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Air and Radiation

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# Technical Support Document for the Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Control Requirements:

# Air Quality Modeling Analyses

Printed on Recycled Paper

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# I. Introduction

This document describes the procedures and results of the air quality modeling analyses used to support the Heavy Duty Engine and Vehicle Standards and Highway Diesel Fuel (HDE) final rulemaking. The air quality modeling was conducted to support several components of the rulemaking including:

(a) an assessment of the need for the HDE program,
(b) an assessment of the costs and benefits associated with the rulemaking, and
(c) an assessment of the expected impact of the program on ozone and PM levels.

The air quality model applications include episodic regional scale ozone modeling for the eastern and western U.S. and annual particulate matter (PM) modeling on a continental scale covering the 48 contiguous States. For both ozone and PM, 1996 base year simulations were made to examine the ability of the modeling systems to replicate observed concentrations of these pollutants.[1] This was followed by simulations for several future-year "base case" scenarios (i.e., 2007, 2020, and 2030)[2]. The results of the future base case model runs were used to support the need for the HDE emissions reductions to help mitigate unhealthy concentrations of ozone and PM. In this regard, the predictions from these model runs were used to determine the extent of future 1-hour ozone exceedances (i.e., 1-hour daily maximum ozone concentrations >=125 ppb) and the magnitude of "exposures"[3] to unhealthy concentrations of ozone and PM2.5 (i.e., particulates with a diameter <= 2.5 ug/m$^3$). For 2020 and 2030 additional simulations were made to examine the impacts of the HDE controls on air quality in these years. In addition, the outputs of the 2030 base and control case model runs were used to calculate portions of the monetized benefits of the rule as part of the cost-benefits analysis.

The air quality model simulations, associated input and output data sets, and model performance statistics used to support the above analyses are described in this document. The procedures for calculating the monetized benefits of the rule are described in Chapter VII of the Regulatory Impact Assessment (RIA) document (EPA, 2000a). Also, in Chapter II of the RIA are discussions of (1) how the projected future-year exposures to ozone and PM2.5 were calculated along with the results of these analyses and (2) the impacts of the rule on future 1-hour ozone exceedances.

The remainder of this report includes a description of the overall magnitude of emissions

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[1] As described in Section III , base year ozone predictions from the western model simulations seriously underestimated observed concentrations to the extent that the results were not used for the HDE rulemaking.

[2] PM modeling was performed for the 2020 and 2030 scenarios and ozone modeling was performed for all three scenarios. The rationale for selecting these time periods is described in the preamble for this rule.

[3] For this analysis the term exposure is used to describe the number of people living in areas with concentrations above various cut-points.

for each of the scenarios modeled, the ozone and PM modeling systems, the time periods modeled, the base year model performance evaluations, and procedures for generating the results of the modeling for subsequent use in various HDE analyses. All of the air quality modeling input and output data sets can be obtained from the following ftp site: *ftp.epa.gov/modelingcenter/Heavy_Duty_Diesel*

# II. Emissions Inventory Estimates

In order to complete the requisite ozone and PM modeling, it was necessary to first develop a national mass emissions inventory. This mass emissions inventory was then used as the basis for developing component input files for the modeling. The development and details of these inventories for each of the scenarios (i.e., 1996 base, 2007 base, 2020 base, 2020 control, 2030 base, and 2030 control) are more fully described elsewhere (EPA, 2000b, 2000c).

The mass inventories are prepared at the county-level for on-highway mobile, electric generating unit (EGU), non-EGU point, stationary area, and nonroad sources. The inventories contain annual and typical summer season day (SSD) emissions for the following pollutants: oxides of nitrogen ($NO_x$), volatile organic compounds (VOC), carbon monoxide (CO), oxides of sulfur ($SO_x$), primary particulate matter with an aerodynamic diameter less than or equal to 10 micrometers and 2.5 micrometers ($PM_{10}$ and $PM_{2.5}$), ammonia ($NH_3$), and secondary organic aerosols (SOA). The 2007, 2020, and 2030 Base Case inventories are prepared by applying growth and control assumptions to the 1996 Base Year inventory. The 2007, 2020, and 2030 Control Case inventories are developed from the 2007, 2020, and 2030 Base Case inventories, respectively, by applying HDE control and fuel measures to the on-highway vehicle and nonroad emission source sectors. Section II.A. and II.B. below provide summaries of the emissions for a summer season day and on an annual basis, respectively. The summer day emissions are provided to give a general sense of the magnitude of emissions used in the ozone modeling. Similarly, the annual emissions give a general sense of what was used for modeling concentrations of primary and secondary PM. The procedures for developing the model-ready emissions inputs are described in Section III for ozone modeling and Section IV for PM modeling.

## A. Ozone Precursor Emissions (Summer Season Day)

Table II-1 displays the typical summer season day 1996 base year emissions for those States within the Eastern U.S. ozone modeling domain (see Section III). Emissions are provided for volatile organic compounds (VOC), nitrogen oxides (NOx), and carbon monoxide (CO) which are the anthropogenic precursor emissions for ozone.

Table II-2 shows the total summer day emissions for all States in the East combined along with the percent change between various emissions scenarios.

**Table II-1.** Summer season daily State-level emissions (tons) for the 1996 Base.

| State | VOC | $NO_x$ | CO | State | VOC | $NO_x$ | CO |
|---|---:|---:|---:|---|---:|---:|---:|
| Alabama | 1,254 | 1,971 | 5,866 | Nebraska[1] | 612 | 875 | 2,750 |
| Arkansas | 709 | 935 | 3,092 | New Hampshire | 240 | 267 | 1,011 |
| Connecticut | 476 | 603 | 2,335 | New Jersey | 1,330 | 1,333 | 4,785 |
| Delaware | 167 | 243 | 663 | New York | 2,385 | 2,054 | 9,589 |
| DC | 61 | 60 | 223 | North Carolina | 2,089 | 2,292 | 8,140 |
| Florida[1] | 2,791 | 3,443 | 16,065 | North Dakota[1] | 350 | 857 | 1,096 |
| Georgia | 1,715 | 2,255 | 9,615 | Ohio | 2,364 | 3,758 | 11,977 |
| Illinois | 2,428 | 3,187 | 8,498 | Oklahoma[1] | 1,149 | 1,495 | 6,510 |
| Indiana | 1,536 | 2,652 | 7,177 | Pennsylvania | 2,068 | 2,924 | 10,112 |
| Iowa | 785 | 1,216 | 2,893 | Rhode Island | 159 | 103 | 635 |
| Kansas[1] | 782 | 1,661 | 3,212 | South Carolina | 996 | 1,230 | 4,412 |
| Kentucky | 998 | 2,276 | 3,857 | South Dakota[1] | 270 | 460 | 1,069 |
| Louisiana | 1,274 | 2,562 | 6,501 | Tennessee | 1,660 | 2,384 | 5,915 |
| Maine[1] | 323 | 273 | 1,379 | Texas[1] | 4,350 | 6,893 | 17,932 |
| Maryland | 601 | 1,078 | 3,641 | Vermont | 139 | 118 | 602 |
| Massachusetts | 901 | 958 | 3,669 | Virginia | 1,459 | 1,865 | 6,560 |
| Michigan[1] | 2,427 | 2,420 | 9,269 | West Virginia | 418 | 1,340 | 1,931 |
| Minnesota[1] | 1,263 | 1,511 | 4,214 | Wisconsin | 1,354 | 1,450 | 4,720 |
| Mississippi | 934 | 1,109 | 3,500 | | | | |
| Missouri | 1,158 | 1,761 | 5,563 | **Total** | 45,975 | 63,872 | 200,978 |

[1] State is partially outside the ozone modeling domain, but the emissions totals are provided for the entire State.

**Table II-2.** Total summer season daily emissions (tons) for the 37 States within the Eastern modeling domain for each of the six modeling scenarios.

| | VOC | NOx | CO |
|---|---:|---:|---:|
| **1996 Base** | 45,975 | 63,872 | 200,978 |
| **2007 Base** | 36,285 | 46,822 | 195,401 |
| **2020 Base** | 37,190 | 39,948 | 230,507 |
| **2020 Control** | 36,801 | 36,086 | 228,481 |
| **2030 Base** | 41,007 | 42,239 | 261,829 |
| **2030 Control** | 40,499 | 36,806 | 259,186 |

| Scenario Diff (%) | VOC | NOx | CO |
|---:|---:|---:|---:|
| From 1996 | -21.1 | -26.7 | -2.8 |
| From 2007 Base | 2.5 | -14.7 | 18.0 |
| From 2020 Base | -1.0 | -9.7 | -0.9 |
| From 2020 Base | 10.2 | 5.7 | 13.6 |
| From 2030 Base | -1.2 | -12.9 | -1.0 |

## B. Particulate Matter and Precursor Emissions (Annual)

Table II-3a shows the national annual emissions of primary PM and precursor species for secondary PM for the 1996 base year, 2030 base case, and 2030 control case scenarios. Table II-

3b shows the percent change in emissions between several of these scenarios.

**Table II-3a.** Total national annual emissions (tons) for the 48 States included in the PM modeling.

| | Organic Carbon | Elemental Carbon | Gaseous Sulfate | Primary Nitrate | Other[1] PM-2.5 | Total PM-2.5 |
|---|---|---|---|---|---|---|
| **1996 Base** | 1,224,857 | 566,051 | 167,392 | 13,386 | 2,210,692 | 4,182,378 |
| **2030 Base** | 1,416,023 | 536,979 | 220,966 | 17,618 | 2,611,202 | 4,802,789 |
| **2030 Control** | 1,394,587 | 465,905 | 220,189 | 17,481 | 2,615,144 | 4,713,306 |

1. Other PM-2.5 contains primarily crustal material.

| | VOC | NOx | CO | SO2 | NH3 | SOA |
|---|---|---|---|---|---|---|
| **1996 Base** | 18,522,037 | 26,117,335 | 98,637,147 | 18,789,382 | 4,762,317 | 202,517 |
| **2030 Base** | 15,676,964 | 18,717,720 | 120,491,650 | 16,436,874 | 5,400,554 | 163,196 |
| **2030 Control** | 15,430,241 | 16,157,296 | 119,211,301 | 16,285,231 | 5,400,554 | 157,884 |

**Table II-3b.** The percent change in total national annual emissions for selected scenarios.

| | Organic Carbon | Elemental Carbon | Gaseous Sulfate | Primary Nitrate | Other PM-2.5 | Total PM-2.5 |
|---|---|---|---|---|---|---|
| **2030 Base vs 1996 Base** | 15.6 % | - 5.1 % | 32.0 % | 31.6 % | 18.1 % | 14.8 % |
| **2030 Control vs 2030 Base** | - 1.5 % | - 13.2 % | - 0.4 % | - 0.8 % | 0.1 % | - 1.9 % |

| | VOC | NOx | CO | SO2 | NH3 | SOA |
|---|---|---|---|---|---|---|
| **2030 Base vs 1996 Base** | -15.4 % | -28.3 % | 22.2 % | -12.5 % | 13.4 % | -19.4 % |
| **2030 Control vs 2030 Base** | -1.6 % | -13.7 % | -1.1 % | -0.9 % | 0.0 % | -3.3 % |

# III. Ozone Modeling over the Eastern United States

The Urban Airshed Model-Variable Grid (UAM-V), (SAI, 1996) was used as the tool for simulating base year and future concentrations of ozone in support of the HDE air quality assessments. UAM-V was designed for the expressed purpose of modeling regional ozone episodes. The model contains a subgrid-scale plume model, allows for nested finer resolution grids, and requires hourly meteorological fields. Model runs were made for the 1996 base year as well as for a 2007 base, and 2020 and 2030 base and control scenarios. As described below, each of these emissions scenarios was simulated for three meteorological datasets during the summer of 1995.

## A. Episode Selection

There are several considerations involved in selecting episodes for an ozone modeling analysis (EPA, 1999a). In general, the goal should be to model several differing sets of meteorological conditions leading to ambient ozone levels similar to an area’s 1 -hour design value[4]. Ideally, the modeling time periods would be supported by large amounts of ambient data that could be used in input development and model evaluation. The issue, in terms of regional modeling, is how to meet these episode selection goals over a large number of individual ozone non-attainment areas without having to model several entire ozone seasons (impossibly time consuming and resource-intensive). It is inevitable that the chosen episodes will feature observed ozone lower than the design value in some areas and greater than the design value in other areas. For the HDE analyses, we simulated the same episodes during the summer of 1995 as used for the Tier 2 rule. These periods were selected because 1995 is a recent time period for which we had model-ready meteorological inputs.

Based on a review of observed daily maximum ozone concentrations across the eastern U.S. during June through August, three episodes were selected for ozone modeling: June 12-24, July 5-15, and August 10-21. The start of each episode was chosen to correspond to days with no ozone exceedances. Thirty episode days were modeled in all, not including the three ramp-up days used in each episode to minimize the effects of initial conditions. The meteorological conditions and ozone levels during each episode are described below.

### 1. Episodic Meteorological Conditions and Ozone Levels

Warm temperatures, light winds, cloud-free skies, and stable boundary layers are some of the typical characteristics of ozone episodes. On a synoptic scale, these conditions usually result from a combination of high pressure aloft (500 millibars) and at the surface. At a smaller scale, the conditions that lead to local ozone exceedances can vary from location to location (based on factors such as wind direction, sea/lake breezes, etc.) The meteorological and resultant ozone patterns for the three 1995 modeling episodes are discussed in more detail below.

June 12-24, 1995

The initial stages of this episode were fairly typical from the standpoint of regional meteorology. A 500-millibar ridge propagated into the eastern U.S. from the west. The ridge was associated with a surface high that migrated south from Canada. A cold front passed completely through the region by June 13 (Wednesday) allowing the modeling to start with a clean set of initial conditions. Maximum temperatures during the June 15 - 17-period were generally in the 80s and little precipitation was measured. By June 17, a strong (1028 mb) surface high was anchored over the region.

The observed ozone fields in the early part of the episode were high (e.g., 125-130 ppb) only in locations such as Houston, Beaumont, and Lake Michigan. It was not until June 17 that concentrations exceeded 100 ppb over large parts of the domain (i.e., Midwest and Northeast

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[4] Generally, the design value for a monitoring site is the 4th highest 1-hour daily maximum concentration over a 3 year period. The design value for an area is the highest design value among all sites in the area.

Corridor).

However, as the aloft pattern amplified, a cut off low developed over the southeastern U.S. On the 19th and 20th, cooler temperatures and occasional rain prevailed in the Southeast. This resulted in a temperature pattern that featured maximums of 90-100 degrees F over the northern tier of States and 75-85 degrees F in the south. Additionally, the strong cyclonic circulation around this low resulted in aloft flow from east to west over the mid-Atlantic and Ohio Valley States. Ozone continued to build throughout this period in the Northeast, peaking on the 19th and 20th with values greater than 125 ppb common from Washington, D.C. to Boston.

The last four days of the episode were relatively clean in the Northeast due to the combination of a "backdoor" cold front and the northward migration of the cut off low. Meanwhile ozone conducive conditions returned to the Texas Gulf Coast and Lake Michigan areas. The highest value over the entire summer of 1995 (210 ppb) was recorded near Houston on the 22nd. The episode came to an end on the 25th as a long-wave trough replaced the 500-mb ridge over the eastern U.S.

Table III-1 shows a State-by-State listing of daily exceedance counts during the June 1995 HDE episode. There were 85 exceedances of the ozone NAAQS during this period. The peak day of the episode was June 19. Texas had the most exceedances (28).

**Table III-1.** Summary of exceedance days, by State/day, for the June 1995 HDE episode. Dates in bold indicate episode days (i.e., non-ramp-up days).

| | AL | AR | CT | DE | DC | FL | GA | IL | IN | KY | LA | ME | MD | MA | MI | M | NH | NJ | NY | NC | OH | OK | PA | RI | SC | TN | TX | VA | W | WI | TOT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6/12/95 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 0 |
| 6/13/95 | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | | | | 1 |
| 6/14/95 | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | | | | 1 |
| **6/15/95** | | | | | | | | | 1 | | | | | | | | | | | | | | | | | | 1 | | | | 2 |
| **6/16/95** | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | | | 1 | 2 |
| **6/17/95** | | | 1 | | | | | | | | | | | | 4 | | | | | | | | | | | | | | | 2 | 7 |
| **6/18/95** | | | 2 | | 1 | | | | 1 | | | | 1 | | | | | | | | | | | | | | | 1 | | | 6 |
| **6/19/95** | | | 3 | 3 | 1 | | | | | | | | 7 | 2 | | | | 4 | 2 | | 1 | | 8 | 1 | | | | | | | 32 |
| **6/20/95** | | | 2 | 2 | | | | | | | 2 | | 1 | | | | | 3 | | | | | | | | | 3 | | | | 13 |
| **6/21/95** | | | | | | | | | | | | | | | | | | | | | | | | | | | 7 | | | | 7 |
| **6/22/95** | | | | | | | | | | | | | | | | | | | | | | | | | | | 7 | | | | 7 |
| **6/23/95** | | | | | | | | | | | 2 | | | | | | | | | | | | | | | | 4 | | | | 6 |
| **6/24/95** | | | | | | | | 4 | 2 | | | | | | | 2 | | | | | | | | | | | 3 | | | | 11 |

### July 5-15, 1995

The mid-July episode, which covered most of the Ozone Transport Assessment Group (OTAG) July 1995 episode, is much easier to characterize from a meteorological perspective. A strong 500-mb ridge progressed from west to east across the eastern U.S. over the period. This feature was centered over Colorado on the 8th, over Kansas on the 11th, over Illinois on the 13th, and over Pennsylvania on the 15th. The ridge finally flattened out on the 16th allowing a surface cold front to clean out the northern portions of the domain and less stable conditions to prevail over the southern portions.

Excessively hot temperatures accompanied the core of this strong ridge. Temperatures in the 90s and 100s were common throughout the episode. Rainfall was confined primarily to the coastal regions in the south and southeast. Wind speeds were moderate and the mean transport direction was southwest to northeast, especially over the northern half of the domain.

From the 8th through the 10th, ozone levels in the airmass over the eastern U.S. were gradually increasing. Ozone hot spots occurred in urban areas like Houston, Dallas, and Atlanta. By the 11th, the area of regionally high ozone (roughly defined as the area where peak ozone was greater than 75 ppb) had expanded to encompass most of the domain. On top of that "background," local contributions from urban emissions yielded ozone exceedances in places like Kansas City, St. Louis, Birmingham, Dallas, Memphis, Atlanta, Baton Rouge, Evansville, Louisville, Cincinnati, Chicago, Milwaukee, Columbus, and Baltimore/Washington on the 11th and 12th.

July 13 and 14 marked the highest regional ozone levels of the summer as most sites, with the exception of those in the Southeast, exceeded 100 ppb. Almost all major metropolitan areas in the northern two-thirds of the domain measured values greater than 125 ppb on this day. For the 14th and 15th, most of the ozone problem shifted east and south due to both transport and the location of the aloft core of warm air. The Northeast Corridor, Charlotte, Greensboro, Birmingham, and Atlanta all had exceedances of the standard on this day. The episode ended abruptly on the 16th (Sunday) for most of the domain, although elevated ozone lingered over the southern regions into the early part of the next week.

Table III-2 shows a State-by-State listing of daily exceedance counts during the July 1995 HDE episode. There were 199 exceedances of the ozone NAAQS during this period. The peak day of the episode, in terms of exceedance monitors was July 14. Texas had the most exceedances (26).

**Table III-2.** Summary of exceedance days, by State/day, for the July 1995 HDE episode. Dates in bold indicate episode days (i.e., non-ramp-up days).

| | AL | AR | CT | DE | DC | FL | GA | IL | IN | KY | LA | ME | MD | MA | MI | M | NH | NJ | NY | NC | OH | OK | PA | RI | SC | TN | TX | VA | W | WI | TOT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7/05/95 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 0 |
| 7/06/95 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 0 |
| 7/07/95 | | | | | | | | | | | | | | | | | | | | | | | | | | | 2 | | | | 2 |
| **7/08/95** | | | | | | | | | | | | | | | | | | | | | | | | | | | 2 | | | | 2 |
| **7/09/95** | | | | | | | 1 | | | | | | | | | | | | | | | | | | | | 4 | | | | 5 |
| **7/10/95** | | | | | | | 4 | | | | | | | | | 1 | | | | | | | | | | | 1 | | | | 6 |
| **7/11/95** | 1 | 1 | | | | | 3 | | | | 1 | | | | | 3 | | | | | | | | | | 1 | 5 | | | | 15 |
| **7/12/95** | 1 | | | | | | | | 1 | 1 | 1 | | 5 | | | 4 | | 1 | | | 3 | | | | | 1 | 5 | | | 7 | 30 |
| **7/13/95** | | 1 | 5 | | | | | 8 | 1 | | | | 2 | 3 | 7 | 6 | | | 1 | | 4 | | 1 | | | | 6 | | 1 | | 46 |
| **7/14/95** | | | 7 | 3 | | | | 2 | 2 | | | 1 | 4 | 2 | 6 | | | 7 | 5 | 3 | 3 | | 3 | 3 | | 1 | 1 | | | | 53 |
| **7/15/95** | 1 | | 3 | 3 | | | | 2 | 2 | | | | 10 | | 1 | | | 6 | 3 | | | | 5 | | | | | 4 | | | 40 |

## August 7-21, 1995

A one-day ozone event occurred over New England on August 10, and a separate one-day event occurred in the Lake Michigan region on the 12th. By the 14th, high pressure aloft and at the surface dominated the eastern half of the U.S. Temperatures ranged from 90 to 100 degrees F over most of the domain throughout this period. Ozone was highest over Georgia, Tennessee, Kentucky, North Carolina, and Virginia during this period. Hurricane Felix brushed the East Coast from the 16th – 18th, but appeared to have little effect on ozone levels or ozone transport away from the immediate eastern seaboard.

A weak cold front, draped across the Great Lakes over most of the episode, moved slowly southward over the eastern half of the Appalachians during the August 18-21 period. This front initiated precipitation that helped keep ozone concentrations low in the upper Midwest. The 18th featured high ozone across the South in cities such as: Atlanta, Charlotte, Birmingham, Augusta, as well as St. Louis. On the 19th and 20th, as the front slid further south, ozone air quality improved over this region as well. Only sites in Texas and Louisiana remain above 125 ppb. The 21st marked the fourth day that the same airmass has resided over the Northeast.

Table III-3 shows a State-by-State listing of daily exceedance counts during the August 1995 HDE episode. There were 90 exceedances of the ozone NAAQS during this period. The peak day of the episode, in terms of exceedance monitors was August 21st.

**Table III-3.** Summary of exceedance days, by State/day, for the August 1995 HDE episode. Dates in bold indicate episode days (i.e., non-ramp-up days).

| | AL | AR | CT | DE | DC | FL | GA | IL | IN | KY | LA | ME | MD | MA | MI | M | NH | NJ | NY | NC | OH | OK | PA | RI | SC | TN | TX | VA | W | WI | TOT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8/07/95 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 0 |
| 8/08/95 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 0 |
| 8/09/95 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 0 |
| **8/10/95** | **1** | | | | | | | | | | | **1** | | **2** | | | **1** | | | | | | | | | | | | | | **5** |
| **8/11/95** | **1** | | | | | | **1** | | | | | | | | | | | | | | | | | | | | **1** | | | | **3** |
| **8/12/95** | **1** | | | | | | | **4** | **1** | | **1** | | | | **1** | | | | | | | | | | | | | | | | **8** |
| **8/13/95** | | | | | | | | | | | | | | | **1** | | | | | | | | | | | | | | | | **1** |
| **8/14/95** | **1** | | | | | | | | | | | | **3** | | | | | **1** | | **1** | | | | | | | | **1** | | | **7** |
| **8/15/95** | **1** | | | | | | **3** | | **1** | | | | | | | | | | | | | | **1** | | | | | **2** | | | **8** |
| **8/16/95** | | | | | | | **2** | | | **3** | | | | | | | | | | | | | | | | | | | | | **5** |
| **8/17/95** | | | | | | | **2** | | | **2** | | | | | | | | | | **1** | | | | | | **1** | **1** | | | | **7** |
| **8/18/95** | **4** | | | | | | **5** | **1** | | | | | | | | **1** | | | | | | | | | **1** | | | | | | **12** |
| **8/19/95** | | | | | | | **1** | | | | **2** | | | | | | | | | | | | | | | | **6** | | | | **9** |
| **8/20/95** | | | | | | | | | | | | | | | | | | | | | | | | | | | **6** | | | | **6** |
| **8/21/95** | | | **3** | **3** | | | | | | | **1** | | **3** | **2** | | | | **2** | **2** | | | | **1** | **1** | | | **1** | | | | **19** |

## 2. General Representativeness of Episodic Ozone as Compared to Design Values

In order to examine the representativeness of ozone levels during the episodes selected for modeling, a comparison was made between the daily maximum observed values to recent design values. In this analysis, the magnitude of county-specific design values for 1996-1998 were compared to the highest through 5th highest concentrations measured in the county during the three episodes. Counties with design values (DV) >120 ppb were selected for analysis in order to focus on concentrations approaching and exceeding the NAAQS. As can be seen in Table III-4, 70 of the 110 counties examined have design values within 15 ppb of the highest observed ozone in the HDE episodes. Additionally, the second-high observed value yields more values below the design value than above it. The results indicate that the selected episodes contain measured ozone concentrations that are representative of design values over a large portion of the eastern U.S.

**Table III-4.** Summary of Comparing the Five Highest Daily Maxima to Recent Design Values.

| Ranking of Observation within HDE Days | # of cases in which the observed was greater than the design value by 15 ppb | # of cases in which the observed was within 15 ppb of the design value | # of cases in which the observed was less than the design value by 15 ppb |
|---|---|---|---|
| Highest ozone | 32 | 70 | 8 |
| 2nd high ozone | 10 | 80 | 20 |
| 3rd high ozone | 2 | 71 | 37 |
| 4th high ozone | 0 | 57 | 53 |
| 5th high ozone | 0 | 45 | 65 |

## B. Domain and Grid Configuration

As with episode selection, there are also several considerations involved in selecting the domain and grid configuration to be used in the ozone modeling analysis. The modeling domain should encompass the area of intended analysis with an additional buffer of grid cells to minimize the effects of uncertain boundary condition inputs. Grid resolution should be equivalent to the resolution of the primary model inputs (emissions, winds, etc.) and equivalent to the scale of the air quality issue being addressed. The regional/national HDE ozone analyses used the previously established Tier 2 domain to model regional ozone over the eastern U.S.

The HDE UAM-V modeling was completed using two grids of varying extent (shown in Figure III-1) and resolution as described below.

Main Grid: Resolution: 1/2° longitude, 1/3° latitude (approximately 36 km)
East-West extent: -99 W to -67 W
North-South extent: 26 N to 47 N
Vertical extent: Surface to 4 km
Dimensions: 64 by 63 by 9

Nested Grid[5]: Resolution: 1/6° longitude, 1/9° latitude (approximately 12 km)
East-West extent: -92 W to -69.5 W
North-South extent: 32 N to 44 N
Vertical extent: Surface to 4 km
Dimensions: 137 by 110 by 9

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[5] Model concentrations are not calculated for the outer periphery of the nested grid. Two buffer rows and columns are needed to solve the advection portion of the mass balance equation.

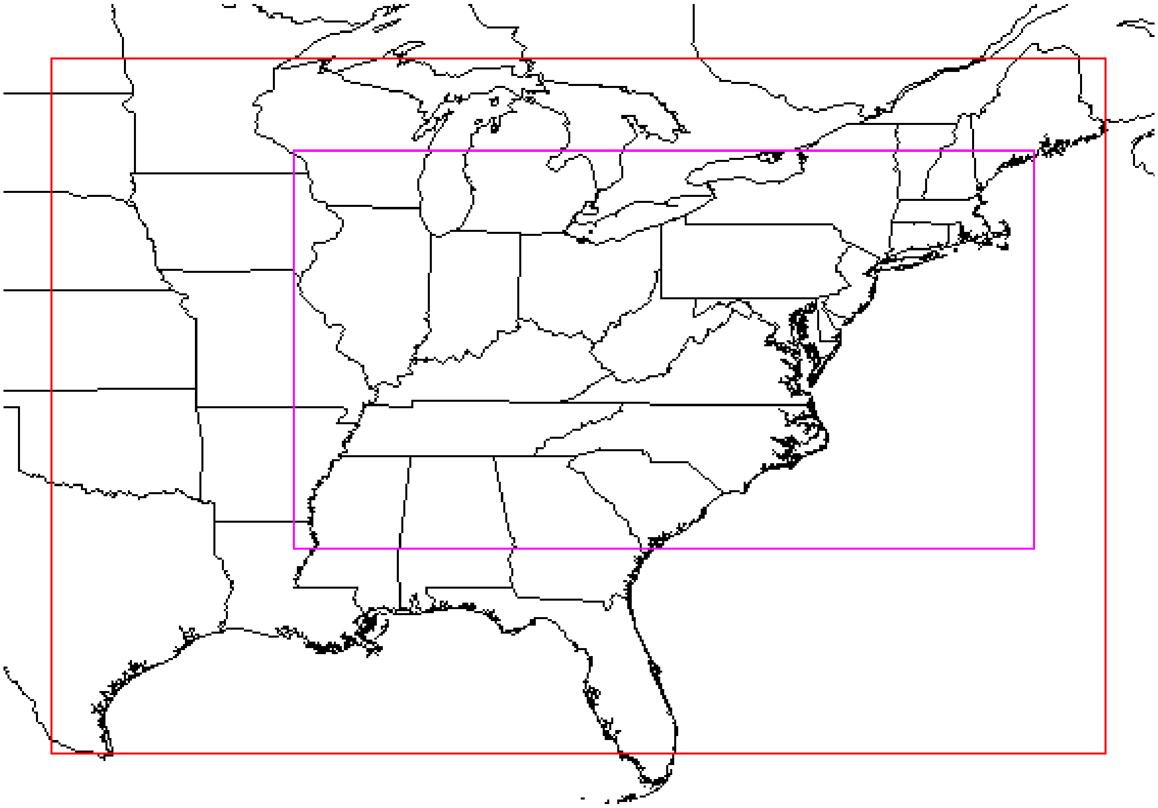

**Figure III-1.** Map of the HDE Eastern U.S. modeling domain. The outer box denotes the entire modeling domain (36 km) and the inner box indicates the fine grid location (12 km).

The vertical layers were consistent between the two grids: 0-50, 50-100, 100-300, 300-600, 600-1000, 1000-1500, 1500-2000, 2000-2500, 2500-4000. All model heights are in meters above ground level. The number of vertical layers is greater than past regional-scale modeling applications (e.g., OTAG) and was intended to better capture the depth of the planetary boundary layer.

This modeling domain allows for the calculation of residual future ozone exceedances and the effects of HDE emissions reductions over most major metropolitan areas in the eastern U.S. (The Dallas-Fort Worth area may be the exception given its proximity to the western boundary.)

## C. Meteorological Modeling

In order to solve for the change in pollutant concentrations over time and space, the air quality model requires certain meteorological inputs that, in part, govern the formation, transport, and destruction of pollutant material. In particular, the UAM-V model used in the HDE analyses requires five meteorological input files: wind (u- and v-vector wind components), temperature, water vapor mixing ratio, atmospheric air pressure, and vertical diffusion coefficient. Fine grid values of wind and vertical diffusivity are used; the other fine grid meteorological inputs are interpolated from the coarse grid files.

The gridded meteorological data for the three historical 1995 episodes were developed by the New York Department of Environment and Conservation (NYDEC) using the Regional Atmospheric Modeling System (RAMS), version 3b. RAMS (Pielke *et. al.*, 1992) is a numerical meteorological model that solves the full set of physical and thermodynamic equations which govern atmospheric motions. The output data from RAMS, which is run in a polar stereographic projection and a sigma-p coordinate system, are then mapped to the UAM-V grid. Two separate meteorological UAM-V inputs, cloud fractions and rainfall rates, were developed based on observed data.

RAMS was run in a nested-grid mode with three levels of resolution: 108 km, 36 km, and 12 km with 28-34[6] vertical layers. The top of the surface layer was 16.7 m in the 36 and 12km grids. The two finer grids were at least as large as their UAM-V counterparts. In order to keep the model results in line with reality, the simulated fields were nudged to an European Center for Medium-Range Weather Forecasting (ECMWF) analysis field every six hours. This assimilation data set was bolstered by every four-hourly special soundings regularly collected as part of the North American Research Strategy on Tropospheric Ozone (NARSTO) field study in the northeast U.S.

A summary of the settings and assorted input files employed in this RAMS application are listed below in Table III-5. For more detail on the meteorological model configuration, see Lagouvardos *et al.* (1997).

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[6] The inner nests were modeled with 34 layers while the outer 108 km domain was modeled with 28 layers.

**Table III-5.** Summary of RAMS model settings and inputs.

| Model Setting/Input File | Description |
|---|---|
| Input- Topography | 30 arc-second data from EROS Data Center. |
| Input - Sea-surface temperature | Mean monthly climatological data from NCAR. |
| Input - Vegetation type | 10 arc-minute data from NOAA/NGDC. |
| Input - Initial conditions | The model was initialized with gridded one-degree ECMWF data |
| Input - Soil moisture | Six layer soil model.  Assumed deeper layers were more moist than |
| Setting | Non-hydrostatic |
| Setting - Lateral boundary conditions | Klemp-Wilhelmson |
| Setting - Horizontal diffusivity | Smagorinsky |
| Setting - Vertical diffusivity | Mellor and Yamada parameterization scheme |
| Setting - Shortwave/Longwave radiation | Mahrer and Pielke |

A limited model performance evaluation (Sistla, 1999) was completed for a portion of the 1995 meteorological modeling (July 12-15). Observed data not used in the assimilation procedure were compared against modeled data at the surface and aloft. In general, there were no widespread biases in temperatures and winds. Furthermore, the meteorological fields were compared before and after being processed into UAM-V inputs. It was concluded that this preprocessing did not distort the meteorological fields.

## D. Development of Other UAM-V Input Files

The hourly, gridded, model-ready anthropogenic emissions for the six modeling scenarios were created using EMS-95 (Alpine Geophysics, 1994). As part of this processing, emissions for stationary and nonroad sources were developed for typical summer weekday, Saturday, and Sunday emissions levels and then used for the corresponding day-types that occurred during the episodes. The exceptions to this are utility emissions which were adjusted to reflect differing emissions levels during June, July, and August (EPA, 2000b). Hourly mobile source emissions were developed using grid-specific temperature data. Biogenic emissions were developed using the BEIS-2 model (Pierce et al., 1998). In addition, the photochemical grid model requires several other types of input data. In general, most of these miscellaneous model files were taken from existing regional modeling applications. Clean conditions were used to initialize the model and as lateral and top boundary conditions as in Tier 2 (EPA, 1999b).

The model requires information regarding land use type and surface albedo for all Layer 1 grid cells in the domain. Existing Tier 2/OTAG data were used for these non-day-specific files. Photolysis rates were developed using the JCALC portion of the UAM-V modeling system (SAI, 1996). Turbidity values were set equal to a constant thought to be representative of regional conditions.

## E. Model Performance Evaluation

The goal of the base year modeling was to reproduce the atmospheric processes resulting in high ozone concentrations over the eastern United States during the three 1995 episodes selected for modeling. Note that the base year of the emissions was 1996 while the episodes are in 1995. The effects on model performance of using 1996 base year emissions for the 1995 episodes are unknown.

An operational model performance evaluation for surface ozone for the 1995 episodes was performed in order to estimate the ability of the modeling system to replicate base year ozone concentrations. This evaluation is comprised principally of statistical assessments of model versus observed pairs. The robustness of an operational evaluation is directly proportional to the amount and quality of the ambient data available for comparison.

### 1. Statistical Definitions

Below are the definitions of those statistics used for the evaluation. The format of all the statistics is such that negative values indicate model ozone predictions that were less than their observed counterparts. Positively-valued statistics indicate model overestimation of surface ozone. Statistics were not generated for the first three days of an episode to avoid the initialization period. The operational statistics were principally generated on a regional basis in accordance with the primary purpose of the modeling which is to assess the need for, and impacts of, a national mobile source emissions control program. However, a local assessment of model performance was also completed to ensure that the model did not significantly overestimate the need for controls in individual areas. The statistics were calculated for (a) the entire HDE domain, (b) four quadrants (Midwest, Northeast, Southeast, Southwest), and (c) 47 local areas. The statistics that were calculated for each of these sets of areas are described below.

<u>Domainwide unpaired peak prediction accuracy:</u> This metric simply compares the peak concentration modeled anywhere in the selected area against the peak ambient concentration anywhere in the same area. The difference of the peaks (model - observed) is then normalized by the peak observed concentration.

<u>Peak prediction accuracy:</u> This metric averages the paired peak prediction accuracy calculated for each monitor in the subregion. It characterizes the capacity of the model to replicate peak (afternoon) ozone over a subregion. The daily peak model versus daily peak observed residuals are paired in space but not in time.

<u>Mean normalized bias:</u> This performance statistic averages the normalized (by observation) difference (model - observed) over all pairs in which the observed values were greater than 60 ppb. A value of zero would indicate that the model over predictions and model under predictions exactly cancel each other out.

Mean normalized gross error: The last metric used to assess the performance of the HDE base cases is similar to the above statistic, except in this case it is the absolute value of the residual which is normalized by the observation, and then averaged over all sites. A zero gross error value would indicate that all model concentrations (in which their observed counterpart was greater than 60 ppb) exactly matched the ambient values.

### 2. Domainwide and Regional Model Performance

As with previous regional photochemical modeling studies, the HDE base year simulations are accurate representations of the historical ozone patterns at certain times and locations and poor representations at other times and locations over this large modeling domain. From a qualitative standpoint, there appears to be considerable similarity on most days between the observed and simulated ozone patterns. Additionally, where possible to discern, the model appears to follow the day-to-day variations in synoptic-scale ozone fairly closely. Other relevant observations, in terms of model performance, are listed below.

- Mean normalized bias and mean normalized gross error values are similar to the Tier 2 model performance statistics for the entire domain and the four quadrants as summarized in Table III-6. In turn, the Tier 2 model performance was very similar to what was observed in OTAG, as summarized in the Tier 2/Low Sulfur Technical Support Document (TSD) (EPA, 1999b).

**Table III-6.** Tier 2 and HDE Base Year model performance for the entire grid and by quadrant.

| Mean Normalized Bias | Tier 2 June 95 | Tier 2 July 95 | Tier 2 August 95 | HDE June 95 | HDE July 95 | HDE August 95 |
|---|---|---|---|---|---|---|
| Domain | -10 | -6 | +2 | -13 | -11 | +5 |
| Midwest | -11 | -13 | +7 | -15 | -16 | +10 |
| Northeast | -17 | -9 | -9 | -20 | -11 | -15 |
| Southeast | -4 | +4 | +7 | -7 | -3 | +12 |
| Southwest | +2 | +8 | +6 | +1 | +3 | +11 |

| Mean Normalized Gross Error | Tier 2 June 95 | Tier 2 July 95 | Tier 2 August 95 | HDE June 95 | HDE July 95 | HDE August 95 |
|---|---|---|---|---|---|---|
| Domain | 24 | 24 | 23 | 22 | 23 | 24 |
| Midwest | 24 | 26 | 22 | 22 | 24 | 22 |
| Northeast | 27 | 22 | 24 | 27 | 23 | 24 |
| Southeast | 20 | 24 | 22 | 18 | 21 | 25 |
| Southwest | 24 | 27 | 24 | 22 | 24 | 27 |

- In general, the model under predicts ozone for the June and July episodes (-13 and -11 percent, respectively). This underestimation bias generally occurs over the first half of an episode. The latter portions of these episodes are generally unbiased.

- Mean normalized gross error ranges from 18 to 27 percent. Bias and errors are generally lowest in the Southeast region.

- The model typically underestimates the peaks as well as the mean ozone, but not as severely.

- Although the overall tendency (June/July episodes) is to underestimate the observed ozone, there are several instances in which large overestimations occurred.

- The model is slightly biased toward overestimation in the August episode (5 percent). Only the Northeast quadrant is underestimated (-15 percent) in this episode.

- While there are no established statistical criteria for evaluating the adequacy of regional modeling applications, the relatively low values of bias and error plus the OTAG and Tier 2 equivalent performance indicate the modeling is sufficient for a national assessment of the need for (and impact of) HDE controls.

### 3. Local-scale Model Performance

The HDE modeling results were also evaluated at a “local” level. The purpose of this analysis was to ensure that areas determined to need the HDE emissions reductions based on 1-hour exceedances of the ozone standard were not unduly influenced by local overestimation of ozone in the model base year. For this analysis, the modeling domain was broken up into 47 local subregions as shown in Figure III-2. The primary statistics for each of the 47 subregions is shown in Table III-7.

If one were to compare the performance of the 1995 eastern base year modeling against the performance criteria recommended in EPA's ozone modeling guidance (EPA, 1996) for accuracy (within +/- 20 percent), bias (within +/- 15 percent), and error (less than 35 percent), the results indicate that 57% of the regions would meet these criteria for the June episode, 45% of the regions would for the July episodes, and 55% of the regions would for the August episode. Most of the areas that did not meet the local-scale criteria exhibited an under prediction bias of 15 percent or more.

