Chapter 4

Safer Food and Public Health

The Clinton Administration brought great change to the regulation of pesticides and toxic chemicals, which resulted in stronger protections of public health, especially for children. Essential to that change was a new law, a scientific review of the older pesticides, cancellations of products deemed unsafe and a process that involved everyone: consumers, health experts, farmers and chemical producers.

In the opening months of the Clinton Administration, the National Academy of Sciences (NAS) issued a report, which concluded that the scientific and regulatory approaches to pesticide regulation and food safety did not adequately protect infants and children. In response, EPA, the Department of Agriculture and the Food and Drug Administration -- in cooperation with the White House -- developed a set of comprehensive legislative principles to strengthen the Nation's pesticide and food safety laws, which had not been updated in more than a generation and spoke only to cancer risks in processed foods. This set of principles called for a new system of standards for all health risks and all foods and specifically a requirement that infants and children be fully protected.

These legislative principles were sent to Congress on September 1993, and proposed legislative language was sent to Congress on April 1994. For the next two years, Congressmen Henry Waxman, D-Ca., and Tom Bliley, R-Va., worked with Administration representatives from the White House, EPA, the Department of Agriculture and the Food and Drug Administration, to produce a bipartisan package that would receive broad support and become the Food Quality Protection Act of 1996 (FQPA).

Congress took up the Food Quality Protection Act in July 1996. The Senate debate lasted 28 seconds -- the House debated just a little bit longer. The bill passed unanimously passed within days and was signed into law by President Clinton on August 3, 1996.

This landmark environmental law established stronger safety standards for all pesticides used on food. And for the first time in history, the special vulnerabilities of children would have to be explicitly considered when setting pesticide safety standards.

"This legislation is long overdue," President Clinton said in his radio address that day as he prepared to sign the bill. "The old safeguards that protected our foods from pesticides were written with the best intentions, but they're simply no longer up to the job. Bad pesticides have stayed on the market too long, good alternatives have been kept out. There are strong protections against cancer, but not against other health dangers. Those weaknesses in the present law put us all at risk, but especially our children."

The new act also directed EPA to revisit all existing tolerance limits for pesticide residues on food to ensure they met these tougher standards. At the same time, EPA was implementing its ongoing re-registration program to ensure that all pesticides were evaluated based on the most current scientific information.

On August 2, 1999, using the new tougher standards, EPA announced cancellation agreements and use reduction of methyl parathion and azinphos methyl -- two of the oldest, most widely used pesticides then in use. These pesticides, known as organophosphates, can affect the nervous system. On December 5, 2000, EPA announced an agreement to phase-out diazinon, one of the most widely used pesticides in the United States. By December 2000, of the 45 organophosphates 43 had been subjected to a final risk assessment.

By the end of the Administration, of the 612 pesticides subject to re-registration review, only 167 had yet to be reviewed. EPA also completed one-third of the required pesticide residue limit reviews under the tougher standard.

Congressional Threats to FQPA

In the 106th Congress, Representative Richard W. Pombo (R-CA) and Senator Charles Hagel (R-NE) introduced legislation to roll back the health protections included in FQPA. A majority of members in both the House and Senate cosponsored the legislation that would have imposed new procedures on EPA when assessing risk and evaluating data in reassessing existing pesticide tolerances or residues. The proposed bills would have effectively constructed two unequal sequences of science and information requirements: One for new registrations and unaltered tolerances; and another more laborious process to change or cancel a tolerance.

These bills would have defeated FQPA's primary goal of ensuring the uniform application of new safety standard for all pesticides used on foods. A number of members had threatened to attach the FQPA roll back bill on the VA-HUD Appropriations Bill or the Omnibus Appropriations Bill. They were unsuccessful.

Safer Pesticides

EPA also streamlined the registration process for reduced-risk pesticides, giving their applications priority treatment for review. In fact, in the final four years of the Clinton Administration, EPA had registered more than 100 safer pesticides and reduced-risk conventional chemicals. By the year 2001, over half of all new pesticide approvals were for reduced-risk, safer pesticides.

In December 1994, EPA established the Pesticide Environmental Stewardship Program (PESP) to teach and promote safer pest control techniques with farmers, environmental groups, all levels of government and community groups. More than 130 partnerships were formed and resulted in the reduced use of chemical pesticides. For example, through the PESP program, the Department of Defense reduced their overall pesticide use by 50 percent, which meant a reduction of 442,000 pounds over the course of the Clinton Administration.

Endocrine Disruptors

As part of the growing concern that pesticides and chemicals were adversely affecting the endocrine (hormone) system of humans and animals, EPA went to Congress with a plan to research and evaluate this potential threat. These endocrine disrupters can damage a woman's reproductive system and lead to birth defects and other congenital problems in children.

As part of FQPA, Congress adopted EPA's proposal to establish a screening and testing program to determine if pesticides and other chemicals affect the endocrine system. The screening and testing program established by EPA involved cutting edge science -- both by EPA and outside scientists. The work reflected the Clinton Administration's commitment to promoting public health and environmental protection using the best available science.

Expanding Chemical Information and Public's Right to Know

On Earth Day 1998, the Vice President launched the Chemical Right-to-Know Initiative to respond to studies that determined that very little basic toxicity information is publicly available on toxic chemicals, and that the traditional approaches to implementation of the Toxic Substances Control Act were not effective. This voluntary program linked two major themes driving EPA's efforts: identification of and protection from chemical hazards; and a commitment to increase the

public's right-to-know. The goals of this initiative were to acquire absent chemical data and make basic information available to the public on chemicals routinely used in the U.S. The program incorporated a combination of voluntary and regulatory approaches to encourage industry to voluntarily sponsor chemicals to fill the gaps in missing test data. EPA proposed test rules that sought basic screening-level data on chemicals not captured in the voluntary program. At the end of 2000, more than 469 companies, either individually or as part of 161 consortia, had agreed to test over 2,155 high volume chemicals. The goal is to have all the information available by 2004.

Consumer Labeling Initiative (CLI)

To further increase information available to the public, the Consumer Labeling Initiative (CLI) was introduced in March 1996 to foster pollution prevention, empower consumer choice and improve consumer understanding of safe use, environmental, and health information on household consumer product labels. The initiative was a voluntary partnership involving EPA, other government agencies, companies that make and distribute household cleaners and pesticides, and various stakeholders. In 2000 the first redesigned labels hit product shelves and EPA launched the "READ the Label First" campaign, a public outreach effort to assist consumers in choosing the right product for their needs -- keeping themselves, their children and their pets safe, while also saving money and helping the environment.

Protecting Pesticide Workers

While regulations protecting farm worker from pesticide exposure had been in development since the 1970s, the Clinton Administration successfully finalized and implemented the program, providing enhanced protection to thousands of farm workers. In 1994, EPA fought off Congressional attempts to weaken and delay the program. EPA required updated pesticide

labels with new worker protection information and also produced and distributing bilingual or multi-lingual educational materials about pesticide safety. These efforts include the publication of more than 1 one million grower compliance manuals, 2.7 million safety training manuals, 680,000 safety posters and more than 11,000 safety training videos and training sessions to learn or review the appropriate methods for applying pesticides.

Chapter 5

Enforcement and Compliance Assistance

One of the earliest actions of the Clinton Administration was a reorganization of EPA's enforcement efforts. Vice President Gore, in a personal visit with EPA senior career managers, announced a consolidated and strengthened Office of Enforcement complemented by compliance incentives and compliance assistance -- an approach designed to allow EPA to help businesses understand and meet their obligations, and to provide strong federal enforcement to ensure that no unfair competitive advantages were obtained by those not meeting their environmental protection requirements.

The result was a new Office of Enforcement and Compliance Assurance (OECA), which enjoyed unprecedented success. By the end of the Administration, EPA was collecting the largest penalties ever paid under each environmental statute it enforced. It was also securing more injunctive relief than ever, achieving the greatest emissions and discharge reductions, obtaining longer jail sentences, entering into more facility-wide consent decrees that addressed all pollution sources at a facility, and providing new levels of compliance assistance and incentives.

From 1981 to 1993, the organization of EPA's enforcement program was largely decentralized. Attorneys and media-specific (i.e., air, water, toxics) technical compliance staff were divided among the individual media program offices and regional media offices. Only cross-cutting policy and judicial cases were coordinated through the Office of Enforcement.

While this method of organization and strategic approach was generally successful in resolving specific violations and providing a general enforcement "presence," it had several major limitations. First, it was difficult to prioritize or effectively address violations based on

considerations of environmental "risk" or significant impact on public health and the environment. Second, it was difficult to analyze regulated sectors as a whole in order to develop integrated strategies to promote overall compliance. Third, it was difficult to measure or assess overall improvements in environmental quality and compliance rates.

The Office of Enforcement and Compliance Assurance was reorganized to consolidate all its activities to a single headquarters organization. The reorganization provided the opportunity to improve the effectiveness of traditional enforcement activities and develop new approaches to compliance incentives and compliance assistance.

From 1996 through 1999, EPA actions resulted in emission reductions of 5.8 billion pounds of nitrogen oxide, more than 409 million pounds of carbon monoxide and the elimination of more than 700 million pounds of PCB-contaminated material.

In the same four-year period, EPA actions also resulted in the collection of $849 million in penalties, almost $500 million in supplemental environmental improvement projects beyond what the law mandated, and $8.7 billion to correct violations.

Targeted Enforcement

With the reorganization, OECA undertook a new enforcement strategy. It shifted its focus from pursuing individual cases, hoping to achieve a general deterrent effect, to one that looked at combined media (air, water, waste and toxic) problems across sectors, geographic areas, and communities. OECA dramatically enhanced its ability to target its work to the most significant environmental problems and areas of high rates of noncompliance. Over time, EPA had increasingly come to recognize that if one or two companies in a particular sector were engaged in particular behaviors, than many others in that sector were likely doing the same things.

Similarly, certain types of violations tended to occur in particular places or regions of the country. This was not only bad for public health and environmental protections, but it created a fairness issue for those who had made the investments to comply with environmental laws.

Using advanced data techniques and analyzing factors such as risk, environmental harm, and length and rates of noncompliance, OECA developed compliance priorities. As part of this strategy, OECA targeted specific geographic areas or select industry sectors where noncompliance patterns posed significant risks. This allowed EPA to pursue actions that would yield the greatest environmental benefits, including the most significant Clean Air Act enforcement initiatives in the history of the Agency. The actions resulted in consent decrees across a number of sectors, including coal-fired electric utilities, petroleum refineries, and the pulp and paper industry.

One of the best examples of the effect of this enforcement strategy was EPA's work on the "grandfathered" power plants. On November 3, 1999, Administrator Browner and Attorney General Janet Reno announced the result of the largest investigation in the history of EPA – a two-year operation involving nearly 100 people: complaints against seven utility companies and 17 of the coal-fired plants under their control who had for years been illegally releasing massive amounts of air pollutants. Another eight coal-fired plants were also issued notices of violation, including administrative orders against the Tennessee Valley Authority. Ultimately, the number of actions grew to eight lawsuits and 42 plants.

Under the 1990 amendments to the Clean Air Act, the electric utility companies were allowed to perform routine maintenance, but they were not allowed to make significant changes to the plant – such as increased generating capacity, increased burning of coal, or modifications that

prolonged the life of the plant – without seeking permits and adding state-of-the-art pollution control devices. When Congress amended the Clean Air Act in 1977, it believed the old plants would be replaced by newer, cleaner technologies. So it largely "grandfathered" these plants from meeting the tougher standards applied to new facilities, unless the facilities engaged in major modifications. In 1998, coal-fired plants dumped 12.4 million tons of acid rain-producing sulfur dioxide and 5.4 million tons of smog-producing nitrogen oxide into the air.

EPA investigators found evidence that these utilities spent hundreds of millions of dollars modifying their plants – increasing their life and increasing their pollution without applying for permits, without public notice and without installing pollution control technology required by law. One plant spent $60 million on five new furnaces. Another spent $10 million on 10 new burners.

In 2000, EPA reached landmark agreements with three power companies – Tampa Electric Company, Virginia Power, and Cinergy Corporation – system wide agreements which together could yield hundreds of thousands of tons of reductions in sulfur dioxide and nitrogen oxide emissions annually. The other suits were still ongoing.

Throughout the Administration, several large-scale cases produced unprecedented results. In July 1997, a judge ordered Smithfield Foods to pay $12.6 million for over 6,900 violations of the Clean Water Act at its hog slaughterhouse operations in Smithfield, Virginia. At the time of the violations, the facilities were illegally discharging over 1 million gallons of wastewater per day into the Pagan River, a tributary of the James River which flowed into the Chesapeake Bay. The State of Virginia had declined to act so EPA stepped in.

In October 1998, EPA reached a settlement with seven major diesel engine manufacturers that had illegally installed defeat devices to disable emission control systems. The settlement

would ultimately prevent 75 million tons of nitrogen oxide emissions from entering the atmosphere by the year 2025 and included $83.4 million in penalties.

In January 2000, Koch Industries agreed to pay $30 million -- the largest civil fine ever imposed under a federal environmental law -- to settle claims related to more than 300 oil spills. Koch was also required to spend $5 million on environmental projects.

In July 2000, EPA settled with Willamette Industries for failing to obtain Clean Air Act permits at 13 facilities in four states. The company agreed to pay $11.2 million, the largest Clean Air Act civil penalty ever assessed for factory emissions of air pollution. The penalty was shared with the three states that joined EPA in the suit. The new pollution control equipment required by the settlement would prevent the release of approximately 27,000 tons of pollutants.

Compliance Assistance and Incentives

As EPA reorganized its enforcement programs, it recognized that enforcement actions alone could not assure compliance across the regulated community. Thus, as part of the reorganization, EPA also created an extensive sector-based approach to compliance assistance. This approach focused Agency efforts on developing industry-based strategies to improve compliance in ways that were cheaper, cleaner and smarter. EPA created 10 Compliance Assistance Centers. Each Center was targeted to a specific industry or local government sector and worked to explain, in plain language, the federal environmental regulations that applied to that sector. During the Administration, those centers were visited on average more than 700 times a day by small and large businesses, farmers, local governments, technical assistance providers and the public, resulting in positive change. Based on an on-line Centers survey, more than 70 percent of the respondents said they took one or more of actions as a result of visiting a

Compliance Center. These actions included changing a production process; changing how they handled waste; obtaining a required permit; and/or contacting a regulatory agency for more information or requested technical assistance from EPA. Vice President Gore's National Performance Review recognized the Compliance Assistance Centers in 1996 with a Hammer Award.

Audit Policy

Recognizing that many companies were prepared to "get right," EPA developed the Self-Disclosure (or Audit) Policy, which provided incentives for self-disclosure and correction of environmental violations. Companies that self-policed and discovered environmental violations and promptly disclosed their violations to EPA could receive a partial or complete waiver of penalties. By 2000, more than 670 companies had disclosed violations at more than 2700 facilities. American Airlines alone eliminated nearly 700 tons of air pollutants annually.

Several states sought to develop their own audit programs. While EPA consistently supported state policies that provided incentives for self-disclosure of environmental violations, it did not approve of audit laws which undermined a state's enforcement authority by providing loopholes that allowed polluters to hide important information from the state and its citizens, or limit the state's ability to respond to serious threats to public health and the environment. Over the years, a number of states had enacted self-audit laws with positive results. Regrettably, some of these laws had provisions that allowed companies to keep information on harmful pollution and public health effects secret, or provided broad immunity for environmental crimes. EPA's position was that these provisions were not in the best interests of the public, and oftentimes were in potential violation of federal environmental programs for which the states had accepted

responsibility to manage. Of particular concern to EPA were laws and programs developed in Texas, Michigan, Ohio and Colorado. EPA worked to close the loopholes in those laws to ensure that businesses could operate in an atmosphere that encouraged voluntary self-policing, assured citizens that they would have access to important information, and ensure serious violations would be dealt with appropriately.

Policing Polluters

During the Clinton Administration, EPA doubled the number of criminal investigators and completed many high-impact prosecutions, including a record 208 years of jail time imposed on criminal defendants in 1999. EPA's criminal enforcement program investigated and prosecuted environmental crimes that seriously threatened or harmed public health and the environment. Successful investigations encompassed a wide range of criminal activities, including toxic waste dumping that resulted in serious injuries and death; industry-wide ocean dumping by cruise ships; oil spills that caused significant damage to waterways, wetlands, and beaches; international smuggling of chlorofluorocarbon (CFC) refrigerants that damaged the ozone layer and increased skin cancer risk; and illegal handling of hazardous substances, such as pesticides and asbestos, that exposed children and other vulnerable groups to potentially serious illness.

Successful prosecutions included Alan Elias, the owner and operator of Evergreen Resources, who was sentenced by a federal district court in April 2000 to serve 17 years in prison for environmental violations that left one of his employees with permanent and severe brain damage. Royal Caribbean Cruise Lines pled guilty to illegally dumping oil and hazardous chemicals into the ocean and was ordered to pay fines totaling $27 million. In some cases, Royal

Caribbean was discharging chemicals from their on-board dry cleaning and photoprocessing facilities into coastal waters.

Chapter 6

Science, Research and Development

Recognizing that good science was critical to EPA's work, EPA took a number of actions to improve the quality and management of its science. The Clinton Administration's work in this area was recognized and lauded by the Agency's Science Advisory Board and the Office of Research and Development (ORD) Board of Scientific Counselors -- an independent advisory group. EPA's groundbreaking work on the health hazards of fine particle matter in the air also received growing recognition. Numerous external scientific reviews of EPA's work and other scientific studies also confirmed EPA's original work in that area. Changes within ORD also helped set a new standard for the other scientific work conducted throughout the EPA's program offices and research facilities.

Since EPA's creation in 1970, its scientific practices and results received constant attention -- and often criticism. Congressional oversight committees and the judiciary expressed concern over the Agency's ability to base its regulatory and enforcement actions on defensible, reliable, credible science. EPA's science had been reviewed critically in reports from the National Research Council, the Agency's Science Advisory Board and the General Accounting Office.

The year before the Administration came to office, a panel was convened to report on the role of science at EPA. That report, *Safeguarding the Future: Credible Science, Credible Decisions*, concluded that "EPA science is of uneven quality, and the Agency's policies and regulations are frequently perceived as lacking a strong scientific foundation."

Paramount among the improvements undertaken by the Administration was the adoption of Agency-wide peer review requirements and the increased outreach to the scientific community,

including the Administration's "Science to Achieve Results" (STAR) program. In January 2001, the EPA's independent Board of Scientific Counselors approved the second edition of the EPA Peer Review Handbook.

As EPA's work became even more complex, the importance of good science only increased. For EPA's research to have credibility within the scientific community, the Agency recognized that its work had to withstand the rigors of scientific scrutiny. But it also knew that in addition to comprehensive scientific peer review, the Agency's science also had to withstand review by Congress, the regulated industry and the public, some of whom did not always understand the appropriate role of science in guiding the work of a regulatory agency or even the nature of scientific study, analysis and review itself.

The work of EPA in making important public health decisions -- and yet simultaneously continuing to ask more scientific questions -- would only continue to grow. Opponents of EPA argued that as long as there was yet another study that could be done, then no decisions could be made. This argument ignored the fact that the very nature of science itself is to ask another question.

EPA, along with other science agencies, needed to educate the public and Congress on the appropriate role of science – both its opportunities and its limitations. EPA's work to provide the protections Congress promised the American people was based on the best available science at that point in time, subject to a comprehensive peer review. Allowing those who would misuse the scientific process of asking that next question to delay action would be unfair to the public.

Science Management Improvements

Early in the Administration and continuing throughout, EPA commissioned a number of different studies and reviews of the Office of Research and Development. In response to the recommendations received, EPA undertook a functional reorganization of its Office of Research and Development (ORD) in 1995. This reorganization consolidated 12 laboratories, three field stations and four assessment centers into three national research laboratories and a national assessment center.

This reorganization reduced Washington, D.C., headquarters staff by half and established a National Center for Environmental Research to manage a $100 million competitive research grants program and a $10 million competitive graduate fellowship program.

The reorganization strengthened and expanded ORD peer-review practices for proposals, publications, risk assessments and laboratory programs. It also improved science quality through regular strategic planning based on risk assessment and risk management criteria. This allowed more rational and consistent prioritization of EPA's research activities and facilitated EPA's ability to focus on longer-term high payoff scientific issues and problems.

In 1995, EPA established an inter-office Science Policy Council to provide a more integrated approach to science and technology issues and a more effective means to use science information in its decision-making process. The Council made notable contributions toward improving agency peer review, children's health assessment, risk characterization, cumulative risk assessment, and human health and ecological risk assessment guidance.

Risk Analysis

An important principle in establishing the new ORD organization was improved risk modeling, which consisted of two related phases -- risk assessment and risk management. Under the Clinton Administration, EPA adopted the risk assessment process proposed by the National Academy of Sciences in 1983. The new process took into account exposure assessment, hazard identification, dose-response assessment, and risk characterization. Risk management entails determining whether and how risks should be managed, reduced or prevented.

Peer Review

The central role of peer-review to excellent and relevant science was affirmed in a memorandum dated June 7, 1994, from Administrator Browner. The Administrator implemented an Agency-wide peer-review program which called for office and region-specific standard operating procedures. In 1995, ORD was assigned responsibility to coordinate the all of the Agency's scientific planning and peer-review activities.

In 1997, the EPA Science Policy Council decided that a single, Agency-wide document was needed to guide Agency staff in the appropriate review of scientific and technical information. In response, the Science Policy Council published the first edition of its *Peer Review Handbook* in 1998. The Handbook recognized that Agency peer review should not be restricted to the final draft of work products. It said that such reviews undertaken at the planning stage of work could often be extremely beneficial.

Before the end of the Clinton Administration, peer review of final EPA research was tracked closely, detailed procedures had been developed for peer review and response to comments, and candidate documents for peer review were evaluated annually for consistency with

Agency policy and record keeping. The second edition of the EPA *Peer Review Handbook* was approved by the Council in January 2001.

Economic Analysis

At the beginning of the Clinton Administration, EPA was still using the same economic guidelines that had been issued ten years earlier. Recognizing the need to modernize these guidelines, EPA issued a new set of economic guidelines to improve the quality and consistency of economic analyses that support EPA's decision-making. Like any science, economics constantly evolved in response to new knowledge and technical innovations.

The new economic guidelines were a critical tool for the Agency's work. They specified the economic principles and procedures used by EPA to evaluate the costs and benefits associated with environmental policies and regulations. They also specified how to analyze the economic impacts of decisions and assess the distribution of costs and benefits among various segments of the populations, with a special emphasis on disadvantaged and vulnerable groups. EPA was recognized as being a leader in this area by the Science Advisory Board.

Advancing Science and Technology

During the Clinton Administration, EPA researchers made significant advances in science and technology. Examples include the areas of drinking water, clean air, ecosystem protection, children's health and pollution prevention. In support of the Safe Drinking Water Act, EPA Research improved the understanding of the risks posed by microbial pathogens and chemical contaminants. ORD research demonstrated potential adverse health effects of arsenic and chlorination by-products. EPA research also identified potentially harmful chemicals created when ozone is used to disinfect water.

EPA made advances in science for clean air. Particulate matter from power plants and motor vehicles posed a significant air pollution problem to the nation. EPA played a major role in assessing the health risks of airborne particles and understanding their sources. In 1996, EPA completed a comprehensive Air Quality Criteria Document that served as the scientific foundation for EPA's standards to control particulate matter.

Protecting children's health by taking into account their particular sensitivities was one of EPA's highest priorities. During the Clinton Administration, EPA made important strides in its research programs to better understand and respond to risks to children. In 1997, EPA revised its Exposure Factors Handbook to take into account children's unique patterns of activity. In 1998, EPA joined with the HHS to establish "Centers of Excellence in Children's Environmental Health Research" at eight leading research institutions.

In December of 1997, EPA released its eight-volume *Mercury Study Report to Congress* that evaluated the human health and environmental impacts of mercury emissions to air resulting from human activity. This work became the basis for EPA's finding under the Clean Air Act that mercury should be regulated.

Advancing technology to protect the environment was an important goal of EPA. Through the Environmental Technology Verification Program, EPA was able to develop twelve public-private partnerships and verify sixty-six technologies for the marketplace.

Outreach

Through creation of programs such as the "Science To Achieve Results" (STAR) grants and graduate fellowship programs, the Agency engaged the nation's best academic scientists in research to provide the basis for sound environmental decisions and policies.

The STAR program was one of EPA's tools for focusing on science and for improving the scientific basis for decisions on national environmental issues. The program worked through a competitive, merit-based process that encouraged the participation of the nation's best scientists. STAR was structured to bring new ideas and solutions to deal with current environmental problems, and to identify and help resolve issues likely to become environmental problems in the future.

In 1998, ORD initiated a post-doctoral program designed to employ scientists and engineers at the beginning stages of their careers. The program provided a fresh stream of highly trained and motivated professionals who could apply state-of-the-science solutions to environmental problems.

Chapter 7

EPA and the Courts

Dring the Clinton Administration, EPA and other regulatory agencies found themselves facing an increasingly conservative federal judiciary that was willing to revive constitutional theories briefly held -- and quickly discarded -- during the early years of Franklin Roosevelt's first term.

For example, before Franklin Roosevelt's time, the Supreme Court had never found an act of Congress to be unconstitutional because Congress had given away, or "delegated," many of its powers to the Executive Branch. But in 1935, the Court made such a finding. Around that time, the Court also restricted the power of Congress to enact laws -- and the President to enforce them -- under the Interstate Commerce Clause of the Constitution. That period lasted from just 1935 to 1937, when the Court retreated from these positions.

But during the Clinton Administration, both these restrictive legal theories gained currency again. By the end of the Administration, EPA and other agencies watched as legal theories, long thought dormant, either become precedent or awaited Supreme Court deliberation. Other legal theories, previously robust, changed shape significantly during this time.

Legal Challenges Expected

Since EPA was founded, between 50 to 80 percent of its major regulations in any given year have been challenged in court. Certain lawsuits filed by regulated industries or their representatives have aimed to reduce or delay environmental requirements. But in other cases, environmental groups have used the legal system to attempt to strengthen environmental

protections or increase the speed at which such requirements are carried out. Often EPA has been sued by both industry and environmental groups on the same matter.

The 1980's saw the development of the "Chevron Doctrine," under which the Supreme Court said that lower courts should give deference to a reasonable agency interpretation of ambiguities in a statute as long as there was a plausible basis for Agency's approach. Chevron U.S.A., Inc. v. Natural Resources Defense Council, 467 U.S. 837 (1984).

The 1990's witnessed an erosion of this doctrine. At the same time as the Clinton Administration sought to apply the environmental laws to a new range of problems, and as Congress largely disengaged from the task of refreshing the environmental laws to meet emerging challenges, courts became increasingly unwilling to acknowledge that environmental statutes may harbor ambiguities – and EPA received less deference as a result. Following are some of the most important cases the Administration faced.

Reducing Smog and Soot

By far the most significant legal matter faced by EPA during the Clinton Administration was litigation concerning its revised National Ambient Air Quality Standards specifying permissible levels of air pollution from ozone (smog) and particulate matter (soot). These rules were designed to protect millions of Americans from the harmful effects of soot and smog, such as lung injury, asthma problems, and premature death. The Clinton Administration had found in 1994 that it was not credible to defend, in litigation, the Bush Administration's decision to ignore 3,000 relevant new scientific studies, particularly those demonstrating the effects of exposure to ozone over a longer period of time and at lower levels.

A large industry coalition and several states sued EPA on nearly every conceivable ground in the U.S. Court of Appeals for the D.C. Circuit to set aside EPA's revised standards. In May 1999, a split three-judge panel of the court held that the revised air quality standards could not be implemented by EPA. (American Trucking Associations v. Browner, 175 F. 3d 1027.) The court sent the standards back to EPA with instructions to develop an intelligible principle for determining what level of risk to public health should guide the setting of air quality standards.

