1 (0 - 3)	1 (0 - 1)	0 (0 - 1)
					0.5% (-0.1% - 1.1%)	0.2% (0.0% - 0.4%)	0.1% (0.0% - 0.2%)	0.1% (0.0% - 0.1%)
	Schwartz (2003b) [reanalysis of Schwartz et al. (1996)]	Non-accidental	all	mean of lag 0 & 1 day	731 (526 - 935)	270 (194 - 344)	123 (89 - 157)	55 (40 - 70)
					8 (6 - 10)	3 (2 - 4)	1 (1 - 2)	1 (0 - 1)
					1.3% (1.0% - 1.7%)	0.5% (0.4% - 0.6%)	0.2% (0.2% - 0.3%)	0.1% (0.1% - 0.1%)
Philadelphia	Lipfert et al. (2000) -- 7 counties	Cardiovascular	all	1 day	367 (175 - 560)	189 (90 - 288)	106 (51 - 162)	57 (27 - 87)
					24 (12 - 37)	12 (6 - 19)	7 (3 - 11)	4 (2 - 6)
					5.8% (2.8% - 8.8%)	3.0% (1.4% - 4.5%)	1.7% (0.8% - 2.6%)	0.9% (0.4% - 1.4%)
	Schwartz (2003b) [reanalysis of Schwartz et al. (1996)]	Non-accidental	all	mean of lag 0 & 1 day	213 (153 - 273)	103 (74 - 132)	50 (36 - 65)	24 (17 - 31)
					14 (10 - 18)	7 (5 - 9)	3 (2 - 4)	2 (1 - 2)
					1.3% (0.9% - 1.7%)	0.6% (0.5% - 0.8%)	0.3% (0.2% - 0.4%)	0.2% (0.1% - 0.2%)
Pittsburgh	Chock et al. (2000)	Non-accidental	75+	0 day	50 (-108 - 200)	22 (-48 - 87)	10 (-23 - 41)	5 (-11 - 18)
					4 (-8 - 16)	2 (-4 - 7)	1 (-2 - 3)	0 (-1 - 1)
					0.5% (-1.1% - 2.1%)	0.2% (-0.5% - 0.9%)	0.1% (-0.2% - 0.4%)	0.1% (-0.1% - 0.2%)
	Schwartz (2003b) [reanalysis of Schwartz et al. (1996)]	Non-accidental	all	mean of lag 0 & 1 day	174 (125 - 223)	68 (49 - 87)	27 (19 - 34)	11 (8 - 14)
					14 (10 - 17)	5 (4 - 7)	2 (1 - 3)	1 (1 - 1)
					1.2% (0.8% - 1.5%)	0.5% (0.3% - 0.6%)	0.2% (0.1% - 0.2%)	0.1% (0.1% - 0.1%)
St. Louis	Schwartz (2003b) [reanalysis of Schwartz et al. (1996)]	Non-accidental	all	mean of lag 0 & 1 day	191 (70 - 311)	75 (28 - 122)	29 (11 - 46)	9 (3 - 14)
					8 (3 - 12)	3 (1 - 5)	1 (0 - 2)	0 (0 - 1)
					0.9% (0.3% - 1.4%)	0.3% (0.1% - 0.6%)	0.1% (0.1% - 0.2%)	0.0% (0.0% - 0.1%)
	Schwartz (2003b) [reanalysis of Schwartz et al. (1996)]	Non-accidental	all	mean of lag 0 & 1 day	256 (183 - 328)	97 (69 - 124)	36 (25 - 46)	10 (7 - 13)
					10 (7 - 13)	4 (3 - 5)	1 (1 - 2)	0 (0 - 1)
					1.2% (0.8% - 1.5%)	0.4% (0.3% - 0.6%)	0.2% (0.1% - 0.2%)	0.1% (0.0% - 0.1%)

*All results are for single pollutant models.
**Policy relevant background is 2.5 µg/m3 in the West (Los Angeles) and 3.5 µg/m3 in the East (Detroit, Philadelphia, Pittsburgh, and St. Louis).
***For the cutpoints above policy relevant background, the slope of the C-R function has been modified based on a simple hockeystick model (see discussion in section 2.5).

8.2.3 Comparison of risk estimates based on annual standard design values calculated from maximum versus average of monitor-specific averages

The percent rollback necessary to just meet the annual standards depends on whether the maximum or the spatial average of the monitor-specific annual averages is used. Exhibit 8.11 shows the percent rollbacks that would be required to just meet the current annual standard using four of the assessment locations which do not currently meet the annual standard and which meet the minimum criteria for use of spatial averaging.[29] The three-year period from 2001-2003 was used to determine the amount of rollback required to meet the current annual standard.

Exhibit 8.11 Air Quality Adjustments Required to Just Meet the Current Annual PM$_{2.5}$ Standard of 15 µg/m^3 Using the Maximum vs. the Average of Monitor-Specific Averages

Assessment Location	Percent Rollback Necessary to Just Meet the Annual PM$_{2.5}$ Standard	
	Using Maximum of Monitor-Specific Annual Averages	Using Average of Monitor-Specific Annual Averages*
Detroit	28.1%	11.5%
Philadelphia	10.9%	-0.9%
Pittsburgh	35.0%	22.8%
St. Louis	17.9%	13.5%

*The design values based on the maximum of monitor-specific annual averages are given in Exhibit 2.4. The design values based on the spatial average of the monitor-specific annual averages are 16.5 for Detroit, 14.9 for Philadelphia, 18.4 for Pittsburgh, and 16.8 for St. Louis.

The results shown in Exhibits 8.4 - 8.7 and E.1 - E.32 are based on percent rollbacks calculated from annual and daily standard design values that used the maximum of monitor-specific values. If the design values had been based on the average, rather than the maximum, of monitor-specific values, the estimated mortality would have been, in many cases, greater than the estimates shown in those exhibits.

Exhibits 8.12 and 8.13 show the effect of using an annual standard design value based on the *maximum* versus the *average* of monitor-specific averages (while keeping the design values for the daily standards as they were, based on the maximum of monitor-specific values). Exhibit 8.12 shows estimated mortality associated with short-term exposures to PM$_{2.5}$ in Detroit; Exhibit 8.13 shows estimated mortality associated with long-term exposures. Both exhibits present the

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[29] The Los Angeles area does not meet the minimum EPA criteria for considering the use of spatial averaging and, thus is not included in Exhibit 8.11.

Exhibit 8.12. Sensitivity Analysis: Estimated Annual Mortality Associated with Short-Term Exposure to PM$_{2.5}$

When Alternative Standards Are Just Met, Assuming Various Cutpoint Levels -- Rollbacks
to Meet Annual Standards Using Design Values Based on Maximum vs. Average of Monitor-Specific Averages*
Detroit, MI, 2003

Alternative Standards		Incidence Associated with PM2.5 Using an Annual Design Value Based on the Maximum of Monitor-Specific Averages** (95% Confidence Interval) Percent Reduction in Incidence from Current Standards				Incidence Associated with PM2.5 Using an Annual Design Value Based on the Average of Monitor-Specific Averages** (95% Confidence Interval) Percent Reduction in Incidence from Current Standards			
Annual (µg/m3)	Daily (µg/m3)	Policy Relevant Background =3.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =15 µg/m3	Cutpoint** =20 µg/m3	Policy Relevant Background =3.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =15 µg/m3	Cutpoint** =20 µg/m3
15	65, 98th percentile value***	122 (-123 - 358) 0.0%	54 (-55 - 159) 0.0%	26 (-27 - 77) 0.0%	12 (-12 - 35) 0.0%	150 (-151 - 442) 0.0%	80 (-81 - 236) 0.0%	46 (-47 - 137) 0.0%	25 (-26 - 75) 0.0%
15	40, 98th percentile value	122 (-123 - 358) 0.0%	54 (-55 - 159) 0.0%	26 (-27 - 77) 0.0%	12 (-12 - 35) 0.0%	150 (-151 - 442) 0.0%	80 (-81 - 236) 0.0%	46 (-47 - 137) 0.0%	25 (-26 - 75) 0.0%
15	35, 98th percentile value	122 (-123 - 358) 0.0%	54 (-55 - 159) 0.0%	26 (-27 - 77) 0.0%	12 (-12 - 35) 0.0%	132 (-133 - 388) 12.0%	63 (-64 - 186) 21.3%	33 (-33 - 97) 28.3%	16 (-17 - 47) 36.0%
15	30, 98th percentile value	111 (-112 - 325) 9.0%	45 (-45 - 131) 16.7%	20 (-20 - 58) 23.1%	8 (-9 - 24) 33.3%	111 (-112 - 325) 26.0%	45 (-45 - 131) 43.8%	20 (-20 - 58) 56.5%	8 (-9 - 24) 68.0%
15	25, 98th percentile value	90 (-91 - 263) 26.2%	28 (-29 - 82) 48.1%	10 (-10 - 28) 61.5%	3 (-4 - 10) 75.0%	90 (-91 - 263) 40.0%	28 (-29 - 82) 65.0%	10 (-10 - 28) 78.3%	3 (-4 - 10) 88.0%
15	65, 99th percentile value	122 (-123 - 358) 0.0%	54 (-55 - 159) 0.0%	26 (-27 - 77) 0.0%	12 (-12 - 35) 0.0%	150 (-151 - 442) 0.0%	80 (-81 - 236) 0.0%	46 (-47 - 137) 0.0%	25 (-26 - 75) 0.0%
15	40, 99th percentile value	122 (-123 - 358) 0.0%	54 (-55 - 159) 0.0%	26 (-27 - 77) 0.0%	12 (-12 - 35) 0.0%	139 (-140 - 409) 7.3%	70 (-70 - 206) 12.5%	38 (-39 - 112) 17.4%	20 (-20 - 58) 20.0%
15	35, 99th percentile value	120 (-121 - 352) 1.6%	53 (-53 - 154) 1.9%	25 (-26 - 74) 3.8%	11 (-12 - 33) 8.3%	120 (-121 - 352) 20.0%	53 (-53 - 154) 33.8%	25 (-26 - 74) 45.7%	11 (-12 - 33) 56.0%
15	30, 99th percentile value	101 (-102 - 296) 17.2%	37 (-37 - 107) 31.5%	15 (-15 - 42) 42.3%	6 (-6 - 16) 50.0%	101 (-102 - 296) 32.7%	37 (-37 - 107) 53.8%	15 (-15 - 42) 67.4%	6 (-6 - 16) 76.0%
15	25, 99th percentile value	82 (-83 - 239) 32.8%	22 (-23 - 65) 59.3%	7 (-7 - 19) 73.1%	2 (-2 - 6) 83.3%	82 (-83 - 239) 45.3%	22 (-23 - 65) 72.5%	7 (-7 - 19) 84.8%	2 (-2 - 6) 92.0%
14	40, 98th percentile value	111 (-112 - 326) 9.0%	45 (-46 - 132) 16.7%	20 (-20 - 58) 23.1%	8 (-9 - 24) 33.3%	137 (-138 - 403) 8.7%	68 (-68 - 200) 15.0%	37 (-37 - 108) 19.6%	19 (-19 - 55) 24.0%
14	35, 98th percentile value	111 (-112 - 326) 9.0%	45 (-46 - 132) 16.7%	20 (-20 - 58) 23.1%	8 (-9 - 24) 33.3%	132 (-133 - 388) 12.0%	63 (-64 - 186) 21.3%	33 (-33 - 97) 28.3%	16 (-17 - 47) 36.0%

Alternative Standards		Incidence Associated with PM2.5 Using an Annual Design Value Based on the Maximum of Monitor-Specific Averages** (95% Confidence Interval) Percent Reduction in Incidence from Current Standards				Incidence Associated with PM2.5 Using an Annual Design Value Based on the Average of Monitor-Specific Averages** (95% Confidence Interval) Percent Reduction in Incidence from Current Standards			
Annual (µg/m3)	Daily (µg/m3)	Policy Relevant Background =3.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =15 µg/m3	Cutpoint** =20 µg/m3	Policy Relevant Background =3.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =15 µg/m3	Cutpoint** =20 µg/m3
14	30, 98th percentile value	111 (-112 - 325) 9.0%	45 (-45 - 131) 16.7%	20 (-20 - 58) 23.1%	8 (-9 - 24) 33.3%	111 (-112 - 325) 26.0%	45 (-45 - 131) 43.8%	20 (-20 - 58) 56.5%	8 (-9 - 24) 68.0%
14	25, 98th percentile value	90 (-91 - 263) 26.2%	28 (-29 - 82) 48.1%	10 (-10 - 28) 61.5%	3 (-4 - 10) 75.0%	90 (-91 - 263) 40.0%	28 (-29 - 82) 65.0%	10 (-10 - 28) 78.3%	3 (-4 - 10) 88.0%
14	40, 99th percentile value	111 (-112 - 326) 9.0%	45 (-46 - 132) 16.7%	20 (-20 - 58) 23.1%	8 (-9 - 24) 33.3%	137 (-138 - 403) 8.7%	68 (-68 - 200) 15.0%	37 (-37 - 108) 19.6%	19 (-19 - 55) 24.0%
14	35, 99th percentile value	111 (-112 - 326) 9.0%	45 (-46 - 132) 16.7%	20 (-20 - 58) 23.1%	8 (-9 - 24) 33.3%	120 (-121 - 352) 20.0%	53 (-53 - 154) 33.8%	25 (-26 - 74) 45.7%	11 (-12 - 33) 56.0%
14	30, 99th percentile value	101 (-102 - 296) 17.2%	37 (-37 - 107) 31.5%	15 (-15 - 42) 42.3%	6 (-6 - 16) 50.0%	101 (-102 - 296) 32.7%	37 (-37 - 107) 53.8%	15 (-15 - 42) 67.4%	6 (-6 - 16) 76.0%
14	25, 99th percentile value	82 (-83 - 239) 32.8%	22 (-23 - 65) 59.3%	7 (-7 - 19) 73.1%	2 (-2 - 6) 83.3%	82 (-83 - 239) 45.3%	22 (-23 - 65) 72.5%	7 (-7 - 19) 84.8%	2 (-2 - 6) 92.0%
13	40, 98th percentile value	101 (-101 - 295) 17.2%	36 (-37 - 106) 33.3%	14 (-15 - 42) 46.2%	6 (-6 - 16) 50.0%	124 (-125 - 364) 17.3%	56 (-57 - 165) 30.0%	28 (-28 - 81) 39.1%	13 (-13 - 38) 48.0%
13	35, 98th percentile value	101 (-101 - 295) 17.2%	36 (-37 - 106) 33.3%	14 (-15 - 42) 46.2%	6 (-6 - 16) 50.0%	124 (-125 - 364) 17.3%	56 (-57 - 165) 30.0%	28 (-28 - 81) 39.1%	13 (-13 - 38) 48.0%
13	30, 98th percentile value	101 (-101 - 295) 17.2%	36 (-37 - 106) 33.3%	14 (-15 - 42) 46.2%	6 (-6 - 16) 50.0%	111 (-112 - 325) 26.0%	45 (-45 - 131) 43.8%	20 (-20 - 58) 56.5%	8 (-9 - 24) 68.0%
13	25, 98th percentile value	90 (-91 - 263) 26.2%	28 (-29 - 82) 48.1%	10 (-10 - 28) 61.5%	3 (-4 - 10) 75.0%	90 (-91 - 263) 40.0%	28 (-29 - 82) 65.0%	10 (-10 - 28) 78.3%	3 (-4 - 10) 88.0%
13	40, 99th percentile value	101 (-101 - 295) 17.2%	36 (-37 - 106) 33.3%	14 (-15 - 42) 46.2%	6 (-6 - 16) 50.0%	124 (-125 - 364) 17.3%	56 (-57 - 165) 30.0%	28 (-28 - 81) 39.1%	13 (-13 - 38) 48.0%
13	35, 99th percentile value	101 (-101 - 295) 17.2%	36 (-37 - 106) 33.3%	14 (-15 - 42) 46.2%	6 (-6 - 16) 50.0%	120 (-121 - 352) 20.0%	53 (-53 - 154) 33.8%	25 (-26 - 74) 45.7%	11 (-12 - 33) 56.0%
13	30, 99th percentile value	101 (-101 - 295) 17.2%	36 (-37 - 106) 33.3%	14 (-15 - 42) 46.2%	6 (-6 - 16) 50.0%	101 (-102 - 296) 32.7%	37 (-37 - 107) 53.8%	15 (-15 - 42) 67.4%	6 (-6 - 16) 76.0%
13	25, 99th percentile value	82 (-83 - 239) 32.8%	22 (-23 - 65) 59.3%	7 (-7 - 19) 73.1%	2 (-2 - 6) 83.3%	82 (-83 - 239) 45.3%	22 (-23 - 65) 72.5%	7 (-7 - 19) 84.8%	2 (-2 - 6) 92.0%

Alternative Standards		Incidence Associated with PM2.5 Using an Annual Design Value Based on the Maximum of Monitor-Specific Averages** (95% Confidence Interval) Percent Reduction in Incidence from Current Standards				Incidence Associated with PM2.5 Using an Annual Design Value Based on the Average of Monitor-Specific Averages** (95% Confidence Interval) Percent Reduction in Incidence from Current Standards			
Annual (µg/m3)	Daily (µg/m3)	Policy Relevant Background =3.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =15 µg/m3	Cutpoint** =20 µg/m3	Policy Relevant Background =3.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =15 µg/m3	Cutpoint** =20 µg/m3
12	40, 98th percentile value	90 (-91 - 264) 26.2%	28 (-29 - 82) 48.1%	10 (-10 - 28) 61.5%	3 (-4 - 10) 75.0%	111 (-112 - 325) 26.0%	45 (-45 - 131) 43.8%	20 (-20 - 58) 56.5%	8 (-9 - 24) 68.0%
12	35, 98th percentile value	90 (-91 - 264) 26.2%	28 (-29 - 82) 48.1%	10 (-10 - 28) 61.5%	3 (-4 - 10) 75.0%	111 (-112 - 325) 26.0%	45 (-45 - 131) 43.8%	20 (-20 - 58) 56.5%	8 (-9 - 24) 68.0%
12	30, 98th percentile value	90 (-91 - 264) 26.2%	28 (-29 - 82) 48.1%	10 (-10 - 28) 61.5%	3 (-4 - 10) 75.0%	111 (-112 - 325) 26.0%	45 (-45 - 131) 43.8%	20 (-20 - 58) 56.5%	8 (-9 - 24) 68.0%
12	25, 98th percentile value	90 (-91 - 263) 26.2%	28 (-29 - 82) 48.1%	10 (-10 - 28) 61.5%	3 (-4 - 10) 75.0%	90 (-91 - 263) 40.0%	28 (-29 - 82) 65.0%	10 (-10 - 28) 78.3%	3 (-4 - 10) 88.0%
12	40, 99th percentile value	90 (-91 - 264) 26.2%	28 (-29 - 82) 48.1%	10 (-10 - 28) 61.5%	3 (-4 - 10) 75.0%	111 (-112 - 325) 26.0%	45 (-45 - 131) 43.8%	20 (-20 - 58) 56.5%	8 (-9 - 24) 68.0%
12	35, 99th percentile value	90 (-91 - 264) 26.2%	28 (-29 - 82) 48.1%	10 (-10 - 28) 61.5%	3 (-4 - 10) 75.0%	111 (-112 - 325) 26.0%	45 (-45 - 131) 43.8%	20 (-20 - 58) 56.5%	8 (-9 - 24) 68.0%
12	30, 99th percentile value	90 (-91 - 264) 26.2%	28 (-29 - 82) 48.1%	10 (-10 - 28) 61.5%	3 (-4 - 10) 75.0%	101 (-102 - 296) 32.7%	37 (-37 - 107) 53.8%	15 (-15 - 42) 67.4%	6 (-6 - 16) 76.0%
12	25, 99th percentile value	82 (-83 - 239) 32.8%	22 (-23 - 65) 59.3%	7 (-7 - 19) 73.1%	2 (-2 - 6) 83.3%	82 (-83 - 239) 45.3%	22 (-23 - 65) 72.5%	7 (-7 - 19) 84.8%	2 (-2 - 6) 92.0%

*This analysis used a C-R function from Ito (2003).
**For the cutpoints above policy relevant background, the slope of the C-R function has been modified based on a simple hockeystick model (see discussion in section 2.5).
***Current standards.
Note: Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Exhibit 8.13. Sensitivity Analysis: Estimated Annual Mortality Associated with Long-Term Exposure to PM$_{2.5}$

When Alternative Standards Are Just Met, Assuming Various Cutpoint Levels -- Rollbacks
to Meet Annual Standards Using Design Values Based on Maximum vs. Average of Monitor-Specific Averages*
Detroit, MI, 2003

Alternative Standards		Incidence Associated with PM2.5 Using an Annual Design Value Based on the Maximum of Monitor-Specific Averages** (95% Confidence Interval) Percent Reduction in Incidence from Current Standards			Incidence Associated with PM2.5 Using an Annual Design Value Based on the Average of Monitor-Specific Averages** (95% Confidence Interval) Percent Reduction in Incidence from Current Standards		
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
15	65, 98th percentile value***	522 (181 - 910) 0.0%	282 (98 - 494) 0.0%	41 (14 - 72) 0.0%	747 (259 - 1309) 0.0%	535 (185 - 941) 0.0%	322 (111 - 568) 0.0%
15	40, 98th percentile value	522 (181 - 910) 0.0%	282 (98 - 494) 0.0%	41 (14 - 72) 0.0%	747 (259 - 1309) 0.0%	535 (185 - 941) 0.0%	322 (111 - 568) 0.0%
15	35, 98th percentile value	522 (181 - 910) 0.0%	282 (98 - 494) 0.0%	41 (14 - 72) 0.0%	602 (209 - 1051) 19.4%	372 (129 - 652) 30.5%	140 (48 - 247) 56.5%
15	30, 98th percentile value	435 (151 - 757) 16.7%	185 (64 - 323) 34.4%	0 (0 - 0) 100.0%	435 (151 - 757) 41.8%	185 (64 - 323) 65.4%	0 (0 - 0) 100.0%
15	25, 98th percentile value	270 (94 - 468) 48.3%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	270 (94 - 468) 63.9%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	65, 99th percentile value	522 (181 - 910) 0.0%	282 (98 - 494) 0.0%	41 (14 - 72) 0.0%	747 (259 - 1309) 0.0%	535 (185 - 941) 0.0%	322 (111 - 568) 0.0%
15	40, 99th percentile value	522 (181 - 910) 0.0%	282 (98 - 494) 0.0%	41 (14 - 72) 0.0%	659 (229 - 1153) 11.8%	437 (151 - 766) 18.3%	212 (73 - 374) 34.2%
15	35, 99th percentile value	507 (176 - 884) 2.9%	266 (92 - 465) 5.7%	23 (8 - 40) 43.9%	507 (176 - 884) 32.1%	266 (92 - 465) 50.3%	23 (8 - 40) 92.9%
15	30, 99th percentile value	356 (124 - 619) 31.8%	97 (34 - 168) 65.6%	0 (0 - 0) 100.0%	356 (124 - 619) 52.3%	97 (34 - 168) 81.9%	0 (0 - 0) 100.0%

Alternative Standards		Incidence Associated with PM2.5 Using an Annual Design Value Based on the Maximum of Monitor-Specific Averages** (95% Confidence Interval) Percent Reduction in Incidence from Current Standards			Incidence Associated with PM2.5 Using an Annual Design Value Based on the Average of Monitor-Specific Averages** (95% Confidence Interval) Percent Reduction in Incidence from Current Standards		
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
15	25, 99th percentile value	207 (72 - 358) 60.3%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	207 (72 - 358) 72.3%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	40, 98th percentile value	438 (152 - 762) 16.1%	188 (65 - 328) 33.3%	0 (0 - 0) 100.0%	642 (223 - 1123) 14.1%	418 (144 - 733) 21.9%	191 (66 - 336) 40.7%
14	35, 98th percentile value	438 (152 - 762) 16.1%	188 (65 - 328) 33.3%	0 (0 - 0) 100.0%	602 (209 - 1051) 19.4%	372 (129 - 652) 30.5%	140 (48 - 247) 56.5%
14	30, 98th percentile value	435 (151 - 757) 16.7%	185 (64 - 323) 34.4%	0 (0 - 0) 100.0%	435 (151 - 757) 41.8%	185 (64 - 323) 65.4%	0 (0 - 0) 100.0%
14	25, 98th percentile value	270 (94 - 468) 48.3%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	270 (94 - 468) 63.9%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	40, 99th percentile value	438 (152 - 762) 16.1%	188 (65 - 328) 33.3%	0 (0 - 0) 100.0%	642 (223 - 1123) 14.1%	418 (144 - 733) 21.9%	191 (66 - 336) 40.7%
14	35, 99th percentile value	438 (152 - 762) 16.1%	188 (65 - 328) 33.3%	0 (0 - 0) 100.0%	507 (176 - 884) 32.1%	266 (92 - 465) 50.3%	23 (8 - 40) 92.9%
14	30, 99th percentile value	356 (124 - 619) 31.8%	97 (34 - 168) 65.6%	0 (0 - 0) 100.0%	356 (124 - 619) 52.3%	97 (34 - 168) 81.9%	0 (0 - 0) 100.0%
14	25, 99th percentile value	207 (72 - 358) 60.3%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	207 (72 - 358) 72.3%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	40, 98th percentile value	354 (123 - 615) 32.2%	94 (33 - 164) 66.7%	0 (0 - 0) 100.0%	538 (187 - 939) 28.0%	301 (104 - 526) 43.7%	61 (21 - 107) 81.1%
13	35, 98th percentile value	354 (123 - 615) 32.2%	94 (33 - 164) 66.7%	0 (0 - 0) 100.0%	538 (187 - 939) 28.0%	301 (104 - 526) 43.7%	61 (21 - 107) 81.1%

Alternative Standards		Incidence Associated with PM2.5 Using an Annual Design Value Based on the Maximum of Monitor-Specific Averages** (95% Confidence Interval) Percent Reduction in Incidence from Current Standards			Incidence Associated with PM2.5 Using an Annual Design Value Based on the Average of Monitor-Specific Averages** (95% Confidence Interval) Percent Reduction in Incidence from Current Standards		
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
13	30, 98th percentile value	354 (123 - 615) 32.2%	94 (33 - 164) 66.7%	0 (0 - 0) 100.0%	435 (151 - 757) 41.8%	185 (64 - 323) 65.4%	0 (0 - 0) 100.0%
13	25, 98th percentile value	270 (94 - 468) 48.3%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	270 (94 - 468) 63.9%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	40, 99th percentile value	354 (123 - 615) 32.2%	94 (33 - 164) 66.7%	0 (0 - 0) 100.0%	538 (187 - 939) 28.0%	301 (104 - 526) 43.7%	61 (21 - 107) 81.1%
13	35, 99th percentile value	354 (123 - 615) 32.2%	94 (33 - 164) 66.7%	0 (0 - 0) 100.0%	507 (176 - 884) 32.1%	266 (92 - 465) 50.3%	23 (8 - 40) 92.9%
13	30, 99th percentile value	354 (123 - 615) 32.2%	94 (33 - 164) 66.7%	0 (0 - 0) 100.0%	356 (124 - 619) 52.3%	97 (34 - 168) 81.9%	0 (0 - 0) 100.0%
13	25, 99th percentile value	207 (72 - 358) 60.3%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	207 (72 - 358) 72.3%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	40, 98th percentile value	271 (94 - 469) 48.1%	0 (0 - 1) 100.0%	0 (0 - 0) 100.0%	435 (151 - 756) 41.8%	184 (64 - 322) 65.6%	0 (0 - 0) 100.0%
12	35, 98th percentile value	271 (94 - 469) 48.1%	0 (0 - 1) 100.0%	0 (0 - 0) 100.0%	435 (151 - 756) 41.8%	184 (64 - 322) 65.6%	0 (0 - 0) 100.0%
12	30, 98th percentile value	271 (94 - 469) 48.1%	0 (0 - 1) 100.0%	0 (0 - 0) 100.0%	435 (151 - 756) 41.8%	184 (64 - 322) 65.6%	0 (0 - 0) 100.0%
12	25, 98th percentile value	270 (94 - 468) 48.3%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	270 (94 - 468) 63.9%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	40, 99th percentile value	271 (94 - 469) 48.1%	0 (0 - 1) 100.0%	0 (0 - 0) 100.0%	435 (151 - 756) 41.8%	184 (64 - 322) 65.6%	0 (0 - 0) 100.0%

Alternative Standards		Incidence Associated with PM2.5 Using an Annual Design Value Based on the Maximum of Monitor-Specific Averages** (95% Confidence Interval)			Incidence Associated with PM2.5 Using an Annual Design Value Based on the Average of Monitor-Specific Averages** (95% Confidence Interval)		
		Percent Reduction in Incidence from Current Standards			Percent Reduction in Incidence from Current Standards		
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
12	35, 99th percentile value	271 (94 - 469) 48.1%	0 (0 - 1) 100.0%	0 (0 - 0) 100.0%	435 (151 - 756) 41.8%	184 (64 - 322) 65.6%	0 (0 - 0) 100.0%
12	30, 99th percentile value	271 (94 - 469) 48.1%	0 (0 - 1) 100.0%	0 (0 - 0) 100.0%	356 (124 - 619) 52.3%	97 (34 - 168) 81.9%	0 (0 - 0) 100.0%
12	25, 99th percentile value	207 (72 - 358) 60.3%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	207 (72 - 358) 72.3%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%

*This analysis used a C-R function from Pope et al. (2002) -- ACS extended.

**For the cutpoints above 7.5 µg/m3, the slope of the C-R function has been modified based on a simple hockeystick model (see discussion in section 2.5).

***Current standards.

Note: Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

results based on annual standard design values calculated from the maximum of monitor-specific values (see Exhibit 2.4) alongside the corresponding results based on design values calculated from the average of monitor-specific values. The corresponding comparisons for Pittsburgh, PA and St. Louis, MO (the other two locations that do not meet the current standards and for which both the maximum-based and the average-based annual standard design values result in positive percent rollbacks) are given in Exhibits E.37 - E.40.

Changing the basis of the annual standard design value from the maximum to the average of monitor-specific averages reduces the percent rollback necessary to just meet an annual standard. If the daily standard had previously been the controlling standard (i.e., requiring a greater percent rollback than the annual standard), then reducing the percent rollback necessary to just meet the annual standard will have no effect. If, however, the annual standard had previously been the controlling standard, the new (smaller) percent rollback necessary to just meet the annual standard using an average-based annual standard design value will result in a larger estimated mortality associated with any set of alternative standards. The new smaller percent rollback may still exceed the percent rollback necessary to meet the daily standard. In this case, the annual standard will still be the controlling standard, but the incidence reduction achieved by just meeting the alternative standards will be smaller than it would be if the maximum-based annual standard design value were used. Alternatively, the new (smaller) percent rollback necessary to just meet the annual standard may be less than the percent rollback necessary to meet the daily standard. In this case, the daily standard would become controlling, and the incidence reduction achieved by just meeting the alternative standards would be smaller than it had previously been. However, the incidence reduction, in this case, would be larger than it would be if the new annual standard based on the average of monitor-specific averages were controlling.

Exhibits 8.12 and 8.13 provide examples of each possibility. To meet an annual standard of 15 $\mu g/m^3$ requires a 28.1% rollback when the annual standard design value is based on the maximum of monitor-specific averages, and an 11.5% rollback when it is based on the average of monitor-specific averages. To meet a daily standard of 25 $\mu g/m^3$ based on the 98th percentile value, however, requires a 46.9% rollback (using a daily design value based on the maximum of monitor-specific values). In this case, the daily standard is controlling, whichever of the two annual standard design values is used, so the reduced incidences associated with just meeting the 15 $\mu g/m^3$ annual standard and 25 $\mu g/m^3$ daily standard combination are the same, regardless of whether the annual standard design value is based on the maximum or the spatial average of monitor-specific averages (although the percent reductions from current standards are different).

The combination of an annual standard of 15 $\mu g/m^3$ and a daily standard of 35 $\mu g/m^3$ based on the 98th percentile value presents a different situation. To just meet this daily standard (using the maximum of monitor-specific values) requires a 22.2% rollback. As noted above, the required rollbacks to just meet the annual standard are 28.1% and 11.5% when the annual standard design value is based on the maximum and average, respectively, of monitor-specific

averages. In this case, the change from maximum-monitor based to averaged-monitors based annual standard design value changes the controlling standard from the annual to the daily standard. The estimated mortality associated with short-term exposures to $PM_{2.5}$ in Detroit correspondingly increases from 122 to 132 when, for example, the cutpoint is PRB (see Exhibit 8.12). If the averaged-monitors based annual standard had been controlling, the estimated mortality associated with short-term exposure would have been 150 (as it is whenever the averaged-monitors based annual standard of 15 µg/m^3 is controlling – for example, when combined with daily standards of 65 or 40 µg/m^3 based on the 98th percentile value).

The change from a maximum-monitor based to an averaged-monitors based annual standard design value induces a change not only in the estimated mortality associated with just meeting alternative more stringent standards, but also in the estimated mortality associated with just meeting the current standards. Because of this, there does not appear to be any clear pattern to the impact on the percent reduction achieved by just meeting alternative more stringent standards. For example, using a cutpoint of 7.5 µg/m^3, mortality associated with long-term exposure to $PM_{2.5}$ in Detroit when the current standards are just met is estimated to be 522 using a maximum-monitor based annual standard design value, and 747 using an annual standard design value that is averaged-monitors based. The percent reduction in incidence when the more stringent 14 µg/m^3 annual and 40 µg/m^3 daily 98th percentile standards are just met is greater when the maximum-monitor based annual standard design value is used – a 16 percent (= (522-438)/522) reduction in mortality using the maximum-monitor based annual standard design value versus a 14 percent (= (747 - 642)/747) reduction using the averaged-monitors based annual standard design value. In contrast, the percent reduction in incidence when the more stringent 14 µg/m^3 annual and 35 µg/m^3 daily 99th percentile standards are just met is greater when the averaged-monitors based annual standard design value is used – a 32 percent (= (747-507)/747) reduction in mortality using the averaged-monitors based annual standard design value vs. a 16 percent (= (522-438)/522) reduction using the maximum-monitor based annual standard design value.

Higher cutpoints tend to accentuate the impact of the change from a maximum-monitor based to an averaged-monitors based annual standard design value in the estimation of mortality when alternative standards are just met. As noted above, using an averaged-monitors based annual standard design value will result in mortality estimates that are at least as large as those calculated using the maximum-monitor based annual standard design value, and in many cases (whenever the annual standard was the controlling standard) mortality estimates will be larger. In almost all cases, the percent increase (from one estimate to the other) is larger when a cutpoint of 10 µg/m^3 is used than when a cutpoint of 7.5 µg/m^3 is used, and it increases with increasing cutpoints. For example, when a 15 µg/m^3 annual standard and a 40 µg/m^3 98th percentile daily standard are just met, estimated mortality associated with long-term exposure to $PM_{2.5}$ in Detroit in excess of 7.5 µg/m^3 calculated using an averaged-monitors based annual standard design value is 747; using a maximum-monitor based annual standard design value it is 522. The percent

increase is therefore 43.2% (=(747-522)/522).[30] The corresponding mortality estimates using a cutpoint of 10 µg/m^3 are 535 and 282, resulting in a percent increase of 89.6% (=(535-282)/282). The corresponding percent increase using a cutpoint of 12 µg/m^3 is 684.3% (=(322-41)/41).

The pattern is the same for mortality associated with short-term exposure to PM$_{2.5}$. For example, estimated mortality associated with short-term exposure to PM$_{2.5}$ in excess of the PRB of 3.5 µg/m^3 in Detroit when a 15 µg/m^3 annual standard and a 65 µg/m^3 98th percentile daily standard are just met, calculated using an averaged-monitors based annual standard design value is 150; using a maximum-monitor based annual standard design value it is 122. The percent increase is therefore 23.0% (=(150-122)/122). The corresponding mortality estimates using a cutpoint of 10 µg/m^3 threshold are 80 and 54, resulting in a percent increase of 47.5% (=(80-54)/54). The corresponding percent increases using cutpoints of 15 µg/m^3 and 20 µg/m^3 are 75.9% and 109.8%, respectively.

Measured in terms of percent increase (from the maximum-monitor based to the averaged-monitors based mortality estimate), there was substantial variability in the impact of using an averaged-monitors based annual standard design value versus one that is maximum-monitor based. For mortality associated with short-term exposure to PM$_{2.5}$ in Detroit in excess of the PRB of 3.5 µg/m^3, for example, positive percent increases ranged from 0.0% to about 23.4%.[31] Using a cutpoint of 20 µg/m^3, positive percent increases ranged from 0.0% to about 167%.

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[30] Incidence numbers shown in Exhibits 8.12, 8.13, and E.37 - E.40 are rounded to the nearest whole number; the percentages shown here are based on the rounded incidence numbers.

[31] Whenever the daily standard had been the controlling standard, the change from maximum-monitor based to averaged-monitors based annual standard design value had no impact – i.e., the percent increase was zero.

9.   Assessment of the Health Risks Associated with "As Is" PM$_{10\text{-}2.5}$ Concentrations and the Reduced Risks Associated with Just Meeting Alternative PM$_{10\text{-}2.5}$ Standards

9.1   Base case analysis

In this section we present the results of the risk assessment for PM$_{10\text{-}2.5}$. Only three locations – Detroit, Seattle, and St. Louis – had both C-R functions for health endpoints associated with PM$_{10\text{-}2.5}$ and sufficient PM$_{10\text{-}2.5}$ air quality data to be included in the risk assessment. The results of the first part of the risk assessment, assessing the health risks associated with "as is" PM$_{10\text{-}2.5}$ concentrations (representing levels measured in 2003 for all three locations) in excess of various cutpoints, are summarized across the three urban areas in figures and, for Detroit, in Exhibits 9.1 and 9.2. Exhibit 9.1 shows incidence, incidence per 100,000 general population, and percent of total incidence of hospital admissions in Detroit associated with short-term exposure to "as is" PM$_{10\text{-}2.5}$ concentrations in excess of an estimated PRB concentration of 4.5 µg/m^3. Exhibit 9.2 shows incidence and percent of total incidence of hospital admissions in Detroit associated with short-term exposure to "as is" PM$_{10\text{-}2.5}$ concentrations in excess of various cutpoints. Results for the other locations corresponding to those shown for Detroit in Exhibits 9.1 and 9.2 are shown in Exhibits F.1, F.3, and F.5 for Seattle, and Exhibits F.2, F.4, and F.6 for St. Louis.
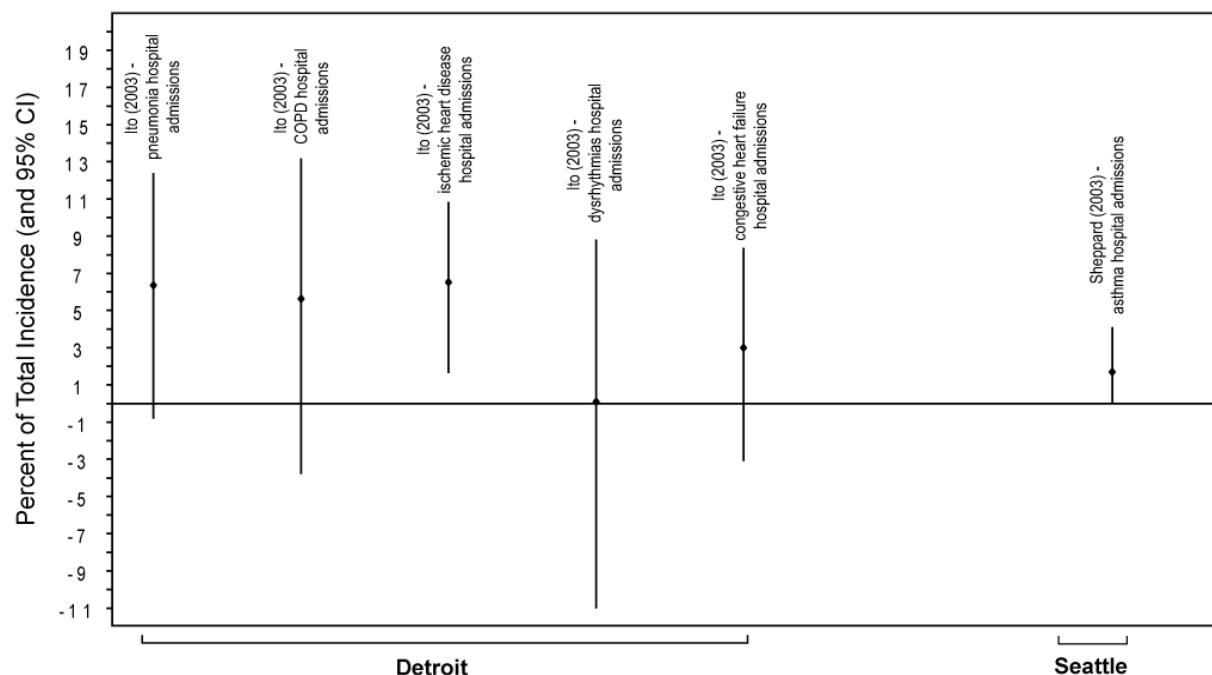
In the second (just meeting alternative standards) part of the risk assessment for PM$_{10\text{-}2.5}$, only daily standards were considered. One set of standards was based on the ninety-eighth percentile daily value, and another set was based on the ninety-ninth percentile value. The alternative daily PM$_{10\text{-}2.5}$ standards considered in this part of the risk assessment are given in Exhibit 9.3.[32] The design values used to calculate percent rollbacks necessary to just meet alternative PM$_{10\text{-}2.5}$ standards were given in Exhibit 2.5. The results of the second part of the risk assessment for PM$_{10\text{-}2.5}$ are shown in Exhibit 9.4 for Detroit, and in Exhibits F.5 and F.6 for Seattle and St. Louis, respectively. These exhibits show the reduced incidence, and the percent reduction from incidence under "as is" PM$_{10\text{-}2.5}$ concentrations, when each of several alternative standards is just met, assuming various cutpoint levels.

The central tendency estimates in both figures and in Exhibits 9.1, F.1 and F.2 are based on the PM$_{10\text{-}2.5}$ coefficients estimated in the studies, and the ranges are based on the 95 percent CIs around those estimates. In Exhibits 9.2 and 9.4, and Exhibits F.3 - F.6, for results based on cutpoints in excess of the estimated PRB level, the central tendency estimates and 95 percent CIs are based on the adjusted PM$_{10\text{-}2.5}$ coefficients estimated in the studies, as described in Section 2.5. All estimated incidences were rounded to the nearest whole number, except respiratory symptoms, which were rounded to the nearest 100. All percentages were rounded to one decimal place.

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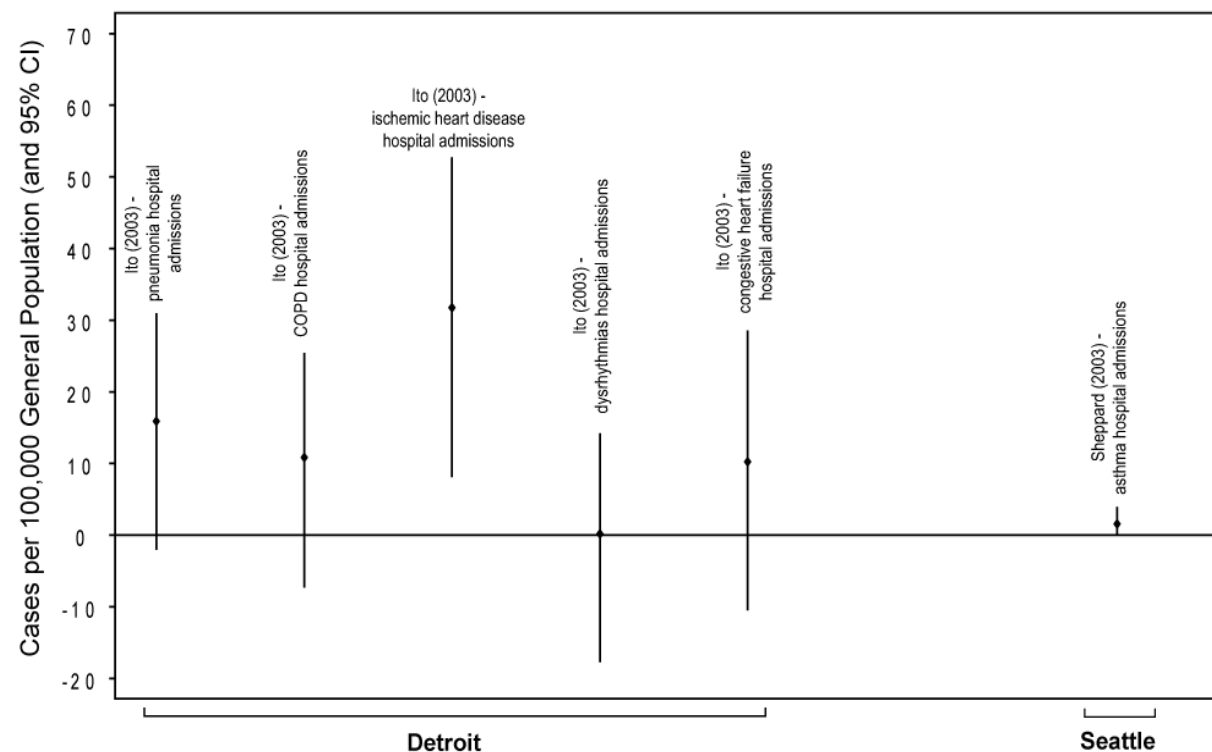
[32] See U.S. EPA (2005a) for a discussion of the rationale for selecting these alternative standards.

Figure 9.1a. Estimated Annual Percent of Hospital Admissions Associated with Short-Term Exposure to PM$_{10-2.5}$ Above Background
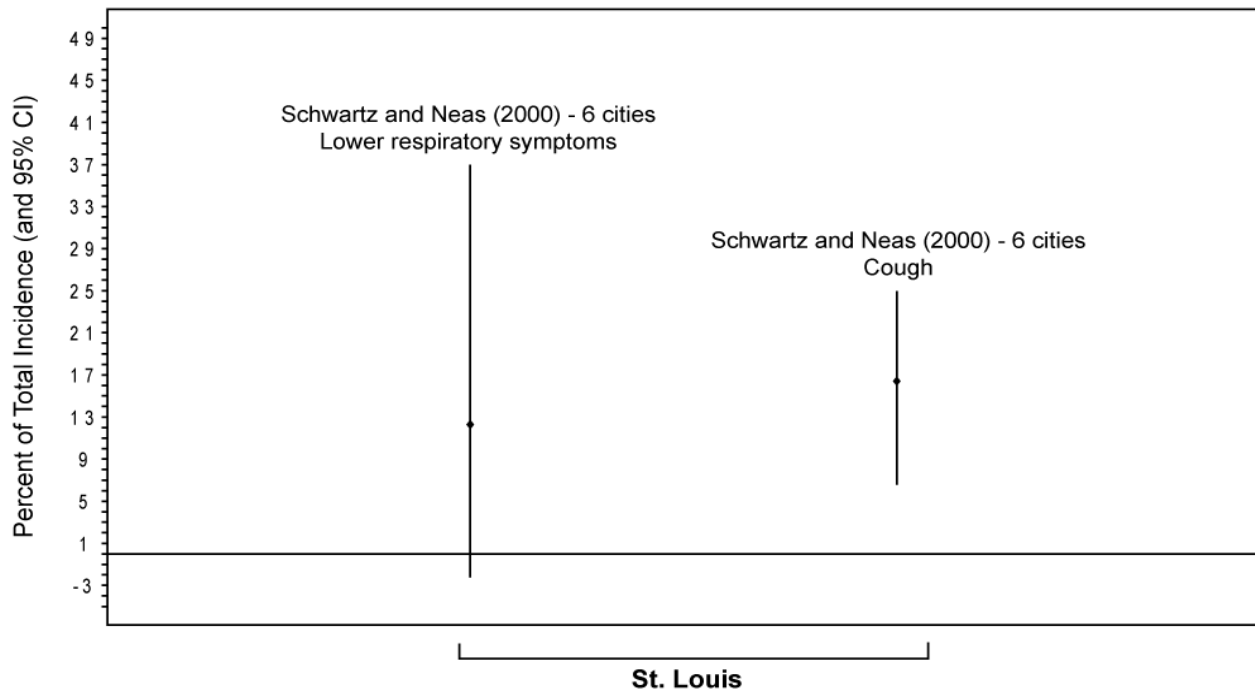
Figure 9.1b. Estimated Annual Cases of Hospital Admissions per 100,000 General Population Associated with Short-Term Exposure to PM$_{10-2.5}$ Above Background
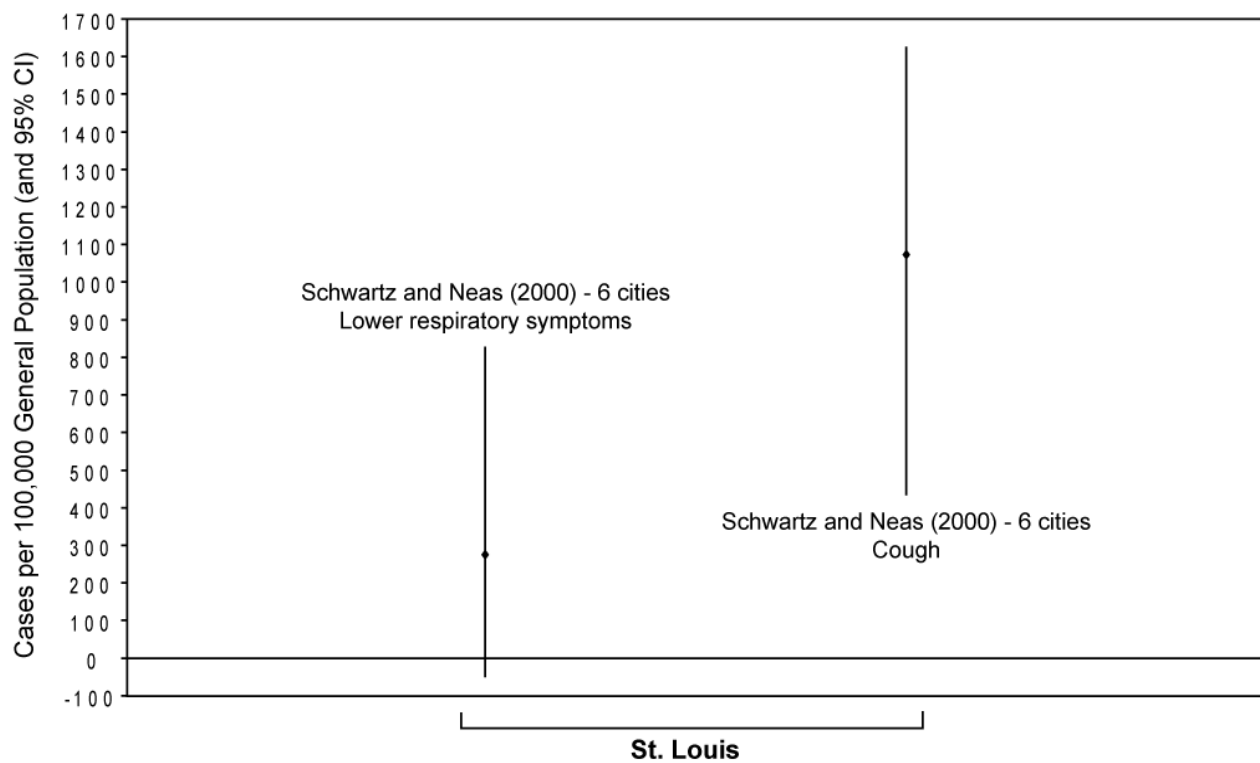
Figure 9.2a. Estimated Annual Percent of Respiratory Symptoms Associated with Short-Term Exposure to PM$_{10-2.5}$ Above Background

Figure 9.2b. Estimated Annual Cases of Respiratory Symptoms per 100,000 General Population Associated with Short-Term Exposure to PM$_{10-2.5}$ Above Background

Exhibit 9.1. Estimated Annual Health Risks Associated with Short-Term Exposure to "As Is" PM$_{10-2.5}$ Concentrations
Detroit, MI, 2003

Health Effects	Study	Type	Ages	Lag	Other Pollutants in Model	Health Effects Associated with PM$_{10-2.5}$ Above Policy Relevant Background*		
						Incidence	Incidence per 100,000 General Population	Percent of Total Incidence
Hospital Admissions					**Single Pollutant Models**			
	Ito (2003) [reanalysis of Lippmann et al. (2000)]	Pneumonia	65+	1 day		327 (-40 - 635)	16 (-2 - 31)	6.4% (-0.8% - 12.4%)
	Ito (2003) [reanalysis of Lippmann et al. (2000)]	COPD+	65+	3 day		223 (-148 - 521)	11 (-7 - 25)	5.6% (-3.8% - 13.2%)
	Ito (2003) [reanalysis of Lippmann et al. (2000)]	Ischemic heart disease	65+	2 day		654 (169 - 1083)	32 (8 - 53)	6.5% (1.7% - 10.8%)
	Ito (2003) [reanalysis of Lippmann et al. (2000)]	Dysrhythmias	65+	0 day		3 (-363 - 290)	0 (-18 - 14)	0.1% (-11.0% - 8.8%)
	Ito (2003) [reanalysis of Lippmann et al. (2000)]	Congestive heart failure	65+	0 day		211 (-214 - 585)	10 (-10 - 28)	3.0% (-3.1% - 8.4%)

*Health effects incidence was quantified down to the estimated policy relevant background level of 4.5 ug/m3. Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.
Note: Numbers in parentheses are 95% confidence intervals based on statistical uncertainty surrounding the PM$_{10-2.5}$ coefficient.

Exhibit 9.2. Estimated Annual Health Risks Associated with Short-Term Exposure to "As Is" PM$_{10-2.5}$ Concentrations, Assuming Various Cutpoint Levels*

Detroit, MI, 2003

Health Effects	Study	Type	Ages	Lag	Other Pollutants in Model	Incidence Associated with PM$_{10-2.5}$ Assuming Various Cutpoint Levels** (95% Confidence Interval) Percent of Total Incidence (95% Confidence Interval)			
						Policy Relevant Background =4.5 µg/m3	Cutpoint =10 µg/m3	Cutpoint =15 µg/m3	Cutpoint =20 µg/m3
					Single Pollutant Models				
Hospital Admissions	Ito (2003) [reanalysis of Lippmann et al. (2000)]	Pneumonia	65+	1 day		327 (-40 - 635) 6.4% (-0.8% - 12.4%)	284 (-35 - 547) 5.5% (-0.7% - 10.7%)	244 (-31 - 463) 4.8% (-0.6% - 9.0%)	213 (-28 - 396) 4.2% (-0.5% - 7.7%)
	Ito (2003) [reanalysis of Lippmann et al. (2000)]	COPD+	65+	3 day		223 (-148 - 521) 5.6% (-3.8% - 13.2%)	194 (-131 - 448) 4.9% (-3.3% - 11.3%)	167 (-116 - 379) 4.2% (-3.0% - 9.6%)	147 (-106 - 323) 3.7% (-2.7% - 8.2%)
	Ito (2003) [reanalysis of Lippmann et al. (2000)]	Ischemic heart disease	65+	2 day		654 (169 - 1083) 6.5% (1.7% - 10.8%)	569 (149 - 934) 5.7% (1.5% - 9.3%)	489 (129 - 794) 4.9% (1.3% - 7.9%)	426 (115 - 682) 4.3% (1.2% - 6.8%)
	Ito (2003) [reanalysis of Lippmann et al. (2000)]	Dysrhythmias	65+	0 day		3 (-363 - 290) 0.1% (-11.0% - 8.8%)	2 (-326 - 251) 0.1% (-9.9% - 7.6%)	2 (-296 - 215) 0.1% (-9.0% - 6.5%)	2 (-279 - 186) 0.1% (-8.4% - 5.6%)
	Ito (2003) [reanalysis of Lippmann et al. (2000)]	Congestive heart failure	65+	0 day		211 (-214 - 585) 3.0% (-3.1% - 8.4%)	185 (-190 - 507) 2.6% (-2.7% - 7.2%)	160 (-168 - 434) 2.3% (-2.4% - 6.2%)	142 (-152 - 376) 2.0% (-2.2% - 5.4%)

*Incidence was quantified down to policy relevant background level of 4.5 µg/m3, as well as down to each of the alternative cutpoints. For the cutpoints above policy relevant background, the slope of the C-R function has been modified based on a simple hockeystick model (see discussion in section 2.5).

**Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Exhibit 9.3. Alternative PM$_{10\text{-}2.5}$ Standards Considered in the PM$_{10\text{-}2.5}$ Risk Assessment*

Daily Standards Based on the 98th Percentile Value	Daily Standards Based on the 99th Percentile Value
80	100
65	80
50	60
30	35
25	30

*All standards are in µg/m^3.

Exhibit 9.4. Estimated Annual Hospital Admissions for Ischemic Heart Disease Associated with Short-Term Exposure to PM$_{10-2.5}$ When Alternative Standards Are Just Met, Assuming Various Cutpoint Levels*

Detroit, MI, 2003

(2003 As Is Levels = 21.7 ug/m3 Annual Average; 105.9 ug/m3 98th Percentile Daily Value)

"As Is" PM$_{10-2.5}$ Concentrations and Alternative Daily Standards (µg/m3)	Incidence Associated with PM$_{10-2.5}$ (95% Confidence Interval) Percent Reduction in Incidence from "As Is" PM$_{10-2.5}$ Concentrations			
	Policy Relevant Background =4.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =15 µg/m3	Cutpoint** =20 µg/m3
"As is" PM$_{10-2.5}$ concentrations	654 (169 - 1083) 0.0%	569 (149 - 934) 0.0%	489 (129 - 794) 0.0%	426 (115 - 682) 0.0%
80 ug/m3 daily 98th percentile value	654 (169 - 1083) 0.0%	569 (149 - 934) 0.0%	489 (129 - 794) 0.0%	426 (115 - 682) 0.0%
65 ug/m3 daily 98th percentile value	600 (156 - 989) 8.3%	508 (134 - 829) 10.7%	425 (114 - 683) 13.1%	360 (99 - 567) 15.5%
50 ug/m3 daily 98th percentile value	443 (117 - 719) 32.3%	334 (90 - 532) 41.3%	248 (69 - 384) 49.3%	183 (54 - 271) 57.0%
30 ug/m3 daily 98th percentile value	242 (65 - 386) 63.0%	125 (36 - 190) 78.0%	65 (20 - 91) 86.7%	44 (15 - 57) 89.7%
25 ug/m3 daily 98th percentile value	193 (52 - 307) 70.5%	81 (24 - 120) 85.8%	39 (13 - 52) 92.0%	25 (9 - 30) 94.1%
100 ug/m3 daily 99th percentile value	654 (169 - 1083) 0.0%	569 (149 - 934) 0.0%	489 (129 - 794) 0.0%	426 (115 - 682) 0.0%
80 ug/m3 daily 99th percentile value	654 (169 - 1083) 0.0%	569 (149 - 934) 0.0%	489 (129 - 794) 0.0%	426 (115 - 682) 0.0%
60 ug/m3 daily 99th percentile value	491 (129 - 801) 24.9%	387 (104 - 621) 32.0%	301 (83 - 472) 38.4%	233 (67 - 353) 45.3%

"As Is" PM$_{10-2.5}$ Concentrations and Alternative Daily Standards (µg/m3)	Incidence Associated with PM$_{10-2.5}$ (95% Confidence Interval)			
	Percent Reduction in Incidence from "As Is" PM$_{10-2.5}$ Concentrations			
	Policy Relevant Background =4.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =15 µg/m3	Cutpoint** =20 µg/m3
35 ug/m3 daily 99th percentile value	262 (70 - 419) 59.9%	144 (41 - 221) 74.7%	79 (24 - 113) 83.8%	53 (18 - 68) 87.6%
30 ug/m3 daily 99th percentile value	218 (59 - 347) 66.7%	103 (30 - 154) 81.9%	51 (16 - 70) 89.6%	34 (12 - 43) 92.0%

*This analysis used a C-R function from Ito (2003).

**For the cutpoints above policy relevant background, the slope of the C-R function has been modified based on a simple hockeystick model (see discussion in section 2.5).

Note: Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

As noted in Section 2, estimated reduced risks are determined by changes only at the composite monitor for a location and only for a single year (2003, in the case of $PM_{10-2.5}$). The percent reduction of $PM_{10-2.5}$ concentrations at the composite monitor to just meet a standard, however, is determined by the design value for that location based on data from 2001 - 2003. (EPA design values for 98th and 99th percentile daily $PM_{10-2.5}$ standards are given in Exhibit 2.5.) In Detroit, the design value for the 98th percentile daily $PM_{10-2.5}$ standards is 70 µg/m^3 whereas the 98th percentile daily value in 2003 based on the measured $PM_{10-2.5}$ values is 105.9 µg/m^3. Because the design value is lower than 80 ug/m^3, the highest 98th percentile daily $PM_{10-2.5}$ standard, zero risk reductions were estimated to result from this standard, even though the 98th percentile daily value at the composite monitor in 2003, 105.9 µg/m^3, is well above the standard level. Similarly, the design value for the 99th percentile daily $PM_{10-2.5}$ standards is 77 µg/m^3 for Detroit, whereas the 99th percentile daily value at the composite monitor in Detroit in 2003 is substantially greater than 100 µg/m^3, the highest 99th percentile daily $PM_{10-2.5}$ standard level. So zero risk reductions were similarly estimated to result from this standard. In general, estimated reduced risks decrease and the confidence intervals around them become more narrow as the daily standards become more stringent.

9.2   Sensitivity Analyses

As with $PM_{2.5}$, we carried out sensitivity analyses to examine the impact of different assumed PRB levels on estimated risks associated with short-term exposure to $PM_{10-2.5}$. The results of these sensitivity analyses for Detroit are shown in Exhibit 9.5. The results for the other two locations are shown in Appendix F.

Exhibit 9.5. Sensitivity Analysis: Estimated Annual Health Risks Associated with Short-Term Exposure to "As Is" PM$_{10-2.5}$ Concentrations, Using Different Estimates of Policy Relevant Background Level

Detroit, MI, 2003

Health Effects	Study	Type	Ages	Lag	Other Pollutants in Model	Health Effects Associated with PM$_{10-2.5}$ Above Policy Relevant Background of: *					
						1 ug/m3		4.5 ug/m3		9 ug/m3	
						Incidence	Percent of Total Incidence	Incidence	Percent of Total Incidence	Incidence	Percent of Total Incidence
Hospital Admissions					Single Pollutant Models						
	Ito (2003) [reanalysis of Lippmann et al. (2000)]	Pneumonia	65+	1 day		380 (-46 - 738)	7.4% (-0.9% - 14.4%)	327 (-40 - 635)	6.4% (-0.8% - 12.4%)	265 (-32 - 516)	5.2% (-0.6% - 10.0%)
	Ito (2003) [reanalysis of Lippmann et al. (2000)]	COPD+	65+	3 day		260 (-173 - 606)	6.6% (-4.4% - 15.3%)	223 (-148 - 521)	5.6% (-3.8% - 13.2%)	181 (-121 - 423)	4.6% (-3.1% - 10.7%)
	Ito (2003) [reanalysis of Lippmann et al. (2000)]	Ischemic heart disease	65+	2 day		761 (197 - 1258)	7.6% (2.0% - 12.6%)	654 (169 - 1083)	6.5% (1.7% - 10.8%)	531 (138 - 879)	5.3% (1.4% - 8.8%)
	Ito (2003) [reanalysis of Lippmann et al. (2000)]	Dysrhythmias	65+	0 day		3 (-422 - 337)	0.1% (-12.8% - 10.2%)	3 (-363 - 290)	0.1% (-11.0% - 8.8%)	2 (-295 - 235)	0.1% (-8.9% - 7.1%)
	Ito (2003) [reanalysis of Lippmann et al. (2000)]	Congestive heart failure	65+	0 day		246 (-249 - 680)	3.5% (-3.6% - 9.7%)	211 (-214 - 585)	3.0% (-3.1% - 8.4%)	171 (-174 - 475)	2.5% (-2.5% - 6.8%)

*Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Note: Numbers in parentheses are 95% confidence intervals based on statistical uncertainty surrounding the PM $_{10-2.5}$ coefficient.

