Risk and Exposure Assessment to Support the Review of the NO_2 Primary National Ambient Air Quality Standard: Appendices

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Risk and Exposure Assessment to Support the Review of the NO_2 Primary National Ambient Air Quality Standard

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Appendix A. Supplement to the NO_2 Air Quality Characterization

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A-1 Overview

This appendix contains supplemental descriptions of the data and methods used in the NO_2 air quality characterization in support of the Risk and Exposure Assessment (REA) conducted for the NO_2 NAAQS review. First, ambient monitoring data form years 1995 through 2006 have been characterized based on siting characteristics, proximity to stationary source emissions, and distance to roadways. Then, ambient NO_2 concentration trends were evaluated considering the year of monitoring and distribution of monitors within a location.

The primary output of the air quality characterization was the numbers of exceedances of potential health effect benchmark levels identified in the Integrated Science Assessment. The ambient NO_2 concentrations were evaluated for the numbers of exceedances of the selected benchmarks in several locations and considering four scenarios. The first scenario considered *as is* air quality as obtained from EPA's Air Quality System (US EPA, 2007a; 2007b). A second scenario used a portion of the *as is* air quality to estimate on-road NO_2 concentrations. A third and fourth scenario followed in a similar manner, only these used air quality adjusted to just meeting the current and potential alternative standards. Each of these scenarios, in addition to the reasoning for the methods and data used, are described in detail in the sections that follow.

A-2 Air Quality Data Screen

A-2.1 Introduction

The current NO_2 standard of 53 ppb annual arithmetic average was set in 1971 and has been retained since by subsequent reviews (i.e., 1985, 1995). Minor revisions to the standard made in 1985 included an explicit rounding convention, stated annual averages would be determined on a calendar year basis, and indicated an explicit 75% completeness requirement for monitoring (60 FR 52874). Each of these components of the standard were considered in characterizing the air quality monitoring data, beginning first with the selection of valid data.

A-2.2 Approach

NO_2 air quality data from years 1995 through 2006 and associated documentation were downloaded from EPA's Air Quality System (US EPA, 2007a; 2007b). As of the date of the first analyses were performed, hourly measurements for year 2006 were only available for January 1 through October 31, 2006. A *site* was defined by the state, county, site code, and parameter occurrence code (POC), which gives a 10-digit monitor ID code. The POC identifies collocated measurements at the same monitoring location, so that each measuring instrument is treated as a different site. Typically there was only one POC at a given monitoring location.

As required by the NO_2 NAAQS, a valid year of monitoring data is needed to calculate the annual average concentration. A valid year at a monitoring site is comprised of 75% of valid days in a year, with at least 18 hourly measurements for a valid day (thus at least 274 or 275 valid days depending on presence of a leap year, a minimum of 4,932 or 4,950 hours). This served as a screening criterion for data to be used for analysis.

Site-years of data are the total numbers of years the collective monitors in a location were in operation. For example, from years 1995-2006, the Boston CMSA had 27 total monitors in operation, some of which did not contain sufficient numbers of monitoring values, while others contained upwards of 11 years (Table A-1). Thus in summing the number of operating years, this particular location contained a total of 105 site-years of data across the monitoring period.

In all of the subsequent analyses, where hourly values were missing they were treated as such. Reported values of zero (0) concentration were also retained as is. For certain illustrations, values of zero were substituted with 0.5 ppb, derived from one-half the lowest recorded 1-hour concentration (1 ppb).

A-2.3 Results

Of a total of 5,243 site-years of data in the entire NO_2 1-hour concentration database, 1,039 site-years did not meet the above criterion and were excluded from any further analyses. In addition, since shorter term average concentrations are of interest, the remaining site-years of data were further screened for 75% completeness on hourly measures in a year (i.e., containing a minimum of 6,570 or 6,588, depending on presence of a leap year). Twenty-seven additional site-years were excluded, resulting in 4,177 complete site-years in the analytical database. Table

A-2 provides a summary of the site-years included in the analysis, relative to those excluded, by location and by two site-year groupings.[1] Location selection is defined in the Section A-1.2.

Table A-1. Example of ambient monitor years of operation, using the Boston CMSA.

	Year of monitoring (1995-2006)												Totals	
Monitor ID	**95**	**96**	**97**	**98**	**99**	**00**	**01**	**02**	**03**	**04**	**05**	**06**	**Complete**	**Incomplete**
2303130021	i	c	c	c	i	c	c	c	c	i	i		7	4
2500510021								i					0	1
2500510051		i	c	c	i	i	i						2	4
2500900051								i					0	1
2500920061	c	c	c	c	i	i	c	c	c	c	c	c	10	2
2500940041	c	c	c	c	i	i	c	i	i	i	i	i	5	7
2500950051										i	c	c	2	1
2502100091	c												1	0
2502130031								i	i	i	i	i	0	5
2502500021	c	c	c	c	c	c	c	c	i	c	c	c	11	1
2502500211	c	c	c	c	c	c	c	c					8	0
2502500351	c												1	0
2502500361	c												1	0
2502500401	c	c	c	c	c	c	c	c	c	c	c	i	11	1
2502500411					i	i	c	i	i	i	i	i	1	7
2502500421						i	c	c	c	c	c	c	6	1
2502510031	c	c	c	c	c								5	0
2502700201	c	c	c	c	c	c	c	c	i				8	1
2502700231										c	c	c	3	0
3301100161	c	c	c	c	i								4	1
3301100191					i	c	i						1	2
3301100201							i	c	c	c	c	c	5	1
3301110111										i	i	i	0	3
3301500091	c	c	c	c	c	i	i						5	2
3301500131				i	c	c	c	c	i				4	2
3301500141									i	c	c	c	3	1
3301500151							i	c	i				1	2
Complete	**12**	**10**	**11**	**11**	**7**	**7**	**10**	**10**	**5**	**7**	**8**	**7**	**105**	
Incomplete	**1**	**1**	**0**	**1**	**7**	**6**	**5**	**5**	**8**	**6**	**5**	**5**		**50**

Notes:
c = met criteria for valid year of monitoring data.
i = did not met criteria for valid year of monitoring data.

[1] 14 of 18 named locations and the 2 grouped locations contained enough data to be considered valid for year 2006.

Table A-2. Counts of complete site-years of NO_2 monitoring data.

	Number of Site-Years				% Complete	
	Complete		Incomplete			
Location	**1995-2000**	**2001-2006**	**1995-2000**	**2001-2006**	**1995-2000**	**2001-2006**
Atlanta	24	29	5	1	83%	97%
Boston	58	47	16	34	78%	58%
Chicago	47	36	20	22	70%	62%
Cleveland	11	11	2	2	85%	85%
Colorado Springs	26	ND	4	4	87%	ND
Denver	26	10	10	4	72%	71%
Detroit	12	12	4	1	75%	92%
El Paso	14	30	11	0	56%	100%
Jacksonville	6	4	0	2	100%	67%
Las Vegas	16	35	4	9	80%	80%
Los Angeles	193	177	16	19	92%	90%
Miami	24	20	1	4	96%	83%
New York	93	81	12	24	89%	77%
Philadelphia	46	39	6	8	88%	83%
Phoenix	22	27	8	25	73%	52%
Provo	6	6	0	0	100%	100%
St. Louis	56	43	3	9	95%	83%
Washington	69	66	21	18	77%	79%
Other MSA	1135	1177	249	235	82%	83%
Other Not MSA	200	243	112	141	64%	63%
Total	**4177**		**1066**		**80%**	

Notes:
ND no available monitoring data

A-3 Selection of Locations

A-3.1 Introduction

The next step in this analysis was to identify similarities and differences in air quality among locations for the purpose of either aggregating or segregating data using a combination of descriptive statistics and health based criteria. *Location* in this context would include a geographic area that encompasses more than a single air quality monitor (e.g., particular city, consolidated metropolitan statistical area or CMSA).

A-3.2 Approach

Criteria were established for selecting sites with high annual means and/or frequent exceedances of potential health effect benchmarks. Selected locations were those that had a maximum annual mean NO_2 level at a particular monitor greater than or equal to 25.7 ppb, which represents the 90th percentile across all locations and site-years, and/or had at least one reported 1-hour NO_2 level greater than or equal to 200 ppb, the lowest level of the potential health effect benchmarks. A *location* in this context would include a geographic area that encompasses more than a single air quality monitor (e.g., particular city, metropolitan statistical area (MSA), or consolidated metropolitan statistical area or CMSA). First, all monitors were identified as either belonging to a CMSA, a MSA, or neither. Then, locations of interest were identified through statistical analysis of the ambient NO_2 air quality data for each site within a location.

A-3.3 Results

Fifteen locations met both selection criteria, that is, having at least one site-year annual mean above 25.7 ppb and at least one exceedance of 200 ppb. Upon further analysis of the more recent ambient data (2001-2006), four additional locations were observed to have met at least one of the criteria (either high annual mean and/or at least one exceedance of 200 ppb). New Haven, CT, while meeting the earlier criteria, did not have any recent exceedances of 200 ppb and contained one of the lowest maximum concentration-to-mean ratios, therefore was not separated out as a specific location. Thus, 14 locations were retained from the initial selection and 4 locations selected from a second screening to provide additional geographical representation. In addition to these 18 specific locations, the remaining sites were grouped into two broad location groupings. The *Other CMSA* location contains all the other sites that are in MSAs or CMSAs but are not in any of the 18 specified locations. The *Not MSA* location contains all the sites that are not in an MSA or CMSA. The selected locations are summarized in Table A-3.

The final database for analysis included air quality data from a total of 204 monitors within the named locations, 332 monitors in the Other CMSA group, and 92 monitors in the Not MSA group. Again, the monitors that were retained contained the criteria for estimating a valid annual average concentration described above.

Table A-3. Locations selected for NO_2 Air Quality Characterization, associated abbreviations, and values of selection criteria.

Location				Maximum # of Exceedances of 200 ppb	Maximum Annual Mean (ppb)
Type[1]	Code	Description	Abbreviation		
MSA	0520	Atlanta, GA	Atlanta*	1	26.6
CMSA	1122	Boston-Worcester-Lawrence, MA-NH-ME-CT	Boston*	1	31.1
CMSA	1602	Chicago-Gary-Kenosha, IL-IN-WI	Chicago	0	33.6
CMSA	1692	Cleveland-Akron, OH	Cleveland*	1	28.1
MSA	1720	Colorado Springs, CO	Colorado Springs*	69	34.8
CMSA	2082	Denver-Boulder-Greeley, CO	Denver*	2	36.8
CMSA	2162	Detroit-Ann Arbor-Flint, MI	Detroit*	12	25.9
MSA	2320	El Paso, TX	El Paso*	2	35.1
MSA	3600	Jacksonville, FL	Jacksonville	2	15.9
MSA	4120	Las Vegas, NV-AZ	Las Vegas*	11	27.1
CMSA	4472	Los Angeles-Riverside-Orange County, CA	Los Angeles*	5	50.6
CMSA	4992	Miami-Fort Lauderdale, FL	Miami	3	16.8
CMSA	5602	New York-Northern New Jersey-Long Island, NY-NJ-CT-PA	New York*	3	42.2
CMSA	6162	Philadelphia-Wilmington-Atlantic City, PA-NJ-DE-MD	Philadelphia*	3	34.00
MSA	6200	Phoenix-Mesa, AZ	Phoenix*	37	40.5
MSA	6520	Provo-Orem, UT	Provo	0	28.9
MSA	7040	St, Louis, MO-IL	St. Louis*	8	27.2
CMSA	8872	Washington-Baltimore, DC-MD-VA-WV	Washington DC*	2	27.2
MSA/CMSA	-	Other MSA/CMSA	Other MSA	10	31.9
-	-	Other Not MSA	Other Not MSA	2	19.7

[1] CMSA is consolidated metropolitan statistical area; MSA is metropolitan statistical area according to the 1999 Office of Management and Budget definitions (January 28, 2002 revision).
* Indicates locations that satisfied both the annual average and exceedance criteria.

A-4 Ambient Monitoring Site Characteristics

A-4.1 Introduction

Siting of monitors is of particular importance, recognizing that proximity of local sources could influence on measured NO_2 concentrations. As part of the risk and exposure scope and methods document (US EPA, 2007c), both mobile and stationary sources (in particular power generating utilities using fossil fuels) were indicated as significant contributors to nitrogen oxides (NO_x) emissions in the U.S. Analyses were performed to determine the distance of all location-specific monitors to these source categories. In addition, emissions of NO_x from stationary sources within close proximity of the location-specific monitoring sites were estimated.

A-4.2 Approach

Major road distances to each monitor were first determined using a Tele-Atlas roads database in a GIS application. For road-monitor pairs that showed particularly close distances, the values were refined using GoogleEarth® to estimate the distance to road edge. Distances of monitoring sites to stationary sources and those source's emissions were estimated using data within the 2002 National Emissions Inventory (NEI; US EPA, 2007d). The NEI database reports emissions of NO_x in tons per year (tpy) for 131,657 unique emission sources at various points of release. The release locations were all taken from the latitude longitude values within the NEI. First, all NO_x emissions were summed for identical latitude and longitude entries while retaining source codes for the emissions (e.g., Standard Industrial Code (SIC), or North American Industrial Classification System (NAICS)). Therefore, any facility containing similar emission processes were summed at the stack location, resulting in 40,855 observations. These data were then screened for sources with emissions greater than 5 tpy, yielding 18,798 unique NO_x emission sources. Locations of these stationary source emissions were compared with ambient monitoring locations using the following formula:

$$d = \arccos(\sin(lat_1) \times \sin(lat_2) + \cos(lat_1) \times \cos(lat_2) \times \cos(lon_2 - lon_1)) \times r$$

where

d	=	distance (kilometers)
lat_1	=	latitude of a monitor (radians)
lat_2	=	latitude of source emission (radians)
lon_1	=	longitude of monitor (radians)
lon_2	=	longitude of source emission (radians)
r	=	approximate radius of the earth (or 6,371 km)

Location data for monitors and sources provided in the AQS and NEI data bases were given in units of degrees therefore, these were first converted to radians by dividing by 180/π. For each monitor, source emissions with estimated distances within 10 km were retained.

A-4.3 Summary Results

Summary statistics for the monitoring site characteristics are presented in Tables A-4 through A-6 for the selected locations. Detailed results for the distance to major roadways, the distance and emissions from stationary sources for each ambient monitor are provided in section A-4.4, Tables A-7 and A-8.

The distribution of the nearest distance of the ambient monitors to major roads for each of the named locations is summarized in Table A-4. On average, most monitors are placed at a distance of 100 meters or greater from a major road, however in locations with a large monitoring network such as Boston, Chicago, or New York CMSA, there may be one or two monitors sited within close proximity (<20 meters) of a road. Since there is potential for roadway emissions to affect concentrations at monitors sited close to major roads, the ambient monitors were further categorized based on the monitor distance from major roads. Three proximity bins were identified, the first containing those monitors sited at or within 20 meters, (≤20 m), those between 20 m and 100 m, and those located at least 100 meters from a major road (≥100 m).[2]

Table A-4. Distribution of the distance of ambient monitors to the nearest major road in selected locations.

Location	n	Distance (m) of monitor to nearest major road						
		mean	std	min	2.5	50	97.5	max
Atlanta	4	488	283	134	134	505	809	809
Boston	21	101	93	7	7	70	337	337
Chicago	12	158	212	2	2	93	738	738
Cleveland	4	114	90	2	2	134	187	187
Colorado Springs	6	196	103	79	79	180	386	386
Denver	7	166	260	18	18	65	748	748
Detroit	3	382	39	339	339	393	415	415
El Paso	7	282	266	33	33	128	718	718
Jacksonville	1	144						
Las Vegas	10	244	286	1	1	181	914	914
Los Angeles	43	155	150	1	2	89	522	570
Miami	4	57	45	15	15	55	103	103
New York	26	145	130	6	6	119	508	508
Philadelphia	10	247	199	45	45	167	630	630
Phoenix	7	190	177	7	7	141	433	433
Provo	1	353						
St Louis	13	126	123	5	5	97	421	421
Washington DC	16	129	104	14	14	83	338	338

[1] n is the number of monitors operating in a particular location between 1995 and 2006. The min, 2.5, med, 97.5, and max represent the minimum, 2.5th, median, 97.5th, and maximum percentiles of the distribution for the distance in meters (m) to the nearest major road. Monitors >1km from road are not included.

Table A-5 contains a summary of the distance of stationary source emissions to monitors within each named location. There were a number of sources emitting >5 tpy of NO_x and located within a 10 km radius for many of the monitors. On average though, most monitors are placed at greater distances from stationary source emissions than roads with most sources at a distance of greater than 5 km. Most of the stationary source emissions of NO_x within a 10 km radius of monitors were less than 50 tpy (Table A-6). Details regarding individual monitors are provided in Table A-8.

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[2] As part of our initial analysis, the historical data were separated into two-road distance categories, <100 m and ≥100 m from a major road. The recent data were separated into both the two- and three-road distance categories for analysis.

Table A-5. Distribution of the distance of ambient monitors to stationary sources with NO_x emissions >5 tons per year and within a 10 kilometers radius.

Location	n[1]	Distance of monitor to NO_x emission source (m)[2]						
		mean	std	min	2.5	50	97.5	max
Atlanta	9	6522	3164	656	656	7327	9847	9847
Boston	595	5333	2603	142	761	5363	9733	9988
Chicago	394	6586	2657	411	770	7277	9834	9994
Cleveland	19	7092	2439	956	956	7278	9884	9884
Colorado Springs	66	6109	2632	782	1034	6340	9847	9933
Denver	140	5655	2593	910	1029	5904	9862	9979
Detroit	87	6889	2254	321	1963	7549	9974	9997
El Paso	126	5694	3185	119	1384	6085	9945	9991
Jacksonville	20	5125	2962	708	708	5720	9558	9558
Las Vegas	18	6700	2184	3837	3837	7237	9950	9950
Los Angeles	523	6003	2435	140	1483	6165	9801	9991
Miami	11	6184	3151	1323	1323	7611	9117	9117
New York	736	6101	2555	103	1383	6467	9818	9983
Philadelphia	382	5837	2474	231	1299	5689	9754	9982
Phoenix	59	6298	2279	833	1312	6355	9803	9890
Provo	7	6558	3664	1214	1214	8178	9433	9433
St Louis	253	6799	2337	396	1989	7120	9863	9990
Washington DC	160	6173	2425	288	704	6254	9777	9973

[1] n is the number of sources emitting >5 tons per year (tpy) NO_x within a 10 kilometer radius of a monitor in a particular location.
[2] The min, 2.5, med, 97.5, and max represent the minimum, 2.5th, median, 97.5th, and maximum percentiles of the distribution for the distance in meters (m) to the source emission.

Table A-6. Distribution of NO_x emissions from stationary sources within 10 kilometers of monitoring site, where emissions were >5 tons per year.

Location	n[1]	Emissions (tpy) of NO_x from sources within 10 km of monitor[2]						
		mean	std	min	2.5	50	97.5	max
Atlanta	9	709	1621	22	22	35	4895	4895
Boston	595	128	344	5	5	10	1155	3794
Chicago	394	204	919	5	5	10	2204	8985
Cleveland	19	702	612	126	126	284	1476	1476
Colorado Springs	66	387	1091	5	5	19	4205	4205
Denver	140	252	1286	5	5	15	5404	9483
Detroit	87	251	637	5	6	24	2398	3762
El Paso	126	117	286	5	5	31	912	1679
Jacksonville	20	201	407	5	5	31	1642	1642
Las Vegas	18	483	636	18	18	84	1665	1665
Los Angeles	523	70	310	5	5	12	577	4256
Miami	11	24	16	8	8	22	51	51
New York	736	284	1024	5	6	31	3676	9022
Philadelphia	382	154	408	5	5	29	1304	4968
Phoenix	59	85	234	5	5	14	1049	1049
Provo	7	60	38	7	7	83	102	102
St Louis	253	167	1032	5	5	16	848	14231
Washington DC	160	320	1254	6	6	34	6009	10756

[1] n is the number of sources emitting >5 tons per year (tpy) of NO_x within a 10 kilometer radius of a monitor in a particular location.
[2] The min, 2.5, med, 97.5, and max represent the minimum, 2.5th, median, 97.5th, and maximum percentiles of the distribution for

the source emissions.

A-4.4 Detailed Monitoring Site Characteristics

Detailed physical attributes of each monitor used within the named locations (i.e., 18 specific locations were defined; it does not include the broadly grouped locations of "Other CMSA" or Not MSA). Each of these monitors met the criteria for containing a valid number of reported concentrations and were used throughout the air quality characterization. Data provided include monitor location and purpose, ground height and elevation above sea level, and distance to the nearest major roadway (Table A-7). In addition, the distances and emissions of stationary sources that emit >5 tons NO_x per year were calculated for each monitor (Table A-8)

Table A-7. Attributes of location-specific ambient monitors used for air quality characterization and the distance to nearest major roadway.

Location	Monitor ID	Latitude	Longitude	Objective[1]	Setting[2]	Land Use[3]	Scale[4]	Monitor[5]			Roadway[6]	
								Years	Ht (m)	Elev (m)	Dist (m)	Type
Atlanta	130890002	33.68801	-84.2903	POPULATION EXPOSURE	SUBURBAN	RESIDENTIAL	URBAN SCALE	10	5	308	432	3
Atlanta	130893001	33.84568	-84.2134	UNKNOWN	RURAL	RESIDENTIAL	NEIGHBORHOOD	9	5	0	579	2
Atlanta	131210048	33.77919	-84.3958	POPULATION EXPOSURE	URBAN AND CENTER CITY	COMMERCIAL	NEIGHBORHOOD	12	5	290	134	3
Atlanta	132230003	33.92855	-85.0455	POPULATION EXPOSURE	RURAL	AGRICULTURAL	URBAN SCALE	10	4	417	1000	
Atlanta	132470001	33.59093	-84.0654	POPULATION EXPOSURE	RURAL	AGRICULTURAL	URBAN SCALE	12	5	219	809	3
Boston	230313002	43.08333	-70.75	POPULATION EXPOSURE	SUBURBAN	RESIDENTIAL	NEIGHBORHOOD	7	4	40	70	2
Boston	250051005	42.06306	-71.1489	POPULATION EXPOSURE	RURAL	AGRICULTURAL	URBAN SCALE	2	4	61	17	3
Boston	250092006	42.47467	-70.9714	POPULATION EXPOSURE	URBAN AND CENTER CITY	COMMERCIAL	URBAN SCALE	10	5	52	158	3
Boston	250094004	42.79027	-70.8083	POPULATION EXPOSURE	SUBURBAN	RESIDENTIAL	URBAN SCALE	5	4	1	15	3
Boston	250095005	42.77077	-71.1023	POPULATION EXPOSURE	SUBURBAN	RESIDENTIAL	NEIGHBORHOOD	2		0	337	3
Boston	250210009	42.31667	-71.1333	UNKNOWN	URBAN AND CENTER CITY	RESIDENTIAL	MICROSCALE	1	4	0	144	3
Boston	250250002	42.34887	-71.0972	HIGHEST CONCENTRATION	URBAN AND CENTER CITY	COMMERCIAL	MICROSCALE	11	5	6	7	2
Boston	250250021	42.37783	-71.0271	HIGHEST CONCENTRATION	URBAN AND CENTER CITY	RESIDENTIAL	NEIGHBORHOOD	8	4	6	7	3
Boston	250250035	42.33333	-71.1167	UNKNOWN	URBAN AND CENTER CITY	RESIDENTIAL		1		0	158	3
Boston	250250036	42.33333	-71.1167	UNKNOWN	URBAN AND CENTER CITY	RESIDENTIAL		1		0	158	3
Boston	250250040	42.34025	-71.0383	POPULATION EXPOSURE	URBAN AND CENTER CITY	INDUSTRIAL	NEIGHBORHOOD	11	4	0	37	3
Boston	250250041	42.31717	-70.9662	POPULATION EXPOSURE	RURAL	COMMERCIAL	URBAN SCALE	1	6	10	1000	
Boston	250250042	42.3294	-71.0825	POPULATION EXPOSURE	URBAN AND CENTER CITY	COMMERCIAL	NEIGHBORHOOD	6	5	6	26	3
Boston	250251003	42.40167	-71.0311	POPULATION EXPOSURE	SUBURBAN	RESIDENTIAL	URBAN SCALE	5	4	59	228	4
Boston	250270020	42.26722	-71.7989	UNKNOWN	URBAN AND CENTER CITY	COMMERCIAL		8	3	145	44	3
Boston	250270023	42.26388	-71.7942	POPULATION EXPOSURE	URBAN AND CENTER CITY	COMMERCIAL	URBAN SCALE	3	4	145	49	3
Boston	330110016	42.99278	-71.4594	UNKNOWN	URBAN AND CENTER CITY	COMMERCIAL		4	5	75	168	3
Boston	330110019	43.00056	-71.4681	UNKNOWN	URBAN AND CENTER CITY	COMMERCIAL		1		61	70	3
Boston	330110020	43.00056	-71.4681	UNKNOWN	URBAN AND CENTER CITY	COMMERCIAL	NEIGHBORHOOD	5	5	61	70	3

Table A-7. Attributes of location-specific ambient monitors used for air quality characterization and the distance to nearest major roadway.

Location	Monitor ID	Latitude	Longitude	Objective[1]	Setting[2]	Land Use[3]	Scale[4]	Monitor[5]			Roadway[6]	
								Years	Ht (m)	Elev (m)	Dist (m)	Type
Boston	330150009	43.07806	-70.7628	UNKNOWN	SUBURBAN	COMMERCIAL		5	3	3	48	3
Boston	330150013	43	-71.2	OTHER	RURAL	RESIDENTIAL	REGIONAL SCALE	4	1	0	1000	
Boston	330150014	43.07528	-70.7481	POPULATION EXPOSURE	URBAN AND CENTER CITY	RESIDENTIAL	NEIGHBORHOOD	3	2	4	266	3
Boston	330150015	43.0825	-70.7619	POPULATION EXPOSURE	SUBURBAN	COMMERCIAL	NEIGHBORHOOD	1	4	3	38	3
Chicago	170310037	41.97944	-87.67	UNKNOWN	URBAN AND CENTER CITY	RESIDENTIAL		1	9	183	17	3
Chicago	170310063	41.87697	-87.6343	HIGHEST CONCENTRATION	URBAN AND CENTER CITY	MOBILE	MIDDLE SCALE	12	3	181	68	3
Chicago	170310064	41.79079	-87.6016	POPULATION EXPOSURE	SUBURBAN	RESIDENTIAL	NEIGHBORHOOD	6	15	180	346	3
Chicago	170310075	41.96417	-87.6586	POPULATION EXPOSURE	SUBURBAN	RESIDENTIAL	NEIGHBORHOOD	4	15	180	136	3
Chicago	170310076	41.7514	-87.7135	POPULATION EXPOSURE	SUBURBAN	RESIDENTIAL	NEIGHBORHOOD	5	4	186	2	3
Chicago	170313101	41.96525	-87.8763	HIGHEST CONCENTRATION	SUBURBAN	MOBILE	MIDDLE SCALE	3	3	197	20	2
Chicago	170313103	41.96519	-87.8763	HIGHEST CONCENTRATION	SUBURBAN	MOBILE	MIDDLE SCALE	9	4	195	20	2
Chicago	170314002	41.85524	-87.7525	POPULATION EXPOSURE	SUBURBAN	RESIDENTIAL	NEIGHBORHOOD	12	4	184	118	3
Chicago	170314201	42.14	-87.7992	POPULATION EXPOSURE	SUBURBAN	RESIDENTIAL	URBAN SCALE	8	8	198	239	2
Chicago	170318003	41.63139	-87.5681	POPULATION EXPOSURE	SUBURBAN	RESIDENTIAL	NEIGHBORHOOD	8	4	179	2	3
Chicago	171971011	41.22154	-88.191	GENERAL/BACKGR OUND	RURAL	AGRICULTURAL	REGIONAL SCALE	5	5	181	1000	
Chicago	180890022	41.60667	-87.3047	HIGHEST CONCENTRATION	URBAN AND CENTER CITY	INDUSTRIAL	NEIGHBORHOOD	8	5	183	738	1
Chicago	180891016	41.60028	-87.3347	POPULATION EXPOSURE	URBAN AND CENTER CITY	RESIDENTIAL	NEIGHBORHOOD	2	14	183	187	3
Cleveland	390350043	41.46278	-81.5792	POPULATION EXPOSURE	SUBURBAN	RESIDENTIAL	URBAN SCALE	2	4	287	187	2
Cleveland	390350060	41.49396	-81.6785	POPULATION EXPOSURE	URBAN AND CENTER CITY	COMMERCIAL	NEIGHBORHOOD	12	4	206	2	4
Cleveland	390350066	41.46278	-81.5803	POPULATION EXPOSURE	SUBURBAN	RESIDENTIAL	URBAN SCALE	6	5	287	187	2
Cleveland	390350070	41.45694	-81.5922	POPULATION EXPOSURE	URBAN AND CENTER CITY	RESIDENTIAL	NEIGHBORHOOD	2	4	278	81	3
Colorado Springs	080416001	38.63361	-104.716	UNKNOWN	RURAL	INDUSTRIAL		6	4	1673	1000	
Colorado Springs	080416004	38.92139	-104.813	UNKNOWN	URBAN AND CENTER CITY	RESIDENTIAL		6	4	1931	150	1
Colorado Springs	080416005	38.76333	-104.757	UNKNOWN	URBAN AND CENTER CITY	AGRICULTURAL		1	4	1747	79	3
Colorado Springs	080416006	38.9225	-104.996	UNKNOWN	RURAL	RESIDENTIAL		1	4	2313	199	2
Colorado Springs	080416009	38.64083	-104.714	UNKNOWN	RURAL	INDUSTRIAL		1	4	1707	1000	

Table A-7. Attributes of location-specific ambient monitors used for air quality characterization and the distance to nearest major roadway.

Location	Monitor ID	Latitude	Longitude	Objective[1]	Setting[2]	Land Use[3]	Scale[4]	Monitor[5]			Roadway[6]	
								Years	Ht (m)	Elev (m)	Dist (m)	Type
Colorado Springs	080416011	38.84667	-104.827	UNKNOWN	URBAN AND CENTER CITY	RESIDENTIAL		6	3	1832	198	3
Colorado Springs	080416013	38.81056	-104.817	UNKNOWN	URBAN AND CENTER CITY	RESIDENTIAL		1	3	1823	386	4
Colorado Springs	080416018	38.81139	-104.751	UNKNOWN	URBAN AND CENTER CITY	COMMERCIAL		4	3	1795	163	2
Denver	080013001	39.83812	-104.95	POPULATION EXPOSURE	RURAL	AGRICULTURAL	URBAN SCALE	11	4	1559	748	3
Denver	080050003	39.65722	-104.998	HIGHEST CONCENTRATION	SUBURBAN	COMMERCIAL	NEIGHBORHOOD	1	4	1654	138	2
Denver	080310002	39.75118	-104.988	HIGHEST CONCENTRATION	URBAN AND CENTER CITY	COMMERCIAL	NEIGHBORHOOD	9	5	1589	18	3
Denver	080590006	39.9129	-105.189	UNKNOWN	RURAL	INDUSTRIAL		3		1774	65	3
Denver	080590008	39.87639	-105.166	GENERAL/BACKGR OUND	RURAL	INDUSTRIAL	NEIGHBORHOOD	4	4	1715	31	3
Denver	080590009	39.86194	-105.203	GENERAL/BACKGR OUND	RURAL	INDUSTRIAL	NEIGHBORHOOD	3	4	1848	99	3
Denver	080590010	39.89972	-105.24	UNKNOWN	RURAL	AGRICULTURAL	NEIGHBORHOOD	5	4	1877	63	2
Detroit	260990009	42.73139	-82.7935	UNKNOWN	SUBURBAN	COMMERCIAL		2		189	415	3
Detroit	261630016	42.35781	-83.096	HIGHEST CONCENTRATION	URBAN AND CENTER CITY	RESIDENTIAL	NEIGHBORHOOD	11	4	191	393	5
Detroit	261630019	42.43084	-83.0001	POPULATION EXPOSURE	SUBURBAN	RESIDENTIAL	URBAN SCALE	11	4	192	339	3
El Paso	481410027	31.76308	-106.487	GENERAL/BACKGR OUND	URBAN AND CENTER CITY	COMMERCIAL	URBAN SCALE	4	5	1140	33	4
El Paso	481410028	31.75361	-106.404	SOURCE ORIENTED	SUBURBAN	RESIDENTIAL	MICROSCALE	1	4	1126	718	3
El Paso	481410037	31.76828	-106.501	POPULATION EXPOSURE	URBAN AND CENTER CITY	COMMERCIAL	NEIGHBORHOOD	11	4	1143	128	3
El Paso	481410044	31.76567	-106.455	HIGHEST CONCENTRATION	URBAN AND CENTER CITY	COMMERCIAL	NEIGHBORHOOD	8	5	1128	38	3
El Paso	481410055	31.74676	-106.403	POPULATION EXPOSURE	URBAN AND CENTER CITY	COMMERCIAL		7	5	0	127	3
El Paso	481410057	31.66219	-106.303	POPULATION EXPOSURE	SUBURBAN	RESIDENTIAL		7		0	450	3
El Paso	481410058	31.89393	-106.426	POPULATION EXPOSURE	URBAN AND CENTER CITY	RESIDENTIAL	NEIGHBORHOOD	6	5	0	478	3
Jacksonville	120310032	30.35611	-81.6356	UNKNOWN	SUBURBAN	COMMERCIAL		10	3	7	144	1
Las Vegas	320030022	36.39078	-114.907	SOURCE ORIENTED	RURAL	INDUSTRIAL	NEIGHBORHOOD	7	3.5	0	122	2
Las Vegas	320030023	36.80806	-114.061	POPULATION EXPOSURE	RURAL	RESIDENTIAL	NEIGHBORHOOD	4	4	490	303	3
Las Vegas	320030073	36.17306	-115.332	POPULATION EXPOSURE	SUBURBAN	RESIDENTIAL	NEIGHBORHOOD	7	3.5	0	515	2
Las Vegas	320030078	35.46505	-114.92	REGIONAL TRANSPORT	RURAL	DESERT	REGIONAL SCALE	1	4	1094	25	3
Las Vegas	320030539	36.14444	-115.086	POPULATION EXPOSURE	SUBURBAN	MOBILE	NEIGHBORHOOD	8	3.5	533	11	3

Table A-7. Attributes of location-specific ambient monitors used for air quality characterization and the distance to nearest major roadway.

Location	Monitor ID	Latitude	Longitude	Objective[1]	Setting[2]	Land Use[3]	Scale[4]	Monitor[5] Years	Monitor[5] Ht (m)	Monitor[5] Elev (m)	Roadway[6] Dist (m)	Roadway[6] Type
Las Vegas	320030557	36.15889	-115.11	UNKNOWN	SUBURBAN	RESIDENTIAL		2	3	567	1	3
Las Vegas	320030563	36.17639	-115.103	POPULATION EXPOSURE	SUBURBAN	RESIDENTIAL	NEIGHBORHOOD	3	4	570	254	3
Las Vegas	320030601	35.97889	-114.844	POPULATION EXPOSURE	SUBURBAN	COMMERCIAL	NEIGHBORHOOD	5	4	0	52	3
Las Vegas	320031019	35.78563	-115.357	GENERAL/BACKGROUND	RURAL	DESERT	URBAN SCALE	7	4	950	914	3
Las Vegas	320032002	36.19111	-115.122	HIGHEST CONCENTRATION	URBAN AND CENTER CITY	COMMERCIAL	NEIGHBORHOOD	7	3.5	0	240	3
Los Angeles	060370002	34.1365	-117.924	POPULATION EXPOSURE	SUBURBAN	RESIDENTIAL	URBAN SCALE	12	2	183	329	3
Los Angeles	060370016	34.14435	-117.85	UNKNOWN	SUBURBAN	RESIDENTIAL		12	6	275	300	3
Los Angeles	060370030	34.03528	-118.217	UNKNOWN	URBAN AND CENTER CITY	RESIDENTIAL		1	5	65	50	3
Los Angeles	060370113	34.05111	-118.456	UNKNOWN	URBAN AND CENTER CITY	MOBILE		12	5	91	190	3
Los Angeles	060370206	33.95833	-117.842	UNKNOWN	URBAN AND CENTER CITY	COMMERCIAL	MIDDLE SCALE	1		300	1000	
Los Angeles	060371002	34.17605	-118.317	UNKNOWN	URBAN AND CENTER CITY	COMMERCIAL		11	5	168	58	3
Los Angeles	060371103	34.06659	-118.227	HIGHEST CONCENTRATION	URBAN AND CENTER CITY	RESIDENTIAL	NEIGHBORHOOD	11	13	87	55	3
Los Angeles	060371201	34.19925	-118.533	UNKNOWN	SUBURBAN	COMMERCIAL		12	6	226	206	3
Los Angeles	060371301	33.92899	-118.211	UNKNOWN	URBAN AND CENTER CITY	COMMERCIAL		12	7	27	29	3
Los Angeles	060371601	34.01407	-118.061	POPULATION EXPOSURE	SUBURBAN	COMMERCIAL	NEIGHBORHOOD	10	6	75	78	3
Los Angeles	060371701	34.06703	-117.751	UNKNOWN	SUBURBAN	COMMERCIAL		12	6	270	15	3
Los Angeles	060372005	34.1326	-118.127	UNKNOWN	URBAN AND CENTER CITY	RESIDENTIAL		12	4	250	385	3
Los Angeles	060374002	33.82376	-118.189	UNKNOWN	SUBURBAN	RESIDENTIAL		11	6	6	1	3
Los Angeles	060375001	33.92288	-118.37	UNKNOWN	URBAN AND CENTER CITY	COMMERCIAL		9		21	10	3
Los Angeles	060375005	33.9508	-118.43	UPWIND BACKGROUND	SUBURBAN	RESIDENTIAL	NEIGHBORHOOD	2	4	21	149	3
Los Angeles	060376002	34.3875	-118.534	POPULATION EXPOSURE	SUBURBAN	COMMERCIAL	MIDDLE SCALE	2		375	2	3
Los Angeles	060376012	34.38344	-118.528	UNKNOWN	SUBURBAN	COMMERCIAL		5		397	143	3
Los Angeles	060379002	34.69	-118.132	UNKNOWN	URBAN AND CENTER CITY	COMMERCIAL	MIDDLE SCALE	6	5	725	61	3
Los Angeles	060379033	34.67139	-118.131	UNKNOWN	URBAN AND CENTER CITY	COMMERCIAL	MIDDLE SCALE	5	3	725	146	3
Los Angeles	060590001	33.83062	-117.938	POPULATION EXPOSURE	SUBURBAN	RESIDENTIAL	URBAN SCALE	5	5	45	225	3
Los Angeles	060590007	33.83062	-117.938	POPULATION EXPOSURE	SUBURBAN	RESIDENTIAL	URBAN SCALE	4	4	10	225	3

Table A-7. Attributes of location-specific ambient monitors used for air quality characterization and the distance to nearest major roadway.

Location	Monitor ID	Latitude	Longitude	Objective[1]	Setting[2]	Land Use[3]	Scale[4]	Monitor[5] Years	Monitor[5] Ht (m)	Monitor[5] Elev (m)	Roadway[6] Dist (m)	Roadway[6] Type
Los Angeles	060591003	33.67464	-117.926	UNKNOWN	SUBURBAN	RESIDENTIAL	MIDDLE SCALE	12	6	0	202	3
Los Angeles	060595001	33.92513	-117.953	UNKNOWN	SUBURBAN	RESIDENTIAL		11	82	82	570	3
Los Angeles	060650012	33.92086	-116.858	POPULATION EXPOSURE	SUBURBAN	COMMERCIAL	NEIGHBORHOOD	9	4	677	432	1
Los Angeles	060655001	33.85275	-116.541	UNKNOWN	SUBURBAN	RESIDENTIAL		12	6	171	75	3
Los Angeles	060658001	33.99958	-117.416	UNKNOWN	SUBURBAN	RESIDENTIAL		12	4	250	133	3
Los Angeles	060659001	33.67649	-117.331	UNKNOWN	SUBURBAN	RESIDENTIAL	MIDDLE SCALE	12		1440	522	4
Los Angeles	060710001	34.895	-117.024	UNKNOWN	URBAN AND CENTER CITY	COMMERCIAL		12	8	690	64	3
Los Angeles	060710012	34.42611	-117.563	UNKNOWN	RURAL	COMMERCIAL		2		4100	30	3
Los Angeles	060710014	34.5125	-117.33	UNKNOWN	SUBURBAN	RESIDENTIAL		5	4	876	18	3
Los Angeles	060710015	35.775	-117.367	UNKNOWN	SUBURBAN	INDUSTRIAL		2		498	42	3
Los Angeles	060710017	34.14194	-116.055	UNKNOWN	URBAN AND CENTER CITY	MOBILE		3	4	607	64	3
Los Angeles	060710306	34.51	-117.331	UNKNOWN	SUBURBAN	RESIDENTIAL		7	4	913	38	3
Los Angeles	060711004	34.10374	-117.629	POPULATION EXPOSURE	URBAN AND CENTER CITY	RESIDENTIAL	NEIGHBORHOOD	11	6	369	349	2
Los Angeles	060711234	35.76389	-117.396	OTHER	RURAL	DESERT		9	1	545	1000	
Los Angeles	060712002	34.10002	-117.492	UNKNOWN	SUBURBAN	INDUSTRIAL		12	5	381	81	3
Los Angeles	060714001	34.41806	-117.285	UNKNOWN	SUBURBAN	RESIDENTIAL		3		1006	111	3
Los Angeles	060719004	34.10688	-117.274	HIGHEST CONCENTRATION	SUBURBAN	COMMERCIAL	URBAN SCALE	12	5	0	169	3
Los Angeles	061110005	34.38694	-119.416	POPULATION EXPOSURE	RURAL	AGRICULTURAL		7	1	320	63	3
Los Angeles	061110007	34.21	-118.869	UNKNOWN	SUBURBAN	RESIDENTIAL	NEIGHBORHOOD	9	5	244	89	3
Los Angeles	061111003	34.44667	-119.27	UNKNOWN	SUBURBAN	MOBILE	NEIGHBORHOOD	1		231	18	2
Los Angeles	061111004	34.44833	-119.23	POPULATION EXPOSURE	SUBURBAN	RESIDENTIAL	URBAN SCALE	7	4	262	56	3
Los Angeles	061112002	34.2775	-118.685	HIGHEST CONCENTRATION	SUBURBAN	RESIDENTIAL	URBAN SCALE	12	4	314	471	1
Los Angeles	061112003	34.2804	-119.314	GENERAL/BACKGR OUND	SUBURBAN	RESIDENTIAL	MIDDLE SCALE	9	2	3	90	1
Los Angeles	061113001	34.255	-119.143	POPULATION EXPOSURE	RURAL	RESIDENTIAL	URBAN SCALE	12	4	43	307	3
Miami	120110003	26.28111	-80.2828	HIGHEST CONCENTRATION	RURAL	INDUSTRIAL	NEIGHBORHOOD	3	6	3	22	3
Miami	120110031	26.272	-80.295	HIGHEST CONCENTRATION	SUBURBAN	RESIDENTIAL	URBAN SCALE	8	4	3	103	4
Miami	120118002	26.087	-80.111	POPULATION EXPOSURE	SUBURBAN	RESIDENTIAL	URBAN SCALE	11	4	3	1000	
Miami	120860027	25.733	-80.162	POPULATION EXPOSURE	SUBURBAN	RESIDENTIAL	NEIGHBORHOOD	11	16	2	15	3
Miami	120864002	25.79833	-80.2103	HIGHEST	URBAN AND	COMMERCIAL	NEIGHBORHOOD	11	4	5	87	3

Table A-7. Attributes of location-specific ambient monitors used for air quality characterization and the distance to nearest major roadway.

Location	Monitor ID	Latitude	Longitude	Objective[1]	Setting[2]	Land Use[3]	Scale[4]	Monitor[5]			Roadway[6]	
								Years	Ht (m)	Elev (m)	Dist (m)	Type
				CONCENTRATION	CENTER CITY							
New York	090010113	41.18361	-73.1903	HIGHEST CONCENTRATION	URBAN AND CENTER CITY	COMMERCIAL	NEIGHBORHOOD	3	4	3	8	3
New York	090019003	41.11833	-73.3367	POPULATION EXPOSURE	RURAL	FOREST	NEIGHBORHOOD	8	5	4	508	4
New York	090090027	41.30111	-72.9028	POPULATION EXPOSURE	URBAN AND CENTER CITY	COMMERCIAL	NEIGHBORHOOD	2	3.67	11	237	1
New York	090091123	41.31083	-72.9169	UNKNOWN	URBAN AND CENTER CITY	RESIDENTIAL		9	5	18	14	2
New York	340030001	40.80833	-73.9928	UNKNOWN	SUBURBAN	RESIDENTIAL		3	4	61	82	3
New York	340030005	40.89858	-74.0299	POPULATION EXPOSURE	SUBURBAN	RESIDENTIAL	NEIGHBORHOOD	4	3	6	172	5
New York	340130011	40.72667	-74.1442	UNKNOWN	URBAN AND CENTER CITY	INDUSTRIAL		5	4	3	232	1
New York	340130016	40.72222	-74.1469	POPULATION EXPOSURE	URBAN AND CENTER CITY	INDUSTRIAL	NEIGHBORHOOD	1	5	3	6	1
New York	340131003	40.7575	-74.2005	HIGHEST CONCENTRATION	URBAN AND CENTER CITY	COMMERCIAL	NEIGHBORHOOD	11	4	48.45	25	3
New York	340170006	40.67025	-74.1261	POPULATION EXPOSURE	URBAN AND CENTER CITY	COMMERCIAL	URBAN SCALE	11	5	3	266	3
New York	340210005	40.28319	-74.7422	POPULATION EXPOSURE	SUBURBAN	RESIDENTIAL	NEIGHBORHOOD	11	4	30	442	1
New York	340230011	40.46218	-74.4294	POPULATION EXPOSURE	RURAL	AGRICULTURAL	NEIGHBORHOOD	11	4	21	298	3
New York	340273001	40.78763	-74.6763	UNKNOWN	RURAL	AGRICULTURAL		11	5	274	227	3
New York	340390004	40.64144	-74.2084	HIGHEST CONCENTRATION	SUBURBAN	INDUSTRIAL	NEIGHBORHOOD	11	4	5.4	37	4
New York	340390008	40.60083	-74.4419	POPULATION EXPOSURE	SUBURBAN	RESIDENTIAL	NEIGHBORHOOD	3	4	0	99	3
New York	360050080	40.83608	-73.9202	HIGHEST CONCENTRATION	URBAN AND CENTER CITY	RESIDENTIAL	NEIGHBORHOOD	5	15	15	122	3
New York	360050083	40.86586	-73.8808	UNKNOWN	URBAN AND CENTER CITY	COMMERCIAL		12	15	24	132	5
New York	360050110	40.81616	-73.9021	UNKNOWN	URBAN AND CENTER CITY	RESIDENTIAL		6		0	76	3
New York	360470011	40.73277	-73.9472	HIGHEST CONCENTRATION	URBAN AND CENTER CITY	INDUSTRIAL	NEIGHBORHOOD	1	13	9	171	3
New York	360590005	40.74316	-73.5855	HIGHEST CONCENTRATION	SUBURBAN	COMMERCIAL	NEIGHBORHOOD	11	5	27	32	3
New York	360610010	40.73944	-73.9861	HIGHEST CONCENTRATION	URBAN AND CENTER CITY	RESIDENTIAL	NEIGHBORHOOD	4	38	38	55	3
New York	360610056	40.75917	-73.9665	HIGHEST CONCENTRATION	URBAN AND CENTER CITY	COMMERCIAL	MIDDLE SCALE	10	10	15	62	3
New York	360810097	40.75527	-73.7586	GENERAL/BACKGR OUND	URBAN AND CENTER CITY	RESIDENTIAL		3	12	0	197	3
New York	360810098	40.7842	-73.8476	UNKNOWN	URBAN AND CENTER CITY	RESIDENTIAL		7	8	6	9	3

Table A-7. Attributes of location-specific ambient monitors used for air quality characterization and the distance to nearest major roadway.

Location	Monitor ID	Latitude	Longitude	Objective[1]	Setting[2]	Land Use[3]	Scale[4]	Monitor[5] Years	Monitor[5] Ht (m)	Monitor[5] Elev (m)	Roadway[6] Dist (m)	Roadway[6] Type
New York	360810124	40.7362	-73.8232	POPULATION EXPOSURE	SUBURBAN	RESIDENTIAL		5		8	150	3
New York	361030009	40.8275	-73.0569	UNKNOWN	SUBURBAN	RESIDENTIAL		6		0	116	2
Philadelphia	100031003	39.76111	-75.4919	POPULATION EXPOSURE	SUBURBAN	RESIDENTIAL		5		65	189	2
Philadelphia	100031007	39.55111	-75.7308	OTHER	RURAL	AGRICULTURAL		1		20	144	3
Philadelphia	100032004	39.73944	-75.5581	UNKNOWN	URBAN AND CENTER CITY	COMMERCIAL		4		0	82	3
Philadelphia	340070003	39.92304	-75.0976	POPULATION EXPOSURE	SUBURBAN	RESIDENTIAL	NEIGHBORHOOD	10	5	7.6	405	3
Philadelphia	420170012	40.10722	-74.8822	POPULATION EXPOSURE	SUBURBAN	RESIDENTIAL	NEIGHBORHOOD	12	2	12	393	3
Philadelphia	420450002	39.83556	-75.3725	POPULATION EXPOSURE	URBAN AND CENTER CITY	INDUSTRIAL	NEIGHBORHOOD	12	2	3	413	3
Philadelphia	420910013	40.11222	-75.3092	POPULATION EXPOSURE	SUBURBAN	RESIDENTIAL	NEIGHBORHOOD	11	4	53	630	1
Philadelphia	421010004	40.00889	-75.0978	POPULATION EXPOSURE	URBAN AND CENTER CITY	RESIDENTIAL	URBAN SCALE	11	7	22	45	3
Philadelphia	421010029	39.95722	-75.1731	HIGHEST CONCENTRATION	URBAN AND CENTER CITY	COMMERCIAL	NEIGHBORHOOD	10	11	25	103	3
Philadelphia	421010047	39.94472	-75.1661	POPULATION EXPOSURE	URBAN AND CENTER CITY	RESIDENTIAL	NEIGHBORHOOD	9	11	21	66	2
Phoenix	040130019	33.48385	-112.143	POPULATION EXPOSURE	SUBURBAN	RESIDENTIAL	NEIGHBORHOOD	10	4.3	333	401	3
Phoenix	040133002	33.45793	-112.046	HIGHEST CONCENTRATION	URBAN AND CENTER CITY	RESIDENTIAL	NEIGHBORHOOD	12	11.3	339	141	3
Phoenix	040133003	33.47968	-111.917	POPULATION EXPOSURE	SUBURBAN	RESIDENTIAL	URBAN SCALE	10	5.8	368	78	3
Phoenix	040133010	33.46093	-112.117	POPULATION EXPOSURE	SUBURBAN	RESIDENTIAL	MIDDLE SCALE	9	4.2	325	7	3
Phoenix	040134005	33.4124	-111.935	UNKNOWN	URBAN AND CENTER CITY	RESIDENTIAL		1	4	352	259	3
Phoenix	040134011	33.37005	-112.621	SOURCE ORIENTED	RURAL	AGRICULTURAL	URBAN SCALE	2	4	258	12	3
Phoenix	040139997	33.50364	-112.095	POPULATION EXPOSURE	URBAN AND CENTER CITY	RESIDENTIAL		5		346	433	3
Provo	490490002	40.25361	-111.663	UNKNOWN	URBAN AND CENTER CITY	COMMERCIAL		12	4	1402	353	2
St. Louis	171630010	38.61203	-90.1605	POPULATION EXPOSURE	SUBURBAN	INDUSTRIAL	NEIGHBORHOOD	12	4	125	18	4
St. Louis	291830010	38.57917	-90.8411	UNKNOWN	RURAL	AGRICULTURAL		3	3	0	340	3
St. Louis	291831002	38.8725	-90.2264	POPULATION EXPOSURE	RURAL	AGRICULTURAL	URBAN SCALE	12	4	131	31	3
St. Louis	291890001	38.52167	-90.3436	UNKNOWN	SUBURBAN	RESIDENTIAL		3	4	183	161	2
St. Louis	291890004	38.5325	-90.3828	UNKNOWN	SUBURBAN	RESIDENTIAL		6	4	183	95	2
St. Louis	291890006	38.61361	-90.4958	UNKNOWN	RURAL	RESIDENTIAL		11	4	175	97	3
St. Louis	291893001	38.64139	-90.3458	UNKNOWN	SUBURBAN	COMMERCIAL		11	4	161	5	1

Table A-7. Attributes of location-specific ambient monitors used for air quality characterization and the distance to nearest major roadway.

Location	Monitor ID	Latitude	Longitude	Objective[1]	Setting[2]	Land Use[3]	Scale[4]	Monitor[5]			Roadway[6]	
								Years	Ht (m)	Elev (m)	Dist (m)	Type
St. Louis	291895001	38.76611	-90.2858	UNKNOWN	SUBURBAN	COMMERCIAL		10	2	168	421	3
St. Louis	291897002	38.72722	-90.3794	UNKNOWN	SUBURBAN	RESIDENTIAL		6	4	168	59	3
St. Louis	291897003	38.72092	-90.367	HIGHEST CONCENTRATION	SUBURBAN	RESIDENTIAL	NEIGHBORHOOD	4	4	0	112	3
St. Louis	295100072	38.62422	-90.1987	UNKNOWN	URBAN AND CENTER CITY	COMMERCIAL		10	14	154	43	4
St. Louis	295100080	38.68283	-90.2468	HIGHEST CONCENTRATION	URBAN AND CENTER CITY	RESIDENTIAL	NEIGHBORHOOD	5	4	152	116	3
St. Louis	295100086	38.67227	-90.239	HIGHEST CONCENTRATION	URBAN AND CENTER CITY	RESIDENTIAL	NEIGHBORHOOD	6	4	0	133	3
Washington DC	110010017	38.90361	-77.0517	HIGHEST CONCENTRATION	URBAN AND CENTER CITY	COMMERCIAL	NEIGHBORHOOD	1	10	20	54	3
Washington DC	110010025	38.97528	-77.0228	POPULATION EXPOSURE	URBAN AND CENTER CITY	COMMERCIAL	URBAN SCALE	12	11	91	106	3
Washington DC	110010041	38.89722	-76.9528	UNKNOWN	URBAN AND CENTER CITY	RESIDENTIAL	NEIGHBORHOOD	12		8	141	4
Washington DC	110010043	38.91889	-77.0125	HIGHEST CONCENTRATION	URBAN AND CENTER CITY	COMMERCIAL	URBAN SCALE	12		50	278	3
Washington DC	240053001	39.31083	-76.4744	MAX PRECURSOR EMISSIONS IMPACT	SUBURBAN	RESIDENTIAL	NEIGHBORHOOD	8	4.6	5	186	3
Washington DC	245100040	39.29806	-76.6047	HIGHEST CONCENTRATION	URBAN AND CENTER CITY	RESIDENTIAL	NEIGHBORHOOD	11	4.2	12	14	3
Washington DC	245100050	39.31861	-76.5825	POPULATION EXPOSURE	URBAN AND CENTER CITY	RESIDENTIAL	REGIONAL SCALE	1	4	49	338	2
Washington DC	510130020	38.8575	-77.0592	UNKNOWN	URBAN AND CENTER CITY	COMMERCIAL		12	7	171	80	3
Washington DC	510590005	38.89389	-77.4653	POPULATION EXPOSURE	RURAL	AGRICULTURAL	NEIGHBORHOOD	11	4	77	315	5
Washington DC	510590018	38.7425	-77.0775	UNKNOWN	SUBURBAN	RESIDENTIAL		3	4	11	54	3
Washington DC	510591004	38.86806	-77.1431	UNKNOWN	SUBURBAN	COMMERCIAL		6	11	110	84	5
Washington DC	510591005	38.83752	-77.1632	POPULATION EXPOSURE	SUBURBAN	RESIDENTIAL		4		83.9	50	3
Washington DC	510595001	38.93194	-77.1989	POPULATION EXPOSURE	SUBURBAN	RESIDENTIAL	NEIGHBORHOOD	10	4	106	18	5
Washington DC	511071005	39.02444	-77.49	POPULATION EXPOSURE	SUBURBAN	RESIDENTIAL	NEIGHBORHOOD	8	4	0	75	3
Washington DC	511530009	38.85528	-77.6356	POPULATION EXPOSURE	SUBURBAN	RESIDENTIAL	URBAN SCALE	12	4	111	196	2
Washington DC	515100009	38.81083	-77.0447	UNKNOWN	URBAN AND CENTER CITY	RESIDENTIAL		12	11	23	83	3

Notes:

[1] Objective indicates the reason for measuring air quality by the monitor. Sites located to determine the highest concentration expected to occur in the area covered by the network (Highest Concentration), sites located to measure typical concentrations in areas of high population (Population Exposure), sites located to determine the impact of significant sources or source categories on air quality (Source Oriented), sites located to determine general background concentration levels (General Background), sites located to determine the extent of regional pollutant transport among populated areas and in support of secondary standards (Regional Transport), sites located to measure air pollution impacts on visibility, vegetation damage, or other welfare-based impacts (Welfare Related Impacts), sites are established to characterize upwind background and transported ozone and its precursor concentrations entering the area and will identify those areas which are subjected to transport (Upwind Background), sites are established to monitor the magnitude and type of precursor emissions in the area where maximum precursor emissions are expected to impact and are suited for the

Table A-7. Attributes of location-specific ambient monitors used for air quality characterization and the distance to nearest major roadway.

Location	Monitor ID	Latitude	Longitude	Objective[1]	Setting[2]	Land Use[3]	Scale[4]	Monitor[5]			Roadway[6]	
								Years	Ht (m)	Elev (m)	Dist (m)	Type

monitoring of urban air toxic pollutants (Max. Precursor Impact), sites are intended to monitor maximum ozone concentrations occurring downwind from the area of maximum precursor emissions (Max. Ozone Concentration), and sites are established to characterize the downwind transported ozone and its precursor concentrations exiting the area and will identify those areas which are potentially contributing to overwhelming transport in other areas (Extreme Downwind).

[2] Setting is the description of the environmental setting within which the site is located

[3] Land use indicates the prevalent land use within 1/4 mile of that site.

[4] Scale indicates what the data from a monitor can represent in terms of air volumes associated with area dimensions. Micro - 0 to 100 meters; Middle - 100 to 500 meters; Neighborhood - 500 meters to 4 kilometers; Urban Scale - 4 to 50 kilometers; Regional Scale - 50 kilometers up to 1000km.

[5] Years is the number of valid site-years available for the monitor. Monitor probe height (Ht) and site elevation (Elev) above sea level are given in meters (m).

[6] Distances (Dist) to nearest major roadway are given in meters (m). Major road types were defined as: 1=primary limited access or interstate, 2=primary US and State highways, 3=Secondary State and County, 4=freeway ramp, 5=other ramps.

Table A-8. Distance of location-specific ambient monitors to stationary sources emitting >5 tons of NO_x per year, within a 10 kilometer distance of monitoring site.

			Distance (km) to Source emissions >5 tpy and within 10 km							Emissions (tpy) of Sources within 10 km and >5 tpy						
Location	**ID**	**n[1]**	**mean**	**std**	**min**	**2.5**	**50**	**97.5**	**max**	**mean**	**std**	**min**	**2.5**	**50**	**97.5**	**max**
Atlanta	130890002	1	4.9		4.9	4.9	4.9	4.9	4.9	34		34	34	34	34	34
Atlanta	130893001	3	7.2	4.0	2.7	2.7	9.2	9.8	9.8	34	2	32	32	34	36	36
Atlanta	131210048	5	6.4	3.3	0.7	0.7	7.3	8.9	8.9	1249	2106	22	22	39	4895	4895
Atlanta	132230003	0														
Atlanta	132470001	0														
Boston	230313002	5	3.5	1.5	1.0	1.0	3.8	4.9	4.9	642	769	31	31	203	1860	1860
Boston	250051005	3	6.7	1.6	5.5	5.5	6.0	8.5	8.5	9	4	5	5	8	14	14
Boston	250092006	12	6.8	2.7	2.5	2.5	7.4	9.9	9.9	439	1083	5	5	21	3794	3794
Boston	250094004	0														
Boston	250095005	10	5.8	2.3	1.7	1.7	6.7	8.6	8.6	201	347	6	6	29	923	923
Boston	250210009	57	5.8	2.5	1.0	1.8	5.9	9.9	9.9	106	283	5	5	9	1155	1419
Boston	250250002	62	4.6	2.4	0.6	1.1	4.3	9.4	9.7	98	273	5	5	9	1155	1419
Boston	250250021	55	6.1	2.3	1.5	1.7	6.5	9.8	9.8	130	304	5	5	11	1155	1419
Boston	250250035	62	5.1	2.6	0.3	0.8	5.1	9.0	9.6	99	273	5	5	9	1155	1419
Boston	250250036	62	5.1	2.6	0.3	0.8	5.1	9.0	9.6	99	273	5	5	9	1155	1419
Boston	250250040	56	5.3	2.4	0.4	0.9	5.6	9.0	9.3	106	286	5	5	9	1155	1419
Boston	250250041	25	7.8	2.0	0.7	0.7	8.2	9.9	9.9	81	206	5	5	11	957	957
Boston	250250042	65	5.3	2.8	0.7	1.0	4.9	10.0	10.0	94	267	5	5	9	1155	1419
Boston	250251003	49	6.4	2.4	0.6	1.0	7.0	9.6	9.6	145	319	5	5	11	1155	1419
Boston	250270020	28	3.7	2.5	0.1	0.1	2.9	8.6	8.6	58	165	5	5	13	868	868
Boston	250270023	28	3.6	2.4	0.4	0.4	3.0	8.4	8.4	58	165	5	5	13	868	868
Boston	330110016	0														
Boston	330110019	0														
Boston	330110020	0														
Boston	330150009	5	3.3	1.0	2.0	2.0	3.3	4.4	4.4	642	769	31	31	203	1860	1860
Boston	330150013	1	8.4		8.4	8.4	8.4	8.4	8.4	29		29	29	29	29	29
Boston	330150014	5	4.0	1.8	1.0	1.0	4.4	5.5	5.5	642	769	31	31	203	1860	1860
Boston	330150015	5	3.1	0.9	1.9	1.9	3.0	4.1	4.1	642	769	31	31	203	1860	1860
Chicago	170310037	17	5.6	2.7	0.7	0.7	5.7	9.5	9.5	18	31	5	5	7	126	126
Chicago	170310063	57	4.9	3.2	0.4	0.5	4.9	9.4	10.0	110	416	5	5	9	1677	2465
Chicago	170310064	33	6.9	2.5	1.2	1.2	6.9	10.0	10.0	94	428	5	5	10	2465	2465
Chicago	170310075	31	7.3	2.7	0.8	0.8	8.4	9.9	9.9	10	7	5	5	7	36	36
Chicago	170310076	46	7.8	2.3	1.3	1.6	8.4	9.8	9.9	170	463	5	5	10	1677	2204
Chicago	170313101	30	6.6	2.2	2.7	2.7	7.2	9.7	9.7	313	1638	5	5	9	8985	8985
Chicago	170313103	30	6.6	2.2	2.7	2.7	7.2	9.7	9.7	313	1638	5	5	9	8985	8985
Chicago	170314002	63	6.7	2.6	0.5	0.5	7.2	9.8	9.9	122	407	5	5	9	1677	2465
Chicago	170314201	7	6.5	1.5	4.0	4.0	6.6	9.0	9.0	8	3	5	5	8	14	14
Chicago	170318003	63	7.3	2.0	1.7	2.3	8.0	9.6	9.7	361	1201	5	5	18	6216	7141
Chicago	171971011	1	4.0		4.0	4.0	4.0	4.0	4.0	20		20	20	20	20	20
Chicago	180890022	8	5.1	3.8	0.8	0.8	4.1	9.4	9.4	815	1680	8	8	243	4936	4936

Table A-8. Distance of location-specific ambient monitors to stationary sources emitting >5 tons of NO_x per year, within a 10 kilometer distance of monitoring site.

Location	ID	n[1]	Distance (km) to Source emissions >5 tpy and within 10 km							Emissions (tpy) of Sources within 10 km and >5 tpy						
			mean	std	min	2.5	50	97.5	max	mean	std	min	2.5	50	97.5	max
Chicago	180891016	8	4.7	2.4	2.1	2.1	4.1	7.6	7.6	815	1680	8	8	243	4936	4936
Cleveland	390350043	5	8.1	1.9	5.2	5.2	8.3	9.9	9.9	673	664	126	126	284	1476	1476
Cleveland	390350060	4	4.1	2.4	1.0	1.0	4.4	6.4	6.4	810	681	165	165	800	1476	1476
Cleveland	390350066	5	8.0	1.9	5.2	5.2	8.3	9.8	9.8	673	664	126	126	284	1476	1476
Cleveland	390350070	5	7.6	1.8	5.5	5.5	7.3	9.7	9.7	673	664	126	126	284	1476	1476
Colorado Springs	080416001	4	5.1	4.4	0.8	0.8	5.1	9.1	9.1	780	1374	16	16	133	2835	2835
Colorado Springs	080416004	10	5.9	2.2	3.5	3.5	5.6	9.8	9.8	48	80	5	5	17	267	267
Colorado Springs	080416005	9	7.5	2.1	3.3	3.3	8.1	9.5	9.5	490	1393	5	5	11	4205	4205
Colorado Springs	080416006	0														
Colorado Springs	080416009	4	5.2	4.3	1.0	1.0	5.3	9.3	9.3	780	1374	16	16	133	2835	2835
Colorado Springs	080416011	14	5.0	2.3	2.0	2.0	5.8	9.6	9.6	345	1113	5	5	22	4205	4205
Colorado Springs	080416013	14	6.3	2.9	2.1	2.1	6.9	9.9	9.9	346	1113	5	5	27	4205	4205
Colorado Springs	080416018	11	6.9	1.7	4.3	4.3	7.1	9.6	9.6	430	1254	5	5	34	4205	4205
Denver	080013001	34	5.3	1.8	1.6	1.6	4.7	9.5	9.5	310	1622	5	5	15	9483	9483
Denver	080050003	19	6.7	3.7	1.0	1.0	9.1	10.0	10.0	313	1233	5	5	17	5404	5404
Denver	080310002	52	5.3	2.5	0.9	0.9	5.8	9.7	9.8	319	1495	5	5	14	5404	9483
Denver	080590006	9	5.9	2.1	2.7	2.7	6.3	8.6	8.6	63	66	11	11	39	182	182
Denver	080590008	9	6.2	2.0	3.7	3.7	6.1	10.0	10.0	59	68	8	8	13	182	182
Denver	080590009	10	6.5	3.2	2.5	2.5	7.0	9.9	9.9	53	66	6	6	13	182	182
Denver	080590010	7	5.5	3.1	1.1	1.1	5.6	9.2	9.2	73	71	12	12	44	182	182
Detroit	260990009	4	4.9	3.2	0.3	0.3	5.7	7.7	7.7	63	70	7	7	46	152	152
Detroit	261630016	51	7.4	2.1	1.3	2.0	7.9	9.8	9.9	387	797	5	6	41	3087	3762
Detroit	261630019	32	6.3	2.2	2.6	2.6	6.5	10.0	10.0	57	168	5	5	12	837	837
El Paso	481410027	22	8.1	1.6	1.5	1.5	8.6	9.3	9.3	99	195	5	5	29	912	912
El Paso	481410028	24	2.2	1.9	0.9	0.9	1.6	9.3	9.3	127	338	5	5	32	1679	1679
El Paso	481410037	15	8.7	2.6	0.1	0.1	9.4	10.0	10.0	135	230	5	5	38	912	912
El Paso	481410044	25	5.9	1.2	4.4	4.4	5.6	9.5	9.5	158	366	5	5	32	1679	1679
El Paso	481410055	24	2.8	1.8	1.6	1.6	2.2	9.6	9.6	127	338	5	5	32	1679	1679
El Paso	481410057	0														
El Paso	481410058	16	8.8	0.4	8.4	8.4	8.6	9.5	9.5	31	30	5	5	23	106	106
Jacksonville	120310032	20	5.1	3.0	0.7	0.7	5.7	9.6	9.6	201	407	5	5	31	1642	1642
Las Vegas	320030022	7	4.6	0.9	3.8	3.8	3.9	5.6	5.6	175	222	30	30	77	650	650
Las Vegas	320030023	0														
Las Vegas	320030073	0														
Las Vegas	320030078	0														
Las Vegas	320030539	5	6.9	1.2	4.7	4.7	7.2	7.9	7.9	816	760	18	18	851	1665	1665
Las Vegas	320030557	4	9.1	1.2	7.3	7.3	9.7	9.7	9.7	807	877	18	18	772	1665	1665
Las Vegas	320030563	1	7.6		7.6	7.6	7.6	7.6	7.6	84		84	84	84	84	84
Las Vegas	320030601	0														
Las Vegas	320031019	0														
Las Vegas	320032002	1	9.9		9.9	9.9	9.9	9.9	9.9	84		84	84	84	84	84
Los Angeles	060370002	7	3.1	1.1	1.6	1.6	2.9	4.5	4.5	10	4	5	5	9	16	16

Table A-8. Distance of location-specific ambient monitors to stationary sources emitting >5 tons of NO_x per year, within a 10 kilometer distance of monitoring site.

Location	ID	n[1]	Distance (km) to Source emissions >5 tpy and within 10 km							Emissions (tpy) of Sources within 10 km and >5 tpy						
			mean	std	min	2.5	50	97.5	max	mean	std	min	2.5	50	97.5	max
Los Angeles	060370016	7	7.5	1.8	4.5	4.5	8.5	8.9	8.9	12	8	5	5	9	29	29
Los Angeles	060370030	35	5.5	2.3	2.1	2.1	5.2	9.8	9.8	23	27	5	5	11	115	115
Los Angeles	060370113	7	4.3	3.1	1.3	1.3	3.2	9.8	9.8	15	10	5	5	13	36	36
Los Angeles	060370206	11	5.6	2.2	2.3	2.3	5.8	9.2	9.2	32	31	6	6	20	109	109
Los Angeles	060371002	18	5.7	2.6	0.1	0.1	6.0	9.9	9.9	47	59	6	6	24	215	215
Los Angeles	060371103	31	6.5	2.7	1.8	1.8	7.2	10.0	10.0	18	21	5	5	10	86	86
Los Angeles	060371201	7	5.1	1.2	3.3	3.3	5.5	6.5	6.5	10	4	6	6	10	15	15
Los Angeles	060371301	45	6.8	2.1	1.2	2.5	7.1	9.7	10.0	22	24	5	5	12	86	115
Los Angeles	060371601	22	6.5	2.3	2.3	2.3	7.2	9.7	9.7	28	33	5	5	12	115	115
Los Angeles	060371701	13	6.1	3.0	1.1	1.1	7.0	9.7	9.7	22	20	5	5	16	70	70
Los Angeles	060372005	10	5.2	3.5	0.2	0.2	5.5	10.0	10.0	12	8	5	5	9	30	30
Los Angeles	060374002	55	6.4	2.3	1.7	2.2	6.2	9.9	9.9	76	159	5	5	16	744	789
Los Angeles	060375001	32	5.1	2.4	0.3	0.3	4.8	9.6	9.6	205	754	6	6	21	4256	4256
Los Angeles	060375005	25	4.6	2.4	1.4	1.4	4.6	9.9	9.9	224	850	6	6	21	4256	4256
Los Angeles	060376002	5	5.6	1.8	3.6	3.6	5.8	7.8	7.8	29	20	8	8	18	54	54
Los Angeles	060376012	6	6.2	2.5	3.0	3.0	6.8	9.7	9.7	26	19	8	8	18	54	54
Los Angeles	060379002	4	7.8	1.0	6.8	6.8	7.7	9.2	9.2	22	28	6	6	9	64	64
Los Angeles	060379033	4	6.3	0.8	5.3	5.3	6.4	7.1	7.1	22	28	6	6	9	64	64
Los Angeles	060590001	17	6.4	2.4	2.8	2.8	7.2	9.4	9.4	14	12	5	5	8	46	46
Los Angeles	060590007	17	6.4	2.4	2.8	2.8	7.2	9.4	9.4	14	12	5	5	8	46	46
Los Angeles	060591003	14	6.1	2.2	2.1	2.1	6.0	9.3	9.3	65	116	5	5	10	434	434
Los Angeles	060595001	16	7.9	1.6	3.4	3.4	8.2	9.5	9.5	19	26	6	6	9	109	109
Los Angeles	060650012	0														
Los Angeles	060655001	0														
Los Angeles	060658001	12	7.4	2.2	3.6	3.6	7.4	9.8	9.8	119	358	5	5	10	1254	1254
Los Angeles	060659001	2	4.6	5.9	0.4	0.4	4.6	8.7	8.7	11	9	5	5	11	17	17
Los Angeles	060710001	3	6.9	1.9	5.3	5.3	6.5	9.0	9.0	209	321	10	10	38	579	579
Los Angeles	060710012	0														
Los Angeles	060710014	3	6.0	2.6	3.5	3.5	5.9	8.6	8.6	199	327	6	6	15	577	577
Los Angeles	060710015	3	4.4	4.6	1.7	1.7	1.8	9.7	9.7	752	1045	12	12	296	1948	1948
Los Angeles	060710017	0														
Los Angeles	060710306	3	6.1	2.6	3.6	3.6	5.7	8.9	8.9	199	327	6	6	15	577	577
Los Angeles	060711004	19	7.3	1.7	4.3	4.3	7.4	9.8	9.8	57	120	5	5	18	492	492
Los Angeles	060711234	2	1.6	0.4	1.3	1.3	1.6	1.9	1.9	1122	1168	296	296	1122	1948	1948
Los Angeles	060712002	20	5.7	2.2	2.0	2.0	5.8	9.6	9.6	44	65	5	5	17	250	250
Los Angeles	060714001	1	6.5		6.5	6.5	6.5	6.5	6.5	577		577	577	577	577	577
Los Angeles	060719004	8	5.8	2.5	1.5	1.5	5.7	9.0	9.0	171	438	5	5	10	1254	1254
Los Angeles	061110005	5	6.9	2.5	3.1	3.1	7.7	9.6	9.6	68	118	8	8	19	278	278
Los Angeles	061110007	20	4.7	2.2	1.7	1.7	4.2	9.3	9.3	25	20	5	5	18	76	76
Los Angeles	061111003	0														
Los Angeles	061111004	0														
Los Angeles	061112002	4	6.6	1.0	5.2	5.2	6.8	7.5	7.5	63	113	5	5	7	232	232

Table A-8. Distance of location-specific ambient monitors to stationary sources emitting >5 tons of NO_x per year, within a 10 kilometer distance of monitoring site.

Location	ID	n[1]	Distance (km) to Source emissions >5 tpy and within 10 km							Emissions (tpy) of Sources within 10 km and >5 tpy						
			mean	std	min	2.5	50	97.5	max	mean	std	min	2.5	50	97.5	max
Los Angeles	061112003	3	5.5	1.3	4.1	4.1	5.6	6.7	6.7	18	4	14	14	20	22	22
Los Angeles	061113001	7	5.1	2.3	1.9	1.9	5.9	7.4	7.4	35	51	5	5	13	146	146
Miami	120110003	0														
Miami	120110031	0														
Miami	120118002	0														
Miami	120860027	3	4.1	4.2	1.6	1.6	1.8	8.9	8.9	31	19	14	14	27	51	51
Miami	120864002	8	7.0	2.6	1.3	1.3	7.8	9.1	9.1	22	15	8	8	18	51	51
New York	090010113	7	4.4	3.1	1.4	1.4	3.4	8.8	8.8	538	711	48	48	192	1689	1689
New York	090019003	3	6.3	2.0	4.0	4.0	7.4	7.5	7.5	127	179	12	12	37	333	333
New York	090090027	5	2.7	1.0	1.3	1.3	2.7	3.9	3.9	280	484	14	14	86	1144	1144
New York	090091123	6	3.3	2.8	1.2	1.2	2.4	8.9	8.9	234	447	7	7	64	1144	1144
New York	340030001	48	6.5	2.2	2.9	2.9	6.3	9.8	9.9	468	1506	6	7	31	4440	9022
New York	340030005	18	6.8	2.9	0.1	0.1	7.4	10.0	10.0	53	79	6	6	21	307	307
New York	340130011	43	5.4	2.9	0.7	0.8	5.8	9.4	9.5	273	1372	5	5	18	640	9022
New York	340130016	44	5.5	2.8	0.1	1.0	6.3	9.4	9.6	267	1357	5	5	18	640	9022
New York	340131003	32	6.4	2.0	2.1	2.1	6.8	9.3	9.3	77	149	5	5	22	640	640
New York	340170006	42	6.9	2.5	1.1	1.6	7.7	9.5	9.5	369	1420	5	6	24	2213	9022
New York	340210005	8	5.4	1.7	3.2	3.2	5.5	7.3	7.3	115	244	8	8	32	718	718
New York	340230011	20	6.1	2.8	1.0	1.0	7.0	9.5	9.5	95	175	6	6	36	792	792
New York	340273001	1	8.5		8.5	8.5	8.5	8.5	8.5	20		20	20	20	20	20
New York	340390004	46	6.3	2.4	0.7	0.9	6.6	9.6	9.7	134	341	5	6	21	594	2213
New York	340390008	12	7.2	2.1	3.2	3.2	8.0	10.0	10.0	23	36	5	5	10	134	134
New York	360050080	54	6.4	2.3	1.8	1.8	6.4	9.9	9.9	241	776	6	6	29	3676	4440
New York	360050083	37	6.0	2.8	1.6	1.6	6.3	9.9	9.9	171	725	6	6	21	4440	4440
New York	360050110	55	5.9	2.2	2.1	2.6	5.7	9.6	9.9	236	769	6	6	29	3676	4440
New York	360470011	56	5.9	2.7	0.7	1.5	5.7	9.7	10.0	296	787	7	7	42	3676	4440
New York	360590005	7	6.3	3.4	1.9	1.9	8.1	9.8	9.8	372	500	7	7	223	1451	1451
New York	360610010	52	5.9	2.5	0.3	1.4	6.1	9.6	9.8	494	1453	5	7	50	4440	9022
New York	360610056	54	5.4	2.6	0.3	1.4	5.5	9.9	10.0	470	1429	7	7	50	4440	9022
New York	360810097	11	6.3	2.1	2.9	2.9	6.9	9.5	9.5	65	77	13	13	26	246	246
New York	360810098	48	7.1	2.3	1.6	2.8	7.8	9.8	9.8	262	820	6	7	31	3676	4440
New York	360810124	24	7.0	2.6	2.1	2.1	8.0	10.0	10.0	436	1136	8	8	26	4440	4440
New York	361030009	3	3.8	3.2	2.0	2.0	2.0	7.6	7.6	537	759	40	40	161	1410	1410
Philadelphia	100031003	39	5.5	2.5	1.6	1.6	6.2	9.7	9.7	282	481	5	5	62	2058	2058
Philadelphia	100031007	11	9.2	0.6	8.0	8.0	9.3	9.8	9.8	323	494	6	6	63	1351	1351
Philadelphia	100032004	32	4.8	1.9	0.7	0.7	4.7	8.4	8.4	223	403	5	5	45	1312	1312
Philadelphia	340070003	69	7.7	2.3	1.8	2.0	8.5	10.0	10.0	87	196	5	5	24	477	1478
Philadelphia	420170012	10	4.1	2.3	1.2	1.2	4.2	9.4	9.4	85	96	11	11	57	275	275
Philadelphia	420450002	30	4.8	2.6	0.2	0.2	5.4	9.5	9.5	504	1055	5	5	73	4968	4968
Philadelphia	420910013	12	5.1	2.5	1.4	1.4	4.3	8.8	8.8	89	232	5	5	12	823	823
Philadelphia	421010004	32	5.9	2.5	1.0	1.0	5.6	9.9	9.9	58	111	5	5	20	571	571
Philadelphia	421010029	74	5.7	2.1	1.1	1.8	5.6	9.7	9.7	74	148	5	5	19	477	1033

Table A-8. Distance of location-specific ambient monitors to stationary sources emitting >5 tons of NO_x per year, within a 10 kilometer distance of monitoring site.

			Distance (km) to Source emissions >5 tpy and within 10 km							Emissions (tpy) of Sources within 10 km and >5 tpy						
Location	**ID**	**n[1]**	**mean**	**std**	**min**	**2.5**	**50**	**97.5**	**max**	**mean**	**std**	**min**	**2.5**	**50**	**97.5**	**max**
Philadelphia	421010047	73	5.2	2.1	0.6	0.8	4.8	9.6	9.7	95	221	5	5	19	1033	1478
Phoenix	040130019	11	6.8	2.2	4.2	4.2	6.7	9.8	9.8	106	313	5	5	10	1049	1049
Phoenix	040133002	6	4.1	2.3	1.3	1.3	4.1	6.9	6.9	21	19	5	5	15	56	56
Phoenix	040133003	10	6.7	1.4	4.1	4.1	6.6	9.0	9.0	50	80	9	9	24	272	272
Phoenix	040133010	10	5.0	0.9	3.5	3.5	4.9	6.6	6.6	115	328	5	5	10	1049	1049
Phoenix	040134005	11	5.8	2.9	0.8	0.8	7.0	9.4	9.4	81	116	6	6	38	350	350
Phoenix	040134011	1	6.4		6.4	6.4	6.4	6.4	6.4	18		18	18	18	18	18
Phoenix	040139997	10	8.5	1.2	5.6	5.6	8.7	9.9	9.9	115	328	5	5	10	1049	1049
Provo	490490002	7	6.6	3.7	1.2	1.2	8.2	9.4	9.4	60	38	7	7	83	102	102
St Louis	171630010	48	7.0	2.8	1.3	1.9	8.0	9.8	9.9	112	178	5	5	17	538	848
St Louis	291830010	1	1.7		1.7	1.7	1.7	1.7	1.7	7821		7821	7821	7821	7821	7821
St Louis	291831002	9	7.5	2.1	4.3	4.3	7.7	9.9	9.9	1868	4704	7	7	8	14231	14231
St Louis	291890001	10	7.7	1.3	6.2	6.2	7.4	9.8	9.8	24	20	5	5	15	60	60
St Louis	291890004	6	8.9	1.5	6.9	6.9	9.8	10.0	10.0	38	37	7	7	28	105	105
St Louis	291890006	8	7.0	1.7	4.2	4.2	7.9	8.7	8.7	25	34	6	6	11	105	105
St Louis	291893001	16	7.3	2.0	3.4	3.4	7.6	9.6	9.6	22	43	5	5	11	181	181
St Louis	291895001	11	7.5	1.7	4.3	4.3	7.7	9.7	9.7	46	62	5	5	15	181	181
St Louis	291897002	16	5.7	1.8	2.0	2.0	5.4	9.7	9.7	28	37	5	5	15	143	143
St Louis	291897003	16	6.2	2.0	2.5	2.5	6.0	9.6	9.6	24	33	5	5	15	143	143
St Louis	295100072	46	6.3	2.5	0.7	2.0	6.5	9.9	9.9	77	150	5	5	16	508	848
St Louis	295100080	31	6.9	2.2	0.4	0.4	7.3	10.0	10.0	98	176	5	5	17	848	848
St Louis	295100086	35	6.7	2.3	1.7	1.7	6.6	9.9	9.9	94	168	5	5	17	848	848
Washington DC	110010017	13	5.4	2.4	2.9	2.9	4.5	9.7	9.7	557	1643	11	11	34	6009	6009
Washington DC	110010025	6	6.4	1.0	4.8	4.8	6.5	7.6	7.6	40	35	11	11	26	98	98
Washington DC	110010041	10	6.1	2.4	0.6	0.6	6.1	9.8	9.8	124	137	11	11	66	410	410
Washington DC	110010043	12	5.0	3.2	0.3	0.3	4.6	9.8	9.8	109	129	11	11	46	410	410
Washington DC	240053001	11	7.5	2.1	2.6	2.6	7.9	9.7	9.7	1034	3225	6	6	45	10756	10756
Washington DC	245100040	26	5.0	2.5	0.3	0.3	4.9	9.5	9.5	122	220	6	6	56	1118	1118
Washington DC	245100050	24	6.2	2.1	2.4	2.4	6.0	10.0	10.0	129	227	6	6	56	1118	1118
Washington DC	510130020	14	6.2	2.6	1.5	1.5	5.4	9.8	9.8	558	1579	11	11	46	6009	6009
Washington DC	510590005	2	4.9	4.8	1.4	1.4	4.9	8.3	8.3	13	7	8	8	13	18	18
Washington DC	510590018	6	8.4	0.4	8.0	8.0	8.4	9.2	9.2	1104	2413	9	9	13	6009	6009
Washington DC	510591004	10	7.4	1.6	3.7	3.7	7.8	9.3	9.3	80	173	14	14	19	571	571
Washington DC	510591005	8	6.3	2.0	4.6	4.6	5.5	9.4	9.4	94	193	14	14	19	571	571
Washington DC	510595001	4	6.5	2.8	3.2	3.2	6.8	9.2	9.2	30	19	17	17	22	58	58
Washington DC	511071005	5	7.1	2.3	4.5	4.5	6.5	9.6	9.6	14	8	8	8	12	27	27
Washington DC	511530009	0														
Washington DC	515100009	9	7.0	2.4	1.1	1.1	7.9	8.8	8.8	809	1959	14	14	156	6009	6009

Notes:
[1] n is the number of sources emitting >5 tons per year (tpy) NO_x within a 10 kilometer radius of a monitor in a particular location.
[2] The min, 2.5, med, 97.5, and max represent the minimum, 2.5^{th}, median, 97.5^{th}, and maximum percentiles of the distribution for the distance in meters (m) to the source emission.

A-5 Spatial and Temporal Air Quality Analyses

A-5.1 Introduction

An analysis of the air quality was performed to determine spatial and temporal trends, considering locations, monitoring sites within locations, and time-averaging of ambient NO_2 concentrations collected from 1995 through 2006. The purpose is to present relevant information on the air quality as it relates to both the current form of the standard (annual average concentration) and the exposure concentration and duration associated with adverse health effects (1-hour).

A-5.2 Approach

To evaluate variability in NO_2 concentrations, temporal and spatial distributions of summary statistics were computed in addition to use of statistical tests to compare distributions between years and/or monitors and/or locations. For a given location, the variability within that location is defined by the distribution of the annual summary statistics across years and monitors and by the distribution of the hourly concentrations across hours and monitors. The summary statistics were compiled into tables and used to construct figures for visual comparison and for statistical analysis.

Box-plots were constructed to display the distribution across sites and years (or hours for the hourly concentrations) for a single location. The box extends from the 25th to the 75th percentile, with the median shown as the line inside the box. The whiskers extend from the box to the 5th and 95th percentiles. The extreme values in the upper and lower tails beyond the 5th and 95th percentiles are not shown to allow for similar scaling along the y-axis for the plotted independent variables. The mean is plotted as a dot; typically it would appear inside the box, however it will fall outside the box if the distribution is highly skewed. All concentrations are shown in parts per billion (ppb).

Q-Q plots also display the distribution in the calculated air quality metrics across sites and years (or hours for the hourly concentrations) for a single location. The Q-Q plot is used to compare the observed cumulative distribution to a standard statistical distribution. In this case the observed distributions are compared with a log-normal distribution, so that the vertical scale is logarithmic. The horizontal scale is the quantile of a standard normal distribution, so that if there are N observed values, then the kth highest value is plotted against the quantile probit(p), where probit is the inverse of the standard normal distribution function, and *p* is the plotting point. The plotting points were chosen as $p = (k-3/8)/(N+1/4)$ for the annual statistics and $p = k/(N+1)$ for the hourly concentrations. If the distribution were exactly log-normal, then the curve would be a straight line. The median value is the y-value when the normal quantile equals zero. The slope of the line is related to the standard deviation of the logarithms, so that the higher the slope, the higher the coefficient of variation (standard deviation divided by the mean for the raw data, before taking logarithms).

In addition to the tabular and graphical comparisons of the summary statistics, the distributions of each variable were compared using various statistical tests. An F-Statistic comparison compares the mean values between locations using a one way analysis of variance (ANOVA). This test assumed that for each location, the site-year or site-hour variables are normally distributed, with a mean that may vary with the location and a constant variance (i.e., the same for each location). Statistical significance was assigned for p-values less than or equal to 0.05. The Kruskal-Wallis Statistics are non-parametric tests that are extensions of the more familiar Wilcoxon tests to two or more groups. The analysis is valid if the difference between the variable and the location median has the same distribution for each location. If so, this procedure tests whether the location medians are equal. The test is also consistent under weaker assumptions against more general alternatives. The Mood Statistic comparisons are non-parametric tests that compare the scale statistics for two or more groups. The scale statistic measures variation about the central value, which is a non-parametric generalization of the standard deviation. This test assumes that all the groups have the same median. Specifically, suppose there is a total of N values, summing across all the locations to be compared. These N values are ranked from 1 to N, and the j^{th} highest value is given a score of $\{j - (N+1)/2\}^2$. The Mood statistic uses a one-way ANOVA statistic to compare the mean scores for each location. Thus the Mood statistic compares the variability between the different locations assuming that the medians are equal.

A-5.3 Summary Results by Locations

A summary of the important trends in NO_2 concentrations is reported in this section. Detailed air quality results (i.e., by year and within-location) are presented in section A-5.4, containing both tabular and graphic summaries of the spatial and temporal concentration distributions.

A broad view of the NO_2 monitoring concentrations across locations is presented in Figures A-1 and A-2. In general there is variability in NO_2 concentrations between the 20 locations. For example, in Los Angeles, the mean of annual means is approximately 24.3 ppb over the period of analysis, while considering the Not MSA grouping, the mean annual mean was about 7.0 ppb. Phoenix contained the highest mean annual mean of 27.3 ppb. Variability in the annual average concentrations was also present within locations, the magnitude of which varied by location. On average, the coefficient of variation in the annual mean concentrations was about 35%, however locations such as Jacksonville or Provo had COVs as low as 6% while locations such as Las Vegas and Not MSA contained COVs above 60%. Reasons for differing variability arise from the size of the monitoring network in a location, level of the annual mean concentration, underlying influence of temporal variability within particular locations, among others.

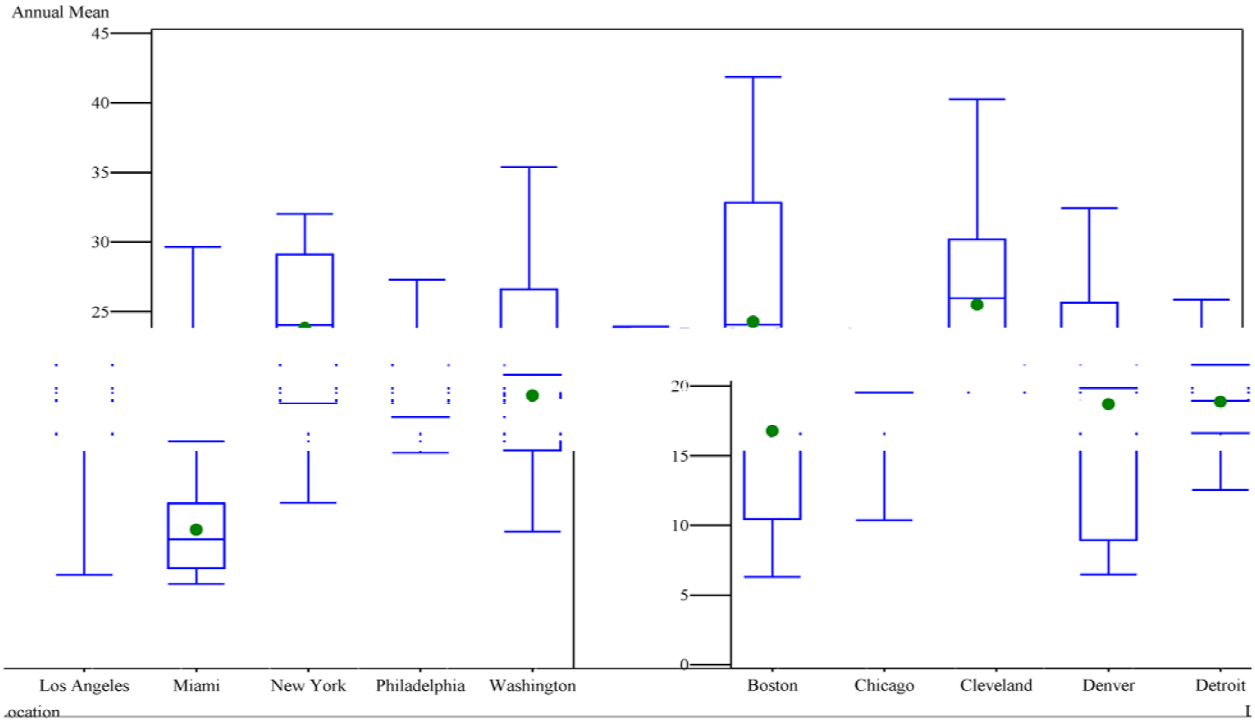

Figure A-1. Distributions of annual mean NO_2 ambient monitoring concentrations for selected CMSA locations, years 1995-2006.

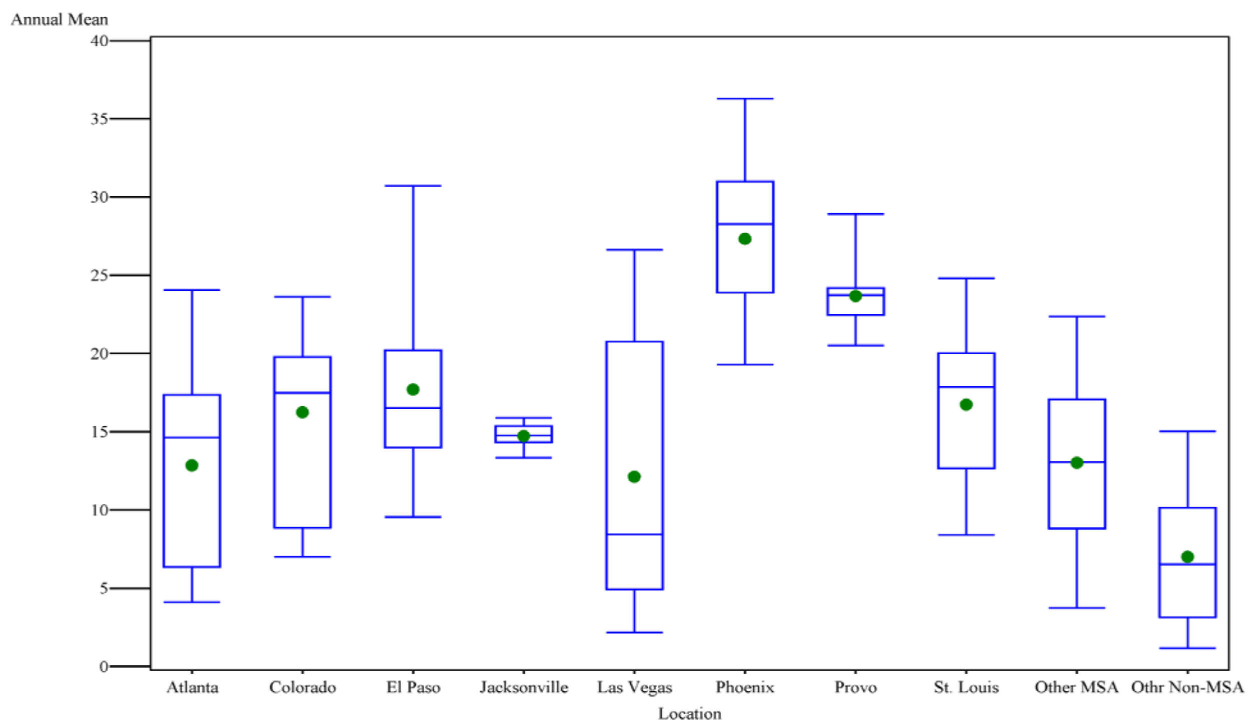

Figure A-2. Distributions of annual mean NO_2 ambient monitoring concentrations for selected MSA and grouped locations, years 1995-2006.

Differences in the distributions of hourly concentrations were of course consistent with that observed for the annual mean concentrations, and as expected there were differences in the

COVs across locations, ranging from about 60 to 120%. However, in comparing the 90 percent intervals (from the 5th to the 95th percentiles) of hourly concentrations across locations, the ranges are somewhat similar (for example see Figure 3 for the CMSA locations). This means that the intervals for the annual mean differ more than that of the hourly concentrations between locations likely due to the influence of high 1-hour NO_2 concentrations for certain locations.

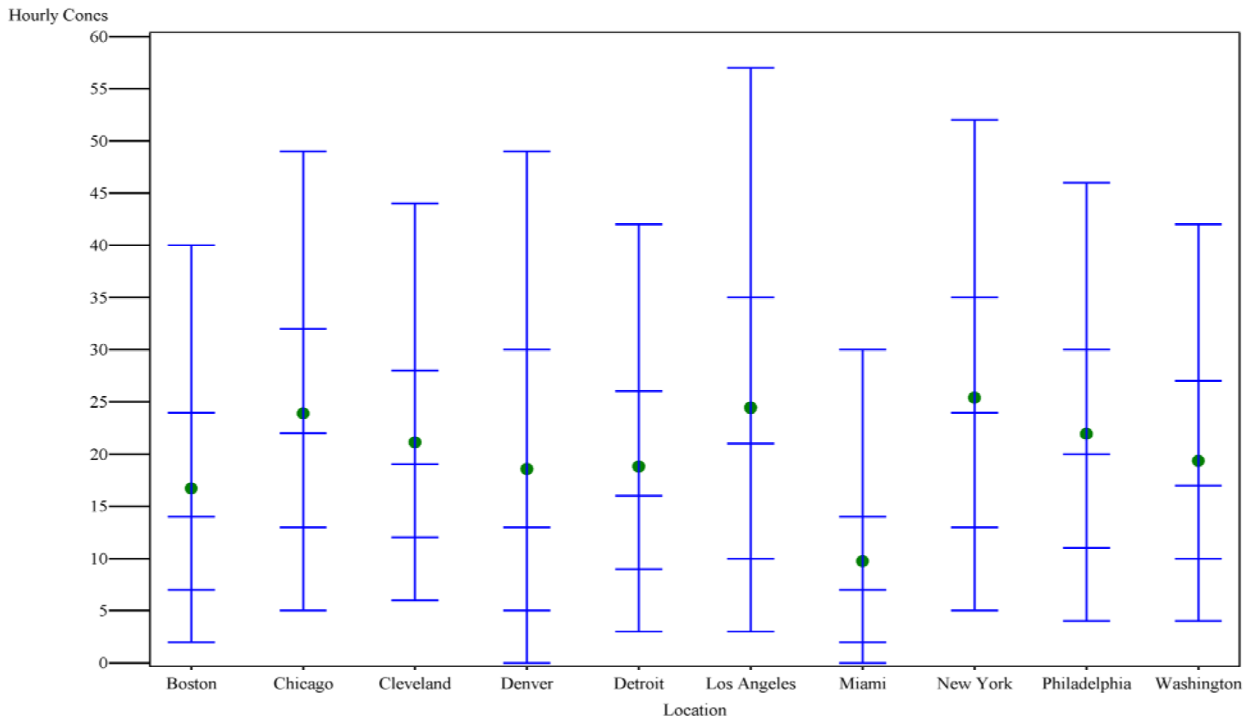

Figure A-3. Distributions[3] of hourly NO_2 ambient monitoring concentrations for selected CMSA locations, years 1995-2006.

This presence of extreme NO_2 concentrations is best illustrated in Figure 4 using a Q-Q plot that captures the full concentration distribution for each CMSA location. The Q-Q plots are generally curved rather than straight, such that the distributions do not appear to be log-normal. However, the annual mean and hourly concentration curves do tend to be approximately straight and parallel for values above the median (normal quantile = 0) through the 3rd quantile, suggesting that these upper tails of the distributions are approximately log-normal with approximately the same coefficients of variation. Beyond the 3rd quantile though, each distribution similarly and distinctly curves upwards, indicating a number of uncharacteristic NO_2 concentrations at each location when compared with the rest of their respective concentration distributions.

[3] The box-plots for hourly concentrations were created using a different procedure than for the annual statistics, because of the large number of hourly values and the inability of the graphing procedure to allow frequency weights. Therefore, the appropriate weighted percentiles and means were calculated and plotted as shown, but the vertical lines composing the sides of the box were omitted.

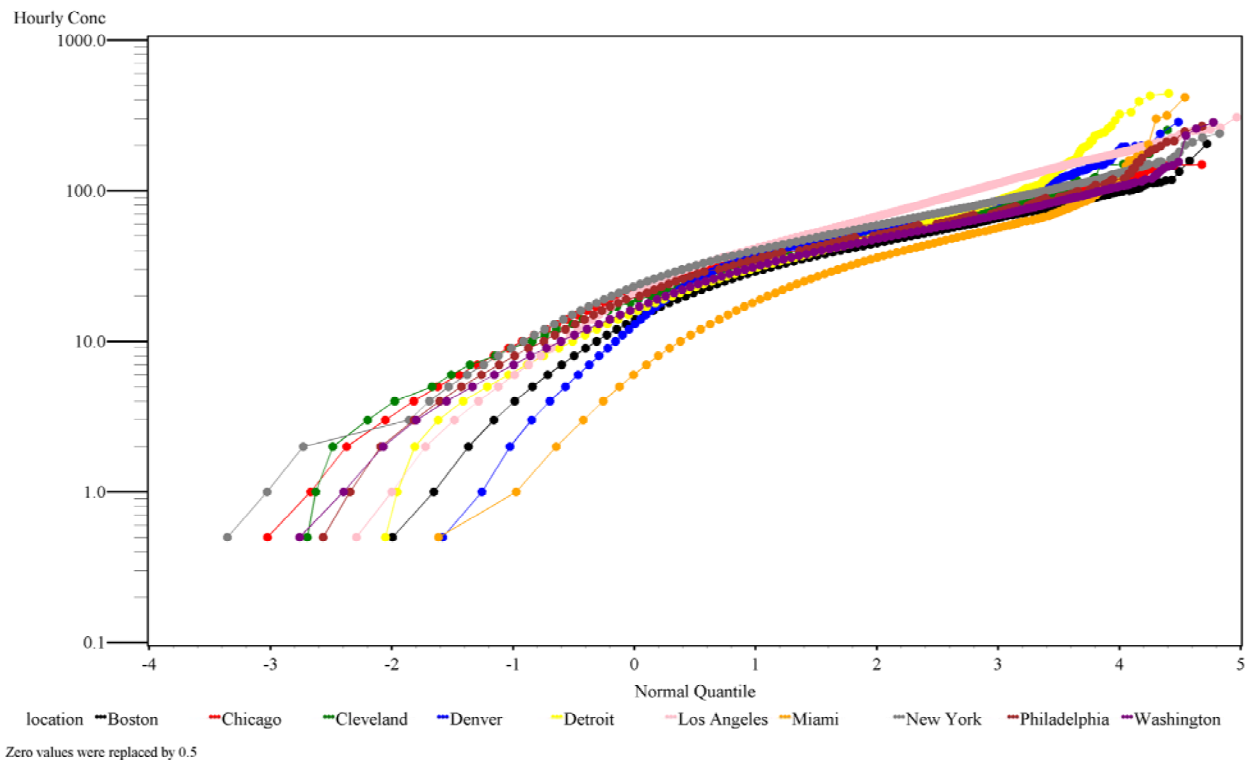

Figure A-4. Distributions of hourly NO_2 ambient concentration for selected CMSA locations, years 1995-2006.

Distributions of each variable (annual means and hourly concentrations) were compared between the different locations using statistical tests. The results in Table A-9 show statistically significant differences between locations for both variables and all three summary statistics (means, medians, and scales). This supports the previous observation that the distributions for the different locations are dissimilar.

Table A-9. Statistical test results for spatial comparisons of all location parameter distributions.

Concentration Parameter	Means Comparison		Central Values Comparison		Scales Comparison	
	F Statistic	p-value	Kruskal-Wallis	p-value	Mood	p-value
Annual Mean	148	<0.0001	1519	<0.0001	729	<0.0001
Hourly	330272	<0.0001	5414056	<0.0001	1354075	<0.0001

The distributions of NO_2 concentrations within locations were also evaluated. As an example, Figure A-5 illustrates the distribution of the annual mean NO_2 concentration at 10 monitoring sites within Philadelphia. The mean annual means vary from a minimum of 14.8 ppb (site 1000310071) to a maximum of 30.5 ppb (site 4210100471). The range of within-site variability can be attributed to the number of monitoring years available coupled with the observed trends in temporal variability across the monitoring period (discussed below in Section 2.4.4).

Distributions of each variable (annual means and hourly NO_2 concentrations) within locations (i.e., site distributions) were compared using statistical tests. The results in Table A-10 indicate statistically significant differences within locations for both variables and the central tendency statistics (means and medians), while scales were statistically significant for 38 out of 40 possible tests. This supports the previous observation that the distributions for the different locations are dissimilar.

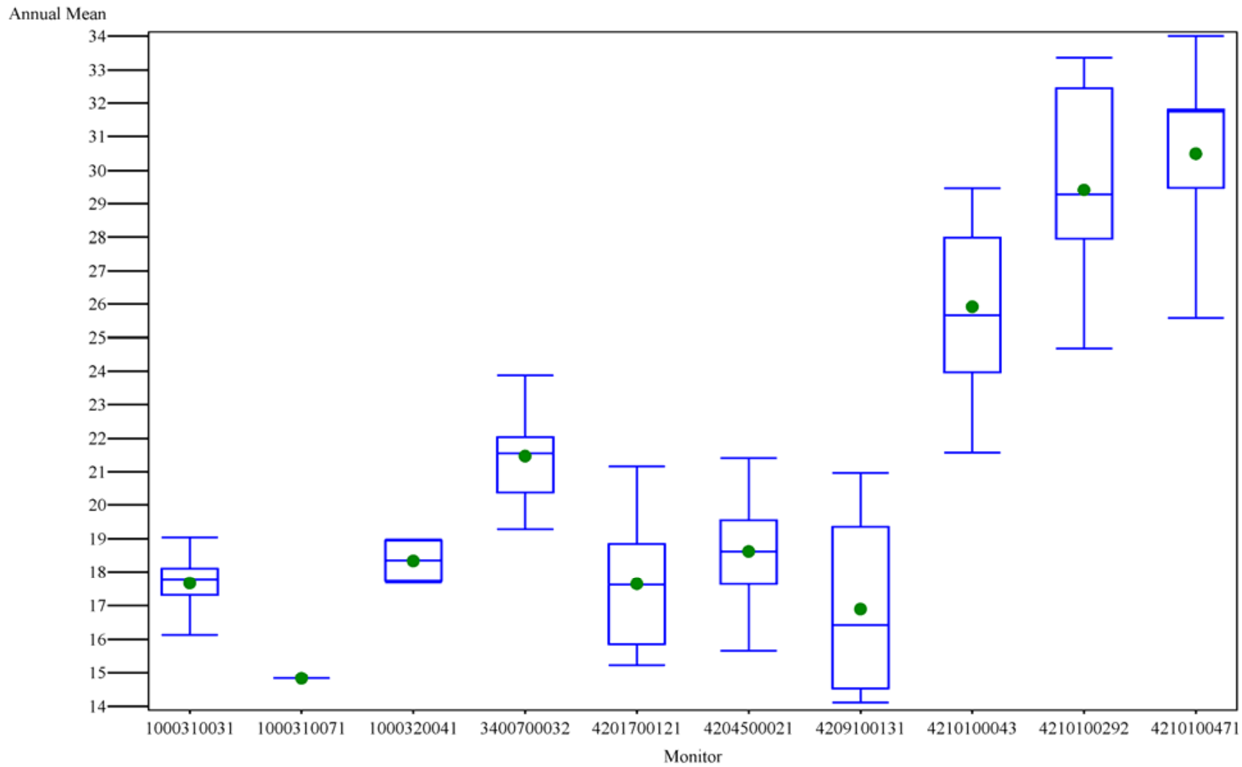

Figure A-5. Distributions of annual average NO_2 concentrations among 10 monitoring sites in Philadelphia CMSA, years 1995-2006.

Table A-10. Statistical test results for spatial comparisons of within-location parameter distributions.

		Means Comparison		Central Values Comparison		Scales Comparison	
Concentration Parameter	**Location**	**F Statistic**	**p-value**	**Kruskal-Wallis**	**p-value**	**Mood**	**p-value**
Annual Mean	Atlanta	119	<0.001	45.2	<0.001	28.6	<0.001
	Boston	47.3	<0.001	96.5	<0.001	79.9	<0.001
	Chicago	123	<0.001	76.7	<0.001	68.5	<0.001
	Cleveland	12.1	<0.001	15.4	0.002	7.5	0.058
	Colorado Springs	8.7	<0.001	18.8	0.009	8.7	0.273
	Denver	85.3	<0.001	32.0	<0.001	23.0	0.001
	Detroit	13.2	<0.001	13.1	0.001	7.8	0.020
	El Paso	36.0	<0.001	31.6	<0.001	35.3	<0.001
	Las Vegas	137	<0.001	45.4	<0.001	35.2	<0.001
	Los Angeles	49.0	<0.001	325	<0.001	240	<0.001
	Miami	111	<0.001	36.2	<0.001	29.9	<0.001
	New York	106	<0.001	163	<0.001	151	<0.001
	Philadelphia	48.9	<0.001	68.8	<0.001	33.0	<0.001
	Phoenix	20.4	<0.001	32.2	<0.001	23.6	0.001
	St. Louis	51.5	<0.001	82.1	<0.001	69.0	<0.001

Concentration Parameter	Location	Means Comparison F Statistic	Means Comparison p-value	Central Values Comparison Kruskal-Wallis	Central Values Comparison p-value	Scales Comparison Mood	Scales Comparison p-value
	Washington DC	48.6	<0.001	104	<0.001	71.2	<0.001
	Other MSA	82.5	<0.001	2152	<0.001	1934	<0.001
	Other Not MSA	76.9	<0.001	424	<0.001	372	<0.001
Hourly	Atlanta	35917	<0.001	137022	<0.001	17330	<0.001
	Boston	17884	<0.001	312994	<0.001	59896	<0.001
	Chicago	11611	<0.001	142034	<0.001	37224	<0.001
	Cleveland	4191	<0.001	14102	<0.001	1985	<0.001
	Denver	25130	<0.001	104800	<0.001	2864	<0.001
	Colorado Springs	5541	<0.001	48252	<0.001	3921	<0.001
	Detroit	4125	<0.001	10442	<0.001	424	<0.001
	El Paso	10503	<0.001	57694	<0.001	18334	<0.001
	Las Vegas	22567	<0.001	136455	<0.001	28972	<0.001
	Los Angeles	27288	<0.001	1050310	<0.001	269190	<0.001
	Miami	10669	<0.001	68580	<0.001	43090	<0.001
	New York	20052	<0.001	404234	<0.001	91104	<0.001
	Philadelphia	13759	<0.001	112129	<0.001	4903	<0.001
	Phoenix	5626	<0.001	35645	<0.001	6747	<0.001
	St. Louis	14807	<0.001	178180	<0.001	47842	<0.001
	Washington	14262	<0.001	223040	<0.001	30974	<0.001
	Other MSA	19557	<0.001	6306431	<0.001	2164452	<0.001
	Other Not MSA	17630	<0.001	1580139	<0.001	491390	<0.001

A-5.4 Summary Results by Year

A broad view of the trend of NO_2 monitoring concentrations over time is presented in Figure A-6. The annual mean concentrations were calculated for each monitor site within each year to create a distribution of annual mean concentrations for each year. The distribution of annual mean concentrations generally decreases with each increasing year. On average, mean annual mean NO_2 concentrations consistently decrease from a high of 17.5 ppb in 1995 to the most recent mean of 12.3 ppb. Also notable is the consistent pattern in the decreasing concentrations across each years distribution, the shape of each curve is similar indicating that while concentrations have declined, the variability within each year is similar from year to year. The variability within a given year is representing spatial differences in annual average concentrations across the 20 locations.

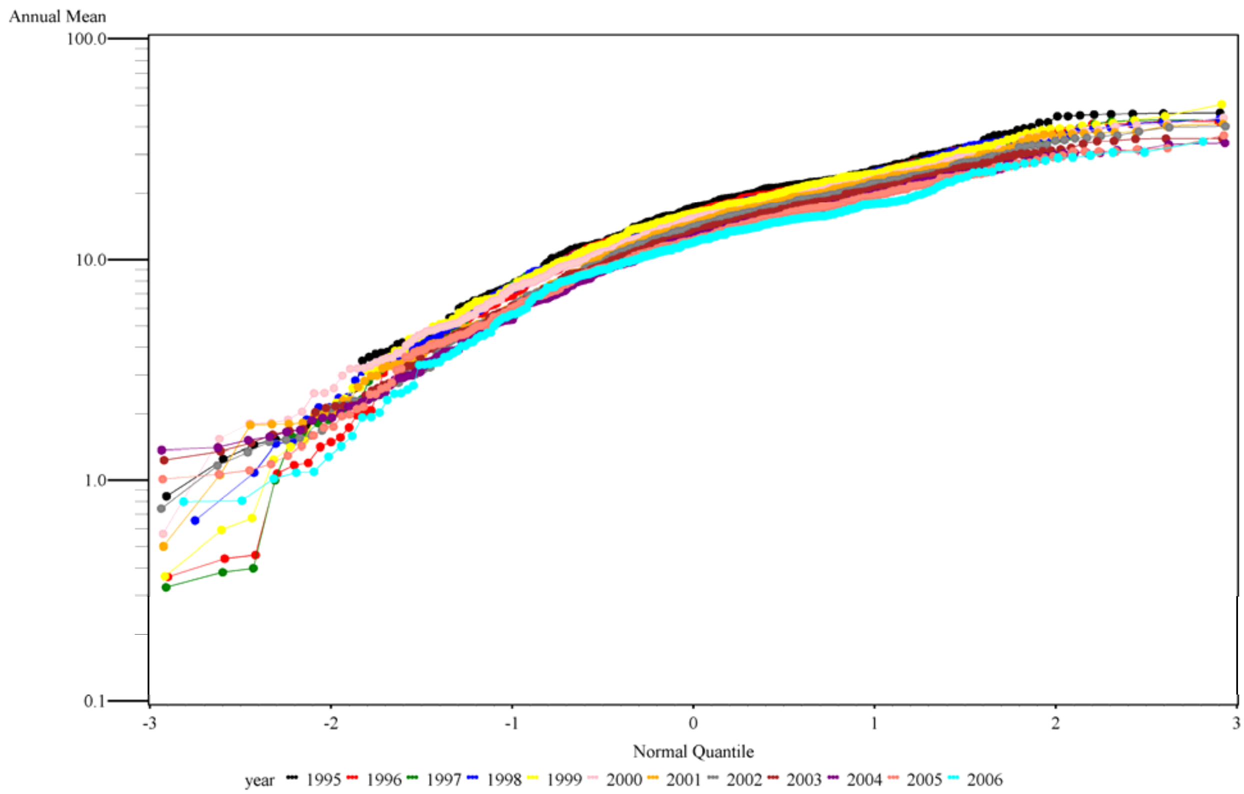

Figure A-6. Distributions of annual mean NO_2 concentrations for all monitors, years 1995-2006.

In general, temporal trends within a location were also consistent with the trends observed in all monitors, particularly where the location's monitoring network was comprised of several monitors. For example, Figure A-7 illustrates the temporal distributions of annual average NO_2 concentration in the Philadelphia CMSA, each comprising between 4 and 8 monitors in operation per year. Clearly NO_2 concentrations are decreased with increasing calendar year of monitoring with the lowest NO_2 concentrations in the more recent years of monitoring. The pattern of variability in NO_2 concentration within a year at this location is also similar when comparing across years based on similarities in the shape of each years respective curve.

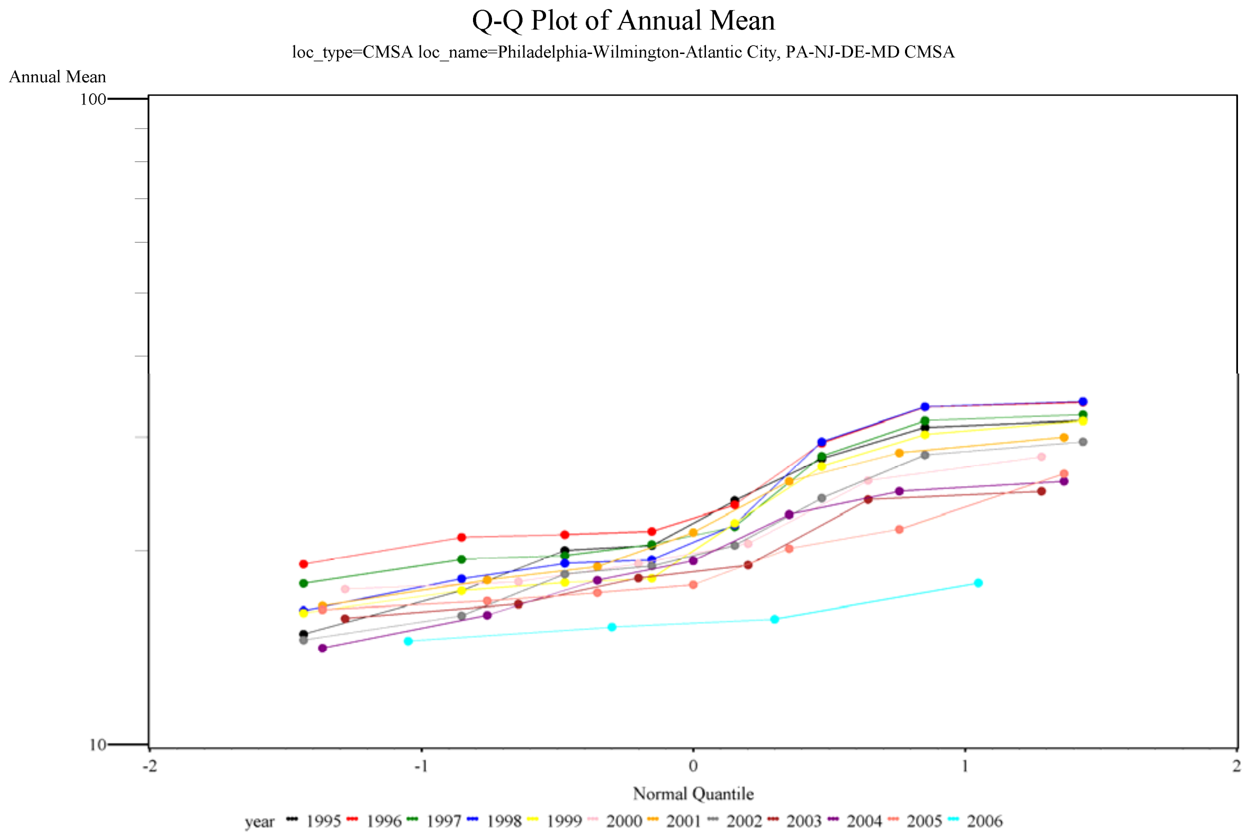

Figure A-7. Distributions of annual mean NO_2 concentrations for the Philadelphia CMSA, years 1995-2006.

In general, temporal trends within a location considering the hourly concentration data were consistent with the above, particularly where the monitoring network was comprised of several monitors. For example, Figure A-8 illustrates the temporal distribution for hourly NO_2 concentration in the Los Angeles CMSA, comprising between 26 and 36 monitors in operation per year. NO_2 concentrations are decreased with increasing calendar year of monitoring with the distribution of hourly concentrations lowest in the more recent years of monitoring. The pattern of variability in NO_2 concentration within a year at this location is also similar when comparing across years based on similarities in the shape of each years respective curve.

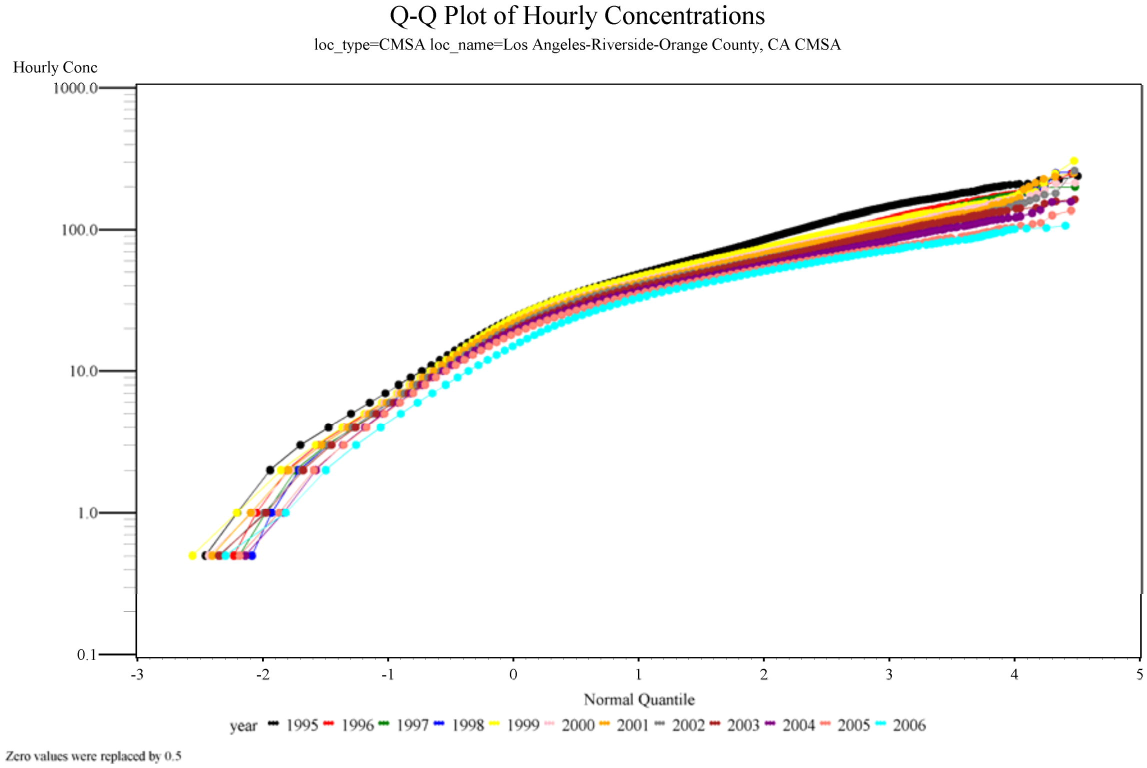

Figure A-8. Distributions of hourly NO_2 concentrations in the Los Angeles CMSA, years 1995-2006.

These temporal trends were confirmed by statistical comparison tests. The means and medians of the annual means and hourly concentrations compared across the different years were statistically significant (all $p<0.0001$). A Mood test indicated that, for the annual means, the scales were also significantly different (both the annual and hourly $p<0.001$). Note, however, that the Mood test derivation assumes that the medians of the annual means are the same for each year, whereas the plots and the Kruskall-Wallis test result implies that the medians are not the same. As noted before, Figure A-8 indicates that the Q-Q curves for different years have similar slopes but different intercepts, which implies that the annual means for different years have different mean values but similar coefficients of variation. In fact the coefficients of variation of the annual means are nearly identical for different years, ranging from 52 % to 55 %.

There were some exceptions to this temporal trend, particularly when considering the distribution of hourly concentrations and where a given location had only few monitors per year. Using Jacksonville as an example, Figure A-9 illustrates the same temporal trend in NO_2 concentrations as was observed above for much of the distribution, however distinctions are noted at the upper tails of the distribution for two years of data, 2002 and 2004. For Jacksonville, each years' hourly concentration distribution was based on only a single monitor. Where few monitors exist in a given location, atypical variability in one or a few monitors from year to year can greatly influence the distribution of short-term concentrations, particularly at the upper percentiles.

The same follows for assignment of statistical significance to temporal trends within locations. While annual average concentrations are observed to have declined over time within a location, the number of sites were typically few thus limiting the power of the statistical tests.

Only Los Angeles, El Paso, Phoenix, and Other CMSA were significant ($p<0.05$) for the central tendency tests, while only Los Angeles and Other CMSA were significant ($p<0.05$) for scale (data not shown). All hourly concentrations comparison tests for years within each location were statistically significant ($p<0.05$) for all three test statistics (mean, median, scale).

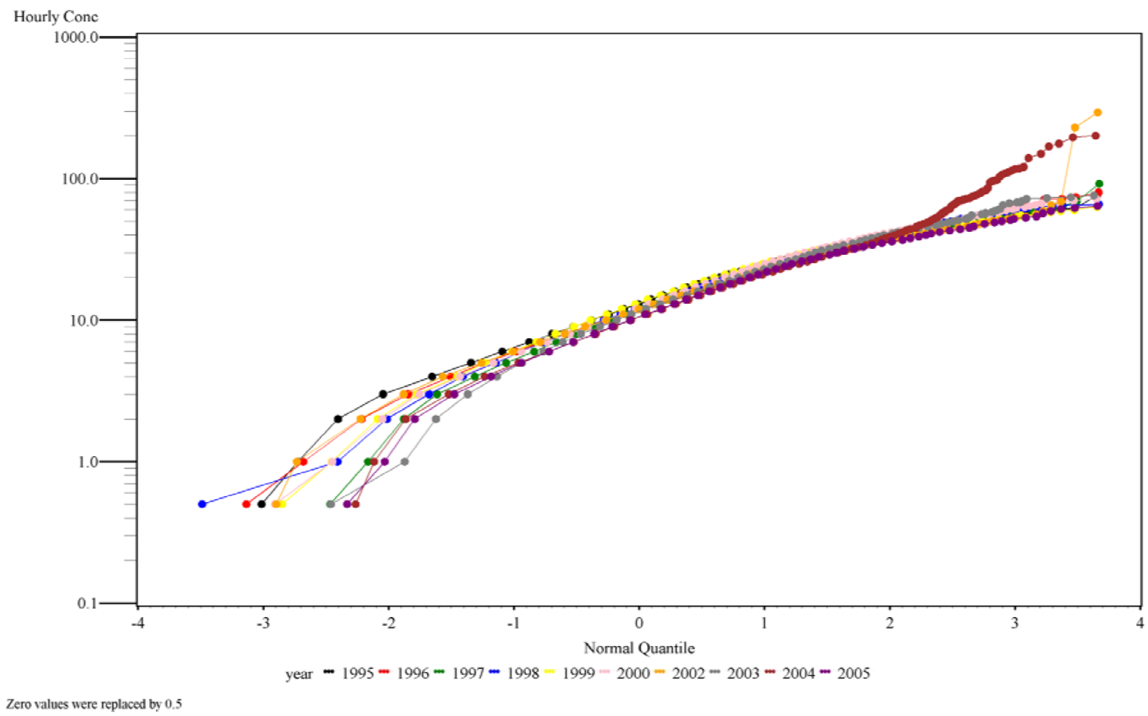

Figure A-9. Distributions of hourly NO_2 concentrations in the Jacksonville MSA, years 1995-2006, one monitor.

There is very little difference in annual average concentrations across the 1995-2006 monitoring period for the grouped Not MSA location. While percentage-wise the reduction in concentration is about 25%, on a concentration basis this amounts to a reduction of about 2 ppb over the 11 year period (Figure A-10). When considering the last 5 years of data, the reduction in annual average concentration was only 0.5 ppb. This could indicate that many of these monitoring sites are affected less by local sources of NO_2 (e.g., emissions from major roads and stationary sources) compared with the other locations. Therefore, the areas that these monitors represent may also be less likely to see significant benefit by changes in source emissions and/or NO_2 standard levels compared with the named CMSA/MSA locations.

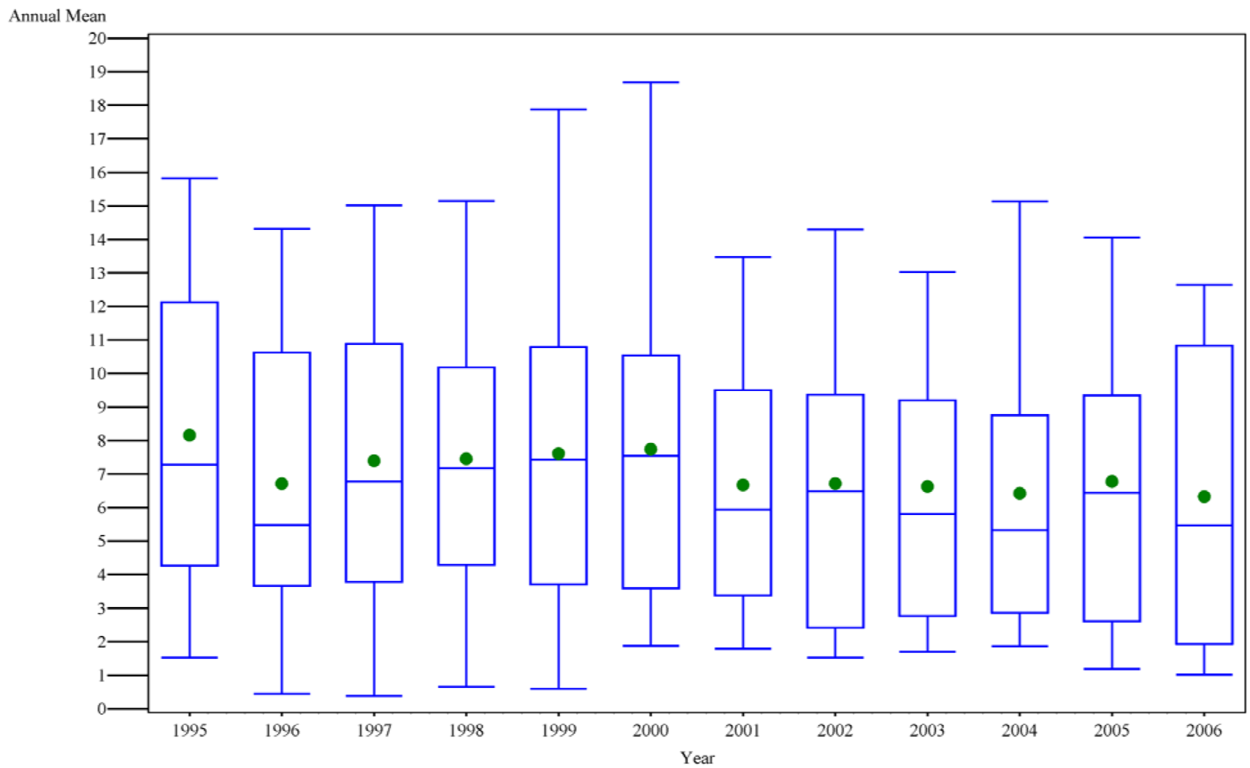

Figure A-10. Distributions of annual average NO_2 concentrations in the Other Not MSA group location, years 1995-2006.

A-5.5 Detailed Results by Year and Location

This section contains the ambient air quality analysis results by year for each of the named locations. Boxplots were constructed to display the annual average and hourly concentration distributions across years for a single location. The box extends from the 25th to the 75th percentile, with the median shown as the line inside the box. The whiskers extend from the box to the 5th and 95th percentiles. The extreme values in the upper and lower tails beyond the 5th and 95th percentiles are not shown to allow for similar scaling along the y-axis for the plotted independent variables. The mean is plotted as a dot; typically it would appear inside the box, however it will fall outside the box if the distribution is highly skewed. All concentrations are shown in parts per billion (ppb). The boxplots for hourly concentrations were created using a different procedure than for the annual statistics, because of the large number of hourly values and the inability of the graphing procedure to allow frequency weights. Therefore, the appropriate weighted percentiles and means were calculated and plotted as shown, but the vertical lines composing the sides of the box are essentially omitted. Tables are provided that summarize the complete distribution, with percentiles given in segments of 10.

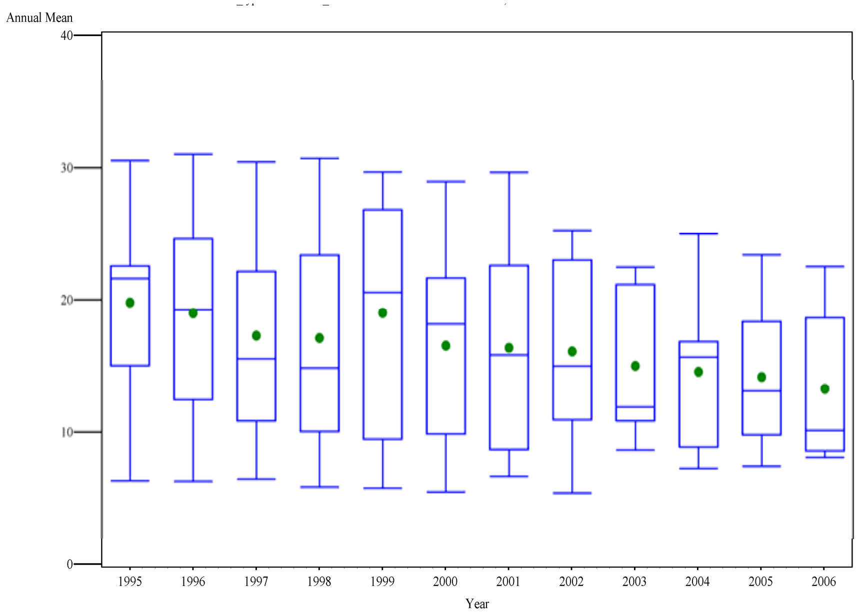

Figure A-11. Distribution of annual average NO_2 ambient concentrations (ppb) by year, Boston CMSA.

Table A-11. Distribution of annual average NO_2 ambient concentrations (ppb) by year, Boston CMSA.

Year	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
1995	12	20	7	34	6	12	14	16	21	22	22	23	23	27	31
1996	10	19	8	42	6	8	11	14	17	19	21	24	26	29	31
1997	11	17	8	44	6	9	11	13	15	16	19	22	22	27	30
1998	11	17	8	48	6	8	10	12	15	15	19	23	23	28	31
1999	7	19	9	45	6	6	9	20	20	21	21	21	27	30	30
2000	7	17	8	49	5	5	10	11	11	18	20	20	22	29	29
2001	10	16	8	50	7	7	8	10	12	16	20	22	24	28	30
2002	10	16	7	43	5	7	10	12	13	15	19	22	24	25	25
2003	5	15	6	42	9	9	10	11	11	12	17	21	22	22	22
2004	7	15	6	41	7	7	9	12	12	16	16	16	17	25	25
2005	8	14	6	39	7	7	10	10	11	13	15	18	19	23	23
2006	7	13	6	42	8	8	9	10	10	10	15	15	19	23	23

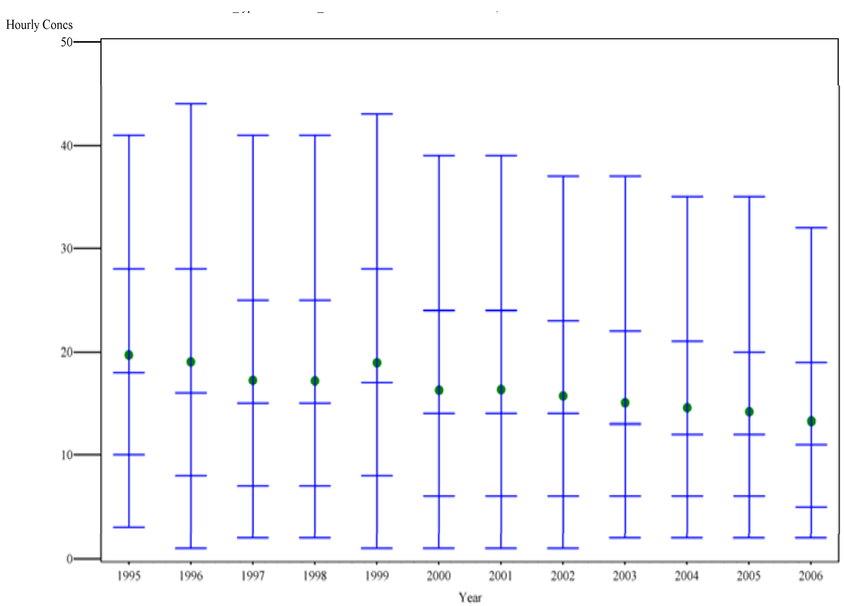

Figure A-12. Distribution of hourly NO_2 ambient concentrations (ppb) by year, Boston CMSA.

Table A-12. Distribution of hourly NO_2 ambient concentrations (ppb) by year, Boston CMSA.

Year	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
1995	99946	20	12	62	0	5	9	12	15	18	22	26	30	36	100
1996	83541	19	14	72	0	3	7	10	13	16	21	25	30	38	205
1997	90161	17	12	72	0	3	6	9	11	15	18	23	28	35	134
1998	89710	17	13	75	0	3	5	8	11	15	18	23	28	35	112
1999	54043	19	13	70	0	3	7	10	13	17	21	25	30	37	117
2000	56196	16	12	76	0	2	5	7	11	14	18	22	27	34	95
2001	82048	16	13	77	0	2	4	7	10	14	18	22	27	34	114
2002	80472	16	12	75	0	2	5	7	10	14	17	21	26	32	93
2003	41198	15	11	75	0	3	5	7	10	13	16	19	24	31	99
2004	56831	15	10	71	0	3	5	7	10	12	15	19	23	29	96
2005	66244	14	11	75	0	3	5	7	9	12	15	18	23	29	113
2006	57681	13	10	74	0	3	4	6	8	11	14	17	22	28	79

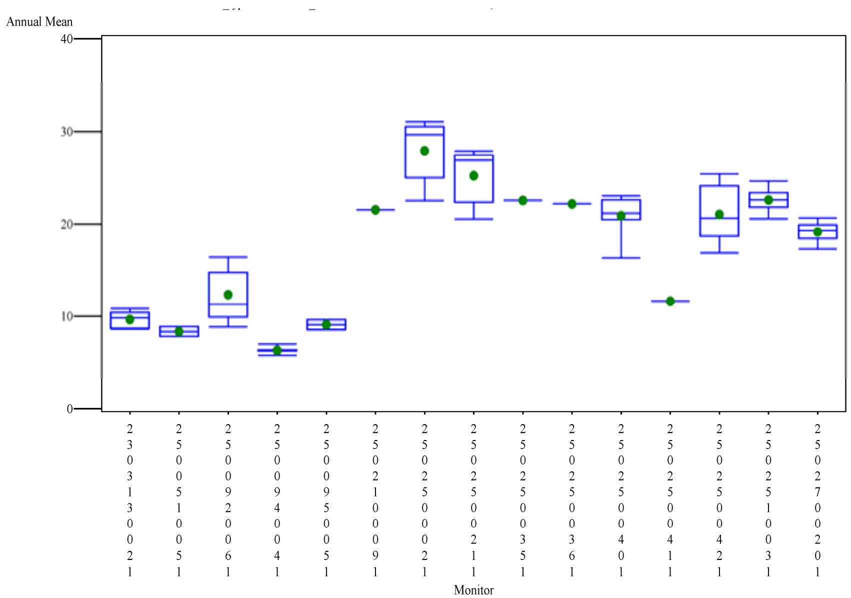

Figure A-13. Distribution of annual average NO_2 ambient concentration (ppb) by monitor, Boston CMSA set A, 1995-2006.

Table A-13. Distribution of annual average NO_2 ambient concentration (ppb) by monitor, Boston CMSA set A, 1995-2006.

Monitor ID	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
2303130021	7	10	1	9	9	9	9	9	9	10	10	10	10	11	11
2500510051	2	8	1	9	8	8	8	8	8	8	9	9	9	9	9
2500920061	10	12	3	22	9	9	10	10	11	11	13	15	15	16	16
2500940041	5	6	0	7	6	6	6	6	6	6	6	6	7	7	7
2500950051	2	9	1	8	9	9	9	9	9	9	10	10	10	10	10
2502100091	1	22			22	22	22	22	22	22	22	22	22	22	22
2502500021	11	28	3	11	23	23	25	25	29	30	30	30	31	31	31
2502500211	8	25	3	12	21	21	22	23	27	27	27	27	28	28	28
2502500351	1	23			23	23	23	23	23	23	23	23	23	23	23
2502500361	1	22			22	22	22	22	22	22	22	22	22	22	22
2502500401	11	21	2	10	16	18	20	21	21	21	22	22	23	23	23
2502500411	1	12			12	12	12	12	12	12	12	12	12	12	12
2502500421	6	21	3	16	17	17	19	19	19	21	22	24	24	25	25
2502510031	5	23	2	7	21	21	21	22	22	23	23	23	24	25	25
2502700201	8	19	1	6	17	17	18	19	19	19	19	20	20	21	21

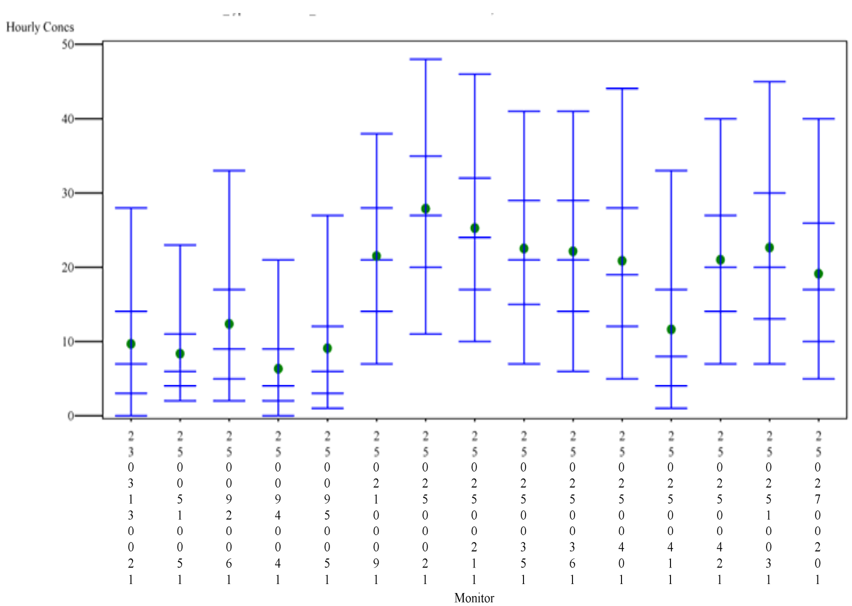

Figure A-14. Distribution of hourly NO_2 ambient concentration (ppb) by monitor, Boston CMSA set A, 1995-2006.

Table A-14. Distribution of hourly NO_2 ambient concentration (ppb) by monitor, Boston CMSA set A, 1995-2006.

Monitor ID	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
2303130021	58123	10	9	94	0	1	2	4	5	7	9	12	16	23	100
2500510051	16732	8	7	81	0	2	3	4	5	6	8	10	13	18	50
2500920061	80761	12	10	80	0	3	4	6	7	9	12	15	20	27	90
2500940041	41337	6	7	108	0	0	1	2	3	4	6	7	10	16	70
2500950051	16228	9	8	91	0	2	3	4	5	6	8	11	14	22	51
2502100091	8546	22	10	46	0	9	13	15	18	21	23	27	30	35	75
2502500021	87534	28	11	40	0	14	18	21	24	27	30	33	37	43	134
2502500211	63990	25	11	45	0	13	16	18	21	24	26	30	34	40	205
2502500351	8539	23	10	47	0	10	13	16	19	21	24	27	31	37	74
2502500361	8542	22	11	49	0	9	12	15	19	21	24	28	31	36	100
2502500401	91196	21	12	59	1	7	10	13	16	19	22	26	31	38	113
2502500411	8319	12	10	89	0	2	3	5	6	8	11	15	19	27	81
2502500421	48078	21	10	48	0	9	12	15	17	20	22	25	29	35	79

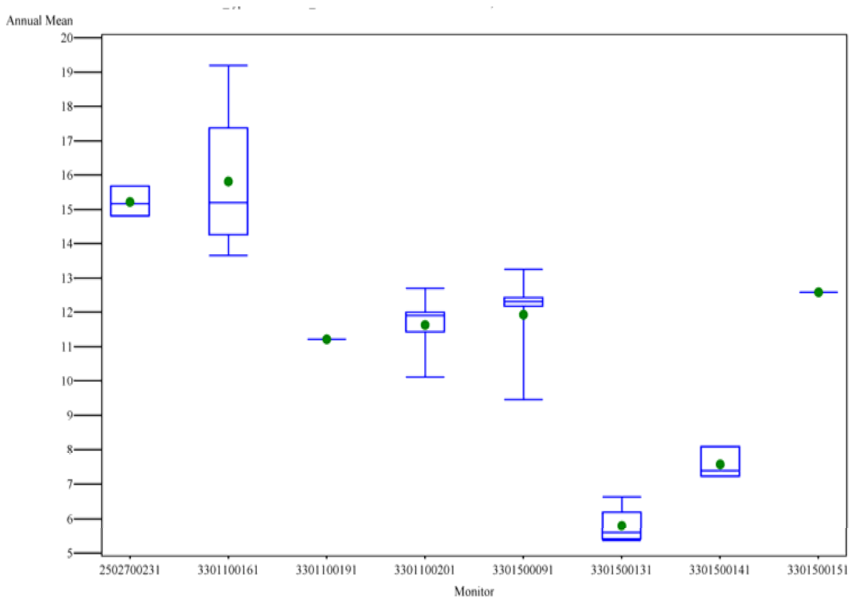

Figure A-15. Distribution of annual average NO_2 ambient concentration (ppb) by monitor, Boston CMSA set B, 1995-2006.

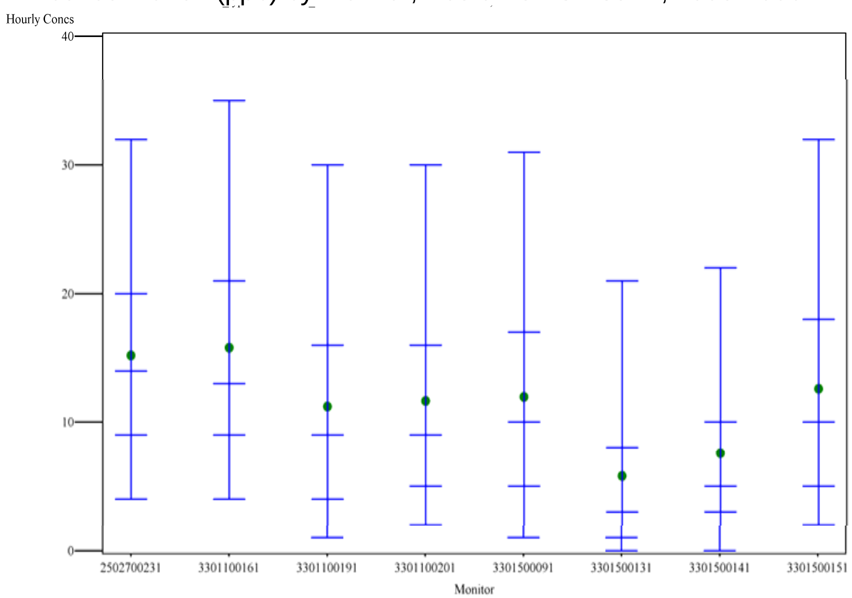

Figure A-16. Distribution of hourly NO_2 ambient concentration (ppb) by monitor, Boston CMSA set B, 1995-2006.

Table A-15. Distribution of annual average NO_2 ambient concentration (ppb) by monitor, Boston CMSA set B, 1995-2006.

Monitor ID	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
2502700231	3	15	0	3	15	15	15	15	15	15	15	16	16	16	16
3301100161	4	16	2	15	14	14	14	15	15	15	16	16	19	19	19
3301100191	1	11			11	11	11	11	11	11	11	11	11	11	11
3301100201	5	12	1	8	10	10	11	11	12	12	12	12	12	13	13
3301500091	5	12	1	12	9	9	11	12	12	12	12	12	13	13	13
3301500131	4	6	1	10	5	5	5	5	5	6	6	6	7	7	7
3301500141	3	8	0	6	7	7	7	7	7	7	7	8	8	8	8
3301500151	1	13			13	13	13	13	13	13	13	13	13	13	13

Table A-16. Distribution of hourly NO_2 ambient concentration (ppb) by monitor, Boston CMSA set B, 1995-2006.

Monitor ID	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
2502510031	40775	23	12	54	0	9	12	14	17	20	24	28	33	40	94
2502700201	63836	19	11	59	0	6	9	11	14	17	21	24	29	35	95
2502700231	24267	15	9	58	0	5	8	10	12	14	16	19	22	27	93
3301100161	33436	16	10	64	0	6	8	9	11	13	16	19	23	29	158
3301100191	8022	11	9	81	0	2	3	5	7	9	11	14	18	24	54
3301100201	41325	12	9	75	0	3	4	6	7	9	11	14	18	25	62
3301500091	40978	12	9	77	0	2	4	6	8	10	12	15	19	25	63
3301500131	33536	6	7	118	0	0	1	2	2	3	5	7	10	15	50
3301500141	25372	8	7	94	0	1	2	3	4	5	7	9	12	17	48
3301500151	8599	13	9	75	0	3	5	6	8	10	12	16	20	27	65

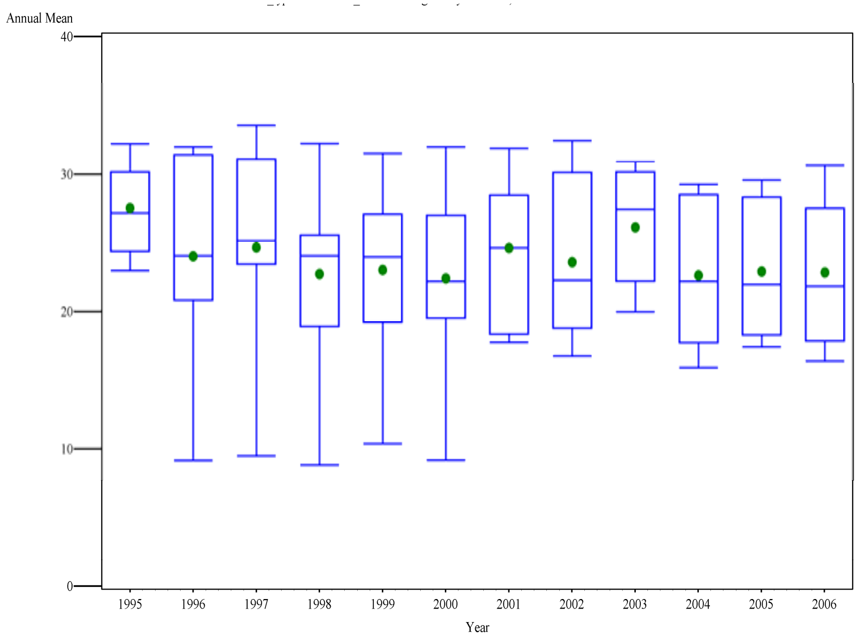

Figure A-17. Distribution of annual average NO_2 ambient concentrations (ppb) by year, Chicago CMSA.

Table A-17. Distribution of annual average NO_2 ambient concentrations (ppb) by year, Chicago CMSA.

Year	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
1995	7	28	3	12	23	23	24	26	26	27	29	29	30	32	32
1996	7	24	8	32	9	9	21	23	23	24	28	28	31	32	32
1997	6	25	8	34	9	9	23	23	24	25	27	31	31	34	34
1998	9	23	7	32	9	9	17	19	23	24	25	26	31	32	32
1999	9	23	7	29	10	10	17	19	22	24	24	27	31	32	32
2000	9	22	7	30	9	9	18	20	21	22	23	27	29	32	32
2001	7	25	5	21	18	18	18	24	24	25	28	28	28	32	32
2002	7	24	6	24	17	17	19	22	22	22	23	23	30	32	32
2003	5	26	5	19	20	20	21	22	25	27	29	30	31	31	31
2004	6	23	6	25	16	16	18	18	20	22	24	29	29	29	29
2005	6	23	5	23	17	17	18	18	20	22	24	28	28	30	30
2006	5	23	6	27	16	16	17	18	20	22	25	28	29	31	31

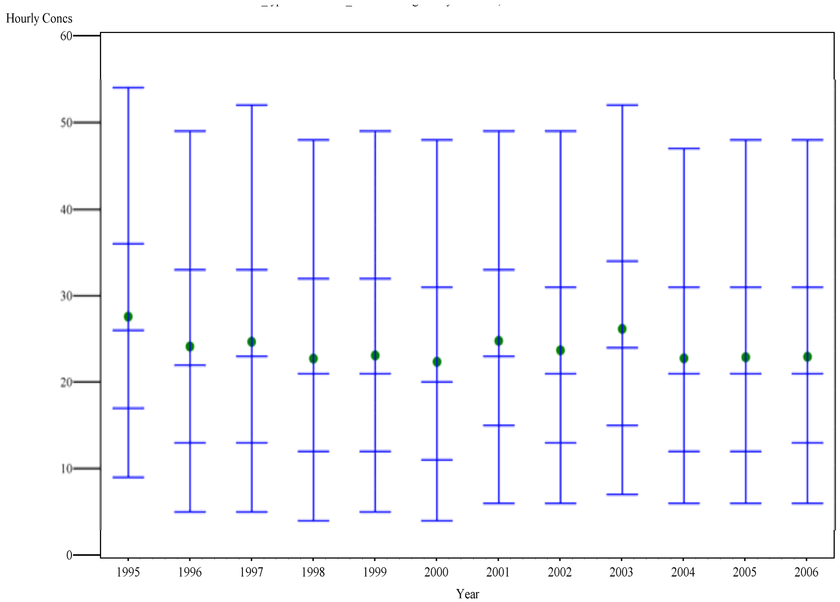

Figure A-18. Distribution of hourly NO_2 ambient concentrations (ppb) by year, Chicago CMSA.

Table A-18. Distribution of hourly NO_2 ambient concentrations (ppb) by year, Chicago CMSA.

Year	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
1995	58998	28	14	51	0	11	15	19	22	26	29	33	38	47	113
1996	59447	24	14	58	0	7	11	15	18	22	26	31	36	43	127
1997	51443	25	15	59	0	7	11	15	19	23	27	31	36	44	113
1998	76365	23	14	61	0	6	10	13	17	21	25	29	34	41	112
1999	74985	23	14	61	0	7	10	13	17	21	25	30	35	42	113
2000	75327	22	14	62	0	6	10	13	17	20	24	29	34	41	108
2001	58268	25	13	54	0	9	13	16	20	23	27	31	36	43	114
2002	58383	24	14	59	0	8	12	15	18	21	25	29	34	42	149
2003	42406	26	14	54	0	10	14	17	21	24	28	32	37	45	122
2004	49210	23	13	57	0	8	11	14	18	21	25	28	33	41	101
2005	51043	23	13	59	0	8	11	14	17	21	24	29	34	41	106
2006	42009	23	13	57	0	8	11	14	17	21	25	29	34	41	137

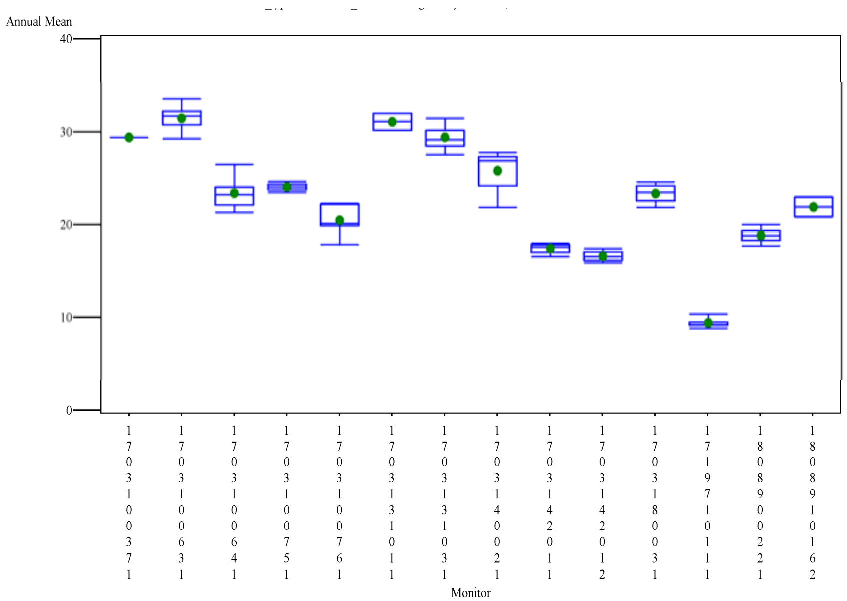

Figure A-19. Distribution of annual average NO_2 ambient concentration (ppb) by monitor, Chicago CMSA, 1995-2006.

Table A-19. Distribution of annual average NO_2 ambient concentration (ppb) by monitor, Chicago CMSA, 1995-2006.

Monitor ID	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
1703100371	1	29			29	29	29	29	29	29	29	29	29	29	29
1703100631	12	31	1	4	29	30	31	31	31	32	32	32	32	32	34
1703100641	6	23	2	8	21	21	22	22	23	23	24	24	24	26	26
1703100751	4	24	0	2	23	23	23	24	24	24	24	24	25	25	25
1703100761	5	20	2	9	18	18	19	20	20	20	21	22	22	22	22
1703131011	3	31	1	3	30	30	30	30	31	31	31	32	32	32	32
1703131031	9	29	1	5	28	28	28	28	29	29	30	30	31	31	31
1703140021	12	26	2	8	22	23	24	24	26	27	27	27	27	28	28
1703142011	4	17	1	4	17	17	17	17	17	18	18	18	18	18	18
1703142012	4	17	1	4	16	16	16	16	16	17	17	17	17	17	17
1703180031	8	23	1	4	22	22	22	23	23	23	24	24	24	25	25
1719710111	5	9	1	6	9	9	9	9	9	9	9	9	10	10	10
1808900221	8	19	1	4	18	18	18	18	19	19	19	19	20	20	20
1808910162	2	22	2	7	21	21	21	21	21	22	23	23	23	23	23

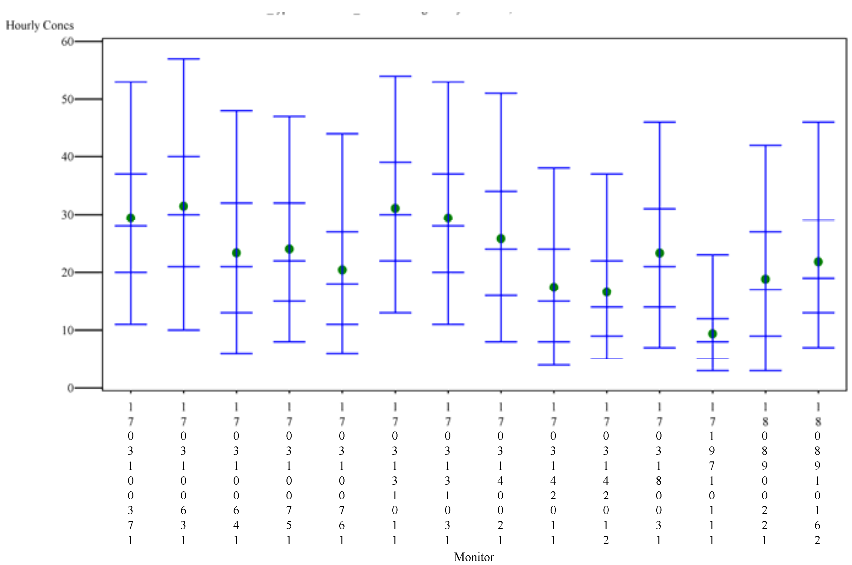

Figure A-20. Distribution of hourly NO_2 ambient concentration (ppb) by monitor, Chicago CMSA, 1995-2006.

Table A-20. Distribution of hourly NO_2 ambient concentration (ppb) by monitor, Chicago CMSA, 1995-2006.

Monitor ID	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
1703100371	8630	29	13	44	0	15	19	22	25	28	31	35	39	47	113
1703100631	101935	31	15	46	0	13	19	23	27	30	34	38	43	51	137
1703100641	52139	23	13	57	0	8	11	15	18	21	25	29	34	41	127
1703100751	34028	24	12	52	0	10	13	16	19	22	26	29	34	41	113
1703100761	42946	20	12	59	0	7	10	12	15	18	21	25	30	37	98
1703131011	25141	31	13	41	3	16	20	23	27	30	33	37	41	48	105
1703131031	75061	29	13	44	0	14	18	22	25	28	31	35	39	47	149
1703140021	102779	26	13	51	0	11	14	17	20	24	27	31	36	44	106
1703142011	32625	17	11	64	0	5	7	10	12	15	19	22	27	33	77
1703142012	32552	17	10	62	0	6	8	10	12	14	17	20	25	31	70
1703180031	68952	23	12	53	0	9	12	15	18	21	25	29	33	40	97
1719710111	41227	9	6	69	0	3	4	5	6	8	9	11	13	18	52
1808900221	63295	19	12	66	0	4	7	10	13	17	20	25	29	36	131
1808910162	16574	22	12	56	3	9	12	14	16	19	22	26	31	39	125

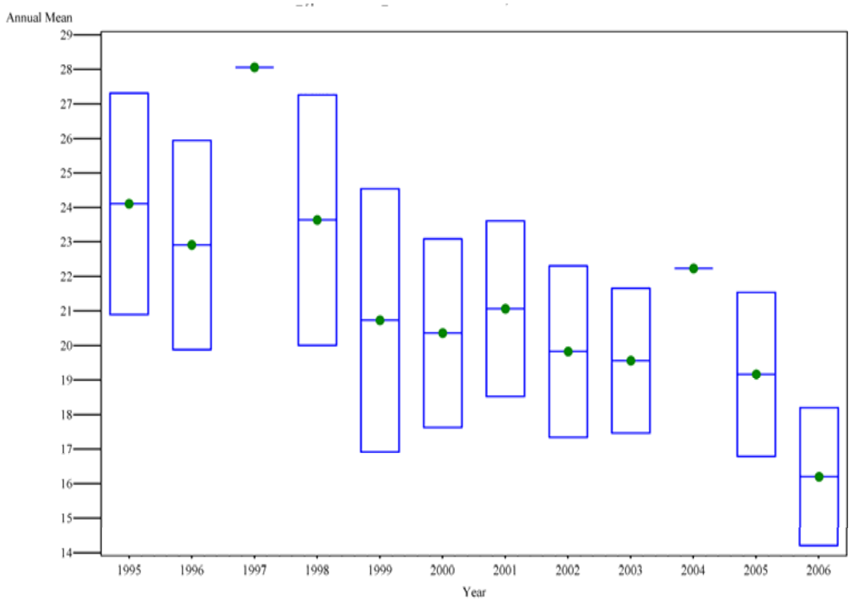

Figure A-21. Distribution of annual average NO_2 ambient concentrations (ppb) by year, Cleveland CMSA.

Table A-21. Distribution of annual average NO_2 ambient concentrations (ppb) by year, Cleveland CMSA.

Year	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
1995	2	24	5	19	21	21	21	21	21	24	27	27	27	27	27
1996	2	23	4	19	20	20	20	20	20	23	26	26	26	26	26
1997	1	28		0	28	28	28	28	28	28	28	28	28	28	28
1998	2	24	5	22	20	20	20	20	20	24	27	27	27	27	27
1999	2	21	5	26	17	17	17	17	17	21	25	25	25	25	25
2000	2	20	4	19	18	18	18	18	18	20	23	23	23	23	23
2001	2	21	4	17	19	19	19	19	19	21	24	24	24	24	24
2002	2	20	4	18	17	17	17	17	17	20	22	22	22	22	22
2003	2	20	3	15	17	17	17	17	17	20	22	22	22	22	22
2004	1	22		0	22	22	22	22	22	22	22	22	22	22	22
2005	2	19	3	17	17	17	17	17	17	19	22	22	22	22	22
2006	2	16	3	17	14	14	14	14	14	16	18	18	18	18	18

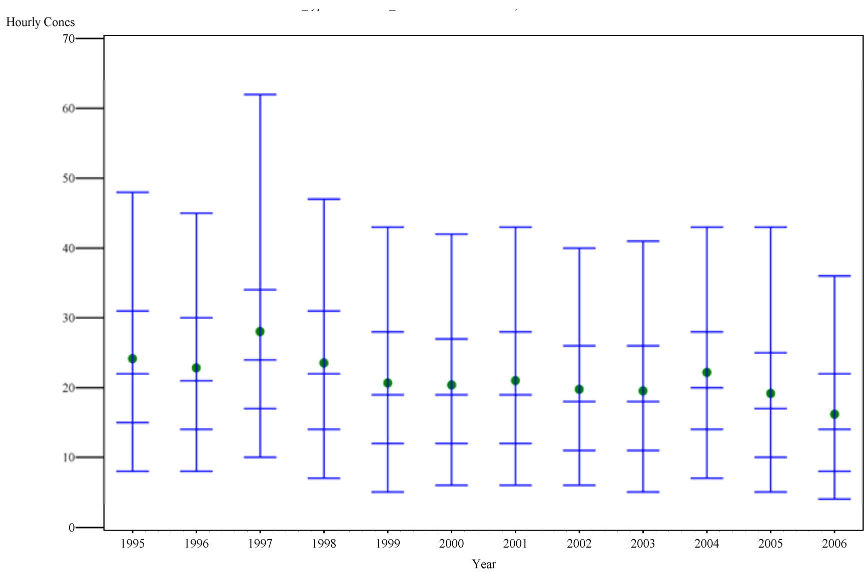

Figure A-22. Temporal distribution of hourly NO_2 ambient concentrations (ppb) by year, Cleveland CMSA.

Table A-22. Distribution of hourly NO_2 ambient concentrations (ppb) by year, Cleveland CMSA.

Year	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
1995	16042	24	13	53	2	10	13	16	19	22	25	29	34	41	108
1996	16593	23	12	52	1	9	13	15	18	21	24	28	32	39	148
1997	8300	28	17	59	0	12	15	18	21	24	28	32	38	49	253
1998	16680	24	13	53	0	9	13	16	19	22	25	29	33	40	89
1999	16743	21	12	58	0	7	10	13	16	19	22	26	30	37	86
2000	16399	20	11	55	0	8	10	13	16	19	22	25	30	36	74
2001	16566	21	12	56	0	8	10	13	16	19	22	26	30	37	103
2002	16464	20	11	56	1	8	10	12	15	18	21	24	28	35	88
2003	16948	20	11	57	0	7	10	13	15	18	20	24	28	35	90
2004	8484	22	11	51	0	10	13	15	18	20	23	26	30	37	83
2005	16558	19	12	60	0	7	9	12	14	17	20	23	28	35	85
2006	16853	16	10	64	0	5	8	10	12	14	16	20	24	30	175

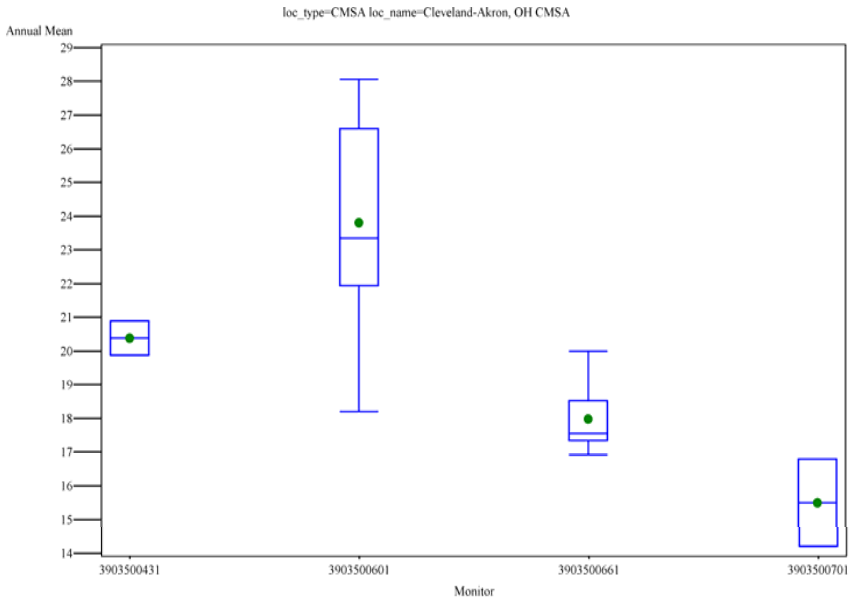

Figure A-23. Distribution of annual average NO_2 ambient concentration (ppb) by monitor, Cleveland CMSA, 1995-2006.

Table A-23. Distribution of annual average NO_2 ambient concentration (ppb) by monitor, Cleveland CMSA, 1995-2006.

Monitor ID	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
3903500431	2	20	1	4	20	20	20	20	20	20	21	21	21	21	21
3903500601	12	24	3	12	18	22	22	22	22	23	25	26	27	27	28
3903500661	6	18	1	6	17	17	17	17	17	18	18	19	19	20	20
3903500701	2	15	2	12	14	14	14	14	14	15	17	17	17	17	17

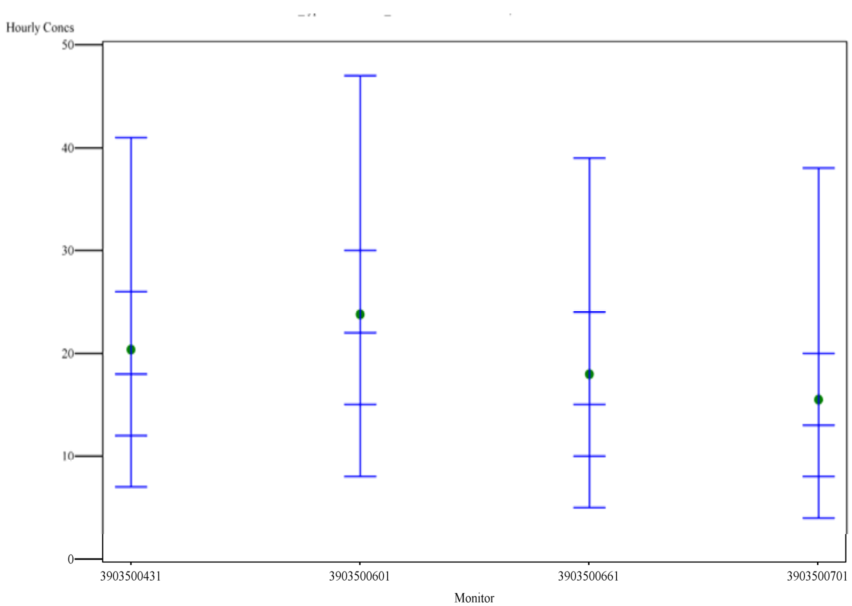

Figure A-24. Distribution of hourly NO_2 ambient concentration (ppb) by monitor, Cleveland CMSA, 1995-2006.

Table A-24. Distribution of hourly NO_2 ambient concentration (ppb) by monitor, Cleveland CMSA, 1995-2006.

Monitor ID	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
3903500431	16215	20	11	54	1	8	11	13	16	18	21	24	28	35	92
3903500601	99696	24	13	53	0	10	13	16	19	22	25	28	33	40	253
3903500661	50100	18	11	60	0	7	9	11	13	15	18	22	26	33	103
3903500701	16619	15	11	70	0	5	7	9	10	13	15	18	23	30	175

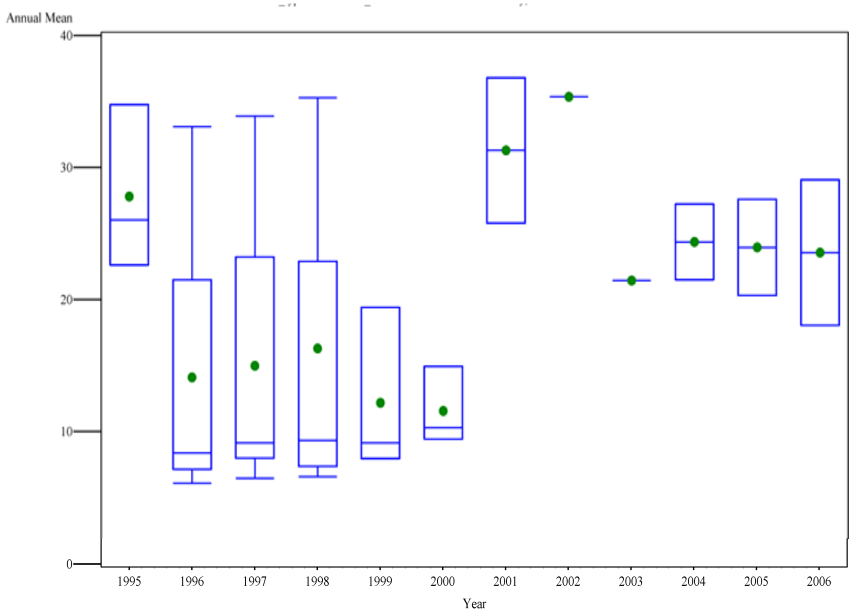

Figure A-25. Distribution of annual average NO_2 ambient concentrations (ppb) by year, Denver CMSA.

Table A-25. Temporal distribution of annual average NO_2 ambient concentrations (ppb) by year, Denver CMSA.

Year	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
1995	3	28	6	23	23	23	23	23	26	26	26	35	35	35	35
1996	6	14	11	77	6	6	7	7	8	8	9	22	22	33	33
1997	6	15	11	74	6	6	8	8	9	9	9	23	23	34	34
1998	5	16	13	77	7	7	7	7	8	9	16	23	29	35	35
1999	3	12	6	52	8	8	8	8	9	9	9	19	19	19	19
2000	3	12	3	26	9	9	9	9	10	10	10	15	15	15	15
2001	2	31	8	25	26	26	26	26	26	31	37	37	37	37	37
2002	1	35		0	35	35	35	35	35	35	35	35	35	35	35
2003	1	21		0	21	21	21	21	21	21	21	21	21	21	21
2004	2	24	4	17	21	21	21	21	21	24	27	27	27	27	27
2005	2	24	5	21	20	20	20	20	20	24	28	28	28	28	28
2006	2	24	8	33	18	18	18	18	18	24	29	29	29	29	29

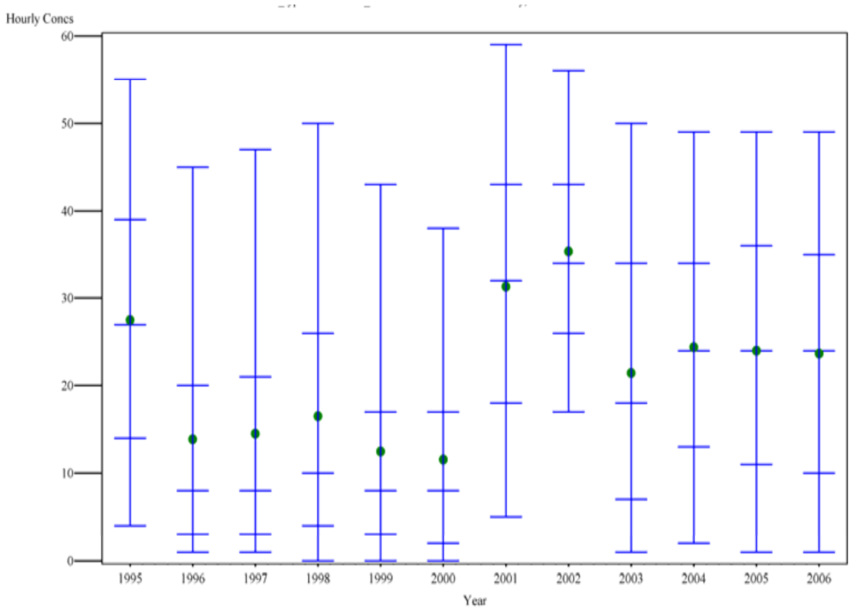

Figure A-26. Distribution of hourly NO_2 ambient concentrations (ppb) by year, Denver CMSA.

Table A-26. Temporal distribution of hourly NO_2 ambient concentrations (ppb) by year, Denver CMSA.

Year	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
1995	23204	28	17	62	0	6	11	16	22	27	32	36	41	48	286
1996	46816	14	15	108	0	1	2	4	6	8	11	16	25	37	137
1997	45049	15	15	106	0	1	3	4	6	8	12	17	26	39	141
1998	40258	17	17	100	0	1	3	5	7	10	15	22	31	42	148
1999	23164	12	13	108	0	0	2	4	6	8	10	14	21	33	96
2000	24649	12	13	108	0	0	1	3	5	8	10	14	19	30	141
2001	15204	31	17	55	0	8	15	21	27	32	36	41	45	52	157
2002	7688	35	13	36	0	20	24	28	31	34	38	41	45	51	159
2003	6989	21	17	78	0	3	5	8	13	18	25	31	37	44	136
2004	15878	24	15	60	0	4	10	16	20	24	28	32	37	43	115
2005	15467	24	16	65	0	3	8	14	19	24	29	33	38	44	114
2006	13775	24	15	65	0	3	7	13	19	24	28	33	38	44	169

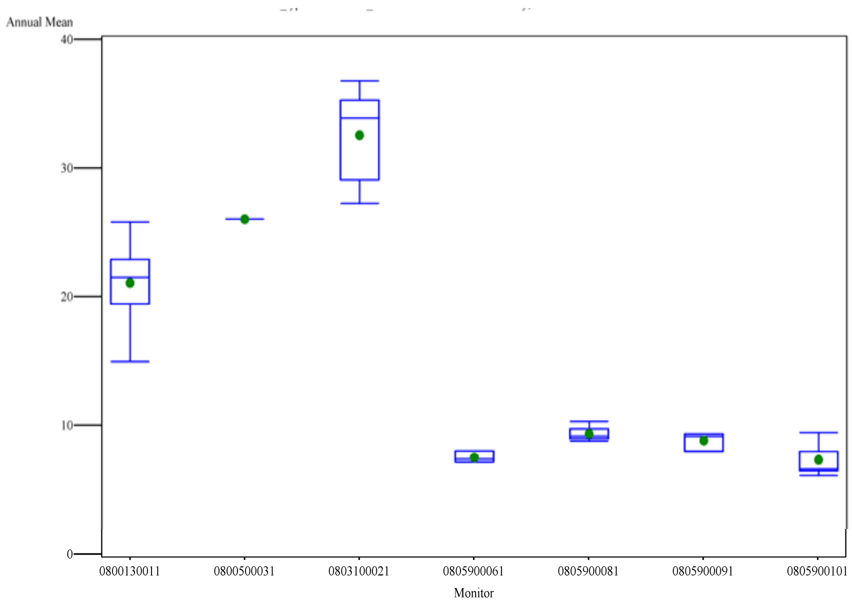

Figure A-27. Distribution of annual average NO_2 ambient concentration (ppb) by monitor, Denver CMSA, 1995-2006.

Table A-27. Distribution of annual average NO_2 ambient concentration (ppb) by monitor, Denver CMSA, 1995-2006.

Monitor ID	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
0800130011	11	21	3	14	15	18	19	20	21	21	22	23	23	23	26
0800500031	1	26			26	26	26	26	26	26	26	26	26	26	26
0803100021	9	33	4	11	27	27	28	29	33	34	35	35	35	37	37
0805900061	3	7	0	6	7	7	7	7	7	7	7	8	8	8	8
0805900081	4	9	1	7	9	9	9	9	9	9	9	9	10	10	10
0805900091	3	9	1	8	8	8	8	8	9	9	9	9	9	9	9
0805900101	5	7	1	19	6	6	6	6	7	7	7	8	9	9	9

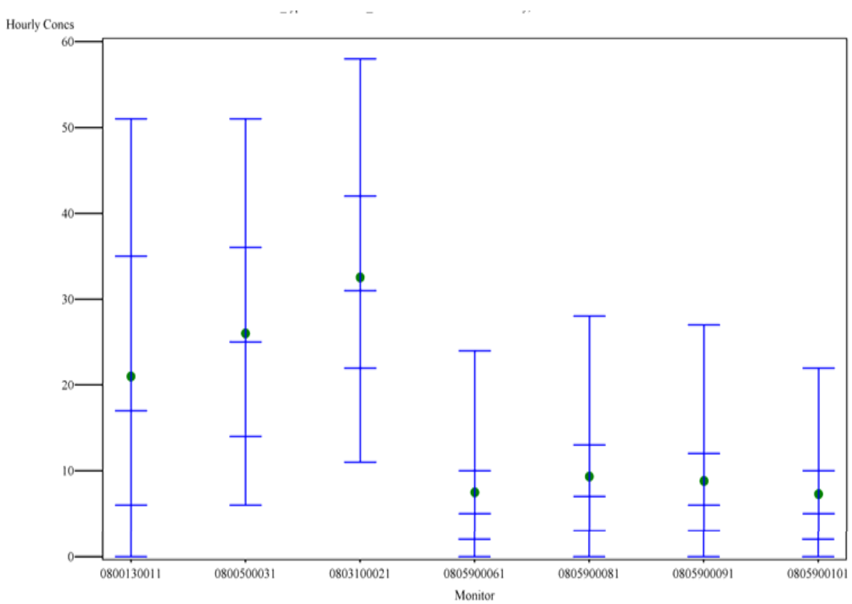

Figure A-28. Distribution of hourly NO_2 ambient concentration (ppb) by monitor, Denver CMSA, 1995-2006.

Table A-28. Distribution of hourly NO_2 ambient concentration (ppb) by monitor, Denver CMSA, 1995-2006.

Monitor ID	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
0800130011	83703	21	17	82	0	2	4	7	11	17	25	32	38	45	239
0800500031	7790	26	15	57	0	8	12	16	20	25	29	34	39	45	176
0803100021	68630	33	15	46	0	15	20	24	28	31	35	39	44	51	286
0805900061	22077	7	8	109	0	1	1	3	4	5	6	9	12	18	66
0805900081	32449	9	9	97	0	0	2	3	5	7	9	12	15	22	68
0805900091	24368	9	9	100	0	1	2	3	5	6	8	10	14	20	88
0805900101	39124	7	8	106	0	1	2	2	4	5	6	9	12	17	98

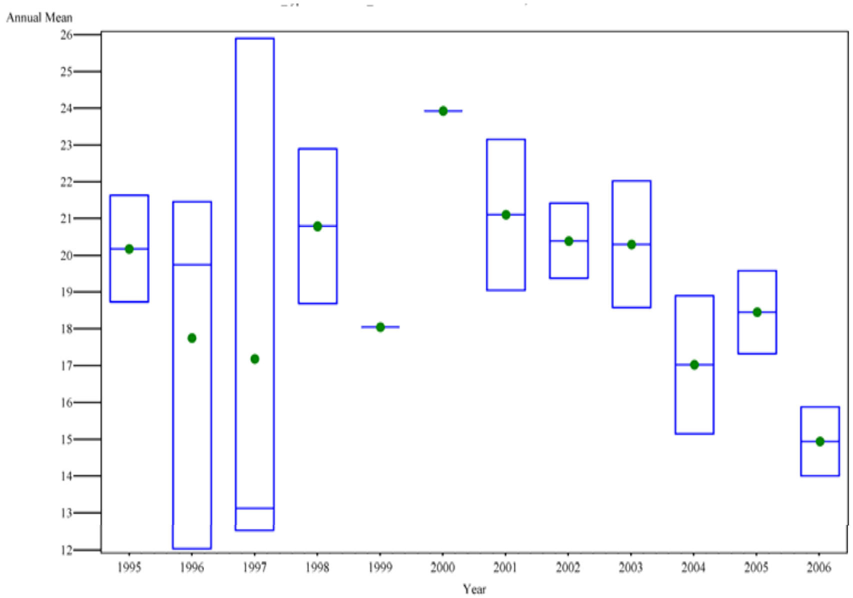

Figure A-29. Distribution of annual average NO_2 ambient concentrations (ppb) by year, Detroit CMSA.

Table A-29. Distribution of annual average NO_2 ambient concentrations (ppb) by year, Detroit CMSA.

Year	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
1995	2	20	2	10	19	19	19	19	19	20	22	22	22	22	22
1996	3	18	5	28	12	12	12	12	20	20	20	21	21	21	21
1997	3	17	8	44	13	13	13	13	13	13	13	26	26	26	26
1998	2	21	3	14	19	19	19	19	19	21	23	23	23	23	23
1999	1	18		0	18	18	18	18	18	18	18	18	18	18	18
2000	1	24		0	24	24	24	24	24	24	24	24	24	24	24
2001	2	21	3	14	19	19	19	19	19	21	23	23	23	23	23
2002	2	20	1	7	19	19	19	19	19	20	21	21	21	21	21
2003	2	20	2	12	19	19	19	19	19	20	22	22	22	22	22
2004	2	17	3	16	15	15	15	15	15	17	19	19	19	19	19
2005	2	18	2	9	17	17	17	17	17	18	20	20	20	20	20
2006	2	15	1	9	14	14	14	14	14	15	16	16	16	16	16

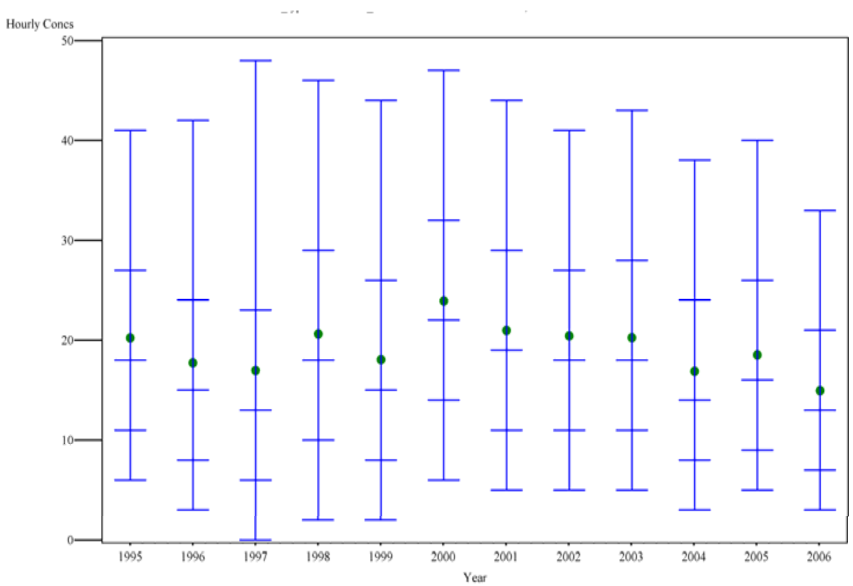

Figure A-30. Distribution of hourly NO_2 ambient concentrations (ppb) by year, Detroit CMSA.

Table A-30. Distribution of hourly NO_2 ambient concentrations (ppb) by year, Detroit CMSA.

Year	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
1995	16629	20	12	58	0	8	10	12	15	18	21	25	29	35	117
1996	23600	18	13	74	0	4	7	9	12	15	18	22	27	35	167
1997	24117	17	16	94	0	2	5	7	10	13	16	21	26	36	322
1998	14863	21	14	68	0	5	9	12	15	18	22	27	31	39	136
1999	7110	18	13	73	0	4	7	9	12	15	19	24	29	36	104
2000	8590	24	13	56	0	8	12	15	19	22	26	30	35	42	128
2001	15154	21	13	61	0	7	9	12	15	19	23	27	32	38	194
2002	16623	20	15	73	0	7	10	12	15	18	22	25	30	36	443
2003	16569	20	13	62	0	7	9	12	15	18	21	25	30	36	139
2004	14779	17	11	66	0	5	7	9	12	14	17	21	26	33	78
2005	15827	19	12	63	0	6	8	10	13	16	19	23	28	35	84
2006	17273	15	10	64	0	4	6	8	10	13	16	19	23	29	58

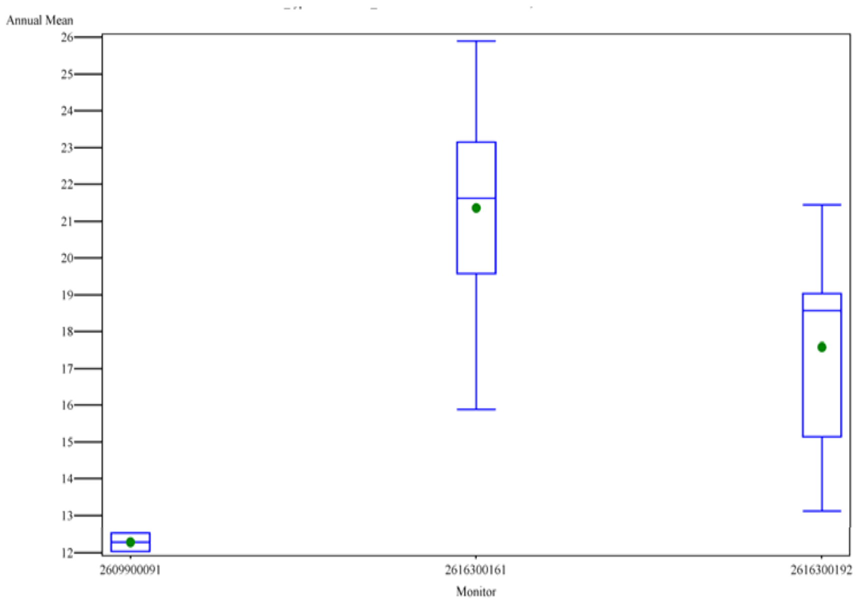

Figure A-31. Distribution of annual average NO_2 ambient concentration (ppb) by monitor, Detroit CMSA, 1995-2006.

Table A-31. Distribution of annual average NO_2 ambient concentration (ppb) by monitor, Detroit CMSA, 1995-2006.

Monitor ID	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
2609900091	2	12	0	3	12	12	12	12	12	12	13	13	13	13	13
2616300161	11	21	3	13	16	19	20	20	21	22	22	23	23	24	26
2616300192	11	18	3	14	13	14	15	17	18	19	19	19	19	19	21

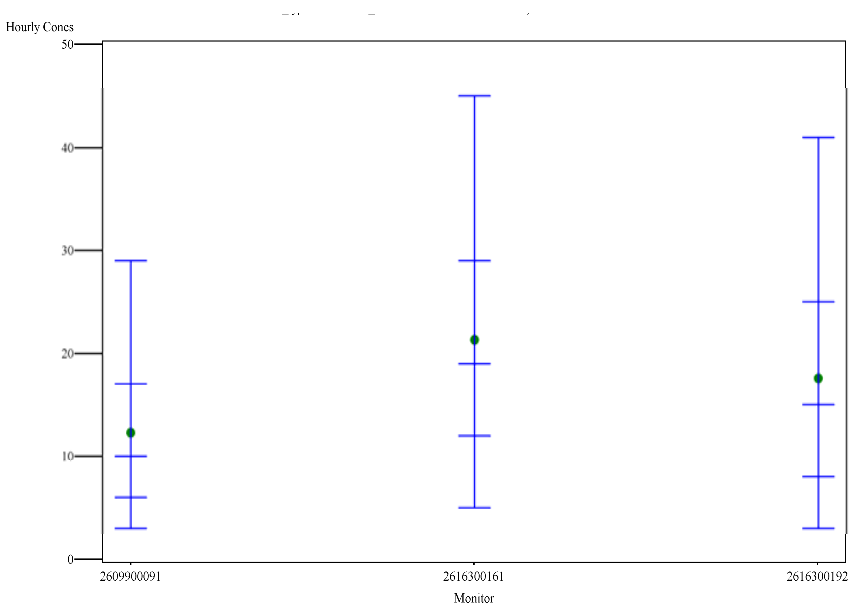

Figure A-32. Distribution of annual average NO_2 ambient concentration (ppb) by monitor, Detroit CMSA, 1995-2006.

Table A-32. Distribution of annual average NO_2 ambient concentration (ppb) by monitor, Detroit CMSA, 1995-2006.

Monitor ID	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
2609900091	16523	12	9	75	0	3	5	6	8	10	12	15	19	25	322
2616300161	86487	21	13	62	0	7	10	13	16	19	23	26	31	38	244
2616300192	88124	18	13	75	0	5	7	9	12	15	18	22	27	35	443

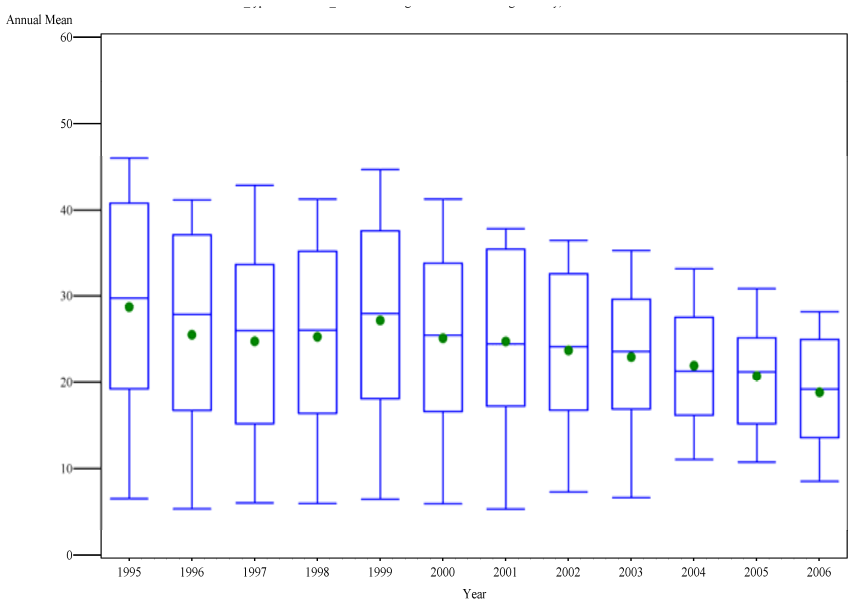

Figure A-33. Distribution of annual average NO_2 ambient concentrations (ppb) by year, Los Angeles CMSA.

Table A-33. Distribution of annual average NO_2 ambient concentrations (ppb) by year, Los Angeles CMSA.

Year	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
1995	36	29	13	47	5	8	18	20	23	30	37	39	45	46	46
1996	29	25	12	46	4	6	15	17	21	28	31	35	38	41	42
1997	33	25	12	47	4	8	14	16	20	26	29	33	34	42	43
1998	32	25	11	44	4	9	16	19	21	26	33	34	36	39	43
1999	31	27	12	44	5	10	18	20	23	28	32	35	39	39	51
2000	32	25	11	43	4	10	16	20	22	25	28	32	36	39	44
2001	31	25	11	43	4	9	17	19	24	24	27	33	36	37	41
2002	32	24	9	39	5	10	16	18	22	24	25	29	33	36	40
2003	32	23	9	37	5	11	15	18	21	24	26	29	31	34	35
2004	28	22	7	33	5	13	15	17	20	21	24	27	30	31	34
2005	28	21	7	34	5	12	14	16	19	21	22	25	27	31	31
2006	26	19	7	35	5	9	13	15	17	19	20	23	25	27	30

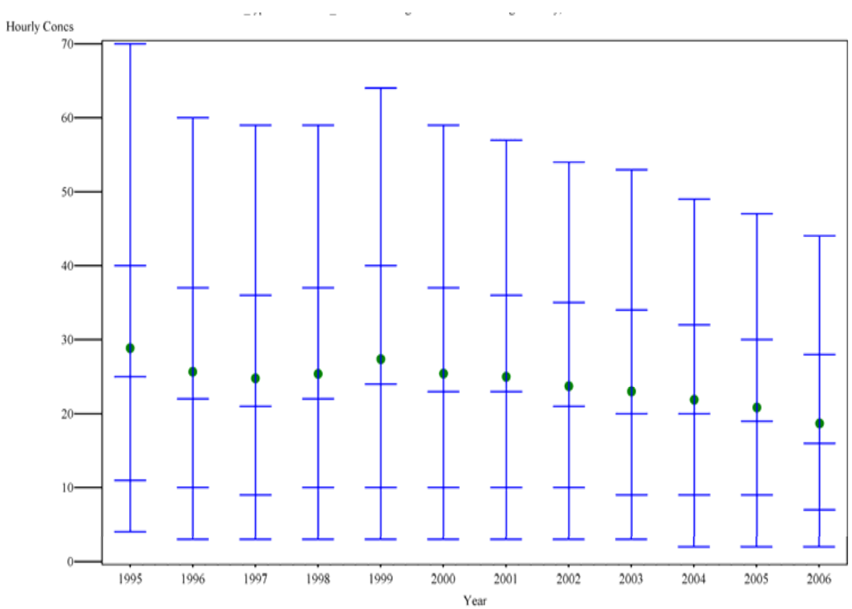

Figure A-34. Distribution of hourly NO_2 ambient concentrations (ppb) by year, Los Angeles CMSA.

Table A-34. Distribution of hourly NO_2 ambient concentrations (ppb) by year, Los Angeles CMSA.

Year	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
1995	290519	29	22	78	0	6	9	14	19	25	30	37	45	57	239
1996	232203	26	19	74	0	5	8	12	17	22	28	34	40	50	250
1997	263050	25	19	75	0	4	7	11	16	21	27	33	40	50	200
1998	257541	25	19	74	0	5	8	12	17	22	28	34	40	50	255
1999	253401	27	20	73	0	5	8	13	18	24	30	37	43	54	307
2000	263311	25	18	72	0	5	8	12	17	23	28	34	40	50	214
2001	251895	25	18	71	0	5	8	12	17	23	28	33	39	48	251
2002	258452	24	17	71	0	5	8	11	16	21	26	32	38	46	262
2003	259935	23	17	72	0	4	7	11	15	20	25	31	37	45	163
2004	225075	22	15	70	0	4	7	11	15	20	25	29	35	42	157
2005	227769	21	14	69	0	4	7	11	15	19	23	28	33	40	136
2006	184205	19	14	74	0	3	6	9	12	16	20	25	31	38	107

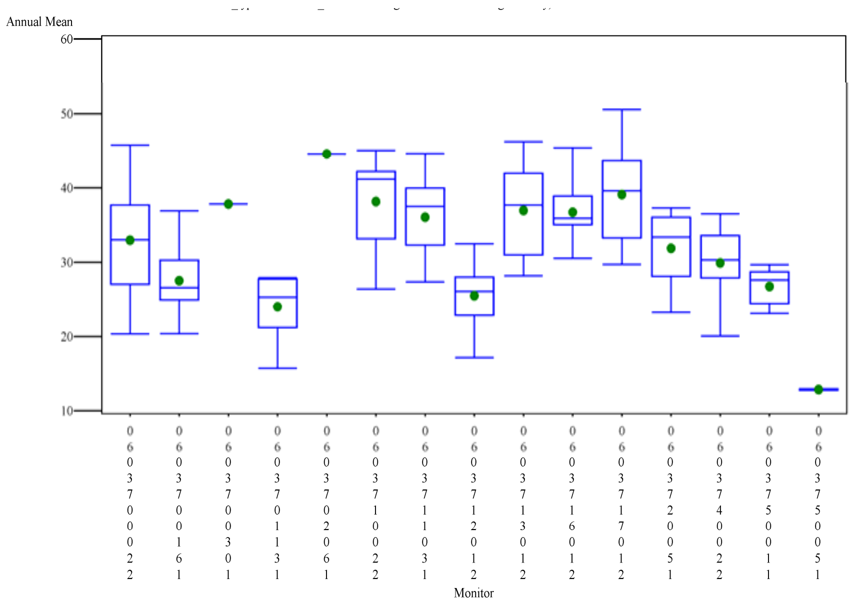

Figure A-35. Distribution of annual average NO_2 ambient concentration (ppb) by monitor, Los Angeles CMSA set A, 1995-2006.

Table A-35. Distribution of annual average NO_2 ambient concentration (ppb) by monitor, Los Angeles CMSA set A, 1995-2006.

