REGULATORY IMPACT ANALYSES

FOR THE PARTICULATE MATTER

AND OZONE

NATIONAL AMBIENT AIR QUALITY STANDARDS

AND PROPOSED REGIONAL HAZE RULE

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TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

SELECTED LIST OF ACRONYMS

ACT	Alternative Control Techniques
AIRS	Aerometric Information Retrieval System
AIRCOST	utility SO_2 control cost model (E.H.Pechan & Associates)
AF	air/fuel adjustment
ALAPCO	Association of Local Air Pollution Control Officers
AP-42	compilation of air pollutant emissions factors
AQSSD	Air Quality Strategies and Standards Division
AV	annualized value
BARCT	best available retrofit control technology
BEA	Bureau of Economic Analysis
BOOS	burners out-of-service
CAA	Clean Air Act
CAAAC	Clean Air Act Advisory Committee
CAM	Compliance Assurance Monitoring
CASAC	Clean Air Scientific Advisory Committee
CD	Criteria Document
CFC	chlorofluorocarbons
CFR	Code of Federal Regulations
CRDM	Climatological Regional Dispersion Model
CARB	California Air Resources Board
CARM	California Air Resources Management
CO	carbon monoxide
CS-C	control strategy-cost
CTG	control technique guideline
DOC	Department of Commerce
DOD	Department of Defense
DOE	Department of Energy
DOT	Department of Transportation
E.O.	Executive Order
EP	environmental protection
EPA	Environmental Protection Agency
EIA	Energy Information Administration
ERCAM	Emission Reductions and Cost Analysis Models
ERCAM NOx	Enhancements to the Emission Reduction and Cost Analysis Models for NOx
ERCAM VOC	Enhancements to the Emission Reduction and Cost Analysis Models for VOC
ESP	electrostatic precipitator
FAC	aerosol coefficients
FACA	Federal Advisory Committee Act
FGD	flue gas desulfurization
FGR	flue gas recirculation
FIP	Federal implementation plan
FLM	Federal Land Manager

SELECTED LIST OF ACRONYMS (continued)

FMVCP	Federal Motor Vehicle Control Program
FR	Federal Register
FTE	full time equivalent
GCVTC	Grand Canyon Visibility Transport Commission
GDP	gross domestic product
GNP	gross national product
GSP	gross State product
ICI	industrial, commercial, and institutional
ICR	Information Collection Request
ISCST	Industrial Source Complex Short Term
I/M	inspection/maintenance
I-O	input-output
IPM	Integrated Planning Model
IR	ignition timing retardation
LAER	lowest achievable emission rate
LEA	low excess air
LEV	low emission vehicle
LMOS	Lake Michigan Ozone Study Group
LNB	low-NO_x burner
MACT	maximum achievable control technology
MSA	metropolitan statistical area
MW	megawatts
NAAQS	national ambient air quality standards
NAMS	National Air Monitoring Stations
NAPAP	National Acid Precipitation Assessment Program
NAS	nonattainment areas
NEI	National Emissions Inventory
NH_3	ammonia
NPV	net present value
NSR	New Source Review
NGR	natural gas recirculation
NO_X	oxides of nitrogen
NPI	National Particulate Inventory
NSCR	non-selective catalytic reduction
NSPS	New Source Performance Standard
O&M	operating and maintenance
OAQPS	Office of Air Quality Planning and Standards
OCS	outer continental shelf
OFA	overfire air
OMB	Office of Management and Budget
OMS	Office of Mobile Sources
OMTG	open market trading guidelines

SELECTED LIST OF ACRONYMS (continued)

OTAG	Ozone Transport Assessment Group
OTC	Ozone Transport Commission
OXYFIRING	firing of glass furnaces with oxygen-enriched combustion air
PAMS	Photochemical Assessment Monitoring Stations
PM	Particulate Matter
PRA	Paperwork Reduction Act
P-V valves	pressure-vacuum valves
RACT	reasonably available control technology
RADM	Regional Acid Deposition Model
RAMP	Regional Air Management Plan
REMI	Regional Economic Model
REMSAD	Regulatory Modeling System for Aerosols and Deposition
RFA	Regulatory Flexibility Analysis
RH	Regional Haze
RIA	Regulatory Impact Analysis
RIS	Regulatory Impact Statement
RNA	residual nonattainment area
ROM	Regional Oxidant Modeling
RVP	Reid Vapor Pressure
S-R	source-receptor
SBREFA	Small Business Regulatory Enforcement Fairness Act
SCAQMD	South Coast Air Quality Management District
SCC	Source Classification Code
SCR	selective catalytic reduction
SIC	Standard Industrial Classification
SIP	State implementation plan
SLAMS	State and Local Air Monitoring Stations
SNCR	selective non-catalytic reduction
SOA	secondary organic aerosols
SOCMI	Synthetic Organic Chemical Manufacturing Industry
SO_2	sulfur dioxide
SOx	sulfur oxides
SBA	Small Business Administration
SP	Staff Paper
SPMS	special purpose monitors
STAPPA	State and Territorial Air Pollution Program Administration
TAC	total annual costs
TCI	total capital investment
TSP	total suspended particulate
TVA	Tennessee Valley Authority
ULNB	ultra low-NO_x burner
UMRA	Unfunded Mandates Reform Act

SELECTED LIST OF ACRONYMS (continued)

USDA	U.S. Department of Agriculture
VOC	volatile organic compounds
VMT	vehicle miles traveled

EXECUTIVE SUMMARY

Purpose

The Clean Air Act (CAA) directs the Environmental Protection Agency (EPA) to identify and set national standards for pollutants which cause adverse effects to public health and the environment. The EPA is also required to review these health and welfare-based standards at least once every five years to determine whether, based on new research, revisions to the standards are necessary to continue to protect public health and the environment. Recent evidence indicates that two pollutants, ground level ozone and particulate matter (PM), (specifically fine particles which are smaller than 2.5μm in diameter, termed $PM_{2.5}$) are associated with significant health and welfare effects below current regulated levels. As a result of the most recent review process, EPA is revising the primary (health-based) and secondary (welfare-based) National Ambient Air Quality Standards (NAAQS) for both of these pollutants. In addition, in the final action on PM, EPA recognized that visibility impairment is an important effect of PM on public welfare. The EPA concluded that the most appropriate approach for addressing visibility impairment is the establishment of secondary standards for PM identical to the suite of primary standards, in conjunction with a revised visibility protection program to address regional haze in certain large national parks and wilderness areas.

To some degree, the problems of ground level ozone, PM and regional haze all result from commonly shared elements. Pollutants which are precursors to ozone formation are also precursors to the formation of fine PM. Both ozone and fine PM are components of regional haze. These similarities clearly provide management opportunities for optimizing and coordinating monitoring networks, emission inventories and air quality models, and for creating opportunities for coordinating and minimizing the regulatory burden for sources that would otherwise be required to comply with separate controls for each of these pollutants. Thus, these new standards are likely to be considered jointly by the various authorities responsible for their implementation. With this in mind, EPA has developed an economic impact analysis which looks at the coordinated implementation of all of these new rules. Pursuant to Executive Order

12866, this Regulatory Impact Analysis (RIA) assesses the potential costs, economic impacts, and benefits associated with illustrative implementation scenarios of these NAAQS for ozone and PM, including monitoring for these pollutants. It also assesses the costs, economic impacts, and benefits associated with the implementation of alternative regional haze programs.

In setting the primary air quality standards, EPA's first responsibility under the law is to select standards that protect public health. In the words of the CAA, for each criteria pollutant EPA is required to set a standard that protects public health with "an adequate margin of safety." As interpreted by the Agency and the courts, this decision is a *health-based* decision that specifically is *not* to be based on cost or other economic considerations. However, under the CAA, cost can be considered in establishing an alternative regional haze program.

This reliance on science and prohibition against the consideration of cost in setting of the primary air quality standard does not mean that cost or other economic considerations are not important or should be ignored. The Agency believes that consideration of cost is an essential decision making tool for the cost-effective implementation of these standards. Over time, EPA will continue to update this economic analysis as more information on the implementation strategies becomes known. However, under the health-based approach required by the CAA, the appropriate place for cost and efficiency considerations is during the development of implementation strategies, strategies that will allow communities, over time, to meet the health-based standards. The implementation process is where decisions are made -- both nationally and within each community -- affecting how much progress can be made, and what time lines, strategies and policies make the most sense. For example, the implementation process includes the development of national emissions standards for cars, trucks, fuels, large industrial sources and power plants, and through the development of appropriately tailored state and local implementation plans.

In summary, this RIA and associated analyses are intended to generally inform the public about the potential costs and benefits that may result when the promulgated revisions to the ozone and PM NAAQS are implemented by the States, but are not relevant to establishing the

standards themselves. This RIA also presents the benefits and costs of alternative regional haze goals which may be relevant to establishing provisions of the regional haze rule.

General Limitations of this Analysis

Cost-benefit analysis provides a valuable framework for organizing and evaluating information on the effects of environmental programs. When used properly, cost-benefit analysis helps illuminate important potential effects of changes in policy and helps set priorities for closing information gaps and reducing uncertainty. However, nonmonetized benefits are not included here. Executive Order 12866 is clear that unquantifiable or nonmonetizable categories of both costs and benefits should not be ignored. It is particularly important to note that there are many unquantifiable and nonmonetizable benefits categories. Including many health and welfare effects.

Several specific limitations need to be mentioned. The state of atmospheric modeling is not sufficiently advanced to adequately account for all the interactions between these pollutants and the implementation strategies which may be used to control them. Additionally, significant shortcomings exist as to the data available for these analyses. While containing uncertainties, the models used by EPA and the assumptions in the analysis are thought to be reasonable based on the available evidence.

Another major limitation is the illustrative implementation scenario which EPA uses in this analysis to measure the cost of meeting the new standards. The strategies used are limited in part because of our inability to predict the breadth and depth of the creative approaches to implementing these new NAAQS, and in part by technical limitations in modeling capabilities. These limitations, in effect, force costs to be developed based on compliance strategies that may reflect suboptimal approaches to implementation, and therefore, may reflect higher potential costs for attaining the new standards. This approach renders the result specifically useful as an incentive to pursue lower cost options, but not as a precise indicator of likely costs.

Another dimension adding to the uncertainty of this analysis is time. In the case of air

pollution control, thirteen years is a very long time over which to carry assumptions. Pollution control technology has advanced considerably in the last thirteen years and can be expected to continue to advance in the future. Yet there is no clear way model this advance for use in this analysis.

Furthermore, using 2010 as the analytical year for our analysis may not allow sufficient time for all areas to reach attainment. This analysis recognizes this by not arbitrarily assuming all areas reach attainment in 2010. Because 2010 is earlier than many areas are likely to be required to attain, especially for $PM_{2.5}$, the result is a snapshot in time, reflecting progress and partial attainment but not complete attainment.

What we know about 2010 is limited by several factors. This is because EPA's modeling was not able to identify specific measures sufficient to attain the standards in all areas by the analytical year. Further, in EPA's effort to realistically model control measures which might actually be put into practice, our analysis excludes control measures which historically have been seen to be cost-ineffective.

However, even though the control measures identified in our models may be insufficient to reduce pollutants to reach the standards in all areas, there is sufficient evidence to predict that technological innovation and innovative policy mechanisms over the 13 years will make substantial progress towards improving techniques to remove pollutants in these areas in a cost-effective fashion. Chapter 9 of the RIA provides examples of how technological innovation has improved air pollution control measures over the last 10 years and lists emerging technologies which may be available in the year 2010. It also provides a rough estimate of full attainment costs that might result from the implementation of these and other control technologies yet to be developed.

It is important to recognize that with the finalization of the new ozone and PM standards, the Act, and the implementation package accompanying the standards, allow for flexibility in the development of implementation strategies, both for control strategies as well as schedules. The

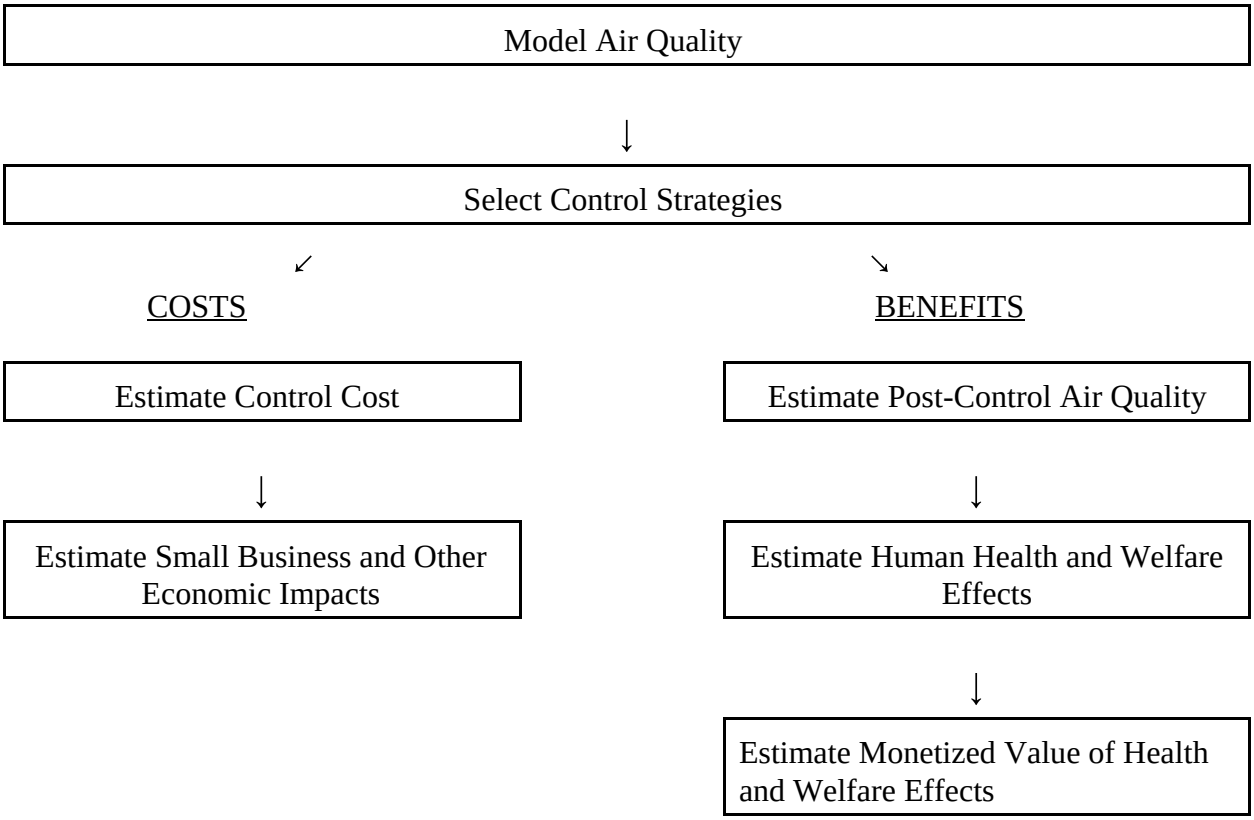
actual determination of how areas or counties will meet the standards is done by States during the development of their State Implementation Plans (SIPs). These SIPs are generally based on the results from more detailed area specific models using more complete information than is available to EPA for the development of its national analysis. For this reason, while EPA believes that this RIA is a good approximation of the national costs and benefits of these rules (subject to the limitations described elsewhere), this analysis cannot accurately predict what will occur account for what happens in individual areas. In addition, this RIA does not take into account all the creativity and flexibility which a State will have when actually implementing these standards. Thus, cheaper ways of implementing the new standards and obtaining the same amount of benefits may well be found.

Qualitative and more detailed discussions of the above and other uncertainties and limitations are included in the analysis. Where information and data exists, quantitative characterizations of these and other uncertainties are included. However, data limitations prevent an overall quantitative estimate of the uncertainty associated with final estimates. Nevertheless, the reader should keep all of these uncertainties and limitations in mind when reviewing and interpreting the results.

Overview of RIA Methodology: Inputs and Assumptions

The potential costs, economic impacts and benefits have been estimated for each of the three rules. The flow chart below summarizes the analytical steps taken in developing the results presented in this RIA.

FIGURE ES-1: Flowchart of Analytical Steps



The assessment of costs, economic impacts and benefits consists of multiple analytical components, dependent upon emissions and air quality modeling. In order to estimate baseline air quality in the year 2010, emission inventories are developed for 1990 and then projected to 2010, based upon estimated national growth in industry earnings and other factors. Current CAA-mandated controls (e.g., Title I reasonably available control measures, Title II mobile source controls, Title III air toxics controls, Title IV acid rain sulfur dioxide (SO_2) controls) are applied to these emissions to take account of emission reductions that should be achieved in 2010 as a result of implementation of the current PM and ozone requirements. These 2010 CAA

emissions in turn are input to an air quality model that relates emission sources to county-level pollutant concentrations. This modeled air quality is used to identify projected counties, based on these assumptions, that exceed the alternative pollutant concentration levels[1]. A cost optimization model is then employed to determine, based on a range of assumptions, the least cost control strategies to achieve the alternatives in violating counties. Given the estimated costs of attaining alternative standards, the potential economic impacts of these estimated costs on potentially affected industry sectors is subsequently analyzed. Potential health and welfare benefits are also estimated from modeled changes in air quality as a result of control strategies applied in the cost analysis. Finally, benefits and costs are compared.

This RIA presents results for the coordinated implementation of these three rules as well as providing an estimate of their costs and benefits separately. Due to the lack of an integrated air quality model, it is impossible to concurrently estimate the joint impacts. In an attempt to provide as much information as possible regarding joint impacts, EPA is able to model the two NAAQS sequentially by assuming first the imposition of controls to meet the new ozone standard, followed by the new PM standard and regional haze target but was unable to sufficiently model adequately the imposition of controls to meet the new PM standard, followed by the new ozone and regional haze standards. Neither approach correctly models the actual process which would be used by decision makers trying to simultaneously develop an optimal program to control all three pollutants. The coordinated implementation national results do not show much difference from the sum of the three rules. This is thought to occur due more to model limitations than a true result.

This analysis estimates the potential costs, economic impacts and benefits for three PM standard options, three ozone standard options and two regional haze options. The alternatives analyzed include:

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1 For the purposes of this RIA, the term “attain” or “attainment” is used to indicate that the air quality level specified by the standard alternative is achieved. Because the analyses in this RIA are based on one-year of air quality data, they are only estimates of actual attainment; all standard alternatives are specified as 3-year averages.

For PM_{10}

- the promulgated PM_{10} standard set at 50μg/m^3 annual mean, and 150μg/m^3, 99th percentile 24-hour average

For $PM_{2.5}$

- the promulgated $PM_{2.5}$ standard set at 15μg/m^3, spatially averaged annual mean, and 65 μg/m^3, 98th percentile 24-hour average and two alternatives: 1) an annual standard set at 15μg/m^3, in combination with a 24-hour standard set at 50μg/m^3; and 2) an annual standard set at 16μg/m^3, in combination with a 24-hour standard set at 65μg/m^3.

For Ozone

- the promulgated ozone standard set at .08 parts per million (ppm) in an eight hour concentration based fourth highest average daily maximum form, and two alternatives: 1) .08 ppm in an eight hour concentration based third highest average daily maximum form; and 2) .08 ppm in an eight hour concentration based fifth highest average daily maximum form.

For Regional Haze

- a regional haze visibility target reduction of 0.67 and 1 deciview. These reductions are analyzed incremental to the implementation of the new $PM_{2.5}$ standard.

The RIA analyses have been constructed such that benefits and costs are estimated incremental to those derived from the combined effects of implementing both the 1990 CAA Amendments and the current PM_{10} and ozone NAAQS as of the year 2010. These analyses provide a "snapshot" of potential benefits and costs of the new NAAQS and regional haze rule in the context of (1) implementation of CAA requirements between now and 2010, (2) the effects on air quality that derive from economic and population growth, and (3) the beneficial effects on air quality that the Agency expects will result from a series of current efforts to provide regional-level strategies to manage the long range transport of NOx and SO_2. It should be kept in mind that 2010 is earlier than attainment with the new standards will be required.

This RIA does not attempt to force its models to project full attainment of the new standards in areas not predicted to achieve attainment by 2010. However, further calculations are performed to attempt to project full attainment benefits and costs in this RIA. For the benefit estimates, the same general methodology used in our base analysis is extended to derive the estimates and are reported within this RIA. For the cost estimates a limited methodology is used to predict potential costs of full attainment, with the last increment of reductions being "achieved" through the use of unspecified measures having an average emission cost-effectiveness of $10,000 per ton. It is important to recognize that EPA has much less confidence in these cost estimates because of the length of time over which full attainment would be achieved.

In that regard, the $10,000 cost estimate for these reductions is intended to provide an ample margin to account for unknown factors associated with future projections, and may tend to overestimate the final costs of attainment. In fact, EPA will encourage, and expects that States will utilize, market based approaches that would allow individual sources to avoid incurring costs greater than $10,000/ton. Chapter 9 discusses EPA's particular interest in applying the concept of a Clean Air Investment Fund that would allow individual sources to avoid incurring costs greater than $10,000 per ton. Based on this analysis, EPA believes that a large number of emissions reductions are available at under $10,000 a ton; sources facing higher control costs could finance through such a fund. Compliance strategies like this will likely lower costs of compliance through more efficient allocation, and can serve to stimulate technology innovation.

The estimation of benefits from environmental regulations poses special challenges. The include the difficulty of quantifying the incidence of health, welfare, environmental endpoints of concern, and the difficulty of assigning monetized values to these endpoints. As a result, many categories of potential benefits have not been monetized at all, and those that have been are given in ranges. Specifically, this RIA has adopted the approach of presenting a "plausible range" of monetized benefits to reflect these uncertainties by selecting alternative values for each of several key assumptions. Taken together, these alternative sets of assumptions define a "high end" and a "low end" estimate for the monetized benefits categories.

In choosing alternative assumptions, EPA has tried to be responsive to the many comment it received on the RIAs that accompanied the proposed rules. It should be emphasized, however, that the high and low ends of the plausible range are not the same as upper and lower bounds. For many of the quantitative assumptions involved in the analysis, arguments could be made for an even higher or lower choice, which could lead to an even greater spread between the high end and low end estimates. The analysis attempts to present a plausible range of monetized benefits for the categories that have been analyzed. Again, it must be stressed that many benefits categories have not been monetized at all, because of both conceptual and technical difficulties in doing so. These benefits are in addition to the plausible range of monetized benefits considered here.

SUMMARY OF RESULTS

Direct Cost and Economic Impact Analyses

Potential annual control costs (in 1990 dollars) are estimated for attainment of each alternative standard. Potential administrative costs of revising the PM_{10} monitoring network and the costs of a new $PM_{2.5}$ monitoring network as well as the administrative costs of implementing the new rules are also reported.

Possible economic impacts based on these control costs are estimated for the same alternative standards. This impacts analysis also include a screening analysis providing estimated annual average cost-to-sales ratios for all potentially affected industries.

Key Results and Conclusions

OZONE

- Estimated annual identifiable control costs corresponding to the partial attainment of the promulgated ozone standard is $1.1 billion per year incremental to the current standard. This estimate is based on the adoption, where needed, of all currently identifiable reasonably available control technologies for which EPA has cost data, and which cost less

than $10,000/ton.

- Under the partial attainment scenario, there are estimated to be 17 potential residual nonattainment areas, 7 of which are also in residual nonattainment for the current ozone standard.

- The implication of residual nonattainment is that areas with a VOC or NOx deficit will likely need more time beyond 2010; new control strategies (e.g., regional controls or economic incentive programs); and/or new technologies in order to attain the standard.

- Under the illustrative scenario selected, at least one or more establishments (e.g. industrial plant) in up to 227 of U.S. industries (as defined by 3-digit SIC codes) which are estimated to have cost-to-sales ratios of at least 0.01 percent by the chosen standard. Approximately 25 of these are industries which have some establishments which are estimated to have cost-to-sales ratios exceeding 3 percent, and therefore may experience potentially significant impacts. These results are highly sensitive to the choice of control strategy.

- A very small proportion of establishments are potentially affected for most of the SIC codes affected by the new ozone standard. The number of establishments potentially affected is 0.13 percent of all establishments in affected SIC codes for the selected standard.

- This RIA does not attempt to force its models to project full attainment of the new standard in areas not predicted to achieve attainment by 2010. However, full attainment costs of the selected standard are estimated at $9.6 billion per year incremental to the current standard. It is important to recognize that EPA has much less confidence in these cost estimates because of the inherent uncertainties in attributing costs to new technologies.

PM

- Estimated annual identifiable control costs corresponding to the partial attainment of the selected PM standard are $8.6 billion per year incremental to the current PM_{10} standard. This estimate is based on the adoption of the majority of currently identifiable control measures for which EPA had cost-effectiveness data. For the PM analysis, a $1 billion/$\mu g/m^3$ cut-off is used to limit the adoption of control measures. Control measures providing air quality improvements are less than $1 billion/$\mu g/m^3$ are adopted where the air quality model and cost analysis identify control measures as being necessary.

- Under the partial attainment scenario, an estimated 30 potential residual nonattainment counties, 11 of which are also in residual nonattainment for the current PM_{10} standard.

- The implication of residual nonattainment is that counties with $PM_{2.5}$ levels above the standard will likely need more time beyond 2010; new control strategies (e.g., regional controls or economic incentive programs); and/or new technologies in order to attain the standard.

- Under the illustrative scenario selected, at least one or more establishments (e.g. industrial plant) in up to 198 of U.S. industries (as defined by 3-digit SIC codes) which are estimated to have cost-to-sales ratios of at least 0.01 percent by the chosen standard. Approximately 86 of these are industries which have some establishments which are estimated to have cost-to-sales ratios exceeding 3 percent, and therefore may experience potentially significant impacts. These results are highly sensitive to the choice of control scenario.

- A small proportion of establishments are potentially affected for most of the SIC codes affected by the new PM standards. The average number of establishments potentially affected is about 2.7 percent in total affected SIC codes for the selected standard.

- The year 2010 is prior to the time that full attainment is required under the CAA. This RIA

does not attempt to force its models to project full attainment of the new standard in areas not predicted to achieve attainment by 2010. However, full attainment costs of the selected $PM_{2.5}$ standard in 2010 are estimated at $37 billion per year incremental to the current standard. It is important to recognize that EPA has much less confidence in these cost estimates because of the inherent uncertainties in attributing costs to new technologies.

Regional Haze

- The expected annual control cost for the year 2010 associated with the proposed regional haze rule ranges from $0 to a maximum of $2.7 billion. The additional cost of implementation of the proposed regional haze rules will vary depending on the visibility targets selected by States. If targets are adjusted through that process to parallel the implementation programs for the new ozone and PM standards, the costs for meeting the adjusted targets in those areas will be borne by the ozone and PM programs. The proposed rule, however, includes a presumptive target of 1.0 Deciview improvement over either 10 or 15 years (on the 20 percent worst days); any adjustments to this target must be justified by States on a case-by-case basis. The high end costs in this analysis assume that 76 mandated Class I areas will need additional reductions to meet the 10 year presumptive target from 2000 to 2010. The additional control cost associated with meeting the presumptive 1.0 deciview target in 10 years in 48 of these areas, and partial achievement in 28 areas is estimated to be $2.7 billion. If the 1.0 deciview improvement in 15 years target is promulgated, this analysis projects that 58 Class I areas would not meet this target with NAAQS controls alone. To fully attain a 0.67 deciview improvement between 2000 and 2010 in 41 of these areas and partially attain the 0.67 target in 17 areas would cost an estimated $2.1 billion.

Benefit Analysis

Health and welfare benefits are estimated for attainment of the PM and ozone standards and visibility improvements resulting from the proposed regional haze program. The estimated

change in incidence of health and welfare effects is estimated for each air quality change scenario as defined by the 2010 baseline and post-attainment air quality distributions. These estimated changes in incidence are then monetized by multiplying the estimated change in incidence of each endpoint by its associated dollar value of avoiding an occurrence of an adverse effect. These endpoint-specific benefits are then summed across all counties to derive an estimate of total benefit. Because there are potentially significant categories for which health and welfare benefits are not quantified or monetized due to a lack of scientific and economic data, the benefit estimates presented in this analysis are incomplete.

Tables ES-1 and ES-2 list the anticipated health and welfare benefit categories that are reasonably associated with reducing PM and ozone in the atmosphere, specifying those for which sufficient quantitative information exists to permit benefit calculations. Because of the inability to monetize some existing benefit categories, such as changes in pulmonary function and altered host defense mechanisms, some categories are not included in the calculation of the monetized benefits.