The same patterns can be observed in the results for $PM_{10-2.5}$ as were observed in the results for $PM_{2.5}$. For example, changing from the midpoint estimate of 4.5 µg/m^3 for $PM_{10-2.5}$ background in the Eastern U.S. to the lower end of the range for $PM_{10-2.5}$ background (1 µg/m^3) increased the estimated percent of total incidence of hospital admissions for pneumonia in Detroit that is $PM_{10-2.5}$-related using Ito (2003) by about 16 percent (from 6.4 percent to 7.4 percent). Similarly, changing from the midpoint estimate to the upper end of the range for $PM_{10-2.5}$ (9 µg/m^3) decreased the percent of total incidence that is $PM_{2.5}$-related using that same study by about 19 percent (from 6.4 percent to 5.2 percent).

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Appendix A. Air Quality Assessment: The PM Data

Appendix A. Air Quality Assessment: The PM Data

This Appendix describes the PM data for the urban counties used in the risk assessment (see Section 3 for selection of locations). The average ambient PM concentration in an assessment location on a given day is represented by the *average* of 24-hour average PM levels at the different monitors in that location that reported on that day. This approach is consistent with what has been done in epidemiological studies estimating PM C-R functions. Also, because people are often quite mobile (e.g., living in one part of a county and working in another), an area-wide average PM level may be a more meaningful measure of ambient PM concentration than PM levels at individual monitors. Ito et al. (1995), for example, found that averaging PM_{10} concentrations reported at monitors in different places generally improved the significance of the association between PM_{10} and mortality in Chicago, compared with using individual monitors.

In order for an urban area to be included in the $PM_{2.5}$ or $PM_{10-2.5}$ risk assessment the location must contain at least one monitor (for the $PM_{10-2.5}$ risk assessment, at least one pair of co-located PM_{10} and $PM_{2.5}$ monitors) with 11 or more observations per quarter. Because there are substantially more monitoring data for $PM_{2.5}$ than for PM_{10}, we added the additional criterion for the $PM_{2.5}$ risk assessment that there be at least 122 observations per year (1 in 3 day monitoring). Once the criteria for inclusion were met, all monitors with at least 11 observations per quarter were used for each location. The cutoff of 11 observations per quarter is based on EPA guidance on measuring attainment of the daily and annual particulate matter standards outlined in Appendix N of the July 18, 1997 Federal Register Notice (available on the web at www.epa.gov/ttn/oarpg/t1pfpr.html). The guidance requires that at least 75 percent of the scheduled sampling days for each quarter have valid data. Based on a one in six day sampling protocol, the minimum required number of observations would be 11 per quarter.

The numbers of days of observations by monitor and at the composite monitor, by quarter and for the year, along with annual averages and 98th and 99th percentile concentrations, are given in the exhibits below. In these exhibits the first five digits, which denote the FIPS code designation, are omitted in the legends. The annual average at each monitor, and at the composite monitor, is the average of the four quarterly averages at the monitor. The 98th and 99th percentiles at each monitor, and at the composite monitor, are calculated using the method used by EPA, as described in Appendix N of the July 18, 1997 Federal Register Notice (available on the web at www.epa.gov/ttn/oarpg/t1pfpr.html). The only difference between the method used in calculating the monitor-specific annual averages and 98th and 99th percentile values shown in the exhibits in this appendix and the standard EPA convention in calculating annual averages and 98th and 99th percentile values is that the EPA convention uses three years of data whereas the calculations here are based on only a single year of data.

A.1.   The PM$_{2.5}$ data

PM$_{2.5}$ data for each of the urban areas identified in Section 3 for the PM$_{2.5}$ risk assessment (Boston, Detroit, Los Angeles, Philadelphia, Phoenix, Pittsburgh, San Jose, Seattle, and St. Louis) were obtained for the years 1999 through 2003 from EPA's Air Quality System (AQS). For all urban areas except Phoenix, year 2003 data were used. For Phoenix there were no monitors in 2003 and only two monitors in 2002 that met the inclusion criterion. The number of days covered by the two 2002 monitors in Phoenix is 178 compared with 362 days covered in 2003. Because the annual averages in those two years in Phoenix were comparable and the 2001 data provided much better coverage of the year, we used the year 2001 data. The numbers of days of observations by monitor and at the composite monitor, by quarter and for the year, along with annual averages and 98th and 99th percentile concentrations, are given in Exhibits A.1 through A.9.

EPA design values (described in Section 2.3 of the report) are used to determine the percent rollback necessary to just meet annual, 98th percentile daily, and 99th percentile daily standards. Although the composite monitor is not used in determining the percent rollback in the PM risk assessment, the percent rollback to simulate just meeting alternative standards is applied to the composite monitor.

Exhibit A.1. Number of Days on which PM$_{2.5}$ Concentration Data are Available, by Monitor and by Quarter, and PM$_{2.5}$ Concentrations. Boston, 2003*

Monitor	Q1	Q2	Q3	Q4	Year Total	Annual Avg.	98th Percentile	99th Percentile
AQS 250250027881011	17	12	22	24	75	12.0	41.3	53.7
AQS 250250042881011	47	49	91	83	270	11.4	30.6	39.6
AQS 250250043881011	22	30	25	29	106	13.6	35.5	42.5
Composite[1]	62	63	91	86	302	12.1	34.1	41.1
Design Values**	–	–	–	–	–	14.4	44	60

*All concentrations are in µg/m^3; includes Middlesex, Norfolk and Suffolk Counties.

** The calculation of design values is described in Section 2.3 of this report.

1. The number of days at the composite monitor is the number of days on which at least one of the monitors reported.

Exhibit A.2. Number of Days on which PM$_{2.5}$ Concentration Data are Available, by Monitor and by Quarter, and PM$_{2.5}$ Concentrations. Detroit, 2003*

Monitor	Q1	Q2	Q3	Q4	Year Total	Annual Avg.	98th Percentile	99th Percentile
AQS 261630001881011	80	86	80	80	326	15.2	40.5	48.3
AQS 261630015881011	27	27	30	27	111	16.6	33.6	34.3
AQS 261630016881011	85	85	86	71	327	15.8	46.2	50.4
AQS 261630019881011	27	30	30	29	116	14.6	37.1	39.2
AQS 261630025881011	27	28	31	27	113	14.1	38.1	38.5
AQS 261630033881011	29	27	27	28	111	19.1	42.8	44.1
AQS 261630036881011	25	24	28	29	106	16.3	34.8	36.0
Composite[1]	88	90	90	89	357	15.7	41.5	48.5
Design Values**	–	–	–	–	–	19.5	44.0	48

*All concentrations are in µg/m^3; includes Wayne County.

** The calculation of design values is described in Section 2.3 of this report.

1. The number of days at the composite monitor is the number of days on which at least one of the monitors reported.

Exhibit A.3. Number of Days on which PM$_{2.5}$ Concentration Data are Available, by Monitor and by Quarter, and PM$_{2.5}$ Concentrations. Los Angeles, 2003*

Monitor	Q1	Q2	Q3	Q4	Year Total	Annual Avg.	98th Percentile	99th Percentile
AQS 060370002881011	87	79	80	68	314	19.3	55.5	63.9
AQS 060371002881011	30	23	28	11	92	22.1	60.1	120.6
AQS 060371103881011	80	85	85	75	325	21.4	61.3	68.9
AQS 060371201881011	29	30	31	25	115	16.5	44.7	45.0
AQS 060371301881011	29	29	31	28	117	20.3	52.4	53.3
AQS 060371601881011	29	27	27	28	111	20.5	50.4	51.1
AQS 060372005881011	29	28	29	24	110	18.6	48.4	51.3
AQS 060374002881011	81	84	78	81	324	18.0	46.5	51.4
AQS 060379033881011	30	30	31	29	120	9.4	17.0	21.0
Composite[1]	90	91	92	92	365	19.1	55.0	60.4
Design Values**	–	–	–	–	–	23.6	62.0	96

*All concentrations are in µg/m^3; includes Los Angeles County.

** The calculation of design values is described in Section 2.3 of this report.

1. The number of days at the composite monitor is the number of days on which at least one of the monitors reported.

Exhibit A.4. Number of Days on which PM$_{2.5}$ Concentration Data are Available, by Monitor and by Quarter, and PM$_{2.5}$ Concentrations. Philadelphia, 2003*

Monitor	Q1	Q2	Q3	Q4	Year Total	Annual Avg.	98th Percentile	99th Percentile
AQS 421010004881011	12	76	82	92	322	14.8	39.9	40.7
AQS 421010014881011	11	15	26	21	73	13.3	39.3	60.7
AQS 421010020881011	24	28	27	29	108	13.7	39.3	39.9
AQS 421010024881011	21	24	23	40	108	13.2	38.7	40.9
AQS 421010047881011	15	18	23	14	70	16.1	42.3	56.5
AQS 421010136881011	63	69	81	83	296	14.0	35.6	44.9
Composite[1]	82	89	86	92	349	14.3	38.4	42.2
Design Values**	–	–	–	–	–	16.4	51.0	89

*All concentrations are in µg/m^3; includes Philadelphia County.

** The calculation of design values is described in Section 2.3 of this report.

1. The number of days at the composite monitor is the number of days on which at least one of the monitors reported.

Exhibit A.5. Number of Days on which PM$_{2.5}$ Concentration Data are Available, by Monitor and by Quarter, and PM$_{2.5}$ Concentrations. Phoenix, 2001*

Monitor	Q1	Q2	Q3	Q4	Year Total	Annual Avg.	98th Percentile	99th Percentile
AQS 040130019881011	50	85	91	86	312	10.9	30.4	36.5
AQS 040139990881011	27	31	28	30	116	9.4	22.7	25
AQS 040139992881011	77	87	85	87	336	10.9	35.3	40.5
AQS 040139997881011	75	75	91	73	314	9.2	25.0	28.2
Composite[1]	88	90	92	92	362	10.4	28.9	36.4
Design Values**	–	–	–	–	–	11.5	35.0	41

*All concentrations are in µg/m^3; includes Maricopa County.

** The calculation of design values is described in Section 2.3 of this report.

1. The number of days at the composite monitor is the number of days on which at least one of the monitors reported.

Exhibit A.6. Number of Days on which PM$_{2.5}$ Concentration Data are Available, by Monitor and by Quarter, and PM$_{2.5}$ Concentrations. Pittsburgh, 2003*

Monitor	Q1	Q2	Q3	Q4	Year Total	Annual Avg.	98th Percentile	99th Percentile
AQS 420030008881011	84	90	88	90	352	15.2	35.9	39.5
AQS 420030021881011	23	29	26	30	108	14.6	30.7	40.0
AQS 420030064881011	86	91	90	92	359	20.2	66.6	76.1
AQS 420030067881011	26	28	19	26	99	13.2	42.1	52.0
AQS 420030095881011	12	12	15	14	53	15.7	38.6	53.7
AQS 420030116881011	26	27	28	27	108	15.3	42.9	45.9
AQS 420031008881011	25	27	29	30	111	15.5	41.9	44.5
AQS 420031301881011	20	28	30	26	104	16.8	38.3	50.4
AQS 420033007881011	15	14	16	15	60	12.0	58.8	59.3
AQS 420039002881011	13	13	16	15	57	16.0	33.4	58.6
Composite[1]	89	91	91	92	363	16.9	43.9	55.1
Design Values**	–	–	–	–	–	21.2	63.0	70

*All concentrations are in µg/m^3; includes Allegheny County.

** The calculation of design values is described in Section 2.3 of this report.

1. The number of days at the composite monitor is the number of days on which at least one of the monitors reported.

Exhibit A.7. Number of Days on which PM$_{2.5}$ Concentration Data are Available, by Monitor and by Quarter, and PM$_{2.5}$ Concentrations. San Jose, 2003*

Monitor	Q1	Q2	Q3	Q4	Year Total	Annual Avg.	98th Percentile	99th Percentile
AQS 60850005881011	87	14	17	87	205	11.7	40.1	45.5
AQS 60852003881011	85	19	18	79	201	10.1	36.9	37.5
Composite[1]	89	19	19	91	218	11.1	37.6	41
Design Values**	–	–	–	–	–	14.6	47.0	53

*All concentrations are in µg/m^3; includes Santa Clara County.

** The calculation of design values is described in Section 2.3 of this report.

1. The number of days at the composite monitor is the number of days on which at least one of the monitors reported.

Exhibit A.8. Number of Days on which PM$_{2.5}$ Concentration Data are Available, by Monitor and by Quarter, and PM$_{2.5}$ Concentrations. Seattle, 2003*

Monitor	Q1	Q2	Q3	Q4	Year Total	Annual Avg.	98th Percentile	99th Percentile
AQS 530330017881011	18	15	16	14	63	10.3	10.9	12.6
AQS 530330024881011	30	28	30	29	117	10.8	28.2	31.7
AQS 530330037881011	17	12	14	15	58	7.8	17.6	30.7
AQS 530330057881011	34	30	31	28	123	8.3	28.4	28.6
AQS 530330080881011	88	85	92	92	357	8.6	20.5	22.9
AQS 530332004881011	29	30	29	28	116	10.3	28.4	30.2
Composite[1]	89	87	92	92	360	8.3	21.7	23.8
Design Values**	–	–	–	–	–	11.1	41.0	48

*All concentrations are in µg/m^3; includes King County.

** The calculation of design values is described in Section 2.3 of this report.

1. The number of days at the composite monitor is the number of days on which at least one of the monitors reported.

Exhibit A.9. Number of Days on which PM$_{2.5}$ Concentration Data are Available, by Monitor and by Quarter, and PM$_{2.5}$ Concentrations. St. Louis, 2003*

Monitor	Q1	Q2	Q3	Q4	Year Total	Annual Avg.	98th Percentile	99th Percentile
AQS 171191007881011	29	30	26	28	113	17.5	40.8	41.7
AQS 171192009881011	29	29	30	29	117	14.0	31.5	36.1
AQS 171193007881011	29	29	30	29	117	14.0	31.6	32.7
AQS 171630010881011	26	28	31	25	110	14.8	32.6	32.9
AQS 171634001881011	29	22	31	30	112	14.3	34.2	36.2
AQS 290990012881011	85	87	88	88	348	13.9	34.2	36.3
AQS 291831002881011	30	29	31	30	120	14.0	35.5	37.9
AQS 291890004881011	29	28	30	29	116	13.0	30.5	36.2
AQS 291892003881011	88	89	82	89	348	13.6	31.5	32.4
AQS 295100007881011	88	87	86	90	351	14.4	33.2	34.8
AQS 295100085881011	90	91	89	92	362	14.1	32.0	33.5
AQS 295100086881011	90	91	88	86	355	13.5	31.5	33.8
AQS 295100087881011	82	91	90	90	353	14.7	33.2	34.5
Composite[1]	90	91	92	92	365	14.0	30.6	33.7
Design Values**	–	–	–	–	–	17.5	42	46

*All concentrations are in µg/m^3; includes St. Louis (MO), Franklin (MO), Jefferson (MO), St. Charles (MO), Clinton (IL), Madison (IL), Monroe (IL), and St. Clair (IL) Counties and St. Louis City (MO).

** The calculation of design values is described in Section 2.3 of this report.

1. The number of days at the composite monitor is the number of days on which at least one of the monitors reported.

A.2.   The PM$_{10-2.5}$ data

PM$_{10-2.5}$ data for each of the urban areas identified in Section 3 for the PM$_{10-2.5}$ risk assessment (Detroit, Seattle, and St. Louis) were calculated based on data obtained from EPA's Air Quality System (AQS) for 1999-2003. PM$_{10}$ and PM$_{2.5}$ monitoring data collected on the same day at the same site were used to calculate PM$_{10-2.5}$ levels. Year 2003 data were used for all three locations because not only is this the most recent year for which we have data, but data in 2003 were more complete for each location than in any of the other years.

In the AQS database, PM$_{2.5}$ data is collected and reported at local temperature and pressure. In order to calculate PM$_{10-2.5}$ levels using comparable data, PM$_{10}$ local condition data were obtained, when available, and PM$_{10}$ standard condition data were converted to PM$_{10}$ local condition data using site-specific algorithms.

The numbers of days of observations by monitor and at the composite monitor, by quarter and for the year, along with annual averages and maximum concentrations, are given in Exhibits A.10 through A.12 for each of the urban locations in the $PM_{10-2.5}$ risk assessment. Since $PM_{10-2.5}$ data are based on co-located monitors at a single site, the data are presented by site, rather than by monitor. As with the $PM_{2.5}$ data, the annual average at each site, and at the composite site, is the average of the four quarterly averages at the site.

Exhibit A.10. Number of Days on which $PM_{10-2.5}$ Concentration Data are Available, by Monitor and by Quarter, and $PM_{10-2.5}$ Concentrations. Detroit, 2003*

Monitor	Q1	Q2	Q3	Q4	Year Total	Annual Avg.	98th Percentile	99th Percentile
AQS 261630015	13	12	16	12	53	12.3	40.2	48.7
AQS 261630033	29	27	27	28	111	25.0	105.9	122.4
Composite[1]	30	27	29	29	115	21.7	105.9	122.4
Design Values**	–	–	–	–	–	–	70.0	77.0

*All concentrations are in $\mu g/m^3$; includes Wayne County.

**The calculation of design values is described in Section 2.3 of this report.

1. The number of days at the composite monitor is the number of days on which at least one of the monitors reported.

Exhibit A.11. Number of Days on which $PM_{10-2.5}$ Concentration Data are Available, by Monitor and by Quarter, and $PM_{10-2.5}$ Concentrations. Seattle, 2003*

Monitor	Q1	Q2	Q3	Q4	Year Total	Annual Avg.	98th Percentile	99th Percentile
AQS 530330057	15	14	16	13	58	12.6	30.3	45.0
AQS 530332004	14	15	14	13	56	10.0	25.4	30.1
Composite[1]	15	16	16	14	61	11.4	26.2	30.3
Design Values**	–	–	–	–	–	–	31.0	39.0

*All concentrations are in $\mu g/m^3$; includes King County.

**The calculation of design values is described in Section 2.3 of this report.

1. The number of days at the composite monitor is the number of days on which at least one of the monitors reported.

Exhibit A.12. Number of Days on which PM$_{10\text{-}2.5}$ Concentration Data are Available, by Monitor and by Quarter, and PM$_{10\text{-}2.5}$ Concentrations. St. Louis, 2003*

Monitor	Q1	Q2	Q3	Q4	Year Total	Annual Avg.	98th Percentile	99th Percentile
AQS 171193007	13	15	15	15	58	10.6	24.2	42.8
AQS 295100086	15	15	16	14	60	10.1	24.7	34.9
AQS 295100087	15	15	15	15	60	14.9	33.3	47.0
Composite[1]	15	15	16	15	61	12.0	24.1	41.6
Design Values**	–	–	–	–	–	–	33.0	47.0

*All concentrations are in µg/m³; includes St. Louis (MO), Franklin (MO), Jefferson (MO), St. Charles (MO), Clinton (IL), Madison (IL), Monroe (IL), and St. Clair (IL) Counties and St. Louis City (MO).

**The calculation of design values is described in Section 2.3 of this report.

1. The number of days at the composite monitor is the number of days on which at least one of the monitors reported.

Appendix B. Linear Trends in Historical PM$_{2.5}$ Data in Philadelphia and Los Angeles

memorandum
Environmental Research Area

4800 Montgomery Lane, Suite 600 ■ Bethesda, MD 20814-5341 ■ (301) 913-0500

Abt Associates Inc.

Date   May 8, 2002

To   Harvey Richmond, U.S. EPA/OAQPS

From   Ellen Post, Abt Associates Inc.

Subject   **Linear Trends in Historical PM$_{2.5}$ Data in Philadelphia and Los Angeles: Revision of November 26, 2001 Memo**

The method used to simulate just meeting a standard in the 1995/96 PM risk analysis and proposed for the current risk analysisis to "roll back" the anthropogenic portion of PM levels (i.e., the portion above background level) by the same percentage on each day. This method assumes that, all else held constant:

$$(y_i - B) = \beta * (x_i - B)$$

,

where[1]

• x_i is the ith PM$_{2.5}$ concentration in a location before the standard is met,
• y_i is the ith PM$_{2.5}$ concentration in that location when the standard is just met,
•   B is the background concentration in that location, and
• $\beta < 1$.

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[1] We first examined the plausibility of this assumption in preparation for the PM risk analysis carried out in 1995/1996. At that time, we examined pairs of years of PM$_{2.5}$ data in several locations, but none of the data reflected efforts to meet PM$_{2.5}$ standards, because this exercise (and the data it used) preceded the setting of PM$_{2.5}$ standards. That investigation, however, found that the change in the distribution of PM$_{2.5}$ concentrations from one year to another year in the same location tended to be linear. This is described in Section 8.2 of Abt Associates Inc., 1996. "A Particulate Matter Risk Assessment for Philadelphia and Los Angeles."

We don't have data on $PM_{2.5}$ concentrations in any location before and after the $PM_{2.5}$ standards have just been met, so we cannot directly test whether this "rollback" assumption accurately models how $PM_{2.5}$ concentrations would change if a standard were just met. We can, however, examine historical changes in $PM_{2.5}$ concentrations for any location for which we have sufficient data to determine if the proportional rollback model is consistent with these historical changes. We currently have sufficient data in each of two locations, Philadelphia and Los Angeles, to compare the distribution of daily $PM_{2.5}$ concentrations in the year 2000 with the distribution in an earlier year. In each location, we compared the two distributions to see if the change was well described as proportional. The method and results are described below.

In Philadelphia we have 353 days of observations in a year which crosses calendar years 1992 and 1993, and 296 days of observations in the year 2000. In Los Angeles we have 214 days of observations in 1995 and 357 days of observations in 2000. We first grouped the $PM_{2.5}$ concentrations in each distribution into deciles and averaged the concentrations within each decile.[2] These average concentrations within deciles are shown in Exhibit B.1 and in graph form in Exhibits B.2 and B.3, for Philadelphia and Los Angeles, respectively.

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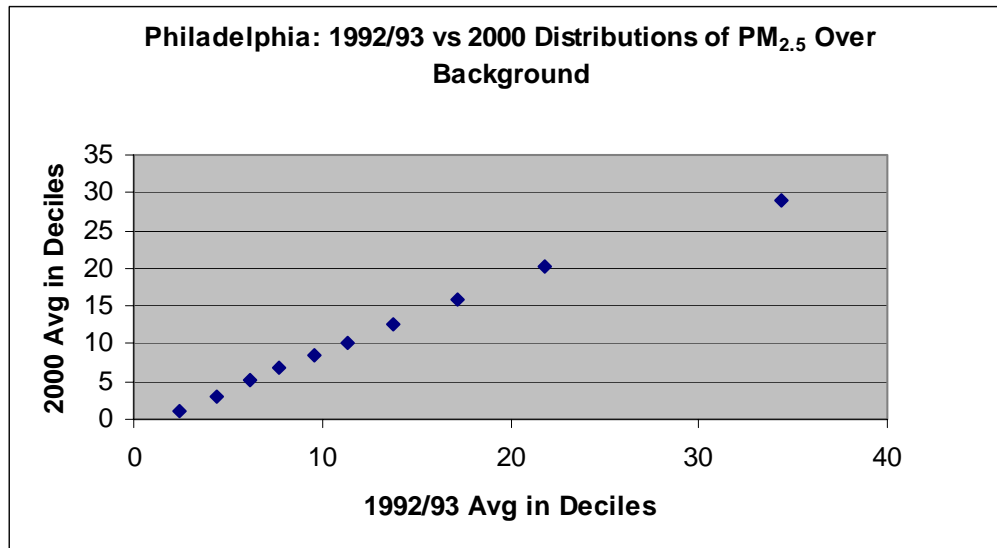
[2] We considered using the decile points themselves rather than the averages within deciles. However, the decile points would be expected to be less stable from one year to another than the averages of the concentrations within deciles. A comparison of the averages within deciles from one year to another is therefore likely to give a more accurate picture of how the distribution has changed from one year to another. This is the method that was used in the earlier comparison for the 1995/96 PM risk assessment.

Exhibit B.1. Average PM$_{2.5}$ Concentrations (µg/m^3) in Each Decile of Earlier Year and Year 2000 Distributions at Composite Monitors in Philadelphia and Los Angeles*
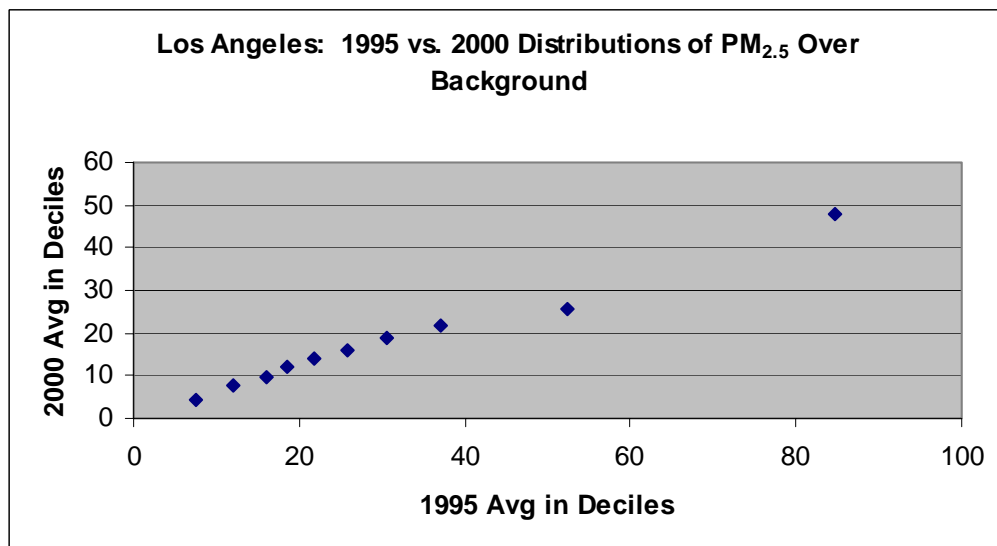
Decile*	Philadelphia		Los Angeles	
	1992/93	2000	1995	2000
1	5.91	4.62	10.02	6.67
2	7.94	6.58	14.62	10.19
3	9.71	8.82	18.50	12.39
4	11.19	10.25	21.06	14.59
5	13.07	12.07	24.19	16.59
6	14.87	13.72	28.40	18.55
7	17.23	16.01	32.96	21.27
8	20.67	19.4	39.72	24.22
9	25.34	23.77	54.77	28.27
10	37.90	32.58	87.12	50.50

*The first decile is the tenth percentile, the second decile is the twentieth percentile, and so on. The average concentration in the nth decile is the average of those values that are greater than the (n-1)st decile point and less than or equal to the nth decile point.

Exhibit B.2

Philadelphia: 1992/93 vs 2000 Distributions of $PM_{2.5}$ Over Background

Exhibit B.3

Los Angeles: 1995 vs. 2000 Distributions of $PM_{2.5}$ Over Background

To examine how reasonable the proportional rollback hypothesis is we estimated the following regression equation separately for Philadelphia and for Los Angeles:

$$(y_i - B) = \alpha + \beta * (x_i - B) + \varepsilon_i$$

where now,

- y_i is the average $PM_{2.5}$ concentration in the ith decile of the distribution of $PM_{2.5}$ concentrations in the location in the year 2000,
- x_i is the average $PM_{2.5}$ concentration in the ith decile of the distribution of $PM_{2.5}$ concentrations in that location in an earlier year (1995 for Los Angeles and 1992/93 for Philadelphia),
- B is the background concentration in that location (2.5 $\mu g/m^3$ in Los Angeles and 3.5 $\mu g/m^3$ in Philadelphia), and
- ε_i is an error term.

If the change in $PM_{2.5}$ concentrations from the earlier year to the year 2000 is consistent with a proportional rollback model, we would expect

- the linear fit to be good,
- the slope (β) to be less than one, and
- the intercept (α) to be close to zero

The results of the regressions in Philadelphia and Los Angeles do support the hypothesis underlying the proportional rollback method, as shown in Exhibit B.4. In both cases, the linear fit is very good (R^2 = 0.992 in Philadelphia and 0.986 in Los Angeles), the slopes are less than 1.0, and the intercepts are close to zero.[3] This supports the hypothesis that, at least in these two locations, the change in daily $PM_{2.5}$ concentrations that would result if a $PM_{2.5}$ standard were just met is reasonably modeled as a proportional rollback.

---

[3] Because decile points are not independent observations, the usual test of statistical significance are not valid. What is most important, however, is that the linear relationship is very good and the intercept is near zero.

Exhibit B.4. Results of Regressions of Year 2000 Average PM$_{2.5}$ Concentrations over Background on Earlier Year Average PM$_{2.5}$ Concentrations over Background.

	Philadelphia	Los Angeles
Intercept	-0.136	1.387
Slope	0.886	0.537
R^2	0.992	0.986

Appendix C. Study-Specific Information for the PM$_{2.5}$ and PM$_{10\text{-}2.5}$ Risk Assessments

C.1. The PM$_{2.5}$ data

Exhibit C.1. Study-Specific Information for PM$_{2.5}$ Studies in Boston, MA

Study	Health Effect	ICD-9 Codes	Ages	Model	Other Pollutants in Model	Observed Concentrations min.	max.	Lag	Exposure Metric	PM2.5 Coeff.	Lower Bound	Upper Bound
					Short-Term Exposure Total Mortality -- Single Pollutant Models							
Schwartz (2003b) [reanalysis of Schwartz et al. (1996)]	Non-accidental	< 800	all	log-linear, GAM (stringent)	none	0	70.8	mean of lag 0 & 1	2-day avg	0.00206	0.00139	0.00273
Schwartz (2003b) [reanalysis of Schwartz et al. (1996)] -- 6 cities	Non-accidental	< 800	all	log-linear, GAM (stringent)	none	0	174	mean of lag 0 & 1	2-day avg	0.00137	0.00098	0.00176
					Short-Term Exposure Cause-Specific Mortality -- Single Pollutant Models							
Klemm and Mason (2003) [reanalysis of Klemm et al. (2000)]	COPD	490-492, 494-496	all	log-linear, GAM (stringent)	none	0	70.8	0 day	2-day avg	0.00276	-0.00131	0.00658
Klemm and Mason (2003) [reanalysis of Klemm et al. (2000)]	Ischemic heart disease	410-414	all	log-linear, GAM (stringent)	none	0	70.8	0 day	2-day avg	0.00266	0.00149	0.00383
Klemm and Mason (2003) [reanalysis of Klemm et al. (2000)]	Pneumonia	480-487	all	log-linear, GAM (stringent)	none	0	70.8	0 day	2-day avg	0.00573	0.00257	0.00871
Klemm and Mason (2003) [reanalysis of Klemm et al. (2000)] -- 6 cities	COPD	490-492, 494-496	all	log-linear, GAM (stringent)	none	0	174	0 day	2-day avg	0.00227	0.00010	0.00440
Klemm and Mason (2003) [reanalysis of Klemm et al. (2000)] -- 6 cities	Ischemic heart disease	410-414	all	log-linear, GAM (stringent)	none	0	174	0 day	2-day avg	0.00178	0.00109	0.00247
Klemm and Mason (2003) [reanalysis of Klemm et al. (2000)] -- 6 cities	Pneumonia	480-487	all	log-linear, GAM (stringent)	none	0	174	0 day	2-day avg	0.00402	0.00188	0.00602

Study	Health Effect	ICD-9 Codes	Ages	Model	Other Pollutants in Model	Observed Concentrations min.	Observed Concentrations max.	Lag	Exposure Metric	PM2.5 Coeff.	Lower Bound	Upper Bound
Respiratory Symptoms and Illnesses* -- Single Pollutant Models												
Schwartz and Neas (2000) -- 6 cities	Lower respiratory symptoms	n/a	7-14	logistic	none	N/A	N/A	1 day	1-day avg	0.01901	0.00696	0.03049
Schwartz and Neas (2000) -- 6 cities	Cough	n/a	7-14	logistic	none	N/A	N/A	0 day	3-day avg	0.00989	-0.00067	0.02050
Respiratory Symptoms and Illnesses* -- Multi-Pollutant Models												
Schwartz and Neas (2000) -- 6 cities	Lower respiratory symptoms	n/a	7-14	logistic	PM10-2.5	N/A	N/A	1 day	1-day avg	0.01698	0.00388	0.03007
Schwartz and Neas (2000) -- 6 cities	Cough	n/a	7-14	logistic	PM10-2.5	N/A	N/A	0 day	3-day avg	0.00451	-0.00702	0.01541
Long-Term Exposure Mortality -- Single Pollutant Models												
Krewski et al. (2000) - Six Cities	All cause	all	25+	log-linear	none	11	29.6	n/a	annual mean	0.01243	0.00414	0.02071
Krewski et al. (2000) - ACS	All cause	all	30+	log-linear	none	10	38	n/a	annual mean	0.00463	0.00238	0.00710
Pope et al. (2002) - ACS extended	All cause	all	30+	log-linear	none	7.5	30	n/a	annual mean	0.00583	0.00198	0.01044
Krewski et al. (2000) - Six Cities	Cardiopulmonary	400-440, 485-495	25+	log-linear	none	11	29.6	n/a	annual mean	0.01693	0.00561	0.02789
Krewski et al. (2000) - ACS	Cardiopulmonary	401-440, 460-519	30+	log-linear	none	10	38	n/a	annual mean	0.00943	0.00606	0.01315
Pope et al. (2002) - ACS extended	Cardiopulmonary	401-440, 460-519	30+	log-linear	none	7.5	30	n/a	annual mean	0.00862	0.00296	0.01484
Pope et al. (2002) - ACS extended	Lung cancer	162	30+	log-linear	none	7.5	30	n/a	annual mean	0.01310	0.00392	0.02070
Long-Term Exposure Mortality -- Multi-Pollutant Models												
Krewski et al. (2000) - ACS	All cause	all	30+	log-linear	CO	10	38	n/a	annual mean	0.00676	0.00389	0.00976
Krewski et al. (2000) - ACS	All cause	all	30+	log-linear	NO2	10	38	n/a	annual mean	0.00812	0.00426	0.01164
Krewski et al. (2000) - ACS	All cause	all	30+	log-linear	O3	10	38	n/a	annual mean	0.00676	0.00389	0.00976
Krewski et al. (2000) - ACS	All cause	all	30+	log-linear	SO2	10	38	n/a	annual mean	0.00121	-0.00209	0.00499

*The C-R functions for lower respiratory symptoms and cough were calculated for the summer period April 1 through August 31.

Exhibit C.2. Study-Specific Information for PM$_{2.5}$ Studies in Detroit, MI

Study	Health Effect	ICD-9 Codes	Ages	Model	Other Pollutants in Model	Observed Concentrations min.	Observed Concentrations max.	Lag	Exposure Metric	PM2.5 Coeff.	Lower Bound	Upper Bound
Short-Term Exposure Total Mortality -- Single Pollutant Models												
Ito (2003) [reanalysis of Lippmann et al. (2000)]	Non-accidental	<800	all	log-linear, GAM (stringent)	none	4	86	3 day	1-day avg	0.00074	-0.00073	0.00221
Short-Term Exposure Cause-Specific Mortality -- Single Pollutant Models												
Ito (2003) [reanalysis of Lippmann et al. (2000)]	Circulatory	390-459	all	log-linear, GAM (stringent)	none	4	86	1 day	1-day avg	0.00087	-0.00131	0.00305
Ito (2003) [reanalysis of Lippmann et al. (2000)]	Respiratory	460-519	all	log-linear, GAM (stringent)	none	4	86	0 day	1-day avg	0.00090	-0.00438	0.00618
Hospital Admissions -- Single Pollutant Models												
Ito (2003) [reanalysis of Lippmann et al. (2000)]	Pneumonia	480-486	65+	log-linear, GAM (stringent)	none	4	86	1 day	1-day avg	0.00398	0.00074	0.00725
Ito (2003) [reanalysis of Lippmann et al. (2000)]	COPD	490-496	65+	log-linear, GAM (stringent)	none	4	86	3 day	1-day avg	0.00117	-0.00287	0.00523
Ito (2003) [reanalysis of Lippmann et al. (2000)]	Ischemic heart disease	410-414	65+	log-linear, GAM (stringent)	none	4	86	2 day	1-day avg	0.00143	-0.00082	0.00371
Ito (2003) [reanalysis of Lippmann et al. (2000)]	Congestive heart failure	428	65+	log-linear, GAM (stringent)	none	4	86	1 day	1-day avg	0.00307	0.00055	0.00561
Ito (2003) [reanalysis of Lippmann et al. (2000)]	Dysrhythmias	427	65+	log-linear, GAM (stringent)	none	4	86	1 day	1-day avg	0.00125	-0.00274	0.00523

Study	Health Effect	ICD-9 Codes	Ages	Model	Other Pollutants in Model	Observed Concentrations min.	Observed Concentrations max.	Lag	Exposure Metric	PM2.5 Coeff.	Lower Bound	Upper Bound
Long-Term Exposure Mortality -- Single Pollutant Models												
Krewski et al. (2000) - ACS	All cause	all	30+	log-linear	none	10	38	n/a	annual mean	0.00463	0.00238	0.00710
Pope et al. (2002) - ACS extended	All cause	all	30+	log-linear	none	7.5	30	n/a	annual mean	0.00583	0.00198	0.01044
Krewski et al. (2000) - ACS	Cardiopulmonary	401-440, 460-519	30+	log-linear	none	10	38	n/a	annual mean	0.00943	0.00606	0.01315
Pope et al. (2002) - ACS extended	Cardiopulmonary	401-440, 460-519	30+	log-linear	none	7.5	30	n/a	annual mean	0.00862	0.00296	0.01484
Pope et al. (2002) - ACS extended	Lung cancer	162	30+	log-linear	none	7.5	30	n/a	annual mean	0.01310	0.00392	0.02070
Long-Term Exposure Mortality -- Multi-Pollutant Models												
Krewski et al. (2000) - ACS	All cause	all	30+	log-linear	CO	10	38	n/a	annual mean	0.00676	0.00389	0.00976
Krewski et al. (2000) - ACS	All cause	all	30+	log-linear	NO2	10	38	n/a	annual mean	0.00812	0.00426	0.01164
Krewski et al. (2000) - ACS	All cause	all	30+	log-linear	O3	10	38	n/a	annual mean	0.00676	0.00389	0.00976
Krewski et al. (2000) - ACS	All cause	all	30+	log-linear	SO2	10	38	n/a	annual mean	0.00121	-0.00209	0.00499

Exhibit C.3. Study-Specific Information for PM$_{2.5}$ Studies in Los Angeles, CA

Study	Health Effect	ICD-9 Codes	Ages	Model	Other Pollutants in Model	Observed Concentrations min.	max.	Lag	Exposure Metric	PM2.5 Coeff.	Lower Bound	Upper Bound
Short-Term Exposure Total Mortality -- Single Pollutant Models												
Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Non-accidental	<800	all	log-linear, GAM (stringent), 100 df	none	4	86	0 day	1-day avg	0.00032	-0.00023	0.00086
Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Non-accidental	<800	all	log-linear, GAM (stringent), 100 df	none	4	86	1 day	1-day avg	0.00010	-0.00046	0.00066
Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Non-accidental	<800	all	log-linear, GAM (stringent), 30 df	none	4	86	0 day	1-day avg	0.00054	-0.00007	0.00114
Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Non-accidental	<800	all	log-linear, GLM, 30 df	none	4	86	0 day	1-day avg	0.00040	-0.00034	0.00113
Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Non-accidental	<800	all	log-linear, GAM (stringent), 100 df	none	4	86	0 day	1-day avg	0.00032	-0.00023	0.00086
Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Non-accidental	<800	all	log-linear, GLM, 100 df	none	4	86	0 day	1-day avg	0.00030	-0.00043	0.00102
Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Non-accidental	<800	all	log-linear, GAM (stringent), 30 df	none	4	86	1 day	1-day avg	0.00059	0.00000	0.00117
Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Non-accidental	<800	all	log-linear, GLM, 30 df	none	4	86	1 day	1-day avg	0.00055	-0.00017	0.00126
Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Non-accidental	<800	all	log-linear, GAM (stringent), 100 df	none	4	86	1 day	1-day avg	0.00010	-0.00046	0.00066
Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Non-accidental	<800	all	log-linear, GLM, 100 df	none	4	86	1 day	1-day avg	-0.00001	-0.00099	0.00097

Study	Health Effect	ICD-9 Codes	Ages	Model	Other Pollutants in Model	Observed Concentrations min.	max.	Lag	Exposure Metric	PM2.5 Coeff.	Lower Bound	Upper Bound
Short-Term Exposure Cause-Specific Mortality -- Single Pollutant Models												
Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Cardiovascular	390-429	all	log-linear, GAM (stringent), 30 df	none	4	86	0 day	1-day avg	0.00099	0.00010	0.00187
Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Cardiovascular	390-429	all	log-linear, GAM (stringent), 100 df	none	4	86	0 day	1-day avg	0.00097	0.00014	0.00179
Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Cardiovascular	390-429	all	log-linear, GLM, 100 df	none	4	86	0 day	1-day avg	0.00097	-0.00002	0.00195
Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Cardiovascular	390-429	all	log-linear, GAM (stringent), 30 df	none	4	86	1 day	1-day avg	0.00103	0.00016	0.00189
Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Cardiovascular	390-429	all	log-linear, GAM (stringent), 100 df	none	4	86	1 day	1-day avg	0.00080	-0.00003	0.00162
Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Cardiovascular	390-429	all	log-linear, GLM, 100 df	none	4	86	1 day	1-day avg	0.00069	-0.00032	0.00169
Short-Term Exposure Total Mortality -- Multi-Pollutant Models												
Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Non-accidental	<800	all	log-linear, GAM (stringent), 30 df	CO	4	86	1 day	1-day avg	-0.00053	-0.00132	0.00025
Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Non-accidental	<800	all	log-linear, GAM (stringent), 100 df	CO	4	86	1 day	1-day avg	-0.00033	-0.00105	0.00039
Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Non-accidental	<800	all	log-linear, GLM, 100 df	CO	4	86	1 day	1-day avg	-0.00033	-0.00118	0.00051

Study	Health Effect	ICD-9 Codes	Ages	Model	Other Pollutants in Model	Observed Concentrations min.	max.	Lag	Exposure Metric	PM2.5 Coeff.	Lower Bound	Upper Bound
Short-Term Exposure Cause-Specific Mortality -- Multi-Pollutant Models												
Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Cardiovascular	390-429	all	log-linear, GAM (stringent), 100 df	CO	4	86	0 day	1-day avg	0.00178	0.00076	0.00279
Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Cardiovascular	390-429	all	log-linear, GLM, 100 df	CO	4	86	0 day	1-day avg	0.00188	0.00068	0.00306
Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Cardiovascular	390-429	all	log-linear, GAM (stringent), 100 df	CO	4	86	1 day	1-day avg	0.00091	-0.00012	0.00193
Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Cardiovascular	390-429	all	log-linear, GLM, 100 df	CO	4	86	1 day	1-day avg	0.00091	-0.00034	0.00215
Hospital Admissions -- Single Pollutant Models												
Moolgavkar (2003) [reanalysis of Moolgavkar (2000b)]	Cardiovascular	390-429	65+	log-linear, GAM (stringent), 30 df	none	4	86	0 day	1-day avg	0.00158	0.00091	0.00224
Moolgavkar (2003) [reanalysis of Moolgavkar (2000b)]	Cardiovascular	390-429	65+	log-linear, GAM (stringent), 100 df	none	4	86	0 day	1-day avg	0.00116	0.00051	0.00181
Moolgavkar (2003) [reanalysis of Moolgavkar (2000b)]	Cardiovascular	390-429	65+	log-linear, GLM, 100 df	none	4	86	0 day	1-day avg	0.00126	0.00045	0.00206
Moolgavkar (2003) [reanalysis of Moolgavkar (2000b)]	Cardiovascular	390-429	65+	log-linear, GAM (stringent), 30 df	none	4	86	1 day	1-day avg	0.00139	0.00070	0.00208
Moolgavkar (2003) [reanalysis of Moolgavkar (2000b)]	Cardiovascular	390-429	65+	log-linear, GAM (stringent), 100 df	none	4	86	1 day	1-day avg	0.00113	0.00047	0.00179
Moolgavkar (2003) [reanalysis of Moolgavkar (2000b)]	Cardiovascular	390-429	65+	log-linear, GLM, 100 df	none	4	86	1 day	1-day avg	0.00120	0.00039	0.00200
Moolgavkar (2003) [reanalysis of Moolgavkar (2000c)]	COPD+	490-496	all	log-linear, GAM (stringent), 30 df	none	4	86	0 day	1-day avg	0.00167	0.00069	0.00264

Study	Health Effect	ICD-9 Codes	Ages	Model	Other Pollutants in Model	Observed Concentrations min.	Observed Concentrations max.	Lag	Exposure Metric	PM2.5 Coeff.	Lower Bound	Upper Bound
Moolgavkar (2003) [reanalysis of Moolgavkar (2000c)]	COPD+	490-496	all	log-linear, GAM (stringent), 100 df	none	4	86	0 day	1-day avg	0.00138	0.00052	0.00223
Moolgavkar (2003) [reanalysis of Moolgavkar (2000c)]	COPD+	490-496	all	log-linear, GLM, 100 df	none	4	86	0 day	1-day avg	0.00149	0.00042	0.00255
Moolgavkar (2003) [reanalysis of Moolgavkar (2000c)]	COPD+	490-496	all	log-linear, GAM (stringent), 30 df	none	4	86	1 day	1-day avg	0.00119	0.00023	0.00214
Moolgavkar (2003) [reanalysis of Moolgavkar (2000c)]	COPD+	490-496	all	log-linear, GAM (stringent), 100 df	none	4	86	1 day	1-day avg	0.00075	-0.00011	0.00160
Moolgavkar (2003) [reanalysis of Moolgavkar (2000c)]	COPD+	490-496	all	log-linear, GLM, 100 df	none	4	86	1 day	1-day avg	0.00077	-0.00027	0.00180
Moolgavkar (2003) [reanalysis of Moolgavkar (2000c)]	COPD+	490-496	all	log-linear, GAM (stringent), 30 df	none	4	86	2 day	1-day avg	0.00185	0.00084	0.00285
Moolgavkar (2003) [reanalysis of Moolgavkar (2000c)]	COPD+	490-496	all	log-linear, GAM (stringent), 100 df	none	4	86	2 day	1-day avg	0.00114	0.00022	0.00205
Moolgavkar (2003) [reanalysis of Moolgavkar (2000c)]	COPD+	490-496	all	log-linear, GLM, 100 df	none	4	86	2 day	1-day avg	0.00103	-0.00011	0.00216
Hospital Admissions -- Single City, Multi-Pollutant Models												
Moolgavkar (2003) [reanalysis of Moolgavkar (2000b)]	Cardiovascular	390-429	65+	log-linear, GAM (stringent), 100 df	CO	4	86	0 day	1-day avg	0.00039	-0.00044	0.00121
Moolgavkar (2003) [reanalysis of Moolgavkar (2000b)]	Cardiovascular	390-429	65+	log-linear, GLM, 100 df	CO	4	86	0 day	1-day avg	0.00058	-0.00041	0.00156
Moolgavkar (2003) [reanalysis of Moolgavkar (2000b)]	Cardiovascular	390-429	65+	log-linear, GAM (stringent), 100 df	CO	4	86	1 day	1-day avg	0.00024	-0.00065	0.00112
Moolgavkar (2003) [reanalysis of Moolgavkar (2000b)]	Cardiovascular	390-429	65+	log-linear, GLM, 100 df	CO	4	86	1 day	1-day avg	0.00027	-0.00075	0.00128

Study	Health Effect	ICD-9 Codes	Ages	Model	Other Pollutants in Model	Observed Concentrations min.	Observed Concentrations max.	Lag	Exposure Metric	PM2.5 Coeff.	Lower Bound	Upper Bound
Moolgavkar (2003) [reanalysis of Moolgavkar (2000c)]	COPD+	490-496	all	log-linear, GAM (stringent), 100 df	NO2	4	86	0 day	1-day avg	0.00042	-0.00091	0.00173
Moolgavkar (2003) [reanalysis of Moolgavkar (2000c)]	COPD+	490-496	all	log-linear, GAM (stringent), 100 df	NO2	4	86	1 day	1-day avg	-0.00004	-0.00162	0.00152
Moolgavkar (2003) [reanalysis of Moolgavkar (2000c)]	COPD+	490-496	all	log-linear, GAM (stringent), 100 df	NO2	4	86	2 day	1-day avg	0.00035	-0.00103	0.00171
Long-Term Exposure Mortality -- Single Pollutant Models												
Krewski et al. (2000) - ACS	All cause	all	30+	log-linear	none	10	38	n/a	annual mean	0.00463	0.00238	0.00710
Pope et al. (2002) - ACS extended	All cause	all	30+	log-linear	none	7.5	30	n/a	annual mean	0.00583	0.00198	0.01044
Krewski et al. (2000) - ACS	Cardiopulmonary	401-440, 460-519	30+	log-linear	none	10	38	n/a	annual mean	0.00943	0.00606	0.01315
Pope et al. (2002) - ACS extended	Cardiopulmonary	401-440, 460-519	30+	log-linear	none	7.5	30	n/a	annual mean	0.00862	0.00296	0.01484
Pope et al. (2002) - ACS extended	Lung cancer	162	30+	log-linear	none	7.5	30	n/a	annual mean	0.01310	0.00392	0.02070
Long-Term Exposure Mortality -- Multi-Pollutant Models												
Krewski et al. (2000) - ACS	All cause	all	30+	log-linear	CO	10	38	n/a	annual mean	0.00676	0.00389	0.00976
Krewski et al. (2000) - ACS	All cause	all	30+	log-linear	NO2	10	38	n/a	annual mean	0.00812	0.00426	0.01164
Krewski et al. (2000) - ACS	All cause	all	30+	log-linear	O3	10	38	n/a	annual mean	0.00676	0.00389	0.00976
Krewski et al. (2000) - ACS	All cause	all	30+	log-linear	SO2	10	38	n/a	annual mean	0.00121	-0.00209	0.00499

Exhibit C.4. Study-Specific Information for Studies PM$_{2.5}$ in Philadelphia, PA

Study*	Health Effect	ICD-9 Codes	Ages	Model	Other Pollutants in Model	Observed Concentrations min.	Observed Concentrations max.	Lag	Exposure Metric	PM2.5 Coeff.	Lower Bound	Upper Bound
Short-Term Exposure Cause-Specific Mortality -- Single Pollutant Models												
Lipfert et al. (2000) -- 7 counties	Cardiovascular	390-448	all	linear	none	-0.6	72.6	1 day	1-day avg	0.10440	0.04983	0.15897
Long-Term Exposure Mortality -- Single Pollutant Models												
Krewski et al. (2000) - ACS	All cause	all	30+	log-linear	none	10	38	n/a	annual mean	0.00463	0.00238	0.00710
Pope et al. (2002) - ACS extended	All cause	all	30+	log-linear	none	7.5	30	n/a	annual mean	0.00583	0.00198	0.01044
Krewski et al. (2000) - ACS	Cardiopulmonary	401-440, 460-519	30+	log-linear	none	10	38	n/a	annual mean	0.00943	0.00606	0.01315
Pope et al. (2002) - ACS extended	Cardiopulmonary	401-440, 460-519	30+	log-linear	none	7.5	30	n/a	annual mean	0.00862	0.00296	0.01484
Pope et al. (2002) - ACS extended	Lung cancer	162	30+	log-linear	none	7.5	30	n/a	annual mean	0.01310	0.00392	0.02070
Long-Term Exposure Mortality -- Multi-Pollutant Models												
Krewski et al. (2000) - ACS	All cause	all	30+	log-linear	CO	10	38	n/a	annual mean	0.00676	0.00389	0.00976
Krewski et al. (2000) - ACS	All cause	all	30+	log-linear	NO2	10	38	n/a	annual mean	0.00812	0.00426	0.01164
Krewski et al. (2000) - ACS	All cause	all	30+	log-linear	O3	10	38	n/a	annual mean	0.00676	0.00389	0.00976
Krewski et al. (2000) - ACS	All cause	all	30+	log-linear	SO2	10	38	n/a	annual mean	0.00121	-0.00209	0.00499

*The Lipfert et al. (2000) study does not provide the statistical uncertainties surrounding the PM2.5 non-accidental mortality coefficients and the cardiovascular mortality multi-pollutant coefficient.

Exhibit C.5. Study-Specific Information for PM$_{2.5}$ Studies in Phoenix, AZ

Study	Health Effect	ICD-9 Codes	Ages	Model	Other Pollutants in Model	Observed Concentrations min.	max.	Lag	Exposure Metric	PM2.5 Coeff.	Lower Bound	Upper Bound
Short-Term Exposure Cause-Specific Mortality -- Single Pollutant Models												
Mar (2003) [reanalysis of Mar (2000)]	Cardiovascular	390-448.9	65+	log-linear, GAM (stringent)	none	0	42	0 day	1-day avg	0.00371	-0.00101	0.00843
Mar (2003) [reanalysis of Mar (2000)]	Cardiovascular	390-448.9	65+	log-linear, GAM (stringent)	none	0	42	1 day	1-day avg	0.00661	0.00193	0.01129
Long-Term Exposure Mortality -- Single Pollutant Models												
Krewski et al. (2000) - ACS	All cause	all	30+	log-linear	none	10	38	n/a	annual mean	0.00463	0.00238	0.00710
Pope et al. (2002) - ACS extended	All cause	all	30+	log-linear	none	7.5	30	n/a	annual mean	0.00583	0.00198	0.01044
Krewski et al. (2000) - ACS	Cardiopulmonary	401-440, 460-519	30+	log-linear	none	10	38	n/a	annual mean	0.00943	0.00606	0.01315
Pope et al. (2002) - ACS extended	Cardiopulmonary	401-440, 460-519	30+	log-linear	none	7.5	30	n/a	annual mean	0.00862	0.00296	0.01484
Pope et al. (2002) - ACS extended	Lung cancer	162	30+	log-linear	none	7.5	30	n/a	annual mean	0.01310	0.00392	0.02070
Long-Term Exposure Mortality -- Multi-Pollutant Models												
Krewski et al. (2000) - ACS	All cause	all	30+	log-linear	CO	10	38	n/a	annual mean	0.00676	0.00389	0.00976
Krewski et al. (2000) - ACS	All cause	all	30+	log-linear	NO2	10	38	n/a	annual mean	0.00812	0.00426	0.01164
Krewski et al. (2000) - ACS	All cause	all	30+	log-linear	O3	10	38	n/a	annual mean	0.00676	0.00389	0.00976
Krewski et al. (2000) - ACS	All cause	all	30+	log-linear	SO2	10	38	n/a	annual mean	0.00121	-0.00209	0.00499

Exhibit C.6. Study-Specific Information for PM$_{2.5}$ Studies in Pittsburgh, PA

Study	Health Effect	ICD-9 Codes	Ages	Model	Other Pollutants in Model	Observed Concentrations min.	max.	Lag	Exposure Metric	PM2.5 Coeff.	Lower Bound	Upper Bound
Short-Term Exposure Total Mortality -- Single Pollutant Models												
Chock et al. (2000)	Non-accidental	<800	<75	log-linear	none	3	86	0 day	1-day avg	0.00101	-0.00079	0.00281
Chock et al. (2000)	Non-accidental	<800	75+	log-linear	none	3	86	0 day	1-day avg	0.00059	-0.00125	0.00243
Short-Term Exposure Total Mortality -- Multi-Pollutant Models												
Chock et al. (2000)	Non-accidental	<800	<75	log-linear	CO, O3, SO2, NO2, PM10-2.5	3	86	0 day	1-day avg	0.00130	-0.00086	0.00346
Chock et al. (2000)	Non-accidental	<800	75+	log-linear	CO, O3, SO2, NO2, PM10-2.5	3	86	0 day	1-day avg	0.00040	-0.00178	0.00258
Long-Term Exposure Mortality -- Single Pollutant Models												
Krewski et al. (2000) - ACS	All cause	all	30+	log-linear	none	10	38	n/a	annual mean	0.00463	0.00238	0.00710
Pope et al. (2002) - ACS extended	All cause	all	30+	log-linear	none	7.5	30	n/a	annual mean	0.00583	0.00198	0.01044
Krewski et al. (2000) - ACS	Cardiopulmonary	401-440, 460-519	30+	log-linear	none	10	38	n/a	annual mean	0.00943	0.00606	0.01315
Pope et al. (2002) - ACS extended	Cardiopulmonary	401-440, 460-519	30+	log-linear	none	7.5	30	n/a	annual mean	0.00862	0.00296	0.01484
Pope et al. (2002) - ACS extended	Lung cancer	162	30+	log-linear	none	7.5	30	n/a	annual mean	0.01310	0.00392	0.02070
Long-Term Exposure Mortality -- Multi-Pollutant Models												
Krewski et al. (2000) - ACS	All cause	all	30+	log-linear	CO	10	38	n/a	annual mean	0.00676	0.00389	0.00976
Krewski et al. (2000) - ACS	All cause	all	30+	log-linear	NO2	10	38	n/a	annual mean	0.00812	0.00426	0.01164
Krewski et al. (2000) - ACS	All cause	all	30+	log-linear	O3	10	38	n/a	annual mean	0.00676	0.00389	0.00976
Krewski et al. (2000) - ACS	All cause	all	30+	log-linear	SO2	10	38	n/a	annual mean	0.00121	-0.00209	0.00499

Exhibit C.7. Study-Specific Information for PM$_{2.5}$ Studies in San Jose, CA

Study	Health Effect	ICD-9 Codes	Ages	Model	Other Pollutants in Model	Observed Concentrations min.	max.	Lag	Exposure Metric	PM2.5 Coeff.	Lower Bound	Upper Bound
Short-Term Exposure Total Mortality -- Single Pollutant Models												
Fairley (2003) [reanalysis of Fairley (1999)]	Non-accidental	<800	all	log-linear, GAM (stringent)	none	2	105	0 day	1-day avg	0.00314	0.00064	0.00567
Fairley (2003) [reanalysis of Fairley (1999)]	Non-accidental	<800	all	log-linear, GAM (stringent)	none	2	105	1 day	1-day avg	-0.00153	-0.00380	0.00071
Short-Term Exposure Cause-Specific Mortality -- Single Pollutant Models												
Fairley (2003) [reanalysis of Fairley (1999)]	Respiratory	11, 35, 472-519, 710.0, 710.2, 710.4	all	log-linear, GAM (stringent)	none	2	105	0 day	1-day avg	0.00446	-0.00416	0.01307
Fairley (2003) [reanalysis of Fairley (1999)]	Cardiovascular	390-459	all	log-linear, GAM (stringent)	none	2	105	0 day	1-day avg	0.00248	-0.00168	0.00666
Short-Term Exposure Total Mortality -- Multi-Pollutant Models												
Fairley (2003) [reanalysis of Fairley (1999)]	Non-accidental	<800	all	log-linear, GAM (stringent)	NO2	2	105	0 day	1-day avg	0.00402	0.00106	0.00698
Fairley (2003) [reanalysis of Fairley (1999)]	Non-accidental	<800	all	log-linear, GAM (stringent)	CO	2	105	0 day	1-day avg	0.00363	0.00085	0.00636
Fairley (2003) [reanalysis of Fairley (1999)]	Non-accidental	<800	all	log-linear, GAM (stringent)	O3 - 8hr	2	105	0 day	1-day avg	0.00340	0.00085	0.00594
Long-Term Exposure Mortality -- Single Pollutant Models												
Krewski et al. (2000) - ACS	All cause	all	30+	log-linear	none	10	38	n/a	annual mean	0.00463	0.00238	0.00710
Pope et al. (2002) - ACS extended	All cause	all	30+	log-linear	none	7.5	30	n/a	annual mean	0.00583	0.00198	0.01044
Krewski et al. (2000) - ACS	Cardiopulmonary	401-440, 460-519	30+	log-linear	none	10	38	n/a	annual mean	0.00943	0.00606	0.01315
Pope et al. (2002) - ACS extended	Cardiopulmonary	401-440, 460-519	30+	log-linear	none	7.5	30	n/a	annual mean	0.00862	0.00296	0.01484
Pope et al. (2002) - ACS extended	Lung cancer	162	30+	log-linear	none	7.5	30	n/a	annual mean	0.01310	0.00392	0.02070

Study	Health Effect	ICD-9 Codes	Ages	Model	Other Pollutants in Model	Observed Concentrations min.	max.	Lag	Exposure Metric	PM2.5 Coeff.	Lower Bound	Upper Bound
Long-Term Exposure Mortality -- Multi-Pollutant Models												
Krewski et al. (2000) - ACS	All cause	all	30+	log-linear	CO	10	38	n/a	annual mean	0.00676	0.00389	0.00976
Krewski et al. (2000) - ACS	All cause	all	30+	log-linear	NO2	10	38	n/a	annual mean	0.00812	0.00426	0.01164
Krewski et al. (2000) - ACS	All cause	all	30+	log-linear	O3	10	38	n/a	annual mean	0.00676	0.00389	0.00976
Krewski et al. (2000) - ACS	All cause	all	30+	log-linear	SO2	10	38	n/a	annual mean	0.00121	-0.00209	0.00499

Exhibit C.8. Study-Specific Information for PM$_{2.5}$ Studies in Seattle, WA

Study	Health Effect	ICD-9 Codes	Ages	Model	Other Pollutants in Model	Observed Concentrations min.	Observed Concentrations max.	Lag	Exposure Metric	PM2.5 Coeff.	Lower Bound	Upper Bound
Hospital Admissions -- Single Pollutant Models												
Sheppard (2003) [reanalysis of Sheppard et al. (1999)]*	Asthma	493	<65	log-linear, GAM (stringent)	none	2.5	96	1 day	1-day avg	0.00332	0.00084	0.00494
Long-Term Exposure Mortality -- Single Pollutant Models												
Pope et al. (2002) - ACS extended	All cause	all	30+	log-linear	none	7.5	30	n/a	annual mean	0.00583	0.00198	0.01044
Pope et al. (2002) - ACS extended	Cardiopulmonary	401-440, 460-519	30+	log-linear	none	7.5	30	n/a	annual mean	0.00862	0.00296	0.01484
Pope et al. (2002) - ACS extended	Lung cancer	162	30+	log-linear	none	7.5	30	n/a	annual mean	0.01310	0.00392	0.02070

*Sheppard (2003) [reanalysis of Sheppard et al. (1999)] used daily PM2.5 values obtained from nephelometry measurements rather than from air quality monitors.