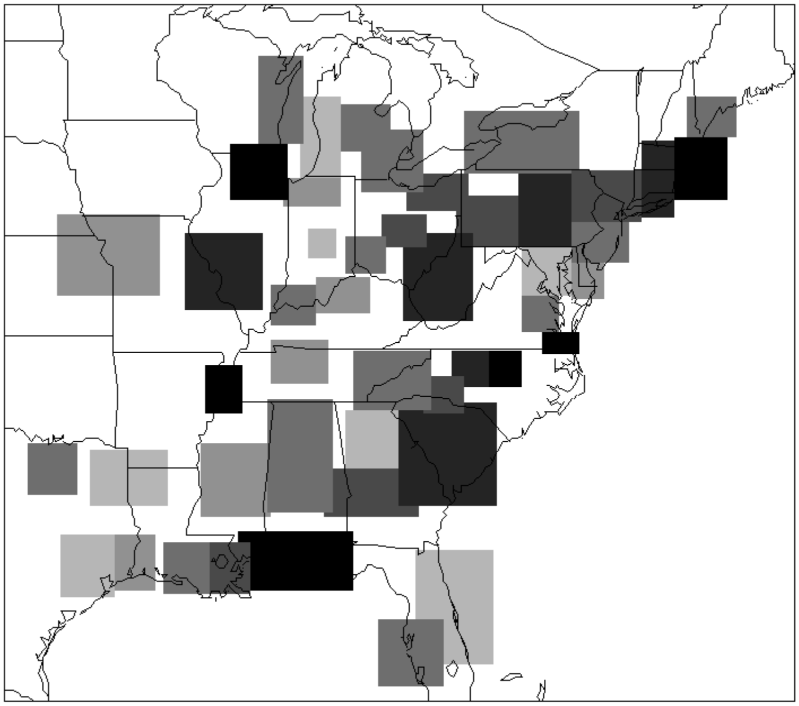

**Figure III-2.** Map of the 47 HDE local-scale evaluation zones.

The general tendency of the model, as discussed above, is to underestimate observed ozone concentrations. Given that one of the primary uses of the model is to calculate potential exceedance areas in the future that may require additional ozone precursor control, this model tendency should lead to a conservative estimate of future-year air quality need. When the model is used in a relative sense to assess potential impacts from the rulemaking, any model bias will be in both the base and control simulations and should be canceled out as comparisons are made.

**Table III-7.** HDE Base Year model performance for the 47 local regions.

| Region | Domainwide Unpaired Accuracy | Average Accuracy of the Peak | Mean Normalized Bias | Mean Normalized Gross Error |
|---|---|---|---|---|
| Dallas | -0.155 | -0.079 | -0.102 | 0.216 |
| Houston-Galveston | -0.128 | 0.043 | 0.032 | 0.267 |
| Beaumont-Port Arthur | 0.078 | 0.151 | 0.167 | 0.251 |
| Baton Rouge | 0.055 | 0.212 | 0.254 | 0.308 |
| New Orleans | 0.266 | 0.198 | 0.212 | 0.264 |
| St. Louis | 0.002 | -0.015 | -0.007 | 0.205 |
| Memphis | 0.102 | -0.090 | -0.078 | 0.200 |
| Alabama | 0.052 | 0.024 | 0.047 | 0.201 |
| Atlanta | 0.235 | 0.079 | 0.079 | 0.244 |
| Nashville | 0.172 | 0.078 | 0.071 | 0.265 |
| Eastern TN | -0.005 | -0.159 | -0.195 | 0.257 |
| Charlotte | 0.198 | 0.039 | 0.061 | 0.182 |
| Greensboro | 0.137 | 0.031 | 0.021 | 0.177 |
| Raleigh-Durham | 0.093 | -0.026 | -0.036 | 0.179 |
| Evansville-Owensboro | 0.097 | -0.025 | 0.002 | 0.236 |
| Indianapolis | -0.045 | -0.104 | -0.115 | 0.217 |
| Louisville | 0.159 | 0.104 | 0.094 | 0.265 |
| Cincinnati-Dayton | -0.038 | -0.077 | -0.057 | 0.230 |
| Columbus OH | -0.039 | -0.117 | -0.109 | 0.204 |
| West Virginia | 0.150 | 0.043 | 0.048 | 0.225 |
| Chicago | 0.048 | -0.156 | -0.228 | 0.291 |
| Milwaukee | 0.141 | -0.148 | -0.190 | 0.239 |
| Muskegon-Grand Rapids | 0.057 | -0.126 | -0.153 | 0.226 |
| Gary-South Bend | -0.097 | -0.173 | -0.212 | 0.271 |
| Detroit | 0.058 | -0.119 | -0.196 | 0.275 |
| Pittsburgh | -0.027 | -0.059 | -0.073 | 0.218 |
| Central PA | 0.120 | -0.040 | -0.069 | 0.213 |
| Norfolk | 0.236 | -0.015 | -0.075 | 0.246 |
| Richmond | 0.203 | 0.032 | 0.040 | 0.192 |
| Baltimore-Washington | 0.029 | -0.045 | -0.074 | 0.213 |
| Delaware | 0.083 | -0.074 | -0.047 | 0.156 |
| Philadelphia | -0.021 | -0.114 | -0.191 | 0.269 |
| New York City | 0.125 | -0.108 | -0.207 | 0.294 |
| Hartford | -0.008 | -0.134 | -0.144 | 0.243 |
| Boston | 0.122 | -0.103 | -0.177 | 0.270 |
| Maine | 0.116 | -0.135 | -0.187 | 0.262 |
| Longview-Shreveport | 0.014 | -0.049 | -0.088 | 0.251 |
| Kansas City | -0.113 | -0.178 | -0.197 | 0.238 |
| Western NY | 0.106 | -0.136 | -0.178 | 0.229 |
| Northeast OH | 0.014 | -0.060 | -0.081 | 0.209 |
| South Carolina | 0.161 | 0.060 | 0.053 | 0.188 |
| Gulf Coast | 0.239 | 0.167 | 0.216 | 0.279 |
| FL West Coast | 0.424 | 0.337 | 0.299 | 0.382 |
| FL East Coast | 0.248 | 0.137 | 0.133 | 0.250 |
| Jackson, MS | 0.347 | 0.084 | 0.084 | 0.198 |
| Central MI | -0.016 | -0.102 | -0.161 | 0.227 |
| Macon-Columbus AL | 0.273 | 0.012 | 0.033 | 0.187 |

Because one of the primary uses of the model is to determine areas at risk of having exceedances in the future, it is important to determine how well the model is doing at estimating peak ozone concentrations in the base year. Particularly, it is important to ensure that the highest model ozone concentrations are not overestimated, which could lead to an exaggerated assessment of potential future exceedance areas. As such, the domainwide peak prediction accuracy was calculated for each day and area for which a model exceedance was predicted in the future. If the model peak was more than 20 percent overestimated, then that day/area was flagged as a possible performance issue. Of the 37 areas[7] determined to need additional controls in the future based on HDE modeling projections of exceedances, 11 areas have an overprediction of the peak on some exceedance days in the base year modeling: Charlotte, Huntington KY, Macon, Nashville, Richmond, Charleston WV, Cincinnati, Cleveland, Norfolk, Orlando, and Tampa-St. Petersburg. However, for Cincinnati and Richmond there were also days with observed exceedances on which the modeling underpredicted ozone and therefore did not identify any exceedances.

### 4. Model Performance over the Western U.S. Domain

UAM-V modeling was also performed for the western U.S. using the domain and all of the inputs, except anthropogenic emissions, which were used in the western modeling for Tier 2 (EPA, 1999b). Anthropogenic emissions developed for the HDE rule (EPA, 2000b) were used for this modeling. An operational evaluation was performed for the western modeling using the same procedures and statistics discussed in section III-E-1. Model performance measures were calculated over the entire modeling domain, the 12 km fine grid, and 10 individual areas (Albuquerque, Denver, El Paso, Phoenix, Portland, Salt Lake City, the San Joaquin Valley, Seattle, San Francisco, and Southern California). Table III-8 contains the operational evaluation statistics. Observations on the evaluation results are listed below.

- Mean normalized bias and mean gross error values indicate that the model almost exclusively underestimates the amounts of ozone actually measured (where observed ozone is greater than 60 ppb). The average under prediction bias is about 40 percent.

- This large negative bias exists over both 1996 episodes (-0.423 for the 1st episode, -0.406 for the 2nd episode). There is a slight tendency for the underestimation bias to be worst in the early stages of the episodes. As seen in the table, model performance is poorest in southern California where there are a high number of monitors.

- There is a deterioration in the performance of the western U.S. HDE base case simulations relative to the same simulations completed as part of the Tier 2 air quality modeling exercise. Overall, the HDE base case exhibits even more underprediction (about 2-3 percent), mostly due to model-observed pairs in southern California.

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[7] These 37 areas are listed in Appendix A, as described in Section III.F..

**Table III-8.** Model performance statistics for individual local areas in the western U.S.

| Region | Unpaired Peak Prediction Accuracy | Average Peak Prediction Accuracy | Mean Normalized Bias | Mean Normalized Gross Error |
|---|---|---|---|---|
| Albuquerque | -0.205 | -0.340 | -0.354 | 0.354 |
| Denver | -0.182 | -0.327 | -0.351 | 0.352 |
| El Paso | -0.279 | -0.408 | -0.437 | 0.437 |
| Phoenix | -0.245 | -0.398 | -0.456 | 0.459 |
| Portland | 0.021 | -0.145 | -0.209 | 0.251 |
| Salt Lake City | -0.199 | -0.311 | -0.347 | 0.353 |
| San Joaquin Valley | -0.236 | -0.372 | -0.396 | 0.403 |
| Seattle | 0.144 | -0.155 | -0.252 | 0.359 |
| San Francisco | -0.287 | -0.361 | -0.373 | 0.375 |
| Southern California | -0.320 | -0.571 | -0.585 | 0.591 |

While model performance for ozone in the western U.S. for the HDE 1996 base is roughly similar to the performance found in the Tier 2 modeling for this same region, it is the different scope of the HDE rule that calls into question the use of these data in the HDE rulemaking. One of the primary differences relative to California between Tier 2 and HDE is that the HDE rule will provide additional emissions reductions in California[8]. Also, the HDE analysis has given more consideration to longer term ozone exposure analyses, which will certainly be compromised by inadequate model performance of this magnitude. The magnitude of the underpredictions, especially for areas of California, calls into question the credibility of the directional response of the model to controls. Also, considering the performance in the West relative to the performance of the model for the eastern U.S. (biases within plus/minus 10 percent) and what is typically expected out of such regional modeling applications, it was determined that this application of the model should not be used to support the air quality assessments in this rule.

## F. Ozone Modeling Results For Future-Year Scenarios

The HDE modeling output for the East was analyzed to provide information to (a) support the determination of the need for HDE, and (b) examine the air quality impacts of the rulemaking. The procedures and results of each of these analyses are described below.

### 1. Future-Year Model-Predicted Exceedances

To support the determination of the need for HDE, the modeling results were examined to identify those CMSA and MSAs that have predicted exceedances of the 1-hour NAAQS in the 2007, 2020, and/or 2030 base scenarios. This determination was limited to those areas which

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[8] This is in contrast to the Tier 2 assessment which included emissions reductions from the California Low Emissions Vehicle Program in the future-year baseline scenarios.

had ambient 1-hour design values above the standard (i.e., >= 125 ppb) or within 10 percent of the standard (i.e., >= 113 ppb). A CMSA/MSA is determined to contain a predicted exceedance if at least one of the grid cells assigned to the area has at least one exceedance during the episodes modeled. The procedures for assigning grid cells to areas are defined below. The CMSA/MSAs with predicted 2007, 2020, and/or 2030 base case exceedances are listed in Appendix A.

## 2. Impacts of the HDE Rule on 1-Hour Ozone

### *a. Definition of Areas for Analysis*

In order to analyze the impacts of the HDE emissions reductions, it was necessary to "link" or assign the model's grid cells to individual CMSA/MSAs. The rules for assigning grid cells to CMSA/MSAs (i.e., areas) is as follows. The first step was to assign grid cells to States based on the fraction of the grid cells' area in a State. A grid cell was assigned to the State which contains most of the cells' area. Next, grid cells were assigned to an individual CMSA/MSAs if (1) the grid is wholly contained within the CMSA/MSA or (2) partially within (i.e., overlapping) the area, but *not* also partially within another CMSA/MSA. Grid cells that partially overlap two or more CMSA/MSAs are assigned to the county, and thereby the corresponding CMSA/MSA, which contains the largest portion of the grid cell. Each grid cell in the "coarse" or 36 km grid portion of the domain was divided into nine 12 km grids before applying the preceding methodology. The number of grid cells assigned to each metric area is listed in Appendix B.

### *b. Description of Ozone Metrics*

The impacts of HDE on ozone were quantified using a number of metrics (i.e., measures of ozone concentrations). These metrics include:

(1) the peak 1-hour ozone concentrations,
(2) the number of exceedances,
(3) the total amount of ozone >= 125 ppb,
(4) the decrease in ozone, on average, and
(5) the increase in ozone, on average.

(1) The peak 1-hour ozone represents the highest ozone prediction within the area (i.e., CMSA or MSA) across all episodes modeled.

(2) The number of exceedances is the total number of grid cells with predicted exceedances in the area across all days. This exceedance metric counts each grid cell every day there is a predicted exceedance in that grid. Thus, an individual grid cell can be counted more than once if there are multiple days with predicted exceedances in that grid.

(3) The total amount of ozone above 125 ppb in an area is determined by taking the difference between the predicted daily maximum ozone concentration and 125 ppb (i.e., daily maximum - 125 ppb) in each grid cell and then summing this amount across all grid cells in the area and days modeled. This metric is referred to as the "amount of nonattainment".

(4) The decrease, on average is determined by first summing all the reductions predicted in those grid cells with daily maximum ozone >=125 ppb in the base case (i.e., base case exceedances). This total reduction is then divided by the number of base case exceedances in the area to yield the "ppb" decrease that occurs, on average, for the exceedances predicted in the area.

(5) The increase, on average is determined by summing any increases in ozone that occur in values already >= 125 ppb in the base case together with any increases that cause a value below 125 ppb in the base case to go above 125 ppb in the control case. This total increase is then divided by the number of exceedances in the base case.

The impacts of HDE on 1-hour ozone exceedances were examined for the individual CMSA/MSAs as well as by aggregating the metrics across all areas to obtain the overall impact expected from the program. The values of the metrics are provided in Appendix C for 2007, 2020 and 2030.

### 3. Need for HDE Rule Based on Unhealthy 8-Hour Ozone Concentrations

One component of the analysis to support the need for this rule was the calculation of the number of people living in metropolitan counties that experience 8-hour ozone concentrations above certain concentration levels for different lengths of time. This “exposure” type analysis was based on current 1997-1999 ambient 8-hour concentrations and projected future 8-hour concentrations, based on modeling of the HDE emissions scenarios. To provide the future-year estimates of 8-hour concentrations, 8-hour relative reduction factors (RRFs) were calculated then applied to ambient 8-hour daily maximum concentrations. The procedures for determining the RRFs are similar to those in EPA’s draft guidance for modeling for an 8-hour ozone standard (EPA, 1999a). Hourly model predictions were processed to determine daily maximum 8-hour concentrations for each grid cell for each non-ramp-up day modeled. The RRF for a monitoring site was determined by first calculating the multi-day mean of the 8-hour daily maximum predictions in the nine grid cells surrounding the site using only those predictions >= 70 ppb, as recommended in the guidance. This calculations was performed for the base year scenario and each future-year scenario. The RRF for a site is the ratio of the mean 8-hour prediction in the future-year scenario to the mean 8-hour prediction in the base year scenario. This value was then multiplied by the ambient 8-hour concentrations to provide estimates of future 8-hour concentrations. These future concentrations were then used in the “exposure” analysis as described in the HDE docket (Docket A-99-06, item IV-B-09). The 8-hour RRFs are provided for each monitoring site in Appendix D.

### 4. One-Hour Ozone Relative Reduction Factors

EPA received comments that recommended using relative reduction factors applied to ambient design values as an approach to estimate which areas are expected to have a future problem attaining the1-hour ozone standard. Specifically, the commenters recommended that EPA follow draft guidance for demonstrating attainment of the 8-hour NAAQS for such an analysis (EPA, 1999a). In response, we calculated relative reduction factors for the 2007, 2020, and 2030 base case and control scenarios using the general methodology in this guidance. The exceptions to this guidance is that we used a cut-off of 80 ppb as appropriate for considering 1-

hour model predictions as opposed to 70 ppb recommended in the guidance for 8-hour concentrations (see the Tier 2 Air Quality Modeling TSD, 1999). The 1-hour monitor-specific RRFs were applied to the ambient 1-hour design value (i.e., 4th highest 1-hour daily maximum concentration at the monitor from 1997-1999) at each site with valid data. The resulting future-year 1-hour design values were examined for all monitors in an area to select the highest value for the area. These data can be found in Docket A-99-06; item IV-B-06.. Information on the use of these data for this rule can be found in the Response to Comments Document.

# IV. Particulate Matter Modeling over the Continental U.S.

## A. REMSAD Model Description

The REgulatory Modeling System for Aerosols and Deposition (REMSAD), (ICF Kaiser, 1998) model was used as the tool for simulating base year and future concentrations of PM in support of the HDE air quality assessments. Model runs were made for the 1996 base year as well as for the 2020 and 2030 base and control scenarios. As described below, each of these emissions scenarios was simulated using 1996 meteorological data in order to provide the annual mean PM concentrations and estimates of visibility needed for the PM "exposure" analysis and benefits calculations.

REMSAD was designed to calculate the concentrations of both inert and chemically reactive pollutants by simulating the physical and chemical processes in the atmosphere that affect pollutant concentrations. Version 4.1 of REMSAD was used for the HDE modeling. The framework of this model is taken from version 1.23 of the UAM-V regional-scale photochemical model, without Plume-in-Grid and with a modified Carbon Bond IV routine, as described below. The UAM-V framework has been extended vertically to treat the entire troposphere and converted to a sigma (terrain following) vertical coordinate. REMSAD includes a cumulus convective parameterization scheme and a stratiform cloud parameterization scheme for the distribution and removal of pollutant species.

The basis for REMSAD is the atmospheric diffusion equation (also called the species continuity or advection/diffusion equation). This equation represents a mass balance in which all of the relevant emissions, transport, diffusion, chemical reactions, and removal processes are expressed in mathematical terms. REMSAD employs finite-difference numerical techniques for the solution of the advection/diffusion equation.

REMSAD uses a latitude/longitude horizontal grid structure in which the horizontal grids are generally divided into areas of equal latitude and longitude. The vertical layer structure of REMSAD is defined in terms of sigma-pressure coordinates. The top and bottom of the domain are defined as 0 and 1 respectively. The vertical layers are defined as a percent of the atmospheric pressure between the top and bottom of the domain. For example, a vertical layer of 0.50 sigma is exactly halfway between the top and bottom of the domain as defined by the local atmospheric pressure. Usually, the vertical layers are defined to match the vertical layer structure of the meteorological model used to generate the REMSAD meteorological inputs.

### 1. Gas Phase Chemistry

REMSAD simulates gas phase chemistry using a reduced-form version of CB4 termed "micro-CB4" (mCB4) which treats fewer VOC species compared to the full CB4 mechanism. The inorganic and radical parts of the reduced mechanism are identical to CB4. In this version of mCB4 the organic portion is based on one primary species (VOC) and one primary and secondary carbonyl species (CARB). The VOC species was incorporated with kinetics representing an average anthropogenic hydrocarbon species. A second primary VOC species representing biogenic emissions is also included with kinetic characteristics representing isoprene. The intent of the mCB4 mechanism is to (a) provide a physically faithful representation of the linkages between emissions of ozone precursor species and secondary PM precursors species, (b) treat the oxidizing capacity of the troposphere, represented primarily by the concentrations of radicals and hydrogen peroxide, and (c) simulate the rate of oxidation of the nitrogen oxide ($NO_x$) and sulfur dioxide ($SO_2$) PM precursors. Box model testing of mCB4 has found that it performs very closely to the full CBM4 that is contained in UAM-V (Whitten, 1999).

### 2. PM Chemistry

Primary PM emissions in REMSAD are treated as inert species. They are advected and deposited without any chemical interaction with other species. Secondary PM species, such as sulfate and nitrate are formed through chemical reactions within the model. $SO_2$ is the gas phase precursor for particulate sulfate, while nitric acid is the gas phase precursor for particulate nitrate. Several other gas phase species are also involved in the secondary reactions.

There are two pathways for sulfate formation; gas phase and aqueous phase. Aqueous phase reactions take place within clouds, rain, and/or fog. In-cloud processes can account for the majority of atmospheric sulfate formation in many areas. In REMSAD, aqueous $SO_2$ reacts with hydrogen peroxide ($H_2O_2$) to form sulfate[9]. This reaction also occurs in the gas phase although the gas phase reaction is much slower. $SO_2$ also reacts with OH radicals in the gas phase to form sulfate.

Particulate nitrate is calculated in an equilibrium reaction between nitric acid, sulfuric acid, and ammonia. Nitric acid is a product of gas phase chemistry and is formed through the mCB4 reactions. The acids are neutralized by ammonia with sulfuric acid reacting more quickly than nitric acid. An equilibrium is established among ammonium sulfate and ammonium nitrate which strongly favors ammonium sulfate unless the available ammonia exceeds twice the available sulfate. Nitrate is then partitioned between particulate nitrate and gas phase nitric acid. The partitioning of nitrate depends on the availability of ammonia as well meteorological factors such as temperature and relative humidity.

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[9] Hydrogen peroxide is formed from photochemical reactions within the mCB4 mechanism.

## B. REMSAD Modeling Domain

The modeling domain used for the HDE modeling was designed to provide air quality predictions for the lower 48 States, as shown in Figure IV-1. The geographic characteristics of the domain are as follows:

120 (E-W) X 84 (N-S) grid cells
Cell size (~36 km)
    1/2 degree longitude (0.5)
    1/3 degree latitude (0.3333)
E-W range: 66 degrees W - 126 degrees W
N-S range: 24 degrees N - 52 degrees N
Vertical extent: Ground to 16,200 meters (100mb) with 8 layers

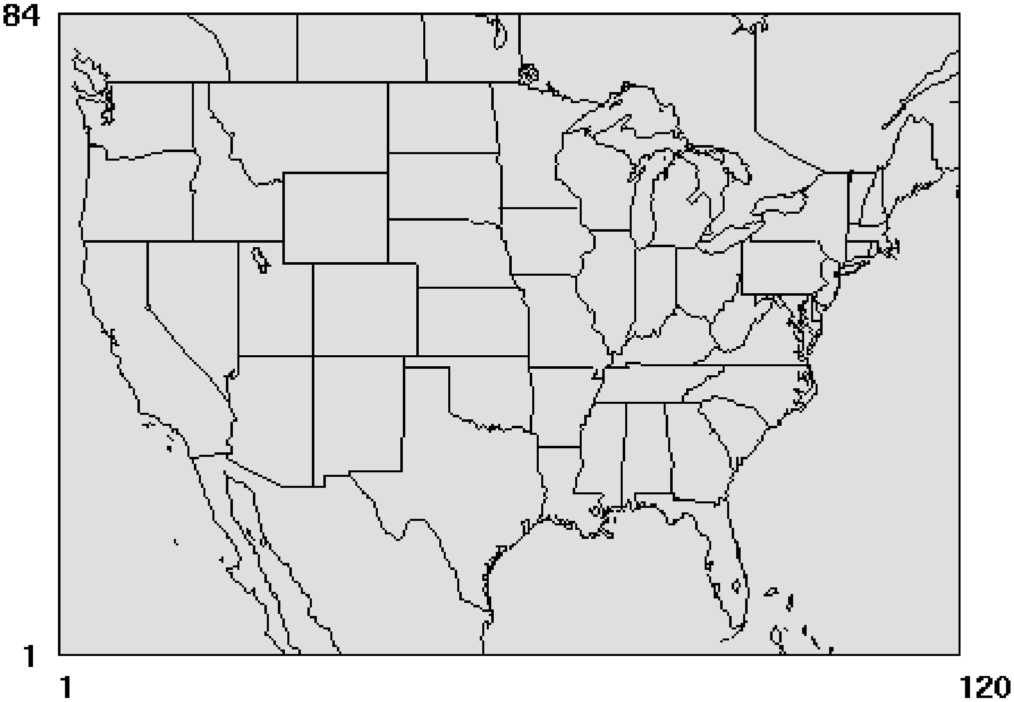

**Figure IV-1.** REMSAD Modeling Domain.

## C. REMSAD Inputs

Input data for REMSAD can be classified into six categories: (1) simulation control, (2) emissions, (3) initial and boundary concentrations, (4) meteorological, (5) surface characteristics, and (6) chemical rates. The REMSAD predictions of pollutant concentrations are calculated from the emissions, advection, and dispersion processes coupled with the formation and deposition of secondary PM species within every grid cell of the modeling domain. To adequately replicate the full three-dimensional structure of the atmosphere, the REMSAD program requires hourly (or 3-hour average) input data for a number of variables. Table IV-1 lists the required REMSAD input files.

**Table IV-1.** List of REMSAD input files.

| Data type | Files | Description |
|---|---|---|
| Control | CONTROL | Simulation control information |
| Emissions | PTSOURCE<br>EMISSIONS | Elevated source emissions<br>Surface emissions |
| Initial and boundary concentrations | AIRQUALITY<br>BOUNDARY | Initial concentrations<br>Lateral boundary concentrations |
| Meteorological | WIND<br>TEMPERATURE<br>PSURF<br>H2O<br>VDIFFUSION<br>RAIN | X,Y-components of winds<br>3D array of temperature<br>2D array of surface pressure<br>3D array of water vapor<br>3D array of vertical turbulent diffusivity coefficients<br>2D array of rainfall rates |
| Surface characteristics | SURFACE<br>TERRAIN | Gridded land use<br>Terrain heights |
| Chemical rates | CHEMPARAM<br>RATES | Chemical reaction rates<br>Photolysis rates file |

### 1. Meteorological Data

REMSAD requires input of winds (u- and v-vector wind components), temperatures, surface pressure, specific humidity, vertical diffusion coefficients, and rainfall rates. The meteorological input files were developed from a 1996 annual MM5 model run that was developed for previous projects. MM5 is the Fifth-Generation NCAR / Penn State Mesoscale Model. MM5 (Grell *et. al.*, 1994) is a numerical meteorological model that solves the full set of physical and thermodynamic equations which govern atmospheric motions. MM5 was run in a nested-grid mode with 2 levels of resolution: 108 km, and 36km with 23 vertical layers sigma layers extending from the surface to the 100 mb pressure level. The model was simulated in five day segments with an eight hour ramp-up period. The MM5 runs were started at 0Z, which is 7PM EST. The first eight hours of each five day period were removed before being input into REMSAD. Figure IV-2 shows the MM5 and REMSAD 36km domain superimposed on each other. Table IV-2 lists the vertical grid structures for the MM5 and REMSAD domains. Further detailed information concerning the development of the 1996 MM5 datasets can be found in (Olerud, 2000)

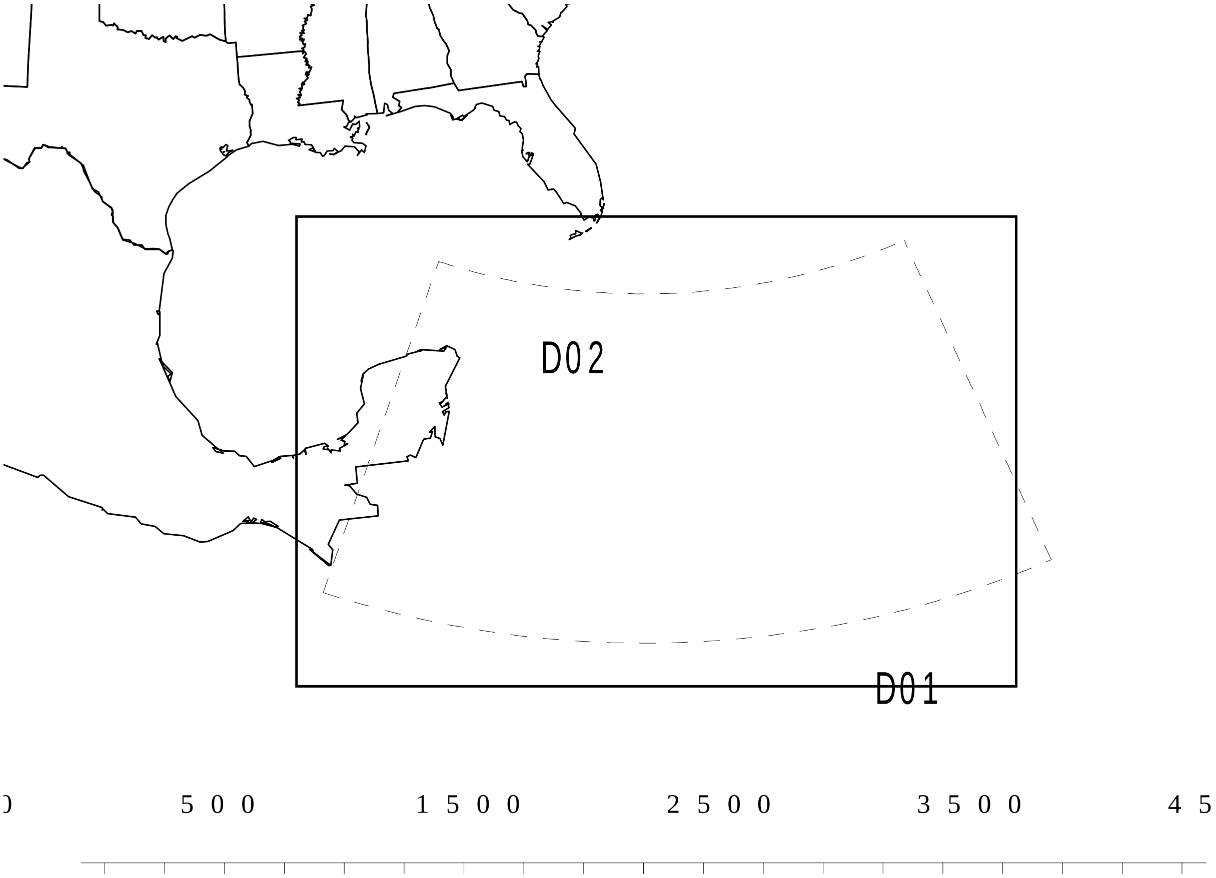

**Figure IV-2.** MM5 36km Domain (solid box) and REMSAD Domain (dashed lines).

**Table IV-2.** Vertical Grid Structure for 1996 MM5 and HDE REMSAD Domains. Layer heights represent the top of each layer. The first layer is from the ground up to 153 meters.

| REMSAD Layer | MM5 Layer | Sigma | Approximate Height(m) | Pressure(mb) |
|---|---|---|---|---|
| 0 | 0 | 1.000 | 0.0 | 1000.0 |
|  | 1 | 0.995 | 38.0 | 995.5 |
|  | 2 | 0.988 | 91.5 | 989.2 |
| 1 | 3 | 0.980 | 152.9 | 982.0 |
|  | 4 | 0.970 | 230.3 | 973.0 |

| REMSAD Layer | MM5 Layer | Sigma | Approximate Height(m) | Pressure(mb) |
|---|---|---|---|---|
| | 5 | 0.956 | 339.5 | 960.4 |
| 2 | 6 | 0.938 | 481.6 | 944.2 |
| | 7 | 0.916 | 658.1 | 924.4 |
| | 8 | 0.893 | 845.8 | 903.7 |
| | 9 | 0.868 | 1053.9 | 881.2 |
| 3 | 10 | 0.839 | 1300.7 | 855.1 |
| | 11 | 0.808 | 1571.4 | 827.2 |
| | 12 | 0.777 | 1849.6 | 799.3 |
| | 13 | 0.744 | 2154.5 | 769.6 |
| 4 | 14 | 0.702 | 2556.6 | 731.8 |
| | 15 | 0.648 | 3099.0 | 683.2 |
| | 16 | 0.582 | 3805.8 | 623.8 |
| 5 | 17 | 0.500 | 4763.7 | 550.0 |
| | 18 | 0.400 | 6082.5 | 460.0 |
| 6 | 19 | 0.300 | 7627.9 | 370.0 |
| | 20 | 0.200 | 9510.5 | 280.0 |
| 7 | 21 | 0.120 | 11465.1 | 208.0 |
| | 22 | 0.052 | 13750.2 | 146.0 |
| 8 | 23 | 0.000 | 16262.4 | 100.0 |

The physical options selected for this configuration of MM5 include the following:

1. One-way nested grids
2. Nonhydrostatic dynamics
3. Four-dimensional data assimilation (FDDA):
    - Analysis nudging of wind, temperature, and mixing ratios
    - Nudging coefficients range from $1.0 \times 10^{-5}\ s^{-1}$ to $3.0 \times 10^{-4}\ s^{-1}$
4. Explicit moisture treatment:
    - 3-D predictions of cloud and precipitation fields
    - Simple ice microphysics
    - Cloud effects on surface radiation
    - Moist vertical diffusion in clouds
    - Normal evaporative cooling
5. Boundary conditions:
    - Time and inflow/outflow relaxation
6. Cumulus cloud parameterization schemes:
    - Anthes-Kuo (108-km grid)
    - Kain-Fritsch (36-km grid)

7. No shallow convection
8. Full 3-dimensional Coriolis force
9. Drag coefficients vary with stability
10. Vertical mixing of momentum in mixed layer
11. Virtual temperature effects
12. PBL process parameterization: MRF scheme
13. Surface layer parameterization:
    - Fluxes of momentum, sensible and latent heat
    - Ground temperature prediction using energy balance equation
    - 24 land use categories
14. Atmospheric radiation schemes:
    - Simple cooling
    - Long- and short-wave radiation scheme
15. Sea ice treatment:
    - Forced Great Lakes/Hudson Bay to permanent ice under very cold conditions
    - 36-km treatment keyed by observations of sea ice over the Great Lakes
16. Snow cover:
    - Assumed no snow cover for July and August
    - National Center for Environmental Prediction (NCEP) snow cover for January to June, and for September to December

The MM5 model output cannot be directly input into REMSAD due to differences in the grid coordinate systems and file formats. A postprocessor called MM5REMSAD was developed to convert the MM5 data into REMSAD format. This postprocessor was used to develop 3-hour average meteorological input files from the MM5 output. Documentation of the MM5REMSAD code and further details on the development of the input files is contained in (Mansell, 2000).

### 2. Initial and Boundary Conditions, and Surface Characteristics

Application of the REMSAD modeling system requires data files specifying the initial species concentration fields (AIRQUALITY) and lateral species concentrations (BOUNDARY). Due the extent of the proposed modeling domains and the regional-scale nature of the REMSAD model, these inputs were developed based on "clean" background concentration values. The HDE modeling used temporally and spatially (horizontal) invariant data for both initial and boundary conditions. Species concentration values were allowed to decay vertically for most species. Table IV-3 summarizes the initial and boundary conditions used in the HDE REMSAD modeling.

**Table IV-3.** REMSAD Initial and Boundary Conditions (ppm)

| | **Layer 1** | **Layer 2** | **Layer 3** | **Layer 4** | **Layer 5** | **Layer 6** | **Layer 7** | **Layer 8** |
|---|---|---|---|---|---|---|---|---|
| **Species** | | | | | | | | |
| **NO** | 1.00E-12 | 1.00E-12 | 1.00E-12 | 1.00E-12 | 8.57E-13 | 5.71E-13 | 2.86E-13 | 7.14E-14 |
| **NO2** | 1.00E-04 | 1.00E-04 | 1.00E-04 | 1.00E-04 | 8.57E-05 | 5.71E-05 | 2.86E-05 | 7.14E-06 |
| **O3** | 4.00E-02 | 4.00E-02 | 4.00E-02 | 4.00E-02 | 4.00E-02 | 4.00E-02 | 4.00E-02 | 4.00E-02 |
| **SO2** | 7.00E-04 | 7.00E-04 | 7.00E-04 | 7.00E-04 | 6.00E-04 | 4.00E-04 | 2.00E-04 | 5.00E-05 |
| **NH3** | 5.00E-04 | 5.00E-04 | 5.00E-04 | 5.00E-04 | 3.67E-04 | 1.63E-04 | 4.08E-05 | 2.55E-06 |

|  | Layer 1 | Layer 2 | Layer 3 | Layer 4 | Layer 5 | Layer 6 | Layer 7 | Layer 8 |
|---|---|---|---|---|---|---|---|---|
| **VOC** | 2.00E-02 | 2.00E-02 | 2.00E-02 | 2.00E-02 | 1.71E-02 | 1.14E-02 | 5.71E-03 | 1.43E-03 |
| **CARB** | 1.00E-07 | 1.00E-07 | 1.00E-07 | 1.00E-07 | 1.00E-07 | 1.00E-07 | 1.00E-07 | 1.00E-07 |
| **ISOP** | 1.00E-09 | 1.00E-09 | 1.00E-09 | 1.00E-09 | 1.00E-09 | 1.00E-09 | 1.00E-09 | 1.00E-09 |
| **CO** | 1.00E-01 | 1.00E-01 | 1.00E-01 | 1.00E-01 | 1.00E-01 | 1.00E-01 | 1.00E-01 | 1.00E-01 |
| **HNO3** | 1.00E-05 | 1.00E-05 | 1.00E-05 | 1.00E-05 | 8.57E-06 | 5.71E-06 | 2.86E-06 | 7.14E-07 |
| **PNO3** | 1.00E-05 | 1.00E-05 | 1.00E-05 | 1.00E-05 | 7.35E-06 | 3.27E-06 | 8.16E-07 | 5.10E-08 |
| **GSO4** | 1.00E-04 | 1.00E-04 | 1.00E-04 | 1.00E-04 | 7.35E-05 | 3.27E-05 | 8.16E-06 | 5.10E-07 |
| **ASO4** | 1.00E-12 | 1.00E-12 | 1.00E-12 | 1.00E-12 | 8.57E-13 | 5.71E-13 | 2.86E-13 | 7.14E-14 |
| **NH4N** | 1.00E-05 | 1.00E-05 | 1.00E-05 | 1.00E-05 | 7.35E-06 | 3.27E-06 | 8.16E-07 | 5.10E-08 |
| **NH4S** | 1.00E-04 | 1.00E-04 | 1.00E-04 | 1.00E-04 | 7.35E-05 | 3.27E-05 | 8.16E-06 | 5.10E-07 |
| **SOA** | 1.00E-03 | 1.00E-03 | 1.00E-03 | 1.00E-03 | 7.35E-04 | 3.27E-04 | 8.16E-05 | 5.10E-06 |
| **POA** | 1.00E-03 | 1.00E-03 | 1.00E-03 | 1.00E-03 | 7.35E-04 | 3.27E-04 | 8.16E-05 | 5.10E-06 |
| **PEC** | 5.00E-03 | 5.00E-03 | 5.00E-03 | 5.00E-03 | 3.67E-03 | 1.63E-03 | 4.08E-04 | 2.55E-05 |
| **PMFINE** | 1.00E-03 | 1.00E-03 | 1.00E-03 | 1.00E-03 | 7.35E-04 | 3.27E-04 | 8.16E-05 | 5.10E-06 |
| **PMCOARS** | 1.00E-03 | 1.00E-03 | 1.00E-03 | 1.00E-03 | 6.30E-04 | 1.87E-04 | 2.33E-05 | 3.64E-07 |

Application of the REMSAD model requires specification of gridded terrain elevations (TERRAIN) and landuse characteristics (SURFACE). The SURFACE data files provides the fraction of the 11 landuse categories recognized by REMSAD in each grid cell. Landuse characteristics are used in the model for the calculation of deposition parameters. For this task, a landuse/terrain processor, PROC_LUTERR, was developed based on the MM5 TERRAIN preprocessor. Landuse data was obtained from the USGS Global 30 sec. vegetation database which is the same database used in the 1996 MM5 models runs. This dataset provides 24 landuse categories, including urban. For the REMSAD application, the 10 min. (1/6 deg.) datasets was utilized. The processor remapped the 24 USGS vegetation categories to those required for application of REMSAD. It also aggregated the 10 min resolution data to the ~36 km horizontal resolution used for this REMSAD application.

For the TERRAIN input data files, a similar global terrain elevation dataset is also available from NCAR and was used for this task. While it is possible to use the terrain elevations obtained from the MM5 model output data files, it was deemed more appropriate to begin with the USGS 10 min. resolution database due to the various map projections and interpolations involved in developing the required data files for the geodetic coordinates used in REMSAD. However, because proper application of REMSAD will require zero terrain elevations, “dummy” terrain files (with all zeroes) were developed and provided for input to REMSAD.

### 3. Emissions Inputs

The REMSAD emissions input files were generated using the EPS2.5 emissions preprocessing system. The annual county level HDE emissions inventory data was speciated, temporally allocated and gridded to the REMSAD domain. The individual species contained in these inventory files were oxides of nitrogen ($NO_x$), volatile organic compounds (VOC), carbon monoxide (CO), sulfur dioxide ($SO_2$), ammonia ($NH_3$), primary $PM_{10}$, and primary $PM_{2.5}$. The primary PM emissions were further speciated into primary elemental carbon (PEC), primary organic aerosols[10] (POA), primary sulfate (GSO4), primary nitrate (PNO3), crustal/fugitive (PMFINE), and primary course particles in the 2.5-10 um range (PMCOARS). Secondary organic aerosols (SOA) are estimated from the total anthropogenic VOC emissions. The yield of SOA is calculated from the raw county level VOC inventory and the SOA emissions were input into REMSAD in the same way as primary PM emissions (EPA, 2000b).

The annual emissions for stationary and nonroad sources were processed to generate separate sets of emissions representing typical weekday, Saturday, and Sunday emissions for each season. For mobile sources, monthly emissions were obtained from the mass emissions files and processed to create emissions for each day-type for each month. Hourly emissions for anthropogenic emissions were created by applying diurnal profile factors to the daily emissions. Hourly biogenic emissions were created by applying a typical diurnal pattern to monthly average biogenic VOC emissions developed using the BEIS2 model. Biogenic emissions were not altered for any of the scenarios modeled.