The major holding by the court surprised all the parties and observers -- reviving a long-dormant constitutional doctrine from the New Deal known as "nondelegation." The court ruled that the Clean Air Act, as interpreted by EPA, violated the Constitution's separation of powers clause, because the Act gave the agency too much freedom to choose among alternative levels of clean air protection -- Congress had thus given away, or delegated, too much of its legislative authority to EPA.

While the court recognized, under its long-standing decisions, that EPA's decision could not be based upon the consideration of costs and benefits, it implied that the Agency would be unable to satisfy the remand's call for an "intelligible principle" without considering cost, and ultimately would have to go back to Congress to have the law fixed. The court also found that while EPA had authority to revise the ozone standards, Congress had taken away, in 1990, EPA's authority to enforce those revised standards.

EPA asked the full Court of Appeals to review the decision. Even though five judges agreed it should be reconsidered and only four disagreed, rehearing was denied because this did not represent a majority of the eleven judges of the court. Two judges had removed themselves from the case.

EPA asked the Supreme Court to overturn the D.C. Circuit's ruling in the American Trucking case. The Court accepted the case for review. In a related petition, the American Trucking Association and other industry parties asked the Supreme Court to reverse the D.C. Circuit's established position that EPA should not consider costs to industry when setting the national ambient air quality standards -- suggesting that costs could provide the missing "intelligible principle" that could avoid the constitutional problem. The Supreme Court granted the industry petition as well, and heard oral argument in the two cases on Election Day 2000. EPA's position was presented by Solicitor General Seth Waxman.

As the Administration prepared to leave office, many observers thought American Trucking could become the most significant environmental law case of a generation. It raised fundamental questions about the appropriate role of expert administrative agencies and about how much authority Congress may delegate under the Constitution. Because the Clean Air Act placed many constraints on EPA -- including that the standards be set at levels "requisite to protect public health with an adequate margin of safety," in consultation with an expert scientific advisory committee -- a finding of unconstitutionality could call into question a wide range of public health, safety, and consumer protections.

Reducing Interstate Transport of Smog

EPA collaborated with states and industry groups to study how best to reduce the long-range transport of nitrogen oxides (NOx), a key precursor to ozone pollution -- across the entire eastern U.S. This resulted in EPA's decision to address the interstate movement of air pollutants through the NOx SIP Call, a rule requiring 22 states and the District of Columbia to limit NOx emissions to specified numerical levels (budgets) in order to help downwind urban

areas meet the ozone standards. The NOx SIP Call offered the affected states the flexibility to choose their own mix of pollution controls, so long as they met the NOx budgets.

Various upwind states and industry groups sued EPA in the D.C. Circuit. The Court largely upheld EPA's approach. Michigan v. EPA, 213 F.3d 663 (2000). It found that EPA reasonably interpreted the statute to seek cost-effective pollution reductions in defining the scope of an upwind state's obligations. States are now in the process of complying with the SIP Call, which should lead to large reductions in transported NOx emissions by the start of the summer ozone season in 2004, likely through significant pollution controls placed on old Midwestern coal-fired power plants.

Protecting Isolated Waters

On January 9, 2001, the Supreme Court issued an opinion with significant implications for the scope of waters regulated under the Clean Water Act. Solid Waste Authority of Northern Cook County v. United States Army Corps of Engineers ("SWANCC").

For twenty-five years, the government had interpreted the Clean Water Act as regulating discharges into most waters in the United States, including isolated, non- navigable intrastate waters where the use, destruction or degradation of such isolated waters could affect interstate or foreign commerce. Since the 1980's, the government had specifically recognized isolated wetlands used as habitat by migratory birds as falling within the protection of the Clean Water Act.

In a series of cases in the late 1990's, the Supreme Court had constricted the scope of Commerce Clause federal jurisdiction, recognizing a greater role for states under the Constitution. The Court agreed to hear a challenge to the Solid Waste Authority's permit on Commerce Clause

grounds, as well as on the narrower issue of whether Congress intended the Clean Water Act to cover such waters.

While the Court did not address the constitutional question -- avoiding a potentially dangerous limit on the constitutional basis for federal environmental actions -- the Court did decide that Congress had not clearly indicated an intent to regulate such waters. In the Court's view, in enacting the Clean Water Act, Congress had exercised its authority to regulate navigation, and the only waters it had clearly expressed an intent to regulate were navigable waters, their tributaries, and adjacent wetlands. What remains unclear from the Court's decision is whether it also established a further limitation of the "Chevron Doctrine" -- requiring a clear Congressional statement of intent -- any time state concerns are implicated.

Excavation in Wetlands

In a case that significantly limited protection of wetlands and other waters covered by the Clean Water Act, the court in National Mining Association v. Corps, 145 F.3d 1399 (D.C. Cir. 1998), held that the Act did not prevent dredging that had the effect of draining wetlands. EPA and the Army Corps of Engineers had promulgated a rule in 1993 (known as the "Tulloch rule") that required a permit under the Act when excavation activities cause redeposits of even small amounts of material, where the activity would destroy or degrade a protected water. According to the court in National Mining Association, the fallback of small volumes of material during excavation was not an "addition" of a pollutant, and the Agencies therefore lacked statutory authority to regulate the material. In 1999, EPA and the Corps modified their rule to implement the court's decision and, in 2000, promulgated a new rule clarifying the scope of their authority

under the Act. The Administration repeatedly called upon Congress to fix this significant limitation on wetlands protections.

Protecting Polluted Watersheds

During the Clinton Administration, there were several citizen suits addressing EPA's obligations to develop total maximum daily loads ("TMDLs"), which are maximum allowable amounts of pollutants for rivers, lakes, and other water bodies that do not meet water quality standards. Section 303(d) of the Clean Water Act directs states to identify their impaired waters and develop the necessary TMDLs. Many courts have held that EPA has a duty to step in and develop TMDLs in those states that are not carrying out the Act's requirement. While courts have dismissed a number of these cases, EPA was under court order in 18 states to develop TMDLs if the states failed to do so.

EPA's development of TMDLs subsequently resulted in litigation challenging these EPA actions. In two leading cases, the courts have upheld EPA's development of TMDLs where states have defaulted. Dioxin/Organochlorine Center v. Clarke, 57 F.3d 1517, 9th Cir. 1995) (upholding EPA's authority to issue a TMDL for dioxin in the Columbia River); Pronsolino v. Marcus, 91 F. Supp. 1337, N.D. Calif. 2000 (upholding EPA's authority to develop TMDLs for waters impaired solely by nonpoint sources of pollution, such as agricultural runoff). The extent of the obligations posed by consent decrees led EPA to develop a comprehensive approach to TMDLs through new regulation.

Empowering Indian Tribes to Carry out Environmental Programs

Under several of its statutes, EPA can authorize Indian tribes to administer environmental programs in their territories similar to the way in which EPA authorizes states to administer

environmental programs in their states. A 1998 case, Montana v. EPA, concerned EPA's decision to treat the Confederated Salish and Kootenai Tribes of the Flathead Reservation in Montana in the same manner as a state under Clean Water Act section 518(e) for purposes of setting water quality standards for all surface waters within the exterior boundaries of the Reservation. Montana challenged the legal test used by EPA in determining that the Tribes have adequate authority to set for surface waters on or adjacent to lands within the Reservation that are owned by nonmembers of the Tribes, so-called fee lands. In a significant victory for EPA's approach to tribal delegation issues, the Ninth Circuit Court of Appeals upheld tribal regulation of non-Indian activities on fee lands under an EPA-authorized program. This was a significant victory for EPA's work to support tribal environmental capacity.

Addressing Hazardous Wastes

Regulations identifying waste as hazardous are a pivotal element of EPAs hazardous waste management program, since only wastes that are identified as hazardous are subject to EPAs stringent hazardous waste management regulations. Accordingly, EPA ensures that these regulations capture wastes that pose a hazard to human health or the environment, but do not capture, and impose unnecessary costs on, wastes that do not pose a hazard. EPA has had significant victories in cases challenging EPA decisions regarding the identification of hazardous waste. American Petroleum Inst. v. EPA, 216 F.3d 50 (D.C. Cir. 2000); Environmental Defense Fund v. EPA, 210 F.3d 396 (D.C. Cir. 2000); Association of Battery Recyclers v. EPA, 208 F.3d 1047 (D.C. Cir. 2000) (hazardous wastes can be regulated even where a only small number of people are exposed to the potential hazard).

EPA has had significant litigation success in defending industry challenges to important regulatory controls on the burning and treatment of hazardous wastes. Horsehead Resource Development Corp. v. Browner, 16 F.3d 1246 (D.C. Cir. 1994) (controls on emissions from burning of hazardous waste); Steel Mfr's. Ass'n. v. Browner, 27 F.3d 642 (D.C. Cir. 1994) (treatment of hazardous waste prior to disposal); Edison Electric Inst. v. EPA, 996 F.2d 326 (D.C. Cir. 1993) (same); Louisiana Environmental Action Network v. EPA, 172 F.3d 65 (D.C. Cir. 1999); Association of Battery Recyclers v. EPA, 218 F.3d 1047, 1058-59 (D.C. Cir. 2000). EPA also prevailed in litigation challenging the expansion of its toxic waste reporting requirements on the Toxics Release Inventory (TRI). Troy v. Browner, 120 F.3d 277 (D.C. Cir. 1997).

Advancing Hazardous Waste Cleanups

EPA identifies the most hazardous toxic waste sites and lists them on the National Priorities List for cleanup. EPA has successfully defended challenges to these listing decisions, thus allowing EPA to focus its cleanup efforts on the worst sites. See, e.g., RSR Corp. v. EPA, 102 F.3d 1266 (D.C. Cir. 1997).

During the Clinton Administration, EPA was successful in preventing polluters or other parties from halting EPA cleanup activities through Court injunctions and also ensuring that polluters pay for the cleanups. EPA's approach ensured that litigation would not interfere with prompt cleanup of hazardous sites, and that cleanups fully protect public health and the environment, comply with Federal and State environmental requirements, and are undertaken in consultation with all interested parties, including citizens, governments, and businesses. EPA has won virtually all of the lawsuits in which polluters challenged EPA's cleanup decisions. See

United States v. Vertac, 33 F. Supp. 2d 769 (E.D. Ark. 1998); United States v. Burlington Northern R. Co., 200 F.3d 679 (10th Cir. 1999).

EPA also ensured that cleanups were performed or financed by the persons responsible for the contamination, rather than by public funds. EPA won numerous cases where polluters have disputed their liability for costs. See, e.g., United States v. Occidental Chemical Corp., 200 F. 3d 143 (3d Cir. 1999); A&W Smelter and Refiners, Inc. v. Clinton, 146 F. 3d 1107 (9th Cir. 1998); United States v. Lowe, 118 F.3d 399 (5th Cir. 1997); United States v. Keystone Sanitation Co., Inc., 867 F. Supp. 275 (M.D. Pa. 1994). EPA also has successfully opposed polluters' efforts to have Superfund declared unconstitutional under the Commerce Clause. United States v. Olin Corp., 107 F.3d 1506 (11th Cir. 1997).

Maintaining a Role for Citizen Enforcement

Most of our environmental laws contain provisions that allow citizens to sue businesses they believe have violated the laws or regulations. These citizen suits are an important component of an effective environmental enforcement program. EPA has supported citizens' right to sue violators. In two important cases, the Supreme Court recently addressed the scope of these citizen suits. In Steel Co. v. Citizens for a Better Environment (118 S. Ct. 1003, 1998), the Court held that although citizens cannot sue under the Emergency Planning and Community Right-to-Know Act for violations that are wholly past at the time they file their suit, they may bring suit when there is a continuing violation or a threat of a future violation. In Friends of the Earth v. Laidlaw Environmental Services (120 S. Ct. 693, 2000), the Court held that an industry that violates the Clean Water Act cannot defeat a citizen suit by coming into compliance with the Act

only after the citizen suit was filed. EPA supported the citizen groups in both these cases by filing briefs in the Supreme Court.

Challenges to EPA Guidance Documents

Two emerging issues of law posed special challenges to EPA. These concerned the reviewability of guidance documents, and the review of the Agency's scientific decisions.

EPA issues many policy and interpretive documents that are not legally binding but provide useful guidance to EPA staff and the public about EPA's programs. Different parties have challenged a number of EPA's policy and interpretive documents, arguing that the documents should be subject to judicial review and, in some cases, that the documents should have been issued through notice and comment rulemaking procedures. In some cases, courts have agreed with EPA, finding that these explanatory documents were not subject to judicial review and that notice and comment rulemaking was not required. Public Service Co. of Colorado v. EPA, 225 F.3d 1114 (10th Cir. 2000) (EPA letter); Molycorp, Inc. v. EPA, 197 F.3d 543 (D.C. Cir. 1999) (background document); Florida Power & Light Co. v. EPA, 145 F.3d 1414 (D.C. Cir. 1998) (statement in preamble to proposed rule). However, in Appalachian Power Co. v. EPA, 208 F.3d 1015 (2000), the D.C. Circuit found that an EPA guidance document "significantly broadened" the rule it purported to interpret and in effect amended the underlying rule, an action for which notice and comment rulemaking would be required. In Barrick Goldstrike Mines v. Browner, 215 F.3d 45 (D.C. Cir. 2000), the Court found that judicial review was available for certain documents, including a letter and preamble statements, that "commanded" certain actions. As the agency seeks to interact more openly and informally with

the public and provide helpful guidance to industry, these rulings could portend significant difficulties.

Science-Based Decisions

In several recent cases, the courts have engaged in a searching examination of EPA's scientific analyses and conclusions. This is a highly technical area, where courts traditionally have been at their most deferential when reviewing agency decisions. Chlorine Chemistry Council v. Browner, 206 F.3d 1286 (D.C. Cir. 2000) involved regulation of the level of chloroform in drinking water. EPA had developed and made available to the public scientific information indicating that the risk of cancer posed by chloroform is lower than for most other carcinogens, i.e., that there might be a level of chloroform in drinking water below which there is no risk of cancer. In establishing the final standard, EPA chose not to rely on that information because EPA had not yet fully evaluated the implications of such a scientific finding on its overall approach to regulating carcinogens. The court criticized EPA for not using the results of its own scientific model and found that the Agency had ignored the best available science in establishing the chloroform standard. Although the court acknowledged that using a new approach to estimating cancer risk might set a significant precedent, it determined that that was not a sufficient reason to justify establishing the standard on the basis of an older approach which was not the most scientifically accurate. See also Leather Industries Ass'n v. Browner (40 F.3d 392, D.C. Cir. 1994) (in challenge to EPA regulations establishing maximum concentrations of toxic pollutants that can be present in sewage sludge intended for use as fertilizer, court determined that assumption that children would come into contact with fertilized land every day for the first five years of their lives was not rational).

Likewise, EPA's extensive 1993 risk assessment of the hazards posed by environmental tobacco smoke, and, in particular, its conclusions that second hand tobacco smoke is a human lung carcinogen, has been subject to extensive attack by the tobacco industry. EPA has appealed to the U.S. Court of Appeals for the Fourth Circuit an adverse North Carolina District Court finding that the agency erred in failing to place industry representatives on its independent advisory panel. As part of that appeal, EPA is vigorously defending the scientific basis for its 1993 study. Flue-Cured Tobacco Coop. Stabilization Corp. v. EPA, 4 F. Supp. 2d 435 (M.D.N.C. 1998).

CHRONOLOGY
1993-2000

1993

01/21 Carol M. Browner is sworn in as the 8th EPA Administrator.

02/17 In his State of the Union address, President Clinton announces his budget economic stimulus package and specifically mentions Superfund reform.

03/04 Carol Browner, in her first press conference as Administrator, announces a program to make smoke-belching buses a thing of the past by establishing new diesel exhaust limits for new buses and requiring older buses to be retrofitted with emission controls.

03/11 Robert M. Sussman is sworn in as the 8th EPA Deputy Administrator.

Apr. Cryptosporidium outbreak in Milwaukee drinking water. Over 50 people die, and 400,000 become ill.

04/21 President Clinton signs Executive Order 12843 on Procurement Regulations and Policies for Federal Agencies for Ozone-Depleting-Substances, directing federal agencies to reduce the use of ODSs.

05/14 EPA launches its web page. In the first month, the page gets 100,000 hits. Later, the number of hits per month grows to 100 million.

June National Academy of Sciences report concludes that scientific and regulatory approaches do not adequately protect infants and children from pesticide residues in food. The report calls on EPA to make significant changes in methods for assessing exposures to pesticides, analyze the potential for harmful or toxic effects, and use the data to characterize actual risks to children.

June EPA announces the first round of Superfund reform, focusing on expediting site cleanups and increasing enforcement fairness.

06/14 EPA's national refrigerant recycling program requirements become effective. These requirements will protect the ozone layer and enable a smooth, cost-effective transition to non-ozone-depleting substitutes.

06/17 EPA launches the ENERGY STAR Computers program to helps consumers identify money-saving, energy efficient computers. By the end of the Clinton Administration, the ENERGY STAR program expands dramatically and more than 350 million ENERGY STAR labeled products are sold, saving consumers over $1 billion in energy bills each year.

Jul. EPA publishes a report that quantifies the risk to adults and children of exposures to second-hand tobacco smoke indoors.

Jul. EPA launches the Reduced-Risk Initiative to expedite the registration of reduced-risk pesticides to replace more toxic, older chemicals.

08/03 President Clinton issues Executive Order 12856, Federal Compliance with Right to Know Laws and Pollution Prevention Requirements, requiring all federal facilities to report their emissions to the TRI.

08/24 The Clinton-Gore Administration unveils a wetlands protection initiative which includes more than 40 changes to current wetlands policy, including establishing a more effective process so that landowners and farmers can seek review of permit decisions without having to go to court.

08/31 Bethlehem Steel pays $6 million penalty for RCRA violations as part of the Agency's Great Lakes Initiative.

09/22 EPA issues a final rule establishing the first air toxics standard under the 1990 CAAA. The rule will reduce toxic air emissions from approximately 30,000 dry cleaners by about 7,300 tons per year.

09/28 EPA announces its first Hazardous Waste Combustion Initiative against 38 violators of hazardous waste combustion regulations, seeking over $22 million in penalties.

09/29 President Clinton and Vice President Gore announce in a Rose Garden ceremony the Partnership for a New Generation of Vehicles.

09/30 EPA establishes the National Environmental Justice Advisory Committee.

10/20 President Clinton signs Executive Order 12873, on Acquisition, Recycling and Waste Prevention, directing federal agencies to use recycled paper and other recycled products.

10/27 EPA issues a final rule that will reduce toxic air emissions at 29 coke ovens by approximately 1,500 tons per year.

Nov. Clinton Administration launches the Brownfields initiative with a $200,000 grant to Cleveland, Ohio.

Dec. EPA adds hydrochlororfluorcarbons (HCFCs) and certain waste chemicals to the TRI.

12/03 EPA promulgates program-specific grant regulations for specific grants applied to Tribes under the Indian Environmental General Assistance Program Act of 1992.

1994

01/01 EPA successfully phases out the production and consumption of ozone-depleting halons in the United States, while working closely with the Department of Defense to ensure an adequate supply of halons for mission-critical uses.

Feb. The Clinton Administration submits to the Congress a "Safe Drinking Water Act Reauthorization Overview." This document presents the background information and explanation of the Administration's 10 recommendations for reauthorization of the Safe Drinking Water Act.

02/03 Administrator Browner introduces the Clinton Administration's Superfund Reform Bill.

02/11 President Clinton issues Executive Order 12898 on environmental justice, directing all federal agencies to make environmental justice an integral part of their policies, programs, and activities.

04/06 EPA issues a final rule implementing the control of vehicle refueling emissions through the use of vehicle-based systems. It applies to light-duty vehicles and light-duty trucks, and will phase-in such that by 1998, 100% of light-duty vehicles must meet the standards.

04/19 EPA issues the Combined Sewer Overflow Policy that will eventually help protect the health of 40 million people.

04/20 The Clinton Administration's Pesticide and Food Safety Reform proposed legislation is submitted to Congress.

04/22 EPA issues a final rule establishing new standards for chemical plants that will take more than half a million tons of toxic pollution out of the air (a 90% reduction).

04/29 President Clinton issues a presidential memorandum directing federal agencies to build more effective day-to-day working relationships with Tribal governments by respecting the tribes' sovereign rights of self-government.

May MITRE corporation releases its independent assessment of EPA's laboratories, which becomes the basis for a series of science management improvements.

June EPA scientists, working with the National Weather Service, establish a UV-B Radiation Index, and a 50-station network provides daily predictions of population exposure to UV-B radiation.

06/07 EPA implements an agency-wide peer review program which calls for office and region-specific standard operating procedures.

07/14 Administrator Browner announces the establishment of a new EPA/Tribal Operations Committee, composed of Tribal representatives and EPA senior managers, to facilitate communication and understanding between EPA and Tribes.

07/20 Administrator Browner announces the agency's Common Sense Initiative to develop "cleaner, cheaper, and smarter" ways of protecting the environment for six industry sectors.

10/07 Second largest RCRA settlement ($32 million) with Kodak for hazardous waste violations.

10/14 Two men sentenced to prison for 27 months under RCRA for illegal hazardous waste disposal which resulted in the deaths of two nine-year old boys.

10/18 Fred Hansen sworn in as 9th EPA Deputy Administrator.

Nov. EPA adds 286 additional chemicals and chemical categories to the TRI inventory.

11/29 EPA provides funds to create first National Compliance Assistance Center, which eventually leads to the ten centers currently in operation. The first center (metal finishing) goes on line in early 1995.

11/29 Tenneco Pipeline pays $6.2 million TSCA penalty and is required to cleanup contamination at over 40 compressor stations.

1995

01/01 EPA's Acid Rain Program begins. The innovative market-based trading program cost-effectively cuts emissions of sulfur dioxide from power plants in half (from 1980 levels). Within two years researchers report unprecedented reductions in acid rain.

01/01 EPA initiates the 1st phase of the cleaner-burning gasoline program. With the 2nd phase (introduced in June 2000), the cleaner-burning gas will reduce smog-forming air pollution by over 100,000 tons and toxic air pollution by about 24,000 tons per year.

01/03 104th Congress is sworn in. The House of Representatives elects Newt Gingrich as Speaker, leading to the "Contract with America."

01/25 EPA Administrator Carol Browner announces the Brownfields Action Agenda, outlining EPA's activities and future plans to help States, Tribes and communities implement and realize the benefits of the Brownfields Initiative.

02/07 The Department of Justice announces that Miami-Dade County will spend an estimated $500 million to repair its sewage system.

02/17 EPA announces enforcement-oriented Superfund Administrative Reforms to promote fairer, faster and more effective settlements. EPA issues the "Superfund Administrative Improvements Closeout Report."

03/16 President Clinton announces an initiative to reinvent environmental regulation, in part by consolidating all federal air rules for any single industry into one rule. In September 2000, EPA issues its pilot rule which consolidates the requirements of 16 federal rules for the synthetic organic chemical manufacturing industry.

03/23 EPA sets the first-ever water quality standards for toxic substances for all of the Great Lakes, which provide drinking water for 23 million Americans.

May EPA begins using self-certification to streamline the pesticide registration process.

05/16 The House of Representatives passes H.R. 961, which would have weakened significant provisions in the Clean Water Act, including EPA's basic authorities to protect the nation's wetlands and to establish national, minimum technology-based standards to control toxics and other discharges to the nation's waters.

05/17 EPA and State leaders implement the National Environmental Performance Partnership System (NEPPS) to improve how EPA and the States work together to protect the environment.

05/18 Working with ECOS, EPA sets up the Ozone Transport Assessment Group to develop recommendations on transboundary smog problems in the eastern U.S. The 2-year consultative process involves 37 states, the District of Columbia, EPA, industry and environmental groups.

05/23 EPA announces Project XL (eXcellence and Leadership), a national pilot program that allows state and local governments, businesses and federal facilities to develop innovative strategies with EPA to test better or more cost-effective ways of achieving environmental and public health protection

June-Oct. Pfiesteria outbreak in North Carolina kills 2 million fish.

07/26 Clinton Administration announces selection of 15 cities as Brownfields Redevelopment Projects.

08/08 President Clinton issues Executive Order 12969, requiring those who would do business with the federal government to report on over 650 toxic chemicals that are emitted.

Oct. EPA announces a third round of Superfund reforms to promote cost-effective cleanup choices, to reduce litigation and transaction costs, and to ensure that states and communities are informed and involved in cleanup decisions.

Oct. EPA creates the Environmental Technology Verification Program to accelerate the commercialization of new technologies.

10/23 EPA announces a policy to explicitly take children into account when assessing environmental risks.

Nov. EPA and other federal agencies experience first shutdown due to lack of appropriations.

11/25 The *New York Times* publishes a front page story on EPA's enforcement actions and inspections forced to be cut due to budget cuts imposed by stop-gap funding bills.

11/30 EPA reaches $45 million settlement with GM, resulting in the first judicial recall aimed at curbing damage to the environment.

Dec. EPA and almost all other federal agencies shutdown again due to lack of appropriations. All federal employees return to work by Jan. 6, 1996, following negotiations between the White House and Congress.

12/21 US recovers $128 million from Occidental Petroleum in final litigation surrounding the cleanup of Love Canal.

<u>1996</u>

Jan. President Clinton and Congress reach agreement on EPA's budget. The cuts are minimal compared to initial proposals.

01/01 EPA successfully phases out production and consumption of ozone-depleting CFCs, methyl chloroform, and carbon tetrachloride, while assuring continued limited production for essential uses, including metered-dose inhalers utilized by asthma sufferers.

01/01 EPA's first rule regulating pollution from non-road engines takes effect. This rule address non-road diesel engines used in construction and agricultural equipment. Later rules address other categories such as lawn and garden equipment, locomotives and recreational boats. These rules provide needed pollution reductions in urban areas.

Apr. EPA publishes the *Air Quality Criteria Document for Particulate Matter*, which reviews the latest data associated with risks from both fine and coarse particles in support of the national ambient air quality standards.

05/22 EPA reaches $140 million CAA settlement with Colorado Public Service Company that reduces air pollution in the Mt. Zirkel Wilderness Area.

05/24 Iroquois Pipeline company is assessed a $22 million CWA criminal fine for polluting streams and wetlands while building a pipeline from Canada to New York.

07/04 Washington DC residents wake up on the 4th of July to a "boil water" alert. Later investigations found that District officials had diverted $41 million in water and sewer funds to the District government's budget, while letting sewage and water systems fall into disrepair. EPA stepped in to rebuild and restructure DC's water and sewer systems and restore public confidence in the safety of their drinking water.

07/18 $35 million CAA settlement with Georgia-Pacific, part of the air pollution initiative on the woods products industry.

07/24 The White House Agreement to dredge the New York/New Jersey Harbor is finalized. This completes Vice President Gore's July 24, 1996 announcement of a break-through plan "to protect and preserve the environment and promote economic growth in the Port of New York and New Jersey."

08/03 President Clinton signs the Food Quality Protection Act of 1996, establishing strong new standards for pesticide residues in food and requiring for the first time that the standards take into account special risks to children.

08/06 President Clinton signs into law the 1996 Amendments to the Safe Drinking Water Act, which include the establishment of the first ever drinking water State Revolving Loan Fund, protection of water source areas, and requirements that drinking water systems report to the public on the quality of their drinking water.

08/28 President Clinton announces new initiatives to accelerate cleanup of brownfields and Superfund sites, strengthen environmental enforcement, and expand community right-to-know.

Sept. EPA announces a seven step National Agenda to Protect Children's Health from Environmental Threats.

