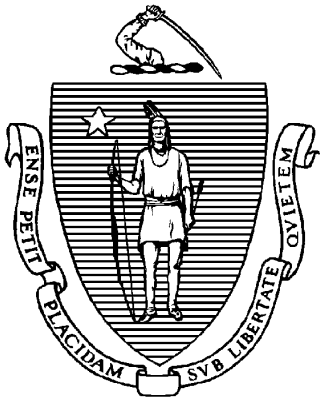
MASSACHUSETTS
1996 PERIODIC EMISSION INVENTORIES:

VOLATILE ORGANIC COMPOUNDS
NITROGEN OXIDES
CARBON MONOXIDE



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June 2000

MASSACHUSETTS 1996 PERIODIC EMISSION INVENTORIES:

VOLATILE ORGANIC COMPOUNDS (VOC)

NITROGEN OXIDES (NOx)

CARBON MONOXIDE (CO)

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TABLE OF CONTENTS

SECTION

APPENDICES

LIST OF TABLES

LIST OF TABLES (Cont'd)

LIST OF TABLES (Cont'd)

APPENDIX

LIST OF FIGURES

7Table96

PREFACE

1996 Periodic Emission Inventories are required by Title I of the Clean Air Act to be submitted to the Environmental Protection Agency. Emission inventories are required every three years for the precursors of ozone, i.e., volatile organic compounds (VOC), nitrogen oxides (NOx), and carbon monoxide (CO), until Massachusetts is redesignated to attainment.

Atmospheric ground level ozone or smog is formed indirectly when VOC, NOx and CO which are emitted from automobiles, power plants, combustion, and industrial processes, chemically react in the presence of sunlight and high temperatures during the summer. Ozone is a photochemical oxidant that can cause lung dysfunction, eye, nose, and throat irritation. Children, asthmatics, and those exercising or working outdoors for prolonged periods are particularly sensitive to ozone. Ozone damages vegetation, agricultural crops, and synthetic materials such as rubber.

The periodic inventories provide estimates of the contributions of various source categories. It serves as a base for developing and tracking reduction control programs in order to achieve target emission levels.

DEP developed the periodic emission inventories using EPA's methodology and emission factor guidance documents. The basic emission estimation methodology involves multiplying an activity factor (e.g., fuel use) by an emission factor (e.g., pounds VOC/gallon). The estimated emissions represent a typical summer day, when ozone violations are most likely to occur.

The emission inventories include a range of source categories that are covered by the five sections in the report. The Stationary Point source section includes electric utilities, large industrial, and commercial/institutional facilities. Stationary Area sources include small industrial, commercial/institutional, and residential processes that are too small or numerous to be individually counted in the point source section. On-Road Mobile Sources include cars, trucks, buses, and automobiles. The Off-Road Mobile sources include small engines such as lawnmowers, construction and farm equipment, aircraft, locomotives, and marine vessels. The Biogenics section includes VOC emissions from trees, agricultural crops, grass and other vegetation.

Care should be taken when comparing this periodic inventory with previous estimates because methodologies and emission factors have been revised over the years. DEP will continue to improve the emission inventory process and report emissions triennially to EPA until the ozone standard is attained.

LIST OF ACRONYMS

BEIS-2	Biogenic Emission Inventory System (Version 2.0)
BTP&D	Bureau of Transportation Planning & Development
BWP	Bureau of Waste Prevention (Department of Environmental Protection)
CAA	Clean Air Act
CO	Carbon Monoxide
CNG	Compressed Natural Gas
CTPS	Central Transportation Planning Staff
DEP	Massachusetts Department of Environmental Protection
DOER	Massachusetts Division of Energy Resources
DOE/EIA	US Department of Energy/Energy Information Administration
DVMT	Daily Vehicle Miles Traveled
EIIP	Emission Inventory Improvement Program
EI/M	Enhanced Inspection/Maintenance
EOEA	Massachusetts Executive Office of Environmental Affairs
EOTC	Massachusetts Executive Office of Transportation and Construction
EPA	US Environmental Protection Agency
ES	Emission Statement
FAA	Federal Aviation Administration
FAEED	Federal Aviation Emission Estimation Database
FHWA	Federal Highway Administration
FR	Federal Register
HC	Hydrocarbon
IWW	Industrial Wastewater
LAEEM	Landfill Air Emission Estimation Model
LBSD	Pounds per Summer Day
LPG	Liquid Petroleum Gas
LTO	Landing and Take-off (cycle)
MASSPORT	Massachusetts Port Authority
MHD	Massachusetts Highway Department
MISER	Massachusetts Institute for Social and Economic Research
MOBILE5ah	EPA's On-road Mobile Source Emission Factor Model
MPO	Metropolitan Planning Organization
NAAQS	National Ambient Air Quality Standard
NON	Notice of Non-Compliance
IPP	Inventory Preparation Plan
NOx	Nitrogen Oxides
NO_2	Nitrogen Dioxide
OMS	Office of Mobile Sources EPA
PEI	Periodic Emission Inventories
POTW	Publicly Owned Treatment Works
PPM	Parts per million
QA/QC	Quality Assurance/Quality Control
RE/RP	Rule Effectiveness/Rule Penetration
RVP	Reid Vapor Pressure
SCC	Source Classification Code
SIC	Standard Industrial Code

SIP	State Implementation Plan
SSEIS	Stationary Source Emission Inventory System
TDM	Travel Demand Model
TPD	Tons per Day
TPSD	Tons per Summer Day
TPWD	Tons per Winter Day
TPY	Tons per Year
TSDF	Treatment, Storage and Disposal Facilities
UST	Underground Storage Tanks
VOC(s)	Volatile Organic Compound

1. EXECUTIVE SUMMARY

MASSACHUSETTS 1996 PERIODIC EMISSION INVENTORIES: VOC, NOx AND CO

1.1 INTRODUCTION

In November 1990, the US Congress passed amendments to the Clean Air Act (CAA). Title I of the CAA required states to develop or revise State Implementation Plans (SIPs) for areas that failed to meet the National Ambient Air Quality Standards (NAAQS).

For calendar year 1996, Massachusetts was in non-attainment of the ozone and carbon monoxide standards. Title I of the CAA requires Massachusetts to revise and develop strategies and control programs to attain these standards. The CAA required states to develop the 1990 base year emission inventories, and subsequent three-year periodic updates of these inventories for the precursors of ozone, and carbon monoxide. The Ozone SIP required emission inventories for a typical summer day for the three precursors of ozone: volatile organic compounds (VOC), nitrogen oxides (NOx), and carbon monoxide (CO).

Ozone is a respiratory irritant and can result in serious pulmonary effects as well as damage materials and vegetation. In July 1997, EPA revised the federal ozone standard from 0.12 ppm, averaged over a one-hour period to 0.08 ppm, averaged over an eight-hour period.