Table ES-1 PM and Regional Haze Benefits Categories

	PM Health and Welfare Benefit Categories	
	Unquantified Benefit Categories	**Quantified Benefit Categories (incidences reduced and/or dollars)**
Health Categories	Changes in pulmonary function Morphological changes Altered host defense mechanisms Cancer Other chronic respiratory disease Infant Mortality Mercury Emission Reductions	Mortality (acute and long-term) Hospital admissions for: all respiratory illnesses congestive heart failure ischemic heart disease Acute and chronic bronchitis Lower, upper, and acute respiratory symptoms Respiratory activity days Minor respiratory activity days Shortness of breath Moderate or worse asthma Work loss days
Welfare Categories	Materials damage (other than consumer cleaning cost savings) Damage to ecosystems (e.g., acid sulfate deposition) Nitrates in drinking water Brown Clouds	Consumer Cleaning Cost Savings Visibility Nitrogen deposition in estuarine and coastal waters

Table ES-2 Ozone Benefits Categories

	Ozone Health and Welfare Benefit Categories	
	Unquantified Health Benefit Categories	**Quantified Benefit Categories (in terms of incidences reduced or dollars)**
Health Categories	Airway responsiveness Pulmonary inflammation Increased susceptibility to respiratory infection Acute inflammation and respiratory cell damage Chronic respiratory damage/ Premature aging of lungs	Coughs Pain upon deep inhalation Mortality Hospital admissions for: all respiratory illnesses pneumonia chronic obstructive pulmonary disease (COPD) Acute respiratory symptoms Restricted activity days Lower respiratory symptoms Self-reported asthma attacks Cancer from air toxics Change in lung function
Welfare Categories	Ecosystem and vegetation effects in Class I areas (e.g., national parks) Damage to urban ornamentals (e.g., grass, flowers, shrubs, and trees in urban areas) Reduced yields of tree seedlings and non-commercial forests Damage to ecosystems Materials damage (other than consumer cleaning cost savings) Nitrates in drinking water Brown Clouds	Commodity crops Fruit and vegetable crops Commercial forests Consumer Cleaning Cost Savings Visibility Nitrogen deposition in estuarine and coastal waters Worker productivity

Key Results and Conclusions

There are a number of uncertainties inherent in the underlying functions used to produce quantitative estimates. Some important factors influencing the uncertainty associated with the benefits estimates are: whether a threshold concentration exists below which associated health risks are not likely to occur, the valuation estimate applied to premature mortality and the estimation of post-control air quality. Additionally, there is greater uncertainty about the existence and the magnitude of estimated excess mortality and other effects associated with exposures as one considers increasingly lower concentrations approaching background levels. The high and low end benefits estimates, as discussed above, attempt to bracket a plausible range that accounts for some of these uncertainties.

<u>OZONE</u>

- Partial attainment of the selected ozone standard results in estimated monetized annual benefits in a range of $0.4 and $2.1 billion per year incremental to the current ozone standard. The estimate includes from 0 to 330 incidences of premature mortality avoided.

- The major benefit categories that contribute to the quantified benefits include mortality, hospital admissions, acute respiratory symptoms and welfare effects. Mortality benefits represent about 90% of the high end benefits estimates. However, this analysis excludes a number of other benefit categories.

- Full attainment of the preferred ozone standard results in estimated monetized benefits of in a range of $1.5 to $8.5 billion per year incremental to the current ozone standard. The estimate includes 0 to 1300 incidences of premature mortality avoided (corresponding to long-term mortality, respectively).

- There are benefits from ozone control that could not be monetized in the benefits analysis, which in turn, affect the benefit-cost comparison. Nonmonetized potential benefits categories include: effects in lung function; chronic respiratory damage and premature

aging of the lungs; increased susceptibility to respiratory infection; protection of ornamental plants, mature trees, seedlings, Class I areas, and ecosystems; reduced nitrates in drinking water, and reduced brown cloud effects. The effect of our inability to monetize these benefits categories leads to an underestimation of the monetized benefits presented in this RIA.

PM

- Partial attainment of the selected $PM_{2.5}$ standard results in estimated monetized annual benefits in a range of $19 to $104 billion per year incremental to the current PM_{10} standard, including 3,300 to 15,600 incidences of premature mortality avoided.

- The major benefit categories that contribute to the quantified benefits include mortality, hospital admissions, acute respiratory symptoms and welfare effects. Mortality benefits represent about 12% to 70% of the benefits estimates. However, this analysis excludes a number of other benefit categories.

- Full attainment of the preferred $PM_{2.5}$ standard results in estimated monetized benefits of in a range of $20 and $110 billion per year incremental to the current PM_{10} standard, including 3,700 to 16,600 incidences of premature mortality avoided (corresponding to short-term and long-term mortality, respectively). These numbers are significant underestimates because EPA has no procedure to predict full attainment benefits outside nonattainment county boundaries for $PM_{2.5}$.

- There are benefits from PM control that could not be monetized in the benefits analysis, which in turn affect the benefit-cost comparison. Nonmonetized potential benefits categories include: effects in pulmonary function; increased susceptibility to respiratory infection; cancer; infant mortality; effects associated with exposure to mercury; protection of ecosystems; reduced acid sulfate deposition; reduced materials damage; reduced nitrates in drinking water; and reduced brown cloud effects. The effect of our inability to monetize

these benefit categories leads to an underestimation of the monetized benefits presented in this RIA.

Regional Haze

- The expected visibility and associated health and welfare annual benefits for the year 2010 associated with the proposed regional haze rule ranges from $0 to a maximum of $5.7 billion. The amount of benefits from implementation of the proposed regional haze rules will vary depending on the visibility targets selected by States. If targets are adjusted through that process to parallel the implementation programs for the new ozone and PM standards, the benefits for meeting the adjusted targets in those areas will not exceed those calculated for ozone and PM programs. The proposed rule, however, includes a presumptive target of a 1.0 Deciview improvement over either 10 or 15 years (on the 20 percent worst days); any adjustments to this target must be justified by States on a case-by-case basis. The high end benefits in this analysis assume that 76 mandated Class I areas will need additional emissions reductions to meet the 10 year presumptive target from 2000 to 2010. The additional benefits, resulting from 48 of the 76 areas meeting the presumptive 1.0 deciview target, and 28 of the 76 areas having partial achievement, are estimated to range from $1.7 to $5.7 billion. The additional benefits resulting from 41 Class I areas meeting the presumptive 0.67 deciview improvement target between 2000 and 2010, and 17 areas partially meeting the 0.67 deciview target range from $1.3 to $3.2 billion.

Monetized Benefit-Cost Comparison

Comparing the benefits and the costs provides one framework for comparing alternatives in the RIA. As noted above, both the Agency and the courts have defined the NAAQS standard setting decisions, both the initial standard setting and each subsequent review, as *health-based* decisions that specifically are *not* to be based on cost or other economic considerations. This benefit-cost comparison is intended to generally inform the public about the potential costs and

benefits that may result when revisions to the ozone and PM NAAQS are implemented by the States. Costs and benefits of the proposed regional haze rule are also presented. Monetized benefit-cost comparisons are presented for both the full and partial attainment scenarios nonmonetized effects by definition cannot be included. In considering these estimates, it should be stressed that these estimates contain significant uncertainties as discussed throughout this analysis.

Estimated quantifiable partial attainment (P/A) benefits of implementation of the particulate matter (PM) and ozone NAAQS exceed estimated P/A costs. Estimated quantifiable net P/A benefits (P/A benefits minus P/A costs) for the combined $PM_{2.5}$ 15/65 and ozone 0.08 ppm 4th max standards range from approximately $10 to $96 billion.

Considered separately, estimated quantifiable P/A benefits of $PM_{2.5}$ standard far outweigh estimated P/A costs. Estimated quantifiable net P/A benefits of the selected $PM_{2.5}$ 15/65 standard range from $10 to $95 billion. Estimated quantifiable full-attainment (F/A) benefits may or may not exceed estimated F/A costs for PM depending on whether the low end or high end estimates are used. Net benefits for the $PM_{2.5}$ F/A scenario range from negative $18 billion to positive $67 billion . Estimated quantifiable P/A benefits of the ozone standard also exceed estimated quantifiable P/A costs, though by a smaller margin. Estimated quantifiable net P/A benefits of the ozone 0.08 ppm 4th max standard range from negative $0.7 to positive $1.0 billion. The full range of F/A benefit estimates are smaller than the F/A costs for ozone with net benefits ranging from negative $1.1 billion to negative $8.1 billion. Estimated quantifiable net benefits from the proposed regional haze program range from $0 to $3.0 billion.

Table ES-3. Comparison of Annual Benefits and Costs of PM-Only Alternatives in 2010[a] (1990$)

$PM_{2.5}$ Alternative ($\mu g/m^3$)	Annual Benefits of Partial Attainment[b] (billion $) (A)	Annual Costs of Partial Attainment (billion $) (B)	Net Benefits of Partial Attainment (billion $) (A - B)	Number of RNA Counties
16/65 (high end estimate)[c]	**90**	**5.5**	**85**	**19**
15/65 low end estimate[d] high end estimate[c]	**19** **104**	**8.6**	**10** **95**	**30**
15/50 (high end estimate)[c]	**107**	**9.4**	**98**	**41**

a All estimates are measured incremental to the baseline of the current ozone standard (0.12ppm , 1 expected exceedance per year), and the current PM_{10} standard (PM_{10} $\mu g/m^3$ annual/150 $\mu g/m^3$ daily, 1 expected exceedance per year).

b Partial attainment benefits based upon post-control air quality as defined in the control cost analysis.

c The high end estimates are based on assumptions of effects down to 12 $\mu g/m^3$ for PM mortality, down to background for chronic bronchitis, and a valuation approach to mortality benefits based on averting premature statistical deaths valued at $4.8 million each.

d The low-end estimates are based on assumptions of a threshold at 15 $\mu g/m^3$ for PM mortality and chronic bronchitis, an assumption that two-thirds of short-term deaths are premature by only days or weeks, a valuation approach to mortality benefits based on life-years valued at $120,000 each, and an adjustment to visibility benefits derived from a contingent valuation survey.

Table ES-4. Comparison of Annual Benefits and Costs of Ozone-Only Alternatives in 2010[a] (1990$)

Ozone Alternative (ppm)	Annual Benefits of Partial Attainment (billion $)[b] (A)	Annual Costs of Partial Attainment (billion $) (B)	Net Benefits of Partial Attainment (billion $) (A - B)	Number of RNA Areas
0.08 5th Max (high end estimate)[c]	**1.6**	**0.9**	**0.7**	**12**
0.08 4th Max low end estimate[d] high end estimate[c]	**0.4** **2.1**	**1.1**	**-0.7** **1.0**	**17**
0.08 3rd Max (high end estimate)[c]	**2.9**	**1.4**	**1.5**	**27**

a All estimates are measured incremental to the baseline current ozone standard (0.12ppm , 1 expected exceedance per year).

b Partial attainment benefits based upon post-control air quality estimates as defined in the control cost analysis.

c The high-end estimates use a meta-analysis of epidemiological studies of associations between ozone and short-term mortality, and PM related benefits of ozone controls.

d The low-end estimates are based on assumptions of no ozone mortality, and no ancillary PM-related benefits from ozone controls.

1.0 INTRODUCTION AND OVERVIEW

The Clean Air Act (CAA) directs the Environmental Protection Agency (EPA) to identify and set national standards for pollutants which cause adverse effects to public health and the environment. The EPA is also required to review national health and welfare-based standards at least once every 5 years to determine whether, based on new research, revisions to the standards are necessary to continue to protect public health and the environment. A growing list of health effects studies on particulate matter (PM) and ozone report associations between ambient fine particles [which is PM smaller than 2.5 micrometers (μm) in diameter, termed $PM_{2.5}$] and/or ambient ozone and serious effects such as increased mortality. As a result of the most recent review process, EPA has proposed to revise the National Ambient Air Quality Standards (NAAQS) for PM and ozone. In addition, EPA is proposing a regional haze (RH) rulemaking to achieve progress toward visibility goals. Pursuant to Executive Order 12866, this Regulatory Impact Analysis (RIA) assesses the potential costs, economic impacts, and benefits associated with the *implementation* of these and alternative NAAQS for PM and ozone as well as for a proposed RH rule. Potential costs, economic impacts, and benefits are estimated incremental to attainment of existing standards.

In setting the primary air quality standards, EPA's first responsibility under the law is to select standards that protect public health. In the words of the CAA, for each criteria pollutant EPA is required to set a standard that protects public health with "an adequate margin of safety." As interpreted by the Agency and the courts, this decision is a *health-based* decision that specifically is *not* to be based on cost or other economic considerations. This reliance on science and prohibition against the consideration of cost does not mean that cost or other economic considerations are not important or should be ignored. However, under the health-based approach required by the CAA, the appropriate place for cost and efficiency considerations is during the development of implementation strategies, strategies that will allow communities to meet the health-based standards. Through the development of national emissions standards for cars, trucks, fuels, large industrial sources and power plants, for example, and through the development of appropriately tailored state and local implementation plans, the implementation

process is where decisions are made -- both nationally and within each community -- affecting how much progress can be made, and what time lines, strategies and polices make the most sense. In summary, this RIA and associated analyses are intended to generally inform the public about the potential costs and benefits that may result when the new PM and ozone NAAQS are implemented by the States, but are not relevant to establishing the standards themselves. In contrast, results from this analysis may be used to support the RH rule development process.

1.1 THE NATIONAL AIR QUALITY CHALLENGE

1.1.1 Particulate Matter

PM represents a broad class of chemically and physically diverse substances. It can be principally characterized as discrete particles that exist in the condensed (liquid or solid) phase spanning several orders of magnitude in size. For regulatory purposes, fine particles can be generally defined as those particles with an aerodynamic diameter of 2.5 μm. or less, while coarse fraction particles are those particles with an aerodynamic diameter greater than 2.5 μm., but less than or equal a nominal 10 μm. The health and environmental effects of PM are strongly related to the size of the particles.

Emission sources, formation processes, chemical composition, atmospheric residence times, transport distances and other parameters of fine and coarse particles are distinct (U.S. EPA, 1996d). Fine particles are generally formed secondarily from gaseous precursors such as sulfur dioxide (SO_2) , nitrogen oxides, and/or organic compounds, and are composed of sulfate, nitrate, and/or ammonium compounds; elemental carbon; and metals. Fine particles can also be directly emitted. Combustion of coal, oil, diesel, gasoline, and wood, as well as high temperature process sources such as smelters and steel mills, produce emissions that contribute to fine particle formation. In contrast, coarse particles are typically mechanically generated by crushing or grinding and are often dominated by resuspended dusts and crustal material from paved or unpaved roads or from construction, farming, and mining activities. Fine particles can remain in the atmosphere for days to weeks and travel through the atmosphere hundreds to

thousands of kilometers, while coarse particles deposit to the earth within minutes to hours and within tens of kilometers from the emission source.

Geographic differences (e.g., rural vs. urban locations, East vs. West) also exist between ambient levels of fine and coarse particles and their related characteristics (U.S. EPA, 1996d). For instance, total concentrations of coarse fraction particles are generally higher and the crustal material contribution relatively larger in arid areas of the Western and Southwestern U.S. In the Eastern U.S., fine particle sulfate is a significant component of ambient $PM_{2.5}$ concentrations. The differences in fine and coarse particle characteristics and their geographic variability are significant considerations in the design of control strategies to reduce levels of ambient PM.

Since the last review of the PM air standards, there has been significant new evidence from community epidemiological studies that serious health effects are associated with exposures to ambient concentrations of fine particle PM found in the urban U.S. even at levels below current PM standards. The U.S. EPA PM Criteria Document (U.S. EPA, 1996b) and U.S. EPA PM Staff Paper (U.S. EPA, 1996d) discuss and evaluate scientific information identifying the key health effects associated with fine particle PM, including: premature mortality (particularly among the elderly and people with respiratory or cardiovascular disease), increased hospital admissions and emergency room visits (primarily for the elderly and individuals with cardiopulmonary disease); increased respiratory symptoms and disease (e.g., for children and individuals with cardiopulmonary disease); decreased lung function (particularly in children and individuals with asthma); and alterations in lung tissue and structure and in respiratory tract defense mechanisms. Elevated concentrations of fine particles also contribute to visibility impairment, and materials damage and soiling effects.

1.1.2 Ozone

Ozone is created when its two primary components, volatile organic compounds (VOC) and oxides of nitrogen (NOx), combine in the presence of sunlight under specific meteorological conditions. VOC and NOx, are often referred to as ozone *precursors*, which are, for the most

part, emitted directly into the atmosphere from a combination of natural and anthropogenic sources. Attempts to decrease ozone pollution in the United States have been confounded by a number of factors, including the inherent non-linearity of the photochemical mechanism, the contribution of natural precursor emissions, long range transport of ozone and its precursors (primarily NOx), meteorological variability, the general lack of essential data (primarily inventory related), and the limitations of current modeling tools.

Recent scientific evidence indicates that ground-level ozone not only affects people with impaired respiratory systems (such as asthmatics), but healthy adults and children as well. The new studies taken into account during this latest review show health effects at levels below that of the current standard (0.12 ppm, 1-hour form) (U.S. EPA, 1996a,c). In particular, active children and outdoor workers exposed for 6-8 hours of ozone levels as low as 0.08 ppm may experience several acute effects such as decreased lung function, acute lung inflammation, and premature aging of the lung. Recent epidemiological studies also provide evidence of an association between elevated ozone levels and increases in hospital admissions and mortality; and animal studies indicate repeated exposure to high levels of ozone for several months can produce permanent structural damage in the lungs.

1.1.3 Regional Haze

Under Section 16A and 169B of the CAA, 156 Class I Federal areas are identified for visability protection. The CAA require that “reasonable progress” be made toward achieving a visibility goal of essentially no manmade visibility impairment in areas of concern. The EPA is proposing that reasonable progress be defined as equivalent to a 1 deciview improvement (a perceptible change) in the most impaired days over a 10-year period, with no degradation occurring in the cleanest days. Impairment is primarily due to transport since there are few emission sources within the areas of concern. Thus to achieve reasonable progress, emission controls must be employed in surrounding areas.

1.1.4 The Integrated Air Quality Management Challenge

The EPA is promulgating the PM and ozone NAAQS and proposing the RH rule concurrently. While not all attributes of ozone and PM are linked, important commonalities exist among the PM, ozone, and RH problems, which provide the technical and scientific rationale for integrated analysis. Similarities in pollutant sources, formation, and control exist between PM, ozone, and RH, in particular with respect to the fine fraction of particles addressed by the current PM NAAQS. These similarities include:

(1) atmospheric residence times of several days, leading to regional-scale transport of the pollutants,

(2) similar gaseous precursors, including NOx and VOC, which may contribute to the formation of PM, ozone, and RH in the atmosphere,

(3) similar combustion-related source categories, such as utilities, industrial boilers, and mobile sources, which emit particles directly as well as gaseous precursors of particles (e.g., SO_2, NOx, VOC) and ozone (e.g., NOx, VOC), and

(4) similar atmospheric chemistry driven by the same chemical reactions and intermediate chemical species which often favor high fine particle levels, ozone, and RH.

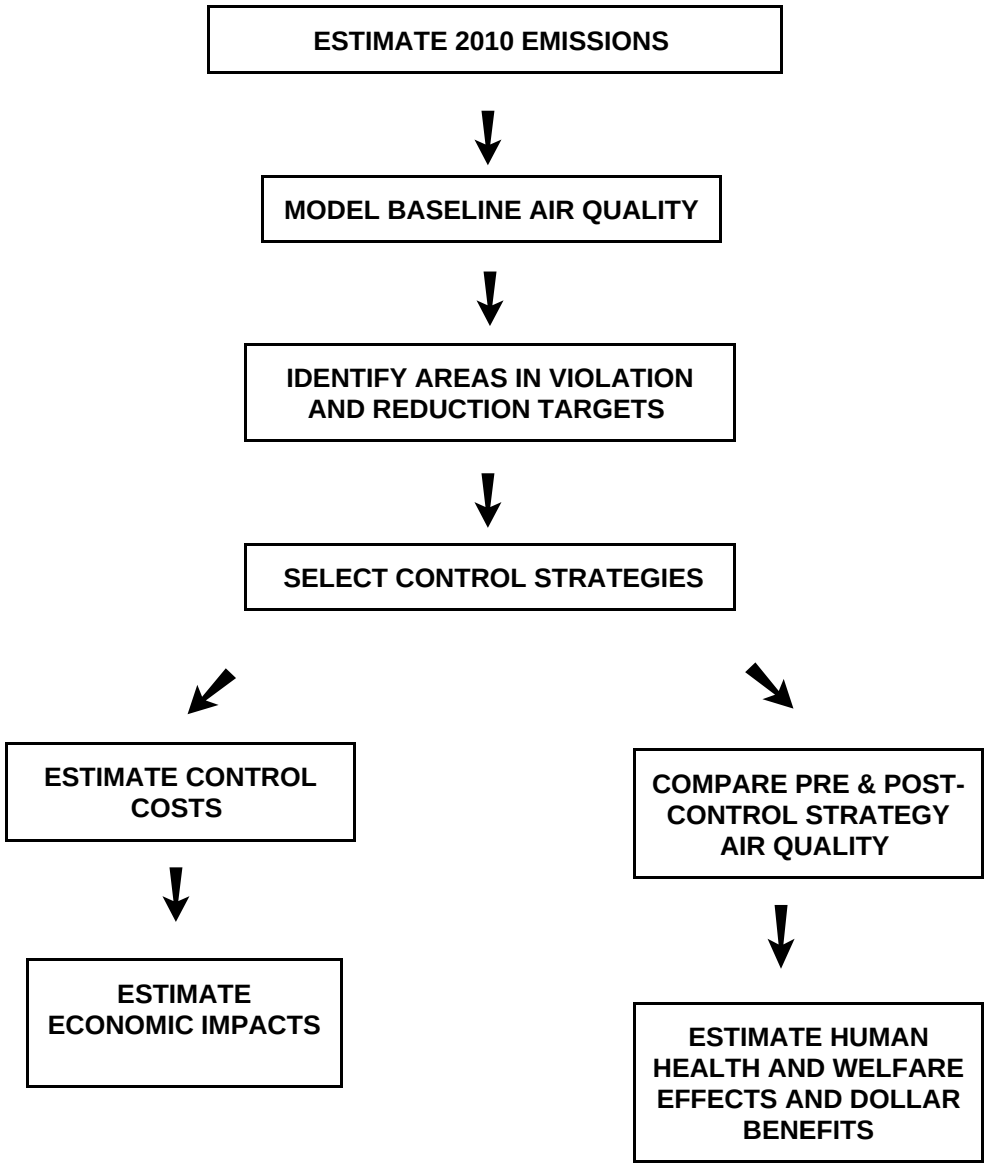
These similarities provide opportunities for optimizing technical analysis tools (i.e., monitoring networks, emission inventories, air quality models) and integrated emission reduction strategies to yield important co-benefits across various air quality management programs. Integration of implementation is likely to result in a net reduction of the regulatory burden on some source category sectors that would otherwise be impacted separately by PM, ozone, and visibility protection control strategies.

1.2 OVERVIEW OF THE RIA METHODOLOGY

1.2.1 Basic Analytical Approach

Figure 1.1 displays the basic analytical structure of this RIA. An emissions inventory is developed and projected to the year 2010 (see Chapter 4). The year 2010 was selected as the base year for the analysis primarily because by this year the vast majority of CAA Amendment requirements will have fully taken effect. Baseline air quality is then estimated using air quality models, areas in violation with alternative NAAQS and with regional haze targets are identified, and air quality or emission reduction targets are computed (see Chapter 4). Control strategies to achieve air quality goals are then selected and potential costs are computed based on the control measures chosen (see Chapters 5-8). Based on these potential costs as well as potential administrative costs to governments (see Chapter 10), potential economic impacts to large and small businesses and governments are assessed (see Chapter 11). Since the controls employed and costed in chapters 5-7 do not achieve full attainment of the NAAQS, a rough full attainment cost assessment also is provided (see Chapter 9). Based on estimated air quality changes resulting from the control measures employed, the resulting change in human health and welfare effects is predicted and the monetized value of these effects is estimated (see Chapter 12). Finally, benefit and cost estimates are compared (see Chapter 13).

FIGURE 1.1: Flowchart of Analytical Steps



1.2.2 Limited PM/Ozone/RH Integration

Ideally, analyses of the concurrent implementation of the PM and ozone NAAQS and a proposed RH rule should be fully integrated. However, since each NAAQS review is a separate regulatory decision, the health effects and scientific information for each pollutant need to be judged separately and on their own merits. For purposes of consistency, this RIA presents cost, benefit, and other economic impact results of a separate PM and a separate ozone NAAQS.

It is not possible at this time to perform a fully integrated benefit-cost analysis of these rules. Air quality models are not currently available to sufficiently assess the atmospheric interactions of PM, ozone, and precursor pollutants at the national level. Moreover, efforts to develop integrated implementation strategies have not been completed. The joint impacts of a PM and ozone NAAQS are assessed as a sensitivity study in this RIA by a layering strategy. For example, attainment of one NAAQS is attempted, baseline emissions and air quality are changed, then attainment of the other NAAQS is attempted. This approach eliminates double-counting of controls and allows for the computation of the ancillary benefits associated with attaining one NAAQS toward attaining the other NAAQS. Full integration is not achieved, however, since air chemistry interactions associated with joint implementation are not modeled and because the control selection approach to attain one standard does not consider the potential beneficial impact toward achievement of the other standard. For this latter reason, a least cost estimate associated with joint implementation of a PM and ozone NAAQS is not presented in this analysis.

Concurrent with the review of the PM and ozone NAAQS and development of the RH proposed rule, EPA has requested the assistance of stakeholder groups to help design a new implementation approach to controlling PM, ozone, and RH and is setting forth critical implementation principles accompanying the new standards. This stakeholder group has been charged to evaluate new approaches to controlling these pollutants, focusing on the interaction of these pollutants in the atmosphere. As part of this process, EPA will strive to perform more fully integrated analyses to support subsequent stages of the implementation process.

1.2.3 Control Strategies Modeled

To perform an RIA for NAAQS and for a proposed RH rule, it is necessary for EPA to make certain broad assumptions concerning control strategies on a national level. The fact the EPA has selected control strategies as part of this assessment should not be taken to mean that EPA recommends these control strategies or anticipates that these control strategies and measures will be imposed in all nonattainment areas. The CAA requires EPA to set NAAQS and develop a RH rule, and it requires the states, with assistance from EPA, to develop implementation plans and submit them to EPA for review. This places primary responsibility for implementing the air quality management process on the states and allows for Federal oversight of states' efforts to achieve and maintain the required level of air quality. Because states have considerable flexibility in developing control strategies for attaining the PM and ozone NAAQS as well as the RH rule, it is unlikely that the control strategy assumptions in this RIA will exactly correspond to the attainment strategy ultimately developed for any particular area. Moreover, this analysis forecasts control strategies for year 2010. Substantial uncertainty is inherent in any projections so far into the future. Finally, there may be some cases where the strategies that are assumed to be applied nationwide are not appropriate for application in a particular area.

The CAA allows for substantial flexibility in the development of implementation strategies, both for control strategies and schedules, for attaining the new NAAQS and RH reduction goals. Specific to the new standards, EPA has established a formal advisory committee under the Federal Advisory Committee Act (FACA). The specific purpose of the broad-based stakeholder group is to advise EPA on ways to develop innovative, flexible, practical and cost-effective implementation strategies, and to advise us directly on transitional strategies as well.

Control strategies employed in this RIA are limited in part because of our inability to predict the breadth and depth of the creative approaches to implementation that may be forthcoming via the FACA process, and in part by technical limitations in modeling capabilities. For example, lower-cost "market-based" strategies are modeled in this analysis only to a limited extent. This limitation, in effect, may force cost estimates to be developed based on compliance

strategies that reflect suboptimal implementation approaches. Thus, cost estimates presented in this analysis may overstate actual implementation costs.

1.3 KEY IMPROVEMENTS FROM THE PROPOSAL RIAs

In December, 1996, EPA published separate RIAs that assessed the benefits, costs, and other economic impacts associated with the proposed PM and ozone NAAQS. Since December, EPA has made various revisions, updates, and other improvements to the these proposal RIAs. This document incorporates these improvements, merges and to some extent integrates the PM and ozone analyses, and includes an assessment of the proposed RH rule.

Many of the improvements made to the proposal RIAs and incorporated in this document are made as the direct result of helpful comments received by the EPA from RIA Interagency Committee members and the public. Among the most important of these improvements are:

- A more integrated analysis that avoids double-counting of costs is performed based on a common emission inventory;

- Air quality modeling is improved (e.g., an updated source receptor matrix is used for PM, ozone attainment targets are revised in accordance with new modeling information, etc.);

- The baseline year for the analyses is changed from 2007 to 2010, primarily to better reflect the actual implementation of the new standards;

- Administrative costs are estimated;

- Costs in marginal ozone nonattainment areas are estimated;

- Additional control measures are included and control cost and emission reduction

estimates are updated;

- The residual nonattainment problem is assessed and characterized more fully and explicitly;

- The potential impact of technological progress in pollution control is more fully assessed;

- Rough estimates of full-attainment costs are calculated;

- Additional benefit categories are monetized and qualitatively discussed;

- The analysis of valuation of mortality risk reduction from reduced ozone is updated and strengthened substantially;

- Long-term mortality risk from PM is reassessed to correct for a previous statisticalerror;

- The valuation estimate for cases of chronic bronchitis has been adjusted downward to reflect new information;

- The economic impact assessment is revised (e.g., the cost to sales ratio approach is improved, impacts on the utility and pollution control industries are assessed, etc.);

- A plausible range of monetized benefits is presented that reflects some of the key uncertainties in the analysis.