09/25 Three corporations are fined $75 million for a Puerto Rico oil spill, the largest Federal environmental criminal fine in US history.

09/30 The 400th Superfund construction is completed at the Lord-Shope landfill in Grand Township, PA.

Oct. In Kalamazoo, Michigan, President Clinton proposes new initiatives to increase the protection of communities from toxic pollution. The main components of the proposal were to accelerate Superfund cleanup, expand the Brownfields Redevelopment Initiative, improve community access to information on toxic pollution, and strengthen criminal enforcement of environmental laws.

Nov. Intel commits to making its environmental performance data publicly available on the internet under a Project XL agreement, the first company ever to do so.

12/19 EPA issues final rules to implement the 2nd phase of the Acid Rain program for NO_X emissions. The electric utility industry again sues EPA, but the U.S. Court of Appeals upholds the rules in their entirety in August 1997.

1997

02/02 EPA issues the Arsenic Research Plan, as required by the 1996 Amendments to the SDWA, which will build a foundation for the new arsenic standard proposed in June 2000.

04/07 EPA and the Canadian Ministry of the Environment sign the Great Lakes Binational Toxics Strategy to reduce pollution in the Great Lakes.

04/20 On Earth Day, EPA releases *Surf Your Watershed*, a new internet tool that allows citizens to find their watershed address and learn about environmental conditions in their community.

04/21 President Clinton issues an Executive Order on the Protection of Children From Environmental Health Risks, which requires all federal agencies to assign a high priority to addressing health and safety risks to children, to coordinate research priorities on children's health, and to ensure that their standards take into account special risks to children. The Executive Order also creates a Task Force on Environmental Health Risks and Safety Risks to Children, co-chaired by EPA Administrator Carol Browner and Department of Health and Human Services Secretary Donna Shalala.

May EPA announces the Beaches Environmental Assessment, Closure and Health program to reduce the risk of disease to the nation's users of recreational water.

May EPA issues its first-ever "plain language" compliance guide. This one is for dry cleaners.

May EPA adds seven new industries required to report waste releases to the TRI.

05/13 Vice President Al Gore announces the Clinton Administration's Brownfields National Partnership, a new round of Brownfields project grants, and President Clinton's Brownfields legislative package.

05/30 Smithfield Foods is fined $12.6 million (the second largest CWA penalty ever) for polluting a river with slaughterhouse waste water.

07/16 President Clinton approves stronger, more protective air quality standards to further control pollution from ozone and particulate matter (smog and soot) and issues a memo to EPA on implementation of the standards.

07/18 EPA publishes final rules announcing tougher health standards for smog and soot pollution. A coalition of industry and states sue EPA. In May 1999, the DC Circuit Court of Appeals remands the standards and raises fundamental legal issues regarding Congress' delegation of authority, while upholding the scientific basis of the new standards. In May 2000, the Supreme Court accepts an appeal from EPA and DOJ, and arguments were presented before the court on November 7, 2000. A ruling expected is in Spring 2001. In the meantime, EPA reinstates the 1-hour ozone standard on July 5, 2000.

Aug. The Taxpayer Relief Act removes the tax disincentive for cleaning up brownfields properties.

08/06 Fish kill in the Pokomoke River on the Chesapeake Bay in Maryland is attributed to a toxic Pfiesteria outbreak.

08/15 The Clinton Administration forms a Federal Interagency Task Force, lead by EPA and NOAA, to address Pfiesteria outbreaks.

Sept. EPA completes the award of the first allotment of the Drinking Water State Revolving Fund to all 50 States.

09/10 Fish kill in the Maryland's King's Creek on the Chesapeake Bay is attributed to a toxic Pfiesteria outbreak.

09/11 President Clinton signs Executive Order 13061 establishing the American Heritage River initiative.

10/15 GTE, in the biggest use of the self-disclosure (audit) policy, resolves 600 CWA and EPCRA violations at 314 GTE facilities in 21 states.

10/18 Vice President Gore directs federal departments and agencies to develop an action plan to clean up America's waterways.

Nov. The Clinton Administration signs the Kyoto Protocol, the first-ever international agreement to address the threat of global warming. As of Dec. 2000, the protocol has not been ratified by the Senate.

11/10 The Interagency Task Force lead by EPA and NOAA publishes the *National Harmful Algal Bloom Research and Monitoring Strategy: An Initial Focus on Pfiesteria, Fish Lesions and Public Health*, in response to toxic Pfiesteria outbreaks in the mid-Atlantic.

11/14 First guilty plea in a criminal enforcement initiative involving illegal dumping and discharges into oceans by cruise lines.

Dec. The metal finishing industry announces an ambitious set of environmental performance goals developed through the Common Sense Initiative.

1998

01/07 EPA issues the final rule announcing the National Low Emissions Vehicle (NLEV) Program after an unprecedented effort with states, auto and fuel companies, environmentalists, and others. Northeastern states and environmentalists sparked the effort by pushing for adoption of the California Low Emission Vehicle standards. By 2001, the NLEV program will provide 99% reduction in VOCs and 94% reductions for NO_x for light duty vehicles.

01/12 EPA's Science Policy Council publishes the first edition of the *Peer Review Handbook* to provide detailed procedures to ensure effective peer review.

01/23 $56 million settlement with ASARCO is EPA's first multi-media settlement involving different statutes at different facilities.

Feb. President Clinton proposes a Global Climate Change Technology Initiative (CCTI) to promote reductions in greenhouse gases by supporting advances in energy efficiency, renewable energy, and carbon-reduction technologies.

02/06 EPA issues the first Contaminant Candidate List (CCL), mandated by the 1996 SDWA Amendments, which identifies known or anticipated priority contaminants that may require regulation.

02/12 EPA issues the final Tribal Authority Rule. The TAR specifies, for the first time, the provisions of the Clean Air Act for which EPA may treat Indian tribes like states to implement air programs in Indian Country. Several industry groups sue EPA, but in May 2000 the DC Circuit Court of Appeals upholds the rule.

02/12 Vice President Gore announces that major auto manufacturers voluntarily agree to produce a cleaner car that emits 70 percent less pollution.

02/14 EPA issues the Clean Water Action Plan, a Clinton Administration proposal to ensure clean, healthy water for all Americans. The plan targets the largest remaining threats to water quality to help clean up the almost 40 percent of America's surveyed waterways still too polluted for fishing and swimming.

Mar. Vice President Gore announces the first round of sixteen communities in the "Showcase Communities" initiative in the Brownfields National Partnership agenda

04/15 EPA promulgates the Pulp & Paper Cluster Rule, which cuts toxic air pollutant emissions by 60 percent. This is the first integrated multi-media regulation.

04/22 Vice President Gore announces High Production Chemical Testing Challenge, a program designed to ensure that the American public has access to basic public health and environmental effects data for those chemicals which are produced in the highest volumes in the U.S.

04/28 Administrator Browner and Attorney General Janet Reno announce indictments against three individuals who transported homeless men across state lines to illegally remove asbestos without providing them with the required training or safety equipment. This is part of the agency's on-going national initiative against the improper handling of asbestos.

May EPA and State Officials sign a joint agreement to pursue regulatory innovations.

05/01 EPA launches the Sector Facility Indexing Project, making environmental compliance data from six sectors publicly available on the internet.

05/08 CWA settlement with Hudson Foods, which will reduce agricultural/livestock runoff into the Chesapeake Bay.

05/14 President Clinton issues Executive Order 13084, Consultation and Coordination with Indian Tribal Governments. Each agency is directed to develop and utilize an effective process to permit elected officials and other representatives of Indian tribal governments to provide meaningful and timely input in the development of polices on matters that significantly or uniquely affect their communities.

05/20 New York City signs a consent decree requiring it to build a filtration plans for its Croton Drinking Water System, which provides drinking water to 1 million New York City citizens.

05/21 First Lady Hillary Clinton announces EPA's Child Health Champion Campaign in eleven pilot communities nationwide. The program is designed to empower local citizens and communities to take steps to protect their children from environmental health threats like lead paint and asthma-causing pollutants.

06/01 EPA initiates the SunWise School Program, which aims to reduce childhood incidence of morbidity and mortality from skin cancer and other harmful effects of overexposure to ultraviolet rays. The program now reaches over 10,000 children in 42 states.

06/08 CAA Settlement requires Honda to spend $268 million to settle allegations it sold cars with disabled emission control diagnostic systems.

08/06 EPA issues guidelines to states for water conservation plans for public water supply systems.

08/10 Vice President Gore announces the establishment of the first eight Centers of Excellence in Children's Environmental Health Research – research centers dedicated solely to the study of children's environmental health hazards.

08/11 President Clinton expands the public's right to know with the announcement of a new proposed rule requiring water utilities to provide regular reports to their customers.

08/14 EPA announces 11 Job Training and Development Demonstration Projects as part of the Brownfields Program.

08/18 EPA and NOAA issue a Federal Event Response Plan for Harmful Algal Blooms, in response to previous pfiesteria outbreaks. It will be expanded to include other harmful algae like red tide.

08/19 EPA promulgates the Consumer Confidence Reporting Rule, requiring drinking water systems to report to their customers on the quality of the drinking water they supply.

08/20 Pilot process initiated for risk assessment of organophosphate pesticides.

09/02 Vice President Gore announces the Clinton-Gore Livable Communities Initiative to coordinate and enhance federal programs that can help communities grow in ways that ensure a high quality of life and strong, sustainable economic growth.

09/03 EPA issues its first annual national assessment of drinking waster compliance.

10/16 FMC Corporation pays $170 million to settle hazardous waste charges at its phosphorus production facility in Idaho. The settlement includes an $11.8 million fine, the largest RCRA civil penalty ever assessed.

10/22 The diesel engine manufacturers cases are settled for $1 billion. The settlement is expected to remove over 75 million tons of NO_X from the air. The settles stems from EPA research determining that some diesel trucks emit much more nitrogen oxide under certain conditions than expected. These findings lead to further EPA testing that indicates certain diesel manufacturers used "defeat devices" to enable their engines to improperly pass federal emissions tests.

10/27 Following the OTAG process, EPA issues a plan to reduce NO_X emissions across the Eastern U.S. After a coalition of industry and states sue EPA, the DC Circuit Court upholds EPA's rule on March 3, 2000. Pollution controls must be in place by May 2004.

11/02 The 600th Superfund construction is completed at Revere Chemical in Nockamixon, PA.

11/25 EPA announces the Compliance Incentive Initiative with pork producers, with the goal of significantly reducing pollution runoff from CAFOs.

Dec. EPA opens the Environmental Permitting Clearinghouse on the internet to provide information about permitting procedures, reforms, and innovations.

Dec. President Clinton signs first ever requirement to protect against cryptosporidium in drinking water. This is the first new standard set under the 1996 Safe Drinking Water Act.

12/16 EPA promulgates first rules addressing microbial contamination of drinking water: the Stage 1 Disinfectant/Disinfection By-Products rule and the Interim Enhanced Surface Water Treatment rule.

12/22 The Federal Government reaches settlement with environmental plaintiffs in Bragg v. Robertson regarding CWA regulations. This resolves claims against the Army Corps of Engineers concerning CWA permitting in mountaintop mining and valley fills. Limits on permits were imposed, and a comprehensive EIS was ordered.

1999

01/28 The Clinton Administration issues "Asthma and the Environment: A Strategy to Protect Children," a report that lays out a 10-year plan of research and public health programs and

surveillance, with a special focus on eliminating the disproportionate impact on the poor and minorities.

Feb. President Clinton proposes the Better America Bonds program, as part of the Administration's Livability Initiative, to help state and local governments initiate land and water protections for future generations.

Feb. President Clinton proposes a new Clean Air Partnership Fund to help local, state and tribal governments form partnerships to initiate local clean air projects.

03/09 Vice President Gore, Secretary of Agriculture Glickman, and Administrator Browner release the Unified National Strategy for Animal Feeding Operations to reduce potentially harmful runoff from animal feeding operations.

03/15 The Federal Government issues the Federal Event Response Plan for Harmful Algal Blooms and Pfiesteria, in response to the toxic Pfiesteria outbreaks.

Apr. Vice President Gore challenges chemical industry to expand public access to data on the most widely used chemicals.

04/22 On Earth Day, Vice President Gore announces new standards to restore visibility in our National Parks and Wilderness Areas to natural conditions. Scenic vistas in these areas will be improved by this rule as EPA requires, for the first time, that many "grandfathered" power plants install pollution control devices.

May Vice President Gore announces the expansion of the Water Alliances for Voluntary Efficiency Program at the Sustainable American Conference in Detroit.

05/01 EPA launches the Tools for Schools Program to improve the health and performance of school children nationwide by improving the operation and maintenance practices in their school buildings.

05/04 EPA overhauls the compliance assurance program for certifying that new cars and light-duty trucks meet national air pollution standards. Known as CAP 2000, the program will save vehicle manufacturers about $55 million a year and lead to improved air quality.

05/14 EPA issues new final rules to improve the accuracy of emission measurement techniques that also lower operating costs for the Acid Rain Program.

July EPA announces a set of priority actions to encourage environmental stewardship and accelerate environmental progress in the *Aiming for Excellence* report.

07/19 Under a self-disclosure (audit) policy settlement, American Airlines agrees to use lower sulphur fuel, which is expected to eliminate almost 700 tons of pollution from the air annually.

07/21 Royal Carribean Cruise Lines pleads guilty and pays $18 million criminal fine for dumping waste oil and hazardous chemicals into the oceans. Total criminal fines against the company amounted to over $27 million.

08/03 EPA meets and surpasses the first tolerance reassessment deadline under the Food Quality Protection Act, and cancels significant food uses of two organophosphate pesticides – azinphos-methyl and methyl parathion.

08/06 EPA establishes the National Contaminant Occurrence Database, as required by the 1996 SDWA Amendments, to provide a repository and access to data on the occurrence of contaminants in drinking water, which will support decision making for future drinking water contaminant regulations.

08/14 President Clinton announces new steps to restore America's rivers, lakes and coastal waters. Under a proposed rule, EPA will work with states to better assess the health of U.S. waterways and to develop detailed plans to make them safe for fishing and swimming.

09/01 EPA issues Federal Guidance on estimating cancer risks from radiation. The new cancer risk coefficients for over 800 radionuclides take into account age-specific data that includes risks to infants and children in calculating average population risks.

09/06 The 750th Superfund construction is completed at Pepe Field in Boonton, NJ.

09/15 EPA's Blue Ribbon Panel – formed to investigate the health effects and environmental benefits and challenges of MTBE – issues a package of recommendations. The Panel concludes that water concerns are driven primarily by aesthetic issues (odor and taste) and that health concerns arise only rarely. The issue flares up in early 2000 when *60 Minutes* does a segment on the issue. The following March, the Clinton Administration announces legislative principles to address the MTBE issue. Several Congressmen and Senators introduce bills to address the issue, and several states request waivers from the RFG program.

09/16 W. Michael McCabe is appointed Acting Deputy Administrator.

Oct. Over 50,000 community water systems issue their first ever consumer confidence reports, giving some 250 million Americans access to information about the quality of their drinking water.

10/30 President Clinton announces a new EPA rule strengthening the public's right to know about highly toxic chemicals released to the environment. The rule establishes or strengthens reporting requirements for 27 persistent bioaccumulative toxics, including mercury, dioxin, and PCBs.

Nov. EPA completes the report *Ecological Conditions of Estuaries in the Gulf of Mexico* to present an ecological report card on conditions of estuaries in the Gulf.

11/02 EPA proposes the Radon Rule, setting out a unique multimedia approach to allow local flexibility in addressing risks.

11/03 Historic CAA lawsuit filed against 17 electric utility companies charged with expanding operations at their coal-fired plants and increasing pollution without seeking required permits.

12/01 EPA announces that while the air quality plans for 10 major urban areas (including Atlanta, Houston, New York, Chicago, and Washington, D.C.) show a strong commitment to reducing smog, most will need to take additional steps.

12/17 EPA takes action on petitions filed by eight northeastern states seeking to mitigate what they describe as significant transport of NO_X, one of the main precursors of ground-level ozone. This action will reduce NO_X emissions from 392 facilities by 50%. Several states and industries sue the Agency in 2000, and a court decision is expected in 2001.

12/21 President Clinton announces new standards for passenger vehicles and gasoline. For the first time, larger vehicles like SUVs and trucks will have to meet the same standards as cars. The gasoline sulfur standards will ensure the effectiveness of low emission-control technologies in

vehicles and reduce harmful air pollution. These new standards require passenger vehicles to be 77 to 95 % cleaner than those on the road today.

2000

Jan. The National Academy of Sciences' Institute of Medicine releases a landmark study of indoor air and asthma.

01/01 EPA is successful in converting the agency's major systems to Year 2000 without problems.

01/12 EPA issues final revisions to the Lead and Copper rule which strengthen protection to approximately 20 percent of human exposure to lead in drinking water.

01/13 Koch Industries assessed largest EPA civil penalty in history – $30 million.

02/29 First settlement with electric utility (Tampa Electric Company) resulting from EPA's enforcement initiative against coal-fired power plants.

Mar. EPA, along with HUD, HHS, and other federal agencies, releases an integrated strategy to eliminated childhood lead poisoning by 2010.

03/06 EPA launches the "Read the Label First" and the Consumer Labeling Initiative, which will make household product labels easier to read and understand.

03/30 A Federal Court upholds, in *Pronsolino v. Marcus*, EPA's longstanding interpretation and practice of identifying waters impaired by nonpoint sources of pollution and developing TMDLs for such waters.

May-July EPA performs extensive radiation monitoring to ensure protection of public health as uncontrolled fires rage near the Los Alamos National Laboratory (May) and the Hanford nuclear reservation (July).

05/01 EPA teams up with *USA Today* and *The Weather Channel* to publish the Air Quality Index (a daily indicator of the healthfulness of local air quality) on their daily weather page and websites, respectively, throughout the ozone season (May-September).

05/04 EPA promulgates a final public notification rule requiring public water systems to alert consumers within 24 hours if there is a serious problem with their drinking water that may pose a health risk.

05/05 Longest prison sentence for an environmental crime – 17 years – set following an individual's conviction on RCRA violations that left an employee with permanent brain damage due to exposure to cyanide gas.

05/10 EPA proposes the ground water rule to address the health threats to consumers by microbial contamination in ground water.

05/25 President Clinton issues Executive Order 13158, Marine Protected Areas, to better protect beaches, coasts, and ocean waters from pollution.

June EPA launches the National Environmental Performance Track program to provide rewards and incentives for strong environmental performance.

June EPA proposes the arsenic rule to provide adequate human health protection.

06/01 The premium for new cleaner-burning reformulated gasoline soars, eventually peaking at over 50¢. The issue remains volatile all summer. However, after EPA and DOE request that the Federal Trade Commission investigate, the price increment settles down to levels predicted by EPA and other analysts (4-8¢).

06/02 EPA proposes rules to clean up pollution from heavy duty trucks and buses. EPA announces the 1st phase in July and intends to issue the 2nd phase by the end of 2000. When both of phases are fully in effect, heavy duty trucks and buses will be 95% cleaner than today's models for smog-causing emissions and 90% cleaner for soot – almost as clean as alternatively fueled vehicles such as compressed natural gas vehicles.

06/08 EPA reaches agreement to phase out the residential uses of the commonly used pesticide Dursban, or chlorpyrifos.

06/30 Congress passes the FY 2000 military construction supplemental appropriations bill, which contains a rider prohibiting EPA from implementing the TMDL rule in FY 2000 and 2001.

07/11 Administrator Browner signs the final Total Maximum Daily Load Rule, strengthening the framework for identifying and cleaning up polluted water bodies, two days prior to the Congressional rider becoming effective. The final rule is published 07/13.

07/20 Willamette Industries spends $90 million to settle CAA enforcement, part of the Agency's on-going wood products enforcement initiative. This includes an $11.2 million penalty, the largest civil penalty assessed against a single stationary source facility under the CAA.

07/25 $600 million CAA settlement with BP-Amoco and Koch Refining will remove 60,000 tons of air pollution annually.

08/03 W. Michael McCabe is sworn in as 10th EPA Deputy Administrator.

08/07 EPA announces the summary results of its annual report on, and evaluation of, status and trends in our nation's air. The 1999 *Trends Report* shows that while levels of all six criteria air pollutants are down since 1990, work must continue to ensure improvements in air quality – especially as the economy, the number of vehicle miles traveled, and the population continue to grow.

08/17 EPA releases the results of the first phase of its national assessment of emissions of toxic air pollutants containing data on emissions and ambient concentrations.

Oct. EPA announces Commuter Choice – a new voluntary program in which EPA partners with the private sector and state and local governments to implement new programs designed to encourage environmentally friendly commuter choices for employees.

10/12 The Clinton Administration and Canada finalize a draft agreement to reduce emissions of smog-forming chemicals. Under the agreement, Canada agrees to have its power plants meet the standards of EPA's NO_X SIP Call and to strengthen to U.S. levels its fuel standards, its vehicle and non-road equipment emissions standards, and emissions from certain other industries. EPA hopes to have the agreement signed by the end of 2000.

10/12 EPA's Brownfields Initiative wins the Innovations in Government Award from the John F. Kennedy School of Government, Harvard University and the Council for Excellence in Government.

10/19 EPA makes public, for the first time ever, data that list tailpipe pollution levels for, and ranks accordingly, all new-model cars, wagons, pickup trucks, minivans, vans and SUVs on the basis of their tailpipe emissions. The rankings are the pollution equivalent to the gas mileage ratings that EPA issues annually.

11/06 President Clinton signs Executive Order 13175 which supercedes E.O. 13084 on Consultation and coordination with Indian Tribal Governments. The new E.O. now requires federal agencies to develop and utilize a process for consulting Indian tribal governments on matters that significantly affect them, and to appoint a federal official in each agency to ensure the process is implemented.

11/16 EPA announces multi-million dollar settlement in principle with Virginia Power (VEPCO) as part of its national initiative against CAA violations by electric utilities.

Dec. EPA launches its interactive on-line compliance assistance clearinghouse that provides links to all of the agency's compliance assistance materials as well as materials from all 50 states and other public and private organizations.

12/08 Administrator Browner joins with the State of Illinois and the City of Chicago to sign the 50th XL project.

12/13 EPA holds the National Achievement Track Charter Event, recognizing the 250 facilities that are initial members of the program.

12/14 EPA finds it is "appropriate and necessary" to develop regulations to control and reduce emissions of mercury and other toxic air pollutants from coal and oil fired power plants.

12/20 EPA publishes the final rule on mercury determination which

<u>2001</u>

01/05 EPA announces a new, enhanced internet site *Window to My Environment* to improve local and national access to integrated and dynamic geographic information.

01/12 EPA proposes the Concentrated Animal Feeding Operations rule which addresses harmful runoff from animal feedlots containing nutrients, pathogens, heavy metals, and antibiotics.

01/18 EPA requires for the first time that all copy/printing paper used by EPA Headquarters will be 100% recycled.

ORGANIZATIONAL & LEADERSHIP HISTORY 1993 - 2000

Administrator

Carol M. Browner	01/21/93	-	present

Deputy Administrator

Robert M. Sussman	03/11/93	-	10/17/94
Fred Hansen	10/18/94	-	09/30/98
Peter D. Robertson (Acting)	10/01/98	-	12/07/99
W. Michael McCabe (Acting)	12/08/99	-	08/05/00
W. Michael McCabe	08/06/00	-	present

Associate Administrator, Office of Congressional & Intergovernmental Relations[1]

Robert W. Hickmott	1993	-	07/26/97
Joseph R. Crapa	07/27/97	-	02/28/99
Diane E. Thompson	03/01/99	-	present

Associate Administrator, Office of Policy, Economics and Innovation[2]

Richard T. Farrell	07/02/99	-	present

Associate Administrator, Office of Reinvention[3]

J. Charles Fox	02/10/97	-	11/01/97
Jay Benforado (Acting)	11/02/97	-	07/01/99

Assistant Administrator, Office of Policy[4]

---

[1]From 1989 to 1997, the Office of Congressional and Legislative Affairs.

[2]From 1999 to 2000, the Office of Policy and Reinvention. Created from two separate organizations: the Office of Reinvention (Associate Administrator) and the Office of Policy (Assistant Administrator).

[3]Created in 1997.

[4]From 1983 to 1998, the Office of Policy, Planning and Evaluation.

Richard D. Morgenstern (Acting)	03/31/91	-	06/12/93
David M. Gardiner	06/13/93	-	07/01/99

Associate Administrator, Office of Communications, Education, and Media Relations[5]

Loretta M. Ucelli	02/09/93	-	04/24/99
Stephanie A. Cutter	04/25/99	-	06/05/99
Vacant	06/06/99	-	11/17/99
Steve Snider	11/18/99	-	present

Assistant Administrator, Office of Administration and Resources Management

Sallyanne Harper (Acting)	05/02/93	-	11/14/93
Jonathan Z. Cannon	11/15/93	-	07/05/95
Sallyanne Harper (Acting)	07/06/95	-	07/06/96
Alvin Pesachowitz (Acting)	07/07/96	-	10/22/98
Romulo L. Diaz, Jr.	10/23/98	-	present

Assistant Administrator, Office of Air and Radiation

Michael H. Shapiro (Acting)	01/19/93	-	11/13/93
Mary D. Nichols	11/14/93	-	08/16/97
Richard D. Wilson (Acting)	08/17/97	-	02/20/98
Robert Perciasepe (Acting)	02/21/98	-	10/29/98
Robert Perciasepe	10/30/98	-	present

Assistant Administrator, Office of Enforcement and Compliance Assurance[6]

Scott C. Fulton (Acting)	01/21/93	-	06/12/93
Steven A. Herman	06/13/93	-	present

Assistant Administrator, Office of Environmental Information[7]

Vacant	09/26/99	-	12/21/00
Edwin A. Levine	12/22/00	-	present

Assistant Administrator, Office of International Activities

Alan D. Hecht (Acting)	01/21/93	-	08/30/94

---

[5]From 1991 to 1998, the Office of Communications, Education, and Public Affairs.

[6]From 1990 to 1993, the Office of Enforcement.

[7]Created in 1999.

William A. Nitze	08/31/97	-	present

Assistant Administrator, Office of Prevention, Pesticides, and Toxic Substances[8]

Victor J. Kimm (Acting)	01/21/93	-	10/21/93
Lynn R. Goldman	10/22/93	-	12/31/98
Susan H. Wayland (Acting)	01/01/99	-	08/03/99
Vacant	08/04/99	-	03/01/00
Susan H. Wayland (Acting)	03/02/00	-	12/21/00
James V. Aidala	12/22/00	-	present

Assistant Administrator, Office of Research and Development

Gary J. Foley (Acting)	01/20/93	-	08/29/94
Robert J. Huggett	08/30/94	-	05/31/97
Henry L. Longest II (Acting)	06/01/97	-	10/22/98
Norine E. Noonan	10/23/98	-	present

Assistant Administrator, Office of Solid Waste and Emergency Response

Richard J. Guimond	01/21/93	-	10/21/93
Elliott P. Laws	10/22/93	-	02/15/97
Timothy J. Fields (Acting)	02/16/97	-	06/30/99
Timothy J. Fields	07/01/99	-	present

Assistant Administrator, Office of Water

Martha G. Protho (Acting)	01/05/93	-	10/14/93
Robert Perciasepe	10/15/93	-	07/21/98
J. Charles Fox (Acting)	07/21/98	-	10/22/98
J. Charles Fox	10/23/98	-	present

Chief Financial Officer[9]

Sallyanne Harper	07/13/97	-	01/15/00
Michael W.S. Ryan (Acting)	01/16/00	-	08/30/00
Vacant	08/31/00	-	present

General Counsel

Gerald H. Yamada (Acting)	03/08/93	-	10/21/93

---

[8]From 1980 to 1990, the Office of Pesticides and Toxic Substances.