## D. Model Performance Evaluation

The goal of the 1996 base year modeling was to reproduce the atmospheric processes resulting in formation and dispersion of fine particulate matter across the U.S. An operational model performance evaluation for $PM_{2.5}$ and its related speciated components (e.g., sulfate, nitrate, elemental carbon etc.) for 1996 was performed in order to estimate the ability of the modeling system to replicate base year concentrations. All of the observational data used in this analysis can be found at the CAPITA website:

*http://capita.wustl.edu/datawarehouse/Datasets/CAPITA/NAMPM_fine/Data/NAMPM_f.html*

This evaluation is comprised principally of statistical assessments of model versus observed pairs. The robustness of any evaluation is directly proportional to the amount and quality of the ambient data available for comparison. Unfortunately, there are few $PM_{2.5}$ monitoring networks with available data for evaluation of the HDE PM modeling. Critical limitations of the existing databases are a lack of urban monitoring sites with speciated measurements and poor geographic representation of ambient concentration in the East. $PM_{2.5}$ monitoring networks were recently expanded in 1999 to include more than 1000 Federal Reference Method (FRM) monitoring sites. The purpose of this network is to monitor $PM_{2.5}$ mass levels in urban areas. These monitors only measure total $PM_{2.5}$ mass and do not measure PM species. In the next 1-2 years a new network of ~300 urban oriented speciation monitor sites will begin operation across the country. These monitors will collect a full range of $PM_{2.5}$ species that are necessary to evaluate models and to develop $PM_{2.5}$ control strategies.

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[10] The primary organic carbon emissions were multiplied by a factor of 1.2 to account for the additional mass of oxygen and other compounds typically found attached to particulate organic carbon.

The largest available ambient database for 1996 comes from the **I**nteragency **M**onitoring of **PRO**tected **V**isual **E**nvironments (IMPROVE) network. IMPROVE is a cooperative visibility monitoring effort between EPA, federal land management agencies, and state air agencies. Data is collected at Class I areas across the United States mostly at National Parks, National Wilderness Areas, and other protected pristine areas (IMPROVE 2000). There were approximately 60 IMPROVE sites that had complete annual $PM_{2.5}$ mass and/or $PM_{2.5}$ species data for 1996. Forty two sites were in the West[11] and 18 sites were in the East. Figure IV-3 shows the locations of the IMPROVE monitoring sites used in this evaluation. IMPROVE data is collected twice weekly (Wednesday and Saturday). Thus, there is a total of 104 possible samples per year or 26 samples per season. For this analysis, a 50% completeness criteria was used. That is, in order to be counted in the statistics a site had to have > 50% complete data in all 4 seasons. If any season was missing, an annual average was not calculated for the site. See Appendix F for a list of the IMPROVE sites used in the evaluation.

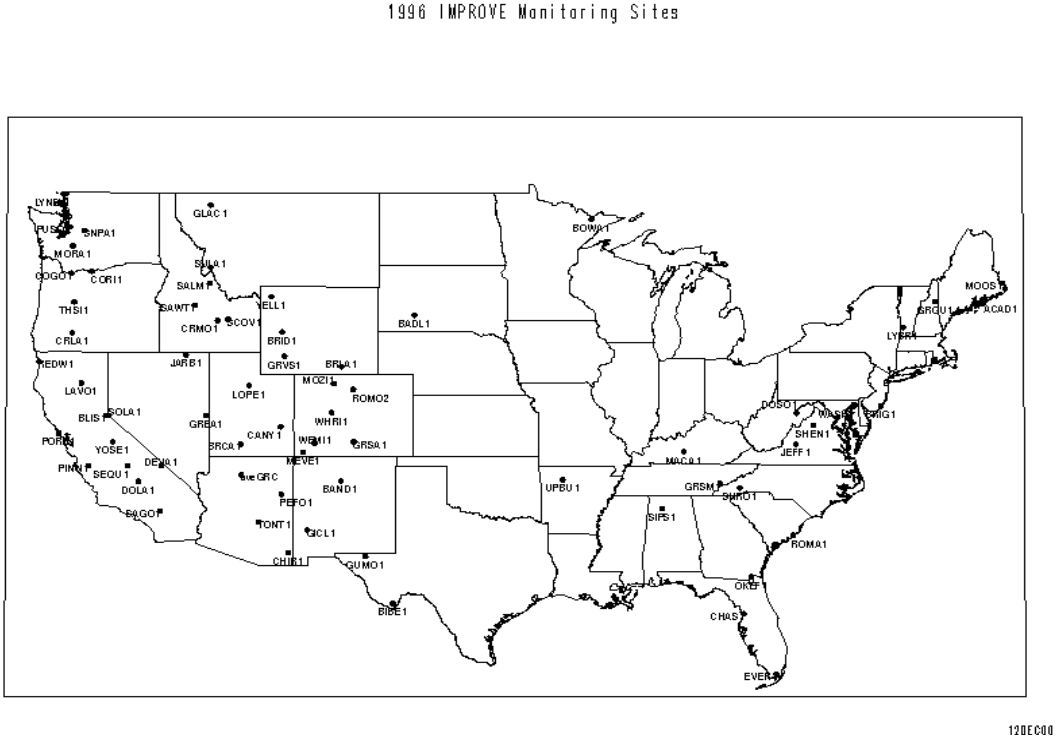

**Figure IV-3.** Map of 1996 IMPROVE monitoring sites used in the REMSAD model performance evaluation.

The observed IMPROVE data used for the performance evaluation was $PM_{2.5}$ mass, sulfate ion, nitrate ion, elemental carbon, organic aerosols, and crustal material (soils). The REMSAD model output species were postprocessed in order to achieve compatibility with the observation species. The following is the translation of the REMSAD output species into $PM_{2.5}$ and related species:

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[11] The dividing line between the West and East was defined as the 100th meridian.

Sulfate Ion: $TSO4 = ASO4 + GSO4$
Nitrate Ion: $PNO3$
Organic aerosols: $TOA = POA + SOA$
Elemental Carbon: $PEC$
Crustal Material (soils): $PMFINE$
$PM_{2.5}$: $PM_{2.5} = PMFINE + 1.375 * (ASO4 + GSO4) + 1.29 * (PNO3) + POA + SOA + PEC$

where, TSO4 is total sulfate ion, ASO4 is aqueous path sulfate, GSO4 is gaseous path sulfate, PNO3 is nitrate ion, TOA is total organic aerosols, POA is primary organic aerosol, SOA is secondary organic aerosol, PEC is primary elemental carbon, and PMFINE is primary fine particles (other unspeciated primary $PM_{2.5}$). $PM_{2.5}$ is defined as the sum of the individual species. Sulfate ion is multiplied by 1.375 and nitrate ion is multiplied by 1.29 in order to account for particulate ammonium. It is assumed that sulfate and nitrate exist in the atmosphere and in the model as ammonium sulfate and ammonium nitrate respectively.

### 1. Statistical Definitions

Below are the definitions of statistics used for the evaluation. The statistics are similar to those used for a previous REMSAD evaluation of a 1990 basecase (Wayland, 1999). The format of all the statistics is such that negative values indicate model predictions that were less than their observed counterparts. Positive statistics indicate model overestimation of observed PM. The statistics were calculated for the entire REMSAD domain and separately for the East and West. The dividing line between East and West is the 100th meridian.

**Mean Observation:** The mean observed value (in ug/m3) averaged over all monitored days in the year and then averaged over all sites in the region.

$$OBS = \frac{1}{N}\sum_{i=1}^{N} Obs_{x,t}^{i}$$

**Mean REMSAD Prediction:** The mean predicted value (in ug/m3) paired in time and space with the observations and then averaged over all sites in the region.

$$PRED = \frac{1}{N}\sum_{i=1}^{N} Pred_{x,t}^{i}$$

**Ratio of the Means**: Ratio of the predicted over the observed values. A ratio of greater than 1 indicates on overprediction and a ratio of less than 1 indicates an underprediction.

$$RATIO \; \frac{1}{N} \, {}_{i\;1}^{\;N} \, \frac{Pred_{x,t}^{i}}{Obs_{x,t}^{i}}$$

**Mean Bias (ug/m3):** This performance statistic averages the difference (model - observed) over all pairs in which the observed values were greater than zero. A mean bias of zero indicates that the model over predictions and model under predictions exactly cancel each other out. Note that the model bias is defined such that it is a positive quantity when model prediction exceeds the observation, and vice versa. This model performance estimate is used to make statements about the absolute or unnormalized bias in the model simulation

$$BIAS \; \frac{1}{N} \, {}_{i\;1}^{\;N} \, (Pred_{x,t}^{i} \quad Obs_{x,t}^{i})$$

**Mean Fractional Bias (percent):** Normalized bias can become very large when a minimum threshold is not used. Therefore fractional bias is used as a substitute. The fractional bias for cases with factors of 2 under- and over-prediction are -67 and + 67 percent, respectively (as opposed to -50 and +100 percent, when using normalized bias, which is not presented here). Fractional bias is a useful model performance indicator because it has the advantage of equally weighting positive and negative bias estimates. The single largest disadvantage in this estimate of model performance is that the estimated concentration (i.e., prediction, Pred) is found in both the numerator and denominator.

**M**

$$FBIAS \quad \frac{2}{N} \, {}_{i\;1}^{\;N} \, \frac{(Pred_{x,t}^{i} \quad Obs_{x,t}^{i})}{(Pred_{x,t}^{i} \quad Obs_{x,t}^{i})} \;\; 100$$

**ean Error (ug/m3):** This performance statistic averages the absolute value of the difference (model - observed) over all pairs in which the observed values were greater than zero. It is similar to mean bias except that the absolute value of the difference is used so that the error is always positive.

$$ERR \quad \frac{1}{N} \, {}_{i\;1}^{\;N} \, Pred_{x,t}^{i} \quad Obs_{x,t}^{i}$$

**Mean Fractional Error:** Normalized error can become very large when a minimum threshold is not used. Therefore fractional error is used as a substitute. It is similar to the fractional bias except the absolute value of the difference is used so that the error is always positive.

$$FERROR = \frac{2}{N}\sum_{i=1}^{N}\frac{\left|Pred_{x,t}^{i} - Obs_{x,t}^{i}\right|}{Pred_{x,t}^{i} + Obs_{x,t}^{i}} \times 100$$

### 2. Results of REMSAD Performance Evaluation

The statistics described above are presented for the entire domain, the Eastern sites, and the Western sites. The model's ability to replicate annual average $PM_{2.5}$ and $PM_{2.5}$ species concentrations at the IMPROVE sites is as follows:

#### a. $PM_{2.5}$ Performance

Table IV-4 lists the performance statistics for $PM_{2.5}$ at the IMPROVE sites. For the full domain, $PM_{2.5}$ is underpredicted ~25%. The ratio of the means is 0.77 with a bias of -0.93 ug/m3. It can be seen that most of this underprediction is due to the Western sites. The West is underpredicted by ~35% while the East is overpredicted by ~10 %. The fractional bias is less than 10% in the East, while the fractional error is ~40%. The fractional bias and error in the West is 31% and 65% respectively. The observed $PM_{2.5}$ concentrations in the East are relatively high compared to the West. REMSAD displays an ability to differentiate between generally high and low $PM_{2.5}$ areas.

**Table IV-4.** Annual mean $PM_{2.5}$ performance at IMPROVE sites.

| | No. of Sites | Mean REMSAD Predictions (ug/m3) | Mean Observations (ug/m3) | Ratio of Means (pred/obs) | Bias (ug/m3) | Fractional Bias (%) | Error (ug/m3) | Fractional Error (%) |
|---|---|---|---|---|---|---|---|---|
| National | 59 | 5.14 | 6.07 | 0.77 | -0.93 | -21.1 | 3.04 | 58.2 |
| East | 17 | 11.38 | 10.55 | 1.07 | 0.82 | 2.8 | 4.40 | 41.8 |
| West | 42 | 2.61 | 4.26 | 0.65 | -1.64 | -30.7 | 2.48 | 64.9 |

#### b. Sulfate Performance

Table IV-5 lists the performance statistics for particulate sulfate at the IMPROVE sites. Domainwide, sulfate performance is better than PM2.5 with a slight overprediction of 9%. The sulfate bias in the West is close to zero, while there is a ~25% overprediction of annual sulfate levels in the East. The biases are relatively low, however the errors are considerably higher indicating that some overpredicted values are canceling out some underpredicted values.

**Table IV-5.** Annual mean sulfate ion performance at IMPROVE sites.

| | No. of Sites | Mean REMSAD Predictions (ug/m3) | Mean Observations (ug/m3) | Ratio of Means (pred/obs) | Bias (ug/m3) | Fractional Bias (%) | Error (ug/m3) | Fractional Error (%) |
|---|---|---|---|---|---|---|---|---|
| National | 60 | 1.87 | 1.63 | 1.09 | 0.24 | 4.4 | 0.85 | 51.5 |
| East | 18 | 4.71 | 3.81 | 1.25 | 0.90 | 9.0 | 2.00 | 47.6 |
| West | 42 | 0.65 | 0.70 | 1.02 | -0.05 | 2.4 | 0.35 | 53.2 |

### c. Elemental Carbon Performance

Table IV-6 lists the performance statistics for primary elemental carbon at the IMPROVE sites. Performance for elemental carbon predictions is similar to that of sulfate with a slight overprediction in the East and a slight underprediction in the West. Model performance between the East and West was remarkably similar. The bias is very low, but the fractional error is ~50% of the observed values.

**Table IV-6.** Annual mean elemental carbon performance at IMPROVE sites

| | No. of Sites | Mean REMSAD Predictions (ug/m3) | Mean Observations (ug/m3) | Ratio of Means (pred/obs) | Bias (ug/m3) | Fractional Bias (%) | Error (ug/m3) | Fractional Error (%) |
|---|---|---|---|---|---|---|---|---|
| National | 48 | 0.30 | 0.31 | 1.10 | -0.01 | 10.5 | 0.18 | 56.2 |
| East | 16 | 0.50 | 0.47 | 1.26 | 0.03 | 14.8 | 0.24 | 50.8 |
| West | 32 | 0.21 | 0.24 | 1.02 | -0.03 | 8.3 | 0.14 | 58.9 |

### d. Organic Aerosol Performance

Table IV-7 lists the performance statistics for primary organic aerosols at the IMPROVE sites. Organic aerosols are underpredicted nationwide. The East and West are equally underpredicted by about 35%. Both the fractional bias and fractional errors are higher than for PM2.5, sulfate, and elemental carbon. It is clear that the model is not accounting for all of the organics that were observed.

Currently REMSAD has a very crude accounting for secondarily formed organics (SOA). In the atmosphere, SOA is formed from both anthropogenic and biogenic VOC emissions. REMSAD accounts for anthropogenic SOA by estimating the SOA yield from anthropogenic VOC emissions. Currently REMSAD does not account for biogenic SOA which mostly comes from terpene emissions from coniferous trees. It is expected that in the IMPROVE Class I areas, the majority of the SOA will be from biogenic emissions. This is a possible explanation for the modeled underprediction of measured organic aerosols.

Also, at some Class I areas, particularly in the West, wildfires account for a portion of the annual observed organic aerosol measurements. The current emission inventory is lacking in detailed representation of wildfires that occurred in 1996 which may be important for model evaluation, but not necessarily for the HDE analysis.

**Table IV-7.** Annual mean organic aerosol performance at IMPROVE sites

| | No. of Sites | Mean REMSAD Predictions (ug/m3) | Mean Observations (ug/m3) | Ratio of Means (pred/obs) | Bias (ug/m3) | Fractional Bias (%) | Error (ug/m3) | Fractional Error (%) |
|---|---|---|---|---|---|---|---|---|
| National | 48 | 0.76 | 1.25 | 0.67 | -0.48 | -44.1 | 0.81 | 74.8 |
| East | 16 | 1.11 | 1.74 | 0.68 | -0.63 | -38.3 | 0.99 | 64.5 |
| West | 32 | 0.60 | 1.01 | 0.67 | -0.41 | -47.0 | 0.72 | 79.9 |

### e. Nitrate Performance

Table IV-8 lists the performance statistics for nitrate ion at the IMPROVE sites. Nitrate is generally overpredicted in the East and somewhat underpredicted in the West. The ratio of the means in the East is 2.80 indicating an overprediction. The fractional bias is close to zero, but the fractional error is > 100%. This indicates that on a day to day basis the model is relatively unbiased, but it does a poor job of predicting individual days (indicated by the high error). When the model overpredicts, it overpredicts by a large margin (which causes the high overall ratio of means). In the western United States, the overall ratio of the means is near unity, but the fractional bias is strongly negative, which indicates an underprediction. And the fractional error is slightly higher than in the East. Again, the model is not accurately predicting day to day concentrations.

It is important to consider these results in the context that the observed nitrate concentrations at the IMPROVE sites are very low. The mean nationwide observations are only 0.40 ug/m3. It is often difficult for models to replicate very low concentrations of secondarily formed pollutants. Nitrate is generally a small percentage of the measured $PM_{2.5}$ at almost all of the IMPROVE sites. Nitrate can be an important contributor to $PM_{2.5}$ in some urban areas (particularly in California) but performance for those areas could not be assessed due to the lack of urban area speciated nitrate data for 1996.

**Table IV-8.** Annual mean nitrate ion performance at IMPROVE sites

| | No. of Sites | Mean REMSAD Predictions (ug/m3) | Mean Observations (ug/m3) | Ratio of Means (pred/obs) | Bias (ug/m3) | Fractional Bias (%) | Error (ug/m3) | Fractional Error (%) |
|---|---|---|---|---|---|---|---|---|
| National | 51 | 0.68 | 0.40 | 1.64 | 0.29 | -46.7 | 0.63 | 134.4 |
| East | 17 | 1.48 | 0.54 | 2.80 | 0.94 | -1.1 | 1.19 | 126.8 |
| West | 33 | 0.27 | 0.32 | 1.04 | -.05 | -70.3 | 0.35 | 138.3 |

### f. PMFINE-Other (crustal) Performance

Table IV-9 lists the performance statistics for PMFINE-other or primary crustal emissions. The observations show crustal $PM_{2.5}$ to be generally higher in the West than in the East. But REMSAD is predicting higher crustal concentrations in the East. The largest categories of PMFINE-other are fugitive dust sources such as paved roads, unpaved roads, construction, and animal feed lots. There is a large uncertainty in the handling of these emissions in the inventory. It is apparent that too much fugitive dust is being emitted in the East. It is evident from the performance statistics that further work needs to be done to study the magnitude of these emissions and how they are emitted into the model.

**Table IV-9.** Annual mean PMFINE (crustal) performance at IMPROVE sites

| | No. of Sites | Mean REMSAD Predictions (ug/m3) | Mean Observations (ug/m3) | Ratio of Means (pred/obs) | Bias (ug/m3) | Fractional Bias (%) | Error (ug/m3) | Fractional Error (%) |
|---|---|---|---|---|---|---|---|---|
| National | 60 | 0.96 | 0.63 | 2.11 | 0.33 | 47.1 | 0.86 | 96.0 |
| East | 18 | 1.76 | 0.52 | 4.10 | 1.24 | 106.1 | 1.46 | 118.1 |
| West | 42 | 0.62 | 0.68 | 1.26 | -0.06 | 21.8 | 0.61 | 86.6 |

### g. Summary of Model Performance Results Using Improve Data

The purpose of this model performance evaluation was to evaluate the capabilities of the REMSAD modeling system in reproducing annual average concentrations for all IMPROVE sites in the contiguous U.S. for fine particulate mass and its associated speciated components. When considering annual average statistics (e.g., predicted versus observed), which are computed and aggregated over all sites and all days, REMSAD underpredicts fine particulate mass ($PM_{2.5}$), by ~20%. $PM_{2.5}$ in the Eastern U.S. is slightly overpredicted, while $PM_{2.5}$ in the West is underpredicted by about 35%. Eastern sulfate and elemental carbon are slightly overpredicted while nitrate and crustal are largely overpredicted. This is balanced by an underprediction in organic aerosols. Overall the $PM_{2.5}$ performance in the East is relatively unbiased due to the dominance of sulfate in the observations. Western predictions of sulfate, nitrate, elemental carbon, and crustal are all relatively unbiased, while organic aerosols are underpredicted by ~30%. Since organic aerosols are the largest $PM_{2.5}$ component in the West, overall Western $PM_{2.5}$ is underpredicted by ~35%.

It should be noted that $PM_{2.5}$ modeling is an evolving science. There have been few regional or national scale model applications for primary and secondary PM. In fact, this is the one of the first nationwide applications of a full chemistry Eulerian grid model for the purpose of estimating annual average concentrations of $PM_{2.5}$ and its component species. Also, unlike ozone modeling, there is essentially no database of past performance statistics against which to measure the performance of the HDE PM modeling. Given the state of the science relative to PM modeling, it is inappropriate to judge PM model performance using criteria derived for other pollutants, like ozone. Still, the performance of the HDE PM modeling is very encouraging, especially considering that the results may be limited by our current knowledge of PM science and chemistry, and by the emissions inventories for primary PM and secondary PM precursor pollutants.

### h. Comparisons to Other Observational Databases

Although IMPROVE was the largest and most complete nationwide fine particulate network operating in 1996, there were several other smaller networks operating at the time that can provide useful ambient data for comparison with REMSAD results. Among those networks are the CASTNET Dry Deposition network and the California Air Resources Board (CARB) PM2.5 monitoring network. There were 26 CASTNET sites which collected weekly average data for several PM species and 16 CARB sites which collected PM2.5 mass and several elemental species.

Both datasets are inconsistent with the sampling methodologies and sampling frequency of the IMPROVE sites. Further analysis needs to be completed to determine the reliability of these data. A preliminary review of REMSAD model performance for these networks confirms what was seen relative to the IMPROVE evaluation. Total nitrate values (particulate nitrate plus nitric acid) at the CASTNET sites were overpredicted in the East and underpredicted in the West. At the CARB sites, PM2.5 mass was underpredicted similar to what was seen at the Western IMPROVE sites.

## E. Visibility Calculations

Several visibility parameters were calculated from the REMSAD model output for use in the benefits analysis. These included light extinction coefficient ($b_{ext}$) and deciviews. The extinction coefficient values in units of inverse megameters (1/M) were calculated based on the IMPROVE protocol (IMPROVE, 2000). The reconstructed bext values were calculated as follows:

$$b_{ext} = 10.0 + [3.0 * f(RH) * (1.375 * (GSO4 + ASO4)) + 3.0 * f(RH) * (1.29 * PNO3) + 4.0 * (SOA + POA) + 10.0 * PEC + 1.0 * (PMFINE) + 0.6 * (PMCOARS)]$$

The 10.0 initial value accounts for atmospheric background (i.e., Rayleigh) scattering. f(RH) refers to the relative humidity correction function as defined by IMPROVE (2000). The relative humidity correction factor was calculated from the 3-hour average modeled relative humidity at each grid cell for each time period. The 3-hour average $b_{ext}$ was then calculated. All of the hours in the day were then averaged to derive a daily average $b_{ext}$ for each grid cell. The daily average $b_{ext}$ were averaged to derive the annual average $b_{ext}$. The annual average $b_{ext}$ were used to calculate the annual average deciviews (dv) using the following formula:

$$dv = 10.0 \times \ln\left[\frac{(b_{ext})}{10.0\ Mm^{-1}}\right]$$

## F. Need for HDE Rule Based on Unhealthy Annual Mean PM2.5 Concentrations

One component of the analysis to support the need for this rule was the calculation of the number of people living in metropolitan counties that experience annual PM2.5 concentrations above certain concentration levels. This “exposure” type analysis was based on 1999 ambient annual mean PM2.5 concentrations and projected future PM2.5 concentrations, based on modeling of the HDE emissions scenarios. To provide the future-year estimates of PM2.5 concentrations, relative reduction factors (RRFs) were calculated then applied to the ambient data. The procedures for determining the RRFs are similar to those in EPA’s draft guidance for demonstrating attainment of air quality goals for PM2.5 and regional haze (EPA, 2000d). One aspect of the procedures in the guidance is to develop RRFs for each component species of PM2.5 and then to apply these to the corresponding species measured at the monitoring site. However, the only extensive nationwide data base of ambient PM2.5 data available for this analysis does not contain speciated data. Thus, the RRFs were calculated for PM2.5 and applied to the monitoring data as described as follows. First, the REMSAD predictions of individual PM2.5 component species were postprocessed to provide annual mean PM2.5 concentrations in each grid cell for the 1996 base year and each future year scenario modeled (i.e., 2020 base and control and 2030 base and control). The gridded data were used to determine RRFs at each monitoring site with valid annual mean PM2.5 data. The RRFs were calculated as the ratio of mean PM2.5 in the future-year scenario to the mean for the 1996 base year. This value was then multiplied by the ambient PM2.5 concentration at the monitoring site to provide an estimate of the future PM2.5 concentrations at that site. These future concentrations were then used in the “exposure” analysis as described in the HDE docket (Docket A-99-06, item IV-B-01). The annual mean PM2.5 data along with the corresponding future-year estimates, based on RRFs, are provided in Appendix E.

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## Appendix A:
## Areas in the East with Predicted Exceedances in 2007, 2020, and/or 2030 and 1-Hour Design Values >=125 ppb or >=113 ppb.

| MSA/ CMSA / State |
|---|
| Atlanta, GA |
| Barnstable-Yarmouth, MA |
| Baton Rouge, LA |
| Benton Harbor, MI |
| Beaumont-Port Arthur, TX |
| Biloxi-Gulfport-Pascagoula, MS |
| Birmingham, AL |
| Boston-Worcester-Lawrence, MA-HN-ME-CT |
| Charleston, WV |
| Charlotte-Gastonia-Rock Hill, NC-SC |
| Chicago-Gary-Kenosha, IL-IN-WI |
| Cincinnati-Hamilton, OH-KY-IN |
| Cleveland-Akron, OH |
| Detroit-Ann Arbor-Flint, MI |
| Grand Rapids-Muskegon-Holland, MI |
| Hartford, CT |
| Houma, LA |
| Houston-Galveston-Brazoria, TX |
| Huntington-Ashland, WV-KY-OH |
| Lake Charles, LA |
| Louisville, KY-IN |
| Macon, GA MSA |
| Memphis, TN-AR-MS |
| Milwaukee-Racine, WI |
| Nashville, TN |
| New Orleans, LA |
| New London-Norwich, CT-RI |
| New York-Northern New Jersey-Long Island, NY-NJ-CT-PA |
| Norfolk-Virginia Beach-Newport News, VA-NC |
| Orlando, FL |
| Pensacola, FL |
| Philadelphia-Wilmington- Atlantic City, PA-NJ-DE-MD |
| Providence-Fall River-Warwick, RI-MA |
| Richmond-Petersburg, VA |
| St. Louis, MO-IL |
| Tampa-St. Petersburg-Clearwater, FL |
| Washington, DC-Baltimore, DC, MD, VA |

# Appendix B:
# Number of 12km Grid Cells Assigned to Each CMSA/MSA

| CMSA/MSAs | Total Number of Grid Cells in Area |
|---|---|
| Atlanta, GA MSA | 115 |
| Barnstable, MA MSA | 19 |
| Baton Rouge, LA MSA | 30 |
| Beaumont-Port Arthur, TX MSA | 39 |
| Benton Harbor, MI MSA | 15 |
| Biloxi, MS MSA | 41 |
| Birmingham, AL MSA | 64 |
| Boston, MA CMSA | 189 |
| Charleston, WV MSA | 31 |
| Charlotte, NC MSA | 69 |
| Chicago, IL CMSA | 129 |
| Cincinnati, OH CMSA | 71 |
| Cleveland, OH CMSA | 68 |
| Detroit, MI CMSA | 126 |
| Grand Rapids, MI MSA | 58 |
| Hartford, CT MSA | 41 |
| Houma, LA MSA | 51 |
| Houston, TX CMSA | 132 |
| Huntington, WV MSA | 47 |
| Lake Charles, LA MSA | 20 |
| Louisville, KY MSA | 45 |
| Macon, GA MSA | 37 |
| Memphis, TN MSA | 58 |
| Milwaukee, WI CMSA | 39 |
| Nashville, TN MSA | 78 |
| New London, CT MSA | 12 |
| New Orleans, LA MSA | 96 |
| New York City, NY CMSA | 195 |
| Norfolk, VA MSA | 60 |

| | |
|---|---|
| Orlando, FL  MSA | 61 |
| Pensacola, FL  MSA | 34 |
| Philadelphia, PA  CMSA | 118 |
| Providence, RI  MSA | 20 |
| Richmond, VA  MSA | 66 |
| St. Louis, MO  MSA | 127 |
| Tampa, FL  MSA | 56 |
| Washington, DC-Baltimore, MD CMSA | 187 |

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# Appendix C :
# 1-hour Ozone Metrics

# APPENDIX C
## 1-Hour Ozone Metrics
## Total ppb Increase

| **Total ppb Increase** | **Total** | **Atlanta** | **Barnstable, MA** | **Baton Rouge** | **Beaumont** | **Benton Harbor, MI** | **Biloxi** | **Birmingham** |
|---|---|---|---|---|---|---|---|---|
| 1996 Base vs 2007 Base | 56.9 | 0 | 0 | 0 | 0 | 0 | 0 | 18.9 |
| 2020 Base vs 2020 Control | 196.3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2030 Base vs 2030 Control | 352.1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| **Increase, on Average (ppb)** | **Total** | **Atlanta** | **Barnstable, MA** | **Baton Rouge** | **Beaumont** | **Benton Harbor, MI** | **Biloxi** | **Birmingham** |
|---|---|---|---|---|---|---|---|---|
| 1996 Base vs 2007 Base | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 |
| 2020 Base vs 2020 Control | 0.2 | 0.0 | N.A. | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2030 Base vs Control | 0.3 | 0.0 | N.A. | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Note: N.A. is used to denote that there are no exceedances in the Base Case or Control Case | | | | | | | | |

## APPENDIX C
## 1-Hour Ozone Metrics
## Total ppb Increase

| **Total ppb Increase** | **Boston** | **Charleston, WV** | **Charlotte** | **Chicago** | **Cincinnati** | **Cleveland** | **Detroit** | **Grand Rapids** |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| 1996 Base vs 2007 Base | 0 | 0 | 0 | 0 | 5.8 | 0 | 16.3 | 0 |
| | | | | | | | | |
| 2020 Base vs 2020 Control | 0 | 0 | 0 | 11.4 | 0 | 0 | 35 | 0 |
| | | | | | | | | |
| 2030 Base vs 2030 Control | 0 | 0 | 0 | 36.3 | 0 | 0 | 68.8 | 0 |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| **Increase, on Average (ppb)** | **Boston** | **Charleston, WV** | **Charlotte** | **Chicago** | **Cincinnati** | **Cleveland** | **Detroit** | **Grand Rapids** |
| | | | | | | | | |
| 1996 Base vs 2007 Base | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.5 | 0.0 |
| | | | | | | | | |
| 2020 Base vs 2020 Control | 0.0 | 0.0 | 0.0 | 0.9 | 0.0 | 0.0 | 2.3 | 0.0 |
| | | | | | | | | |
| 2030 Base vs Control | 0.0 | 0.0 | 0.0 | 2.0 | 0.0 | 0.0 | 3.3 | 0.0 |
| | | | | | | | | |
| Note: N.A. is used to denote that there are no exceedances in the Base Case or Control Case | | | | | | | | |

# APPENDIX C
## 1-Hour Ozone Metrics
## Total ppb Increase

| **Total ppb Increase** | **Hartford** | **Houma, LA** | **Houston** | **Huntington, WV** | **Lake Charles, LA** | **Louisville** | **Macon, GA** | **Memphis** |
|---|---|---|---|---|---|---|---|---|
| 1996 Base vs 2007 Base | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 11.2 |
| 2020 Base vs 2020 Control | 0 | 0 | 0.6 | 0 | 0 | 4 | 0 | 0 |
| 2030 Base vs 2030 Control | 0 | 0 | 1.9 | 0 | 0 | 5.5 | 0 | 0 |
| **Increase, on Average (ppb)** | **Hartford** | **Houma, LA** | **Houston** | **Huntington, WV** | **Lake Charles, LA** | **Louisville** | **Macon, GA** | **Memphis** |
| 1996 Base vs 2007 Base | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 |
| 2020 Base vs 2020 Control | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 |
| 2030 Base vs Control | 0.0 | 0.0 | 0.0 | 0.0 | N.A. | 0.2 | N.A. | 0.0 |
| Note: N.A. is used to denote that there are no exceedances in the Base Case or Control Case | | | | | | | | |

# APPENDIX C
## 1-Hour Ozone Metrics
## Total ppb Increase

| **Total ppb Increase** | **Milwaukee** | **Nashville** | **New London, CT** | **New Orleans** | **New York City** | **Norfolk** | **Orlando** | **Pensacola** |
|---|---|---|---|---|---|---|---|---|
| 1996 Base vs 2007 Base | 0 | 0 | 0 | 0 | 3.5 | 0 | 0 | 0 |
| 2020 Base vs 2020 Control | 0 | 0 | 0 | 3.9 | 141.3 | 0 | 0 | 0 |
| 2030 Base vs 2030 Control | 0 | 0 | 0 | 6.3 | 221.1 | 0 | 0 | 0 |

| **Increase, on Average (ppb)** | **Milwaukee** | **Nashville** | **New London, CT** | **New Orleans** | **New York City** | **Norfolk** | **Orlando** | **Pensacola** |
|---|---|---|---|---|---|---|---|---|
| 1996 Base vs 2007 Base | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2020 Base vs 2020 Control | 0.0 | 0.0 | 0.0 | 0.0 | 0.8 | 0.0 | 0.0 | N.A. |
| 2030 Base vs Control | 0.0 | 0.0 | 0.0 | 0.0 | 1.1 | N.A. | 0.0 | N.A. |
| Note: N.A. is used to denote that there are no exceedances in the Base Case or Control Case | | | | | | | | |

APPENDIX C
1-Hour Ozone Metrics
Total ppb Increase

| **Total ppb Increase** | **Philadelphia** | **Providence** | **Richmond** | **St. Louis** | **Tampa** | **Wash-Baltimore** |
|---|---|---|---|---|---|---|
| | | | | | | |
| 1996 Base vs 2007 Base | 0 | 0 | 0 | 0 | 1.2 | 0 |
| | | | | | | |
| 2020 Base vs 2020 Control | 0 | 0 | 0 | 0 | 0 | 0.1 |
| | | | | | | |
| 2030 Base vs 2030 Control | 0 | 0 | 0 | 0 | 0 | 12.2 |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| **Increase, on Average (ppb)** | **Philadelphia** | **Providence** | **Richmond** | **St. Louis** | **Tampa** | **Wash-Baltimore** |
| | | | | | | |
| 1996 Base vs 2007 Base | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | | | | |
| 2020 Base vs 2020 Control | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | | | | |
| 2030 Base vs Control | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 |
| | | | | | | |
| Note: N.A. is used to denote that there are no exceedances in the Base Case or Control Case | | | | | | |

# APPENDIX C
## 1-Hour Ozone Metics
## Peak Ozone

| **Peak 1-Hour Ozone (ppb)** | **Max** | **Mean** | **Atlanta** | **Barnstable, MA** | **Baton Rouge** | **Beaumont** | **Benton Harbor, MI** | **Biloxi** | **Birmingham** |
|---|---|---|---|---|---|---|---|---|---|
| 1996 Base | 219 | 162 | 219 | 160 | 154 | 135 | 160 | 144 | 153 |
| 2007 Base | 191 | 147 | 191 | 134 | 148 | 134 | 148 | 140 | 135 |
| 2020 Base | 183 | 143 | 183 | 124 | 144 | 129 | 144 | 136 | 132 |
| 2020 Control | 171 | 138 | 171 | 116 | 142 | 127 | 140 | 134 | 126 |
| 2030 Base | 191 | 147 | 191 | 128 | 148 | 132 | 148 | 138 | 135 |
| 2030 Control | 176 | 140 | 176 | 118 | 145 | 130 | 143 | 136 | 128 |

| **Percent Change** | **Max** | **Mean** | **Atlanta** | **Barnstable, MA** | **Baton Rouge** | **Beaumont** | **Benton Harbor, MI** | **Biloxi** | **Birmingham** |
|---|---|---|---|---|---|---|---|---|---|
| 1996 vs 2007 Base | -12.8% | -9.6% | -12.8% | -16.2% | -3.9% | -0.7% | -7.5% | -2.8% | -11.8% |
| 2007 Base vs 2020 Base | -4.2% | -2.9% | -4.2% | -7.5% | -2.7% | -3.7% | -2.7% | -2.9% | -2.2% |
| 2020 Base vs 2020 Control | -6.6% | -3.4% | -6.6% | -6.5% | -1.4% | -1.6% | -2.8% | -1.5% | -4.5% |
| 2020 Base vs 2030 Base | 4.4% | 2.7% | 4.4% | 3.2% | 2.8% | 2.3% | 2.8% | 1.5% | 2.3% |
| 2030 Base vs 2030 Control | -7.9% | -4.2% | -7.9% | -7.8% | -2.0% | -1.5% | -3.4% | -1.4% | -5.2% |
| 1996 vs 2030 Control | -19.6% | -13.6% | -19.6% | -26.2% | -5.8% | -3.7% | -10.6% | -5.6% | -16.3% |

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APPENDIX C
1-Hour Ozone Metics
Peak Ozone

| **Peak 1-Hour Ozone (ppb)** | **Boston** | **Charleston, WV** | **Charlotte** | **Chicago** | **Cincinnati** | **Cleveland** | **Detroit** | **Grand Rapids** |
|---|---|---|---|---|---|---|---|---|
| 1996 Base | 167 | 152 | 153 | 169 | 167 | 144 | 160 | 163 |
| 2007 Base | 145 | 134 | 141 | 150 | 135 | 136 | 146 | 151 |
| 2020 Base | 138 | 129 | 138 | 147 | 135 | 140 | 156 | 147 |
| 2020 Control | 130 | 125 | 132 | 143 | 130 | 139 | 158 | 143 |
| 2030 Base | 142 | 130 | 144 | 151 | 139 | 143 | 157 | 152 |
| 2030 Control | 132 | 124 | 136 | 146 | 134 | 142 | 161 | 146 |

| **Percent Change** | **Boston** | **Charleston, WV** | **Charlotte** | **Chicago** | **Cincinnati** | **Cleveland** | **Detroit** | **Grand Rapids** |
|---|---|---|---|---|---|---|---|---|
| 1996 vs 2007 Base | -13.2% | -11.8% | -7.8% | -11.2% | -19.2% | -5.6% | -8.7% | -7.4% |
| 2007 Base vs 2020 Base | -4.8% | -3.7% | -2.1% | -2.0% | 0.0% | 2.9% | 6.8% | -2.6% |
| 2020 Base vs 2020 Control | -5.8% | -3.1% | -4.3% | -2.7% | -3.7% | -0.7% | 1.3% | -2.7% |
| 2020 Base vs 2030 Base | 2.9% | 0.8% | 4.3% | 2.7% | 3.0% | 2.1% | 0.6% | 3.4% |
| 2030 Base vs 2030 Control | -7.0% | -4.6% | -5.6% | -3.3% | -3.6% | -0.7% | 2.5% | -3.9% |
| 1996 vs 2030 Control | -21.0% | -18.4% | -11.1% | -13.6% | -19.8% | -1.4% | 0.6% | -10.4% |

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# APPENDIX C
## 1-Hour Ozone Metics
## Peak Ozone

| **Peak 1-Hour Ozone (ppb)** | **Hartford** | **Houma, LA** | **Houston** | **Huntington, WV** | **Lake Charles, LA** | **Louisville** | **Macon, GA** | **Memphis** |
|---|---|---|---|---|---|---|---|---|
| 1996 Base | 188 | 147 | 165 | 171 | 132 | 172 | 173 | 160 |
| 2007 Base | 171 | 143 | 156 | 151 | 129 | 149 | 132 | 151 |
| 2020 Base | 166 | 140 | 155 | 150 | 125 | 148 | 126 | 144 |
| 2020 Control | 159 | 138 | 153 | 147 | 124 | 147 | 118 | 140 |
| 2030 Base | 171 | 143 | 159 | 153 | 128 | 151 | 129 | 148 |
| 2030 Control | 162 | 140 | 157 | 150 | 126 | 152 | 118 | 142 |

| **Percent Change** | **Hartford** | **Houma, LA** | **Houston** | **Huntington, WV** | **Lake Charles, LA** | **Louisville** | **Macon, GA** | **Memphis** |
|---|---|---|---|---|---|---|---|---|
| 1996 vs 2007 Base | -9.0% | -2.7% | -5.5% | -11.7% | -2.3% | -13.4% | -23.7% | -5.6% |
| 2007 Base vs 2020 Base | -2.9% | -2.1% | -0.6% | -0.7% | -3.1% | -0.7% | -4.5% | -4.6% |
| 2020 Base vs 2020 Control | -4.2% | -1.4% | -1.3% | -2.0% | -0.8% | -0.7% | -6.3% | -2.8% |
| 2020 Base vs 2030 Base | 3.0% | 2.1% | 2.6% | 2.0% | 2.4% | 2.0% | 2.4% | 2.8% |
| 2030 Base vs 2030 Control | -5.3% | -2.1% | -1.3% | -2.0% | -1.6% | 0.7% | -8.5% | -4.1% |
| 1996 vs 2030 Control | -13.8% | -4.8% | -4.8% | -12.3% | -4.5% | -11.6% | -31.8% | -11.2% |