Monitor ID	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
0603700022	12	33	7	22	20	25	25	29	33	33	36	36	39	41	46
0603700161	12	28	5	17	20	22	24	26	26	27	28	29	32	33	37
0603700301	1	38			38	38	38	38	38	38	38	38	38	38	38
0603701131	12	24	4	18	16	17	20	23	24	25	26	28	28	28	28
0603702061	1	45			45	45	45	45	45	45	45	45	45	45	45
0603710022	11	38	6	16	26	29	33	35	40	41	41	41	42	45	45
0603711031	11	36	6	16	27	27	32	33	34	37	39	39	40	43	45
0603712012	12	26	4	17	17	20	21	24	25	26	26	28	28	31	32
0603713012	12	37	6	16	28	30	31	31	36	38	39	41	43	43	46
0603716012	10	37	4	11	31	33	35	35	35	36	37	38	39	42	45
0603717012	12	39	7	17	30	31	31	35	36	40	43	43	44	46	51
0603720051	12	32	5	15	23	24	27	29	32	33	34	35	37	37	37
0603740022	11	30	5	16	20	24	28	29	29	30	32	33	34	34	37
0603750011	9	27	2	9	23	23	23	24	27	28	28	29	29	30	30
0603750051	2	13	0	1	13	13	13	13	13	13	13	13	13	13	13

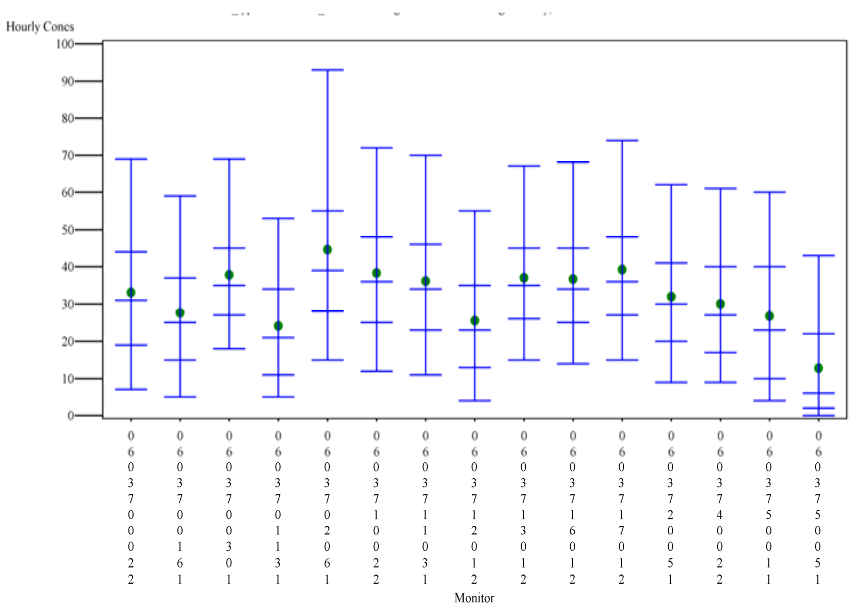

Figure A-36. Distribution of hourly NO_2 ambient concentration (ppb) by monitor, Los Angeles CMSA set A, 1995-2006.

Table A-36. Distribution of hourly NO_2 ambient concentration (ppb) by monitor, Los Angeles CMSA set A, 1995-2006.

Monitor ID	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
0603700022	97734	33	20	59	0	11	16	21	26	31	35	41	47	58	223
0603700161	97838	28	18	63	0	8	13	17	21	25	29	34	40	50	196
0603700301	6817	38	17	44	8	21	25	28	32	35	38	42	48	57	160
0603701131	97124	24	16	67	0	7	9	12	16	21	26	32	37	45	201
0603702061	7604	45	25	56	0	19	25	30	34	39	45	51	60	75	208
0603710022	88656	38	19	49	0	17	23	28	32	36	41	45	52	62	262
0603711031	88425	36	19	52	0	15	20	25	30	34	38	43	49	60	239
0603712012	96922	26	16	64	0	7	11	15	19	23	28	33	38	47	163
0603713012	97352	37	17	45	0	19	24	28	31	35	39	43	48	57	250
0603716012	81411	37	18	48	0	17	23	27	31	34	38	42	48	58	225
0603717012	98551	39	18	47	0	19	25	29	33	36	40	45	52	63	184
0603720051	98151	32	17	54	0	13	18	22	26	30	34	38	44	52	225
0603740022	88730	30	17	58	0	12	16	19	23	27	31	37	43	52	208
0603750011	74014	27	19	72	0	5	9	12	17	23	30	37	43	51	178
0603750051	15047	13	15	114	0	0	1	2	4	6	10	17	26	36	91

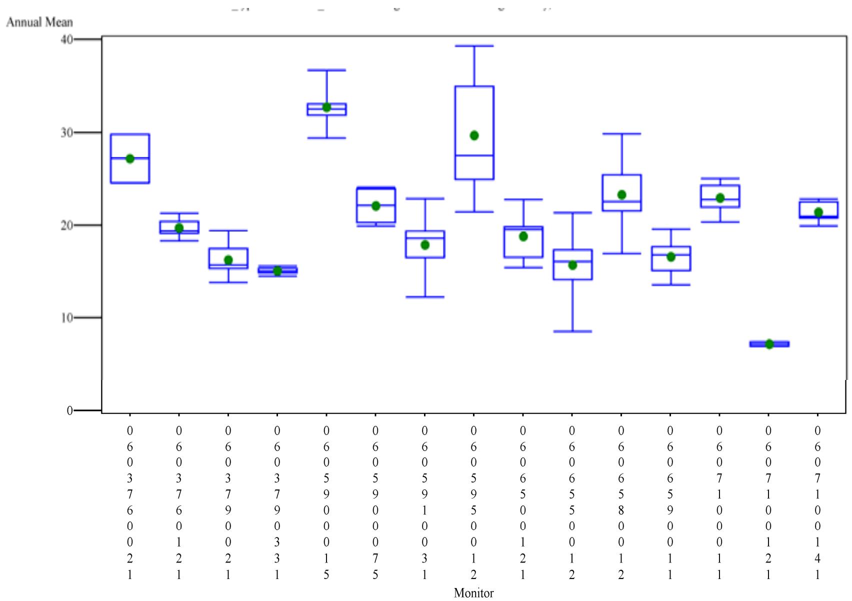

Figure A-37. Distribution of annual average NO_2 ambient concentration (ppb) by monitor, Los Angeles CMSA set B 1995-2006.

Table A-37. Distribution of annual average NO_2 ambient concentration (ppb) by monitor, Los Angeles CMSA set B, 1995-2006.

Monitor ID	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
0603760021	2	27	4	14	25	25	25	25	25	27	30	30	30	30	30
0603760121	5	20	1	6	18	18	19	19	19	19	20	20	21	21	21
0603790021	6	16	2	12	14	14	15	15	16	16	16	18	18	19	19
0603790331	5	15	0	3	15	15	15	15	15	15	15	15	15	16	16
0605900015	5	33	3	8	29	29	31	32	32	33	33	33	35	37	37
0605900075	4	22	2	10	20	20	20	21	21	22	24	24	24	24	24
0605910031	12	18	3	16	12	13	16	17	18	19	19	19	20	20	23
0605950012	11	30	6	19	21	25	25	25	27	28	33	34	35	35	39
0606500121	9	19	3	14	15	15	16	17	18	20	20	20	22	23	23
0606550012	12	16	3	22	9	12	13	15	16	16	16	17	18	20	21
0606580012	12	23	4	16	17	19	21	22	22	23	24	25	26	29	30
0606590011	12	17	2	11	14	14	15	15	17	17	17	18	18	19	20
0607100011	12	23	1	6	20	21	22	22	22	23	24	24	24	25	25
0607100121	2	7	0	5	7	7	7	7	7	7	7	7	7	7	7
0607100141	5	21	1	6	20	20	20	21	21	21	22	23	23	23	23

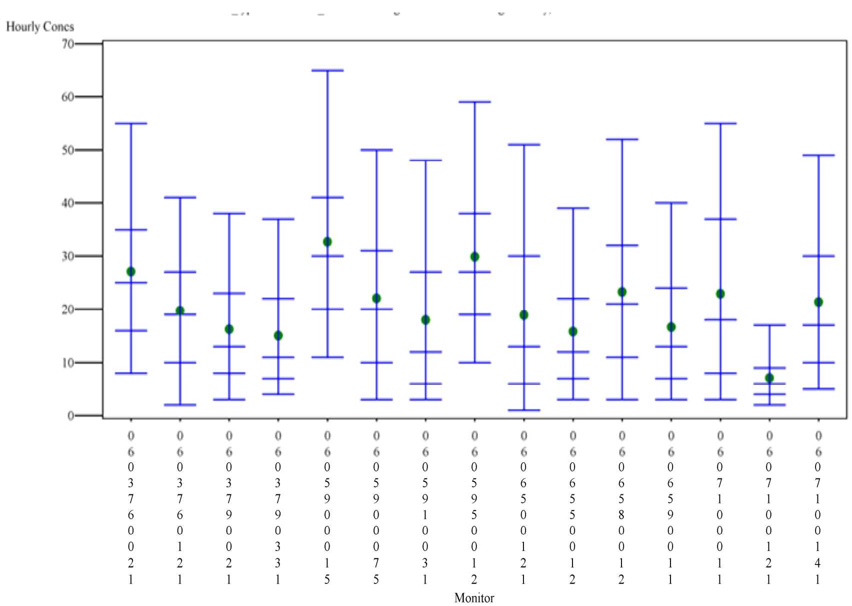

Figure A-38. Distribution of hourly NO_2 ambient concentration (ppb) by monitor, Los Angeles CMSA set B, 1995-2006.

Table A-38. Distribution of hourly NO_2 ambient concentration (ppb) by monitor, Los Angeles CMSA set B, 1995-2006.

Monitor ID	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
0603760021	16534	27	15	57	0	10	14	18	21	25	28	32	37	46	159
0603760121	39399	20	12	61	0	4	9	12	16	19	22	25	30	36	120
0603790021	46871	16	11	69	0	5	7	9	11	13	17	21	26	32	140
0603790331	40341	15	11	73	0	5	6	7	9	11	14	18	25	32	103
0605900015	40987	33	17	53	0	14	19	22	26	30	34	38	44	55	175
0605900075	33847	22	15	70	0	5	9	10	14	20	23	30	36	42	127
0605910031	97546	18	15	85	0	4	6	7	9	12	16	23	31	40	183
0605950012	88510	30	16	54	0	12	17	20	24	27	31	35	41	50	192
0606500121	69857	19	17	91	0	3	5	7	10	13	18	25	34	43	307
0606550012	95624	16	12	73	0	4	6	8	10	12	15	19	25	33	82
0606580012	95642	23	16	67	0	6	10	13	17	21	25	30	35	44	150
0606590011	95010	17	13	75	0	4	6	8	10	13	17	22	27	34	127
0607100011	94741	23	17	76	0	5	7	9	12	18	25	33	40	48	196
0607100121	14753	7	5	69	0	2	4	4	5	6	7	8	10	14	57
0607100141	39719	21	14	67	0	7	9	11	14	17	22	27	33	41	113

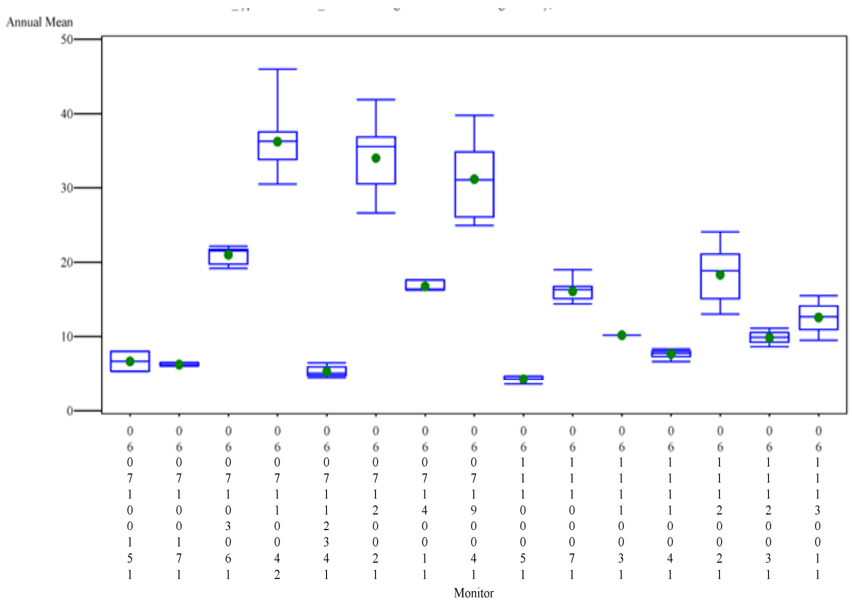

Figure A-39. Distribution of annual average NO_2 ambient concentration (ppb) by monitor, Los Angeles CMSA set C 1995-2006.

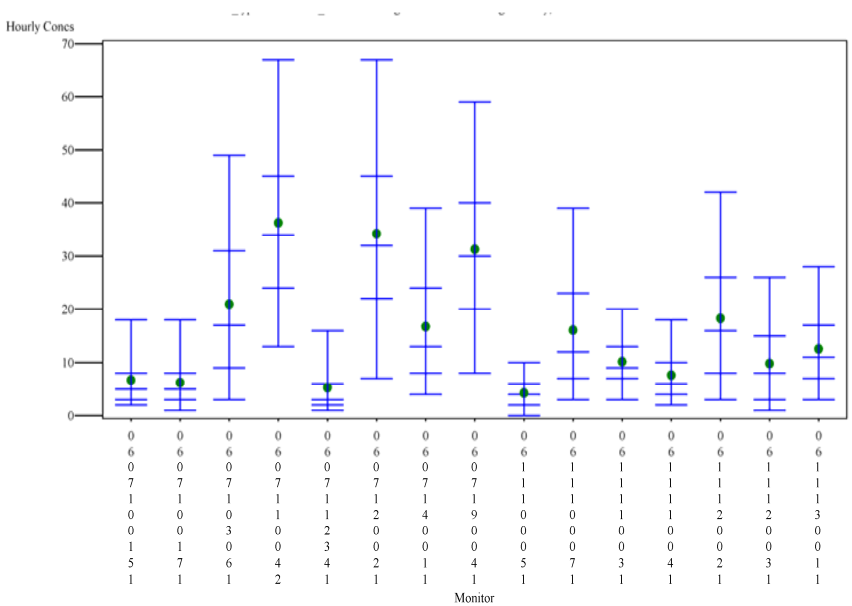

Figure A-40. Distribution of hourly NO_2 ambient concentration (ppb) by monitor, Los Angeles CMSA set C 1995-2006.

Table A-39. Distribution of annual average NO_2 ambient concentration (ppb) by monitor, Los Angeles CMSA set C, 1995-2006.

Monitor ID	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
0607100151	2	7	2	28	5	5	5	5	5	7	8	8	8	8	8
0607100171	3	6	0	4	6	6	6	6	6	6	6	7	7	7	7
0607103061	7	21	1	5	19	19	20	21	21	22	22	22	22	22	22
0607110042	11	36	4	12	31	31	34	34	36	36	37	38	38	39	46
0607112341	9	5	1	12	5	5	5	5	5	5	5	6	6	6	6
0607120021	12	34	5	13	27	27	30	31	33	36	36	36	38	38	42
0607140011	3	17	1	4	16	16	16	16	16	16	16	18	18	18	18
0607190041	12	31	5	16	25	26	26	26	29	31	33	34	35	38	40
0611100051	7	4	0	8	4	4	4	4	4	4	4	4	5	5	5
0611100071	9	16	1	9	14	14	14	15	16	16	16	17	17	19	19
0611110031	1	10			10	10	10	10	10	10	10	10	10	10	10
0611110041	7	8	1	7	7	7	7	8	8	8	8	8	8	8	8
0611120021	12	18	4	20	13	14	15	15	17	19	20	20	22	22	24
0611120031	9	10	1	8	9	9	9	9	9	10	10	11	11	11	11
0611130011	12	13	2	16	9	10	11	11	11	13	14	14	14	15	16

Table A-40. Distribution of hourly NO_2 ambient concentration (ppb) by monitor, Los Angeles CMSA set C, 1995-2006.

Monitor ID	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
0607100151	15531	7	6	82	0	2	3	3	4	5	6	7	10	14	60
0607100171	23713	6	5	84	0	2	3	3	4	5	6	7	9	13	73
0607103061	56831	21	15	70	0	5	8	11	13	17	22	28	34	42	100
0607110042	88766	36	17	48	0	17	22	26	30	34	38	43	49	58	199
0607112341	69325	5	5	103	0	1	2	2	3	3	4	5	7	12	62
0607120021	95054	34	18	54	0	12	19	24	28	32	37	42	48	58	170
0607140011	24587	17	11	68	0	6	7	9	11	13	16	21	27	34	86
0607190041	97785	31	16	51	0	12	18	22	26	30	33	38	43	51	162
0611100051	54034	4	4	89	0	0	1	3	3	4	5	5	6	8	81
0611100071	73031	16	12	74	0	4	6	8	10	12	16	20	26	33	123
0611110031	8240	10	5	52	0	4	6	7	8	9	10	12	14	16	61
0611110041	56869	8	5	66	0	3	4	5	6	6	7	9	11	14	66
0611120021	94238	18	13	70	0	4	7	9	12	16	19	24	29	36	124
0611120031	70332	10	8	85	0	1	2	4	6	8	10	13	17	21	93
0611130011	95263	13	8	65	0	4	6	7	9	11	13	15	18	23	127

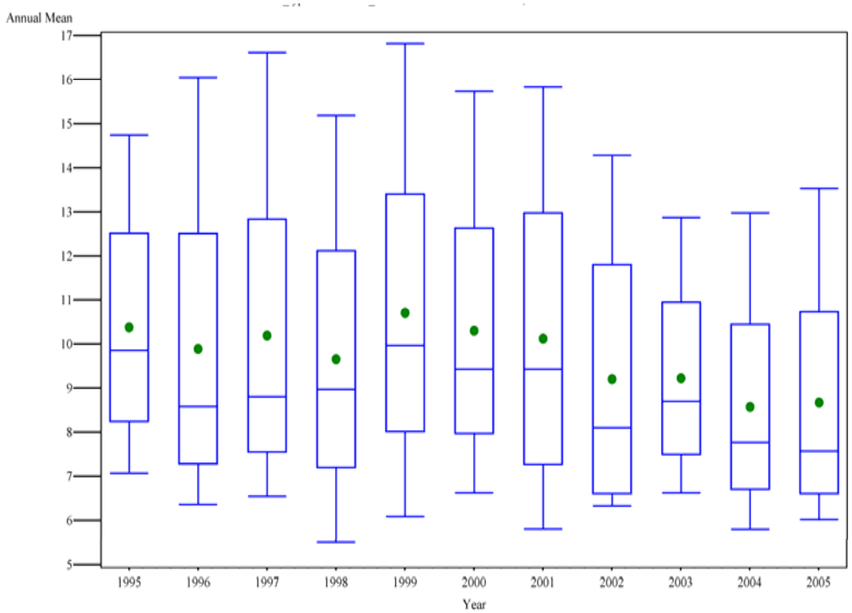

Figure A-41. Distribution of annual average NO_2 ambient concentrations (ppb) by year, Miami CMSA.

Table A-41. Distribution of annual average NO_2 ambient concentrations (ppb) by year, Miami CMSA.

Year	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
1995	4	10	3	31	7	7	7	9	9	10	10	10	15	15	15
1996	4	10	4	43	6	6	6	8	8	9	9	9	16	16	16
1997	4	10	4	43	7	7	7	9	9	9	9	9	17	17	17
1998	4	10	4	42	6	6	6	9	9	9	9	9	15	15	15
1999	4	11	4	42	6	6	6	10	10	10	10	10	17	17	17
2000	4	10	4	37	7	7	7	9	9	9	10	10	16	16	16
2001	4	10	4	42	6	6	6	9	9	9	10	10	16	16	16
2002	4	9	4	39	6	6	6	7	7	8	9	9	14	14	14
2003	4	9	3	29	7	7	7	8	8	9	9	9	13	13	13
2004	4	9	3	36	6	6	6	8	8	8	8	8	13	13	13
2005	4	9	3	38	6	6	6	7	7	8	8	8	14	14	14

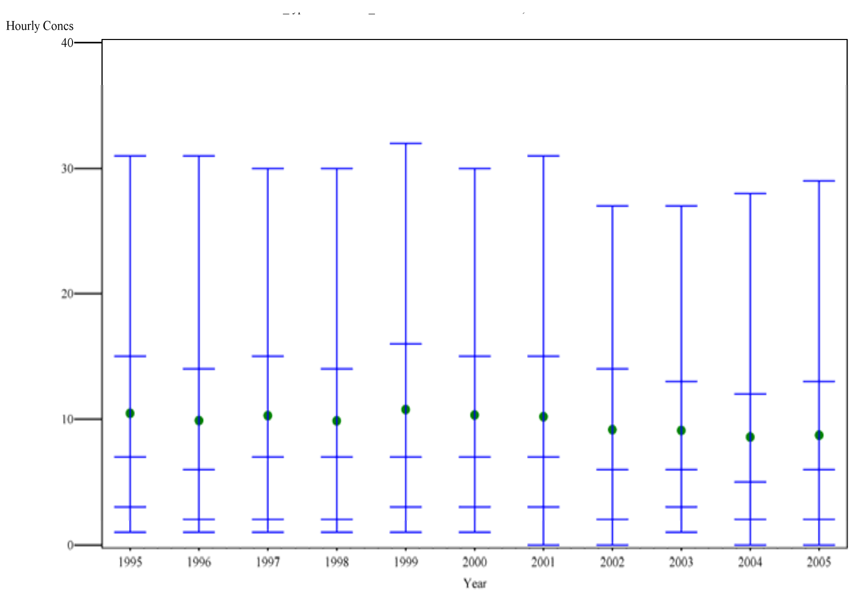

Figure A-42. Distribution of hourly NO_2 ambient concentrations (ppb) by year, Miami CMSA.

Table A-42. Distribution of hourly NO_2 ambient concentrations (ppb) by year, Miami CMSA.

Year	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
1995	32713	10	10	95	0	1	2	3	5	7	10	13	18	25	75
1996	33086	10	10	103	0	1	2	3	4	6	9	12	17	25	96
1997	32754	10	10	97	0	1	2	3	5	7	10	13	18	25	94
1998	30849	10	10	98	0	1	2	3	5	7	10	12	16	23	69
1999	32721	11	11	99	0	1	2	3	5	7	10	14	18	26	128
2000	31833	10	10	99	0	1	2	4	5	7	10	13	17	24	203
2001	33063	10	10	98	0	1	2	3	5	7	10	13	17	24	86
2002	33755	9	9	96	0	1	2	3	4	6	9	12	16	22	80
2003	31031	9	9	97	0	1	2	3	4	6	8	11	15	21	85
2004	33625	9	10	117	0	1	2	2	4	5	7	10	14	21	417
2005	32342	9	10	109	0	0	1	2	4	6	8	11	15	22	94

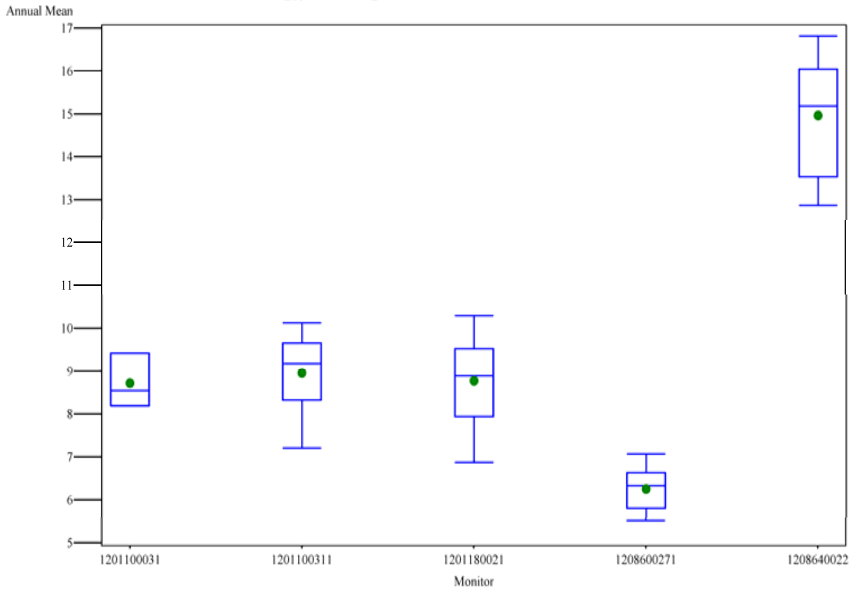

Figure A-43. Distribution of annual average NO_2 ambient concentration (ppb) by monitor, Miami CMSA, 1995-2006.

Table A-43. Distribution of annual average NO_2 ambient concentration (ppb) by monitor, Miami CMSA, 1995-2006.

Monitor ID	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
1201100031	3	9	1	7	8	8	8	8	9	9	9	9	9	9	9
1201100311	8	9	1	12	7	7	8	9	9	9	9	9	10	10	10
1201180021	11	9	1	11	7	8	8	8	9	9	9	9	10	10	10
1208600271	11	6	0	7	6	6	6	6	6	6	6	7	7	7	7
1208640022	11	15	1	9	13	13	14	14	15	15	16	16	16	17	17

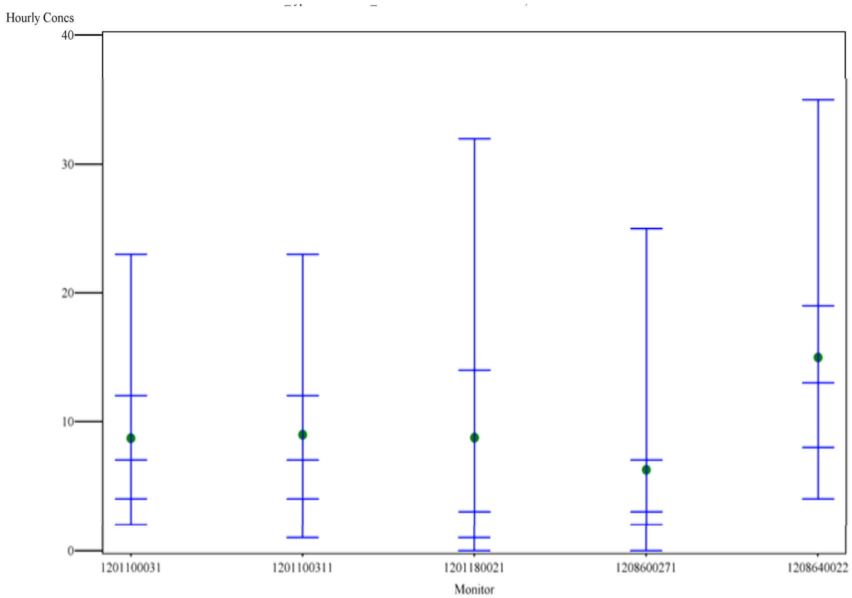

Figure A-44. Distribution of hourly NO_2 ambient concentration (ppb) by monitor, Miami CMSA, 1995-2006.

Table A-44. Distribution of hourly NO_2 ambient concentration (ppb) by monitor, Miami CMSA, 1995-2006.

Monitor ID	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
1201100031	24440	9	7	81	0	2	3	4	5	7	8	10	13	18	65
1201100311	63306	9	7	78	0	2	3	5	6	7	9	11	14	18	64
1201180021	92241	9	11	128	0	0	1	1	2	3	5	11	18	26	128
1208600271	87068	6	8	132	0	1	1	2	2	3	4	5	9	17	75
1208640022	90717	15	10	67	0	5	7	9	11	13	15	18	22	28	417

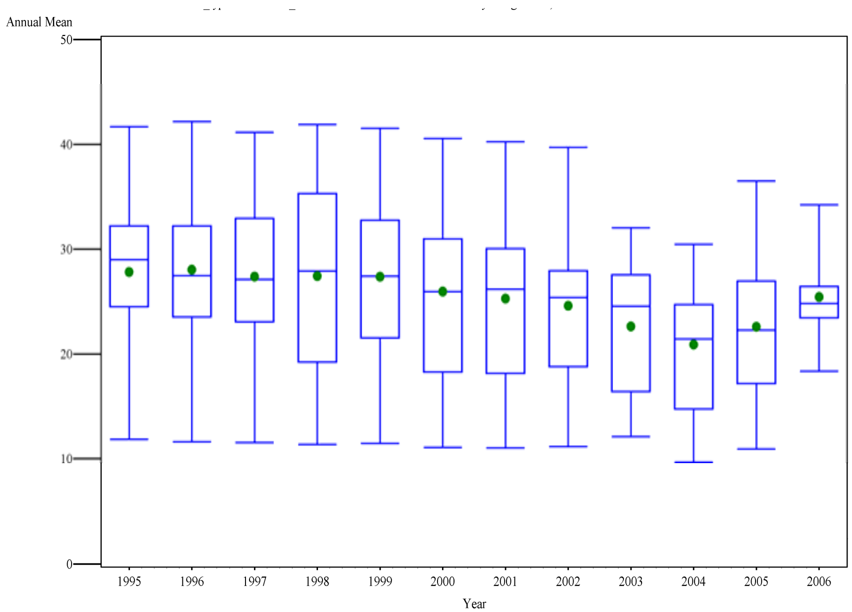

Figure A-45. Distribution of annual average NO_2 ambient concentrations (ppb) by year, New York CMSA.

Table A-45. Distribution of annual average NO_2 ambient concentrations (ppb) by year, New York CMSA.

Year	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
1995	16	28	8	28	12	16	24	25	26	29	30	31	33	39	42
1996	15	28	8	29	12	17	22	26	27	27	29	32	34	41	42
1997	16	27	8	30	12	17	23	24	26	27	29	31	35	40	41
1998	14	27	9	34	11	15	18	22	27	28	30	33	36	40	42
1999	16	27	9	31	11	17	19	24	26	27	29	33	33	41	42
2000	16	26	8	32	11	16	18	19	25	26	29	30	32	38	41
2001	14	25	8	32	11	17	17	21	24	26	27	27	31	38	40
2002	17	25	8	31	11	16	17	20	22	25	28	28	29	38	40
2003	15	23	6	28	12	14	16	18	21	25	26	27	29	30	32
2004	14	21	7	31	10	13	14	17	20	21	24	24	28	30	30
2005	16	23	7	31	11	13	16	18	22	22	25	27	27	32	36
2006	5	25	6	23	18	18	21	23	24	25	26	26	30	34	34

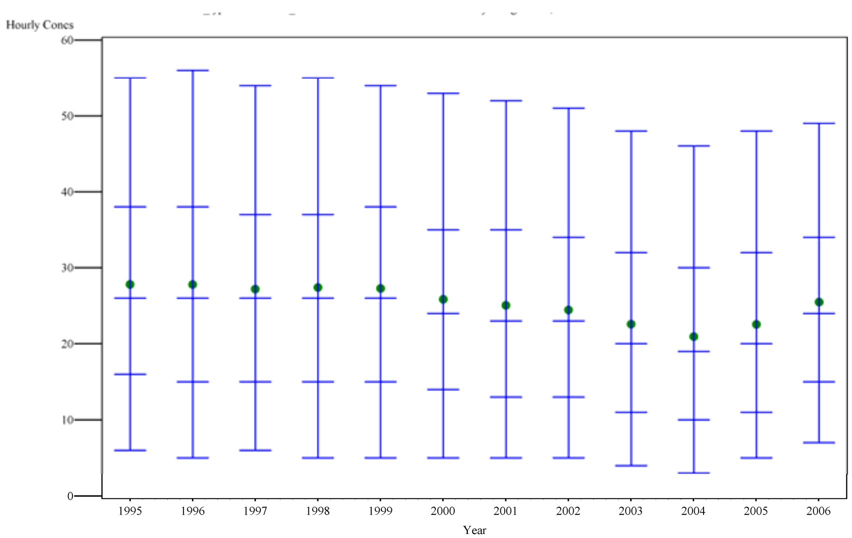

Figure A-46. Distribution of hourly NO_2 ambient concentrations (ppb) by year, New York CMSA.

Table A-46. Distribution of hourly NO_2 ambient concentrations (ppb) by year, New York CMSA.

Year	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
1995	133504	28	16	56	0	9	14	18	22	26	31	35	40	48	162
1996	122074	28	16	57	0	8	13	18	22	26	31	35	40	48	162
1997	131144	27	15	56	0	9	13	17	22	26	30	35	40	47	181
1998	116748	27	16	58	0	8	13	17	22	26	31	35	40	48	240
1999	132646	27	16	57	0	8	13	17	22	26	30	35	40	48	148
2000	134037	26	15	58	0	8	12	16	20	24	28	33	38	46	118
2001	114478	25	15	61	0	7	10	15	19	23	28	33	38	45	142
2002	141480	24	15	60	0	7	11	14	18	23	27	32	37	44	129
2003	122724	23	14	61	0	6	10	13	16	20	25	29	35	42	138
2004	115578	21	13	64	0	5	8	12	15	19	23	27	32	40	156
2005	133856	23	14	63	1	6	9	13	16	20	24	29	35	42	119
2006	42223	25	13	51	0	10	13	17	20	24	28	32	37	43	92

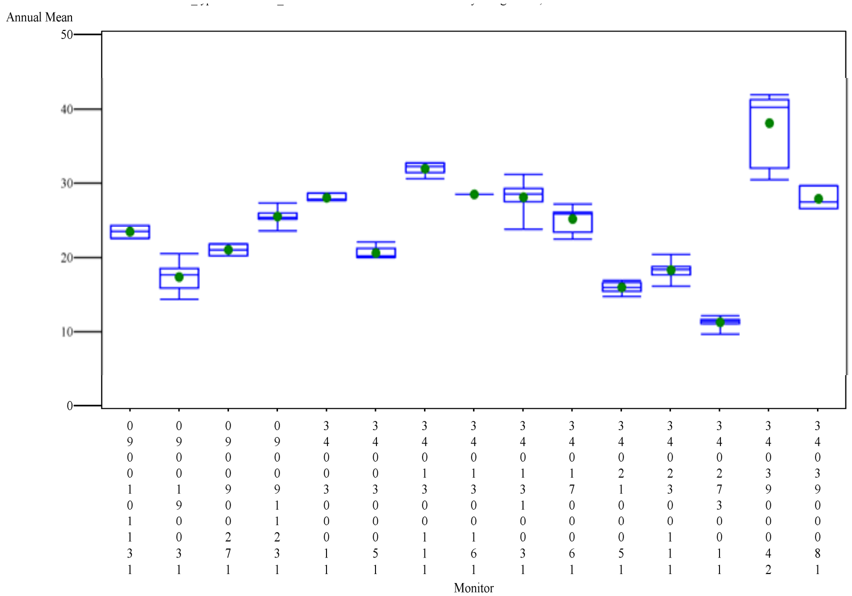

Figure A-47. Distribution of annual average NO_2 ambient concentration (ppb) by monitor, New York CMSA set a, 1995-2006.

Table A-47. Distribution of annual average NO_2 ambient concentration (ppb) by monitor, New York CMSA set A, 1995-2006.

Monitor ID	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
0900101131	3	23	1	4	23	23	23	23	24	24	24	24	24	24	24
0900190031	8	17	2	11	14	14	15	16	18	18	18	18	19	21	21
0900900271	2	21	1	5	20	20	20	20	20	21	22	22	22	22	22
0900911231	9	26	1	4	24	24	25	25	25	25	26	26	27	27	27
3400300011	3	28	1	2	28	28	28	28	28	28	28	29	29	29	29
3400300051	4	21	1	5	20	20	20	20	20	20	20	20	22	22	22
3401300111	5	32	1	3	31	31	31	31	32	32	32	33	33	33	33
3401300161	1	29			29	29	29	29	29	29	29	29	29	29	29
3401310031	11	28	2	7	24	26	27	28	28	29	29	29	29	29	31
3401700061	11	25	2	6	22	23	23	25	26	26	26	26	26	27	27
3402100051	11	16	1	4	15	15	15	16	16	16	16	17	17	17	17
3402300111	11	18	1	6	16	17	18	18	18	18	19	19	19	19	20
3402730011	11	11	1	6	10	11	11	11	11	11	11	12	12	12	12
3403900042	11	38	4	12	30	32	32	39	40	40	41	41	41	42	42
3403900081	3	28	2	6	27	27	27	27	27	27	27	30	30	30	30

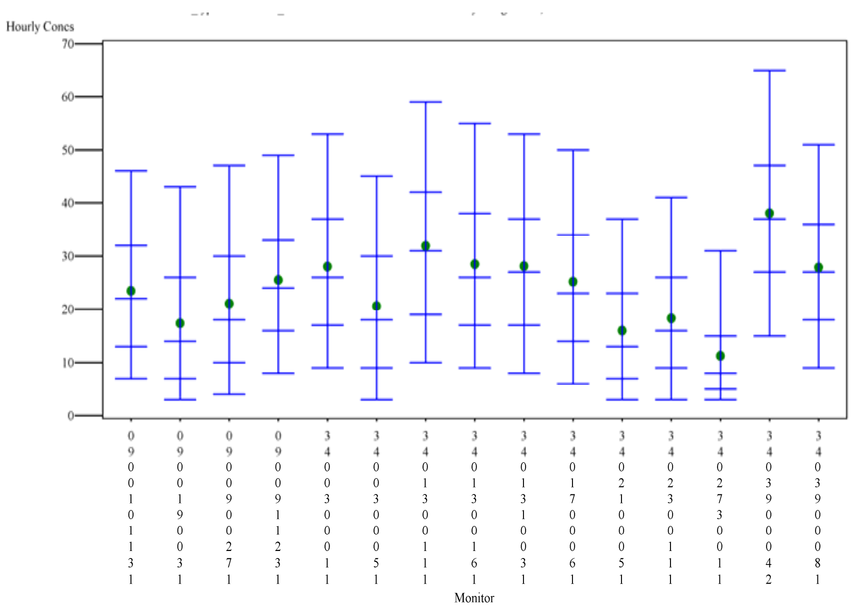

Figure A-48. Distribution of hourly NO_2 ambient concentration (ppb) by monitor, New York CMSA set a, 1995-2006.

Table A-48. Distribution of hourly NO_2 ambient concentration (ppb) by monitor, New York CMSA set A, 1995-2006.

Monitor ID	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
0900101131	25148	23	13	55	0	9	12	15	18	22	25	29	34	40	109
0900190031	67123	17	13	75	0	4	6	8	10	14	18	23	29	36	103
0900900271	16002	21	14	65	0	6	8	11	14	18	22	27	33	40	101
0900911231	76418	26	13	50	0	11	14	17	20	24	27	31	36	43	240
3400300011	25620	28	14	50	3	11	15	19	23	26	31	35	40	47	119
3400300051	34090	21	14	66	3	5	8	11	14	18	22	27	33	40	124
3401300111	41642	32	16	50	3	12	17	21	26	31	35	40	45	53	148
3401300161	8368	29	15	52	3	11	15	18	22	26	31	36	41	49	103
3401310031	93578	28	14	51	3	11	15	19	23	27	31	35	40	47	150
3401700061	93886	25	14	56	2	9	12	16	19	23	27	32	37	44	147
3402100051	94591	16	11	67	2	4	7	8	11	13	16	20	25	32	79
3402300111	94366	18	12	65	3	5	8	10	13	16	19	23	28	35	99
3402730011	92642	11	9	82	0	3	3	5	7	8	10	13	17	24	95
3403900042	92472	38	15	41	3	19	25	29	33	37	41	45	50	58	225
3403900081	23611	28	13	47	3	11	16	20	24	27	30	34	38	44	122

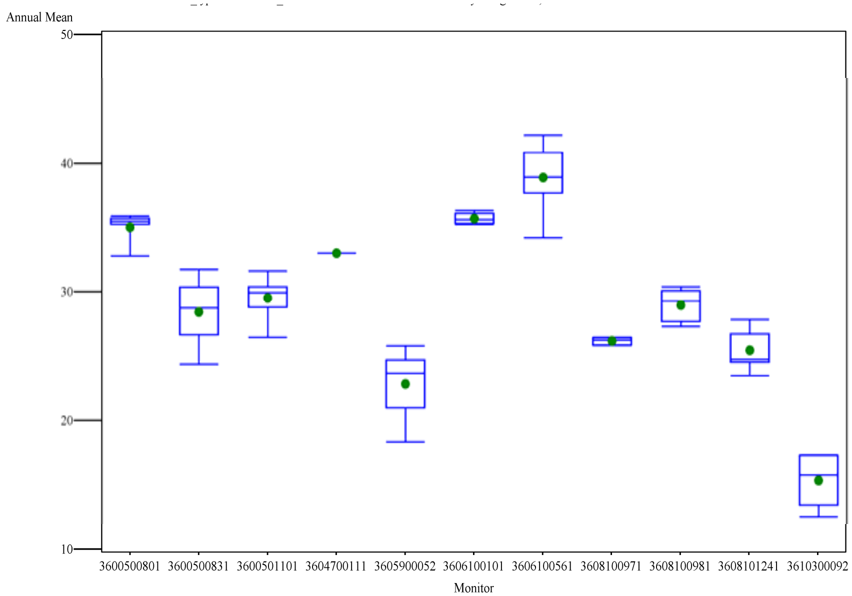

Figure A-49. Distribution of annual average NO_2 ambient concentration (ppb) by monitor, New York CMSA set b, 1995-2006.

Table A-49. Distribution of annual average NO_2 ambient concentration (ppb) by monitor, New York CMSA set B, 1995-2006.

Monitor ID	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
3600500801	5	35	1	4	33	33	34	35	35	35	36	36	36	36	36
3600500831	12	28	2	9	24	25	27	27	28	29	30	30	31	31	32
3600501101	6	30	2	6	26	26	29	29	30	30	30	30	30	32	32
3604700111	1	33			33	33	33	33	33	33	33	33	33	33	33
3605900052	11	23	2	10	18	20	21	22	22	24	24	24	25	25	26
3606100101	4	36	1	1	35	35	35	35	35	36	36	36	36	36	36
3606100561	10	39	2	6	34	35	37	38	38	39	40	40	41	42	42
3608100971	3	26	0	1	26	26	26	26	26	26	26	26	26	26	26
3608100981	7	29	1	4	27	27	28	28	28	29	30	30	30	30	30
3608101241	5	25	2	7	23	23	24	25	25	25	26	27	27	28	28
3610300092	6	15	2	14	13	13	13	13	14	16	17	17	17	17	17

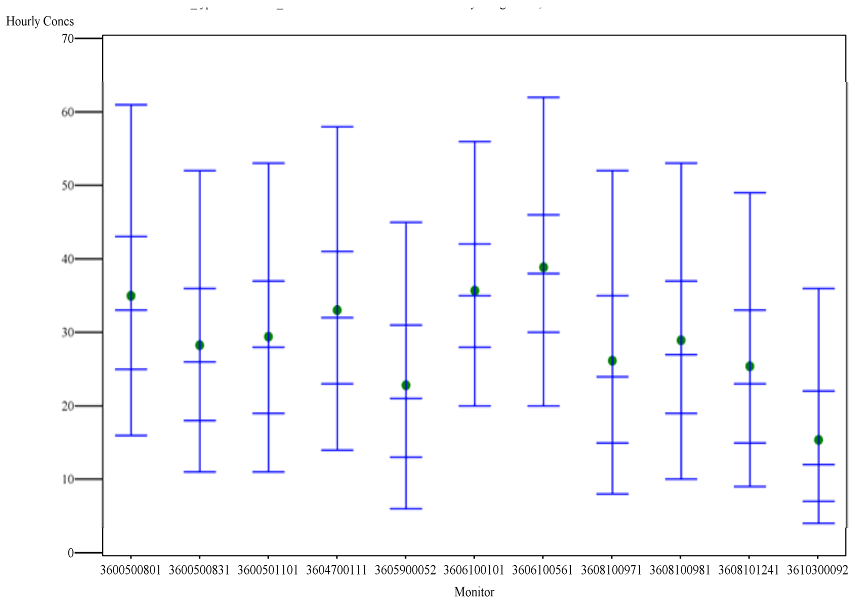

Figure A-50. Distribution of hourly NO_2 ambient concentration (ppb) by monitor, New York CMSA set b, 1995-2006.

Table A-50. Distribution of hourly NO_2 ambient concentration (ppb) by monitor, New York CMSA set B, 1995-2006.

3600500801	41120	35	14	40	0	19	23	26	30	33	37	40	45	54	181
3600500831	95448	28	13	47	0	13	17	20	23	26	30	34	39	46	136
3600501101	46299	29	13	45	0	14	18	21	24	28	31	35	40	47	119
3604700111	8300	33	14	41	3	17	21	25	28	32	35	39	43	51	155
3605900052	89801	23	13	56	0	8	11	14	18	21	25	29	34	40	162
3606100101	30694	36	11	31	0	23	27	29	32	35	37	40	44	50	118
3606100561	81341	39	13	33	0	24	28	32	35	38	41	44	48	55	162
3608100971	24104	26	14	54	0	10	13	17	20	24	28	33	38	45	95
3608100981	56186	29	13	46	0	13	17	20	24	27	31	35	40	47	114
3608101241	39406	25	13	50	0	11	14	17	20	23	27	31	36	43	144
3610300092	48236	15	10	67	0	5	7	8	10	12	15	19	24	31	86

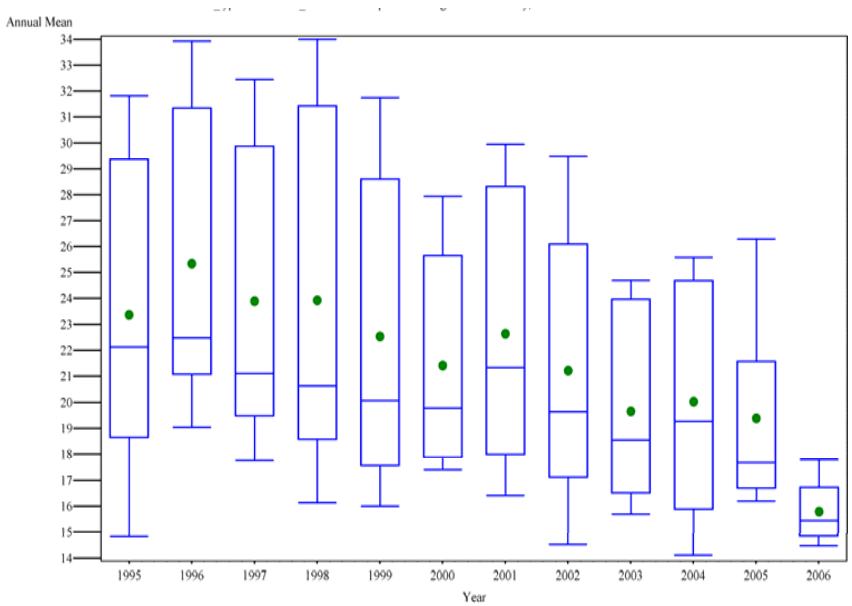

Figure A-51. Distribution of annual average NO_2 ambient concentrations (ppb) by year, Philadelphia CMSA.

Table A-51. Distribution of annual average NO_2 ambient concentrations (ppb) by year, Philadelphia CMSA.

Year	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
1995	8	23	6	27	15	15	17	20	20	22	24	28	31	32	32
1996	8	25	6	24	19	19	21	21	21	22	24	29	33	34	34
1997	8	24	6	25	18	18	19	20	20	21	22	28	32	32	32
1998	8	24	7	30	16	16	18	19	19	21	22	29	33	34	34
1999	8	23	6	28	16	16	17	18	18	20	22	27	30	32	32
2000	6	21	4	20	17	17	18	18	19	20	20	26	26	28	28
2001	7	23	5	24	16	16	18	19	19	21	26	26	28	30	30
2002	8	21	5	26	15	15	16	18	19	20	20	24	28	29	29
2003	6	20	4	19	16	16	17	17	18	19	19	24	24	25	25
2004	7	20	4	22	14	14	16	18	18	19	23	23	25	26	26
2005	7	19	4	19	16	16	17	17	17	18	20	20	22	26	26
2006	4	16	1	9	14	14	14	15	15	15	16	16	18	18	18

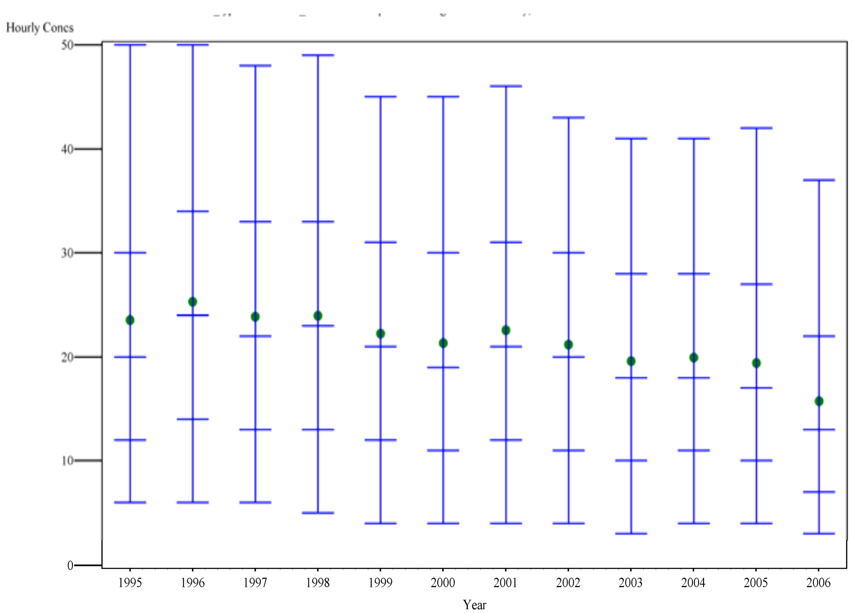

Figure A-52. Distribution of hourly NO_2 ambient concentrations (ppb) by year, Philadelphia CMSA.

Table A-52. Distribution of hourly NO_2 ambient concentrations (ppb) by year, Philadelphia CMSA.

Year	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
1995	65415	24	14	60	0	8	10	14	19	20	26	30	35	40	140
1996	67989	25	14	55	0	8	11	17	20	24	30	30	40	42	100
1997	68291	24	14	57	0	8	11	15	19	22	26	30	35	42	247
1998	66847	24	14	58	0	7	11	15	19	23	27	31	36	42	97
1999	64813	22	13	59	0	6	10	14	17	21	25	29	33	40	109
2000	51145	21	13	60	0	6	10	13	16	19	23	27	32	39	97
2001	59227	23	13	59	0	6	10	14	17	21	25	29	34	40	96
2002	66779	21	12	59	0	6	10	13	16	20	23	27	32	38	268
2003	49256	20	12	62	0	5	8	11	15	18	22	26	30	36	105
2004	58509	20	12	59	0	6	9	12	15	18	22	26	30	36	101
2005	56459	19	12	62	0	6	9	11	14	17	21	25	29	36	120
2006	32357	16	11	69	0	4	6	8	10	13	16	20	25	31	95

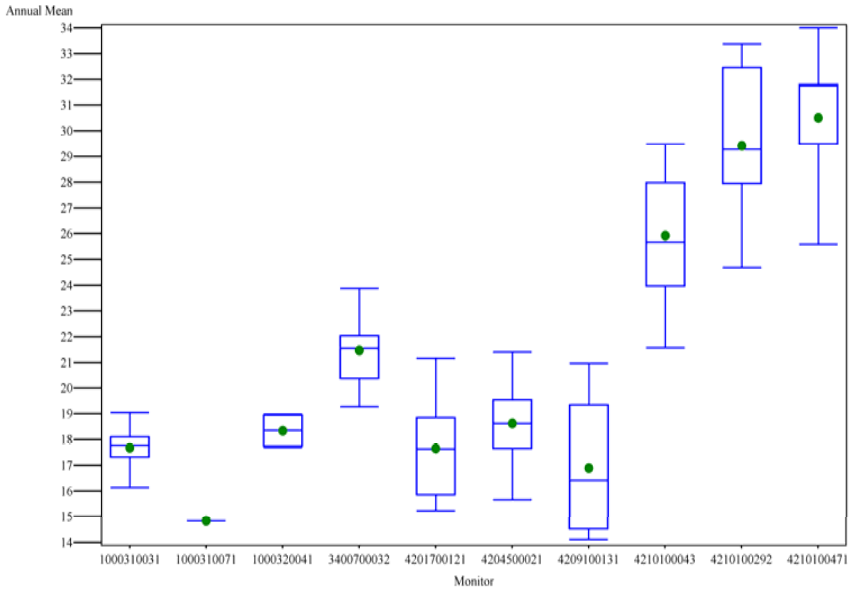

Figure A-53. Distribution of annual average NO_2 ambient concentration (ppb) by monitor, Philadelphia CMSA, 1995-2006.

Table A-53. Distribution of annual average NO_2 ambient concentration (ppb) by monitor, **Philadelphia** CMSA, 1995-2006.

Monitor ID	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
1000310031	5	18	1	6	16	16	17	17	18	18	18	18	19	19	19
1000310071	1	15			15	15	15	15	15	15	15	15	15	15	15
1000320041	4	18	1	4	18	18	18	18	18	18	19	19	19	19	19
3400700032	10	21	1	7	19	20	20	20	21	22	22	22	23	24	24
4201700121	12	18	2	11	15	16	16	16	17	18	18	18	20	20	21
4204500021	12	19	2	8	16	17	17	18	18	19	19	19	20	20	21
4209100131	11	17	2	13	14	14	15	16	16	16	17	18	19	19	21
4210100043	11	26	3	10	22	23	24	24	26	26	27	28	28	29	29
4210100292	10	29	3	11	25	25	26	28	28	29	31	32	33	33	33
4210100471	9	31	3	10	26	26	26	29	30	32	32	32	34	34	34

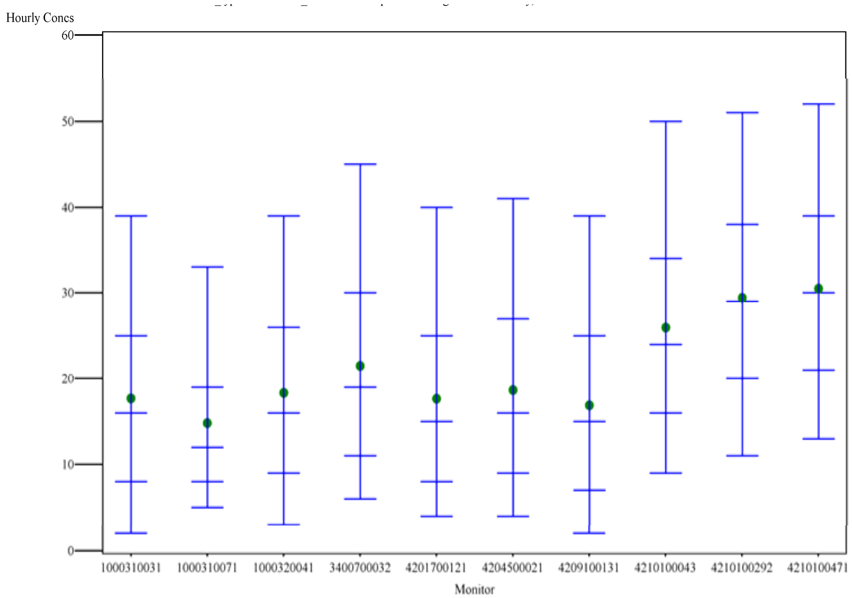

Figure A-54. Distribution of hourly NO_2 ambient concentration (ppb) by monitor, Philadelphia CMSA, 1995-2006.

Table A-54. Distribution of hourly NO_2 ambient concentration (ppb) by monitor, Philadelphia CMSA, 1995-2006.

Monitor ID	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
1000310031	40363	18	12	69	0	4	7	10	12	16	19	23	28	34	247
1000310071	6611	15	9	62	1	6	7	9	10	12	15	17	21	28	69
1000320041	31615	18	12	63	0	5	8	11	13	16	20	23	28	34	115
3400700032	84603	22	13	59	3	7	10	13	16	19	23	27	32	39	114
4201700121	102584	18	12	67	0	5	7	9	12	15	19	23	28	34	106
4204500021	100344	19	12	64	0	5	8	10	13	16	20	24	29	36	268
4209100131	93572	17	12	69	0	4	6	9	11	15	18	22	27	33	99
4210100043	90975	26	13	49	0	10	14	18	20	24	28	31	37	43	190
4210100292	81218	29	13	43	0	15	19	21	25	29	30	35	40	46	120
4210100471	75202	31	12	40	0	16	20	23	26	30	31	36	40	47	140

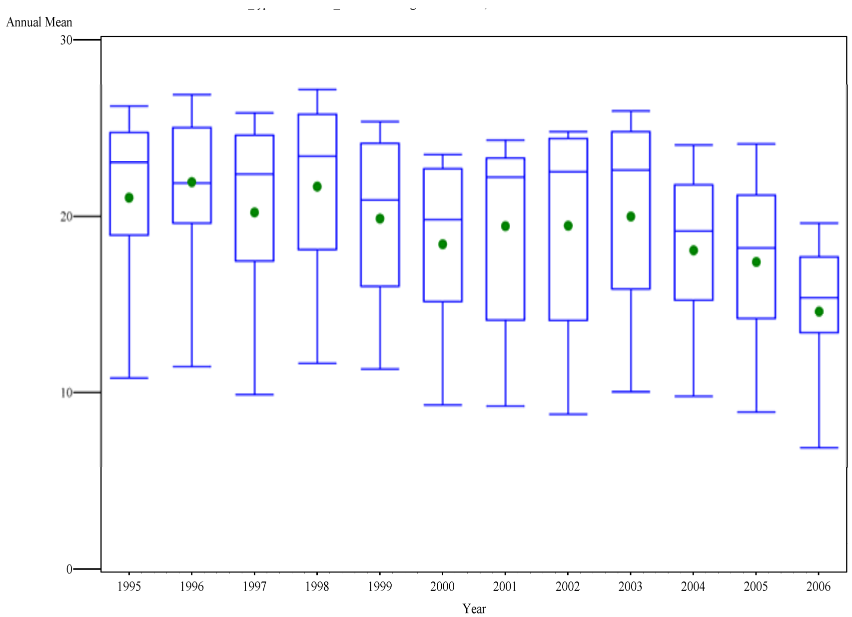

Figure A-55. Distribution of annual average NO_2 ambient concentrations (ppb) by year, Washington DC CMSA.

Table A-55. Distribution of annual average NO_2 ambient concentrations (ppb) by year, Washington DC CMSA.

Year	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
1995	12	21	5	25	11	11	19	19	22	23	23	25	25	26	26
1996	11	22	4	20	11	20	20	21	22	22	24	24	25	26	27
1997	11	20	5	27	10	11	17	19	21	22	22	24	25	26	26
1998	11	22	5	23	12	15	18	20	22	23	24	25	26	26	27
1999	12	20	5	25	11	12	14	18	20	21	23	24	24	25	25
2000	12	18	5	27	9	10	13	17	18	20	21	23	23	23	23
2001	11	19	5	28	9	11	14	19	20	22	23	23	23	24	24
2002	10	19	6	31	9	10	13	16	20	23	23	24	25	25	25
2003	11	20	6	28	10	12	16	18	18	23	23	23	25	26	26
2004	12	18	5	27	10	10	15	15	17	19	21	21	22	23	24
2005	12	17	5	28	9	10	14	15	17	18	21	21	21	22	24
2006	10	15	4	30	7	7	10	14	15	15	16	17	18	19	20

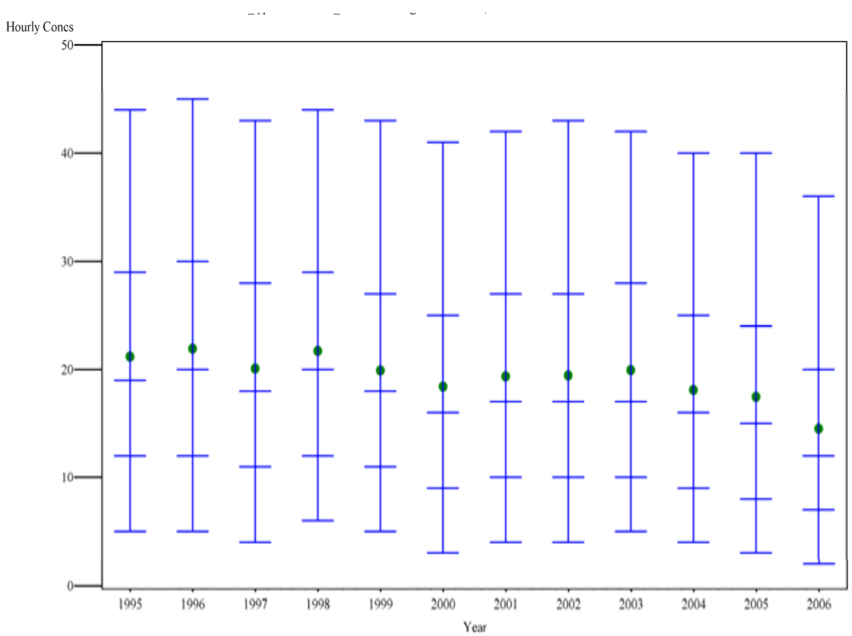

Figure A-56. Distribution of hourly NO_2 ambient concentrations (ppb) by year, Washington DC CMSA.

Table A-56. Distribution of hourly NO_2 ambient concentrations (ppb) by year, Washington DC CMSA.

Year	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
1995	98349	21	13	59	0	7	10	13	16	19	23	27	31	38	145
1996	91551	22	12	57	0	7	11	14	17	20	24	28	32	39	107
1997	87646	20	12	62	0	6	9	12	15	18	21	25	30	37	155
1998	89335	22	12	57	0	8	11	14	16	20	23	27	32	38	285
1999	100112	20	12	61	0	6	9	12	15	18	21	25	30	37	114
2000	101494	18	12	64	0	5	8	11	13	16	19	23	28	35	141
2001	91594	19	12	62	0	6	9	11	14	17	20	24	29	36	89
2002	83969	19	12	64	0	6	9	11	14	17	20	24	30	37	108
2003	93111	20	12	61	0	6	9	12	14	17	21	25	30	37	102
2004	99370	18	11	63	0	5	8	10	13	16	19	23	28	34	115
2005	96396	17	12	68	0	5	7	10	12	15	18	22	27	34	115
2006	83691	15	11	73	0	4	6	7	9	12	14	18	23	30	129

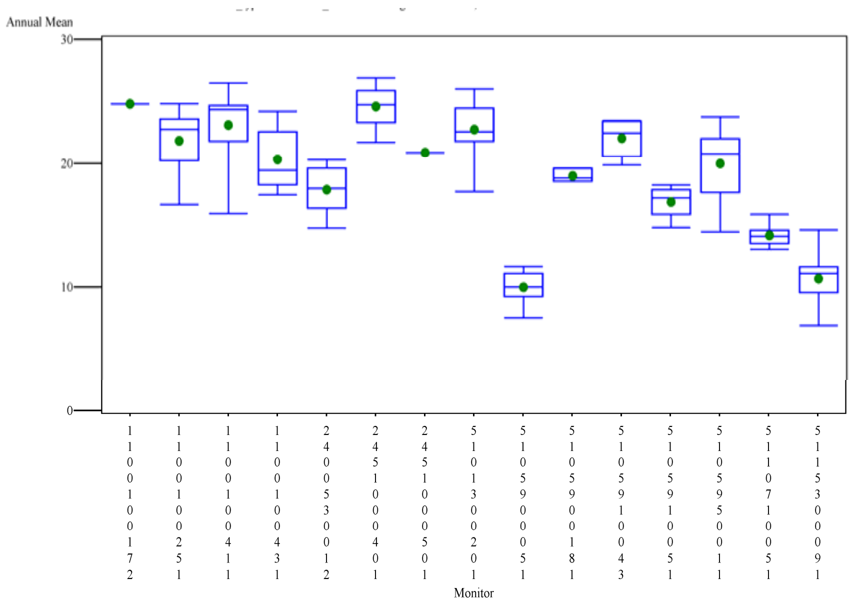

Figure A-57. Distribution of annual average NO_2 ambient concentration (ppb) by monitor, Washington DC CMSA set A, 1995-2006.

Table A-57. Distribution of annual average NO_2 ambient concentration (ppb) by monitor, Washington DC CMSA set A, 1995-2006.

Monitor ID	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
1100100172	1	25			25	25	25	25	25	25	25	25	25	25	25
1100100251	12	22	2	11	17	19	20	21	22	23	23	23	24	24	25
1100100411	12	23	3	12	16	21	21	23	23	24	24	25	25	25	26
1100100431	12	20	2	12	17	18	18	18	19	19	21	22	23	23	24
2400530012	8	18	2	11	15	15	15	17	18	18	18	19	20	20	20
2451000401	11	25	2	7	22	23	23	23	24	25	26	26	26	26	27
2451000501	1	21			21	21	21	21	21	21	21	21	21	21	21
5101300201	12	23	2	10	18	21	21	22	22	23	23	24	25	25	26
5105900051	11	10	1	12	7	9	9	10	10	10	10	11	11	11	12
5105900181	3	19	1	3	19	19	19	19	19	19	19	20	20	20	20
5105910043	6	22	2	7	20	20	21	21	22	22	23	23	23	23	23
5105910051	4	17	1	9	15	15	15	17	17	17	17	17	18	18	18
5105950011	10	20	3	15	14	16	17	19	20	21	22	22	22	23	24
5110710051	8	14	1	6	13	13	13	14	14	14	14	14	15	16	16
5115300091	12	11	2	18	7	9	9	10	10	11	11	11	12	12	15

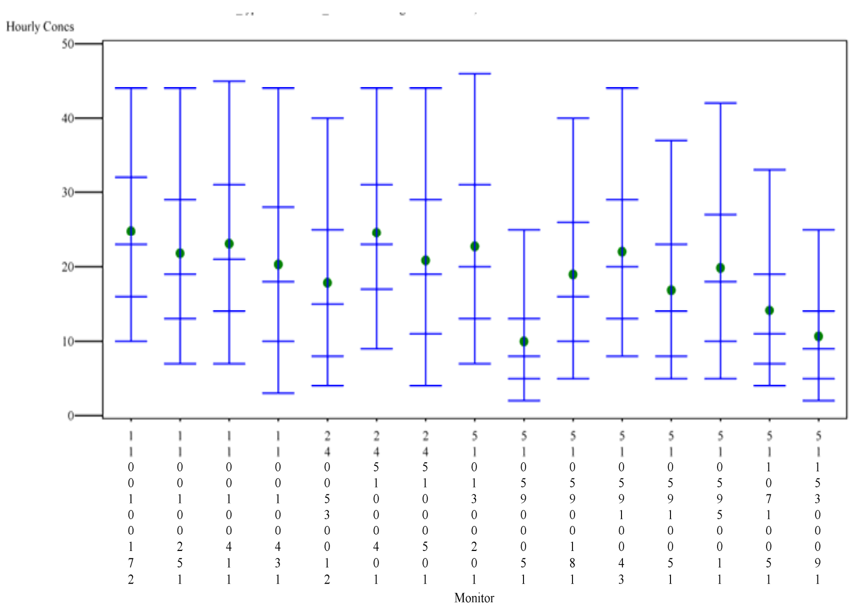

Figure A-58. Distribution of hourly NO_2 ambient concentration (ppb) by monitor, Washington DC CMSA set A, 1995-2006.

Table A-58. Distribution of hourly NO_2 ambient concentration (ppb) by monitor, Washington DC CMSA set A, 1995-2006.

Monitor ID	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
1100100172	8584	25	11	45	4	12	15	18	20	23	27	30	33	39	113
1100100251	102444	22	12	55	0	9	11	14	16	19	23	27	32	39	285
1100100411	103173	23	12	53	0	9	12	15	18	21	24	28	33	39	141
1100100431	102217	20	13	64	0	6	9	12	15	18	22	26	31	38	258
2400530012	63983	18	12	65	0	5	7	10	12	15	19	23	28	34	114
2451000401	89589	25	11	44	0	12	15	18	21	23	26	29	33	39	108
2451000501	7872	21	12	60	0	6	9	12	16	19	23	27	32	38	75
5101300201	97517	23	13	56	0	8	11	14	17	20	24	28	34	41	110
5105900051	89964	10	7	73	0	3	4	5	6	8	10	12	15	20	101
5105900181	22689	19	11	60	0	6	9	11	13	16	20	24	29	36	89
5105910043	50294	22	11	52	0	10	12	14	17	20	23	27	31	38	91
5105910051	34022	17	11	63	0	6	8	9	12	14	17	21	26	32	129
5105950011	79051	20	12	61	0	6	9	12	14	18	21	25	30	36	155
5110710051	65327	14	9	65	0	5	7	8	10	11	14	17	21	28	64
5115300091	101671	11	7	68	0	3	5	6	7	9	11	13	16	21	84

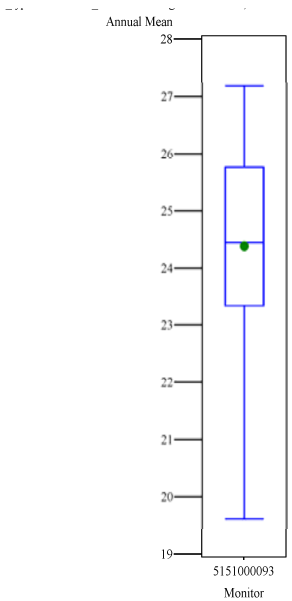

Figure A-59. Distribution of annual average NO_2 ambient concentration (ppb) by monitor, Washington DC CMSA set B, 1995-2006.

Table A-59. Distribution of annual average NO_2 ambient concentration (ppb) by monitor, Washington DC CMSA set B, 1995-2006.

Monitor ID	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
5151000093	12	24	2	8	20	23	23	23	24	24	25	26	26	26	27

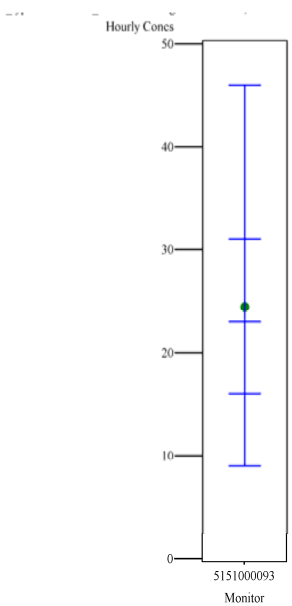

Figure A-60. Distribution of hourly NO_2 ambient concentration (ppb) by monitor, Washington DC CMSA set B, 1995-2006.

Table A-60. Distribution of hourly NO_2 ambient concentration (ppb) by monitor, Washington DC CMSA set B, 1995-2006.

Monitor ID	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
5151000093	98221	24	12	48	0	11	14	17	20	23	26	29	34	40	115

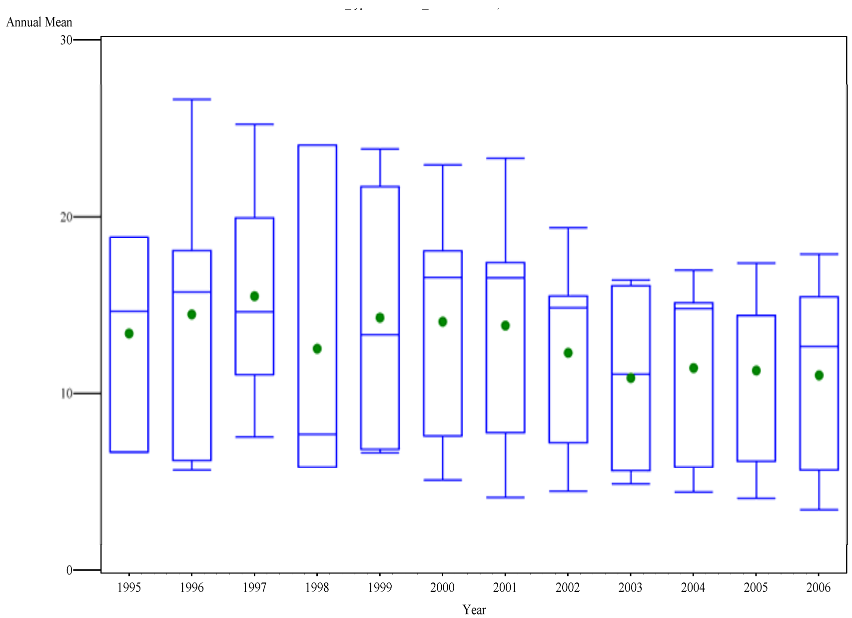

Figure A-61. Distribution of annual average NO_2 ambient concentrations (ppb) by year, Atlanta MSA.

Table A-61. Distribution of annual average NO_2 ambient concentrations (ppb) by year, Atlanta MSA.

Year	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
1995	3	13	6	46	7	7	7	7	15	15	15	19	19	19	19
1996	5	14	9	61	6	6	6	6	11	16	17	18	22	27	27
1997	4	15	7	47	8	8	8	15	15	15	15	15	25	25	25
1998	3	13	10	80	6	6	6	6	8	8	8	24	24	24	24
1999	4	14	9	61	7	7	7	7	7	13	20	20	24	24	24
2000	5	14	7	53	5	5	6	8	12	17	17	18	21	23	23
2001	5	14	8	56	4	4	6	8	12	17	17	17	20	23	23
2002	5	12	6	51	4	4	6	7	11	15	15	16	17	19	19
2003	4	11	6	56	5	5	5	6	6	11	16	16	16	16	16
2004	5	11	6	51	4	4	5	6	10	15	15	15	16	17	17
2005	5	11	6	51	4	4	5	6	10	14	14	14	16	17	17
2006	5	11	6	57	3	3	5	6	9	13	14	15	17	18	18

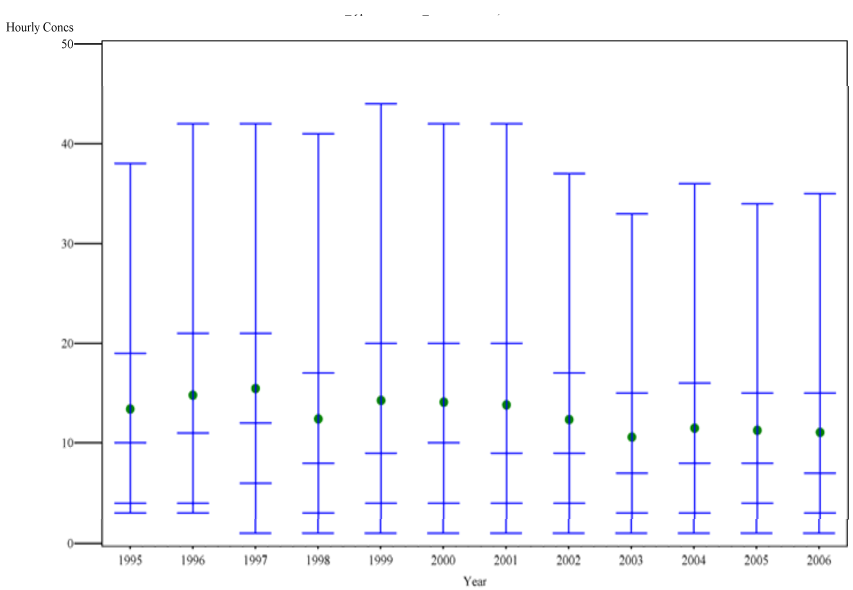

Figure A-62. Distribution of hourly NO_2 ambient concentrations (ppb) by year, Atlanta MSA.

Table A-62. Distribution of hourly NO_2 ambient concentrations (ppb) by year, Atlanta MSA.

Year	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
1995	25213	13	12	89	1	3	3	5	7	10	13	16	22	30	93
1996	40576	15	13	89	1	3	3	5	8	11	14	18	24	34	122
1997	31069	15	13	86	1	3	5	7	9	12	15	18	23	33	181
1998	24142	12	13	105	0	1	3	4	6	8	11	14	20	30	124
1999	31121	14	14	99	0	2	4	5	7	9	12	17	23	35	242
2000	40584	14	14	97	1	1	3	5	7	10	13	17	23	33	110
2001	42761	14	14	98	1	1	3	5	7	9	13	17	23	33	172
2002	42076	12	12	95	1	1	3	5	6	9	11	15	20	29	136
2003	32215	11	11	101	0	1	2	3	5	7	9	13	17	26	91
2004	42124	11	11	98	1	1	3	4	6	8	10	14	19	28	127
2005	42279	11	11	96	1	1	3	4	6	8	10	13	18	27	97
2006	41052	11	11	98	1	2	3	4	5	7	9	13	18	27	73

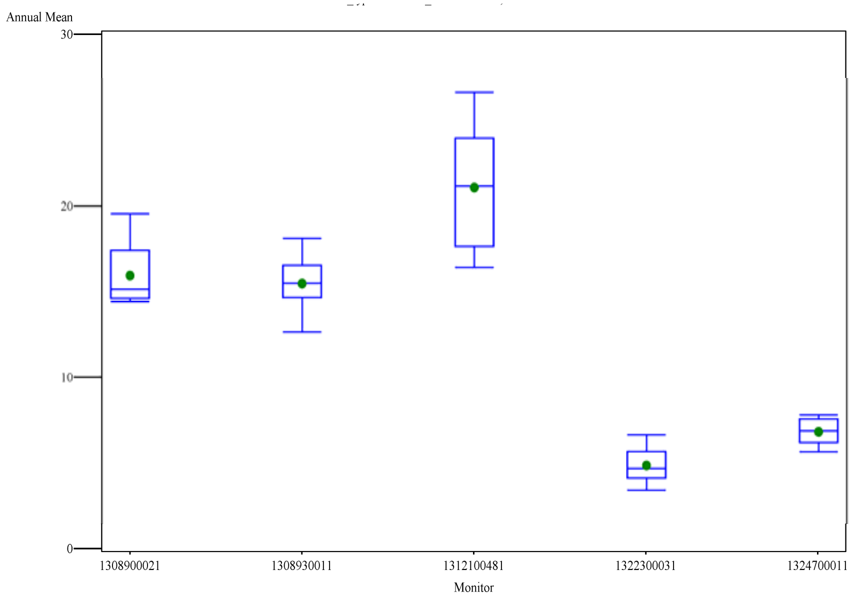

Figure A-63. Distribution of annual average NO_2 ambient concentration (ppb) by monitor, Atlanta MSA, 1995-2006.

Table A-63. Distribution of annual average NO_2 ambient concentration (ppb) by monitor, Atlanta MSA, 1995-2006.

Monitor ID	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
1308900021	10	16	2	11	14	14	15	15	15	15	16	17	18	19	20
1308930011	9	15	2	10	13	13	14	15	15	16	16	17	17	18	18
1312100481	12	21	4	17	16	17	17	18	19	21	23	24	24	25	27
1322300031	10	5	1	20	3	4	4	4	4	5	5	5	6	6	7
1324700011	12	7	1	11	6	6	6	6	6	7	7	8	8	8	8

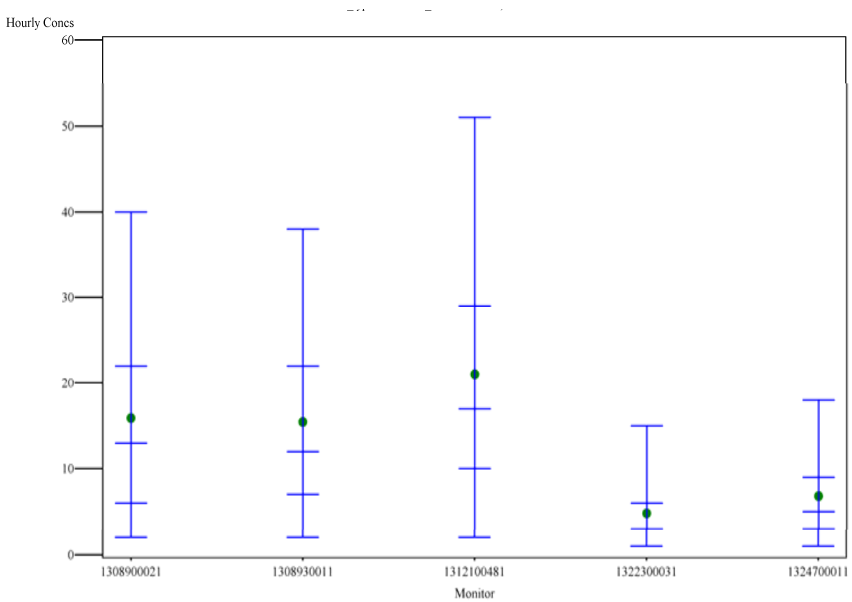

Figure A-64. Distribution of hourly NO_2 ambient concentration (ppb) by monitor, Atlanta MSA, 1995-2006.

Table A-64. Distribution of hourly NO_2 ambient concentration (ppb) by monitor, Atlanta MSA, 1995-2006.

Monitor ID	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
1308900021	83891	16	12	77	0	3	5	8	10	13	16	20	25	33	139
1308930011	72029	15	11	73	1	4	6	8	10	12	15	19	24	32	95
1312100481	98975	21	15	73	0	5	8	11	14	17	21	26	33	43	181
1322300031	80168	5	5	108	0	1	1	2	3	3	4	5	7	11	70
1324700011	100149	7	6	81	0	2	3	3	4	5	6	8	10	14	242

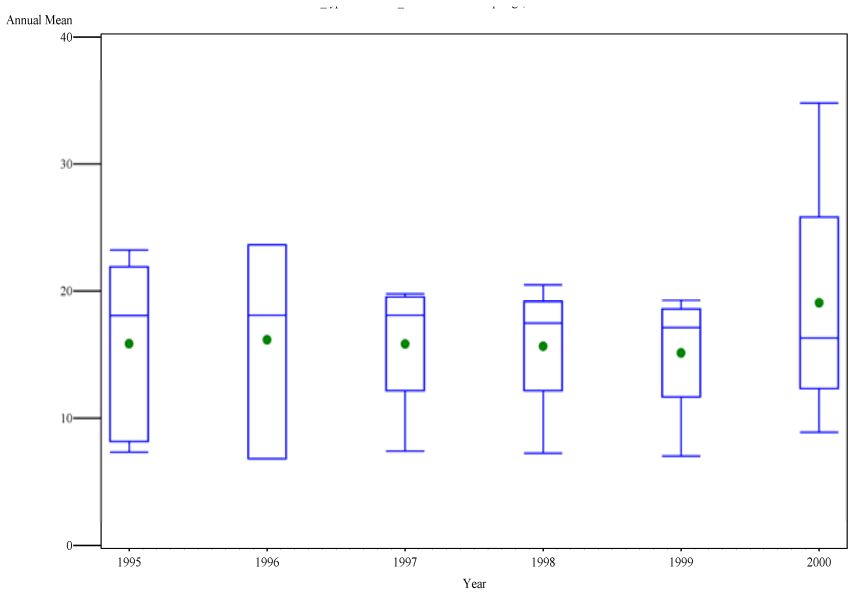

Figure A-65. Distribution of annual average NO_2 ambient concentrations (ppb) by year, Colorado Springs MSA.

Table A-65. Distribution of annual average NO_2 ambient concentrations (ppb) by year, Colorado Springs MSA.

Year	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
1995	7	16	7	42	7	7	8	12	12	18	21	21	22	23	23
1996	3	16	9	53	7	7	7	7	18	18	18	24	24	24	24
1997	4	16	6	36	7	7	7	17	17	18	19	19	20	20	20
1998	4	16	6	37	7	7	7	17	17	17	18	18	20	20	20
1999	4	15	6	37	7	7	7	16	16	17	18	18	19	19	19
2000	4	19	11	58	9	9	9	16	16	16	17	17	35	35	35

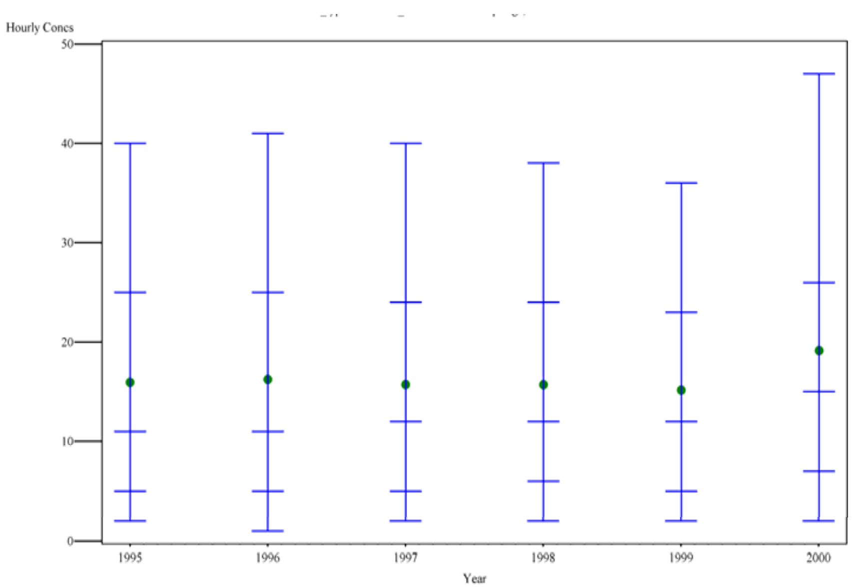

Figure A-66. Distribution of hourly NO_2 ambient concentrations (ppb) by year, Colorado Springs MSA.

Table A-66. Distribution of hourly NO_2 ambient concentrations (ppb) by year, Colorado Springs MSA.

Year	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
1995	58569	16	14	91	0	2	4	6	8	11	16	22	29	36	148
1996	25387	16	16	101	0	2	4	6	8	11	16	21	28	35	246
1997	33469	16	13	80	0	3	5	6	9	12	16	21	27	35	118
1998	34509	16	12	76	0	3	5	7	9	12	16	22	27	34	85
1999	34472	15	12	82	0	3	4	6	9	12	16	21	26	32	230
2000	33956	19	20	106	0	3	6	8	11	15	20	24	28	34	308

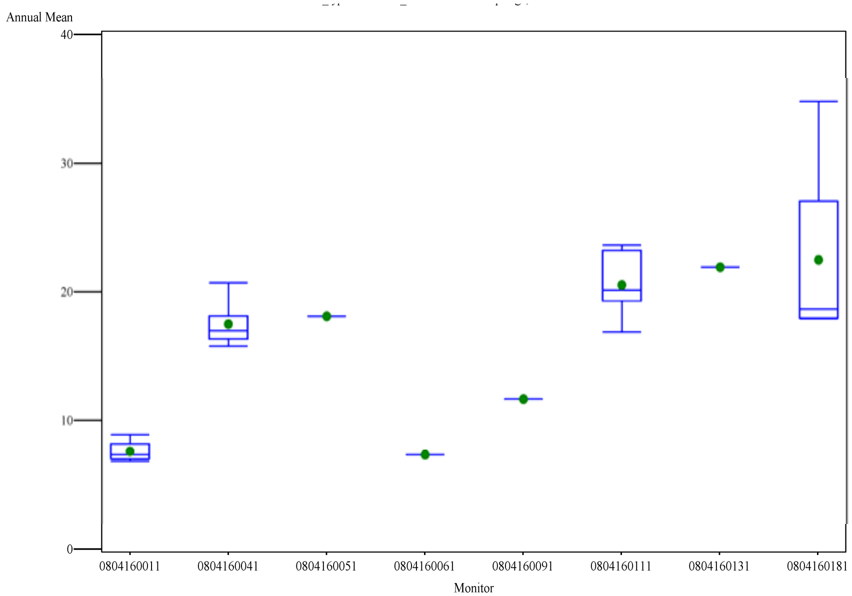

Figure A-67. Distribution of annual average NO_2 ambient concentration (ppb) by monitor, Colorado Springs MSA, 1995-2006.

Table A-67. Distribution of annual average NO_2 ambient concentration (ppb) by monitor, Colorado Springs MSA, 1995-2006.

Monitor ID	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
0804160011	6	8	1	10	7	7	7	7	7	7	7	8	8	9	9
0804160041	6	17	2	10	16	16	16	16	17	17	17	18	18	21	21
0804160051	1	18			18	18	18	18	18	18	18	18	18	18	18
0804160061	1	7			7	7	7	7	7	7	7	7	7	7	7
0804160091	1	12			12	12	12	12	12	12	12	12	12	12	12
0804160111	6	21	3	12	17	17	19	19	20	20	20	23	23	24	24
0804160131	1	22			22	22	22	22	22	22	22	22	22	22	22
0804160181	4	22	8	37	18	18	18	18	18	19	19	19	35	35	35

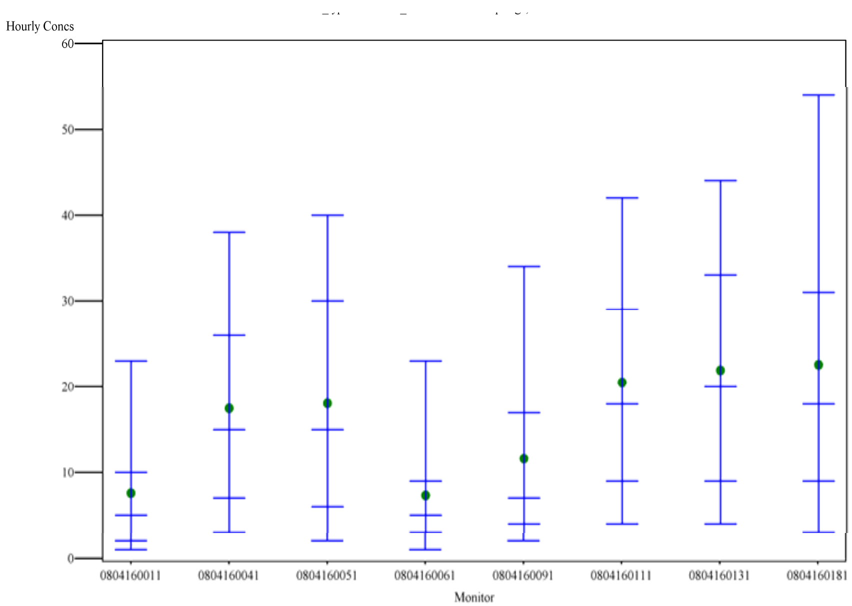

Figure A-68. Distribution of hourly NO_2 ambient concentration (ppb) by monitor, Colorado Springs MSA, 1995-2006.

Table A-68. Distribution of hourly NO_2 ambient concentration (ppb) by monitor, Colorado Springs MSA, 1995-2006.

Monitor ID	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
0804160011	51373	8	7	94	0	1	2	3	4	5	7	9	12	18	59
0804160041	51288	17	11	66	0	4	6	9	12	15	20	24	28	34	115
0804160051	8345	18	13	74	1	3	5	7	10	15	21	27	32	36	143
0804160061	7993	7	7	99	0	1	2	3	4	5	6	8	11	16	49
0804160091	8282	12	10	89	0	2	3	4	6	7	10	14	20	29	56
0804160111	50707	21	16	77	0	5	7	10	14	18	23	27	31	37	246
0804160131	8637	22	14	62	0	5	8	11	15	20	26	31	36	41	87
0804160181	33737	23	21	94	0	5	7	10	14	18	23	28	33	41	308

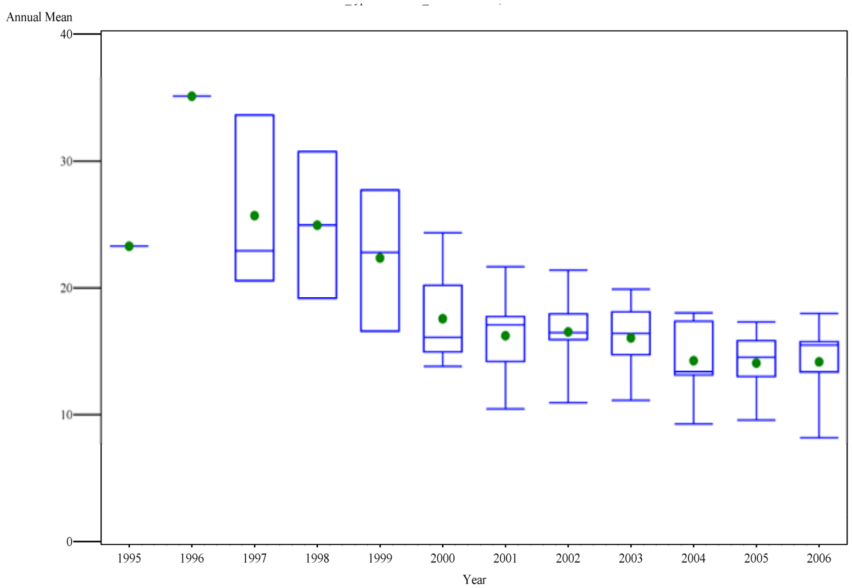

Figure A-69. Distribution of annual average NO_2 ambient concentrations (ppb) by year, El Paso MSA.

Table A-69. Distribution of annual average NO_2 ambient concentrations (ppb) by year, El Paso MSA.

Year	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
1995	1	23		0	23	23	23	23	23	23	23	23	23	23	23
1996	1	35		0	35	35	35	35	35	35	35	35	35	35	35
1997	3	26	7	27	21	21	21	21	23	23	23	34	34	34	34
1998	2	25	8	33	19	19	19	19	19	25	31	31	31	31	31
1999	3	22	6	25	17	17	17	17	23	23	23	28	28	28	28
2000	4	18	5	26	14	14	14	16	16	16	16	16	24	24	24
2001	5	16	4	26	10	10	12	14	16	17	17	18	20	22	22
2002	5	17	4	23	11	11	13	16	16	16	17	18	20	21	21
2003	5	16	3	21	11	11	13	15	16	16	17	18	19	20	20
2004	5	14	4	25	9	9	11	13	13	13	15	17	18	18	18
2005	5	14	3	21	10	10	11	13	14	15	15	16	17	17	17
2006	5	14	4	26	8	8	11	13	14	15	16	16	17	18	18

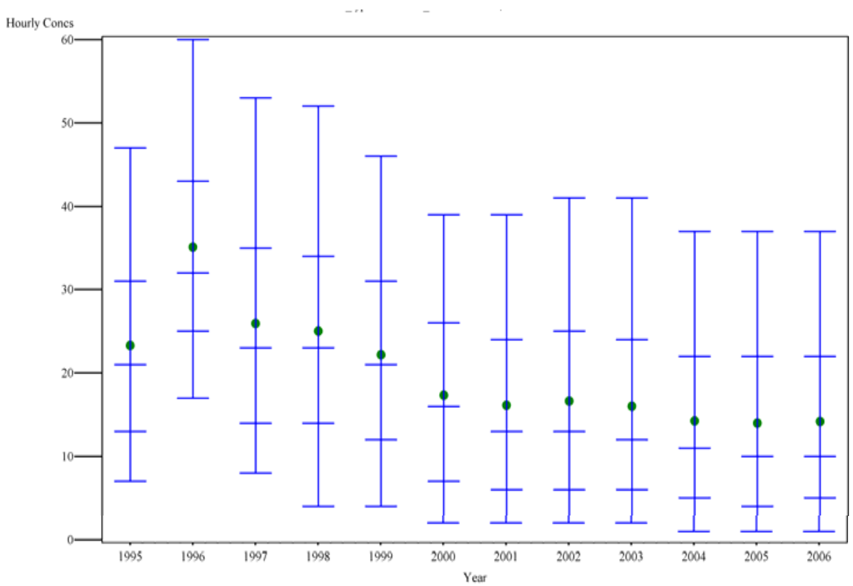

Figure A-70. Distribution of hourly NO_2 ambient concentrations (ppb) by year, El Paso MSA.

Table A-70. Distribution of hourly NO_2 ambient concentrations (ppb) by year, El Paso MSA.

Year	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
1995	6960	23	13	58	3	9	12	14	17	21	25	29	34	41	113
1996	6627	35	15	43	2	20	23	27	29	32	36	40	46	54	219
1997	22888	26	15	58	0	10	13	16	20	23	28	32	38	45	174
1998	15523	25	15	61	0	7	12	15	19	23	27	32	37	45	166
1999	23447	22	13	60	0	6	10	14	17	21	25	28	33	40	108
2000	30772	17	13	72	0	3	5	8	12	16	20	24	28	34	125
2001	38020	16	12	77	0	3	5	7	10	13	16	21	27	34	102
2002	41466	17	13	77	0	4	5	7	10	13	17	22	28	35	153
2003	39968	16	13	80	0	3	5	7	9	12	16	21	27	35	106
2004	41952	14	12	83	0	2	4	6	8	11	14	19	25	32	97
2005	41496	14	12	86	0	2	4	5	7	10	14	19	24	31	87
2006	37203	14	12	84	0	2	4	6	8	10	14	19	25	32	99

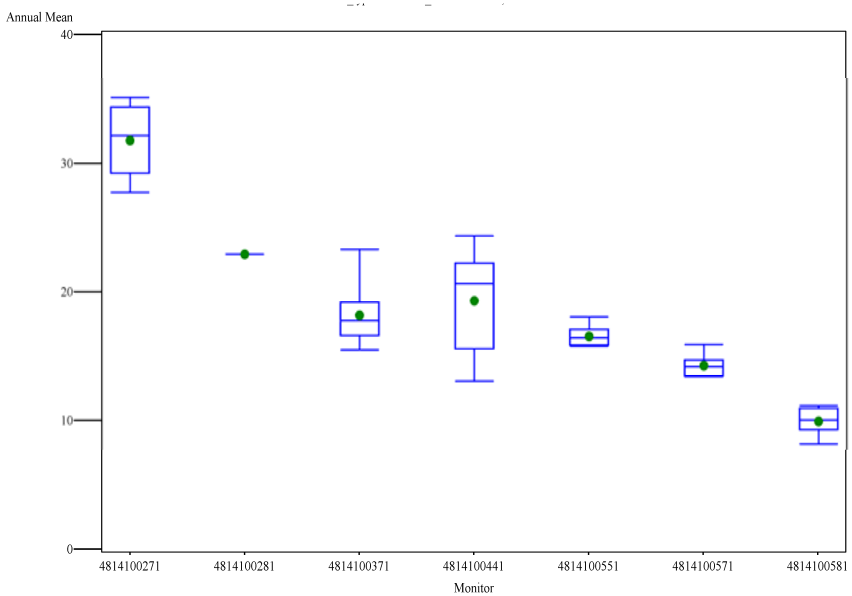

Figure A-71. Distribution of annual average NO_2 ambient concentration (ppb) by monitor, El Paso MSA, 1995-2006.

Table A-71. Distribution of annual average NO_2 ambient concentration (ppb) by monitor, El Paso MSA, 1995-2006.

Monitor ID	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
4814100271	4	32	3	10	28	28	28	31	31	32	34	34	35	35	35
4814100281	1	23			23	23	23	23	23	23	23	23	23	23	23
4814100371	11	18	2	12	15	16	17	17	17	18	18	18	19	21	23
4814100441	8	19	4	22	13	13	13	18	20	21	21	22	23	24	24
4814100551	7	17	1	5	16	16	16	16	16	16	16	16	17	18	18
4814100571	7	14	1	6	13	13	13	14	14	14	15	15	15	16	16
4814100581	6	10	1	11	8	8	9	9	10	10	10	11	11	11	11

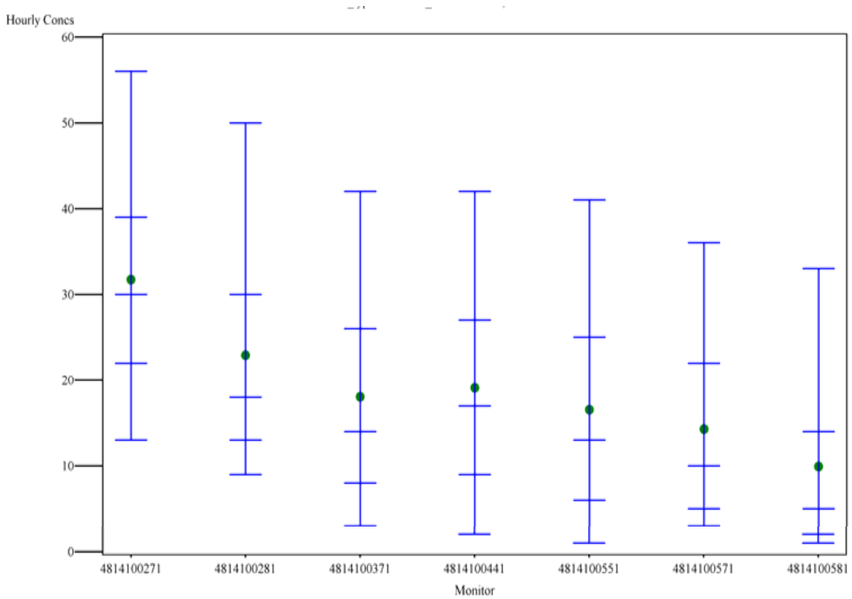

Figure A-72. Distribution of hourly NO_2 ambient concentration (ppb) by monitor, El Paso MSA, 1995-2006.

Table A-72. Distribution of hourly NO_2 ambient concentration (ppb) by monitor, El Paso MSA, 1995-2006.

Monitor ID	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
4814100271	29730	32	14	45	1	16	20	24	27	30	33	37	42	49	219
4814100281	8045	23	14	60	5	10	12	13	15	18	22	27	34	42	117
4814100371	87748	18	13	71	0	5	7	9	12	14	18	23	29	36	153
4814100441	62362	19	13	67	0	5	8	11	14	17	21	25	30	36	125
4814100551	53960	17	13	78	0	3	5	7	10	13	18	23	28	35	87
4814100571	57229	14	11	79	0	3	4	6	8	10	14	19	25	31	85
4814100581	47248	10	11	109	0	1	2	3	4	5	7	11	18	27	84

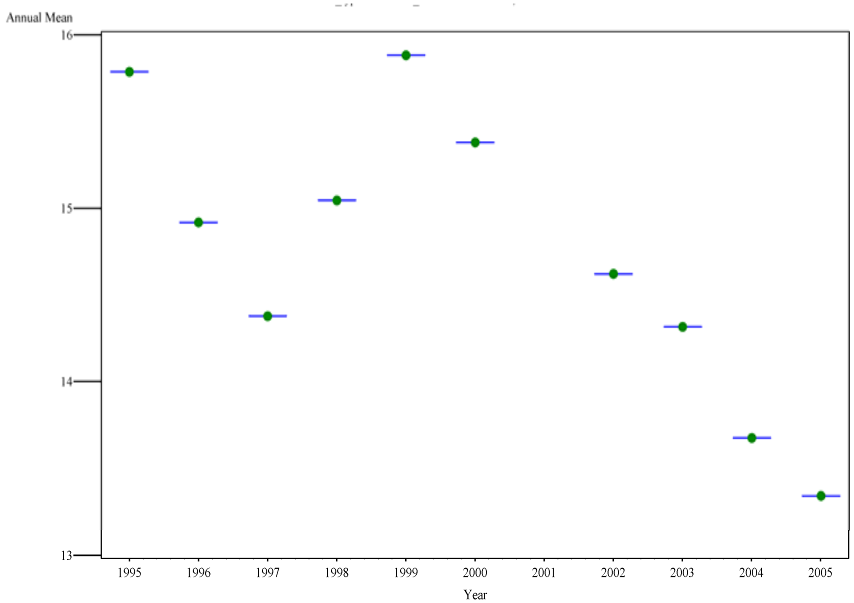

Figure A-73. Distribution of annual average NO_2 ambient concentrations (ppb) by year, Jacksonville MSA.

Table A-73. Distribution of annual average NO_2 ambient concentrations (ppb) by year, Jacksonville MSA.

Year	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
1995	1	16		0	16	16	16	16	16	16	16	16	16	16	16
1996	1	15		0	15	15	15	15	15	15	15	15	15	15	15
1997	1	14		0	14	14	14	14	14	14	14	14	14	14	14
1998	1	15		0	15	15	15	15	15	15	15	15	15	15	15
1999	1	16		0	16	16	16	16	16	16	16	16	16	16	16
2000	1	15		0	15	15	15	15	15	15	15	15	15	15	15
2002	1	15		0	15	15	15	15	15	15	15	15	15	15	15
2003	1	14		0	14	14	14	14	14	14	14	14	14	14	14
2004	1	14		0	14	14	14	14	14	14	14	14	14	14	14
2005	1	13		0	13	13	13	13	13	13	13	13	13	13	13

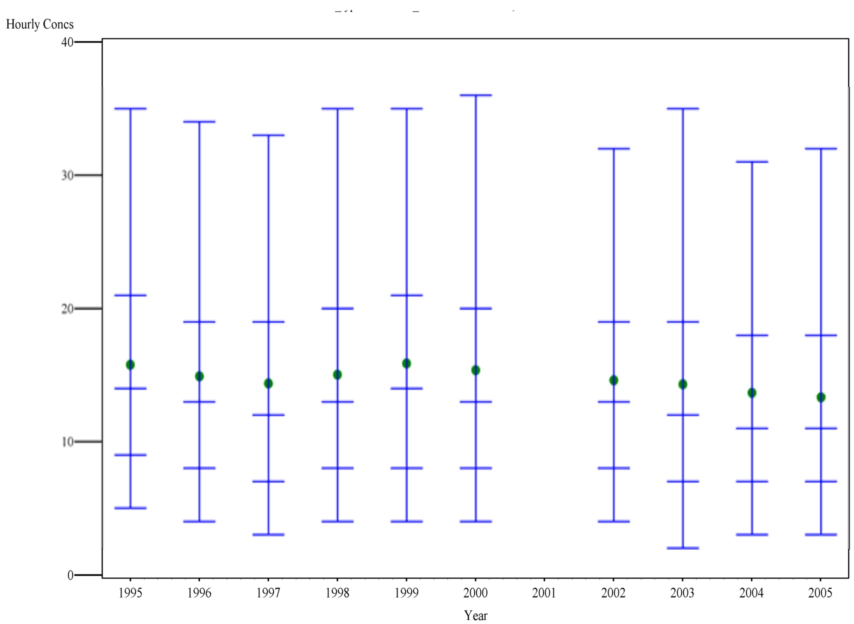

Figure A-74. Distribution of hourly NO_2 ambient concentrations (ppb) by year, Jacksonville MSA.

Table A-74. Distribution of hourly NO_2 ambient concentrations (ppb) by year, Jacksonville MSA.

Year	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
1995	7755	16	10	60	0	6	8	9	11	14	16	19	23	29	76
1996	8148	15	10	64	0	5	7	9	11	13	15	18	21	28	80
1997	8326	14	9	65	0	5	6	8	10	12	15	17	21	27	92
1998	8211	15	10	65	0	5	7	9	11	13	15	18	22	28	66
1999	7795	16	10	61	0	5	7	9	12	14	16	20	24	30	63
2000	7661	15	10	67	0	5	7	9	11	13	15	18	23	30	72
2002	7944	15	10	66	0	5	7	9	11	13	15	17	21	27	294
2003	7041	14	10	71	0	4	6	8	10	12	14	17	21	28	76
2004	7451	14	11	83	0	4	6	7	9	11	13	16	20	26	201
2005	7890	13	9	67	0	4	6	8	9	11	13	16	20	26	64

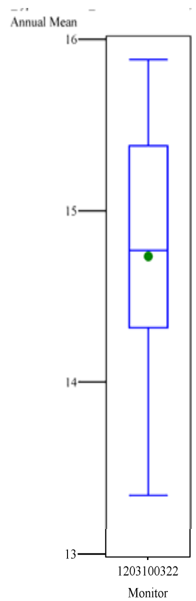

Figure A-75. Distribution of annual average NO_2 ambient concentration (ppb) by monitor, Jacksonville MSA, 1995-2006.

Table A-75. Distribution of annual average NO_2 ambient concentration (ppb) by monitor, Jacksonville MSA, 1995-2006.

Monitor ID	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
1203100322	10	15	1	6	13	14	14	14	15	15	15	15	16	16	16

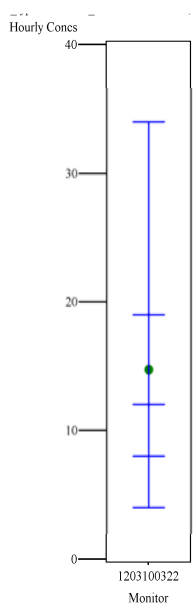

Figure A-76. Distribution of hourly NO_2 ambient concentration (ppb) by monitor, Jacksonville MSA, 1995-2006.

Table A-76. Distribution of hourly NO_2 ambient concentration (ppb) by monitor, Jacksonville MSA, 1995-2006.

Monitor ID	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
1203100322	78222	15	10	67	0	5	7	9	10	12	15	18	22	28	294

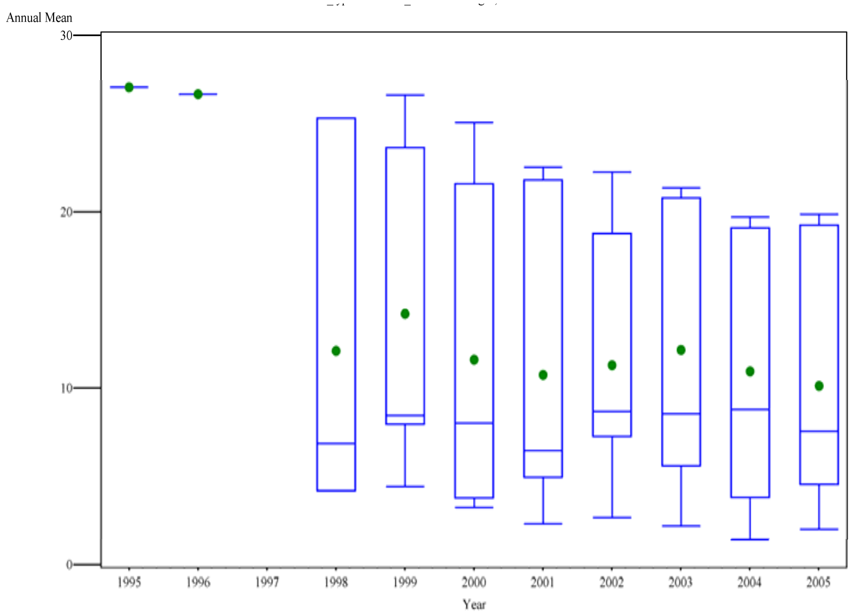

Figure A-77. Distribution of annual average NO_2 ambient concentrations (ppb) by year, Las Vegas MSA.

Table A-77. Distribution of annual average NO_2 ambient concentrations (ppb) by year, Las Vegas MSA.

Year	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
1995	1	27		0	27	27	27	27	27	27	27	27	27	27	27
1996	1	27		0	27	27	27	27	27	27	27	27	27	27	27
1998	3	12	12	95	4	4	4	4	7	7	7	25	25	25	25
1999	5	14	10	71	4	4	6	8	8	8	16	24	25	27	27
2000	6	12	9	81	3	3	4	4	8	8	8	22	22	25	25
2001	6	11	9	84	2	2	5	5	6	6	7	22	22	23	23
2002	9	11	8	68	3	3	3	7	7	9	10	19	22	22	22
2003	7	12	8	66	2	2	6	8	8	9	19	19	21	21	21
2004	7	11	8	73	1	1	4	5	5	9	19	19	19	20	20
2005	6	10	8	76	2	2	5	5	6	8	9	19	19	20	20

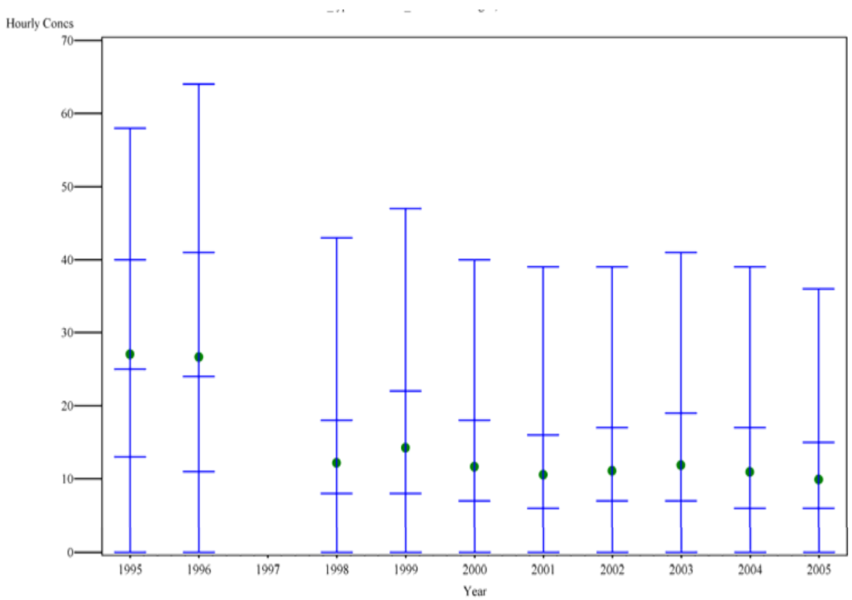

Figure A-78. Distribution of hourly NO_2 ambient concentrations (ppb) by year, Las Vegas MSA.

Table A-78. Distribution of hourly NO_2 ambient concentrations (ppb) by year, Las Vegas MSA.

Year	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
1995	7951	27	20	74	0	0	11	15	20	25	31	37	42	50	410
1996	8723	27	22	81	0	0	9	12	17	24	31	38	44	54	149
1998	25234	12	14	118	0	0	0	0	5	8	10	14	23	35	103
1999	43110	14	16	110	0	0	0	5	6	8	12	18	28	39	110
2000	46403	12	14	119	0	0	0	0	5	7	10	15	23	34	100
2001	49734	11	14	128	0	0	0	0	0	6	8	13	21	33	104
2002	74814	11	13	117	0	0	0	0	5	7	10	14	21	32	87
2003	58398	12	14	119	0	0	0	0	5	7	10	15	24	35	103
2004	57484	11	13	120	0	0	0	0	0	6	9	14	23	33	73
2005	48911	10	12	123	0	0	0	0	0	6	9	12	18	30	75

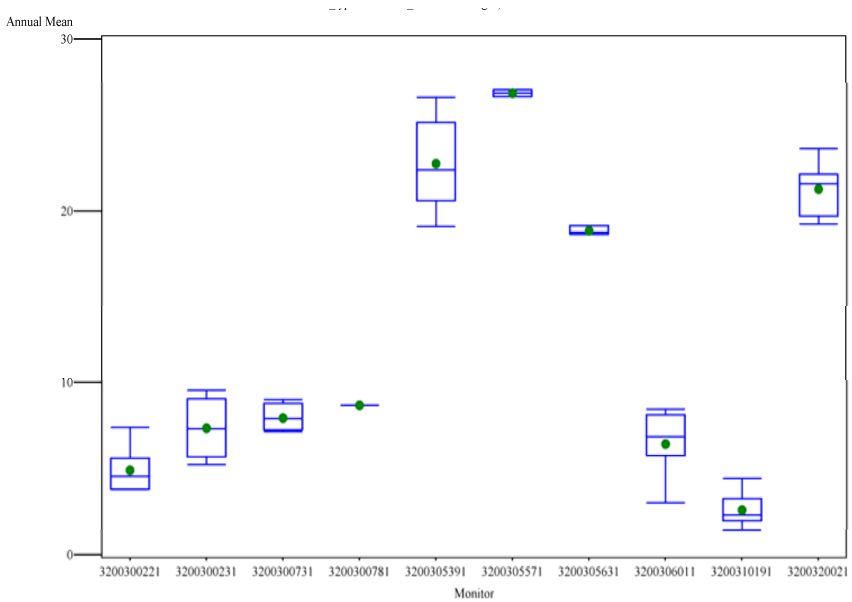

Figure A-79. Distribution of annual average NO_2 ambient concentration (ppb) by monitor, Las Vegas MSA, 1995-2006.

Table A-79. Distribution of annual average NO_2 ambient concentration (ppb) by monitor, Las Vegas MSA, 1995-2006.

Monitor ID	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
3200300221	7	5	1	26	4	4	4	4	4	5	5	5	6	7	7
3200300231	4	7	2	28	5	5	5	6	6	7	9	9	10	10	10
3200300731	7	8	1	9	7	7	7	8	8	8	8	8	9	9	9
3200300781	1	9			9	9	9	9	9	9	9	9	9	9	9
3200305391	8	23	3	12	19	19	20	21	22	22	23	25	25	27	27
3200305571	2	27	0	1	27	27	27	27	27	27	27	27	27	27	27
3200305631	3	19	0	1	19	19	19	19	19	19	19	19	19	19	19
3200306011	5	6	2	34	3	3	4	6	6	7	7	8	8	8	8
3200310191	7	3	1	38	1	1	2	2	2	2	3	3	3	4	4
3200320021	7	21	2	7	19	19	20	21	21	22	22	22	22	24	24

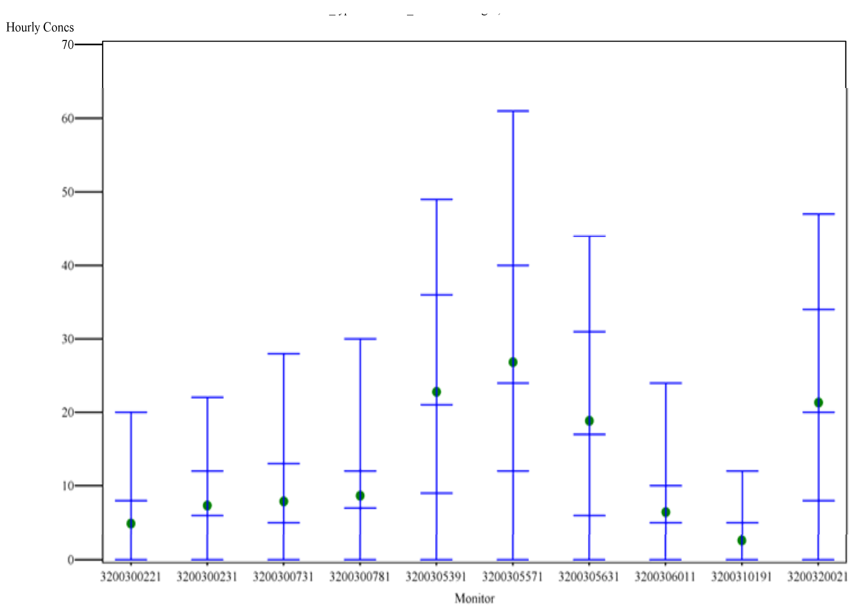

Figure A-80. Distribution of hourly NO_2 ambient concentration (ppb) by monitor, Las Vegas MSA, 1995-2006.

Table A-80. Distribution of hourly NO_2 ambient concentration (ppb) by monitor, Las Vegas MSA, 1995-2006.

Monitor ID	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
3200300221	58087	5	7	152	0	0	0	0	0	0	5	7	10	15	91
3200300231	34550	7	8	105	0	0	0	0	5	6	8	10	13	18	52
3200300731	56906	8	10	124	0	0	0	0	0	5	8	11	15	22	104
3200300781	8672	9	10	115	0	0	0	0	5	7	8	10	14	22	87
3200305391	64921	23	16	70	0	5	7	10	14	21	28	33	38	44	103
3200305571	16674	27	21	78	0	0	10	14	19	24	31	37	43	52	410
3200305631	25061	19	15	78	0	0	5	7	11	17	23	28	33	39	87
3200306011	42417	6	8	124	0	0	0	0	0	5	7	8	12	18	51
3200310191	57230	3	5	186	0	0	0	0	0	0	0	0	6	9	71
3200320021	56244	21	16	73	0	0	6	9	13	20	27	32	36	42	110

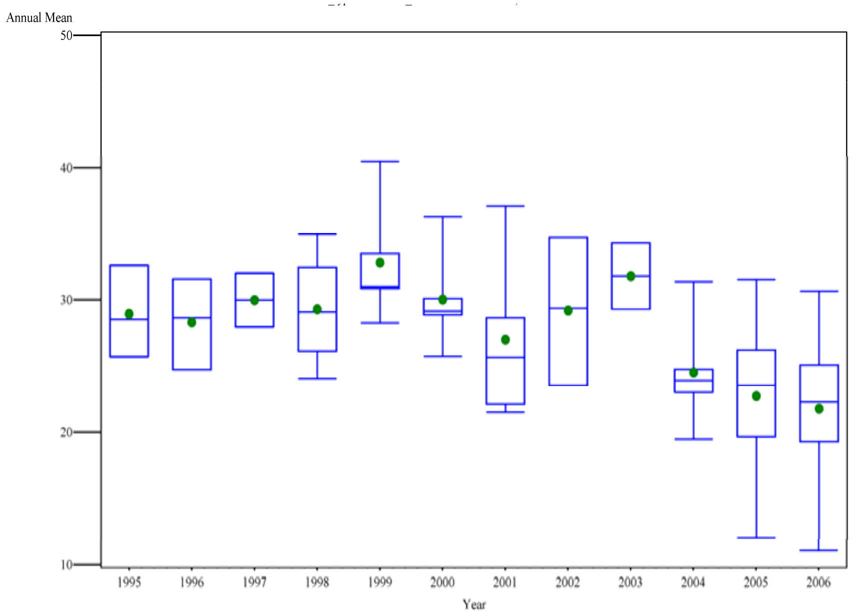

Figure A-81. Distribution of annual average NO_2 ambient concentrations (ppb) by year, Phoenix MSA.

Table A-81. Distribution of annual average NO_2 ambient concentrations (ppb) by year, Phoenix MSA.

Year	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
1995	3	29	3	12	26	26	26	26	29	29	29	33	33	33	33
1996	3	28	3	12	25	25	25	25	29	29	29	32	32	32	32
1997	2	30	3	10	28	28	28	28	28	30	32	32	32	32	32
1998	4	29	5	15	24	24	24	28	28	29	30	30	35	35	35
1999	5	33	5	14	28	28	30	31	31	31	32	34	37	40	40
2000	5	30	4	13	26	26	27	29	29	29	30	30	33	36	36
2001	5	27	6	23	22	22	22	22	24	26	27	29	33	37	37
2002	3	29	6	19	24	24	24	24	29	29	29	35	35	35	35
2003	2	32	4	11	29	29	29	29	29	32	34	34	34	34	34
2004	5	25	4	18	19	19	21	23	23	24	24	25	28	31	31
2005	6	23	7	29	12	12	20	20	24	24	24	26	26	32	32
2006	6	22	7	30	11	11	19	19	21	22	24	25	25	31	31

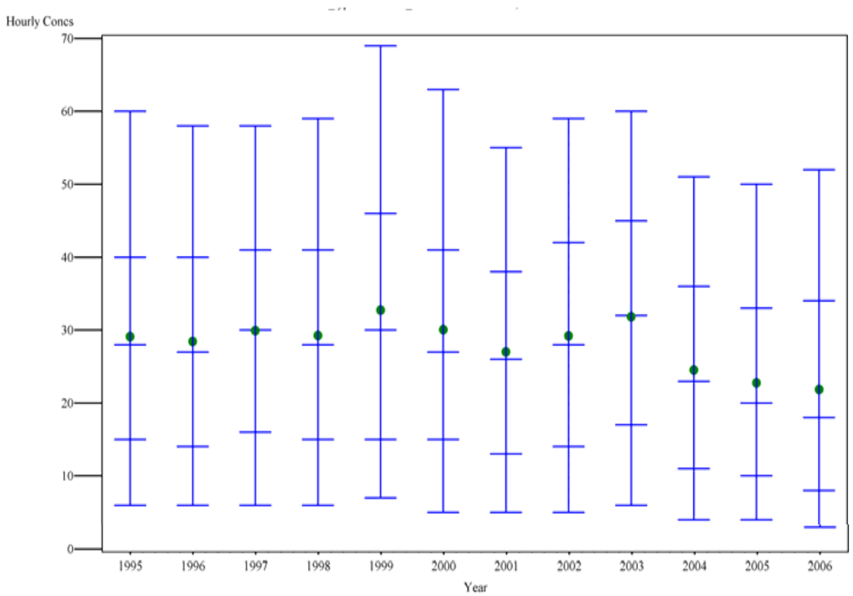

Figure A-82. Distribution of hourly NO_2 ambient concentrations (ppb) by year, Phoenix MSA.

Table A-82. Distribution of hourly NO_2 ambient concentrations (ppb) by year, Phoenix MSA.

Year	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
1995	23196	29	17	59	0	8	12	17	23	28	33	37	44	53	128
1996	23598	28	17	59	0	8	12	17	22	27	32	37	43	51	115
1997	14629	30	16	55	0	8	13	18	25	30	35	39	44	52	114
1998	32078	29	17	58	0	8	12	17	23	28	33	38	44	52	116
1999	40996	33	22	66	0	9	13	18	24	30	36	42	49	60	198
2000	41686	30	21	71	0	8	12	17	22	27	32	38	45	54	267
2001	40463	27	16	59	1	7	11	15	21	26	31	36	41	49	118
2002	25028	29	17	59	0	7	12	17	23	28	34	39	45	53	108
2003	14195	32	17	55	0	8	14	20	27	32	37	42	48	55	101
2004	42176	25	15	62	0	6	9	13	18	23	28	33	39	45	104
2005	50583	23	15	66	0	5	8	12	16	20	25	31	36	44	131
2006	48791	22	16	73	0	4	7	10	13	18	24	30	37	46	111

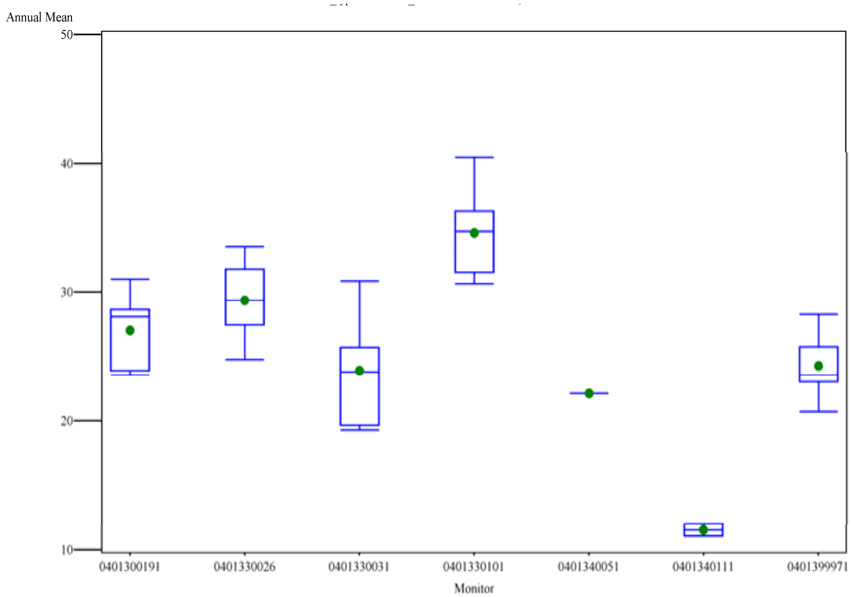

Figure A-83. Distribution of annual average NO_2 ambient concentration (ppb) by monitor, Phoenix MSA, 1995-2006.

Table A-83. Distribution of annual average NO_2 ambient concentration (ppb) by monitor, Phoenix MSA, 1995-2006.

Monitor ID	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
0401300191	10	27	3	10	24	24	24	25	27	28	28	29	29	30	31
0401330026	12	29	3	10	25	25	26	29	29	29	30	32	32	33	34
0401330031	10	24	4	17	19	19	20	21	23	24	24	25	28	30	31
0401330101	9	35	3	9	31	31	31	32	34	35	35	36	37	40	40
0401340051	1	22			22	22	22	22	22	22	22	22	22	22	22
0401340111	2	12	1	6	11	11	11	11	11	12	12	12	12	12	12
0401399971	5	24	3	12	21	21	22	23	23	24	25	26	27	28	28

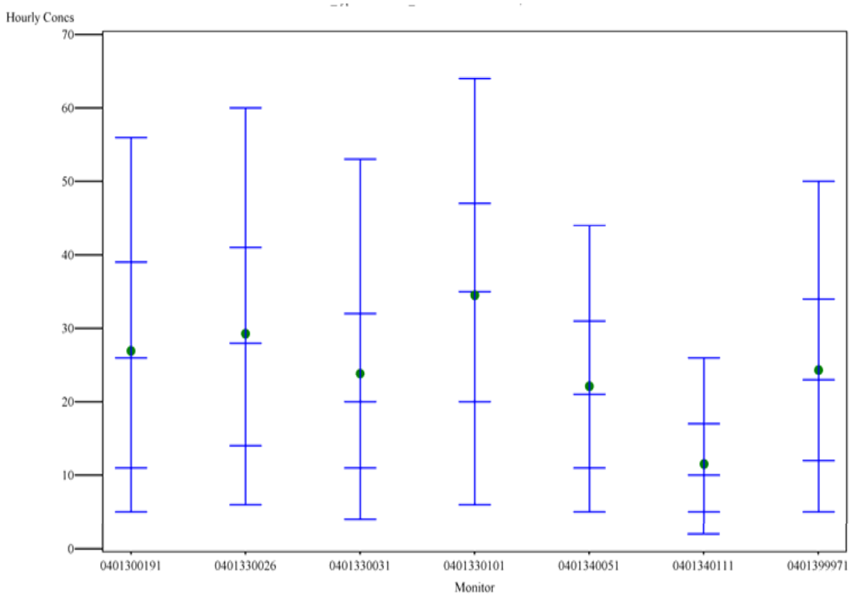

Figure A-84. Distribution of hourly NO_2 ambient concentration (ppb) by monitor, Phoenix MSA, 1995-2006.

Table A-84. Distribution of hourly NO_2 ambient concentration (ppb) by monitor, Phoenix MSA, 1995-2006.

Monitor ID	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
0401300191	81411	27	17	63	0	6	9	14	20	26	32	37	42	50	148
0401330026	97376	29	17	59	0	8	12	17	23	28	33	38	44	53	151
0401330031	80162	24	19	78	0	6	9	12	16	20	25	30	35	45	267
0401330101	73070	35	18	53	0	9	16	23	30	35	40	45	50	58	164
0401340051	7420	22	13	58	2	7	9	13	17	21	25	29	33	39	99
0401340111	16459	12	8	69	0	2	4	6	8	10	13	16	18	22	53
0401399971	41521	24	15	60	0	7	10	14	19	23	27	32	37	45	131

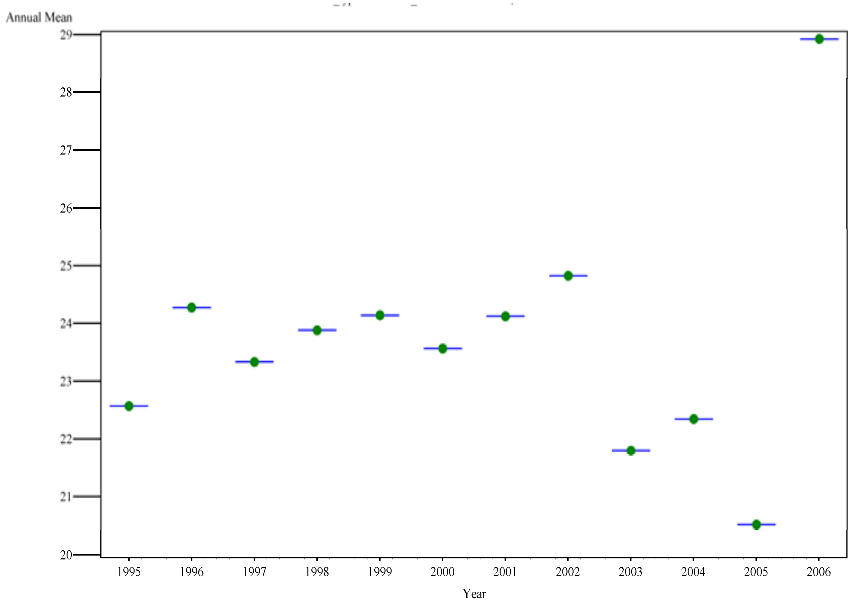

Figure A-85. Distribution of annual average NO_2 ambient concentrations (ppb) by year, Provo MSA.

Table A-85. Distribution of annual average NO_2 ambient concentrations (ppb) by year, Provo MSA.

Year	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
1995	1	23		0	23	23	23	23	23	23	23	23	23	23	23
1996	1	24		0	24	24	24	24	24	24	24	24	24	24	24
1997	1	23		0	23	23	23	23	23	23	23	23	23	23	23
1998	1	24		0	24	24	24	24	24	24	24	24	24	24	24
1999	1	24		0	24	24	24	24	24	24	24	24	24	24	24
2000	1	24		0	24	24	24	24	24	24	24	24	24	24	24
2001	1	24		0	24	24	24	24	24	24	24	24	24	24	24
2002	1	25		0	25	25	25	25	25	25	25	25	25	25	25
2003	1	22		0	22	22	22	22	22	22	22	22	22	22	22
2004	1	22		0	22	22	22	22	22	22	22	22	22	22	22
2005	1	21		0	21	21	21	21	21	21	21	21	21	21	21
2006	1	29		0	29	29	29	29	29	29	29	29	29	29	29

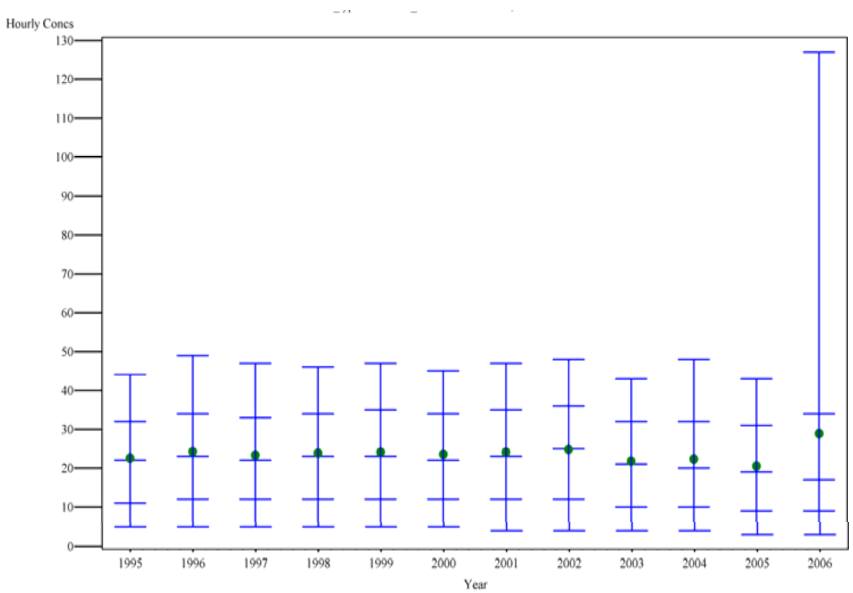

Figure A-86. Temporal distribution of hourly NO_2 ambient concentrations (ppb) by year, Provo MSA.

Table A-86. Distribution of hourly NO_2 ambient concentrations (ppb) by year, Provo MSA.

Year	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
1995	8002	23	13	55	0	7	10	13	17	22	26	30	34	40	67
1996	8430	24	15	61	0	7	10	14	18	23	28	32	37	43	97
1997	7034	23	13	57	0	7	10	14	18	22	26	31	35	41	81
1998	8210	24	13	56	0	7	10	14	18	23	28	32	37	42	78
1999	8563	24	13	55	0	7	11	14	19	23	28	33	37	42	77
2000	8406	24	13	56	0	7	10	14	18	22	27	32	37	42	74
2001	8501	24	14	57	0	6	10	14	19	23	28	33	38	43	72
2002	8200	25	14	57	0	6	10	15	20	25	30	34	38	43	80
2003	7730	22	13	59	0	6	8	12	16	21	26	30	34	39	72
2004	8302	22	15	66	0	5	8	12	16	20	25	30	35	42	90
2005	8502	21	13	62	0	5	8	11	15	19	23	28	33	39	64
2006	6993	29	34	118	0	5	7	10	13	17	22	30	38	61	164

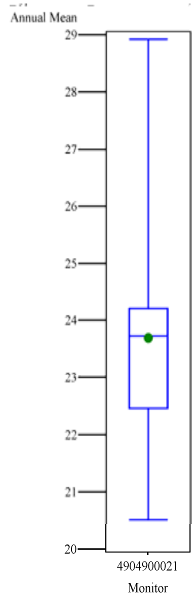

Figure A-87. Distribution of annual average NO_2 ambient concentration (ppb) by monitor, Provo MSA, 1995-2006.

Table A-87. Distribution of annual average NO_2 ambient concentration (ppb) by monitor, Provo MSA, 1995-2006.

Monitor ID	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
4904900021	12	24	2	9	21	22	22	23	23	24	24	24	24	25	29

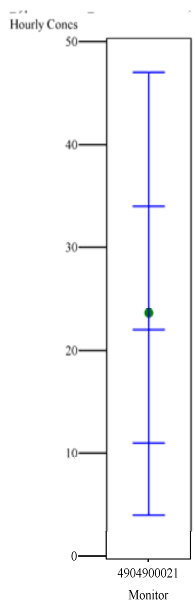

Figure A-88. Distribution of hourly NO_2 ambient concentration (ppb) by monitor, Provo MSA, 1995-2006.

Table A-88. Distribution of hourly NO_2 ambient concentration (ppb) by monitor, Provo MSA, 1995-2006.

Monitor ID	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
4904900021	96873	24	16	68	0	6	9	13	17	22	27	31	36	42	164

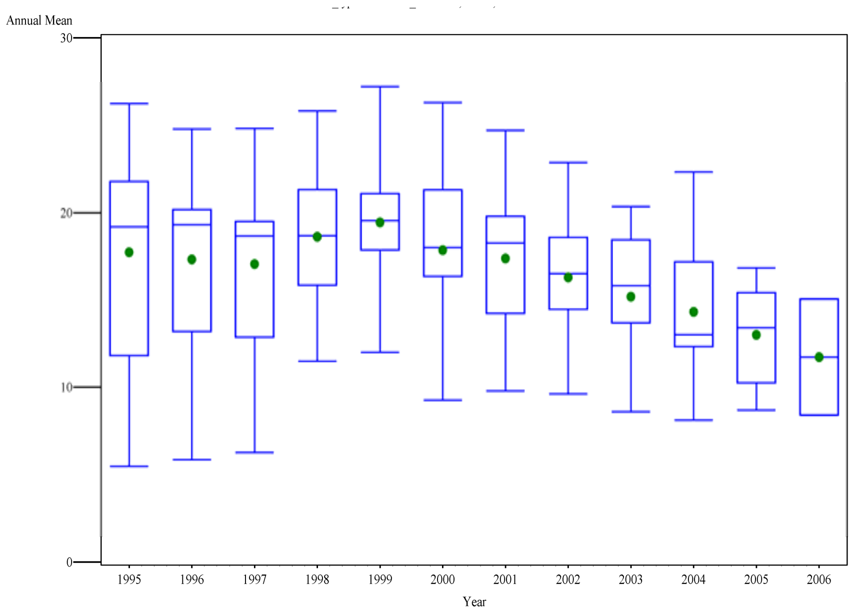

Figure A-89. Distribution of annual average NO_2 ambient concentrations (ppb) by year, St. Louis MSA.

Table A-89. Distribution of annual average NO_2 ambient concentrations (ppb) by year, St. Louis MSA.

Year	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
1995	10	18	6	35	5	8	12	15	19	19	20	22	22	24	26
1996	10	17	6	33	6	8	12	16	19	19	20	20	21	23	25
1997	10	17	6	32	6	8	12	16	19	19	19	19	21	23	25
1998	8	19	5	25	11	11	13	18	19	19	19	20	22	26	26
1999	9	19	5	24	12	12	14	18	18	20	21	21	24	27	27
2000	9	18	5	29	9	9	12	16	17	18	19	21	21	26	26
2001	8	17	5	28	10	10	12	17	17	18	19	20	20	25	25
2002	9	16	4	26	10	10	11	14	15	16	17	19	21	23	23
2003	9	15	4	26	9	9	10	14	14	16	16	18	19	20	20
2004	9	14	4	31	8	8	10	12	13	13	16	17	18	22	22
2005	6	13	3	24	9	9	10	10	12	13	15	15	15	17	17
2006	2	12	5	40	8	8	8	8	8	12	15	15	15	15	15

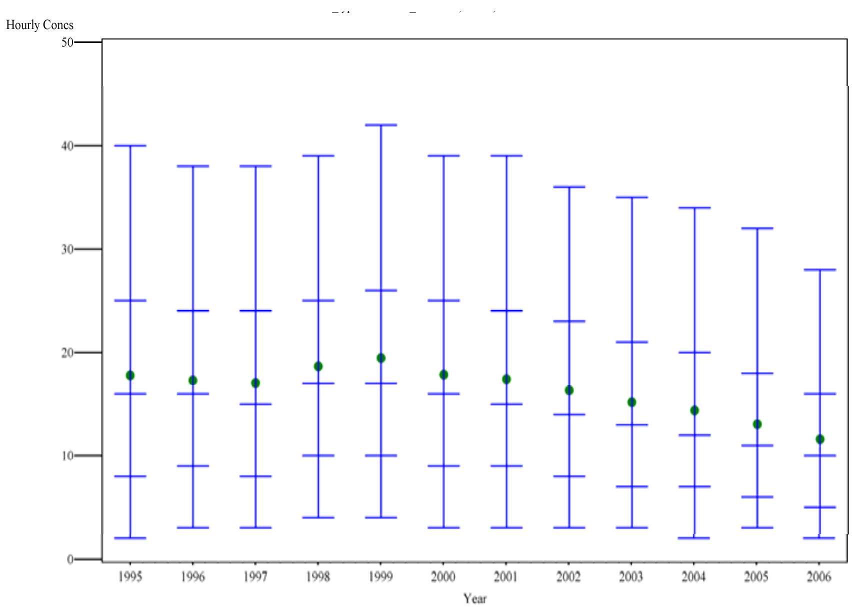

Figure A-90. Temporal distribution of hourly NO_2 ambient concentrations (ppb) by year, St. Louis MSA.

Table A-90. Distribution of hourly NO_2 ambient concentrations (ppb) by year, St. Louis MSA.

Year	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
1995	85072	18	12	68	0	4	7	10	13	16	19	23	28	34	103
1996	86085	17	11	65		4	7	10	13	16	19	22	26	32	84
1997	86314	17	11	67	0	4	7	10	12	15	18	22	26	33	274
1998	68308	19	11	58	0	6	9	12	14	17	20	23	28	33	97
1999	77611	19	12	61	0	6	9	12	14	17	20	24	29	36	99
2000	77327	18	11	64	0	5	8	10	13	16	19	22	27	34	85
2001	67871	17	11	64	0	5	7	10	13	15	19	22	27	33	95
2002	76693	16	11	65	0	5	7	9	12	14	17	21	25	31	124
2003	77543	15	10	67	0	4	6	8	11	13	16	19	23	29	123
2004	75493	14	10	69	0	4	6	8	10	12	15	18	22	28	130
2005	49948	13	9	70	0	4	5	7	9	11	13	16	20	26	70
2006	16688	12	8	70	0	3	5	6	8	10	12	15	18	23	53

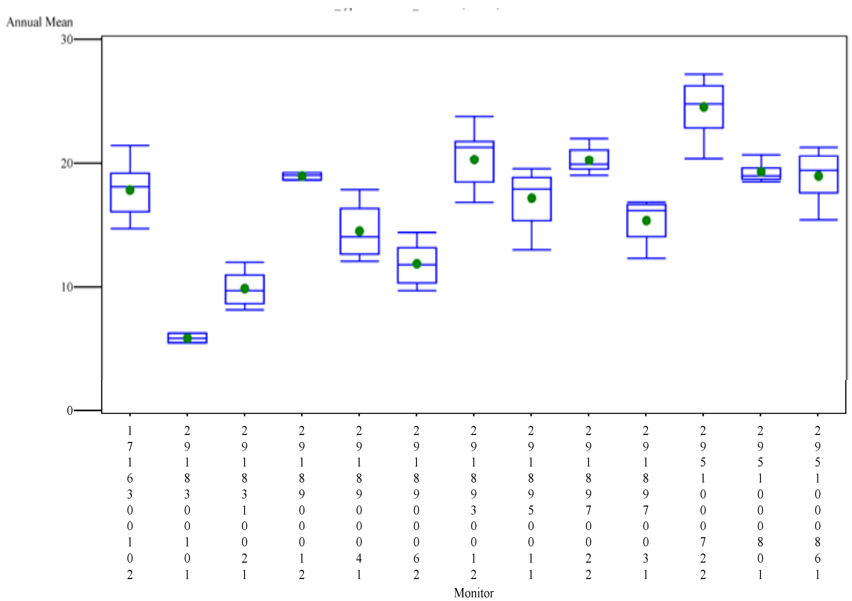

Figure A-91. Distribution of annual average NO_2 ambient concentration (ppb) by monitor, St. Louis MSA, 1995-2006.

Table A-91. Distribution of annual average NO_2 ambient concentration (ppb) by monitor, St. Louis MSA, 1995-2006.

Monitor ID	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
1716300102	12	18	2	12	15	15	16	16	17	18	18	19	19	20	21
2918300101	3	6	0	7	5	5	5	5	6	6	6	6	6	6	6
2918310021	12	10	1	13	8	8	9	9	9	10	11	11	11	11	12
2918900012	3	19	0	2	19	19	19	19	19	19	19	19	19	19	19
2918900041	6	15	2	15	12	12	13	13	14	14	14	16	16	18	18
2918900062	11	12	1	12	10	10	10	11	12	12	12	13	13	13	14
2918930012	11	20	2	11	17	17	18	19	20	21	22	22	22	22	24
2918950011	10	17	2	13	13	14	15	16	17	18	19	19	19	19	20
2918970022	6	20	1	6	19	19	20	20	20	20	20	21	21	22	22
2918970031	4	15	2	14	12	12	12	16	16	16	16	16	17	17	17
2951000722	10	25	2	9	20	21	23	24	25	25	25	26	26	27	27
2951000801	5	19	1	5	19	19	19	19	19	19	19	20	20	21	21
2951000861	6	19	2	11	15	15	18	18	19	19	20	21	21	21	21

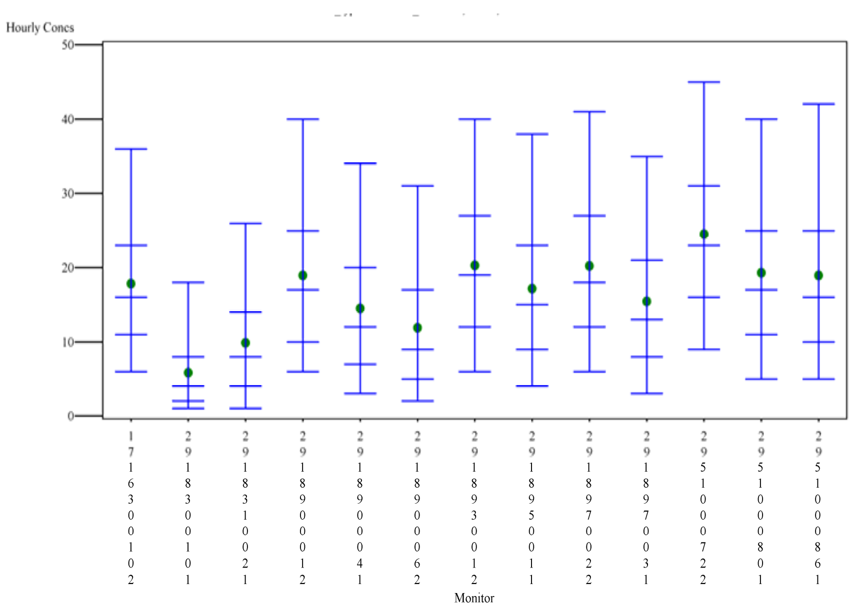

Figure A-92. Distribution of hourly NO_2 ambient concentration (ppb) by monitor, St. Louis MSA, 1995-2006.

Table A-92. Distribution of hourly NO_2 ambient concentration (ppb) by monitor, St. Louis MSA, 1995-2006.

Monitor ID	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
1716300102	101236	18	9	52	0	8	10	12	14	16	19	21	25	31	123
2918300101	25873	6	6	98	0	1	2	2	3	4	5	7	9	13	51
2918310021	99623	10	8	81	0	2	3	4	6	8	10	12	16	21	73
2918900012	25801	19	11	58	0	7	9	12	14	17	20	23	28	34	89
2918900041	51987	15	10	68	0	4	6	8	10	12	15	18	22	29	80
2918900062	93770	12	9	79	0	3	4	5	7	9	12	15	19	25	79
2918930012	95589	20	11	52	0	8	11	13	16	19	22	25	29	35	101
2918950011	86912	17	11	62	0	6	8	10	12	15	18	21	26	32	124
2918970022	51777	20	11	54	0	8	11	13	16	18	21	25	29	36	103
2918970031	32235	15	10	66	0	4	7	9	11	13	16	19	24	30	64
2951000722	85643	25	11	46	0	11	15	18	20	23	26	29	33	40	130
2951000801	42884	19	11	59	0	7	10	12	15	17	20	23	28	34	274
2951000861	51623	19	12	62	0	6	9	11	14	16	19	23	28	36	87

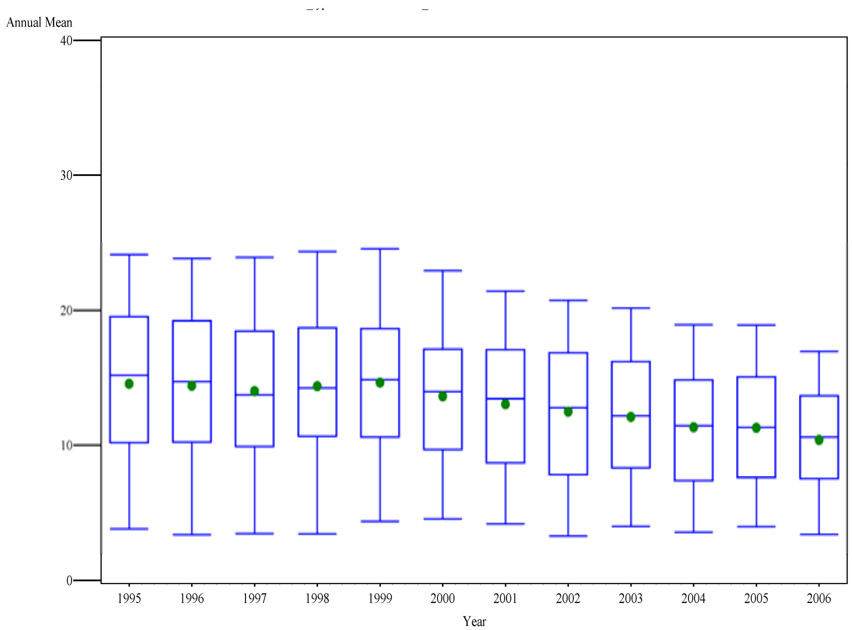

Figure A-93. Distribution of annual average NO_2 ambient concentrations (ppb) by year, Other MSA/CMSA.

Table A-93. Distribution of annual average NO_2 ambient concentrations (ppb) by year, Other MSA/CMSA.

Year	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
1995	186	15	6	44	1	5	8	11	13	15	17	18	21	22	32
1996	186	14	6	43	1	5	9	11	13	15	16	18	20	22	30
1997	187	14	6	43	2	5	9	11	12	14	16	18	19	22	29
1998	185	14	6	43	1	5	10	11	13	14	16	18	20	22	31
1999	192	15	6	42	1	6	9	11	14	15	16	18	20	23	29
2000	199	14	6	41	1	5	8	11	12	14	16	17	18	21	26
2001	201	13	6	43	1	5	7	10	12	13	15	17	18	20	27
2002	209	12	6	45	1	5	7	9	11	13	14	16	17	20	27
2003	202	12	5	42	1	5	7	9	11	12	14	15	17	18	26
2004	211	11	5	44	1	5	7	9	10	11	13	14	16	17	25
2005	207	11	5	43	1	5	7	9	10	11	12	14	16	17	24
2006	147	10	4	41	1	4	6	9	9	11	12	13	14	16	18

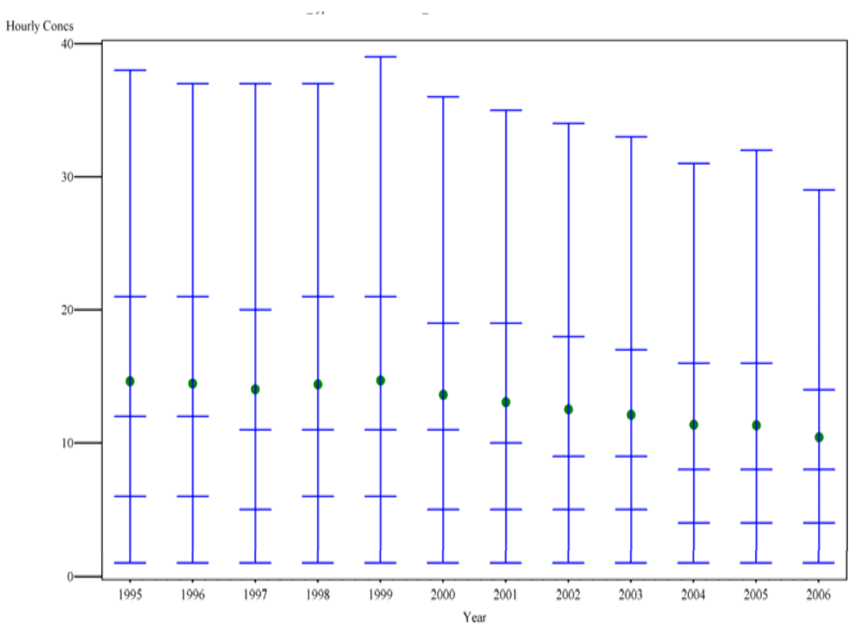

Figure A-94. Distribution of hourly NO_2 ambient concentrations (ppb) by year, Other MSA/CMSA.

Table A-94. Distribution of hourly NO_2 ambient concentrations (ppb) by year, Other MSA/CMSA.

Year	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
1995	186	15	6	44	1	5	8	11	13	15	17	18	21	22	32
1996	1520743	14	12	81	0	2	5	7	9	12	15	18	23	31	336
1997	1520290	14	11	82	0	2	4	6	9	11	14	18	23	30	313
1998	1503051	14	11	80	0	2	5	7	9	11	15	18	23	31	300
1999	1560074	15	12	83	0	3	5	7	9	11	14	18	24	32	172
2000	1630060	14	11	81	0	2	4	6	8	11	13	17	22	29	289
2001	1648640	13	11	84	0	2	4	6	8	10	13	16	21	29	193
2002	1713558	13	11	85	0	2	4	5	7	9	12	15	20	28	158
2003	1661992	12	10	84	0	2	4	5	7	9	12	15	19	26	148
2004	1738133	11	10	87	0	2	3	5	7	8	11	14	18	25	160
2005	1706730	11	10	87	0	2	3	5	6	8	11	14	18	25	153
2006	1168444	10	9	87	0	2	3	5	6	8	10	13	17	23	240

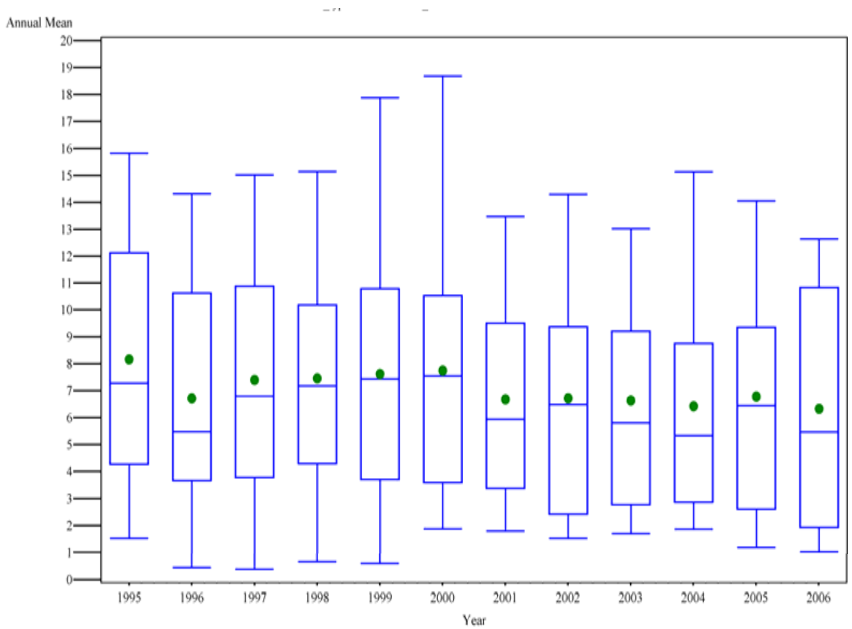

Figure A-95. Distribution of annual average NO_2 ambient concentrations (ppb) by year, Other Not MSA.

Table A-95. Distribution of annual average NO_2 ambient concentrations (ppb) by year, Other Not MSA.

Year	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
1995	28	8	5	59	1	2	4	5	7	7	8	10	13	15	19
1996	29	7	5	71	0	0	2	4	5	5	7	10	13	14	14
1997	35	7	5	67	0	1	3	4	5	7	9	10	12	14	20
1998	33	7	5	62	1	1	3	4	5	7	7	10	12	14	19
1999	36	8	5	67	0	1	3	4	5	7	8	9	12	16	20
2000	39	8	4	57	2	2	3	5	6	8	8	10	11	14	19
2001	41	7	4	60	1	2	3	4	5	6	8	9	10	13	17
2002	42	7	4	65	1	2	2	3	4	6	8	8	10	13	16
2003	44	7	4	61	1	2	3	3	4	6	8	9	11	13	15
2004	47	6	4	64	2	2	2	3	4	5	7	8	11	13	16
2005	43	7	4	63	1	2	2	3	5	6	8	9	11	12	17
2006	26	6	5	71	1	1	2	2	3	5	8	10	11	12	16

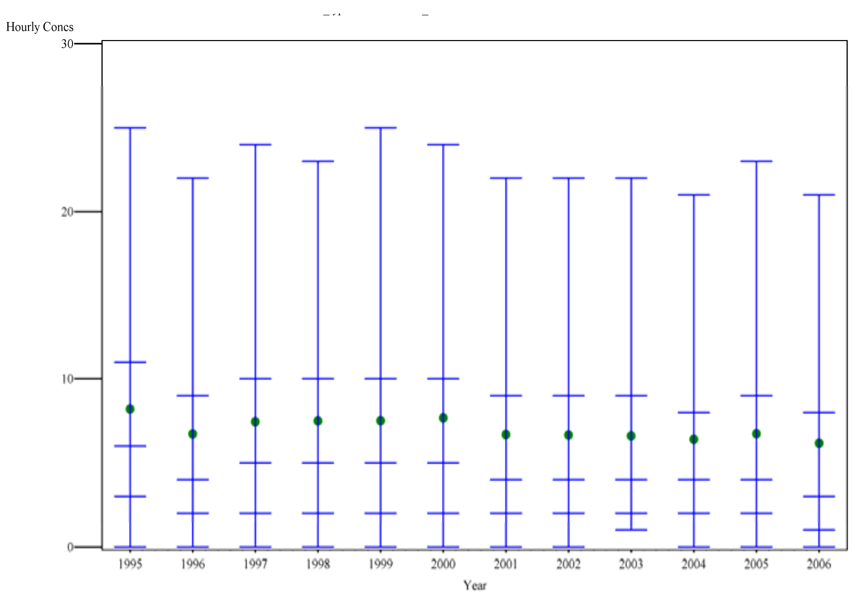

Figure A-96. Distribution of hourly NO_2 ambient concentrations (ppb) by year, Other Not MSA.

Table A-96. Distribution of hourly NO_2 ambient concentrations (ppb) by year, Other Not MSA.

Year	n	Mean	SD	COV	Min	p10	p20	p30	p40	p50	p60	p70	p80	p90	Max
1995	225810	8	9	104	0	0	2	3	4	6	7	10	13	19	217
1996	234628	7	8	118	0	0	1	2	3	4	6	8	11	17	164
1997	278906	7	8	113	0	0	1	2	3	5	6	9	12	18	207
1998	264015	8	8	105	0	1	2	3	4	5	7	9	12	18	181
1999	290382	8	9	113	0	0	2	2	3	5	6	9	12	18	286
2000	316568	8	8	104	0	1	2	3	4	5	7	9	12	18	192
2001	328407	7	7	109	0	1	1	2	3	4	6	8	11	16	139
2002	340873	7	7	112	0	1	1	2	3	4	5	8	11	17	267
2003	351652	7	7	110	0	1	2	2	3	4	5	7	10	16	201
2004	375716	6	7	115	0	1	1	2	3	4	5	7	10	16	285
2005	353229	7	8	114	0	1	1	2	3	4	6	8	11	17	262
2006	207114	6	7	119	0	0	1	2	2	3	5	7	10	16	101

A-6 Technical Memorandum on Regression Modeling

This section provides a technical memorandum submitted to EPA by ICF International. The memo has been formatted for consistency with the entire appendix. The work documented in section A-6 was part of the initial exploratory analyses conducted to develop and evaluate the relationship between the annual average concentration and the number of exceedances of potential health effect benchmark levels. Conceptually, the approach was based on analyses conducted for the last NO_2 NAAQS review in 1995 (McCurdy, 1994).

Staff found that use of a regression model applied to the 1995-2006 ambient air quality unsatisfactory, both because the models did not show a strong relationship between the annual means and the number of exceedances, and because the predicted numbers of exceedances for evaluating the current annual standard scenario were in many cases extremely high and uncertain. In addition, due to the lack of data containing a number of values at or above 200 ppb 1-hour, staff decided to develop empirical exceedance estimates, as described in the REA.

There have been no modifications or re-analyses to the regression models or results since they were first produced and documented in the 1st draft REA Technical Support Document (TSD). They do not have any relationship to the estimated concentrations or numbers of exceedances provided in the Final REA. Nevertheless, the regression models explored, developed, and applied are described with the following to give the reader justification as to why the regression model was not used and for why an empirical approach was ultimately used in the Final REA to estimate the number of exceedances of the short-term (1-hour) potential health effect benchmark levels.

A-6.1 Summary

This section describes the regression analyses of 1995 to 2006 NO_2 hourly concentration data. Regression was used to estimate the annual number of exceedances of 150 ppb from the annual mean, in 20 locations (mostly large urban areas). Exposures to concentrations above certain thresholds may be associated with adverse health effects. These models were applied in an as-is scenario to estimate the annual exceedances at sites with annual means equal to the 1995-2006 current average for their location. These models were also applied in a current-standard scenario to predict the annual exceedances at sites with annual means equal to the current annual average NO_2 standard of 0.053 ppm. The current-standard scenario is an extrapolation to higher annual means than currently observed; the maximum annual mean across all complete site-years was 51 ppb, in Los Angeles.

A-6.2 Data Used

All of the 1995 to 2006 NO_2 hourly concentration data from AQS were compiled and annual summary statistics for each site-year combination were computed. Of particular interest is the long-term air quality measured by the annual mean and the short-term air quality measured by the annual numbers of hourly exceedances of selected levels 150, 200, 250 and 300 ppb. Exposures to concentrations above these thresholds may be associated with adverse health effects. To make the results temporally representative, we restricted the analyses to the 20 percent of site-years that were 75 % complete, as defined by having data for 75 % of the hours in a year and having data for at least 75 % of the hours in a day (i.e., 18 hours or more) on at least

75 % of the days in a year. We also spatially grouped the data into 18 urban areas with high annual means and high exceedances; these locations were all CMSAs or MSAs either with at least one site-year annual mean above 25.7 ppb (the 90th percentile) or with at least one exceedance of 200 ppb, as follows.

- Atlanta
- Boston
- Chicago
- Cleveland
- Colorado Springs
- Denver
- Detroit
- El Paso
- Jacksonville
- Las Vegas
- Los Angeles
- Miami
- New York
- Philadelphia
- Phoenix
- Provo
- St. Louis
- Washington DC

The remaining site-years were analyzed as two additional location groups: "Other MSA/CMSA" site-years in an MSA or CMSA, and "Other Not MSA" site-years not in an MSA. Thus we have a total of 20 "locations."

A-6.3 Regression Models

The regression modeling of the 1995-2006 NO_2 data continues the analyses by McCurdy (1994)[4] of the 1988-1992 data. A regression model is used to estimate the mean number of exceedances from the annual mean. McCurdy (1994) assumed normally distributed exceedances and an exponential link function to estimate exceedances of 150, 200, 250, and 300 ppb based on the 1988-1992 data. In this section we present the results of the regression analyses for exceedances of 150 ppb using eight alternative models based on the 1995-2006 data. Throughout this discussion, "exceedances" will refer to annual numbers of hourly exceedances of 150 ppb, unless otherwise stated.

Of the eight models, the two selected regression models were the Poisson exponential model and the normal linear model, stratified by location. The Poisson exponential model is of the form:

- Number of exceedances has a Poisson distribution.
- Mean exceedances = exp(a + b × annual mean).
- The intercept a, and slope b, depend on the location.

[4] McCurdy TR (1994). Analysis of high 1 hour NO_2 values and associated annual averages using 1988-1992 data. Report to the Office of Air Quality Planning and Standards, Durham NC.

The normal linear model is of the form:

- Number of exceedances has a normal distribution with standard deviation s.
- Mean exceedances = a + b × annual mean.
- The intercept a, slope b, and s all depend on the location.

The first issue to be resolved was to decide whether to apply the regression analyses to the means and exceedances for each season separately or to each year. We examined the exceedance data for Colorado Springs, which had the highest maximum number of annual exceedances of 200 ppb, 69, which occurred at site 804160181 in 2000. Of these 69 exceedances, 34 occurred in the winter on January 18-20, 2000, and 35 occurred in the summer on June 12-14, 2000. This limited analysis suggests that there is no clear pattern of seasonality in the exceedances. We decided to apply the regression modeling to the annual means and annual exceedances.

Table 1 describes the eight regression models fitted. As described shortly, we fitted two distributions (normal and Poisson), two link functions (identity and exponential), and two stratifications (all data and stratified by location). The McCurdy (1994) analysis used a normal distribution, an exponential link, and stratified by location into Los Angeles and Not Los Angeles.

We fitted generalized linear models where the number of exceedances has a given distribution (we fitted normal and Poisson distributions) and where the mean number of exceedances is a given function g of the annual mean. The function g(x) is called the link function. We can also define the link by defining the inverse link, i.e., the solution for x of the equation g(x) = y.

We fitted two link functions, an identity link g(x) = x and a logarithmic link g(x) = log(x), where "log" denote the natural logarithm. The corresponding inverse links are the identity link, which we also call the "linear" function, and the exponential function. Thus, the linear inverse link models are of the form:

Mean exceedances = a + b × annual mean.

The exponential inverse link models are of the form:

Mean exceedances = exp(a + b × annual mean).

Table A-97. Goodness-of-fit statistics for eight generalized linear models.

Distribution	Inverse Link	Strata (a separate model is fitted in each stratum)	R squared for all data	Min R squared among locations	Max R squared among locations	Log-Likelihood	Number of strata in final model
Normal	Linear	All	0.033			-11527	1
Normal	Linear	Location	0.244	0.006	0.616	-6065	13**
Normal	Exponential	All	0.066			-11438	1
Normal	Exponential	Location	0.401	0.005	0.981	-8734	11***

Poisson	Linear	All	0.025			-4737	1
Poisson	Linear	Location	Not Shown*	Not Shown*	Not Shown*	Not Shown*	Not Shown*
Poisson	Exponential	All	0.064			-3660	1
Poisson	Exponential	Location	0.406	0.004	0.976	-2694	13**

Notes:
* Model converged for only Cleveland, Atlanta, and "Other Not MSA" locations. Results are not shown since the model failed to converge for the "Other MSA" location, so the overall goodness-of-fit is not comparable to the other seven models.
** "Other MSA" includes Chicago, Detroit, Philadelphia, Jacksonville, Las Vegas, Provo, St. Louis.
*** "Other MSA" includes Chicago, Cleveland, Detroit, Philadelphia, Jacksonville, Las Vegas, Phoenix, Provo, St. Louis.

For each link function we fitted models using the normal distribution and the Poisson distribution. The normal model is at best an approximation since the numbers of exceedances must be positive or zero integers, but the normal distribution is continuous and includes negative values. T he Poisson model takes the form:

$$\text{Prob(y exceedances)} = (M^y/y!)e^{-M},\ y = 0, 1, 2, \ldots,$$

where M is the mean exceedances.

We fitted these four models (two links, two distributions) either to all the data or stratified by location. Thus the model fitted to all the data assumes that *a* and *b* have the same value for all site-years, and the model fitted by location assumes that a and b have the same value for all site-years at the same location but these values may vary between locations. For the normal models, the variance of the number of exceedances is assumed to be the same for all site-years in each stratum. For the Poisson models, the variance equals the mean number of exceedances.

The models stratified by location were fitted in two steps. First, each model was separately fitted to each of the 20 locations. For several models and locations, there were problem cases where the algorithm failed to converge to a solution, predicted a negative slope for the annual mean, or had only zero or one site-year with at least one exceedance. In the second case, if the slope is negative, then the model implies that exceedances decrease when the annual mean increases, which is unexpected and could lead to inconsistent results for projecting exceedances to the current-standard scenario. In the third case, there would be zero degrees of freedom and the model would be over-fitted for that location. To deal with these problem cases, we re-allocated all the problem locations into the "Other MSA" combined location and refitted the models. The results in Table 1 stratified by location are for the refitted models. The re-allocated locations are listed in the footnotes.

Table A-97 gives R squared and log-likelihood goodness-of-fit summary statistics. The R squared statistic is the squared Pearson correlation coefficient between the observed number of exceedances and the predicted mean number of exceedances. Negative predicted means are replaced by zero for this calculation. Values close to 1 indicate a good fit and values close to zero indicate a poor fit. For the models stratified by location, it is evident that the R squared value has a wide range across the locations, varying from a very poor fit at some locations to a very good fit at other locations.

For these models the log-likelihood is a better overall goodness-of-fit statistic. The log-likelihood is defined as the logarithm of the fitted joint density function to all 4,177 site-years. The better-fitting models are those with the highest values of the log-likelihood. (The log-likelihood can only be used to compare different models; its value for a single statistical model is not meaningful). Of the various normal models, the best-fitting is stratified by location and uses a linear inverse link. Of the various Poisson models, the best-fitting is stratified by location and uses an exponential inverse link. The Poisson models fit better than the normal models, which is to be expected since the actual data are positive or zero discrete count data and the numbers of exceedances are frequently zero, implying a very small mean.

We selected the Poisson exponential model stratified by location and the normal linear model stratified by location. The estimated parameter values for these models are displayed in Tables A-98 and A-99, respectively.

The fitted models for the CMSA locations are displayed in Figures A-97 to A-99. Figure A-97 and the first three attached plots show the number of exceedances plotted against the annual mean. These plots clearly show how weak the relationship between the exceedances and the annual mean is. Figure A-98 and the next three attached plots are for the Poisson exponential model, plotting predicted versus observed exceedances. Figure A-99 and the final three attached plots are for the normal linear model, plotting predicted versus observed exceedances (negative predictions were replaced by zero). Comparing the normal and Poisson model predictions, the normal model tends to under-predict the higher numbers of observed exceedances.

Tables A-100 and A-101 indicate the predictions for a mean of 53 ppb and for the mean annual mean for each the Poisson exponential model and the normal linear model, respectively. The predictions for a mean of 53 ppb estimate the number of exceedances for a hypothetical site-year with the highest annual mean concentration under the current-standard scenario, i.e., when the highest annual mean site-year for a given location just meets the annual standard. The predictions for a mean equal to the mean annual mean estimate the number of exceedances for the typical "as-is" scenario, i.e., for a hypothetical site-year with an annual mean that is the average annual mean for that location. 95 percent confidence and prediction intervals for the number of exceedances at given mean levels were also estimated using each model. In addition, exceedances were also estimated at alternative annual mean concentrations. Tables A-103 and A-104 give calculated predictions at annual mean values of 20, 30, 40, 50, 53, and 60 ppb and at the minimum, mean, and maximum annual mean value for each location using the Poisson exponential model and the normal linear model, respectively.

The 95% confidence interval gives the uncertainty of the expected value, i.e., of the average number of exceedances over hypothetically infinitely many site-years with the same annual mean. The 95% prediction interval gives the uncertainty of the value for a single site-year, taking into account both the uncertainty of the estimated parameters and the variability of the number of exceedances in a given site-year about the overall mean. All prediction intervals were truncated to be greater than or equal to zero and less than or equal to 1,000. The maximum possible number of exceedances in a year is the maximum number of hours in a leap year, 8,784. The maximum observed exceedances in a year was 69.

For annual means within the range of the data, the predicted numbers of exceedances are generally within the range of the observed numbers of exceedances. The normal model predictions tend to be lower than the Poisson model predictions. At annual mean levels above the range of the data, the Poisson model with the exponential inverse link sometimes gives extremely high estimates, well beyond the truncation limit of 1,000. This is mainly due to the exponential link; each increase of the annual mean by 1 ppb increases the predicted exceedances by a multiplicative factor of exp(b), where $b > 0$. The upper bounds of the normal linear model prediction intervals are at most a more reasonable 202, but these predictions are less reliable because the Poisson model with an exponential inverse link fits the data much better. For the normal linear model, each increase of the annual mean by 1 ppb increases the predicted exceedances by b ppb.

Not shown here are the results for the normal model with an exponential inverse link, which was the model formulation selected by McCurdy (1994). That model gives roughly similar predictions to the Poisson model with the exponential inverse link.

Table A-98. Parameters for Poisson exponential model stratified by location.

Location Type	Location Name	Parameter*	Estimate	Standard Error	Lower Confidence Bound	Upper Confidence Bound	P-value **
MSA	Atlanta,GA	Intercept	-5.081	1.917	-9.975	-2.139	0.01
MSA	Atlanta,GA	mean	0.140	0.099	-0.040	0.363	0.16
MSA	Atlanta,GA	Scale	1.000	0.000	1.000	1.000	_
CMSA	Boston-Worcester-Lawrence, MA-NH-ME-CT CMSA	Intercept	-6.887	2.832	-14.693	-2.757	0.02
CMSA	Boston-Worcester-Lawrence, MA-NH-ME-CT CMSA	mean	0.144	0.116	-0.061	0.430	0.22
CMSA	Boston-Worcester-Lawrence, MA-NH-ME-CT CMSA	Scale	1.000	0.000	1.000	1.000	_
CMSA	Cleveland-Akron, OH CMSA	Intercept	-14.209	4.374	-25.210	-7.312	0.00
CMSA	Cleveland-Akron, OH CMSA	mean	0.548	0.164	0.283	0.952	0.00
CMSA	Cleveland-Akron, OH CMSA	Scale	1.000	0.000	1.000	1.000	_
MSA	Colorado Springs,CO	Intercept	-4.846	0.401	-5.675	-4.097	0.00
MSA	Colorado Springs,CO	mean	0.284	0.012	0.261	0.309	0.00
MSA	Colorado Springs,CO	Scale	1.000	0.000	1.000	1.000	_
CMSA	Denver-Boulder-Greeley, CO CMSA	Intercept	-4.399	1.186	-7.182	-2.435	0.00
CMSA	Denver-Boulder-Greeley, CO CMSA	mean	0.137	0.038	0.070	0.222	0.00
CMSA	Denver-Boulder-Greeley, CO CMSA	Scale	1.000	0.000	1.000	1.000	_
MSA	El Paso,TX	Intercept	-10.436	2.455	-16.783	-6.664	0.00
MSA	El Paso,TX	mean	0.350	0.074	0.233	0.538	0.00
MSA	El Paso,TX	Scale	1.000	0.000	1.000	1.000	_
CMSA	Los Angeles-Riverside-Orange County, CA CMSA	Intercept	-5.628	0.253	-6.134	-5.142	0.00
CMSA	Los Angeles-Riverside-Orange County, CA CMSA	mean	0.181	0.006	0.169	0.194	0.00
CMSA	Los Angeles-Riverside-Orange County, CA CMSA	Scale	1.000	0.000	1.000	1.000	_
CMSA	Miami-Fort Lauderdale, FL CMSA	Intercept	-5.780	1.641	-9.774	-3.068	0.00
CMSA	Miami-Fort Lauderdale, FL CMSA	mean	0.342	0.114	0.138	0.606	0.00
CMSA	Miami-Fort Lauderdale, FL CMSA	Scale	1.000	0.000	1.000	1.000	_
CMSA	New York-Northern New Jersey-Long Island, NY-NJ-CT-PA CMS	Intercept	-6.800	1.269	-9.560	-4.537	0.00
CMSA	New York-Northern New Jersey-Long Island, NY-NJ-CT-PA CMS	mean	0.147	0.037	0.079	0.224	0.00
CMSA	New York-Northern New Jersey-Long Island, NY-NJ-CT-PA CMS	Scale	1.000	0.000	1.000	1.000	_
MSA	Phoenix-Mesa,AZ	Intercept	-1.568	0.400	-2.363	-0.798	0.00
MSA	Phoenix-Mesa,AZ	mean	0.106	0.013	0.081	0.131	0.00

Location Type	Location Name	Parameter*	Estimate	Standard Error	Lower Confidence Bound	Upper Confidence Bound	P-value **
MSA	Phoenix-Mesa,AZ	Scale	1.000	0.000	1.000	1.000	_
CMSA	Washington-Baltimore, DC-MD-VA-WV CMSA	Intercept	-6.559	3.054	-14.610	-2.054	0.03
CMSA	Washington-Baltimore, DC-MD-VA-WV CMSA	mean	0.145	0.135	-0.073	0.482	0.28
CMSA	Washington-Baltimore, DC-MD-VA-WV CMSA	Scale	1.000	0.000	1.000	1.000	_
MSA/CMSA	Other MSA	Intercept	-5.137	0.222	-5.580	-4.711	0.00
MSA/CMSA	Other MSA	mean	0.152	0.010	0.132	0.172	0.00
MSA/CMSA	Other MSA	Scale	1.000	0.000	1.000	1.000	_
Not MSA	Other Not MSA	Intercept	-4.672	0.467	-5.654	-3.818	0.00
Not MSA	Other Not MSA	mean	0.227	0.036	0.158	0.300	0.00
Not MSA	Other Not MSA	Scale	1.000	0.000	1.000	1.000	_

Notes:
* using the report notation, a = “Intercept”, and b = “mean.” “Scale” equals 1, by definition, for this model.
** probability that the Chi-square test for that parameter = 0.

Table A-99. Parameters for normal linear model stratified by location.

Location Type	Location Name	Parameter*	Estimate	Standard Error	Lower Confidence Bound	Upper Confidence Bound	P-value **
MSA	Atlanta,GA	Intercept	-0.041	0.069	-0.178	0.096	0.55
MSA	Atlanta,GA	mean	0.008	0.005	-0.002	0.017	0.11
MSA	Atlanta,GA	Scale	0.226	0.022	0.189	0.277	_
CMSA	Boston-Worcester-Lawrence, MA-NH-ME-CT CMSA	Intercept	-0.023	0.034	-0.090	0.043	0.49
CMSA	Boston-Worcester-Lawrence, MA-NH-ME-CT CMSA	mean	0.003	0.002	-0.001	0.006	0.17
CMSA	Boston-Worcester-Lawrence, MA-NH-ME-CT CMSA	Scale	0.135	0.009	0.119	0.156	_
CMSA	Cleveland-Akron, OH CMSA	Intercept	-3.259	2.127	-7.617	1.098	0.13
CMSA	Cleveland-Akron, OH CMSA	mean	0.176	0.099	-0.027	0.378	0.08
CMSA	Cleveland-Akron, OH CMSA	Scale	1.755	0.265	1.341	2.436	_
MSA	Colorado Springs,CO	Intercept	-36.358	11.812	-60.391	-12.326	0.00
MSA	Colorado Springs,CO	mean	2.689	0.674	1.318	4.061	0.00
MSA	Colorado Springs,CO	Scale	22.519	3.123	17.551	30.362	_
CMSA	Denver-Boulder-Greeley, CO CMSA	Intercept	-0.439	0.383	-1.211	0.332	0.25
CMSA	Denver-Boulder-Greeley, CO CMSA	mean	0.044	0.018	0.008	0.080	0.01

Location Type	Location Name	Parameter*	Estimate	Standard Error	Lower Confidence Bound	Upper Confidence Bound	P-value **
CMSA	Denver-Boulder-Greeley, CO CMSA	Scale	1.097	0.129	0.885	1.408	_
MSA	El Paso,TX	Intercept	-2.017	0.440	-2.898	-1.135	0.00
MSA	El Paso,TX	mean	0.131	0.024	0.083	0.178	0.00
MSA	El Paso,TX	Scale	0.920	0.098	0.757	1.151	_
CMSA	Los Angeles-Riverside-Orange County, CA CMSA	Intercept	-3.301	0.620	-4.519	-2.083	0.00
CMSA	Los Angeles-Riverside-Orange County, CA CMSA	mean	0.194	0.023	0.148	0.240	0.00
CMSA	Los Angeles-Riverside-Orange County, CA CMSA	Scale	4.723	0.174	4.402	5.085	_
CMSA	Miami-Fort Lauderdale, FL CMSA	Intercept	-0.496	0.384	-1.265	0.273	0.20
CMSA	Miami-Fort Lauderdale, FL CMSA	mean	0.070	0.037	-0.005	0.144	0.06
CMSA	Miami-Fort Lauderdale, FL CMSA	Scale	0.828	0.088	0.681	1.036	_
CMSA	New York-Northern New Jersey-Long Island, NY-NJ-CT-PA CMS	Intercept	-0.230	0.104	-0.435	-0.024	0.03
CMSA	New York-Northern New Jersey-Long Island, NY-NJ-CT-PA CMS	mean	0.013	0.004	0.005	0.020	0.00
CMSA	New York-Northern New Jersey-Long Island, NY-NJ-CT-PA CMS	Scale	0.407	0.022	0.368	0.454	_
MSA	Phoenix-Mesa,AZ	Intercept	-7.102	15.545	-38.177	23.974	0.65
MSA	Phoenix-Mesa,AZ	mean	0.423	0.557	-0.689	1.536	0.45
MSA	Phoenix-Mesa,AZ	Scale	22.513	2.274	18.697	27.828	_
CMSA	Washington-Baltimore, DC-MD-VA-WV CMSA	Intercept	-0.032	0.069	-0.167	0.104	0.64
CMSA	Washington-Baltimore, DC-MD-VA-WV CMSA	mean	0.003	0.003	-0.004	0.010	0.35
CMSA	Washington-Baltimore, DC-MD-VA-WV CMSA	Scale	0.208	0.013	0.186	0.236	_
MSA/CMSA	Other MSA	Intercept	-0.100	0.051	-0.201	0.000	0.05
MSA/CMSA	Other MSA	mean	0.013	0.003	0.006	0.019	0.00
MSA/CMSA	Other MSA	Scale	1.098	0.015	1.069	1.128	_
Not MSA	Other Not MSA	Intercept	-0.064	0.049	-0.160	0.031	0.19
Not MSA	Other Not MSA	mean	0.021	0.006	0.009	0.032	0.00
Not MSA	Other Not MSA	Scale	0.549	0.018	0.514	0.587	_

Notes:

Using the report notation, a = “Intercept”, b = “mean”, and standard deviation = “Scale.”

****** probability that the Chi-square test for that parameter = 0.

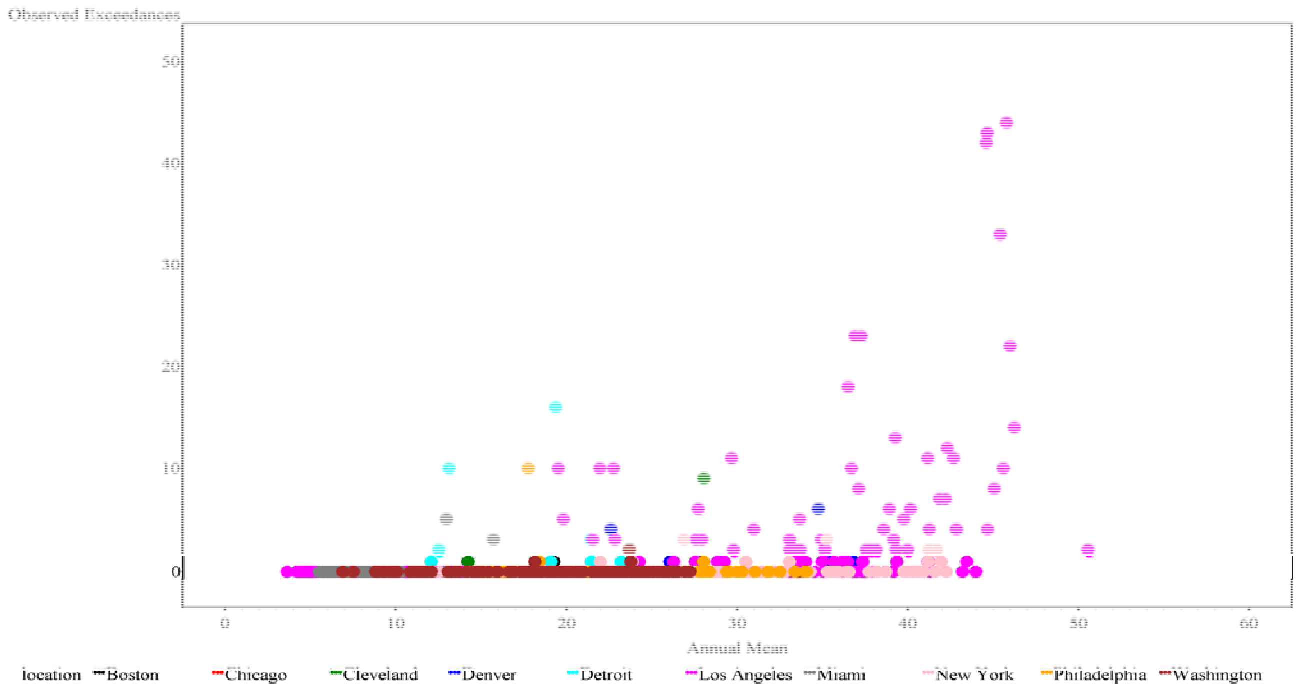

Figure A-97. Measured number of exceedances of 1-hour NO_2 concentrations of 150 ppb versus annual mean NO_2 concentrations (ppb) for CMSA locations.

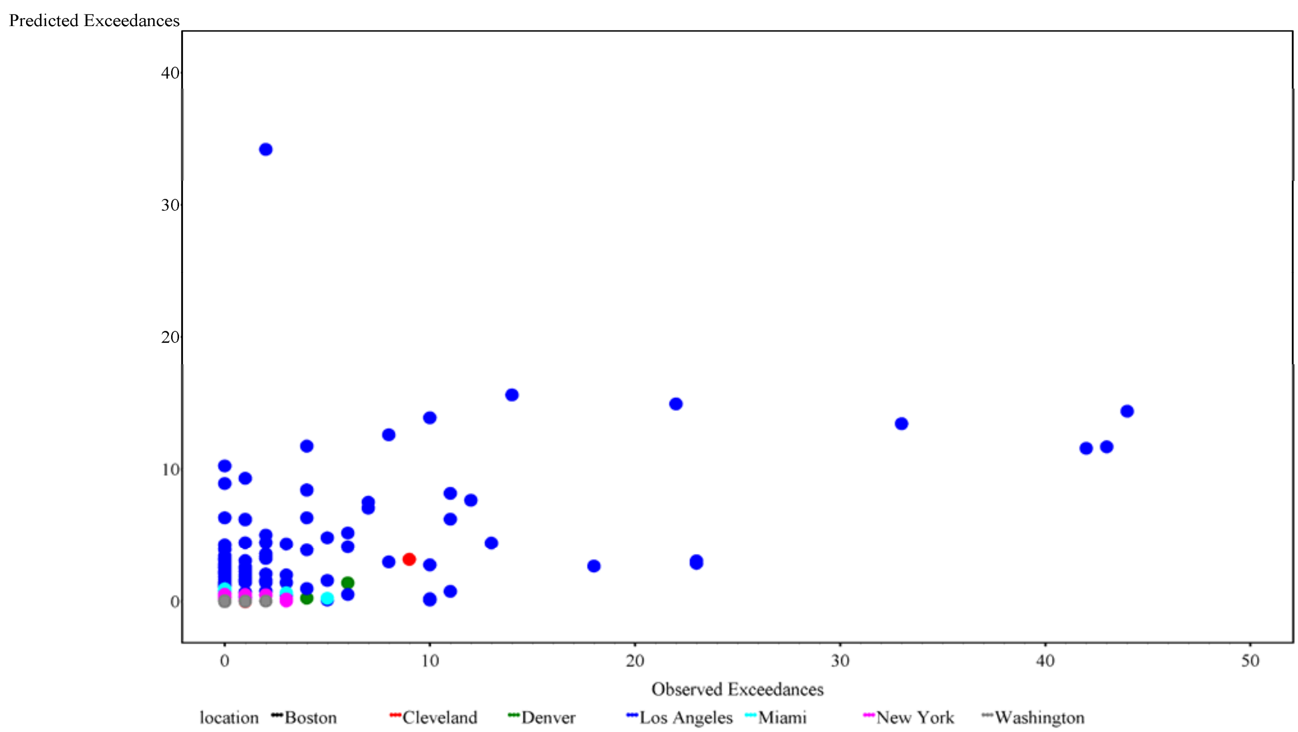

Figure A-98. Predicted and observed exceedances of 1-hour NO_2 concentrations of 150 ppb for CMSA locations using Poisson exponential model.

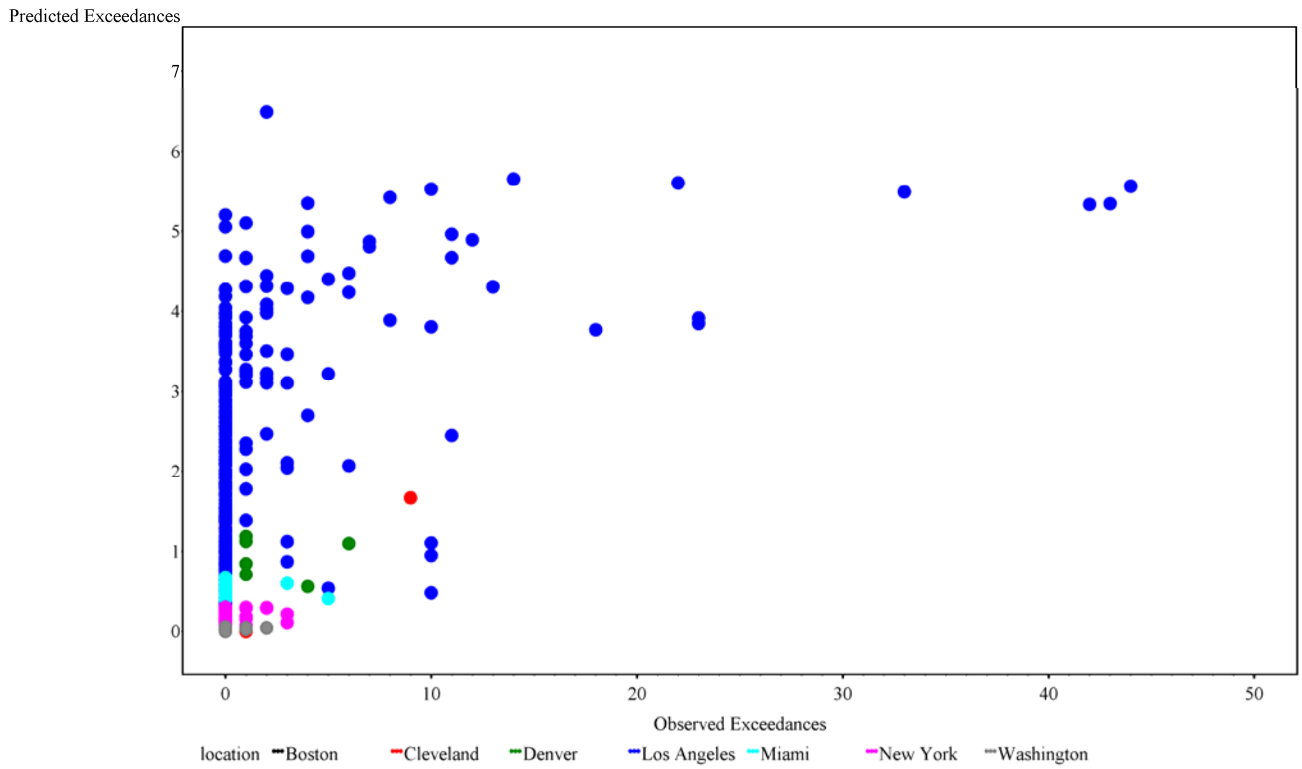

Figure A-99. Predicted and observed exceedances of 1-hour NO_2 concentrations of 150 ppb for CMSA locations using normal linear model

Table A-100. Predicted number of exceedances of of 1-hour NO_2 concentrations of 150 ppb using a Poisson exponential model for the as-is and current-standard scenarios.

Location	Annual Mean (ppb)	Observed Mean Exceed-ances	Observed Max Exceed-ances	Predicted Exceed-ances	95% Confidence Interval for Mean Number of Exceedances		95% Prediction Interval for Number of Exceedances	
					Lower Bound	Upper Bound	Lower Bound	Upper Bound
Atlanta	53.0	0.057	1	10.242	0.012	1000.000	0	1000
Atlanta	12.9	0.057	1	0.038	0.008	0.181	0	1
Boston	53.0	0.019	1	2.081	0.002	1000.000	0	1000
Boston	16.8	0.019	1	0.011	0.001	0.091	0	0
Cleveland	53.0	0.455	9	1000.000	578.253	1000.000	364	1000
Cleveland	21.2	0.455	9	0.073	0.011	0.474	0	1
Colorado Springs	53.0	7.346	143	1000.000	1000.000	1000.000	1000	1000
Colorado Springs	16.3	7.346	143	0.792	0.528	1.189	0	3
Denver	53.0	0.389	6	17.140	2.958	99.308	2	98
Denver	18.7	0.389	6	0.158	0.057	0.438	0	1
El Paso	53.0	0.295	7	1000.000	177.602	1000.000	156	1000
El Paso	17.7	0.295	7	0.015	0.001	0.142	0	1
Los Angeles	53.0	1.403	44	53.244	44.092	64.297	37	73
Los Angeles	24.3	1.403	44	0.293	0.238	0.360	0	2
Miami	53.0	0.182	5	1000.000	35.520	1000.000	29	1000
Miami	9.7	0.182	5	0.086	0.026	0.281	0	1
New York	53.0	0.092	3	2.737	0.646	11.604	0	13
New York	25.5	0.092	3	0.048	0.022	0.104	0	1
Phoenix	53.0	4.469	147	56.901	31.702	102.130	26	106
Phoenix	27.3	4.469	147	3.760	3.221	4.389	0	8
Washington	53.0	0.030	2	3.038	0.001	1000.000	0	1000
Washington	19.4	0.030	2	0.023	0.007	0.082	0	0
Other MSA	53.0	0.079	39	18.369	9.388	35.940	7	41
Other MSA	13.9	0.079	39	0.048	0.040	0.058	0	1
Other Not MSA	53.0	0.081	7	1000.000	85.717	1000.000	75	1000
Other Not MSA	7.0	0.081	7	0.046	0.028	0.075	0	1

Table A-101. Predicted number of exceedances of of 1-hour NO_2 concentrations of 150 ppb using a Normal linear model for the as-is and current-standard scenarios.

Location Name	Annual Mean (ppb)	Observed Mean Exceed-ances	Observed Max Exceed-ances	Predicted Exceed-ances	95% Confidence Interval for Mean Number of Exceedances		95% Prediction Interval for Number of Exceedances	
					Lower Bound	Upper Bound	Lower Bound	Upper Bound
Atlanta	53.0	0.057	1	0.360	0.000	0.739	0.000	0.957
Atlanta	12.9	0.057	1	0.057	0.000	0.117	0.000	0.514
Boston	53.0	0.019	1	0.111	0.000	0.245	0.000	0.412
Boston	16.8	0.019	1	0.019	0.000	0.045	0.000	0.289
Cleveland	53.0	0.455	9	6.046	0.000	12.267	0.000	13.612
Cleveland	21.2	0.455	9	0.455	0.000	1.188	0.000	4.198
Colorado Springs	53.0	7.346	143	106.169	56.853	155.486	36.477	175.862
Colorado Springs	16.3	7.346	143	7.346	0.000	16.002	0.000	54.709
Denver	53.0	0.389	6	1.906	0.645	3.168	0.000	4.490
Denver	18.7	0.389	6	0.389	0.031	0.747	0.000	2.648
El Paso	53.0	0.295	7	4.902	3.249	6.555	2.384	7.421
El Paso	17.7	0.295	7	0.295	0.024	0.567	0.000	2.172
Los Angeles	53.0	1.403	44	6.965	5.561	8.369	0.000	16.360
Los Angeles	24.3	1.403	44	1.403	0.921	1.884	0.000	10.703
Miami	53.0	0.182	5	3.199	0.024	6.375	0.000	6.871
Miami	9.7	0.182	5	0.182	0.000	0.426	0.000	1.871
New York	53.0	0.092	3	0.439	0.220	0.658	0.000	1.272
New York	25.5	0.092	3	0.092	0.031	0.152	0.000	0.897
Phoenix	53.0	4.469	147	15.339	0.000	44.043	0.000	69.369
Phoenix	27.3	4.469	147	4.469	0.000	10.773	0.000	50.219
Washington	53.0	0.030	2	0.136	0.000	0.364	0.000	0.608
Washington	19.4	0.030	2	0.030	0.000	0.065	0.000	0.443
Other MSA	53.0	0.079	39	0.584	0.324	0.844	0.000	2.752
Other MSA	13.9	0.079	39	0.079	0.037	0.120	0.000	2.232
Other Not MSA	53.0	0.081	7	1.036	0.505	1.566	0.000	2.238
Other Not MSA	7.0	0.081	7	0.081	0.030	0.132	0.000	1.161

We can compare these predictions with the predictions for Los Angeles from McCurdy (1994) based on 1988-1992 data. Table A-102 gives the McCurdy (1994) exceedance estimates for exceedances of 150 ppb together with our estimates for the 1995-2006 data based on the Poisson exponential model (see Table A-103) and the normal linear model (see Table A-104). It is easily seen that the McCurdy (1994) estimates agree reasonably well with our Poisson exponential model predictions, with predicted exceedances being a little lower for annual means up to 53 ppb, but a little higher at 60 ppb. The McCurdy (1994) model predicts 75 exceedances at 53 ppb, compared to our Poisson exponential model prediction of 53 exceedances. However, the McCurdy (1994) estimates are all much higher than our normal linear model predictions. For example, the McCurdy (1994) model predicts 75 exceedances at 53 ppb, compared to our normal linear model prediction of 7 exceedances. These findings are primarily due to the fact that McCurdy also used an exponential link function.

Table A-102. Comparison of predicted exceedances of 150 ppb using McCurdy (1994) for 1988-1992 data and the Poisson exponential and normal linear models for 1995-2006 data.

	Predicted Exceedances of 150 ppb		
Annual Mean (ppb)	**McCurdy (1994) Normal exponential 1988-1992 data**	**Current Analysis Poisson exponential 1995-2006 data**	**Current Analysis Normal linear 1995-2006 data**
20	4	0	1
30	9	1	3
40	33	5	4
50	57	31	6
53	75	53	7
60	142	189	8

A-6.4 Conclusion

These analyses found a poor relationship between the annual means and the exceedances of 150 ppb, as well as frequently unrealistically high predictions of exceedances of 150 ppb for the current-standard scenario. The uncertainty at higher exceedance threshold concentration levels (200 to 300 ppb) would be expected to be even higher because the numbers of site-years with non-zero exceedances are even lower (which implies a much weaker numerical relationship between the annual mean and the annual exceedances). For example, for Los Angeles, the maximum number of exceedances of 150 ppb was 44, but the maximum number of exceedances of 200 ppb was only 5. Therefore we chose not to continue the regression analyses to higher exceedance threshold concentration levels.

A-6.5 Detailed Regression Model Predictions

Table A-103. Predicted number of exceedances of of 1-hour NO_2 concentrations of 150 ppb using a Poisson exponential model and at several annual average concentrations.