[9]Created in 1997.

Jean C. Nelson	10/22/93	-	07/05/95
Jonathan Z. Cannon (Acting)	07/06/95	-	07/04/98
Gary S. Guzy (Acting)	11/17/98	-	07/06/99
Gary S. Guzy	07/07/99	-	present

Inspector General

John C. Martin	11/07/83	-	01/03/97
Nikki L. Tinsley (Acting)	01/04/97	-	10/21/98
Nikki L. Tinsley	10/22/98	-	present

Regional Administrator, Region 1

John P. Devillars	02/06/94	-	01/07/00
Mindy S. Lubber (Acting)	01/08/00	-	03/15/00
Mindy S. Lubber	03/16/00	-	present

Regional Administrator, Region 2

William J. Muszynski (Acting)	01/20/93	-	04/02/94
Jeanne M. Fox	04/03/94	-	present

Regional Administrator, Region 3

Stanley Laskowski (Acting)	01/20/93	-	03/13/94
Peter H. Kostmayer	03/14/94	-	06/02/95
Stanley Laskowski (Acting)	06/03/95	-	07/16/95
W. Michael McCabe	07/17/95	-	12/07/99
Vacant	12/08/99	-	12/14/99
Bradley M. Campbell	12/15/99	-	present

Regional Administrator, Region 4

Patrick M. Tobin (Acting)	12/07/92	-	07/08/94
John H. Hankinson, Jr.	01/09/94	-	present

Regional Administrator, Region 5

Valdas V. Adamkus	10/08/81	-	05/30/97
David Ullrich (Acting)	06/01/97	-	05/02/99
Francis X. Lyons	05/03/99	-	present

Regional Administrator, Region 6

Joe D. Winkle (Acting)	01/20/93	-	01/08/94
Jane N. Saginaw	01/09/94	-	07/22/95
Stanley Meiburg (Acting)	07/23/95	-	06/14/97

Gerald Clifford (Acting)	06/15/97	-	05/09/98
Gregg A. Cooke	05/10/98	-	present

Regional Administrator, Region 7

William Rice (Acting)	01/21/93	-	01/18/94
Vacant	01/19/94	-	01/30/94
Dennis D. Grams	01/30/94	-	present

Regional Administrator, Region 8

Jack W. McGraw (Acting)	01/24/93	-	01/18/94
William P. Yellowtail	01/30/94	-	03/10/96
Jack W. McGraw (Acting)	03/19/96	-	09/01/97
William P. Yellowtail	09/02/97	-	04/27/00
Rebecca Hanmer (Acting)	04/28/00	-	09/03/00
William P. Yellowtail	09/04/00	-	present

Regional Administrator, Region 9

John C. Wise (Acting)	01/21/93	-	10/02/93
Felicia Marcus	10/04/93	-	present

Regional Administrator, Region 10

Dana A. Rasmussen	11/13/90	-	07/10/93
Gerald Emison (Acting)	07/11/93	-	03/05/94
Charles C. Clarke	03/06/94	-	07/15/00
Charles Findley	07/16/00	-	present

Biographical information for the above can be found at: www.epa.gov/history

LIST OF BACKGROUND DOCUMENTS

Title	Source	Date
Tier 2 – Report to Congress	EPA	Jul. 31, 1998
Achieving Clean Air and Clean Water: The Report of the Blue Ribbon Panel on Oxygenates in Gasoline	EPA	Sept. 15, 1999
EPA Staff Paper on Gasoline Sulfur Issues	EPA	May 1, 1998
Summary Documents relating to the D.C. Circuit Court's Decision on EPA's Public Health Air Standards for Smog and Soot	EPA	May 1999
Latest Findings on National Air Quality: 1999	EPA	Aug. 2000
Progress Report on the EPA Acid Rain Program Nov. 1999	EPA	
NAPAP Biennial Report to Congress: An Integrated Assessment	National Science and Technology Council	May 1988
Carol M. Browner memorandum: "Announcement of Actions for Strengthening EPA's Tribal Operations"	EPA	Jul. 14, 1994
Robert Perciasepe memorandum: "Progress on Implementing the President's Executive Memorandum Concerning Government-to-Government Relations with Native American Tribal Governments"	EPA	Sept. 1997
Executive Order, Consultation and Coordination with Indian Tribal Governments	White House	Nov. 6, 2000
Protecting America's Wetlands: A Fair, Flexible and Effective Approach	White House Office on Environmental Policy	Aug. 24, 1993
Robert Perciasepe memorandum: "The Watershed Approach: Our Framework for	EPA	Oct. 7, 1994

Ecosystem Protection"

President Clinton's Clean Water Initiative	EPA	Feb. 1994
Watershed Approach Framework	EPA	June 1996
25 Years of the Safe Drinking Water Act: Protecting Our Health from Source to Tap	EPA	Dec. 1999
Liquid Assets 2000: America's Water Resources at a Turning Point	EPA	May 2000
Safe Drinking Water Act Reauthorization Overview	EPA	Feb. 1994
Protecting Public Health and Water Resources in Indian County – A Strategy for EPA/Tribal Partnership	EPA	Oct. 1998
Clean Water Action Plan – The first year. The future.	EPA and other Federal Agencies	Feb. 1999
Clean Water Action Plan - The Second Year Report: Progress Through Partnerships	EPA and other Federal Agencies	Feb. 2000
Watershed Success Stories – Applying the Principles and Spirit of the Clean Water Action Plan	EPA and other Federal Agencies	Sept. 2000
Superfund Reforms Annual Report FY 1998	EPA	Mar. 1999
Innovations in OSWER: Making Safer, More Livable Communities	EPA	Apr. 2000
Brownfields Application for Innovations in American Government Award	EPA	Undated
Environmental Health Threats to Children	EPA	Sept. 1996
Executive Order, Protection of Children from Environmental Health Risks and Safety Risks	White House	Apr. 21, 1997

Asthma and the Environment: A Strategy to Protect Children May 2000	President's Task Force On Environmental Health Risks & Safety Risks to Children	Jan. 28, 1999 Revised:
America's Children and the Environment A First View of Available Measures	EPA	Dec. 2000
Office of Pollution Prevention and Toxics Dec. 1999 Program Activities for Fiscal Years 1998 and 1999	EPA	
Office of Pesticide Programs Biennial Report Dec. 1999 for FY 1998 and 1999	EPA	
Innovative Approaches to Enforcement and Compliance Assurance – Action Plan for Innovation	EPA	Sept. 1999
"A Look Back and a Look Forward: EPA's Office of Enforcement and Compliance Assurance Activities Yield Significant Environmental Results"	Steve Herman, EPA Published in the NAAG Journal	Spring 2000
Protecting Your Health & the Environment Through Innovative Approaches to Compliance – Highlights from the Past 5 Years	EPA	Jan. 1999
Clinton Administration enforcement statistics	EPA	1993-present
Major Enforcement Cases: 1993- 2000 (By Statute)	EPA	Nov. 2000
Carol M. Browner memorandum: "New Strategic Enforcement Organization"	EPA	Oct. 12, 1993
Steve Herman memorandum: "Operating Principles for an Integrated Enforcement and Compliance Assurance Program"	EPA	Nov. 27, 1996

Steven A. Herman memorandum: "Core EPA Enforcement and Compliance Assurance Functions"	EPA	Feb. 21, 1996
The "Audit Policy" – Encouraging Voluntary Self-Disclosure and Correction	EPA	Nov. 2000
1998 Environmental Justice Biennial Report: Moving Towards Collaborative and Constructive Problem-Solving	EPA	July 2000
The Model Plan for Public Participation (In both English and Spanish)	Public Participation and Accountability Subcommittee, National Environmental Justice Advisory Committee	Nov. 1996
Environmental Justice Fact Sheet	EPA	Nov. 2000
Environmental Justice Implementation Plan	EPA	Apr. 1996

In the order listed in Appendix III,

List of Background Documents

United States
Environmental Protection
Agency

Air and Radiation

EPA420-R-98-008
July 1998

EPA

Tier 2
Report to Congress

Printed on Recycled Paper

EPA420-R-98-008

Tier 2 Study

July 31, 1998

FINAL

I. EXECUTIVE SUMMARY

Purpose of the Tier 2 Study

This Tier 2 Study examines whether it is appropriate to require more stringent emission standards for new passenger cars and light duty trucks, which make up the majority of motor vehicles on the road today. As directed by Congress, the Environmental Protection Agency (EPA) in this examination assesses the air quality need, technical feasibility, and cost effectiveness of such technologies. This study is the first step in determining if more stringent vehicle standards are needed to meet the National Ambient Air Quality Standards.

The Clean Air Act (CAA) directs the EPA to identify and set national ambient air quality standards (NAAQS) for pollutants that cause adverse effects to public health and the environment. EPA has set standards for six common air pollutants, known as "criteria pollutants." They are ground-level ozone (an important component of smog), carbon monoxide, lead, nitrogen dioxide, sulfur dioxide, and particulate matter (measured as PM_{10} and $PM_{2.5}$). For each of these six pollutants, EPA set health-based or "primary" standards to protect public health and welfare-based or "secondary" standards to protect the environment (crops, vegetation, wildlife, buildings and national monuments, visibility, etc).

The CAA sets specific exhaust emission standards, beginning with the 1994 model year, for light-duty vehicles (LDV), or passenger cars, and light-duty trucks (LDT), including sport utility vehicles, minivans, and pick-up trucks. These are "Tier 1" emission standards. The Act requires the study of whether or not further reductions in emissions from these vehicles should be required by setting more stringent "Tier 2" emission standards. This assessment must address the need for further reductions in motor vehicle emissions to attain and maintain the NAAQS, including, at a minimum, three factors:

- the air quality need for more stringent standards,
- the availability of technology to implement more stringent standards, and
- the cost effectiveness of more stringent motor vehicle standards, as well as alternative means to attain and maintain the NAAQS.

This "Tier 2 Study" addresses these factors, as well as others relevant to the consideration of whether to establish more stringent light-duty car and truck emission standards. For example, the study incorporates in its analysis the National Low Emission Vehicle (National LEV or NLEV) program, a voluntary agreement among automakers and Northeastern states to produce cleaner cars nationally. The National LEV program ensures that, beginning in model year 1999 and fully phased in by model year 2001, vehicles will meet emission standards that are cleaner

than Tier 1 standards by harmonizing with the more stringent exhaust emission standards required by California.

The requirements for the Tier 2 Study and the manner by which the study was developed are described in *Chapter II, Introduction*. As required by Congress, this study was released to the public for comment on April 23, 1998. After the close of the public comment period, EPA summarized the comments received, modified the draft study as necessary, and created this final report for submission to Congress. The public comments and EPA's response, when appropriate, are summarized in *Appendices E and F*. Overall, the comments resulted in minor changes to the study and did not change any of the findings of the study.

This study does not include proposed new emission standards. Instead, it focuses on addressing the three factors identified in the statute and raises and discusses broadly other related issues. If it is determined that more stringent emission standards are necessary and viable, the Agency will, through a rulemaking process, promulgate such standards by the end of 1999. The issues discussed in this study would be more fully developed and analyzed as part of this rulemaking.

Status of Air Quality in the United States

Air quality in the United States continues to improve. Nationally, the 1996 air quality levels are the best on record for all six criteria pollutants. In fact, the 1990s show a steady trend of improvement.

The improvements in air quality and economic prosperity that have occurred since EPA initiated air pollution control programs in the early 1970s illustrate that economic growth and environmental protection can be compatible. Since 1970, national total emissions of the six criteria pollutants declined 32 percent, while U.S. population increased 29 percent and gross domestic product increased 104 percent. Motor vehicle emissions have decreased 58% for volatile organic compounds, 40% for carbon monoxide, and 3% for nitrogen oxides while vehicle miles traveled have increased 121 percent.

Despite these continued improvements in air quality, however, approximately 46 million people live in counties where air quality levels exceeded the level of the national air quality standards for at least one of the six criteria pollutants that were in effect in 1996.

Even taking into consideration the trend toward improving air quality, many areas will not be in attainment with the NAAQS in 2007, in spite of implementation of the National Low Emission Vehicle (National LEV) program, programs to reduce regional transport of ozone emissions, and other air pollution controls. Furthermore, many areas that are in attainment will need ongoing programs to maintain their attainment, especially in light of continued economic growth.

Motor Vehicles' Contribution to Air Pollution

While current cars emit about 97% fewer pollutants than 1970 models, emissions from motor vehicles still contribute a large portion of our air pollution. Nationwide, mobile sources are estimated to contribute more than half of the nitrogen oxides (NOx) inventory; 42% of the volatile organic compounds (VOC) inventory; one-quarter of the particulate matter-10 (PM-10) inventory; and 80% of the carbon monoxide (CO) emissions.

In 1996, LDVs and LDTs contributed more than 25% of national VOC emissions. LDV and LDTs contributed more than 53% of national CO and contributions to national NOx were almost 22%.

American motorists traveled 2.5 trillion miles in 1997, with a nearly constant growth of 2% a year. In addition, sport utility vehicles, minivans and small pick-up trucks comprise almost half of the passenger vehicles sold in the United States today, dramatically changing the overall composition of motor vehicles on the road, as well as the emissions inventory.

Overview of the Tier 2 Study

Emissions from motor vehicles include volatile organic compounds, carbon monoxide, nitrogen oxides, and particulate matter. VOC and NOx emissions combine to produce ozone, or smog, in the atmosphere. Gaseous VOC and NOx emissions also help form PM in the atmosphere. Elevated levels of ambient ozone, CO, and PM have been associated with increases in both human morbidity and mortality. In addition, VOC emissions from motor vehicles include known and probable human carcinogens. NOx emissions contribute to impaired visibility and crop damage, as well as the acidification of lakes and estuaries.

Chapter III. Assessment of Air Quality Need describes and assesses the air quality need for more stringent control of LDV and LDT emissions. The available evidence, discussed in this chapter, supports the need for emission reductions beyond that provided by the Tier 1 standards, the National LEV program and other control programs.

LDV and LDT emissions primarily affect the attainment of NAAQS for three pollutants: ozone, particulate matter, and carbon monoxide. Motor vehicles' emission of these pollutants or their precursors and the effects on NAAQS attainment is discussed. The atmospheric pathways through which LDV and LDT emissions affect these NAAQS are identified, as well as health and welfare impacts that are not directly addressed by the NAAQS.

This assessment finds that, in the time frame contemplated for Tier 2 standards, there will be an air quality need for emission reductions to aid in meeting and maintaining the NAAQS for both ozone and PM. Air quality projections of both ozone and PM-10 in the years 2007 to 2010 show continued nonattainment in a number of local areas, even after the implementation of existing emission controls. The contribution of LDVs and LDTs to VOC and NOx emissions

that form ozone is projected to be substantial. Further VOC and/or NOx emission reductions beyond those provided by the Tier 1 light-duty motor vehicle standards, National LEV, and other programs are still needed in order for all areas of the nation to attain the NAAQS for ozone. These reductions would also provide needed assistance to additional areas in maintaining their projected compliance with the ozone NAAQS.

Further reductions in emissions of PM and PM precursors beyond those provided by the Clean Air Act are still needed in order for all areas of the nation to attain the NAAQS for PM_{10}. These reductions would also provide needed assistance to additional areas in maintaining their projected compliance with the PM_{10} NAAQS.

While emissions of PM from LDVs are relatively small, the trend toward heavier vehicles and the use of diesel fuel makes this an issue that must be analyzed. PM emissions from gasoline-fueled vehicles are quite low, while PM emissions from diesel vehicles meeting the Tier 1 PM standards are at least an order of magnitude greater. Widespread use of the diesel engine in LDVs and LDTs without more stringent Tier 2 standards for particulate emissions could significantly increase ambient levels of PM_{10}, worsening compliance further.

In contrast with ozone and PM, EPA does not project significant numbers of CO nonattainment areas in the future. Furthermore, any future exceedances will occur during wintertime conditions. The air quality need for further CO emission reductions from motor vehicles is being evaluated separately, in the context of the requirement to evaluate cold CO emission reductions.

Chapter IV. Assessment of Technical Feasibility examines the technological feasibility of controlling light-duty vehicle and light-duty truck emissions beyond the level of control provided for by Tier 1 emission standards. The technological feasibility of more stringent LDV and LDT emission standards is apparent. There is abundant evidence that technology exists to reduce LDV and LDT emissions below Tier 1 levels.

The review of vehicle emission control technology begins with a discussion of the emission performance of current Tier 1, National LEV, and California LEV technology vehicles. The chapter then reviews the status and potential of a number of emission control technologies which could be used to get emission control beyond Tier 1, and even beyond National LEV, standards. Various technologies that could be used to reduce vehicle emissions below levels currently incorporated in the National LEV and California LEV programs are described, ranging from improvements to base engine designs to advancements in exhaust after-treatment systems. The effect that gasoline sulfur may have on potential Tier 2 technologies is examined, as it has become apparent that this is a critical factor to be considered.

The technologies discussed in this chapter are either currently in production on one or more vehicle models or are in the final stages of development. Given the rapid pace of technological advances made in the motor vehicle manufacturing industry in recent years, one

can assume even greater opportunities available in 2004 and beyond. Automotive manufacturing companies are already producing LDVs that meet National LEV standards, achieving much lower emission levels than currently required. Some manufacturers have committed to market LDTs that meet National LEV standards as soon as the 1999 model year.

An examination of the cost effectiveness of more stringent light-duty emissions standards is found in *Chapter V, Assessment of Cost and Cost Effectiveness*, including a review of the cost effectiveness of both mobile and stationary source controls for the primary pollutants of concern. Information on costs and cost effectiveness for potential future emission control technologies is presented in this chapter. This includes the cost effectiveness of LEV technologies, as well as technologies that achieve emission reductions beyond LEV standards. The chapter estimates cost effectiveness of certain emission reductions without making a determination of the specific numerical values of potential regulatory standards.

Estimates of the cost of future technologies are highly uncertain and often inflated. Frequently, engineers from the auto industry, as well as government regulators and outside experts, predict future costs that eventually prove to be too high when the technology is actually manufactured and installed on mass-produced vehicles. As stated previously, Tier 2 standards cannot be effective until the 2004 model year at the earliest. Therefore, although the cost estimates included in this study are EPA's best assessment of future technology, they may be conservatively high.

EPA evaluates specific motor vehicle emission control technologies, including tighter air-fuel controls and improved catalyst designs. EPA estimates that these technologies should be able to reduce NMHC (non-methane hydrocarbons) by as much as 77% and NOx emissions by 80%, relative to Tier 1 vehicles on a per mile basis, at a cost well below $5000 per ton on an annual basis. Comparing these reductions relative to National LEV yields a 7% reduction in NMHC and 30% in NOx, at a cost also well below $5000 per ton. These emission reductions would also be more than sufficient to meet the default Tier 2 standards listed in Table 3 of section 202(i) of the CAA.

EPA evaluates the cost effectiveness of other current or potential control methods for controlling emissions. The techniques for reducing LDV and LDT emissions appear to be comparable to or more cost effective than many alternative methods of emission reduction. In developing the National LEV regulations, EPA found that the National LEV standards provided cost effective emission reductions from the Tier 1 standards relative to other emission control programs (roughly $2000 per ton of NMHC and NOx controlled).

In addition to estimates of cost, this chapter also attempts to quantify the emission reduction capabilities of these future technologies. In this way, the cost effectiveness, in units of dollars per ton of emissions reduced, can be calculated and compared.

Next Steps

Following submission of this Report to Congress, EPA will by rule, determine whether: 1) there is an air quality need for further emission reductions; 2) the technology for meeting more stringent emissions standards will be available; and 3) obtaining further reductions in emissions from light-duty vehicles and certain light-duty trucks will be needed and cost effective. If these conditions exist, EPA will promulgate emission standards for such vehicles by December 1999, providing significant and frequent opportunities for the involvement of interested parties throughout the rulemaking process.

In its rulemaking, EPA will examine additional issues, as discussed in *Chapter VI: Regulatory Issues* of this Tier 2 study. They will include the relative stringency of LDV and LDT standards, the appropriateness of having separate standards for gasoline and diesel vehicles versus having the same standards for such vehicles, and effects of sulfur in gasoline on catalyst efficiency.

All LDVs have historically been required to meet the same numerical emission standards. For example, large luxury cars and small sub-compacts both meet the same emission standards, because both types of vehicles are used as personal transportation. In contrast, higher numerical emission standards have historically been established for LDTs. As LDTs become a larger portion of the passenger fleet, they have a disproportionate impact on in-use emissions. Options for setting LDT emission standards given a particular set of LDV standards include: requiring LDTs to meet the same numerical emission standards as LDVs; setting the LDT standards to require use of the same emission control technology as the LDV standards; or setting different standards based on vehicle use.

Another consideration is whether the same emission standards should be applied to similar vehicles regardless of what fuel is utilized. Here, the primary fuel options for conventional vehicles are gasoline and diesel fuel. The pollutants of most interest with regard to applying the same standards to gasoline and diesel vehicles are NOx and PM exhaust emissions. Both diesel and gasoline vehicles appear to be capable of meeting the range of possible Tier 2 NMHC and CO emission standards, so the issue of equivalent standards does not arise with respect to these pollutants.

Sulfur in gasoline affects emissions of HC, CO and NOx by inhibiting the performance of the catalyst. Recent information from test programs performed by the Coordinating Research Council (CRC) and the auto industry suggests that not only do LEV and Tier 1 vehicles exhibit decreased emissions performance due to fuel sulfur, but the more advanced the technology, the more sensitive (on a percentage basis) the catalysts are to sulfur. The studies indicate that increasing sulfur content could more than double NOx emissions and have a less severe, though noticeable, effect on HC emissions. EPA addressed this issue in a recently released *Staff Paper on Gasoline Sulfur Issues* (May 1998). EPA plans to consider issues related to sulfur levels in gasoline, including geographic applicability and costs of controls, as part of the Tier 2 rulemaking.

II. INTRODUCTION

In drafting the Clean Air Act, as amended in 1990, Congress envisioned that it may be necessary to require additional emission reductions from new passenger vehicles in the beginning of the 21st Century to provide needed protection of public health. Section 202 (i) of the CAA outlines a process for assessing whether more stringent exhaust emission reductions from light-duty vehicles and light-duty trucks should be required. Congress required the Environmental Protection Agency to report the results of this assessment to Congress. Congress identified specific standards[1] that EPA must consider in making this assessment, but stated that the study should also consider other possible standards. These standards, referred to as the "Tier 2 standards" in this study, would be more stringent than the standards required for LDVs and LDTs in the CAA beginning in model year 1994[2], but could not be implemented prior to the 2004 model year.

Specifically, Congress mandated that this study examine[3]:

1) the need for further reductions in emissions in order to attain or maintain the National Ambient Air Quality Standards, taking into consideration the waiver provisions of section 209(b),

2) the availability of technology (including the costs thereof) in the case of light-duty vehicles and light-duty trucks with a loaded vehicle weight of 3750 lbs or less, for meeting more stringent emission standards than those provided in subsections (g) and (h) for model years commencing not earlier than after January 1, 2003, and not later than model year 2006, including the lead time and safety and energy impacts of meeting more stringent emission standards; and

---

[1] Clean Air Act; Section 202 (i); Table 3: Pending Emission Standards for Gasoline and Diesel Fueled Light-duty Vehicles and Light-duty Trucks 3,750 lbs LVW or Less.

Pollutant	Emission Level in grams per mile (g/mi)
NMHC	0.125 g/mi
NOx	0.2 g/mi
CO	1.7 g/mi

[2] Section 202 (g) and (h).

[3] Section 202 (i), Congress specified that, "The Administrator, with the participation of the Office of Technology Assessment, shall..." However, the 104th Congress voted to cease funding the Office of Technology Assessment after September 30, 1995, prior to the Agency developing plans for the Tier 2 study.

3) the need for, and cost effectiveness of, obtaining further reductions in emissions from such light-duty vehicles and light-duty trucks, taking into consideration alternative means of attaining or maintaining the national primary ambient air quality standards pursuant to state implementation plans and other requirement of this Act, including their feasibility and cost effectiveness.

As the first draft of this study was being completed, an historic agreement between automakers and the states, coordinated by EPA, established a voluntary National Low Emission Vehicle program. This program requires that vehicles, sold in model year 1999 in the Northeast and sold nationwide in model year 2001, meet more stringent emission standards than current federal Tier 1 standards. The National LEV program also harmonizes, to the greatest practical extent, federal requirements with the more stringent exhaust emission standards established by the state of California.[4] This program was prompted by the established air quality need in the northeastern United States to assist states in meeting the National Ambient Air Quality Standards. The National LEV program provides an additional feasibility and cost effectiveness baseline for more stringent exhaust emission standards in the future compared to that identified by Congress for the Tier 2 standards.

In conducting this study, EPA ensured that issues relevant to the study were explored using a public process. The Agency published a Staff White Paper (See 62 FR 18346; April 15, 1997) and conducted a public workshop on April 23, 1997. In addition, the Agency participated in numerous meetings with states, environmental organizations and industry representatives.

As required by Congress, this study was released to the public for comment on April 23, 1998. After providing 45 days for public comment, EPA summarized the comments received (see Appendices E and F), modified the draft study as necessary, and created this final report for submission to Congress.

Based on the conclusions of this study, EPA now plans to determine, by rule, whether: 1) there is a need for further emission reductions; 2) the technology for meeting more stringent emissions standards will be available; and, 3) further reductions in emissions from light-duty vehicles and certain light-duty trucks will be needed and cost effective, taking into consideration other alternatives. If EPA determines that these conditions exist, then EPA shall promulgate emission standards for such vehicles.

---

[4] California has the authority under section 209(b) of the CAA to establish state specific vehicle and engine emissions and testing programs.

III. ASSESSING THE AIR QUALITY NEED

The goal of this chapter is to assess the air quality need for additional control of motor vehicle emissions that hinder areas of the country from attaining and/or maintaining National Ambient Air Quality Standards, in particular those for ozone, particulate matter and carbon monoxide.[5] To understand the impact of these pollutants, and ozone precursors, this chapter outlines their threat to public health and welfare and the manner in which they are formed and transported in air. In assessing air quality need, EPA examined projections of future areas of NAAQS nonattainment, as well as projections of areas needing to closely monitor maintenance plans in the future. This chapter then assesses the contribution of light-duty vehicles (LDVs) and light-duty trucks (LDTs) to the overall inventory for each pollutant and briefly explains other benefits of LDV and LDT emission controls. Finally, this chapter reviews future projections of air quality given all known and projected control strategies in the time frame contemplated for potential Tier 2 controls. Evidence that additional motor vehicle controls should be considered would include the fact that motor vehicles substantially contribute to total emission inventories in nonattainment areas and in areas which affect nonattainment through transport, as well as areas that may have difficulty maintaining their attainment status.

The available data indicate that in the time frame contemplated for Tier 2 standards there will be an air quality need for emission reductions to aid in meeting the NAAQS for both ozone and PM. EPA is continuing to evaluate the air quality need for further CO emission reductions in the context of the requirement to evaluate cold CO emission reductions as discussed later in this chapter. The available evidence also indicates that motor vehicle emissions will remain a significant contributor to air pollution in a significant number of areas of the country.

A. Health and Welfare Effects of Ozone

Ground-level ozone is the prime ingredient of smog, the pollution that blankets many areas during the summer.[6] Short-term exposures (1-3 hours) to high ambient ozone concentrations have been linked to increased hospital admissions and emergency room visits for respiratory problems. Repeated exposures to ozone can exacerbate symptoms and the frequency of episodes for people with respiratory diseases such as asthma. Other health effects attributed to short term exposures include significant decreases in lung function and increased respiratory symptoms such as chest pain and cough. These effects are generally associated with moderate or heavy exercise or exertion. Those most at risk include children who are active outdoors during the summer, outdoor workers, and people with pre-existing respiratory diseases like asthma. In

---

[5] The Tier 2 standards would have no direct impact on the NAAQS for sulfur dioxide. However, gasoline sulfur controls to enable tighter Tier 2 standards, as discussed in Chapter VI, would reduce ambient levels of sulfur dioxide.