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# APPENDIX C
## 1-Hour Ozone Metics
## Peak Ozone

| **Peak 1-Hour Ozone (ppb)** | **Milwaukee** | **Nashville** | **New London, CT** | **New Orleans** | **New York City** | **Norfolk** | **Orlando** | **Pensacola** |
|---|---|---|---|---|---|---|---|---|
| 1996 Base | 148 | 166 | 180 | 165 | 192 | 146 | 145 | 139 |
| 2007 Base | 130 | 154 | 159 | 160 | 178 | 127 | 138 | 127 |
| 2020 Base | 125 | 149 | 152 | 157 | 175 | 126 | 132 | 121 |
| 2020 Control | 125 | 142 | 145 | 156 | 168 | 123 | 125 | 115 |
| 2030 Base | 130 | 154 | 157 | 160 | 180 | 130 | 137 | 124 |
| 2030 Control | 128 | 145 | 148 | 158 | 171 | 126 | 127 | 116 |

| **Percent Change** | **Milwaukee** | **Nashville** | **New London, CT** | **New Orleans** | **New York City** | **Norfolk** | **Orlando** | **Pensacola** |
|---|---|---|---|---|---|---|---|---|
| 1996 vs 2007 Base | -12.2% | -7.2% | -11.7% | -3.0% | -7.3% | -13.0% | -4.8% | -8.6% |
| 2007 Base vs 2020 Base | -3.8% | -3.2% | -4.4% | -1.9% | -1.7% | -0.8% | -4.3% | -4.7% |
| 2020 Base vs 2020 Control | 0.0% | -4.7% | -4.6% | -0.6% | -4.0% | -2.4% | -5.3% | -5.0% |
| 2020 Base vs 2030 Base | 4.0% | 3.4% | 3.3% | 1.9% | 2.9% | 3.2% | 3.8% | 2.5% |
| 2030 Base vs 2030 Control | -1.5% | -5.8% | -5.7% | -1.2% | -5.0% | -3.1% | -7.3% | -6.5% |
| 1996 vs 2030 Control | -13.5% | -12.7% | -17.8% | -4.2% | -10.9% | -13.7% | -12.4% | -16.5% |

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APPENDIX C
1-Hour Ozone Metics
Peak Ozone

| **Peak 1-Hour Ozone (ppb)** | **Philadelphia** | **Providence** | **Richmond** | **St. Louis** | **Tampa** | **Wash-Baltimore** |
|---|---|---|---|---|---|---|
| 1996 Base | 166 | 173 | 170 | 151 | 188 | 172 |
| 2007 Base | 142 | 149 | 150 | 141 | 173 | 154 |
| 2020 Base | 135 | 141 | 141 | 136 | 161 | 150 |
| 2020 Control | 127 | 134 | 137 | 128 | 150 | 143 |
| 2030 Base | 139 | 146 | 145 | 140 | 166 | 154 |
| 2030 Control | 129 | 136 | 139 | 129 | 152 | 145 |

| **Percent Change** | **Philadelphia** | **Providence** | **Richmond** | **St. Louis** | **Tampa** | **Wash-Baltimore** |
|---|---|---|---|---|---|---|
| 1996 vs 2007 Base | -14.5% | -13.9% | -11.8% | -6.6% | -8.0% | -10.5% |
| 2007 Base vs 2020 Base | -4.9% | -5.4% | -6.0% | -3.5% | -6.9% | -2.6% |
| 2020 Base vs 2020 Control | -5.9% | -5.0% | -2.8% | -5.9% | -6.8% | -4.7% |
| 2020 Base vs 2030 Base | 3.0% | 3.5% | 2.8% | 2.9% | 3.1% | 2.7% |
| 2030 Base vs 2030 Control | -7.2% | -6.8% | -4.1% | -7.9% | -8.4% | -5.8% |
| 1996 vs 2030 Control | -22.3% | -21.4% | -18.2% | -14.6% | -19.1% | -15.7% |

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APPENDIX C
1-Hour Ozone Metrics
Total Nonattainment

| **Total Nonattainment** | **Total** | **Atlanta** | **Barnstable, MA** | **Baton Rouge** | **Beaumont** | **Benton Harbor, MI** | **Biloxi** | **Birmingham** |
|---|---|---|---|---|---|---|---|---|
| **(ppb >= 125)** | | | | | | | | |
| 1996 Base | 39665.2 | 7738.3 | 192.8 | 1176.9 | 111.1 | 205.6 | 191.9 | 534.2 |
| 2007 Base | 12743.4 | 2604.9 | 11.6 | 687.4 | 49.5 | 65.5 | 81.6 | 36.7 |
| 2020 Base | 8334.2 | 1319.4 | 0 | 389.8 | 7.8 | 45.4 | 28.5 | 10.7 |
| 2020 Control | 5288.3 | 546.6 | 0 | 257.9 | 4 | 36.1 | 13.8 | 2 |
| 2030 Base | 12129.2 | 1945.1 | 3.7 | 635.4 | 24.4 | 61.1 | 59.8 | 17.5 |
| 2030 Control | 6841.1 | 636.9 | 0 | 406 | 10.5 | 42.6 | 29.2 | 3.5 |

| **Percent Change** | **Total** | **Atlanta** | **Barnstable, MA** | **Baton Rouge** | **Beaumont** | **Benton Harbor, MI** | **Biloxi** | **Birmingham** |
|---|---|---|---|---|---|---|---|---|
| 1996 vs 2007 Base | -67.9% | -66.3% | -94.0% | -41.6% | -55.4% | -68.1% | -57.5% | -93.1% |
| 2007 Base vs 2020 Base | -34.6% | -49.3% | -100.0% | -43.3% | -84.2% | -30.7% | -65.1% | -70.8% |
| 2020 Base vs 2020 Control | -36.5% | -58.6% | 0.0% | -33.8% | -48.7% | -20.5% | -51.6% | -81.3% |
| 2020 Base vs 2030 Base | 45.5% | 47.4% | N.A. | 63.0% | 212.8% | 34.6% | 109.8% | 63.6% |
| 2030 Base vs 2030 Control | -43.6% | -67.3% | -100.0% | -36.1% | -57.0% | -30.3% | -51.2% | -80.0% |
| Note: N.A. denotes predicted exceedances in the 2030 Base, but not in the 2020 Base | | | | | | | | |

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# APPENDIX C
## 1-Hour Ozone Metrics
## Total Nonattainment

| **Total Nonattainment (ppb >= 125)** | **Boston** | **Charleston, WV** | **Charlotte** | **Chicago** | **Cincinnati** | **Cleveland** | **Detroit** | **Grand Rapids** |
|---|---|---|---|---|---|---|---|---|
| 1996 Base | 608.8 | 288.2 | 292 | 374.9 | 1025.1 | 191.9 | 294.7 | 1160.5 |
| 2007 Base | 95.8 | 9.5 | 36.5 | 125.8 | 50.8 | 15.4 | 163.8 | 491.8 |
| 2020 Base | 23.5 | 4.2 | 22.6 | 120 | 33.6 | 15.4 | 212.2 | 343.2 |
| 2020 Control | 5.5 | 0.2 | 7.4 | 101 | 14.5 | 14.1 | 212 | 214.5 |
| 2030 Base | 56.3 | 5.3 | 48.3 | 174.7 | 72.5 | 27.5 | 254.5 | 472.8 |
| 2030 Control | 7.5 | 0 | 11.6 | 149.3 | 28.6 | 17.8 | 263.9 | 275.1 |
| **Percent Change** | **Boston** | **Charleston, WV** | **Charlotte** | **Chicago** | **Cincinnati** | **Cleveland** | **Detroit** | **Grand Rapids** |
| 1996 vs 2007 Base | -84.3% | -96.7% | -87.5% | -66.4% | -95.0% | -92.0% | -44.4% | -57.6% |
| 2007 Base vs 2020 Base | -75.5% | -55.8% | -38.1% | -4.6% | -33.9% | 0.0% | 29.5% | -30.2% |
| 2020 Base vs 2020 Control | -76.6% | -95.2% | -67.3% | -15.8% | -56.8% | -8.4% | -0.1% | -37.5% |
| 2020 Base vs 2030 Base | 139.6% | 26.2% | 113.7% | 45.6% | 115.8% | 78.6% | 19.9% | 37.8% |
| 2030 Base vs 2030 Control | -86.7% | -100.0% | -76.0% | -14.5% | -60.6% | -35.3% | 3.7% | -41.8% |
| Note: N.A. denotes predicted exceedances in the 2030 Base, but not in the 2020 Base | | | | | | | | |

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APPENDIX C
1-Hour Ozone Metrics
Total Nonattainment

| **Total Nonattainment** | **Hartford** | **Houma, LA** | **Houston** | **Huntington, WV** | **Lake Charles, LA** | **Louisville** | **Macon, GA** | **Memphis** |
|---|---|---|---|---|---|---|---|---|
| **(ppb >= 125)** | | | | | | | | |
| 1996 Base | 649.6 | 586.6 | 1597.5 | 1411.4 | 36.3 | 1437.1 | 491.8 | 284.1 |
| | | | | | | | | |
| 2007 Base | 346.7 | 288.2 | 640.5 | 71.7 | 12.7 | 267.3 | 7.6 | 89 |
| | | | | | | | | |
| 2020 Base | 303.5 | 165.3 | 437.4 | 52.7 | 0.8 | 277.3 | 1.6 | 72.5 |
| | | | | | | | | |
| 2020 Control | 219.6 | 119.5 | 325.8 | 36.1 | 0 | 229.6 | 0 | 47.7 |
| | | | | | | | | |
| 2030 Base | 377.9 | 285 | 663.2 | 68.9 | 8.5 | 347 | 4.7 | 100.5 |
| | | | | | | | | |
| 2030 Control | 263.9 | 182.8 | 441 | 44.5 | 2.3 | 272 | 0 | 63.8 |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| **Percent Change** | **Hartford** | **Houma, LA** | **Houston** | **Huntington, WV** | **Lake Charles, LA** | **Louisville** | **Macon, GA** | **Memphis** |
| | | | | | | | | |
| 1996 vs 2007 Base | -46.6% | -50.9% | -59.9% | -94.9% | -65.0% | -81.4% | -98.5% | -68.7% |
| | | | | | | | | |
| 2007 Base vs 2020 Base | -12.5% | -42.6% | -31.7% | -26.5% | -93.7% | 3.7% | -78.9% | -18.5% |
| | | | | | | | | |
| 2020 Base vs 2020 Control | -27.6% | -27.7% | -25.5% | -31.5% | -100.0% | -17.2% | -100.0% | -34.2% |
| | | | | | | | | |
| 2020 Base vs 2030 Base | 24.5% | 72.4% | 51.6% | 30.7% | 962.4% | 25.1% | 193.7% | 38.6% |
| | | | | | | | | |
| 2030 Base vs 2030 Control | -30.2% | -35.9% | -33.5% | -35.4% | -72.9% | -21.6% | -100.0% | -36.5% |
| | | | | | | | | |
| Note: N.A. denotes predicted | | | | | | | | |
| exceedances in the 2030 Base, | | | | | | | | |
| but not in the 2020 Base | | | | | | | | |

# APPENDIX C
## 1-Hour Ozone Metrics
## Total Nonattainment

| **Total Nonattainment (ppb >= 125)** | **Milwaukee** | **Nashville** | **New London, CT** | **New Orleans** | **New York City** | **Norfolk** | **Orlando** | **Pensacola** |
|---|---|---|---|---|---|---|---|---|
| 1996 Base | 69.4 | 1263.1 | 612.7 | 1857.5 | 5787.7 | 92.6 | 100.7 | 33.6 |
| 2007 Base | 5.3 | 103.8 | 259.6 | 1108 | 2190.4 | 5.5 | 40.6 | 2.3 |
| 2020 Base | 0.8 | 53 | 195.1 | 742.3 | 1870.2 | 1.3 | 11.6 | 0 |
| 2020 Control | 0.1 | 30.4 | 113.9 | 581.2 | 1430.6 | 0 | 0.2 | 0 |
| 2030 Base | 11.9 | 76.6 | 278.5 | 1130.3 | 2503.6 | 8.2 | 33 | 0 |
| 2030 Control | 4.1 | 36.6 | 152.5 | 826.4 | 1778.2 | 1.2 | 2.4 | 0 |
| **Percent Change** | **Milwaukee** | **Nashville** | **New London, CT** | **New Orleans** | **New York City** | **Norfolk** | **Orlando** | **Pensacola** |
| 1996 vs 2007 Base | -92.4% | -91.8% | -57.6% | -40.3% | -62.2% | -94.1% | -59.7% | -93.2% |
| 2007 Base vs 2020 Base | -84.9% | -48.9% | -24.8% | -33.0% | -14.6% | -76.4% | -71.4% | -100.0% |
| 2020 Base vs 2020 Control | -87.5% | -42.6% | -41.6% | -21.7% | -23.5% | -100.0% | -98.3% | 0.0% |
| 2020 Base vs 2030 Base | 1387.3% | 44.5% | 42.7% | 52.3% | 33.9% | 530.7% | 184.5% | 0.0% |
| 2030 Base vs 2030 Control | -65.5% | -52.2% | -45.2% | -26.9% | -29.0% | -85.4% | -92.7% | 0.0% |
| Note: N.A. denotes predicted exceedances in the 2030 Base, but not in the 2020 Base | | | | | | | | |

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# APPENDIX C
## 1-Hour Ozone Metrics
## Total Nonattainment

| **Total Nonattainment** | **Philadelphia** | **Providence** | **Richmond** | **St. Louis** | **Tampa** | **Wash-Baltimore** |
|---|---|---|---|---|---|---|
| **(ppb >= 125)** | | | | | | |
| 1996 Base | 1588.3 | 512.6 | 495.3 | 591.5 | 2396.9 | 3382 |
| 2007 Base | 162.3 | 155.4 | 160.3 | 74.2 | 1380.4 | 845 |
| 2020 Base | 68.7 | 79.4 | 85.3 | 32.9 | 803.8 | 502.4 |
| 2020 Control | 10.5 | 29.2 | 33 | 4.9 | 402.2 | 244.2 |
| 2030 Base | 150.9 | 133.6 | 121.1 | 61.5 | 1124.2 | 781.2 |
| 2030 Control | 24.3 | 43.3 | 42.4 | 9.9 | 464.8 | 302.2 |
| **Percent Change** | **Philadelphia** | **Providence** | **Richmond** | **St. Louis** | **Tampa** | **Wash-Baltimore** |
| 1996 vs 2007 Base | -89.8% | -69.7% | -67.6% | -87.5% | -42.4% | -75.0% |
| 2007 Base vs 2020 Base | -57.7% | -48.9% | -46.8% | -55.7% | -41.8% | -40.5% |
| 2020 Base vs 2020 Control | -84.7% | -63.2% | -61.3% | -85.1% | -50.0% | -51.4% |
| 2020 Base vs 2030 Base | 119.7% | 68.3% | 42.0% | 86.9% | 39.9% | 55.5% |
| 2030 Base vs 2030 Control | -83.9% | -67.6% | -65.0% | -83.9% | -58.7% | -61.3% |
| Note: N.A. denotes predicted exceedances in the 2030 Base, but not in the 2020 Base | | | | | | |

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APPENDIX C
1-Hour Metrics
Total ppb Reduction

| **Total ppb Reduction** | **Total** | **Atlanta** | **Barnstable, MA** | **Baton Rouge** | **Beaumont** | **Benton Harbor, MI** | **Biloxi** | **Birmingham** |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| 1996 Base vs 2007 Base | 47890.1 | 7584.5 | 377.5 | 576 | 83.9 | 281.2 | 146.5 | 1331.7 |
| | | | | | | | | |
| 2020 Base vs 2020 Control | 4161.8 | 1098 | 0 | 152.8 | 4.8 | 13 | 20.7 | 12.6 |
| | | | | | | | | |
| 2030 Base vs Control | 7569.8 | 2007.2 | 10.5 | 266 | 24.2 | 25.4 | 40.6 | 17 |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| **Reduction, on Average (ppb)** | **Total** | **Atlanta** | **Barnstable, MA** | **Baton Rouge** | **Beaumont** | **Benton Harbor, MI** | **Biloxi** | **Birmingham** |
| | | | | | | | | |
| 1996 Base vs 2007 Base | 16.2 | 20.2 | 18.0 | 4.6 | 3.1 | 14.8 | 3.8 | 23.8 |
| | | | | | | | | |
| 2020 Base vs 2020 Control | 4.9 | 12.2 | N.A. | 2.4 | 1.6 | 3.3 | 1.9 | 6.3 |
| | | | | | | | | |
| 2030 Base vs Control | 6.5 | 16.2 | 10.5 | 3.3 | 2.4 | 4.2 | 2.5 | 8.5 |
| | | | | | | | | |
| Note: N.A. is used to denote that there are no exceedances in the Base Case or Control Case | | | | | | | | |

# APPENDIX C
## 1-Hour Metrics
## Total ppb Reduction

| **Total ppb Reduction** | **Boston** | **Charleston, WV** | **Charlotte** | **Chicago** | **Cincinnati** | **Cleveland** | **Detroit** | **Grand Rapids** |
|---|---|---|---|---|---|---|---|---|
| 1996 Base vs 2007 Base | 909.5 | 1152 | 1137.7 | 382.6 | 2127.4 | 611.4 | 291.9 | 937.8 |
| 2020 Base vs 2020 Control | 31.9 | 4 | 32.1 | 36.5 | 28 | 1.3 | 24.7 | 142.4 |
| 2030 Base vs Control | 87 | 5.4 | 47.7 | 56.7 | 61.6 | 13.9 | 62.7 | 208.4 |

| **Reduction, on Average (ppb)** | **Boston** | **Charleston, WV** | **Charlotte** | **Chicago** | **Cincinnati** | **Cleveland** | **Detroit** | **Grand Rapids** |
|---|---|---|---|---|---|---|---|---|
| 1996 Base vs 2007 Base | 16.5 | 37.2 | 25.3 | 11.6 | 25.6 | 15.3 | 8.6 | 12.8 |
| 2020 Base vs 2020 Control | 8.0 | 4.0 | 6.4 | 2.8 | 4.0 | 1.3 | 1.6 | 4.3 |
| 2030 Base vs Control | 10.9 | 5.4 | 8.0 | 3.2 | 5.1 | 3.5 | 3.0 | 5.6 |
| Note: N.A. is used to denote that there are no exceedances in the Base Case or Control Case | | | | | | | | |

APPENDIX C
1-Hour Metrics
Total ppb Reduction

| **Total ppb Reduction** | **Hartford** | **Houma, LA** | **Houston** | **Huntington, WV** | **Lake Charles, LA** | **Louisville** | **Macon, GA** | **Memphis** |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| 1996 Base vs 2007 Base | 432.3 | 405.8 | 1321.8 | 3231.4 | 41.9 | 2575.7 | 1273.3 | 427.4 |
| | | | | | | | | |
| 2020 Base vs 2020 Control | 91.9 | 52.4 | 143.9 | 19.6 | 1.3 | 57.6 | 7.8 | 26.7 |
| | | | | | | | | |
| 2030 Base vs Control | 122.8 | 128 | 284.1 | 30.3 | 7.2 | 90.6 | 10.8 | 39.2 |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| **Reduction, on Average (ppb)** | **Hartford** | **Houma, LA** | **Houston** | **Huntington, WV** | **Lake Charles, LA** | **Louisville** | **Macon, GA** | **Memphis** |
| | | | | | | | | |
| 1996 Base vs 2007 Base | 12.7 | 4.4 | 7.9 | 35.1 | 3.2 | 23.8 | 33.5 | 11.9 |
| | | | | | | | | |
| 2020 Base vs 2020 Control | 5.1 | 1.9 | 2.5 | 3.3 | 1.3 | 2.4 | 7.8 | 3.3 |
| | | | | | | | | |
| 2030 Base vs Control | 6.5 | 2.5 | 3.3 | 4.3 | 1.8 | 3.4 | 10.8 | 3.9 |
| | | | | | | | | |
| Note: N.A. is used to denote that | | | | | | | | |
| there are no exceedances in the | | | | | | | | |
| Base Case or Control Case | | | | | | | | |

# APPENDIX C
## 1-Hour Metrics
## Total ppb Reduction

| **Total ppb Reduction** | **Milwaukee** | **Nashville** | **New London, CT** | **New Orleans** | **New York City** | **Norfolk** | **Orlando** | **Pensacola** |
|---|---|---|---|---|---|---|---|---|
| 1996 Base vs 2007 Base | 85.4 | 3959.9 | 390.1 | 953.9 | 4625.2 | 276.9 | 77.6 | 86.4 |
| 2020 Base vs 2020 Control | 6.4 | 37.5 | 98 | 195.6 | 687.8 | 2.9 | 21 | 0 |
| 2030 Base vs Control | 12.8 | 50.2 | 155.3 | 344 | 1156.1 | 10.5 | 55.3 | 0 |

| **Reduction, on Average (ppb)** | **Milwaukee** | **Nashville** | **New London, CT** | **New Orleans** | **New York City** | **Norfolk** | **Orlando** | **Pensacola** |
|---|---|---|---|---|---|---|---|---|
| 1996 Base vs 2007 Base | 14.2 | 38.8 | 13.9 | 4.4 | 14.0 | 16.3 | 6.5 | 10.8 |
| 2020 Base vs 2020 Control | 3.2 | 7.5 | 5.2 | 1.8 | 4.1 | 2.9 | 7.0 | N.A. |
| 2030 Base vs Control | 3.2 | 10.0 | 6.5 | 2.3 | 5.6 | 5.3 | 9.2 | N.A. |

Note: N.A. is used to denote that there are no exceedances in the Base Case or Control Case

# APPENDIX C
## 1-Hour Metrics
## Total ppb Reduction

| **Total ppb Reduction** | **Philadelphia** | **Providence** | **Richmond** | **St. Louis** | **Tampa** | **Wash-Baltimore** |
|---|---|---|---|---|---|---|
| | | | | | | |
| 1996 Base vs 2007 Base | 2431.8 | 504.5 | 537.3 | 1141 | 1311.1 | 3867.8 |
| | | | | | | |
| 2020 Base vs 2020 Control | 93.4 | 69.4 | 59 | 43.6 | 460.1 | 383.1 |
| | | | | | | |
| 2030 Base vs Control | 221.5 | 118.5 | 100.3 | 64.6 | 862.1 | 771.3 |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| **Reduction, on Average (ppb)** | **Philadelphia** | **Providence** | **Richmond** | **St. Louis** | **Tampa** | **Wash-Baltimore** |
| | | | | | | |
| 1996 Base vs 2007 Base | 19.6 | 15.8 | 17.9 | 16.8 | 10.2 | 17.8 |
| | | | | | | |
| 2020 Base vs 2020 Control | 6.2 | 6.9 | 6.6 | 7.3 | 8.1 | 7.4 |
| | | | | | | |
| 2030 Base vs Control | 7.9 | 8.5 | 9.1 | 9.2 | 11.1 | 10.3 |
| | | | | | | |
| Note: N.A. is used to denote that | | | | | | |
| there are no exceedances in the | | | | | | |
| Base Case or Control Case | | | | | | |

# APPENDIX C
## 1-Hour Ozone Metrics
## Total ppb Increase

| **Total ppb Increase** | **Total** | **Atlanta** | **Barnstable, MA** | **Baton Rouge** | **Beaumont** | **Benton Harbor, MI** | **Biloxi** | **Birmingham** |
|---|---|---|---|---|---|---|---|---|
| 1996 Base vs 2007 Base | 56.9 | 0 | 0 | 0 | 0 | 0 | 0 | 18.9 |
| 2020 Base vs 2020 Control | 196.3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2030 Base vs 2030 Control | 352.1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| **Increase, on Average (ppb)** | **Total** | **Atlanta** | **Barnstable, MA** | **Baton Rouge** | **Beaumont** | **Benton Harbor, MI** | **Biloxi** | **Birmingham** |
|---|---|---|---|---|---|---|---|---|
| 1996 Base vs 2007 Base | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 |
| 2020 Base vs 2020 Control | 0.2 | 0.0 | N.A. | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2030 Base vs Control | 0.3 | 0.0 | N.A. | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

Note: N.A. is used to denote that there are no exceedances in the Base Case or Control Case

# APPENDIX C
## 1-Hour Ozone Metrics
## Total ppb Increase

| **Total ppb Increase** | **Boston** | **Charleston, WV** | **Charlotte** | **Chicago** | **Cincinnati** | **Cleveland** | **Detroit** | **Grand Rapids** |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| 1996 Base vs 2007 Base | 0 | 0 | 0 | 0 | 5.8 | 0 | 16.3 | 0 |
| | | | | | | | | |
| 2020 Base vs 2020 Control | 0 | 0 | 0 | 11.4 | 0 | 0 | 35 | 0 |
| | | | | | | | | |
| 2030 Base vs 2030 Control | 0 | 0 | 0 | 36.3 | 0 | 0 | 68.8 | 0 |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| **Increase, on Average (ppb)** | **Boston** | **Charleston, WV** | **Charlotte** | **Chicago** | **Cincinnati** | **Cleveland** | **Detroit** | **Grand Rapids** |
| | | | | | | | | |
| 1996 Base vs 2007 Base | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.5 | 0.0 |
| | | | | | | | | |
| 2020 Base vs 2020 Control | 0.0 | 0.0 | 0.0 | 0.9 | 0.0 | 0.0 | 2.3 | 0.0 |
| | | | | | | | | |
| 2030 Base vs Control | 0.0 | 0.0 | 0.0 | 2.0 | 0.0 | 0.0 | 3.3 | 0.0 |
| | | | | | | | | |
| Note: N.A. is used to denote that there are no exceedances in the Base Case or Control Case | | | | | | | | |

APPENDIX C
1-Hour Ozone Metrics
Total ppb Increase

| **Total ppb Increase** | **Hartford** | **Houma, LA** | **Houston** | **Huntington, WV** | **Lake Charles, LA** | **Louisville** | **Macon, GA** | **Memphis** |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| 1996 Base vs 2007 Base | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 11.2 |
| | | | | | | | | |
| 2020 Base vs 2020 Control | 0 | 0 | 0.6 | 0 | 0 | 4 | 0 | 0 |
| | | | | | | | | |
| 2030 Base vs 2030 Control | 0 | 0 | 1.9 | 0 | 0 | 5.5 | 0 | 0 |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| **Increase, on Average (ppb)** | **Hartford** | **Houma, LA** | **Houston** | **Huntington, WV** | **Lake Charles, LA** | **Louisville** | **Macon, GA** | **Memphis** |
| | | | | | | | | |
| 1996 Base vs 2007 Base | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 |
| | | | | | | | | |
| 2020 Base vs 2020 Control | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 |
| | | | | | | | | |
| 2030 Base vs Control | 0.0 | 0.0 | 0.0 | 0.0 | N.A. | 0.2 | N.A. | 0.0 |
| | | | | | | | | |
| Note: N.A. is used to denote that there are no exceedances in the Base Case or Control Case | | | | | | | | |

## APPENDIX C
## 1-Hour Ozone Metrics
## Total ppb Increase

| **Total ppb Increase** | **Milwaukee** | **Nashville** | **New London, CT** | **New Orleans** | **New York City** | **Norfolk** | **Orlando** | **Pensacola** |
|---|---|---|---|---|---|---|---|---|
| 1996 Base vs 2007 Base | 0 | 0 | 0 | 0 | 3.5 | 0 | 0 | 0 |
| 2020 Base vs 2020 Control | 0 | 0 | 0 | 3.9 | 141.3 | 0 | 0 | 0 |
| 2030 Base vs 2030 Control | 0 | 0 | 0 | 6.3 | 221.1 | 0 | 0 | 0 |
| **Increase, on Average (ppb)** | **Milwaukee** | **Nashville** | **New London, CT** | **New Orleans** | **New York City** | **Norfolk** | **Orlando** | **Pensacola** |
| 1996 Base vs 2007 Base | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2020 Base vs 2020 Control | 0.0 | 0.0 | 0.0 | 0.0 | 0.8 | 0.0 | 0.0 | N.A. |
| 2030 Base vs Control | 0.0 | 0.0 | 0.0 | 0.0 | 1.1 | N.A. | 0.0 | N.A. |
| Note: N.A. is used to denote that there are no exceedances in the Base Case or Control Case | | | | | | | | |

# APPENDIX C
## 1-Hour Ozone Metrics
## Total ppb Increase

| **Total ppb Increase** | **Philadelphia** | **Providence** | **Richmond** | **St. Louis** | **Tampa** | **Wash-Baltimore** |
|---|---|---|---|---|---|---|
| | | | | | | |
| 1996 Base vs 2007 Base | 0 | 0 | 0 | 0 | 1.2 | 0 |
| | | | | | | |
| 2020 Base vs 2020 Control | 0 | 0 | 0 | 0 | 0 | 0.1 |
| | | | | | | |
| 2030 Base vs 2030 Control | 0 | 0 | 0 | 0 | 0 | 12.2 |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| **Increase, on Average (ppb)** | **Philadelphia** | **Providence** | **Richmond** | **St. Louis** | **Tampa** | **Wash-Baltimore** |
| | | | | | | |
| 1996 Base vs 2007 Base | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | | | | |
| 2020 Base vs 2020 Control | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | | | | |
| 2030 Base vs Control | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 |
| | | | | | | |
| Note: N.A. is used to denote that there are no exceedances in the Base Case or Control Case | | | | | | |

# Appendix D:
# 8 Hour Relative Reduction Factors

## APPENDIX D
## 8-Hour Relative Reduction Factors

| Site Id. | State | County | Area Name | RRF 2007 Base | RRF 2020 Base | RRF 2020 Control | RRF 2030 Base | RRF 2030 Control |
|---|---|---|---|---|---|---|---|---|
| 010270001 | AL | CLAY CO | CLAY CO, AL | 0.8211 | 0.7747 | 0.7277 | 0.7953 | 0.7304 |
| 010510001 | AL | ELMORE CO | MONTGOMERY, AL | 0.8784 | 0.8301 | 0.7836 | 0.8546 | 0.7903 |
| 010731003 | AL | JEFFERSON CO | BIRMINGHAM, AL | 0.8765 | 0.8145 | 0.7594 | 0.8385 | 0.7623 |
| 010731005 | AL | JEFFERSON CO | BIRMINGHAM, AL | 0.8541 | 0.8001 | 0.7532 | 0.8208 | 0.7555 |
| 010732006 | AL | JEFFERSON CO | BIRMINGHAM, AL | 0.8734 | 0.8133 | 0.7592 | 0.8370 | 0.7621 |
| 010735002 | AL | JEFFERSON CO | BIRMINGHAM, AL | 0.8634 | 0.8103 | 0.7612 | 0.8354 | 0.7679 |
| 010736002 | AL | JEFFERSON CO | BIRMINGHAM, AL | 0.8728 | 0.8154 | 0.7625 | 0.8389 | 0.7662 |
| 010790002 | AL | LAWRENCE CO | LAWRENCE CO, AL | 0.8428 | 0.8010 | 0.7628 | 0.8224 | 0.7700 |
| 010890014 | AL | MADISON CO | HUNTSVILLE, AL | 0.8743 | 0.8272 | 0.7817 | 0.8493 | 0.7872 |
| 010970003 | AL | MOBILE CO | MOBILE, AL | 0.9107 | 0.8786 | 0.8464 | 0.9007 | 0.8566 |
| 010970028 | AL | MOBILE CO | MOBILE, AL | 0.9035 | 0.8711 | 0.8385 | 0.8932 | 0.8485 |
| 011011002 | AL | MONTGOMERY CO | MONTGOMERY, AL | 0.8835 | 0.8398 | 0.7936 | 0.8667 | 0.8033 |
| 011170004 | AL | SHELBY CO | BIRMINGHAM, AL | 0.8632 | 0.8069 | 0.7546 | 0.8300 | 0.7578 |
| 011190002 | AL | SUMTER CO | SUMTER CO, AL | 0.8460 | 0.8266 | 0.7986 | 0.8497 | 0.8113 |
| 050350005 | AR | CRITTENDEN CO | MEMPHIS, TN-AR-MS | 0.9027 | 0.8899 | 0.8720 | 0.9102 | 0.8857 |
| 050970001 | AR | MONTGOMERY CO | MONTGOMERY CO, AR | 0.8917 | 0.8432 | 0.8071 | 0.8614 | 0.8118 |
| 051010002 | AR | NEWTON CO | NEWTON CO, AR | 0.8744 | 0.8421 | 0.8164 | 0.8580 | 0.8224 |
| 051190007 | AR | PULASKI CO | LITTLE ROCK-NORTH LITTLE ROCK, | 0.9008 | 0.8425 | 0.7992 | 0.8674 | 0.8071 |
| 051191002 | AR | PULASKI CO | LITTLE ROCK-NORTH LITTLE ROCK, | 0.9008 | 0.8426 | 0.7994 | 0.8675 | 0.8072 |
| 090010017 | CT | FAIRFIELD CO | NEW YORK CMSA | 0.9458 | 0.9508 | 0.9392 | 0.9690 | 0.9550 |
| 090011123 | CT | FAIRFIELD CO | NEW YORK CMSA | 0.9323 | 0.9324 | 0.9135 | 0.9516 | 0.9288 |
| 090013007 | CT | FAIRFIELD CO | NEW YORK CMSA | 0.9329 | 0.9197 | 0.8958 | 0.9423 | 0.9115 |
| 090019003 | CT | FAIRFIELD CO | NEW YORK CMSA | 0.9396 | 0.9437 | 0.9311 | 0.9622 | 0.9474 |
| 090031003 | CT | HARTFORD CO | HARTFORD, CT | 0.9059 | 0.8735 | 0.8332 | 0.8978 | 0.8447 |
| 090050006 | CT | LITCHFIELD CO | HARTFORD, CT | 0.8993 | 0.8672 | 0.8306 | 0.8921 | 0.8437 |
| 090070007 | CT | MIDDLESEX CO | HARTFORD, CT | 0.9197 | 0.8974 | 0.8657 | 0.9226 | 0.8812 |
| 090091123 | CT | NEW HAVEN CO | NEW YORK CMSA | 0.9274 | 0.9148 | 0.8899 | 0.9376 | 0.9064 |
| 090093002 | CT | NEW HAVEN CO | NEW YORK CMSA | 0.9165 | 0.8956 | 0.8663 | 0.9210 | 0.8822 |
| 090110008 | CT | NEW LONDON CO | NEW YORK CMSA | 0.9130 | 0.8929 | 0.8612 | 0.9184 | 0.8771 |
| 090131001 | CT | TOLLAND CO | HARTFORD, CT | 0.8935 | 0.8528 | 0.8173 | 0.8767 | 0.8283 |
| 100010002 | DE | KENT CO | PHILADELPHIA CMSA | 0.8729 | 0.8377 | 0.7971 | 0.8595 | 0.8040 |
| 100031003 | DE | NEW CASTLE CO | PHILADELPHIA CMSA | 0.9003 | 0.8823 | 0.8509 | 0.9020 | 0.8596 |
| 100031007 | DE | NEW CASTLE CO | PHILADELPHIA CMSA | 0.8726 | 0.8441 | 0.8033 | 0.8667 | 0.8110 |
| 100031010 | DE | NEW CASTLE CO | PHILADELPHIA CMSA | 0.8933 | 0.8733 | 0.8418 | 0.8933 | 0.8504 |
| 100051002 | DE | SUSSEX CO | SUSSEX CO, DE | 0.8759 | 0.8388 | 0.7973 | 0.8622 | 0.8053 |
| 100051003 | DE | SUSSEX CO | SUSSEX CO, DE | 0.8809 | 0.8473 | 0.8111 | 0.8680 | 0.8184 |
| 110010025 | DC | WASHINGTON | WASHINGTON, DC-MD-VA-WV | 0.9282 | 0.9206 | 0.8933 | 0.9410 | 0.9070 |
| 110010041 | DC | WASHINGTON | WASHINGTON, DC-MD-VA-WV | 0.9022 | 0.8828 | 0.8562 | 0.9018 | 0.8685 |
| 110010043 | DC | WASHINGTON | WASHINGTON, DC-MD-VA-WV | 0.9282 | 0.9206 | 0.8933 | 0.9410 | 0.9070 |
| 120013011 | FL | ALACHUA CO | GAINESVILLE, FL | 0.8972 | 0.8472 | 0.7903 | 0.8736 | 0.7935 |
| 120030002 | FL | BAKER CO | BAKER CO, FL | 0.8909 | 0.8416 | 0.7923 | 0.8652 | 0.7965 |
| 120094001 | FL | BREVARD CO | MELBOURNE-TITUSVILLE-PALM BAY, | 0.9393 | 0.8850 | 0.8357 | 0.9145 | 0.8446 |
| 120095001 | FL | BREVARD CO | MELBOURNE-TITUSVILLE-PALM BAY, | 0.9407 | 0.8882 | 0.8409 | 0.9166 | 0.8499 |
| 120310070 | FL | DUVAL CO | JACKSONVILLE, FL | 0.9173 | 0.8499 | 0.7976 | 0.8761 | 0.8025 |

APPENDIX D

8-Hour Relative Reduction Factors

| Site Id. | State | County | Area Name | RRF 2007 Base | RRF 2020 Base | RRF 2020 Control | RRF 2030 Base | RRF 2030 Control |
|---|---|---|---|---|---|---|---|---|
| 120310077 | FL | DUVAL CO | JACKSONVILLE, FL | 0.9117 | 0.8570 | 0.8100 | 0.8831 | 0.8177 |
| 120330004 | FL | ESCAMBIA CO | PENSACOLA, FL | 0.9224 | 0.8859 | 0.8480 | 0.9086 | 0.8564 |
| 120330018 | FL | ESCAMBIA CO | PENSACOLA, FL | 0.9223 | 0.8857 | 0.8486 | 0.9085 | 0.8573 |
| 120330024 | FL | ESCAMBIA CO | PENSACOLA, FL | 0.9223 | 0.8857 | 0.8486 | 0.9085 | 0.8573 |
| 120570081 | FL | HILLSBOROUGH CO | TAMPA-ST. PETERSBURG-CLEARWA | 0.9513 | 0.9105 | 0.8676 | 0.9390 | 0.8792 |
| 120571035 | FL | HILLSBOROUGH CO | TAMPA-ST. PETERSBURG-CLEARWA | 0.9524 | 0.9090 | 0.8621 | 0.9372 | 0.8720 |
| 120571065 | FL | HILLSBOROUGH CO | TAMPA-ST. PETERSBURG-CLEARWA | 0.9656 | 0.9336 | 0.8895 | 0.9630 | 0.9018 |
| 120590004 | FL | HOLMES CO | HOLMES CO, FL | 0.9059 | 0.8648 | 0.8232 | 0.8880 | 0.8303 |
| 120712001 | FL | LEE CO | FORT MYERS-CAPE CORAL, FL | 0.9655 | 0.9179 | 0.8719 | 0.9481 | 0.8822 |
| 120713002 | FL | LEE CO | FORT MYERS-CAPE CORAL, FL | 0.9644 | 0.9146 | 0.8664 | 0.9468 | 0.8780 |
| 120813002 | FL | MANATEE CO | SARASOTA-BRADENTON, FL | 0.9590 | 0.9292 | 0.8875 | 0.9609 | 0.9035 |
| 120814010 | FL | MANATEE CO | SARASOTA-BRADENTON, FL | 0.9496 | 0.9108 | 0.8641 | 0.9445 | 0.8803 |
| 120950008 | FL | ORANGE CO | ORLANDO, FL | 0.9370 | 0.8892 | 0.8341 | 0.9233 | 0.8482 |
| 120952002 | FL | ORANGE CO | ORLANDO, FL | 0.9368 | 0.8889 | 0.8330 | 0.9236 | 0.8477 |
| 120972002 | FL | OSCEOLA CO | ORLANDO, FL | 0.9328 | 0.8846 | 0.8330 | 0.9159 | 0.8433 |
| 120990007 | FL | PALM BEACH CO | MIAMI CMSA | 0.9260 | 0.8553 | 0.8086 | 0.8868 | 0.8212 |
| 120992004 | FL | PALM BEACH CO | MIAMI CMSA | 0.9237 | 0.8512 | 0.8009 | 0.8849 | 0.8146 |
| 121012001 | FL | PASCO CO | TAMPA-ST. PETERSBURG-CLEARWA | 0.9499 | 0.9020 | 0.8475 | 0.9320 | 0.8563 |
| 121030004 | FL | PINELLAS CO | TAMPA-ST. PETERSBURG-CLEARWA | 0.9688 | 0.9411 | 0.8979 | 0.9710 | 0.9111 |
| 121030018 | FL | PINELLAS CO | TAMPA-ST. PETERSBURG-CLEARWA | 0.9726 | 0.9505 | 0.9093 | 0.9808 | 0.9238 |
| 121035002 | FL | PINELLAS CO | TAMPA-ST. PETERSBURG-CLEARWA | 0.9548 | 0.9141 | 0.8642 | 0.9440 | 0.8747 |
| 121056005 | FL | POLK CO | LAKELAND-WINTER HAVEN, FL | 0.9370 | 0.8854 | 0.8374 | 0.9121 | 0.8447 |
| 121056006 | FL | POLK CO | LAKELAND-WINTER HAVEN, FL | 0.9411 | 0.8955 | 0.8491 | 0.9209 | 0.8558 |
| 121111002 | FL | ST LUCIE CO | FORT PIERCE-PORT ST. LUCIE, FL | 0.9516 | 0.9068 | 0.8640 | 0.9340 | 0.8733 |
| 121151002 | FL | SARASOTA CO | SARASOTA-BRADENTON, FL | 0.9459 | 0.9058 | 0.8600 | 0.9393 | 0.8759 |
| 121151005 | FL | SARASOTA CO | SARASOTA-BRADENTON, FL | 0.9459 | 0.9058 | 0.8600 | 0.9393 | 0.8759 |
| 121171002 | FL | SEMINOLE CO | ORLANDO, FL | 0.9297 | 0.8762 | 0.8184 | 0.9100 | 0.8299 |
| 121272001 | FL | VOLUSIA CO | DAYTONA BEACH, FL | 0.9150 | 0.8603 | 0.8061 | 0.8876 | 0.8115 |
| 121275002 | FL | VOLUSIA CO | DAYTONA BEACH, FL | 0.9108 | 0.8575 | 0.7999 | 0.8857 | 0.8048 |
| 130210012 | GA | BIBB CO | MACON, GA | 0.8144 | 0.7683 | 0.7188 | 0.7903 | 0.7222 |
| 130510021 | GA | CHATHAM CO | SAVANNAH, GA | 0.8960 | 0.8665 | 0.8282 | 0.8900 | 0.8375 |
| 130850001 | GA | DAWSON CO | DAWSON CO, GA | 0.8365 | 0.7706 | 0.7007 | 0.8022 | 0.7056 |
| 130890002 | GA | DE KALB CO | ATLANTA, GA | 0.8898 | 0.8497 | 0.7965 | 0.8784 | 0.8081 |
| 130893001 | GA | DE KALB CO | ATLANTA, GA | 0.9073 | 0.8728 | 0.8190 | 0.9018 | 0.8318 |
| 130970004 | GA | DOUGLAS CO | ATLANTA, GA | 0.8781 | 0.8232 | 0.7641 | 0.8551 | 0.7747 |
| 131110094 | GA | FANNIN CO | FANNIN CO, GA | 0.8221 | 0.7641 | 0.7038 | 0.7892 | 0.7057 |
| 131130001 | GA | FAYETTE CO | ATLANTA, GA | 0.8700 | 0.8117 | 0.7458 | 0.8443 | 0.7546 |
| 131210055 | GA | FULTON CO | ATLANTA, GA | 0.8992 | 0.8626 | 0.8075 | 0.8925 | 0.8200 |
| 131350002 | GA | GWINNETT CO | ATLANTA, GA | 0.8766 | 0.8119 | 0.7360 | 0.8458 | 0.7433 |
| 132150008 | GA | MUSCOGEE CO | COLUMBUS, GA-AL | 0.8694 | 0.8047 | 0.7473 | 0.8313 | 0.7526 |
| 132151003 | GA | MUSCOGEE CO | COLUMBUS, GA-AL | 0.8694 | 0.8047 | 0.7473 | 0.8313 | 0.7526 |
| 132230003 | GA | PAULDING CO | ATLANTA, GA | 0.8432 | 0.7945 | 0.7399 | 0.8206 | 0.7458 |
| 132450091 | GA | RICHMOND CO | AUGUSTA-AIKEN, GA-SC | 0.8531 | 0.7869 | 0.7367 | 0.8149 | 0.7458 |
| 132470001 | GA | ROCKDALE CO | ATLANTA, GA | 0.8660 | 0.8018 | 0.7275 | 0.8328 | 0.7310 |

