The Emission Reduction Potential of the Congestion Mitigation and Air Quality Program

Preliminary Assessment

Office of Policy, Planning and Evaluation

U.S. Environmental Protection Agency

May 19, 1997

THE EMISSIONS REDUCTION POTENTIAL OF THE CMAQ PROGRAM[1]

OVERVIEW

The Congestion Mitigation and Air Quality Improvement Program (CMAQ) provides funds to states for projects designed to help attain and maintain the national ambient air quality standards (NAAQS) set under the Clean Air Act (CAA). CMAQ was created in 1991 by the Intermodal Surface Transportation Efficiency Act (ISTEA), and Congress is now considering reauthorization of ISTEA. This report analyzes the impact of the CMAQ program in reducing air pollutant emissions of volatile organic compounds (VOC), carbon monoxide (CO), and oxides of nitrogen (NO_X) under ISTEA and in the Administration's NEXTEA reauthorization proposal. Data used in this analysis came from estimates of emission benefits and funding obligations reported by the states to the Federal Highway Administration (FHWA) and published in FHWA's CMAQ Program Annual Report for FY 1994.[2]

KEY CONCLUSIONS

- The CMAQ program, under ISTEA, is projected to reduce VOC emissions by 52,135 tons per year, CO emissions by 336,349 tons per year, and NOx by 62,406 tons per year (Table 1 and Figures 1a-c)[3]. Under NEXTEA, annual CMAQ emission reductions could grow substantially to 165,151 tons per year of VOC, 856,166 tons of CO, and 275,837 tons of NO_X. These estimates represent the cumulative reductions from CMAQ projects funded through 1997 and 2003. Projects funded after 1997 are assumed to achieve improved effectiveness compared to projects funded prior to 1997.
- Under NEXTEA, the projected emission reductions from CMAQ could have a significant affect on improving urban air quality. For example, by 2005, CAA requirements for on-road vehicles will have reduced VOC emissions by approximately 888,000[4] tons per year, while CMAQ is projected to reduce VOC emissions by 104,200 to 165,151 tons per year. While NEXTEA ends in 2003, emission reductions are estimated to 2005 since this is when projects funded in 2003 are expected to produce results.
- While increasing VMT threatens to reverse air quality gains made through ISTEA programs and through cleaner cars and cleaner fuels, Figure 2 suggests that CMAQ may help keep emission trends moving downward. Figure 2 illustrates EPA's different estimates of emission trends from on-road vehicles with and without CMAQ.
- By 2005, CMAQ VOC emission reductions could equal 10 to 16 percent of total on-road vehicle emission reductions for the period 1995 to 2005 (Figure 3). For NOx and CO, CMAQ would contribute 11 to 23 percent, and 8 to 10 percent, respectively of total emission reductions.

---

[1] For additional information concerning this report, please contact Ken Adler, U.S. EPA, 260-6925, or Camille Mittelholtz, U.S. DOT, 366-4861.
[2] Federal Highway Administration. "The Congestion Mitigation and Air Quality Improvement Program: A Summary of Third Year Activities (FY 1994)." December 1995. (As of the date of this analysis, the FY 1995 report had not been released.)
[3] These estimates are slightly higher than the estimates released by EPA and DOT on May 7, 1997 because of a correction in the amount of funds available for CMAQ.
[4] U.S. EPA. National Air Pollution Emission Trends. EPA-454/R-95-0111. October 1995. These emission estimates reflect existing and projected regulatory requirements as of 1994.

- Estimates of emission benefits from the CMAQ program are sensitive to assumptions about the effectiveness of individual projects. There is a large range in the estimated effectiveness of CMAQ projects funded in FY 1994. The balance of this report address these issues, and provide information to place the data in the proper context.

Estimated Potential Emissions Effect of CMAQ

The report presents potential tons of pollutants reduced through the CMAQ program when it reaches its potential effectiveness. FHWA analysis shows that obligation rates have risen rapidly since the inception of the program. As states become more familiar with the CMAQ program and institutionalize procedures to select projects, the effectiveness of projects is expected to increase. This analysis assumes steady state conditions under which the program has ramped-up to potential effectiveness. To coincide with the ISTEA legislative cycle, the years 1997 and 2003 was selected for analysis, and CMAQ spending was assumed to be equal to the annual obligation levels for CMAQ. Emission estimates for ISTEA and NEXTEA, however, are reported for 1999 and 2005, respectively, because projects are assumed to take 2 years to reach their full effect. Emission estimates were derived by dividing deflated CMAQ expenditures by a range of effectiveness estimates for each project type. A more detailed description of our approach is provided in the Methodology section.