Location	Annual Mean (ppb)	Observed Mean Exceed-ances	Observed Max Exceed-ances	Predicted Exceed-ances	95% Confidence Interval for Mean Number of Exceedances		95% Prediction Interval for Number of Exceedances	
					Lower Bound	Upper Bound	Lower Bound	Upper Bound
Atlanta	20.0	0.057	1	0.102	0.032	0.327	0	1
Atlanta	30.0	0.057	1	0.412	0.034	4.953	0	5
Atlanta	40.0	0.057	1	1.665	0.023	122.647	0	103
Atlanta	50.0	0.057	1	6.735	0.014	1000.000	0	1000
Atlanta	53.0	0.057	1	10.242	0.012	1000.000	0	1000
Atlanta	60.0	0.057	1	27.243	0.008	1000.000	0	1000
Atlanta	3.4	0.057	1	0.010	0.000	0.230	0	0
Atlanta	12.9	0.057	1	0.038	0.008	0.181	0	1
Atlanta	26.6	0.057	1	0.257	0.037	1.770	0	3
Boston	20.0	0.019	1	0.018	0.004	0.090	0	1
Boston	30.0	0.019	1	0.076	0.010	0.576	0	1
Boston	40.0	0.019	1	0.321	0.006	17.564	0	14
Boston	50.0	0.019	1	1.352	0.003	661.873	0	680
Boston	53.0	0.019	1	2.081	0.002	1000.000	0	1000
Boston	60.0	0.019	1	5.692	0.001	1000.000	0	1000
Boston	5.4	0.019	1	0.002	0.000	0.175	0	0
Boston	16.8	0.019	1	0.011	0.001	0.091	0	0
Boston	31.0	0.019	1	0.089	0.010	0.801	0	1
Cleveland	20.0	0.455	9	0.039	0.004	0.358	0	1
Cleveland	30.0	0.455	9	9.244	2.693	31.732	2	32
Cleveland	40.0	0.455	9	1000.000	29.509	1000.000	23	1000
Cleveland	50.0	0.455	9	1000.000	291.652	1000.000	184	1000
Cleveland	53.0	0.455	9	1000.000	578.253	1000.000	364	1000
Cleveland	60.0	0.455	9	1000.000	1000.000	1000.000	1000	1000
Cleveland	14.2	0.455	9	0.002	0.000	0.092	0	0
Cleveland	21.2	0.455	9	0.073	0.011	0.474	0	1
Cleveland	28.1	0.455	9	3.193	1.490	6.845	0	9
Colorado Springs	20.0	7.346	143	2.295	1.662	3.168	0	6
Colorado Springs	30.0	7.346	143	39.206	33.759	45.531	26	53
Colorado Springs	40.0	7.346	143	669.766	526.509	852.001	523	870
Colorado Springs	50.0	7.346	143	1000.000	1000.000	1000.000	1000	1000
Colorado Springs	53.0	7.346	143	1000.000	1000.000	1000.000	1000	1000
Colorado Springs	60.0	7.346	143	1000.000	1000.000	1000.000	1000	1000
Colorado Springs	6.8	7.346	143	0.054	0.029	0.102	0	1
Colorado	16.3	7.346	143	0.792	0.528	1.189	0	3

Location	Annual Mean (ppb)	Observed Mean Exceed-ances	Observed Max Exceed-ances	Predicted Exceed-ances	95% Confidence Interval for Mean Number of Exceedances		95% Prediction Interval for Number of Exceedances	
					Lower Bound	Upper Bound	Lower Bound	Upper Bound
Springs								
Colorado Springs	34.8	7.346	143	153.247	130.906	179.401	121	189
Denver	20.0	0.389	6	0.189	0.074	0.482	0	2
Denver	30.0	0.389	6	0.740	0.438	1.251	0	3
Denver	40.0	0.389	6	2.902	1.201	7.014	0	9
Denver	50.0	0.389	6	11.376	2.426	53.350	1	53
Denver	53.0	0.389	6	17.140	2.958	99.308	2	98
Denver	60.0	0.389	6	44.600	4.659	426.973	4	454
Denver	6.1	0.389	6	0.028	0.004	0.186	0	1
Denver	18.7	0.389	6	0.158	0.057	0.438	0	1
Denver	36.8	0.389	6	1.871	0.925	3.786	0	6
El Paso	20.0	0.295	7	0.032	0.005	0.230	0	1
El Paso	30.0	0.295	7	1.075	0.536	2.156	0	4
El Paso	40.0	0.295	7	35.703	11.290	112.906	11	119
El Paso	50.0	0.295	7	1000.000	95.081	1000.000	94	1000
El Paso	53.0	0.295	7	1000.000	177.602	1000.000	156	1000
El Paso	60.0	0.295	7	1000.000	757.520	1000.000	634	1000
El Paso	8.2	0.295	7	0.001	0.000	0.020	0	0
El Paso	17.7	0.295	7	0.015	0.001	0.142	0	1
El Paso	35.1	0.295	7	6.447	3.454	12.036	1	14
Los Angeles	20.0	1.403	44	0.135	0.104	0.174	0	1
Los Angeles	30.0	1.403	44	0.825	0.713	0.954	0	3
Los Angeles	40.0	1.403	44	5.050	4.632	5.505	1	10
Los Angeles	50.0	1.403	44	30.917	26.439	36.154	20	44
Los Angeles	53.0	1.403	44	53.244	44.092	64.297	37	73
Los Angeles	60.0	1.403	44	189.281	144.681	247.629	138	260
Los Angeles	3.6	1.403	44	0.007	0.004	0.011	0	0
Los Angeles	24.3	1.403	44	0.293	0.238	0.360	0	2
Los Angeles	50.6	1.403	44	34.208	29.084	40.236	22	48
Miami	20.0	0.182	5	2.882	0.636	13.069	0	13
Miami	30.0	0.182	5	88.023	2.282	1000.000	2	1000
Miami	40.0	0.182	5	1000.000	7.591	1000.000	7	1000
Miami	50.0	0.182	5	1000.000	24.900	1000.000	33	1000
Miami	53.0	0.182	5	1000.000	35.520	1000.000	29	1000
Miami	60.0	0.182	5	1000.000	81.274	1000.000	40	1000
Miami	5.5	0.182	5	0.020	0.003	0.154	0	1
Miami	9.7	0.182	5	0.086	0.026	0.281	0	1
Miami	16.8	0.182	5	0.970	0.380	2.475	0	4
New York	20.0	0.092	3	0.021	0.007	0.065	0	0
New York	30.0	0.092	3	0.092	0.052	0.163	0	1
New York	40.0	0.092	3	0.403	0.211	0.773	0	2
New York	50.0	0.092	3	1.760	0.507	6.107	0	7
New York	53.0	0.092	3	2.737	0.646	11.604	0	13
New York	60.0	0.092	3	7.677	1.121	52.548	0	53
New York	9.7	0.092	3	0.005	0.001	0.028	0	0
New York	25.5	0.092	3	0.048	0.022	0.104	0	1
New York	42.2	0.092	3	0.557	0.260	1.193	0	3

Location	Annual Mean (ppb)	Observed Mean Exceed-ances	Observed Max Exceed-ances	Predicted Exceed-ances	95% Confidence Interval for Mean Number of Exceedances		95% Prediction Interval for Number of Exceedances	
					Lower Bound	Upper Bound	Lower Bound	Upper Bound
Phoenix	20.0	4.469	147	1.731	1.287	2.329	0	5
Phoenix	30.0	4.469	147	4.988	4.367	5.698	1	10
Phoenix	40.0	4.469	147	14.375	10.922	18.919	7	24
Phoenix	50.0	4.469	147	41.422	24.843	69.066	21	71
Phoenix	53.0	4.469	147	56.901	31.702	102.130	26	106
Phoenix	60.0	4.469	147	119.362	55.901	254.864	56	254
Phoenix	11.1	4.469	147	0.673	0.404	1.119	0	3
Phoenix	27.3	4.469	147	3.760	3.221	4.389	0	8
Phoenix	40.5	4.469	147	15.110	11.361	20.098	7	25
Washington	20.0	0.030	2	0.026	0.008	0.081	0	1
Washington	30.0	0.030	2	0.109	0.011	1.044	0	2
Washington	40.0	0.030	2	0.463	0.004	55.438	0	57
Washington	50.0	0.030	2	1.968	0.001	1000.000	0	1000
Washington	53.0	0.030	2	3.038	0.001	1000.000	0	1000
Washington	60.0	0.030	2	8.368	0.000	1000.000	0	1000
Washington	6.9	0.030	2	0.004	0.000	0.256	0	1
Washington	19.4	0.030	2	0.023	0.007	0.082	0	0
Washington	27.2	0.030	2	0.072	0.014	0.366	0	1
Other MSA	20.0	0.079	39	0.122	0.107	0.140	0	1
Other MSA	30.0	0.079	39	0.559	0.442	0.707	0	2
Other MSA	40.0	0.079	39	2.552	1.681	3.874	0	6
Other MSA	50.0	0.079	39	11.648	6.317	21.480	4	25
Other MSA	53.0	0.079	39	18.369	9.388	35.940	7	41
Other MSA	60.0	0.079	39	53.171	23.650	119.541	20	116
Other MSA	0.5	0.079	39	0.006	0.004	0.010	0	0
Other MSA	13.9	0.079	39	0.048	0.040	0.058	0	1
Other MSA	34.0	0.079	39	1.025	0.756	1.391	0	4
Other Not MSA	20.0	0.081	7	0.878	0.459	1.681	0	3
Other Not MSA	30.0	0.081	7	8.514	2.297	31.556	1	32
Other Not MSA	40.0	0.081	7	82.532	11.133	611.822	10	573
Other Not MSA	50.0	0.081	7	799.989	53.545	1000.000	57	1000
Other Not MSA	53.0	0.081	7	1000.000	85.717	1000.000	75	1000
Other Not MSA	60.0	0.081	7	1000.000	256.785	1000.000	226	1000
Other Not MSA	0.3	0.081	7	0.010	0.004	0.025	0	0
Other Not MSA	7.0	0.081	7	0.046	0.028	0.075	0	1
Other Not MSA	19.7	0.081	7	0.823	0.438	1.547	0	3

Table A-104. Predicted number of exceedances of of 1-hour NO_2 concentrations of 150 ppb using a Normal linear model and at several annual average concentrations.

Location Name	Annual Mean	Observed Mean Exceed-ances	Observed Max Exceed-ances	Predicted Exceed-ances	95% Confidence Interval for Mean Number of Exceedances		95% Prediction Interval for Number of Exceedances	
					Lower Bound	Upper Bound	Lower Bound	Upper Bound
Atlanta	20.0	0.057	1	0.110	0.020	0.201	0.000	0.573
Atlanta	30.0	0.057	1	0.186	0.015	0.357	0.000	0.672
Atlanta	40.0	0.057	1	0.262	0.001	0.522	0.000	0.787
Atlanta	50.0	0.057	1	0.337	0.000	0.689	0.000	0.916
Atlanta	53.0	0.057	1	0.360	0.000	0.739	0.000	0.957
Atlanta	60.0	0.057	1	0.413	0.000	0.857	0.000	1.055
Atlanta	3.4	0.057	1	0.000	0.000	0.092	0.000	0.452
Atlanta	12.9	0.057	1	0.057	0.000	0.117	0.000	0.514
Atlanta	26.6	0.057	1	0.161	0.019	0.303	0.000	0.637
Boston	20.0	0.019	1	0.027	0.000	0.056	0.000	0.297
Boston	30.0	0.019	1	0.052	0.000	0.107	0.000	0.327
Boston	40.0	0.019	1	0.078	0.000	0.166	0.000	0.361
Boston	50.0	0.019	1	0.103	0.000	0.226	0.000	0.399
Boston	53.0	0.019	1	0.111	0.000	0.245	0.000	0.412
Boston	60.0	0.019	1	0.128	0.000	0.287	0.000	0.441
Boston	5.4	0.019	1	0.000	0.000	0.039	0.000	0.263
Boston	16.8	0.019	1	0.019	0.000	0.045	0.000	0.289
Boston	31.0	0.019	1	0.055	0.000	0.113	0.000	0.330
Cleveland	20.0	0.455	9	0.252	0.000	1.019	0.000	4.003
Cleveland	30.0	0.455	9	2.008	0.141	3.874	0.000	6.173
Cleveland	40.0	0.455	9	3.763	0.035	7.492	0.000	9.163
Cleveland	50.0	0.455	9	5.519	0.000	11.163	0.000	12.553
Cleveland	53.0	0.455	9	6.046	0.000	12.267	0.000	13.612
Cleveland	60.0	0.455	9	7.275	0.000	14.846	0.000	16.125
Cleveland	14.2	0.455	9	0.000	0.000	0.769	0.000	3.243
Cleveland	21.2	0.455	9	0.455	0.000	1.188	0.000	4.198
Cleveland	28.1	0.455	9	1.667	0.140	3.194	0.000	5.673
Colorado Springs	20.0	7.346	143	17.426	7.454	27.398	0.000	65.075
Colorado Springs	30.0	7.346	143	44.318	24.197	64.439	0.000	95.397
Colorado Springs	40.0	7.346	143	71.210	38.662	103.758	13.462	128.958
Colorado Springs	50.0	7.346	143	98.102	52.682	143.522	31.411	164.793
Colorado Springs	53.0	7.346	143	106.169	56.853	155.486	36.477	175.862
Colorado Springs	60.0	7.346	143	124.994	66.550	183.438	47.873	202.115
Colorado Springs	6.8	7.346	143	0.000	0.000	0.000	0.000	31.109
Colorado Springs	16.3	7.346	143	7.346	0.000	16.002	0.000	54.709
Colorado Springs	34.8	7.346	143	57.235	31.241	83.228	3.296	111.173

Location Name	Annual Mean	Observed Mean Exceed-ances	Observed Max Exceed-ances	Predicted Exceed-ances	95% Confidence Interval for Mean Number of Exceedances		95% Prediction Interval for Number of Exceedances	
					Lower Bound	Upper Bound	Lower Bound	Upper Bound
Denver	20.0	0.389	6	0.446	0.085	0.807	0.000	2.706
Denver	30.0	0.389	6	0.888	0.353	1.424	0.000	3.185
Denver	40.0	0.389	6	1.331	0.499	2.163	0.000	3.720
Denver	50.0	0.389	6	1.773	0.613	2.934	0.000	4.306
Denver	53.0	0.389	6	1.906	0.645	3.168	0.000	4.490
Denver	60.0	0.389	6	2.216	0.716	3.716	0.000	4.933
Denver	6.1	0.389	6	0.000	0.000	0.402	0.000	2.136
Denver	18.7	0.389	6	0.389	0.031	0.747	0.000	2.648
Denver	36.8	0.389	6	1.189	0.458	1.920	0.000	3.543
El Paso	20.0	0.295	7	0.594	0.303	0.886	0.000	2.474
El Paso	30.0	0.295	7	1.900	1.270	2.529	0.000	3.866
El Paso	40.0	0.295	7	3.205	2.140	4.270	1.049	5.361
El Paso	50.0	0.295	7	4.511	2.994	6.027	2.085	6.936
El Paso	53.0	0.295	7	4.902	3.249	6.555	2.384	7.421
El Paso	60.0	0.295	7	5.816	3.844	7.789	3.065	8.568
El Paso	8.2	0.295	7	0.000	0.000	0.000	0.000	0.981
El Paso	17.7	0.295	7	0.295	0.024	0.567	0.000	2.172
El Paso	35.1	0.295	7	2.567	1.719	3.416	0.516	4.619
Los Angeles	20.0	1.403	44	0.573	0.053	1.093	0.000	9.876
Los Angeles	30.0	1.403	44	2.510	1.962	3.058	0.000	11.814
Los Angeles	40.0	1.403	44	4.447	3.579	5.315	0.000	13.776
Los Angeles	50.0	1.403	44	6.384	5.109	7.660	0.000	15.760
Los Angeles	53.0	1.403	44	6.965	5.561	8.369	0.000	16.360
Los Angeles	60.0	1.403	44	8.321	6.612	10.031	0.000	17.766
Los Angeles	3.6	1.403	44	0.000	0.000	0.000	0.000	6.747
Los Angeles	24.3	1.403	44	1.403	0.921	1.884	0.000	10.703
Los Angeles	50.6	1.403	44	6.492	5.193	7.792	0.000	15.871
Miami	20.0	0.182	5	0.899	0.108	1.689	0.000	2.757
Miami	30.0	0.182	5	1.596	0.092	3.099	0.000	3.873
Miami	40.0	0.182	5	2.293	0.065	4.521	0.000	5.131
Miami	50.0	0.182	5	2.990	0.034	5.947	0.000	6.463
Miami	53.0	0.182	5	3.199	0.024	6.375	0.000	6.871
Miami	60.0	0.182	5	3.687	0.001	7.373	0.000	7.834
Miami	5.5	0.182	5	0.000	0.000	0.281	0.000	1.607
Miami	9.7	0.182	5	0.182	0.000	0.426	0.000	1.871
Miami	16.8	0.182	5	0.677	0.103	1.250	0.000	2.449
New York	20.0	0.092	3	0.023	0.000	0.096	0.000	0.829
New York	30.0	0.092	3	0.149	0.079	0.218	0.000	0.955
New York	40.0	0.092	3	0.275	0.148	0.401	0.000	1.088
New York	50.0	0.092	3	0.401	0.204	0.598	0.000	1.228
New York	53.0	0.092	3	0.439	0.220	0.658	0.000	1.272
New York	60.0	0.092	3	0.527	0.256	0.798	0.000	1.375
New York	9.7	0.092	3	0.000	0.000	0.028	0.000	0.707
New York	25.5	0.092	3	0.092	0.031	0.152	0.000	0.897
New York	42.2	0.092	3	0.302	0.161	0.444	0.000	1.118
Phoenix	20.0	4.469	147	1.367	0.000	11.546	0.000	47.846
Phoenix	30.0	4.469	147	5.601	0.000	12.546	0.000	51.449
Phoenix	40.0	4.469	147	9.835	0.000	25.027	0.000	57.734

Location Name	Annual Mean	Observed Mean Exceed-ances	Observed Max Exceed-ances	Predicted Exceed-ances	95% Confidence Interval for Mean Number of Exceedances		95% Prediction Interval for Number of Exceedances	
					Lower Bound	Upper Bound	Lower Bound	Upper Bound
Phoenix	50.0	4.469	147	14.069	0.000	39.591	0.000	66.390
Phoenix	53.0	4.469	147	15.339	0.000	44.043	0.000	69.369
Phoenix	60.0	4.469	147	18.303	0.000	54.495	0.000	76.880
Phoenix	11.1	4.469	147	0.000	0.000	16.406	0.000	46.824
Phoenix	27.3	4.469	147	4.469	0.000	10.773	0.000	50.219
Phoenix	40.5	4.469	147	10.035	0.000	25.696	0.000	58.093
Washington	20.0	0.030	2	0.032	0.000	0.067	0.000	0.445
Washington	30.0	0.030	2	0.063	0.000	0.143	0.000	0.483
Washington	40.0	0.030	2	0.095	0.000	0.237	0.000	0.531
Washington	50.0	0.030	2	0.127	0.000	0.335	0.000	0.589
Washington	53.0	0.030	2	0.136	0.000	0.364	0.000	0.608
Washington	60.0	0.030	2	0.158	0.000	0.432	0.000	0.654
Washington	6.9	0.030	2	0.000	0.000	0.081	0.000	0.412
Washington	19.4	0.030	2	0.030	0.000	0.065	0.000	0.443
Washington	27.2	0.030	2	0.054	0.000	0.117	0.000	0.471
Other MSA	20.0	0.079	39	0.158	0.100	0.216	0.000	2.311
Other MSA	30.0	0.079	39	0.287	0.173	0.401	0.000	2.442
Other MSA	40.0	0.079	39	0.416	0.239	0.593	0.000	2.576
Other MSA	50.0	0.079	39	0.545	0.304	0.786	0.000	2.711
Other MSA	53.0	0.079	39	0.584	0.324	0.844	0.000	2.752
Other MSA	60.0	0.079	39	0.674	0.368	0.980	0.000	2.848
Other MSA	0.5	0.079	39	0.000	0.000	0.003	0.000	2.061
Other MSA	13.9	0.079	39	0.079	0.037	0.120	0.000	2.232
Other MSA	34.0	0.079	39	0.339	0.200	0.477	0.000	2.495
Other Not MSA	20.0	0.081	7	0.351	0.193	0.508	0.000	1.440
Other Not MSA	30.0	0.081	7	0.558	0.290	0.827	0.000	1.669
Other Not MSA	40.0	0.081	7	0.766	0.384	1.148	0.000	1.910
Other Not MSA	50.0	0.081	7	0.973	0.477	1.469	0.000	2.161
Other Not MSA	53.0	0.081	7	1.036	0.505	1.566	0.000	2.238
Other Not MSA	60.0	0.081	7	1.181	0.571	1.791	0.000	2.421
Other Not MSA	0.3	0.081	7	0.000	0.000	0.035	0.000	1.024
Other Not MSA	7.0	0.081	7	0.081	0.030	0.132	0.000	1.161
Other Not MSA	19.7	0.081	7	0.345	0.190	0.499	0.000	1.434

A-7 Adjustment of Air Quality to Just Meet the Current and Alternative Standards

A-7.1 Introduction

This section provides supplemental data and discussion on the approach used in adjusting air quality to just meet the current and alternative standards. As a reminder, every location across the U.S. meets the current NO_2 annual standard (US EPA, 2007e). Even considering air quality data as far back as 1995, no location/monitoring site exceeded the current standard. Therefore, simulation of air quality data was required to evaluate just meeting the current standard or standards that are more stringent.

In developing a simulation approach to adjust air quality to meet a particular standard level, policy-relevant background (PRB) levels in the U.S. were first considered. Policy-relevant background is defined as the distribution of NO_2 concentrations that would be observed in the U.S. in the absence of anthropogenic (man-made) emissions of NO_2 precursors in the U.S., Canada, and Mexico. Estimates of PRB have been reported in the draft ISA (Section 1.5.5) and the Annex (AX2.9), and for most of the continental U.S. the PRB is estimated to be less than 300 parts per trillion (ppt). In the Northeastern U.S. where present-day NO_2 concentrations are highest, this amounts to a contribution of about 1% percent of the total observed ambient NO_2 concentration (AX2.9). This low contribution of PRB to NO_2 concentrations provides support for a proportional method to adjust air quality, i.e., an equal adjustment of air quality values across the entire air quality distribution to just meet a target value.

Next, the variability in NO_2 concentrations was evaluated to determine whether a proportional approach would be reasonable if applied broadly across all years of data. Because the adjustment factor to meet the current standard would likely increase with increasing year, it was of interest to determine the trend in both the hourly concentrations and variability by year. Figure A-100 presents a summary of the annual average and hourly mean concentrations, as well as the coefficient of variation (COV, standard deviation as a percent of the mean) for each respective mean. Sample size for the annual average concentrations was about 350 per year, while hourly concentrations numbered about 3 million per year.

As expected, there was no observed difference in the mean concentrations when comparing each concentration metric within a year. The mean of the annual averages of all monitors is nearly identical to the mean of the hourly concentrations. However, statistically significant decreases in concentration are evident from year-to-year ($p<0.0001$), with concentrations decreasing by about 30% across the monitoring period. Contrary to this, there is no apparent trend in the COV for the annual average concentrations across the 12 years of data, generally centered about 53%. The COV of the hourly concentrations is larger than the annual COV as expected, however it increases with increasing year. The hourly COV ranges from a low of 84% in 1998 to a high of 92% in 2006, amounting to a relative percent difference of only 10% across the entire monitoring period. A non-parametric Mann-Whitney U-test indicates that there is a significant difference in the COVs when comparing each year-group ($p=0.004$). This may result in a small upward bias in the number of estimated exceedances of short-term (1-hour) potential health benchmark levels if using a proportional roll-up on the more recent monitoring data relative to that estimated by rolling up the historical data to just meet the current standard. While the trend of increasing COV is apparent across the entire monitoring period, based on the limited difference in COV from year-to-year for both the annual and hourly concentration data within each year-group (each is <4%), it was concluded that a proportional method could be broadly applied to each data set. Additional analyses by Rizzo (2008) on the trends within six selected locations also support the findings here.

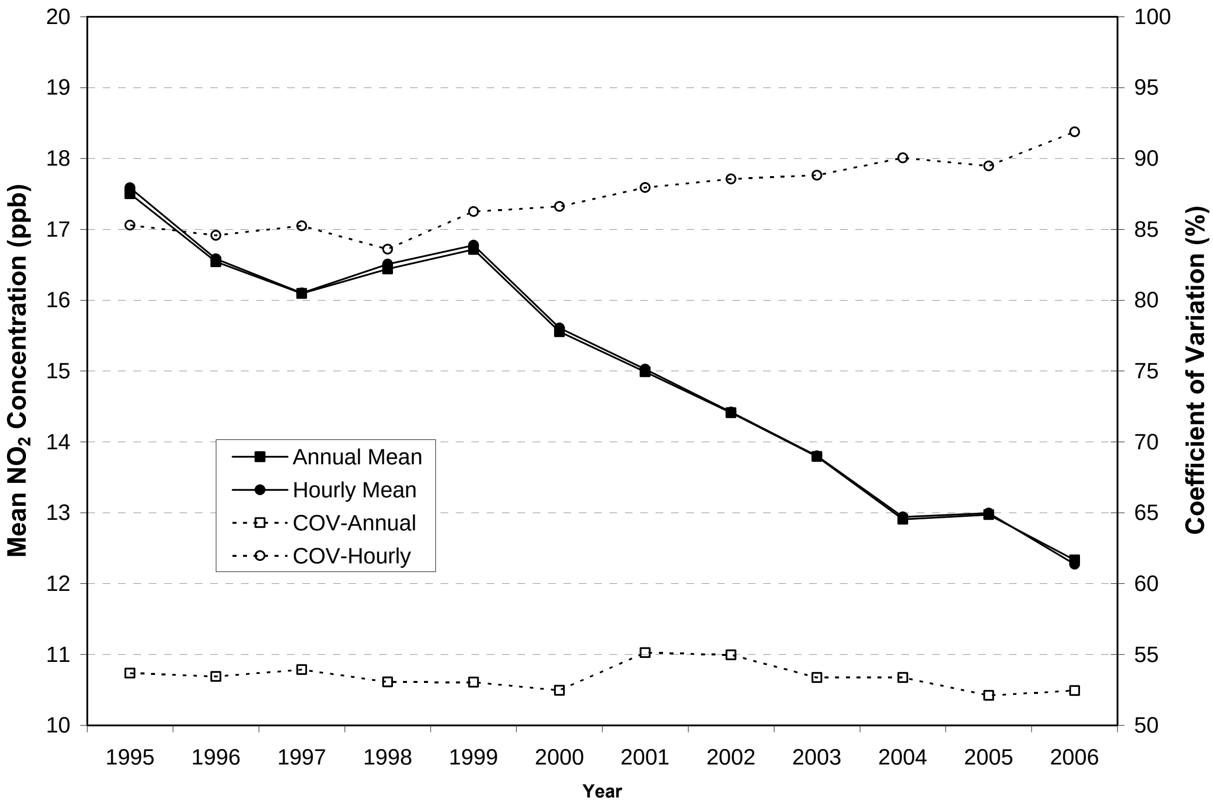

Figure A-100. Trends in hourly and annual average NO_2 ambient monitoring concentrations and their associated coefficients of variation (COV) for all monitors, years 1995-2006.

A-7.2 Approach

For the air quality characterization, data were first separated into two groups, an historical set of monitoring data (1995-2000) and one containing the most recent air quality (2001-2006). This grouping would further reduce any potential influential monitoring data affecting the variability in hourly concentrations that may exist in one year to the next within a location. The following air quality scenarios were considered for these sets of data:

- "*as is*" representing the historical and recent ambient monitoring hourly concentration data as reported by US EPA's Air Quality System (AQS).
- "*simulated*" concentrations to just meet the current NO_2 NAAQS (53 ppb annual average).

Based on the form of the current standard and observed trends in ambient monitoring, such as the retention of similar hourly and annual COVs over time while annual average concentrations significantly decrease over the same time period, NO_2 concentrations were proportionally modified at each location using the maximum annual average concentration that occurred in each year. To just meet the current standard adjustment factors *F* for each location (*i*) and year (*j*) were derived by the following

$$F_{ij} = S / C_{\max,ij} \qquad \text{equation (1)}$$

where,

F_{ij}	=	NO_2 concentration adjustment factor (unitless) in location *i* given the annual average standard and for each year *j*
S	=	Current standard level (i.e., 53 ppb, annual average NO_2 concentration)
$C_{max,ij}$	=	The maximum annual average NO_2 concentration at a monitor in each location *i* and for each year *j* (ppb)

Values for each air quality adjustment factor used for each location to simulate just meeting the current standard are given in Tables A-105 and A-106. It should be noted that a different monitor could have been used for each year to estimate *F*, the selection dependent only on whether the monitor contained the highest annual concentration for that year in the particular location. For each location and calendar year, all the hourly concentrations were multiplied by the same constant value *F* to make the highest annual mean equal to 53 ppb for that location and year. For example, for Boston in 1995, the maximum annual mean was 30.5 ppb, giving an adjustment factor of $F = 53/30.5 = 1.74$ using equation 1. All hourly concentrations in Boston in 1995 were multiplied by 1.74. Then, using the adjusted hourly concentrations, the distributions of the annual means and annual number of exceedances are computed in the same manner as the as-is scenario.[5]

Following review of the NO_2 ISA and summarization of relevant epidemiological and clinical health studies, alternative NO_2 standards of differing averaging time, form, and level were also considered. Much of the discussion regarding the selection of each of these components of the standard is provided in Chapter 5 of the Final NO_2 REA, with only the broad conclusions provided here. For averaging time, the epidemiological evidence does not provide clear guidance in choosing between 1-hour and 24-hour averaging times, and given that the experimental literature provides support for the occurrence of effects following exposures of shorter duration than 24-hours (e.g., 1-hour), staff evaluated standards with 1-hour averaging times. For the form, we have focused on standards with statistical, concentration-based forms. Staff selected the 98^{th} and 99^{th} percentiles daily maximum concentration averaged over 3 years to balance the desire to provide a stable regulatory target with the desire to limit the occurrence of peak concentrations. Concentration levels ranging from 50 ppb to 200 ppb in increments of 50

[5] Because of the large database, we did not implement this procedure exactly as stated. For the annual means we computed and applied the adjustment factors directly to each annual mean. For the hourly concentrations we used the frequency distributions of the rounded hourly values, so that, in effect, we applied the adjustment factors to the hourly values after rounding them to the nearest integer. This has a negligible impact on the calculated number of exceedances.

ppb were selected by staff based largely on the observed concentrations from both epidemiologic and controlled human exposure studies. Using these criteria for the investigated alternative standards, the following scenarios were considered using the most recent years of data (i.e., 2001-2006) and divided into two three-year groups for analysis (years 2001-2003 and 2004-2006):

- "*as is*" representing the recent ambient monitoring hourly concentration data as reported by US EPA's Air Quality System (AQS).
- "*simulated*" concentrations to just meet the current NO_2 NAAQS (53 ppb annual average as described above) and alternative 1-hour standards.

Proportional adjustment factors were also derived considering the form, averaging time, and levels of the potential alternative standards under consideration. Discussion regarding the staff selection of each of these components is provided in chapter 5 of this document. The 98th and 99th percentile 1-hour NO_2 daily maximum concentrations averaged across three years of monitoring were used in calculating the adjustment factors at each of four standard levels as follows:

$$F_{ikl} = S_l / \left(\frac{\sum_{j=1}^{3} C_{ijk}}{3} \right)_{\max,i} \qquad \text{equation (6-2)}$$

F_{ikl} = NO_2 concentration adjustment factor (unitless) in location i given alternative standard percentile form k and standard level l across a 3-year period

S_l = Standard level l (i.e., 50, 100, 150, 200 ppb 1-hour NO_2 concentration (ppb))

C_{ijk} = Selected percentile k (i.e., 98th or 99th) 1-hour daily maximum NO_2 concentration at a monitor in location i (ppb) for each year j

Values for each air quality adjustment factor used for each location and year-group to simulate just meeting the alternatives standards are given in Tables A-107 and A-108. It should be noted that a different monitor could have been used for each year group to estimate F, the selection dependent only on whether the monitor contained the highest 98th or 99th daily maximum 1-hour concentration averaged across the three year period in the particular location. For each location and year-group, all monitor hourly concentrations were multiplied by the same constant value F, whereas the monitor used to develop the adjustment factor would have a 3-year averaged daily maximum 1-hour concentration at the selected percentile equivalent to the level of the alternative standard. For example, for Atlanta in years 2001-2003, the maximum 3-year average 98th percentile of daily maximum 1-hour NO_2 concentrations was 81.7 ppb, giving an adjustment factor F = 100/81.7 = 1.224 for the 1-hour alternative standard level of 200 ppb using equation (2). All hourly concentrations in Atlanta for each year in 2001-2003 were multiplied by 1.224. Then, using the adjusted hourly concentrations, the distributions of the annual number of exceedances are computed in the same manner as the as-is scenario.

Table A-105. Maximum annual average NO_2 concentrations and air quality adjustment factors (*F*) to just meet the current standard, historical monitoring data.

Location	Metric	1995	1996	1997	1998	1999	2000
Atlanta	Max Annual Mean	18.8	26.6	25.2	24.1	23.8	22.9
Atlanta	*F*	2.81	1.99	2.10	2.20	2.22	2.31
Boston	Max Annual Mean	30.5	31.0	30.4	30.7	29.7	29.0
Boston	*F*	1.74	1.71	1.74	1.73	1.79	1.83
Chicago	Max Annual Mean	32.2	32.0	33.6	32.2	31.5	32.0
Chicago	*F*	1.64	1.66	1.58	1.64	1.68	1.66
Cleveland	Max Annual Mean	27.3	25.9	28.1	27.3	24.5	23.1
Cleveland	*F*	1.94	2.04	1.89	1.94	2.16	2.30
Colorado Springs	Max Annual Mean	23.2	23.6	19.8	20.5	19.3	34.8
Colorado Springs	*F*	2.28	2.24	2.68	2.59	2.75	1.52
Denver	Max Annual Mean	34.8	33.1	33.9	35.3	19.4	14.9
Denver	*F*	1.52	1.60	1.56	1.50	2.73	3.55
Detroit	Max Annual Mean	21.6	21.5	25.9	22.9	18.0	23.9
Detroit	*F*	2.45	2.47	2.05	2.31	2.94	2.22
El Paso	Max Annual Mean	23.3	35.1	33.6	30.7	27.7	24.3
El Paso	*F*	2.27	1.51	1.58	1.72	1.91	2.18
Jacksonville	Max Annual Mean	15.8	14.9	14.4	15.0	15.9	15.4
Jacksonville	*F*	3.36	3.55	3.69	3.52	3.34	3.45
Las Vegas	Max Annual Mean	27.1	26.7		25.3	26.6	25.1
Las Vegas	*F*	1.96	1.99		2.09	1.99	2.12
Los Angeles	Max Annual Mean	46.2	42.3	43.2	43.4	50.6	43.9
Los Angeles	*F*	1.15	1.25	1.23	1.22	1.05	1.21
Miami	Max Annual Mean	14.7	16.0	16.6	15.2	16.8	15.7
Miami	*F*	3.60	3.30	3.19	3.49	3.15	3.37
New York	Max Annual Mean	41.7	42.2	41.1	41.9	41.5	40.6
New York	*F*	1.27	1.26	1.29	1.26	1.28	1.31
Philadelphia	Max Annual Mean	31.8	33.9	32.4	34.0	31.7	27.9
Philadelphia	*F*	1.67	1.56	1.63	1.56	1.67	1.90
Phoenix	Max Annual Mean	32.6	31.6	32.0	35.0	40.5	36.3
Phoenix	*F*	1.63	1.68	1.66	1.52	1.31	1.46
Provo	Max Annual Mean	22.6	24.3	23.3	23.9	24.1	23.6
Provo	*F*	2.35	2.18	2.27	2.22	2.20	2.25
St. Louis	Max Annual Mean	26.2	24.8	24.8	25.8	27.2	26.3
St. Louis	*F*	2.02	2.14	2.14	2.05	1.95	2.02
Washington DC	Max Annual Mean	26.2	26.9	25.9	27.2	25.4	23.5
Washington DC	*F*	2.02	1.97	2.05	1.95	2.09	2.26
Other MSA	Max Annual Mean	31.9	30.3	29.4	31.0	29.3	26.5
Other MSA	*F*	1.66	1.75	1.80	1.71	1.81	2.00
Other Not MSA	Max Annual Mean	19.1	14.5	19.7	18.8	19.7	18.7
Other Not MSA	*F*	2.78	3.66	2.69	2.82	2.69	2.83

Table A-106. Maximum annual average NO_2 concentrations and air quality adjustment factors (*F*) to just meet the current standard, recent monitoring data.

Location	Metric	2001	2002	2003	2004	2005	2006
Atlanta	Max Annual Mean	23.3	19.4	16.4	17.0	17.4	17.9
Atlanta	*F*	2.27	2.73	3.23	3.12	3.05	2.96
Boston	Max Annual Mean	29.7	25.3	22.5	25.0	23.4	22.5
Boston	*F*	1.79	2.10	2.36	2.12	2.26	2.35
Chicago	Max Annual Mean	31.9	32.4	30.9	29.3	29.6	30.6
Chicago	*F*	1.66	1.63	1.72	1.81	1.79	1.73
Cleveland	Max Annual Mean	23.6	22.3	21.7	22.2	21.5	18.2
Cleveland	*F*	2.25	2.38	2.45	2.38	2.46	2.91
Colorado Springs	Max Annual Mean						
Colorado Springs	*F*						
Denver	Max Annual Mean	36.8	35.4	21.4	27.2	27.6	29.1
Denver	*F*	1.44	1.50	2.47	1.95	1.92	1.82
Detroit	Max Annual Mean	23.2	21.4	22.0	18.9	19.6	15.9
Detroit	*F*	2.29	2.47	2.41	2.80	2.71	3.34
El Paso	Max Annual Mean	21.7	21.4	19.9	18.0	17.3	18.0
El Paso	*F*	2.45	2.48	2.66	2.94	3.06	2.94
Jacksonville	Max Annual Mean		14.6	14.3	13.7	13.3	
Jacksonville	*F*		3.62	3.70	3.88	3.97	
Las Vegas	Max Annual Mean	22.5	22.3	21.4	19.7	19.9	
Las Vegas	*F*	2.35	2.38	2.48	2.69	2.67	
Los Angeles	Max Annual Mean	41.2	40.2	35.3	33.7	30.9	29.7
Los Angeles	*F*	1.29	1.32	1.50	1.57	1.72	1.78
Miami	Max Annual Mean	15.8	14.3	12.9	13.0	13.5	
Miami	*F*	3.35	3.71	4.12	4.08	3.92	
New York	Max Annual Mean	40.3	39.7	32.0	30.5	36.5	34.2
New York	*F*	1.32	1.33	1.65	1.74	1.45	1.55
Philadelphia	Max Annual Mean	29.9	29.5	24.7	25.6	26.3	17.8
Philadelphia	*F*	1.77	1.80	2.15	2.07	2.02	2.98
Phoenix	Max Annual Mean	37.1	34.7	34.3	31.4	31.5	30.6
Phoenix	*F*	1.43	1.53	1.54	1.69	1.68	1.73
Provo	Max Annual Mean	24.1	24.8	21.8	22.3	20.5	28.9
Provo	*F*	2.20	2.14	2.43	2.37	2.58	1.83
St. Louis	Max Annual Mean	24.7	22.9	20.3	22.3	16.8	15.0
St. Louis	*F*	2.15	2.32	2.60	2.37	3.15	3.52
Washington DC	Max Annual Mean	24.3	24.8	26.0	24.0	24.1	19.6
Washington DC	*F*	2.18	2.14	2.04	2.20	2.20	2.70
Other MSA	Max Annual Mean	26.5	27.4	26.4	25.3	24.0	18.5
Other MSA	*F*	2.00	1.93	2.01	2.09	2.21	2.87
Other Not MSA	Max Annual Mean	16.5	16.4	15.5	15.8	17.1	15.6
Other Not MSA	*F*	3.21	3.23	3.42	3.36	3.11	3.39

Table A-107. Air quality adjustment factors (*F*) to just meet the alternative 1-hour standards, using recent monitoring data.

Year Group	Location	1-hour Standard Level	98th Percentile		99th Percentile	
			Maximum Monitor	Adjustment Factor[1]	Maximum Monitor	Adjustment Factor[1]
2001-2003	Atlanta	50	1312100481	0.612	1312100481	0.564
2001-2003	Atlanta	100	1312100481	1.224	1312100481	1.128
2001-2003	Atlanta	150	1312100481	1.837	1312100481	1.692
2001-2003	Atlanta	200	1312100481	2.449	1312100481	2.256
2004-2006	Atlanta	50	1312100481	0.703	1312100481	0.641
2004-2006	Atlanta	100	1312100481	1.405	1312100481	1.282
2004-2006	Atlanta	150	1312100481	2.108	1312100481	1.923
2004-2006	Atlanta	200	1312100481	2.810	1312100481	2.564
2001-2003	Boston	50	2502500401	0.688	2502500401	0.622
2001-2003	Boston	100	2502500401	1.376	2502500401	1.245
2001-2003	Boston	150	2502500401	2.064	2502500401	1.867
2001-2003	Boston	200	2502500401	2.752	2502500401	2.490
2004-2006	Boston	50	2502500401	0.719	2502500401	0.613
2004-2006	Boston	100	2502500401	1.439	2502500401	1.227
2004-2006	Boston	150	2502500401	2.158	2502500401	1.840
2004-2006	Boston	200	2502500401	2.878	2502500401	2.454
2001-2003	Chicago	50	1703100631	0.577	1703131031	0.512
2001-2003	Chicago	100	1703100631	1.154	1703131031	1.024
2001-2003	Chicago	150	1703100631	1.731	1703131031	1.536
2001-2003	Chicago	200	1703100631	2.308	1703131031	2.048
2004-2006	Chicago	50	1703100631	0.570	1703100631	0.538
2004-2006	Chicago	100	1703100631	1.141	1703100631	1.075
2004-2006	Chicago	150	1703100631	1.711	1703100631	1.613
2004-2006	Chicago	200	1703100631	2.281	1703100631	2.151
2001-2003	Cleveland	50	3903500601	0.711	3903500601	0.664
2001-2003	Cleveland	100	3903500601	1.422	3903500601	1.327
2001-2003	Cleveland	150	3903500601	2.133	3903500601	1.991
2001-2003	Cleveland	200	3903500601	2.844	3903500601	2.655
2004-2006	Cleveland	50	3903500601	0.765	3903500601	0.691
2004-2006	Cleveland	100	3903500601	1.531	3903500601	1.382
2004-2006	Cleveland	150	3903500601	2.296	3903500601	2.074
2004-2006	Cleveland	200	3903500601	3.061	3903500601	2.765
2001-2003	Denver	50	0803100021	0.518	0803100021	0.459
2001-2003	Denver	100	0803100021	1.036	0803100021	0.917
2001-2003	Denver	150	0803100021	1.554	0803100021	1.376
2001-2003	Denver	200	0803100021	2.073	0803100021	1.835
2004-2006	Denver	50	0800130011	0.658	0800130011	0.584
2004-2006	Denver	100	0800130011	1.316	0800130011	1.167
2004-2006	Denver	150	0800130011	1.974	0800130011	1.751
2004-2006	Denver	200	0800130011	2.632	0800130011	2.335
2001-2003	Detroit	50	2616300192	0.554	2616300192	0.374
2001-2003	Detroit	100	2616300192	1.107	2616300192	0.748
2001-2003	Detroit	150	2616300192	1.661	2616300192	1.122

Year Group	Location	1-hour Standard Level	98th Percentile		99th Percentile	
			Maximum Monitor	Adjustment Factor[1]	Maximum Monitor	Adjustment Factor[1]
2001-2003	Detroit	200	2616300192	2.214	2616300192	1.496
2004-2006	Detroit	50	2616300161	0.915	2616300161	0.862
2004-2006	Detroit	100	2616300161	1.829	2616300161	1.724
2004-2006	Detroit	150	2616300161	2.744	2616300161	2.586
2004-2006	Detroit	200	2616300161	3.659	2616300161	3.448
2001-2003	El Paso	50	4814100441	0.655	4814100441	0.573
2001-2003	El Paso	100	4814100441	1.310	4814100441	1.145
2001-2003	El Paso	150	4814100441	1.965	4814100441	1.718
2001-2003	El Paso	200	4814100441	2.620	4814100441	2.290
2004-2006	El Paso	50	4814100551	0.743	4814100371	0.664
2004-2006	El Paso	100	4814100551	1.485	4814100371	1.327
2004-2006	El Paso	150	4814100551	2.228	4814100371	1.991
2004-2006	El Paso	200	4814100551	2.970	4814100371	2.655
2001-2003	Jacksonville	50	1203100322	0.901	1203100322	0.840
2001-2003	Jacksonville	100	1203100322	1.802	1203100322	1.681
2001-2003	Jacksonville	150	1203100322	2.703	1203100322	2.521
2001-2003	Jacksonville	200	1203100322	3.604	1203100322	3.361
2004-2006	Jacksonville	50	1203100322	0.962	1203100322	0.658
2004-2006	Jacksonville	100	1203100322	1.923	1203100322	1.316
2004-2006	Jacksonville	150	1203100322	2.885	1203100322	1.974
2004-2006	Jacksonville	200	1203100322	3.846	1203100322	2.632
2001-2003	Las Vegas	50	3200305391	0.718	3200305391	0.652
2001-2003	Las Vegas	100	3200305391	1.435	3200305391	1.304
2001-2003	Las Vegas	150	3200305391	2.153	3200305391	1.957
2001-2003	Las Vegas	200	3200305391	2.871	3200305391	2.609
2004-2006	Las Vegas	50	3200320021	0.820	3200305391	0.758
2004-2006	Las Vegas	100	3200320021	1.639	3200305391	1.515
2004-2006	Las Vegas	150	3200320021	2.459	3200305391	2.273
2004-2006	Las Vegas	200	3200320021	3.279	3200305391	3.030
2001-2003	Los Angeles	50	0603700301	0.394	0603700301	0.379
2001-2003	Los Angeles	100	0603700301	0.787	0603700301	0.758
2001-2003	Los Angeles	150	0603700301	1.181	0603700301	1.136
2001-2003	Los Angeles	200	0603700301	1.575	0603700301	1.515
2004-2006	Los Angeles	50	0603716012	0.549	0603711031	0.505
2004-2006	Los Angeles	100	0603716012	1.099	0603711031	1.010
2004-2006	Los Angeles	150	0603716012	1.648	0603711031	1.515
2004-2006	Los Angeles	200	0603716012	2.198	0603711031	2.020
2001-2003	Miami	50	1208640022	0.929	1208640022	0.817
2001-2003	Miami	100	1208640022	1.858	1208640022	1.635
2001-2003	Miami	150	1208640022	2.786	1208640022	2.452
2001-2003	Miami	200	1208640022	3.715	1208640022	3.270
2004-2006	Miami	50	1208640022	0.877	1208640022	0.826
2004-2006	Miami	100	1208640022	1.754	1208640022	1.653
2004-2006	Miami	150	1208640022	2.632	1208640022	2.479
2004-2006	Miami	200	1208640022	3.509	1208640022	3.306

Year Group	Location	1-hour Standard Level	98th Percentile		99th Percentile	
			Maximum Monitor	Adjustment Factor[1]	Maximum Monitor	Adjustment Factor[1]
2001-2003	New York	50	3403900042	0.542	3403900042	0.476
2001-2003	New York	100	3403900042	1.083	3403900042	0.952
2001-2003	New York	150	3403900042	1.625	3403900042	1.429
2001-2003	New York	200	3403900042	2.166	3403900042	1.905
2004-2006	New York	50	3403900042	0.613	3401310031	0.532
2004-2006	New York	100	3403900042	1.227	3401310031	1.064
2004-2006	New York	150	3403900042	1.840	3401310031	1.596
2004-2006	New York	200	3403900042	2.454	3401310031	2.128
2001-2003	Philadelphia	50	4210100471	0.694	4210100471	0.637
2001-2003	Philadelphia	100	4210100471	1.389	4210100471	1.274
2001-2003	Philadelphia	150	4210100471	2.083	4210100471	1.911
2001-2003	Philadelphia	200	4210100471	2.778	4210100471	2.548
2004-2006	Philadelphia	50	1000320041	0.758	1000320041	0.610
2004-2006	Philadelphia	100	1000320041	1.515	1000320041	1.220
2004-2006	Philadelphia	150	1000320041	2.273	1000320041	1.829
2004-2006	Philadelphia	200	1000320041	3.030	1000320041	2.439
2001-2003	Phoenix	50	0401330101	0.577	0401330101	0.526
2001-2003	Phoenix	100	0401330101	1.154	0401330101	1.053
2001-2003	Phoenix	150	0401330101	1.731	0401330101	1.579
2001-2003	Phoenix	200	0401330101	2.308	0401330101	2.105
2004-2006	Phoenix	50	0401330101	0.598	0401330101	0.538
2004-2006	Phoenix	100	0401330101	1.195	0401330101	1.075
2004-2006	Phoenix	150	0401330101	1.793	0401330101	1.613
2004-2006	Phoenix	200	0401330101	2.390	0401330101	2.151
2001-2003	Provo	50	4904900021	0.785	4904900021	0.735
2001-2003	Provo	100	4904900021	1.571	4904900021	1.471
2001-2003	Provo	150	4904900021	2.356	4904900021	2.206
2001-2003	Provo	200	4904900021	3.141	4904900021	2.941
2004-2006	Provo	50	4904900021	0.532	4904900021	0.521
2004-2006	Provo	100	4904900021	1.064	4904900021	1.042
2004-2006	Provo	150	4904900021	1.596	4904900021	1.563
2004-2006	Provo	200	4904900021	2.128	4904900021	2.083
2001-2003	St. Louis	50	2951000861	0.769	2951000861	0.704
2001-2003	St. Louis	100	2951000861	1.538	2951000861	1.408
2001-2003	St. Louis	150	2951000861	2.308	2951000861	2.113
2001-2003	St. Louis	200	2951000861	3.077	2951000861	2.817
2004-2006	St. Louis	50	2951000722	0.820	2951000722	0.794
2004-2006	St. Louis	100	2951000722	1.639	2951000722	1.587
2004-2006	St. Louis	150	2951000722	2.459	2951000722	2.381
2004-2006	St. Louis	200	2951000722	3.279	2951000722	3.175
2001-2003	Washington DC	50	2451000401	0.701	1100100411	0.633
2001-2003	Washington DC	100	2451000401	1.402	1100100411	1.266
2001-2003	Washington DC	150	2451000401	2.103	1100100411	1.899
2001-2003	Washington DC	200	2451000401	2.804	1100100411	2.532
2004-2006	Washington DC	50	2451000401	0.758	1100100411	0.617

Year Group	Location	1-hour Standard Level	98th Percentile		99th Percentile	
			Maximum Monitor	Adjustment Factor[1]	Maximum Monitor	Adjustment Factor[1]
2004-2006	Washington DC	100	2451000401	1.515	1100100411	1.235
2004-2006	Washington DC	150	2451000401	2.273	1100100411	1.852
2004-2006	Washington DC	200	2451000401	3.030	1100100411	2.469
2001-2003	Other MSA	50	4905700021	0.508	4905700021	0.439
2001-2003	Other MSA	100	4905700021	1.015	4905700021	0.877
2001-2003	Other MSA	150	4905700021	1.523	4905700021	1.316
2001-2003	Other MSA	200	4905700021	2.030	4905700021	1.754
2004-2006	Other MSA	50	0607320071	0.578	0607320071	0.532
2004-2006	Other MSA	100	0607320071	1.156	0607320071	1.064
2004-2006	Other MSA	150	0607320071	1.734	0607320071	1.596
2004-2006	Other MSA	200	0607320071	2.312	0607320071	2.128
2001-2003	Other Not MSA	50	0602500061	0.547	0602500061	0.466
2001-2003	Other Not MSA	100	0602500061	1.095	0602500061	0.932
2001-2003	Other Not MSA	150	0602500061	1.642	0602500061	1.398
2001-2003	Other Not MSA	200	0602500061	2.190	0602500061	1.863
2004-2006	Other Not MSA	50	5600508921	0.535	5600508921	0.429
2004-2006	Other Not MSA	100	5600508921	1.070	5600508921	0.858
2004-2006	Other Not MSA	150	5600508921	1.604	5600508921	1.288
2004-2006	Other Not MSA	200	5600508921	2.139	5600508921	1.717

Notes:
1 The selected percentile (98th or 99th) in 1-hour daily maximum NO_2 concentration at each monitor was averaged across the 3-years of data (either 2001-2003 or 2004-2006), with the highest concentration monitor retained for use in calculating the adjustment to just meet the alternative standard.

A-8 Method for Estimating On-Road Concentrations

A-8.1 Introduction

As an additional step in the air quality characterization, the potential impact of motor vehicles on the surrogate exposure metrics was evaluated. Several studies have shown that concentrations of NO_2 are at elevated levels when compared to ambient concentrations measured at increasing distances from the roadway (e.g., Rodes and Holland, 1981; Gilbert et al., 2003; Cape et al., 2004; Pleijel et al., 2004; Singer et al., 2004). On average, concentrations on or near a roadway can be from 2 to 3 times greater than ambient concentrations (ISA, section 2.5.4), but on occasion, as high as 7 times greater (Bell and Ashenden, 1997; Bignal et al., 2007). A strong relationship between measured on-road NO_2 concentrations and those with increasing distance from the road has been reported under a variety of conditions (e.g., variable traffic counts, different seasons, wind direction) and can be described (e.g., Cape et al., 2004) with an exponential decay equation of the form

$$C_x = C_b + C_v e^{-kx} \qquad \text{equation (3)}$$

where,

- C_x = NO_2 concentration at a given distance (x) from a roadway (ppb)
- C_b = NO_2 concentration (ppb) at a distance from a roadway, not directly influenced by road or non-road source emissions
- C_v = NO_2 concentration contribution from vehicles on a roadway (ppb)
- k = Removal rate constant describing NO_2 combined formation/decay with perpendicular distance from roadway (meters^{-1})
- x = Distance from roadway (meters)

As a function of reported concentration measurements and the derived relationship, much of the decline in NO_2 concentrations with distance from the road has been shown to occur within the first few meters (by approximately 90% within a 10 meter distance), returning to near ambient levels between 200 to 500 meters (Rodes and Holland, 1981; Bell and Ashenden, 1997; Gilbert et al., 2003; Pleijel et al., 2004). At a distance of 0 meters, referred to here as *on-road*, the equation reduces to the sum of the non-source influenced NO_2 concentration and the concentration contribution expected from vehicle emissions on the roadway using

$$C_r = C_a (1 + m) \qquad \text{equation (4)}$$

where,

- C_r = 1-hour on-road NO_2 concentration (ppb)
- C_a = 1-hour ambient monitoring NO_2 concentration (ppb) either *as is* or modified to just meet the current or alternative standards
- m = Ratio derived from estimates of C_v/C_b (from eq (1))

and assuming that $C_a = C_b$. [6]

A-8.2 Derivation of On-Road Ratios

A literature review was conducted to identify published studies containing NO_2 concentrations both on-roads and with various distances from roadways. Principal criteria for inclusion in this analysis were that either tabular, graphical, or equations were provided in the paper that related distances from roadways and associated NO_2 concentrations. Eleven papers were identified using these criteria, spanning several countries, various years, roadway locations, seasons, wind directions, and averaging times (Table A-108). The final data set contained 501 data points, encompassing multiple NO_2 measurements at a distance from a total of 56 individual roads, some of which were collected within 10 m of the road.

Table A-108. Studies reviewed containing NO_2 concentrations at a distance from roadways.

First Author	Year	Country/State	Season	Type	Wind Direction	Averaging time
Bell	1987	Wales	Summer, winter	Rural	Up, down	7 days
Bignal	2004	England	Summer, fall	Urban	Combined	14 days
Cape	2002	Scotland	Annual	Urban	Combined	14 days
Gilbert	2001	Quebec	Summer	Urban	Down, up, Combined	7 days
Maruo	2001	Japan	Summer	Urban	Combined	14 days
Monn	1995	Switzerland	Summer, Winter	Urban	Combined	7 days
Nitta	1982	Japan	Not reported	Urban	Combined	7 days
Pleijel	1994	Sweden	Summer	Rural	Combined	30 days
Rodes	1978	California	Summer	Urban	Down	> 1 day
Roorda-Knape	1995	Holland	Summer	Urban	Combined	14 days
Singer	2001	California	Spring through Fall	Urban	Up, Down	7 days

Although there were, on occasion, data from several roads within a particular study, data for factors thought to influence on-road concentrations were very limited or were not distinctly defined for all studies. Factors that were reported and already noted as influential are the individual roadway (where the study included multiple roads) and the time of the year. Wind direction (upwind versus downwind) was also indicated as an important factor influencing concentrations at a distance from a roadway (Singer, 2004). Note however that the averaging time for measurements of 11 of the 12 studies is a week or more in length (Table A-108). Even for where the wind direction is reported as either downwind or upwind it is possible that the wind direction was variable (combined downwind and upwind) over the monitoring period.

The relationship noted in equation (3) was iteratively solved using the data collected from the above reviewed literature and employing the SAS procedure ***proc nlin***, generally as follows,

```
proc nlin data=no2 maxiter=1000 noprint NOITPRINT;
   parms    Cb=0 to 80 by 1
            Cv= 0 to 80 by 1
            k= 0 to 1 by .025;
```

[6] Note that C_a differs from C_b since C_a may include the influence of on-road as well as non-road sources. However, it is expected that for most monitors the influence of on-road emissions is minimal so that $C_a \cong C_b$.

```
   model Cx=Cb + Cv*exp(-k*distance);
   by author road season wind;
   output out=outdata parms=Cb Cv k;
run;
```

As an example, data were compiled from Table 1 and Table 4 reported in Singer et al. (2004) for NO_2 measurements collected at six outdoor locations with varying distance from Interstate-880 in San Francisco, CA as follows:

Table A-109. Example data used to estimate on-road adjustment factor (*m*) obtained from Tables 1 and 4 reported in Singer et. al (2004).

Distance to Road (m)	Measured Concentration C_x (ppb)	Season	Wind	Road
60	30	SPR-FALL	D	I-880
130	26	SPR-FALL	D	I-880
200	26	SPR-FALL	D	I-880
230	24	SPR-FALL	D	I-880
1200	21	SPR-FALL	D	I-880
1400	21	SPR-FALL	D	I-880

The non-linear procedure was applied to these data and all other individual roads identified within each study location listed in Table A-108. The results of this analysis were screened for data that yielded no unique solutions (lack of model convergence) or irrational parameters. Criteria for censoring data included the following, as well as the number of individual roads censored:

- Model did not converge (number (n) of roads = 5)
- k<0 (n=1)
- k>1 (n=2)
- Both k=0 and C_v =0 (n=1)
- Extremely large C_v (>8,000 ppb; n=2)
- C_b<0 (n=1)

These data were then evaluated for trends using the limited influential factors reported in the collection of studies, considering the number of values of *m* available for potential groupings, and how the data were to be applied to the ambient monitoring data. In general, the measurements reported in the summer and resultant parameter estimates were observed as distinct from the measures and parameter estimates from other seasons, including data for where only annual averages were reported. The data were then grouped accordingly into two seasonal groups, *summer* and *not summer*, containing 23 and 21 samples, respectively. These two groups were also further censored for unusual parameter estimates. Resulting criteria for censoring the grouped data included the following:

- An extreme value of *k* (0.354) in the *summer* category compared with others in group (mean=0.020, std=0.014)
- Extreme values of estimated *m* (24.4 and 59.0) in the *not summer* category due to combined low estimated C_b (≤1 ppb) relative to high estimated C_v in comparison with the other derived *m* (mean=0.73, std=0.38)

Therefore the final data set contained 19 and 22 values for use in the *not summer* and *summer* categories, respectively (Table A-110).

Table A-110. Estimated on-road adjustment factors (C_v/C_b or *m*) for two season groups and potential influential factors.

Author	Location	Road Name	Season[1]	Wind Direction[2]	Area Type[3]	Traffic Count	Season2	C_v/C_b or *m*
Bell	WAL	A5	SU	D	R	5000	Summer	2.45
Bell	WAL	A5	SU	U	R	5000	Summer	1.32
Bell	WAL	A5	WI	D	R	2500	Not Summer	1.14
Bell	WAL	A5	WI	U	R	2500	Not Summer	0.58
Bell	WAL	B4547	SU	D	R	3500	Summer	0.90
Bignal	ENG	M40	SU	B	U*	94000	Summer	2.70
Bignal	ENG	M62	FA	B	U*	74000	Not Summer	0.64
Cape	SCT	d1	AN	B	U*	57786	Not Summer	0.78
Cape	SCT	d3	AN	B	U	85623	Not Summer	0.86
Cape	SCT	d5	AN	B	U*	20134	Not Summer	0.59
Cape	SCT	o1	AN	B	R	3433	Not Summer	0.75
Cape	SCT	o3	AN	B	U	NR	Not Summer	0.25
Cape	SCT	o4	AN	B	R*	240	Not Summer	1.50
Cape	SCT	o5	AN	B	R	1299	Not Summer	0.36
Cape	SCT	t1	AN	B	R	11997	Not Summer	0.79
Cape	SCT	t2	AN	B	R*	3551	Not Summer	1.08
Cape	SCT	t4	AN	B	R*	9373	Not Summer	0.79
Cape	SCT	t5	AN	B	R	5052	Not Summer	0.82
Gilbert	QUE	HW15	SU	B	U	185000	Summer	0.78
Gilbert	QUE	HW15	SU	D	U	185000	Summer	0.75
Gilbert	QUE	HW15	SU	U	U	185000	Summer	0.94
Maruo	JAP	L1L2	SU	B	U	24000	Summer	0.92
Monn	SWZ	1	SU	B	U	8800	Summer	0.74

Author	Location	Road Name	Season[1]	Wind Direction[2]	Area Type[3]	Traffic Count	Season2	C_v/C_b *or m*
Nitta	JAP	a	NR	B	U*	106000	Not Summer	0.36
Nitta	JAP	b	NR	B	U*	106000	Not Summer	0.22
Nitta	JAP	e	NR	B	U*	60000	Not Summer	0.42
Nitta	JAP	f	NR	B	U*	60000	Not Summer	0.47
Pleijel	SWE	1	SU	D	R	32500	Summer	1.21
Pleijel	SWE	2	SU	D	R	32500	Summer	1.19
Pleijel	SWE	3	SU	D	R	18900	Summer	0.51
Pleijel	SWE	4	SU	D	R	18900	Summer	1.13
Pleijel	SWE	5	SU	D	R	18900	Summer	0.79
Rodes	CAL	HiO3	SU	D	U	200000	Summer	0.93
Rodes	CAL	LowO3	SU	D	U	200000	Summer	2.43
Roorda-Knape	HOL	1	SU	B	U	131907	Summer	0.78
Roorda-Knape	HOL	1p2	SU	B	U	131907	Summer	0.67
Roorda-Knape	HOL	1p3	SU	B	U	131907	Summer	0.70
Roorda-Knape	HOL	1p4	SU	B	U	131907	Summer	0.49
Roorda-Knape	HOL	2	SU	B	U	142512	Summer	0.52
Roorda-Knape	HOL	2p2	SU	B	U	142512	Summer	1.95
Singer	CAL	I880D	SPFA	D	U*	200000	Not Summer	1.54

Notes:
[1] Season: AN – Annual, SP – Spring, FA – Fall, SU – Summer, WI - Winter
[2] Wind: B – Both, D – Downwind, U – Upwind
[3] Type: R – Rural, U – Urban, * Inferred by staff using traffic count data
NR – Not reported

Two approaches were considered for estimating *m* from the C_v and C_b pairs in each season. The first approach considered was to regress C_b on C_v (either with or without an intercept) and use the fitted slope to estimate *m*. Ignoring meteorological effects, equation 3 implies that C_v results solely from on-road emission sources and that C_b results solely from non-road emission sources. Since these two source types are likely to have quite different diurnal profiles, we expect the hourly C_v and C_b values to be approximately independent.[7] Regressing C_b against C_v would imply that there is some correlation between the values, which would be inconsistent with the conceptual model underlying equation (3). Further, if C_b were regressed against C_v using an intercept, the physical meaning of the intercept would be unclear.

[7] Although the fact that C_v and C_b are subject to the same meteorology introduces some correlation, because meteorology tends to vary on a longer time scale than hourly, it is likely to have less influence than the emissions on the correlation between hourly concentrations.

An empirical method was selected for the approach to characterize *m* based on the two seasonal sets of ratios of C_v/C_b. The resulting cumulative distribution for each group is depicted by Figure A-101 using the data from Table A-110. In applying the factors for use in equation (4), the selection criteria for a given *m* are based on equivalent probability (e.g., 1/19 for the *not summer* data).

Means from the two seasons were tested for significant difference using a Student's t (p=0.026), while the season distributions were compared using a Kolmogorov-Smirnov test (p= 0.196). It was decided to retain the season-groups as separate to allow for some apportioning of variability resulting from an apparent seasonal influence, even though the statistical test results were mixed.

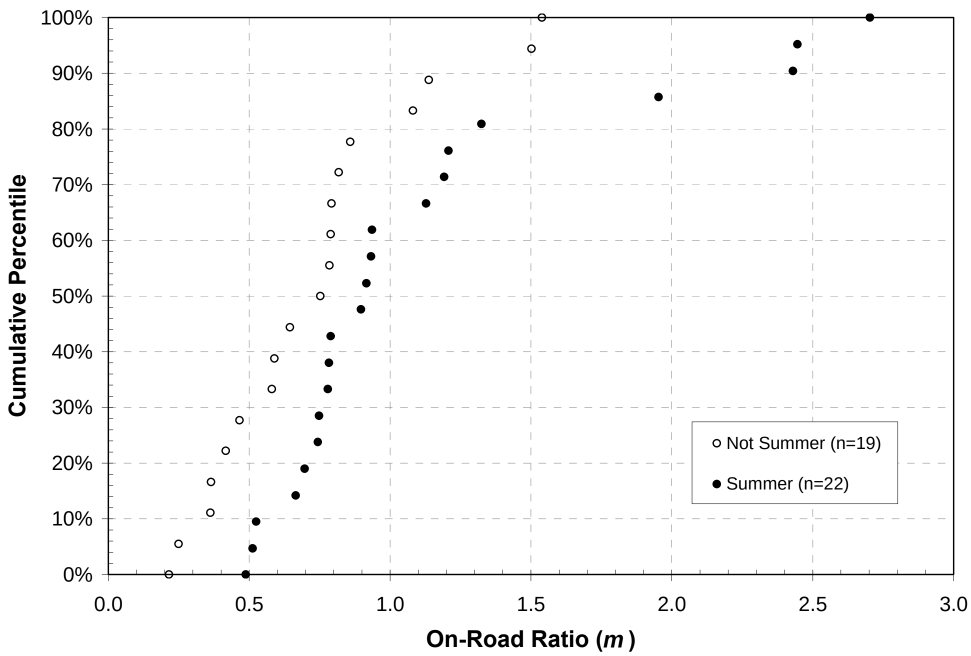

Figure A-101. Distribution of estimated C_v/C_b ratios or *m* for two season groups.

A-8.3 Application of On-Road Factors

The purpose of this particular analysis was to estimate on-road concentrations using equation (4) above along with the required inputs, namely, the hourly ambient monitoring concentrations and derived on-road factors. The derived on-road factors for the two season groups could not be assigned a particular statistical distribution (e.g., normal, lognormal, gamma) with confidence. Therefore, an empirical approach was selected to still allow for some seasonal variability in the on-road concentration estimates. Summer months were first defined as *June*, *July*, *August*, while the remaining months were not summer. Although there may be distinctions among what may be designated as a summer month across the U.S., the reviewed data are not robust to allow for such an application.

Each monitor site was then randomly assigned two on-road factors selected from the derived empirical distribution for a given year, one for summer months and one for the other months, using the appropriate distribution. Because the influence of on-road and non-road sources is likely different in each location and at each monitor, it would be expected that the empirical relationship between the two values C_v and C_b to vary from place to place. If source category emissions data for each study location were available to derive an equation (3) regression, that could have been used to match each of the study locations here, or, perhaps, each of the monitoring sites, to a similar equation (3) study area for assigning an appropriate ratio. However, since this information was not available, an empirical approach was used to randomly match the literature-derived ratios to the NO_2 site-seasons.

A particular *summer* on-road factor has a 1/22 chance of selection, while a specific *not summer* value has a 1/19 probability of selection, based on respective sample sizes. This random assignment was repeated for all site-years of data. Hourly NO_2 concentrations were estimated for each site-year of data in a location using equation (4) and the randomly assigned on-road factors. Finally, the process was simulated 100 times for each site-year of hourly data. For example, the Boston CMSA location had 210 random selections from the on-road distributions applied independently to the total site-years of data (105). Following 100 simulations, a total of 10,500 site-years of data were generated using this procedure (along with 21,000 randomly assigned on-road values selected from the appropriate empirical distribution).

Simulated on-road NO_2 concentrations were used to generate concentration distributions for the annual average concentrations and distributions for the number of exceedances of short-term potential health effect benchmark levels. Means and median values are reported to represent the central tendency of each parameter estimate. Since there were multiple simulations performed at each location using all available site-years of data, results for the upper percentiles were expanded to the 95th, 98th and 99th percentiles of the distribution. It is more appropriate to apply the parameter estimates outside the central tendencies to particular sites, areas within locations, or for certain conditions. Minimum values for the annual mean and annual number of exceedances were also estimated. One approach would have been to use the minimum values across the 100 simulations. However, that approach may not give the lowest possible value, because it is unlikely that in 100 simulations for a site-year there is a simulation where both seasonal adjustment factors are chosen to be the lowest values of $1 + m$. To obtain the lowest value, two simulations were conducted for each site-year. The *Summer* adjustment factor was set to the lowest possible value (1.49) and the Not-Summer adjustment factor was the lowest possible value (1.22). The annual means and exceedances for those two separate simulations were used to compute the minimum values for each distribution.

As part of the air quality characterization, these data were used to estimate the number of short-term concentrations above selected levels that might occur on roadways using the estimated hourly C_r values, associated with air quality as is. For evaluating just meeting the current annual and alternative standards, the approach described in Section A-7 to adjust the ambient concentrations was applied before estimating on-road NO_2 concentrations.

A-9 Supplemental Results Tables to the REA

A-9.1 Annual average NO_2 concentration data for 2001-2003

Table A-111. Estimated annual average NO_2 concentrations for monitors ≥100 m from a major road using 2001-2003 air quality *as is* and air quality adjusted to just meet the current and alternative standards.

Location	Scenario[1]	Percentile[2]	Site-Years	Annual Average NO_2 (ppb)[3]				
				Mean	Min	Med	p98	p99
Atlanta	As is		14	12	4	15	23	23
Atlanta	Current Std		14	33	9	39	53	53
Atlanta	50	98	14	8	3	9	14	14
Atlanta	50	99	14	7	2	9	13	13
Atlanta	100	98	14	15	5	19	29	29
Atlanta	100	99	14	14	5	17	26	26
Atlanta	150	98	14	23	8	28	43	43
Atlanta	150	99	14	21	7	26	39	39
Atlanta	200	98	14	30	10	37	57	57
Atlanta	200	99	14	28	9	34	53	53
Atlanta	250	98	14	38	13	46	71	71
Atlanta	250	99	14	35	12	43	66	66
Atlanta	300	98	14	46	15	56	86	86
Atlanta	300	99	14	42	14	51	79	79
Boston	As is		6	10	5	11	12	12
Boston	Current Std		6	19	11	21	26	26
Boston	50	98	6	7	4	7	8	8
Boston	50	99	6	6	3	7	7	7
Boston	100	98	6	13	7	15	16	16
Boston	100	99	6	12	7	14	15	15
Boston	150	98	6	20	11	22	24	24
Boston	150	99	6	18	10	20	22	22
Boston	200	98	6	26	15	30	32	32
Boston	200	99	6	24	13	27	29	29
Boston	250	98	6	33	18	37	40	40
Boston	250	99	6	30	17	34	36	36
Boston	300	98	6	39	22	45	48	48
Boston	300	99	6	36	20	41	44	44
Chicago	As is		9	22	17	20	28	28
Chicago	Current Std		9	36	27	34	47	47
Chicago	50	98	9	12	10	12	16	16
Chicago	50	99	9	11	9	10	14	14
Chicago	100	98	9	25	19	23	32	32
Chicago	100	99	9	22	17	20	28	28
Chicago	150	98	9	37	29	35	48	48
Chicago	150	99	9	33	26	31	43	43
Chicago	200	98	9	50	39	46	64	64
Chicago	200	99	9	44	34	41	57	57

Location	Scenario[1]	Percentile[2]	Site-Years	Annual Average NO_2 (ppb)[3] Mean	Min	Med	p98	p99
Chicago	250	98	9	62	48	58	80	80
Chicago	250	99	9	55	43	51	71	71
Chicago	300	98	9	75	58	69	96	96
Chicago	300	99	9	66	51	61	85	85
Cleveland	As is		3	18	17	17	19	19
Cleveland	Current Std		3	42	41	42	43	43
Cleveland	50	98	3	13	12	12	13	13
Cleveland	50	99	3	12	12	12	12	12
Cleveland	100	98	3	25	25	25	26	26
Cleveland	100	99	3	24	23	23	25	25
Cleveland	150	98	3	38	37	37	40	40
Cleveland	150	99	3	35	35	35	37	37
Cleveland	200	98	3	51	49	50	53	53
Cleveland	200	99	3	47	46	46	49	49
Cleveland	250	98	3	63	62	62	66	66
Cleveland	250	99	3	59	58	58	61	61
Cleveland	300	98	3	76	74	75	79	79
Cleveland	300	99	3	71	69	70	74	74
Denver	As is		2	24	21	24	26	26
Denver	Current Std		2	45	37	45	53	53
Denver	50	98	2	12	11	12	13	13
Denver	50	99	2	11	10	11	12	12
Denver	100	98	2	24	22	24	27	27
Denver	100	99	2	22	20	22	24	24
Denver	150	98	2	37	33	37	40	40
Denver	150	99	2	33	30	33	35	35
Denver	200	98	2	49	44	49	53	53
Denver	200	99	2	43	39	43	47	47
Denver	250	98	2	61	56	61	67	67
Denver	250	99	2	54	49	54	59	59
Denver	300	98	2	73	67	73	80	80
Denver	300	99	2	65	59	65	71	71
Detroit	As is		6	21	19	20	23	23
Detroit	Current Std		6	49	44	50	53	53
Detroit	50	98	6	11	10	11	13	13
Detroit	50	99	6	8	7	8	9	9
Detroit	100	98	6	23	21	23	26	26
Detroit	100	99	6	15	14	15	17	17
Detroit	150	98	6	34	31	34	38	38
Detroit	150	99	6	23	21	23	26	26
Detroit	200	98	6	46	41	45	51	51
Detroit	200	99	6	31	28	31	35	35
Detroit	250	98	6	57	51	56	64	64
Detroit	250	99	6	39	35	38	43	43
Detroit	300	98	6	68	62	68	77	77

Location	Scenario[1]	Percentile[2]	Site-Years	Annual Average NO_2 (ppb)[3]				
				Mean	Min	Med	p98	p99
Detroit	300	99	6	46	42	46	52	52
El Paso	As is		12	15	10	16	18	18
El Paso	Current Std		12	38	26	40	48	48
El Paso	50	98	12	10	7	11	12	12
El Paso	50	99	12	9	6	9	10	10
El Paso	100	98	12	20	14	21	24	24
El Paso	100	99	12	17	12	18	21	21
El Paso	150	98	12	30	21	32	36	36
El Paso	150	99	12	26	18	28	31	31
El Paso	200	98	12	40	27	42	47	47
El Paso	200	99	12	35	24	37	41	41
El Paso	250	98	12	49	34	53	59	59
El Paso	250	99	12	43	30	46	52	52
El Paso	300	98	12	59	41	63	71	71
El Paso	300	99	12	52	36	55	62	62
Jacksonville	As is		2	14	14	14	15	15
Jacksonville	Current Std		2	53	53	53	53	53
Jacksonville	50	98	2	13	13	13	13	13
Jacksonville	50	99	2	12	12	12	12	12
Jacksonville	100	98	2	26	26	26	26	26
Jacksonville	100	99	2	24	24	24	25	25
Jacksonville	150	98	2	39	39	39	40	40
Jacksonville	150	99	2	36	36	36	37	37
Jacksonville	200	98	2	52	52	52	53	53
Jacksonville	200	99	2	49	48	49	49	49
Jacksonville	250	98	2	65	64	65	66	66
Jacksonville	250	99	2	61	60	61	61	61
Jacksonville	300	98	2	78	77	78	79	79
Jacksonville	300	99	2	73	72	73	74	74
Las Vegas	As is		16	10	2	7	22	22
Las Vegas	Current Std		16	25	5	18	53	53
Las Vegas	50	98	16	8	2	5	16	16
Las Vegas	50	99	16	7	1	5	14	14
Las Vegas	100	98	16	15	3	11	32	32
Las Vegas	100	99	16	14	3	10	29	29
Las Vegas	150	98	16	23	5	16	48	48
Las Vegas	150	99	16	21	4	15	43	43
Las Vegas	200	98	16	30	6	21	64	64
Las Vegas	200	99	16	27	6	19	58	58
Las Vegas	250	98	16	38	8	27	79	79
Las Vegas	250	99	16	34	7	24	72	72
Las Vegas	300	98	16	45	9	32	95	95
Las Vegas	300	99	16	41	8	29	87	87
Los Angeles	As is		51	22	5	24	36	37
Los Angeles	Current Std		51	31	7	32	48	52

Location	Scenario[1]	Percentile[2]	Site-Years	Annual Average NO_2 (ppb)[3]				
				Mean	Min	Med	p98	p99
Los Angeles	50	98	51	9	2	9	14	15
Los Angeles	50	99	51	8	2	9	14	14
Los Angeles	100	98	51	18	4	19	29	29
Los Angeles	100	99	51	17	4	18	28	28
Los Angeles	150	98	51	26	6	28	43	44
Los Angeles	150	99	51	25	5	27	41	42
Los Angeles	200	98	51	35	8	37	57	59
Los Angeles	200	99	51	34	7	36	55	57
Los Angeles	250	98	51	44	9	47	71	73
Los Angeles	250	99	51	42	9	45	69	71
Los Angeles	300	98	51	53	11	56	86	88
Los Angeles	300	99	51	51	11	54	83	85
Miami	As is		6	9	7	9	10	10
Miami	Current Std		6	32	26	34	37	37
Miami	50	98	6	8	6	8	9	9
Miami	50	99	6	7	6	7	8	8
Miami	100	98	6	16	13	16	19	19
Miami	100	99	6	14	11	15	17	17
Miami	150	98	6	24	19	25	28	28
Miami	150	99	6	21	17	22	25	25
Miami	200	98	6	32	26	33	38	38
Miami	200	99	6	29	22	29	33	33
Miami	250	98	6	41	32	41	47	47
Miami	250	99	6	36	28	36	41	41
Miami	300	98	6	49	38	49	56	56
Miami	300	99	6	43	34	44	50	50
New York	As is		26	20	11	18	31	31
New York	Current Std		26	29	15	27	44	44
New York	50	98	26	11	6	10	17	17
New York	50	99	26	10	5	9	15	15
New York	100	98	26	22	12	20	34	34
New York	100	99	26	19	11	18	30	30
New York	150	98	26	32	18	30	51	51
New York	150	99	26	29	16	26	45	45
New York	200	98	26	43	24	40	68	68
New York	200	99	26	38	21	35	59	59
New York	250	98	26	54	30	50	84	84
New York	250	99	26	48	26	44	74	74
New York	300	98	26	65	36	60	101	101
New York	300	99	26	57	32	53	89	89
Philadelphia	As is		14	20	15	18	28	28
Philadelphia	Current Std		14	37	26	35	53	53
Philadelphia	50	98	14	14	10	13	20	20
Philadelphia	50	99	14	13	9	12	18	18
Philadelphia	100	98	14	27	20	25	39	39

Location	Scenario[1]	Percentile[2]	Site-Years	Annual Average NO_2 (ppb)[3]				
				Mean	Min	Med	p98	p99
Philadelphia	100	99	14	25	19	23	36	36
Philadelphia	150	98	14	41	30	38	59	59
Philadelphia	150	99	14	38	28	35	54	54
Philadelphia	200	98	14	55	40	51	79	79
Philadelphia	200	99	14	50	37	46	72	72
Philadelphia	250	98	14	68	50	63	98	98
Philadelphia	250	99	14	63	46	58	90	90
Philadelphia	300	98	14	82	61	76	118	118
Philadelphia	300	99	14	75	56	70	108	108
Phoenix	As is		5	27	22	29	29	29
Phoenix	Current Std		5	40	32	41	45	45
Phoenix	50	98	5	16	13	17	17	17
Phoenix	50	99	5	14	12	15	15	15
Phoenix	100	98	5	31	26	33	34	34
Phoenix	100	99	5	28	23	30	31	31
Phoenix	150	98	5	47	38	50	51	51
Phoenix	150	99	5	43	35	45	46	46
Phoenix	200	98	5	62	51	66	68	68
Phoenix	200	99	5	57	47	60	62	62
Phoenix	250	98	5	78	64	83	85	85
Phoenix	250	99	5	71	58	75	77	77
Phoenix	300	98	5	94	77	99	102	102
Phoenix	300	99	5	85	70	90	93	93
Provo	As is		3	24	22	24	25	25
Provo	Current Std		3	53	53	53	53	53
Provo	50	98	3	19	17	19	19	19
Provo	50	99	3	17	16	18	18	18
Provo	100	98	3	37	34	38	39	39
Provo	100	99	3	35	32	35	37	37
Provo	150	98	3	56	51	57	58	58
Provo	150	99	3	52	48	53	55	55
Provo	200	98	3	74	68	76	78	78
Provo	200	99	3	69	64	71	73	73
Provo	250	98	3	93	86	95	97	97
Provo	250	99	3	87	80	89	91	91
Provo	300	98	3	111	103	114	117	117
Provo	300	99	3	104	96	106	110	110
St. Louis	As is		9	17	14	17	21	21
St. Louis	Current Std		9	41	36	38	49	49
St. Louis	50	98	9	13	11	13	16	16
St. Louis	50	99	9	12	10	12	14	14
St. Louis	100	98	9	27	22	26	32	32
St. Louis	100	99	9	24	20	24	29	29
St. Louis	150	98	9	40	33	39	48	48
St. Louis	150	99	9	36	30	36	43	43

Location	Scenario[1]	Percentile[2]	Site-Years	Annual Average NO_2 (ppb)[3]				
				Mean	Min	Med	p98	p99
St. Louis	200	98	9	53	44	52	63	63
St. Louis	200	99	9	49	40	47	58	58
St. Louis	250	98	9	66	55	65	79	79
St. Louis	250	99	9	61	50	59	72	72
St. Louis	300	98	9	80	66	78	95	95
St. Louis	300	99	9	73	60	71	87	87
Washington DC	As is		18	18	9	21	25	25
Washington DC	Current Std		18	39	19	44	53	53
Washington DC	50	98	18	13	6	15	17	17
Washington DC	50	99	18	12	6	13	16	16
Washington DC	100	98	18	26	12	29	35	35
Washington DC	100	99	18	23	11	26	31	31
Washington DC	150	98	18	39	18	44	52	52
Washington DC	150	99	18	35	17	40	47	47
Washington DC	200	98	18	52	25	59	70	70
Washington DC	200	99	18	47	22	53	63	63
Washington DC	250	98	18	64	31	73	87	87
Washington DC	250	99	18	58	28	66	78	78
Washington DC	300	98	18	77	37	88	104	104
Washington DC	300	99	18	70	33	79	94	94
Other MSA	As is		612	13	1	13	22	24
Other MSA	Current Std		612	25	1	25	45	48
Other MSA	50	98	612	6	0	7	11	12
Other MSA	50	99	612	6	0	6	10	11
Other MSA	100	98	612	13	1	13	23	25
Other MSA	100	99	612	11	0	11	20	21
Other MSA	150	98	612	19	1	20	34	37
Other MSA	150	99	612	17	1	17	30	32
Other MSA	200	98	612	25	1	26	46	49
Other MSA	200	99	612	22	1	23	39	42
Other MSA	250	98	612	32	1	33	57	61
Other MSA	250	99	612	28	1	28	49	53
Other MSA	300	98	612	38	2	39	68	74
Other MSA	300	99	612	33	1	34	59	64
Other Not MSA	As is		127	7	1	6	15	16
Other Not MSA	Current Std		127	22	3	20	53	53
Other Not MSA	50	98	127	4	1	3	8	9
Other Not MSA	50	99	127	3	0	3	7	8
Other Not MSA	100	98	127	7	1	7	17	18
Other Not MSA	100	99	127	6	1	6	14	15
Other Not MSA	150	98	127	11	2	10	25	27
Other Not MSA	150	99	127	9	1	8	22	23
Other Not MSA	200	98	127	15	2	13	34	36
Other Not MSA	200	99	127	12	2	11	29	31
Other Not MSA	250	98	127	18	3	16	42	45

Location	Scenario[1]	Percentile[2]	Site-Years	Annual Average NO_2 (ppb)[3]				
				Mean	Min	Med	p98	p99
Other Not MSA	250	99	127	16	2	14	36	38
Other Not MSA	300	98	127	22	3	20	51	54
Other Not MSA	300	99	127	19	3	17	43	46

Notes:
[1] Scenario: As is – unadjusted air quality, Current Std – air quality that just meets the current annual standard, All others – air quality that just meets 1-hour concentration level given percentile form of alternative standard.
[2] Percentile: 98th or 99th percentile of daily maximum 1-hour concentration averaged over three years at maximum monitor in location.
[3] Annual means for each monitor were first calculated based on all simulated hourly values in a year. Then the mean of the annual means was estimated as the sum of all the annual means in a particular location divided by the number of simulated site-years across the monitoring period. The min, med, p98, p99 represent the minimum, median, 98th, and 99th percentiles of the distribution for the annual means.

Table A-112. Estimated annual average NO_2 concentrations for monitors >20 m and <100 m from a major road using 2001-2003 air quality *as is* and air quality adjusted to just meet the current and alternative standards.

	Scenario[1]	Percentile[2]	Site-Years	Annual Average NO_2 (ppb)[3]				
				Mean	Min	Med	p98	p99
Boston	As is		14	17	9	19	25	25
Boston	Current Std		14	35	16	36	53	53
Boston	50	98	14	12	6	13	17	17
Boston	50	99	14	11	5	12	16	16
Boston	100	98	14	23	12	26	35	35
Boston	100	99	14	21	11	23	32	32
Boston	150	98	14	35	18	39	52	52
Boston	150	99	14	32	16	35	47	47
Boston	200	98	14	47	24	51	70	70
Boston	200	99	14	42	22	46	63	63
Boston	250	98	14	58	30	64	87	87
Boston	250	99	14	53	27	58	79	79
Boston	300	98	14	70	36	77	105	105
Boston	300	99	14	63	32	70	95	95
Chicago	As is		6	31	28	31	32	32
Chicago	Current Std		6	51	47	52	53	53
Chicago	50	98	6	18	16	18	19	19
Chicago	50	99	6	16	15	16	17	17
Chicago	100	98	6	35	33	35	37	37
Chicago	100	99	6	31	29	31	33	33
Chicago	150	98	6	53	49	53	56	56
Chicago	150	99	6	47	44	47	50	50
Chicago	200	98	6	71	66	70	75	75
Chicago	200	99	6	63	58	63	66	66
Chicago	250	98	6	88	82	88	94	94
Chicago	250	99	6	78	73	78	83	83
Chicago	300	98	6	106	99	106	112	112
Chicago	300	99	6	94	87	94	100	100
El Paso	As is		3	21	20	21	22	22
El Paso	Current Std		3	53	53	53	53	53
El Paso	50	98	3	14	13	14	14	14
El Paso	50	99	3	12	11	12	12	12
El Paso	100	98	3	27	26	28	28	28
El Paso	100	99	3	24	23	25	25	25
El Paso	150	98	3	41	39	42	43	43
El Paso	150	99	3	36	34	37	37	37
El Paso	200	98	3	55	52	56	57	57
El Paso	200	99	3	48	46	49	50	50
El Paso	250	98	3	69	65	70	71	71
El Paso	250	99	3	60	57	61	62	62
El Paso	300	98	3	82	78	84	85	85
El Paso	300	99	3	72	68	74	74	74

	Scenario[1]	Percentile[2]	Site-Years	Annual Average NO_2 (ppb)[3]				
				Mean	Min	Med	p98	p99
Las Vegas	As is		3	6	3	6	9	9
Las Vegas	Current Std		3	14	7	14	21	21
Las Vegas	50	98	3	4	2	4	6	6
Las Vegas	50	99	3	4	2	4	6	6
Las Vegas	100	98	3	8	4	8	12	12
Las Vegas	100	99	3	8	4	8	11	11
Las Vegas	150	98	3	13	6	12	19	19
Las Vegas	150	99	3	11	6	11	17	17
Las Vegas	200	98	3	17	9	17	25	25
Las Vegas	200	99	3	15	8	15	23	23
Las Vegas	250	98	3	21	11	21	31	31
Las Vegas	250	99	3	19	10	19	28	28
Las Vegas	300	98	3	25	13	25	37	37
Las Vegas	300	99	3	23	12	23	34	34
Los Angeles	As is		35	24	4	24	41	41
Los Angeles	Current Std		35	33	5	33	53	53
Los Angeles	50	98	35	10	2	9	16	16
Los Angeles	50	99	35	9	2	9	16	16
Los Angeles	100	98	35	19	3	19	32	32
Los Angeles	100	99	35	18	3	18	31	31
Los Angeles	150	98	35	29	5	28	49	49
Los Angeles	150	99	35	28	5	27	47	47
Los Angeles	200	98	35	38	7	38	65	65
Los Angeles	200	99	35	37	6	36	62	62
Los Angeles	250	98	35	48	8	47	81	81
Los Angeles	250	99	35	46	8	46	78	78
Los Angeles	300	98	35	57	10	57	97	97
Los Angeles	300	99	35	55	10	55	94	94
Miami	As is		3	14	13	14	16	16
Miami	Current Std		3	53	53	53	53	53
Miami	50	98	3	13	12	13	15	15
Miami	50	99	3	12	11	12	13	13
Miami	100	98	3	27	24	27	29	29
Miami	100	99	3	23	21	23	26	26
Miami	150	98	3	40	36	40	44	44
Miami	150	99	3	35	32	35	39	39
Miami	200	98	3	53	48	53	59	59
Miami	200	99	3	47	42	47	52	52
Miami	250	98	3	67	60	66	74	74
Miami	250	99	3	59	53	58	65	65
Miami	300	98	3	80	72	80	88	88
Miami	300	99	3	70	63	70	78	78
New York	As is		13	31	21	30	40	40
New York	Current Std		13	44	30	46	53	53
New York	50	98	13	17	11	16	22	22
New York	50	99	13	15	10	14	19	19

	Scenario[1]	Percentile[2]	Site-Years	Annual Average NO_2 (ppb)[3]				
				Mean	Min	Med	p98	p99
New York	100	98	13	33	23	33	44	44
New York	100	99	13	29	20	29	38	38
New York	150	98	13	50	34	49	65	65
New York	150	99	13	44	30	43	58	58
New York	200	98	13	66	45	65	87	87
New York	200	99	13	58	40	57	77	77
New York	250	98	13	83	57	82	109	109
New York	250	99	13	73	50	72	96	96
New York	300	98	13	100	68	98	131	131
New York	300	99	13	88	60	86	115	115
Philadelphia	As is		7	24	19	24	30	30
Philadelphia	Current Std		7	46	34	45	53	53
Philadelphia	50	98	7	17	13	17	21	21
Philadelphia	50	99	7	16	12	15	19	19
Philadelphia	100	98	7	34	26	33	42	42
Philadelphia	100	99	7	31	24	31	38	38
Philadelphia	150	98	7	51	39	50	62	62
Philadelphia	150	99	7	47	36	46	57	57
Philadelphia	200	98	7	68	53	67	83	83
Philadelphia	200	99	7	62	48	61	76	76
Philadelphia	250	98	7	85	66	84	104	104
Philadelphia	250	99	7	78	60	77	95	95
Philadelphia	300	98	7	102	79	100	125	125
Philadelphia	300	99	7	93	72	92	114	114
Phoenix	As is		2	23	22	23	24	24
Phoenix	Current Std		2	33	31	33	36	36
Phoenix	50	98	2	13	12	13	14	14
Phoenix	50	99	2	12	11	12	12	12
Phoenix	100	98	2	26	25	26	27	27
Phoenix	100	99	2	24	23	24	25	25
Phoenix	150	98	2	39	37	39	41	41
Phoenix	150	99	2	36	34	36	37	37
Phoenix	200	98	2	52	50	52	54	54
Phoenix	200	99	2	47	45	47	50	50
Phoenix	250	98	2	65	62	65	68	68
Phoenix	250	99	2	59	57	59	62	62
Phoenix	300	98	2	78	74	78	81	81
Phoenix	300	99	2	71	68	71	74	74
St. Louis	As is		11	14	9	12	25	25
St. Louis	Current Std		11	34	21	27	53	53
St. Louis	50	98	11	11	7	9	19	19
St. Louis	50	99	11	10	6	8	17	17
St. Louis	100	98	11	22	13	18	38	38
St. Louis	100	99	11	20	12	16	35	35
St. Louis	150	98	11	33	20	27	57	57
St. Louis	150	99	11	30	18	24	52	52

	Scenario[1]	Percentile[2]	Site-Years	Annual Average NO_2 (ppb)[3]				
				Mean	Min	Med	p98	p99
St. Louis	200	98	11	44	26	36	76	76
St. Louis	200	99	11	40	24	33	70	70
St. Louis	250	98	11	55	33	45	95	95
St. Louis	250	99	11	50	30	41	87	87
St. Louis	300	98	11	66	40	54	114	114
St. Louis	300	99	11	60	36	49	104	104
Washington DC	As is		10	20	14	22	26	26
Washington DC	Current Std		10	43	30	47	53	53
Washington DC	50	98	10	14	10	16	18	18
Washington DC	50	99	10	13	9	14	16	16
Washington DC	100	98	10	29	20	31	36	36
Washington DC	100	99	10	26	18	28	33	33
Washington DC	150	98	10	43	30	47	55	55
Washington DC	150	99	10	39	27	42	49	49
Washington DC	200	98	10	57	40	62	73	73
Washington DC	200	99	10	52	36	56	66	66
Washington DC	250	98	10	71	49	78	91	91
Washington DC	250	99	10	65	45	70	82	82
Washington DC	300	98	10	86	59	93	109	109
Washington DC	300	99	10	77	54	84	99	99

Notes:
[1] Scenario: As is – unadjusted air quality, Current Std – air quality that just meets the current annual standard, All others – air quality that just meets 1-hour concentration level given percentile form of alternative standard.
[2] Percentile: 98th or 99th percentile of daily maximum 1-hour concentration averaged over three years at maximum monitor in location.
[3] Annual means for each monitor were first calculated based on all simulated hourly values in a year. Then the mean of the annual means was estimated as the sum of all the annual means in a particular location divided by the number of simulated site-years across the monitoring period. The min, med, p98, p99 represent the minimum, median, 98th, and 99th percentiles of the distribution for the annual means.

Table A-113. Estimated annual average NO_2 concentrations for monitors ≤20 m from a major road using 2001-2003 air quality *as is* and air quality adjusted to just meet the current and alternative standards.

Location	Scenario[1]	Percentile[2]	Site-Years	Annual Average NO_2 (ppb)[3]				
				Mean	Min	Med	p98	p99
Boston	As is		5	21	7	23	30	30
Boston	Current Std		5	41	13	48	53	53
Boston	50	98	5	15	5	16	20	20
Boston	50	99	5	13	4	14	18	18
Boston	100	98	5	29	10	32	41	41
Boston	100	99	5	26	9	29	37	37
Boston	150	98	5	44	14	48	61	61
Boston	150	99	5	39	13	43	55	55
Boston	200	98	5	58	19	63	82	82
Boston	200	99	5	53	17	57	74	74
Boston	250	98	5	73	24	79	102	102
Boston	250	99	5	66	22	72	92	92
Boston	300	98	5	87	29	95	122	122
Boston	300	99	5	79	26	86	111	111
Chicago	As is		4	22	22	22	24	24
Chicago	Current Std		4	37	36	37	39	39
Chicago	50	98	4	13	13	13	14	14
Chicago	50	99	4	11	11	11	12	12
Chicago	100	98	4	26	25	26	27	27
Chicago	100	99	4	23	22	23	24	24
Chicago	150	98	4	39	38	38	41	41
Chicago	150	99	4	34	34	34	36	36
Chicago	200	98	4	52	50	51	54	54
Chicago	200	99	4	46	45	46	48	48
Chicago	250	98	4	65	63	64	68	68
Chicago	250	99	4	57	56	57	60	60
Chicago	300	98	4	78	76	77	81	81
Chicago	300	99	4	69	67	68	72	72
Cleveland	As is		3	23	22	22	24	24
Cleveland	Current Std		3	53	53	53	53	53
Cleveland	50	98	3	16	15	16	17	17
Cleveland	50	99	3	15	14	15	16	16
Cleveland	100	98	3	32	31	32	34	34
Cleveland	100	99	3	30	29	30	31	31
Cleveland	150	98	3	48	46	48	50	50
Cleveland	150	99	3	45	43	44	47	47
Cleveland	200	98	3	64	62	63	67	67
Cleveland	200	99	3	60	57	59	63	63
Cleveland	250	98	3	80	77	79	84	84
Cleveland	250	99	3	75	72	74	78	78
Cleveland	300	98	3	96	92	95	101	101
Cleveland	300	99	3	90	86	89	94	94
Denver	As is		2	36	35	36	37	37
Denver	Current Std		2	53	53	53	53	53

Location	Scenario[1]	Percentile[2]	Site-Years	Annual Average NO_2 (ppb)[3]				
				Mean	Min	Med	p98	p99
Denver	50	98	2	19	18	19	19	19
Denver	50	99	2	17	16	17	17	17
Denver	100	98	2	37	37	37	38	38
Denver	100	99	2	33	32	33	34	34
Denver	150	98	2	56	55	56	57	57
Denver	150	99	2	50	49	50	51	51
Denver	200	98	2	75	73	75	76	76
Denver	200	99	2	66	65	66	68	68
Denver	250	98	2	93	92	93	95	95
Denver	250	99	2	83	81	83	84	84
Denver	300	98	2	112	110	112	114	114
Denver	300	99	2	99	97	99	101	101
Las Vegas	As is		3	22	21	22	23	23
Las Vegas	Current Std		3	53	53	53	53	53
Las Vegas	50	98	3	16	15	16	16	16
Las Vegas	50	99	3	14	14	15	15	15
Las Vegas	100	98	3	32	31	32	32	32
Las Vegas	100	99	3	29	28	29	29	29
Las Vegas	150	98	3	47	46	48	48	48
Las Vegas	150	99	3	43	42	44	44	44
Las Vegas	200	98	3	63	61	64	65	65
Las Vegas	200	99	3	57	56	58	59	59
Las Vegas	250	98	3	79	77	80	81	81
Las Vegas	250	99	3	72	70	73	73	73
Las Vegas	300	98	3	95	92	96	97	97
Las Vegas	300	99	3	86	84	87	88	88
Los Angeles	As is		9	30	23	29	37	37
Los Angeles	Current Std		9	41	30	39	53	53
Los Angeles	50	98	9	12	9	12	15	15
Los Angeles	50	99	9	11	9	11	14	14
Los Angeles	100	98	9	23	18	23	29	29
Los Angeles	100	99	9	23	17	22	28	28
Los Angeles	150	98	9	35	27	35	44	44
Los Angeles	150	99	9	34	26	33	42	42
Los Angeles	200	98	9	47	36	46	58	58
Los Angeles	200	99	9	45	35	45	56	56
Los Angeles	250	98	9	59	45	58	73	73
Los Angeles	250	99	9	56	44	56	70	70
Los Angeles	300	98	9	70	54	69	87	87
Los Angeles	300	99	9	68	52	67	84	84
Miami	As is		3	6	6	6	7	7
Miami	Current Std		3	23	19	23	27	27
Miami	50	98	3	6	5	6	6	6
Miami	50	99	3	5	5	5	5	5
Miami	100	98	3	12	11	12	12	12

Location	Scenario[1]	Percentile[2]	Site-Years	Annual Average NO_2 (ppb)[3]				
				Mean	Min	Med	p98	p99
Miami	100	99	3	10	9	10	11	11
Miami	150	98	3	17	16	18	18	18
Miami	150	99	3	15	14	16	16	16
Miami	200	98	3	23	22	24	25	25
Miami	200	99	3	20	19	21	22	22
Miami	250	98	3	29	27	29	31	31
Miami	250	99	3	26	24	26	27	27
Miami	300	98	3	35	32	35	37	37
Miami	300	99	3	31	28	31	33	33
New York	As is		7	28	25	28	30	30
New York	Current Std		7	39	34	38	49	49
New York	50	98	7	15	13	15	16	16
New York	50	99	7	13	12	13	14	14
New York	100	98	7	30	27	30	33	33
New York	100	99	7	26	23	26	29	29
New York	150	98	7	45	40	45	49	49
New York	150	99	7	39	35	40	43	43
New York	200	98	7	60	53	60	65	65
New York	200	99	7	53	47	53	57	57
New York	250	98	7	75	67	75	81	81
New York	250	99	7	66	59	66	72	72
New York	300	98	7	90	80	90	98	98
New York	300	99	7	79	70	79	86	86
Phoenix	As is		3	35	34	35	37	37
Phoenix	Current Std		3	53	53	53	53	53
Phoenix	50	98	3	20	20	20	21	21
Phoenix	50	99	3	19	18	18	20	20
Phoenix	100	98	3	41	40	40	43	43
Phoenix	100	99	3	37	36	37	39	39
Phoenix	150	98	3	61	59	60	64	64
Phoenix	150	99	3	56	54	55	59	59
Phoenix	200	98	3	82	79	80	86	86
Phoenix	200	99	3	74	72	73	78	78
Phoenix	250	98	3	102	99	100	107	107
Phoenix	250	99	3	93	90	91	98	98
Phoenix	300	98	3	122	119	120	128	128
Phoenix	300	99	3	112	108	110	117	117
St. Louis	As is		6	18	16	19	20	20
St. Louis	Current Std		6	43	40	42	48	48
St. Louis	50	98	6	14	13	14	15	15
St. Louis	50	99	6	13	11	13	14	14
St. Louis	100	98	6	28	25	29	30	30
St. Louis	100	99	6	26	23	26	28	28
St. Louis	150	98	6	42	38	43	45	45
St. Louis	150	99	6	39	34	39	41	41

Location	Scenario[1]	Percentile[2]	Site-Years	Annual Average NO_2 (ppb)[3]				
				Mean	Min	Med	p98	p99
St. Louis	200	98	6	56	50	57	60	60
St. Louis	200	99	6	51	46	52	55	55
St. Louis	250	98	6	70	63	71	75	75
St. Louis	250	99	6	64	57	65	69	69
St. Louis	300	98	6	84	75	86	90	90
St. Louis	300	99	6	77	69	78	83	83
Washington DC	As is		4	23	20	24	26	26
Washington DC	Current Std		4	50	43	52	53	53
Washington DC	50	98	4	16	14	17	18	18
Washington DC	50	99	4	15	12	15	16	16
Washington DC	100	98	4	33	28	34	36	36
Washington DC	100	99	4	30	25	30	33	33
Washington DC	150	98	4	49	42	50	54	54
Washington DC	150	99	4	44	37	46	49	49
Washington DC	200	98	4	66	55	67	72	72
Washington DC	200	99	4	59	50	61	65	65
Washington DC	250	98	4	82	69	84	91	91
Washington DC	250	99	4	74	62	76	82	82
Washington DC	300	98	4	98	83	101	109	109
Washington DC	300	99	4	89	75	91	98	98

Notes:
[1] Scenario: As is – unadjusted air quality, Current Std – air quality that just meets the current annual standard, All others – air quality that just meets 1-hour concentration level given percentile form of alternative standard.
[2] Percentile: 98th or 99th percentile of daily maximum 1-hour concentration averaged over three years at maximum monitor in location.
[3] Annual means for each monitor were first calculated based on all simulated hourly values in a year. Then the mean of the annual means was estimated as the sum of all the annual means in a particular location divided by the number of simulated site-years across the monitoring period. The min, med, p98, p99 represent the minimum, median, 98th, and 99th percentiles of the distribution for the annual means.

Table A-114. Estimated annual average NO_2 concentrations on-roads using 2001-2003 air quality *as is*, air quality adjusted to just meet the current and alternative standards, and an on-road adjustment factor.

Location	Standard[1]	Percentile[2]	Site-Years	Annual Average NO_2 (ppb)[3]				
				Mean	Min	Med	p98	p99
Atlanta	As is		1400	22	5	24	47	53
Atlanta	Current Std		1400	60	12	62	127	130
Atlanta	50	98	1400	14	3	15	29	32
Atlanta	50	99	1400	13	3	13	26	30
Atlanta	100	98	1400	27	6	29	57	65
Atlanta	100	99	1400	25	6	27	53	60
Atlanta	150	98	1400	41	9	44	86	97
Atlanta	150	99	1400	38	9	40	79	90
Atlanta	200	98	1400	55	13	58	115	130
Atlanta	200	99	1400	50	12	54	106	120
Atlanta	250	98	1400	68	16	73	144	162
Atlanta	250	99	1400	63	14	67	132	149
Atlanta	300	98	1400	82	19	87	172	195
Atlanta	300	99	1400	75	17	80	159	179
Boston	As is		600	17	7	18	29	30
Boston	Current Std		600	34	14	36	60	61
Boston	50	98	600	12	5	12	20	21
Boston	50	99	600	11	4	11	18	19
Boston	100	98	600	24	9	24	40	41
Boston	100	99	600	22	8	22	36	37
Boston	150	98	600	36	14	37	59	62
Boston	150	99	600	32	13	33	54	56
Boston	200	98	600	48	19	49	79	82
Boston	200	99	600	43	17	44	72	74
Boston	250	98	600	59	23	61	99	103
Boston	250	99	600	54	21	55	89	93
Boston	300	98	600	71	28	73	119	123
Boston	300	99	600	65	25	66	107	112
Chicago	As is		900	39	21	37	65	68
Chicago	Current Std		900	65	35	62	111	114
Chicago	50	98	900	23	12	22	37	39
Chicago	50	99	900	20	11	19	33	35
Chicago	100	98	900	45	25	43	75	78
Chicago	100	99	900	40	22	38	66	69
Chicago	150	98	900	68	37	65	112	117
Chicago	150	99	900	60	33	57	100	104
Chicago	200	98	900	91	49	86	150	156
Chicago	200	99	900	80	44	77	133	138
Chicago	250	98	900	113	62	108	187	195
Chicago	250	99	900	100	55	96	166	173
Chicago	300	98	900	136	74	129	224	234
Chicago	300	99	900	121	66	115	199	207
Cleveland	As is		300	32	22	32	43	45
Cleveland	Current Std		300	76	53	75	102	106

Location	Standard[1]	Percentile[2]	Site-Years	Annual Average NO_2 (ppb)[3]				
				Mean	Min	Med	p98	p99
Cleveland	50	98	300	23	16	23	30	32
Cleveland	50	99	300	21	15	21	28	30
Cleveland	100	98	300	46	32	45	61	64
Cleveland	100	99	300	43	29	42	57	60
Cleveland	150	98	300	69	47	68	91	96
Cleveland	150	99	300	64	44	64	85	90
Cleveland	200	98	300	92	63	91	122	128
Cleveland	200	99	300	86	59	85	114	120
Cleveland	250	98	300	115	79	113	152	160
Cleveland	250	99	300	107	74	106	142	150
Cleveland	300	98	300	138	95	136	183	192
Cleveland	300	99	300	129	88	127	171	180
Denver	As is		200	42	27	40	63	64
Denver	Current Std		200	80	48	81	127	129
Denver	50	98	200	22	14	21	33	33
Denver	50	99	200	19	12	19	29	30
Denver	100	98	200	44	28	42	65	67
Denver	100	99	200	39	25	37	58	59
Denver	150	98	200	66	42	63	98	100
Denver	150	99	200	58	37	56	87	89
Denver	200	98	200	88	56	84	131	134
Denver	200	99	200	78	50	74	116	118
Denver	250	98	200	110	70	105	163	167
Denver	250	99	200	97	62	93	145	148
Denver	300	98	200	131	84	126	196	200
Denver	300	99	200	116	75	111	174	178
Detroit	As is		600	37	24	36	54	57
Detroit	Current Std		600	89	56	87	130	131
Detroit	50	98	600	21	13	20	30	32
Detroit	50	99	600	14	9	13	20	21
Detroit	100	98	600	41	26	40	59	63
Detroit	100	99	600	28	18	27	40	43
Detroit	150	98	600	62	39	60	89	95
Detroit	150	99	600	42	27	40	60	64
Detroit	200	98	600	83	52	80	119	126
Detroit	200	99	600	56	35	54	80	85
Detroit	250	98	600	103	66	100	149	158
Detroit	250	99	600	70	44	67	100	107
Detroit	300	98	600	124	79	119	178	189
Detroit	300	99	600	84	53	81	120	128
El Paso	As is		1200	27	13	27	43	44
El Paso	Current Std		1200	69	32	68	111	116
El Paso	50	98	1200	18	9	18	28	29
El Paso	50	99	1200	16	8	15	24	25
El Paso	100	98	1200	36	17	35	56	58

Location	Standard[1]	Percentile[2]	Site-Years	Annual Average NO_2 (ppb)[3]				
				Mean	Min	Med	p98	p99
El Paso	100	99	1200	31	15	31	49	51
El Paso	150	98	1200	54	26	53	84	87
El Paso	150	99	1200	47	23	46	73	76
El Paso	200	98	1200	71	34	70	112	116
El Paso	200	99	1200	62	30	61	98	101
El Paso	250	98	1200	89	43	88	140	145
El Paso	250	99	1200	78	38	77	122	126
El Paso	300	98	1200	107	52	105	168	174
El Paso	300	99	1200	94	45	92	147	152
Jacksonville	As is		200	26	18	26	36	37
Jacksonville	Current Std		200	96	68	94	130	135
Jacksonville	50	98	200	24	16	23	32	34
Jacksonville	50	99	200	22	15	22	30	31
Jacksonville	100	98	200	47	33	47	64	67
Jacksonville	100	99	200	44	31	43	60	63
Jacksonville	150	98	200	71	49	70	96	101
Jacksonville	150	99	200	66	46	65	90	94
Jacksonville	200	98	200	95	66	93	128	134
Jacksonville	200	99	200	88	61	87	119	125
Jacksonville	250	98	200	118	82	117	160	168
Jacksonville	250	99	200	110	77	109	149	157
Jacksonville	300	98	200	142	99	140	192	201
Jacksonville	300	99	200	132	92	130	179	188
Las Vegas	As is		1600	19	3	14	48	51
Las Vegas	Current Std		1600	46	7	33	117	124
Las Vegas	50	98	1600	14	2	10	35	36
Las Vegas	50	99	1600	12	2	9	32	33
Las Vegas	100	98	1600	27	4	20	69	73
Las Vegas	100	99	1600	25	4	18	63	66
Las Vegas	150	98	1600	41	6	29	104	109
Las Vegas	150	99	1600	37	5	27	95	99
Las Vegas	200	98	1600	54	8	39	139	146
Las Vegas	200	99	1600	50	7	36	126	133
Las Vegas	250	98	1600	68	10	49	174	182
Las Vegas	250	99	1600	62	9	45	158	166
Las Vegas	300	98	1600	82	12	59	208	219
Las Vegas	300	99	1600	74	11	54	189	199
Los Angeles	As is		5100	41	6	40	77	82
Los Angeles	Current Std		5100	56	8	55	106	113
Los Angeles	50	98	5100	16	2	16	31	32
Los Angeles	50	99	5100	15	2	15	29	31
Los Angeles	100	98	5100	32	5	32	61	65
Los Angeles	100	99	5100	31	5	31	59	62
Los Angeles	150	98	5100	48	7	48	92	97
Los Angeles	150	99	5100	46	7	46	88	94

Location	Standard[1]	Percentile[2]	Site-Years	Annual Average NO_2 (ppb)[3]				
				Mean	Min	Med	p98	p99
Los Angeles	200	98	5100	64	10	63	122	130
Los Angeles	200	99	5100	62	9	61	117	125
Los Angeles	250	98	5100	80	12	79	153	162
Los Angeles	250	99	5100	77	12	76	147	156
Los Angeles	300	98	5100	97	14	95	183	194
Los Angeles	300	99	5100	93	14	92	176	187
Miami	As is		600	16	9	15	24	25
Miami	Current Std		600	59	33	58	87	92
Miami	50	98	600	15	8	14	22	23
Miami	50	99	600	13	7	13	20	20
Miami	100	98	600	29	16	29	45	46
Miami	100	99	600	26	14	25	39	40
Miami	150	98	600	44	24	43	67	68
Miami	150	99	600	39	22	38	59	60
Miami	200	98	600	59	33	57	89	91
Miami	200	99	600	52	29	50	78	80
Miami	250	98	600	73	41	71	111	114
Miami	250	99	600	65	36	63	98	100
Miami	300	98	600	88	49	86	134	137
Miami	300	99	600	78	43	75	117	121
New York	As is		2600	36	14	34	65	73
New York	Current Std		2600	52	18	49	98	103
New York	50	98	2600	20	8	18	35	39
New York	50	99	2600	17	7	16	31	35
New York	100	98	2600	39	15	37	70	79
New York	100	99	2600	35	13	33	62	69
New York	150	98	2600	59	23	55	105	118
New York	150	99	2600	52	20	49	93	104
New York	200	98	2600	79	30	74	140	158
New York	200	99	2600	69	27	65	123	139
New York	250	98	2600	98	38	92	175	197
New York	250	99	2600	86	33	81	154	173
New York	300	98	2600	118	45	111	211	237
New York	300	99	2600	104	40	98	185	208
Philadelphia	As is		1400	36	18	33	64	66
Philadelphia	Current Std		1400	67	33	63	119	126
Philadelphia	50	98	1400	25	13	23	44	46
Philadelphia	50	99	1400	23	12	21	41	42
Philadelphia	100	98	1400	50	26	46	89	92
Philadelphia	100	99	1400	46	23	42	81	84
Philadelphia	150	98	1400	74	38	69	133	138
Philadelphia	150	99	1400	68	35	63	122	127
Philadelphia	200	98	1400	99	51	92	177	184
Philadelphia	200	99	1400	91	47	85	163	169
Philadelphia	250	98	1400	124	64	115	222	230

Location	Standard[1]	Percentile[2]	Site-Years	Annual Average NO_2 (ppb)[3]				
				Mean	Min	Med	p98	p99
Philadelphia	250	99	1400	114	59	106	203	211
Philadelphia	300	98	1400	149	77	138	266	276
Philadelphia	300	99	1400	137	70	127	244	253
Phoenix	As is		500	49	28	47	72	77
Phoenix	Current Std		500	72	40	69	110	114
Phoenix	50	98	500	28	16	27	42	44
Phoenix	50	99	500	26	15	25	38	40
Phoenix	100	98	500	56	33	55	83	88
Phoenix	100	99	500	51	30	50	76	81
Phoenix	150	98	500	84	49	82	125	133
Phoenix	150	99	500	77	45	75	114	121
Phoenix	200	98	500	113	65	109	166	177
Phoenix	200	99	500	103	59	100	152	161
Phoenix	250	98	500	141	81	137	208	221
Phoenix	250	99	500	128	74	125	190	202
Phoenix	300	98	500	169	98	164	250	265
Phoenix	300	99	500	154	89	150	228	242
Provo	As is		300	43	28	41	61	64
Provo	Current Std		300	96	67	93	132	144
Provo	50	98	300	33	22	32	48	50
Provo	50	99	300	31	20	30	45	47
Provo	100	98	300	67	44	65	96	101
Provo	100	99	300	63	41	61	89	94
Provo	150	98	300	100	65	97	143	151
Provo	150	99	300	94	61	91	134	141
Provo	200	98	300	134	87	129	191	201
Provo	200	99	300	125	82	121	179	188
Provo	250	98	300	167	109	162	239	252
Provo	250	99	300	156	102	151	224	236
Provo	300	98	300	200	131	194	287	302
Provo	300	99	300	188	123	182	268	283
St. Louis	As is		900	31	18	30	48	50
St. Louis	Current Std		900	74	45	71	114	118
St. Louis	50	98	900	24	14	23	37	38
St. Louis	50	99	900	22	13	21	34	35
St. Louis	100	98	900	48	28	47	75	76
St. Louis	100	99	900	44	26	43	68	70
St. Louis	150	98	900	72	42	70	112	114
St. Louis	150	99	900	66	38	64	102	105
St. Louis	200	98	900	96	56	94	149	152
St. Louis	200	99	900	88	51	86	137	140
St. Louis	250	98	900	120	70	117	186	190
St. Louis	250	99	900	110	64	107	171	174
St. Louis	300	98	900	145	84	141	224	229
St. Louis	300	99	900	132	77	129	205	209

Location	Standard[1]	Percentile[2]	Site-Years	Annual Average NO_2 (ppb)[3]				
				Mean	Min	Med	p98	p99
Washington DC	As is		1800	33	11	34	58	63
Washington DC	Current Std		1800	71	24	73	125	133
Washington DC	50	98	1800	23	8	24	41	44
Washington DC	50	99	1800	21	7	22	37	40
Washington DC	100	98	1800	47	15	48	82	88
Washington DC	100	99	1800	42	14	43	74	80
Washington DC	150	98	1800	70	23	72	123	133
Washington DC	150	99	1800	63	21	65	111	120
Washington DC	200	98	1800	93	31	96	163	177
Washington DC	200	99	1800	84	28	87	148	160
Washington DC	250	98	1800	117	39	120	204	221
Washington DC	250	99	1800	105	35	108	185	199
Washington DC	300	98	1800	140	46	144	245	265
Washington DC	300	99	1800	126	42	130	221	239
Other MSA	As is		61200	23	1	22	47	50
Other MSA	Current Std		61200	45	1	44	93	99
Other MSA	50	98	61200	12	0	11	24	25
Other MSA	50	99	61200	10	0	10	21	22
Other MSA	100	98	61200	23	1	23	48	51
Other MSA	100	99	61200	20	1	20	41	44
Other MSA	150	98	61200	35	1	34	71	76
Other MSA	150	99	61200	30	1	30	62	66
Other MSA	200	98	61200	46	1	46	95	102
Other MSA	200	99	61200	40	1	39	82	88
Other MSA	250	98	61200	58	2	57	119	127
Other MSA	250	99	61200	50	1	49	103	110
Other MSA	300	98	61200	69	2	68	143	153
Other MSA	300	99	61200	60	2	59	124	132
Other Not MSA	As is		12700	12	1	11	31	33
Other Not MSA	Current Std		12700	40	4	35	101	109
Other Not MSA	50	98	12700	7	1	6	17	18
Other Not MSA	50	99	12700	6	1	5	14	16
Other Not MSA	100	98	12700	13	1	12	34	37
Other Not MSA	100	99	12700	11	1	10	29	31
Other Not MSA	150	98	12700	20	2	17	51	55
Other Not MSA	150	99	12700	17	2	15	43	47
Other Not MSA	200	98	12700	26	3	23	67	73
Other Not MSA	200	99	12700	22	2	20	57	62
Other Not MSA	250	98	12700	33	4	29	84	91
Other Not MSA	250	99	12700	28	3	25	72	78
Other Not MSA	300	98	12700	40	4	35	101	110
Other Not MSA	300	99	12700	34	4	30	86	93

Notes:
[1] Scenario: As is – unadjusted air quality, Current Std – air quality that just meets the current annual standard, All others – air quality that just meets 1-hour concentration level given percentile form of alternative standard.

Location	Standard[1]	Percentile[2]	Site-Years	Annual Average NO_2 (ppb)[3]				
				Mean	Min	Med	p98	p99

[2] Percentile: 98th or 99th percentile of daily maximum 1-hour concentration averaged over three years at maximum monitor in location.
[3] Annual means for each monitor were first calculated based on all simulated hourly values in a year. Then the mean of the annual means was estimated as the sum of all the annual means in a particular location divided by the number of simulated site-years across the monitoring period. The min, med, p98, p99 represent the minimum, median, 98th, and 99th percentiles of the distribution for the annual means.

A-9.2 Number of 1-hour NO_2 exceedances in a year, 2001-2003

Table A-115. Estimated number of exceedances of 1-hour concentration levels (100, 150, and 200 ppb) for monitors ≥100 m from a major road using 2001-2003 air quality *as is* and air quality adjusted to just meet the current and alternative standards.

				Number of Daily Maximum Exceedances[3]														
				≥ 100 ppb					≥ 150 ppb					≥ 200 ppb				
Location	Standard[1]	Percentile[2]	Site-Years	Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
Atlanta	As is		14	0	0	0	3	3	0	0	0	1	1	0	0	0	0	0
Atlanta	Current Std		14	80	2	85	215	215	18	0	8	75	75	3	0	0	18	18
Atlanta	50	98	14	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
Atlanta	50	99	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Atlanta	100	98	14	2	0	0	15	15	0	0	0	1	1	0	0	0	1	1
Atlanta	100	99	14	1	0	0	8	8	0	0	0	1	1	0	0	0	0	0
Atlanta	150	98	14	20	0	9	84	84	2	0	0	15	15	0	0	0	1	1
Atlanta	150	99	14	13	0	4	57	57	1	0	0	8	8	0	0	0	1	1
Atlanta	200	98	14	65	1	66	196	196	10	0	3	53	53	2	0	0	15	15
Atlanta	200	99	14	48	0	39	162	162	7	0	1	42	42	1	0	0	8	8
Boston	As is		6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Boston	Current Std		6	3	0	1	12	12	0	0	0	0	0	0	0	0	0	0
Boston	50	98	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Boston	50	99	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Boston	100	98	6	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
Boston	100	99	6	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
Boston	150	98	6	3	0	2	10	10	0	0	0	1	1	0	0	0	0	0
Boston	150	99	6	2	0	1	6	6	0	0	0	1	1	0	0	0	0	0
Boston	200	98	6	34	7	35	62	62	1	0	1	5	5	0	0	0	1	1
Boston	200	99	6	17	3	14	34	34	1	0	1	3	3	0	0	0	1	1
Chicago	As is		9	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0
Chicago	Current Std		9	23	1	15	82	82	1	0	0	4	4	0	0	0	1	1
Chicago	50	98	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chicago	50	99	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chicago	100	98	9	1	0	0	4	4	0	0	0	1	1	0	0	0	0	0
Chicago	100	99	9	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0

Location	Standard[1]	Percentile[2]	Site-Years	Number of Daily Maximum Exceedances[3]														
				≥ 100 ppb					≥ 150 ppb					≥ 200 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
Chicago	150	98	9	31	4	24	86	86	1	0	0	4	4	0	0	0	1	1
Chicago	150	99	9	12	1	7	45	45	0	0	0	2	2	0	0	0	1	1
Chicago	200	98	9	106	51	104	193	193	14	1	8	51	51	1	0	0	4	4
Chicago	200	99	9	72	30	57	146	146	4	0	3	16	16	0	0	0	2	2
Cleveland	As is		3	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
Cleveland	Current Std		3	70	59	68	82	82	5	4	5	7	7	1	0	1	1	1
Cleveland	50	98	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cleveland	50	99	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cleveland	100	98	3	2	1	3	3	3	0	0	0	0	0	0	0	0	0	0
Cleveland	100	99	3	1	1	1	2	2	0	0	0	0	0	0	0	0	0	0
Cleveland	150	98	3	49	32	54	60	60	2	1	3	3	3	0	0	0	1	1
Cleveland	150	99	3	31	20	32	41	41	1	1	1	2	2	0	0	0	1	1
Cleveland	200	98	3	133	120	129	151	151	27	16	28	38	38	2	1	3	3	3
Cleveland	200	99	3	117	108	109	135	135	14	12	13	17	17	1	1	1	2	2
Denver	As is		2	2	1	2	2	2	0	0	0	0	0	0	0	0	0	0
Denver	Current Std		2	99	24	99	174	174	21	1	21	41	41	2	0	2	4	4
Denver	50	98	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Denver	50	99	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Denver	100	98	2	2	1	2	2	2	0	0	0	0	0	0	0	0	0	0
Denver	100	99	2	1	0	1	2	2	0	0	0	0	0	0	0	0	0	0
Denver	150	98	2	37	29	37	44	44	2	1	2	2	2	1	0	1	1	1
Denver	150	99	2	17	13	17	21	21	1	0	1	2	2	0	0	0	0	0
Denver	200	98	2	149	104	149	193	193	17	13	17	21	21	2	1	2	2	2
Denver	200	99	2	89	62	89	116	116	5	4	5	6	6	1	0	1	2	2
Detroit	As is		6	3	0	2	7	7	1	0	1	5	5	1	0	0	4	4
Detroit	Current Std		6	99	83	96	115	115	14	4	15	20	20	4	1	4	7	7
Detroit	50	98	6	1	0	1	4	4	1	0	0	3	3	0	0	0	2	2
Detroit	50	99	6	1	0	0	3	3	0	0	0	1	1	0	0	0	0	0
Detroit	100	98	6	3	1	3	7	7	2	0	1	7	7	1	0	1	4	4
Detroit	100	99	6	2	0	1	7	7	1	0	0	4	4	1	0	0	3	3
Detroit	150	98	6	17	7	18	23	23	3	1	3	7	7	2	0	1	7	7

Location	Standard[1]	Percentile[2]	Site-Years	Number of Daily Maximum Exceedances[3]														
				≥ 100 ppb					≥ 150 ppb					≥ 200 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
Detroit	150	99	6	3	1	3	7	7	2	0	1	7	7	1	0	1	4	4
Detroit	200	98	6	73	46	70	99	99	9	2	10	14	14	3	1	3	7	7
Detroit	200	99	6	10	2	11	14	14	3	0	2	7	7	2	0	1	7	7
El Paso	As is		12	0	0	0	1	1	0	0	0	1	1	0	0	0	0	0
El Paso	Current Std		12	115	48	125	189	189	13	3	12	27	27	2	0	2	7	7
El Paso	50	98	12	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
El Paso	50	99	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
El Paso	100	98	12	3	0	2	8	8	0	0	0	1	1	0	0	0	1	1
El Paso	100	99	12	1	0	0	5	5	0	0	0	1	1	0	0	0	0	0
El Paso	150	98	12	35	11	34	60	60	3	0	2	8	8	0	0	0	1	1
El Paso	150	99	12	14	3	13	28	28	1	0	0	5	5	0	0	0	1	1
El Paso	200	98	12	125	59	129	174	174	16	4	14	30	30	3	0	2	8	8
El Paso	200	99	12	76	30	77	118	118	6	2	7	13	13	1	0	0	5	5
Jacksonville	As is		2	1	0	1	1	1	1	0	1	1	1	1	0	1	1	1
Jacksonville	Current Std		2	152	142	152	161	161	44	35	44	53	53	7	3	7	11	11
Jacksonville	50	98	2	1	0	1	1	1	1	0	1	1	1	1	0	1	1	1
Jacksonville	50	99	2	1	0	1	1	1	1	0	1	1	1	1	0	1	1	1
Jacksonville	100	98	2	7	3	7	10	10	1	0	1	1	1	1	0	1	1	1
Jacksonville	100	99	2	4	3	4	5	5	1	0	1	1	1	1	0	1	1	1
Jacksonville	150	98	2	74	70	74	77	77	7	3	7	10	10	1	1	1	1	1
Jacksonville	150	99	2	55	50	55	60	60	4	3	4	5	5	1	0	1	1	1
Jacksonville	200	98	2	152	142	152	161	161	41	35	41	46	46	7	3	7	10	10
Jacksonville	200	99	2	132	128	132	135	135	29	22	29	35	35	4	3	4	5	5
Las Vegas	As is		16	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
Las Vegas	Current Std		16	69	0	21	218	218	6	0	1	34	34	0	0	0	1	1
Las Vegas	50	98	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Las Vegas	50	99	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Las Vegas	100	98	16	1	0	0	7	7	0	0	0	0	0	0	0	0	0	0
Las Vegas	100	99	16	1	0	0	2	2	0	0	0	0	0	0	0	0	0	0
Las Vegas	150	98	16	41	0	5	143	143	1	0	0	7	7	0	0	0	1	1
Las Vegas	150	99	16	22	0	3	79	79	1	0	0	2	2	0	0	0	1	1

Location	Standard[1]	Percentile[2]	Site-Years	Number of Daily Maximum Exceedances[3]														
				≥ 100 ppb					≥ 150 ppb					≥ 200 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
Las Vegas	200	98	16	114	1	61	293	293	19	0	3	70	70	1	0	0	7	7
Las Vegas	200	99	16	87	0	31	252	252	9	0	2	38	38	1	0	0	2	2
Los Angeles	As is		51	4	0	1	17	18	0	0	0	1	8	0	0	0	0	4
Los Angeles	Current Std		51	21	0	16	67	78	2	0	0	10	11	0	0	0	1	7
Los Angeles	50	98	51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Los Angeles	50	99	51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Los Angeles	100	98	51	1	0	0	5	10	0	0	0	0	5	0	0	0	0	0
Los Angeles	100	99	51	0	0	0	3	9	0	0	0	0	4	0	0	0	0	0
Los Angeles	150	98	51	9	0	4	43	46	1	0	0	5	10	0	0	0	0	5
Los Angeles	150	99	51	8	0	3	36	39	0	0	0	3	9	0	0	0	0	5
Los Angeles	200	98	51	37	0	31	110	128	5	0	1	26	27	1	0	0	5	10
Los Angeles	200	99	51	32	0	27	98	117	4	0	1	19	19	0	0	0	3	9
Miami	As is		6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Miami	Current Std		6	106	75	102	157	157	23	6	15	52	52	4	0	2	12	12
Miami	50	98	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Miami	50	99	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Miami	100	98	6	4	0	3	14	14	0	0	0	2	2	0	0	0	0	0
Miami	100	99	6	2	0	2	7	7	0	0	0	0	0	0	0	0	0	0
Miami	150	98	6	41	9	35	80	80	4	0	3	14	14	1	0	0	3	3
Miami	150	99	6	23	2	15	53	53	2	0	2	7	7	0	0	0	2	2
Miami	200	98	6	107	59	111	145	145	23	2	15	53	53	4	0	3	14	14
Miami	200	99	6	72	35	75	111	111	12	1	7	37	37	2	0	2	7	7
New York	As is		26	0	0	0	3	3	0	0	0	0	0	0	0	0	0	0
New York	Current Std		26	8	0	6	39	39	0	0	0	3	3	0	0	0	1	1
New York	50	98	26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
New York	50	99	26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
New York	100	98	26	1	0	0	5	5	0	0	0	0	0	0	0	0	0	0
New York	100	99	26	0	0	0	3	3	0	0	0	0	0	0	0	0	0	0
New York	150	98	26	16	0	7	42	42	1	0	0	5	5	0	0	0	1	1
New York	150	99	26	7	0	2	25	25	0	0	0	3	3	0	0	0	0	0
New York	200	98	26	72	9	68	141	141	7	0	2	25	25	1	0	0	5	5

Location	Standard[1]	Percentile[2]	Site-Years	Number of Daily Maximum Exceedances[3]														
				≥ 100 ppb					≥ 150 ppb					≥ 200 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
New York	200	99	26	40	3	30	87	87	3	0	2	15	15	0	0	0	3	3
Philadelphia	As is		14	0	0	0	1	1	0	0	0	1	1	0	0	0	1	1
Philadelphia	Current Std		14	29	4	21	75	75	1	0	1	4	4	0	0	0	1	1
Philadelphia	50	98	14	0	0	0	1	1	0	0	0	1	1	0	0	0	0	0
Philadelphia	50	99	14	0	0	0	1	1	0	0	0	1	1	0	0	0	0	0
Philadelphia	100	98	14	3	0	2	15	15	0	0	0	1	1	0	0	0	1	1
Philadelphia	100	99	14	1	0	1	5	5	0	0	0	1	1	0	0	0	1	1
Philadelphia	150	98	14	53	18	41	140	140	3	0	2	15	15	1	0	1	1	1
Philadelphia	150	99	14	30	7	19	91	91	1	0	1	5	5	0	0	0	1	1
Philadelphia	200	98	14	171	99	176	265	265	27	6	16	83	83	3	0	2	15	15
Philadelphia	200	99	14	121	52	120	215	215	16	1	9	58	58	1	0	1	5	5
Phoenix	As is		5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phoenix	Current Std		5	32	2	29	65	65	0	0	0	0	0	0	0	0	0	0
Phoenix	50	98	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phoenix	50	99	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phoenix	100	98	5	1	0	1	2	2	0	0	0	0	0	0	0	0	0	0
Phoenix	100	99	5	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
Phoenix	150	98	5	89	14	111	146	146	1	0	1	2	2	0	0	0	0	0
Phoenix	150	99	5	45	7	56	88	88	0	0	0	1	1	0	0	0	0	0
Phoenix	200	98	5	213	115	227	272	272	41	4	52	79	79	1	0	1	2	2
Phoenix	200	99	5	171	71	190	235	235	17	2	22	31	31	0	0	0	1	1
Provo	As is		3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Provo	Current Std		3	162	148	160	177	177	4	3	4	6	6	0	0	0	0	0
Provo	50	98	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Provo	50	99	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Provo	100	98	3	6	4	6	9	9	0	0	0	0	0	0	0	0	0	0
Provo	100	99	3	4	3	4	5	5	0	0	0	0	0	0	0	0	0	0
Provo	150	98	3	200	156	221	223	223	6	4	6	9	9	0	0	0	0	0
Provo	150	99	3	144	107	160	164	164	4	3	4	5	5	0	0	0	0	0
Provo	200	98	3	327	295	341	345	345	112	81	122	133	133	6	4	6	9	9
Provo	200	99	3	316	281	332	335	335	65	42	63	91	91	4	3	4	5	5

Location	Standard[1]	Percentile[2]	Site-Years	Number of Daily Maximum Exceedances[3]														
				≥ 100 ppb					≥ 150 ppb					≥ 200 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
St. Louis	As is		9	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
St. Louis	Current Std		9	65	22	44	128	128	5	0	1	18	18	0	0	0	1	1
St. Louis	50	98	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
St. Louis	50	99	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
St. Louis	100	98	9	3	0	1	15	15	0	0	0	1	1	0	0	0	0	0
St. Louis	100	99	9	1	0	0	5	5	0	0	0	1	1	0	0	0	0	0
St. Louis	150	98	9	60	20	51	118	118	3	0	1	15	15	0	0	0	1	1
St. Louis	150	99	9	37	7	24	81	81	1	0	0	5	5	0	0	0	1	1
St. Louis	200	98	9	175	109	171	245	245	31	5	18	70	70	3	0	1	15	15
St. Louis	200	99	9	141	76	133	215	215	15	1	7	38	38	1	0	0	5	5
Washington DC	As is		18	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
Washington DC	Current Std		18	61	0	66	146	146	4	0	3	16	16	0	0	0	1	1
Washington DC	50	98	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Washington DC	50	99	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Washington DC	100	98	18	4	0	3	11	11	0	0	0	0	0	0	0	0	0	0
Washington DC	100	99	18	1	0	1	5	5	0	0	0	0	0	0	0	0	0	0
Washington DC	150	98	18	58	0	67	131	131	4	0	3	11	11	0	0	0	1	1
Washington DC	150	99	18	34	0	34	87	87	1	0	1	5	5	0	0	0	0	0
Washington DC	200	98	18	153	10	196	251	251	30	0	28	78	78	4	0	3	11	11
Washington DC	200	99	18	117	4	150	214	214	15	0	16	43	43	1	0	1	5	5
Other MSA	As is		612	0	0	0	1	4	0	0	0	0	0	0	0	0	0	0
Other MSA	Current Std		612	16	0	8	78	94	1	0	0	9	12	0	0	0	1	3
Other MSA	50	98	612	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other MSA	50	99	612	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other MSA	100	98	612	0	0	0	1	4	0	0	0	0	0	0	0	0	0	0
Other MSA	100	99	612	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
Other MSA	150	98	612	3	0	0	25	30	0	0	0	1	4	0	0	0	0	1
Other MSA	150	99	612	1	0	0	9	14	0	0	0	1	1	0	0	0	0	0
Other MSA	200	98	612	18	0	8	81	102	1	0	0	10	16	0	0	0	1	4
Other MSA	200	99	612	8	0	2	50	56	0	0	0	4	6	0	0	0	1	1
Other Not MSA	As is		127	0	0	0	5	5	0	0	0	1	1	0	0	0	0	1

Location	Standard[1]	Percentile[2]	Site-Years	Number of Daily Maximum Exceedances[3]														
				≥ 100 ppb					≥ 150 ppb					≥ 200 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
Other Not MSA	Current Std		127	37	0	12	170	192	6	0	0	74	80	1	0	0	21	34
Other Not MSA	50	98	127	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
Other Not MSA	50	99	127	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Not MSA	100	98	127	0	0	0	6	6	0	0	0	1	1	0	0	0	1	1
Other Not MSA	100	99	127	0	0	0	3	5	0	0	0	1	1	0	0	0	0	0
Other Not MSA	150	98	127	1	0	0	23	32	0	0	0	6	6	0	0	0	2	2
Other Not MSA	150	99	127	1	0	0	14	16	0	0	0	3	5	0	0	0	1	1
Other Not MSA	200	98	127	6	0	0	78	79	1	0	0	16	18	0	0	0	6	6
Other Not MSA	200	99	127	3	0	0	49	52	0	0	0	10	11	0	0	0	3	5

Notes:

[1] Scenario: As is – unadjusted air quality, Current Std – air quality that just meets the current annual standard, All others – air quality that just meets 1-hour concentration level given percentile form of alternative standard.

[2] Percentile: 98th or 99th percentile of daily maximum 1-hour concentration averaged over three years at maximum monitor in location.

[3] The mean number of exceedances represents the sum of daily maximum exceedances occurring at all monitors in a particular location divided by the number of site-years across the monitoring period. The min, med, p98, and p99 represent the minimum, median, 98th, and 99th percentiles of the distribution for the number of daily maximum exceedances in any one year within the monitoring period.

Table A-116. Estimated number of exceedances of 1-hour concentration levels (250 and 300 ppb) for monitors ≥100 m from a major road using 2001-2003 air quality *as is* and air quality adjusted to just meet the current and alternative standards.

				Number of Daily Maximum Exceedances[3]									
				≥ 250 ppb					≥ 300 ppb				
Location	Standard[1]	Percentile[2]	Site-Years	Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
Atlanta	As is		14	0	0	0	0	0	0	0	0	0	0
Atlanta	Current Std		14	1	0	0	4	4	0	0	0	1	1
Atlanta	50	98	14	0	0	0	0	0	0	0	0	0	0
Atlanta	50	99	14	0	0	0	0	0	0	0	0	0	0
Atlanta	100	98	14	0	0	0	0	0	0	0	0	0	0
Atlanta	100	99	14	0	0	0	0	0	0	0	0	0	0
Atlanta	150	98	14	0	0	0	1	1	0	0	0	1	1
Atlanta	150	99	14	0	0	0	1	1	0	0	0	0	0
Atlanta	200	98	14	0	0	0	2	2	0	0	0	1	1
Atlanta	200	99	14	0	0	0	1	1	0	0	0	1	1
Boston	As is		6	0	0	0	0	0	0	0	0	0	0
Boston	Current Std		6	0	0	0	0	0	0	0	0	0	0
Boston	50	98	6	0	0	0	0	0	0	0	0	0	0
Boston	50	99	6	0	0	0	0	0	0	0	0	0	0
Boston	100	98	6	0	0	0	0	0	0	0	0	0	0
Boston	100	99	6	0	0	0	0	0	0	0	0	0	0
Boston	150	98	6	0	0	0	0	0	0	0	0	0	0
Boston	150	99	6	0	0	0	0	0	0	0	0	0	0
Boston	200	98	6	0	0	0	0	0	0	0	0	0	0
Boston	200	99	6	0	0	0	0	0	0	0	0	0	0
Chicago	As is		9	0	0	0	0	0	0	0	0	0	0
Chicago	Current Std		9	0	0	0	0	0	0	0	0	0	0
Chicago	50	98	9	0	0	0	0	0	0	0	0	0	0
Chicago	50	99	9	0	0	0	0	0	0	0	0	0	0
Chicago	100	98	9	0	0	0	0	0	0	0	0	0	0
Chicago	100	99	9	0	0	0	0	0	0	0	0	0	0
Chicago	150	98	9	0	0	0	0	0	0	0	0	0	0
Chicago	150	99	9	0	0	0	0	0	0	0	0	0	0
Chicago	200	98	9	0	0	0	1	1	0	0	0	1	1
Chicago	200	99	9	0	0	0	1	1	0	0	0	0	0
Cleveland	As is		3	0	0	0	0	0	0	0	0	0	0
Cleveland	Current Std		3	0	0	0	0	0	0	0	0	0	0
Cleveland	50	98	3	0	0	0	0	0	0	0	0	0	0
Cleveland	50	99	3	0	0	0	0	0	0	0	0	0	0
Cleveland	100	98	3	0	0	0	0	0	0	0	0	0	0
Cleveland	100	99	3	0	0	0	0	0	0	0	0	0	0
Cleveland	150	98	3	0	0	0	0	0	0	0	0	0	0
Cleveland	150	99	3	0	0	0	0	0	0	0	0	0	0
Cleveland	200	98	3	1	0	1	1	1	0	0	0	0	0
Cleveland	200	99	3	0	0	0	1	1	0	0	0	0	0
Denver	As is		2	0	0	0	0	0	0	0	0	0	0
Denver	Current Std		2	1	0	1	2	2	1	0	1	1	1

Location	Standard[1]	Percentile[2]	Site-Years	Number of Daily Maximum Exceedances[3]									
				≥ 250 ppb					≥ 300 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
Denver	50	98	2	0	0	0	0	0	0	0	0	0	0
Denver	50	99	2	0	0	0	0	0	0	0	0	0	0
Denver	100	98	2	0	0	0	0	0	0	0	0	0	0
Denver	100	99	2	0	0	0	0	0	0	0	0	0	0
Denver	150	98	2	0	0	0	0	0	0	0	0	0	0
Denver	150	99	2	0	0	0	0	0	0	0	0	0	0
Denver	200	98	2	1	0	1	1	1	0	0	0	0	0
Denver	200	99	2	0	0	0	0	0	0	0	0	0	0
Detroit	As is		6	1	0	0	4	4	0	0	0	2	2
Detroit	Current Std		6	2	0	1	7	7	2	0	1	7	7
Detroit	50	98	6	0	0	0	0	0	0	0	0	0	0
Detroit	50	99	6	0	0	0	0	0	0	0	0	0	0
Detroit	100	98	6	1	0	0	4	4	1	0	0	3	3
Detroit	100	99	6	0	0	0	2	2	0	0	0	1	1
Detroit	150	98	6	1	0	1	5	5	1	0	1	4	4
Detroit	150	99	6	1	0	0	4	4	1	0	0	3	3
Detroit	200	98	6	2	0	1	7	7	2	0	1	7	7
Detroit	200	99	6	1	0	1	5	5	1	0	0	4	4
El Paso	As is		12	0	0	0	0	0	0	0	0	0	0
El Paso	Current Std		12	0	0	0	3	3	0	0	0	1	1
El Paso	50	98	12	0	0	0	0	0	0	0	0	0	0
El Paso	50	99	12	0	0	0	0	0	0	0	0	0	0
El Paso	100	98	12	0	0	0	0	0	0	0	0	0	0
El Paso	100	99	12	0	0	0	0	0	0	0	0	0	0
El Paso	150	98	12	0	0	0	1	1	0	0	0	1	1
El Paso	150	99	12	0	0	0	1	1	0	0	0	0	0
El Paso	200	98	12	1	0	0	3	3	0	0	0	1	1
El Paso	200	99	12	0	0	0	1	1	0	0	0	1	1
Jacksonville	As is		2	1	0	1	1	1	0	0	0	0	0
Jacksonville	Current Std		2	3	2	3	3	3	1	0	1	1	1
Jacksonville	50	98	2	1	0	1	1	1	0	0	0	0	0
Jacksonville	50	99	2	0	0	0	0	0	0	0	0	0	0
Jacksonville	100	98	2	1	0	1	1	1	1	0	1	1	1
Jacksonville	100	99	2	1	0	1	1	1	1	0	1	1	1
Jacksonville	150	98	2	1	0	1	1	1	1	0	1	1	1
Jacksonville	150	99	2	1	0	1	1	1	1	0	1	1	1
Jacksonville	200	98	2	2	1	2	2	2	1	0	1	1	1
Jacksonville	200	99	2	1	1	1	1	1	1	0	1	1	1
Las Vegas	As is		16	0	0	0	0	0	0	0	0	0	0
Las Vegas	Current Std		16	0	0	0	0	0	0	0	0	0	0
Las Vegas	50	98	16	0	0	0	0	0	0	0	0	0	0
Las Vegas	50	99	16	0	0	0	0	0	0	0	0	0	0
Las Vegas	100	98	16	0	0	0	0	0	0	0	0	0	0
Las Vegas	100	99	16	0	0	0	0	0	0	0	0	0	0
Las Vegas	150	98	16	0	0	0	0	0	0	0	0	0	0

Location	Standard[1]	Percentile[2]	Site-Years	Number of Daily Maximum Exceedances[3]									
				≥ 250 ppb					≥ 300 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
Las Vegas	150	99	16	0	0	0	0	0	0	0	0	0	0
Las Vegas	200	98	16	0	0	0	1	1	0	0	0	0	0
Las Vegas	200	99	16	0	0	0	1	1	0	0	0	0	0
Los Angeles	As is		51	0	0	0	0	0	0	0	0	0	0
Los Angeles	Current Std		51	0	0	0	0	4	0	0	0	0	1
Los Angeles	50	98	51	0	0	0	0	0	0	0	0	0	0
Los Angeles	50	99	51	0	0	0	0	0	0	0	0	0	0
Los Angeles	100	98	51	0	0	0	0	0	0	0	0	0	0
Los Angeles	100	99	51	0	0	0	0	0	0	0	0	0	0
Los Angeles	150	98	51	0	0	0	0	3	0	0	0	0	0
Los Angeles	150	99	51	0	0	0	0	2	0	0	0	0	0
Los Angeles	200	98	51	0	0	0	0	7	0	0	0	0	5
Los Angeles	200	99	51	0	0	0	0	6	0	0	0	0	4
Miami	As is		6	0	0	0	0	0	0	0	0	0	0
Miami	Current Std		6	1	0	1	3	3	0	0	0	0	0
Miami	50	98	6	0	0	0	0	0	0	0	0	0	0
Miami	50	99	6	0	0	0	0	0	0	0	0	0	0
Miami	100	98	6	0	0	0	0	0	0	0	0	0	0
Miami	100	99	6	0	0	0	0	0	0	0	0	0	0
Miami	150	98	6	0	0	0	0	0	0	0	0	0	0
Miami	150	99	6	0	0	0	0	0	0	0	0	0	0
Miami	200	98	6	2	0	1	6	6	0	0	0	2	2
Miami	200	99	6	1	0	0	3	3	0	0	0	0	0
New York	As is		26	0	0	0	0	0	0	0	0	0	0
New York	Current Std		26	0	0	0	0	0	0	0	0	0	0
New York	50	98	26	0	0	0	0	0	0	0	0	0	0
New York	50	99	26	0	0	0	0	0	0	0	0	0	0
New York	100	98	26	0	0	0	0	0	0	0	0	0	0
New York	100	99	26	0	0	0	0	0	0	0	0	0	0
New York	150	98	26	0	0	0	0	0	0	0	0	0	0
New York	150	99	26	0	0	0	0	0	0	0	0	0	0
New York	200	98	26	0	0	0	1	1	0	0	0	0	0
New York	200	99	26	0	0	0	1	1	0	0	0	0	0
Philadelphia	As is		14	0	0	0	1	1	0	0	0	0	0
Philadelphia	Current Std		14	0	0	0	1	1	0	0	0	1	1
Philadelphia	50	98	14	0	0	0	0	0	0	0	0	0	0
Philadelphia	50	99	14	0	0	0	0	0	0	0	0	0	0
Philadelphia	100	98	14	0	0	0	1	1	0	0	0	1	1
Philadelphia	100	99	14	0	0	0	1	1	0	0	0	1	1
Philadelphia	150	98	14	0	0	0	1	1	0	0	0	1	1
Philadelphia	150	99	14	0	0	0	1	1	0	0	0	1	1
Philadelphia	200	98	14	1	0	1	1	1	0	0	0	1	1
Philadelphia	200	99	14	0	0	0	1	1	0	0	0	1	1
Phoenix	As is		5	0	0	0	0	0	0	0	0	0	0
Phoenix	Current Std		5	0	0	0	0	0	0	0	0	0	0

Location	Standard[1]	Percentile[2]	Site-Years	Number of Daily Maximum Exceedances[3]									
				≥ 250 ppb					≥ 300 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
Phoenix	50	98	5	0	0	0	0	0	0	0	0	0	0
Phoenix	50	99	5	0	0	0	0	0	0	0	0	0	0
Phoenix	100	98	5	0	0	0	0	0	0	0	0	0	0
Phoenix	100	99	5	0	0	0	0	0	0	0	0	0	0
Phoenix	150	98	5	0	0	0	0	0	0	0	0	0	0
Phoenix	150	99	5	0	0	0	0	0	0	0	0	0	0
Phoenix	200	98	5	0	0	0	0	0	0	0	0	0	0
Phoenix	200	99	5	0	0	0	0	0	0	0	0	0	0
Provo	As is		3	0	0	0	0	0	0	0	0	0	0
Provo	Current Std		3	0	0	0	0	0	0	0	0	0	0
Provo	50	98	3	0	0	0	0	0	0	0	0	0	0
Provo	50	99	3	0	0	0	0	0	0	0	0	0	0
Provo	100	98	3	0	0	0	0	0	0	0	0	0	0
Provo	100	99	3	0	0	0	0	0	0	0	0	0	0
Provo	150	98	3	0	0	0	0	0	0	0	0	0	0
Provo	150	99	3	0	0	0	0	0	0	0	0	0	0
Provo	200	98	3	0	0	0	1	1	0	0	0	0	0
Provo	200	99	3	0	0	0	0	0	0	0	0	0	0
St. Louis	As is		9	0	0	0	0	0	0	0	0	0	0
St. Louis	Current Std		9	0	0	0	1	1	0	0	0	0	0
St. Louis	50	98	9	0	0	0	0	0	0	0	0	0	0
St. Louis	50	99	9	0	0	0	0	0	0	0	0	0	0
St. Louis	100	98	9	0	0	0	0	0	0	0	0	0	0
St. Louis	100	99	9	0	0	0	0	0	0	0	0	0	0
St. Louis	150	98	9	0	0	0	1	1	0	0	0	0	0
St. Louis	150	99	9	0	0	0	1	1	0	0	0	0	0
St. Louis	200	98	9	0	0	0	2	2	0	0	0	1	1
St. Louis	200	99	9	0	0	0	1	1	0	0	0	1	1
Washington DC	As is		18	0	0	0	0	0	0	0	0	0	0
Washington DC	Current Std		18	0	0	0	0	0	0	0	0	0	0
Washington DC	50	98	18	0	0	0	0	0	0	0	0	0	0
Washington DC	50	99	18	0	0	0	0	0	0	0	0	0	0
Washington DC	100	98	18	0	0	0	0	0	0	0	0	0	0
Washington DC	100	99	18	0	0	0	0	0	0	0	0	0	0
Washington DC	150	98	18	0	0	0	0	0	0	0	0	0	0
Washington DC	150	99	18	0	0	0	0	0	0	0	0	0	0
Washington DC	200	98	18	0	0	0	2	2	0	0	0	0	0

Location	Standard[1]	Percentile[2]	Site-Years	Number of Daily Maximum Exceedances[3]									
				≥ 250 ppb					≥ 300 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
Washington DC	200	99	18	0	0	0	1	1	0	0	0	0	0
Other MSA	As is		612	0	0	0	0	0	0	0	0	0	0
Other MSA	Current Std		612	0	0	0	1	1	0	0	0	0	0
Other MSA	50	98	612	0	0	0	0	0	0	0	0	0	0
Other MSA	50	99	612	0	0	0	0	0	0	0	0	0	0
Other MSA	100	98	612	0	0	0	0	0	0	0	0	0	0
Other MSA	100	99	612	0	0	0	0	0	0	0	0	0	0
Other MSA	150	98	612	0	0	0	0	0	0	0	0	0	0
Other MSA	150	99	612	0	0	0	0	0	0	0	0	0	0
Other MSA	200	98	612	0	0	0	1	1	0	0	0	0	0
Other MSA	200	99	612	0	0	0	0	1	0	0	0	0	0
Other Not MSA	As is		127	0	0	0	0	0	0	0	0	0	0
Other Not MSA	Current Std		127	1	0	0	12	12	0	0	0	6	6
Other Not MSA	50	98	127	0	0	0	0	0	0	0	0	0	0
Other Not MSA	50	99	127	0	0	0	0	0	0	0	0	0	0
Other Not MSA	100	98	127	0	0	0	0	0	0	0	0	0	0
Other Not MSA	100	99	127	0	0	0	0	0	0	0	0	0	0
Other Not MSA	150	98	127	0	0	0	1	1	0	0	0	1	1
Other Not MSA	150	99	127	0	0	0	1	1	0	0	0	0	0
Other Not MSA	200	98	127	0	0	0	3	3	0	0	0	1	1
Other Not MSA	200	99	127	0	0	0	1	1	0	0	0	1	1

Notes:

[1] Scenario: As is – unadjusted air quality, Current Std – air quality that just meets the current annual standard, All others – air quality that just meets 1-hour concentration level given percentile form of alternative standard.

[2] Percentile: 98th or 99th percentile of daily maximum 1-hour concentration averaged over three years at maximum monitor in location.

[3] The mean number of exceedances represents the sum of daily maximum exceedances occurring at all monitors in a particular location divided by the number of site-years across the monitoring period. The min, med, p98, and p99 represent the minimum, median, 98th, and 99th percentiles of the distribution for the number of daily maximum exceedances in any one year within the monitoring period.

Table A-117. Estimated number of exceedances of 1-hour concentration levels (100, 150 and 200 ppb) for monitors >20 m and <100 m from a major road using 2001-2003 air quality *as is* and air quality adjusted to just meet the current and alternative standards.

Location	Standard[1]	Percentile[2]	Site-Years	Number of Daily Maximum Exceedances[3]														
				≥ 100 ppb					≥ 150 ppb					≥ 200 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
Boston	As is		14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Boston	Current Std		14	38	0	24	145	145	3	0	1	20	20	0	0	0	4	4
Boston	50	98	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Boston	50	99	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Boston	100	98	14	3	0	2	11	11	0	0	0	0	0	0	0	0	0	0
Boston	100	99	14	1	0	0	6	6	0	0	0	0	0	0	0	0	0	0
Boston	150	98	14	35	2	27	89	89	3	0	2	11	11	0	0	0	1	1
Boston	150	99	14	20	0	14	64	64	1	0	0	6	6	0	0	0	0	0
Boston	200	98	14	116	21	120	226	226	19	0	13	59	59	3	0	2	11	11
Boston	200	99	14	82	11	79	182	182	9	0	6	28	28	1	0	0	6	6
Chicago	As is		6	2	0	1	6	6	0	0	0	0	0	0	0	0	0	0
Chicago	Current Std		6	74	34	74	111	111	5	1	4	9	9	1	0	0	5	5
Chicago	50	98	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chicago	50	99	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chicago	100	98	6	7	1	4	21	21	1	0	0	3	3	0	0	0	0	0
Chicago	100	99	6	2	0	1	7	7	0	0	0	2	2	0	0	0	0	0
Chicago	150	98	6	90	48	86	144	144	7	1	4	21	21	1	0	0	5	5
Chicago	150	99	6	50	20	48	95	95	2	0	1	7	7	1	0	0	3	3
Chicago	200	98	6	212	147	216	280	280	53	24	51	99	99	7	1	4	21	21
Chicago	200	99	6	164	108	163	242	242	24	6	21	51	51	2	0	1	7	7
El Paso	As is		3	2	0	2	3	3	0	0	0	0	0	0	0	0	0	0
El Paso	Current Std		3	170	128	187	196	196	32	17	35	44	44	6	2	7	8	8
El Paso	50	98	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
El Paso	50	99	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
El Paso	100	98	3	6	2	7	9	9	0	0	0	0	0	0	0	0	0	0
El Paso	100	99	3	4	1	5	5	5	0	0	0	0	0	0	0	0	0	0
El Paso	150	98	3	77	54	71	105	105	6	2	7	9	9	1	0	1	2	2
El Paso	150	99	3	38	23	34	57	57	4	1	5	5	5	0	0	0	0	0
El Paso	200	98	3	178	141	174	218	218	40	25	34	62	62	6	2	7	9	9

Location	Standard[1]	Percentile[2]	Site-Years	Number of Daily Maximum Exceedances[3]														
				≥ 100 ppb					≥ 150 ppb					≥ 200 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
El Paso	200	99	3	137	104	137	169	169	16	12	16	19	19	4	1	5	5	5
Las Vegas	As is		3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Las Vegas	Current Std		3	24	0	4	67	67	2	0	0	5	5	0	0	0	1	1
Las Vegas	50	98	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Las Vegas	50	99	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Las Vegas	100	98	3	1	0	0	4	4	0	0	0	0	0	0	0	0	0	0
Las Vegas	100	99	3	1	0	0	2	2	0	0	0	0	0	0	0	0	0	0
Las Vegas	150	98	3	11	0	0	34	34	1	0	0	4	4	0	0	0	0	0
Las Vegas	150	99	3	5	0	0	16	16	1	0	0	2	2	0	0	0	0	0
Las Vegas	200	98	3	46	1	25	113	113	5	0	0	14	14	1	0	0	4	4
Las Vegas	200	99	3	32	0	10	86	86	3	0	0	9	9	1	0	0	2	2
Los Angeles	As is		35	6	0	1	31	31	0	0	0	2	2	0	0	0	1	1
Los Angeles	Current Std		35	31	0	25	82	82	3	0	0	21	21	0	0	0	2	2
Los Angeles	50	98	35	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
Los Angeles	50	99	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Los Angeles	100	98	35	1	0	0	7	7	0	0	0	1	1	0	0	0	1	1
Los Angeles	100	99	35	1	0	0	4	4	0	0	0	1	1	0	0	0	0	0
Los Angeles	150	98	35	15	0	2	59	59	1	0	0	7	7	0	0	0	2	2
Los Angeles	150	99	35	13	0	2	49	49	1	0	0	4	4	0	0	0	2	2
Los Angeles	200	98	35	53	0	63	131	131	8	0	1	36	36	1	0	0	7	7
Los Angeles	200	99	35	48	0	47	124	124	7	0	1	33	33	1	0	0	4	4
Miami	As is		3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Miami	Current Std		3	152	137	154	166	166	42	38	43	44	44	8	6	7	11	11
Miami	50	98	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Miami	50	99	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Miami	100	98	3	8	4	6	15	15	0	0	0	1	1	0	0	0	0	0
Miami	100	99	3	2	0	1	6	6	0	0	0	0	0	0	0	0	0	0
Miami	150	98	3	73	48	75	97	97	8	4	6	15	15	1	0	1	3	3
Miami	150	99	3	42	27	38	62	62	2	0	1	6	6	0	0	0	1	1
Miami	200	98	3	155	113	166	187	187	42	27	38	62	62	8	4	6	15	15
Miami	200	99	3	114	80	122	140	140	25	19	20	35	35	2	0	1	6	6

Location	Standard[1]	Percentile[2]	Site-Years	Number of Daily Maximum Exceedances[3] ≥ 100 ppb Mean	Min	Med	p98	p99	≥ 150 ppb Mean	Min	Med	p98	p99	≥ 200 ppb Mean	Min	Med	p98	p99
New York	As is		13	1	0	0	8	8	0	0	0	0	0	0	0	0	0	0
New York	Current Std		13	26	1	16	48	48	1	0	1	4	4	0	0	0	0	0
New York	50	98	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
New York	50	99	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
New York	100	98	13	3	0	1	13	13	0	0	0	2	2	0	0	0	0	0
New York	100	99	13	1	0	0	5	5	0	0	0	0	0	0	0	0	0	0
New York	150	98	13	50	10	42	121	121	3	0	1	13	13	0	0	0	3	3
New York	150	99	13	25	2	20	67	67	1	0	0	5	5	0	0	0	2	2
New York	200	98	13	154	66	148	258	258	25	2	20	67	67	3	0	1	13	13
New York	200	99	13	102	23	95	197	197	12	1	8	33	33	1	0	0	5	5
Philadelphia	As is		7	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
Philadelphia	Current Std		7	44	10	48	73	73	2	0	2	5	5	0	0	0	1	1
Philadelphia	50	98	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Philadelphia	50	99	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Philadelphia	100	98	7	5	0	4	11	11	0	0	0	0	0	0	0	0	0	0
Philadelphia	100	99	7	2	0	1	4	4	0	0	0	0	0	0	0	0	0	0
Philadelphia	150	98	7	84	36	80	136	136	5	0	4	11	11	0	0	0	1	1
Philadelphia	150	99	7	47	18	32	89	89	2	0	1	4	4	0	0	0	0	0
Philadelphia	200	98	7	216	155	219	275	275	42	16	30	82	82	5	0	4	11	11
Philadelphia	200	99	7	168	107	172	231	231	22	6	15	51	51	2	0	1	4	4
Phoenix	As is		2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phoenix	Current Std		2	4	3	4	5	5	0	0	0	0	0	0	0	0	0	0
Phoenix	50	98	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phoenix	50	99	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phoenix	100	98	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phoenix	100	99	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phoenix	150	98	2	49	39	49	59	59	0	0	0	0	0	0	0	0	0	0
Phoenix	150	99	2	15	13	15	17	17	0	0	0	0	0	0	0	0	0	0
Phoenix	200	98	2	210	190	210	229	229	11	6	11	15	15	0	0	0	0	0
Phoenix	200	99	2	162	140	162	184	184	2	0	2	3	3	0	0	0	0	0
St. Louis	As is		11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Location	Standard[1]	Percentile[2]	Site-Years	Number of Daily Maximum Exceedances[3] ≥ 100 ppb Mean	Min	Med	p98	p99	≥ 150 ppb Mean	Min	Med	p98	p99	≥ 200 ppb Mean	Min	Med	p98	p99
St. Louis	Current Std		11	41	0	26	120	120	3	0	0	13	13	0	0	0	2	2
St. Louis	50	98	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
St. Louis	50	99	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
St. Louis	100	98	11	2	0	0	11	11	0	0	0	0	0	0	0	0	0	0
St. Louis	100	99	11	1	0	0	5	5	0	0	0	0	0	0	0	0	0	0
St. Louis	150	98	11	37	0	24	120	120	2	0	0	11	11	0	0	0	1	1
St. Louis	150	99	11	24	0	11	82	82	1	0	0	5	5	0	0	0	0	0
St. Louis	200	98	11	119	28	90	265	265	21	0	10	74	74	2	0	0	11	11
St. Louis	200	99	11	90	11	63	235	235	11	0	4	42	42	1	0	0	5	5
Washington DC	As is		10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Washington DC	Current Std		10	57	5	67	103	103	2	0	2	6	6	0	0	0	0	0
Washington DC	50	98	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Washington DC	50	99	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Washington DC	100	98	10	2	0	2	5	5	0	0	0	0	0	0	0	0	0	0
Washington DC	100	99	10	1	0	0	2	2	0	0	0	0	0	0	0	0	0	0
Washington DC	150	98	10	57	4	64	111	111	2	0	2	5	5	0	0	0	0	0
Washington DC	150	99	10	31	0	34	69	69	1	0	0	2	2	0	0	0	0	0
Washington DC	200	98	10	168	56	201	271	271	28	0	30	65	65	2	0	2	5	5
Washington DC	200	99	10	124	29	149	221	221	12	0	12	34	34	1	0	0	2	2

Notes:

[1] Scenario: As is – unadjusted air quality, Current Std – air quality that just meets the current annual standard, All others – air quality that just meets 1-hour concentration level given percentile form of alternative standard.

[2] Percentile: 98th or 99th percentile of daily maximum 1-hour concentration averaged over three years at maximum monitor in location.

[3] The mean number of exceedances represents the sum of daily maximum exceedances occurring at all monitors in a particular location divided by the number of site-years across the monitoring period. The min, med, p98, and p99 represent the minimum, median, 98th, and 99th percentiles of the distribution for the number of daily maximum exceedances in any one year within the monitoring period.

Table A-118. Estimated number of exceedances of 1-hour concentration levels (250 and 300 ppb) for monitors >20 m and <100 m from a major road using 2001-2003 air quality *as is* and air quality adjusted to just meet the current and alternative standards.

Location	Standard[1]	Percentile[2]	Site-Years	Number of Daily Maximum Exceedances[3] ≥ 250 ppb Mean	Min	Med	p98	p99	≥ 300 ppb Mean	Min	Med	p98	p99
Boston	As is		14	0	0	0	0	0	0	0	0	0	0
Boston	Current Std		14	0	0	0	0	0	0	0	0	0	0
Boston	50	98	14	0	0	0	0	0	0	0	0	0	0
Boston	50	99	14	0	0	0	0	0	0	0	0	0	0
Boston	100	98	14	0	0	0	0	0	0	0	0	0	0
Boston	100	99	14	0	0	0	0	0	0	0	0	0	0
Boston	150	98	14	0	0	0	0	0	0	0	0	0	0
Boston	150	99	14	0	0	0	0	0	0	0	0	0	0
Boston	200	98	14	0	0	0	2	2	0	0	0	0	0
Boston	200	99	14	0	0	0	0	0	0	0	0	0	0
Chicago	As is		6	0	0	0	0	0	0	0	0	0	0
Chicago	Current Std		6	0	0	0	0	0	0	0	0	0	0
Chicago	50	98	6	0	0	0	0	0	0	0	0	0	0
Chicago	50	99	6	0	0	0	0	0	0	0	0	0	0
Chicago	100	98	6	0	0	0	0	0	0	0	0	0	0
Chicago	100	99	6	0	0	0	0	0	0	0	0	0	0
Chicago	150	98	6	0	0	0	2	2	0	0	0	0	0
Chicago	150	99	6	0	0	0	0	0	0	0	0	0	0
Chicago	200	98	6	1	0	0	5	5	1	0	0	3	3
Chicago	200	99	6	1	0	0	5	5	0	0	0	2	2
El Paso	As is		3	0	0	0	0	0	0	0	0	0	0
El Paso	Current Std		3	2	0	2	5	5	0	0	0	0	0
El Paso	50	98	3	0	0	0	0	0	0	0	0	0	0
El Paso	50	99	3	0	0	0	0	0	0	0	0	0	0
El Paso	100	98	3	0	0	0	0	0	0	0	0	0	0
El Paso	100	99	3	0	0	0	0	0	0	0	0	0	0
El Paso	150	98	3	0	0	0	0	0	0	0	0	0	0
El Paso	150	99	3	0	0	0	0	0	0	0	0	0	0
El Paso	200	98	3	3	0	3	5	5	0	0	0	0	0
El Paso	200	99	3	0	0	0	0	0	0	0	0	0	0
Las Vegas	As is		3	0	0	0	0	0	0	0	0	0	0
Las Vegas	Current Std		3	0	0	0	0	0	0	0	0	0	0
Las Vegas	50	98	3	0	0	0	0	0	0	0	0	0	0
Las Vegas	50	99	3	0	0	0	0	0	0	0	0	0	0
Las Vegas	100	98	3	0	0	0	0	0	0	0	0	0	0
Las Vegas	100	99	3	0	0	0	0	0	0	0	0	0	0
Las Vegas	150	98	3	0	0	0	0	0	0	0	0	0	0
Las Vegas	150	99	3	0	0	0	0	0	0	0	0	0	0
Las Vegas	200	98	3	0	0	0	0	0	0	0	0	0	0
Las Vegas	200	99	3	0	0	0	0	0	0	0	0	0	0
Los Angeles	As is		35	0	0	0	1	1	0	0	0	0	0
Los Angeles	Current		35	0	0	0	1	1	0	0	0	1	1

Location	Standard[1]	Percentile[2]	Site-Years	Number of Daily Maximum Exceedances[3]									
				≥ 250 ppb					≥ 300 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
	Std												
Los Angeles	50	98	35	0	0	0	0	0	0	0	0	0	0
Los Angeles	50	99	35	0	0	0	0	0	0	0	0	0	0
Los Angeles	100	98	35	0	0	0	0	0	0	0	0	0	0
Los Angeles	100	99	35	0	0	0	0	0	0	0	0	0	0
Los Angeles	150	98	35	0	0	0	1	1	0	0	0	1	1
Los Angeles	150	99	35	0	0	0	1	1	0	0	0	0	0
Los Angeles	200	98	35	0	0	0	2	2	0	0	0	1	1
Los Angeles	200	99	35	0	0	0	2	2	0	0	0	1	1
Miami	As is		3	0	0	0	0	0	0	0	0	0	0
Miami	Current Std		3	1	0	1	1	1	0	0	0	1	1
Miami	50	98	3	0	0	0	0	0	0	0	0	0	0
Miami	50	99	3	0	0	0	0	0	0	0	0	0	0
Miami	100	98	3	0	0	0	0	0	0	0	0	0	0
Miami	100	99	3	0	0	0	0	0	0	0	0	0	0
Miami	150	98	3	0	0	0	0	0	0	0	0	0	0
Miami	150	99	3	0	0	0	0	0	0	0	0	0	0
Miami	200	98	3	2	0	1	4	4	0	0	0	1	1
Miami	200	99	3	0	0	0	1	1	0	0	0	0	0
New York	As is		13	0	0	0	0	0	0	0	0	0	0
New York	Current Std		13	0	0	0	0	0	0	0	0	0	0
New York	50	98	13	0	0	0	0	0	0	0	0	0	0
New York	50	99	13	0	0	0	0	0	0	0	0	0	0
New York	100	98	13	0	0	0	0	0	0	0	0	0	0
New York	100	99	13	0	0	0	0	0	0	0	0	0	0
New York	150	98	13	0	0	0	0	0	0	0	0	0	0
New York	150	99	13	0	0	0	0	0	0	0	0	0	0
New York	200	98	13	1	0	0	4	4	0	0	0	2	2
New York	200	99	13	0	0	0	3	3	0	0	0	0	0
Philadelphia	As is		7	0	0	0	0	0	0	0	0	0	0
Philadelphia	Current Std		7	0	0	0	0	0	0	0	0	0	0
Philadelphia	50	98	7	0	0	0	0	0	0	0	0	0	0
Philadelphia	50	99	7	0	0	0	0	0	0	0	0	0	0
Philadelphia	100	98	7	0	0	0	0	0	0	0	0	0	0
Philadelphia	100	99	7	0	0	0	0	0	0	0	0	0	0
Philadelphia	150	98	7	0	0	0	0	0	0	0	0	0	0
Philadelphia	150	99	7	0	0	0	0	0	0	0	0	0	0
Philadelphia	200	98	7	1	0	1	2	2	0	0	0	0	0
Philadelphia	200	99	7	0	0	0	1	1	0	0	0	0	0
Phoenix	As is		2	0	0	0	0	0	0	0	0	0	0
Phoenix	Current Std		2	0	0	0	0	0	0	0	0	0	0
Phoenix	50	98	2	0	0	0	0	0	0	0	0	0	0
Phoenix	50	99	2	0	0	0	0	0	0	0	0	0	0
Phoenix	100	98	2	0	0	0	0	0	0	0	0	0	0
Phoenix	100	99	2	0	0	0	0	0	0	0	0	0	0

Location	Standard[1]	Percentile[2]	Site-Years	Number of Daily Maximum Exceedances[3]									
				≥ 250 ppb					≥ 300 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
Phoenix	150	98	2	0	0	0	0	0	0	0	0	0	0
Phoenix	150	99	2	0	0	0	0	0	0	0	0	0	0
Phoenix	200	98	2	0	0	0	0	0	0	0	0	0	0
Phoenix	200	99	2	0	0	0	0	0	0	0	0	0	0
St. Louis	As is		11	0	0	0	0	0	0	0	0	0	0
St. Louis	Current Std		11	0	0	0	0	0	0	0	0	0	0
St. Louis	50	98	11	0	0	0	0	0	0	0	0	0	0
St. Louis	50	99	11	0	0	0	0	0	0	0	0	0	0
St. Louis	100	98	11	0	0	0	0	0	0	0	0	0	0
St. Louis	100	99	11	0	0	0	0	0	0	0	0	0	0
St. Louis	150	98	11	0	0	0	0	0	0	0	0	0	0
St. Louis	150	99	11	0	0	0	0	0	0	0	0	0	0
St. Louis	200	98	11	0	0	0	1	1	0	0	0	0	0
St. Louis	200	99	11	0	0	0	0	0	0	0	0	0	0
Washington DC	As is		10	0	0	0	0	0	0	0	0	0	0
Washington DC	Current Std		10	0	0	0	0	0	0	0	0	0	0
Washington DC	50	98	10	0	0	0	0	0	0	0	0	0	0
Washington DC	50	99	10	0	0	0	0	0	0	0	0	0	0
Washington DC	100	98	10	0	0	0	0	0	0	0	0	0	0
Washington DC	100	99	10	0	0	0	0	0	0	0	0	0	0
Washington DC	150	98	10	0	0	0	0	0	0	0	0	0	0
Washington DC	150	99	10	0	0	0	0	0	0	0	0	0	0
Washington DC	200	98	10	0	0	0	1	1	0	0	0	0	0
Washington DC	200	99	10	0	0	0	0	0	0	0	0	0	0

Notes:

[1] Scenario: As is – unadjusted air quality, Current Std – air quality that just meets the current annual standard, All others – air quality that just meets 1-hour concentration level given percentile form of alternative standard.

[2] Percentile: 98th or 99th percentile of daily maximum 1-hour concentration averaged over three years at maximum monitor in location.

[3] The mean number of exceedances represents the sum of daily maximum exceedances occurring at all monitors in a particular location divided by the number of site-years across the monitoring period. The min, med, p98, and p99 represent the minimum, median, 98th, and 99th percentiles of the distribution for the number of daily maximum exceedances in any one year within the monitoring period.

Table A-119. Estimated number of exceedances of 1-hour concentration levels (100, 150 and 200 ppb) for monitors ≤ 20 m from a major road using 2001-2003 air quality *as is* and air quality adjusted to just meet the current and alternative standards.

Location	Standard[1]	Percentile[2]	Site-Years	Number of Daily Maximum Exceedances[3]														
				≥ 100 ppb					≥ 150 ppb					≥ 200 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
Boston	As is		5	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
Boston	Current Std		5	19	0	26	38	38	1	0	0	3	3	0	0	0	1	1
Boston	50	98	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Boston	50	99	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Boston	100	98	5	2	0	0	6	6	0	0	0	1	1	0	0	0	0	0
Boston	100	99	5	1	0	0	4	4	0	0	0	0	0	0	0	0	0	0
Boston	150	98	5	29	0	22	91	91	2	0	0	6	6	0	0	0	2	2
Boston	150	99	5	17	0	16	46	46	1	0	0	4	4	0	0	0	1	1
Boston	200	98	5	104	9	60	249	249	15	0	15	39	39	2	0	0	6	6
Boston	200	99	5	72	3	46	196	196	8	0	7	23	23	1	0	0	4	4
Chicago	As is		4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chicago	Current Std		4	21	14	23	26	26	1	0	1	4	4	0	0	0	0	0
Chicago	50	98	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chicago	50	99	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chicago	100	98	4	2	0	1	6	6	0	0	0	0	0	0	0	0	0	0
Chicago	100	99	4	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
Chicago	150	98	4	28	19	30	35	35	2	0	1	6	6	0	0	0	0	0
Chicago	150	99	4	14	7	14	20	20	0	0	0	1	1	0	0	0	0	0
Chicago	200	98	4	119	107	118	132	132	15	9	14	23	23	2	0	1	6	6
Chicago	200	99	4	76	72	76	80	80	7	4	6	13	13	0	0	0	1	1
Cleveland	As is		3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cleveland	Current Std		3	111	103	107	122	122	14	13	15	15	15	1	1	1	2	2
Cleveland	50	98	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cleveland	50	99	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cleveland	100	98	3	7	3	7	10	10	0	0	0	0	0	0	0	0	0	0
Cleveland	100	99	3	4	2	4	7	7	0	0	0	0	0	0	0	0	0	0
Cleveland	150	98	3	79	68	77	92	92	7	3	7	10	10	0	0	0	0	0
Cleveland	150	99	3	57	46	55	69	69	4	2	4	7	7	0	0	0	0	0
Cleveland	200	98	3	187	177	179	204	204	50	40	48	62	62	7	3	7	10	10

Location	Standard[1]	Percentile[2]	Site-Years	Number of Daily Maximum Exceedances[3]														
				≥ 100 ppb					≥ 150 ppb					≥ 200 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
Cleveland	200	99	3	166	161	167	171	171	30	19	28	43	43	4	2	4	7	7
Denver	As is		2	7	3	7	10	10	1	1	1	1	1	0	0	0	0	0
Denver	Current Std		2	48	43	48	53	53	5	3	5	7	7	2	1	2	3	3
Denver	50	98	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Denver	50	99	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Denver	100	98	2	7	3	7	10	10	2	1	2	3	3	0	0	0	0	0
Denver	100	99	2	4	2	4	6	6	0	0	0	0	0	0	0	0	0	0
Denver	150	98	2	68	54	68	81	81	7	3	7	10	10	2	1	2	3	3
Denver	150	99	2	33	24	33	42	42	4	2	4	6	6	2	1	2	3	3
Denver	200	98	2	224	224	224	224	224	33	24	33	42	42	7	3	7	10	10
Denver	200	99	2	157	144	157	170	170	18	11	18	24	24	4	2	4	6	6
Las Vegas	As is		3	1	0	0	2	2	0	0	0	0	0	0	0	0	0	0
Las Vegas	Current Std		3	211	203	212	218	218	22	15	22	28	28	1	0	0	4	4
Las Vegas	50	98	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Las Vegas	50	99	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Las Vegas	100	98	3	7	1	10	11	11	0	0	0	0	0	0	0	0	0	0
Las Vegas	100	99	3	2	0	2	4	4	0	0	0	0	0	0	0	0	0	0
Las Vegas	150	98	3	141	112	142	168	168	7	1	10	11	11	1	0	0	2	2
Las Vegas	150	99	3	85	65	89	102	102	2	0	2	4	4	0	0	0	1	1
Las Vegas	200	98	3	280	261	261	319	319	76	59	78	92	92	7	1	10	11	11
Las Vegas	200	99	3	248	229	236	278	278	46	36	40	63	63	2	0	2	4	4
Los Angeles	As is		9	6	0	6	9	9	0	0	0	0	0	0	0	0	0	0
Los Angeles	Current Std		9	42	25	37	77	77	4	0	2	9	9	0	0	0	1	1
Los Angeles	50	98	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Los Angeles	50	99	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Los Angeles	100	98	9	1	0	0	3	3	0	0	0	0	0	0	0	0	0	0
Los Angeles	100	99	9	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0
Los Angeles	150	98	9	21	7	20	32	32	1	0	0	3	3	0	0	0	0	0
Los Angeles	150	99	9	17	5	18	28	28	0	0	0	2	2	0	0	0	0	0
Los Angeles	200	98	9	72	46	55	118	118	7	3	9	11	11	1	0	0	3	3
Los Angeles	200	99	9	62	35	49	110	110	6	1	6	10	10	0	0	0	2	2
Miami	As is		3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Location	Standard[1]	Percentile[2]	Site-Years	Number of Daily Maximum Exceedances[3]														
				≥ 100 ppb					≥ 150 ppb					≥ 200 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
Miami	Current Std		3	78	56	79	100	100	17	14	15	23	23	1	0	0	2	2
Miami	50	98	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Miami	50	99	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Miami	100	98	3	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0
Miami	100	99	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Miami	150	98	3	28	25	30	30	30	1	0	1	1	1	0	0	0	0	0
Miami	150	99	3	16	13	15	19	19	0	0	0	0	0	0	0	0	0	0
Miami	200	98	3	76	68	79	80	80	16	13	15	19	19	1	0	1	1	1
Miami	200	99	3	53	46	52	61	61	8	5	6	13	13	0	0	0	0	0
New York	As is		7	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0
New York	Current Std		7	18	6	17	52	52	1	0	0	2	2	0	0	0	0	0
New York	50	98	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
New York	50	99	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
New York	100	98	7	1	0	1	2	2	0	0	0	0	0	0	0	0	0	0
New York	100	99	7	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
New York	150	98	7	38	18	42	55	55	1	0	1	2	2	0	0	0	0	0
New York	150	99	7	18	4	17	31	31	0	0	0	1	1	0	0	0	0	0
New York	200	98	7	143	107	141	168	168	18	4	17	31	31	1	0	1	2	2
New York	200	99	7	88	53	96	117	117	7	3	6	12	12	0	0	0	1	1
Phoenix	As is		3	2	1	1	4	4	0	0	0	0	0	0	0	0	0	0
Phoenix	Current Std		3	72	58	67	90	90	2	1	1	4	4	0	0	0	0	0
Phoenix	50	98	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phoenix	50	99	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phoenix	100	98	3	6	4	4	11	11	0	0	0	0	0	0	0	0	0	0
Phoenix	100	99	3	4	2	4	6	6	0	0	0	0	0	0	0	0	0	0
Phoenix	150	98	3	160	135	170	174	174	6	4	4	11	11	0	0	0	1	1
Phoenix	150	99	3	96	79	102	107	107	4	2	4	6	6	0	0	0	0	0
Phoenix	200	98	3	293	266	297	316	316	88	67	97	100	100	6	4	4	11	11
Phoenix	200	99	3	260	236	259	284	284	39	31	40	46	46	4	2	4	6	6
St. Louis	As is		6	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
St. Louis	Current Std		6	56	28	47	112	112	3	0	2	6	6	1	0	1	2	2
St. Louis	50	98	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Location	Standard[1]	Percentile[2]	Site-Years	Number of Daily Maximum Exceedances[3]														
				≥ 100 ppb					≥ 150 ppb					≥ 200 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
St. Louis	50	99	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
St. Louis	100	98	6	3	1	3	6	6	0	0	0	1	1	0	0	0	0	0
St. Louis	100	99	6	1	0	1	4	4	0	0	0	1	1	0	0	0	0	0
St. Louis	150	98	6	46	21	50	68	68	3	1	3	6	6	1	0	1	2	2
St. Louis	150	99	6	26	16	23	40	40	1	0	1	4	4	1	0	1	2	2
St. Louis	200	98	6	175	126	192	209	209	23	15	22	36	36	3	1	3	6	6
St. Louis	200	99	6	136	95	149	169	169	10	6	9	15	15	1	0	1	4	4
Washington DC	As is		4	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
Washington DC	Current Std		4	78	61	81	88	88	7	6	7	8	8	0	0	0	1	1
Washington DC	50	98	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Washington DC	50	99	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Washington DC	100	98	4	6	3	6	9	9	0	0	0	1	1	0	0	0	0	0
Washington DC	100	99	4	2	0	2	4	4	0	0	0	0	0	0	0	0	0	0
Washington DC	150	98	4	73	47	77	92	92	6	3	6	9	9	0	0	0	1	1
Washington DC	150	99	4	43	25	45	55	55	2	0	2	4	4	0	0	0	1	1
Washington DC	200	98	4	209	158	217	243	243	38	22	38	53	53	6	3	6	9	9
Washington DC	200	99	4	154	106	162	184	184	22	15	20	32	32	2	0	2	4	4

Notes:

[1] Scenario: As is – unadjusted air quality, Current Std – air quality that just meets the current annual standard, All others – air quality that just meets 1-hour concentration level given percentile form of alternative standard.

[2] Percentile: 98th or 99th percentile of daily maximum 1-hour concentration averaged over three years at maximum monitor in location.

[3] The mean number of exceedances represents the sum of daily maximum exceedances occurring at all monitors in a particular location divided by the number of site-years across the monitoring period. The min, med, p98, and p99 represent the minimum, median, 98th, and 99th percentiles of the distribution for the number of daily maximum exceedances in any one year within the monitoring period.

Table A-120. Estimated number of exceedances of 1-hour concentration levels (250 and 300 ppb) for monitors ≤ 20 m from a major road using 2001-2003 air quality *as is* and air quality adjusted to just meet the current and alternative standards.

Location	Standard[1]	Percentile[2]	Site-Years	Number of Daily Maximum Exceedances[3] ≥ 250 ppb Mean	Min	Med	p98	p99	≥ 300 ppb Mean	Min	Med	p98	p99
Boston	As is		5	0	0	0	0	0	0	0	0	0	0
Boston	Current Std		5	0	0	0	0	0	0	0	0	0	0
Boston	50	98	5	0	0	0	0	0	0	0	0	0	0
Boston	50	99	5	0	0	0	0	0	0	0	0	0	0
Boston	100	98	5	0	0	0	0	0	0	0	0	0	0
Boston	100	99	5	0	0	0	0	0	0	0	0	0	0
Boston	150	98	5	0	0	0	0	0	0	0	0	0	0
Boston	150	99	5	0	0	0	0	0	0	0	0	0	0
Boston	200	98	5	0	0	0	2	2	0	0	0	1	1
Boston	200	99	5	0	0	0	1	1	0	0	0	0	0
Chicago	As is		4	0	0	0	0	0	0	0	0	0	0
Chicago	Current Std		4	0	0	0	0	0	0	0	0	0	0
Chicago	50	98	4	0	0	0	0	0	0	0	0	0	0
Chicago	50	99	4	0	0	0	0	0	0	0	0	0	0
Chicago	100	98	4	0	0	0	0	0	0	0	0	0	0
Chicago	100	99	4	0	0	0	0	0	0	0	0	0	0
Chicago	150	98	4	0	0	0	0	0	0	0	0	0	0
Chicago	150	99	4	0	0	0	0	0	0	0	0	0	0
Chicago	200	98	4	0	0	0	0	0	0	0	0	0	0
Chicago	200	99	4	0	0	0	0	0	0	0	0	0	0
Cleveland	As is		3	0	0	0	0	0	0	0	0	0	0
Cleveland	Current Std		3	0	0	0	0	0	0	0	0	0	0
Cleveland	50	98	3	0	0	0	0	0	0	0	0	0	0
Cleveland	50	99	3	0	0	0	0	0	0	0	0	0	0
Cleveland	100	98	3	0	0	0	0	0	0	0	0	0	0
Cleveland	100	99	3	0	0	0	0	0	0	0	0	0	0
Cleveland	150	98	3	0	0	0	0	0	0	0	0	0	0
Cleveland	150	99	3	0	0	0	0	0	0	0	0	0	0
Cleveland	200	98	3	1	1	1	2	2	0	0	0	0	0
Cleveland	200	99	3	0	0	0	0	0	0	0	0	0	0
Denver	As is		2	0	0	0	0	0	0	0	0	0	0
Denver	Current Std		2	0	0	0	0	0	0	0	0	0	0
Denver	50	98	2	0	0	0	0	0	0	0	0	0	0
Denver	50	99	2	0	0	0	0	0	0	0	0	0	0
Denver	100	98	2	0	0	0	0	0	0	0	0	0	0
Denver	100	99	2	0	0	0	0	0	0	0	0	0	0
Denver	150	98	2	0	0	0	0	0	0	0	0	0	0
Denver	150	99	2	0	0	0	0	0	0	0	0	0	0
Denver	200	98	2	3	1	3	4	4	2	1	2	3	3
Denver	200	99	2	2	1	2	3	3	0	0	0	0	0
Las Vegas	As is		3	0	0	0	0	0	0	0	0	0	0

Location	Standard[1]	Percentile[2]	Site-Years	Number of Daily Maximum Exceedances[3]									
				≥ 250 ppb					≥ 300 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
Las Vegas	Current Std		3	1	0	0	2	2	0	0	0	0	0
Las Vegas	50	98	3	0	0	0	0	0	0	0	0	0	0
Las Vegas	50	99	3	0	0	0	0	0	0	0	0	0	0
Las Vegas	100	98	3	0	0	0	0	0	0	0	0	0	0
Las Vegas	100	99	3	0	0	0	0	0	0	0	0	0	0
Las Vegas	150	98	3	0	0	0	0	0	0	0	0	0	0
Las Vegas	150	99	3	0	0	0	0	0	0	0	0	0	0
Las Vegas	200	98	3	1	0	0	2	2	0	0	0	0	0
Las Vegas	200	99	3	1	0	0	2	2	0	0	0	0	0
Los Angeles	As is		9	0	0	0	0	0	0	0	0	0	0
Los Angeles	Current Std		9	0	0	0	0	0	0	0	0	0	0
Los Angeles	50	98	9	0	0	0	0	0	0	0	0	0	0
Los Angeles	50	99	9	0	0	0	0	0	0	0	0	0	0
Los Angeles	100	98	9	0	0	0	0	0	0	0	0	0	0
Los Angeles	100	99	9	0	0	0	0	0	0	0	0	0	0
Los Angeles	150	98	9	0	0	0	0	0	0	0	0	0	0
Los Angeles	150	99	9	0	0	0	0	0	0	0	0	0	0
Los Angeles	200	98	9	0	0	0	0	0	0	0	0	0	0
Los Angeles	200	99	9	0	0	0	0	0	0	0	0	0	0
Miami	As is		3	0	0	0	0	0	0	0	0	0	0
Miami	Current Std		3	0	0	0	0	0	0	0	0	0	0
Miami	50	98	3	0	0	0	0	0	0	0	0	0	0
Miami	50	99	3	0	0	0	0	0	0	0	0	0	0
Miami	100	98	3	0	0	0	0	0	0	0	0	0	0
Miami	100	99	3	0	0	0	0	0	0	0	0	0	0
Miami	150	98	3	0	0	0	0	0	0	0	0	0	0
Miami	150	99	3	0	0	0	0	0	0	0	0	0	0
Miami	200	98	3	0	0	0	0	0	0	0	0	0	0
Miami	200	99	3	0	0	0	0	0	0	0	0	0	0
New York	As is		7	0	0	0	0	0	0	0	0	0	0
New York	Current Std		7	0	0	0	0	0	0	0	0	0	0
New York	50	98	7	0	0	0	0	0	0	0	0	0	0
New York	50	99	7	0	0	0	0	0	0	0	0	0	0
New York	100	98	7	0	0	0	0	0	0	0	0	0	0
New York	100	99	7	0	0	0	0	0	0	0	0	0	0
New York	150	98	7	0	0	0	0	0	0	0	0	0	0
New York	150	99	7	0	0	0	0	0	0	0	0	0	0
New York	200	98	7	0	0	0	0	0	0	0	0	0	0
New York	200	99	7	0	0	0	0	0	0	0	0	0	0
Phoenix	As is		3	0	0	0	0	0	0	0	0	0	0
Phoenix	Current Std		3	0	0	0	0	0	0	0	0	0	0
Phoenix	50	98	3	0	0	0	0	0	0	0	0	0	0
Phoenix	50	99	3	0	0	0	0	0	0	0	0	0	0
Phoenix	100	98	3	0	0	0	0	0	0	0	0	0	0

				Number of Daily Maximum Exceedances[3]									
				≥ 250 ppb					≥ 300 ppb				
Location	Standard[1]	Percentile[2]	Site-Years	Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
Phoenix	100	99	3	0	0	0	0	0	0	0	0	0	0
Phoenix	150	98	3	0	0	0	0	0	0	0	0	0	0
Phoenix	150	99	3	0	0	0	0	0	0	0	0	0	0
Phoenix	200	98	3	0	0	0	1	1	0	0	0	0	0
Phoenix	200	99	3	0	0	0	0	0	0	0	0	0	0
St. Louis	As is		6	0	0	0	0	0	0	0	0	0	0
St. Louis	Current Std		6	0	0	0	1	1	0	0	0	1	1
St. Louis	50	98	6	0	0	0	0	0	0	0	0	0	0
St. Louis	50	99	6	0	0	0	0	0	0	0	0	0	0
St. Louis	100	98	6	0	0	0	0	0	0	0	0	0	0
St. Louis	100	99	6	0	0	0	0	0	0	0	0	0	0
St. Louis	150	98	6	0	0	0	1	1	0	0	0	0	0
St. Louis	150	99	6	0	0	0	1	1	0	0	0	0	0
St. Louis	200	98	6	1	0	1	2	2	0	0	0	1	1
St. Louis	200	99	6	1	0	1	2	2	0	0	0	1	1
Washington DC	As is		4	0	0	0	0	0	0	0	0	0	0
Washington DC	Current Std		4	0	0	0	0	0	0	0	0	0	0
Washington DC	50	98	4	0	0	0	0	0	0	0	0	0	0
Washington DC	50	99	4	0	0	0	0	0	0	0	0	0	0
Washington DC	100	98	4	0	0	0	0	0	0	0	0	0	0
Washington DC	100	99	4	0	0	0	0	0	0	0	0	0	0
Washington DC	150	98	4	0	0	0	0	0	0	0	0	0	0
Washington DC	150	99	4	0	0	0	0	0	0	0	0	0	0
Washington DC	200	98	4	1	0	0	2	2	0	0	0	1	1
Washington DC	200	99	4	0	0	0	1	1	0	0	0	0	0

Notes:

[1] Scenario: As is – unadjusted air quality, Current Std – air quality that just meets the current annual standard, All others – air quality that just meets 1-hour concentration level given percentile form of alternative standard.

[2] Percentile: 98th or 99th percentile of daily maximum 1-hour concentration averaged over three years at maximum monitor in location.

[3] The mean number of exceedances represents the sum of daily maximum exceedances occurring at all monitors in a particular location divided by the number of site-years across the monitoring period. The min, med, p98, and p99 represent the minimum, median, 98th, and 99th percentiles of the distribution for the number of daily maximum exceedances in any one year within the monitoring period.

Table A-121. Estimated number of exceedances of 1-hour concentration levels (100, 150, and 200 ppb) on-roads using 2001-2003 air quality *as is* and air quality adjusted to just meet the current and alternative standards and an on-road adjustment factor.