[6] Ozone also occurs naturally in the stratosphere and provides a protective layer high above the earth.

addition, long-term exposures to ozone may cause irreversible changes in the lungs which can lead to chronic aging of the lungs or chronic respiratory disease.

Ambient ozone also affects crop yield, forest growth, and the durability of materials. Because ground-level ozone interferes with the ability of a plant to produce and store food, plants become more susceptible to disease, insect attack, harsh weather and other environmental stresses. Ozone chemically attacks elastomers (natural rubber and certain synthetic polymers), textile fibers and dyes, and, to a lesser extent, paints. For example, elastomers become brittle and crack, and dyes fade after exposure to ozone.

Ozone is not emitted directly into the atmosphere, but is formed by a reaction of VOC and NOx in the presence of heat and sunlight. Ground-level ozone forms readily in the lower atmosphere, usually during hot summer weather. VOCs are emitted from a variety of sources, including motor vehicles, chemical plants, refineries, factories, consumer and commercial products, and other industrial sources. VOCs are also emitted by natural sources such as vegetation. NOx is emitted from motor vehicles, power plants and other source of combustion. Changing weather patterns contribute to yearly differences in ozone concentrations and differences from city to city. Ozone can also be transported into an area from pollution sources found hundreds of miles upwind.

VOC emissions are not only important for their contribution to ambient ozone. Some fraction of the VOCs emitted from motor vehicle are toxic compounds. At elevated concentrations and exposures, human health effects from air toxics can range from respiratory effects to cancer. Other health impacts include neurological, developmental and reproductive effects.

NOx emissions produce a wide variety of health and welfare effects. Nitrogen dioxide can irritate the lungs and lower resistance to respiratory infection (such as influenza). NOx emissions are an important precursor to acid rain and may affect both terrestrial and aquatic ecosystems. Atmospheric deposition of nitrogen leads to excess nutrient enrichment problems ("eutrophication") in the Chesapeake Bay and several other nationally important estuaries along the East and Gulf Coasts. Eutrophication can produce multiple adverse effects on water quality and the aquatic environment, including increased nuisance and toxic algal blooms, excessive phytoplankton growth, low or no dissolved oxygen in bottom waters, and reduced sunlight causing losses in submerged aquatic vegetation critical for healthy estuarine ecosystems. Nitrogen dioxide and airborne nitrate also contribute to pollutant haze, which impairs visibility and can reduce residential property values and revenues from tourism.

B. Role of VOC and NOx Emissions in Producing Atmospheric Ozone

The production of ozone from VOC and NOx emissions[7] involves a complex set of chemical reactions, and different mixtures of VOCs and NOx can result in different ozone levels. For example, large amounts of VOC and small amounts of NOx make ozone rapidly, but ozone production is quickly limited by removal of the NOx. VOC reductions under these circumstances show little effect on ozone while NOx reductions reduce ozone. (This condition is referred to as NOx limited.)

Large amounts of NOx and small amounts of VOC result in the formation of inorganic nitrates, but little ozone. In these cases, reduction of VOC emissions reduces ozone, but the reduction of NOx emissions can actually increase ozone. (This condition is referred to as VOC limited.) The highest levels of ozone are produced when both VOC and NOx emissions are present in significant quantities.

The formation of ozone is further complicated by biogenic (natural) emissions, meteorology and transport of ozone and ozone precursors. The contribution of VOC emissions from biogenic sources to local ambient ozone concentrations can be significant and often produces conditions which are NOx limited. Many of the above chemical reactions are sensitive to temperature. When ambient temperatures remain high for several days and the air is relatively stagnant, ozone and its precursors can actually build up and produce more ozone than typically would occur on a single high temperature day. When air is moving, ozone and its precursors can be transported downwind and contribute to elevated ozone levels outside of the area where the NOx is emitted.

This study focuses on the response of ambient ozone to the reduction in either VOC or NOx emissions, or both. In general, specific local areas are often described as being VOC or NOx limited. Rural areas are almost always NOx limited, due to the relatively large amounts of biogenic (from plants and trees) VOC emissions there. Urbanized areas can be either VOC or NOx-limited, or a mixture of the two (moderate sensitivity to either pollutant, versus strong sensitivity to one and little sensitivity to the other). In projecting future attainment of the revised ozone NAAQS, EPA found that significant reductions in both VOC and NOx emissions would be necessary.

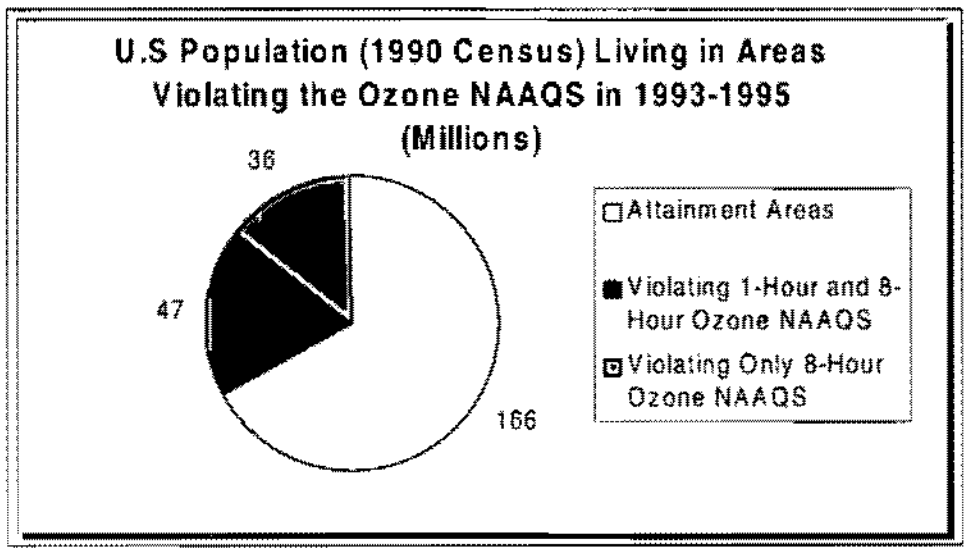
C. Current Compliance with the Ozone NAAQS

As of October, 1997, EPA classified 59 ozone nonattainment areas with respect to the 1-hour ozone standard, encompassing all or part of 249 counties. The population of these 59 areas, based on the 1990 Census, is approximately 102 million, or 40 percent of the total U.S. population. These areas are located in the 37 easternmost states, Arizona, New Mexico, and California.

---

[7] CO also participates in the production of ozone, much like a slowly reacting VOC.

In July 1997, EPA established a new 8-hour ozone NAAQS to better protect against longer exposure periods at lower concentrations than the current 1-hour standard. The 1-hour NAAQS is still applicable in certain areas during the transition to the eight-hour standard (62 FR 38856, July 17, 1997). EPA reviewed ambient ozone monitoring data for the period 1993 through 1995 to determine which counties violated either the 1-hour or 8-hour NAAQS for ozone during this time period.[8,9] Eighty-four counties violated the 1-hour NAAQS during this 3-year period, while 248 counties violated the 8-hour NAAQS. The 84 counties had a 1990 population of 47 million, while the 248 counties had a 1990 population of 83 million. EPA is reviewing more recent air quality data for 1996 and 1997. A preliminary assessment of 1994 through 1996 ozone monitoring data reveals only marginal changes in the number of counties experiencing a nonattainment problem with the 8-hour NAAQS, and essentially no change in the population levels impacted by nonattainment.



D. Future Ambient Ozone Levels

The analysis of future ozone attainment provides a basis for assessment of the need for additional emission reductions to achieve attainment and assure maintenance of the NAAQS. EPA recently performed two projections of future ozone attainment status in the years 2007 to 2010. The first was part of EPA's 1997 ozone NAAQS rulemaking.

---

[8] This use of the term "nonattainment" in reference to a specific area is not meant as an official designation or future determination as to the attainment status of the area.

[9] U.S. Environmental Protection Agency, Finding of Significant Contribution and Rulemaking for Certain States in the Ozone Transport Assessment Group Region for Purposes of Reducing Regional Transport of Ozone; Proposed Rule, 62 FR 60318 (November 7, 1997) ("OTAG SIP Call NPRM").

The second was conducted for the EPA's recent notice of proposed rulemaking regarding requirements for State Implementation Plans for 37 easternmost states. Through a two-year effort known as the Ozone Transport Assessment Group (OTAG), EPA worked in partnership with state and local government agencies in the 37 easternmost states, industry and academia to address ozone transport. The work resulted in a proposed rule to reduce the regional transport of ozone (OTAG SIP Call NPRM). The ozone projections supporting the OTAG SIP Call NPRM used more advanced regional ozone modeling tools than those made in support of the revised ozone NAAQS. However, the ozone NAAQS analysis covered the entire nation, while the OTAG SIP Call NPRM only addressed ozone levels in the eastern U.S. Therefore, both are discussed below. In developing a projection of future ozone nonattainment for the purpose of this study, EPA combined the projections from the OTAG SIP Call NPRM for the 37-state OTAG region with the projections from the Regulatory Impact Analysis (RIA) for the revised ozone NAAQS for the remaining 11 states in the continental United States.

As part of the RIA for the revised ozone NAAQS, EPA projected future ambient ozone levels in 2010 using a Regional Oxidant Model (ROM) extrapolation methodology. One of the scenarios evaluated was a 2010 baseline, which included emission controls which have already been implemented or mandated by the Clean Air Act, regional NOx emission control in the eastern U.S. estimated to be associated with the then upcoming OTAG SIP Call NPRM, plus the National Low Emission Vehicle program. This set of emission control strategies generally represents all of the emissions reductions which may be expected from measures currently adopted or planned by the states.

EPA used ROM air quality modeling, historical ozone air quality monitoring data and emission inventory estimates to project baseline 2010 ozone levels for counties in the 48 contiguous states. For the purpose of this study, the standard and consolidated metropolitan statistical areas (MSAs and CMSAs) containing these counties were identified. Nine areas with a 1990 population of approximately 49 million people were projected to be in nonattainment of the 1-hour ozone standard, 32 million people outside of California. Nineteen areas (with approximately 79 million people as of 1990) were projected to be in nonattainment with the 8-hour ozone NAAQS, 51 million people outside of California. The 51 million people living in the projected nonattainment areas outside of California represent more than a fifth of the U.S. population in 1990.[10]

The Tier 2 standards would primarily affect ozone outside of California due to the applicability of California's traditionally more stringent motor vehicle standards to vehicles sold in California. However, the Tier 2 standards would also indirectly, but significantly improve ozone levels within California. This indirect benefit is due to the migration of non-California vehicles into California when people move into that state. It is also due to the temporary business and leisure travel of non-Californians into California. The California Air Resources

---

[10] Populations in 1990 are presented in this study because of their ready availability and accuracy. Populations in future NAAQS nonattainment and maintenance areas will generally be much higher.

Board (ARB) recognized this benefit in the context of the NLEV program. The California ARB used the benefits of the NLEV program to compensate for emission increases associated with a delay in the implementation schedule for zero-emission vehicles.

Once an area attains a NAAQS, the CAA requires that it establish a plan for maintaining this attainment. Otherwise, future economic and population growth can increase emissions to the point where the area again violates the NAAQS. To estimate the number of areas that need to be concerned about ozone NAAQS compliance in the future, EPA (for the Tier 2 study) also identified metropolitan areas containing counties that were projected to be below the 8-hour ozone NAAQS, but with a relatively small margin of safety (i.e., 15%). VOC and NOx emission reductions associated with the Tier 2 standards would assist these areas in maintaining their compliance.

In the ozone NAAQS RIA, EPA also projected that available local VOC and NOx controls (at a cost of up to $10,000 per ton of VOC or NOx in 1990 dollars) could bring only two of these 19 areas into attainment with the new 8-hour NAAQS. Seventeen (17) of the 19 areas remained out of attainment after all available local controls. Overall, the available local controls in the 19 areas only achieved 38% and 23% of the necessary VOC and NOx emission reductions required. Clearly, these areas would need additional emission reductions in order to achieve the new ozone NAAQS. As mentioned above, both the OTAG SIP Call and National LEV programs were included in the baseline projections. Therefore, only motor vehicle controls beyond those provided by Tier 1 and National LEV would qualify as additional control.

In the OTAG SIP Call NPRM, EPA proposed that 22 states and the District of Columbia be required to submit revised SIPs demonstrating reductions in NOx emissions in order to reduce the transport of ozone into ozone nonattainment areas. EPA relied upon the ambient ozone modeling conducted during the OTAG process in developing the proposed emission reductions. OTAG evaluated a wide variety of VOC and NOx emission controls for stationary, area and mobile sources over a two year period. EPA reviewed OTAG ozone modeling which included utility NOx emission reductions most closely resembling those being proposed, and controls for other sources (stationary, areas and mobile) required by the CAA or which had already been implemented. This modeling, like that conducted during the ozone NAAQS revisions process, also assumed the implementation of a National LEV program. Complete details of the modeling process can be found in the OTAG SIP Call NPRM and associated documents. A list of the specific emission control strategies assumed in this modeling is presented in *Appendix A. Future Ozone Nonattainment Projections*.

For the purpose of the Tier 2 study, EPA reviewed the results of the OTAG SIP Call NPRM analyses and found that 8 areas with a population of approximately 41 million people were projected to be in nonattainment of the 1-hour ozone standard. Fifteen areas (with approximately 63 million people) were projected to be in nonattainment with the 8-hour ozone NAAQS.

Combining the OTAG SIP Call NPRM projections for the OTAG region with those of the ozone NAAQS RIA for the remainder of the country, EPA developed the following projections of ozone nonattainment and maintenance areas in 2007 (OTAG region) and 2010 (remaining 11 states). The metropolitan areas projected to be in nonattainment are presented in *Appendix A*.

Table 3.1 2007/2010 Ozone Nonattainment with CAA Controls, OTAG SIP Call, & NLEV

	OTAG Region (2007)	Non-CA, Non-OTAG (2010)	California (2010)
Violating 1-Hour NAAQS			
Number of Areas	8	0	4
1990 Population (millions)	41	0	18
Violating 8-Hour NAAQS			
Number of Areas	15	1	6
1990 Population (millions)	63	2	28
Maintenance of the 8-Hour NAAQS (within 15% of NAAQS)			
Number of Areas	85	11	7
1990 Population (millions)	118	11	9

For the purposes of this study, EPA also identified the Standard Metropolitan Statistical Areas (SMSA) and CMSAs containing counties which were projected to be below the 8-hour ozone NAAQS, but within 15% of the NAAQS. EPA found 103 areas (96 non-California areas) to have projected ozone levels within 15% of the NAAQS, with a 1990 population of 136 million (129 million outside of California). As already stated, additional emission reductions would certainly assist such areas to maintain their attainment status and may actually be required, given meteorological variability and uncertainties in emission and ozone modeling.

These projections of future ozone nonattainment provide evidence for the need for additional VOC and NOx emission reductions beyond those considered in these studies. The CAA provides states flexibility in selecting local emission control strategies to achieve the NAAQS. EPA has augmented these local controls with cost effective national programs, some mandated by the CAA and others using EPA's discretionary authority under the CAA. The above analyses indicate that both local and national measures appear to be necessary for the nation to achieve the ozone NAAQS. Tier 2 standards for LDVs and LDTs appear to be a reasonable national control option for consideration. Because the above ozone projections of future nonattainment already assumed and incorporated the permanent implementation of the National LEV program, the focus for motor vehicle control programs should be on VOC and NOx emission controls beyond the National LEV standards.

E. Contribution of LDV/LDT Emissions to Total VOC and NOx Inventories

Since motor vehicles and their fuels were first regulated 25 to 30 years ago, their relative contribution to ozone nonattainment problems has diminished, in spite of explosive growth in the amount of travel. The relative cost of adopting further motor vehicle controls compared to other reduction strategies depends in part on their future contribution to VOC and NOx emissions in ozone nonattainment areas and areas contributing to ozone nonattainment through pollutant transport. Auto industry comments received by EPA after publication of a preliminary white paper on Tier 2 standards issues indicated that an updated assessment should be made of the importance of LDVs and LDTs to the ozone nonattainment problem. Specifically, commenters suggested that new information about the durability of emission control systems would alter the projections of nonattainment made in the studies mentioned previously, perhaps to the extent that no additional measures would be needed. In developing the study, EPA analyzed new mobile source modeling data associated with a number of factors.

Emissions from motor vehicles are usually estimated by combining estimates of emissions per mile (commonly called emission factors) with local estimates of vehicle miles traveled. EPA developed a series of models to project in-use emission factors from on-road motor vehicles. EPA is currently revising the MOBILE5 model. MOBILE6 will be issued in 1999.

While the analytical efforts involved in developing MOBILE6 are still underway, EPA performed preliminary assessments of four key factors which could affect the need for Tier 2 standards.[11] These factors are:

1) In-use emission deterioration rates for Tier 1 vehicles, LEVs, and late model Tier 0 vehicles;

2) The effect of "off-cycle" driving patterns and conditions on LDV and LDT emissions, as well as the effect of off-cycle emission standards on these emissions;[12]

3) The effect of fuel sulfur on emissions from low emitting vehicles, such as CA LEVs and NLEVs; and

---

[11] MOBILE6 is being developed through an extensive and open process which is continuing in parallel with the Tier 2 standards process. The changes to MOBILE5b described herein should not be construed as pre-judging the outcome of the MOBILE6 development process, but simply represent EPA's current best estimate of some of the factors which are most relevant to the evaluation of the Tier 2 LDV/LDT standards.

[12] "Off-cycle" emissions are those which occur during driving conditions not included in EPA's historical certification driving cycle, the LA-4 cycle. The specific off-cycle driving conditions addressed here are aggressive driving (high speeds and high accelerations) and driving with the air conditioner on.

4) The characterization of the LDT fleet (i.e., relative LDV and LDT sales, and LDT registrations and annual mileage versus age)

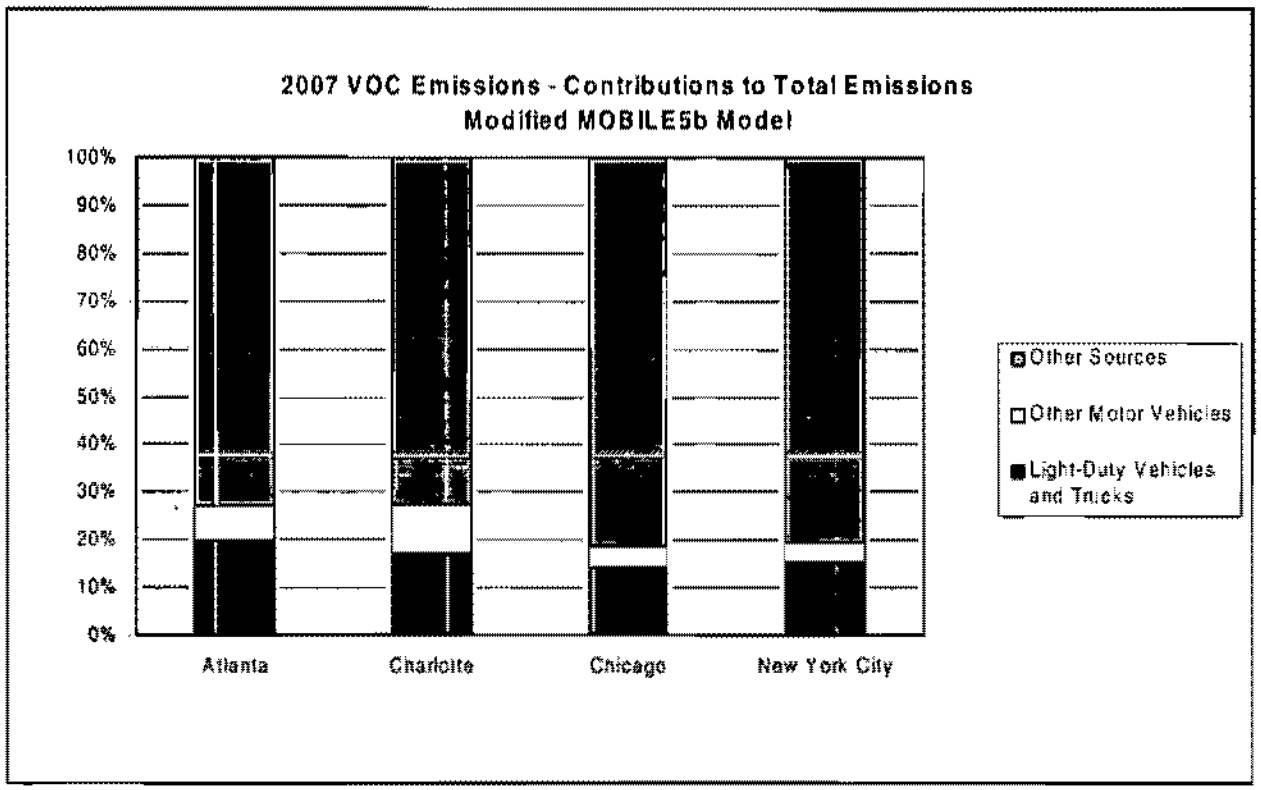
Regarding the first factor, recent testing of in-use vehicles produced since the late 1980s shows much lower deterioration rates than were projected in 1993. As most of the in-use emissions from LDVs and LDTs projected by MOBILE5 were due to deterioration in emission control after a vehicle was first sold, reducing this deterioration decreases projected in-use emissions dramatically.

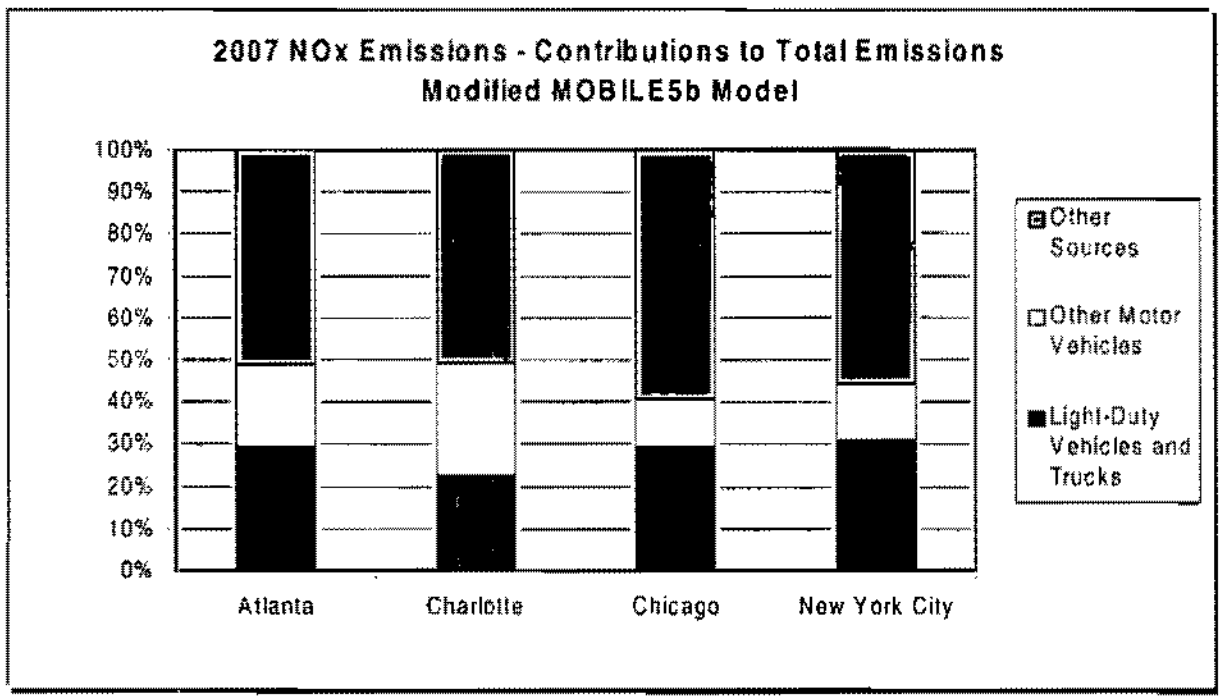
In contrast, updated estimates of the other three factors all tend to increase in-use emission projections. Emissions during driving conditions not represented in EPA's certification driving cycle tend to be higher than those included in the test, since prior to implementation of the Supplemental FTP there is little incentive for manufacturers to reduce these "off-cycle" emissions. Higher levels of fuel sulfur have been shown to increase emissions by reducing catalyst efficiency. In-use emissions increase whenever vehicles operate on fuel containing more sulfur than certification fuel. Moreover, vehicles with very low emissions, such as LEVs, now appear to be much more sensitive to sulfur than Tier 1 vehicles. Finally, LDTs tend to emit more than LDVs as their emission standards have traditionally been numerically higher. The recent dramatic trend toward the purchase of LDTs (e.g., sport utility vehicles) over LDVs was not predicted in MOBILE5b. Increasing the fraction of in-use driving represented by LDTs increases fleet-wide emission projections.

Overall, the four changes to MOBILE5b increase projected in-use emissions from LDVs and LDTs (relative to MOBILE5b) in areas with enhanced Inspection and Maintenance (I/M) programs. CO and NOx emissions also increase in areas without I/M. However, NMHC emission projections decrease in areas without I/M. A more detailed discussion of this analysis and the modifications made to MOBILE5b can be found in *Appendix A*.

EPA used the modified MOBILE5b model described above to estimate the contribution of LDV and LDT emissions in four urban ozone nonattainment areas. The four areas were: New York City, Chicago, Atlanta, and Charlotte. The first three areas represent the three greatest ozone air quality challenges in the eastern U.S. according to the OTAG ozone modeling. Charlotte represents a smaller, but growing area with a growing ozone problem.

The LDV/LDT and total motor vehicle contributions to total VOC and NOx emissions in the four ozone areas are shown in the figures below. Light-duty vehicles and trucks contribute 14-20% of total VOC emissions and 22-32% of total NOx emissions based on the modified MOBILE5b model. All of these percentage contributions are higher than would have been predicted using MOBILE5b.


2007 VOC Emissions - Contributions to Total Emissions
Modified MOBILE5b Model
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Atlanta
Charlotte
Chicago
New York City
Other Sources
Other Motor Vehicles
Light-Duty Vehicles and Trucks



Given that the modified MOBILE5b model projects higher emissions than MOBILE5b, the number of ozone nonattainment areas projected to exist in 2007 should be at least as high as was described above. Thus, the new MOBILE6 model is unlikely to eliminate the need for further VOC and NOx emission reductions in order for all areas to attain the ozone NAAQS. The contribution of LDVs and LDTs to emission inventories in ozone nonattainment areas is also sufficiently large to be considered a reasonable target for further emission control.

F. Health and Welfare Effects of Particulate Matter

Particulate matter is the general term for the mixture of solid particles and liquid droplets found in the air. Particulate matter includes dust, dirt, soot, smoke, and liquid droplets that are directly emitted into the air from natural and manmade sources, such as windblown dust, motor vehicles, construction sites, factories, and fires. Particles are also formed in the atmosphere by condensation or the transformation of emitted gases such as sulfur dioxide, nitrogen oxides, and volatile organic compounds.

Scientific studies suggest a likely causal role of ambient particulate matter in contributing to a series of health effects. The key health effects categories associated with particulate matter include premature mortality, 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), changes in lung function and increased respiratory symptoms,

changes to lung tissues and structure, and altered respiratory defense mechanisms. PM also causes damage to materials and soiling. It is a major cause of substantial visibility impairment in many parts of the U.S.