Lower and upper bound estimates are presented in the analysis for the 2000 to 2005 year estimates. The lower bound estimate assumes that the typical project funded will be as effective as the median or 50^{th} percentile project in 1994. For the upper bound estimate we assume that project effectiveness increases moderately, beginning in 1998, as states and metropolitan areas learn more about the administration and impact of CMAQ projects. For the upper bound we assume that the typical project will be as effective as the 60^{th} percentile project in 1994. (The 60-percentile project is more effective than 60 percent of projects, on a dollar per ton basis, and less effective than 40 percent.) Corresponding to the large range in effectiveness estimates, there is a large range in the estimated national emissions effect.

METHODOLOGY

This analysis involved estimating the potential effectiveness, by project type, of all CMAQ projects in FY 1994 where CMAQ emission reductions and expenditures were reported by states. These effectiveness estimates were then used to develop a range of estimates for potential national emissions reductions associated with the CMAQ program to be expected in 1999 (ISTEA), and 2005 (NEXTEA).

The methodology for this analysis is detailed below:

1. Project effectiveness was calculated for each project and pollutant by dividing FY 1994 CMAQ project expenditures by estimated tons of each pollutant reduced per year. Since the CMAQ database presented emissions reductions in kilograms per day, daily reductions were multiplied by 240 days per year to calculate annual reductions, assuming most projects affect workweek travel. This assumption is conservative, i.e., tends to underestimate emissions reductions, since many projects—such as enhanced inspection and maintenance (I&M) programs and traffic flow improvements—affect travel every day of the year.
2. The projects were then grouped into the six project categories according to classifications under the CMAQ Program guidance: traffic flow improvements, transit, shared ride, demand management, bicycle and pedestrian, and I&M and other.
3. For each project category, projects were then ranked by effectiveness in order from highest to lowest for each pollutant. Projects were ranked in separate analyses for each pollutant. Projects with no reported emissions reductions (including those with emissions increases) were excluded

from these rankings.[5] The projects at the 50th and 60th-percentile were selected. The project at the 50-percentile is the median project—half of all projects were less cost-effective and half were more cost-effective. The 60-percentile project is more cost effective than 60 percent of projects, and less cost-effective than 40 percent.

4. The average life of the projects was based on a methodology developed by California's Department of Transportation and the California Air Resources Board for estimating emissions effects of CMAQ projects. The average for the range was used in this analysis:
   - Traffic flow improvements – 12.5 years (average of 5-20 years)
   - Transit – 12 years (average of 5-12 years)[6]
   - Shared ride – 14 years (average of 8 – 20 years)
   - Demand management – 12.5 years (average of 5-20 years)
   - Bicycle and Pedestrian – 20 years
   - I/M and Other – 5 years (not estimated in the California methodology)

5. Total year 1997 and 2003 federal CMAQ expenditures were calculated for each category of spending. According to the President's reauthorization proposal for ISTEA, $1.3 billion would be authorized and $1.047 billion would be obligated annually for CMAQ for FY 1998-2003. The table below provides annual obligation rates. For the analysis, these dollar values were converted into 1994 dollars[7] since the cost effectiveness estimates represent emissions reductions per 1994 dollar spent.

CMAQ Obligations (millions of dollars)

FY 1992--Actual	FY 1993--Actual	FY 1994—Actual	FY 1995--Actual	FY 1996—Actual	FY 1997--Actual
340	601	815	950	939	878
FY 1998-Estimate	**FY 1999-Estimate**	**FY 2000-Estimate**	**FY 2001-Estimate**	**FY 2002-Estimate**	**FY 2003-Estimate**
1047	1047	1047	1047	1047	1047

6. The proportion of spending for each project type was assumed to be the same as in 1994:
   - Traffic flow improvements – 34.1%
   - Transit – 40.4%
   - Shared ride – 4.3%
   - Demand management – 4.6%
   - Bicycle and Pedestrian – 2.1%
   - I&M and Other – 5.5%

[5] It would be incorrect to assume that no emissions reductions occur for projects that report no emissions benefits. For example, these projects may have been located in areas that were in attainment for the non-reported pollutant. Projects that resulted in increased emissions were dropped from the analysis since negative cost-effectiveness values are not meaningful in this context.