The Massachusetts Department of Environmental Protection (DEP) is the lead agency for SIP development, including emission inventories development. The 1996 Periodic Emission Inventories reflect revisions of the 1990 Base Year Inventory together with updated methodologies and emission factors from the Environmental Protection Agency's (EPA) latest guidance documents. Caution should be exercised when comparing 1990 base year emissions with 1996 estimates. Note that the emissions presented in this and previous inventories are estimates with various levels of uncertainty in emission factors, activity factors, and electronic emission models. The emission inventories are dynamic because of the on-going inclusion of new source categories and improvement in methodologies, emission models, and emission factors. DEP followed the six core EPA procedural guidance documents for developing the 1996 Periodic Emission Inventories. These core guidance documents are referenced at the end of this section.

Table 1.1 presents a summary of the 1990 and 1996 statewide emissions with the percentage breakdown by the major source categories.

1.2 INVENTORY PREPARATION PLAN AND QUALITY ASSURANCE

In February 1992, DEP submitted an Inventory Preparation Plan (IPP) to EPA prior to developing the 1990 Base Year Emission Inventories. The 1990 IPP was followed as closely as possible for the 1996 update. The IPP specified how the Massachusetts inventories were to be

developed, quality assured, documented, and presented. The 1990 IPP included a Quality Assurance (QA) Plan, which DEP implemented while developing the 1990 Base Year Emission Inventories. The QA plan included a review by an EPA Level of Effort (LOE) contractor and the results of that review are presented in Appendix F of the 1990 Base Year Emission Inventories. Additional QA reviews of the Base Year Inventories included the August 1993 public hearing comments, EPA's comments, and DEP's internal reviews. Since the 1990 Base Year Inventory was used as a template, its QA procedures were incorporated into the 1996 Periodic Inventory. The 1996 Periodic Emission Inventories were further enhanced by internal MADEP staff review. The QA process ensured that DEP used approaches to develop the most accurate emission estimates consistent with EPA's CAA requirements and emission inventory guidance documents.

1.3 NON-ATTAINMENT STATUS

The non-attainment classification of the area of study determined the level of emission inventory requirements. The Federal Register 56 FR 56693 (November 6, 1991) established the Boston and Springfield non-attainment areas which together cover the entire state. The Boston ozone non-attainment area includes the following counties: Worcester, Middlesex, Essex, Suffolk, Norfolk, Bristol, Plymouth, Barnstable, Dukes and Nantucket. The Springfield ozone non-attainment area includes the remainder of the state: Berkshire, Franklin, Hampshire and Hampden Counties. Figure 1.1 shows the location of these counties that comprise the two ozone non-attainment areas.

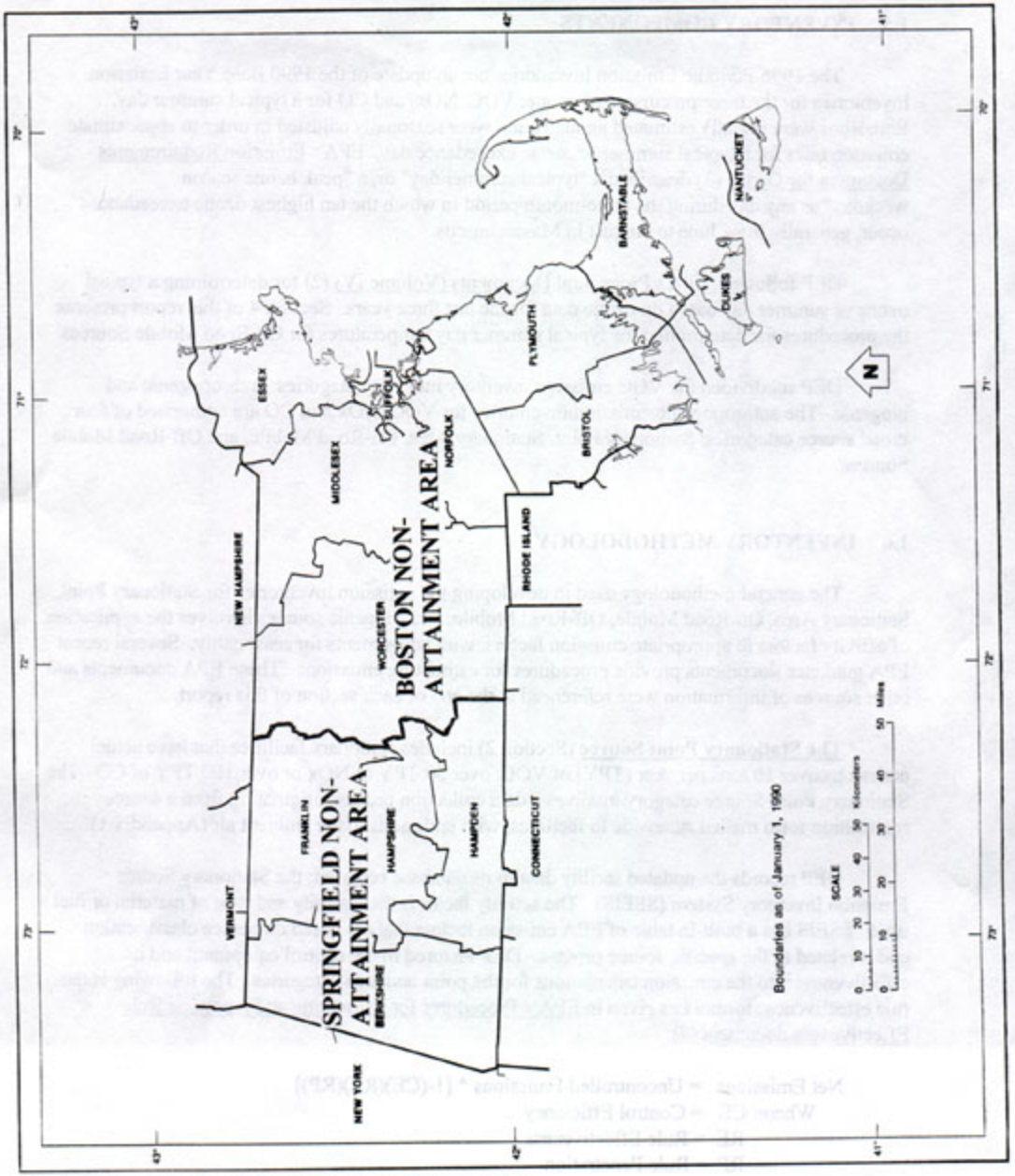
1.4 POLLUTANTS INVENTORIED

A volatile organic compound (VOC) as defined by EPA in 310 CMR 7.00, is any compound of carbon which either participates in atmospheric reactions or which is measured by the applicable reference methods under 40 CFR 60, excluding certain compounds or classes of compounds. The Stationary Point Source (Section 2 of this report) lists the excluded non-reactive VOC compounds. VOC's are emitted from industrial, commercial and residential solvent and fuel combustion processes, on-road and off-road mobile, and biogenic sources. VOC, NOx and CO react photochemically at high temperatures in the presence of sunlight to form ozone.