# APPENDIX D

## 8-Hour Relative Reduction Factors

| Site Id. | State | County | Area Name | RRF 2007 Base | RRF 2020 Base | RRF 2020 Control | RRF 2030 Base | RRF 2030 Control |
|---|---|---|---|---|---|---|---|---|
| 132611001 | GA | SUMTER CO | SUMTER CO, GA | 0.8616 | 0.8145 | 0.7635 | 0.8383 | 0.7680 |
| 170010006 | IL | ADAMS CO | ADAMS CO, IL | 0.8903 | 0.8575 | 0.8329 | 0.8745 | 0.8405 |
| 170190004 | IL | CHAMPAIGN CO | CHAMPAIGN-URBANA, IL | 0.8658 | 0.8318 | 0.8023 | 0.8511 | 0.8105 |
| 170310001 | IL | COOK CO | CHICAGO CMSA | 0.9265 | 0.9462 | 0.9537 | 0.9610 | 0.9730 |
| 170310032 | IL | COOK CO | CHICAGO CMSA | 0.9111 | 0.9071 | 0.8958 | 0.9240 | 0.9094 |
| 170310050 | IL | COOK CO | CHICAGO CMSA | 0.9111 | 0.9071 | 0.8958 | 0.9240 | 0.9094 |
| 170310063 | IL | COOK CO | CHICAGO CMSA | 0.9163 | 0.9165 | 0.9087 | 0.9325 | 0.9226 |
| 170310064 | IL | COOK CO | CHICAGO CMSA | 0.9163 | 0.9165 | 0.9087 | 0.9325 | 0.9226 |
| 170310072 | IL | COOK CO | CHICAGO CMSA | 0.9363 | 0.9444 | 0.9451 | 0.9592 | 0.9607 |
| 170311003 | IL | COOK CO | CHICAGO CMSA | 0.9022 | 0.8897 | 0.8963 | 0.9046 | 0.9124 |
| 170311601 | IL | COOK CO | CHICAGO CMSA | 0.9292 | 0.9254 | 0.9183 | 0.9422 | 0.9333 |
| 170314002 | IL | COOK CO | CHICAGO CMSA | 0.9114 | 0.8994 | 0.8883 | 0.9166 | 0.9020 |
| 170314006 | IL | COOK CO | CHICAGO CMSA | 0.9310 | 0.9423 | 0.9612 | 0.9534 | 0.9811 |
| 170314201 | IL | COOK CO | CHICAGO CMSA | 0.9171 | 0.9268 | 0.9302 | 0.9408 | 0.9472 |
| 170317002 | IL | COOK CO | CHICAGO CMSA | 0.9171 | 0.9268 | 0.9302 | 0.9408 | 0.9472 |
| 170318003 | IL | COOK CO | CHICAGO CMSA | 0.9030 | 0.9094 | 0.9014 | 0.9257 | 0.9158 |
| 170436001 | IL | DU PAGE CO | CHICAGO CMSA | 0.9390 | 0.9441 | 0.9391 | 0.9594 | 0.9559 |
| 170491001 | IL | EFFINGHAM CO | EFFINGHAM CO, IL | 0.8431 | 0.8059 | 0.7762 | 0.8240 | 0.7828 |
| 170650001 | IL | HAMILTON CO | HAMILTON CO, IL | 0.8280 | 0.7748 | 0.7501 | 0.7887 | 0.7545 |
| 170831001 | IL | JERSEY CO | ST. LOUIS, MO-IL | 0.8936 | 0.8451 | 0.8014 | 0.8713 | 0.8117 |
| 170890005 | IL | KANE CO | CHICAGO CMSA | 0.9417 | 0.9441 | 0.9427 | 0.9619 | 0.9624 |
| 170970001 | IL | LAKE CO | CHICAGO CMSA | 0.9193 | 0.9200 | 0.9314 | 0.9339 | 0.9508 |
| 170971002 | IL | LAKE CO | CHICAGO CMSA | 0.9168 | 0.9044 | 0.8904 | 0.9237 | 0.9067 |
| 170971007 | IL | LAKE CO | CHICAGO CMSA | 0.9250 | 0.9226 | 0.9149 | 0.9417 | 0.9327 |
| 170973001 | IL | LAKE CO | CHICAGO CMSA | 0.9165 | 0.9100 | 0.9014 | 0.9282 | 0.9181 |
| 171110001 | IL | MC HENRY CO | CHICAGO CMSA | 0.9389 | 0.9404 | 0.9368 | 0.9591 | 0.9563 |
| 171150013 | IL | MACON CO | DECATUR, IL | 0.8580 | 0.8280 | 0.8011 | 0.8471 | 0.8097 |
| 171170002 | IL | MACOUPIN CO | ST. LOUIS, MO-IL | 0.8536 | 0.8140 | 0.7763 | 0.8390 | 0.7869 |
| 171190008 | IL | MADISON CO | ST. LOUIS, MO-IL | 0.8922 | 0.8501 | 0.8123 | 0.8732 | 0.8213 |
| 171191009 | IL | MADISON CO | ST. LOUIS, MO-IL | 0.8929 | 0.8521 | 0.8126 | 0.8745 | 0.8205 |
| 171192007 | IL | MADISON CO | ST. LOUIS, MO-IL | 0.8992 | 0.8570 | 0.8177 | 0.8809 | 0.8281 |
| 171193007 | IL | MADISON CO | ST. LOUIS, MO-IL | 0.8992 | 0.8570 | 0.8177 | 0.8809 | 0.8281 |
| 171430024 | IL | PEORIA CO | PEORIA-PEKIN, IL | 0.9056 | 0.8803 | 0.8570 | 0.8970 | 0.8653 |
| 171431001 | IL | PEORIA CO | PEORIA-PEKIN, IL | 0.9056 | 0.8803 | 0.8570 | 0.8970 | 0.8653 |
| 171570001 | IL | RANDOLPH CO | RANDOLPH CO, IL | 0.8538 | 0.8230 | 0.7939 | 0.8400 | 0.7996 |
| 171610003 | IL | ROCK ISLAND CO | DAVENPORT-MOLINE-ROCK ISLAND, | 0.9264 | 0.8983 | 0.8772 | 0.9163 | 0.8876 |
| 171630010 | IL | ST CLAIR CO | ST. LOUIS, MO-IL | 0.9078 | 0.8693 | 0.8298 | 0.8919 | 0.8381 |
| 171670010 | IL | SANGAMON CO | SPRINGFIELD, IL | 0.8632 | 0.8297 | 0.7961 | 0.8509 | 0.8046 |
| 171971008 | IL | WILL CO | CHICAGO CMSA | 0.9281 | 0.9268 | 0.9139 | 0.9449 | 0.9288 |
| 171971011 | IL | WILL CO | CHICAGO CMSA | 0.8908 | 0.8722 | 0.8503 | 0.8903 | 0.8611 |
| 172010009 | IL | WINNEBAGO CO | ROCKFORD, IL | 0.9129 | 0.8875 | 0.8604 | 0.9095 | 0.8728 |
| 172012001 | IL | WINNEBAGO CO | ROCKFORD, IL | 0.9059 | 0.8783 | 0.8497 | 0.9005 | 0.8620 |
| 180030002 | IN | ALLEN CO | FORT WAYNE, IN | 0.8919 | 0.8557 | 0.8268 | 0.8750 | 0.8349 |
| 180030004 | IN | ALLEN CO | FORT WAYNE, IN | 0.8954 | 0.8602 | 0.8306 | 0.8797 | 0.8389 |

# APPENDIX D
## 8-Hour Relative Reduction Factors

| Site Id. | State | County | Area Name | RRF 2007 Base | RRF 2020 Base | RRF 2020 Control | RRF 2030 Base | RRF 2030 Control |
|---|---|---|---|---|---|---|---|---|
| 180190003 | IN | CLARK CO | LOUISVILLE, KY-IN | 0.8857 | 0.8729 | 0.8538 | 0.8892 | 0.8638 |
| 180390002 | IN | ELKHART CO | ELKHART-GOSHEN, IN | 0.8810 | 0.8471 | 0.8189 | 0.8655 | 0.8266 |
| 180431004 | IN | FLOYD CO | LOUISVILLE, KY-IN | 0.8914 | 0.8859 | 0.8731 | 0.9022 | 0.8858 |
| 180571001 | IN | HAMILTON CO | INDIANAPOLIS, IN | 0.8918 | 0.8620 | 0.8332 | 0.8819 | 0.8428 |
| 180590003 | IN | HANCOCK CO | INDIANAPOLIS, IN | 0.8899 | 0.8621 | 0.8342 | 0.8812 | 0.8436 |
| 180810002 | IN | JOHNSON CO | INDIANAPOLIS, IN | 0.8542 | 0.8227 | 0.7932 | 0.8402 | 0.7997 |
| 180890022 | IN | LAKE CO | CHICAGO CMSA | 0.9042 | 0.8940 | 0.8778 | 0.9115 | 0.8902 |
| 180890024 | IN | LAKE CO | CHICAGO CMSA | 0.8893 | 0.8669 | 0.8434 | 0.8841 | 0.8521 |
| 180892008 | IN | LAKE CO | CHICAGO CMSA | 0.9049 | 0.9015 | 0.8881 | 0.9191 | 0.9018 |
| 180910005 | IN | LA PORTE CO | LA PORTE CO, IN | 0.9180 | 0.9026 | 0.8855 | 0.9207 | 0.8974 |
| 180910010 | IN | LA PORTE CO | LA PORTE CO, IN | 0.9104 | 0.8892 | 0.8677 | 0.9070 | 0.8781 |
| 180950010 | IN | MADISON CO | INDIANAPOLIS, IN | 0.8833 | 0.8466 | 0.8144 | 0.8673 | 0.8229 |
| 180970042 | IN | MARION CO | INDIANAPOLIS, IN | 0.8865 | 0.8648 | 0.8411 | 0.8825 | 0.8501 |
| 180970050 | IN | MARION CO | INDIANAPOLIS, IN | 0.8960 | 0.8802 | 0.8603 | 0.8982 | 0.8716 |
| 180970057 | IN | MARION CO | INDIANAPOLIS, IN | 0.9062 | 0.9035 | 0.8873 | 0.9202 | 0.8992 |
| 180970073 | IN | MARION CO | INDIANAPOLIS, IN | 0.8960 | 0.8802 | 0.8603 | 0.8982 | 0.8716 |
| 181090005 | IN | MORGAN CO | INDIANAPOLIS, IN | 0.8688 | 0.8431 | 0.8181 | 0.8602 | 0.8260 |
| 181230008 | IN | PERRY CO | PERRY CO, IN | 0.8203 | 0.8058 | 0.7842 | 0.8189 | 0.7889 |
| 181270020 | IN | PORTER CO | CHICAGO CMSA | 0.9161 | 0.9077 | 0.8943 | 0.9251 | 0.9069 |
| 181270024 | IN | PORTER CO | CHICAGO CMSA | 0.9042 | 0.8940 | 0.8778 | 0.9115 | 0.8902 |
| 181270026 | IN | PORTER CO | CHICAGO CMSA | 0.9246 | 0.9113 | 0.8938 | 0.9281 | 0.9045 |
| 181290003 | IN | POSEY CO | EVANSVILLE-HENDERSON, IN-KY | 0.8773 | 0.8506 | 0.8325 | 0.8659 | 0.8408 |
| 181410010 | IN | ST JOSEPH CO | SOUTH BEND, IN | 0.8853 | 0.8547 | 0.8278 | 0.8725 | 0.8358 |
| 181411007 | IN | ST JOSEPH CO | SOUTH BEND, IN | 0.8889 | 0.8620 | 0.8368 | 0.8796 | 0.8450 |
| 181411008 | IN | ST JOSEPH CO | SOUTH BEND, IN | 0.8889 | 0.8622 | 0.8377 | 0.8801 | 0.8467 |
| 181630012 | IN | VANDERBURGH CO | EVANSVILLE-HENDERSON, IN-KY | 0.8800 | 0.8529 | 0.8311 | 0.8685 | 0.8382 |
| 181630013 | IN | VANDERBURGH CO | EVANSVILLE-HENDERSON, IN-KY | 0.8633 | 0.8364 | 0.8140 | 0.8511 | 0.8201 |
| 181670018 | IN | VIGO CO | TERRE HAUTE, IN | 0.8695 | 0.8393 | 0.8134 | 0.8550 | 0.8191 |
| 181730002 | IN | WARRICK CO | EVANSVILLE-HENDERSON, IN-KY | 0.8336 | 0.8140 | 0.7921 | 0.8275 | 0.7969 |
| 181730008 | IN | WARRICK CO | EVANSVILLE-HENDERSON, IN-KY | 0.8315 | 0.8109 | 0.7887 | 0.8243 | 0.7935 |
| 181730009 | IN | WARRICK CO | EVANSVILLE-HENDERSON, IN-KY | 0.8424 | 0.8188 | 0.7962 | 0.8329 | 0.8015 |
| 190851101 | IA | HARRISON CO | HARRISON CO, IA | 0.9155 | 0.8819 | 0.8590 | 0.8980 | 0.8662 |
| 191130033 | IA | LINN CO | CEDAR RAPIDS, IA | 0.9185 | 0.8886 | 0.8653 | 0.9069 | 0.8749 |
| 191131015 | IA | LINN CO | CEDAR RAPIDS, IA | 0.9183 | 0.8919 | 0.8703 | 0.9108 | 0.8814 |
| 191530058 | IA | POLK CO | DES MOINES, IA | 0.9051 | 0.8646 | 0.8360 | 0.8839 | 0.8445 |
| 191632011 | IA | SCOTT CO | DAVENPORT-MOLINE-ROCK ISLAND, | 0.9283 | 0.9011 | 0.8792 | 0.9194 | 0.8892 |
| 191690011 | IA | STORY CO | STORY CO, IA | 0.9052 | 0.8657 | 0.8377 | 0.8847 | 0.8460 |
| 191770004 | IA | VAN BUREN CO | VAN BUREN CO, IA | 0.9032 | 0.8725 | 0.8489 | 0.8899 | 0.8572 |
| 191810022 | IA | WARREN CO | DES MOINES, IA | 0.8980 | 0.8596 | 0.8316 | 0.8784 | 0.8398 |
| 201730001 | KS | SEDGWICK CO | WICHITA, KS | 0.9406 | 0.8963 | 0.8669 | 0.9157 | 0.8752 |
| 201730010 | KS | SEDGWICK CO | WICHITA, KS | 0.9408 | 0.8966 | 0.8673 | 0.9159 | 0.8756 |
| 202090001 | KS | WYANDOTTE CO | KANSAS CITY, MO-KS | 0.9366 | 0.9083 | 0.8848 | 0.9264 | 0.8943 |
| 210130002 | KY | BELL CO | BELL CO, KY | 0.7997 | 0.7395 | 0.6929 | 0.7561 | 0.6914 |
| 210150003 | KY | BOONE CO | CINCINNATI CMSA | 0.8478 | 0.8205 | 0.7965 | 0.8383 | 0.8055 |

## APPENDIX D
## 8-Hour Relative Reduction Factors

| Site Id. | State | County | Area Name | RRF 2007 Base | RRF 2020 Base | RRF 2020 Control | RRF 2030 Base | RRF 2030 Control |
|---|---|---|---|---|---|---|---|---|
| 210190015 | KY | BOYD CO | HUNTINGTON-ASHLAND, WV-KY-OH | 0.8522 | 0.8276 | 0.8033 | 0.8430 | 0.8104 |
| 210290006 | KY | BULLITT CO | LOUISVILLE, KY-IN | 0.8603 | 0.8479 | 0.8287 | 0.8632 | 0.8365 |
| 210371001 | KY | CAMPBELL CO | CINCINNATI CMSA | 0.8988 | 0.8804 | 0.8628 | 0.9005 | 0.8776 |
| 210430500 | KY | CARTER CO | HUNTINGTON-ASHLAND, WV-KY-OH | 0.8055 | 0.7818 | 0.7572 | 0.7953 | 0.7619 |
| 210470006 | KY | CHRISTIAN CO | CHRISTIAN CO, KY | 0.7743 | 0.7452 | 0.7214 | 0.7578 | 0.7250 |
| 210590005 | KY | DAVIESS CO | OWENSBORO, KY | 0.8295 | 0.8131 | 0.7919 | 0.8260 | 0.7965 |
| 210610501 | KY | EDMONSON CO | EDMONSON CO, KY | 0.7963 | 0.7700 | 0.7441 | 0.7839 | 0.7481 |
| 210670001 | KY | FAYETTE CO | LEXINGTON, KY | 0.8567 | 0.8365 | 0.8094 | 0.8559 | 0.8189 |
| 210670012 | KY | FAYETTE CO | LEXINGTON, KY | 0.8702 | 0.8477 | 0.8192 | 0.8685 | 0.8297 |
| 210830003 | KY | GRAVES CO | GRAVES CO, KY | 0.8414 | 0.7950 | 0.7699 | 0.8097 | 0.7753 |
| 210890007 | KY | GREENUP CO | HUNTINGTON-ASHLAND, WV-KY-OH | 0.8454 | 0.8238 | 0.8015 | 0.8377 | 0.8076 |
| 210910012 | KY | HANCOCK CO | OWENSBORO, KY | 0.8107 | 0.7966 | 0.7752 | 0.8099 | 0.7802 |
| 210930005 | KY | HARDIN CO | HARDIN CO, KY | 0.8262 | 0.8077 | 0.7844 | 0.8221 | 0.7901 |
| 211010013 | KY | HENDERSON CO | EVANSVILLE-HENDERSON, IN-KY | 0.8737 | 0.8523 | 0.8319 | 0.8667 | 0.8385 |
| 211010014 | KY | HENDERSON CO | EVANSVILLE-HENDERSON, IN-KY | 0.8559 | 0.8375 | 0.8179 | 0.8510 | 0.8239 |
| 211110027 | KY | JEFFERSON CO | LOUISVILLE, KY-IN | 0.8918 | 0.8929 | 0.8832 | 0.9105 | 0.8979 |
| 211110051 | KY | JEFFERSON CO | LOUISVILLE, KY-IN | 0.8929 | 0.8866 | 0.8713 | 0.9024 | 0.8812 |
| 211111021 | KY | JEFFERSON CO | LOUISVILLE, KY-IN | 0.8946 | 0.8846 | 0.8703 | 0.9019 | 0.8833 |
| 211130001 | KY | JESSAMINE CO | LEXINGTON, KY | 0.8684 | 0.8485 | 0.8198 | 0.8700 | 0.8314 |
| 211170007 | KY | KENTON CO | CINCINNATI CMSA | 0.8940 | 0.8787 | 0.8611 | 0.8987 | 0.8758 |
| 211390003 | KY | LIVINGSTON CO | LIVINGSTON CO, KY | 0.8319 | 0.7814 | 0.7572 | 0.7960 | 0.7626 |
| 211390004 | KY | LIVINGSTON CO | LIVINGSTON CO, KY | 0.8306 | 0.7834 | 0.7592 | 0.7980 | 0.7646 |
| 211451024 | KY | MC CRACKEN CO | MC CRACKEN CO, KY | 0.8341 | 0.7802 | 0.7566 | 0.7948 | 0.7624 |
| 211490001 | KY | MC LEAN CO | MC LEAN CO, KY | 0.8412 | 0.8261 | 0.8045 | 0.8386 | 0.8087 |
| 211850004 | KY | OLDHAM CO | LOUISVILLE, KY-IN | 0.8678 | 0.8494 | 0.8296 | 0.8658 | 0.8384 |
| 211930002 | KY | PERRY CO | PERRY CO, KY | 0.7778 | 0.7387 | 0.7039 | 0.7513 | 0.7034 |
| 211950002 | KY | PIKE CO | PIKE CO, KY | 0.7805 | 0.7392 | 0.6984 | 0.7529 | 0.6966 |
| 211990003 | KY | PULASKI CO | PULASKI CO, KY | 0.8096 | 0.7977 | 0.7643 | 0.8118 | 0.7657 |
| 212090001 | KY | SCOTT CO | LEXINGTON, KY | 0.8302 | 0.8027 | 0.7734 | 0.8203 | 0.7799 |
| 212130004 | KY | SIMPSON CO | SIMPSON CO, KY | 0.8091 | 0.7747 | 0.7456 | 0.7906 | 0.7504 |
| 220050004 | LA | ASCENSION PAR | BATON ROUGE, LA | 0.9647 | 0.9364 | 0.9171 | 0.9597 | 0.9343 |
| 220110002 | LA | BEAUREGARD PAR | LAKE CHARLES, LA | 0.9552 | 0.9230 | 0.9023 | 0.9435 | 0.9155 |
| 220150008 | LA | BOSSIER PAR | SHREVEPORT-BOSSIER CITY, LA | 0.9307 | 0.8880 | 0.8550 | 0.9075 | 0.8630 |
| 220170001 | LA | CADDO PAR | SHREVEPORT-BOSSIER CITY, LA | 0.9329 | 0.8899 | 0.8587 | 0.9081 | 0.8661 |
| 220190002 | LA | CALCASIEU PAR | LAKE CHARLES, LA | 0.9680 | 0.9377 | 0.9220 | 0.9585 | 0.9376 |
| 220190008 | LA | CALCASIEU PAR | LAKE CHARLES, LA | 0.9638 | 0.9348 | 0.9175 | 0.9563 | 0.9338 |
| 220190009 | LA | CALCASIEU PAR | LAKE CHARLES, LA | 0.9708 | 0.9369 | 0.9212 | 0.9577 | 0.9367 |
| 220330003 | LA | EAST BATON ROUGE PAR | BATON ROUGE, LA | 0.9565 | 0.9173 | 0.8938 | 0.9401 | 0.9092 |
| 220330009 | LA | EAST BATON ROUGE PAR | BATON ROUGE, LA | 0.9513 | 0.9077 | 0.8809 | 0.9308 | 0.8956 |
| 220330013 | LA | EAST BATON ROUGE PAR | BATON ROUGE, LA | 0.9471 | 0.9013 | 0.8727 | 0.9232 | 0.8853 |
| 220331001 | LA | EAST BATON ROUGE PAR | BATON ROUGE, LA | 0.9472 | 0.9007 | 0.8713 | 0.9238 | 0.8852 |
| 220430001 | LA | GRANT PAR | ALEXANDRIA, LA | 0.9443 | 0.8978 | 0.8695 | 0.9171 | 0.8789 |
| 220470002 | LA | IBERVILLE PAR | BATON ROUGE, LA | 0.9663 | 0.9395 | 0.9230 | 0.9606 | 0.9388 |
| 220470007 | LA | IBERVILLE PAR | BATON ROUGE, LA | 0.9565 | 0.9166 | 0.8932 | 0.9395 | 0.9086 |

# APPENDIX D

## 8-Hour Relative Reduction Factors

| Site Id. | State | County | Area Name | RRF 2007 Base | RRF 2020 Base | RRF 2020 Control | RRF 2030 Base | RRF 2030 Control |
|---|---|---|---|---|---|---|---|---|
| 220470009 | LA | IBERVILLE PAR | BATON ROUGE, LA | 0.9659 | 0.9372 | 0.9208 | 0.9581 | 0.9363 |
| 220511001 | LA | JEFFERSON PAR | NEW ORLEANS, LA | 0.9510 | 0.9279 | 0.9107 | 0.9451 | 0.9226 |
| 220550005 | LA | LAFAYETTE PAR | LAFAYETTE, LA | 0.9468 | 0.9061 | 0.8814 | 0.9259 | 0.8927 |
| 220570002 | LA | LAFOURCHE PAR | HOUMA, LA | 0.9616 | 0.9382 | 0.9211 | 0.9596 | 0.9369 |
| 220630002 | LA | LIVINGSTON PAR | BATON ROUGE, LA | 0.9626 | 0.9369 | 0.9185 | 0.9599 | 0.9353 |
| 220710012 | LA | ORLEANS PAR | NEW ORLEANS, LA | 0.9469 | 0.9409 | 0.9303 | 0.9527 | 0.9390 |
| 220730004 | LA | OUACHITA PAR | MONROE, LA | 0.9421 | 0.9137 | 0.8900 | 0.9323 | 0.8995 |
| 220770001 | LA | POINTE COUPEE PAR | BATON ROUGE, LA | 0.9466 | 0.9007 | 0.8719 | 0.9226 | 0.8845 |
| 220870002 | LA | ST BERNARD PAR | NEW ORLEANS, LA | 0.9534 | 0.9396 | 0.9260 | 0.9551 | 0.9371 |
| 220890003 | LA | ST CHARLES PAR | NEW ORLEANS, LA | 0.9529 | 0.9464 | 0.9343 | 0.9620 | 0.9464 |
| 220930002 | LA | ST JAMES PAR | BATON ROUGE, LA | 0.9629 | 0.9394 | 0.9221 | 0.9613 | 0.9385 |
| 220950002 | LA | ST JOHN THE BAPTIST PAR | NEW ORLEANS, LA | 0.9592 | 0.9392 | 0.9224 | 0.9593 | 0.9374 |
| 221010003 | LA | ST MARY PAR | ST MARY PAR, LA | 0.9656 | 0.9448 | 0.9307 | 0.9633 | 0.9445 |
| 221210001 | LA | WEST BATON ROUGE PAR | BATON ROUGE, LA | 0.9513 | 0.9077 | 0.8809 | 0.9308 | 0.8956 |
| 230052003 | ME | CUMBERLAND CO | PORTLAND, ME | 0.9038 | 0.8662 | 0.8281 | 0.8915 | 0.8399 |
| 230090102 | ME | HANCOCK CO | HANCOCK CO, ME | 0.8928 | 0.8448 | 0.8011 | 0.8716 | 0.8123 |
| 230090103 | ME | HANCOCK CO | HANCOCK CO, ME | 0.8928 | 0.8448 | 0.8011 | 0.8716 | 0.8123 |
| 230112005 | ME | KENNEBEC CO | LEWISTON-AUBURN, ME | 0.8970 | 0.8492 | 0.8076 | 0.8755 | 0.8188 |
| 230130004 | ME | KNOX CO | KNOX CO, ME | 0.8984 | 0.8576 | 0.8163 | 0.8834 | 0.8276 |
| 230173001 | ME | OXFORD CO | OXFORD CO, ME | 0.9190 | 0.8980 | 0.8651 | 0.9207 | 0.8774 |
| 230194008 | ME | PENOBSCOT CO | PENOBSCOT CO, ME | 0.8873 | 0.8379 | 0.7965 | 0.8641 | 0.8075 |
| 230230003 | ME | SAGADAHOC CO | SAGADAHOC CO, ME | 0.9005 | 0.8652 | 0.8251 | 0.8901 | 0.8366 |
| 230312002 | ME | YORK CO | PORTLAND, ME | 0.9030 | 0.8690 | 0.8299 | 0.8934 | 0.8414 |
| 230313002 | ME | YORK CO | PORTLAND, ME | 0.9128 | 0.8793 | 0.8453 | 0.9020 | 0.8566 |
| 240030014 | MD | ANNE ARUNDEL CO | BALTIMORE, MD | 0.8853 | 0.8518 | 0.8089 | 0.8764 | 0.8185 |
| 240030019 | MD | ANNE ARUNDEL CO | BALTIMORE, MD | 0.9012 | 0.8707 | 0.8293 | 0.8953 | 0.8407 |
| 240051007 | MD | BALTIMORE CO | BALTIMORE, MD | 0.9071 | 0.8816 | 0.8468 | 0.9040 | 0.8575 |
| 240053001 | MD | BALTIMORE CO | BALTIMORE, MD | 0.9162 | 0.8985 | 0.8667 | 0.9188 | 0.8779 |
| 240090010 | MD | CALVERT CO | WASHINGTON, DC-MD-VA-WV | 0.8663 | 0.8252 | 0.7814 | 0.8483 | 0.7883 |
| 240130001 | MD | CARROLL CO | BALTIMORE, MD | 0.8873 | 0.8569 | 0.8147 | 0.8802 | 0.8249 |
| 240150003 | MD | CECIL CO | PHILADELPHIA CMSA | 0.8783 | 0.8488 | 0.8060 | 0.8726 | 0.8141 |
| 240170010 | MD | CHARLES CO | WASHINGTON, DC-MD-VA-WV | 0.8614 | 0.8171 | 0.7689 | 0.8403 | 0.7746 |
| 240210037 | MD | FREDERICK CO | WASHINGTON, DC-MD-VA-WV | 0.8822 | 0.8488 | 0.8061 | 0.8731 | 0.8160 |
| 240251001 | MD | HARFORD CO | BALTIMORE, MD | 0.9129 | 0.8885 | 0.8543 | 0.9099 | 0.8642 |
| 240259001 | MD | HARFORD CO | BALTIMORE, MD | 0.9021 | 0.8734 | 0.8321 | 0.8974 | 0.8413 |
| 240290002 | MD | KENT CO | PHILADELPHIA CMSA | 0.8826 | 0.8576 | 0.8199 | 0.8795 | 0.8282 |
| 240313001 | MD | MONTGOMERY CO | WASHINGTON, DC-MD-VA-WV | 0.9097 | 0.8907 | 0.8535 | 0.9149 | 0.8671 |
| 240330002 | MD | PRINCE GEORGES CO | WASHINGTON, DC-MD-VA-WV | 0.9012 | 0.8707 | 0.8293 | 0.8953 | 0.8407 |
| 240338001 | MD | PRINCE GEORGES CO | WASHINGTON, DC-MD-VA-WV | 0.8922 | 0.8731 | 0.8464 | 0.8909 | 0.8562 |
| 245100051 | MD | BALTIMORE | BALTIMORE, MD | 0.9084 | 0.8903 | 0.8602 | 0.9110 | 0.8723 |
| 250010002 | MA | BARNSTABLE CO | BOSTON CMSA | 0.9026 | 0.8622 | 0.8214 | 0.8884 | 0.8337 |
| 250051002 | MA | BRISTOL CO | BOSTON CMSA | 0.8972 | 0.8662 | 0.8283 | 0.8941 | 0.8434 |
| 250051005 | MA | BRISTOL CO | BOSTON CMSA | 0.8983 | 0.8530 | 0.8097 | 0.8787 | 0.8205 |
| 250090005 | MA | ESSEX CO | BOSTON CMSA | 0.9128 | 0.8863 | 0.8592 | 0.9069 | 0.8694 |

## APPENDIX D
## 8-Hour Relative Reduction Factors

| Site Id. | State | County | Area Name | RRF 2007 Base | RRF 2020 Base | RRF 2020 Control | RRF 2030 Base | RRF 2030 Control |
|---|---|---|---|---|---|---|---|---|
| 250092006 | MA | ESSEX CO | BOSTON CMSA | 0.9226 | 0.8943 | 0.8622 | 0.9145 | 0.8726 |
| 250094004 | MA | ESSEX CO | BOSTON CMSA | 0.9180 | 0.8802 | 0.8451 | 0.9041 | 0.8572 |
| 250130003 | MA | HAMPDEN CO | SPRINGFIELD, MA | 0.9100 | 0.8820 | 0.8491 | 0.9062 | 0.8625 |
| 250130008 | MA | HAMPDEN CO | SPRINGFIELD, MA | 0.9120 | 0.8863 | 0.8577 | 0.9080 | 0.8710 |
| 250150103 | MA | HAMPSHIRE CO | SPRINGFIELD, MA | 0.9275 | 0.8991 | 0.8706 | 0.9228 | 0.8835 |
| 250154002 | MA | HAMPSHIRE CO | SPRINGFIELD, MA | 0.9262 | 0.9033 | 0.8739 | 0.9248 | 0.8868 |
| 250171102 | MA | MIDDLESEX CO | BOSTON CMSA | 0.9067 | 0.8780 | 0.8453 | 0.8969 | 0.8549 |
| 250171801 | MA | MIDDLESEX CO | BOSTON CMSA | 0.9067 | 0.8780 | 0.8453 | 0.8969 | 0.8549 |
| 250174003 | MA | MIDDLESEX CO | BOSTON CMSA | 0.9148 | 0.8875 | 0.8553 | 0.9048 | 0.8638 |
| 250251003 | MA | SUFFOLK CO | BOSTON CMSA | 0.9068 | 0.8725 | 0.8409 | 0.8922 | 0.8493 |
| 250270015 | MA | WORCESTER CO | WORCESTER, MA-CT | 0.9021 | 0.8649 | 0.8264 | 0.8880 | 0.8368 |
| 260050003 | MI | ALLEGAN CO | ALLEGAN CO, MI | 0.9196 | 0.9023 | 0.8821 | 0.9230 | 0.8968 |
| 260190003 | MI | BENZIE CO | BENZIE CO, MI | 0.9080 | 0.8779 | 0.8466 | 0.8991 | 0.8570 |
| 260210014 | MI | BERRIEN CO | BENTON HARBOR, MI | 0.9019 | 0.8740 | 0.8461 | 0.8953 | 0.8573 |
| 260270003 | MI | CASS CO | CASS CO, MI | 0.8844 | 0.8528 | 0.8233 | 0.8721 | 0.8317 |
| 260370001 | MI | CLINTON CO | LANSING-EAST LANSING, MI | 0.9092 | 0.8804 | 0.8507 | 0.9012 | 0.8609 |
| 260490021 | MI | GENESEE CO | FLINT, MI | 0.9051 | 0.8759 | 0.8456 | 0.8961 | 0.8551 |
| 260492001 | MI | GENESEE CO | FLINT, MI | 0.9016 | 0.8679 | 0.8396 | 0.8875 | 0.8495 |
| 260630007 | MI | HURON CO | HURON CO, MI | 0.9174 | 0.8978 | 0.8757 | 0.9164 | 0.8869 |
| 260650012 | MI | INGHAM CO | LANSING-EAST LANSING, MI | 0.9003 | 0.8736 | 0.8474 | 0.8933 | 0.8578 |
| 260770008 | MI | KALAMAZOO CO | KALAMAZOO-BATTLE CREEK, MI | 0.8917 | 0.8612 | 0.8309 | 0.8813 | 0.8401 |
| 260810020 | MI | KENT CO | GRAND RAPIDS-MUSKEGON-HOLLAN | 0.9041 | 0.8781 | 0.8515 | 0.8989 | 0.8632 |
| 260812001 | MI | KENT CO | GRAND RAPIDS-MUSKEGON-HOLLAN | 0.9040 | 0.8726 | 0.8422 | 0.8941 | 0.8525 |
| 260910007 | MI | LENAWEE CO | LENAWEE CO, MI | 0.9115 | 0.8825 | 0.8553 | 0.9020 | 0.8653 |
| 260990009 | MI | MACOMB CO | DETROIT CMSA | 0.9387 | 0.9447 | 0.9392 | 0.9606 | 0.9546 |
| 260991003 | MI | MACOMB CO | DETROIT CMSA | 0.9480 | 0.9580 | 0.9656 | 0.9723 | 0.9811 |
| 261050007 | MI | MASON CO | MASON CO, MI | 0.9074 | 0.8823 | 0.8545 | 0.9044 | 0.8668 |
| 261130001 | MI | MISSAUKEE CO | MISSAUKEE CO, MI | 0.8944 | 0.8593 | 0.8296 | 0.8783 | 0.8375 |
| 261210039 | MI | MUSKEGON CO | GRAND RAPIDS-MUSKEGON-HOLLAN | 0.9185 | 0.8984 | 0.8783 | 0.9183 | 0.8910 |
| 261250001 | MI | OAKLAND CO | DETROIT CMSA | 0.9391 | 0.9641 | 0.9823 | 0.9757 | 0.9997 |
| 261390005 | MI | OTTAWA CO | GRAND RAPIDS-MUSKEGON-HOLLAN | 0.9123 | 0.8891 | 0.8652 | 0.9097 | 0.8783 |
| 261470005 | MI | ST CLAIR CO | DETROIT CMSA | 0.9197 | 0.9061 | 0.8849 | 0.9263 | 0.8990 |
| 261610007 | MI | WASHTENAW CO | DETROIT CMSA | 0.9230 | 0.9048 | 0.8839 | 0.9229 | 0.8958 |
| 261630001 | MI | WAYNE CO | DETROIT CMSA | 0.9292 | 0.9227 | 0.9282 | 0.9414 | 0.9448 |
| 261630016 | MI | WAYNE CO | DETROIT CMSA | 0.9305 | 0.9388 | 0.9479 | 0.9508 | 0.9634 |
| 261630019 | MI | WAYNE CO | DETROIT CMSA | 0.9305 | 0.9388 | 0.9479 | 0.9508 | 0.9634 |
| 270031001 | MN | ANOKA CO | MINNEAPOLIS-ST. PAUL, MN-WI | 0.9440 | 0.9090 | 0.8822 | 0.9305 | 0.8950 |
| 270031002 | MN | ANOKA CO | MINNEAPOLIS-ST. PAUL, MN-WI | 0.9324 | 0.9258 | 0.9167 | 0.9378 | 0.9272 |
| 270376018 | MN | DAKOTA CO | MINNEAPOLIS-ST. PAUL, MN-WI | 0.9254 | 0.9074 | 0.8926 | 0.9208 | 0.9018 |
| 280010004 | MS | ADAMS CO | ADAMS CO, MS | 0.9361 | 0.8952 | 0.8702 | 0.9171 | 0.8831 |
| 280330002 | MS | DE SOTO CO | MEMPHIS, TN-AR-MS | 0.8943 | 0.8534 | 0.8233 | 0.8739 | 0.8326 |
| 280450001 | MS | HANCOCK CO | BILOXI-GULFPORT-PASCAGOULA, M | 0.9546 | 0.9149 | 0.8908 | 0.9320 | 0.8995 |
| 280490010 | MS | HINDS CO | JACKSON, MS | 0.9069 | 0.8556 | 0.8124 | 0.8782 | 0.8193 |
| 280590006 | MS | JACKSON CO | BILOXI-GULFPORT-PASCAGOULA, M | 0.9427 | 0.9226 | 0.8978 | 0.9436 | 0.9098 |