- Various additional sensitivity analyses are performed.

While these changes have significantly improved the quality of this analysis, this RIA is still limited in various ways and substantial uncertainties regarding the results from this analysis remain. Data, modeling, time, and resource constraints inevitably limit the rigor of any RIA. Qualitative, and when possible, quantitative discussions of uncertainties, limitations, and potential biases are included in this RIA. Additional refinements to this analysis are planned to support later stages of the implementation process.

1.4 KEY LIMITATIONS

1.4.1 General Limitations of Benefit-Cost Analysis

The consideration of cost and the use of benefit-cost analyses, provides a structured means of evaluating and comparing various implementation policies, as well as a means of comparing the variety of tools and technologies available for air pollution control efforts. The EPA has found the use of such analyses to be of significant value in developing regulatory options over the years.

General limitations, however, continue to affect the accuracy and usefulness of benefit-cost analyses. Wide ranges of uncertainties and omissions often exist within an analysis, especially within complex studies of national scope involving forecasts over extended periods of time. Benefit-cost analyses and results, continue to be limited by inabilities to monetize certain benefit categories. Comparisons of such incomplete benefits to the more quantifiable and usually more complete cost estimates can be misleading. Benefit-cost analyses also can not provide a basis for resolving distributional issues, i.e., to assess the equity of policies that provide benefits to some and costs to others. At best, the distribution of benefits and costs can be described.

These limitations notwithstanding, the process of developing such analyses can provide useful insights for environmental managers and policy makers. These insights can be especially useful to those working to develop implementation strategies because the analytical framework provides a mechanism for measuring, however roughly, alternative strategies or tools against a

common framework.

1.4.2 Specific Limitations with this RIA

In addition to the general limitations associated with benefit-cost analysis described above, the reader should be fully aware of the numerous limitations associated with this particular analysis. Significant uncertainties and limitations exist associated with each analytical block within Figure 1.1. Existing emissions inventories are limited, projections to the year 2010 may involve significant error, available air quality models are limited, control cost estimates are inexact, health and welfare effect predictions are not precise, valuation approaches are controversial and potentially significant benefit categories are not monetized, and so on. The accumulation of these uncertainties is substantial.

To the degree feasible, the analysis that follows attempts to identify and characterize in some detail the various uncertainties and limitations related to the specific components of this analysis. In many cases, however, the lack of data prevent a rigorous quantitative treatment of uncertainties. Whether quantified or not, the reader should keep in mind all of the above uncertainties and limitations when reviewing and interpreting the results presented in the chapters that follow.

1.5 REFERENCES

U.S. Environmental Protection Agency (1996a), Air Quality Criteria for Ozone and Related Photochemical Oxidants. Office of Research and Development; Office of Health and Environmental Assessment; Research Triangle Park, N.C.; EPA report nos. EPA/600/P-93/004aF-cF.

U.S. Environmental Protection Agency (1996b), Air Quality Criteria for Particulate Matter. Office of Research and Development, Office of Health and Environmental Assessment; Research Triangle Park, N.C.; EPA report no. EPA/600/P-95/001aF; April.

U.S. Environmental Protection Agency (1996c), Review of the National Ambient Air Quality Standards for Ozone: Assessment of Scientific and Technical Information. Office of Air Quality Planning and Standards; Research Triangle Park, N.C.; EPA report no. EPA/4521R-96-007.

U.S. Environmental Protection Agency (1996d), Review of the National Ambient Air Quality Standards for Particulate Matter: Assessment of Scientific and Technical Information. Office of Air Quality Planning and Standards; Research Triangle Park, N.C.; EPA report no. EPA/4521R-96-013.

2.0 STATEMENT OF NEED FOR THE PROPOSED REGULATIONS

2.1 INTRODUCTION

Congress passed the Clean Air Act (CAA) to protect public health and the environment from the adverse effects of air pollution. This section summarizes the statutory requirements affecting the development and revision of the National Ambient Air Quality Standard (NAAQS) and briefly describes the health and welfare effects of particulate matter (PM), ozone, and regional haze (RH) and the need for regulatory action at this time.

2.2 STATUTORY AUTHORITY AND LEGISLATIVE REQUIREMENTS FOR PM AND OZONE NAAQS, AND RH RULE

2.2.1 PM and Ozone

Two sections of the CAA govern the establishment and revision of NAAQS. Section 108 (42 U.S.C. 7408) directs the Administrator to identify pollutants which "may reasonably be anticipated to endanger public health or welfare" and to issue air quality criteria for them. These air quality criteria are intended to "accurately reflect the latest scientific knowledge useful in indicating the kind and extent of all identifiable effects on public health or welfare which may be expected from the presence of [a] pollutant in the ambient air . . . ."

Section 109 (42 U.S.C. 7409) directs the Administrator to propose and promulgate "primary" and "secondary" NAAQS for pollutants identified under section 108. Section 109(b)(1) defines a primary standard as one "the attainment and maintenance of which in the judgment of the Administrator, based on [the] criteria and allowing an adequate margin of safety, [are] requisite to protect the public health."[2] A secondary standard, as defined in section

2 The legislative history of section 109 indicates that a primary standard is to be set at "the maximum permissible ambient air level . . . which will protect the health of any [sensitive] group of the population," and that for this purpose "reference should be made to a representative

109(b)(2), must "specify a level of air quality the attainment and maintenance of which in the judgment of the Administrator, based on [the] criteria, [are] requisite to protect the public welfare from any known or anticipated adverse effects associated with the presence of [the] pollutant in the ambient air." Welfare effects as defined in section 302(h) [42 U.S.C. 7602(h)] include, but are not limited to, "effects on soils, water, crops, vegetation, manmade materials, animals, wildlife, weather, visibility and climate, damage to and deterioration of property, and hazards to transportation, as well as effects on economic values and on personal comfort and well-being."

Section 109(d) of the Act directs the Administrator to review existing criteria and standards at 5-year intervals. When warranted by such review, the Administrator is to revise NAAQS. After promulgation or revision of the NAAQS, the standards are implemented by the States.

As discussed in the preambles to the PM and ozone rules (U.S. EPA, 1997 b and c), the costs and technological feasibility of attainment are not to be considered in setting NAAQS. These factors, however, can be considered in the development of State plans to implement such standards. Under section 110 of the Act, the States are to submit to EPA for approval State Implementation Plans (SIP) that provide for the attainment and maintenance of NAAQS by certain deadlines.

The current reviews of the NAAQS for PM and ozone have two separate and distinct components: the development of any new or revised standards which are codified in 40 CFR Part 50; and the development of cost-effective implementation strategies to achieve such standards, codified in 40 CFR Part 51.

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sample of persons comprising the group rather than to a single person in such a group." (S. Rep. No. 91-1196, 91st Cong., 2d Sess. 10 (1970)).

2.2.2 RH

In addition to the NAAQS for PM and ozone, EPA is proposing a RH rulemaking to achieve reasonable progress towards the national visibility protection goal. The EPA recognized that visibility impairment is an important effect of PM on public welfare and concluded that the most appropriate approach for addressing it is to establish secondary standards for PM identical to the suite of primary standards, along with a revised visibility protection program to address RH in Class I Federal areas. The sources, precursor pollutants, and geographical areas of concern that ozone, PM and RH have in common provide the opportunity to minimize the regulatory burden on sources that would otherwise be required to comply with separate controls for each of these pollutants. These pollutants will most likely be considered jointly by the various authorities responsible for the implementation of the new standards.

In 1970, section 169A of the CAA set forth a national visibility goal that calls for "the prevention of any future, and the remedying of any existing, impairment of visibility in mandatory Class I Federal areas which impairment results from manmade air pollution."

The EPA's 1980 visibility regulations address visibility impairment that is "reasonably attributable" to a single source or small group of sources. These rules were designed to be the first phase in EPA's overall program to protect visibility. The EPA explicitly deferred action addressing RH impairment until some future date "when improvement in monitoring techniques provides more data on source-specific levels of visibility impairment, regional scale models become refined, and our scientific knowledge about the relationships between emitted air pollutants and visibility impairment improves." (U.S. EPA, 1997a).

Congress added section 169B as part of the 1990 Amendments to focus attention on RH issues. Section 169B(f) called for EPA to establish the Grand Canyon Visibility Transport Commission (GCVTC) to assess scientific and technical information pertaining to RH in the Grand Canyon National Park. The final report from the Commission, "Recommendations for Improving Western Vistas," was completed in June 1996. Section 169B(e) calls for the

Administrator, within 18 months of receipt of the Commission's report, to carry out her "regulatory responsibilities under section [169A], including criteria for measuring 'reasonable progress' toward the national goal." (U.S. EPA, 1997a)

2.3 AUTHORITY FOR THIS RIA

Pursuant to Executive Order (E.O.) 12866, this Regulatory Impact Analysis (RIA) assesses the costs, economic impacts, and benefits associated with the implementation of these and alternative NAAQS for PM and ozone, as well as for the proposed RH rule. E.O. 12866 states that "Federal agencies should promulgate only such regulations as are required by law, are necessary to interpret the law, or are made necessary or compelling by public need . . . . In deciding whether and how to regulate, agencies should assess all costs and benefits of available regulatory alternatives, including the alternative of not regulating. Costs and benefits shall be understood to include both quantifiable measures . . . and qualitative measures of costs and benefits that are difficult to quantify, but nevertheless essential to consider. Further, in choosing among alternative regulatory approaches, agencies should select those approaches that maximize net benefits . . ., unless a statute requires another regulatory approach." Since the CAA precludes consideration of costs or technological feasibility in determining the ambient standards, the results of this RIA were not taken into account by the Administrator in her decision on whether to change the current NAAQS. Further discussion of other alternatives pursuant to E.O. 12866 is contained in Chapter 3 of this document.

The Unfunded Mandates Reform Act of 1995 (UMRA), in title II, section 201, directs agencies "unless otherwise prohibited by law [to] assess the effects of Federal regulatory actions on State, local, and tribal governments, and the private sector . . . ." Section 202 of title II directs agencies to provide a qualitative and quantitative assessment of the anticipated costs and benefits of a Federal mandate resulting in annual expenditures of $100 million or more, including the costs and benefits to State, local, and tribal governments, or the private sector. This section does not apply to the NAAQS because EPA cannot consider economic or technological feasibility in setting the PM and ozone NAAQS, and the NAAQS will not in themselves establish any new

regulatory requirements. Section 205 requires that the least costly, most cost-effective or least burdensome alternative that achieves the objectives of the rule be selected or an explanation of why such alternative was not selected. This section applies only when a written statement is required under section 202. Section 204 requires each Agency to develop a process to permit State, local and tribal officials to provide meaningful and timely input in the development of regulatory proposals containing significant Federal intergovernmental mandates. The EPA had a series of preproposal outreach meetings that solicited input on issues related to the NAAQS (U.S. EPA, 1997 b and c)

The proposed RH rule establishes presumptive targets for visibility improvements in mandatory Class I Federal areas, but also provides discretion to the States to establish alternative targets where warranted. This RIA fulfills the UMRA section 202 requirement to analyze the costs and benefits of implementing a RH program. In view of the discretion the proposed rule would provide the States, the RIA analyzes two different presumptive targets for visibility improvement; one target equal to a rate over 10 years, the other over 15 years. The RIA analysis estimates that the RH rule would likely result in the expenditure by State, local, and tribal governments in the aggregate, or by the private sector of over $100 million per year for either presumptive option.

The UMRA section 204 consultation requirement was met by providing numerous opportunities for State, local and tribal governments to provide input during development of the proposed RH rule as described in the preamble to the final rule.

The Regulatory Flexibility Act as amended by the Small Business Regulatory Enforcement Fairness Act of 1996 (SBREFA) provides that, whenever an agency is required to publish a general notice of rulemaking for a proposed rule, the Agency must prepare regulatory flexibility analyses for the proposed and final rule unless the head of the Agency certifies that it will not have a significant economic impact on a substantial number of small entities. Since the NAAQS themselves do not establish any requirements applicable to small entities, the Agency may certify that the rules will not have a significant economic impact on a substantial number of

small entities. The EPA has explained in some detail in the preambles to the NAAQS rules and the proposed RH rules why these rules do not have a significant adverse impact on a substantial number of small entities. While speculative, the Agency has conducted general analyses of the potential cost impacts on small entities of control measures the States might adopt to attain the proposed NAAQS and proposed RH rule, and has included these analyses in this RIA.

Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," requires that each Federal agency make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minorities and low-income populations. The implementation plans determining which control measures will be used to attain the PM and ozone NAAQS and RH rule are developed by the States, therefore it is not possible to rigorously assess environmental justice concerns in this analysis.

Detailed discussions of the applicability of the above mentioned Executive Order and Acts to the PM and ozone NAAQS and the RH rule can be found in the preambles to these rules.

2.4 KEY HEALTH AND WELFARE EFFECTS

2.4.1 PM

As identified and discussed in the PM Criteria Document (CD) and PM Staff Paper (SP) (U.S. EPA, 1996c and d), key health effects categories associated with PM include: 1) premature mortality; 2) aggravation of respiratory and cardiovascular disease (as indicated by increased hospital admissions and emergency room visits, school absences, work loss days, and restricted activity days); 3) changes in lung function and increased respiratory symptoms; 4) changes to lung tissues and structure; and 5) altered respiratory defense mechanisms.

Based on a qualitative assessment of the epidemiological evidence of effects associated

with PM, the populations that appear to be at greatest risk from exposure to PM are: 1) individuals with respiratory disease and cardiovascular disease; 2) individuals with infectious respiratory disease; 3) elderly individuals; 4) asthmatic individuals; and 5) children.

In formulating alternative approaches to establishing adequately protective, effective, and efficient PM standards, it is necessary to specify the fraction of particles found in the ambient air that should be used as the indicator(s) for the standards. The scientific evidence indicates that continued use of PM_{10} as the *sole* indicator for the PM standards would not provide the most effective and efficient protection from the health effects of PM. The recent health effects evidence and the fundamental physical and chemical differences between fine and coarse fraction particles have prompted consideration of separate standards for the fine and coarse fractions of PM_{10}. In this regard, the CD (U.S. EPA, 1996d) concludes that fine and coarse fractions of PM_{10} should be considered separately. Taking into account such information, the Clean Air Scientific Advisory Committee (CASAC) found sufficient scientific and technical bases to support establishment of separate standards relating to these two fractions of PM_{10}. Specifically, CASAC advised the Administrator that "there is a consensus that retaining an annual PM_{10} NAAQS . . . is reasonable at this time" and that there is "also a consensus that a new $PM_{2.5}$ NAAQS be established."

There are significant physical and chemical differences between the two subclasses of PM_{10} and it is reasonable to expect that differences may exist between fine and coarse fraction particles in both the nature of potential effects and the relative concentrations required to produce such effects. The specific components of PM that could be of concern to health include components typically within the fine fraction (e.g., acid aerosols, sulfates, nitrates, transition metals, diesel particles, and ultra fine particles), and other components typically within the coarse fraction (e.g., silica and resuspended dust). While components of both fractions can produce health effects, in general, the fine fraction appears to contain more of the reactive substances potentially linked to the kinds of effects observed in the epidemiological studies. The fine fraction also contains the largest number of particles and a much larger aggregate surface area than the coarse fraction which enables the fine fraction to have a substantially greater

potential for absorption and deposition in the thoracic region, as well as for dissolution or absorption of pollutant gases.

With respect to welfare or secondary effects, fine particles have been clearly associated with the impairment of visibility over urban areas and large multi-state regions. Fine particles and their major constituents are also implicated in materials damage, soiling, and acid deposition. Coarse fraction particles also contribute to soiling and materials damage.

Particulate pollution is a problem affecting localities, both urban and non-urban, in all regions of the United States. Manmade emissions that contribute to airborne PM result principally from stationary point sources (fuel combustion and industrial processes), industrial process fugitive particulate emission sources, non-industrial fugitive sources (roadway dust from paved and unpaved roads, wind erosion from cropland, etc.) and transportation sources. In addition to manmade emissions, consideration must also be given to natural emissions including dust, sea spray, volcanic emissions, biogenic emissions (e.g., from plants and animals), and emissions from wild fires when assessing particulate pollution and devising control strategies (U.S. EPA, 1996c and d).

2.4.2 Ozone

As identified and discussed in the ozone CD and SP (U.S. EPA, 1996a and b), key health effects categories associated with ozone exposure include: 1) change in pulmonary function responses; 2) increased respiratory symptoms and effects on exercise performance; 3) increased airway responsiveness; 4) acute inflammation and respiratory cell damage; and based on animal studies 5) chronic respiratory damage.

In addition to the various health effects associated with exposure to ozone identified in the ozone CD and Staff Paper (U.S. EPA, 1996 a and b), recent peer reviewed scientific publications indicate that exposure to ambient ozone increases the risk of mortality. While this evidence was not used in the NAAQS standard setting process, this new evidence suggests that substantial

additional health benefits associated with reducing ozone concentrations may exist.

The populations identified as having demonstrated particular susceptibility to ozone include "exercising" or active healthy and asthmatic individuals, including children, adolescents, and adults working outdoors. There are limited data on the ozone susceptibility of individuals with preexisting respiratory disease or other limitations on their pulmonary function and exercise capacity (e.g., those with chronic obstructive pulmonary disease, ischemic heart disease). However, these individuals may be of concern based on the likelihood that decrements in lung function or exercise capacity due to ozone exposure may have greater clinical importance to them than similar changes in healthy persons.

Welfare effects of ozone include, but are not limited to, effects on soils, water, crops, vegetation, man-made materials, animals, wildlife, weather, visibility and climate, damage to and deterioration of property, and hazards to transportation. Of these welfare effect categories, the effects of ozone on crops, vegetation, and ecosystems are of significant concern at concentrations typically occurring in the U.S. As stated in a previous ozone CD and SP (U.S. EPA, 1989), "of the phytotoxic compounds commonly found in the ambient air, ozone is the most prevalent, impairing crop production and injuring native vegetation and ecosystems more than any other air pollutant." By affecting crops and native vegetation, ozone also directly affects natural ecosystem components such as soils, water, animals, and wildlife, and ultimately the ecosystem itself. Some of these impacts have direct, quantifiable economic value, while others are currently not quantifiable.

Finally, additional health and welfare effects and benefits accrue directly from control of ozone precursors (NOx and VOC). For example, reduced NOx results in substantial benefits from reduced nitrogen deposition into water bodies such as the Chesapeake Bay and from reduced PM. Reduced VOC results in air toxics reductions and reduced cancer risk.

2.4.3 RH

Regional haze is produced from a multitude of sources and impairs visibility in every direction over a large area, possibly over several states. Regional haze masks objects on the horizon and reduces the contrast of nearby objects. The formation, extent, and intensity of RH is a function of meteorological and chemical processes, which sometimes cause fine particle loadings to remain suspended in the atmosphere for several days and to be transported hundreds of kilometers from their sources. It is this type of visibility degradation that is principally responsible for impairment in national parks and wilderness areas across the country. Visibility in urban areas may be dominated by local sources, but may be significantly affected by long-range transport of haze as well. Fine particles transported from urban areas in turn may be significant contributors to regional-scale visibility impairment.

Visibility has direct significance to people's enjoyment of daily activities in all parts of the country. Individuals value good visibility for the well-being it provides them directly, both in the places where they live and work, and in the places where they enjoy recreational opportunities. Visibility is also highly valued because of the importance people place on protecting nationally-significant natural areas.

2.5 NEED FOR REGULATORY ACTION

2.5.1 Market Failure (Externality)

In the absence of government regulation, market systems have failed to deal effectively with air pollution because air sheds have been treated as public goods and because most air polluters do not internalize the full damage caused by their emissions. For an individual firm, pollution is usually an unusable by-product which can be disposed of at no cost by venting it to the atmosphere. However, in the atmosphere, pollution causes real costs to be incurred by others. This is generally referred to in economic theory as a negative externality.

The fact that the producer, or consumer, whose activity results in air pollution, does not bear the full costs of his/her action leads to a divergence between private costs and social costs.

This negative externality causes a "market failure" because it causes a misallocation of society's resources, with more resources being devoted to the polluting activity than would be if the polluter had to bear the full social cost of his/her actions..

There are a variety of market and nonmarket mechanisms available to correct this situation. Examples of market mechanisms include emission fees and trading systems. Other than regulation, nonmarket approaches would include negotiations or litigation under tort law and general common law. In theory, these latter approaches might result in payments to individuals to compensate them for the damages they incur.

Such resolutions may not occur, however, in the absence of government intervention. Two major impediments often block the correction of pollution inefficiencies and inequities by the private market. The first is high transaction costs when millions of individuals are affected by thousands of polluters, such as is the case with PM, ozone, and RH pollution problems. The transaction costs of compensating individuals adversely impacted by air pollution include contacting the individuals affected, apportioning injury to each from each pollution source, and executing the appropriate damage suits or negotiations. If left to the private market, each polluter and each affected individual must litigate or negotiate on their own or organize into groups for these purposes. The transaction costs involved could be so high as to exceed the benefits of the pollution reduction.

The second factor discouraging private sector resolution of the PM, ozone, and RH pollution problem is that pollution abatement tends to be a public good. That is, after pollution has been abated, benefits of the abatement can be enjoyed by additional people at no additional cost. This constitutes the classic "free rider" problem. Any particular individual is reluctant to contribute time or money to reduce PM, ozone, and RH expecting that they may be able to "free ride" on others' efforts to mitigate the problem.

In view of the clear legal requirements placed on the EPA by the CAA, the Agency is proposing to revise the NAAQS for PM and ozone and propose a RH rule to provide adequate

protection of public health and welfare. As this RIA shows, there are resource costs associated with the implementation of these standards by the States. However, governmental action is required by the CAA. Moreover, these standards, when implemented by the States, will mitigate the negative externalities which would otherwise occur due to the failure of the marketplace.

2.6 REFERENCES

U.S. Environmental Protection Agency (1989), Review of the National Ambient Air Quality Standards for Ozone: Assessment of Scientific and Technical Information. Office of Air Quality Planning and Standards; Research Triangle Park, N.C.; EPA report no. EPA-450/2-92/001.

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U.S. Environmental Protection Agency (1997b), Draft National Ambient Air Quality Standards for Ozone--Final Decision (Ozone Preamble). Office of Air Quality Planning and Standards; Research Triangle Park, N.C.; May.

U.S. Environmental Protection Agency (1997c). Draft National Ambient Air Quality Standards for Particulate Matter--Final Decision (PM Preamble). Office of Air Quality Planning and Standards; Research Triangle Park, N.C.; May.

3.0 NATIONAL AMBIENT AIR QUALITY STANDARDS (NAAQS) AND REGIONAL HAZE (RH) ALTERNATIVES ASSESSED

3.1 INTRODUCTION

The assessment of the available quantitative and qualitative health effects data presented in the criteria documents and the Office of Air Quality Planning and Standards (OAQPS) Staff Papers, together with recommendations from the Clean Air Scientific Advisory Committee (CASAC) and other public commenters, suggest a range of alternatives for short-term (24-hour) and long-term (annual) particulate matter (PM) standards and for an 8-hour ozone standard. Based on the available scientific data, the Environmental Protection Agency (EPA) proposed new and revised PM and ozone standards on November 27, 1996. The EPA is also proposing a rulemaking on RH.

For a comprehensive discussion of the scientific data that serve as a basis for these alternatives as well as the rationale for the Administrator's approach to this decision, the reader is referred to the OAQPS Staff Papers and Criteria Documents, as well as the Federal Register notices announcing the Administrator’s proposed and final decisions.

Although EPA received numerous comments and suggestions concerning the alternatives that should be evaluated in this regulatory impact analysis (RIA), there is a limit to the number of different analyses that could be performed, due to time, resource, and other constraints. The alternatives described below are chosen because EPA believes they provide a sufficient variation within the range indicated by the data and because these alternatives could be assessed given available data and models. This RIA includes an evaluation of the incremental benefits and costs associated with these alternatives in relation to the current PM and ozone NAAQS baseline. The current standards are the appropriate baseline to use because they represent the point of comparison for the future if no new standards are implemented. The analysis assists in informing the public regarding which alternatives may return the greatest benefits in relation to the costs incurred when implemented by the States.

3.2 DESCRIPTIONS AND RATIONALES FOR STANDARDS EVALUATED

3.2.1 Current PM_{10} Standards

The current particulate matter annual and 24-hour standards 50 $\mu g/m^3$, annual arithmetic mean and 150 $\mu g/m^3$ 24-hour, one expected exceedance. These standards are abbreviated as PM_{10} 50/150. The EPA is retaining the PM_{10} standards at their current level, but is changing the form of the 24-hour PM_{10} standard to the 99th percentile concentration over a 3-year period. This form of the standard is not analyzed in this RIA because it is considered a relaxation from the current standard and would, therefore, result in a cost savings when compared to the current standard. The annual standard will be retained in its current form.

3.2.2 Alternative New PM Standards

On November 27, 1996, EPA proposed to revise the current primary PM_{10} standards by adding two new primary $PM_{2.5}$ standards set at 15 $\mu g/m^3$, annual mean, and 50 $\mu g/m^3$, 24-hour average, to provide increased protection against a wide range of fine particle PM-related health effects as described in Chapter 2. The proposed annual $PM_{2.5}$ standard was based on the 3-year average of the annual arithmetic mean $PM_{2.5}$ concentrations, spatially averaged across an area. The proposed 24-hour $PM_{2.5}$ standard was based on the 3-year average of the 98th percentile of 24-hour $PM_{2.5}$ concentrations at each monitor within an area. After reviewing comments on these proposed standards, EPA has selected final standards of 15 $\mu g/m^3$, annual mean, and 65 $\mu g/m^3$, 24-hour average. The proposed 24-hour $PM_{2.5}$ standard is based on the 3-year average of the 98th percentile of 24-hour $PM_{2.5}$ concentrations at each monitor within an area.

The EPA proposed to revise the current secondary PM standards by making them identical to the suite of proposed primary standards. These standards, in conjunction with the establishment of a regional haze program under section 169A of the Act, would provide appropriate protection against PM-related public welfare effects including soiling, material

damage, and visibility impairment.

This RIA evaluates three sets of alternative $PM_{2.5}$ standards as shown in Table 3.1. Figure 3.1 is a schematic of the process for evaluating these standards. The term "2010 Baseline" in Figure 3.1 and the other figures that follow refers to estimated air quality in the year 2010 if current Clean Air Act (CAA) requirements are implemented. This is used as a starting point for all of the analyses in this RIA. This is discussed in more detail in Chapter 4. The first of these are standards of 15 $\mu g/m^3$ spatially-averaged annual arithmetic mean and 50 $\mu g/m^3$ 24-hr, average of the 98th percentile concentration over a 3-year period ($PM_{2.5}$ 15/50). These standards were chosen because they are the levels of the proposed new standards as discussed above. The second set of standards are 15 $\mu g/m^3$ spatially-averaged annual arithmetic mean and 65 $\mu g/m^3$ 24-hr ($PM_{2.5}$ 15/65). These were chosen because they are the selected standards. The third set of standards are 16 $\mu g/m^3$ spatially-averaged annual arithmetic mean and 65 $\mu g/m^3$ 24-hr ($PM_{2.5}$ 16/65). These standards were chosen because they bound the selected standards. All of these standards are within the range recommended by CASAC. A sensitivity analysis also was performed to compare the 98th and 99th percentile forms for the $PM_{2.5}$ 15/50 standards.

Figure 3.1 Schematic of PM Alternatives

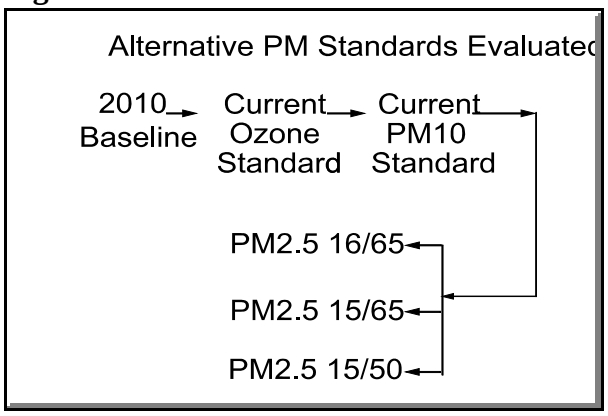

Table 3.1 PM Alternatives Assessed

PM Alternatives	Cost	Benefit	Economic Impact
$PM_{2.5}$ Standard 15$\mu g/m^3$, 24-hour/50$\mu g/m^3$, annual ($PM_{2.5}$ 15/50)	✔	✔	
$PM_{2.5}$ Standard 15$\mu g/m^3$, 24-hour/65$\mu g/m^3$, annual ($PM_{2.5}$ 15/65)	✔	✔	✔
$PM_{2.5}$ Standard 16$\mu g/m^3$, 24-hour/65$\mu g/m^3$, annual ($PM_{2.5}$ 16/65)	✔	✔	

3.2.3 Regional Haze Rulemaking Scenarios

The proposed presumptive standard for visibility improvement is a 1 deciview improvement every 10 years. As shown in table 3.2, costs, benefits and economic impacts are evaluated after application of the selected $PM_{2.5}$ standards of 15/65. In addition, a standard of 1 deciview improvement over every 15 years (or .67 deciview over 10 years) is evaluated. Figure 3.2 is a schematic of the process for evaluating these scenarios. The regional haze scenarios are evaluated after application of the PM standards because implementation of the PM standards should provide significant progress toward meeting regional haze requirements.