Nitrogen dioxide (NO_2) is one of the major components of NOx. NOx is emitted from fuel combustion by on-road mobile, off-road mobile, industrial, commercial, and residential sources. Even though Massachusetts is in attainment of the annual NO_2 National Ambient Air Quality Standard (NAAQS) of 0.053 ppm averaged over one year, a NOx emissions inventory is required because NOx is an ozone precursor.

CO is an asphyxiant gas with a federal one-hour standard of 35 ppm and an eight-hour standard of 9 ppm. The same combustion process described for NOx generally produces CO. CO is also a minor precursor to ozone formation in the summer. There is no biogenic inventory for NOx or CO; only VOC's have biogenic sources, such as vegetation and trees.

FIGURE 1.1 MASSACHUSETTS COUNTIES AND OZONE NON-ATTAINMENT AREAS



U.S. DEPARTMENT OF COMMERCE Economics and Statistics Administration Bureau of the Census

1.5 INVENTORY COMPONENTS

The 1996 Periodic Emission Inventories are an update of the 1990 Base Year Emission Inventories for the three precursors of ozone: VOC, NOx, and CO for a typical summer day. Emissions were initially estimated annually and were seasonally adjusted in order to approximate emission rates for a typical summer or ozone exceedance day. EPA's Emission Requirements Document for Ozone (3) described a "typical summer day" or, a "peak ozone season weekday" as any day during the three-month period in which the ten highest ozone exceedances occur, generally from June to August in Massachusetts.

DEP followed EPA's Procedural Documents (Volume IV) (2) for determining a typical ozone or summer day based on ozone data for the last three years. Section 4 of this report presents the procedures for determining the typical summer day temperatures for On-Road Mobile Sources.

DEP subdivided the VOC emission inventory into two categories: anthropogenic and biogenic. The anthropogenic emission inventories for VOC, NOx and CO are comprised of four broad source categories: Stationary Point, Stationary Area, On-Road Mobile, and Off-Road Mobile Sources.

1.6 INVENTORY METHODOLOGY

The general methodology used in developing the emission inventories for Stationary Point, Stationary Area, On-Road Mobile, Off-Road Mobile, and Biogenic sources involves the application of activity factors to appropriate emission factors, with adjustments for seasonality. Several recent EPA guidance documents provide procedures for estimating emissions. These EPA documents and other sources of information were referenced at the end of each section of this report.

The Stationary Point Source (Section 2) includes stationary facilities that have actual emissions over 10 tons per year (TPY) of VOC, over 50 TPY of NOx or over 100 TPY of CO. The Stationary Point Source category involves a data collection process originating from a source registration form mailed statewide to facilities, with emissions to the ambient air (Appendix 1).

DEP records the updated facility data in its database program: the Stationary Source Emission Inventory System (SSEIS). The activity factor is the quantity and type of material or fuel used. SSEIS has a built-in table of EPA emission factors that are based on source classification codes related to the specific source process. DEP factored in the control equipment and its effectiveness into the emission calculations for the point and area categories. The following is the rule effectiveness formula as given in EPA's Procedures for Estimating and Applying Rule Effectiveness document (7):

Net Emissions = Uncontrolled Emissions * [1-(CE)(RE)(RP)]
Where: CE = Control Efficiency
RE = Rule Effectiveness
RP = Rule Penetration

In 1997, DEP uploaded the 1996 point source emissions and associated data into the EPA National Aerometric Information Retrieval System, Facility Subsystem (AIRS-AFS) for submittal to the EPA National Emission Trends (NET) Database.

DEP included the Emission Trading (ET) emission reduction credits (ERC) as an addition to the point source inventory. EPA requires states to count banked emission reduction credits as actual emissions in the inventory. Table 1.19 provides a listing of the participating ET facilities with their VOC and NOx emissions.

The Stationary Area Source category (Section 3) represents point sources that were too small and numerous to be recorded in the point source inventory (e.g., gasoline stations). The Stationary Area source section is comprised of four basic categories: waste management practices, gasoline distribution, solvent use, and combustion processes. The activity factors include material sales records, state registration records, fuel/material usage, and default employment and per capita data. DEP obtained emission factors from EPA guidance documents. Several source categories were estimated based on surrogate state employment and population data. DEP applied a rule effectiveness formula to those categories which are subject to state regulatory controls e.g., gasoline station stage I tank truck unloading. In order to avoid double counting, DEP subtracted the point source employment or emissions from those categories (e.g., degreasing, dry-cleaning) which overlapped with the point source inventory. Area source emissions were apportioned to counties based on available fuel/material used, employment, state registration, and population data.

The On-Road Mobile Source category (Section 4) represents emissions from roadway and highway vehicles, such as cars, trucks, and buses. The Massachusetts Highway Department (MHD) and Central Transportation Planning Staff (CTPS) developed the activity factor, which is daily vehicle miles traveled (DVMT). CTPS developed the emission factors by speed from EPA's latest MOBILE5ah emissions model. MOBILE5ah requires a wide range of state input parameters such as Inspection/Maintenance (I/M) data, temperature, vehicle mix, age distribution, and mileage accumulation rates. I/M inputs include start year, anti-tampering rates, and emission failure rates. MOBILE5ah calculated emission factors for the eight vehicle types for speeds up to 65 mph. MOBILE5ah emissions were calculated for a typical summer day with temperatures based on the ten days with the highest ozone levels, over the last three years. EPA recommended that DEP use the same typical summer day temperatures in the 1990 Base Year Inventory for the 1996 inventory. DEP multiplied the DVMT by the MOBILE5ah emission factors according to roadway type and speeds in order to calculate on-road mobile emissions by county.

The Off-Road Mobile Source category (Section 5) includes emission estimates from various types of engines used by aircraft, locomotives, lawn and garden equipment, and other numerous off-road mobile operations. The basic activity factor is the number of various engines and type of fuel multiplied by appropriate emission factors. DEP used the February 1999 draft version of the EPA/Office of Mobile Sources NONROAD computer model to generate Off-Road emissions.

The EPA Biogenic Source category (Section 6) was estimated by EPA's Biogenic Estimation Inventory System (BEIS-2). EPA recommended using the 1990 BEIS-2 estimates for the 1996 Inventory. The model incorporated default land use, crop acreage, and forest type by county, and assigned emission rates to different land use types. It estimated emissions based on calculations using crop acreage and leaf biomass for the summer growing season, and utilized meteorological data inputs, including temperature and insolation for a typical summer day.

1.7 EMISSION TRENDS

Table 1.1 and Figures 1.2 to 1.5 present the statewide VOC, NOx and CO emissions by source categories. Table 1.2 presents the emissions by ozone non-attainment area.