Exhibit C.9. Study-Specific Information for PM$_{2.5}$ Studies in St. Louis, MO

Study	Health Effect	ICD-9 Codes	Ages	Model	Other Pollutants in Model	Observed Concentrations min.	Observed Concentrations max.	Lag	Exposure Metric	PM2.5 Coeff.	Lower Bound	Upper Bound
Short-Term Exposure Total Mortality -- Single Pollutant Models												
Schwartz (2003b) [reanalysis of Schwartz et al. (1996)]	Non-accidental	< 800	all	log-linear, GAM (stringent)	none	0.9	88.9	mean of lag 0 & 1	2-day avg	0.00102	0.00037	0.00167
Schwartz (2003b) [reanalysis of Schwartz et al. (1996)] -- 6 cities	Non-accidental	< 800	all	log-linear, GAM (stringent)	none	0	174	mean of lag 0 & 1	2-day avg	0.00137	0.00098	0.00176
Short-Term Exposure Cause-Specific Mortality -- Single Pollutant Models												
Klemm and Mason (2003) [reanalysis of Klemm et al. (2000)]	COPD	490-492, 494-496	all	Log-linear, GAM (stringent)	none	0.9	88.9	0 day	2-day avg	0.00060	-0.00294	0.00411
Klemm and Mason (2003) [reanalysis of Klemm et al. (2000)]	Ischemic heart disease	410-414	all	Log-linear, GAM (stringent)	none	0.9	88.9	0 day	2-day avg	0.00129	0.00030	0.00237
Klemm and Mason (2003) [reanalysis of Klemm et al. (2000)]	Pneumonia	480-487	all	Log-linear, GAM (stringent)	none	0.9	88.9	0 day	2-day avg	0.00109	-0.00253	0.00459
Klemm and Mason (2003) [reanalysis of Klemm et al. (2000)] -- 6 cities	COPD	490-492, 494-496	all	Log-linear, GAM (stringent)	none	0	174	0 day	2-day avg	0.00227	0.00010	0.00440
Klemm and Mason (2003) [reanalysis of Klemm et al. (2000)] -- 6 cities	Ischemic heart disease	410-414	all	Log-linear, GAM (stringent)	none	0	174	0 day	2-day avg	0.00178	0.00109	0.00247
Klemm and Mason (2003) [reanalysis of Klemm et al. (2000)] -- 6 cities	Pneumonia	480-487	all	Log-linear, GAM (stringent)	none	0	174	0 day	2-day avg	0.00402	0.00188	0.00602
Respiratory Symptoms and Illnesses* -- Single Pollutant Models												
Schwartz and Neas (2000) - - 6 cities	Lower respiratory symptoms	n/a	7-14	logistic	none	N/A	N/A	1 day	1-day avg	0.01901	0.00696	0.03049
Schwartz and Neas (2000) - - 6 cities	Cough	n/a	7-14	logistic	none	N/A	N/A	0 day	3-day avg	0.00989	-0.00067	0.02050

Study	Health Effect	ICD-9 Codes	Ages	Model	Other Pollutants in Model	Observed Concentrations min.	Observed Concentrations max.	Lag	Exposure Metric	PM2.5 Coeff.	Lower Bound	Upper Bound
Respiratory Symptoms and Illnesses* -- Multi-Pollutant Models												
Schwartz and Neas (2000) - - 6 cities	Lower respiratory symptoms	n/a	7-14	logistic	PM10-2.5	N/A	N/A	1 day	1-day avg	0.01698	0.00388	0.03007
Schwartz and Neas (2000) - - 6 cities	Cough	n/a	7-14	logistic	PM10-2.5	N/A	N/A	0 day	3-day avg	0.00451	-0.00702	0.01541
Long-Term Exposure Mortality -- Single Pollutant Models												
Krewski et al. (2000) - Six Cities	All cause	all	25+	log-linear	none	11	29.6	n/a	annual mean	0.01243	0.00414	0.02071
Krewski et al. (2000) - ACS	All cause	all	30+	log-linear	none	10	38	n/a	annual mean	0.00463	0.00238	0.00710
Pope et al. (2002) - ACS extended	All cause	all	30+	log-linear	none	7.5	30	n/a	annual mean	0.00583	0.00198	0.01044
Krewski et al. (2000) - Six Cities	Cardiopulmonary	400-440, 485-495	25+	log-linear	none	11	29.6	n/a	annual mean	0.01693	0.00561	0.02789
Krewski et al. (2000) - ACS	Cardiopulmonary	401-440, 460-519	30+	log-linear	none	10	38	n/a	annual mean	0.00943	0.00606	0.01315
Pope et al. (2002) - ACS extended	Cardiopulmonary	401-440, 460-519	30+	log-linear	none	7.5	30	n/a	annual mean	0.00862	0.00296	0.01484
Pope et al. (2002) - ACS extended	Lung cancer	162	30+	log-linear	none	7.5	30	n/a	annual mean	0.01310	0.00392	0.02070
Long-Term Exposure Mortality -- Multi-Pollutant Models												
Krewski et al. (2000) - ACS	All cause	all	30+	log-linear	CO	10	38	n/a	annual mean	0.00676	0.00389	0.00976
Krewski et al. (2000) - ACS	All cause	all	30+	log-linear	NO2	10	38	n/a	annual mean	0.00812	0.00426	0.01164
Krewski et al. (2000) - ACS	All cause	all	30+	log-linear	O3	10	38	n/a	annual mean	0.00676	0.00389	0.00976
Krewski et al. (2000) - ACS	All cause	all	30+	log-linear	SO2	10	38	n/a	annual mean	0.00121	-0.00209	0.00499

*The C-R functions for lower respiratory symptoms and cough were calculated for the summer period April 1 through August 31.

Exhibit C.10. Study-Specific Information for Studies on Mortality Associated with Long-Term Exposure to PM$_{2.5}$

Study	Health Effect	ICD-9 Codes	Ages	Model	Other Pollutants in Model	Observed Concentrations min.	Observed Concentrations max.	Lag	Exposure Metric	PM2.5 Coeff.	Lower Bound	Upper Bound
Long-Term Exposure Mortality -- Single Pollutant Models												
Krewski et al. (2000) - Six Cities	All cause	all	25+	log-linear	none	11	29.6	n/a	annual mean	0.012425	0.004138	0.020713
Krewski et al. (2000) - ACS	All cause	all	30+	log-linear	none	10	38	n/a	annual mean	0.004626	0.002378	0.007100
Pope et al. (2002) - ACS extended	All cause	all	30+	log-linear	none	7.5	30	n/a	annual mean	0.005827	0.001980	0.010436
Krewski et al. (2000) - Six Cities	Cardiopulmonary	400-440, 485-495	25+	log-linear	none	11	29.6	n/a	annual mean	0.016925	0.005611	0.027892
Krewski et al. (2000) - ACS	Cardiopulmonary	401-440, 460-519	30+	log-linear	none	10	38	n/a	annual mean	0.009433	0.006058	0.013146
Pope et al. (2002) - ACS extended	Cardiopulmonary	401-440, 460-519	30+	log-linear	none	7.5	30	n/a	annual mean	0.008618	0.002956	0.014842
Pope et al. (2002) - ACS extended	Lung cancer	162	30+	log-linear	none	7.5	30	n/a	annual mean	0.013103	0.003922	0.020701
Long-Term Exposure Mortality -- Multi-Pollutant Models												
Krewski et al. (2000) - ACS	All cause	all	30+	log-linear	CO	10	38	n/a	annual mean	0.006756	0.003890	0.009756
Krewski et al. (2000) - ACS	All cause	all	30+	log-linear	NO2	10	38	n/a	annual mean	0.008116	0.004260	0.011640
Krewski et al. (2000) - ACS	All cause	all	30+	log-linear	O3	10	38	n/a	annual mean	0.006756	0.003890	0.009756
Krewski et al. (2000) - ACS	All cause	all	30+	log-linear	SO2	10	38	n/a	annual mean	0.001206	-0.002094	0.004988

C.2. The PM$_{10-2.5}$ data

Exhibit C.11. Study-Specific Information for PM$_{10-2.5}$ Studies in Detroit, MI

Study	Health Effect	ICD-9 Codes	Ages	Model	Other Pollutants in Model	Observed Concentrations min.	max.	Lag	Exposure Metric	PM Coarse Coefficient	Lower Bound	Upper Bound
					Short-Term Exposure Total Mortality -- Single Pollutant Models							
Ito (2003) [reanalysis of Lippmann et al. (2000)]	Non-accidental	<800	all	log-linear, GAM (stringent)	none	1	50	1 day	1-day avg	0.0012721	-0.0007568	0.0032838
					Short-Term Exposure Cause-Specific Mortality -- Single Pollutant Models							
Ito (2003) [reanalysis of Lippmann et al. (2000)]	Circulatory	390-459	all	log-linear, GAM (stringent)	none	1	50	1 day	1-day avg	0.0025848	-0.0004188	0.0055690
Ito (2003) [reanalysis of Lippmann et al. (2000)]	Respiratory	460-519	all	log-linear, GAM (stringent)	none	1	50	2 day	1-day avg	0.0027021	-0.0039754	0.0093975
					Hospital Admissions -- Single Pollutant Models							
Ito (2003) [reanalysis of Lippmann et al. (2000)]	Pneumonia	480-486	65+	log-linear, GAM (stringent)	none	1	50	1 day	1-day avg	0.0037814	-0.0004188	0.0079769
Ito (2003) [reanalysis of Lippmann et al. (2000)]	COPD+	490-496	65+	log-linear, GAM (stringent)	none	1	50	3 day	1-day avg	0.0033223	-0.0019622	0.0085917
Ito (2003) [reanalysis of Lippmann et al. (2000)]	Ischemic heart disease	410-414	65+	log-linear, GAM (stringent)	none	1	50	2 day	1-day avg	0.0038954	0.0009475	0.0068258
Ito (2003) [reanalysis of Lippmann et al. (2000)]	Dysrhythmias	427	65+	log-linear, GAM (stringent)	none	1	50	0 day	1-day avg	0.0000416	-0.0052791	0.0053863
Ito (2003) [reanalysis of Lippmann et al. (2000)]	Congestive heart failure	428	65+	log-linear, GAM (stringent)	none	1	50	0 day	1-day avg	0.0017142	-0.0016142	0.0050924

Exhibit C.12. Study-Specific Information for PM$_{10-2.5}$ Studies in Seattle, WA

Study	Health Effect	ICD-9 Codes	Ages	Model	Other Pollutants in Model	Observed Concentrations min.	max.	Lag	Exposure Metric	PM Coarse Coefficient	Lower Bound	Upper Bound
Hospital Admissions -- Single Pollutant Models												
Sheppard (2003) [reanalysis of Sheppard et al. (1999)]*	Asthma	493	<65	log-linear, GAM (stringent)	none	N/A	88	1 day	1-day avg	0.0021293	0.0000000	0.0052463

*Sheppard (2003) [reanalysis of Sheppard et al. (1999)] used daily PM2.5 values obtained from nephelometry measurements rather than from air quality monitors.

Exhibit C.13. Study-Specific Information for Studies in St. Louis, MO

Study	Health Effect	ICD-9 Codes	Ages	Model	Other Pollutants in Model	Observed Concentrations min.	max.	Lag	Exposure Metric	PM Coarse Coefficient	Lower Bound	Upper Bound
Short-Term Exposure Total Mortality -- Single Pollutant Models													
[reanalysis of Schwartz et al. (1996)]	Non-accidental	< 800	all	log-linear, penalized spline model	none	-2.3	102.6	0 day	2-day avg	0.0001090	-0.0008632	0.0010812
Respiratory Symptoms and Illnesses* -- Single Pollutant Models													
Schwartz and Neas, 2000 -- 6 cities	Lower respiratory symptoms	N/A	7-14	logistic	none	0	121	0 day	3-day avg	0.0163785	-0.0025253	0.0633522
Schwartz and Neas, 2000 -- 6 cities	Cough	N/A	7-14	logistic	none	0	121	0 day	3-day avg	0.0227902	0.0084573	0.0375131
Respiratory Symptoms and Illnesses* -- Multi-Pollutant Models													
Schwartz and Neas, 2000 -- 6 cities	Lower respiratory symptoms	N/A	7-14	logistic	PM2.5	0	121	0 day	3-day avg	0.0060988	-0.0131701	0.0258768
Schwartz and Neas, 2000 -- 6 cities	Cough	N/A	7-14	logistic	PM2.5	0	121	0 day	3-day avg	0.0206893	0.0049026	0.0365837

*The C-R functions for lower respiratory symptoms and cough were calculated for the summer period April 1 through August 31.

Appendix D. Estimated Annual Health Risks Associated with "As Is" PM$_{2.5}$ Concentrations

D.1 Primary analysis

Exhibit D.1. Estimated Annual Health Risks Associated with "As Is" PM$_{2.5}$ Concentrations

Boston, MA, 2003

Health Effects*	Study	Type	Ages	Lag	Other Pollutants in Model	Health Effects Associated with PM2.5 Above Specified Levels**		
						Incidence	Incidence per 100,000 General Population	Percent of Total Incidence
					Single Pollutant Models (Total Mortality)			
Short-Term Exposure Mortality	Schwartz (2003b) [reanalysis of Schwartz et al. (1996)]	Non-accidental	all	mean of lag 0 & 1		390 (265 - 514)	14 (9 - 18)	1.8% (1.2% - 2.4%)
	Schwartz (2003b) [reanalysis of Schwartz et al. (1996) -- 6 cities	Non-accidental	all	mean of lag 0 & 1		261 (186 - 334)	9 (7 - 12)	1.2% (0.9% - 1.5%)
					Single Pollutant Models (Cause-Specific Mortality)			
	Klemm and Mason (2003) [reanalysis of Klemm et al. (2000)]	COPD	all	0 day		24 (-12 - 56)	1 (0 - 2)	2.4% (-1.2% - 5.6%)
	Klemm and Mason (2003) [reanalysis of Klemm et al. (2000)]	Ischemic heart disease	all	0 day		79 (44 - 112)	3 (2 - 4)	2.3% (1.3% - 3.3%)
	Klemm and Mason (2003) [reanalysis of Klemm et al. (2000)]	Pneumonia	all	0 day		36 (16 - 53)	1 (1 - 2)	4.9% (2.2% - 7.3%)
	Klemm and Mason (2003) [reanalysis of Klemm et al. (2000)] -- 6 cities	COPD	all	0 day		20 (1 - 38)	1 (0 - 1)	2.0% (0.1% - 3.8%)
	Klemm and Mason (2003) [reanalysis of Klemm et al. (2000)] -- 6 cities	Ischemic heart disease	all	0 day		53 (33 - 73)	2 (1 - 3)	1.6% (1.0% - 2.1%)
	Klemm and Mason (2003) [reanalysis of Klemm et al. (2000)] -- 6 cities	Pneumonia	all	0 day		25 (12 - 37)	1 (0 - 1)	3.5% (1.6% - 5.1%)
Long-Term Exposure Mortality					**Single Pollutant Models**			
	Krewski et al. (2000) - Six Cities	All cause	25+			1258 (427 - 2058)	45 (15 - 73)	5.6% (1.9% - 9.1%)
	Krewski et al. (2000) - ACS	All cause	30+			473 (245 - 722)	17 (9 - 26)	2.1% (1.1% - 3.2%)
	Krewski et al. (2000) - Six Cities	Cardiopulmonary	25+			626 (213 - 1007)	22 (8 - 36)	7.5% (2.6% - 12.1%)
	Krewski et al. (2000) - ACS	Cardiopulmonary	30+			415 (269 - 574)	15 (10 - 20)	4.3% (2.8% - 5.9%)
	Pope et al. (2002) - ACS extended	All cause	30+			594 (204 - 1053)	21 (7 - 38)	2.7% (0.9% - 4.7%)
	Pope et al. (2002) - ACS extended	Cardiopulmonary	30+			380 (132 - 645)	14 (5 - 23)	3.9% (1.4% - 6.6%)
	Pope et al. (2002) - ACS extended	Lung cancer	30+			91 (28 - 141)	3 (1 - 5)	5.9% (1.8% - 9.1%)

Health Effects*	Study	Type	Ages	Lag	Other Pollutants in Model	Health Effects Associated with PM2.5 Above Specified Levels**		
						Incidence	Incidence per 100,000 General Population	Percent of Total Incidence
	Multi-Pollutant Models							
	Krewski et al. (2000) - ACS	All cause	30+		CO	688 (399 - 986)	25 (14 - 35)	3.1% (1.8% - 4.4%)
	Krewski et al. (2000) - ACS	All cause	30+		NO2	824 (436 - 1172)	29 (16 - 42)	3.7% (2.0% - 5.2%)
	Krewski et al. (2000) - ACS	All cause	30+		O3	688 (399 - 986)	25 (14 - 35)	3.1% (1.8% - 4.4%)
	Krewski et al. (2000) - ACS	All cause	30+		SO2	124 (-217 - 510)	4 (-8 - 18)	0.6% (-1.0% - 2.3%)
Respiratory Symptoms*	**Single Pollutant Models**							
	Schwartz and Neas (2000) -- 6 cities	Lower respiratory symptoms	7-14	1 day		7900 (3800 - 14500)	300 (100 - 500)	15.1% (7.3% - 27.9%)
	Schwartz and Neas (2000) -- 6 cities	Cough	7-14	0 day		12500 (-900 - 24300)	400 (0 - 900)	8.3% (-0.6% - 16.1%)
	Multi-Pollutant Models							
	Schwartz and Neas (2000) -- 6 cities	Lower respiratory symptoms	7-14	1 day	PM10-2.5	7100 (2200 - 14300)	300 (100 - 500)	13.7% (4.2% - 27.6%)
	Schwartz and Neas (2000) -- 6 cities	Cough	7-14	0 day	PM10-2.5	5900 (-9900 - 18900)	200 (-400 - 700)	3.9% (-6.5% - 12.5%)

*Health effects are associated with short-term exposure to PM2.5 unless otherwise specified.

**For the short-term exposure studies, incidence was quantified down to the estimated policy relevant background level of 3.5 µg/m3. For the long-term exposure studies, incidence was quantified down to 7.5 ug/m3, which was the lowest of the lowest measured levels in the long-term exposure studies. Incidences are rounded to the nearest whole number, except respiratory symptoms incidences which are rounded to the nearest 100; percents are rounded to the nearest tenth.

***The C-R functions for lower respiratory symptoms and cough were calculated for the summer period April 1 through August 31.

Note 1: Numbers in parentheses are 95% confidence intervals based on statistical uncertainty surrounding the PM2.5 coefficient.

Note 2: Multi-city short-term exposure C-R functions were applied only to urban areas included among the cities used to estimate the function.

Exhibit D.2a. Estimated Annual Health Risks Associated with "As Is" PM$_{2.5}$ Concentrations

Los Angeles, CA, 2003

Health Effects*	Study	Type	Ages	Model	Lag	Other Pollutants in Model	Health Effects Associated with PM2.5 Above Policy Relevant Background or Lowest Measured Level**		
							Incidence	Incidence per 100,000 General Population	Percent of Total Incidence
Short-Term Exposure Mortality	Single Pollutant Models (Total Mortality)								
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Non-accidental	all	log-linear, GAM (stringent), 30 df	0 day		494 (-62 - 1038)	5 (-1 - 11)	0.9% (-0.1% - 1.9%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Non-accidental	all	log-linear, GAM (stringent), 30 df	1 day		540 (2 - 1067)	6 (0 - 11)	1.0% (0.0% - 1.9%)
	Single Pollutant Models (Cause-Specific Mortality)								
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Cardiovascular	all	log-linear, GAM (stringent), 30 df	0 day		321 (33 - 601)	3 (0 - 6)	1.6% (0.2% - 3.1%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Cardiovascular	all	log-linear, GAM (stringent), 30 df	1 day		334 (52 - 608)	4 (1 - 6)	1.7% (0.3% - 3.1%)
	Multi-Pollutant Models (Total Mortality)								
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Non-accidental	all	log-linear, GAM (stringent), 30 df	1 day	CO	-492 (-1235 - 232)	-5 (-13 - 2)	-0.9% (-2.2% - 0.4%)
	Multi-Pollutant Models (Cause-Specific Mortality)								
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Cardiovascular	all	log-linear, GAM (stringent), 100 df	0 day	CO	572 (249 - 884)	6 (3 - 9)	2.9% (1.3% - 4.5%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Cardiovascular	all	log-linear, GAM (stringent), 100 df	1 day	CO	296 (-40 - 620)	3 (0 - 7)	1.5% (-0.2% - 3.1%)
Long-Term Exposure Mortality	Single Pollutant Models								
	Krewski et al. (2000) - ACS	All cause	30+	log-linear			2945 (1534 - 4456)	31 (16 - 47)	5.2% (2.7% - 7.9%)
	Krewski et al. (2000) - ACS	Cardiopulmonary	30+	log-linear			3097 (2028 - 4225)	33 (21 - 44)	10.4% (6.8% - 14.2%)
	Pope et al. (2002) - ACS extended	All cause	30+	log-linear			3684 (1280 - 6426)	39 (13 - 68)	6.6% (2.3% - 11.4%)
	Pope et al. (2002) - ACS extended	Cardiopulmonary	30+	log-linear			2842 (1007 - 4725)	30 (11 - 50)	9.5% (3.4% - 15.9%)
	Pope et al. (2002) - ACS extended	Lung cancer	30+	log-linear			450 (142 - 681)	5 (1 - 7)	14.1% (4.5% - 21.4%)
	Multi-Pollutant Models								
	Krewski et al. (2000) - ACS	All cause	30+	log-linear		CO	4249 (2487 - 6031)	45 (26 - 63)	7.6% (4.4% - 10.7%)
	Krewski et al. (2000) - ACS	All cause	30+	log-linear		NO2	5065 (2718 - 7119)	53 (29 - 75)	9.0% (4.8% - 12.7%)
	Krewski et al. (2000) - ACS	All cause	30+	log-linear		O3	4249 (2487 - 6031)	45 (26 - 63)	7.6% (4.4% - 10.7%)
	Krewski et al. (2000) - ACS	All cause	30+	log-linear		SO2	783 (-1386 - 3169)	8 (-15 - 33)	1.4% (-2.5% - 5.6%)

*Health effects are associated with short-term exposure to PM2.5 unless otherwise specified.

** For the short-term exposure studies, health effects incidence was quantified down to the estimated policy relevant background level of 2.5 µg/m3. For the long-term exposure studies, health effects incidence was quantified down to 7.5 ug/m3, which was the lowest of the lowest measured levels in the long-term exposure studies. Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Note: Numbers in parentheses are 95% confidence intervals based on statistical uncertainty surrounding the PM2.5 coefficient.

Exhibit D.2b. Estimated Annual Health Risks of Hospital Admissions Associated with "As Is" PM$_{2.5}$ Concentrations

Los Angeles, CA, 2003

Health Effects	Study	Type	Ages	Model	Lag	Other Pollutants in Model	Health Effects Associated with PM2.5 Above Policy Relevant Background*		
							Incidence	Incidence per 100,000 General Population	Percent of Total Incidence
Hospital Admissions	*Single Pollutant Models*								
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000b)]	Cardiovascular	65+	log-linear, GAM (stringent), 30 df	0 day		1787 (1042 - 2516)	19 (11 - 26)	2.6% (1.5% - 3.6%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000b)]	Cardiovascular	65+	log-linear, GAM (stringent), 30 df	1 day		1576 (795 - 2339)	17 (8 - 25)	2.3% (1.2% - 3.4%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000c)]	COPD+	all	log-linear, GAM (stringent), 30 df	0 day		824 (346 - 1286)	9 (4 - 14)	2.7% (1.1% - 4.3%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000c)]	COPD+	all	log-linear, GAM (stringent), 30 df	1 day		591 (115 - 1050)	6 (1 - 11)	2.0% (0.4% - 3.5%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000c)]	COPD+	all	log-linear, GAM (stringent), 30 df	2 day		911 (417 - 1387)	10 (4 - 15)	3.0% (1.4% - 4.6%)
	Multi-Pollutant Models								
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000b)]	Cardiovascular	65+	log-linear, GAM (stringent), 100 df	0 day	CO	448 (-512 - 1380)	5 (-5 - 14)	0.7% (-0.7% - 2.0%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000b)]	Cardiovascular	65+	log-linear, GAM (stringent), 100 df	1 day	CO	276 (-755 - 1276)	3 (-8 - 13)	0.4% (-1.1% - 1.8%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000c)]	COPD+	all	log-linear, GAM (stringent), 100 df	0 day	NO2	210 (-464 - 855)	2 (-5 - 9)	0.7% (-1.5% - 2.8%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000c)]	COPD+	all	log-linear, GAM (stringent), 100 df	1 day	NO2	-20 (-833 - 750)	0 (-9 - 8)	-0.1% (-2.8% - 2.5%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000c)]	COPD+	all	log-linear, GAM (stringent), 100 df	2 day	NO2	176 (-524 - 842)	2 (-6 - 9)	0.6% (-1.7% - 2.8%)

*Health effects are associated with short-term exposure to PM2.5 unless otherwise specified.

**Health effects incidence was quantified down to the estimated policy relevant background level of 2.5 µg/m3. Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Note: Numbers in parentheses are 95% confidence intervals based on statistical uncertainty surrounding the PM2.5 coefficient.

Exhibit D.3. Estimated Annual Health Risks Associated with "As Is" PM$_{2.5}$ Concentrations Philadelphia, PA, 2003

Health Effects	Study	Type	Ages	Lag	Other Pollutants in Model	Health Effects Associated with PM2.5 Above Specified Levels*		
						Incidence	Incidence per 100,000 General Population	Percent of Total Incidence
Short-Term Exposure Mortality	Single Pollutant Models (Cause-Specific Mortality)							
	Lipfert et al. (2000) -- 7 counties	Cardiovascular	all	1 day		412 (197 - 628)	27 (13 - 41)	2.5% (1.2% - 3.9%)
Long-Term Exposure Mortality	Single Pollutant Models							
	Krewski et al. (2000) - ACS	All cause	30+			518 (268 - 789)	34 (18 - 52)	3.1% (1.6% - 4.7%)
	Krewski et al. (2000) - ACS	Cardiopulmonary	30+			462 (300 - 636)	30 (20 - 42)	6.2% (4.1% - 8.6%)
	Pope et al. (2002) - ACS extended	All cause	30+			650 (224 - 1146)	43 (15 - 76)	3.9% (1.3% - 6.9%)
	Pope et al. (2002) - ACS extended	Cardiopulmonary	30+			424 (148 - 714)	28 (10 - 47)	5.7% (2.0% - 9.6%)
	Pope et al. (2002) - ACS extended	Lung cancer	30+			94 (29 - 144)	6 (2 - 10)	8.6% (2.6% - 13.2%)
	Multi-Pollutant Models							
	Krewski et al. (2000) - ACS	All cause	30+		CO	751 (437 - 1074)	50 (29 - 71)	4.5% (2.6% - 6.4%)
	Krewski et al. (2000) - ACS	All cause	30+		NO2	899 (478 - 1273)	59 (31 - 84)	5.4% (2.9% - 7.6%)
	Krewski et al. (2000) - ACS	All cause	30+		O3	751 (437 - 1074)	50 (29 - 71)	4.5% (2.6% - 6.4%)
	Krewski et al. (2000) - ACS	All cause	30+		SO2	137 (-240 - 558)	9 (-16 - 37)	0.8% (-1.4% - 3.3%)

*For the short-term exposure studies, incidence was quantified down to the estimated policy relevant background level of 3.5 µg/m3. For the long-term exposure studies, incidence was quantified down to 7.5 ug/m3, which was the lowest of the lowest measured levels in the long-term exposure studies. Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Note 1: Numbers in parentheses are 95% confidence intervals based on statistical uncertainty surrounding the PM2.5 coefficient.
Note 2: Multi-county short-term exposure C-R functions were applied only to counties included among those used to estimate the function.

Exhibit D.4. Estimated Annual Health Risks Associated with "As Is" PM$_{2.5}$ Concentrations

Phoenix, AZ, 2001

Health Effects	Study	Type	Ages	Lag	Other Pollutants in Model	Health Effects Associated with PM2.5 Above Specified Levels*		
						Incidence	Incidence per 100,000 General Population	Percent of Total Incidence
Short-Term Exposure Mortality	Single Pollutant Models (Cause-Specific Mortality)							
	Mar (2003) [reanalysis of Mar (2000)]	Cardiovascular	65+	0 day		185 (-52 - 407)	6 (-2 - 13)	2.9% (-0.8% - 6.3%)
	Mar (2003) [reanalysis of Mar (2000)]	Cardiovascular	65+	1 day		323 (97 - 536)	11 (3 - 17)	5.0% (1.5% - 8.3%)
Long-Term Exposure Mortality	Single Pollutant Models							
	Krewski et al. (2000) - ACS	All cause	30+			277 (143 - 424)	9 (5 - 14)	1.3% (0.7% - 2.0%)
	Krewski et al. (2000) - ACS	Cardiopulmonary	30+			259 (167 - 360)	8 (5 - 12)	2.7% (1.7% - 3.8%)
	Pope et al. (2002) - ACS extended	All cause	30+			349 (119 - 620)	11 (4 - 20)	1.7% (0.6% - 3.0%)
	Pope et al. (2002) - ACS extended	Cardiopulmonary	30+			237 (82 - 405)	8 (3 - 13)	2.5% (0.9% - 4.2%)
	Pope et al. (2002) - ACS extended	Lung cancer	30+			48 (14 - 74)	2 (0 - 2)	3.7% (1.1% - 5.8%)
	Multi-Pollutant Models							
	Krewski et al. (2000) - ACS	All cause	30+		CO	404 (233 - 580)	13 (8 - 19)	1.9% (1.1% - 2.8%)
	Krewski et al. (2000) - ACS	All cause	30+		NO2	484 (255 - 690)	16 (8 - 22)	2.3% (1.2% - 3.3%)
	Krewski et al. (2000) - ACS	All cause	30+		O3	404 (233 - 580)	13 (8 - 19)	1.9% (1.1% - 2.8%)
	Krewski et al. (2000) - ACS	All cause	30+		SO2	73 (-127 - 299)	2 (-4 - 10)	0.4% (-0.6% - 1.4%)

*For the short-term exposure studies, incidence was quantified down to the estimated policy relevant background level of 2.5 µg/m3. For the long-term exposure studies, incidence was quantified down to 7.5 ug/m3, which was the lowest of the lowest measured levels in the long-term exposure studies. Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Note: Numbers in parentheses are 95% confidence intervals based on statistical uncertainty surrounding the PM2.5 coefficient.

Exhibit D.5. Estimated Annual Health Risks Associated with "As Is" PM$_{2.5}$ Concentrations
Pittsburgh, PA, 2003

Health Effects	Study	Type	Ages	Lag	Other Pollutants in Model	Health Effects Associated with PM2.5 Above Specified Levels*		
						Incidence	Incidence per 100,000 General Population	Percent of Total Incidence
Short-Term Exposure Mortality	Single Pollutant Models (Total Mortality)							
	Chock et al. (2000)	Non-accidental	<75	0 day		69 (-55 - 188)	5 (-4 - 15)	1.4% (-1.1% - 3.7%)
	Chock et al. (2000)	Non-accidental	75+	0 day		77 (-166 - 311)	6 (-13 - 24)	0.8% (-1.7% - 3.2%)
	Multi-Pollutant Models (Total Mortality)							
	Chock et al. (2000)	Non-accidental	<75	0 day	CO, O3, SO2, NO2, PM10-2.5	88 (-60 - 230)	7 (-5 - 18)	1.7% (-1.2% - 4.5%)
	Chock et al. (2000)	Non-accidental	75+	0 day	CO, O3, SO2, NO2, PM10-2.5	52 (-238 - 330)	4 (-19 - 26)	0.5% (-2.4% - 3.4%)
Long-Term Exposure Mortality	Single Pollutant Models							
	Krewski et al. (2000) - ACS	All cause	30+			651 (338 - 988)	51 (26 - 77)	4.3% (2.2% - 6.5%)
	Krewski et al. (2000) - ACS	Cardiopulmonary	30+			626 (408 - 857)	49 (32 - 67)	8.5% (5.6% - 11.7%)
	Pope et al. (2002) - ACS extended	All cause	30+			816 (282 - 1430)	64 (22 - 112)	5.4% (1.9% - 9.4%)
	Pope et al. (2002) - ACS extended	Cardiopulmonary	30+			574 (202 - 960)	45 (16 - 75)	7.8% (2.8% - 13.1%)
	Pope et al. (2002) - ACS extended	Lung cancer	30+			116 (36 - 177)	9 (3 - 14)	11.6% (3.6% - 17.8%)
	Multi-Pollutant Models							
	Krewski et al. (2000) - ACS	All cause	30+		CO	942 (550 - 1341)	73 (43 - 105)	6.2% (3.6% - 8.8%)
	Krewski et al. (2000) - ACS	All cause	30+		NO2	1124 (601 - 1586)	88 (47 - 124)	7.4% (3.9% - 10.4%)
	Krewski et al. (2000) - ACS	All cause	30+		O3	942 (550 - 1341)	73 (43 - 105)	6.2% (3.6% - 8.8%)
	Krewski et al. (2000) - ACS	All cause	30+		SO2	173 (-304 - 701)	13 (-24 - 55)	1.1% (-2.0% - 4.6%)

*For the short-term exposure studies, incidence was quantified down to the estimated policy relevant background level of 3.5 µg/m3 . For the long-term exposure studies, incidence was quantified down to 7.5 ug/m3, which was the lowest of the lowest measured levels in the long-term exposure studies. Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Note: Numbers in parentheses are 95% confidence intervals based on statistical uncertainty surrounding the PM2.5 coefficient.

Exhibit D.6. Estimated Annual Health Risks Associated with "As Is" PM$_{2.5}$ Concentrations

San Jose, CA, 2003

Health Effects	Study	Type	Ages	Lag	Other Pollutants in Model	Health Effects Associated with PM2.5 Above Specified Levels*		
						Incidence	Incidence per 100,000 General Population	Percent of Total Incidence
Short-Term Exposure Mortality	Single Pollutant Models (Total Mortality)							
	Fairley (2003) [reanalysis of Fairley (1999)]	Non-accidental	all	0 day		218 (45 - 387)	13 (3 - 23)	2.6% (0.5% - 4.7%)
	Fairley (2003) [reanalysis of Fairley (1999)]	Non-accidental	all	1 day		-110 (-278 - 50)	-7 (-17 - 3)	-1.3% (-3.4% - 0.6%)
	Single Pollutant Models (Cause-Specific Mortality)							
	Fairley (2003) [reanalysis of Fairley (1999)]	Respiratory	all	0 day		32 (-32 - 88)	2 (-2 - 5)	3.7% (-3.7% - 10.2%)
	Fairley (2003) [reanalysis of Fairley (1999)]	Cardiovascular	all	0 day		72 (-50 - 188)	4 (-3 - 11)	2.1% (-1.5% - 5.4%)
	Multi-Pollutant Models (Total Mortality)							
	Fairley (2003) [reanalysis of Fairley (1999)]	Non-accidental	all	0 day	NO2	277 (74 - 472)	16 (4 - 28)	3.3% (0.9% - 5.7%)
	Fairley (2003) [reanalysis of Fairley (1999)]	Non-accidental	all	0 day	CO	251 (60 - 432)	15 (4 - 26)	3.0% (0.7% - 5.2%)
	Fairley (2003) [reanalysis of Fairley (1999)]	Non-accidental	all	0 day	O3 - 8hr	236 (60 - 404)	14 (4 - 24)	2.8% (0.7% - 4.9%)
Long-Term Exposure Mortality	Single Pollutant Models							
	Krewski et al. (2000) - ACS	All cause	30+			137 (71 - 210)	8 (4 - 12)	1.6% (0.8% - 2.5%)
	Krewski et al. (2000) - ACS	Cardiopulmonary	30+			137 (88 - 190)	8 (5 - 11)	3.3% (2.1% - 4.6%)
	Pope et al. (2002) - ACS extended	All cause	30+			172 (59 - 306)	10 (4 - 18)	2.1% (0.7% - 3.6%)
	Pope et al. (2002) - ACS extended	Cardiopulmonary	30+			125 (43 - 213)	7 (3 - 13)	3.0% (1.1% - 5.1%)
	Pope et al. (2002) - ACS extended	Lung cancer	30+			23 (7 - 35)	1 (0 - 2)	4.6% (1.4% - 7.1%)
	Multi-Pollutant Models							
	Krewski et al. (2000) - ACS	All cause	30+		CO	199 (115 - 287)	12 (7 - 17)	2.4% (1.4% - 3.4%)
	Krewski et al. (2000) - ACS	All cause	30+		NO2	239 (126 - 341)	14 (8 - 20)	2.9% (1.5% - 4.1%)
	Krewski et al. (2000) - ACS	All cause	30+		O3	199 (115 - 287)	12 (7 - 17)	2.4% (1.4% - 3.4%)
	Krewski et al. (2000) - ACS	All cause	30+		SO2	36 (-63 - 148)	2 (-4 - 9)	0.4% (-0.8% - 1.8%)

*For the short-term exposure studies, incidence was quantified down to the estimated policy relevant background level of 2.5 µg/m3 . For the long-term exposure studies, incidence was quantified down to 7.5 ug/m3, which was the lowest of the lowest measured levels in the long-term exposure studies. Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Note: Numbers in parentheses are 95% confidence intervals based on statistical uncertainty surrounding the PM2.5 coefficient.

Exhibit D.7. Estimated Annual Health Risks Associated with "As Is" PM$_{2.5}$ Concentrations Seattle, WA, 2003

Health Effects*	Study	Type	Ages	Lag	Other Pollutants in Model	Health Effects Associated with PM2.5 Above Specified Levels**		
						Incidence	Incidence per 100,000 General Population	Percent of Total Incidence
Long-Term Exposure Mortality	Single Pollutant Models							
	Krewski et al. (2000) - ACS	All cause	30+			40 (20 - 61)	2 (1 - 3)	0.4% (0.2% - 0.6%)
	Krewski et al. (2000) - ACS	Cardiopulmonary	30+			36 (23 - 50)	2 (1 - 3)	0.7% (0.5% - 1.0%)
	Pope et al. (2002) - ACS extended	All cause	30+			50 (17 - 89)	3 (1 - 5)	0.5% (0.2% - 0.8%)
	Pope et al. (2002) - ACS extended	Cardiopulmonary	30+			33 (11 - 57)	2 (1 - 3)	0.7% (0.2% - 1.1%)
	Pope et al. (2002) - ACS extended	Lung cancer	30+			8 (2 - 12)	0 (0 - 1)	1.0% (0.3% - 1.6%)
	Multi-Pollutant Models							
	Krewski et al. (2000) - ACS	All cause	30+		CO	58 (33 - 83)	3 (2 - 5)	0.5% (0.3% - 0.8%)
	Krewski et al. (2000) - ACS	All cause	30+		NO2	69 (36 - 99)	4 (2 - 6)	0.6% (0.3% - 0.9%)
	Krewski et al. (2000) - ACS	All cause	30+		O3	58 (33 - 83)	3 (2 - 5)	0.5% (0.3% - 0.8%)
	Krewski et al. (2000) - ACS	All cause	30+		SO2	10 (-18 - 43)	1 (-1 - 2)	0.1% (-0.2% - 0.4%)
Hospital Admissions	Single Pollutant Models							
	Sheppard (2003) [reanalysis of Sheppard et al. (1999)]***	Asthma	<65	1 day		30 (8 - 45)	2 (0 - 3)	1.9% (0.5% - 2.8%)

*Health effects are associated with short-term exposure to PM2.5 unless otherwise specified.

**For the short-term exposure studies, incidence was quantified down to the estimated policy relevant background level of 2.5 µg/m3 . For the long-term exposure studies, incidence was quantified down to 7.5 ug/m3, which was the lowest of the lowest measured levels in the long-term exposure studies. Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

***Sheppard (2003) [reanalysis of Sheppard et al. (1999)] used daily PM2.5 values obtained from nephelometer measurements rather than from air quality monitors.

Note: Numbers in parentheses are 95% confidence intervals based on statistical uncertainty surrounding the PM2.5 coefficient.

Exhibit D.8. Estimated Annual Health Risks Associated with "As Is" PM$_{2.5}$ Concentrations

St. Louis, MO, 2003

Health Effects*	Study	Type	Ages	Lag	Other Pollutants in Model	Health Effects Associated with PM2.5 Above Specified Levels**		
						Incidence	Incidence per 100,000 General Population	Percent of Total Incidence
Short-Term Exposure Mortality	Single Pollutant Models (Total Mortality)							
	Schwartz (2003b) [reanalysis of Schwartz et al. (1996)]	Non-accidental	all	mean of lag 0 & 1		233 (86 - 379)	9 (3 - 15)	1.1% (0.4% - 1.7%)
	Schwartz (2003b) [reanalysis of Schwartz et al. (1996)] -- 6 cities	Non-accidental	all	mean of lag 0 & 1		312 (224 - 401)	12 (9 - 16)	1.4% (1.0% - 1.8%)
	Single Pollutant Models (Cause-Specific Mortality)							
	Klemm and Mason (2003) [reanalysis of Klemm et al. (2000)]	COPD	all	0 day		6 (-31 - 42)	0 (-1 - 2)	0.6% (-3.2% - 4.2%)
	Klemm and Mason (2003) [reanalysis of Klemm et al. (2000)]	Ischemic heart disease	all	0 day		70 (16 - 127)	3 (1 - 5)	1.4% (0.3% - 2.5%)
	Klemm and Mason (2003) [reanalysis of Klemm et al. (2000)]	Pneumonia	all	0 day		8 (-18 - 31)	0 (-1 - 1)	1.1% (-2.7% - 4.7%)
	Klemm and Mason (2003) [reanalysis of Klemm et al. (2000)] -- 6 cities	COPD	all	0 day		23 (1 - 44)	1 (0 - 2)	2.4% (0.1% - 4.5%)
	Klemm and Mason (2003) [reanalysis of Klemm et al. (2000)] -- 6 cities	Ischemic heart disease	all	0 day		96 (59 - 132)	4 (2 - 5)	1.9% (1.1% - 2.6%)
	Klemm and Mason (2003) [reanalysis of Klemm et al. (2000)] -- 6 cities	Pneumonia	all	0 day		28 (13 - 41)	1 (1 - 2)	4.1% (2.0% - 6.1%)
Long-Term Exposure Mortality	Single Pollutant Models							
	Krewski et al. (2000) - Six Cities	All cause	25+			1773 (606 - 2878)	70 (24 - 114)	7.8% (2.7% - 12.6%)
	Krewski et al. (2000) - ACS	All cause	30+			671 (348 - 1022)	27 (14 - 41)	3.0% (1.5% - 4.5%)
	Krewski et al. (2000) - Six Cities	Cardiopulmonary	25+			1028 (353 - 1636)	41 (14 - 65)	10.4% (3.6% - 16.6%)
	Krewski et al. (2000) - ACS	Cardiopulmonary	30+			659 (428 - 907)	26 (17 - 36)	6.0% (3.9% - 8.2%)
	Pope et al. (2002) - ACS extended	All cause	30+			842 (290 - 1486)	33 (12 - 59)	3.7% (1.3% - 6.6%)
	Pope et al. (2002) - ACS extended	Cardiopulmonary	30+			603 (211 - 1018)	24 (8 - 40)	5.5% (1.9% - 9.2%)
	Pope et al. (2002) - ACS extended	Lung cancer	30+			125 (38 - 192)	5 (2 - 8)	8.2% (2.5% - 12.6%)

Health Effects*	Study	Type	Ages	Lag	Other Pollutants in Model	Health Effects Associated with PM2.5 Above Specified Levels**		
						Incidence	Incidence per 100,000 General Population	Percent of Total Incidence
	Multi-Pollutant Models							
	Krewski et al. (2000) - ACS	All cause	30+		CO	973 (566 - 1392)	39 (22 - 55)	4.3% (2.5% - 6.2%)
	Krewski et al. (2000) - ACS	All cause	30+		NO2	1164 (619 - 1651)	46 (25 - 66)	5.2% (2.7% - 7.3%)
	Krewski et al. (2000) - ACS	All cause	30+		O3	973 (566 - 1392)	39 (22 - 55)	4.3% (2.5% - 6.2%)
	Krewski et al. (2000) - ACS	All cause	30+		SO2	177 (-310 - 723)	7 (-12 - 29)	0.8% (-1.4% - 3.2%)
Respiratory Symptoms*	**Single Pollutant Models**							
	Schwartz and Neas (2000) -- 6 cities	Lower respiratory symptoms	7-14	1 day		10800 (4300 - 16300)	400 (200 - 600)	19.2% (7.7% - 28.9%)
	Schwartz and Neas (2000) -- 6 cities	Cough	7-14	0 day		17600 (-1300 - 34000)	700 (-100 - 1300)	10.7% (-0.8% - 20.7%)
	Multi-Pollutant Models							
	Schwartz and Neas (2000) -- 6 cities	Lower respiratory symptoms	7-14	1 day	PM10-2.5	9800 (2500 - 16100)	400 (100 - 600)	17.4% (4.4% - 28.6%)
	Schwartz and Neas (2000) -- 6 cities	Cough	7-14	0 day	PM10-2.5	8300 (-14000 - 26400)	300 (-600 - 1000)	5.1% (-8.5% - 16.0%)

*Health effects are associated with short-term exposure to PM2.5 unless otherwise specified.

** For the short-term exposure studies, incidence was quantified down to the estimated policy relevant background level of 3.5 µg/m3. For the long-term exposure studies, incidence was quantified down to 7.5 ug/m3, which was the lowest of the lowest measured levels in the long-term exposure studies. Incidences are rounded to the nearest whole number, except respiratory symptoms incidences which are rounded to the nearest 100; percents are rounded to the nearest tenth.

***The C-R functions for lower respiratory symptoms and cough were calculated for the summer period April 1 through August 31.

Note 1: Numbers in parentheses are 95% confidence intervals based on statistical uncertainty surrounding the PM2.5 coefficient.

Note 2: Multi-city short-term exposure C-R functions were applied only to urban areas included among the cities used to estimate the function.

Exhibit D.9. Estimated Annual Mortality Associated with Short-Term and Long-Term Exposure to "As Is" PM$_{2.5}$ Concentrations, Assuming Various Cutpoint Levels*

Boston, MA, 2003

Health Effects	Study	Type	Ages	Lag	Other Pollutants in Model	Incidence Associated with PM2.5 Assuming Various Cutpoint Levels** (95% Confidence Interval) Percent of Total Incidence (95% Confidence Interval)			
						Policy Relevant Background =3.5 µg/m3	Cutpoint =10 µg/m3	Cutpoint =15 µg/m3	Cutpoint =20 µg/m3
Short-Term Exposure Mortality	Single Pollutant Models (Total Mortality)								
	Schwartz (2003b) [reanalysis of Schwartz et al. (1996)]	Non-accidental	all	mean of lag 0 & 1		390 (265 - 514) 1.8% (1.2% - 2.4%)	173 (118 - 228) 0.8% (0.5% - 1.1%)	82 (56 - 109) 0.4% (0.3% - 0.5%)	41 (28 - 53) 0.2% (0.1% - 0.2%)
	Schwartz (2003b) [reanalysis of Schwartz et al. (1996)] -- 6 cities	Non-accidental	all	mean of lag 0 & 1		261 (186 - 334) 1.2% (0.9% - 1.5%)	109 (78 - 140) 0.5% (0.4% - 0.6%)	49 (35 - 63) 0.2% (0.2% - 0.3%)	23 (16 - 29) 0.1% (0.1% - 0.1%)
Long-Term Exposure Mortality						Cutpoint = 7.5 µg/m3	Cutpoint =10 µg/m3	Cutpoint =12 µg/m3	
	Single Pollutant Models								
	Krewski et al. (2000) - Six Cities	All cause	25+			1258 (427 - 2058) 5.6% (1.9% - 9.1%)	661 (222 - 1091) 2.9% (1.0% - 4.8%)	44 (15 - 73) 0.2% (0.1% - 0.3%)	
	Krewski et al. (2000) - ACS	All cause	30+			473 (245 - 722) 2.1% (1.1% - 3.2%)	238 (123 - 364) 1.1% (0.6% - 1.6%)	15 (8 - 23) 0.1% (0.0% - 0.1%)	
	Pope et al. (2002) - ACS extended	All cause	30+			594 (204 - 1053) 2.7% (0.9% - 4.7%)	309 (106 - 551) 1.4% (0.5% - 2.5%)	20 (7 - 36) 0.1% (0.0% - 0.2%)	
	Multi-Pollutant Models								
	Krewski et al. (2000) - ACS	All cause	30+		CO	688 (399 - 986) 3.1% (1.8% - 4.4%)	347 (200 - 499) 1.6% (0.9% - 2.2%)	22 (13 - 32) 0.1% (0.1% - 0.1%)	
	Krewski et al. (2000) - ACS	All cause	30+		NO2	824 (436 - 1172) 3.7% (2.0% - 5.2%)	416 (219 - 594) 1.9% (1.0% - 2.7%)	26 (14 - 38) 0.1% (0.1% - 0.2%)	
	Krewski et al. (2000) - ACS	All cause	30+		O3	688 (399 - 986) 3.1% (1.8% - 4.4%)	347 (200 - 499) 1.6% (0.9% - 2.2%)	22 (13 - 32) 0.1% (0.1% - 0.1%)	
	Krewski et al. (2000) - ACS	All cause	30+		SO2	124 (-217 - 510) 0.6% (-1.0% - 2.3%)	62 (-109 - 257) 0.3% (-0.5% - 1.2%)	4 (-7 - 16) 0.0% (0.0% - 0.1%)	

*For the short-term exposure studies, incidence was quantified down to policy relevant background level of 3.5 µg/m3, as well as down to each of the alternative cutpoints. For the long-term exposure studies, incidence was quantified down to 7.5 µg/m3, the lowest of the lowest measured levels in the long-term exposure studies, as well as down to each of the alternative cutpoints. For the cutpoints above policy relevant background, the slope of the C-R function has been modified based on a simple hockeystick model (see discussion in section 2.5).

**Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Exhibit D.10. Estimated Annual Health Risks of Short-Term and Long-Term Exposure Mortality Associated with "As Is" PM$_{2.5}$ Concentrations Assuming Various Cutpoint Levels*

Los Angeles, CA, 2003

Health Effects	Study	Type	Ages	Model	Lag	Other Pollutants in Model	Incidence Associated with PM2.5 Assuming Various Cutpoint Levels** (95% Confidence Interval) Percent of Total Incidence (95% Confidence Interval)			
							Policy Relevant Background =2.5 µg/m3	Cutpoint =10 µg/m3	Cutpoint =15 µg/m3	Cutpoint =20 µg/m3
							Single Pollutant Models (Total Mortality)			
Short-Term Exposure Mortality	Moolgavkar (2003) [reanalysis of Moolgavkar	Non-accidental	all	log-linear, GAM (stringent), 30 df	0 day		494 (-62 - 1038) 0.9% (-0.1% - 1.9%)	308 (-38 - 647) 0.6% (-0.1% - 1.2%)	212 (-26 - 445) 0.4% (-0.1% - 0.8%)	146 (-18 - 306) 0.3% (0.0% - 0.6%)
	Moolgavkar (2003) [reanalysis of Moolgavkar	Non-accidental	all	log-linear, GAM (stringent), 30 df	1 day		540 (2 - 1067) 1.0% (0.0% - 1.9%)	336 (1 - 665) 0.6% (0.0% - 1.2%)	231 (1 - 457) 0.4% (0.0% - 0.8%)	159 (0 - 314) 0.3% (0.0% - 0.6%)
							Multi-Pollutant Models (Total Mortality)			
	Moolgavkar (2003) [reanalysis of Moolgavkar	Non-accidental	all	log-linear, GAM (stringent), 30 df	1 day	CO	-492 (-1235 - 232) -0.9% (-2.2% - 0.4%)	-306 (-770 - 144) -0.6% (-1.4% - 0.3%)	-211 (-531 - 99) -0.4% (-1.0% - 0.2%)	-145 (-366 - 68) -0.3% (-0.7% - 0.1%)
Long-Term Exposure Mortality							Cutpoint = 7.5 µg/m3	Cutpoint =10 µg/m3	Cutpoint =12 µg/m3	
							Single Pollutant Models			
	Krewski et al. (2000) - ACS	All cause	30+	log-linear			2945 (1534 - 4456) 5.2% (2.7% - 7.9%)	2528 (1314 - 3834) 4.5% (2.3% - 6.8%)	2134 (1108 - 3242) 3.8% (2.0% - 5.8%)	
	Pope et al. (2002) - ACS extended	All cause	30+	log-linear			3684 (1280 - 6426) 6.6% (2.3% - 11.4%)	3267 (1132 - 5715) 5.8% (2.0% - 10.2%)	2846 (984 - 4994) 5.1% (1.8% - 8.9%)	
							Multi-Pollutant Models			
	Krewski et al. (2000) - ACS	All cause	30+	log-linear		CO	4249 (2487 - 6031) 7.6% (4.4% - 10.7%)	3654 (2134 - 5199) 6.5% (3.8% - 9.3%)	3089 (1800 - 4406) 5.5% (3.2% - 7.8%)	
	Krewski et al. (2000) - ACS	All cause	30+	log-linear		NO2	5065 (2718 - 7119) 9.0% (4.8% - 12.7%)	4360 (2332 - 6147) 7.8% (4.2% - 10.9%)	3691 (1968 - 5217) 6.6% (3.5% - 9.3%)	
	Krewski et al. (2000) - ACS	All cause	30+	log-linear		O3	4249 (2487 - 6031) 7.6% (4.4% - 10.7%)	3654 (2134 - 5199) 6.5% (3.8% - 9.3%)	3089 (1800 - 4406) 5.5% (3.2% - 7.8%)	
	Krewski et al. (2000) - ACS	All cause	30+	log-linear		SO2	783 (-1386 - 3169) 1.4% (-2.5% - 5.6%)	671 (-1183 - 2722) 1.2% (-2.1% - 4.8%)	565 (-993 - 2298) 1.0% (-1.8% - 4.1%)	

*For the short-term exposure studies, incidence was quantified down to policy relevant background level of 2.5 µg/m3, as well as down to each of the alternative cutpoints. For the long-term exposure studies, incidence was quantified down to 7.5 µg/m3, the lowest of the lowest measured levels in the long-term exposure studies, as well as down to each of the alternative cutpoints. For the cutpoints above policy relevant background, the slope of the C-R function has been modified based on a simple hockeystick model (see discussion in section 2.5).

**Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth. Numbers in parentheses are 95% confidence intervals based on statistical uncertainty surrounding the PM2.5 coefficient.

Exhibit D.11. Estimated Annual Mortality Associated with Short-Term and Long-Term Exposure to "As Is" PM$_{2.5}$ Concentrations Assuming Various Cutpoint Levels*

Philadelphia, PA, 2003

Health Effects	Study	Type	Ages	Lag	Other Pollutants in Model	Incidence Associated with PM2.5 Assuming Various Cutpoint Levels** (95% Confidence Interval) Percent of Total Incidence (95% Confidence Interval)			
						Policy Relevant Background =3.5 µg/m3	Cutpoint =10 µg/m3	Cutpoint =15 µg/m3	Cutpoint =20 µg/m3
Short-Term Exposure Mortality	Single Pollutant Models (Total Mortality)								
	Lipfert et al. (2000) -- 7 counties	Cardiovascular	all	1 day		412 (197 - 628) 2.5% (1.2% - 3.9%)	231 (110 - 352) 1.4% (0.7% - 2.2%)	141 (67 - 215) 0.9% (0.4% - 1.3%)	83 (40 - 127) 0.5% (0.2% - 0.8%)
Long-Term Exposure Mortality						Cutpoint = 7.5 µg/m3	Cutpoint =10 µg/m3	Cutpoint =12 µg/m3	
	Single Pollutant Models								
	Krewski et al. (2000) - ACS	All cause	30+			518 (268 - 789) 3.1% (1.6% - 4.7%)	359 (186 - 548) 2.2% (1.1% - 3.3%)	209 (108 - 319) 1.3% (0.6% - 1.9%)	
	Pope et al. (2002) - ACS extended	All cause	30+			650 (224 - 1146) 3.9% (1.3% - 6.9%)	466 (160 - 825) 2.8% (1.0% - 4.9%)	280 (96 - 497) 1.7% (0.6% - 3.0%)	
	Multi-Pollutant Models								
	Krewski et al. (2000) - ACS	All cause	30+		CO	751 (437 - 1074) 4.5% (2.6% - 6.4%)	522 (303 - 749) 3.1% (1.8% - 4.5%)	304 (176 - 437) 1.8% (1.1% - 2.6%)	
	Krewski et al. (2000) - ACS	All cause	30+		NO2	899 (478 - 1273) 5.4% (2.9% - 7.6%)	625 (331 - 889) 3.8% (2.0% - 5.3%)	364 (192 - 520) 2.2% (1.2% - 3.1%)	
	Krewski et al. (2000) - ACS	All cause	30+		O3	751 (437 - 1074) 4.5% (2.6% - 6.4%)	522 (303 - 749) 3.1% (1.8% - 4.5%)	304 (176 - 437) 1.8% (1.1% - 2.6%)	
	Krewski et al. (2000) - ACS	All cause	30+		SO2	137 (-240 - 558) 0.8% (-1.4% - 3.3%)	94 (-165 - 387) 0.6% (-1.0% - 2.3%)	55 (-95 - 225) 0.3% (-0.6% - 1.4%)	

*For the short-term exposure studies, incidence was quantified down to policy relevant background level of 3.5 µg/m3, as well as down to each of the alternative cutpoints. For the long-term exposure studies, incidence was quantified down to 7.5 µg/m3, the lowest of the lowest measured levels in the long-term exposure studies, as well as down to each of the alternative cutpoints. For the cutpoints above policy relevant background, the slope of the C-R function has been modified based on a simple hockeystick model (see discussion in section 2.5).

**Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Exhibit D.12. Estimated Annual Health Risks of Short-Term and Long-Term Exposure Mortality Associated with "As Is" PM$_{2.5}$ Concentrations Assuming Various Cutpoint Levels*

Phoenix, AZ, 2001

Health Effects	Study	Type	Ages	Lag	Other Pollutants in Model	Incidence Associated with PM2.5 Assuming Various Cutpoint Levels** (95% Confidence Interval) Percent of Total Incidence (95% Confidence Interval)			
						Policy Relevant Background =2.5 µg/m3	Cutpoint =10 µg/m3	Cutpoint =15 µg/m3	Cutpoint =20 µg/m3
Short-Term Exposure Mortality	Single Pollutant Models (Total Mortality)								
	Mar (2003) [reanalysis of Mar (2000)]	Cardiovascular	65+	1 day		323 (97 - 536) 5.0% (1.5% - 8.3%)	115 (35 - 190) 1.8% (0.5% - 2.9%)	67 (21 - 109) 1.0% (0.3% - 1.7%)	43 (13 - 69) 0.7% (0.2% - 1.1%)
Long-Term Exposure Mortality						Cutpoint = 7.5 µg/m3	Cutpoint =10 µg/m3	Cutpoint =12 µg/m3	
	Single Pollutant Models								
	Krewski et al. (2000) - ACS	All cause	30+			277 (143 - 424) 1.3% (0.7% - 2.0%)	42 (22 - 65) 0.2% (0.1% - 0.3%)	0 (0 - 0) 0.0% (0.0% - 0.0%)	
	Pope et al. (2002) - ACS extended	All cause	30+			349 (119 - 620) 1.7% (0.6% - 3.0%)	55 (19 - 98) 0.3% (0.1% - 0.5%)	0 (0 - 0) 0.0% (0.0% - 0.0%)	
	Multi-Pollutant Models								
	Krewski et al. (2000) - ACS	All cause	30+		CO	404 (233 - 580) 1.9% (1.1% - 2.8%)	62 (36 - 89) 0.3% (0.2% - 0.4%)	0 (0 - 0) 0.0% (0.0% - 0.0%)	
	Krewski et al. (2000) - ACS	All cause	30+		NO2	484 (255 - 690) 2.3% (1.2% - 3.3%)	74 (39 - 106) 0.4% (0.2% - 0.5%)	0 (0 - 0) 0.0% (0.0% - 0.0%)	
	Krewski et al. (2000) - ACS	All cause	30+		O3	404 (233 - 580) 1.9% (1.1% - 2.8%)	62 (36 - 89) 0.3% (0.2% - 0.4%)	0 (0 - 0) 0.0% (0.0% - 0.0%)	
	Krewski et al. (2000) - ACS	All cause	30+		SO2	73 (-127 - 299) 0.4% (-0.6% - 1.4%)	11 (-19 - 46) 0.1% (-0.1% - 0.2%)	0 (0 - 0) 0.0% (0.0% - 0.0%)	

*For the short-term exposure studies, incidence was quantified down to policy relevant background level of 2.5 µg/m3, as well as down to each of the alternative cutpoints. For the long-term exposure studies, incidence was quantified down to 7.5 µg/m3, the lowest of the lowest measured levels in the long-term exposure studies, as well as down to each of the alternative cutpoints. For the cutpoints above policy relevant background, the slope of the C-R function has been modified based on a simple hockeystick model (see discussion in section 2.5).

**Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Exhibit D.13. Estimated Annual Mortality Associated with Short-Term and Long-Term Exposure to "As Is" PM$_{2.5}$ Concentrations Assuming Various Cutpoint Levels*

Pittsburgh, PA, 2003

Health Effects	Study	Type	Ages	Lag	Other Pollutants in Model	Incidence Associated with PM2.5 Assuming Various Cutpoint Levels** (95% Confidence Interval) Percent of Total Incidence (95% Confidence Interval)			
						Policy Relevant Background =3.5 µg/m3	Cutpoint =10 µg/m3	Cutpoint =15 µg/m3	Cutpoint =20 µg/m3
Short-Term Exposure Mortality	Single Pollutant Models (Total Mortality)								
	Chock et al. (2000)	Non-accidental	<75	0 day		69 (-55 - 188) 1.4% (-1.1% - 3.7%)	43 (-34 - 117) 0.8% (-0.7% - 2.3%)	28 (-22 - 76) 0.5% (-0.4% - 1.5%)	18 (-14 - 48) 0.4% (-0.3% - 1.0%)
	Chock et al. (2000)	Non-accidental	75+	0 day		77 (-166 - 311) 0.8% (-1.7% - 3.2%)	48 (-103 - 193) 0.5% (-1.1% - 2.0%)	31 (-67 - 125) 0.3% (-0.7% - 1.3%)	20 (-43 - 80) 0.2% (-0.4% - 0.8%)
	Multi-Pollutant Models (Total Mortality)								
	Chock et al. (2000)	Non-accidental	<75	0 day	CO, O3, SO2, NO2, PM10-2.5	88 (-60 - 230) 1.7% (-1.2% - 4.5%)	55 (-37 - 143) 1.1% (-0.7% - 2.8%)	36 (-24 - 92) 0.7% (-0.5% - 1.8%)	23 (-15 - 59) 0.5% (-0.3% - 1.2%)
	Chock et al. (2000)	Non-accidental	75+	0 day	CO, O3, SO2, NO2, PM10-2.5	52 (-238 - 330) 0.5% (-2.4% - 3.4%)	32 (-148 - 204) 0.3% (-1.5% - 2.1%)	21 (-96 - 133) 0.2% (-1.0% - 1.4%)	14 (-62 - 85) 0.1% (-0.6% - 0.9%)
Long-Term Exposure Mortality						Cutpoint = 7.5 µg/m3	Cutpoint =10 µg/m3	Cutpoint =12 µg/m3	
	Single Pollutant Models								
	Krewski et al. (2000) - ACS	All cause	30+			651 (338 - 988) 4.3% (2.2% - 6.5%)	524 (272 - 797) 3.4% (1.8% - 5.2%)	403 (209 - 614) 2.6% (1.4% - 4.0%)	
	Pope et al. (2002) - ACS extended	All cause	30+			816 (282 - 1430) 5.4% (1.9% - 9.4%)	678 (234 - 1193) 4.5% (1.5% - 7.8%)	539 (185 - 951) 3.5% (1.2% - 6.2%)	
	Multi-Pollutant Models								
	Krewski et al. (2000) - ACS	All cause	30+		CO	942 (550 - 1341) 6.2% (3.6% - 8.8%)	759 (442 - 1084) 5.0% (2.9% - 7.1%)	585 (340 - 838) 3.8% (2.2% - 5.5%)	
	Krewski et al. (2000) - ACS	All cause	30+		NO2	1124 (601 - 1586) 7.4% (3.9% - 10.4%)	907 (483 - 1284) 6.0% (3.2% - 8.4%)	700 (372 - 994) 4.6% (2.4% - 6.5%)	
	Krewski et al. (2000) - ACS	All cause	30+		O3	942 (550 - 1341) 6.2% (3.6% - 8.8%)	759 (442 - 1084) 5.0% (2.9% - 7.1%)	585 (340 - 838) 3.8% (2.2% - 5.5%)	
	Krewski et al. (2000) - ACS	All cause	30+		SO2	173 (-304 - 701) 1.1% (-2.0% - 4.6%)	138 (-243 - 564) 0.9% (-1.6% - 3.7%)	106 (-186 - 434) 0.7% (-1.2% - 2.9%)	

*For the short-term exposure studies, incidence was quantified down to policy relevant background level of 3.5 µg/m3, as well as down to each of the alternative cutpoints. For the long-term exposure studies, incidence was quantified down to 7.5 µg/m3, the lowest of the lowest measured levels in the long-term exposure studies, as well as down to each of the alternative cutpoints. For the cutpoints above policy relevant background, the slope of the C-R function has been modified based on a simple hockeystick model (see discussion in section 2.5).

**Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Exhibit D.14. Estimated Annual Health Risks of Short-Term and Long-Term Exposure Mortality Associated with "As Is" PM$_{2.5}$ Concentrations Assuming Various Cutpoint Levels*

San Jose, CA, 2003

Health Effects	Study	Type	Ages	Lag	Other Pollutants in Model	Incidence Associated with PM2.5 Assuming Various Cutpoint Levels** (95% Confidence Interval) Percent of Total Incidence (95% Confidence Interval)			
						Policy Relevant Background =2.5 µg/m3	Cutpoint =10 µg/m3	Cutpoint =15 µg/m3	Cutpoint =20 µg/m3
Short-Term Exposure Mortality	Single Pollutant Models (Total Mortality)								
	Fairley (2003) [reanalysis of Fairley (1999)]	Non-accidental	all	0 day		218 (45 - 387) 2.6% (0.5% - 4.7%)	80 (17 - 141) 1.0% (0.2% - 1.7%)	44 (9 - 77) 0.5% (0.1% - 0.9%)	28 (6 - 50) 0.3% (0.1% - 0.6%)
	Fairley (2003) [reanalysis of Fairley (1999)]	Non-accidental	all	1 day		-110 (-278 - 50) -1.3% (-3.4% - 0.6%)	-41 (-103 - 18) -0.5% (-1.2% - 0.2%)	-22 (-57 - 10) -0.3% (-0.7% - 0.1%)	-14 (-37 - 7) -0.2% (-0.4% - 0.1%)
	Multi-Pollutant Models (Total Mortality)								
	Fairley (2003) [reanalysis of Fairley (1999)]	Non-accidental	all	0 day	NO2	277 (74 - 472) 3.3% (0.9% - 5.7%)	101 (27 - 172) 1.2% (0.3% - 2.1%)	56 (15 - 94) 0.7% (0.2% - 1.1%)	36 (10 - 60) 0.4% (0.1% - 0.7%)
	Fairley (2003) [reanalysis of Fairley (1999)]	Non-accidental	all	0 day	CO	251 (60 - 432) 3.0% (0.7% - 5.2%)	92 (22 - 158) 1.1% (0.3% - 1.9%)	51 (12 - 86) 0.6% (0.2% - 1.0%)	32 (8 - 55) 0.4% (0.1% - 0.7%)
	Fairley (2003) [reanalysis of Fairley (1999)]	Non-accidental	all	0 day	O3 - 8hr	236 (60 - 404) 2.8% (0.7% - 4.9%)	86 (22 - 148) 1.0% (0.3% - 1.8%)	47 (12 - 81) 0.6% (0.2% - 1.0%)	30 (8 - 52) 0.4% (0.1% - 0.6%)
Long-Term Exposure Mortality						Cutpoint = 7.5 µg/m3	Cutpoint =10 µg/m3	Cutpoint =12 µg/m3	
	Single Pollutant Models								
	Krewski et al. (2000) - ACS	All cause	30+			137 (71 - 210) 1.6% (0.8% - 2.5%)	45 (23 - 68) 0.5% (0.3% - 0.8%)	0 (0 - 0) 0.0% (0.0% - 0.0%)	
	Pope et al. (2002) - ACS extended	All cause	30+			172 (59 - 306) 2.1% (0.7% - 3.6%)	58 (20 - 104) 0.7% (0.2% - 1.2%)	0 (0 - 0) 0.0% (0.0% - 0.0%)	
	Multi-Pollutant Models								
	Krewski et al. (2000) - ACS	All cause	30+		CO	199 (115 - 287) 2.4% (1.4% - 3.4%)	65 (38 - 94) 0.8% (0.5% - 1.1%)	0 (0 - 0) 0.0% (0.0% - 0.0%)	
	Krewski et al. (2000) - ACS	All cause	30+		NO2	239 (126 - 341) 2.9% (1.5% - 4.1%)	78 (41 - 112) 0.9% (0.5% - 1.3%)	0 (0 - 0) 0.0% (0.0% - 0.0%)	
	Krewski et al. (2000) - ACS	All cause	30+		O3	199 (115 - 287) 2.4% (1.4% - 3.4%)	65 (38 - 94) 0.8% (0.5% - 1.1%)	0 (0 - 0) 0.0% (0.0% - 0.0%)	
	Krewski et al. (2000) - ACS	All cause	30+		SO2	36 (-63 - 148) 0.4% (-0.8% - 1.8%)	12 (-20 - 48) 0.1% (-0.2% - 0.6%)	0 (0 - 0) 0.0% (0.0% - 0.0%)	

*For the short-term exposure studies, incidence was quantified down to policy relevant background level of 2.5 µg/m3, as well as down to each of the alternative cutpoints. For the long-term exposure studies, incidence was quantified down to 7.5 µg/m3, the lowest of the lowest measured levels in the long-term exposure studies, as well as down to each of the alternative cutpoints. For the cutpoints above policy relevant background, the slope of the C-R function has been modified based on a simple hockeystick model (see discussion in section 2.5).

**Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Exhibit D.15. Estimated Annual Health Risks of Short-Term and Long-Term Exposure Mortality Associated with "As Is" PM$_{2.5}$ Concentrations Assuming Various Cutpoint Levels*

Seattle, WA, 2003

Health Effects	Study	Type	Ages	Lag	Other Pollutants in Model	Incidence Associated with PM2.5 Assuming Various Cutpoint Levels** (95% Confidence Interval) Percent of Total Incidence (95% Confidence Interval)		
						Cutpoint = 7.5 µg/m3	Cutpoint =10 µg/m3	Cutpoint =12 µg/m3
Long-Term Exposure Mortality								
	Single Pollutant Models							
	Krewski et al. (2000) - ACS	All cause	30+			40 (20 - 61) 0.4% (0.2% - 0.6%)	0 (0 - 0) 0.0% (0.0% - 0.0%)	0 (0 - 0) 0.0% (0.0% - 0.0%)
	Pope et al. (2002) - ACS extended	All cause	30+			50 (17 - 89) 0.5% (0.2% - 0.8%)	0 (0 - 0) 0.0% (0.0% - 0.0%)	0 (0 - 0) 0.0% (0.0% - 0.0%)
	Multi-Pollutant Models							
	Krewski et al. (2000) - ACS	All cause	30+		CO	58 (33 - 83) 0.5% (0.3% - 0.8%)	0 (0 - 0) 0.0% (0.0% - 0.0%)	0 (0 - 0) 0.0% (0.0% - 0.0%)
	Krewski et al. (2000) - ACS	All cause	30+		NO2	69 (36 - 99) 0.6% (0.3% - 0.9%)	0 (0 - 0) 0.0% (0.0% - 0.0%)	0 (0 - 0) 0.0% (0.0% - 0.0%)
	Krewski et al. (2000) - ACS	All cause	30+		O3	58 (33 - 83) 0.5% (0.3% - 0.8%)	0 (0 - 0) 0.0% (0.0% - 0.0%)	0 (0 - 0) 0.0% (0.0% - 0.0%)
	Krewski et al. (2000) - ACS	All cause	30+		SO2	10 (-18 - 43) 0.1% (-0.2% - 0.4%)	0 (0 - 0) 0.0% (0.0% - 0.0%)	0 (0 - 0) 0.0% (0.0% - 0.0%)

*For the short-term exposure studies, incidence was quantified down to policy relevant background level of 2.5 µg/m3, as well as down to each of the alternative cutpoints. For the long-term exposure studies, incidence was quantified down to 7.5 µg/m3, the lowest of the lowest measured levels in the long-term exposure studies, as well as down to each of the alternative cutpoints. For the cutpoints above policy relevant background, the slope of the C-R function has been modified based on a simple hockeystick model (see discussion in section 2.5).

**Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Exhibit D.16. Estimated Annual Mortality Associated with Short-Term and Long-Term Exposure to "As Is"
PM$_{2.5}$ Concentrations Assuming Various Cutpoint Levels*

St. Louis, MO, 2003

Health Effects	Study	Type	Ages	Lag	Other Pollutants in Model	Incidence Associated with PM2.5 Assuming Various Cutpoint Levels** (95% Confidence Interval) Percent of Total Incidence (95% Confidence Interval)			
						Policy Relevant Background =3.5 µg/m3	Cutpoint =10 µg/m3	Cutpoint =15 µg/m3	Cutpoint =20 µg/m3
Short-Term Exposure Mortality						**Single Pollutant Models (Total Mortality)**			
	Schwartz (2003b) [reanalysis of Schwartz et al. (1996)]	Non-accidental	all	mean of lag 0 & 1		233 (86 - 379) 1.1% (0.4% - 1.7%)	114 (42 - 185) 0.5% (0.2% - 0.8%)	55 (20 - 89) 0.3% (0.1% - 0.4%)	23 (8 - 38) 0.1% (0.0% - 0.2%)
	Schwartz (2003b) [reanalysis of Schwartz et al. (1996)] -- 6 cities	Non-accidental	all	mean of lag 0 & 1		312 (224 - 401) 1.4% (1.0% - 1.8%)	146 (105 - 188) 0.7% (0.5% - 0.9%)	68 (49 - 87) 0.3% (0.2% - 0.4%)	28 (20 - 35) 0.1% (0.1% - 0.2%)
Long-Term Exposure Mortality						Cutpoint = 7.5 µg/m3	Cutpoint =10 µg/m3	Cutpoint =12 µg/m3	
						Single Pollutant Models			
	Krewski et al. (2000) - Six Cities	All cause	25+			1773 (606 - 2878) 7.8% (2.7% - 12.6%)	1247 (423 - 2041) 5.5% (1.9% - 9.0%)	706 (238 - 1165) 3.1% (1.0% - 5.1%)	
	Krewski et al. (2000) - ACS	All cause	30+			671 (348 - 1022) 3.0% (1.5% - 4.5%)	453 (234 - 691) 2.0% (1.0% - 3.1%)	246 (127 - 376) 1.1% (0.6% - 1.7%)	
	Pope et al. (2002) - ACS extended	All cause	30+			842 (290 - 1486) 3.7% (1.3% - 6.6%)	587 (201 - 1041) 2.6% (0.9% - 4.6%)	330 (113 - 587) 1.5% (0.5% - 2.6%)	
						Multi-Pollutant Models			
	Krewski et al. (2000) - ACS	All cause	30+		CO	973 (566 - 1392) 4.3% (2.5% - 6.2%)	658 (381 - 944) 2.9% (1.7% - 4.2%)	358 (207 - 516) 1.6% (0.9% - 2.3%)	
	Krewski et al. (2000) - ACS	All cause	30+		NO2	1164 (619 - 1651) 5.2% (2.7% - 7.3%)	788 (417 - 1122) 3.5% (1.9% - 5.0%)	430 (227 - 614) 1.9% (1.0% - 2.7%)	
	Krewski et al. (2000) - ACS	All cause	30+		O3	973 (566 - 1392) 4.3% (2.5% - 6.2%)	658 (381 - 944) 2.9% (1.7% - 4.2%)	358 (207 - 516) 1.6% (0.9% - 2.3%)	
	Krewski et al. (2000) - ACS	All cause	30+		SO2	177 (-310 - 723) 0.8% (-1.4% - 3.2%)	119 (-208 - 488) 0.5% (-0.9% - 2.2%)	64 (-112 - 265) 0.3% (-0.5% - 1.2%)	

*For the short-term exposure studies, incidence was quantified down to policy relevant background level of 3.5 µg/m3, as well as down to each of the alternative cutpoints. For the long-term exposure studies, incidence was quantified down to 7.5 µg/m3, the lowest of the lowest measured levels in the long-term exposure studies, as well as down to each of the alternative cutpoints. For the cutpoints above policy relevant background, the slope of the C-R function has been modified based on a simple hockeystick model (see discussion in section 2.5).

**Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Exhibit D.17. Sensitivity Analysis: Estimated Annual Health Risks Associated with Short-Term Exposure to "As Is" PM$_{2.5}$ Concentrations, Using Different Estimates of Policy Relevant Background Level
Boston, MA, 2003

Health Effects	Study	Type	Ages	Lag	Other Pollutants in Model	Health Effects Associated with PM2.5 Above Policy Relevant Background of: *					
						2 ug/m3		3.5 ug/m3		5 ug/m3	
						Incidence	Percent of Total Incidence	Incidence	Percent of Total Incidence	Incidence	Percent of Total Incidence
Short-Term Exposure Mortality	Single Pollutant Models (Total Mortality)										
	Schwartz (2003b) [reanalysis of Schwartz et al. (1996)]	Non-accidental	all	mean of lag 0 & 1		455 (310 - 600)	2.1% (1.4% - 2.8%)	390 (265 - 514)	1.8% (1.2% - 2.4%)	325 (221 - 428)	1.5% (1.0% - 2.0%)
	Schwartz (2003b) [reanalysis of Schwartz et al. (1996)] -- 6 cities	Non-accidental	all	mean of lag 0 & 1		304 (218 - 390)	1.4% (1.0% - 1.8%)	261 (186 - 334)	1.2% (0.9% - 1.5%)	217 (155 - 278)	1.0% (0.7% - 1.3%)
	Single Pollutant Models (Cause-Specific Mortality)										
	Klemm and Mason (2003) [reanalysis of Klemm et al. (2000)]	COPD	all	0 day		28 (-14 - 66)	2.8% (-1.4% - 6.5%)	24 (-12 - 56)	2.4% (-1.2% - 5.6%)	20 (-10 - 47)	2.0% (-1.0% - 4.6%)
	Klemm and Mason (2003) [reanalysis of Klemm et al. (2000)]	Ischemic heart disease	all	0 day		92 (52 - 131)	2.7% (1.5% - 3.8%)	79 (44 - 112)	2.3% (1.3% - 3.3%)	66 (37 - 93)	1.9% (1.1% - 2.7%)
	Klemm and Mason (2003) [reanalysis of Klemm et al. (2000)]	Pneumonia	all	0 day		42 (19 - 62)	5.7% (2.6% - 8.5%)	36 (16 - 53)	4.9% (2.2% - 7.3%)	30 (14 - 44)	4.1% (1.9% - 6.1%)
	Klemm and Mason (2003) [reanalysis of Klemm et al. (2000)] -- 6 cities	COPD	all	0 day		23 (1 - 45)	2.3% (0.1% - 4.4%)	20 (1 - 38)	2.0% (0.1% - 3.8%)	17 (1 - 32)	1.6% (0.1% - 3.1%)
	Klemm and Mason (2003) [reanalysis of Klemm et al. (2000)] -- 6 cities	Ischemic heart disease	all	0 day		62 (38 - 85)	1.8% (1.1% - 2.5%)	53 (33 - 73)	1.6% (1.0% - 2.1%)	44 (27 - 61)	1.3% (0.8% - 1.8%)
	Klemm and Mason (2003) [reanalysis of Klemm et al. (2000)] -- 6 cities	Pneumonia	all	0 day		30 (14 - 44)	4.0% (1.9% - 5.9%)	25 (12 - 37)	3.5% (1.6% - 5.1%)	21 (10 - 31)	2.9% (1.4% - 4.3%)
Respiratory Symptoms**	Single Pollutant Models										
	Schwartz and Neas (2000) -- 6 cities	Lower respiratory symptoms	7-14	1 day		9100 (4400 - 16700)	17.4% (8.5% - 32.1%)	7900 (3800 - 14500)	15.1% (7.3% - 27.9%)	6700 (3200 - 12300)	12.8% (6.1% - 23.6%)
	Schwartz and Neas (2000) -- 6 cities	Cough	7-14	0 day		14500 (-1100 - 28100)	9.6% (-0.7% - 18.6%)	12500 (-900 - 24300)	8.3% (-0.6% - 16.1%)	10500 (-800 - 20500)	6.9% (-0.5% - 13.5%)
	Multi-Pollutant Models										
	Schwartz and Neas (2000) -- 6 cities	Lower respiratory symptoms	7-14	1 day	PM10-2.5	8200 (2500 - 16500)	15.8% (4.8% - 31.7%)	7100 (2200 - 14300)	13.7% (4.2% - 27.6%)	6000 (1800 - 12100)	11.6% (3.5% - 23.3%)
	Schwartz and Neas (2000) -- 6 cities	Cough	7-14	0 day	PM10-2.5	6900 (-11600 - 21800)	4.5% (-7.6% - 14.4%)	5900 (-9900 - 18900)	3.9% (-6.5% - 12.5%)	4900 (-8200 - 15800)	3.3% (-5.4% - 10.5%)

*Incidences are rounded to the nearest whole number, except respiratory symptoms incidences which are rounded to the nearest 100; percents are rounded to the nearest tenth.
**The C-R functions for lower respiratory symptoms and cough were calculated for the summer period April 1 through August 31.
Note 1: Numbers in parentheses are 95% confidence intervals based on statistical uncertainty surrounding the PM2.5 coefficient.
Note 2: Multi-city short-term exposure C-R functions were applied only to urban areas included among the cities used to estimate the function

Exhibit D.18a. Sensitivity Analysis: Estimated Annual Mortality Associated with Short-Term Exposure to "As Is" PM$_{2.5}$ Concentrations, Using Different Estimates of Policy Relevant Background Level
Los Angeles, CA, 2003

Health Effects	Study	Type	Ages	Model	Lag	Other Pollutants in Model	Health Effects Associated with PM2.5 Above Policy Relevant Background of: *					
							1 ug/m3		2.5 ug/m3		4 ug/m3	
							Incidence	Percent of Total Incidence	Incidence	Percent of Total Incidence	Incidence	Percent of Total Incidence
							Single Pollutant Models (Total Mortality)					
Short-Term Exposure Mortality	Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Non-accidental	all	log-linear, GAM (stringent), 30 df	0 day		539 (-67 - 1131)	1.0% (-0.1% - 2.1%)	494 (-62 - 1038)	0.9% (-0.1% - 1.9%)	450 (-56 - 945)	0.8% (-0.1% - 1.7%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Non-accidental	all	log-linear, GAM (stringent), 30 df	1 day		588 (2 - 1162)	1.1% (0.0% - 2.1%)	540 (2 - 1067)	1.0% (0.0% - 1.9%)	491 (1 - 971)	0.9% (0.0% - 1.8%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Non-accidental	all	log-linear, GAM (stringent), 30 df	0 day		539 (-67 - 1131)	1.0% (-0.1% - 2.1%)	494 (-62 - 1038)	0.9% (-0.1% - 1.9%)	450 (-56 - 945)	0.8% (-0.1% - 1.7%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Non-accidental	all	log-linear, GAM (stringent), 30 df	1 day		588 (2 - 1162)	1.1% (0.0% - 2.1%)	540 (2 - 1067)	1.0% (0.0% - 1.9%)	491 (1 - 971)	0.9% (0.0% - 1.8%)
							Single Pollutant Models (Cause-Specific Mortality)					
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Cardiovascular	all	log-linear, GAM (stringent), 30 df	0 day		350 (36 - 654)	1.8% (0.2% - 3.3%)	321 (33 - 601)	1.6% (0.2% - 3.1%)	292 (30 - 547)	1.5% (0.2% - 2.8%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Cardiovascular	all	log-linear, GAM (stringent), 30 df	1 day		364 (56 - 662)	1.9% (0.3% - 3.4%)	334 (52 - 608)	1.7% (0.3% - 3.1%)	304 (47 - 554)	1.5% (0.2% - 2.8%)
							Multi-Pollutant Models (Total Mortality)					
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Non-accidental	all	log-linear, GAM (stringent), 30 df	1 day	CO	-536 (-1347 - 252)	-1.0% (-2.4% - 0.5%)	-492 (-1235 - 232)	-0.9% (-2.2% - 0.4%)	-447 (-1123 - 211)	-0.8% (-2.0% - 0.4%)
							Multi-Pollutant Models (Cause-Specific Mortality)					
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Cardiovascular	all	log-linear, GAM (stringent), 100 df	0 day	CO	623 (271 - 963)	3.2% (1.4% - 4.9%)	572 (249 - 884)	2.9% (1.3% - 4.5%)	521 (226 - 806)	2.6% (1.2% - 4.1%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Cardiovascular	all	log-linear, GAM (stringent), 100 df	1 day	CO	322 (-44 - 675)	1.6% (-0.2% - 3.4%)	296 (-40 - 620)	1.5% (-0.2% - 3.1%)	269 (-37 - 564)	1.4% (-0.2% - 2.9%)

*Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.
Note: Numbers in parentheses are 95% confidence intervals based on statistical uncertainty surrounding the PM2.5 coefficient.

Exhibit D.18b. Sensitivity Analysis: Estimated Annual Morbidity Associated with Short-Term Exposure to "As Is" PM$_{2.5}$ Concentrations, Using Different Estimates of Policy Relevant Background Level
Los Angeles, CA, 2003

Health Effects	Study	Type	Ages	Model	Lag	Other Pollutants in Model	Health Effects Associated with PM2.5 Above Policy Relevant Background of:*					
							1 ug/m3		2.5 ug/m3		4 ug/m3	
							Incidence	Percent of Total Incidence	Incidence	Percent of Total Incidence	Incidence	Percent of Total Incidence
Hospital Admissions							**Single Pollutant Models**					
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000b)]	Cardiovascular	65+	log-linear, GAM (stringent), 30 df	0 day		1947 (1135 - 2740)	2.8% (1.6% - 4.0%)	1787 (1042 - 2516)	2.6% (1.5% - 3.6%)	1627 (949 - 2291)	2.4% (1.4% - 3.3%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000b)]	Cardiovascular	65+	log-linear, GAM (stringent), 30 df	1 day		1717 (866 - 2547)	2.5% (1.3% - 3.7%)	1576 (795 - 2339)	2.3% (1.2% - 3.4%)	1435 (724 - 2130)	2.1% (1.0% - 3.1%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000c)]	COPD+	all	log-linear, GAM (stringent), 30 df	0 day		897 (377 - 1400)	3.0% (1.3% - 4.6%)	824 (346 - 1286)	2.7% (1.1% - 4.3%)	750 (315 - 1171)	2.5% (1.0% - 3.9%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000c)]	COPD+	all	log-linear, GAM (stringent), 30 df	1 day		643 (125 - 1144)	2.1% (0.4% - 3.8%)	591 (115 - 1050)	2.0% (0.4% - 3.5%)	538 (105 - 957)	1.8% (0.4% - 3.2%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000c)]	COPD+	all	log-linear, GAM (stringent), 30 df	2 day		992 (454 - 1511)	3.3% (1.5% - 5.0%)	911 (417 - 1387)	3.0% (1.4% - 4.6%)	829 (380 - 1264)	2.7% (1.3% - 4.2%)
							Multi-Pollutant Models					
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000b)]	Cardiovascular	65+	log-linear, GAM (stringent), 100 df	0 day	CO	488 (-558 - 1503)	0.7% (-0.8% - 2.2%)	448 (-512 - 1380)	0.7% (-0.7% - 2.0%)	407 (-466 - 1256)	0.6% (-0.7% - 1.8%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000b)]	Cardiovascular	65+	log-linear, GAM (stringent), 100 df	1 day	CO	301 (-823 - 1390)	0.4% (-1.2% - 2.0%)	276 (-755 - 1276)	0.4% (-1.1% - 1.8%)	251 (-687 - 1161)	0.4% (-1.0% - 1.7%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000c)]	COPD+	all	log-linear, GAM (stringent), 100 df	0 day	NO2	229 (-506 - 931)	0.8% (-1.7% - 3.1%)	210 (-464 - 855)	0.7% (-1.5% - 2.8%)	192 (-422 - 778)	0.6% (-1.4% - 2.6%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000c)]	COPD+	all	log-linear, GAM (stringent), 100 df	1 day	NO2	-22 (-909 - 817)	-0.1% (-3.0% - 2.7%)	-20 (-833 - 750)	-0.1% (-2.8% - 2.5%)	-18 (-758 - 682)	-0.1% (-2.5% - 2.3%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000c)]	COPD+	all	log-linear, GAM (stringent), 100 df	2 day	NO2	191 (-571 - 917)	0.6% (-1.9% - 3.0%)	176 (-524 - 842)	0.6% (-1.7% - 2.8%)	160 (-476 - 767)	0.5% (-1.6% - 2.5%)

*Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Note: Numbers in parentheses are 95% confidence intervals based on statistical uncertainty surrounding the PM2.5 coefficient.

Exhibit D.19. Sensitivity Analysis: Estimated Annual Health Risks Associated with Short-Term Exposure to "As Is" PM$_{2.5}$ Concentrations, Using Different Estimates of Policy Relevant Background Level
Philadelphia, PA, 2003

Health Effects	Study	Type	Ages	Lag	Other Pollutants in Model	Health Effects Associated with PM2.5 Above Policy Relevant Background of: *					
						2 ug/m3		3.5 ug/m3		5 ug/m3	
						Incidence	Percent of Total Incidence	Incidence	Percent of Total Incidence	Incidence	Percent of Total Incidence
Short-Term Exposure Mortality	Single Pollutant Models (Cause-Specific Mortality)										
	Lipfert et al. (2000) -- 7 counties	Cardiovascular	all	1 day		469 (224 - 714)	2.9% (1.4% - 4.4%)	412 (197 - 628)	2.5% (1.2% - 3.9%)	357 (170 - 544)	2.2% (1.1% - 3.4%)

*Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Note 1: Numbers in parentheses are 95% confidence intervals based on statistical uncertainty surrounding the PM2.5 coefficient.

Note 2: Multi-county short-term exposure C-R functions were applied only to counties included among those used to estimate the function.

Exhibit D.20. Sensitivity Analysis: Estimated Annual Health Risks Associated with Short-Term Exposure to "As Is" PM$_{2.5}$ Concentrations, Using Different Estimates of Policy Relevant Background Level
Phoenix, AZ, 2001

Health Effects*	Study	Type	Ages	Lag	Other Pollutants in Model	Health Effects Associated with PM2.5 Above Policy Relevant Background of: *					
						1 ug/m3		2.5 ug/m3		4 ug/m3	
						Incidence**	Percent of Total Incidence**	Incidence**	Percent of Total Incidence**	Incidence**	Percent of Total Incidence**
Short-Term Exposure Mortality	Single Pollutant Models (Cause-Specific Mortality)										
	Mar (2003) [reanalysis of Mar (2000)]	Cardiovascular	65+	0 day		219 (-62 - 483)	3.4% (-1.0% - 7.5%)	185 (-52 - 407)	2.9% (-0.8% - 6.3%)	150 (-42 - 331)	2.3% (-0.7% - 5.1%)
	Mar (2003) [reanalysis of Mar (2000)]	Cardiovascular	65+	1 day		383 (115 - 636)	5.9% (1.8% - 9.9%)	323 (97 - 536)	5.0% (1.5% - 8.3%)	262 (79 - 435)	4.1% (1.2% - 6.7%)

*Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.
Note: Numbers in parentheses are 95% confidence intervals based on statistical uncertainty surrounding the PM2.5 coefficient.

Exhibit D.21. Sensitivity Analysis: Estimated Annual Health Risks Associated with Short-Term Exposure to "As Is" PM$_{2.5}$ Concentrations, Using Different Estimates of Policy Relevant Background Level
Pittsburgh, PA, 2003

Health Effects	Study	Type	Ages	Lag	Other Pollutants in Model	Health Effects Associated with PM2.5 Above Policy Relevant Background of: *					
						2 ug/m3		3.5 ug/m3		5 ug/m3	
						Incidence	Percent of Total Incidence	Incidence	Percent of Total Incidence	Incidence	Percent of Total Incidence
Short-Term Exposure Mortality	**Single Pollutant Models (Total Mortality)**										
	Chock et al. (2000)	Non-accidental	<75	0 day		71 (-57 - 195)	1.4% (-1.1% - 3.8%)	69 (-55 - 188)	1.4% (-1.1% - 3.7%)	61 (-49 - 168)	1.2% (-1.0% - 3.3%)
	Chock et al. (2000)	Non-accidental	75+	0 day		80 (-172 - 322)	0.8% (-1.8% - 3.3%)	77 (-166 - 311)	0.8% (-1.7% - 3.2%)	69 (-148 - 277)	0.7% (-1.5% - 2.8%)
	Multi-Pollutant Models (Total Mortality)										
	Chock et al. (2000)	Non-accidental	<75	0 day	CO, O3, SO2, NO2, PM10-2.5	92 (-62 - 238)	1.8% (-1.2% - 4.7%)	88 (-60 - 230)	1.7% (-1.2% - 4.5%)	79 (-53 - 205)	1.5% (-1.0% - 4.0%)
	Chock et al. (2000)	Non-accidental	75+	0 day	CO, O3, SO2, NO2, PM10-2.5	54 (-247 - 342)	0.6% (-2.5% - 3.5%)	52 (-238 - 330)	0.5% (-2.4% - 3.4%)	47 (-212 - 294)	0.5% (-2.2% - 3.0%)

*Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.
Note: Numbers in parentheses are 95% confidence intervals based on statistical uncertainty surrounding the PM2.5 coefficient.

Exhibit D.22. Sensitivity Analysis: Estimated Annual Health Risks Associated with Short-Term Exposure to "As Is" PM$_{2.5}$ Concentrations, Using Different Estimates of Policy Relevant Background Level

San Jose, CA, 2003

Health Effects	Study	Type	Ages	Lag	Other Pollutants in Model	Health Effects Associated with PM2.5 Above Policy Relevant Background of: *					
						1 ug/m3		2.5 ug/m3		4 ug/m3	
						Incidence	Percent of Total Incidence	Incidence	Percent of Total Incidence	Incidence	Percent of Total Incidence
Short-Term Exposure Mortality	Single Pollutant Models (Total Mortality)										
	Fairley (2003) [reanalysis of Fairley (1999)]	Non-accidental	all	0 day		231 (48 - 409)	2.8% (0.6% - 4.9%)	218 (45 - 387)	2.6% (0.5% - 4.7%)	181 (37 - 320)	2.2% (0.5% - 3.9%)
	Fairley (2003) [reanalysis of Fairley (1999)]	Non-accidental	all	1 day		-117 (-295 - 53)	-1.4% (-3.6% - 0.6%)	-110 (-278 - 50)	-1.3% (-3.4% - 0.6%)	-91 (-230 - 41)	-1.1% (-2.8% - 0.5%)
	Single Pollutant Models (Cause-Specific Mortality)										
	Fairley (2003) [reanalysis of Fairley (1999)]	Respiratory	all	0 day		34 (-34 - 93)	3.9% (-3.9% - 10.8%)	32 (-32 - 88)	3.7% (-3.7% - 10.2%)	26 (-26 - 73)	3.1% (-3.0% - 8.4%)
	Fairley (2003) [reanalysis of Fairley (1999)]	Cardiovascular	all	0 day		76 (-53 - 199)	2.2% (-1.5% - 5.7%)	72 (-50 - 188)	2.1% (-1.5% - 5.4%)	60 (-42 - 155)	1.7% (-1.2% - 4.5%)
	Multi-Pollutant Models (Total Mortality)										
	Fairley (2003) [reanalysis of Fairley (1999)]	Non-accidental	all	0 day	NO2	293 (79 - 499)	3.5% (1.0% - 6.0%)	277 (74 - 472)	3.3% (0.9% - 5.7%)	229 (62 - 390)	2.8% (0.7% - 4.7%)
	Fairley (2003) [reanalysis of Fairley (1999)]	Non-accidental	all	0 day	CO	266 (63 - 457)	3.2% (0.8% - 5.5%)	251 (60 - 432)	3.0% (0.7% - 5.2%)	208 (49 - 357)	2.5% (0.6% - 4.3%)
	Fairley (2003) [reanalysis of Fairley (1999)]	Non-accidental	all	0 day	O3 - 8hr	250 (63 - 428)	3.0% (0.8% - 5.2%)	236 (60 - 404)	2.8% (0.7% - 4.9%)	195 (49 - 335)	2.4% (0.6% - 4.0%)

*Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.
Note: Numbers in parentheses are 95% confidence intervals based on statistical uncertainty surrounding the PM2.5 coefficient.

Exhibit D.23. Sensitivity Analysis: Estimated Annual Health Risks Associated with Short-Term Exposure to "As Is" PM$_{2.5}$ Concentrations, Using Different Estimates of Policy Relevant Background Level
Seattle, WA, 2003

Health Effects	Study	Type	Ages	Lag	Other Pollutants in Model	Health Effects Associated with PM2.5 Above Policy Relevant Background of: *					
						1 ug/m3		2.5 ug/m3		4 ug/m3	
						Incidence	Percent of Total Incidence	Incidence	Percent of Total Incidence	Incidence	Percent of Total Incidence
Hospital Admission	**Single Pollutant Models**										
	Sheppard (2003) [reanalysis of Sheppard et al. (1999)]**	Asthma	<65	1 day		30 (8 - 45)	1.9% (0.5% - 2.8%)	30 (8 - 45)	1.9% (0.5% - 2.8%)	23 (6 - 34)	1.4% (0.4% - 2.1%)

*Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.
**Sheppard (2003) [reanalysis of Sheppard et al. (1999)] used daily PM2.5 values obtained from nephelometer measurements rather than from air quality monitors.
Note: Numbers in parentheses are 95% confidence intervals based on statistical uncertainty surrounding the PM2.5 coefficient.

Exhibit D.24. Sensitivity Analysis: Estimated Annual Health Risks Associated with Short-Term Exposure to "As Is" PM$_{2.5}$ Concentrations, Using Different Estimates of Policy Relevant Background Level
St. Louis, MO, 2003

Health Effects	Study	Type	Ages	Lag	Other Pollutants in Model	Health Effects Associated with PM2.5 Above Policy Relevant Background of: *					
						2 ug/m3		3.5 ug/m3		5 ug/m3	
						Incidence	Percent of Total Incidence	Incidence	Percent of Total Incidence	Incidence	Percent of Total Incidence
Short-Term Exposure Mortality	Single Pollutant Models (Total Mortality)										
	Schwartz (2003b) [reanalysis of Schwartz et al. (1996)]	Non-accidental	all	mean of lag 0 & 1		266 (98 - 433)	1.2% (0.5% - 2.0%)	233 (86 - 379)	1.1% (0.4% - 1.7%)	200 (74 - 326)	0.9% (0.3% - 1.5%)
	Schwartz (2003b) [reanalysis of Schwartz et al. (1996)] -- 6 cities	Non-accidental	all	mean of lag 0 & 1		357 (255 - 457)	1.6% (1.2% - 2.1%)	312 (224 - 401)	1.4% (1.0% - 1.8%)	268 (192 - 344)	1.2% (0.9% - 1.6%)
	Single Pollutant Models (Cause-Specific Mortality)										
	Klemm and Mason (2003) [reanalysis of Klemm et al. (2000)]	COPD	all	0 day		7 (-36 - 47)	0.7% (-3.6% - 4.8%)	6 (-31 - 42)	0.6% (-3.2% - 4.2%)	5 (-27 - 36)	0.5% (-2.7% - 3.6%)
	Klemm and Mason (2003) [reanalysis of Klemm et al. (2000)]	Ischemic heart disease	all	0 day		80 (19 - 145)	1.5% (0.4% - 2.8%)	70 (16 - 127)	1.4% (0.3% - 2.5%)	60 (14 - 109)	1.2% (0.3% - 2.1%)
	Klemm and Mason (2003) [reanalysis of Klemm et al. (2000)]	Pneumonia	all	0 day		9 (-21 - 36)	1.3% (-3.1% - 5.3%)	8 (-18 - 31)	1.1% (-2.7% - 4.7%)	7 (-16 - 27)	1.0% (-2.3% - 4.0%)
	Klemm and Mason (2003) [reanalysis of Klemm et al. (2000)] -- 6 cities	COPD	all	0 day		27 (1 - 51)	2.7% (0.1% - 5.1%)	23 (1 - 44)	2.4% (0.1% - 4.5%)	20 (1 - 38)	2.0% (0.1% - 3.9%)
	Klemm and Mason (2003) [reanalysis of Klemm et al. (2000)] -- 6 cities	Ischemic heart disease	all	0 day		110 (68 - 151)	2.1% (1.3% - 2.9%)	96 (59 - 132)	1.9% (1.1% - 2.6%)	83 (51 - 114)	1.6% (1.0% - 2.2%)
	Klemm and Mason (2003) [reanalysis of Klemm et al. (2000)] -- 6 cities	Pneumonia	all	0 day		31 (15 - 46)	4.7% (2.2% - 6.9%)	28 (13 - 41)	4.1% (2.0% - 6.1%)	24 (11 - 35)	3.5% (1.7% - 5.2%)
Respiratory Symptoms**	Single Pollutant Models										
	Schwartz and Neas (2000) -- 6 cities	Lower respiratory symptoms	7-14	1 day		12100 (4900 - 18100)	21.4% (8.6% - 32.1%)	10800 (4300 - 16300)	19.2% (7.7% - 28.9%)	9500 (3800 - 14400)	16.9% (6.7% - 25.6%)
	Schwartz and Neas (2000) -- 6 cities	Cough	7-14	0 day		19700 (-1400 - 37900)	12.0% (-0.9% - 23.0%)	17600 (-1300 - 34000)	10.7% (-0.8% - 20.7%)	15400 (-1100 - 29900)	9.4% (-0.7% - 18.2%)
	Multi-Pollutant Models										
	Schwartz and Neas (2000) -- 6 cities	Lower respiratory symptoms	7-14	1 day	PM10-2.5	11000 (2800 - 17900)	19.4% (4.9% - 31.7%)	9800 (2500 - 16100)	17.4% (4.4% - 28.6%)	8600 (2200 - 14300)	15.3% (3.8% - 25.3%)
	Schwartz and Neas (2000) -- 6 cities	Cough	7-14	0 day	PM10-2.5	9400 (-15900 - 29500)	5.7% (-9.7% - 18.0%)	8300 (-14000 - 26400)	5.1% (-8.5% - 16.0%)	7200 (-12100 - 23200)	4.4% (-7.4% - 14.1%)

*Incidences are rounded to the nearest whole number, except respiratory symptoms incidences which are rounded to the nearest 100; percents are rounded to the nearest tenth.
**The C-R functions for lower respiratory symptoms and cough were calculated for the summer period April 1 through August 31.
Note 1: Numbers in parentheses are 95% confidence intervals based on statistical uncertainty surrounding the PM2.5 coefficient.
Note 2: Multi-city short-term exposure C-R functions were applied only to urban areas included among the cities used to estimate the function.

Exhibit D.25. Sensitivity Analysis: Estimated Annual Health Risks of Short-Term Exposure Mortality Associated with "As Is" PM$_{2.5}$ Concentrations With Adjustments for the Estimated Increases in Incidence if Distributed Lag Models Had Been Estimated Boston, MA, 2003

Health Effects	Study	Type	Ages	Lag	Other Pollutants in Model	Health Effects Associated with PM-2.5 Above Policy Relevant Background:*			
						Single Lag		Adjusted for Distributed Lag	
						Incidence	Percent of Total Incidence	Incidence	Percent of Total Incidence
Short-Term Exposure Mortality	Single Pollutant Models (Total Mortality)								
	Schwartz (2003b) [reanalysis of Schwartz et al. (1996)]	Non-accidental	all	mean of lag 0 & 1		390 (265 - 514)	1.8% (1.2% - 2.4%)	761 (519 - 999)	3.5% (2.4% - 4.6%)
	Schwartz (2003b) [reanalysis of Schwartz et al. (1996)] -- 6 cities	Non-accidental	all	mean of lag 0 & 1		261 (186 - 334)	1.2% (0.9% - 1.5%)	511 (367 - 654)	2.4% (1.7% - 3.0%)

*Health effects incidence was quantified down to estimated policy relevant background level of 3.5 ug/m3. Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.
Note 1: Numbers in parentheses are 95% confidence intervals based on statistical uncertainty surrounding the PM2.5 coefficient.
Note 2: Multi-city short-term exposure C-R functions were applied only to urban areas included among the cities used to estimate the function.

Exhibit D.26. Sensitivity Analysis: Estimated Mortality Associated with Short-Term Exposure to "As Is" PM$_{2.5}$ Concentrations, With Adjustments for the Estimated Increases in Incidence if Distributed Lag Models Had Been Estimated
Los Angeles, CA, 2003

Health Effects	Study	Type	Ages	Model	Lag	Other Pollutants in Model	Health Effects Associated with PM2.5 Above Policy Relevant Background*			
							Single Lag		Adjusted for Distributed Lag	
							Incidence	Percent of Total Incidence	Incidence	Percent of Total Incidence
Short-Term Exposure Mortality	**Single Pollutant Models (Total Mortality)**									
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Non-accidental	all	log-linear, GAM (stringent), 30 df	0 day		494 (-62 - 1038)	0.9% (-0.1% - 1.9%)	971 (-122 - 2026)	1.8% (-0.2% - 3.7%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Non-accidental	all	log-linear, GAM (stringent), 30 df	1 day		540 (2 - 1067)	1.0% (0.0% - 1.9%)	1060 (3 - 2081)	1.9% (0.0% - 3.8%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Non-accidental	all	log-linear, GAM (stringent), 30 df	0 day		494 (-62 - 1038)	0.9% (-0.1% - 1.9%)	971 (-122 - 2026)	1.8% (-0.2% - 3.7%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Non-accidental	all	log-linear, GAM (stringent), 30 df	1 day		540 (2 - 1067)	1.0% (0.0% - 1.9%)	1060 (3 - 2081)	1.9% (0.0% - 3.8%)
	Multi-Pollutant Models (Total Mortality)									
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Non-accidental	all	log-linear, GAM (stringent), 30 df	1 day	CO	-492 (-1235 - 232)	-0.9% (-2.2% - 0.4%)	-979 (-2484 - 457)	-1.8% (-4.5% - 0.8%)

*Health effects incidence was quantified down to estimated policy relevant background level of 2.5 ug/m3. Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.
Note: Numbers in parentheses are 95% confidence intervals based on statistical uncertainty surrounding the PM2.5 coefficient.

Exhibit D.27. Sensitivity Analysis: Estimated Annual Mortality Associated with Short-Term Exposure to "As Is" PM$_{2.5}$ Concentrations With Adjustments for the Estimated Increases in Incidence if Distributed Lag Models Had Been Estimated Pittsburgh, PA, 2003

Health Effects	Study	Type	Ages	Lag	Other Pollutants in Model	Health Effects Associated with PM2.5 Above Policy Relevant Background*			
						Single Lag		Adjusted for Distributed Lag	
						Incidence	Percent of Total Incidence	Incidence	Percent of Total Incidence
Short-Term Exposure Mortality	Single Pollutant Models (Total Mortality)								
	Chock et al. (2000)	Non-accidental	<75	0 day		69 (-55 - 188)	1.4% (-1.1% - 3.7%)	135 (-109 - 361)	2.6% (-2.1% - 7.1%)
	Chock et al. (2000)	Non-accidental	75+	0 day		77 (-166 - 311)	0.8% (-1.7% - 3.2%)	151 (-332 - 600)	1.6% (-3.4% - 6.2%)
	Multi-Pollutant Models (Total Mortality)								
	Chock et al. (2000)	Non-accidental	<75	0 day	CO, O3, SO2, NO2, PM10-2.5	88 (-60 - 230)	1.7% (-1.2% - 4.5%)	172 (-119 - 439)	3.4% (-2.3% - 8.6%)
	Chock et al. (2000)	Non-accidental	75+	0 day	CO, O3, SO2, NO2, PM10-2.5	52 (-238 - 330)	0.5% (-2.4% - 3.4%)	103 (-480 - 635)	1.1% (-4.9% - 6.5%)

*Health effects incidence was quantified down to estimated policy relevant background level of 3.5 ug/m3. Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.
Note: Numbers in parentheses are 95% confidence intervals based on statistical uncertainty surrounding the PM2.5 coefficient.

Exhibit D.28. Sensitivity Analysis: Estimated Annual Mortality Associated with Short-Term Exposure to "As Is" PM$_{2.5}$ Concentrations, With Adjustments for the Estimated Increases in Incidence if Distributed Lag Models Had Been Estimated San Jose, CA, 2003

Health Effects	Study	Type	Ages	Lag	Other Pollutants in Model	Health Effects Associated with PM2.5 Above Policy Relevant Background*			
						Single Lag		Adjusted for Distributed Lag	
						Incidence	Percent of Total Incidence	Incidence	Percent of Total Incidence
Short-Term Exposure Mortality	Single Pollutant Models (Total Mortality)								
	Fairley (2003) [reanalysis of Fairley (1999)]	Non-accidental	all	0 day		218 (45 - 387)	2.6% (0.5% - 4.7%)	422 (89 - 736)	5.1% (1.1% - 8.9%)
	Fairley (2003) [reanalysis of Fairley (1999)]	Non-accidental	all	1 day		-110 (-278 - 50)	-1.3% (-3.4% - 0.6%)	-221 (-567 - 98)	-2.7% (-6.8% - 1.2%)
	Multi-Pollutant Models (Total Mortality)								
	Fairley (2003) [reanalysis of Fairley (1999)]	Non-accidental	all	0 day	NO2	277 (74 - 472)	3.3% (0.9% - 5.7%)	533 (146 - 890)	6.4% (1.8% - 10.7%)
	Fairley (2003) [reanalysis of Fairley (1999)]	Non-accidental	all	0 day	CO	251 (60 - 432)	3.0% (0.7% - 5.2%)	485 (118 - 818)	5.8% (1.4% - 9.8%)
	Fairley (2003) [reanalysis of Fairley (1999)]	Non-accidental	all	0 day	O3 - 8hr	236 (60 - 404)	2.8% (0.7% - 4.9%)	456 (118 - 768)	5.5% (1.4% - 9.3%)

*Health effects incidence was quantified down to estimated policy relevant background level of 2.5 ug/m3. Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.
Note: Numbers in parentheses are 95% confidence intervals based on statistical uncertainty surrounding the PM2.5 coefficient.

Exhibit D.29. Sensitivity Analysis: Estimated Annual Mortality Associated with Short-Term Exposure to "As Is" PM$_{2.5}$ Concentrations, With Adjustments for the Estimated Increases in Incidence if Distributed Lag Models Had Been Estimated St. Louis, MO, 2003

Health Effects	Study	Type	Ages	Lag	Other Pollutants in Model	Health Effects Associated with PM2.5 Above Policy Relevant Background*			
						Single Lag		Adjusted for Distributed Lag	
						Incidence	Percent of Total Incidence	Incidence	Percent of Total Incidence
Short-Term	Single Pollutant Models (Total Mortality)								
Exposure Mortality	Schwartz (2003b) [reanalysis of Schwartz et al. (1996)]	Non-accidental	all	mean of lag 0 & 1		230 (90 - 380)	1.1% (0.4% - 1.7%)	460 (170 - 740)	2.1% (0.8% - 3.4%)
	Schwartz (2003b) [reanalysis of Schwartz et al. (1996)] -- 6 cities	Non-accidental	all	mean of lag 0 & 1		310 (220 - 400)	1.4% (1.0% - 1.8%)	610 (440 - 780)	2.8% (2.0% - 3.6%)

*Health effects incidence was quantified down to estimated policy relevant background level of 3.5 ug/m3. Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.
Note 1: Numbers in parentheses are 95% confidence intervals based on statistical uncertainty surrounding the PM2.5 coefficient.
Note 2: Multi-city short-term exposure C-R functions were applied only to urban areas included among the cities used to estimate the function.

Exhibit D.30. Sensitivity Analysis: The Effect of Assumptions About Historical Air Quality on Estimates of Mortality Associated with Long-Term Exposure to "As Is" PM$_{2.5}$ Concentrations

Boston, MA, 2003

Health Effects	Study	Type	Ages	Other Pollutants in Model	Percent of Total Incidence*		
					Base Case: Assuming AQ as Reported	Assuming relevant AQ 50% higher	Assuming relevant AQ twice as high
	Single Pollutant Models						
Long-Term Exposure Mortality	Krewski et al. (2000) - Six Cities	All cause	25+		5.6% (1.9% - 9.1%)	3.8% (1.3% - 6.2%)	2.8% (1.0% - 4.7%)
	Krewski et al. (2000) - ACS	All cause	30+		2.1% (1.1% - 3.2%)	1.4% (0.7% - 2.2%)	1.1% (0.6% - 1.6%)
	Krewski et al. (2000) - Six Cities	Cardiopulmonary	25+		7.5% (2.6% - 12.1%)	5.1% (1.7% - 8.2%)	3.8% (1.3% - 6.3%)
	Krewski et al. (2000) - ACS	Cardiopulmonary	30+		4.3% (2.8% - 5.9%)	2.9% (1.9% - 4.0%)	2.2% (1.4% - 3.0%)
	Pope et al. (2002) - ACS extended	All cause	30+		2.7% (0.9% - 4.7%)	1.8% (0.6% - 3.2%)	1.3% (0.5% - 2.4%)
	Pope et al. (2002) - ACS extended	Cardiopulmonary	30+		3.9% (1.4% - 6.6%)	2.6% (0.9% - 4.5%)	2.0% (0.7% - 3.4%)
	Pope et al. (2002) - ACS extended	Lung cancer	30+		5.9% (1.8% - 9.1%)	4.0% (1.2% - 6.2%)	3.0% (0.9% - 4.7%)
	Multi-Pollutant Models						
	Krewski et al. (2000) - ACS	All cause	30+	CO	3.1% (1.8% - 4.4%)	2.1% (1.2% - 3.0%)	1.6% (0.9% - 2.2%)
	Krewski et al. (2000) - ACS	All cause	30+	NO2	3.7% (2.0% - 5.2%)	2.5% (1.3% - 3.5%)	1.9% (1.0% - 2.7%)
	Krewski et al. (2000) - ACS	All cause	30+	O3	3.1% (1.8% - 4.4%)	2.1% (1.2% - 3.0%)	1.6% (0.9% - 2.2%)
	Krewski et al. (2000) - ACS	All cause	30+	SO2	0.6% (-1.0% - 2.3%)	0.4% (-0.7% - 1.5%)	0.3% (-0.5% - 1.2%)

* For the long-term exposure studies, health effects incidence was quantified down to 7.5 ug/m3, which was the lowest of the lowest measured levels in the long-term exposure studies. Percents are rounded to the nearest tenth.

Note: Numbers in parentheses are 95% confidence intervals based on statistical uncertainty surrounding the PM2.5 coefficient.

Exhibit D.31. Sensitivity Analysis: The Effect of Assumptions About Historical Air Quality on Estimates of Mortality Associated with Long-Term Exposure to "As Is" PM$_{2.5}$ Concentrations
Los Angeles, CA, 2003

Health Effects	Study	Type	Ages	Other Pollutants in Model	Percent of Total Incidence*		
					Base Case: Assuming AQ as Reported	Assuming relevant AQ 50% higher	Assuming relevant AQ twice as high
Long-Term Exposure Mortality	Single Pollutant Models						
	Krewski et al. (2000) - ACS	All cause	30+		5.2% (2.7% - 7.9%)	3.5% (1.8% - 5.4%)	2.7% (1.4% - 4.1%)
	Krewski et al. (2000) - ACS	Cardiopulmonary	30+		10.4% (6.8% - 14.2%)	7.1% (4.6% - 9.7%)	5.3% (3.5% - 7.4%)
	Pope et al. (2002) - ACS extended	All cause	30+		6.6% (2.3% - 11.4%)	4.4% (1.5% - 7.8%)	3.3% (1.2% - 5.9%)
	Pope et al. (2002) - ACS extended	Cardiopulmonary	30+		9.5% (3.4% - 15.9%)	6.5% (2.3% - 10.9%)	4.9% (1.7% - 8.3%)
	Pope et al. (2002) - ACS extended	Lung cancer	30+		14.1% (4.5% - 21.4%)	9.7% (3.0% - 14.8%)	7.3% (2.3% - 11.3%)
	Multi-Pollutant Models						
	Krewski et al. (2000) - ACS	All cause	30+	CO	7.6% (4.4% - 10.7%)	5.1% (3.0% - 7.3%)	3.9% (2.2% - 5.5%)
	Krewski et al. (2000) - ACS	All cause	30+	NO2	9.0% (4.8% - 12.7%)	6.1% (3.3% - 8.6%)	4.6% (2.5% - 6.6%)
	Krewski et al. (2000) - ACS	All cause	30+	O3	7.6% (4.4% - 10.7%)	5.1% (3.0% - 7.3%)	3.9% (2.2% - 5.5%)
	Krewski et al. (2000) - ACS	All cause	30+	SO2	1.4% (-2.5% - 5.6%)	0.9% (-1.6% - 3.8%)	0.7% (-1.2% - 2.9%)

* For the long-term exposure studies, health effects incidence was quantified down to 7.5 ug/m3, which was the lowest of the lowest measured levels in the long-term exposure studies.
Percents are rounded to the nearest tenth.
Note: Numbers in parentheses are 95% confidence intervals based on statistical uncertainty surrounding the PM2.5 coefficient.

Exhibit D.32. Sensitivity Analysis: The Effect of Assumptions About Historical Air Quality on Estimates of Mortality Associated with Long-Term Exposure to "As Is" PM$_{2.5}$ Concentrations Philadelphia, PA, 2003

Health Effects	Study	Type	Ages	Other Pollutants in Model	Percent of Total Incidence*		
					Base Case: Assuming AQ as Reported	Assuming relevant AQ 50% higher	Assuming relevant AQ twice as high
Long-Term Exposure Mortality	Single Pollutant Models						
	Krewski et al. (2000) - ACS	All cause	30+		3.1% (1.6% - 4.7%)	2.1% (1.1% - 3.2%)	1.6% (0.8% - 2.4%)
	Krewski et al. (2000) - ACS	Cardiopulmonary	30+		6.2% (4.1% - 8.6%)	4.2% (2.7% - 5.8%)	3.2% (2.0% - 4.4%)
	Pope et al. (2002) - ACS extended	All cause	30+		3.9% (1.3% - 6.9%)	2.6% (0.9% - 4.6%)	2.0% (0.7% - 3.5%)
	Pope et al. (2002) - ACS extended	Cardiopulmonary	30+		5.7% (2.0% - 9.6%)	3.8% (1.3% - 6.5%)	2.9% (1.0% - 4.9%)
	Pope et al. (2002) - ACS extended	Lung cancer	30+		8.6% (2.6% - 13.2%)	5.8% (1.8% - 9.0%)	4.4% (1.3% - 6.8%)
	Multi-Pollutant Models						
	Krewski et al. (2000) - ACS	All cause	30+	CO	4.5% (2.6% - 6.4%)	3.0% (1.8% - 4.3%)	2.3% (1.3% - 3.3%)
	Krewski et al. (2000) - ACS	All cause	30+	NO2	5.4% (2.9% - 7.6%)	3.6% (1.9% - 5.2%)	2.7% (1.4% - 3.9%)
	Krewski et al. (2000) - ACS	All cause	30+	O3	4.5% (2.6% - 6.4%)	3.0% (1.8% - 4.3%)	2.3% (1.3% - 3.3%)
	Krewski et al. (2000) - ACS	All cause	30+	SO2	0.8% (-1.4% - 3.3%)	0.6% (-1.0% - 2.2%)	0.4% (-0.7% - 1.7%)

* For the long-term exposure studies, health effects incidence was quantified down to 7.5 ug/m3, which was the lowest of the lowest measured levels in the long-term exposure studies. Percents are rounded to the nearest tenth.

Note: Numbers in parentheses are 95% confidence intervals based on statistical uncertainty surrounding the PM2.5 coefficient.

Exhibit D.33. Sensitivity Analysis: The Effect of Assumptions About Historical Air Quality on Estimates of Mortality Associated with Long-Term Exposure to "As Is" PM$_{2.5}$ Concentrations Phoenix, AZ, 2001

Health Effects	Study	Type	Ages	Other Pollutants in Model	Percent of Total Incidence*		
					Base Case: Assuming AQ as Reported	Assuming Relevant AQ 50% higher	Assuming Relevant AQ Twice as High
Long-Term Exposure Mortality	Single Pollutant Models						
	Krewski et al. (2000) - ACS	All cause	30+		1.3% (0.7% - 2.0%)	0.9% (0.5% - 1.4%)	0.7% (0.3% - 1.0%)
	Krewski et al. (2000) - ACS	Cardiopulmonary	30+		2.7% (1.7% - 3.8%)	1.8% (1.2% - 2.5%)	1.4% (0.9% - 1.9%)
	Pope et al. (2002) - ACS extended	All cause	30+		1.7% (0.6% - 3.0%)	1.1% (0.4% - 2.0%)	0.8% (0.3% - 1.5%)
	Pope et al. (2002) - ACS extended	Cardiopulmonary	30+		2.5% (0.9% - 4.2%)	1.7% (0.6% - 2.8%)	1.2% (0.4% - 2.1%)
	Pope et al. (2002) - ACS extended	Lung cancer	30+		3.7% (1.1% - 5.8%)	2.5% (0.8% - 3.9%)	1.9% (0.6% - 3.0%)
	Multi-Pollutant Models						
	Krewski et al. (2000) - ACS	All cause	30+	CO	1.9% (1.1% - 2.8%)	1.3% (0.8% - 1.9%)	1.0% (0.6% - 1.4%)
	Krewski et al. (2000) - ACS	All cause	30+	NO2	2.3% (1.2% - 3.3%)	1.6% (0.8% - 2.2%)	1.2% (0.6% - 1.7%)
	Krewski et al. (2000) - ACS	All cause	30+	O3	1.9% (1.1% - 2.8%)	1.3% (0.8% - 1.9%)	1.0% (0.6% - 1.4%)
	Krewski et al. (2000) - ACS	All cause	30+	SO2	0.4% (-0.6% - 1.4%)	0.2% (-0.4% - 1.0%)	0.2% (-0.3% - 0.7%)

* For the long-term exposure studies, health effects incidence was quantified down to 7.5 ug/m3, which was the lowest of the lowest measured levels in the long-term exposure studies. Percents are rounded to the nearest tenth.

Note: Numbers in parentheses are 95% confidence intervals based on statistical uncertainty surrounding the PM2.5 coefficient.

Exhibit D.34. Sensitivity Analysis: The Effect of Assumptions About Historical Air Quality on Estimates of Mortality Associated with Long-Term Exposure to "As Is" PM$_{2.5}$ Concentrations Pittsburgh, PA, 2003

Health Effects	Study	Type	Ages	Other Pollutants in Model	Percent of Total Incidence*		
					Base Case: Assuming AQ as Reported	Assuming relevant AQ 50% higher	Assuming relevant AQ twice as high
Long-Term Exposure Mortality	Single Pollutant Models						
	Krewski et al. (2000) - ACS	All cause	30+		4.3% (2.2% - 6.5%)	2.9% (1.5% - 4.4%)	2.2% (1.1% - 3.3%)
	Krewski et al. (2000) - ACS	Cardiopulmonary	30+		8.5% (5.6% - 11.7%)	5.8% (3.7% - 7.9%)	4.4% (2.8% - 6.0%)
	Pope et al. (2002) - ACS extended	All cause	30+		5.4% (1.9% - 9.4%)	3.6% (1.2% - 6.4%)	2.7% (0.9% - 4.8%)
	Pope et al. (2002) - ACS extended	Cardiopulmonary	30+		7.8% (2.8% - 13.1%)	5.3% (1.8% - 8.9%)	4.0% (1.4% - 6.8%)
	Pope et al. (2002) - ACS extended	Lung cancer	30+		11.6% (3.6% - 17.8%)	7.9% (2.4% - 12.2%)	6.0% (1.8% - 9.3%)
	Multi-Pollutant Models						
	Krewski et al. (2000) - ACS	All cause	30+	CO	6.2% (3.6% - 8.8%)	4.2% (2.4% - 6.0%)	3.1% (1.8% - 4.5%)
	Krewski et al. (2000) - ACS	All cause	30+	NO2	7.4% (3.9% - 10.4%)	5.0% (2.6% - 7.1%)	3.8% (2.0% - 5.4%)
	Krewski et al. (2000) - ACS	All cause	30+	O3	6.2% (3.6% - 8.8%)	4.2% (2.4% - 6.0%)	3.1% (1.8% - 4.5%)
	Krewski et al. (2000) - ACS	All cause	30+	SO2	1.1% (-2.0% - 4.6%)	0.8% (-1.3% - 3.1%)	0.6% (-1.0% - 2.3%)

* For the long-term exposure studies, health effects incidence was quantified down to 7.5 ug/m3, which was the lowest of the lowest measured levels in the long-term exposure studies. Percents are rounded to the nearest tenth.

Note: Numbers in parentheses are 95% confidence intervals based on statistical uncertainty surrounding the PM2.5 coefficient.

Exhibit D.35. Sensitivity Analysis: The Effect of Assumptions About Historical Air Quality on Estimates of Mortality Associated with Long-Term Exposure to "As Is" PM$_{2.5}$ Concentrations
San Jose, CA, 2003

Health Effects	Study	Type	Ages	Other Pollutants in Model	Percent of Total Incidence*		
					Base Case: Assuming AQ as Reported	Assuming relevant AQ 50% higher	Assuming relevant AQ twice as high
Long-Term Exposure Mortality	**Single Pollutant Models**						
	Krewski et al. (2000) - ACS	All cause	30+		1.6% (0.8% - 2.5%)	1.1% (0.6% - 1.7%)	0.8% (0.4% - 1.3%)
	Krewski et al. (2000) - ACS	Cardiopulmonary	30+		3.3% (2.1% - 4.6%)	2.2% (1.4% - 3.1%)	1.7% (1.1% - 2.3%)
	Pope et al. (2002) - ACS extended	All cause	30+		2.1% (0.7% - 3.6%)	1.4% (0.5% - 2.4%)	1.0% (0.4% - 1.8%)
	Pope et al. (2002) - ACS extended	Cardiopulmonary	30+		3.0% (1.1% - 5.1%)	2.0% (0.7% - 3.5%)	1.5% (0.5% - 2.6%)
	Pope et al. (2002) - ACS extended	Lung cancer	30+		4.6% (1.4% - 7.1%)	3.1% (0.9% - 4.8%)	2.3% (0.7% - 3.6%)
	Multi-Pollutant Models						
	Krewski et al. (2000) - ACS	All cause	30+	CO	2.4% (1.4% - 3.4%)	1.6% (0.9% - 2.3%)	1.2% (0.7% - 1.7%)
	Krewski et al. (2000) - ACS	All cause	30+	NO2	2.9% (1.5% - 4.1%)	1.9% (1.0% - 2.7%)	1.4% (0.8% - 2.1%)
	Krewski et al. (2000) - ACS	All cause	30+	O3	2.4% (1.4% - 3.4%)	1.6% (0.9% - 2.3%)	1.2% (0.7% - 1.7%)
	Krewski et al. (2000) - ACS	All cause	30+	SO2	0.4% (-0.8% - 1.8%)	0.3% (-0.5% - 1.2%)	0.2% (-0.4% - 0.9%)

*For the long-term exposure studies, health effects incidence was quantified down to 7.5 ug/m3, which was the lowest of the lowest measured levels in the long-term exposure studies. Percents are rounded to the nearest tenth.
Note: Numbers in parentheses are 95% confidence intervals based on statistical uncertainty surrounding the PM2.5 coefficient.