[6] The mid-range estimate for transit projects appears low, given that many rail projects can last 25 to 35 years, so the upper bound estimate was chosen for transit.

[7] A GDP price deflator was used to convert the current-dollar CMAQ obligations for each year into constant 1994 dollars. The 1992-1995 GDP deflators were calculated from *Economic Report to the President, 1996.* The 1996-2003 GDP deflators were calculated from GDP price index growth rate projections reported in CBO's *The Economic and Budget Outlook: Fiscal Years 1998-2007* (January 1997, Table 1-1).

7. Annual CMAQ expenditures for each category of projects were divided by various effectiveness estimates (computed in steps 3 and 4), in dollars per ton, to estimate a range for the tons of pollutants reduced nationally.

CAVEATS

While this analysis provides an order-of-magnitude approximation of *potential* emissions benefits from CMAQ funding, it is important to note a few significant caveats for this analysis:

Accuracy of reported emissions estimates is uncertain.

Emissions estimates associated with CMAQ-spending are reported by individual states. Since Federal guidance imposes no uniform approach, each state performs air quality analyses using its own methods, and quality control and quality assurance mechanisms. Analyses may use different underlying assumptions, emissions estimation methodologies, and types of data. FHWA has noted that occasionally numbers were reported that appeared unreasonable and required extensive follow-up. In some cases, it was not possible to obtain better information, and these figures were deleted by FHWA from their database. It is not clear to what extent, if at all, the states have taken into account the secondary effects of projects. For example, it is possible that traffic flow improvements that reduce travel times, and mass transit projects that reduce congestion levels could lead to induced travel that would reduce emissions effectiveness. It is also possible that an interconnected bicycle path system could be much more effective than the sum of the individual bicycle paths.

This analysis deals with uncertainties in estimating CMAQ effects by performing statistical analysis using the entire database of projects, rather than pre-selecting an individual project or case study for analysis, which may or may not be representative of most projects. This analysis also uses a range of estimates in order to deal with the uncertainty in individual estimates.

No emissions estimates are reported for a number of projects.

About 77 percent of all CMAQ projects reported quantified emissions reductions. Many of these projects reported emissions reductions for fewer than all four pollutants (VOC was the pollutant reported most often). Projects with no reported data for individual pollutants were dropped from the ranking of projects when selecting the 50- and 60-percentile projects within each category. Dropping these projects may have eliminated some projects with small impacts and lowered the effectiveness of the 50-and 60-percentile projects. However, it would not be appropriate to assume that no emissions reductions occur for projects that do not report emissions benefits. These projects may have been located in areas that were in attainment for the non-reported pollutant. Non-attainment areas would be expected to target funding to projects that help them reach attainment status.

Nine (9) percent of CMAQ funds were spent by states that did not have any non-attainment areas. This analysis uses the conservative assumption that CMAQ spending in states without any non-attainment areas does not result in emissions reductions. This assumption tends to underestimate CMAQ's effectiveness. Since states are expected to target CMAQ funds toward projects that help them meet attainment, emissions reductions would be proportionally larger in non-attainment and maintenance areas.

Timing of emission reductions

There is significant variation in the nature of benefits of CMAQ-projects. In particular, some projects may have multiple-year impacts, e.g., replacement of old transit buses with cleaner ones, development of bicycle facilities, and improvement of signalization, while others have one-time effects, e.g., operating costs for park-and-ride lots or vanpooling service. For some projects, it may take many years to reach full benefits while for others the effect may occur immediately. For analytic purposes we assumed that projects would need 2 years to reach effectiveness. The database of CMAQ projects does not provide information on the duration of benefits or peak year for benefits. This analysis projects emissions estimates under steady-state conditions in which the CMAQ-program has ten years to reach potential effectiveness.

FHWA guidance suggests that emission reductions for each project be estimated for the year when the implemented project is expected to realize its maximum benefits. Some projects may require multiple years in order to reach full impact, in which case there will be some interim years in which the emissions impact of spending is less than in subsequent years. For example, CMAQ funding has been used to help establish Transportation Management Organizations, which may not yield reported impacts for a number of years. In addition, 1994 projects that continue to produce benefits in 2005 may be on-average less effective than the 50-or 60-percentile projects. As a result, the total emissions benefits estimated using the assumption of multiple year impacts may overstate the total benefits that would occur in one year.