Figure 3.2 Schematic of Regional Haze Scenarios

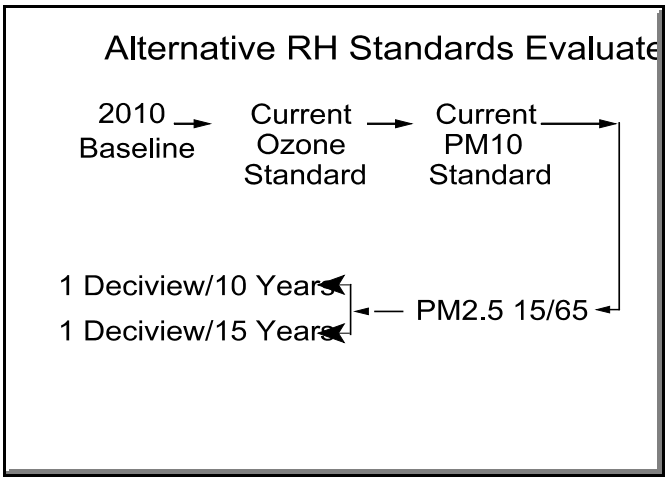

Table 3.2 Regional Haze Alternatives Assessed

Regional Haze Alternatives	Cost	Benefit	Economic Impact
1 deciview improvement per 10 years (after $PM_{2.5}$ 15/65)	✔	✔	
1 deciview improvement per 15 years (after $PM_{2.5}$ 15/65)	✔	✔	

3.2.4 Current Ozone Standard

The current ozone standard is 0.12 parts per million (ppm), 1-hour, 1 expected exceedance averaged over 3 years. This standard is abbreviated as 0.12, 1Ex.

3.2.5 Alternative New Ozone Standards

On November 27, 1996, EPA proposed to change the current primary ozone standard in the following respects: 1) attainment of the standard would no longer be based upon 1-hour averages, but instead on 8-hour averages; 2) the level of the standard would be lowered from the present 0.12 parts per million (ppm) to 0.08 ppm; and 3) the proposed NAAQS would be met in an area if the 3rd maximum daily maximum ozone concentration, averaged over 3 years, is less than or equal to .08 ppm. After reviewing comments, EPA selected a standard of 0.08 ppm, 4th maximum 8-hour daily maximum.

The EPA also proposed to replace the current secondary standard with one of two alternative standards: one set identical to the proposed new primary standard or, alternatively, a new seasonal standard expressed as a sum of hourly ozone concentrations greater than or equal to 0.06 ppm, cumulated over 12 hours per day during the consecutive 3-month period of maximum concentrations during the ozone monitoring season, set at a level of 25 ppm/hour. Either of the proposed alternative secondary standards would provide increased protection against ozone-induced effects, such as agricultural crop loss, damage to forests and ecosystems, and visible foliar injury to sensitive species. The EPA has chosen to set the secondary standard identical to the primary standard. Therefore, no separate analysis of the secondary standard is included in this RIA.

This RIA evaluates three alternative primary ozone standards as shown in Table 3.3. The selected standard of 0.08 ppm, 4th maximum 8-hour daily maximum (0.08 4th max) is assessed. In addition, a standard of 0.08 ppm, 3rd maximum 8-hour daily maximum (0.08 3rd max) and a standard of 0.08 ppm, 5th maximum 8-hour daily maximum (0.08 5th max) are analyzed. These latter two standards are chosen for analysis and presentation to bound the selected standard. Figure 3.3 is a schematic of the process of evaluating these standards.

Figure 3.3 Schematic of Ozone Alternatives

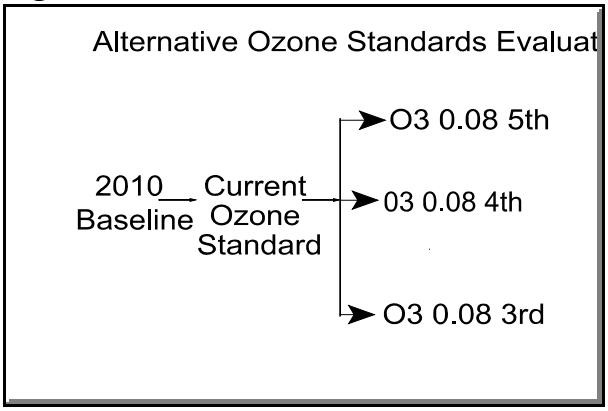

Table 3.3 Ozone Alternatives Evaluated

Ozone Alternatives	Cost	Benefit	Economic Impact
Alternative 0.08 ppm, 3rd Maximum 8-hour Daily Maximum (0.08 3rd max)	✔	✔	✔
Alternative 0.08 ppm, 4th Maximum 8-hour Daily Maximum (0.08 4th max)	✔	✔	✔
Alternative 0.08 ppm, 5th Maximum 8-hour Daily Maximum (0.08 5th max)	✔	✔	

Although Executive Order 12866 requires that all alternatives be examined, only the most likely ones need to be analyzed in detail. Because the CAA requires EPA to promulgate national standards, there are few likely alternatives to be considered. One alternative to changing the PM and ozone standards is to maintain the *status quo*. This is the "no regulation" alternative. For both PM and ozone, recent new scientific evidence examined in the Criteria Documents and Staff Papers indicates that the current standards do not provide an adequate level of protection as required by the CAA. Therefore, given the requirements of the CAA for the Agency to provide an adequate level of public health protection, a "no regulation" alternative is not considered a reasonable option.

Given the statutory requirements, other alternatives are not specifically evaluated. However, to the extent possible, these alternatives are factored into the analysis and may provide important tools for flexible implementation of the standards. For example, other regulatory approaches such as performance- and technology-based standards and regional controls are considered. Performance- and technology-based standards serve as useful adjuncts to ambient standards. However, they cannot serve as substitutes for ambient standards since even perfect compliance with them may not produce acceptable air quality levels. Performance- and technology-based standards are required by the present law in a variety of forms (e.g., new source performance standards for new and modified sources, lowest achievable emission rate,

and reasonably available control technology in non-attainment areas, etc.). They are not based solely on health and welfare criteria but are designed, in part, to augment control strategies for attainment of the NAAQS. These standards generally specify allowable emission rates for specific source categories. Emission reductions from such standards were considered in the baseline for this analysis as appropriate. In addition, the analysis incorporates in the baseline certain regional control strategies that serve to reduce the amount of transported pollutants. This, in turn, reduces the burden on downwind areas and may result in a more cost-effective approach to attaining standards.

This analysis also considers market based approaches to the extent they are currently in place (e.g., acid rain) as well as through modeling of an emissions cap and trade program for utilities. Additional opportunities for PM and ozone management through the application of market based mechanisms for further nitrogen oxides and sulfur dioxide reductions may be identified and evaluated during the development of implementation plans for the new and revised standards.

3.3 REFERENCES

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4.0 BASELINE EMISSIONS AND AIR QUALITY

4.1 RESULTS IN BRIEF

Baseline 2010 emissions are projected from 1990 by application of sector-specific growth factors and Clean Air Act (CAA)-mandated controls to 1990 base year emissions. Total 2010 emissions of VOC, NOx, SO_2 and secondary organic aerosols are estimated to decrease from 1990 levels; however, emissions of primary PM_{10} and $PM_{2.5}$ are estimated to increase.

Baseline particulate matter (PM) air quality concentrations in 2010 are estimated using the Phase II Climatological Regional Dispersion Model (CRDM). Initial nonattainment counties (i.e., prior to application of controls) for each PM_{10} and $PM_{2.5}$ standard alternative are estimated based on these modeled air quality predictions for counties with PM monitors during 1993 - 1995. At the national level, 45 counties are estimated to be in initial nonattainment of the current PM_{10} standard (50/150- 1 expected exceedance). Before applying the National PM Strategy, 102 counties are estimated to initially violate the selected $PM_{2.5}$ standard (15/65- 98th percentile) incremental to the current PM_{10} standard. These projections are for purposes of estimating costs and benefits; specific nonattainment designations will be based on monitoring data collected in the future for each area. As discussed in Chapter 6, the National PM Strategy brings 35 counties into attainment of the selected $PM_{2.5}$ standard, leaving 67 counties requiring additional control for attainment. At the national level, 11 counties are estimated to be in initial nonattainment of the selected PM_{10} standard (50/150- 99th percentile).

Baseline ozone air quality concentrations in 2010 are estimated using a Regional Oxidant Model (ROM) extrapolation methodology. Initial nonattainment areas for alternative ozone standards are identified based on these modeled values for counties with ozone monitors in 1990. At the national level, nine areas are predicted to be in initial nonattainment of the current one-hour ozone standard; an additional 10 areas (19 total areas) are predicted to violate the 0.08 ppm/8-hr/4th max ozone alternative. These projections are for purposes of estimating costs and benefits; specific nonattainment designations will be based on monitoring data collected in the

future for each area.

4.2 INTRODUCTION

This chapter describes the methods used to estimate baseline emissions and air quality in 2010 in order to assess the costs, benefits and economic impacts of alternative ozone and PM standards and regional haze goals. The assessments are conducted from a consistent analytical baseline. A single emissions inventory employing consistent methods is used as the basis for the ozone, PM and RH analyses. The year 2010 is selected as the year of analysis to provide an appropriate period in which 1) major programs of the CAA of 1990 will be reaching full implementation; 2) current standards are to be achieved; and 3) new standards are being implemented.

The PM and ozone analyses have been constructed such that benefits and costs are estimated incremental to those derived from the combined effects of implementing both the CAA of 1990 and the current ozone and PM standards as of the year 2010. These analyses provide a "snapshot" of air quality impacts, costs, and benefits associated with implementation of the new ozone and PM standards from a baseline of future CAA implementation and attainment of current standards. RH visibility goals are evaluated incremental to implementation of the new ozone and PM standards.

For the purpose of identifying the nonattainment areas associated with alternative NAAQS, this RIA excludes areas that did not have monitors during 1990 - 1995. Once nonattainment areas have been identified within the set of monitored areas, the analysis assumes control strategies on a local, regional, and national basis for the purpose of bringing identified nonattainment areas into attainment. Therefore, while the nonattainment areas are identified from within monitored areas only, control requirements, costs, benefits, and other economic impacts are estimated for both monitored and unmonitored areas.

EPA believes that the monitored counties analytic approach for identifying nonattainment

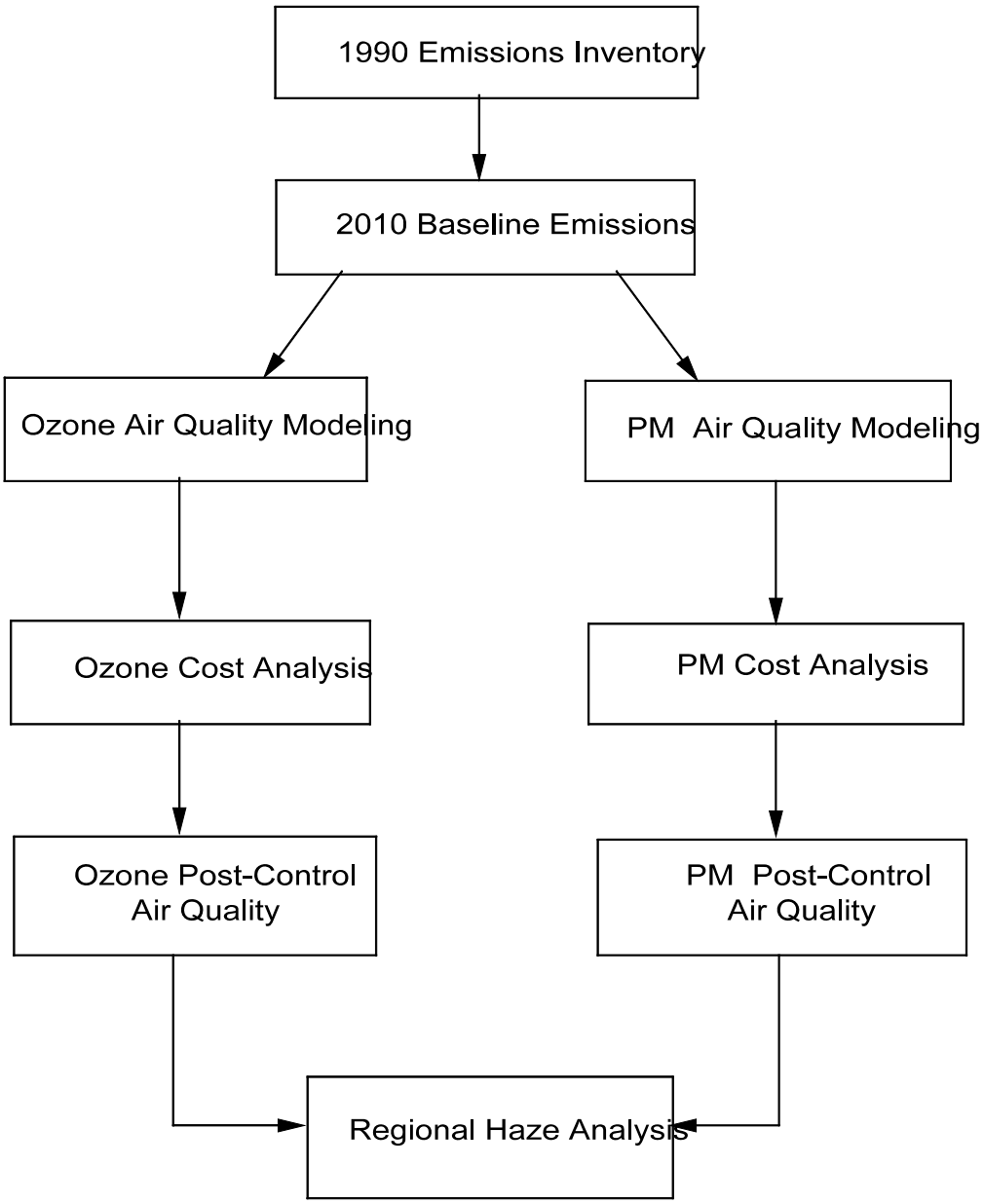
areas is most appropriate because 1) the likelihood of significant nonattainment in unmonitored areas after RIA controls are imposed is small; 2) serious modeling difficulties exist that prevent reliable prediction of nonattainment in unmonitored areas; and 3) any such nonattainment in unmonitored areas may not be detected (U.S. EPA, 1997c). It is possible, however, that even after all controls are imposed, nonattainment areas may exist that are not identified in the RIA, but may be identified in the future by the placement of new monitors.

Figure 4.1 illustrates the analytical approach employed for this assessment. Base year emissions for 1990 are projected to 2010 by applying sector-specific growth factors. CAA-mandated controls (i.e., control efficiencies or control-specific emission factors) then are applied to these future emissions to capture implementation of the CAA. The 2010 post-CAA control emissions are input to air quality models to predict baseline PM and ozone air quality from which PM and ozone nonattainment areas subsequently are identified. Control measures to bring these areas into attainment of alternative PM and ozone standards are evaluated and applied in the cost analyses. Emission reductions achieved by these control measures determine the "post-control" PM and ozone air quality in these areas. Given that regional haze goals are to be evaluated by areas after implementation of proposed PM and ozone standards, the post-control PM and ozone air quality serve as the baseline from which regional haze goals are analyzed. The methodologies used to estimate visibility for assessing the RH targets are discussed in Chapter 8.

4.3 ESTIMATION OF 1990 EMISSIONS AND 2010 EMISSIONS PROJECTIONS

The initial step in the assessment of alternative ozone and PM standards and RH goals is the development of the 2010 CAA emission estimates. These emissions serve as the baseline for

Figure 4.1 Overview of Emissions and Air Quality Analytical Approach



evaluation of alternative control measures for reducing ozone and PM precursor emissions for attainment of ozone and PM standards. The emissions estimation and projection methodologies build upon work conducted for the December 1996 ozone and PM Regulatory Impact Analyses (RIAs) (U.S. EPA, 1996f, 1996g). Major updates and refinements to the December 1996 emissions estimation methodologies are listed below.

- Version 3 of the 1990 National Particulates Inventory (NPI v.3)(Pechan, 1996c) is used as the base year emissions inventory (Version 2 was used in the December 1996 assessments (Pechan, 1995));

- Bureau of Economic Analysis (BEA) projections of Gross State Product (GSP) (BEA, 1995) are used to estimate 2010 emissions (BEA earnings data were employed in the December 1996 assessments (BEA, 1990));

- Utility sector CAA-control emission projections incorporate future utility deregulation and a 0.15 lb/MMBtu nitrogen oxides (NOx) cap with trading and banking;

- The following CAA-mandated control assumptions are updated in the 2010 baseline emissions:

    - Control measure effectiveness for volatile organic compounds (VOC) and NOx control measures is increased from 80% to 95%;

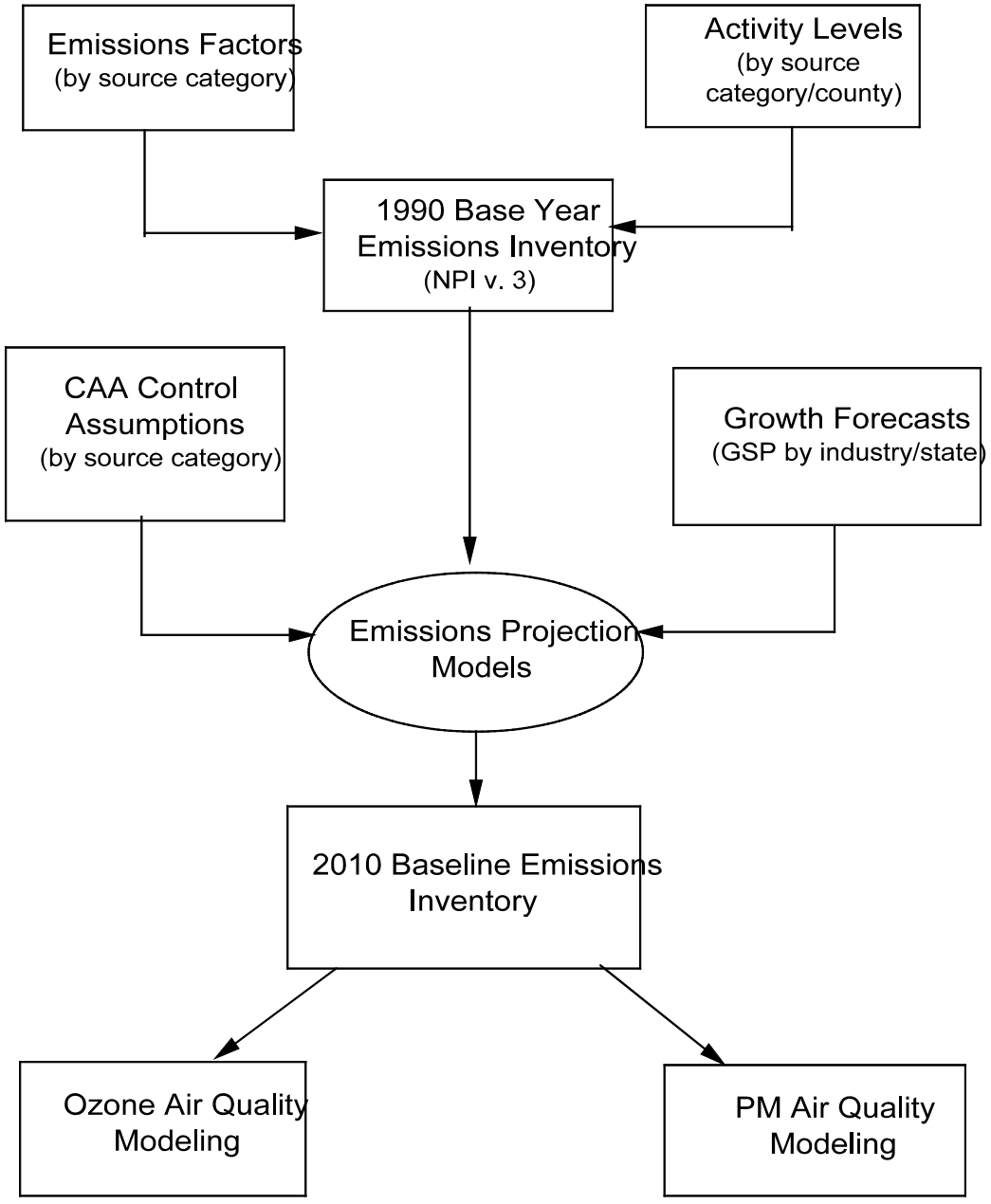
    - OTAG Level 2 NOx controls on industrial point sources in 37 OTAG states are applied;

    - Estimated emission reductions from 7/10 year Maximum Achievable Control Technology (MACT) standards are included;

    - Proposed control requirements for Architectural and Industrial Maintenance (AIM) coatings and consumer and commercial products rules are incorporated.

Figure 4.2 illustrates the steps followed in the development of 2010 baseline emissions. First, source category-specific activity levels and emissions factors are used to estimate emissions for the base year 1990. Any pollution controls in place prior to 1990 are reflected in these base

Figure 4.2 Development of 2010 Baseline Emissions



year values. Emissions are estimated for VOC, NOx, sulfur dioxide (SO_2), primary PM_{10} and $PM_{2.5}$, secondary organic aerosols (SOA) and ammonia. As described in the introduction, certain VOC species, based on the reactivity of these organic compounds with atmospheric oxidants, form SOA (Grosjean and Seinfeld, 1989). To estimate SOA emissions, fractional aerosol coefficients (FACs) based on VOC species profiles for each Source Classification Code (SCC) are applied to 1990 VOC emissions (Pechan, 1997a).

Biogenic VOC emissions are involved in ozone and SOA formation and are estimated for the base year inventory.

Additionally, ammonia plays a role in the formation of particulate ammonium sulfate and ammonium nitrate. However, anthropogenic emissions of ammonia are a small component of total ammonia emissions. The majority of the ammonia that enters the atmosphere is produced by the biological decomposition of organic material in soils, plant residues, and wastes from animals and humans (NAPAP, 1991). Given that ammonia is not a limiting factor in the formation of secondary particles, ammonia emissions are not considered in the PM NAAQS control strategy analysis.

Because air quality modeling is conducted on the county level, emissions are estimated for all counties in the contiguous 48 states. The 1990 emissions are then input to an emissions projection model (e.g., Emission Reduction and Cost Analysis Model (ERCAM) for VOC and NOx) that predicts emissions in 2010 based on state-level growth forecasts and control assumptions reflective of implementation of CAA-mandated programs. The resultant 2010 emissions then serve as inputs to the ozone and PM air quality modeling.

4.3.1 Development of 1990 Base Year Emissions Inventory

The 1990 base year emissions inventory is based on Version 3 of the NPI (Pechan, 1996c; Pechan, 1997a). This is a more recent version of the NPI than was used in the December 1996 RIAs (i.e., NPI version 2 (Pechan, 1995)). The major difference in the inventories is in the

fugitive dust PM emissions estimates: version 3 fugitive dust emissions estimates are lower than version 2.

The NPI is developed using a "top-down" approach to estimate national emissions at the county level. Top-down methods rely on existing data sources and use estimation techniques that are comprehensive but with less area-specific detail. In general, emissions factors for individual source types are applied to activity levels for source categories within the major emitting sectors (i.e., utility, industrial point, area, nonroad engines/vehicles, mobile sources and biogenics/natural sources). Emissions factors are expressed in terms of amount of a pollutant emitted for a given activity level (e.g., per ton of fuel consumed, per vehicle mile travelled). EPA emission factors are available for VOC, NOx, SO_2, and PM_{10}. Because there are no emission factors for $PM_{2.5}$, a PM calculator program containing particle size distribution data for various source categories is used to develop these estimates (Pechan, 1994). The program estimates the fraction of PM emissions from both controlled and uncontrolled sources that are within the fine particle fraction (i.e., < 2.5 microns in diameter) and coarse particle fraction (i.e., between 2.5 and 10 microns in diameter). Finally, anthropogenic ammonia emission factors are a compilation of estimates based primarily on recent European studies (Asman, 1992; Battye et al., 1994).

For the states of California and Oregon and for prescribed burning and wildfire emissions in the 11 western states, emissions estimates based on a bottom-up assessment conducted by the Grand Canyon Visibility Transport Commission (GCVTC) are used (Radian, 1995). These emission estimates are derived from more recent and detailed surveys of emissions from various source categories.

Biogenic VOC emissions are developed based on EPA's Biogenic Emissions Inventory System (BEIS) (Pierce et al., 1990). Biogenic SOA is estimated from application of VOC species-specific FACs to biogenic VOC emissions (Pechan, 1997a). Natural sources of PM emissions (i.e., wind erosion) are taken from the National Emission Trends Inventory (U.S. EPA, 1996h).

Table 4.1 summarizes the approaches used in development of the base year inventory. Appendix A.1 describes in more detail the emissions estimation methodologies used for each major emitting sector.

4.3.2 1990 Emissions Inventory Results and Discussion

Table 4.2 presents a summary of 1990 emissions by pollutant and major sector. Appendix A.2 presents 1990 emissions by source category and major sector. Area sources are the largest contributor to anthropogenic VOC emissions in 1990 (45% of total national anthropogenic VOC emissions). Biogenic and natural sources of VOC emissions are estimated to be roughly equivalent in magnitude to the anthropogenic total. Motor vehicles account for 33% of total national NO_x emissions with 46% of the motor vehicle emissions contributed by cars (i.e., light-duty gasoline vehicles). With regard to national SO_2 emissions, the utility sector is the largest emitter (71%). Area sources account for the bulk of PM_{10} and $PM_{2.5}$ emissions. Anthropogenic fugitive dust sources contribute the majority of primary PM_{10} and $PM_{2.5}$ emissions. More recent emission inventory efforts indicate that these estimates are overestimated. Refer to Section 4.3.3 for a discussion of the potential biases in these estimates.

Although biogenic and anthropogenic VOC are approximately equivalent, biogenic SOA is almost 17 times greater than anthropogenic SOA. This difference is due to the FACs used to estimate SOA. The FAC for terpenes, which account for 15 - 60% of biogenic VOCs, is 30%, while the average FAC for anthropogenic VOC sources is less than 1%.

Anthropogenic ammonia emissions are estimated to be approximately 4 million tons per year in 1990, but are believed to be a small component relative to natural sources of ammonia. Given that ammonia is not a limiting factor in the formation of secondary particles, ammonia

Table 4.1 Base Year Emission Inventory - Summary of Approach

Major Source Type	Modeling Approach/Data Sources
Industrial Point Sources	1985 National Acid Precipitation Assessment Program (U.S. EPA, 1989) emissions inventory grown to 1990 based on historical BEA earnings data (BEA, 1990). PM_{10} and $PM_{2.5}$ emissions based on total suspended particulate (TSP) emissions and particle-size multipliers (U.S. EPA, 1994b). California and Oregon State data substituted (Radian, 1995).
Electric Utilities	Based on EIA-767 fuel use for 1990 and unit-specific emission limits (DOE, 1991b) and AP-42 emission rates (U.S. EPA, 1995a)
Nonroad	Internal Combustion Engines/Vehicles (VOC, NO_x, $PM_{2.5}$, PM_{10}): 1991 Office of Mobile Sources (OMS) Nonroad Inventory (U.S. EPA, 1991b) Internal Combustion Engines/Vehicles (SO_2) and Aircraft, Commercial Marine Vessels, Railroads: 1985 NAPAP (U.S. EPA, 1989) grown to 1990 based on historical BEA earnings data (BEA, 1990).
Motor Vehicles	Federal Highway Administration travel data (FHWA, 1992), MOBILE5a/PART5 emission factors (U.S. EPA, 1993a).
Area Sources	1985 NAPAP inventory grown to 1990 based on historical BEA earnings data (BEA, 1990) and State Energy Data System (SEDS) fuel use data (DOE, 1991a); emission factor changes for selected categories (U.S. EPA, 1995a). California and Oregon State data substituted (Radian, 1995).
Solvents	National solvent usage estimates by end-use category from U.S. Paint Industry Data Base and industrial solvent marketing reports (Connolly et al., 1990). Allocated to county level based on industry employment and population (BOC, 1987, 1988a, 1988b).
Fugitive Dust (PM_{10}, $PM_{2.5}$)	
Agricultural Tilling	U.S. Department of Agriculture data (USDA,1991), U.S.EPA PM_{10} emission factors (U.S. EPA ,1995a).
Construction	Census Bureau Construction Expenditures (BOC, 1992), EPA PM_{10} emission factors (U.S. EPA, 1995a).
Unpaved and Paved Roads	EPA PART5 emission factors (U.S. EPA, 1994c), FHWA travel data (FWHA, 1992).
Livestock	USDA farming activity levels (USDA, 1991), EPA PM_{10} emission factors (U.S. EPA, 1995a).
	Particle size multipliers are applied to PM_{10} emissions to estimate $PM_{2.5}$ emissions (U.S. EPA, 1994b).
Biogenic VOC	Emissions for eight landcover types based on a forest canopy model which was used to account for the effects of solar radiation, temperature, humidity, and wind speed on predicted VOC emission rates (Lamb et al., 1993).
Wind Erosion	PM wind erosion emissions from agricultural lands based on acres of spring- or fall-planted crops in each State from the USDA and the expected dust flux (emission rate) based on a simplified version of the NAPAP method (Gillette, 1991). Emissions were distributed to the county level based on rural land area.
Agricultural Ammonia (NH_3)	NH_3 emissions for livestock feedlots and fertilizers based on Census of Agriculture data (BOC, 1992)and EPA-recommended emission factors (Battye et al., 1994).

emissions are not considered for control in the PM control strategy-cost analysis.