Exhibit D.36. Sensitivity Analysis: The Effect of Assumptions About Historical Air Quality on Estimates of Mortality Associated with Long-Term Exposure to "As Is" PM$_{2.5}$ Concentrations
Seattle, WA, 2003

Health Effects	Study	Type	Ages	Other Pollutants in Model	Percent of Total Incidence*		
					Base Case: Assuming AQ as Reported	Assuming relevant AQ 50% higher	Assuming relevant AQ twice as high
Long-Term Exposure Mortality	**Single Pollutant Models**						
	Krewski et al. (2000) - ACS	All cause	30+		0.4% (0.2% - 0.6%)	0.2% (0.1% - 0.4%)	0.2% (0.1% - 0.3%)
	Krewski et al. (2000) - ACS	Cardiopulmonary	30+		0.7% (0.5% - 1.0%)	0.5% (0.3% - 0.7%)	0.4% (0.2% - 0.5%)
	Pope et al. (2002) - ACS extended	All cause	30+		0.5% (0.2% - 0.8%)	0.3% (0.1% - 0.5%)	0.2% (0.1% - 0.4%)
	Pope et al. (2002) - ACS extended	Cardiopulmonary	30+		0.7% (0.2% - 1.1%)	0.4% (0.2% - 0.8%)	0.3% (0.1% - 0.6%)
	Pope et al. (2002) - ACS extended	Lung cancer	30+		1.0% (0.3% - 1.6%)	0.7% (0.2% - 1.1%)	0.5% (0.2% - 0.8%)
	Multi-Pollutant Models						
	Krewski et al. (2000) - ACS	All cause	30+	CO	0.5% (0.3% - 0.8%)	0.4% (0.2% - 0.5%)	0.3% (0.2% - 0.4%)
	Krewski et al. (2000) - ACS	All cause	30+	NO2	0.6% (0.3% - 0.9%)	0.4% (0.2% - 0.6%)	0.3% (0.2% - 0.5%)
	Krewski et al. (2000) - ACS	All cause	30+	O3	0.5% (0.3% - 0.8%)	0.4% (0.2% - 0.5%)	0.3% (0.2% - 0.4%)
	Krewski et al. (2000) - ACS	All cause	30+	SO2	0.1% (-0.2% - 0.4%)	0.1% (-0.1% - 0.3%)	0.1% (-0.1% - 0.2%)

*For the long-term exposure studies, health effects incidence was quantified down to 7.5 ug/m3, which was the lowest of the lowest measured levels in the long-term exposure studies. Percents are rounded to the nearest tenth.

Note: Numbers in parentheses are 95% confidence intervals based on statistical uncertainty surrounding the PM2.5 coefficient.

Exhibit D.37. Sensitivity Analysis: The Effect of Assumptions About Historical Air Quality on Estimates of Mortality Associated with Long-Term Exposure to "As Is" PM$_{2.5}$ Concentrations

St. Louis, MO, 2003

Health Effects	Study	Type	Ages	Other Pollutants in Model	Percent of Total Incidence*		
					Base Case: Assuming AQ as Reported	Assuming relevant AQ 50% higher	Assuming relevant AQ twice as high
Long-Term Exposure Mortality	Single Pollutant Models						
	Krewski et al. (2000) - Six Cities	All cause	25+		7.8% (2.7% - 12.6%)	5.3% (1.8% - 8.6%)	4.0% (1.3% - 6.5%)
	Krewski et al. (2000) - ACS	All cause	30+		3.0% (1.5% - 4.5%)	2.0% (1.0% - 3.0%)	1.5% (0.8% - 2.3%)
	Krewski et al. (2000) - Six Cities	Cardiopulmonary	25+		10.4% (3.6% - 16.6%)	7.1% (2.4% - 11.4%)	5.4% (1.8% - 8.7%)
	Krewski et al. (2000) - ACS	Cardiopulmonary	30+		6.0% (3.9% - 8.2%)	4.0% (2.6% - 5.6%)	3.0% (2.0% - 4.2%)
	Pope et al. (2002) - ACS extended	All cause	30+		3.7% (1.3% - 6.6%)	2.5% (0.9% - 4.4%)	1.9% (0.6% - 3.3%)
	Pope et al. (2002) - ACS extended	Cardiopulmonary	30+		5.5% (1.9% - 9.2%)	3.7% (1.3% - 6.2%)	2.8% (1.0% - 4.7%)
	Pope et al. (2002) - ACS extended	Lung cancer	30+		8.2% (2.5% - 12.6%)	5.5% (1.7% - 8.6%)	4.2% (1.3% - 6.5%)
	Multi-Pollutant Models						
	Krewski et al. (2000) - ACS	All cause	30+	CO	4.3% (2.5% - 6.2%)	2.9% (1.7% - 4.2%)	2.2% (1.3% - 3.1%)
	Krewski et al. (2000) - ACS	All cause	30+	NO2	5.2% (2.7% - 7.3%)	3.5% (1.8% - 4.9%)	2.6% (1.4% - 3.7%)
	Krewski et al. (2000) - ACS	All cause	30+	O3	4.3% (2.5% - 6.2%)	2.9% (1.7% - 4.2%)	2.2% (1.3% - 3.1%)
	Krewski et al. (2000) - ACS	All cause	30+	SO2	0.8% (-1.4% - 3.2%)	0.5% (-0.9% - 2.1%)	0.4% (-0.7% - 1.6%)

*For the long-term exposure studies, health effects incidence was quantified down to 7.5 ug/m3, which was the lowest of the lowest measured levels in the long-term exposure studies. Percents are rounded to the nearest tenth.

Note: Numbers in parentheses are 95% confidence intervals based on statistical uncertainty surrounding the PM2.5 coefficient.

**Appendix E. Estimated Annual Reduced Risks Associated with PM$_{2.5}$ Concentrations
When the Current and Alternative Standards Are Just Met**

E.1 Primary analysis

Exhibit E.1. Estimated Annual Mortality Associated with Short-Term Exposure to PM$_{2.5}$ When Alternative Standards Are Just Met, Assuming Various Cutpoint Levels*
Boston, MA, 2003
(2003 As Is Levels = 12.1 ug/m3 Annual Average; 34.1 ug/m3 98th Percentile Daily Value)

Alternative Standards		Percent Reduction in Incidence from As Is Levels (95% Confidence Interval)			
		Percent Reduction in Incidence from As is Levels			
Annual (µg/m3)	Daily (µg/m3)	Policy Relevant Background =3.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =15 µg/m3	Cutpoint** =20 µg/m3
15	65, 98th percentile value***	390 (265 - 514) 0.0%	173 (118 - 228) 0.0%	82 (56 - 109) 0.0%	41 (28 - 53) 0.0%
15	40, 98th percentile value	351 (239 - 462) 10.0%	139 (95 - 183) 19.7%	60 (41 - 79) 26.8%	27 (19 - 36) 34.1%
15	35, 98th percentile value	302 (206 - 398) 22.6%	99 (67 - 130) 42.8%	37 (25 - 48) 54.9%	16 (11 - 20) 61.0%
15	30, 98th percentile value	254 (173 - 334) 34.9%	63 (43 - 83) 63.6%	20 (14 - 26) 75.6%	7 (5 - 9) 82.9%
15	25, 98th percentile value	206 (140 - 270) 47.2%	35 (24 - 46) 79.8%	9 (6 - 12) 89.0%	2 (1 - 2) 95.1%
15	65, 99th percentile value	390 (265 - 514) 0.0%	173 (118 - 228) 0.0%	82 (56 - 109) 0.0%	41 (28 - 53) 0.0%
15	40, 99th percentile value	251 (171 - 330) 35.6%	61 (42 - 80) 64.7%	19 (13 - 25) 76.8%	6 (4 - 8) 85.4%
15	35, 99th percentile value	216 (147 - 284) 44.6%	40 (28 - 53) 76.9%	11 (7 - 14) 86.6%	2 (2 - 3) 95.1%
15	30, 99th percentile value	182 (124 - 239) 53.3%	24 (16 - 31) 86.1%	5 (3 - 7) 93.9%	1 (1 - 1) 97.6%
15	25, 99th percentile value	147 (100 - 193) 62.3%	11 (8 - 15) 93.6%	1 (1 - 2) 98.8%	0 (0 - 0) 100.0%
14	40, 98th percentile value	351 (239 - 462) 10.0%	139 (95 - 183) 19.7%	60 (41 - 79) 26.8%	27 (19 - 36) 34.1%
14	35, 98th percentile value	302 (206 - 398) 22.6%	99 (67 - 130) 42.8%	37 (25 - 48) 54.9%	16 (11 - 20) 61.0%
14	30, 98th percentile value	254 (173 - 334) 34.9%	63 (43 - 83) 63.6%	20 (14 - 26) 75.6%	7 (5 - 9) 82.9%
14	25, 98th percentile value	206 (140 - 270) 47.2%	35 (24 - 46) 79.8%	9 (6 - 12) 89.0%	2 (1 - 2) 95.1%
14	40, 99th percentile value	251 (171 - 330) 35.6%	61 (42 - 80) 64.7%	19 (13 - 25) 76.8%	6 (4 - 8) 85.4%
14	35, 99th percentile value	216 (147 - 284) 44.6%	40 (28 - 53) 76.9%	11 (7 - 14) 86.6%	2 (2 - 3) 95.1%
14	30, 99th percentile value	182 (124 - 239) 53.3%	24 (16 - 31) 86.1%	5 (3 - 7) 93.9%	1 (1 - 1) 97.6%

| Alternative Standards | | Percent Reduction in Incidence from As Is Levels (95% Confidence Interval) | | | |
| | | Percent Reduction in Incidence from As is Levels | | | |
Annual (µg/m3)	Daily (µg/m3)	Policy Relevant Background =3.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =15 µg/m3	Cutpoint** =20 µg/m3
14	25, 99th percentile value	147 (100 - 193) 62.3%	11 (8 - 15) 93.6%	1 (1 - 2) 98.8%	0 (0 - 0) 100.0%
13	40, 98th percentile value	339 (231 - 447) 13.1%	129 (88 - 170) 25.4%	54 (37 - 71) 34.1%	24 (16 - 32) 41.5%
13	35, 98th percentile value	302 (206 - 398) 22.6%	99 (67 - 130) 42.8%	37 (25 - 48) 54.9%	16 (11 - 20) 61.0%
13	30, 98th percentile value	254 (173 - 334) 34.9%	63 (43 - 83) 63.6%	20 (14 - 26) 75.6%	7 (5 - 9) 82.9%
13	25, 98th percentile value	206 (140 - 270) 47.2%	35 (24 - 46) 79.8%	9 (6 - 12) 89.0%	2 (1 - 2) 95.1%
13	40, 99th percentile value	251 (171 - 330) 35.6%	61 (42 - 80) 64.7%	19 (13 - 25) 76.8%	6 (4 - 8) 85.4%
13	35, 99th percentile value	216 (147 - 284) 44.6%	40 (28 - 53) 76.9%	11 (7 - 14) 86.6%	2 (2 - 3) 95.1%
13	30, 99th percentile value	182 (124 - 239) 53.3%	24 (16 - 31) 86.1%	5 (3 - 7) 93.9%	1 (1 - 1) 97.6%
13	25, 99th percentile value	147 (100 - 193) 62.3%	11 (8 - 15) 93.6%	1 (1 - 2) 98.8%	0 (0 - 0) 100.0%
12	40, 98th percentile value	303 (206 - 399) 22.3%	99 (68 - 131) 42.8%	37 (25 - 49) 54.9%	16 (11 - 21) 61.0%
12	35, 98th percentile value	302 (206 - 398) 22.6%	99 (67 - 130) 42.8%	37 (25 - 48) 54.9%	16 (11 - 20) 61.0%
12	30, 98th percentile value	254 (173 - 334) 34.9%	63 (43 - 83) 63.6%	20 (14 - 26) 75.6%	7 (5 - 9) 82.9%
12	25, 98th percentile value	206 (140 - 270) 47.2%	35 (24 - 46) 79.8%	9 (6 - 12) 89.0%	2 (1 - 2) 95.1%
12	40, 99th percentile value	251 (171 - 330) 35.6%	61 (42 - 80) 64.7%	19 (13 - 25) 76.8%	6 (4 - 8) 85.4%
12	35, 99th percentile value	216 (147 - 284) 44.6%	40 (28 - 53) 76.9%	11 (7 - 14) 86.6%	2 (2 - 3) 95.1%
12	30, 99th percentile value	182 (124 - 239) 53.3%	24 (16 - 31) 86.1%	5 (3 - 7) 93.9%	1 (1 - 1) 97.6%
12	25, 99th percentile value	147 (100 - 193) 62.3%	11 (8 - 15) 93.6%	1 (1 - 2) 98.8%	0 (0 - 0) 100.0%

*This analysis used a C-R function from Schwartz (2003b).

**For the cutpoints above policy relevant background, the slope of the C-R function has been modified based on a simple hockeystick model (see discussion in section 2.5).

***Current standards.

Note: Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Exhibit E.2. Estimated Annual Mortality Associated with Short-Term Exposure to PM$_{2.5}$ When Alternative Standards Are Just Met, Assuming Various Cutpoint Levels*
Los Angeles, CA, 2003

Alternative Standards		Incidence Associated with PM2.5 (95% Confidence Interval)			
		Percent Reduction in Incidence from Current Standards			
Annual (µg/m3)	Daily (µg/m3)	Policy Relevant Background =2.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =15 µg/m3	Cutpoint** =20 µg/m3
15	65, 98th percentile value***	292 (-37 - 612) 0.0%	115 (-14 - 240) 0.0%	58 (-7 - 121) 0.0%	29 (-4 - 61) 0.0%
15	40, 98th percentile value	292 (-37 - 612) 0.0%	115 (-14 - 240) 0.0%	58 (-7 - 121) 0.0%	29 (-4 - 61) 0.0%
15	35, 98th percentile value	269 (-34 - 564) 7.9%	96 (-12 - 200) 16.5%	45 (-6 - 94) 22.4%	22 (-3 - 46) 24.1%
15	30, 98th percentile value	228 (-28 - 476) 21.9%	65 (-8 - 135) 43.5%	26 (-3 - 54) 55.2%	12 (-2 - 25) 58.6%
15	25, 98th percentile value	186 (-23 - 389) 36.3%	39 (-5 - 80) 66.1%	13 (-2 - 27) 77.6%	5 (-1 - 11) 82.8%
15	65, 99th percentile value	292 (-37 - 612) 0.0%	115 (-14 - 240) 0.0%	58 (-7 - 121) 0.0%	29 (-4 - 61) 0.0%
15	40, 99th percentile value	197 (-25 - 413) 32.5%	45 (-6 - 94) 60.9%	16 (-2 - 33) 72.4%	7 (-1 - 14) 75.9%
15	35, 99th percentile value	171 (-21 - 358) 41.4%	30 (-4 - 63) 73.9%	10 (-1 - 20) 82.8%	3 (0 - 7) 89.7%
15	30, 99th percentile value	145 (-18 - 302) 50.3%	18 (-2 - 37) 84.3%	5 (-1 - 10) 91.4%	1 (0 - 3) 96.6%
15	25, 99th percentile value	118 (-15 - 247) 59.6%	9 (-1 - 18) 92.2%	2 (0 - 4) 96.6%	0 (0 - 1) 100.0%
14	40, 98th percentile value	269 (-34 - 562) 7.9%	96 (-12 - 199) 16.5%	45 (-6 - 93) 22.4%	22 (-3 - 45) 24.1%
14	35, 98th percentile value	269 (-34 - 562) 7.9%	96 (-12 - 199) 16.5%	45 (-6 - 93) 22.4%	22 (-3 - 45) 24.1%
14	30, 98th percentile value	228 (-28 - 476) 21.9%	65 (-8 - 135) 43.5%	26 (-3 - 54) 55.2%	12 (-2 - 25) 58.6%
14	25, 98th percentile value	186 (-23 - 389) 36.3%	39 (-5 - 80) 66.1%	13 (-2 - 27) 77.6%	5 (-1 - 11) 82.8%
14	40, 99th percentile value	197 (-25 - 413) 32.5%	45 (-6 - 94) 60.9%	16 (-2 - 33) 72.4%	7 (-1 - 14) 75.9%
14	35, 99th percentile value	171 (-21 - 358) 41.4%	30 (-4 - 63) 73.9%	10 (-1 - 20) 82.8%	3 (0 - 7) 89.7%
14	30, 99th percentile value	145 (-18 - 302) 50.3%	18 (-2 - 37) 84.3%	5 (-1 - 10) 91.4%	1 (0 - 3) 96.6%
14	25, 99th percentile value	118 (-15 - 247) 59.6%	9 (-1 - 18) 92.2%	2 (0 - 4) 96.6%	0 (0 - 1) 100.0%

Alternative Standards		Incidence Associated with PM2.5 (95% Confidence Interval) Percent Reduction in Incidence from Current Standards			
Annual (µg/m3)	Daily (µg/m3)	Policy Relevant Background =2.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =15 µg/m3	Cutpoint** =20 µg/m3
13	40, 98th percentile value	245 (-31 - 513) 16.1%	77 (-10 - 161) 33.0%	34 (-4 - 69) 41.4%	16 (-2 - 33) 44.8%
13	35, 98th percentile value	245 (-31 - 513) 16.1%	77 (-10 - 161) 33.0%	34 (-4 - 69) 41.4%	16 (-2 - 33) 44.8%
13	30, 98th percentile value	228 (-28 - 476) 21.9%	65 (-8 - 135) 43.5%	26 (-3 - 54) 55.2%	12 (-2 - 25) 58.6%
13	25, 98th percentile value	186 (-23 - 389) 36.3%	39 (-5 - 80) 66.1%	13 (-2 - 27) 77.6%	5 (-1 - 11) 82.8%
13	40, 99th percentile value	197 (-25 - 413) 32.5%	45 (-6 - 94) 60.9%	16 (-2 - 33) 72.4%	7 (-1 - 14) 75.9%
13	35, 99th percentile value	171 (-21 - 358) 41.4%	30 (-4 - 63) 73.9%	10 (-1 - 20) 82.8%	3 (0 - 7) 89.7%
13	30, 99th percentile value	145 (-18 - 302) 50.3%	18 (-2 - 37) 84.3%	5 (-1 - 10) 91.4%	1 (0 - 3) 96.6%
13	25, 99th percentile value	118 (-15 - 247) 59.6%	9 (-1 - 18) 92.2%	2 (0 - 4) 96.6%	0 (0 - 1) 100.0%
12	40, 98th percentile value	222 (-28 - 464) 24.0%	61 (-8 - 126) 47.0%	24 (-3 - 50) 58.6%	11 (-1 - 23) 62.1%
12	35, 98th percentile value	222 (-28 - 464) 24.0%	61 (-8 - 126) 47.0%	24 (-3 - 50) 58.6%	11 (-1 - 23) 62.1%
12	30, 98th percentile value	222 (-28 - 464) 24.0%	61 (-8 - 126) 47.0%	24 (-3 - 50) 58.6%	11 (-1 - 23) 62.1%
12	25, 98th percentile value	186 (-23 - 389) 36.3%	39 (-5 - 80) 66.1%	13 (-2 - 27) 77.6%	5 (-1 - 11) 82.8%
12	40, 99th percentile value	197 (-25 - 413) 32.5%	45 (-6 - 94) 60.9%	16 (-2 - 33) 72.4%	7 (-1 - 14) 75.9%
12	35, 99th percentile value	171 (-21 - 358) 41.4%	30 (-4 - 63) 73.9%	10 (-1 - 20) 82.8%	3 (0 - 7) 89.7%
12	30, 99th percentile value	145 (-18 - 302) 50.3%	18 (-2 - 37) 84.3%	5 (-1 - 10) 91.4%	1 (0 - 3) 96.6%
12	25, 99th percentile value	118 (-15 - 247) 59.6%	9 (-1 - 18) 92.2%	2 (0 - 4) 96.6%	0 (0 - 1) 100.0%

*This analysis was performed using Moolgavkar (2003).

**For the cutpoints above policy relevant background, the slope of the C-R function has been modified based on a simple hockeystick model (see discussion in section 2.5).

***Current standards.

Note: Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Exhibit E.3. Estimated Annual Cardiovascular Mortality Associated with Short-Term Exposure to PM$_{2.5}$ When Alternative Standards Are Just Met, Assuming Various Cutpoint Levels*
Philadelphia, PA, 2003

Alternative Standards		Incidence Associated with PM2.5			
		(95% Confidence Interval)			
		Percent Reduction in Incidence from Current Standards			
Annual (µg/m3)	Daily (µg/m3)	Policy Relevant Background =3.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =15 µg/m3	Cutpoint** =20 µg/m3
15	65, 98th percentile value***	367 (175 - 560) 0.0%	189 (90 - 288) 0.0%	106 (51 - 162) 0.0%	57 (27 - 87) 0.0%
15	40, 98th percentile value	317 (151 - 482) 13.6%	143 (68 - 218) 24.3%	71 (34 - 107) 33.0%	34 (16 - 51) 40.4%
15	35, 98th percentile value	273 (130 - 416) 25.6%	106 (50 - 161) 43.9%	45 (22 - 69) 57.5%	18 (9 - 28) 68.4%
15	30, 98th percentile value	230 (110 - 350) 37.3%	71 (34 - 108) 62.4%	25 (12 - 38) 76.4%	7 (3 - 11) 87.7%
15	25, 98th percentile value	187 (89 - 284) 49.0%	41 (20 - 63) 78.3%	11 (5 - 16) 89.6%	2 (1 - 3) 96.5%
15	65, 99th percentile value	297 (142 - 451) 19.1%	126 (60 - 191) 33.3%	58 (28 - 89) 45.3%	26 (12 - 40) 54.4%
15	40, 99th percentile value	176 (84 - 268) 52.0%	35 (17 - 53) 81.5%	8 (4 - 12) 92.5%	1 (1 - 2) 98.2%
15	35, 99th percentile value	152 (72 - 231) 58.6%	22 (11 - 34) 88.4%	3 (2 - 5) 97.2%	0 (0 - 1) 100.0%
15	30, 99th percentile value	128 (61 - 195) 65.1%	12 (6 - 19) 93.7%	1 (1 - 2) 99.1%	0 (0 - 0) 100.0%
15	25, 99th percentile value	104 (49 - 158) 71.7%	5 (2 - 8) 97.4%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	65, 98th percentile value	336 (160 - 511) 8.4%	160 (76 - 243) 15.3%	83 (40 - 127) 21.7%	42 (20 - 63) 26.3%
14	40, 98th percentile value	317 (151 - 482) 13.6%	143 (68 - 218) 24.3%	71 (34 - 107) 33.0%	34 (16 - 51) 40.4%
14	35, 98th percentile value	273 (130 - 416) 25.6%	106 (50 - 161) 43.9%	45 (22 - 69) 57.5%	18 (9 - 28) 68.4%
14	30, 98th percentile value	230 (110 - 350) 37.3%	71 (34 - 108) 62.4%	25 (12 - 38) 76.4%	7 (3 - 11) 87.7%
14	25, 98th percentile value	187 (89 - 284) 49.0%	41 (20 - 63) 78.3%	11 (5 - 16) 89.6%	2 (1 - 3) 96.5%
14	40, 99th percentile value	176 (84 - 268) 52.0%	35 (17 - 53) 81.5%	8 (4 - 12) 92.5%	1 (1 - 2) 98.2%
14	35, 99th percentile value	152 (72 - 231) 58.6%	22 (11 - 34) 88.4%	3 (2 - 5) 97.2%	0 (0 - 1) 100.0%
14	30, 99th percentile value	128 (61 - 195) 65.1%	12 (6 - 19) 93.7%	1 (1 - 2) 99.1%	0 (0 - 0) 100.0%

Alternative Standards		Incidence Associated with PM2.5 (95% Confidence Interval)			
		Percent Reduction in Incidence from Current Standards			
Annual (µg/m3)	Daily (µg/m3)	Policy Relevant Background =3.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =15 µg/m3	Cutpoint** =20 µg/m3
14	25, 99th percentile value	104 (49 - 158) 71.7%	5 (2 - 8) 97.4%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	40, 98th percentile value	304 (145 - 462) 17.2%	132 (63 - 200) 30.2%	62 (30 - 95) 41.5%	29 (14 - 44) 49.1%
13	35, 98th percentile value	273 (130 - 416) 25.6%	106 (50 - 161) 43.9%	45 (22 - 69) 57.5%	18 (9 - 28) 68.4%
13	30, 98th percentile value	230 (110 - 350) 37.3%	71 (34 - 108) 62.4%	25 (12 - 38) 76.4%	7 (3 - 11) 87.7%
13	25, 98th percentile value	187 (89 - 284) 49.0%	41 (20 - 63) 78.3%	11 (5 - 16) 89.6%	2 (1 - 3) 96.5%
13	40, 99th percentile value	176 (84 - 268) 52.0%	35 (17 - 53) 81.5%	8 (4 - 12) 92.5%	1 (1 - 2) 98.2%
13	35, 99th percentile value	152 (72 - 231) 58.6%	22 (11 - 34) 88.4%	3 (2 - 5) 97.2%	0 (0 - 1) 100.0%
13	30, 99th percentile value	128 (61 - 195) 65.1%	12 (6 - 19) 93.7%	1 (1 - 2) 99.1%	0 (0 - 0) 100.0%
13	25, 99th percentile value	104 (49 - 158) 71.7%	5 (2 - 8) 97.4%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	40, 98th percentile value	272 (130 - 414) 25.9%	104 (50 - 159) 45.0%	44 (21 - 68) 58.5%	18 (9 - 27) 68.4%
12	35, 98th percentile value	272 (130 - 414) 25.9%	104 (50 - 159) 45.0%	44 (21 - 68) 58.5%	18 (9 - 27) 68.4%
12	30, 98th percentile value	230 (110 - 350) 37.3%	71 (34 - 108) 62.4%	25 (12 - 38) 76.4%	7 (3 - 11) 87.7%
12	25, 98th percentile value	187 (89 - 284) 49.0%	41 (20 - 63) 78.3%	11 (5 - 16) 89.6%	2 (1 - 3) 96.5%
12	40, 99th percentile value	176 (84 - 268) 52.0%	35 (17 - 53) 81.5%	8 (4 - 12) 92.5%	1 (1 - 2) 98.2%
12	35, 99th percentile value	152 (72 - 231) 58.6%	22 (11 - 34) 88.4%	3 (2 - 5) 97.2%	0 (0 - 1) 100.0%
12	30, 99th percentile value	128 (61 - 195) 65.1%	12 (6 - 19) 93.7%	1 (1 - 2) 99.1%	0 (0 - 0) 100.0%
12	25, 99th percentile value	104 (49 - 158) 71.7%	5 (2 - 8) 97.4%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%

*This analysis used a C-R function from Lipfert et al. (2000).

**For the cutpoints above policy relevant background, the slope of the C-R function has been modified based on a simple hockeystick model (see discussion in section 2.5).

***Current standards.

Note: Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Exhibit E.4. Estimated Annual Cardiovascular Mortality Associated with Short-Term Exposure to PM$_{2.5}$ When Alternative Standards Are Just Met, Assuming Various Cutpoint Levels*
Phoenix, AZ, 2001
(2001 As Is Levels = 10.4 ug/m3 Annual Average; 28.9 ug/m3 98th Percentile Daily Value)

Alternative Standards		Incidence Associated with PM2.5			
		(95% Confidence Interval)			
		Percent Reduction in Incidence from As Is Levels			
Annual (µg/m3)	Daily (µg/m3)	Policy Relevant Background =2.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =15 µg/m3	Cutpoint** =20 µg/m3
15	65, 98th percentile value***	323 (97 - 536) 0.0%	115 (35 - 190) 0.0%	67 (21 - 109) 0.0%	43 (13 - 69) 0.0%
15	40, 98th percentile value	323 (97 - 536) 0.0%	115 (35 - 190) 0.0%	67 (21 - 109) 0.0%	43 (13 - 69) 0.0%
15	35, 98th percentile value	323 (97 - 536) 0.0%	115 (35 - 190) 0.0%	67 (21 - 109) 0.0%	43 (13 - 69) 0.0%
15	30, 98th percentile value	272 (82 - 449) 15.8%	78 (24 - 127) 32.2%	40 (13 - 64) 40.3%	22 (7 - 35) 48.8%
15	25, 98th percentile value	221 (67 - 363) 31.6%	48 (15 - 76) 58.3%	21 (7 - 33) 68.7%	8 (3 - 12) 81.4%
15	65, 99th percentile value	323 (97 - 536) 0.0%	115 (35 - 190) 0.0%	67 (21 - 109) 0.0%	43 (13 - 69) 0.0%
15	40, 99th percentile value	314 (94 - 521) 2.8%	109 (33 - 178) 5.2%	62 (19 - 101) 7.5%	39 (12 - 63) 9.3%
15	35, 99th percentile value	271 (82 - 447) 16.1%	78 (24 - 126) 32.2%	40 (13 - 64) 40.3%	22 (7 - 34) 48.8%
15	30, 99th percentile value	228 (69 - 375) 29.4%	52 (16 - 82) 54.8%	24 (8 - 37) 64.2%	10 (3 - 15) 76.7%
15	25, 99th percentile value	185 (56 - 304) 42.7%	30 (10 - 46) 73.9%	11 (4 - 16) 83.6%	4 (2 - 6) 90.7%
14	40, 98th percentile value	323 (97 - 536) 0.0%	115 (35 - 190) 0.0%	67 (21 - 109) 0.0%	43 (13 - 69) 0.0%
14	35, 98th percentile value	323 (97 - 536) 0.0%	115 (35 - 190) 0.0%	67 (21 - 109) 0.0%	43 (13 - 69) 0.0%
14	30, 98th percentile value	272 (82 - 449) 15.8%	78 (24 - 127) 32.2%	40 (13 - 64) 40.3%	22 (7 - 35) 48.8%
14	25, 98th percentile value	221 (67 - 363) 31.6%	48 (15 - 76) 58.3%	21 (7 - 33) 68.7%	8 (3 - 12) 81.4%
14	40, 99th percentile value	314 (94 - 521) 2.8%	109 (33 - 178) 5.2%	62 (19 - 101) 7.5%	39 (12 - 63) 9.3%
14	35, 99th percentile value	271 (82 - 447) 16.1%	78 (24 - 126) 32.2%	40 (13 - 64) 40.3%	22 (7 - 34) 48.8%
14	30, 99th percentile value	228 (69 - 375) 29.4%	52 (16 - 82) 54.8%	24 (8 - 37) 64.2%	10 (3 - 15) 76.7%
14	25, 99th percentile value	185 (56 - 304) 42.7%	30 (10 - 46) 73.9%	11 (4 - 16) 83.6%	4 (2 - 6) 90.7%

Alternative Standards		Incidence Associated with PM2.5 (95% Confidence Interval) Percent Reduction in Incidence from As Is Levels			
Annual (µg/m3)	Daily (µg/m3)	Policy Relevant Background =2.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =15 µg/m3	Cutpoint** =20 µg/m3
13	40, 98th percentile value	323 (97 - 536) 0.0%	115 (35 - 190) 0.0%	67 (21 - 109) 0.0%	43 (13 - 69) 0.0%
13	35, 98th percentile value	323 (97 - 536) 0.0%	115 (35 - 190) 0.0%	67 (21 - 109) 0.0%	43 (13 - 69) 0.0%
13	30, 98th percentile value	272 (82 - 449) 15.8%	78 (24 - 127) 32.2%	40 (13 - 64) 40.3%	22 (7 - 35) 48.8%
13	25, 98th percentile value	221 (67 - 363) 31.6%	48 (15 - 76) 58.3%	21 (7 - 33) 68.7%	8 (3 - 12) 81.4%
13	40, 99th percentile value	314 (94 - 521) 2.8%	109 (33 - 178) 5.2%	62 (19 - 101) 7.5%	39 (12 - 63) 9.3%
13	35, 99th percentile value	271 (82 - 447) 16.1%	78 (24 - 126) 32.2%	40 (13 - 64) 40.3%	22 (7 - 34) 48.8%
13	30, 99th percentile value	228 (69 - 375) 29.4%	52 (16 - 82) 54.8%	24 (8 - 37) 64.2%	10 (3 - 15) 76.7%
13	25, 99th percentile value	185 (56 - 304) 42.7%	30 (10 - 46) 73.9%	11 (4 - 16) 83.6%	4 (2 - 6) 90.7%
12	40, 98th percentile value	323 (97 - 536) 0.0%	115 (35 - 190) 0.0%	67 (21 - 109) 0.0%	43 (13 - 69) 0.0%
12	35, 98th percentile value	323 (97 - 536) 0.0%	115 (35 - 190) 0.0%	67 (21 - 109) 0.0%	43 (13 - 69) 0.0%
12	30, 98th percentile value	272 (82 - 449) 15.8%	78 (24 - 127) 32.2%	40 (13 - 64) 40.3%	22 (7 - 35) 48.8%
12	25, 98th percentile value	221 (67 - 363) 31.6%	48 (15 - 76) 58.3%	21 (7 - 33) 68.7%	8 (3 - 12) 81.4%
12	40, 99th percentile value	314 (94 - 521) 2.8%	109 (33 - 178) 5.2%	62 (19 - 101) 7.5%	39 (12 - 63) 9.3%
12	35, 99th percentile value	271 (82 - 447) 16.1%	78 (24 - 126) 32.2%	40 (13 - 64) 40.3%	22 (7 - 34) 48.8%
12	30, 99th percentile value	228 (69 - 375) 29.4%	52 (16 - 82) 54.8%	24 (8 - 37) 64.2%	10 (3 - 15) 76.7%
12	25, 99th percentile value	185 (56 - 304) 42.7%	30 (10 - 46) 73.9%	11 (4 - 16) 83.6%	4 (2 - 6) 90.7%

*This analysis used a C-R function from Mar et al. (2003), 1-day lag model.

**For the cutpoints above policy relevant background, the slope of the C-R function has been modified based on a simple hockeystick model (see discussion in section 2.5).

***Current standards.

Note: Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Exhibit E.5. Estimated Annual Mortality Associated with Short-Term Exposure to PM$_{2.5}$ When Alternative Standards Are Just Met, Assuming Various Cutpoint Levels*
Pittsburgh, PA, 2003

Alternative Standards		Incidence Associated with PM2.5			
		(95% Confidence Interval)			
		Percent Reduction in Incidence from Current Standards			
Annual (µg/m3)	Daily (µg/m3)	Policy Relevant Background =3.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =15 µg/m3	Cutpoint** =20 µg/m3
15	65, 98th percentile value***	50 (-108 - 200) 0.0%	22 (-48 - 87) 0.0%	10 (-23 - 41) 0.0%	5 (-11 - 18) 0.0%
15	40, 98th percentile value	47 (-102 - 189) 6.0%	19 (-43 - 77) 13.6%	9 (-19 - 34) 10.0%	4 (-9 - 15) 20.0%
15	35, 98th percentile value	41 (-88 - 162) 18.0%	14 (-31 - 56) 36.4%	5 (-12 - 21) 50.0%	2 (-5 - 8) 60.0%
15	30, 98th percentile value	34 (-74 - 136) 32.0%	9 (-21 - 37) 59.1%	3 (-6 - 11) 70.0%	1 (-2 - 4) 80.0%
15	25, 98th percentile value	28 (-60 - 110) 44.0%	5 (-12 - 20) 77.3%	1 (-3 - 5) 90.0%	0 (-1 - 2) 100.0%
15	65, 99th percentile value	50 (-108 - 200) 0.0%	22 (-48 - 87) 0.0%	10 (-23 - 41) 0.0%	5 (-11 - 18) 0.0%
15	40, 99th percentile value	42 (-92 - 168) 16.0%	15 (-34 - 61) 31.8%	6 (-13 - 24) 40.0%	3 (-6 - 10) 40.0%
15	35, 99th percentile value	36 (-79 - 145) 28.0%	11 (-24 - 43) 50.0%	4 (-8 - 14) 60.0%	1 (-3 - 5) 80.0%
15	30, 99th percentile value	31 (-67 - 122) 38.0%	7 (-15 - 27) 68.2%	2 (-4 - 7) 80.0%	1 (-2 - 3) 80.0%
15	25, 99th percentile value	25 (-54 - 99) 50.0%	4 (-8 - 14) 81.8%	1 (-2 - 3) 90.0%	0 (-1 - 1) 100.0%
14	40, 98th percentile value	46 (-99 - 182) 8.0%	18 (-40 - 72) 18.2%	8 (-17 - 31) 20.0%	3 (-8 - 13) 40.0%
14	35, 98th percentile value	41 (-88 - 162) 18.0%	14 (-31 - 56) 36.4%	5 (-12 - 21) 50.0%	2 (-5 - 8) 60.0%
14	30, 98th percentile value	34 (-74 - 136) 32.0%	9 (-21 - 37) 59.1%	3 (-6 - 11) 70.0%	1 (-2 - 4) 80.0%
14	25, 98th percentile value	28 (-60 - 110) 44.0%	5 (-12 - 20) 77.3%	1 (-3 - 5) 90.0%	0 (-1 - 2) 100.0%
14	40, 99th percentile value	42 (-92 - 168) 16.0%	15 (-34 - 61) 31.8%	6 (-13 - 24) 40.0%	3 (-6 - 10) 40.0%
14	35, 99th percentile value	36 (-79 - 145) 28.0%	11 (-24 - 43) 50.0%	4 (-8 - 14) 60.0%	1 (-3 - 5) 80.0%
14	30, 99th percentile value	31 (-67 - 122) 38.0%	7 (-15 - 27) 68.2%	2 (-4 - 7) 80.0%	1 (-2 - 3) 80.0%
14	25, 99th percentile value	25 (-54 - 99) 50.0%	4 (-8 - 14) 81.8%	1 (-2 - 3) 90.0%	0 (-1 - 1) 100.0%

| Alternative Standards | | Incidence Associated with PM2.5 (95% Confidence Interval) | | | |
| | | Percent Reduction in Incidence from Current Standards | | | |
Annual (µg/m3)	Daily (µg/m3)	Policy Relevant Background =3.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =15 µg/m3	Cutpoint** =20 µg/m3
13	40, 98th percentile value	41 (-90 - 165) 18.0%	15 (-32 - 58) 31.8%	6 (-13 - 22) 40.0%	2 (-5 - 9) 60.0%
13	35, 98th percentile value	41 (-88 - 162) 18.0%	14 (-31 - 56) 36.4%	5 (-12 - 21) 50.0%	2 (-5 - 8) 60.0%
13	30, 98th percentile value	34 (-74 - 136) 32.0%	9 (-21 - 37) 59.1%	3 (-6 - 11) 70.0%	1 (-2 - 4) 80.0%
13	25, 98th percentile value	28 (-60 - 110) 44.0%	5 (-12 - 20) 77.3%	1 (-3 - 5) 90.0%	0 (-1 - 2) 100.0%
13	40, 99th percentile value	41 (-90 - 165) 18.0%	15 (-32 - 58) 31.8%	6 (-13 - 22) 40.0%	2 (-5 - 9) 60.0%
13	35, 99th percentile value	36 (-79 - 145) 28.0%	11 (-24 - 43) 50.0%	4 (-8 - 14) 60.0%	1 (-3 - 5) 80.0%
13	30, 99th percentile value	31 (-67 - 122) 38.0%	7 (-15 - 27) 68.2%	2 (-4 - 7) 80.0%	1 (-2 - 3) 80.0%
13	25, 99th percentile value	25 (-54 - 99) 50.0%	4 (-8 - 14) 81.8%	1 (-2 - 3) 90.0%	0 (-1 - 1) 100.0%
12	40, 98th percentile value	37 (-80 - 147) 26.0%	11 (-25 - 44) 50.0%	4 (-8 - 15) 60.0%	1 (-3 - 6) 80.0%
12	35, 98th percentile value	37 (-80 - 147) 26.0%	11 (-25 - 44) 50.0%	4 (-8 - 15) 60.0%	1 (-3 - 6) 80.0%
12	30, 98th percentile value	34 (-74 - 136) 32.0%	9 (-21 - 37) 59.1%	3 (-6 - 11) 70.0%	1 (-2 - 4) 80.0%
12	25, 98th percentile value	28 (-60 - 110) 44.0%	5 (-12 - 20) 77.3%	1 (-3 - 5) 90.0%	0 (-1 - 2) 100.0%
12	40, 99th percentile value	37 (-80 - 147) 26.0%	11 (-25 - 44) 50.0%	4 (-8 - 15) 60.0%	1 (-3 - 6) 80.0%
12	35, 99th percentile value	36 (-79 - 145) 28.0%	11 (-24 - 43) 50.0%	4 (-8 - 14) 60.0%	1 (-3 - 5) 80.0%
12	30, 99th percentile value	31 (-67 - 122) 38.0%	7 (-15 - 27) 68.2%	2 (-4 - 7) 80.0%	1 (-2 - 3) 80.0%
12	25, 99th percentile value	25 (-54 - 99) 50.0%	4 (-8 - 14) 81.8%	1 (-2 - 3) 90.0%	0 (-1 - 1) 100.0%

*This analysis used a C-R function from Chock et al. (2000), age 75+ model.

**For the cutpoints above policy relevant background, the slope of the C-R function has been modified based on a simple hockeystick model (see discussion in section 2.5).

***Current standards.

Note: Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Exhibit E.6. Estimated Annual Mortality Associated with Short-Term Exposure to PM$_{2.5}$ When Alternative Standards Are Just Met, Assuming Various Cutpoint Levels*

San Jose, CA, 2003

(2003 As Is Levels = 11.1 ug/m3 Annual Average; 37.6 ug/m3 98th Percentile Daily Value)

Alternative Standards		Incidence Associated with PM2.5			
		(95% Confidence Interval)			
		Percent Reduction in Incidence from As Is Levels			
Annual (µg/m3)	Daily (µg/m3)	Policy Relevant Background =2.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =15 µg/m3	Cutpoint** =20 µg/m3
15	65, 98th percentile value***	218 (45 - 387) 0.0%	80 (17 - 141) 0.0%	44 (9 - 77) 0.0%	28 (6 - 50) 0.0%
15	40, 98th percentile value	183 (38 - 324) 16.1%	55 (11 - 96) 31.3%	29 (6 - 50) 34.1%	17 (3 - 29) 39.3%
15	35, 98th percentile value	158 (33 - 279) 27.5%	39 (8 - 68) 51.3%	20 (4 - 34) 54.5%	10 (2 - 17) 64.3%
15	30, 98th percentile value	134 (28 - 235) 38.5%	26 (6 - 45) 67.5%	12 (3 - 20) 72.7%	5 (1 - 8) 82.1%
15	25, 98th percentile value	109 (23 - 191) 50.0%	16 (3 - 27) 80.0%	6 (1 - 10) 86.4%	1 (0 - 2) 96.4%
15	65, 99th percentile value	218 (45 - 387) 0.0%	80 (17 - 141) 0.0%	44 (9 - 77) 0.0%	28 (6 - 50) 0.0%
15	40, 99th percentile value	161 (33 - 284) 26.1%	41 (9 - 71) 48.8%	21 (4 - 36) 52.3%	11 (2 - 18) 60.7%
15	35, 99th percentile value	139 (29 - 245) 36.2%	29 (6 - 50) 63.8%	13 (3 - 23) 70.5%	6 (1 - 10) 78.6%
15	30, 99th percentile value	118 (24 - 207) 45.9%	19 (4 - 33) 76.3%	8 (2 - 13) 81.8%	2 (0 - 4) 92.9%
15	25, 99th percentile value	96 (20 - 168) 56.0%	11 (2 - 20) 86.3%	3 (1 - 6) 93.2%	1 (0 - 1) 96.4%
14	40, 98th percentile value	183 (38 - 324) 16.1%	55 (11 - 96) 31.3%	29 (6 - 50) 34.1%	17 (3 - 29) 39.3%
14	35, 98th percentile value	158 (33 - 279) 27.5%	39 (8 - 68) 51.3%	20 (4 - 34) 54.5%	10 (2 - 17) 64.3%
14	30, 98th percentile value	134 (28 - 235) 38.5%	26 (6 - 45) 67.5%	12 (3 - 20) 72.7%	5 (1 - 8) 82.1%
14	25, 98th percentile value	109 (23 - 191) 50.0%	16 (3 - 27) 80.0%	6 (1 - 10) 86.4%	1 (0 - 2) 96.4%
14	40, 99th percentile value	161 (33 - 284) 26.1%	41 (9 - 71) 48.8%	21 (4 - 36) 52.3%	11 (2 - 18) 60.7%
14	35, 99th percentile value	139 (29 - 245) 36.2%	29 (6 - 50) 63.8%	13 (3 - 23) 70.5%	6 (1 - 10) 78.6%
14	30, 99th percentile value	118 (24 - 207) 45.9%	19 (4 - 33) 76.3%	8 (2 - 13) 81.8%	2 (0 - 4) 92.9%
14	25, 99th percentile value	96 (20 - 168) 56.0%	11 (2 - 20) 86.3%	3 (1 - 6) 93.2%	1 (0 - 1) 96.4%

Alternative Standards		Incidence Associated with PM2.5 (95% Confidence Interval) Percent Reduction in Incidence from As Is Levels			
Annual (µg/m3)	Daily (µg/m3)	Policy Relevant Background =2.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =15 µg/m3	Cutpoint** =20 µg/m3
13	40, 98th percentile value	183 (38 - 324) 16.1%	55 (11 - 96) 31.3%	29 (6 - 50) 34.1%	17 (3 - 29) 39.3%
13	35, 98th percentile value	158 (33 - 279) 27.5%	39 (8 - 68) 51.3%	20 (4 - 34) 54.5%	10 (2 - 17) 64.3%
13	30, 98th percentile value	134 (28 - 235) 38.5%	26 (6 - 45) 67.5%	12 (3 - 20) 72.7%	5 (1 - 8) 82.1%
13	25, 98th percentile value	109 (23 - 191) 50.0%	16 (3 - 27) 80.0%	6 (1 - 10) 86.4%	1 (0 - 2) 96.4%
13	40, 99th percentile value	161 (33 - 284) 26.1%	41 (9 - 71) 48.8%	21 (4 - 36) 52.3%	11 (2 - 18) 60.7%
13	35, 99th percentile value	139 (29 - 245) 36.2%	29 (6 - 50) 63.8%	13 (3 - 23) 70.5%	6 (1 - 10) 78.6%
13	30, 99th percentile value	118 (24 - 207) 45.9%	19 (4 - 33) 76.3%	8 (2 - 13) 81.8%	2 (0 - 4) 92.9%
13	25, 99th percentile value	96 (20 - 168) 56.0%	11 (2 - 20) 86.3%	3 (1 - 6) 93.2%	1 (0 - 1) 96.4%
12	40, 98th percentile value	171 (35 - 301) 21.6%	47 (10 - 81) 41.3%	24 (5 - 41) 45.5%	13 (3 - 22) 53.6%
12	35, 98th percentile value	158 (33 - 279) 27.5%	39 (8 - 68) 51.3%	20 (4 - 34) 54.5%	10 (2 - 17) 64.3%
12	30, 98th percentile value	134 (28 - 235) 38.5%	26 (6 - 45) 67.5%	12 (3 - 20) 72.7%	5 (1 - 8) 82.1%
12	25, 98th percentile value	109 (23 - 191) 50.0%	16 (3 - 27) 80.0%	6 (1 - 10) 86.4%	1 (0 - 2) 96.4%
12	40, 99th percentile value	161 (33 - 284) 26.1%	41 (9 - 71) 48.8%	21 (4 - 36) 52.3%	11 (2 - 18) 60.7%
12	35, 99th percentile value	139 (29 - 245) 36.2%	29 (6 - 50) 63.8%	13 (3 - 23) 70.5%	6 (1 - 10) 78.6%
12	30, 99th percentile value	118 (24 - 207) 45.9%	19 (4 - 33) 76.3%	8 (2 - 13) 81.8%	2 (0 - 4) 92.9%
12	25, 99th percentile value	96 (20 - 168) 56.0%	11 (2 - 20) 86.3%	3 (1 - 6) 93.2%	1 (0 - 1) 96.4%

*This analysis used a C-R function from Fairley (2003).

**For the cutpoints above policy relevant background, the slope of the C-R function has been modified based on a simple hockeystick model (see discussion in section 2.5).

***Current standards.

Note: Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Exhibit E.7. Estimated Annual Hospital Admissions for Asthma (Age < 65) Associated with Short-Term Exposure to PM$_{2.5}$ When Alternative Standards Are Just Met, Assuming Various Cutpoint Levels*
Seattle, WA, 2003
(2003 As Is Levels = 8.3 ug/m3 Annual Average; 21.7 ug/m3 98th Percentile Daily Value)

Alternative Standards		Incidence Associated with PM2.5			
		(95% Confidence Interval)			
		Percent Reduction in Incidence from As Is Levels			
Annual (µg/m3)	Daily (µg/m3)	Policy Relevant Background =2.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =15 µg/m3	Cutpoint** =20 µg/m3
15	65, 98th percentile value***	30 (8 - 45) 0.0%	7 (2 - 11) 0.0%	3 (1 - 4) 0.0%	1 (0 - 1) 0.0%
15	40, 98th percentile value	29 (8 - 43) 3.3%	7 (2 - 10) 0.0%	2 (1 - 3) 33.3%	0 (0 - 1) 100.0%
15	35, 98th percentile value	25 (7 - 37) 16.7%	4 (1 - 7) 42.9%	1 (0 - 2) 66.7%	0 (0 - 0) 100.0%
15	30, 98th percentile value	21 (6 - 32) 30.0%	3 (1 - 4) 57.1%	0 (0 - 1) 100.0%	0 (0 - 0) 100.0%
15	25, 98th percentile value	18 (5 - 26) 40.0%	1 (0 - 2) 85.7%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	65, 99th percentile value	30 (8 - 45) 0.0%	7 (2 - 11) 0.0%	3 (1 - 4) 0.0%	1 (0 - 1) 0.0%
15	40, 99th percentile value	25 (6 - 37) 16.7%	4 (1 - 6) 42.9%	1 (0 - 2) 66.7%	0 (0 - 0) 100.0%
15	35, 99th percentile value	21 (6 - 32) 30.0%	3 (1 - 4) 57.1%	0 (0 - 1) 100.0%	0 (0 - 0) 100.0%
15	30, 99th percentile value	18 (5 - 27) 40.0%	1 (0 - 2) 85.7%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	25, 99th percentile value	15 (4 - 22) 50.0%	1 (0 - 1) 85.7%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	40, 98th percentile value	29 (8 - 43) 3.3%	7 (2 - 10) 0.0%	2 (1 - 3) 33.3%	0 (0 - 1) 100.0%
14	35, 98th percentile value	25 (7 - 37) 16.7%	4 (1 - 7) 42.9%	1 (0 - 2) 66.7%	0 (0 - 0) 100.0%
14	30, 98th percentile value	21 (6 - 32) 30.0%	3 (1 - 4) 57.1%	0 (0 - 1) 100.0%	0 (0 - 0) 100.0%
14	25, 98th percentile value	18 (5 - 26) 40.0%	1 (0 - 2) 85.7%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	40, 99th percentile value	25 (6 - 37) 16.7%	4 (1 - 6) 42.9%	1 (0 - 2) 66.7%	0 (0 - 0) 100.0%
14	35, 99th percentile value	21 (6 - 32) 30.0%	3 (1 - 4) 57.1%	0 (0 - 1) 100.0%	0 (0 - 0) 100.0%
14	30, 99th percentile value	18 (5 - 27) 40.0%	1 (0 - 2) 85.7%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	25, 99th percentile value	15 (4 - 22) 50.0%	1 (0 - 1) 85.7%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%

Alternative Standards		Incidence Associated with PM2.5			
		(95% Confidence Interval)			
		Percent Reduction in Incidence from As Is Levels			
Annual (µg/m3)	Daily (µg/m3)	Policy Relevant Background =2.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =15 µg/m3	Cutpoint** =20 µg/m3
13	40, 98th percentile value	29 (8 - 43) 3.3%	7 (2 - 10) 0.0%	2 (1 - 3) 33.3%	0 (0 - 1) 100.0%
13	35, 98th percentile value	25 (7 - 37) 16.7%	4 (1 - 7) 42.9%	1 (0 - 2) 66.7%	0 (0 - 0) 100.0%
13	30, 98th percentile value	21 (6 - 32) 30.0%	3 (1 - 4) 57.1%	0 (0 - 1) 100.0%	0 (0 - 0) 100.0%
13	25, 98th percentile value	18 (5 - 26) 40.0%	1 (0 - 2) 85.7%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	40, 99th percentile value	25 (6 - 37) 16.7%	4 (1 - 6) 42.9%	1 (0 - 2) 66.7%	0 (0 - 0) 100.0%
13	35, 99th percentile value	21 (6 - 32) 30.0%	3 (1 - 4) 57.1%	0 (0 - 1) 100.0%	0 (0 - 0) 100.0%
13	30, 99th percentile value	18 (5 - 27) 40.0%	1 (0 - 2) 85.7%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	25, 99th percentile value	15 (4 - 22) 50.0%	1 (0 - 1) 85.7%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	40, 98th percentile value	29 (8 - 43) 3.3%	7 (2 - 10) 0.0%	2 (1 - 3) 33.3%	0 (0 - 1) 100.0%
12	35, 98th percentile value	25 (7 - 37) 16.7%	4 (1 - 7) 42.9%	1 (0 - 2) 66.7%	0 (0 - 0) 100.0%
12	30, 98th percentile value	21 (6 - 32) 30.0%	3 (1 - 4) 57.1%	0 (0 - 1) 100.0%	0 (0 - 0) 100.0%
12	25, 98th percentile value	18 (5 - 26) 40.0%	1 (0 - 2) 85.7%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	40, 99th percentile value	25 (6 - 37) 16.7%	4 (1 - 6) 42.9%	1 (0 - 2) 66.7%	0 (0 - 0) 100.0%
12	35, 99th percentile value	21 (6 - 32) 30.0%	3 (1 - 4) 57.1%	0 (0 - 1) 100.0%	0 (0 - 0) 100.0%
12	30, 99th percentile value	18 (5 - 27) 40.0%	1 (0 - 2) 85.7%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	25, 99th percentile value	15 (4 - 22) 50.0%	1 (0 - 1) 85.7%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%

*This analysis used a C-R function from Sheppard (2003).

**For the cutpoints above policy relevant background, the slope of the C-R function has been modified based on a simple hockeystick model (see discussion in section 2.5).

***Current standards.

Note: Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Exhibit E.8. Estimated Annual Mortality Associated with Short-Term Exposure to PM$_{2.5}$ When Alternative Standards Are Just Met, Assuming Various Cutpoint Levels*
St. Louis, MO, 2003

| Alternative Standards | | Incidence Associated with PM2.5 (95% Confidence Interval) | | | |
| | | Percent Reduction in Incidence from Current Standards | | | |
Annual (µg/m3)	Daily (µg/m3)	Policy Relevant Background =3.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =15 µg/m3	Cutpoint** =20 µg/m3
15	65, 98th percentile value***	191 (70 - 311) 0.0%	75 (28 - 122) 0.0%	29 (11 - 46) 0.0%	9 (3 - 14) 0.0%
15	40, 98th percentile value	191 (70 - 311) 0.0%	75 (28 - 122) 0.0%	29 (11 - 46) 0.0%	9 (3 - 14) 0.0%
15	35, 98th percentile value	190 (70 - 310) 0.5%	75 (27 - 121) 0.0%	28 (10 - 46) 3.4%	8 (3 - 14) 11.1%
15	30, 98th percentile value	160 (59 - 260) 16.2%	49 (18 - 80) 34.7%	14 (5 - 23) 51.7%	3 (1 - 4) 66.7%
15	25, 98th percentile value	130 (48 - 211) 31.9%	28 (10 - 45) 62.7%	5 (2 - 8) 82.8%	1 (0 - 1) 88.9%
15	65, 99th percentile value	191 (70 - 311) 0.0%	75 (28 - 122) 0.0%	29 (11 - 46) 0.0%	9 (3 - 14) 0.0%
15	40, 99th percentile value	191 (70 - 311) 0.0%	75 (28 - 122) 0.0%	29 (11 - 46) 0.0%	9 (3 - 14) 0.0%
15	35, 99th percentile value	172 (63 - 280) 9.9%	59 (22 - 96) 21.3%	19 (7 - 31) 34.5%	5 (2 - 7) 44.4%
15	30, 99th percentile value	145 (53 - 235) 24.1%	38 (14 - 62) 49.3%	9 (3 - 14) 69.0%	2 (1 - 3) 77.8%
15	25, 99th percentile value	118 (43 - 191) 38.2%	20 (7 - 33) 73.3%	3 (1 - 4) 89.7%	0 (0 - 1) 100.0%
14	40, 98th percentile value	175 (64 - 284) 8.4%	61 (22 - 99) 18.7%	20 (7 - 33) 31.0%	5 (2 - 8) 44.4%
14	35, 98th percentile value	175 (64 - 284) 8.4%	61 (22 - 99) 18.7%	20 (7 - 33) 31.0%	5 (2 - 8) 44.4%
14	30, 98th percentile value	160 (59 - 260) 16.2%	49 (18 - 80) 34.7%	14 (5 - 23) 51.7%	3 (1 - 4) 66.7%
14	25, 98th percentile value	130 (48 - 211) 31.9%	28 (10 - 45) 62.7%	5 (2 - 8) 82.8%	1 (0 - 1) 88.9%
14	40, 99th percentile value	175 (64 - 284) 8.4%	61 (22 - 99) 18.7%	20 (7 - 33) 31.0%	5 (2 - 8) 44.4%
14	35, 99th percentile value	172 (63 - 280) 9.9%	59 (22 - 96) 21.3%	19 (7 - 31) 34.5%	5 (2 - 7) 44.4%
14	30, 99th percentile value	145 (53 - 235) 24.1%	38 (14 - 62) 49.3%	9 (3 - 14) 69.0%	2 (1 - 3) 77.8%
14	25, 99th percentile value	118 (43 - 191) 38.2%	20 (7 - 33) 73.3%	3 (1 - 4) 89.7%	0 (0 - 1) 100.0%

Alternative Standards		Incidence Associated with PM2.5 (95% Confidence Interval)			
		Percent Reduction in Incidence from Current Standards			
Annual (µg/m3)	Daily (µg/m3)	Policy Relevant Background =3.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =15 µg/m3	Cutpoint** =20 µg/m3
13	40, 98th percentile value	158 (58 - 256) 17.3%	47 (17 - 77) 37.3%	13 (5 - 21) 55.2%	3 (1 - 4) 66.7%
13	35, 98th percentile value	158 (58 - 256) 17.3%	47 (17 - 77) 37.3%	13 (5 - 21) 55.2%	3 (1 - 4) 66.7%
13	30, 98th percentile value	158 (58 - 256) 17.3%	47 (17 - 77) 37.3%	13 (5 - 21) 55.2%	3 (1 - 4) 66.7%
13	25, 98th percentile value	130 (48 - 211) 31.9%	28 (10 - 45) 62.7%	5 (2 - 8) 82.8%	1 (0 - 1) 88.9%
13	40, 99th percentile value	158 (58 - 256) 17.3%	47 (17 - 77) 37.3%	13 (5 - 21) 55.2%	3 (1 - 4) 66.7%
13	35, 99th percentile value	158 (58 - 256) 17.3%	47 (17 - 77) 37.3%	13 (5 - 21) 55.2%	3 (1 - 4) 66.7%
13	30, 99th percentile value	145 (53 - 235) 24.1%	38 (14 - 62) 49.3%	9 (3 - 14) 69.0%	2 (1 - 3) 77.8%
13	25, 99th percentile value	118 (43 - 191) 38.2%	20 (7 - 33) 73.3%	3 (1 - 4) 89.7%	0 (0 - 1) 100.0%
12	40, 98th percentile value	141 (52 - 229) 26.2%	35 (13 - 57) 53.3%	8 (3 - 12) 72.4%	1 (1 - 2) 88.9%
12	35, 98th percentile value	141 (52 - 229) 26.2%	35 (13 - 57) 53.3%	8 (3 - 12) 72.4%	1 (1 - 2) 88.9%
12	30, 98th percentile value	141 (52 - 229) 26.2%	35 (13 - 57) 53.3%	8 (3 - 12) 72.4%	1 (1 - 2) 88.9%
12	25, 98th percentile value	130 (48 - 211) 31.9%	28 (10 - 45) 62.7%	5 (2 - 8) 82.8%	1 (0 - 1) 88.9%
12	40, 99th percentile value	141 (52 - 229) 26.2%	35 (13 - 57) 53.3%	8 (3 - 12) 72.4%	1 (1 - 2) 88.9%
12	35, 99th percentile value	141 (52 - 229) 26.2%	35 (13 - 57) 53.3%	8 (3 - 12) 72.4%	1 (1 - 2) 88.9%
12	30, 99th percentile value	141 (52 - 229) 26.2%	35 (13 - 57) 53.3%	8 (3 - 12) 72.4%	1 (1 - 2) 88.9%
12	25, 99th percentile value	118 (43 - 191) 38.2%	20 (7 - 33) 73.3%	3 (1 - 4) 89.7%	0 (0 - 1) 100.0%

*This analysis used a C-R function from Schwartz (2003b).

**For the cutpoints above policy relevant background, the slope of the C-R function has been modified based on a simple hockeystick model (see discussion in section 2.5).

***Current standards.

Note: Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Exhibit E.9. Estimated Annual Mortality Associated with Long-Term Exposure to PM$_{2.5}$ When Alternative Standards Are Just Met, Assuming Various Cutpoint Levels*
Boston, MA, 2003
(2003 As Is Levels = 12.1 ug/m3 Annual Average; 34.1 ug/m3 98th Percentile Daily Value)

Alternative Standards		Incidence Associated with PM2.5		
		(95% Confidence Interval)		
		Percent Reduction in Incidence from As Is Levels		
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
15	65, 98th percentile value***	594 (204 - 1053) 0.0%	309 (106 - 551) 0.0%	20 (7 - 36) 0.0%
15	40, 98th percentile value	484 (166 - 855) 18.5%	185 (63 - 328) 40.1%	0 (0 - 0) 100.0%
15	35, 98th percentile value	346 (119 - 611) 41.8%	30 (10 - 53) 90.3%	0 (0 - 0) 100.0%
15	30, 98th percentile value	209 (72 - 368) 64.8%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	25, 98th percentile value	73 (25 - 129) 87.7%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	65, 99th percentile value	594 (204 - 1053) 0.0%	309 (106 - 551) 0.0%	20 (7 - 36) 0.0%
15	40, 99th percentile value	200 (69 - 352) 66.3%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	35, 99th percentile value	103 (35 - 180) 82.7%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	30, 99th percentile value	6 (2 - 10) 99.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	40, 98th percentile value	484 (166 - 855) 18.5%	185 (63 - 328) 40.1%	0 (0 - 0) 100.0%
14	35, 98th percentile value	346 (119 - 611) 41.8%	30 (10 - 53) 90.3%	0 (0 - 0) 100.0%
14	30, 98th percentile value	209 (72 - 368) 64.8%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	25, 98th percentile value	73 (25 - 129) 87.7%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	40, 99th percentile value	200 (69 - 352) 66.3%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	35, 99th percentile value	103 (35 - 180) 82.7%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%

Alternative Standards		Incidence Associated with PM2.5 (95% Confidence Interval) Percent Reduction in Incidence from As Is Levels		
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
14	30, 99th percentile value	6 (2 - 10) 99.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	40, 98th percentile value	451 (155 - 796) 24.1%	147 (50 - 262) 52.4%	0 (0 - 0) 100.0%
13	35, 98th percentile value	346 (119 - 611) 41.8%	30 (10 - 53) 90.3%	0 (0 - 0) 100.0%
13	30, 98th percentile value	209 (72 - 368) 64.8%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	25, 98th percentile value	73 (25 - 129) 87.7%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	40, 99th percentile value	200 (69 - 352) 66.3%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	35, 99th percentile value	103 (35 - 180) 82.7%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	30, 99th percentile value	6 (2 - 10) 99.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	40, 98th percentile value	348 (120 - 615) 41.4%	33 (11 - 58) 89.3%	0 (0 - 0) 100.0%
12	35, 98th percentile value	346 (119 - 611) 41.8%	30 (10 - 53) 90.3%	0 (0 - 0) 100.0%
12	30, 98th percentile value	209 (72 - 368) 64.8%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	25, 98th percentile value	73 (25 - 129) 87.7%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	40, 99th percentile value	200 (69 - 352) 66.3%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	35, 99th percentile value	103 (35 - 180) 82.7%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	30, 99th percentile value	6 (2 - 10) 99.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%

*This analysis used a C-R function from Pope et al. (2002) -- ACS extended.