Motor vehicle particle emissions and the particles formed by the transformation of motor vehicle gaseous emissions tend to be in the fine particle range. Fine particles (those less than 2.5 micrometers in diameter) are of health concern because they easily reach the deepest recesses of the lungs. Scientific studies have linked fine particles (alone or in combination with other air pollutants), with a series of significant health problems, including premature death; respiratory related hospital admissions and emergency room visits; aggravated asthma; acute respiratory symptoms, including aggravated coughing and difficult or painful breathing; chronic bronchitis; and decreased lung function that can be experienced as shortness of breath.

G. Current and Future Nonattainment Status

The first NAAQS for particulate matter regulated total suspended particulate in the atmosphere. In 1987, EPA replaced that standard with one for inhalable PM (PM_{10} - particles less than ten microns in size), because the smaller particles, due to their ability to reach the lower regions of the respiratory tract, are more likely responsible for the adverse health effects. The major source of PM_{10} is fugitive emissions from agricultural tilling, construction, fires, and unpaved roads. Some revisions to the PM_{10} standards were made in 1997. EPA has also recently added new fine particle standards ($PM_{2.5}$). Most of the particulate due to motor vehicles falls in the fine particle category. These standards have both an annual and a daily component. The annual component is set to protect against long-term exposures, while the daily component protects against more extreme short-term events.

EPA recently projected ambient PM_{10} levels and the number of U.S. counties expected to be in violation of the revised PM_{10} NAAQS in 2010.[13] Forty-five CMSAs, SMSAs and counties[14] were projected to be in nonattainment of the original PM_{10} standards in 2010; Eleven CMSAs, SMSAs and counties were projected to be in nonattainment of the revised PM_{10} standards. Using the same methodology, 102 CMSAs, SMSAs and counties were projected to violate the new $PM_{2.5}$ NAAQS. More information about this analysis may be found in *Appendix A*.

It should be noted that an error was made in the figure in the Draft Tier 2 Study which indicated the number of areas that would be in nonattainment of the PM standards ("Counties

---

[13] Regulatory Impact Analyses for the Particulate Matter and Ozone National Ambient Air Quality Standards and Proposed Regional Haze Rule, Innovative Strategies and Economics Group, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, N.C., July 16, 1997.

[14] Current definitions of PM_{10} nonattainment counties were used. These definitions sometimes include the entire CMSA or SMSA and sometimes include only a county.

Projected to violate NAAQS for PM in 2010," page 23). That figure showed 147 areas violating the new NAAQS for $PM_{2.5}$. This error resulted from a double-counting of 45 of the counties which are also projected to be in violation of the PM_{10} standard. The correct number is 102 counties, as shown in Table 3.2.

Table 3.2 Projected 2010 PM10/PM2.5 Nonattainment

	22-State OTAG Region *	Non-CA, Non-OTAG	California
Violating Original PM10 NAAQS			
Number of Areas	8	25	12
1990 Population (millions)	8	3	7
Violating Revised PM10 NAAQS			
Number of Areas	2	3	6
1990 Population (millions)	4	1	5
Violating New PM2.5 NAAQS			
Number of Areas	59	33	10
1990 Population (millions)	34	8	13

* Plus ME, VT, NH, and future ozone nonattainment areas in TX and AZ

Based on the 1990 census, about 10 million people lived in the 11 counties projected to be in nonattainment of the revised PM_{10} NAAQS, with about half living in the 22-state OTAG region (plus areas with future ozone problems) and about half living in California. Ambient PM reductions from more stringent motor vehicle standards would primarily affect areas outside of California, because California has its own motor vehicle emission control program. California areas would also benefit, however, through the temporary travel and permanent migration of out-state vehicles into California. Of the nonattainment counties outside of California, two are within urban areas (Dallas, Philadelphia). These urban areas contain the vast majority of the non-California, nonattainment population.

In 1990, about 55 million people lived in the 102 counties projected to be in nonattainment with the new $PM_{2.5}$ NAAQS, with about 60% living in the 22-state OTAG region (plus areas with future ozone problems) and about 25% living in California.

Overall, a significant number of areas are projected to exceed the PM_{10} NAAQS in 2010 with existing emission controls, indicating that further particulate emission reductions appear to be needed. Tier 2 particulate standards would reduce ambient levels of $PM_{2.5}$, as well as PM_{10} (or at least prevent increases), since the majority of particulate emissions from both gasoline and diesel powered vehicles are smaller than 2.5 micrometers in diameter. As mentioned above, the number of counties projected to violate the new $PM_{2.5}$ NAAQS is much larger than that for the

revised PM_{10} standards. Thus, Tier 2 particulate standards intended to assist attainment of the PM_{10} NAAQS could also benefit areas with elevated $PM_{2.5}$ levels.

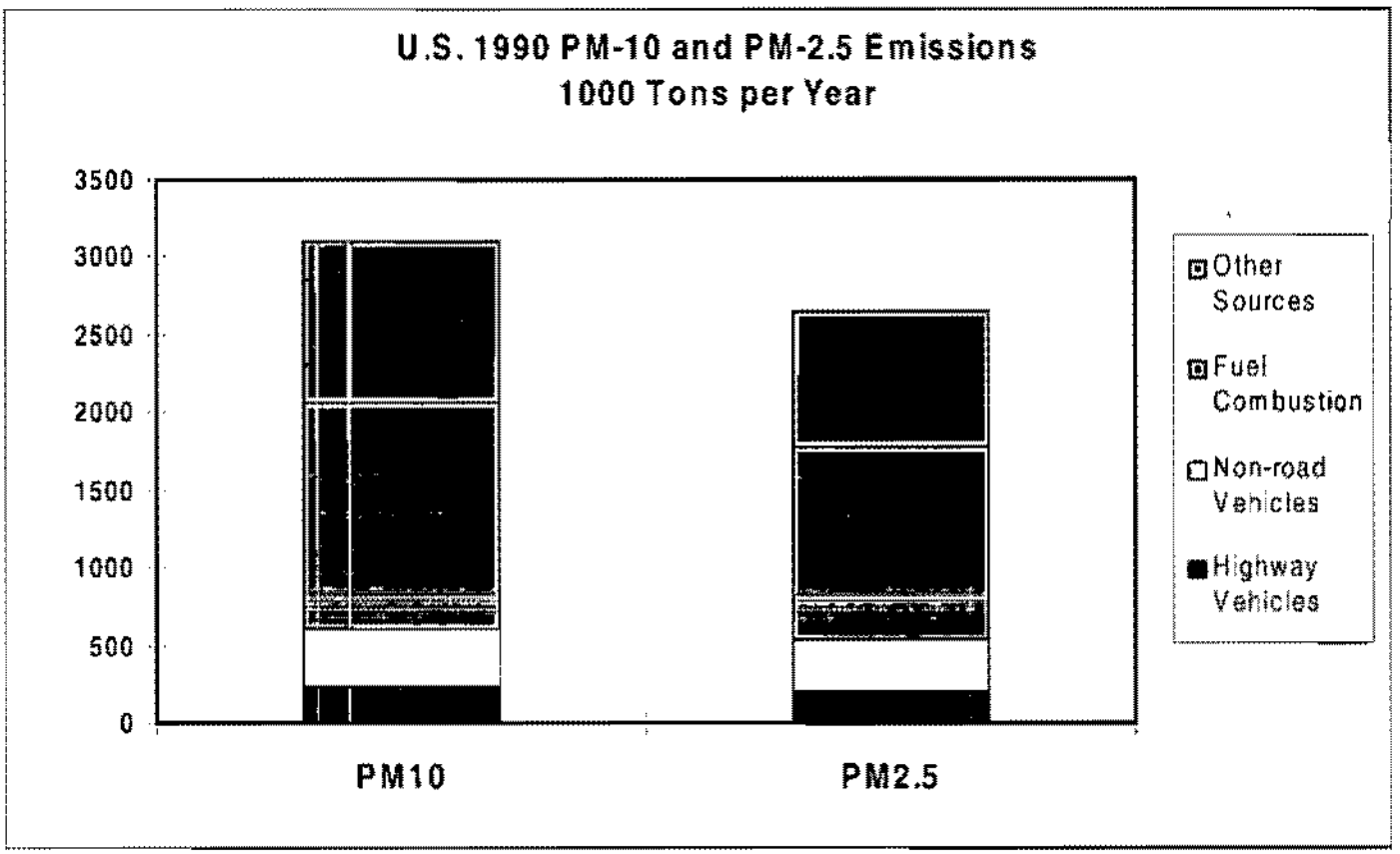
H. Particulate Emissions from Light-Duty Vehicles and Trucks

1. Direct Tailpipe Emissions

Congress set Tier 1 PM emission standards for LDVs and LDTs in the 1990 amendments to the CAA. These standards are 0.10-0.12 g/mi at 100,000 miles. Tier 1 and LEV gasoline LDVs and LDTs emit well below these Tier 1 PM standards (less than 0.010 g/mi). Diesel vehicles meet the standards, but with very little compliance margin.

EPA projects that PM emissions from Tier 1 and LEV LDVs and LDTs average 0.01 g/mi at 20 mph and 0.02-0.03 g/mi at 35 mph (from PART5 model). In contrast, diesel vehicles are projected to emit 0.10-0.11 g/mi PM. Thus, diesel PM emissions are 3.5-10 times higher than those from gasoline vehicles. The greater PM emission level of light-duty diesels currently has a limited impact on ambient PM levels, due to the small number of light-duty diesels being sold. However, diesel engines are becoming a more popular option for larger LDTs and lighter HDVs, particularly pick-ups and sport utility vehicles. PM emissions from the light-duty fleet could increase dramatically if diesel sales increased without a change in the Tier 1 diesel PM standard.

The following chart shows the relative contribution of vehicles versus other fine particle emission sources (excluding fugitive dust emissions).



Secondary Formation of PM from Gaseous Emissions

In addition to their direct tailpipe PM emissions, gaseous emissions from LDVs and LDTs can also affect ambient PM levels. In particular, gaseous emissions of SOx, NOx and VOC form aerosols in the atmosphere through chemical transformation. These aerosols exist as PM in the atmosphere.

The great majority of sulfur that enters the gasoline engine via the fuel is emitted in the form of sulfur dioxide. A small fraction (1-2%) of the sulfur is emitted directly as sulfuric acid. Sulfur dioxide reacts in the atmosphere to produce sulfur trioxide, which quickly combines with water to form sulfuric acid. Sulfuric acid exists as a particulate matter in the atmosphere, due to its low vapor pressure. Sulfuric acid can subsequently react with ammonia to form ammonium bi-sulfate and ammonium sulfate, both of which also exist as PM in the atmosphere.

Most NOx emitted converts to gaseous nitric acid in the atmosphere. Nitric acid can react with ammonia to form ammonium nitrate, which becomes PM in the atmosphere. However, ammonia reacts preferentially with sulfuric acid over nitric acid. As there is generally an excess of sulfuric acid in the atmosphere relative to ammonia, the presence of sulfuric acid suppresses

the formation of ammonium nitrate and therefore the contribution of NOx emissions to fine ambient PM. Implementation of control programs required by the CAA is leading to significant reductions in sulfur dioxide emissions, which will reduce ambient levels of sulfuric acid. Therefore, the conversion of NOx to nitrate PM could increase.

Organic aerosol can be formed in the atmosphere from gaseous VOC emissions. The reactions that form secondary organic aerosol are generally more complex than those forming sulfates and nitrates, primarily because of the great variety of specific organic molecules comprising VOCs.[15] Cyclic-olefins and aromatics produce the most secondary organic aerosol per mass of VOC. Coniferous trees are the primary source of cyclic-olefins (pinene and terpinene), while gasoline-fueled vehicles are a primary source of ambient aromatics.

I. Health and Welfare Effects of Carbon Monoxide

Carbon monoxide (CO) is a tasteless, odorless, and colorless gas produced though the incomplete combustion of carbon-based fuels. CO enters the bloodstream through the lungs and reduces the delivery of oxygen to the body's organs and tissues. The health threat from CO is most serious for those who suffer from cardiovascular disease, particularly those with angina or peripheral vascular disease. Healthy individuals also are affected, but only at higher levels. Exposure to elevated CO levels is associated with impairment of visual perception, work capacity, manual dexterity, learning ability and performance of complex tasks.

1. Current and Future Nonattainment Status

Since 1979, the number of areas in the nation violating the NAAQS for CO[16] has decreased by a factor of almost ten, from 48 areas in 1979 to five areas in 1995 and 1996. For the 1997 calendar year through the end of November 1997, only one area of the country had experienced an exceedance of the standard.

In addition to the substantial decrease in the number of areas where the NAAQS is exceeded, the severity of the exceedances has also decreased significantly. From 1979 to 1996, the measured atmospheric concentrations of CO during an exceedance decreased from 20-25 ppm at the beginning of the period to 10-12 ppm at the end of the period. Expressed as a multiple of the standard, atmospheric concentration of CO during an exceedance was two to almost three times the standard in 1979. By 1996, the CO levels present during an exceedance decreased to 10-30% over the 9 ppm standard.

---

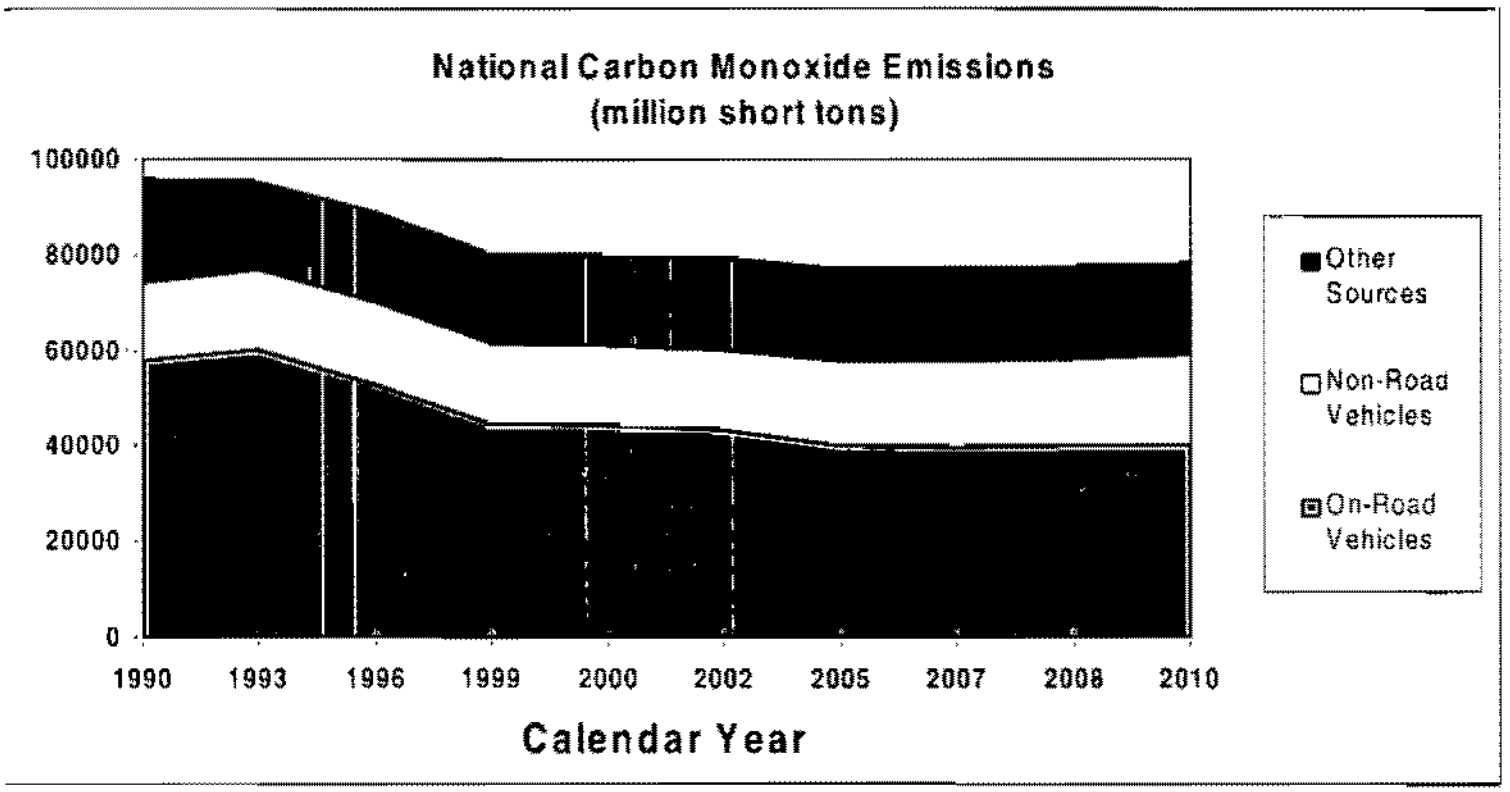
[15] A more detailed discussion of secondary organic aerosol can be found in Appendix 1.

[16] The NAAQS for CO as defined in *40 CFR Part 50.8* is: "9 parts per million for an 8-hour average concentration not to be exceeded more than once per year."

Unlike the case with ozone and PM, EPA has not made any recent comprehensive projections of future ambient CO levels and attainment and maintenance of the CO NAAQS. However, similar to the Congressional requirement for this Tier 2 study, section 202(j) of the CAA requires a separate study of the need for more stringent Cold CO standards. EPA is currently conducting this study.

2. Contribution of LDVs/LDTs to Carbon Monoxide Emissions

At the national level, motor vehicle exhaust is estimated to contribute more than three-fourths of all CO emissions; In cities, 95 percent of all CO emissions are produced by automobiles. Other sources of CO include industrial processes within large factories, power plants, and natural sources such as wild fires.



Exceedences of the CO NAAQS over the past three years tended to occur during winter months of the year. This may indicate that further reductions in emission standards should be directed towards emissions during cold weather ("cold CO standards," which apply at temperatures of 15 to 25 degrees Fahrenheit), rather than warm weather (Tier 1 CO standards, which apply at temperatures of 68-86 degrees Fahrenheit). However, as many of the CO nonattainment areas are in the southern part of the U.S., more stringent "warm weather CO" standards should not be ruled out at this time.

J. Air Toxic Emissions from Motor Vehicles

The Clean Air Act lists 188 hazardous air pollutants (HAPs) or air toxics requiring EPA evaluation and regulation (see CAA Section 112). The measurable health effects of exposure to air toxics include not only cancer, but also non-cancer effects, such as immunological, neurological, reproductive, developmental, and respiratory effects. Usually cancer incidence is chosen to measure the problem since non-carcinogenic end points are much more difficult to relate to specific toxic emissions.

EPA is developing an Integrated Urban Air Toxics Strategy, to be finalized by the end of 1998. The strategy will list certain area source categories of HAP emissions for later regulation under section 112(d) and will reduce the incidence of cancer attributable to exposure to HAPs emitted by stationary sources by not less than 75 percent. Another goal, per section 202(l) of the Clean Air Act, is to develop cost-effective standards for motor vehicles and their fuels for at least benzene and formaldehyde.

Mobile sources contribute significantly to only a small subset of the 188 HAPs. In 1993, EPA published the Motor Vehicle-Related Air Toxics Study (MVRATS). This study comprehensively summarized what was known about motor vehicle-related air toxics, focusing on carcinogenic risk. Only qualitative discussion of non-cancer effects was included due to the lack of sufficient health data to quantify these effects. The primary carcinogens examined were benzene, formaldehyde, 1,3-butadiene, acetaldehyde and diesel particulate matter. Roughly 8-9% of total VOC emissions from gasoline vehicles consist of benzene, formaldehyde, 1,3-butadiene, or acetaldehyde. In general, emissions of air toxics from gasoline vehicle exhaust are expected to decrease proportionately with reductions in VOC emissions. The primary diesel-related air toxic addressed quantitatively by MVRATS is diesel particulate. The consideration of Tier 2 particulate emission standards is addressed in more detail in Chapter VI.

CHAPTER IV. ASSESSMENT OF TECHNICAL FEASIBILITY

The purpose of this chapter is to examine the technical feasibility of controlling light-duty vehicle emissions beyond the level of control provided for by Tier 1 emission standards. This chapter reviews and describes a variety of technologies capable of reducing emissions from Tier 1 levels. This chapter also estimates the emission reductions of selected technologies. Automotive emission control technology has made remarkable advances in the past several years and many of the technologies discussed in this chapter are technically feasible.

Some of the technologies discussed in this chapter, such as improvements to base engine designs (to reduce engine-out emissions) and advancements in exhaust aftertreatment systems (improved catalyst designs), are either in production on at least one or more vehicle models or are in the final stages of development and will likely be introduced in model year (MY)1999 or MY2000 vehicles. Other technologies, such as fuel cells, are in earlier stages of development and are potentially feasible by MY2004.

The next question to be addressed by this study is how cost effective these technologies are. The cost-effectiveness discussion can be found in *Chapter V. Assessment of Cost and Cost Effectiveness*. For illustrative purposes, this chapter will provide a brief discussion of potential Tier 2 technologies. A more extensive discussion of the various technologies can be found in *Appendix B. Vehicle Technology*.

In section 202(i), Table 3, of the CAA, Congress provided specific numerical values for Tier 2 standards for EPA to consider in this study. Congress also instructed EPA to consider standards that were different (either more or less stringent) than those specified in the CAA, as long as such standards were more stringent than the Tier 1 standards. The emission reductions associated with the selected emission control technologies discussed in this study will be compared with those required to meet the standards shown in Table 3 of the CAA.

The review of vehicle emission control technology begins with a discussion of the emission performance of technology found on current Tier 1, National LEV, and California Low Emission Vehicle (LEV) technology vehicles. The first section also reviews the status and potential of a number of emission control technologies which could be used to get emission control beyond Tier 1 standards. The second section describes various technologies that could be used to reduce vehicle emissions below levels currently incorporated in the National LEV and California LEV programs. The third section provides a brief overview of the effect fuel sulfur may have on potential Tier 2 technologies.

A. Currently Feasible Vehicle Emission Control Technology

There have been considerable advances in emission control technology on conventional vehicles over the past several years. Many of these advances occurred as a result of the standards incorporated in the California LEV program which are more stringent than Tier 1 levels, i.e., Transitional Low Emission Vehicle (TLEV), LEV, and Ultra Low Emission Vehicle (ULEV). These standards are included in the NLEV program, which will generally require the introduction of vehicles meeting the LEV standards nationwide in MY2001. In fact, there are already many vehicles in production, including some federal models, that meet TLEV and LEV standards, and in some cases, ULEV standards.

Table 4.1 Tier 1, Default Tier 2, and LEV Emission Standards and Certification Levels for Light Duty Vehicles (LDV)*

		50,000 Mile (g/mi)			100,000 Mile (g/mi)		
		NMHC	CO	NOx	NMHC	CO	NOx
Standard	Tier 1	0.25	3.4	0.4	0.31	4.2	0.60
	Tier 2**	--	--	--	0.125	1.7	0.20
	LEV	0.075	3.4	0.2	0.09	4.2	0.30
Cert Levels	Tier 1	0.03-0.25	0.47-3.3	0.03-0.40	0.04-0.24	0.6-3.4	0.04-0.60
	LEV	0.04-0.06	0.2-1.3	0.06-0.13	0.023-0.078	0.2-1.7	0.07-0.26

* Particulate standards: Tier 1 = 0.08 g/mi (50,000 miles), 0.10 g/mi (100,000 miles)
LEV = 0.08 g/mi (100,000 miles)

** Default Tier 2 standards in Table 3 of the CAA

Certification data in Table 4.1 derives from manufacturer certifications for 1998 LEV-certified vehicles. As the data show, manufacturers are certifying LEVs with NMHC emissions and NOx emissions at less than one-third the level of the 100,000 mile standards. Certification to one-half or more of the standard is more typical. EPA recognizes that this additional margin gives manufacturers the ability to ensure their LEVs comply with the standards even with in-use variability and uncertainty of vehicle performance of the newer LEV vehicles, but it also demonstrates that the technology is feasible to produce vehicles with emissions well below Tier 1 levels. It is quite clear, given current federal and California certification information, that the technology exists for essentially all conventional vehicles to achieve lower emissions than are required by Tier 1 standards.[17]

[17] This study focuses on feasible technology that can achieve HC and NOx reductions. Even though technology relating specifically to CO reductions is not discussed in detail, EPA notes that many of the technologies used to reduce HC emissions also yield CO reductions as well.

EPA also analyzed various individual technologies for their ability to provide further emissions reductions. Improvement in emission controls requires reducing emissions levels coming out of the engine ("engine-out" emissions) or increasing the efficiency of exhaust aftertreatment systems. Typically, manufacturers use both approaches when trying to lower emission levels. Emission reduction improvements for conventional vehicle technology (i.e., vehicles equipped with gasoline-fueled engines) come from four main technological areas. These are improvements in base engine design, more precise air-fuel ratio control, better fuel delivery and atomization, and continued advances in exhaust aftertreatment. The table below summarizes technologies that can be used to reduce emissions from Tier 1 vehicles. It is important to point out that the use of all of the following technologies is not required to further reduce emissions. The choices and combinations of technologies will depend on several factors, such as cost, current engine-out emission levels, effectiveness of existing emission control systems and individual manufacturer preferences. As noted above, with the exception of a few technologies, many of these technologies are used on at least a few Tier 1, TLEV, LEV and ULEV vehicles already in production.

Table 4.2 Feasible Technologies for Emission Reductions (Reductions from Tier 1 Levels)

Technology	HC	NOx
Modifications to combustion chamber	3-10%	3-10%
Multiple valves with variable valve timing	30%	3-10%
Increased EGR (including electronic control)	0%	≥10%
Improved A/F control (i.e., improved HEGO, improved power-train control module microprocessor, faster fuel injectors, transient adaptive fuel control algorithms, dual HEGO, and improved calibration)	10%	20%
UEGO	5%	23-35%
Air/fuel control in individual cylinders	22%	3%
Increased EGR (including electronic EGR)	0%	≥10%
Air-assisted fuel injectors	3-10%	0%
Catalyst improvements (thermal stability, washcoat, cell densities)	10%	10%
Increased catalyst loading and volume	10%	20%
Advanced catalyst designs (tri-metal, multi-layered)	20-37%	30-57%
Close-coupled catalysts	50-70%	0-10%
Electrically-heated catalysts	≥10%	5-10%
HC adsorbers	≥10%	0%

NOTE: In general, these percentages cannot be simply summed to achieve a total emission reduction when more than one emission control technology is being applied.

Most of these technologies are either conventional technologies or extensions of conventional technologies that have been in existence for some time now and have been proven commercially, and are currently used on at least a few Tier 1, TLEV, LEV, or ULEV vehicles. EPA is not aware of any potential safety concerns or energy impacts associated with their use. Again, because these technologies are established technologies, EPA does not feel that any of these technologies require unique lead time considerations. The primary lead time issue is development of specific sets of control technology and engine calibrations for individual engine families and vehicle models. This aspect of lead time will be considered during the Tier 2 rulemaking process.

The following discussion, focusing on technology needed for HC and NOx reductions, is based on "Low-Emission Vehicle and Zero-Emission Vehicle Program Review", a staff report published in November, 1996 by the California Air Resources Board (CARB) as part of its biannual review of the California LEV program, information from the Manufacturers of Emission Controls Association (MECA) and numerous vehicle manufacturers. EPA also contracted Energy and Environmental Analysis, Inc. (EEA) to conduct a study evaluating the potential availability of emission control technology to meet more stringent emission standards for light-duty vehicles and light-duty trucks. The report is titled "Benefits and Cost of Potential Tier 2 Emission Reduction Technologies." A detailed discussion of these technologies is provided in *Appendix B. Vehicle Technology*.