The anthropogenic VOC emissions decreased by 13% from 1990 to 1996. The area, on-road and off-road categories each accounted for approximately one-third of the 1996 emissions. When biogenic emissions (42%) are included in the VOC emissions, the area, on-road and off-road categories each accounted for about one-fifth of the emissions, as shown in Table 1.2 and Figure 1.3.

NOx emissions increased slightly (5%) from 1990 to 1996. This increase is attributable to the increase in on-road mobile source emissions because controls had been targeted towards VOC reductions. Mobile source NOx controls were put in place recently and reductions should occur with vehicle fleet turnover. On-road mobile emissions accounted for approximately half of the 1996 NOx emissions followed by off-road (29%), and stationary point (17%), as shown in Figure 1.4.

CO emissions showed a slight decrease (5%) from 1990 to 1996. On-road and off-road mobile sources together account for 98% of the CO emissions, as shown in Figure 1.5.

TABLE 1.1

SUMMARY 1990 & 1996 MASSACHUSETTS PERIODIC EMISSION INVENTORIES VOLATILE ORGANIC COMPOUNDS, NITROGEN OXIDES AND CARBON MONOXIDE Tons per Summer Day (TPSD)

VOLATILE ORGANIC COMPOUNDS (VOC)

	ANTHROPOGENIC			WITH BIOGENICS		
	TPSD 1990	TPSD 1996	PERCENT 1996	1990	TPSD 1996	PERCENT 1996
1 STATIONARY POINT *	64	43	5%	64	43	3%
2 STATIONARY AREA	366	289	34%	366	289	19%
3 ON-ROAD MOBILE **	349	252	30%	349	252	17%
4 OFF-ROAD MOBILE	207	270	32%	207	270	18%
5 BIOGENICS				651	651	43%
TOTAL	986	853	100%	1,637	1,504	100%

NITROGEN OXIDES (NOx)

	TPSD 1990	TPSD 1996	PERCENT 1996
1 STATIONARY POINT *	318	171	17%
2 STATIONARY AREA	33	34	3%
3 ON-ROAD MOBILE **	407	495	50%
4 OFF-ROAD MOBILE	176	283	29%
TOTAL	934	983	100%

CARBON MONOXIDE (CO)

	TPSD 1990	TPSD 1996	PERCENT 1996
1 STATIONARY POINT	40	40	1%
2 STATIONARY AREA	53	23	1%
3 ON-ROAD MOBILE **	2,548	1,735	46%
4 OFF-ROAD MOBILE	1,355	1,992	53%
TOTAL	3,997	3,789	100%

* Emission reduction credits included in Point Source emissions (0.7 TPSD VOC and 15.2 TPSD NOx) -Table 1.19

** Used EPA's MOBILE5ah emissions model

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FIGURE 1.2

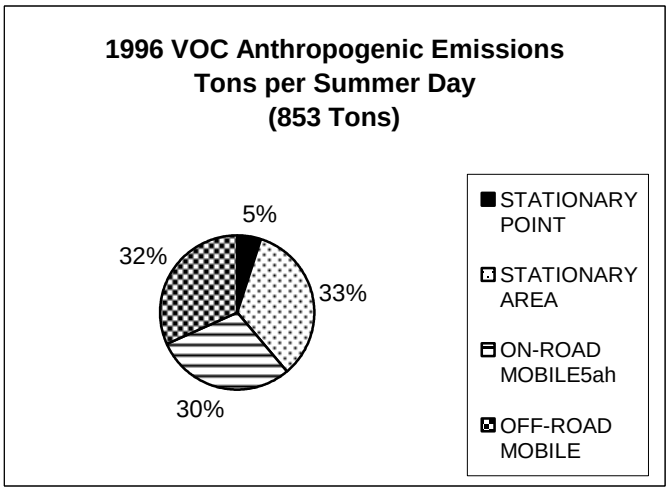


FIGURE 1.3

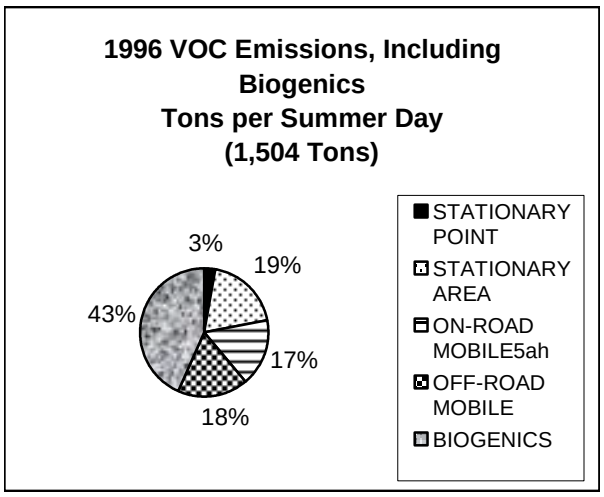


FIGURE 1.4

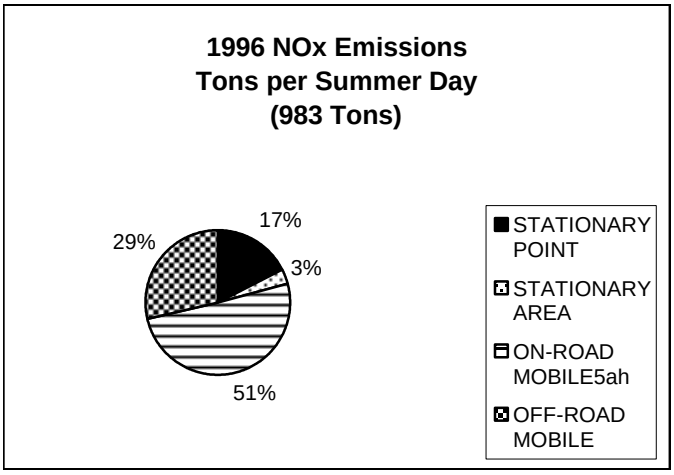
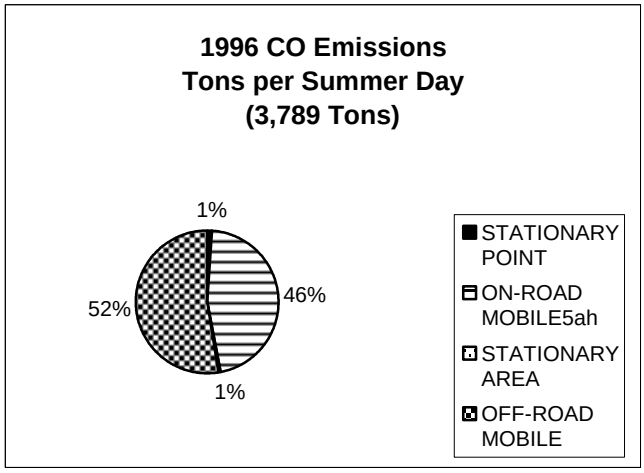