**For the cutpoints above 7.5 µg/m3, the slope of the C-R function has been modified based on a simple hockeystick model (see discussion in section 2.5).

***Current standards.

Note: Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Exhibit E.10. Estimated Annual Mortality Associated with Long-Term Exposure to PM$_{2.5}$ When Alternative Standards Are Just Met, Assuming Various Cutpoint Levels*
Los Angeles, CA, 2003

Alternative Standards		Incidence Associated with PM2.5 (95% Confidence Interval)		
		Percent Reduction in Incidence from Current Standards		
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
15	65, 98th percentile value***	1507 (531 - 2587) 0.0%	823 (290 - 1415) 0.0%	138 (48 - 237) 0.0%
15	40, 98th percentile value	1507 (531 - 2587) 0.0%	823 (290 - 1415) 0.0%	138 (48 - 237) 0.0%
15	35, 98th percentile value	1265 (446 - 2168) 16.1%	553 (195 - 949) 32.8%	0 (0 - 0) 100.0%
15	30, 98th percentile value	829 (293 - 1416) 45.0%	65 (23 - 111) 92.1%	0 (0 - 0) 100.0%
15	25, 98th percentile value	396 (140 - 675) 73.7%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	65, 99th percentile value	1507 (531 - 2587) 0.0%	823 (290 - 1415) 0.0%	138 (48 - 237) 0.0%
15	40, 99th percentile value	514 (182 - 876) 65.9%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	35, 99th percentile value	240 (85 - 408) 84.1%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	30, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	40, 98th percentile value	1259 (444 - 2158) 16.5%	546 (192 - 937) 33.7%	0 (0 - 0) 100.0%
14	35, 98th percentile value	1259 (444 - 2158) 16.5%	546 (192 - 937) 33.7%	0 (0 - 0) 100.0%
14	30, 98th percentile value	829 (293 - 1416) 45.0%	65 (23 - 111) 92.1%	0 (0 - 0) 100.0%
14	25, 98th percentile value	396 (140 - 675) 73.7%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	40, 99th percentile value	514 (182 - 876) 65.9%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	35, 99th percentile value	240 (85 - 408) 84.1%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	30, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%

Alternative Standards		Incidence Associated with PM2.5 (95% Confidence Interval)		
		Percent Reduction in Incidence from Current Standards		
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
14	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	40, 98th percentile value	1013 (358 - 1732) 32.8%	270 (95 - 463) 67.2%	0 (0 - 0) 100.0%
13	35, 98th percentile value	1013 (358 - 1732) 32.8%	270 (95 - 463) 67.2%	0 (0 - 0) 100.0%
13	30, 98th percentile value	829 (293 - 1416) 45.0%	65 (23 - 111) 92.1%	0 (0 - 0) 100.0%
13	25, 98th percentile value	396 (140 - 675) 73.7%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	40, 99th percentile value	514 (182 - 876) 65.9%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	35, 99th percentile value	240 (85 - 408) 84.1%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	30, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	40, 98th percentile value	767 (271 - 1310) 49.1%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	35, 98th percentile value	767 (271 - 1310) 49.1%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	30, 98th percentile value	767 (271 - 1310) 49.1%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	25, 98th percentile value	396 (140 - 675) 73.7%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	40, 99th percentile value	514 (182 - 876) 65.9%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	35, 99th percentile value	240 (85 - 408) 84.1%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	30, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%

*This analysis used a C-R function from Pope et al. (2002) -- ACS extended.

**For the cutpoints above 7.5 µg/m3, the slope of the C-R function has been modified based on a simple hockeystick model (see discussion in section 2.5).

***Current standards.

Note: Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Exhibit E.11. Estimated Annual Mortality Associated with Long-Term Exposure to PM$_{2.5}$ When Alternative Standards Are Just Met, Assuming Various Cutpoint Levels*
Philadelphia, PA, 2003

Alternative Standards		Incidence Associated with PM2.5 (95% Confidence Interval)		
		Percent Reduction in Incidence from Current Standards		
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
15	65, 98th percentile value***	536 (185 - 943) 0.0%	338 (116 - 597) 0.0%	137 (47 - 244) 0.0%
15	40, 98th percentile value	408 (141 - 716) 23.9%	194 (67 - 341) 42.6%	0 (0 - 0) 100.0%
15	35, 98th percentile value	299 (104 - 524) 44.2%	72 (25 - 126) 78.7%	0 (0 - 0) 100.0%
15	30, 98th percentile value	191 (67 - 334) 64.4%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	25, 98th percentile value	84 (29 - 146) 84.3%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	65, 99th percentile value	357 (124 - 626) 33.4%	137 (47 - 241) 59.5%	0 (0 - 0) 100.0%
15	40, 99th percentile value	58 (20 - 101) 89.2%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	35, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	30, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	65, 98th percentile value	456 (157 - 799) 14.9%	247 (85 - 435) 26.9%	37 (13 - 65) 73.0%
14	40, 98th percentile value	408 (141 - 716) 23.9%	194 (67 - 341) 42.6%	0 (0 - 0) 100.0%
14	35, 98th percentile value	299 (104 - 524) 44.2%	72 (25 - 126) 78.7%	0 (0 - 0) 100.0%
14	30, 98th percentile value	191 (67 - 334) 64.4%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	25, 98th percentile value	84 (29 - 146) 84.3%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	40, 99th percentile value	58 (20 - 101) 89.2%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	35, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	30, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%

Alternative Standards		Incidence Associated with PM2.5 (95% Confidence Interval) Percent Reduction in Incidence from Current Standards		
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
14	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	40, 98th percentile value	375 (130 - 657) 30.0%	157 (54 - 276) 53.6%	0 (0 - 0) 100.0%
13	35, 98th percentile value	299 (104 - 524) 44.2%	72 (25 - 126) 78.7%	0 (0 - 0) 100.0%
13	30, 98th percentile value	191 (67 - 334) 64.4%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	25, 98th percentile value	84 (29 - 146) 84.3%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	40, 99th percentile value	58 (20 - 101) 89.2%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	35, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	30, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	40, 98th percentile value	295 (102 - 516) 45.0%	67 (23 - 118) 80.2%	0 (0 - 0) 100.0%
12	35, 98th percentile value	295 (102 - 516) 45.0%	67 (23 - 118) 80.2%	0 (0 - 0) 100.0%
12	30, 98th percentile value	191 (67 - 334) 64.4%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	25, 98th percentile value	84 (29 - 146) 84.3%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	40, 99th percentile value	58 (20 - 101) 89.2%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	35, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	30, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%

*This analysis used a C-R function from Pope et al. (2002) -- ACS extended.

**For the cutpoints above 7.5 µg/m3, the slope of the C-R function has been modified based on a simple hockeystick model (see discussion in section 2.5).
***Current standards.

Note: Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Exhibit E.12. Estimated Annual Mortality Associated with Long-Term Exposure to PM$_{2.5}$ When Alternative Standards Are Just Met, Assuming Various Cutpoint Levels*

Phoenix, AZ, 2001

(2001 As Is Levels = 10.4 ug/m3 Annual Average; 28.9 ug/m3 98th Percentile Daily Value]

Alternative Standards		Incidence Associated with PM2.5		
		(95% Confidence Interval)		
		Percent Reduction in Incidence from As Is Levels		
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
15	65, 98th percentile value***	349 (119 - 620) 0.0%	55 (19 - 98) 0.0%	0 (0 - 0) ---
15	40, 98th percentile value	349 (119 - 620) 0.0%	55 (19 - 98) 0.0%	0 (0 - 0) ---
15	35, 98th percentile value	349 (119 - 620) 0.0%	55 (19 - 98) 0.0%	0 (0 - 0) ---
15	30, 98th percentile value	202 (69 - 358) 42.1%	0 (0 - 0) 100.0%	0 (0 - 0) ---
15	25, 98th percentile value	56 (19 - 100) 84.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---
15	65, 99th percentile value	349 (119 - 620) 0.0%	55 (19 - 98) 0.0%	0 (0 - 0) ---
15	40, 99th percentile value	324 (111 - 576) 7.2%	27 (9 - 48) 50.9%	0 (0 - 0) ---
15	35, 99th percentile value	200 (69 - 355) 42.7%	0 (0 - 0) 100.0%	0 (0 - 0) ---
15	30, 99th percentile value	77 (26 - 136) 77.9%	0 (0 - 0) 100.0%	0 (0 - 0) ---
15	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---
14	40, 98th percentile value	349 (119 - 620) 0.0%	55 (19 - 98) 0.0%	0 (0 - 0) ---
14	35, 98th percentile value	349 (119 - 620) 0.0%	55 (19 - 98) 0.0%	0 (0 - 0) ---
14	30, 98th percentile value	202 (69 - 358) 42.1%	0 (0 - 0) 100.0%	0 (0 - 0) ---
14	25, 98th percentile value	56 (19 - 100) 84.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---
14	40, 99th percentile value	324 (111 - 576) 7.2%	27 (9 - 48) 50.9%	0 (0 - 0) ---
14	35, 99th percentile value	200 (69 - 355) 42.7%	0 (0 - 0) 100.0%	0 (0 - 0) ---
14	30, 99th percentile value	77 (26 - 136) 77.9%	0 (0 - 0) 100.0%	0 (0 - 0) ---

Alternative Standards		Incidence Associated with PM2.5 (95% Confidence Interval)		
		Percent Reduction in Incidence from As Is Levels		
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
14	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---
13	40, 98th percentile value	349 (119 - 620) 0.0%	55 (19 - 98) 0.0%	0 (0 - 0) ---
13	35, 98th percentile value	349 (119 - 620) 0.0%	55 (19 - 98) 0.0%	0 (0 - 0) ---
13	30, 98th percentile value	202 (69 - 358) 42.1%	0 (0 - 0) 100.0%	0 (0 - 0) ---
13	25, 98th percentile value	56 (19 - 100) 84.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---
13	40, 99th percentile value	324 (111 - 576) 7.2%	27 (9 - 48) 50.9%	0 (0 - 0) ---
13	35, 99th percentile value	200 (69 - 355) 42.7%	0 (0 - 0) 100.0%	0 (0 - 0) ---
13	30, 99th percentile value	77 (26 - 136) 77.9%	0 (0 - 0) 100.0%	0 (0 - 0) ---
13	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---
12	40, 98th percentile value	349 (119 - 620) 0.0%	55 (19 - 98) 0.0%	0 (0 - 0) ---
12	35, 98th percentile value	349 (119 - 620) 0.0%	55 (19 - 98) 0.0%	0 (0 - 0) ---
12	30, 98th percentile value	202 (69 - 358) 42.1%	0 (0 - 0) 100.0%	0 (0 - 0) ---
12	25, 98th percentile value	56 (19 - 100) 84.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---
12	40, 99th percentile value	324 (111 - 576) 7.2%	27 (9 - 48) 50.9%	0 (0 - 0) ---
12	35, 99th percentile value	200 (69 - 355) 42.7%	0 (0 - 0) 100.0%	0 (0 - 0) ---
12	30, 99th percentile value	77 (26 - 136) 77.9%	0 (0 - 0) 100.0%	0 (0 - 0) ---
12	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---

*This analysis used a C-R function from Pope et al. (2002) -- ACS extended.

**For the cutpoints above 7.5 µg/m3, the slope of the C-R function has been modified based on a simple hockeystick model (see discussion in section 2.5).

***Current standards.

Note: Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Exhibit E.13. Estimated Annual Mortality Associated with Long-Term Exposure to PM2.5 When Alternative Standards Are Just Met, Assuming Various Cutpoint Levels*
Pittsburgh, PA, 2003

Alternative Standards		Incidence Associated with PM2.5 (95% Confidence Interval)		
		Percent Reduction in Incidence from Current Standards		
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
15	65, 98th percentile value***	403 (141 - 699) 0.0%	215 (75 - 373) 0.0%	25 (9 - 43) 0.0%
15	40, 98th percentile value	361 (126 - 626) 10.4%	168 (58 - 291) 21.9%	0 (0 - 0) 100.0%
15	35, 98th percentile value	264 (93 - 456) 34.5%	59 (21 - 102) 72.6%	0 (0 - 0) 100.0%
15	30, 98th percentile value	168 (59 - 289) 58.3%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	25, 98th percentile value	72 (25 - 124) 82.1%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	65, 99th percentile value	403 (141 - 699) 0.0%	215 (75 - 373) 0.0%	25 (9 - 43) 0.0%
15	40, 99th percentile value	287 (100 - 495) 28.8%	84 (29 - 145) 60.9%	0 (0 - 0) 100.0%
15	35, 99th percentile value	200 (70 - 345) 50.4%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	30, 99th percentile value	114 (40 - 197) 71.7%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	25, 99th percentile value	29 (10 - 50) 92.8%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	40, 98th percentile value	338 (118 - 585) 16.1%	141 (49 - 245) 34.4%	0 (0 - 0) 100.0%
14	35, 98th percentile value	264 (93 - 456) 34.5%	59 (21 - 102) 72.6%	0 (0 - 0) 100.0%
14	30, 98th percentile value	168 (59 - 289) 58.3%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	25, 98th percentile value	72 (25 - 124) 82.1%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	40, 99th percentile value	287 (100 - 495) 28.8%	84 (29 - 145) 60.9%	0 (0 - 0) 100.0%
14	35, 99th percentile value	200 (70 - 345) 50.4%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	30, 99th percentile value	114 (40 - 197) 71.7%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%

Alternative Standards		Incidence Associated with PM2.5 (95% Confidence Interval)		
		Percent Reduction in Incidence from Current Standards		
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
14	25, 99th percentile value	29 (10 - 50) 92.8%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	40, 98th percentile value	273 (96 - 471) 32.3%	68 (24 - 118) 68.4%	0 (0 - 0) 100.0%
13	35, 98th percentile value	264 (93 - 456) 34.5%	59 (21 - 102) 72.6%	0 (0 - 0) 100.0%
13	30, 98th percentile value	168 (59 - 289) 58.3%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	25, 98th percentile value	72 (25 - 124) 82.1%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	40, 99th percentile value	273 (96 - 471) 32.3%	68 (24 - 118) 68.4%	0 (0 - 0) 100.0%
13	35, 99th percentile value	200 (70 - 345) 50.4%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	30, 99th percentile value	114 (40 - 197) 71.7%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	25, 99th percentile value	29 (10 - 50) 92.8%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	40, 98th percentile value	208 (73 - 358) 48.4%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	35, 98th percentile value	208 (73 - 358) 48.4%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	30, 98th percentile value	168 (59 - 289) 58.3%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	25, 98th percentile value	72 (25 - 124) 82.1%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	40, 99th percentile value	208 (73 - 358) 48.4%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	35, 99th percentile value	200 (70 - 345) 50.4%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	30, 99th percentile value	114 (40 - 197) 71.7%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	25, 99th percentile value	29 (10 - 50) 92.8%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%

*This analysis used a C-R function from Pope et al. (2002) -- ACS extended.

**For the cutpoints above 7.5 µg/m3, the slope of the C-R function has been modified based on a simple hockeystick model (see discussion in section 2.5).

***Current standards.

Note: Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Exhibit E.14. Estimated Annual Mortality Associated with Long-Term Exposure to PM$_{2.5}$ When Alternative Standards Are Just Met, Assuming Various Cutpoint Levels*

San Jose, CA, 2003

(2003 As Is Levels = 11.1 ug/m3 Annual Average; 37.6 ug/m3 98th Percentile Daily Value]

Alternative Standards		Incidence Associated with PM2.5		
		(95% Confidence Interval)		
		Percent Reduction in Incidence from As Is Levels		
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
15	65, 98th percentile value***	172 (59 - 306) 0.0%	58 (20 - 104) 0.0%	0 (0 - 0) ---
15	40, 98th percentile value	107 (37 - 189) 37.8%	0 (0 - 0) 100.0%	0 (0 - 0) ---
15	35, 98th percentile value	60 (21 - 106) 65.1%	0 (0 - 0) 100.0%	0 (0 - 0) ---
15	30, 98th percentile value	14 (5 - 24) 91.9%	0 (0 - 0) 100.0%	0 (0 - 0) ---
15	25, 98th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---
15	65, 99th percentile value	172 (59 - 306) 0.0%	58 (20 - 104) 0.0%	0 (0 - 0) ---
15	40, 99th percentile value	65 (22 - 115) 62.2%	0 (0 - 0) 100.0%	0 (0 - 0) ---
15	35, 99th percentile value	24 (8 - 43) 86.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---
15	30, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---
15	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---
14	40, 98th percentile value	107 (37 - 189) 37.8%	0 (0 - 0) 100.0%	0 (0 - 0) ---
14	35, 98th percentile value	60 (21 - 106) 65.1%	0 (0 - 0) 100.0%	0 (0 - 0) ---
14	30, 98th percentile value	14 (5 - 24) 91.9%	0 (0 - 0) 100.0%	0 (0 - 0) ---
14	25, 98th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---
14	40, 99th percentile value	65 (22 - 115) 62.2%	0 (0 - 0) 100.0%	0 (0 - 0) ---
14	35, 99th percentile value	24 (8 - 43) 86.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---
14	30, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---

Alternative Standards		Incidence Associated with PM2.5 (95% Confidence Interval)		
		Percent Reduction in Incidence from As Is Levels		
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
14	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---
13	40, 98th percentile value	107 (37 - 189) 37.8%	0 (0 - 0) 100.0%	0 (0 - 0) ---
13	35, 98th percentile value	60 (21 - 106) 65.1%	0 (0 - 0) 100.0%	0 (0 - 0) ---
13	30, 98th percentile value	14 (5 - 24) 91.9%	0 (0 - 0) 100.0%	0 (0 - 0) ---
13	25, 98th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---
13	40, 99th percentile value	65 (22 - 115) 62.2%	0 (0 - 0) 100.0%	0 (0 - 0) ---
13	35, 99th percentile value	24 (8 - 43) 86.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---
13	30, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---
13	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---
12	40, 98th percentile value	83 (28 - 146) 51.7%	0 (0 - 0) 100.0%	0 (0 - 0) ---
12	35, 98th percentile value	60 (21 - 106) 65.1%	0 (0 - 0) 100.0%	0 (0 - 0) ---
12	30, 98th percentile value	14 (5 - 24) 91.9%	0 (0 - 0) 100.0%	0 (0 - 0) ---
12	25, 98th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---
12	40, 99th percentile value	65 (22 - 115) 62.2%	0 (0 - 0) 100.0%	0 (0 - 0) ---
12	35, 99th percentile value	24 (8 - 43) 86.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---
12	30, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---
12	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---

*This analysis used a C-R function from Pope et al. (2002) -- ACS extended.

**For the cutpoints above 7.5 µg/m3, the slope of the C-R function has been modified based on a simple hockeystick model (see discussion in section 2.5).

***Current standards.

Note: Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Exhibit E.15. Estimated Annual Mortality Associated with Long-Term Exposure to PM$_{2.5}$ When Alternative Standards Are Just Met, Assuming Various Cutpoint Levels*
Seattle, WA, 2003
(2003 As Is Levels = 8.3 ug/m3 Annual Average; 21.7 ug/m3 98th Percentile Daily Value)

Alternative Standards		Incidence Associated with PM2.5		
		(95% Confidence Interval)		
		Percent Reduction in Incidence from As Is Levels		
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
15	65, 98th percentile value***	50 (17 - 89) 0.0%	0 (0 - 0) ---	0 (0 - 0) ---
15	40, 98th percentile value	40 (14 - 72) 20.0%	0 (0 - 0) ---	0 (0 - 0) ---
15	35, 98th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
15	30, 98th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
15	25, 98th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
15	65, 99th percentile value	50 (17 - 89) 0.0%	0 (0 - 0) ---	0 (0 - 0) ---
15	40, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
15	35, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
15	30, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
15	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
14	40, 98th percentile value	40 (14 - 72) 20.0%	0 (0 - 0) ---	0 (0 - 0) ---
14	35, 98th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
14	30, 98th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
14	25, 98th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
14	40, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
14	35, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
14	30, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---

Alternative Standards		Incidence Associated with PM2.5 (95% Confidence Interval)		
		Percent Reduction in Incidence from As Is Levels		
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
14	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
13	40, 98th percentile value	40 (14 - 72) 20.0%	0 (0 - 0) ---	0 (0 - 0) ---
13	35, 98th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
13	30, 98th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
13	25, 98th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
13	40, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
13	35, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
13	30, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
13	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
12	40, 98th percentile value	40 (14 - 72) 20.0%	0 (0 - 0) ---	0 (0 - 0) ---
12	35, 98th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
12	30, 98th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
12	25, 98th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
12	40, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
12	35, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
12	30, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
12	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---

*This analysis used a C-R function from Pope et al. (2002) -- ACS extended.

**For the cutpoints above 7.5 µg/m3, the slope of the C-R function has been modified based on a simple hockeystick model (see discussion in section 2.5).
***Current standards.

Note: Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Exhibit E.16. Estimated Annual Mortality Associated with Long-Term Exposure to PM$_{2.5}$ When Alternative Standards Are Just Met, Assuming Various Cutpoint Levels*
St. Louis, MO, 2003

Alternative Standards		Incidence Associated with PM2.5 (95% Confidence Interval)		
		Percent Reduction in Incidence from Current Standards		
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
15	65, 98th percentile value***	596 (206 - 1047) 0.0%	311 (107 - 548) 0.0%	23 (8 - 40) 0.0%
15	40, 98th percentile value	596 (206 - 1047) 0.0%	311 (107 - 548) 0.0%	23 (8 - 40) 0.0%
15	35, 98th percentile value	592 (204 - 1039) 0.7%	306 (105 - 539) 1.6%	17 (6 - 30) 26.1%
15	30, 98th percentile value	414 (144 - 726) 30.5%	107 (37 - 188) 65.6%	0 (0 - 0) 100.0%
15	25, 98th percentile value	239 (83 - 417) 59.9%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	65, 99th percentile value	596 (206 - 1047) 0.0%	311 (107 - 548) 0.0%	23 (8 - 40) 0.0%
15	40, 99th percentile value	596 (206 - 1047) 0.0%	311 (107 - 548) 0.0%	23 (8 - 40) 0.0%
15	35, 99th percentile value	486 (168 - 853) 18.5%	188 (65 - 330) 39.5%	0 (0 - 0) 100.0%
15	30, 99th percentile value	327 (113 - 571) 45.1%	8 (3 - 15) 97.4%	0 (0 - 0) 100.0%
15	25, 99th percentile value	168 (58 - 293) 71.8%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	40, 98th percentile value	498 (172 - 874) 16.4%	201 (69 - 354) 35.4%	0 (0 - 0) 100.0%
14	35, 98th percentile value	498 (172 - 874) 16.4%	201 (69 - 354) 35.4%	0 (0 - 0) 100.0%
14	30, 98th percentile value	414 (144 - 726) 30.5%	107 (37 - 188) 65.6%	0 (0 - 0) 100.0%
14	25, 98th percentile value	239 (83 - 417) 59.9%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	40, 99th percentile value	498 (172 - 874) 16.4%	201 (69 - 354) 35.4%	0 (0 - 0) 100.0%
14	35, 99th percentile value	486 (168 - 853) 18.5%	188 (65 - 330) 39.5%	0 (0 - 0) 100.0%
14	30, 99th percentile value	327 (113 - 571) 45.1%	8 (3 - 15) 97.4%	0 (0 - 0) 100.0%

Alternative Standards		Incidence Associated with PM2.5 (95% Confidence Interval)		
		Percent Reduction in Incidence from Current Standards		
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
14	25, 99th percentile value	168 (58 - 293) 71.8%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	40, 98th percentile value	401 (139 - 702) 32.7%	92 (32 - 162) 70.4%	0 (0 - 0) 100.0%
13	35, 98th percentile value	401 (139 - 702) 32.7%	92 (32 - 162) 70.4%	0 (0 - 0) 100.0%
13	30, 98th percentile value	401 (139 - 702) 32.7%	92 (32 - 162) 70.4%	0 (0 - 0) 100.0%
13	25, 98th percentile value	239 (83 - 417) 59.9%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	40, 99th percentile value	401 (139 - 702) 32.7%	92 (32 - 162) 70.4%	0 (0 - 0) 100.0%
13	35, 99th percentile value	401 (139 - 702) 32.7%	92 (32 - 162) 70.4%	0 (0 - 0) 100.0%
13	30, 99th percentile value	327 (113 - 571) 45.1%	8 (3 - 15) 97.4%	0 (0 - 0) 100.0%
13	25, 99th percentile value	168 (58 - 293) 71.8%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	40, 98th percentile value	304 (106 - 532) 49.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	35, 98th percentile value	304 (106 - 532) 49.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	30, 98th percentile value	304 (106 - 532) 49.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	25, 98th percentile value	239 (83 - 417) 59.9%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	40, 99th percentile value	304 (106 - 532) 49.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	35, 99th percentile value	304 (106 - 532) 49.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	30, 99th percentile value	304 (106 - 532) 49.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	25, 99th percentile value	168 (58 - 293) 71.8%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%

*This analysis used a C-R function from Pope et al. (2002) -- ACS extended.

**For the cutpoints above 7.5 µg/m3, the slope of the C-R function has been modified based on a simple hockeystick model (see discussion in section 2.5).

***Current standards.

Note: Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Exhibit E.17. Estimated Annual Cardiopulmonary Mortality Associated with Long-Term Exposure to PM$_{2.5}$ When Alternative Standards Are Just Met, Assuming Various Cutpoint Levels*
Boston, MA, 2003
(2003 As Is Levels = 12.1 ug/m3 Annual Average; 34.1 ug/m3 98th Percentile Daily Value)

Alternative Standards		Incidence Associated with PM2.5 (95% Confidence Interval) Percent Reduction in Incidence from As Is Levels		
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
15	65, 98th percentile value***	380 (132 - 645) 0.0%	198 (68 - 339) 0.0%	13 (4 - 22) 0.0%
15	40, 98th percentile value	309 (108 - 523) 18.7%	118 (41 - 202) 40.4%	0 (0 - 0) 100.0%
15	35, 98th percentile value	221 (77 - 372) 41.8%	19 (7 - 33) 90.4%	0 (0 - 0) 100.0%
15	30, 98th percentile value	133 (47 - 224) 65.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	25, 98th percentile value	47 (16 - 78) 87.6%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	65, 99th percentile value	380 (132 - 645) 0.0%	198 (68 - 339) 0.0%	13 (4 - 22) 0.0%
15	40, 99th percentile value	127 (45 - 214) 66.6%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	35, 99th percentile value	65 (23 - 110) 82.9%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	30, 99th percentile value	4 (1 - 6) 98.9%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	40, 98th percentile value	309 (108 - 523) 18.7%	118 (41 - 202) 40.4%	0 (0 - 0) 100.0%
14	35, 98th percentile value	221 (77 - 372) 41.8%	19 (7 - 33) 90.4%	0 (0 - 0) 100.0%
14	30, 98th percentile value	133 (47 - 224) 65.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	25, 98th percentile value	47 (16 - 78) 87.6%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	40, 99th percentile value	127 (45 - 214) 66.6%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	35, 99th percentile value	65 (23 - 110) 82.9%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%

Alternative Standards		Incidence Associated with PM2.5		
		(95% Confidence Interval)		
		Percent Reduction in Incidence from As Is Levels		
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
14	30, 99th percentile value	4 (1 - 6) 98.9%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	40, 98th percentile value	288 (100 - 487) 24.2%	94 (33 - 161) 52.5%	0 (0 - 0) 100.0%
13	35, 98th percentile value	221 (77 - 372) 41.8%	19 (7 - 33) 90.4%	0 (0 - 0) 100.0%
13	30, 98th percentile value	133 (47 - 224) 65.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	25, 98th percentile value	47 (16 - 78) 87.6%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	40, 99th percentile value	127 (45 - 214) 66.6%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	35, 99th percentile value	65 (23 - 110) 82.9%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	30, 99th percentile value	4 (1 - 6) 98.9%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	40, 98th percentile value	222 (78 - 375) 41.6%	21 (7 - 35) 89.4%	0 (0 - 0) 100.0%
12	35, 98th percentile value	221 (77 - 372) 41.8%	19 (7 - 33) 90.4%	0 (0 - 0) 100.0%
12	30, 98th percentile value	133 (47 - 224) 65.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	25, 98th percentile value	47 (16 - 78) 87.6%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	40, 99th percentile value	127 (45 - 214) 66.6%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	35, 99th percentile value	65 (23 - 110) 82.9%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	30, 99th percentile value	4 (1 - 6) 98.9%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%

*This analysis used a C-R function from Pope et al. (2002) -- ACS extended.

**For the cutpoints above 7.5 µg/m3, the slope of the C-R function has been modified based on a simple hockeystick model (see discussion in section 2.5).
***Current standards.

Note: Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Exhibit E.18. Estimated Annual Cardiopulmonary Mortality Associated with Long-Term Exposure to PM$_{2.5}$ When Alternative Standards Are Just Met, Assuming Various Cutpoint Levels*
Los Angeles, CA, 2003

Alternative Standards		Incidence Associated with PM2.5		
		(95% Confidence Interval)		
		Percent Reduction in Incidence from Current Standards		
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
15	65, 98th percentile value***	1151 (416 - 1873) 0.0%	629 (227 - 1025) 0.0%	105 (38 - 172) 0.0%
15	40, 98th percentile value	1151 (416 - 1873) 0.0%	629 (227 - 1025) 0.0%	105 (38 - 172) 0.0%
15	35, 98th percentile value	966 (350 - 1567) 16.1%	422 (153 - 686) 32.9%	0 (0 - 0) 100.0%
15	30, 98th percentile value	632 (230 - 1020) 45.1%	50 (18 - 80) 92.1%	0 (0 - 0) 100.0%
15	25, 98th percentile value	301 (110 - 485) 73.8%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	65, 99th percentile value	1151 (416 - 1873) 0.0%	629 (227 - 1025) 0.0%	105 (38 - 172) 0.0%
15	40, 99th percentile value	391 (143 - 630) 66.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	35, 99th percentile value	182 (67 - 292) 84.2%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	30, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	40, 98th percentile value	961 (348 - 1559) 16.5%	417 (151 - 677) 33.7%	0 (0 - 0) 100.0%
14	35, 98th percentile value	961 (348 - 1559) 16.5%	417 (151 - 677) 33.7%	0 (0 - 0) 100.0%
14	30, 98th percentile value	632 (230 - 1020) 45.1%	50 (18 - 80) 92.1%	0 (0 - 0) 100.0%
14	25, 98th percentile value	301 (110 - 485) 73.8%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	40, 99th percentile value	391 (143 - 630) 66.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	35, 99th percentile value	182 (67 - 292) 84.2%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	30, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%

Alternative Standards		Incidence Associated with PM2.5 (95% Confidence Interval)		
		Percent Reduction in Incidence from Current Standards		
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
14	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	40, 98th percentile value	772 (280 - 1250) 32.9%	206 (75 - 334) 67.2%	0 (0 - 0) 100.0%
13	35, 98th percentile value	772 (280 - 1250) 32.9%	206 (75 - 334) 67.2%	0 (0 - 0) 100.0%
13	30, 98th percentile value	632 (230 - 1020) 45.1%	50 (18 - 80) 92.1%	0 (0 - 0) 100.0%
13	25, 98th percentile value	301 (110 - 485) 73.8%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	40, 99th percentile value	391 (143 - 630) 66.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	35, 99th percentile value	182 (67 - 292) 84.2%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	30, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	40, 98th percentile value	584 (213 - 943) 49.3%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	35, 98th percentile value	584 (213 - 943) 49.3%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	30, 98th percentile value	584 (213 - 943) 49.3%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	25, 98th percentile value	301 (110 - 485) 73.8%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	40, 99th percentile value	391 (143 - 630) 66.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	35, 99th percentile value	182 (67 - 292) 84.2%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	30, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%

*This analysis used a C-R function from Pope et al. (2002) -- ACS extended.

**For the cutpoints above 7.5 µg/m3, the slope of the C-R function has been modified based on a simple hockeystick model (see discussion in section 2.5).

***Current standards.

Note: Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Exhibit E.19. Estimated Annual Cardiopulmonary Mortality Associated with Long-Term Exposure to PM$_{2.5}$ When Alternative Standards Are Just Met, Assuming Various Cutpoint Levels*
Philadelphia, PA, 2003

Alternative Standards		Incidence Associated with PM2.5 (95% Confidence Interval)		
		Percent Reduction in Incidence from Current Standards		
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
15	65, 98th percentile value***	349 (122 - 586) 0.0%	220 (77 - 372) 0.0%	90 (31 - 153) 0.0%
15	40, 98th percentile value	265 (93 - 443) 24.1%	126 (44 - 212) 42.7%	0 (0 - 0) 100.0%
15	35, 98th percentile value	194 (69 - 324) 44.4%	47 (16 - 78) 78.6%	0 (0 - 0) 100.0%
15	30, 98th percentile value	124 (44 - 206) 64.5%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	25, 98th percentile value	54 (19 - 90) 84.5%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	65, 99th percentile value	232 (82 - 387) 33.5%	89 (31 - 149) 59.5%	0 (0 - 0) 100.0%
15	40, 99th percentile value	37 (13 - 62) 89.4%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	35, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	30, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	65, 98th percentile value	296 (104 - 496) 15.2%	161 (56 - 271) 26.8%	24 (8 - 41) 73.3%
14	40, 98th percentile value	265 (93 - 443) 24.1%	126 (44 - 212) 42.7%	0 (0 - 0) 100.0%
14	35, 98th percentile value	194 (69 - 324) 44.4%	47 (16 - 78) 78.6%	0 (0 - 0) 100.0%
14	30, 98th percentile value	124 (44 - 206) 64.5%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	25, 98th percentile value	54 (19 - 90) 84.5%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	40, 99th percentile value	37 (13 - 62) 89.4%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	35, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	30, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%

Alternative Standards		Incidence Associated with PM2.5 (95% Confidence Interval)		
		Percent Reduction in Incidence from Current Standards		
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
14	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	40, 98th percentile value	243 (86 - 407) 30.4%	102 (36 - 171) 53.6%	0 (0 - 0) 100.0%
13	35, 98th percentile value	194 (69 - 324) 44.4%	47 (16 - 78) 78.6%	0 (0 - 0) 100.0%
13	30, 98th percentile value	124 (44 - 206) 64.5%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	25, 98th percentile value	54 (19 - 90) 84.5%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	40, 99th percentile value	37 (13 - 62) 89.4%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	35, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	30, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	40, 98th percentile value	191 (68 - 319) 45.3%	44 (15 - 73) 80.0%	0 (0 - 0) 100.0%
12	35, 98th percentile value	191 (68 - 319) 45.3%	44 (15 - 73) 80.0%	0 (0 - 0) 100.0%
12	30, 98th percentile value	124 (44 - 206) 64.5%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	25, 98th percentile value	54 (19 - 90) 84.5%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	40, 99th percentile value	37 (13 - 62) 89.4%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	35, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	30, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%

*This analysis used a C-R function from Pope et al. (2002) -- ACS extended.

**For the cutpoints above 7.5 µg/m3, the slope of the C-R function has been modified based on a simple hockeystick model (see discussion in section 2.5).

***Current standards.

Note: Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Exhibit E.20. Estimated Annual Cardiopulmonary Mortality Associated with Long-Term Exposure to PM$_{2.5}$ When Alternative Standards Are Just Met, Assuming Various Cutpoint Levels*
Phoenix, AZ, 2001
(2001 As Is Levels = 10.4 ug/m3 Annual Average; 28.9 ug/m3 98th Percentile Daily Value)

Alternative Standards		Incidence Associated with PM2.5		
		(95% Confidence Interval)		
		Percent Reduction in Incidence from As Is Levels		
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
15	65, 98th percentile value***	237 (82 - 405) 0.0%	38 (13 - 65) 0.0%	0 (0 - 0) ---
15	40, 98th percentile value	237 (82 - 405) 0.0%	38 (13 - 65) 0.0%	0 (0 - 0) ---
15	35, 98th percentile value	237 (82 - 405) 0.0%	38 (13 - 65) 0.0%	0 (0 - 0) ---
15	30, 98th percentile value	137 (48 - 233) 42.2%	0 (0 - 0) 100.0%	0 (0 - 0) ---
15	25, 98th percentile value	38 (13 - 65) 84.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---
15	65, 99th percentile value	237 (82 - 405) 0.0%	38 (13 - 65) 0.0%	0 (0 - 0) ---
15	40, 99th percentile value	220 (76 - 376) 7.2%	19 (6 - 32) 50.0%	0 (0 - 0) ---
15	35, 99th percentile value	136 (47 - 231) 42.6%	0 (0 - 0) 100.0%	0 (0 - 0) ---
15	30, 99th percentile value	52 (18 - 89) 78.1%	0 (0 - 0) 100.0%	0 (0 - 0) ---
15	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---
14	40, 98th percentile value	237 (82 - 405) 0.0%	38 (13 - 65) 0.0%	0 (0 - 0) ---
14	35, 98th percentile value	237 (82 - 405) 0.0%	38 (13 - 65) 0.0%	0 (0 - 0) ---
14	30, 98th percentile value	137 (48 - 233) 42.2%	0 (0 - 0) 100.0%	0 (0 - 0) ---
14	25, 98th percentile value	38 (13 - 65) 84.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---
14	40, 99th percentile value	220 (76 - 376) 7.2%	19 (6 - 32) 50.0%	0 (0 - 0) ---
14	35, 99th percentile value	136 (47 - 231) 42.6%	0 (0 - 0) 100.0%	0 (0 - 0) ---

Alternative Standards		Incidence Associated with PM2.5 (95% Confidence Interval)		
		Percent Reduction in Incidence from As Is Levels		
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
14	30, 99th percentile value	52 (18 - 89) 78.1%	0 (0 - 0) 100.0%	0 (0 - 0) ---
14	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---
13	40, 98th percentile value	237 (82 - 405) 0.0%	38 (13 - 65) 0.0%	0 (0 - 0) ---
13	35, 98th percentile value	237 (82 - 405) 0.0%	38 (13 - 65) 0.0%	0 (0 - 0) ---
13	30, 98th percentile value	137 (48 - 233) 42.2%	0 (0 - 0) 100.0%	0 (0 - 0) ---
13	25, 98th percentile value	38 (13 - 65) 84.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---
13	40, 99th percentile value	220 (76 - 376) 7.2%	19 (6 - 32) 50.0%	0 (0 - 0) ---
13	35, 99th percentile value	136 (47 - 231) 42.6%	0 (0 - 0) 100.0%	0 (0 - 0) ---
13	30, 99th percentile value	52 (18 - 89) 78.1%	0 (0 - 0) 100.0%	0 (0 - 0) ---
13	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---
12	40, 98th percentile value	237 (82 - 405) 0.0%	38 (13 - 65) 0.0%	0 (0 - 0) ---
12	35, 98th percentile value	237 (82 - 405) 0.0%	38 (13 - 65) 0.0%	0 (0 - 0) ---
12	30, 98th percentile value	137 (48 - 233) 42.2%	0 (0 - 0) 100.0%	0 (0 - 0) ---
12	25, 98th percentile value	38 (13 - 65) 84.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---
12	40, 99th percentile value	220 (76 - 376) 7.2%	19 (6 - 32) 50.0%	0 (0 - 0) ---
12	35, 99th percentile value	136 (47 - 231) 42.6%	0 (0 - 0) 100.0%	0 (0 - 0) ---
12	30, 99th percentile value	52 (18 - 89) 78.1%	0 (0 - 0) 100.0%	0 (0 - 0) ---
12	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---

*This analysis used a C-R function from Pope et al. (2002) -- ACS extended.

**For the cutpoints above 7.5 µg/m3, the slope of the C-R function has been modified based on a simple hockeystick model (see discussion in section 2.5).

***Current standards.

Note: Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Exhibit E.21. Estimated Annual Cardiopulmonary Mortality Associated with Long-Term Exposure to PM$_{2.5}$ When Alternative Standards Are Just Met, Assuming Various Cutpoint Levels*
Pittsburgh, PA, 2003

Alternative Standards		Incidence Associated with PM2.5		
		(95% Confidence Interval)		
		Percent Reduction in Incidence from Current Standards		
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
15	65, 98th percentile value***	282 (101 - 464) 0.0%	150 (53 - 248) 0.0%	17 (6 - 29) 0.0%
15	40, 98th percentile value	252 (90 - 415) 10.6%	117 (42 - 193) 22.0%	0 (0 - 0) 100.0%
15	35, 98th percentile value	184 (66 - 302) 34.8%	41 (15 - 68) 72.7%	0 (0 - 0) 100.0%
15	30, 98th percentile value	117 (42 - 191) 58.5%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	25, 98th percentile value	50 (18 - 82) 82.3%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	65, 99th percentile value	282 (101 - 464) 0.0%	150 (53 - 248) 0.0%	17 (6 - 29) 0.0%
15	40, 99th percentile value	200 (72 - 328) 29.1%	59 (21 - 96) 60.7%	0 (0 - 0) 100.0%
15	35, 99th percentile value	139 (50 - 228) 50.7%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	30, 99th percentile value	80 (29 - 130) 71.6%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	25, 99th percentile value	20 (7 - 33) 92.9%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	40, 98th percentile value	236 (84 - 388) 16.3%	99 (35 - 163) 34.0%	0 (0 - 0) 100.0%
14	35, 98th percentile value	184 (66 - 302) 34.8%	41 (15 - 68) 72.7%	0 (0 - 0) 100.0%
14	30, 98th percentile value	117 (42 - 191) 58.5%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	25, 98th percentile value	50 (18 - 82) 82.3%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	40, 99th percentile value	200 (72 - 328) 29.1%	59 (21 - 96) 60.7%	0 (0 - 0) 100.0%
14	35, 99th percentile value	139 (50 - 228) 50.7%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	30, 99th percentile value	80 (29 - 130) 71.6%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%

Alternative Standards		Incidence Associated with PM2.5		
		(95% Confidence Interval)		
		Percent Reduction in Incidence from Current Standards		
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
14	25, 99th percentile value	20 (7 - 33) 92.9%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	40, 98th percentile value	190 (68 - 312) 32.6%	48 (17 - 78) 68.0%	0 (0 - 0) 100.0%
13	35, 98th percentile value	184 (66 - 302) 34.8%	41 (15 - 68) 72.7%	0 (0 - 0) 100.0%
13	30, 98th percentile value	117 (42 - 191) 58.5%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	25, 98th percentile value	50 (18 - 82) 82.3%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	40, 99th percentile value	190 (68 - 312) 32.6%	48 (17 - 78) 68.0%	0 (0 - 0) 100.0%
13	35, 99th percentile value	139 (50 - 228) 50.7%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	30, 99th percentile value	80 (29 - 130) 71.6%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	25, 99th percentile value	20 (7 - 33) 92.9%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	40, 98th percentile value	145 (52 - 237) 48.6%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	35, 98th percentile value	145 (52 - 237) 48.6%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	30, 98th percentile value	117 (42 - 191) 58.5%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	25, 98th percentile value	50 (18 - 82) 82.3%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	40, 99th percentile value	145 (52 - 237) 48.6%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	35, 99th percentile value	139 (50 - 228) 50.7%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	30, 99th percentile value	80 (29 - 130) 71.6%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	25, 99th percentile value	20 (7 - 33) 92.9%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%

*This analysis used a C-R function from Pope et al. (2002) -- ACS extended.

**For the cutpoints above 7.5 µg/m3, the slope of the C-R function has been modified based on a simple hockeystick model (see discussion in section 2.5).
***Current standards.

Note: Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Exhibit E.22. Estimated Annual Cardiopulmonary Mortality Associated with Long-Term Exposure to PM$_{2.5}$ When Alternative Standards Are Just Met, Assuming Various Cutpoint Levels*
San Jose, CA, 2003
(2003 As Is Levels = 11.1 ug/m3 Annual Average; 37.6 ug/m3 98th Percentile Daily Value]

Alternative Standards		Incidence Associated with PM2.5		
		(95% Confidence Interval)		
		Percent Reduction in Incidence from As Is Levels		
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
15	65, 98th percentile value***	125 (43 - 213) 0.0%	42 (15 - 73) 0.0%	0 (0 - 0) ---
15	40, 98th percentile value	77 (27 - 131) 38.4%	0 (0 - 0) 100.0%	0 (0 - 0) ---
15	35, 98th percentile value	44 (15 - 74) 64.8%	0 (0 - 0) 100.0%	0 (0 - 0) ---
15	30, 98th percentile value	10 (4 - 17) 92.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---
15	25, 98th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---
15	65, 99th percentile value	125 (43 - 213) 0.0%	42 (15 - 73) 0.0%	0 (0 - 0) ---
15	40, 99th percentile value	47 (16 - 80) 62.4%	0 (0 - 0) 100.0%	0 (0 - 0) ---
15	35, 99th percentile value	18 (6 - 30) 85.6%	0 (0 - 0) 100.0%	0 (0 - 0) ---
15	30, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---
15	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---
14	40, 98th percentile value	77 (27 - 131) 38.4%	0 (0 - 0) 100.0%	0 (0 - 0) ---
14	35, 98th percentile value	44 (15 - 74) 64.8%	0 (0 - 0) 100.0%	0 (0 - 0) ---
14	30, 98th percentile value	10 (4 - 17) 92.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---
14	25, 98th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---
14	40, 99th percentile value	47 (16 - 80) 62.4%	0 (0 - 0) 100.0%	0 (0 - 0) ---
14	35, 99th percentile value	18 (6 - 30) 85.6%	0 (0 - 0) 100.0%	0 (0 - 0) ---
14	30, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---

Alternative Standards		Incidence Associated with PM2.5		
		(95% Confidence Interval)		
		Percent Reduction in Incidence from As Is Levels		
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
14	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---
13	40, 98th percentile value	77 (27 - 131) 38.4%	0 (0 - 0) 100.0%	0 (0 - 0) ---
13	35, 98th percentile value	44 (15 - 74) 64.8%	0 (0 - 0) 100.0%	0 (0 - 0) ---
13	30, 98th percentile value	10 (4 - 17) 92.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---
13	25, 98th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---
13	40, 99th percentile value	47 (16 - 80) 62.4%	0 (0 - 0) 100.0%	0 (0 - 0) ---
13	35, 99th percentile value	18 (6 - 30) 85.6%	0 (0 - 0) 100.0%	0 (0 - 0) ---
13	30, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---
13	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---
12	40, 98th percentile value	60 (21 - 102) 52.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---
12	35, 98th percentile value	44 (15 - 74) 64.8%	0 (0 - 0) 100.0%	0 (0 - 0) ---
12	30, 98th percentile value	10 (4 - 17) 92.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---
12	25, 98th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---
12	40, 99th percentile value	47 (16 - 80) 62.4%	0 (0 - 0) 100.0%	0 (0 - 0) ---
12	35, 99th percentile value	18 (6 - 30) 85.6%	0 (0 - 0) 100.0%	0 (0 - 0) ---
12	30, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---
12	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---

*This analysis used a C-R function from Pope et al. (2002) -- ACS extended.

**For the cutpoints above 7.5 µg/m3, the slope of the C-R function has been modified based on a simple hockeystick model (see discussion in section 2.5).

***Current standards.

Note: Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Exhibit E.23. Estimated Annual Cardiopulmonary Mortality Associated with Long-Term Exposure to PM$_{2.5}$ When Alternative Standards Are Just Met, Assuming Various Cutpoint Levels*
Seattle, WA, 2003
(2003 As Is Levels = 8.3 ug/m3 Annual Average; 21.7 ug/m3 98th Percentile Daily Value]

Alternative Standards		Incidence Associated with PM2.5		
		(95% Confidence Interval)		
		Percent Reduction in Incidence from As Is Levels		
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
15	65, 98th percentile value***	33 (11 - 57) 0.0%	0 (0 - 0) ---	0 (0 - 0) ---
15	40, 98th percentile value	27 (9 - 46) 18.2%	0 (0 - 0) ---	0 (0 - 0) ---
15	35, 98th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
15	30, 98th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
15	25, 98th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
15	65, 99th percentile value	33 (11 - 57) 0.0%	0 (0 - 0) ---	0 (0 - 0) ---
15	40, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
15	35, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
15	30, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
15	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
14	40, 98th percentile value	27 (9 - 46) 18.2%	0 (0 - 0) ---	0 (0 - 0) ---
14	35, 98th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
14	30, 98th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
14	25, 98th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
14	40, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
14	35, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
14	30, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---

Alternative Standards		Incidence Associated with PM2.5 (95% Confidence Interval)		
		Percent Reduction in Incidence from As Is Levels		
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
14	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
13	40, 98th percentile value	27 (9 - 46) 18.2%	0 (0 - 0) ---	0 (0 - 0) ---
13	35, 98th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
13	30, 98th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
13	25, 98th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
13	40, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
13	35, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
13	30, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
13	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
12	40, 98th percentile value	27 (9 - 46) 18.2%	0 (0 - 0) ---	0 (0 - 0) ---
12	35, 98th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
12	30, 98th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
12	25, 98th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
12	40, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
12	35, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
12	30, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
12	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---

*This analysis used a C-R function from Pope et al. (2002) -- ACS extended.

**For the cutpoints above 7.5 µg/m3, the slope of the C-R function has been modified based on a simple hockeystick model (see discussion in section 2.5).

***Current standards.

Note: Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Exhibit E.24. Estimated Annual Cardiopulmonary Mortality Associated with Long-Term Exposure to PM$_{2.5}$ When Alternative Standards Are Just Met, Assuming Various Cutpoint Levels*
St. Louis, MO, 2003

Alternative Standards		Incidence Associated with PM2.5 (95% Confidence Interval) Percent Reduction in Incidence from Current Standards		
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
15	65, 98th percentile value***	426 (150 - 715) 0.0%	223 (78 - 376) 0.0%	16 (6 - 27) 0.0%
15	40, 98th percentile value	426 (150 - 715) 0.0%	223 (78 - 376) 0.0%	16 (6 - 27) 0.0%
15	35, 98th percentile value	423 (148 - 709) 0.7%	219 (77 - 369) 1.8%	12 (4 - 21) 25.0%
15	30, 98th percentile value	296 (104 - 494) 30.5%	76 (27 - 128) 65.9%	0 (0 - 0) 100.0%
15	25, 98th percentile value	170 (60 - 283) 60.1%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	65, 99th percentile value	426 (150 - 715) 0.0%	223 (78 - 376) 0.0%	16 (6 - 27) 0.0%
15	40, 99th percentile value	426 (150 - 715) 0.0%	223 (78 - 376) 0.0%	16 (6 - 27) 0.0%
15	35, 99th percentile value	347 (122 - 581) 18.5%	134 (47 - 226) 39.9%	0 (0 - 0) 100.0%
15	30, 99th percentile value	233 (82 - 388) 45.3%	6 (2 - 10) 97.3%	0 (0 - 0) 100.0%
15	25, 99th percentile value	120 (42 - 198) 71.8%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	40, 98th percentile value	356 (125 - 596) 16.4%	144 (50 - 242) 35.4%	0 (0 - 0) 100.0%
14	35, 98th percentile value	356 (125 - 596) 16.4%	144 (50 - 242) 35.4%	0 (0 - 0) 100.0%
14	30, 98th percentile value	296 (104 - 494) 30.5%	76 (27 - 128) 65.9%	0 (0 - 0) 100.0%
14	25, 98th percentile value	170 (60 - 283) 60.1%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	40, 99th percentile value	356 (125 - 596) 16.4%	144 (50 - 242) 35.4%	0 (0 - 0) 100.0%
14	35, 99th percentile value	347 (122 - 581) 18.5%	134 (47 - 226) 39.9%	0 (0 - 0) 100.0%
14	30, 99th percentile value	233 (82 - 388) 45.3%	6 (2 - 10) 97.3%	0 (0 - 0) 100.0%

Alternative Standards		Incidence Associated with PM2.5 (95% Confidence Interval)		
		Percent Reduction in Incidence from Current Standards		
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
14	25, 99th percentile value	120 (42 - 198) 71.8%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	40, 98th percentile value	286 (101 - 478) 32.9%	66 (23 - 110) 70.4%	0 (0 - 0) 100.0%
13	35, 98th percentile value	286 (101 - 478) 32.9%	66 (23 - 110) 70.4%	0 (0 - 0) 100.0%
13	30, 98th percentile value	286 (101 - 478) 32.9%	66 (23 - 110) 70.4%	0 (0 - 0) 100.0%
13	25, 98th percentile value	170 (60 - 283) 60.1%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	40, 99th percentile value	286 (101 - 478) 32.9%	66 (23 - 110) 70.4%	0 (0 - 0) 100.0%
13	35, 99th percentile value	286 (101 - 478) 32.9%	66 (23 - 110) 70.4%	0 (0 - 0) 100.0%
13	30, 99th percentile value	233 (82 - 388) 45.3%	6 (2 - 10) 97.3%	0 (0 - 0) 100.0%
13	25, 99th percentile value	120 (42 - 198) 71.8%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	40, 98th percentile value	217 (77 - 361) 49.1%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	35, 98th percentile value	217 (77 - 361) 49.1%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	30, 98th percentile value	217 (77 - 361) 49.1%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	25, 98th percentile value	170 (60 - 283) 60.1%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	40, 99th percentile value	217 (77 - 361) 49.1%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	35, 99th percentile value	217 (77 - 361) 49.1%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	30, 99th percentile value	217 (77 - 361) 49.1%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	25, 99th percentile value	120 (42 - 198) 71.8%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%

*This analysis used a C-R function from Pope et al. (2002) -- ACS extended.

**For the cutpoints above 7.5 µg/m3, the slope of the C-R function has been modified based on a simple hockeystick model (see discussion in section 2.5).

***Current standards.

Note: Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Exhibit E.25. Estimated Annual Lung Cancer Mortality Associated with Long-Term Exposure to PM2.5 When Alternative Standards Are Just Met, Assuming Various Cutpoint Levels*
Boston, MA, 2003
(2003 As Is Levels = 12.1 ug/m3 Annual Average; 34.1 ug/m3 98th Percentile Daily Value)

Alternative Standards		Incidence Associated with PM2.5 (95% Confidence Interval)		
		Percent Reduction in Incidence from As Is Levels		
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
15	65, 98th percentile value***	91 (28 - 141) 0.0%	47 (14 - 74) 0.0%	3 (1 - 5) 0.0%
15	40, 98th percentile value	73 (23 - 114) 19.8%	28 (9 - 44) 40.4%	0 (0 - 0) 100.0%
15	35, 98th percentile value	52 (16 - 81) 42.9%	5 (1 - 7) 89.4%	0 (0 - 0) 100.0%
15	30, 98th percentile value	32 (10 - 48) 64.8%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	25, 98th percentile value	11 (3 - 17) 87.9%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	65, 99th percentile value	91 (28 - 141) 0.0%	47 (14 - 74) 0.0%	3 (1 - 5) 0.0%
15	40, 99th percentile value	30 (9 - 46) 67.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	35, 99th percentile value	15 (5 - 24) 83.5%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	30, 99th percentile value	1 (0 - 1) 98.9%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	40, 98th percentile value	73 (23 - 114) 19.8%	28 (9 - 44) 40.4%	0 (0 - 0) 100.0%
14	35, 98th percentile value	52 (16 - 81) 42.9%	5 (1 - 7) 89.4%	0 (0 - 0) 100.0%
14	30, 98th percentile value	32 (10 - 48) 64.8%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	25, 98th percentile value	11 (3 - 17) 87.9%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	40, 99th percentile value	30 (9 - 46) 67.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	35, 99th percentile value	15 (5 - 24) 83.5%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%

Alternative Standards		Incidence Associated with PM2.5 (95% Confidence Interval)		
		Percent Reduction in Incidence from As Is Levels		
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
14	30, 99th percentile value	1 (0 - 1) 98.9%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	40, 98th percentile value	68 (21 - 106) 25.3%	23 (7 - 35) 51.1%	0 (0 - 0) 100.0%
13	35, 98th percentile value	52 (16 - 81) 42.9%	5 (1 - 7) 89.4%	0 (0 - 0) 100.0%
13	30, 98th percentile value	32 (10 - 48) 64.8%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	25, 98th percentile value	11 (3 - 17) 87.9%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	40, 99th percentile value	30 (9 - 46) 67.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	35, 99th percentile value	15 (5 - 24) 83.5%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	30, 99th percentile value	1 (0 - 1) 98.9%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	40, 98th percentile value	53 (16 - 81) 41.8%	5 (2 - 8) 89.4%	0 (0 - 0) 100.0%
12	35, 98th percentile value	52 (16 - 81) 42.9%	5 (1 - 7) 89.4%	0 (0 - 0) 100.0%
12	30, 98th percentile value	32 (10 - 48) 64.8%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	25, 98th percentile value	11 (3 - 17) 87.9%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	40, 99th percentile value	30 (9 - 46) 67.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	35, 99th percentile value	15 (5 - 24) 83.5%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	30, 99th percentile value	1 (0 - 1) 98.9%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%

*This analysis used a C-R function from Pope et al. (2002) -- ACS extended.

**For the cutpoints above 7.5 µg/m3, the slope of the C-R function has been modified based on a simple hockeystick model (see discussion in section 2.5).

***Current standards.

Note: Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Exhibit E.26. Estimated Annual Lung Cancer Mortality Associated with Long-Term Exposure to PM$_{2.5}$ When Alternative Standards Are Just Met, Assuming Various Cutpoint Levels*
Los Angeles, CA, 2003

Alternative Standards		Incidence Associated with PM2.5 (95% Confidence Interval)		
		Percent Reduction in Incidence from Current Standards		
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
15	65, 98th percentile value***	179 (58 - 264) 0.0%	98 (32 - 145) 0.0%	16 (5 - 24) 0.0%
15	40, 98th percentile value	179 (58 - 264) 0.0%	98 (32 - 145) 0.0%	16 (5 - 24) 0.0%
15	35, 98th percentile value	150 (49 - 221) 16.2%	66 (21 - 97) 32.7%	0 (0 - 0) 100.0%
15	30, 98th percentile value	98 (32 - 143) 45.3%	8 (3 - 11) 91.8%	0 (0 - 0) 100.0%
15	25, 98th percentile value	47 (15 - 68) 73.7%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	65, 99th percentile value	179 (58 - 264) 0.0%	98 (32 - 145) 0.0%	16 (5 - 24) 0.0%
15	40, 99th percentile value	60 (20 - 88) 66.5%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	35, 99th percentile value	28 (9 - 41) 84.4%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	30, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	40, 98th percentile value	150 (49 - 220) 16.2%	65 (21 - 96) 33.7%	0 (0 - 0) 100.0%
14	35, 98th percentile value	150 (49 - 220) 16.2%	65 (21 - 96) 33.7%	0 (0 - 0) 100.0%
14	30, 98th percentile value	98 (32 - 143) 45.3%	8 (3 - 11) 91.8%	0 (0 - 0) 100.0%
14	25, 98th percentile value	47 (15 - 68) 73.7%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	40, 99th percentile value	60 (20 - 88) 66.5%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	35, 99th percentile value	28 (9 - 41) 84.4%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	30, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%

Alternative Standards		Incidence Associated with PM2.5 (95% Confidence Interval)		
		Percent Reduction in Incidence from Current Standards		
Annual (μg/m3)	Daily (μg/m3)	Cutpoint** =7.5 μg/m3	Cutpoint** =10 μg/m3	Cutpoint** =12 μg/m3
14	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	40, 98th percentile value	120 (39 - 176) 33.0%	32 (10 - 47) 67.3%	0 (0 - 0) 100.0%
13	35, 98th percentile value	120 (39 - 176) 33.0%	32 (10 - 47) 67.3%	0 (0 - 0) 100.0%
13	30, 98th percentile value	98 (32 - 143) 45.3%	8 (3 - 11) 91.8%	0 (0 - 0) 100.0%
13	25, 98th percentile value	47 (15 - 68) 73.7%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	40, 99th percentile value	60 (20 - 88) 66.5%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	35, 99th percentile value	28 (9 - 41) 84.4%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	30, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	40, 98th percentile value	91 (30 - 132) 49.2%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	35, 98th percentile value	91 (30 - 132) 49.2%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	30, 98th percentile value	91 (30 - 132) 49.2%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	25, 98th percentile value	47 (15 - 68) 73.7%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	40, 99th percentile value	60 (20 - 88) 66.5%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	35, 99th percentile value	28 (9 - 41) 84.4%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	30, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%

*This analysis used a C-R function from Pope et al. (2002) -- ACS extended.

**For the cutpoints above 7.5 μg/m3, the slope of the C-R function has been modified based on a simple hockeystick model (see discussion in section 2.5).

***Current standards.

Note: Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Exhibit E.27. Estimated Annual Lung Cancer Mortality Associated with Long-Term Exposure to PM$_{2.5}$ When Alternative Standards Are Just Met, Assuming Various Cutpoint Levels*
Philadelphia, PA, 2003

Alternative Standards		Incidence Associated with PM2.5		
		(95% Confidence Interval)		
		Percent Reduction in Incidence from Current Standards		
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
15	65, 98th percentile value***	77 (24 - 118) 0.0%	49 (15 - 75) 0.0%	20 (6 - 31) 0.0%
15	40, 98th percentile value	58 (18 - 89) 24.7%	28 (9 - 43) 42.9%	0 (0 - 0) 100.0%
15	35, 98th percentile value	43 (13 - 65) 44.2%	10 (3 - 16) 79.6%	0 (0 - 0) 100.0%
15	30, 98th percentile value	27 (9 - 41) 64.9%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	25, 98th percentile value	12 (4 - 18) 84.4%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	65, 99th percentile value	51 (16 - 78) 33.8%	20 (6 - 30) 59.2%	0 (0 - 0) 100.0%
15	40, 99th percentile value	8 (3 - 12) 89.6%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	35, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	30, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	65, 98th percentile value	65 (20 - 100) 15.6%	36 (11 - 55) 26.5%	5 (2 - 8) 75.0%
14	40, 98th percentile value	58 (18 - 89) 24.7%	28 (9 - 43) 42.9%	0 (0 - 0) 100.0%
14	35, 98th percentile value	43 (13 - 65) 44.2%	10 (3 - 16) 79.6%	0 (0 - 0) 100.0%
14	30, 98th percentile value	27 (9 - 41) 64.9%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	25, 98th percentile value	12 (4 - 18) 84.4%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	40, 99th percentile value	8 (3 - 12) 89.6%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	35, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	30, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%

Alternative Standards		Incidence Associated with PM2.5 (95% Confidence Interval)		
		Percent Reduction in Incidence from Current Standards		
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
14	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	40, 98th percentile value	54 (17 - 82) 29.9%	23 (7 - 34) 53.1%	0 (0 - 0) 100.0%
13	35, 98th percentile value	43 (13 - 65) 44.2%	10 (3 - 16) 79.6%	0 (0 - 0) 100.0%
13	30, 98th percentile value	27 (9 - 41) 64.9%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	25, 98th percentile value	12 (4 - 18) 84.4%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	40, 99th percentile value	8 (3 - 12) 89.6%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	35, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	30, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	40, 98th percentile value	42 (13 - 64) 45.5%	10 (3 - 15) 79.6%	0 (0 - 0) 100.0%
12	35, 98th percentile value	42 (13 - 64) 45.5%	10 (3 - 15) 79.6%	0 (0 - 0) 100.0%
12	30, 98th percentile value	27 (9 - 41) 64.9%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	25, 98th percentile value	12 (4 - 18) 84.4%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	40, 99th percentile value	8 (3 - 12) 89.6%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	35, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	30, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%

*This analysis used a C-R function from Pope et al. (2002) -- ACS extended.