Assuming only one-year effects for each project, rather than multiple-year effects, underestimates the total emissions reductions in 2005 since many projects from prior years will continue to have an emissions effect in 2005 (for example a park and ride lot funded in 1998 will produce benefits in 2005). To estimate cumulative/steady state emission reductions in 2005, this analysis sums emission reductions from all potential projects initiated between 1992 and 2003.

It is also important to note that some projects reported in the FY 1994 DOT Annual CMAQ Report do not report the total CMAQ funds needed for the projects. This can occur when a project is funded over a two or three year period. If a large number of projects were funded over a multi-year period it would lead to an over-estimate of the emission reductions from CMAQ projects. To assess the magnitude of this problem we reviewed 3 years of CMAQ project data from Pennsylvania and California. While 9 percent of the Pennsylvania projects were multi-year projects, they only accounted for 2.7 percent of the emission reductions. California's multi-year projects only accounted for 2.5 percent of the state's emission reductions. To adjust for multi-year projects, we reduced total emission estimates by 2.5 percent.

Effectiveness of CMAQ projects in 2005

Predicting future effectiveness associated with transportation control measures (TCMs) in general is not certain. On the one hand, the effectiveness of a particular type of project may decrease in the future since each vehicle mile of travel (VMT) reduced will result in fewer grams of pollution reduced (since the average vehicle on the road will be cleaner, due to stricter emission regulations, and emit less pollution per mile traveled). On the other hand, each dollar spent may affect more vehicle miles since projected increases in travel and congestion nationwide may mean that a particular project, such as rideshare services, reduces more VMT. This analysis estimated the potential of the CMAQ program in 2005 using the effectiveness of the 50- and 60-percentile of projects in FY 1994. Our upper bound assumption, supported by our analysis of the California and Pennsylvania data (see table below), is that as the program continues, States will become more effective at targeting CMAQ funding, and so projects are likely to have higher than the median 1994 cost effectiveness in future years.

Change in Cost-Effectiveness

	5 year signal + hwy project life		10 year signal + hwy project life	
	1993	1996	1993	1996
VOC				
California	$ 15,630	$ 9,121	$ 11,301	$7,437
Pennsylvania	$ 72,734	28,181	$ 44,076	$19,848
NO_X				
California	$ 20,192	$11,756	$ 16,813	$10,008
Pennsylvania	$ 99,084	27,588	$ 93,706	$24,667

This analysis is also conservative in that it assumes spending will continue to be apportioned among the six categories of CMAQ projects in the same manner as in 1994. That is, this analysis does not assume that funding shifts to the more effective *categories* of projects, only to more effective projects within each category. The assumptions used on this issue tend to underestimate potential effectiveness.

Costs measured in this analysis only account for Federal expenditures on CMAQ.

For most CMAQ-funded projects, federal CMAQ-funds are only a portion of total project costs. For our analysis, the CMAQ portion of the project costs was used as an intermediate step to analyzing the potential effectiveness of CMAQ funding in the future. We were not attempting to assess the relative cost-effectiveness of different types of project. As a result, the effectiveness estimates should not be confused with cost-effectiveness estimates that include total costs. The analysis presented here assumes that the CMAQ program leverages other funds that would not have otherwise been spent on these projects. That is, if CMAQ-spending were reduced, the states would not spend money on these projects. CMAQ projects often have substantial state and other funding sources. For example, $1.9 million in CMAQ funds contributed to total project costs of $6.4 million for a Freeway Service Patrol (to clear highway incidents) in San Francisco. CMAQ contributed $7.3 million out of $13.7 million in total project costs to build an elevated pedestrian walkway connecting Tower City Center transit station to the Gateway Sports and Entertainment Complex in Cleveland. In some cases, CMAQ funds have been used to pay for most or all of project costs. For example, CMAQ provided $1.7 million out of $2.2 million for a transit operating assistance project in Ventura County, CA.[8] Some TCMs have financial costs for the private sector as well.