It should be noted that the ambient air quality impacts of emissions from any individual sector may not be proportional to their contribution to national emissions. The reader is referred to the PM and ozone air quality modeling sections (Chapter 4) and the PM and ozone cost chapters (Chapters 5 and 6) to understand how emissions from various source categories impact PM and ozone air quality.

4.3.3 Key Uncertainties Associated with 1990 Base Year Emissions

Given the on-going nature of emissions research, improvements to emissions estimation methodologies will continue to be made. However, there will be uncertainties associated with top-down approaches that rely on existing data sources and less source-specific data.

Because development of 1990 emissions employs emissions factors as primary inputs, more uncertain emission estimates result than if source-specific stack tests, load-curve based factors or continuous emissions monitoring (CEM) data are used. The differences in utility SO_2 and NOx emissions between alternative estimation methodologies, however, are not that large. Recent comparisons of SO_2 CEM data with estimates based on SO_2 emission factors and fuel consumption for a sample of plants showed that the two techniques produced emission estimates within an average of 8 percent at the State level (Schott, 1996). A comparison of NOx emissions based on CEM data and NOx emissions based on EPA emission factors for a sample of utilities in Louisiana resulted in a difference of 22 percent between the two methods (Schott, 1996). However, for area, non-road and motor vehicle sources where source-specific data is mostly unavailable, emission factors are applied to activity levels for each county. Thus, the potential uncertainties are greater for these sources than the better inventoried utility and industrial point sources (Pechan, 1996a). Finally, any possible biases in national emissions estimates from using emissions factors is unclear.

Table 4.2 Summary of National 1990 Base Year Emissions Estimates by Major Sector

Major Sector	VOC (1000 tpy)	NOx (1000 tpy)	SO_2 (1000 tpy)	PM_{10} (1000 tpy)	$PM_{2.5}$ (1000 tpy)	SOA (1000 tpy)
Utility	37	7,426	15,865	283	109	1
Industrial Point	3,467	2,850	4,644	926	589	35
Area	10,098	2,100	1042	35,290	7,639	92
Nonroad	2,054	2,836	242	336	293	23
Motor Vehicle	6,811	7,446	568	355	291	48
Anthropogenic Subtotal	**22,466**	**22,656**	**22,359**	**37,190**	**8,921**	**198**
Biogenics	25,988					3,325
Natural Sources	248	89	1	5,429	995	
TOTAL	**48,702**	**22,745**	**22,360**	**42,619**	**9,916**	**3,525**

Note: Emissions estimates may not sum due to rounding.

1990 fugitive dust emissions have not been adjusted here as described in Section 4.4.2.3.

Air quality impacts from major emitting sectors are not necessarily proportional to their contribution to national emissions estimates. See PM and Ozone Air Quality Modeling Sections 4.4 and 4.5 and Chapters 6 and 7.

Use of particle size multipliers to estimate PM_{10} and $PM_{2.5}$ emissions from TSP data yields uncertain results relative to application of PM_{10} or $PM_{2.5}$ emission factors. The degree of uncertainty may vary by source category; however, there is no known bias in these factors.

The more recent biogenic emissions estimates from BEIS2 (Geron et al., 1994) are not incorporated in version 3 of the NPI. VOC emissions estimated using BEIS2 are 28 percent higher than biogenics included in the base year emissions. These higher VOC estimates also lead to higher biogenic SOA. However, given that BEIS2 emission estimates have better spatial resolution, higher or lower biogenic VOC emissions for specific counties may result relative to the NPI estimates. Thus at the national level, biogenic VOC and SOA may be underestimated, but in any individual county the bias is unclear (Pechan, 1997a).

The most recent fugitive dust emissions estimates developed for the National Emissions Trends Inventory (U.S. EPA, 1997h) indicate that NPI version 3 PM_{10} fugitive dust emissions may be overestimated by 40% and $PM_{2.5}$ fugitive dust emissions may be overestimated by 72% relative to the Trends estimates. The Trends fugitive dust information was available after PM air quality modeling had been completed and therefore could not be incorporated into this analysis. See Section 4.4.2.3 for a discussion of the implications of this overestimate of fugitive dust emissions on modeled PM air quality. Of particular interest is that the $PM_{2.5}$ emission estimate for agricultural operations (tilling and windblown dust) was decreased by about 50%, or 1 million tons per year. The emissions decrease from farming operations is clearly concentrated in the farm belt of the central US. Thus, the PM air quality analysis is likely biased toward overestimating fugitive dust impacts in farming areas, relative to other areas. While some other categories of fugitive dust emissions were also decreased, the net effect of those changes on the PM air quality analysis is unclear.

Fractional aerosol coefficients are used to estimate the percentage of VOCs that may react in the atmosphere and form secondary organic aerosols. There is considerable uncertainty associated with this estimation approach. This assessment assumes that 100% of all photochemically-reactive VOC species released eventually react to form SOA. This assumption

may lead to overstated modeled SOA concentrations in areas close to the emission sources of organic species having long reaction times (Pechan, 1997a).

For the nonroad emissions category, the extrapolation of the nonroad inventory for 27 nonattainment areas to the rest of the country introduces uncertainty to the nonroad emissions estimates, however, with no known bias.

Because the 1985 NAPAP inventory serves as the basis for the 1990 base year inventory for some source categories, a number of factors are not accounted for. New plant construction, control equipment installation and retirement of emissions sources between 1985 and 1990 are not incorporated in the 1990 inventory. The magnitude of the uncertainty and direction of potential bias in national 1990 emission estimates as a result of these factors is unclear. Additionally, state-level industry earnings data is used to grow emissions from 1985 to 1990 rather than applying the more recent BEA GSP estimates. This may result in a small underestimate of 1990 emissions (Pechan, 1997a).

Considering relative uncertainty across emissions of individual pollutants, SO_2 emission estimates are the most certain. SO_2 is generated during combustion of any sulfur-containing fuel and is emitted by industrial processes that consume sulfur-containing raw materials. Apart from control efforts, sulfur emissions are directly related to the fuel sulfur content. As long as fuel usage and fuel sulfur content are measured, SO_2 emissions can be estimated within a relatively narrow range. For example, as part of the GCVTC emission inventory, uncertainty estimates were developed for various major SO_2 sources (Balentine and Dickson, 1995). The uncertainty estimate calculated for SO_2 emissions from copper smelting is $\pm$ 50 percent. However, associated uncertainty for emissions estimates from diesel and gasoline vehicles are assessed at $\pm$ 150 percent. Most of this uncertainty is due to the variability in the sulfur content of the fuels.

The NOx estimates are the next most certain category of emissions. Like SO_2, NOx is a product of fuel combustion. Since NOx formation is somewhat more complicated than SO_2,

emission estimates are more variable, and uncertain, as well.

The level of uncertainty in PM_{10} emission estimates varies widely by source category. The largest component of the 1990 PM_{10} emission estimates is fugitive dust including fugitive emissions from paved and unpaved roads, construction activities, agricultural tilling, and windblown dust. The GCVTC study estimated the uncertainty for unpaved road emissions to be $\pm$ 400 percent. The estimated uncertainty for $PM_{2.5}$ emissions from paved road dust is $\pm$ 180 percent (Ballentine and Dickson, 1995). PM_{10} emission estimates for large point sources such as utility boilers are likely more certain than the fugitive dust source estimates, because these stacks are typically controlled using baghouses or electrostatic precipitators, the outlets of which are frequently tested to ensure compliance with regulations.

VOC emissions are uncertain because organics are emitted both as a product of fuel combustion and through evaporation. Evaporative emissions are difficult to quantify due to measurement problems. The GCVTC study estimated VOC emissions uncertainty for motor vehicles to be $\pm$ 150 percent (Ballentine and Dickson, 1995).

Table 4.3 summarizes the key uncertainties associated with estimation of 1990 emissions (Pechan, 1997a). For each potential source of uncertainty in the base year emissions, the direction of bias is provided. "Positive bias" indicates that 1990 emissions may be overestimated; "negative bias" indicates that they may be underestimated; and "bias unclear" indicates that the direction of potential bias in the emission estimates is unknown.

Table 4.3 Uncertainties and Possible Biases in Estimating 1990 Emissions

Potential Source of Uncertainty	Positive Bias? (Overestimate)	Negative Bias? (Underestimate)	Bias Unclear
Use of emission factors rather than stack test, load-curve, or CEM data			✓
Use of particle-size multipliers to estimate PM_{10} and $PM_{2.5}$ emissions from TSP emissions			✓
Extrapolation of nonroad inventory from 27 nonattainment areas to nation			✓
Use BEIS rather than more recent BEIS2 for biogenic VOC		✓ (total biogenic VOC and SOA)	✓ (county-level biogenic VOC and SOA)
Use NPI version 3 for fugitive dust emissions rather than more recent data from National Emissions Trends	✓		
Use FACs to estimate SOA from VOC emissions	✓		
Use of 1985 NAPAP inventory for some source categories: - lack data to incorporate for 1985- 1990 new plant construction, control equipment installation, retirement of sources. - used state-level earnings data rather than recent BEA GSP to grow emissions from 1985 to 1990.		✓ (small)	✓

4.3.4 Development of 2010 Emission Projections

The base year emissions are projected to 2010 to develop the emissions baseline from which to evaluate additional control measures needed to meet alternative ozone and PM standards and RH goals. In general, emissions are projected by applying expected increases in 1990 emissions or activity levels and incorporating the effects of 2010 CAA-mandated controls

through application of control efficiencies or emission factors, respectively.

4.3.5 Growth Assumptions by Major Sector

This section describes the sector-specific growth assumptions used to project emissions to 2010. Table 4.4 summarizes the emissions projection modeling approach by major sector. Version 3 of the NPI employs 1995 BEA Gross State Product (GSP) 2010 projections by State/Industry for industrial point sources and, in combination with BEA population projections, for nonroad and area source categories. In the absence of product output projections, value added projections such as GSP are superior than earnings or employment projections for estimating future emissions (U.S. EPA, 1991a). Value added is the difference between the value of industry outputs and inputs. BEA GSP projections are a fuller measure of growth given that future changes in production processes, efficiency, and technological changes are captured.

For the utility sector, the Integrated Planning Model (IPM) is used to predict how the electric power industry will operate in the future given deregulation (i.e., movement from cost-of-service pricing to competitive pricing) and consequent industry restructuring (U.S. EPA, 1996j). Utility deregulation was not accounted for in the December 1996 RIAs. National Electric Reliability Council (NERC) forecasts of regional electricity demand are used to reflect the assumption that utility deregulation will likely lead to lower electricity prices for many users and therefore increased electricity demand. Additional major assumptions included in the utility modeling are the following: 1) technology will continue to improve for coal and natural gas

Table 4.4 2010 Growth Assumptions by Major Sector

Sector	Growth Forecast	Modeling Approach
Industrial Point	BEA Gross State Product (GSP) Projections by State/Industry (BEA, 1995)	VOC, NO_x – Emission Reduction and Cost Analysis Model (ERCAM): applies BEA growth projections to base year emissions and applies future year controls as selected by the user (Pechan, 1994, 1996b). PM_{10}, $PM_{2.5}$, SO_2, NH_3 – While no formal model exists, the same basic approach applied in ERCAM was used for these pollutants (Pechan, 1997a).
Utility	Projections of heat input by unit based on National Electric Reliability Council (NERC) data, price and demand forecasts, and technology assumptions.	SO_2, NO_x - Integrated Planning Model (IPM) (U.S. EPA, 1996i). VOC, PM_{10}, $PM_{2.5}$ – base year emission rates or AP-42 emission factors applied to IPM projected heat input by unit (Pechan, 1997a). NH_3 – NH_3 slippage for units controlling with selective catalytic reduction (SCR) (Pechan, 1997a).
Nonroad	BEA GSP and Population Projections by State/Industry (BEA, 1995)	VOC, NO_x – ERCAM (Pechan, 1994, 1996b). PM_{10}, $PM_{2.5}$, SO_2, NH_3 – ERCAM approach (no formal model)(Pechan, 1997a).
Motor Vehicle	National Vehicle Miles Traveled (VMT) Projections from the EPA OMS MOBILE Fuel Consumption Model (FCM) Scaled to Metropolitan/Rest-of-State Areas by Population (U.S. EPA, 1993)	NO_x, VOC – ERCAM: applies MOBILE5a emission factors to projected VMT by month and county/vehicle type/roadway classification (U.S. EPA, 1991c, 1993a). PM_{10}, $PM_{2.5}$, SO_2 – PART5 emission factors(U.S. EPA, 1994c) applied to projected VMT (U.S. EPA, 1991c). NH_3 – special study emission factors applied to projected VMT (Pechan, 1997a).
Area	BEA GSP and Population Projections by State/Industry (BEA, 1995)	VOC, NO_x – ERCAM (Pechan, 1994, 1996b). PM_{10}, $PM_{2.5}$, SO_2, NH_3 – ERCAM approach (no formal model)(Pechan, 1997a).
Biogenic VOC and PM Wind Erosion	Emissions held at 1990 levels	--

production so that energy prices for these fuels will not substantially increase between 1990 and 2010; 2) the large steam electric generation stock fueled by coal, oil, and gas will be the source of a large amount of power in the future; 3) improvement of the performance and reduction of the costs of electric generation technologies will continue; and 4) movement of power will be primarily constrained at the 16 NERC regions modeled in the analysis (U.S. EPA, 1997a).

Mobile source 1990 emissions are projected to 2010 based on growth in VMT. EPA's MOBILE4.1 Fuel Consumption Model (FCM) is used as the basis for the VMT projections (U.S. EPA, 1991c).

There is no growth assumed in biogenic emissions of VOC or SOA. Similarly, 2010 PM emissions from natural sources are assumed equal to 1990 levels.

4.3.6 2010 CAA Control Emissions by Major Sector

In order to capture the effects in 2010 of implementation of the CAA, future year control efficiencies or emission factors are applied to projected 2010 emissions or activity levels respectively. Table 4.5 summarizes the major CAA requirements that are modeled for the 2010 baseline. These control requirements are discussed in Appendix A.3 for each major sector.

For the 2010 CAA-control emissions, refined control measure effectiveness (CME) estimates are employed in combination with control efficiencies. CME reflects the degree to which individual control measures achieve their intended effect. An 80% CME was applied in the December 1996 RIAs for a subset of primarily VOC source category-control measure combinations. For this assessment, CME is assumed to be 95% for this subset. The refined CME estimate is based upon a recent study of historical EPA monitoring and enforcement data that indicate that, on average, control measures achieve 95 - 100 percent of the intended impact (PQA, 1997). The new CME is applied to the appropriate control measure efficiencies in place prior to

Table 4.5 CAA 2010 Projection Scenario Summary by Major Sector

Major Sector	Major CAA Scenario Requirements
Industrial Point	VOC and NO_x RACT for all NAAs (except NO_x waivers). New control technique guidelines (CTGs). 0.15 pounds per million British thermal unit (lb/MMBtu) Ozone Transport Assessment Group (OTAG)-wide NO_x cap on fuel combustors $\geq$ 250 MW. OTAG Level 2 NO_x controls across OTAG States. MACT standards (primarily VOC).
Utility	Title IV Phase I and Phase II limits for all boiler types. 250 ton Prevention of Significant Deterioration (PSD) and New Source Performance Standards (NSPS). RACT and New Source Review (NSR) for all non-waived (NO_x waiver) NAAs. Phase II of the Ozone Transport Commission (OTC) NO_x memorandum of understanding (MOU). 0.15 lb/MMBtu OTAG-wide seasonal NO_x cap utility boilers with banking/trading.
Nonroad	Federal Phase I and II compression ignition (CI) engine standards. Federal Phase I and II spark ignition (SI) engine standards. Federal locomotive standards. Federal commercial marine vessel standards. Federal recreational marine vessel standards.
Motor Vehicles	Tier 1 tailpipe standards. 49-State LEV program. Phase 2 Reid vapor pressure (RVP) limits. I/M programs for O_3 and carbon monoxide (CO) NAAs. Federal reformulated gasoline for O_3 NAAs. California LEV (California only). California reformulated gasoline (California only). Diesel fuel sulfur content limits. Oxygenated fuel in CO NAAs.
Area	VOC and NO_x RACT requirements. New CTGs (VOC). MACT Standards (VOC). PM NAA controls. Onboard vapor recovery (vehicle refueling). Stage II vapor recovery systems. Federal rules (consumer/commercial product limits, architectural and industrial maintenance (AIM) coating limits).

1990 and those controls assumed in the 2010 CAA-control emissions projections.

Rate of Progress (ROP) and Reasonable Further Progress (RFP) requirements are not modeled for the 2010 emissions baseline; instead, the emission reductions and costs are assessed for future attainment of the current ozone standard. Appendix C discusses the methodology and results of this analysis.

Additionally, updated information regarding proposed Title I AIM Coatings and Consumer and Commercial Products rules and Title III 7 and 10 year MACT rules are incorporated in the 2010 CAA-control emissions.

Ozone air quality modeling analyses show that NOx emissions must be substantially reduced in broad areas of the country in order for areas that are not meeting the current ozone standard to meet that standard (U.S. EPA, 1996b). Efforts to address long-range ozone transport issues have been undertaken by the Northeast Ozone Transport Commission (OTC, 1994) and the Ozone Transport Assessment Group (OTAG). These efforts will likely result in implementation of regional NOx control measures far in advance of the 2010 air quality assessment undertaken for this RIA. Because these control measures will be applied for the purpose of attaining the current standard, they are included in the analytical baseline of this RIA.

The 2010 baseline reflects the application of regional NOx reductions that are intended to approximate the reductions EPA would propose based upon OTAG recommendations. The regional NOx controls applied for this analysis include: 1) OTAG-wide 0.15 lb/MMBtu NOx emission limit on utilities and on non-utility boilers $\geq$ 250 MW; 2) OTAG Level 2 NOx controls on non-utility point sources across OTAG states; National Low Emission Vehicle (LEV) emissions standards on light duty vehicles in 49 states, beginning with the 1999 model year. The OTAG recommendation covers a broader universe of sources and provides for an emissions trading program. In addition, OTAG's recommendation does not include uniform control measures across the entire 37-State region. Of the States for which OTAG did not currently recommend controls, only Louisiana, Oklahoma and Texas have areas that are projected to be

nonattainment for one or more of the standards evaluated. Because regional controls were not recommended for these States, the RIA may underpredict costs and benefits for these areas.

The LEV program is included in the baseline based on negotiations with the automobile industry that were initiated several years ago in order to help meet the current standard. Although no agreement has yet been reached, additional reductions from mobile sources likely will be required, either nationally or on a State-by-State basis, in order to meet the current standard. Therefore, inclusion of these reductions in the baseline is appropriate. This analysis, however, does not prejudge the outcome of negotiations with the automobile industry.

4.3.7 2010 Baseline Emissions Results and Discussion

Table 4.6 summarizes national 2010 CAA emissions by major sector. Appendix A.4 presents 2010 emissions by source category and major sector. Total emissions of VOC, NOx, SO_2, and SOA are estimated to decrease from 1990 levels; however, emissions of PM_{10} and $PM_{2.5}$ are estimated to increase between 1990 and 2010. The increases in PM emissions are due primarily to growth in anthropogenic sources of fugitive dust (i.e., paved roads and construction activity).

Emission reductions in 2010 attributable to individual CAA programs are also estimated (U.S. EPA. 1997j). These emission reductions reflect the change in emissions between projected 2010 emissions (i.e., incorporating growth between 1990 and 2010) with and without the application of CAA-mandated controls. National VOC emission reductions estimated to be achieved in 2010 due to Titles I and III point source controls are 1.0 million tons of VOC per year. 2010 Title I and III area source controls are projected to achieve 5.7 million tons of VOC emission reductions per year.

National NOx emission reductions for Title I industrial point source controls are estimated to total 1.6 million tons per year: CAA-mandated controls and the NOx cap account for approximately 500,00 tons and 100,000 tons of NOx reductions respectively and OTAG-wide

Level 2 NOx controls contribute an additional 1 million tons per year of NOx reductions (U.S. EPA, 1997j). Title I area source NOx controls account for reductions of 1.4 million tons of NOx per year. Title I mandated controls, Title IV Acid Rain NOx requirements, and the OTAG-wide NOx cap result in an estimated 3 million tons of summertime NOx reductions from the utility sector (U.S. EPA, 1997a).

Title II mobile source VOC and NOx controls including a national LEV program are estimated to result in annual reductions of 2.8 million tons of VOC and 3.5 million tons of NOx nationally in 2010 (U.S. EPA, 1997j).

The Title IV Acid Rain Program accounts for an 8 million ton reduction in utility SO_2 emissions from 2010 no-control levels (U.S. EPA, 1997a).

4.3.8 Key Uncertainties Associated with 2010 Baseline Emissions

Table 4.8 summarizes the key uncertainties associated with the 2010 baseline emissions. Because 1990 emissions and activity levels are the basis from which 2010 emissions are projected, the uncertainties associated with 1990 emissions estimates are carried through to the 2010 baseline. These uncertainties are discussed in Section 4.3.4.

There are uncertainties associated with the activity surrogates and projections data used to make 2010 growth forecasts for each source sector. However, there are no known biases in either of these data inputs.

Table 4.6 Summary of National 2010 CAA Emissions Estimates by Major Sector

Major Sector	**VOC (1000 tpy)**	**NOx (1000 tpy)**	**SO_2 (1000 tpy)**	**PM_{10} (1000 tpy)**	**$PM_{2.5}$ (1000 tpy)**	**SOA** (1000 tpy)
Utility	**50**	**3,755**	**9,746**	**277**	**111**	0
Industrial Point	2,164	1,958	5,990	1,170	745	25
Area	7,533	2,932	1,518	41,051	8,931	73
Nonroad	1,888	2,063	236	336	292	24
Motor Vehicle	3,946	5,574	409	204	141	27
Anthropogenic Subtotal	**15,581**	**16,282**	**17,899**	**43,038**	**10,220**	**150**
Biogenics	25,988					3,325
Natural Sources	248	89	1	5,429	995	
TOTAL	**41,817**	**16,371**	**17,900**	**48,467**	**11,215**	**3,475**

Note: Emissions estimates may not sum due to rounding.
1990 fugitive dust emissions have not been adjusted.
Air quality impacts from major emitting sectors are not necessarily proportional to their contribution to national emissions estimates. See PM and Ozone Air Quality Modeling Sections 4.4 and 4.5 and Chapters 6 and 7.

The 2010 control assumptions used to incorporate the effects of CAA-mandated controls also have related uncertainties. Potential revisions to existing rules or rules that are currently in draft form but would be implemented in 2010 are not incorporated in the 2010 emissions baseline. It is unclear the net effect of these omissions on baseline emissions. Because RFP and ROP are not incorporated in the baseline, 2010 emissions could be underestimated. There may be an overestimate in baseline emissions given that the co-control emission reductions (e.g., PM, NOx) from MACT standards and off-set requirements in the OTR and ozone nonattainment areas have not been estimated. Finally, because the NPI is a top-down inventory, area-specific control measures as outlined in nonattainment State Implementation Plans (SIPs) have not been incorporated in the baseline emissions. The potential bias is unclear for this potential source of uncertainty.

Table 4.8 Uncertainties and Possible Biases in Estimating 2010 Emissions

Potential Source of Uncertainty	Positive Bias? (Overestimate)	Negative Bias? (Underestimate)	Bias Unclear
1990 Emissions	✓ (fugitive dust)	✓ (total biogenic VOC and SOA)	✓
Growth Forecasts: - activity surrogates - projections data			 ✓ ✓
2010 Control Assumptions: - Potential revisions to existing rules or rules in draft form not incorporated; - RFP/ROP for individual ozone nonattainment areas not estimated; - Co-control from MACT standards not estimated; - Off-set requirements in OTR and ozone nonattainment areas not estimated; - Area-specific reductions as reflected in SIPs not incorporated.	 ✓ ✓ 	 ✓ 	✓ ✓

4.4 ESTIMATION OF BASELINE PM AIR QUALITY CONCENTRATIONS IN 2010

The methodology for estimation of baseline PM air quality concentrations for this assessment builds upon the previous method used in the December 1996 PM NAAQS RIA. The CRDM is used to estimate ambient PM concentrations in 2010. This model predicts quantitative relationships (i.e., source-receptor relationships) between county-level emissions of primary particles and secondary particle precursors and annual concentrations of PM_{10} and $PM_{2.5}$ at county-level receptors. The following updates to data inputs, methodological refinements, and sensitivity analyses are implemented for this assessment:

- Updated Phase II CRDM air quality modeling results are employed;
- The source-receptor matrix is calibrated using 1993 -1995 Aerometric Information Retrieval System (AIRS) monitoring data for all 711 counties monitored for PM_{10} in the 48 contiguous states during this 3-year period;
- The number of monitored counties covered in the nonattainment county analysis is increased (i.e., 504 counties vs. 470 in the December 1996 analysis);
- Sensitivity analyses of the following are conducted:
    - number of counties covered in the baseline PM nonattainment county analysis
    - fugitive dust adjustment factor;
- Analysis of PM air quality as it relates to regional haze visibility improvement goals is included.

4.4.1 Overview of Phase II PM Air Quality Modeling

This section provides a general overview of the Phase II PM air quality modeling analysis. More detailed information follows in subsequent sections. The December 1996 PM RIA assessment employed the Phase I source-receptor (S-R) matrix as produced by the CRDM. The Phase I modeling results are thought to be deficient in that they likely underestimated the impacts of secondary particle precursor emissions. For Phase II, the Lagrangian Regional Model is used to guide the refinement of the CRDM to correct for this misestimation (Latimer, 1996). Using 1990 meteorology, the refined CRDM is applied to 1990 emissions to calculate a transfer

matrix of S-R relationships for all relevant primary and precursor emissions to estimate cumulative regional ambient concentrations of $PM_{2.5}$ and PM_{10}, as well as the important chemical constituents of secondary particulates: sulfate, nitrate, secondary organics and ammonium. As described in section 4.4.2, the refined CRDM, when used with adjusted primary PM fugitive dust emissions, provides representative estimates of the spatial distribution of annual PM concentrations in the United States (Pechan, 1997b).

The S-R matrix next is calibrated using 1993 - 1995 PM_{10} and $PM_{2.5}$ annual monitoring data to benchmark the modeling to ambient air quality values. Additionally, this calibration provides a way to capture the 3-year and spatial averaging aspects of the $PM_{2.5}$ annual standard alternatives.

In order to predict ambient PM concentrations in 2010, emissions projections as described in Section 4.3 are input to the calibrated S-R matrix to produce annual PM_{10} and $PM_{2.5}$ concentration values at county-level receptors. Finally, 1993 - 1995 peak-to-mean ratios (i.e., ratio of 24-hour value to annual average value) for each monitored county in the analysis are used to estimate the 24-hour PM concentration (i.e., 4th highest daily maximum for the current PM_{10} daily form and 98th percentile value for the $PM_{2.5}$ daily form alternatives) from the model-predicted annual PM concentration. Nonmonitored counties are calibrated using regional average normalization factors. Additionally, regional peak-to-mean ratios are used to derive the 24-hour PM concentration in the nonmonitored counties.

Once 2010 baseline air quality is developed, monitored counties are evaluated for violation of alternative standards. Figure 4.3 illustrates the development of 2010 baseline PM air quality concentrations.