**For the cutpoints above 7.5 µg/m3, the slope of the C-R function has been modified based on a simple hockeystick model (see discussion in section 2.5).
***Current standards.

Note: Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Exhibit E.28. Estimated Annual Lung Cancer Mortality Associated with Long-Term Exposure to PM$_{2.5}$ When Alternative Standards Are Just Met, Assuming Various Cutpoint Levels*
Phoenix, AZ, 2001
(2001 As Is Levels = 10.4 ug/m3 Annual Average; 28.9 ug/m3 98th Percentile Daily Value)

Alternative Standards		Incidence Associated with PM2.5		
		(95% Confidence Interval)		
		Percent Reduction in Incidence from As Is Levels		
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
15	65, 98th percentile value***	48 (14 - 74) 0.0%	8 (2 - 12) 0.0%	0 (0 - 0) ---
15	40, 98th percentile value	48 (14 - 74) 0.0%	8 (2 - 12) 0.0%	0 (0 - 0) ---
15	35, 98th percentile value	48 (14 - 74) 0.0%	8 (2 - 12) 0.0%	0 (0 - 0) ---
15	30, 98th percentile value	27 (8 - 43) 43.8%	0 (0 - 0) 100.0%	0 (0 - 0) ---
15	25, 98th percentile value	8 (2 - 12) 83.3%	0 (0 - 0) 100.0%	0 (0 - 0) ---
15	65, 99th percentile value	48 (14 - 74) 0.0%	8 (2 - 12) 0.0%	0 (0 - 0) ---
15	40, 99th percentile value	44 (13 - 69) 8.3%	4 (1 - 6) 50.0%	0 (0 - 0) ---
15	35, 99th percentile value	27 (8 - 42) 43.8%	0 (0 - 0) 100.0%	0 (0 - 0) ---
15	30, 99th percentile value	10 (3 - 16) 79.2%	0 (0 - 0) 100.0%	0 (0 - 0) ---
15	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---
14	40, 98th percentile value	48 (14 - 74) 0.0%	8 (2 - 12) 0.0%	0 (0 - 0) ---
14	35, 98th percentile value	48 (14 - 74) 0.0%	8 (2 - 12) 0.0%	0 (0 - 0) ---
14	30, 98th percentile value	27 (8 - 43) 43.8%	0 (0 - 0) 100.0%	0 (0 - 0) ---
14	25, 98th percentile value	8 (2 - 12) 83.3%	0 (0 - 0) 100.0%	0 (0 - 0) ---
14	40, 99th percentile value	44 (13 - 69) 8.3%	4 (1 - 6) 50.0%	0 (0 - 0) ---
14	35, 99th percentile value	27 (8 - 42) 43.8%	0 (0 - 0) 100.0%	0 (0 - 0) ---

Alternative Standards		Incidence Associated with PM2.5 (95% Confidence Interval)		
		Percent Reduction in Incidence from As Is Levels		
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
14	30, 99th percentile value	10 (3 - 16) 79.2%	0 (0 - 0) 100.0%	0 (0 - 0) ---
14	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---
13	40, 98th percentile value	48 (14 - 74) 0.0%	8 (2 - 12) 0.0%	0 (0 - 0) ---
13	35, 98th percentile value	48 (14 - 74) 0.0%	8 (2 - 12) 0.0%	0 (0 - 0) ---
13	30, 98th percentile value	27 (8 - 43) 43.8%	0 (0 - 0) 100.0%	0 (0 - 0) ---
13	25, 98th percentile value	8 (2 - 12) 83.3%	0 (0 - 0) 100.0%	0 (0 - 0) ---
13	40, 99th percentile value	44 (13 - 69) 8.3%	4 (1 - 6) 50.0%	0 (0 - 0) ---
13	35, 99th percentile value	27 (8 - 42) 43.8%	0 (0 - 0) 100.0%	0 (0 - 0) ---
13	30, 99th percentile value	10 (3 - 16) 79.2%	0 (0 - 0) 100.0%	0 (0 - 0) ---
13	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---
12	40, 98th percentile value	48 (14 - 74) 0.0%	8 (2 - 12) 0.0%	0 (0 - 0) ---
12	35, 98th percentile value	48 (14 - 74) 0.0%	8 (2 - 12) 0.0%	0 (0 - 0) ---
12	30, 98th percentile value	27 (8 - 43) 43.8%	0 (0 - 0) 100.0%	0 (0 - 0) ---
12	25, 98th percentile value	8 (2 - 12) 83.3%	0 (0 - 0) 100.0%	0 (0 - 0) ---
12	40, 99th percentile value	44 (13 - 69) 8.3%	4 (1 - 6) 50.0%	0 (0 - 0) ---
12	35, 99th percentile value	27 (8 - 42) 43.8%	0 (0 - 0) 100.0%	0 (0 - 0) ---
12	30, 99th percentile value	10 (3 - 16) 79.2%	0 (0 - 0) 100.0%	0 (0 - 0) ---
12	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---

*This analysis used a C-R function from Pope et al. (2002) -- ACS extended.

**For the cutpoints above 7.5 µg/m3, the slope of the C-R function has been modified based on a simple hockeystick model (see discussion in section 2.5).

***Current standards.

Note: Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Exhibit E.29. Estimated Annual Lung Cancer Mortality Associated with Long-Term Exposure to PM$_{2.5}$ When Alternative Standards Are Just Met, Assuming Various Cutpoint Levels*
Pittsburgh, PA, 2003

Alternative Standards		Incidence Associated with PM2.5 (95% Confidence Interval)		
		Percent Reduction in Incidence from Current Standards		
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
15	65, 98th percentile value***	56 (18 - 84) 0.0%	30 (10 - 45) 0.0%	4 (1 - 5) 0.0%
15	40, 98th percentile value	50 (16 - 75) 10.7%	23 (7 - 35) 23.3%	0 (0 - 0) 100.0%
15	35, 98th percentile value	37 (12 - 55) 33.9%	8 (3 - 12) 73.3%	0 (0 - 0) 100.0%
15	30, 98th percentile value	23 (8 - 34) 58.9%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	25, 98th percentile value	10 (3 - 15) 82.1%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	65, 99th percentile value	56 (18 - 84) 0.0%	30 (10 - 45) 0.0%	4 (1 - 5) 0.0%
15	40, 99th percentile value	40 (13 - 59) 28.6%	12 (4 - 17) 60.0%	0 (0 - 0) 100.0%
15	35, 99th percentile value	28 (9 - 41) 50.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	30, 99th percentile value	16 (5 - 23) 71.4%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	25, 99th percentile value	4 (1 - 6) 92.9%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	40, 98th percentile value	47 (15 - 70) 16.1%	20 (6 - 30) 33.3%	0 (0 - 0) 100.0%
14	35, 98th percentile value	37 (12 - 55) 33.9%	8 (3 - 12) 73.3%	0 (0 - 0) 100.0%
14	30, 98th percentile value	23 (8 - 34) 58.9%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	25, 98th percentile value	10 (3 - 15) 82.1%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	40, 99th percentile value	40 (13 - 59) 28.6%	12 (4 - 17) 60.0%	0 (0 - 0) 100.0%
14	35, 99th percentile value	28 (9 - 41) 50.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	30, 99th percentile value	16 (5 - 23) 71.4%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%

Alternative Standards		Incidence Associated with PM2.5		
		(95% Confidence Interval)		
		Percent Reduction in Incidence from Current Standards		
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
14	25, 99th percentile value	4 (1 - 6) 92.9%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	40, 98th percentile value	38 (12 - 56) 32.1%	10 (3 - 14) 66.7%	0 (0 - 0) 100.0%
13	35, 98th percentile value	37 (12 - 55) 33.9%	8 (3 - 12) 73.3%	0 (0 - 0) 100.0%
13	30, 98th percentile value	23 (8 - 34) 58.9%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	25, 98th percentile value	10 (3 - 15) 82.1%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	40, 99th percentile value	38 (12 - 56) 32.1%	10 (3 - 14) 66.7%	0 (0 - 0) 100.0%
13	35, 99th percentile value	28 (9 - 41) 50.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	30, 99th percentile value	16 (5 - 23) 71.4%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	25, 99th percentile value	4 (1 - 6) 92.9%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	40, 98th percentile value	29 (9 - 43) 48.2%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	35, 98th percentile value	29 (9 - 43) 48.2%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	30, 98th percentile value	23 (8 - 34) 58.9%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	25, 98th percentile value	10 (3 - 15) 82.1%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	40, 99th percentile value	29 (9 - 43) 48.2%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	35, 99th percentile value	28 (9 - 41) 50.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	30, 99th percentile value	16 (5 - 23) 71.4%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	25, 99th percentile value	4 (1 - 6) 92.9%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%

*This analysis used a C-R function from Pope et al. (2002) -- ACS extended.

**For the cutpoints above 7.5 µg/m3, the slope of the C-R function has been modified based on a simple hockeystick model (see discussion in section 2.5).

***Current standards.

Note: Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Exhibit E.30. Estimated Annual Lung Cancer Mortality Associated with Long-Term Exposure to PM$_{2.5}$ When Alternative Standards Are Just Met, Assuming Various Cutpoint Levels*
San Jose, CA, 2003
(2003 As Is Levels = 11.1 ug/m3 Annual Average; 37.6 ug/m3 98th Percentile Daily Value]

Alternative Standards		Incidence Associated with PM2.5		
		(95% Confidence Interval)		
		Percent Reduction in Incidence from As Is Levels		
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
15	65, 98th percentile value***	23 (7 - 35) 0.0%	8 (2 - 12) 0.0%	0 (0 - 0) ---
15	40, 98th percentile value	14 (4 - 22) 39.1%	0 (0 - 0) 100.0%	0 (0 - 0) ---
15	35, 98th percentile value	8 (2 - 12) 65.2%	0 (0 - 0) 100.0%	0 (0 - 0) ---
15	30, 98th percentile value	2 (1 - 3) 91.3%	0 (0 - 0) 100.0%	0 (0 - 0) ---
15	25, 98th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---
15	65, 99th percentile value	23 (7 - 35) 0.0%	8 (2 - 12) 0.0%	0 (0 - 0) ---
15	40, 99th percentile value	8 (3 - 13) 65.2%	0 (0 - 0) 100.0%	0 (0 - 0) ---
15	35, 99th percentile value	3 (1 - 5) 87.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---
15	30, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---
15	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---
14	40, 98th percentile value	14 (4 - 22) 39.1%	0 (0 - 0) 100.0%	0 (0 - 0) ---
14	35, 98th percentile value	8 (2 - 12) 65.2%	0 (0 - 0) 100.0%	0 (0 - 0) ---
14	30, 98th percentile value	2 (1 - 3) 91.3%	0 (0 - 0) 100.0%	0 (0 - 0) ---
14	25, 98th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---
14	40, 99th percentile value	8 (3 - 13) 65.2%	0 (0 - 0) 100.0%	0 (0 - 0) ---
14	35, 99th percentile value	3 (1 - 5) 87.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---
14	30, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---

Alternative Standards		Incidence Associated with PM2.5 (95% Confidence Interval)		
		Percent Reduction in Incidence from As Is Levels		
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
14	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---
13	40, 98th percentile value	14 (4 - 22) 39.1%	0 (0 - 0) 100.0%	0 (0 - 0) ---
13	35, 98th percentile value	8 (2 - 12) 65.2%	0 (0 - 0) 100.0%	0 (0 - 0) ---
13	30, 98th percentile value	2 (1 - 3) 91.3%	0 (0 - 0) 100.0%	0 (0 - 0) ---
13	25, 98th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---
13	40, 99th percentile value	8 (3 - 13) 65.2%	0 (0 - 0) 100.0%	0 (0 - 0) ---
13	35, 99th percentile value	3 (1 - 5) 87.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---
13	30, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---
13	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---
12	40, 98th percentile value	11 (3 - 17) 52.2%	0 (0 - 0) 100.0%	0 (0 - 0) ---
12	35, 98th percentile value	8 (2 - 12) 65.2%	0 (0 - 0) 100.0%	0 (0 - 0) ---
12	30, 98th percentile value	2 (1 - 3) 91.3%	0 (0 - 0) 100.0%	0 (0 - 0) ---
12	25, 98th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---
12	40, 99th percentile value	8 (3 - 13) 65.2%	0 (0 - 0) 100.0%	0 (0 - 0) ---
12	35, 99th percentile value	3 (1 - 5) 87.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---
12	30, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---
12	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	0 (0 - 0) ---

*This analysis used a C-R function from Pope et al. (2002) -- ACS extended.

**For the cutpoints above 7.5 µg/m3, the slope of the C-R function has been modified based on a simple hockeystick model (see discussion in section 2.5).

***Current standards.

Note: Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Exhibit E.31. Estimated Annual Lung Cancer Mortality Associated with Long-Term Exposure to PM$_{2.5}$ When Alternative Standards Are Just Met, Assuming Various Cutpoint Levels*
Seattle, WA, 2003
(2003 As Is Levels = 8.3 ug/m3 Annual Average; 21.7 ug/m3 98th Percentile Daily Value]

Alternative Standards		Incidence Associated with PM2.5		
		(95% Confidence Interval)		
		Percent Reduction in Incidence from As Is Levels		
Annual (μg/m3)	Daily (μg/m3)	Cutpoint** =7.5 μg/m3	Cutpoint** =10 μg/m3	Cutpoint** =12 μg/m3
15	65, 98th percentile value***	8 (2 - 12) 0.0%	0 (0 - 0) ---	0 (0 - 0) ---
15	40, 98th percentile value	6 (2 - 10) 25.0%	0 (0 - 0) ---	0 (0 - 0) ---
15	35, 98th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
15	30, 98th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
15	25, 98th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
15	65, 99th percentile value	8 (2 - 12) 0.0%	0 (0 - 0) ---	0 (0 - 0) ---
15	40, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
15	35, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
15	30, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
15	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
14	40, 98th percentile value	6 (2 - 10) 25.0%	0 (0 - 0) ---	0 (0 - 0) ---
14	35, 98th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
14	30, 98th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
14	25, 98th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
14	40, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
14	35, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
14	30, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---

Alternative Standards		Incidence Associated with PM2.5		
		(95% Confidence Interval)		
		Percent Reduction in Incidence from As Is Levels		
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
14	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
13	40, 98th percentile value	6 (2 - 10) 25.0%	0 (0 - 0) ---	0 (0 - 0) ---
13	35, 98th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
13	30, 98th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
13	25, 98th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
13	40, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
13	35, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
13	30, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
13	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
12	40, 98th percentile value	6 (2 - 10) 25.0%	0 (0 - 0) ---	0 (0 - 0) ---
12	35, 98th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
12	30, 98th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
12	25, 98th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
12	40, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
12	35, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
12	30, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---
12	25, 99th percentile value	0 (0 - 0) 100.0%	0 (0 - 0) ---	0 (0 - 0) ---

*This analysis used a C-R function from Pope et al. (2002) -- ACS extended.

**For the cutpoints above 7.5 µg/m3, the slope of the C-R function has been modified based on a simple hockeystick model (see discussion in section 2.5).

***Current standards.

Note: Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Exhibit E.32. Estimated Annual Lung Cancer Mortality Associated with Long-Term Exposure to PM$_{2.5}$ When Alternative Standards Are Just Met, Assuming Various Cutpoint Levels*
St. Louis, MO, 2003

Alternative Standards		Incidence Associated with PM2.5 (95% Confidence Interval)		
		Percent Reduction in Incidence from Current Standards		
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
15	65, 98th percentile value***	88 (27 - 134) 0.0%	46 (14 - 71) 0.0%	3 (1 - 5) 0.0%
15	40, 98th percentile value	88 (27 - 134) 0.0%	46 (14 - 71) 0.0%	3 (1 - 5) 0.0%
15	35, 98th percentile value	87 (27 - 133) 1.1%	45 (14 - 70) 2.2%	3 (1 - 4) 0.0%
15	30, 98th percentile value	61 (19 - 92) 30.7%	16 (5 - 24) 65.2%	0 (0 - 0) 100.0%
15	25, 98th percentile value	35 (11 - 53) 60.2%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	65, 99th percentile value	88 (27 - 134) 0.0%	46 (14 - 71) 0.0%	3 (1 - 5) 0.0%
15	40, 99th percentile value	88 (27 - 134) 0.0%	46 (14 - 71) 0.0%	3 (1 - 5) 0.0%
15	35, 99th percentile value	71 (22 - 109) 19.3%	28 (9 - 42) 39.1%	0 (0 - 0) 100.0%
15	30, 99th percentile value	48 (15 - 72) 45.5%	1 (0 - 2) 97.8%	0 (0 - 0) 100.0%
15	25, 99th percentile value	24 (8 - 37) 72.7%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	40, 98th percentile value	73 (23 - 112) 17.0%	30 (9 - 46) 34.8%	0 (0 - 0) 100.0%
14	35, 98th percentile value	73 (23 - 112) 17.0%	30 (9 - 46) 34.8%	0 (0 - 0) 100.0%
14	30, 98th percentile value	61 (19 - 92) 30.7%	16 (5 - 24) 65.2%	0 (0 - 0) 100.0%
14	25, 98th percentile value	35 (11 - 53) 60.2%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	40, 99th percentile value	73 (23 - 112) 17.0%	30 (9 - 46) 34.8%	0 (0 - 0) 100.0%
14	35, 99th percentile value	71 (22 - 109) 19.3%	28 (9 - 42) 39.1%	0 (0 - 0) 100.0%
14	30, 99th percentile value	48 (15 - 72) 45.5%	1 (0 - 2) 97.8%	0 (0 - 0) 100.0%

| Alternative Standards | | Incidence Associated with PM2.5 (95% Confidence Interval) | | |
| | | Percent Reduction in Incidence from Current Standards | | |
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
14	25, 99th percentile value	24 (8 - 37) 72.7%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	40, 98th percentile value	59 (18 - 89) 33.0%	14 (4 - 21) 69.6%	0 (0 - 0) 100.0%
13	35, 98th percentile value	59 (18 - 89) 33.0%	14 (4 - 21) 69.6%	0 (0 - 0) 100.0%
13	30, 98th percentile value	59 (18 - 89) 33.0%	14 (4 - 21) 69.6%	0 (0 - 0) 100.0%
13	25, 98th percentile value	35 (11 - 53) 60.2%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	40, 99th percentile value	59 (18 - 89) 33.0%	14 (4 - 21) 69.6%	0 (0 - 0) 100.0%
13	35, 99th percentile value	59 (18 - 89) 33.0%	14 (4 - 21) 69.6%	0 (0 - 0) 100.0%
13	30, 99th percentile value	48 (15 - 72) 45.5%	1 (0 - 2) 97.8%	0 (0 - 0) 100.0%
13	25, 99th percentile value	24 (8 - 37) 72.7%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	40, 98th percentile value	44 (14 - 67) 50.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	35, 98th percentile value	44 (14 - 67) 50.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	30, 98th percentile value	44 (14 - 67) 50.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	25, 98th percentile value	35 (11 - 53) 60.2%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	40, 99th percentile value	44 (14 - 67) 50.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	35, 99th percentile value	44 (14 - 67) 50.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	30, 99th percentile value	44 (14 - 67) 50.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	25, 99th percentile value	24 (8 - 37) 72.7%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%

*This analysis used a C-R function from Pope et al. (2002) -- ACS extended.

**For the cutpoints above 7.5 µg/m3, the slope of the C-R function has been modified based on a simple hockeystick model (see discussion in section 2.5).

***Current standards.

Note: Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Exhibit E.33. Sensitivity Analysis: Estimated Annual Reductions of Short-Term and Long-Term Exposure Mortality Associated with Rolling Back PM$_{2.5}$ Concentrations to Just Meet the Current Annual Standard of 15 ug/m3 and the Current Daily Standard of 65 ug/m3 Using an Alternative Rollback Method
Los Angeles, CA, 2003

Health Effects	Study	Type	Ages	Model	Lag	Other Pollutants in Model	Annual and Daily Standards	Percent Change in PM-Associated Incidence*		Portion of Proportional Rollback Incidence Reduction Achieved by Alternative Rollback Method
								All PM concentrations rolled back equally	Percent rollback of upper 10% of AQ distribution = 1.6 x percent rollback of lower 90% of AQ distribution	
						Single Pollutant Models (Total Mortality)				
Short-Term Exposure Mortality	Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Non-accidental	all	log-linear, GAM (stringent), 30 df	0 day		15 ug/m3 annual	40.9%	41.0%	100.2%
							65 ug/m3 daily	0.0%	0.0%	--
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Non-accidental	all	log-linear, GAM (stringent), 30 df	1 day		15 ug/m3 annual	40.9%	41.0%	100.2%
							65 ug/m3 daily	0.0%	0.0%	--
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Non-accidental	all	log-linear, GAM (stringent), 30 df	0 day		15 ug/m3 annual	40.9%	41.0%	100.2%
							65 ug/m3 daily	0.0%	0.0%	--
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Non-accidental	all	log-linear, GAM (stringent), 30 df	1 day		15 ug/m3 annual	40.9%	41.0%	100.2%
							65 ug/m3 daily	0.0%	0.0%	--
Long-Term Exposure Mortality						**Single Pollutant Models**				
	Krewski et al. (2000) - ACS	All cause	30+	log-linear			15 ug/m3 annual	58.9%	59.1%	100.3%
							65 ug/m3 daily	0.0%	0.0%	--
	Pope et al. (2002) - ACS extended	All cause	30+	log-linear			15 ug/m3 annual	59.1%	59.3%	100.3%
							65 ug/m3 daily	0.0%	0.0%	--
						Multi-Pollutant Models				
	Krewski et al. (2000) - ACS	All cause	30+	log-linear		CO	15 ug/m3 annual	59.2%	59.4%	100.3%
							65 ug/m3 daily	0.0%	0.0%	--
	Krewski et al. (2000) - ACS	All cause	30+	log-linear		NO2	15 ug/m3 annual	59.4%	59.6%	100.3%
							65 ug/m3 daily	0.0%	0.0%	--
	Krewski et al. (2000) - ACS	All cause	30+	log-linear		O3	15 ug/m3 annual	59.2%	59.4%	100.3%
							65 ug/m3 daily	0.0%	0.0%	--
	Krewski et al. (2000) - ACS	All cause	30+	log-linear		SO2	15 ug/m3 annual	58.5%	58.6%	100.2%
							65 ug/m3 daily	0.0%	0.0%	--

* For the short-term exposure studies, health effects incidence was quantified down to estimated policy relevant background level of 2.5 ug/m3. For the long-term exposure studies, health effects incidence was quantified down to 7.5 ug/m3, which was the lowest of the lowest measured levels in the long-term exposure studies. Percents are rounded to the nearest tenth.

Note: Only those C-R functions for which rollbacks are predicted to result in a positive number of cases avoided are included.

Exhibit E.34. Sensitivity Analysis: Estimated Annual Reductions of Short-Term and Long-Term Exposure Mortality Associated with Rolling Back PM$_{2.5}$ Concentrations to Just Meet the Current Annual Standard of 15 ug/m3 and the Current Daily Standard of 65 ug/m3 Using an Alternative Rollback Method
Philadelphia, PA, 2003

Health Effects	Study	Type	Ages	Lag	Other Pollutants in Model	Annual and Daily Standards	Percent Change in PM-Associated Incidence*		Portion of Proportional Rollback Incidence Reduction Achieved by Alternative Rollback Method
							All PM concentrations rolled back equally	Percent rollback of upper 10% of AQ distribution = 1.6 x percent rollback of lower 90% of AQ distribution	
Short-Term Exposure Mortality	Single Pollutant Models (Total Mortality)								
	Lipfert et al. (2000)	Non-accidental	all	0 day		15 ug/m3 annual	10.9%	10.6%	97.2%
						65 ug/m3 daily	0.0%	0.0%	--
	Multi-Pollutant Models (Total Mortality)								
	Lipfert et al. (2000)	Non-accidental	all	0 day	O3	15 ug/m3 annual	10.9%	10.6%	97.2%
						65 ug/m3 daily	0.0%	0.0%	--
Long-Term Exposure Mortality	Single Pollutant Models								
	Krewski et al. (2000) - ACS	All cause	30+			15 ug/m3 annual	17.4%	17.6%	101.1%
						65 ug/m3 daily	0.0%	0.0%	--
	Pope et al. (2002) - ACS extended	All cause	30+			15 ug/m3 annual	17.5%	17.6%	100.6%
						65 ug/m3 daily	0.0%	0.0%	--
	Multi-Pollutant Models								
	Krewski et al. (2000) - ACS	All cause	30+		CO	15 ug/m3 annual	17.6%	17.7%	100.6%
						65 ug/m3 daily	0.0%	0.0%	--
	Krewski et al. (2000) - ACS	All cause	30+		NO2	15 ug/m3 annual	17.6%	17.7%	100.6%
						65 ug/m3 daily	0.0%	0.0%	--
	Krewski et al. (2000) - ACS	All cause	30+		O3	15 ug/m3 annual	17.6%	17.7%	100.6%
						65 ug/m3 daily	0.0%	0.0%	--
	Krewski et al. (2000) - ACS	All cause	30+		SO2	15 ug/m3 annual	17.3%	17.4%	100.6%
						65 ug/m3 daily	0.0%	0.0%	--

*For the short-term exposure studies, health effects incidence was quantified down to estimated policy relevant background level of 3.5 ug/m3. For the long-term exposure studies, health effects incidence was quantified down to 7.5 ug/m3, which was the lowest of the lowest measured levels in the long-term exposure studies. Percents are rounded to the nearest tenth.

Note: Only those C-R functions for which rollbacks are predicted to result in a positive number of cases avoided are included.

Exhibit E.35. Sensitivity Analysis: Estimated Annual Reductions of Short-Term and Long-Term Exposure Mortality Associated with Rolling Back PM$_{2.5}$ Concentrations to Just Meet the Current Annual Standard of 15 ug/m3 and the Current Daily Standard of 65 ug/m3 Using an Alternative Rollback Method
Pittsburgh, PA, 2003

Health Effects	Study	Type	Ages	Lag	Other Pollutants in Model	Annual and Daily Standards	Percent Change in PM-Associated Incidence*		Portion of Proportional Rollback Incidence Reduction Achieved by Alternative Rollback Method
							All PM concentrations rolled back equally	Percent rollback of upper 10% of AQ distribution = 1.6 x percent rollback of lower 90% of AQ distribution	
Short-Term Exposure Mortality	Single Pollutant Models (Total Mortality)								
	Chock et al. (2000)	Non-accidental	<75	0 day		15 ug/m3 annual	35.3%	35.4%	100.3%
						65 ug/m3 daily	0.0%	0.0%	--
	Chock et al. (2000)	Non-accidental	75+	0 day		15 ug/m3 annual	35.2%	35.3%	100.3%
						65 ug/m3 daily	0.0%	0.0%	--
	Multi-Pollutant Models (Total Mortality)								
	Chock et al. (2000)	Non-accidental	<75	0 day	CO, O3, SO2, NO2, PM10-2.5	15 ug/m3 annual	35.3%	35.5%	100.6%
						65 ug/m3 daily	0.0%	0.0%	--
	Chock et al. (2000)	Non-accidental	75+	0 day	CO, O3, SO2, NO2, PM10-2.5	15 ug/m3 annual	35.1%	35.3%	100.6%
						65 ug/m3 daily	0.0%	0.0%	--
Long-Term Exposure Mortality	Single Pollutant Models								
	Krewski et al. (2000) - ACS	All cause	30+			15 ug/m3 annual	50.4%	50.6%	100.4%
						65 ug/m3 daily	0.0%	0.0%	--
	Pope et al. (2002) - ACS extended	All cause	30+			15 ug/m3 annual	50.6%	50.8%	100.4%
						65 ug/m3 daily	0.0%	0.0%	--
	Multi-Pollutant Models								
	Krewski et al. (2000) - ACS	All cause	30+		CO	15 ug/m3 annual	50.7%	50.9%	100.4%
						65 ug/m3 daily	0.0%	0.0%	--
	Krewski et al. (2000) - ACS	All cause	30+		NO2	15 ug/m3 annual	50.8%	51.1%	100.6%
						65 ug/m3 daily	0.0%	0.0%	--
	Krewski et al. (2000) - ACS	All cause	30+		O3	15 ug/m3 annual	50.7%	50.9%	100.4%
						65 ug/m3 daily	0.0%	0.0%	--
	Krewski et al. (2000) - ACS	All cause	30+		SO2	15 ug/m3 annual	50.0%	50.2%	100.4%
						65 ug/m3 daily	0.0%	0.0%	--

*For the short-term exposure studies, health effects incidence was quantified down to estimated policy relevant background level of 3.5 ug/m3. For the long-term exposure studies, health effects incidence was quantified down to 7.5 ug/m3, which was the lowest of the lowest measured levels in the long-term exposure studies. Percents are rounded to the nearest tenth.

Note: Only those C-R functions for which rollbacks are predicted to result in a positive number of cases avoided are included.

Exhibit E.36. Sensitivity Analysis: Estimated Annual Reductions of Short-Term and Long-Term Exposure Mortality Associated with Rolling Back PM$_{2.5}$ Concentrations to Just Meet the Current Annual Standard of 15 ug/m^3 and the Current Daily Standard of 65 ug/m^3 Using an Alternative Rollback Method
St. Louis, MO, 2003

Health Effects	Study	Type	Ages	Lag	Other Pollutants in Model	Annual and Daily Standards	Percent Change in PM-Associated Incidence*		Portion of Proportional Rollback Incidence Reduction Achieved by Alternative Rollback Method
							All PM concentrations rolled back equally	Percent rollback of upper 10% of AQ distribution = 1.6 x percent rollback of lower 90% of AQ distribution	
Short-Term Exposure Mortality	Single Pollutant Models (Total Mortality)								
	Schwartz (2003b) [reanalysis of Schwartz et al. (1996)]	Non-accidental	all	mean of lag 0 & 1		15 ug/m3 annual 65 ug/m3 daily	18.0% 0.0%	17.5% 0.0%	97.2% --
	Schwartz (2003b) [reanalysis of Schwartz et al. (1996)] -- 6 cities	Non-accidental	all	mean of lag 0 & 1		15 ug/m3 annual 65 ug/m3 daily	18.0% 0.0%	17.6% 0.0%	97.8% --
Long-Term Exposure Mortality	Single Pollutant Models								
	Krewski et al. (2000) - Six Cities	All cause	25+			15 ug/m3 annual 65 ug/m3 daily	29.7% 0.0%	29.8% 0.0%	100.3% --
	Krewski et al. (2000) - ACS	All cause	30+			15 ug/m3 annual 65 ug/m3 daily	29.1% 0.0%	29.2% 0.0%	100.3% --
	Pope et al. (2002) - ACS extended	All cause	30+			15 ug/m3 annual 65 ug/m3 daily	29.2% 0.0%	29.3% 0.0%	100.3% --
	Multi-Pollutant Models								
	Krewski et al. (2000) - ACS	All cause	30+		CO	15 ug/m3 annual 65 ug/m3 daily	29.3% 0.0%	29.4% 0.0%	100.3% --
	Krewski et al. (2000) - ACS	All cause	30+		NO2	15 ug/m3 annual 65 ug/m3 daily	29.4% 0.0%	29.5% 0.0%	100.3% --
	Krewski et al. (2000) - ACS	All cause	30+		O3	15 ug/m3 annual 65 ug/m3 daily	29.3% 0.0%	29.4% 0.0%	100.3% --
	Krewski et al. (2000) - ACS	All cause	30+		SO2	15 ug/m3 annual 65 ug/m3 daily	28.9% 0.0%	29.0% 0.0%	100.3% --

*For the short-term exposure studies, health effects incidence was quantified down to estimated policy relevant background level of 3.5 ug/m3. For the long-term exposure studies, health effects incidence was quantified down to 7.5 ug/m3, which was the lowest of the lowest measured levels in the long-term exposure studies. Percents are rounded to the nearest tenth.
Note 1: Multi-city short-term exposure C-R functions were applied only to urban areas included among the cities used to estimate the function.
Note 2: Only those C-R functions for which rollbacks are predicted to result in a positive number of cases avoided are included.

Exhibit E.37. Sensitivity Analysis: Estimated Annual Mortality Associated with Short-Term Exposure to PM$_{2.5}$

When Alternative Standards Are Just Met, Assuming Various Cutpoint Levels -- Rollbacks
to Meet Annual Standards Using Design Values Based on Maximum vs. Average of Monitor-Specific Averages*
Pittsburgh, PA, 2003

Alternative Standards		Incidence Associated with PM2.5 Using an Annual Design Value Based on the Maximum of Monitor-Specific Averages** (95% Confidence Interval) Percent Reduction in Incidence from Current Standards				Incidence Associated with PM2.5 Using an Annual Design Value Based on the Average of Monitor-Specific Averages** (95% Confidence Interval) Percent Reduction in Incidence from Current Standards			
Annual (µg/m3)	Daily (µg/m3)	Policy Relevant Background =3.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =15 µg/m3	Cutpoint** =20 µg/m3	Policy Relevant Background =3.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =15 µg/m3	Cutpoint** =20 µg/m3
15	65, 98th percentile value***	50 (-108 - 200) 0.0%	22 (-48 - 87) 0.0%	10 (-23 - 41) 0.0%	5 (-11 - 18) 0.0%	59 (-128 - 238) 0.0%	31 (-66 - 122) 0.0%	17 (-37 - 67) 0.0%	9 (-19 - 35) 0.0%
15	40, 98th percentile value	47 (-102 - 189) 6.0%	19 (-43 - 77) 13.6%	9 (-19 - 34) 10.0%	4 (-9 - 15) 20.0%	47 (-102 - 189) 20.3%	19 (-43 - 77) 38.7%	9 (-19 - 34) 47.1%	4 (-9 - 15) 55.6%
15	35, 98th percentile value	41 (-88 - 162) 18.0%	14 (-31 - 56) 36.4%	5 (-12 - 21) 50.0%	2 (-5 - 8) 60.0%	41 (-88 - 162) 30.5%	14 (-31 - 56) 54.8%	5 (-12 - 21) 70.6%	2 (-5 - 8) 77.8%
15	30, 98th percentile value	34 (-74 - 136) 32.0%	9 (-21 - 37) 59.1%	3 (-6 - 11) 70.0%	1 (-2 - 4) 80.0%	34 (-74 - 136) 42.4%	9 (-21 - 37) 71.0%	3 (-6 - 11) 82.4%	1 (-2 - 4) 88.9%
15	25, 98th percentile value	28 (-60 - 110) 44.0%	5 (-12 - 20) 77.3%	1 (-3 - 5) 90.0%	0 (-1 - 2) 100.0%	28 (-60 - 110) 52.5%	5 (-12 - 20) 83.9%	1 (-3 - 5) 94.1%	0 (-1 - 2) 100.0%
15	65, 99th percentile value	50 (-108 - 200) 0.0%	22 (-48 - 87) 0.0%	10 (-23 - 41) 0.0%	5 (-11 - 18) 0.0%	59 (-128 - 238) 0.0%	31 (-66 - 122) 0.0%	17 (-37 - 67) 0.0%	9 (-19 - 35) 0.0%
15	40, 99th percentile value	42 (-92 - 168) 16.0%	15 (-34 - 61) 31.8%	6 (-13 - 24) 40.0%	3 (-6 - 10) 40.0%	42 (-92 - 168) 28.8%	15 (-34 - 61) 51.6%	6 (-13 - 24) 64.7%	3 (-6 - 10) 66.7%
15	35, 99th percentile value	36 (-79 - 145) 28.0%	11 (-24 - 43) 50.0%	4 (-8 - 14) 60.0%	1 (-3 - 5) 80.0%	36 (-79 - 145) 39.0%	11 (-24 - 43) 64.5%	4 (-8 - 14) 76.5%	1 (-3 - 5) 88.9%
15	30, 99th percentile value	31 (-67 - 122) 38.0%	7 (-15 - 27) 68.2%	2 (-4 - 7) 80.0%	1 (-2 - 3) 80.0%	31 (-67 - 122) 47.5%	7 (-15 - 27) 77.4%	2 (-4 - 7) 88.2%	1 (-2 - 3) 88.9%
15	25, 99th percentile value	25 (-54 - 99) 50.0%	4 (-8 - 14) 81.8%	1 (-2 - 3) 90.0%	0 (-1 - 1) 100.0%	25 (-54 - 99) 57.6%	4 (-8 - 14) 87.1%	1 (-2 - 3) 94.1%	0 (-1 - 1) 100.0%
14	40, 98th percentile value	46 (-99 - 182) 8.0%	18 (-40 - 72) 18.2%	8 (-17 - 31) 20.0%	3 (-8 - 13) 40.0%	47 (-102 - 189) 20.3%	19 (-43 - 77) 38.7%	9 (-19 - 34) 47.1%	4 (-9 - 15) 55.6%
14	35, 98th percentile value	41 (-88 - 162) 18.0%	14 (-31 - 56) 36.4%	5 (-12 - 21) 50.0%	2 (-5 - 8) 60.0%	41 (-88 - 162) 30.5%	14 (-31 - 56) 54.8%	5 (-12 - 21) 70.6%	2 (-5 - 8) 77.8%

		Incidence Associated with PM2.5 Using an Annual Design Value Based on the Maximum of Monitor-Specific Averages** (95% Confidence Interval) Percent Reduction in Incidence from Current Standards				Incidence Associated with PM2.5 Using an Annual Design Value Based on the Average of Monitor-Specific Averages** (95% Confidence Interval) Percent Reduction in Incidence from Current Standards			
Alternative Standards									
Annual (µg/m3)	Daily (µg/m3)	Policy Relevant Background =3.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =15 µg/m3	Cutpoint** =20 µg/m3	Policy Relevant Background =3.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =15 µg/m3	Cutpoint** =20 µg/m3
14	30, 98th percentile value	34 (-74 - 136) 32.0%	9 (-21 - 37) 59.1%	3 (-6 - 11) 70.0%	1 (-2 - 4) 80.0%	34 (-74 - 136) 42.4%	9 (-21 - 37) 71.0%	3 (-6 - 11) 82.4%	1 (-2 - 4) 88.9%
14	25, 98th percentile value	28 (-60 - 110) 44.0%	5 (-12 - 20) 77.3%	1 (-3 - 5) 90.0%	0 (-1 - 2) 100.0%	28 (-60 - 110) 52.5%	5 (-12 - 20) 83.9%	1 (-3 - 5) 94.1%	0 (-1 - 2) 100.0%
14	40, 99th percentile value	42 (-92 - 168) 16.0%	15 (-34 - 61) 31.8%	6 (-13 - 24) 40.0%	3 (-6 - 10) 40.0%	42 (-92 - 168) 28.8%	15 (-34 - 61) 51.6%	6 (-13 - 24) 64.7%	3 (-6 - 10) 66.7%
14	35, 99th percentile value	36 (-79 - 145) 28.0%	11 (-24 - 43) 50.0%	4 (-8 - 14) 60.0%	1 (-3 - 5) 80.0%	36 (-79 - 145) 39.0%	11 (-24 - 43) 64.5%	4 (-8 - 14) 76.5%	1 (-3 - 5) 88.9%
14	30, 99th percentile value	31 (-67 - 122) 38.0%	7 (-15 - 27) 68.2%	2 (-4 - 7) 80.0%	1 (-2 - 3) 80.0%	31 (-67 - 122) 47.5%	7 (-15 - 27) 77.4%	2 (-4 - 7) 88.2%	1 (-2 - 3) 88.9%
14	25, 99th percentile value	25 (-54 - 99) 50.0%	4 (-8 - 14) 81.8%	1 (-2 - 3) 90.0%	0 (-1 - 1) 100.0%	25 (-54 - 99) 57.6%	4 (-8 - 14) 87.1%	1 (-2 - 3) 94.1%	0 (-1 - 1) 100.0%
13	40, 98th percentile value	41 (-90 - 165) 18.0%	15 (-32 - 58) 31.8%	6 (-13 - 22) 40.0%	2 (-5 - 9) 60.0%	47 (-102 - 189) 20.3%	19 (-43 - 77) 38.7%	9 (-19 - 34) 47.1%	4 (-9 - 15) 55.6%
13	35, 98th percentile value	41 (-88 - 162) 18.0%	14 (-31 - 56) 36.4%	5 (-12 - 21) 50.0%	2 (-5 - 8) 60.0%	41 (-88 - 162) 30.5%	14 (-31 - 56) 54.8%	5 (-12 - 21) 70.6%	2 (-5 - 8) 77.8%
13	30, 98th percentile value	34 (-74 - 136) 32.0%	9 (-21 - 37) 59.1%	3 (-6 - 11) 70.0%	1 (-2 - 4) 80.0%	34 (-74 - 136) 42.4%	9 (-21 - 37) 71.0%	3 (-6 - 11) 82.4%	1 (-2 - 4) 88.9%
13	25, 98th percentile value	28 (-60 - 110) 44.0%	5 (-12 - 20) 77.3%	1 (-3 - 5) 90.0%	0 (-1 - 2) 100.0%	28 (-60 - 110) 52.5%	5 (-12 - 20) 83.9%	1 (-3 - 5) 94.1%	0 (-1 - 2) 100.0%
13	40, 99th percentile value	41 (-90 - 165) 18.0%	15 (-32 - 58) 31.8%	6 (-13 - 22) 40.0%	2 (-5 - 9) 60.0%	42 (-92 - 168) 28.8%	15 (-34 - 61) 51.6%	6 (-13 - 24) 64.7%	3 (-6 - 10) 66.7%
13	35, 99th percentile value	36 (-79 - 145) 28.0%	11 (-24 - 43) 50.0%	4 (-8 - 14) 60.0%	1 (-3 - 5) 80.0%	36 (-79 - 145) 39.0%	11 (-24 - 43) 64.5%	4 (-8 - 14) 76.5%	1 (-3 - 5) 88.9%
13	30, 99th percentile value	31 (-67 - 122) 38.0%	7 (-15 - 27) 68.2%	2 (-4 - 7) 80.0%	1 (-2 - 3) 80.0%	31 (-67 - 122) 47.5%	7 (-15 - 27) 77.4%	2 (-4 - 7) 88.2%	1 (-2 - 3) 88.9%
13	25, 99th percentile value	25 (-54 - 99) 50.0%	4 (-8 - 14) 81.8%	1 (-2 - 3) 90.0%	0 (-1 - 1) 100.0%	25 (-54 - 99) 57.6%	4 (-8 - 14) 87.1%	1 (-2 - 3) 94.1%	0 (-1 - 1) 100.0%

Alternative Standards		Incidence Associated with PM2.5 Using an Annual Design Value Based on the Maximum of Monitor-Specific Averages** (95% Confidence Interval) Percent Reduction in Incidence from Current Standards				Incidence Associated with PM2.5 Using an Annual Design Value Based on the Average of Monitor-Specific Averages** (95% Confidence Interval) Percent Reduction in Incidence from Current Standards			
Annual (µg/m3)	Daily (µg/m3)	Policy Relevant Background =3.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =15 µg/m3	Cutpoint** =20 µg/m3	Policy Relevant Background =3.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =15 µg/m3	Cutpoint** =20 µg/m3
12	40, 98th percentile value	37 (-80 - 147) 26.0%	11 (-25 - 44) 50.0%	4 (-8 - 15) 60.0%	1 (-3 - 6) 80.0%	44 (-95 - 175) 25.4%	17 (-36 - 66) 45.2%	7 (-15 - 27) 58.8%	3 (-7 - 11) 66.7%
12	35, 98th percentile value	37 (-80 - 147) 26.0%	11 (-25 - 44) 50.0%	4 (-8 - 15) 60.0%	1 (-3 - 6) 80.0%	41 (-88 - 162) 30.5%	14 (-31 - 56) 54.8%	5 (-12 - 21) 70.6%	2 (-5 - 8) 77.8%
12	30, 98th percentile value	34 (-74 - 136) 32.0%	9 (-21 - 37) 59.1%	3 (-6 - 11) 70.0%	1 (-2 - 4) 80.0%	34 (-74 - 136) 42.4%	9 (-21 - 37) 71.0%	3 (-6 - 11) 82.4%	1 (-2 - 4) 88.9%
12	25, 98th percentile value	28 (-60 - 110) 44.0%	5 (-12 - 20) 77.3%	1 (-3 - 5) 90.0%	0 (-1 - 2) 100.0%	28 (-60 - 110) 52.5%	5 (-12 - 20) 83.9%	1 (-3 - 5) 94.1%	0 (-1 - 2) 100.0%
12	40, 99th percentile value	37 (-80 - 147) 26.0%	11 (-25 - 44) 50.0%	4 (-8 - 15) 60.0%	1 (-3 - 6) 80.0%	42 (-92 - 168) 28.8%	15 (-34 - 61) 51.6%	6 (-13 - 24) 64.7%	3 (-6 - 10) 66.7%
12	35, 99th percentile value	36 (-79 - 145) 28.0%	11 (-24 - 43) 50.0%	4 (-8 - 14) 60.0%	1 (-3 - 5) 80.0%	36 (-79 - 145) 39.0%	11 (-24 - 43) 64.5%	4 (-8 - 14) 76.5%	1 (-3 - 5) 88.9%
12	30, 99th percentile value	31 (-67 - 122) 38.0%	7 (-15 - 27) 68.2%	2 (-4 - 7) 80.0%	1 (-2 - 3) 80.0%	31 (-67 - 122) 47.5%	7 (-15 - 27) 77.4%	2 (-4 - 7) 88.2%	1 (-2 - 3) 88.9%
12	25, 99th percentile value	25 (-54 - 99) 50.0%	4 (-8 - 14) 81.8%	1 (-2 - 3) 90.0%	0 (-1 - 1) 100.0%	25 (-54 - 99) 57.6%	4 (-8 - 14) 87.1%	1 (-2 - 3) 94.1%	0 (-1 - 1) 100.0%

*This analysis used a function from Chock et al. (2000), age 75+ model.

**For the cutpoints above policy relevant background, the slope of the C-R function has been modified based on a simple hockeystick model (see discussion in section 2.5).

***Current standards.

Note: Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Exhibit E.38. Sensitivity Analysis: Estimated Annual Mortality Associated with Long-Term Exposure to PM$_{2.5}$

When Alternative Standards Are Just Met, Assuming Various Cutpoint Levels -- Rollbacks
to Meet Annual Standards Using Design Values Based on Maximum vs. Average of Monitor-Specific Averages*
Pittsburgh, PA, 2003

Alternative Standards		Incidence Associated with PM2.5 Using an Annual Design Value Based on the Maximum of Monitor-Specific Averages** (95% Confidence Interval) Percent Reduction in Incidence from Current Standards			Incidence Associated with PM2.5 Using an Annual Design Value Based on the Average of Monitor-Specific Averages** (95% Confidence Interval) Percent Reduction in Incidence from Current Standards		
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
15	65, 98th percentile value***	403 (141 - 699) 0.0%	215 (75 - 373) 0.0%	25 (9 - 43) 0.0%	546 (190 - 950) 0.0%	375 (130 - 654) 0.0%	202 (70 - 354) 0.0%
15	40, 98th percentile value	361 (126 - 626) 10.4%	168 (58 - 291) 21.9%	0 (0 - 0) 100.0%	361 (126 - 626) 33.9%	168 (58 - 291) 55.2%	0 (0 - 0) 100.0%
15	35, 98th percentile value	264 (93 - 456) 34.5%	59 (21 - 102) 72.6%	0 (0 - 0) 100.0%	264 (93 - 456) 51.6%	59 (21 - 102) 84.3%	0 (0 - 0) 100.0%
15	30, 98th percentile value	168 (59 - 289) 58.3%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	168 (59 - 289) 69.2%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	25, 98th percentile value	72 (25 - 124) 82.1%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	72 (25 - 124) 86.8%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	65, 99th percentile value	403 (141 - 699) 0.0%	215 (75 - 373) 0.0%	25 (9 - 43) 0.0%	546 (190 - 950) 0.0%	375 (130 - 654) 0.0%	202 (70 - 354) 0.0%
15	40, 99th percentile value	287 (100 - 495) 28.8%	84 (29 - 145) 60.9%	0 (0 - 0) 100.0%	287 (100 - 495) 47.4%	84 (29 - 145) 77.6%	0 (0 - 0) 100.0%
15	35, 99th percentile value	200 (70 - 345) 50.4%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	200 (70 - 345) 63.4%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	30, 99th percentile value	114 (40 - 197) 71.7%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	114 (40 - 197) 79.1%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	25, 99th percentile value	29 (10 - 50) 92.8%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	29 (10 - 50) 94.7%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%

	Alternative Standards	Incidence Associated with PM2.5 Using an Annual Design Value Based on the Maximum of Monitor-Specific Averages** (95% Confidence Interval)			Incidence Associated with PM2.5 Using an Annual Design Value Based on the Average of Monitor-Specific Averages** (95% Confidence Interval)		
		Percent Reduction in Incidence from Current Standards			Percent Reduction in Incidence from Current Standards		
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
14	40, 98th percentile value	338 (118 - 585) 16.1%	141 (49 - 245) 34.4%	0 (0 - 0) 100.0%	361 (126 - 626) 33.9%	168 (58 - 291) 55.2%	0 (0 - 0) 100.0%
14	35, 98th percentile value	264 (93 - 456) 34.5%	59 (21 - 102) 72.6%	0 (0 - 0) 100.0%	264 (93 - 456) 51.6%	59 (21 - 102) 84.3%	0 (0 - 0) 100.0%
14	30, 98th percentile value	168 (59 - 289) 58.3%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	168 (59 - 289) 69.2%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	25, 98th percentile value	72 (25 - 124) 82.1%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	72 (25 - 124) 86.8%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	40, 99th percentile value	287 (100 - 495) 28.8%	84 (29 - 145) 60.9%	0 (0 - 0) 100.0%	287 (100 - 495) 47.4%	84 (29 - 145) 77.6%	0 (0 - 0) 100.0%
14	35, 99th percentile value	200 (70 - 345) 50.4%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	200 (70 - 345) 63.4%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	30, 99th percentile value	114 (40 - 197) 71.7%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	114 (40 - 197) 79.1%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	25, 99th percentile value	29 (10 - 50) 92.8%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	29 (10 - 50) 94.7%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	40, 98th percentile value	273 (96 - 471) 32.3%	68 (24 - 118) 68.4%	0 (0 - 0) 100.0%	361 (126 - 626) 33.9%	168 (58 - 291) 55.2%	0 (0 - 0) 100.0%
13	35, 98th percentile value	264 (93 - 456) 34.5%	59 (21 - 102) 72.6%	0 (0 - 0) 100.0%	264 (93 - 456) 51.6%	59 (21 - 102) 84.3%	0 (0 - 0) 100.0%
13	30, 98th percentile value	168 (59 - 289) 58.3%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	168 (59 - 289) 69.2%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	25, 98th percentile value	72 (25 - 124) 82.1%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	72 (25 - 124) 86.8%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%

Alternative Standards		Incidence Associated with PM2.5 Using an Annual Design Value Based on the Maximum of Monitor-Specific Averages** (95% Confidence Interval) Percent Reduction in Incidence from Current Standards			Incidence Associated with PM2.5 Using an Annual Design Value Based on the Average of Monitor-Specific Averages** (95% Confidence Interval) Percent Reduction in Incidence from Current Standards		
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
13	40, 99th percentile value	273 (96 - 471) 32.3%	68 (24 - 118) 68.4%	0 (0 - 0) 100.0%	287 (100 - 495) 47.4%	84 (29 - 145) 77.6%	0 (0 - 0) 100.0%
13	35, 99th percentile value	200 (70 - 345) 50.4%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	200 (70 - 345) 63.4%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	30, 99th percentile value	114 (40 - 197) 71.7%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	114 (40 - 197) 79.1%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	25, 99th percentile value	29 (10 - 50) 92.8%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	29 (10 - 50) 94.7%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	40, 98th percentile value	208 (73 - 358) 48.4%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	312 (109 - 539) 42.9%	112 (39 - 194) 70.1%	0 (0 - 0) 100.0%
12	35, 98th percentile value	208 (73 - 358) 48.4%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	264 (93 - 456) 51.6%	59 (21 - 102) 84.3%	0 (0 - 0) 100.0%
12	30, 98th percentile value	168 (59 - 289) 58.3%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	168 (59 - 289) 69.2%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	25, 98th percentile value	72 (25 - 124) 82.1%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	72 (25 - 124) 86.8%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	40, 99th percentile value	208 (73 - 358) 48.4%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	287 (100 - 495) 47.4%	84 (29 - 145) 77.6%	0 (0 - 0) 100.0%
12	35, 99th percentile value	200 (70 - 345) 50.4%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	200 (70 - 345) 63.4%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	30, 99th percentile value	114 (40 - 197) 71.7%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	114 (40 - 197) 79.1%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	25, 99th percentile value	29 (10 - 50) 92.8%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	29 (10 - 50) 94.7%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%

*This analysis used a C-R function from Pope et al. (2002) -- ACS extended.

**For the cutpoints above 7.5 µg/m3, the slope of the C-R function has been modified based on a simple hockeystick model (see discussion in section 2.5).

***Current standards.

Note: Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Exhibit E.39. Sensitivity Analysis: Estimated Annual Mortality Associated with Short-Term Exposure to PM$_{2.5}$

When Alternative Standards Are Just Met, Assuming Various Cutpoint Levels -- Rollbacks
to Meet Annual Standards Using Design Values Based on Maximum vs. Average of Monitor-Specific Averages*
St. Louis, MO, 2003

Alternative Standards		Incidence Associated with PM2.5 Using an Annual Design Value Based on the Maximum of Monitor-Specific Averages** (95% Confidence Interval) Percent Reduction in Incidence from Current Standards				Incidence Associated with PM2.5 Using an Annual Design Value Based on the Average of Monitor-Specific Averages** (95% Confidence Interval) Percent Reduction in Incidence from Current Standards			
Annual (µg/m3)	Daily (µg/m3)	Policy Relevant Background =3.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =15 µg/m3	Cutpoint** =20 µg/m3	Policy Relevant Background =3.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =15 µg/m3	Cutpoint** =20 µg/m3
15	65, 98th percentile value***	191 (70 - 311) 0.0%	75 (28 - 122) 0.0%	29 (11 - 46) 0.0%	9 (3 - 14) 0.0%	201 (74 - 327) 0.0%	84 (31 - 137) 0.0%	34 (13 - 56) 0.0%	11 (4 - 19) 0.0%
15	40, 98th percentile value	191 (70 - 311) 0.0%	75 (28 - 122) 0.0%	29 (11 - 46) 0.0%	9 (3 - 14) 0.0%	201 (74 - 327) 0.0%	84 (31 - 137) 0.0%	34 (13 - 56) 0.0%	11 (4 - 19) 0.0%
15	35, 98th percentile value	190 (70 - 310) 0.5%	75 (27 - 121) 0.0%	28 (10 - 46) 3.4%	8 (3 - 14) 11.1%	190 (70 - 310) 5.5%	75 (27 - 121) 10.7%	28 (10 - 46) 17.6%	8 (3 - 14) 27.3%
15	30, 98th percentile value	160 (59 - 260) 16.2%	49 (18 - 80) 34.7%	14 (5 - 23) 51.7%	3 (1 - 4) 66.7%	160 (59 - 260) 20.4%	49 (18 - 80) 41.7%	14 (5 - 23) 58.8%	3 (1 - 4) 72.7%
15	25, 98th percentile value	130 (48 - 211) 31.9%	28 (10 - 45) 62.7%	5 (2 - 8) 82.8%	1 (0 - 1) 88.9%	130 (48 - 211) 35.3%	28 (10 - 45) 66.7%	5 (2 - 8) 85.3%	1 (0 - 1) 90.9%
15	65, 99th percentile value	191 (70 - 311) 0.0%	75 (28 - 122) 0.0%	29 (11 - 46) 0.0%	9 (3 - 14) 0.0%	201 (74 - 327) 0.0%	84 (31 - 137) 0.0%	34 (13 - 56) 0.0%	11 (4 - 19) 0.0%
15	40, 99th percentile value	191 (70 - 311) 0.0%	75 (28 - 122) 0.0%	29 (11 - 46) 0.0%	9 (3 - 14) 0.0%	200 (74 - 325) 0.5%	83 (31 - 135) 1.2%	34 (12 - 55) 0.0%	11 (4 - 18) 0.0%
15	35, 99th percentile value	172 (63 - 280) 9.9%	59 (22 - 96) 21.3%	19 (7 - 31) 34.5%	5 (2 - 7) 44.4%	172 (63 - 280) 14.4%	59 (22 - 96) 29.8%	19 (7 - 31) 44.1%	5 (2 - 7) 54.5%
15	30, 99th percentile value	145 (53 - 235) 24.1%	38 (14 - 62) 49.3%	9 (3 - 14) 69.0%	2 (1 - 3) 77.8%	145 (53 - 235) 27.9%	38 (14 - 62) 54.8%	9 (3 - 14) 73.5%	2 (1 - 3) 81.8%
15	25, 99th percentile value	118 (43 - 191) 38.2%	20 (7 - 33) 73.3%	3 (1 - 4) 89.7%	0 (0 - 1) 100.0%	118 (43 - 191) 41.3%	20 (7 - 33) 76.2%	3 (1 - 4) 91.2%	0 (0 - 1) 100.0%
14	40, 98th percentile value	175 (64 - 284) 8.4%	61 (22 - 99) 18.7%	20 (7 - 33) 31.0%	5 (2 - 8) 44.4%	184 (68 - 299) 8.5%	69 (25 - 112) 17.9%	25 (9 - 40) 26.5%	7 (3 - 11) 36.4%
14	35, 98th percentile value	175 (64 - 284) 8.4%	61 (22 - 99) 18.7%	20 (7 - 33) 31.0%	5 (2 - 8) 44.4%	184 (68 - 299) 8.5%	69 (25 - 112) 17.9%	25 (9 - 40) 26.5%	7 (3 - 11) 36.4%

Alternative Standards		Incidence Associated with PM2.5 Using an Annual Design Value Based on the Maximum of Monitor-Specific Averages** (95% Confidence Interval) Percent Reduction in Incidence from Current Standards				Incidence Associated with PM2.5 Using an Annual Design Value Based on the Average of Monitor-Specific Averages** (95% Confidence Interval) Percent Reduction in Incidence from Current Standards			
Annual (µg/m3)	Daily (µg/m3)	Policy Relevant Background =3.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =15 µg/m3	Cutpoint** =20 µg/m3	Policy Relevant Background =3.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =15 µg/m3	Cutpoint** =20 µg/m3
14	30, 98th percentile value	160 (59 - 260) 16.2%	49 (18 - 80) 34.7%	14 (5 - 23) 51.7%	3 (1 - 4) 66.7%	160 (59 - 260) 20.4%	49 (18 - 80) 41.7%	14 (5 - 23) 58.8%	3 (1 - 4) 72.7%
14	25, 98th percentile value	130 (48 - 211) 31.9%	28 (10 - 45) 62.7%	5 (2 - 8) 82.8%	1 (0 - 1) 88.9%	130 (48 - 211) 35.3%	28 (10 - 45) 66.7%	5 (2 - 8) 85.3%	1 (0 - 1) 90.9%
14	40, 99th percentile value	175 (64 - 284) 8.4%	61 (22 - 99) 18.7%	20 (7 - 33) 31.0%	5 (2 - 8) 44.4%	184 (68 - 299) 8.5%	69 (25 - 112) 17.9%	25 (9 - 40) 26.5%	7 (3 - 11) 36.4%
14	35, 99th percentile value	172 (63 - 280) 9.9%	59 (22 - 96) 21.3%	19 (7 - 31) 34.5%	5 (2 - 7) 44.4%	172 (63 - 280) 14.4%	59 (22 - 96) 29.8%	19 (7 - 31) 44.1%	5 (2 - 7) 54.5%
14	30, 99th percentile value	145 (53 - 235) 24.1%	38 (14 - 62) 49.3%	9 (3 - 14) 69.0%	2 (1 - 3) 77.8%	145 (53 - 235) 27.9%	38 (14 - 62) 54.8%	9 (3 - 14) 73.5%	2 (1 - 3) 81.8%
14	25, 99th percentile value	118 (43 - 191) 38.2%	20 (7 - 33) 73.3%	3 (1 - 4) 89.7%	0 (0 - 1) 100.0%	118 (43 - 191) 41.3%	20 (7 - 33) 76.2%	3 (1 - 4) 91.2%	0 (0 - 1) 100.0%
13	40, 98th percentile value	158 (58 - 256) 17.3%	47 (17 - 77) 37.3%	13 (5 - 21) 55.2%	3 (1 - 4) 66.7%	166 (61 - 270) 17.4%	54 (20 - 88) 35.7%	17 (6 - 27) 50.0%	4 (1 - 6) 63.6%
13	35, 98th percentile value	158 (58 - 256) 17.3%	47 (17 - 77) 37.3%	13 (5 - 21) 55.2%	3 (1 - 4) 66.7%	166 (61 - 270) 17.4%	54 (20 - 88) 35.7%	17 (6 - 27) 50.0%	4 (1 - 6) 63.6%
13	30, 98th percentile value	158 (58 - 256) 17.3%	47 (17 - 77) 37.3%	13 (5 - 21) 55.2%	3 (1 - 4) 66.7%	160 (59 - 260) 20.4%	49 (18 - 80) 41.7%	14 (5 - 23) 58.8%	3 (1 - 4) 72.7%
13	25, 98th percentile value	130 (48 - 211) 31.9%	28 (10 - 45) 62.7%	5 (2 - 8) 82.8%	1 (0 - 1) 88.9%	130 (48 - 211) 35.3%	28 (10 - 45) 66.7%	5 (2 - 8) 85.3%	1 (0 - 1) 90.9%
13	40, 99th percentile value	158 (58 - 256) 17.3%	47 (17 - 77) 37.3%	13 (5 - 21) 55.2%	3 (1 - 4) 66.7%	166 (61 - 270) 17.4%	54 (20 - 88) 35.7%	17 (6 - 27) 50.0%	4 (1 - 6) 63.6%
13	35, 99th percentile value	158 (58 - 256) 17.3%	47 (17 - 77) 37.3%	13 (5 - 21) 55.2%	3 (1 - 4) 66.7%	166 (61 - 270) 17.4%	54 (20 - 88) 35.7%	17 (6 - 27) 50.0%	4 (1 - 6) 63.6%
13	30, 99th percentile value	145 (53 - 235) 24.1%	38 (14 - 62) 49.3%	9 (3 - 14) 69.0%	2 (1 - 3) 77.8%	145 (53 - 235) 27.9%	38 (14 - 62) 54.8%	9 (3 - 14) 73.5%	2 (1 - 3) 81.8%
13	25, 99th percentile value	118 (43 - 191) 38.2%	20 (7 - 33) 73.3%	3 (1 - 4) 89.7%	0 (0 - 1) 100.0%	118 (43 - 191) 41.3%	20 (7 - 33) 76.2%	3 (1 - 4) 91.2%	0 (0 - 1) 100.0%

		Incidence Associated with PM2.5 Using an Annual Design Value Based on the Maximum of Monitor-Specific Averages** (95% Confidence Interval) Percent Reduction in Incidence from Current Standards				Incidence Associated with PM2.5 Using an Annual Design Value Based on the Average of Monitor-Specific Averages** (95% Confidence Interval) Percent Reduction in Incidence from Current Standards			
Annual (µg/m3)	Daily (µg/m3)	Policy Relevant Background =3.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =15 µg/m3	Cutpoint** =20 µg/m3	Policy Relevant Background =3.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =15 µg/m3	Cutpoint** =20 µg/m3
12	40, 98th percentile value	141 (52 - 229) 26.2%	35 (13 - 57) 53.3%	8 (3 - 12) 72.4%	1 (1 - 2) 88.9%	149 (55 - 241) 25.9%	41 (15 - 66) 51.2%	10 (4 - 16) 70.6%	2 (1 - 3) 81.8%
12	35, 98th percentile value	141 (52 - 229) 26.2%	35 (13 - 57) 53.3%	8 (3 - 12) 72.4%	1 (1 - 2) 88.9%	149 (55 - 241) 25.9%	41 (15 - 66) 51.2%	10 (4 - 16) 70.6%	2 (1 - 3) 81.8%
12	30, 98th percentile value	141 (52 - 229) 26.2%	35 (13 - 57) 53.3%	8 (3 - 12) 72.4%	1 (1 - 2) 88.9%	149 (55 - 241) 25.9%	41 (15 - 66) 51.2%	10 (4 - 16) 70.6%	2 (1 - 3) 81.8%
12	25, 98th percentile value	130 (48 - 211) 31.9%	28 (10 - 45) 62.7%	5 (2 - 8) 82.8%	1 (0 - 1) 88.9%	130 (48 - 211) 35.3%	28 (10 - 45) 66.7%	5 (2 - 8) 85.3%	1 (0 - 1) 90.9%
12	40, 99th percentile value	141 (52 - 229) 26.2%	35 (13 - 57) 53.3%	8 (3 - 12) 72.4%	1 (1 - 2) 88.9%	149 (55 - 241) 25.9%	41 (15 - 66) 51.2%	10 (4 - 16) 70.6%	2 (1 - 3) 81.8%
12	35, 99th percentile value	141 (52 - 229) 26.2%	35 (13 - 57) 53.3%	8 (3 - 12) 72.4%	1 (1 - 2) 88.9%	149 (55 - 241) 25.9%	41 (15 - 66) 51.2%	10 (4 - 16) 70.6%	2 (1 - 3) 81.8%
12	30, 99th percentile value	141 (52 - 229) 26.2%	35 (13 - 57) 53.3%	8 (3 - 12) 72.4%	1 (1 - 2) 88.9%	145 (53 - 235) 27.9%	38 (14 - 62) 54.8%	9 (3 - 14) 73.5%	2 (1 - 3) 81.8%
12	25, 99th percentile value	118 (43 - 191) 38.2%	20 (7 - 33) 73.3%	3 (1 - 4) 89.7%	0 (0 - 1) 100.0%	118 (43 - 191) 41.3%	20 (7 - 33) 76.2%	3 (1 - 4) 91.2%	0 (0 - 1) 100.0%

*This analysis used a C-R function from Schwartz (2003b).