APPENDIX D

8-Hour Relative Reduction Factors

| Site Id. | State | County | Area Name | RRF 2007 Base | RRF 2020 Base | RRF 2020 Control | RRF 2030 Base | RRF 2030 Control |
|---|---|---|---|---|---|---|---|---|
| 280750003 | MS | LAUDERDALE CO | LAUDERDALE CO, MS | 0.8624 | 0.8265 | 0.7837 | 0.8480 | 0.7896 |
| 280810005 | MS | LEE CO | LEE CO, MS | 0.8347 | 0.7886 | 0.7505 | 0.8079 | 0.7557 |
| 280890002 | MS | MADISON CO | JACKSON, MS | 0.9322 | 0.9075 | 0.8865 | 0.9202 | 0.8911 |
| 281490004 | MS | WARREN CO | WARREN CO, MS | 0.9453 | 0.9220 | 0.9026 | 0.9452 | 0.9192 |
| 290390001 | MO | CEDAR CO | CEDAR CO, MO | 0.9287 | 0.8852 | 0.8523 | 0.9033 | 0.8575 |
| 290470003 | MO | CLAY CO | KANSAS CITY, MO-KS | 0.9176 | 0.8770 | 0.8458 | 0.8966 | 0.8532 |
| 290470005 | MO | CLAY CO | KANSAS CITY, MO-KS | 0.9270 | 0.8917 | 0.8638 | 0.9108 | 0.8722 |
| 290470025 | MO | CLAY CO | KANSAS CITY, MO-KS | 0.9244 | 0.8905 | 0.8635 | 0.9094 | 0.8720 |
| 290770026 | MO | GREENE CO | SPRINGFIELD, MO | 0.8574 | 0.8097 | 0.7578 | 0.8341 | 0.7610 |
| 290770036 | MO | GREENE CO | SPRINGFIELD, MO | 0.8567 | 0.8091 | 0.7573 | 0.8336 | 0.7605 |
| 290950036 | MO | JACKSON CO | KANSAS CITY, MO-KS | 0.9260 | 0.8946 | 0.8689 | 0.9132 | 0.8780 |
| 290990012 | MO | JEFFERSON CO | ST. LOUIS, MO-IL | 0.8919 | 0.8405 | 0.7965 | 0.8630 | 0.8013 |
| 291370001 | MO | MONROE CO | MONROE CO, MO | 0.8910 | 0.8566 | 0.8295 | 0.8743 | 0.8365 |
| 291650023 | MO | PLATTE CO | KANSAS CITY, MO-KS | 0.9381 | 0.9096 | 0.8859 | 0.9277 | 0.8953 |
| 291831002 | MO | ST CHARLES CO | ST. LOUIS, MO-IL | 0.9032 | 0.8577 | 0.8138 | 0.8824 | 0.8229 |
| 291831004 | MO | ST CHARLES CO | ST. LOUIS, MO-IL | 0.8825 | 0.8206 | 0.7668 | 0.8482 | 0.7738 |
| 291860005 | MO | STE GENEVIEVE CO | STE GENEVIEVE CO, MO | 0.8689 | 0.8299 | 0.7930 | 0.8495 | 0.7985 |
| 291890004 | MO | ST LOUIS CO | ST. LOUIS, MO-IL | 0.9096 | 0.8653 | 0.8227 | 0.8878 | 0.8291 |
| 291890006 | MO | ST LOUIS CO | ST. LOUIS, MO-IL | 0.9126 | 0.8719 | 0.8265 | 0.8958 | 0.8348 |
| 291893001 | MO | ST LOUIS CO | ST. LOUIS, MO-IL | 0.9126 | 0.8719 | 0.8265 | 0.8958 | 0.8348 |
| 291895001 | MO | ST LOUIS CO | ST. LOUIS, MO-IL | 0.9071 | 0.8630 | 0.8195 | 0.8856 | 0.8272 |
| 291897002 | MO | ST LOUIS CO | ST. LOUIS, MO-IL | 0.9093 | 0.8639 | 0.8168 | 0.8887 | 0.8248 |
| 295100007 | MO | ST LOUIS | ST. LOUIS, MO-IL | 0.9082 | 0.8661 | 0.8274 | 0.8873 | 0.8340 |
| 295100072 | MO | ST LOUIS | ST. LOUIS, MO-IL | 0.9147 | 0.8753 | 0.8331 | 0.8986 | 0.8415 |
| 295100080 | MO | ST LOUIS | ST. LOUIS, MO-IL | 0.9071 | 0.8630 | 0.8195 | 0.8856 | 0.8272 |
| 310550028 | NE | DOUGLAS CO | OMAHA, NE-IA | 0.9204 | 0.8874 | 0.8626 | 0.9055 | 0.8709 |
| 310550032 | NE | DOUGLAS CO | OMAHA, NE-IA | 0.9196 | 0.8843 | 0.8594 | 0.9024 | 0.8674 |
| 310550035 | NE | DOUGLAS CO | OMAHA, NE-IA | 0.9204 | 0.8874 | 0.8626 | 0.9055 | 0.8709 |
| 311090016 | NE | LANCASTER CO | LINCOLN, NE | 0.9190 | 0.8823 | 0.8523 | 0.9031 | 0.8618 |
| 330012003 | NH | BELKNAP CO | BELKNAP CO, NH | 0.9263 | 0.8963 | 0.8594 | 0.9184 | 0.8700 |
| 330031002 | NH | CARROLL CO | CARROLL CO, NH | 0.9102 | 0.8813 | 0.8452 | 0.9034 | 0.8557 |
| 330050007 | NH | CHESHIRE CO | CHESHIRE CO, NH | 0.8926 | 0.8451 | 0.7992 | 0.8712 | 0.8100 |
| 330090008 | NH | GRAFTON CO | GRAFTON CO, NH | 0.8885 | 0.8370 | 0.7895 | 0.8643 | 0.7998 |
| 330110016 | NH | HILLSBOROUGH CO | HILLSBOROUGH CO, NH | 0.9073 | 0.8712 | 0.8364 | 0.8929 | 0.8469 |
| 330111010 | NH | HILLSBOROUGH CO | BOSTON CMSA | 0.9011 | 0.8648 | 0.8287 | 0.8875 | 0.8396 |
| 330130007 | NH | MERRIMACK CO | MANCHESTER, NH | 0.9030 | 0.8638 | 0.8230 | 0.8876 | 0.8328 |
| 330150009 | NH | ROCKINGHAM CO | PORTSMOUTH-ROCHESTER, NH-ME | 0.9128 | 0.8793 | 0.8453 | 0.9020 | 0.8566 |
| 330150012 | NH | ROCKINGHAM CO | PORTSMOUTH-ROCHESTER, NH-ME | 0.9128 | 0.8793 | 0.8453 | 0.9020 | 0.8566 |
| 330173002 | NH | STRAFFORD CO | PORTSMOUTH-ROCHESTER, NH-ME | 0.9125 | 0.8771 | 0.8360 | 0.9028 | 0.8487 |
| 330190003 | NH | SULLIVAN CO | SULLIVAN CO, NH | 0.9016 | 0.8476 | 0.8033 | 0.8759 | 0.8163 |
| 340010005 | NJ | ATLANTIC CO | ATLANTIC-CAPE MAY, NJ | 0.8894 | 0.8659 | 0.8294 | 0.8894 | 0.8398 |
| 340070003 | NJ | CAMDEN CO | PHILADELPHIA CMSA | 0.9193 | 0.9126 | 0.8940 | 0.9307 | 0.9062 |
| 340071001 | NJ | CAMDEN CO | PHILADELPHIA CMSA | 0.9057 | 0.8877 | 0.8561 | 0.9085 | 0.8657 |
| 340110007 | NJ | CUMBERLAND CO | PHILADELPHIA CMSA | 0.8747 | 0.8463 | 0.8104 | 0.8670 | 0.8181 |

# APPENDIX D
## 8-Hour Relative Reduction Factors

| Site Id. | State | County | Area Name | RRF 2007 Base | RRF 2020 Base | RRF 2020 Control | RRF 2030 Base | RRF 2030 Control |
|---|---|---|---|---|---|---|---|---|
| 340130011 | NJ | ESSEX CO | NEW YORK CMSA | 0.9339 | 0.9268 | 0.9067 | 0.9464 | 0.9201 |
| 340150002 | NJ | GLOUCESTER CO | PHILADELPHIA CMSA | 0.9024 | 0.8862 | 0.8594 | 0.9039 | 0.8685 |
| 340170006 | NJ | HUDSON CO | NEW YORK CMSA | 0.9339 | 0.9268 | 0.9067 | 0.9464 | 0.9201 |
| 340190001 | NJ | HUNTERDON CO | NEW YORK CMSA | 0.9270 | 0.9062 | 0.8741 | 0.9282 | 0.8858 |
| 340210005 | NJ | MERCER CO | PHILADELPHIA CMSA | 0.9412 | 0.9355 | 0.9107 | 0.9553 | 0.9237 |
| 340230011 | NJ | MIDDLESEX CO | NEW YORK CMSA | 0.9255 | 0.9102 | 0.8778 | 0.9312 | 0.8896 |
| 340250005 | NJ | MONMOUTH CO | NEW YORK CMSA | 0.9227 | 0.9045 | 0.8701 | 0.9265 | 0.8809 |
| 340273001 | NJ | MORRIS CO | NEW YORK CMSA | 0.9054 | 0.8865 | 0.8571 | 0.9062 | 0.8670 |
| 340290006 | NJ | OCEAN CO | NEW YORK CMSA | 0.9198 | 0.9053 | 0.8781 | 0.9264 | 0.8907 |
| 340315001 | NJ | PASSAIC CO | NEW YORK CMSA | 0.9178 | 0.9018 | 0.8791 | 0.9189 | 0.8884 |
| 360010012 | NY | ALBANY CO | ALBANY-SCHENECTADY-TROY, NY | 0.9095 | 0.8673 | 0.8271 | 0.8910 | 0.8359 |
| 360050080 | NY | BRONX CO | NEW YORK CMSA | 0.9626 | 0.9847 | 0.9826 | 0.9966 | 0.9974 |
| 360050083 | NY | BRONX CO | NEW YORK CMSA | 0.9626 | 0.9847 | 0.9826 | 0.9966 | 0.9974 |
| 360130011 | NY | CHAUTAUQUA CO | JAMESTOWN, NY | 0.8935 | 0.8653 | 0.8410 | 0.8845 | 0.8514 |
| 360150003 | NY | CHEMUNG CO | ELMIRA, NY | 0.8853 | 0.8471 | 0.8118 | 0.8665 | 0.8183 |
| 360270007 | NY | DUTCHESS CO | DUTCHESS COUNTY, NY | 0.9030 | 0.8816 | 0.8508 | 0.9028 | 0.8626 |
| 360290002 | NY | ERIE CO | BUFFALO CMSA | 0.9081 | 0.8910 | 0.8734 | 0.9072 | 0.8841 |
| 360310002 | NY | ESSEX CO | ESSEX CO, NY | 0.9070 | 0.8786 | 0.8577 | 0.8926 | 0.8637 |
| 360310003 | NY | ESSEX CO | ESSEX CO, NY | 0.9070 | 0.8786 | 0.8577 | 0.8926 | 0.8637 |
| 360410005 | NY | HAMILTON CO | HAMILTON CO, NY | 0.8987 | 0.8677 | 0.8410 | 0.8847 | 0.8484 |
| 360430005 | NY | HERKIMER CO | HERKIMER CO, NY | 0.9043 | 0.8778 | 0.8558 | 0.8929 | 0.8628 |
| 360450002 | NY | JEFFERSON CO | JEFFERSON CO, NY | 0.9041 | 0.8802 | 0.8581 | 0.8966 | 0.8662 |
| 360530006 | NY | MADISON CO | SYRACUSE, NY | 0.9047 | 0.8625 | 0.8305 | 0.8799 | 0.8363 |
| 360551004 | NY | MONROE CO | ROCHESTER, NY | 0.9042 | 0.8773 | 0.8558 | 0.8951 | 0.8654 |
| 360610010 | NY | NEW YORK CO | NEW YORK CMSA | 0.9143 | 0.8968 | 0.8709 | 0.9167 | 0.8827 |
| 360631006 | NY | NIAGARA CO | BUFFALO CMSA | 0.9006 | 0.8667 | 0.8392 | 0.8849 | 0.8476 |
| 360650004 | NY | ONEIDA CO | UTICA-ROME, NY | 0.8844 | 0.8502 | 0.8199 | 0.8700 | 0.8284 |
| 360671015 | NY | ONONDAGA CO | SYRACUSE, NY | 0.8930 | 0.8539 | 0.8221 | 0.8746 | 0.8310 |
| 360715001 | NY | ORANGE CO | NEWBURGH, NY-PA | 0.9119 | 0.9010 | 0.8755 | 0.9200 | 0.8869 |
| 360790005 | NY | PUTNAM CO | NEW YORK CMSA | 0.9184 | 0.9071 | 0.8828 | 0.9275 | 0.8962 |
| 360810097 | NY | QUEENS CO | NEW YORK CMSA | 0.9115 | 0.8905 | 0.8607 | 0.9122 | 0.8720 |
| 360850067 | NY | RICHMOND CO | NEW YORK CMSA | 0.9231 | 0.9145 | 0.8906 | 0.9350 | 0.9032 |
| 360910004 | NY | SARATOGA CO | ALBANY-SCHENECTADY-TROY, NY | 0.8735 | 0.8286 | 0.7877 | 0.8521 | 0.7963 |
| 360930003 | NY | SCHENECTADY CO | ALBANY-SCHENECTADY-TROY, NY | 0.9028 | 0.8771 | 0.8431 | 0.8987 | 0.8545 |
| 361030002 | NY | SUFFOLK CO | NEW YORK CMSA | 0.9081 | 0.8907 | 0.8703 | 0.9115 | 0.8848 |
| 361030004 | NY | SUFFOLK CO | NEW YORK CMSA | 0.9197 | 0.9129 | 0.8927 | 0.9337 | 0.9077 |
| 361111005 | NY | ULSTER CO | ULSTER CO, NY | 0.8898 | 0.8608 | 0.8249 | 0.8825 | 0.8345 |
| 361173001 | NY | WAYNE CO | ROCHESTER, NY | 0.9101 | 0.8892 | 0.8667 | 0.9092 | 0.8787 |
| 361192004 | NY | WESTCHESTER CO | NEW YORK CMSA | 0.9343 | 0.9357 | 0.9231 | 0.9536 | 0.9374 |
| 370030003 | NC | ALEXANDER CO | HICKORY-MORGANTON, NC | 0.8421 | 0.8006 | 0.7559 | 0.8238 | 0.7609 |
| 370210030 | NC | BUNCOMBE CO | ASHEVILLE, NC | 0.8175 | 0.7771 | 0.7237 | 0.8010 | 0.7269 |
| 370270003 | NC | CALDWELL CO | CALDWELL CO, NC | 0.8307 | 0.7869 | 0.7391 | 0.8093 | 0.7427 |
| 370290099 | NC | CAMDEN CO | CAMDEN CO, NC | 0.9116 | 0.8866 | 0.8574 | 0.9077 | 0.8681 |
| 370330001 | NC | CASWELL CO | CASWELL CO, NC | 0.8497 | 0.8179 | 0.7767 | 0.8395 | 0.7807 |

APPENDIX D

8-Hour Relative Reduction Factors

| Site Id. | State | County | Area Name | RRF 2007 Base | RRF 2020 Base | RRF 2020 Control | RRF 2030 Base | RRF 2030 Control |
|---|---|---|---|---|---|---|---|---|
| 370370004 | NC | CHATHAM CO | RALEIGH-DURHAM-CHAPEL HILL, NC | 0.8542 | 0.8160 | 0.7693 | 0.8419 | 0.7771 |
| 370510008 | NC | CUMBERLAND CO | FAYETTEVILLE, NC | 0.8644 | 0.8169 | 0.7617 | 0.8440 | 0.7667 |
| 370511003 | NC | CUMBERLAND CO | FAYETTEVILLE, NC | 0.8534 | 0.8043 | 0.7477 | 0.8309 | 0.7515 |
| 370590002 | NC | DAVIE CO | GREENSBORO--WINSTON-SALEM--H | 0.8328 | 0.7742 | 0.7221 | 0.8004 | 0.7276 |
| 370610002 | NC | DUPLIN CO | WILMINGTON, NC | 0.8504 | 0.8109 | 0.7659 | 0.8342 | 0.7711 |
| 370630013 | NC | DURHAM CO | RALEIGH-DURHAM-CHAPEL HILL, NC | 0.8734 | 0.8282 | 0.7802 | 0.8565 | 0.7883 |
| 370650099 | NC | EDGECOMBE CO | EDGECOMBE CO, NC | 0.8608 | 0.8250 | 0.7825 | 0.8485 | 0.7888 |
| 370670022 | NC | FORSYTH CO | GREENSBORO--WINSTON-SALEM--H | 0.8534 | 0.8042 | 0.7504 | 0.8314 | 0.7564 |
| 370670027 | NC | FORSYTH CO | GREENSBORO--WINSTON-SALEM--H | 0.8404 | 0.7943 | 0.7453 | 0.8163 | 0.7471 |
| 370670028 | NC | FORSYTH CO | GREENSBORO--WINSTON-SALEM--H | 0.8537 | 0.8030 | 0.7482 | 0.8288 | 0.7517 |
| 370671008 | NC | FORSYTH CO | GREENSBORO--WINSTON-SALEM--H | 0.8667 | 0.8200 | 0.7653 | 0.8479 | 0.7725 |
| 370690001 | NC | FRANKLIN CO | RALEIGH-DURHAM-CHAPEL HILL, NC | 0.8556 | 0.8121 | 0.7614 | 0.8393 | 0.7685 |
| 370770001 | NC | GRANVILLE CO | RALEIGH-DURHAM-CHAPEL HILL, NC | 0.8617 | 0.8195 | 0.7714 | 0.8456 | 0.7790 |
| 370810011 | NC | GUILFORD CO | GREENSBORO--WINSTON-SALEM--H | 0.8629 | 0.8224 | 0.7735 | 0.8474 | 0.7797 |
| 370870035 | NC | HAYWOOD CO | HAYWOOD CO, NC | 0.8235 | 0.7798 | 0.7258 | 0.8050 | 0.7296 |
| 370870036 | NC | HAYWOOD CO | HAYWOOD CO, NC | 0.8106 | 0.7710 | 0.7207 | 0.7945 | 0.7249 |
| 371010002 | NC | JOHNSTON CO | RALEIGH-DURHAM-CHAPEL HILL, NC | 0.8656 | 0.8159 | 0.7618 | 0.8443 | 0.7685 |
| 371070004 | NC | LENOIR CO | LENOIR CO, NC | 0.8578 | 0.8185 | 0.7730 | 0.8418 | 0.7783 |
| 371090004 | NC | LINCOLN CO | CHARLOTTE-GASTONIA-ROCK HILL, | 0.8625 | 0.8223 | 0.7743 | 0.8480 | 0.7817 |
| 371170001 | NC | MARTIN CO | MARTIN CO, NC | 0.8834 | 0.8517 | 0.8147 | 0.8738 | 0.8227 |
| 371190034 | NC | MECKLENBURG CO | CHARLOTTE-GASTONIA-ROCK HILL, | 0.8771 | 0.8325 | 0.7854 | 0.8604 | 0.7965 |
| 371191005 | NC | MECKLENBURG CO | CHARLOTTE-GASTONIA-ROCK HILL, | 0.8917 | 0.8569 | 0.8161 | 0.8846 | 0.8299 |
| 371191009 | NC | MECKLENBURG CO | CHARLOTTE-GASTONIA-ROCK HILL, | 0.8598 | 0.8113 | 0.7616 | 0.8389 | 0.7704 |
| 371290002 | NC | NEW HANOVER CO | WILMINGTON, NC | 0.8793 | 0.8465 | 0.8080 | 0.8734 | 0.8210 |
| 371310002 | NC | NORTHAMPTON CO | NORTHAMPTON CO, NC | 0.8632 | 0.8339 | 0.7974 | 0.8539 | 0.8033 |
| 371450003 | NC | PERSON CO | RALEIGH-DURHAM-CHAPEL HILL, NC | 0.8516 | 0.8232 | 0.7833 | 0.8442 | 0.7879 |
| 371470099 | NC | PITT CO | PITT CO, NC | 0.8614 | 0.8231 | 0.7773 | 0.8478 | 0.7839 |
| 371570099 | NC | ROCKINGHAM CO | ROCKINGHAM CO, NC | 0.8528 | 0.8056 | 0.7570 | 0.8300 | 0.7625 |
| 371590021 | NC | ROWAN CO | CHARLOTTE-GASTONIA-ROCK HILL, | 0.8366 | 0.7873 | 0.7323 | 0.8149 | 0.7382 |
| 371590022 | NC | ROWAN CO | CHARLOTTE-GASTONIA-ROCK HILL, | 0.8552 | 0.7987 | 0.7513 | 0.8250 | 0.7586 |
| 371730002 | NC | SWAIN CO | SWAIN CO, NC | 0.8249 | 0.7797 | 0.7345 | 0.7993 | 0.7366 |
| 371830014 | NC | WAKE CO | RALEIGH-DURHAM-CHAPEL HILL, NC | 0.8886 | 0.8464 | 0.7923 | 0.8761 | 0.8021 |
| 371830015 | NC | WAKE CO | RALEIGH-DURHAM-CHAPEL HILL, NC | 0.8886 | 0.8464 | 0.7923 | 0.8761 | 0.8021 |
| 371830016 | NC | WAKE CO | RALEIGH-DURHAM-CHAPEL HILL, NC | 0.8792 | 0.8257 | 0.7681 | 0.8567 | 0.7757 |
| 371830017 | NC | WAKE CO | RALEIGH-DURHAM-CHAPEL HILL, NC | 0.8867 | 0.8495 | 0.7977 | 0.8772 | 0.8072 |
| 371990003 | NC | YANCEY CO | YANCEY CO, NC | 0.8241 | 0.7819 | 0.7329 | 0.8052 | 0.7373 |
| 390030002 | OH | ALLEN CO | LIMA, OH | 0.8955 | 0.8687 | 0.8441 | 0.8888 | 0.8559 |
| 390071001 | OH | ASHTABULA CO | CLEVELAND CMSA | 0.9007 | 0.8771 | 0.8528 | 0.8974 | 0.8648 |
| 390170004 | OH | BUTLER CO | CINCINNATI CMSA | 0.8957 | 0.8710 | 0.8455 | 0.8917 | 0.8572 |
| 390171004 | OH | BUTLER CO | CINCINNATI CMSA | 0.8816 | 0.8507 | 0.8225 | 0.8711 | 0.8325 |
| 390230001 | OH | CLARK CO | DAYTON-SPRINGFIELD, OH | 0.8749 | 0.8360 | 0.8037 | 0.8573 | 0.8131 |
| 390230003 | OH | CLARK CO | DAYTON-SPRINGFIELD, OH | 0.8748 | 0.8399 | 0.8098 | 0.8606 | 0.8194 |
| 390250020 | OH | CLERMONT CO | CINCINNATI CMSA | 0.8834 | 0.8600 | 0.8335 | 0.8796 | 0.8445 |
| 390271002 | OH | CLINTON CO | CINCINNATI CMSA | 0.8560 | 0.8191 | 0.7877 | 0.8384 | 0.7953 |

| Site Id. | State | County | Area Name | RRF 2007 Base | RRF 2020 Base | RRF 2020 Control | RRF 2030 Base | RRF 2030 Control |
|---|---|---|---|---|---|---|---|---|
| 390350034 | OH | CUYAHOGA CO | CLEVELAND CMSA | 0.8929 | 0.8671 | 0.8465 | 0.8876 | 0.8604 |
| 390350064 | OH | CUYAHOGA CO | CLEVELAND CMSA | 0.9165 | 0.9039 | 0.8881 | 0.9218 | 0.9020 |
| 390355002 | OH | CUYAHOGA CO | CLEVELAND CMSA | 0.8996 | 0.8761 | 0.8557 | 0.8970 | 0.8693 |
| 390410002 | OH | DELAWARE CO | COLUMBUS, OH | 0.8731 | 0.8374 | 0.8068 | 0.8574 | 0.8154 |
| 390490004 | OH | FRANKLIN CO | COLUMBUS, OH | 0.8923 | 0.8780 | 0.8613 | 0.8958 | 0.8751 |
| 390490081 | OH | FRANKLIN CO | COLUMBUS, OH | 0.8884 | 0.8715 | 0.8554 | 0.8905 | 0.8692 |
| 390550004 | OH | GEAUGA CO | CLEVELAND-LORAIN-ELYRIA, OH | 0.8938 | 0.8634 | 0.8358 | 0.8849 | 0.8478 |
| 390570006 | OH | GREENE CO | DAYTON-SPRINGFIELD, OH | 0.8665 | 0.8333 | 0.8026 | 0.8536 | 0.8116 |
| 390610006 | OH | HAMILTON CO | CINCINNATI CMSA | 0.8949 | 0.8771 | 0.8570 | 0.8973 | 0.8709 |
| 390610010 | OH | HAMILTON CO | CINCINNATI CMSA | 0.8826 | 0.8749 | 0.8654 | 0.8915 | 0.8796 |
| 390610037 | OH | HAMILTON CO | CINCINNATI CMSA | 0.9095 | 0.8969 | 0.8819 | 0.9171 | 0.8974 |
| 390830002 | OH | KNOX CO | COLUMBUS, OH | 0.8767 | 0.8526 | 0.8261 | 0.8722 | 0.8363 |
| 390850003 | OH | LAKE CO | CLEVELAND CMSA | 0.9004 | 0.8787 | 0.8577 | 0.9002 | 0.8723 |
| 390853002 | OH | LAKE CO | CLEVELAND CMSA | 0.9019 | 0.8777 | 0.8544 | 0.8995 | 0.8685 |
| 390870006 | OH | LAWRENCE CO | HUNTINGTON-ASHLAND, WV-KY-OH | 0.8522 | 0.8276 | 0.8033 | 0.8430 | 0.8104 |
| 390870011 | OH | LAWRENCE CO | HUNTINGTON-ASHLAND, WV-KY-OH | 0.8531 | 0.8231 | 0.7978 | 0.8379 | 0.8036 |
| 390890005 | OH | LICKING CO | COLUMBUS, OH | 0.8679 | 0.8412 | 0.8127 | 0.8608 | 0.8221 |
| 390911001 | OH | LOGAN CO | LOGAN CO, OH | 0.8771 | 0.8389 | 0.8063 | 0.8597 | 0.8154 |
| 390931003 | OH | LORAIN CO | CLEVELAND CMSA | 0.9174 | 0.9079 | 0.8933 | 0.9250 | 0.9063 |
| 390950034 | OH | LUCAS CO | TOLEDO, OH | 0.9056 | 0.8901 | 0.8717 | 0.9060 | 0.8823 |
| 390950081 | OH | LUCAS CO | TOLEDO, OH | 0.8990 | 0.8793 | 0.8590 | 0.8919 | 0.8659 |
| 390970007 | OH | MADISON CO | COLUMBUS, OH | 0.8742 | 0.8421 | 0.8131 | 0.8623 | 0.8228 |
| 390990009 | OH | MAHONING CO | YOUNGSTOWN-WARREN, OH | 0.8693 | 0.8275 | 0.7903 | 0.8479 | 0.7978 |
| 391030003 | OH | MEDINA CO | CLEVELAND CMSA | 0.8814 | 0.8510 | 0.8213 | 0.8714 | 0.8321 |
| 391090005 | OH | MIAMI CO | DAYTON-SPRINGFIELD, OH | 0.8756 | 0.8400 | 0.8097 | 0.8615 | 0.8202 |
| 391130019 | OH | MONTGOMERY CO | DAYTON-SPRINGFIELD, OH | 0.8786 | 0.8502 | 0.8216 | 0.8711 | 0.8325 |
| 391331001 | OH | PORTAGE CO | CLEVELAND CMSA | 0.8838 | 0.8510 | 0.8178 | 0.8728 | 0.8284 |
| 391351001 | OH | PREBLE CO | DAYTON-SPRINGFIELD, OH | 0.8594 | 0.8209 | 0.7886 | 0.8390 | 0.7944 |
| 391510016 | OH | STARK CO | CANTON-MASSILLON, OH | 0.8734 | 0.8397 | 0.8054 | 0.8603 | 0.8143 |
| 391510019 | OH | STARK CO | CANTON-MASSILLON, OH | 0.8649 | 0.8367 | 0.8055 | 0.8559 | 0.8136 |
| 391511009 | OH | STARK CO | CANTON-MASSILLON, OH | 0.8736 | 0.8388 | 0.8043 | 0.8595 | 0.8130 |
| 391514005 | OH | STARK CO | CANTON-MASSILLON, OH | 0.8811 | 0.8464 | 0.8126 | 0.8675 | 0.8220 |
| 391530020 | OH | SUMMIT CO | CLEVELAND CMSA | 0.8951 | 0.8709 | 0.8431 | 0.8899 | 0.8543 |
| 391550008 | OH | TRUMBULL CO | YOUNGSTOWN-WARREN, OH | 0.8709 | 0.8290 | 0.7916 | 0.8500 | 0.7997 |
| 391550009 | OH | TRUMBULL CO | YOUNGSTOWN-WARREN, OH | 0.8678 | 0.8284 | 0.7938 | 0.8494 | 0.8024 |
| 391591001 | OH | UNION CO | UNION CO, OH | 0.8732 | 0.8356 | 0.8037 | 0.8551 | 0.8116 |
| 391650006 | OH | WARREN CO | CINCINNATI CMSA | 0.8851 | 0.8576 | 0.8292 | 0.8791 | 0.8407 |
| 391670004 | OH | WASHINGTON CO | PARKERSBURG-MARIETTA, WV-OH | 0.8203 | 0.7896 | 0.7627 | 0.8033 | 0.7665 |
| 391730003 | OH | WOOD CO | TOLEDO, OH | 0.9002 | 0.8756 | 0.8516 | 0.8935 | 0.8615 |
| 400270049 | OK | CLEVELAND CO | OKLAHOMA CITY, OK | 0.9306 | 0.8694 | 0.8296 | 0.8904 | 0.8351 |
| 400770440 | OK | LATIMER CO | LATIMER CO, OK | 0.9519 | 0.9187 | 0.8940 | 0.9348 | 0.9011 |
| 400870073 | OK | MC CLAIN CO | OKLAHOMA CITY, OK | 0.9320 | 0.8711 | 0.8313 | 0.8914 | 0.8360 |
| 401090033 | OK | OKLAHOMA CO | OKLAHOMA CITY, OK | 0.9362 | 0.8758 | 0.8373 | 0.8971 | 0.8434 |
| 401091037 | OK | OKLAHOMA CO | OKLAHOMA CITY, OK | 0.9340 | 0.8726 | 0.8342 | 0.8933 | 0.8399 |

# APPENDIX D
## 8-Hour Relative Reduction Factors

| Site Id. | State | County | Area Name | RRF 2007 Base | RRF 2020 Base | RRF 2020 Control | RRF 2030 Base | RRF 2030 Control |
|---|---|---|---|---|---|---|---|---|
| 401430127 | OK | TULSA CO | TULSA, OK | 0.9375 | 0.8825 | 0.8433 | 0.9066 | 0.8534 |
| 401430137 | OK | TULSA CO | TULSA, OK | 0.9375 | 0.8828 | 0.8451 | 0.9071 | 0.8556 |
| 401430174 | OK | TULSA CO | TULSA, OK | 0.9327 | 0.8781 | 0.8390 | 0.9003 | 0.8467 |
| 420030008 | PA | ALLEGHENY CO | PITTSBURGH CMSA | 0.9122 | 0.8904 | 0.8627 | 0.9096 | 0.8719 |
| 420030010 | PA | ALLEGHENY CO | PITTSBURGH CMSA | 0.9120 | 0.8961 | 0.8739 | 0.9145 | 0.8850 |
| 420030067 | PA | ALLEGHENY CO | PITTSBURGH CMSA | 0.8809 | 0.8661 | 0.8425 | 0.8832 | 0.8520 |
| 420030088 | PA | ALLEGHENY CO | PITTSBURGH CMSA | 0.9028 | 0.8824 | 0.8540 | 0.9013 | 0.8629 |
| 420031005 | PA | ALLEGHENY CO | PITTSBURGH CMSA | 0.9025 | 0.8814 | 0.8554 | 0.8996 | 0.8642 |
| 420050001 | PA | ARMSTRONG CO | ARMSTRONG CO, PA | 0.8708 | 0.8395 | 0.8093 | 0.8568 | 0.8154 |
| 420070002 | PA | BEAVER CO | PITTSBURGH CMSA | 0.8987 | 0.8701 | 0.8434 | 0.8858 | 0.8498 |
| 420070005 | PA | BEAVER CO | PITTSBURGH CMSA | 0.9088 | 0.8812 | 0.8566 | 0.8982 | 0.8645 |
| 420070014 | PA | BEAVER CO | PITTSBURGH CMSA | 0.9191 | 0.8945 | 0.8704 | 0.9109 | 0.8780 |
| 420110001 | PA | BERKS CO | READING, PA | 0.8819 | 0.8375 | 0.7969 | 0.8584 | 0.8030 |
| 420110009 | PA | BERKS CO | READING, PA | 0.8804 | 0.8472 | 0.8103 | 0.8679 | 0.8181 |
| 420130801 | PA | BLAIR CO | ALTOONA, PA | 0.8482 | 0.8213 | 0.7900 | 0.8361 | 0.7932 |
| 420170012 | PA | BUCKS CO | PHILADELPHIA CMSA | 0.9287 | 0.9258 | 0.9064 | 0.9444 | 0.9195 |
| 420210011 | PA | CAMBRIA CO | JOHNSTOWN, PA | 0.8770 | 0.8582 | 0.8314 | 0.8725 | 0.8356 |
| 420274000 | PA | CENTRE CO | STATE COLLEGE, PA | 0.8530 | 0.8153 | 0.7768 | 0.8344 | 0.7819 |
| 420334000 | PA | CLEARFIELD CO | CLEARFIELD CO, PA | 0.8516 | 0.8177 | 0.7840 | 0.8353 | 0.7890 |
| 420430401 | PA | DAUPHIN CO | HARRISBURG-LEBANON-CARLISLE, | 0.8826 | 0.8306 | 0.7834 | 0.8511 | 0.7874 |
| 420431100 | PA | DAUPHIN CO | HARRISBURG-LEBANON-CARLISLE, | 0.8867 | 0.8355 | 0.7883 | 0.8562 | 0.7928 |
| 420450002 | PA | DELAWARE CO | PHILADELPHIA CMSA | 0.8997 | 0.8786 | 0.8500 | 0.8980 | 0.8587 |
| 420490003 | PA | ERIE CO | ERIE, PA | 0.8956 | 0.8703 | 0.8461 | 0.8902 | 0.8573 |
| 420550001 | PA | FRANKLIN CO | FRANKLIN CO, PA | 0.8455 | 0.8052 | 0.7622 | 0.8245 | 0.7655 |
| 420590002 | PA | GREENE CO | GREENE CO, PA | 0.8087 | 0.7774 | 0.7506 | 0.7907 | 0.7539 |
| 420690101 | PA | LACKAWANNA CO | SCRANTON--WILKES-BARRE--HAZLE | 0.8660 | 0.8217 | 0.7811 | 0.8419 | 0.7867 |
| 420692006 | PA | LACKAWANNA CO | SCRANTON--WILKES-BARRE--HAZLE | 0.8647 | 0.8232 | 0.7845 | 0.8438 | 0.7913 |
| 420710007 | PA | LANCASTER CO | LANCASTER, PA | 0.8974 | 0.8653 | 0.8270 | 0.8873 | 0.8351 |
| 420730015 | PA | LAWRENCE CO | LAWRENCE CO, PA | 0.8774 | 0.8387 | 0.8041 | 0.8583 | 0.8110 |
| 420770004 | PA | LEHIGH CO | ALLENTOWN-BETHLEHEM-EASTON, | 0.8955 | 0.8628 | 0.8286 | 0.8824 | 0.8360 |
| 420791100 | PA | LUZERNE CO | SCRANTON--WILKES-BARRE--HAZLE | 0.8487 | 0.8060 | 0.7677 | 0.8243 | 0.7723 |
| 420791101 | PA | LUZERNE CO | SCRANTON--WILKES-BARRE--HAZLE | 0.8687 | 0.8262 | 0.7866 | 0.8472 | 0.7934 |
| 420810403 | PA | LYCOMING CO | WILLIAMSPORT, PA | 0.8636 | 0.8265 | 0.7892 | 0.8447 | 0.7937 |
| 420814000 | PA | LYCOMING CO | WILLIAMSPORT, PA | 0.8490 | 0.8155 | 0.7808 | 0.8335 | 0.7859 |
| 420850100 | PA | MERCER CO | YOUNGSTOWN-WARREN, OH | 0.8627 | 0.8208 | 0.7831 | 0.8412 | 0.7902 |
| 420890001 | PA | MONROE CO | MONROE CO, PA | 0.8966 | 0.8652 | 0.8325 | 0.8842 | 0.8398 |
| 420910013 | PA | MONTGOMERY CO | PHILADELPHIA CMSA | 0.9060 | 0.9055 | 0.8898 | 0.9224 | 0.9026 |
| 420950025 | PA | NORTHAMPTON CO | ALLENTOWN-BETHLEHEM-EASTON, | 0.8955 | 0.8628 | 0.8286 | 0.8824 | 0.8360 |
| 420950100 | PA | NORTHAMPTON CO | ALLENTOWN-BETHLEHEM-EASTON, | 0.8992 | 0.8635 | 0.8297 | 0.8833 | 0.8371 |
| 420990301 | PA | PERRY CO | HARRISBURG-LEBANON-CARLISLE, | 0.8563 | 0.8108 | 0.7688 | 0.8296 | 0.7720 |
| 421010004 | PA | PHILADELPHIA CO | PHILADELPHIA CMSA | 0.9310 | 0.9286 | 0.9091 | 0.9471 | 0.9218 |
| 421010014 | PA | PHILADELPHIA CO | PHILADELPHIA CMSA | 0.9053 | 0.8967 | 0.8766 | 0.9155 | 0.8883 |
| 421010024 | PA | PHILADELPHIA CO | PHILADELPHIA CMSA | 0.9310 | 0.9286 | 0.9091 | 0.9471 | 0.9218 |
| 421010136 | PA | PHILADELPHIA CO | PHILADELPHIA CMSA | 0.9042 | 0.8901 | 0.8662 | 0.9082 | 0.8760 |

APPENDIX D

8-Hour Relative Reduction Factors

| Site Id. | State | County | Area Name | RRF 2007 Base | RRF 2020 Base | RRF 2020 Control | RRF 2030 Base | RRF 2030 Control |
|---|---|---|---|---|---|---|---|---|
| 421250005 | PA | WASHINGTON CO | PITTSBURGH CMSA | 0.8648 | 0.8394 | 0.8141 | 0.8554 | 0.8206 |
| 421250200 | PA | WASHINGTON CO | PITTSBURGH CMSA | 0.8394 | 0.8073 | 0.7783 | 0.8226 | 0.7826 |
| 421255001 | PA | WASHINGTON CO | PITTSBURGH CMSA | 0.9044 | 0.8816 | 0.8582 | 0.8980 | 0.8662 |
| 421290006 | PA | WESTMORELAND CO | PITTSBURGH CMSA | 0.9147 | 0.8947 | 0.8671 | 0.9140 | 0.8761 |
| 421330008 | PA | YORK CO | YORK, PA | 0.8871 | 0.8497 | 0.8098 | 0.8718 | 0.8165 |
| 440030002 | RI | KENT CO | PROVIDENCE CMSA | 0.9094 | 0.8806 | 0.8440 | 0.9060 | 0.8579 |
| 440071010 | RI | PROVIDENCE CO | PROVIDENCE CMSA | 0.9020 | 0.8634 | 0.8228 | 0.8892 | 0.8358 |
| 440090007 | RI | WASHINGTON CO | PROVIDENCE CMSA | 0.8972 | 0.8688 | 0.8322 | 0.8961 | 0.8477 |
| 450010001 | SC | ABBEVILLE CO | ABBEVILLE CO, SC | 0.8424 | 0.7909 | 0.7296 | 0.8169 | 0.7324 |
| 450030003 | SC | AIKEN CO | AUGUSTA-AIKEN, GA-SC | 0.8421 | 0.7831 | 0.7367 | 0.8089 | 0.7454 |
| 450070003 | SC | ANDERSON CO | GREENVILLE-SPARTANBURG-ANDEF | 0.8518 | 0.8015 | 0.7469 | 0.8269 | 0.7527 |
| 450110001 | SC | BARNWELL CO | BARNWELL CO, SC | 0.8444 | 0.8072 | 0.7620 | 0.8308 | 0.7684 |
| 450150002 | SC | BERKELEY CO | CHARLESTON-NORTH CHARLESTON | 0.8663 | 0.8325 | 0.7894 | 0.8575 | 0.7986 |
| 450190042 | SC | CHARLESTON CO | CHARLESTON-NORTH CHARLESTON | 0.8663 | 0.8325 | 0.7894 | 0.8575 | 0.7986 |
| 450190046 | SC | CHARLESTON CO | CHARLESTON-NORTH CHARLESTON | 0.8573 | 0.8275 | 0.7886 | 0.8500 | 0.7963 |
| 450210002 | SC | CHEROKEE CO | CHEROKEE CO, SC | 0.8445 | 0.8074 | 0.7562 | 0.8352 | 0.7639 |
| 450230002 | SC | CHESTER CO | CHARLOTTE-GASTONIA-ROCK HILL, | 0.8719 | 0.8389 | 0.7945 | 0.8651 | 0.8039 |
| 450290002 | SC | COLLETON CO | COLLETON CO, SC | 0.8500 | 0.8127 | 0.7666 | 0.8341 | 0.7702 |
| 450310003 | SC | DARLINGTON CO | DARLINGTON CO, SC | 0.8780 | 0.8548 | 0.8126 | 0.8827 | 0.8252 |
| 450370001 | SC | EDGEFIELD CO | EDGEFIELD CO, SC | 0.8422 | 0.7963 | 0.7446 | 0.8209 | 0.7497 |
| 450730001 | SC | OCONEE CO | OCONEE CO, SC | 0.8253 | 0.7763 | 0.7205 | 0.8003 | 0.7231 |
| 450770002 | SC | PICKENS CO | GREENVILLE-SPARTANBURG-ANDEF | 0.8424 | 0.7888 | 0.7285 | 0.8136 | 0.7303 |
| 450790007 | SC | RICHLAND CO | COLUMBIA, SC | 0.8607 | 0.8134 | 0.7526 | 0.8408 | 0.7581 |
| 450791002 | SC | RICHLAND CO | COLUMBIA, SC | 0.8653 | 0.8168 | 0.7570 | 0.8447 | 0.7623 |
| 450830009 | SC | SPARTANBURG CO | GREENVILLE-SPARTANBURG-ANDEF | 0.8489 | 0.8095 | 0.7601 | 0.8337 | 0.7654 |
| 450870001 | SC | UNION CO | UNION CO, SC | 0.8444 | 0.8070 | 0.7592 | 0.8315 | 0.7649 |
| 450910006 | SC | YORK CO | CHARLOTTE-GASTONIA-ROCK HILL, | 0.8749 | 0.8404 | 0.7953 | 0.8676 | 0.8055 |
| 470010101 | TN | ANDERSON CO | KNOXVILLE, TN | 0.8271 | 0.7622 | 0.7126 | 0.7814 | 0.7133 |
| 470090101 | TN | BLOUNT CO | KNOXVILLE, TN | 0.8387 | 0.7780 | 0.7244 | 0.7983 | 0.7246 |
| 470090102 | TN | BLOUNT CO | KNOXVILLE, TN | 0.8355 | 0.7775 | 0.7264 | 0.7972 | 0.7269 |
| 470370011 | TN | DAVIDSON CO | NASHVILLE, TN | 0.8893 | 0.8531 | 0.8192 | 0.8748 | 0.8295 |
| 470370026 | TN | DAVIDSON CO | NASHVILLE, TN | 0.8853 | 0.8474 | 0.8142 | 0.8689 | 0.8240 |
| 470650028 | TN | HAMILTON CO | CHATTANOOGA, TN-GA | 0.8492 | 0.7851 | 0.7248 | 0.8094 | 0.7266 |
| 470651011 | TN | HAMILTON CO | CHATTANOOGA, TN-GA | 0.8493 | 0.7811 | 0.7185 | 0.8058 | 0.7198 |
| 470750003 | TN | HAYWOOD CO | HAYWOOD CO, TN | 0.8672 | 0.8235 | 0.7949 | 0.8407 | 0.8012 |
| 470890001 | TN | JEFFERSON CO | JEFFERSON CO, TN | 0.8120 | 0.7519 | 0.7057 | 0.7700 | 0.7062 |
| 470890002 | TN | JEFFERSON CO | JEFFERSON CO, TN | 0.8120 | 0.7519 | 0.7057 | 0.7700 | 0.7062 |
| 470930021 | TN | KNOX CO | KNOXVILLE, TN | 0.8472 | 0.7900 | 0.7406 | 0.8091 | 0.7413 |
| 470931020 | TN | KNOX CO | KNOXVILLE, TN | 0.8450 | 0.7854 | 0.7344 | 0.8050 | 0.7353 |
| 470990002 | TN | LAWRENCE CO | LAWRENCE CO, TN | 0.7858 | 0.7505 | 0.7183 | 0.7678 | 0.7238 |
| 471410004 | TN | PUTNAM CO | PUTNAM CO, TN | 0.8160 | 0.7610 | 0.7201 | 0.7782 | 0.7217 |
| 471490101 | TN | RUTHERFORD CO | NASHVILLE, TN | 0.8625 | 0.8140 | 0.7721 | 0.8363 | 0.7791 |
| 471550101 | TN | SEVIER CO | KNOXVILLE, TN | 0.8176 | 0.7634 | 0.7162 | 0.7813 | 0.7161 |
| 471550102 | TN | SEVIER CO | KNOXVILLE, TN | 0.7977 | 0.7537 | 0.7106 | 0.7720 | 0.7121 |