4.4.2 Elements of PM Air Quality Modeling

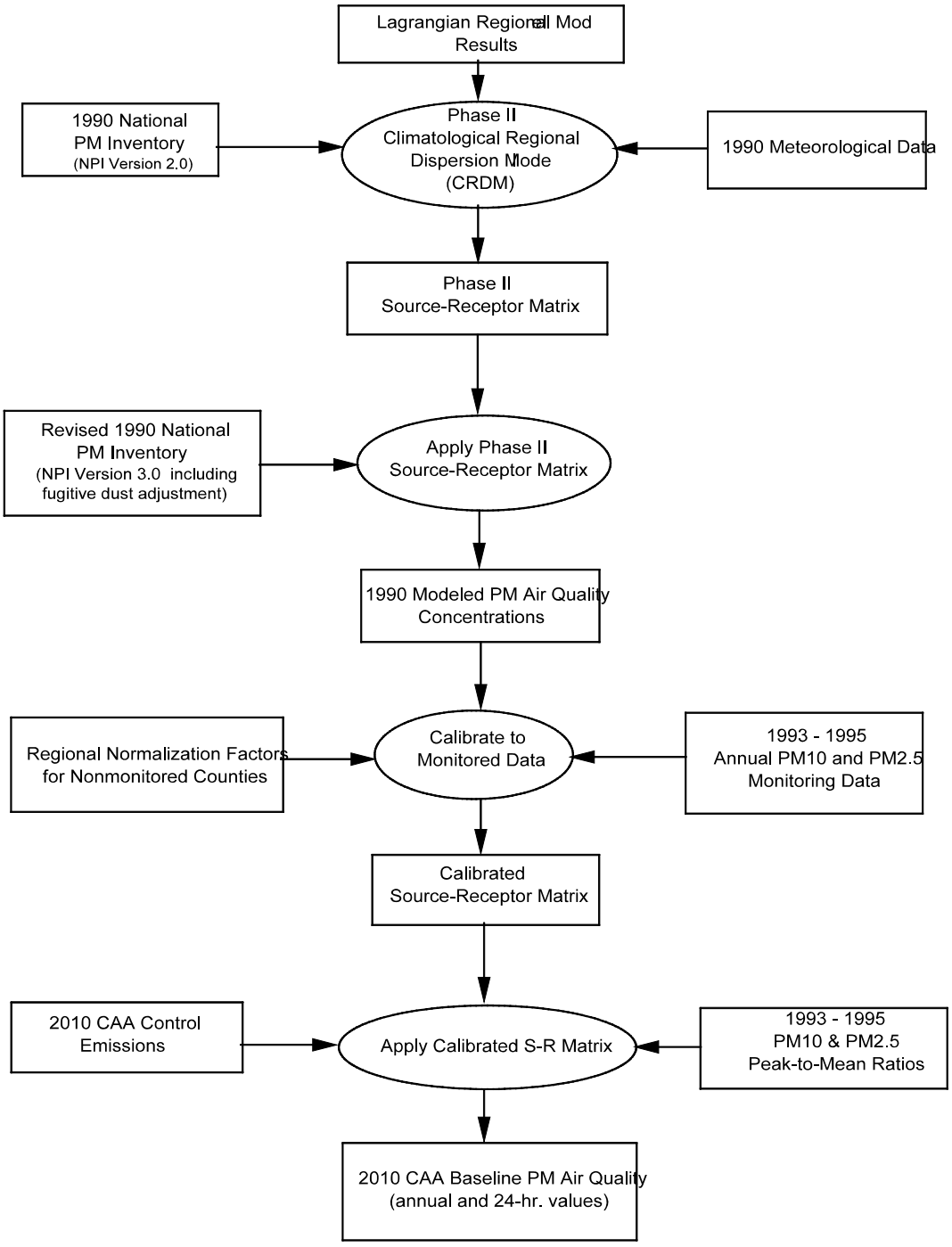
4.4.2.1 Lagrangian Regional Model

The Lagrangian Regional Model (LRM) is used to guide the refinement of the CRDM through the estimation of the transport, diffusion, deposition, and chemical conversion of emissions using a spatially and temporally varying wind field. Because the computer memory and
run times are excessive to run the LRM for the entire country with 6,000 sources and 3,000 receptors, the LRM was tested for a single point source for a few days of 1990 meteorological data from the MM-4 mesoscale model. The LRM simulates the hourly release of puffs which are transported by the averaged winds appropriate for the time and location of the puff. In general, puff-type air quality models are better than Gaussian dispersion models at handling transport and diffusion of pollutants at low wind speeds and therefore show a greater air quality impact from emissions in the local area. A single uniform concentration of each particulate chemical constituent for each hourly puff is calculated based on standard vertical diffusion coefficients, limited by the mixed layer height, and mesoscale diffusion coefficients. Results from the LRM are subsequently used to refine CRDM assumptions to take account of long-range transport of secondary particles and impacts of a county's primary emissions on its air quality (Latimer, 1996).

4.4.2.2 Climatological Regional Dispersion Model

The CRDM is used to generate a matrix of S-R relationships that relate emissions of direct PM_{10} and $PM_{2.5}$ and particle precursors to annual average PM_{10} and $PM_{2.5}$ concentrations (Pechan, 1997b). The S-R matrix reflects the relationship between PM concentration values at a single receptor in each county (a hypothetical design value monitor sited at the county population centroid) and the contribution by PM species to this concentration from each emission source. The CRDM uses assumptions similar to the Industrial Source Complex Short Term (ISCST3), an EPA-recommended short range Gaussian dispersion model (U.S. EPA, 1995b). CRDM

Figure 4.3
Development of 2010 Baseline PM Air Quality



incorporates terms for wet and dry deposition and chemical conversion of SO_2 and NOx, and uses climatological summaries (annual average mixing heights and joint frequency distributions of wind speed and direction) from 100 upper air meteorological sites throughout North America. For this analysis, meteorological data for 1990 is used.

The CRDM uses Turner's sector-average approach, a probabilistic method in which the frequencies of occurrence of various wind and stability conditions are used to calculate the frequencies of transport of pollutants in various sectors. This method is recommended for estimation of long-term average pollutant concentrations and is discussed more fully in a contractor report (Pechan, 1997b). The assumptions related to chemical conversion of secondary particle precursors, long-range transport of secondary particles and the impact of a county's primary emissions on itself are refined based upon the LRM results. For the Phase II modeling, chemical conversion, transport and deposition equations are updated. Additionally, it was assumed that all primary emissions from the county are evenly distributed over a square with the same area as the county. It is also assumed that primary emissions from the county are always impacting the county. A simple box model is used for each wind speed and stability category. The vertical diffusion coefficient is calculated at a downwind distance corresponding to the length of the side of the square. These assumptions are necessary since spatial variation of emissions within a county cannot be provided for a national scale model.

Emissions data from version 2.0 of the 1990 NPI are input to the CRDM. Stationary and mobile source emissions, as well as ground-level area source emissions, for 3,081 counties in the contiguous United States are contained in the 1990 NPI. The high number of point sources in the inventory (61,619 point sources) made it impractical to model each point source individually. As a result, elevated point source emissions are aggregated at the county level by plume height. The effective stack height of each of these sources was calculated for an average wind speed (5 meters/second) using the plume rise algorithm for ISCST3. Two aggregated elevated point source groupings are made: one for sources with effective stack heights less than 250 m, and one for sources with effective stack heights between 250 and 500 m. Sources with effective stack heights greater than 500 m are modeled as separate sources. In addition to point sources,

the modeled emission sources also include total area/mobile sources for each county and emissions for 10 Canadian provinces and 29 Mexican cities/states. Receptors modeled include all county centroids plus receptors in Canada and Mexico.

A total of 5,944 sources (i.e., industrial point, utility, area, nonroad, and motor vehicle) of primary and precursor emissions are modeled. In addition, secondary organic aerosols formed from anthropogenic and biogenic VOC emissions are modeled. Natural sources of PM_{10} and $PM_{2.5}$ (i.e., wind erosion and wild fires) are also included. Emissions of SO_2, NOx, and ammonia are modeled in order to calculate ammonium sulfate and ammonium nitrate concentrations, the primary particulate forms of sulfate and nitrate. The CRDM produces an S-R matrix of transfer coefficients for each of these primary and particulate precursor pollutants. These coefficients can be applied to the emissions of any unit (area source or individual point source) to calculate a particular source's contribution to a county receptor's total annual PM_{10} or $PM_{2.5}$ concentration. Each individual unit in the inventory is associated with one of the source types (i.e., area, point sources with effective stack height of 0 to 250 m, 250 m to 500 m, and individual point sources with effective stack height above 500 m) for each county.

Once the S-R matrix is developed, the transfer coefficients must be adjusted to reflect concentrations of secondarily-formed particulates (Latimer, 1996). First, the transfer coefficients for SO_2, NOx, and ammonia are multiplied by the ratios of the molecular weights of sulfate/SO_2, nitrate/nitrogen dioxide and ammonium/ammonia to obtain concentrations of sulfate, nitrate and ammonium.[a] The relative concentrations in the atmosphere of ammonium sulfate and ammonium nitrate depend on complex chemical reactions. In the presence of sulfate and nitric acid (the gas phase oxidation product of NOx), ammonia reacts preferentially with sulfate to form particulate ammonium sulfate rather than react with nitric acid to form particulate ammonium nitrate. Under conditions of excess ammonium and low temperatures, ammonium nitrate forms. For each county receptor, the sulfate-nitrate-ammonium equilibrium is estimated

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a Ratio of molecular weights: Sulfate/SO_2= 1.5; nitrate/nitrogen dioxide = 1.35; ammonium/ammonia = 1.06.

based on the following simplifing assumptions:

- All sulfate is neutralized by ammonium;
- Ammonium nitrate forms only when there is excess ammonium;
- Because ammonium nitrate forms only under low temperatures, annual average particle nitrate concentrations are divided by four assuming that sufficiently low temperatures are present only one-quarter of the year.

Finally, the total particle mass of ammonium sulfate and ammonium nitrate is calculated.[a]

4.4.2.3 Comparison of Modeled and Measured PM Concentrations

In order to evaluate the performance of the Phase II CRDM, model-predicted PM concentrations and measured ambient PM concentrations are compared. Measured annual average PM concentrations by chemical species from the Interagency Monitoring for Protection of Visual Environments (IMPROVE) network are examined for the three-year period March 1988 - February 1991. This period is chosen because it relates closely to 1990 emissions and meteorological data used in the CRDM. Given that IMPROVE network monitors visibility impairment in predominantly rural Class I areas, these comparisons are incomplete due to the lack of coverage in urban areas. With the exception of the fugitive dust component of $PM_{2.5}$ and PM_{10}, modeled and measured concentrations of sulfate, nitrate and organics are comparable (Latimer, 1996).

Additionally, some preliminary air quality modeling has been conducted using the Regional Acid Deposition Model-Regional Particulate Model (RADM-RPM) for the Eastern U.S. using 1990 emissions and meteorology (U.S. EPA, 1997b). This is a Eulerian gridded model incorporating more comprehensive physics and chemistry to enable better characterization

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a To calculate total particle mass of ammonium sulfate and ammonium nitrate, the anion concentrations of sulfate and nitrate are multiplied by 1.375 and 1.29 respectively.

of secondarily-formed pollutants than Lagrangian-based methods. In general, the CRDM results show a similar East-West trend in sulfate and nitrate concentrations within the same modeling region. Also, the CRDM-predicted annual average concentrations of sulfate are within the range of RADM-RPM base-case predictions. Relative to RADM-RPM base case results, CRDM appears to overpredict nitrate concentrations in the Mid-west and underpredict nitrate concentrations in the Mid-Atlantic states.

This PM air quality modeling effort attempts to model the "background" contribution to ambient PM concentrations. Background PM is defined as the distribution of PM concentrations that would be observed in the U.S. in the absence of anthropogenic emissions of PM and precursor emissions of VOC, NOx and SOx in North America (U.S. EPA, 1996l). Estimating background PM concentrations is important for the cost analysis as it represents that portion of PM mass that is uncontrollable. Background PM levels vary by geographic location and season. The natural component of background arises from physical processes of the atmosphere that entrain small particles of crustal material (i.e., soil from wind erosion) as well as emissions of organic particles and nitrate precursors resulting from natural combustion sources such as wildfire. In addition, certain vegetation can emit SOA. Biogenic sources and volcanos also emit sulfate precursors. The exact magnitude of this natural portion of PM for a given geographic location can not be precisely determined because it is difficult to distinguish from the long-range transport of anthropogenic particles and precursors. The PM Criteria Document (U.S. EPA, 1996a) reports that annual average $PM_{2.5}$ concentrations range from 1 - 4 ug/m^3 in the West and from 2 - 5 ug/m^3 in the East.

Given the uncertainties in estimating biogenic VOC and SOA emissions and primary PM emissions from natural sources as well as the uncertainties in the PM air quality model, there is considerable uncertainty in the modeled predictions of the background contribution to PM mass. For some nonattainment counties, apparent overpredictions in the background contribution to PM mass reduces the relative contribution of anthropogenic sources to PM mass. This in turn can significantly diminish the modeled effectiveness of control measures on anthropogenic sources in reducing estimated PM concentration levels. This issue is discussed in Chapter 6 for

PM residual nonattainment areas.

Although the bulk of primary PM emissions are from anthropogenic and natural fugitive dust sources[a], available speciated monitoring data indicate that fugitive dust contributes substantially less to total $PM_{2.5}$ levels relative to other particle species such as sulfates and nitrates. The CRDM-predicted average fugitive dust contribution to $PM_{2.5}$ mass is 31% in the East and 32% in the West (Pechan, 1997b). Speciated monitoring data show that minerals (i.e., crustal material) comprise approximately 5 percent of $PM_{2.5}$ mass in the East and approximately 15 percent of $PM_{2.5}$ mass in the West (U.S. EPA, 1996a). The 1990 model predictions therefore are not consistent with ambient data. These disparate results may suggest a systematic overbias in the fugitive dust emission estimates. Subsequent PM emission inventory efforts indicate that fugitive dust emissions are overestimated in the baseline emissions inventory. The NPI version 3 fugitive dust PM_{10} and $PM_{2.5}$ emissions used in this analysis are 40% and 73% greater, respectively, than the most recent National Emissions Trends Inventory estimates[b] (U.S. EPA, 1997h). Furthermore, this overestimate in the contribution of fugitive dust to modeled ambient fine particle concentrations relative to speciated monitoring data is likely to be compounded by uncertainties in the air quality modeling (U.S. EPA, 1996c).

To address this bias, a multiplicative factor is applied nationally to fugitive dust emissions as a reasonable first-order attempt to reconcile differences between modeled predictions of $PM_{2.5}$ and actual ambient data. Two multiplicative factors are examined: 0.25 and 0.10. The 0.25 multiplicative adjustment results in a fugitive dust contribution to modeled ambient $PM_{2.5}$ concentrations of 10 - 17%, while the 0.10 multiplicative factor results in a 4 - 8% contribution.[c]

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a Natural and anthropogenic fugitive dust emissions account for 93% of PM_{10} emissions and 76% of $PM_{2.5}$ emissions in the 1990 base year inventory (NPI version 3).

b Natural and anthropogenic fugitive dust emissions account for 86% of PM_{10} emissions and 59% of $PM_{2.5}$ emissions in the most recent 1990 National Emission Trends Inventory.

c See map on p. 6-5 for delineation of cost modeling regions. Using 0.25 multiplicative factor, fugitive dust as percentage of $PM_{2.5}$ mass for: Central U.S. = 17.2%; Eastern U.S.= 10.4%; Western U.S.= 10.6%. Using 0.10 multiplicative factor, fugitive dust as

Given that the 0.25 multiplicative factor appears to bring the modeled fugitive dust contribution to $PM_{2.5}$ mass more within the range of values reported from speciated monitoring data, the main PM analysis of costs and benefits uses the 0.25 multiplicative factor to adjust fugitive emissions. However, a sensitivity analysis is conducted using the 0.10 multiplicative factor. The impact of the fugitive dust adjustment factor on PM nonattainment county counts is discussed in section 4.4.3. Appendix D provides more detailed information on this sensitivity analysis.

4.4.2.4 Application of Phase II S-R Matrix to Updated 1990 National Particulate Emissions Inventory

As described in section 4.3, version 3 of the NPI is used as the base year 1990 inventory. This recent emissions inventory update concluded after completion of Phase II CRDM modeling. In order to account for this emission inventory refinement as well as the fugitive dust adjustment as discussed above, the Phase II S-R matrix next is applied to the revised PM emissions inventory to predict 1990 PM air quality concentrations.

4.4.2.5 Normalization of S-R Matrix for Annual Estimates of PM_{10} and $PM_{2.5}$

The resulting 1990 annual PM_{10} and $PM_{2.5}$ values are compared and calibrated to monitored annual PM_{10} and $PM_{2.5}$ concentrations. All predictions are normalized regardless of overprediction or underprediction relative to monitored values. This is done by application of a "normalization factor", calculated as the monitored value divided by the modeled value. This factor was applied consistently across particle species contributing to the air quality value at a county-level receptor. Calibration is conducted for county-level modeled PM_{10} and $PM_{2.5}$ estimates falling into one of four air quality data tiers. The tiering scheme reflects increasing

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percentage of $PM_{2.5}$ mass for: Central U.S. = 7.8%; Eastern U.S.= 4.5%; Western U.S.= 4.6%. By comparison, without using a multiplicative factor, fugitive dust as a percentage of $PM_{2.5}$ mass for: Central U.S. = 44.6%; Eastern U.S. = 30.9%; Western U.S. = 31.5%. As discussed previously, the overestimation of fugitive dust emissions from farming operations could easily account for the increased fugitive dust contribution in the Central U.S., where farming operations are concentrated.

relaxation of data completeness criteria and therefore increasing uncertainty for the annual design value (U.S. EPA, 1997k). Tier 1 monitored counties cover the 504 counties with at least 50% data completeness and therefore have the highest level of certainty associated with the annual design value. Tier 2 monitored counties cover 100 additional counties with at least one data point (i.e., one 24-hour value) for each of the three years during the period 1993 -1995. Tier 3 monitored counties cover 107 additional counties with missing monitoring data for one or two of the three years 1993 - 1995. In total, Tiers 1, 2 and 3 cover 711 counties currently monitored for PM_{10} in the 48 contiguous states.[a] Tier 4 covers the remaining 2369 nonmonitored counties. Normalization factors are calculated and applied to the respective counties for Tiers 1 through 3. Tier 4 nonmonitored counties are calibrated using the appropriate regional normalization factor calculated as the average of Tier 1 normalization factors across a given modeling region[b].

The calibration procedure is conducted employing 1993 - 1995 PM_{10} ambient monitoring data from the AIRS database following the air quality tier data completeness parameters discussed above. The PM_{10} data represent the annual average of design value monitors averaged over three years (U.S. EPA, 1996i). The standardization for temperature and pressure was eliminated from this concentration data based upon proposed revisions to the reference method for PM_{10}.[c]

Because there is little $PM_{2.5}$ monitoring data available, a general linear model is developed to predict $PM_{2.5}$ concentrations directly from the 1993 - 1995 PM_{10} values (U.S. EPA, 1996e). A SAS™ general linear model (i.e., GLM) procedure is used to predict $PM_{2.5}$ values (dependent variable) as a function of independent variables for season, region, and measured PM_{10} value.

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a The current PM_{10} monitoring network consists of approximately 1600 individual monitors with a coverage of approximately 711 counties in the 48 contiguous states.

b As presented in Chapter 6, the contiguous 48 states are divided into six modeling regions for the control strategy-cost analysis. See p. 6-5.

c See Proposed Revisions to Appendix J - Reference Method for PM_{10} , Proposed Rule for National Ambient Air Quality Standards for Particulate Matter (Federal Register, Vol. 61, No. 241, p. 65666, December 13, 1996).

These derived $PM_{2.5}$ data are used to calibrate model predictions of annual average $PM_{2.5}$. Given the $PM_{2.5}$ annual standard alternatives allow for spatial averaging, model-predicted annual average $PM_{2.5}$ air quality data are calibrated to the spatially-averaged annual $PM_{2.5}$ value[a] from the derived $PM_{2.5}$ dataset. Additionally, the proposed form of the standard allows for averaging over three years of air quality data. These derived, annual $PM_{2.5}$ data represent the annual average value over a three-year period. These $PM_{2.5}$ concentrations also reflect the elimination of the temperature and pressure standardization, given that they are developed from the previously discussed PM_{10} dataset.

4.4.2.6 Application of Calibrated Phase II S-R Matrix to 2010 CAA Control Emissions

The calibrated Phase II S-R matrix is next applied to the 2010 CAA control emissions to predict baseline PM annual air quality at the county level. This baseline air quality reflects the fugitive dust emissions adjustment of 0.25.

4.4.2.7 Peak-to-mean Ratios for Calculating 24-hour Average Concentration Value

Since the CRDM predicts only annual average PM_{10} and $PM_{2.5}$ concentrations, peak-to-mean ratios are employed to derive these values. For each annual PM concentration for the Tier 1 through 3 monitored counties, three sets of peak-to-mean ratios are used to predict 24-hour peak PM_{10} and $PM_{2.5}$ concentrations reflective of the forms of the alternatives being analyzed.[b] The first peak-to-mean ratio is the three-year average 4th highest 24-hour maximum PM_{10} value to the annual arithmetic mean PM_{10} value. This ratio is applied to the modeled annual average PM_{10} value to predict the 4th highest daily maximum PM_{10} value, the form of the current PM_{10} daily standard. The ratio of annual mean PM_{10} to 99th percentile 24-hour PM_{10} is used to predict

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a County-level spatial averaging is used for this analysis.

b Used 1993 - 1995 AIRS monitoring data following air quality data tiering scheme discussed in section 4.3.2.4.

the three-year average 99th percentile PM_{10} value (i.e., form of the selected PM_{10} standard) from the annual mean PM_{10}. The $PM_{2.5}$ peak-to-mean ratio is calculated as the three-year average 98th percentile 24-hour peak $PM_{2.5}$ value to the spatially averaged annual arithmetic mean $PM_{2.5}$ value. This ratio is applied to the annual mean $PM_{2.5}$ value to predict the three-year average 98th percentile 24-hour peak $PM_{2.5}$ value (U.S. EPA, 1996e).

4.4.3 PM Nonattainment Counties by Alternative

The model-predicted PM_{10} and $PM_{2.5}$ air quality data for the 2010 CAA-control baseline is used to determine county air quality status. The rounding convention proposed for the PM NAAQS is used in the identification of counties predicted to have PM levels in 2010 greater than the standards examined.[a] Table 4.9 presents estimates of PM nonattainment counties by region. These results also reflect application of the 0.25 fugitive dust adjustment factor as discussed in Section 4.4.2.3. For the main analysis, nonattainment counties are identified from the Tier 1 set of 504 counties monitored during 1993 - 1995 for reasons discussed in Section 4.2 and because there is relatively more certainty associated with predicted air quality in these counties. Predicted PM concentrations are the most certain for the Tier 1 counties since the estimates are calibrated using 50% complete AIRS data as described in Section 4.4.2.5. This set represents approximately 70% of the counties within the 48 contiguous states monitored for PM_{10} during 1993 -1995, covering approximately 150 million people.

A sensitivity analysis is conducted for the 15/50 alternative to examine the extent of PM nonattainment when the Tier 1 county scope assumption is relaxed. In this sensitivity assessment, the set of counties from which nonattainment counties is identified is extended to include Tiers 2 and 3. This assumption increases monitored county coverage to all 711 counties monitored for PM_{10} in the contiguous 48 states during 1993 - 1995. It should be noted that the

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a Rounding convention: $PM_{2.5}$ annual standard - rounded to the nearest 0.1; $PM_{2.5}$ daily standard - rounded to the nearest 1; PM_{10} annual - rounded to the nearest 1; PM_{10} daily - rounded to the nearest 10.

Tier 2 and 3 air quality estimates are less certain relative to Tier 1 estimates. The number of estimated nonattainment counties increases by 10 counties for the current PM_{10} standard (total of 53) and by 23 for the proposed $PM_{2.5}$ standard (15/50) (total of 108). Appendix D presents the detailed results of this sensitivity analysis.

A sensitivity analysis also is conducted for the 15/50 alternative to examine the extent of PM nonattainment when the 0.10 fugitive dust adjustment factor is employed. By reducing fugitive dust emissions by 90%, the number of initial nonattainment counties decreases by 11 counties for the proposed $PM_{2.5}$ standard (15/50) and stays the same for the current PM_{10} standard. The 0.10 adjustment factor has implications for cost and residual nonattainment as discussed in Appendix D.

4.4.4 Uncertainties in PM Air Quality Modeling

The methodology used to project PM concentrations in 2010 from 1990 emissions and ambient concentration data introduces several sources of uncertainty to the control strategy-cost and benefits analyses. Table 4.6 presents potential sources of uncertainty and associated biases in estimating 2010 initial PM nonattainment counties. "Positive bias" indicates that estimated 2010 nonattainment counties may be overestimated; "negative bias" indicates that estimated 2010 nonattainment counties may be underestimated; "bias unclear" indicates that the direction of impact from a given potential source of uncertainty on 2010 nonattainment counties is unknown. The level of uncertainty associated with a particular input variable to the air quality projection procedure has been quantified to the extent possible based on information from published literature or internal EPA studies.

Because 1990 emissions are an input to the CRDM model, the uncertainties associated with the emissions inventory are carried through to the PM air quality modeling. As discussed in section 4.3.3, apart from the fugitive dust and biogenic VOC and SOA categories, emissions of primary PM and PM precursors are uncertain although with no known bias. Fugitive dust PM emissions appear to be overestimated by 40% for PM_{10} and 73% for $PM_{2.5}$ relative to the more

recent National Emissions Trends Inventory. The biogenic VOC emissions are underestimated relative to the more recent BEIS2 estimates. Finally, the methodology used to estimate SOA formation from reactive VOCs may overestimate SOA emissions and therefore ambient concentrations of SOA.

There is uncertainty associated with the 1993 - 1995 monitored annual average and 24-hour PM_{10} concentration values that are used to calibrate the ambient concentrations generated by the CRDM at the county-level receptors. These monitoring values are taken from the AIRS data base, which has a performance requirement of 5 $\mu g/m^3$ for concentrations less than 80 $\mu g/m^3$ and $\pm$ 7 percent for concentrations greater than 80 $\mu g/m^3$. However, a comparison of AIRS data obtained from side-by-side samplers of the same and different types indicated measurement differences ranging from 10 to 14 percent for like samplers to 16 to 26 percent for dissimilar samplers (U.S. EPA, 1996k). However, there is no known bias associated with these values.

Since the $PM_{2.5}$ data are derived from monitored PM_{10} concentrations, they too have associated uncertainty due to instrument measurement error, as described above. Additionally, and more importantly, the $PM_{2.5}$ values are predicted from a regression model (U.S. EPA, 1996e), and therefore are subject to uncertainty associated with this model. Subsequent reanalysis of the model has shown that there is no systematic bias to the $PM_{2.5}$ estimates (U.S. EPA, 1997i).

Table 4.9 Predicted Counties in Initial Nonattainment of PM Standards in 2010 Using 0.25 Fugitive Dust Adjustment Factor (Tier 1 counties only)

Region[a]	Total Tier 1 Counties in Region[b]	Number of Counties Predicted in Initial Nonattainment of PM Alternative				
		PM_{10} 50/150 - 1Ex) (current)	PM_{10}[c] 50/150-99th (selected)	$PM_{2.5}$[d] 16/65-98th	$PM_{2.5}$[4] 15/65-98th (selected)	$PM_{2.5}$[4] 15/50-98th (proposal)
Midwest/Northeast	218	6	2	38	56	58
Southeast	86	1	0	8	16	16
South Central	59	4	1	5	7	8
Rocky Mountain	64	12	1	8	11	18
West	49	15	6	11	12	16
Northwest	28	7	1	0	0	6
Total Counties in Nonattainment		45	11	70	102	122

a See map on p. 6-5 for delineation of control strategy modeling regions.

b Total number of monitored counties modeled in analysis = 504

c This alternative is analyzed incremental to 2010 baseline (i.e., prioit to application of the National PM Strategy).

d These alternatives are analyzed incremental to the current PM_{10} standard and are assessed prior to application of the National PM Strategy.

The CRDM used to generate a matrix of S-R transfer coefficients employs a large number of input variables in its calculations, including meteorological data (i.e., wind speed, wind velocity, and stability conditions). While there have been no studies of uncertainty associated with CRDM output, Freeman *et al.* (1986) used error propagation and Monte Carlo simulation to study the uncertainty of short range concentration estimates calculated by a similar model, EPA's ISCST Gaussian dispersion model for a single point source. Freeman *et al.* found that for relatively low values of uncertainty assigned to input values (1 to 10 percent), the uncertainty of the concentration at distances from 3 to 15 kilometers downwind of a source averaged 16 percent. When input data uncertainties were increased by a factor of 4, however, the output uncertainty ranged from about 75 - 160 percent.

Despite application of the fugitive dust adjustment factor, comparisons of modeled PM predictions to ambient data indicate that the CRDM overpredicts the contribution of fugitive dust to total $PM_{2.5}$ mass. CRDM may overestimate or underestimate other fine particle species when evaluating county-level model predictions relative to $PM_{2.5}$ ambient data. For example, in some PM residual nonattainment counties, the predicted biogenic organic contribution to $PM_{2.5}$ mass appears to be overestimated relative to speciated monitoring data. However, at the national level, there appears to be no systematic bias to the modeled air quality predictions for the non-fugitive dust particle species.

The uncertainties and biases in the 1990 modeled predictions combined with uncertainites in 2010 emission projections bring about similar uncertainties and biases in the 2010 PM air quality predictions.

Although the CRDM S-R matrix serves as a useful tool in the design of cost-effective PM control strategies, the modeling approach does not reflect application of state-of-the-art techniques. Many of the physical and chemical formulations in the CRDM are crude representations of actual mixing and reaction phenomena required to address aerosol formation, transport and removal phenomena. Where available, more scientifically credible Regional Acid Deposition Model (RADM) results are used to complement the CRDM results. However, even

with the anticipated delivery of more comprehensive modeling techniques, the scarcity of speciated ambient data in both urban and rural environments to evaluate model behavior will continue to compromise the certainty of model-derived conclusions.