Location	Standard[1]	Percentile[2]	Site-Years	Number of Daily Maximum Exceedances[3]														
				≥ 100 ppb					≥ 150 ppb					≥ 200 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
Atlanta	As is		1400	23	0	5	130	169	4	0	0	36	51	1	0	0	8	13
Atlanta	Current Std		1400	183	12	228	341	348	110	1	103	290	299	58	0	29	228	238
Atlanta	50	98	1400	2	0	0	26	38	0	0	0	4	5	0	0	0	1	1
Atlanta	50	99	1400	2	0	0	20	25	0	0	0	1	3	0	0	0	0	1
Atlanta	100	98	1400	46	0	22	190	229	10	0	1	70	104	2	0	0	26	38
Atlanta	100	99	1400	36	0	13	166	203	7	0	0	53	76	2	0	0	20	25
Atlanta	150	98	1400	117	0	123	295	312	46	0	22	190	229	17	0	3	106	146
Atlanta	150	99	1400	102	0	96	282	298	36	0	13	166	203	12	0	1	79	113
Atlanta	200	98	1400	170	5	202	339	344	95	0	83	273	289	46	0	22	190	229
Atlanta	200	99	1400	156	2	178	331	340	80	0	62	254	275	36	0	13	166	203
Boston	As is		600	5	0	1	36	40	0	0	0	3	5	0	0	0	1	1
Boston	Current Std		600	86	1	83	209	227	20	0	7	96	105	4	0	1	31	41
Boston	50	98	600	0	0	0	3	6	0	0	0	0	0	0	0	0	0	0
Boston	50	99	600	0	0	0	3	3	0	0	0	0	0	0	0	0	0	0
Boston	100	98	600	26	0	13	125	131	3	0	0	22	25	0	0	0	3	6
Boston	100	99	600	16	0	4	89	99	1	0	0	13	18	0	0	0	3	3
Boston	150	98	600	95	3	87	219	248	26	0	13	125	131	6	0	1	40	44
Boston	150	99	600	76	0	67	200	220	16	0	4	89	99	3	0	0	22	25
Boston	200	98	600	163	27	166	283	293	72	0	60	196	220	26	0	13	125	131
Boston	200	99	600	139	15	141	263	279	53	0	38	180	188	16	0	4	89	99
Chicago	As is		900	52	0	35	180	191	9	0	2	62	68	2	0	0	24	29
Chicago	Current Std		900	193	24	192	328	332	74	1	56	235	250	26	0	13	123	135
Chicago	50	98	900	4	0	0	43	49	0	0	0	4	7	0	0	0	0	0
Chicago	50	99	900	2	0	0	31	34	0	0	0	1	3	0	0	0	0	0
Chicago	100	98	900	83	2	68	238	257	18	0	7	92	106	4	0	0	43	49
Chicago	100	99	900	56	0	40	188	197	10	0	2	65	74	2	0	0	31	34
Chicago	150	98	900	205	45	207	331	336	83	2	68	238	257	29	0	16	126	142
Chicago	150	99	900	167	18	161	316	321	56	0	40	188	197	18	0	7	90	104
Chicago	200	98	900	281	129	285	354	356	168	18	163	316	322	83	2	68	238	257

Location	Standard[1]	Percentile[2]	Site-Years	Number of Daily Maximum Exceedances[3]														
				≥ 100 ppb					≥ 150 ppb					≥ 200 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
Chicago	200	99	900	253	91	257	344	350	130	9	118	291	301	56	0	40	188	197
Cleveland	As is		300	31	0	21	83	102	5	0	1	30	30	1	0	0	10	10
Cleveland	Current Std		300	264	154	277	332	335	134	31	134	241	264	58	8	51	137	154
Cleveland	50	98	300	7	0	2	37	38	1	0	0	7	8	0	0	0	2	2
Cleveland	50	99	300	5	0	1	30	30	0	0	0	3	3	0	0	0	1	1
Cleveland	100	98	300	104	19	98	209	225	24	0	15	73	86	7	0	2	37	38
Cleveland	100	99	300	84	12	80	179	192	19	0	10	62	70	5	0	1	30	30
Cleveland	150	98	300	235	114	240	320	324	104	19	98	209	225	40	2	32	107	116
Cleveland	150	99	300	212	84	214	307	313	84	12	80	179	192	30	0	21	82	98
Cleveland	200	98	300	305	220	314	348	348	196	66	198	298	304	104	19	98	209	225
Cleveland	200	99	300	291	181	301	342	344	174	50	173	283	295	84	12	80	179	192
Denver	As is		200	89	8	74	242	259	17	0	5	80	94	3	0	1	25	26
Denver	Current Std		200	267	137	286	315	316	157	8	162	282	284	76	0	79	227	238
Denver	50	98	200	4	0	1	36	37	0	0	0	1	1	0	0	0	1	1
Denver	50	99	200	2	0	1	14	15	0	0	0	1	1	0	0	0	1	1
Denver	100	98	200	99	8	82	252	269	19	0	6	86	103	4	0	1	36	37
Denver	100	99	200	66	4	52	209	221	11	0	3	66	73	2	0	1	14	15
Denver	150	98	200	232	90	238	317	318	99	8	82	252	269	33	0	18	130	135
Denver	150	99	200	197	55	192	311	312	66	4	52	209	221	19	0	6	86	103
Denver	200	98	200	288	209	288	325	326	198	55	192	313	315	99	8	82	252	269
Denver	200	99	200	270	158	276	323	323	157	29	143	293	303	66	4	52	209	221
Detroit	As is		600	41	1	30	130	141	9	0	5	44	46	3	0	2	16	18
Detroit	Current Std		600	282	181	285	345	349	166	52	167	299	307	77	6	63	210	219
Detroit	50	98	600	5	0	3	26	28	1	0	1	7	7	1	0	0	5	6
Detroit	50	99	600	1	0	1	7	7	1	0	0	4	5	0	0	0	4	4
Detroit	100	98	600	59	4	46	170	186	13	1	8	56	57	5	0	3	26	28
Detroit	100	99	600	14	1	8	57	59	3	0	2	16	18	1	0	1	7	7
Detroit	150	98	600	178	52	183	301	308	59	4	46	170	186	20	1	13	70	84
Detroit	150	99	600	62	6	50	176	191	14	1	8	57	59	5	0	3	26	28
Detroit	200	98	600	265	131	271	334	343	140	31	131	278	286	59	4	46	170	186
Detroit	200	99	600	143	35	134	284	287	41	1	30	125	137	14	1	8	57	59

Location	Standard[1]	Percentile[2]	Site-Years	Number of Daily Maximum Exceedances[3]														
				≥ 100 ppb					≥ 150 ppb					≥ 200 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
El Paso	As is		1200	32	0	19	136	145	4	0	1	24	26	0	0	0	5	6
El Paso	Current Std		1200	272	122	284	339	348	168	13	168	291	301	79	2	69	224	236
El Paso	50	98	1200	3	0	0	23	24	0	0	0	3	3	0	0	0	0	1
El Paso	50	99	1200	1	0	0	10	12	0	0	0	1	1	0	0	0	0	0
El Paso	100	98	1200	89	4	79	231	249	17	0	8	80	91	3	0	0	23	24
El Paso	100	99	1200	56	1	42	190	201	8	0	3	46	49	1	0	0	10	12
El Paso	150	98	1200	216	47	222	313	327	89	4	79	231	249	30	0	17	127	136
El Paso	150	99	1200	174	15	176	297	306	56	1	42	190	201	15	0	7	76	83
El Paso	200	98	1200	278	135	288	342	348	180	15	180	298	313	89	4	79	231	249
El Paso	200	99	1200	255	97	265	334	342	136	10	133	274	288	56	1	42	190	201
Jacksonville	As is		200	13	0	7	55	56	1	0	1	6	7	1	0	1	1	1
Jacksonville	Current Std		200	290	227	278	338	340	205	103	206	307	310	123	26	122	217	240
Jacksonville	50	98	200	7	0	4	34	34	1	0	1	3	3	1	0	1	1	1
Jacksonville	50	99	200	5	0	3	25	25	1	0	1	2	2	1	0	1	1	1
Jacksonville	100	98	200	119	26	118	217	235	32	2	25	97	114	7	0	4	34	34
Jacksonville	100	99	200	100	19	98	201	212	23	1	18	79	86	5	0	3	25	25
Jacksonville	150	98	200	233	135	232	323	325	119	26	118	217	235	51	3	44	127	147
Jacksonville	150	99	200	214	111	212	314	317	100	19	98	201	212	39	2	31	115	128
Jacksonville	200	98	200	289	227	278	338	340	201	96	201	306	310	119	26	118	217	235
Jacksonville	200	99	200	279	200	273	336	337	182	81	182	290	297	100	19	98	201	212
Las Vegas	As is		1600	23	0	4	171	194	4	0	0	54	62	0	0	0	8	9
Las Vegas	Current Std		1600	189	2	194	335	338	106	0	71	309	316	49	0	18	250	278
Las Vegas	50	98	1600	5	0	0	63	71	0	0	0	6	7	0	0	0	0	0
Las Vegas	50	99	1600	3	0	0	49	58	0	0	0	2	3	0	0	0	0	0
Las Vegas	100	98	1600	82	0	43	298	307	19	0	3	149	172	5	0	0	63	71
Las Vegas	100	99	1600	64	0	27	276	292	13	0	1	102	120	3	0	0	49	58
Las Vegas	150	98	1600	167	0	161	330	333	82	0	43	298	307	32	0	8	199	230
Las Vegas	150	99	1600	148	0	127	325	329	64	0	27	276	292	21	0	3	158	182
Las Vegas	200	98	1600	218	5	237	343	344	143	0	118	324	328	82	0	43	298	307
Las Vegas	200	99	1600	201	3	212	337	339	123	0	89	318	321	64	0	27	276	292
Los Angeles	As is		5100	71	0	57	231	251	17	0	6	94	108	5	0	0	41	48

Location	Standard[1]	Percentile[2]	Site-Years	Number of Daily Maximum Exceedances[3]														
				≥ 100 ppb					≥ 150 ppb					≥ 200 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
Los Angeles	Current Std		5100	152	0	152	319	330	55	0	40	196	225	19	0	8	101	117
Los Angeles	50	98	5100	1	0	0	15	20	0	0	0	1	3	0	0	0	0	0
Los Angeles	50	99	5100	1	0	0	13	17	0	0	0	0	2	0	0	0	0	0
Los Angeles	100	98	5100	33	0	19	142	160	6	0	1	46	55	1	0	0	15	20
Los Angeles	100	99	5100	29	0	16	132	148	5	0	0	42	49	1	0	0	13	17
Los Angeles	150	98	5100	111	0	101	280	299	33	0	19	142	160	10	0	2	66	77
Los Angeles	150	99	5100	100	0	89	266	288	29	0	16	132	148	8	0	1	58	68
Los Angeles	200	98	5100	191	0	204	338	346	81	0	69	246	262	33	0	19	142	160
Los Angeles	200	99	5100	181	0	189	334	344	73	0	59	236	254	29	0	16	132	148
Miami	As is		600	7	0	2	50	64	1	0	0	6	10	0	0	0	1	2
Miami	Current Std		600	232	147	233	316	323	146	25	147	243	253	78	3	74	191	200
Miami	50	98	600	5	0	1	37	48	0	0	0	5	7	0	0	0	0	1
Miami	50	99	600	3	0	0	21	31	0	0	0	2	3	0	0	0	0	0
Miami	100	98	600	78	2	74	181	189	19	0	10	92	110	5	0	1	37	48
Miami	100	99	600	53	0	48	151	173	11	0	4	67	84	3	0	0	21	31
Miami	150	98	600	174	44	178	267	276	78	2	74	181	189	31	0	21	114	141
Miami	150	99	600	144	21	150	237	245	53	0	48	151	173	18	0	9	89	104
Miami	200	98	600	232	139	228	317	322	145	21	150	242	253	78	2	74	181	189
Miami	200	99	600	208	84	202	299	307	114	9	115	210	225	53	0	48	151	173
New York	As is		2600	42	0	28	177	201	7	0	1	55	63	2	0	0	24	24
New York	Current Std		2600	129	0	124	298	310	36	0	22	157	196	10	0	2	71	82
New York	50	98	2600	3	0	0	33	34	0	0	0	3	4	0	0	0	0	0
New York	50	99	2600	1	0	0	19	22	0	0	0	1	2	0	0	0	0	0
New York	100	98	2600	57	0	43	212	226	10	0	3	67	73	3	0	0	33	34
New York	100	99	2600	35	0	22	156	179	6	0	1	48	56	1	0	0	19	22
New York	150	98	2600	169	5	170	316	324	57	0	43	212	226	17	0	8	89	110
New York	150	99	2600	129	0	119	294	307	35	0	22	156	179	10	0	2	67	72
New York	200	98	2600	249	40	266	344	351	132	0	125	294	307	57	0	43	212	226
New York	200	99	2600	216	20	229	332	340	94	0	80	263	279	35	0	22	156	179
Philadelphia	As is		1400	37	0	19	149	172	6	0	1	49	62	1	0	0	11	24
Philadelphia	Current Std		1400	222	29	231	339	347	87	0	71	250	280	29	0	15	127	150

Location	Standard[1]	Percentile[2]	Site-Years	Number of Daily Maximum Exceedances[3]														
				≥ 100 ppb					≥ 150 ppb					≥ 200 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
Philadelphia	50	98	1400	7	0	1	54	68	1	0	0	8	20	0	0	0	1	1
Philadelphia	50	99	1400	4	0	1	41	56	0	0	0	4	10	0	0	0	1	1
Philadelphia	100	98	1400	116	1	102	284	294	27	0	12	118	137	7	0	1	54	68
Philadelphia	100	99	1400	91	0	75	256	275	18	0	5	93	105	4	0	1	41	56
Philadelphia	150	98	1400	254	65	261	346	350	116	1	102	284	294	44	0	27	169	196
Philadelphia	150	99	1400	228	42	235	335	347	91	0	75	256	275	31	0	15	132	155
Philadelphia	200	98	1400	312	192	317	364	364	217	31	223	332	342	116	1	102	284	294
Philadelphia	200	99	1400	299	152	304	359	359	187	21	191	325	332	91	0	75	256	275
Phoenix	As is		500	101	1	83	280	315	16	0	2	113	124	2	0	0	17	20
Phoenix	Current Std		500	245	23	266	345	352	96	1	77	286	299	29	0	8	174	191
Phoenix	50	98	500	6	0	0	44	48	0	0	0	2	3	0	0	0	0	0
Phoenix	50	99	500	3	0	0	19	24	0	0	0	1	1	0	0	0	0	0
Phoenix	100	98	500	153	2	152	319	337	35	0	14	182	206	6	0	0	44	48
Phoenix	100	99	500	118	1	103	290	323	22	0	4	135	156	3	0	0	19	24
Phoenix	150	98	500	293	92	297	356	360	153	2	152	319	337	58	0	37	230	254
Phoenix	150	99	500	269	48	283	351	356	118	1	103	290	323	40	0	19	195	218
Phoenix	200	98	500	332	245	345	362	363	262	41	278	350	354	153	2	152	319	337
Phoenix	200	99	500	325	199	334	361	362	231	22	250	343	349	118	1	103	290	323
Provo	As is		300	61	1	38	248	289	9	0	0	62	64	1	0	0	11	11
Provo	Current Std		300	338	293	347	363	364	235	55	258	351	355	100	4	77	297	327
Provo	50	98	300	18	0	4	86	106	2	0	0	18	18	0	0	0	2	2
Provo	50	99	300	13	0	2	75	82	1	0	0	9	9	0	0	0	0	0
Provo	100	98	300	257	60	277	353	358	75	1	51	273	301	18	0	4	86	106
Provo	100	99	300	229	38	248	352	355	56	1	33	235	283	13	0	2	75	82
Provo	150	98	300	343	289	352	364	364	257	60	277	353	358	121	4	97	318	342
Provo	150	99	300	337	264	347	363	364	229	38	248	352	355	93	2	71	300	327
Provo	200	98	300	351	321	362	365	365	331	236	342	363	364	257	60	277	353	358
Provo	200	99	300	350	320	360	365	365	322	204	329	362	363	229	38	248	352	355
St. Louis	As is		900	25	0	12	128	139	3	0	0	28	37	0	0	0	5	6
St. Louis	Current Std		900	262	112	268	346	350	131	4	124	276	295	51	0	37	200	207
St. Louis	50	98	900	7	0	1	45	51	1	0	0	7	10	0	0	0	1	1

Location	Standard[1]	Percentile[2]	Site-Years	Number of Daily Maximum Exceedances[3]														
				≥ 100 ppb					≥ 150 ppb					≥ 200 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
St. Louis	50	99	900	4	0	0	35	41	0	0	0	4	4	0	0	0	1	1
St. Louis	100	98	900	125	2	118	274	288	28	0	15	144	153	7	0	1	45	51
St. Louis	100	99	900	96	1	85	256	263	19	0	6	105	114	4	0	0	35	41
St. Louis	150	98	900	258	92	262	345	351	125	2	118	274	288	47	0	32	189	204
St. Louis	150	99	900	233	63	237	335	347	96	1	85	256	263	33	0	18	156	166
St. Louis	200	98	900	316	211	322	358	361	224	52	229	329	341	125	2	118	274	288
St. Louis	200	99	900	301	166	306	356	357	195	30	197	315	329	96	1	85	256	263
Washington DC	As is		1800	36	0	17	169	205	6	0	0	46	54	1	0	0	9	14
Washington DC	Current Std		1800	222	6	268	348	353	111	0	100	293	312	46	0	25	199	230
Washington DC	50	98	1800	7	0	0	56	63	0	0	0	6	8	0	0	0	0	0
Washington DC	50	99	1800	5	0	0	38	45	0	0	0	2	2	0	0	0	0	0
Washington DC	100	98	1800	109	0	99	287	310	27	0	10	139	168	7	0	0	56	63
Washington DC	100	99	1800	83	0	65	260	291	18	0	4	102	123	5	0	0	38	45
Washington DC	150	98	1800	221	4	269	347	352	109	0	99	287	310	44	0	23	186	225
Washington DC	150	99	1800	194	1	227	339	344	83	0	65	260	291	29	0	12	146	176
Washington DC	200	98	1800	279	38	325	360	362	190	1	221	336	343	109	0	99	287	310
Washington DC	200	99	1800	262	20	313	357	360	161	0	176	326	334	83	0	65	260	291
Other MSA	As is		61200	16	0	3	105	129	2	0	0	22	32	0	0	0	4	7
Other MSA	Current Std		61200	133	0	129	320	336	47	0	25	208	239	15	0	3	102	124
Other MSA	50	98	61200	0	0	0	5	8	0	0	0	0	1	0	0	0	0	0
Other MSA	50	99	61200	0	0	0	2	3	0	0	0	0	0	0	0	0	0	0
Other MSA	100	98	61200	17	0	4	110	133	2	0	0	23	34	0	0	0	5	8
Other MSA	100	99	61200	8	0	1	68	85	1	0	0	11	17	0	0	0	2	3
Other MSA	150	98	61200	73	0	52	258	287	17	0	4	110	133	4	0	0	40	53
Other MSA	150	99	61200	47	0	25	208	238	8	0	1	68	85	2	0	0	20	30
Other MSA	200	98	61200	138	0	136	324	338	51	0	29	216	247	17	0	4	110	133
Other MSA	200	99	61200	104	0	91	298	320	30	0	12	161	191	8	0	1	68	85
Other Not MSA	As is		12700	4	0	0	43	62	1	0	0	9	15	0	0	0	2	5
Other Not MSA	Current Std		12700	126	0	104	333	343	63	0	26	255	282	28	0	6	172	200
Other Not MSA	50	98	12700	0	0	0	4	8	0	0	0	1	1	0	0	0	0	1
Other Not MSA	50	99	12700	0	0	0	2	4	0	0	0	1	1	0	0	0	0	0

Location	Standard[1]	Percentile[2]	Site-Years	Number of Daily Maximum Exceedances[3]														
				≥ 100 ppb					≥ 150 ppb					≥ 200 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
Other Not MSA	100	98	12700	6	0	0	64	86	1	0	0	12	17	0	0	0	4	8
Other Not MSA	100	99	12700	3	0	0	33	44	0	0	0	6	13	0	0	0	2	4
Other Not MSA	150	98	12700	28	0	6	172	199	6	0	0	64	86	2	0	0	19	27
Other Not MSA	150	99	12700	16	0	2	127	149	3	0	0	33	44	1	0	0	11	16
Other Not MSA	200	98	12700	63	0	26	254	280	19	0	3	139	164	6	0	0	64	86
Other Not MSA	200	99	12700	42	0	12	207	235	10	0	1	92	118	3	0	0	33	44
Atlanta	As is		1500	17	0	2	114	120	2	0	0	26	27	0	0	0	6	7
Atlanta	Current Std		1500	193	4	259	337	341	126	0	148	285	300	72	0	57	225	237
Atlanta	50	98	1500	3	0	0	29	31	0	0	0	4	5	0	0	0	0	0
Atlanta	50	99	1500	2	0	0	21	23	0	0	0	1	2	0	0	0	0	0
Atlanta	100	98	1500	58	0	39	206	218	13	0	1	93	100	3	0	0	29	31
Atlanta	100	99	1500	45	0	21	185	198	8	0	0	64	75	2	0	0	21	23
Atlanta	150	98	1500	133	0	162	295	304	58	0	39	206	218	22	0	3	126	141
Atlanta	150	99	1500	116	0	131	276	288	45	0	21	185	198	15	0	1	103	110
Atlanta	200	98	1500	181	3	241	328	334	111	0	123	266	281	58	0	39	206	218
Atlanta	200	99	1500	167	1	219	319	326	94	0	91	249	262	45	0	21	185	198
Boston	As is		800	2	0	0	18	21	0	0	0	1	1	0	0	0	0	0
Boston	Current Std		800	95	4	91	207	221	25	0	15	104	109	6	0	1	44	50
Boston	50	98	800	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0
Boston	50	99	800	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Boston	100	98	800	19	0	8	92	99	1	0	0	12	13	0	0	0	1	2
Boston	100	99	800	8	0	2	54	65	0	0	0	3	5	0	0	0	0	1
Boston	150	98	800	84	4	78	189	207	19	0	8	92	99	3	0	0	26	33
Boston	150	99	800	52	1	42	150	162	8	0	2	54	65	1	0	0	10	12
Boston	200	98	800	153	32	151	249	267	59	1	50	161	174	19	0	8	92	99
Boston	200	99	800	114	14	111	215	238	34	0	24	119	129	8	0	2	54	65
Chicago	As is		800	36	0	20	148	161	5	0	0	41	53	1	0	0	7	18
Chicago	Current Std		800	189	25	187	329	339	69	0	54	225	241	22	0	8	117	126
Chicago	50	98	800	2	0	0	24	30	0	0	0	0	0	0	0	0	0	0
Chicago	50	99	800	1	0	0	15	24	0	0	0	0	0	0	0	0	0	0
Chicago	100	98	800	59	0	43	201	220	10	0	2	63	78	2	0	0	24	30

Location	Standard[1]	Percentile[2]	Site-Years	Number of Daily Maximum Exceedances[3]														
				≥ 100 ppb					≥ 150 ppb					≥ 200 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
Chicago	100	99	800	47	0	31	181	193	8	0	1	54	67	1	0	0	15	24
Chicago	150	98	800	176	20	169	320	329	59	0	43	201	220	18	0	6	98	109
Chicago	150	99	800	157	14	148	313	320	47	0	31	181	193	14	0	4	80	93
Chicago	200	98	800	259	94	261	352	355	138	9	127	302	309	59	0	43	201	220
Chicago	200	99	800	244	64	248	348	353	119	7	108	291	296	47	0	31	181	193
Denver	As is		300	63	2	49	190	195	10	0	4	47	52	2	0	0	11	14
Denver	Current Std		300	257	135	259	314	320	134	12	133	260	264	52	0	41	164	174
Denver	50	98	300	9	0	2	41	45	1	0	0	5	9	0	0	0	0	0
Denver	50	99	300	5	0	1	23	25	0	0	0	2	3	0	0	0	0	0
Denver	100	98	300	148	20	151	263	269	38	0	23	132	150	9	0	2	41	45
Denver	100	99	300	106	10	100	236	242	23	0	11	87	95	5	0	1	23	25
Denver	150	98	300	263	170	264	315	321	148	20	151	263	269	61	1	48	180	192
Denver	150	99	300	239	114	243	309	313	106	10	100	236	242	38	0	23	132	150
Denver	200	98	300	296	241	308	330	332	239	122	243	309	313	148	20	151	263	269
Denver	200	99	300	286	217	287	323	327	204	66	209	294	299	106	10	100	236	242
Detroit	As is		600	20	0	9	90	103	2	0	0	20	24	0	0	0	3	6
Detroit	Current Std		600	287	166	286	350	352	189	35	193	300	315	95	3	86	222	258
Detroit	50	98	600	13	0	4	57	66	1	0	0	12	18	0	0	0	1	1
Detroit	50	99	600	10	0	2	52	53	1	0	0	9	14	0	0	0	0	1
Detroit	100	98	600	165	29	166	293	296	50	0	37	165	180	13	0	4	57	66
Detroit	100	99	600	146	18	143	275	284	40	0	27	146	163	10	0	2	52	53
Detroit	150	98	600	273	163	271	341	346	165	29	166	293	296	77	1	66	203	221
Detroit	150	99	600	261	141	260	337	342	146	18	143	275	284	62	0	50	186	204
Detroit	200	98	600	313	237	318	355	359	249	117	251	331	337	165	29	166	293	296
Detroit	200	99	600	307	234	309	354	357	235	90	237	327	332	146	18	143	275	284
El Paso	As is		1200	24	0	12	114	143	3	0	0	20	23	0	0	0	4	4
El Paso	Current Std		1200	281	137	285	349	354	198	22	205	309	320	109	3	102	255	265
El Paso	50	98	1200	5	0	1	32	37	0	0	0	4	4	0	0	0	0	1
El Paso	50	99	1200	3	0	0	20	23	0	0	0	2	2	0	0	0	0	0
El Paso	100	98	1200	108	3	102	254	263	23	0	11	113	137	5	0	1	32	37
El Paso	100	99	1200	75	2	62	225	234	13	0	5	72	86	3	0	0	20	23

Location	Standard[1]	Percentile[2]	Site-Years	Number of Daily Maximum Exceedances[3]														
				≥ 100 ppb					≥ 150 ppb					≥ 200 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
El Paso	150	98	1200	229	63	235	323	327	108	3	102	254	263	39	0	23	164	178
El Paso	150	99	1200	199	26	205	309	317	75	2	62	225	234	23	0	12	113	137
El Paso	200	98	1200	281	137	286	349	353	197	26	205	308	317	108	3	102	254	263
El Paso	200	99	1200	264	97	271	340	346	162	12	166	289	296	75	2	62	225	234
Jacksonville	As is		200	11	0	5	48	59	2	0	2	5	6	1	0	1	4	4
Jacksonville	Current Std		200	295	229	295	341	342	216	114	223	309	318	134	31	133	260	279
Jacksonville	50	98	200	9	0	5	39	50	2	0	2	5	5	1	0	1	4	4
Jacksonville	50	99	200	2	0	2	5	5	1	0	1	4	4	0	0	0	3	3
Jacksonville	100	98	200	127	30	124	256	269	35	0	23	138	151	9	0	5	39	50
Jacksonville	100	99	200	39	1	27	145	158	6	0	4	25	29	2	0	2	5	5
Jacksonville	150	98	200	241	145	243	320	327	127	30	124	256	269	55	1	42	169	193
Jacksonville	150	99	200	135	33	131	265	279	39	1	27	145	158	10	0	5	47	59
Jacksonville	200	98	200	293	229	294	339	340	211	104	214	302	312	127	30	124	256	269
Jacksonville	200	99	200	218	118	223	309	318	102	12	95	232	253	39	1	27	145	158
Las Vegas	As is		1100	15	0	0	133	148	2	0	0	54	64	0	0	0	6	8
Las Vegas	Current Std		1100	177	2	171	343	346	99	0	55	317	324	50	0	11	260	275
Las Vegas	50	98	1100	6	0	0	77	79	1	0	0	17	19	0	0	0	0	2
Las Vegas	50	99	1100	4	0	0	71	73	0	0	0	6	8	0	0	0	0	0
Las Vegas	100	98	1100	83	0	39	305	312	22	0	1	174	187	6	0	0	77	79
Las Vegas	100	99	1100	70	0	24	288	304	16	0	0	142	151	4	0	0	71	73
Las Vegas	150	98	1100	161	1	146	342	343	83	0	39	305	312	36	0	5	219	239
Las Vegas	150	99	1100	145	0	118	337	339	70	0	24	288	304	26	0	2	191	206
Las Vegas	200	98	1100	210	6	224	350	350	138	0	108	335	336	83	0	39	305	312
Las Vegas	200	99	1100	198	3	205	348	349	123	0	83	329	333	70	0	24	288	304
Los Angeles	As is		5400	38	0	25	150	169	6	0	1	43	55	1	0	0	11	14
Los Angeles	Current Std		5400	160	2	163	314	326	58	0	45	187	215	18	0	8	90	105
Los Angeles	50	98	5400	2	0	0	18	24	0	0	0	1	2	0	0	0	0	0
Los Angeles	50	99	5400	1	0	0	12	15	0	0	0	1	1	0	0	0	0	0
Los Angeles	100	98	5400	54	0	41	188	208	10	0	2	62	75	2	0	0	18	24
Los Angeles	100	99	5400	40	0	27	153	176	6	0	1	44	55	1	0	0	12	15
Los Angeles	150	98	5400	155	2	155	314	325	54	0	41	188	208	17	0	6	85	104

Location	Standard[1]	Percentile[2]	Site-Years	Number of Daily Maximum Exceedances[3]														
				≥ 100 ppb					≥ 150 ppb					≥ 200 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
Los Angeles	150	99	5400	132	0	127	296	310	40	0	27	153	176	11	0	3	68	79
Los Angeles	200	98	5400	227	13	240	349	352	122	0	115	285	304	54	0	41	188	208
Los Angeles	200	99	5400	208	8	217	342	348	100	0	91	258	281	40	0	27	153	176
Miami	As is		400	6	0	1	46	46	0	0	0	6	6	0	0	0	1	1
Miami	Current Std		400	202	100	201	284	286	130	30	139	197	204	77	1	76	160	163
Miami	50	98	400	3	0	0	24	24	0	0	0	1	1	0	0	0	1	1
Miami	50	99	400	2	0	0	18	21	0	0	0	1	1	0	0	0	0	0
Miami	100	98	400	56	0	47	144	148	13	0	4	72	77	3	0	0	24	24
Miami	100	99	400	46	0	34	134	140	9	0	2	62	65	2	0	0	18	21
Miami	150	98	400	128	24	135	194	199	56	0	47	144	148	21	0	11	97	101
Miami	150	99	400	117	17	123	187	192	46	0	34	134	140	16	0	7	81	92
Miami	200	98	400	182	75	188	260	262	106	12	111	178	183	56	0	47	144	148
Miami	200	99	400	171	63	178	248	250	94	7	96	170	174	46	0	34	134	140
New York	As is		2200	35	0	23	149	171	5	0	1	40	45	1	0	0	13	15
New York	Current Std		2200	147	0	148	308	321	45	0	31	188	202	13	0	4	75	89
New York	50	98	2200	3	0	0	32	34	0	0	0	3	4	0	0	0	0	1
New York	50	99	2200	2	0	0	17	23	0	0	0	1	1	0	0	0	0	0
New York	100	98	2200	75	0	62	225	248	14	0	6	73	88	3	0	0	32	34
New York	100	99	2200	45	0	32	175	196	7	0	2	49	53	2	0	0	17	23
New York	150	98	2200	192	2	204	326	333	75	0	62	225	248	25	0	13	120	135
New York	150	99	2200	149	0	151	305	312	45	0	32	175	196	13	0	4	67	80
New York	200	98	2200	264	38	284	350	353	157	0	162	310	317	75	0	62	225	248
New York	200	99	2200	232	20	250	339	343	115	0	108	278	294	45	0	32	175	196
Philadelphia	As is		1200	22	0	10	101	130	2	0	0	20	22	0	0	0	3	3
Philadelphia	Current Std		1200	232	54	242	321	326	110	2	99	269	280	43	0	27	188	202
Philadelphia	50	98	1200	5	0	1	37	42	0	0	0	4	4	0	0	0	0	0
Philadelphia	50	99	1200	1	0	0	14	14	0	0	0	0	1	0	0	0	0	0
Philadelphia	100	98	1200	112	5	102	258	276	24	0	10	109	139	5	0	1	37	42
Philadelphia	100	99	1200	53	0	39	187	214	8	0	1	49	53	1	0	0	14	14
Philadelphia	150	98	1200	237	76	245	325	329	112	5	102	258	276	39	0	27	155	189
Philadelphia	150	99	1200	172	24	178	297	311	53	0	39	187	214	14	0	4	77	83

Location	Standard[1]	Percentile[2]	Site-Years	Number of Daily Maximum Exceedances[3]														
				≥ 100 ppb					≥ 150 ppb					≥ 200 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
Philadelphia	200	98	1200	295	186	302	339	345	204	51	213	313	319	112	5	102	258	276
Philadelphia	200	99	1200	256	105	264	329	332	134	7	130	277	296	53	0	39	187	214
Phoenix	As is		900	77	0	53	275	293	10	0	1	57	71	1	0	0	7	8
Phoenix	Current Std		900	284	127	296	357	359	124	2	111	307	325	38	0	11	186	211
Phoenix	50	98	900	4	0	0	26	35	0	0	0	1	1	0	0	0	0	0
Phoenix	50	99	900	2	0	0	12	14	0	0	0	0	0	0	0	0	0	0
Phoenix	100	98	900	146	3	140	320	332	28	0	7	159	171	4	0	0	26	35
Phoenix	100	99	900	103	0	84	293	312	16	0	2	101	107	2	0	0	12	14
Phoenix	150	98	900	299	151	309	358	360	146	3	140	320	332	49	0	19	222	245
Phoenix	150	99	900	268	95	280	353	357	103	0	84	293	312	30	0	7	165	184
Phoenix	200	98	900	338	227	347	363	364	264	92	277	352	356	146	3	140	320	332
Phoenix	200	99	900	328	204	337	361	363	225	39	236	345	352	103	0	84	293	312
Provo	As is		300	51	0	44	160	160	17	0	2	68	70	12	0	0	44	44
Provo	Current Std		300	306	153	331	360	361	192	44	187	331	340	87	1	61	260	278
Provo	50	98	300	13	0	0	45	45	4	0	0	42	42	1	0	0	20	20
Provo	50	99	300	13	0	0	44	45	4	0	0	42	42	1	0	0	15	15
Provo	100	98	300	63	0	48	187	187	20	0	5	78	79	13	0	0	45	45
Provo	100	99	300	60	0	46	182	183	19	0	3	78	79	13	0	0	44	45
Provo	150	98	300	209	38	214	328	335	63	0	48	187	187	26	0	17	95	95
Provo	150	99	300	201	30	210	328	334	60	0	46	182	183	24	0	15	91	91
Provo	200	98	300	298	217	300	356	359	160	7	157	306	314	63	0	48	187	187
Provo	200	99	300	294	204	290	354	356	151	6	147	299	306	60	0	46	182	183
St. Louis	As is		400	15	0	5	76	83	1	0	0	20	24	0	0	0	2	5
St. Louis	Current Std		400	233	82	228	341	347	121	1	113	280	300	50	0	33	198	221
St. Louis	50	98	400	4	0	0	35	41	0	0	0	9	10	0	0	0	0	0
St. Louis	50	99	400	3	0	0	31	35	0	0	0	4	9	0	0	0	0	0
St. Louis	100	98	400	107	3	100	238	249	23	0	12	105	108	4	0	0	35	41
St. Louis	100	99	400	98	2	90	227	240	20	0	10	96	101	3	0	0	31	35
St. Louis	150	98	400	226	96	221	331	340	107	3	100	238	249	39	0	28	135	142
St. Louis	150	99	400	217	82	211	328	340	98	2	90	227	240	33	0	22	124	133
St. Louis	200	98	400	287	166	291	357	357	194	62	190	308	320	107	3	100	238	249

Location	Standard[1]	Percentile[2]	Site-Years	Number of Daily Maximum Exceedances[3]														
				≥ 100 ppb					≥ 150 ppb					≥ 200 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
St. Louis	200	99	400	282	162	283	355	356	186	49	181	305	317	98	2	90	227	240
Washington DC	As is		1700	21	0	7	119	143	2	0	0	20	22	0	0	0	4	6
Washington DC	Current Std		1700	207	10	238	340	345	102	0	88	270	289	41	0	21	176	202
Washington DC	50	98	1700	5	0	1	37	42	0	0	0	5	6	0	0	0	1	1
Washington DC	50	99	1700	2	0	0	15	16	0	0	0	2	2	0	0	0	0	0
Washington DC	100	98	1700	96	0	81	269	283	22	0	8	126	150	5	0	1	37	42
Washington DC	100	99	1700	50	0	29	209	226	8	0	1	52	66	2	0	0	15	16
Washington DC	150	98	1700	200	2	232	337	345	96	0	81	269	283	36	0	17	173	192
Washington DC	150	99	1700	148	0	157	309	322	50	0	29	209	226	14	0	3	85	110
Washington DC	200	98	1700	260	42	299	358	362	171	0	191	323	335	96	0	81	269	283
Washington DC	200	99	1700	220	8	256	346	352	117	0	108	288	298	50	0	29	209	226
Other MSA	As is		56500	10	0	1	79	100	1	0	0	12	18	0	0	0	2	3
Other MSA	Current Std		56500	143	0	143	322	336	59	0	36	233	257	22	0	5	138	163
Other MSA	50	98	56500	0	0	0	5	8	0	0	0	0	1	0	0	0	0	0
Other MSA	50	99	56500	0	0	0	2	5	0	0	0	0	0	0	0	0	0	0
Other MSA	100	98	56500	20	0	5	123	152	2	0	0	26	37	0	0	0	5	8
Other MSA	100	99	56500	14	0	2	96	121	1	0	0	17	25	0	0	0	2	5
Other MSA	150	98	56500	80	0	62	264	288	20	0	5	123	152	5	0	0	44	60
Other MSA	150	99	56500	63	0	43	237	263	14	0	2	96	121	3	0	0	30	43
Other MSA	200	98	56500	143	0	144	322	337	57	0	36	228	255	20	0	5	123	152
Other MSA	200	99	56500	125	0	119	311	328	44	0	23	201	228	14	0	2	96	121
Other Not MSA	As is		11600	4	0	0	43	65	1	0	0	7	13	0	0	0	2	5
Other Not MSA	Current Std		11600	124	0	100	331	339	62	0	24	257	272	29	0	4	180	201
Other Not MSA	50	98	11600	0	0	0	2	6	0	0	0	1	2	0	0	0	0	1
Other Not MSA	50	99	11600	0	0	0	2	3	0	0	0	0	2	0	0	0	0	1
Other Not MSA	100	98	11600	6	0	0	61	86	1	0	0	10	17	0	0	0	2	6
Other Not MSA	100	99	11600	2	0	0	23	35	0	0	0	3	7	0	0	0	2	3
Other Not MSA	150	98	11600	28	0	4	173	198	6	0	0	61	86	1	0	0	18	26
Other Not MSA	150	99	11600	13	0	1	113	134	2	0	0	23	35	0	0	0	6	11
Other Not MSA	200	98	11600	60	0	22	249	269	19	0	2	141	164	6	0	0	61	86
Other Not MSA	200	99	11600	34	0	6	193	216	8	0	0	80	104	2	0	0	23	35

Location	Standard[1]	Percentile[2]	Site-Years	Number of Daily Maximum Exceedances[3]														
				≥ 100 ppb					≥ 150 ppb					≥ 200 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99

Notes:
[1] Scenario: As is – unadjusted air quality, Current Std – air quality that just meets the current annual standard, All others – air quality that just meets 1-hour concentration level given percentile form of alternative standard.
[2] Percentile: 98th or 99th percentile of daily maximum 1-hour concentration averaged over three years at maximum monitor in location.
[3] The mean number of exceedances represents the sum of daily maximum exceedances occurring at all monitors in a particular location divided by the number of site-years across the monitoring period. The min, med, p98, and p99 represent the minimum, median, 98th, and 99th percentiles of the distribution for the number of daily maximum exceedances in any one year within the monitoring period.

Table A-122. Estimated number of exceedances of 1-hour concentration levels (250, and 300 ppb) on-roads using 2001-2003 air quality *as is* and air quality adjusted to just meet the current and alternative standards and an on-road adjustment factor.

Location	Standard [1]	Percentile [2]	Site-Years	Number of Daily Maximum Exceedances [3]									
				≥ 250 ppb					≥ 300 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
Atlanta	As is		1400	0	0	0	3	4	0	0	0	1	1
Atlanta	Current Std		1400	29	0	7	157	189	15	0	1	102	125
Atlanta	50	98	1400	0	0	0	0	0	0	0	0	0	0
Atlanta	50	99	1400	0	0	0	0	0	0	0	0	0	0
Atlanta	100	98	1400	1	0	0	8	10	0	0	0	4	5
Atlanta	100	99	1400	0	0	0	6	8	0	0	0	1	3
Atlanta	150	98	1400	6	0	0	47	70	2	0	0	26	38
Atlanta	150	99	1400	4	0	0	39	53	2	0	0	20	25
Atlanta	200	98	1400	21	0	4	122	165	10	0	1	70	104
Atlanta	200	99	1400	15	0	2	101	137	7	0	0	53	76
Boston	As is		600	0	0	0	0	0	0	0	0	0	0
Boston	Current Std		600	1	0	0	11	12	0	0	0	3	3
Boston	50	98	600	0	0	0	0	0	0	0	0	0	0
Boston	50	99	600	0	0	0	0	0	0	0	0	0	0
Boston	100	98	600	0	0	0	1	1	0	0	0	0	0
Boston	100	99	600	0	0	0	1	1	0	0	0	0	0
Boston	150	98	600	1	0	0	13	18	0	0	0	3	6
Boston	150	99	600	1	0	0	7	13	0	0	0	3	3
Boston	200	98	600	9	0	1	59	67	3	0	0	22	25
Boston	200	99	600	5	0	1	33	37	1	0	0	13	18
Chicago	As is		900	0	0	0	5	12	0	0	0	1	3
Chicago	Current Std		900	9	0	2	64	69	4	0	0	37	45
Chicago	50	98	900	0	0	0	0	0	0	0	0	0	0
Chicago	50	99	900	0	0	0	0	0	0	0	0	0	0
Chicago	100	98	900	1	0	0	15	21	0	0	0	4	7
Chicago	100	99	900	0	0	0	8	13	0	0	0	1	3
Chicago	150	98	900	11	0	2	68	76	4	0	0	43	49
Chicago	150	99	900	6	0	1	49	56	2	0	0	31	34
Chicago	200	98	900	38	0	23	150	164	18	0	7	92	106
Chicago	200	99	900	23	0	11	109	125	10	0	2	65	74
Cleveland	As is		300	0	0	0	3	3	0	0	0	1	1
Cleveland	Current Std		300	24	0	15	70	83	10	0	3	44	48
Cleveland	50	98	300	0	0	0	0	0	0	0	0	0	0
Cleveland	50	99	300	0	0	0	0	0	0	0	0	0	0
Cleveland	100	98	300	3	0	0	19	19	1	0	0	7	8
Cleveland	100	99	300	2	0	0	15	16	0	0	0	3	3
Cleveland	150	98	300	15	0	8	57	63	7	0	2	37	38
Cleveland	150	99	300	11	0	4	48	54	5	0	1	30	30
Cleveland	200	98	300	50	4	44	123	136	24	0	15	73	86
Cleveland	200	99	300	40	2	32	105	116	19	0	10	62	70
Denver	As is		200	1	0	0	5	5	0	0	0	1	1
Denver	Current Std		200	36	0	22	156	163	16	0	7	94	97

Location	Standard [1]	Percentile [2]	Site-Years	Number of Daily Maximum Exceedances[3]									
				≥ 250 ppb					≥ 300 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
Denver	50	98	200	0	0	0	1	1	0	0	0	0	0
Denver	50	99	200	0	0	0	0	0	0	0	0	0	0
Denver	100	98	200	1	0	0	5	5	0	0	0	1	1
Denver	100	99	200	0	0	0	2	2	0	0	0	1	1
Denver	150	98	200	12	0	3	71	77	4	0	1	36	37
Denver	150	99	200	6	0	1	50	52	2	0	1	14	15
Denver	200	98	200	43	1	27	162	165	19	0	6	86	103
Denver	200	99	200	26	0	10	105	121	11	0	3	66	73
Detroit	As is		600	2	0	1	7	7	1	0	1	7	7
Detroit	Current Std		600	34	1	25	109	120	17	1	11	66	72
Detroit	50	98	600	1	0	0	4	4	0	0	0	4	4
Detroit	50	99	600	0	0	0	2	3	0	0	0	2	2
Detroit	100	98	600	2	0	1	11	12	1	0	1	7	7
Detroit	100	99	600	1	0	1	5	7	1	0	0	4	5
Detroit	150	98	600	9	0	5	43	46	5	0	3	26	28
Detroit	150	99	600	2	0	1	11	12	1	0	1	7	7
Detroit	200	98	600	26	1	18	80	100	13	1	8	56	57
Detroit	200	99	600	7	0	3	33	37	3	0	2	16	18
El Paso	As is		1200	0	0	0	1	1	0	0	0	0	1
El Paso	Current Std		1200	33	0	20	160	168	14	0	7	76	86
El Paso	50	98	1200	0	0	0	0	0	0	0	0	0	0
El Paso	50	99	1200	0	0	0	0	0	0	0	0	0	0
El Paso	100	98	1200	1	0	0	6	7	0	0	0	3	3
El Paso	100	99	1200	0	0	0	3	3	0	0	0	1	1
El Paso	150	98	1200	10	0	4	51	56	3	0	0	23	24
El Paso	150	99	1200	5	0	1	27	31	1	0	0	10	12
El Paso	200	98	1200	39	0	24	159	171	17	0	8	80	91
El Paso	200	99	1200	21	0	11	104	118	8	0	3	46	49
Jacksonville	As is		200	1	0	1	1	1	1	0	1	1	1
Jacksonville	Current Std		200	67	3	64	153	168	34	2	26	103	114
Jacksonville	50	98	200	1	0	1	1	1	1	0	1	1	1
Jacksonville	50	99	200	1	0	1	1	1	1	0	1	1	1
Jacksonville	100	98	200	2	0	1	11	11	1	0	1	3	3
Jacksonville	100	99	200	1	0	1	6	7	1	0	1	2	2
Jacksonville	150	98	200	20	0	11	68	74	7	0	4	34	34
Jacksonville	150	99	200	14	0	8	55	56	5	0	3	25	25
Jacksonville	200	98	200	64	3	60	145	168	32	2	25	97	114
Jacksonville	200	99	200	50	3	42	127	147	23	1	18	79	86
Las Vegas	As is		1600	0	0	0	1	1	0	0	0	0	0
Las Vegas	Current Std		1600	20	0	3	155	172	9	0	0	76	90
Las Vegas	50	98	1600	0	0	0	0	0	0	0	0	0	0
Las Vegas	50	99	1600	0	0	0	0	0	0	0	0	0	0
Las Vegas	100	98	1600	1	0	0	24	30	0	0	0	6	7
Las Vegas	100	99	1600	1	0	0	13	15	0	0	0	2	3
Las Vegas	150	98	1600	12	0	1	97	116	5	0	0	63	71

Location	Standard [1]	Percentile [2]	Site-Years	Number of Daily Maximum Exceedances[3]									
				≥ 250 ppb					≥ 300 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
Las Vegas	150	99	1600	8	0	0	73	82	3	0	0	49	58
Las Vegas	200	98	1600	42	0	13	231	264	19	0	3	149	172
Las Vegas	200	99	1600	28	0	7	186	215	13	0	1	102	120
Los Angeles	As is		5100	1	0	0	16	23	0	0	0	7	10
Los Angeles	Current Std		5100	7	0	1	53	59	3	0	0	29	34
Los Angeles	50	98	5100	0	0	0	0	0	0	0	0	0	0
Los Angeles	50	99	5100	0	0	0	0	0	0	0	0	0	0
Los Angeles	100	98	5100	0	0	0	5	7	0	0	0	1	3
Los Angeles	100	99	5100	0	0	0	4	6	0	0	0	0	2
Los Angeles	150	98	5100	3	0	0	33	39	1	0	0	15	20
Los Angeles	150	99	5100	3	0	0	28	34	1	0	0	13	17
Los Angeles	200	98	5100	14	0	3	79	92	6	0	1	46	55
Los Angeles	200	99	5100	11	0	2	71	84	5	0	0	42	49
Miami	As is		600	0	0	0	0	0	0	0	0	0	0
Miami	Current Std		600	40	0	33	143	154	19	0	10	97	103
Miami	50	98	600	0	0	0	0	0	0	0	0	0	0
Miami	50	99	600	0	0	0	0	0	0	0	0	0	0
Miami	100	98	600	1	0	0	12	18	0	0	0	5	7
Miami	100	99	600	0	0	0	5	9	0	0	0	2	3
Miami	150	98	600	12	0	5	68	85	5	0	1	37	48
Miami	150	99	600	7	0	2	47	61	3	0	0	21	31
Miami	200	98	600	40	0	31	127	156	19	0	10	92	110
Miami	200	99	600	24	0	14	105	123	11	0	4	67	84
New York	As is		2600	0	0	0	6	9	0	0	0	1	2
New York	Current Std		2600	4	0	0	38	47	1	0	0	19	27
New York	50	98	2600	0	0	0	0	0	0	0	0	0	0
New York	50	99	2600	0	0	0	0	0	0	0	0	0	0
New York	100	98	2600	1	0	0	11	14	0	0	0	3	4
New York	100	99	2600	0	0	0	4	7	0	0	0	1	2
New York	150	98	2600	6	0	1	53	58	3	0	0	33	34
New York	150	99	2600	3	0	0	36	40	1	0	0	19	22
New York	200	98	2600	23	0	12	117	137	10	0	3	67	73
New York	200	99	2600	13	0	4	73	87	6	0	1	48	56
Philadelphia	As is		1400	0	0	0	3	5	0	0	0	1	1
Philadelphia	Current Std		1400	10	0	2	69	75	4	0	1	41	46
Philadelphia	50	98	1400	0	0	0	1	1	0	0	0	1	1
Philadelphia	50	99	1400	0	0	0	1	1	0	0	0	1	1
Philadelphia	100	98	1400	2	0	0	26	40	1	0	0	8	20
Philadelphia	100	99	1400	1	0	0	14	27	0	0	0	4	10
Philadelphia	150	98	1400	17	0	4	90	100	7	0	1	54	68
Philadelphia	150	99	1400	11	0	2	69	83	4	0	1	41	56
Philadelphia	200	98	1400	56	0	38	198	225	27	0	12	118	137
Philadelphia	200	99	1400	40	0	24	158	184	18	0	5	93	105
Phoenix	As is		500	0	0	0	4	5	0	0	0	0	0
Phoenix	Current		500	8	0	0	58	69	2	0	0	18	22

Location	Standard [1]	Percentile [2]	Site-Years	Number of Daily Maximum Exceedances [3]									
				≥ 250 ppb					≥ 300 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
	Std												
Phoenix	50	98	500	0	0	0	0	0	0	0	0	0	0
Phoenix	50	99	500	0	0	0	0	0	0	0	0	0	0
Phoenix	100	98	500	1	0	0	11	12	0	0	0	2	3
Phoenix	100	99	500	0	0	0	5	5	0	0	0	1	1
Phoenix	150	98	500	20	0	3	135	147	6	0	0	44	48
Phoenix	150	99	500	11	0	1	81	88	3	0	0	19	24
Phoenix	200	98	500	76	1	54	259	284	35	0	14	182	206
Phoenix	200	99	500	52	0	27	221	244	22	0	4	135	156
Provo	As is		300	0	0	0	2	2	0	0	0	0	0
Provo	Current Std		300	37	0	16	174	204	15	0	2	74	90
Provo	50	98	300	0	0	0	0	0	0	0	0	0	0
Provo	50	99	300	0	0	0	0	0	0	0	0	0	0
Provo	100	98	300	7	0	0	52	56	2	0	0	18	18
Provo	100	99	300	5	0	0	38	40	1	0	0	9	9
Provo	150	98	300	47	0	24	208	253	18	0	4	86	106
Provo	150	99	300	34	0	14	161	203	13	0	2	75	82
Provo	200	98	300	151	11	128	331	348	75	1	51	273	301
Provo	200	99	300	121	4	97	318	342	56	1	33	235	283
St. Louis	As is		900	0	0	0	1	1	0	0	0	1	1
St. Louis	Current Std		900	19	0	7	103	122	7	0	1	50	59
St. Louis	50	98	900	0	0	0	1	1	0	0	0	0	1
St. Louis	50	99	900	0	0	0	1	1	0	0	0	0	1
St. Louis	100	98	900	2	0	0	22	27	1	0	0	7	10
St. Louis	100	99	900	1	0	0	12	18	0	0	0	4	4
St. Louis	150	98	900	17	0	6	99	103	7	0	1	45	51
St. Louis	150	99	900	11	0	2	68	70	4	0	0	35	41
St. Louis	200	98	900	61	0	47	215	230	28	0	15	144	153
St. Louis	200	99	900	44	0	28	181	200	19	0	6	105	114
Washington DC	As is		1800	0	0	0	1	1	0	0	0	0	0
Washington DC	Current Std		1800	18	0	4	107	128	8	0	0	60	65
Washington DC	50	98	1800	0	0	0	0	0	0	0	0	0	0
Washington DC	50	99	1800	0	0	0	0	0	0	0	0	0	0
Washington DC	100	98	1800	2	0	0	22	28	0	0	0	6	8
Washington DC	100	99	1800	1	0	0	10	14	0	0	0	2	2
Washington DC	150	98	1800	18	0	4	100	123	7	0	0	56	63
Washington DC	150	99	1800	11	0	1	72	84	5	0	0	38	45
Washington DC	200	98	1800	56	0	36	213	251	27	0	10	139	168
Washington DC	200	99	1800	38	0	18	175	211	18	0	4	102	123

Location	Standard [1]	Percentile [2]	Site-Years	Number of Daily Maximum Exceedances [3]									
				≥ 250 ppb					≥ 300 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
Other MSA	As is		61200	0	0	0	1	2	0	0	0	0	0
Other MSA	Current Std		61200	5	0	0	47	62	2	0	0	21	30
Other MSA	50	98	61200	0	0	0	0	0	0	0	0	0	0
Other MSA	50	99	61200	0	0	0	0	0	0	0	0	0	0
Other MSA	100	98	61200	0	0	0	1	2	0	0	0	0	1
Other MSA	100	99	61200	0	0	0	0	1	0	0	0	0	0
Other MSA	150	98	61200	1	0	0	13	22	0	0	0	5	8
Other MSA	150	99	61200	0	0	0	6	9	0	0	0	2	3
Other MSA	200	98	61200	6	0	0	51	66	2	0	0	23	34
Other MSA	200	99	61200	3	0	0	28	39	1	0	0	11	17
Other Not MSA	As is		12700	0	0	0	1	2	0	0	0	1	1
Other Not MSA	Current Std		12700	13	0	1	107	130	6	0	0	63	82
Other Not MSA	50	98	12700	0	0	0	0	0	0	0	0	0	0
Other Not MSA	50	99	12700	0	0	0	0	0	0	0	0	0	0
Other Not MSA	100	98	12700	0	0	0	2	3	0	0	0	1	1
Other Not MSA	100	99	12700	0	0	0	1	1	0	0	0	1	1
Other Not MSA	150	98	12700	1	0	0	9	14	0	0	0	4	8
Other Not MSA	150	99	12700	0	0	0	5	8	0	0	0	2	4
Other Not MSA	200	98	12700	2	0	0	25	35	1	0	0	12	17
Other Not MSA	200	99	12700	1	0	0	14	18	0	0	0	6	13

Notes:

[1] Scenario: As is – unadjusted air quality, Current Std – air quality that just meets the current annual standard, All others – air quality that just meets 1-hour concentration level given percentile form of alternative standard.

[2] Percentile: 98th or 99th percentile of daily maximum 1-hour concentration averaged over three years at maximum monitor in location.

[3] The mean number of exceedances represents the sum of daily maximum exceedances occurring at all monitors in a particular location divided by the number of site-years across the monitoring period. The min, med, p98, and p99 represent the minimum, median, 98th, and 99th percentiles of the distribution for the number of daily maximum exceedances in any one year within the monitoring period.

A-9.3 Annual average NO_2 concentration data for 2004-2006

Table A-123. Estimated annual average NO_2 concentrations for monitors ≥100 m from a major road using 2004-2006 air quality *as is* and adjusted to just meet the current and alternative standards.

Location	Scenario[1]	Percentile[2]	Site-Years	Annual Average NO_2 (ppb)[3]				
				Mean	Min	med	p98	p99
Atlanta	As is		15	11	3	14	18	18
Atlanta	Current Std		15	34	10	44	53	53
Atlanta	50	98	15	8	2	10	13	13
Atlanta	50	99	15	7	2	9	11	11
Atlanta	100	98	15	16	5	20	25	25
Atlanta	100	99	15	14	4	18	23	23
Atlanta	150	98	15	24	7	30	38	38
Atlanta	150	99	15	22	7	28	34	34
Atlanta	200	98	15	32	10	40	50	50
Atlanta	200	99	15	29	9	37	46	46
Atlanta	250	98	15	39	12	51	63	63
Atlanta	250	99	15	36	11	46	57	57
Atlanta	300	98	15	47	14	61	75	75
Atlanta	300	99	15	43	13	55	69	69
Boston	As is		8	9	7	9	10	10
Boston	Current Std		8	20	15	20	23	23
Boston	50	98	8	6	5	6	7	7
Boston	50	99	8	5	4	5	6	6
Boston	100	98	8	12	10	13	14	14
Boston	100	99	8	11	9	11	12	12
Boston	150	98	8	19	16	19	21	21
Boston	150	99	8	16	13	16	18	18
Boston	200	98	8	25	21	25	29	29
Boston	200	99	8	21	18	21	24	24
Boston	250	98	8	31	26	31	36	36
Boston	250	99	8	27	22	27	30	30
Boston	300	98	8	37	31	38	43	43
Boston	300	99	8	32	27	32	36	36
Chicago	As is		8	19	16	18	24	24
Chicago	Current Std		8	35	28	32	44	44
Chicago	50	98	8	11	9	10	14	14
Chicago	50	99	8	10	9	10	13	13
Chicago	100	98	8	22	18	21	28	28
Chicago	100	99	8	21	17	19	26	26
Chicago	150	98	8	33	27	31	42	42
Chicago	150	99	8	31	26	29	39	39
Chicago	200	98	8	44	36	41	55	55
Chicago	200	99	8	42	34	39	52	52
Chicago	250	98	8	56	45	51	69	69
Chicago	250	99	8	52	43	48	65	65
Chicago	300	98	8	67	54	62	83	83

Location	Scenario[1]	Percentile[2]	Site-Years	Annual Average NO_2 (ppb)[3]				
				Mean	Min	med	p98	p99
Chicago	300	99	8	63	51	58	78	78
Denver	As is		3	20	18	20	21	21
Denver	Current Std		3	38	33	39	42	42
Denver	50	98	3	13	12	13	14	14
Denver	50	99	3	12	11	12	13	13
Denver	100	98	3	26	24	27	28	28
Denver	100	99	3	23	21	24	25	25
Denver	150	98	3	39	36	40	42	42
Denver	150	99	3	35	32	36	38	38
Denver	200	98	3	53	48	53	57	57
Denver	200	99	3	47	42	47	50	50
Denver	250	98	3	66	59	67	71	71
Denver	250	99	3	58	53	59	63	63
Denver	300	98	3	79	71	80	85	85
Denver	300	99	3	70	63	71	75	75
Detroit	As is		6	17	14	17	20	20
Detroit	Current Std		6	49	42	50	53	53
Detroit	50	98	6	15	13	15	18	18
Detroit	50	99	6	14	12	14	17	17
Detroit	100	98	6	31	26	30	36	36
Detroit	100	99	6	29	24	29	34	34
Detroit	150	98	6	46	38	46	54	54
Detroit	150	99	6	43	36	43	51	51
Detroit	200	98	6	61	51	61	72	72
Detroit	200	99	6	58	48	57	68	68
Detroit	250	98	6	77	64	76	90	90
Detroit	250	99	6	72	60	72	84	84
Detroit	300	98	6	92	77	91	107	107
Detroit	300	99	6	87	72	86	101	101
El Paso	As is		12	14	8	15	18	18
El Paso	Current Std		12	42	24	45	53	53
El Paso	50	98	12	10	6	11	13	13
El Paso	50	99	12	9	5	10	12	12
El Paso	100	98	12	21	12	22	27	27
El Paso	100	99	12	19	11	20	24	24
El Paso	150	98	12	31	18	33	40	40
El Paso	150	99	12	28	16	30	36	36
El Paso	200	98	12	42	24	45	54	54
El Paso	200	99	12	37	22	40	48	48
El Paso	250	98	12	52	30	56	67	67
El Paso	250	99	12	46	27	50	60	60
El Paso	300	98	12	62	36	67	80	80
El Paso	300	99	12	56	33	60	72	72
Jacksonville	As is		2	14	13	14	14	14
Jacksonville	Current Std		2	53	53	53	53	53

Location	Scenario[1]	Percentile[2]	Site-Years	Annual Average NO_2 (ppb)[3]				
				Mean	Min	med	p98	p99
Jacksonville	50	98	2	13	13	13	13	13
Jacksonville	50	99	2	9	9	9	9	9
Jacksonville	100	98	2	26	26	26	26	26
Jacksonville	100	99	2	18	18	18	18	18
Jacksonville	150	98	2	39	38	39	39	39
Jacksonville	150	99	2	27	26	27	27	27
Jacksonville	200	98	2	52	51	52	53	53
Jacksonville	200	99	2	36	35	36	36	36
Jacksonville	250	98	2	65	64	65	66	66
Jacksonville	250	99	2	44	44	44	45	45
Jacksonville	300	98	2	78	77	78	79	79
Jacksonville	300	99	2	53	53	53	54	54
Las Vegas	As is		11	9	1	6	20	20
Las Vegas	Current Std		11	24	4	16	53	53
Las Vegas	50	98	11	7	1	5	16	16
Las Vegas	50	99	11	7	1	5	15	15
Las Vegas	100	98	11	15	2	10	32	32
Las Vegas	100	99	11	14	2	9	30	30
Las Vegas	150	98	11	22	3	15	48	48
Las Vegas	150	99	11	20	3	14	45	45
Las Vegas	200	98	11	29	5	20	65	65
Las Vegas	200	99	11	27	4	18	60	60
Las Vegas	250	98	11	37	6	25	81	81
Las Vegas	250	99	11	34	5	23	75	75
Las Vegas	300	98	11	44	7	30	97	97
Las Vegas	300	99	11	41	6	28	90	90
Los Angeles	As is		54	18	5	18	31	31
Los Angeles	Current Std		54	30	8	31	48	53
Los Angeles	50	98	54	10	2	10	17	17
Los Angeles	50	99	54	9	2	9	15	16
Los Angeles	100	98	54	20	5	20	34	34
Los Angeles	100	99	54	18	5	18	31	31
Los Angeles	150	98	54	30	7	29	50	51
Los Angeles	150	99	54	27	7	27	46	47
Los Angeles	200	98	54	40	10	39	67	68
Los Angeles	200	99	54	37	9	36	62	62
Los Angeles	250	98	54	50	12	49	84	85
Los Angeles	250	99	54	46	11	45	77	78
Los Angeles	300	98	54	60	15	59	101	102
Los Angeles	300	99	54	55	14	54	92	94
Miami	As is		4	8	7	8	8	8
Miami	Current Std		4	31	28	31	32	32
Miami	50	98	4	7	6	7	7	7
Miami	50	99	4	6	6	6	7	7
Miami	100	98	4	13	13	14	14	14

Location	Scenario[1]	Percentile[2]	Site-Years	Annual Average NO_2 (ppb)[3]				
				Mean	Min	med	p98	p99
Miami	100	99	4	13	12	13	13	13
Miami	150	98	4	20	19	20	21	21
Miami	150	99	4	19	18	19	20	20
Miami	200	98	4	27	25	27	28	28
Miami	200	99	4	25	24	26	26	26
Miami	250	98	4	34	32	34	35	35
Miami	250	99	4	32	30	32	33	33
Miami	300	98	4	40	38	41	42	42
Miami	300	99	4	38	36	39	39	39
New York	As is		22	19	10	20	27	27
New York	Current Std		22	30	16	32	43	43
New York	50	98	22	12	6	12	16	16
New York	50	99	22	10	5	11	14	14
New York	100	98	22	23	12	25	33	33
New York	100	99	22	20	10	21	28	28
New York	150	98	22	35	18	37	49	49
New York	150	99	22	30	15	32	42	42
New York	200	98	22	47	24	49	65	65
New York	200	99	22	41	21	43	57	57
New York	250	98	22	59	30	62	82	82
New York	250	99	22	51	26	54	71	71
New York	300	98	22	70	36	74	98	98
New York	300	99	22	61	31	64	85	85
Philadelphia	As is		12	17	14	16	25	25
Philadelphia	Current Std		12	39	29	39	51	51
Philadelphia	50	98	12	13	11	12	19	19
Philadelphia	50	99	12	11	9	10	15	15
Philadelphia	100	98	12	26	21	25	37	37
Philadelphia	100	99	12	21	17	20	30	30
Philadelphia	150	98	12	39	32	37	56	56
Philadelphia	150	99	12	32	26	30	45	45
Philadelphia	200	98	12	52	43	50	75	75
Philadelphia	200	99	12	42	34	40	60	60
Philadelphia	250	98	12	65	53	62	94	94
Philadelphia	250	99	12	53	43	50	75	75
Philadelphia	300	98	12	79	64	75	112	112
Philadelphia	300	99	12	63	52	60	90	90
Phoenix	As is		9	24	21	24	26	26
Phoenix	Current Std		9	41	36	40	44	44
Phoenix	50	98	9	14	12	14	16	16
Phoenix	50	99	9	13	11	13	14	14
Phoenix	100	98	9	29	25	29	31	31
Phoenix	100	99	9	26	22	26	28	28
Phoenix	150	98	9	43	37	43	47	47
Phoenix	150	99	9	38	33	39	42	42

Location	Scenario[1]	Percentile[2]	Site-Years	Annual Average NO_2 (ppb)[3]				
				Mean	Min	med	p98	p99
Phoenix	200	98	9	57	50	57	63	63
Phoenix	200	99	9	51	45	51	56	56
Phoenix	250	98	9	71	62	71	78	78
Phoenix	250	99	9	64	56	64	70	70
Phoenix	300	98	9	86	74	86	94	94
Phoenix	300	99	9	77	67	77	85	85
Provo	As is		3	24	21	22	29	29
Provo	Current Std		3	53	53	53	53	53
Provo	50	98	3	13	11	12	15	15
Provo	50	99	3	12	11	12	15	15
Provo	100	98	3	25	22	24	31	31
Provo	100	99	3	25	21	23	30	30
Provo	150	98	3	38	33	36	46	46
Provo	150	99	3	37	32	35	45	45
Provo	200	98	3	51	44	48	62	62
Provo	200	99	3	50	43	47	60	60
Provo	250	98	3	64	55	59	77	77
Provo	250	99	3	62	53	58	75	75
Provo	300	98	3	76	65	71	92	92
Provo	300	99	3	75	64	70	90	90
St. Louis	As is		4	15	12	14	18	18
St. Louis	Current Std		4	38	29	36	49	49
St. Louis	50	98	4	12	10	12	14	14
St. Louis	50	99	4	12	10	11	14	14
St. Louis	100	98	4	24	20	23	29	29
St. Louis	100	99	4	23	20	23	28	28
St. Louis	150	98	4	36	30	35	43	43
St. Louis	150	99	4	35	29	34	42	42
St. Louis	200	98	4	48	40	47	58	58
St. Louis	200	99	4	46	39	45	56	56
St. Louis	250	98	4	60	50	58	72	72
St. Louis	250	99	4	58	49	56	70	70
St. Louis	300	98	4	72	61	70	87	87
St. Louis	300	99	4	69	59	68	84	84
Washington DC	As is		17	15	7	16	22	22
Washington DC	Current Std		17	36	19	42	51	51
Washington DC	50	98	17	12	5	12	17	17
Washington DC	50	99	17	9	4	10	14	14
Washington DC	100	98	17	23	10	24	33	33
Washington DC	100	99	17	19	8	20	27	27
Washington DC	150	98	17	35	16	36	50	50
Washington DC	150	99	17	28	13	30	41	41
Washington DC	200	98	17	46	21	48	67	67
Washington DC	200	99	17	38	17	39	54	54
Washington DC	250	98	17	58	26	60	84	84

Location	Scenario[1]	Percentile[2]	Site-Years	Annual Average NO_2 (ppb)[3]				
				Mean	Min	med	p98	p99
Washington DC	250	99	17	47	21	49	68	68
Washington DC	300	98	17	69	31	72	100	100
Washington DC	300	99	17	56	25	59	82	82
Other MSA	As is		565	11	1	11	21	23
Other MSA	Current Std		565	26	2	26	49	52
Other MSA	50	98	565	6	0	6	12	13
Other MSA	50	99	565	6	0	6	11	12
Other MSA	100	98	565	13	1	13	24	27
Other MSA	100	99	565	12	1	12	22	25
Other MSA	150	98	565	19	1	19	36	40
Other MSA	150	99	565	18	1	18	33	37
Other MSA	200	98	565	26	2	26	48	54
Other MSA	200	99	565	24	2	24	44	50
Other MSA	250	98	565	32	2	32	59	67
Other MSA	250	99	565	29	2	30	55	62
Other MSA	300	98	565	38	3	39	71	81
Other MSA	300	99	565	35	3	36	66	74
Other Not MSA	As is		116	7	1	6	16	16
Other Not MSA	Current Std		116	21	3	19	53	53
Other Not MSA	50	98	116	3	0	3	8	8
Other Not MSA	50	99	116	3	0	3	7	7
Other Not MSA	100	98	116	7	1	7	17	17
Other Not MSA	100	99	116	6	1	5	13	14
Other Not MSA	150	98	116	10	1	10	25	25
Other Not MSA	150	99	116	8	1	8	20	20
Other Not MSA	200	98	116	14	2	13	33	34
Other Not MSA	200	99	116	11	1	10	27	27
Other Not MSA	250	98	116	17	2	16	42	42
Other Not MSA	250	99	116	14	2	13	34	34
Other Not MSA	300	98	116	21	3	20	50	51
Other Not MSA	300	99	116	17	2	16	40	41

Notes:

[1] Scenario: As is – unadjusted air quality, Current Std – air quality that just meets the current annual standard, All others – air quality that just meets 1-hour concentration level given percentile form of alternative standard.

[2] Percentile: 98th or 99th percentile of daily maximum 1-hour concentration averaged over three years at maximum monitor in location.

[3] Annual means for each monitor were first calculated based on all simulated hourly values in a year. Then the mean of the annual means was estimated as the sum of all the annual means in a particular location divided by the number of simulated site-years across the monitoring period. The min, med, p98, p99 represent the minimum, median, 98th, and 99th percentiles of the distribution for the annual means.

Table A-124. Estimated annual average NO_2 concentrations for monitors >20 m and <100 m from a major road using 2004-2006 air quality *as is* and air quality adjusted to just meet the current and alternative standards.

Location	Scenario[1]	Percentile[2]	Site-Years	Annual Average NO_2 (ppb)[3]				
				Mean	Min	med	p98	p99
Boston	As is		11	15	10	16	19	19
Boston	Current Std		11	34	24	35	44	44
Boston	50	98	11	11	7	11	13	13
Boston	50	99	11	9	6	10	11	11
Boston	100	98	11	22	15	23	27	27
Boston	100	99	11	19	12	19	23	23
Boston	150	98	11	33	22	34	40	40
Boston	150	99	11	28	19	29	34	34
Boston	200	98	11	44	29	45	54	54
Boston	200	99	11	37	25	38	46	46
Boston	250	98	11	55	36	56	67	67
Boston	250	99	11	47	31	48	57	57
Boston	300	98	11	66	44	68	81	81
Boston	300	99	11	56	37	58	69	69
Chicago	As is		6	29	28	29	31	31
Chicago	Current Std		6	52	48	52	53	53
Chicago	50	98	6	17	16	16	17	17
Chicago	50	99	6	16	15	16	16	16
Chicago	100	98	6	33	31	33	35	35
Chicago	100	99	6	31	30	31	33	33
Chicago	150	98	6	50	47	49	52	52
Chicago	150	99	6	47	44	47	49	49
Chicago	200	98	6	66	63	66	70	70
Chicago	200	99	6	62	59	62	66	66
Chicago	250	98	6	83	79	82	87	87
Chicago	250	99	6	78	74	78	82	82
Chicago	300	98	6	99	94	99	105	105
Chicago	300	99	6	93	89	93	99	99
Cleveland	As is		2	15	14	15	17	17
Cleveland	Current Std		2	41	41	41	41	41
Cleveland	50	98	2	12	11	12	13	13
Cleveland	50	99	2	11	10	11	12	12
Cleveland	100	98	2	24	22	24	26	26
Cleveland	100	99	2	21	20	21	23	23
Cleveland	150	98	2	36	33	36	39	39
Cleveland	150	99	2	32	29	32	35	35
Cleveland	200	98	2	47	43	47	51	51
Cleveland	200	99	2	43	39	43	46	46
Cleveland	250	98	2	59	54	59	64	64
Cleveland	250	99	2	54	49	54	58	58
Cleveland	300	98	2	71	65	71	77	77

Location	Scenario[1]	Percentile[2]	Site-Years	Annual Average NO_2 (ppb)[3]				
				Mean	Min	med	p98	p99
Cleveland	300	99	2	64	59	64	70	70
El Paso	As is		3	15	13	13	18	18
El Paso	Current Std		3	44	39	40	53	53
El Paso	50	98	3	11	10	10	13	13
El Paso	50	99	3	10	9	9	12	12
El Paso	100	98	3	22	19	20	27	27
El Paso	100	99	3	20	17	17	24	24
El Paso	150	98	3	33	29	29	40	40
El Paso	150	99	3	29	26	26	36	36
El Paso	200	98	3	44	39	39	53	53
El Paso	200	99	3	39	35	35	48	48
El Paso	250	98	3	55	48	49	67	67
El Paso	250	99	3	49	43	44	60	60
El Paso	300	98	3	66	58	59	80	80
El Paso	300	99	3	59	52	52	72	72
Los Angeles	As is		22	25	9	27	34	34
Los Angeles	Current Std		22	41	15	47	53	53
Los Angeles	50	98	22	14	5	15	19	19
Los Angeles	50	99	22	12	4	14	17	17
Los Angeles	100	98	22	27	9	30	37	37
Los Angeles	100	99	22	25	9	27	34	34
Los Angeles	150	98	22	41	14	44	56	56
Los Angeles	150	99	22	37	13	41	51	51
Los Angeles	200	98	22	54	19	59	74	74
Los Angeles	200	99	22	50	17	54	68	68
Los Angeles	250	98	22	68	23	74	93	93
Los Angeles	250	99	22	62	22	68	85	85
Los Angeles	300	98	22	81	28	89	111	111
Los Angeles	300	99	22	75	26	82	102	102
Miami	As is		2	13	13	13	14	14
Miami	Current Std		2	53	53	53	53	53
Miami	50	98	2	12	11	12	12	12
Miami	50	99	2	11	11	11	11	11
Miami	100	98	2	23	23	23	24	24
Miami	100	99	2	22	21	22	22	22
Miami	150	98	2	35	34	35	36	36
Miami	150	99	2	33	32	33	34	34
Miami	200	98	2	46	46	46	47	47
Miami	200	99	2	44	43	44	45	45
Miami	250	98	2	58	57	58	59	59
Miami	250	99	2	55	54	55	56	56
Miami	300	98	2	70	68	70	71	71
Miami	300	99	2	66	64	66	67	67
New York	As is		11	28	18	29	36	36
New York	Current Std		11	43	28	42	53	53

Location	Scenario[1]	Percentile[2]	Site-Years	Annual Average NO_2 (ppb)[3]				
				Mean	Min	med	p98	p99
New York	50	98	11	17	11	18	22	22
New York	50	99	11	15	10	15	19	19
New York	100	98	11	34	22	35	45	45
New York	100	99	11	30	20	31	39	39
New York	150	98	11	51	34	53	67	67
New York	150	99	11	44	29	46	58	58
New York	200	98	11	68	45	71	90	90
New York	200	99	11	59	39	61	78	78
New York	250	98	11	85	56	88	112	112
New York	250	99	11	74	49	77	97	97
New York	300	98	11	102	67	106	134	134
New York	300	99	11	89	59	92	116	116
Philadelphia	As is		6	22	18	22	26	26
Philadelphia	Current Std		6	48	36	50	53	53
Philadelphia	50	98	6	17	13	17	20	20
Philadelphia	50	99	6	13	11	14	16	16
Philadelphia	100	98	6	33	27	34	40	40
Philadelphia	100	99	6	27	22	27	32	32
Philadelphia	150	98	6	50	40	50	60	60
Philadelphia	150	99	6	40	32	41	48	48
Philadelphia	200	98	6	66	54	67	80	80
Philadelphia	200	99	6	54	43	54	64	64
Philadelphia	250	98	6	83	67	84	100	100
Philadelphia	250	99	6	67	54	68	80	80
Philadelphia	300	98	6	100	80	101	120	120
Philadelphia	300	99	6	80	65	81	96	96
Phoenix	As is		3	19	19	19	20	20
Phoenix	Current Std		3	33	33	33	33	33
Phoenix	50	98	3	12	12	12	12	12
Phoenix	50	99	3	10	10	10	11	11
Phoenix	100	98	3	23	23	23	24	24
Phoenix	100	99	3	21	21	21	21	21
Phoenix	150	98	3	35	35	35	35	35
Phoenix	150	99	3	31	31	31	32	32
Phoenix	200	98	3	47	46	47	47	47
Phoenix	200	99	3	42	41	42	42	42
Phoenix	250	98	3	58	58	58	59	59
Phoenix	250	99	3	52	52	52	53	53
Phoenix	300	98	3	70	69	70	71	71
Phoenix	300	99	3	63	62	63	63	63
St. Louis	As is		8	12	8	10	22	22
St. Louis	Current Std		8	32	19	30	53	53
St. Louis	50	98	8	9	7	8	18	18
St. Louis	50	99	8	9	6	8	18	18
St. Louis	100	98	8	19	13	16	37	37

Location	Scenario[1]	Percentile[2]	Site-Years	Annual Average NO_2 (ppb)[3]				
				Mean	Min	med	p98	p99
St. Louis	100	99	8	18	13	16	35	35
St. Louis	150	98	8	28	20	25	55	55
St. Louis	150	99	8	27	19	24	53	53
St. Louis	200	98	8	38	27	33	73	73
St. Louis	200	99	8	37	26	32	71	71
St. Louis	250	98	8	47	33	41	92	92
St. Louis	250	99	8	46	32	40	89	89
St. Louis	300	98	8	57	40	49	110	110
St. Louis	300	99	8	55	39	48	106	106
Washington DC	As is		12	18	13	18	24	24
Washington DC	Current Std		12	43	30	43	53	53
Washington DC	50	98	12	14	10	13	18	18
Washington DC	50	99	12	11	8	11	15	15
Washington DC	100	98	12	28	20	27	37	37
Washington DC	100	99	12	23	17	22	30	30
Washington DC	150	98	12	42	30	40	55	55
Washington DC	150	99	12	34	25	33	45	45
Washington DC	200	98	12	55	41	53	73	73
Washington DC	200	99	12	45	33	43	60	60
Washington DC	250	98	12	69	51	67	91	91
Washington DC	250	99	12	56	41	54	74	74
Washington DC	300	98	12	83	61	80	110	110
Washington DC	300	99	12	68	50	65	89	89

Notes:

[1] Scenario: As is – unadjusted air quality, Current Std – air quality that just meets the current annual standard, All others – air quality that just meets 1-hour concentration level given percentile form of alternative standard.

[2] Percentile: 98^{th} or 99^{th} percentile of daily maximum 1-hour concentration averaged over three years at maximum monitor in location.

[3] Annual means for each monitor were first calculated based on all simulated hourly values in a year. Then the mean of the annual means was estimated as the sum of all the annual means in a particular location divided by the number of simulated site-years across the monitoring period. The min, med, p98, p99 represent the minimum, median, 98^{th}, and 99^{th} percentiles of the distribution for the annual means.

Table A-125. Estimated annual average NO_2 concentrations for monitors ≤ 20 m from a major road using 2004-2006 air quality *as is* and air quality adjusted to just meet the current and alternative standards.

Location	Scenario[1]	Percentile[2]	Site-Years	Annual Average NO_2 (ppb)[3]				
				Mean	Min	med	p98	p99
Boston	As is		3	24	23	23	25	25
Boston	Current Std		3	53	53	53	53	53
Boston	50	98	3	17	16	17	18	18
Boston	50	99	3	15	14	14	15	15
Boston	100	98	3	34	32	34	36	36
Boston	100	99	3	29	28	29	31	31
Boston	150	98	3	51	49	51	54	54
Boston	150	99	3	44	41	43	46	46
Boston	200	98	3	68	65	67	72	72
Boston	200	99	3	58	55	57	61	61
Boston	250	98	3	85	81	84	90	90
Boston	250	99	3	73	69	72	77	77
Boston	300	98	3	102	97	101	108	108
Boston	300	99	3	87	83	86	92	92
Chicago	As is		3	19	18	20	20	20
Chicago	Current Std		3	34	31	36	36	36
Chicago	50	98	3	11	10	11	11	11
Chicago	50	99	3	10	10	11	11	11
Chicago	100	98	3	22	20	23	23	23
Chicago	100	99	3	21	19	21	22	22
Chicago	150	98	3	33	31	34	34	34
Chicago	150	99	3	31	29	32	32	32
Chicago	200	98	3	44	41	45	46	46
Chicago	200	99	3	41	38	43	43	43
Chicago	250	98	3	55	51	57	57	57
Chicago	250	99	3	52	48	53	54	54
Chicago	300	98	3	66	61	68	69	69
Chicago	300	99	3	62	58	64	65	65
Cleveland	As is		3	21	18	22	22	22
Cleveland	Current Std		3	53	53	53	53	53
Cleveland	50	98	3	16	14	16	17	17
Cleveland	50	99	3	14	13	15	15	15
Cleveland	100	98	3	32	28	33	34	34
Cleveland	100	99	3	29	25	30	31	31
Cleveland	150	98	3	47	42	49	51	51
Cleveland	150	99	3	43	38	45	46	46
Cleveland	200	98	3	63	56	66	68	68
Cleveland	200	99	3	57	50	60	61	61
Cleveland	250	98	3	79	70	82	85	85
Cleveland	250	99	3	71	63	74	77	77
Cleveland	300	98	3	95	84	99	102	102
Cleveland	300	99	3	86	75	89	92	92
Denver	As is		3	28	27	28	29	29
Denver	Current Std		3	53	53	53	53	53

Location	Scenario[1]	Percentile[2]	Site-Years	Annual Average NO_2 (ppb)[3]				
				Mean	Min	med	p98	p99
Denver	50	98	3	18	18	18	19	19
Denver	50	99	3	16	16	16	17	17
Denver	100	98	3	37	36	36	38	38
Denver	100	99	3	33	32	32	34	34
Denver	150	98	3	55	54	54	57	57
Denver	150	99	3	49	48	48	51	51
Denver	200	98	3	74	72	73	76	76
Denver	200	99	3	65	64	64	68	68
Denver	250	98	3	92	90	91	96	96
Denver	250	99	3	82	79	81	85	85
Denver	300	98	3	110	107	109	115	115
Denver	300	99	3	98	95	97	102	102
Las Vegas	As is		2	19	19	19	20	20
Las Vegas	Current Std		2	52	51	52	53	53
Las Vegas	50	98	2	16	16	16	16	16
Las Vegas	50	99	2	15	14	15	15	15
Las Vegas	100	98	2	32	31	32	33	33
Las Vegas	100	99	2	30	29	30	30	30
Las Vegas	150	98	2	48	47	48	49	49
Las Vegas	150	99	2	44	43	44	45	45
Las Vegas	200	98	2	64	63	64	65	65
Las Vegas	200	99	2	59	58	59	60	60
Las Vegas	250	98	2	80	78	80	81	81
Las Vegas	250	99	2	74	72	74	75	75
Las Vegas	300	98	2	96	94	96	98	98
Las Vegas	300	99	2	89	87	89	90	90
Los Angeles	As is		6	27	20	29	31	31
Los Angeles	Current Std		6	46	36	47	53	53
Los Angeles	50	98	6	15	11	16	17	17
Los Angeles	50	99	6	14	10	15	16	16
Los Angeles	100	98	6	30	22	32	34	34
Los Angeles	100	99	6	28	20	29	32	32
Los Angeles	150	98	6	45	33	47	52	52
Los Angeles	150	99	6	41	30	44	47	47
Los Angeles	200	98	6	60	44	63	69	69
Los Angeles	200	99	6	55	40	58	63	63
Los Angeles	250	98	6	75	55	79	86	86
Los Angeles	250	99	6	69	51	73	79	79
Los Angeles	300	98	6	90	66	95	103	103
Los Angeles	300	99	6	83	61	87	95	95
Miami	As is		2	6	6	6	6	6
Miami	Current Std		2	24	24	24	24	24
Miami	50	98	2	5	5	5	5	5
Miami	50	99	2	5	5	5	5	5
Miami	100	98	2	10	10	10	11	11

Location	Scenario[1]	Percentile[2]	Site-Years	Annual Average NO_2 (ppb)[3]				
				Mean	Min	med	p98	p99
Miami	100	99	2	10	10	10	10	10
Miami	150	98	2	16	15	16	16	16
Miami	150	99	2	15	14	15	15	15
Miami	200	98	2	21	20	21	21	21
Miami	200	99	2	20	19	20	20	20
Miami	250	98	2	26	25	26	26	26
Miami	250	99	2	24	24	24	25	25
Miami	300	98	2	31	30	31	32	32
Miami	300	99	2	29	29	29	30	30
New York	As is		2	28	27	28	28	28
New York	Current Std		2	44	40	44	49	49
New York	50	98	2	17	17	17	17	17
New York	50	99	2	15	15	15	15	15
New York	100	98	2	34	33	34	35	35
New York	100	99	2	30	29	30	30	30
New York	150	98	2	51	50	51	52	52
New York	150	99	2	44	44	44	45	45
New York	200	98	2	68	67	68	69	69
New York	200	99	2	59	58	59	60	60
New York	250	98	2	85	84	85	87	87
New York	250	99	2	74	73	74	75	75
New York	300	98	2	102	100	102	104	104
New York	300	99	2	89	87	89	90	90
Phoenix	As is		5	23	11	31	32	32
Phoenix	Current Std		5	40	19	53	53	53
Phoenix	50	98	5	14	7	18	19	19
Phoenix	50	99	5	13	6	16	17	17
Phoenix	100	98	5	28	13	37	38	38
Phoenix	100	99	5	25	12	33	34	34
Phoenix	150	98	5	42	20	55	57	57
Phoenix	150	99	5	38	18	49	51	51
Phoenix	200	98	5	56	26	73	75	75
Phoenix	200	99	5	50	24	66	68	68
Phoenix	250	98	5	70	33	92	94	94
Phoenix	250	99	5	63	30	82	85	85
Phoenix	300	98	5	84	40	110	113	113
Phoenix	300	99	5	75	36	99	102	102
St. Louis	As is		5	16	15	16	17	17
St. Louis	Current Std		5	46	38	46	53	53
St. Louis	50	98	5	13	12	13	14	14
St. Louis	50	99	5	13	12	13	14	14
St. Louis	100	98	5	26	24	26	28	28
St. Louis	100	99	5	25	23	25	27	27
St. Louis	150	98	5	39	36	39	42	42
St. Louis	150	99	5	38	35	38	41	41

Location	Scenario[1]	Percentile[2]	Site-Years	Annual Average NO_2 (ppb)[3]				
				Mean	Min	med	p98	p99
St. Louis	200	98	5	52	48	52	56	56
St. Louis	200	99	5	51	47	50	55	55
St. Louis	250	98	5	65	60	65	70	70
St. Louis	250	99	5	63	58	63	68	68
St. Louis	300	98	5	78	72	78	85	85
St. Louis	300	99	5	76	70	75	82	82
Washington DC	As is		5	19	14	18	23	23
Washington DC	Current Std		5	43	36	39	50	50
Washington DC	50	98	5	14	11	13	17	17
Washington DC	50	99	5	12	9	11	14	14
Washington DC	100	98	5	28	22	27	35	35
Washington DC	100	99	5	23	18	22	28	28
Washington DC	150	98	5	42	33	40	52	52
Washington DC	150	99	5	35	27	33	42	42
Washington DC	200	98	5	57	44	53	69	69
Washington DC	200	99	5	46	36	44	57	57
Washington DC	250	98	5	71	55	67	87	87
Washington DC	250	99	5	58	45	54	71	71
Washington DC	300	98	5	85	66	80	104	104
Washington DC	300	99	5	69	54	65	85	85

Notes:
[1] Scenario: As is – unadjusted air quality, Current Std – air quality that just meets the current annual standard, All others – air quality that just meets 1-hour concentration level given percentile form of alternative standard.
[2] Percentile: 98th or 99th percentile of daily maximum 1-hour concentration averaged over three years at maximum monitor in location.
[3] Annual means for each monitor were first calculated based on all simulated hourly values in a year. Then the mean of the annual means was estimated as the sum of all the annual means in a particular location divided by the number of simulated site-years across the monitoring period. The min, med, p98, p99 represent the minimum, median, 98th, and 99th percentiles of the distribution for the annual means.

Table A-126. Estimated annual average NO_2 concentrations on-roads using 2004-2006 air quality *as is*, air quality adjusted to just meet the current and alternative standards, and an on-road adjustment factor.

Location	Scenario[1]	Percentile[2]	Site-Years	Annual Average NO_2 (ppb)[3]				
				Mean	Min	Med	p98	p99
Atlanta	As is		1500	20	4	22	40	42
Atlanta	Current Std		1500	62	13	68	124	128
Atlanta	50	98	1500	14	3	16	28	30
Atlanta	50	99	1500	13	3	14	26	27
Atlanta	100	98	1500	28	6	31	57	59
Atlanta	100	99	1500	26	6	29	52	54
Atlanta	150	98	1500	43	9	47	85	89
Atlanta	150	99	1500	39	8	43	78	81
Atlanta	200	98	1500	57	12	63	114	118
Atlanta	200	99	1500	52	11	57	104	108
Atlanta	250	98	1500	71	15	78	142	148
Atlanta	250	99	1500	65	14	71	130	135
Atlanta	300	98	1500	85	18	94	170	177
Atlanta	300	99	1500	78	17	86	155	162
Boston	As is		800	16	9	15	24	24
Boston	Current Std		800	35	19	34	54	57
Boston	50	98	800	11	7	11	17	18
Boston	50	99	800	10	6	9	14	15
Boston	100	98	800	23	13	22	34	35
Boston	100	99	800	19	11	19	29	30
Boston	150	98	800	34	20	33	51	53
Boston	150	99	800	29	17	28	43	45
Boston	200	98	800	45	26	43	68	70
Boston	200	99	800	38	22	37	58	60
Boston	250	98	800	56	33	54	85	88
Boston	250	99	800	48	28	46	72	75
Boston	300	98	800	68	40	65	102	106
Boston	300	99	800	58	34	56	87	90
Chicago	As is		800	35	20	33	57	60
Chicago	Current Std		800	63	35	59	103	107
Chicago	50	98	800	20	12	19	33	34
Chicago	50	99	800	19	11	18	31	32
Chicago	100	98	800	40	23	38	65	68
Chicago	100	99	800	38	22	36	61	64
Chicago	150	98	800	60	35	57	98	102
Chicago	150	99	800	57	33	54	92	96
Chicago	200	98	800	80	46	76	130	136
Chicago	200	99	800	75	43	72	123	128
Chicago	250	98	800	100	58	95	163	170
Chicago	250	99	800	94	54	89	153	160
Chicago	300	98	800	120	69	114	195	204
Chicago	300	99	800	113	65	107	184	193
Denver	As is		300	36	23	36	51	53
Denver	Current Std		300	69	42	68	99	103

Location	Scenario[1]	Percentile[2]	Site-Years	Annual Average NO_2 (ppb)[3]				
				Mean	Min	Med	p98	p99
Denver	50	98	300	24	15	24	33	35
Denver	50	99	300	21	13	21	30	31
Denver	100	98	300	48	30	47	67	69
Denver	100	99	300	43	27	42	59	62
Denver	150	98	300	72	46	71	100	104
Denver	150	99	300	64	40	63	89	92
Denver	200	98	300	96	61	95	134	139
Denver	200	99	300	85	54	84	119	123
Denver	250	98	300	120	76	118	167	173
Denver	250	99	300	106	67	105	148	154
Denver	300	98	300	144	91	142	201	208
Denver	300	99	300	128	81	126	178	185
Detroit	As is		600	31	18	30	45	47
Detroit	Current Std		600	90	54	88	128	141
Detroit	50	98	600	28	16	27	41	43
Detroit	50	99	600	27	15	26	39	41
Detroit	100	98	600	56	33	55	83	86
Detroit	100	99	600	53	31	52	78	81
Detroit	150	98	600	85	49	82	124	129
Detroit	150	99	600	80	46	78	117	122
Detroit	200	98	600	113	65	110	166	172
Detroit	200	99	600	106	61	103	156	162
Detroit	250	98	600	141	81	137	207	215
Detroit	250	99	600	133	77	129	196	203
Detroit	300	98	600	169	98	164	249	258
Detroit	300	99	600	160	92	155	235	243
El Paso	As is		1200	25	10	25	42	43
El Paso	Current Std		1200	75	30	75	124	127
El Paso	50	98	1200	19	8	19	31	32
El Paso	50	99	1200	17	7	17	28	28
El Paso	100	98	1200	37	15	37	62	63
El Paso	100	99	1200	33	14	33	55	57
El Paso	150	98	1200	56	23	56	93	95
El Paso	150	99	1200	50	21	50	83	85
El Paso	200	98	1200	75	31	74	124	127
El Paso	200	99	1200	67	27	66	111	113
El Paso	250	98	1200	93	38	93	155	159
El Paso	250	99	1200	83	34	83	138	142
El Paso	300	98	1200	112	46	112	186	190
El Paso	300	99	1200	100	41	100	166	170
Jacksonville	As is		200	24	17	23	36	37
Jacksonville	Current Std		200	96	67	93	143	145
Jacksonville	50	98	200	23	16	23	35	35
Jacksonville	50	99	200	16	11	15	24	24
Jacksonville	100	98	200	47	32	45	70	71
Jacksonville	100	99	200	32	22	31	48	49

Location	Scenario[1]	Percentile[2]	Site-Years	Annual Average NO_2 (ppb)[3]				
				Mean	Min	Med	p98	p99
Jacksonville	150	98	200	70	49	68	105	106
Jacksonville	150	99	200	48	33	46	72	73
Jacksonville	200	98	200	94	65	90	140	142
Jacksonville	200	99	200	64	44	62	96	97
Jacksonville	250	98	200	117	81	113	175	177
Jacksonville	250	99	200	80	55	77	119	121
Jacksonville	300	98	200	141	97	136	209	213
Jacksonville	300	99	200	96	67	93	143	146
Las Vegas	As is		1100	16	2	11	44	46
Las Vegas	Current Std		1100	43	5	30	118	123
Las Vegas	50	98	1100	13	1	9	36	38
Las Vegas	50	99	1100	12	1	8	33	35
Las Vegas	100	98	1100	26	3	18	72	76
Las Vegas	100	99	1100	24	3	17	67	70
Las Vegas	150	98	1100	40	4	27	108	113
Las Vegas	150	99	1100	37	4	25	100	105
Las Vegas	200	98	1100	53	6	36	145	151
Las Vegas	200	99	1100	49	5	34	134	140
Las Vegas	250	98	1100	66	7	45	181	189
Las Vegas	250	99	1100	61	7	42	167	174
Las Vegas	300	98	1100	79	9	54	217	227
Las Vegas	300	99	1100	73	8	50	200	209
Los Angeles	As is		5400	33	6	32	60	65
Los Angeles	Current Std		5400	56	10	54	102	109
Los Angeles	50	98	5400	18	3	18	33	36
Los Angeles	50	99	5400	17	3	16	31	33
Los Angeles	100	98	5400	36	6	35	66	72
Los Angeles	100	99	5400	33	6	32	61	66
Los Angeles	150	98	5400	54	9	53	100	107
Los Angeles	150	99	5400	50	9	49	92	99
Los Angeles	200	98	5400	73	13	71	133	143
Los Angeles	200	99	5400	67	12	65	122	131
Los Angeles	250	98	5400	91	16	88	166	179
Los Angeles	250	99	5400	83	15	81	153	164
Los Angeles	300	98	5400	109	19	106	199	215
Los Angeles	300	99	5400	100	17	97	183	197
Miami	As is		400	14	9	13	19	20
Miami	Current Std		400	55	35	53	77	80
Miami	50	98	400	12	8	12	17	17
Miami	50	99	400	11	7	11	16	16
Miami	100	98	400	24	16	23	34	34
Miami	100	99	400	23	15	22	32	32
Miami	150	98	400	36	24	35	51	51
Miami	150	99	400	34	22	33	48	48
Miami	200	98	400	48	32	47	68	69
Miami	200	99	400	45	30	44	64	65

Location	Scenario[1]	Percentile[2]	Site-Years	Annual Average NO_2 (ppb)[3]				
				Mean	Min	Med	p98	p99
Miami	250	98	400	60	40	59	85	86
Miami	250	99	400	57	37	55	80	81
Miami	300	98	400	72	48	70	102	103
Miami	300	99	400	68	45	66	96	97
New York	As is		2200	35	12	35	58	61
New York	Current Std		2200	55	20	55	94	99
New York	50	98	2200	21	7	21	36	37
New York	50	99	2200	18	6	18	31	32
New York	100	98	2200	42	15	42	71	75
New York	100	99	2200	37	13	37	62	65
New York	150	98	2200	64	22	64	107	112
New York	150	99	2200	55	19	55	93	97
New York	200	98	2200	85	30	85	142	150
New York	200	99	2200	74	26	74	123	130
New York	250	98	2200	106	37	106	178	187
New York	250	99	2200	92	32	92	154	162
New York	300	98	2200	127	45	127	214	225
New York	300	99	2200	110	39	110	185	195
Philadelphia	As is		1200	31	18	30	51	59
Philadelphia	Current Std		1200	70	37	68	112	123
Philadelphia	50	98	1200	24	14	23	39	45
Philadelphia	50	99	1200	19	11	18	31	36
Philadelphia	100	98	1200	47	27	45	78	89
Philadelphia	100	99	1200	38	22	36	63	72
Philadelphia	150	98	1200	71	41	68	117	134
Philadelphia	150	99	1200	57	33	55	94	108
Philadelphia	200	98	1200	95	54	91	155	178
Philadelphia	200	99	1200	76	44	73	125	143
Philadelphia	250	98	1200	118	68	113	194	223
Philadelphia	250	99	1200	95	54	91	156	179
Philadelphia	300	98	1200	142	81	136	233	267
Philadelphia	300	99	1200	114	65	109	188	215
Phoenix	As is		900	43	26	42	64	65
Phoenix	Current Std		900	73	45	71	107	109
Phoenix	50	98	900	26	16	25	38	39
Phoenix	50	99	900	23	14	23	34	35
Phoenix	100	98	900	51	31	50	76	77
Phoenix	100	99	900	46	28	45	68	70
Phoenix	150	98	900	77	47	75	114	116
Phoenix	150	99	900	69	42	68	103	105
Phoenix	200	98	900	103	63	100	152	155
Phoenix	200	99	900	92	56	90	137	139
Phoenix	250	98	900	128	78	125	190	194
Phoenix	250	99	900	116	70	113	171	174
Phoenix	300	98	900	154	94	150	228	232
Phoenix	300	99	900	139	85	135	205	209

Location	Scenario[1]	Percentile[2]	Site-Years	Annual Average NO_2 (ppb)[3]				
				Mean	Min	Med	p98	p99
Provo	As is		300	43	26	41	70	71
Provo	Current Std		300	94	67	93	129	131
Provo	50	98	300	23	14	22	37	38
Provo	50	99	300	22	14	21	37	37
Provo	100	98	300	45	28	43	75	76
Provo	100	99	300	45	27	42	73	74
Provo	150	98	300	68	41	65	112	114
Provo	150	99	300	67	41	64	110	111
Provo	200	98	300	91	55	87	149	151
Provo	200	99	300	89	54	85	146	148
Provo	250	98	300	114	69	108	186	189
Provo	250	99	300	111	68	106	183	185
Provo	300	98	300	136	83	130	224	227
Provo	300	99	300	134	81	127	219	222
St. Louis	As is		400	27	16	26	41	42
St. Louis	Current Std		400	68	38	66	114	119
St. Louis	50	98	400	22	13	21	34	34
St. Louis	50	99	400	21	13	20	33	33
St. Louis	100	98	400	43	26	42	67	68
St. Louis	100	99	400	42	25	41	65	66
St. Louis	150	98	400	65	39	63	101	102
St. Louis	150	99	400	63	38	61	98	99
St. Louis	200	98	400	87	52	84	134	136
St. Louis	200	99	400	84	50	81	130	132
St. Louis	250	98	400	109	65	105	168	171
St. Louis	250	99	400	105	63	102	163	165
St. Louis	300	98	400	130	78	126	201	205
St. Louis	300	99	400	126	75	122	195	198
Washington DC	As is		1700	28	9	28	51	52
Washington DC	Current Std		1700	64	23	66	114	121
Washington DC	50	98	1700	21	7	21	39	40
Washington DC	50	99	1700	17	5	17	31	32
Washington DC	100	98	1700	42	13	42	77	79
Washington DC	100	99	1700	34	11	35	63	65
Washington DC	150	98	1700	63	20	64	116	119
Washington DC	150	99	1700	51	16	52	94	97
Washington DC	200	98	1700	84	26	85	154	158
Washington DC	200	99	1700	68	21	69	126	129
Washington DC	250	98	1700	104	33	106	193	198
Washington DC	250	99	1700	85	27	86	157	161
Washington DC	300	98	1700	125	39	127	231	238
Washington DC	300	99	1700	102	32	104	189	194
Other MSA	As is		56500	20	1	20	41	45
Other MSA	Current Std		56500	47	3	45	97	105
Other MSA	50	98	56500	12	1	11	24	26
Other MSA	50	99	56500	11	1	10	22	24

Location	Scenario[1]	Percentile[2]	Site-Years	Annual Average NO_2 (ppb)[3]				
				Mean	Min	Med	p98	p99
Other MSA	100	98	56500	23	1	23	48	52
Other MSA	100	99	56500	21	1	21	44	48
Other MSA	150	98	56500	35	2	34	72	77
Other MSA	150	99	56500	32	2	31	66	71
Other MSA	200	98	56500	46	2	45	96	103
Other MSA	200	99	56500	43	2	42	88	95
Other MSA	250	98	56500	58	3	57	120	129
Other MSA	250	99	56500	53	3	52	110	119
Other MSA	300	98	56500	70	4	68	144	155
Other MSA	300	99	56500	64	3	62	132	143
Other Not MSA	As is		11600	12	1	10	31	33
Other Not MSA	Current Std		11600	39	3	34	100	109
Other Not MSA	50	98	11600	6	1	6	16	18
Other Not MSA	50	99	11600	5	0	5	13	14
Other Not MSA	100	98	11600	13	1	11	33	35
Other Not MSA	100	99	11600	10	1	9	26	28
Other Not MSA	150	98	11600	19	2	17	49	53
Other Not MSA	150	99	11600	15	1	14	39	43
Other Not MSA	200	98	11600	25	2	22	65	71
Other Not MSA	200	99	11600	20	2	18	53	57
Other Not MSA	250	98	11600	32	3	28	82	88
Other Not MSA	250	99	11600	25	2	23	66	71
Other Not MSA	300	98	11600	38	3	34	98	106
Other Not MSA	300	99	11600	30	3	27	79	85

Notes:

[1] Scenario: As is – unadjusted air quality, Current Std – air quality that just meets the current annual standard, All others – air quality that just meets 1-hour concentration level given percentile form of alternative standard.

[2] Percentile: 98th or 99th percentile of daily maximum 1-hour concentration averaged over three years at maximum monitor in location.

[3] Annual means for each monitor were first calculated based on all simulated hourly values in a year. Then the mean of the annual means was estimated as the sum of all the annual means in a particular location divided by the number of simulated site-years across the monitoring period. The min, med, p98, p99 represent the minimum, median, 98th, and 99th percentiles of the distribution for the annual means.

Table A-127. Estimated number of exceedances of 1-hour concentration levels (100, 150, and 200 ppb) for monitors ≥100 m from a major road following adjustment to just meeting the current and alternative standards, 2004-2006 air quality.

Location	Standard	Percentile	Site-Years	Number of Daily Maximum Exceedances														
				≥ 100 ppb					≥ 150 ppb					≥ 200 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
Atlanta	As is		15	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
Atlanta	Current Std		15	96	1	121	188	188	24	0	15	73	73	4	0	0	20	20
Atlanta	50	98	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Atlanta	50	99	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Atlanta	100	98	15	2	0	0	17	17	0	0	0	1	1	0	0	0	0	0
Atlanta	100	99	15	1	0	0	7	7	0	0	0	1	1	0	0	0	0	0
Atlanta	150	98	15	28	0	16	83	83	2	0	0	17	17	0	0	0	1	1
Atlanta	150	99	15	19	0	10	65	65	1	0	0	7	7	0	0	0	1	1
Atlanta	200	98	15	81	0	90	168	168	15	0	6	58	58	2	0	0	17	17
Atlanta	200	99	15	66	0	67	144	144	8	0	2	39	39	1	0	0	7	7
Atlanta	250	98	15	122	3	171	235	235	47	0	43	114	114	11	0	3	49	49
Atlanta	250	99	15	105	1	133	205	205	32	0	19	89	89	5	0	0	25	25
Atlanta	300	98	15	157	8	228	281	281	81	0	90	168	168	28	0	16	83	83
Atlanta	300	99	15	143	4	209	266	266	66	0	67	144	144	19	0	10	65	65
Boston	As is		8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Boston	Current Std		8	5	0	5	10	10	0	0	0	0	0	0	0	0	0	0
Boston	50	98	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Boston	50	99	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Boston	100	98	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Boston	100	99	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Boston	150	98	8	2	0	2	7	7	0	0	0	0	0	0	0	0	0	0
Boston	150	99	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Boston	200	98	8	29	13	26	54	54	0	0	0	2	2	0	0	0	0	0
Boston	200	99	8	9	2	8	20	20	0	0	0	0	0	0	0	0	0	0
Boston	250	98	8	72	32	67	102	102	7	1	6	13	13	0	0	0	0	0
Boston	250	99	8	38	15	35	67	67	1	0	1	6	6	0	0	0	0	0
Boston	300	98	8	105	56	102	138	138	29	13	26	54	54	2	0	2	7	7
Boston	300	99	8	72	32	67	102	102	9	2	8	20	20	0	0	0	0	0
Chicago	As is		8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chicago	Current Std		8	23	7	14	69	69	1	0	0	3	3	0	0	0	0	0

Location	Standard	Percentile	Site-Years	Number of Daily Maximum Exceedances														
				≥ 100 ppb					≥ 150 ppb					≥ 200 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
Chicago	50	98	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chicago	50	99	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chicago	100	98	8	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
Chicago	100	99	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chicago	150	98	8	18	5	9	56	56	0	0	0	1	1	0	0	0	0	0
Chicago	150	99	8	13	2	5	42	42	0	0	0	0	0	0	0	0	0	0
Chicago	200	98	8	84	32	69	158	158	9	2	4	32	32	0	0	0	1	1
Chicago	200	99	8	62	22	49	123	123	5	0	2	21	21	0	0	0	0	0
Chicago	250	98	8	161	90	149	240	240	34	10	20	83	83	4	0	2	16	16
Chicago	250	99	8	138	69	123	215	215	25	7	14	69	69	2	0	1	8	8
Chicago	300	98	8	227	149	231	298	298	84	32	69	158	158	18	5	9	56	56
Chicago	300	99	8	214	132	217	285	285	62	22	49	123	123	13	2	5	42	42
Denver	As is		3	1	0	0	3	3	0	0	0	0	0	0	0	0	0	0
Denver	Current Std		3	60	41	67	73	73	4	2	4	7	7	1	0	0	2	2
Denver	50	98	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Denver	50	99	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Denver	100	98	3	6	4	6	9	9	0	0	0	0	0	0	0	0	0	0
Denver	100	99	3	3	1	1	7	7	0	0	0	0	0	0	0	0	0	0
Denver	150	98	3	76	67	80	81	81	6	4	6	9	9	1	0	0	2	2
Denver	150	99	3	40	30	41	50	50	3	1	1	7	7	0	0	0	0	0
Denver	200	98	3	211	184	215	233	233	45	32	49	53	53	6	4	6	9	9
Denver	200	99	3	159	141	153	183	183	15	6	17	22	22	3	1	1	7	7
Denver	250	98	3	263	232	276	281	281	124	111	120	142	142	27	18	31	33	33
Denver	250	99	3	231	199	247	248	248	68	57	73	73	73	11	4	13	16	16
Denver	300	98	3	289	255	305	306	306	211	184	215	233	233	76	67	80	81	81
Denver	300	99	3	274	240	289	294	294	159	141	153	183	183	40	30	41	50	50
Detroit	As is		6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Detroit	Current Std		6	142	91	145	174	174	13	7	13	21	21	0	0	0	1	1
Detroit	50	98	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Detroit	50	99	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Detroit	100	98	6	8	1	6	18	18	0	0	0	1	1	0	0	0	0	0
Detroit	100	99	6	5	0	4	10	10	0	0	0	0	0	0	0	0	0	0

Location	Standard	Percentile	Site-Years	Number of Daily Maximum Exceedances														
				≥ 100 ppb					≥ 150 ppb					≥ 200 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
Detroit	150	98	6	107	67	100	164	164	8	1	6	18	18	1	0	1	1	1
Detroit	150	99	6	88	52	84	137	137	5	0	4	10	10	0	0	0	1	1
Detroit	200	98	6	209	172	201	265	265	67	40	61	108	108	8	1	6	18	18
Detroit	200	99	6	194	159	188	247	247	44	19	42	73	73	5	0	4	10	10
Detroit	250	98	6	273	241	274	320	320	149	116	143	208	208	44	19	42	73	73
Detroit	250	99	6	253	220	250	307	307	127	90	120	188	188	27	9	26	54	54
Detroit	300	98	6	297	263	302	335	335	209	172	201	265	265	107	67	100	164	164
Detroit	300	99	6	290	258	293	329	329	194	159	188	247	247	88	52	84	137	137
El Paso	As is		12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
El Paso	Current Std		12	157	79	172	216	216	26	5	24	58	58	4	0	4	11	11
El Paso	50	98	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
El Paso	50	99	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
El Paso	100	98	12	4	0	4	10	10	0	0	0	0	0	0	0	0	0	0
El Paso	100	99	12	2	0	1	4	4	0	0	0	0	0	0	0	0	0	0
El Paso	150	98	12	52	12	48	111	111	4	0	4	10	10	0	0	0	1	1
El Paso	150	99	12	26	6	23	59	59	2	0	1	4	4	0	0	0	0	0
El Paso	200	98	12	159	79	172	227	227	26	6	23	59	59	4	0	4	10	10
El Paso	200	99	12	116	45	123	192	192	12	2	11	25	25	2	0	1	4	4
El Paso	250	98	12	228	130	238	290	290	84	27	85	156	156	18	4	14	37	37
El Paso	250	99	12	188	94	198	251	251	46	11	42	100	100	8	1	8	15	15
El Paso	300	98	12	259	163	265	314	314	159	79	172	227	227	52	12	48	111	111
El Paso	300	99	12	236	133	245	296	296	116	45	123	192	192	26	6	23	59	59
Jacksonville	As is		2	2	0	2	3	3	1	0	1	2	2	1	0	1	1	1
Jacksonville	Current Std		2	178	161	178	194	194	51	42	51	60	60	8	6	8	9	9
Jacksonville	50	98	2	2	0	2	3	3	1	0	1	2	2	0	0	0	0	0
Jacksonville	50	99	2	1	0	1	2	2	0	0	0	0	0	0	0	0	0	0
Jacksonville	100	98	2	7	5	7	9	9	2	0	2	4	4	2	0	2	3	3
Jacksonville	100	99	2	2	0	2	4	4	2	0	2	3	3	1	0	1	2	2
Jacksonville	150	98	2	78	65	78	90	90	7	5	7	9	9	3	0	3	5	5
Jacksonville	150	99	2	9	6	9	11	11	2	0	2	4	4	2	0	2	3	3
Jacksonville	200	98	2	178	161	178	194	194	48	42	48	54	54	7	5	7	9	9
Jacksonville	200	99	2	53	46	53	60	60	4	2	4	6	6	2	0	2	4	4

Location	Standard	Percentile	Site-Years	Number of Daily Maximum Exceedances														
				≥ 100 ppb					≥ 150 ppb					≥ 200 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
Jacksonville	250	98	2	237	226	237	247	247	109	97	109	121	121	32	31	32	32	32
Jacksonville	250	99	2	117	103	117	131	131	15	12	15	18	18	3	1	3	5	5
Jacksonville	300	98	2	271	262	271	279	279	178	161	178	194	194	78	65	78	90	90
Jacksonville	300	99	2	178	161	178	194	194	53	46	53	60	60	9	6	9	11	11
Las Vegas	As is		11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Las Vegas	Current Std		11	72	0	12	249	249	6	0	0	26	26	0	0	0	1	1
Las Vegas	50	98	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Las Vegas	50	99	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Las Vegas	100	98	11	2	0	0	9	9	0	0	0	0	0	0	0	0	0	0
Las Vegas	100	99	11	1	0	0	4	4	0	0	0	0	0	0	0	0	0	0
Las Vegas	150	98	11	55	0	5	209	209	2	0	0	9	9	0	0	0	0	0
Las Vegas	150	99	11	40	0	3	165	165	1	0	0	4	4	0	0	0	0	0
Las Vegas	200	98	11	108	2	43	305	305	31	0	2	128	128	2	0	0	9	9
Las Vegas	200	99	11	97	1	31	286	286	17	0	0	66	66	1	0	0	4	4
Las Vegas	250	98	11	150	7	105	327	327	77	0	15	257	257	19	0	1	81	81
Las Vegas	250	99	11	134	5	81	322	322	60	0	7	219	219	10	0	0	39	39
Las Vegas	300	98	11	186	18	167	339	339	108	2	43	305	305	55	0	5	209	209
Las Vegas	300	99	11	176	16	150	337	337	97	1	31	286	286	40	0	3	165	165
Los Angeles	As is		54	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0
Los Angeles	Current Std		54	19	0	17	55	85	1	0	0	4	6	0	0	0	0	0
Los Angeles	50	98	54	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Los Angeles	50	99	54	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Los Angeles	100	98	54	1	0	0	5	8	0	0	0	0	0	0	0	0	0	0
Los Angeles	100	99	54	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0
Los Angeles	150	98	54	17	0	15	66	75	1	0	0	5	8	0	0	0	0	1
Los Angeles	150	99	54	10	0	8	45	46	0	0	0	2	2	0	0	0	0	0
Los Angeles	200	98	54	70	2	68	176	186	8	0	6	29	32	1	0	0	5	8
Los Angeles	200	99	54	50	0	46	135	157	4	0	2	18	21	0	0	0	2	2
Los Angeles	250	98	54	139	12	153	279	284	31	0	30	98	112	6	0	4	22	24
Los Angeles	250	99	54	112	10	120	248	257	19	0	18	68	79	3	0	2	14	14
Los Angeles	300	98	54	194	30	209	322	328	70	2	68	176	186	17	0	15	66	75
Los Angeles	300	99	54	176	24	190	306	318	50	0	46	135	157	10	0	8	45	46

Location	Standard	Percentile	Site-Years	Number of Daily Maximum Exceedances														
				≥ 100 ppb					≥ 150 ppb					≥ 200 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
Miami	As is		4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Miami	Current Std		4	102	57	104	143	143	33	7	33	59	59	7	0	4	18	18
Miami	50	98	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Miami	50	99	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Miami	100	98	4	3	0	2	8	8	0	0	0	1	1	0	0	0	0	0
Miami	100	99	4	2	0	1	5	5	0	0	0	1	1	0	0	0	0	0
Miami	150	98	4	33	7	30	64	64	3	0	2	8	8	0	0	0	1	1
Miami	150	99	4	23	2	23	45	45	2	0	1	5	5	0	0	0	1	1
Miami	200	98	4	74	36	72	115	115	18	1	18	34	34	3	0	2	8	8
Miami	200	99	4	64	29	62	104	104	12	1	12	25	25	2	0	1	5	5
Miami	250	98	4	122	82	124	157	157	44	12	44	77	77	12	1	12	25	25
Miami	250	99	4	105	62	108	143	143	37	10	35	66	66	9	0	8	18	18
Miami	300	98	4	157	129	160	181	181	74	36	72	115	115	33	7	30	64	64
Miami	300	99	4	139	106	139	171	171	64	29	62	104	104	23	2	23	45	45
New York	As is		22	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0
New York	Current Std		22	11	0	12	36	36	0	0	0	2	2	0	0	0	1	1
New York	50	98	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
New York	50	99	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
New York	100	98	22	1	0	1	4	4	0	0	0	1	1	0	0	0	0	0
New York	100	99	22	1	0	0	4	4	0	0	0	1	1	0	0	0	0	0
New York	150	98	22	27	0	31	56	56	1	0	1	4	4	0	0	0	1	1
New York	150	99	22	12	0	13	28	28	1	0	0	4	4	0	0	0	1	1
New York	200	98	22	108	8	132	178	178	13	0	14	35	35	1	0	1	4	4
New York	200	99	22	63	0	79	111	111	5	0	5	15	15	1	0	0	4	4
New York	250	98	22	185	46	213	266	266	52	0	67	96	96	8	0	9	22	22
New York	250	99	22	135	17	162	211	211	21	0	24	52	52	3	0	3	9	9
New York	300	98	22	233	75	257	312	312	108	8	132	178	178	27	0	31	56	56
New York	300	99	22	196	52	226	275	275	63	0	79	111	111	12	0	13	28	28
Philadelphia	As is		12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Philadelphia	Current Std		12	54	7	38	138	138	4	0	2	14	14	0	0	0	2	2
Philadelphia	50	98	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Philadelphia	50	99	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Location	Standard	Percentile	Site-Years	Number of Daily Maximum Exceedances														
				≥ 100 ppb					≥ 150 ppb					≥ 200 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
Philadelphia	100	98	12	3	0	2	10	10	0	0	0	1	1	0	0	0	0	0
Philadelphia	100	99	12	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0
Philadelphia	150	98	12	52	21	46	96	96	3	0	2	10	10	0	0	0	1	1
Philadelphia	150	99	12	12	1	12	33	33	0	0	0	2	2	0	0	0	0	0
Philadelphia	200	98	12	163	103	149	246	246	24	4	21	54	54	3	0	2	10	10
Philadelphia	200	99	12	77	40	67	134	134	4	0	3	14	14	0	0	0	2	2
Philadelphia	250	98	12	231	186	229	293	293	85	42	75	146	146	16	2	16	41	41
Philadelphia	250	99	12	163	103	149	246	246	24	4	21	54	54	3	0	2	10	10
Philadelphia	300	98	12	278	239	281	325	325	163	103	149	246	246	52	21	46	96	96
Philadelphia	300	99	12	220	165	218	290	290	77	40	67	134	134	12	1	12	33	33
Phoenix	As is		9	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
Phoenix	Current Std		9	40	19	29	78	78	1	0	0	2	2	0	0	0	0	0
Phoenix	50	98	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phoenix	50	99	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phoenix	100	98	9	1	0	1	5	5	0	0	0	0	0	0	0	0	0	0
Phoenix	100	99	9	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0
Phoenix	150	98	9	65	37	55	105	105	1	0	1	5	5	0	0	0	0	0
Phoenix	150	99	9	25	10	23	43	43	0	0	0	2	2	0	0	0	0	0
Phoenix	200	98	9	224	167	235	245	245	21	8	18	36	36	1	0	1	5	5
Phoenix	200	99	9	163	126	160	195	195	6	0	7	10	10	0	0	0	2	2
Phoenix	250	98	9	298	208	307	324	324	116	80	100	158	158	12	0	11	21	21
Phoenix	250	99	9	265	188	275	292	292	65	37	55	105	105	3	0	3	7	7
Phoenix	300	98	9	330	249	337	352	352	224	167	235	245	245	65	37	55	105	105
Phoenix	300	99	9	317	230	326	338	338	163	126	160	195	195	25	10	23	43	43
Provo	As is		3	14	0	0	43	43	7	0	0	20	20	0	0	0	0	0
Provo	Current Std		3	129	56	137	194	194	19	3	12	43	43	14	0	1	42	42
Provo	50	98	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Provo	50	99	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Provo	100	98	3	14	0	0	43	43	10	0	0	29	29	0	0	0	0	0
Provo	100	99	3	14	0	0	43	43	8	0	0	23	23	0	0	0	0	0
Provo	150	98	3	19	1	14	43	43	14	0	0	43	43	13	0	0	40	40
Provo	150	99	3	19	1	12	43	43	14	0	0	43	43	13	0	0	40	40

Location	Standard	Percentile	Site-Years	Number of Daily Maximum Exceedances														
				≥ 100 ppb					≥ 150 ppb					≥ 200 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
Provo	200	98	3	84	64	90	98	98	16	0	6	43	43	14	0	0	43	43
Provo	200	99	3	74	50	82	91	91	16	0	5	43	43	14	0	0	43	43
Provo	250	98	3	209	198	213	216	216	25	5	22	49	49	15	0	2	43	43
Provo	250	99	3	196	191	194	202	202	23	3	20	47	47	15	0	2	43	43
Provo	300	98	3	281	242	296	305	305	84	64	90	98	98	19	1	14	43	43
Provo	300	99	3	281	242	296	305	305	74	50	82	91	91	19	1	12	43	43
St. Louis	As is		4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
St. Louis	Current Std		4	67	15	50	154	154	6	0	1	22	22	0	0	0	1	1
St. Louis	50	98	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
St. Louis	50	99	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
St. Louis	100	98	4	1	0	1	3	3	0	0	0	0	0	0	0	0	0	0
St. Louis	100	99	4	1	0	1	2	2	0	0	0	0	0	0	0	0	0	0
St. Louis	150	98	4	58	31	54	94	94	1	0	1	3	3	0	0	0	0	0
St. Louis	150	99	4	49	23	42	88	88	1	0	1	2	2	0	0	0	0	0
St. Louis	200	98	4	146	112	143	186	186	25	2	22	55	55	1	0	1	3	3
St. Louis	200	99	4	134	100	128	179	179	16	1	14	36	36	1	0	1	2	2
St. Louis	250	98	4	211	160	206	272	272	88	57	83	127	127	16	1	13	35	35
St. Louis	250	99	4	201	153	197	256	256	82	49	78	121	121	12	0	9	28	28
St. Louis	300	98	4	255	191	258	313	313	146	112	143	186	186	58	31	54	94	94
St. Louis	300	99	4	255	191	258	313	313	134	100	128	179	179	49	23	42	88	88
Washington DC	As is		17	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0
Washington DC	Current Std		17	52	0	61	149	149	4	0	3	14	14	1	0	0	3	3
Washington DC	50	98	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Washington DC	50	99	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Washington DC	100	98	17	3	0	2	12	12	0	0	0	2	2	0	0	0	0	0
Washington DC	100	99	17	1	0	0	6	6	0	0	0	0	0	0	0	0	0	0
Washington DC	150	98	17	50	0	52	120	120	3	0	2	12	12	1	0	0	4	4
Washington DC	150	99	17	16	0	14	46	46	1	0	0	6	6	0	0	0	1	1
Washington DC	200	98	17	133	12	149	246	246	26	0	25	67	67	3	0	2	12	12
Washington DC	200	99	17	69	0	69	160	160	5	0	3	20	20	1	0	0	6	6
Washington DC	250	98	17	190	42	230	299	299	77	0	80	171	171	17	0	14	49	49
Washington DC	250	99	17	133	12	149	246	246	29	0	28	74	74	4	0	2	14	14

Location	Standard	Percentile	Site-Years	Number of Daily Maximum Exceedances														
				≥ 100 ppb					≥ 150 ppb					≥ 200 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
Washington DC	300	98	17	237	90	278	333	333	133	12	149	246	246	50	0	52	120	120
Washington DC	300	99	17	190	42	230	299	299	69	0	69	160	160	16	0	14	46	46
Other MSA	As is		565	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
Other MSA	Current Std		565	28	0	12	141	156	2	0	0	23	27	0	0	0	2	4
Other MSA	50	98	565	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other MSA	50	99	565	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other MSA	100	98	565	0	0	0	2	4	0	0	0	0	1	0	0	0	0	0
Other MSA	100	99	565	0	0	0	1	1	0	0	0	0	1	0	0	0	0	0
Other MSA	150	98	565	4	0	1	29	37	0	0	0	2	4	0	0	0	0	1
Other MSA	150	99	565	2	0	0	18	23	0	0	0	1	1	0	0	0	0	1
Other MSA	200	98	565	24	0	12	112	128	2	0	0	15	19	0	0	0	2	4
Other MSA	200	99	565	16	0	7	85	110	1	0	0	8	10	0	0	0	1	1
Other MSA	250	98	565	65	0	53	212	228	8	0	2	52	63	1	0	0	9	13
Other MSA	250	99	565	48	0	34	170	191	4	0	1	31	41	0	0	0	5	7
Other MSA	300	98	565	109	0	104	267	300	24	0	12	112	128	4	0	1	29	37
Other MSA	300	99	565	86	0	77	242	274	16	0	7	85	110	2	0	0	18	23
Other Not MSA	As is		116	0	0	0	2	3	0	0	0	0	2	0	0	0	0	1
Other Not MSA	Current Std		116	37	0	11	192	195	7	0	0	69	78	1	0	0	20	22
Other Not MSA	50	98	116	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Other Not MSA	50	99	116	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Other Not MSA	100	98	116	0	0	0	3	5	0	0	0	0	2	0	0	0	0	1
Other Not MSA	100	99	116	0	0	0	2	2	0	0	0	0	2	0	0	0	0	1
Other Not MSA	150	98	116	1	0	0	16	19	0	0	0	3	5	0	0	0	1	2
Other Not MSA	150	99	116	0	0	0	7	9	0	0	0	2	2	0	0	0	0	2
Other Not MSA	200	98	116	7	0	0	71	80	1	0	0	12	14	0	0	0	3	5
Other Not MSA	200	99	116	2	0	0	26	26	0	0	0	3	6	0	0	0	2	2
Other Not MSA	250	98	116	18	0	2	116	147	2	0	0	30	31	0	0	0	9	11
Other Not MSA	250	99	116	7	0	0	71	80	1	0	0	12	15	0	0	0	3	5
Other Not MSA	300	98	116	34	0	8	165	199	7	0	0	71	80	1	0	0	16	19
Other Not MSA	300	99	116	16	0	1	112	144	2	0	0	26	26	0	0	0	7	9

Table a-128. Estimated number of exceedances of 1-hour concentration levels (250 and 300 ppb) for monitors ≥100 m from a major road following adjustment to just meeting the current and alternative standards, 2004-2006 air quality.

				Number of Daily Maximum Exceedances									
				≥ 250 ppb					≥ 300 ppb				
Location	Standard	Percentile	Site-Years	Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
Atlanta	As is		15	0	0	0	0	0	0	0	0	0	0
Atlanta	Current Std		15	0	0	0	4	4	0	0	0	1	1
Atlanta	50	98	15	0	0	0	0	0	0	0	0	0	0
Atlanta	50	99	15	0	0	0	0	0	0	0	0	0	0
Atlanta	100	98	15	0	0	0	0	0	0	0	0	0	0
Atlanta	100	99	15	0	0	0	0	0	0	0	0	0	0
Atlanta	150	98	15	0	0	0	1	1	0	0	0	0	0
Atlanta	150	99	15	0	0	0	0	0	0	0	0	0	0
Atlanta	200	98	15	0	0	0	2	2	0	0	0	1	1
Atlanta	200	99	15	0	0	0	1	1	0	0	0	1	1
Atlanta	250	98	15	2	0	0	17	17	0	0	0	2	2
Atlanta	250	99	15	1	0	0	7	7	0	0	0	1	1
Atlanta	300	98	15	8	0	1	36	36	2	0	0	17	17
Atlanta	300	99	15	4	0	0	22	22	1	0	0	7	7
Boston	As is		8	0	0	0	0	0	0	0	0	0	0
Boston	Current Std		8	0	0	0	0	0	0	0	0	0	0
Boston	50	98	8	0	0	0	0	0	0	0	0	0	0
Boston	50	99	8	0	0	0	0	0	0	0	0	0	0
Boston	100	98	8	0	0	0	0	0	0	0	0	0	0
Boston	100	99	8	0	0	0	0	0	0	0	0	0	0
Boston	150	98	8	0	0	0	0	0	0	0	0	0	0
Boston	150	99	8	0	0	0	0	0	0	0	0	0	0
Boston	200	98	8	0	0	0	0	0	0	0	0	0	0
Boston	200	99	8	0	0	0	0	0	0	0	0	0	0
Boston	250	98	8	0	0	0	0	0	0	0	0	0	0
Boston	250	99	8	0	0	0	0	0	0	0	0	0	0
Boston	300	98	8	0	0	0	0	0	0	0	0	0	0
Boston	300	99	8	0	0	0	0	0	0	0	0	0	0
Chicago	As is		8	0	0	0	0	0	0	0	0	0	0
Chicago	Current Std		8	0	0	0	0	0	0	0	0	0	0
Chicago	50	98	8	0	0	0	0	0	0	0	0	0	0
Chicago	50	99	8	0	0	0	0	0	0	0	0	0	0
Chicago	100	98	8	0	0	0	0	0	0	0	0	0	0
Chicago	100	99	8	0	0	0	0	0	0	0	0	0	0
Chicago	150	98	8	0	0	0	0	0	0	0	0	0	0
Chicago	150	99	8	0	0	0	0	0	0	0	0	0	0
Chicago	200	98	8	0	0	0	0	0	0	0	0	0	0
Chicago	200	99	8	0	0	0	0	0	0	0	0	0	0
Chicago	250	98	8	0	0	0	1	1	0	0	0	0	0
Chicago	250	99	8	0	0	0	0	0	0	0	0	0	0
Chicago	300	98	8	2	0	2	10	10	0	0	0	1	1
Chicago	300	99	8	1	0	1	5	5	0	0	0	0	0

Location	Standard	Percentile	Site-Years	Number of Daily Maximum Exceedances ≥ 250 ppb Mean	Min	Med	p98	p99	≥ 300 ppb Mean	Min	Med	p98	p99
Denver	As is		3	0	0	0	0	0	0	0	0	0	0
Denver	Current Std		3	0	0	0	0	0	0	0	0	0	0
Denver	50	98	3	0	0	0	0	0	0	0	0	0	0
Denver	50	99	3	0	0	0	0	0	0	0	0	0	0
Denver	100	98	3	0	0	0	0	0	0	0	0	0	0
Denver	100	99	3	0	0	0	0	0	0	0	0	0	0
Denver	150	98	3	0	0	0	0	0	0	0	0	0	0
Denver	150	99	3	0	0	0	0	0	0	0	0	0	0
Denver	200	98	3	2	0	1	4	4	0	0	0	0	0
Denver	200	99	3	0	0	0	1	1	0	0	0	0	0
Denver	250	98	3	5	4	5	7	7	2	0	1	5	5
Denver	250	99	3	3	1	1	7	7	1	0	0	2	2
Denver	300	98	3	17	8	20	24	24	6	4	6	9	9
Denver	300	99	3	9	4	11	11	11	3	1	1	7	7
Detroit	As is		6	0	0	0	0	0	0	0	0	0	0
Detroit	Current Std		6	0	0	0	0	0	0	0	0	0	0
Detroit	50	98	6	0	0	0	0	0	0	0	0	0	0
Detroit	50	99	6	0	0	0	0	0	0	0	0	0	0
Detroit	100	98	6	0	0	0	0	0	0	0	0	0	0
Detroit	100	99	6	0	0	0	0	0	0	0	0	0	0
Detroit	150	98	6	0	0	0	0	0	0	0	0	0	0
Detroit	150	99	6	0	0	0	0	0	0	0	0	0	0
Detroit	200	98	6	1	0	1	1	1	0	0	0	1	1
Detroit	200	99	6	1	0	1	1	1	0	0	0	0	0
Detroit	250	98	6	8	1	6	18	18	1	0	1	2	2
Detroit	250	99	6	5	0	4	10	10	1	0	1	1	1
Detroit	300	98	6	32	14	32	61	61	8	1	6	18	18
Detroit	300	99	6	19	6	19	38	38	5	0	4	10	10
El Paso	As is		12	0	0	0	0	0	0	0	0	0	0
El Paso	Current Std		12	1	0	0	2	2	0	0	0	0	0
El Paso	50	98	12	0	0	0	0	0	0	0	0	0	0
El Paso	50	99	12	0	0	0	0	0	0	0	0	0	0
El Paso	100	98	12	0	0	0	0	0	0	0	0	0	0
El Paso	100	99	12	0	0	0	0	0	0	0	0	0	0
El Paso	150	98	12	0	0	0	0	0	0	0	0	0	0
El Paso	150	99	12	0	0	0	0	0	0	0	0	0	0
El Paso	200	98	12	0	0	0	2	2	0	0	0	0	0
El Paso	200	99	12	0	0	0	1	1	0	0	0	0	0
El Paso	250	98	12	4	0	4	10	10	1	0	1	2	2
El Paso	250	99	12	2	0	1	4	4	0	0	0	1	1
El Paso	300	98	12	12	2	11	25	25	4	0	4	10	10
El Paso	300	99	12	6	1	7	12	12	2	0	1	4	4
Jacksonville	As is		2	0	0	0	0	0	0	0	0	0	0
Jacksonville	Current Std		2	3	1	3	5	5	2	0	2	4	4
Jacksonville	50	98	2	0	0	0	0	0	0	0	0	0	0

Location	Standard	Percentile	Site-Years	Number of Daily Maximum Exceedances									
				≥ 250 ppb					≥ 300 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
Jacksonville	50	99	2	0	0	0	0	0	0	0	0	0	0
Jacksonville	100	98	2	1	0	1	2	2	1	0	1	2	2
Jacksonville	100	99	2	1	0	1	1	1	0	0	0	0	0
Jacksonville	150	98	2	2	0	2	4	4	2	0	2	3	3
Jacksonville	150	99	2	1	0	1	2	2	1	0	1	2	2
Jacksonville	200	98	2	3	0	3	5	5	2	0	2	4	4
Jacksonville	200	99	2	2	0	2	4	4	2	0	2	3	3
Jacksonville	250	98	2	7	5	7	9	9	3	1	3	5	5
Jacksonville	250	99	2	2	0	2	4	4	2	0	2	4	4
Jacksonville	300	98	2	25	23	25	27	27	7	5	7	9	9
Jacksonville	300	99	2	3	1	3	5	5	2	0	2	4	4
Las Vegas	As is		11	0	0	0	0	0	0	0	0	0	0
Las Vegas	Current Std		11	0	0	0	0	0	0	0	0	0	0
Las Vegas	50	98	11	0	0	0	0	0	0	0	0	0	0
Las Vegas	50	99	11	0	0	0	0	0	0	0	0	0	0
Las Vegas	100	98	11	0	0	0	0	0	0	0	0	0	0
Las Vegas	100	99	11	0	0	0	0	0	0	0	0	0	0
Las Vegas	150	98	11	0	0	0	0	0	0	0	0	0	0
Las Vegas	150	99	11	0	0	0	0	0	0	0	0	0	0
Las Vegas	200	98	11	0	0	0	0	0	0	0	0	0	0
Las Vegas	200	99	11	0	0	0	0	0	0	0	0	0	0
Las Vegas	250	98	11	1	0	0	7	7	0	0	0	1	1
Las Vegas	250	99	11	1	0	0	4	4	0	0	0	0	0
Las Vegas	300	98	11	14	0	0	52	52	2	0	0	9	9
Las Vegas	300	99	11	7	0	0	30	30	1	0	0	4	4
Los Angeles	As is		54	0	0	0	0	0	0	0	0	0	0
Los Angeles	Current Std		54	0	0	0	0	0	0	0	0	0	0
Los Angeles	50	98	54	0	0	0	0	0	0	0	0	0	0
Los Angeles	50	99	54	0	0	0	0	0	0	0	0	0	0
Los Angeles	100	98	54	0	0	0	0	0	0	0	0	0	0
Los Angeles	100	99	54	0	0	0	0	0	0	0	0	0	0
Los Angeles	150	98	54	0	0	0	0	0	0	0	0	0	0
Los Angeles	150	99	54	0	0	0	0	0	0	0	0	0	0
Los Angeles	200	98	54	0	0	0	1	2	0	0	0	0	0
Los Angeles	200	99	54	0	0	0	0	0	0	0	0	0	0
Los Angeles	250	98	54	1	0	0	5	8	0	0	0	1	2
Los Angeles	250	99	54	0	0	0	2	2	0	0	0	0	1
Los Angeles	300	98	54	4	0	2	17	19	1	0	0	5	8
Los Angeles	300	99	54	2	0	1	10	11	0	0	0	2	2
Miami	As is		4	0	0	0	0	0	0	0	0	0	0
Miami	Current Std		4	2	0	1	4	4	0	0	0	1	1
Miami	50	98	4	0	0	0	0	0	0	0	0	0	0
Miami	50	99	4	0	0	0	0	0	0	0	0	0	0
Miami	100	98	4	0	0	0	0	0	0	0	0	0	0
Miami	100	99	4	0	0	0	0	0	0	0	0	0	0

Location	Standard	Percentile	Site-Years	Number of Daily Maximum Exceedances									
				≥ 250 ppb					≥ 300 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
Miami	150	98	4	0	0	0	0	0	0	0	0	0	0
Miami	150	99	4	0	0	0	0	0	0	0	0	0	0
Miami	200	98	4	0	0	0	1	1	0	0	0	1	1
Miami	200	99	4	0	0	0	1	1	0	0	0	1	1
Miami	250	98	4	3	0	2	8	8	1	0	1	1	1
Miami	250	99	4	2	0	1	5	5	0	0	0	1	1
Miami	300	98	4	10	0	10	21	21	3	0	2	8	8
Miami	300	99	4	6	0	5	13	13	2	0	1	5	5
New York	As is		22	0	0	0	0	0	0	0	0	0	0
New York	Current Std		22	0	0	0	1	1	0	0	0	0	0
New York	50	98	22	0	0	0	0	0	0	0	0	0	0
New York	50	99	22	0	0	0	0	0	0	0	0	0	0
New York	100	98	22	0	0	0	0	0	0	0	0	0	0
New York	100	99	22	0	0	0	0	0	0	0	0	0	0
New York	150	98	22	0	0	0	1	1	0	0	0	0	0
New York	150	99	22	0	0	0	0	0	0	0	0	0	0
New York	200	98	22	0	0	0	2	2	0	0	0	1	1
New York	200	99	22	0	0	0	1	1	0	0	0	1	1
New York	250	98	22	1	0	1	4	4	0	0	0	2	2
New York	250	99	22	1	0	0	4	4	0	0	0	1	1
New York	300	98	22	7	0	7	18	18	1	0	1	4	4
New York	300	99	22	2	0	1	8	8	1	0	0	4	4
Philadelphia	As is		12	0	0	0	0	0	0	0	0	0	0
Philadelphia	Current Std		12	0	0	0	0	0	0	0	0	0	0
Philadelphia	50	98	12	0	0	0	0	0	0	0	0	0	0
Philadelphia	50	99	12	0	0	0	0	0	0	0	0	0	0
Philadelphia	100	98	12	0	0	0	0	0	0	0	0	0	0
Philadelphia	100	99	12	0	0	0	0	0	0	0	0	0	0
Philadelphia	150	98	12	0	0	0	0	0	0	0	0	0	0
Philadelphia	150	99	12	0	0	0	0	0	0	0	0	0	0
Philadelphia	200	98	12	0	0	0	2	2	0	0	0	1	1
Philadelphia	200	99	12	0	0	0	0	0	0	0	0	0	0
Philadelphia	250	98	12	3	0	2	10	10	1	0	0	2	2
Philadelphia	250	99	12	0	0	0	2	2	0	0	0	1	1
Philadelphia	300	98	12	12	1	12	33	33	3	0	2	10	10
Philadelphia	300	99	12	2	0	1	7	7	0	0	0	2	2
Phoenix	As is		9	0	0	0	0	0	0	0	0	0	0
Phoenix	Current Std		9	0	0	0	0	0	0	0	0	0	0
Phoenix	50	98	9	0	0	0	0	0	0	0	0	0	0
Phoenix	50	99	9	0	0	0	0	0	0	0	0	0	0
Phoenix	100	98	9	0	0	0	0	0	0	0	0	0	0
Phoenix	100	99	9	0	0	0	0	0	0	0	0	0	0
Phoenix	150	98	9	0	0	0	0	0	0	0	0	0	0
Phoenix	150	99	9	0	0	0	0	0	0	0	0	0	0
Phoenix	200	98	9	0	0	0	0	0	0	0	0	0	0

Location	Standard	Percentile	Site-Years	Number of Daily Maximum Exceedances									
				≥ 250 ppb					≥ 300 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
Phoenix	200	99	9	0	0	0	0	0	0	0	0	0	0
Phoenix	250	98	9	1	0	1	5	5	0	0	0	0	0
Phoenix	250	99	9	0	0	0	2	2	0	0	0	0	0
Phoenix	300	98	9	6	0	7	10	10	1	0	1	5	5
Phoenix	300	99	9	2	0	1	7	7	0	0	0	2	2
Provo	As is		3	0	0	0	0	0	0	0	0	0	0
Provo	Current Std		3	10	0	0	31	31	0	0	0	1	1
Provo	50	98	3	0	0	0	0	0	0	0	0	0	0
Provo	50	99	3	0	0	0	0	0	0	0	0	0	0
Provo	100	98	3	0	0	0	0	0	0	0	0	0	0
Provo	100	99	3	0	0	0	0	0	0	0	0	0	0
Provo	150	98	3	2	0	0	7	7	0	0	0	0	0
Provo	150	99	3	1	0	0	3	3	0	0	0	0	0
Provo	200	98	3	13	0	0	40	40	10	0	0	29	29
Provo	200	99	3	13	0	0	40	40	8	0	0	23	23
Provo	250	98	3	14	0	0	43	43	14	0	0	42	42
Provo	250	99	3	14	0	0	43	43	14	0	0	41	41
Provo	300	98	3	15	0	2	43	43	14	0	0	43	43
Provo	300	99	3	15	0	2	43	43	14	0	0	43	43
St. Louis	As is		4	0	0	0	0	0	0	0	0	0	0
St. Louis	Current Std		4	0	0	0	0	0	0	0	0	0	0
St. Louis	50	98	4	0	0	0	0	0	0	0	0	0	0
St. Louis	50	99	4	0	0	0	0	0	0	0	0	0	0
St. Louis	100	98	4	0	0	0	0	0	0	0	0	0	0
St. Louis	100	99	4	0	0	0	0	0	0	0	0	0	0
St. Louis	150	98	4	0	0	0	0	0	0	0	0	0	0
St. Louis	150	99	4	0	0	0	0	0	0	0	0	0	0
St. Louis	200	98	4	0	0	0	0	0	0	0	0	0	0
St. Louis	200	99	4	0	0	0	0	0	0	0	0	0	0
St. Louis	250	98	4	1	0	1	3	3	0	0	0	0	0
St. Louis	250	99	4	1	0	1	2	2	0	0	0	0	0
St. Louis	300	98	4	12	0	9	28	28	1	0	1	3	3
St. Louis	300	99	4	9	0	6	25	25	1	0	1	2	2
Washington DC	As is		17	0	0	0	0	0	0	0	0	0	0
Washington DC	Current Std		17	0	0	0	2	2	0	0	0	1	1
Washington DC	50	98	17	0	0	0	0	0	0	0	0	0	0
Washington DC	50	99	17	0	0	0	0	0	0	0	0	0	0
Washington DC	100	98	17	0	0	0	0	0	0	0	0	0	0
Washington DC	100	99	17	0	0	0	0	0	0	0	0	0	0
Washington	150	98	17	0	0	0	1	1	0	0	0	0	0

Location	Standard	Percentile	Site-Years	Number of Daily Maximum Exceedances ≥ 250 ppb Mean	Min	Med	p98	p99	≥ 300 ppb Mean	Min	Med	p98	p99
DC													
Washington DC	150	99	17	0	0	0	0	0	0	0	0	0	0
Washington DC	200	98	17	1	0	0	5	5	0	0	0	2	2
Washington DC	200	99	17	0	0	0	2	2	0	0	0	0	0
Washington DC	250	98	17	3	0	2	12	12	1	0	0	6	6
Washington DC	250	99	17	1	0	0	6	6	0	0	0	2	2
Washington DC	300	98	17	13	0	10	39	39	3	0	2	12	12
Washington DC	300	99	17	2	0	1	10	10	1	0	0	6	6
Other MSA	As is		565	0	0	0	0	0	0	0	0	0	0
Other MSA	Current Std		565	0	0	0	1	1	0	0	0	0	1
Other MSA	50	98	565	0	0	0	0	0	0	0	0	0	0
Other MSA	50	99	565	0	0	0	0	0	0	0	0	0	0
Other MSA	100	98	565	0	0	0	0	0	0	0	0	0	0
Other MSA	100	99	565	0	0	0	0	0	0	0	0	0	0
Other MSA	150	98	565	0	0	0	0	1	0	0	0	0	0
Other MSA	150	99	565	0	0	0	0	0	0	0	0	0	0
Other MSA	200	98	565	0	0	0	1	1	0	0	0	0	1
Other MSA	200	99	565	0	0	0	0	1	0	0	0	0	1
Other MSA	250	98	565	0	0	0	2	4	0	0	0	1	1
Other MSA	250	99	565	0	0	0	1	1	0	0	0	1	1
Other MSA	300	98	565	1	0	0	7	9	0	0	0	2	4
Other MSA	300	99	565	0	0	0	4	7	0	0	0	1	1
Other Not MSA	As is		116	0	0	0	0	1	0	0	0	0	0
Other Not MSA	Current Std		116	0	0	0	7	9	0	0	0	3	5
Other Not MSA	50	98	116	0	0	0	0	0	0	0	0	0	0
Other Not MSA	50	99	116	0	0	0	0	0	0	0	0	0	0
Other Not MSA	100	98	116	0	0	0	0	1	0	0	0	0	0
Other Not MSA	100	99	116	0	0	0	0	0	0	0	0	0	0
Other Not MSA	150	98	116	0	0	0	0	2	0	0	0	0	1
Other Not MSA	150	99	116	0	0	0	0	1	0	0	0	0	1
Other Not MSA	200	98	116	0	0	0	2	2	0	0	0	0	2
Other Not	200	99	116	0	0	0	0	2	0	0	0	0	2

Location	Standard	Percentile	Site-Years	Number of Daily Maximum Exceedances									
				≥ 250 ppb					≥ 300 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
MSA													
Other Not MSA	250	98	116	0	0	0	3	5	0	0	0	2	2
Other Not MSA	250	99	116	0	0	0	2	2	0	0	0	0	2
Other Not MSA	300	98	116	0	0	0	7	9	0	0	0	3	5
Other Not MSA	300	99	116	0	0	0	3	3	0	0	0	2	2

Table A-129. Estimated number of exceedances of 1-hour concentration levels (100, 150, and 200 ppb) for monitors > 20 m and < 100 m from a major road following adjustment to just meeting the current and alternative standards, 2004-2006 air quality.

Location	Standard	Percentile	Site-Years	Number of Daily Maximum Exceedances														
				≥ 100 ppb					≥ 150 ppb					≥ 200 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
Boston	As is		11	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
Boston	Current Std		11	25	2	12	73	73	2	0	0	10	10	0	0	0	2	2
Boston	50	98	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Boston	50	99	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Boston	100	98	11	1	0	0	9	9	0	0	0	1	1	0	0	0	0	0
Boston	100	99	11	1	0	0	4	4	0	0	0	0	0	0	0	0	0	0
Boston	150	98	11	19	1	11	67	67	1	0	0	9	9	0	0	0	1	1
Boston	150	99	11	8	0	2	34	34	1	0	0	4	4	0	0	0	1	1
Boston	200	98	11	84	20	65	153	153	9	0	3	42	42	1	0	0	9	9
Boston	200	99	11	42	7	32	102	102	4	0	1	18	18	1	0	0	4	4
Boston	250	98	11	165	78	143	247	247	36	6	28	91	91	7	0	1	31	31
Boston	250	99	11	103	30	79	175	175	16	0	8	62	62	2	0	0	13	13
Boston	300	98	11	214	115	208	291	291	84	20	65	153	153	19	1	11	67	67
Boston	300	99	11	165	78	143	247	247	42	7	32	102	102	8	0	2	34	34
Chicago	As is		6	1	0	1	5	5	0	0	0	0	0	0	0	0	0	0
Chicago	Current Std		6	94	39	90	152	152	6	0	5	15	15	0	0	0	2	2
Chicago	50	98	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chicago	50	99	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chicago	100	98	6	4	0	3	15	15	0	0	0	1	1	0	0	0	0	0
Chicago	100	99	6	3	0	1	12	12	0	0	0	0	0	0	0	0	0	0
Chicago	150	98	6	80	34	74	147	147	4	0	3	15	15	0	0	0	2	2
Chicago	150	99	6	64	17	62	118	118	3	0	1	12	12	0	0	0	2	2
Chicago	200	98	6	206	161	200	267	267	44	10	43	88	88	4	0	3	15	15
Chicago	200	99	6	178	133	172	239	239	30	4	30	62	62	3	0	1	12	12
Chicago	250	98	6	277	248	273	314	314	122	78	112	190	190	27	3	26	58	58
Chicago	250	99	6	261	230	257	299	299	99	58	90	164	164	19	1	17	46	46
Chicago	300	98	6	324	309	325	338	338	206	161	200	267	267	80	34	74	147	147
Chicago	300	99	6	320	302	319	338	338	178	133	172	239	239	64	17	62	118	118
Cleveland	As is		2	1	0	1	1	1	1	0	1	1	1	0	0	0	0	0
Cleveland	Current Std		2	97	86	97	108	108	11	10	11	12	12	2	1	2	2	2

Location	Standard	Percentile	Site-Years	Number of Daily Maximum Exceedances														
				≥ 100 ppb					≥ 150 ppb					≥ 200 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
Cleveland	50	98	2	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0
Cleveland	50	99	2	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0
Cleveland	100	98	2	4	2	4	6	6	1	0	1	1	1	1	0	1	1	1
Cleveland	100	99	2	2	2	2	2	2	1	0	1	1	1	1	0	1	1	1
Cleveland	150	98	2	60	48	60	71	71	4	2	4	6	6	1	0	1	1	1
Cleveland	150	99	2	33	18	33	47	47	2	2	2	2	2	1	0	1	1	1
Cleveland	200	98	2	153	140	153	166	166	33	18	33	47	47	4	2	4	6	6
Cleveland	200	99	2	110	95	110	124	124	16	7	16	24	24	2	2	2	2	2
Cleveland	250	98	2	208	199	208	217	217	83	68	83	97	97	20	10	20	30	30
Cleveland	250	99	2	188	180	188	195	195	60	48	60	71	71	13	6	13	19	19
Cleveland	300	98	2	259	258	259	259	259	153	140	153	166	166	60	48	60	71	71
Cleveland	300	99	2	230	227	230	233	233	110	95	110	124	124	33	18	33	47	47
El Paso	As is		3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
El Paso	Current Std		3	160	137	143	201	201	25	16	17	42	42	6	4	4	9	9
El Paso	50	98	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
El Paso	50	99	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
El Paso	100	98	3	6	4	4	9	9	0	0	0	0	0	0	0	0	0	0
El Paso	100	99	3	3	2	3	4	4	0	0	0	0	0	0	0	0	0	0
El Paso	150	98	3	57	33	56	83	83	6	4	4	9	9	1	0	1	2	2
El Paso	150	99	3	26	15	20	42	42	3	2	3	4	4	0	0	0	0	0
El Paso	200	98	3	160	132	147	201	201	26	15	20	42	42	6	4	4	9	9
El Paso	200	99	3	118	90	106	157	157	14	8	10	24	24	3	2	3	4	4
El Paso	250	98	3	239	220	225	273	273	88	59	82	124	124	17	12	12	26	26
El Paso	250	99	3	197	167	181	243	243	51	27	51	76	76	10	6	8	15	15
El Paso	300	98	3	276	263	267	297	297	160	132	147	201	201	57	33	56	83	83
El Paso	300	99	3	251	234	238	281	281	118	90	106	157	157	26	15	20	42	42
Los Angeles	As is		22	1	0	1	9	9	0	0	0	1	1	0	0	0	0	0
Los Angeles	Current Std		22	50	0	53	116	116	3	0	2	12	12	0	0	0	2	2
Los Angeles	50	98	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Los Angeles	50	99	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Los Angeles	100	98	22	3	0	1	17	17	0	0	0	2	2	0	0	0	0	0
Los Angeles	100	99	22	1	0	1	11	11	0	0	0	1	1	0	0	0	0	0

Location	Standard	Percentile	Site-Years	Number of Daily Maximum Exceedances														
				≥ 100 ppb					≥ 150 ppb					≥ 200 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
Los Angeles	150	98	22	46	0	51	101	101	3	0	1	17	17	0	0	0	2	2
Los Angeles	150	99	22	30	0	30	82	82	1	0	1	11	11	0	0	0	2	2
Los Angeles	200	98	22	139	9	143	235	235	22	0	23	63	63	3	0	1	17	17
Los Angeles	200	99	22	107	2	113	190	190	12	0	11	43	43	1	0	1	11	11
Los Angeles	250	98	22	225	41	242	295	295	75	0	77	143	143	15	0	15	46	46
Los Angeles	250	99	22	196	27	202	282	282	51	0	55	107	107	7	0	5	36	36
Los Angeles	300	98	22	272	69	302	330	330	139	9	143	235	235	46	0	51	101	101
Los Angeles	300	99	22	259	64	283	323	323	107	2	113	190	190	30	0	30	82	82
Miami	As is		2	1	0	1	2	2	1	0	1	1	1	1	0	1	1	1
Miami	Current Std		2	173	171	173	175	175	76	75	76	76	76	20	17	20	23	23
Miami	50	98	2	1	0	1	2	2	1	0	1	1	1	1	0	1	1	1
Miami	50	99	2	1	0	1	1	1	1	0	1	1	1	1	0	1	1	1
Miami	100	98	2	8	6	8	9	9	1	0	1	2	2	1	0	1	2	2
Miami	100	99	2	4	2	4	5	5	1	0	1	2	2	1	0	1	1	1
Miami	150	98	2	77	73	77	80	80	8	6	8	9	9	1	0	1	2	2
Miami	150	99	2	57	52	57	62	62	4	2	4	5	5	1	0	1	2	2
Miami	200	98	2	139	132	139	145	145	47	42	47	52	52	8	6	8	9	9
Miami	200	99	2	122	112	122	132	132	36	34	36	37	37	4	2	4	5	5
Miami	250	98	2	203	197	203	209	209	93	86	93	100	100	36	34	36	37	37
Miami	250	99	2	179	175	179	183	183	83	76	83	89	89	26	23	26	29	29
Miami	300	98	2	249	238	249	260	260	139	132	139	145	145	77	73	77	80	80
Miami	300	99	2	225	218	225	232	232	122	112	122	132	132	57	52	57	62	62
New York	As is		11	1	0	1	3	3	0	0	0	1	1	0	0	0	0	0
New York	Current Std		11	30	2	32	64	64	1	0	0	4	4	0	0	0	2	2
New York	50	98	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
New York	50	99	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
New York	100	98	11	5	1	6	8	8	0	0	0	1	1	0	0	0	0	0
New York	100	99	11	2	0	2	4	4	0	0	0	1	1	0	0	0	0	0
New York	150	98	11	69	14	62	126	126	5	1	6	8	8	1	0	0	2	2
New York	150	99	11	31	4	29	51	51	2	0	2	4	4	0	0	0	1	1
New York	200	98	11	198	84	199	285	285	35	5	33	60	60	5	1	6	8	8
New York	200	99	11	134	36	128	211	211	15	2	14	28	28	2	0	2	4	4

Location	Standard	Percentile	Site-Years	Number of Daily Maximum Exceedances														
				≥ 100 ppb					≥ 150 ppb					≥ 200 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
New York	250	98	11	281	190	287	339	339	115	26	106	190	190	23	3	23	40	40
New York	250	99	11	232	121	235	315	315	58	9	53	104	104	10	2	10	22	22
New York	300	98	11	317	245	331	356	356	198	84	199	285	285	69	14	62	126	126
New York	300	99	11	290	207	302	345	345	134	36	128	211	211	31	4	29	51	51
Philadelphia	As is		6	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0
Philadelphia	Current Std		6	70	28	56	173	173	6	1	3	25	25	2	0	1	6	6
Philadelphia	50	98	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Philadelphia	50	99	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Philadelphia	100	98	6	6	3	6	10	10	1	0	1	1	1	0	0	0	0	0
Philadelphia	100	99	6	2	1	2	4	4	0	0	0	0	0	0	0	0	0	0
Philadelphia	150	98	6	93	62	96	125	125	6	3	6	10	10	2	1	1	3	3
Philadelphia	150	99	6	25	15	24	39	39	2	1	2	4	4	0	0	0	1	1
Philadelphia	200	98	6	216	169	216	267	267	45	28	49	60	60	6	3	6	10	10
Philadelphia	200	99	6	121	76	127	166	166	11	6	10	16	16	2	1	2	4	4
Philadelphia	250	98	6	272	227	272	313	313	131	83	138	173	173	32	19	35	48	48
Philadelphia	250	99	6	216	169	216	267	267	45	28	49	60	60	6	3	6	10	10
Philadelphia	300	98	6	307	274	308	342	342	216	169	216	267	267	93	62	96	125	125
Philadelphia	300	99	6	266	220	265	310	310	121	76	127	166	166	25	15	24	39	39
Phoenix	As is		3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phoenix	Current Std		3	14	13	13	15	15	0	0	0	0	0	0	0	0	0	0
Phoenix	50	98	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phoenix	50	99	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phoenix	100	98	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phoenix	100	99	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phoenix	150	98	3	29	28	29	30	30	0	0	0	0	0	0	0	0	0	0
Phoenix	150	99	3	7	4	9	9	9	0	0	0	0	0	0	0	0	0	0
Phoenix	200	98	3	174	171	174	178	178	5	2	6	6	6	0	0	0	0	0
Phoenix	200	99	3	120	114	121	126	126	1	0	2	2	2	0	0	0	0	0
Phoenix	250	98	3	257	239	264	268	268	68	55	66	83	83	2	0	3	4	4
Phoenix	250	99	3	217	207	221	222	222	29	28	29	30	30	1	0	2	2	2
Phoenix	300	98	3	304	285	309	317	317	174	171	174	178	178	29	28	29	30	30
Phoenix	300	99	3	284	263	294	294	294	120	114	121	126	126	7	4	9	9	9

Location	Standard	Percentile	Site-Years	Number of Daily Maximum Exceedances														
				≥ 100 ppb					≥ 150 ppb					≥ 200 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
St. Louis	As is		8	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
St. Louis	Current Std		8	42	1	35	108	108	2	0	1	6	6	0	0	0	1	1
St. Louis	50	98	8	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
St. Louis	50	99	8	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
St. Louis	100	98	8	1	0	0	8	8	0	0	0	1	1	0	0	0	1	1
St. Louis	100	99	8	1	0	0	4	4	0	0	0	1	1	0	0	0	1	1
St. Louis	150	98	8	26	1	13	124	124	1	0	0	8	8	0	0	0	1	1
St. Louis	150	99	8	22	1	8	115	115	1	0	0	4	4	0	0	0	1	1
St. Louis	200	98	8	83	23	65	242	242	12	0	3	78	78	1	0	0	8	8
St. Louis	200	99	8	75	19	57	231	231	10	0	2	66	66	1	0	0	4	4
St. Louis	250	98	8	142	71	116	319	319	42	3	26	174	174	9	0	1	59	59
St. Louis	250	99	8	131	62	105	304	304	39	3	23	164	164	7	0	1	45	45
St. Louis	300	98	8	187	114	157	344	344	83	23	65	242	242	26	1	13	124	124
St. Louis	300	99	8	187	114	157	344	344	75	19	57	231	231	22	1	8	115	115
Washington DC	As is		12	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
Washington DC	Current Std		12	66	10	74	123	123	3	0	3	7	7	0	0	0	1	1
Washington DC	50	98	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Washington DC	50	99	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Washington DC	100	98	12	3	0	2	7	7	0	0	0	1	1	0	0	0	0	0
Washington DC	100	99	12	0	0	0	1	1	0	0	0	1	1	0	0	0	0	0
Washington DC	150	98	12	59	16	54	115	115	3	0	2	7	7	0	0	0	1	1
Washington DC	150	99	12	15	0	12	38	38	0	0	0	1	1	0	0	0	1	1
Washington DC	200	98	12	165	80	174	245	245	26	2	23	61	61	3	0	2	7	7
Washington DC	200	99	12	85	29	82	154	154	5	0	5	14	14	0	0	0	1	1

Location	Standard	Percentile	Site-Years	Number of Daily Maximum Exceedances														
				≥ 100 ppb					≥ 150 ppb					≥ 200 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
Washington DC	250	98	12	224	127	241	303	303	94	35	93	169	169	16	0	14	40	40
Washington DC	250	99	12	165	80	174	245	245	30	2	25	66	66	3	0	2	9	9
Washington DC	300	98	12	266	182	277	338	338	165	80	174	245	245	59	16	54	115	115
Washington DC	300	99	12	224	127	241	303	303	85	29	82	154	154	15	0	12	38	38

Table A-130. Estimated number of exceedances of 1-hour concentration levels (250 and 300 ppb) for monitors > 20 m and < 100 m from a major road following adjustment to just meeting the current and alternative standards, 2004-2006 air quality.

Location	Standard	Percentile	Site-Years	Number of Daily Maximum Exceedances									
				≥ 250 ppb					≥ 300 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
Boston	As is		11	0	0	0	0	0	0	0	0	0	0
Boston	Current Std		11	0	0	0	1	1	0	0	0	0	0
Boston	50	98	11	0	0	0	0	0	0	0	0	0	0
Boston	50	99	11	0	0	0	0	0	0	0	0	0	0
Boston	100	98	11	0	0	0	0	0	0	0	0	0	0
Boston	100	99	11	0	0	0	0	0	0	0	0	0	0
Boston	150	98	11	0	0	0	0	0	0	0	0	0	0
Boston	150	99	11	0	0	0	0	0	0	0	0	0	0
Boston	200	98	11	0	0	0	2	2	0	0	0	1	1
Boston	200	99	11	0	0	0	1	1	0	0	0	0	0
Boston	250	98	11	1	0	0	9	9	1	0	0	4	4
Boston	250	99	11	1	0	0	4	4	0	0	0	1	1
Boston	300	98	11	5	0	1	29	29	1	0	0	9	9
Boston	300	99	11	2	0	0	12	12	1	0	0	4	4
Chicago	As is		6	0	0	0	0	0	0	0	0	0	0
Chicago	Current Std		6	0	0	0	0	0	0	0	0	0	0
Chicago	50	98	6	0	0	0	0	0	0	0	0	0	0
Chicago	50	99	6	0	0	0	0	0	0	0	0	0	0
Chicago	100	98	6	0	0	0	0	0	0	0	0	0	0
Chicago	100	99	6	0	0	0	0	0	0	0	0	0	0
Chicago	150	98	6	0	0	0	0	0	0	0	0	0	0
Chicago	150	99	6	0	0	0	0	0	0	0	0	0	0
Chicago	200	98	6	0	0	0	2	2	0	0	0	1	1
Chicago	200	99	6	0	0	0	2	2	0	0	0	0	0
Chicago	250	98	6	4	0	3	15	15	1	0	0	3	3
Chicago	250	99	6	2	0	1	9	9	0	0	0	2	2
Chicago	300	98	6	21	1	18	53	53	4	0	3	15	15
Chicago	300	99	6	14	1	11	39	39	3	0	1	12	12
Cleveland	As is		2	0	0	0	0	0	0	0	0	0	0
Cleveland	Current Std		2	1	0	1	1	1	1	0	1	1	1
Cleveland	50	98	2	0	0	0	0	0	0	0	0	0	0
Cleveland	50	99	2	0	0	0	0	0	0	0	0	0	0
Cleveland	100	98	2	1	0	1	1	1	0	0	0	0	0
Cleveland	100	99	2	0	0	0	0	0	0	0	0	0	0
Cleveland	150	98	2	1	0	1	1	1	1	0	1	1	1
Cleveland	150	99	2	1	0	1	1	1	1	0	1	1	1
Cleveland	200	98	2	1	1	1	1	1	1	0	1	1	1
Cleveland	200	99	2	1	0	1	1	1	1	0	1	1	1
Cleveland	250	98	2	4	2	4	6	6	1	1	1	1	1
Cleveland	250	99	2	2	2	2	2	2	1	0	1	1	1
Cleveland	300	98	2	16	7	16	24	24	4	2	4	6	6
Cleveland	300	99	2	7	4	7	10	10	2	2	2	2	2
El Paso	As is		3	0	0	0	0	0	0	0	0	0	0

Location	Standard	Percentile	Site-Years	Number of Daily Maximum Exceedances									
				≥ 250 ppb					≥ 300 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
El Paso	Current Std		3	2	1	2	3	3	0	0	0	0	0
El Paso	50	98	3	0	0	0	0	0	0	0	0	0	0
El Paso	50	99	3	0	0	0	0	0	0	0	0	0	0
El Paso	100	98	3	0	0	0	0	0	0	0	0	0	0
El Paso	100	99	3	0	0	0	0	0	0	0	0	0	0
El Paso	150	98	3	0	0	0	0	0	0	0	0	0	0
El Paso	150	99	3	0	0	0	0	0	0	0	0	0	0
El Paso	200	98	3	2	1	2	2	2	0	0	0	0	0
El Paso	200	99	3	0	0	0	1	1	0	0	0	0	0
El Paso	250	98	3	6	4	4	9	9	2	2	2	3	3
El Paso	250	99	3	3	2	3	4	4	1	0	1	1	1
El Paso	300	98	3	14	8	10	24	24	6	4	4	9	9
El Paso	300	99	3	7	4	5	13	13	3	2	3	4	4
Los Angeles	As is		22	0	0	0	0	0	0	0	0	0	0
Los Angeles	Current Std		22	0	0	0	0	0	0	0	0	0	0
Los Angeles	50	98	22	0	0	0	0	0	0	0	0	0	0
Los Angeles	50	99	22	0	0	0	0	0	0	0	0	0	0
Los Angeles	100	98	22	0	0	0	0	0	0	0	0	0	0
Los Angeles	100	99	22	0	0	0	0	0	0	0	0	0	0
Los Angeles	150	98	22	0	0	0	1	1	0	0	0	0	0
Los Angeles	150	99	22	0	0	0	0	0	0	0	0	0	0
Los Angeles	200	98	22	0	0	0	3	3	0	0	0	2	2
Los Angeles	200	99	22	0	0	0	2	2	0	0	0	1	1
Los Angeles	250	98	22	3	0	1	17	17	0	0	0	5	5
Los Angeles	250	99	22	1	0	1	9	9	0	0	0	3	3
Los Angeles	300	98	22	11	0	10	41	41	3	0	1	17	17
Los Angeles	300	99	22	5	0	4	25	25	1	0	1	11	11
Miami	As is		2	1	0	1	1	1	1	0	1	1	1
Miami	Current Std		2	3	0	3	5	5	1	0	1	2	2
Miami	50	98	2	1	0	1	1	1	1	0	1	1	1
Miami	50	99	2	1	0	1	1	1	1	0	1	1	1
Miami	100	98	2	1	0	1	1	1	1	0	1	1	1
Miami	100	99	2	1	0	1	1	1	1	0	1	1	1
Miami	150	98	2	1	0	1	2	2	1	0	1	2	2
Miami	150	99	2	1	0	1	2	2	1	0	1	1	1
Miami	200	98	2	1	0	1	2	2	1	0	1	2	2
Miami	200	99	2	1	0	1	2	2	1	0	1	2	2
Miami	250	98	2	8	6	8	9	9	1	0	1	2	2
Miami	250	99	2	4	2	4	5	5	1	0	1	2	2
Miami	300	98	2	28	25	28	31	31	8	6	8	9	9
Miami	300	99	2	19	17	19	20	20	4	2	4	5	5
New York	As is		11	0	0	0	0	0	0	0	0	0	0
New York	Current Std		11	0	0	0	1	1	0	0	0	0	0
New York	50	98	11	0	0	0	0	0	0	0	0	0	0
New York	50	99	11	0	0	0	0	0	0	0	0	0	0

Location	Standard	Percentile	Site-Years	Number of Daily Maximum Exceedances									
				≥ 250 ppb					≥ 300 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
New York	100	98	11	0	0	0	0	0	0	0	0	0	0
New York	100	99	11	0	0	0	0	0	0	0	0	0	0
New York	150	98	11	0	0	0	1	1	0	0	0	0	0
New York	150	99	11	0	0	0	0	0	0	0	0	0	0
New York	200	98	11	1	0	1	3	3	0	0	0	1	1
New York	200	99	11	0	0	0	2	2	0	0	0	1	1
New York	250	98	11	5	1	6	8	8	1	0	2	3	3
New York	250	99	11	2	0	2	4	4	1	0	0	2	2
New York	300	98	11	19	2	20	33	33	5	1	6	8	8
New York	300	99	11	7	2	7	14	14	2	0	2	4	4
Philadelphia	As is		6	0	0	0	0	0	0	0	0	0	0
Philadelphia	Current Std		6	1	0	0	3	3	0	0	0	0	0
Philadelphia	50	98	6	0	0	0	0	0	0	0	0	0	0
Philadelphia	50	99	6	0	0	0	0	0	0	0	0	0	0
Philadelphia	100	98	6	0	0	0	0	0	0	0	0	0	0
Philadelphia	100	99	6	0	0	0	0	0	0	0	0	0	0
Philadelphia	150	98	6	0	0	0	1	1	0	0	0	0	0
Philadelphia	150	99	6	0	0	0	0	0	0	0	0	0	0
Philadelphia	200	98	6	2	1	2	4	4	1	0	1	1	1
Philadelphia	200	99	6	0	0	0	1	1	0	0	0	0	0
Philadelphia	250	98	6	6	3	6	10	10	2	1	2	4	4
Philadelphia	250	99	6	2	1	2	4	4	1	0	1	1	1
Philadelphia	300	98	6	25	15	24	39	39	6	3	6	10	10
Philadelphia	300	99	6	4	2	5	6	6	2	1	2	4	4
Phoenix	As is		3	0	0	0	0	0	0	0	0	0	0
Phoenix	Current Std		3	0	0	0	0	0	0	0	0	0	0
Phoenix	50	98	3	0	0	0	0	0	0	0	0	0	0
Phoenix	50	99	3	0	0	0	0	0	0	0	0	0	0
Phoenix	100	98	3	0	0	0	0	0	0	0	0	0	0
Phoenix	100	99	3	0	0	0	0	0	0	0	0	0	0
Phoenix	150	98	3	0	0	0	0	0	0	0	0	0	0
Phoenix	150	99	3	0	0	0	0	0	0	0	0	0	0
Phoenix	200	98	3	0	0	0	0	0	0	0	0	0	0
Phoenix	200	99	3	0	0	0	0	0	0	0	0	0	0
Phoenix	250	98	3	0	0	0	0	0	0	0	0	0	0
Phoenix	250	99	3	0	0	0	0	0	0	0	0	0	0
Phoenix	300	98	3	1	0	2	2	2	0	0	0	0	0
Phoenix	300	99	3	0	0	0	1	1	0	0	0	0	0
St. Louis	As is		8	0	0	0	0	0	0	0	0	0	0
St. Louis	Current Std		8	0	0	0	1	1	0	0	0	1	1
St. Louis	50	98	8	0	0	0	0	0	0	0	0	0	0
St. Louis	50	99	8	0	0	0	0	0	0	0	0	0	0
St. Louis	100	98	8	0	0	0	0	0	0	0	0	0	0
St. Louis	100	99	8	0	0	0	0	0	0	0	0	0	0
St. Louis	150	98	8	0	0	0	1	1	0	0	0	1	1

Location	Standard	Percentile	Site-Years	Number of Daily Maximum Exceedances									
				≥ 250 ppb					≥ 300 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
St. Louis	150	99	8	0	0	0	1	1	0	0	0	1	1
St. Louis	200	98	8	0	0	0	1	1	0	0	0	1	1
St. Louis	200	99	8	0	0	0	1	1	0	0	0	1	1
St. Louis	250	98	8	1	0	0	5	5	0	0	0	1	1
St. Louis	250	99	8	1	0	0	4	4	0	0	0	1	1
St. Louis	300	98	8	7	0	1	45	45	1	0	0	8	8
St. Louis	300	99	8	4	0	0	33	33	1	0	0	4	4
Washington DC	As is		12	0	0	0	0	0	0	0	0	0	0
Washington DC	Current Std		12	0	0	0	1	1	0	0	0	1	1
Washington DC	50	98	12	0	0	0	0	0	0	0	0	0	0
Washington DC	50	99	12	0	0	0	0	0	0	0	0	0	0
Washington DC	100	98	12	0	0	0	0	0	0	0	0	0	0
Washington DC	100	99	12	0	0	0	0	0	0	0	0	0	0
Washington DC	150	98	12	0	0	0	1	1	0	0	0	0	0
Washington DC	150	99	12	0	0	0	0	0	0	0	0	0	0
Washington DC	200	98	12	0	0	0	1	1	0	0	0	1	1
Washington DC	200	99	12	0	0	0	1	1	0	0	0	1	1
Washington DC	250	98	12	3	0	2	7	7	0	0	0	1	1
Washington DC	250	99	12	0	0	0	1	1	0	0	0	1	1
Washington DC	300	98	12	13	0	11	33	33	3	0	2	7	7
Washington DC	300	99	12	2	0	1	6	6	0	0	0	1	1

Table a-131. Estimated number of exceedances of 1-hour concentration levels (100, 150, and 200 ppb) for monitors ≤ 20 m from a major road following adjustment to just meeting the current and alternative standards, 2004-2006 air quality.

Location	Standard	Percentile	Site-Years	Number of Daily Maximum Exceedances														
				≥ 100 ppb					≥ 150 ppb					≥ 200 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
Boston	As is		3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Boston	Current Std		3	68	64	66	75	75	3	1	3	5	5	0	0	0	0	0
Boston	50	98	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Boston	50	99	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Boston	100	98	3	2	1	3	3	3	0	0	0	0	0	0	0	0	0	0
Boston	100	99	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Boston	150	98	3	55	33	60	72	72	2	1	3	3	3	0	0	0	0	0
Boston	150	99	3	18	10	21	22	22	0	0	0	0	0	0	0	0	0	0
Boston	200	98	3	197	179	195	216	216	24	14	26	31	31	2	1	3	3	3
Boston	200	99	3	113	86	123	129	129	5	3	6	7	7	0	0	0	0	0
Boston	250	98	3	291	281	288	304	304	103	76	110	123	123	15	7	18	21	21
Boston	250	99	3	227	207	222	253	253	43	29	43	57	57	4	1	4	6	6
Boston	300	98	3	323	314	322	334	334	197	179	195	216	216	55	33	60	72	72
Boston	300	99	3	291	281	288	304	304	113	86	123	129	129	18	10	21	22	22
Chicago	As is		3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chicago	Current Std		3	22	5	23	38	38	1	0	1	1	1	0	0	0	0	0
Chicago	50	98	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chicago	50	99	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chicago	100	98	3	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
Chicago	100	99	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chicago	150	98	3	15	4	15	26	26	0	0	0	1	1	0	0	0	0	0
Chicago	150	99	3	10	1	11	18	18	0	0	0	0	0	0	0	0	0	0
Chicago	200	98	3	93	66	104	109	109	7	0	10	12	12	0	0	0	1	1
Chicago	200	99	3	69	40	75	91	91	5	0	5	9	9	0	0	0	0	0
Chicago	250	98	3	167	138	179	184	184	33	15	32	51	51	5	0	5	9	9
Chicago	250	99	3	144	112	155	165	165	23	8	23	38	38	2	0	3	4	4
Chicago	300	98	3	235	211	243	250	250	93	66	104	109	109	15	4	15	26	26
Chicago	300	99	3	222	197	232	238	238	69	40	75	91	91	10	1	11	18	18
Cleveland	As is		3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Location	Standard	Percentile	Site-Years	Number of Daily Maximum Exceedances														
				≥ 100 ppb					≥ 150 ppb					≥ 200 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
Cleveland	Current Std		3	119	96	119	142	142	16	11	14	22	22	0	0	0	1	1
Cleveland	50	98	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cleveland	50	99	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cleveland	100	98	3	7	1	9	10	10	0	0	0	0	0	0	0	0	0	0
Cleveland	100	99	3	3	0	4	6	6	0	0	0	0	0	0	0	0	0	0
Cleveland	150	98	3	72	57	76	83	83	7	1	9	10	10	0	0	0	0	0
Cleveland	150	99	3	46	29	48	60	60	3	0	4	6	6	0	0	0	0	0
Cleveland	200	98	3	185	162	184	210	210	46	29	48	60	60	7	1	9	10	10
Cleveland	200	99	3	136	115	138	154	154	25	15	27	32	32	3	0	4	6	6
Cleveland	250	98	3	258	244	257	274	274	113	93	114	131	131	33	21	34	44	44
Cleveland	250	99	3	228	217	224	244	244	72	57	76	83	83	17	8	20	23	23
Cleveland	300	98	3	313	298	320	321	321	185	162	184	210	210	72	57	76	83	83
Cleveland	300	99	3	281	260	289	294	294	136	115	138	154	154	46	29	48	60	60
Denver	As is		3	2	1	1	3	3	0	0	0	1	1	0	0	0	0	0
Denver	Current Std		3	82	79	80	87	87	2	1	2	4	4	2	1	1	3	3
Denver	50	98	3	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
Denver	50	99	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Denver	100	98	3	4	1	4	7	7	2	1	1	3	3	0	0	0	1	1
Denver	100	99	3	2	1	1	3	3	1	0	0	2	2	0	0	0	0	0
Denver	150	98	3	108	92	109	122	122	4	1	4	7	7	2	1	1	3	3
Denver	150	99	3	42	35	44	48	48	2	1	1	3	3	1	0	1	3	3
Denver	200	98	3	241	221	249	252	252	52	38	55	63	63	4	1	4	7	7
Denver	200	99	3	195	176	200	210	210	14	12	14	16	16	2	1	1	3	3
Denver	250	98	3	295	287	295	304	304	164	142	170	181	181	27	24	25	31	31
Denver	250	99	3	265	256	269	269	269	95	79	96	109	109	8	6	8	10	10
Denver	300	98	3	324	302	332	337	337	241	221	249	252	252	108	92	109	122	122
Denver	300	99	3	310	293	318	319	319	195	176	200	210	210	42	35	44	48	48
Las Vegas	As is		2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Las Vegas	Current Std		2	202	196	202	208	208	19	17	19	21	21	0	0	0	0	0
Las Vegas	50	98	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Las Vegas	50	99	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Location	Standard	Percentile	Site-Years	Number of Daily Maximum Exceedances														
				≥ 100 ppb					≥ 150 ppb					≥ 200 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
Las Vegas	100	98	2	8	6	8	10	10	0	0	0	0	0	0	0	0	0	0
Las Vegas	100	99	2	3	1	3	5	5	0	0	0	0	0	0	0	0	0	0
Las Vegas	150	98	2	162	162	162	162	162	8	6	8	10	10	0	0	0	0	0
Las Vegas	150	99	2	123	117	123	128	128	3	1	3	5	5	0	0	0	0	0
Las Vegas	200	98	2	282	279	282	285	285	96	93	96	99	99	8	6	8	10	10
Las Vegas	200	99	2	263	260	263	265	265	50	43	50	57	57	3	1	3	5	5
Las Vegas	250	98	2	312	311	312	313	313	216	213	216	218	218	60	59	60	60	60
Las Vegas	250	99	2	306	304	306	307	307	177	170	177	183	183	35	29	35	40	40
Las Vegas	300	98	2	322	320	322	324	324	282	279	282	285	285	162	162	162	162	162
Las Vegas	300	99	2	318	316	318	319	319	263	260	263	265	265	123	117	123	128	128
Los Angeles	As is		6	3	0	2	8	8	0	0	0	0	0	0	0	0	0	0
Los Angeles	Current Std		6	53	26	48	82	82	4	0	4	9	9	0	0	0	1	1
Los Angeles	50	98	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Los Angeles	50	99	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Los Angeles	100	98	6	3	0	2	9	9	0	0	0	0	0	0	0	0	0	0
Los Angeles	100	99	6	3	0	2	8	8	0	0	0	0	0	0	0	0	0	0
Los Angeles	150	98	6	50	19	60	65	65	3	0	2	9	9	0	0	0	1	1
Los Angeles	150	99	6	31	8	39	47	47	3	0	2	8	8	0	0	0	1	1
Los Angeles	200	98	6	136	59	148	190	190	23	3	26	33	33	3	0	2	9	9
Los Angeles	200	99	6	107	44	118	150	150	14	1	14	23	23	3	0	2	8	8
Los Angeles	250	98	6	216	115	224	285	285	77	29	86	112	112	16	1	17	26	26
Los Angeles	250	99	6	188	91	200	250	250	54	20	65	73	73	8	1	7	16	16
Los Angeles	300	98	6	270	170	270	335	335	136	59	148	190	190	50	19	60	65	65
Los Angeles	300	99	6	252	152	256	319	319	107	44	118	150	150	31	8	39	47	47
Miami	As is		2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Miami	Current Std		2	87	85	87	89	89	36	36	36	36	36	7	6	7	8	8
Miami	50	98	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Miami	50	99	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Miami	100	98	2	3	1	3	4	4	0	0	0	0	0	0	0	0	0	0
Miami	100	99	2	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0
Miami	150	98	2	36	33	36	38	38	3	1	3	4	4	0	0	0	0	0

Location	Standard	Percentile	Site-Years	Number of Daily Maximum Exceedances														
				≥ 100 ppb					≥ 150 ppb					≥ 200 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
Miami	150	99	2	27	25	27	28	28	1	0	1	1	1	0	0	0	0	0
Miami	200	98	2	75	72	75	77	77	20	18	20	22	22	3	1	3	4	4
Miami	200	99	2	66	64	66	68	68	12	9	12	14	14	1	0	1	1	1
Miami	250	98	2	98	89	98	107	107	48	43	48	52	52	12	9	12	14	14
Miami	250	99	2	88	85	88	91	91	39	36	39	42	42	9	6	9	12	12
Miami	300	98	2	122	110	122	133	133	75	72	75	77	77	36	33	36	38	38
Miami	300	99	2	109	99	109	119	119	66	64	66	68	68	27	25	27	28	28
New York	As is		2	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0
New York	Current Std		2	38	17	38	59	59	2	0	2	3	3	0	0	0	0	0
New York	50	98	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
New York	50	99	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
New York	100	98	2	4	4	4	4	4	0	0	0	0	0	0	0	0	0	0
New York	100	99	2	1	0	1	2	2	0	0	0	0	0	0	0	0	0	0
New York	150	98	2	71	60	71	81	81	4	4	4	4	4	0	0	0	0	0
New York	150	99	2	34	33	34	35	35	1	0	1	2	2	0	0	0	0	0
New York	200	98	2	185	175	185	194	194	37	35	37	38	38	4	4	4	4	4
New York	200	99	2	134	132	134	135	135	10	9	10	11	11	1	0	1	2	2
New York	250	98	2	274	260	274	288	288	114	112	114	115	115	25	24	25	26	26
New York	250	99	2	214	201	214	227	227	59	52	59	66	66	7	4	7	9	9
New York	300	98	2	312	296	312	327	327	185	175	185	194	194	71	60	71	81	81
New York	300	99	2	283	269	283	297	297	134	132	134	135	135	34	33	34	35	35
Phoenix	As is		5	2	0	2	3	3	0	0	0	0	0	0	0	0	0	0
Phoenix	Current Std		5	61	0	83	126	126	3	0	2	8	8	0	0	0	1	1
Phoenix	50	98	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phoenix	50	99	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phoenix	100	98	5	5	0	6	11	11	0	0	0	1	1	0	0	0	0	0
Phoenix	100	99	5	2	0	2	6	6	0	0	0	0	0	0	0	0	0	0
Phoenix	150	98	5	82	0	132	143	143	5	0	6	11	11	0	0	0	2	2
Phoenix	150	99	5	48	0	67	97	97	2	0	2	6	6	0	0	0	1	1
Phoenix	200	98	5	182	7	285	311	311	43	0	55	92	92	5	0	6	11	11
Phoenix	200	99	5	150	2	241	256	256	21	0	25	44	44	2	0	2	6	6

Location	Standard	Percentile	Site-Years	Number of Daily Maximum Exceedances														
				≥ 100 ppb					≥ 150 ppb					≥ 200 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
Phoenix	250	98	5	225	41	335	359	359	121	0	197	203	203	28	0	36	61	61
Phoenix	250	99	5	205	18	315	340	340	82	0	132	143	143	12	0	16	23	23
Phoenix	300	98	5	263	120	349	365	365	182	7	285	311	311	82	0	132	143	143
Phoenix	300	99	5	241	73	341	364	364	150	2	241	256	256	48	0	67	97	97
St. Louis	As is		5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
St. Louis	Current Std		5	109	30	119	178	178	11	0	11	28	28	0	0	0	0	0
St. Louis	50	98	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
St. Louis	50	99	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
St. Louis	100	98	5	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0
St. Louis	100	99	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
St. Louis	150	98	5	49	37	44	65	65	1	0	1	1	1	0	0	0	0	0
St. Louis	150	99	5	41	33	38	56	56	0	0	0	0	0	0	0	0	0	0
St. Louis	200	98	5	158	135	143	187	187	20	16	19	24	24	1	0	1	1	1
St. Louis	200	99	5	145	119	130	178	178	12	11	11	15	15	0	0	0	0	0
St. Louis	250	98	5	245	228	239	263	263	86	66	78	107	107	10	9	9	12	12
St. Louis	250	99	5	233	218	222	254	254	74	53	71	98	98	6	5	6	7	7
St. Louis	300	98	5	298	285	289	319	319	158	135	143	187	187	49	37	44	65	65
St. Louis	300	99	5	298	285	289	319	319	145	119	130	178	178	41	33	38	56	56
Washington DC	As is		5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Washington DC	Current Std		5	60	40	63	76	76	4	0	2	11	11	0	0	0	1	1
Washington DC	50	98	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Washington DC	50	99	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Washington DC	100	98	5	4	2	2	13	13	0	0	0	0	0	0	0	0	0	0
Washington DC	100	99	5	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
Washington DC	150	98	5	63	30	59	92	92	4	2	2	13	13	0	0	0	1	1

Location	Standard	Percentile	Site-Years	Number of Daily Maximum Exceedances														
				≥ 100 ppb					≥ 150 ppb					≥ 200 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
Washington DC	150	99	5	17	5	12	43	43	0	0	0	1	1	0	0	0	0	0
Washington DC	200	98	5	173	122	155	222	222	32	12	30	56	56	4	2	2	13	13
Washington DC	200	99	5	85	43	76	118	118	6	2	4	17	17	0	0	0	1	1
Washington DC	250	98	5	247	197	224	307	307	93	54	80	129	129	20	6	14	47	47
Washington DC	250	99	5	173	122	155	222	222	36	13	36	62	62	4	2	2	13	13
Washington DC	300	98	5	293	256	277	336	336	173	122	155	222	222	63	30	59	92	92
Washington DC	300	99	5	247	197	224	307	307	85	43	76	118	118	17	5	12	43	43

Table A-132. Estimated number of exceedances of 1-hour concentration levels (250 and 300 ppb) for monitors ≤ 20 m from a major road following adjustment to just meeting the current and alternative standards, 2004-2006 air quality.

Location	Standard	Percentile	Site-Years	Number of Daily Maximum Exceedances									
				≥ 250 ppb					≥ 300 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
Boston	As is		3	0	0	0	0	0	0	0	0	0	0
Boston	Current Std		3	0	0	0	0	0	0	0	0	0	0
Boston	50	98	3	0	0	0	0	0	0	0	0	0	0
Boston	50	99	3	0	0	0	0	0	0	0	0	0	0
Boston	100	98	3	0	0	0	0	0	0	0	0	0	0
Boston	100	99	3	0	0	0	0	0	0	0	0	0	0
Boston	150	98	3	0	0	0	0	0	0	0	0	0	0
Boston	150	99	3	0	0	0	0	0	0	0	0	0	0
Boston	200	98	3	0	0	0	0	0	0	0	0	0	0
Boston	200	99	3	0	0	0	0	0	0	0	0	0	0
Boston	250	98	3	2	1	3	3	3	0	0	0	0	0
Boston	250	99	3	0	0	0	0	0	0	0	0	0	0
Boston	300	98	3	11	4	11	18	18	2	1	3	3	3
Boston	300	99	3	3	1	3	4	4	0	0	0	0	0
Chicago	As is		3	0	0	0	0	0	0	0	0	0	0
Chicago	Current Std		3	0	0	0	0	0	0	0	0	0	0
Chicago	50	98	3	0	0	0	0	0	0	0	0	0	0
Chicago	50	99	3	0	0	0	0	0	0	0	0	0	0
Chicago	100	98	3	0	0	0	0	0	0	0	0	0	0
Chicago	100	99	3	0	0	0	0	0	0	0	0	0	0
Chicago	150	98	3	0	0	0	0	0	0	0	0	0	0
Chicago	150	99	3	0	0	0	0	0	0	0	0	0	0
Chicago	200	98	3	0	0	0	0	0	0	0	0	0	0
Chicago	200	99	3	0	0	0	0	0	0	0	0	0	0
Chicago	250	98	3	0	0	0	1	1	0	0	0	0	0
Chicago	250	99	3	0	0	0	0	0	0	0	0	0	0
Chicago	300	98	3	4	0	3	9	9	0	0	0	1	1
Chicago	300	99	3	1	0	2	2	2	0	0	0	0	0
Cleveland	As is		3	0	0	0	0	0	0	0	0	0	0
Cleveland	Current Std		3	0	0	0	0	0	0	0	0	0	0
Cleveland	50	98	3	0	0	0	0	0	0	0	0	0	0
Cleveland	50	99	3	0	0	0	0	0	0	0	0	0	0
Cleveland	100	98	3	0	0	0	0	0	0	0	0	0	0
Cleveland	100	99	3	0	0	0	0	0	0	0	0	0	0
Cleveland	150	98	3	0	0	0	0	0	0	0	0	0	0
Cleveland	150	99	3	0	0	0	0	0	0	0	0	0	0
Cleveland	200	98	3	1	0	1	1	1	0	0	0	0	0
Cleveland	200	99	3	0	0	0	0	0	0	0	0	0	0
Cleveland	250	98	3	7	1	9	10	10	1	0	1	2	2
Cleveland	250	99	3	3	0	4	6	6	0	0	0	0	0

Location	Standard	Percentile	Site-Years	Number of Daily Maximum Exceedances									
				≥ 250 ppb					≥ 300 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
Cleveland	300	98	3	25	15	27	32	32	7	1	9	10	10
Cleveland	300	99	3	11	6	14	14	14	3	0	4	6	6
Denver	As is		3	0	0	0	0	0	0	0	0	0	0
Denver	Current Std		3	0	0	0	1	1	0	0	0	1	1
Denver	50	98	3	0	0	0	0	0	0	0	0	0	0
Denver	50	99	3	0	0	0	0	0	0	0	0	0	0
Denver	100	98	3	0	0	0	0	0	0	0	0	0	0
Denver	100	99	3	0	0	0	0	0	0	0	0	0	0
Denver	150	98	3	1	0	0	2	2	0	0	0	1	1
Denver	150	99	3	0	0	0	1	1	0	0	0	0	0
Denver	200	98	3	2	1	1	3	3	2	1	1	3	3
Denver	200	99	3	2	1	1	3	3	1	0	0	2	2
Denver	250	98	3	3	1	3	6	6	2	1	1	3	3
Denver	250	99	3	2	1	1	3	3	2	1	1	3	3
Denver	300	98	3	16	15	16	18	18	4	1	4	7	7
Denver	300	99	3	5	4	5	7	7	2	1	1	3	3
Las Vegas	As is		2	0	0	0	0	0	0	0	0	0	0
Las Vegas	Current Std		2	0	0	0	0	0	0	0	0	0	0
Las Vegas	50	98	2	0	0	0	0	0	0	0	0	0	0
Las Vegas	50	99	2	0	0	0	0	0	0	0	0	0	0
Las Vegas	100	98	2	0	0	0	0	0	0	0	0	0	0
Las Vegas	100	99	2	0	0	0	0	0	0	0	0	0	0
Las Vegas	150	98	2	0	0	0	0	0	0	0	0	0	0
Las Vegas	150	99	2	0	0	0	0	0	0	0	0	0	0
Las Vegas	200	98	2	0	0	0	0	0	0	0	0	0	0
Las Vegas	200	99	2	0	0	0	0	0	0	0	0	0	0
Las Vegas	250	98	2	7	4	7	9	9	1	0	1	1	1
Las Vegas	250	99	2	3	1	3	5	5	0	0	0	0	0
Las Vegas	300	98	2	43	37	43	49	49	8	6	8	10	10
Las Vegas	300	99	2	24	19	24	29	29	3	1	3	5	5
Los Angeles	As is		6	0	0	0	0	0	0	0	0	0	0
Los Angeles	Current Std		6	0	0	0	0	0	0	0	0	0	0
Los Angeles	50	98	6	0	0	0	0	0	0	0	0	0	0
Los Angeles	50	99	6	0	0	0	0	0	0	0	0	0	0
Los Angeles	100	98	6	0	0	0	0	0	0	0	0	0	0
Los Angeles	100	99	6	0	0	0	0	0	0	0	0	0	0
Los Angeles	150	98	6	0	0	0	0	0	0	0	0	0	0
Los Angeles	150	99	6	0	0	0	0	0	0	0	0	0	0
Los Angeles	200	98	6	1	0	0	2	2	0	0	0	0	0
Los Angeles	200	99	6	0	0	0	1	1	0	0	0	0	0
Los Angeles	250	98	6	3	0	2	9	9	1	0	0	2	2
Los Angeles	250	99	6	3	0	2	8	8	0	0	0	1	1

Location	Standard	Percentile	Site-Years	Number of Daily Maximum Exceedances									
				≥ 250 ppb					≥ 300 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
Los Angeles	300	98	6	13	1	13	23	23	3	0	2	9	9
Los Angeles	300	99	6	6	1	5	13	13	3	0	2	8	8
Miami	As is		2	0	0	0	0	0	0	0	0	0	0
Miami	Current Std		2	1	0	1	1	1	0	0	0	0	0
Miami	50	98	2	0	0	0	0	0	0	0	0	0	0
Miami	50	99	2	0	0	0	0	0	0	0	0	0	0
Miami	100	98	2	0	0	0	0	0	0	0	0	0	0
Miami	100	99	2	0	0	0	0	0	0	0	0	0	0
Miami	150	98	2	0	0	0	0	0	0	0	0	0	0
Miami	150	99	2	0	0	0	0	0	0	0	0	0	0
Miami	200	98	2	0	0	0	0	0	0	0	0	0	0
Miami	200	99	2	0	0	0	0	0	0	0	0	0	0
Miami	250	98	2	3	1	3	4	4	0	0	0	0	0
Miami	250	99	2	1	0	1	1	1	0	0	0	0	0
Miami	300	98	2	10	7	10	12	12	3	1	3	4	4
Miami	300	99	2	7	4	7	9	9	1	0	1	1	1
New York	As is		2	0	0	0	0	0	0	0	0	0	0
New York	Current Std		2	0	0	0	0	0	0	0	0	0	0
New York	50	98	2	0	0	0	0	0	0	0	0	0	0
New York	50	99	2	0	0	0	0	0	0	0	0	0	0
New York	100	98	2	0	0	0	0	0	0	0	0	0	0
New York	100	99	2	0	0	0	0	0	0	0	0	0	0
New York	150	98	2	0	0	0	0	0	0	0	0	0	0
New York	150	99	2	0	0	0	0	0	0	0	0	0	0
New York	200	98	2	1	0	1	1	1	0	0	0	0	0
New York	200	99	2	0	0	0	0	0	0	0	0	0	0
New York	250	98	2	4	4	4	4	4	1	0	1	2	2
New York	250	99	2	1	0	1	2	2	0	0	0	0	0
New York	300	98	2	19	18	19	19	19	4	4	4	4	4
New York	300	99	2	5	4	5	5	5	1	0	1	2	2
Phoenix	As is		5	0	0	0	0	0	0	0	0	0	0
Phoenix	Current Std		5	0	0	0	0	0	0	0	0	0	0
Phoenix	50	98	5	0	0	0	0	0	0	0	0	0	0
Phoenix	50	99	5	0	0	0	0	0	0	0	0	0	0
Phoenix	100	98	5	0	0	0	0	0	0	0	0	0	0
Phoenix	100	99	5	0	0	0	0	0	0	0	0	0	0
Phoenix	150	98	5	0	0	0	0	0	0	0	0	0	0
Phoenix	150	99	5	0	0	0	0	0	0	0	0	0	0
Phoenix	200	98	5	1	0	0	2	2	0	0	0	1	1
Phoenix	200	99	5	0	0	0	2	2	0	0	0	0	0
Phoenix	250	98	5	5	0	6	11	11	2	0	2	3	3
Phoenix	250	99	5	2	0	2	5	5	0	0	0	2	2

Location	Standard	Percentile	Site-Years	Number of Daily Maximum Exceedances ≥ 250 ppb Mean	Min	Med	p98	p99	≥ 300 ppb Mean	Min	Med	p98	p99
Phoenix	300	98	5	21	0	25	44	44	5	0	6	11	11
Phoenix	300	99	5	9	0	13	20	20	2	0	2	6	6
St. Louis	As is		5	0	0	0	0	0	0	0	0	0	0
St. Louis	Current Std		5	0	0	0	0	0	0	0	0	0	0
St. Louis	50	98	5	0	0	0	0	0	0	0	0	0	0
St. Louis	50	99	5	0	0	0	0	0	0	0	0	0	0
St. Louis	100	98	5	0	0	0	0	0	0	0	0	0	0
St. Louis	100	99	5	0	0	0	0	0	0	0	0	0	0
St. Louis	150	98	5	0	0	0	0	0	0	0	0	0	0
St. Louis	150	99	5	0	0	0	0	0	0	0	0	0	0
St. Louis	200	98	5	0	0	0	0	0	0	0	0	0	0
St. Louis	200	99	5	0	0	0	0	0	0	0	0	0	0
St. Louis	250	98	5	0	0	0	0	0	0	0	0	0	0
St. Louis	250	99	5	0	0	0	0	0	0	0	0	0	0
St. Louis	300	98	5	6	5	6	7	7	1	0	1	1	1
St. Louis	300	99	5	4	1	4	6	6	0	0	0	0	0
Washington DC	As is		5	0	0	0	0	0	0	0	0	0	0
Washington DC	Current Std		5	0	0	0	0	0	0	0	0	0	0
Washington DC	50	98	5	0	0	0	0	0	0	0	0	0	0
Washington DC	50	99	5	0	0	0	0	0	0	0	0	0	0
Washington DC	100	98	5	0	0	0	0	0	0	0	0	0	0
Washington DC	100	99	5	0	0	0	0	0	0	0	0	0	0
Washington DC	150	98	5	0	0	0	0	0	0	0	0	0	0
Washington DC	150	99	5	0	0	0	0	0	0	0	0	0	0
Washington DC	200	98	5	0	0	0	1	1	0	0	0	0	0
Washington DC	200	99	5	0	0	0	0	0	0	0	0	0	0
Washington DC	250	98	5	4	2	2	13	13	0	0	0	1	1
Washington DC	250	99	5	0	0	0	1	1	0	0	0	0	0
Washington DC	300	98	5	15	4	10	38	38	4	2	2	13	13
Washington DC	300	99	5	3	1	2	11	11	0	0	0	1	1

Table A-133. Estimated number of exceedances of 1-hour concentration levels (100, 150, and 200 ppb) on-roads following adjustment to just meeting the current and alternative standards, 2004-2006 air quality and an on-road road adjustment factor.