# APPENDIX D

## 8-Hour Relative Reduction Factors

| Site Id. | State | County | Area Name | RRF 2007 Base | RRF 2020 Base | RRF 2020 Control | RRF 2030 Base | RRF 2030 Control |
|---|---|---|---|---|---|---|---|---|
| 471570021 | TN | SHELBY CO | MEMPHIS, TN-AR-MS | 0.9229 | 0.9125 | 0.8952 | 0.9328 | 0.9099 |
| 471571004 | TN | SHELBY CO | MEMPHIS, TN-AR-MS | 0.8980 | 0.8596 | 0.8327 | 0.8783 | 0.8414 |
| 471632002 | TN | SULLIVAN CO | JOHNSON CITY-KINGSPORT-BRISTO | 0.8353 | 0.8043 | 0.7687 | 0.8237 | 0.7746 |
| 471632003 | TN | SULLIVAN CO | JOHNSON CITY-KINGSPORT-BRISTO | 0.8357 | 0.8041 | 0.7683 | 0.8236 | 0.7743 |
| 471650007 | TN | SUMNER CO | NASHVILLE, TN | 0.8813 | 0.8441 | 0.8104 | 0.8645 | 0.8192 |
| 471650101 | TN | SUMNER CO | NASHVILLE, TN | 0.8401 | 0.7961 | 0.7605 | 0.8154 | 0.7663 |
| 471870106 | TN | WILLIAMSON CO | NASHVILLE, TN | 0.8044 | 0.7662 | 0.7343 | 0.7860 | 0.7428 |
| 471890103 | TN | WILSON CO | NASHVILLE, TN | 0.8433 | 0.7980 | 0.7598 | 0.8168 | 0.7645 |
| 480391003 | TX | BRAZORIA CO | HOUSTON CMSA | 0.9632 | 0.9339 | 0.9186 | 0.9512 | 0.9304 |
| 480430101 | TX | BREWSTER CO | BREWSTER CO, TX | | | | | |
| 480850005 | TX | COLLIN CO | DALLAS CMSA | 0.9301 | 0.8867 | 0.8532 | 0.9117 | 0.8653 |
| 481130045 | TX | DALLAS CO | DALLAS CMSA | 0.9352 | 0.9097 | 0.8796 | 0.9314 | 0.8909 |
| 481130069 | TX | DALLAS CO | DALLAS CMSA | 0.9361 | 0.9099 | 0.8782 | 0.9318 | 0.8895 |
| 481130087 | TX | DALLAS CO | DALLAS CMSA | 0.9381 | 0.9131 | 0.8818 | 0.9348 | 0.8931 |
| 481210034 | TX | DENTON CO | DALLAS CMSA | 0.9271 | 0.8739 | 0.8360 | 0.9000 | 0.8479 |
| 481210054 | TX | DENTON CO | DALLAS CMSA | 0.9309 | 0.8946 | 0.8617 | 0.9184 | 0.8734 |
| 481390015 | TX | ELLIS CO | DALLAS CMSA | 0.9268 | 0.8632 | 0.8256 | 0.8866 | 0.8346 |
| 481670014 | TX | GALVESTON CO | HOUSTON CMSA | 0.9524 | 0.9423 | 0.9283 | 0.9600 | 0.9409 |
| 481671002 | TX | GALVESTON CO | HOUSTON CMSA | 0.9508 | 0.9406 | 0.9255 | 0.9588 | 0.9376 |
| 481830001 | TX | GREGG CO | LONGVIEW-MARSHALL, TX | 0.9292 | 0.8772 | 0.8428 | 0.8943 | 0.8469 |
| 482010024 | TX | HARRIS CO | HOUSTON CMSA | 0.9485 | 0.9679 | 0.9643 | 0.9816 | 0.9792 |
| 482010029 | TX | HARRIS CO | HOUSTON CMSA | 0.9400 | 0.9064 | 0.8811 | 0.9278 | 0.8934 |
| 482010046 | TX | HARRIS CO | HOUSTON CMSA | 0.9491 | 0.9782 | 0.9787 | 0.9907 | 0.9942 |
| 482010047 | TX | HARRIS CO | HOUSTON CMSA | 0.9472 | 0.9727 | 0.9727 | 0.9858 | 0.9883 |
| 482010051 | TX | HARRIS CO | HOUSTON CMSA | 0.9501 | 0.9598 | 0.9562 | 0.9747 | 0.9713 |
| 482010055 | TX | HARRIS CO | HOUSTON CMSA | 0.9494 | 0.9819 | 0.9842 | 0.9938 | 1.0001 |
| 482010062 | TX | HARRIS CO | HOUSTON CMSA | 0.9505 | 0.9636 | 0.9610 | 0.9781 | 0.9762 |
| 482010066 | TX | HARRIS CO | HOUSTON CMSA | 0.9441 | 0.9486 | 0.9391 | 0.9651 | 0.9545 |
| 482011034 | TX | HARRIS CO | HOUSTON CMSA | 0.9510 | 0.9884 | 0.9922 | 1.0002 | 1.0084 |
| 482011035 | TX | HARRIS CO | HOUSTON CMSA | 0.9510 | 0.9884 | 0.9922 | 1.0002 | 1.0084 |
| 482011037 | TX | HARRIS CO | HOUSTON CMSA | 0.9494 | 0.9819 | 0.9842 | 0.9938 | 1.0001 |
| 482011039 | TX | HARRIS CO | HOUSTON CMSA | 0.9526 | 0.9873 | 0.9922 | 0.9989 | 1.0082 |
| 482450009 | TX | JEFFERSON CO | BEAUMONT-PORT ARTHUR, TX | 0.9685 | 0.9323 | 0.9158 | 0.9536 | 0.9310 |
| 482450011 | TX | JEFFERSON CO | BEAUMONT-PORT ARTHUR, TX | 0.9679 | 0.9479 | 0.9358 | 0.9675 | 0.9511 |
| 483550025 | TX | NUECES CO | CORPUS CHRISTI, TX | | | | | |
| 483550026 | TX | NUECES CO | CORPUS CHRISTI, TX | | | | | |
| 483611001 | TX | ORANGE CO | BEAUMONT-PORT ARTHUR, TX | 0.9718 | 0.9415 | 0.9276 | 0.9620 | 0.9431 |
| 484230004 | TX | SMITH CO | TYLER, TX | 0.9270 | 0.8656 | 0.8275 | 0.8851 | 0.8322 |
| 484390057 | TX | TARRANT CO | DALLAS CMSA | 0.9373 | 0.9059 | 0.8742 | 0.9286 | 0.8863 |
| 484391002 | TX | TARRANT CO | DALLAS CMSA | 0.9337 | 0.8883 | 0.8522 | 0.9125 | 0.8645 |
| 484392003 | TX | TARRANT CO | DALLAS CMSA | 0.9312 | 0.8881 | 0.8527 | 0.9120 | 0.8646 |
| 484530014 | TX | TRAVIS CO | AUSTIN-SAN MARCOS, TX | 0.9304 | 0.8831 | 0.8506 | 0.9067 | 0.8619 |
| 484530020 | TX | TRAVIS CO | AUSTIN-SAN MARCOS, TX | 0.9290 | 0.8794 | 0.8448 | 0.9034 | 0.8557 |
| 484690003 | TX | VICTORIA CO | VICTORIA, TX | 0.9438 | 0.9120 | 0.8905 | 0.9290 | 0.8995 |

# APPENDIX D

## 8-Hour Relative Reduction Factors

| Site Id. | State | County | Area Name | RRF 2007 Base | RRF 2020 Base | RRF 2020 Control | RRF 2030 Base | RRF 2030 Control |
|---|---|---|---|---|---|---|---|---|
| 500030004 | VT | BENNINGTON CO | BENNINGTON CO, VT | 0.8789 | 0.8257 | 0.7832 | 0.8502 | 0.7920 |
| 500070007 | VT | CHITTENDEN CO | CHITTENDEN CO, VT | 0.8847 | 0.8385 | 0.7993 | 0.8594 | 0.8055 |
| 510130020 | VA | ARLINGTON CO | WASHINGTON, DC-MD-VA-WV | 0.9204 | 0.9124 | 0.8836 | 0.9318 | 0.8957 |
| 510330001 | VA | CAROLINE CO | CAROLINE CO, VA | 0.8694 | 0.8238 | 0.7760 | 0.8472 | 0.7821 |
| 510360002 | VA | CHARLES CITY CO | RICHMOND-PETERSBURG, VA | 0.8744 | 0.8440 | 0.8104 | 0.8642 | 0.8180 |
| 510410004 | VA | CHESTERFIELD CO | RICHMOND-PETERSBURG, VA | 0.8772 | 0.8318 | 0.7853 | 0.8541 | 0.7906 |
| 510590005 | VA | FAIRFAX CO | WASHINGTON, DC-MD-VA-WV | 0.8970 | 0.8677 | 0.8277 | 0.8915 | 0.8401 |
| 510590018 | VA | FAIRFAX CO | WASHINGTON, DC-MD-VA-WV | 0.9012 | 0.8819 | 0.8562 | 0.9005 | 0.8671 |
| 510590030 | VA | FAIRFAX CO | WASHINGTON, DC-MD-VA-WV | 0.9012 | 0.8819 | 0.8562 | 0.9005 | 0.8671 |
| 510591004 | VA | FAIRFAX CO | WASHINGTON, DC-MD-VA-WV | 0.9204 | 0.9124 | 0.8836 | 0.9318 | 0.8957 |
| 510595001 | VA | FAIRFAX CO | WASHINGTON, DC-MD-VA-WV | 0.9235 | 0.9157 | 0.8904 | 0.9357 | 0.9049 |
| 510610002 | VA | FAUQUIER CO | FAUQUIER CO, VA | 0.8588 | 0.8187 | 0.7742 | 0.8417 | 0.7815 |
| 510690010 | VA | FREDERICK CO | FREDERICK CO, VA | 0.8516 | 0.8181 | 0.7836 | 0.8366 | 0.7893 |
| 510850001 | VA | HANOVER CO | RICHMOND-PETERSBURG, VA | 0.8683 | 0.8296 | 0.7857 | 0.8523 | 0.7920 |
| 510870014 | VA | HENRICO CO | RICHMOND-PETERSBURG, VA | 0.8763 | 0.8325 | 0.7857 | 0.8563 | 0.7926 |
| 511071005 | VA | LOUDOUN CO | WASHINGTON, DC-MD-VA-WV | 0.8969 | 0.8693 | 0.8301 | 0.8941 | 0.8437 |
| 511130003 | VA | MADISON CO | CHARLOTTESVILLE, VA | 0.8093 | 0.7706 | 0.7288 | 0.7898 | 0.7324 |
| 511530009 | VA | PRINCE WILLIAM CO | WASHINGTON, DC-MD-VA-WV | 0.8793 | 0.8461 | 0.8047 | 0.8712 | 0.8165 |
| 511611004 | VA | ROANOKE CO | ROANOKE, VA | 0.8322 | 0.7865 | 0.7432 | 0.8076 | 0.7484 |
| 511790001 | VA | STAFFORD CO | WASHINGTON, DC-MD-VA-WV | 0.8774 | 0.8290 | 0.7781 | 0.8539 | 0.7851 |
| 511970002 | VA | WYTHE CO | WYTHE CO, VA | 0.7877 | 0.7462 | 0.7029 | 0.7632 | 0.7033 |
| 515100009 | VA | ALEXANDRIA | WASHINGTON, DC-MD-VA-WV | 0.9204 | 0.9124 | 0.8836 | 0.9318 | 0.8957 |
| 516500004 | VA | HAMPTON | NORFOLK-VIRGINIA BEACH-NEWPOR | 0.9099 | 0.8864 | 0.8568 | 0.9089 | 0.8684 |
| 518000004 | VA | SUFFOLK | NORFOLK-VIRGINIA BEACH-NEWPOR | 0.9042 | 0.8844 | 0.8585 | 0.9059 | 0.8696 |
| 518000005 | VA | SUFFOLK | NORFOLK-VIRGINIA BEACH-NEWPOR | 0.8708 | 0.8375 | 0.8026 | 0.8588 | 0.8113 |
| 540110006 | WV | CABELL CO | HUNTINGTON-ASHLAND, WV-KY-OH | 0.8605 | 0.8347 | 0.8099 | 0.8502 | 0.8170 |
| 540250003 | WV | GREENBRIER CO | GREENBRIER CO, WV | 0.7290 | 0.6921 | 0.6642 | 0.7034 | 0.6649 |
| 540291004 | WV | HANCOCK CO | STEUBENVILLE-WEIRTON, OH-WV | 0.8802 | 0.8523 | 0.8244 | 0.8686 | 0.8303 |
| 540390004 | WV | KANAWHA CO | CHARLESTON, WV | 0.8574 | 0.8209 | 0.7912 | 0.8329 | 0.7917 |
| 540690007 | WV | OHIO CO | WHEELING, WV-OH | 0.8564 | 0.8275 | 0.7999 | 0.8421 | 0.8043 |
| 541071002 | WV | WOOD CO | PARKERSBURG-MARIETTA, WV-OH | 0.8299 | 0.7943 | 0.7674 | 0.8074 | 0.7706 |
| 550090026 | WI | BROWN CO | GREEN BAY, WI | 0.9074 | 0.8750 | 0.8458 | 0.8943 | 0.8543 |
| 550210015 | WI | COLUMBIA CO | MADISON, WI | 0.8973 | 0.8606 | 0.8269 | 0.8809 | 0.8349 |
| 550250041 | WI | DANE CO | MADISON, WI | 0.9122 | 0.8776 | 0.8430 | 0.8997 | 0.8531 |
| 550270007 | WI | DODGE CO | DODGE CO, WI | 0.9043 | 0.8710 | 0.8389 | 0.8921 | 0.8482 |
| 550290004 | WI | DOOR CO | DOOR CO, WI | 0.9160 | 0.8931 | 0.8688 | 0.9155 | 0.8827 |
| 550370001 | WI | FLORENCE CO | FLORENCE CO, WI | | | | | |
| 550390006 | WI | FOND DU LAC CO | FOND DU LAC CO, WI | 0.9040 | 0.8696 | 0.8392 | 0.8886 | 0.8471 |
| 550550002 | WI | JEFFERSON CO | MILWAUKEE-RACINE CMSA | 0.9075 | 0.8754 | 0.8449 | 0.8959 | 0.8543 |
| 550590002 | WI | Kenosha Co. | CHICAGO CMSA | 0.9212 | 0.9167 | 0.9049 | 0.9366 | 0.9227 |
| 550590019 | WI | Kenosha Co. | CHICAGO CMSA | 0.9250 | 0.9226 | 0.9149 | 0.9417 | 0.9327 |
| 550590022 | WI | Kenosha Co. | | 0.9167 | 0.9048 | 0.8886 | 0.9254 | 0.9047 |
| 550610002 | WI | KEWAUNEE CO | KEWAUNEE CO, WI | 0.9085 | 0.8818 | 0.8561 | 0.9029 | 0.8684 |
| 550710004 | WI | MANITOWOC CO | MANITOWOC CO, WI | 0.9100 | 0.8843 | 0.8600 | 0.9046 | 0.8718 |

# APPENDIX D
## 8-Hour Relative Reduction Factors

| Site Id. | State | County | Area Name | RRF 2007 Base | RRF 2020 Base | RRF 2020 Control | RRF 2030 Base | RRF 2030 Control |
|---|---|---|---|---|---|---|---|---|
| 550710007 | WI | MANITOWOC CO | MANITOWOC CO, WI | 0.9147 | 0.8929 | 0.8690 | 0.9143 | 0.8820 |
| 550730012 | WI | MARATHON CO | WAUSAU, WI | 0.8919 | 0.8558 | 0.8245 | 0.8742 | 0.8315 |
| 550790041 | WI | MILWAUKEE CO | MILWAUKEE-RACINE CMSA | 0.9132 | 0.8979 | 0.8789 | 0.9189 | 0.8946 |
| 550790044 | WI | MILWAUKEE CO | MILWAUKEE-RACINE CMSA | 0.9186 | 0.9096 | 0.8965 | 0.9288 | 0.9125 |
| 550790048 | WI | MILWAUKEE CO | MILWAUKEE-RACINE CMSA | 0.9164 | 0.8994 | 0.8791 | 0.9217 | 0.8950 |
| 550790085 | WI | MILWAUKEE CO | MILWAUKEE-RACINE CMSA | 0.9026 | 0.8814 | 0.8609 | 0.9034 | 0.8758 |
| 550791025 | WI | MILWAUKEE CO | MILWAUKEE-RACINE CMSA | 0.9164 | 0.8994 | 0.8791 | 0.9217 | 0.8950 |
| 550850004 | WI | ONEIDA CO | ONEIDA CO, WI | 0.8905 | 0.8553 | 0.8238 | 0.8740 | 0.8309 |
| 550870009 | WI | OUTAGAMIE CO | APPLETON-OSHKOSH-NEENAH, WI | 0.9044 | 0.8722 | 0.8444 | 0.8897 | 0.8516 |
| 550890008 | WI | OZAUKEE CO | MILWAUKEE-RACINE CMSA | 0.9091 | 0.8939 | 0.8740 | 0.9160 | 0.8897 |
| 550890009 | WI | OZAUKEE CO | MILWAUKEE-RACINE CMSA | 0.9183 | 0.9064 | 0.8901 | 0.9275 | 0.9063 |
| 551010017 | WI | RACINE CO | MILWAUKEE-RACINE CMSA | 0.9214 | 0.9196 | 0.9126 | 0.9391 | 0.9319 |
| 551050021 | WI | ROCK CO | JANESVILLE-BELOIT, WI | 0.9052 | 0.8758 | 0.8505 | 0.8959 | 0.8615 |
| 551050024 | WI | ROCK CO | JANESVILLE-BELOIT, WI | 0.9017 | 0.8696 | 0.8408 | 0.8911 | 0.8516 |
| 551091002 | WI | ST CROIX CO | MINNEAPOLIS-ST. PAUL, MN-WI | 0.9305 | 0.8886 | 0.8620 | 0.9065 | 0.8703 |
| 551110007 | WI | SAUK CO | SAUK CO, WI | 0.9007 | 0.8632 | 0.8314 | 0.8830 | 0.8393 |
| 551170006 | WI | SHEBOYGAN CO | SHEBOYGAN, WI | 0.9199 | 0.9080 | 0.8910 | 0.9292 | 0.9072 |
| 551230008 | WI | VERNON CO | VERNON CO, WI | 0.9021 | 0.8653 | 0.8354 | 0.8841 | 0.8426 |
| 551250001 | WI | Vilas Co. |  | 0.8822 | 0.8482 | 0.8158 | 0.8676 | 0.8235 |
| 551270005 | WI | WALWORTH CO | MILWAUKEE-RACINE CMSA | 0.9089 | 0.8821 | 0.8555 | 0.9039 | 0.8679 |
| 551310009 | WI | WASHINGTON CO | MILWAUKEE-RACINE CMSA | 0.9174 | 0.9026 | 0.8843 | 0.9231 | 0.8989 |
| 551330017 | WI | WAUKESHA CO | MILWAUKEE-RACINE CMSA | 0.9176 | 0.9006 | 0.8786 | 0.9207 | 0.8923 |
| 551390011 | WI | WINNEBAGO CO | APPLETON-OSHKOSH-NEENAH, WI | 0.8999 | 0.8661 | 0.8377 | 0.8834 | 0.8443 |

# Appendix E:
# 1999 Annual Mean PM2.5 Values and Future Year Predictions Based on RRfs

# APPENDIX E

## 1999 Annual Mean PM2.5 Values and Future-Year Predictions Based on RRFs

| | | | | **PM2.5 Concentrations** | | | | |
|---|---|---|---|---|---|---|---|---|
| **MONITOR ID** | **STATE** | **COUNTY** | | **1999 Ambient** | **2020 Base** | **2020 Control** | **2030 Base** | **2030 Control** |
| 40139990 | ARIZONA | MARICOPA | | 10.8 | 14.6 | 14.2 | 16.1 | 15.4 |
| 40139991 | ARIZONA | MARICOPA CO | | 13.0 | 17.6 | 16.9 | 19.4 | 18.5 |
| 40139992 | ARIZONA | MARICOPA | | 11.4 | 15.5 | 14.9 | 17.1 | 16.3 |
| 40139997 | ARIZONA | MARICOPA | | 12.6 | 17.1 | 16.4 | 18.9 | 18.0 |
| 40190011 | ARIZONA | PIMA CO | | 9.7 | 12.0 | 11.8 | 13.1 | 12.7 |
| 40191028 | ARIZONA | PIMA | | 8.8 | 11.7 | 11.3 | 12.7 | 12.2 |
| 60011001 | CALIFORNIA | ALAMEDA CO | | 13.9 | 15.3 | 14.4 | 16.6 | 15.3 |
| 60070002 | CALIFORNIA | BUTTE CO | | 17.5 | 18.6 | 18.1 | 19.3 | 18.6 |
| 60090001 | CALIFORNIA | CALAVERAS | | 11.1 | 12.1 | 11.5 | 12.7 | 11.8 |
| 60111002 | CALIFORNIA | COLUSA | | 13.2 | 13.4 | 13.0 | 13.7 | 13.2 |
| 60170011 | CALIFORNIA | EL DORADO CO | | 8.3 | 8.3 | 7.9 | 8.8 | 8.1 |
| 60170011 | CALIFORNIA | EL DORADO | | 8.1 | 8.1 | 7.6 | 8.5 | 7.9 |
| 60190008 | CALIFORNIA | FRESNO CO | | 27.7 | 28.1 | 26.5 | 30.2 | 27.8 |
| 60190008 | CALIFORNIA | FRESNO | | 21.4 | 21.7 | 20.4 | 23.3 | 21.5 |
| 60195001 | CALIFORNIA | FRESNO | | 20.0 | 20.3 | 19.1 | 21.8 | 20.1 |
| 60231002 | CALIFORNIA | HUMBOLDT | | 9.0 | 10.2 | 10.1 | 10.5 | 10.3 |
| 60250005 | CALIFORNIA | IMPERIAL | | 15.4 | 16.2 | 15.0 | 17.2 | 15.5 |
| 60251003 | CALIFORNIA | IMPERIAL | | 11.5 | 12.4 | 11.5 | 13.3 | 12.0 |
| 60290010 | CALIFORNIA | KERN | | 26.2 | 26.9 | 25.3 | 28.3 | 26.0 |
| 60290014 | CALIFORNIA | KERN | | 27.8 | 28.4 | 26.8 | 30.0 | 27.6 |
| 60310004 | CALIFORNIA | KINGS | | 22.2 | 21.9 | 20.4 | 23.1 | 20.9 |
| 60371002 | CALIFORNIA | LOS ANGELES | | 22.8 | 27.5 | 26.0 | 30.0 | 27.9 |
| 60371103 | CALIFORNIA | LOS ANGELES | | 23.9 | 28.8 | 27.2 | 31.4 | 29.2 |
| 60371201 | CALIFORNIA | LOS ANGELES CO | | 17.5 | 22.7 | 21.7 | 24.4 | 23.0 |
| 60371301 | CALIFORNIA | LOS ANGELES | | 24.6 | 31.4 | 30.1 | 34.2 | 32.3 |
| 60371601 | CALIFORNIA | LOS ANGELES | | 25.9 | 31.2 | 29.5 | 34.0 | 31.6 |
| 60374002 | CALIFORNIA | LOS ANGELES | | 21.3 | 27.1 | 26.0 | 29.6 | 28.0 |
| 60379002 | CALIFORNIA | LOS ANGELES | | 10.8 | 11.2 | 10.5 | 11.8 | 10.8 |
| 60450006 | CALIFORNIA | MENDOCINO | | 8.7 | 9.0 | 8.7 | 9.3 | 8.9 |
| 60490001 | CALIFORNIA | MODOC | | 7.9 | 8.7 | 8.6 | 8.8 | 8.6 |
| 60570005 | CALIFORNIA | NEVADA | | 7.6 | 7.4 | 7.1 | 7.7 | 7.3 |
| 60610006 | CALIFORNIA | PLACER CO | | 13.4 | 13.7 | 13.1 | 14.6 | 13.7 |
| 60651003 | CALIFORNIA | RIVERSIDE CO | | 27.1 | 35.2 | 33.4 | 38.5 | 36.0 |
| 60652002 | CALIFORNIA | RIVERSIDE | | 12.8 | 15.2 | 13.9 | 16.7 | 14.9 |
| 60658001 | CALIFORNIA | RIVERSIDE | | 30.2 | 36.5 | 34.3 | 39.7 | 36.6 |
| 60670010 | CALIFORNIA | SACRAMENTO | | 16.5 | 17.4 | 16.3 | 18.8 | 17.2 |

# APPENDIX E
## 1999 Annual Mean PM2.5 Values and Future-Year Predictions Based on RRFs

| | | | PM2.5 Concentrations | | | | |
|---|---|---|---|---|---|---|---|
| MONITOR ID | STATE | COUNTY | 1999 Ambient | 2020 Base | 2020 Control | 2030 Base | 2030 Control |
| 60674001 | CALIFORNIA | SACRAMENTO | 16.2 | 17.0 | 15.9 | 18.3 | 16.9 |
| 60710025 | CALIFORNIA | SAN BERNARDINO CO | 25.4 | 31.4 | 30.0 | 33.9 | 31.9 |
| 60712002 | CALIFORNIA | SAN BERNARDINO | 25.3 | 31.3 | 29.9 | 33.8 | 31.8 |
| 60718001 | CALIFORNIA | SAN BERNARDINO | 10.3 | 12.5 | 11.8 | 13.7 | 12.6 |
| 60719004 | CALIFORNIA | SAN BERNARDINO | 25.6 | 30.9 | 29.1 | 33.6 | 31.0 |
| 60730001 | CALIFORNIA | SAN DIEGO CO | 14.7 | 17.9 | 17.1 | 19.5 | 18.3 |
| 60730003 | CALIFORNIA | SAN DIEGO | 16.6 | 21.1 | 19.9 | 23.2 | 21.5 |
| 60730006 | CALIFORNIA | SAN DIEGO | 13.7 | 17.8 | 16.9 | 19.6 | 18.3 |
| 60731002 | CALIFORNIA | SAN DIEGO | 17.8 | 22.2 | 20.5 | 24.5 | 22.0 |
| 60731007 | CALIFORNIA | SAN DIEGO | 17.5 | 22.8 | 21.7 | 25.2 | 23.5 |
| 60771002 | CALIFORNIA | SAN JOAQUIN CO | 19.8 | 20.5 | 19.1 | 22.0 | 20.1 |
| 60792002 | CALIFORNIA | SAN LUIS OBISPO CO | 8.2 | 8.5 | 8.1 | 8.9 | 8.4 |
| 60798001 | CALIFORNIA | SAN LUIS OBISPO | 9.6 | 9.8 | 9.5 | 10.3 | 9.7 |
| 60798001 | CALIFORNIA | SAN LUIS OBISPO | 9.5 | 9.7 | 9.4 | 10.2 | 9.6 |
| 60811001 | CALIFORNIA | SAN MATEO CO | 12.1 | 13.4 | 12.8 | 14.5 | 13.6 |
| 60830010 | CALIFORNIA | SANTA BARBARA | 13.3 | 16.5 | 15.9 | 17.4 | 16.6 |
| 60890004 | CALIFORNIA | SHASTA CO | 12.9 | 13.9 | 13.6 | 14.4 | 13.9 |
| 60970003 | CALIFORNIA | SONOMA CO | 11.7 | 11.6 | 11.0 | 12.2 | 11.4 |
| 60990005 | CALIFORNIA | STANISLAUS CO | 24.4 | 24.6 | 22.7 | 26.2 | 23.5 |
| 61010003 | CALIFORNIA | SUTTER | 15.9 | 15.8 | 15.3 | 16.4 | 15.6 |
| 61072002 | CALIFORNIA | TULARE CO | 27.6 | 28.4 | 26.3 | 30.3 | 27.2 |
| 61110007 | CALIFORNIA | VENTURA | 12.0 | 15.5 | 14.8 | 16.7 | 15.7 |
| 61110007 | CALIFORNIA | VENTURA | 13.8 | 17.9 | 17.2 | 19.3 | 18.2 |
| 61112002 | CALIFORNIA | VENTURA | 13.8 | 17.9 | 17.1 | 19.3 | 18.1 |
| 61113001 | CALIFORNIA | VENTURA CO | 12.1 | 16.6 | 16.1 | 17.7 | 16.9 |
| 61131003 | CALIFORNIA | YOLO CO | 16.3 | 16.7 | 16.0 | 17.7 | 16.6 |
| 80010001 | COLORADO | ADAMS CO | 8.5 | 11.6 | 11.3 | 12.6 | 12.2 |
| 80130003 | COLORADO | BOULDER CO | 8.3 | 10.2 | 9.9 | 10.8 | 10.5 |
| 80130012 | COLORADO | BOULDER | 6.9 | 8.5 | 8.3 | 9.0 | 8.7 |
| 80770003 | COLORADO | MESA | 6.9 | 8.3 | 8.1 | 8.6 | 8.4 |
| 81230006 | COLORADO | WELD | 7.6 | 9.0 | 8.6 | 9.5 | 9.1 |
| 100010002 | DELAWARE | KENT CO | 11.6 | 11.4 | 10.9 | 12.0 | 11.3 |
| 100010003 | DELAWARE | KENT | 12.4 | 12.5 | 12.0 | 13.2 | 12.5 |
| 100031003 | DELAWARE | NEW CASTLE | 13.8 | 15.0 | 14.5 | 16.0 | 15.3 |
| 100031011 | DELAWARE | NEW CASTLE | 13.3 | 13.8 | 13.3 | 14.6 | 13.8 |
| 100032004 | DELAWARE | NEW CASTLE | 15.6 | 16.1 | 15.5 | 17.0 | 16.2 |

# APPENDIX E
## 1999 Annual Mean PM2.5 Values and Future-Year Predictions Based on RRFs

| | | | | **PM2.5 Concentrations** | | | | |
|---|---|---|---|---|---|---|---|---|
| **MONITOR ID** | **STATE** | **COUNTY** | | **1999 Ambient** | **2020 Base** | **2020 Control** | **2030 Base** | **2030 Control** |
| 100051002 | DELAWARE | SUSSEX | | 14.2 | 14.1 | 13.6 | 14.8 | 14.0 |
| 110010041 | DISTRICT OF COLU | WASHINGTON | | 15.2 | 16.1 | 15.5 | 17.1 | 16.2 |
| 110010043 | DISTRICT OF COLU | WASHINGTON | | 14.9 | 16.4 | 15.7 | 17.7 | 16.6 |
| 120111002 | FLORIDA | BROWARD CO | | 9.3 | 11.9 | 11.7 | 12.9 | 12.5 |
| 120251016 | FLORIDA | DADE | | 12.1 | 15.3 | 14.9 | 16.5 | 16.0 |
| 120256001 | FLORIDA | DADE CO | | 8.6 | 9.6 | 9.4 | 10.1 | 9.9 |
| 120330004 | FLORIDA | ESCAMBIA CO | | 14.8 | 15.6 | 15.1 | 16.4 | 15.6 |
| 120570030 | FLORIDA | HILLSBOROUGH CO | | 12.8 | 14.6 | 14.1 | 15.7 | 15.0 |
| 120571075 | FLORIDA | HILLSBOROUGH | | 13.0 | 14.5 | 13.8 | 15.5 | 14.5 |
| 120710005 | FLORIDA | LEE CO | | 10.2 | 11.1 | 10.8 | 11.8 | 11.3 |
| 120730012 | FLORIDA | LEON CO | | 14.0 | 14.6 | 14.2 | 15.3 | 14.7 |
| 120814012 | FLORIDA | MANATEE CO | | 11.6 | 12.8 | 12.5 | 13.4 | 13.1 |
| 120830003 | FLORIDA | MARION CO | | 11.4 | 11.8 | 11.4 | 12.5 | 11.8 |
| 120951004 | FLORIDA | ORANGE CO | | 11.3 | 13.8 | 13.3 | 14.8 | 14.1 |
| 120952002 | FLORIDA | ORANGE | | 11.4 | 13.9 | 13.5 | 15.0 | 14.3 |
| 120992003 | FLORIDA | PALM BEACH CO | | 9.3 | 11.1 | 10.8 | 11.9 | 11.5 |
| 121030018 | FLORIDA | PINELLAS CO | | 11.9 | 13.6 | 13.3 | 14.7 | 14.1 |
| 121031008 | FLORIDA | PINELLAS | | 11.8 | 12.6 | 12.3 | 13.5 | 12.9 |
| 121056006 | FLORIDA | POLK CO | | 11.1 | 12.1 | 11.6 | 12.8 | 12.1 |
| 121111002 | FLORIDA | ST LUCIE CO | | 9.7 | 10.0 | 9.9 | 10.5 | 10.2 |
| 121150013 | FLORIDA | SARASOTA CO | | 10.6 | 10.9 | 10.7 | 11.3 | 11.1 |
| 121171002 | FLORIDA | SEMINOLE CO | | 10.9 | 12.2 | 11.8 | 13.1 | 12.4 |
| 121275002 | FLORIDA | VOLUSIA CO | | 11.4 | 12.4 | 12.0 | 13.1 | 12.6 |
| 130210007 | GEORGIA | BIBB CO | | 19.6 | 20.6 | 20.0 | 21.7 | 20.9 |
| 130210012 | GEORGIA | BIBB | | 17.8 | 18.7 | 18.2 | 19.7 | 19.0 |
| 130510017 | GEORGIA | CHATHAM CO | | 18.2 | 19.6 | 19.1 | 20.5 | 19.8 |
| 130590001 | GEORGIA | CLARKE CO | | 17.9 | 18.1 | 17.2 | 19.1 | 17.9 |
| 130630091 | GEORGIA | CLAYTON CO | | 20.9 | 22.7 | 21.6 | 24.4 | 22.8 |
| 130890002 | GEORGIA | DE KALB CO | | 21.0 | 25.1 | 24.0 | 27.5 | 25.8 |
| 130892001 | GEORGIA | DE KALB | | 21.6 | 25.8 | 24.6 | 28.2 | 26.5 |
| 131150005 | GEORGIA | FLOYD | | 21.1 | 21.3 | 20.3 | 22.6 | 21.2 |
| 131210032 | GEORGIA | FULTON | | 20.3 | 24.3 | 23.2 | 26.6 | 25.0 |
| 131210039 | GEORGIA | FULTON | | 23.0 | 27.5 | 26.2 | 30.1 | 28.3 |
| 131211001 | GEORGIA | FULTON CO | | 18.9 | 20.6 | 19.5 | 22.1 | 20.6 |
| 131390003 | GEORGIA | HALL | | 17.9 | 17.1 | 16.0 | 18.3 | 16.6 |
| 132150011 | GEORGIA | MUSCOGEE | | 18.5 | 19.6 | 19.2 | 20.5 | 19.8 |

# APPENDIX E
## 1999 Annual Mean PM2.5 Values and Future-Year Predictions Based on RRFs

| | | | | PM2.5 Concentrations | | | | |
|---|---|---|---|---|---|---|---|---|
| MONITOR ID | STATE | COUNTY | | 1999 Ambient | 2020 Base | 2020 Control | 2030 Base | 2030 Control |
| 132230003 | GEORGIA | PAULDING CO | | 18.5 | 18.7 | 17.9 | 19.8 | 18.6 |
| 132450005 | GEORGIA | RICHMOND | | 19.4 | 19.5 | 18.7 | 20.6 | 19.4 |
| 132450091 | GEORGIA | RICHMOND CO | | 19.9 | 20.3 | 19.6 | 21.4 | 20.3 |
| 133030001 | GEORGIA | WASHINGTON | | 18.2 | 18.8 | 18.4 | 19.6 | 19.1 |
| 160010017 | IDAHO | ADA | | 8.0 | 8.4 | 8.2 | 8.7 | 8.4 |
| 160050006 | IDAHO | BANNOCK | | 8.1 | 8.6 | 8.4 | 9.0 | 8.7 |
| 160270004 | IDAHO | CANYON CO | | 8.7 | 8.2 | 8.0 | 8.3 | 8.0 |
| 160270005 | IDAHO | CANYON | | 9.9 | 9.3 | 9.1 | 9.4 | 9.1 |
| 170310014 | ILLINOIS | COOK | | 18.0 | 20.1 | 19.5 | 21.6 | 20.8 |
| 170310022 | ILLINOIS | COOK | | 17.4 | 19.4 | 18.8 | 20.8 | 20.1 |
| 170310050 | ILLINOIS | COOK | | 17.2 | 19.2 | 18.6 | 20.6 | 19.9 |
| 170311016 | ILLINOIS | COOK | | 21.8 | 24.3 | 23.6 | 26.2 | 25.2 |
| 170311701 | ILLINOIS | COOK | | 18.2 | 20.3 | 19.7 | 21.8 | 21.0 |
| 170313301 | ILLINOIS | COOK | | 17.5 | 19.5 | 18.9 | 21.0 | 20.2 |
| 170314006 | ILLINOIS | COOK | | 15.1 | 16.6 | 16.1 | 17.7 | 17.0 |
| 170314201 | ILLINOIS | COOK | | 15.5 | 17.0 | 16.5 | 18.1 | 17.4 |
| 170434002 | ILLINOIS | DU PAGE CO | | 15.5 | 17.2 | 16.7 | 18.3 | 17.6 |
| 171191007 | ILLINOIS | MADISON | | 17.2 | 17.7 | 17.1 | 18.9 | 18.0 |
| 171430037 | ILLINOIS | PEORIA CO | | 16.0 | 16.4 | 16.0 | 17.2 | 16.5 |
| 171610003 | ILLINOIS | ROCK ISLAND CO | | 16.4 | 16.7 | 16.2 | 17.4 | 16.7 |
| 171670012 | ILLINOIS | SANGAMON CO | | 15.9 | 15.5 | 15.0 | 16.2 | 15.5 |
| 171971002 | ILLINOIS | WILL | | 15.5 | 16.6 | 16.1 | 17.5 | 16.9 |
| 180030004 | INDIANA | ALLEN CO | | 12.3 | 12.4 | 11.9 | 13.1 | 12.4 |
| 180190005 | INDIANA | CLARK CO | | 15.9 | 16.2 | 15.6 | 17.1 | 16.4 |
| 180431004 | INDIANA | FLOYD CO | | 14.1 | 14.4 | 13.9 | 15.2 | 14.6 |
| 180890006 | INDIANA | LAKE | | 14.3 | 15.1 | 14.6 | 15.9 | 15.3 |
| 180890022 | INDIANA | LAKE | | 15.5 | 16.4 | 15.9 | 17.3 | 16.6 |
| 180891003 | INDIANA | LAKE | | 13.6 | 14.3 | 13.9 | 15.2 | 14.5 |
| 180891016 | INDIANA | LAKE | | 15.4 | 16.2 | 15.7 | 17.1 | 16.4 |
| 181270024 | INDIANA | PORTER | | 12.0 | 12.7 | 12.3 | 13.4 | 12.9 |
| 190130008 | IOWA | BLACK HAWK CO | | 12.1 | 12.1 | 11.7 | 12.6 | 12.0 |
| 190450021 | IOWA | CLINTON | | 12.7 | 12.8 | 12.3 | 13.3 | 12.7 |
| 191032001 | IOWA | JOHNSON CO | | 12.3 | 12.3 | 11.9 | 12.8 | 12.2 |
| 191130036 | IOWA | LINN CO | | 11.8 | 11.8 | 11.4 | 12.3 | 11.7 |
| 191130037 | IOWA | LINN | | 11.7 | 11.7 | 11.3 | 12.2 | 11.6 |
| 191390016 | IOWA | MUSCATINE | | 12.9 | 13.1 | 12.7 | 13.7 | 13.1 |