FIGURE 1.5



TONS PER SUMMER DAY

CATEGORY	VOC	NOX	CO
STATIONARY POINT*	43	171	40
STATIONARY AREA	289	34	23
ON-ROAD MOBILE	252	495	1,735
OFF-ROAD MOBILE	270	283	1,992
TOTAL ANTHROPOGENIC	853	983	3,789
BIOGENICS	651		
TOTAL EMISSIONS	1,504		

*Point Source includes emission reduction credits

TABLE 1.2
1996 MASSACHUSETTS PERIODIC EMISSION INVENTORIES VOC, NOx AND CO
IN TONS PER SUMMER DAY (TPSD)
FOR BOSTON AND SPRINGFIELD OZONE NON-ATTAINMENT AREAS

	BOSTON NON-ATTAINMENT AREA -TPSD	PER CENT	SPRINGFIELD NON-ATTAIN-MENT AREA TPSD	PERCENT	STATE TOTAL	STATE PER CENT
ANTHROPOGENIC VOC						
1 STATIONARY POINT *	34	5%	9	7%	43	5%
2 STATIONARY AREA	248	34%	40	35%	289	34%
3 ON-ROAD MOBILE **	211	29%	41	36%	252	30%
4 OFF-ROAD MOBILE	245	33%	25	22%	269	32%
TOTAL ANTHROPOGENIC	738	100%	115	100%	853	100%
VOC WITH BIOGENICS						
5 BIOGENICS	374	34%	277	71%	651	43%
TOTAL VOC	1,112	100%	392	100%	1,504	100%
NITROGEN OXIDES (NOx)						
1 STATIONARY POINT *	158	18%	13	10%	171	17%
2 STATIONARY AREA	30	3%	5	4%	34	3%
3 ON-ROAD MOBILE **	416	48%	79	65%	495	50%
4 OFF-ROAD MOBILE	257	30%	26	21%	283	29%
TOTAL	861	100%	122	100%	983	100%
CARBON MONOXIDE (CO)						
1 STATIONARY POINT	33	1%	7	1%	40	1%
2 STATIONARY AREA	19	1%	4	1%	23	1%
3 ON-ROAD MOBILE **	1,453	44%	281	56%	1,735	46%
4 OFF-ROAD MOBILE	1,780	54%	212	42%	1,992	53%
TOTAL	3,285	100%	504	100%	3,789	100%

* Emission reduction credits included in Point Source emissions - see Table 1.19.

** Used EPA's MOBILE5ah emissions model

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TABLE 1.3
1996 VOC, NOx AND CO EMISSIONS BY COUNTY
IN TONS PER SUMMER DAY (TPSD)

COUNTIES	ANTHROPO-GENIC VOC TPSD	BIOGENIC VOC TPSD	NOX TPSD	CO TPSD
BARNSTABLE	58	93	45	266
BERKSHIRE	23	119	26	106
BRISTOL	67	102	119	290
DUKES	12	22	3	43
ESSEX	95	126	114	420
FRANKLIN	13	87	17	54
HAMPDEN	57	116	59	249
HAMPSHIRE	22	71	20	95
MIDDLESEX	179	228	193	842
NANTUCKET	9	12	8	38
NORFOLK	88	112	91	415
PLYMOUTH	64	117	55	307
SUFFOLK	72	73	126	283
WORCESTER	96	227	108	381
TOTAL MA	**853**	**1,504**	**983**	**3,789**

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TABLE 1.4
ALL SOURCE CATEGORIES 1996 VOC EMISSIONS IN TONS PER SUMMER DAY BY COUNTY

	COUNTY	POINT TPSD	AREA TPSD	ON-ROAD TPSD	TOTAL OFF-ROAD TPSD	BIOGENIC TPSD	ANTHROPO--GENIC VOC TPSD	WITH BIOGENIC TPSD
1	BARNSTABLE	0	8	12	38	36	58	93
2	BERKSHIRE	1	7	9	6	96	23	119
3	BRISTOL	6	24	21	16	35	67	102
4	DUKES	0	1	0	11	9	12	22
5	ESSEX	6	32	28	28	31	95	126
6	FRANKLIN	1	4	6	2	74	13	87
7	HAMPDEN	4	23	18	12	59	57	116
8	HAMPSHIRE	2	7	8	5	49	22	71
9	MIDDLESEX	8	68	55	48	49	179	228
10	NANTUCKET	0	0	0	8	3	9	12
11	NORFOLK	3	32	31	21	25	88	112
12	PLYMOUTH	1	19	17	26	53	64	117
13	SUFFOLK	2	28	14	28	2	72	73
14	WORCESTER	7	37	32	20	132	96	227
	TOTAL MA	43	289	252	269	651	853	1,504

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TABLE 1.5

ALL SOURCE CATEGORIES 1996 NOx EMISSIONS IN TONS PER SUMMER DAY BY COUNTY

	COUNTY	POINT TPSD	ST.AREA TPSD	ON-ROAD TPSD	OFF-ROAD TPSD	TOTAL NOX TPSD
1	BARNSTABLE	9	1	21	13	44
2	BERKSHIRE	2	1	17	6	26
3	BRISTOL	60	3	40	16	119
4	DUKES	0	0	1	2	3
5	ESSEX	31	4	56	24	114
6	FRANLIN	1	0	12	3	16
7	HAMPDEN	9	3	36	12	59
8	HAMPSHIRE	1	1	14	4	20
9	MIDDLESEX	19	8	111	54	192
10	NANTUCKET	5	0	0	3	8
11	NORFOLK	5	4	62	21	91
12	PLYMOUTH	4	3	35	14	55
13	SUFFOLK	17	4	25	81	126
14	WORCESTER	10	4	65	29	108
	TOTAL MA	171	34	495	283	983

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TABLE 1.6

ALL SOURCE CATEGORIES 1996 CO EMISSIONS IN TONS PER SUMMER DAY BY COUNTY

	COUNTY	STATIONARY POINT TPSD	STATIONARY AREA TPSD	MOBILE5ah ON-ROAD TPSD	OFF-ROAD MOBILE TPSD	TOTAL CO TPSD
1	BARNSTABLE	1	1	76	188	266
2	BERKSHIRE	1	1	60	45	106
3	BRISTOL	8	2	141	139	290
4	DUKES	0	0	3	40	43
5	ESSEX	3	3	201	213	420
6	FRANKLIN	0	0	38	15	54
7	HAMPDEN	6	2	128	114	249
8	HAMPSHIRE	1	1	55	38	95
9	MIDDLESEX	2	5	386	449	842
10	NANTUCKET	1	0	1	35	38
11	NORFOLK	0	2	223	190	415
12	PLYMOUTH	15	2	122	169	307
13	SUFFOLK	2	3	94	184	283
14	WORCESTER	1	3	206	172	381
	TOTAL MA	40	23	1,735	1,991	3,789

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TABLE 1.7 1996 STATIONARY POINT SOURCE VOC, NOx AND CO EMISSIONS BY COUNTY