***Projects have different levels of effectiveness at reducing various pollutants*.**

This analysis estimated potential effectiveness based on individual analyses of the 50- and 60-percentile projects for each pollutant. In reality, a project that is near the top in effectiveness for one pollutant may be average or near the bottom in effectiveness for another pollutant, measured in terms of CMAQ expenditures per ton of emission reduction. Metropolitan areas would be expected to target funding priority to projects that help them meet attainment status. As a result, regions may select projects that most effectively reduce pollutants of their concern. However, at the national level, it may not be possible to achieve the full potential of CMAQ reported for all pollutants. Targeting projects that are highly effective in reducing one pollutant often results in less effectiveness at targeting the others. For example, 33 CMAQ-funded projects that reduce VOC and CO were expected to result in *increased* emissions of NO_X. This is true for a number of traffic flow improvement projects, since increasing travel speeds often reduces VOC and CO, but increases NO_X emissions. These findings stress the importance of examining CMAQ from a regional perspective—since regions can target funding to help

[8] U.S. Department of Transportation. *CMAQ, Innovations in Transportation & Air Quality: Twelve Exemplary Projections* (FHWA-PD-016).

implement their transportation/air quality plans—rather than solely from a national emissions inventory perspective.

Figure 1a. Estimated On-road Vehicle VOC Emission Reductions from CMAQ

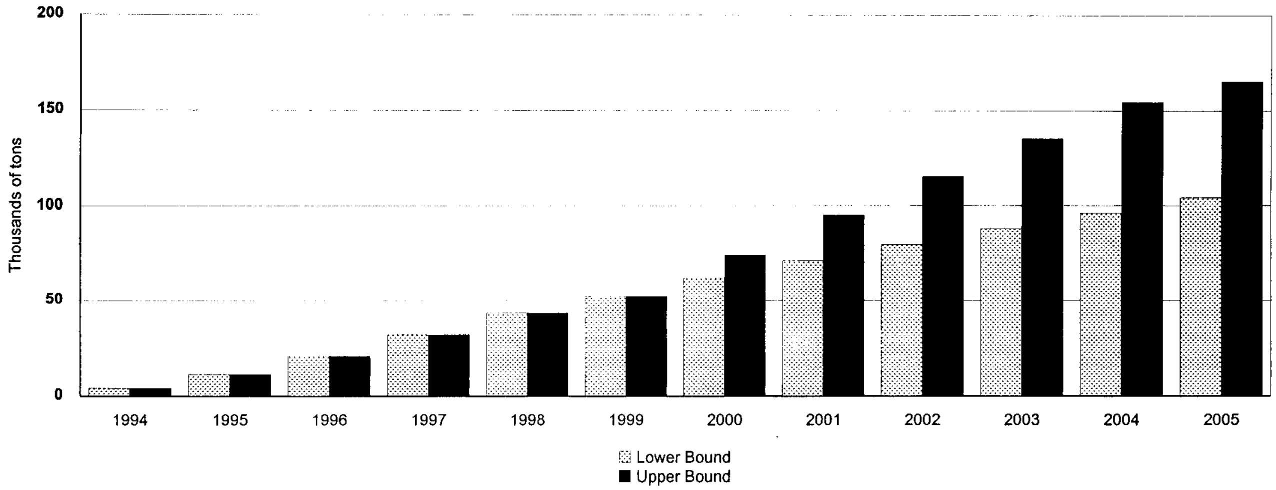


Figure 1b. Estimated On-road Vehicle CO Emission Reductions from CMAQ

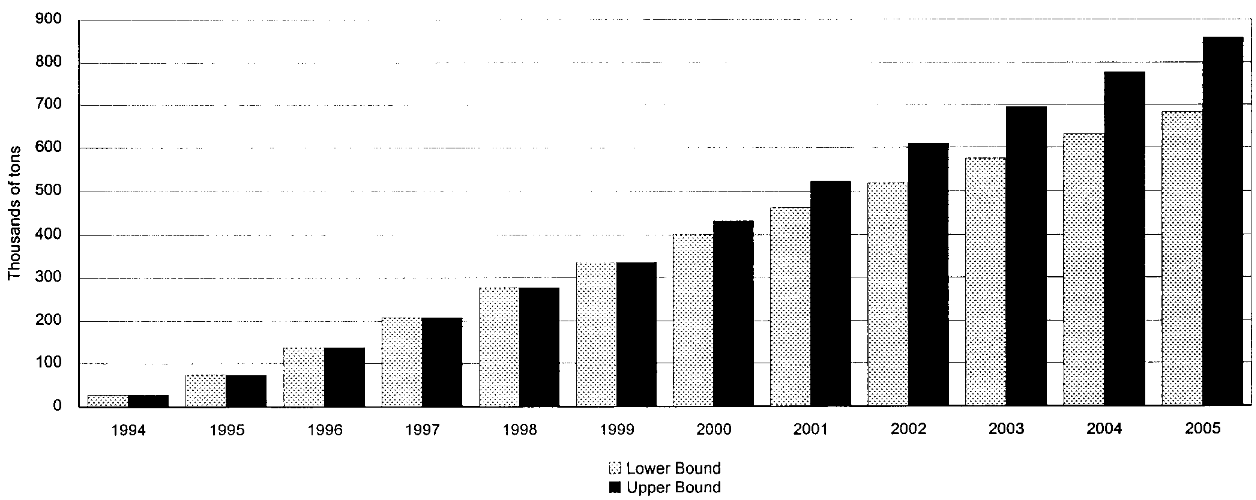


Figure 1c. Estimated On-road Vehicle NOx Emission Reductions from CMAQ

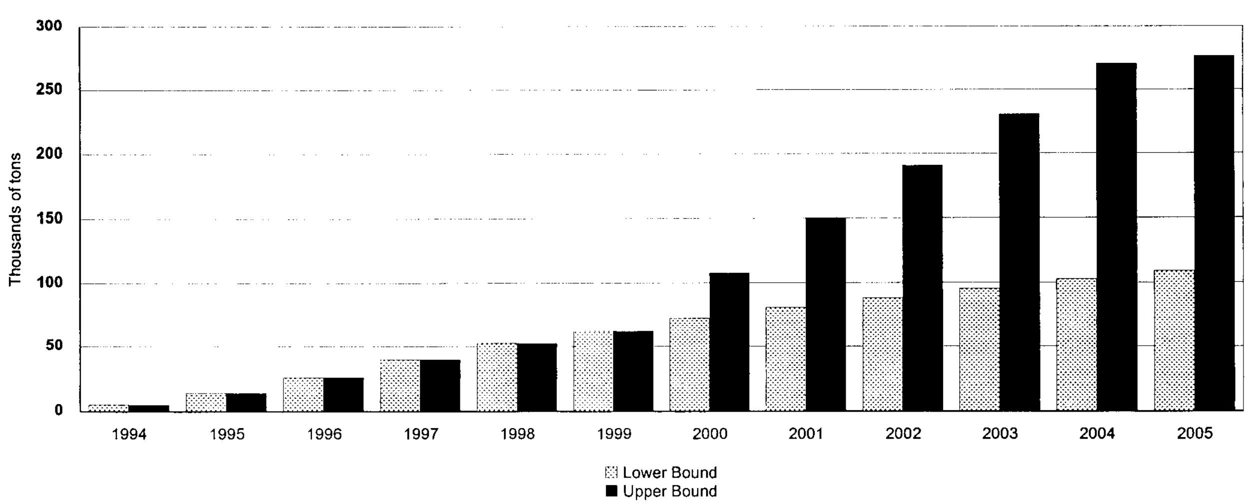
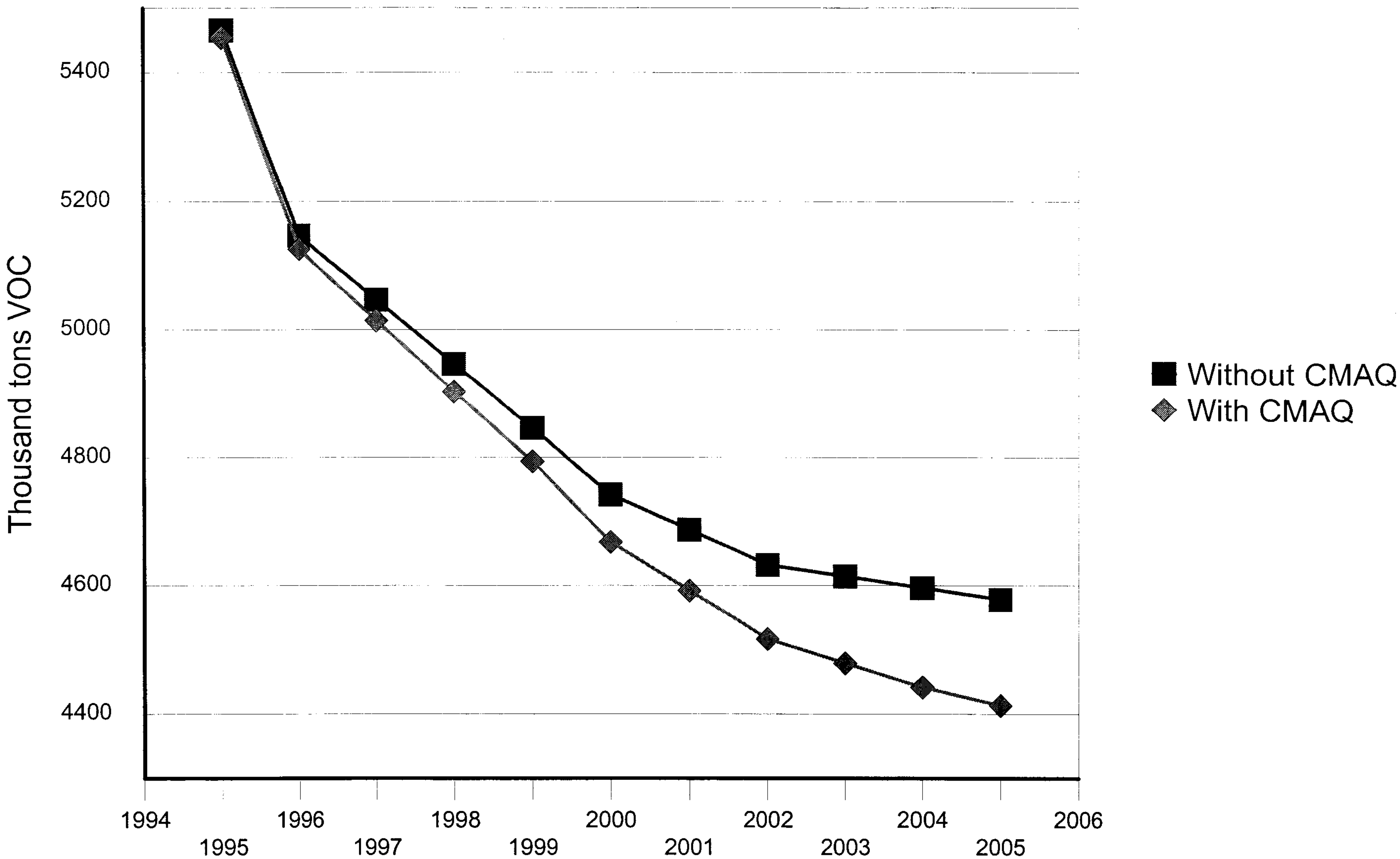