As indicated in the sensitivity analysis in Section 4.4.3, the Tier 1 geographic scope assumption underestimates to a small degree the number of predicted PM nonattainment areas relative to identifying potential nonattainment areas from across Tiers 1, 2 and 3 counties.

Table 4.6 Uncertainties and Possible Biases in Estimating 2010 Nonattainment Counties

Potential Source of Uncertainty	Positive Bias? (Overestimate)	Negative Bias? (Underestimate)	Bias Unclear
<u>Base Year 1990</u>			
- 1990 emissions	✓ (fugitive dust, SOA)	✓(total biogenic VOC and SOA)	✓ (other emissions)
- 1993 - 1995 PM10 ambient data			✓
- 1993 - 1995 PM2.5 derived data			✓
- CRDM 1990 adjusted S-R matrix	✓ (fugitive dust)		✓ (other emissions)
<u>Projection Year 2010</u>			
- Uncertainties from 1990 adjusted S-R matrix	✓ (fugitive dust)		✓
- 2010 emissions projections	✓ (fugitive dust, SOA)	✓ (total biogenic VOC and SOA)	✓ (other emissions)
- 2010 air quality predictions	✓ (fugitive dust)		✓ (other particle species)
<u>2010 Nonattainment Counties</u>			
- Tier 1 geogphraphic scope assumption		✓ (small)	

4.5 ESTIMATION OF BASELINE OZONE AIR QUALITY CONCENTRATIONS IN 2010

The methodology for estimating baseline ozone air quality concentrations for this assessment builds upon previous work conducted for the December 1996 Ozone NAAQS RIA (U.S. EPA, 1996g). Monitoring data for 1990 and ROM 2007 air quality estimates are used to develop 2010 baseline air quality and identify potential nonattainment areas of alternative ozone standards. Updates to data inputs and methodological refinements have been incorporated where feasible. Major updates and refinements to the December 1996 ozone air quality analysis are listed below.

- A more informed picture of the future ozone nonattainment situation is provided based on comparison of model-predicted nonattainment with:
  - 1993 - 1995 monitored air quality data;
  - Air quality modeling from comparable emission reduction scenarios using ROM and Urban Airshed Model-Variable scale (UAM-V);
  - State Implementation Plan air quality modeling information;
- Model-predicted nonattainment counties are based on counties having ozone monitors in 1990;
- The concept of marginal nonattainment areas is eliminated;
- The concept of downwind transport areas is incorporated into the baseline ozone nonattainment area analysis.

4.5.1 Overview of Development of 2010 Baseline Ozone Air Quality

To assess national annual costs and benefits of alternative ozone standards in the absence of temporally and spatially comprehensive air quality modeling tools is a challenging task. Most ozone air quality models are run to examine peak ozone concentrations for specific ozone episodes. Rarely are models run for an entire ozone season. Additionally, available ozone air quality modeling is limited in its geographic scope. The Eastern U.S. is covered by regional-

scale models such as the ROM or the UAM-V; however, geographic coverage of available models outside of the Eastern U.S. is limited. Therefore, the development of baseline ozone air quality data relies upon a full year of ozone monitoring data and available seasonal air quality modeling results to create a national picture of ozone air quality concentrations across a full year.

Figure 4.4 illustrates the steps followed to develop 2010 baseline air quality. ROM air quality modeling information for 2007 is used in combination with 1990 historical ozone air quality monitoring data to develop 2007 ozone air quality for the 48 contiguous states. The 2007 predicted air quality is then adjusted to account for 2010 emissions inventory differences and additional ozone modeling and monitoring information (i.e., 1993 - 1995 AIRS monitoring data, ROM and UAM-V air quality modeling data) to yield 2010 baseline ozone air quality data. Because this future air quality is based on counties with monitoring data in 1990, the centroid model is used to develop air quality for nonmonitored counties through geographic interpolatation. This data is input to the benefits analysis. The 2010 baseline ozone air quality data for monitored counties is used to identify ozone nonattainment areas. This information is input to the control strategy and cost analysis. The following sections describe in more detail the various components of the analysis as illustrated in Figure 4.4.

4.5.2 Elements of Ozone Air Quality Modeling

4.5.2.1 2007 ROM Air Quality Modeling

A series of ROM analyses are conducted for the ozone NAAQS proposal to serve as rough planning tools for the development of policies to implement a new ozone NAAQS as well as for estimation of costs and benefits. Covering the eastern 37 states, ROM air quality modeling results are available for the following scenarios: (1) 1990 basecase; (2) 2007 CAA-mandated control; (3) NOx and VOC across-the-board reductions (i.e., matrix runs) from this 2007 CAA scenario; and (4) 2007 regional control strategy (U.S. EPA, 1996b). Because of the limited geographic scope of the ROM modeling domain and the need for ozone air quality predictions

for the entire continental U.S. in order to assess national costs and benefits of alternative ozone standards, a methodology is developed to extrapolate ROM predictions to all counties in the U.S.

Given the limited availability of meteorological data for input to the air quality model, the ROM simulations selected 1987 meteorological conditions to predict hourly ozone concentrations for the June through August period. It is desirable to employ for air quality modeling purposes meteorological data that are representative of typical ozone-forming conditions. According to a method discussed by Cox and Chu (1996), 1987 is not a particularly severe year in the Northeast nor in the Gulf regions. In the South and the Midwest, 1987 does stand out as a rather conducive year for high ozone, though not as severe as 1988. When viewed in the context of the 10 year period 1986 - 1995, overall the year 1987 is not an unusually conducive year for high ozone across the Eastern U.S. Thus, 1987 is considered a representative meteorological year for ROM modeling purposes.

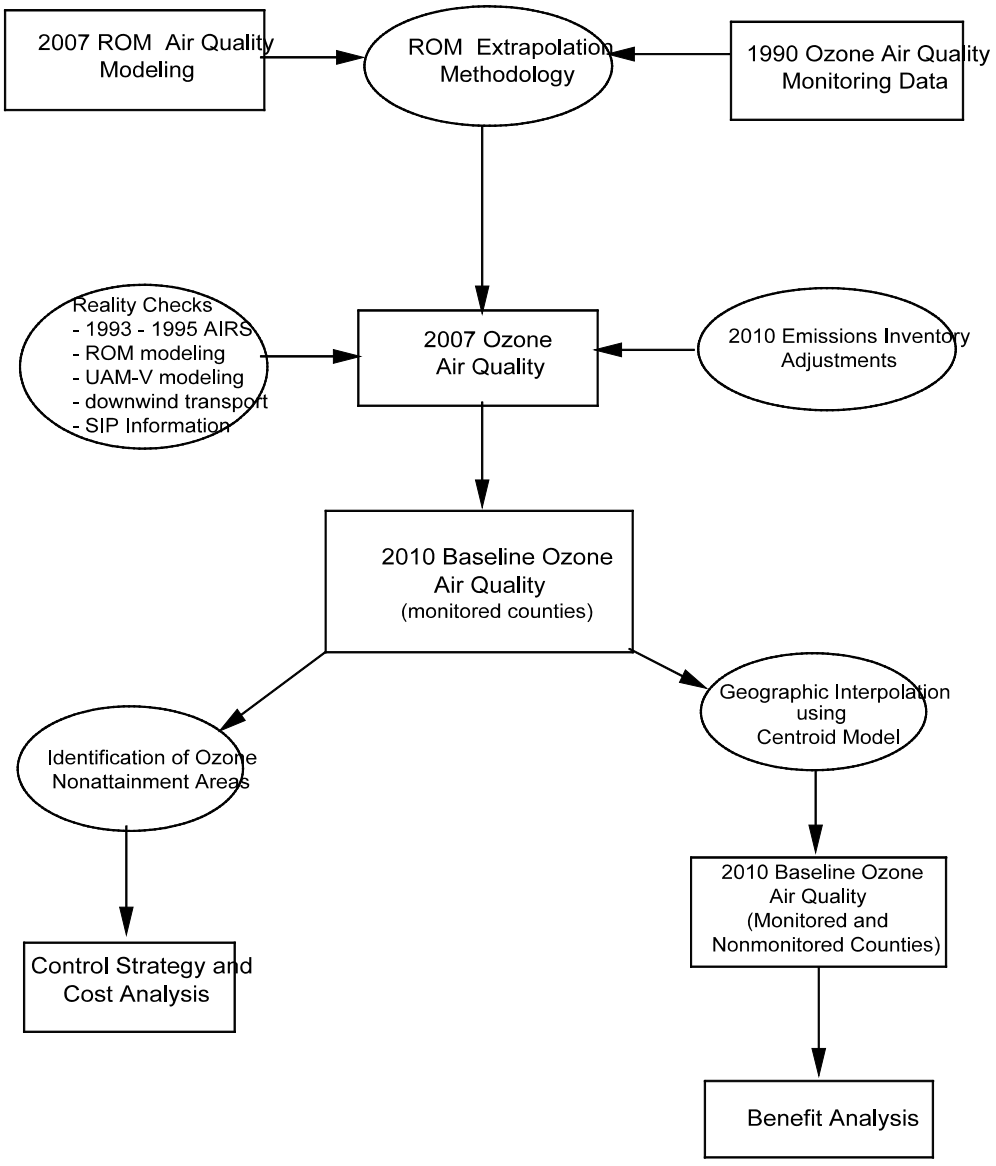
4.5.2.2 Development of 1990 Ozone Air Quality Data

A dataset of empirical ozone concentration data was developed from AIRS. Hourly ozone concentration values meeting data inclusion criteria are obtained for the year 1990 for the contiguous 48 states. Given that the baseline emissions inventory from which 2007 emissions projections were made and the basecase ROM modeling both used 1990 emissions, the year 1990 was selected as a representative baseline year for ambient air quality. This 1990 air quality data set was corrected for duplicate monitor site records, obsolescence of monitor data and missing values (MathTech, 1997).

Although the form of the proposed standard is expressed as the average 3rd max concentration over a three year period and this analysis uses only one year of ozone monitoring data, an examination of the data shows that at the national level, 1990 compares well with the 1993 - 1995 period. An evaluation of 1990 annual 3rd max 8-hour design values relative to 1993 - 1995 average 3rd max design values was conducted. This assessment indicates that across the U.S. the difference between the 1990 annual 3rd maximum concentrations and the 1993-1995

average annual 3rd maximum concentrations is less than or equal to 0.015 ppm 90 percent of the time (U.S. EPA, 1997e). In spite of area-specific differences in 8-hour 3rd maximum values between 1990 and 1993-1995, ozone air quality data for the year 1990 is considered to be comparable at the national level to 8-hour average 3rd max design values for 1993-1995.

Figure 4.4. Development of 2010 Baseline Ozone Air Quality



4.5.2.3 Temporal Extrapolation of 1990 Monitored Air Quality to 2007/2010 based on Regional Oxidant Model Results

This analysis next develops equations to predict expected ozone concentration values for the year 2007 for monitored counties based on available air quality modeling conducted under alternative future year emissions assumptions. The temporal extrapolations lead to future year baseline ozone concentrations that incorporate anticipated air quality improvements due to implementation of current CAA requirements. The 2007 air quality predictions for monitored counties are used to identify and define nonattainment areas for the control strategy and cost analysis. The year 2007 was used as the year of analysis for the December 1996 assessment (U.S. EPA, 1996g). The current analysis examines the ozone nonattainment situation in the year 2010. Adjustments are made to the 2007 nonattainment area air quality to account for the different analytical year. The adjustment methodology is discussed at the end of this section.

ROM ozone air quality predictions for the 1990 basecase, 2007 CAA-mandated control, and 2007 regional control strategy scenarios are used in two regression equations to determine the statistical relationships between 1990 and 2007 ozone air quality concentrations under two alternative emission scenarios. The first emissions scenario, the 2007 CAA control scenario, simulates the net effects of growth and application of control measures currently required by the CAA on ozone concentrations in 2007 throughout the modeling domain. The second scenario, the 2007 regional control strategy, augments the CAA control scenario with application of a NOx cap limiting emissions from utility boilers and other boilers $\geq$ 250 MW to 0.15 lb/MMBtu and initiation of a national low emission vehicle (NLEV) requirement beginning with the 1999 model year to the entire modeling domain. It should be noted that biogenic VOC emissions are modeled for all scenarios as an uncontrollable component of VOC emissions. Thus, biogenic VOCs are factored into the responsiveness of simulated ozone concentrations to changes in anthropogenic ozone precursors.

The equations used to predict average expected changes in ozone concentrations between 1990 and 2007 are generated through Ordinary Least Squares (OLS) regression of 1990 ROM

basecase ozone concentration predictions and a number of explanatory variables against 2007 ROM predictions for the two emissions scenarios (MathTech, 1997). As noted earlier, ROM air quality results are available for the Eastern U.S. However, air quality concentrations are needed for the entire country to assess national benefits and costs. Through the inclusion of other explanatory variables, the regression equations control for factors that may differ between the east and west and could therefore explain variations in concentration values between 1990 and 2007. The specifics of these regression equations are outlined in Appendix A.5.

The results for the CAA-control scenario indicate that, all else equal, 2007 hourly ozone concentrations can be expected to decrease relative to 1990 hourly ozone concentrations. The results for the regional control strategy scenario suggest that, all else equal, 2007 hourly ozone concentrations also can be expected to decrease relative to 1990 hourly ozone concentrations. Evaluating the mean 1-hour ozone concentration in the regression function indicates that the regional control strategy results in a 7% decrease in mean hourly ozone concentrations relative to 1990 mean air quality concentrations. In comparison, the CAA-control scenario results in a 3% decrease in mean hourly ozone concentrations relative to the 1990 modeled predictions (MathTech, 1997).

The regression analyses show that the projected concentration values for 2007 are primarily affected by 1990 concentration values. Given that the goal of this method is to create a dataset of predicted hourly ozone data for each monitor in 2007, the results of the regression analysis are next applied to each monitor by multiplying each hourly 1990 monitored value by the appropriate coefficient. Adjustments are made at the county level by computing the quantitative impacts of the remaining terms in the regression equation. For the East, the results under the 2007 regional control strategy are applied given that the NOx cap and NLEV are assumed to be in place by 2010 in the emissions baseline for the current analysis. For the Western U.S., the results of the regression analysis for the 2007 CAA-control scenario are applied since a comparable NOx cap is not assumed in the 2010 emissions baseline for these areas. The NOx cap constitutes the bulk of the NOx emissions under the regional control scenario as the NLEV program in the Eastern 37 states is assumed to be fully implemented

sometime beyond 2010. Thus application of the 2007 CAA-control case for the West is more appropriate.

4.5.2.4 Identification of Ozone Nonattainment Areas

The predicted 2007 air quality for counties with ozone monitoring data in 1990 is next used to determine nonattainment status of individual counties. The air quality distribution for each monitored county is reviewed to identify the concentration value that triggers nonattainment for a specific form of the ozone standard. For example, the 3rd highest daily maximum 8-hour value is identified to determine whether that value exceeds an alternative standard level. This value for each monitor is defined as the "standard measure" for that monitor and standard. The highest standard measure for each standard alternative among the monitors in a given county is used as the county "design value". The design value location (i.e., monitor) may vary from one standard alternative to another in a given county. The design value for each county is evaluated against the concentration level triggering nonattainment to identify counties that do not meet each standard alternative. The rounding convention associated with the proposed ozone standard is factored into the concentration level triggering noncompliance for each standard alternative.[a]

A series of steps are then followed to define nonattainment areas for each standard alternative based on the county design value. Nonattainment areas may be a single county or a group of counties in a Consolidated Metropolitan Statistical Area or Metropolitan Statistical Area (C/MSA). The general principle used here in identification of nonattainment areas is that if the air quality of an area violates the ozone standard or if sources in that area contribute to violations in a nearby area, the area is considered nonattainment. This is not to prejudge how States may make future decisions in implementing the new standards. Ozone monitors generally are placed in areas with a high probability of recording standard violations, typically in counties

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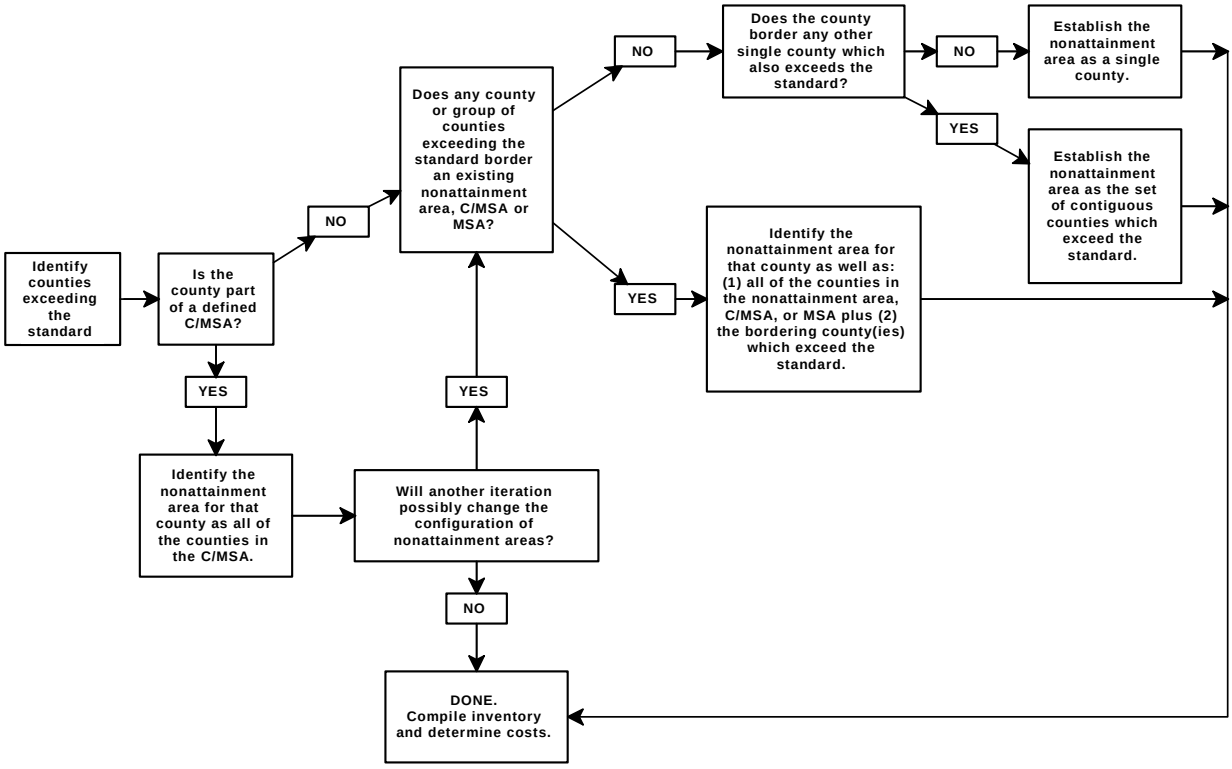
a The Federal Register Notice for the proposed ozone NAAQS (FR Vol. 61, No. 241, December 13, 1996) states that the rounding convention associated with the proposed standard is to round to the nearest 0.001 ppm. The current rounding convention is to round up digits equal to or greater than 5.

downwind of urban areas. Therefore, when these counties record violations of the standard, the upwind area(s) contributing the emissions should be included in the nonattainment area definition. The following schematic in Figure 4.5 describes the decision rules used to identify and define nonattainment areas (U.S. EPA, 1997d).

Figure 4.5 Process for Identification and Definition of Ozone Nonattainment Areas



4.5.2.5 Adjustments to 2007 Ozone Air Quality to Develop 2010 Air Quality

2010 Emissions Inventory Adjustments

As noted previously, the current analysis examines ozone air quality concentrations in the year 2010 assuming implementation of CAA-mandated controls and a regional control strategy in the East and CAA-mandated controls in the West. Because new air quality modeling is not conducted for this alternative analytical year, a method is developed to adjust 2007 baseline air quality in Eastern nonattainment areas to reflect changes in emissions between 2007 and 2010.

This adjustment is performed by comparing the 2010 NOx and VOC emissions for each

nonattainment area to the 2007 ROM-predicted NOx and VOC emission reduction targets (U.S. EPA, 1997f) needed for attainment of the most stringent ozone alternative considered in the analysis, the .08 ppm/8 hour/3rd max concentration. The change in VOC and/NOx emissions between 2007 and 2010 are counted towards achievement of the VOC and NOx emission reduction targets for the .08 ppm/8 hour/3rd max estimated for a given area as described below (U.S. EPA, 1997g):

$$\text{Air Quality Adjustment} = \frac{(NOx_{2007} - NOx_{2010}) + (VOC_{2007} - VOC_{2010})}{\text{NOx emission reduction target}_{2007} + \text{VOC emission reduction target}_{2007}}$$

where: NOx_{2007} = NOx emissions in 2007 (tpd)

NOx_{2010} = NOx emissions in 2010 (tpd)

VOC_{2007} = VOC emissions in 2007 (tpd)

VOC_{2010} = VOC emissions in 2010 (tpd)

NOx/VOC emission reduction target = amount of NOx or VOC that needs to be reduced to achieve attainment in 2007 (tpd)

The air quality adjustment is then applied to the nonattainment area design value monitor for the 0.08 ppm/8 hour/3rd max alternative to determine the percent rollback to be applied at all monitors in the nonattainment area. This alternative is used because it is the most stringent of the ozone alternatives analyzed and adjustment to air quality for this alternative only preserves a consistent air quality distribution across all alternatives.

Once the necessary baseline air quality adjustments have been made to capture nonattainment area emission inventory differences between 2007 and 2010, the development of air quality values in monitored counties for 2010 is complete. Thus, for the remaining discussion, the baseline air quality is referred to as 2010 baseline ozone air quality. This adjusted air quality is used to evaluate for a second time nonattainment status of monitored

counties.

Additional Information Applied to 2010 Baseline Ozone Air Quality

Given uncertainties in the method for predicting future year ozone concentrations, additional ozone air quality monitoring and modeling information is utilized to better characterize the 2010 ozone nonattainment picture.

1993 - 1995 Ambient Ozone Air Quality Monitoring Data

Ozone design values based on 1993 - 1995 AIRS data corresponding to the appropriate standard form are compared to the model-predicted design values. Those areas for which the 1993 - 1995 ozone design value is less than or equal to the level specified in the standard alternative are considered attainment for that alternative (U.S. EPA, 1997g). It is assumed for these areas that CAA-mandated controls will be sufficient to attain the specific standard alternative. There are three areas excluded from the current standard analyses based on this comparison. There are no areas excluded for the selected standard (0.08/4th max) analysis based on this comparison.

ROM and UAM-V Air Quality Modeling Results

Air quality modeling results for comparable emission reduction scenarios from ROM and UAM-V modeling for the Ozone Transport Assessment Group (OTAG) are also examined (U.S. EPA, 1997g). Those areas for which air quality modeling predicts will be in attainment of alternative standards in 2007 are considered attainment for this analysis based on this comparison. There are three areas excluded from the current standard analysis and 4 areas excluded from the selected standard (0.08/4th max) analysis based on this comparison.

Downwind Nonattainment Areas Identified through Air Quality Modeling

A number of small, individual counties are predicted to violate alternative standards in 2010. Upon closer inspection and examination of available ROM air quality results, these counties are determined to be downwind transport areas. Many of these counties are rural counties that have low NOx and VOC emissions. The predicted violations are a result of upwind contributions of ozone precursor emissions. Thus for control strategy and cost analysis purposes, control measures are not applied in these counties as it is assumed that upwind NOx and VOC reductions will mitigate the ozone problem in these downwind areas. For the benefit analysis, these downwind transport areas are assumed to be "attached" to the associated upwind nonattainment area. Thus, when calculating partial attainment air quality, air quality rollbacks for the upwind nonattainment area are applied to the downwind transport area in order to capture the air quality impacts of the upwind controls (U.S. EPA, 1997f).

4.5.3 Ozone Nonattainment Areas by Alternative

The model-predicted ozone air quality data for the 2010 CAA-control baseline is used to determine county air quality status. Nonattainment areas are identified from the set of counties monitored for ozone in 1990 as described in Section 4.5.2.4. Areas predicted to be in initial nonattainment of alternative ozone standards in 2010 for the East (i.e., 37 eastern States) versus the West are listed in Table 4.11. These are projections based on estimates and assumptions. Ultimate nonattainment area designations will be based on actual ambient monitoring data.

Table 4.11 Predicted Nonattainment Areas for Alternative Ozone Standards in 2010

Region	Number of Areas Predicted in Nonattainment of Ozone Alternatives			
	0.12ppm/1xx (current)	0.08ppm/3rd max (proposed)	0.08/4th max (selected)	0.08/5th max
East	5	20	12	8
West	4	8	7	7
TOTAL	**9**	**28**	**19**	**15**

4.5.4 Geographic Interpolation of Baseline Ozone Air Quality Using the Centroid Model for Ozone Standard Benefit Analysis

In order to assess national ozone benefits of implementation of alternative ozone standards, hourly ozone concentrations across the entire country are required. Because there are counties both within and outside of nonattainment areas for which no monitoring data exists, the centroid model is used to predict hourly ozone air quality concentrations in those nonmonitored counties. Additionally, given that some counties may have more than one monitor, the centroid approach can be used to assign a single hourly value to the monitored county centroid for each hour throughout the year. The centroid model is an interpolation method which permits data from monitors proximate to a county centroid to be interpolated to the centroid location (MathTech, 1997). This analysis uses the geographic centroid available from the Bureau of the Census (BOC, 1992) rather than the population centroid. "Proxy" monitors are assumed to be located at each geographic county centroid throughout the U.S. The centroid model is used to calculate hourly ozone concentrations for each of the "proxy" monitors for 2010.

4.5.5 Key Uncertainties Associated with 2010 Baseline Ozone Air Quality

There are many potential sources of uncertainty in the development of 2010 baseline ozone air quality. Although it is not possible to quantify the magnitude of the uncertainty, a qualitative discussion of uncertainties can be provided. In general, we believe that the national baseline ozone air quality results on net are not biased in either direction. Underestimates for individual nonattainment areas are balanced out by overestimates for other nonattainment areas. Given that

the methodologies used in the assessment of national costs and benefits are not sufficient to capture unique characteristics of each individual nonattainment area, area-specific baseline air quality results have a higher probability of bias (U.S. EPA, 1997l).

Table 4.12 presents potential sources of uncertainty and associated biases in estimating national 2010 baseline air quality. As described in Sections 4.3.3 and 4.3.8, there are uncertainties related to development of the 1990 emissions inventory and projection of those emissions to 2010. Biogenic VOCs may be underestimated relative to the more recent BEIS2 estimates, but potential biases in anthropogenic NOx and VOC emissions are unknown.

The emissions projections are input to the ROM model to produce future year ozone air quality predictions. The ROM is a regional-scale air quality model that is used in this analysis to estimate area-specific air quality. By definition, urban-scale characteristics of individual nonattainment areas are not captured in the ROM modeling. This approach increases the level of uncertainty in the national analysis and may produce positive or negative bias for any specific area. However, it is unclear if there is an overall bias in air quality at the national level.

Additionally, the ROM modeling relied on 1987 meteorology. Despite geographic variability in the severity of the meteorological data, overall, 1987 is not an unusually conducive year for high ozone for the period 1986 - 1995. Although there is uncertainty in predicting future meteorological conditions, reliance on 1987 data is not believed to bias the ozone air quality estimates. Finally, evaluation of ROM modeling has indicated that ROM 1990 base case predictions are higher relative to ozone monitoring data for some locations (U.S. EPA, 1996b). However, it is unknown whether or not ROM overpredicts for the future year scenarios. Because the prediction of future year air quality through the ROM extrapolation approach is primarily driven by the 1990 ozone concentration values, it is unclear if 2010 baseline ozone air quality is biased given ROM overprediction in the 1990 base case.

There are a number of potential sources of uncertainty associated with the ROM extrapolation methodology. As discussed previously, the extrapolation method is used to

develop air quality data for areas not covered by available air quality modeling. The extrapolation method employs one year of data for the year 1990. As discussed in section 4.5.2.2, there appear to be no biases introduced to the ozone analysis from these two potential sources of uncertainty. There is no reason to believe that the regression equation used to factor in growth and emissions control between the base case and projection years is biased (MathTech, 1997). Because of the lack of air quality modeling, extrapolation of air quality modeling results from the East to the West is necessary. This clearly brings uncertainty to the baseline ozone air quality concentrations for the West, although as discussed in Section 4.5.2.3, this method is largely driven by base case 1990 ambient monitoring values. It is unclear if there is any bias to this extrapolation procedure.

An air quality adjustment procedure is used to to account for CAA-control emissions inventory changes between 2007 and 2010. For the most part, emissions are projected to decrease between 2007 and 2010. It is therefore reasonable to assume that air quality would improve as a result of these reductions. Because it is not possible to account for the air quality impacts of these changes outside of the nonattainment area, there may be a small overestimate in baseline air quality. Similary, the centroid model used to predict ozone concentrations in nonmonitored counties cannot fully account for ozone transport from nonattainment areas to downwind areas. The centroid model employs geographic interpolation between ozone concentration values in monitored counties to derive ozone concentrations in nonmonitored counties. The centroid model is not an air quality model and therefore any transport impacts from emission changes between 2007 and 2010 cannot be assessed. Thus there may be a small overestimate of ozone air quality in nonmonitored counties outside of nonattainment areas.