Location	Standard	Percentile	Site-Years	Number of Daily Maximum Exceedances														
				≥ 100 ppb					≥ 150 ppb					≥ 200 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
Atlanta	As is		1500	17	0	2	114	120	2	0	0	26	27	0	0	0	6	7
Atlanta	Current Std		1500	193	4	259	337	341	126	0	148	285	300	72	0	57	225	237
Atlanta	50	98	1500	3	0	0	29	31	0	0	0	4	5	0	0	0	0	0
Atlanta	50	99	1500	2	0	0	21	23	0	0	0	1	2	0	0	0	0	0
Atlanta	100	98	1500	58	0	39	206	218	13	0	1	93	100	3	0	0	29	31
Atlanta	100	99	1500	45	0	21	185	198	8	0	0	64	75	2	0	0	21	23
Atlanta	150	98	1500	133	0	162	295	304	58	0	39	206	218	22	0	3	126	141
Atlanta	150	99	1500	116	0	131	276	288	45	0	21	185	198	15	0	1	103	110
Atlanta	200	98	1500	181	3	241	328	334	111	0	123	266	281	58	0	39	206	218
Atlanta	200	99	1500	167	1	219	319	326	94	0	91	249	262	45	0	21	185	198
Boston	As is		800	2	0	0	18	21	0	0	0	1	1	0	0	0	0	0
Boston	Current Std		800	95	4	91	207	221	25	0	15	104	109	6	0	1	44	50
Boston	50	98	800	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0
Boston	50	99	800	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Boston	100	98	800	19	0	8	92	99	1	0	0	12	13	0	0	0	1	2
Boston	100	99	800	8	0	2	54	65	0	0	0	3	5	0	0	0	0	1
Boston	150	98	800	84	4	78	189	207	19	0	8	92	99	3	0	0	26	33
Boston	150	99	800	52	1	42	150	162	8	0	2	54	65	1	0	0	10	12
Boston	200	98	800	153	32	151	249	267	59	1	50	161	174	19	0	8	92	99
Boston	200	99	800	114	14	111	215	238	34	0	24	119	129	8	0	2	54	65
Chicago	As is		800	36	0	20	148	161	5	0	0	41	53	1	0	0	7	18
Chicago	Current Std		800	189	25	187	329	339	69	0	54	225	241	22	0	8	117	126
Chicago	50	98	800	2	0	0	24	30	0	0	0	0	0	0	0	0	0	0
Chicago	50	99	800	1	0	0	15	24	0	0	0	0	0	0	0	0	0	0
Chicago	100	98	800	59	0	43	201	220	10	0	2	63	78	2	0	0	24	30
Chicago	100	99	800	47	0	31	181	193	8	0	1	54	67	1	0	0	15	24
Chicago	150	98	800	176	20	169	320	329	59	0	43	201	220	18	0	6	98	109
Chicago	150	99	800	157	14	148	313	320	47	0	31	181	193	14	0	4	80	93
Chicago	200	98	800	259	94	261	352	355	138	9	127	302	309	59	0	43	201	220
Chicago	200	99	800	244	64	248	348	353	119	7	108	291	296	47	0	31	181	193

Location	Standard	Percentile	Site-Years	Number of Daily Maximum Exceedances														
				≥ 100 ppb					≥ 150 ppb					≥ 200 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
Denver	As is		300	63	2	49	190	195	10	0	4	47	52	2	0	0	11	14
Denver	Current Std		300	257	135	259	314	320	134	12	133	260	264	52	0	41	164	174
Denver	50	98	300	9	0	2	41	45	1	0	0	5	9	0	0	0	0	0
Denver	50	99	300	5	0	1	23	25	0	0	0	2	3	0	0	0	0	0
Denver	100	98	300	148	20	151	263	269	38	0	23	132	150	9	0	2	41	45
Denver	100	99	300	106	10	100	236	242	23	0	11	87	95	5	0	1	23	25
Denver	150	98	300	263	170	264	315	321	148	20	151	263	269	61	1	48	180	192
Denver	150	99	300	239	114	243	309	313	106	10	100	236	242	38	0	23	132	150
Denver	200	98	300	296	241	308	330	332	239	122	243	309	313	148	20	151	263	269
Denver	200	99	300	286	217	287	323	327	204	66	209	294	299	106	10	100	236	242
Detroit	As is		600	20	0	9	90	103	2	0	0	20	24	0	0	0	3	6
Detroit	Current Std		600	287	166	286	350	352	189	35	193	300	315	95	3	86	222	258
Detroit	50	98	600	13	0	4	57	66	1	0	0	12	18	0	0	0	1	1
Detroit	50	99	600	10	0	2	52	53	1	0	0	9	14	0	0	0	0	1
Detroit	100	98	600	165	29	166	293	296	50	0	37	165	180	13	0	4	57	66
Detroit	100	99	600	146	18	143	275	284	40	0	27	146	163	10	0	2	52	53
Detroit	150	98	600	273	163	271	341	346	165	29	166	293	296	77	1	66	203	221
Detroit	150	99	600	261	141	260	337	342	146	18	143	275	284	62	0	50	186	204
Detroit	200	98	600	313	237	318	355	359	249	117	251	331	337	165	29	166	293	296
Detroit	200	99	600	307	234	309	354	357	235	90	237	327	332	146	18	143	275	284
El Paso	As is		1200	24	0	12	114	143	3	0	0	20	23	0	0	0	4	4
El Paso	Current Std		1200	281	137	285	349	354	198	22	205	309	320	109	3	102	255	265
El Paso	50	98	1200	5	0	1	32	37	0	0	0	4	4	0	0	0	0	1
El Paso	50	99	1200	3	0	0	20	23	0	0	0	2	2	0	0	0	0	0
El Paso	100	98	1200	108	3	102	254	263	23	0	11	113	137	5	0	1	32	37
El Paso	100	99	1200	75	2	62	225	234	13	0	5	72	86	3	0	0	20	23
El Paso	150	98	1200	229	63	235	323	327	108	3	102	254	263	39	0	23	164	178
El Paso	150	99	1200	199	26	205	309	317	75	2	62	225	234	23	0	12	113	137
El Paso	200	98	1200	281	137	286	349	353	197	26	205	308	317	108	3	102	254	263
El Paso	200	99	1200	264	97	271	340	346	162	12	166	289	296	75	2	62	225	234
Jacksonville	As is		200	11	0	5	48	59	2	0	2	5	6	1	0	1	4	4
Jacksonville	Current Std		200	295	229	295	341	342	216	114	223	309	318	134	31	133	260	279

Location	Standard	Percentile	Site-Years	Number of Daily Maximum Exceedances														
				≥ 100 ppb					≥ 150 ppb					≥ 200 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
Jacksonville	50	98	200	9	0	5	39	50	2	0	2	5	5	1	0	1	4	4
Jacksonville	50	99	200	2	0	2	5	5	1	0	1	4	4	0	0	0	3	3
Jacksonville	100	98	200	127	30	124	256	269	35	0	23	138	151	9	0	5	39	50
Jacksonville	100	99	200	39	1	27	145	158	6	0	4	25	29	2	0	2	5	5
Jacksonville	150	98	200	241	145	243	320	327	127	30	124	256	269	55	1	42	169	193
Jacksonville	150	99	200	135	33	131	265	279	39	1	27	145	158	10	0	5	47	59
Jacksonville	200	98	200	293	229	294	339	340	211	104	214	302	312	127	30	124	256	269
Jacksonville	200	99	200	218	118	223	309	318	102	12	95	232	253	39	1	27	145	158
Las Vegas	As is		1100	15	0	0	133	148	2	0	0	54	64	0	0	0	6	8
Las Vegas	Current Std		1100	177	2	171	343	346	99	0	55	317	324	50	0	11	260	275
Las Vegas	50	98	1100	6	0	0	77	79	1	0	0	17	19	0	0	0	0	2
Las Vegas	50	99	1100	4	0	0	71	73	0	0	0	6	8	0	0	0	0	0
Las Vegas	100	98	1100	83	0	39	305	312	22	0	1	174	187	6	0	0	77	79
Las Vegas	100	99	1100	70	0	24	288	304	16	0	0	142	151	4	0	0	71	73
Las Vegas	150	98	1100	161	1	146	342	343	83	0	39	305	312	36	0	5	219	239
Las Vegas	150	99	1100	145	0	118	337	339	70	0	24	288	304	26	0	2	191	206
Las Vegas	200	98	1100	210	6	224	350	350	138	0	108	335	336	83	0	39	305	312
Las Vegas	200	99	1100	198	3	205	348	349	123	0	83	329	333	70	0	24	288	304
Los Angeles	As is		5400	38	0	25	150	169	6	0	1	43	55	1	0	0	11	14
Los Angeles	Current Std		5400	160	2	163	314	326	58	0	45	187	215	18	0	8	90	105
Los Angeles	50	98	5400	2	0	0	18	24	0	0	0	1	2	0	0	0	0	0
Los Angeles	50	99	5400	1	0	0	12	15	0	0	0	1	1	0	0	0	0	0
Los Angeles	100	98	5400	54	0	41	188	208	10	0	2	62	75	2	0	0	18	24
Los Angeles	100	99	5400	40	0	27	153	176	6	0	1	44	55	1	0	0	12	15
Los Angeles	150	98	5400	155	2	155	314	325	54	0	41	188	208	17	0	6	85	104
Los Angeles	150	99	5400	132	0	127	296	310	40	0	27	153	176	11	0	3	68	79
Los Angeles	200	98	5400	227	13	240	349	352	122	0	115	285	304	54	0	41	188	208
Los Angeles	200	99	5400	208	8	217	342	348	100	0	91	258	281	40	0	27	153	176
Miami	As is		400	6	0	1	46	46	0	0	0	6	6	0	0	0	1	1
Miami	Current Std		400	202	100	201	284	286	130	30	139	197	204	77	1	76	160	163
Miami	50	98	400	3	0	0	24	24	0	0	0	1	1	0	0	0	1	1
Miami	50	99	400	2	0	0	18	21	0	0	0	1	1	0	0	0	0	0

Location	Standard	Percentile	Site-Years	Number of Daily Maximum Exceedances														
				≥ 100 ppb					≥ 150 ppb					≥ 200 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
Miami	100	98	400	56	0	47	144	148	13	0	4	72	77	3	0	0	24	24
Miami	100	99	400	46	0	34	134	140	9	0	2	62	65	2	0	0	18	21
Miami	150	98	400	128	24	135	194	199	56	0	47	144	148	21	0	11	97	101
Miami	150	99	400	117	17	123	187	192	46	0	34	134	140	16	0	7	81	92
Miami	200	98	400	182	75	188	260	262	106	12	111	178	183	56	0	47	144	148
Miami	200	99	400	171	63	178	248	250	94	7	96	170	174	46	0	34	134	140
New York	As is		2200	35	0	23	149	171	5	0	1	40	45	1	0	0	13	15
New York	Current Std		2200	147	0	148	308	321	45	0	31	188	202	13	0	4	75	89
New York	50	98	2200	3	0	0	32	34	0	0	0	3	4	0	0	0	0	1
New York	50	99	2200	2	0	0	17	23	0	0	0	1	1	0	0	0	0	0
New York	100	98	2200	75	0	62	225	248	14	0	6	73	88	3	0	0	32	34
New York	100	99	2200	45	0	32	175	196	7	0	2	49	53	2	0	0	17	23
New York	150	98	2200	192	2	204	326	333	75	0	62	225	248	25	0	13	120	135
New York	150	99	2200	149	0	151	305	312	45	0	32	175	196	13	0	4	67	80
New York	200	98	2200	264	38	284	350	353	157	0	162	310	317	75	0	62	225	248
New York	200	99	2200	232	20	250	339	343	115	0	108	278	294	45	0	32	175	196
Philadelphia	As is		1200	22	0	10	101	130	2	0	0	20	22	0	0	0	3	3
Philadelphia	Current Std		1200	232	54	242	321	326	110	2	99	269	280	43	0	27	188	202
Philadelphia	50	98	1200	5	0	1	37	42	0	0	0	4	4	0	0	0	0	0
Philadelphia	50	99	1200	1	0	0	14	14	0	0	0	0	1	0	0	0	0	0
Philadelphia	100	98	1200	112	5	102	258	276	24	0	10	109	139	5	0	1	37	42
Philadelphia	100	99	1200	53	0	39	187	214	8	0	1	49	53	1	0	0	14	14
Philadelphia	150	98	1200	237	76	245	325	329	112	5	102	258	276	39	0	27	155	189
Philadelphia	150	99	1200	172	24	178	297	311	53	0	39	187	214	14	0	4	77	83
Philadelphia	200	98	1200	295	186	302	339	345	204	51	213	313	319	112	5	102	258	276
Philadelphia	200	99	1200	256	105	264	329	332	134	7	130	277	296	53	0	39	187	214
Phoenix	As is		900	77	0	53	275	293	10	0	1	57	71	1	0	0	7	8
Phoenix	Current Std		900	284	127	296	357	359	124	2	111	307	325	38	0	11	186	211
Phoenix	50	98	900	4	0	0	26	35	0	0	0	1	1	0	0	0	0	0
Phoenix	50	99	900	2	0	0	12	14	0	0	0	0	0	0	0	0	0	0
Phoenix	100	98	900	146	3	140	320	332	28	0	7	159	171	4	0	0	26	35
Phoenix	100	99	900	103	0	84	293	312	16	0	2	101	107	2	0	0	12	14

Location	Standard	Percentile	Site-Years	Number of Daily Maximum Exceedances														
				≥ 100 ppb					≥ 150 ppb					≥ 200 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
Phoenix	150	98	900	299	151	309	358	360	146	3	140	320	332	49	0	19	222	245
Phoenix	150	99	900	268	95	280	353	357	103	0	84	293	312	30	0	7	165	184
Phoenix	200	98	900	338	227	347	363	364	264	92	277	352	356	146	3	140	320	332
Phoenix	200	99	900	328	204	337	361	363	225	39	236	345	352	103	0	84	293	312
Provo	As is		300	51	0	44	160	160	17	0	2	68	70	12	0	0	44	44
Provo	Current Std		300	306	153	331	360	361	192	44	187	331	340	87	1	61	260	278
Provo	50	98	300	13	0	0	45	45	4	0	0	42	42	1	0	0	20	20
Provo	50	99	300	13	0	0	44	45	4	0	0	42	42	1	0	0	15	15
Provo	100	98	300	63	0	48	187	187	20	0	5	78	79	13	0	0	45	45
Provo	100	99	300	60	0	46	182	183	19	0	3	78	79	13	0	0	44	45
Provo	150	98	300	209	38	214	328	335	63	0	48	187	187	26	0	17	95	95
Provo	150	99	300	201	30	210	328	334	60	0	46	182	183	24	0	15	91	91
Provo	200	98	300	298	217	300	356	359	160	7	157	306	314	63	0	48	187	187
Provo	200	99	300	294	204	290	354	356	151	6	147	299	306	60	0	46	182	183
St. Louis	As is		400	15	0	5	76	83	1	0	0	20	24	0	0	0	2	5
St. Louis	Current Std		400	233	82	228	341	347	121	1	113	280	300	50	0	33	198	221
St. Louis	50	98	400	4	0	0	35	41	0	0	0	9	10	0	0	0	0	0
St. Louis	50	99	400	3	0	0	31	35	0	0	0	4	9	0	0	0	0	0
St. Louis	100	98	400	107	3	100	238	249	23	0	12	105	108	4	0	0	35	41
St. Louis	100	99	400	98	2	90	227	240	20	0	10	96	101	3	0	0	31	35
St. Louis	150	98	400	226	96	221	331	340	107	3	100	238	249	39	0	28	135	142
St. Louis	150	99	400	217	82	211	328	340	98	2	90	227	240	33	0	22	124	133
St. Louis	200	98	400	287	166	291	357	357	194	62	190	308	320	107	3	100	238	249
St. Louis	200	99	400	282	162	283	355	356	186	49	181	305	317	98	2	90	227	240
Washington DC	As is		1700	21	0	7	119	143	2	0	0	20	22	0	0	0	4	6
Washington DC	Current Std		1700	207	10	238	340	345	102	0	88	270	289	41	0	21	176	202
Washington DC	50	98	1700	5	0	1	37	42	0	0	0	5	6	0	0	0	1	1
Washington DC	50	99	1700	2	0	0	15	16	0	0	0	2	2	0	0	0	0	0
Washington DC	100	98	1700	96	0	81	269	283	22	0	8	126	150	5	0	1	37	42
Washington DC	100	99	1700	50	0	29	209	226	8	0	1	52	66	2	0	0	15	16
Washington DC	150	98	1700	200	2	232	337	345	96	0	81	269	283	36	0	17	173	192
Washington DC	150	99	1700	148	0	157	309	322	50	0	29	209	226	14	0	3	85	110

Location	Standard	Percentile	Site-Years	Number of Daily Maximum Exceedances														
				≥ 100 ppb					≥ 150 ppb					≥ 200 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
Washington DC	200	98	1700	260	42	299	358	362	171	0	191	323	335	96	0	81	269	283
Washington DC	200	99	1700	220	8	256	346	352	117	0	108	288	298	50	0	29	209	226
Other MSA	As is		56500	10	0	1	79	100	1	0	0	12	18	0	0	0	2	3
Other MSA	Current Std		56500	143	0	143	322	336	59	0	36	233	257	22	0	5	138	163
Other MSA	50	98	56500	0	0	0	5	8	0	0	0	0	1	0	0	0	0	0
Other MSA	50	99	56500	0	0	0	2	5	0	0	0	0	0	0	0	0	0	0
Other MSA	100	98	56500	20	0	5	123	152	2	0	0	26	37	0	0	0	5	8
Other MSA	100	99	56500	14	0	2	96	121	1	0	0	17	25	0	0	0	2	5
Other MSA	150	98	56500	80	0	62	264	288	20	0	5	123	152	5	0	0	44	60
Other MSA	150	99	56500	63	0	43	237	263	14	0	2	96	121	3	0	0	30	43
Other MSA	200	98	56500	143	0	144	322	337	57	0	36	228	255	20	0	5	123	152
Other MSA	200	99	56500	125	0	119	311	328	44	0	23	201	228	14	0	2	96	121
Other Not MSA	As is		11600	4	0	0	43	65	1	0	0	7	13	0	0	0	2	5
Other Not MSA	Current Std		11600	124	0	100	331	339	62	0	24	257	272	29	0	4	180	201
Other Not MSA	50	98	11600	0	0	0	2	6	0	0	0	1	2	0	0	0	0	1
Other Not MSA	50	99	11600	0	0	0	2	3	0	0	0	0	2	0	0	0	0	1
Other Not MSA	100	98	11600	6	0	0	61	86	1	0	0	10	17	0	0	0	2	6
Other Not MSA	100	99	11600	2	0	0	23	35	0	0	0	3	7	0	0	0	2	3
Other Not MSA	150	98	11600	28	0	4	173	198	6	0	0	61	86	1	0	0	18	26
Other Not MSA	150	99	11600	13	0	1	113	134	2	0	0	23	35	0	0	0	6	11
Other Not MSA	200	98	11600	60	0	22	249	269	19	0	2	141	164	6	0	0	61	86
Other Not MSA	200	99	11600	34	0	6	193	216	8	0	0	80	104	2	0	0	23	35

Table A-134. Estimated number of exceedances of 1-hour concentration levels (250 and 300 ppb) on-roads following adjustment to just meeting the current and alternative standards, 2004-2006 air quality and an on-road road adjustment factor.

Location	Standard	Percentile	Site-Years	Number of Daily Maximum Exceedances									
				≥ 250 ppb					≥ 300 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
Atlanta	As is		1500	0	0	0	1	1	0	0	0	0	0
Atlanta	Current Std		1500	38	0	15	169	179	19	0	3	117	127
Atlanta	50	98	1500	0	0	0	0	0	0	0	0	0	0
Atlanta	50	99	1500	0	0	0	0	0	0	0	0	0	0
Atlanta	100	98	1500	1	0	0	13	15	0	0	0	4	5
Atlanta	100	99	1500	0	0	0	8	8	0	0	0	1	2
Atlanta	150	98	1500	8	0	0	61	74	3	0	0	29	31
Atlanta	150	99	1500	5	0	0	44	49	2	0	0	21	23
Atlanta	200	98	1500	28	0	6	145	160	13	0	1	93	100
Atlanta	200	99	1500	20	0	3	119	131	8	0	0	64	75
Boston	As is		800	0	0	0	0	0	0	0	0	0	0
Boston	Current Std		800	1	0	0	11	12	0	0	0	2	2
Boston	50	98	800	0	0	0	0	0	0	0	0	0	0
Boston	50	99	800	0	0	0	0	0	0	0	0	0	0
Boston	100	98	800	0	0	0	0	0	0	0	0	0	0
Boston	100	99	800	0	0	0	0	0	0	0	0	0	0
Boston	150	98	800	1	0	0	5	7	0	0	0	1	2
Boston	150	99	800	0	0	0	1	2	0	0	0	0	1
Boston	200	98	800	6	0	1	39	51	1	0	0	12	13
Boston	200	99	800	2	0	0	15	19	0	0	0	3	5
Chicago	As is		800	0	0	0	1	2	0	0	0	0	0
Chicago	Current Std		800	8	0	1	54	63	3	0	0	33	38
Chicago	50	98	800	0	0	0	0	0	0	0	0	0	0
Chicago	50	99	800	0	0	0	0	0	0	0	0	0	0
Chicago	100	98	800	0	0	0	5	11	0	0	0	0	0
Chicago	100	99	800	0	0	0	2	6	0	0	0	0	0
Chicago	150	98	800	6	0	0	48	55	2	0	0	24	30
Chicago	150	99	800	4	0	0	39	45	1	0	0	15	24
Chicago	200	98	800	25	0	11	121	132	10	0	2	63	78
Chicago	200	99	800	19	0	6	99	111	8	0	1	54	67
Denver	As is		300	0	0	0	3	3	0	0	0	0	0
Denver	Current Std		300	21	0	10	79	91	8	0	1	38	43
Denver	50	98	300	0	0	0	0	0	0	0	0	0	0
Denver	50	99	300	0	0	0	0	0	0	0	0	0	0
Denver	100	98	300	3	0	0	16	18	1	0	0	5	9
Denver	100	99	300	1	0	0	7	10	0	0	0	2	3
Denver	150	98	300	25	0	11	93	103	9	0	2	41	45
Denver	150	99	300	13	0	4	59	64	5	0	1	23	25
Denver	200	98	300	75	4	64	210	216	38	0	23	132	150
Denver	200	99	300	49	1	34	158	174	23	0	11	87	95

Location	Standard	Percentile	Site-Years	Number of Daily Maximum Exceedances									
				≥ 250 ppb					≥ 300 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
Detroit	As is		600	0	0	0	0	0	0	0	0	0	0
Detroit	Current Std		600	42	0	28	147	185	18	0	7	73	103
Detroit	50	98	600	0	0	0	0	0	0	0	0	0	0
Detroit	50	99	600	0	0	0	0	0	0	0	0	0	0
Detroit	100	98	600	4	0	0	33	40	1	0	0	12	18
Detroit	100	99	600	3	0	0	25	30	1	0	0	9	14
Detroit	150	98	600	32	0	20	130	145	13	0	4	57	66
Detroit	150	99	600	24	0	12	101	113	10	0	2	52	53
Detroit	200	98	600	96	4	84	231	246	50	0	37	165	180
Detroit	200	99	600	79	1	66	206	226	40	0	27	146	163
El Paso	As is		1200	0	0	0	1	1	0	0	0	0	0
El Paso	Current Std		1200	52	0	35	191	203	24	0	11	119	133
El Paso	50	98	1200	0	0	0	0	0	0	0	0	0	0
El Paso	50	99	1200	0	0	0	0	0	0	0	0	0	0
El Paso	100	98	1200	1	0	0	11	14	0	0	0	4	4
El Paso	100	99	1200	0	0	0	5	8	0	0	0	2	2
El Paso	150	98	1200	13	0	6	72	92	5	0	1	32	37
El Paso	150	99	1200	7	0	2	47	52	3	0	0	20	23
El Paso	200	98	1200	50	0	32	189	201	23	0	11	113	137
El Paso	200	99	1200	32	0	18	141	163	13	0	5	72	86
Jacksonville	As is		200	1	0	0	3	3	1	0	0	3	3
Jacksonville	Current Std		200	72	6	61	202	227	38	1	26	141	158
Jacksonville	50	98	200	1	0	0	3	3	0	0	0	2	2
Jacksonville	50	99	200	0	0	0	2	2	0	0	0	1	1
Jacksonville	100	98	200	3	0	4	9	10	2	0	2	5	5
Jacksonville	100	99	200	1	0	1	4	4	1	0	1	4	4
Jacksonville	150	98	200	22	0	9	96	112	9	0	5	39	50
Jacksonville	150	99	200	3	0	4	12	13	2	0	2	5	5
Jacksonville	200	98	200	68	4	58	196	221	35	0	23	138	151
Jacksonville	200	99	200	15	0	5	67	81	6	0	4	25	29
Las Vegas	As is		1100	0	0	0	0	1	0	0	0	0	0
Las Vegas	Current Std		1100	21	0	1	170	181	9	0	0	86	96
Las Vegas	50	98	1100	0	0	0	0	0	0	0	0	0	0
Las Vegas	50	99	1100	0	0	0	0	0	0	0	0	0	0
Las Vegas	100	98	1100	2	0	0	52	59	1	0	0	17	19
Las Vegas	100	99	1100	1	0	0	31	49	0	0	0	6	8
Las Vegas	150	98	1100	14	0	0	123	138	6	0	0	77	79
Las Vegas	150	99	1100	10	0	0	89	100	4	0	0	71	73
Las Vegas	200	98	1100	46	0	10	247	265	22	0	1	174	187
Las Vegas	200	99	1100	34	0	5	219	235	16	0	0	142	151
Los Angeles	As is		5400	0	0	0	2	3	0	0	0	1	1
Los Angeles	Current		5400	6	0	1	45	55	2	0	0	21	28

Location	Standard	Percentile	Site-Years	Number of Daily Maximum Exceedances ≥ 250 ppb Mean	Min	Med	p98	p99	≥ 300 ppb Mean	Min	Med	p98	p99
	Std												
Los Angeles	50	98	5400	0	0	0	0	0	0	0	0	0	0
Los Angeles	50	99	5400	0	0	0	0	0	0	0	0	0	0
Los Angeles	100	98	5400	0	0	0	4	6	0	0	0	1	2
Los Angeles	100	99	5400	0	0	0	2	3	0	0	0	1	1
Los Angeles	150	98	5400	6	0	1	42	54	2	0	0	18	24
Los Angeles	150	99	5400	3	0	0	31	38	1	0	0	12	15
Los Angeles	200	98	5400	22	0	11	102	126	10	0	2	62	75
Los Angeles	200	99	5400	15	0	5	80	96	6	0	1	44	55
Miami	As is		400	0	0	0	0	0	0	0	0	0	0
Miami	Current Std		400	42	0	32	126	128	22	0	11	98	100
Miami	50	98	400	0	0	0	0	0	0	0	0	0	0
Miami	50	99	400	0	0	0	0	0	0	0	0	0	0
Miami	100	98	400	1	0	0	7	8	0	0	0	1	1
Miami	100	99	400	0	0	0	5	6	0	0	0	1	1
Miami	150	98	400	7	0	2	59	59	3	0	0	24	24
Miami	150	99	400	5	0	1	44	46	2	0	0	18	21
Miami	200	98	400	27	0	15	108	110	13	0	4	72	77
Miami	200	99	400	21	0	11	97	101	9	0	2	62	65
New York	As is		2200	0	0	0	3	4	0	0	0	1	1
New York	Current Std		2200	4	0	0	41	45	2	0	0	20	26
New York	50	98	2200	0	0	0	0	0	0	0	0	0	0
New York	50	99	2200	0	0	0	0	0	0	0	0	0	0
New York	100	98	2200	1	0	0	12	14	0	0	0	3	4
New York	100	99	2200	0	0	0	5	8	0	0	0	1	1
New York	150	98	2200	9	0	2	54	61	3	0	0	32	34
New York	150	99	2200	4	0	0	36	40	2	0	0	17	23
New York	200	98	2200	33	0	20	140	158	14	0	6	73	88
New York	200	99	2200	17	0	8	88	99	7	0	2	49	53
Philadelphia	As is		1200	0	0	0	0	0	0	0	0	0	0
Philadelphia	Current Std		1200	16	0	5	101	115	6	0	1	53	58
Philadelphia	50	98	1200	0	0	0	0	0	0	0	0	0	0
Philadelphia	50	99	1200	0	0	0	0	0	0	0	0	0	0
Philadelphia	100	98	1200	1	0	0	11	14	0	0	0	4	4
Philadelphia	100	99	1200	0	0	0	2	2	0	0	0	0	1
Philadelphia	150	98	1200	14	0	4	73	83	5	0	1	37	42
Philadelphia	150	99	1200	4	0	0	32	36	1	0	0	14	14
Philadelphia	200	98	1200	52	0	38	187	213	24	0	10	109	139
Philadelphia	200	99	1200	20	0	8	94	119	8	0	1	49	53
Phoenix	As is		900	0	0	0	1	1	0	0	0	0	0
Phoenix	Current Std		900	11	0	1	74	87	3	0	0	21	22
Phoenix	50	98	900	0	0	0	0	0	0	0	0	0	0

Location	Standard	Percentile	Site-Years	Number of Daily Maximum Exceedances									
				≥ 250 ppb					≥ 300 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
Phoenix	50	99	900	0	0	0	0	0	0	0	0	0	0
Phoenix	100	98	900	1	0	0	5	7	0	0	0	1	1
Phoenix	100	99	900	0	0	0	2	2	0	0	0	0	0
Phoenix	150	98	900	16	0	2	101	107	4	0	0	26	35
Phoenix	150	99	900	8	0	1	44	62	2	0	0	12	14
Phoenix	200	98	900	65	0	35	256	274	28	0	7	159	171
Phoenix	200	99	900	41	0	13	196	227	16	0	2	101	107
Provo	As is		300	7	0	0	43	43	3	0	0	40	40
Provo	Current Std		300	40	0	43	166	167	24	0	17	69	69
Provo	50	98	300	0	0	0	0	0	0	0	0	0	0
Provo	50	99	300	0	0	0	0	0	0	0	0	0	0
Provo	100	98	300	9	0	0	43	43	4	0	0	42	42
Provo	100	99	300	8	0	0	43	43	4	0	0	42	42
Provo	150	98	300	16	0	1	61	64	13	0	0	45	45
Provo	150	99	300	16	0	1	57	62	13	0	0	44	45
Provo	200	98	300	31	0	23	105	105	20	0	5	78	79
Provo	200	99	300	29	0	22	101	101	19	0	3	78	79
St. Louis	As is		400	0	0	0	0	0	0	0	0	0	0
St. Louis	Current Std		400	19	0	8	124	140	8	0	0	80	87
St. Louis	50	98	400	0	0	0	0	0	0	0	0	0	0
St. Louis	50	99	400	0	0	0	0	0	0	0	0	0	0
St. Louis	100	98	400	1	0	0	17	22	0	0	0	9	10
St. Louis	100	99	400	1	0	0	17	20	0	0	0	4	9
St. Louis	150	98	400	13	0	4	67	75	4	0	0	35	41
St. Louis	150	99	400	11	0	3	61	69	3	0	0	31	35
St. Louis	200	98	400	51	0	41	159	167	23	0	12	105	108
St. Louis	200	99	400	45	0	35	147	162	20	0	10	96	101
Washington DC	As is		1700	0	0	0	1	2	0	0	0	0	0
Washington DC	Current Std		1700	15	0	3	93	110	6	0	1	43	56
Washington DC	50	98	1700	0	0	0	0	0	0	0	0	0	0
Washington DC	50	99	1700	0	0	0	0	0	0	0	0	0	0
Washington DC	100	98	1700	1	0	0	14	15	0	0	0	5	6
Washington DC	100	99	1700	0	0	0	4	6	0	0	0	2	2
Washington DC	150	98	1700	13	0	3	81	102	5	0	1	37	42
Washington DC	150	99	1700	5	0	1	34	36	2	0	0	15	16
Washington DC	200	98	1700	47	0	26	202	216	22	0	8	126	150
Washington	200	99	1700	20	0	7	115	141	8	0	1	52	66

Location	Standard	Percentile	Site-Years	Number of Daily Maximum Exceedances									
				≥ 250 ppb					≥ 300 ppb				
				Mean	Min	Med	p98	p99	Mean	Min	Med	p98	p99
DC													
Other MSA	As is		56500	0	0	0	0	1	0	0	0	0	0
Other MSA	Current Std		56500	8	0	0	70	90	3	0	0	32	45
Other MSA	50	98	56500	0	0	0	0	0	0	0	0	0	0
Other MSA	50	99	56500	0	0	0	0	0	0	0	0	0	0
Other MSA	100	98	56500	0	0	0	1	2	0	0	0	0	1
Other MSA	100	99	56500	0	0	0	1	1	0	0	0	0	0
Other MSA	150	98	56500	1	0	0	15	23	0	0	0	5	8
Other MSA	150	99	56500	1	0	0	9	14	0	0	0	2	5
Other MSA	200	98	56500	7	0	0	58	76	2	0	0	26	37
Other MSA	200	99	56500	4	0	0	41	56	1	0	0	17	25
Other Not MSA	As is		11600	0	0	0	2	2	0	0	0	0	2
Other Not MSA	Current Std		11600	14	0	1	119	137	6	0	0	66	86
Other Not MSA	50	98	11600	0	0	0	0	1	0	0	0	0	0
Other Not MSA	50	99	11600	0	0	0	0	0	0	0	0	0	0
Other Not MSA	100	98	11600	0	0	0	2	3	0	0	0	1	2
Other Not MSA	100	99	11600	0	0	0	0	2	0	0	0	0	2
Other Not MSA	150	98	11600	0	0	0	6	11	0	0	0	2	6
Other Not MSA	150	99	11600	0	0	0	2	5	0	0	0	2	3
Other Not MSA	200	98	11600	2	0	0	23	34	1	0	0	10	17
Other Not MSA	200	99	11600	1	0	0	8	15	0	0	0	3	7

A-9.4 Comparison of Historical and Recent Ambient Air Quality (As Is)

This section presents the preliminary results using the ambient monitoring data obtained from AQS that were separated into two six-year groups, one representing historical data (1995-2000) and the other representing more recent data (2001-2006). This initial analysis performed in the 1st draft REA used the *total* number of exceedances of the potential benchmark levels of 150, 200, 250, and 300 ppb, for monitors sited ≥100 m and <100 m from a major road. It differs from the analyses performed in Chapter 7 of the final REA where the number of times the *daily maximum* exceeded the potential benchmark levels was recorded (including a benchmark level of 100 ppb) for different monitor road categories (≥100 m, 20 m< x <100 m, and ≤20 m from a major road) and for two three-year groups (2001-2003 and 2004-2006). It is presented here mainly for comparison of the two six-year groups of data, because the historical data set was not re-analyzed using the added benchmark level, was not separated into three monitor-to-major road categories, and did not calculate the number of daily maximum exceedances in a year.

A summary of the descriptive statistics for the annual average ambient NO_2 concentrations at each selected location is provided in Tables A-111 and A-112 for monitors sited ≥100 m and <100 m from a major road, respectively. None of the locations contained a measured exceedance of the current annual average standard of 0.053 ppm at any monitor. The highest observed annual average NO_2 concentrations were measured in Los Angeles and Phoenix during the historical monitoring period and considering the monitors ≥100 m from a major road. There were a fewer number of locations with monitors sited <100 m of a major road, however in most of the locations where comparative monitoring data were available, the annual average NO_2 concentrations were greater at the monitors <100 m of a major road (in 23 of 27 possible location/year-group combinations). Four locations (Denver, Los Angeles, Phoenix, St. Louis) contained higher concentrations at the more distant monitors for one year-group when compared with the monitors <100 m from a major road. Where concentrations were greater at the near road monitors, the concentrations were on average about 20-25% higher when compared with the more distant monitors in each corresponding location, regardless of year-group. A comparison of the year-group of data within each monitor site-group indicates that the more recent monitoring concentrations were lower, on average by about 13-15%. These average trends in concentration across year-group and monitor site group were generally observed across all percentiles of the distribution.

Table A-135. Monitoring site-years and annual average NO_2 concentrations for two monitoring periods, historical and recent air quality data (as is) using monitors sited ≥100 m of a major road.

	1995-2000							2001-2006						
	Site-	Annual Mean (ppb) [1]						Site-	Annual Mean (ppb) [1]					
Location	Years	mean	min	med	p95	p98	p99	Years	mean	min	med	p95	p98	p99
Atlanta	24	14	5	15	25	27	27	29	12	3	14	19	23	23
Boston	18	18	5	18	25	25	25	14	9	5	9	12	12	12
Chicago	28	20	9	22	27	28	28	17	21	16	19	28	28	28
Cleveland	5	19	17	20	21	21	21	3	18	17	17	19	19	19
Colorado Springs	25	16	7	17	24	35	35	-	-	-	-	-	-	-
Denver	7	22	15	23	26	26	26	5	21	18	21	26	26	26

Location	1995-2000 Site-Years	Annual Mean (ppb) [1] mean	min	med	p95	p98	p99	2001-2006 Site-Years	Annual Mean (ppb) [1] mean	min	med	p95	p98	p99
Detroit	12	19	12	19	26	26	26	12	19	14	19	23	23	23
El Paso	8	19	14	18	23	23	23	24	15	8	16	18	18	18
Jacksonville	6	15	14	15	16	16	16	4	14	13	14	15	15	15
Las Vegas	8	10	3	6	24	24	24	27	10	1	7	22	22	22
Los Angeles	92	27	6	28	40	46	46	105	20	5	20	33	34	36
Miami	9	9	9	9	10	10	10	10	8	7	8	10	10	10
New York	47	24	11	26	35	36	36	48	20	10	19	28	31	31
Philadelphia	35	21	15	20	33	33	33	26	19	14	18	28	28	28
Phoenix	14	30	26	29	34	34	34	14	25	21	24	29	29	29
Provo	6	24	23	24	24	24	24	6	24	21	23	29	29	29
St. Louis	18	17	5	19	21	21	21	13	16	12	16	21	21	21
Washington DC	33	18	9	19	25	26	26	35	17	7	18	24	25	25
Other MSA	1135	14	1	14	24	26	28	1177	12	1	12	20	22	24
Other Not MSA	200	8	0	7	16	19	19	243	7	1	6	14	16	16

[1] Annual means for each monitor were first calculated based on all hourly values in a year. Then the mean of the annual means was estimated as the sum of all the annual means in a particular location divided by the number of site-years across the monitoring period. The min, med, p95, p98, p99 represent the minimum, median, 95th, 98th, and 99th percentiles of the distribution for the annual mean.
[2] Colorado Springs monitoring data were collected as part of short-term study completed in September 2001, therefore there are no 2001-2006 data.

Table A-136. Monitoring site-years and annual average NO_2 concentrations for two monitoring periods, historical and recent air quality data (as is) using monitors sited <100 m of a major road.

Location	1995-2000 Site-Years	Annual Mean (ppb) [1] mean	min	med	p95	p98	p99	2001-2006 Site-Years	Annual Mean (ppb) [1] mean	min	med	p95	p98	p99
Boston	40	18	6	20	31	31	31	33	18	7	18	25	30	30
Chicago	19	29	22	31	34	34	34	19	27	18	28	32	32	32
Cleveland	6	26	23	27	28	28	28	8	20	14	22	24	24	24
Colorado Springs	1	18	18	18	18	18	18							
Denver	19	14	6	9	35	35	35	5	31	27	29	37	37	37
El Paso	6	29	23	29	35	35	35	6	18	13	19	22	22	22
Las Vegas	8	19	7	25	27	27	27	8	15	3	19	23	23	23
Los Angeles	101	25	4	23	45	46	46	72	25	4	27	37	40	41
Miami	15	11	6	9	17	17	17	10	10	6	10	16	16	16
New York	46	31	22	29	42	42	42	33	29	18	28	40	40	40
Philadelphia	11	30	26	29	34	34	34	13	23	18	24	30	30	30
Phoenix	8	31	24	30	40	40	40	13	25	11	24	37	37	37
St. Louis	38	18	9	19	26	27	27	30	15	8	15	23	25	25
Washington DC	36	23	13	23	27	27	27	31	20	13	20	26	26	26

[1] Annual means for each monitor were first calculated based on all hourly values in a year. Then the mean of the annual means was estimated as the sum of all the annual means in a particular location divided by the number of site-years across the monitoring period. The min, med, p95, p98, p99 represent the minimum, median, 95th, 98th, and 99th percentiles of the distribution for the annual mean.
[2] Colorado Springs monitoring data were collected as part of short-term study completed in September 2001, therefore there are no 2001-2006 data.

The estimated total number of exceedances of four potential health effect benchmark levels (150, 200, 250, and 300 ppb NO_2 for 1-hr) is shown in Tables A-113 and A-114 for the historical and recent ambient monitoring data, respectively, and where the monitors were sited ≥100 m from a major road. The number of exceedances of each benchmark were summed for the year at each monitor; a single monitor value of 10 could represent ten 1-hr exceedances that occurred in one day, 10 exceedances in 10 days, or some combination of multiple hours or days that totaled 10 exceedances for the year. In general, the number of benchmark exceedances was low across all locations and considering both year-groups of the *as is* air quality. The average number of exceedances of the lowest 1-hour concentration level of 150 ppb across each location was typically none or one. Considering that there are 8,760 hours in a year, this number of exceedances amounts to a small fraction of the year (0.01%) containing an exceedance of the potential health effect benchmark level. For locations with greater than 1 yearly average exceedance, the numbers were primarily driven by a single site-year of data. For example, the Colorado Springs mean is 3 exceedances per year for the years 1995-2000; however, this mean was driven by a single site-year that contained 69 exceedances of 200 ppb. That particular monitor (ID 0804160181) does not appear to have any unusual attributes (e.g., the closest major road is beyond a distance of 160 meters and the closest stationary source emitting >5 tons per year (tpy) is at a distance >4 km) except that a power generating utility (NAICS code 221112) located 7.2 km from the monitor has estimated emissions of 4,205 tpy. It is not known at this time whether this particular facility is influencing the observed concentration exceedances at this specific monitoring site. Similarly, Detroit contained the largest number of excedances of 200 ppb (a maximum of 12) for *as is* air quality data from years 2001-2006 (Table A-112). Again, all of those exceedances occurred at one monitor (ID 2616300192) during one year (2002). The number of exceedances of higher potential benchmark concentration levels at each of the locations was less than that observed at the 200 ppb level. Most locations had no exceedances of 250 or 300 ppb, with higher numbers confined to the same aforementioned cities where exceedances of 200 ppb were observed.

When considering the historical data and monitors sited <100 m of a major road (Table A-115), a few locations contained exceedances of the potential health effect benchmark levels, driven mainly by observations from one or two monitors. For example, in Phoenix a single year from one monitor (ID 0401330031) was responsible for all observed exceedances of 200 ppb. This monitor is located 78 m from a major road along with 10 stationary sources located within 10 km of this monitor, 9 of which contained estimated emissions of less than 60 tpy (one source emitted 272 tpy, see Appendix A, section 4). It is not known if observed exceedances of 200 ppb at this monitor are a result of proximity of major roads or the stationary sources. There were fewer locations with observed exceedances of the benchmark levels at the monitors sited within 100 m of a major road considering the more recent *as is* air quality. Eleven of thirteen total locations contained an average of zero exceedances of the 150 ppb benchmark level (Table A-116).

Table A-137. Total number of exceedances of short-term (1-hour) potential health effect benchmark levels in a year, 1995-2000 historical NO_2 air quality (as is) using monitors sited ≥100 m of a major road.

Location	Exceedances of 150 ppb [1]						Exceedances of 200 ppb [1]						Exceedances of 250 ppb [1]						Exceedances of 300 ppb [1]					
	mean	min	med	p95	P98	p99	mean	min	med	p95	p98	p99	mean	min	med	p95	p98	p99	mean	min	med	p95	p98	p99
Atlanta	0	0	0	1	1	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Boston	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chicago	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cleveland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Colorado Springs	8	0	0	47	143	143	3	0	0	3	69	69	1	0	0	0	23	23	0	0	0	0	4	4
Denver	1	0	0	4	4	4	0	0	0	2	2	2	0	0	0	0	0	0	0	0	0	0	0	0
Detroit	1	0	0	10	10	10	0	0	0	3	3	3	0	0	0	1	1	1	0	0	0	1	1	1
El Paso	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jacksonville	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Las Vegas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Los Angeles	3	0	0	22	42	44	0	0	0	2	2	4	0	0	0	0	1	2	0	0	0	0	0	1
Miami	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
New York	0	0	0	0	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Philadelphia	0	0	0	0	10	10	0	0	0	0	3	3	0	0	0	0	0	0	0	0	0	0	0	0
Phoenix	0	0	0	2	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Provo	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
St. Louis	1	0	0	12	12	12	0	0	0	8	8	8	0	0	0	4	4	4	0	0	0	0	0	0
Washington DC	0	0	0	1	2	2	0	0	0	1	2	2	0	0	0	1	1	1	0	0	0	0	0	0
Other MSA	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Not MSA	0	0	0	0	2	4	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0

Notes:
[1] The mean number of exceedances represents the number of exceedances occurring at all monitors in a particular location divided by the number of site-years across the monitoring period. The min, med, p95, p98, and p99 represent the minimum, median, 95th, 98th, and 99th percentiles of the distribution for the number of exceedances in any one year within the monitoring period.

Table A-138. Total number of exceedances of short-term (1-hour) potential health effect benchmark levels in a year, 2001-2006 recent NO_2 air quality (as is) using monitors sited ≥100 m of a major road.

Location	Exceedances of 150 ppb [1]						Exceedances of 200 ppb [1]						Exceedances of 250 ppb [1]						Exceedances of 300 ppb [1]					
	mean	min	med	p95	P98	p99	mean	min	med	p95	p98	p99	mean	min	med	p95	p98	p99	mean	min	med	p95	p98	p99
Atlanta	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Boston	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chicago	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cleveland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Denver	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Detroit	2	0	0	16	16	16	1	0	0	12	12	12	1	0	0	8	8	8	0	0	0	5	5	5
El Paso	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jacksonville	2	0	1	6	6	6	1	0	1	2	2	2	0	0	0	1	1	1	0	0	0	0	0	0
Las Vegas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Los Angeles	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Miami	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
New York	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Philadelphia	0	0	0	0	1	1	0	0	0	0	1	1	0	0	0	0	1	1	0	0	0	0	0	0
Phoenix	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Provo	7	0	0	39	39	39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
St. Louis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Washington DC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other MSA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Not MSA	0	0	0	0	1	2	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0

Notes:

[1] The mean number of exceedances represents the number of exceedances occurring at all monitors in a particular location divided by the number of site-years across the monitoring period. The min, med, p95, p98, and p99 represent the minimum, median, 95th, 98th, and 99th percentiles of the distribution for the number of exceedances in any one year within the monitoring period.

[2] Colorado Springs monitoring data were collected as part of short-term study completed in September 2001, therefore there are no 2001-2006 data.

Table A-139. Total number of exceedances of short-term (1-hour) potential health effect benchmark levels in a year, 1995-2000 historical NO_2 air quality (as is) using monitors sited <100 m of a major road.

	Exceedances of 150 ppb [1]						Exceedances of 200 ppb [1]						Exceedances of 250 ppb [1]						Exceedances of 300 ppb [1]					
Location	**mean**	**min**	**med**	**p95**	**P98**	**p99**	**mean**	**min**	**med**	**p95**	**p98**	**p99**	**mean**	**min**	**med**	**p95**	**p98**	**p99**	**mean**	**min**	**med**	**p95**	**p98**	**p99**
Boston	0	0	0	0	1	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Chicago	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cleveland	2	0	0	9	9	9	0	0	0	1	1	1	0	0	0	1	1	1	0	0	0	0	0	0
Colorado Springs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Denver	0	0	0	6	6	6	0	0	0	1	1	1	0	0	0	1	1	1	0	0	0	0	0	0
El Paso	2	0	1	7	7	7	0	0	0	2	2	2	0	0	0	0	0	0	0	0	0	0	0	0
Las Vegas	1	0	0	11	11	11	1	0	0	11	11	11	0	0	0	3	3	3	0	0	0	3	3	3
Los Angeles	2	0	0	11	18	33	0	0	0	1	2	2	0	0	0	0	0	0	0	0	0	0	0	0
Miami	0	0	0	3	3	3	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
New York	0	0	0	2	3	3	0	0	0	0	3	3	0	0	0	0	0	0	0	0	0	0	0	0
Philadelphia	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phoenix	27	0	1	147	147	147	5	0	0	37	37	37	0	0	0	3	3	3	0	0	0	0	0	0
St. Louis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Washington DC	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Notes:
[1] The mean number of exceedances represents the number of exceedances occurring at all monitors in a particular location divided by the number of site-years across the monitoring period. The min, med, p95, p98, and p99 represent the minimum, median, 95^{th}, 98^{th}, and 99^{th} percentiles of the distribution for the number of exceedances in any one year within the monitoring period.

Table A-140. Total number of exceedances of short-term (1-hour) potential health effect benchmark levels in a year, 2001-2006 recent NO_2 air quality (as is) using monitors sited <100 m of a major road.

Location	Exceedances of 150 ppb [1]						Exceedances of 200 ppb [1]						Exceedances of 250 ppb [1]						Exceedances of 300 ppb [1]					
	mean	min	med	p95	P98	p99	mean	min	med	p95	p98	p99	mean	min	med	p95	p98	p99	mean	min	med	p95	p98	p99
Boston	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chicago	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cleveland	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Denver	1	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
El Paso	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Las Vegas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Los Angeles	0	0	0	2	2	6	0	0	0	0	1	1	0	0	0	0	1	1	0	0	0	0	0	0
Miami	1	0	0	5	5	5	0	0	0	3	3	3	0	0	0	3	3	3	0	0	0	3	3	3
New York	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Philadelphia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phoenix	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
St. Louis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Washington DC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Notes:
[1] The mean number of exceedances represents the number of exceedances occurring at all monitors in a particular location divided by the number of site-years across the monitoring period. The min, med, p95, p98, and p99 represent the minimum, median, 95^{th}, 98^{th}, and 99^{th} percentiles of the distribution for the number of exceedances in any one year within the monitoring period.

A-9.5 Comparison of On-Road Concentrations Derived From Historical and Recent Ambient Air Quality (As Is)

This section presents the preliminary results using the ambient monitoring data obtained from AQS that were separated into two six-year groups, one representing historical data (1995-2000) and the other representing more recent data (2001-2006). These estimated on-road concentrations were generated by applying the simulation procedure described above in section A-8 to ambient monitors ≥100 m of a major road and represent the second scenario evaluated. This initial analysis used the *total number* of exceedances of the potential benchmark levels of 150, 200, 250, and 300 ppb. It differs from the analyses performed in Chapter 7 of the final REA where the number of times the *daily maximum* exceeded the potential benchmark levels was recorded (also including a benchmark level of 100 ppb). It is presented here mainly for comparison of the two six-year groups, because the historical data set was not re-analyzed using the added benchmark level and did have the number of daily maximum exceedances in a year calculated.

Descriptive statistics for estimated on-road NO_2 concentrations are presented in Table A-117. For the 18 named locations, the calculation only used monitors sited at a distance ≥100 m of a major road. The two grouped locations (i.e., "Other CMSA" and "Not MSA") did not have estimated monitor distances to major roads therefore all monitoring data available were used to estimate the distribution of on-road NO_2 concentrations.

The simulated on-road annual average NO_2 concentrations are, on average, a factor of 1.8 higher than their respective ambient levels. This falls within the range of ratios reported in the ISA (about 2-fold higher concentrations on roads) (ISA, section 2.5.4). Los Angeles, New York, and Phoenix were predicted to have the highest on-road NO_2 levels. This is a direct result of these locations already containing some of the highest "*as-is*" NO_2 concentrations prior to the on-road simulation (see Table A-111).

The median of the simulated concentration estimates for Los Angeles were compared with NO_2 measurements provided by Westerdahl et al. (2005) for arterial roads and freeways in the same general location during spring 2003. Although the averaging time is not exactly the same, comparison of the medians is judged to be appropriate.[8] The estimated median on-road concentration for 2001-2006 is 36 ppb which falls within the range of 31 ppb to 55 ppb identified by Westerdahl et al. (2005).

On average, most locations are predicted to have fewer than 10 exceedances per year for the 200 ppb potential health effect benchmark while the median frequency of exceedances in most locations is estimated to be 1 or less per year (Tables A-118 and A-119). When considering the lower 1-hour benchmark of 150 ppb, most locations (17 out of 20) were estimated to have less than 50/year, on average. There are generally fewer predicted mean exceedances of the potential health effect benchmark levels when considering recent air quality compared with the historical

[8] Table A-118 considers annual average of hourly measurements while Westerdahl et al. (2005) reported between 2 to 4 hour average concentrations. Over time, the mean of 2-4 hour averages will be similar to the mean of hourly concentrations, with the main difference being in the variability (and hence the various percentiles of the distribution outside the central tendency).

air quality. Areas with a relatively high number of estimated exceedances (e.g., Provo) are likely influenced by the presence of a small number of monitors and one or a few exceptional site-years where there were unusually high concentrations at the upper percentiles of the concentration distribution.

The upper percentiles for estimated number of exceedances of the 150 ppb, 1-hr average level in most locations using the historical ambient monitoring data was between 100 and 300 per year, while a few locations were estimated to contain up to a several hundred exceedances (e.g., Los Angeles, New York, and Phoenix). There were lower numbers of estimated exceedances considering the 2001-2006 air quality compared with the historical data, with most locations containing under 200 estimated exceedances of 150 ppb per year at the 98^{th} and 99^{th} percentiles. As expected, the frequency of benchmark exceedances at all locations was lower when considering any of the higher benchmark levels (i.e., 200, 250, 300 ppb, 1-hr average) compared with 150 ppb.

The number of predicted benchmark exceedances across large urban areas may be used to broadly represent particular locations within those types of areas. For example, Chicago, New York, and Los Angeles are large CMSAs, have several monitoring sites, and have a large number of roadways. Each of these locations was estimated to have, on average, about 10 exceedances of 200 ppb per year on-roads. Assuming that the on-road exceedances distribution generated from the existing monitoring is proportionally representing the distribution of roadways within each location, about one-half of the roads in these areas would not have any on-road concentrations in excess of 200 ppb. This is because the median value for exceedances of 200 ppb in most locations was estimated as zero. However, Tables A-118 and A-119 indicate that there is also a possibility of tens to just over a hundred exceedances of 200 ppb in a year as an upper bound estimate on certain roads/sites in a particular year.

Table A-141. Estimated annual average on-road NO_2 concentrations for two monitoring periods, historical and recent air quality data (as is).

	1995-2000							2001-2006						
	Site-Years	Annual Mean (ppb) [1]						Site-Years	Annual Mean (ppb) [1]					
Location		mean	min	med	p95	p98	p99		mean	min	med	p95	p98	p99
Atlanta	2400	26	6	25	49	57	60	2900	21	4	23	40	43	47
Boston	1800	32	7	32	51	55	57	1400	16	7	16	25	28	29
Chicago	2800	37	11	39	59	63	66	1700	37	20	35	57	64	66
Cleveland	500	35	22	34	47	49	53	300	32	22	32	42	43	45
Colorado Springs[2]	2500	30	9	30	52	64	73	-	-	-	-	-	-	-
Denver	700	39	19	38	55	58	62	500	39	23	38	54	61	62
Detroit	1200	35	15	34	52	57	59	1200	34	18	34	47	52	54
El Paso	800	34	17	33	49	54	57	2400	26	10	26	39	43	43
Jacksonville	600	28	18	27	37	39	41	400	25	17	25	34	36	37
Las Vegas	800	17	4	11	45	50	55	2700	18	2	13	43	46	50
Los Angeles	9200	50	8	49	83	91	97	10500	37	6	36	63	72	77
Miami	900	17	11	17	23	25	26	1000	15	9	14	21	24	24
New York	4700	43	14	42	73	78	83	4800	35	12	34	56	62	66
Philadelphia	3500	39	19	36	63	73	77	2600	34	18	32	52	60	64

	1995-2000							2001-2006						
	Site-	Annual Mean (ppb) [1]						Site-	Annual Mean (ppb) [1]					
Location	**Years**	**mean**	**min**	**med**	**p95**	**p98**	**p99**	**Years**	**mean**	**min**	**med**	**p95**	**p98**	**p99**
Phoenix	1400	54	33	52	75	78	80	1400	45	26	43	63	70	72
Provo	600	43	29	42	58	62	64	600	43	26	41	61	69	70
St. Louis	1800	31	7	33	47	50	52	1300	30	16	29	41	46	49
Washington DC	3300	33	12	33	53	58	61	3500	31	9	31	51	56	59
Other MSA	113500	26	1	25	47	53	57	117700	21	1	21	39	45	48
Other Not MSA	20000	14	0	12	31	35	39	24300	12	1	11	27	31	33

[1] Annual means for each monitor were first calculated based on all simulated hourly values in a year. Then the mean of the annual means was estimated as the sum of all the annual means in a particular location divided by the number of simulated site-years across the monitoring period. The min, med, p95, p98, p99 represent the minimum, median, 95th, 98th, and 99th percentiles of the distribution for the annual mean.

[2] Colorado Springs monitoring data were collected as part of short-term study completed in September 2001, therefore there are no 2001-2006 data.

Table A-142. Estimated total number of exceedances of short-term (1-hour) potential health effect benchmark levels in a year on-roads, 1995-2000 historical NO_2 air quality (as is).

	Exceedances of 150 ppb [1]						Exceedances of 200 ppb [1]						Exceedances of 250 ppb [1]						Exceedances of 300 ppb [1]					
Location	**mean**	**min**	**med**	**p95**	**P98**	**p99**	**mean**	**min**	**med**	**p95**	**p98**	**p99**	**mean**	**min**	**med**	**p95**	**p98**	**p99**	**mean**	**min**	**med**	**p95**	**p98**	**p99**
Atlanta	24	0	1	160	271	357	4	0	0	31	57	87	1	0	0	3	11	21	0	0	0	1	1	2
Boston	11	0	1	79	106	125	1	0	0	9	20	24	0	0	0	1	4	7	0	0	0	0	1	1
Chicago	39	0	2	212	338	385	7	0	0	41	97	118	1	0	0	6	23	30	0	0	0	0	3	7
Cleveland	15	0	1	108	130	146	2	0	0	19	27	31	0	0	0	1	5	5	0	0	0	1	1	1
Colorado Springs	45	0	0	267	447	626	21	0	0	171	264	325	12	0	0	111	183	219	7	0	0	55	121	160
Denver	48	0	17	185	230	288	8	0	4	36	46	53	2	0	1	10	12	15	1	0	0	4	6	7
Detroit	39	0	19	158	207	270	10	0	2	48	72	86	4	0	1	21	34	35	2	0	0	14	21	26
El Paso	21	0	8	96	141	149	4	0	0	20	31	39	1	0	0	5	7	8	0	0	0	0	2	2
Jacksonville	3	0	0	13	30	36	0	0	0	1	2	4	0	0	0	0	1	1	0	0	0	0	0	0
Las Vegas	14	0	0	95	294	306	2	0	0	5	34	36	0	0	0	0	6	6	0	0	0	0	0	0
Los Angeles	166	0	54	738	1023	1268	43	0	6	213	348	508	12	0	0	63	118	188	4	0	0	17	39	68
Miami	3	0	0	13	27	27	0	0	0	2	4	5	0	0	0	0	0	1	0	0	0	0	0	0
New York	63	0	8	397	560	685	13	0	0	92	155	212	3	0	0	21	44	55	1	0	0	4	10	14
Philadelphia	25	0	2	124	311	369	4	0	0	20	45	63	1	0	0	4	11	15	0	0	0	0	5	7
Phoenix	104	0	31	447	630	670	14	0	2	65	89	102	2	0	0	13	21	27	1	0	0	3	6	11
Provo	21	0	0	112	195	245	2	0	0	9	33	34	0	0	0	0	1	4	0	0	0	0	0	0
St. Louis	14	0	0	74	121	132	2	0	0	15	25	28	1	0	0	10	13	14	1	0	0	7	11	13
Washington DC	21	0	1	128	208	240	3	0	0	20	39	56	1	0	0	2	8	11	0	0	0	1	2	3
Other MSA	10	0	0	55	109	168	1	0	0	6	18	32	0	0	0	1	3	6	0	0	0	0	1	2
Other Not MSA	2	0	0	11	31	55	1	0	0	2	7	14	0	0	0	1	2	4	0	0	0	0	1	2

Notes:
[1] The mean number of exceedances represents the number of exceedances occurring at all monitors in a particular location divided by the number of site-years across the monitoring period. The min, med, p95, p98, and p99 represent the minimum, median, 95^{th}, 98^{th}, and 99^{th} percentiles of the distribution for the number of exceedances in any one year within the monitoring period.

Table A-143. Estimated total number of exceedances of short-term (1-hour) potential health effect benchmark levels in a year on-roads, 2001-2006 recent NO_2 air quality (as is).

	Exceedances of 150 ppb [1]						Exceedances of 200 ppb [1]						Exceedances of 250 ppb [1]						Exceedances of 300 ppb [1]					
Location[2]	**mean**	**min**	**med**	**p95**	**P98**	**p99**	**mean**	**min**	**med**	**p95**	**p98**	**p99**	**mean**	**min**	**med**	**p95**	**p98**	**p99**	**mean**	**min**	**med**	**p95**	**p98**	**p99**
Atlanta	8	0	0	52	101	121	1	0	0	8	16	25	0	0	0	1	3	6	0	0	0	0	1	2
Boston	0	0	0	1	2	10	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Chicago	24	0	1	160	211	337	4	0	0	17	44	69	0	0	0	1	5	10	0	0	0	0	1	1
Cleveland	14	0	3	79	89	89	2	0	0	16	23	23	0	0	0	4	5	6	0	0	0	2	3	3
Denver	41	0	6	171	270	379	4	0	0	25	40	53	0	0	0	3	6	7	0	0	0	0	1	1
Detroit	20	0	3	116	149	171	5	0	0	29	44	45	2	0	0	16	22	28	1	0	0	13	14	21
El Paso	6	0	0	34	45	54	1	0	0	4	8	9	0	0	0	1	1	1	0	0	0	0	0	0
Jacksonville	7	0	2	29	53	53	3	0	1	15	23	24	2	0	0	8	15	15	1	0	0	5	8	8
Las Vegas	9	0	0	39	169	205	1	0	0	3	14	15	0	0	0	0	0	2	0	0	0	0	0	0
Los Angeles	42	0	4	227	405	546	7	0	0	37	87	129	1	0	0	7	20	28	0	0	0	1	3	10
Miami	1	0	0	4	9	16	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0
New York	21	0	1	129	210	280	3	0	0	22	45	72	1	0	0	3	10	16	0	0	0	0	1	2
Philadelphia	12	0	1	62	110	211	1	0	0	5	12	30	0	0	0	1	1	7	0	0	0	0	1	1
Phoenix	37	0	2	184	302	350	3	0	0	14	28	44	0	0	0	1	3	4	0	0	0	0	0	0
Provo	117	0	1	658	702	703	70	0	0	547	662	662	33	0	0	234	606	612	13	0	0	3	423	435
St. Louis	7	0	0	48	84	102	1	0	0	3	10	14	0	0	0	0	2	2	0	0	0	0	0	1
Washington DC	11	0	0	81	130	141	1	0	0	7	14	21	0	0	0	0	1	2	0	0	0	0	0	0
Other MSA	4	0	0	17	44	76	0	0	0	1	5	10	0	0	0	0	1	1	0	0	0	0	0	0
Other Not MSA	1	0	0	4	14	27	0	0	0	1	4	8	0	0	0	0	2	3	0	0	0	0	1	2

Notes:

[1] The mean number of exceedances represents the number of exceedances occurring at all monitors in a particular location divided by the number of site-years across the monitoring period. The min, med, p95, p98, and p99 represent the minimum, median, 95^{th}, 98^{th}, and 99^{th} percentiles of the distribution for the number of exceedances in any one year within the monitoring period.

[2] Colorado Springs monitoring data were collected as part of short-term study completed in September 2001, therefore there are no 2001-2006 data.

A-9.6 Results Tables of Historical NO_2 Ambient Monitoring Data (1995-2000) Adjusted to Just Meeting the Current Standard

This section presents the preliminary results using the historical ambient monitoring data (1995-2000) adjusted to just meet the current annual average standard only. This initial analysis calculated the *total number* of exceedances of the potential benchmark levels of 150, 200, 250, and 300 ppb, for ambient monitors sited ≥100 m and <100 m from a major road. These results are presented in Tables A-120 and A-121, respectively. In addition on-road concentrations were also estimated using the adjusted air quality concentrations, using the same procedure described in section A-8. The total estimated number of exceedances of the potential health effect benchmark levels on-roads given just meeting the current standard is provided in Table A-122. Each of the result tables presented in this section differs from the analyses performed in Chapter 7 of the final REA where the number of times the *daily maximum* exceeded the potential benchmark levels was recorded (including a benchmark level of 100 ppb) for different monitor road categories (≥100 m, 20 m< x <100 m, and ≤20 m from a major road), and for not just the current standard but all of the potential alternative standards. It is presented here mainly as a companion to the *as is* air quality results presented in sections A-9.1 and A-9.2.

Table A-144. Total number of exceedances of short-term (1-hour) potential health effect benchmark levels in a year, 1995-2000 historical NO_2 air quality adjusted to just meeting the current annual average standard (0.053 ppm) using monitors sited ≥100 m of a major road.

	Exceedances of 150 ppb [1]						Exceedances of 200 ppb [1]						Exceedances of 250 ppb [1]						Exceedances of 300 ppb [1]					
Location	**mean**	**min**	**med**	**p95**	**P98**	**p99**	**mean**	**min**	**med**	**p95**	**p98**	**p99**	**mean**	**min**	**med**	**p95**	**p98**	**p99**	**mean**	**min**	**med**	**p95**	**p98**	**p99**
Atlanta	42	0	2	197	233	233	4	0	0	19	21	21	0	0	0	2	3	3	0	0	0	1	1	1
Boston	1	0	0	7	7	7	0	0	0	1	1	1	0	0	0	1	1	1	0	0	0	0	0	0
Chicago	1	0	1	5	7	7	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Cleveland	2	0	1	7	7	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Colorado Springs	50	0	3	283	318	318	32	0	0	180	241	241	16	0	0	123	135	135	8	0	0	72	83	83
Denver	141	1	12	648	648	648	24	0	2	141	141	141	5	0	1	28	28	28	2	0	0	9	9	9
Detroit	75	2	65	162	162	162	13	0	13	25	25	25	4	0	2	15	15	15	2	0	1	10	10	10
El Paso	16	1	9	69	69	69	2	0	1	14	14	14	0	0	0	2	2	2	0	0	0	0	0	0
Jacksonville	122	82	137	147	147	147	12	2	15	20	20	20	2	0	1	7	7	7	0	0	0	1	1	1
Las Vegas	3	0	1	11	11	11	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Los Angeles	9	0	2	56	83	96	1	0	0	4	6	8	0	0	0	1	2	2	0	0	0	0	1	2
Miami	72	4	91	133	133	133	10	0	10	27	27	27	1	0	0	6	6	6	0	0	0	2	2	2
New York	1	0	0	4	7	7	0	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0
Philadelphia	2	0	0	10	18	18	0	0	0	0	12	12	0	0	0	0	9	9	0	0	0	0	5	5
Phoenix	8	0	5	26	26	26	0	0	0	4	4	4	0	0	0	0	0	0	0	0	0	0	0	0
Provo	16	2	4	71	71	71	1	0	0	5	5	5	0	0	0	0	0	0	0	0	0	0	0	0
St. Louis	4	0	1	16	16	16	1	0	0	15	15	15	1	0	0	14	14	14	1	0	0	13	13	13
Washington DC	9	0	3	34	38	38	1	0	0	3	4	4	0	0	0	2	3	3	0	0	0	1	2	2
Other MSA	2	0	0	13	28	40	0	0	0	1	3	6	0	0	0	0	1	1	0	0	0	0	0	1
Other Not MSA	20	0	0	116	241	336	4	0	0	18	53	87	1	0	0	4	15	42	1	0	0	1	8	21

Notes:
[1] The mean number of exceedances represents the number of exceedances occurring at all monitors in a particular location divided by the number of site-years across the monitoring period. The min, med, p95, p98, and p99 represent the minimum, median, 95th, 98th, and 99th percentiles of the distribution for the number of exceedances in any one year within the monitoring period.

Table 145. Total estimated number of exceedances of short-term (1-hour) potential health effect benchmark levels in a year, 1995-2000 historical NO_2 air quality adjusted to just meeting the current annual average standard (0.053 ppm) using monitors sited <100 m of a major road.

	Exceedances of 150 ppb [1]						Exceedances of 200 ppb [1]						Exceedances of 250 ppb [1]						Exceedances of 300 ppb [1]					
Location	**mean**	**min**	**med**	**p95**	**P98**	**p99**	**mean**	**min**	**med**	**p95**	**p98**	**p99**	**mean**	**min**	**med**	**p95**	**p98**	**p99**	**mean**	**min**	**med**	**p95**	**p98**	**p99**
Boston	2	0	0	11	22	22	0	0	0	1	2	2	0	0	0	0	1	1	0	0	0	0	1	1
Chicago	4	0	2	16	16	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cleveland	35	9	16	110	110	110	5	0	1	24	24	24	2	0	0	10	10	10	1	0	0	3	3	3
Colorado Springs	7	7	7	7	7	7	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1
Denver	12	0	0	77	77	77	1	0	0	10	10	10	0	0	0	5	5	5	0	0	0	2	2	2
El Paso	23	5	24	36	36	36	6	0	7	13	13	13	2	0	1	6	6	6	0	0	0	2	2	2
Las Vegas	47	0	25	226	226	226	6	0	1	28	28	28	3	0	0	13	13	13	1	0	0	11	11	11
Los Angeles	8	0	0	42	56	79	1	0	0	6	8	9	0	0	0	0	1	2	0	0	0	0	0	0
Miami	70	2	56	161	161	161	9	0	7	34	34	34	2	0	0	15	15	15	1	0	0	8	8	8
New York	1	0	0	6	10	10	0	0	0	1	3	3	0	0	0	0	3	3	0	0	0	0	1	1
Philadelphia	5	0	3	26	26	26	0	0	0	3	3	3	0	0	0	1	1	1	0	0	0	1	1	1
Phoenix	77	0	9	339	339	339	32	0	1	198	198	198	12	0	0	92	92	92	4	0	0	31	31	31
St. Louis	2	0	1	11	13	13	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Washington DC	12	0	9	47	61	61	1	0	0	9	17	17	0	0	0	0	3	3	0	0	0	0	2	2

Notes:
[1] The mean number of exceedances represents the number of exceedances occurring at all monitors in a particular location divided by the number of site-years across the monitoring period. The min, med, p95, p98, and p99 represent the minimum, median, 95th, 98th, and 99th percentiles of the distribution for the number of exceedances in any one year within the monitoring period.

Table A-146. Total estimated number of exceedances of short-term (1-hour) potential health effect benchmark levels in a year on-roads, 1995-2000 historical NO_2 air quality adjusted to just meeting the current annual average standard (0.053 ppm).

Location	Exceedances of 150 ppb [1]						Exceedances of 200 ppb [1]						Exceedances of 250 ppb [1]						Exceedances of 300 ppb [1]					
	mean	min	med	p95	P98	p99	mean	min	med	p95	p98	p99	mean	min	med	p95	p98	p99	mean	min	med	p95	p98	p99
Atlanta	597	0	215	2122	2566	2778	251	0	42	1094	1472	1640	106	0	7	535	843	947	45	0	1	277	435	514
Boston	231	0	108	930	1282	1394	53	0	11	299	369	390	14	0	1	95	132	161	4	0	0	28	52	65
Chicago	386	0	242	1288	1609	1802	111	0	32	498	615	707	36	0	2	195	289	364	13	0	0	86	153	196
Cleveland	526	42	407	1305	1568	1762	157	1	83	457	586	700	51	0	13	215	269	306	18	0	1	102	131	149
Colorado Springs	866	0	565	2666	3106	3332	308	0	80	1348	1792	1902	123	0	11	574	803	934	61	0	1	299	373	421
Denver	980	15	585	2765	3021	3149	497	0	111	2097	2304	2451	254	0	26	1467	1695	1930	126	0	12	866	1182	1286
Detroit	982	5	860	2413	2771	2882	405	2	284	1227	1439	1589	175	2	97	576	776	872	80	0	40	317	424	482
El Paso	488	19	317	1443	2106	2391	152	0	67	545	997	1126	54	0	16	186	440	485	21	0	6	83	190	251
Jacksonville	1381	365	1328	2485	2677	3110	610	40	549	1426	1515	1801	263	2	195	773	839	1002	114	0	66	407	443	470
Las Vegas	348	0	47	1618	2108	2908	106	0	6	663	894	1248	38	0	1	318	526	596	15	0	0	98	297	355
Los Angeles	323	0	154	1219	1555	1935	97	0	24	427	671	865	32	0	4	158	264	366	11	0	0	54	105	172
Miami	802	33	788	1637	1885	2043	359	2	289	985	1201	1353	159	0	95	550	683	797	72	0	26	297	364	451
New York	199	0	64	950	1251	1384	50	0	5	313	475	602	14	0	0	103	175	230	4	0	0	35	64	81
Philadelphia	362	0	174	1352	1967	2536	86	0	21	400	689	865	24	0	2	125	245	341	7	0	0	38	76	138
Phoenix	811	15	605	2493	2818	2922	229	0	88	954	1293	1375	63	0	12	304	436	544	17	0	2	78	132	181
Provo	1434	84	1363	3215	3526	3729	443	1	230	1643	1871	2058	135	0	32	543	697	817	43	0	2	208	303	339
St. Louis	486	0	368	1402	1630	1843	144	0	51	523	693	728	46	0	9	232	289	323	16	0	0	92	133	163
Washington	562	0	358	1843	2409	2563	176	0	64	721	949	1073	60	0	9	316	411	478	23	0	1	133	217	247
Other MSA	199	0	65	858	1262	1572	52	0	6	268	444	592	15	0	0	84	156	231	5	0	0	25	57	90
Other Not MSA	247	0	45	1234	1771	2130	95	0	7	549	928	1203	39	0	1	221	438	635	17	0	0	91	198	318

Notes:
[1] The mean number of exceedances represents the number of exceedances occurring at all monitors in a particular location divided by the number of site-years across the monitoring period. The min, med, p95, p98, and p99 represent the minimum, median, 95th, 98th, and 99th percentiles of the distribution for the number of exceedances in any one year within the monitoring period.

A-9.7 Results Tables of Recent NO_2 Ambient Monitoring Data (2001-2006) As Is and Just Meeting the Current and Alternative Standards

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Appendix B. Supplement to the NO_2 Exposure Assessment

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B-1 Overview

This appendix contains supplemental descriptions of the methods and data used in the NO_2 exposure assessment, as well as detailed results from the exposure analyses performed. First, a broad description of the exposure modeling approach is described, applicable to the two exposure modeling case-studies conducted to date: Philadelphia and Atlanta. This is followed with details regarding the required inputs for the model and the assumptions made for both of the case-study assessments. The primary output for each exposure assessment was the numbers of exceedances of short-term (1-hour) potential health effect benchmark levels experienced by the asthmatic population residing within each location.

The first simulation location included Philadelphia County and was summarized in the 1st draft Risk and Exposure Assessment (REA). The results from this assessment are presented here as they existed in that document and the draft Technical Support Document draft (TSD) and no adjustments were made to modeling approach used to generate the exposure results. However, additional comparative analyses are presented here to clarify certain issues raised in the review of this case-study by CASAC in May, 2008. These include additional comparisons of the AERMOD modeled air quality with the available ambient monitor data (section 3.6.2) as well as a comparison of the two on-road concentration estimation approaches used (section 3.6.3).

It should be noted that due to the differences in the approach used in the Philadelphia analysis, the results are not directly comparable to the Atlanta case-study. In the dispersion modeling approach used for Philadelphia, minor roadway link emissions were not estimated. This lack of accounting for a potentially large emission source could have been responsible for the underestimations in modeled ambient concentrations when compared with available ambient monitoring data. It followed that the modeled air quality was then adjusted to account for the difference in concentration using the monitored data. This was another difference in the approach used for Philadelphia that was not used in Atlanta. The results for the Philadelphia analysis are still included here since they still estimate exposures for the population within the County, only with different uncertainties in the results when compared with the Atlanta data due to the differing approach used. Most of the uncertainties in the results described in the Atlanta REA can be similarly applied to the Philadelphia assessment (e.g., uncertainty in the CHAD data base, population data bases, asthma prevalence rate, etc.), however, this Appendix does not include a full characterization of uncertainty in the Philadelphia results since it was not used in the final REA.

As mentioned above second case-study was conducted in portions of the Atlanta Metropolitan Statistical Area (MSA) that included four counties. This is the exposure assessment case study included in the final REA. Supplemental data and discussion not included in the final REA regarding the dispersion modeling and exposure modeling approaches for the Atlanta exposure case-study are provided here.

The discussion that follows includes three main sections. First is a broad overview of the APEX model that was used in this NO_2 National Ambient Air Quality Standard (NAAQS) review to estimate human exposures. This is followed with a description of the Philadelphia County approach, data inputs, and results. And third, additional data and discussion regarding the Atlanta exposure assessment are described. This is then followed with a series of

Attachments, further documenting some of the data sources and modeling approaches used, as well as previously conducted uncertainty analyses on selected input parameters.

B-2 Human Exposure Modeling using APEX

The Air Pollutants Exposure model (APEX) is a personal computer (PC)-based program designed to estimate human exposure to criteria and air toxic pollutants at the local, urban, and consolidated metropolitan levels. APEX, also known as TRIM.Expo, is the human inhalation exposure module of EPA's Total Risk Integrated Methodology (TRIM) model framework (US EPA, 1999), a modeling system with multimedia capabilities for assessing human health and ecological risks from hazardous and criteria air pollutants. It is being developed to support evaluations with a scientifically sound, flexible, and user-friendly methodology. Additional information on the TRIM modeling system, as well as downloads of the APEX Model, user's guide, and other supporting documentation, can be found on EPA's Technology Transfer Network (TTN) at http://www.epa.gov/ttn/fera.

B-2.1 History

APEX was derived from the National Ambient Air Quality Standards (NAAQS) Exposure Model (NEM) series of models, developed to estimate exposure to the criteria pollutants (e.g., carbon monoxide (CO), ozone O_3). In 1979, EPA began by assembling a database of human activity patterns that could be used to estimate exposures to indoor and outdoor pollutants (Roddin et al., 1979). These data were then combined with measured outdoor concentrations in NEM to estimate exposures to CO (Biller et al., 1981; Johnson and Paul, 1983). In 1988, OAQPS began to incorporate probabilistic elements into the NEM methodology and use activity pattern data based on various human activity diary studies to create an early version of probabilistic NEM for O_3 (i.e., pNEM/O_3). In 1991, a probabilistic version of NEM was extended to CO (pNEM/CO) that included a one-compartment mass-balance model to estimate CO concentrations in indoor microenvironments. The application of this model to Denver, Colorado has been documented in Johnson et al. (1992). Additional enhancements to pNEM/O_3 in the early- to mid-1990's allowed for probabilistic exposure assessments in nine urban areas for the general population, outdoor children, and outdoor workers (Johnson et al., 1996a; 1996b; 1996c). Between 1999 and 2001, updated versions of pNEM/CO (versions 2.0 and 2.1) were developed that relied on activity diary data from EPA's Consolidated Human Activities Database (CHAD) and enhanced algorithms for simulating gas stove usage, estimating alveolar ventilation rate (a measure of human respiration), and modeling home-to-work commuting patterns.

The first version of APEX was essentially identical to pNEM/CO (version 2.0) except that it was capable of running on a PC instead of a mainframe. The next version, APEX2, was substantially different, particularly in the use of a personal profile approach (i.e., simulation of individuals) rather than a cohort simulation (i.e., groups of similar persons). APEX3 introduced a number of new features including automatic site selection from national databases, a series of new output tables providing summary exposure and dose statistics, and a thoroughly reorganized method of describing microenvironments and their parameters. Most of the spatial and temporal constraints of pNEM and APEX1 were removed or relaxed by version 3.

The version of APEX used in this exposure assessment is APEX4, described in the APEX User's Guide and the APEX Technical Support Document (US EPA, 2006a; 2006b) and referred to here as the APEX User's Guide and TSD.

B-2.2 APEX Model Overview

APEX estimates human exposure to criteria and toxic air pollutants at the local, urban, or consolidated metropolitan area levels using a stochastic, microenvironmental approach. The model randomly selects data for a sample of hypothetical individuals from an actual population database and simulates each hypothetical individual's movements through time and space (e.g., at home, in vehicles) to estimate their exposure to a pollutant. APEX simulates commuting, and thus exposures that occur at home and work locations, for individuals who work in different areas than they live.

A **microenvironment** is a three-dimensional space in which human contact with an environmental pollutant takes place and which can be treated as a well-characterized, relatively homogeneous location with respect to pollutant concentrations for a specified time period.

APEX can be conceptualized as a simulated field study that would involve selecting an actual sample of specific individuals who live in (or work and live in) a geographic area and then continuously monitoring their activities and subsequent inhalation exposure to a specific air pollutant during a specific period of time.

The main differences between APEX and an actual field study are that in APEX:

- The sample of individuals is a virtual sample, not actual persons. However, the population of individuals appropriately balanced according to various demographic variables and census data using their relative frequencies, in order to obtain a representative sample (to the extent possible) of the actual people in the study area
- The activity patterns of the sampled individuals (e.g., the specification of indoor and other microenvironments visited and the time spent in each) are assumed by the model to be comparable to individuals with similar demographic characteristics, according to activity data such as diaries compiled in EPA's Consolidated Human Activity Database (or CHAD; US EPA, 2002; McCurdy et al., 2000)
- The pollutant exposure concentrations are estimated by the model using a set of user-input ambient outdoor concentrations (either modeled or measured) and information on the behavior of the pollutant in various microenvironments;
- Variation in ambient air quality levels can be simulated by either adjusting air quality concentrations to just meet alternative ambient standards, or by reducing source emissions and obtaining resulting air quality modeling outputs that reflect these potential emission reductions, and
- The model accounts for the most significant factors contributing to inhalation exposure – the temporal and spatial distribution of people and pollutant concentrations throughout the study area and among microenvironments – while also allowing the flexibility to adjust some of these factors for alternative scenarios and sensitivity analyses.

APEX is designed to simulate human population exposure to criteria and air toxic pollutants at local, urban, and regional scales. The user specifies the geographic area to be modeled and the number of individuals to be simulated to represent this population. APEX then generates a personal profile for each simulated person that specifies various parameter values required by the model. The model next uses diary-derived time/activity data matched to each personal profile to generate an exposure event sequence (also referred to as *activity pattern* or *diary*) for the modeled individual that spans a specified time period, such as one year. Each event in the sequence specifies a start time, exposure duration, geographic location, microenvironment, and activity performed. Probabilistic algorithms are used to estimate the pollutant concentration associated with each exposure event. The estimated pollutant concentrations account for the effects of ambient (outdoor) pollutant concentration, penetration factors, air exchange rates, decay/deposition rates, and proximity to emission sources, depending on the microenvironment, available data, and estimation method selected by the user. Because the modeled individuals represent a random sample of the population of interest, the distribution of modeled individual exposures can be extrapolated to the larger population. The model simulation can be broadly described in five steps that follow:

1. **Characterize the study area**. APEX selects census tracts within a study area – and thus identifies the potentially exposed population – based on user-defined criteria and availability of air quality and meteorological data for the area.
2. **Generate simulated individuals**. APEX stochastically generates a sample of hypothetical individuals based on the census data for the study area and human profile distribution data (such as age-specific employment probabilities).
3. **Construct a sequence of activity events**. APEX constructs an exposure event sequence spanning the period of the simulation for each of the simulated individuals and based on the activity pattern data.
4. **Calculate hourly concentrations in microenvironments**. APEX users define microenvironments that people in the study area would visit by assigning location codes in the activity pattern to the user-specified microenvironments. The model then calculates hourly concentrations of a pollutant in each of these microenvironments for the period of simulation, based on the user-provided microenvironment descriptions and hourly air quality data. Microenvironmental concentrations are calculated for each of the simulated individuals.
5. **Estimate exposures**.

APEX estimates a concentration for each exposure event based on the microenvironment occupied during the event. These values can be averaged by clock hour to produce a sequence of hourly average exposures spanning the specified exposure period. These hourly values may be further aggregated to produce daily, monthly, and annual average exposure values.

B-2.2.1 Study Area Characterization

The APEX study area has traditionally been on the scale of a city or slightly larger metropolitan area, although it is now possible to model larger areas such as combined statistical areas (CSAs). In the exposure analyses performed as part of this NAAQS review, the study area is defined by either a single or a few counties. The demographic data used by the model to create personal profiles is provided at the census block level. For each block the model requires demographic information representing the distribution of age, gender, race, and work status within the study population. Each block has a location specified by latitude and longitude for some representative point (e.g., geographic center). The current release of APEX includes input files that already contain this demographic and location data for all census tracts, block groups, and blocks in the 50 United States, based on the 2000 Census. In this assessment, exposures were evaluated at the block level.

B-2.2.1.1 Air Quality Data

Air quality data can be input to the model as measured data from an ambient monitor or that generated by air quality modeling. This exposure analysis used modeled air quality data, whereas the principal emission sources included both mobile and stationary sources as well as fugitive emissions. Air quality data used for input to APEX were generated using AERMOD, a steady-state, Gaussian plume model (EPA, 2004). The following steps were performed using AERMOD.

1. **Collect and analyze general input parameters.** Meteorological data, processing methodologies used to derive input meteorological fields (e.g., temperature, wind speed, precipitation), and information on surface characteristics and land use are needed to help determine pollutant dispersion characteristics, atmospheric stability and mixing heights.
2. **Estimate emissions**. The emission sources modeled included, major stationary emission sources, on-road emissions that occur on major roadways, and fugitive emissions.
3. **Define receptor locations**. Three sets of receptors were identified for the dispersion modeling, including ambient monitoring locations, census block centroids, and links along major roadways.
4. **Estimate concentrations at receptors**. Hourly concentrations were estimated for each year of the simulation (years 2001 through 2003) by combining concentration contributions from each of the emission sources and accounting for sources not modeled.

In APEX, the ambient air quality data are assigned to geographic areas called districts. The districts are used to assign pollutant concentrations to the blocks/tracts and microenvironments being modeled. The ambient air quality data are provided by the user as hourly time series for each district. As with blocks/tracts, each district has a representative location (latitude and longitude). APEX calculates the distance from each block/tract to each district center, and assigns the block/tract to the nearest district, provided the block/tract representative location point (e.g., geographic center) is in the district. Each block/tract can be assigned to only one district. In this assessment the district was synonymous with the receptor modeled in the dispersion modeling.

B-2.2.1.2 Meteorological Data

Ambient temperatures are input to APEX for different sites (locations). As with districts, APEX calculates the distance from each block to each temperature site and assigns each block to the nearest site. Hourly temperature data are from the National Climatic Data Center Surface Airways Hourly TD-3280 dataset (NCDC Surface Weather Observations). Daily average and 1-hour maxima are computed from these hourly data.

There are two files that are used to provide meteorological data to APEX. One file, the meteorological station location file, contains the locations of meteorological data recordings expressed in latitude and longitude coordinates. This file also contains start and end dates for the data recording periods. The temperature data file contains the data from the locations in the temperature zone location file. This file contains hourly temperature readings for the period being modeled for the meteorological stations in and around the study area.

B-2.2.2 Simulated Individuals

APEX stochastically generates a user-specified number of simulated persons to represent the population in the study area. Each simulated person is represented by a personal profile, a summary of personal attributes that define the individual. APEX generates the simulated person or profile by probabilistically selecting values for a set of profile variables (Table B-1). The profile variables could include:

- Demographic variables, generated based on the census data;
- Physical variables, generated based on sets of distribution data;
- Other daily varying variables, generated based on literature-derived distribution data that change daily during the simulation period.

APEX first selects demographic and physical attributes for each specified individual, and then follows the individual over time and calculates his or her time series of exposure.

Table B-1. Examples of profile variables in APEX.

Variable Type	Profile Variables	Description
Demographic	Age	Age (years)
	Gender	Male or Female
	Home block	Block in which a simulated person lives
	Work tract	Tract in which a simulated person works
	Employment status	Indicates employment outside home
Physical	Air conditioner	Indicates presence of air conditioning at home
	Gas Stove	Indicates presence of gas stove at home

B-2.2.2.1 Population Demographics

APEX takes population characteristics into account to develop accurate representations of study area demographics. Specifically, population counts by area and employment probability estimates are used to develop representative profiles of hypothetical individuals for the simulation.

APEX is flexible in the resolution of population data provided. As long as the data are available, any resolution can be used (e.g., county, census tract, census block). For this application of the model, census block level data were used. Block-level population counts come from the 2000 Census of Population and Housing Summary File 1 (SF-1). This file contains the 100-percent data, which is the information compiled from the questions asked of all people and about every housing unit.

As part of the population demographics inputs, it is important to integrate working patterns into the assessment. In the 2000 U.S. Census, estimates of employment were developed by census information (US Census Bureau, 2007). The employment statistics are broken down by gender and age group, so that each gender/age group combination is given an employment probability fraction (ranging from 0 to 1) within each census tract. The age groupings used are: 16-19, 20-21, 22-24, 25-29, 30-34, 35-44, 45-54, 55-59, 60-61, 62-64, 65-69, 70-74, and >75. Children under 16 years of age were assumed to be not employed.

Since this analysis was conducted at the census block level, block level employment probabilities were required. It was assumed that the employment probabilities for a census tract apply uniformly to the constituent census blocks.

B-2.2.2.2 Commuting

In addition to using estimates of employment by tract, APEX also incorporates home-to-work commuting data. Commuting data were originally derived from the 2000 Census and were collected as part of the Census Transportation Planning Package (CTPP) (US DOT, 2007). The data used contain counts of individuals commuting from home to work locations at a number of geographic scales. These data were processed to calculate fractions for each tract-to-tract flow to create the national commuting data distributed with APEX. This database contains commuting data for each of the 50 states and Washington, D.C.

Commuting within the Home Tract

The APEX data set does not differentiate people that work at home from those that commute within their home tract.

Commuting Distance Cutoff

A preliminary data analysis of the home-work counts showed that a graph of log(flows) versus log(distance) had a near-constant slope out to a distance of around 120 kilometers. Beyond that distance, the relationship also had a fairly constant slope but it was flatter, meaning that flows were not as sensitive to distance. A simple interpretation of this result is that up to 120 km, the majority of the flow was due to persons traveling back and forth daily, and the numbers of such persons decrease fairly rapidly with increasing distance. Beyond 120 km, the majority of the flow is made up of persons who stay at the workplace for extended times, in which case the separation distance is not as crucial in determining the flow.

To apply the home-work data to commuting patterns in APEX, a simple rule was chosen. It was assumed that all persons in home-work flows up to 120 km are daily commuters, and no persons in more widely separated flows commute daily. This meant that the list of destinations for each home tract was restricted to only those work tracts that are within 120 km of the home tract. When the same cutoff was performed on the 1990 census data, it resulted in 4.75% of the home-work pairs in the nationwide database being eliminated, representing 1.3% of the workers. The assumption is that this 1.3% of workers do not commute from home to work on a daily basis. It is expected that the cutoff reduced the 2000 data by similar amounts.

Eliminated Records

A number of tract-to-tract pairs were eliminated from the database for various reasons. A fair number of tract-to-tract pairs represented workers who either worked outside of the U.S. (9,631 tract pairs with 107,595 workers) or worked in an unknown location (120,830 tract pairs with 8,940,163 workers). An additional 515 workers in the commuting database whose data were missing from the original files, possibly due to privacy concerns or errors, were also deleted.

Commuting outside the study area

APEX allows for some flexibility in the treatment of persons in the modeled population who commute to destinations outside the study area. By specifying "KeepLeavers = No" in the simulation control parameters file, people who work inside the study area but live outside of it are not modeled, nor are people who live in the study area but work outside of it. By specifying "KeepLeavers = Yes," these commuters are modeled. This triggers the use of two additional parameters, called LeaverMult and LeaverAdd. While a commuter is at work, if the workplace is outside the study area, then the ambient concentration is assumed to be related to the average concentration over all air districts at the same point in time, and is calculated as:

$$Ambient\ Concentrat\ ion = LeaverMult \times avg(t) + LeaverAdd \qquad \text{equation (1)}$$

where:

Ambient Concentration	=	Calculated ambient air concentrations for locations outside of the study area (ppm or ppm)
LeaverMult	=	Multiplicative factor for city-wide average concentration, applied when working outside study area
avg(t)	=	Average ambient air concentration over all air districts in study area, for time *t* (ppm or ppm)
LeaverAdd	=	Additive term applied when working outside study area

All microenvironmental concentrations for locations outside of the study area are determined from this ambient concentration by the same function as applies inside the study area.

Block-level commuting

For census block simulations, APEX requires block-level commuting file. A special software preprocesser was created to generate these files for APEX on the basis of the tract-level commuting data and finely-resolved land use data. The software calculates commuting flows between census blocks for the employed population according equation (2).

$$Flow_{block} = Flow_{tract} \times F_{pop} \times F_{land} \qquad \text{equation (2)}$$

where:

$Flow_{block}$ = flow of working population between a home block and a work block.
$Flow_{tract}$ = flow of working population between a home tract and a work tract.
F_{pop} = fraction of home tract's working population residing in the home block.
F_{land} = fraction of work tract's commercial/industrial land area in the work block

Thus, it is assumed that the frequency of commuting to a workplace block within a tract is proportional to the amount of commercial and industrial land in the block.

B-2.2.2.3 Profile Functions

A *Profile Functions* file contains settings used to generate results for variables related to simulated individuals. While certain settings for individuals are generated automatically by APEX based on other input files, including demographic characteristics, others can be specified using this file. For example, the file may contain settings for determining whether the profiled individual's residence has an air conditioner, a gas stove, etc. As an example, the *Profile Functions* file contains fractions indicating the prevalence of air conditioning in the cities modeled in this assessment (Figure B-1). APEX uses these fractions to stochastically generate air conditioning status for each individual. The derivation of particular data used in specific microenvironments is provided below.

```
AC_Home
! Has air conditioning at home
TABLE
INPUT1 PROBABILITY 2     "A/C probabilities"
0.85 0.15
RESULT INTEGER 2        "Yes/No"
1 2
#
```

Figure B-1. Example of a profile function file for A/C prevalence.

B-2.2.3 Activity Pattern Sequences

Exposure models use human activity pattern data to predict and estimate exposure to pollutants. Different human activities, such as spending time outdoors, indoors, or driving, will have varying pollutant exposure concentrations. To accurately model individuals and their exposure to pollutants, it is critical to understand their daily activities.

The Consolidated Human Activity Database (CHAD) provides data for where people spend time and the activities performed. CHAD was designed to provide a basis for conducting multi-route, multi-media exposure assessments (McCurdy et al., 2000). The data contained within CHAD come from multiple activity pattern surveys with varied structures (Table B-2), however the surveys have commonality in containing daily diaries of human activities and personal attributes (e.g., age and gender).

There are four CHAD-related input files used in APEX. Two of these files can be downloaded directly from the CHADNet (http://www.epa.gov/chadnet1), and adjusted to fit into the APEX framework. These are the human activity diaries file and the personal data file, and are discussed below. A third input file contains metabolic information for different activities listed in the diary file, these are not used in this exposure analysis. The fourth input file maps five-digit location codes used in the diary file to APEX microenvironments; this file is discussed in the section describing microenvironmental calculations (Section B-2.2.4.4).

B-2.2.3.1 Personal Information file

Personal attribute data are contained in the CHAD questionnaire file that is distributed with APEX. This file also has information for each day individuals have diaries. The different variables in this file are:

- The study, person, and diary day identifiers
- Day of week
- Gender
- Employment status
- Age in years
- Maximum temperature in degrees Celsius for this diary day
- Mean temperature in degrees Celsius for this diary day
- Occupation code
- Time, in minutes, during this diary day for which no data are included in the database

B-2.2.3.2 Diary Events file

The human activity diary data are contained in the events file that is distributed with APEX. This file contains the activities for the nearly 23,000 people with intervals ranging from one minute to one hour. An individuals' diary varies in length from one to 15 days. This file contains the following variables:

- The study, person, and diary day identifiers
- Start time of this activity
- Number of minutes for this activity
- Activity code (a record of what the individual was doing)
- Location code (a record of where the individual was)

Table B-2. Summary of activity pattern studies used in CHAD.

Study Name	Location	Study time period	Ages	Persons	Person -days	Diary type /study design	Reference
Baltimore	A single building in Baltimore	01/1997-02/1997, 07/1998-08/1998	72-93	26	292	Diary	Williams et al. (2000)
California Adolescents and Adults (CARB)	California	10/1987-09/1988	12-17 18-94	181 1,552	181 1,552	Recall /Random	Robinson et al. (1989); Wiley et al. (1991a)
California Children (CARB)	California	04/1989-02/1990	0-11	1,200	1,200	Recall /Random	Wiley et al. (1991b)
Cincinnati (EPRI)	Cincinnati MSA	03/1985-04/1985, 08/1985	0-86	888	2,587	Diary /Random	Johnson (1989)
Denver (EPA)	Denver MSA	11/1982-02/1983	18-70	432	791	Diary /Random	Johnson (1984); Akland et al. (1985)
Los Angeles: Elementary School Children	Los Angeles	10/1989	10-12	17	51	Diary	Spier et al. (1992)
Los Angeles: High School Adolescents	Los Angeles	09/1990-10/1990	13-17	19	42	Diary	Spier et al. (1992)
National: NHAPS-Air	National	09/1992-10/1994	0-93	4,326	4,326	Recall /Random	Klepeis et al. (1996); Tsang and Klepeis (1996)
National: NHAPS-Water	National	09/1992-10/1994	0-93	4,332	4,332	Recall /Random	Klepeis et al. (1996); Tsang and Klepeis (1996)
Washington, D.C. (EPA)	Wash. DC MSA	11/1982-02/1983	18-98	639	639	Diary /Random	Hartwell et al. (1984); Akland et al. (1985)

B-2.2.3.3 Construction of Longitudinal Activity Sequences

Typical time-activity pattern data available for inhalation exposure modeling consist of a sequence of location/activity combinations spanning a 24-hour duration, with 1 to 3 diary-days for any single individual. Exposure modeling requires information on activity patterns over longer periods of time, e.g., a full year. For example, even for pollutant health effects with short averaging times (e.g., NO_2 1-hour average concentration) it may be desirable to know the frequency of exceedances of a concentration over a long period of time (e.g., the annual number of exceedances of a 1-hour average NO_2 concentration of 200 ppb for each simulated individual).

Long-term multi-day activity patterns can be estimated from single days by combining the daily records in various ways, and the method used for combining them will influence the variability of the long-term activity patterns across the simulated population. This in turn will influence the ability of the model to accurately represent either long-term average high-end exposures, or the number of individuals exposed multiple times to short-term high-end concentrations.

A common approach for constructing long-term activity patterns from short-term records is to re-select a daily activity pattern from the pool of data for each day, with the implicit assumption that there is no correlation between activities from day to day for the simulated individual. This approach tends to result in long-term activity patterns that are very similar across the simulated population. Thus, the resulting exposure estimates are likely to underestimate the variability across the population, and therefore, underestimate the high-end exposure concentrations or the frequency of exceedances.

A contrasting approach is to select a single activity pattern (or a single pattern for each season and/or weekday-weekend) to represent a simulated individual's activities over the duration of the exposure assessment. This approach has the implicit assumption that an individual's day-to-day activities are perfectly correlated. This approach tends to result in long-term activity patterns that are very different across the simulated population, and therefore may over-estimate the variability across the population.

Cluster-Markov Algorithm

A new algorithm has been developed and incorporated into APEX to represent the day-to-day correlation of activities for individuals. The algorithms first use cluster analysis to divide the daily activity pattern records into groups that are similar, and then select a single daily record from each group. This limited number of daily patterns is then used to construct a long-term sequence for a simulated individual, based on empirically-derived transition probabilities. This approach is intermediate between the assumption of no day-to-day correlation (i.e., re-selection for each time period) and perfect correlation (i.e., selection of a single daily record to represent all days).

The steps in the algorithm are as follows.

1. For each demographic group (age, gender, employment status), temperature range, and day-of-week combination, the associated time-activity records are partitioned into 3 groups using cluster analysis. The clustering criterion is a vector of 5 values: the time spent in each of 5 microenvironment categories (indoors – residence; indoors – other building; outdoors – near road; outdoors – away from road; in vehicle).
2. For each simulated individual, a single time-activity record is randomly selected from each cluster.
3. A Markov process determines the probability of a given time-activity pattern occurring on a given day based on the time-activity pattern of the previous day and cluster-to-cluster transition probabilities. The cluster-to-cluster transition probabilities are estimated from the available multi-day time-activity records. If insufficient multi-day time-activity records are available for a demographic group, season, day-of-week combination, then the cluster-to-cluster transition probabilities are estimated from the frequency of time-activity records in each cluster in the CHAD data base.

Details regarding the Cluster-Markov algorithm and supporting evaluations are provided in Attachment 1.

B-2.2.4 Calculating Microenvironmental Concentrations

Probabilistic algorithms are used to estimate the pollutant concentration associated with each exposure event. The estimated pollutant concentrations account for the effects of ambient (outdoor) pollutant concentration, penetration factor, air exchange rate, decay/deposition rate, and proximity to microenvironments can use the transfer factors method while the others use the mass balance emission sources, depending on the microenvironment, available data, and the estimation method selected by the user.

APEX calculates air concentrations in the various microenvironments visited by the simulated person by using the ambient air data for the relevant blocks, the user-specified estimation method, and input parameters specific to each microenvironment. APEX calculates hourly concentrations in all the microenvironments at each hour of the simulation for each of the simulated individuals using one of two methods: by mass balance or a transfer factors method.

B-2.2.4.1 Mass Balance Model

The mass balance method simulates an enclosed microenvironment as a well-mixed volume in which the air concentration is spatially uniform at any specific time. The concentration of an air pollutant in such a microenvironment is estimated using the following processes:

- Inflow of air into the microenvironment
- Outflow of air from the microenvironment
- Removal of a pollutant from the microenvironment due to deposition, filtration, and chemical degradation
- Emissions from sources of a pollutant inside the microenvironment.

Table B-3 lists the parameters required by the mass balance method to calculate concentrations in a microenvironment. A proximity factor ($f_{proximity}$) is used to account for differences in ambient concentrations between the geographic location represented by the ambient air quality data (e.g., a regional fixed-site monitor or modeled concentration) and the geographic location of the microenvironment (e.g., near a roadway). This factor could take a value either greater than or less than 1. Emission source (ES) represents the emission rate for the emission source and concentration source (CS) is the mean air concentration resulting from the source. $R_{removal}$ is defined as the removal rate of a pollutant from a microenvironment due to deposition, filtration, and chemical reaction. The air exchange rate ($R_{air\ exchange}$) is expressed in air changes per hour.

Table B-3. Mass balance model parameters.

Variable	Definition	Units	Value Range
$f_{proximity}$	Proximity factor	unitless	$f_{proximity} \geq 0$
CS	Concentration source	ppb	$CS \geq 0$
$R_{removal}$	Removal rate due to deposition, filtration, and chemical reaction	1/hr	$R_{removal} \geq 0$
$R_{air\ exchange}$	Air exchange rate	1/hr	$R_{air\ exchange} \geq 0$
V	Volume of microenvironment	m^3	$V > 0$

The mass balance equation for a pollutant in a microenvironment is described by:

$$\frac{dC_{ME}(t)}{dt} = \Delta C_{in} - \Delta C_{out} - \Delta C_{removal} + \Delta C_{source} \qquad \text{equation (3)}$$

where:

$dC_{ME}(t)$	=	Change in concentration in a microenvironment at time *t* (ppb),
ΔC_{in}	=	Rate of change in microenvironmental concentration due to influx of air (ppb/hour),
ΔC_{out}	=	Rate of change in microenvironmental concentration due to outflux of air (ppb/hour),
$\Delta C_{removal}$	=	Rate of change in microenvironmental concentration due to removal processes (ppb/hour), and
ΔC_{source}	=	Rate of change in microenvironmental concentration due to an emission source inside the microenvironment (ppb/hour).

Within the time period of an hour each of the rates of change, ΔC_{in}, ΔC_{out}, $\Delta C_{removal}$, and ΔC_{source}, is assumed to be constant. At each hour time step of the simulation period, APEX estimates the hourly equilibrium, hourly ending, and hourly mean concentrations using a series of equations that account for concentration changes expected to occur due to these physical processes. Details regarding these equations are provided in the APEX User's Guide. APEX reports hourly mean concentration as hourly concentration for a specific hour. The calculation then continues to the next hour by using the end concentration for the previous hour as the initial microenvironmental concentration. A description of the input parameters estimates used for microenvironments using the mass balance approach is provided below.

B-2.2.4.2 Factors Model

The factors method is simpler than the mass balance method. It does not calculate concentration in a microenvironment from the concentration in the previous hour and it has fewer parameters. Table B-4 lists the parameters required by the factors method to calculate concentrations in a microenvironment without emissions sources.

Table B-4. Factors model parameters.

Variable	Definition	Units	Value Range
$f_{proximity}$	Proximity factor	unitless	$f_{proximity} \geq 0$
$f_{penetration}$	Penetration factor	unitless	$0 \leq f_{penetration} \leq 1$

The factors method uses the following equation to calculate hourly mean concentration in a microenvironment from the user-provided hourly air quality data:

$$C_{ME}^{hourlymean} = C_{ambient} \; x \; f_{proximity} \; x \; f_{penetration} \qquad \text{equation (4)}$$

where:

$C_{ME}^{hourlymean}$	=	Hourly concentration in a microenvironment (ppb)
$C_{ambient}$	=	Hourly concentration in ambient environment (ppb)
$f_{proximity}$	=	Proximity factor (unitless)
$f_{penetration}$	=	Penetration factor (unitless)

The ambient NO_2 concentrations are from the air quality data input file. The proximity factor is a unitless parameter that represents the proximity of the microenvironment to a monitoring station. The penetration factor is a unitless parameter that represents the fraction of pollutant entering a microenvironment from outside the microenvironment via air exchange. The development of the specific proximity and penetration factors used in this analysis are discussed below for each microenvironment using this approach.

B-2.2.4.3 Microenvironments Modeled

In APEX, microenvironments represent the exposure locations for simulated individuals. For exposures to be estimated accurately, it is important to have realistic microenvironments that match closely to the locations where actual people spend time on a daily basis. As discussed above, the two methods available in APEX for calculating pollutant levels within microenvironments are: 1) factors and 2) mass balance. A list of microenvironments used in this study, the calculation method used, and the parameters used to calculate the microenvironment concentrations can be found in Table B-5.

Table B-5. List of microenvironments and calculation methods used.

Microenvironment		Calculation Method	Parameter Types used [1]
No.	Name		
1	Indoors – Residence	Mass balance	AER and DE
2	Indoors – Bars and restaurants	Mass balance	AER and DE
3	Indoors – Schools	Mass balance	AER and DE
4	Indoors – Day-care centers	Mass balance	AER and DE
5	Indoors – Office	Mass balance	AER and DE
6	Indoors – Shopping	Mass balance	AER and DE
7	Indoors – Other	Mass balance	AER and DE
8	Outdoors – Near road	Factors	PR
9	Outdoors – Public garage - parking lot	Factors	PR
10	Outdoors – Other	Factors	None
11	In-vehicle – Cars and Trucks	Factors	PE and PR
12	In-vehicle - Mass Transit (bus, subway, train)	Factors	PE and PR
0	Not modeled		
[1] AER=air exchange rate, DE=decay-deposition rate, PR=proximity factor, PE=penetration factor			

Each of the microenvironments is designed to simulate an environment in which people spend time during the day. CHAD locations are linked to the different microenvironments in the *Microenvironment Mapping* File (see below). There are many more CHAD locations than microenvironment locations (there are 113 CHAD codes versus 12 microenvironments in this assessment), therefore most of the microenvironments have multiple CHAD locations mapped to them.

B-2.2.4.4 Mapping of APEX Microenvironments to CHAD Diaries

The *Microenvironment Mapping* file matches the APEX Microenvironments to CHAD Location codes. Table B-6 gives the mapping used for the APEX simulations.

Table B-6. Mapping of CHAD activity locations to APEX microenvironments.

CHAD Loc.	Description		APEX micro	
U	Uncertain of correct code	=	-1	Unknown
X	No data	=	-1	Unknown
30000	Residence, general	=	1	Indoors-Residence
30010	Your residence	=	1	Indoors-Residence
30020	Other residence	=	1	Indoors-Residence
30100	Residence, indoor	=	1	Indoors-Residence
30120	Your residence, indoor	=	1	Indoors-Residence
30121	..., kitchen	=	1	Indoors-Residence
30122	..., living room or family room	=	1	Indoors-Residence
30123	..., dining room	=	1	Indoors-Residence
30124	..., bathroom	=	1	Indoors-Residence
30125	..., bedroom	=	1	Indoors-Residence
30126	..., study or office	=	1	Indoors-Residence
30127	..., basement	=	1	Indoors-Residence
30128	..., utility or laundry room	=	1	Indoors-Residence
30129	..., other indoor	=	1	Indoors-Residence
30130	Other residence, indoor	=	1	Indoors-Residence
30131	..., kitchen	=	1	Indoors-Residence
30132	..., living room or family room	=	1	Indoors-Residence
30133	..., dining room	=	1	Indoors-Residence
30134	..., bathroom	=	1	Indoors-Residence
30135	..., bedroom	=	1	Indoors-Residence
30136	..., study or office	=	1	Indoors-Residence
30137	..., basement	=	1	Indoors-Residence
30138	..., utility or laundry room	=	1	Indoors-Residence
30139	..., other indoor	=	1	Indoors-Residence
30200	Residence, outdoor	=	10	Outdoors-Other
30210	Your residence, outdoor	=	10	Outdoors-Other
30211	..., pool or spa	=	10	Outdoors-Other
30219	..., other outdoor	=	10	Outdoors-Other
30220	Other residence, outdoor	=	10	Outdoors-Other
30221	..., pool or spa	=	10	Outdoors-Other
30229	..., other outdoor	=	10	Outdoors-Other
30300	Residential garage or carport	=	7	Indoors-Other
30310	..., indoor	=	7	Indoors-Other
30320	..., outdoor	=	10	Outdoors-Other
30330	Your garage or carport	=	1	Indoors-Residence
30331	..., indoor	=	1	Indoors-Residence
30332	..., outdoor	=	10	Outdoors-Other
30340	Other residential garage or carport	=	1	Indoors-Residence
30341	..., indoor	=	1	Indoors-Residence
30342	..., outdoor	=	10	Outdoors-Other
30400	Residence, none of the above	=	1	Indoors-Residence
31000	Travel, general	=	11	In Vehicle-Cars_and_Trucks
31100	Motorized travel	=	11	In Vehicle-Cars_and_Trucks
31110	Car	=	11	In Vehicle-Cars_and_Trucks
31120	Truck	=	11	In Vehicle-Cars_and_Trucks
31121	Truck (pickup or van)	=	11	In Vehicle-Cars_and_Trucks
31122	Truck (not pickup or van)	=	11	In Vehicle-Cars_and_Trucks
31130	Motorcycle or moped	=	8	Outdoors-Near_Road
31140	Bus	=	12	In Vehicle-Mass_Transit
31150	Train or subway	=	12	In Vehicle-Mass_Transit
31160	Airplane	=	0	Zero_concentration
31170	Boat	=	10	Outdoors-Other
31171	Boat, motorized	=	10	Outdoors-Other

31172	Boat, other	=	10	Outdoors-Other
31200	Non-motorized travel	=	10	Outdoors-Other
31210	Walk	=	10	Outdoors-Other
31220	Bicycle or inline skates/skateboard	=	10	Outdoors-Other
31230	In stroller or carried by adult	=	10	Outdoors-Other
31300	Waiting for travel	=	10	Outdoors-Other
31310	..., bus or train stop	=	8	Outdoors-Near_Road
31320	..., indoors	=	7	Indoors-Other
31900	Travel, other	=	11	In Vehicle-Cars_and_Trucks
31910	..., other vehicle	=	11	In Vehicle-Cars_and_Trucks
32000	Non-residence indoor, general	=	7	Indoors-Other
32100	Office building/ bank/ post office	=	5	Indoors-Office
32200	Industrial/ factory/ warehouse	=	5	Indoors-Office
32300	Grocery store/ convenience store	=	6	Indoors-Shopping
32400	Shopping mall/ non-grocery store	=	6	Indoors-Shopping
32500	Bar/ night club/ bowling alley	=	2	Indoors-Bars_and_Restaurants
32510	Bar or night club	=	2	Indoors-Bars_and_Restaurants
32520	Bowling alley	=	2	Indoors-Bars_and_Restaurants
32600	Repair shop	=	7	Indoors-Other
32610	Auto repair shop/ gas station	=	7	Indoors-Other
32620	Other repair shop	=	7	Indoors-Other
32700	Indoor gym /health club	=	7	Indoors-Other
32800	Childcare facility	=	4	Indoors-Day_Care_Centers
32810	..., house	=	1	Indoors-Residence
32820	..., commercial	=	4	Indoors-Day_Care_Centers
32900	Large public building	=	7	Indoors-Other
32910	Auditorium/ arena/ concert hall	=	7	Indoors-Other
32920	Library/ courtroom/ museum/ theater	=	7	Indoors-Other
33100	Laundromat	=	7	Indoors-Other
33200	Hospital/ medical care facility	=	7	Indoors-Other
33300	Barber/ hair dresser/ beauty parlor	=	7	Indoors-Other
33400	Indoors, moving among locations	=	7	Indoors-Other
33500	School	=	3	Indoors-Schools
33600	Restaurant	=	2	Indoors-Bars_and_Restaurants
33700	Church	=	7	Indoors-Other
33800	Hotel/ motel	=	7	Indoors-Other
33900	Dry cleaners	=	7	Indoors-Other
34100	Indoor parking garage	=	7	Indoors-Other
34200	Laboratory	=	7	Indoors-Other
34300	Indoor, none of the above	=	7	Indoors-Other
35000	Non-residence outdoor, general	=	10	Outdoors-Other
35100	Sidewalk, street	=	8	Outdoors-Near_Road
35110	Within 10 yards of street	=	8	Outdoors-Near_Road
35200	Outdoor public parking lot /garage	=	9	Outdoors-Public_Garage-Parking
35210	..., public garage	=	9	Outdoors-Public_Garage-Parking
35220	..., parking lot	=	9	Outdoors-Public_Garage-Parking
35300	Service station/ gas station	=	10	Outdoors-Other
35400	Construction site	=	10	Outdoors-Other
35500	Amusement park	=	10	Outdoors-Other
35600	Playground	=	10	Outdoors-Other
35610	..., school grounds	=	10	Outdoors-Other
35620	..., public or park	=	10	Outdoors-Other
35700	Stadium or amphitheater	=	10	Outdoors-Other
35800	Park/ golf course	=	10	Outdoors-Other
35810	Park	=	10	Outdoors-Other
35820	Golf course	=	10	Outdoors-Other
35900	Pool/ river/ lake	=	10	Outdoors-Other
36100	Outdoor restaurant/ picnic	=	10	Outdoors-Other
36200	Farm	=	10	Outdoors-Other
36300	Outdoor, none of the above	=	10	Outdoors-Other

B-2.2.5 Exposure Calculations

APEX calculates exposure as a time series of exposure concentrations that a simulated individual experiences during the simulation period. APEX determines the exposure using hourly ambient air concentrations, calculated concentrations in each microenvironment based on these ambient air concentrations (and indoor sources if present), and the minutes spent in a sequence of microenvironments visited according to the composite diary. The hourly exposure concentration at any clock hour during the simulation period is determined using the following equation:

$$C_i = \frac{\sum_{j=1}^{N} C_{ME(j)}^{hourlymean} \; t_{(j)}}{T} \qquad \text{equation (5)}$$

where:

C_i	=	Hourly exposure concentration at clock hour *i* of the simulation period (ppb)
N	=	Number of events (i.e., microenvironments visited) in clock hour *i* of the simulation period.
$C_{ME(j)}^{hourlymean}$	=	Hourly mean concentration in microenvironment *j* (ppm)
$t_{(j)}$	=	Time spent in microenvironment *j* (minutes)
T	=	60 minutes

From the hourly exposures, APEX calculates time series of 1-hour average exposure concentrations that a simulated individual would experience during the simulation period. APEX then statistically summarizes and tabulates the hourly (or daily, annual average) exposures. In this analysis, the exposure indicator is 1-hr exposures above selected health effect benchmark levels. From this, APEX can calculate two general types of exposure estimates: counts of the estimated number of people exposed to a specified NO_2 concentration level and the number of times per year that they are so exposed; the latter metric is in terms of person-occurrences or person-days. The former highlights the number of individuals exposed at least *one or more* times per modeling period to the health effect benchmark level of interest. APEX can also report counts of individuals with multiple exposures. This person-occurrences measure estimates the number of times per season that individuals are exposed to the exposure indicator of interest and then accumulates these estimates for the entire population residing in an area.

APEX tabulates and displays the two measures for exposures above levels ranging from 200 to 300 ppb by 50 ppb increments for 1-hour average exposures. These results are tabulated for the population and subpopulations of interest.

B-2.2.6 Exposure Model Output

All of the output files written by APEX are ASCII text files. Table B-7 lists each of the output data files written for these simulations and provides descriptions of their content. Additional output files that can produced by APEX are given in Table 5-1 of the APEX User's

Guide, and include hourly exposure, ventilation, and energy expenditures, and even detailed event-level information, if desired. The names and locations, as well as the output table levels (e.g., output percentiles, cut-points), for these output files are specified by the user in the simulation control parameters file.

Table B-7. Example of APEX output files.

Output File Type	Description
Log	The *Log* file contains the record of the APEX model simulation as it progresses. If the simulation completes successfully, the log file indicates the input files and parameter settings used for the simulation and reports on a number of different factors. If the simulation ends prematurely, the log file contains error messages describing the critical errors that caused the simulation to end.
Profile Summary	The *Profile Summary* file provides a summary of each individual modeled in the simulation.
Microenvironment Summary	The *Microenvironment Summary* file provides a summary of the time and exposure by microenvironment for each individual modeled in the simulation.
Sites	The *Sites* file lists the tracts, districts, and zones in the study area, and identifies the mapping between them.
Output Tables	The *Output Tables* file contains a series of tables summarizing the results of the simulation. The percentiles and cut-off points used in these tables are defined in the simulation control parameters file.

B-3 Philadelphia Exposure Assessment Case-Study

This section documents detailed methodology and input data used in the Philadelphia inhalation exposure assessment for NO_2 conducted in support of the current review of the NO_2 primary NAAQS. As mentioned in the Overview (section B-1), the Philadelphia analyses were not updated since the 1st draft REA and not used in the final REA. One major difference in the Philadelphia County assessment compared with that performed for Atlanta was the lack of accounting for minor road emissions

Two important components of the analysis include the approach for estimating temporally and spatially variable NO_2 concentrations and simulating contact of humans with these pollutant concentrations. A combined air quality and exposure modeling approach has been used here to generate estimates of 1-hour NO_2 exposures within Philadelphia. Details on the approaches used are provided below and include the following:

- Description of the area assessed and populations considered
- Summary of the air quality modeling methodology and associated input data
- Description of the inhalation exposure model and associated input data
- Evaluation of estimated NO_2 exposures using modeling methodology

B-3.1 Study Area Selection and Description

The selection of areas to include in the exposure analysis takes into consideration the location of field and epidemiology studies, the availability of ambient monitoring and other input data, the desire to represent a range of geographic areas, population demographics, general climatology, and results of the ambient air quality characterization.

Philadelphia was selected as a location of interest through a similar statistical analysis of the ambient NO_2 air quality data described in Appendix A for each monitoring site within a location. Criteria were established for selecting sites with high annual means and/or high numbers of exceedances of potential health effect benchmark concentrations. The analysis considered all data combined, as well as the more recent air quality data (2001-2006) separately.

The 90th percentile served as the point of reference for the annual means, and across all complete site-years for 2001-2006, this value was 23.5 ppb. Seventeen locations contained one or more site-years with an annual average concentration at or above the 90th percentile. When combined with the number of 1-hour NO_2 concentrations at or above 200 ppb, only two locations fit these criteria, Philadelphia and Los Angeles. In comparing the size of the potential modeling domains and the anticipated complexity in modeling influence of roadway exposures, Philadelphia was determined to be a more manageable case-study.

Philadelphia County is comprised of 17,315 blocks containing a population of 1,517,550 persons. For this analysis the population studied was limited those residents of Philadelphia County residing in census blocks that were either within 400 meters of a major roadway or within 10 km of a major emission source (see section B-3.5 for definition). This was done to maintain balance between the representation of the study area/objectives and the computational load regarding file size and processing time. There were 16,857 such blocks containing a population of 1,475,651.

B-3.2 Exposure Period of Analysis

The exposure periods modeled were 2001 through 2003 to envelop the most recent year of travel demand modeling (TDM) data available for the respective study locations (i.e., 2002) and to include a 3 years of meteorological data to achieve a degree of stability in the dispersion and exposure model estimates.

B-3.3 Populations Analyzed

A detailed consideration of the population residing in each modeled area was included where the exposure modeling was performed. The assessment includes the general population (All Persons) residing in each modeled area and considered susceptible and vulnerable populations as identified in the ISA. These include population subgroups defined from either an exposure or health perspective. The population subgroups identified by the ISA (US EPA, 2007a) that were included and that can be modeled in the exposure assessment include:

- Children (ages 5-18)
- Asthmatic children (ages 5-18)
- All persons (all ages)
- All Asthmatics (all ages)

In addition to these population subgroups, individuals anticipated to be exposed more frequently to NO_2 were considered, including those commuting on roadways and persons residing near major roadways. To date, this document provides a summary of the subpopulations of interest (all asthmatics and asthmatic children), supplemented with additional exposure and risk results for the total population where appropriate.

B-3.4 Simulated Individuals

Due to the large size of the air quality input files, the modeled area was separated into three sections. The number of simulated persons in each model run (3 sections per 3 years) was set to 50,000, yielding a total of 150,000 persons simulated for each year. The parameters controlling the location and size of the simulated area were set to include the county(s) in the selected study area. The settings that allow for replacement of CHAD data that are missing gender, employment or age values were all set to preclude replacing missing data. The width of the age window was set to 20 percent to increase the pool of diaries available for selection. The variable that controls the use of additional ages outside the target age window was set to 0.1 to further enhance variability in diary selection. See the APEX User's Guide for further explanation of these parameters. The total population simulated for Philadelphia County was approximately 1.48 million persons, of which there a total simulated population of 163,000 asthmatics. The model simulated approximately 281,000 children, of which there were about 48,000 asthmatics.

Due to random sampling, the actual number of specific subpopulations modeled varied slightly by year.

B-3.4.1 Asthma Prevalence Rates

One of the important population subgroups for the exposure assessment is asthmatic children. Evaluation of the exposure of this group with APEX requires the estimation of children's asthma prevalence rates. The proportion of the population of children characterized as being asthmatic was estimated by statistics on asthma prevalence rates recently used in the NAAQS review for O_3 (US EPA, 2007d; 2007e). Specifically, the analysis generated age and gender specific asthma prevalence rates for children ages 0-17 using data provided in the National Health Interview Survey (NHIS) for 2003 (CDC, 2007). These asthma rates were characterized by geographic regions, namely Midwest, Northeast, South, and West. Adult asthma prevalence rates for Philadelphia County were obtained from the Behavioral Risk Factor Surveillance System (BRFSS) survey information (PA DOH, 2008). The average rates for adult males and females in Philadelphia for 2001-2003 were 7% and 12%, respectively. These rates were assumed to apply to all adults uniformly. Table B-8 provides a summary of the prevalence rates used in the exposure analysis by age and gender.

Table B-8. Asthma prevalence rates by age and gender used for Philadelphia.

Region (Study Area)	Age	Females				Males			
		Prevalence	se	L95	U95	Prevalence	se	L95	U95
Northeast (Philadelphia)	0	0.068	0.066	0.007	0.442	0.048	0.033	0.010	0.200
	1	0.072	0.038	0.021	0.221	0.046	0.018	0.019	0.108
	2	0.075	0.022	0.038	0.145	0.052	0.015	0.027	0.097
	3	0.077	0.020	0.042	0.138	0.068	0.018	0.037	0.120
	4	0.082	0.023	0.043	0.151	0.100	0.023	0.059	0.164
	5	0.116	0.030	0.063	0.205	0.149	0.029	0.094	0.226
	6	0.161	0.037	0.092	0.266	0.207	0.042	0.129	0.316
	7	0.185	0.041	0.108	0.298	0.228	0.045	0.143	0.343
	8	0.171	0.040	0.096	0.284	0.222	0.043	0.142	0.332
	9	0.145	0.035	0.080	0.246	0.212	0.041	0.136	0.316
	10	0.135	0.031	0.078	0.223	0.177	0.037	0.108	0.275
	11	0.141	0.031	0.084	0.227	0.166	0.035	0.102	0.259
	12	0.166	0.034	0.102	0.259	0.183	0.036	0.116	0.276
	13	0.174	0.034	0.109	0.266	0.171	0.031	0.113	0.250
	14	0.151	0.029	0.095	0.232	0.170	0.029	0.115	0.244
	15	0.146	0.028	0.093	0.221	0.182	0.029	0.127	0.254
	16	0.146	0.031	0.088	0.232	0.204	0.032	0.142	0.284
	17	0.157	0.054	0.068	0.322	0.242	0.061	0.133	0.399
	18+	0.070		0.040	0.140	0.120		0.090	0.150

Notes:
se – Standard error
L95 – Lower limit on 95th confidence interval
U95 – Upper limit on 95th confidence interval

B-3.5 Air Quality Data Generated by AERMOD

Air quality data input to the model were generated by air quality modeling using AERMOD. Principal emission sources included both mobile and stationary sources as well as fugitive emissions. The methodology is described below.

B-3.5.1 Meteorological Inputs

All meteorological data used for the AERMOD dispersion model simulations were processed with the AERMET meteorological preprocessor, version 06341. This section describes the input data and processing methodologies used to derive input meteorological fields for each of the five regions of interest.

B-3.5.1.1 Data Selection

Raw surface meteorological data for the 2001 to 2003 period were obtained from the Integrated Surface Hourly (ISH) Database,[1] maintained by the National Climatic Data Center (NCDC). The ISH data used for this study consists of typical hourly surface parameters (including air and dew point temperature, atmospheric pressure, wind speed and direction, precipitation amount, and cloud cover) from hourly Automated Surface Observing System (ASOS) stations. No on-site observations were used.

The surface meteorological station used for this analysis is located at Philadelphia International (KPHL) airport. The selection of surface meteorological stations minimized the distance from the station to city center, minimized missing data, and maximized land-use representativeness of the station site compared to the city center.

The total number of surface observations and the percentage of those observations accepted by AERMET (i.e., those observations that were both not missing and within the expected ranges of values), are shown by Table B-9. Note that instances of calm winds are not rejected by the AERMET processor, but are later treated as calms in the dispersion analysis. There were 1,772 hours in Philadelphia (7%) with calm winds (see Table B-10).

Table B-9. Number of AERMET raw hourly surface meteorology observations, percent acceptance rate, 2001-2003.

Surface Variable	Philadelphia (KPHL) n=26,268
	% Accepted [a]
Precipitation	100
Station Pressure	99
Cloud Height	99
Sky Cover	95
Horizontal Visibility	99
Temperature	99 *
Dew Point Temperature	99
Relative Humidity	99

[1] http://www1.ncdc.noaa.gov/pub/data/techrpts/tr200101/tr2001-01.pdf

Wind Direction	97
Wind Speed	99
Notes: [a] Percentages are rounded down to the nearest integer. * The majority of unaccepted records are due to values being out of range.	

Table B-10. Number of calms reported by AERMET by year for Philadelphia.

Year	Number of Calms
2001	610
2002	470
2003	692
Total	**1772**

Mandatory and significant levels of upper-air data were obtained from the NOAA Radiosonde Database.[2] Upper air observations show less spatial variation than do surface observations; thus they are both representative of larger areas and measured with less spatial frequency than are surface observations. The selection of upper-air station locations for each city minimized both the proximity of the station to city center and the amount of missing data in the records. The selected stations for Philadelphia was Washington Dulles Airport (KIAD). The total number of upper-air observations per station per height interval, and the percentage of those observations accepted by AERMET, are shown in Table B-11.

Table B-11. Number and AERMET acceptance rate of upper-air observations 2001-2003.

Height Level	Variable	Philadelphia (KIAD)	
		n	% Accepted
Surface	Pressure	2152	100
	Height	2152	100
	Temperature	2152	100
	DewPoint Temperature	2152	100
	WindDirection	2152	100
	WindSpeed	2152	85 *
0-500m	Pressure	4320	100
	Height	4320	100
	Temperature	4320	100
	DewPoint Temperature	4320	99
	WindDirection	4320	63
	WindSpeed	4320	62
500-1000m	Pressure	3702	100
	Height	3702	100
	Temperature	3702	100
	DewPointTemperature	3702	99 *
	WindDirection	3702	73
	WindSpeed	3702	73
1000-1500m	Pressure	4204	100
	Height	4204	100
	Temperature	4204	100
	DewPointTemperature	4204	97 *

[2] http://raob.fsl.noaa.gov/

Height Level	Variable	Philadelphia (KIAD)	
		n	% Accepted
	WindDirection	4204	71
	WindSpeed	4204	71
1500-2000m	Pressure	3354	100
	Height	3354	100
	Temperature	3354	100
	DewPointTemperature	3354	95 *
	WindDirection	3354	50
	WindSpeed	3354	50
2000-2500m	Pressure	3246	100
	Height	3246	100
	Temperature	3246	100
	DewPointTemperature	3246	93 *
	WindDirection	3246	50
	WindSpeed	3246	50
2500-3000m	Pressure	3736	100
	Height	3736	100
	Temperature	3736	100
	DewPointTemperature	3736	90 *
	WindDirection	3736	64
	WindSpeed	3736	64
3000-3500m	Pressure	3614	100
	Height	3614	100
	Temperature	3614	100
	DewPointTemperature	3614	90 *
	WindDirection	3614	65
	WindSpeed	3614	65
3500-4000m	Pressure	2830	100
	Height	2830	100
	Temperature	2830	100
	DewPointTemperature	2830	87 *
	WindDirection	2830	50
	WindSpeed	2830	50
>4000 m	Pressure	7619	88 *
	Height	7619	71 *
	Temperature	7619	99 *
	DewPointTemperature	7619	79 *
	WindDirection	7619	55
	WindSpeed	7619	55

Notes:
[a] Percentages are rounded down to the nearest integer.
* The majority of unaccepted records are due to values being out of range.
Shading:
≤95 of observations were accepted.
≤75 of observations were accepted.
≤50 of observations were accepted.

B-3.5.2 Surface Characteristics and Land Use Analysis

In addition to the standard meteorological observations of wind, temperature, and cloud cover, AERMET analyzes three principal variables to help determine atmospheric stability and mixing heights: the Bowen ratio[3], surface albedo[4] as a function of the solar angle, and surface roughness. [5]

The January 2008 version of AERSURFACE was used to estimate land-use patterns and calculate the Bowen ratio, surface albedo, and surface roughness as part of the AERMET processing. AERSURFACE uses the US Geological Survey (USGS) National Land Cover Data 1992 archives (NLCD92). [6] Three to four land-use sectors were manually identified around the surface meteorological station using this land-use data. These land-use sectors are used to identify the Bowen ratio and surface albedo, which are assumed to represent an area around the station of radius 10 km, and to calculate surface roughness by wind direction.

A monthly temporal resolution was used for the Bowen ratio, albedo, and surface roughness at the meteorological site. Because the site was located at an airport, a lower surface roughness was calculated for the 'Commercial/Industrial/Transportation' land-use type to reflect the dominance of transportation land cover rather than commercial buildings. Philadelphia has at least one winter month of continuous snow cover, which tends to increase albedo, decrease Bowen ratio, and decrease surface roughness for most land-use types during the winter months compared to a snow-free area. Seasons were assigned based on 1971-2000 NCDC 30-year climatic normals and on input from the state climatologist (Table B-12).

Table B-12. Seasonal definitions and specifications for Philadelphia.

Location	Winter (continuous snow)	Winter (no snow)	Spring	Summer	Fall
Philadelphia	Dec, Jan, Feb		Mar, Apr, May	Jun, Jul, Aug	Sep, Oct, Nov
Season definitions provided by the AERSURFACE manual as follows:					
Winter (continuous snow):	Winter with continuous snow on ground				
Winter (no snow):	Late autumn after frost and harvest, or winter with no snow				
Spring:	Transitional spring with partial green coverage or short annuals				
Summer:	Midsummer with lush vegetation				
Fall:	Autumn with unharvested cropland				

Figure B-2 illustrates show the manually created land-use sectors around the application site; a 1.9 mile (3 km) radius circle was used. Data are from the NLCD92 database. Prior to the

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[3] For any moist surface, the Bowen Ratio is the ratio of heat energy used for sensible heating (conduction and convection) to the heat energy used for latent heating (evaporation of water or sublimation of snow). The Bowen ratio ranges from about 0.1 for the ocean surface to more than 2.0 for deserts. Bowen ratio values tend to decrease with increasing surface moisture for most land-use types.

[4] The ratio of the amount of electromagnetic radiation reflected by the earth's surface to the amount incident upon it. Value varies with surface composition. For example, snow and ice vary from 80% to 85% and bare ground from 10% to 20%.

[5] The presence of buildings, trees, and other irregular land topography that is associated with its efficiency as a momentum sink for turbulent air flow, due to the generation of drag forces and increased vertical wind shear.

[6] http://seamless.usgs.gov/

release of AERSURFACE, the user was required to manually pull values of Bowen ratio (β_0), albedo (α), and surface roughness (z_0) per season and per land-use sector from look-up tables in the *AERMET User's Guide*. Using the look-up tables, values of these three surface characteristics vary by the four seasons and by eight basic land-use categories. Furthermore, the *AERMOD Implementation Guide* was somewhat ambiguous about whether Bowen ratio values should also vary with wind direction sector, as does the surface roughness. AERSURFACE resolves these issues by providing a uniform methodology for calculation of surface effects on dispersion; it also only varies surface roughness by wind direction.

Before AERSURFACE, without an automated algorithm to determine land-use patterns, it was simplest for the user to visually estimate land usage by sector. With AERSURFACE, the land-use is automatically determined. The proximity of the meteorological site to an airport and whether the site was located in an arid region were previously not explicitly accounted for as they now are in AERSURFACE. Snow cover, too, is critical for determination of α, but was largely left to user's discretion regarding its presence. With AERSURFACE, the lookup tables have separate columns for winter without much snow and for winter with abundant snow. The user determines if winter at a particular location contains at least one month of continuous snow cover, and AERSURFACE will pull values of the surface characteristics from the appropriate winter column.

We conducted a sensitivity test to evaluate the impacts of using this new tool on the present analysis. Figure B-3 shows a sample comparison of surface roughness values at the Philadelphia site with and without the use of AERSURFACE. In the Figure, estimated surface roughness values using visual land-use estimations and look-up table values are shown in muted shades and AERSURFACE values in dark shades. Monthly season definitions are the same in both cases. However, in the AERSURFACE case, winter was specified as having a one-month period of snow cover. Also, in the AERSURFACE case the site was specified as being at an airport.

In this case, z_0 values are much lower with AERSURFACE than with a visual estimation of land-use. In the AERSURFACE tool, Philadelphia was noted as being at an airport, tending to represent the lower building heights in the region and the inverse distance weighting implemented in the tool. Thus, lower z_0 values were obtained over most developed-area sectors in this scenario. The indication that at least one month of continuous snow cover is present also tends to lower wintertime z_0 values. In addition to these systematic differences, the automated AERSURFACE land-use analysis for Philadelphia tended to identify less urban coverage and more water coverage, lowering roughness values, but it also tended to identify more forest cover and less cultivated land cover than our visual analysis, increasing some z_0 values.

β_0 and α also varied significantly between the scenarios. However, this was largely due to two practical matters: First, the independence of these variables of wind direction in the AERSURFACE case and secondly the use of monthly-varying moisture conditions in one test case and not another. Thus we have not presented those results

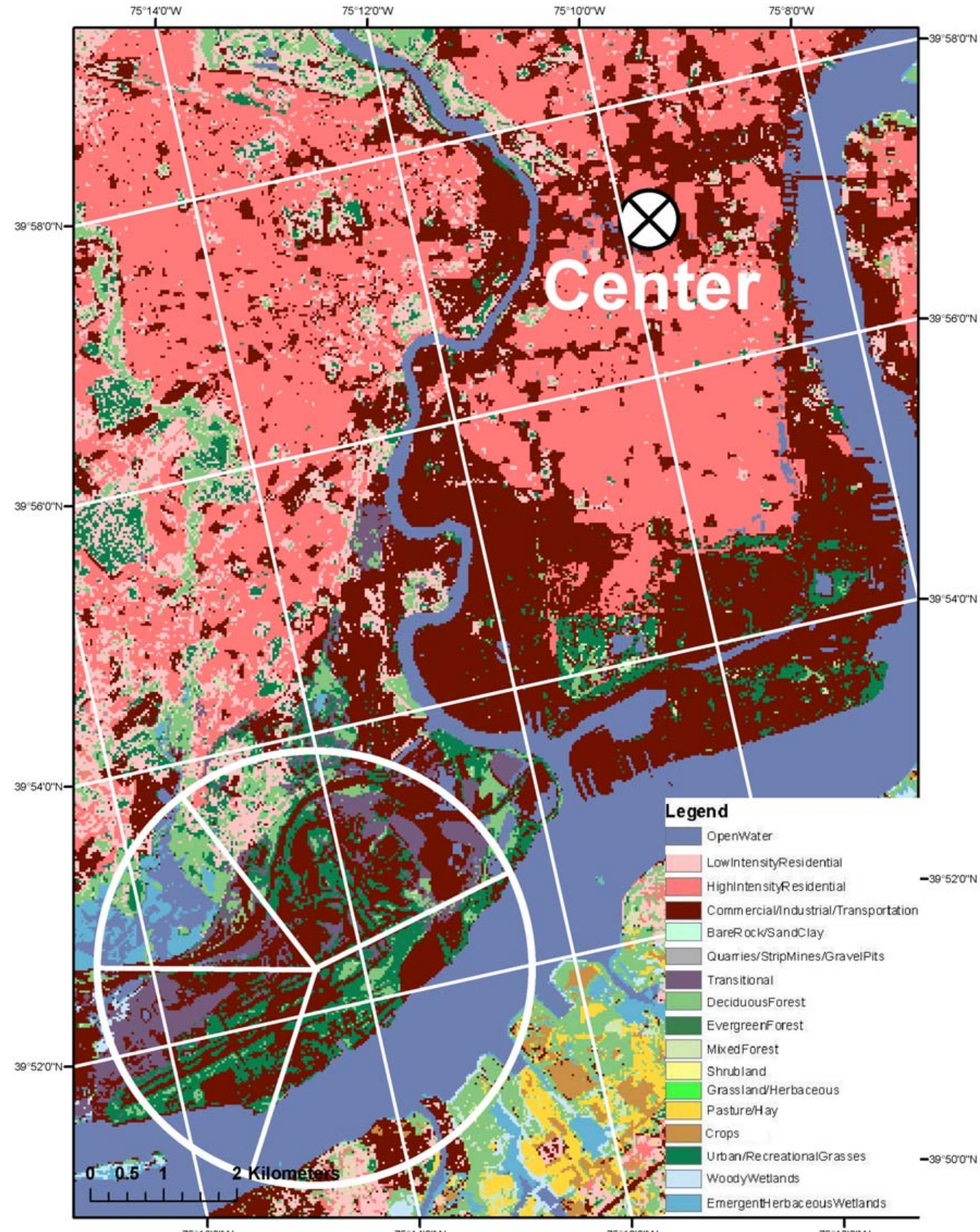

Figure B-2. Land-use and sectors around the Philadelphia-area surface meteorological station (KPHL). Sector borders are 80, 184, 262, and 312 degrees from geographic North. Philadelphia city center is labeled.

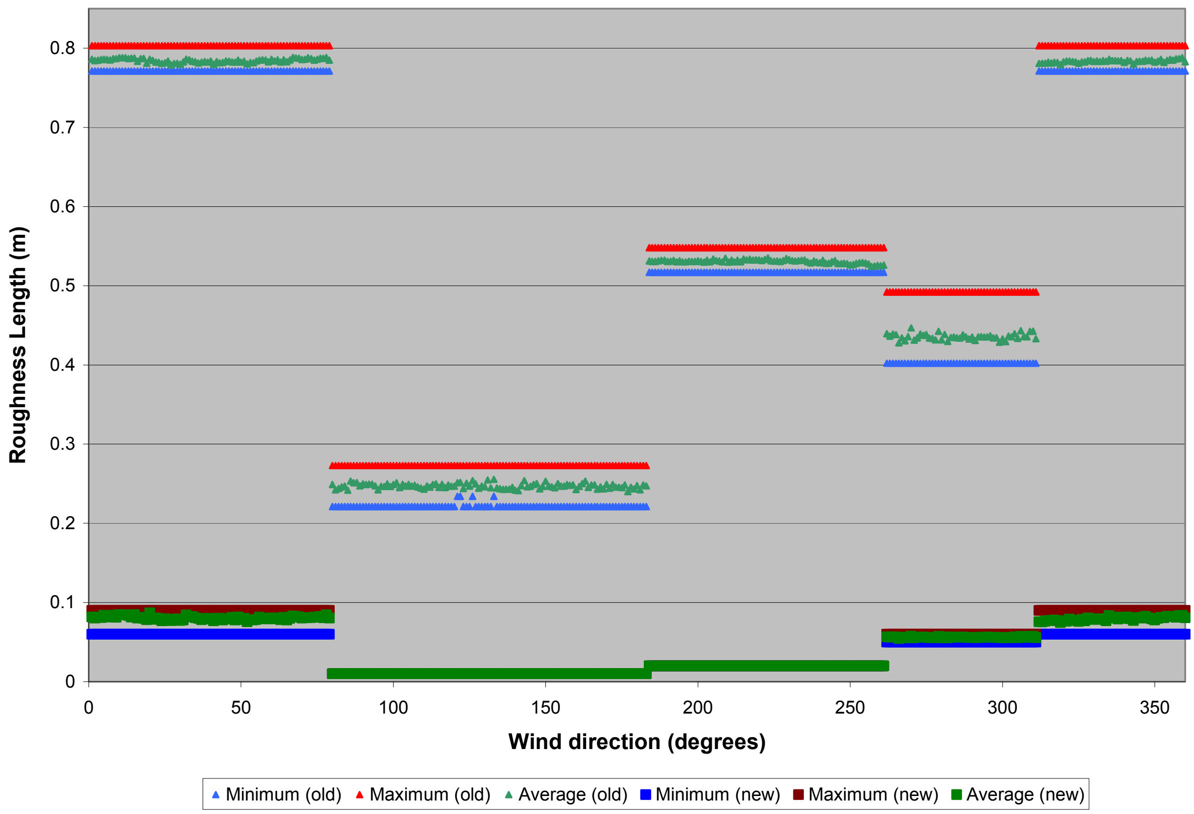

Figure B-3. Estimated z_0 values for the Philadelphia case-study analysis using visual and AERSURFACE land-use estimations.

B-3.5.3 Meteorological Data Analysis

The AERMET application location and elevation were taken as the center of the modeled city, estimated using Google Earth version 4.2.0198.2451 (beta) and defined as 39.952 °N, 75.164 °W, 12 m. The 2001-2003 AERSURFACE processing was run three times – once assuming the entire period was drier than normal, once assuming the entire period was wetter than normal, and once assuming the entire period was of average precipitation accumulation. These precipitation assumptions influence the Bowen ratio, discussed above.

To create meteorological input records that best represent the city for each of the three years, the resulting surface output files for each site were then pieced together on a month-by-month basis, with selection based on the relative amount of precipitation in each month. Any month where the actual precipitation amount received was at least twice the 1971-2000 NCDC 30-year climatic normal monthly precipitation amount was considered wetter than normal, while any month that received less than half the normal amount of precipitation amount was considered drier than normal; all other months were considered to have average surface moisture conditions. Table B-13 indicates the surface moisture condition for each month evaluated in this Philadelphia case-study.

Table B-13. Monthly precipitation compared to NCDC 30-year climatic normal for Philadelphia, 2001-2003.

Year						
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**
2001	74.8%	103.6%	144.2%	43.9%	102.9%	180.1%
	Jul	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
	29.9%	26.0%	67.1%	30.6%	17.9%	64.6%
2002	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**
	69.9%	17.7%	96.4%	52.7%	89.2%	93.9%
	Jul	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
	51.0%	59.0%	89.1%	202.7%	94.2%	117.9%
2003	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**
	53.2%	165.0%	102.7%	62.0%	108.5%	246.2%
	Jul	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
	46.5%	86.1%	120.8%	162.8%	92.9%	158.6%

Shading:

Light gray	Less than or equal to half the normal monthly precipitation amount
None	Less than twice the normal precipitation level and greater than half the normal amount
Dark gray	At least twice the normal precipitation level

B-3.5.4 On-Road Emissions Preparation

Information on traffic data in the Philadelphia area was obtained from the Delaware Valley Regional Planning Council (DVRPC[7]) via their most recent, baseline travel demand modeling (TDM) simulation – that is, the most recent simulation calibrated to match observed traffic data. DVRPC provided the following files.

- Shapefiles of TDM outputs for the 2002 baseline year for all links in their network.
- Input files for the MOBILE6.2 emissions model that characterize local inputs that differ from national defaults, including fleet registration distribution information.
- Postprocessing codes they employ for analysis of TDM outputs into emission inventory data, to ensure as much consistency as possible between the methodology used for this study and that of DVRPC. These include DVRPC's versions of the local SVMT.DEF, HVMT.DEF, and FVMT.DEF MOBILE6.2 input files describing the vehicle miles traveled (VMT) by speed, hour, and facility, respectively, by county in the Delaware Valley area.
- A lookup table used to translate average annual daily traffic (AADT) generated by the TDM into hourly values.

Although considerable effort was expended to maintain consistency between the DVRPC approach to analysis of TDM data and that employed in this analysis, including several personal communications with agency staff on data interpretation, complete consistency was not possible due to the differing analysis objectives. The DVRPC creates countywide emission inventories. This study created spatially and temporally resolved emission strengths for dispersion modeling.

B-3.5.4.1 Emission Sources and Locations

[7] http://www.dvrpc.org/

The TDM simulation's shapefile outputs include annual average daily traffic (AADT) volumes and a description of the loaded highway network. The description of the network consists of a series of nodes joining individual model links (i.e., roadway segments) to which the traffic volumes are assigned, and the characteristics of those links, such as endpoint location, number of lanes, link distance, and TDM-defined link daily capacity.[8]

To reduce the scope of the analysis, the full set of links in the DVRPC network was first filtered to include only those roadway types considered *major* (i.e., freeway, parkway, major arterial, ramp), and that had AADT values greater than 15,000 vehicles per day (one direction).

However, the locations of links in the model do not necessarily agree well with the roads they are attempting to represent. While the exact locations of the links may not be mandatory for DVRPC's travel demand modeling, the impacts of on-road emissions on fixed receptors is crucially linked to the distance between the roadways and receptors. Hence, it was necessary to modify the link locations from the TDM to the best known locations of the actual roadways. The correction of link locations was done based on the locations of the nodes that define the end points of links with a GIS analysis, as follows.

A procedure was developed to relocate TDM nodes to more realistic locations. The nodes in the TDM represent the endpoints of links in the transportation planning network and are specified in model coordinates. The model coordinate system is a Transverse Mercator projection of the TranPlan Coordinate System with a false easting of 31068.5, false northing of -200000.0, central meridian: -75.00000000, origin latitude of 0.0, scale factor of 99.96, and in units of miles. The procedure moved the node locations to the true road locations and translated to dispersion model coordinates. The Pennsylvania Department of Transportation (PA DOT) road network database[9] was used as the specification of the true road locations. The nodes were moved to coincide with the nearest major road of the corresponding roadway type using a built-in function of ArcGIS. Once the nodes had been placed in the corrected locations, a line was drawn connecting each node pair to represent a link of the adjusted planning network.

To determine hourly traffic on each link, the AADT volumes were converted to hourly values by applying DVRPC's seasonal and hourly scaling factors. To determine hourly traffic on each link, the AADT volumes were converted to hourly values by applying DVRPC's seasonal and hourly scaling factors. The heavy-duty vehicle fraction – which is assumed by DVRPC to be about 6% in all locations and times – was also applied.[10] Another important

[8] The TDM capacity specifications are not the same as those defined by the Highway Capacity Manual (HCM). Following consultation with DVRPC, the HCM definition of capacity was used in later calculations discussed below.

[9] http://www.pasda.psu.edu/

[10] As shown by Figure B-4 NO_x emissions from HDVs tend to be higher than their LDV counterparts by about a factor of 10. However, the HDV fraction is less than 10% of the total VMT in most circumstances, mitigating their influence on composite emission factors, although this mitigating effect is less pronounced at some times than others. For example, nighttimes on freeways tend to show a smaller reduction in HDV volume than in total volume, and thus an increased HDV fraction. This effect is not captured in most TDMs or emission postprocessors and – both to maintain consistency with the local MPO's vehicle characterizations and emissions modeling and due to lack of other relevant data – was also not included here. The net result of this is likely to be slightly underestimated emissions from major freeways during late-night times.

variable, the number of traffic signals occurring on a given link, was taken from the TDM link-description information.

Several of these parameters are shown in the following set of tables.

- Table B-14 hourly scaling factors
- Table B-15 seasonal scaling factors
- Table B-16 number of signals per roadway mile
- Table B-17 statistical summaries of AADT volumes for links included in the study.

Table B-14. Hourly scaling factors (in percents) applied to Philadelphia County AADT volumes.

Road Type	Region	0:00	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00
Freeway	CBD	1.23	0.86	0.74	0.84	1.23	2.50	4.87	6.52	6.47	5.75	4.99	5.02
	Fringe	1.23	0.86	0.74	0.84	1.23	2.50	4.87	6.52	6.47	5.75	4.99	5.02
	Urban	1.23	0.86	0.74	0.84	1.23	2.50	4.87	6.52	6.47	5.75	4.99	5.02
	Suburban	0.96	0.64	0.54	0.61	0.90	2.16	5.39	7.33	6.85	5.52	4.90	4.94
	Rural	0.71	0.48	0.38	0.48	0.95	2.54	6.05	7.77	6.79	5.22	4.64	4.78
Arterial	CBD	1.43	0.96	0.61	0.50	0.58	1.17	2.89	5.50	6.87	5.87	5.37	5.17
	Fringe	1.53	0.97	0.62	0.47	0.54	1.10	2.99	5.77	6.53	5.60	5.14	4.86
	Urban	1.13	0.68	0.52	0.45	0.63	1.68	4.26	6.68	6.86	5.47	5.09	5.17
	Suburban	0.70	0.40	0.32	0.33	0.55	1.71	4.51	7.04	6.84	5.37	4.95	5.36
	Rural	0.60	0.36	0.34	0.41	0.77	2.29	5.47	7.37	6.62	5.36	5.09	5.35
Local	CBD	1.11	0.71	0.45	0.37	0.41	0.97	2.39	4.82	6.72	6.50	4.60	4.93
	Fringe	1.00	0.55	0.37	0.21	0.39	0.98	1.98	5.31	5.91	5.78	5.14	5.19
	Urban	1.19	0.74	0.53	0.43	0.54	1.32	3.37	6.54	6.86	5.09	4.65	4.95
	Suburban	0.53	0.29	0.21	0.20	0.37	1.25	3.94	7.51	7.50	5.24	4.66	5.22
	Rural	0.55	0.32	0.25	0.30	0.57	1.89	5.26	7.93	6.84	4.94	4.57	4.89
Ramp	CBD	1.23	0.86	0.74	0.84	1.23	2.50	4.87	6.52	6.47	5.75	4.99	5.02
	Fringe	1.23	0.86	0.74	0.84	1.23	2.50	4.87	6.52	6.47	5.75	4.99	5.02
	Urban	1.23	0.86	0.74	0.84	1.23	2.50	4.87	6.52	6.47	5.75	4.99	5.02
	Suburban	0.96	0.64	0.54	0.61	0.90	2.16	5.39	7.33	6.85	5.52	4.90	4.94
	Rural	0.71	0.48	0.38	0.48	0.95	2.54	6.05	7.77	6.79	5.22	4.64	4.78

Road Type	Region	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00
Freeway	CBD	4.97	5.77	6.40	6.60	7.02	6.76	6.27	4.20	3.52	3.06	2.50	1.92
	Fringe	4.97	5.77	6.40	6.60	7.02	6.76	6.27	4.20	3.52	3.06	2.50	1.92
	Urban	4.97	5.77	6.40	6.60	7.02	6.76	6.27	4.20	3.52	3.06	2.50	1.92
	Suburban	5.05	5.19	5.90	6.80	7.58	7.67	6.51	4.27	3.34	2.97	2.32	1.66
	Rural	4.92	5.01	5.75	7.12	7.88	8.18	6.27	4.31	3.45	2.97	2.10	1.27
Arterial	CBD	5.27	5.57	5.95	6.63	7.39	7.81	6.36	4.78	4.05	3.74	3.18	2.36
	Fringe	5.52	5.40	6.08	6.88	7.36	8.08	6.24	4.98	4.21	3.82	3.13	2.19
	Urban	5.42	5.54	6.16	7.04	7.39	7.42	6.08	4.74	3.77	3.31	2.61	1.93
	Suburban	5.75	5.71	6.12	7.05	7.66	7.98	6.42	4.81	3.83	3.13	2.15	1.34
	Rural	5.55	5.50	6.00	7.11	7.82	7.98	6.26	4.48	3.50	2.80	1.88	1.11
Local	CBD	6.26	6.74	6.88	6.78	7.64	8.10	6.57	4.96	3.96	3.02	2.88	2.25
	Fringe	6.31	5.64	6.64	7.32	7.85	9.52	6.25	5.50	5.29	2.87	2.46	1.56
	Urban	5.25	5.40	6.44	7.35	7.80	7.85	6.41	5.02	4.04	3.46	2.79	2.01

	Suburban	5.78	5.57	6.01	7.11	8.20	8.98	6.83	5.02	3.83	2.90	1.82	1.05
	Rural	5.20	5.11	5.89	7.41	8.53	8.93	6.75	4.82	3.64	2.70	1.73	0.99
Ramp	CBD	4.97	5.77	6.40	6.60	7.02	6.76	6.27	4.20	3.52	3.06	2.50	1.92
	Fringe	4.97	5.77	6.40	6.60	7.02	6.76	6.27	4.20	3.52	3.06	2.50	1.92
	Urban	4.97	5.77	6.40	6.60	7.02	6.76	6.27	4.20	3.52	3.06	2.50	1.92
	Suburban	5.05	5.19	5.90	6.80	7.58	7.67	6.51	4.27	3.34	2.97	2.32	1.66
	Rural	4.92	5.01	5.75	7.12	7.88	8.18	6.27	4.31	3.45	2.97	2.10	1.27

Table B-15. Seasonal scaling factors applied to Philadelphia County AADT volumes.

Season	Road Type	Factor
Winter	Freeway	0.945
Spring	Freeway	1.006
Summer	Freeway	1.041
Autumn	Freeway	1.009
Winter	Arterial	0.942
Spring	Arterial	1.004
Summer	Arterial	1.041
Autumn	Arterial	1.013
Winter	Local	0.933
Spring	Local	1.012
Summer	Local	1.05
Autumn	Local	1.004
Winter	Ramp	0.944
Spring	Ramp	1.005
Summer	Ramp	1.041
Autumn	Ramp	1.011

Table B-16. Signals per mile, by link type, applied to Philadelphia County AADT volumes.

	Region Type				
Functional Class	CBD	Fringe	Rural	Suburban	Urban
Freeway	0	0	0	0	0
Local	8	6	1.5	3	5
Major Arterial	8	6	1	2	4
Minor Arterial	8	6	1.3	2	4
Parkway	4	2	0.5	1	1.5
Ramp	0	0	0	0	0

Table B-17. Statistical summary of AADT volumes (one direction) for Philadelphia County AERMOD simulations.

Statistic	Road Type	CBD	Fringe	Suburban	Urban
Count	Arterial	186	58	210	580
	Freeway	11	10	107	98
	Ramp	0	4	3	1
Minimum AADT	Arterial	15088	15282	15010	15003
	Freeway	15100	18259	15102	15100
	Ramp		16796	15679	16337
Maximum AADT	Arterial	44986	44020	48401	44749
	Freeway	39025	56013	68661	68661

	Ramp		40538	24743	16337
Average AADT	Arterial	21063	21196	20736	22368
	Freeway	25897	40168	33979	31294
	Ramp		24468	18814	16337

B-3.5.4.2 Emission Source Strength

On-road mobile emission factors were derived from the MOBILE6.2 emissions model as follows. The DVRPC-provided external data files describing the vehicle miles traveled (VMT) distribution by speed, functional class, and hour, as well as the registration distribution and *Post-1994 Light Duty Gasoline Implementation* for Philadelphia County were all used in the model runs without modification. To further maintain consistency with the recent DVRPC inventory simulations and maximize temporal resolution, the DVRPC's seasonal particulate matter (PM) MOBILE6 input control files were also used. These files include county-specific data describing the vehicle emissions inspection and maintenance (I/M) programs, on-board diagnostics (OBD) start dates, VMT mix, vehicle age distributions, default diesel fractions, and representative minimum and maximum temperatures, humidity, and fuel parameters. The simulations are designed to calculate average running NO_x emission factors.[11]

These input files were modified for the current project to produce running NOx emissions in grams per mile for a specific functional class (Freeway, Arterial, or Ramp) and speed. Iterative MOBILE6.2 simulations were conducted to create tables of average Philadelphia County emission factors resolved by speed (2.5 to 65 mph), functional class, season, and year (2001, 2002, or 2003) for each of the eight combined MOBILE vehicle classes (LDGV, LDGT12, LDGT34, HDGV, LDDV, LDDT, HDDV, and MC)[12]. The resulting tables were then consolidated into speed, functional class, and seasonal values for combined light- and heavy-duty vehicles. Figure B-4 shows an example of the calculated emission factors for Autumn, 2001.

[11] Basing the present emissions model input files on MPO-provided PM, rather than NO_x input files should not cause confusion. MPO-provided PM files were used because they contain quarterly rather than annual or biannual information. In all cases the output species were modified to produce gaseous emissions. Further, many of the specified input parameters do not affect PM emissions, but were included by the local MPO to best represent local conditions, which were preserved in the present calculations of NO_x emissions. This usage is consistent with the overall approach of preserving local information wherever possible.

[12] HDDV - Heavy-Duty Diesel Vehicle, HDGV - Heavy-Duty Gasoline Vehicle, LDDT - Light-Duty Diesel Truck, LDDV - Light-Duty Diesel Vehicle, LDGT12 - Light-Duty Gasoline Truck with gross vehicle weight rating ≤ 6,000 lbs and a loaded vehicle weight of ≤ 5,750 lbs, LDGT 34 - Light-Duty Gasoline Truck with gross vehicle weight rating between 6,001 - 8,500 and a loaded vehicle weight of ≤ 5,750 lbs, LDGV - Light-Duty Gasoline Vehicle, MC - Motorcycles.

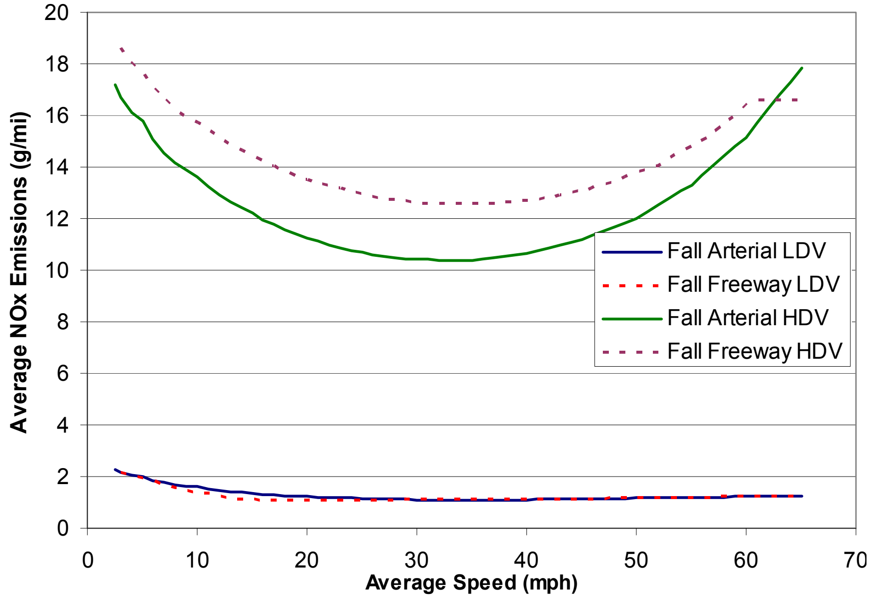

Figure B-4. Example of Light- and heavy-duty vehicle NOx emissions grams/mile (g/mi) for arterial and freeway functional classes, 2001.

To determine the emission strengths for each link for each hour of the year, the Philadelphia County average MOBILE6.2 speed-resolved emissions factor tables were merged with the TDM link data, which had been processed to determine time-resolved speeds. The speed calculations were made as follows.

The spatial-mean speed of each link at each time was calculated following the methodology of the Highway Capacity Manual.[13] Generally, the spatial-mean speed calculation is a function of the time-resolved volume-to-capacity ratio, with capacity the limiting factor. In the case of freeway calculations, this is determined by the HDV fraction, posted speed, and the general hilliness of the terrain, which was assumed to be uniformly flat for this region. The case of arterials without intersections is similar, but also considers urban effects. The case of arterials with intersections further considers the number of signals and length of each link and signalization parameters. It was assumed that all signals are identical, operating with a 120-second cycle and a protected left turn phase. Each link's speed is calculated independently. For example, a series of adjacent arterial links could show very different spatial-mean speeds if one link contains one or more intersections. That is, no up- or down-stream impacts are considered on individual link speeds. Speeds were assumed to be equal for light- and heavy-duty vehicles.

Table B-18 shows the resulting average speed for each functional class within each TDM region. Several values are shown as N/A, due to the focus only on major links as discussed above.

Table B-18. Average calculated speed by link type.

	Average Speed (mph)				
	CBD	Fringe	Suburban	Urban	Rural

[13] As defined in Chapter 9 of Recommended Procedure for Long-Range Transporation Planning and Sketch Planning, NCHRP Report 387, National Academy Press, 1997. 151 pp., ISBN No: 0-309-060-58-3.

Ramp	N/A	35	35	35	N/A
Arterial	34	31	44	32	N/A
Freeway	51	62	66	62	N/A

The resulting emission factors were then coupled with the TDM-based activity estimates to calculate emissions from each of the 1,268 major roadway links. However, many of the links were two sides of the same roadway segment. To speed model execution time, those links that could be combined into a single emission source were merged together. This was done only for the 628 links (314 pairs) where opposing links were paired in space and exhibited similar activity levels within 20% of each other.

B-3.5.4.3 Other Emission Parameters

Each roadway link is characterized as a rectangular area source with the width given by the number of lanes and an assumed universal lane width of 12 ft (3.66 m). The length and orientation of each link is determined as the distance and angle between end nodes from the adjusted TDM locations. In cases where the distance is such that the aspect ratio is greater than 100:1, the links were disaggregated into sequential links, each with a ratio less than that threshold. There were 27 links that exceeded this ratio and were converted to 55 segmented sources. Thus, the total number of area sources included in the dispersion simulations is 982. Table B-19 shows the distribution of on-road area source sizes. Note that there are some road segments whose length was zero after GIS adjustment of node location. This is assumed to be compensated by adjacent links whose length will have been expanded by a corresponding amount.

Table B-19. On-road area source sizes.

	Segment Width (m)	Lanes	Segment Length (m)
Minimum	3.7	1.0	0.0
Median	11.0	3.0	220.6
Average	13.7	3.8	300.2
1-σ Deviation	7.7	2.1	259.5
Maximum	43.9	12.0	1340.2

Resulting daily emission estimates were temporally allocated to hour of the day and season using MOBILE6.2 emission factors, coupled with calculated hourly speeds from the postprocessed TDM and allocated into SEASHR emission profiles for the AERMOD dispersion model. That is, 96 emissions factors are attributed to each roadway link to describe the emission strengths for 24 hours of each day of each of four seasons and written to the AERMOD input control file.

The release height of each source was determined as the average of the light- and heavy-duty vehicle fractions, with an assumed light- and heavy-duty emission release heights of 1.0 ft (0.3048 m) and 13.1 ft (4.0 m), respectively.[14] Because AERMOD only accepts a single release height for each source, the 24-hour average of the composite release heights is used in the modeling. Since surface-based mobile emissions are anticipated to be terrain following, no

[14] 4.0 m includes plume rise from truck exhaust stacks. See Diesel Particulate Matter Exposure Assessment Study for the Ports of Los Angeles and Long Beach, State of California Air Resources Board, Final Report, April 2006.

elevated or complex terrain was included in the modeling. That is, all sources are assumed to lie in a flat plane.

B-3.5.5 Stationary Sources Emissions Preparation

Data for the parameterization of major point sources in Philadelphia comes primarily from two sources: the 2002 National Emissions Inventory (NEI; US EPA, 2007b) and Clean Air Markets Division (CAMD) Unit Level Emissions Database (US EPA, 2007c). These two databases have complimentary information.

The NEI database contains stack locations, emissions release parameters (i.e., height, diameter, exit temperature, exit velocity), and annual emissions for 707 NO_x-emitting stacks (206 of which are considered fugitive release points) in Philadelphia County. The CAMD database, on the other hand, has information on hourly NO_x emission rates for all the units in the US, where the units are the boilers or equivalent, each of which can have multiple stacks. The alignment of facilities between the two databases is not exact, however. Some facilities listed in the NEI, are not included in the CAMD database. Of those facilities that do match, in many cases there is no clear pairing between the individual stacks assigned within the databases.

B-3.5.5.1 Data Source Alignment

To align the information between the two databases and extract the useful portion of each for dispersion modeling, the following methodology was used.

1. Attention was limited stacks within the NEI data base that (a) lie within Philadelphia County and (b) were part of a facility with total emissions from all stacks exceeding 100 tpy NO_x.
2. Individual stacks that had identical stack physical parameters and were co-located within about 10 m were combined to be simulated as a single stack with their emissions summed.
3. All fugitive releases were removed from the list, to be analyzed as a separate source group.

The resulting 19 distinct, combined stacks from the NEI are shown in Table B-20.

The CAMD database was then queried for facilities that matched the facilities identified from the NEI database. Facility matching was done on the facility name, Office of Regulatory Information Systems (ORIS) identification code (when provided) and facility total emissions to ensure a best match between the facilities. Once facilities were paired, individual units and stacks in the data bases were paired, based on annual emission totals. Table B-21 shows the matching scheme for the seven major facilities in Philadelphia County.[15]

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[15] Note that Jefferson Smurfit does not exist in the CAMD database. The matching here was based on facility types as follows. Smurfit in PA was taken as a packaging/recycling facility, and the stack assumed to be a Cogen facility, based on information in the NEEDS database (http://www.epa.gov/interstateairquality/pdfs/NEEDS-NODA.xls). The best matched cogen plant in Philadelphia County in both the NEEDS and CAMD database is the Gray's Ferry Cogen Partnership (ORIS 54785), which was a reasonable match for Smurfit's total emissions. It was assumed that the hourly emission profile also matches well.

In Table B-21, there are sometimes multiple CAMD units that pair with a single NEI combined stack. In these cases the hourly emission rates from the matching CAMD units are summed for each hour. For example, in the case of stack 859 for “Sunoco, Inc – Philadelphia” five CAMD hourly records are summed into a single hourly record. Then each resulting hourly value is scaled by a factor of 1032.8 / 938.9 = 1.10, so that the annual total matches the NEI annual total.

Similarly, there are sometimes multiple combined stacks that pair with single units. In this case the CAMD values are disaggregated according to NEI-defined stack contributions. For example, “Sunoco, Inc – Philadelphia” stack 855’s profile is determined by taking the hourly profile from CAMD unit number 52106-150101, and scaling each value by a factor of 26.2 tpy / 48.2 tpy total = 0.54. Then each resulting hourly value is scaled by a factor of 48.2/162.1 = 0.3 so that the sum of the annual totals for the 4 stacks corresponding to unit number 52106-150101 matches the NEI total. For consistency, in each case the 2001 and 2003 hourly emission profiles were determined using the same scaling factors, but applied to the respective CAMD emission profile.

It is clear from Table B-21 that most facilities agree well in total annual NO_x emissions between the two databases. However, in the case of the “Sunoco Chemicals (Former Allied Signal)” facility, nearly half of the NEI emissions (without fugitives) do not appear in the CAMD database. The reason for this is unknown and no information was readily available on the relative accuracy of the two databases.

Figure B-5 illustrates the discrepancy versus fraction of hours with positive emissions, according to the CAMD data base. The figure suggests that the discrepancies are not primarily the result of facilities with episodic emissions (i.e., “peak load” facilities). Although there is good agreement on facility-wide emissions between the two data bases, there are larger discrepancies between CAMD unit emissions and NEI stack emissions. This is to be expected given the discrepancy in resolution between the two data bases.

Table B-20. Combined stacks parameters for stationary NOx emission sources in Philadelphia County.

Stack No	NEI Site ID	Facility Name	SIC Code	NAICS Code	ORIS Facility Code	Stack Emissions (tpy)	Stack X (deg)	Stack Y (deg)	Stack Ht (m)	Exit Temp (K)	Stack Diam (m)	Exit Velocity (m/s)	Facility Emission with Fugitive (tpy)
817	NEIPA2218	EXELON GENERATION CO - DELAWARE STATION	4911	221112	3160	4.82	-75.1358	39.96769	49	515	4.2	0	297.8
818	NEIPA2218	EXELON GENERATION CO - DELAWARE STATION	4911	221112	3160	287.8	-75.1358	39.96769	64	386	3.7	17	297.8
819	NEI40720	JEFFERSON SMURFIT CORPORATION (U S)	2631	32213		0.148	-75.2391	40.03329	16	477	0.4	19	228.4
820	NEI40720	JEFFERSON SMURFIT CORPORATION (U S)	2631	32213		113.8	-75.2391	40.03329	53	427	2.4	10	228.4
821	NEI40720	JEFFERSON SMURFIT CORPORATION (U S)	2631	32213		114.46	-75.2391	40.03329	53	477	2.4	12	228.4
855	NEI40723	Sunoco Inc. - Philadelphia	2911	32411		26.2	-75.2027	39.92535	24	450	2.1	9	3112.2
856	NEI40723	Sunoco Inc. - Philadelphia	2911	32411		1.3	-75.2003	39.91379	24	644	1.5	22	3112.2
857	NEI40723	Sunoco Inc. - Philadelphia	2911	32411		1.4	-75.203	39.92539	25	511	1.9	10	3112.2
858	NEI40723	Sunoco Inc. - Philadelphia	2911	32411		19.3	-75.2027	39.92535	25	527	1.9	11	3112.2
859	NEI40723	Sunoco Inc. - Philadelphia	2911	32411		1032.8	-75.2124	39.90239	61	489	5.8	11	3112.2
860	NEI7330	SUNOCO CHEMICALS (FORMER ALLIED SIGNAL)	2869	325998		0.033	-75.0715	40.00649	5	476	0.5	7	160.9
861	NEI7330	SUNOCO CHEMICALS (FORMER ALLIED SIGNAL)	2869	325998		49.1	-75.0715	40.00649	41	422	1.4	22	160.9
862	NEI7330	SUNOCO CHEMICALS (FORMER ALLIED SIGNAL)	2869	325998		34.6	-75.0715	40.00649	42	422	1.6	17	160.9
863	NEI7330	SUNOCO CHEMICALS (FORMER ALLIED SIGNAL)	2869	325998		77.2	-75.0715	40.00649	42	422	1.6	22	160.9
864	NEIPA101353	TRIGEN - SCHUYLKILL	4961	22		128.6	-75.1873	39.94239	69	450	4.9	6	190.1
865	NEIPA101353	TRIGEN - SCHUYLKILL	4961	22		61.5	-75.1873	39.94239	78	450	7.3	2	190.1
866	NEIPA101356	GRAYS FERRY COGENERATION PARTNERS	4911	22	54785	143.2	-75.1873	39.94239	78	396	5.5	20	233.5
867	NEIPA101356	GRAYS FERRY COGENERATION PARTNERS	4911	22	54785	90.3	-75.1873	39.94239	85	443	3.2	21	233.5
868	NEIPA2222	TRIGEN - EDISON	4961	62		130.5	-75.1569	39.94604	78	589	3.7	9	130.5

Table B-21. Matched stacks between the CAMD and NEI database.

NEI Facility Name	NEI *Comb. Stack* Number	NEI *Comb. Stack* Emiss (tpy)	NEI Unit Emiss (tpy)	NEI Facility Emiss (tpy, w/out Fugitive)	CAMD Facility Name	CAMD Units *	CAMD Unit Emiss (tpy) *	CAMD Comb. Unit Totals (tpy)	CAMD Facility Totals (tpy)	Stack δ (%, relative to CAMD value)	Stack δ (tpy)	Facility δ (% relative to CAMD value)	Facility δ (tpy)
Exelon Generation Co - Delaware Station	817	4.8	4.8	**292.6**	Delaware	3160-9	1.542	1.542	**289.3**	213%	3.3	**1%**	**3.3**
	818	287.8	287.8			3160-71	123.8	287.8		0%	0.0		
						3160-81	164						
Sunoco Inc. - Philadelphia	855	26.2	48.2	**1081.0**	Philadelphia Refinery	52106-150101	162.1	162.1	**1101.0**	-70%	-113.9	**-2%**	**-20.3**
	856	1.3											
	857	1.4											
	858	19.3											
	859	1032.8	1032.8			52106-150137	194.2	938.9		10%	93.9		
						52106-150110	162.1						
						52106-150138	194.2						
						52106-150139	194.2						
						52106-150140	194.2						
Sunoco Chemicals (Former Allied Signal)	860	0.0	160.9	**160.9**	Sunoco Chemicals Frankford Plant	880007-52	84.5	84.5	**84.5**	90%	76.4	**90%**	**76.4**
	861	49.1											
	862	34.6											
	863	77.2											
Trigen - Schuylkill	864	128.6	128.6	**190.1**	Trigen Energy - Schuylkill	50607-23	163.1	163.1	**178.7**	-21%	-34.5	**6%**	**11.4**
	865	61.5	61.5			50607-24	2.9	15.6		293%	45.9		

NEI Facility Name	NEI *Comb. Stack* Number	NEI *Comb. Stack* Emiss (tpy)	NEI Unit Emiss (tpy)	NEI Facility Emiss (tpy, w/out Fugitive)	CAMD Facility Name	CAMD Units *	CAMD Unit Emiss (tpy) *	CAMD Comb. Unit Totals (tpy)	CAMD Facility Totals (tpy)	Stack δ (%, relative to CAMD value)	Stack δ (tpy)	Facility δ (% relative to CAMD value)	Facility δ (tpy)
						50607-26	12.7						
Grays Ferry Cogeneration Partners	866	143.2	143.2	**233.5**	Grays Ferry Cogen Partnership	54785-2	143.2	143.2	**233.5**	0%	0.0	**0%**	**0.0**
	867	90.3	90.3			54785-25	90.3	90.3		0%	0.0		
Trigen - Edison	868	130.5	130.5	**130.5**	Trigen Energy Corporation-Edison St	880006-1	19.8	111	**111.0**	18%	19.4	**18%**	**19.4**
						880006-2	17.3						
						880006-3	36.1						
						880006-4	37.8						
Jefferson Smurfit Corporation (U S) ***	819	0.1	228.4	**228.4**		54785-2	143.2	233.5	**233.5**	-2%	-5.1	**-2%**	**-5.1**
	820	113.8				54785-25	90.3						
	821	114.5											

Notes:
* In the format "ORIS ID - UNIT ID"
** All CAMD values are for 2002
*** Jefferson Smurfit not in CAMD; will use Grays Ferry as surrogate

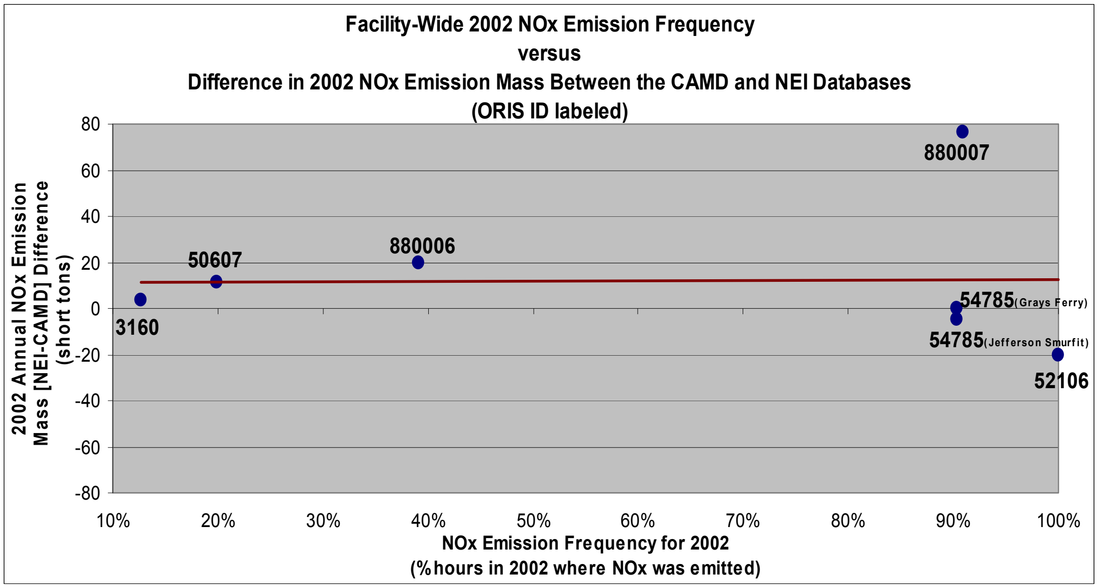

Figure B-5. Differences in facility-wide annual NOx emission totals between NEI and CAMD data bases for Philadelphia County 2002.

B-3.5.6 Fugitive and Airport Emissions Preparation

Fugitive emission releases in Philadelphia County, as totaled in the NEI database, were modeled as area sources with the profile of these releases determined by the overall facility profile of emissions. In addition, emissions associated with the Philadelphia International Airport were estimated.

B-3.5.6.1 Fugitive Releases

Thirty five *combined stacks* were identified during the point source analysis (see previous section) that were associated with facilities considered major emitters, but where the emissions from the stacks are labeled *Fugitive* in the NEI. These stacks have zero stack diameter, zero emission velocity, and exit temperature equal to average ambient conditions (295 K). Thus, we determined it was not appropriate to include these in the point source group simulation.

These 35 stacks occur at only two facilities in the County: Exelon Generation Co – Delaware Station (NEI Site ID: NEIPA2218) and Sunoco Inc. – Philadelphia (NEI Site ID: NEI40723). Consequently, they were grouped by facility. The Sunoco emissions further fall into two distinct categories based on release heights. Thus, to accommodate all these sources most efficiently, we created three area source groups: one for Sunoco emissions at 3.0 m, one for Sunoco emissions greater than 23.0 m, and one for Exelon. The "stacks" within the NEI and their parameters comprising each of these sources are shown in Table B-22 along with their groupings and the resulting combined area source parameters.

Table B-22. Emission parameters for the three Philadelphia County fugitive NOx area emission sources.

Grp. No.	NEI Site ID	Facility Name	NEI 2002 Emissions (tpy)	Stack X	Stack Y	Stack Height (m)	Stacks Used for Emission Profile [1]	Scaled Emissions (tpy) [2]		
								2001	2002	2003

Grp. No.	NEI Site ID	Facility Name	NEI 2002 Emissions (tpy)	Stack X	Stack Y	Stack Height (m)	Stacks Used for Emission Profile [1]	Scaled Emissions (tpy) [2]		
								2001	2002	2003
	NEIPA 2218	EXELON GENERATION CO - DELAWARE STATION	0.1	-75.13582	39.96769	5				
			5.1	-75.12528	39.96680	8				
1			**5.2**			**6.5**	**817+818**	**4.8**	**5.2**	**6.4**
	NEI40 723	Sunoco Inc. - Philadelphia	65.3	-75.21408	39.90811	3				
			350.9	-75.21300	39.90878	3				
			12.7	-75.20972	39.90467	3				
			355.7	-75.20945	39.90778	3				
			31.1	-75.20876	39.90185	3				
			6.2	-75.20845	39.90708	3				
			182.4	-75.20809	39.91580	3				
			1.1	-75.20707	39.90946	3				
			7.5	-75.20651	39.90988	3				
			1.0	-75.20301	39.91362	3				
			2.0	-75.20114	39.91273	3				
			49.4	-75.20090	39.91621	3				
			106.3	-75.20079	39.91615	3				
			188.5	-75.20047	39.91366	3				
			87.8	-75.20043	39.91377	3				
			36.1	-75.20024	39.91406	3				
			9.7	-75.20020	39.91410	3				
			61.2	-75.19995	39.91596	3				
			13.6	-75.19766	39.91696	3				
			17.0	-75.19751	39.91696	3				
			17.2	-75.19735	39.91590	3				
			12.2	-75.19723	39.91597	3				
			12.6	-75.19720	39.91698	3				
			23.7	-75.19713	39.91596	3				
			19.2	-75.19699	39.91599	3				
			10.0	-75.19644	39.91493	3				
2			**1,680.4**			**3.0**	**855+856+857+858+859**	**1,873.8**	**1,681.4**	**2,202.4**
	NEI40 723	Sunoco Inc. - Philadelphia	79.5	-75.21322	39.90899	23				
			13.1	-75.20833	39.90278	26				
			15.3	-75.20850	39.90246	27				
			2.5	-75.20844	39.90239	27				
			10.2	-75.20838	39.90231	27				
			19.0	-75.20828	39.90237	27				
			211.2	-75.20889	39.90279	30				
3			**350.8**			**26.7**	**855+856+857+858+859**	**391.2**	**351.0**	**459.8**

[1] See Table B-20 for stack definitions.

[2] Scaled emissions are determined by summing the scaled, hourly values from the CAMD database, as used in the dispersion modeling.

In the case of the Sunoco emissions, the vertices of the area sources were determined by a convex hull encapsulating all the points. In the case of Excelon, only two points are provided, which is insufficient information to form a closed polygon. Instead, the boundary of the facility was digitized into a 20-sided polygon. Figure B-6 shows the locations of these polygons.

Emission profiles for the fugitive releases were determined from the CAMD hourly emission database in a method similar to that for the point sources. We determined scaling factors based on the ratio of the 2002 fugitive releases described by the NEI to the total, non-fugitive point source releases from the same facility. All stacks within that facility were combined on an hourly basis for each year and the fugitive to non-fugitive scaling factor applied, ensuring that the same temporal emission profile was used for fugitives as for other releases from the facility, since the origins of the emissions should be parallel. We created external hourly emissions files for each of the three fugitive area sources with appropriate units (grams per second per square meter).

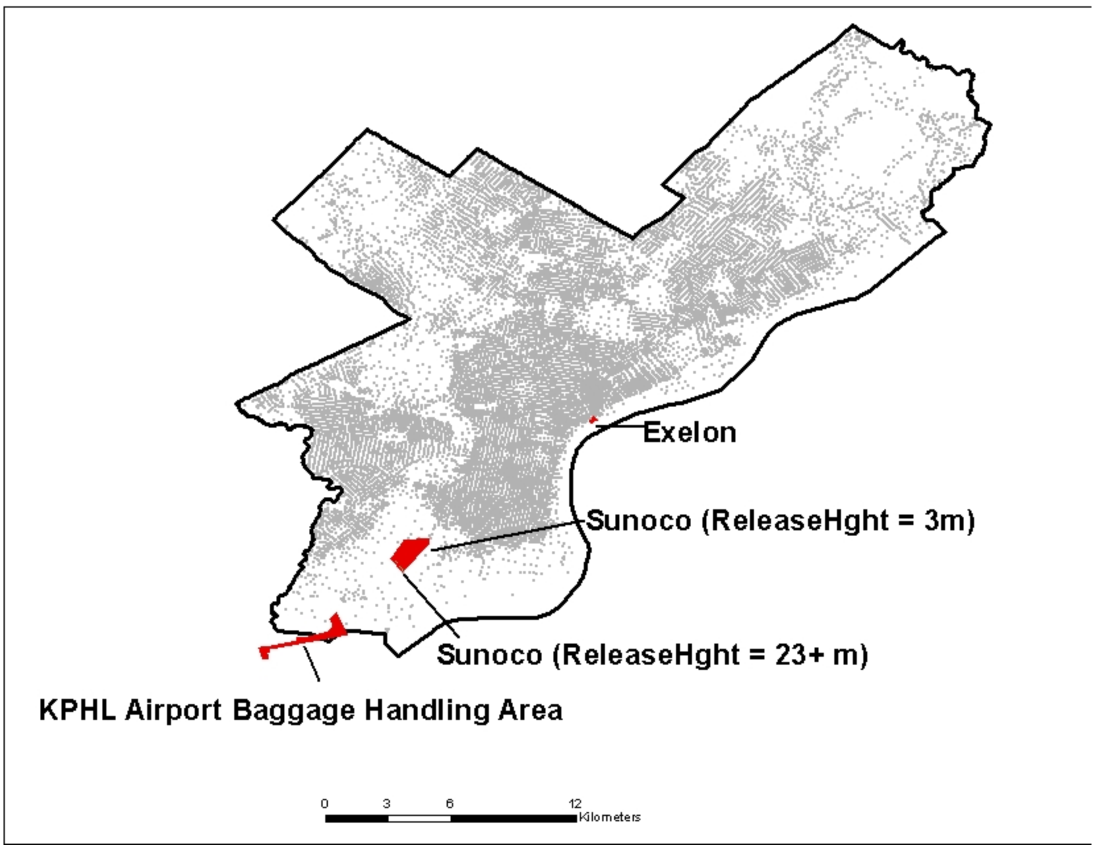

Figure B-6. Locations of the four ancillary area sources. Also shown are centroid receptor locations.

B-3.5.6.2 Philadelphia International Airport Emissions

Another significant source of NOx emissions in Philadelphia County not captured in the earlier simulations is from operation of the Philadelphia International Airport (PHL). PHL is the only major commercial airport in the County and is the largest airport in the Delaware Valley.

The majority of NOx emissions in the NEI[16] database attributable to airports in Philadelphia County are from non-road mobile sources, specifically ground support equipment. There is another airport in the County: Northeast Philadelphia Airport. However, because it serves general aviation, is generally much smaller in operations than PHL, and has little ground support equipment activity – which is associated primarily with commercial aviation – all airport emissions in the County were attributed to PHL. The PHL emissions were taken from the non-road section of the 2002 NEI, and are shown by Table B-23.

Table B-23. Philadelphia International airport (PHL) NO_x emissions.

State and County	SCC	NOx (tpy)	SCC Level 1 Description	SCC Level 3 Description	SCC Level 6 Description	SCC Level 8 Description
Philadelphia, PA	2265008005	4.6	Mobile Sources	Off-highway Vehicle Gasoline, 4-Stroke	Airport Ground Support Equipment	Airport Ground Support Equipment
	2267008005	5.1	Mobile Sources	LPG	Airport Ground Support Equipment	Airport Ground Support Equipment
	2270008005	196.2	Mobile Sources	Off-highway Vehicle Diesel	Airport Ground Support Equipment	Airport Ground Support Equipment
	2275020000	0.01	Mobile Sources	Aircraft	Commercial Aircraft	Total: All Types
	2275050000	2.5	Mobile Sources	Aircraft	General Aviation	Total
PHL Total		**208.4**				

As with the fugitive sources discussed above, the airport emissions are best parameterized as area sources. The boundary of the area source was taken as the region of operation of baggage handling equipment, including the terminal building and the region surrounding the gates. This region was digitized into an 18-sided polygon of size 1,326,000 m^2, and included in the AERMOD input control file.

The activity profile for PHL was taken to have seasonal and hourly variation (SEASHR), based on values from the EMS-HAP model.[17] These factors are disaggregated in the EMS-HAP model database based on source classification codes (SCCs), which were linked to those from the NEI database. The EMS-HAP values provide hourly activity factors by season, day type, and hour; to compress to simple SEASHR modeling, the hourly values from the three individual day types were averaged together. The total emissions for each SCC were then disaggregated into seasonal and hourly components and the resulting components summed to create total PHL emissions for each hour of the four annual seasons. These parameterized emissions were then normalized to the total cargo handling operational area, to produce emission factors in units of grams per second per square meter and included in the AERMOD input file. Figure B-6 also illustrates the location of the PHL area source.

[16] http://www.epa.gov/ttn/chief/net/2002inventory.html
[17] EPA 2004, User's Guide for the Emissions Modeling System for Hazardous Air Pollutants (EMS-HAP) Version 3.0, EPA-454/B-03-006.

B-3.5.7 Receptor Locations

Three sets of receptors were chosen to represent the locations of interest. First, all NOx monitor locations, shown by Table B-24, within the Philadelphia county were included as receptor locations. Although all receptors are assumed to be on a flat plane, they are placed at the standard breathing height of 5.9 ft (1.8 m).

Table B-24. Philadelphia County NOx monitors.

Site ID	Latitude	Longitude
421010004	40.0089	-75.0978
421010029	39.9572	-75.1731
421010047	39.9447	-75.1661

The second receptor locations were selected to represent the locations of census block centroids near major NO_x sources. GIS analysis was used to determine all block centroids in Philadelphia County that lie within a 0.25 mile (400 m) of the roadway segments and also all block centroids that lie within 6.2 miles (10 km) of any major point source. 12,982 block centroids were selected due to their proximity to major roadways; 16,298 centroids were selected due to their proximity to major sources. The union of these sets produced 16,857 unique block centroid receptor locations, each of which was assigned a height of 5.9 ft (1.8 m). The locations of centroids that met either distance criteria – and were thus included in the modeling – is shown by Figure B-7.

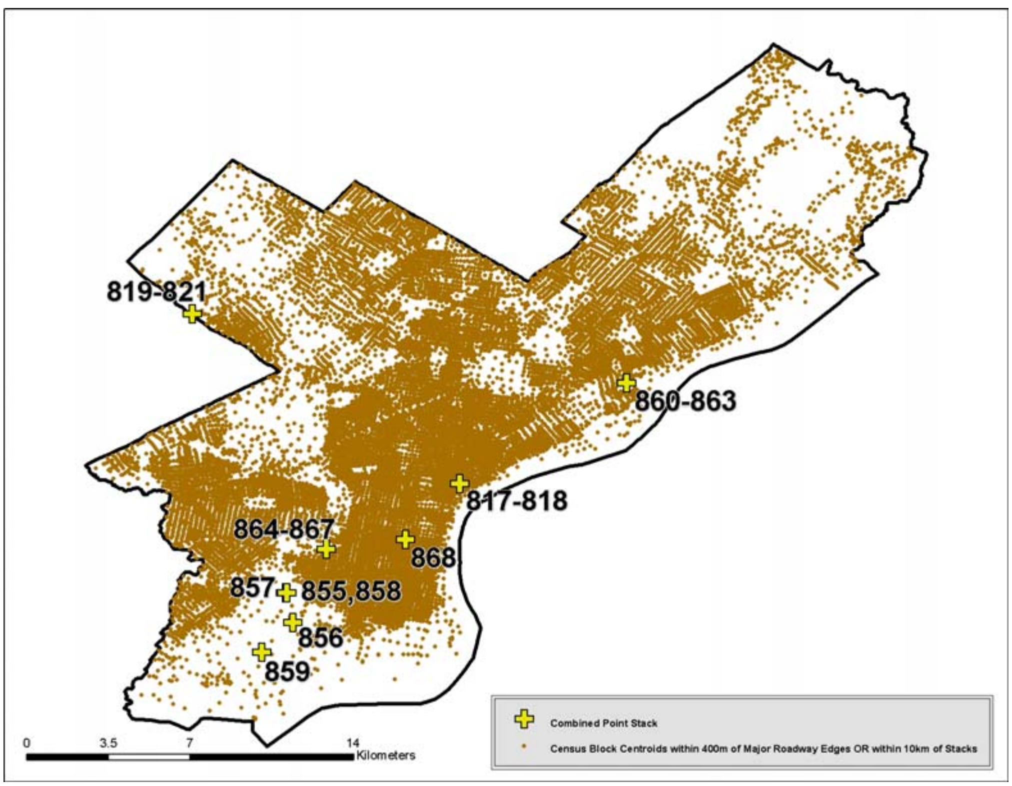

Figure B-7. Centroid locations within fixed distances to major point and mobile sources in Philadelphia county.

The third set of receptors was chosen to represent the on-road microenvironment. For this set, one receptor was placed at the center of each of the 982 sources.

The distance relationship between the road segments and block centroids can be estimated by looking at the distance between the road-centered and the block centroid receptors. Figure B-8 shows the histogram of the shortest distance between each centroid receptor and its nearest roadway-centered receptor.

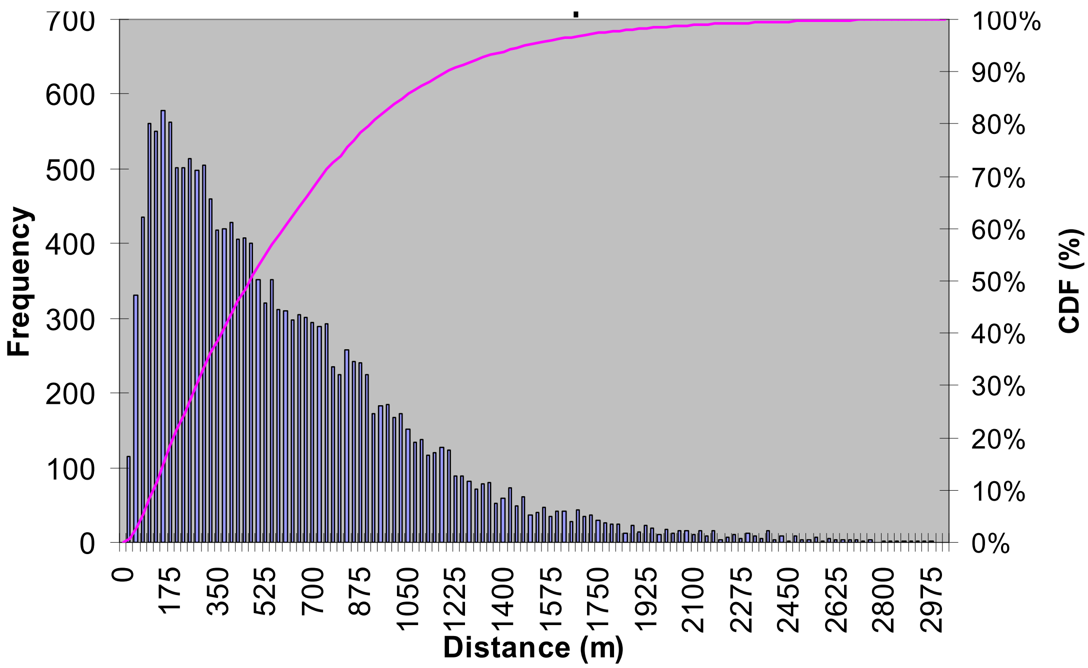

Figure B-8. Frequency distribution of distance between each Census receptor and its nearest road-centered receptor in Philadelphia County.

The block centroids selected were those within 10 km of any major point source or 400 m from any receptor edge, so the distances to the nearest major road segment can be significantly greater than 400 m. The mode of the distribution is about 150 m and the median distance to the closest roadway segment center is about 450 m. However, these values represent the distances of the block centroids to road centers instead of road edges, so that they overestimate the actual distances to the zone most influenced by roadway by an average of 14 m and a range of 4 m to 44 m (see Table B-19 above).

B-3.5.8 Other AERMOD Specifications

Since each of the case-study locations were MSA/CMSAs, all emission sources were characterized as urban. The AERMOD *toxics* enhancements were also employed to speed calculations from area sources. NO_x chemistry was applied to all sources to determine NO_2 concentrations. For the each of the roadway, fugitive, and airport emission sources, the ozone limiting method (OLM) was used, with plumes considered ungrouped. Because an initial NO_2 fraction of NO_x is anticipated to be about 10% or less (Finlayson-Pitts and Pitts, 2000; Yao et al., 2005), a conservative value of 10% for all sources was selected. For all point source simulations the Plume Volume Molar Ratio Method (PVMRM) was used to estimate the conversion of NO_x to NO_2, with the following settings:

1. Hourly series of O_3 concentrations were taken from EPA's AQS database[18]. The complete national hourly record of monitored O_3 concentrations were filtered for the four monitors within Philadelphia County (stations 421010004, 421010014, 421010024, and 421010136). The hourly records of these stations were then averaged together to provide an average Philadelphia County concentrations of O_3 for each hour of 2001-2003.
2. The equilibrium value for the NO_2:NO_x ratio was taken as 75%, the national average ambient ratio.[19]
3. The initial NO_2 fraction of NO_x is anticipated to be about 10% or less. A default value of 10% was used for all stacks (Finlayson-Pitts and Pitts, 2000).

B-3.5.9 Air Quality Concentration Adjustment

The hourly concentrations estimated from each of the three source categories were combined at each receptor. Then a local concentration, reflecting the concentration contribution from emission sources not included in the simulation, was added to the sum of the concentration contributions from each of these sources at each receptor. The local concentration was estimated from the difference between the model predictions at the local NO_2 monitors and the observed values. It should be noted that this local concentration may also include any model error present in estimating concentration at the local monitoring sites. Table B-25 presents a summary of the estimated local concentration added to the AERMOD hourly concentration data.

Table B-25. Comparison of ambient monitoring and AERMOD predicted NO_2 concentrations in Philadelphia.

Year and Monitor ID	Annual Average NO_2 concentration (ppb)			
	Monitor	AERMOD Inititial	Difference[1]	AERMOD Final[2]
2001				
4210100043	26	7	18	19
4210100292	28	22	6	33
4210100471	30	20	10	32
mean			11	
2002				
4210100043	24	7	17	18
4210100292	28	21	7	32
4210100471	29	19	10	31
mean			11	
2003				
4210100043	24	7	17	13
4210100292	25	22	3	28
4210100471*	25	26	-1	32

[18] http://www.epa.gov/ttn/airs/airsaqs/detaildata/downloadaqsdata.htm
[19] Appendix W to CFR 51, page 466. http://www.epa.gov/scram001/guidance/guide/appw_03.pdf.

mean		6	
[1] the difference represents concentrations attributed to sources not modeled by AERMOD and model error. [2] the mean difference between measured and modeled was added uniformly at each receptor hourly concentration to generate the AERMOD final concentrations. * monitor did not meet completeness criteria used in the air quality characterization.			

B-3.5.10 Meteorological Data Used By APEX

APEX used the same meteorological data that was used for the AERMOD modeling, the station located at Philadelphia International (KPHL) airport.

B-3.5.11 Microenvironment Descriptions

B-3.5.11.1 Microenvironment 1: Indoor-Residence

The Indoors-Residence microenvironment uses several variables that affect NO_2 exposure: whether or not air conditioning is present, the average outdoor temperature, the NO_2 removal rate, and an indoor concentration source. The first two of these variables affect the air exchange rate.

Since the selection of an air exchange rate distribution is conditioned on the presence or absence of an air-conditioner, for each modeled area the air conditioning status of the residential microenvironments is simulated randomly using the probability that a residence has an air conditioner. For this study, location-specific air conditioning prevalence was taken from the American Housing Survey of 2003 (AHS, 2003a; 2003b). Previous analyses (US EPA, 2007d) detail the specification of uncertainty estimates in the form of confidence intervals for the air conditioner prevalence using the following:

$$\text{Standard Error}\,(P) = \sqrt{\frac{3850\,P\,(1-P)}{N}},$$

$$\text{Confidence Interval}\,(P) = P \pm 1.96 \times \text{Standard Error}\,(P)$$

where P is the estimated percentage and N is the estimated total number of housing units. Table B-26 contains the values for air conditioning prevalence used for each modeled location.

Table B-26. Air conditioning prevalence estimates with 95% confidence intervals.

AHS Survey	Housing Units	A/C Prevalence (%)	se	L95	U95
Philadelphia	1,943,492	90.6	1.3	88.1	93.2
Notes: se – Standard error L95 – Lower limit on 95th confidence interval U95 – Upper limit on 95th confidence interval					

Air exchange rate data for the indoor residential microenvironment were obtained from US EPA (2007d). Briefly, residential air exchange rate (AER) data were obtained from several studies (Avol et al., 1998; Williams et al., 2003a, 2003b; Meng et al., 2004; Weisel et al., 2004; Chillrud at al, 2004; Kinney et al., 2002; Sax et al., 2004; Wilson et al., 1986, 1996; Colome et al., 1993, 1994; Murray and Burmaster, 1995). Influential characteristics (e.g., temperature, air conditioning), where reported in the study, were also compiled for use in statistical analyses. Descriptive statistics were generated for each location/variable type and evaluated using statistical comparison testing (e.g., ANOVA). Based on the summary statistics and the statistical comparisons, different AER distributions were fit for each combination of A/C type, city, and temperature. In general, lognormal distributions provided the best fit, and are defined by a geometric mean (GM) and standard deviation (GSD). To avoid unusually extreme simulated AER values, bounds of 0.1 and 10 were selected for minimum and maximum AER, respectively.

For Philadelphia, a distribution was selected from a location thought to have similar characteristics to the city to be modeled, qualitatively considering factors that might influence AERs. These factors include the age composition of housing stock, construction methods, and other meteorological variables not explicitly treated in the analysis, such as humidity and wind speed patterns. The distributions used for Philadelphia are provided in Table B-27.

Table B-27. Geometric means (GM) and standard deviations (GSD) for air exchange rates by city, A/C type, and temperature range.

Area Modeled	Study City	A/C Type	Temp (ºC)	N	GM	GSD
Philadelphia	New York City	Central or Room A/C	<=10	20	0.7108	2.0184
			10-25	42	1.1392	2.6773
			>25	19	1.2435	2.1768
		No A/C	<=10	48	1.0165	2.1382
			10-20	59	0.7909	2.0417
			>20	32	1.6062	2.1189

For this analysis, the same NO_2 removal rate distribution was used for all microenvironments that use the mass balance method. This removal rate is based on data provided by Spicer et al. (1993). A total of 6 experiments, under variable source emission characteristics including operation of gas stove, were conducted in an unoccupied test house. A distribution could not be described with the limited data set, therefore a uniform distribution was approximated by the bounds of the 6 values, a minimum of 1.02 and a maximum of 1.45 h^{-1}.

An excerpt from the APEX input file describing the indoor residential microenvironment is provided in Figure B-9. The first section of the input file excerpt specifies the air exchange rate distributions for the microenvironment. Average temperature and air conditioning presence, which are city-specific, were coded into air exchange rate *conditional variables, C1* and *C2*, respectively. Average temperatures were separated into five categories (variable *C1*, numbered 1-5): 50 º F, 50-68 º F, 68-77 º F, 77-86 º F, and 86 º F and above. For variable *C2*, air conditioning status can range from *1* to *2* (*1* for having air conditioning, *2* for not having it). The air exchange rate estimates generated previously in the form of lognormal distributions were entered into the appropriate temperature and A/C category for each location for a total of ten distributions (i.e., 5 temperature distributions by 2 air conditioning distributions). In the input file example however, there are actually four AER distributions for homes with an air conditioner and three for those without; the last few distributions for each air conditioning setting were the same due to the available data to populate the field. The parameter estimates for the removal factor (DE) is also shown following the AER data.

```
Micro number     = 1        !    Indoors - residence - AIR EXCHANGE RATES
Parameter Type    = AER
Condition # 1     = AvgTempCat
Condition # 2     = AC_Home
ResampHours      = NO
ResampDays       = YES
ResampWork       = YES
Block DType Season Area C1  C2  C3   Shape      Par1     Par2  Par3 Par4  LTrunc UTrunc
1       1      1       1   1   1   1   Lognormal  0.711   2.018   0    .       0.1    10
1       1      1       1   2   1   1   Lognormal  1.139   2.677   0    .       0.1    10
1       1      1       1   3   1   1   Lognormal  1.139   2.677   0    .       0.1    10
1       1      1       1   4   1   1   Lognormal  1.244   2.177   0    .       0.1    10
1       1      1       1   5   1   1   Lognormal  1.244   2.177   0    .       0.1    10
1       1      1       1   1   2   1   Lognormal  1.016   2.138   0    .       0.1    10
1       1      1       1   2   2   1   Lognormal  0.791   2.042   0    .       0.1    10
1       1      1       1   3   2   1   Lognormal  1.606   2.119   0    .       0.1    10
1       1      1       1   4   2   1   Lognormal  1.606   2.119   0    .       0.1    10
1       1      1       1   5   2   1   Lognormal  1.606   2.119   0    .       0.1    10

Micro number     = 1              !    DECAY RATES
Pollutant = 1
Parameter Type    = DE
ResampHours      = NO
ResampDays       = NO
ResampWork       = YES
Block DType Season Area C1  C2  C3   Shape      Par1   Par2  Par3 Par4  LTrunc UTrunc
1       1      1       1   1   1   1   Uniform     1.02    1.45     .     .      1.02     1.45
```

Figure B-9. Example input file from APEX for Indoors-residence microenvironment.

Indoor source contributions

A number of studies, as described in the NO_x ISA, have noted the importance of gas cooking appliances as sources of NO_2 emissions. An indoor emission source term was included in the APEX simulations to estimate exposure to indoor sources of NO_2. Three types of data were used to implement this factor:

- The fraction of households in the Philadelphia MSA that use gas for cooking fuel
- The range of contributions to indoor NO_2 concentrations that occur from cooking with gas
- The diurnal pattern of cooking in households.

The fraction of households in Philadelphia County that use gas cooking fuel (i.e., 55%) was taken from the *US Census Bureau's American Housing Survey for the Philadelphia Metropolitan Area: 2003*.

Data used for estimating the contribution to indoor NO_2 concentrations that occur during cooking with gas fuel were derived from a study sponsored by the California Air Resources Board (CARB, 2001). For this study a test house was set up for continuous measurements of NO_2 indoors and outdoors, among several other parameters, and conducted under several different cooking procedures and stove operating conditions. A uniform distribution of concentration contributions for input to APEX was estimated as follows.

- The concurrent outdoor NO_2 concentration measurement was subtracted from each indoor concentration measurement, to yield net indoor concentrations
- Net indoor concentrations for duplicate cooking tests (same food cooked the same way) were averaged for each indoor room, to yield average net indoor concentrations
- The minimum and maximum average net indoor concentrations for any test in any room were used as the lower and upper bounds of a uniform distribution

This resulted in a minimum average net indoor concentration of 4 ppb and a maximum net average indoor concentration of 188 ppb.

An analysis by Johnson et al (1999) of survey data on gas stove usage collected by Koontz et al (1992) showed an average number of meals prepared each day with a gas stove of 1.4. The diurnal allocation of these cooking events was estimated as follows.

- Food preparation time obtained from CHAD diaries was stratified by hour of the day, and summed for each hour, and summed for total preparation time.
- The fraction of food preparation occurring in each hour of the day was calculated as the total number of minutes for that hour divided by the overall total preparation time. The result was a measure of the probability of food preparation taking place during any hour, given one food preparation event per day.
- Each hourly fraction was multiplied by 1.4, to normalize the expected value of daily food preparation events to 1.4.