**For the cutpoints above policy relevant background, the slope of the C-R function has been modified based on a simple hockeystick model (see discussion in section 2.5).

***Current standards.

Note: Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Exhibit E.40. Sensitivity Analysis: Estimated Annual Mortality Associated with Long-Term Exposure to PM$_{2.5}$

When Alternative Standards Are Just Met, Assuming Various Cutpoint Levels -- Rollbacks
to Meet Annual Standards Using Design Values Based on Maximum vs. Average of Monitor-Specific Averages*
St. Louis, MO, 2003

Alternative Standards		Incidence Associated with PM2.5 Using an Annual Design Value Based on the Maximum of Monitor-Specific Averages** (95% Confidence Interval) Percent Reduction in Incidence from Current Standards			Incidence Associated with PM2.5 Using an Annual Design Value Based on the Average of Monitor-Specific Averages** (95% Confidence Interval) Percent Reduction in Incidence from Current Standards		
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
15	65, 98th percentile value***	596 (206 - 1047) 0.0%	311 (107 - 548) 0.0%	23 (8 - 40) 0.0%	655 (226 - 1153) 0.0%	377 (130 - 667) 0.0%	97 (33 - 171) 0.0%
15	40, 98th percentile value	596 (206 - 1047) 0.0%	311 (107 - 548) 0.0%	23 (8 - 40) 0.0%	655 (226 - 1153) 0.0%	377 (130 - 667) 0.0%	97 (33 - 171) 0.0%
15	35, 98th percentile value	592 (204 - 1039) 0.7%	306 (105 - 539) 1.6%	17 (6 - 30) 26.1%	592 (204 - 1039) 9.6%	306 (105 - 539) 18.8%	17 (6 - 30) 82.5%
15	30, 98th percentile value	414 (144 - 726) 30.5%	107 (37 - 188) 65.6%	0 (0 - 0) 100.0%	414 (144 - 726) 36.8%	107 (37 - 188) 71.6%	0 (0 - 0) 100.0%
15	25, 98th percentile value	239 (83 - 417) 59.9%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	239 (83 - 417) 63.5%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
15	65, 99th percentile value	596 (206 - 1047) 0.0%	311 (107 - 548) 0.0%	23 (8 - 40) 0.0%	655 (226 - 1153) 0.0%	377 (130 - 667) 0.0%	97 (33 - 171) 0.0%
15	40, 99th percentile value	596 (206 - 1047) 0.0%	311 (107 - 548) 0.0%	23 (8 - 40) 0.0%	647 (223 - 1138) 1.2%	368 (127 - 651) 2.4%	87 (30 - 153) 10.3%
15	35, 99th percentile value	486 (168 - 853) 18.5%	188 (65 - 330) 39.5%	0 (0 - 0) 100.0%	486 (168 - 853) 25.8%	188 (65 - 330) 50.1%	0 (0 - 0) 100.0%
15	30, 99th percentile value	327 (113 - 571) 45.1%	8 (3 - 15) 97.4%	0 (0 - 0) 100.0%	327 (113 - 571) 50.1%	8 (3 - 15) 97.9%	0 (0 - 0) 100.0%
15	25, 99th percentile value	168 (58 - 293) 71.8%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	168 (58 - 293) 74.4%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%

Alternative Standards		Incidence Associated with PM2.5 Using an Annual Design Value Based on the Maximum of Monitor-Specific Averages** (95% Confidence Interval)			Incidence Associated with PM2.5 Using an Annual Design Value Based on the Average of Monitor-Specific Averages** (95% Confidence Interval)		
		Percent Reduction in Incidence from Current Standards			Percent Reduction in Incidence from Current Standards		
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
14	40, 98th percentile value	498 (172 - 874) 16.4%	201 (69 - 354) 35.4%	0 (0 - 0) 100.0%	552 (191 - 970) 15.7%	262 (90 - 461) 30.5%	0 (0 - 0) 100.0%
14	35, 98th percentile value	498 (172 - 874) 16.4%	201 (69 - 354) 35.4%	0 (0 - 0) 100.0%	552 (191 - 970) 15.7%	262 (90 - 461) 30.5%	0 (0 - 0) 100.0%
14	30, 98th percentile value	414 (144 - 726) 30.5%	107 (37 - 188) 65.6%	0 (0 - 0) 100.0%	414 (144 - 726) 36.8%	107 (37 - 188) 71.6%	0 (0 - 0) 100.0%
14	25, 98th percentile value	239 (83 - 417) 59.9%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	239 (83 - 417) 63.5%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
14	40, 99th percentile value	498 (172 - 874) 16.4%	201 (69 - 354) 35.4%	0 (0 - 0) 100.0%	552 (191 - 970) 15.7%	262 (90 - 461) 30.5%	0 (0 - 0) 100.0%
14	35, 99th percentile value	486 (168 - 853) 18.5%	188 (65 - 330) 39.5%	0 (0 - 0) 100.0%	486 (168 - 853) 25.8%	188 (65 - 330) 50.1%	0 (0 - 0) 100.0%
14	30, 99th percentile value	327 (113 - 571) 45.1%	8 (3 - 15) 97.4%	0 (0 - 0) 100.0%	327 (113 - 571) 50.1%	8 (3 - 15) 97.9%	0 (0 - 0) 100.0%
14	25, 99th percentile value	168 (58 - 293) 71.8%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	168 (58 - 293) 74.4%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
13	40, 98th percentile value	401 (139 - 702) 32.7%	92 (32 - 162) 70.4%	0 (0 - 0) 100.0%	450 (156 - 788) 31.3%	147 (51 - 258) 61.0%	0 (0 - 0) 100.0%
13	35, 98th percentile value	401 (139 - 702) 32.7%	92 (32 - 162) 70.4%	0 (0 - 0) 100.0%	450 (156 - 788) 31.3%	147 (51 - 258) 61.0%	0 (0 - 0) 100.0%
13	30, 98th percentile value	401 (139 - 702) 32.7%	92 (32 - 162) 70.4%	0 (0 - 0) 100.0%	414 (144 - 726) 36.8%	107 (37 - 188) 71.6%	0 (0 - 0) 100.0%
13	25, 98th percentile value	239 (83 - 417) 59.9%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	239 (83 - 417) 63.5%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%

Alternative Standards		Incidence Associated with PM2.5 Using an Annual Design Value Based on the Maximum of Monitor-Specific Averages** (95% Confidence Interval)			Incidence Associated with PM2.5 Using an Annual Design Value Based on the Average of Monitor-Specific Averages** (95% Confidence Interval)		
		Percent Reduction in Incidence from Current Standards			Percent Reduction in Incidence from Current Standards		
Annual (µg/m3)	Daily (µg/m3)	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3	Cutpoint** =7.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =12 µg/m3
13	40, 99th percentile value	401 (139 - 702) 32.7%	92 (32 - 162) 70.4%	0 (0 - 0) 100.0%	450 (156 - 788) 31.3%	147 (51 - 258) 61.0%	0 (0 - 0) 100.0%
13	35, 99th percentile value	401 (139 - 702) 32.7%	92 (32 - 162) 70.4%	0 (0 - 0) 100.0%	450 (156 - 788) 31.3%	147 (51 - 258) 61.0%	0 (0 - 0) 100.0%
13	30, 99th percentile value	327 (113 - 571) 45.1%	8 (3 - 15) 97.4%	0 (0 - 0) 100.0%	327 (113 - 571) 50.1%	8 (3 - 15) 97.9%	0 (0 - 0) 100.0%
13	25, 99th percentile value	168 (58 - 293) 71.8%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	168 (58 - 293) 74.4%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	40, 98th percentile value	304 (106 - 532) 49.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	348 (121 - 608) 46.9%	32 (11 - 56) 91.5%	0 (0 - 0) 100.0%
12	35, 98th percentile value	304 (106 - 532) 49.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	348 (121 - 608) 46.9%	32 (11 - 56) 91.5%	0 (0 - 0) 100.0%
12	30, 98th percentile value	304 (106 - 532) 49.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	348 (121 - 608) 46.9%	32 (11 - 56) 91.5%	0 (0 - 0) 100.0%
12	25, 98th percentile value	239 (83 - 417) 59.9%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	239 (83 - 417) 63.5%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%
12	40, 99th percentile value	304 (106 - 532) 49.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	348 (121 - 608) 46.9%	32 (11 - 56) 91.5%	0 (0 - 0) 100.0%
12	35, 99th percentile value	304 (106 - 532) 49.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	348 (121 - 608) 46.9%	32 (11 - 56) 91.5%	0 (0 - 0) 100.0%
12	30, 99th percentile value	304 (106 - 532) 49.0%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	327 (113 - 571) 50.1%	8 (3 - 15) 97.9%	0 (0 - 0) 100.0%
12	25, 99th percentile value	168 (58 - 293) 71.8%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%	168 (58 - 293) 74.4%	0 (0 - 0) 100.0%	0 (0 - 0) 100.0%

*This analysis used a C-R function from Pope et al. (2002) -- ACS extended.

**For the cutpoints above 7.5 µg/m3, the slope of the C-R function has been modified based on a simple hockeystick model (see discussion in section 2.5).

***Current standards.

Note: Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Appendix F. Estimated Annual Health Risks Associated with PM$_{10-2.5}$ Concentrations

F.1 Primary Analysis

Exhibit F.1. Estimated Annual Health Risks Associated with Short-Term Exposure to "As Is" PM$_{10-2.5}$ Concentrations Seattle, WA, 2003

Health Effects	Study	Type	Ages	Lag	Other Pollutants in Model	Health Effects Associated with PM$_{10-2.5}$ Above Policy Relevant Background*		
						Incidence	Incidence per 100,000 General Population	Percent of Total Incidence
Hospital Admissions	Single Pollutant Models							
	Sheppard (2003) [reanalysis of Sheppard et al. (1999)]**	Asthma	<65	1 day		27 (0 - 65)	2 (0 - 4)	1.7% (0.0% - 4.1%)

*Health effects incidence was quantified down to the estimated policy relevant background level of 3.5 ug/m3. Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

**Sheppard (2003) [reanalysis of Sheppard et al. (1999)] used daily PM$_{10-2.5}$ values obtained from nephelometer measurements rather than from air quality monitors.

Note: Numbers in parentheses are 95% confidence intervals based on statistical uncertainty surrounding the PM $_{10-2.5}$ coefficient.

Exhibit F.2. Estimated Annual Health Risks Associated with Short-Term Exposure to "As Is" PM$_{10-2.5}$ Concentrations St. Louis, MO, 2003

Health Effects	Study	Type	Ages	Lag	Other Pollutants in Model	Health Effects Associated with PM$_{10-2.5}$ Above Policy Relevant Background*		
						Incidence	Incidence per 100,000 General Population	Percent of Total Incidence
Respiratory Symptoms**	Single Pollutant Models							
	Schwartz and Neas, 2000 -- 6 cities	Lower respiratory symptoms	7-14	0 day		6900 (-1200 - 20800)	300 (0 - 800)	12.3% (-2.2% - 36.9%)
	Schwartz and Neas, 2000 -- 6 cities	Cough	7-14	0 day		27000 (11000 - 40900)	1100 (400 - 1600)	16.4% (6.7% - 24.9%)
	Multi-Pollutant Models							
	Schwartz and Neas, 2000 -- 6 cities	Lower respiratory symptoms	7-14	0 day	PM2.5	2800 (-6900 - 10300)	100 (-300 - 400)	4.9% (-12.2% - 18.3%)
	Schwartz and Neas, 2000 -- 6 cities	Cough	7-14	0 day	PM2.5	24800 (6500 - 40100)	1000 (300 - 1600)	15.1% (4.0% - 24.4%)

*Health effects incidence was quantified down to the estimated policy relevant background level of 4.5 ug/m3. Incidences are rounded to the nearest 100; percents are rounded to the nearest tenth.

**The C-R functions for lower respiratory symptoms and cough were calculated for the summer period April 1 through August 31.

Note 1: Numbers in parentheses are 95% confidence intervals based on statistical uncertainty surrounding the PM$_{10-2.5}$ coefficient.

Note 2: Multi-city short-term exposure C-R functions were applied only to urban areas included among the cities used to estimate the function.

Exhibit F.3. Estimated Annual Health Risks Associated with Short-Term Exposure to "As Is" PM$_{10-2.5}$ Concentrations, Assuming Various Cutpoint Levels*

Seattle, WA, 2003

Health Effects	Study	Type	Ages	Lag	Other Pollutants in Model	Incidence Associated with PM$_{10-2.5}$ Assuming Various Cutpoint Levels** (95% Confidence Interval) Percent of Total Incidence (95% Confidence Interval)			
						Policy Relevant Background =3.5 µg/m3	Cutpoint =10 µg/m3	Cutpoint =15 µg/m3	Cutpoint =20 µg/m3
						Single Pollutant Models			
Hospital Admissions	Sheppard (2003) [reanalysis of Sheppard et al. (1999)]***	Asthma	<65	1 day		27 (0 - 65) 1.7% (0.0% - 4.1%)	12 (0 - 28) 0.7% (0.0% - 1.8%)	5 (0 - 11) 0.3% (0.0% - 0.7%)	2 (0 - 4) 0.1% (0.0% - 0.3%)

*Incidence was quantified down to policy relevant background level of 3.5 µg/m3, as well as down to each of the alternative cutpoints. For the cutpoints above policy relevant background, the slope of the C-R function has been modified based on a simple hockeystick model (see discussion in section 2.5).

**Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

***Sheppard (2003) [reanalysis of Sheppard et al. (1999)] used daily PM10-2.5 values obtained from nephelometer measurements rather than from air quality monitors.

Exhibit F.4. Estimated Annual Health Risks Associated with Short-Term Exposure to "As Is" PM10-2.5 Concentrations, Assuming Various Cutpoint Levels*
St. Louis, MO, 2003

Health Effects	Study	Type	Ages	Lag	Other Pollutants in Model	Incidence Associated with PM10-2.5 Assuming Various Cutpoint Levels** (95% Confidence Interval) Percent of Total Incidence (95% Confidence Interval)			
						Policy Relevant Background =4.5 µg/m3	Cutpoint =10 µg/m3	Cutpoint =15 µg/m3	Cutpoint =20 µg/m3
						Single Pollutant Models			
Respiratory Symptoms	Schwartz and Neas, 2000 -- 6 cities	Lower respiratory symptoms	7-14	0 day		6900 (-1200 - 20800) 12.3% (-2.2% - 36.9%)	3100 (-600 - 9100) 5.5% (-1.0% - 16.2%)	1500 (-300 - 4200) 2.7% (-0.5% - 7.4%)	800 (-100 - 1800) 1.3% (-0.3% - 3.2%)
	Schwartz and Neas, 2000 -- 6 cities	Cough	7-14	0 day		27000 (11000 - 40900) 16.4% (6.7% - 24.9%)	12100 (4900 - 18100) 7.3% (3.0% - 11.0%)	5800 (2500 - 8600) 3.6% (1.5% - 5.2%)	2900 (1300 - 4000) 1.7% (0.8% - 2.5%)

*Incidence was quantified down to policy relevant background level of 4.5 µg/m3, as well as down to each of the alternative cutpoints. For the cutpoints above policy relevant background, the slope of the C-R function has been modified based on a simple hockeystick model (see discussion in section 2.5).

**Incidences are rounded to the nearest 100; percents are rounded to the nearest tenth.

Exhibit F.5. Estimated Annual Hospital Admissions for Asthma (Age < 65) Associated with Short-Term Exposure to PM$_{10-2.5}$ When Alternative Standards Are Just Met, Assuming Various Cutpoint Levels*

Seattle, WA, 2003

(2003 As Is Levels = 11.4 ug/m3 Annual Average; 26.2 ug/m3 98th Percentile Daily Value)

"As Is" PM$_{10-2.5}$ Concentrations and Alternative Daily Standards (µg/m3)	Incidence Associated with PM$_{10-2.5}$ (95% Confidence Interval) Percent Reduction in Incidence from "As Is" PM$_{10-2.5}$ Concentrations			
	Policy Relevant Background =3.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =15 µg/m3	Cutpoint** =20 µg/m3
"As is" PM$_{10-2.5}$ concentrations	27 (0 - 65) 0.0%	12 (0 - 28) 0.0%	5 (0 - 11) 0.0%	2 (0 - 4) 0.0%
80 ug/m3 daily 98th percentile value	27 (0 - 65) 0.0%	12 (0 - 28) 0.0%	5 (0 - 11) 0.0%	2 (0 - 4) 0.0%
65 ug/m3 daily 98th percentile value	27 (0 - 65) 0.0%	12 (0 - 28) 0.0%	5 (0 - 11) 0.0%	2 (0 - 4) 0.0%
50 ug/m3 daily 98th percentile value	27 (0 - 65) 0.0%	12 (0 - 28) 0.0%	5 (0 - 11) 0.0%	2 (0 - 4) 0.0%
30 ug/m3 daily 98th percentile value	26 (0 - 63) 3.7%	11 (0 - 26) 8.3%	4 (0 - 10) 20.0%	1 (0 - 3) 50.0%
25 ug/m3 daily 98th percentile value	21 (0 - 51) 22.2%	7 (0 - 16) 41.7%	2 (0 - 5) 60.0%	0 (0 - 1) 100.0%
100 ug/m3 daily 99th percentile value	27 (0 - 65) 0.0%	12 (0 - 28) 0.0%	5 (0 - 11) 0.0%	2 (0 - 4) 0.0%
80 ug/m3 daily 99th percentile value	27 (0 - 65) 0.0%	12 (0 - 28) 0.0%	5 (0 - 11) 0.0%	2 (0 - 4) 0.0%
60 ug/m3 daily 99th percentile value	27 (0 - 65) 0.0%	12 (0 - 28) 0.0%	5 (0 - 11) 0.0%	2 (0 - 4) 0.0%
35 ug/m3 daily 99th percentile value	24 (0 - 58) 11.1%	9 (0 - 22) 25.0%	3 (0 - 8) 40.0%	1 (0 - 2) 50.0%
30 ug/m3 daily 99th percentile value	20 (0 - 48) 25.9%	6 (0 - 14) 50.0%	2 (0 - 4) 60.0%	0 (0 - 1) 100.0%

*This analysis used a C-R function from Sheppard (2003).

**For the cutpoints above policy relevant background, the slope of the C-R function has been modified based on a simple hockeystick model (see discussion in section 2.5).

Note: Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Exhibit F.6. Estimated Annual Days of Cough Among Children Associated with Short-Term Exposure to PM$_{10-2.5}$ When Alternative Standards Are Just Met, Assuming Various Cutpoint Levels*

St. Louis, MO, 2003

(2003 As Is Levels = 12.0 ug/m3 Annual Average; 24.1 ug/m3 98th Percentile Daily Value)

"As Is" PM$_{10-2.5}$ Concentrations and Alternative Daily Standards (µg/m3)	Incidence Associated with PM$_{10-2.5}$ (95% Confidence Interval) Percent Reduction in Incidence from "As Is" PM$_{10-2.5}$ Concentrations			
	Policy Relevant Background =4.5 µg/m3	Cutpoint** =10 µg/m3	Cutpoint** =15 µg/m3	Cutpoint** =20 µg/m3
"As is" PM$_{10-2.5}$ concentrations	27000 (11000 - 40900) 0.0%	12100 (4900 - 18100) 0.0%	5800 (2500 - 8600) 0.0%	2900 (1300 - 4000) 0.0%
80 ug/m3 daily 98th percentile value	27000 (11000 - 40900) 0.0%	12100 (4900 - 18100) 0.0%	5800 (2500 - 8600) 0.0%	2900 (1300 - 4000) 0.0%
65 ug/m3 daily 98th percentile value	27000 (11000 - 40900) 0.0%	12100 (4900 - 18100) 0.0%	5800 (2500 - 8600) 0.0%	2900 (1300 - 4000) 0.0%
50 ug/m3 daily 98th percentile value	27000 (11000 - 40900) 0.0%	12100 (4900 - 18100) 0.0%	5800 (2500 - 8600) 0.0%	2900 (1300 - 4000) 0.0%
30 ug/m3 daily 98th percentile value	23800 (9800 - 35600) 11.9%	9100 (3800 - 13300) 24.8%	4200 (1800 - 6000) 27.6%	2200 (1000 - 2900) 24.1%
25 ug/m3 daily 98th percentile value	18600 (7800 - 27400) 31.1%	5300 (2300 - 7300) 56.2%	2000 (900 - 2500) 65.5%	1300 (600 - 1600) 55.2%
100 ug/m3 daily 99th percentile value	27000 (11000 - 40900) 0.0%	12100 (4900 - 18100) 0.0%	5800 (2500 - 8600) 0.0%	2900 (1300 - 4000) 0.0%
80 ug/m3 daily 99th percentile value	27000 (11000 - 40900) 0.0%	12100 (4900 - 18100) 0.0%	5800 (2500 - 8600) 0.0%	2900 (1300 - 4000) 0.0%
60 ug/m3 daily 99th percentile value	27000 (11000 - 40900) 0.0%	12100 (4900 - 18100) 0.0%	5800 (2500 - 8600) 0.0%	2900 (1300 - 4000) 0.0%
35 ug/m3 daily 99th percentile value	18600 (7700 - 27300) 31.1%	5200 (2300 - 7300) 57.0%	1900 (900 - 2500) 67.2%	1200 (600 - 1600) 58.6%
30 ug/m3 daily 99th percentile value	15200 (6400 - 22200) 43.7%	3300 (1500 - 4400) 72.7%	1100 (600 - 1400) 81.0%	700 (400 - 900) 75.9%

*This analysis used a C-R function from Schwartz and Neas (2000) -- 6 cities.

**For the cutpoints above policy relevant background, the slope of the C-R function has been modified based on a simple hockeystick model (see discussion in section 2.5).

Note: Incidences are rounded to the nearest 100; percents are rounded to the nearest tenth.

F.2 Sensitivity Analyses

Exhibit F.7. Sensitivity Analysis: Estimated Annual Health Risks Associated with Short-Term Exposure to "As Is" PM$_{10-2.5}$ Concentrations, Using Different Estimates of Background Level
Seattle, WA, 2003

Health Effects	Study	Type	Ages	Lag	Other Pollutants in Model	Health Effects Associated with PM10-2.5 Above Policy Relevant Background of:*					
						1 ug/m3		3.5 ug/m3		7 ug/m3	
						Incidence	Percent of Total Incidence	Incidence	Percent of Total Incidence	Incidence	Percent of Total Incidence
Hospital Admissions						**Single Pollutant Models**					
	Sheppard (2003) [reanalysis of Sheppard et al. (1999)]**	Asthma	<65	1 day		35 (0 - 85)	2.2% (0.0% - 5.3%)	27 (0 - 65)	1.7% (0.0% - 4.1%)	17 (0 - 41)	1.1% (0.0% - 2.5%)

*Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.
**Sheppard (2003) [reanalysis of Sheppard et al. (1999)] used daily PM$_{10-2.5}$ values obtained from nephelometer measurements rather than from air quality monitors.
Note: Numbers in parentheses are 95% confidence intervals based on statistical uncertainty surrounding the PM$_{10-2.5}$ coefficient.

Exhibit F.8. Sensitivity Analysis: Estimated Annual Health Risks Associated with Short-Term Exposure to "As Is" PM$_{10-2.5}$ Concentrations, Using Different Estimates of Background Level
St. Louis, MO, 2003

Health Effects	Study	Type	Ages	Lag	Other Pollutants in Model	Health Effects Associated with PM$_{10-2.5}$ Above Policy Relevant Background of:*					
						1 ug/m3		4.5 ug/m3		9 ug/m3	
						Incidence	Percent of Total Incidence	Incidence	Percent of Total Incidence	Incidence	Percent of Total Incidence
Respiratory Symptoms**						**Single Pollutant Models**					
	Schwartz and Neas, 2000 -- 6 cities	Lower respiratory symptoms	7-14	0 day		9700 (-1700 - 27900)	17.2% (-3.1% - 49.4%)	6900 (-1200 - 20800)	12.3% (-2.2% - 36.9%)	3600 (-600 - 10700)	6.3% (-1.1% - 19.1%)
	Schwartz and Neas, 2000 -- 6 cities	Cough	7-14	0 day		37500 (15400 - 56100)	22.8% (9.4% - 34.1%)	27000 (11000 - 40900)	16.4% (6.7% - 24.9%)	13900 (5700 - 21000)	8.5% (3.4% - 12.8%)
						Multi-Pollutant Models					
	Schwartz and Neas, 2000 -- 6 cities	Lower respiratory symptoms	7-14	0 day	PM2.5	3900 (-9900 - 14300)	6.9% (-17.5% - 25.4%)	2800 (-6900 - 10300)	4.9% (-12.2% - 18.3%)	1400 (-3600 - 5300)	2.5% (-6.3% - 9.4%)
	Schwartz and Neas, 2000 -- 6 cities	Cough	7-14	0 day	PM2.5	34600 (9200 - 55000)	21.0% (5.6% - 33.4%)	24800 (6500 - 40100)	15.1% (4.0% - 24.4%)	12800 (3400 - 20600)	7.8% (2.0% - 12.5%)

*Incidences are rounded to the nearest whole number, except respiratory symptoms incidences which are rounded to the nearest 100; percents are rounded to the nearest tenth.

**The C-R functions for lower respiratory symptoms and cough were calculated for the summer period April 1 through August 31.

Note 1: Numbers in parentheses are 95% confidence intervals based on statistical uncertainty surrounding the PM$_{10-2.5}$ coefficient.

Note 2: Multi-city short-term exposure C-R functions were applied only to urban areas included among the cities used to estimate the function.

Appendix G. Estimated Annual Health Risks Associated with "As Is" PM$_{10}$ Concentrations

G.1. Relevant Population Sizes

Exhibit G.1. Relevant Population Sizes for PM$_{10}$ Risk Assessment Locations

City	Population[a]						
	Total	**Ages 7-14**	**Ages ≥30**	**Ages <65**	**Ages ≥ 65**	**Ages <75**	**Ages ≥75**
Boston[1]	2,806,000	283,000 (10%)	---	---	---	---	---
Detroit[2]	2,061,000	---	---		249,000 (12%)	---	---
Los Angeles[3]	9,519,000	---	5,092,000 (53%)	---	927,000 (10%)	---	---
Philadelphia[4]	1,518,000	---	---	---	---	---	---
Phoenix[5]	3,072,000	---	---	---	359,000 (12%)	---	---
Pittsburg[6]	1,282,000	---	---	---	---	1,166,000 (91%)	116,000 (9%)
San Jose[7]	1,683,000	---	---	---	---	---	---
Seattle[8]	1,737,000	---	---	1,555,000 (90%)	---	---	---
St. Louis[9]	2,518,000	307,000 (12%)	---	---	---	---	---

[a] Total population and age-specific population estimates taken from the CDC Wonder website are based on 2000 U.S. Census data. See http://factfinder.census.gov/. Populations are rounded to the nearest thousand. The urban areas given in this exhibit are those considered in the studies used in the PM$_{2.5}$ risk assessment. The percentages in parentheses indicate the percentage of the total population in the specific age category.

[1] Middlesex, Norfolk, and Suffolk Counties.   [2] Wayne County.   [3] Los Angeles County.   [4] Philadelphia County.

[5] Maricopa County.   [6] Allegheny County.   [7] Santa Clara County.   [8] King County.

[9] St. Louis, Franklin, Jefferson, St. Charles, Clinton (IL), Madison (IL), Monroe (IL), and St. Clair (IL) Counties and St. Louis City.

G.2.   Baseline Incidence Rates

Exhibit G.2. Baseline Mortality Rates for 2001 for PM$_{10}$ Risk Assessment Locations*

Health Effect	Boston[1]	Detroit[2]	Los Angeles[3]	Philadelphia[4]	Phoenix[5]	Pittsburgh[6]	San Jose[7]	St. Louis[8]	Seattle[9]	National Average
Mortality[a]:										
A. Mortality Rates Used in Risk Analysis for Short-Term Exposure Studies[b] (deaths per 100,000 general population/year)										
Non-accidental (all ages): ICD-9 codes < 800	776	916	581	---	---	---	494	869	---	791
Non-accidental (75+): ICD-9 codes < 800	---	---	---	---	---	761	---	---	---	469
Non-accidental (<75): ICD-9 codes < 800	---	---	---	---	---	399	---	---	---	322
Cardiovascular (all ages): ICD-9 codes: 390-459	---	416	---	---	---	---	206	---	---	328
Cardiovascular (all ages): ICD-9 codes: 390-448	---	---	---	418	---	---	---	---	---	324
Cardiovascular (65+): ICD-9 codes: 390-448	---	---	---	---	211	---	---	---	---	273
Cardiovascular (all ages): ICD-9 codes: 390-429	---	---	207	---	---	---	---	---	---	252

Health Effect	Boston[1]	Detroit[2]	Los Angeles[3]	Philadelphia[4]	Phoenix[5]	Pittsburgh[6]	San Jose[7]	St. Louis[8]	Seattle[9]	National Average
Respiratory (all ages): ICD-9 codes: 11, 35, 472-519, 710.0, 710.2, 710.4	---	---	---	---	---	---	51	---	---	80
Respiratory (all ages): ICD-9 codes: 460-519	---	72	---	---	---	---	---	---	---	79

*The epidemiological studies used in the risk assessment reported causes of mortality using the ninth revision of the International Classification of Diseases (ICD-9) codes. However, the tenth revision has since come out, and baseline mortality incidence rates for 2001 shown in this exhibit use ICD-10 codes. The groupings of ICD-9 codes used in the epidemiological studies and the corresponding ICD-10 codes used to calculate year 2001 baseline incidence rates is given in Exhibit 5.4.

[a] Mortality figures were obtained from CDC Wonder for 2001. See http://wonder.cdc.gov/.

[b] Mortality rates are presented only for the locations in which the C-R functions were estimated. All incidence rates are rounded to the nearest unit. Mortality rates for St. Louis may be slightly underestimated because some of the mortality counts in the smaller counties were reported as missing in CDC Wonder.

[1] Middlesex, Norfolk, and Suffolk Counties.   [2] Wayne County.   [3] Los Angeles County.   [4] Philadelphia County.

[5] Maricopa County.   [6] Allegheny County.   [7] Santa Clara County.

[8] St. Louis, Franklin, Jefferson, St. Charles, Clinton (IL), Madison (IL), Monroe (IL), and St. Clair (IL) Counties and St. Louis City.

[9] King County.

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Exhibit G.3. Baseline Hospitalization Rates for PM$_{10}$ Risk Assessment Locations [a]

Health Effect	Detroit[1]	Los Angeles[2]	Seattle[3]
Hospital Admissions (per 100,000 general population/year)			
Pneumonia admissions (65 and over): ICD codes 480-487	252	---	---
Pneumonia admissions (65 and over): ICD codes 480-486	250	---	---
COPD and asthma admissions (all ages): ICD codes 490-496	---	152	---
COPD and asthma admissions (65 and over): ICD codes 490-496	192	---	---
COPD without asthma admissions (65 and over): ICD codes 490-492, 494-496	163	---	---
Asthma admissions (30 and over): ICD code 493	---	70	---
Asthma admissions (<65): ICD code 493	---	---	92
Cardiovascular admissions (65 and over): ICD codes: 390-429	---	728	---
Ischemic heart disease (65 and over): ICD codes 410-414	487	---	---
Dysrhythmias (65 and over): ICD code 427	161	---	---
Congestive heart failure (65 and over): ICD code 428	341	---	---

[a] Hospitalization rates are presented only for the locations in which the C-R functions were estimated. For each location, the number of discharges was divided by the location's population from the 2000 U.S. Census estimates to obtain rates. All incidence rates are rounded to the nearest unit.

[1] Wayne County. Year 2000 hospitalization data were obtained from the Michigan Health and Hospital Association.

[2] Los Angeles County. Year 1999 hospitalization data were obtained from California's Office of Statewide Health Planning and Development – Health Care Information Resource Center.

[3] King County. Year 2000 hospitalization data were obtained from the State of Washington Department of Health, Center for Health Statistics, Office of Hospital and Patient Data Systems.

G.3.   The PM_{10} data

PM_{10} data for Boston, Detroit, Los Angeles, Philadelphia, Phoenix, Pittsburgh, San Jose, Seattle, and St. Louis were obtained for the years 1999 through 2002 from EPA's Air Quality System (AQS). For all urban areas except Boston and San Jose, year 2002 data were used. For Boston and San Jose, there were no monitors in any year after 1999 that met the inclusion criterion, so year 1999 data were used.

PM_{10} data for all cities were obtained from monitors measuring concentrations at standard temperature and pressure, because significantly more AQS PM_{10} data are reported under standard conditions than local conditions. The numbers of days of observations by monitor and at the composite monitor, by quarter and for the year, along with annual averages and maximum concentrations, are given in Exhibits G.4 through G.12 for each of the locations in the PM_{10} risk assessment.

Exhibit G.4. Number of Days on which PM_{10} Concentration Data are Available, by Monitor and by Quarter, and PM_{10} Concentrations. Boston, 1999*

Monitor	Q1	Q2	Q3	Q4	Year Total	Annual Avg.	98th Percentile
AQS 250250024811021	11	14	15	12	52	24.3	50
Composite[1]	11	14	15	12	52	24.3	50

*All concentrations are in $\mu g/m^3$; includes Middlesex, Norfolk and Suffolk Counties.

1. The number of days at the composite monitor is the number of days on which at least one of the monitors reported.

Exhibit G.5. Number of Days on which PM_{10} Concentration Data are Available, by Monitor and by Quarter, and PM_{10} Concentrations. Detroit, 2002*

Monitor	Q1	Q2	Q3	Q4	Year Total	Annual Avg.	98th Percentile
AQS 261630001811021	15	15	15	14	59	20.2	49
Composite[1]	15	15	15	14	59	20.2	49

*All concentrations are in $\mu g/m^3$; includes Wayne County.

1. The number of days at the composite monitor is the number of days on which at least one of the monitors reported.

Exhibit G.6. Number of Days on which PM$_{10}$ Concentration Data are Available, by Monitor and by Quarter, and PM$_{10}$ Concentrations. Los Angeles, 2002*

Monitor	Q1	Q2	Q3	Q4	Year Total	Annual Avg.	98th Percentile
AQS 060370002811022	14	15	16	12	57	45.8	79
AQS 060371002811022	14	14	16	14	58	37.7	71
AQS 060374002811022	14	15	15	14	58	36.0	62
AQS 060375001811021	15	15	16	15	61	37.2	97
AQS 060376012811021	15	15	16	14	60	33.3	56
AQS 060379033811021	14	15	14	15	58	29.7	48
Composite[1]	18	19	20	18	75	36.6	55

*All concentrations are in μg/m³; includes Los Angeles County.

1. The number of days at the composite monitor is the number of days on which at least one of the monitors reported.

Exhibit G.7. Number of Days on which PM$_{10}$ Concentration Data are Available, by Monitor and by Quarter, and PM$_{10}$ Concentrations. Philadelphia, 2002*

Monitor	Q1	Q2	Q3	Q4	Year Total	Annual Avg.	98th Percentile
AQS 421010004811021	12	15	14	15	56	22.3	51
AQS 421010037811021	15	13	15	11	54	26.5	83
AQS 421010149811021	11	15	16	14	56	24.6	71
AQS 421010449811021	11	11	15	14	51	25.1	64
Composite[1]	15	15	16	15	61	25.4	72

*All concentrations are in μg/m³; includes Philadelphia County.

1. The number of days at the composite monitor is the number of days on which at least one of the monitors reported.

Exhibit G.8. Number of Days on which PM$_{10}$ Concentration Data are Available, by Monitor and by Quarter, and PM$_{10}$ Concentrations. Phoenix, 2002*

Monitor	Q1	Q2	Q3	Q4	Year Total	Annual Avg.	98th Percentile
AQS 040130019811021	15	15	16	15	61	52.5	98
AQS 040131003811021	15	15	16	15	61	37.9	86
AQS 040131004811021	15	15	16	14	60	36.9	72
AQS 040132001811021	15	15	16	14	60	40.3	85
AQS 040133002811022	15	15	16	15	61	43.1	76
AQS 040133003811021	15	15	16	15	61	36.7	62
AQS 040133006811021	15	15	13	13	56	44.6	90
AQS 040133007811022	14	15	16	15	60	80.5	174
AQS 040133010811021	15	15	16	15	61	54.6	102
AQS 040134003811021	15	15	16	15	61	59.5	123
AQS 040134004811021	15	15	16	15	61	38.5	77
AQS 040134006811021	13	15	16	14	58	62.5	134
AQS 040134007811021	14	14	16	15	59	31.9	67
AQS 040139812811021	15	15	16	15	61	69.9	158
AQS 040139993811021	15	15	15	14	59	28.8	78
Composite[1]	15	15	16	15	61	47.9	83.9

*All concentrations are in µg/m³; includes Maricopa County.

1. The number of days at the composite monitor is the number of days on which at least one of the monitors reported.

Exhibit G.9. Number of Days on which PM$_{10}$ Concentration Data are Available, by Monitor and by Quarter, and PM$_{10}$ Concentrations. Pittsburgh, 2002*

Monitor	Q1	Q2	Q3	Q4	Year Total	Annual Avg.	98th Percentile
AQS 420030067811021	13	15	16	13	57	19.3	54
AQS 420030092811021	13	14	16	15	58	23.2	61
AQS 420030095811021	13	13	16	13	55	18.5	59
Composite[1]	13	15	16	15	59	20.5	58

*All concentrations are in µg/m³; includes Allegheny County.

1. The number of days at the composite monitor is the number of days on which at least one of the monitors reported.

Exhibit G.10. Number of Days on which PM$_{10}$ Concentration Data are Available, by Monitor and by Quarter, and PM$_{10}$ Concentrations. San Jose, 1999*

Monitor	Q1	Q2	Q3	Q4	Year Total	Annual Avg.	98th Percentile
AQS 060850004811024	13	15	12	15	55	24.6	77
Composite[1]	13	15	12	15	55	24.6	77

*All concentrations are in µg/m^3; includes Santa Clara County.

1. The number of days at the composite monitor is the number of days on which at least one of the monitors reported.

Exhibit G.11. Number of Days on which PM$_{10}$ Concentration Data are Available, by Monitor and by Quarter, and PM$_{10}$ Concentrations. Seattle, 2002*

Monitor	Q1	Q2	Q3	Q4	Year Total	Annual Avg.	98th Percentile
AQS 530332004811022	15	15	16	15	61	18.0	44
Composite[1]	15	15	16	15	61	18.0	44

*All concentrations are in µg/m^3; includes King County.

1. The number of days at the composite monitor is the number of days on which at least one of the monitors reported.

Exhibit G.12. Number of Days on which PM$_{10}$ Concentration Data are Available, by Monitor and by Quarter, and PM$_{10}$ Concentrations. St. Louis, 2002*

Monitor	Q1	Q2	Q3	Q4	Year Total	Annual Avg.	98th Percentile
AQS 171630010811021	15	13	15	15	58	29.8	93
AQS 291895001811022	15	15	16	15	61	16.7	36
Composite[1]	15	15	18	15	63	22.8	69

*All concentrations are in µg/m^3; includes St. Louis (MO), Franklin (MO), Jefferson (MO), St. Charles (MO), Clinton (IL), Madison (IL), Monroe (IL), and St. Clair (IL) Counties and St. Louis City (MO).

1. The number of days at the composite monitor is the number of days on which at least one of the monitors reported.

Exhibit G.13. Estimated Annual Health Risks Associated with Short-Term Exposure to "As Is" PM$_{10}$ Concentrations Boston, MA, 1999

Health Effects	Study	Type	Ages	Lag	Other Pollutants in Model	Health Effects Associated with PM10 Above Policy Relevant Background*		
						Incidence	Incidence per 100,000 General Population	Percent of Total Incidence
Short-Term Exposure Mortality	Single Pollutant Models (Total Mortality)							
	Klemm and Mason (2003) [reanalysis of Klemm et al. (2000)]	Non-accidental	all	0 day		420 (247 - 590)	15 (9 - 21)	1.9% (1.1% - 2.7%)
	Klemm and Mason (2003) [reanalysis of Klemm et al. (2000)] -- 6 cities	Non-accidental	all	0 day		247 (142 - 351)	9 (5 - 13)	1.1% (0.7% - 1.6%)
	Dominici et al. (2003) [reanalysis of Samet et al. (2000)] -- regional	Non-accidental	all	1 day		145 (13 - 276)	5 (0 - 10)	0.7% (0.1% - 1.3%)
Respiratory Symptoms*	Single Pollutant Models							
	Schwartz et al. (1994) -- 6 cities	Lower respiratory symptoms	7 - 14	1 day		11600 (16400 - 49600)	400 (600 - 1800)	22.2% (31.6% - 95.4%)

*Incidence was quantified down to the estimated policy relevant background level of 8 µg/m3. Incidences are rounded to the nearest whole number, except respiratory symptoms incidences which are rounded to the nearest 100; percents are rounded to the nearest tenth.

**The C-R functions for lower respiratory symptoms and cough were calculated for the summer period April 1 through August 31.

Note 1: Numbers in parentheses are 95% confidence intervals based on statistical uncertainty surrounding the PM10 coefficient.

Note 2: Multi-city short-term exposure C-R functions were applied only to urban areas included among the cities used to estimate the function.

Exhibit G.14. Estimated Annual Health Risks Associated with Short-Term Exposure to "As Is" PM$_{10}$ Concentrations Detroit, MI, 2002

Health Effects	Study	Type	Ages	Lag	Other Pollutants in Model	Health Effects Associated with PM10 Above Policy Relevant Background*		
						Incidence	Incidence per 100,000 General Population	Percent of Total Incidence
Short-Term Exposure Mortality	Single Pollutant Models (Total Mortality)							
	Dominici et al. (2003) [reanalysis of Samet et al. (2000)]	Non-accidental	all	1 day		54 (9 - 99)	3 (0 - 5)	0.3% (0.1% - 0.5%)
	Ito (2003) [reanalysis of Lippmann et al. (2000)]	Non-accidental	all	1 day		151 (-92 - 389)	7 (-4 - 19)	0.8% (-0.5% - 2.1%)
	Dominici et al. (2003) [reanalysis of Samet et al. (2000)] -- regional	Non-accidental	all	1 day		45 (9 - 80)	2 (0 - 4)	0.2% (0.1% - 0.4%)
	Single Pollutant Models (Cause-Specific Mortality)							
	Ito (2003) [reanalysis of Lippmann et al. (2000)]	Circulatory	all	1 day		110 (-57 - 267)	5 (-3 - 13)	1.3% (-0.7% - 3.1%)
	Ito (2003) [reanalysis of Lippmann et al. (2000)]	Respiratory	all	0 day		26 (-42 - 89)	1 (-2 - 4)	1.8% (-2.8% - 6.0%)
Hospital Admissions	Single Pollutant Models							
	Schwartz and Morris (1995)	Congestive heart failure	65+	mean of lag 0 & 1		84 (32 - 134)	4 (2 - 7)	1.2% (0.5% - 1.9%)
	Ito (2003) [reanalysis of Lippmann et al. (2000)]	Congestive heart failure	65+	0 day		149 (-5 - 297)	7 (0 - 14)	2.1% (-0.1% - 4.2%)
	Zanobetti and Schwartz (2003) [reanalysis of Samet et al. (2000)] -- distr. lag model	COPD	65+	unconst.		127 (68 - 185)	6 (3 - 9)	3.8% (2.0% - 5.5%)
	Zanobetti and Schwartz (2003) [reanalysis of Samet et al. (2000)] -- 14 cities	COPD	65+	unconst.		101 (49 - 151)	5 (2 - 7)	3.0% (1.5% - 4.5%)
	Ito (2003) [reanalysis of Lippmann et al. (2000)]	COPD+	65+	3 day		60 (-81 - 193)	3 (-4 - 9)	1.5% (-2.1% - 4.9%)
	Schwartz and Morris (1995)	Dysrhythmias	65+	1 day		24 (-5 - 54)	1 (0 - 3)	0.7% (-0.2% - 1.6%)
	Ito (2003) [reanalysis of Lippmann et al. (2000)]	Dysrhythmias	65+	1 day		23 (-96 - 134)	1 (-5 - 7)	0.7% (-2.9% - 4.1%)
	Schwartz and Morris (1995)	Ischemic heart disease	65+	0 day		68 (19 - 120)	3 (1 - 6)	0.7% (0.2% - 1.2%)
	Ito (2003) [reanalysis of Lippmann et al. (2000)]	Ischemic heart disease	65+	2 day		187 (-7 - 376)	9 (0 - 18)	1.9% (-0.1% - 3.8%)

Health Effects	Study	Type	Ages	Lag	Other Pollutants in Model	Health Effects Associated with PM10 Above Policy Relevant Background*		
						Incidence	Incidence per 100,000 General Population	Percent of Total Incidence
	Zanobetti and Schwartz (2003) [reanalysis of Samet et al. (2000)] -- distr. lag model	Pneumonia	65+	unconst.		59 (-2 - 120)	3 (0 - 6)	1.2% (0.0% - 2.3%)
	Ito (2003) [reanalysis of Lippmann et al. (2000)]	Pneumonia	65+	1 day		203 (64 - 335)	10 (3 - 16)	4.0% (1.3% - 6.5%)
	Zanobetti and Schwartz (2003) [reanalysis of Samet et al. (2000)] -- 14 cities	Pneumonia	65+	unconst.		100 (60 - 141)	5 (3 - 7)	1.9% (1.2% - 2.7%)

*Incidence was quantified down to the estimated policy relevant background level of 8 µg/m3. Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Note 1: Numbers in parentheses are 95% confidence intervals based on statistical uncertainty surrounding the PM10 coefficient.

Note 2: Multi-city short-term exposure C-R functions were applied only to urban areas included among the cities used to estimate the function.

Exhibit G.15. Estimated Annual Health Risks Associated with Short-Term Exposure to "As Is" PM$_{10}$ Concentrations Los Angeles, CA, 2002

Health Effects	Study	Type	Ages	Model	Lag	Other Pollutants in Model	Health Effects Associated with PM10 Above Policy Relevant Background*		
							Incidence	Incidence per 100,000 General Population	Percent of Total Incidence
Short-Term Exposure Mortality	**Single Pollutant Models (Total Mortality)**								
	Kinney et al. (1995)	Non-accidental	all	log-linear	0 day		819 (0 - 1735)	9 (0 - 18)	1.5% (0.0% - 3.1%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Non-accidental	all	log-linear, GAM (stringent), 30 df	0 day		85 (-610 - 770)	1 (-6 - 8)	0.2% (-1.1% - 1.4%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Non-accidental	all	log-linear, GAM (stringent), 30 df	1 day		169 (-447 - 778)	2 (-5 - 8)	0.3% (-0.8% - 1.4%)
	Dominici et al. (2003) [reanalysis of Samet et al.	Non-accidental	all	log-linear, GLM, Bayes adjusted	1 day		459 (52 - 861)	5 (1 - 9)	0.8% (0.1% - 1.6%)
	Single Pollutant Models (Cause-Specific Mortality)								
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Cardiovascular	all	log-linear, GAM (stringent), 30 df	0 day		198 (-138 - 528)	2 (-1 - 6)	1.0% (-0.7% - 2.7%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Cardiovascular	all	log-linear, GAM (stringent), 30 df	1 day		168 (-177 - 507)	2 (-2 - 5)	0.9% (-0.9% - 2.6%)
	Multi-Pollutant Models (Total Mortality)								
	Kinney et al. (1995)	Non-accidental	all	log-linear	0 day	O3	819 (0 - 1735)	9 (0 - 18)	1.5% (0.0% - 3.1%)
	Kinney et al. (1995)	Non-accidental	all	log-linear	0 day	CO	660 (-343 - 1437)	7 (-4 - 15)	1.2% (-0.6% - 2.6%)
	Dominici et al.(2003) [reanalysis of Samet et	Non-accidental	all	log-linear, GLM, Bayes adjusted	1 day	O3	454 (203 - 738)	5 (2 - 8)	0.8% (0.4% - 1.3%)
	Dominici et al.(2003) [reanalysis of Samet et	Non-accidental	all	log-linear, GLM, Bayes adjusted	1 day	O3, NO2	354 (-17 - 738)	4 (0 - 8)	0.6% (0.0% - 1.3%)
	Dominici et al.(2003) [reanalysis of Samet et	Non-accidental	all	log-linear, GLM, Bayes adjusted	1 day	O3, SO2	354 (34 - 704)	4 (0 - 7)	0.6% (0.1% - 1.3%)
	Dominici et al.(2003) [reanalysis of Samet et	Non-accidental	all	log-linear, GLM, Bayes adjusted	1 day	O3, CO	404 (85 - 721)	4 (1 - 8)	0.7% (0.2% - 1.3%)

Health Effects	Study	Type	Ages	Model	Lag	Other Pollutants in Model	Health Effects Associated with PM10 Above Policy Relevant Background*		
							Incidence	Incidence per 100,000 General Population	Percent of Total Incidence
Hospital Admission	**Single Pollutant Models**								
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000b)]	Cardiovascular	65+	log-linear, GAM (stringent), 30 df	0 day		1404 (508 - 2286)	15 (5 - 24)	2.0% (0.7% - 3.3%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000b)]	Cardiovascular	65+	log-linear, GAM (stringent), 30 df	1 day		1071 (160 - 1970)	11 (2 - 21)	1.6% (0.2% - 2.8%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000c)]	COPD+	all	log-linear, GAM (stringent), 30 df	0 day		473 (198 - 743)	5 (2 - 8)	3.3% (1.4% - 5.1%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000c)]	COPD+	all	log-linear, GAM (stringent), 30 df	1 day		482 (208 - 750)	5 (2 - 8)	3.3% (1.4% - 5.2%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000c)]	COPD+	all	log-linear, GAM (stringent), 30 df	2 day		651 (370 - 926)	7 (4 - 10)	4.5% (2.6% - 6.4%)
	Linn et al. (2000) -- Calif. South Coast Air Basin**	Asthma	30+	log-linear	0 day		61 (-100 - 217)	1 (-1 - 2)	0.9% (-1.5% - 3.3%)
	Multi-Pollutant Models								
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000b)]	Cardiovascular	65+	log-linear, GAM (stringent), 100 df	0 day	CO	-554 (-1631 - 506)	-6 (-17 - 5)	-0.8% (-2.4% - 0.7%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000c)]	COPD+	all	log-linear, GAM (stringent), 100 df	0 day	NO2	-13 (-391 - 354)	0 (-4 - 4)	-0.1% (-2.7% - 2.4%)
	Moolgavkar (2003) [reanalysis of Moolgavkar (2000c)]	COPD+	all	log-linear, GAM (stringent), 100 df	1 day	NO2	167 (-166 - 491)	2 (-2 - 5)	1.2% (-1.2% - 3.4%)

*Incidence was quantified down to the estimated policy relevant background level of 6 μg/m3. Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

**The California South Coast Air Basin represents the area included in Los Angeles, Riverside, San Bernadino and Orange Counties, excluding the mountain and desert regions of the first three counties.

Note 1: Numbers in parentheses are 95% confidence intervals based on statistical uncertainty surrounding the PM10 coefficient.

Note 2: Multi-city or multi-county short-term exposure C-R functions were applied only to counties included among those used to estimate the function.

Exhibit G.16. Estimated Annual Health Risks Associated with Short-Term Exposure to "As Is" PM$_{10}$ Concentrations Philadelphia, PA, 2002

Health Effects	Study	Type	Ages	Lag	Other Pollutants in Model	Health Effects Associated with PM10 Above Policy Relevant Background*		
						Incidence	Incidence per 100,000 General Population	Percent of Total Incidence
Short-Term Exposure Mortality	Single Pollutant Models (Cause-Specific Mortality)							
	Lipfert et al. (2000) -- 7 counties	Cardiovascular	all	1 day		538 (248 - 828)	35 (16 - 55)	8.5% (3.9% - 13.1%)

*Incidence was quantified down to the estimated policy relevant background level of 8 µg/m3. Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Note 1: Numbers in parentheses are 95% confidence intervals based on statistical uncertainty surrounding the PM10 coefficient.

Note 2: Multi-city or multi-county short-term exposure C-R functions were applied only to counties included among those used to estimate the function.

Exhibit G.17. Estimated Annual Health Risks Associated with Short-Term Exposure to "As Is" PM$_{10}$ Concentrations
Phoenix, AZ, 2002

Health Effects	Study	Type	Ages	Lag	Other Pollutants in Model	Health Effects Associated with PM10 Above Policy Relevant Background*		
						Incidence	Incidence per 100,000 General Population	Percent of Total Incidence
Short-Term Exposure Mortality	Single Pollutant Models (Cause-Specific Mortality)							
	Mar et al. (2003) [reanalysis of Mar et al (2000)]	Cardiovascular	65-100	0 day		478 (107 - 862)	16 (3 - 28)	7.4% (1.7% - 13.4%)
	Mar et al. (2003) [reanalysis of Mar et al (2000)]	Cardiovascular	65-100	1 day		373 (0 - 776)	12 (0 - 25)	5.8% (0.0% - 12.0%)

*Incidence was quantified down to the estimated policy relevant background level of 6 µg/m3. Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Note 1: Numbers in parentheses are 95% confidence intervals based on statistical uncertainty surrounding the PM10 coefficient.

Exhibit G.18. Estimated Annual Health Risks Associated with Short-Term Exposure to "As Is" PM$_{10}$ Concentrations Pittsburgh, PA, 2002

Health Effects	Study	Type	Ages	Lag	Other Pollutants in Model	Health Effects Associated with PM10 Above Policy Relevant Background*		
						Incidence	Incidence per 100,000 General Population	Percent of Total Incidence
Short-Term Exposure Mortality	Single Pollutant Models (Total Mortality)							
	Chock et al. (2000)	Non-accidental	<75	0 day		39 (3 - 75)	3 (0 - 6)	0.8% (0.1% - 1.5%)
	Chock et al. (2000)	Non-accidental	75+	0 day		48 (-23 - 118)	4 (-2 - 9)	0.5% (-0.2% - 1.2%)
	Multi-Pollutant Models (Total Mortality)							
	Chock et al. (2000)	Non-accidental	<75	0 day	NO2	54 (9 - 99)	4 (1 - 8)	1.1% (0.2% - 1.9%)
	Chock et al. (2000)	Non-accidental	75+	0 day	CO	88 (3 - 171)	7 (0 - 13)	0.9% (0.0% - 1.8%)

*Incidence was quantified down to the estimated policy relevant background level of 8 µg/m3. Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Note 1: Numbers in parentheses are 95% confidence intervals based on statistical uncertainty surrounding the PM10 coefficient.

Exhibit G.19. Estimated Annual Health Risks Associated with Short-Term Exposure to "As Is" PM$_{10}$ Concentrations San Jose, CA, 1999

Health Effects	Study	Type	Ages	Lag	Other Pollutants in Model	Health Effects Associated with PM10 Above Policy Relevant Background*		
						Incidence	Incidence per 100,000 General Population	Percent of Total Incidence
Short-Term Exposure Mortality	Single Pollutant Models (Total Mortality)							
	Dominici et al. (2003) [reanalysis of Samet et al. (2000)]	Non-accidental	all	1 day		30 (1 - 59)	2 (0 - 3)	0.4% (0.0% - 0.7%)
	Fairley (2003) [reanalysis of Fairley (1999)]	Non-accidental	all	0 day		204 (76 - 329)	12 (5 - 20)	2.5% (0.9% - 4.0%)
	Fairley (2003) [reanalysis of Fairley (1999)]	Non-accidental	all	1 day		-31 (-160 - 94)	-2 (-9 - 6)	-0.4% (-1.9% - 1.1%)
	Dominici et al. (2003) [reanalysis of Samet et al. (2000)] -- regional	Non-accidental	all	1 day		25 (-6 - 55)	1 (0 - 3)	0.3% (-0.1% - 0.7%)
	Single Pollutant Models (Cause-Specific Mortality)							
	Fairley (2003) [reanalysis of Fairley (1999)]	Respiratory	all	0 day		28 (-11 - 65)	2 (-1 - 4)	3.3% (-1.3% - 7.5%)
	Fairley (2003) [reanalysis of Fairley (1999)]	Cardiovascular	all	0 day		92 (7 - 173)	5 (0 - 10)	2.7% (0.2% - 5.0%)
	Multi-Pollutant Models (Total Mortality)							
	Dominici et al.(2003) [reanalysis of Samet et al.(2000)] -- national	Non-accidental	all	1 day	O3	37 (17 - 60)	2 (1 - 4)	0.5% (0.2% - 0.7%)
	Dominici et al.(2003) [reanalysis of Samet et al.(2000)] -- national	Non-accidental	all	1 day	O3, NO2	29 (-1 - 60)	2 (0 - 4)	0.4% (0.0% - 0.7%)
	Dominici et al.(2003) [reanalysis of Samet et al.(2000)] -- national	Non-accidental	all	1 day	O3, SO2	29 (3 - 58)	2 (0 - 3)	0.4% (0.0% - 0.7%)
	Dominici et al.(2003) [reanalysis of Samet et al.(2000)] -- national	Non-accidental	all	1 day	O3, CO	33 (7 - 59)	2 (0 - 4)	0.4% (0.1% - 0.7%)

*Incidence was quantified down to the estimated policy relevant background level of 6 µg/m3. Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

Note 1: Numbers in parentheses are 95% confidence intervals based on statistical uncertainty surrounding the PM10 coefficient.

Note 2: Multi-city short-term exposure C-R functions were applied only to urban areas included among the cities used to estimate the function.

**Exhibit G.20. Estimated Annual Health Risks Associated with Short-Term Exposure to "As Is" PM$_{10}$ Concentrations
Seattle, WA, 2002**

Health Effects	Study	Type	Ages	Lag	Other Pollutants in Model	Health Effects Associated with PM10 Above Policy Relevant Background*		
						Incidence	Incidence per 100,000 General Population	Percent of Total Incidence
Hospital Admissions	Single Pollutant Models							
	Sheppard (2003) [reanalysis of Sheppard et al. (1999)]**	Asthma	<65	1 day		39 (10 - 66)	2 (1 - 4)	2.4% (0.6% - 4.1%)

*Incidence was quantified down to the estimated policy relevant background level of 6 µg/m3. Incidences are rounded to the nearest whole number; percents are rounded to the nearest tenth.

**Sheppard (2003) [reanalysis of Sheppard et al. (1999)] used daily PM2.5 values obtained from nephelometer measurements rather than from air quality monitors.

Note 1: Numbers in parentheses are 95% confidence intervals based on statistical uncertainty surrounding the PM10 coefficient.

Exhibit G.21. Estimated Annual Health Risks Associated with Short-Term Exposure to "As Is" PM$_{10}$ Concentrations

St. Louis, MO, 2002

Health Effects	Study	Type	Ages	Lag	Other Pollutants in Model	Health Effects Associated with PM10 Above Policy Relevant Background*		
						Incidence	Incidence per 100,000 General Population	Percent of Total Incidence
Short-Term	Single Pollutant Models (Total Mortality)							
Exposure Mortality	Klemm and Mason (2003) [reanalysis of Klemm et al. (2000)]	Non-accidental	all	0 day		130 (0 - 259)	5 (0 - 10)	0.6% (0.0% - 1.2%)
	Klemm and Mason (2003) [reanalysis of Klemm et al. (2000)] -- 6 cities	Non-accidental	all	0 day		227 (130 - 322)	9 (5 - 13)	1.0% (0.6% - 1.5%)
	Dominici et al. (2003) [reanalysis of Samet et al. (2000)] -- regional	Non-accidental	all	1 day		63 (13 - 112)	2 (1 - 4)	0.3% (0.1% - 0.5%)
Respiratory Symptoms **	Single Pollutant Models							
	Schwartz et al. (1994) -- 6 cities Lower respiratory symptoms		7 - 14	1 day		4000 (1900 - 5700)	200 (100 - 200)	7.1% (3.3% - 10.2%)

*Incidence was quantified down to the estimated policy relevant background level of 8 µg/m3. Incidences are rounded to the nearest whole number, except respiratory symptoms incidences which are rounded to the nearest 100; percents are rounded to the nearest tenth.

**The C-R functions for lower respiratory symptoms and cough were calculated for the summer period April 1 through August 31.

Note 1: Numbers in parentheses are 95% confidence intervals based on statistical uncertainty surrounding the PM10 coefficient.

Note 2: Multi-city short-term exposure C-R functions were applied only to urban areas included among the cities used to estimate the function.