COUNTIES	VOC TPY	VOC ERC TPY	VOC TOTAL TPY	VOC TPSD	VOC ERC TPSD	VOC TOTAL TPSD	NOX TPY	NOX ERC TPY	NOX TOTAL TPY	NOX TPSD	NOX ERC TPSD	NOX TOTAL TPSD	CO TPY	CO TPSD
BARNSTABL	91		91	0		0	3,227		3,227	9		9	516	1
BERKSHIRE	230		230	1		1	771		771	2		2	250	1
BRISTOL	1,637		1,637	6		6	17,695	1,698	19,393	49	11	60	2,816	8
DUKES	10		10	-		-	23		23	0		0	-	-
ESSEX	1,742	4	1,746	6		6	9,925	508	10,433	27	3	31	1,091	3
FRANKLIN	101		101	1		1	398		398	1		1	20	0
HAMPDEN	863		863	4		4	3,915		3,915	9		9	2,224	6
HAMPSHIRE	571		571	2		2	396		396	1		1	207	1
MIDDLESEX	2,442	110	2,552	8	0.7	9	6,634		6,634	19		19	1,372	2
NANTUCKE	46		46	0		0	1,332	120	1,452	4	1	5	378	1
NORFOLK	975		975	3		3	1,603		1,603	4		4	371	0
PLYMOUTH	364		364	1		1	1,409		1,409	4		4	1,044	15
SUFFOLK	509		509	2		2	5,988		5,988	16		16	838	2
WORCESTE	1,999		1,999	7		7	3,567	2	3,569	10		10	772	1
STATE	**11,580**	**114**	**11,694**	**43**	**0.7**	**43**	**56,883**	**2,328**	**59,211**	**156**	**15**	**171**	**11,899**	**40**

TABLE 1.8
1996 STATIONARY AREA SOURCE VOC EMISSIONS BY COUNTY IN TONS PER YEAR (TPY) AND SUMMER DAY (TPSD)

	COUNTIES	WASTE MGT TPY	WASTE MGT TPSD	GASOL DISTR TPY	GASOL DISTR TPSD	SOLVENT EVAP TPY	SOLVENT EVAP TPSD	FUEL COM & FIRES TPY	FUEL COM & FIRES TPSD	STATIONARY AREA EMIS VOC TPY	STATIONARY AREA EMIS VOC TPSD
1	BARNSTABLE	127	0	173	1	2,000	7	613	0	2,913	8
2	BERKSHIRE	359	1	103	0	1,533	5	423	0	2,418	7
3	BRISTOL	654	2	380	1	5,931	20	1,483	1	8,449	24
4	DUKES	10	0	15	0	139	0	57	0	221	1
5	ESSEX	683	2	489	2	8,046	27	1,982	1	11,200	32
6	FRANKLIN	142	0	55	0	894	3	223	0	1,314	4
7	HAMPDEN	554	2	323	1	5,638	19	1,330	1	7,845	23
8	HAMPSHIRE	250	1	103	0	1,565	5	465	0	2,382	7
9	MIDDLESEX	741	2	1,027	3	17,987	61	3,978	2	23,733	68
10	NANTUCKET	8	0	14	0	75	0	36	0	133	0
11	NORFOLK	509	1	495	2	8,368	28	1,808	1	11,180	32
12	PLYMOUTH	444	1	341	1	4,731	16	1,323	1	6,838	19
13	SUFFOLK	278	1	1,099	3	6,748	22	1,849	1	9,974	28
14	WORCESTER	703	2	535	2	9,274	32	2,050	1	12,561	37
	TOTAL MA	5,460	17	5,151	16	72,929	246	17,620	9	101,159	289

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TABLE 1.9
1996 STATIONARY AREA SOURCE NOx EMISSIONS IN TONS PER YEAR (TPY)
AND SUMMER DAY (TPSD)

COUNTIES	FUEL COMB TPY	FUEL COMB TPSD	FOREST FIRE TPY	FOREST FIRE TPSD	STRUCTURAL FIRES TPY	STRUCTURAL FIRES TPSD	**TOTAL NOx TPY**	**TOTAL NOx TPSD**
BARNSTABLE	906	1	2	0	2	0	910	1
BERKSHIRE	605	1	3	0	2	0	609	1
BRISTOL	2,306	3	3	0	4	0	2,313	3
DUKES	60	0	1	0	0	0	61	0
ESSEX	3,081	4	4	0	5	0	3,091	4
FRANKLIN	320	0	2	0	1	0	322	0
HAMPDEN	1,984	3	5	0	6	0	1,995	3
HAMPSHIRE	671	1	4	0	1	0	676	1
MIDDLESEX	6,338	8	2	0	9	0	6,349	8
NANTUCKET	33	-	1	0	0	0	34	0
NORFOLK	2,860	4	2	0	3	0	2,865	4
PLYMOUTH	2,050	3	2	0	4	0	2,056	3
SUFFOLK	2,894	4	-	-	13	0	2,907	4
WORCESTER	3,228	4	1	0	7	0	3,237	4
TOTAL MA	27,335	34	33	0	55	0	27,423	34

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TABLE 1.10 TOTAL CO EMISSIONS 1996 BY COUNTY FUEL COMBUSTION AND FIRES

COUNTIES	FUEL COMB TPY	FUEL COMB TPSD	FOREST FIRES TPY	FOREST FIRES TPSD	STRUCTURAL FIRES TPY	STRUCT FIRES TPSD	**TOTAL CO TPY**	**TOTAL CO TPSD**
BARNSTABLE	3,873	1	157	0	79	0	4,109	1
BERKSHIRE	2,585	0	214	0	75	0	2,874	1
BRISTOL	9,854	1	243	0	177	0	10,274	2
DUKES	254	-	108	0	4	0	367	0
ESSEX	13,169	2	319	0	218	1	13,707	2
FRANKLIN	1,366	0	123	0	29	0	1,517	0
HAMPDEN	8,479	1	401	0	241	1	9,121	2
HAMPSHIRE	2,869	0	272	0	40	0	3,181	1
MIDDLESEX	27,087	4	168	0	383	1	27,637	5
NANTUCKET	139	-	91	0	3	0	233	0
NORFOLK	12,222	2	168	0	130	0	12,520	2
PLYMOUTH	8,760	1	178	0	163	0	9,101	2
SUFFOLK	12,370	2	-	-	537	1	12,907	3
WORCESTER	13,798	2	113	0	289	1	14,200	3
STATE	116,825	15	2,556	2	2,369	6	121,749	23

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TABLE 1.11

1996 ON-ROAD MOBILE SOURCE EMISSIONS TPSD VOC, NOx AND CO
TONS PER SUMMER DAY

	COUNTIES	VOC TPSD	NOx TPSD	CO SUMMER TPSD
1	BARNSTABLE	12	21	76
2	BERKSHIRE	9	17	60
3	BRISTOL	21	40	141
4	DUKES	0	1	3
5	ESSEX	28	56	201
6	FRANKLIN	6	12	38
7	HAMPDEN	18	36	128
8	HAMPSHIRE	8	14	55
9	MIDDLESEX	55	111	386
10	NANTUCKET	0	0	1
11	NORFOLK	31	62	223
12	PLYMOUTH	17	35	122
13	SUFFOLK	14	25	94
14	WORCESTER	32	65	206
STATE		252	495	1,735