The estimated probabilities of cooking by hour of the day are presented in Table B-28. For this analysis it was assumed that the probability that food preparation would include stove usage was the same for each hour of the day, so that the diurnal allocation of food preparation events would be the same as the diurnal allocation of gas stove usage. It was also assumed that each cooking event lasts for exactly 1 hour, implying that the average total daily gas stove usage is 1.4 hours.

Table B-28. Probability of gas stove cooking by hour of the day.

Hour of Day	Probability of Cooking (%)[1]
0	0
1	0
2	0
3	0
4	0
5	5
6	10
7	10
8	10
9	5

Hour of Day	Probability of Cooking (%)[1]
10	5
11	5
12	10
13	5
14	5
15	5
16	15
17	20
18	15
19	10
20	5
21	5
22	0
23	0
[1] Values rounded to the nearest 5%. Data sum to 145% due to rounding and scaling to 1.4 cooking events/day.	

B-3.5.11.2 *Microenvironments 2-7: All other indoor microenvironments*

The remaining five indoor microenvironments, which represent Bars and Restaurants, Schools, Day Care Centers, Office, Shopping, and Other environments, are all modeled using the same data and functions (Figure B-10). As with the Indoor-Residence microenvironment, these microenvironments use both air exchange rates and removal rates to calculate exposures within the microenvironment. The air exchange rate distribution (GM = 1.109, GSD = 3.015, Min = 0.07, Max = 13.8) was developed based on an indoor air quality study (Persily et al, 2005; see US EPA, 2007d for details in derivation). The decay rate is the same as used in the Indoor-Residence microenvironment discussed previously. The Bars and Restaurants microenvironment included an estimated contribution from indoor sources as was described for the Indoor-Residence, only there was an assumed 100% prevalence rate and the cooking with the gas appliance occurred at any hour of the day.

```
Micro number     = 2       !    Bars & restaurants     - AIR EXCHANGE RATES
Parameter Type   = AER
ResampHours      = NO
ResampDays       = YES
ResampWork       = YES
Block DType Season Area C1  C2  C3   Shape       Par1   Par2  Par3 Par4  LTrunc UTrunc
1       1       1       1    1    1    1   LogNormal  1.109  3.015   0    .      0.07      13.8

Micro number     = 2              !    DECAY RATES
Pollutant = 1
Parameter Type   = DE
ResampHours      = NO
ResampDays       = YES
ResampWork       = YES
Block DType Season Area C1  C2  C3   Shape      Par1   Par2  Par3 Par4  LTrunc UTrunc
1       1       1       1     1     1  1   Uniform    1.02    1.45    .      .      1.02      1.45
```

Figure B-10. Example input file from APEX for all Indoors microenvironments (non-residence).

Microenvironments 8 and 9: Outdoor microenvironments

Two outdoor microenvironments, the Near Road and Public Garage/Parking Lot, used the factors method to calculate pollutant exposure. Penetration factors are not applicable to outdoor environments (effectively, PEN=1). Proximity factors were developed from the AERMOD concentration predictions, i.e., the block-centroid-to-nearest-roadway concentration ratios. Based on the resulting sets of ratio values, the ratio distributions were stratified by hour of the day into 3 groups as indicated by the "hours-block" specification in the example file in Figure B-11. The lower and upper bounds for sampling were specified as the 5th and 95th percentile values, respectively, of each distribution.

```
Micro number     = 8        !    Outdoor near road       PROXIMITY FACTOR
Pollutant = 1
Parameter Type   = PR
Hours - Block     =       1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 3 3 3 1 1
ResampHours      = YES
ResampDays       = YES
ResampWork       = YES
Block DType Season Area C1  C2  C3   Shape      Par1   Par2  Par3 Par4  LTrunc UTrunc  ResampOut
1    1     1      1     1   1   1  LogNormal   1.251  1.478  0.    .   0.86  2.92     Y
2    1     1      1     1   1   1  LogNormal   1.555  1.739  0.    .   0.83  4.50     Y
3    1     1      1     1   1   1  LogNormal   1.397  1.716  0.    .   0.73  4.17     Y
```

Figure B-11. Example input file from APEX for outdoor near road microenvironment.

B-3.5.11.3 Microenvironment 10: Outdoors-General.

The general outdoor environment concentrations are well represented by the modeled concentrations. Therefore, both the penetration factor and proximity factor for this microenvironment were set to 1.

B-3.5.11.4 Microenvironments 11 and 12: In Vehicle- Cars and Trucks, and Mass Transit

Penetration factors were developed from data provided in Chan and Chung (2003). Inside-vehicle and outdoor NO_2 concentrations were measured with for three ventilation conditions, air-recirculation, fresh air intake, and with windows opened. Since major roads were the focus of this assessment, reported indoor/outdoor ratios for highway and urban streets were used here. Mean values range from about 0.6 to just over 1.0, with higher values associated with increased ventilation (i.e., window open). A uniform distribution was selected for the penetration factor for Inside-Cars/Trucks (ranging from 0.6 to 1.0) due to the limited data available to describe a more formal distribution and the lack of data available to reasonably assign potentially influential characteristics such as use of vehicle ventilation systems for each location. Mass transit systems, due to the frequent opening and closing of doors, was assigned a uniform distribution ranging from 0.8 to 1.0 based on the reported mean values for fresh air intake and open windows. Proximity factors were developed as described above for Microenvironments 8 and 9.

B-3.5.12 Adjustment for Just Meeting the Current Standard

To simulate just meeting the current standard, dispersion modeled concentration were not rolled-up as was done for the monitor concentrations used in the air quality characterization. A proportional approach was used as done in the Air Quality Characterization, but to reduce computer processing time, the health effect benchmark levels were proportionally reduced by the similar factors described for each specific location and simulated year. Since it is a proportional adjustment, the end effect of adjusting concentrations upwards versus adjusting benchmark levels downward within the model is the same. The difference in the exposure and risk modeling was that the modeled air quality concentrations were used to generate the adjustment factors. Table B-29 provides the adjustment factors used and the adjusted potential health effect benchmark concentrations to simulate just meeting the current standard. When modeling indoor sources, the indoor concentration contributions needed to be scaled downward by the same proportions.

Table B-29. Adjustment factors and potential health effect benchmark levels used by APEX to simulate just meeting the current standard.

Simulated Year (factor)	Potential Health Effect Benchmark Level (ppb)	
	Actual	Adjusted
2001 (1.59)	150	94
	200	126
	250	157
	300	189
2002 (1.63)	150	92
	200	122
	250	153
	300	184
2003 (1.64)	150	91
	200	122
	250	152
	300	183

When considering the indoor sources, an additional scaling was performed so as not to affect their estimated concentrations while adjusting the benchmark levels downward. To clarify how this was done, exposure concentrations an individual experiences are first defined as the sum of the contribution from ambient concentrations and from indoor sources (if present) and this concentration can be either above or below a selected concentration level of interest:

$$C_{esposure} = A \times C_{ambient} + B \times C_{indoor} > C_{threshold} \quad \text{equation (6)}$$

where,

$C_{exposure}$ = individual exposure concentration
A = proportion of exposure concentration from ambient
$C_{ambient}$ = ambient concentration in the absence of indoor sources

B	= proportion of exposure concentration from indoor
C_{indoor}	= indoor source concentration contribution
$C_{threshold}$	= an exposure concentration of interest

It follows that if we are interested in adjusting the ambient concentrations upwards by some proportional factor *F*, this can be described with the following:

$$F \times A \times C_{ambient} + B \times C_{indoor} > C_{threshold} \qquad \text{equation (7)}$$

This is equivalent to

$$A \times C_{ambient} + B \times (C_{indoor} / F) > (C_{threshold} / F) \qquad \text{equation (8)}$$

Therefore, if the potential health effect benchmark level and the indoor concentrations are both proportionally scaled downward by the same adjustment factor, the contribution of both sources of exposure (i.e., ambient and indoor) are maintained and the same number of estimated exceedances would be obtained as if the ambient concentration were proportionally adjusted upwards by factor *F*.

B-3.6 Philadelphia Exposure Modeling Results

B-3.6.1 Overview

The results of the exposure and risk characterization are presented here for Philadelphia County. These results are not to be directly compared with the results in the final REA, due to differences in the model approach used here. The main difference that does not allow for comparison with the Atlanta exposure assessment is that the minor road emissions were not modeled in the Philadelphia County assessment.

Several scenarios were considered for the exposure assessment, including two averaging time for NO_2 concentrations (annual and 1-hour), inclusion of indoor sources, and for evaluating just meeting the current standard. To date, year 2002 served as the base year for all scenarios, years 2001 and 2003 were only evaluated for a limited number of scenarios. Exposures were simulated for four groups; children and all persons, and the asthmatic population within each of these.

The exposure results summarized below focus on the population group where exposure estimations are of greatest interest, namely asthmatic individuals. The complete results for each of these two population subgroups are provided in section B-3.6.7. However, due to certain limitations in the data summaries output from the current version of APEX, some exposure data could only be output for the entire population modeled (i.e., all persons - includes asthmatics and healthy persons of all ages). The summary data for the entire population (e.g., annual average exposure concentrations, time spent in microenvironments at or above a potential health effect benchmark level) can be representative of the asthmatic population since the asthmatic population does not have its microenvironmental concentrations and activities estimated any differently from those of the total population.

B-3.6.2 Evaluation of Modeled NO_2 Air Quality Concentrations (as is)

Since the current NO_2 standard is 0.053 ppm annual average, the predicted air quality concentrations were first summarized by calculating annual average concentration. The distribution for the AERMOD predicted NO_2 concentrations at each of the 16,857 receptors for years 2001 through 2003 are illustrated in Figure B-12. Variable concentrations were estimated by the dispersion model over the three year period (2001-2003). The NO_2 concentration distribution was similar for years 2001 and 2002, with mean annual average concentrations of about 21 ppb and a COV of just over 30%. On average, NO_2 annual average concentrations were lowest during simulated year 2003 (mean annual average concentration was about 16 ppb), largely a result of the comparably lower local concentration added (Table B-28). While the mean annual average concentrations were lower than those estimated for 2001 and 2002, a greater number of annual average concentrations were estimated above 53 ppb for year 2003. In addition, year 2003 also contained greater variability in annual average concentrations as indicated by a COV of 53%.

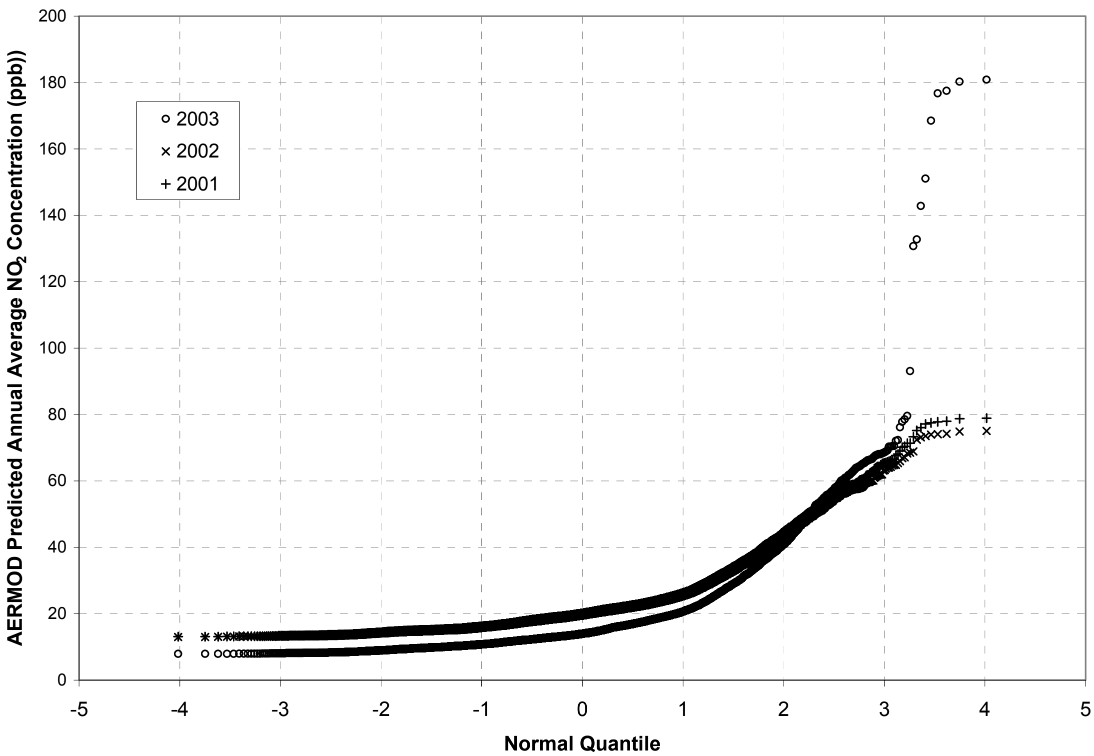

Figure B-12 . Distribution of AERMOD estimated annual average NO_2 concentrations at each of the 16,857 receptors in Philadelphia County for years 2001-2003.

Diurnal variability in NO_2 concentrations was evaluated by comparing the modeled concentrations at the monitor receptors with the measured concentrations at the ambient monitors. Figure B-13 presents the annual average NO_2 concentration at each hour of the day for the three monitors located in Philadelphia County. The diurnal distributions among the modeled versus measured concentrations are similar at all of the monitors, with peak NO_2 concentrations generally coinciding with the typical peak commute times of 6:00-9:00 AM and 5:00-8:00 PM. The pattern is represented best at monitor 4210100043 (top graph in Figure B-13), however the AERMOD concentrations are approximately 8 ppb lower at the earlier times of the day following the adjustment for sources not modeled (section B-3.5.9). There is greater variability in the modeled NO_2 concentrations at the other two monitors when compared with the measured data (middle and bottom graphs of Figure B-13), although the patterns are still similar. The greatest difference in NO_2 concentrations occurs during the later commute period, most notable at monitor 4210100292. Given the concentration adjustment to correct for sources not modeled was applied to all receptors equally across the entire modeling domain, it is not surprising that the modeled concentrations are higher in some instances while others not. The pattern in the concentrations is the important feature to replicate, of which AERMOD does reasonably, and based on these three receptors, may slightly overestimate peak concentrations more times than underestimate them.

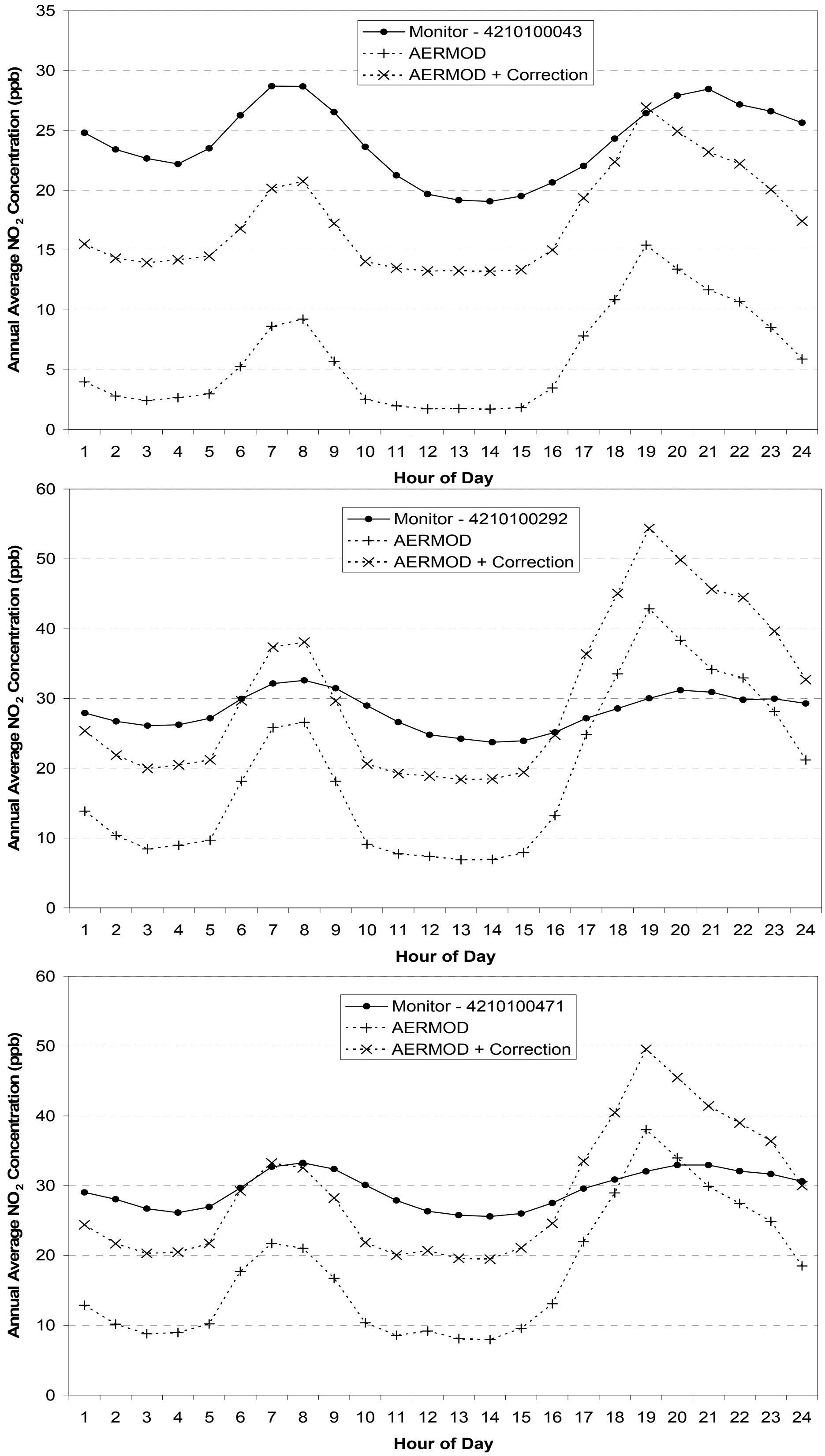

Figure B-13. Measured and modeled diurnal pattern of NO_2 concentrations at three ambient monitor sites.

B-3.6.3 Comparison of estimated on-road NO_2 concentrations

The two independent approaches used to estimate on-road NO_2 concentrations, one using ambient monitor data combined with an on-road adjustment factor (section A-8) and the other using the AERMOD dispersion model (section B-3.5), were compared to one another. There are no on-road NO_2 concentration measurements in Philadelphia for the modeled data to be compared with, although it should be noted that the data used to estimate the adjustment factors and applied to the monitor data are measurement based.

First a comparison can be made between the factor used for estimating on-road concentrations in the air quality analysis and similar factors calculated using AERMOD estimated concentrations. As described in section A-8, an empirical distribution of on-road adjustment factors was derived from on-road and near-road NO_2 concentration measurements published in the extant literature. The derived empirical distribution was separated into two components, one for application to summertime ambient concentrations, and the second for all other seasons. The two empirical distributions are presented in Figure B-14, and represent the on-road adjustment factors multiplied by the ambient monitor concentration (> 100 m from a major road) and used to estimate the on-road concentration in the air quality characterization (chapter 7 of the REA). The one-hour NO_2 concentrations estimated at every AERMOD receptor in Philadelphia were compared with the concentrations estimated at their closest on-road receptor to generate a similar ratio (i.e., on-road/non-road concentrations). These ratios were also stratified into two seasonal categories, one containing the summer ratios (June, July, and August) and the other for all other times of the year. The AERMOD on-road factor distributions in semi-empirical form are also presented in Figure B-14. There are similarities in comparing each of the AERMOD with the measurement study derived distributions, most importantly at the upper percentiles. Intersection of the two approaches occurs at about the 70^{th} percentile and continues through the 90^{th} percentile. While the two seasonal distributions for AERMOD are very similar to one another, they diverge at the upper percentiles, with the summer ratios containing greater values at the same percentiles. This is similar to what was observed in the measurement derived distribution, although the summer ratio distribution consistently contained greater values at all percentiles compared with the non-summer distribution.

There are differences that exist when comparing the two approaches at the mid to lower percentiles, with the AERMOD ratios consistently lower than the empirically derived factors. This is likely due to the differences in the population of samples used to generate each type of distribution. The measurement study derived distribution used data from on-road concentration measurements and from monitoring sites located at a distance from the road, sites that by design of the algorithm and the factor selection criteria are likely not under the influence of non-road NO_2 emission sources. Thus, the measurement study derived ratios never fall below a value of one, there are no on-road concentrations less than any corresponding non-road influenced concentrations. This was, by design, a reasonable assumption for estimating the on-road concentrations for the air quality characterization. The AERMOD receptors however, include all types of emission sources such that there are possibilities for concentrations at non-road receptors that are greater than on-road, a more realistic depiction of the actual relationship between on-road and non-road receptors. Furthermore, the AERMOD distribution extends beyond the range of values offered by the measurement study derived ratios at the very upper percentiles. One issue with this comparison is that the AERMOD developed ratios are from a 1-hour averaging time, while the study derived ratios were from averaging times of mostly 7-14 days. This could be why the AERMOD ratios have much greater variability than with the study derived ratios.

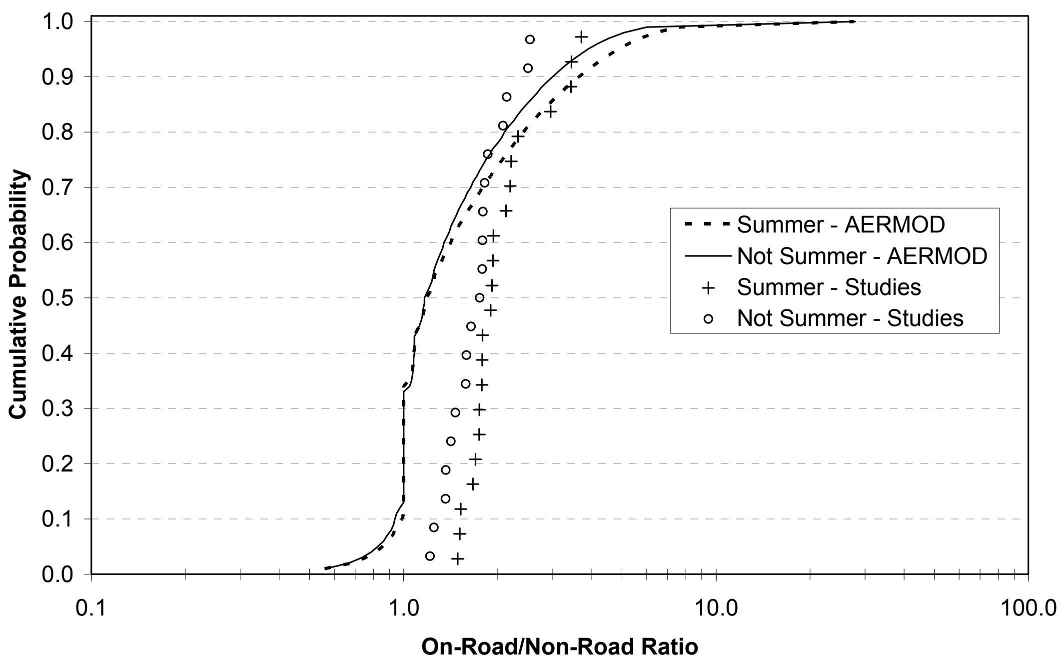

Figure B-14. Comparison of on-road/non-road ratios developed from AERMOD concentration estimates and those derived from published NO_2 measurement studies.

Briefly for the second comparison, hourly on-road NO_2 concentrations were estimated using AERMOD for 979 on-road receptors in Philadelphia for the year 2002. The 24 hourly values modeled for each day at each receptor were rounded to the nearest 1 ppb and then adjusted for sources not modeled using the ambient monitor data (Table B-25). The second set of estimated on-road NO_2 concentrations was generated as part of the Air Quality Characterization by applying randomly selected on-road adjustment factors to the ambient monitor concentrations in the Philadelphia CMSA.

Table B-30 compares the summary statistics of the hourly concentrations and the number of exceedances of the potential health effect benchmark levels. The AERMOD predicted and ambient monitor simulated concentration distributions have very similar means and percentiles. However the variance of the modeled values is about 60 % higher than the variance of the simulated on-road monitor concentrations. This variance difference is largely a function of differences in the extreme upper tails of the distributions and most notable when comparing the numbers of exceedances of the potential health effect benchmark levels. The AERMOD on-road receptors consistently have a greater number of exceedances of potential health effect benchmark levels than that estimated using the on-road monitor simulation. For example, the AERMOD receptors had an average of 35 exceedances of 200 ppb per site-year while the simulated on-road monitors had an average of 2 exceedances per year. The maximum number of exceedances per site-year was 530 for the AERMOD modeled data and 59 for the simulated on-road monitor data.

The apparent contradiction between the similarity of the hourly concentration distributions and the large differences in the exceedance distributions can be explained by the fact that 200 ppb is the 99.605th percentile of the AERMOD hourly concentrations and is the 99.974th percentile of the simulated on-road monitor concentrations. Thus on average, 0.395 % of hourly AERMOD values exceed 200 ppb per year and 0.026 % of hourly simulated on-road monitored values exceed 200 ppb per year. These differences could be due to the greater number of receptors modeled by AERMOD (n=979) compared with the on-road monitor simulation (n=5). Again, the AERMOD generated data could include locations greatly influenced by roadway emissions that are not captured by the simplified approach conducted in the Air Quality Characterization.

Table B-30. Summary statistics of on-road hourly NO_2 concentrations (ppb) and the numbers of potential health effect benchmark levels using AERMOD and the on-road ambient monitor simulation approaches in Philadelphia.

	1-hour NO_2 concentrations		Exceedances of 150 ppb		Exceedances of 200 ppb		Exceedances of 250 ppb	
Statistic	AERMOD	Monitor Simulation	AERMOD	Monitor Simulation	AERMOD	Monitor Simulation	AERMOD	Monitor Simulation
N	8,576,040	4,183,900	979	500	979	500	979	500
Mean	36.2	35.4	113	18	35	2	12	0.6
Stdev	32.1	24.9	142	47	61	8	30	1.6
Variance	1,030	620	20,171	2,187	3,751	61	900	2.6
p0	12	0	0	0	0	0	0	0
p5	12	5	2	0	0	0	0	0
p10	12	9	8	0	0	0	0	0
p15	13	11	13	0	1	0	0	0
p20	14	14	21	0	2	0	0	0
p25	15	16	27	1	3	0	0	0
p30	17	19	32	1	4	0	0	0
p35	18	22	39	1	6	0	1	0
p40	20	25	45	1	8	0	1	0
p45	22	27	56	1	10	0	2	0
p50	25	30	65	1	13	0	2	0
p55	28	34	73	1	15	0	3	0
p60	31	38	86	2	20	1	4	0
p65	35	41	106	3	24	1	5	0
p70	40	45	122	6	31	1	7	0
p75	45	49	143	8	39	1	10	1
p80	52	54	176	15	56	1	15	1
p85	61	60	216	24	72	1	21	1
p90	75	68	267	63	95	4	31	1
p95	98	81	390	92	148	11	58	1
p100	707	681	1,072	278	530	59	299	11

B-3.6.4 Annual Average Exposure Concentrations (as is)

The hourly NO_2 concentrations output from AERMOD were input into the exposure model, providing a range of estimated exposures output by APEX. Figure B-15 illustrates the annual average exposure concentrations for the entire simulated population (both asthmatics and healthy individual of all ages), for each of the years analyzed and where indoor sources were modeled. While years 2001 and 2002 contained very similar population exposure concentration distributions, the modeled year 2003 contained about 20% lower annual average concentrations. The lower exposure concentrations for year 2003 are similar to what was observed for the predicted air quality (Figure B-12), however, all persons were estimated to contain exposures below an annual average concentration of 53 ppb, even considering indoor source concentration contributions. Again, while Figure B-15 summarizes the entire population, the data are representative of what would be observed for the population of asthmatics or asthmatic children.

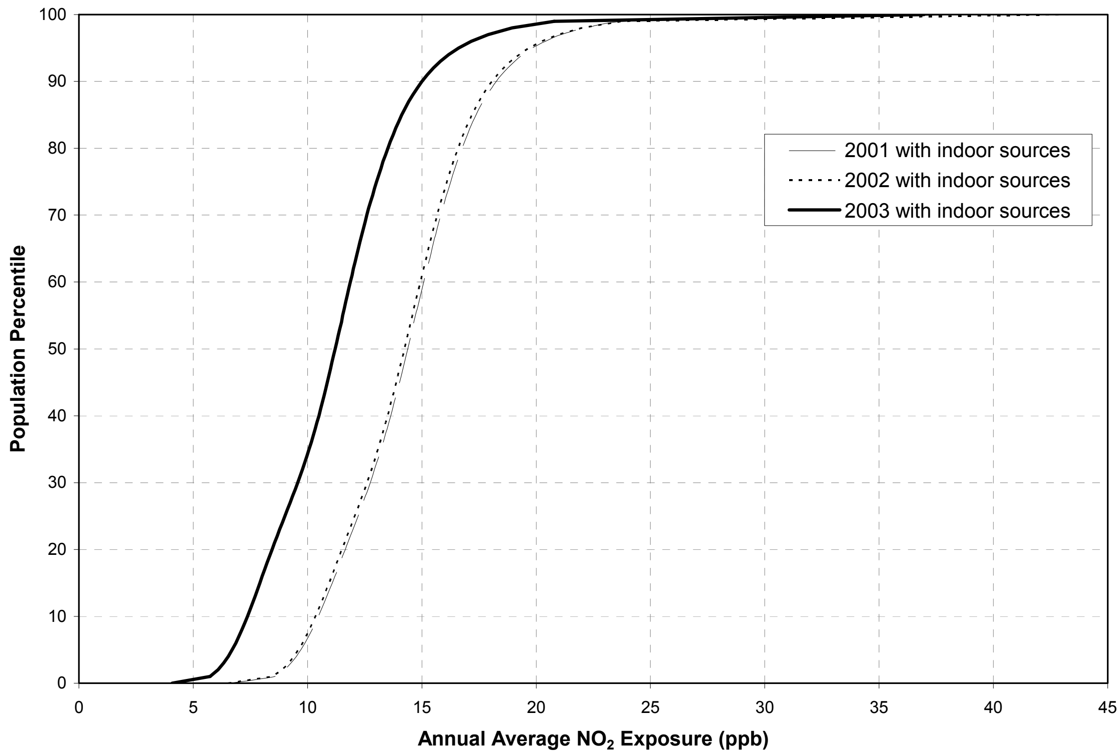

Figure B-15. Estimated annual average total NO_2 exposure concentrations for all simulated persons in Philadelphia County, using modeled 2001-2003 air quality (as is), with modeled indoor sources.

The AERMOD predicted air quality and the estimated exposures for year 2002 were compared using their respective annual average NO_2 concentrations (Figure B-16). As a point of reference, the annual average concentration for 2002 ambient monitors ranged from 24 ppb to 29 ppb. Many of the AERMOD predicted annual average concentrations were below that of the lowest ambient monitoring concentration of 24 ppb, although a few of the receptors contained concentrations above the highest measured annual average concentration. Estimated exposure concentrations were below that of both the modeled and measured air quality. For example, exposure concentrations were about 5 ppb less than the modeled air quality when the exposure estimation included indoor sources, and about 10 ppb less for when exposures were estimated without indoor sources. In comparing the estimated exposures with and without indoor sources, indoor sources were estimated to contribute between 1 and 5 ppb to the total annual average exposures.

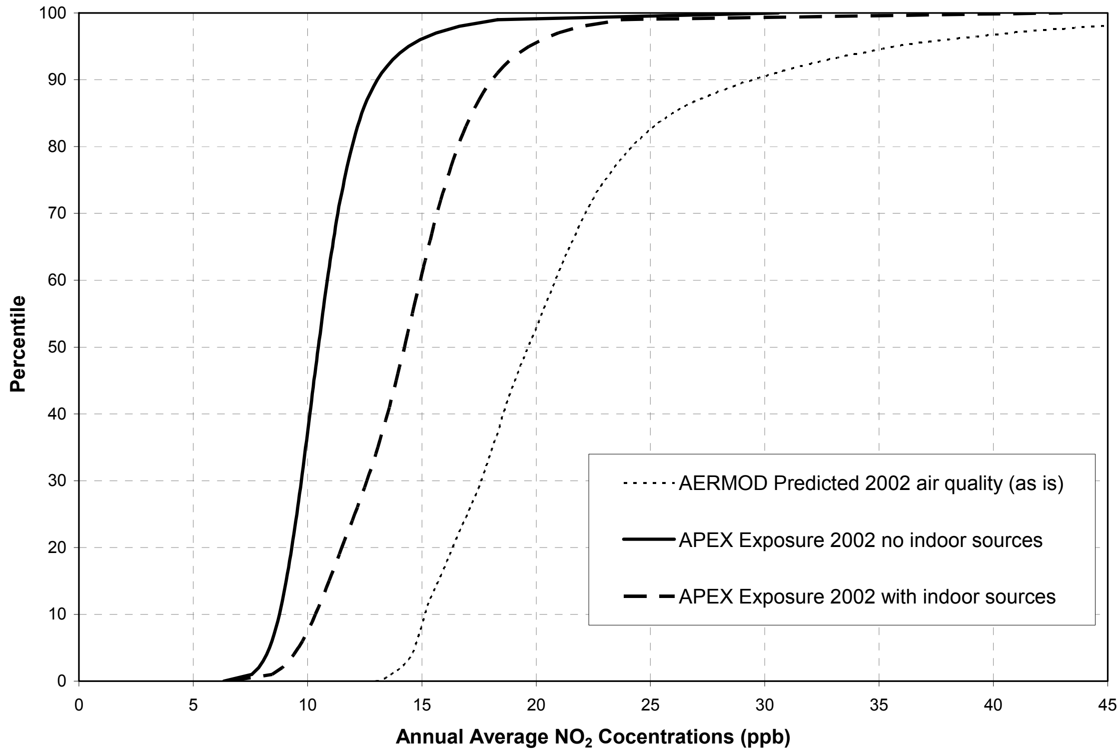

Figure B-16. Comparison of AERMOD predicted and ambient monitoring annual average NO_2 concentrations (as is) and APEX exposure concentrations (with and without modeled indoor sources) in Philadelphia County for year 2002.

B-3.6.5 One-Hour Exposures (as is)

Since there is interest in short-term exposures, a few analyses were performed using the APEX estimated exposure concentrations. As part of the standard analysis, APEX reports the maximum exposure concentration for each simulated individual in the simulated population. This can provide insight into the proportion of the population experiencing any NO_2 exposure concentration level of interest. In addition, exposures are estimated for each of the selected potential health effect benchmark levels (200, 250, and 300 ppb, 1-hour average). An exceedance was recorded when the maximum exposure concentration observed for the individual was above the selected level in a day (therefore, the maximum number of exceedances is 365 for a single person). Estimates of repeated exposures are also recorded, that is where 1-hour exposure concentrations were above a selected level in a day added together across multiple days (therefore, the maximum number of multiple exceedances is also 365). Persons of interest in this exposure analysis are those with particular susceptibility to NO_2 exposure, namely individuals with asthma. The health effect benchmark levels are appropriate for estimating the potential risk of adverse health effects for asthmatics. The majority of the results presented in this section are for the simulated asthmatic population. However, the exposure analysis was performed for the total population to assess numbers of persons exposed to these levels and to provide additional information relevant to the asthmatic population (such as time spent in particular microenvironments).

B-3.6.5.1 Maximum Estimated Exposure Concentrations

A greater variability was observed in maximum exposure concentrations for the 2003 year simulation compared with years 2001 and 2002 (Figure B-17). While annual average exposure concentrations for the total population were the lowest of the 3-year simulation, year 2003 contained a greater number of individual maximum exposures at and above the lowest potential health effect benchmark level. When indoor sources are not modeled however, over 90% of the simulated persons do not have an occurrence of a 1-hour exposure above 200 ppb in a year.

B-3.6.5.2 Number of Estimated Exposures above Selected Levels

When considering the total asthmatic population simulated in Philadelphia County and using current air quality of 2001-2003, nearly 50,000 persons were estimated to be exposed at least one time to a one-hour concentration of 200 ppb in a year (Figure B-18). These exposures include both the NO_2 of ambient origin and that contributed by indoor sources. The number of asthmatics exposed to greater concentrations (e.g., 250 or 300 ppb) drops dramatically and is estimated to be somewhere between 1,000 – 15,000 depending on the 1-hour concentration level and the year of air quality data used. Exposures simulated for year 2003 contained the greatest number of asthmatics exposed in a year consistently for all potential health effect benchmark levels, while year 2002 contained the lowest number of asthmatics. Similar trends across the benchmark levels and the simulation years were observed for asthmatic children, albeit with lower numbers of asthmatic children with exposures at or above the potential health effect benchmark levels.

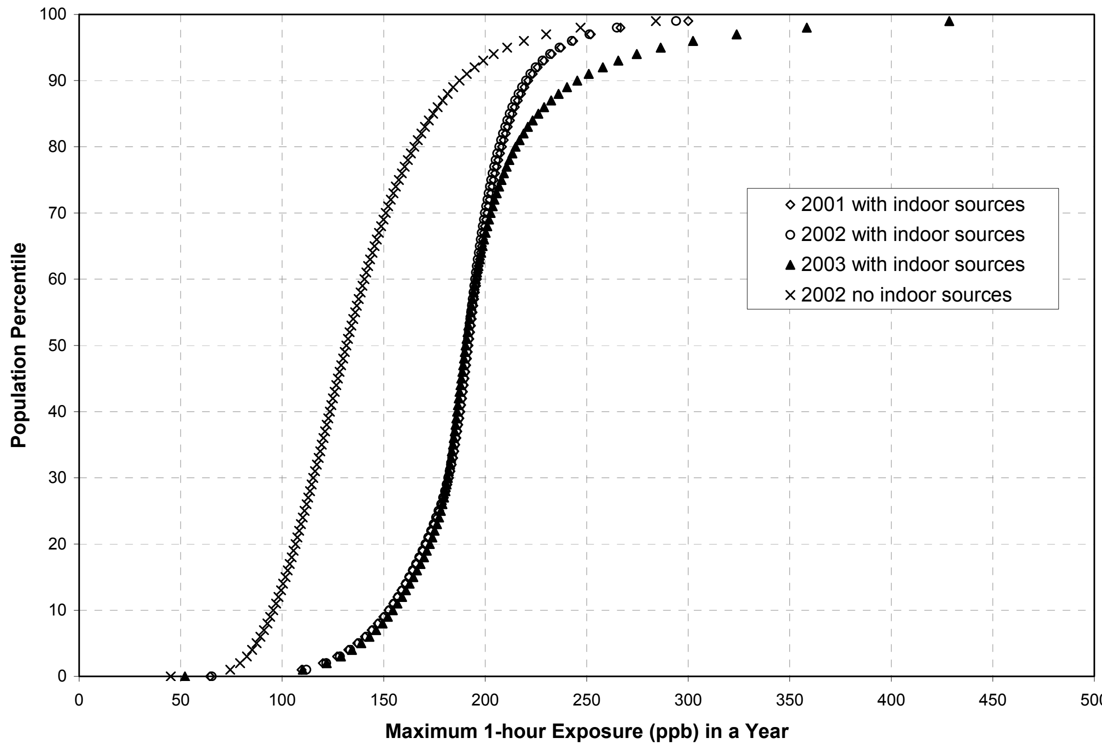

Figure B-17. Estimated maximum NO_2 exposure concentration for all simulated persons in Philadelphia County, using modeled 2001-2003 air quality (as is), with and without modeled indoor sources. Values above the 99th percentile are not shown.

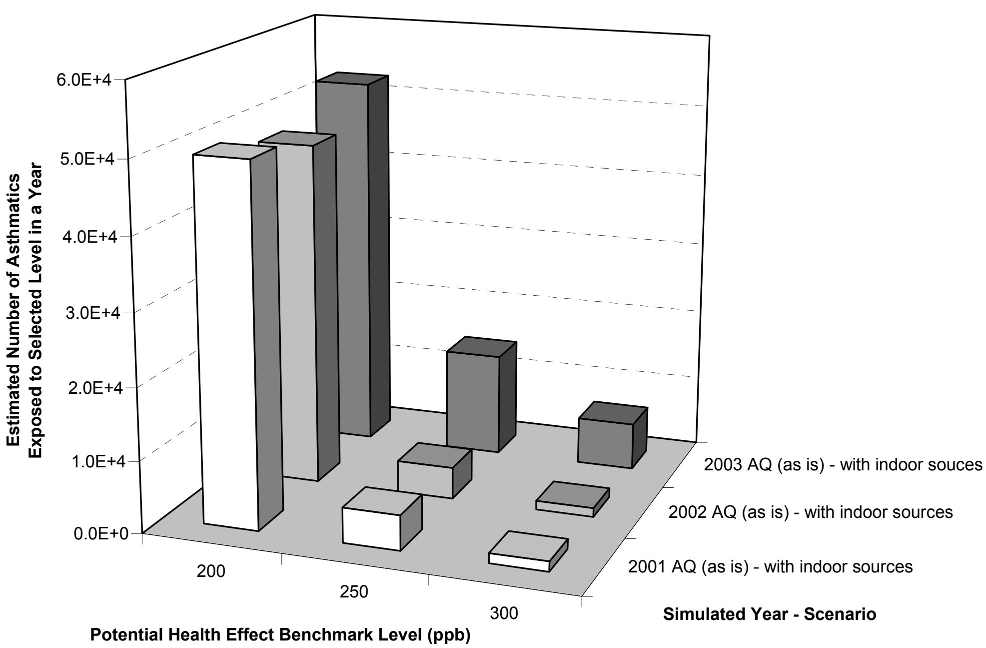

Figure B-18. Estimated number of all simulated asthmatics in Philadelphia County with at least one NO_2 exposure at or above the potential health effect benchmark levels, using modeled 2001-2003 air quality (as is), with modeled indoor sources.

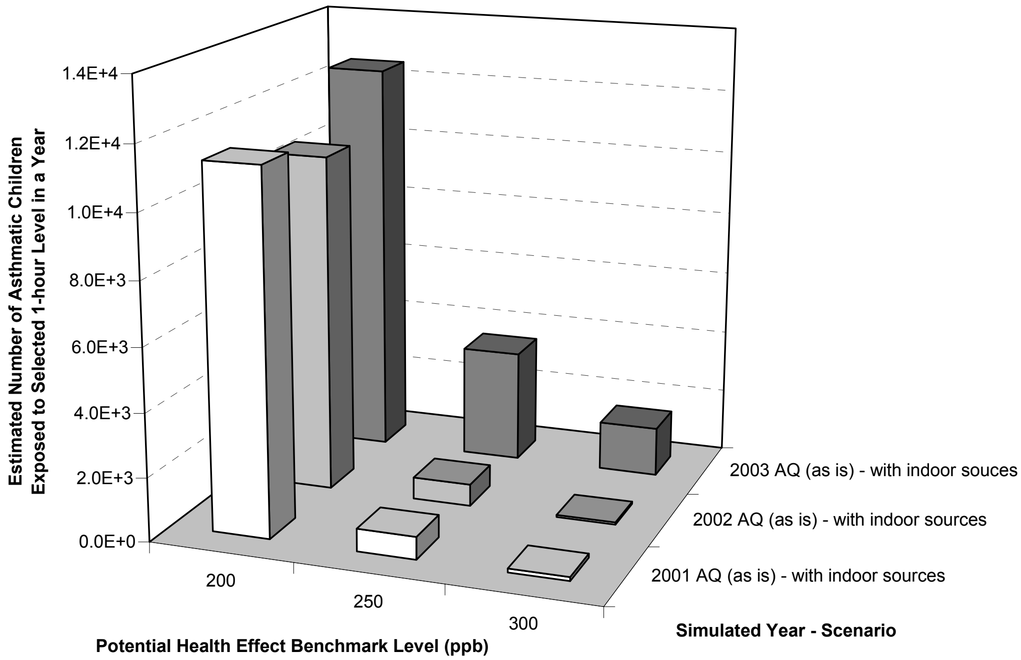

Figure B-19. Estimated number of simulated asthmatic children in Philadelphia County with at least one NO_2 exposure at or above the potential health effect benchmark levels, using modeled 2001-2003 air quality (as is), with modeled indoor sources.

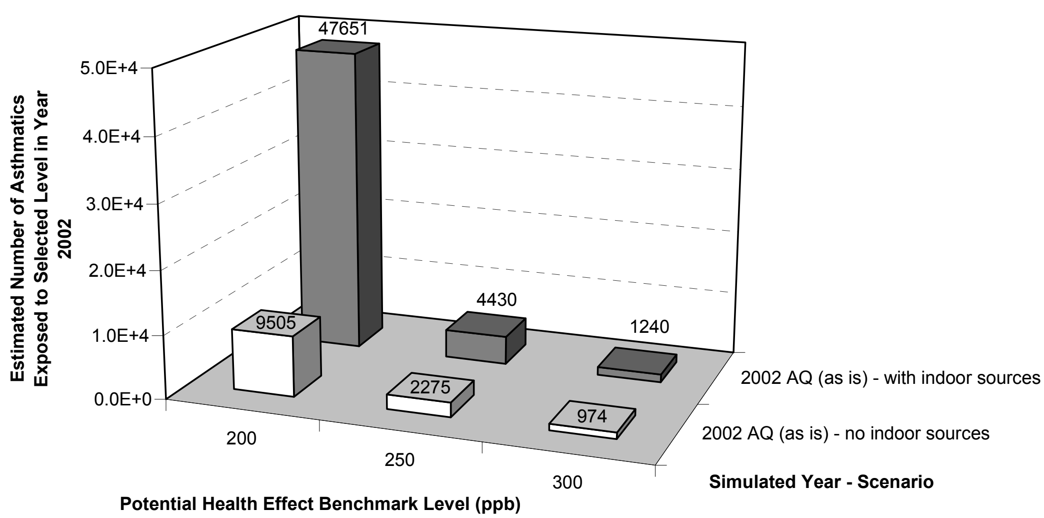

Figure B-20. Comparison of the estimated number of all simulated asthmatics in Philadelphia County with at least one NO_2 exposure at or above potential health effect benchmark levels, using modeled 2002 air quality (as is) , with and without modeled indoor sources.

For example, nearly 12,000 were estimated to be exposed to at least a one-hour NO_2 concentration of 200 ppb in a year (Figure B-19). Additional exposure estimates were generated using the modeled 2002 air quality (as is) and where the contribution from indoor sources was not included in the exposure concentrations. APEX allows for the same persons to be simulated, i.e., demographics of the population were conserved, as well as using the same individual time-location-activity profiles generated for each person. Figure B-20 compares the estimated number of asthmatics experiencing exposures above the potential health effect benchmarks, both with indoor sources and without indoor sources included in the model runs. The number of asthmatics at or above the selected concentrations is reduced by between 50-80%, depending on benchmark level, when not including indoor source (i.e., gas cooking) concentration contributions.

An evaluation of the time spent in the 12 microenvironments was performed to estimate where simulated individuals are exposed to concentrations above the potential health effect benchmark levels. Currently, the output generated by APEX is limited to compiling the microenvironmental time for the total population (includes both asthmatic individuals and healthy persons) and is summarized to the total time spent above the selected potential health effect benchmark levels. As mentioned above, the data still provide a reasonable approximation for each of the population subgroups (e.g., asthmatics or asthmatic children) since their microenvironmental concentrations and activities are not estimated any differently from those of the total population by APEX.

As an example, Figure B-21 (a, b, c) summarizes the percent of total time spent in each microenvironment for simulation year 2002 that was associated with estimated exposure concentrations at or above 200, 250, and 300 ppb (results for years 2001 and 2003 were similar). Estimated exposures included the contribution from one major category of indoor sources (i.e., gas cooking). The time spent in the indoor residence and bars/restaurants were the most important for concentrations ≥200 ppb, contributing to approximately 75% of the time persons were exposed (Figure B-21a). This is likely a result of the indoor source concentration contribution to each individual's exposure concentrations. The importance of the particular microenvironment however changes with differing potential health effect benchmark levels. This is evident when considering the in-vehicle and outdoor near-road microenvironments, progressing from about 19% of the time exposures were at the lowest potential health effect benchmark level (200 ppb) to a high of 64% of the time exposures were at the highest benchmark level (300 ppb, Figure B-21c).

The microenvironments where higher exposure concentrations occur were also evaluated for the exposure estimates generated without indoor source contributions. Figure B-22 illustrates that the time spent in the indoor microenvironments contributes little to the estimated exposures above the selected benchmark levels. The contribution of these microenvironments varied only slightly with increasing benchmark concentration, ranging from about 2-5%. Most of the time associated with high exposures was associated with the transportation microenvironments (In-Vehicle or In-Public Transport) or outdoors (Out-Near Road, Out-Parking Lot, Out-Other). The importance of time spent outdoors near roadways exhibited the greatest change in contribution with increased health benchmark level, increasing from around 30 to 44% of time associated with concentrations of 200 and 300 ppb, respectively. While more persons are likely to spend time inside a vehicle than outdoors near roads, there is attenuation of the on-road concentration that penetrates the in-vehicle microenvironment, leading to lowered concentrations, occurring less frequently above 300 ppb than outdoors near roads.

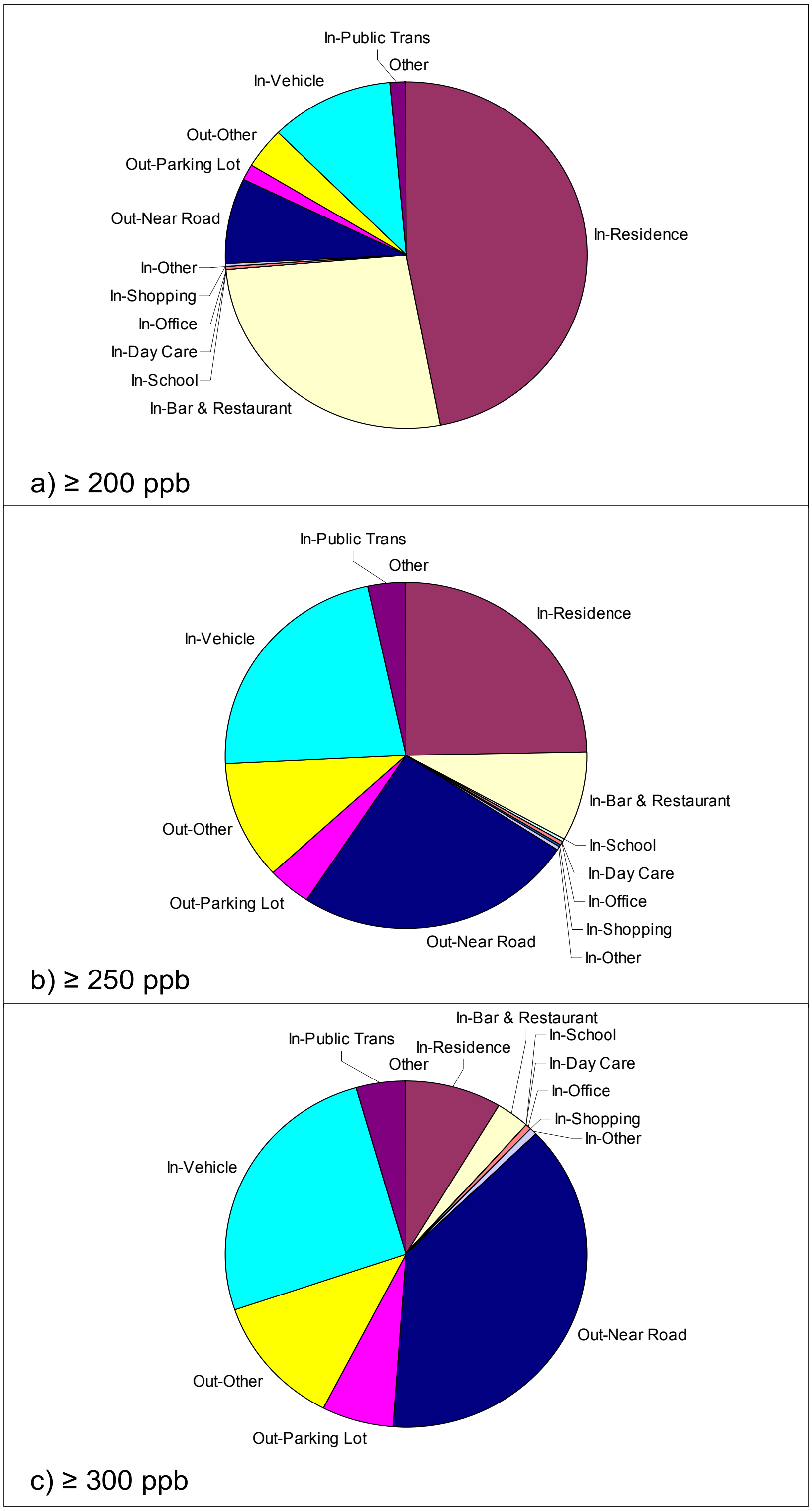

Figure B-21. Fraction of time all simulated persons in Philadelphia County spend in the twelve microenvironments associated with the potential NO_2 health effect benchmark levels, a) ≥ 200 ppb, b) ≥ 250 ppb, and c) ≥ 300 ppb, year 2002 simulation with indoor sources.

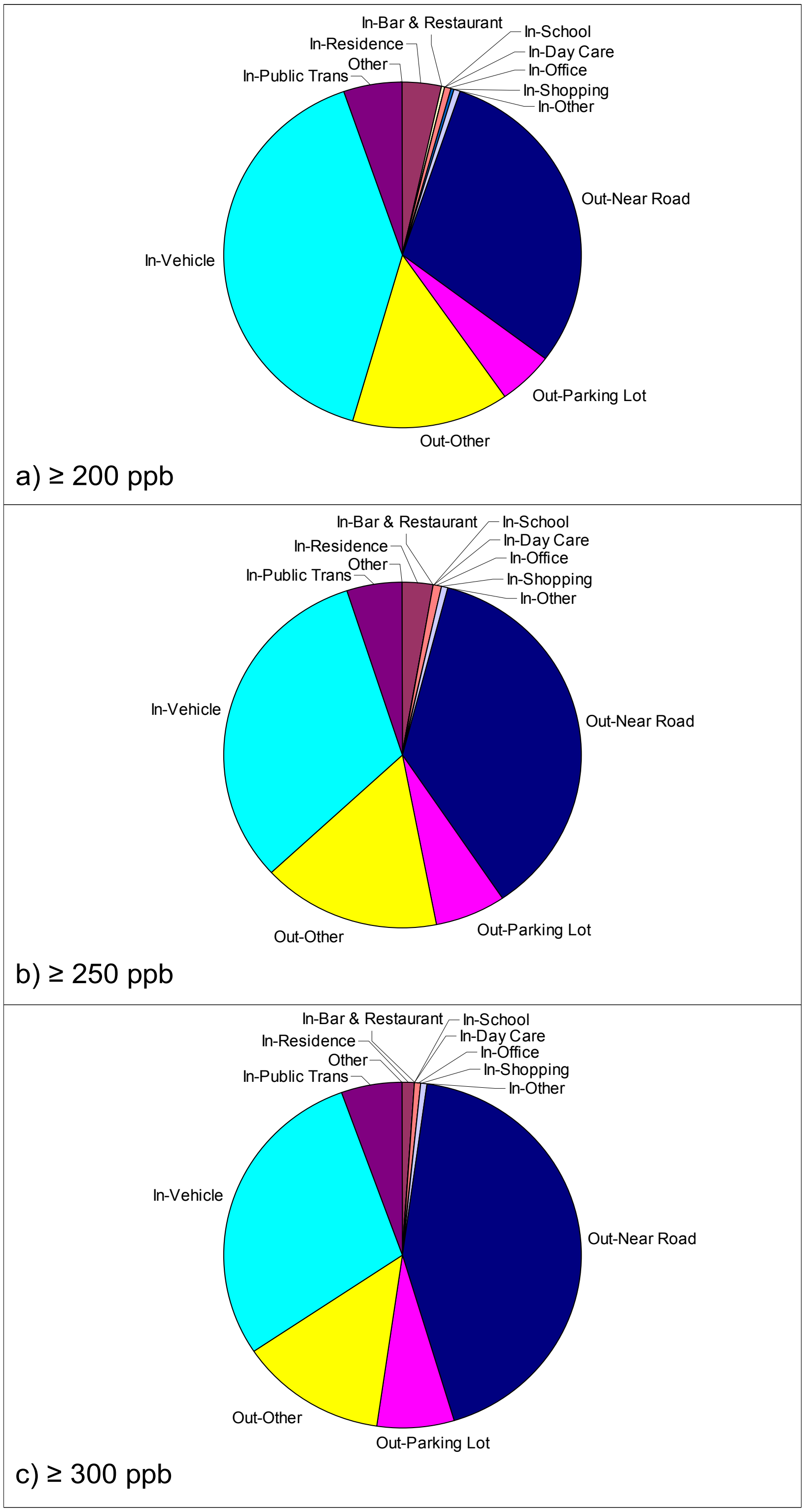

Figure B-22. Fraction of time all simulated persons in Philadelphia County spend in the twelve microenvironments associated with the potential NO_2 health effect benchmark levels, a) ≥ 200 ppb, b) ≥ 250 ppb, and c) ≥ 300 ppb, year 2002 simulation without indoor sources.

B-3.6.5.3 Number of Repeated Exposures Above Selected Levels

In the analysis of persons exposed, the results show the number or percent of those with at least one exposure at or above the selected potential health effect benchmark level. Given that the benchmark is for a small averaging time (i.e., one-hour) it may be possible that individuals are exposed to concentrations at or above the potential health effect benchmark levels more than once in a given year. Since APEX simulates the longitudinal diary profile for each individual, the number of times above a selected level is retained for each person. Figure B-23 presents such an analysis for the year 2003, the year containing the greatest number of exposure concentrations at or above the selected benchmarks. Estimated exposures include both those resulting from exposures to NO_2 of ambient origin and those resulting from indoor source NO_2 contributions. While a large fraction of individuals experience at least one exposure to 200 ppb or greater over a 1-hour time period in a year (about 32 percent), only around 14 percent were estimated to contain at least 2 exposures. Multiple exposures at or above the selected benchmarks greater than or equal to 3 or more times per year are even less frequent, with around 5 percent or less of asthmatics exposed to 1-hour concentrations greater than or equal to 200 ppb 3 or more times in a year.

Exposure estimates for year 2002 are presented to provide an additional perspective, including a lower bound of repeated exposures for this population subgroup and for exposure estimates generated with and without modeled indoor sources (Figure B-24). Most asthmatics exposed to a 200 ppb concentration are exposed once per year and only around 11 percent would experience 2 or more exposures at or above 200 ppb when including indoor source contributions. The percent of asthmatics experiencing multiple exposures a and abovet 250 and 300 ppb is much lower, typically less than 1 percent of all asthmatics are exposed at the higher potential benchmark levels. Also provided in Figure B-24 are the percent of asthmatics exposed to selected levels in the absence of indoor sources. Again, without the indoor source contribution, there are reduced occurrences of multiple exposures at all of the potential health effect benchmark levels compared with when indoor sources were modeled.

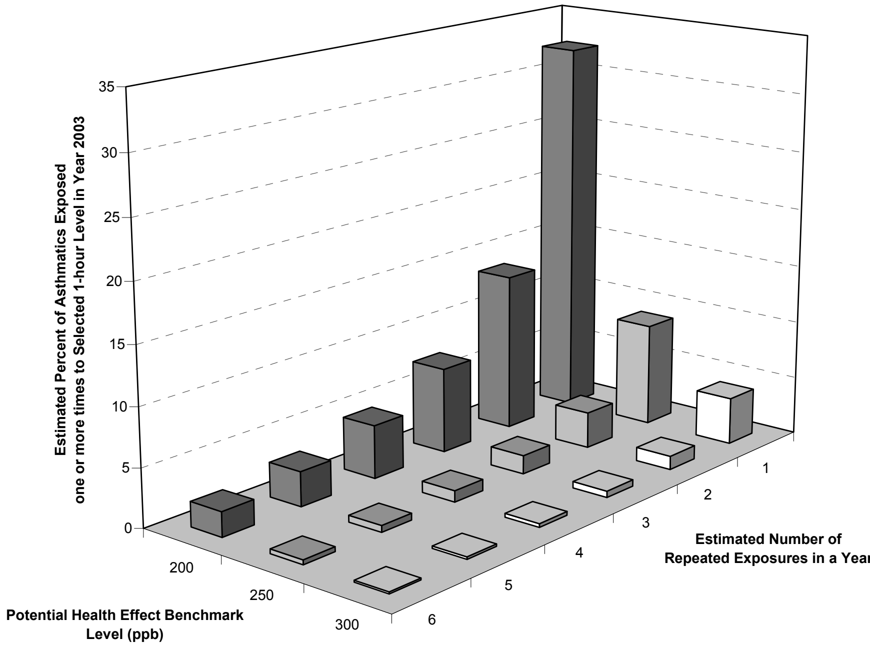

Figure B-23. Estimated percent of all asthmatics in Philadelphia County with repeated NO_2 exposures above potential health effect benchmark levels, using 2003 modeled air quality (as is), with modeled indoor sources.

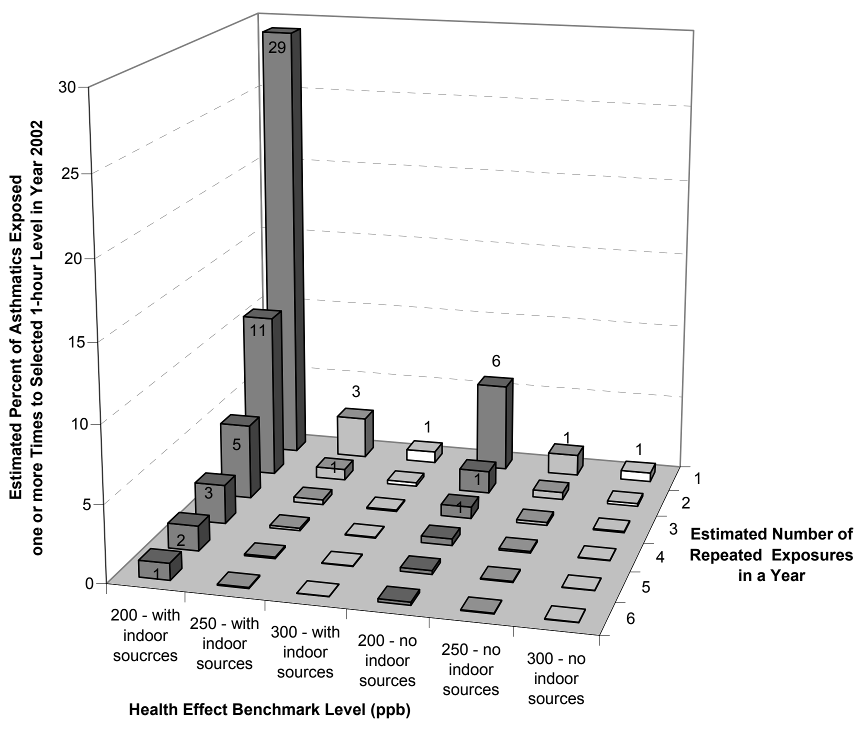

Figure B-24. Estimated percent of all asthmatics in Philadelphia County with repeated NO_2 exposures above potential health effect benchmark levels, using modeled 2002 air quality (as is), with and without indoor sources.

B-3.6.6 One-Hour Exposures Associated with Just Meeting the Current Standard

To simulate just meeting the current NO_2 standard, the potential health effect benchmark level was adjusted in the exposure model, rather than adjusting all of the hourly concentrations for each receptor and year simulated. Similar estimates of short-term exposures (i.e., 1-hour) were generated for the total population and population subgroups of interest (i.e., asthmatics and asthmatic children).

B-3.6.6.1 Number of Estimated Exposures above Selected Levels

In considering exposures estimated to occur associated with air quality simulated to just meet the current annual average NO_2 standard, the number of persons experiencing concentrations at or above the potential health effect benchmarks increased. To allow for reasonable comparison, the number of persons affected considering each scenario is expressed as the percent of the subpopulation of interest. Figure B-25 illustrates the percent of asthmatics estimated to experience at least one exposure at or above the selected potential health effect benchmark concentrations, with just meeting the current standard and including indoor source contributions. While it was estimated that about 30% percent of asthmatics would be exposed to 200 ppb (1-hour average) at least once in a year for as is air quality, it was estimated that around 80 percent of asthmatics would experience at least one concentration above the lowest potential health effect benchmark level in a year representing just meeting the current standard. Again, estimates for asthmatic children exhibited a similar trend, with between 75 to 80 percent exposed to a concentration at or above the lowest potential health effect benchmark level at least once per year for a year just meeting the current standard (data not shown). The percent of all asthmatics experiencing the higher benchmark levels is reduced to between 31 and 45 percent for the 250 ppb, 1-hour benchmark, and between 10 and 24 percent for the 300 ppb, 1-hour benchmark level associated with air quality representing just meeting the current annual average standard.

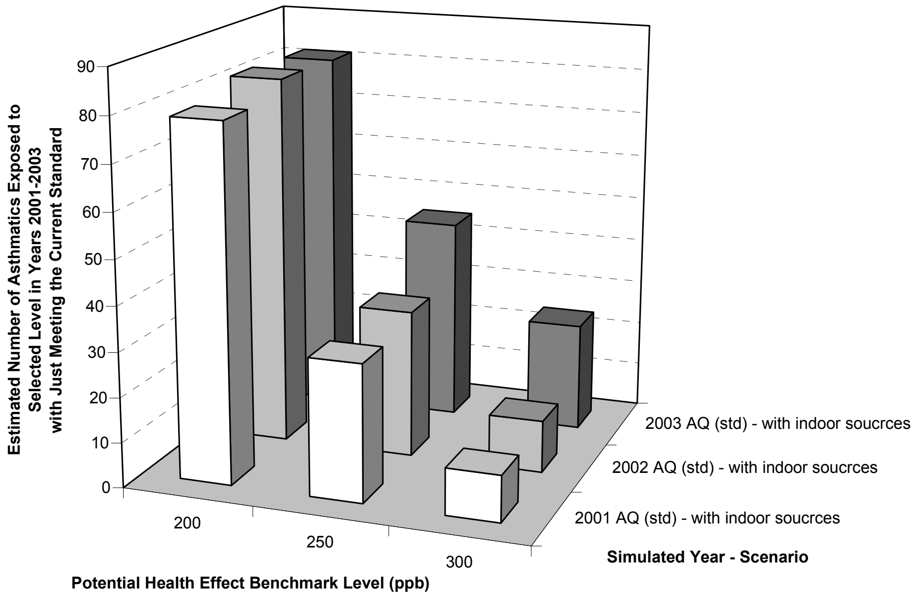

Figure B-25. Estimated percent of all asthmatics in Philadelphia with at least one exposure at or above the potential health effect benchmark level, using modeled 2001-2003 air quality just meeting the current standard, with modeled indoor sources.

In evaluating the influence of indoor source contribution for the scenario just meeting the current standard, the numbers of individuals exposed at selected levels are reduced without indoor sources, ranging from about 26 percent lower for the 200 ppb level to around 11 percent for the 300 ppb level when compared with exposure estimates that accounted for indoor sources (Figure B-26).

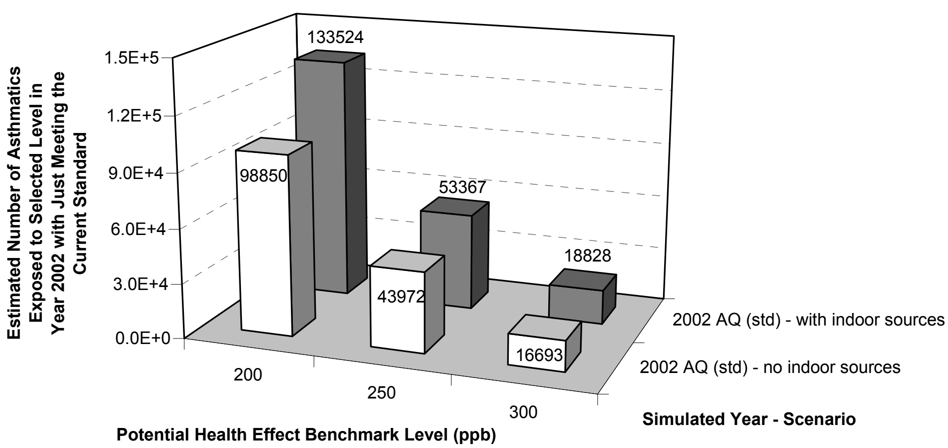

Figure B-26. Estimated number of all asthmatics in Philadelphia with at least one exposure at or above the potential health effect benchmark level, using modeled 2002 air quality just meeting the current standard, with and without modeled indoor sources.

B-3.6.6.2 Number of Repeated Exposures Above Selected Levels

For air quality simulated to just meet the current standard, repeated exposures at the selected potential health effect benchmarks are more frequent than that estimated for the modeled as is air quality. Figure B-27 illustrates this using the simulated asthmatic population for year 2002 data as an example. Many asthmatics that are exposed at or above the selected levels are exposed more than one time. Repeated exposures above the potential health effect benchmark levels are reduced however, when not including the contribution from indoor sources. The percent of asthmatics exposed drops with increasing benchmark level, with progressively fewer persons experiencing multiple exposures for each benchmark level.

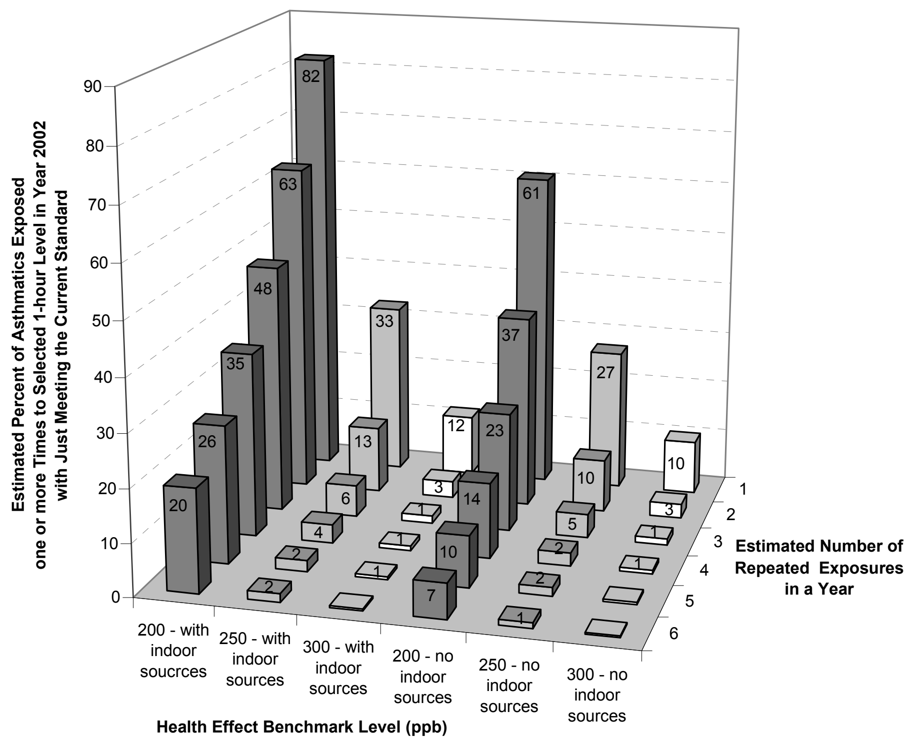

Figure B-27. Estimated percent of asthmatics in Philadelphia County with repeated exposures above health effect benchmark levels, using modeled 2002 air quality just meeting the current standard, with and without modeled indoor sources.

B-3.6.7 Additional Exposure Results

This section provides supplemental exposure and risk characterization results for two subpopulations, all asthmatics and asthmatic children. The data are presented in series of summary tables and figures across each of the scenarios investigated (i.e. with modeled air quality as is and simulating just meeting the current standard), with and without modeled indoor sources (i.e., gas stoves), for each of the potential health effect benchmark levels (i.e., 200, 250, 300 ppb 1-hour), and across three years of modeled air quality (i.e., 2001 to 2003). Repeated exposures are presented only for the lowest potential health effect benchmark level (i.e., 200 ppb 1-hour).

B-3.6.7.1 All Asthmatics

Table B-31. Estimated number of asthmatics in Philadelphia County exposed at or above potential health effect benchmark levels (1 to 6 times per year), using modeled air quality (as is) and with just meeting the current standard (std), and with and without indoor sources.

Year (AQ)	Indoor Source	Level (ppb)	Persons with Number of Repeated Exposures					
			1	2	3	4	5	6
2001 (as is)	Yes	200	49796	19544	8959	4516	2666	1732
		250	4867	1414	658	381	265	157
		300	1388	404	157	108	59	39
	No	200	10544	2577	1230	795	520	422
		250	2584	765	413	295	186	118
		300	1013	344	177	98	39	29
2001 (std)	Yes	200	128147	96119	70079	50253	35965	26167
		250	49632	18322	8523	4808	3095	2152
		300	16805	4480	1828	1219	866	638
	No	200	90211	51600	31720	19805	12899	8938
		250	40466	14362	6155	3225	2141	1414
		300	15100	3590	1595	1003	755	569
2002 (as is)	Yes	200	47652	17720	8056	4170	2662	1765
		250	4430	1173	530	274	166	127
		300	1240	393	147	88	69	49
	No	200	9505	2411	1240	706	401	323
		250	2276	778	332	185	117	88
		300	975	304	137	59	49	49
2002 (std)	Yes	200	133524	102861	77512	57152	42473	31800
		250	53367	20737	9855	5784	3489	2623
		300	18828	5220	2324	1447	925	648
	No	200	98849	60056	36913	23238	15850	10875
		250	43972	16367	7370	4066	2680	1734
		300	16693	4389	1950	1131	766	510
2003 (as is)	Yes	200	52639	22084	11950	7441	4863	3457
		250	14407	5040	2599	1577	935	650
		300	6568	1892	887	512	335	245
	No	200	26120	10007	5857	3783	2609	1842
		250	11142	3927	2040	1261	777	550
		300	5605	1627	778	462	285	206
2003 (std)	Yes	200	132640	102034	76909	58857	44719	34990
		250	73387	38505	22953	15416	11101	8499
		300	39283	16213	9280	6175	4374	3259
	No	200	109726	73489	51133	36551	27509	21181
		250	65437	33096	18948	12710	8964	6862
		300	35948	14502	8474	5654	4098	2935

Table B-32. Estimated percent of asthmatics in Philadelphia County exposed at or above potential health effect benchmark levels (1 to 6 times per year), using modeled air quality (as is) and with just meeting the current standard (std), and with and without indoor sources.

Year (AQ)	Indoor Source	Level (ppb)	Percent (%) of Persons With Repeated Exposures					
			1	2	3	4	5	6
2001 (as is)	Yes	200	31	12	6	3	2	1
		250	3	1	0	0	0	0
		300	1	0	0	0	0	0
	No	200	6	2	1	0	0	0
		250	2	0	0	0	0	0
		300	1	0	0	0	0	0
2001 (std)	Yes	200	79	59	43	31	22	16
		250	31	11	5	3	2	1
		300	10	3	1	1	1	0
	No	200	55	32	20	12	8	5
		250	25	9	4	2	1	1
		300	9	2	1	1	0	0
2002 (as is)	Yes	200	29	11	5	3	2	1
		250	3	1	0	0	0	0
		300	1	0	0	0	0	0
	No	200	6	1	1	0	0	0
		250	1	0	0	0	0	0
		300	1	0	0	0	0	0
2002 (std)	Yes	200	82	63	48	35	26	20
		250	33	13	6	4	2	2
		300	12	3	1	1	1	0
	No	200	61	37	23	14	10	7
		250	27	10	5	2	2	1
		300	10	3	1	1	0	0
2003 (as is)	Yes	200	32	14	7	5	3	2
		250	9	3	2	1	1	0
		300	4	1	1	0	0	0
	No	200	16	6	4	2	2	1
		250	7	2	1	1	0	0
		300	3	1	0	0	0	0
2003 (std)	Yes	200	81	63	47	36	27	21
		250	45	24	14	9	7	5
		300	24	10	6	4	3	2
	No	200	67	45	31	22	17	13
		250	40	20	12	8	6	4
		300	22	9	5	3	3	2

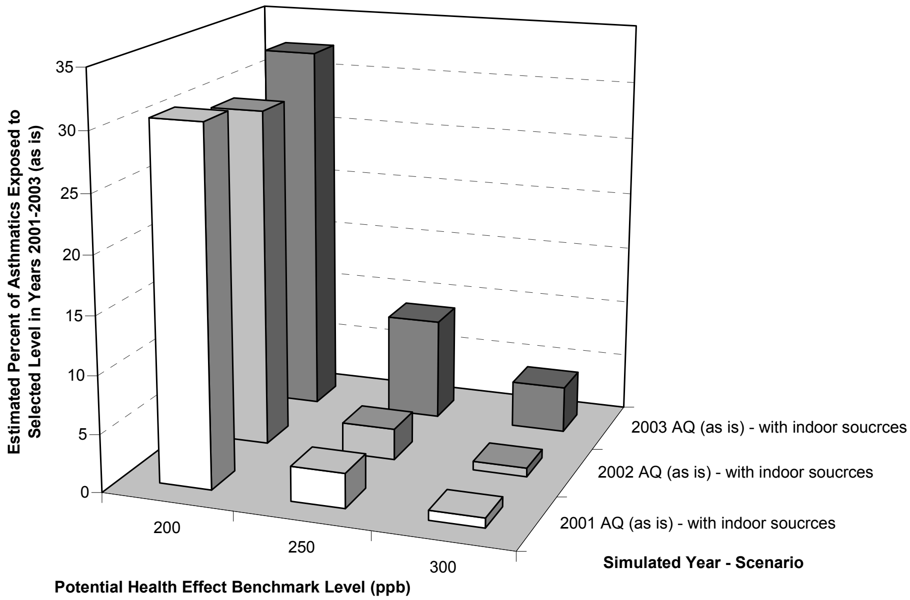

Figure B-28. Estimated percent of all asthmatics in Philadelphia County with at least one NO_2 exposure at or above potential health effect benchmark level, using 2001-2003 modeled air quality (as is), with modeled indoor sources.

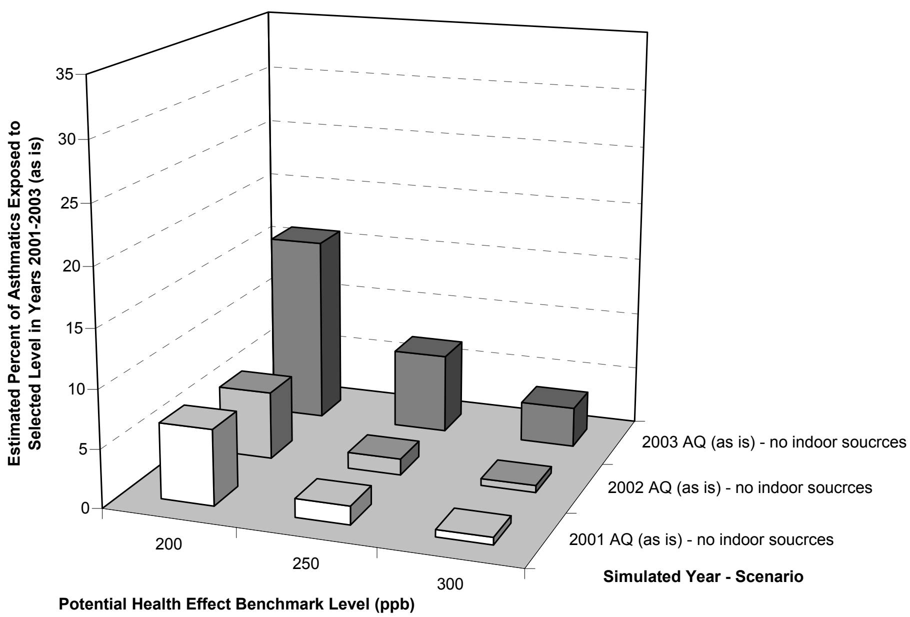

Figure B-29. Estimated percent of all asthmatics in Philadelphia County with at least one NO_2 exposure at or above potential health effect benchmark level, using 2001-2003 modeled air quality (as is), with no indoor sources.

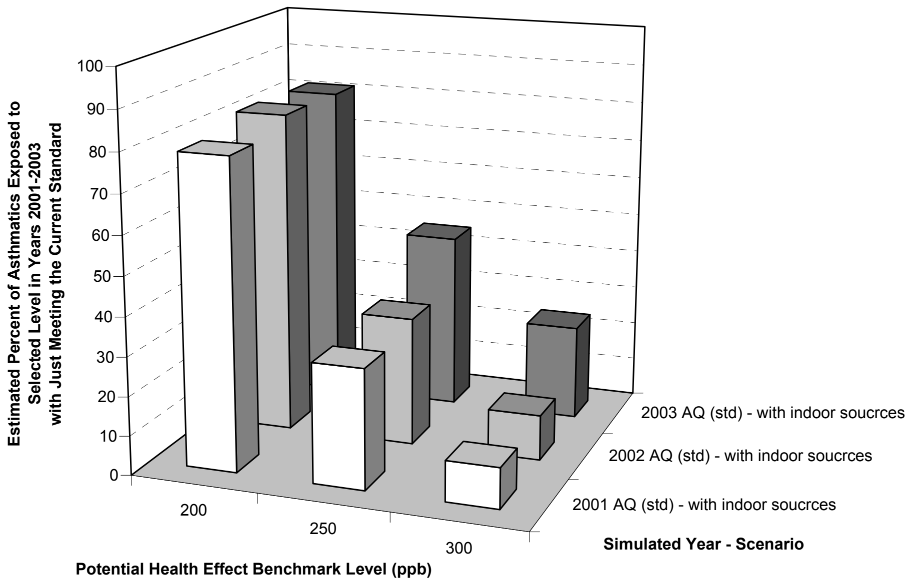

Figure B-30. Estimated percent of all asthmatics in Philadelphia County with at least one NO_2 exposure at or above potential health effect benchmark level, using 2001-2003 modeled air quality just meeting the current standard (std), with modeled indoor sources.

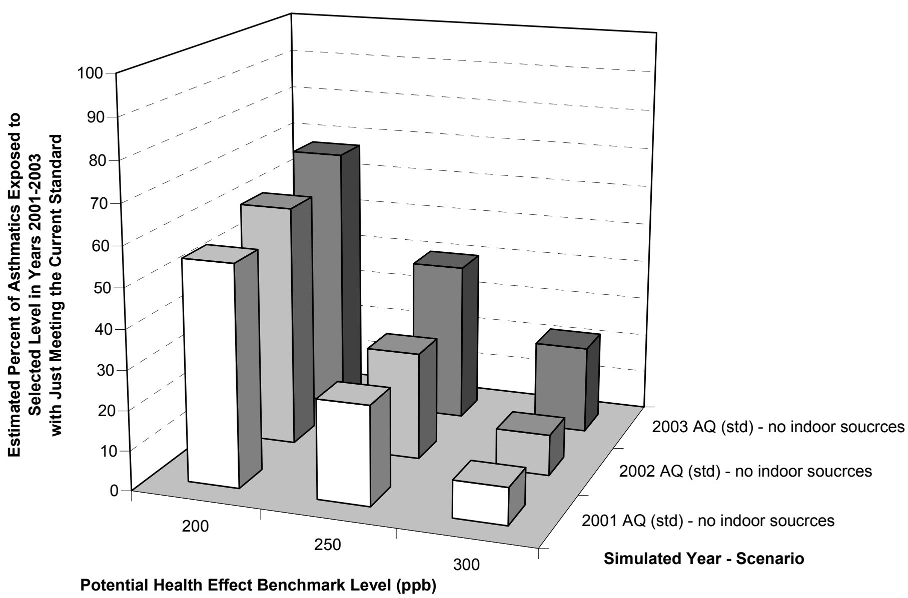

Figure B-31. Estimated percent of all asthmatics in Philadelphia County with at least one NO_2 exposure at or above potential health effect benchmark level, using 2001-2003 modeled air quality just meeting the current standard (std), with no indoor sources.

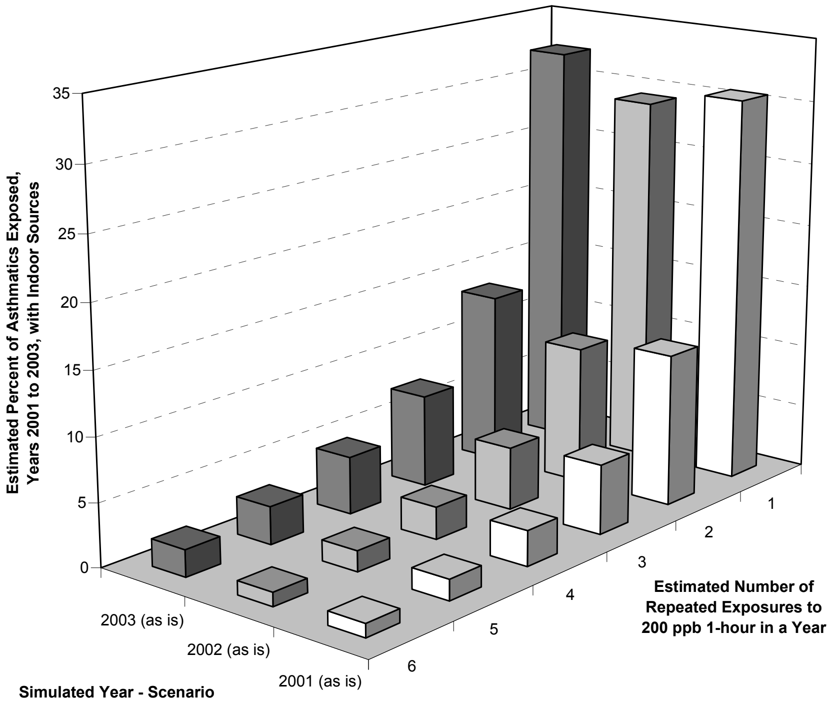

Figure B-32. Estimated percent of all asthmatics in Philadelphia County with repeated NO_2 exposures at or above 200 ppb 1-hr, using 2001-2003 modeled air quality (as is), with modeled indoor sources.

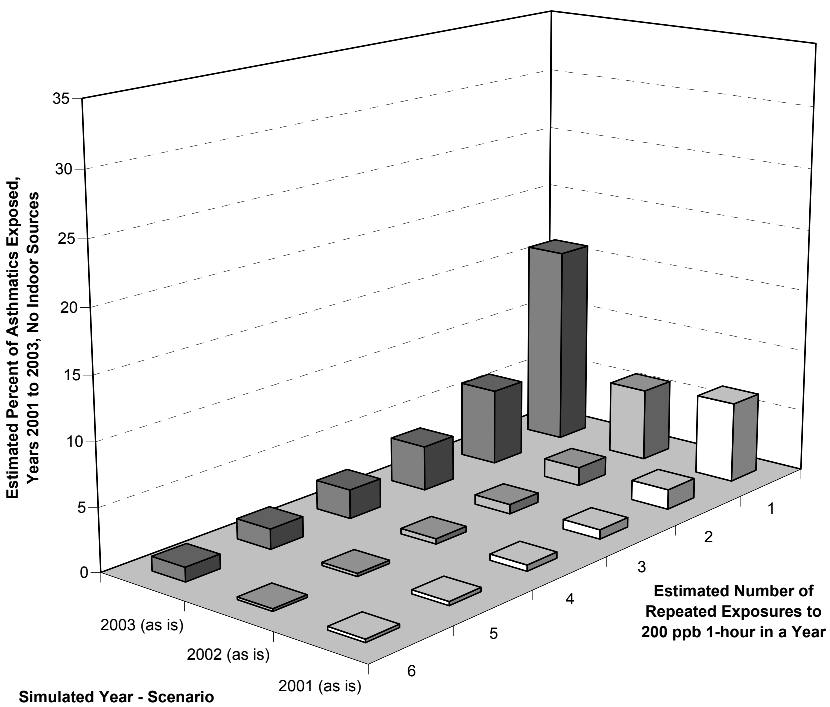

Figure B-33. Estimated percent of all asthmatics in Philadelphia County with repeated NO2 exposures at or above 200 ppb 1-hr, using 2001-2003 modeled air quality (as is), without indoor sources.

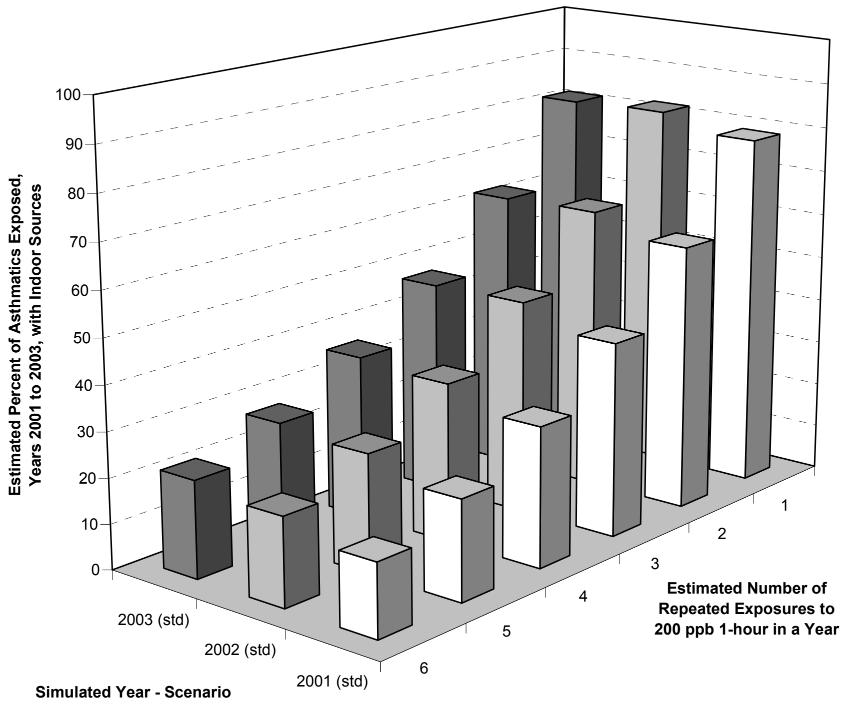

Figure B-34. Estimated percent of all asthmatics in Philadelphia County with repeated NO_2 exposures at or above 200 ppb 1-hour, using 2001-2003 modeled air quality just meeting the current standard (std), with modeled indoor sources.

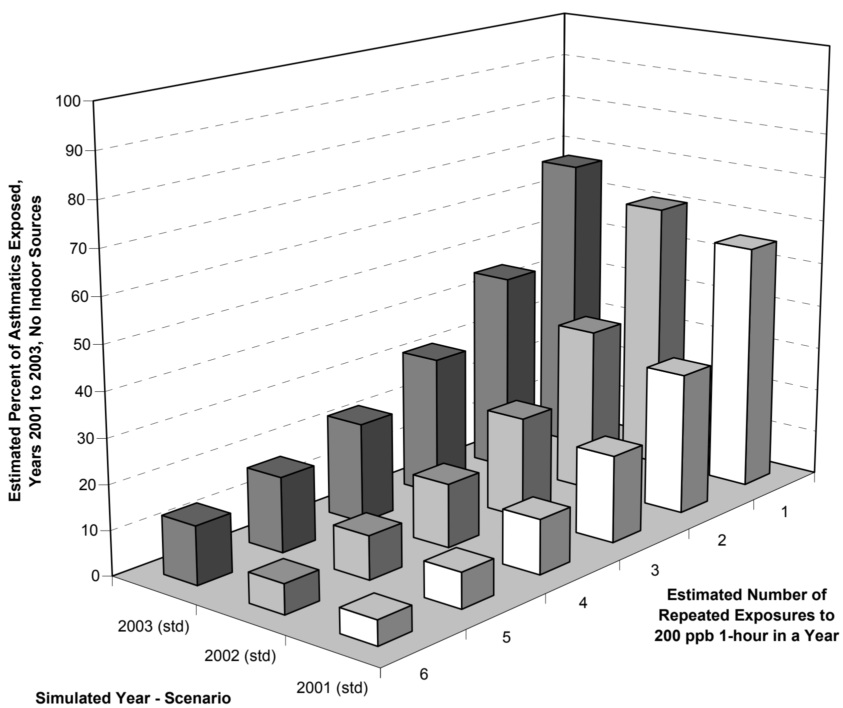

Figure B-35. Estimated percent of all asthmatics in Philadelphia County with repeated NO_2 exposures at or above 200 ppb 1-hour, using 2001-2003 modeled air quality just meeting the current standard (std), with no indoor sources.

B-3.6.7.2 Asthmatic Children

Table B-33. Estimated number of asthmatic children in Philadelphia County exposed at or above potential health effect benchmark levels (1 to 6 times per year), using modeled air quality (as is) and with just meeting the current standard (std), and with and without indoor sources.

Year (AQ)	Indoor Source	Level (ppb)	Persons With Number of Repeated Exposures					
			1	2	3	4	5	6
2001 (as is)	Yes	200	11351	3649	1418	709	424	267
		250	709	167	68	49	20	10
		300	128	49	10	10	0	0
	No	200	2329	401	147	98	58	58
		250	393	97	39	20	0	0
		300	97	29	10	10	0	0
2001 (std)	Yes	200	36656	26353	18272	12133	8271	5783
		250	13543	4530	1877	926	533	295
		300	3909	768	236	187	128	88
	No	200	27511	16067	9890	6094	3757	2430
		250	11282	3735	1413	500	333	197
		300	3440	638	187	128	109	79
2002 (as is)	Yes	200	10636	3338	1439	800	494	346
		250	692	139	49	30	0	0
		300	70	10	0	0	0	0
	No	200	1771	315	158	79	10	0
		250	158	49	20	10	0	0
		300	30	10	0	0	0	0
2002 (std)	Yes	200	38834	28678	20840	14308	10063	6996
		250	14855	4887	1978	1086	652	514
		300	4203	947	336	228	119	79
	No	200	30548	18685	11394	7063	4336	2782
		250	12487	3775	1288	738	493	365
		300	3736	670	276	158	99	39
2003 (as is)	Yes	200	12525	4693	2736	1712	1100	797
		250	3541	1240	678	423	247	178
		300	1545	423	237	138	89	39
	No	200	6724	2526	1515	984	708	492
		250	2784	1032	531	335	188	128
		300	1368	355	208	119	69	39
2003 (std)	Yes	200	37931	28305	20344	15230	11013	8483
		250	20044	9893	6016	4088	2888	2253
		300	10562	4100	2381	1643	1211	906
	No	200	32066	21662	14938	10326	7647	6018
		250	18770	8897	4974	3371	2388	1859
		300	9547	3704	2223	1496	1072	817

Table B-34. Estimated percent of asthmatic children in Philadelphia County exposed at or above potential health effect benchmark levels (1 to 6 times per year), using modeled air quality (as is) and with just meeting the current standard (std), and with and without indoor sources.

Year (AQ)	Indoor Source	Level (ppb)	Percent (%) of Persons With Repeated Exposures					
			1	2	3	4	5	6
2001 (as is)	Yes	200	23	8	3	1	1	1
		250	1	0	0	0	0	0
		300	0	0	0	0	0	0
	No	200	5	1	0	0	0	0
		250	1	0	0	0	0	0
		300	0	0	0	0	0	0
2001 (std)	Yes	200	75	54	38	25	17	12
		250	28	9	4	2	1	1
		300	8	2	0	0	0	0
	No	200	57	33	20	13	8	5
		250	23	8	3	1	1	0
		300	7	1	0	0	0	0
2002 (as is)	Yes	200	22	7	3	2	1	1
		250	1	0	0	0	0	0
		300	0	0	0	0	0	0
	No	200	4	1	0	0	0	0
		250	0	0	0	0	0	0
		300	0	0	0	0	0	0
2002 (std)	Yes	200	81	60	43	30	21	15
		250	31	10	4	2	1	1
		300	9	2	1	0	0	0
	No	200	64	39	24	15	9	6
		250	26	8	3	2	1	1
		300	8	1	1	0	0	0
2003 (as is)	Yes	200	26	10	6	4	2	2
		250	7	3	1	1	1	0
		300	3	1	0	0	0	0
	No	200	14	5	3	2	1	1
		250	6	2	1	1	0	0
		300	3	1	0	0	0	0
2003 (std)	Yes	200	79	59	43	32	23	18
		250	42	21	13	9	6	5
		300	22	9	5	3	3	2
	No	200	67	45	31	22	16	13
		250	39	19	10	7	5	4
		300	20	8	5	3	2	2

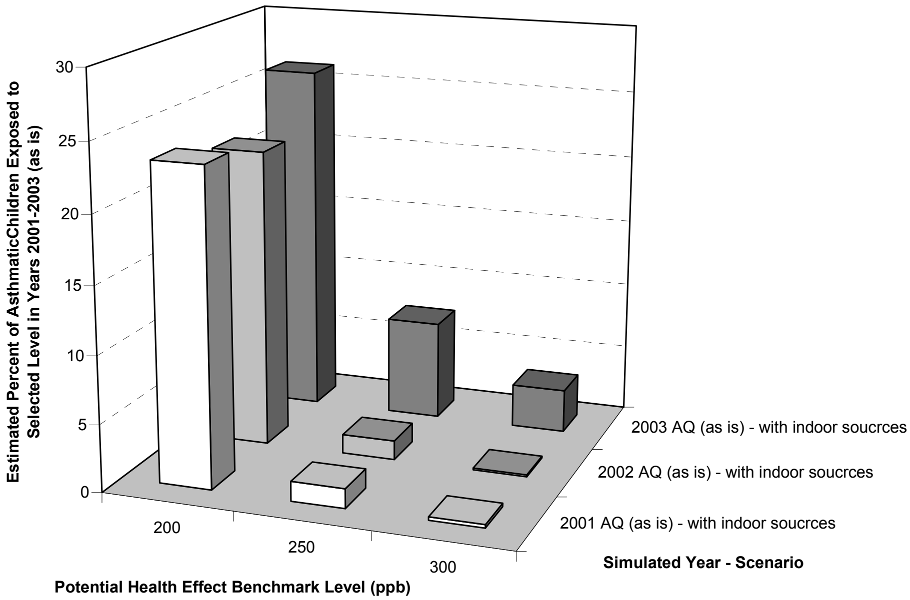

Figure B-36. Estimated percent of asthmatic children in Philadelphia County with at least one NO_2 exposure at or above potential health effect benchmark level, using 2001-2003 modeled air quality (as is), with modeled indoor sources.

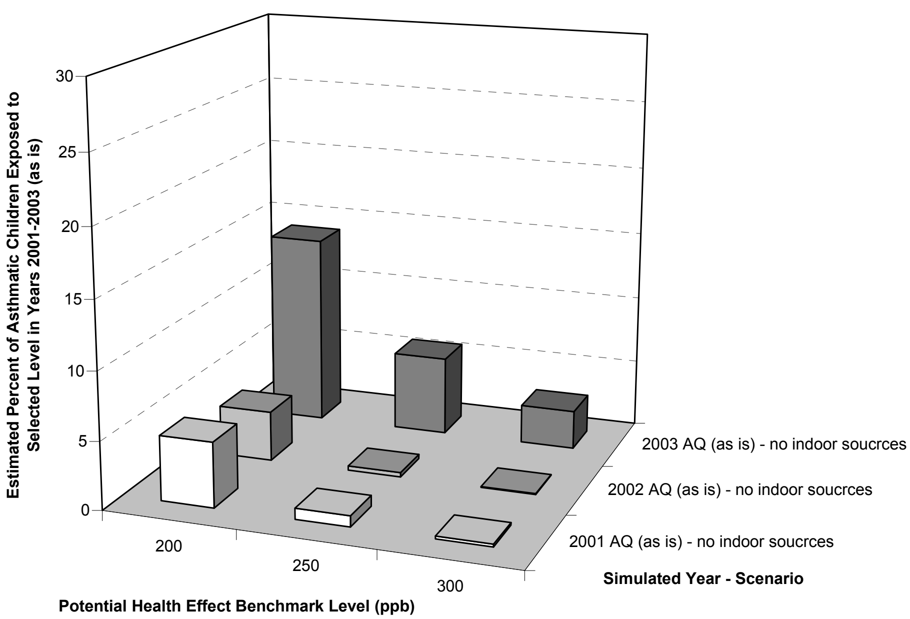

Figure B-37. Estimated percent of asthmatic children in Philadelphia County with at least one NO_2 exposure at or above potential health effect benchmark level, using 2001-2003 modeled air quality (as is), with no indoor sources.

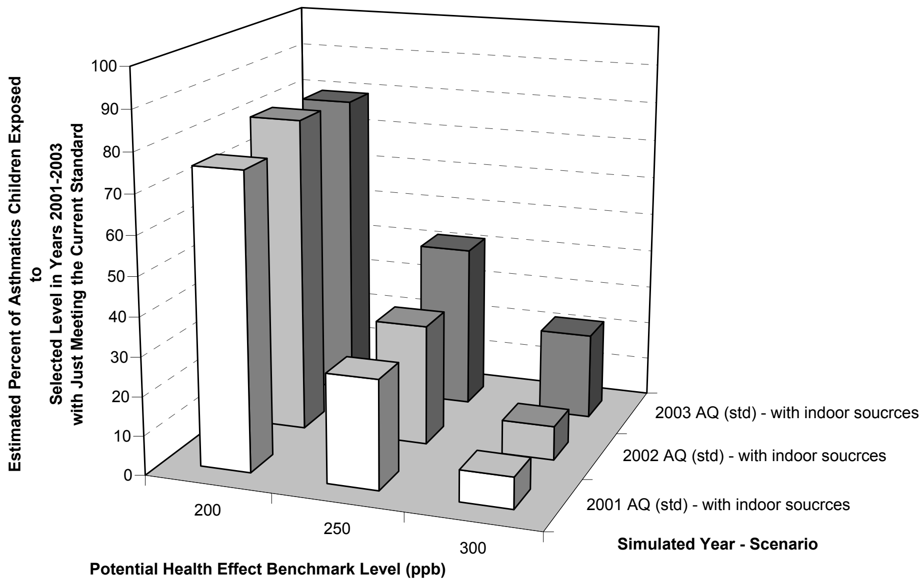

Figure B-38. Estimated percent of asthmatic children in Philadelphia County with at least one NO_2 exposure at or above potential health effect benchmark level, using 2001-2003 modeled air quality just meeting the current standard (std), with modeled indoor sources.

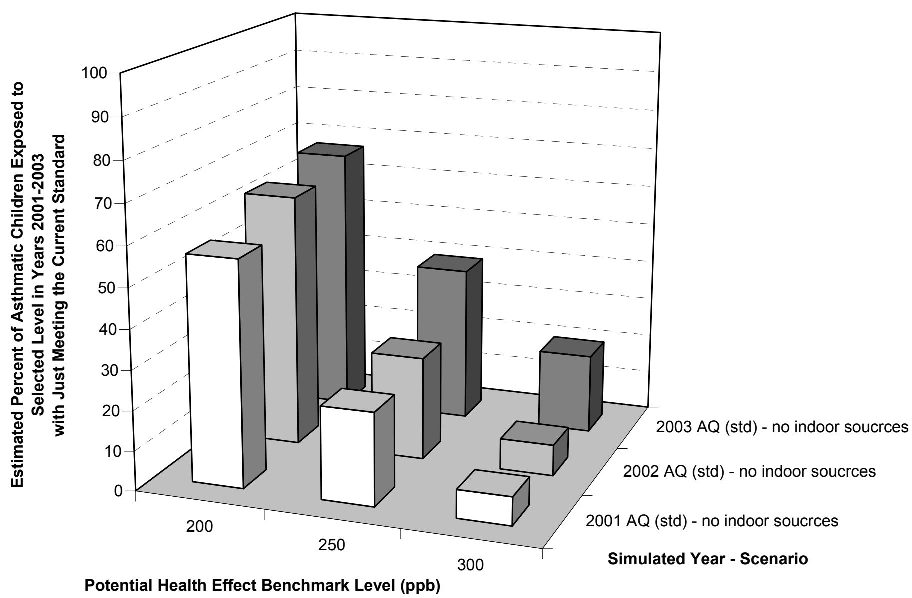

Figure B-39. Estimated percent of asthmatic children in Philadelphia County with at least one NO_2 exposure at or above potential health effect benchmark level, using 2001-2003 modeled air quality just meeting the current standard (std), with no indoor sources.

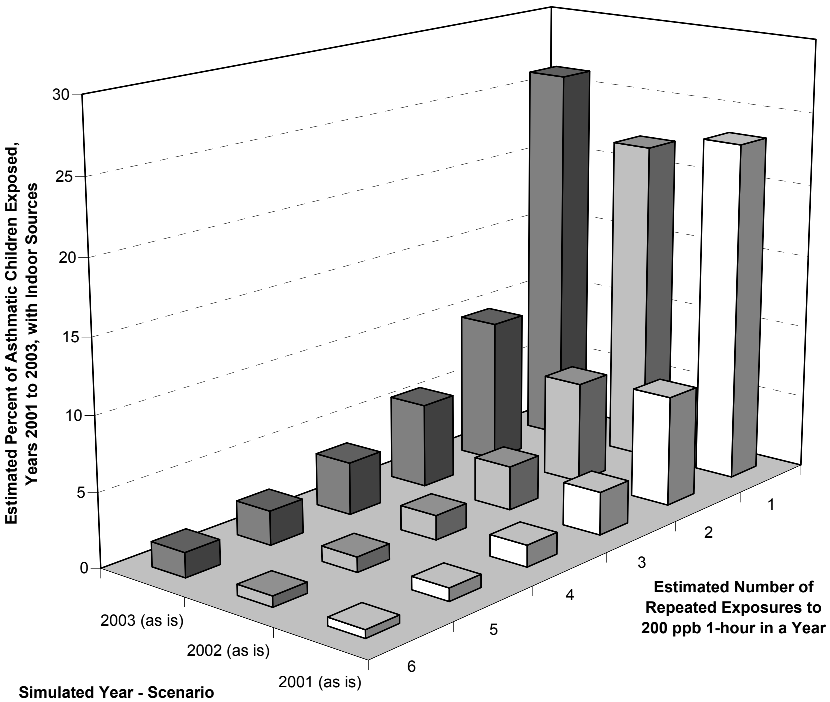

Figure B-40. Estimated percent of asthmatic children in Philadelphia County with repeated NO_2 exposures at or above 200 ppb 1-hr, using 2001-2003 modeled air quality (as is), with modeled indoor sources.

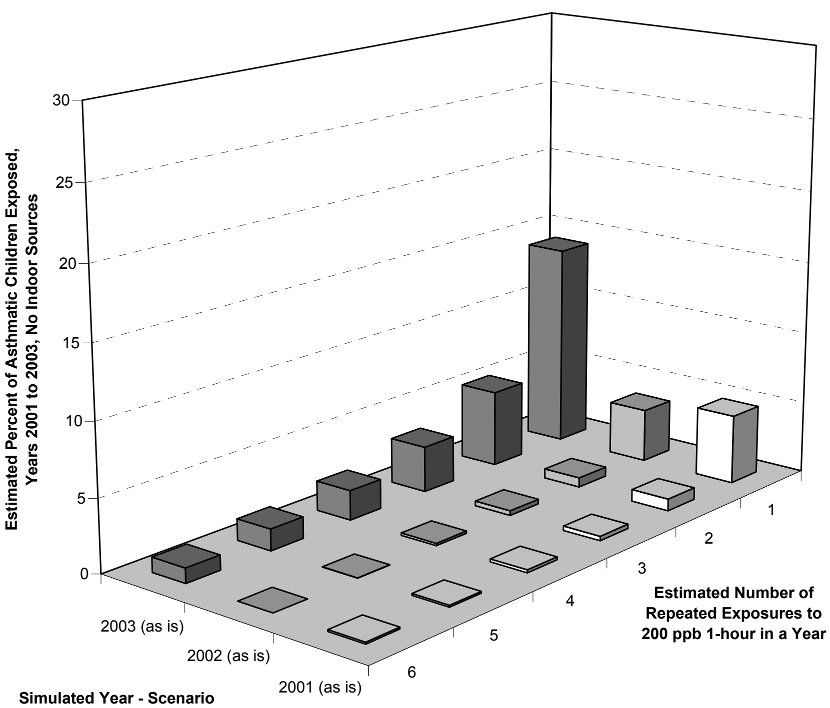

Figure B-41. Estimated percent of asthmatic children in Philadelphia County with repeated NO_2 exposures at or above 200 ppb 1-hr, using 2001-2003 modeled air quality (as is), with no indoor sources.

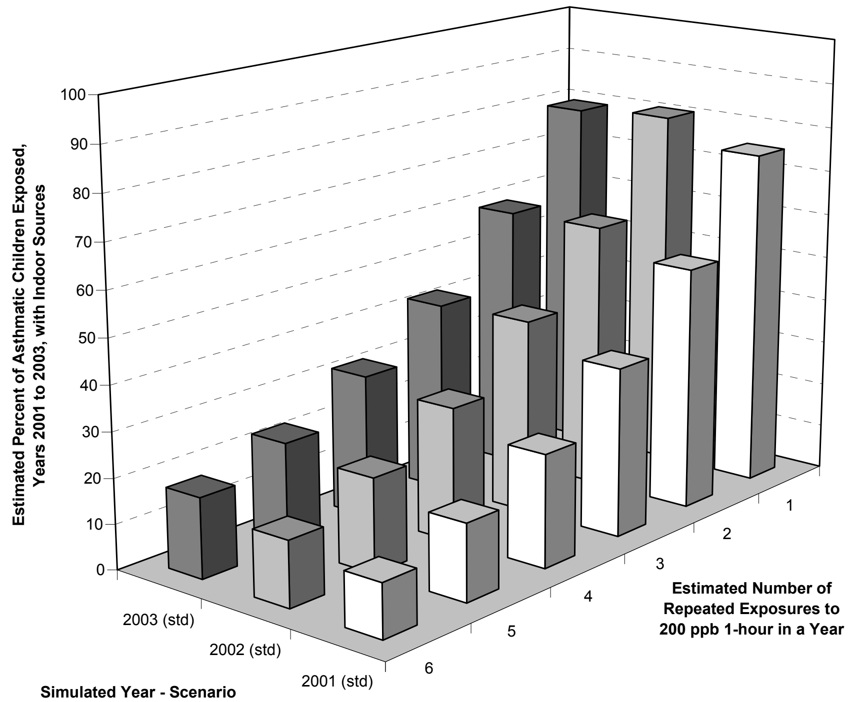

Figure B-42. Estimated percent of asthmatic children in Philadelphia County with repeated NO_2 exposures at or above 200 ppb 1-hr, using 2001-2003 modeled air quality meeting the current standard (std), with modeled indoor sources.

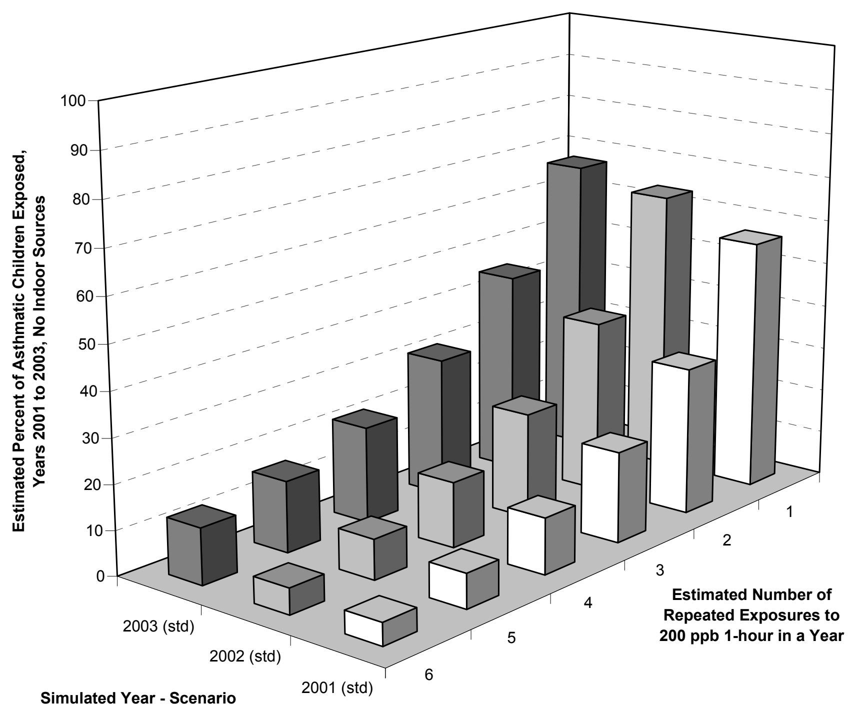

Figure B-43. Estimated percent of asthmatic children in Philadelphia County with repeated NO_2 exposures at or above 200 ppb 1-hr, using 2001-2003 modeled air quality meeting the current standard (std), with no indoor sources.

B-4 Atlanta Exposure Assessment Case-Study

This section provides supplemental discussion on methodology and additional detailed input data used in the Atlanta inhalation exposure assessment for NO_2 conducted in support of the current review of the NO_2 primary NAAQS. The general exposure modeling approach has been broadly defined in Appendix section B-2.

In defining the years modeled, 3-years (2001-2003) were selected to allow for reasonable representation of variability in meteorology. Table B-35 summarizes the temperature and precipitation in Atlanta over the last 30 years, with years 2001-2003 showing a range of values across each variable considered.

Table B-35. 30 year annual average temperature and precipitation summary for Atlanta, GA.

Year	Annual Temperature (◦ F)	Year	Annual Precipitation (inches)
1990	65	1989	63.3
2007	64.4	1992	60.1
1994	64.2	1994	60.0
1991	63.7	1990	57.6
1986	63.7	2005	56.4
2006	63.4	1982	56.2
1993	63.4	1991	55.9
1998	63.4	1984	55.4
1980	63.2	1979	54.7
1995	63.1	2004	53.6
1999	63.1	2003	52.9
2002	62.8	1995	52.8
1987	62.8	1997	51.7
1989	62.7	1983	51.6
2004	62.7	1985	49.8
1996	62.7	2006	48.5
2001	62.5	1993	48.1
2005	62.3	2002	47.8
1985	62.3	1980	46.9
1988	62.3	1987	46.2
2000	62.1	1998	46.2
1992	61.9	1988	45.9
1982	61.9	1996	44.6
1984	61.9	1981	41.9
2003	61.7	1978	41.4
1981	61.7	1986	40.5
1979	61.6	1999	38.9
1997	61.1	2001	38.4
1978	60.9	2000	35.6
1983	60.1	2007	31.9
average	**62.6**	**average**	**49.2**
Notes: Both temperature and precipitation are ordered by			

maximum to minimum values.

B-4.1 Supplemental AERMOD Modeling Inputs and Discussion

Air quality data input to the APEX exposure model were generated by air quality modeling using AERMOD. Principal emission sources included both mobile and stationary sources as well as emissions from Atlanta Hartsfield International Airport.[20] The supplemental data used for estimating the emission sources, in addition to other AERMOD parameters used for the Atlanta exposure analysis are described below.

B-4.1.1 Major Link On-Road Emission Estimates

Information on traffic data in the Atlanta area was obtained from the Atlanta Regional Commission (ARC) – the regional planning and intergovernmental coordination agency for the 10-county metropolitan area.- via their most recent, baseline travel demand modeling (TDM) simulation – that is, the most recent simulation calibrated to match observed traffic data. ARC provided the following files.

- Excel ™ files of loaded network TDM outputs for the 2005 ARC baseline year for all links in the 13 county network domain.
- Excel ™ data file of node end point locations.
- Arterial and freeway MOBILE6.2 emissions model input files for the 2008 summer ozone season, characterizing local inputs that differ from national defaults, and 2002 registration distribution.

Although considerable effort was expended to maintain consistency between the ARC approach to analysis of TDM data and that employed in this analysis, complete consistency was not possible due to the differing analysis objectives. The ARC creates countywide emission inventories. This study created spatially and temporally resolved emission strengths for dispersion modeling. Information about expected differences in traffic between the 2005 data year and 2001-2003 modeled years was not provided, nor was information about seasonal differences in MOBILE6.2 inputs. These are discussed further below.

B-4.1.1.1 Emission Sources and Locations

The TDM simulation's data file outputs include a description of the fixed information for the highway network links and traffic descriptors for four time periods: morning, afternoon, evening, and nighttime. Each period's data includes freeflow speed, total vehicle count, total heavy duty truck count, total single occupancy vehicle count, and TDM-calculated congested speeds for the period. The description of the network consists of a series of nodes joining individual model links (i.e., roadway segments) to which the traffic volumes are assigned, and the characteristics of those links, such as endpoint location, number of lanes, link distance, and TDM-defined link daily capacity.[21]

[20] Fugitive emissions from major point sources in the Atlanta area were not included as was done in the Philadelphia County case study, since the NEI shows all emissions to be accounted by stack totals.
[21] The TDM capacity specifications are not the same as those defined by the Highway Capacity Manual (HCM). Following previous analyses, the HCM definition of capacity was used in later calculations, as discussed below.

The full set of links in the 13 county regional network was filtered to include only those roadway links that are considered *major* as determined by TDM- based vehicle counts and within the four part of a fifth county (Clayton), which contains a small portion of the beltway. That is, all links with AADT values greater than 15,000 vehicles per day (one direction) in Cobb, DeKalb, Fulton, and Gwinnett were included, and those with greater than 15,000 AADT in Clayton County that lie north of 3,717,036 m N in the UTM Zone 16, WGS84 datum were also included. The treatment of non-major links is discussed below.

Link locations from the TDM were modified to represent the best known locations of the actual roadways, since there was not always a direct correlation between the two. The correction of link locations was done based on the locations of the nodes that define the end points of links with a GIS analysis, as follows.

A procedure was developed to relocate TDM nodes to more realistic locations. The nodes in the TDM represent the endpoints of links in the transportation planning network and are specified by node indices, cross-referenced to locations in the Georgia West Stateplane. The procedure moved the node locations to the true road locations and translated to dispersion model coordinates. The ESRI StreetMap™ Pro road network database, an enhanced version of the Tele Atlas North America, Inc database was used as the specification of the true road locations. The nodes were moved to coincide with the nearest major road of the corresponding roadway type using a built in function of ArcGIS. Once the nodes had been placed in the corrected locations, a line was drawn connecting each node pair to represent a link of the adjusted planning network.

B-4.1.1.2 Emission Source Strength

On-road mobile emission factors were derived from the MOBILE6.2 emissions. The simulations were executed to calculate average running NO_x emission factors in grams per mile for a specific functional class (Freeway, Arterial, Local, or Ramp) and speed. Iterative MOBILE6.2 simulations were conducted to create tables of average Atlanta region emission factors resolved by speed (2.5 to 65 mph), functional class, season, and year (2001, 2002, or 2003) for each of the eight combined MOBILE vehicle classes.[22] The resulting tables were then consolidated into speed, functional class, and seasonal values for combined light- and heavy-duty vehicles. To create seasonal-hourly resolved emissions, spring and fall values were taken as the average of corresponding summer and winter values. Figure B-44 shows an example of the calculated emission factors for Summer, 2001.

The resulting emission factors were then coupled with the TDM-based activity estimates to calculate emissions from each of the 4,899 major roadway links. However, many of the links were two sides of the same roadway segment. To speed model execution time, those links that could be combined into a single emission source were merged together. This was done only for the 734 links (367 pairs) where opposing links were paired in space and exhibited similar activity levels within 20% of each other.

[22] HDDV - Heavy-Duty Diesel Vehicle, HDGV - Heavy-Duty Gasoline Vehicle, LDDT - Light-Duty Diesel Truck, LDDV - Light-Duty Diesel Vehicle, LDGT12 - Light-Duty Gasoline Truck with gross vehicle weight rating ≤ 6,000 lbs and a loaded vehicle weight of ≤ 5,750 lbs, LDGT 34 - Light-Duty Gasoline Truck with gross vehicle weight rating between 6,001 - 8,500 and a loaded vehicle weight of ≤ 5,750 lbs, LDGV - Light-Duty Gasoline Vehicle, MC - Motorcycles.

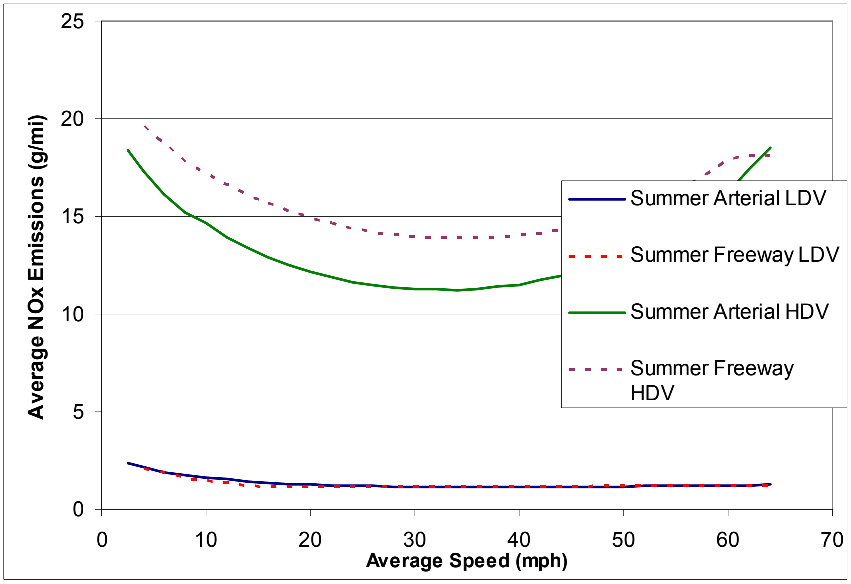

Figure B-44. Example of Light- and heavy-duty vehicle NOx emissions grams/mile (g/mi) for arterial and freeway functional classes, 2001.

B-4.1.2 Stationary Sources Emissions Preparation

Data for the parameterization of major point sources in Atlanta comes primarily from three sources: the 2002 National Emissions Inventory (NEI; US EPA, 2007b), Clean Air Markets Division (CAMD) Unit Level Emissions Database (US EPA, 2007c), and temporal emission profile information contained in the EMS-HAP (version 3.0) emissions model.[23] The NEI database contains stack locations, emissions release parameters (i.e., height, diameter, exit temperature, exit velocity), and annual emissions for NO_x-emitting facilities. The CAMD database, on the other hand, has information on hourly NO_x emission rates for units in the US, where the units are the boilers or equivalent, each of which can have multiple stacks. The alignment of facilities between the two databases is not exact, however. Some facilities listed in the NEI, are not included in the CAMD database. Of those facilities that do match, in many cases there is no clear pairing between the individual stacks assigned within the databases.

Major stationary sources for this analysis were selected from the NEI according to the following criteria:

(1) Stacks within facilities whose total NOx emissions are at least 100 tpy, and
(2) Stacks within facilities located either within the 4-county modeling domain or within 10 km of the modeling domain.

There are 7 NOx-emitting facilities in the NEI that meet these criteria. Stacks within the facilities that were listed separately in the NEI were combined for modeling purposes if they had identical stack physical parameters and were co-located within about 10 m. This process resulted in 28 combined stacks, listed in Table B-36. These 28 major-facility combined stacks

[23] http://www.epa.gov/ttn/chief/emch/projection/emshap30.html

account for 16% of the of NO_x point sources and 51% of the total NO_x point source emissions in this buffered four county Atlanta area.

The CAMD database was then queried for facilities that matched the facilities identified from the NEI database. Facility matching was done on the facility name, Office of Regulatory Information Systems (ORIS) identification code (when provided) and facility total emissions to ensure a best match between the facilities. However, because Georgia was not part of many of the market-based reduction programs that constitute the CAMD emissions database, only one of the 7 major facilities in the four-county focus area was found in the CAMD data base:the Georgia Power Company McDonough Steam-Generating Plant. The CAMD hourly emissions profiles for these two units are summed together and then, after appropriate scaling, used to represent 2 major-facility combined stacks.

For the remaining 26 major-facility combined stacks, hourly NO_x emissions profiles were created based on the hourly profile typical of that stack's SCC, the season, and the day of week. These SCC-based temporal profiles are year-independent, and were developed for the EPA's EMS-HAP model,[24] described in the EMS-HAP model Version 2 User's Guide, Section D-7.[25] As with CAMD hourly emissions, these SCC-based emission profiles are scaled such that the annual total emissions are equal to those of NEI 2002.

B-4.1.3 Airport Emissions Preparation

The Atlanta-Hartsfield International Airport emissions were assigned to a polygon that defined an area source for simulation. The perimeter dimensions of the Atlanta-Hartsfield International Airport were determined by GIS analysis of aerial photographs, and the polygon representing the airport is estimated to have an area of 3 km^2 (see Figure B-45). As with some point source emissions, the annual NO_x emission totals were extracted from the NEI and the temporal profiles from the EPA's EMS-HAP model. These seasonal, SCC-based emissions were scaled such that the annual total emissions are equal to those of NEI 2002: 5,761 tpy, with about 90% coming from commercial aircraft.

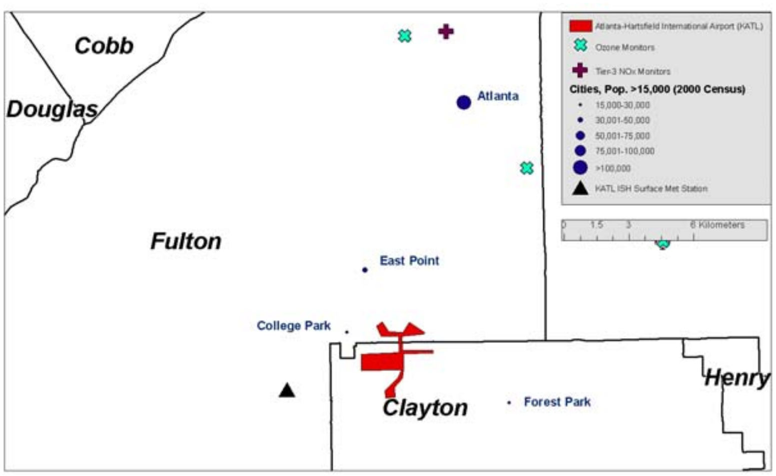

Figure B-45. Polygon representing the Atlanta-Hartsfield International Airport area source.

24 http://www.epa.gov/scram001/dispersion_related.htm#ems-hap
25 http://www.epa.gov/scram001/userg/other/emshapv2ug.pdf

Table B-36. The major-facility combined stacks within 10 km of the Atlanta modeling domain.

County	NEI Site ID	Facility Name	SCC[1]	Lat.	Lon.	Stack-Total NOx Emiss. (TPY)	Facility-Total Emiss. (TPY)	Stack Hght.[2] (m)	Exit Gas Temp.[2] (K)	Stack Diam.[2] (m)	Exit Gas Vel.[2] (m/s)
Clayton	NEI2GA300105	Delta Air Lines Inc TOC	20200102, 20200401	33.6425	-84.41556	1.23	101.6	8	527	0.4	18
Clayton	NEI2GA300105	Delta Air Lines Inc TOC	20400110	33.64417	-84.41805	0.04	101.6	9	977	6.9	10
Clayton	NEI2GA300105	Delta Air Lines Inc TOC	20400110	33.64361	-84.41805	67.51	101.6	14	444	11.3	2
Clayton	NEI2GA300105	Delta Air Lines Inc TOC	10200502, 10200602, 10200603	33.64194	-84.41278	32.82	101.6	18	590	0.8	18
Cobb	NEI12840	Georgia Power Company McDonough Steam-Electric Generating Plant	20100101, 20100201	33.82472	-84.475	11.91	4895.3	17	663	3.5	19
Cobb	NEI12840	Georgia Power Company McDonough Steam-Electric Generating Plant	10100212	33.82472	-84.475	4883.4	4895.3	255	405	7.9	20
Cobb	NEI2GA700022	Caraustar Mill Group Inc	30790001, 30790003	33.81778	-84.64889	1.81	364.1	13	367	0.8	10
Cobb	NEI2GA700022	Caraustar Mill Group Inc	10200202, 10200501, 10200601	33.81778	-84.64889	362.3	364.1	38	450	1.8	25
Fulton	NEIGA1210021	Owens Corning - Fairburn Plant	30501299	33.53861	-84.61694	2.14	602.1	16	352	0.7	13
Fulton	NEIGA1210021	Owens Corning - Fairburn Plant	30501204, 30501205, 30501299	33.53861	-84.61694	12	602.1	19	347	3	13
Fulton	NEIGA1210021	Owens Corning - Fairburn Plant	30501204, 30501205, 30501299	33.53861	-84.61694	13.29	602.1	19	347	3.2	8
Fulton	NEIGA1210021	Owens Corning - Fairburn Plant	30501204, 30501205, 30501299	33.53861	-84.61694	5.63	602.1	19	391	2.4	7
Fulton	NEIGA1210021	Owens Corning - Fairburn Plant	30501203	33.53861	-84.61694	327	602.1	21	316	1.2	8
Fulton	NEIGA1210021	Owens Corning - Fairburn Plant	30501203	33.53861	-84.61694	242	602.1	204	322	1.2	8
Fulton	NEIGA1210401	Lafarge Building Materials	30500606	33.8225	-84.47	943	1252.9	20	586	2	13

County	NEI Site ID	Facility Name	SCC[1]	Lat.	Lon.	Stack-Total NOx Emiss. (TPY)	Facility-Total Emiss. (TPY)	Stack Hght.[2] (m)	Exit Gas Temp.[2] (K)	Stack Diam.[2] (m)	Exit Gas Vel.[2] (m/s)
Fulton	NEIGA1210401	Lafarge Building Materials	30500606, 30500613	33.8225	-84.47	309.89	1252.9	24	336	0.9	12
Fulton	NEIGA1210020	Owens-Brockway Glass Container Inc - Atlanta GA plant	10200602	33.66972	-84.41861	10.06	710.5	18	497	1	8
Fulton	NEIGA1210020	Owens-Brockway Glass Container Inc - Atlanta GA plant	10200602	33.67083	-84.42083	208.49	710.5	27	589	1.2	24
Fulton	NEIGA1210020	Owens-Brockway Glass Container Inc - Atlanta GA plant	10200602	33.67083	-84.42083	402.49	710.5	27	589	1.4	19
Fulton	NEIGA1210020	Owens-Brockway Glass Container Inc - Atlanta GA plant	10200602	33.67083	-84.42083	89.42	710.5	27	644	0.9	25
Henry	NEIGA1315100	Transcontinental Gas Pipe Line - Station 120	20200202	33.56944	-84.255	7.88	2347.4	5	744	0.2	22
Henry	NEIGA1315100	Transcontinental Gas Pipe Line - Station 120	20200252	33.56944	-84.255	642.88	2347.4	8	625	0.6	38
Henry	NEIGA1315100	Transcontinental Gas Pipe Line - Station 120	20200252	33.56944	-84.255	184.17	2347.4	8	625	0.7	31
Henry	NEIGA1315100	Transcontinental Gas Pipe Line - Station 120	20200252	33.56944	-84.255	945.58	2347.4	8	637	0.7	28
Henry	NEIGA1315100	Transcontinental Gas Pipe Line - Station 120	20200202	33.56944	-84.255	36.6	2347.4	8	669	0.4	17
Henry	NEIGA1315100	Transcontinental Gas Pipe Line - Station 120	20200252	33.56944	-84.255	280.57	2347.4	8	670	0.6	41
Henry	NEIGA1315100	Transcontinental Gas Pipe Line - Station 120	20200252	33.56944	-84.255	218.68	2347.4	9	625	0.6	38
Henry	NEIGA1315100	Transcontinental Gas Pipe Line - Station 120	20200201	33.56944	-84.255	31.08	2347.4	10	743	1	42

[1] Combined stacks may have multiple Source Classification Codes (SCCs)
[2] The physical stack parameters are converted from English units into metric units. The stack height, exit gas temperature, and exit gas velocity are rounded to integers, and the stack diameter is rounded to one decimal place.

B-4.1.4 Receptor Locations

The distance relationship between the major roadway link and block centroids receptors can be estimated by looking at the distance between the road-centered and the block centroid receptors. Figure B-46 presents the histogram of the shortest distance between each centroid receptor and its nearest major-roadway-link-centered receptor. Approximately 1% of the blocks are within 50 m of a major roadway link and the geometric mean of the distribution is between 750 m and 800 m. Approximately 26% of the blocks are within 400 m of a major roadway link center. However, these values represent the distances of the block centroids to road centers instead of road edges, so that they overestimate the actual distances to the zone most influenced by roadway by an average of 10 m and a range of 4 m to 29 m (based on the distribution of the on-road area source widths).

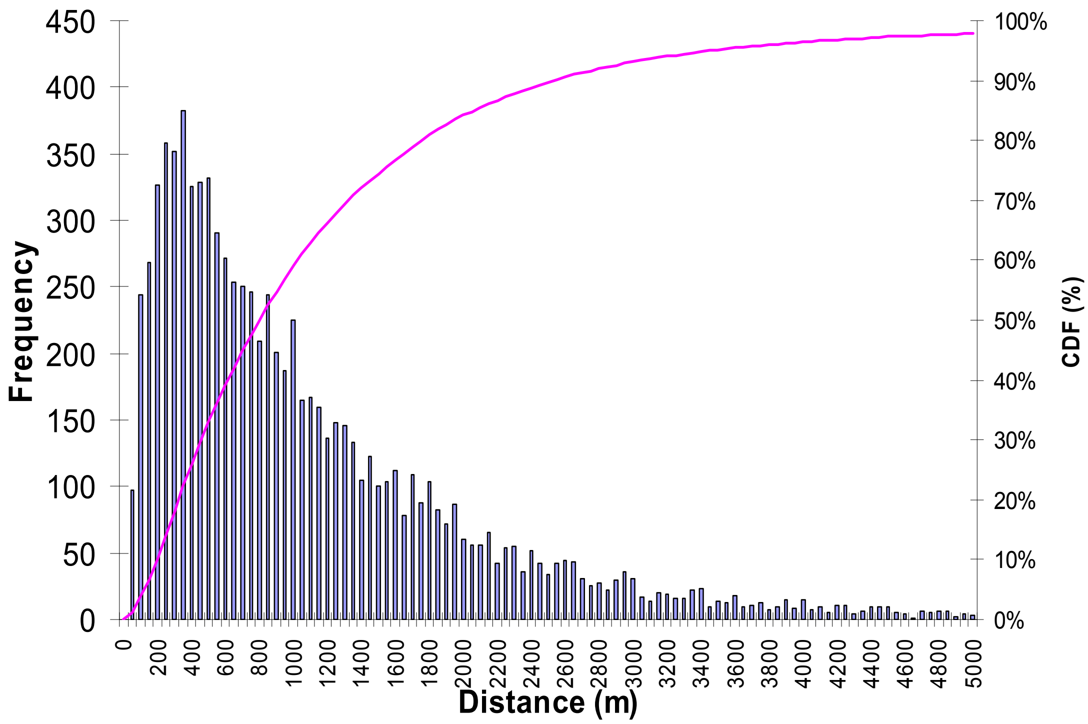

Figure B-46. Frequency distribution of distance between each Census block receptor and its nearest major-roadway-link-centered receptor.

B-4.1.5 Data used to generate dispersion model-to-monitor comparison figures in REA.

Table B-37. Data used to generate cumulative density functions plotted in Figure 8-6 of REA.

Monitor	Receptor(s)	Percentile Concentration (ppb)									
		100	**99**	**95**	**90**	**80**	**70**	**60**	**50**	**25**	**0**
130890002	AERMOD P2.5	108	63	49	41	30	21	14	9	2	0
	AERMOD P50	137	70	51	46	34	28	22	17	8	0
	AERMOD P97.5	169	85	68	59	50	44	38	33	19	0
	AMBIENT MONITOR	90	53	39	32	24	19	15	12	5	1
	AERMOD MONITOR	160	79	60	51	39	29	22	16	3	0
130893001	AERMOD P2.5	94	56	47	40	28	20	14	10	4	0
	AERMOD P50	106	60	49	45	34	26	19	14	6	0
	AERMOD P97.5	145	82	65	57	49	43	36	29	16	0
	AMBIENT MONITOR	66	49	38	32	24	19	16	13	7	1
	AERMOD MONITOR	103	58	48	45	32	24	17	12	5	0
131210048	AERMOD P2.5	111	61	48	43	33	26	21	17	9	0
	AERMOD P50	122	70	52	47	39	31	25	20	12	0
	AERMOD P97.5	157	96	71	61	53	47	40	33	21	0
	AMBIENT MONITOR	136	63	47	39	30	24	19	16	9	1
	AERMOD MONITOR	137	72	52	47	40	31	26	22	14	0

Table B-38. Data used to generate diurnal variation plotted in Figure 8-7 of REA.

Monitor ID	Hour of Day	Annual Average NO_2 Concentration at Given Receptor: AERMOD P2.5	AERMOD P50	AERMOD P97.5	AMBIENT MONITOR	AERMOD MONITOR
130890002	0	15	22	31	20	21
	1	16	22	31	18	23
	2	15	21	30	17	21
	3	16	21	30	16	23
	4	20	28	35	16	27
	5	23	33	38	16	31
	6	23	29	35	16	29
	7	19	23	32	17	24
	8	16	18	29	18	19
	9	13	15	31	15	16
	10	11	13	34	11	15
	11	10	13	36	9	15
	12	10	12	38	8	15
	13	10	12	40	7	16
	14	9	12	40	7	15
	15	9	12	41	8	15
	16	9	12	42	8	15
	17	15	19	45	10	21
	18	19	26	44	14	26
	19	27	39	47	18	34
	20	22	32	40	20	27
	21	15	22	32	21	21
	22	16	23	32	22	22
	23	15	22	30	21	22
130893001	0	15	20	30	18	19
	1	16	21	30	16	19
	2	15	19	29	16	18
	3	15	20	30	15	18
	4	20	25	35	15	24
	5	23	28	38	17	27
	6	23	27	35	19	25
	7	18	21	28	19	20
	8	16	17	23	18	16
	9	12	14	21	14	13
	10	11	13	23	12	12
	11	10	13	25	10	11
	12	10	12	27	9	11
	13	9	12	29	9	10
	14	9	11	29	9	10
	15	9	12	27	10	10
	16	10	13	28	11	11
	17	15	18	34	13	17
	18	20	24	39	17	23
	19	29	34	47	20	33
	20	23	28	40	22	27

Monitor ID	Hour of Day	Annual Average NO_2 Concentration at Given Receptor				
		AERMOD P2.5	AERMOD P50	AERMOD P97.5	AMBIENT MONITOR	AERMOD MONITOR
	21	15	20	31	22	19
	22	16	21	31	21	21
	23	16	20	29	19	19
131210048	0	22	26	35	24	27
	1	22	26	35	23	27
	2	21	25	33	21	26
	3	21	25	34	20	27
	4	28	32	40	20	33
	5	32	34	45	21	36
	6	28	31	40	23	31
	7	22	24	31	24	24
	8	18	20	27	23	21
	9	15	18	26	20	18
	10	13	17	27	16	17
	11	12	16	30	13	16
	12	11	16	32	12	16
	13	11	15	33	11	15
	14	10	15	33	11	15
	15	11	16	33	11	15
	16	12	17	35	12	17
	17	18	23	41	14	23
	18	26	31	45	18	31
	19	39	43	54	23	44
	20	33	37	46	26	38
	21	23	28	37	26	29
	22	23	28	38	26	30
	23	22	26	35	25	28

B-4.1.6 Comparison of estimated on-road NO_2 concentrations

Table B-39 provides the semi-empirical distribution derived from the relationship of the on-road concentrations estimated by AERMOD and the concentrations at receptors located at least 100 meters form a major road. The data were separated in to two season categories, summer (June, July and August) and not summer (all other months). Table B-40 contains the values for each of the same distribution types, however were derived from measurement data reported in published literature sources (see Appendix A-8 for details). Each of the distributions were illustrated in Figure 8-8 of the final REA.

Table B-39. On-road/non-road NO_2 concentration ratios using AERMOD roadway link concentration prediction and nearest corresponding receptor concentration ≥ 100 m of a major road.

	AERMOD Predicted On-road/Non-road	
Probability	Not Summer	Summer
0	0.46	0.30
0.01	1.05	1.10
0.02	1.12	1.22
0.03	1.17	1.29
0.04	1.20	1.35
0.05	1.23	1.40
0.06	1.25	1.44
0.07	1.28	1.47
0.08	1.30	1.50
0.09	1.31	1.53
0.1	1.33	1.55
0.11	1.35	1.58
0.12	1.36	1.60
0.13	1.38	1.62
0.14	1.39	1.64
0.15	1.40	1.66
0.16	1.42	1.68
0.17	1.43	1.70
0.18	1.45	1.72
0.19	1.46	1.73
0.2	1.47	1.75
0.21	1.49	1.77
0.22	1.50	1.79
0.23	1.51	1.81
0.24	1.53	1.82
0.25	1.54	1.84
0.26	1.55	1.86
0.27	1.57	1.87
0.28	1.58	1.89
0.29	1.59	1.91
0.3	1.61	1.93

	AERMOD Predicted On-road/Non-road	
Probability	Not Summer	Summer
0.31	1.62	1.94
0.32	1.63	1.96
0.33	1.65	1.98
0.34	1.66	2.00
0.35	1.67	2.02
0.36	1.69	2.03
0.37	1.70	2.05
0.38	1.72	2.07
0.39	1.73	2.09
0.4	1.75	2.11
0.41	1.76	2.13
0.42	1.77	2.15
0.43	1.79	2.17
0.44	1.81	2.19
0.45	1.82	2.21
0.46	1.84	2.23
0.47	1.85	2.25
0.48	1.87	2.27
0.49	1.89	2.29
0.5	1.90	2.31
0.51	1.92	2.34
0.52	1.94	2.36
0.53	1.96	2.38
0.54	1.97	2.40
0.55	1.99	2.43
0.56	2.01	2.45
0.57	2.03	2.48
0.58	2.05	2.51
0.59	2.07	2.53
0.6	2.09	2.56
0.61	2.11	2.59
0.62	2.14	2.62
0.63	2.16	2.65
0.64	2.18	2.68
0.65	2.21	2.71
0.66	2.23	2.74
0.67	2.26	2.78
0.68	2.28	2.82
0.69	2.31	2.85
0.7	2.34	2.89
0.71	2.37	2.93
0.72	2.40	2.97
0.73	2.43	3.01
0.74	2.46	3.05
0.75	2.50	3.10
0.76	2.54	3.14

	AERMOD Predicted On-road/Non-road	
Probability	Not Summer	Summer
0.77	2.57	3.19
0.78	2.61	3.25
0.79	2.66	3.30
0.8	2.70	3.36
0.81	2.75	3.43
0.82	2.80	3.50
0.83	2.86	3.57
0.84	2.92	3.65
0.85	2.98	3.73
0.86	3.05	3.83
0.87	3.13	3.94
0.88	3.22	4.05
0.89	3.31	4.19
0.9	3.43	4.36
0.91	3.56	4.55
0.92	3.72	4.77
0.93	3.90	5.06
0.94	4.12	5.45
0.95	4.41	5.90
0.96	4.81	6.51
0.97	5.41	7.53
0.98	6.44	8.89
0.99	9.32	12.8
1	122	215

Notes:
This ratio was calculated from 7-day averaged concentrations for the on-road and non-road receptors to allow for a better comparison with the study-derived ratios (Table B-40) that were based on 7-14 day averages.

Table B-40. Estimated on-road/non-road NO_2 concentration ratios using *m* ratio derived from data reported in published NO_2 measurement studies.

	Measurement Derived	
Season	Probability[1]	On-Road/Non-Road[2]
Not Summer	0.03	1.22
	0.08	1.25
	0.14	1.36
	0.19	1.36
	0.24	1.42
	0.29	1.47
	0.34	1.58
	0.40	1.59
	0.45	1.64
	0.50	1.75

Season	Measurement Derived	
	Probability[1]	On-Road/Non-Road[2]
	0.55	1.78
	0.60	1.79
	0.66	1.79
	0.71	1.82
	0.76	1.86
	0.81	2.08
	0.86	2.14
	0.92	2.50
	0.97	2.54
Summer	0.03	1.49
	0.07	1.51
	0.12	1.52
	0.16	1.67
	0.21	1.70
	0.25	1.74
	0.30	1.75
	0.34	1.78
	0.39	1.78
	0.43	1.79
	0.48	1.90
	0.52	1.92
	0.57	1.93
	0.61	1.94
	0.66	2.13
	0.70	2.19
	0.75	2.21
	0.79	2.32
	0.84	2.95
	0.88	3.43
	0.93	3.45
	0.97	3.70

Notes:
[1] In the figure presentation, the *n* ratios for each season are plotted as the i^{th} value against (i-3/8)/(n+1/4), which is the Blom normal score. The lowest value has i=1. It was only used for the plotting.
[2] This value is obtained by (1+*m*) and is what was used to estimate on-road concentrations from ambient monitor concentrations, effectively representing the ratio of on-Road/non-road concentrations. See Appendix A, Section 8.

B-4.2 Supplemental APEX Modeling Inputs and Discussion

B-4.2.1 Simulated Individuals

The number of simulated persons in each model run was set to 50,000 persons simulated for each year. The parameters controlling the location and size of the simulated area were set to include the counties in the selected study area. The settings that allow for replacement of CHAD data that are missing gender, employment or age values were all set to preclude replacing missing data. The width of the age window was set to 20 percent to increase the pool of diaries available for selection. The variable that controls the use of additional ages outside the target age window was set to 0.1 to further enhance variability in diary selection. See the APEX User's Guide for further explanation of these parameters.

B-4.2.2 Asthma Prevalence Rates

One of the important population subgroups for the exposure assessment is asthmatic children. Evaluation of the exposure of this group with APEX requires the estimation of children's asthma prevalence rates. The proportion of the population of children characterized as being asthmatic was estimated by statistics on asthma prevalence rates recently used in the NAAQS review for O_3 (EPA, 2007d; 2007e). Specifically, the analysis generated age and gender specific asthma prevalence rates for children ages 0-17 using data provided in the National Health Interview Survey (NHIS) for 2003 (CDC, 2007). These asthma rates were characterized by geographic regions, namely Midwest, Northeast, South, and West. Adult asthma prevalence rates for Atlanta were derived from the Behavioral Risk Factor Surveillance System (BRFSS) survey information for year 2004-2005 (Blackwell and Kanny, 2007; Georgia Department of Human Resources, 2007). Average rates for adult males and females in Atlanta were derived from reported county prevalence rates for both genders. First each of the four county prevalence rates was weighted by their population, then averaged, and finally stratified by gender using the statewide reported gender prevalence. The adult prevalence rates were assumed to apply to all individuals uniformly. Table B-38 provides a summary of the prevalence rates used in the exposure analysis by age and gender.

Table B-41. Mean asthma prevalence rates, along with lower and upper 95% confidence limits, by age and gender used for Atlanta.

Region (Study Area)	Age	Females				Males			
		Prevalence[1]	se	L95	U95	Prevalence[1]	se	L95	U95
Atlanta (South)	0	0.034	0.013	0.015	0.077	0.041	0.019	0.015	0.110
	1	0.052	0.012	0.031	0.085	0.070	0.016	0.041	0.116
	2	0.071	0.014	0.046	0.109	0.102	0.017	0.070	0.146
	3	0.088	0.017	0.056	0.134	0.129	0.021	0.088	0.184
	4	0.099	0.019	0.064	0.150	0.144	0.024	0.099	0.205
	5	0.119	0.022	0.079	0.175	0.165	0.024	0.118	0.224
	6	0.122	0.023	0.079	0.182	0.164	0.025	0.116	0.226
	7	0.112	0.022	0.072	0.170	0.133	0.023	0.090	0.194
	8	0.093	0.019	0.059	0.144	0.138	0.023	0.095	0.197
	9	0.091	0.018	0.059	0.139	0.168	0.025	0.121	0.230
	10	0.108	0.020	0.071	0.162	0.178	0.025	0.130	0.240
	11	0.132	0.023	0.090	0.191	0.162	0.022	0.119	0.218

Region (Study Area)	Age	Females Prevalence[1]	se	L95	U95	Males Prevalence[1]	se	L95	U95
	12	0.123	0.020	0.085	0.175	0.145	0.020	0.106	0.195
	13	0.097	0.017	0.065	0.142	0.143	0.019	0.105	0.192
	14	0.095	0.016	0.064	0.137	0.153	0.019	0.116	0.200
	15	0.100	0.016	0.070	0.141	0.151	0.017	0.116	0.194
	16	0.115	0.016	0.084	0.156	0.140	0.018	0.105	0.185
	17	0.145	0.029	0.091	0.223	0.122	0.026	0.075	0.193
	17+	0.083				0.050			

Notes:
[1] prevalence is given in fraction of the population. Multiply by 100 to obtain the percent.
se – Standard error
L95 – Lower limit on 95th confidence interval
U95 – Upper limit on 95th confidence interval

B-4.2.3 Meteorological Data Used by APEX

APEX used meteorological data from the station located at Atlanta Hartsfield International (KATL) airport. This was one of the stations used for the AERMOD simulations.

B-4.2.4 Method Used for Indoor Source Contributions

Data used for estimating the contribution to indoor NO_2 concentrations that occur during cooking with gas fuel were derived from a study sponsored by the California Air Resources Board (CARB, 2001). For this study a test house was set up for continuous measurements of NO_2 indoors and outdoors, among several other parameters, and conducted under several different cooking procedures and stove operating conditions. A uniform distribution of concentration contributions for input to APEX was estimated as follows.

- The concurrent outdoor NO_2 concentration measurement was subtracted from each in door concentration measurement, to yield net indoor concentrations
- Net indoor concentrations for duplicate cooking tests (same food cooked the same way) were averaged for each indoor room, to yield average net indoor concentrations
- The minimum and maximum average net indoor concentrations for any test in any room were used as the lower and upper bounds of a uniform distribution.

This resulted in a minimum average net indoor concentration of 4 ppb and a maximum net average indoor concentration of 188 ppb.

B-4.2.5 Method Used for Cooking Probabilities

An analysis by Johnson et al (1999) of survey data on gas stove usage collected by Koontz et al (1992) showed an average number of meals prepared each day with a gas stove of 1.4. The diurnal allocation of these cooking events was estimated as follows.

- Food preparation time obtained from CHAD diaries was stratified by hour of the day, and summed for each hour, and summed for total preparation time.

- The fraction of food preparation occurring in each hour of the day was calculated as the total number of minutes for that hour divided by the overall total preparation time. The result was a measure of the probability of food preparation taking place during any hour, given one food preparation event per day.
- Each hourly fraction was multiplied by 1.4, to normalize the expected value of daily food preparation events to 1.4.

This resulted in estimated probabilities of cooking by hour of the day. For this analysis it was assumed that the probability that food preparation would include stove usage was the same for each hour of the day, so that the diurnal allocation of food preparation events would be the same as the diurnal allocation of gas stove usage. It was also assumed that each cooking event lasts for exactly 1 hour, implying that the average total daily gas stove usage is 1.4 hours.

B-4.2.6 In-vehicle and Near-Road PROX factors

These data were used for the in-vehicle and near-road PROX factors used by APEX. They were developed from the 1-hour on-road to non-road receptor concentrations predicted by AERMOD. The data were stratified by two seasons (summer: June, July, and August) and by hour of the day (Table B-42).

Table B-42. In-vehicle and near-road PROX factors used in APEX.

Season	Hour of Day	Parameter Estimates[1]			
		GM	GSD	Lower Bound	Upper Bound
Not Summer	11PM-6AM	1.942	2.093	1.000	9.4
	6AM-7PM	2.989	2.549	1.021	18.8
	7PM-11PM	1.879	2.085	1.000	9.0
Summer	11PM-6AM	1.992	2.149	1.000	10.2
	6AM-7PM	4.619	2.820	1.067	30.0
	7PM-11PM	1.965	2.177	1.000	10.4

Notes:
[1] A lognormal distribution was selected to fit the data, represented by the geometric mean (GM), geometric standard deviation (GSD). Lower and upper bounds were approximated by the 5th and 95th percentiles of the fitted distribution.

B-4.2.7 Supplemental Exposure Results

B-4.2.6 Supplemental Exposure Results

This section provides complete exposure and risk characterization results for the two subpopulations, all asthmatics and asthmatic children. The data are presented in series of summary tables across each of the scenarios investigated (i.e. with modeled air quality as is and simulating just meeting the current and alternative standards), with and without modeled indoor sources (i.e., gas stoves), for each of the potential health effect benchmark levels (i.e., 100, 150, 200, 250, 300 ppb 1-hour), and across three years of modeled air quality (i.e., 2001 to 2003). Due to limits on the number of benchmarks allowed by APEX per simulation, only the benchmarks of 100, 200, and 300 ppb were evaluated for the potential alternative standards. When evaluating the indoor source contributions, the 99^{th} percentile form was used for each the 50, 100, and 150 ppb 1-hour standard levels, the 98^{th} percentile form was evaluated only at a 100 ppb 1-hour standard level for comparison with the 99^{th} form.

B-4.2.6.1 All Asthmatics, Year 2001, No Indoor sources

Table B-43. Estimated number of asthmatics in the Atlanta modeling domain exposed at or above potential health effect benchmark levels (1 to 6 times per year), using 2001 modeled air quality (as is), with just meeting the current standard (cs), and potential alternative standards, without indoor sources.

Air Quality Adjustment		1-hour Benchmark (ppb)	Persons With Number of Repeated Exposures					
Level[1] (ppb)	Form[2]		1	2	3	4	5	6
100	98	100	212426	212426	212426	212372	212212	211997
100	98	200	207070	197375	185109	170648	155436	140760
100	98	300	162453	118639	87359	63524	47402	35511
100	99	100	212426	212426	212265	212051	211997	211515
100	99	200	203267	187734	170380	150883	133154	118586
100	99	300	145688	96733	66202	44510	31869	22657
150	98	100	212426	212426	212426	212426	212426	212426
150	98	200	212319	211783	211033	209908	208623	205945
150	98	300	207070	197375	185109	170648	155436	140760
150	99	100	212426	212426	212426	212426	212426	212426
150	99	200	211944	211462	210123	208087	204927	200910
150	99	300	203267	187734	170380	150883	133154	118586
200	98	100	212426	212426	212426	212426	212426	212426
200	98	200	212426	212426	212426	212372	212212	211997
200	98	300	211837	210980	208998	205784	201981	197107
200	99	100	212426	212426	212426	212426	212426	212426
200	99	200	212426	212426	212265	212051	211997	211515
200	99	300	211301	209159	205409	200053	193197	186609
50	98	100	207070	197375	185109	170648	155436	140760
50	98	200	97322	49063	25710	14890	8838	5410
50	98	300	23621	5035	1553	750	428	268
50	99	100	203267	187734	170380	150883	133154	118586
50	99	200	77290	34654	16551	8195	5142	2892
50	99	300	15640	2678	911	536	268	161
asis	asis	000	212426	212426	212426	212426	212426	212426
asis	asis	100	212426	212051	211837	211408	210658	209801
asis	asis	150	209426	203963	195018	185217	174343	162078
asis	asis	200	191912	167166	141135	117997	100053	83449
asis	asis	250	158650	112587	81200	58757	43171	31816
asis	asis	300	118104	66738	39636	24960	15801	10337
cs01	cs01	100	212426	212426	212426	212426	212426	212426
cs01	cs01	150	212426	212426	212426	212426	212426	212372
cs01	cs01	200	212426	212426	212319	212158	211997	211730
cs01	cs01	250	212212	211730	210926	209801	208087	205731
cs01	cs01	300	211355	209266	205731	200696	194643	187734

[1] value is the 1-hour concentration that air quality is adjusted considering particular form; cs is the current annual average value of 0.053 ppm.
[2] asis – current air quality, not adjusted; 98 – 98th percentile 1-hour concentration averaged across three years; 99 – 99th 1-hour concentration averaged across three years; cs – current annual average standard.

Table B-44. Estimated percent of asthmatics in the Atlanta modeling domain exposed at or above potential health effect benchmark levels (1 to 6 times per year), using 2001 modeled air quality (as is), with just meeting the current standard (cs), and potential alternative standards, without indoor sources.

Air Quality Adjustment		1-hour Benchmark (ppb)	Percent of Persons With Number of Repeated Exposures					
Level[1] (ppb)	Form[2]		1	2	3	4	5	6
100	98	100	100%	100%	100%	100%	100%	100%
100	98	200	97%	93%	87%	80%	73%	66%
100	98	300	76%	56%	41%	30%	22%	17%
100	99	100	100%	100%	100%	100%	100%	100%
100	99	200	96%	88%	80%	71%	63%	56%
100	99	300	69%	46%	31%	21%	15%	11%
150	98	100	100%	100%	100%	100%	100%	100%
150	98	200	100%	100%	99%	99%	98%	97%
150	98	300	97%	93%	87%	80%	73%	66%
150	99	100	100%	100%	100%	100%	100%	100%
150	99	200	100%	100%	99%	98%	96%	95%
150	99	300	96%	88%	80%	71%	63%	56%
200	98	100	100%	100%	100%	100%	100%	100%
200	98	200	100%	100%	100%	100%	100%	100%
200	98	300	100%	99%	98%	97%	95%	93%
200	99	100	100%	100%	100%	100%	100%	100%
200	99	200	100%	100%	100%	100%	100%	100%
200	99	300	99%	98%	97%	94%	91%	88%
50	98	100	97%	93%	87%	80%	73%	66%
50	98	200	46%	23%	12%	7%	4%	3%
50	98	300	11%	2%	1%	0%	0%	0%
50	99	100	96%	88%	80%	71%	63%	56%
50	99	200	36%	16%	8%	4%	2%	1%
50	99	300	7%	1%	0%	0%	0%	0%
asis	asis	000	100%	100%	100%	100%	100%	100%
asis	asis	100	100%	100%	100%	100%	99%	99%
asis	asis	150	99%	96%	92%	87%	82%	76%
asis	asis	200	90%	79%	66%	56%	47%	39%
asis	asis	250	75%	53%	38%	28%	20%	15%
asis	asis	300	56%	31%	19%	12%	7%	5%
cs01	cs01	100	100%	100%	100%	100%	100%	100%
cs01	cs01	150	100%	100%	100%	100%	100%	100%
cs01	cs01	200	100%	100%	100%	100%	100%	100%
cs01	cs01	250	100%	100%	99%	99%	98%	97%
cs01	cs01	300	99%	99%	97%	94%	92%	88%

[1] value is the 1-hour concentration that air quality is adjusted considering particular form; cs is the current annual average value of 0.053 ppm.
[2] asis – current air quality, not adjusted; 98 – 98th percentile 1-hour concentration averaged across three years; 99 – 99th 1-hour concentration averaged across three years; cs – current annual average standard.

B-4.2.6.2 Asthmatic Children, Year 2001, No Indoor Sources

Table B-45. Estimated number of asthmatic children in the Atlanta modeling domain exposed at or above potential health effect benchmark levels (1 to 6 times per year), using 2001 modeled air quality (as is), with just meeting the current standard (cs), and potential alternative standards, without indoor sources.

Air Quality Adjustment		1-hour Benchmark (ppb)	Persons With Number of Repeated Exposures					
Level[1] (ppb)	Form[2]		1	2	3	4	5	6
100	98	100	64113	64113	64113	64113	64113	64113
100	98	200	62881	60953	58275	54847	51366	48313
100	98	300	51794	39957	31226	23514	17622	14194
100	99	100	64113	64113	64113	64113	64113	64060
100	99	200	61917	58596	54847	50241	45635	41617
100	99	300	47456	33476	23567	16015	12159	9213
150	98	100	64113	64113	64113	64113	64113	64113
150	98	200	64113	64060	64006	63738	63578	63042
150	98	300	62881	60953	58275	54847	51366	48313
150	99	100	64113	64113	64113	64113	64113	64113
150	99	200	64060	64006	63899	63578	63042	62185
150	99	300	61917	58596	54847	50241	45635	41617
200	98	100	64113	64113	64113	64113	64113	64113
200	98	200	64113	64113	64113	64113	64113	64113
200	98	300	64060	63953	63738	63042	62346	61435
200	99	100	64113	64113	64113	64113	64113	64113
200	99	200	64113	64113	64113	64113	64113	64060
200	99	300	64006	63685	62721	61435	60150	58864
50	98	100	62881	60953	58275	54847	51366	48313
50	98	200	32030	17086	9373	5892	3321	2089
50	98	300	7177	1660	321	107	54	0
50	99	100	61917	58596	54847	50241	45635	41617
50	99	200	25656	12587	6535	3053	1821	857
50	99	300	4499	857	107	54	0	0
asis	asis	000	64113	64113	64113	64113	64113	64113
asis	asis	100	64113	64113	64113	64060	64060	63899
asis	asis	150	63685	62560	60525	58168	56722	53883
asis	asis	200	59025	54044	46866	41350	36476	31119
asis	asis	250	51044	38564	29191	22067	15908	12748
asis	asis	300	37868	22924	13444	9320	6374	4338
cs01	cs01	100	64113	64113	64113	64113	64113	64113
cs01	cs01	150	64113	64113	64113	64113	64113	64113
cs01	cs01	200	64113	64113	64113	64113	64113	64060
cs01	cs01	250	64113	64006	63953	63738	63524	63042
cs01	cs01	300	64006	63685	62881	61542	60364	59079

[1] value is the 1-hour concentration that air quality is adjusted considering particular form; cs is the current annual average value of 0.053 ppm.
[2] asis – current air quality, not adjusted; 98 – 98th percentile 1-hour concentration averaged across three years; 99 – 99th 1-hour concentration averaged across three years; cs – current annual average standard.

Table B-46. Estimated percent of asthmatic children in the Atlanta modeling domain exposed at or above potential health effect benchmark levels (1 to 6 times per year), using 2001 modeled air quality (as is), with just meeting the current standard (cs), and potential alternative standards, without indoor sources.

Air Quality Adjustment		1-hour Benchmark (ppb)	Percent of Persons With Number of Repeated Exposures					
Level[1] (ppb)	Form[2]		1	2	3	4	5	6
100	98	100	100%	100%	100%	100%	100%	100%
100	98	200	98%	95%	91%	86%	80%	75%
100	98	300	81%	62%	49%	37%	27%	22%
100	99	100	100%	100%	100%	100%	100%	100%
100	99	200	97%	91%	86%	78%	71%	65%
100	99	300	74%	52%	37%	25%	19%	14%
150	98	100	100%	100%	100%	100%	100%	100%
150	98	200	100%	100%	100%	99%	99%	98%
150	98	300	98%	95%	91%	86%	80%	75%
150	99	100	100%	100%	100%	100%	100%	100%
150	99	200	100%	100%	100%	99%	98%	97%
150	99	300	97%	91%	86%	78%	71%	65%
200	98	100	100%	100%	100%	100%	100%	100%
200	98	200	100%	100%	100%	100%	100%	100%
200	98	300	100%	100%	99%	98%	97%	96%
200	99	100	100%	100%	100%	100%	100%	100%
200	99	200	100%	100%	100%	100%	100%	100%
200	99	300	100%	99%	98%	96%	94%	92%
50	98	100	98%	95%	91%	86%	80%	75%
50	98	200	50%	27%	15%	9%	5%	3%
50	98	300	11%	3%	1%	0%	0%	0%
50	99	100	97%	91%	86%	78%	71%	65%
50	99	200	40%	20%	10%	5%	3%	1%
50	99	300	7%	1%	0%	0%	0%	0%
asis	asis	000	100%	100%	100%	100%	100%	100%
asis	asis	100	100%	100%	100%	100%	100%	100%
asis	asis	150	99%	98%	94%	91%	88%	84%
asis	asis	200	92%	84%	73%	64%	57%	49%
asis	asis	250	80%	60%	46%	34%	25%	20%
asis	asis	300	59%	36%	21%	15%	10%	7%
cs01	cs01	100	100%	100%	100%	100%	100%	100%
cs01	cs01	150	100%	100%	100%	100%	100%	100%
cs01	cs01	200	100%	100%	100%	100%	100%	100%
cs01	cs01	250	100%	100%	100%	99%	99%	98%
cs01	cs01	300	100%	99%	98%	96%	94%	92%

[1] value is the 1-hour concentration that air quality is adjusted considering particular form; cs is the current annual average value of 0.053 ppm.
[2] asis – current air quality, not adjusted; 98 – 98th percentile 1-hour concentration averaged across three years; 99 – 99th 1-hour concentration averaged across three years; cs – current annual average standard.

B-4.2.6.3 All Asthmatics, Year 2002, No Indoor sources

Table B-47. Estimated number of asthmatics in the Atlanta modeling domain exposed at or above potential health effect benchmark levels (1 to 6 times per year), using 2002 modeled air quality (as is), with just meeting the current standard (cs), and potential alternative standards, without indoor sources.

Air Quality Adjustment		1-hour Benchmark (ppb)	Persons With Number of Repeated Exposures					
Level[1] (ppb)	Form[2]		1	2	3	4	5	6
100	98	100	212426	212426	212426	212265	212051	211944
100	98	200	207820	199089	187252	172576	157954	143813
100	98	300	165345	123674	89555	64756	48045	35351
100	99	100	212426	212372	212319	212051	211944	211676
100	99	200	204070	190037	172469	153883	136797	120246
100	99	300	150776	100268	68184	45045	32191	23192
150	98	100	212426	212426	212426	212426	212426	212426
150	98	200	212372	212051	211301	210016	208891	206909
150	98	300	207820	199089	187252	172576	157954	143813
150	99	100	212426	212426	212426	212426	212426	212426
150	99	200	212212	211408	210123	208248	205677	202356
150	99	300	204070	190037	172469	153883	136797	120246
200	98	100	212426	212426	212426	212426	212426	212426
200	98	200	212426	212426	212426	212265	212051	211944
200	98	300	211997	210658	209319	206588	203481	199143
200	99	100	212426	212426	212426	212426	212426	212426
200	99	200	212426	212372	212319	212051	211944	211676
200	99	300	211301	209319	206213	201124	194804	188430
50	98	100	207820	199089	187252	172576	157954	143813
50	98	200	103535	49920	29352	17300	10391	6963
50	98	300	29620	7392	2785	1178	696	321
50	99	100	204070	190037	172469	153883	136797	120246
50	99	200	83824	36904	19496	11141	6160	4178
50	99	300	21264	4285	1500	803	268	107
asis	asis	000	212426	212426	212426	212426	212426	212426
asis	asis	100	212426	212265	211997	211301	210819	209748
asis	asis	150	209855	204713	197429	187359	176540	164756
asis	asis	200	195768	170862	146063	122281	102196	85431
asis	asis	250	161864	117997	84199	59293	43171	32405
asis	asis	300	124531	68988	41350	25870	17782	11944
cs02	cs02	100	212426	212426	212426	212426	212426	212426
cs02	cs02	150	212426	212426	212426	212426	212426	212426
cs02	cs02	200	212426	212426	212426	212426	212372	212319
cs02	cs02	250	212426	212372	212319	211997	211890	211301
cs02	cs02	300	212372	212051	211140	209962	208516	206695

[1] value is the 1-hour concentration that air quality is adjusted considering particular form; cs is the current annual average value of 0.053 ppm.
[2] asis – current air quality, not adjusted; 98 – 98th percentile 1-hour concentration averaged across three years; 99 – 99th 1-hour concentration averaged across three years; cs – current annual average standard.

Table B-48. Estimated percent of asthmatics in the Atlanta modeling domain exposed at or above potential health effect benchmark levels (1 to 6 times per year), using 2002 modeled air quality (as is), with just meeting the current standard (cs), and potential alternative standards, without indoor sources.

Air Quality Adjustment		1-hour Benchmark (ppb)	Percent of Persons With Number of Repeated Exposures					
Level[1] (ppb)	Form[2]		1	2	3	4	5	6
100	98	100	100%	100%	100%	100%	100%	100%
100	98	200	98%	94%	88%	81%	74%	68%
100	98	300	78%	58%	42%	30%	23%	17%
100	99	100	100%	100%	100%	100%	100%	100%
100	99	200	96%	89%	81%	72%	64%	57%
100	99	300	71%	47%	32%	21%	15%	11%
150	98	100	100%	100%	100%	100%	100%	100%
150	98	200	100%	100%	99%	99%	98%	97%
150	98	300	98%	94%	88%	81%	74%	68%
150	99	100	100%	100%	100%	100%	100%	100%
150	99	200	100%	100%	99%	98%	97%	95%
150	99	300	96%	89%	81%	72%	64%	57%
200	98	100	100%	100%	100%	100%	100%	100%
200	98	200	100%	100%	100%	100%	100%	100%
200	98	300	100%	99%	99%	97%	96%	94%
200	99	100	100%	100%	100%	100%	100%	100%
200	99	200	100%	100%	100%	100%	100%	100%
200	99	300	99%	99%	97%	95%	92%	89%
50	98	100	98%	94%	88%	81%	74%	68%
50	98	200	49%	23%	14%	8%	5%	3%
50	98	300	14%	3%	1%	1%	0%	0%
50	99	100	96%	89%	81%	72%	64%	57%
50	99	200	39%	17%	9%	5%	3%	2%
50	99	300	10%	2%	1%	0%	0%	0%
asis	asis	000	100%	100%	100%	100%	100%	100%
asis	asis	100	100%	100%	100%	99%	99%	99%
asis	asis	150	99%	96%	93%	88%	83%	78%
asis	asis	200	92%	80%	69%	58%	48%	40%
asis	asis	250	76%	56%	40%	28%	20%	15%
asis	asis	300	59%	32%	19%	12%	8%	6%
cs02	cs02	100	100%	100%	100%	100%	100%	100%
cs02	cs02	150	100%	100%	100%	100%	100%	100%
cs02	cs02	200	100%	100%	100%	100%	100%	100%
cs02	cs02	250	100%	100%	100%	100%	100%	99%
cs02	cs02	300	100%	100%	99%	99%	98%	97%

[1] value is the 1-hour concentration that air quality is adjusted considering particular form; cs is the current annual average value of 0.053 ppm.
[2] asis – current air quality, not adjusted; 98 – 98th percentile 1-hour concentration averaged across three years; 99 – 99th 1-hour concentration averaged across three years; cs – current annual average standard.

B-4.2.6.4 Asthmatic Children, Year 2002, No Indoor Sources

Table B-49. Estimated number of asthmatic children in the Atlanta modeling domain exposed at or above potential health effect benchmark levels (1 to 6 times per year), using 2002 modeled air quality (as is), with just meeting the current standard (cs), and potential alternative standards, without indoor sources.

Air Quality Adjustment		1-hour Benchmark (ppb)	Persons With Number of Repeated Exposures					
Level[1] (ppb)	Form[2]		1	2	3	4	5	6
100	98	100	64113	64113	64113	64113	64006	63953
100	98	200	63149	61221	58918	55758	52973	49437
100	98	300	53347	42099	31816	22603	16711	12855
100	99	100	64113	64113	64113	64060	64006	63899
100	99	200	62667	59400	55704	51259	47349	43224
100	99	300	49330	34976	24049	15051	10873	7552
150	98	100	64113	64113	64113	64113	64113	64113
150	98	200	64113	64113	63846	63685	63417	63256
150	98	300	63149	61221	58918	55758	52973	49437
150	99	100	64113	64113	64113	64113	64113	64113
150	99	200	64060	64006	63738	63310	62828	61971
150	99	300	62667	59400	55704	51259	47349	43224
200	98	100	64113	64113	64113	64113	64113	64113
200	98	200	64113	64113	64113	64113	64006	63953
200	98	300	64060	63846	63578	62881	62399	61435
200	99	100	64113	64113	64113	64113	64113	64113
200	99	200	64113	64113	64113	64060	64006	63899
200	99	300	64006	63471	62614	61757	60632	59025
50	98	100	63149	61221	58918	55758	52973	49437
50	98	200	34387	16604	9480	5249	3267	2035
50	98	300	8784	1768	428	161	107	54
50	99	100	62667	59400	55704	51259	47349	43224
50	99	200	27263	12051	5999	3321	1928	964
50	99	300	6052	911	107	107	0	0
asis	asis	000	64113	64113	64113	64113	64113	64113
asis	asis	100	64113	64113	64006	63846	63792	63578
asis	asis	150	63524	62506	60900	58971	56775	54097
asis	asis	200	60632	54740	48688	43171	37172	31869
asis	asis	250	52598	40493	30262	20568	14890	11516
asis	asis	300	40975	23996	13819	8034	5731	3428
cs02	cs02	100	64113	64113	64113	64113	64113	64113
cs02	cs02	150	64113	64113	64113	64113	64113	64113
cs02	cs02	200	64113	64113	64113	64113	64113	64113
cs02	cs02	250	64113	64113	64113	64060	64006	63792
cs02	cs02	300	64113	64113	63846	63685	63363	63256

[1] value is the 1-hour concentration that air quality is adjusted considering particular form; cs is the current annual average value of 0.053 ppm.
[2] asis – current air quality, not adjusted; 98 – 98th percentile 1-hour concentration averaged across three years; 99 – 99th 1-hour concentration averaged across three years; cs – current annual average standard.

Table B-50. Estimated percent of asthmatic children in the Atlanta modeling domain exposed at or above potential health effect benchmark levels (1 to 6 times per year), using 2002 modeled air quality (as is), with just meeting the current standard (cs), and potential alternative standards, without indoor sources.

Air Quality Adjustment		1-hour Benchmark (ppb)	Percent of Persons With Number of Repeated Exposures					
Level[1] (ppb)	Form[2]		1	2	3	4	5	6
100	98	100	100%	100%	100%	100%	100%	100%
100	98	200	98%	95%	92%	87%	83%	77%
100	98	300	83%	66%	50%	35%	26%	20%
100	99	100	100%	100%	100%	100%	100%	100%
100	99	200	98%	93%	87%	80%	74%	67%
100	99	300	77%	55%	38%	23%	17%	12%
150	98	100	100%	100%	100%	100%	100%	100%
150	98	200	100%	100%	100%	99%	99%	99%
150	98	300	98%	95%	92%	87%	83%	77%
150	99	100	100%	100%	100%	100%	100%	100%
150	99	200	100%	100%	99%	99%	98%	97%
150	99	300	98%	93%	87%	80%	74%	67%
200	98	100	100%	100%	100%	100%	100%	100%
200	98	200	100%	100%	100%	100%	100%	100%
200	98	300	100%	100%	99%	98%	97%	96%
200	99	100	100%	100%	100%	100%	100%	100%
200	99	200	100%	100%	100%	100%	100%	100%
200	99	300	100%	99%	98%	96%	95%	92%
50	98	100	98%	95%	92%	87%	83%	77%
50	98	200	54%	26%	15%	8%	5%	3%
50	98	300	14%	3%	1%	0%	0%	0%
50	99	100	98%	93%	87%	80%	74%	67%
50	99	200	43%	19%	9%	5%	3%	2%
50	99	300	9%	1%	0%	0%	0%	0%
asis	asis	000	100%	100%	100%	100%	100%	100%
asis	asis	100	100%	100%	100%	100%	99%	99%
asis	asis	150	99%	97%	95%	92%	89%	84%
asis	asis	200	95%	85%	76%	67%	58%	50%
asis	asis	250	82%	63%	47%	32%	23%	18%
asis	asis	300	64%	37%	22%	13%	9%	5%
cs02	cs02	100	100%	100%	100%	100%	100%	100%
cs02	cs02	150	100%	100%	100%	100%	100%	100%
cs02	cs02	200	100%	100%	100%	100%	100%	100%
cs02	cs02	250	100%	100%	100%	100%	100%	99%
cs02	cs02	300	100%	100%	100%	99%	99%	99%

[1] value is the 1-hour concentration that air quality is adjusted considering particular form; cs is the current annual average value of 0.053 ppm.
[2] asis – current air quality, not adjusted; 98 – 98th percentile 1-hour concentration averaged across three years; 99 – 99th 1-hour concentration averaged across three years; cs – current annual average standard.

B-4.2.6.5 All Asthmatics, Year 2003, No Indoor sources

Table B-51. Estimated number of asthmatic in the Atlanta modeling domain exposed at or above potential health effect benchmark levels (1 to 6 times per year), using 2003 modeled air quality (as is), with just meeting the current standard (cs), and potential alternative standards, without indoor sources.

Air Quality Adjustment		1-hour Benchmark (ppb)	Persons With Number of Repeated Exposures					
Level[1] (ppb)	Form[2]		1	2	3	4	5	6
100	98	100	212426	212426	212372	212319	212158	212051
100	98	200	206534	197429	184360	168827	154526	139261
100	98	300	162721	117514	84520	61596	45099	33958
100	99	100	212426	212426	212319	212104	211622	210980
100	99	200	202731	187520	169148	149973	131923	115908
100	99	300	143653	94911	63203	44349	31762	22228
150	98	100	212426	212426	212426	212426	212426	212426
150	98	200	212212	211837	210980	209587	207927	205998
150	98	300	206534	197429	184360	168827	154526	139261
150	99	100	212426	212426	212426	212426	212426	212426
150	99	200	211944	211248	209373	207284	204338	199250
150	99	300	202731	187520	169148	149973	131923	115908
200	98	100	212426	212426	212426	212426	212426	212426
200	98	200	212426	212426	212372	212319	212158	212051
200	98	300	211676	210337	208516	205249	201017	195072
200	99	100	212426	212426	212426	212426	212426	212426
200	99	200	212426	212426	212319	212104	211622	210980
200	99	300	211087	208837	205838	199625	193037	184413
50	98	100	206534	197429	184360	168827	154526	139261
50	98	200	98072	48366	26406	15265	8784	5570
50	98	300	25924	5892	2571	857	268	54
50	99	100	202731	187520	169148	149973	131923	115908
50	99	200	79057	33958	16926	8570	5035	2946
50	99	300	17836	3749	1446	428	107	0
asis	asis	000	212426	212426	212426	212426	212426	212426
asis	asis	100	212426	212158	211837	211194	210016	209051
asis	asis	150	209105	203963	194804	183824	172522	160257
asis	asis	200	192447	165452	139582	117568	97429	80450
asis	asis	250	158114	111730	78843	57204	41296	30744
asis	asis	300	117461	66470	39261	25228	15158	9695
cs03	cs03	100	212426	212426	212426	212426	212426	212426
cs03	cs03	150	212426	212426	212426	212426	212426	212426
cs03	cs03	200	212426	212426	212426	212426	212426	212426
cs03	cs03	250	212426	212426	212426	212319	212265	212265
cs03	cs03	300	212426	212372	212212	211997	211408	210712

[1] value is the 1-hour concentration that air quality is adjusted considering particular form; cs is the current annual average value of 0.053 ppm.
[2] asis – current air quality, not adjusted; 98 – 98th percentile 1-hour concentration averaged across three years; 99 – 99th 1-hour concentration averaged across three years; cs – current annual average standard.

Table B-52. Estimated percent of asthmatics in the Atlanta modeling domain exposed at or above potential health effect benchmark levels (1 to 6 times per year), using 2003 modeled air quality (as is), with just meeting the current standard (cs), and potential alternative standards, without indoor sources.

Air Quality Adjustment		1-hour Benchmark (ppb)	Percent of Persons With Number of Repeated Exposures					
Level[1] (ppb)	Form[2]		1	2	3	4	5	6
100	98	100	100%	100%	100%	100%	100%	100%
100	98	200	97%	93%	87%	79%	73%	66%
100	98	300	77%	55%	40%	29%	21%	16%
100	99	100	100%	100%	100%	100%	100%	99%
100	99	200	95%	88%	80%	71%	62%	55%
100	99	300	68%	45%	30%	21%	15%	10%
150	98	100	100%	100%	100%	100%	100%	100%
150	98	200	100%	100%	99%	99%	98%	97%
150	98	300	97%	93%	87%	79%	73%	66%
150	99	100	100%	100%	100%	100%	100%	100%
150	99	200	100%	99%	99%	98%	96%	94%
150	99	300	95%	88%	80%	71%	62%	55%
200	98	100	100%	100%	100%	100%	100%	100%
200	98	200	100%	100%	100%	100%	100%	100%
200	98	300	100%	99%	98%	97%	95%	92%
200	99	100	100%	100%	100%	100%	100%	100%
200	99	200	100%	100%	100%	100%	100%	99%
200	99	300	99%	98%	97%	94%	91%	87%
50	98	100	97%	93%	87%	79%	73%	66%
50	98	200	46%	23%	12%	7%	4%	3%
50	98	300	12%	3%	1%	0%	0%	0%
50	99	100	95%	88%	80%	71%	62%	55%
50	99	200	37%	16%	8%	4%	2%	1%
50	99	300	8%	2%	1%	0%	0%	0%
asis	asis	000	100%	100%	100%	100%	100%	100%
asis	asis	100	100%	100%	100%	99%	99%	98%
asis	asis	150	98%	96%	92%	87%	81%	75%
asis	asis	200	91%	78%	66%	55%	46%	38%
asis	asis	250	74%	53%	37%	27%	19%	14%
asis	asis	300	55%	31%	18%	12%	7%	5%
cs03	cs03	100	100%	100%	100%	100%	100%	100%
cs03	cs03	150	100%	100%	100%	100%	100%	100%
cs03	cs03	200	100%	100%	100%	100%	100%	100%
cs03	cs03	250	100%	100%	100%	100%	100%	100%
cs03	cs03	300	100%	100%	100%	100%	100%	99%

[1] value is the 1-hour concentration that air quality is adjusted considering particular form; cs is the current annual average value of 0.053 ppm.
[2] asis – current air quality, not adjusted; 98 – 98th percentile 1-hour concentration averaged across three years; 99 – 99th 1-hour concentration averaged across three years; cs – current annual average standard.

B-4.2.6.6 Asthmatic Children, Year 2003, No Indoor Sources

Table B-53. Estimated number of asthmatic children in the Atlanta modeling domain exposed at or above potential health effect benchmark levels (1 to 6 times per year), using 2003 modeled air quality (as is), with just meeting the current standard (cs), and potential alternative standards, without indoor sources.

Air Quality Adjustment		1-hour Benchmark (ppb)	Persons With Number of Repeated Exposures					
Level[1] (ppb)	Form[2]		1	2	3	4	5	6
100	98	100	64113	64113	64113	64060	63953	63899
100	98	200	62935	60846	58061	54579	51312	47723
100	98	300	52008	39582	28977	21907	16818	13444
100	99	100	64113	64113	64060	64006	63846	63846
100	99	200	61864	58864	54526	49812	45045	40921
100	99	300	46492	32405	22603	15747	11355	8570
150	98	100	64113	64113	64113	64113	64113	64113
150	98	200	64006	63953	63738	63471	63363	63149
150	98	300	62935	60846	58061	54579	51312	47723
150	99	100	64113	64113	64113	64113	64113	64113
150	99	200	63953	63846	63471	63256	62560	61596
150	99	300	61864	58864	54526	49812	45045	40921
200	98	100	64113	64113	64113	64113	64113	64113
200	98	200	64113	64113	64113	64060	63953	63899
200	98	300	63953	63685	63363	62560	62024	60632
200	99	100	64113	64113	64113	64113	64113	64113
200	99	200	64113	64113	64060	64006	63846	63846
200	99	300	63899	63417	62774	61435	59989	58275
50	98	100	62935	60846	58061	54579	51312	47723
50	98	200	31334	16818	9373	5463	2999	2035
50	98	300	7981	1821	643	161	0	0
50	99	100	61864	58864	54526	49812	45045	40921
50	99	200	25335	11569	5678	3107	1928	857
50	99	300	5142	1071	321	0	0	0
asis	asis	000	64113	64113	64113	64113	64113	64113
asis	asis	100	64113	64006	63899	63738	63524	63417
asis	asis	150	63578	62292	59936	57900	55543	53133
asis	asis	200	59239	52758	45956	39957	34922	30102
asis	asis	250	50830	37600	27316	20193	15158	12051
asis	asis	300	37547	23192	14676	9373	5249	3214
cs03	cs03	100	64113	64113	64113	64113	64113	64113
cs03	cs03	150	64113	64113	64113	64113	64113	64113
cs03	cs03	200	64113	64113	64113	64113	64113	64113
cs03	cs03	250	64113	64113	64113	64060	64006	64006
cs03	cs03	300	64113	64060	64006	63953	63846	63738

[1] value is the 1-hour concentration that air quality is adjusted considering particular form; cs is the current annual average value of 0.053 ppm.
[2] asis – current air quality, not adjusted; 98 – 98th percentile 1-hour concentration averaged across three years; 99 – 99th 1-hour concentration averaged across three years; cs – current annual average standard.

Table B-54. Estimated percent of asthmatic children in the Atlanta modeling domain exposed at or above potential health effect benchmark levels (1 to 6 times per year), using 2003 modeled air quality (as is), with just meeting the current standard (cs), and potential alternative standards, without indoor sources.

Air Quality Adjustment		1-hour Benchmark (ppb)	Percent of Persons With Number of Repeated Exposures					
Level[1] (ppb)	Form[2]		1	2	3	4	5	6
100	98	100	100%	100%	100%	100%	100%	100%
100	98	200	98%	95%	91%	85%	80%	74%
100	98	300	81%	62%	45%	34%	26%	21%
100	99	100	100%	100%	100%	100%	100%	100%
100	99	200	96%	92%	85%	78%	70%	64%
100	99	300	73%	51%	35%	25%	18%	13%
150	98	100	100%	100%	100%	100%	100%	100%
150	98	200	100%	100%	99%	99%	99%	98%
150	98	300	98%	95%	91%	85%	80%	74%
150	99	100	100%	100%	100%	100%	100%	100%
150	99	200	100%	100%	99%	99%	98%	96%
150	99	300	96%	92%	85%	78%	70%	64%
200	98	100	100%	100%	100%	100%	100%	100%
200	98	200	100%	100%	100%	100%	100%	100%
200	98	300	100%	99%	99%	98%	97%	95%
200	99	100	100%	100%	100%	100%	100%	100%
200	99	200	100%	100%	100%	100%	100%	100%
200	99	300	100%	99%	98%	96%	94%	91%
50	98	100	98%	95%	91%	85%	80%	74%
50	98	200	49%	26%	15%	9%	5%	3%
50	98	300	12%	3%	1%	0%	0%	0%
50	99	100	96%	92%	85%	78%	70%	64%
50	99	200	40%	18%	9%	5%	3%	1%
50	99	300	8%	2%	1%	0%	0%	0%
asis	asis	000	100%	100%	100%	100%	100%	100%
asis	asis	100	100%	100%	100%	99%	99%	99%
asis	asis	150	99%	97%	93%	90%	87%	83%
asis	asis	200	92%	82%	72%	62%	54%	47%
asis	asis	250	79%	59%	43%	31%	24%	19%
asis	asis	300	59%	36%	23%	15%	8%	5%
cs03	cs03	100	100%	100%	100%	100%	100%	100%
cs03	cs03	150	100%	100%	100%	100%	100%	100%
cs03	cs03	200	100%	100%	100%	100%	100%	100%
cs03	cs03	250	100%	100%	100%	100%	100%	100%
cs03	cs03	300	100%	100%	100%	100%	100%	99%

[1] value is the 1-hour concentration that air quality is adjusted considering particular form; cs is the current annual average value of 0.053 ppm.
[2] asis – current air quality, not adjusted; 98 – 98th percentile 1-hour concentration averaged across three years; 99 – 99th 1-hour concentration averaged across three years; cs – current annual average standard.

B-4.2.6.7 All Asthmatics, Year 2002, With Indoor Sources

Table B-55. Estimated number of asthmatics in the Atlanta modeling domain exposed at or above potential health effect benchmark levels (1 to 6 times per year), using 2002 modeled air quality (as is), with just meeting the current standard (cs), and potential alternative standards, with indoor sources.

Air Quality Adjustment		1-hour Benchmark (ppb)	Percent of Persons With Number of Repeated Exposures					
Level[1] (ppb)	Form[2]		1	2	3	4	5	6
asis	asis	0	212426	212426	212426	212426	212426	212426
asis	asis	100	212426	212426	212319	212319	212265	212212
asis	asis	150	211890	210873	208516	205570	201231	196679
asis	asis	200	197268	175843	152383	129191	109694	92930
asis	asis	250	166952	121960	87520	62989	46438	33905
asis	asis	300	127156	72630	44242	26995	17943	11409
cs02	cs02	100	212426	212426	212426	212426	212426	212426
cs02	cs02	150	212426	212426	212426	212426	212426	212426
cs02	cs02	200	212426	212426	212426	212426	212426	212426
cs02	cs02	250	212426	212426	212372	212319	211890	211462
cs02	cs02	300	212372	211944	211515	210712	209373	207605
50	99	100	211890	210980	209801	207766	205463	202838
50	99	200	86556	37707	18532	10070	6535	3910
50	99	300	20514	3856	1071	375	107	0
100	99	100	212426	212426	212426	212426	212426	212319
100	99	200	205731	193786	179110	160792	144938	127370
100	99	300	154204	104070	70594	48313	33637	24049
100	98	100	212426	212426	212426	212426	212426	212426
100	98	200	208677	201017	190948	177718	164649	151205
100	98	300	170273	126191	92394	68077	50134	37386
150	99	100	212426	212426	212426	212426	212426	212426
150	99	200	212158	211569	210980	209641	207605	205356
150	99	300	204284	191001	175147	157097	140278	123674

[1] value is the 1-hour concentration that air quality is adjusted considering particular form; cs is the current annual average value of 0.053 ppm.
[2] asis – current air quality, not adjusted; 98 – 98th percentile 1-hour concentration averaged across three years; 99 – 99th 1-hour concentration averaged across three years; cs – current annual average standard.

Table B-56. Estimated percent of asthmatics in the Atlanta modeling domain exposed at or above potential health effect benchmark levels (1 to 6 times per year), using 2002 modeled air quality (as is), with just meeting the current standard (cs), and potential alternative standards, with indoor sources.

Air Quality Adjustment		1-hour Benchmark (ppb)	Percent of Persons With Number of Repeated Exposures					
Level[1] (ppb)	Form[2]		1	2	3	4	5	6
asis	asis	0	100%	100%	100%	100%	100%	100%
asis	asis	100	100%	100%	100%	100%	100%	100%
asis	asis	150	100%	99%	98%	97%	95%	93%
asis	asis	200	93%	83%	72%	61%	52%	44%
asis	asis	250	79%	57%	41%	30%	22%	16%
asis	asis	300	60%	34%	21%	13%	8%	5%
cs02	cs02	100	100%	100%	100%	100%	100%	100%
cs02	cs02	150	100%	100%	100%	100%	100%	100%
cs02	cs02	200	100%	100%	100%	100%	100%	100%
cs02	cs02	250	100%	100%	100%	100%	100%	100%
cs02	cs02	300	100%	100%	100%	99%	99%	98%
50	99	100	100%	99%	99%	98%	97%	95%
50	99	200	41%	18%	9%	5%	3%	2%
50	99	300	10%	2%	1%	0%	0%	0%
100	99	100	100%	100%	100%	100%	100%	100%
100	99	200	97%	91%	84%	76%	68%	60%
100	99	300	73%	49%	33%	23%	16%	11%
100	98	100	100%	100%	100%	100%	100%	100%
100	98	200	98%	95%	90%	84%	78%	71%
100	98	300	80%	59%	43%	32%	24%	18%
150	99	100	100%	100%	100%	100%	100%	100%
150	99	200	100%	100%	99%	99%	98%	97%
150	99	300	96%	90%	82%	74%	66%	58%

[1] value is the 1-hour concentration that air quality is adjusted considering particular form; cs is the current annual average value of 0.053 ppm.
[2] asis – current air quality, not adjusted; 98 – 98th percentile 1-hour concentration averaged across three years; 99 – 99th 1-hour concentration averaged across three years; cs – current annual average standard.

B-4.2.6.8 Asthmatic Children, Year 2002, With Indoor Sources

Table B-57. Estimated number of asthmatic children in the Atlanta modeling domain exposed at or above potential health effect benchmark levels (1 to 6 times per year), using 2002 modeled air quality (as is), with just meeting the current standard (cs), and potential alternative standards, with indoor sources.

Air Quality Adjustment		1-hour Benchmark (ppb)	Percent of Persons With Number of Repeated Exposures					
Level[1] (ppb)	Form[2]		1	2	3	4	5	6
asis	asis	0	64113	64113	64113	64113	64113	64113
asis	asis	100	64113	64113	64060	64060	64006	64006
asis	asis	150	64006	63738	63203	62292	61221	59507
asis	asis	200	60471	55651	50348	44563	39261	34065
asis	asis	250	52812	40653	31012	23085	16979	12694
asis	asis	300	41028	24638	15212	9534	5785	3696
cs02	cs02	100	64113	64113	64113	64113	64113	64113
cs02	cs02	150	64113	64113	64113	64113	64113	64113
cs02	cs02	200	64113	64113	64113	64113	64113	64113
cs02	cs02	250	64113	64113	64113	64060	64006	63953
cs02	cs02	300	64113	64006	63953	63738	63524	63524
50	99	100	63792	63363	62774	61971	60739	59561
50	99	200	27852	12694	6106	2946	1553	696
50	99	300	5517	1018	214	107	54	0
100	99	100	64113	64113	64113	64113	64113	64006
100	99	200	62560	59882	57150	52544	48848	44403
100	99	300	49170	35297	25067	17729	12105	8570
100	98	100	64113	64113	64113	64113	64113	64113
100	98	200	63363	61757	59882	56775	53722	50723
100	98	300	53508	41725	32351	24960	18532	13819
150	99	100	64113	64113	64113	64113	64113	64113
150	99	200	64060	63899	63792	63524	63363	62989
150	99	300	62292	59239	56400	51848	47777	43974

[1] value is the 1-hour concentration that air quality is adjusted considering particular form; cs is the current annual average value of 0.053 ppm.
[2] asis – current air quality, not adjusted; 98 – 98th percentile 1-hour concentration averaged across three years; 99 – 99th 1-hour concentration averaged across three years; cs – current annual average standard.

Table B-58. Estimated percent of asthmatic children in the Atlanta modeling domain exposed at or above potential health effect benchmark levels (1 to 6 times per year), using 2002 modeled air quality (as is), with just meeting the current standard (cs), and potential alternative standards, with indoor sources.

Air Quality Adjustment		1-hour Benchmark (ppb)	Percent of Persons With Number of Repeated Exposures					
Level[1] (ppb)	Form[2]		1	2	3	4	5	6
asis	asis	0	100%	100%	100%	100%	100%	100%
asis	asis	100	100%	100%	100%	100%	100%	100%
asis	asis	150	100%	99%	99%	97%	95%	93%
asis	asis	200	94%	87%	79%	70%	61%	53%
asis	asis	250	82%	63%	48%	36%	26%	20%
asis	asis	300	64%	38%	24%	15%	9%	6%
cs02	cs02	100	100%	100%	100%	100%	100%	100%
cs02	cs02	150	100%	100%	100%	100%	100%	100%
cs02	cs02	200	100%	100%	100%	100%	100%	100%
cs02	cs02	250	100%	100%	100%	100%	100%	100%
cs02	cs02	300	100%	100%	100%	99%	99%	99%
50	99	100	99%	99%	98%	97%	95%	93%
50	99	200	43%	20%	10%	5%	2%	1%
50	99	300	9%	2%	0%	0%	0%	0%
100	99	100	100%	100%	100%	100%	100%	100%
100	99	200	98%	93%	89%	82%	76%	69%
100	99	300	77%	55%	39%	28%	19%	13%
100	98	100	100%	100%	100%	100%	100%	100%
100	98	200	99%	96%	93%	89%	84%	79%
100	98	300	83%	65%	50%	39%	29%	22%
150	99	100	100%	100%	100%	100%	100%	100%
150	99	200	100%	100%	99%	99%	99%	98%
150	99	300	97%	92%	88%	81%	75%	69%

[1] value is the 1-hour concentration that air quality is adjusted considering particular form; cs is the current annual average value of 0.053 ppm.
[2] asis – current air quality, not adjusted; 98 – 98th percentile 1-hour concentration averaged across three years; 99 – 99th 1-hour concentration averaged across three years; cs – current annual average standard.

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Attachment 1: Technical Memorandum on Meteorological Data Preparation for AERMOD for NO_2 REA for Atlanta, GA 2001-2003

Meteorological data preparation for AERMOD for NO_2 REA for Atlanta, GA 2001-2003

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1. Introduction

While National Weather Service (NWS) surface observational data are often used as the source of meteorological inputs for AERMOD, sometimes the data are not truly representative of the modeling domain, especially for urban applications. Often the meteorological data is from an airport, which has different surface characteristics than the sources being modeled. The airport meteorological tower is often located in open spaces while the sources are located in urban areas with trees, buildings, and other obstacles. For the Atlanta study, the airport, Atlanta Hartsfield Airport was initially chosen as the representative meteorological location. The sources used in the study are located in urban areas. Therefore, the airport data, due to lower surface roughness at the airport, may not adequately represent conditions at the sources.

To address the concern regarding representativeness of the Atlanta NWS data for this study, meteorological data from the Southeast Aerosol Research and Characterization study (SEARCH) site in Atlanta were used as the primary source of meteorology for the AERMOD runs for the years 2001 through 2003. Figure 1a shows the locations of the SEARCH site, located at Jefferson St, and hereafter referenced as JST, and Hartsfield International Airport, hereafter referenced as ATL. The JST site is located in an urban area, while the airport is on the outskirts of the city. Figure 1b provides a closer look at the JST site and it can be clearly seen that the site is in an urban setting.

The methodologies used to prepare meteorological data for AERMOD are described below, including the analysis of surface characteristics data, and AERMET processing for the JST site and ATL. Also discussed is the methodology used to process upper air data from Peachtree City, GA and Birmingham, AL.

Another potential concern related to the use of NWS meteorological data for dispersion modeling is the often high incidence of calms and variable wind conditions. The AERMOD model currently cannot simulate dispersion under these conditions. To reduce the number of calms and missing winds in the ATL data, archived one-minute winds for the ASOS station at ATL were used to calculate hourly average wind speed and directions, which were used to supplement the standard archive of winds reported for ATL in the Integrated Surface Hourly (ISH) database. Details regarding this procedure are described below.

Section 2 describes preparation of the JST data, Section 3 describes the preparation of data and calculation of hourly winds from one-minute ASOS data for ATL, Section 4 describes preparation of upper air data from Peachtree City and Birmingham, Section 5 describes AERSURFACE processing for surface characteristics, and Section 6 describes the AERMET processing. Section 7 describes an additional adjustment that was made to the processed meteorological data to address an issue regarding AERMOD formulation for the urban option that contributed to anomalous modeled concentrations from a preliminary analysis. Section 8 provides a brief analysis of the AERMET output for JST and ATL. References are listed in Section 9.

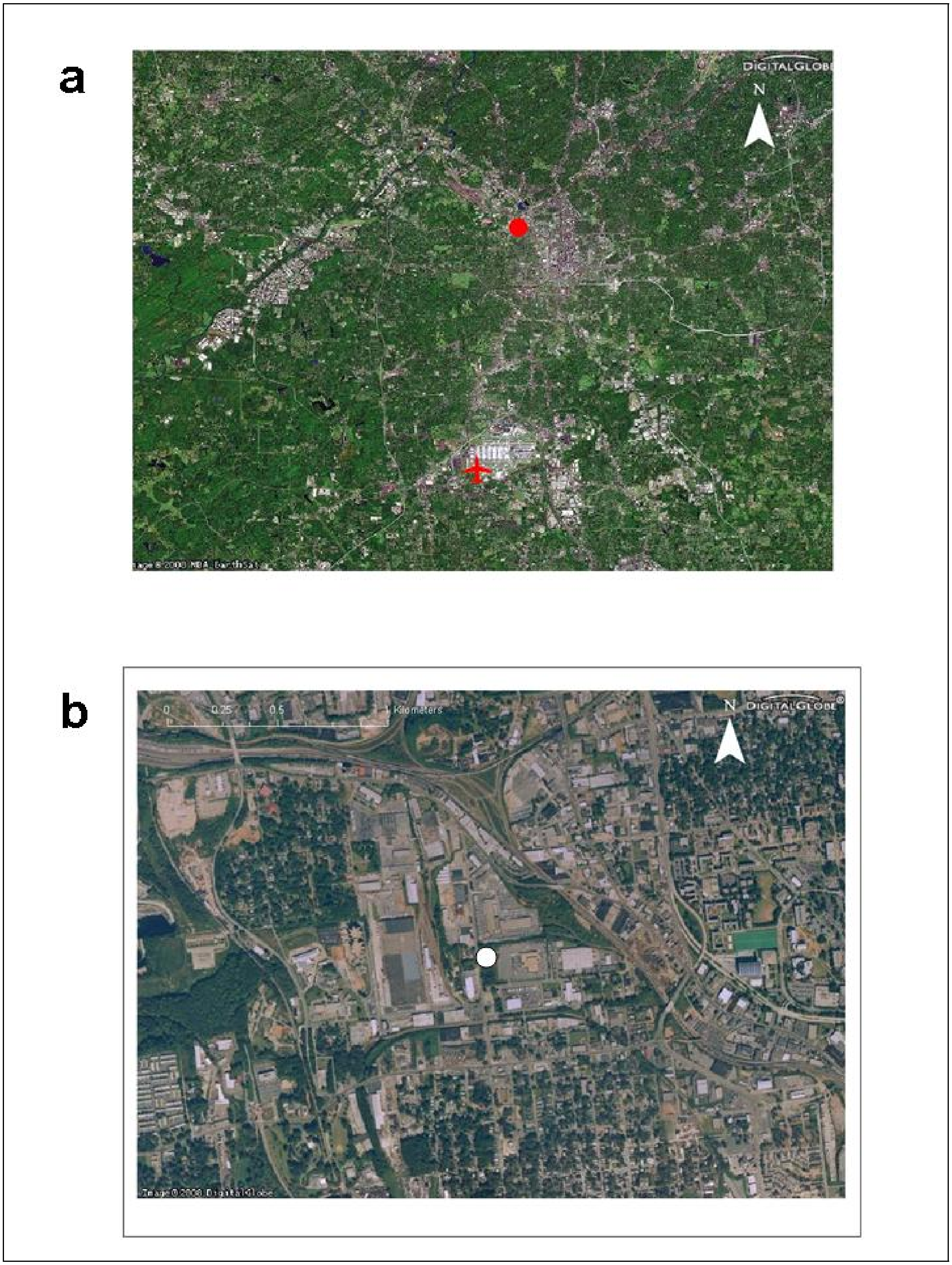

Figure 1. a) location of JST (red dot) relative to ATL (red airplane) and b) zoomed in view of JST (white dot).