1. Base Engine Improvements

There are several design techniques that can be used to reduce engine-out emissions, especially for HC and NOx. The main causes of excessive engine-out emissions are unburned fuel for HC and high combustion temperatures for NOx. Methods for reducing engine-out HC emissions include the reducing of crevice volumes in the combustion chamber, reducing the combustion of lubricating oil in the combustion chamber and developing leak-free exhaust systems. Leak-free exhaust systems are listed under base engine improvements because any modifications or changes made to the exhaust manifold can directly affect the design of the base engine. Base engine control strategies for reducing NOx include the use of "fast burn" combustion chamber designs with increased exhaust gas recirculation (EGR) and multiple valves (intake and exhaust) with variable-valve timing.

2. Improvements in Air-Fuel Ratio Control

Modern three-way catalysts require the air-fuel ratio (A/F) to be as close to stoichiometric operation (the amount of air and fuel just sufficient for nearly complete combustion) as possible. This is because three-way catalysts simultaneously oxidize HC and CO, and reduce NOx. Since HC and CO are oxidized during A/F operation slightly lean of stoichiometry, while NOx is reduced during operation slightly rich of stoichiometry, there exists a very small A/F window of operation around stoichiometry where catalyst conversion efficiency is maximized for all three pollutants (less than 1% deviation in A/F or roughly ± 0.15). Thus, it is imperative to maintain

the A/F ratio within this tight window of stoichiometric operation if emissions are to be further reduced. In fact, the tighter the A/F ratio can be maintained, the higher the overall three-way catalyst conversion efficiency that can generally be achieved, resulting in further reductions to emissions. Therefore, technologies that enhance tighter A/F control can realize significant reductions in HC, CO, and NOx emissions.

Contemporary vehicles have been able to maintain stoichiometric operation, or very close to it, by using closed-loop feedback fuel control systems. At the heart of these systems is a single heated exhaust gas oxygen (HEGO) sensor. The HEGO sensor continuously switches between rich and lean readings. By attempting to maintain an equal number of rich readings with lean readings over a given period, the fuel control system is able to maintain stoichiometric operation. While this fuel control system is capable of maintaining the A/F ratio with the required accuracy under steady-state operating conditions, the system accuracy is challenged during transient operation where rapidly changing throttle conditions occur.

In addition to improved HEGO sensor designs, an additional post-catalyst HEGO sensor can be used for additional fuel control refinements, resulting in a more robust and precise fuel control system and reductions in HC and NOx. Another technology that can improve A/F control is the use of an universal exhaust gas oxygen (UEGO) sensor, also known as a "linear oxygen sensor," in lieu of a conventional HEGO sensor. UEGO sensors are capable of recognizing both the direction and magnitude of A/F transients since the voltage output is "proportional" with changing A/F ratio (each voltage value corresponds to a certain A/F), facilitating faster response of the fuel feedback control system and tighter control of the A/F ratio.

Rich and lean A/F spikes that occur during transient operation can result in high emissions. Therefore, any technologies that can help the fuel control system better anticipate these A/F spikes can result in lower emissions. There are several technologies that can help achieve this, such as controlling the A/F in each individual cylinder, rather than for the entire engine, and the incorporation of transient adaptive fuel control algorithms that compensate for component tolerances, component wear, varying environmental conditions, varying fuel composition conditions, etc., that occur during transient operation. Finally, the use of electronic throttle control in lieu of conventional mechanical systems, faster response fuel injectors, and a quicker power-train control module microprocessor can help further tighten A/F control.

3. Improvements in Fuel Atomization

In addition to maintaining a stoichiometric A/F ratio, it is also important that a homogeneous air-fuel mixture be delivered at the proper time and that the mixture is finely atomized to provide the best combustion characteristics and lowest emissions. Poorly prepared air-fuel mixtures, especially after a cold start and during the warm-up phase of the engine, result in significantly higher emissions of unburned HC, since combustion of the mixture is less complete. By providing better fuel atomization, more efficient combustion can be attained, which should aid in improving fuel economy and reducing pollutants. Sequential multi-point

fuel injection and air-assisted fuel injectors are examples of technologies available for improving fuel atomization.

Typically, conventional multi-point fuel injection systems inject fuel into the intake manifold by injector pairs. This means that rather than injecting fuel into each individual cylinder, a pair of injectors (or even a whole bank of injectors) fires simultaneously into several cylinders. Since only one of the cylinders is actually ready for fuel at the moment of injection, the other cylinder(s) gets fuel at inappropriate times. With this less than optimum fuel injection timing, fuel puddling and intake manifold wall wetting can occur, both of which can hinder complete combustion. Sequential injection, on the other hand, delivers a more precise amount of fuel to each cylinder at the appropriate time. Because of the emission reductions and other performance benefits "timed" fuel injection offers, sequential fuel injection systems are very common on today's vehicles and are expected to be incorporated in most, if not all, vehicles soon.

Another method to further homogenize the air-fuel mixture is through the use of air-assisted fuel injection. By injecting high pressure air into the fuel injector, and subsequently, the fuel spray, greater atomization of the fuel droplets can occur. Since achieving good fuel atomization is difficult when the air flow into the engine is low, air-assisted fuel injection can be particularly beneficial in reducing emissions at low engine speeds. In addition, industry studies show that the short burst of additional fuel needed for responsive, smooth transient maneuvers can be reduced significantly with air-assisted fuel injection due to a decrease in wall wetting in the intake manifold.

4. Improvements to Exhaust Aftertreatment Systems

Tremendous advancements in exhaust aftertreatment systems have emerged in the last few years. The advancements in exhaust aftertreatment systems are probably the single most important area of emission control development. Such advancements allow manufacturers to more effectively reduce exhaust emissions, both during warmed-up operation as well as right after a cold start, when the majority of emissions occur. Catalyst manufacturers are progressively moving to palladium as the main precious metal in automotive catalyst applications. Improvements to catalyst thermal stability and washcoat technologies allow manufacturers to place catalysts closer to the engine, thereby increasing the catalyst's light-off time and thus increasing its emission reduction capability. The design of higher cell densities and the use of two-layer washcoat applications increases catalyst efficiency. There has also been much development in HC and NOx absorber technology, which act to trap pollutants during cold starts and release them after the catalyst is operating effectively. The use of secondary air injection systems and insulated or dual wall exhaust pipes also contribute to the improvements in exhaust aftertreatment and reduction in HC emissions. A detailed discussion of these technologies is provided in *Appendix B. Vehicle Technology*.

5. Improvements in Engine Calibration Techniques

One of the most important emission control strategies is not hardware-related. Rather, it is the software and, more specifically, the algorithms and calibrations contained within the software that are used in the power-train control module (PCM) which control how the various engine and emission control components and systems operate. Advancements in software along with refinements to existing algorithms and calibrations can have a major impact in reducing emissions. As the PCM becomes more powerful with greater memory capability and speed, algorithms can become more sophisticated. Advancements in computer processors, engine control sensors and actuators and computer software, in conjunction with experience in developing calibrations, allows manufacturers to improve and refine their calibration skills, resulting in even lower emissions.

Manufacturers have suggested to EPA that perhaps the single most effective method for controlling NOx emissions will be tighter A/F control which could be accomplished with advancements in calibration techniques without necessarily having to use advanced technologies, such as UEGO sensors. Manufacturers have found ways to improve calibration strategies such that meeting federal cold CO requirements, as well as complying with LEV standards, have not required the use of additional hardware, such as electrically heated catalysts (EHC) or adsorbers.

Since emission control calibrations are typically confidential, it is difficult to predict what advancements will occur in the future. It is clear, however, that improved calibration techniques and strategies are a very important and viable method for further reducing emissions.

6. Technology for Reduction of Particulate Emissions

Particulate emissions from gasoline-fueled vehicles consist of both carbon- and sulfur-containing compounds. The carbonaceous particulate is produced from both the gasoline fuel and engine lubricating oil. Available data indicate that particulate emissions are highest during cold starts and lower during hot starts and warmed up operation. Technology aimed at reducing gaseous NMHC emissions, such as improved air-fuel ratio control, tends to reduce carbonaceous particulate emissions, as well. Carbonaceous particulate emission control from gasoline vehicles will likely accompany required NMHC emission control. The predominant form of sulfur-containing particulate from motor vehicles is sulfuric acid (commonly referred to as sulfate). This sulfate is produced in both the engine and the exhaust system by the oxidation of sulfur dioxide. However, the current approach of operating engines as close to stoichiometric as possible coupled with advanced three-way catalysts appears to keep sulfate emissions at very low levels. Therefore, the primary technique available for reducing sulfate emissions is to reduce gasoline sulfur levels.

Diesel particulate emissions also consist of both carbonaceous and sulfate particulate. Unlike gasoline emissions, carbonaceous particulate and NMHC emissions from a diesel engine are not as directly related. Engine-related techniques for reducing particulate emissions include higher fuel injection pressures, electronic engine control of injection timing, rate and duration

and turbo charging/aftercooling. Exhaust aftertreatment techniques include the use of an oxidation catalyst or a trap. The oxidation catalyst primarily reduces the heavy organic portion of the carbonaceous particulate, which usually represents 30-50% of total carbonaceous particulate emissions. Traps can reduce both organic and solid carbon particulate and are capable of controlling 70-90% of carbonaceous particulate emissions.

Diesel-powered LDVs and LDTs produced in the late 1980s were capable of meeting particulate emission standards in the range of 0.1-0.2 g/mi without the use of exhaust aftertreatment. One manufacturer also produced some vehicles equipped with traps. A few light-duty diesel models are being certified to the current Tier 1 standards of 0.1-0.12 g/mi without the need for aftertreatment.

Sulfate emissions from a diesel engine form primarily in the engine and generally represent 2% of the total sulfur in the fuel. The primary method to reduce sulfate emissions is to reduce the sulfur content of diesel fuel. Under some conditions, the use of an oxidation catalyst or a catalyst-containing trap can increase tailpipe out sulfate emissions.

B. Advanced Technologies

In addition to the technologies described above to reduce emissions from conventional vehicles, technologies providing even greater reductions are being analyzed and developed. These technologies are in various stages of development and some of them could be introduced on ULEVs and zero emission vehicles (ZEV) to meet state and federal programs. Manufacturers are also developing non-conventional vehicle technologies, in part as a response to the desire for vehicles with lower emissions than those vehicles currently available or expected in the next few model years. Many of these technologies could be utilized in the next generation of vehicles sold nationwide.

California's emission control program has served as the impetus for development of advanced emissions control technology, and technologies used to meet current stringent standards in California could also be feasible for introduction nationwide.[18] The California LEV emission control program requires manufacturers to produce ULEV vehicles in order to meet the

[18] California proposed more stringent emission control standards in December, 1997. The California LEV 2 program would reduce by 75% the current NOx standard for LEVs and ULEVs and introduce a new category of standards, the super ULEV (SULEV: NMOG = 0.01 g/mi, CO = 1.0 g/mi, and NOx = 0.02 g/mi). The SULEV standards are 120,000 mile standards. California is expected to make a final decision regarding the LEV 2 program in November, 1998. EPA and California are trying to harmonize their programs when possible (e.g., National LEV). EPA is closely monitoring California's actions regarding its LEV 2 proposal and will determine which parts of the program, if any, are appropriate to address in the federal rulemaking.

fleet average NMOG requirements.[19] In many instances, manufacturers will use a combination of the technologies described above to design and produce vehicles which comply with ULEV standards. As California noted in its November, 1996 staff report, manufacturers may also need to introduce EHCs on some vehicles where emissions control is more difficult, such as vehicles with limited underhood space or larger displacement engines. Electrically-heated catalysts use an auxiliary heating device to bring the catalyst up to its operating temperature more quickly than typical heating by engine exhaust. One manufacturer announced it has developed a gasoline-powered vehicle that utilizes advanced engine designs and catalysts to reduce emissions levels to significantly below ULEV standards. Some manufacturers also chose to produce ULEVs using engines that burn compressed natural gas. These engines give manufacturers additional flexibility in designing and producing vehicles that meet the tighter ULEV standards. In general, these engines are similar to gasoline-powered engines, but have modified fuel delivery and storage systems. Compressed natural gas (CNG) powered vehicles also have lower evaporative emissions than gasoline-powered vehicles.

California also requires manufacturers to develop ZEV technology, with widespread introduction targeted for MY2003. Much of the development effort to date has focused on electric vehicles, and many manufacturers have already made ZEVs available to consumers and fleet purchasers. These vehicles use many newer technologies, such as advanced charging and regenerating systems and vehicle structural design. Battery technology, which has been the major technical limitation to date, has been and will be the focus of much developmental work. Improved nickel-metal hydride, sodium nickel-chloride, lithium polymer, and lithium ion batteries are some of the battery types being developed for use in electric vehicles produced in the near future.

Manufacturers are also actively developing other non-conventional vehicle propulsion systems which could emit pollutants at lower rates, possibly even significantly lower, than current Tier 1 vehicles. While none of these systems are currently available in the United States, they could be technologically feasible early in the next century. One system utilizes a hybrid propulsion system, which combines a gasoline or diesel-powered engine with an electric motor and is optimized to operate at maximum efficiency over changing driving conditions. These designs can result in very high fuel efficiency and also very low emission levels (a manufacturer estimates up to one tenth the current levels of HC, CO, and NOx).[20]

---

[19] The National LEV program does not require ULEVs to be produced for a manufacturer to meet the fleet average NMOG requirements. However, manufacturers are likely to produce and sell vehicles meeting ULEV standards under the National LEV program, especially if a manufacturer needs to offset Tier 1 or TLEVs in its fleet after MY2000 or if a manufacturer produces 50-state ULEV engine families and wants to generate fleet average NMOG credits.

[20] One manufacturer has introduced in Japan a hybrid vehicle which incorporates a gasoline engine and an electric motor. Emissions are reduced in part by operating the engine under a constant load and thus minimizing air-fuel ratio changes.

This type of propulsion is also being developed as part of a joint venture between the federal government and the domestic auto manufacturers. The Partnership for a New Generation Vehicle (PNGV) has a design goal of producing production prototypes by 2004 that would achieve up to 80 miles per gallon with very low emissions. Design work is focusing on hybrid electric drives, powered by direct-injection drives or fuel cells, advanced batteries, advanced combustion engines using renewable fuels and petroleum fuels, and increased use of lightweight materials in vehicle construction. Technologies developed from this process, in addition to being integrated into a PNGV vehicle, could be used to reduce emissions from vehicles meeting more stringent standards.

Fuel cells are a promising propulsion system that is being developed for possible introduction to consumers early in the next century. A fuel cell is an electrochemical device that generates electricity from a chemical reaction between hydrogen and oxygen. The necessary hydrogen can either be carried as a compressed gas or extracted from a fuel carried on the vehicle, such as gasoline or methanol. The electricity produced from a fuel cell drives a traction motor that in turn drives the wheels. Fuel cell use gives a vehicle long range, good performance, rapid refueling and low or even zero emission levels.

C. Sulfur's Effect on Tier 2 Technology

The sulfur found in gasoline does not affect engine-out emissions of HC, CO, and NOx, but it increases exhaust emissions of these pollutants by inhibiting the performance of the three-way catalyst (TWC). The degree of sulfur inhibition to the catalyst has been shown to be variable and depends upon both catalyst formulation and operating conditions. (Sulfur inhibition is very sensitive to A/F ratio.) Sulfur strongly competes with pollutants for "space" on the active catalyst surface. This limits the efficiency of catalyst systems to convert pollutants. Current evidence, however, indicates that sulfur is not a permanent catalyst poison like lead (Pb). This means that increases in emissions caused by high sulfur fuels may be at least partially reversed once the high sulfur fuel is no longer used. Studies are underway to determine how quickly, completely, and easily the sulfur will come off the catalyst when the vehicle is refueled with a low sulfur fuel.

Recent information from the sulfur test programs performed by the Coordinating Research Council (CRC) and the auto industry, suggests that not only do LEV and Tier 1 vehicles exhibit decreased emissions performance due to fuel sulfur, but the more advanced the technology, the more sensitive (on a percentage basis) the catalysts are to sulfur. The studies indicate that increasing sulfur content could more than double NOx emissions and have a less severe, though noticeable, effect on HC emissions. In addition, vehicle manufacturers claim that elevated fuel sulfur levels can interfere with the functioning of vehicle onboard diagnostic systems by triggering the illumination of the vehicle's malfunction light. Any development of Tier 2 standards will review the effect of sulfur on possible Tier 2 technologies, and possible ways to reduce such effect. For example, some catalyst formulations show less sulfur sensitivity than others; EPA will pursue this issue further in an effort to better understand why some

catalysts respond differently to sulfur. EPA is aware that the American Petroleum Institute (API), as well as some catalyst manufacturers, are further analyzing this issue. The Agency will assess appropriate sulfur control programs for commercial fuel and appropriate certification fuel specifications that are more representative of sulfur levels in commerce, as discussed in Chapter VI.

CHAPTER V. ASSESSMENT OF COST AND COST EFFECTIVENESS

The Clean Air Act requires EPA to examine "the need for, and cost effectiveness of, obtaining further reductions in emissions from light-duty vehicles and light-duty trucks, taking into consideration alternative means of attaining or maintaining the national primary ambient air quality standards ..." (emphasis added). As discussed in the previous chapter, technology is available today to reduce emissions from light duty vehicles well below Tier 1 levels. The National LEV program assures that passenger cars and light trucks will be produced beginning in the 1999 model year to LEV levels. The purpose of this chapter is to present information on costs and cost effectiveness for potential emission control technologies beyond Tier 1 technologies. This includes the cost effectiveness of LEV technologies, as well as technologies that achieve emission reductions beyond LEV standards. The chapter estimates cost effectiveness of certain emission reductions without making a determination of the specific numerical values of potential regulatory standards.

One lesson to be learned from the past 30 years of controlling motor vehicle pollution is that the costs of future technologies are usually less than originally estimated. The auto industry, as well as government regulators and outside experts, tend to over-predict future costs. The actual costs are usually lower than predicted when the technology is manufactured and installed on mass-produced vehicles. As stated previously, Tier 2 standards cannot be effective until the 2004 model year at the earliest. That is over five model years from the present. Therefore, although the following cost estimates are EPA's best assessment of the technology discussed in *Chapter IV. Assessment of Technical Feasibility*, they may prove to be over-predictions when viewed several years into the future.

In addition to estimations of cost, this chapter also attempts to quantify the emission reduction capabilities of these technologies. In this way, the cost effectiveness, in units of dollars per ton of emissions reduced, can be calculated and compared.

The sources for the emissions reductions and costs of the various emission control technologies were the EEA report, the CARB report, MECA, API, confidential information from vehicle manufacturers and EPA technical assessments. Of these sources, only EEA, CARB and several vehicle manufacturers supplied information on costs. Consequently, these are the sources that are primarily used for establishing cost effectiveness.

A. Cost Effectiveness of Low Emission Vehicle Technologies

It is not necessary to incorporate all of the technologies discussed in the previous chapter in order to produce vehicles capable of emitting below Tier 1 levels. The choices and combinations of technologies will depend on several factors, such as current engine-out emission levels, effectiveness of current emission control technologies, and individual manufacturer preferences.

As discussed in *Chapter IV. Assessment of Technical Feasibility*, two of the most promising emission control strategies for reducing emissions below Tier 1 levels are more precise air/fuel (A/F) control and improved catalyst designs. One or the other or a combination of these technologies are, in fact, what manufacturers have indicated they will utilize to achieve LEV standards under the California or national LEV programs.

A vehicle designed to meet LEV standards will achieve the following emission reductions relative to Tier 1 vehicles:

Table 5.1 Percent Reduction in Emissions of a LEV Vehicle Compared to Tier 1

Pollutant	Percent Emissions Reduction
NMHC	70%
NOx	50%

In the Regulatory Impact Analysis (RIA) prepared in support of the National LEV rulemaking, EPA estimated the emission reduction benefits of National LEV vehicles in 49 states (other than California). The costs in the RIA were based on California Air Resources Board (CARB) estimates of California LEV (CALEV) program vehicle costs, revised in 1996. As summarized in the table below, the total net present value HC emission reductions were estimated to be 28.0 kilograms (kg), while the NOx emission reductions were estimated to be 25.3 kg. The net present value cost was estimated to be $115 per vehicle.

Table 5.2 Emissions Reduction, Cost and Cost Effectiveness of a LEV Vehicle

Pollutant	Emissions Reduction (kg/vehicle)	Cost/vehicle ($)	Cost Effectiveness ($/ton)
NMHC	28.0	57.5*	2054.
NOx	25.3	57.5*	2273.
NMHC+NOx	53.3	115.++	2158.

* Cost per vehicle assigned 50% each to NMHC and NOx.

++ After full phase in 2001 LEV cost is estimated to be $95 per vehicle.

As can be seen, the overall cost effectiveness of National LEV vehicles, based on a 1996 estimate, is $2158 per ton. Note that the above analysis uses gasoline-powered passenger cars certified on California low sulfur gasoline and operated on higher-sulfur Federal gasoline, based on information available at the time the program was developed and considers year round emission reductions. EPA expects similar cost effectiveness results had the calculations been performed for light trucks. In addition, EPA expects that these cost-effectiveness results are

similar to those for the standards listed in Table 3 of section 202(i). The standards listed in that table (and consequent emission reductions) are similar to LEV standards. The Table 3 NOx standard is somewhat more stringent, the Table 3 NMHC standard is somewhat less stringent. In addition, the technologies expected to be used to meet the Table 3 levels (and consequent costs) are similar to the technologies expected to meet the LEV standards.

The automakers recently voluntarily agreed to produce LEV vehicles under the National LEV regulatory framework. Some auto companies have also announced they would produce certain light-duty trucks to meet LEV standards sooner than they would be required under the National LEV program. In addition, some companies stated they will voluntarily reduce emissions from light-duty trucks not included in the National LEV program. EPA's analysis of the cost effectiveness of future light-duty vehicle emission standards focuses on standards more stringent than LEV levels.

B. Cost Effectiveness of Technologies Beyond LEVs

The previous chapter presents information on the technical feasibility of achieving emission levels beyond the LEV standards. A number of these technologies, such as ultra-precise air-fuel ratio control, increases in catalyst loading or cell density, closer catalyst proximity to the exhaust manifold, and variable valve timing, are available today. Others are expected to be available to vehicle manufacturers before 2004. Although there does not exist a large amount of specific data on the costs of such technologies, this section of the study will summarize the available information. All of the following percentage emission reductions and costs are incremental to Tier 1 technologies.

Estimates of emission reductions resulting from increases in catalyst loading and volume were consistent among the various sources. EEA estimates a benefit of 10% for HC and 20% for NOx. MECA and several vehicle manufacturers concurred with these estimates. For improvements to catalyst formulations and substrate designs, the estimates were again a consensus of 10% for HC and NOx. The benefit of using a close-coupled catalyst were estimated by various vehicle manufacturers to range up to 70% for HC, and 10% for NOx. Information from the American Petroleum Institute suggests that for catalysts utilizing tri-metal and multi-layer designs, emission reductions ranging up to 37% can be achieved for HC and up to 57% for NOx.

Estimates of emission reductions associated with ultra-precise A/F control vary. Information from MECA and two vehicle manufacturers suggest that NOx emission benefits can range up to 70%, while EEA estimated emission reductions of greater than 10% (no upper limit was provided) for HC and NOx. For the purposes of this study, EPA estimates that the combination of faster response fuel injectors, a faster PCM microprocessor, improved HEGO sensor design (i.e., planar design) and the use of dual HEGO sensors and adaptive transient fuel control would result in emission reductions at least up to 10% for NMHC and 20% for NOx. The upper range of the estimates from MECA and the two manufacturers are actually higher than this

estimate, because they believed that an important part of achieving tighter A/F control is the continued development of more sophisticated calibration strategies used in conjunction with the above mentioned technology.

Combining the emissions reduction potential of catalyst improvements and more precise A/F control cited above, EPA estimates that NMHC tailpipe emissions of light-duty vehicles and trucks produced in the 2004 model year time frame would be 77% less than Tier 1 vehicles. This would equate to a NMHC emission standard of approximately 0.06 g/mi for LDV/LDT1 (LDT below 3,450 pounds curb weight). As discussed below, EPA does not believe this is an upper limit of the capability of future technology to reduce NMHC emissions.

In the case of NOx emissions, the above catalyst improvements and more precise A/F control were combined with EPA's technical assessment of the potential for improvements in EGR systems, such as electronically controlled EGR. This analysis shows that NOx emissions from light-duty vehicles and trucks produced in the 2004 model year would be 80% less than Tier 1 vehicles. This would equate to a NOx standard of approximately 0.08 g/mi for LDV/LDT1.

Although the purpose of this study is not to propose Tier 2 emission standards, these emission reductions can also be compared to those needed to achieve the default Tier 2 standards, listed above in Table 4.1. Applying the 77% and 80% NMHC and NOx reductions, respectively, to the 100,000-mile Tier 1 standards (also listed in Table 4.1) yields 100,000-mile emission levels of approximately 0.07 g/mi NMHC and 0.12 g/mi NOx. These levels are below the default Tier 2 standards, suggesting that the default Tier 2 standards are technically feasible.

Emissions tests used to estimate the potential for catalyst-related technologies were primarily performed at low sulfur levels (e.g., 30-100 ppm). Because the effectiveness of some of the above catalyst-related technologies may be adversely affected by fuel sulfur content, the above emission reductions potentials could be less if vehicles are operated on higher sulfur fuels.

Using these emission reduction factors, EPA estimated in-use emissions performance on a per vehicle basis to represent a 77% and 80% reduction in NMHC and NOx emissions, respectively. EPA performed a preliminary cost analysis of these technologies using the sources cited above as well as EPA's own assessment. The results showed that the cost of additional technology to achieve the emission reductions above for NMHC and NOx combined is $136 for LDV/LDT1, and $161 for LDT2/LDT3/LDT4. (See *Appendix C. Emission Reductions, Cost and Cost Effectiveness* for details of this analysis.)

With this information it was possible to calculate the cost effectiveness of the selected technologies that achieve emission reductions beyond LEV levels. This was done using the above cost factors and emission reduction effectiveness for LDVs and LDTs separately. The results are shown below:

Table 5.3 Emissions Reductions, Costs and Cost Effectiveness of Technologies Beyond LEV and Incremental to Tier 1

Vehicle Class/ Pollutant	Nominal Emission Level (g/mi)	Emissions Reduction (g/mi)	Cost per Vehicle ($)	Annual Cost Effectiveness ($/ton)
LDV/LDT1				
NMHC	0.06	0.181	57.33 *	3151.
NOx	0.08	0.422	78.75*	1858.
NMHC+NOx		0.603	136.	2245.
LDT2,3,4				
NMHC	0.07**	0.199	69.93*	3212.
NOx	0.14**	0.456	91.35*	1842.
NMHC+NOx		0.653	161.	2256.

* Cost per vehicle assigned 50% each to NMHC and NOx, after assigning EGR cost ($17) to NOx control.
** Standards shown represent LDT2/LDT3. Nominal standards for LDT4 could be 0.09 g/mi for NMHC and 0.22 for NOx.

EPA has also calculated the cost effectiveness of the package of technologies which would achieve reductions beyond LEV levels as an incremental comparison to the National LEV program. An "in-effect" finding for this voluntary program was published earlier this year, and National LEV vehicles will be available nationwide beginning in the 2001 model year. While EPA believes that the proper cost effectiveness analysis compares control measures against a Tier 1 baseline, an analysis using a National LEV baseline is illustrative for the purposes of this study. Using the same methodology as was presented above, the above package of technologies reduce NMHC plus NOx emissions beyond those levels achieved by the NLEV standards at a cost of $2400 per ton. This is only marginally higher than the cost effectiveness of these technologies relative to the Tier 1 standards.