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THREE TABLES INCLUDED: 1.12, 1.13 & 1.14

TABLE 1.12 1996 OFF-ROAD MOBILE VOC EMISSIONS BY COUNTY
IN TONS PER YEAR (TPY) AND TONS PER SUMMER DAY (TPSD)

	AIRCRAFT TPY	AIRCRAFT TPSD	RAIL TPY	RAIL TPSD	VESSELS TPY	VESSELS TPSD	NONROAD TPSD	**OFF-ROAD TOTAL TPSD**
BARNSTABLE	87	0	11	0	47	0	37	**38**
BERKSHIRE	15	0	25	0	-	-	6	**6**
BRISTOL	12	0	20	0	37	0	16	**16**
DUKES	8	0	-	-	13	0	11	**11**
ESSEX	29	0	27	0	28	0	28	**28**
FRANKLIN	4	0	24	0	-	-	2	**2**
HAMPDEN	40	0	26	0	-	-	12	**12**
HAMPSHIRE	2	0	12	0	-	-	5	**5**
MIDDLESEX	146	0	34	0	-	-	47	**48**
NANTUCKET	38	0	-	-	14	0	8	**8**
NORFOLK	2	0	25	0	31	0	21	**21**
PLYMOUTH	14	0	17	0	3	0	26	**26**
SUFFOLK	1,068	3	14	0	150	0	25	**28**
WORCESTER	30	0	53	0	-	-	19	**20**
TOTAL MA	1,493	4	287	1	322	1	264	**269**

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TABLE 1.13 1996 OFF-ROAD MOBILE NOx EMISSIONS BY COUNTY
IN TONS PER YEAR (TPY) AND TONS PER SUMMER DAY (TPSD)

	AIRCRAFT TPY	AIRCRAFT TPSD	RAIL TPY	RAIL TPSD	VESSELS TPY	VESSELS TPSD	NONROAD TPSD	**OFF-ROAD TOTAL TPSD**
BARNSTABLE	35	0	222	1	417	1	12	**13.44**
BERKSHIRE	1	0	494	1	-	-	4	**5.77**
BRISTOL	2	0	390	1	239	1	15	**16.33**
DUKES	3	0	-	-	122	0	2	**2.11**
ESSEX	4	0	543	1	97	0	22	**24.14**
FRANKLIN	1	0	479	1	-	-	2	**3.21**
HAMPDEN	16	0	528	1	-	-	11	**12.08**
HAMPSHIRE	0	0	242	1	-	-	4	**4.45**
MIDDLESEX	5	0	681	2	-	-	52	**54.00**
NANTUCKET	5	0	-	-	122	0	2	**2.53**
NORFOLK	1	0	494	1	95	0	19	**20.57**
PLYMOUTH	2	0	341	1	20	0	13	**13.74**
SUFFOLK	2,330	6	272	1	668	2	72	**81.28**
WORCESTER	7	0	1,057	3	-	-	26	**28.98**
TOTAL MA	2,411	7	5,743	16	1,780	5	255	**282.65**

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TABLE 1.14 1996 OFF-ROAD MOBILE CO EMISSIONS BY COUNTY
IN TONS PER YEAR (TPY) AND TONS PER SUMMER DAY (TPSD)

	AIRCRAFT TPY	AIRCRAFT TPSD	RAIL TPY	RAIL TPSD	VESSELS TPY	VESSELS TPSD	NON-ROAD TPSD	**OFF-ROAD TOTAL TPSD**
BARNSTABLE	2,821	8	30	0	148	0	180	**188**
BERKSHIRE	241	1	66	0	-	-	44	**45**
BRISTOL	499	1	52	0	321	1	137	**139**
DUKES	415	1	-	-	54	0	39	**40**
ESSEX	1,333	4	72	0	145	0	209	**213**
FRANKLIN	143	0	64	0	-	-	15	**15**
HAMPDEN	356	1	70	0	-	-	113	**114**
HAMPSHIRE	72	0	32	0	-	-	38	**38**
MIDDLESEX	1,037	3	91	0	-	-	446	**449**
NANTUCKET	2,084	6	-	-	52	0	29	**35**
NORFOLK	86	0	66	0	45	0	190	**190**
PLYMOUTH	555	2	45	0	15	0	167	**169**
SUFFOLK	1,641	4	36	0	214	1	179	**184**
WORCESTER	1,108	3	141	0	-	-	168	**172**
TOTAL MA	12,389	34	765	2	993	3	1,953	**1,991**

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TABLE 1.15

1996 BIOGENIC VOC EMISSIONS BY COUNTY IN TONS PER SUMMER DAY (TPSD)

	COUNTIES	TONS PER SUMMER DAY
1	BARNSTABLE	36
2	BERKSHIRE	96
3	BRISTOL	35
4	DUKES	9
5	ESSEX	31
6	FRANKLIN	74
7	HAMPDEN	59
8	HAMPSHIRE	49
9	MIDDLESEX	49
10	NANTUCKET	3
11	NORFOLK	25
12	PLYMOUTH	53
13	SUFFOLK	2
14	WORCESTER	132
	TOTAL MA	651

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TABLE 1.16 ALL SOURCE CATEGORIES 1996 VOC EMISSIONS IN TONS PER YEAR (TPY) AND TONS PER SUMMER DAY (TPSD) BY COUNTY AND NON-ATTAINMENT AREA

COUNTY	POINT TPY	POINT TPSD	ST.AREA TPY	ST.AREA TPSD	ON-ROAD TPSD	OFF-ROAD TPSD	BIOGENIC TPSD	TOTAL ANTHROPOGENIC VOC TPSD	TOTAL VOC WITH BIOGENIC TPSD
1 BARNSTABLE	91	0	2,913	8	12	38	36	58	93
3 BRISTOL	1,637	6	8,449	24	21	16	35	67	102
4 DUKES	10	0	221	1	0	11	9	12	22
5 ESSEX	1,742	6	11,200	32	28	28	31	95	126
9 MIDDLESEX	2,442	8	23,733	68	55	48	49	179	228
10 NANTUCKET	46	0	133	0	0	8	3	9	12
11 NORFOLK	975	3	11,180	32	31	21	25	88	112
12 PLYMOUTH	364	2	6,838	19	17	26	53	64	117
13 SUFFOLK	509	2	9,974	28	14	28	2	72	73
14 WORCESTER	1,999	7	12,561	37	32	20	132	96	227
BOSTON NON ATTAINMENT AREA	9,815	34	87,201	248	211	245	374	738	1,112
2 BERKSHIRE	230	1	2,418	7	9	6	96	23	119
6 FRANKLIN	101	1	1,314	4	6	2	74	13	87
7 HAMPDEN	863	4	7,845	23	18	12	59	57	116
8 HAMPSHIRE	571	2	2,382	7	8	5	49	22	71
SPRINGFIELD NON ATTAINMENT AREA	1,765	9	13,959	40	41	25	277	115	392
TOTAL MA	11,580	43	101,160	289	252	269	651	853	1,504