2. SEARCH data preparation

SEARCH data for the Jefferson St. monitor (JST) in Atlanta was downloaded from the public archive section of the SEARCH website, http://www.atmospheric-research.com/public/index.html, for 2001 through 2003. Trace gas and met data were chosen. The data in the SEARCH spreadsheets were reported on a 0 to 23 hour basis, with the reported time represented the beginning of the observational hour. The convention for meteorological data input to dispersion models is that the reported time represents the end of the averaging period. The AERMOD model also requires meteorological inputs on a 1 to 23 hour basis. After adjusting the JST data to conform to the AERMOD model conventions, missing values for wind speed, wind direction, and temperature were reset to the missing values of those variables as described in AERMET Appendix B, Table B-3. (U.S. EPA, 2004). The anemometer height for the JST data was set to 10 m.

Since data quality is an important consideration for meteorological inputs to dispersion models, the JST data were reviewed for completeness and reasonableness. Specifically, hourly wind speeds, wind directions, and temperatures for JST were compared to the values for Atlanta Hartsfield Airport (ATL) for the three years of 2001 through 2003. Analysis of the wind directions showed generally good agreement between JST and ATL data throughout most of the period. However, this comparison identified somewhat anomalous directions for the period of May 2 through May 8, 2001 (Figure 2). The original wind directions for the JST data (red lines), revealed an approximate 180 degree shift in wind direction when compared to the ATL wind directions (blue lines). This shift followed a significant period of missing data for JST from late April to early May 2001. After May 8, the wind directions appeared to be in better agreement with airport wind directions. A similar problem had been encountered for a SEARCH site in Birmingham as part of another study, and was later confirmed to be a 120-degree offset. Based on this review and prior experience with a similar problem, it was decided to shift the JST wind direction by 180 degrees for the period beginning with 1700 LST May 2 and ending at 1500 LST May 8. Figure 3 shows the resulting directions (green line), which are more in line with the airport directions. After correcting for the wind directions, the hourly winds and temperatures were written to text files for input in to AERMET. Figure 4 shows the wind roses for each year for JST. Winds were predominantly from the northwest with a secondary maximum from the east.

The number of calms and missing hours (winds or temperature) for JST were compiled for each year to determine if data substitution from the airport was necessary in AERMET processing. Table 1 lists the number of calms and missing winds and temperatures for the JST site for 2001 through 2003. Note that a wind speed threshold of 0.28 m/s was used in processing the JST data through AERMET. As a result, any wind speed reported less than 0.28 m/s was treated as a calm hour. Unlike NWS surface observations, which treat any wind speed below 3 knots as a calm, the JST data are based on a sonic anemometer, which has virtually no threshold since the observations are not dependent on mechanical parts. Several manufacturers of sonic anemometers report starting thresholds of 0.01 m/s. While such low winds speeds may be a reasonable starting threshold for an instantaneous wind speed sample from a sonic anemometer, it may not be appropriate as a threshold for defining a valid hourly average wind speed to be used in a steady-state plume model such as AERMOD, with a single hourly average wind direction. Under conditions that would result in an hourly average wind speed on the order of 0.01 m/s, there would be no well-defined transport direction. The AERMOD model formulation includes adjustments to the minimum wind speed to account for turbulence effects under very light wind conditions, with the minimum effective wind speed that will be used for dilution in AERMOD of about 0.2828 m/s. Based on these considerations, a threshold of 0.28 m/s was selected as the most appropriate value to be applied for the JST data, with any hourly average wind speeds below that threshold being classified as calm. Note that the current meteorological monitoring guidance for dispersion modeling applications (EPA, 2000) specifies a maximum acceptable starting threshold of 0.5 m/s for site-specific meteorological monitoring programs.

Table 1. Number of calms, missing winds, and missing temperatures for each year for 2001 through 2003 for the JST site.

Variable	**Year**		
	2001	**2002**	**2003**
Calms[#]	427	287	19
Missing winds*	165	497	792
Missing temperature	187	205	379

anything less than 0.28 m/s was considered calm
* missing wind speed and/or wind direction.

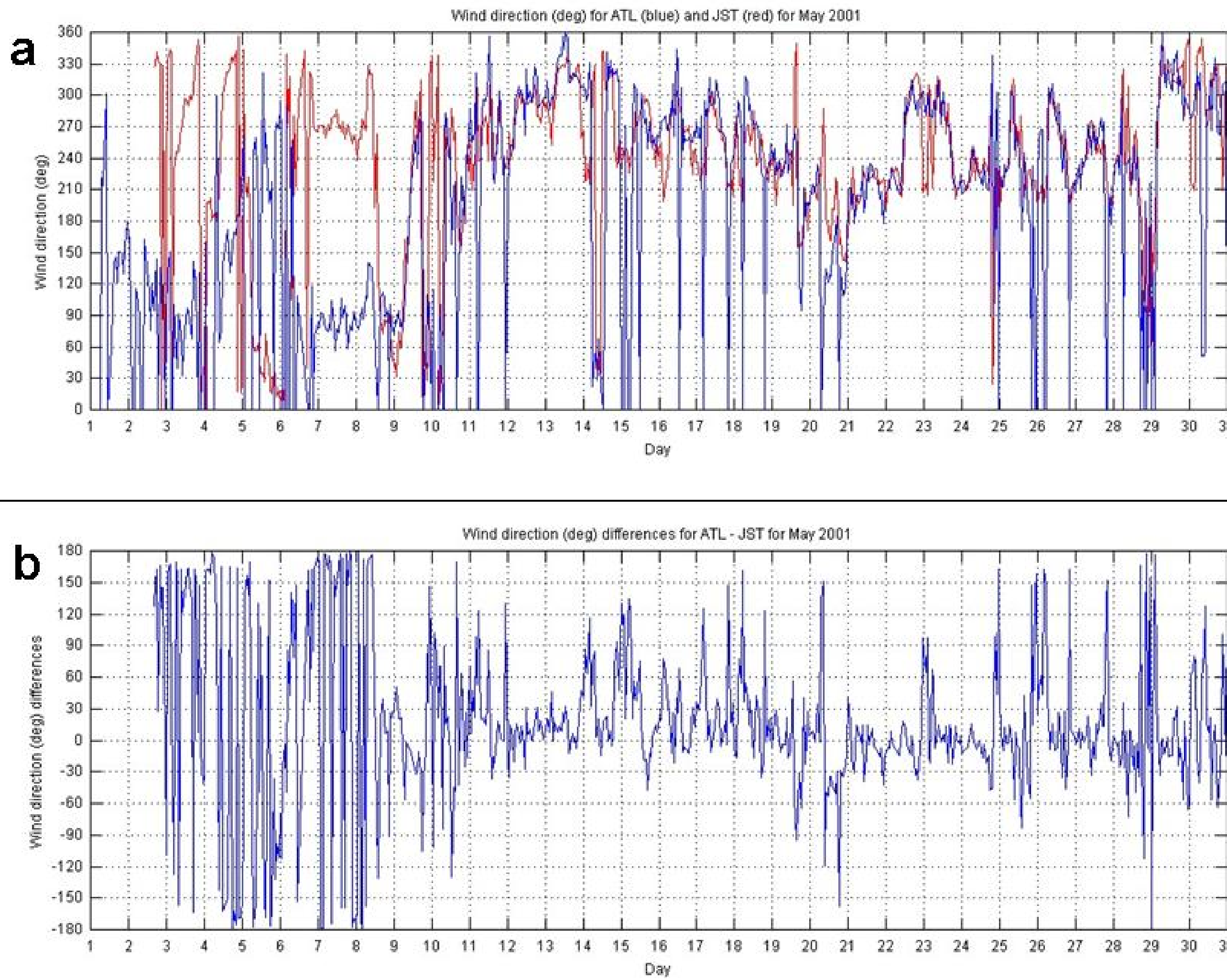

Figure 2. May 2001 a) wind directions for the SEARCH monitor (red line) and Hartsfield International Airport (blue line) and b), wind direction differences (airport – SEARCH).

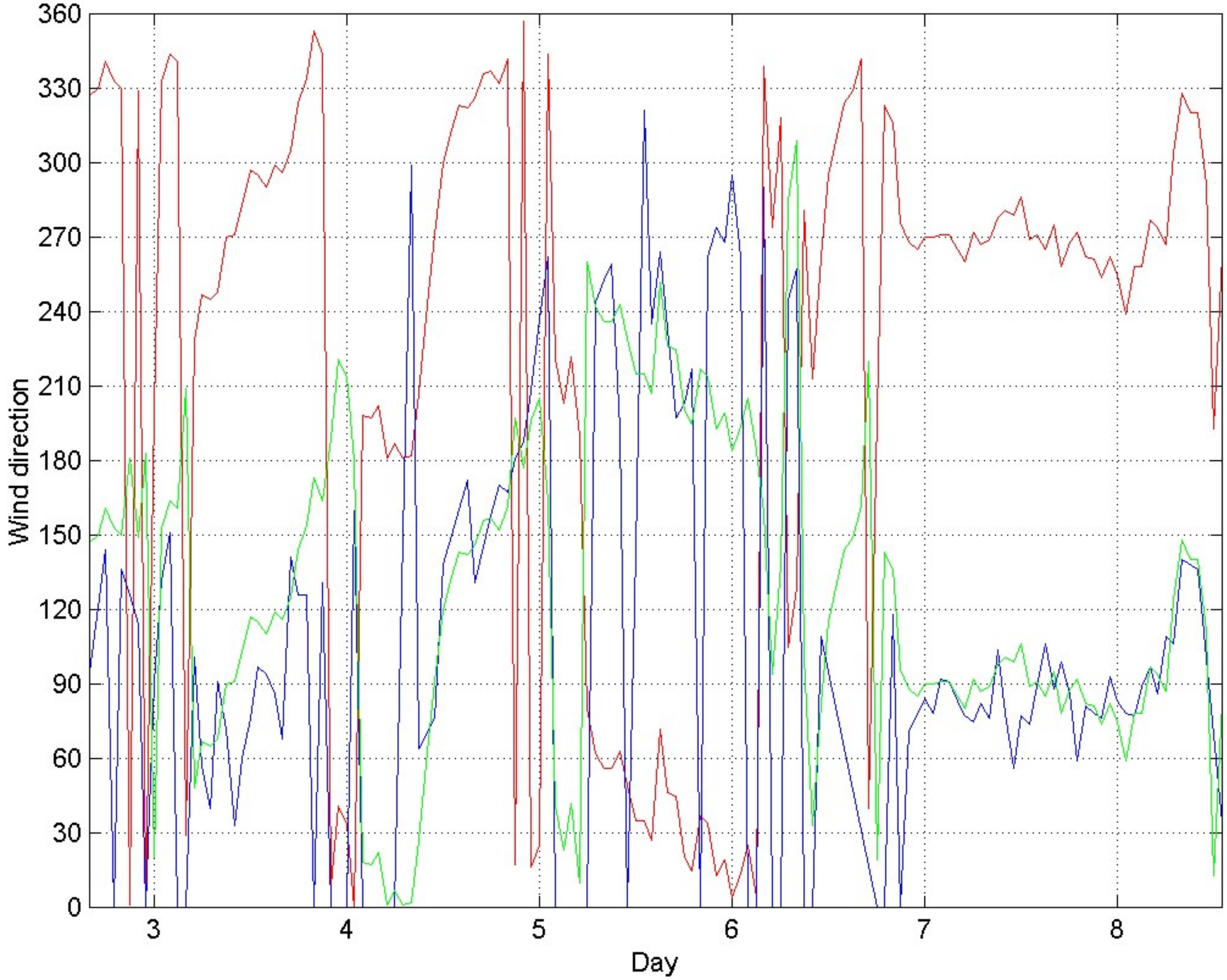

Figure 3. Hourly wind directions for original SEARCH (red), airport (blue) and shifted SEARCH (green) for May 2 through May 8, 2001.

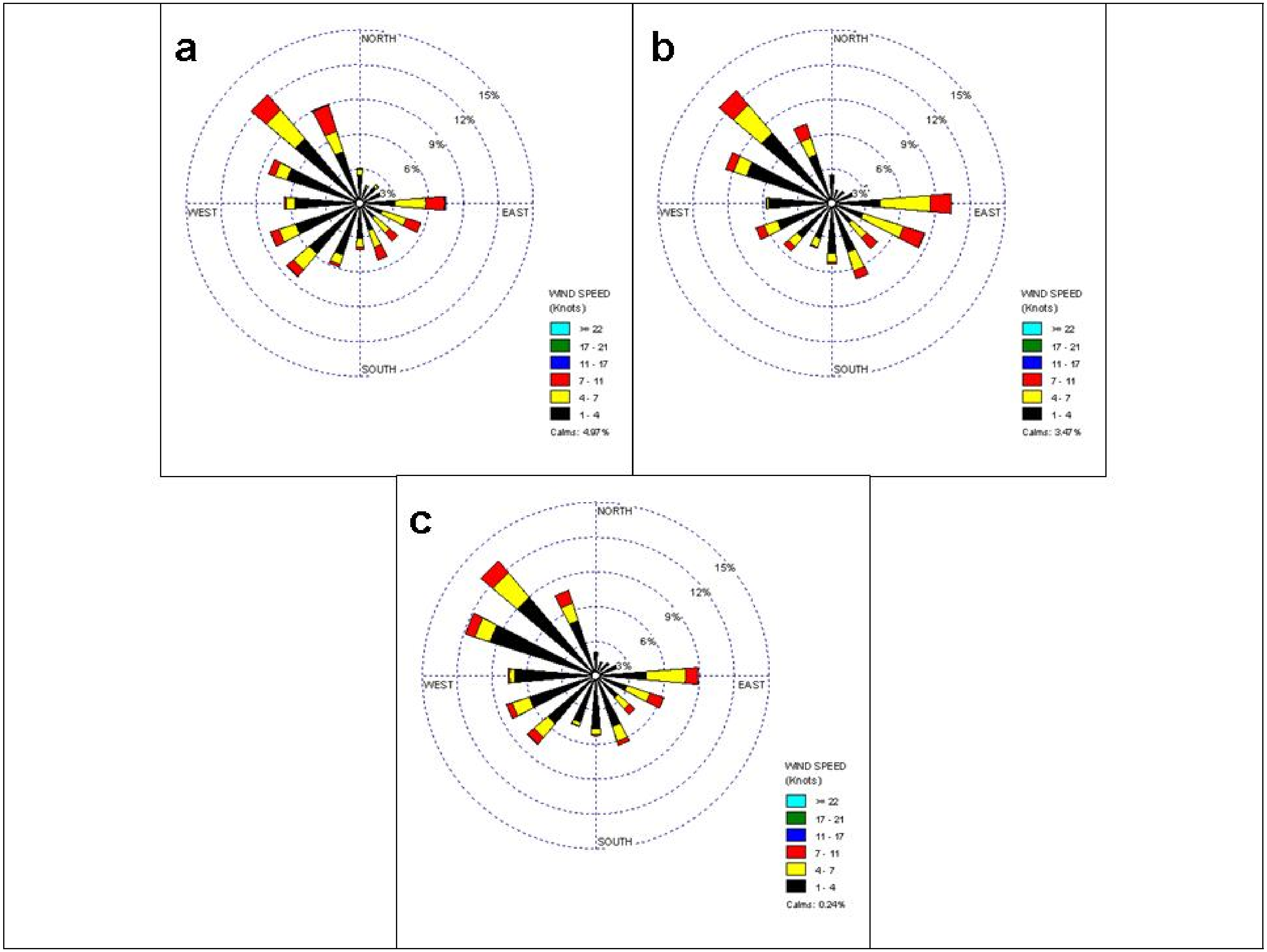

Figure 4. Annual wind roses for JST for a) 2001, b) 2002, and c) 2003.

3. Surface airport data

Surface data from an NWS site was needed to supplement the data from the SEARCH site. For AERMOD, the most representative data for an NWS site should be used, most often the nearest location. For Atlanta, Atlanta Hartsfield Airport (ATL) was chosen as the site. Integrated Surface Hourly (ISH) data was downloaded from the National Climatic Data Center (NCDC) for 2001, 2002, and 2003.

Surface data from NWS locations often contain a large number of calms and variable winds. This is due to the METAR reporting method used for NWS observations. Currently, the wind speed and direction used to represent the hour in AERMOD is a single two-minute average, usually reported about 10 minutes before the hour. The METAR system reports winds of less than three knots as calm, and winds up to six knots will be reported as variable when the variation in the 2-minute wind direction is more than 60 degrees. This variable wind is reported as a non-zero wind speed with a missing wind direction. The number of calms and variable winds can influence concentration calculations in AERMOD because concentrations are not calculated for calms or variable wind hours. For daily or annual averages, this can result in underestimated concentrations. This is especially of concern for applications involving low-level releases since the worst-case dispersion conditions for such sources are associated with low wind speeds, and the hours being discarded as calm or variable are biased toward this condition.

Recently, NCDC began archiving the two-minute average wind speeds for each minute of the hour for most ASOS stations. These values have not been subjected to the METAR coding for calm and variable winds. Recent work in AQMG has focused on utilizing these 1 minute winds to calculate hourly average winds to reduce the number of calms and variable winds for a given station and year. For data input into AERMOD, one minute winds for ATL were used to calculate hourly average winds for 2001 through 2003. These winds would be input to AERMET and replace the winds reported for the hour from the ISH dataset. Following is the methodology used to calculate the hourly average winds:

One minute data files are monthly, so each month for 2001 through 2003 was downloaded. The program used to calculate hourly average winds is executed for each year.

1. Each line of the data file was read and QA performed on the format of the line to check if the line is valid data line. Currently, the one minute data files loosely follow a fixed format, but there are numerous exceptions. The program performed several checks on the line to ensure that wind direction and wind speed were in the correct general location. If a minute was listed twice, the second line for that minute was assumed to be the correct line. In the files, wind directions were recorded at the nearest whole degree and wind speed to the nearest whole knot.

2. If the reported wind speed was less than 2 knots, the wind speed was reset to 1 knot. This was done because anything less than 2 knots was considered below the instrument threshold (if the anemometer is not a sonic anemometer, which was the case for ATL prior to April 2007). So a reported wind speed of 0 knots may not necessarily be a calm wind. This also conforms to the meteorological monitoring guidance recommendation of

applying a wind speed of one half the threshold value to each wind sample below threshold when processing samples to obtain hourly averages. At the same time, the x- and y-components of the wind direction were calculated using equations 1 and 2 below, which are the functions inside the summation of equations 6.2.17 and 6.2.18 of the meteorological guidance document (U.S. EPA, 2000). The components were only calculated for minutes that did not require resetting.

$$v_x = -\sin\theta \qquad (1)$$

$$v_y = -\cos\theta \qquad (2)$$

where v_x and v_y are the x- and y-components of the one minute wind direction θ.

3. For all minutes that passed the QA check in step 1, the wind speeds were converted from knots to m/s.

4. Before calculating hourly averages, the number of valid minutes (those with wind directions) was checked for each hour. An hourly average would be calculated if the there were at least two valid minutes for the hour. This could be even minutes, odd minutes, or a mixture of non-overlapping even and odd minutes. Even minutes were given priority over odd. If at least two valid minutes were found, then all available minutes would be used to calculate hourly averages. The most observations that could be used were 30 2-minute values (30 even or 30 odd).

5. For wind speed averages, all available non-overlapping minutes' speeds were used, even those subject to resets as described in step 2. The hourly wind speed was an arithmetic average of the wind speeds used.

6. For wind directions, the x- and y-components were summed according to equations 6.2.17 and 6.2.18 of the meteorological monitoring guidance (U.S. EPA, 2000), summarized in equations 3 and 4 below with v_{xi} and v_{yi} calculated in equations 1 and 2. The hourly wind direction was calculated using equation 6.2.19 of the meteorological monitoring guidance (U.S.EPA, 2000), summarized in equation 5. The one minute average wind directions do not use the flow correction as shown in equation 6.2.19, since the calculated direction is the direction from which the wind was blowing, not the direction in which it is blowing, as shown by the flow correction in 6.2.19. Instead, the one minute program corrected for the direction from which the wind was blowing.

$$V_X = \frac{1}{N}\sum_{i=1}^{N} v_{xi} \qquad (3)$$

$$V_Y = \frac{1}{N}\sum_{i=1}^{N} v_{yi} \qquad (4)$$

$$\theta = Arc\tan\left(V_X / V_Y\right) + CORR \qquad (5)$$

Where V_x and V_y are the hourly averaged x- and y-components of the wind, θ is the hourly averaged wind direction, N is the number of observations used for the hour, and

$$
\text{CORR} = \begin{cases} 180 \text{ for } V_x > 0 \text{ and } V_y > 0 \text{ or } V_x < 0 \text{ and } V_y > 0 \\ 0 \text{ for } V_x < 0 \text{ and } V_y < 0 \\ 360 \text{ for } V_x \geq 0 \text{ and } V_y < 0 \end{cases}
$$

4. Upper air data

For AERMET processing, an upper air station must be paired with the surface station. For both JST and ATL, the Peachtree City upper air station, FFC, was chosen as the most representative upper air site. Upper air data in the Forecast System Laboratory (FSL) format was downloaded from the FSL, (now Global Systems Division) website, http://www.fsl.noaa.gov/. The data period chosen was January 1, 2001 through December 31, 2003 for all times and all levels. The selected wind speed units were chosen as tenths of a meter per second. The data was downloaded as one file for all three years.

Analysis of the data revealed 31 occurrences of missing 1200 UTC soundings for the three years, mostly in 2001. The AERMOD processor requires a 1200 UTC sounding in order to calculate the convective mixing height for the day. As a result, if the 1200 UTC sounding is missing, all of the daytime convective hours for that day will be considered as missing by the AERMOD model. In order to minimize missing data as much as possible, these gaps in the data were filled with data from the Birmingham, AL upper air station, BMX or from the FFC data itself. Table 2 lists the missing dates and method of data substitution. These substitutions should have very limited impact on the Atlanta NO2 modeling since BMX is reasonably representative of Atlanta, and modeling results for low-level releases, such as mobile sources, are not very sensitive to the convective mixing heights in AERMOD.

Table 2. Missing 1200 UTC sounding dates in upper air data with substitution method. Unless specified otherwise, substitution times are the same as the missing date/time.

Date/time	Substitution	Date/time	Substitution
03/11/01	BMX	04/17/02	BMX
03/12/01	BMX	04/18/02	BMX
03/13/01	BMX	04/19/02	BMX
05/06/01	BMX	04/20/02	BMX
06/13/01	BMX	04/21/02	BMX
06/14/01	BMX	04/22/02	BMX
06/15/01	BMX	04/26/02	BMX
08/11/01	BMX	04/27/02	BMX
11/21/01	BMX	06/14/02	BMX
11/22/01	BMX	06/23/02	BMX
11/23/01	BMX	07/21/02	FFC 07/20/02
01/11/02	BMX	09/08/02	BMX
02/19/02	BMX	09/09/02	BMX
03/23/02	BMX	01/22/03	BMX
03/24/02	BMX	03/09/03	BMX
03/25/02	BMX	06/26/03	BMX

5. AERSURFACE

The AERSURFACE tool (U.S. EPA, 2008a) was used to determine surface characteristics (albedo, Bowen ratio, and surface roughness) for input to AERMET. Surface characteristics were calculated for the JST meteorological tower site (33.77753° N, 84.41666° W) and for the ATL meteorological tower (33.63° N 84.44167° W). As noted in the AERSURFACE User's Guide (U.S. EPA, 2008), AERSURFACE should be run for the location of the actual meteorological tower to ensure accurate representation of the conditions around the site.

A draft version of AERSURFACE (08256) that utilizes 2001 NLCD was used to determine the surface characteristics for this application since the 2001 land cover data will be more representative of this modeling period than the 1992 NLCD data supported by the current version of AERSURFACE available on EPA's SCRAM website. Both meteorological data sites were run according to the methodology in Section 3.2.2 of the 1st draft NO_2 risk and exposure assessment technical support document (U.S. EPA, 2008b): both sites were run as non-arid regions, ATL was considered "at an airport" for the low, medium, and high intensity developed categories, default seasonal assignments to each month, and no continuous snow cover. Moisture conditions for Bowen ratio (average, dry, or wet) were assigned to each month based on the analysis shown in Table 30 of the technical support document (U.S. EPA, 2008b). Months with at least twice the normal precipitation level were denoted as wet, those with less than one-half the normal precipitation level were assigned dry and all others were average. This resulted in three AERSURFACE runs for each site with average, dry, or wet conditions because AERSURFACE can not assign moisture conditions to individual months within one AERSURFACE run. Table 3 shows the assignment to each month for each year. Figures 5 and 6 show the sectors used for surface roughness for JST and ATL.

After running AERSURFACE, a year specific set of surface characteristics was generated for each year by merging results for the appropriate moisture condition for each month for the year, i.e. for 2001, the average moisture surface characteristics for January through June were concatenated with the dry July and August surface characteristics, average September surface characteristics, dry October and November surface characteristics, and average December surface characteristics. These merged AERSURFACE results were used in Stage 3 of AERMET.

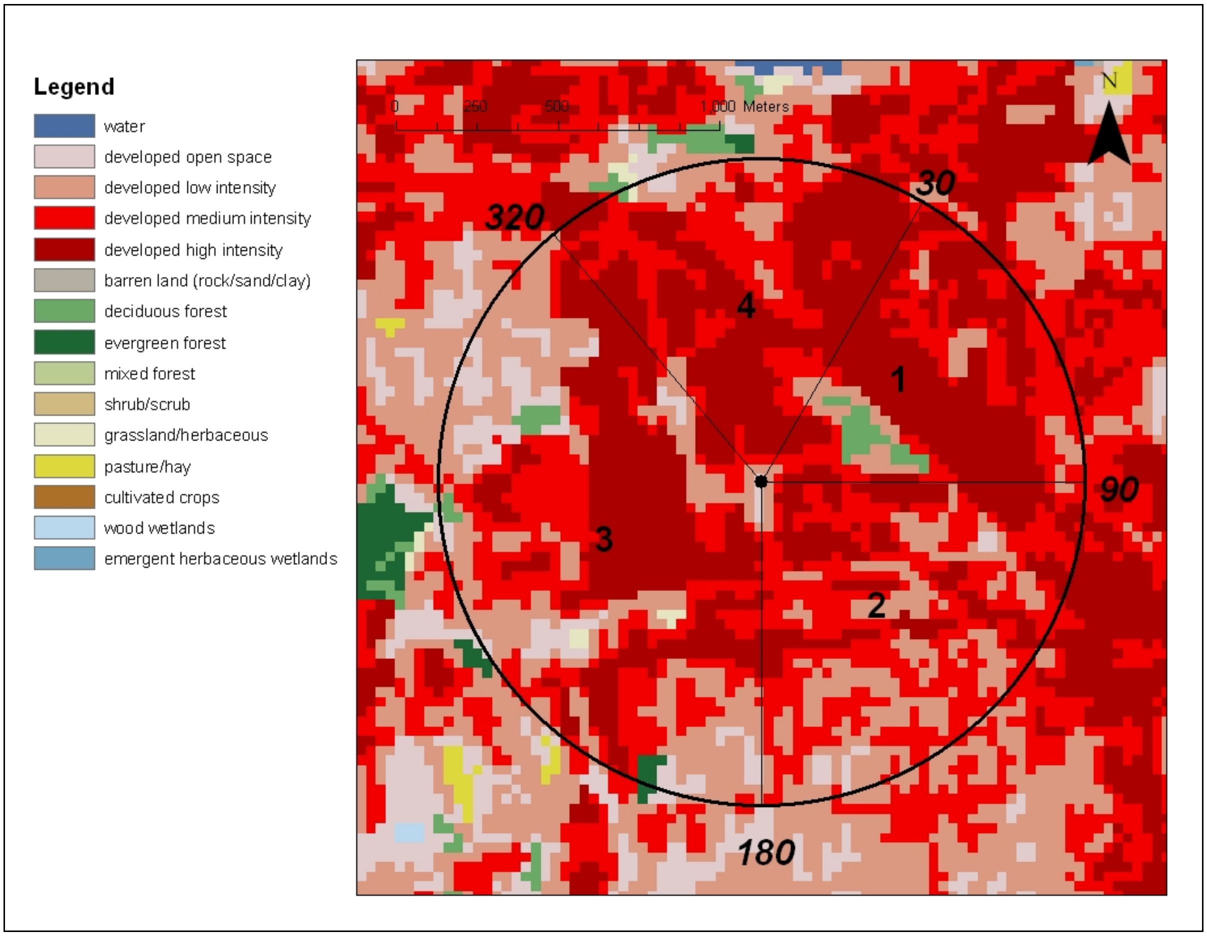

Figure 5. 2001 NLCD for JST with surface roughness 1 km radius and sectors (denoted by numbers 1 through 4). Numbers outside 1 km radius are the starting directions of each sector.

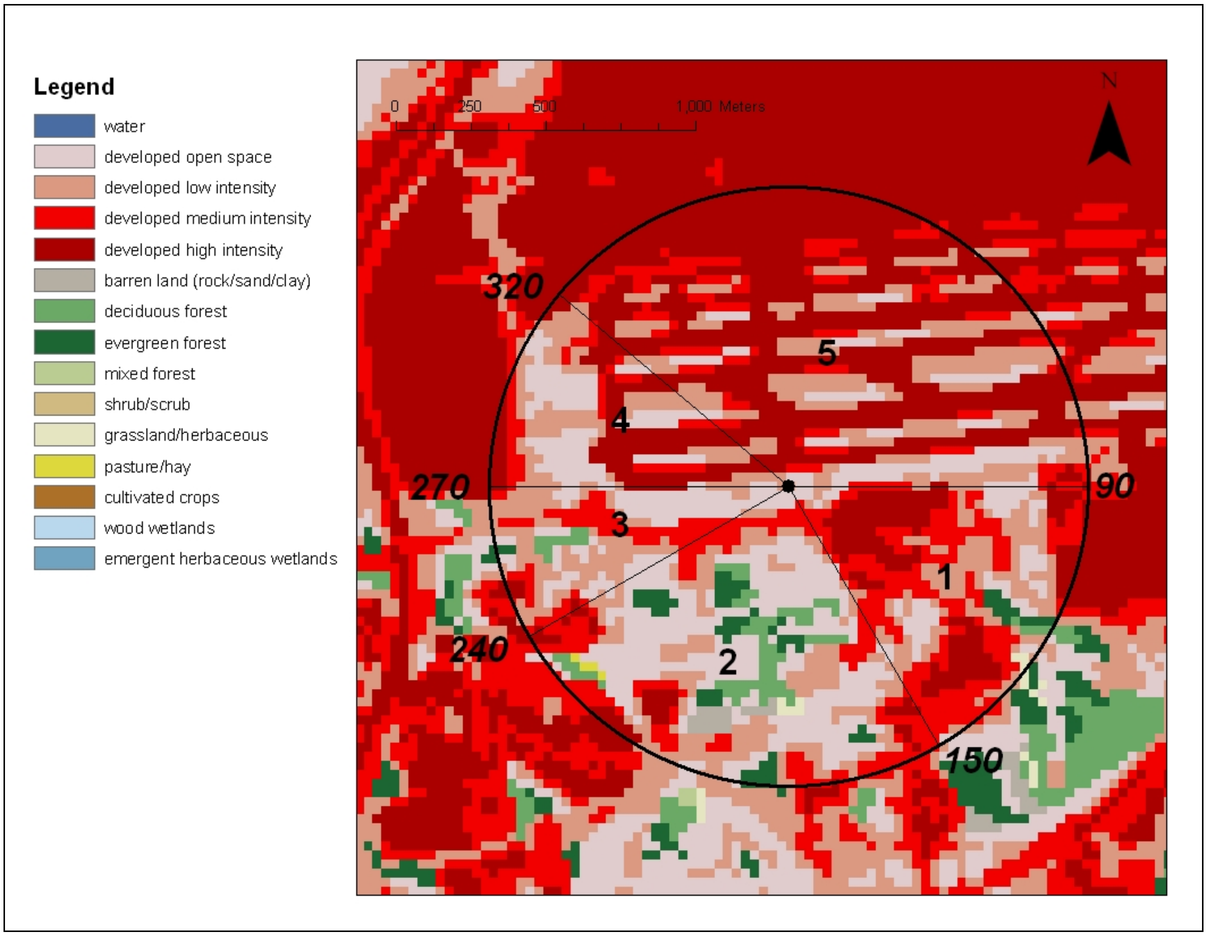

Figure 6. 2001 NLCD for ATL with surface roughness 1 km radius and sectors (denoted by numbers 1 through 5). Numbers outside 1 km radius are the starting directions of each sector.

Table 3. Assignment of average, dry, or wet conditions for each month for ATL and JST for 2001, 2002, and 2003.

Month	Year		
	2001	2002	2003
January	Average	Average	Dry
February	Average	Average	Average
March	Average	Average	Average
April	Average	Average	Average
May	Average	Average	Wet
June	Average	Average	Average
July	Dry	Average	Average
August	Dry	Dry	Average
September	Average	Average	Average
October	Dry	Average	Dry
November	Dry	Average	Average
December	Average	Average	Average

6. AERMET

The meteorological data files (upper air, ATL ISH data, JST surface data, and ATL one minute data) were processed in AERMET, which includes three "Stages" for processing of meteorological data. Stage 1 was used to read in all the data files and perform initial QA. The upper air data was processed via the UPPERAIR pathway. The ATL ISH data was processed via the SURFACE pathway, and the JST surface data and ATL one minute hourly average winds were processed via the ONSITE pathway. Winds and temperatures were read into AERMET for the JST data and hourly averaged winds were read into AERMET for the ATL one minute hourly average winds. For JST, the THRESHOLD keyword was set to 0.28 m/s as described in Section 2. For the hourly averaged one minute ATL winds, the threshold was set to 0.01 m/s.

For each year, there were two separate runs of Stage 2 of AERMET, the merging of surface data and upper air data; one for ATL and one for JST. For ATL, the Stage 1 upper air output, ATL ISH output, and ATL one minute output were merged together via the MERGE pathway. For JST, the upper air output, ATL ISH output, and JST output were merged together.

As with Stage 2, there were two separate Stage 3 runs for each year. First, for ATL, the output from Stage 2 was processed. For each year, the year specific surface characteristics created by concatenating the appropriate surface characteristics for each month were used. The ATL one minute hourly averaged winds would be the primary source of wind data. All other variables would come from the ATL ISH data. ATL ISH winds would be used only when the ATL one minute hourly averaged winds were missing. The substitution was done via the SUBNWS keyword in the Stage 3 input file. The anemometer height was set to 10 m (keyword NWS_HGT).

The second run was for JST. The JST winds and temperature would be the primary source of data. Other variables would come from the ATL ISH data and the ATL winds or temperature would be used only when the values were missing for JST for a particular hour. Surface characteristics were the year specific surface characteristics for JST. For later post-processing, the NWS_HGT keyword was set to 9.9 m. This would allow for identification of hours where the ATL winds were used. For hours with valid data at the JST site, the 10 m height read into AERMET from the JST met file in stage 1 would be used. Note that even for hours using ATL data, surface characteristics for JST were used.

After AERMET processing for each year for JST and ATL, a FORTRAN program was used to substitute the records from the ATL *.SFC and *.PFL files into the JST *.SFC and *.PFL files when ATL data was substituted for missing values in the JST data (anemometer heights of 9.9 m). This substitution was done so that the ATL hours that were substituted into the JST data would have data based on the ATL surface characteristics. The entire record, including anemometer heights, was substituted. The resulting files were a hybrid of JST data and ATL hybrid data. The number of hours substituted with ATL data were 165, 497, and 792 for 2001, 2002, and 2003 respectively.

7. Adjustment of mechanical mixing heights

Preliminary model-to-monitor comparisons using the processed meteorological data for JST should generally good agreement between modeled and observed concentrations. However, several spuriously high 1-hour modeled concentrations were also noted. Examination of the meteorological conditions associated with these high modeled concentrations indicated a consistent pattern of occurring on the first convective hour of the day. This was indicative of an issue with the AERMOD model formulation for the urban option that has been identified, but has not been addressed yet. The urban option in AERMOD currently applies only to nighttime stable hours when the urban heat island effect is expected to increase turbulence relative to the surrounding rural areas. The issue that contributes to these high modeled concentrations for Atlanta is that the urban-enhanced turbulence disappears once the atmosphere becomes convective, with no transitional period to account for residual enhanced turbulence that is likely to occur during the transition from night to day. As a result, low-level releases may be subjected to very limited mixing conditions for the first convective hour of the day, which may lead to unrealistically high concentrations. Every outlier examined was consistent with this pattern, and no such anomalies occurred at other hours of the day. In one case, the 1-hour concentration for the last stable hour was about an order of magnitude lower then the concentration for the first convective hour, with very similar wind speeds and directions.

In order to minimize the impact that these anomalously high 1-hour concentrations may have on the exposure assessment for Atlanta, an adjustment was made to the mechanical mixing heights in the processed meteorological data files for the first convective hour of each day. Morning mechanical mixing heights for both JST and ATL were adjusted for the first convective hour of each day to apply a minimum value of 240 meters. If the mechanical mixing height calculated by AERMET was less than 240 meters, it was reset to 240 meters, and if it was larger than 240 meters then no change was made. This adjustment was intended to account for some limited residual mixing from the urban nighttime boundary layer for the first convective hour. The value of 240 meters is about one half of the urban nighttime boundary layer for a city with the population of Atlanta. Modifying only the mechanical mixing height is considered a reasonable approach to account for residual turbulence since the convective mixing height is driven directly by the daytime solar heating. This adjustment may underestimate the amount of residual mixing that could occur, but is considered to be a reasonable compromise for this application, and subsequent modeling comparisons indicated much better agreement between modeled and monitored concentrations.

8. Analysis of processed meteorology

Table 4 lists the number of hours that were based on one-minute hourly averaged winds for ATL. Table 4 also lists the number of calms and missing winds for the hybrid ATL data and ISH data for ATL. For each year, over 90% of the winds were hourly averaged winds from the one-minute data and the number of calms and missing winds were dramatically reduced.

Table 4. Number of hours using hourly averaged one minute winds and number of calms and missing winds for ATL hybrid data and ATL ISH data.

		One minute		ISH	
Year	**One minute hours**	**calms**	**Missing**	**calms**	**missing**
2001	8028 (92%)	118	48	917	645
2002	7959 (91%)	85	43	856	492
2003	8171 (93%)	123	19	765	277

Wind roses and histograms of wind speed for JST and ATL inputs into AERMOD are shown in Figures 7 through 9 for 2001, 2002, and 2003. Both sites exhibit similar wind roses, with predominant wind directions from the northwest and secondary peaks generally from the east or southwest.

Both the wind roses and histograms show a larger number of lower wind speeds for the JST site than for the ATL site, even with the one minute hourly averaged winds included in the ATL data. This is consistent with expected influence on wind speeds of the higher surface roughness surrounding the JST site as compared to the ATL site.

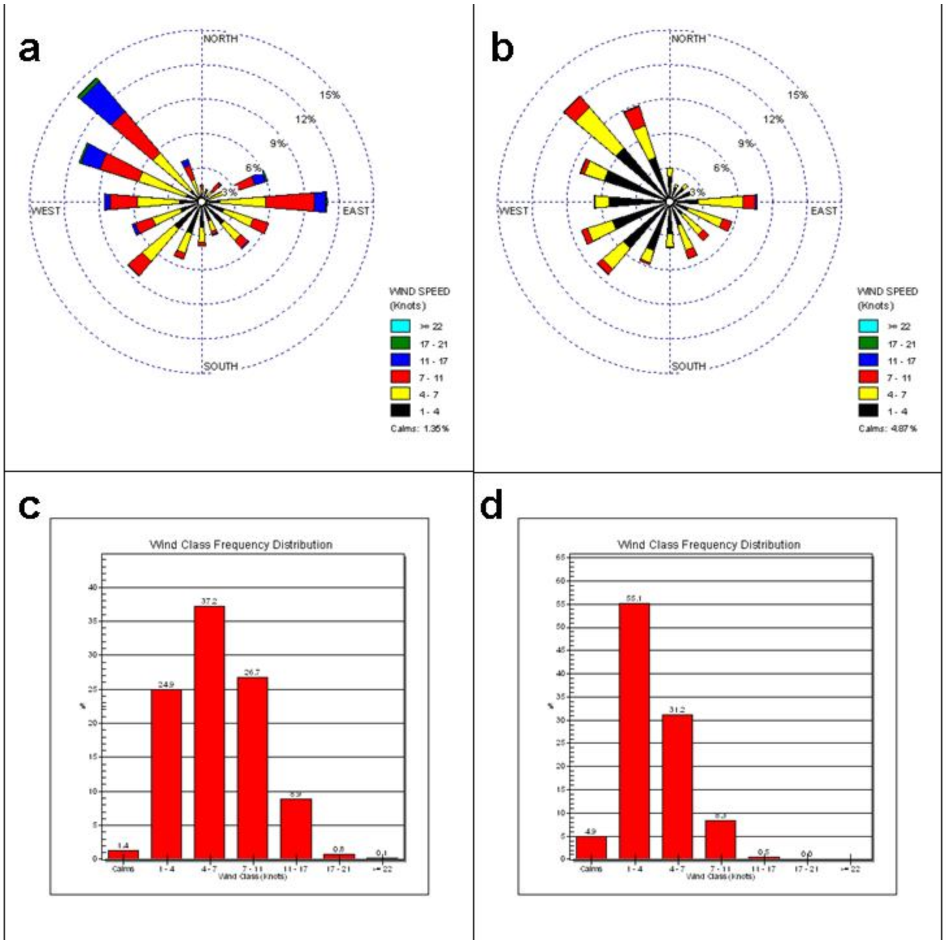

Figure 7. 2001 wind roses and wind speed histograms for a) ATL hybrid, b) JST hybrid, c) ATL hybrid and d) JST hybrid.

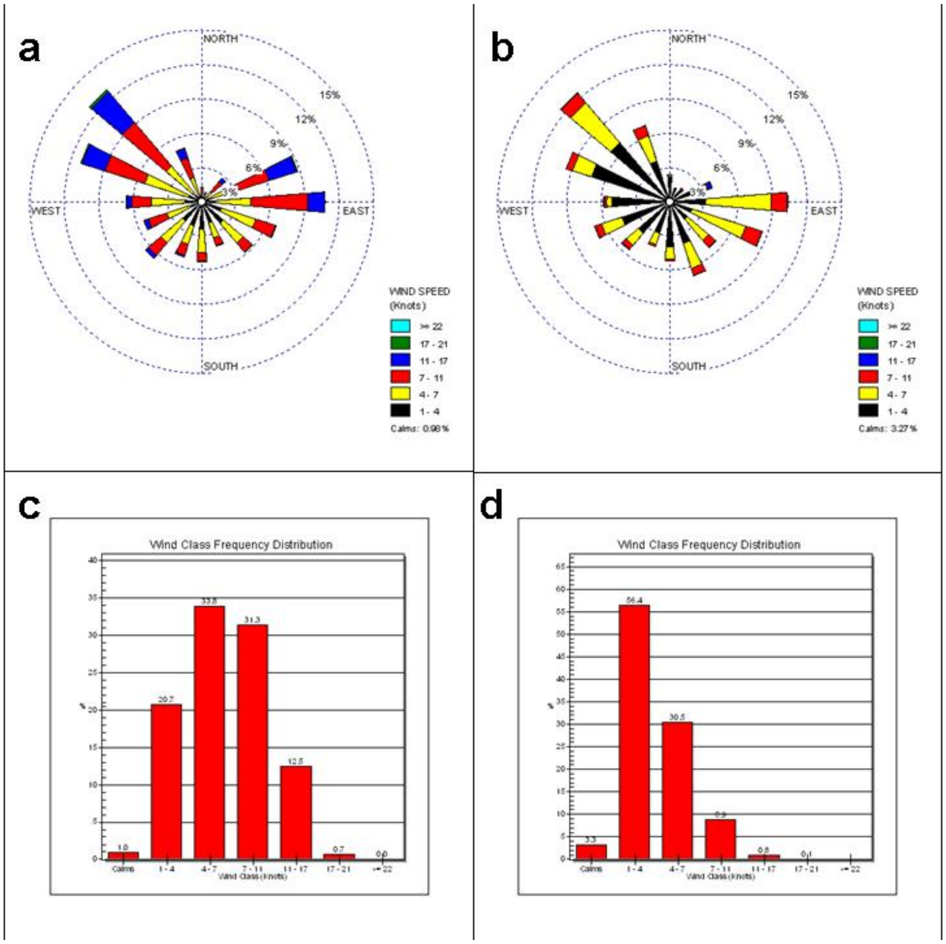

Figure 8. 2002 wind roses and wind speed histograms for a) ATL hybrid, b) JST hybrid, c) ATL hybrid and d) JST hybrid.

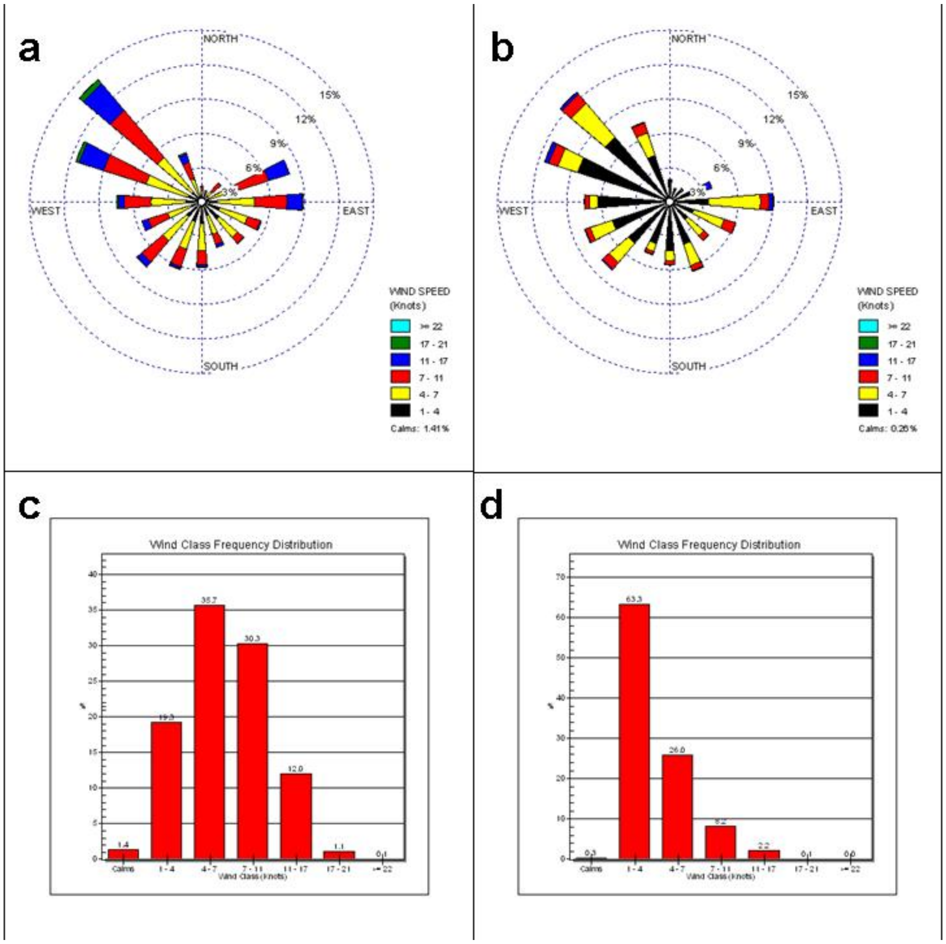

Figure 9. 2002 wind roses and wind speed histograms for a) ATL hybrid, b) JST hybrid, c) ATL hybrid and d) JST hybrid.

9. References

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Attachment 2: Technical Memorandum on Longitudinal Diary Construction Approach

ICF INTERNATIONAL

TECHNICAL MEMORANDUM

TO: Stephen Graham and John Langstaff, US EPA

FROM: Arlene Rosenbaum

DATE: February 29, 2008

SUBJECT: The Cluster-Markov algorithm in APEX

Background

The goals of population exposure assessment generally include an accurate estimate of both the average exposure concentration and the high end of the exposure distribution. One of the factors influencing the number of exposures at the high end of the concentration distribution is time-activity patterns that differ from the average, e.g., a disproportionate amount of time spent near roadways. Whether a model represents these exposure scenarios well depends on whether the treatment of activity pattern data accurately characterizes differences among individuals.

Human time-activity data for population exposure models are generally derived from demographic surveys of individuals' daily activities, the amount of time spent engaged in those activities, and the ME locations where the activities occur. Typical time-activity pattern data available for inhalation exposure modeling consist of a sequence of location/activity combinations spanning a 24-hour duration, with 1 to 3 records for any single individual. But modeling assessments of exposure to air pollutants typically require information on activity patterns over long periods of time, e.g., a full year. For example, even for pollutant health effects with short averaging times (e.g., ozone 8-hour average) it may be desirable to know the frequency of exceedances of a threshold concentration over a long period of time (e.g., the annual number of exceedances of an 8-hour average ozone concentration of 0.07 ppm for each simulated individual).

Long-term activity patterns can be estimated from daily ones by combining the daily records in various ways, and the method used for combining them will influence the variability of the long-term activity patterns across the simulated population. This in turn will influence the ability of the model to accurately represent either long-term average high-end exposures, or the number of individuals exposed multiple times to short-term high-end concentrations.

A common approach for constructing long-term activity patterns from short-term records is to re-select a daily activity pattern from the pool of data for each day, with the implicit assumption that there is no correlation between activities from day to day for the simulated individual. This approach tends to result in long-term activity patterns that are very similar across the simulated population. Thus, the resulting exposure estimates are likely to underestimate the variability across the population, and therefore, underestimate the high-end concentrations.

A contrasting approach is to select a single activity pattern (or a single pattern for each season and/or weekday-weekend) to represent a simulated individual's activities over the modeling period. This approach has the implicit assumption that an individual's day to day activities are perfectly correlated. This approach tends to result in long-term activity patterns that are very different across the simulated population, and therefore may over-estimate the variability across the population.

The Cluster-Markov Algorithm

Recently, a new algorithm has been developed and incorporated into APEX that attempts to more realistically represent the day-to-day correlation of activities for individuals. The algorithms first use cluster analysis to divide the daily activity pattern records into groups that are similar, and then select a single daily record from each group. This limited number of daily patterns is then used to construct a long-term sequence for a simulated individual, based on empirically-derived transition probabilities. This approach is intermediate between the assumption of no day-to-day correlation (i.e., re-selection for each time period) and perfect correlation (i.e., selection of a single daily record to represent all days).

The steps in the algorithm are as follows.

- For each demographic group (age, gender, employment status), temperature range, and day-of-week combination, the associated time-activity records are partitioned into 3 groups using cluster analysis. The clustering criterion is a vector of 5 values: the time spent in each of 5 microenvironment categories (indoors – residence; indoors – other building; outdoors – near road; outdoors – away from road; in vehicle).
- For each simulated individual, a single time-activity record is randomly selected from each cluster.
- Next the Markov process determines the probability of a given time-activity pattern occurring on a given day based on the time-activity pattern of the previous day and cluster-to-cluster transition probabilities. The cluster-to-cluster transition probabilities are estimated from the available multi-day time-activity records. (If insufficient multi-day time-activity records are available for a demographic group, season, day-of-week combination, then the cluster-to-cluster transition probabilities are estimated from the frequency of time-activity records in each cluster in the CHAD data base.).

Figure 1 illustrates the Cluster-Markov algorithm in flow chart format.

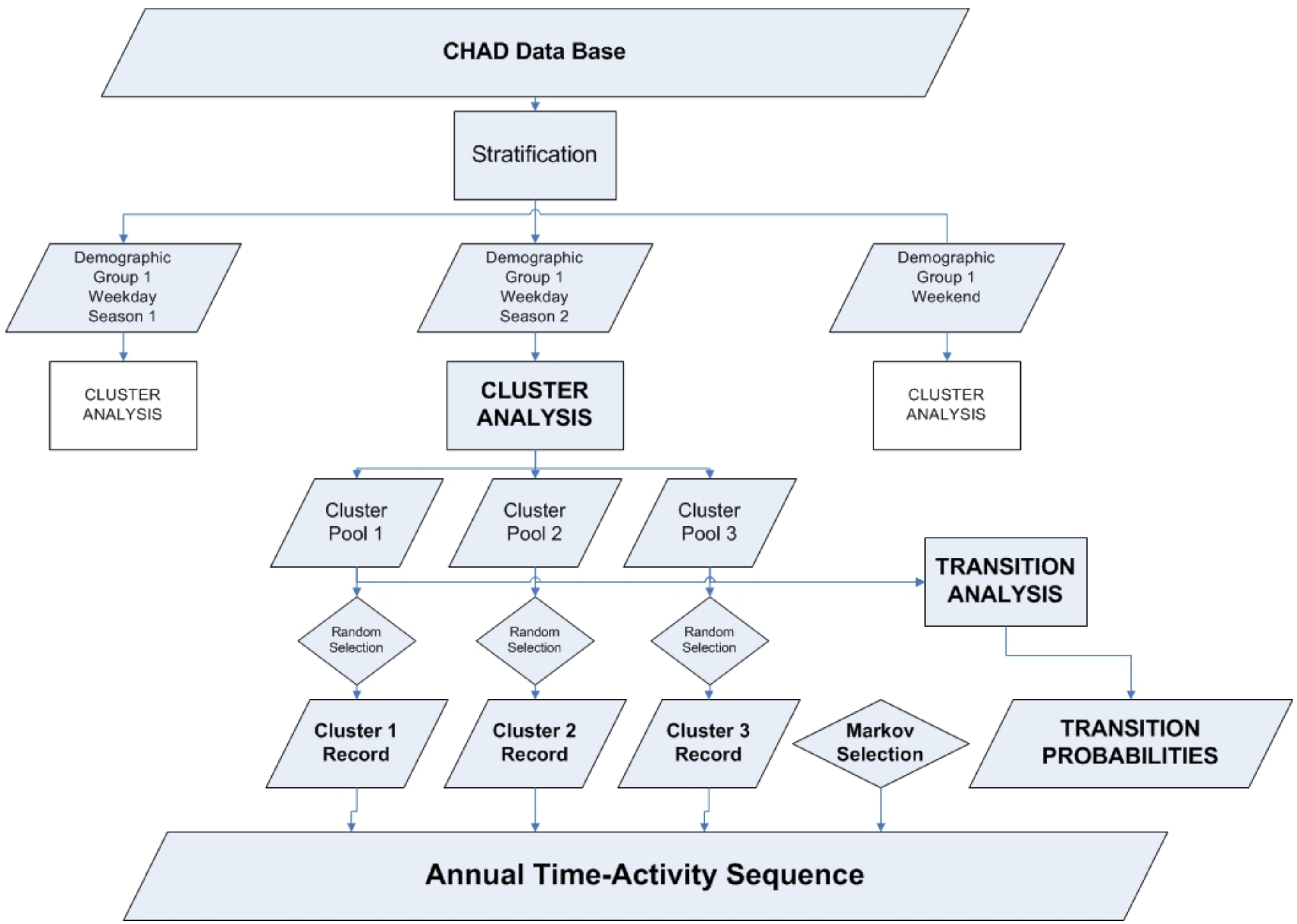

Figure 1. Flow chart of Cluster-Markov algorithm used for constructing longitudinal time-activity diaries.

Evaluation of modeled diary profiles versus observed diary profiles

The Cluster-Markov algorithm is also incorporated into the Hazardous Air Pollutant Exposure Model (HAPEM). Rosebaum and Cohen (2004) incorporated the algorithm in HAPEM and tested modeled longitudinal profiles with multi-day diary data sets collected as part of the Harvard Southern California Chronic Ozone Exposure Study (Xue et al. 2005, Geyh et al. 2000). In this study, 224 children in ages between 7 and 12 yr were followed for 1 year from June 1995 to May 1996, for 6 consecutive days each month. The subjects resided in two separate areas of San Bernardino County: urban Upland CA, and the small mountain towns of Lake Arrowhead, Crestline, and Running Springs, CA.

For purposes of clustering the activity pattern records were characterized according to time spent in each of 5 aggregate microenvironments: indoors-home, indoors-school, indoors-other, outdoors, and in-transit. For purposes of defining diary pools and for clustering and calculating transition probabilities the activity pattern records were divided by day type (i.e., weekday, weekend), season (i.e., summer or ozone season, non-summer or non-ozone season), age (7-10 and 11-12), and gender.

Week-long sequences (Wednesday through Tuesday) for each of 100 people in each age/gender group for each season were simulated. To evaluate the algorithm the following statistics were calculated for the predicted multi-day activity patterns and compared them with the actual multi-day diary data.

- For each age/gender group for each season, the average time in each microenvironment
- For each simulated person-week and microenvironment, the average of the within-person variance across all simulated persons. (The within-person variance was defined as the variance of the total time per day spent in the microenvironment across the week.)
- For each simulated person-week the variance across persons of the mean time spent in each microenvironment.

In each case the predicted statistic for the stratum was compared to the statistic for the corresponding stratum in the actual diary data. The mean normalized bias for the statistic, which is a common performance measure used in dispersion model performance and was also calculated as follows.

$$NBIAS = \frac{100}{N}\sum_{1}^{N}\frac{(predicted - observed)}{observed}$$

The predicted time-in-microenvironment averages matched well with the observed values. For combinations of microenvironment/age/gender/season the normalized bias ranges from –35% to +41%. Sixty percent of the predicted averages have bias between –9% and +9%, and the mean bias across any microenvironment ranges from -9% to +4%. Fourteen predictions have positive bias and 23 have negative bias.

For the variance across persons for the average time spent in each microenvironment, the bias ranged from –40% to +120% for any microenvironment/age/gender/season. Sixty-five percent of the predicted variances had bias between –22% and +24%. The mean normalized bias across any microenvironment ranged from –10% to +28%. Eighteen predictions had positive bias and 20 had negative bias.

For the within-person variance for time spent in each microenvironment, the bias ranged from –47% to +150% for any microenvironment/age/gender/season. Seventy percent of the predicted variances had bias between –25% and +30%. The mean normalized bias across any microenvironment ranged from –11% to +47%. Twenty-eight predictions had positive bias and 12 had negative bias, suggesting some tendency for overprediction of this variance measure.

The overall conclusion was that the proposed algorithm appeared to be able to replicate the observed data reasonably well. Although some discrepancies were rather large for some of the "variance across persons" and "within-person variance" subsets, about two-thirds of the predictions for each case were within 30% of the observed value. A detailed description of the evaluation using HAPEM is presented in Attachment 3.

Comparison of Cluster-Markov approach with other algorithms

As part of the application of APEX in support of US EPA's recent review of the ozone NAAQS several sensitivity analyses were conducted (US EPA, 2007). One of these was to make parallel simulations using each of the three algorithms for constructing multi-day time-activity sequences that are incorporated into APEX.

Table 1 presents the results for the number of persons in Atlanta population groups with moderate exertion exposed to 8-hour average concentrations exceeding 0.07 ppm. The results show that the predictions made with alternative algorithm Cluster-Markov algorithm are substantially different from those made with simple re-sampling or with the Diversity-Autocorrelation algorithm ("base case"). Note that for the cluster algorithm approximately 30% of the individuals with 1 or more exposure have 3 or more exposures. The corresponding values for the other algorithms range from about 13% to 21%.

Table 2 presents the results for the mean and standard deviation of number of days/person with 8-hour average exposures exceeding 0.07 ppm with moderate or greater exertion. The results show that although the mean for the Cluster-Markov algorithm is similar to the other approaches, the standard deviation is substantially higher, i.e., the Cluster-Markov algorithm results in substantially higher inter-individual variability.

Table 1. Sensitivity to longitudinal diary algorithm: 2002 simulated counts of Atlanta general population and children (ages 5-18) with any or three or more 8-hour ozone exposures above 0.07 ppm concomitant with moderate or greater exertion (after US EPA 2007).

Population Group	One or more exposures			Three or more exposures		
	Simple re-sampling	Diversity-Autocorrelation	Cluster-Markov	Simple re-sampling	Diversity-Autocorrelation	Cluster-Markov
General Population	979,533	939,663 (-4%)	668,004 (-32%)	124,687	144,470 (+16%)	188,509 (+51%)
Children (5-18)	411,429	389,372 (-5%)	295,004 (-28%)	71,174	83,377 (+17%)	94,216 (+32%)

Table 2. Sensitivity to longitudinal diary algorithm: 2002 days per person with 8-hour ozone exposures above 0.07 ppm concomitant with moderate or greater exertion for Atlanta general population and children (ages 5-18) (after US EPA 2007).

Population Group	Mean Days/Person			Standard Deviation		
	Simple re-sampling	Base case	Cluster-Markov	Simple re-sampling	Base case	Cluster-Markov
General Population	0.332	0.335 (+1%)	0.342 (+3%)	0.757	0.802 (+6%)	1.197 (+58%)
Children (5-18)	0.746	0.755 (+1%)	0.758 (+2%)	1.077	1.171 (+9%)	1.652 (+53%)

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Rosenbaum AS and Cohen JP. (2004). Evaluation of a multi-day activity pattern algorithm for creating longitudinal activity patterns. Memorandum prepared for Ted Palma, US EPA OAQPS, by ICF International.

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Xue J, Liu SV, Ozkaynak H, Spengler J. (2005). Parameter evaluation and model validation of ozone exposure assessment using Harvard Southern California Chronic Ozone Exposure Study Data. *J. Air & Waste Manage Assoc.* 55:1508–1515.

Attachment 3: Technical Memorandum on the Evaluation Cluster-Markov Algorithm

TECHNICAL MEMORANDUM

TO: Ted Palma, US EPA

FROM: Arlene Rosenbaum and Jonathan Cohen, ICF Consulting

DATE: November 4, 2004

SUBJECT: Evaluation of a multi-day activity pattern algorithm for creating longitudinal activity patterns.

BACKGROUND

In previous work ICF reviewed the HAPEM4 modeling approach for developing annual average activity patterns from the CHAD database and recommended an approach to improve the model's pattern selection process to better represent the variability among individuals. This section summarizes the recommended approach. (For details see Attachment 2)

Using cluster analysis, first the CHAD daily activity patterns are grouped into either two or three categories of similar patterns for each of the 30 combinations of day type (summer weekday, non-summer weekday, and weekend) and demographic group (males or females; age groups: 0-4, 5-11, 12-17, 18-64, 65+). Next, for each combination of day type and demographic group, category-to-category transition probabilities are defined by the relative frequencies of each second-day category associated with each given first-day category, where the same individual was observed for two consecutive days. (Consecutive day activity pattern records for a single individual constitute a small subset of the CHAD data.)

To implement the proposed algorithm, for each day type and demographic group, one daily activity pattern per category is randomly selected from the corresponding CHAD data to represent that category. That is, if there are 3 cluster categories for each of 3 day types, 9 unique activity patterns are selected to be averaged together to create an annual average activity pattern to represent an individual in a given demographic group and census tract.

The weighting for each of the 9 activity patterns used in the averaging process is determined by the product of two factors. The first is the relative frequency of its day type, i.e., 0.18 for summer weekdays, 0.54 for non-summer weekdays, and 0.28 for weekends.

The second factor in the weighting for the selected activity pattern is determined by simulating a sequence of category-types as a one-stage Markov chain process using the transition probabilities. The category for the first day is selected according to the relative frequencies of each category. The category for the second day is selected according to the category-to-category transition probabilities for the category selected for the first day. The category for the third day is selected according to the transition probabilities for the category selected for the second day. This is repeated for all days in the day type (65 for summer weekdays, 195 for non-summer weekdays, 104 for weekends), producing a sequence of daily categories. The relative frequency of the category-type in the sequence associated with the selected activity pattern is the second factor in the weighting.

PROPOSED ALGORITHM STEPS

The proposed algorithm is summarized in Figure 1. Each step is explained in this section.

Data Preparation

Step 1: Each daily activity pattern in the CHAD data base is summarized by the total minutes in each of five micro-environments: indoors – residence; indoors – other building; outdoors – near road; outdoors – away from road; in vehicle. These five numbers are assumed to represent the most important features of the activity pattern for their exposure impact.

Step 2: All CHAD activity patterns for a given day-type and demographic group are subjected to cluster analysis, resulting in 2 or 3 cluster categories. Each daily activity pattern is tagged with a cluster category.

Step 3: For each day-type and demographic group, the relative frequency of each day-type in the CHAD data base is determined.

Step 4: All CHAD activity patterns for a given day-type and demographic group that are consecutive days for a single individual, are analyzed to determine the category-to-category transition frequencies in the CHAD data base. These transition frequencies are used to calculate category-to-category transition probabilities.

For example, if there are 2 categories, A and B, then

P_{AA} = the probability that a type A pattern is followed by a type A pattern,

P_{AB} = the probability that a type A pattern is followed by a type B pattern ($P_{AB} = 1 - P_{AA}$),

P_{BB} = the probability that a type B pattern is followed by a type B pattern, and

P_{BA} = the probability that a type B pattern is followed by a type A pattern ($P_{BA} = 1 - P_{BB}$).

Activity Pattern Selection

For each day-type and demographic group in each census tract:

Step 5: One activity pattern is randomly selected from each cluster category group (i.e., 2 to 3 activity patterns)

Creating Weights for Day-type Averaging

For each day-type and demographic group in each census tract:

Step 6: A cluster category is selected for the first day of the day-type sequence, according to the relative frequency of the cluster category days in the CHAD data set.

Step 7: A cluster category is selected for each subsequent day in the day-type sequence day by day using the category-to-category transition probabilities.

Step 8: The relative frequency of each cluster category in the day-type sequence is determined.

Step 9: The activity patterns selected for each cluster category (Step 5) are averaged together using the cluster category frequencies (Step 8) as weights, to create a day-type average activity pattern.

Creating Annual Average Activity Patterns

For each demographic group in each census tract:

Step 10: The day-type average activity patterns are averaged together using the relative frequency of day-types as weights, to create an annual average activity pattern.

Creating Replicates

For each demographic group in each census tract:

Step 11: Steps 5 through 10 are repeated 29 times to create 30 annual average activity patterns.

EVALUATING THE ALGORITHM

The purpose of this study is to evaluate how well the proposed one-stage Markov chain algorithm can reproduce observed multi-day activity patterns with respect to demographic group means and inter-individual variability, while using one-day selection.

In order to accomplish this we propose to apply the algorithm to observed multi-day activity patterns provided by the WAM, and compare the means and variances of the predicted multi-day patterns with the observed patterns.

Current APEX Algorithm

Because the algorithm is being considered for incorporation into APEX, we would like the evaluation to be consistent with the approach taken in APEX for selection of activity patterns for creating multi-day sequences. The APEX approach for creating multi-day activity sequences is as follows.

Step1: A profile for a simulated individual is generated by selection of gender, age group, and home sector from a given set of distributions consistent with the population of the study area.

Step 2: A specific age within the age group is selected from a uniform distribution.

Step 3: The employment status is simulated as a function of the age.

Step 4: For each simulated day, the user defines an initial pool of possible diary days based on a user-specified function of the day type (e.g., weekday/weekend) and temperature.

Step 5: The pool is further restricted to match the target gender and employment status exactly and the age within 2A years for some parameter A. The diary days within the pool are assigned a weight of 1 if the age is within A years of the target age and a weight of w (user-defined parameter) if the age difference is between A and 2A years. For each simulated day, the probability of selecting a given diary day is equal to the age weight divided by the total of the age weights for all diary days in the pool for that day.

Approach to Incorporation of Day-to-Day Dependence into APEX Algorithm

If we were going to incorporate day-to-day dependence of activity patterns into the APEX model, we would propose preparing the data with cluster analysis and transition probabilities as described in Steps 1-4 for the proposed HAPEM 5 algorithm, with the following modifications.

- For Step 2 the activity patterns would be divided into groups based on day-type (weekday, weekend), temperature, gender, employment status, and age, with cluster analysis applied to each group. However, because the day-to-day transitions in the APEX activity selection algorithm can cross temperature bins, we would propose to use broad temperature bins for the clustering and transition probability calculations so that the cluster definitions would be fairly uniform across temperature bins. Thus we would probably define the bins according to season (e.g., summer, non-summer).
- In contrast to HAPEM, the sequence of activity patterns may be important in APEX. Therefore, for Step 4 transition probabilities would be specified for transitions between days with the same day-type and season, as in HAPEM, and also between days with different day-types and/or seasons. For example, transition probabilities would be specified for transitions between summer weekdays of each category and summer weekends of each category.

Another issue for dividing the CHAD activity records for the purposes of clustering and calculating transition probabilities is that the diary pools specified for the APEX activity selection algorithm use varying and overlapping age ranges. One way to address this problem would be to simply not include consideration of age in the clustering process, under the assumption that cluster categories are similar across age groups, even if the frequency of each cluster category varies by age group. This assumption could be tested by examination of the cluster categories stratified by age group that were developed for HAPEM5. If the assumption is found to be valid, then the cluster categories could be pre-determined for input to APEX, while the transition probabilities could be calculated within APEX during the simulation for each age range specified for dairy pools.

If the assumption is found to be invalid, then an alternative approach could be implemented that would create overlapping age groups for purposes of clustering as follows. APEX age group ranges and age window percentages would be constrained to some maximum values. Then a set of overlapping age ranges that would be at least as large as the largest possible dairy pool age ranges would be defined for the purposes of cluster analysis and transition probability calculation. The resulting sets of cluster categories and transition probabilities would be pre-determined for input into APEX and the appropriate set used by APEX for each diary pool used during the simulation.

The actual activity pattern sequence selection would be implemented as follows. The activity pattern for first day in the year would be selected exactly as is currently done in APEX, as described above. For the selecting the second day's activity pattern, each age weight would be multiplied by the transition probability P_{AB} where A is the cluster for the first day's activity pattern and B is the cluster for a given activity pattern in the available pool of diary days for day 2. (Note that day 2 may be a different day-type and/or season than day 1). The probability of selecting a given diary day on day 2 is equal to the age weight times P_{AB} divided by the total of the products of age weight and P_{AB} for all diary days in the pool for day 2. Similarly, for the transitions from day 2 to day 3, day 3 to day 4, etc.

Testing the Approach with the Multi-day Data set

We tested this approach using the available multi-day data set. For purposes of clustering we characterized the activity pattern records according to time spent in each of 5 microenvironments: indoors-home, indoors-school, indoors-other, outdoors (aggregate of the 3 outdoor microenvironments), and in-transit.

For purposes of defining diary pools and for clustering and calculating transition probabilities we divided the activity pattern records by day type (i.e., weekday, weekend), season (i.e., summer or ozone season, non-summer or non-ozone season), age (6-10 and 11-12), and gender. Since all the subjects are 6-12 years of age and all are presumably unemployed, we need not account for differences in employment status. For each day type, season, age, and gender, we found that the activity patterns appeared to group in three clusters.

In this case, we simulated week-long sequences (Wednesday through Tuesday) for each of 100 people in each age/gender group for each season, using the transition probabilities. To evaluate the algorithm we calculated the following statistics for the predicted multi-day activity patterns for comparison with the actual multi-day diary data.

- For each age/gender group for each season, the average time in each microenvironment
- For each age/gender group, season, and microenvironment, the average of the within-person variance across all simulated persons (We defined the within-person variance as the variance of the total time per day spent in the microenvironment across the week.)
- For each age/gender group, season, and microenvironment, the variance across persons of the mean time spent in that microenvironment

In each case we compared the predicted statistic for the stratum to the statistic for the corresponding stratum in the actual diary data.[26]

We also calculated the mean normalized bias for the statistic, which is a common performance measure used in dispersion model performance and which is calculated as follows.

$$NBIAS = \frac{100}{N} \sum_{1}^{N} \frac{(predicted - observed)}{observed} \quad \%$$

RESULTS

Comparisons of simulated and observed data for time in each of the 5 microenvironments are presented in Tables 1 – 3 and Figures 2-5.

Average Time in Microenvironment

Table 1 and Figure 2 show the comparisons for the average time spent in each of the 5 microenvironments for each age/gender group and season. Figure 3 shows the comparison for all the microenvironments except indoor, home in order to highlight the lower values.

Table 1 and the figures show that the predicted time-in-microenvironment averages match well with the observed values. For combinations of microenvironment/age/gender/season the normalized bias ranges from –35% to +41%. Sixty percent of the predicted averages have bias between –9% and +9%, and the mean bias across any microenvironment ranges from -9% to +4%. Fourteen predictions have positive bias and 23 have negative bias. A Wilcoxon signed rank test that the median bias across the 40 combinations = 0 % was not significant (p-value = 0.40) supporting the conclusion of no overall bias.

Variance Across Persons

Table 2 and Figure 4 show the comparisons for the variance across persons for the average time spent in each microenvironment. In this case the bias ranges from –40% to +120% for any microenvironment/age/gender/season. Sixty-five percent of the predicted variances have bias between –22% and +24%. The mean normalized bias across any microenvironment ranges from –10% to +28%. Eighteen predictions have positive bias and 20 have negative bias. Figure 4 suggests a reasonably good match of predicted to observed variance in spite of 2 or 3 outliers. A Wilcoxon signed rank test that the median bias across the 40 combinations = 0 % was not significant (p-value = 0.93) supporting the conclusion of no overall bias.

Within-Person Variance for Persons

[26] For the diary data, because the number of days per person varies, the average of the within-person variances was calculated as a weighted average, where the weight is the degrees of freedom, i.e., one less than the number of days simulated. Similarly, the variance across persons of the mean time was appropriately adjusted for the different degrees of freedom using analysis of variance.

Table 3 and Figure 5 show the comparisons for the within-person variance for time spent in each microenvironment. In this case the bias ranges from –47% to +150% for any microenvironment/age/gender/season. Seventy percent of the predicted variances have bias between –25% and +30%. The mean normalized bias across any microenvironment ranges from –11% to +47%. Twenty-eight predictions have positive bias and 12 have negative bias, suggesting some tendency for overprediction of this variance measure. And indeed a Wilcoxon signed rank test that the median bias across the 40 combinations = 0 % was very significant (p-value = 0.01) showing that the within-person variance was significantly overpredicted. Still, Figure 4 suggests a reasonably good match of predicted to observed variance in most cases, with a few overpredicting outliers at the higher end of the distribution. So although the positive bias is significant in a statistical sense (i.e., the variance is more likely to be overpredicted than underpredicted), it is not clear whether the bias is large enough to be important.

CONCLUSIONS

The proposed algorithm appears to be able to replicate the observed data reasonably well, although the within-person variance is somewhat overpredicted.

It would be informative to compare this algorithm with the earlier alternative approaches in order to gain perspective on the degree of improvement, if any, afforded by this approach.

Two earlier approaches were:

1. Select a single activity pattern for each day-type/season combination from the appropriate set, and use that pattern for every day in the multi-day sequence that corresponds to that day-type and season.
2. Re-select an activity pattern for each day in the multi-day sequence from the appropriate set for the corresponding day-type and season.

Goodness-of-fit statistics could be developed to compare the three approaches and find which model best fits the data for a given stratum.

Table 1. Average time spent in each microenvironment: comparison of predicted and observed.

Microenvironment	Demographic Group	Season	Observed (hours/day)	Predicted (hours/day)	Normalized Bias
Indoor, home	Girls, 6-10	Summer	15.5	16.5	6%
		Not Summer	15.8	15.5	-2%
	Boys, 6-10	Summer	15.7	15.2	-3%
		Not Summer	15.8	16.4	4%
	Girls, 11-12	Summer	16.2	15.3	-5%
		Not Summer	16.5	16.5	0%
	Boys, 11-12	Summer	16.0	15.6	-3%
		Not Summer	16.2	16.1	-1%
	MEAN				-1%
Indoor, school	Girls, 6-10	Summer	0.7	0.7	-9%
		Not Summer	2.3	2.5	7%
	Boys, 6-10	Summer	0.8	0.5	-34%
		Not Summer	2.2	2.2	0%
	Girls, 11-12	Summer	0.7	0.7	6%
		Not Summer	2.1	2.4	13%
	Boys, 11-12	Summer	0.6	0.9	38%
		Not Summer	2.4	2.7	11%
	MEAN				4%
Indoor, other	Girls, 6-10	Summer	2.9	2.4	-14%
		Not Summer	2.4	2.7	13%
	Boys, 6-10	Summer	2.2	2.7	21%
		Not Summer	1.9	1.8	-3%
	Girls, 11-12	Summer	2.2	1.6	-25%
		Not Summer	2.2	2.1	-2%
	Boys, 11-12	Summer	2.3	2.2	-5%
		Not Summer	1.9	2.0	4%
	MEAN				-2%
Outdoors	Girls, 6-10	Summer	3.7	3.5	-6%
		Not Summer	2.5	2.5	0%
	Boys, 6-10	Summer	4.1	4.3	4%
		Not Summer	3.1	2.7	-12%
	Girls, 11-12	Summer	3.7	5.2	41%
		Not Summer	2.3	2.1	-5%
	Boys, 11-12	Summer	3.9	4.3	9%
		Not Summer	2.6	2.4	-7%
	MEAN				3%
In-vehicle	Girls, 6-10	Summer	1.1	0.9	-20%
		Not Summer	1.0	0.9	-13%
	Boys, 6-10	Summer	1.1	1.3	13%
		Not Summer	1.0	0.9	-16%
	Girls, 11-12	Summer	1.2	1.1	-12%
		Not Summer	0.9	0.8	-15%
	Boys, 11-12	Summer	1.1	1.0	-5%
		Not Summer	0.9	0.8	-7%
	MEAN				-9%

Table 2. Variance across persons for time spent in each microenvironment: comparison of predicted and observed.

Microenvironment	Demographic Group	Season	Observed $(hours/day)^2$	Predicted $(hours/day)^2$	Normalized Bias
Indoor, home	Girls, 6-10	Summer	70	42	-40%
		Not Summer	67	60	-9%
	Boys, 6-10	Summer	54	49	-9%
		Not Summer	35	30	-12%
	Girls, 11-12	Summer	56	47	-17%
		Not Summer	42	38	-10%
	Boys, 11-12	Summer	57	63	12%
		Not Summer	39	42	8%
	MEAN				-10%
Indoor, school	Girls, 6-10	Summer	6.0	5.2	-13%
		Not Summer	9.5	5.9	-38%
	Boys, 6-10	Summer	5.6	3.8	-32%
		Not Summer	5.3	8.2	53%
	Girls, 11-12	Summer	4.9	5.5	11%
		Not Summer	5.4	5.3	-1%
	Boys, 11-12	Summer	5.6	6.0	6%
		Not Summer	9.2	11	23%
	MEAN				1%
Indoor, other	Girls, 6-10	Summer	46	32	-30%
		Not Summer	44	46.	6%
	Boys, 6-10	Summer	34	33	-4%
		Not Summer	23	16	-27%
	Girls, 11-12	Summer	21	18	-15%
		Not Summer	28	22	-22%
	Boys, 11-12	Summer	33	31	-6%
		Not Summer	30	30	0%
	MEAN				-12%
Outdoors	Girls, 6-10	Summer	17	23	37%
		Not Summer	9.3	6.8	-27%
	Boys, 6-10	Summer	17	18	3%
		Not Summer	8.3	7.6	-8%
	Girls, 11-12	Summer	22	22	0%
		Not Summer	9.0	9.1	1%
	Boys, 11-12	Summer	13	29	120%
		Not Summer	10	11	8%
	MEAN				17%
In-vehicle	Girls, 6-10	Summer	1.9	2.3	24%
		Not Summer	1.8	1.6	-11%
	Boys, 6-10	Summer	2.5	4.7	93%
		Not Summer	1.5	1.6	9%
	Girls, 11-12	Summer	3.5	4.7	34%
		Not Summer	2.8	2.0	-28%
	Boys, 11-12	Summer	3.2	5.4	69%
		Not Summer	1.3	1.7	35%
	MEAN				28%

Table 3. Average within person variance for time spent in each microenvironment: comparison of predicted and observed.

Microenvironment	Demographic Group	Season	Observed $(hours/day)^2$	Predicted $(hours/day)^2$	Normalized Bias
Indoor, home	Girls, 6-10	Summer	20	29	49%
		Not Summer	18	23	25%
	Boys, 6-10	Summer	17	30	75%
		Not Summer	15	24	64%
	Girls, 11-12	Summer	22	42	93%
		Not Summer	22	25	13%
	Boys, 11-12	Summer	21	24	16%
		Not Summer	17	24	38%
	MEAN				47%
Indoor, school	Girls, 6-10	Summer	2.3	2.4	5%
		Not Summer	7.3	6.4	-12%
	Boys, 6-10	Summer	2.0	1.5	-25%
		Not Summer	6.7	5.8	-14%
	Girls, 11-12	Summer	1.7	2.1	29%
		Not Summer	7.4	7.6	3%
	Boys, 11-12	Summer	1.4	2.9	101%
		Not Summer	7.3	7.8	6%
	MEAN				12%
Indoor, other	Girls, 6-10	Summer	14	14	-4%
		Not Summer	14	18	30%
	Boys, 6-10	Summer	12	17	42%
		Not Summer	10	13	26%
	Girls, 11-12	Summer	10	10	1%
		Not Summer	14	15	7%
	Boys, 11-12	Summer	11	14	26%
		Not Summer	12	13	7%
	MEAN				17%
Outdoors	Girls, 6-10	Summer	8.4	9.5	13%
		Not Summer	3.4	3.2	-3%
	Boys, 8-10	Summer	6.7	9.5	42%
		Not Summer	3.4	4.4	28%
	Girls, 11-12	Summer	10	25	150%
		Not Summer	4.0	4.5	11%
	Boys, 11-12	Summer	9.2	7.4	-20%
		Not Summer	4.3	3.7	-15%
	MEAN				26%
In-vehicle	Girls, 6-10	Summer	1.0	0.90	-13%
		Not Summer	0.90	0.48	-47%
	Boys, 6-10	Summer	1.1	1.4	31%
		Not Summer	0.81	0.71	-12%
	Girls, 11-12	Summer	1.3	1.3	4%
		Not Summer	1.3	1.1	-16%
	Boys, 11-12	Summer	2.4	1.6	-34%
		Not Summer	0.85	0.85	1%
	MEAN				-11%

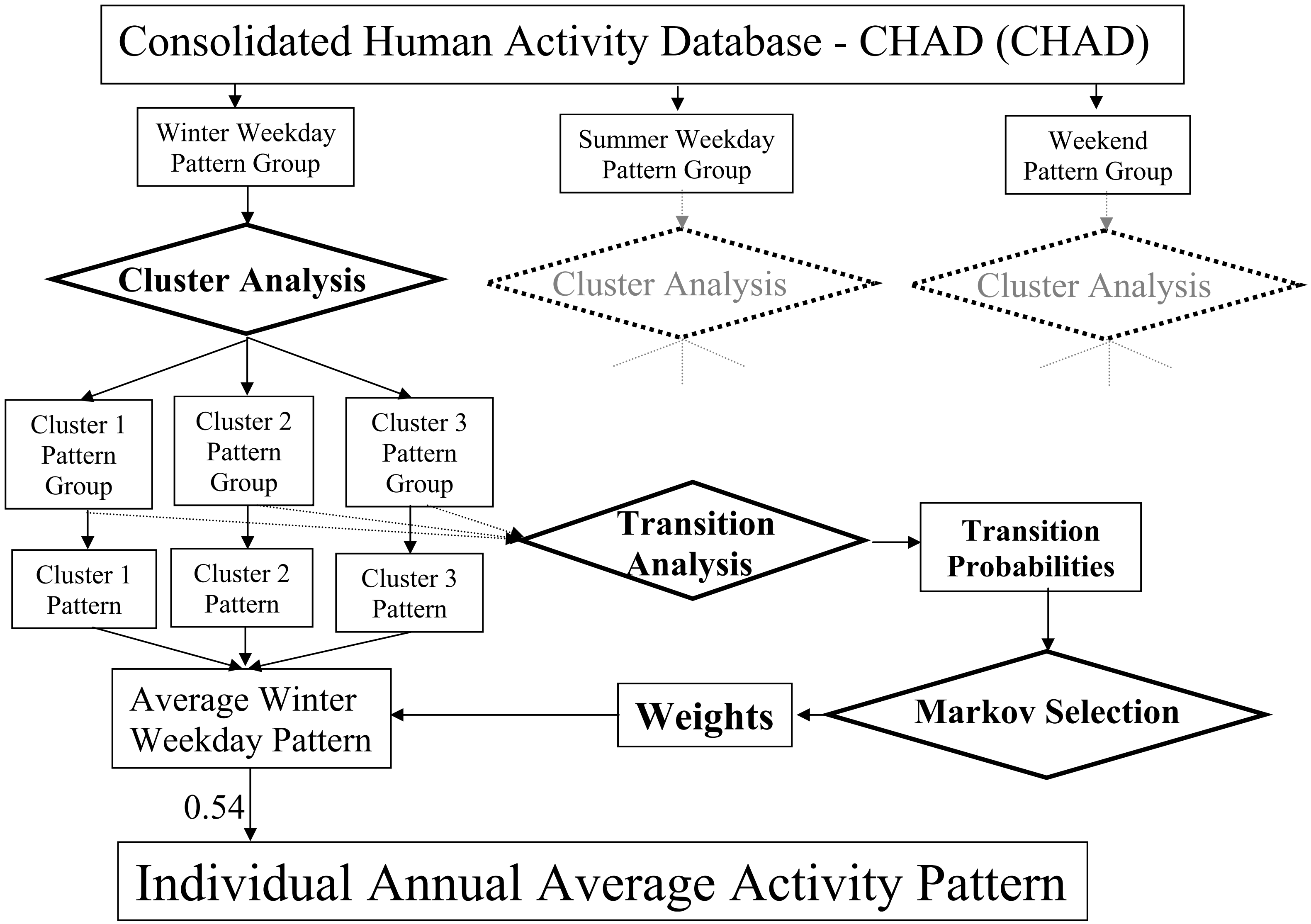

Figure 1. Flow diagram of proposed algorithm for creating annual average activity patterns for HAPEM5.

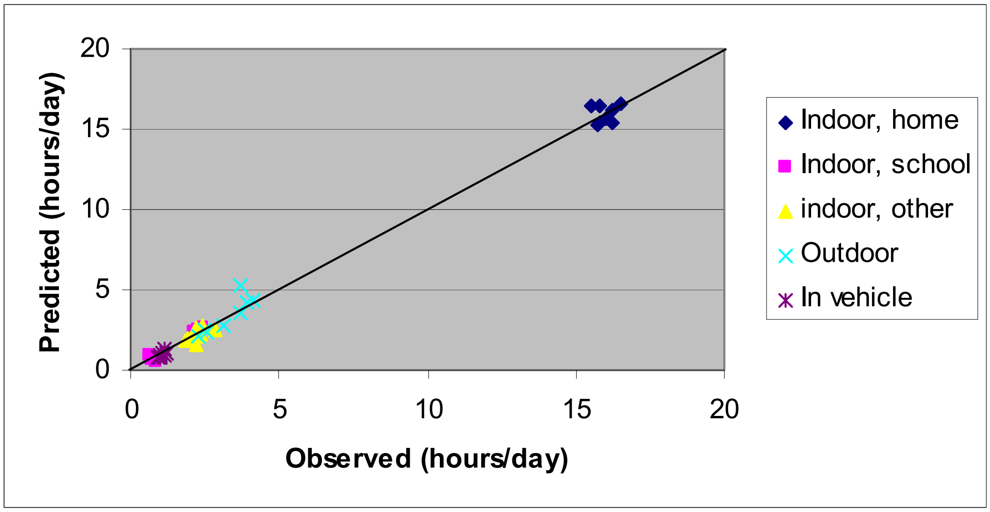

Figure 2. Comparison of predicted and observed average time in each of 5 microenvironments for age/gender groups and seasons.

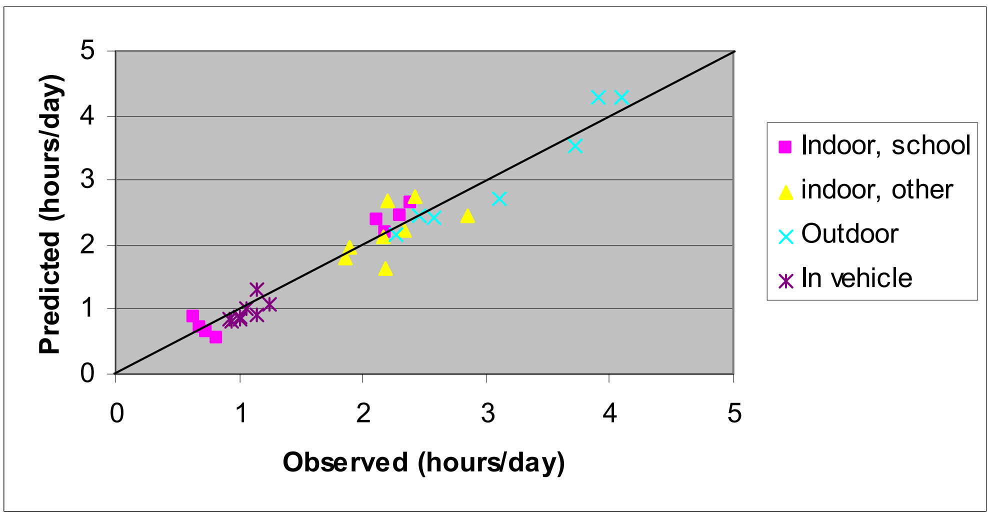

Figure 3. Comparison of predicted and observed average time in each of 4 microenvironments for age/gender groups and seasons.

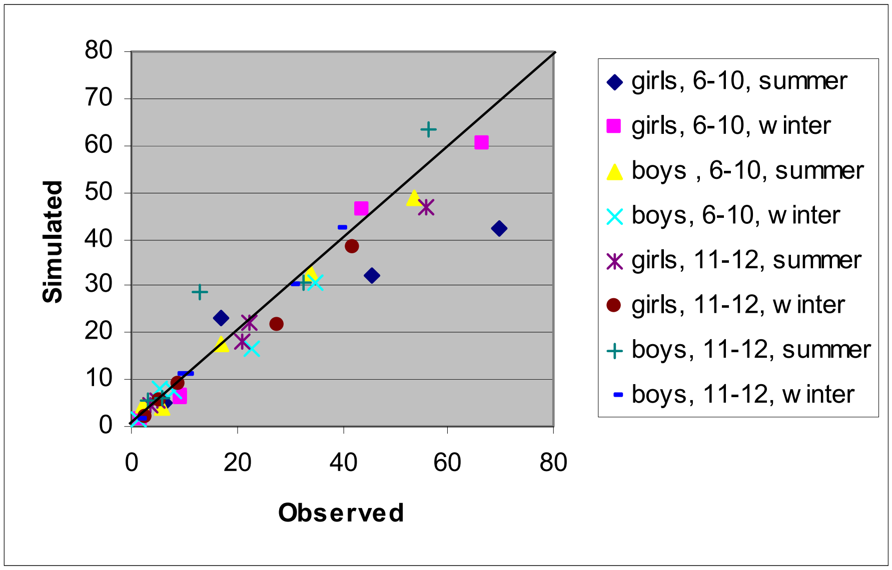

Figure 4. Comparison of predicted and observed variance across persons for time spent in each of 5 microenvironments for age/gender groups and seasons.

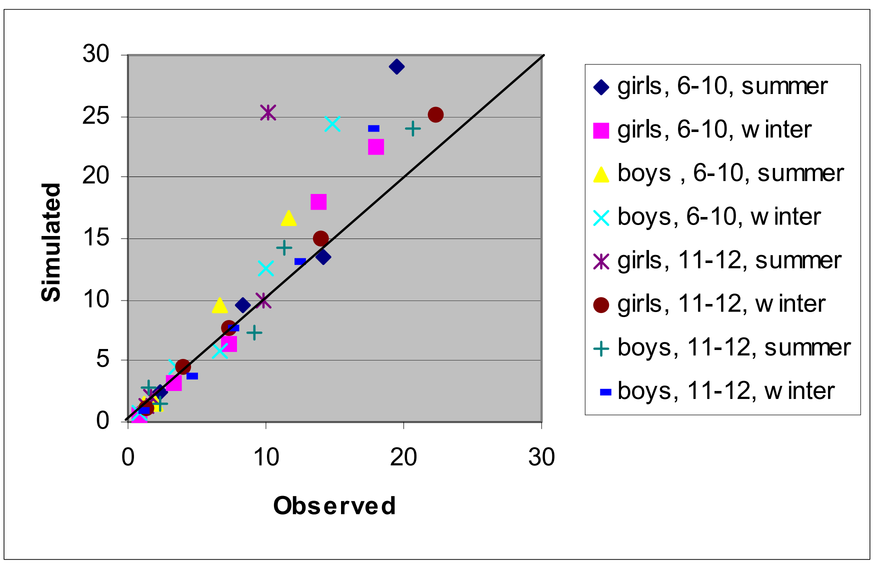

Figure 5. Comparison of predicted and observed the average within-person variance for time spent in each of 5 microenvironments by age/gender groups and seasons.

Attachment 4. Technical Memorandum on the Analysis of NHIS Asthma Prevalence Data

DRAFT MEMORANDUM

To: John Langstaff

From: Jonathan Cohen, Arlene Rosenbaum

Date: September 30, 2005

Re: EPA 68D01052, Work Assignment 3-08. Analysis of NHIS Asthma Prevalence Data

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This memorandum describes our analysis of children's asthma prevalence data from the National Health Interview Survey (NHIS) for 2003. Asthma prevalence rates for children aged 0 to 17 years were calculated for each age, gender, and region. The regions defined by NHIS are "Midwest," "Northeast," "South," and "West." For this project, asthma prevalence was defined as the probability of a Yes response to the question CASHMEV: "Ever been told that … had asthma?" among those that responded Yes or No to this question. The responses were weighted to take into account the complex survey design of the NHIS survey. Standard errors and confidence intervals for the prevalence were calculated using a logistic model, taking into account the survey design. Prevalence curves showing the variation of asthma prevalence against age for a given gender and region were plotted. A scatterplot smoothing technique using the LOESS smoother was applied to smooth the prevalence curves and compute the standard errors and confidence intervals for the smoothed prevalence estimates. Logistic analysis of the prevalence curves shows statistically significant differences in prevalence by gender and by region. Therefore we did not combine the prevalence rates for different genders or regions.

Logistic Models

NHIS survey data for 2003 were provided by EPA. One obvious approach to calculate prevalence rates and their uncertainties for a given gender, region, and age is to calculate the proportion of Yes responses among the Yes and No responses for that demographic group, weighting each response by the survey weight. Although that approach was initially used, two problems are that the distributions of the estimated prevalence rates are not well approximated by normal distributions, and that the estimated confidence intervals based on the normal approximation often extend outside the [0, 1] interval. A better approach is to use a logistic transformation and fit a model of the form:

$$\text{Prob (asthma)} = \exp(\text{beta}) / (1 + \exp(\text{beta})),$$

where beta may depend on the explanatory variables for age, gender, or region. This is equivalent to the model:

Beta = logit {prob (asthma) } = log { prob (asthma) / [1 – prob (asthma)] }.

The distribution of the estimated values of beta is more closely approximated by a normal distribution than the distribution of the corresponding estimates of prob (asthma). By applying a logit transformation to the confidence intervals for beta, the corresponding confidence intervals for prob (asthma) will always be inside [0, 1]. Another advantage of the logistic modeling is that it can be used to compare alternative statistical models, such as models where the prevalence probability depends upon age, region, and gender, or on age and region but not gender.

A variety of logistic models for asthma prevalence were fit and compared, where the transformed probability variable beta is a given function of age, gender, and region. SAS's SURVEYLOGISTIC procedure was used to fit the logistic models, taking into account the NHIS survey weights and survey design (stratification and clustering).

The following Table G-1 lists the models fitted and their log-likelihood goodness-of-fit measures. 16 models were fitted. The Strata column lists the four possible stratifications: no stratification, by gender, by region, by region and gender. For example, "4. region, gender" means that separate prevalence estimates were made for each combination of region and gender. As another example, "2. gender" means that separate prevalence estimates were made for each gender, so that for each gender, the prevalence is assumed to be the same for each region. The prevalence estimates are independently calculated for each stratum.

Table G-1. Alternative logistic models for asthma prevalence.

Model	Description	Strata	- 2 Log Likelihood	DF
1	1. logit(prob) = linear in age	1. none	54168194.62	2
2	1. logit(prob) = linear in age	2. gender	53974657.17	4
3	1. logit(prob) = linear in age	3. region	54048602.57	8
4	1. logit(prob) = linear in age	4. region, gender	53837594.97	16
5	2. logit(prob) = quadratic in age	1. none	53958021.20	3
6	2. logit(prob) = quadratic in age	2. gender	53758240.99	6
7	2. logit(prob) = quadratic in age	3. region	53818198.13	12
8	2. logit(prob) = quadratic in age	4. region, gender	53593569.84	24
9	3. logit(prob) = cubic in age	1. none	53849072.76	4
10	3. logit(prob) = cubic in age	2. gender	53639181.24	8
11	3. logit(prob) = cubic in age	3. region	53694710.66	16
12	3. logit(prob) = cubic in age	4. region, gender	53441122.98	32
13	4. logit(prob) = f(age)	1. none	53610093.48	18
14	4. logit(prob) = f(age)	2. gender	53226610.02	36
15	4. logit(prob) = f(age)	3. region	53099749.33	72
16	4. logit(prob) = f(age)	4. region, gender	52380000.19	144

The Description column describes how beta depends upon the age:

Linear in age:	Beta = $\alpha + \beta \times$ age, where α and β vary with the strata.
Quadratic in age:	Beta = $\alpha + \beta \times$ age + $\gamma \times$ age^2 where α β and γ vary with the strata.
Cubic in age:	Beta = $\alpha + \beta \times$ age + $\gamma \times$ age^2 + $\delta \times$ age^3 where α β, γ, and δ vary with the strata.
f(age)	Beta = arbitrary function of age, with different functions for different strata

The category f(age) is equivalent to making age one of the stratification variables, and is also equivalent to making beta a polynomial of degree 16 in age (since the maximum age for children is 17), with coefficients that may vary with the strata.

The fitted models are listed in order of complexity, where the simplest model (1) is an unstratified linear model in age and the most complex model (16) has a prevalence that is an arbitrary function of age, gender, and region. Model 16 is equivalent to calculating independent prevalence estimates for each of the 144 combinations of age, gender, and region.

Table G-1 also includes the -2 Log Likelihood, a goodness-of-fit measure, and the degrees of freedom, DF, which is the total number of estimated parameters. Two models can be compared using their -2 Log Likelihood values; lower values are preferred. If the first model is a special case of the second model, then the approximate statistical significance of the first model is estimated by comparing the difference in the -2 Log Likelihood values with a chi-squared random variable with r degrees of freedom, where r is the difference in the DF. This is a likelihood ratio test. For all pairs of models from Table G-1, all the differences are at least 70,000 and the likelihood ratios are all extremely statistically significant at levels well below 5 percent. Therefore the model 16 is clearly preferred and was used to model the prevalences.

The SURVEYLOGISTIC model predictions are tabulated in Table G-2 below and plotted in Figures 1 and 3 below. Also shown in Table G-2 and in Figures 2 and 4 are results for smoothed curves calculated using a LOESS scatterplot smoother, as discussed below.

The SURVEYLOGISTIC procedure produces estimates of the beta values and their 95 % confidence intervals for each combination of age, region, and gender. Applying the inverse logit transformation,

$$\text{Prob (asthma)} = \exp(\text{beta}) / (1 + \exp(\text{beta})),$$

converted the beta values and 95 % confidence intervals into predictions and 95 % confidence intervals for the prevalence, as shown in Table G-2 and Figures 1 and 3. The standard error for the prevalence was estimated as

$$\text{Std Error }\{\text{Prob (asthma)}\} = \text{Std Error (beta)} \times \exp(-\text{beta}) / (1 + \exp(\text{beta}))^2,$$

which follows from the delta method (a first order Taylor series approximation).

Loess Smoother

The estimated prevalence curves shows that the prevalence is not a smooth function of age. The linear, quadratic, and cubic functions of age modeled by SURVEYLOGISTIC were one strategy for smoothing the curves, but they did not provide a good fit to the data. One reason for this might be due to the attempt to fit a global regression curve to all the age groups, which means that the predictions for age A are affected by data for very different ages. We instead chose to use a local regression approach that separately fits a regression curve to each age A and its neighboring ages, giving a regression weight of 1 to the age A, and lower weights to the neighboring ages using a tri-weight function:

$$\text{Weight} = \{1 - [\ |\text{age} - A| / q\ ]^3\},\ \text{ where } |\ \text{age} - A| <= q.$$

The parameter q defines the number of points in the neighborhood of the age a. Instead of calling q the smoothing parameter, SAS defines the smoothing parameter as the proportion of points in each neighborhood. We fitted a quadratic function of age to each age neighborhood, separately for each gender and region combination. We fitted these local regression curves to the beta values, the logits of the asthma prevalence estimates, and then converted them back to estimated prevalence rates by applying the inverse logit function exp(beta) / (1 + exp(beta)). In addition to the tri-weight variable, each beta value was assigned a weight of $1 / [\text{std error (beta)}]^2$, to account for their uncertainties.

The SAS LOESS procedure was applied to estimate smoothed curves for beta, the logit of the prevalence, as a function of age, separately for each region and gender. We fitted curves using the choices 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, and 1.0 for the smoothing parameter in an effort to determine the optimum choice based on various regression diagnostics.[27,28]

Quantities predicted in these smoothing parameter tests were the predicted value, standard error, confidence interval lower bound and confidence interval upper bound for the betas, and the corresponding values for the prevalence rates.

The polygonal curves joining values for different ages show the predicted values with vertical lines indicating the confidence intervals in Figures 3 and 4 for smoothing parameters 0 (i.e., no smoothing) and 0.5, respectively. Note that the confidence intervals are not symmetric about the predicted values because of the inverse logit transformation.

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[27] Two outlier cases were adjusted to avoid wild variations in the "smoothed" curves: For the West region, males, age 0, there were 97 children surveyed that all gave No answers to the asthma question, leading to an estimated value of -15.2029 for beta with a standard error of 0.14. For the Northeast region, females, age 0, there were 29 children surveyed that all gave No answers to the asthma question, leading to an estimated value of -15.2029 for beta with a standard error of 0.19. In both cases the raw probability of asthma equals zero, so the corresponding estimated beta would be negative infinity, but SAS's software gives -15.2029 instead. To reduce the impact of these outlier cases, we replaced their estimated standard errors by 4, which is approximately four times the maximum standard error for all other region, gender, and age combinations.

[28] With only 18 points, a smoothing parameter of 0.2 cannot be used because the weight function assigns zero weights to all ages except age A, and a quadratic model cannot be uniquely fitted to a single value. A smoothing parameter of 0.3 also cannot be used because that choice assigns a neighborhood of 5 points only ($0.3 \times 18 = 5$, rounded down), of which the two outside ages have assigned weight zero, making the local quadratic model fit exactly at every point except for the end points (ages 0, 1, 16 and 17). Usually one uses a smoothing parameter below one so that not all the data are used for the local regression at a given x value.

Note that in our application of LOESS, we used weights of 1 / [std error (beta)] ^{2}, so that $\sigma^2 = 1$ for this application. The LOESS procedure estimates σ^2 from the weighted sum of squares. Since in our application we assume $\sigma^2 = 1$, we multiplied the estimated standard errors by 1 / estimated σ, and adjusted the widths of the confidence intervals by the same factor.

Additionally, because the true value of σ equals 1, the best choices of smoothing parameter should give residual standard errors close to one. Using this criterion the best choice varies with gender and region between smoothing parameters 0.4 (3 cases), 0.5 (2 cases), 0.6 (1 case), and 0.7 (1 case).

As a further regression diagnostic the residual errors from the LOESS model were divided by std error (beta) to make their variances approximately constant. These approximately studentized residuals, 'student,' should be approximately normally distributed with a mean of zero and a variance of $\sigma^2 = 1$. To test this assumption, normal probability plots of the residuals were created for each smoothing parameter, combining all the studentized residuals across genders, regions, and ages. The plots for smoothing parameters seem to be equally straight for each smoothing parameter.

The final regression diagnostic is a plot of the studentized residuals against the smoothed beta values. Ideally there should be no obvious pattern and an average studentized residual close to zero. The plots indeed showed no unusual patterns, and the results for smoothing parameters 0.5 and 0.6 seem to showed a fitted LOESS close to the studentized residual equals zero line.

The regression diagnostics suggested the choice of smoothing parameter as 0.4 or 0.5. Normal probability plots did not suggest any preferred choices. The plots of residuals against smoothed predictions suggest the choices of 0.5 or 0.6. We therefore chose the final value of 0.5. These predictions, standard errors, and confidence intervals are presented in tabular form below as Table G-2.

Figure 1. Raw asthma prevalence rates by age and gender for each region
region=Midwest

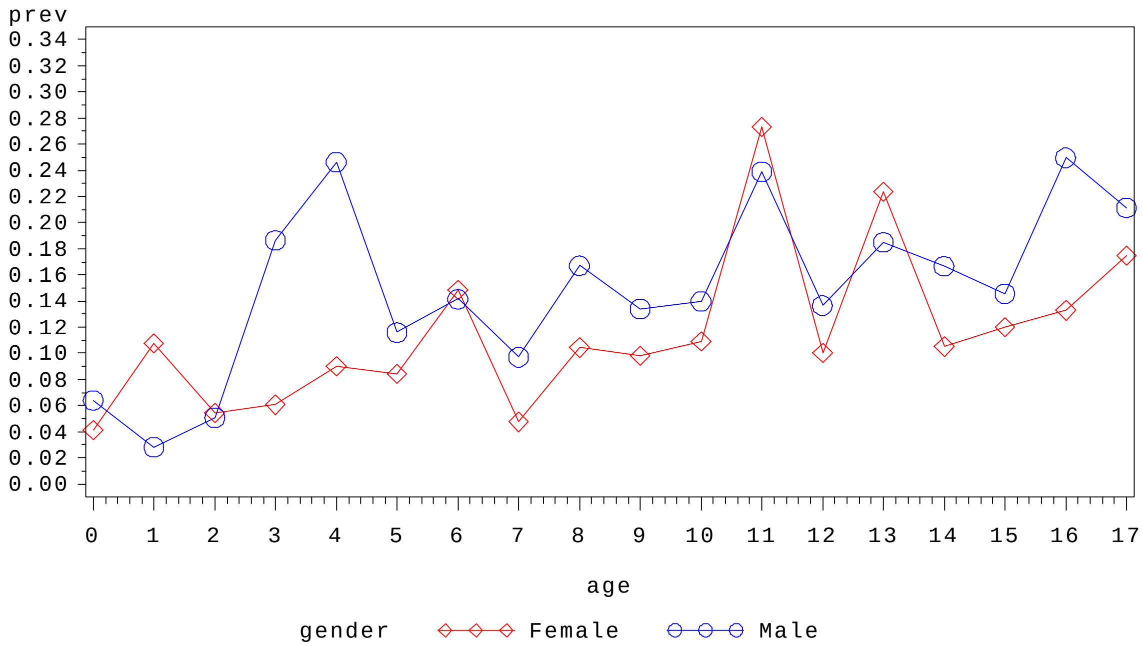

Figure 1. Raw asthma prevalence rates by age and gender for each region
region=Northeast

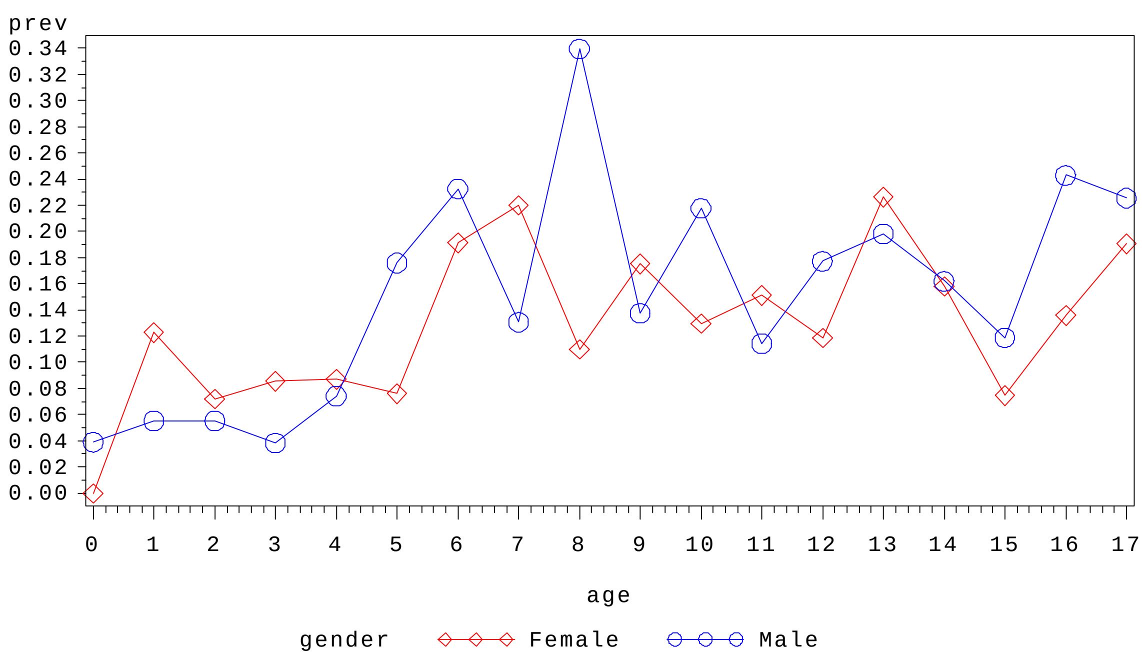

Figure 1. Raw asthma prevalence rates by age and gender for each region
region=South

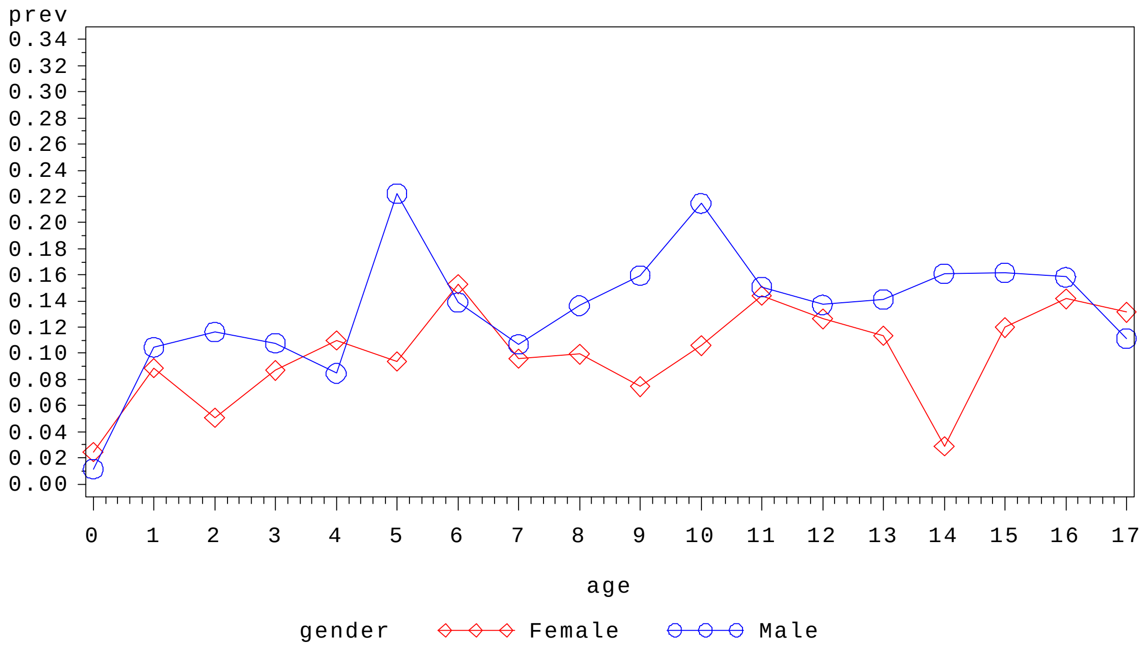

Figure 1. Raw asthma prevalence rates by age and gender for each region
region=West

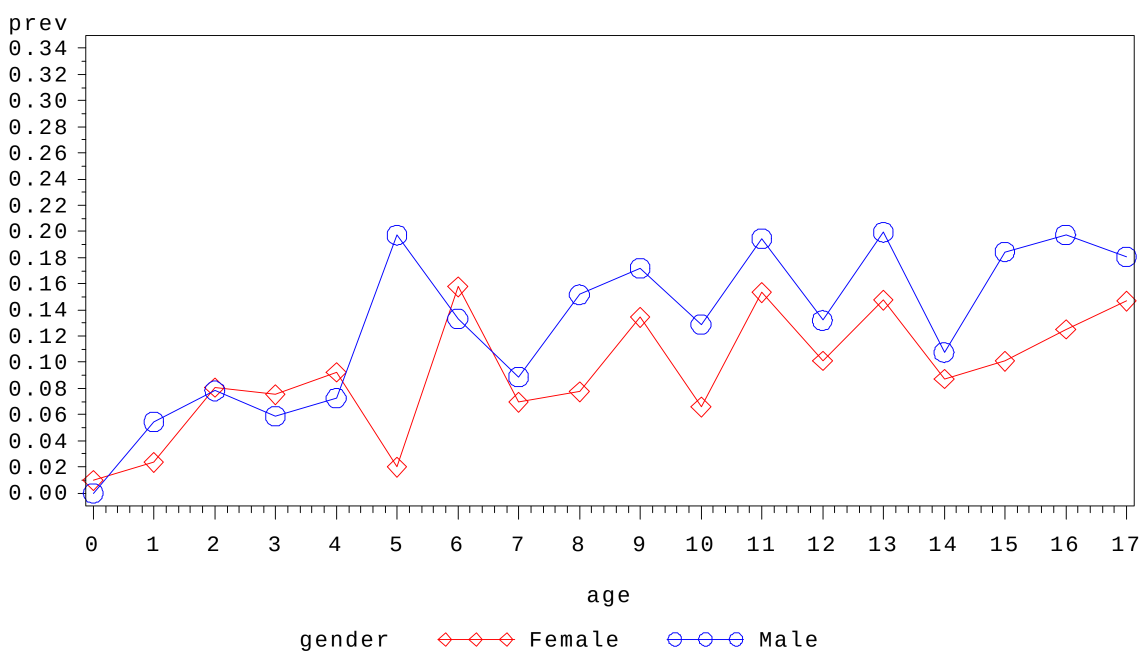

Figure 2. Smoothed asthma prevalence rates by age for each region and gender
region=Midwest

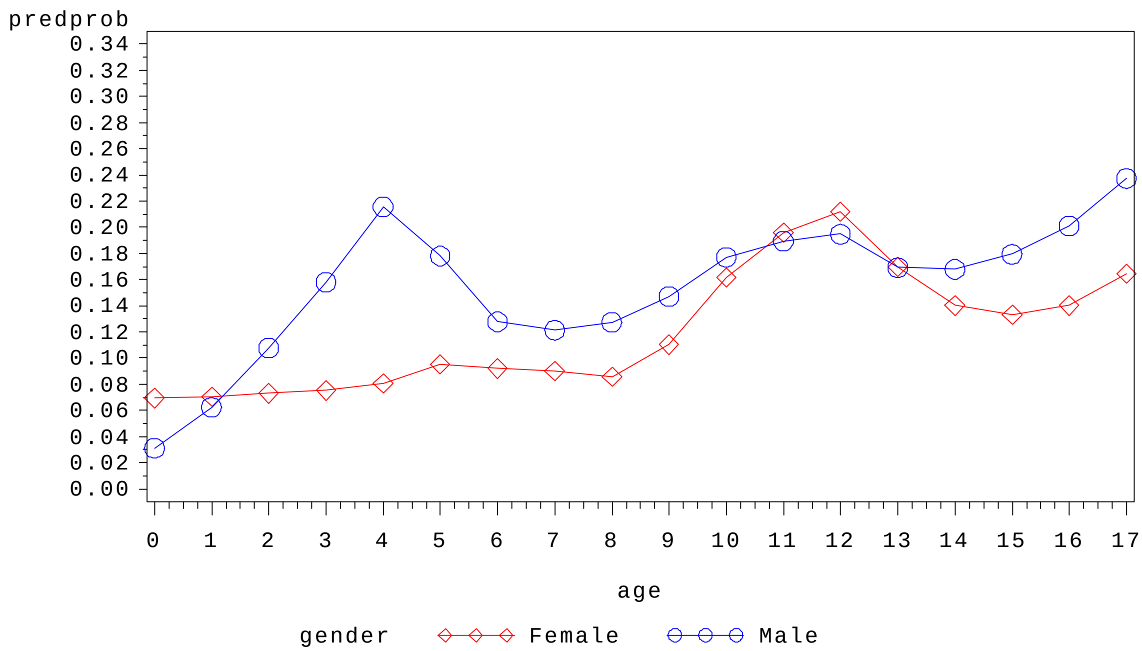

Figure 2. Smoothed asthma prevalence rates by age for each region and gender
region=Northeast

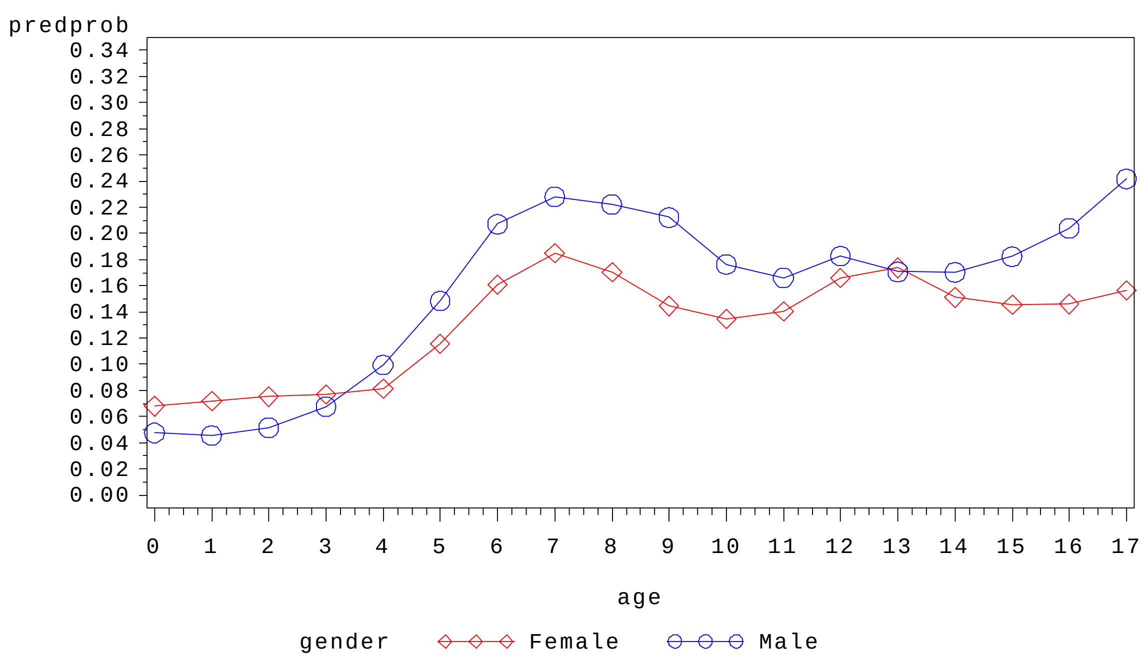

Figure 2. Smoothed asthma prevalence rates by age for each region and gender
region=South

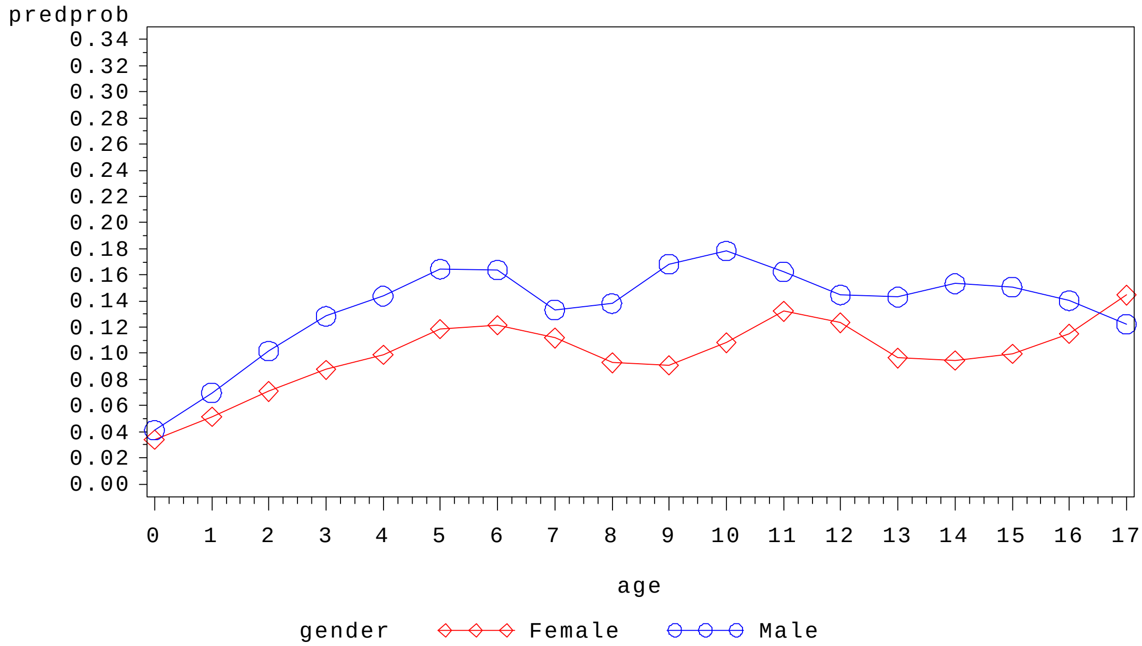

Figure 2. Smoothed asthma prevalence rates by age for each region and gender
region=West

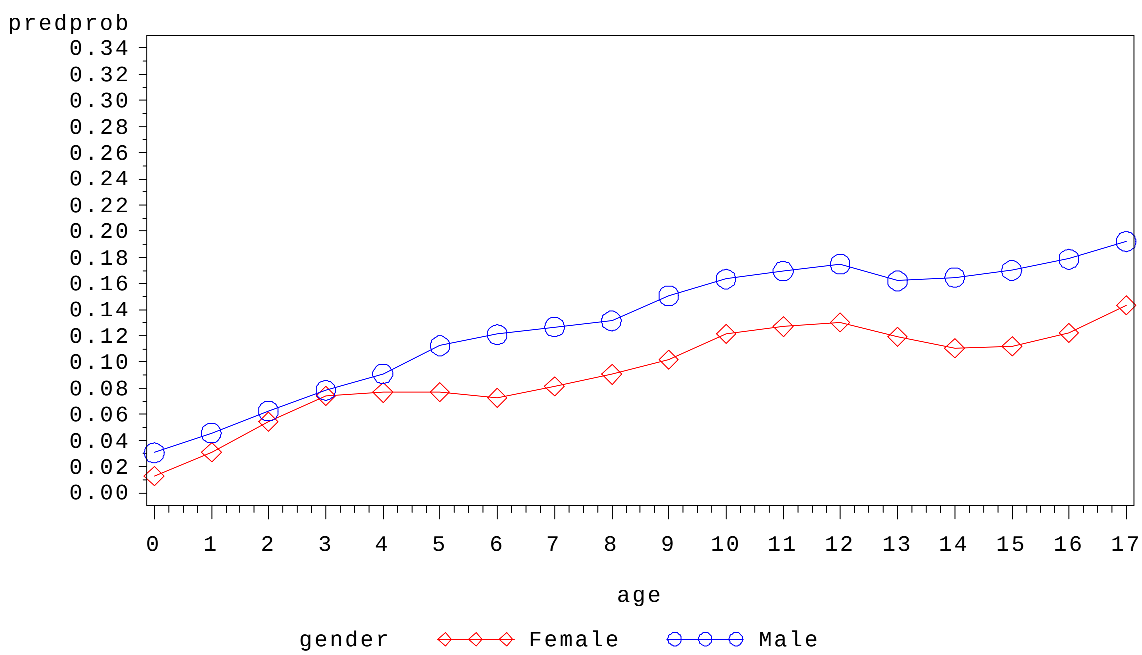

Figure 3. Raw asthma prevalence rates and confidence intervals
region=Midwest

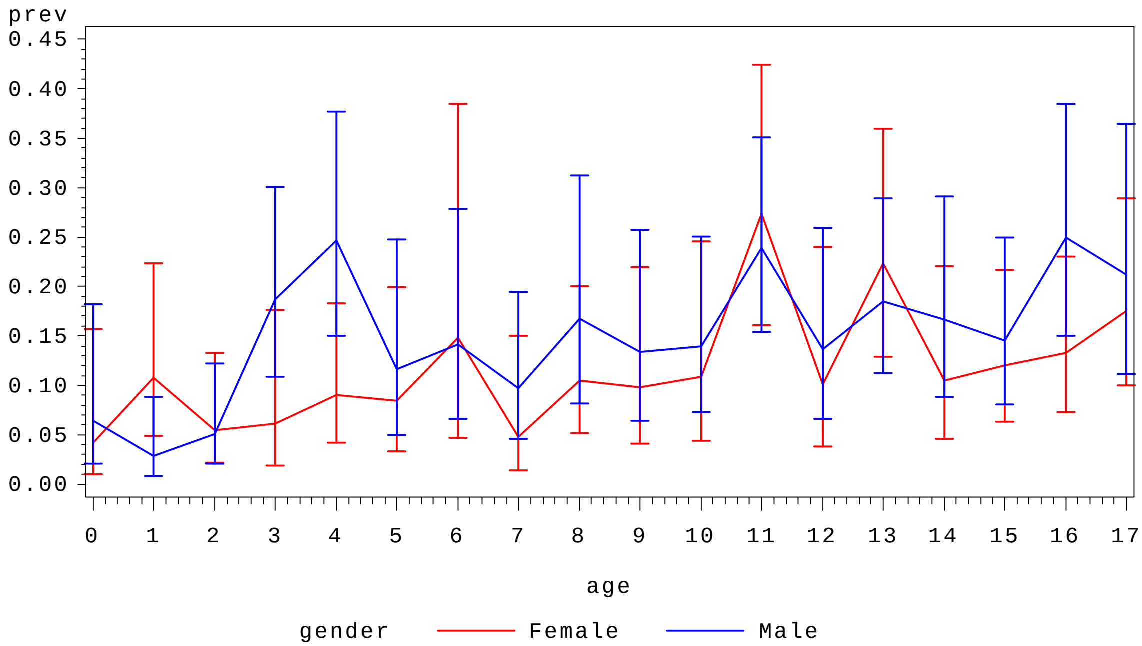

Figure 3. Raw asthma prevalence rates and confidence intervals
region=Northeast

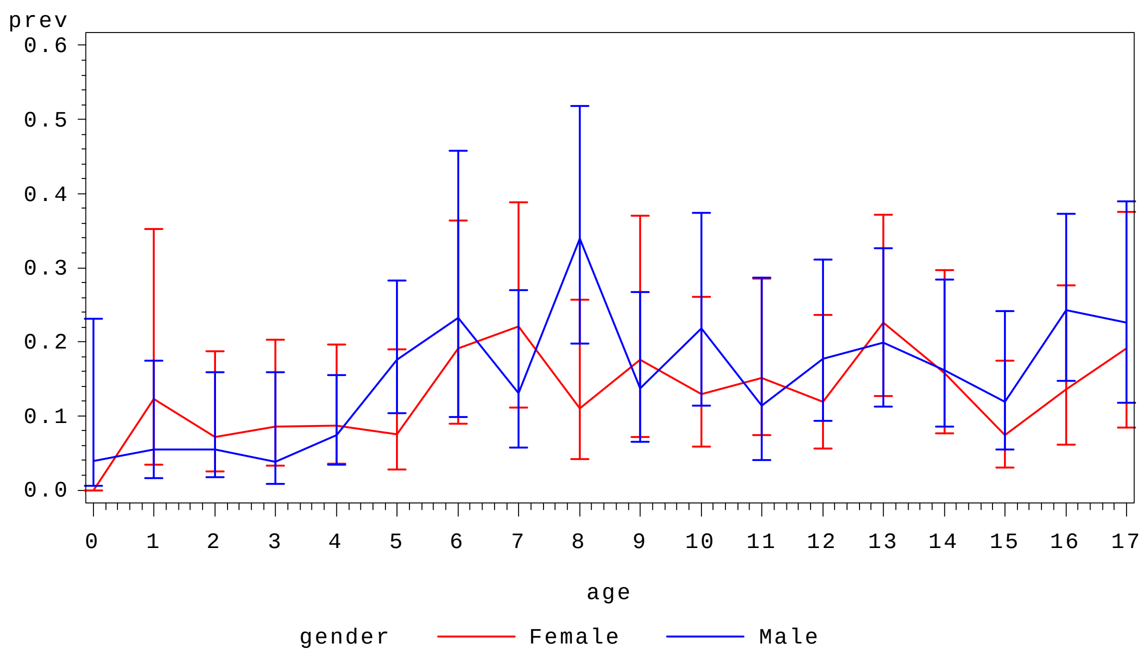

Figure 3. Raw asthma prevalence rates and confidence intervals

region=South

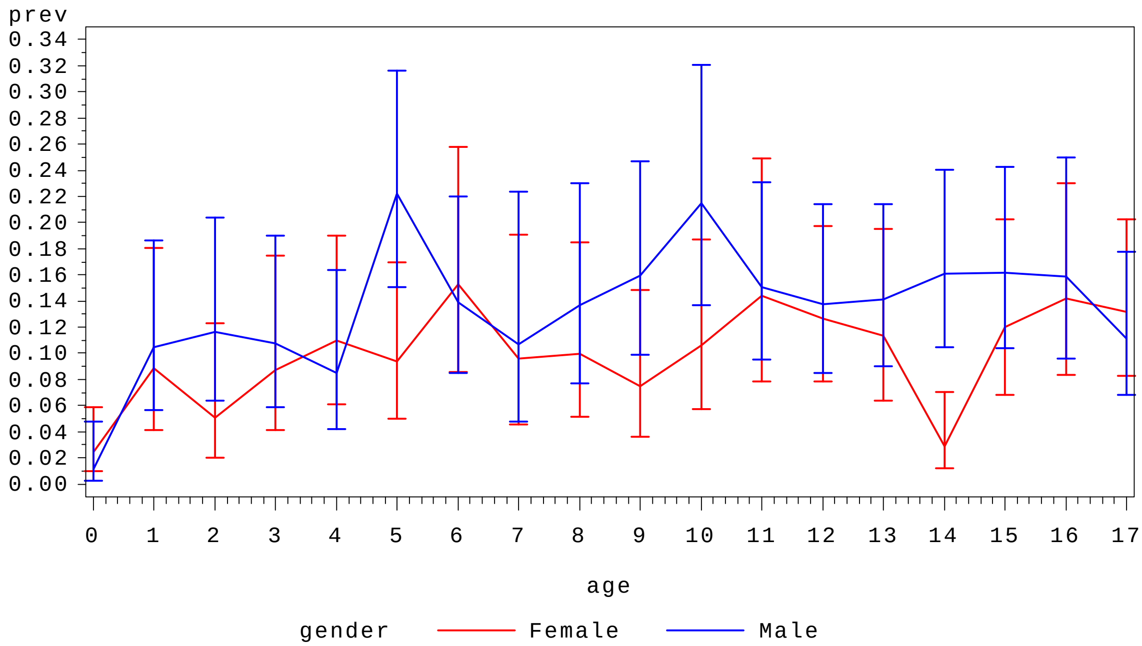

Figure 3. Raw asthma prevalence rates and confidence intervals

region=West

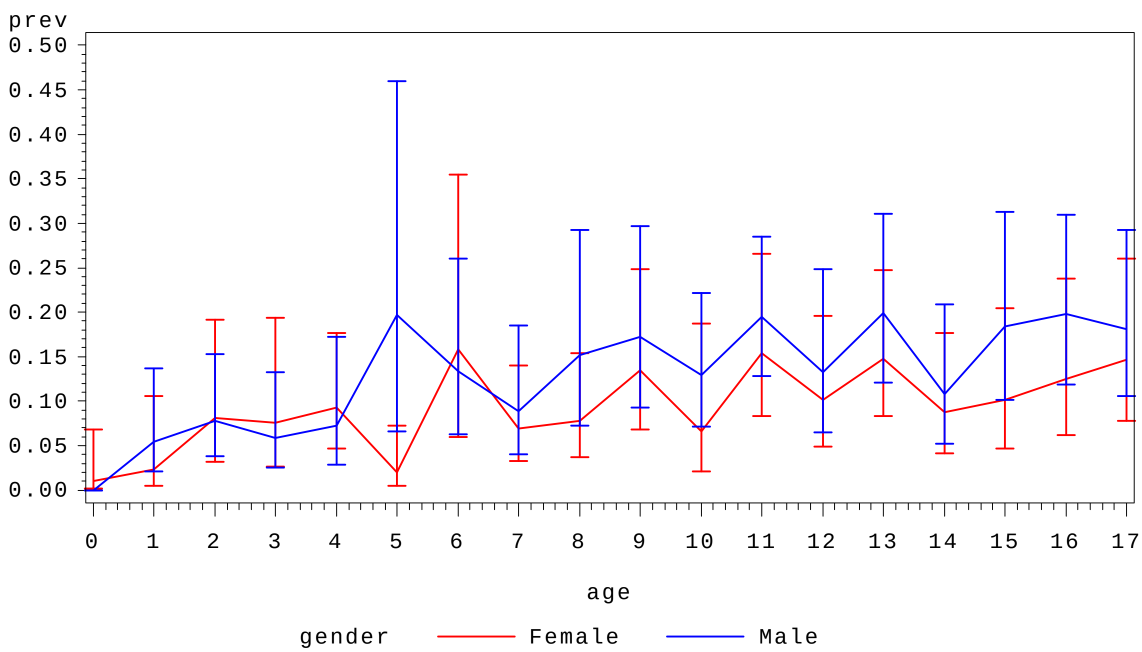

Figure 4. Smoothed asthma prevalence rates and confidence intervals
region=Midwest

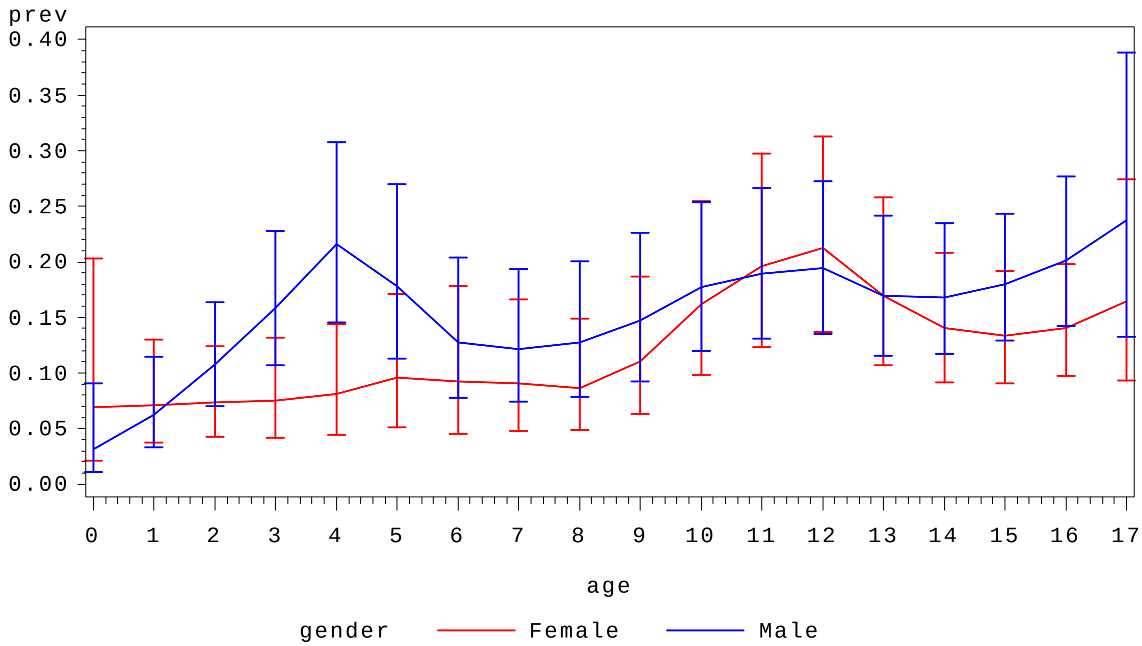

Figure 4. Smoothed asthma prevalence rates and confidence intervals
region=Northeast

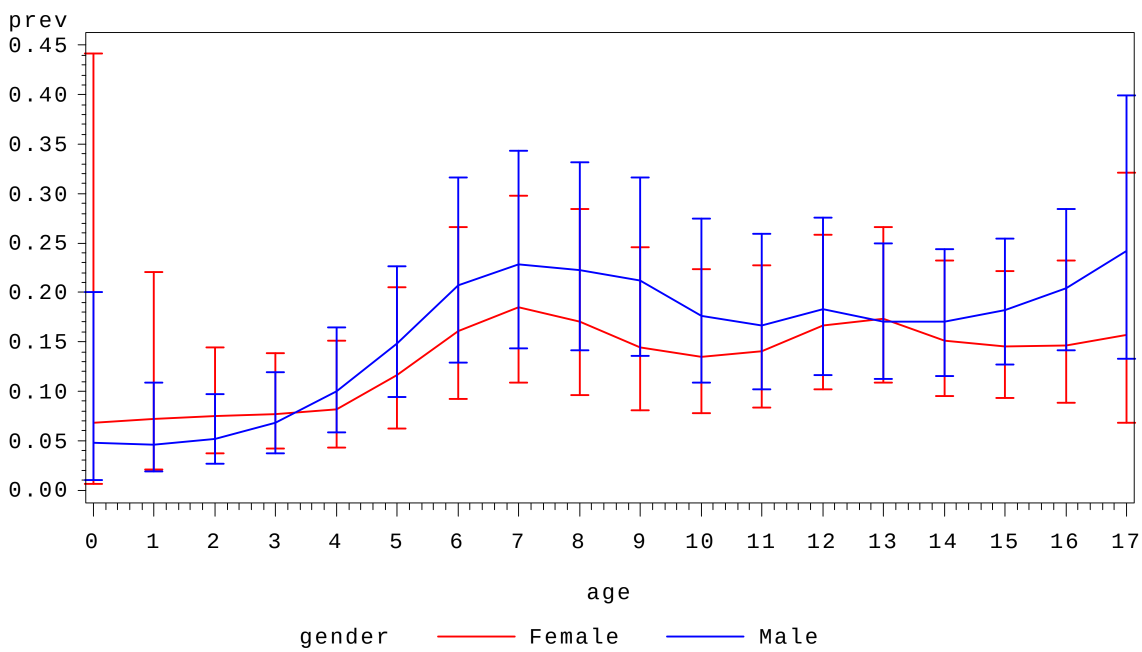

Figure 4. Smoothed asthma prevalence rates and confidence intervals

region=South

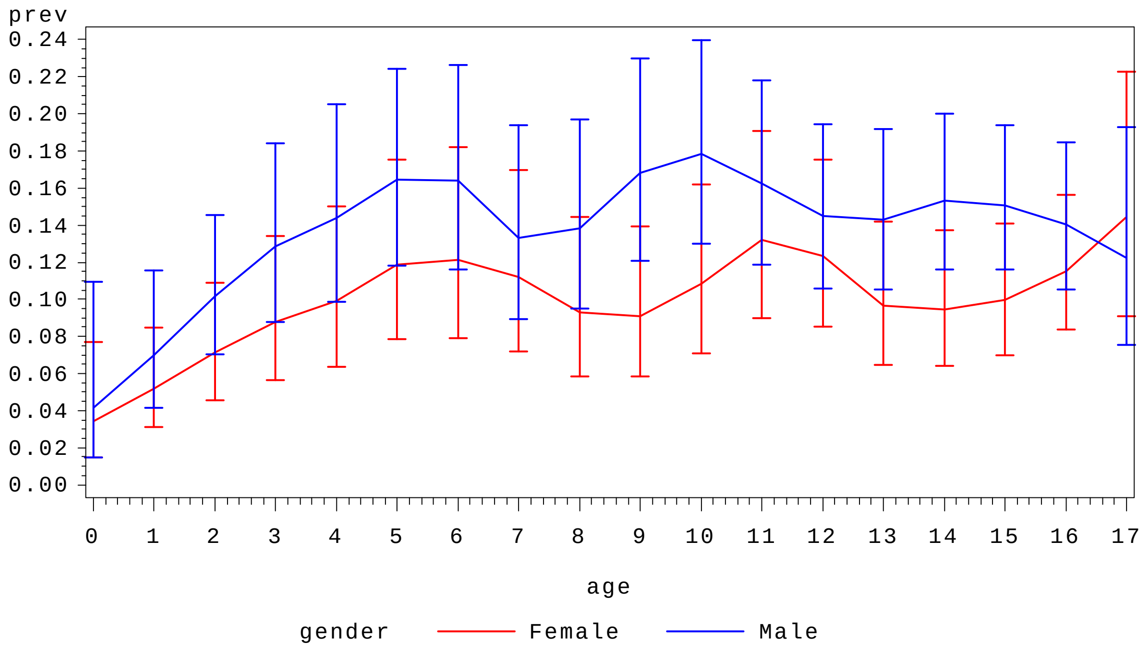

Figure 4. Smoothed asthma prevalence rates and confidence intervals

region=West

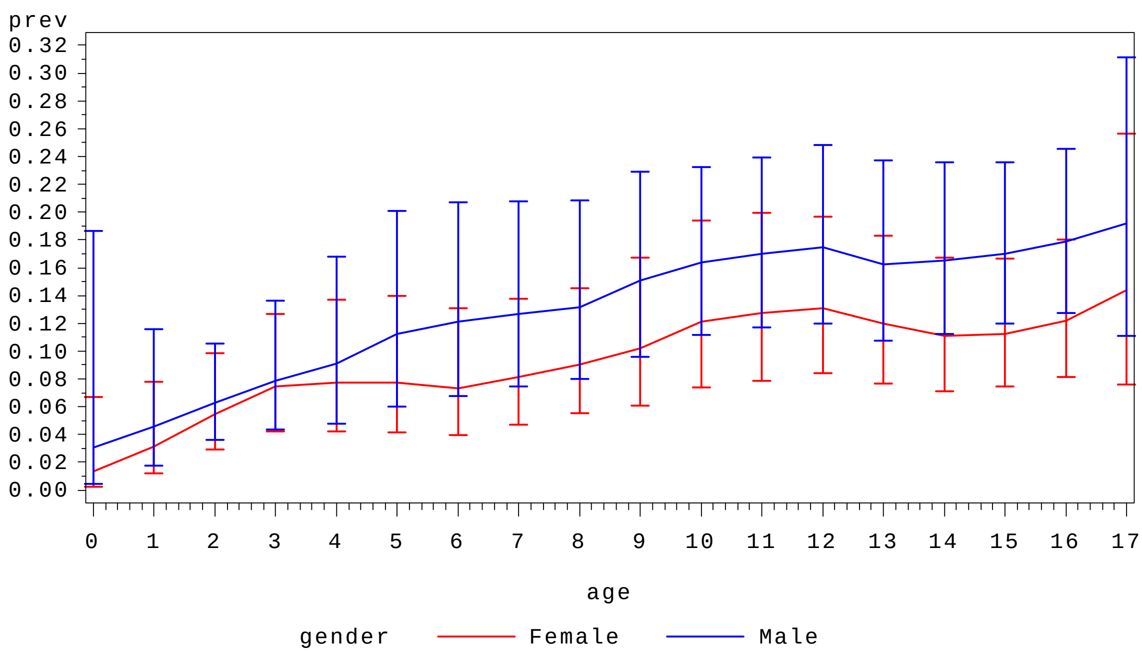

Table G-2. Raw and smoothed prevalence rates, with confidence intervals, by region, gender, and age.

Obs	Region	Gender	Age	Smoothed	Prevalence	Std Error	95 % Conf Interval – Lower Bound	95 % Conf Interval – Upper Bound
1	Midwest	Female	0	No	0.04161	0.02965	0.01001	0.15717
2	Midwest	Female	0	Yes	0.06956	0.03574	0.02143	0.20330
3	Midwest	Female	1	No	0.10790	0.04254	0.04840	0.22336
4	Midwest	Female	1	Yes	0.07078	0.01995	0.03736	0.13008
5	Midwest	Female	2	No	0.05469	0.02578	0.02131	0.13325
6	Midwest	Female	2	Yes	0.07324	0.01778	0.04228	0.12395
7	Midwest	Female	3	No	0.06094	0.03474	0.01936	0.17579
8	Midwest	Female	3	Yes	0.07542	0.01944	0.04205	0.13163
9	Midwest	Female	4	No	0.09049	0.03407	0.04233	0.18298
10	Midwest	Female	4	Yes	0.08100	0.02163	0.04417	0.14393
11	Midwest	Female	5	No	0.08463	0.03917	0.03317	0.19942
12	Midwest	Female	5	Yes	0.09540	0.02613	0.05106	0.17131
13	Midwest	Female	6	No	0.14869	0.08250	0.04643	0.38520
14	Midwest	Female	6	Yes	0.09210	0.02854	0.04534	0.17808
15	Midwest	Female	7	No	0.04757	0.02927	0.01389	0.15051
16	Midwest	Female	7	Yes	0.09032	0.02563	0.04728	0.16571
17	Midwest	Female	8	No	0.10444	0.03638	0.05160	0.19997
18	Midwest	Female	8	Yes	0.08612	0.02181	0.04842	0.14857
19	Midwest	Female	9	No	0.09836	0.04283	0.04062	0.21943
20	Midwest	Female	9	Yes	0.11040	0.02709	0.06298	0.18643
21	Midwest	Female	10	No	0.10916	0.04859	0.04400	0.24600
22	Midwest	Female	10	Yes	0.16190	0.03486	0.09838	0.25484
23	Midwest	Female	11	No	0.27341	0.06817	0.16112	0.42437
24	Midwest	Female	11	Yes	0.19597	0.03920	0.12296	0.29763
25	Midwest	Female	12	No	0.10055	0.04780	0.03816	0.23952
26	Midwest	Female	12	Yes	0.21214	0.03957	0.13724	0.31309
27	Midwest	Female	13	No	0.22388	0.05905	0.12907	0.35959
28	Midwest	Female	13	Yes	0.16966	0.03371	0.10716	0.25807

Obs	Region	Gender	Age	Smoothed	Prevalence	Std Error	95 % Conf Interval – Lower Bound	95 % Conf Interval – Upper Bound
29	Midwest	Female	14	No	0.10511	0.04233	0.04637	0.22104
30	Midwest	Female	14	Yes	0.14020	0.02603	0.09164	0.20857
31	Midwest	Female	15	No	0.12026	0.03805	0.06327	0.21670
32	Midwest	Female	15	Yes	0.13341	0.02266	0.09056	0.19226
33	Midwest	Female	16	No	0.13299	0.03933	0.07288	0.23037
34	Midwest	Female	16	Yes	0.14040	0.02235	0.09764	0.19777
35	Midwest	Female	17	No	0.17497	0.04786	0.09970	0.28884
36	Midwest	Female	17	Yes	0.16478	0.04037	0.09320	0.27468
37	Midwest	Male	0	No	0.06419	0.03612	0.02068	0.18227
38	Midwest	Male	0	Yes	0.03134	0.01537	0.01042	0.09046
39	Midwest	Male	1	No	0.02824	0.01694	0.00859	0.08879
40	Midwest	Male	1	Yes	0.06250	0.01751	0.03321	0.11457
41	Midwest	Male	2	No	0.05102	0.02343	0.02040	0.12189
42	Midwest	Male	2	Yes	0.10780	0.02078	0.06960	0.16328
43	Midwest	Male	3	No	0.18650	0.04864	0.10898	0.30057
44	Midwest	Male	3	Yes	0.15821	0.02705	0.10696	0.22775
45	Midwest	Male	4	No	0.24649	0.05823	0.15035	0.37686
46	Midwest	Male	4	Yes	0.21572	0.03661	0.14543	0.30774
47	Midwest	Male	5	No	0.11609	0.04818	0.04973	0.24793
48	Midwest	Male	5	Yes	0.17822	0.03525	0.11280	0.27003
49	Midwest	Male	6	No	0.14158	0.05280	0.06576	0.27873
50	Midwest	Male	6	Yes	0.12788	0.02799	0.07751	0.20375
51	Midwest	Male	7	No	0.09726	0.03614	0.04588	0.19448
52	Midwest	Male	7	Yes	0.12145	0.02642	0.07391	0.19317
53	Midwest	Male	8	No	0.16718	0.05814	0.08134	0.31276
54	Midwest	Male	8	Yes	0.12757	0.02700	0.07864	0.20031
55	Midwest	Male	9	No	0.13406	0.04783	0.06458	0.25769
56	Midwest	Male	9	Yes	0.14718	0.02976	0.09254	0.22603
57	Midwest	Male	10	No	0.13986	0.04422	0.07331	0.25050
58	Midwest	Male	10	Yes	0.17728	0.02996	0.12020	0.25366
59	Midwest	Male	11	No	0.23907	0.05031	0.15449	0.35075

Obs	Region	Gender	Age	Smoothed	Prevalence	Std Error	95 % Conf Interval – Lower Bound	95 % Conf Interval – Upper Bound
60	Midwest	Male	11	Yes	0.18961	0.03044	0.13100	0.26639
61	Midwest	Male	12	No	0.13660	0.04784	0.06668	0.25946
62	Midwest	Male	12	Yes	0.19487	0.03078	0.13541	0.27221
63	Midwest	Male	13	No	0.18501	0.04498	0.11230	0.28945
64	Midwest	Male	13	Yes	0.16939	0.02841	0.11528	0.24195
65	Midwest	Male	14	No	0.16673	0.05094	0.08886	0.29104
66	Midwest	Male	14	Yes	0.16795	0.02631	0.11734	0.23459
67	Midwest	Male	15	No	0.14583	0.04241	0.08054	0.24967
68	Midwest	Male	15	Yes	0.17953	0.02561	0.12951	0.24347
69	Midwest	Male	16	No	0.24965	0.06037	0.15033	0.38489
70	Midwest	Male	16	Yes	0.20116	0.03048	0.14187	0.27721
71	Midwest	Male	17	No	0.21152	0.06481	0.11131	0.36490
72	Midwest	Male	17	Yes	0.23741	0.05816	0.13243	0.38835
73	Northeast	Female	0	No	0.00000	0.00000	0.00000	0.00000
74	Northeast	Female	0	Yes	0.06807	0.06565	0.00670	0.44174
75	Northeast	Female	1	No	0.12262	0.07443	0.03476	0.35164
76	Northeast	Female	1	Yes	0.07219	0.03765	0.02088	0.22109
77	Northeast	Female	2	No	0.07217	0.03707	0.02561	0.18713
78	Northeast	Female	2	Yes	0.07522	0.02212	0.03764	0.14468
79	Northeast	Female	3	No	0.08550	0.03991	0.03324	0.20269
80	Northeast	Female	3	Yes	0.07709	0.02021	0.04162	0.13840
81	Northeast	Female	4	No	0.08704	0.03804	0.03596	0.19592
82	Northeast	Female	4	Yes	0.08171	0.02252	0.04269	0.15080
83	Northeast	Female	5	No	0.07597	0.03754	0.02801	0.18998
84	Northeast	Female	5	Yes	0.11603	0.03012	0.06258	0.20515
85	Northeast	Female	6	No	0.19149	0.06960	0.08937	0.36372
86	Northeast	Female	6	Yes	0.16106	0.03737	0.09219	0.26629
87	Northeast	Female	7	No	0.22034	0.07076	0.11195	0.38783
88	Northeast	Female	7	Yes	0.18503	0.04087	0.10844	0.29764
89	Northeast	Female	8	No	0.11002	0.05128	0.04241	0.25654
90	Northeast	Female	8	Yes	0.17054	0.04039	0.09628	0.28407

Obs	Region	Gender	Age	Smoothed	Prevalence	Std Error	95 % Conf Interval – Lower Bound	95 % Conf Interval – Upper Bound
91	Northeast	Female	9	No	0.17541	0.07488	0.07159	0.36981
92	Northeast	Female	9	Yes	0.14457	0.03538	0.08042	0.24618
93	Northeast	Female	10	No	0.12980	0.04964	0.05930	0.26087
94	Northeast	Female	10	Yes	0.13487	0.03098	0.07799	0.22319
95	Northeast	Female	11	No	0.15128	0.05287	0.07366	0.28547
96	Northeast	Female	11	Yes	0.14072	0.03068	0.08367	0.22704
97	Northeast	Female	12	No	0.11890	0.04426	0.05568	0.23597
98	Northeast	Female	12	Yes	0.16615	0.03375	0.10211	0.25877
99	Northeast	Female	13	No	0.22638	0.06285	0.12650	0.37158
100	Northeast	Female	13	Yes	0.17374	0.03402	0.10861	0.26626
101	Northeast	Female	14	No	0.15807	0.05513	0.07694	0.29719
102	Northeast	Female	14	Yes	0.15137	0.02946	0.09519	0.23220
103	Northeast	Female	15	No	0.07460	0.03409	0.02971	0.17506
104	Northeast	Female	15	Yes	0.14564	0.02761	0.09279	0.22127
105	Northeast	Female	16	No	0.13603	0.05328	0.06081	0.27686
106	Northeast	Female	16	Yes	0.14601	0.03095	0.08805	0.23241
107	Northeast	Female	17	No	0.19074	0.07382	0.08451	0.37568
108	Northeast	Female	17	Yes	0.15662	0.05374	0.06784	0.32151
109	Northeast	Male	0	No	0.03904	0.03829	0.00547	0.23095
110	Northeast	Male	0	Yes	0.04768	0.03299	0.00991	0.20023
111	Northeast	Male	1	No	0.05533	0.03425	0.01596	0.17461
112	Northeast	Male	1	Yes	0.04564	0.01831	0.01850	0.10821
113	Northeast	Male	2	No	0.05525	0.03119	0.01781	0.15872
114	Northeast	Male	2	Yes	0.05161	0.01505	0.02680	0.09709
115	Northeast	Male	3	No	0.03842	0.02923	0.00840	0.15853
116	Northeast	Male	3	Yes	0.06766	0.01784	0.03734	0.11955
117	Northeast	Male	4	No	0.07436	0.02906	0.03393	0.15522
118	Northeast	Male	4	Yes	0.09964	0.02330	0.05859	0.16441
119	Northeast	Male	5	No	0.17601	0.04519	0.10393	0.28234
120	Northeast	Male	5	Yes	0.14854	0.02948	0.09428	0.22623
121	Northeast	Male	6	No	0.23271	0.09319	0.09832	0.45756

Obs	Region	Gender	Age	Smoothed	Prevalence	Std Error	95 % Conf Interval – Lower Bound	95 % Conf Interval – Upper Bound
122	Northeast	Male	6	Yes	0.20731	0.04235	0.12875	0.31640
123	Northeast	Male	7	No	0.13074	0.05195	0.05785	0.26922
124	Northeast	Male	7	Yes	0.22820	0.04524	0.14338	0.34311
125	Northeast	Male	8	No	0.33970	0.08456	0.19726	0.51855
126	Northeast	Male	8	Yes	0.22240	0.04298	0.14157	0.33157
127	Northeast	Male	9	No	0.13761	0.05024	0.06507	0.26785
128	Northeast	Male	9	Yes	0.21238	0.04071	0.13589	0.31617
129	Northeast	Male	10	No	0.21785	0.06659	0.11464	0.37465
130	Northeast	Male	10	Yes	0.17652	0.03731	0.10824	0.27460
131	Northeast	Male	11	No	0.11448	0.05849	0.04005	0.28601
132	Northeast	Male	11	Yes	0.16617	0.03516	0.10200	0.25907
133	Northeast	Male	12	No	0.17736	0.05489	0.09349	0.31067
134	Northeast	Male	12	Yes	0.18279	0.03589	0.11611	0.27581
135	Northeast	Male	13	No	0.19837	0.05450	0.11222	0.32635
136	Northeast	Male	13	Yes	0.17078	0.03078	0.11288	0.25000
137	Northeast	Male	14	No	0.16201	0.04973	0.08618	0.28386
138	Northeast	Male	14	Yes	0.17033	0.02889	0.11547	0.24408
139	Northeast	Male	15	No	0.11894	0.04584	0.05417	0.24139
140	Northeast	Male	15	Yes	0.18246	0.02858	0.12740	0.25438
141	Northeast	Male	16	No	0.24306	0.05798	0.14759	0.37326
142	Northeast	Male	16	Yes	0.20406	0.03216	0.14187	0.28447
143	Northeast	Male	17	No	0.22559	0.06980	0.11748	0.38930
144	Northeast	Male	17	Yes	0.24185	0.06066	0.13291	0.39898
145	South	Female	0	No	0.02459	0.01116	0.01002	0.05906
146	South	Female	0	Yes	0.03407	0.01282	0.01465	0.07723
147	South	Female	1	No	0.08869	0.03373	0.04118	0.18067
148	South	Female	1	Yes	0.05182	0.01167	0.03127	0.08472
149	South	Female	2	No	0.05097	0.02373	0.02012	0.12319
150	South	Female	2	Yes	0.07110	0.01386	0.04584	0.10869
151	South	Female	3	No	0.08717	0.03240	0.04122	0.17500
152	South	Female	3	Yes	0.08759	0.01718	0.05624	0.13394

Obs	Region	Gender	Age	Smoothed	Prevalence	Std Error	95 % Conf Interval – Lower Bound	95 % Conf Interval – Upper Bound
153	South	Female	4	No	0.11010	0.03209	0.06113	0.19035
154	South	Female	4	Yes	0.09897	0.01914	0.06387	0.15025
155	South	Female	5	No	0.09409	0.02943	0.05015	0.16968
156	South	Female	5	Yes	0.11870	0.02157	0.07855	0.17548
157	South	Female	6	No	0.15318	0.04317	0.08611	0.25777
158	South	Female	6	Yes	0.12150	0.02282	0.07925	0.18182
159	South	Female	7	No	0.09608	0.03538	0.04565	0.19105
160	South	Female	7	Yes	0.11192	0.02171	0.07204	0.16985
161	South	Female	8	No	0.09955	0.03288	0.05111	0.18493
162	South	Female	8	Yes	0.09287	0.01897	0.05850	0.14436
163	South	Female	9	No	0.07477	0.02719	0.03606	0.14864
164	South	Female	9	Yes	0.09117	0.01786	0.05855	0.13929
165	South	Female	10	No	0.10602	0.03214	0.05750	0.18732
166	South	Female	10	Yes	0.10821	0.02026	0.07077	0.16201
167	South	Female	11	No	0.14411	0.04267	0.07875	0.24907
168	South	Female	11	Yes	0.13237	0.02251	0.08989	0.19071
169	South	Female	12	No	0.12646	0.02981	0.07860	0.19723
170	South	Female	12	Yes	0.12346	0.02004	0.08543	0.17519
171	South	Female	13	No	0.11376	0.03270	0.06365	0.19510
172	South	Female	13	Yes	0.09653	0.01717	0.06458	0.14190
173	South	Female	14	No	0.02915	0.01339	0.01174	0.07054
174	South	Female	14	Yes	0.09469	0.01619	0.06436	0.13721
175	South	Female	15	No	0.11985	0.03357	0.06801	0.20259
176	South	Female	15	Yes	0.09988	0.01586	0.06978	0.14099
177	South	Female	16	No	0.14183	0.03685	0.08366	0.23028
178	South	Female	16	Yes	0.11501	0.01620	0.08365	0.15612
179	South	Female	17	No	0.13141	0.03007	0.08280	0.20226
180	South	Female	17	Yes	0.14466	0.02946	0.09067	0.22291
181	South	Male	0	No	0.01164	0.00852	0.00275	0.04790
182	South	Male	0	Yes	0.04132	0.01867	0.01487	0.10956
183	South	Male	1	No	0.10465	0.03216	0.05629	0.18635

Obs	Region	Gender	Age	Smoothed	Prevalence	Std Error	95 % Conf Interval – Lower Bound	95 % Conf Interval – Upper Bound
184	South	Male	1	Yes	0.06981	0.01623	0.04125	0.11576
185	South	Male	2	No	0.11644	0.03486	0.06353	0.20382
186	South	Male	2	Yes	0.10189	0.01672	0.07024	0.14557
187	South	Male	3	No	0.10794	0.03253	0.05874	0.19005
188	South	Male	3	Yes	0.12852	0.02139	0.08793	0.18405
189	South	Male	4	No	0.08480	0.02973	0.04190	0.16410
190	South	Male	4	Yes	0.14393	0.02379	0.09861	0.20534
191	South	Male	5	No	0.22243	0.04227	0.15052	0.31592
192	South	Male	5	Yes	0.16450	0.02373	0.11821	0.22430
193	South	Male	6	No	0.13908	0.03392	0.08485	0.21964
194	South	Male	6	Yes	0.16386	0.02460	0.11613	0.22617
195	South	Male	7	No	0.10695	0.04272	0.04747	0.22347
196	South	Male	7	Yes	0.13329	0.02322	0.08951	0.19392
197	South	Male	8	No	0.13660	0.03841	0.07712	0.23049
198	South	Male	8	Yes	0.13818	0.02276	0.09484	0.19702
199	South	Male	9	No	0.15978	0.03742	0.09920	0.24720
200	South	Male	9	Yes	0.16839	0.02450	0.12062	0.23012
201	South	Male	10	No	0.21482	0.04702	0.13676	0.32086
202	South	Male	10	Yes	0.17848	0.02453	0.13021	0.23972
203	South	Male	11	No	0.15078	0.03440	0.09492	0.23112
204	South	Male	11	Yes	0.16247	0.02224	0.11881	0.21820
205	South	Male	12	No	0.13727	0.03260	0.08489	0.21438
206	South	Male	12	Yes	0.14480	0.01976	0.10610	0.19453
207	South	Male	13	No	0.14136	0.03119	0.09049	0.21409
208	South	Male	13	Yes	0.14318	0.01928	0.10537	0.19165
209	South	Male	14	No	0.16110	0.03444	0.10438	0.24037
210	South	Male	14	Yes	0.15339	0.01875	0.11612	0.19992
211	South	Male	15	No	0.16172	0.03519	0.10394	0.24291
212	South	Male	15	Yes	0.15088	0.01746	0.11598	0.19398
213	South	Male	16	No	0.15836	0.03879	0.09614	0.24974
214	South	Male	16	Yes	0.14038	0.01773	0.10533	0.18467

Obs	Region	Gender	Age	Smoothed	Prevalence	Std Error	95 % Conf Interval – Lower Bound	95 % Conf Interval – Upper Bound
215	South	Male	17	No	0.11156	0.02737	0.06810	0.17746
216	South	Male	17	Yes	0.12247	0.02596	0.07537	0.19286
217	West	Female	0	No	0.00983	0.00990	0.00135	0.06802
218	West	Female	0	Yes	0.01318	0.00987	0.00248	0.06700
219	West	Female	1	No	0.02367	0.01862	0.00497	0.10522
220	West	Female	1	Yes	0.03105	0.01312	0.01204	0.07769
221	West	Female	2	No	0.08097	0.03759	0.03170	0.19166
222	West	Female	2	Yes	0.05440	0.01482	0.02948	0.09825
223	West	Female	3	No	0.07528	0.03851	0.02679	0.19404
224	West	Female	3	Yes	0.07444	0.01842	0.04257	0.12701
225	West	Female	4	No	0.09263	0.03196	0.04621	0.17703
226	West	Female	4	Yes	0.07696	0.02064	0.04194	0.13701
227	West	Female	5	No	0.01976	0.01347	0.00513	0.07302
228	West	Female	5	Yes	0.07737	0.02123	0.04157	0.13949
229	West	Female	6	No	0.15792	0.07301	0.06009	0.35487
230	West	Female	6	Yes	0.07298	0.01985	0.03947	0.13107
231	West	Female	7	No	0.06955	0.02567	0.03321	0.13989
232	West	Female	7	Yes	0.08146	0.01987	0.04691	0.13776
233	West	Female	8	No	0.07753	0.02825	0.03731	0.15417
234	West	Female	8	Yes	0.09062	0.01994	0.05507	0.14558
235	West	Female	9	No	0.13440	0.04481	0.06802	0.24832
236	West	Female	9	Yes	0.10215	0.02347	0.06061	0.16709
237	West	Female	10	No	0.06573	0.03719	0.02102	0.18736
238	West	Female	10	Yes	0.12152	0.02660	0.07376	0.19374
239	West	Female	11	No	0.15354	0.04584	0.08329	0.26584
240	West	Female	11	Yes	0.12719	0.02688	0.07852	0.19950
241	West	Female	12	No	0.10120	0.03594	0.04934	0.19631
242	West	Female	12	Yes	0.13054	0.02498	0.08440	0.19650
243	West	Female	13	No	0.14759	0.04125	0.08346	0.24769
244	West	Female	13	Yes	0.11968	0.02369	0.07629	0.18284
245	West	Female	14	No	0.08748	0.03284	0.04105	0.17675

Obs	Region	Gender	Age	Smoothed	Prevalence	Std Error	95 % Conf Interval – Lower Bound	95 % Conf Interval – Upper Bound
246	West	Female	14	Yes	0.11063	0.02132	0.07145	0.16744
247	West	Female	15	No	0.10099	0.03841	0.04674	0.20471
248	West	Female	15	Yes	0.11236	0.02051	0.07428	0.16645
249	West	Female	16	No	0.12538	0.04343	0.06188	0.23755
250	West	Female	16	Yes	0.12224	0.02210	0.08108	0.18021
251	West	Female	17	No	0.14672	0.04582	0.07743	0.26052
252	West	Female	17	Yes	0.14371	0.03992	0.07558	0.25621
253	West	Male	0	No	0.00000	0.00000	0.00000	0.00000
254	West	Male	0	Yes	0.03075	0.02534	0.00437	0.18642
255	West	Male	1	No	0.05457	0.02662	0.02056	0.13695
256	West	Male	1	Yes	0.04584	0.01889	0.01729	0.11595
257	West	Male	2	No	0.07833	0.02789	0.03833	0.15342
258	West	Male	2	Yes	0.06254	0.01442	0.03627	0.10573
259	West	Male	3	No	0.05897	0.02530	0.02500	0.13281
260	West	Male	3	Yes	0.07844	0.01913	0.04398	0.13607
261	West	Male	4	No	0.07267	0.03354	0.02870	0.17208
262	West	Male	4	Yes	0.09122	0.02482	0.04765	0.16763
263	West	Male	5	No	0.19732	0.10033	0.06632	0.45969
264	West	Male	5	Yes	0.11262	0.02937	0.06021	0.20092
265	West	Male	6	No	0.13335	0.04859	0.06322	0.25970
266	West	Male	6	Yes	0.12119	0.02916	0.06799	0.20680
267	West	Male	7	No	0.08881	0.03493	0.04015	0.18508
268	West	Male	7	Yes	0.12691	0.02806	0.07464	0.20758
269	West	Male	8	No	0.15183	0.05484	0.07210	0.29200
270	West	Male	8	Yes	0.13161	0.02705	0.08037	0.20811
271	West	Male	9	No	0.17199	0.05164	0.09260	0.29715
272	West	Male	9	Yes	0.15079	0.02837	0.09590	0.22915
273	West	Male	10	No	0.12897	0.03747	0.07151	0.22159
274	West	Male	10	Yes	0.16356	0.02584	0.11192	0.23279
275	West	Male	11	No	0.19469	0.04002	0.12785	0.28505
276	West	Male	11	Yes	0.16965	0.02623	0.11699	0.23956

Obs	Region	Gender	Age	Smoothed	Prevalence	Std Error	95 % Conf Interval – Lower Bound	95 % Conf Interval – Upper Bound
277	West	Male	12	No	0.13214	0.04542	0.06547	0.24865
278	West	Male	12	Yes	0.17494	0.02738	0.12002	0.24792
279	West	Male	13	No	0.19947	0.04814	0.12127	0.31029
280	West	Male	13	Yes	0.16217	0.02773	0.10747	0.23732
281	West	Male	14	No	0.10759	0.03838	0.05220	0.20880
282	West	Male	14	Yes	0.16487	0.02644	0.11214	0.23582
283	West	Male	15	No	0.18459	0.05348	0.10138	0.31235
284	West	Male	15	Yes	0.17018	0.02480	0.11996	0.23578
285	West	Male	16	No	0.19757	0.04862	0.11892	0.30993
286	West	Male	16	Yes	0.17888	0.02540	0.12718	0.24569
287	West	Male	17	No	0.18078	0.04735	0.10548	0.29227
288	West	Male	17	Yes	0.19218	0.04291	0.11118	0.31153

Attachment 5: Technical Memorandum on Analysis of Air Exchange Rate Data

DRAFT MEMORANDUM

To: John Langstaff

From: Jonathan Cohen, Hemant Mallya, Arlene Rosenbaum

Date: September 30, 2005

Re: EPA 68D01052, Work Assignment 3-08. Analysis of Air Exchange Rate Data

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EPA is planning to use the APEX exposure model to estimate ozone exposure in 12 cities / metropolitan areas: Atlanta, GA; Boston, MA; Chicago, IL; Cleveland, OH; Detroit, MI; Houston, TX; Los Angeles, CA; New York, NY; Philadelphia, PA; Sacramento, CA; St. Louis, MO-IL; Washington, DC. As part of this effort, ICF Consulting has developed distributions of residential and non-residential air exchange rates (AER) for use as APEX inputs for the cities to be modeled. This memorandum describes the analysis of the AER data and the proposed APEX input distributions. Also included in this memorandum are proposed APEX inputs for penetration and proximity factors for selected microenvironments.

Residential Air Exchange Rates

Studies. Residential air exchange rate (AER) data were obtained from the following seven studies:

> **Avol:** Avol et al, 1998. In this study, ozone concentrations and AERs were measured at 126 residences in the greater Los Angeles metropolitan area between February and December, 1994. Measurements were taken in four communities: Lancaster, Lake Gregory, Riverside, and San Dimas. Data included the daily average outdoor temperature, the presence or absence of an air conditioner (either central or room), and the presence or absence of a swamp (evaporative) cooler. Air exchange rates were computed based on the total house volume and based on the total house volume corrected for the furniture. These data analyses used the corrected AERs.
>
> **RTP Panel:** Williams et al, 2003a, 2003b. In this study particulate matter concentrations and daily average AERs were measured at 37 residences in central North Carolina during 2000 and 2001 (averaging about 23 AER measurements per residence). The residences belong to two specific cohorts: a mostly Caucasian, non-smoking group aged at least 50 years having cardiac defibrillators living in Chapel Hill; a group of non-smoking, African Americans aged at least 50 years with controlled hypertension living in a low-to-moderate SES neighborhood in Raleigh. Data included the daily average outdoor temperature, and the number of air conditioner units (either central or room). Every residence had at least one air conditioner unit.
>
> **RIOPA:** Meng et al, 2004, Weisel et al, 2004. The Relationship of Indoor, Outdoor, and Personal Air (RIOPA) study was undertaken to estimate the impact of outdoor sources of air toxics to indoor concentrations and personal exposures. Volatile organic compounds, carbonyls, fine particles and AERs were measured once or twice at 310 non-smoking residences from summer 1999 to spring 2001. Measurements were made at residences in Elizabeth, NJ, Houston TX, and Los Angeles CA. Residences in California were

randomly selected. Residences in New Jersey and Texas were preferentially selected to be close (< 0.5 km) to sources of air toxics. The AER measurements (generally over 48 hours) used a PMCH tracer. Data included the daily average outdoor temperature, and the presence or absence of central air conditioning, room air conditioning, or a swamp (evaporative) cooler.

TEACH: Chillrud at al, 2004, Kinney et al, 2002, Sax et al, 2004. The Toxic Exposure Assessment, a Columbia/Harvard (TEACH) study was designed to characterize levels of and factors influencing exposures to air toxics among high school students living in inner-city neighborhoods of New York City and Los Angeles, CA. Volatile organic compounds, aldehydes, fine particles, selected trace elements, and AER were measured at 87 high school student's residences in New York City and Los Angeles in 1999 and 2000. Data included the presence or absence of an air conditioner (central or room) and hourly outdoor temperatures (which were converted to daily averages for these analyses).

Wilson 1984: Wilson et al, 1986, 1996. In this 1984 study, AER and other data were collected at about 600 southern California homes with three seven-day tests (in March and July 1984, and January, 1985) for each home. We obtained the data directly from Mr. Wilson. The available data consisted of the three seven-day averages, the month, the residence zip code, the presence or absence of a central air conditioner, and the presence or absence of a window air conditioner. We matched these data by month and zip code to the corresponding monthly average temperatures obtained from EPA's SCRAM website as well as from the archives in www.wunderground.com (personal and airport meteorological stations). Residences more than 25 miles away from the nearest available meteorological station were excluded from the analysis. For our analyses, the city/location was defined by the meteorological station, since grouping the data by zip code would not have produced sufficient data for most of the zip codes.

Wilson 1991: Wilson et al, 1996. Colome et al, 1993, 1994. In this 1991 study, AER and other data were collected at about 300 California homes with one two-day test in the winter for each home. We obtained the data directly from Mr. Wilson. The available data consisted of the two-day averages, the date, city name, the residence zip code, the presence or absence of a central air conditioner, the presence or absence of a swamp (evaporative) cooler, and the presence or absence of a window air conditioner . We matched these data by date, city, and zip code to the corresponding daily average temperatures obtained from EPA's SCRAM website as well as from the archives in www.wunderground.com (personal and airport meteorological stations). Residences more than 25 miles away from the nearest available meteorological station were excluded from the analysis. For our analyses, the city/location was defined by the meteorological station, since grouping the data by zip code would not have produced sufficient data for most of the zip codes.

Murray and Burmaster: Murray and Burmaster (1995). For this article, Murray and Burmaster corrected and compiled nationwide residential AER data from several studies conducted between 1982 and 1987. These data were originally compiled by the Lawrence Berkeley National Laboratory. We acknowledge Mr. Murray's assistance in obtaining these data for us. The available data consisted of AER measurements, dates, cities, and degree-days. Information on air conditioner presence or absence was not available.

Table A-1 summarizes these studies.

For each of the studies, air conditioner usage, window status (open or closed), and fan status (on or off) was not part of the experimental design, although some of these studies included information on whether air conditioners or fans were used (and for how long) and whether windows were closed during the AER measurements (and for how long).

As described above, in the following studies the homes were deliberately sampled from specific subsets of the population at a given location rather than the entire population: The RTP Panel study selected two specific cohorts of older subjects with specific diseases. The RIOPA study was biased towards residences near air toxics sources. The TEACH study focused on inner-city neighborhoods. Nevertheless, we included all these studies because we determined that any potential bias would be likely to be small and we preferred to keep as much data as possible.

Table A-1. Summary of Studies of Residential Air Exchange Rates

	Avol	RTP Panel	RIOPA	TEACH	Wilson 1984	Wilson 1991	Murray and Burmaster
Locations	Lancaster, Lake Gregory, Riverside, San Dimas. All in Southern CA	Research Triangle Park, NC	CA; NJ; TX	Los Angeles, CA; New York City, NY	Southern CA	Southern CA	AZ, CA, CO, CT, FL, ID, MD, MN, MT, NJ
Years	1994	2000; 2001	1999; 2000; 2001	1999; 2000	1984, 1985	1984	1982 – 1987
Months/Seasons	Feb; Mar; Apr; May; Jun; Jul; Aug; Sep; Oct; Nov	2000 (Jun; Jul; Aug; Sep; Oct; Nov), 2001 (Jan; Feb; Apr; May)	1999 (July to Dec); 2000 (all months); 2001 (Jan and Feb)	1999 (Feb; Mar; Apr; Jul; Aug); 2000 (Jan; Feb; Mar; Sep; Oct)	Mar 1984, Jul 1984, Jan 1985	Jan, Mar, Jul	Various
Number of Homes	86	37	284	85	581	288	1,884
Total AER Measurements	161	854	524	151	1,362	316	2,844
Average Number of Measurements per Home	1.87	23.08	1.85	1.78	2.34	1.10	1.51
Measurement Duration	Not Available	24 hour	24 to 96 hours	Sample time (hours) reported. Ranges from about 1 to 7 days.	7 days	7 days	Not available
Measurement Technique	Not Available	Perflourocarbon tracer.	PMCH tracer	Perflourocarbon tracer.	Perflourocarbon tracer.	Perflourocarbon tracer.	Not available
Min AER Value	0.01	0.02	0.08	0.12	0.03	0.01	0.01
Max AER Value	2.70	21.44	87.50	8.87	11.77	2.91	11.77
Mean AER Value	0.80	0.72	1.41	1.71	1.05	0.57	0.76
Min Temperature (C)	-0.04	-2.18	-6.82	-1.36	11.00	3.00	Not available

	Avol	RTP Panel	RIOPA	TEACH	Wilson 1984	Wilson 1991	Murray and Burmaster
Max Temperature (C)	36.25	30.81	32.50	32.00	28.00	25.00	Not available
Air Conditioner Categories	No A/C; Central or Room A/C; Swamp Cooler only; Swamp + [Central or Room]	Central or Room A/C (Y/N)	Window A/C (Y/N); Evap Coolers (Y/N)	Central or Room A/C (Y/N)	Central A/C (Y/N); Room A/C (Y/N);	Central A/C (Y/N); Room A/C (Y/N); Swamp Cooler(Y/N)	Not available
Air Conditioner Measurements	A/C use in minutes	Not Available	Duration measurements in Hrs and Mins	Not Available	Not Available	Not Available	Not available
Fan Categories	Not available	Fan (Y/N)	Fan (Y/N)	Not Available	Not Available	Not Available	Not available
Fan Measurements	Time on or off for various fan types during sampling was recorded, but not included in database provided.	Not Available	Duration measurements in Hrs and Mins	Not Available	Not Available	Not Available	Not available
Window Open/ Closed Data	Duration open between times 6am-12 pm; 12pm - 6 pm; and 6pm - 6am	Windows (open / closed along with duration open in inch-hours units	Windows (Open / Closed) along with window open duration measurements	Not Available	Not Available	Not Available	Not available
Comments			CA sample was a random sample of homes. NJ and TX homes were deliberately chosen to be near to ambient sources.	Restricted to inner-city homes with high school students.	Contemporaneous temperature data obtained for these analyses from SCRAM and www.wunderground.com meteorological data.	Contemporaneous temperature data obtained for these analyses from SCRAM and www.wunderground.com meteorological data.	

We compiled the data from these seven studies to create the following variables, of which some had missing values:

- Study
- Date
- Time – Time of the day that the AER measurement was made
- House_ID – Residence identifier
- Measurement_ID – Uniquely identifies each AER measurement for a given study
- AER – Air Exchange Rate (per hour)
- AER_Duration – Length of AER measurement period
- Have_AC – Indicates if the residence has any type of air conditioner (A/C), either a room A/C or central A/C or swamp cooler or any of them in combination. “Y” = “Yes.” “N” = “No.”
- Type_of_AC1 – Indicates the types of A/C or swamp cooler available in each house measured. Possible values: “Central A/C” “Central and Room A/C” “Central or Room A/C” “No A/C” “Swamp + (Central or Room)” “Swamp Cooler only” “Window A/C” “Window and Evap”
- Type_of_AC2 – Indicates if a house measured has either no A/C or some A/C. Possible values are “No A/C” and “Central or Room A/C.”
- Have_Fan – Indicates if the house studied has any fans
- Mean_Temp – Daily average outside temperature
- Min_Temp – Minimum hourly outside temperature
- Max_Temp – Maximum hourly outside temperature
- State
- City
- Location – Two character abbreviation
- Flag – Data status. Murray and Burmaster study: “Used” or “Not Used.” Other studies: “Used”; “Missing” (missing values for AER, Type_of_AC2, and/or Mean_Temp); “Outlier”.

The main data analysis was based on the first six studies. The Murray and Burmaster data were excluded because of the absence of information on air conditioner presence. (However, a subset of these data was used for a supplementary analysis described below.) .

Based on our review of the AER data we excluded seven outlying high AER values – above 10 per hour. The main data analysis used all the remaining data that had non-missing values for AER, Type_of_AC2, and Mean_Temp. We decided to base the A/C type variable on the broad characterization “No A/C” versus “Central or Room A/C” since this variable could be calculated from all of the studies (excluding Murray and Burmaster). Information on the presence or absence of swamp coolers was not available from all the studies, and, also importantly, the corresponding information on swamp cooler prevalence for the subsequent ozone modeling cities was not available from the American Housing Survey. It is plausible that AER distributions depend upon the presence or absence of a swamp cooler. It is also plausible that AER distributions also depend upon whether the residence specifically has a central A/C, room or window A/C, or both. However we determined to use the broader A/C type definition, which in effect assumes that the exact A/C type and the presence of a swamp cooler are approximately proportionately represented in the surveyed residences.

Most of the studies had more than one AER measurement for the same house. It is reasonable to assume that the AER varies with the house as well as other factors such as the temperature. (The A/C type can be assumed to be the same for each measurement of the same house). We expected the temperature to be an important factor since the AER will be affected by the use of the available ventilation (air conditioners, windows, fans), which in turn will depend upon the outside meteorology. Therefore it is not appropriate to average data for the same house under different conditions, which might have been one way to account for dependence between multiple measurements on the same house. To simplify the data analysis, we chose to ignore possible dependence between measurements on the same house on different days and treat all the AER values as if they were statistically independent.

Summary Statistics. We computed summary statistics for AER and its natural logarithm LOG_AER on selected strata defined from the study, city, A/C type, and mean temperature. Cities were defined as in the original databases, except that for Los Angeles we combined all the data in the Los Angeles ozone modeling region, i.e. the counties of Los Angeles, Orange, Ventura, Riverside, and San Bernardino. A/C type was defined from the Type_of_AC2 variable, which we abbreviated as "NA" = "No A/C" and "AC" = "Central or Room A/C." The mean temperature was grouped into the following temperature bins: -10 to 0 ºC, 0 to 10 ºC, 10 to 20 ºC, 20 to 25 ºC, 25 to 30 ºC, 30 to 40 ºC.(Values equal to the lower bounds are excluded from each interval.) Also included were strata defined by study = "All" and/or city = "All," and/or A/C type = "All" and/or temperature bin = "All." The following summary statistics for AER and LOG_AER were computed:

- Number of values
- Arithmetic Mean
- Arithmetic Standard Deviation
- Arithmetic Variance
- Deciles (Min, 10^{th}, 20^{th} … 90^{th} percentiles, Max)

These calculations exclude all seven outliers and results are not used for strata with 10 or fewer values, since those summary statistics are extremely unreliable.

Examination of these summary tables clearly demonstrates that the AER distributions vary greatly across cities and A/C types and temperatures, so that the selected AER distributions for the modeled cities should also depend upon the city, A/C type and temperature. For example, the mean AER for residences with A/C ranges from 0.39 for Los Angeles between 30 and 40 ºC to 1.73 for New York between 20 and 25 ºC. The mean AER for residences without A/C ranges from 0.46 for San Francisco between 10 and 20 ºC to 2.29 for New York between 20 and 25 ºC. The need to account for the city as well as the A/C type and temperature is illustrated by the result that for residences with A/C and between 20 and 25 ºC, the mean AER ranges from 0.52 for Research Triangle Park to 1.73 for New York. Statistical comparisons are described below.

Statistical Comparisons. Various statistical comparisons were carried out between the different strata, for the AER and its logarithm. The various strata are defined as in the Summary Statistics section, excluding the "All" cases. For each analysis, we fixed one or two of the variables Study, City, A/C type, temperature, and tested for statistically significant differences among other variables. The comparisons are listed in Table A-2.

Table A-2. Summary of Comparisons of Means

Comparison Analysis Number.	Comparison Variable(s) “Groups Compared”	Stratification Variable(s) (not missing in worksheet)	Total Comparisons	Cases with significantly different means (5 % level)	
				AER	Log AER
1.	City	Type of A/C AND Temp. Range	12	8	8
2.	Temp. Range	Study AND City	12	5	5
3.	Type of A/C	Study AND City	15	5	5
4.	City	Type of A/C	2	2	2
5.	City	Temp. Range	6	5	6
6.	Type of A/C AND Temp. Range	Study AND City	17	6	6

For example, the first set of comparisons fix the Type of A/C and the temperature range; there are twelve such combinations. For each of these twelve combinations, we compare the AER distributions across different cities. This analysis determines whether the AER distribution is appropriately defined by the A/C type and temperature range, without specifying the city. Similarly, for the sixth set of comparisons, the study and city are held fixed (17 combinations) and in each case we compare AER distributions across groups defined by the combination of the A/C type and the temperature range.

The F Statistic comparisons compare the mean values between groups using a one way analysis of variance (ANOVA). This test assumes that the AER or log(AER) values are normally distributed with a mean that may vary with the comparison variable(s) and a constant variance. We calculated the F Statistic and its P-value. P-values above 0.05 indicate cases where all the group means are not statistically significantly different at the 5 percent level. Those results are summarized in the last two columns of the above table “Summary of Comparisons of Means” which gives the number of cases where the means are significantly different. Comparison analyses 2, 3, and 6 show that for a given study and city, slightly less than half of the comparisons show significant differences in the means across temperature ranges, A/C types, or both. Comparison analyses 1, 4, and 5 show that for the majority of cases, means vary significantly across cities, whether you first stratify by temperature range, A/C type, or both.

The Kruskal-Wallis Statistic comparisons are non-parametric tests that are extensions of the more familiar Wilcoxon tests to two or more groups. The analysis is valid if the AER minus the group median has the same distribution for each group, and tests whether the group medians are equal. (The test is also consistent under weaker assumptions against more general alternatives) The P-values show similar patterns to the parametric F test comparisons of the means. Since the logarithm is a strictly increasing function and the test is non-parametric, the Kruskal-Wallis tests give identical results for AER and Log (AER).

The Mood Statistic comparisons are non-parametric tests that compare the scale statistics for two or more groups. The scale statistic measures variation about the central value, which is a non-parametric generalization of the standard deviation. Specifically, suppose there is a total of N AER or log(AER) values, summing across all the groups. These N values are ranked from 1 to N, and the j’th highest value is given a score of $\{j - (N+1)/2\}^2$. The Mood statistic uses a one way ANOVA statistic to compare the total scores for each group. Generally, the Mood statistics show that in most cases the scale statistics are not statistically significantly different. Since the logarithm is a strictly increasing function and the test is non-parametric, the Mood tests give identical results for AER and Log (AER).

Fitting Distributions. Based on the summary statistics and the statistical comparisons, the need to fit different AER distributions to each combination of A/C type, city, and temperature is apparent. For each combination with a minimum of 11 AER values, we fitted and compared exponential, log-normal, normal, and Weibull distributions to the AER values.

The first analysis used the same stratifications as in the above "Summary Statistics" and "Statistical Comparisons" sections. Results are not reported for all strata because of the minimum data requirement of 11 values. Results for each combination of A/C type, city, and temperature (i.e., A, C, and T) were analyzed. Each combination has four rows, one for each fitted distribution. For each distribution we report the fitted parameters (mean, standard deviation, scale, shape) and the p-value for three standard goodness-of-fit tests: Kolmogorov-Smirnov (K-S), Cramer-Von-Mises (C-M), Anderson-Darling (A-D). Each goodness-of-fit test compares the empirical distribution of the AER values to the fitted distribution. The K-S and C-M tests are different tests examining the overall fit, while the Anderson-Darling test gives more weight to the fit in the tails of the distribution. For each combination, the best-fitting of the four distributions has the highest p-value and is marked by an x in the final three columns. The mean and standard deviation (Std_Dev) are the values for the fitted distribution. The scale and shape parameters are defined by:

- Exponential: density = $\sigma^{-1} \exp(-x/\sigma)$, where shape = mean = σ
- Log-normal: density = $\{\sigma x\sqrt{(2\pi)}\}^{-1} \exp\{ -(\log x - \zeta)^2 / (2\sigma^2)\}$, where shape = σ and scale = ζ. Thus the geometric mean and geometric standard deviation are given by $\exp(\zeta)$ and $\exp(\sigma)$, respectively.
- Normal: density = $\{\sigma\sqrt{(2\pi)}\}^{-1} \exp\{ -(x - \mu)^2 / (2\sigma^2)\}$, where mean = μ and standard deviation = σ
- Weibull: density = $(c/\sigma)\ (x/\sigma)^{c-1} \exp\{-(x/\sigma)^c\}$, where shape = c and scale = σ

Generally, the log-normal distribution was the best-fitting of the four distributions, and so, for consistency, we recommend using the fitted log-normal distributions for all the cases.

One limitation of the initial analysis was that distributions were available only for selected cities, and yet the summary statistics and comparisons demonstrate that the AER distributions depend upon the city as well as the temperature range and A/C type. As one option to address this issue, we considered modeling cities for which distributions were not available by using the AER distributions across all cities and dates for a given temperature range and A/C type.

Another important limitation of the initial analysis was that distributions were not fitted to all of the temperature ranges due to inadequate data. There are missing values between temperature ranges, and the temperature ranges are all bounded. To address this issue, the temperature ranges were regrouped to cover the entire range of temperatures from minus to plus infinity, although obviously the available data to fit these ranges have finite temperatures. Stratifying by A/C type, city, and the new temperature ranges produces results for four cities: Houston (AC and NA); Los Angeles (AC and NA); New York (AC and NA); Research Triangle Park (AC). For each of the fitted distributions we created histograms to compare the fitted distributions with the empirical distributions.

AER Distributions for The First Nine Cities. Based upon the results for the above four cities and the corresponding graphs, we propose using those fitted distributions for the three cities Houston, Los Angeles, and New York. For another 6 of the cities to be modeled, we propose using the distribution for one of the four cities thought to have similar characteristics to the city to be modeled with respect to factors that might influence AERs. These factors include the age composition of housing stock, construction methods, and other meteorological variables not explicitly treated in the analysis, such as humidity and wind speed patterns. The distributions proposed for these cities are as follows:

- Atlanta, GA, A/C: Use log-normal distributions for Research Triangle Park. Residences with A/C only.
- Boston, MA: Use log-normal distributions for New York
- Chicago, IL: Use log-normal distributions for New York
- Cleveland, OH: Use log-normal distributions for New York
- Detroit, MI: Use log-normal distributions for New York
- Houston, TX: Use log-normal distributions for Houston
- Los Angeles, CA: Use log-normal distributions for Los Angeles
- New York, NY: Use log-normal distributions for New York
- Philadelphia, PA: Use log-normal distributions for New York

Since the AER data for Research Triangle Park was only available for residences with air conditioning, AER distributions for Atlanta residences without air conditioning are discussed below.

To avoid unusually extreme simulated AER values, we propose to set a minimum AER value of 0.01 and a maximum AER value of 10.

Obviously, we would be prefer to model each city using data from the same city, but this approach was chosen as a reasonable alternative, given the available AER data.

AER Distributions for Sacramento and St. Louis. For these two cities, a direct mapping to one of the four cities Houston, Los Angeles, New York, and Research Triangle Park is not recommended because the cities are likely to be too dissimilar. Instead, we decided to use the distribution for the inland parts of Los Angeles to represent Sacramento and to use the aggregate distributions for all cities outside of California to represent St. Louis. The results for the city Sacramento were obtained by combining all the available AER data for Sacramento, Riverside, and San Bernardino counties. The results for the city St. Louis were obtained by combining all non-California AER data.

AER Distributions for Washington DC. Washington DC was judged likely to have similar characteristics both to Research Triangle Park and to New York City. To choose between these two cities, we compared the Murray and Burmaster AER data for Maryland with AER data from each of those cities. The Murray and Burmaster study included AER data for Baltimore and for Gaithersburg and Rockville, primarily collected in March. April, and May 1987, although there is no information on mean daily temperatures or A/C type. We collected all the March, April, and May AER data for Research Triangle Park and for New York City, and compared those distributions with the Murray and Burmaster Maryland data for the same three months.

The results for the means and central values show significant differences at the 5 percent level between the New York and Maryland distributions. Between Research Triangle Park and

Maryland, the central values and the mean AER values are not statistically significantly different, and the differences in the mean log (AER) values are much less statistically significant than between New York and Maryland. The scale statistic comparisons are not statistically significantly different between New York and Maryland, but were statistically significantly different between Research Triangle Park and Maryland. Since matching central and mean values is generally more important than matching the scales, we propose to model Washington DC residences with air conditioning using the Research Triangle Park distributions, stratified by temperature:

- Washington DC, A/C: Use log-normal distributions for Research Triangle Park. Residences with A/C only.

Since the AER data for Research Triangle Park was only available for residences with air conditioning, the estimated AER distributions for Washington DC residences without air conditioning are discussed below.

AER Distributions for Washington DC and Atlanta GA Residences With No A/C. For Atlanta and Washington DC we have proposed to use the AER distributions for Research Triangle Park. However, all the Research Triangle Park data (from the RTP Panel study) were from houses with air conditioning, so there are no available distributions for the “No A/C” cases. For these two cities, one option is to use AER distributions fitted to all the study data for residences without A/C, stratified by temperature. We propose applying the “No A/C” distributions for modeling these two cities for residences without A/C. However, since Atlanta and Washington DC residences are expected to be better represented by residences outside of California, we instead propose to use the “No A/C” AER distributions aggregated across cities outside of California, which is the same as the recommended choice for the St. Louis “No A/C” AER distributions.

A/C Type and Temperature Distributions. Since the proposed AER distribution is conditional on the A/C type and temperature range, these values also need to be simulated using APEX in order to select the appropriate AER distribution. Mean daily temperatures are one of the available APEX inputs for each modeled city, so that the temperature range can be determined for each modeled day according to the mean daily temperature. To simulate the A/C type, we obtained estimates of A/C prevalence from the American Housing Survey. Thus for each city/metropolitan area, we obtained the estimated fraction of residences with Central or Room A/C (see Table A-3), which gives the probability p for selecting the A/C type “Central or Room A/C.” Obviously, 1-p is the probability for “No A/C.” For comparison with Washington DC and Atlanta, we have included the A/C type percentage for Charlotte, NC (representing Research Triangle Park, NC). As discussed above, we propose modeling the 96-97 % of Washington DC and Atlanta residences with A/C using the Research Triangle Park AER distributions, and modeling the 3-4 % of Washington DC and Atlanta residences without A/C using the combined study No A/C AER distributions.

Table A-3. Fraction of residences with central or room A/C (from American Housing Survey)

CITY	SURVEY AREA & YEAR	PERCENTAGE
Atlanta	Atlanta, 2003	97.01
Boston	Boston, 2003	85.23
Chicago	Chicago, 2003	87.09

Cleveland	Cleveland, 2003	74.64
Detroit	Detroit, 2003	81.41
Houston	Houston, 2003	98.70
Los Angeles	Los Angeles, 2003	55.05
New York	New York, 2003	81.57
Philadelphia	Philadelphia, 2003	90.61
Sacramento	Sacramento, 2003	94.63
St. Louis	St. Louis, 2003	95.53
Washington DC	Washington DC, 2003	96.47
Research Triangle Park	Charlotte, 2002	96.56

Other AER Studies

We recently became aware of some additional residential and non-residential AER studies that might provide additional information or data. Indoor / outdoor ozone and PAN distributions were studied by Jakobi and Fabian (1997). Liu et al (1995) studied residential ozone and AER distributions in Toronto, Canada. Weschler and Shields (2000) describes a modeling study of ventilation and air exchange rates. Weschler (2000) includes a useful overview of residential and non-residential AER studies.

AER Distributions for Other Indoor Environments

To estimate AER distributions for non-residential, indoor environments (e.g., offices and schools), we obtained and analyzed two AER data sets: "Turk" (Turk et al, 1989); and "Persily" (Persily and Gorfain 2004; Persily et al. 2005).

The earlier "Turk" data set (Turk et al, 1989) includes 40 AER measurements from offices (25 values), schools (7 values), libraries (3 values), and multi-purpose (5 values), each measured using an SF6 tracer over two- or four-hours in different seasons of the year.

The more recent "Persily" data (Persily and Gorfain 2004; Persily et al. 2005) were derived from the U.S. EPA Building Assessment Survey and Evaluation (BASE) study, which was conducted to assess indoor air quality, including ventilation, in a large number of randomly selected office buildings throughout the U.S. The data base consists of a total of 390 AER measurements in 96 large, mechanically ventilated offices; each office was measured up to four times over two days, Wednesday and Thursday AM and PM. The office spaces were relatively large, with at least 25 occupants, and preferably 50 to 60 occupants. AERs were measured both by a volumetric method and by a CO2 ratio method, and included their uncertainty estimates. For these analyses, we used the recommended "Best Estimates" defined by the values with the lower estimated uncertainty; in the vast majority of cases the best estimate was from the volumetric method.

Another study of non-residential AERs was performed by Lagus Applied Technology (1995) using a tracer gas method. That study was a survey of AERs in 16 small office buildings, 6 large office buildings, 13 retail establishments, and 14 schools. We plan to obtain and analyze these data and compare those results with the Turk and Persily studies.

Due to the small sample size of the Turk data, the data were analyzed without stratification by building type and/or season. For the Persily data, the AER values for each office space were averaged, rather using the individual measurements, to account for the strong dependence of the AER measurements for the same office space over a relatively short period.

Summary statistics of AER and log (AER) for the two studies are presented in Table A-4.

Table A-4. AER summary statistics for offices and other non-residential buildings

Study	Variable	N	Mean	Std Dev	Min	25^{th} %ile	Median	75^{th} %ile	Max
Persily	AER	96	1.9616	2.3252	0.0712	0.5009	1.0795	2.7557	13.8237
Turk	AER	40	1.5400	0.8808	0.3000	0.8500	1.5000	2.0500	4.1000
Persily	Log(AER)	96	0.1038	1.1036	-2.6417	-0.6936	0.0765	1.0121	2.6264
Turk	Log(AER)	40	0.2544	0.6390	-1.2040	-0.1643	0.4055	0.7152	1.4110

The mean values are similar for the two studies, but the standard deviations are about twice as high for the Persily data. The proposed AER distributions were derived from the more recent Persily data only.

Similarly to the analyses of the residential AER distributions, we fitted exponential, log-normal, normal, and Weibull distributions to the 96 office space average AER values. The results are shown in Table A-5.

Table A-5. Best fitting office AER distributions from the Persily et al. (2004, 2005)

Scale	Shape	Mean	Std_Dev	Distribution	P-Value Kolmogorov-Smirnov	P-Value Cramer-von Mises	P-Value Anderson-Darling
1.9616		1.9616	1.9616	Exponential	0.13	0.04	0.05
0.1038	1.1036	2.0397	3.1469	Lognormal	0.15	0.46	0.47
		1.9616	2.3252	Normal	0.01	0.01	0.01
1.9197	0.9579	1.9568	2.0433	Weibull		0.01	0.01

(For an explanation of the Kolmogorov-Smirnov, Cramer-von Mises, and Anderson-Darling P-values see the discussion residential AER distributions above.) According to all three goodness-of-fit measures the best-fitting distribution is the log-normal. Reasonable choices for the lower and upper bounds are the observed minimum and maximum AER values.