Table 4.12 Uncertainties and Possible Biases in Estimating National 2010 Baseline Ozone Air Quality

Potential Source of Uncertainty	Positive Bias? (Overestimate)	Negative Bias? (Underestimate)	Bias Unclear
Development of 1990 emissions inventories and 2010 projections		✓ (biogenic VOC)	✓
ROM Modeling - Use 1987 meteorology - Use of regional model to estimate city- specific air quality - ROM tendency to overpredict			 ✓ ✓ ✓
ROM Extrapolation Methodology - Use 1 year of monitoring data - Use 1990 monitored air quality data - Regression - ROM extrapolation from East to West			 ✓ ✓ ✓ ✓
Emissions Inventory Adjustments	✓ (small)		
Centroid Model to predict ozone concentrations in nonmonitored counties	✓ (small)		

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5.0 CONTROL MEASURES

5.1 INTRODUCTION

This chapter briefly discusses the control measures for ozone, particulate matter (PM_{10} and $PM_{2.5}$), and regional haze employed in this regulatory impact analysis (RIA). The Environmental Protection Agency (EPA) has attempted to identify and develop impact estimates for control measures covering emission sources in nearly every source category that contribute to PM and ozone formation and visibility impairment. These control measures are in addition to the measures described in Chapter 4 as part of the baseline. The measures discussed in the chapter consist primarily of controls already in use, and are intended as illustrative of measures that could be chosen by states or local areas. Generally, the measures involve more conventional control approaches (e.g., "add-on" control devices installed downstream from an air pollution source) that are proven effective at reducing air pollution. Pollution prevention measures such as material substitution, source minimization, and fuel switching are considered to a lesser degree. Several less conventional measures are also included, such as education and advisory programs, sulfur dioxide (SO_2) emissions trading programs for utilities, and transportation control measures designed to slow growth in vehicle miles traveled (VMT). Technologies emerging now, or to be developed in the future, will likely play a key role in attaining the new standards 10 to 15 years in the future. These new technologies may be more cost effective than control measures analzyed in this RIA, but have not been included in the analyses presented in Chapters 6, 7, and 8. Chapter 9 discussess the potential benefits of new technologies and more flexibile implementation strategies.

In this analysis, five major emitting sectors are delineated: 1) utility point sources, 2) non-utility stationary point sources, 3) stationary area sources, 4) on-highway mobile sources, and 5) nonroad mobile sources. For each of these source categories, a variety of control measures for primary PM_{10} and $PM_{2.5}$, $PM_{2.5}$ precursors (SO_2, nitrogen oxides (NOx), volatile organic compounds (VOC)), ozone precursors (VOC, NOx), and regional haze contributors (primary

PM, SO_2, NOx, VOC), have been analyzed[a]. The list of control measures included in this analysis is not exhaustive. Many other control measures may exist, but are not included in this analysis because: 1) the EPA is not able to obtain reliable cost and/or emission reduction estimates; 2) at a specific source, another control measure is identified that achieves equal or greater control efficiency at equal or lower overall cost; or 3) the measure is not currently being implemented for administrative or social reasons.

Appendix B.1 contains a table listing the control measures employed in the PM, regional haze, and ozone emission reduction and cost analyses. This table indicates the emissions source category that is impacted and the national *average annual incremental cost per ton* of reduction associated with the area-specific application of a control measure[b]. For this analysis, all cost and emission reduction estimates for a given control measure are calculated incremental to controls already in place, or incremental to the next less stringent new control measure. As shown in Appendix B.1, several control measures achieve reductions in more than one pollutant. These types of control measures may be especially beneficial in areas that need to address multiple pollution problems (i.e., ozone and $PM_{2.5}$, or $PM_{2.5}$ and regional haze).

The application of some control measures may result in cost savings (i.e., negative average annual incremental cost per ton values). In these cases, the estimated cost savings are due to the recovery of valuable products or switching to technologies with lower long-run operating costs. Where these control measures are selected, the estimated savings is credited. Further, some control measures are assigned a zero incremental cost per ton. These measures involve either a long-run transition to a substitute technology with equivalent capital and operating costs, or behavioral change-inducing public information programs for which cost information could not

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a Controls for ammonia emissions were not included because: 1) ammonia emissions are not a particle-limiting pollutant in the formation of $PM_{2.5}$, and 2) ammonia emissions in the National Particulate Inventory used in this analysis are more uncertain than emissions of VOC, NOx, SO_2, and primary PM.

b For purposes of this analysis, *average annual incremental cost per ton* is defined as the *difference* in the annual cost of a control measure and the annual cost of the baseline control (if any), divided by the *difference* in the annual mass of pollutant emissions removed by the control measure and the emissions removed by the baseline control.

be found or easily developed.

Appendix B.2 contains a table listing all control measures included in this analysis, along with a document reference where the reader can find a more detailed discussion of how a specific control measure is developed. The table in Appendix B.2 indicates which control measures have been added or revised since the RIAs for the proposed NAAQS. Of the more than 200 source category-control measure combinations shown, more than half have been added or revised for this RIA.

In developing control efficiency estimates, it is assumed that control measures on average achieve 95 to 100 percent of their intended effect. This differs from EPA's recommended default rule effectiveness assumption of 80 percent. The EPA currently allows States to develop alternate rule effectiveness methods for control measures included in NAAQS implementation plans as long as they follow certain basic requirements as described in the 1992 and 1994 guidelines for rule effectiveness (U.S. EPA, 1992b and 1994). The EPA has routinely accepted plan provisions with 95 to 100 percent control measure effectiveness assumptions.

The degree of effectiveness applied to each measure depends on a variety of factors including the extent of monitoring and recordkeeping requirements, difficulty of control equipment maintenance, extent of over-control achieved by "margin of safety" engineering, and gross noncompliance (PQA, 1997). Generally, stack pollutants like NOx are more easily measured and monitored than, for instance, VOC emissions from fugitive sources. For that reason some NOx control measures may be expected to have a higher control measure effectiveness than some VOC control measures. Also, it may be easier to enforce effectively a handful of point sources than a large number of area sources. For that reason, control measures affecting a small group of point sources may have a higher control measure effectiveness than measures affecting a large group of area sources.

In order to derive county-specific cost and control efficiency estimates for mobile and area source control measures, it is necessary to estimate the degree of *rule penetration*. In this

context, rule penetration refers to the percentage of the county-level mobile or area source emissions inventory that is affected by the control measure. As used here, rule penetration effectively accounts for applicability constraints, such as size cut-offs. For example, a penetration rate of more than 90 percent indicates that the control measure applies to nearly every major emitting source within the source category. Conversely, a penetration rate of less than 10 percent indicates that only a few emitting sources may be affected. Rule penetration estimates generally are taken from published reports from state and local agencies.

The final emission reduction factor attributable to mobile and area source control measures is a combination of the estimated control efficiency, control measure effectiveness, and rule penetration. For example, an area source control measure with a 50 percent control efficiency, 95 percent control measure effectiveness, and 60 percent rule penetration rate, results in an emission reduction factor of 28.5 percent (0.5 * 0.95 * 0.6).

5.2 UTILITY POINT SOURCE CONTROL MEASURES

Under the Clean Air Act (CAA), the EPA's primary focus has been further controls on NOx and SO_2. Table 5.1 summarizes the controls in the baseline for the analysis of national ambient air quality standards (NAAQS) revisions. This baseline, which is estimated for the year 2010, assumes that all of the CAA's Title IV requirements are in effect, tighter new source controls are in place than exist in 1997 (based on today's best available control technology (BACT) decisions that have occurred in New Source Review), and a NOx cap-and-trade program has been implemented in the 37 Eastern States in the Ozone Transport Assessment Group (OTAG).

The EPA examined a number of additional NOx and SO_2 control measures for the utility sector. These include more stringent NOx reductions for the utility cap-and-trade program in the OTAG states, and more stringent SO_2 reductions for the nationwide Title IV utility cap-and-trade program. For the analysis presented in Chapters 6 and 7 of this RIA, it was decided not to include any additional NOx reductions for utilities beyond the levels currently required under Title IV and the levels recently recommended by the OTAG states. However, for the purpose of

reducing $PM_{2.5}$ formation on a broad geographic scale, the EPA is including in the analysis presented in Chapter 6 of this RIA a cost-effective control strategy that reduces the Title IV SO_2 emissions cap for utilities and large industrial boilers.

Table 5.1 Levels of Federal NOx and SO_2 Controls for Electric Power Generation in the Baseline for the Analysis of NAAQS Revisions

Pollutant	Baseline CAA Requirements for the Analysis of NAAQS Revisions
SO_2	Existing units: Comply with the Acid Rain Allowance Trading Program under Title IV of the 1990 CAA with phased-in requirements. Phase I covers the largest 110 coal-fired power plants beginning in 1995. All other units above 25 megawatts are covered in Phase II beginning in 2000. New units: Comply with the more stringent of New Source Performance Standards (NSPS) set in 1978, BACT/Lowest achievable emission rate (LAER) requirements, and the Acid Rain Allowance Trading Program under Title IV of the CAA 1990.
NOx	Existing units: Application of Reasonably Available Control Technology (RACT) occurred in 1995 in the Ozone Transport Region and all ozone non-attainment areas. Many States filed for and received waivers from RACT requirements. Compliance by coal-fired units with the Title IV NOx requirements that are phased in over time, or RACT, whichever is more stringent. Group 1/Phase I units comply with the Title IV emission limitations in 1996. Group 1/Phase II units and Group 2 units comply with the Title IV requirements in 2000. Collective action of the 37 Eastern States in OTAG leads to further summer season requirements on NOx emissions throughout the eastern US via a cap-and-trade program. New units: Comply with the more stringent of NSPS, BACT, and the Title IV standards for coal-fired units, whichever is more stringent. Units are also covered by the OTAG requirements of a cap-and-trade program.

To meet existing Title IV requirements and the more stringent SO_2 cap modeled for the new NAAQS, the EPA has modeled the following SO_2 control options:

1. Scrubber Installation. New coal-fired units must install scrubbers in accordance with the NSPS, but do have some freedom on how much SO_2 reduction they obtain above the limitations in the NSPS. Existing units can install them. Those operating units that already have scrubbers can choose to increase the scrubber's performance levels to avoid purchasing allowances, or to free up allowances to trade with other operators of other units.

2. Fuel switching. Select coals or fuel oils with sulfur contents that will allow operators to minimize costs. Cost factors include the cost of scrubbers, the cost of allowances that operators may need to purchase if they continue using the same grades of fuel, and the prices of fuels with lower sulfur contents.

3. Repowering. Repower existing coal-fired or oil-fired units to natural gas combined-cycle, or switch to natural gas. (This choice reflects the fact that the units can simultaneously reduce NOx and SO_2 emissions to minimize the total cost of both sets of pollution controls.)

4. Natural Gas Replacement. Retire existing coal-fired, or oil-fired units and replace them with combined cycle natural gas units. (This choice also reflects the fact that units can reduce both NOx and SO_2 emissions simultaneously.)

5. Purchase Emission Allowances. Operate units so that they do not exceed allowance levels, or purchase of limited numbers of allowances.

Several types of hybrid actions are also possible. Notably, the modeling framework allows units to install both NOx and SO_2 pollution controls (under Title IV) together where it would economically make sense for a unit to do so. The costs and performance of scrubbers, repowering, and adding new capacity appear in EPA's Analyzing Electric Power Generation under the CAA (U.S. EPA, 1996).

For the analysis of the alternative $PM_{2.5}$ NAAQS, the EPA has modeled a trading and banking control strategy that reduces the annual SO_2 emissions cap by 60 percent to 3.58 million tons in 2005. In this report, this control strategy is referred to as the National $PM_{2.5}$ Strategy. The National $PM_{2.5}$ Strategy is a 60 percent reduction beyond Title IV Phase II levels, and is achievable with existing technology. It is assumed that lowering the SO_2 emissions cap would occur in 2005 and lead to nearly a 50 percent reduction nationwide of annual SO_2 emissions by 2010. Table 5.2 shows the regional emission reductions that EPA expects to occur by the analysis year 2010. Most of the SO_2 reductions occur in the Midwest/Northeast and Southeast

control regions.

Table 5.2 Emission Reductions for National $PM_{2.5}$ Strategy: 60% Utility SO_2 Reduction from Title IV Phase II Levels (thousand tons per year)

PM Control Region[a]	SO_2	NOx	VOC	Primary PM_{10}	Primary $PM_{2.5}$	SOA (tons per year)
Midwest/Northeast	2,789.0	108.6	(1.0)	4.4	0.6	18
Southeast	1,290.4	86.7	(3.0)	10.4	(0.1)	11
South Central	354.1	(9.0)	(0.2)	0.9	0.2	5
Rocky Mountain	72.9	8.8	(0.1)	0.1	0.0	3
Northwest	4.5	0.1	0.0	1.6	0.6	0
West	0.0	(0.1)	0.0	0.0	0.0	0
Nation	4,510.9	195.1	(4.3)	17.4	1.2	36

a See Chapter 6 for a discussion of PM Control Regions

Since utilities are predicted to over control emissions initially and bank allowances for later use, the SO_2 emissions level in 2010 is expected to be 5.2 million tons, or a 47 percent reduction from the NAAQS baseline. The additional 13 percent reduction is expected to be realized sometime after 2010. The estimated annual incremental cost in the year 2010 of implementing this regional SO_2 reduction strategy for the electric power industry is $2.6 billion (1990$).

It is important to note that regional shifts in power generation due to utility deregulation, and regional shifts in emissions control responsibility due to emissions trading can mean that reductions in NOx and SO_2 emissions are not realized in specific locations. For instance, note that Table 5.2 indicates minor increases in NOx emissions in the South Central and West control regions.

5.3 NON-UTILITY STATIONARY POINT SOURCE CONTROL MEASURES

The non-utility stationary point source category contains a diverse group of sources including combustion sources at various manufacturing operations and institutional facilities, larger surface coating operations, and process fugitive dust sources at mineral processing plants. Examples of stationary point source control measures include “add-on” stack controls (such as fabric filters and carbon adsorbers), process fugitive controls (e.g., wet dust suppression), and combustion modifications (low-NOx burners, etc.). Control costs for these measures are estimated at either the point source or source category level. Where sufficient source data are available for point sources, the cost is calculated using control measure and process size-specific cost equations based on a size indicator available in the emissions inventory. Examples of this indicator include stack gas volumetric flowrate and boiler design capacity.

Other point source emission reduction and control cost estimates are developed from information contained in published reports from state and local agencies. Every effort is made to verify that the estimates derived from these published reports are broadly applicable in a nationwide analysis, and that sound engineering cost procedures are used to develop the published estimates.

5.4 STATIONARY AREA SOURCE CONTROL MEASURES

The stationary area source category also contains a diverse group of sources including smaller combustion sources at various manufacturing operations and institutional facilities, surface coating operations, and fugitive dust sources like paved and unpaved roads. Examples of area source control measures include combustion modifications (low-NOx burners, etc.), fugitive controls (vacuum sweeping and wet dust suppression), add-on stack controls (incineration), and VOC content limits for coatings and various consumer products.

Since the National Particulate Inventory (NPI) does not contain source-specific information on area sources, emission reduction and control cost estimates are developed from information contained in published reports from state and local agencies. In a few cases, the area source categories correspond to point source categories where control efficiency and control cost

estimates are already developed. For example, the cost for low-NOx burner controls on industrial coal, oil, and gas combustion is adapted from low-NOx burner controls for industrial point source boilers. In these cases, the point source control efficiency and cost estimates, expressed in dollars per ton of pollutant reduced, are applied to the area source control. An effort is made, if appropriate, to use the point source data associated with the source size expected to be present in the area source category. Also for a few control measures, control efficiency and control cost estimates are transferred from similar, but not identical, applications. For example, the VOC control measure for metal can coating is transferred from industrial surface coating categories.

5.5 MOBILE SOURCE CONTROL MEASURES

The mobile source control measures employed in this analysis are classified in two groups: national measures and local measures. Mobile source control measures that are based on changes in vehicle or engine emission standards are best applied at the national level. It would be expensive and difficult for vehicle and engine manufacturers to comply with a patchwork of standards applied at the local level, and, because motor vehicles and engines are mobile, much of the benefit of vehicle or engine emission standards applied at the local level would be lost to immigration of dirtier vehicles or engines into the local area. In contrast, control measures like vehicle inspection and maintenance (I/M) programs, cleaner burning fuels, and VMT management programs are more effectively implemented at the local level.

5.5.1 National Mobile Source Control Measures

Several potential mobile source control measures involving the creation of new emissions standards for on-highway and nonroad mobile sources were examined. Many of these measures, particularly those involving nonroad and heavy duty engines, have the potential to result in significant long-term reductions in NOx, VOC, and/or PM emissions. However, given the implementation schedules of current and planned standards which are already included in the 2010 CAA baseline, most of these new measures can not be implemented soon enough to

provide substantial reductions by 2010. As a result, only one mobile source control measure, tighter exhaust emissions standards for light duty trucks, is included in this analysis. This control measure is applied here as an ozone control measure, and the cost of the program is attributed to the ozone standard. However, the VOC and NOx reductions from this measure may also benefit the $PM_{2.5}$ NAAQS and regional haze.

The baseline of this analysis assumes the existence of a voluntary National Low Emission Vehicle (NLEV) program. The NLEV program in the baseline is based on California emission standards that are more stringent than the standards required in the CAA (referred to as "Tier 1" standards). However, the EPA has the option to require still more stringent standards (referred to as "Tier 2" standards) beginning as early as the 2004 model year. The CAA requires the EPA to conduct a "Tier 2" study to determine if additional reductions in emissions from light duty gasoline vehicles (LDGV) and light duty gasoline trucks (LDGT), beyond the Tier 1 standard reductions required in the CAA, are necessary to meet the NAAQS.

The required study is not yet complete, and it is not the intent of this analysis to prejudge the outcome of the study. However, if the study concludes that additional reductions are needed, one likely way to get these reductions would be to target the four categories of light duty trucks for more stringent standards. Motor vehicle sales statistics indicate that light duty trucks are becoming a greater proportion of the light duty motor vehicle fleet. At the same time, they are subject to less stringent exhaust emissions standards than passenger cars. Further, the heavier categories of light duty trucks (those with a gross vehicle weight rating of 6,000 to 8,500 pounds) are not included in the NLEV program, while the lighter categories could have emissions standards tightened to more closely match those for passenger cars.

The following limits are assumed for passenger cars and light duty trucks beginning with the 2004 model year:

Category	NMOG (grams/mile)	NOx (grams/mile)
LDGV	0.075	0.20
LDGT1	0.075	0.20
LDGT2	0.100	0.20
LDGT3	0.195	0.40
LDGT4	0.195	0.40

These standards are chosen to maximize the NOx benefits of the potential Tier 2 program. The non-methane organic gases (NMOG) and NOx standards used in this analysis for the LDGV and LDGT1 categories are identical to those in the NLEV program. The standards for the LDGT2 category are the same for NMOG, but a tighter NOx standard is used in this analysis. The heavier categories of light duty trucks, LDGT3 and LDGT4 categories, are not included in the NLEV program. The LDGT3 standard included in this analysis is less stringent than the equivalent California LEV standard for NMOG but more stringent for NOx. The LDGT4 standard is identical to the equivalent California LEV standard for NMOG but more stringent for NOx. Emission reductions associated with these standards are modeled using MOBILE5a with alternate basic emission rate equations.

Costs for these standards are based on estimates developed by the California Air Resources Board (CARB) for its LEV program. CARB estimates the incremental per vehicle cost to achieve LEV standards at $120. Because the LDGV and LDGT1 standards are equivalent to the NLEV standards, no incremental cost is assumed for these vehicles. For the LDGT2 category, it is assumed that because only the NOx standard is further tightened, the additional cost will be half of CARB's estimate for achieving the LEV standard, or $60 per vehicle. For the LDGT3 and LDGT4 categories an incremental cost of $120 per vehicle is assumed.

5.5.2 Local Mobile Source Control Measures

In this analysis, local mobile source control measures include heavy duty engine retrofit programs, transportation control programs designed to reduce VMT, clean engine fleet vehicles, and clean burning fuels. Each of these control measures is discussed in this section.

5.5.2.1 Heavy Duty Engine Retrofit Programs

Heavy duty engine retrofit programs can be applied at the local level to target emission reductions where they are most needed. Heavy duty engines for both highway and nonroad vehicles are a significant source of PM emissions. Tighter standards for new engines (Tier 2 or Tier 3 standards depending on engine size classification), which are included in the 2010 CAA baseline, will help to reduce PM emissions from the heavy duty highway and nonroad fleets. However, because of slow fleet turnover rates for these engines, significant numbers of older engines certified to less stringent emissions standards will still be present in the fleet in 2010. One way to reduce the emissions of these engines is to upgrade or retrofit them with after-treatment devices. Upgrades or retrofits can be done when the engines are being rebuilt, which typically occurs at least once during their lifetimes.

The EPA has experience with these programs through the existing Urban Bus Retrofit Program. However, the costs and emission reductions associated with broader application of these programs is somewhat uncertain, particularly for nonroad engines. It is assumed that both highway and nonroad engines subject to the program can achieve a 25% reduction in PM emissions at a cost of $1,000 per engine. These estimates are based on EPA's experience to date with the existing Urban Bus Retrofit Program, which has achieved similar reductions at similar cost. The number of engine retrofit candidates will vary based on the design of the local program. Based on the limited period preceding the analysis year 2010 over which these programs can be phased in, it is assumed that 25% of all pre-1994 highway heavy duty engines still in the fleet in 2010 can be retrofitted. For nonroad engines, it is assumed that 25% of all pre-2001 engines can be retrofitted by 2010 (Dolce, 1997).

5.5.2.2 Transportation Control Measures

It has been shown in several pilot projects, most notably in the Portland, Oregon metropolitan area, that implementing innovative, voluntary transportation measures can directionally influence the growth rate of VMT. Due to the voluntary nature of these programs and the wide variety of transportation measures available to states and localities, it is difficult to estimate specific reductions in the growth rate of VMT, and hence emission reductions attributable to these measures. However, there is general agreement among expert sources that a nationwide 5% reduction in the rate of VMT growth over a ten year period (2000-2010) is reasonable. For instance, an area that had 2.0 percent annual VMT growth would instead experience 1.9 percent growth. The cost of transportation control measures (TCMs) is not easily estimated and will vary depending upon the collection of measures employed and many area-specific factors. For this analysis, the cost of an area-specific package of TCMs that reduces the growth rate of VMT by 5 percent is assumed to be $10,000 per ton of NOx reduced. (Dolce, 1997)

5.5.2.3 Fleet ILEV Program

The use of cleaner fuels could be a source of additional emission reductions for the light duty vehicle category. However, estimating the amount of additional exhaust reductions associated with burning cleaner fuels when compared to normal gasoline fueled vehicles already meeting the baseline NLEV standards is uncertain. Certain liquid fuels that have relatively low vapor pressures or gaseous fuels that must be contained in pressurized fuel systems provide clear advantages over normal gasoline with respect to evaporative emissions. Vehicles that properly use these fuels and, as a result, have zero evaporative emissions, are referred to as Inherently Low Emission Vehicles (ILEVs).

This analysis assumes that localities could impose requirements that all centrally-fueled light duty fleet vehicles meet ILEV standards by 2010. These ILEVs are assumed to have no evaporative emissions, to comprise 3% of the light duty vehicle and truck VMT, and to have a

lifetime incremental cost of $1800 per vehicle. (U.S. EPA, 1992a)

5.5.2.4 Reformulated Gasoline

Beginning with the year 2000, more stringent standards will take effect for all reformulated gasoline (RFG) areas. These standards require that VOC emissions be reduced by about 27.5 percent, and that NOx emissions be reduced by 6.8 percent, on average, relative to the emissions of baseline gasoline as defined in the CAA. These more stringent standards, called Phase II standards, also require a 21.5 percent year-round reduction, on average, in air toxics, which is based on mass reductions in benzene, formaldehyde, 1,3-butadiene, acetaldehyde, and polycyclic organic matter (POM). The EPA had previously determined that the overall cost for Phase II RFG, incremental to the cost of the baseline fuel and including the required addition of oxygen and removal of much of the benzene, would be 5.1 cents per gallon (U.S. EPA, 1993).

The costs reflected in Appendix B.1 were developed prior to the development of the 2010 CAA baseline projection. Based on the subsequently false assumption that most major cities east of the Mississippi River would be out of attainment for the proposed ozone NAAQS, the EPA assumed RFG would be chosen as a control strategy over most of this region of the country. The estimated incremental cost for implementing the RFG program under this scenario is 6.7 cents per gallon, reflecting the higher costs associated with reformulating a greater fraction of the gasoline pool. However, based on the 2010 CAA baseline projection, the number of areas which ultimately might use the RFG program represent a much smaller portion of U.S. gasoline consumption than originally assumed. Thus, the costs are overestimated by as much as 1.6 cents per gallon (6.7 minus 5.1 cents per gallon). If a lower cost had been used in this analysis, the average incremental cost per ton for the RFG program would be lower than indicated in Appendix B.1.

In addition, the manner in which the full costs of the RFG program are allocated to either VOC control or to NOx control results in the program appearing to be less cost effective than previous EPA projections have indicated. When finalizing the RFG program, EPA evaluated the

costs of the VOC and NOx standards independently using only the incremental cost associated with meeting each standard (U.S. EPA, 1993). The EPA thus concluded that the Phase II RFG NOx standard is cost-effective (about $5,000 per ton of NOx controlled), while the VOC standard similarly is determined to be cost-effective (about $500 per ton of VOC reduced). The remaining costs of the program were attributed to the toxics reductions achieved. Clearly, in this RIA where the full costs of the program are allocated to either NOx or VOC control, the cost-effectiveness value will be larger than shown in previous work. The EPA does not view the costs in Appendix B.1 to be inconsistent with previous work because the bases for the analyses are so different.

5.6 ANALYTICAL UNCERTAINTIES, LIMITATIONS, AND POTENTIAL BIASES

The cost and emission control effectiveness estimates for the control measures used in this analysis are developed using inputs from several reliable data sources and using best engineering judgement. Cost and effectiveness values may vary significantly among specific applications due to a variety of source-specific variables. Air pollution officials in airshed planning regions will decide exactly how the area-specific control measures are applied. Their actions will ultimately determine the actual costs and effectiveness of these measures, and of the overall air pollution control program.

The NPI characterizes the emission sources that may potentially be affected by control measures. Because of the vast number of emission sources for most pollutants (e.g., VOC emissions from filling gasoline storage tanks), data are not developed for each individual emission source. Control measure cost estimates are developed by applying cost algorithms to the available information in the NPI. The lack of detailed information in the NPI reduces the level of confidence in the cost estimates, but does not necessarily introduce systematic bias.

For some point source categories appearing in the NPI, data are available for a range of model plant sizes. In such cases, cost equations are developed relating size of the emission production activity to costs. For example, costs for flue gas desulfurization (FGD) scrubbers on

SO_2 emission sources are based on a spreadsheet model that relates input parameters such as stack gas flowrate and annual operating time to costs for FGD scrubbers. These variables are available for many point sources in the NPI. For other point source categories and all area and mobile source categories, an average incremental cost-effectiveness value (dollar per ton of emission reduction) or other similar average cost value (cents per gallon of gasoline) is used. Costs are developed at the source category level for these sources because the readily available data do not provide enough information to differentiate costs by emission source size or other cost differentiating parameters. Another limitation relates to many of the PM area source control measures. For many of the area source PM control measures it is sometimes necessary to estimate the PM_{10} cost effectiveness from total suspended particulate (TSP) cost-effectiveness data.

Another source of uncertainty is associated with the fact that costs are estimated for a projected year of 2010 (in 1990 dollars). The projected level of emissions and level of learning and technological innovation that will occur in emission control industries between now and 2010 are inherently uncertain.

Another limitation associated with the cost estimation procedure involves the transfer of cost information, which was developed for other purposes, to this analysis. The extent of this limitation is largely a function of the available cost data. Given the vast number of control measures and potentially affected sources, it is not possible to develop detailed control cost estimates for each individual emission source or even each source classification code (SCC). Cost information is taken from or developed using EPA costing manuals and guidance documents, State and local agency attainment plans, background documents for New Source Performance Standards (NSPSs), and other sources. Cost methods, where they are adequately documented, are reviewed to verify that correct procedures are used. However, some potential data sources provide emission reduction and cost estimates with little or no supporting documentation. For this reason, several measures lacking sufficient supporting documentation are excluded from this analysis. The extent to which such measures can achieve genuine reductions at the costs estimated is unknown.

In addition, many of the available cost estimates are based on cost studies that were conducted in the 1980s. For this analysis, these estimates are adjusted to reflect 1990 price levels using an appropriate price index. It would be possible, with a significant additional time commitment, to develop current estimates that would reflect any production-oriented advances that may have affected these costs (e.g., any scale production/cost effects that may have occurred from increased demand for the control technology). As noted above, no attempt is made to account for the potential effects of future technological innovations.

5.7 REFERENCES

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