# APPENDIX E

## 1999 Annual Mean PM2.5 Values and Future-Year Predictions Based on RRFs

| | | | | **PM2.5 Concentrations** | | | | |
|---|---|---|---|---|---|---|---|---|
| **MONITOR ID** | **STATE** | **COUNTY** | | **1999 Ambient** | **2020 Base** | **2020 Control** | **2030 Base** | **2030 Control** |
| 191532510 | IOWA | POLK | | 11.3 | 11.6 | 11.2 | 12.1 | 11.6 |
| 191532520 | IOWA | POLK | | 11.7 | 12.1 | 11.6 | 12.6 | 12.0 |
| 191630015 | IOWA | SCOTT CO | | 13.1 | 13.3 | 12.9 | 13.9 | 13.3 |
| 191930017 | IOWA | WOODBURY CO | | 9.9 | 10.4 | 10.1 | 10.8 | 10.4 |
| 200910008 | KANSAS | JOHNSON | | 12.3 | 13.0 | 12.6 | 13.6 | 13.0 |
| 200910009 | KANSAS | JOHNSON | | 11.5 | 12.1 | 11.7 | 12.7 | 12.2 |
| 201730008 | KANSAS | SEDGWICK CO | | 12.0 | 12.6 | 12.3 | 13.0 | 12.6 |
| 201730009 | KANSAS | SEDGWICK | | 11.9 | 12.5 | 12.2 | 12.9 | 12.5 |
| 201730010 | KANSAS | SEDGWICK | | 12.5 | 13.0 | 12.7 | 13.5 | 13.0 |
| 201770010 | KANSAS | SHAWNEE CO | | 12.3 | 12.7 | 12.3 | 13.2 | 12.6 |
| 201770011 | KANSAS | SHAWNEE | | 12.5 | 12.8 | 12.4 | 13.3 | 12.7 |
| 210190017 | KENTUCKY | BOYD CO | | 14.9 | 15.0 | 14.6 | 15.7 | 15.2 |
| 210290006 | KENTUCKY | BULLITT CO | | 15.4 | 14.3 | 13.8 | 14.9 | 14.2 |
| 210370003 | KENTUCKY | CAMPBELL CO | | 15.4 | 15.5 | 14.9 | 16.4 | 15.5 |
| 210430500 | KENTUCKY | CARTER CO | | 11.9 | 11.7 | 11.5 | 12.1 | 11.8 |
| 210590014 | KENTUCKY | DAVIESS CO | | 15.4 | 14.8 | 14.3 | 15.5 | 14.9 |
| 210670012 | KENTUCKY | FAYETTE | | 15.4 | 14.0 | 13.4 | 14.7 | 13.8 |
| 210670014 | KENTUCKY | FAYETTE CO | | 16.4 | 15.3 | 14.7 | 16.1 | 15.2 |
| 210730006 | KENTUCKY | FRANKLIN | | 14.1 | 13.2 | 12.6 | 13.8 | 13.1 |
| 211110043 | KENTUCKY | JEFFERSON CO | | 17.5 | 17.8 | 17.2 | 18.9 | 18.1 |
| 211110044 | KENTUCKY | JEFFERSON | | 16.9 | 17.2 | 16.6 | 18.2 | 17.5 |
| 211110048 | KENTUCKY | JEFFERSON | | 17.2 | 17.5 | 16.9 | 18.5 | 17.7 |
| 211110051 | KENTUCKY | JEFFERSON | | 15.2 | 15.5 | 15.0 | 16.4 | 15.7 |
| 211170007 | KENTUCKY | KENTON CO | | 15.7 | 16.0 | 15.4 | 17.0 | 16.1 |
| 211451004 | KENTUCKY | MC CRACKEN | | 15.7 | 14.9 | 14.5 | 15.6 | 15.0 |
| 211950002 | KENTUCKY | PIKE | | 17.7 | 17.6 | 17.3 | 18.3 | 17.8 |
| 212270007 | KENTUCKY | WARREN | | 16.1 | 14.7 | 14.1 | 15.3 | 14.6 |
| 220171002 | LOUISIANA | CADDO PAR | | 14.2 | 15.3 | 14.9 | 16.0 | 15.4 |
| 220190010 | LOUISIANA | CALCASIEU | | 13.0 | 14.7 | 14.4 | 15.6 | 15.1 |
| 220290002 | LOUISIANA | CONCORDIA | | 13.8 | 15.0 | 14.7 | 15.8 | 15.4 |
| 220330002 | LOUISIANA | EAST BATON ROUGE PAR | | 15.3 | 18.1 | 17.8 | 19.2 | 18.7 |
| 220330009 | LOUISIANA | EAST BATON ROUGE | | 15.1 | 17.9 | 17.6 | 19.0 | 18.5 |
| 220331001 | LOUISIANA | EAST BATON ROUGE | | 13.5 | 16.1 | 15.7 | 17.0 | 16.6 |
| 220470005 | LOUISIANA | IBERVILLE | | 15.3 | 17.9 | 17.5 | 18.7 | 18.2 |
| 220470009 | LOUISIANA | IBERVILLE | | 12.6 | 14.7 | 14.4 | 15.4 | 15.0 |
| 220511001 | LOUISIANA | JEFFERSON | | 13.8 | 16.6 | 16.3 | 17.6 | 17.1 |

# APPENDIX E
## 1999 Annual Mean PM2.5 Values and Future-Year Predictions Based on RRFs

| | | | **PM2.5 Concentrations** | | | | |
|---|---|---|---|---|---|---|---|
| **MONITOR ID** | **STATE** | **COUNTY** | **1999 Ambient** | **2020 Base** | **2020 Control** | **2030 Base** | **2030 Control** |
| 220512001 | LOUISIANA | JEFFERSON PAR | 14.8 | 18.8 | 18.4 | 20.0 | 19.5 |
| 220550005 | LOUISIANA | LAFAYETTE PAR | 12.9 | 14.1 | 13.7 | 14.7 | 14.2 |
| 220710010 | LOUISIANA | ORLEANS PAR | 15.1 | 19.2 | 18.8 | 20.4 | 19.9 |
| 220710012 | LOUISIANA | ORLEANS | 15.0 | 19.1 | 18.7 | 20.3 | 19.7 |
| 220730004 | LOUISIANA | OUACHITA PAR | 13.9 | 15.3 | 15.0 | 16.0 | 15.6 |
| 220790001 | LOUISIANA | RAPIDES PAR | 14.3 | 15.2 | 14.9 | 15.9 | 15.4 |
| 221050001 | LOUISIANA | TANGIPAHOA | 13.9 | 16.2 | 15.9 | 17.0 | 16.5 |
| 221210001 | LOUISIANA | WEST BATON ROUGE PAR | 14.9 | 17.6 | 17.3 | 18.7 | 18.2 |
| 230010011 | MAINE | ANDROSCOGGIN CO | 10.0 | 13.1 | 13.0 | 14.8 | 14.6 |
| 230010011 | MAINE | ANDROSCOGGIN CO | 10.0 | 13.1 | 13.0 | 14.8 | 14.6 |
| 230030013 | MAINE | AROOSTOOK | 10.6 | 11.0 | 11.0 | 11.4 | 11.4 |
| 230031011 | MAINE | AROOSTOOK | 8.1 | 9.2 | 9.1 | 9.8 | 9.8 |
| 230050027 | MAINE | CUMBERLAND CO | 10.0 | 12.7 | 12.6 | 14.3 | 14.1 |
| 230172011 | MAINE | OXFORD | 10.2 | 11.6 | 11.5 | 12.5 | 12.4 |
| 230190002 | MAINE | PENOBSCOT CO | 8.9 | 11.5 | 11.4 | 12.9 | 12.8 |
| 230194003 | MAINE | PENOBSCOT CO | 8.6 | 11.0 | 10.9 | 12.4 | 12.3 |
| 260050003 | MICHIGAN | ALLEGAN CO | 12.2 | 12.2 | 11.8 | 12.9 | 12.2 |
| 260210014 | MICHIGAN | BERRIEN CO | 12.3 | 12.3 | 11.8 | 12.8 | 12.2 |
| 260490021 | MICHIGAN | GENESEE CO | 12.0 | 12.0 | 11.7 | 12.6 | 12.1 |
| 260650012 | MICHIGAN | INGHAM CO | 12.6 | 12.4 | 12.0 | 13.0 | 12.4 |
| 260650012 | MICHIGAN | INGHAM | 12.9 | 12.7 | 12.2 | 13.3 | 12.6 |
| 260770008 | MICHIGAN | KALAMAZOO CO | 14.9 | 14.9 | 14.3 | 15.6 | 14.8 |
| 260770008 | MICHIGAN | KALAMAZOO | 14.7 | 14.7 | 14.1 | 15.4 | 14.6 |
| 260810020 | MICHIGAN | KENT CO | 13.8 | 14.0 | 13.5 | 14.8 | 14.0 |
| 260990009 | MICHIGAN | MACOMB CO | 12.7 | 12.8 | 12.5 | 13.3 | 12.9 |
| 261210040 | MICHIGAN | MUSKEGON CO | 12.2 | 12.4 | 12.0 | 13.1 | 12.5 |
| 261250001 | MICHIGAN | OAKLAND CO | 14.2 | 15.2 | 14.7 | 16.2 | 15.5 |
| 261390005 | MICHIGAN | OTTAWA CO | 12.9 | 13.1 | 12.6 | 13.9 | 13.1 |
| 261450018 | MICHIGAN | SAGINAW | 10.4 | 10.3 | 10.0 | 10.8 | 10.4 |
| 261470005 | MICHIGAN | ST CLAIR CO | 13.2 | 13.2 | 13.0 | 13.6 | 13.3 |
| 290210010 | MISSOURI | BUCHANAN CO | 12.5 | 12.7 | 12.3 | 13.2 | 12.6 |
| 290390001 | MISSOURI | CEDAR | 11.2 | 11.0 | 10.6 | 11.4 | 10.9 |
| 290470005 | MISSOURI | CLAY | 11.3 | 11.4 | 11.0 | 11.9 | 11.4 |
| 290470026 | MISSOURI | CLAY CO | 12.3 | 13.1 | 12.7 | 13.8 | 13.3 |
| 290470041 | MISSOURI | CLAY | 11.6 | 11.7 | 11.3 | 12.3 | 11.7 |
| 290770032 | MISSOURI | GREENE CO | 12.2 | 12.2 | 11.8 | 12.7 | 12.1 |

## APPENDIX E
## 1999 Annual Mean PM2.5 Values and Future-Year Predictions Based on RRFs

| | | | **PM2.5 Concentrations** | | | | |
|---|---|---|---|---|---|---|---|
| **MONITOR ID** | **STATE** | **COUNTY** | **1999 Ambient** | **2020 Base** | **2020 Control** | **2030 Base** | **2030 Control** |
| 290910003 | MISSOURI | HOWELL | 13.1 | 13.3 | 13.1 | 13.9 | 13.6 |
| 290950036 | MISSOURI | JACKSON CO | 10.9 | 11.4 | 11.1 | 12.0 | 11.5 |
| 290952002 | MISSOURI | JACKSON | 14.1 | 15.0 | 14.6 | 15.8 | 15.2 |
| 290990012 | MISSOURI | JEFFERSON CO | 15.1 | 15.8 | 15.2 | 16.8 | 16.0 |
| 291370001 | MISSOURI | MONROE | 10.9 | 10.6 | 10.3 | 11.0 | 10.6 |
| 291831002 | MISSOURI | ST CHARLES CO | 14.1 | 14.6 | 14.1 | 15.5 | 14.8 |
| 291860006 | MISSOURI | STE GENEVIEVE | 13.7 | 13.3 | 12.9 | 13.9 | 13.3 |
| 291892003 | MISSOURI | ST LOUIS CO | 15.3 | 16.0 | 15.4 | 17.0 | 16.2 |
| 291895001 | MISSOURI | ST LOUIS | 14.6 | 15.1 | 14.6 | 16.0 | 15.4 |
| 295100086 | MISSOURI | ST LOUIS (CITY) | 15.1 | 15.6 | 15.1 | 16.6 | 15.9 |
| 300290039 | MONTANA | FLATHEAD | 10.5 | 11.3 | 11.1 | 11.5 | 11.3 |
| 300490018 | MONTANA | LEWIS AND CLARK | 6.3 | 6.9 | 6.9 | 7.1 | 7.0 |
| 300530018 | MONTANA | LINCOLN | 15.9 | 18.3 | 18.1 | 18.6 | 18.3 |
| 300630024 | MONTANA | MISSOULA | 9.0 | 10.6 | 10.5 | 10.8 | 10.6 |
| 300630031 | MONTANA | MISSOULA | 9.8 | 11.2 | 11.0 | 11.4 | 11.2 |
| 300930005 | MONTANA | SILVER BOW | 7.3 | 8.3 | 8.2 | 8.6 | 8.4 |
| 301111065 | MONTANA | YELLOWSTONE CO | 8.0 | 8.8 | 8.7 | 9.1 | 8.9 |
| 311090022 | NEBRASKA | LANCASTER CO | 10.6 | 11.2 | 10.9 | 11.6 | 11.2 |
| 311090022 | NEBRASKA | LANCASTER | 11.6 | 12.2 | 11.9 | 12.6 | 12.2 |
| 320030022 | NEVADA | CLARK | 4.7 | 5.6 | 5.4 | 5.9 | 5.6 |
| 320030560 | NEVADA | CLARK | 11.2 | 17.3 | 16.6 | 19.3 | 18.2 |
| 320310016 | NEVADA | WASHOE | 9.9 | 11.3 | 10.7 | 12.1 | 11.4 |
| 320310016 | NEVADA | WASHOE | 9.8 | 11.1 | 10.6 | 12.0 | 11.2 |
| 340030003 | NEW JERSEY | BERGEN CO | 13.4 | 14.9 | 14.5 | 15.9 | 15.4 |
| 340171003 | NEW JERSEY | HUDSON CO | 14.4 | 15.5 | 15.1 | 16.6 | 16.0 |
| 340210008 | NEW JERSEY | MERCER CO | 12.4 | 13.2 | 12.8 | 14.0 | 13.4 |
| 340230006 | NEW JERSEY | MIDDLESEX CO | 10.9 | 11.4 | 11.1 | 12.2 | 11.8 |
| 340292002 | NEW JERSEY | OCEAN CO | 10.4 | 10.9 | 10.7 | 11.5 | 11.1 |
| 340310005 | NEW JERSEY | PASSAIC CO | 12.4 | 13.3 | 12.9 | 14.3 | 13.7 |
| 340390004 | NEW JERSEY | UNION CO | 14.7 | 15.5 | 15.1 | 16.5 | 16.0 |
| 340390006 | NEW JERSEY | UNION | 13.5 | 14.6 | 14.1 | 15.6 | 15.0 |
| 350010024 | NEW MEXICO | BERNALILLO | 6.3 | 7.4 | 7.2 | 7.8 | 7.6 |
| 350050005 | NEW MEXICO | CHAVES | 7.0 | 7.5 | 7.4 | 7.8 | 7.6 |
| 350130017 | NEW MEXICO | DONA ANA CO | 11.2 | 11.8 | 11.4 | 12.3 | 11.8 |
| 350131006 | NEW MEXICO | DONA ANA | 6.6 | 6.6 | 6.4 | 6.8 | 6.6 |
| 350171002 | NEW MEXICO | GRANT | 5.6 | 5.8 | 5.7 | 6.1 | 6.0 |

# APPENDIX E
## 1999 Annual Mean PM2.5 Values and Future-Year Predictions Based on RRFs

| | | | | PM2.5 Concentrations | | | | |
|---|---|---|---|---|---|---|---|---|
| **MONITOR ID** | **STATE** | **COUNTY** | | **1999 Ambient** | **2020 Base** | **2020 Control** | **2030 Base** | **2030 Control** |
| 350250007 | NEW MEXICO | LEA | | 7.2 | 7.4 | 7.3 | 7.6 | 7.5 |
| 350431003 | NEW MEXICO | SANDOVAL CO | | 5.2 | 6.1 | 6.0 | 6.5 | 6.3 |
| 350450006 | NEW MEXICO | SAN JUAN | | 5.8 | 5.7 | 5.6 | 5.9 | 5.8 |
| 350490020 | NEW MEXICO | SANTA FE CO | | 4.9 | 6.6 | 6.5 | 6.7 | 6.6 |
| 370210034 | NORTH CAROLINA | BUNCOMBE | | 16.4 | 16.3 | 15.9 | 17.1 | 16.5 |
| 370670022 | NORTH CAROLINA | FORSYTH CO | | 16.4 | 16.4 | 15.7 | 17.5 | 16.4 |
| 370670024 | NORTH CAROLINA | FORSYTH | | 16.4 | 16.4 | 15.7 | 17.5 | 16.4 |
| 380150003 | NORTH DAKOTA | BURLEIGH CO | | 7.6 | 8.2 | 8.1 | 8.4 | 8.3 |
| 380171004 | NORTH DAKOTA | CASS CO | | 9.4 | 10.1 | 9.9 | 10.4 | 10.1 |
| 380350004 | NORTH DAKOTA | GRAND FORKS CO | | 10.2 | 11.1 | 10.9 | 11.3 | 11.1 |
| 380570004 | NORTH DAKOTA | MERCER | | 6.9 | 7.3 | 7.2 | 7.4 | 7.3 |
| 390090003 | OHIO | ATHENS | | 13.7 | 12.6 | 12.4 | 13.1 | 12.7 |
| 390170003 | OHIO | BUTLER CO | | 18.7 | 18.4 | 17.7 | 19.4 | 18.4 |
| 390350013 | OHIO | CUYAHOGA CO | | 17.9 | 19.0 | 18.4 | 20.1 | 19.4 |
| 390350027 | OHIO | CUYAHOGA | | 18.2 | 19.3 | 18.8 | 20.5 | 19.7 |
| 390350038 | OHIO | CUYAHOGA | | 20.9 | 22.2 | 21.6 | 23.5 | 22.7 |
| 390350060 | OHIO | CUYAHOGA | | 18.6 | 19.7 | 19.2 | 20.9 | 20.2 |
| 390350065 | OHIO | CUYAHOGA | | 17.6 | 18.7 | 18.2 | 19.8 | 19.1 |
| 390350066 | OHIO | CUYAHOGA | | 15.0 | 15.9 | 15.4 | 16.8 | 16.2 |
| 390351002 | OHIO | CUYAHOGA | | 15.3 | 16.3 | 15.8 | 17.2 | 16.6 |
| 390490024 | OHIO | FRANKLIN CO | | 18.3 | 18.5 | 17.9 | 19.4 | 18.7 |
| 390490025 | OHIO | FRANKLIN | | 17.1 | 17.3 | 16.8 | 18.2 | 17.4 |
| 390490081 | OHIO | FRANKLIN | | 17.0 | 17.0 | 16.4 | 17.8 | 17.1 |
| 390610014 | OHIO | HAMILTON | | 19.9 | 20.1 | 19.3 | 21.2 | 20.1 |
| 390617001 | OHIO | HAMILTON | | 17.2 | 17.3 | 16.6 | 18.3 | 17.4 |
| 390810016 | OHIO | JEFFERSON | | 19.3 | 18.7 | 18.3 | 19.5 | 19.0 |
| 390811001 | OHIO | JEFFERSON CO | | 18.3 | 17.0 | 16.5 | 17.6 | 17.0 |
| 390851001 | OHIO | LAKE CO | | 13.8 | 14.6 | 14.3 | 15.3 | 14.9 |
| 390932003 | OHIO | LORAIN CO | | 14.4 | 14.5 | 14.1 | 15.1 | 14.6 |
| 390950024 | OHIO | LUCAS CO | | 14.9 | 15.4 | 15.0 | 16.3 | 15.6 |
| 390990005 | OHIO | MAHONING CO | | 16.9 | 16.7 | 16.2 | 17.5 | 16.9 |
| 391130014 | OHIO | MONTGOMERY CO | | 17.6 | 17.9 | 17.2 | 18.9 | 18.0 |
| 391130031 | OHIO | MONTGOMERY | | 16.0 | 16.3 | 15.6 | 17.2 | 16.3 |
| 391330002 | OHIO | PORTAGE CO | | 15.0 | 15.1 | 14.7 | 15.9 | 15.3 |
| 391450013 | OHIO | SCIOTO | | 24.2 | 23.0 | 22.4 | 23.9 | 23.2 |
| 391510017 | OHIO | STARK CO | | 18.4 | 17.9 | 17.3 | 18.8 | 17.9 |

# APPENDIX E
## 1999 Annual Mean PM2.5 Values and Future-Year Predictions Based on RRFs

| | | | | PM2.5 Concentrations | | | | |
|---|---|---|---|---|---|---|---|---|
| MONITOR ID | STATE | COUNTY | | 1999 Ambient | 2020 Base | 2020 Control | 2030 Base | 2030 Control |
| 391510020 | OHIO | STARK | | 17.4 | 16.9 | 16.3 | 17.7 | 16.9 |
| 391530017 | OHIO | SUMMIT | | 18.0 | 18.1 | 17.6 | 19.0 | 18.3 |
| 391550007 | OHIO | TRUMBULL CO | | 16.7 | 16.4 | 16.0 | 17.2 | 16.6 |
| 410030013 | OREGON | BENTON | | 7.1 | 7.5 | 7.4 | 7.7 | 7.5 |
| 410290133 | OREGON | JACKSON CO | | 11.8 | 13.8 | 13.6 | 14.0 | 13.7 |
| 410291001 | OREGON | JACKSON | | 6.4 | 6.9 | 6.8 | 7.0 | 6.9 |
| 410350004 | OREGON | KLAMATH | | 10.7 | 11.4 | 11.2 | 11.6 | 11.3 |
| 410370001 | OREGON | LAKE | | 8.7 | 9.3 | 9.2 | 9.4 | 9.2 |
| 410390060 | OREGON | LANE | | 8.5 | 9.4 | 9.3 | 9.6 | 9.4 |
| 410392013 | OREGON | LANE | | 12.8 | 14.4 | 14.3 | 14.6 | 14.4 |
| 410470040 | OREGON | MARION CO | | 7.5 | 7.8 | 7.6 | 8.0 | 7.8 |
| 410510080 | OREGON | MULTNOMAH CO | | 8.8 | 10.0 | 9.8 | 10.6 | 10.3 |
| 410510244 | OREGON | MULTNOMAH | | 8.5 | 9.6 | 9.4 | 10.2 | 9.9 |
| 410590121 | OREGON | UMATILLA | | 8.8 | 9.5 | 9.4 | 9.7 | 9.5 |
| 410670111 | OREGON | WASHINGTON CO | | 7.3 | 8.3 | 8.1 | 8.8 | 8.5 |
| 420010001 | PENNSYLVANIA | ADAMS | | 13.1 | 12.5 | 11.9 | 13.2 | 12.3 |
| 420030064 | PENNSYLVANIA | ALLEGHENY | | 18.8 | 17.0 | 16.4 | 17.7 | 16.8 |
| 420030064 | PENNSYLVANIA | ALLEGHENY | | 22.0 | 19.9 | 19.1 | 20.7 | 19.7 |
| 420030116 | PENNSYLVANIA | ALLEGHENY | | 16.4 | 16.3 | 15.8 | 17.1 | 16.4 |
| 420110009 | PENNSYLVANIA | BERKS CO | | 13.5 | 13.3 | 12.7 | 14.0 | 13.2 |
| 420170012 | PENNSYLVANIA | BUCKS CO | | 12.0 | 12.8 | 12.4 | 13.6 | 13.0 |
| 420210011 | PENNSYLVANIA | CAMBRIA CO | | 14.8 | 13.8 | 13.4 | 14.3 | 13.7 |
| 420430401 | PENNSYLVANIA | DAUPHIN CO | | 14.4 | 13.7 | 13.0 | 14.4 | 13.4 |
| 420450002 | PENNSYLVANIA | DELAWARE CO | | 13.1 | 14.3 | 13.8 | 15.2 | 14.6 |
| 420692006 | PENNSYLVANIA | LACKAWANNA CO | | 11.0 | 10.7 | 10.4 | 11.1 | 10.7 |
| 420710007 | PENNSYLVANIA | LANCASTER CO | | 15.6 | 14.5 | 13.7 | 15.3 | 14.1 |
| 420770004 | PENNSYLVANIA | LEHIGH CO | | 11.9 | 12.4 | 12.0 | 13.1 | 12.5 |
| 420791101 | PENNSYLVANIA | LUZERNE CO | | 12.5 | 12.3 | 12.0 | 12.9 | 12.4 |
| 420910013 | PENNSYLVANIA | MONTGOMERY CO | | 13.0 | 14.0 | 13.5 | 14.9 | 14.3 |
| 420950025 | PENNSYLVANIA | NORTHAMPTON CO | | 12.9 | 13.4 | 12.9 | 14.2 | 13.5 |
| 421010004 | PENNSYLVANIA | PHILADELPHIA | | 14.4 | 15.5 | 14.9 | 16.5 | 15.7 |
| 421250005 | PENNSYLVANIA | WASHINGTON | | 15.4 | 14.0 | 13.4 | 14.5 | 13.8 |
| 421250200 | PENNSYLVANIA | WASHINGTON CO | | 14.6 | 13.6 | 13.2 | 14.1 | 13.6 |
| 421255001 | PENNSYLVANIA | WASHINGTON | | 13.0 | 12.9 | 12.5 | 13.5 | 13.0 |
| 421290008 | PENNSYLVANIA | WESTMORELAND CO | | 14.9 | 13.5 | 12.9 | 14.0 | 13.3 |
| 421330008 | PENNSYLVANIA | YORK CO | | 15.4 | 14.9 | 14.2 | 15.7 | 14.7 |

# APPENDIX E
## 1999 Annual Mean PM2.5 Values and Future-Year Predictions Based on RRFs

| | | | | PM2.5 Concentrations | | | | |
|---|---|---|---|---|---|---|---|---|
| MONITOR ID | STATE | COUNTY | | 1999 Ambient | 2020 Base | 2020 Control | 2030 Base | 2030 Control |
| 450190049 | SOUTH CAROLINA | CHARLESTON | | 13.1 | 13.9 | 13.7 | 14.5 | 14.2 |
| 450410002 | SOUTH CAROLINA | FLORENCE CO | | 14.3 | 14.7 | 14.3 | 15.4 | 14.8 |
| 450430009 | SOUTH CAROLINA | GEORGETOWN | | 13.5 | 14.0 | 13.8 | 14.6 | 14.2 |
| 450430009 | SOUTH CAROLINA | GEORGETOWN | | 12.9 | 13.4 | 13.1 | 13.9 | 13.6 |
| 450470003 | SOUTH CAROLINA | GREENWOOD | | 15.5 | 15.8 | 15.3 | 16.5 | 15.7 |
| 450790007 | SOUTH CAROLINA | RICHLAND | | 15.4 | 15.9 | 15.4 | 16.7 | 16.0 |
| 450790019 | SOUTH CAROLINA | RICHLAND CO | | 15.9 | 16.5 | 15.9 | 17.3 | 16.4 |
| 450830010 | SOUTH CAROLINA | SPARTANBURG CO | | 16.0 | 16.6 | 15.9 | 17.5 | 16.5 |
| 481130050 | TEXAS | DALLAS | | 17.0 | 20.3 | 19.6 | 21.9 | 20.9 |
| 481410037 | TEXAS | EL PASO CO | | 9.4 | 9.8 | 9.6 | 10.3 | 9.9 |
| 484393006 | TEXAS | TARRANT | | 12.6 | 14.8 | 14.2 | 15.9 | 15.1 |
| 490110001 | UTAH | DAVIS CO | | 7.9 | 10.1 | 9.8 | 10.8 | 10.5 |
| 490350003 | UTAH | SALT LAKE CO | | 10.9 | 13.9 | 13.4 | 15.0 | 14.4 |
| 490350012 | UTAH | SALT LAKE | | 12.5 | 16.0 | 15.6 | 17.3 | 16.7 |
| 490353006 | UTAH | SALT LAKE | | 9.9 | 12.7 | 12.4 | 13.7 | 13.2 |
| 490353007 | UTAH | SALT LAKE | | 10.2 | 13.0 | 12.6 | 14.0 | 13.5 |
| 490450002 | UTAH | TOOELE | | 9.3 | 10.9 | 10.7 | 11.6 | 11.2 |
| 490490002 | UTAH | UTAH CO | | 9.4 | 11.0 | 10.7 | 11.8 | 11.3 |
| 490494001 | UTAH | UTAH | | 9.3 | 11.9 | 11.5 | 12.9 | 12.3 |
| 490495010 | UTAH | UTAH | | 7.7 | 9.1 | 8.8 | 9.8 | 9.4 |
| 490570001 | UTAH | WEBER CO | | 9.9 | 11.3 | 11.1 | 11.9 | 11.5 |
| 490570007 | UTAH | WEBER | | 8.1 | 9.2 | 9.1 | 9.7 | 9.4 |
| 500030005 | VERMONT | BENNINGTON | | 9.9 | 9.9 | 9.7 | 10.3 | 10.0 |
| 500070007 | VERMONT | CHITTENDEN CO | | 7.0 | 6.8 | 6.7 | 7.1 | 6.9 |
| 500210002 | VERMONT | RUTLAND | | 10.9 | 10.8 | 10.6 | 11.2 | 10.9 |
| 500230005 | VERMONT | WASHINGTON | | 10.8 | 10.5 | 10.4 | 10.9 | 10.6 |
| 500230005 | VERMONT | WASHINGTON | | 10.6 | 10.3 | 10.1 | 10.6 | 10.4 |
| 510130020 | VIRGINIA | ARLINGTON CO | | 13.8 | 15.2 | 14.5 | 16.4 | 15.4 |
| 510590030 | VIRGINIA | FAIRFAX CO | | 13.3 | 14.7 | 14.0 | 15.8 | 14.9 |
| 510591004 | VIRGINIA | FAIRFAX | | 14.5 | 15.9 | 15.2 | 17.2 | 16.2 |
| 510870015 | VIRGINIA | HENRICO CO | | 13.3 | 13.8 | 13.5 | 14.5 | 14.0 |
| 511071005 | VIRGINIA | LOUDOUN CO | | 12.7 | 13.4 | 12.8 | 14.3 | 13.4 |
| 515200006 | VIRGINIA | BRISTOL CITY | | 16.4 | 15.4 | 14.9 | 16.1 | 15.4 |
| 515500012 | VIRGINIA | CHESAPEAKE CITY | | 12.9 | 14.9 | 14.5 | 15.8 | 15.2 |
| 516500004 | VIRGINIA | HAMPTON CITY | | 12.1 | 13.7 | 13.5 | 14.5 | 14.1 |
| 517000013 | VIRGINIA | NEWPORT NEWS CITY | | 12.5 | 14.1 | 13.8 | 14.9 | 14.4 |

# APPENDIX E
## 1999 Annual Mean PM2.5 Values and Future-Year Predictions Based on RRFs

| | | | | PM2.5 Concentrations | | | | |
|---|---|---|---|---|---|---|---|---|
| MONITOR ID | STATE | COUNTY | | 1999 Ambient | 2020 Base | 2020 Control | 2030 Base | 2030 Control |
| 517600020 | VIRGINIA | RICHMOND CITY | | 14.5 | 15.9 | 15.4 | 16.8 | 16.1 |
| 517750010 | VIRGINIA | SALEM CITY | | 13.2 | 12.7 | 12.3 | 13.2 | 12.7 |
| 518100008 | VIRGINIA | VIRGINIA BEACH CITY | | 13.5 | 15.6 | 15.2 | 16.5 | 15.9 |
| 530110013 | WASHINGTON | CLARK CO | | 9.4 | 10.6 | 10.4 | 11.2 | 10.9 |
| 530330021 | WASHINGTON | KING | | 10.3 | 12.8 | 12.4 | 13.9 | 13.4 |
| 530330057 | WASHINGTON | KING | | 11.5 | 14.3 | 13.9 | 15.5 | 14.9 |
| 530330080 | WASHINGTON | KING | | 8.9 | 11.1 | 10.7 | 12.0 | 11.5 |
| 530332004 | WASHINGTON | KING | | 10.9 | 13.6 | 13.1 | 14.7 | 14.1 |
| 530530031 | WASHINGTON | PIERCE | | 11.1 | 13.7 | 13.2 | 14.7 | 14.1 |
| 530531018 | WASHINGTON | PIERCE | | 9.7 | 11.9 | 11.5 | 12.8 | 12.2 |
| 530611007 | WASHINGTON | SNOHOMISH | | 10.0 | 11.4 | 11.1 | 12.1 | 11.7 |
| 530630016 | WASHINGTON | SPOKANE CO | | 10.3 | 13.1 | 12.9 | 13.4 | 13.1 |
| 530630047 | WASHINGTON | SPOKANE | | 8.5 | 10.7 | 10.5 | 11.0 | 10.8 |
| 530670013 | WASHINGTON | THURSTON CO | | 9.3 | 10.7 | 10.4 | 11.4 | 10.9 |
| 530730015 | WASHINGTON | WHATCOM CO | | 8.1 | 8.5 | 8.4 | 8.8 | 8.6 |
| 540030003 | WEST VIRGINIA | BERKEKEY CO | | 16.1 | 15.3 | 14.7 | 16.0 | 15.1 |
| 540090005 | WEST VIRGINIA | BROOKE CO | | 17.8 | 17.2 | 16.9 | 18.0 | 17.5 |
| 540110006 | WEST VIRGINIA | CABELL CO | | 18.2 | 18.2 | 17.9 | 19.0 | 18.5 |
| 540290011 | WEST VIRGINIA | HANCOCK CO | | 16.9 | 16.4 | 16.0 | 17.1 | 16.6 |
| 540290011 | WEST VIRGINIA | HANCOCK | | 17.3 | 16.7 | 16.4 | 17.4 | 16.9 |
| 540291004 | WEST VIRGINIA | HANCOCK | | 16.8 | 16.3 | 15.9 | 16.9 | 16.5 |
| 540330003 | WEST VIRGINIA | HARRISON | | 15.0 | 14.1 | 13.8 | 14.6 | 14.2 |
| 540390009 | WEST VIRGINIA | KANAWHA CO | | 17.1 | 17.8 | 17.4 | 18.5 | 18.1 |
| 540391005 | WEST VIRGINIA | KANAWHA | | 18.3 | 19.0 | 18.6 | 19.8 | 19.3 |
| 540391005 | WEST VIRGINIA | KANAWHA | | 19.6 | 20.4 | 20.0 | 21.3 | 20.7 |
| 540511002 | WEST VIRGINIA | MARSHALL CO | | 17.1 | 15.9 | 15.6 | 16.5 | 16.1 |
| 540610003 | WEST VIRGINIA | MONONGALIA | | 14.9 | 13.9 | 13.6 | 14.3 | 13.9 |
| 540690008 | WEST VIRGINIA | OHIO CO | | 15.9 | 14.8 | 14.4 | 15.4 | 14.8 |
| 540810002 | WEST VIRGINIA | RALEIGH | | 14.0 | 13.4 | 13.1 | 13.9 | 13.5 |
| 540890001 | WEST VIRGINIA | SUMMERS | | 11.8 | 11.2 | 11.0 | 11.6 | 11.3 |
| 541071002 | WEST VIRGINIA | WOOD CO | | 17.8 | 17.3 | 17.0 | 18.0 | 17.5 |
| 550090005 | WISCONSIN | BROWN CO | | 11.1 | 11.1 | 10.7 | 11.6 | 11.1 |
| 550090026 | WISCONSIN | BROWN | | 10.6 | 10.6 | 10.2 | 11.1 | 10.6 |
| 550250025 | WISCONSIN | DANE CO | | 13.1 | 13.3 | 12.8 | 14.0 | 13.3 |
| 550250047 | WISCONSIN | DANE | | 13.4 | 13.6 | 13.1 | 14.4 | 13.6 |
| 550310025 | WISCONSIN | DOUGLAS CO | | 8.6 | 9.7 | 9.5 | 10.3 | 10.1 |

# APPENDIX E
## 1999 Annual Mean PM2.5 Values and Future-Year Predictions Based on RRFs

| | | | | PM2.5 Concentrations | | | | |
|---|---|---|---|---|---|---|---|---|
| **MONITOR ID** | **STATE** | **COUNTY** | | **1999 Ambient** | **2020 Base** | **2020 Control** | **2030 Base** | **2030 Control** |
| 550550008 | WISCONSIN | JEFFERSON | | 13.5 | 13.6 | 13.1 | 14.3 | 13.6 |
| 550790010 | WISCONSIN | MILWAUKEE | | 14.5 | 15.9 | 15.4 | 17.0 | 16.2 |
| 550790026 | WISCONSIN | MILWAUKEE | | 13.8 | 15.2 | 14.7 | 16.2 | 15.5 |
| 550790059 | WISCONSIN | MILWAUKEE | | 15.0 | 16.1 | 15.6 | 17.1 | 16.4 |
| 550870009 | WISCONSIN | OUTAGAMIE CO | | 11.2 | 11.4 | 11.0 | 12.0 | 11.4 |
| 551050002 | WISCONSIN | ROCK CO | | 14.3 | 14.6 | 14.1 | 15.3 | 14.6 |
| 551330027 | WISCONSIN | WAUKESHA CO | | 14.9 | 15.8 | 15.2 | 16.7 | 15.9 |
| 551330034 | WISCONSIN | WAUKESHA | | 13.5 | 14.2 | 13.7 | 15.1 | 14.4 |
| 551390011 | WISCONSIN | WINNEBAGO CO | | 11.6 | 11.6 | 11.2 | 12.1 | 11.6 |
| 551410016 | WISCONSIN | WOOD | | 11.2 | 10.9 | 10.6 | 11.4 | 10.9 |
| 560210001 | WYOMING | LARAMIE CO | | 5.6 | 6.6 | 6.4 | 6.9 | 6.7 |
| 560330001 | WYOMING | SHERIDAN | | 8.5 | 9.3 | 9.2 | 9.5 | 9.3 |
| 560330002 | WYOMING | SHERIDAN | | 9.5 | 10.4 | 10.2 | 10.6 | 10.4 |

# Appendix F:
# IMPROVE Monitoring Sites used in the REMSAD Model Performance Evaluation

| IMPROVE Site Code | Site Name | State |
|---|---|---|
| ACAD1 | Acadia National Park | Maine |
| BADL1 | Badlands National Park | South Dakota |
| BAND1 | Bandelier National Monument | New Mexico |
| BIBE1 | Big Bend National Park | Texas |
| BLIS1 | Bliss State Park(TRPA) | California |
| BOWA1 | Boundary Waters Canoe Area | Minnesota |
| BRCA1 | Bryce Canyon National Park | Colorado |
| BRID1 | Bridger Wilderness | Wyoming |
| BRIG1 | Brigantine National Wildlife Refu | New Jersey |
| BRLA1 | Brooklyn Lake | Wyoming |
| CANY1 | Canyonlands National Park | Utah |
| CHAS1 | Chassahowitzka National Wildlife | Florida |
| CHIR1 | Chiricahua National Monument | Arizona |
| CORI1 | Columbia River Gorge | Washington |
| CRLA1 | Crater Lake National Park | Oregon |
| CRMO1 | Craters of the Moon NM(US DOE) | Idaho |
| DEVA1 | Death Valley Monument | California |
| DOLA1 | Dome Lands Wilderness | California |
| DOSO1 | Dolly Sods /Otter Creek Wildernes | West Virginia |
| EVER1 | Everglades National Park | Florida |
| GICL1 | Gila Wilderness | New Mexico |
| GLAC1 | Glacier National Park | Montana |
| GRBA1 | Great Basin National Park | Nevada |
| GRCA1 | Grand Canyon NP- Hopi Point | Arizona |
| GRSA1 | Great Sand Dunes National Monument | Colorado |
| GRSM1 | Great Smoky Mountains National Park | Tennessee |
| GUMO1 | Guadalupe Mountains National Park | Texas |
| JARB1 | Jarbidge Wilderness | Nevada |
| JEFF1 | Jefferson/James River Face Wildern | Virginia |
| LAVO1 | Lassen Volcanic National Park | California |
| LOPE1 | Lone Peak Wilderness | Utah |
| LYBR1 | Lye Brook Wilderness | Vermont |
| MACA1 | Mammoth Cave National Park | Kentucky |
| MEVE1 | Mesa Verde National Park | Colorado |
| MOOS1 | Moosehorn NWR | Maine |
| MORA1 | Mount Rainier National Park | Washington |
| MOZI1 | Mount Zirkel Wilderness | Colorado |
| OKEF1 | Okefenokee National Wildlife Refu | Georgia |
| PEFO1 | Petrified Forest National Park | Arizona |
| PINN1 | Pinnacles National Monument | California |
| PORE1 | Point Reyes National Seashore | California |

# APPENDIX F

## IMPROVE Monitoring Sites used in the REMSAD Performance Evaluation (Continued)

| **IMPROVE Site Code** | **Site Name** | **State** |
|---|---|---|
| PUSO1 | Puget Sound | Washington |
| REDW1 | Redwood National Park | California |
| ROMA1 | Cape Romain National Wildlife Ref | South Carolina |
| ROMO2 | Rocky Mountain National Park | Colorado |
| SAGO1 | San Gorgonio Wilderness | California |
| SALM1 | Salmon National Forest | Idaho |
| SAWT1 | Sawtooth National Forest | Idaho |
| SCOV1 | Scoville (US DOE) | Idaho |
| SEQU1 | Sequoia National Park | California |
| SHEN1 | Shenandoah National Park | Virginia |
| SHRO1 | Shining Rock Wilderness | North Carolina |
| SIPS1 | Sipsy Wilderness | Alabama |
| SNPA1 | Snoqualamie Pass, Snoqualamie N.F | Washington |
| SOLA1 | South Lake Tahoe (TRPA) | California |
| SULA1 | Sula (Selway Bitteroot Wilderness) | Montana |
| THSI1 | Three Sisters Wilderness | Idaho |
| TONT1 | Tonto National Monument | Arizona |
| UPBU1 | Upper Buffalo Wilderness | Arkansas |
| WASH1 | Washington D.C. | Washington D.C. |