These estimates of the cost effectiveness of Tier 2 technologies do not include any cost for reducing the sulfur level of commercial gasoline. Since the emission tests used to estimate the potential for catalyst improvements were primarily performed at low sulfur levels (e.g., <100 ppm and nominally 40 ppm), these cost per ton estimates are most directly applicable when low sulfur fuel is assumed to be used in both the Tier 1 and Tier 2 cases. The technologies described above also reduce emissions when higher sulfur fuels are used. However, the potential for catalyst-related technologies, including improved air-fuel ratio control, can be adversely affected by fuel sulfur content. This is mitigated by the fact that the baseline Tier 1 emission levels would be higher with high sulfur fuel and the overall emission reduction is a combination of the

percentage emission reduction times the baseline emission level. Still, similar cost per ton estimates assuming the use of high sulfur gasoline may be slightly higher. In the case where the cost effectiveness of Tier 2 technologies is compared to the NLEV standards, the cost per ton estimates should be approximately the same at either low or high sulfur fuels, since the effect of high sulfur levels is affecting both NLEV and Tier 2 technology.

It is important to note that the presentation of these estimates does not imply that EPA believes these levels of emission reductions are upper limits of future technology. As discussed in the previous chapter, there are a number of emission control technologies that either have been demonstrated to date or are expected to be available for use on production vehicles by 2004 that can achieve emission reductions beyond those discussed above. For purposes of this study, EPA selected certain technologies for which estimates of emissions performance and costs were available. EPA expects that other, more effective, technology will be available prior to 2004. Nonetheless, it appears the cost effectiveness of technology that exists today to reduce emissions of light-duty vehicles and trucks beyond LEV levels is within the range of other available control strategies.

C. Comparison to Other Control Strategies

This section discusses the cost effectiveness of other emission control strategies that may provide alternative means of attaining or maintaining the NAAQS. EPA estimates the cost and cost effectiveness of specific control measures as part of individual rulemaking. The estimates are made available for public review and comment before final regulations are promulgated. Numerous control measures have been put in place since the 1990 Clean Air Act amendments.

A review of national vehicle control measures mentioned in this report showed a range of cost effectiveness estimates. Regarding motor vehicle controls, EPA estimates of the cost effectiveness of recently promulgated programs are:

- Tier 1 standards for LDVs and LDTs: $6000 per ton of HC and $1380-1800 per ton of NOx
- Supplemental FTP (SFTP) standards for aggressive driving: $457-$552 per ton of HC and $150-$172 per ton of NOx
- SFTP standards for emissions with the air conditioning on: $2,050-$2,574 per ton of NOx
- On-board diagnostics (OBD) requirements: $1,974 per ton of HC, $1,974 per ton of NOx, and $124 per ton of CO

Recent controls required on stationary point sources have been in the same general range.

The question relevant to this study is, how do the cost effectiveness estimates for technologies beyond Tier 1 compare with alternative control measures that have not yet been put in place? The Regulatory Impact Analyses prepared for the recently revised NAAQS contains the most comprehensive set of cost effectiveness estimates for potential emission control measures. The RIA included measures for ozone precursors and particulate matter control ranging from strategies that produce a cost savings up to and more than $10,000 per ton of pollutant reduced.

The NAAQS analysis indicates that even after known and available control measures are implemented, there will remain a substantial number of areas that are in need of additional pollutant reductions in order to attain the new air quality standards. For these emission reductions, which will need to come from a combination of mobile and stationary sources, the NAAQS RIA incorporates a cost effectiveness threshold of $10,000 per ton of pollutant reduced. The analysis documents many current technologies with control costs less than $10,000 per ton and expects future and emerging technologies to produce similar cost effective control strategies. The average control cost for measures included in the NAAQS ozone analysis is approximately $2,600 per ton for NOx and $3,700 per ton for HC reductions.

The following are examples of potential control strategies and the cost per ton estimates from the NAAQS RIA (incremental cost in 1990$):

- Industrial boilers conversion to natural gas: approximately $2,000 per ton of NOx removed.

- Marine commercial engines: approximately $6,503 per ton of NOx removed.

- New heavy-duty vehicles powered by natural gas: approximately $2,400 per ton of NOx avoided.

Based on this review of the NAAQS RIA, which is the best and most recent analyses of cost effectiveness for a wide range of control measures, it appears that light-duty vehicle emission standards that are more stringent than Tier 1 would be cost effective relative to the control measures included in the NAAQS RIA. Further, it appears that technology is known today that could reduce emission levels of HC and NOx from light-duty vehicles beyond LEV levels in a cost effective manner. As shown above, it appears to EPA that technology is known that has the potential to reduce HC emissions to levels at least 77% below Tier 1 levels at a cost effectiveness of about $3300 per ton. Likewise, it appears that technology is known that has the potential to reduce NOx emissions to levels at least 80% below Tier 1 levels at about $1800 per ton, with a combined HC + NOx cost effectiveness of about $2,300 per ton. These cost effectiveness estimates are well within the range of cost effectiveness of other, alternative control measures that could be applied to both stationary and mobile sources in the future in order to attain or maintain the NAAQS. In the above analysis the cost effectiveness on a per ton basis examines both national control programs and local, regional or seasonal measures.

As mentioned previously, the above estimates of potential emission reductions from Tier I levels (77% HC and 80% NOx) are not meant to imply limits of any future emission standards. They were selected for analyses in this report to illustrate point estimates of emission reductions that appear technically feasible and cost effective. EPA expects there are additional control technologies that are or will soon be available that have potential to result in reductions that go beyond the estimates analyzed here.

The discussion above addresses costs and cost effectiveness of HC and NOx reductions. It does not include information on carbon monoxide or particulate matter reductions. As mentioned earlier in this report, EPA is working on a study of the need for more stringent light-duty vehicle CO standards that would apply at cold temperatures. That study is the appropriate forum to address issues related to future CO emission requirements. It should be noted, however, that most of the technology discussed in this report as reducing HC will also cause significant reductions in CO emissions. The cost estimates presented above for HC-reducing technology were calculated by assigning the costs to HC or HC + NOx control. If a portion of the costs had been assigned to account for the expected CO reductions, the HC and NOx cost effectiveness would appear more favorable.

No cost or cost effectiveness calculations were performed for additional future PM controls, although *Chapter IV. Assessment of Technical Feasibility* discussed PM control technology. The contribution of light-duty vehicles to the overall PM emissions inventory is small. It may grow in the future, however. A number of auto and engine manufacturers recently announced their intentions to consider the use of small diesel engines for the light-duty segment, particularly light trucks and sport utility vehicles. For this reason it is appropriate for EPA to consider the levels of future PM emission standards for light-duty vehicles as part of the rulemaking that will be initiated following this study. If EPA decides to propose more stringent PM standards for future vehicles, a full cost and cost effectiveness analysis will be performed as part of proposed rulemaking.

VI. REGULATORY ISSUES

In determining whether Tier 2 standards for LDVs and LDTs are appropriate, there are a number of important issues that EPA will need to resolve that relate to the broader issues of air quality, technical feasibility, and cost effectiveness. Seven issues are presented in this chapter:

A) Relative stringency of the Tier 2 LDV and LDT standards
B) Uniform versus separate standards for gasoline and diesel vehicles
C) Evaporative HC emission standards
D) Corporate average emission standards
E) Extended useful life and other ways to improve in-use emission performance
F) Test fuel specifications
G) Fuel sulfur and distillation properties

A. Relative Stringency of LDV and LDT Standards

All LDVs are required to meet the same numerical emission standards according to Clean Air Act requirements. For example, large luxury cars and small sub-compacts, both used as for personal transportation, meet the same emission standards. In contrast, EPA and CARB have historically set higher numerical emission standards for LDTs than LDVs. While this was done in part due to the larger size and mass of many LDTs, it was also due to their ability to haul cargo. Higher loads produce higher exhaust temperatures, which require that catalysts be placed further back from the engine, delaying light-off. Higher loads can also limit use of EGR for NOx control. Today, mini-vans, small pick-ups, and sport-utility vehicles dominate LDT sales. Full size pick-ups and vans (those vehicles most likely to be used in commercial applications) represent less than 30% of total LDT sales. Also, over the past few years, improvements in the temperature limits of automotive catalysts appear to have reduced the need to set less stringent LDT emission standards as may have been true in the past.

In addition to the trend of designing LDTs explicitly for passenger transportation, total LDT sales increased dramatically and now approach total car sales. Because of their numerically higher emission standards, LDTs have a disproportionate impact on in-use emissions. Using the modified MOBILE5b model described in *Chapter III. Assessment of Air Quality Need*, national LDT emissions of HC and NOx will exceed LDV emissions by 83% and 66% respectively, in the year 2007.

There are many options available for setting LDT emission standards given a particular set of LDV standards. Three possible options are:

1) Require LDTs to meet the same numerical emission standards as LDVs, which would mean setting standards regardless of vehicle use;

2) Set the LDT performance standards based on use of the same emission control technology most likely to be used to meet the LDV standards; or
3) Set different standards based on vehicle use.

Option 1 provides the greatest environmental benefit and could be justified based on the belief that the great majority of LDT use is the same as that of LDVs. Under the current California LEV standards, requiring LDTs to meet the same emission standards as LDVs would provide the same emission benefits as reducing the LDV and LDT standards by 50%. (The details of this analysis are presented in Appendix D.) This option would also most closely lead to a determination of emission standards based on the expected use of the vehicle. It could, however, result in higher emission control costs for some LDTs. This option might be appropriate for those LDTs that were not used primarily for personal transportation.

The second option seeks to impose roughly equivalent emission control technology for both LDTs and LDVs. LDVs and LDTs would still have marginally different emission standards to account for the different vehicle weights and payloads, but the types of emission control technologies found on each vehicle type would not differ as much as current LDVs and LDTs.

The third option may provide manufacturers with an incentive to produce LDTs in lieu of LDVs if there is a significant difference in standards, though this choice is limited to an extent by consumer demand. For example, more stringent LDV vehicle standards could be applied proportionately to LDTs.

Another issue involved in setting LDT emission standards is the classification of LDTs into weight categories, each potentially with its own set of emission standards. The current LDT classifications are based on both curb weight and gross vehicle weight rating (GVWR) (see Table 6.1). The higher the curb weight or GVWR, the numerically higher the applicable emission standards. While recognizing the increasingly more difficult task of meeting a given set of emission standards with a heavier vehicle, this system also provides an incentive for manufacturers to add weight to their vehicles in order to bump them up into a heavier classification. There can also be a fuel consumption penalty associated with this action.

Table 6.1 Federal Light Truck Classifications

Classification	Gross Vehicle Weight Rating (GVWR), pounds*	Curb Weight, pounds*	Adjusted Loaded Vehicle Weight, pounds*
LDT1	0-6000	0-3450	
LDT2	0-6000	>3450	
LDT3	6001-8500		<5750
LDT4	6001-8500		>5750

* Curb weight is the weight of the vehicle sitting empty. GVWR is the measure of how much cargo a vehicle can carry. Literally, GVWR is the maximum allowed weight of the vehicle when it is fully loaded. Adjusted loaded vehicle weight is the numerical average of the curb weight and the GVWR.

CARB recently proposed a second phase of LEV emission standards for LDVs and LDTs. As part of this proposal, CARB proposed to require LDVs and LDTs to meet essentially the same emission standards and to redefine LDTs to include any truck at or below 7000 pounds curb weight. If this approach were to be used by EPA for nationwide standards, it would move a significant number of current HDVs into the LDT class. EPA's rulemaking will examine whether the current divisions of LDTs based on curb weight and GVWR should be changed to use more appropriate criteria.

B. Uniform Application of Emission Standards

Uniform standards refers to the application of the same emission standards to similar vehicles regardless of what fuel is utilized. Here, the primary fuel options for conventional engines are gasoline and diesel fuel. The pollutants of most interest in this section are NOx and PM exhaust emissions. Both diesel and gasoline vehicles appear to be capable of meeting the range of possible Tier 2 HC and CO emission standards, so the issue of equivalent standards does not arise with respect to these pollutants. Therefore, NOx emission standards are discussed first below, followed by PM emission standards.

1. NOx Standards

Section 202(g) of the CAA provides that light-duty diesels are required to meet less stringent Tier 1 LDV/LDT NOx standards through model year 2003 than light-duty gasoline vehicles. For example, diesel LDVs and LDTIs are only required to meet a 1.0 g/mi NOx standard at 50,000 miles instead of the 0.4 g/mi NOx standard applicable to gasoline-fueled vehicles. This does not apply in California or to National LEV vehicles certified to TLEV, LEV, and ULEV standards. Should EPA decide not to promulgate Tier 2 standards, this difference in standards would expire and both gasoline and diesel vehicles would be required to meet the same Tier 1 emission standards. The CAA does not mention any continuation of this relaxation in the context of the Tier 2 standards;. Further, the default Tier 2 emission standards[21] apply to both gasoline and diesel vehicles. While it is clear that Congress intended to ease the NOx standards

[21] The default Tier 2 emission standards would apply where EPA finds that there is a need for the Tier 2 standards and that such emission controls are feasible and cost effective, but does not promulgate any alternative Tier 2 standard (see section 202(i)(3)(B) of the CAA). These default standards for LDVs are 0.125 g/mi NMHC, 1.7 g/mi CO and 0.20 g/mi NOx, at 100,000 miles.

of diesel Tier 1 vehicles through 2003, it also appears that Congress intended this to be a temporary measure.

Diesel engines are currently used in a small portion of the LDV and LDT fleets. Therefore, they have little impact on fleet-wide emissions or fuel consumption. Diesels could, however, comprise a greater fraction of sales in years to come. For example, the diesel engine has been identified by the Partnership for a New Generation of Vehicles as the most promising near term technology for high fuel efficiency vehicles. The U.S. government recently committed significant research funds to promote the development of high-efficiency, low-emissions diesels for future vehicles sold in the U.S. The target for the NOx emissions of the PNGV vehicle is 0.20 g/mi, or the current California LEV standard, for LDVs and LDT1s. However, EPA has projected in this study (see Chapter V) that emission levels for NOx below 0.20 g/mi are feasible for gasoline engines. In order to meet such NOx levels, significant development work to diesel engine and aftertreatment performance would be required.

The selection of the diesel as the near-term PNGV technology is due to its high fuel efficiency, as compared to gasoline vehicles. When used in the same vehicle, the diesel engine is more efficient than today's gasoline engine. There is a trend in the automotive marketplace, however, toward larger, heavier vehicles that also sit higher off the road and are equipped with 4-wheel or all-wheel drive. These features decrease fuel economy. Thus, the diesel engine could be used to increase the average size and weight of the vehicle fleet while still complying with the Corporate Average Fuel Economy (CAFÉ) standards. In this case, fleet average fuel economy would not increase. Another advantage of the diesel engine is that its fuel produces essentially no evaporative emissions.

2. Tier 2 Particulate Standards

The CAA set Tier 1 particulate standards of 0.10-0.12 g/mi for LDVs and LDTs at 100,000 miles. These standards were based on the capabilities of diesel engine technology. Gasoline vehicles can meet much more stringent PM standards (e.g., less than 0.01 g/mi). The CAA does not include default Tier 2 PM standards, as it does for NMHC, CO and NOx standards. It directs EPA to consider standards more stringent than the Tier 1 standards to meet all NAAQS, which include the particulate NAAQS. It is appropriate to consider Tier 2 PM standards along with those for the three gaseous pollutants.

Diesel LDVs and LDTs emit more PM emissions than gasoline-fueled vehicles, and the small number of light-duty diesels currently sold makes their overall air quality impact small. Diesels could become more prevalent in the future, however, and the public health impact of their particulate emissions could be quite substantial. The primary technical issue is whether to set Tier 2 particulate standards based on the capability of the gasoline engine and require diesels to meet this standard in order to be sold or to set a more relaxed standard based on current and projected diesel technology.

EPA has not performed a detailed analysis of the capability of diesel engines to meet stringent PM standards. California recently proposed a 0.01 g/mi PM standard for all LDVs and LDTs, which would begin phasing in with the 2004 model year. The goals of the Partnership for a New Generation of Vehicles include a 0.01 g/mi PM target.

In developing the proposed Tier 2 standards, EPA will perform assessments of the environmental impacts of diesel PM emissions to facilitate resolution of this issue. One assessment will estimate the ambient levels of PM_{10} and $PM_{2.5}$ which would likely occur in urban areas should substantial numbers of light-duty diesels be sold. This assessment will be performed for possible Tier 2 PM standards ranging between 0.01 and 0.10 g/mi. EPA will also assess the personal exposure to diesel PM emissions and project the resultant cancer impact of this exposure.

In addition, EPA will assess the capability of future diesel engine designs to meet these standards and whether the environmental impacts are severe enough to require PM standards below the current capability of diesel engines. The diesel engine is not the only technology that provides higher fuel efficiency than the current gasoline engine. Direct injection gasoline (GDI) engines are being developed by a large number of automakers. These engines appear to provide much of the fuel efficiency improvement available from a diesel engine. EPA will include these engines in this assessment.

One last issue regarding Tier 2 PM emission standards is whether to establish such standards only for operation over the traditional FTP driving cycle, or to also establish standards for emissions during aggressive driving and air conditioner operation. EPA did not establish any Tier 1 SFTP standards for PM emissions. EPA has not performed any assessments of the costs or benefits of such standards, but will consider them in developing the proposed Tier 2 standards.

C. Evaporative HC Emission Standards

Evaporative HC emissions from Tier 1 and LEV vehicles exceed exhaust NMHC emissions in-use. (Evaporative HC emissions as used herein include running losses, hot soak emissions, diurnal emissions and resting losses.) It may be appropriate to consider tightening the current evaporative HC emission standards in the process of considering tighter Tier 2 exhaust emission standards.

CARB recently proposed a "zero evaporative emission" requirement which would essentially require that evaporative HC emissions be below measurable levels. One manufacturer recently announced the ability to produce a vehicle with "zero evaporative emissions" in-use. CARB pointed to this vehicle, as well as to several other emission control technologies, as a basis for the recently proposed zero-evap standards. These technologies included a second charcoal canister to trap HC emissions not absorbed by the standard canister, bladder fuel tank systems, pressurized fuel tanks, pressurized vapor reservoir systems, insulated fuel tanks and

improved seals for the onboard vapor recovery systems (refueling emission controls). CARB also pointed out that a number of current vehicles have certification levels of evaporative emissions that equal less than one-fifth of the current emission standards.

EPA has not assessed the feasibility of tighter evaporative HC standards, nor their cost and air quality benefit. These assessments will be performed prior to the proposal of the Tier 2 emission standards and will be used to determine whether more stringent evaporative HC standards should be proposed along with more stringent exhaust emission standards. Should EPA decide to include evaporative HC standards in its Tier 2 standards proposal, EPA will also evaluate several new regulatory options for their control to provide the manufacturers greater compliance flexibility.

D. Corporate Average Tier 2 Standards

The current Tier 1 emission standards apply to each LDV or LDT separately. There is no flexibility to have some vehicles meet a more stringent and some vehicles meet a less stringent standard and allow manufacturers to comply with standards based on a fleet average. EPA has, however, established corporate average emissions standards in other contexts (e.g., heavy-duty engine standards). The voluntary National LEV program uses a fleet average standard to help determine manufacturer compliance with the requirements. Also, compliance with CARB's LEV and proposed LEV-II standards is accomplished on a corporate average basis. CARB and the National LEV program limit this flexibility somewhat, however, by specifying a limited number of NMOG emission standards to which individual vehicle models may be certified. NOx emission standards are directly tied to the specific NMOG emission standard selected for each vehicle model (i.e., TLEV, LEV, ULEV).

The flexibility of a corporate average standard can encourage the design and production of vehicles with advanced emission controls, as manufacturers can receive credit for the additional emission reductions provided by vehicles certified to more stringent emission levels. Such controls could include such vehicular concepts as gasoline-electric or diesel-electric hybrid vehicles, electric vehicles and fuel-cell powered vehicles, as well as more optimal combinations of emission control technologies. It can also facilitate the application of more stringent standards, because the flexibility of averaging across a product line would allow manufacturers to meet an overall corporate standard even when their highest emitting vehicles are less able to meet a stringent standard (e.g., uniform standards for gasoline and diesel powered vehicles).

An additional advantage of averaging and trading systems generally is that they achieve the target emission reductions at the lowest cost without EPA having to consider the incremental cost-effectiveness of controls on a vehicle model basis. Without some form of averaging and trading, it is possible that none of the three options for dealing with LDTs discussed above would minimize the cost of the emission reductions that could be achieved.

E. Extended Useful Life and Other Options to Improve In-Use Performance

Section 202(i) of the CAA, in directing EPA to perform this Tier 2 study, also directed EPA to consider extending the useful lives of the LDV and LDT emission standards. EPA believes that the purpose of this direction was to emphasize Congress' focus on the reduction of emissions in-use and not simply by vehicle prototypes or by vehicles at low-mileage. Congress extended the useful life of the LDV standards from 50,000 miles to 100,000 miles in the 1990 amendments to the CAA, but clearly believed that more might be needed to ensure appropriate in-use emissions performance.

This focus on in-use emissions is consistent with EPA's focus on ensuring that its emission standards produce emission reductions in the real world. Examples of this include the onboard diagnostic (OBD) system requirements, the cold temperature CO standards and the supplemental Federal Test Procedure (FTP) standards addressing off-cycle vehicle operation. Extending the useful life of the emission standards is one possible approach to improving in-use emissions performance. Such an extension would be consistent with marketplace trends toward longer actual vehicle lives, as was mentioned in *Chapter III. Assessment of Air Quality Need.* California has also proposed to extend the useful life of its Phase 2 LEV emission standards for LDVs and LDTs to 120,000 miles from their current 100,000 miles. (EPA's useful life requirements for its LDT standards is already 120,000-130,000 miles.)

EPA has not performed assessments of either the cost or in-use emission benefits of this option. The in-use emission benefits will clearly depend on the baseline level of in-use emission deterioration, which is being updated in MOBILE6. EPA plans to perform these economic and environmental assessments to determine if this (or any related) options should be included in the proposed Tier 2 standards.

F. Test Fuel Specifications

In order for EPA emission standards to produce emission reductions in the real world, the test procedures used to determine compliance with these standards must be representative of real world conditions. If test procedures are not representative, increases in emissions in use may not be discovered in testing and thus mask substantially higher in-use emissions. That was EPA's rationale behind the recent development of emission standards and test procedures for:

1) Aggressive driving patterns and air conditioning use;
2) Evaporative, running loss and resting loss emissions at high ambient temperatures and during extended, multi-day soaks; and
3) CO emissions at low ambient temperatures.

Regarding test fuels, while the current specifications for the certification gasoline are sufficiently broad to include a wide range of gasoline, including average or typical gasolines, in practice the composition of the fuel used for emission testing (commonly referred to as Indolene) has not been representative of commercial gasoline. In particular, both the olefin and sulfur contents of Indolene tend to be quite low relative to average commercial gasolines. For example, Indolene tends to have a sulfur content of 100 ppm or less, while commercial gasoline averages more than 300 ppm sulfur, with some commercial fuels containing 1000 ppm sulfur.

As mentioned above in *Chapter III. Assessment of Air Quality Need* and *Chapter IV. Assessment of Technical Feasibility*, sulfur reduces catalyst efficiency significantly, particularly for LEVs. Differences between sulfur levels in test and in-use fuels could have a significant impact on the in-use emissions performance of motor vehicles. EPA believes that it is very important that the fuel used for emission testing of Tier 2 vehicles be as representative as possible of commercial gasoline. EPA will review its test procedures to consider more representative fuel in testing. An issue with respect to sulfur would be whether the emission test fuel sulfur level should be matched to that of the average commercial gasoline, the worst commercial gasoline, or the average or worst gasoline sold in a smaller geographic area, such as the worst ozone nonattainment areas.

G. Gasoline Sulfur

As discussed briefly in *Chapter IV. Assessment of Technical Feasibility*, the presence of sulfur in gasoline has an impact on the performance of catalysts and thus on tailpipe emissions. As catalyst technology has progressed, the sensitivity of catalyst efficiency to sulfur has appeared to increase. Because the impact of gasoline sulfur on emissions is significant, EPA has started to analyze the issues associated with a gasoline sulfur control program. This section discusses the issues that must be considered when evaluating the cost and cost-effectiveness of reducing gasoline sulfur. A more complete evaluation of these issues, including analyses of the data available to date, is presented in a recently released Staff Paper on gasoline sulfur.[22] This Staff Paper is part of EPA's commitment to undertake a parallel process, involving all interested stakeholders, to determine appropriate measures to address the impact of sulfur on vehicle performance.

[22] "EPA Staff Paper on Gasoline Sulfur Issues," EPA-420-R-98-005, May 1998.

Sulfur occurs naturally in crude oil and ends up in gasoline as a result of the refining process. Currently, the sulfur content of both conventional and reformulated gasolines (RFG) sold nationally average over 300 ppm. Maximum levels may get as high as 1000 ppm in conventional gasoline and 500 ppm in reformulated gasoline (RFG). California gasoline averages around 30 ppm, and is capped at a maximum 80 ppm. The oil industry estimates that beginning in the year 2000, Federal Phase II RFG will average around 150 ppm sulfur, due to the NOx reduction requirements for summertime RFG.

The amount of sulfur in the gasoline from any refinery depends on a number of factors, including the amount of sulfur in the crude oil used and the extent and type of processing within the refinery. Typically, sulfur in gasoline is reduced by hydrotreating certain hydrocarbon streams. Hydrotreating requires hydrogen, which must be produced in the refinery or purchased at substantial cost. The cost to the refining industry of reducing gasoline sulfur levels is impacted by a number of variables and assumptions made when analyzing a control strategy, including:

- Where would low sulfur gasoline be required? The size of the program (national, regional, local) will have an impact on the net costs to the refining industry. This is due to many factors, including the varied capabilities of refineries located in different parts of the country to produce low sulfur gasoline.

- What level of sulfur reduction would be required? Reduction of sulfur in gasoline requires the installation of capital equipment as well as increased operating expenses. The greater the level of reduction, the greater cost per gallon.

- Is the inhibiting effect of sulfur on motor vehicle catalysts reversible? An irreversible emissions impact could mean that motor vehicles that are fueled with a high sulfur gasoline may have permanent catalyst damage, and thus higher emissions, even when refueled on very low sulfur gasoline. This would be a reason for considering a national sulfur reduction program. In contrast, if the effect were largely or wholly reversible upon the use of low sulfur gasoline, sulfur reductions could be targeted to those areas most in need of emission reductions.

- Does sulfur affect motor vehicle onboard diagnostic systems? If high sulfur levels are found to cause substantial interference with OBD systems, causing illumination of the malfunction indicator lights, it may be more appropriate to establish a national sulfur program to avoid such illumination. However, if such illuminations are not substantial or can be remedied through other means, than a national approach to sulfur control may not be needed to appropriately address the problem.

There is great interest in determining whether changes can be made to catalyst designs and fuel control strategies of those vehicles that prove to be highly sensitive to sulfur inhibition.

Presently, there are no catalyst designs that are fully sulfur tolerant. Data from laboratory, engine dynamometer testing and vehicle fleet studies show that all automotive catalyst designs have some inhibition in performance resulting from sulfur. EPA will investigate the latest work being done on the developing of sulfur resistant catalyst technology and attempt to determine the feasibility, cost, and effectiveness of such technology.

There are many other factors that impact the final costs to the refining industry and additional issues to be considered. For example, the availability of new technologies to reduce gasoline sulfur at less cost than current technologies will make it more attractive and less burdensome to the industry to reduce sulfur levels. However, some refiners, particularly small refiners, may have difficulty in raising the capital necessary to invest in new equipment. All of these issues and concerns will be addressed during the processes of evaluating Tier 2 standards and sulfur control programs.