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TABLE 1.17 ALL SOURCE CATEGORIES 1996 NOx EMISSIONS IN TONS PER YEAR (TPY) AND TONS PER SUMMER DAY (TPSD) BY COUNTY AND NON-ATTAINMENT AREA

	COUNTY	POINT TPY	POINT TPSD	ST. AREA TPY	ST. AREA TPSD	ON-ROAD TPSD	OFF-ROAD TPSD	TOTAL NOX TPSD
1	BARNSTABLE	3,227	9	910	1	21	13	44
3	BRISTOL	19,393	60	2,313	3	40	16	119
4	DUKES	23	0	61	0	1	2	3
5	ESSEX	10,433	31	3,091	4	56	24	114
9	MIDDLESEX	6,634	19	6,349	8	111	54	192
10	NANTUCKET	1,452	5	34	0	0	3	8
11	NORFOLK	1,603	4	2,865	4	62	21	91
12	PLYMOUTH	1,409	4	2,056	3	35	14	55
13	SUFFOLK	5,988	16	2,907	4	25	81	126
14	WORCESTER	3,567	10	3,237	4	65	29	108
	BOSTON NON-ATTAINMENT AREA	53,729	159	23,823	30	416	257	861
2	BERKSHIRE	771	2	609	1	17	6	26
6	FRANKLIN	398	1	322	0	12	3	17
7	HAMPDEN	3,915	9	1,995	3	36	12	59
8	HAMPSHIRE	396	1	676	1	14	4	20
	SPRINGFIELD NON ATTAINMENT AREA	5,480	13	3,602	5	79	26	122
	TOTAL MA	59,209	171	27,425	34	495	283	983

TABLE 1.18 ALL SOURCE CATEGORIES 1996 CO EMISSIONS IN TONS PER YEAR (TPY) AND TONS PER SUMMER DAY (TPSD) BY COUNTY AND NON-ATTAINMENT AREAS

	COUNTY	ST. POINT TPY	ST. POINT TPSD	ST. AREA TPY	ST. AREA TPSD	ON-ROAD MOBILE TPSD	OFF-ROAD MOBILE TPSD	TOTAL CO TPSD
1	BARNSTABLE	516	1	4,109	1	76	188	266
3	BRISTOL	2,816	8	10,274	2	141	139	290
4	DUKES	-	-	367	0	3	40	43
5	ESSEX	1,091	3	13,707	3	201	213	420
9	MIDDLESEX	1,372	2	27,637	5	386	449	842
10	NANTUCKET	378	1	233	0	1	35	38
11	NORFOLK	371	0	12,520	2	223	190	415
12	PLYMOUTH	1,044	15	9,101	2	122	169	307
13	SUFFOLK	838	2	12,907	3	94	184	283
14	WORCESTER	772	1	14,200	3	206	172	381
	BOSTON NON-ATTAINMENT AREA	9,198	33	105,055	19	1,453	1,780	3,285
2	BERKSHIRE	250	1	2,874	1	60	45	106
6	FRANKLIN	20	0	1,517	0	38	15	54
7	HAMPDEN	2,224	6	9,121	2	128	114	249
8	HAMPSHIRE	207	1	3,181	1	55	38	95
	SPRINGFIELD NON-ATTAINMENT AREA	2,701	7	16,693	4	281	212	504
	TOTAL MA	11,899	40	121,748	23	1,735	1,991	3,789

TABLE 1.19

EMISSION REDUCTION CREDITS FROM POINT SOURCES 1996
TONS PER OZONE SEASON

	FACILITY	ID #	COUNTY	USE CATEGORY	NOX TPY	NOX TPSD	VOC TPY	VOC TPSD	DATE APPROVED
1	Eastern Utilities Montaup	NA	Bristol	RACT	65.0	0.4	-		12/20/1996
2	Nantucket Electric	NA	Nantucket	RACT	120.0	0.8	-		04/30/1996
3	Applied Graphics	NA	Essex	RACT	-	-	4.0		09/03/1996
4	Avery Dennison	91098	Middlesex	Shutdown	-	-	47.0	0.3	10/12/1996
5	PG&E Gen Brayton	101953	Bristol	Overcontrol	606.0	4.0	-		11/04/1996
6	Sithe N.England Mystic	116434	Essex	Overcontrol	183.0	1.2	-		08/02/1996
7	BASF	90325	Middlesex	Shutdown	-	-	63.0	0.4	05/08/1996
8	PG&E Gen Brayton	101943	Bristol	Early	296.0	1.9	-		12/08/1996
9	DCPO	41472	Worcester	Shutdown	2.0	-	-		05/30/1995
10	Sithe N.England	93903	Essex	Overcontrol	325.0	2.1	-		09/18/1995
11	PG&E Gen Brayton	83238	Bristol	Early	398.0	2.6	-		06/06/1996
12	Somerset St	81882	Bristol	Curtailment	333.0	2.2	-		05/30/1995
					2,328.0		114.0		
				/153 days = TPSD	15.2	15.2	0.7	0.7	

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REFERENCES FOR EXECUTIVE SUMMARY

1. "Procedures for the Preparation of Emission Inventories for Carbon Monoxide and Precursors of Ozone, Volume 1: General Guidance for Stationary Sources", known as the"Procedures Document" or "Volume 1"(EPA 450/4-91-016), May 1991.

2. "Procedures for Emission Inventory Preparation, Volume IV: Mobile Sources," (EPA450/4-91-026), together with the revised "Interim Guidance", February 1992.

3. Emission Inventory Requirements for Ozone State Implementation Plans" (EPA-4504-91-010) known as the "Ozone Requirements Document", February 1992.

4. "Emission Inventory Requirements for Carbon Monoxide State Implementation Plans" (EPA-450/4-91-011), known as the "CO Requirements Document", March 1991.

5. "Emission Inventory Improvement Program" (EIIP). Guidance for Emission Inventory Development, Volumes 1 to 7. EPA 454/R-97-004A OAQPS MD-14, STAPPA/ALAPCO/EPA, July 1997.

6. " AP-42 Compilation of Air Pollution Emission Factors, Volume 1." Stationary Point and Area Sources, 4th Edition, EPA OAQPS RTP NC. Supplement D September 1991. AP-42 5th Edition, January 1995, Supplement A, February 1996.

7. "Procedures for Estimating and Applying Rule Effectiveness in Post –1987 Base Year Emission Inventories for Ozone and Carbon Monoxide State Implementation Plans." EPA OAQPS Policy Development Section. RTP N.C. June, 1989.

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