Table 1.Estimated On-road Vehicle Emissions Reductions from the CMAQ Program (tons reduced per year)

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Volatile Organic Compounds (VOC)														
Lower Bound	0	0	4,263	11,607	21,338	32,438	43,284	52,135	62,061	71,209	79,796	88,180	96,485	104,200
Upper Bound	0	0	4,263	11,607	21,338	32,438	43,284	52,135	74,262	95,303	115,480	135,161	154,477	165,151
Carbon Monoxide (CO)														
Lower Bound	0	0	27,437	74,707	137,343	208,789	277,955	336,349	401,584	462,252	519,554	575,487	630,740	682,494
Upper Bound	0	0	27,437	74,707	137,343	208,789	277,955	336,349	432,439	523,180	609,793	694,294	777,391	856,166
Oxides of Nitrogen (NOX)														
Lower Bound	0	0	5,201	14,160	26,033	39,576	52,686	62,406	72,447	80,868	88,217	95,419	102,784	108,979
Upper Bound	0	0	5,201	14,160	26,033	39,576	52,686	62,406	107,558	150,200	190,903	230,614	269,664	275,837

These estimates represent the cumulative reductions from existing CMAQ projects funded through each year.
Emissions reductions were calculated based on the cost-effectiveness of the 50th percentile projects in FY 1994 for obligations in FY 1992 to FY 1997.
In the Lower Bound, projects obligated in FY 1998 to FY 2003 are assumed to remain as cost-effective as the 50th percentile FY 1994 projects.
In the Upper Bound, projects obligated in FY 1998 to FY 2003 are assumed to be as cost-effective as the 60th percentile FY 1994 projects.
Please refer to memo for assumptions.

Figure 2. Estimated VOC Emission Trends from On-Road Vehicles



U.S. EPA. National Air Pollutant Emission Trends. EPA-454/R-95-011. October 1995. These estimates reflect existing and projected regulatory requirements, as of 1994.
U.S. EPA. Emission Reduction Potential of the CMAQ Program--Preliminary Assessment. May 1997.

Figure 3. Estimated Emission Reductions from On-road Vehicles--1995 to 2005