We therefore propose the following indoor, non-residential AER distributions.

- AER distribution for indoor, non-residential microenvironments: Lognormal, with scale and shape parameters 0.1038 and 1.1036, i.e., geometric mean = 1.1094, geometric standard deviation = 3.0150. Lower Bound = 0.07. Upper bound = 13.8.

Proximity and Penetration Factors For Outdoors, In-vehicle, and Mass Transit

For the APEX modeling of the outdoor, in-vehicle, and mass transit micro-environments, an approach using proximity and penetration factors is proposed, as follows.

Outdoors Near Road

Penetration factor = 1.

For the Proximity factor, we propose using ratio distributions developed from the Cincinnati Ozone Study (American Petroleum Institute, 1997, Appendix B; Johnson et al. 1995). The field study was conducted in the greater Cincinnati metropolitan area in August and September, 1994. Vehicle tests were conducted according to an experimental design specifying the vehicle type, road type, vehicle speed, and ventilation mode. Vehicle types were defined by the three study vehicles: a minivan, a full-size car, and a compact car. Road types were interstate highways (interstate), principal urban arterial roads (urban), and local roads (local). Nominal vehicle speeds (typically met over one minute intervals within 5 mph) were at 35 mph, 45 mph, or 55 mph. Ventilation modes were as follows:

- Vent Open: Air conditioner off. Ventilation fan at medium. Driver's window half open. Other windows closed.
- Normal A/C. Air conditioner at normal. All windows closed.
- Max A/C: Air conditioner at maximum. All windows closed.

Ozone concentrations were measured inside the vehicle, outside the vehicle, and at six fixed site monitors in the Cincinnati area.

The proximity factor can be estimated from the distributions of the ratios of the outside-vehicle ozone concentrations to the fixed-site ozone concentrations, reported in Table 8 of Johnson et al. (1995). Ratio distributions were computed by road type (local, urban, interstate, all) and by the fixed-site monitor (each of the six sites, as well as the nearest monitor to the test location). For this analysis we propose to use the ratios of outside-vehicle concentrations to the concentrations at the nearest fixed site monitor, as shown in Table A-6.

Table A-6. Ratio of outside-vehicle ozone to ozone at nearest fixed site[1]

Road Type[1]	Number of cases[1]	Mean[1]	Standard Deviation[1]	25th Percentile[1]	50th Percentile[1]	75th Percentile[1]	Estimated 5th Percentile[2]
Local	191	0.755	0.203	0.645	0.742	0.911	0.422
Urban	299	0.754	0.243	0.585	0.722	0.896	0.355
Interstate	241	0.364	0.165	0.232	0.369	0.484	0.093
All	731	0.626	0.278	0.417	0.623	0.808	0.170

1. From Table 8 of Johnson et al. (1995). Data excluded if fixed-site concentration < 40 ppb.
2. Estimated using a normal approximation as Mean – 1.64 × Standard Deviation

For the outdoors-near- road microenvironment, we recommend using the distribution for local roads, since most of the outdoors-near-road ozone exposure will occur on local roads. The summary data from the Cincinnati Ozone Study are too limited to allow fitting of distributions, but the 25th and 75th percentiles appear to be approximately equidistant from the median (50th percentile). Therefore we propose using a normal distribution with the observed mean and standard deviation. A plausible upper bound for the proximity factor equals 1. Although the normal distribution allows small positive values and can even produce impossible, negative values (with a very low probability), the titration of ozone concentrations near a road is limited. Therefore, as an empirical approach, we recommend a lower bound of the estimated 5th percentile, as shown in the final column of the above table. Therefore in summary we propose:

- Penetration factor for outdoors, near road: 1.
- Proximity factor for outdoors, near road: Normal distribution. Mean = 0.755. Standard Deviation = 0.203. Lower Bound = 0.422. Upper Bound = 1.

Outdoors, Public Garage / Parking Lot

This micro-environment is similar to the outdoors-near-road microenvironment. We therefore recommend the same distributions as for outdoors-near-road:

- Penetration factor for outdoors, public garage / parking lot: 1.
- Proximity factor for outdoors, public garage / parking lot: Normal distribution. Mean = 0.755. Standard Deviation = 0.203. Lower Bound = 0.422. Upper Bound = 1.

Outdoors, Other

The outdoors, other ozone concentrations should be well represented by the ambient monitors. Therefore we propose:

- Penetration factor for outdoors, other: 1.
- Proximity factor for outdoors, other: 1.

In-Vehicle

For the proximity factor for in-vehicle, we also recommend using the results of the Cincinnati Ozone Study presented in Table A-6. For this microenvironment, the ratios depend upon the road type, and the relative prevalences of the road types can be estimated by the proportions of vehicle miles traveled in each city. The proximity factors are assumed, as before, to be normally distributed, the upper bound to be 1, and the lower bound to be the estimated 5th percentile.

- Proximity factor for in-vehicle, local roads: Normal distribution. Mean = 0.755. Standard Deviation = 0.203. Lower Bound = 0.422. Upper Bound = 1.
- Proximity factor for in-vehicle, urban roads: Normal distribution. Mean = 0.754. Standard Deviation = 0.243. Lower Bound = 0.355. Upper Bound = 1.
- Proximity factor for in-vehicle, interstates: Normal distribution. Mean = 0.364. Standard Deviation = 0.165. Lower Bound = 0.093. Upper Bound = 1.

To complete the specification, the distribution of road type needs to be estimated for each city to be modeled. Vehicle miles traveled (VMT) in 2003 by city (defined by the Federal-Aid urbanized area) and road type were obtained from the Federal Highway Administration. (http://www.fhwa.dot.gov/policy/ohim/hs03/htm/hm71.htm). For local and interstate road types, the VMT for the same DOT categories were used. For urban roads, the VMT for all other road types was summed (Other freeways/expressways, Other principal arterial, Minor arterial, Collector). The computed VMT ratios for each city are shown in Table A-7.

Table A-7. Vehicle Miles Traveled by City and Road Type in 2003 (FHWA, October 2004)

FEDERAL-AID URBANIZED AREA	FRACTION VMT BY ROAD TYPE		
	INTERSTATE	URBAN	LOCAL
Atlanta	0.38	0.45	0.18
Boston	0.31	0.55	0.14
Chicago	0.30	0.59	0.12
Cleveland	0.39	0.45	0.16
Detroit	0.26	0.63	0.11
Houston	0.24	0.72	0.04
Los Angeles	0.29	0.65	0.06
New York	0.18	0.67	0.15
Philadelphia	0.23	0.65	0.11
Sacramento	0.21	0.69	0.09
St. Louis	0.36	0.45	0.19
Washington	0.31	0.61	0.08

Note that a "Federal-Aid Urbanized Area" is an area with 50,000 or more persons that at a minimum encompasses the land area delineated as the urbanized area by the Bureau of the Census. Urbanized areas that have been combined with others for reporting purposes are not shown separately. The Illinois portion of Round Lake Beach-McHenry-Grayslake has been reported with Chicago.

Thus to simulate the proximity factor in APEX, we propose to first select the road type according to the above probability table of road types, then select the AER distribution (normal) for that road type as defined in the last set of bullets.

For the penetration factor for in-vehicle, we recommend using the inside-vehicle to outside-vehicle ratios from the Cincinnati Ozone Study. The ratio distributions were summarized for all the data and for stratifications by vehicle type, vehicle speed, road type, traffic (light, moderate, or heavy), and ventilation. The overall results and results by ventilation type are shown in Table A-8.

Table A-8. Ratio of inside-vehicle ozone to outside-vehicle ozone[1]

Ventilation[1]	Number of cases[1]	Mean[1]	Standard Deviation[1]	25th Percentile[1]	50th Percentile[1]	75th Percentile[1]	Estimated 5th Percentile[2]
Vent Open	226	0.361	0.217	0.199	0.307	0.519	0.005
Normal A/C	332	0.417	0.211	0.236	0.408	0.585	0.071
Maximum A/C	254	0.093	0.088	0.016	0.071	0.149	0.000[3]
All	812	0.300	0.232	0.117	0.251	0.463	0.000[3]

1. From Table 7 of Johnson et al.(1995). Data excluded if outside-vehicle concentration < 20 ppb.

2. Estimated using a normal approximation as Mean – 1.64 × Standard Deviation
3. Negative estimate (impossible value) replaced by zero.

Although the data in Table A-8 indicate that the inside-to-outside ozone ratios strongly depend upon the ventilation type, it would be very difficult to find suitable data to estimate the ventilation type distributions for each modeled city. Furthermore, since the Cincinnati Ozone Study was scripted, the ventilation conditions may not represent real-world vehicle ventilation scenarios. Therefore, we propose to use the overall average distributions.

- Penetration factor for in-vehicle: Normal distribution. Mean = 0.300. Standard Deviation = 0.232. Lower Bound = 0.000. Upper Bound = 1.

Mass Transit

The mass transit microenvironment is expected to be similar to the in-vehicle microenvironment. Therefore we recommend using the same APEX modeling approach:

- Proximity factor for mass transit, local roads: Normal distribution. Mean = 0.755. Standard Deviation = 0.203. Lower Bound = 0.422. Upper Bound = 1.
- Proximity factor for mass transit, urban roads: Normal distribution. Mean = 0.754. Standard Deviation = 0.243. Lower Bound = 0.355. Upper Bound = 1.
- Proximity factor for mass transit, interstates: Normal distribution. Mean = 0.364. Standard Deviation = 0.165. Lower Bound = 0.093. Upper Bound = 1.
- Road type distributions for mass transit: See Table A-6
- Penetration factor for mass transit: Normal distribution. Mean = 0.300. Standard Deviation = 0.232. Lower Bound = 0.000. Upper Bound = 1.

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Attachment 6: Technical Memorandum on HAPEM Near Road Population Data Base Development (from Task 2. Near roadway concentrations (revised))

MEMORANDUM

To: Chad Bailey and Rich Cook

From: Jonathan Cohen and Arlene Rosenbaum

Date: September 30, 2005

Re: Task 2. Near roadway concentrations (revised)

The objective of this task was to estimate the enhancement near major roadways of air toxic pollutant concentrations from onroad motor vehicle emissions relative to concentrations at other outdoor locations.

For this task, we reviewed several studies of near roadway concentration gradients (Cohen et al, 2005; Kwon, 2005; Meng et al, 2004; Riediker et al, 2003; Rodes et al, 1998; Weisel et al, 2004; Zhu et al, 2002). We analyzed the available data using summary statistics and regression modeling in order to obtain distributions of concentration ratios. One distribution describes the ratio of concentrations within D1 meters of a major roadway to concentrations at locations greater than D2 meters from a major roadway. A second distribution describes the ratio of concentrations D1 - D2 meters of a major roadway to concentrations at locations greater than D2 meters from a major roadway. We chose distances D1 = 75 m and D2 = 200 m to best represent the near roadway concentration gradient. These ratio distributions were used in Task 3 to estimate the spatial distribution of concentrations within a census tract from the ASPEN concentration prediction.

Rodes and Riediker Studies

In order to stratify the concentration ratios according distance from major roadways we required concentration databases that specify those distances. EPA provided data from the Riediker et al (2003) study of concentrations inside patrol cars, near roadways, and at fixed ambient monitoring sites in Wake County, NC. We also evaluated the study by Rodes et al (1998), which includes near roadway monitoring in Sacramento and Los Angeles, CA. However, in neither study do the distances of the near roadway concentration measurements from the roadways span the range required for this analysis. The measurements in the Riediker study were taken within 20 feet of the roadway. The report for the Rodes study states that permission for placing the roadside monitors was obtained from the California Transportation Agency, implying they were located within the right-of-way of the road. The goal of this task was to estimate concentration ratios for concentrations within about 50 to 150 m and within about 150 to 300 m to concentrations further away from the roadway. Therefore, we determined that the results from the Rodes and Riediker studies could not be used for the Task 2 analyses since those studies had concentration measurements much nearer to the roadway.

Zhu et al (2002) Study

Zhu et al (2002) measured concentrations of black carbon (BC), carbon monoxide (CO), and particle number at various distances upwind and downwind from the 710 and 405 freeways in Los Angeles. We used these data to calculate mean CO concentrations and concentration ratios at different distances from the freeways. For freeway 710, the distances were 17, 20, 30, 90, 150, and 300 m downwind and 200m upwind. For freeway 405, the distances were 30, 60, 90, 150, and 300 m downwind and 300m upwind. Three measurements per day were taken at approximately the same time (various times between 10 am and 4:30 pm) for all downwind distances. One measurement was made on the same day at the upwind distance. We calculated the daily average concentrations and used them to calculate the distribution of the mean concentration upwind or downwind as a function of the distance to the freeway. These results for each freeway, season, and overall, are shown in Table 1. The concentrations drop very sharply as the distances increase. For Table 2, we calculated the ratios of the average concentration between 0 and 50 m from the road to the average concentration greater than 150 m from the road and of the average concentration between 50 and 150 m from the road to the average concentration greater than 150 m from the road. The distributions of these ratios are shown in Table 2.

After reviewing the Zhu et al (2002) study and the analyses of Tables 1 and 2, we determined that the results of the Zhu et al (2002) could not be used for this project because the available ratios were only for the downwind distances, and did not represent ratios under more general meteorological conditions.

RIOPA Study

The Relationship of Indoor, Outdoor, and Personal Air (RIOPA) study (Meng et al, 2004; Weisel et al, 2004) was undertaken to estimate the impact of outdoor sources of air toxics to indoor concentrations and personal exposures. Volatile organic compounds, carbonyls, fine particles and air exchange ratios were measured once or twice at 310 non-smoking residences from summer 1999 to spring 2001. Measurements were made at residences in Elizabeth, NJ, Houston TX, and Los Angeles CA. Residences in California were randomly selected. Residences in New Jersey and Texas were preferentially selected to be close (< 0.5 km) to sources of air toxics.

Since the residences studied were at various distances from major roads, we analyzed the results of this study to estimate the relationship between the concentration (outside the residence) and the distance from the roadway. We obtained the relevant data from the Appendix of Kwon (2005), who used GIS mapping to calculate distances from the residences to major roads, gas stations, and other important emissions sources. Kwon (2005) used these data in various regression models to estimate the concentration as a function of these distances. Our analyses used a similar regression approach. but our modeling only used the distances to the major roadways. For the main analyses, we excluded residences within 150 m of a gas station to avoid confounding our analysis of roadway emissions with the effects of gas station emissions. Unlike Kwon (2005) we chose not to eliminate any values as potential outliers, since there were no “obvious” outlier data values.

For the preliminary analysis, all the available data, including residences within 150 m of a gas station, were included. For each residence, two-day average pollutant concentrations were measured for benzene, carbon tetrachloride, ethylbenzene, MTBE, PCE (perchloroethylene), toluene, m & p-xylene, and o-xylene. We computed the distributions of the pollutant concentrations for residences within 50 m of a major roadway, between 50 and 150 m of a major roadway, and more than 150 m from a major roadway. These distances, from Kwon (2005), are the distances to the nearest roadway among functional classes FC11 (urban interstate highways), FC12 (urban other freeways), and FC14 (urban major arterials). The results are tabulated in Table 3.

Also shown in Table 3 are the ratios of the average concentration between 0 and 50 m from the road to the average concentration greater than 150 m from the road, and of the average concentration between 50 and 150 m from the road to the average concentration greater than 150 m from the road. The standard deviation of the ratio was estimated using the delta method (first order Taylor series approximation). The CV (standard deviation divided by mean) is also presented. Of particular interest is the finding that for all of the pollutants except toluene and the xylenes, the mean concentrations are higher in the 50 to 150 m range than the concentrations in the 0 to 50 m and greater than 150 m ranges. For toluene and the xylenes, the mean concentrations decrease with distance. This preliminary analysis does not account for seasonality and meteorology, and it also ignores the possible confounding effect of the distance to the nearest gas station, an important emissions source.

For the main data analyses of the RIOPA data, we first removed all data from residences within 150 m of a gas station.

The attached file graphs.riopa.doc contains graphs of the concentrations versus distance to the roadway. Four distance definitions are used, depending upon the road type: FC11 = distance to functional class FC11, urban interstate highways; FC12 = distance to functional class FC12, urban other freeways and expressways; FC14 = distance to functional class FC14, urban major arterials; Min = minimum (FC11, FC12, FC14). Also shown on the graphs is a cubic regression curve for log(concentration) against distance. The graphs show significant scatter, and no clear tendency for concentrations to decrease with distance.

We then fitted various regression models to log (concentration) using a stepwise regression procedure to determine the best model.

The attached Excel spreadsheet file riopa.two distance intervals.xls contains regression analyses where the distance effect is represented by one indicator term for the 0-D1 distance (i.e., a dummy variable that equals 1 for residences within D1 of the roadway and equals zero for other residences), and another indicator term for the 0-D2 distance. The fitted regression model always has an intercept and coefficients for the 0-D1 distance (to the nearest major road) and for the 0-D2 distance. Other terms that could be in the "best" model were season indicators (for spring, summer, or fall), wind speed, temperature, RH, Precipitation, Mixing Height, Stability, log wind speed, log temperature, log RH, log Mixing Height, log Stability.

The spreadsheet shows results for the best-fitting models for each distance type and each pair of distances, when either a) there are no season terms, or b) all three season terms are forced into the model. The predicted values for the logarithm of the concentration are given by

$$\text{Log(concentration)} = \text{Intercept} + a\times\text{Indic(0-D1)} + b\times\text{Indic(0-D2)} + \text{Meteorological terms}$$

$$= \text{Intercept} + a + b + \text{Met terms}, \qquad \text{if distance} < D1$$

$$= \text{Intercept} + b + \text{Met terms}, \qquad \text{if } D1 <= \text{distance} < D2$$

$$= \text{Intercept} + \text{Met terms}, \qquad \text{if distance} >= D2$$

so this model is mathematically equivalent to having different coefficients for the ranges 0-D1, D1-D2, D2 - infinity.

The spreadsheet gives D1 and D2 (columns X and Y), all the coefficients, the R squared statistic (column U), and the Akaike Information Criterion, AIC, a good-of-fit measure. For these analyses, the AIC is a better measure of the goodness-of-fit than R squared, since the R squared will obviously improve if you add terms to the model, but the AIC used for SAS's regression procedure adds a penalty term to the negative log-likelihood for the number of fitted parameters. There is no absolute scale to decide what AIC values are good, but the models with the lowest AIC are the best ones according to this statistic. The final column indicates the model with the lowest AIC for each HAP.

None of these models fit the data very well. The R-Squared values range from 0.17 for MTBE, 0.25 for ethyl-benzene, 0.26 for toluene, 0.28 for m&p-xylene, 0.27 for benzene, and 0.31 for o-xylene, which are all quite poor, but consistent with Kwon's results. For the "best" models, the estimated values for D1 are either 25 m or 450 m.

As a second approach, we fitted models with indicator terms for 12 distance intervals instead of 2. The results are shown in the attached Excel spreadsheet riopa.all distance intervals.xls. The same approach was used except that instead of just having indicators for 0-D1 and 0-D2, we have indicators for each interval group: 0-25, 25-50, 50-75, 75-100, 100-150, 150-200, … 450-500 m. In most cases the coefficient is high for the 0-25 m group, then decreases, and then increases again. The coefficients at the high distances are almost as high as for 0-25 m (for MTBE they are even higher). This is not the expected pattern of coefficients decreasing with distance, reflecting the expected tendency for concentrations to decrease with distance (if there are no other sources).

As a third approach, we developed the models shown in the Excel spreadsheet riopa.three times two distance intervals.xls. In this approach, instead of fitting separate two-distance models for each functional class, we fit a model with six distance indicators, two for each functional class, defining combinations of distances to the nearest FC11, FC12, and FC14 road. Using the same D1 and D2 for each functional class, the R squared goodness-of-fit measures are a slight improvement over the first approach (based on a single functional class), but the AIC statistics show no improvement after accounting for the 4 extra terms in the model.

The ability of the RIOPA regression models to predict the near roadway concentrations was generally poor, as discussed above. This is likely due to the problem that the near roadway concentrations are also impacted by other emissions sources that cannot be easily adjusted for. Furthermore, the true relationship between the concentrations and the distance from the road, meteorology and season is known to be very much more complicated than these simple regression model formulations. In view of these findings we chose to use modeled data rather than measured values, as discussed in the next section.

Portland Air Toxics Assessment Study

The Portland Air Toxics Assessment (PATA) Study (e.g., Cohen et al (2005)) was a recent air toxics modeling study in the Portland area, funded by the Oregon Department of Environmental Quality and U.S. EPA. PATA evaluated the air quality impact in Calendar Year 1999 of emissions from over 1000 roadway links using the CALPUFF dispersion model. CALPUFF is a non-steady state Gaussian puff model, and was selected for modeling in Portland because of its capability for handling complex terrain and coastal interaction effects. For these Task 2 analyses, we used the CALPUFF predictions of the benzene, 1,3-butadiene, and diesel particulate matter (PM) from major on-road sources only. We used the predicted quarterly and annual mean concentrations together with the distances from the receptor (block group centroid) to the nearest major road.

We restricted these analyses to block group receptors only, and to the 211 block groups in the 54 tracts that had at least one block group within 300 m of a road and at least one block group more than 300 m from a road. The idea was to restrict the analysis to the census tracts where the HAPEM adjustments to the ASPEN predictions would be applied. 300 m was chosen as a maximum possible realistic value for the far distance, D2.

The statistical regression analyses of the PATA data were similar to the regression analyses of the RIOPA data described above. In this case stepwise regression was not needed to select the "best" set of meteorological variables since it was not feasible to define and calculate meteorological variables to adjust the quarterly and annual means. The quarterly/seasonal means are for Dec-Feb, Mar-May, Jun-Aug, and Sep-Nov. In this case we only have one distance variable, the distance from a block group centroid to the nearest road for the major road links used in our CALPUFF modeling.

The attached file graphs.pata.doc contains graphs of annual and seasonal mean concentrations plotted against the distance, together with a cubic regression curve for log(concentration) against distance. The pattern of concentrations decreasing with distance is much stronger here compared to the RIOPA plots, as should be expected since these CALPUFF modeling results use on-road emissions only. These preliminary graphs show all block group and census tract centroid receptors, not just the 211 block groups in the 54 tracts that had at least one block group within 300 m of a road and at least one block group more than 300 m from a road.

The attached file pata.two.distance intervals.by season.xls shows the fitted models with two distance terms (indicators for the distance ranges 0-D1 and 0-D2) for each season and for the annual mean. The best models have D1 = 75 m and D2 = 250 or 300 m in most cases.

The attached file pata.two.distance intervals.quarterly mean.xls shows results from fitting the same set of two-distance models to the entire set of quarterly means after including indicator terms for the spring, summer, and fall quarters. The fact that the coefficients of these three indicators are the same for all pairs of distances is perhaps unexpected, but this follows from the facts that a) the experiment is balanced, i.e., there is one concentration for each and every block group and season, and b) there are no interaction terms in the regression model (between the season indicators and the distance terms). The best models have D1=75 m and D2=300 m for all three pollutants.

The attached file pata.all.distance intervals.by season.xls shows the fitted models for each season and the annual mean with indicator terms for the interval groups: 0-25, 25-50, 50-75, 75-100, 100-150. 150-200, 200-250, 250-300, and >= 300. The models were fitted without an intercept. The estimated coefficients for the distance ranges therefore equal the mean of the log(concentration) for all block groups in the given range and season. While there is a general tendency for the means of the logarithms to decrease with the distance from the nearest road, the mean does not consistently decrease when the distance range is further away from the road. This is due to the fact that different roads can have very different levels of emissions, so that the concentration can increase if you move further away from a road A with relatively low emissions but closer to another road B that is even further away than the road A but has very high emissions.

The attached file pata.all.distance intervals.quarterly mean.xls shows the fitted models for the quarterly means with indicator functions for the spring, summer, and fall seasons together with indicator terms for all the interval groups: 0-25, 25-50, 50-75, 75-100, 100-150, 150-200, 200-250, 250-300, and >= 300. The models were fitted without an intercept.

Generally, the two-distance regression models show that the optimal distances are D1 = 75m and D2 = 300m. The regression models favor the higher distances for D2 because the CALPUFF estimates for PATA continue to decrease significantly with distance from the road. However, the R squared and AIC values are not much different between the models with D2 = 200 or 300 m. Since some other studies, including Zhu et al (2002), have shown typical zones of influence for roadways no further than 200 m, we selected the distances D1 = 75 m and D2 = 200 m.

Concentration Ratios

As described above, we selected the distance thresholds D1 = 75 m and D2 = 200 m. Using the same set of PATA study predicted block group concentrations at distances 0 to 75 m, 75 to 200 m, and 200 m or greater we computed the concentration ratios, using a regression approach and an empirical approach.

We begin with the empirical approach. We considered two sets of ratios. The first set of ratios are given by a block group concentration at distance 0-75 m divided by a block group concentration in the same census tract at distance >= 200 m. The second set of ratios are given by a block group concentration at distance 75-200 m divided by a block group concentration in the same census tract at distance >= 200 m. Each set contains all such ratios for each pollutant. For each set of ratios we fitted normal and log-normal distributions. The results are tabulated in Table 4. In the rows marked “RAW,” the number, mean, and variance of the ratios are tabulated for each set of ratios and each pollutant. Also shown is the p-value of a Shapiro-Wilk test of normality; higher values are evidence supporting normality. In the rows marked “LOG” the number, mean, and variance of the logarithms of the ratios are tabulated for each set of ratios and each pollutant. Also shown is the p-value of a Shapiro-Wilk test of normality for the logarithms; higher values are evidence supporting normality for the logs of the ratios, which is the same as log-normality of the ratios themselves. The log-normal distributions fitted a little better. Using the log-normal distributions, the geometric mean is given by exp(mean) and the geometric standard deviation is given by exp(sqrt(variance)). As well as doing this analysis by pollutant, we also combined all the ratios for all three pollutants and repeated the analysis. The combined distribution (shown in the Table 4 rows with pollutant = ”All”) might be a good choice for modeling some HAPs other than Benzene, 1,3-Butadiene, or Diesel PM.

Tables 5 and 6 present the results of the regression approach whereby the log(ratio) distributions are computed from the regression model. Table 5 uses the regressions stratified by season, which are exactly the same as the regression models with D1 = 75 and D2 = 200 in the spreadsheet pata.two distance intervals.by season.xls. Table 6 uses the regressions of the quarterly means against the season indicators and the two distance indicators, which are exactly the same as the regression models with D1 = 75 and D2 = 200 in pata.two distance intervals.quarterly means.xls. For each pollutant, season (quarter or annual mean), and numerator distance range, we tabulate the predicted mean and variance of the logarithm of the ratio. Two estimates of the variance, Variance1 and Variance2, are tabulated. Variance2 is the more accurate calculation. The Appendix gives details on these regression calculations..

The regression-based estimated means and variances are both larger than the estimates from the empirical distributions of the logarithms of the ratios. The variances are presumably higher because the regression approach assumes that the numerator and denominator are independent, whereas it is likely that there is a strong correlation between concentrations for block groups that are near enough to be in the same tract. It is not obvious why the means are higher.

Since the empirical ratio distributions only use ratios from block groups in the same census tract, but the regression ratio distributions do not assume the numerator block groups are in the same tract as the denominator block groups, the empirical approach is more consistent with the intended application to ASPEN predictions. The log-normal distributions fitted a little better. We therefore recommend using the empirical log-normal distributions for the ratio, shown in Table 4. Another possibility is to use the set of ratios as a data set and randomly select ratios from that data set, but that approach has the disadvantage of only having a small discrete number of possible values compared to the continuous log-normal model.

HAPEM requires specification of mimimum and maximum values for a lognormal distribution in order to avoid unrealistic predictions. We recommend using 1.0 for the minimum value and the 95^{th} percentile ratio as the maximum value for each ratio distribution.

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Appendix

The derivation of the regression distributions is as follows:

Suppose the regression model is written in the form

Log(conc) = intercept + slope1 × Indicator (0-75 m) + slope2 × Indicator (75-200 m) + error.

where the error is normally distributed with a mean of 0 and a standard deviation of sigma, and the errors for different block groups are independent.

Then for two block groups at distances < 75 m and > 200m, we have

log(ratio) = log{conc(< 75) / conc (> 200) }
= intercept + slope1 × Indicator (0-75 m) + slope2 × Indicator (75-200 m) + error (< 75m).
- (intercept + slope1 × Indicator (0-75 m) + slope2 × Indicator (75-200 m) + error (> 200 m))
= intercept + slope1 + error(< 75 m) – (intercept + error(> 200 m)
= slope1 + error(< 75 m) – error(> 200m),

which is normally distributed with mean = slope1 and variance = 2×sigma×sigma = Variance1.

The more accurate calculation takes into account the fact that the values of slope1 and sigma are unknown, but estimated from the regression model. Define Variance2 = 2×sigma×sigma + 2×se×se, where se is the standard error of the estimated slope1. An exact calculation uses the easily proven result that {log(ratio) – estimated slope1}/{sqrt(Variance2)) has a t distribution. A very accurate approximation (since the degrees of freedom are large) shows that log(ratio) has a normal distribution with mean = slope1 and variance = Variance2.

Table 1. Analysis of mean CO concentration versus. Distance from freeway based on Zhu et al (2002).

Freeway 405, 710 or both (405710)	Season S=Summer W=Winter A=All	Distance(s) From Freeway (m)	Upwind (U) or Downwind(D)	Distribution of Daily Means Across Measurement Days							
				n	mean	std	min	q1	median	q3	max
405	A	30	D	6	2.03	0.10	1.87	2.03	2.03	2.03	2.17
405	A	60	D	6	1.16	0.30	0.87	0.90	1.08	1.50	1.50
405	A	90	D	6	0.81	0.23	0.60	0.60	0.78	1.03	1.07
405	A	150	D	6	0.56	0.16	0.40	0.40	0.55	0.70	0.73
405	A	300	D	6	0.34	0.17	0.13	0.23	0.32	0.50	0.57
405	A	300	U	6	0.12	0.04	0.10	0.10	0.10	0.10	0.20
405	A	d < 50m	D	6	2.03	0.10	1.87	2.03	2.03	2.03	2.17
405	A	50m <= d < 150m	D	6	0.98	0.26	0.73	0.75	0.96	1.23	1.27
405	A	150m <= d	D	6	0.45	0.16	0.27	0.32	0.44	0.62	0.62
405	S	30	D	3	1.98	0.10	1.87	1.87	2.03	2.03	2.03
405	S	60	D	3	0.90	0.03	0.87	0.87	0.90	0.93	0.93
405	S	90	D	3	0.60	0.00	0.60	0.60	0.60	0.60	0.60
405	S	150	D	3	0.41	0.02	0.40	0.40	0.40	0.43	0.43
405	S	300	D	3	0.20	0.06	0.13	0.13	0.23	0.23	0.23
405	S	300	U	3	0.10	0.00	0.10	0.10	0.10	0.10	0.10
405	S	d < 50m	D	3	1.98	0.10	1.87	1.87	2.03	2.03	2.03
405	S	50m <= d < 150m	D	3	0.75	0.02	0.73	0.73	0.75	0.77	0.77
405	S	150m <= d	D	3	0.31	0.03	0.27	0.27	0.32	0.33	0.33
405	W	30	D	3	2.08	0.08	2.03	2.03	2.03	2.17	2.17
405	W	60	D	3	1.41	0.15	1.23	1.23	1.50	1.50	1.50
405	W	90	D	3	1.02	0.05	0.97	0.97	1.03	1.07	1.07
405	W	150	D	3	0.70	0.03	0.67	0.67	0.70	0.73	0.73
405	W	300	D	3	0.49	0.08	0.40	0.40	0.50	0.57	0.57
405	W	300	U	3	0.13	0.06	0.10	0.10	0.10	0.20	0.20
405	W	d < 50m	D	3	2.08	0.08	2.03	2.03	2.03	2.17	2.17
405	W	50m <= d < 150m	D	3	1.22	0.06	1.15	1.15	1.23	1.27	1.27
405	W	150m <= d	D	3	0.59	0.04	0.55	0.55	0.62	0.62	0.62

Freeway 405, 710 or both (405710)	Season S=Summer W=Winter A=All	Distance(s) From Freeway (m)	Upwind (U) or Downwind(D)	Distribution of Daily Means Across Measurement Days							
				n	mean	std	min	q1	median	q3	max
710	A	17	D	7	2.24	0.19	2.00	2.03	2.17	2.43	2.47
710	A	20	D	7	1.98	0.17	1.73	1.83	1.97	2.13	2.23
710	A	30	D	7	1.56	0.25	1.27	1.33	1.57	1.83	1.87
710	A	90	D	7	0.52	0.09	0.33	0.50	0.57	0.57	0.57
710	A	150	D	7	0.43	0.07	0.33	0.40	0.40	0.50	0.53
710	A	200	U	7	0.13	0.05	0.10	0.10	0.10	0.20	0.20
710	A	300	D	7	0.26	0.12	0.10	0.17	0.23	0.40	0.43
710	A	d < 50m	D	7	1.93	0.14	1.76	1.76	1.98	2.03	2.10
710	A	50m <= d < 150m	D	7	0.52	0.09	0.33	0.50	0.57	0.57	0.57
710	A	150m <= d	D	7	0.34	0.09	0.25	0.27	0.32	0.47	0.47
710	S	17	D	5	2.30	0.19	2.03	2.17	2.40	2.43	2.47
710	S	20	D	5	2.02	0.19	1.73	1.97	2.03	2.13	2.23
710	S	30	D	5	1.66	0.22	1.33	1.57	1.70	1.83	1.87
710	S	90	D	5	0.50	0.10	0.33	0.50	0.53	0.57	0.57
710	S	150	D	5	0.39	0.04	0.33	0.40	0.40	0.40	0.43
710	S	200	U	5	0.10	0.00	0.10	0.10	0.10	0.10	0.10
710	S	300	D	5	0.19	0.06	0.10	0.17	0.20	0.23	0.27
710	S	d < 50m	D	5	1.99	0.10	1.83	1.98	2.02	2.03	2.10
710	S	50m <= d < 150m	D	5	0.50	0.10	0.33	0.50	0.53	0.57	0.57
710	S	150m <= d	D	5	0.29	0.03	0.25	0.27	0.30	0.32	0.33
710	W	17	D	2	2.08	0.12	2.00	2.00	2.08	2.17	2.17
710	W	20	D	2	1.87	0.05	1.83	1.83	1.87	1.90	1.90
710	W	30	D	2	1.32	0.07	1.27	1.27	1.32	1.37	1.37
710	W	90	D	2	0.57	0.00	0.57	0.57	0.57	0.57	0.57
710	W	150	D	2	0.52	0.02	0.50	0.50	0.52	0.53	0.53
710	W	200	U	2	0.20	0.00	0.20	0.20	0.20	0.20	0.20
710	W	300	D	2	0.42	0.02	0.40	0.40	0.42	0.43	0.43
710	W	d < 50m	D	2	1.76	0.00	1.76	1.76	1.76	1.76	1.76
710	W	50m <= d < 150m	D	2	0.57	0.00	0.57	0.57	0.57	0.57	0.57
710	W	150m <= d	D	2	0.47	0.00	0.47	0.47	0.47	0.47	0.47
405710	A	17	D	7	2.24	0.19	2.00	2.03	2.17	2.43	2.47
405710	A	20	D	7	1.98	0.17	1.73	1.83	1.97	2.13	2.23

Freeway 405, 710 or both (405710)	Season S=Summer W=Winter A=All	Distance(s) From Freeway (m)	Upwind (U) or Downwind(D)	Distribution of Daily Means Across Measurement Days							
				n	mean	std	min	q1	median	q3	max
405710	A	30	D	13	1.78	0.30	1.27	1.57	1.87	2.03	2.17
405710	A	60	D	6	1.16	0.30	0.87	0.90	1.08	1.50	1.50
405710	A	90	D	13	0.65	0.22	0.33	0.57	0.57	0.60	1.07
405710	A	150	D	13	0.49	0.13	0.33	0.40	0.43	0.53	0.73
405710	A	200	U	7	0.13	0.05	0.10	0.10	0.10	0.20	0.20
405710	A	300	D	13	0.30	0.15	0.10	0.20	0.23	0.40	0.57
405710	A	300	U	6	0.12	0.04	0.10	0.10	0.10	0.10	0.20
405710	A	d < 50m	D	13	1.97	0.13	1.76	1.87	2.03	2.03	2.17
405710	A	50m <= d < 150m	D	13	0.73	0.30	0.33	0.57	0.57	0.77	1.27
405710	A	150m <= d	D	13	0.39	0.13	0.25	0.30	0.33	0.47	0.62
405710	S	17	D	5	2.30	0.19	2.03	2.17	2.40	2.43	2.47
405710	S	20	D	5	2.02	0.19	1.73	1.97	2.03	2.13	2.23
405710	S	30	D	8	1.78	0.24	1.33	1.63	1.85	1.95	2.03
405710	S	60	D	3	0.90	0.03	0.87	0.87	0.90	0.93	0.93
405710	S	90	D	8	0.54	0.09	0.33	0.52	0.57	0.60	0.60
405710	S	150	D	8	0.40	0.03	0.33	0.40	0.40	0.42	0.43
405710	S	200	U	5	0.10	0.00	0.10	0.10	0.10	0.10	0.10
405710	S	300	D	8	0.20	0.06	0.10	0.15	0.22	0.23	0.27
405710	S	300	U	3	0.10	0.00	0.10	0.10	0.10	0.10	0.10
405710	S	d < 50m	D	8	1.99	0.09	1.83	1.92	2.03	2.03	2.10
405710	S	50m <= d < 150m	D	8	0.59	0.15	0.33	0.52	0.57	0.74	0.77
405710	S	150m <= d	D	8	0.30	0.03	0.25	0.27	0.31	0.33	0.33
405710	W	17	D	2	2.08	0.12	2.00	2.00	2.08	2.17	2.17
405710	W	20	D	2	1.87	0.05	1.83	1.83	1.87	1.90	1.90
405710	W	30	D	5	1.77	0.42	1.27	1.37	2.03	2.03	2.17
405710	W	60	D	3	1.41	0.15	1.23	1.23	1.50	1.50	1.50
405710	W	90	D	5	0.84	0.25	0.57	0.57	0.97	1.03	1.07
405710	W	150	D	5	0.63	0.10	0.50	0.53	0.67	0.70	0.73
405710	W	200	U	2	0.20	0.00	0.20	0.20	0.20	0.20	0.20
405710	W	300	D	5	0.46	0.07	0.40	0.40	0.43	0.50	0.57
405710	W	300	U	3	0.13	0.06	0.10	0.10	0.10	0.20	0.20
405710	W	d < 50m	D	5	1.95	0.18	1.76	1.76	2.03	2.03	2.17

Freeway 405, 710 or both (405710)	Season S=Summer W=Winter A=All	Distance(s) From Freeway (m)	Upwind (U) or Downwind(D)	Distribution of Daily Means Across Measurement Days							
				n	mean	std	min	q1	median	q3	max
405710	W	50m <= d < 150m	D	5	0.96	0.36	0.57	0.57	1.15	1.23	1.27
405710	W	150m <= d	D	5	0.54	0.08	0.47	0.47	0.55	0.62	0.62

Table 2. CO concentration ratios based on Zhu et al (2002).

Freeway	Season	Distance(s)	Upwind (U)	Distribution of Mean (Group) / Mean (d >= 150m) Across Measurement Days							
405, 710 or both (405710)	S=Summer W=Winter A=All	From Freeway (m)	or Downwind(D)	n	mean	std	min	q1	median	q3	max
405	A	d < 50m	D	6	5.03	1.79	3.30	3.51	4.65	6.42	7.63
405	A	50m <= d < 150m	D	6	2.26	0.32	2.00	2.05	2.17	2.32	2.88
405	S	d < 50m	D	3	6.55	1.02	5.60	5.60	6.42	7.63	7.63
405	S	50m <= d < 150m	D	3	2.48	0.34	2.25	2.25	2.32	2.88	2.88
405	W	d < 50m	D	3	3.50	0.20	3.30	3.30	3.51	3.70	3.70
405	W	50m <= d < 150m	D	3	2.05	0.05	2.00	2.00	2.05	2.09	2.09
710	A	d < 50m	D	7	5.98	1.69	3.76	3.76	6.25	7.63	8.09
710	A	50m <= d < 150m	D	7	1.58	0.39	1.11	1.21	1.70	2.00	2.00
710	S	d < 50m	D	5	6.87	0.91	6.11	6.25	6.30	7.63	8.09
710	S	50m <= d < 150m	D	5	1.72	0.36	1.11	1.70	1.79	2.00	2.00
710	W	d < 50m	D	2	3.76	0.00	3.76	3.76	3.76	3.76	3.76
710	W	50m <= d < 150m	D	2	1.21	0.00	1.21	1.21	1.21	1.21	1.21
405710	A	d < 50m	D	13	5.54	1.74	3.30	3.76	6.11	6.42	8.09
405710	A	50m <= d < 150m	D	13	1.89	0.50	1.11	1.70	2.00	2.09	2.88
405710	S	d < 50m	D	8	6.75	0.90	5.60	6.18	6.36	7.63	8.09
405710	S	50m <= d < 150m	D	8	2.01	0.51	1.11	1.74	2.00	2.28	2.88
405710	W	d < 50m	D	5	3.61	0.20	3.30	3.51	3.70	3.76	3.76
405710	W	50m <= d < 150m	D	5	1.71	0.46	1.21	1.21	2.00	2.05	2.09

Table 3. RIOPA Data. Analysis of mean concentrations vs. distance (d) from nearest major roadway (classes FC11, FC13, FC14).

			Concentrations							Mean (group) / Mean (d >= 150 m)		
Pollutant	**Distance Group**	**n**	**mean**	**std**	**min**	**q1**	**median**	**q3**	**max**	**ratio**	**Std error**	**CV (%)**
Benzene	d < 50m	12	1.54	0.43	0.67	1.25	1.59	1.87	2.19	1.13	0.12	10.42
Benzene	50m <= d < 150m	54	1.77	2.43	0.12	0.82	1.26	2.01	18.06	1.29	0.26	19.77
Benzene	150m <= d	117	1.37	0.98	0.06	0.63	1.09	1.84	5.17	.	.	.
Carbon Tetrachloride	d < 50m	12	0.64	0.21	0.17	0.53	0.67	0.74	1.01	0.93	0.09	10.12
Carbon Tetrachloride	50m <= d < 150m	54	1.23	4.17	0.17	0.56	0.68	0.84	31.23	1.81	0.83	46.17
Carbon Tetrachloride	150m <= d	117	0.68	0.23	0.17	0.56	0.70	0.84	1.13	.	.	.
Ethylbenzene	d < 50m	12	1.33	0.97	0.09	0.81	1.14	1.51	3.78	1.20	0.27	22.18
Ethylbenzene	50m <= d < 150m	54	1.87	4.86	0.09	0.42	1.03	1.85	36.24	1.68	0.61	36.18
Ethylbenzene	150m <= d	117	1.11	0.84	0.02	0.46	0.89	1.74	3.30	.	.	.
MTBE	d < 50m	12	6.43	7.69	0.06	0.89	4.27	9.51	27.17	1.24	0.44	35.62
MTBE	50m <= d < 150m	54	6.82	5.48	0.06	3.22	5.60	8.09	26.89	1.32	0.18	14.04
MTBE	150m <= d	117	5.18	4.94	0.06	2.09	3.74	7.04	26.72	.	.	.
PCE	d < 50m	12	0.85	0.42	0.44	0.59	0.73	1.04	1.98	0.97	0.15	15.45
PCE	50m <= d < 150m	54	1.66	5.60	0.10	0.50	0.75	1.11	41.82	1.90	0.88	46.35
PCE	150m <= d	117	0.88	0.60	0.10	0.49	0.74	1.11	3.68	.	.	.
Toluene	d < 50m	12	9.11	6.13	1.47	4.69	7.62	12.93	21.88	1.41	0.30	21.23
Toluene	50m <= d < 150m	54	7.07	5.36	0.11	2.36	5.82	11.51	22.27	1.09	0.15	13.41
Toluene	150m <= d	117	6.47	6.00	0.11	2.59	4.43	8.10	32.88	.	.	.
m,p,-Xylene	d < 50m	12	4.68	4.31	0.71	2.18	4.28	4.77	17.52	1.72	0.47	27.48
m,p,-Xylene	50m <= d < 150m	54	4.07	6.94	0.42	1.72	2.45	4.41	51.21	1.49	0.36	24.27
m,p,-Xylene	150m <= d	117	2.73	2.09	0.15	1.43	2.17	3.39	10.52	.	.	.
o-Xylene	d < 50m	12	7.85	23.03	0.30	1.02	1.30	1.46	80.98	7.74	6.57	84.89
o-Xylene	50m <= d < 150m	54	1.84	5.00	0.28	0.58	0.95	1.56	37.49	1.82	0.68	37.40
o-Xylene	150m <= d	117	1.01	0.65	0.07	0.59	0.92	1.26	3.27	.	.	.

Table 4. Empirical distributions of concentration ratios from PATA (see text). Denominator distance range is 200+ m.

Pollutant	Concentration metric	Numerator	N	Mean	Variance	P-Value for Shapiro-Wilk test of normality	geom mean	geom stdev	95th percentile
All	LOG	0-75 m	99	0.9267	0.5352	0.0008	2.5263	2.0783	8.4161
All	RAW	0-75 m	99	3.2170	4.8067	0.0001			
All	LOG	75-200 m	306	0.4950	0.4667	0.0001	1.6404	1.9802	5.0469
All	RAW	75-200 m	306	2.1611	5.2366	0.0001			
Benzene	LOG	0-75 m	33	0.9071	0.5137	0.1423	2.4770	2.0477	8.0532
Benzene	RAW	0-75 m	33	3.1121	4.3349	0.0042			
Benzene	LOG	75-200 m	102	0.4770	0.4318	0.0122	1.6113	1.9292	4.7492
Benzene	RAW	75-200 m	102	2.0607	3.6804	0.0001			
1,3-Butadiene	LOG	0-75 m	33	0.9708	0.5767	0.1110	2.6402	2.1371	9.2083
1,3-Butadiene	RAW	0-75 m	33	3.3989	5.6575	0.0026			
1,3-Butadiene	LOG	75-200 m	102	0.5252	0.5384	0.0063	1.6907	2.0829	5.6533
1,3-Butadiene	RAW	75-200 m	102	2.3384	8.1519	0.0001			
Diesel PM	LOG	0-75 m	33	0.9023	0.5455	0.1541	2.4653	2.0930	8.3088
Diesel PM	RAW	0-75 m	33	3.1400	4.6767	0.0032			
Diesel PM	LOG	75-200 m	102	0.4827	0.4378	0.0065	1.6204	1.9380	4.8119
Diesel PM	RAW	75-200 m	102	2.0843	3.9332	0.0001			

Table 5. Regression-based log-normal distributions of concentration ratios for each season from PATA (see text). Denominator distance range is 200+ m. Reported values are estimated means and variances of the logarithms of the ratios.

Numerator Distance Range	Pollutant	Season	Mean	Variance1	Variance2
0 - 75 m	Benzene	Annual	1.3504	0.8345	0.8634
75 - 200 m	Benzene	Annual	0.6288	0.8345	0.8462
0 - 75 m	Benzene	Dec-Feb	1.3808	0.9631	0.9965
75 - 200 m	Benzene	Dec-Feb	0.6402	0.9631	0.9766
0 - 75 m	Benzene	Jun-Aug	1.4028	1.0775	1.1148
75 - 200 m	Benzene	Jun-Aug	0.6503	1.0775	1.0926
0 - 75 m	Benzene	Mar-May	1.3528	0.8556	0.8853
75 - 200 m	Benzene	Mar-May	0.6408	0.8556	0.8676
0 - 75 m	Benzene	Sep-Nov	1.3133	0.7871	0.8144
75 - 200 m	Benzene	Sep-Nov	0.6184	0.7871	0.7982
0 - 75 m	1,3-Butadiene	Annual	1.4577	1.0006	1.0353
75 - 200 m	1,3-Butadiene	Annual	0.6965	1.0006	1.0147
0 - 75 m	1,3-Butadiene	Dec-Feb	1.4669	1.1340	1.1733
75 - 200 m	1,3-Butadiene	Dec-Feb	0.6969	1.1340	1.1499
0 - 75 m	1,3-Butadiene	Jun-Aug	1.5131	1.2286	1.2711
75 - 200 m	1,3-Butadiene	Jun-Aug	0.7183	1.2286	1.2458
0 - 75 m	1,3-Butadiene	Mar-May	1.4710	1.0223	1.0578
75 - 200 m	1,3-Butadiene	Mar-May	0.7143	1.0223	1.0367
0 - 75 m	1,3-Butadiene	Sep-Nov	1.4392	0.9771	1.0109
75 - 200 m	1,3-Butadiene	Sep-Nov	0.6959	0.9771	0.9908
0 - 75 m	Diesel PM	Annual	1.3163	0.8449	0.8742
75 - 200 m	Diesel PM	Annual	0.6284	0.8449	0.8568
0 - 75 m	Diesel PM	Dec-Feb	1.3460	0.9638	0.9972
75 - 200 m	Diesel PM	Dec-Feb	0.6394	0.9638	0.9773
0 - 75 m	Diesel PM	Jun-Aug	1.3664	1.0973	1.1353
75 - 200 m	Diesel PM	Jun-Aug	0.6471	1.0973	1.1127
0 - 75 m	Diesel PM	Mar-May	1.3251	0.8767	0.9070
75 - 200 m	Diesel PM	Mar-May	0.6405	0.8767	0.8890
0 - 75 m	Diesel PM	Sep-Nov	1.2848	0.8065	0.8344
75 - 200 m	Diesel PM	Sep-Nov	0.6177	0.8065	0.8178

Table 6. Regression-based log-normal distributions of quarterly mean concentration ratios from PATA (see text). Denominator distance range is 200+ m. Reported values are estimated means and variances of the logarithms of the ratios.

Numerator Distance Range	Pollutant	Mean	Variance1	Variance2
0 - 75 m	Benzene	1.3624	0.9144	0.9224
75 - 200 m	Benzene	0.6374	0.9144	0.9176
0 - 75 m	1,3-Butadiene	1.4726	1.0828	1.0922
75 - 200 m	1,3-Butadiene	0.7063	1.0828	1.0866
0 - 75 m	Diesel PM	1.3306	0.9295	0.9376
75 - 200 m	Diesel PM	0.6362	0.9295	0.9328

Attachment 7: Technical Memorandum on HAPEM Near Road Population Data Base Development (Estimating near roadway populations and areas for HAPEM6)

MEMORANDUM

To: Chad Bailey

From: Arlene Rosenbaum and Kevin Wright

Date: December 28, 2005

Re: Estimating near roadway populations and areas for HAPEM6

PURPOSE AND BACKGROUND

In its 2001 regulation of mobile source air toxics (the "MSAT Rule") EPA's Office of Transportation and Air Quality (OTAQ) committed to further study of the range of concentrations to which people are exposed for consideration in future rulemaking. As part of the Technical Analysis Plan outlined in that research, OTAQ undertook research activity looking at the air quality in immediate proximity of busy roadways and highways. Concentrations of pollutants directly emitted by motor vehicles show statistically significant elevation in concentrations with increased proximity to busy roadways.

The Hazardous Air Pollutant Exposure Model (HAPEM) is a screening-level exposure model appropriate for assessing average long-term inhalation exposures of the general population, or a specific sub-population, over spatial scales ranging from urban to national. HAPEM uses the general approach of tracking representatives of specified demographic groups as they move among indoor and outdoor microenvironments and among geographic locations. The estimated pollutant concentrations in each microenvironment visited are combined into a time-weighted average concentration, which is assigned to members of the demographic group.

Indoor microenvironment concentrations are estimated by applying scalar factors to outdoor tract concentrations, which are some of the required inputs. These scalar factors are derived from published studies of concurrent concentration measurements indoors and outdoors.

In the previous version, HAPEM5, if only a single outdoor concentration is provided for each Census tract, as is typical, this concentration is assumed to uniformly apply to the entire Census tract. For this version, HAPEM6, we refined the model to account for the spatial variability of outdoor concentrations within a tract due to enhanced outdoor concentrations of onroad mobile source pollutants at locations near major roadways. The term "major roadway" is used to describe a "Limited Access Highway", "Highway", "Major Road" or "Ramp", as defined by the Census Feature Class Codes (CFCC). The new version of HAPEM more accurately reflects the average and variability of exposure concentrations within each Census tract by accounting for some of the spatial variability in the outdoor concentrations within the tract, and by extension some of the spatial variability in indoor concentrations within the tract.

Accomplishing this refinement to HAPEM required several activities, including the development and implementation of an approach for creating a database of the fraction of people within each US Census tract living near major roadways. This memorandum describes that activity.

OVERVIEW AND SPECIFICATIONS

The objective of this task was to estimate the fraction of people in each of 6 demographic groups in each US Census tract living near major roadways.

The basic analysis was conducted at the US Census block level for populations stratified by age, gender, and race/ethnicity. The block level data was then aggregated up to the tract level for populations stratified by age only for use in HAPEM6.

The data bases used for this task were:

- The Environmental Sciences Research Center (ESRI) StreetMap US roadway geographic database (which includes NavTech, GDT and TeleAtlas rectified street data)
- A geographic database of US Census block boundaries, extracted using the PCensus 2000 Census data extraction tool for Census file SF1
- A geographic data for US Census block boundaries in Puerto Rico and the US Virgin Islands obtained from Proximity

Although the block file is an intermediate product for this project, it will be retained to facilitate the re-specification of demographic groups for possible future analyses. Therefore, this file contains the most resolved age-gender groups available at the block level from the US Census STF1. The age groups for the block level data are as follows:

- 19 single-year age groups from 0-19 (P14)
- 2 single-year age groups 20-21 (P12)
- 16 age groups (P12)
    - 22 to 24 years
    - 25 to 29 years
    - 30 to 34 years
    - 35 to 39 years
    - 40 to 44 years
    - 45 to 49 years
    - 50 to 54 years
    - 55 to 59 years
    - 60 and 61 years
    - 62 to 64 years
    - 65 and 66 years
    - 67 to 69 years
    - 70 to 74 years
    - 75 to 79 years
    - 80 to 84 years
    - 85 years and over.

The aggregated age groups for the tract level data are:

- 0-1
- 2-4
- 5-15
- 16-17
- 18-64
- 65+

The race/ethnic groups (block level only) are:

- non-Hispanic White (alone or in combination - P010003)
- non-Hispanic Black (alone or in combination - P010004)
- non-Hispanic American Indian /Alaskan Native (alone or in combination - P010005)
- non-Hispanic Asian (alone or in combination - P010006)
- non-Hispanic Native Hawaiian/ Pacific Isalander (P010007)
- non-Hispanic other (alone or in combination - P010008)
- Hispanic (alone or in combination - P010009)

The spatial stratifications of the populations (block and tract level) are:

- Those residing within 75 meters of a major roadway
- Those residing from 75 to 200 meters from a major roadway
- Those residing at greater than 200 meters from a roadway.

In addition, the fraction of the area of each Census block and tract that is located within the same distance ranges from a major roadway was determined.

PROCEDURES

For all the spatial modeling and geoprocessing operations in this study ICF utilized ArcInfo software. ArcInfo is the most extensive version of ArcGIS 9.1, the industry's standard for Geographic Information Systems, produced by ESRI of Redlands, CA.

Due to the size of the roadway and block geography files, most of the processing was conducted on a county-by-county basis. The files for some counties, however, still exceeded ArcInfo's capacity and were processed tract-by-tract. A few counties in Arizona needed special handling because even at the tract level they exceeded ArcInfo's capacity and were disaggregated into smaller pieces for processing.

1. Because populations are not generally evenly distributed within blocks, it was assumed that the block populations all reside within 150 meters of *any* road within the block of designation "local" or greater as defined by the Census Feature Class Codes (CFCC). Thus, the first step was to create a 150-meter buffer around all roadways within the block. This buffer served as a "clipped" block boundary defining the

portion of the block containing residential populations. The block population was assumed to be uniformly distributed within the "clipped" block boundary.

2. Next a 75-meter buffer and a 200-meter buffer were created around all major roadways within the block. These buffers were overlaid on the "clipped" block boundary, and the fraction of the "clipped" block area that that fell within each buffer was calculated. This area fraction was assumed to equal the population fraction that fell within each buffer, and the fractions were applied to each population stratification.

3. The 75-meter buffer and the 200-meter buffer were also overlaid on the unclipped block boundary to determine the fraction of the total block area that fell with each of the buffers.

4. The block level fractions for area and populations were then aggregated up to the tract level, and the population stratifications were aggregated up to the 6 tract age groups only.

RESULTS

The resulting database consists of 2 files types: (1) a block file for each state, and (2) a nation-wide tract file.

The block files contains the following 249 fields for each block:

- block FIPS code
- total population
- total area
- area within 75 meters of a major roadway
- area from 75 to 200 meters from a major roadway
- for each of 74 age-gender groups:
    - population residing within 75 meters of a major roadway
    - population residing between 75 and 200 meters from a major roadway
    - population residing more than 200 meters from a major roadway
- sum of race/ethnic populations (note; this may differ slightly from the total population due to some double-counting of persons with more than 1 race/ethnicity)
- for each of 7 race/ethnic groups:
    - population residing within 75 meters of a major roadway
    - population residing between 75 and 200 meters from a major roadway
    - population residing more than 200 meters from a major roadway

Note that because of the limitations of the US Census data the block level populations could not be stratified by age, gender, and race together,

The tract file contains the following 22 fields for each tract

- tract FIPS code
- fraction of area within 75 meters of a major roadway
- fraction of area between 75 and 200 meters from a major roadway
- fraction of area more than 200 meters from a major roadway
- for each of 6 age groups:
    - fraction of population residing within 75 meters of a major roadway
    - fraction of population residing between 75 and 200 meters from a major roadway
    - fraction of population residing more than 200 meters from a major roadway

To date only a subset of states have been completely processed. For this subset state summaries of the fraction of population living within various distances of major roadways are presented in Table 1.

Table 1. Fraction of population residing at various distances from major roadways for selected states.

STATE	Distance from major roadways		
	< 75 meters	75 – 200 meters	> 200 meters
Colorado	**0.22**	**0.33**	**0.45**
Georgia	**0.17**	**0.24**	**0.59**
New York	**0.31**	**0.36**	**0.33**

Attachment 8. Technical Memorandum on the Uncertainty Analysis Of Residential Air Exchange Rate Distributions

MEMORANDUM

To: John Langstaff, EPA OAQPS

From: Jonathan Cohen, Arlene Rosenbaum, ICF International

Date: June 5, 2006

Re: Uncertainty analysis of residential air exchange rate distributions

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This memorandum describes our assessment of some of the sources of the uncertainty of city-specific distributions of residential air exchange rates that were fitted to the available study data. City-specific distributions for use with the APEX ozone model were developed for 12 modeling cities, as detailed in the memorandum by Cohen, Mallya and Rosenbaum, 2005[29] (Appendix A of this report). In the first part of the memorandum, we analyze the between-city uncertainty by examining the variation of the geometric means and standard deviations across cities and studies. In the second part of the memorandum, we assess the within-city uncertainty by using a bootstrap distribution to estimate the effects of sampling variation on the fitted geometric means and standard deviations for each city. The bootstrap distributions assess the uncertainty due to random sampling variation but do not address uncertainties due to the lack of representativeness of the available study data, the matching of the study locations to the modeled cities, and the variation in the lengths of the AER monitoring periods.

Variation of geometric means and standard deviations across cities and studies

The memorandum by Cohen, Mallya and Rosenbaum, 2005[30] (Attachment 5 of this report) describes the analysis of residential air exchange rate (AER) data that were obtained from seven studies. The AER data were subset by location, outside temperature range, and the A/C type, as defined by the presence or absence of an air conditioner (central or window). In each case we chose to fit a log-normal distribution to the AER data, so that the logarithm of the AER for a given city, temperature range, and A/C type is assumed to be normally distributed. If the AER data has geometric mean GM and geometric standard deviation GSD, then the logarithm of the AER is assumed to have a normal distribution with mean log(GM) and standard deviation log(GSD).

Table D-1 shows the assignment of the AER data to the 12 modeled cities. Note that for Atlanta, GA and Washington DC, the Research Triangle Park, NC data for houses with A/C was used to represent the AER distributions for houses with A/C, and the non-California data for houses without A/C was used to represent the AER distributions for houses without A/C. Sacramento, CA AER distributions were estimated using the AER data from the inland California counties of

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[29] Cohen, J., H. Mallya, and A. Rosenbaum. 2005. Memorandum to John Langstaff. *EPA 68D01052, Work Assignment 3-08. Analysis of Air Exchange Rate Data*. September 30, 2005.
[30] *Op. Cit.*

Sacramento, Riverside, and San Bernardino; these combined data are referred to by the City Name "Inland California." St Louis, MO AER distributions were estimated using the AER data from all states except for California and so are referred to be the City Name "Outside California."

Table D-1. Assignment of Residential AER distributions to modeled cities

Modeled city	AER distribution
Atlanta, GA, A/C	Research Triangle Park, A/C only
Atlanta, GA, no A/C	All non-California, no A/C ("Outside California")
Boston, MA	New York
Chicago, IL	New York
Cleveland, OH	New York
Detroit, MI	New York
Houston, TX	Houston
Los Angeles, CA	Los Angeles
New York, NY	New York
Philadelphia, PA	New York
Sacramento	Inland parts of Los Angeles ("Inland California")
St. Louis	All non-California ("Outside California")
Washington, DC, A/C	Research Triangle Park, A/C only
Washington, DC, no A/C	All non-California, no A/C ("Outside California")

It is evident from Table D-1 that for some of the modeled cities, some potentially large uncertainty was introduced because we modeled their AER distributions using available data from another city or group of cities thought to be representative of the first city on the basis of geography and other characteristics. This was necessary for cities where we did not have any or sufficient AER data measured in the same city that also included the necessary temperature and A/C type information. One way to assess the impact of these assignments on the uncertainty of the AER distributions is to evaluate the variation of the fitted log-normal distributions across the cities with AER data. In this manner we can examine the effect on the AER distribution if a different allocation of study data to the modeled cities had been used.

Even for the cities where we have study AER data, there is uncertainty about the fitted AER distributions. First, the studies used different measurement and residence selection methods. In some cases the residences were selected by a random sampling method designed to represent the entire population. In other cases the residences were selected to represent sub-populations. For example, for the RTP study, the residences belong to two specific cohorts: a mostly Caucasian, non-smoking group aged at least 50 years having cardiac defibrillators living in Chapel Hill; a group of non-smoking, African Americans aged at least 50 years with controlled hypertension living in a low-to-moderate SES neighborhood in Raleigh. The TEACH study was restricted to residences of inner-city high school students. The RIOPA study was a random sample for Los Angeles, but was designed to preferentially sample locations near major air toxics sources for Elizabeth, NJ and Houston TX. Furthermore, some of the studies focused on different towns or cities within the larger metropolitan areas, so that, for example, the Los Angeles data from the Avol study was only measured in Lancaster, Lake Gregory, Riverside, and San Dimas but the Los Angeles data from the Wilson studies were measured in multiple cities in Southern California. One way to assess the uncertainty of the AER distributions due to variations of study methodologies and study sampling locations is to evaluate the variation of the fitted log-normal distributions within each modeled city across the different studies.

We evaluated the variation between cities, and the variation within cities and between studies, by tabulating and plotting the AER distributions for all the study/city combinations. Since the original analyses by Cohen, Mallya and Rosenbaum, 2005 clearly showed that the AER distribution depends strongly on the outside temperature and the A/C type (whether or not the residence has air conditioning), this analysis was stratified by the outside temperature range and the A/C type. Otherwise, study or city differences would have been confounded by the temperature and A/C type differences and you would not be able to tell how much of the AER difference was due to the variation of temperature and A/C type across cities or studies. In order to be able to compare cities and studies we could not use different temperature ranges for the different modeled cities as we did for the original AER distribution modeling. For these analyses we stratified the temperature into the ranges <= 10, 10-20, 20-25, and >25 ºC and categorized the A/C type as "Central or Window A/C" versus 'No A/C," giving 8 temperature and A/C type strata.

Table D-2 shows the geometric means and standard deviations by city and study. These geometric mean and standard deviation pairs are plotted in Figure D-1 through D-8. Each figure shows the variation across cities and studies for a given temperature range and A/C type. The results for a city with only one available study are shown with a blank study name. For cities with multiple studies, results are shown for the individual studies and the city overall distribution is designated by a blank value for the study name.

Table D-2. Geometric means and standard deviations by city and study.

A/C Type	Temperature	City	Study*	N	Geo Mean	Geo Std Dev**
Central or Room A/C	<= 10	Houston		2	0.32	1.80
Central or Room A/C	<= 10	Los Angeles		5	0.62	1.51
Central or Room A/C	<= 10	Los Angeles	Avol	2	0.72	1.22
Central or Room A/C	<= 10	Los Angeles	RIOPA	1	0.31	
Central or Room A/C	<= 10	Los Angeles	Wilson 1991	2	0.77	1.12
Central or Room A/C	<= 10	New York City		20	0.71	2.02
Central or Room A/C	<= 10	Research Triangle Park		157	0.96	1.81
Central or Room A/C	<= 10	Sacramento		3	0.38	1.82
Central or Room A/C	<= 10	San Francisco		2	0.43	1.00
Central or Room A/C	<= 10	Stockton		7	0.48	1.64
Central or Room A/C	10-20	Arcata		1	0.17	

Table D-2. Geometric means and standard deviations by city and study.

A/C Type	Temperature	City	Study*	N	Geo Mean	Geo Std Dev**
Central or Room A/C	10-20	Bakersfield		2	0.36	1.34
Central or Room A/C	10-20	Fresno		8	0.30	1.62
Central or Room A/C	10-20	Houston		13	0.42	2.19
Central or Room A/C	10-20	Los Angeles		716	0.59	1.90
Central or Room A/C	10-20	Los Angeles	Avol	33	0.48	1.87
Central or Room A/C	10-20	Los Angeles	RIOPA	11	0.60	1.87
Central or Room A/C	10-20	Los Angeles	TEACH	1	0.68	
Central or Room A/C	10-20	Los Angeles	Wilson 1984	634	0.59	1.89
Central or Room A/C	10-20	Los Angeles	Wilson 1991	37	0.64	2.11
Central or Room A/C	10-20	New York City		5	1.36	2.34
Central or Room A/C	10-20	New York City	RIOPA	4	1.20	2.53
Central or Room A/C	10-20	New York City	TEACH	1	2.26	
Central or Room A/C	10-20	Redding		1	0.31	
Central or Room A/C	10-20	Research Triangle Park		320	0.56	1.91
Central or Room A/C	10-20	Sacramento		7	0.26	1.67
Central or Room A/C	10-20	San Diego		23	0.41	1.55
Central or Room A/C	10-20	San Francisco		5	0.42	1.25
Central or Room A/C	10-20	Santa Maria		1	0.23	
Central or Room A/C	10-20	Stockton		4	0.73	1.42
Central or Room A/C	20-25	Houston		20	0.47	1.94
Central or Room A/C	20-25	Los Angeles		273	1.10	2.36
Central or Room A/C	20-25	Los Angeles	Avol	32	0.61	1.95
Central or Room A/C	20-25	Los Angeles	RIOPA	26	0.90	2.42
Central or Room A/C	20-25	Los Angeles	Wilson 1984	215	1.23	2.33
Central or Room A/C	20-25	New York City		37	1.11	2.74
Central or Room A/C	20-25	New York City	RIOPA	20	0.93	2.91
Central or Room A/C	20-25	New York City	TEACH	17	1.37	2.52
Central or Room A/C	20-25	Red Bluff		2	0.61	3.20
Central or Room A/C	20-25	Research Triangle Park		196	0.40	1.89
Central or Room A/C	> 25	Houston		79	0.43	2.17
Central or Room A/C	> 25	Los Angeles		114	0.72	2.60
Central or Room A/C	> 25	Los Angeles	Avol	25	0.37	3.10
Central or Room A/C	> 25	Los Angeles	RIOPA	10	0.94	1.71
Central or Room A/C	> 25	Los Angeles	Wilson 1984	79	0.86	2.33
Central or Room A/C	> 25	New York City		19	1.24	2.18
Central or Room A/C	> 25	New York City	RIOPA	14	1.23	2.28
Central or Room A/C	> 25	New York City	TEACH	5	1.29	2.04
Central or Room A/C	> 25	Research Triangle Park		145	0.38	1.71
No A/C	<= 10	Houston		13	0.66	1.68
No A/C	<= 10	Los Angeles		18	0.54	3.09
No A/C	<= 10	Los Angeles	Avol	14	0.51	3.60
No A/C	<= 10	Los Angeles	RIOPA	2	0.72	1.11
No A/C	<= 10	Los Angeles	Wilson 1991	2	0.60	1.00
No A/C	<= 10	New York City		48	1.02	2.14
No A/C	<= 10	New York City	RIOPA	44	1.04	2.20
No A/C	<= 10	New York City	TEACH	4	0.79	1.28

Table D-2. Geometric means and standard deviations by city and study.

A/C Type	Temperature	City	Study*	N	Geo Mean	Geo Std Dev**
No A/C	<= 10	Sacramento		3	0.58	1.30
No A/C	<= 10	San Francisco		9	0.39	1.42
No A/C	10-20	Bakersfield		1	0.85	
No A/C	10-20	Fresno		4	0.90	2.42
No A/C	10-20	Houston		28	0.63	2.92
No A/C	10-20	Los Angeles		390	0.75	2.09
No A/C	10-20	Los Angeles	Avol	23	0.78	2.55
No A/C	10-20	Los Angeles	RIOPA	87	0.78	1.96
No A/C	10-20	Los Angeles	TEACH	9	2.32	2.05
No A/C	10-20	Los Angeles	Wilson 1984	241	0.70	2.06
No A/C	10-20	Los Angeles	Wilson 1991	30	0.75	1.82
No A/C	10-20	New York City		59	0.79	2.04
No A/C	10-20	Sacramento		1	1.09	
No A/C	10-20	San Diego		49	0.47	1.95
No A/C	10-20	San Francisco		15	0.34	3.05
No A/C	10-20	Santa Maria		2	0.27	1.23
No A/C	20-25	Houston		10	0.92	2.41
No A/C	20-25	Los Angeles		148	1.37	2.28
No A/C	20-25	Los Angeles	Avol	19	0.95	1.87
No A/C	20-25	Los Angeles	RIOPA	38	1.30	2.11
No A/C	20-25	Los Angeles	Wilson 1984	91	1.52	2.40
No A/C	20-25	New York City		26	1.62	2.24
No A/C	20-25	New York City	RIOPA	19	1.50	2.30
No A/C	20-25	New York City	TEACH	7	1.99	2.11
No A/C	20-25	Red Bluff		1	0.55	
No A/C	> 25	Houston		2	0.92	3.96
No A/C	> 25	Los Angeles		25	0.99	1.97
No A/C	> 25	Los Angeles	Avol	6	1.56	1.36
No A/C	> 25	Los Angeles	RIOPA	4	1.33	1.37
No A/C	> 25	Los Angeles	TEACH	3	0.86	1.02
No A/C	> 25	Los Angeles	Wilson 1984	12	0.74	2.29
No A/C	> 25	New York City		6	1.54	1.65
No A/C	> 25	New York City	RIOPA	3	1.73	2.00
No A/C	> 25	New York City	TEACH	3	1.37	1.38

* For a given city, if AER data were available from only one study, then the study name is missing. If AER data were available for two or more studies, then the overall city distribution is shown in the row where the study name is missing, and the distributions by study and city are shown in the rows with a specific study name.
** The geometric standard deviation is undefined if the sample size equals 1.

In general, there is a relatively wide variation across different cities. This implies that the AER modeling results would be very different if the matching of modeled cities to study cities was changed, although a sensitivity study using the APEX model would be needed to assess the impact on the ozone exposure estimates. In particular the ozone exposure estimates may be sensitive to the assumption that the St. Louis AER distributions can be represented by the combined non-California AER data. One way to address this is to perform a Monte Carlo analysis where the first stage is to randomly select a city outside of California, the second stage picks the A/C type, and the third stage picks the AER value from the assigned distribution for the city, A/C type and temperature range. Note that this will result in a very different distribution to the current approach that fits a single log-normal distribution to all the non-California data for a given temperature range and A/C type. The current approach weights each data point equally, so that cities like New York with most of the data values get the greatest statistical weight. The Monte Carlo approach gives the same total statistical weight for each city and fits a mixture of log-normal distributions rather than a single distribution.

In general, there is also some variation within studies for the same city, but this is much smaller than the variation across cities. This finding tends to support the approach of combining different studies. Note that the graphs can be deceptive in this regard because some of the data points are based on very small sample sizes (N) ; those data points are less precise and the differences would not be statistically significant. For example, for the No A/C data in the range 10-20 ºC, the Los Angeles TEACH study had a geometric mean of 2.32 based on only nine AER values, but the overall geometric mean, based on 390 values, was 0.75 and the geometric means for the Los Angeles Avol, RIOPA, Wilson 1984, and Wilson 1991 studies were each close to 0.75. One noticeable case where the studies show big differences for the same city is for the A/C houses in Los Angeles in the range 20-25 ºC where the study geometric means are 0.61 (Avol, N=32), 0.90 (RIOPA, N=26) and 1.23 (Wilson 1984, N=215).

Bootstrap analyses

The 39 AER subsets defined in the Cohen, Mallya, and Rosenbaum, 2005 memorandum (Appendix A of this report) and their allocation to the 12 modeled cities are shown in Table D-3. To make the distributions sufficiently precise in each AER subset and still capture the variation across temperature and A/C type, different modeled cities were assigned different temperature range and A/C type groupings. Therefore these temperature range groupings are sometimes different to those used to develop Table D-2 and Figure D-1 through D-8.

Table D-3. AER subsets by city, A/C type, and temperature range.

Subset City Name	Study Cities	Represents Modeled Cities:	A/C Type	Temperature Range (ºC)
Houston	Houston	Houston, TX	Central or Room A/C	<=20
Houston	Houston	Houston, TX	Central or Room A/C	20-25
Houston	Houston	Houston, TX	Central or Room A/C	25-30
Houston	Houston	Houston, TX	Central or Room A/C	>30
Houston	Houston	Houston, TX	No A/C	<=10
Houston	Houston	Houston, TX	No A/C	10-20
	Houston	Houston, TX	No A/C	>20
Inland California	Sacramento, Riverside, and San Bernardino counties, CA	Sacramento, CA	Central or Room A/C	<=25
Inland California	Sacramento, Riverside, and San Bernardino counties, CA	Sacramento, CA	Central or Room A/C	>25
Inland California	Sacramento, Riverside, and San Bernardino counties, CA	Sacramento, CA	No A/C	<=10
Inland California	Sacramento, Riverside, and San Bernardino counties, CA	Sacramento, CA	No A/C	10-20

Table D-3. AER subsets by city, A/C type, and temperature range.

Subset City Name	Study Cities	Represents Modeled Cities:	A/C Type	Temperature Range (ºC)
Inland California	Sacramento, Riverside, and San Bernardino counties, CA	Sacramento, CA	No A/C	20-25
Inland California	Sacramento, Riverside, and San Bernardino counties, CA	Sacramento, CA	No A/C	>25
Los Angeles	Los Angeles, Orange, Riverside, San Bernardino, and Ventura counties, CA	Los Angeles, CA	Central or Room A/C	<=20
Los Angeles	Los Angeles, Orange, Riverside, San Bernardino, and Ventura counties, CA	Los Angeles, CA	Central or Room A/C	20-25
Los Angeles	Los Angeles, Orange, Riverside, San Bernardino, and Ventura counties, CA	Los Angeles, CA	Central or Room A/C	25-30
Los Angeles	Los Angeles, Orange, Riverside, San Bernardino, and Ventura counties, CA	Los Angeles, CA	Central or Room A/C	>30
Los Angeles	Los Angeles, Orange, Riverside, San Bernardino, and Ventura counties, CA	Los Angeles, CA	No A/C	<=10
Los Angeles	Los Angeles, Orange, Riverside, San Bernardino, and Ventura counties, CA	Los Angeles, CA	No A/C	10-20
Los Angeles	Los Angeles, Orange, Riverside, San Bernardino, and Ventura counties, CA	Los Angeles, CA	No A/C	20-25
Los Angeles	Los Angeles, Orange, Riverside, San Bernardino, and Ventura counties, CA	Los Angeles, CA	No A/C	>25
New York City	New York, NY	Boston, MA, Chicago, IL, Cleveland, OH, Detroit, MI, New York, NY, Philadelphia, PA	Central or Room A/C	<=10
New York City	New York, NY	Boston, MA, Chicago, IL, Cleveland, OH, Detroit, MI, New York, NY, Philadelphia, PA	Central or Room A/C	10-25
New York City	New York, NY	Boston, MA, Chicago, IL, Cleveland, OH, Detroit, MI, New York, NY, Philadelphia, PA	Central or Room A/C	>25
New York City	New York, NY	Boston, MA,	No A/C	<=10

Table D-3. AER subsets by city, A/C type, and temperature range.

Subset City Name	Study Cities	Represents Modeled Cities:	A/C Type	Temperature Range (ºC)
		Chicago, IL, Cleveland, OH, Detroit, MI, New York, NY, Philadelphia, PA		
New York City	New York, NY	Boston, MA, Chicago, IL, Cleveland, OH, Detroit, MI, New York, NY, Philadelphia, PA	No A/C	10-20
New York City	New York, NY	Boston, MA, Chicago, IL, Cleveland, OH, Detroit, MI, New York, NY, Philadelphia, PA	No A/C	>20
Outside California	Cities outside CA	St. Louis, MO	Central or Room A/C	<=10
Outside California	Cities outside CA	St. Louis, MO	Central or Room A/C	10-20
Outside California	Cities outside CA	St. Louis, MO	Central or Room A/C	20-25
Outside California	Cities outside CA	St. Louis, MO	Central or Room A/C	25-30
Outside California	Cities outside CA	St. Louis, MO	Central or Room A/C	>30
Outside California	Cities outside CA	St. Louis, MO Atlanta, GA Washington DC	No A/C	<=10
Outside California	Cities outside CA	St. Louis, MO Atlanta, GA Washington DC	No A/C	10-20
Outside California	Cities outside CA	St. Louis, MO Atlanta, GA Washington DC	No A/C	>20
Research Triangle Park	Research Triangle Park, NC	Atlanta, GA Washington DC	Central or Room A/C	<=10
Research Triangle Park	Research Triangle Park, NC	Atlanta, GA Washington DC	Central or Room A/C	10-20
Research Triangle Park	Research Triangle Park, NC	Atlanta, GA Washington DC	Central or Room A/C	20-25
Research Triangle Park	Research Triangle Park, NC	Atlanta, GA Washington DC	Central or Room A/C	>25

The GM and GSD values that define the fitted log-normal distributions for these 39 AER subsets are shown in Table D-4. Examples of these pairs are also plotted in Figures D-9 through D-19, to be further described below. Each of the example figures D-9 through D-19 corresponds to a single GM/GSD “Original Data” pair. The GM and GSD values for the “Original Data” are at the intersection of the horizontal and vertical lines that are parallel to the x- and y-axes in the figures.

Table D-4. Geometric means and standard deviations for AER subsets by city, A/C type, and temperature range.

Subset City Name	A/C Type	Temperature Range (°C)	N	Geometric Mean	Geometric Standard Deviation
Houston	Central or Room A/C	<=20	15	0.4075	2.1135
Houston	Central or Room A/C	20-25	20	0.4675	1.9381
Houston	Central or Room A/C	25-30	65	0.4221	2.2579
Houston	Central or Room A/C	>30	14	0.4989	1.7174
Houston	No A/C	<=10	13	0.6557	1.6794
Houston	No A/C	10-20	28	0.6254	2.9162
	No A/C	>20	12	0.9161	2.4512
Inland California	Central or Room A/C	<=25	226	0.5033	1.9210
Inland California	Central or Room A/C	>25	83	0.8299	2.3534
Inland California	No A/C	<=10	17	0.5256	3.1920
Inland California	No A/C	10-20	52	0.6649	2.1743
Inland California	No A/C	20-25	13	1.0536	1.7110
Inland California	No A/C	>25	14	0.8271	2.2646
Los Angeles	Central or Room A/C	<=20	721	0.5894	1.8948
Los Angeles	Central or Room A/C	20-25	273	1.1003	2.3648
Los Angeles	Central or Room A/C	25-30	102	0.8128	2.4151
Los Angeles	Central or Room A/C	>30	12	0.2664	2.7899
Los Angeles	No A/C	<=10	18	0.5427	3.0872
Los Angeles	No A/C	10-20	390	0.7470	2.0852
Los Angeles	No A/C	20-25	148	1.3718	2.2828
Los Angeles	No A/C	>25	25	0.9884	1.9666
New York City	Central or Room A/C	<=10	20	0.7108	2.0184
New York City	Central or Room A/C	10-25	42	1.1392	2.6773
New York City	Central or Room A/C	>25	19	1.2435	2.1768
New York City	No A/C	<=10	48	1.0165	2.1382
New York City	No A/C	10-20	59	0.7909	2.0417
New York City	No A/C	>20	32	1.6062	2.1189
Outside California	Central or Room A/C	<=10	179	0.9185	1.8589
Outside California	Central or Room A/C	10-20	338	0.5636	1.9396
Outside California	Central or Room A/C	20-25	253	0.4676	2.2011
Outside California	Central or Room A/C	25-30	219	0.4235	2.0373

Table D-4. Geometric means and standard deviations for AER subsets by city, A/C type, and temperature range.

Subset City Name	A/C Type	Temperature Range (°C)	N	Geometric Mean	Geometric Standard Deviation
Outside California	Central or Room A/C	>30	24	0.5667	1.9447
Outside California	No A/C	<=10	61	0.9258	2.0836
Outside California	No A/C	10-20	87	0.7333	2.3299
Outside California	No A/C	>20	44	1.3782	2.2757
Research Triangle Park	Central or Room A/C	<=10	157	0.9617	1.8094
Research Triangle Park	Central or Room A/C	10-20	320	0.5624	1.9058
Research Triangle Park	Central or Room A/C	20-25	196	0.3970	1.8887
Research Triangle Park	Central or Room A/C	>25	145	0.3803	1.7092

To evaluate the uncertainty of the GM and GSD values, a bootstrap simulation was performed, as follows. Suppose that a given AER subset has N values. A bootstrap sample is obtained by sampling N times at random with replacement from the N AER values. The first AER value in the bootstrap sample is selected randomly from the N values, so that each of the N values is equally likely. The second, third, …, N'th values in the bootstrap sample are also selected randomly from the N values, so that for each selection, each of the N values is equally likely. The same value can be selected more than once. Using this bootstrap sample, the geometric mean and geometric standard deviation of the N values in the bootstrap sample was calculated. This pair of values is plotted as one of the points in a figure for that AER subset. 1,000 bootstrap samples were randomly generated for each AER subset, producing a set of 1,000 geometric mean and geometric standard deviation pairs, which were plotted in example Figures D-9 through D-19.

The bootstrap distributions display the part of the uncertainty of the GM and GSD that is entirely due to random sampling variation. The analysis is based on the assumption that the study AER data are a random sample from the population distribution of AER values for the given city, temperature range, and A/C type. On that basis, the 1,000 bootstrap GM and GSD pairs estimate the variation of the GM and GSD across all possible samples of N values from the population. Since each GM, GSD pair uniquely defines a fitted log-normal distribution, the pairs also estimate the uncertainty of the fitted log-normal distribution. The choice of 1,000 was made as a compromise between having enough pairs to accurately estimate the GM, GSD distribution and not having too many pairs so that the graph appears as a smudge of overlapped points. Note that even if there were infinitely many bootstrap pairs, the uncertainty distribution would still be an estimate of the true uncertainty because the N is finite, so that the empirical distribution of the N measured AER values does not equal the unknown population distribution.

In most cases the uncertainty distribution appears to be a roughly circular or elliptical geometric mean and standard deviation region. The size of the region depends upon the sample size and on the variability of the AER values; the region will be smallest when the sample size N is large and/or the variability is small, so that there are a large number of values that are all close together.

The bootstrap analyses show that the geometric standard deviation uncertainty for a given CMSA/air-conditioning-status/temperature-range combination tends to have a range of at most from “fitted GSD-1.0 hr^{-1}” to “fitted GSD+1.0 hr^{-1}”, but the intervals based on larger AER sample sizes are frequently much narrower. The ranges for the geometric means tend to be approximately from “fitted GM-0.5 hr^{-1}” to “fitted GM+0.5 hr^{-1}”, but in some cases were much smaller.

The bootstrap analysis only evaluates the uncertainty due to the random sampling. It does not account for the uncertainty due to the lack of representativeness, which in turn is due to the fact that the samples were not always random samples from the entire population of residences in a city, and were sometimes used to represent different cities. Since only the GM and GSD were used, the bootstrap analyses does not account for uncertainties about the true distributional shape, which may not necessarily be log-normal. Furthermore, the bootstrap uncertainty does not account for the effect of the calendar year (possible trends in AER values) or of the uncertainty due to the AER measurement period; the distributions were intended to represent distributions of 24 hour average AER values although the study AER data were measured over a variety of measurement periods.

To use the bootstrap distributions to estimate the impact of sample size on the fitted distributions, a Monte Carlo approach could be used with the APEX model. Instead of using the Original Data distributions, a bootstrap GM, GSD pair could be selected at random and the AER value could be selected randomly from the log-normal distribution with the bootstrap GM and GSD.

Figure D-1

Geometric mean and standard deviation of air exchange rate
For different cities and studies
Air Conditioner Type: Central or Room A/C
Temperature Range: <= 10 Degrees Celsius

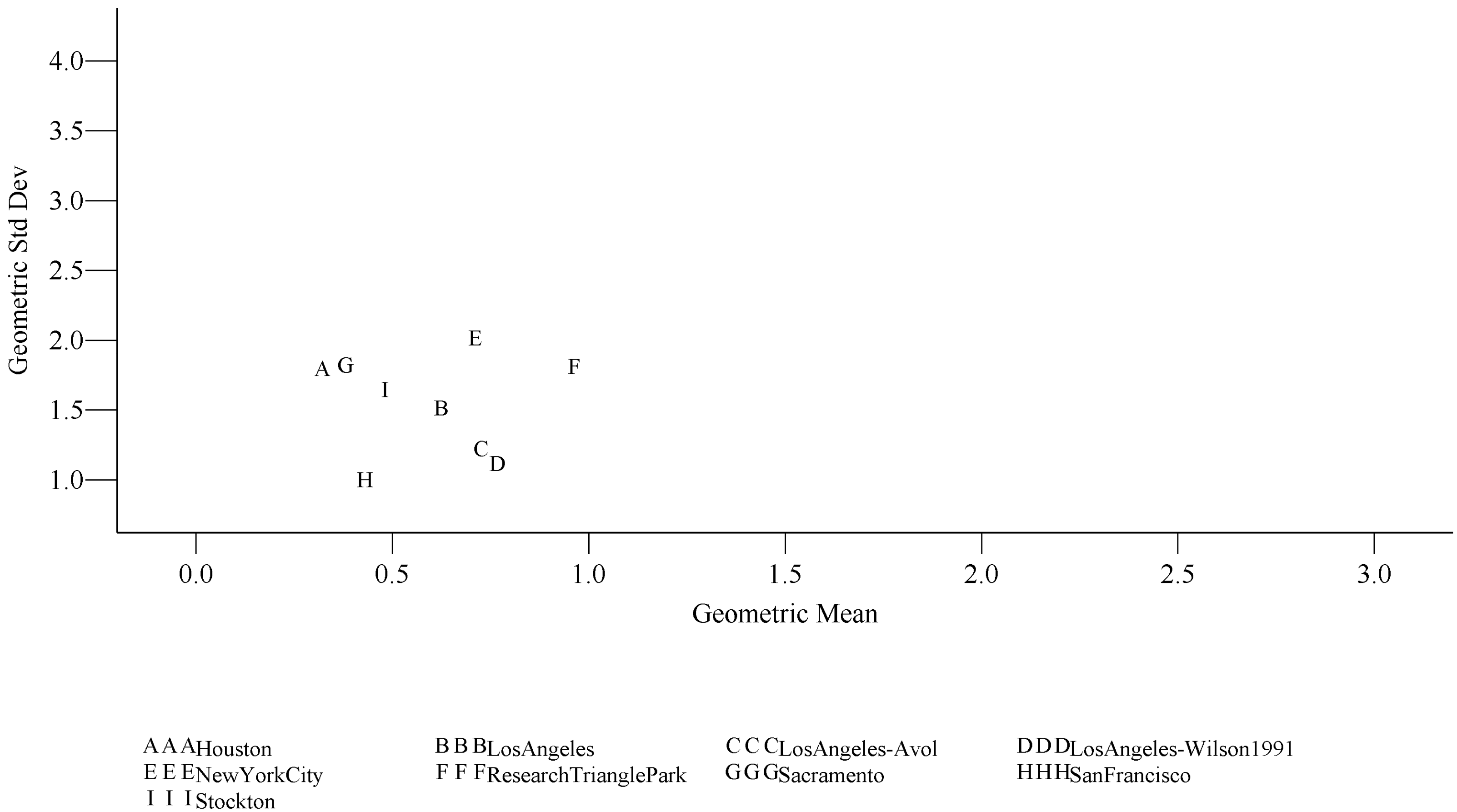


Figure D-2

Geometric mean and standard deviation of air exchange rate
For different cities and studies
Air Conditioner Type: Central or Room A/C
Temperature Range: 10-20 Degrees Celsius

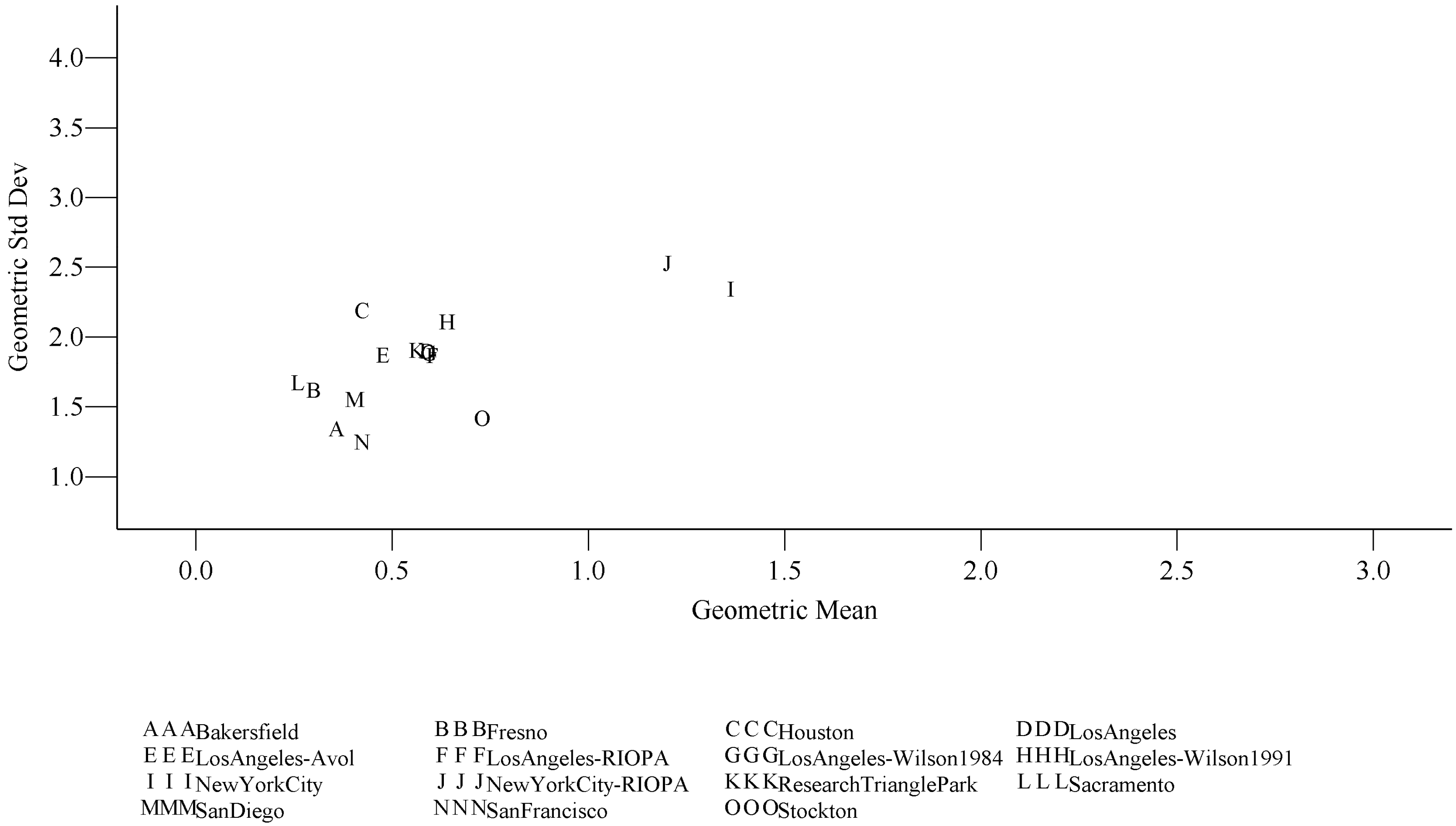


Figure D-3

Geometric mean and standard deviation of air exchange rate
For different cities and studies
Air Conditioner Type: Central or Room A/C
Temperature Range: 20-25 Degrees Celsius

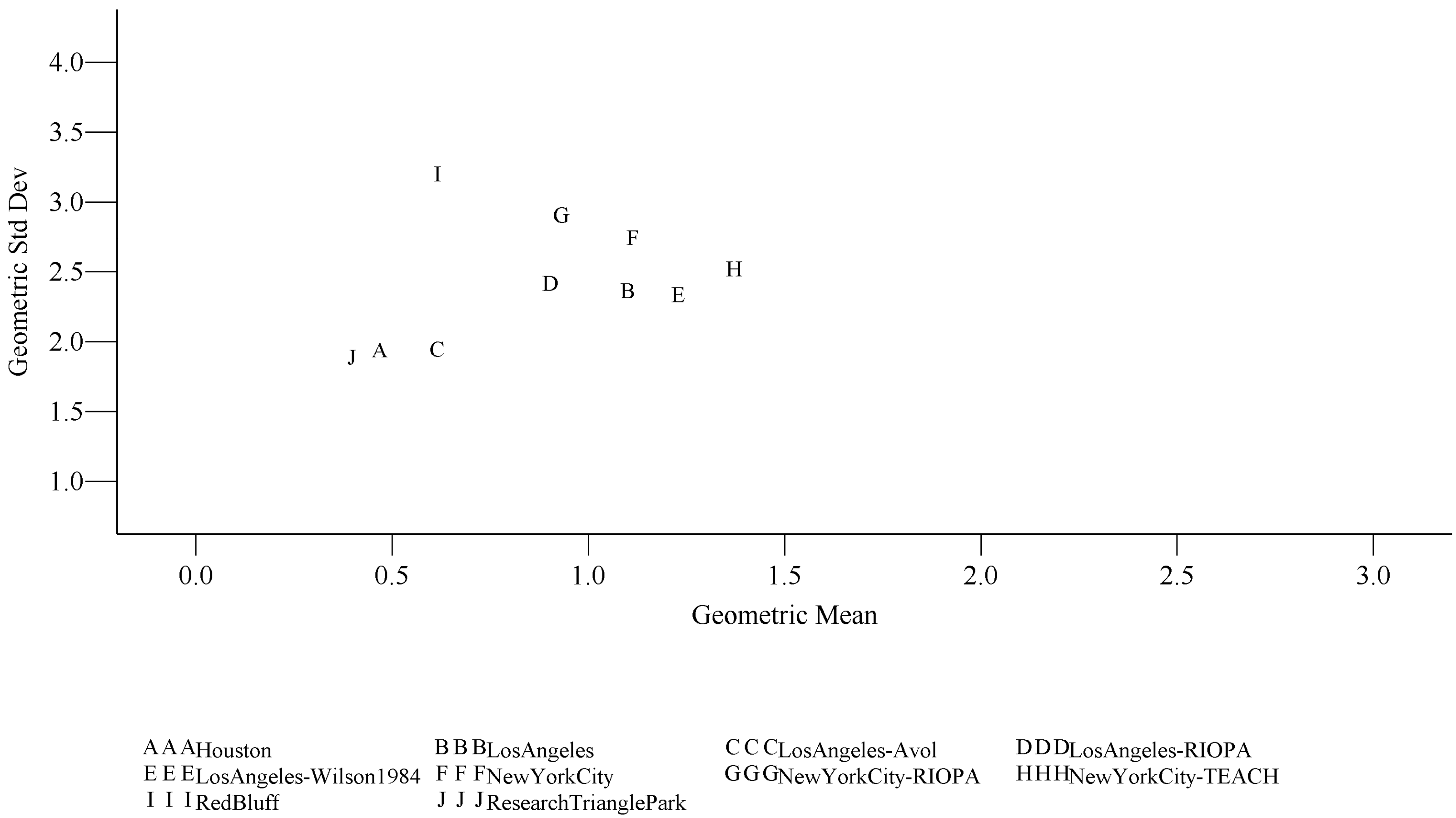


Figure D-4

Geometric mean and standard deviation of air exchange rate
For different cities and studies
Air Conditioner Type: Central or Room A/C
Temperature Range: > 25 Degrees Celsius

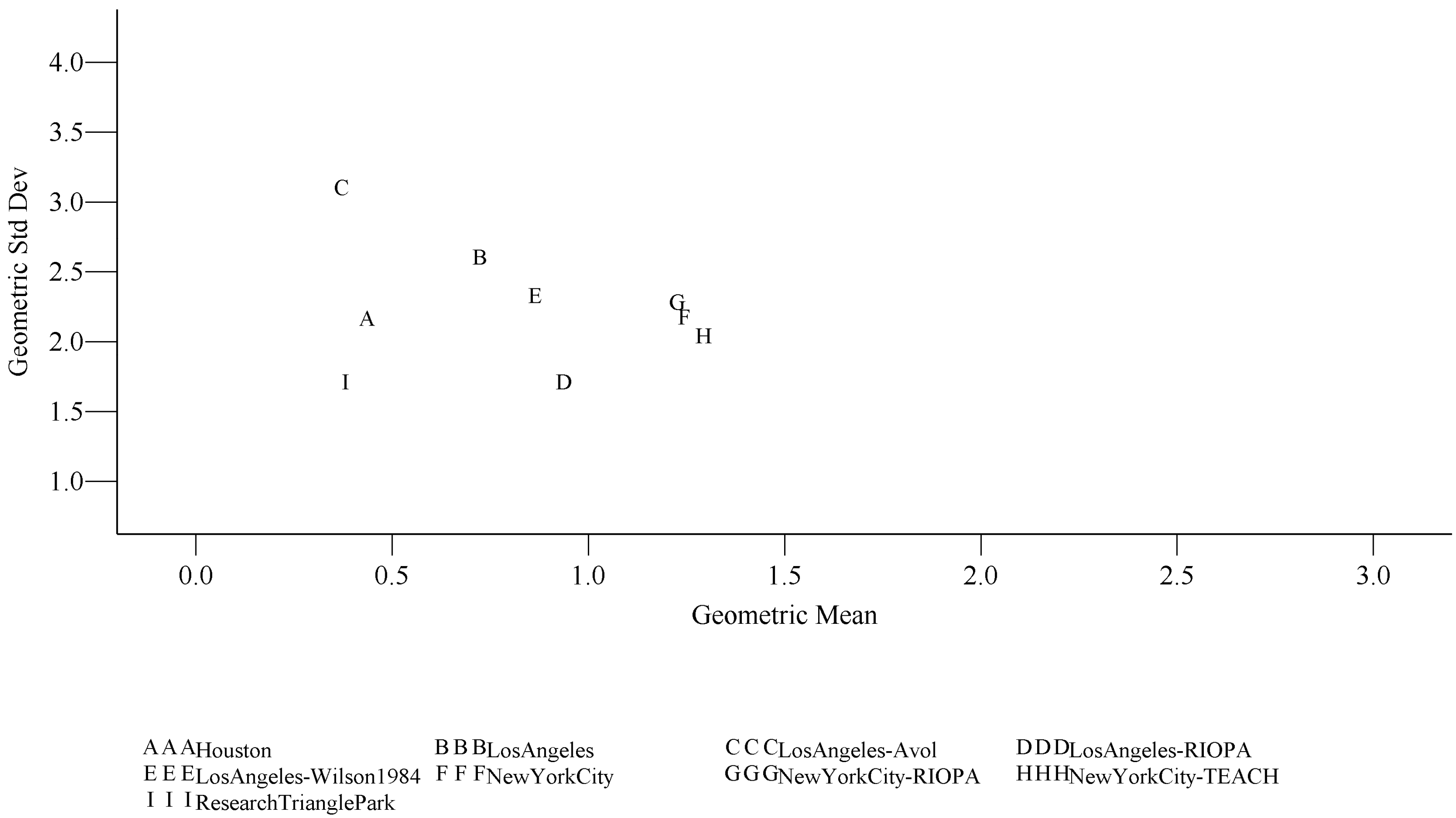


Figure D-5

Geometric mean and standard deviation of air exchange rate
For different cities and studies
Air Conditioner Type: No A/C
Temperature Range: <= 10 Degrees Celsius

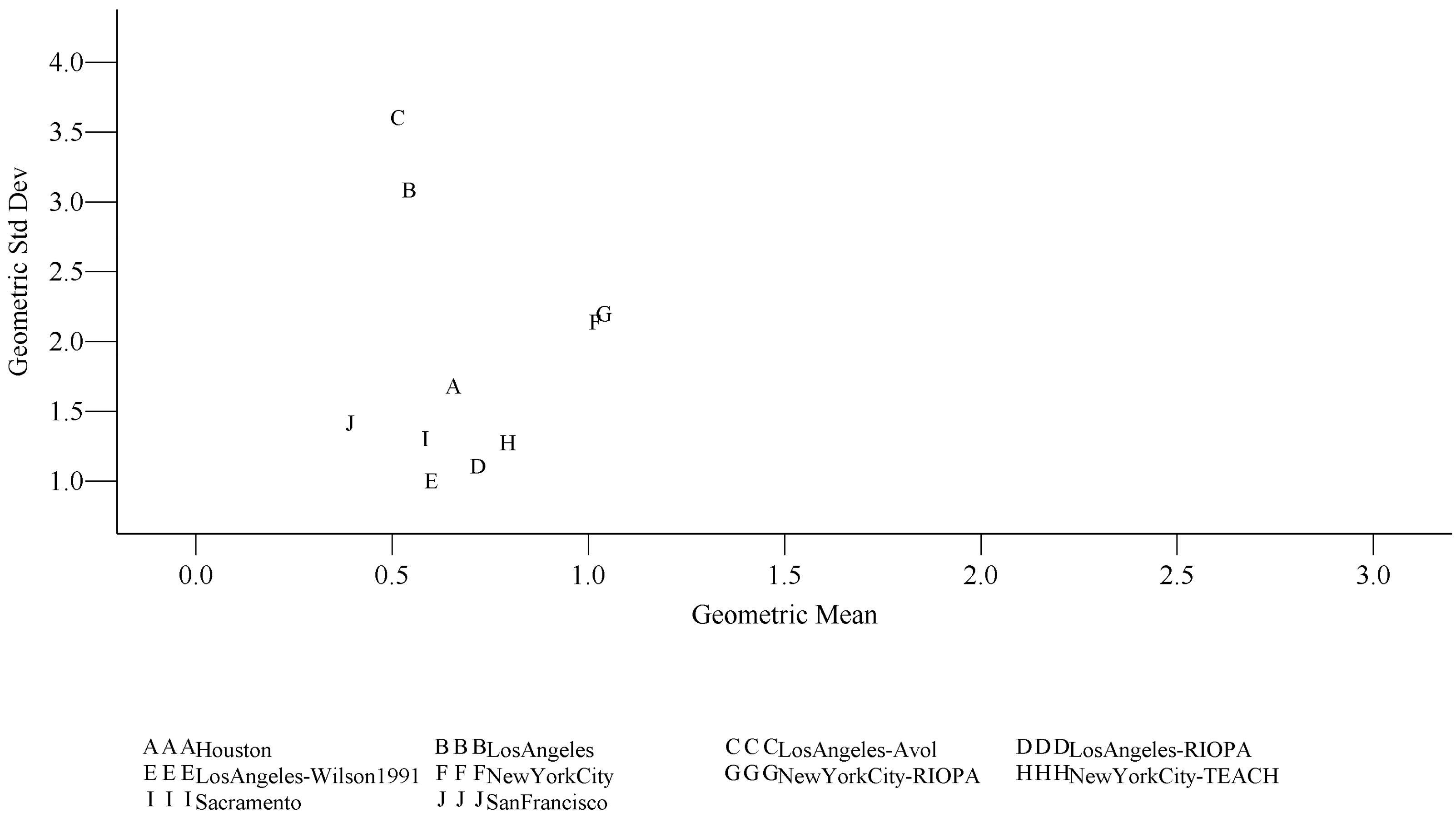
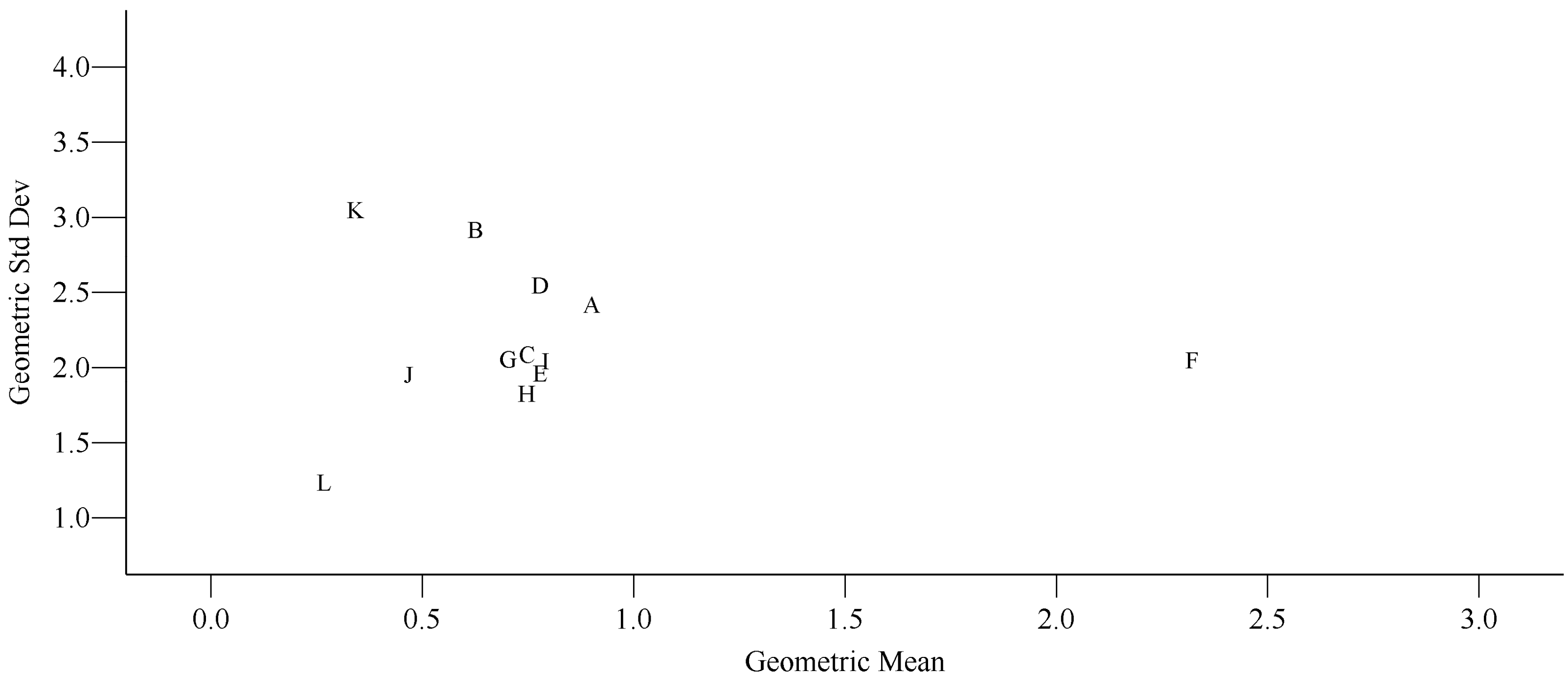


Figure D-6

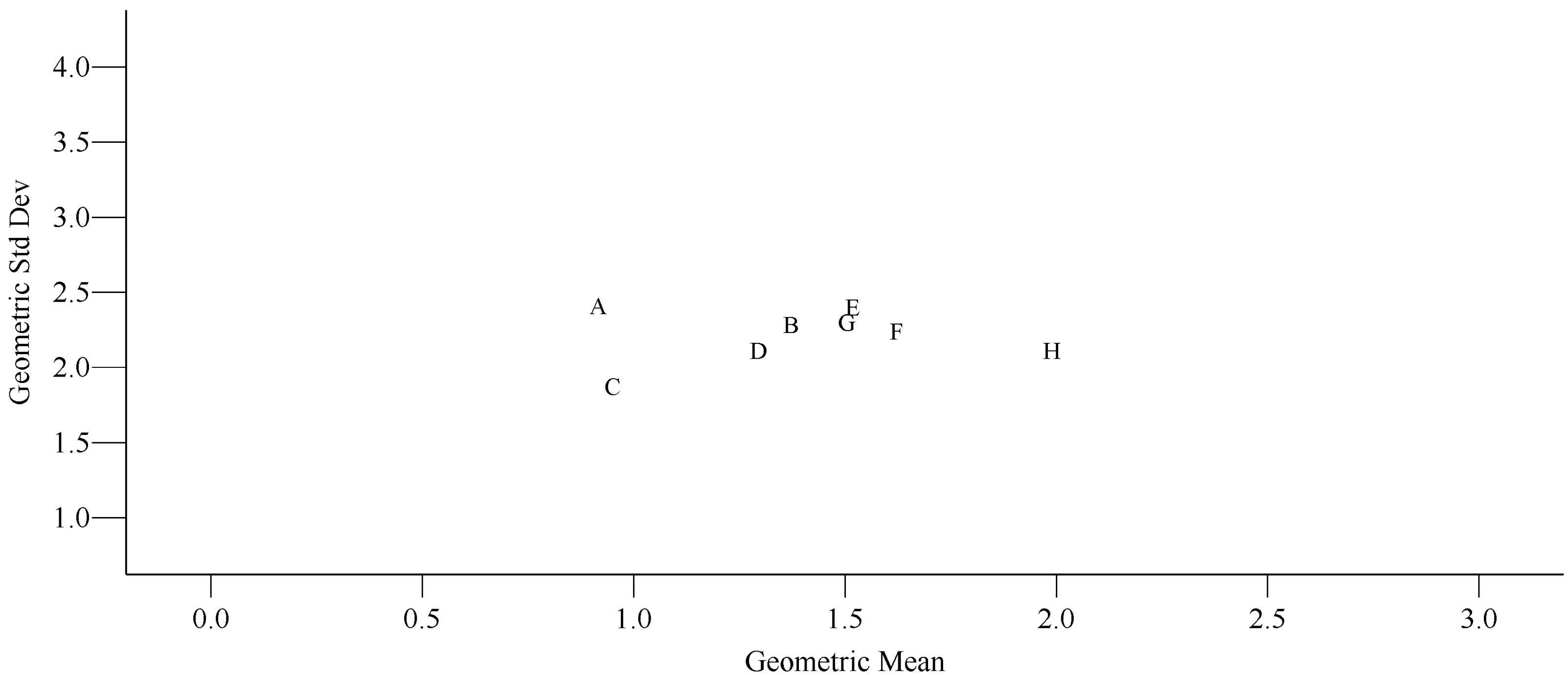
Geometric mean and standard deviation of air exchange rate
For different cities and studies
Air Conditioner Type: No A/C
Temperature Range: 10-20 Degrees Celsius



A A A Fresno
B B B Houston
C C C LosAngeles
D D D LosAngeles-Avol
E E E LosAngeles-RIOPA
F F F LosAngeles-TEACH
G G G LosAngeles-Wilson1984
H H H LosAngeles-Wilson1991
I I I NewYorkCity
J J J SanDiego
K K K SanFrancisco
L L L SantaMaria

Figure D-7

Geometric mean and standard deviation of air exchange rate
For different cities and studies
Air Conditioner Type: No A/C
Temperature Range: 20-25 Degrees Celsius



A A A Houston
B B B LosAngeles
C C C LosAngeles-Avol
D D D LosAngeles-RIOPA
E E E LosAngeles-Wilson1984
F F F NewYorkCity
G G G NewYorkCity-RIOPA
H H H NewYorkCity-TEACH

Figure D-8

Geometric mean and standard deviation of air exchange rate
For different cities and studies
Air Conditioner Type: No A/C
Temperature Range: > 25 Degrees Celsius

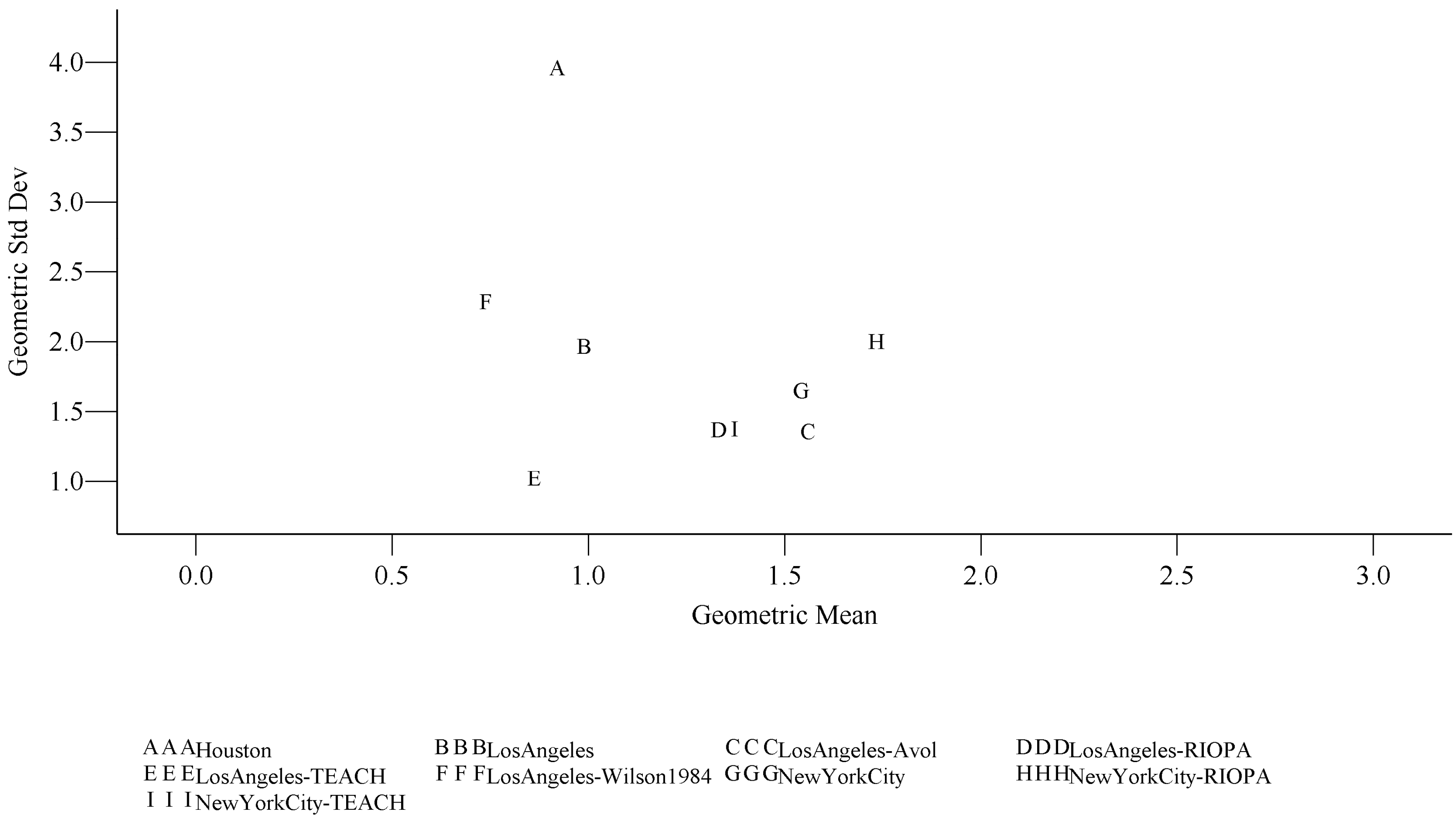


Figure D-9

Geometric mean and standard deviation of air exchange rate
Bootstrapped distributions for different cities
City: Houston
Air Conditioner Type: Central or Room A/C
Temperature Range: 20-25 Degrees Celsius

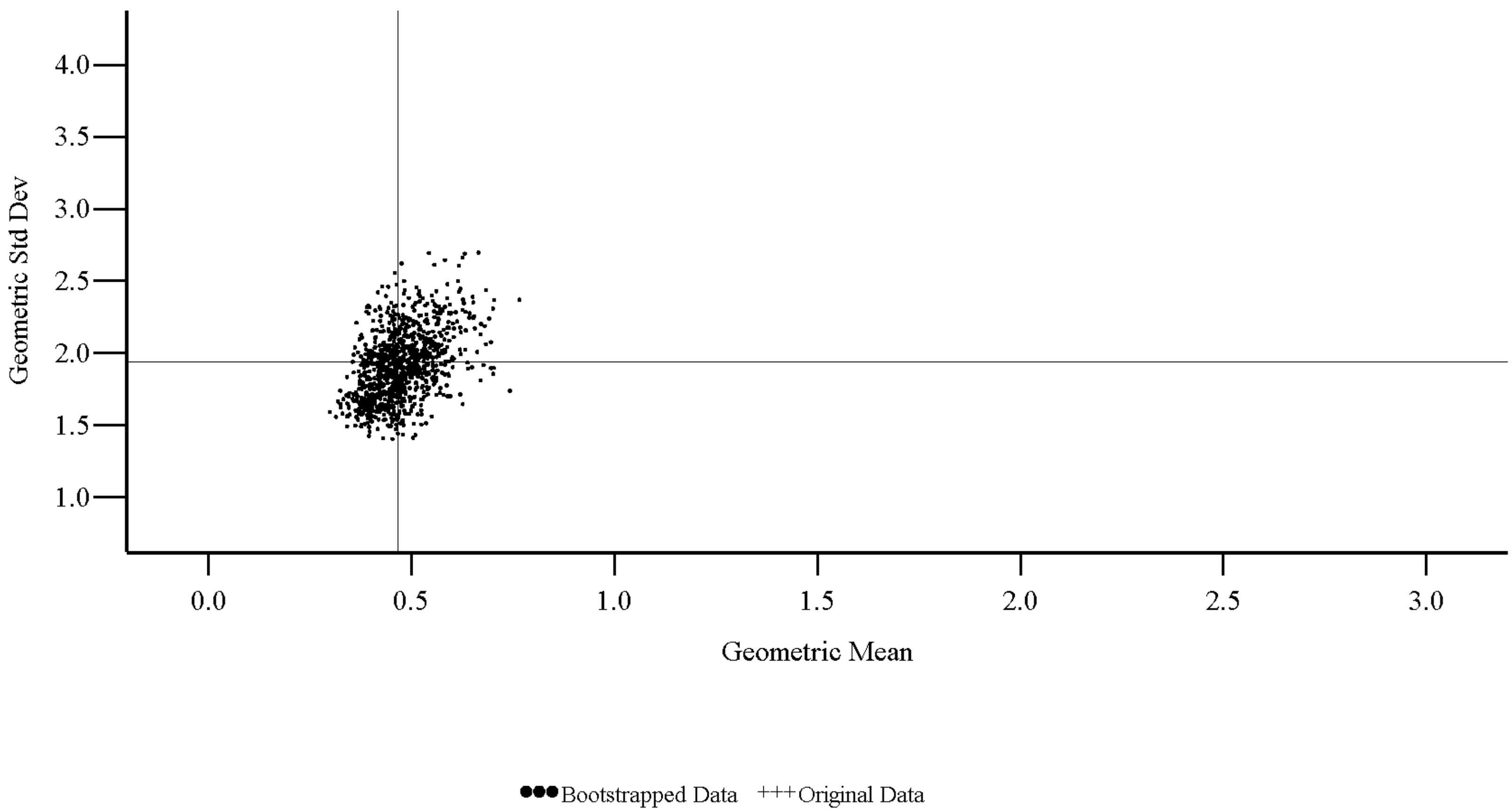


Figure D-10

Geometric mean and standard deviation of air exchange rate
Bootstrapped distributions for different cities
City: Houston
Air Conditioner Type: No A/C
Temperature Range: >20 Degrees Celsius

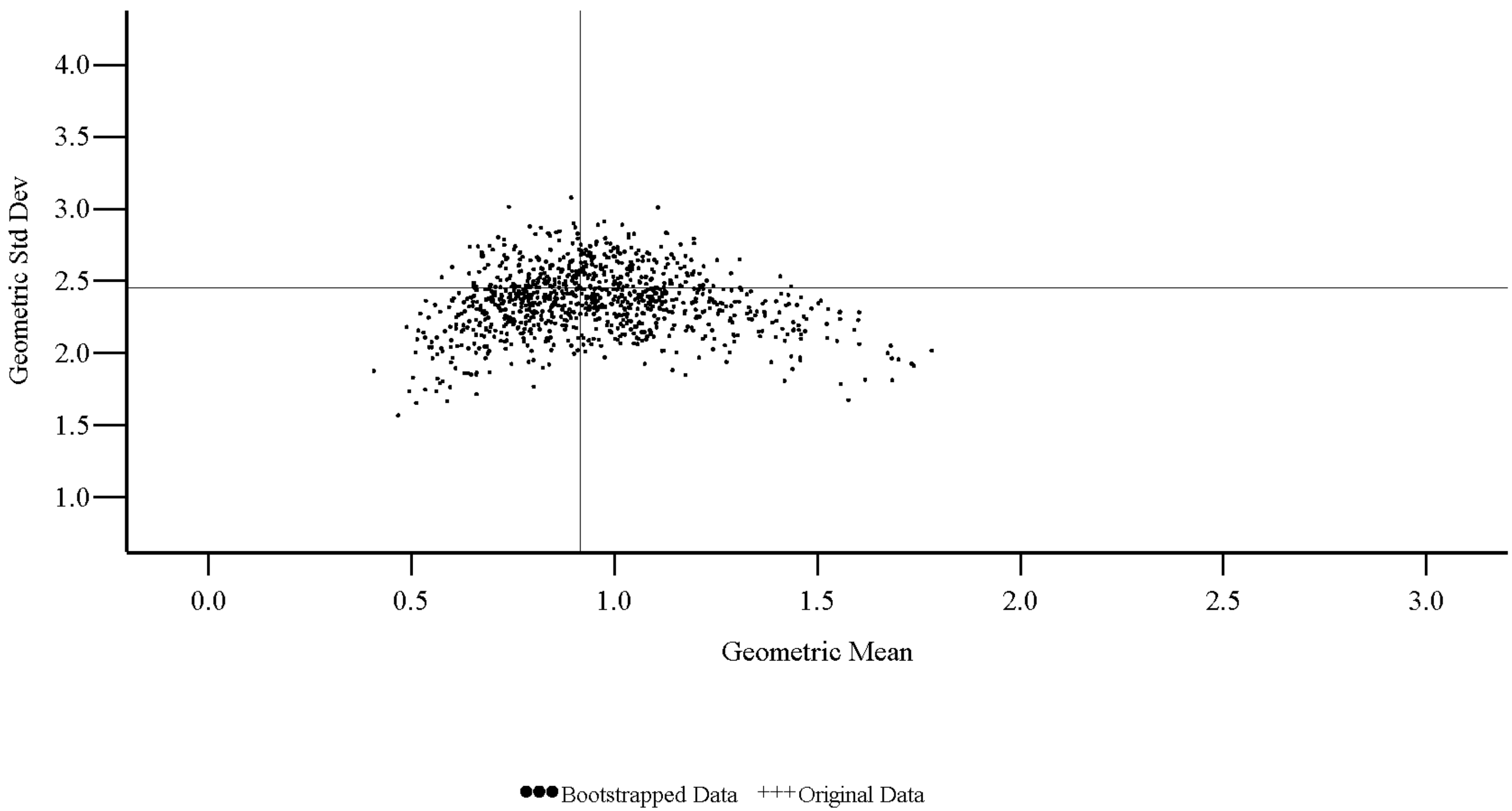


Figure D-11

Geometric mean and standard deviation of air exchange rate
Bootstrapped distributions for different cities
City: Inland California
Air Conditioner Type: Central or Room A/C
Temperature Range: <=25 Degrees Celsius

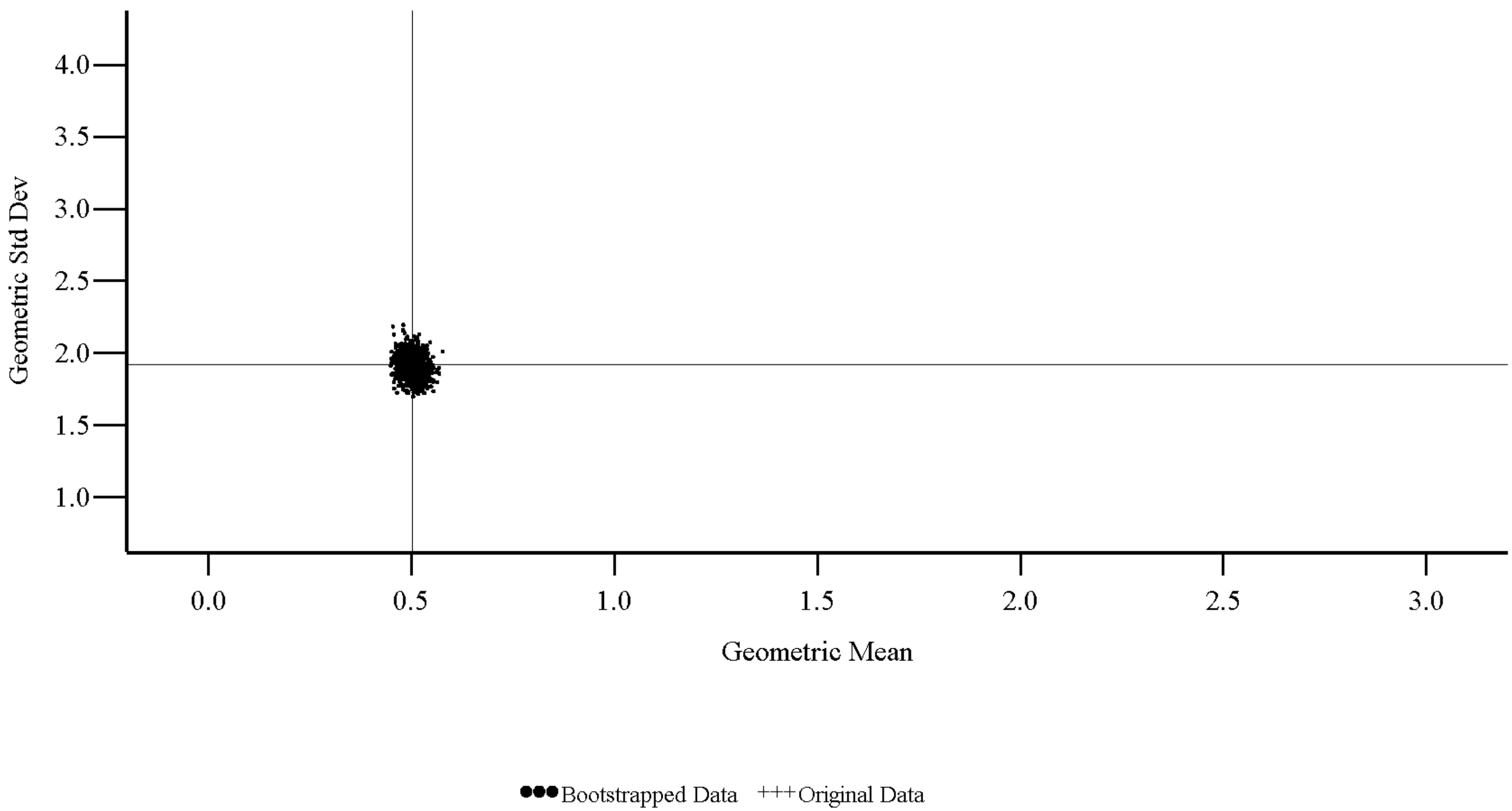


Figure D-12

Geometric mean and standard deviation of air exchange rate
Bootstrapped distributions for different cities
City: Inland California
Air Conditioner Type: No A/C
Temperature Range: 20-25 Degrees Celsius

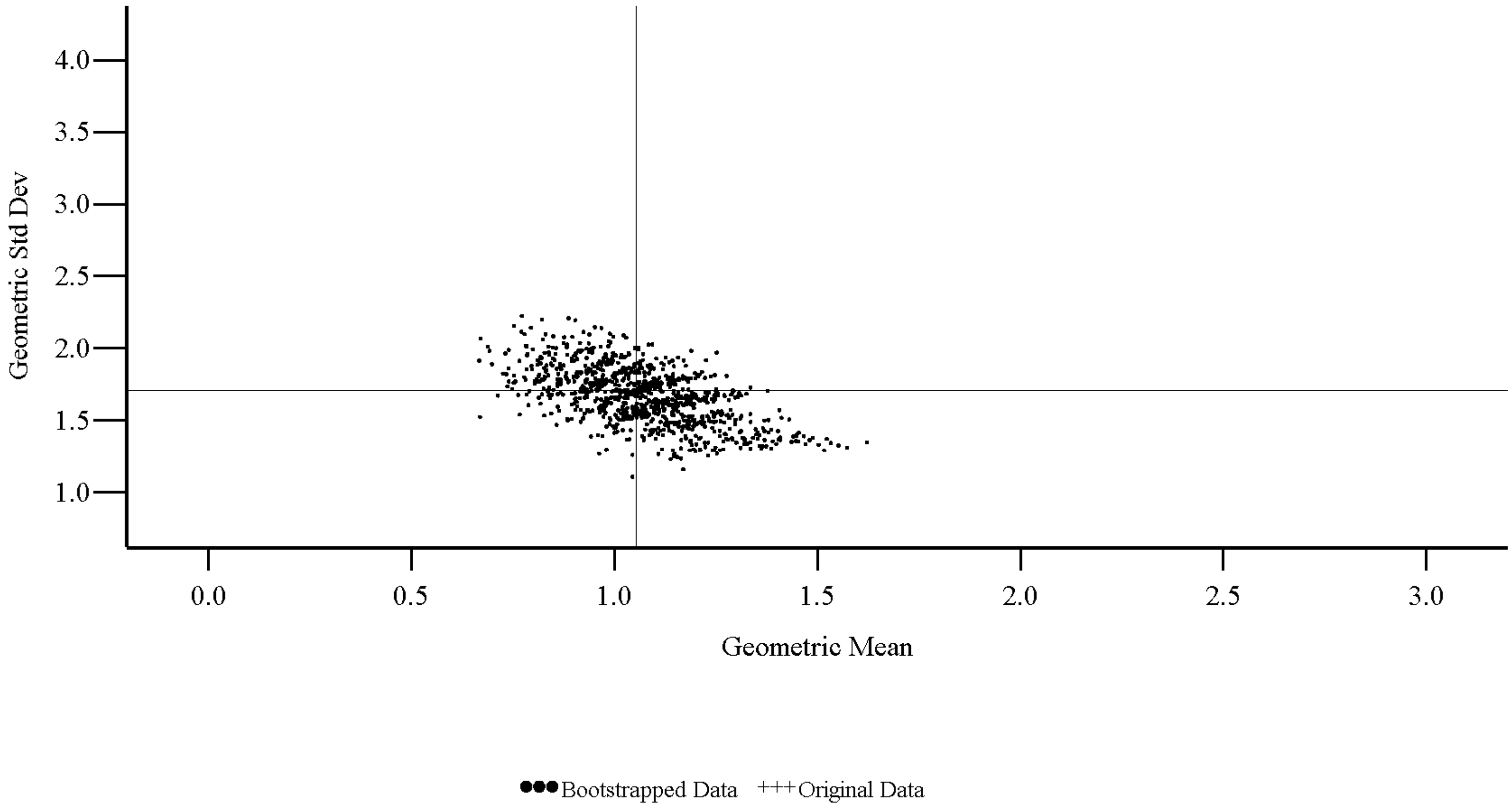


Figure D-13

Geometric mean and standard deviation of air exchange rate
Bootstrapped distributions for different cities
City: Los Angeles
Air Conditioner Type: Central or Room A/C
Temperature Range: 20-25 Degrees Celsius

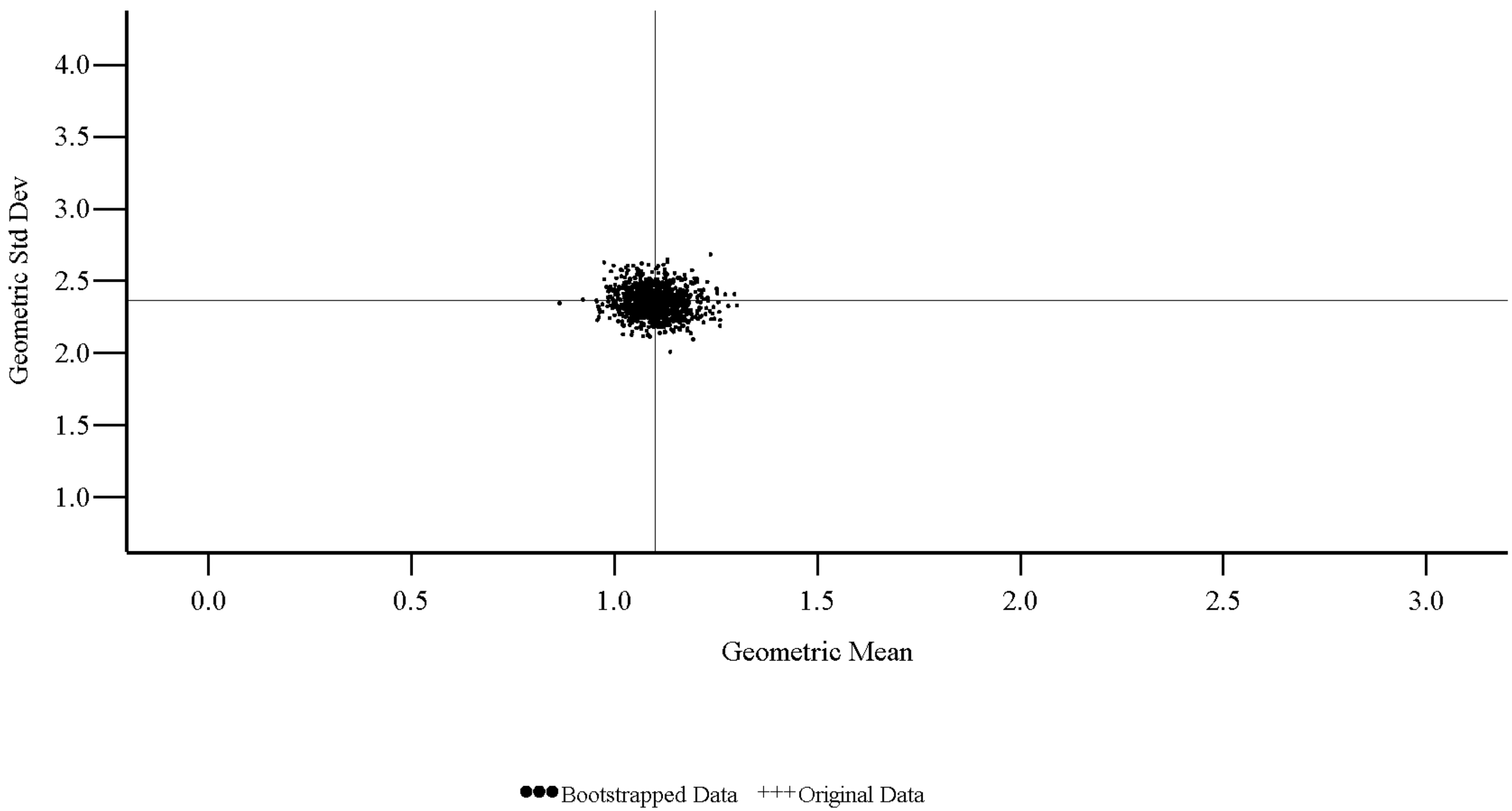


Figure D-14

Geometric mean and standard deviation of air exchange rate
Bootstrapped distributions for different cities
City: Los Angeles
Air Conditioner Type: No A/C
Temperature Range: 20-25 Degrees Celsius

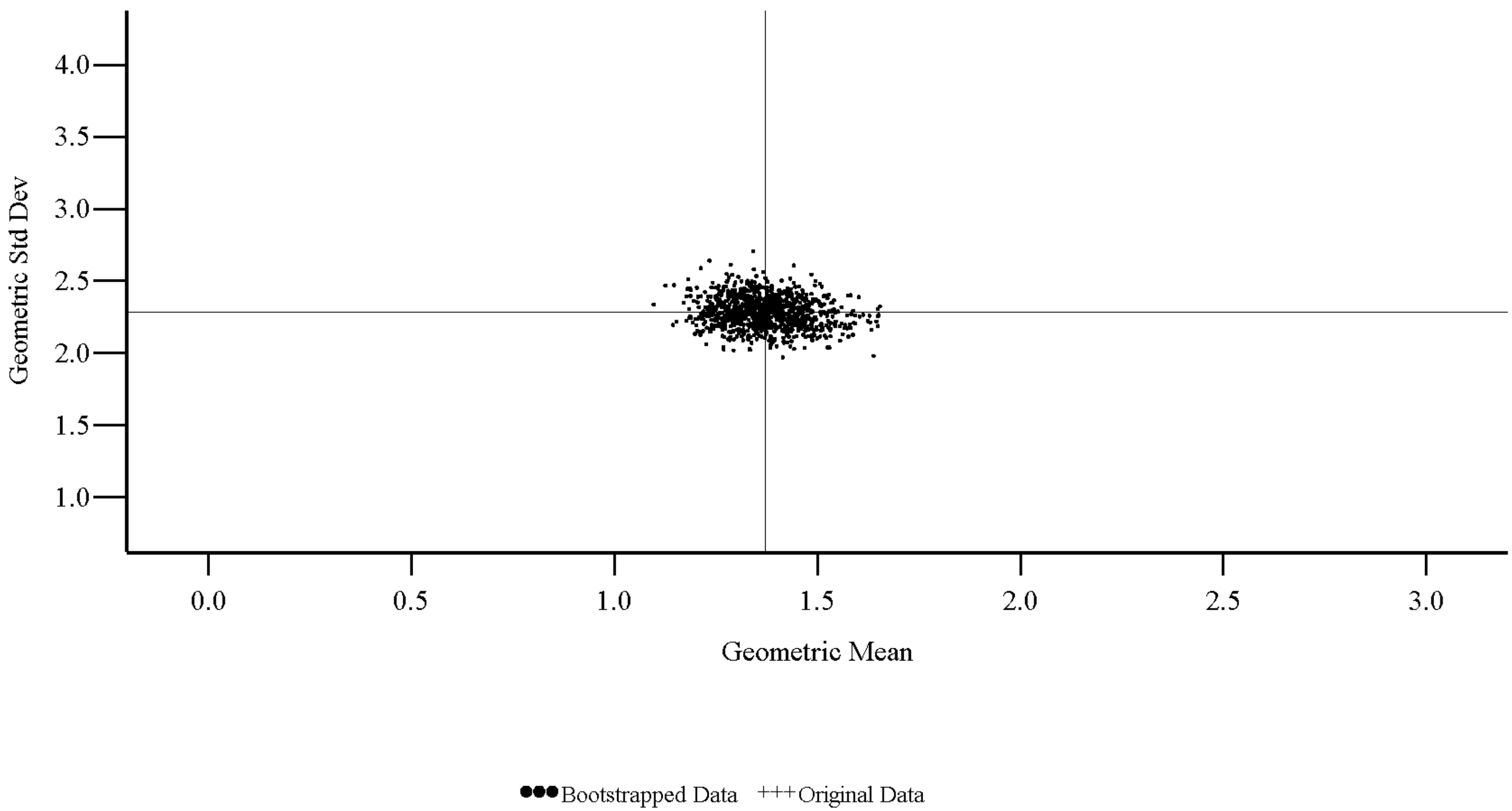


Figure D-15

Geometric mean and standard deviation of air exchange rate
Bootstrapped distributions for different cities
City: New York City
Air Conditioner Type: Central or Room A/C
Temperature Range: 10-25 Degrees Celsius

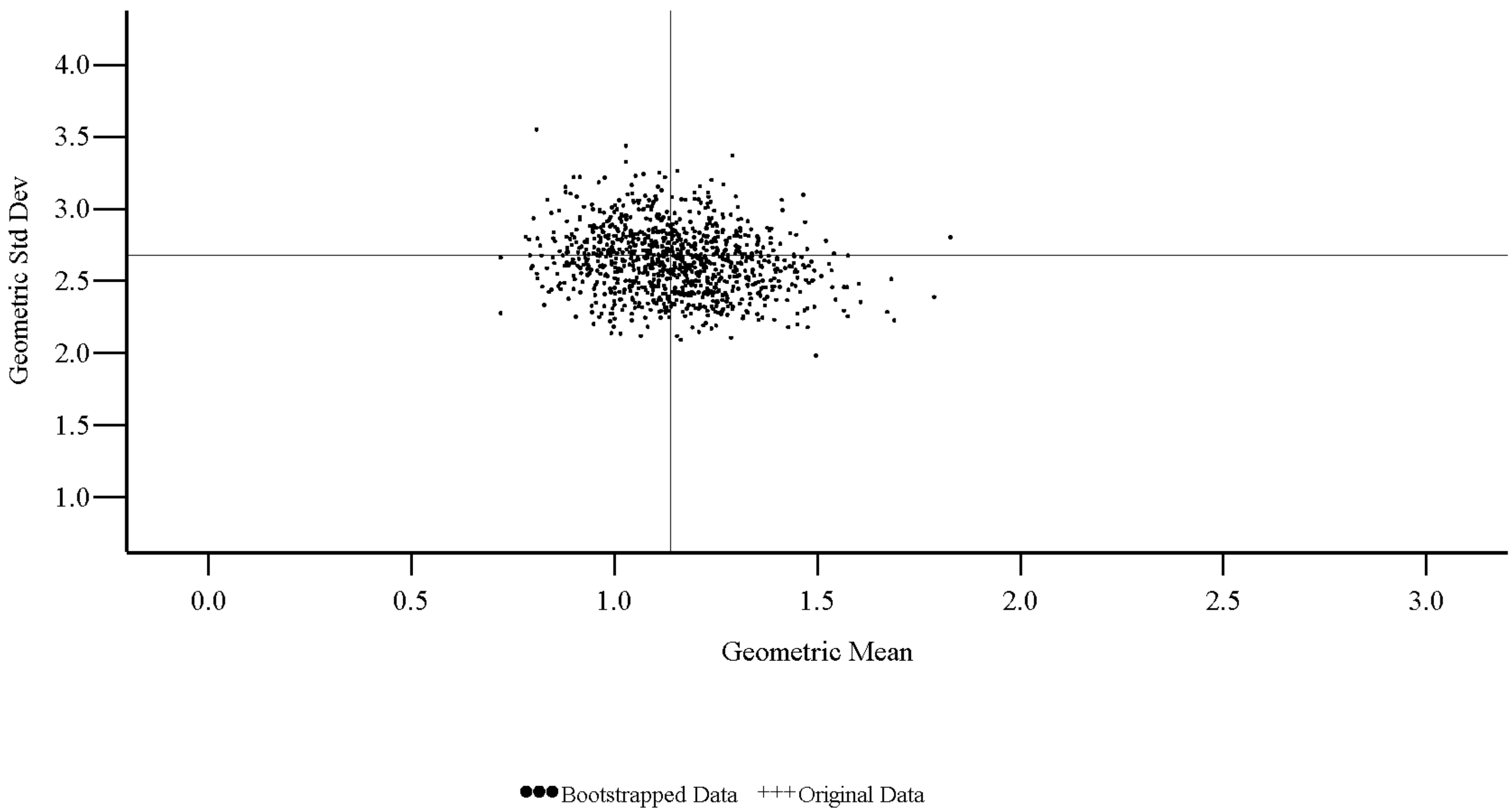


Figure D-16

Geometric mean and standard deviation of air exchange rate
Bootstrapped distributions for different cities
City: New York City
Air Conditioner Type: No A/C
Temperature Range: >20 Degrees Celsius

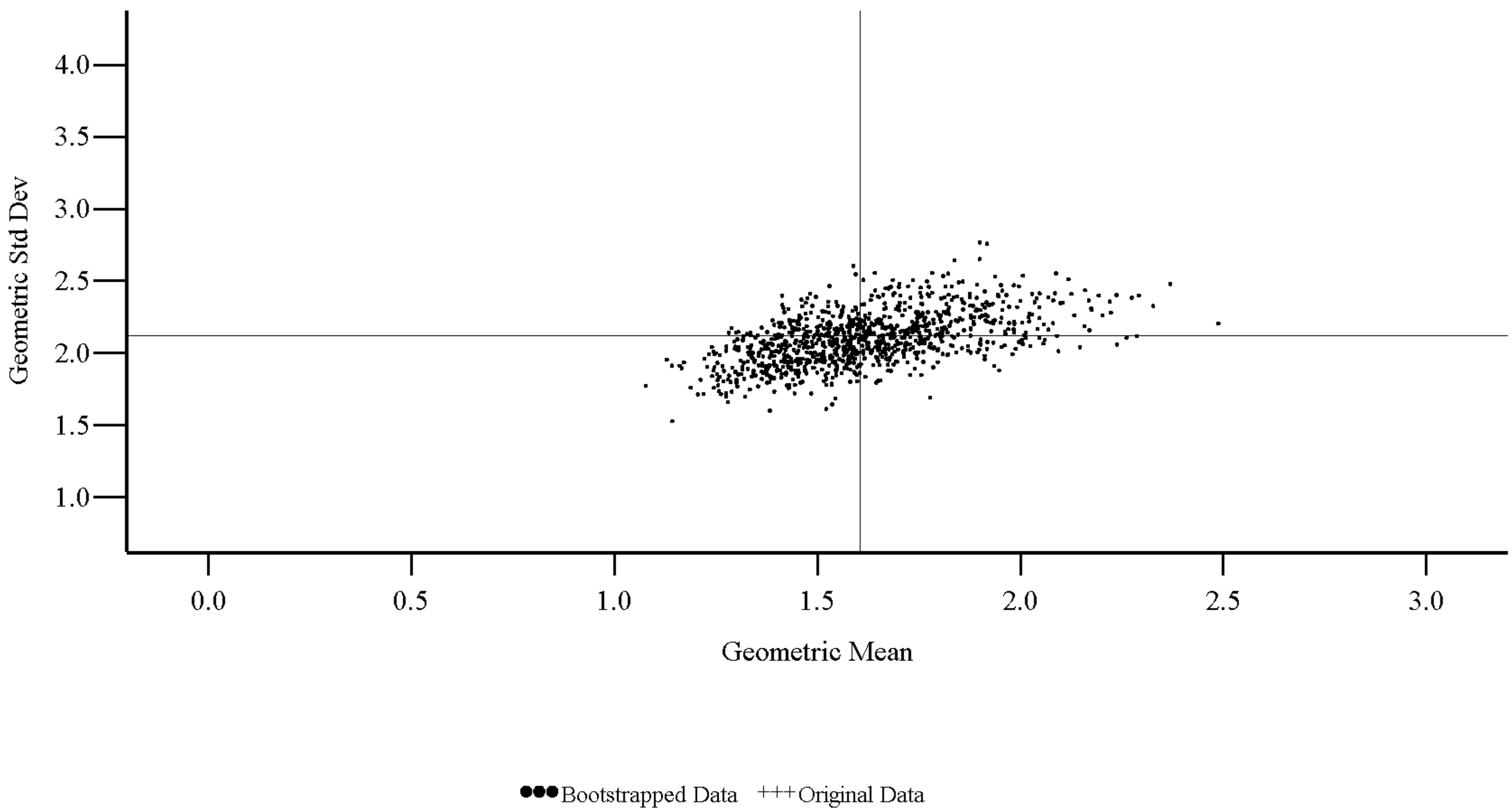


Figure D-17

Geometric mean and standard deviation of air exchange rate
Bootstrapped distributions for different cities
City: Outside California
Air Conditioner Type: Central or Room A/C
Temperature Range: 20-25 Degrees Celsius

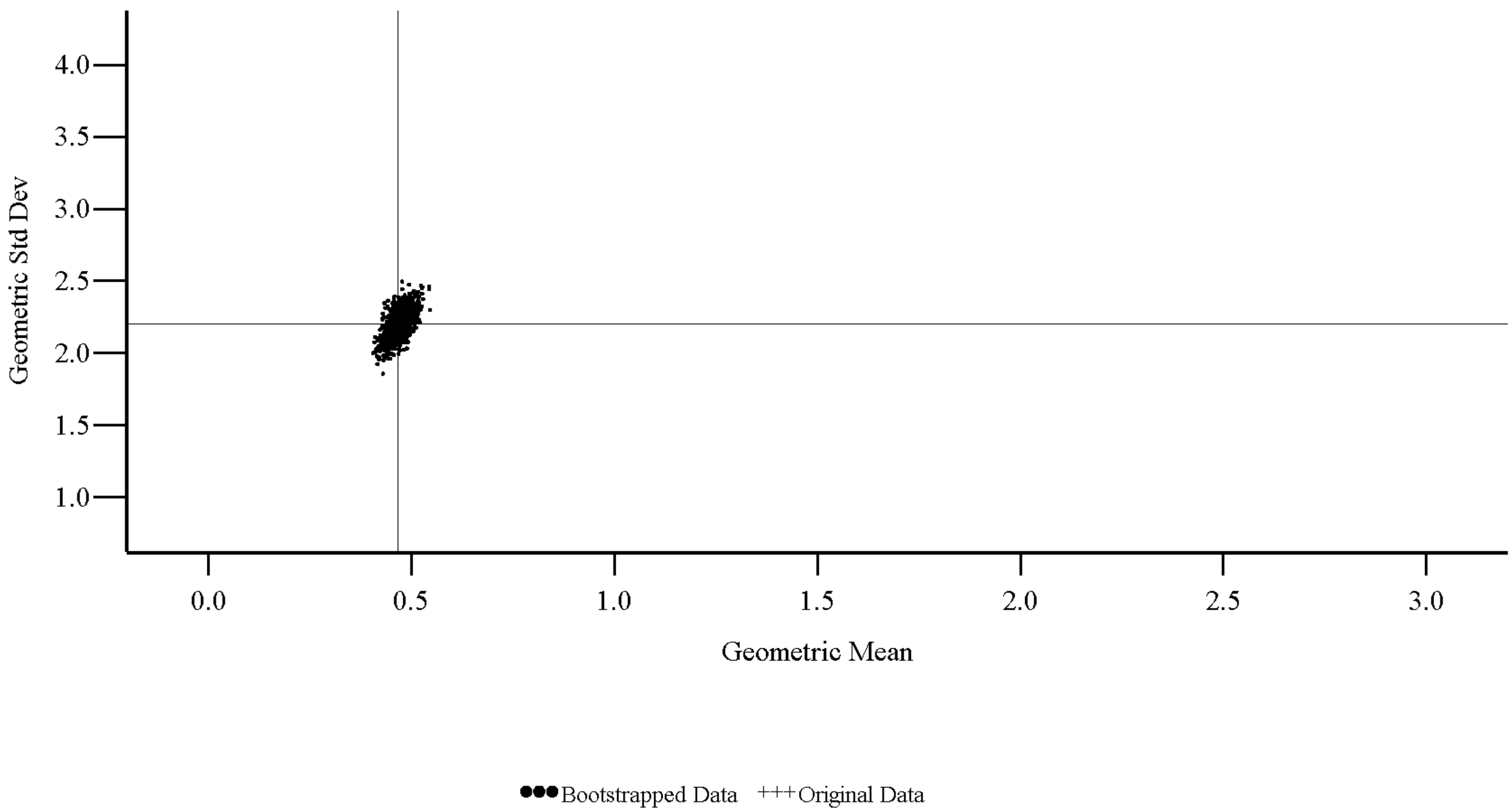


Figure D-18

Geometric mean and standard deviation of air exchange rate
Bootstrapped distributions for different cities
City: Outside California
Air Conditioner Type: No A/C
Temperature Range: >20 Degrees Celsius

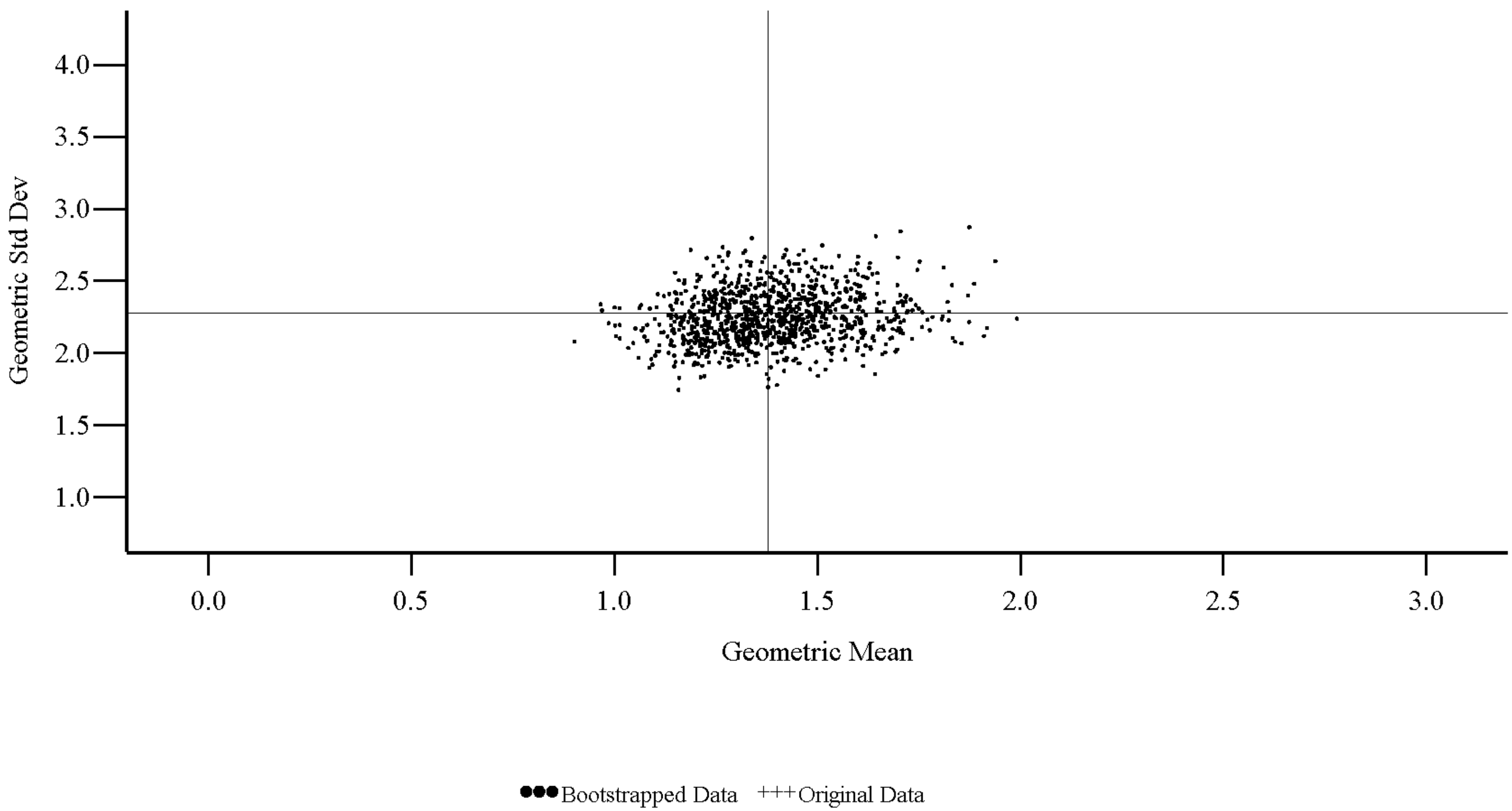
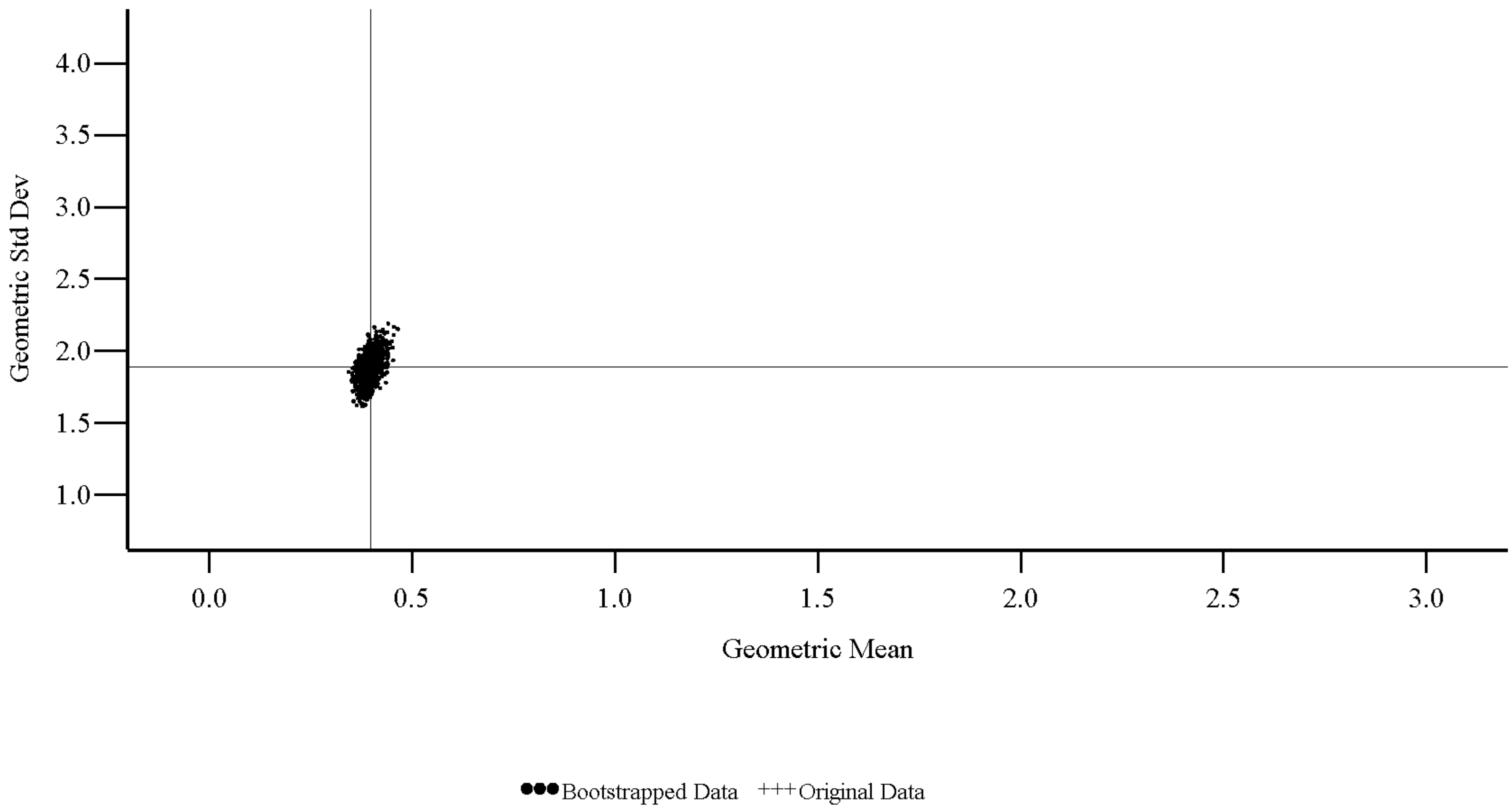


Figure D-19

Geometric mean and standard deviation of air exchange rate
Bootstrapped distributions for different cities
City: Research Triangle Park
Air Conditioner Type: Central or Room A/C
Temperature Range: 20-25 Degrees Celsius



Attachment 9. Technical Memorandum on the Distributions of Air Exchange Rate Averages Over Multiple Days

ICF INTERNATIONAL

M E M O R A N D U M

To: John Langstaff, EPA OAQPS
From: Jonathan Cohen, Arlene Rosenbaum, ICF International
Date: June 8, 2006
Re: Distributions of air exchange rate averages over multiple days

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As detailed in the memorandum by Cohen, Mallya and Rosenbaum, 2005[31] (Appendix A of this report) we have proposed to use the APEX model to simulate the residential air exchange rate (AER) using different log-normal distributions for each combination of outside temperature range and the air conditioner type, defined as the presence or absence of an air conditioner (central or room).

Although the averaging periods for the air exchange rates in the study databases varied from one day to seven days, our analyses did not take the measurement duration into account and treated the data as if they were a set of statistically independent daily averages. In this memorandum we present some analyses of the Research Triangle Park Panel Study that show extremely strong correlations between consecutive 24-hour air exchange rates measured at the same house. This provides support for the simplified approach of treating all averaging periods as if they were 24-hour averages.

In the current version of the APEX model, there are several options for stratification of time periods with respect to AER distributions, and for when to re-sample from a distribution for a given stratum. The options selected for this current set of simulations resulted in a uniform AER for each 24-hour period and re-sampling of the 24-hour AER for each simulated day. This re-sampling for each simulated day implies that the simulated AERs on consecutive days in the same microenvironment are statistically independent. Although we have not identified sufficient data to test the assumption of uniform AERs throughout a 24-hour period, the analyses described in this memorandum suggest that AERs on consecutive days are highly correlated. Therefore, we performed sensitivity simulations to assess the impact of the assumption of temporally independent air exchange rates, but found little difference between APEX predictions for the two scenarios (i.e., temporally independent and autocorrelated air exchange rates).

[31] Cohen, J., H. Mallya, and A. Rosenbaum. 2005. Memorandum to John Langstaff. *EPA 68D01052, Work Assignment 3-08. Analysis of Air Exchange Rate Data*. September 30, 2005.

Distributions of multi-day averages from the RTP Panel Study

The RTP Panel study included measurements of 24-hour averages at 38 residences for up to four periods of at least seven days. These periods were in different seasons and/or calendar years. Daily outside temperatures were also provided. All the residences had either window or room air conditioners or both. We used these data to compare the distributions of daily averages taken over 1, 2, 3, .. 7 days.

The analysis is made more complicated because the previous analyses showed the dependence of the air exchange rate on the outside temperature, and the daily temperatures often varied considerably. Two alternative approaches were employed to group consecutive days. For the first approach, A, we sorted the data by the HOUSE_ID number and date and began a new group of days for each new HOUSE_ID and whenever the sorted measurement days on the same HOUSE_ID were 30 days or more apart. In most cases, a home was measured over four different seasons for seven days, potentially giving 38 × 4 = 152 groups; the actual number of groups was 124. For the second approach, B, we again sorted the data by the HOUSE_ID number and date, but this time we began a new group of days for each new HOUSE_ID and whenever the sorted measurement days on the same HOUSE_ID were 30 days or more apart or were for different temperature ranges. We used the same four temperature ranges chosen for the analysis in the Cohen, Mallya, and Rosenbaum, 2005, memorandum (Appendix A): <= 10, 10-20, 20-25, and > 25 ºC. For example, if the first week of measurements on a given HOUSE_ID had the first three days in the <= 10 ºC range, the next day in the 10-20 ºC range, and the last three days in the <= 10 ºC range, then the first approach would treat this as a single group of days. The second approach would treat this as three groups of days, i.e., the first three days, the fourth day, and the last three days. Using the first approach, the days in each group can be in different temperature ranges. Using the second approach, every day in a group is in the same temperature range. Using the first approach we treat groups of days as being independent following a transition to a different house or season. Using the second approach we treat groups of days as being independent following a transition to a different house or season or temperature range.

To evaluate the distributions of multi-day air exchange rate (AER) averages, we averaged the AERs over consecutive days in each group. To obtain a set of one-day averages, we took the AERs for the first day of each group. To obtain a set of two-day averages, we took the average AER over the first two days from each group. We continued this process to obtain three-, four-, five-, six-, and seven-day averages. There were insufficiently representative data for averaging periods longer then seven days. Averages over non-consecutive days were excluded. Each averaging period was assigned the temperature range using the average of the daily temperatures for the averaging period. Using Approach A, some or all of the days in the averaging period might be in different temperature ranges than the overall average. . Using Approach B, every day is in the same temperature range as the overall average. For each averaging period and temperature range, we calculated the mean, standard deviation, and variance of the period average AER and of its natural logarithm. Note than the geometric mean equals *e* raised to the power Mean log (AER) and the geometric standard deviation equals *e* raised to the power Std Dev log (AER). The results are shown in Tables E-1 (Approach A) and E-2 (Approach B).

Table E-1. Distribution of AER averaged over K days and its logarithm. Groups defined by Approach A.

Temperature (ºC)	K	Groups	Mean AER	Mean log(AER)	Std Dev AER	Std Dev log(AER)	Variance AER	Variance log(AER)
<= 10	1	35	1.109	-0.066	0.741	0.568	0.549	0.322
<= 10	2	30	1.149	-0.009	0.689	0.542	0.474	0.294
<= 10	3	28	1.065	-0.088	0.663	0.546	0.440	0.298
<= 10	4	28	1.081	-0.090	0.690	0.584	0.476	0.341
<= 10	5	24	1.103	-0.082	0.754	0.598	0.568	0.358
<= 10	6	24	1.098	-0.083	0.753	0.589	0.567	0.347
<= 10	7	29	1.054	-0.109	0.704	0.556	0.496	0.309
10-20	1	48	0.652	-0.659	0.417	0.791	0.174	0.625
10-20	2	55	0.654	-0.598	0.411	0.607	0.169	0.368
10-20	3	51	0.641	-0.622	0.416	0.603	0.173	0.363
10-20	4	50	0.683	-0.564	0.440	0.619	0.194	0.384
10-20	5	53	0.686	-0.546	0.419	0.596	0.175	0.355
10-20	6	49	0.677	-0.533	0.379	0.544	0.144	0.296
10-20	7	34	0.638	-0.593	0.343	0.555	0.118	0.308
20-25	1	32	0.500	-1.005	0.528	0.760	0.279	0.577
20-25	2	28	0.484	-0.972	0.509	0.623	0.259	0.388
20-25	3	27	0.495	-0.933	0.491	0.604	0.241	0.365
20-25	4	17	0.536	-0.905	0.623	0.652	0.389	0.425
20-25	5	17	0.543	-0.905	0.672	0.649	0.452	0.421
20-25	6	17	0.529	-0.899	0.608	0.617	0.370	0.381
20-25	7	14	0.571	-0.889	0.745	0.683	0.555	0.466
> 25	1	9	0.470	-1.058	0.423	0.857	0.179	0.734
> 25	2	11	0.412	-1.123	0.314	0.742	0.098	0.551
> 25	3	12	0.411	-1.036	0.243	0.582	0.059	0.339
> 25	4	23	0.385	-1.044	0.176	0.429	0.031	0.184
> 25	5	23	0.390	-1.028	0.175	0.425	0.031	0.181
> 25	6	23	0.399	-1.010	0.193	0.435	0.037	0.189
> 25	7	17	0.438	-0.950	0.248	0.506	0.061	0.256

Using both approaches, Tables E-1 and E-2 show that the mean values for the AER and its logarithm are approximately constant for the same temperature range but different averaging periods. This is expected if the daily AER values all have the same statistical distribution, regardless of whether or not they are independent. More interesting is the observation that the standard deviations and variances are also approximately constant for the same temperature range but different averaging periods, except for the data at > 25 ºC where the standard deviations and variances tend to decrease as the length of the averaging period increases. If the daily AER values were statistically independent, then the variance of an average over K days is given by Var / K, where Var is the variance of a single daily AER value. Clearly this formula does not apply. Since the variance is approximately constant for different values of K in the same temperature range (except for the relatively limited data at > 25 ºC), this shows that the daily AER values are strongly correlated. Of course the correlation is not perfect, since otherwise the AER for a given day would be identical to the AER for the next day, if the temperature range were the same, which did not occur.

Table E-2. Distribution of AER averaged over K days and its logarithm. Groups defined by Approach B.

Temperature (°C)	K	Groups	Mean AER	Mean log(AER)	Std Dev AER	Std Dev log(AER)	Variance AER	Variance log(AER)
<= 10	1	62	1.125	-0.081	0.832	0.610	0.692	0.372
<= 10	2	41	1.059	-0.063	0.595	0.481	0.355	0.231
<= 10	3	32	1.104	-0.040	0.643	0.530	0.413	0.281
<= 10	4	17	1.292	0.115	0.768	0.531	0.590	0.282
<= 10	5	5	1.534	0.264	1.087	0.608	1.182	0.370
10-20	1	109	0.778	-0.482	0.579	0.721	0.336	0.520
10-20	2	81	0.702	-0.532	0.451	0.603	0.204	0.363
10-20	3	63	0.684	-0.540	0.409	0.580	0.167	0.336
10-20	4	27	0.650	-0.626	0.414	0.663	0.171	0.440
10-20	5	22	0.629	-0.660	0.417	0.654	0.174	0.428
10-20	6	12	0.614	-0.679	0.418	0.638	0.175	0.407
10-20	7	6	0.720	-0.587	0.529	0.816	0.280	0.667
20-25	1	107	0.514	-0.915	0.518	0.639	0.269	0.409
20-25	2	63	0.511	-0.930	0.584	0.603	0.341	0.364
20-25	3	23	0.577	-0.837	0.641	0.659	0.411	0.434
20-25	4	3	1.308	-0.484	1.810	1.479	3.277	2.187
> 25	1	54	0.488	-0.949	0.448	0.626	0.201	0.392
> 25	2	32	0.486	-0.900	0.351	0.595	0.123	0.354
> 25	3	23	0.427	-0.970	0.218	0.506	0.048	0.256
> 25	4	12	0.401	-1.029	0.207	0.509	0.043	0.259
> 25	5	12	0.410	-1.003	0.207	0.507	0.043	0.257
> 25	6	6	0.341	-1.164	0.129	0.510	0.017	0.261
> 25	7	6	0.346	-1.144	0.125	0.494	0.016	0.244

These arguments suggest that, based on the RTP Panel study data, to a reasonable approximation, the distribution of an AER measurement does not depend upon the length of the averaging period for the measurement, although it does depend upon the average temperature. This supports the methodology used in the Cohen, Mallya, and Rosenbaum, 2005, analyses that did not take into account the length of the averaging period.

The above argument suggests that the assumption that daily AER values are statistically independent is not justified. Statistical modeling of the correlation structure between consecutive daily AER values is not easy because of the problem of accounting for temperature effects, since temperatures vary from day to day. In the next section we present some statistical models of the daily AER values from the RTP Panel Study.

Statistical models of AER auto-correlations from the RTP Panel Study

We used the MIXED procedure from SAS to fit several mixed models with fixed effects and random effects to the daily values of AER and log(AER). The fixed effects are the population average values of AER or log(AER), and are assumed to depend upon the temperature range. The random effects have expected values of zero and define the correlations between pairs of measurements from the same Group, where the Groups are defined either using Approach A or Approach B above. As described above, a Group is a period of up to 14 consecutive days of measurements at the same house. For these mixed model analyses we included periods with one or more missing days. For all the statistical models, we assume that AER values in different

Groups are statistically independent, which implies that data from different houses or in different seasons are independent.

The main statistical model for AER was defined as follows:

AER = Mean(Temp Range) + A(Group, Temp Range)
+ B(Group, Day Number) + Error(Group, Day Number)

Mean(Temp Range) is the fixed effects term. There is a different overall mean value for each of the four temperature ranges.

A(Group, Temp Range) is the random effect of temperature. For each Group, four error terms are independently drawn from four different normal distributions, one for each temperature range. These normal distributions all have mean zero, but may have different variances. Because of this term, there is a correlation between AER values measured in the same Group of days for a pair of days in the same temperature range.

B(Group, Day Number) is the repeated effects term. The day number is defined so that the first day of a Group has day number 1, the next calendar day has day number 2, and so on. In some cases AER's were missing for some of the day numbers. B(Group, Day Number) is a normally distributed error term for each AER measurement. The expected value (i.e., the mean) is zero. The variance is V. The covariance between B(Group g, day i) and B(Group h, day j) is zero for days in different Groups g and h, and equals $V \times \exp(d \times |i-j|)$ for days in the same Group. V and d are fitted parameters. This is a first order auto-regressive model. Because of this term, there is a correlation between AER values measured in the same Group of days, and the correlation decreases if the days are further apart.

Finally, Error(Group, Day Number) is the Residual Error term. There is one such error term for every AER measurement, and all these terms are independently drawn from the same normal distribution, with mean 0 and variance W.

We can summarize this rather complicated model as follows. The AER measurements are uncorrelated if they are from different Groups. If they are in the same Group, they have a correlation that decreases with the day difference, and they have an additional correlation if they are in the same temperature range.

Probably the most interesting parameter for these models is the parameter d, which defines the strength of the auto-correlation between pairs of days. This parameter d lies between -1 (perfect negative correlation) and +1 (perfect positive correlation) although values exactly equal to +1 or -1 are impossible for a stationary model. Negative values of d would be unusual since they would imply a tendency for a high AER day to be followed by a low AER day, and vice versa. The case d=0 is for no auto-correlation.

Table E-3 gives the fitted values of d for various versions of the model. The variants considered were:

- model AER or log(AER)
- include or exclude the term A(Group, Temp Range) (the "random" statement in the SAS code)

- use Approach A or Approach B to define the Groups

Since Approach B forces the temperature ranges to be the same for very day in a Group, the random temperature effect term is difficult to distinguish from the other terms. Therefore this term was not fitted using Approach B.

Table E-3. Autoregressive parameter d for various statistical models for the RTP Panel Study AERs.

Dependent variable	Include A(Group, Temp Range)?	Approach	d
AER	Yes	A	0.80
AER	No	A	0.82
AER	No	B	0.80
Log(AER)	Yes	A	0.87
Log(AER)	No	A	0.87
Log(AER)	No	B	0.85

In all cases, the parameter d is 0.8 or above, showing the very strong correlations between AER measurements on consecutive or almost consecutive days.

Impact of accounting for daily average AER auto-correlation

In the current version of the APEX model, there are several options for stratification of time periods with respect to AER distributions, and for when to re-sample from a distribution for a given stratum. The options selected for this current set of simulations resulted in a uniform AER for each 24-hour period and re-sampling of the 24-hour AER for each simulated day. This re-sampling for each simulated day implies that the simulated AERs on consecutive days in the same microenvironment are statistically independent. Although we have not identified sufficient data to test the assumption of uniform AERs throughout a 24-hour period, the analyses described in this memorandum suggest that AERs on consecutive days are highly correlated.

Therefore, in order to determine if bias was introduced into the APEX estimates with respect to either the magnitudes or variability of exposure concentrations by implicitly assuming uncorrelated air exchange rates, we re-ran the 2002 base case simulations using the option to not re-sample the AERs. For this option APEX selects a single AER for each microenvironment/stratum combination and uses it throughout the simulation.

The comparison of the two scenarios indicates little difference in APEX predictions, probably because the AERs pertain only to indoor microenvironments and for the base cases most exposure to elevated concentrations occurs in the “other outdoors” microenvironment. Figures E-1 and E-2 below present the comparison for exceedances of 8-hour average concentration during moderate exertion for active person in Boston and Houston, respectively.

Figure E-1

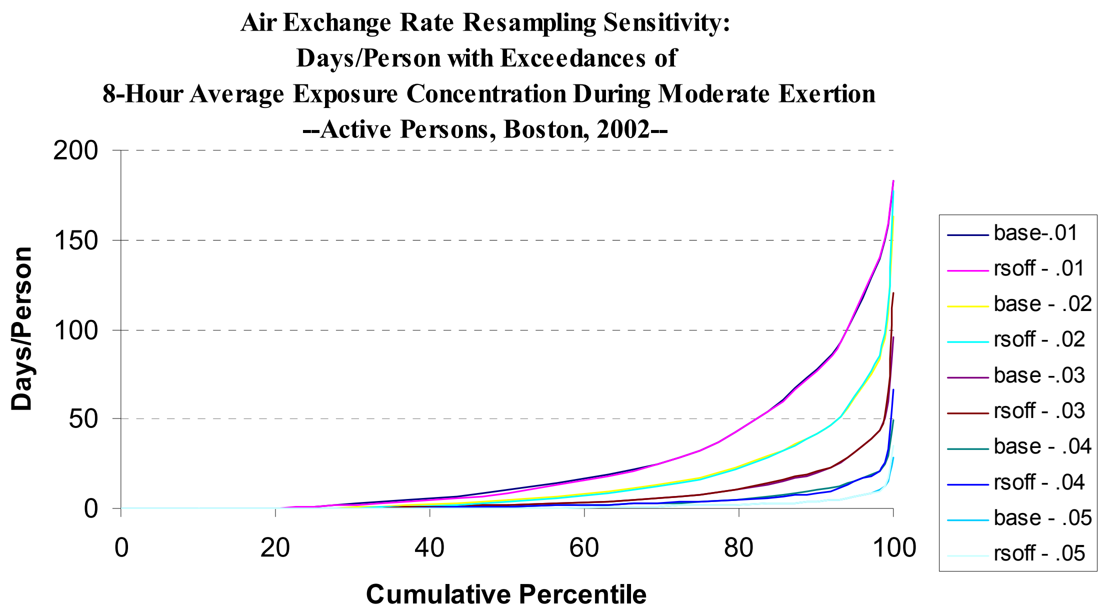
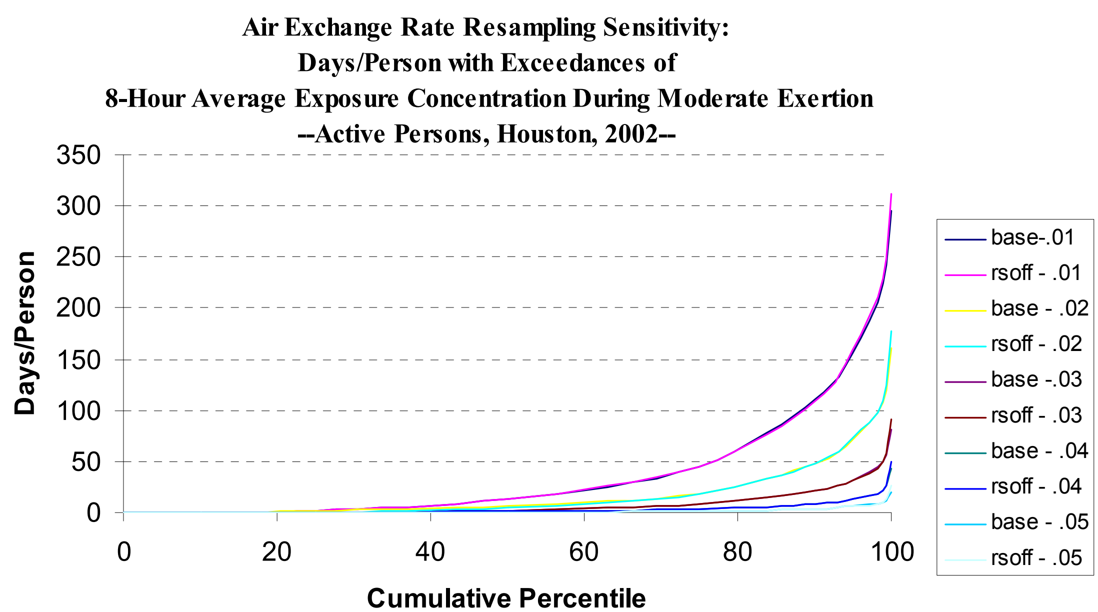

Air Exchange Rate Resampling Sensitivity:
Days/Person with Exceedances of
8-Hour Average Exposure Concentration During Moderate Exertion
--Active Persons, Boston, 2002--
Days/Person
200
150
100
50
0
0
20
40
60
80
100
Cumulative Percentile
base-.01
rsoff - .01
base - .02
rsoff - .02
base -.03
rsoff - .03
base - .04
rsoff - .04
base - .05
rsoff - .05

Figure E-2


Air Exchange Rate Resampling Sensitivity:
Days/Person with Exceedances of
8-Hour Average Exposure Concentration During Moderate Exertion
--Active Persons, Houston, 2002--
Days/Person
350
300
250
200
150
100
50
0
0
20
40
60
80
100
Cumulative Percentile
base-.01
rsoff - .01
base - .02
rsoff - .02
base -.03
rsoff - .03
base - .04
rsoff - .04
base - .05
rsoff - .05

Appendix C

Nitrogen Dioxide Health Risk Assessment for Atlanta, GA

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Prepared for
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Research Triangle Park, NC

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Nitrogen Dioxide Health Risk Assessment for Atlanta, GA

1 INTRODUCTION

The U.S. Environmental Protection Agency (EPA) is presently conducting a review of the national ambient air quality standards (NAAQS) for nitrogen dioxide (NO_2). Sections 108 and 109 of the Clean Air Act (Act) govern the establishment and periodic review of the NAAQS. These standards are established for pollutants that may reasonably be anticipated to endanger public health and welfare, and whose presence in the ambient air results from numerous or diverse mobile or stationary sources. The NAAQS are to be based on air quality criteria, which are to accurately reflect the latest scientific knowledge useful in indicating the kind and extent of identifiable effects on public health or welfare that may be expected from the presence of the pollutant in ambient air. The EPA Administrator is to promulgate and periodically review, at five-year intervals, "primary" (health-based) and "secondary" (welfare-based) NAAQS for such pollutants.[1] Based on periodic reviews of the air quality criteria and standards, the Administrator is to make revisions in the criteria and standards, and promulgate any new standards, as may be appropriate. The Act also requires that an independent scientific review committee advise the Administrator as part of this NAAQS review process, a function performed by the Clean Air Scientific Advisory Committee (CASAC).

EPA's plan and schedule for this NO_2 NAAQS review is presented in the "Integrated Review Plan for the Primary National Ambient Air Quality Standard for Nitrogen Dioxide" (U.S. EPA, 2007a). The plan discusses the preparation of two key components in the NAAQS review process: an Integrated Science Assessment (ISA) and risk/exposure assessments. The ISA critically evaluates and integrates scientific information on the health effects associated with exposure to oxides of nitrogen (NOx) in the ambient air. The risk/exposure assessments develop qualitative characterization and quantitative estimates, where judged appropriate, of human exposure and health risk and related variability and uncertainties, drawing upon the information summarized in the ISA.

In early March 2008, EPA's National Center for Environmental Assessment released a second draft of the "Integrated Science Assessment for Oxides of Nitrogen – Health Criteria (Second External Review Draft)," henceforth referred to as the draft ISA (U.S. EPA, 2008a). EPA's Office of Air Quality Planning and Standards (OAQPS) in early April released a first draft of its "Risk and Exposure Assessment to Support the Review of the NO_2 Primary National Ambient Air Quality Standard," henceforth referred to as the 1st draft REA (U.S. EPA, 2008b). Both of these documents were reviewed by the CASAC NO_2 Panel on May 1-2, 2008.

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[1]Section 109(b)(1) [42 U.S.C. 7409] of the Act defines a primary standard as one "the attainment and maintenance of which in the judgment of the Administrator, based on such criteria and allowing an adequate margin of safety, are requisite to protect the public health."

As a result of the May 2008 CASAC NO_2 Panel review and in response to advice offered by the CASAC Panel, OAQPS decided to expand the health risk assessment to include a quantitative assessment of respiratory-related emergency department (ED) visits estimated to be associated with exposures to NO_2 for the Atlanta metropolitan statistical area (MSA).

NO_2 is one of a group of substances known as nitrogen oxides (NO_x), which include multiple gaseous (e.g., NO_2, NO) and particulate (e.g., nitrate) species. As in past NAAQS reviews, NO_2 is considered as the surrogate for the gaseous NO_x species for the purpose of this assessment, with particulate species addressed as part of the particulate matter (PM) NAAQS review.

Previous reviews of the NO_2 primary NAAQS completed in 1985 and 1994 did not include quantitative health risk assessments. Thus, the risk assessment described in this document builds upon the methodology and lessons learned from the risk assessment work conducted for the recently concluded PM and O_3 NAAQS reviews (Abt Associates, 2005; Abt Associates, 2007a). Many of the same methodological issues are present for each of these criteria air pollutants where epidemiological studies provided the basis for the concentration-response (C-R) relationships used in the quantitative risk assessment.

In July 2008, EPA issued the final ISA, "Integrated Science Assessment for Oxides of Nitrogen – Health Criteria (Final Report), henceforth referred to as the final ISA (U.S. EPA, 2008c). The risk assessment described in this document is also based on the information and evaluation contained in the final ISA. In August 2008, EPA is releasing its 2^{nd} draft REA, henceforth referred to as the draft REA (U.S. EPA, 2008d).

The NO_2 health risk assessment described in this document estimates the incidence of respiratory-related ED visits associated with short-term exposures to NO_2 under recent ("as is") air quality levels and upon just meeting the current NO_2 standard of 0.053 ppm annual average and several alternative NO_2 primary NAAQS in the Atlanta MSA.[2] The alternative standards considered are daily maximum 1-hour standards, with levels of 0.05, 0.10, 0.15, and 0.20 ppm, using a 98^{th} percentile form and also using a 99th percentile form, using a three-year period.[3] The risk assessment is intended as a tool that, together with other information on this health endpoint and other health effects evaluated in the final ISA, can aid the Administrator in judging whether the current primary standard protects public health with an adequate margin of safety, or whether revisions to the standard are appropriate.

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[2] The current NO_2 standard refers to a two-year period and requires that the annual average NO_2 level be less than or equal to 0.053 ppm in each of the two years.

[3] For the alternative standards using, say, the 98^{th} percentile form, the standard is met when the average of the three annual 98^{th} percentile daily maximum 1-hr concentrations for the 3-year period is at or below the specified standard level.

Preliminary considerations and the basic structure of the risk assessment are described in section 2. Section 3 describes the methods used, and section 4 presents the results of the risk assessment.

2 PRELIMINARY CONSIDERATIONS

The health risk assessment described in this document estimates the incidence of respiratory-related ED visits associated with NO_2 exposures for recent ("as is") NO_2 levels, based on 2005, 2006, and 2007 air quality data, as well as the risks associated with just meeting the current standard and the reduced risks associated with just meeting each of several alternative NO_2 NAAQS.[4] In this section we address preliminary considerations. Section 2.1 briefly discusses the broad empirical basis for a relationship between NO_2 exposures and adverse health effects. Section 2.2 describes the basic structure of the risk assessment. Finally, section 2.3 addresses air quality considerations.

2.1 The Broad Empirical Basis for a Relationship Between NO_2 and Adverse Health Effects

The final ISA concludes that there is a broad empirical basis supporting the inference of a likely causal relationship between short-term NO_2 exposure and respiratory effects:

> Taken together, the findings of epidemiologic, human clinical, and animal toxicological studies provided evidence that is sufficient to infer a likely causal relationship for respiratory effects with short-term NO_2 exposure. The body of evidence from epidemiologic studies has grown substantially since the 1993 AQCD and provided scientific evidence that short-term exposure to NO_2 is associated with a broad range of respiratory morbidity effects, including altered lung host defense, inflammation, airway hyperresponsiveness, respiratory symptoms, lung function decrements, and ED visits and hospital admissions for respiratory diseases (final ISA, section 3.1.7, p. 3-41).

2.2 Basic Structure of the Risk Assessment

The general approach used in this risk assessment, as in the risk assessment that was part of the recent PM NAAQS review, relies upon C-R functions that have been estimated in epidemiological studies. Since these studies estimate C-R functions using ambient air quality data from fixed-site, population-oriented monitors, the appropriate application of these functions in a NO_2 risk assessment similarly requires the use of ambient air quality data at fixed-site, population-oriented monitors. The NO_2 health risk model combines information about NO_2 air quality for a specific urban area with C-R functions derived from an epidemiological study and baseline health incidence data for a specific health endpoint to derive estimates of the annual incidence of the specified health effect attributable to ambient NO_2 concentrations. The analyses have been conducted for both "as is" air quality and for air quality simulated to reflect attainment of the current and alternative NO_2 ambient standards.

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[4] The current NO_2 standard is met in all locations in the United States. The risks associated with just meeting the current standard are therefore *greater* than the risks associated with "as is" NO_2 concentrations, which are *lower* than NO_2 concentrations simulated to just meet the current standard.

As described more fully below, a risk assessment based on epidemiological studies requires baseline incidence data or baseline incidence rates and population data for the risk assessment locations.

The characteristics that are relevant to carrying out a risk assessment based on epidemiology studies can be summarized as follows:

- A risk assessment based on epidemiology studies uses C-R functions, and therefore requires as input (monitored) ambient NO_2 concentrations.

- Epidemiological studies are carried out in specific real world locations (e.g., specific urban areas). A risk assessment focused on locations in which the epidemiologic studies providing the C-R functions were carried out will minimize uncertainties.

- A risk assessment based on epidemiological studies requires baseline incidences or baseline incidence rates and population data for the risk assessment locations.

The methods for the NO_2 risk assessment are discussed in section 3 below. The risk assessment was implemented within a new probabilistic version of TRIM.Risk, the component of EPA's Total Risk Integrated Methodology (TRIM) model that estimates human health risks.[5]

2.3 Air Quality Considerations

The risk assessment includes risk estimates for three recent years of air quality ("as is" air quality) and for air quality adjusted so that it simulates just meeting the current or alternative NO_2 standards based on that recent three-year period (2005-2007). This period was selected to represent the most recent air quality for which complete data were available.

In order to estimate health risks associated with just meeting the current and alternative NO_2 standards, it is necessary to estimate the distribution of hourly NO_2 concentrations that would occur under any given standard. Since all locations in the United States are in attainment of the current NO_2 standard, and since compliance with the current NO_2 standard is based on examining a 2-year period, air quality data from 2006 to 2007 were used to determine the amount of *increase* in NO_2 concentrations that would occur if the current standard were just met in the risk assessment location. Estimated design values were used to determine the (upward) adjustment necessary to just meet the current NO_2 standard. The adjustment was then applied to each year of data (2006 and 2007) to estimate risks in each of these individual years. For alternative 1-hour daily maximum standards, staff specified the form as being the 3-year average of the 98th (or 99th) percentile of the daily maximum 1-hour concentrations. Thus, the three-year period including 2005 to 2007 was used for analyses involving alternative 1-hour standards. Estimated design values were used to determine the

[5] TRIM.Risk was most recently applied to EPA's O_3 health risk assessment. A User's Guide for the Application of TRIM.Risk to the O_3 health risk assessment (Abt Associates, 2007b) is available online at: http://epa.gov/ttn/fera/data/trim/trimrisk_ozone_ra_userguide_8-6-07.pdf.

upward (or downward) adjustments necessary to just meet alternative NO_2 standards, and the adjustments were then applied to each year of data to estimate risks in each of these individual years.

As described in section 6.2.1 of the draft REA, EPA concluded that the proportional (linear) air quality adjustment procedure adequately represented the pattern of reductions across the NO_2 air quality distribution observed over recent years. The proportional air quality adjustment procedure was applied in the Atlanta MSA to the filled in 2006 and 2007 NO_2 monitoring data, based on the 2-year period (2006-2007) NO_2 design value for the current standard, to generate new time series of hourly NO_2 concentrations for 2006 and 2007 that simulate air quality levels that just meet the current NO_2 standard of 0.053 ppm annual average. Because every location across the U.S. meets the current NO_2 standard (see U.S. EPA, 2007b, Figure 1), simulation of just meeting the current standard required rolling *up* air quality.

The proportional air quality adjustment procedure was similarly applied in the Atlanta MSA to the filled in 2005, 2006, and 2007 NO_2 monitoring data, based on the 3-year period (2005-2007) NO_2 design values for the alternative 1-hour standards, to generate new time series of hourly NO_2 concentrations for 2005, 2006, and 2007 that simulate air quality levels that just meet each of the alternative NO_2 standards considered in the risk assessment over this three year period.

Because compliance with the alternative 1-hour daily maximum standards is based on the 3-year average of the values for the chosen metric, the air quality distribution in each of the 3 years can and generally does vary. As a result, the risk estimates associated with air quality just meeting a standard also will vary depending on the year chosen for the analysis. The risk assessment for the alternative 1-hour standards includes risk estimates involving adjustment of 2005, 2006, and 2007 air quality data to illustrate the magnitude of this year-to-year variability in the estimates.

The risk estimates developed for the recently concluded PM and O_3 NAAQS reviews represented risks associated with PM and O_3 levels in excess of estimated policy-relevant background (PRB) levels in the U.S. PRB levels of NO_2 are defined as the distribution of NO_2 concentrations that would be observed in the U.S. in the absence of anthropogenic (man-made) emissions of NO_2 precursors in the U.S., Canada, and Mexico. Estimates of NO_2 PRB are reported in section 2.4.6 of the final ISA, and for most of the continental U.S. the PRB is estimated to be less than 300 parts per trillion (ppt). In the Northeastern U.S., where present-day NO_2 concentrations are highest, this amounts to a contribution of about 1% percent of the total observed ambient NO_2 concentration (final ISA, p. 2-28). Since this is well below concentrations that might be considered to cause a potential health effect, there was no adjustment made for risks associated with PRB concentrations in the current NO_2 health risk assessment.

3 METHODS

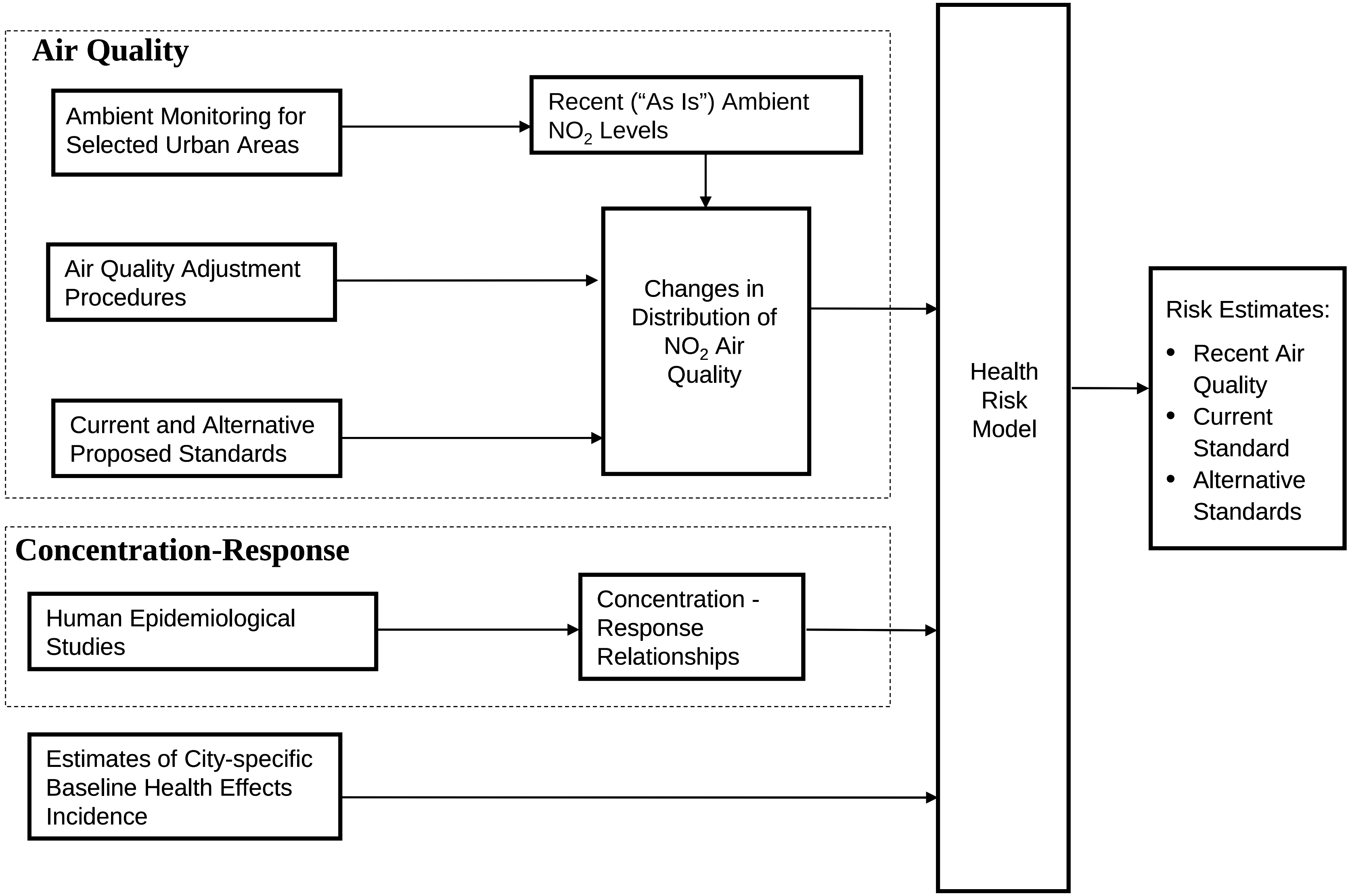
The major components of the NO_2 health risk assessment are illustrated in Figure 3-1. The air quality component that is integral to the health risk assessment is discussed in chapters 2 and 6 of the draft REA. As described in the final ISA and the draft REA, recent studies, when taken together, provide scientific evidence that NO_2 is associated with a range of respiratory effects. The evidence is judged to be sufficient to infer a likely causal relationship between short-term NO_2 exposure and adverse effects on the respiratory system. This finding is supported by a large body of epidemiologic evidence, in combination with findings from human and animal experimental studies (final ISA, sections 3.1.6 and 3.1.7).

3.1 General approach

As in the PM risk assessment (Abt Associates, 2005) and part of the recently completed O_3 risk assessment (Abt Associates, 2007a), the general approach used in the NO_2 risk assessment relies upon C-R functions which have been estimated in epidemiological studies. Since these studies estimate C-R functions using ambient air quality data from fixed-site, population-oriented monitors, the appropriate application of these functions in a risk assessment similarly requires the use of ambient air quality data at fixed-site, ambient monitors. The NO_2 health risk model combines information about NO_2 air quality for a specific urban area with C-R functions derived from epidemiological studies and baseline incidence data for a specific health endpoint to derive estimates of the incidence of the health endpoint attributable to ambient NO_2 concentrations during the period examined.

In the first part of the risk assessment, we estimate health effects incidence associated with “as is” NO_2 levels. In the second part, we estimate the (increased) health effects incidence associated with NO_2 concentrations simulated to just meet the current NO_2 annual standard and the health effects incidence associated with NO_2 concentrations simulated to just meet alternative 1-hour daily maximum NO_2 standards in the assessment location. In both parts, we consider the incidence of health effects associated with NO_2 concentrations in excess of 0 ppm (as opposed to in excess of PRB, as explained in section 2.3).

Figure 3-1. Major Components of NO_2 Health Risk Assessment Based on Epidemiology Studies



Both parts of the risk assessment may be viewed as assessing the change in incidence of the health effect associated with a change in NO_2 concentrations from some upper levels to specified (lower) levels – in the NO_2 risk assessment, the lower level is 0 ppm in both cases. The important operational difference between the two parts is in the upper NO_2 levels. In the first part, the upper NO_2 levels are "as is" concentrations. In contrast, the upper NO_2 levels in the second part are the estimated NO_2 levels that would occur when the current NO_2 standard of 0.053 ppm annual average is just met in the assessment location or when one of several alternative 1-hour daily maximum NO_2 standards is just met in this location. The second part therefore requires that a method be developed to simulate just meeting the current or alternative standards. This method is described in chapter 6 of the draft REA.

To estimate the incidence of a given health effect associated with "as is" ambient NO_2 concentrations or NO_2 concentrations that just meet the current or an alternative standard in an assessment location, the following analysis inputs are necessary:

- **Air quality information** including: (1) "as is" air quality data for NO_2 from ambient monitors in the assessment location, and (2) "as is" concentrations adjusted to simulate just meeting the specified standard. (These air quality inputs are discussed in more detail in chapter 2 of this report and in chapter 6 of the draft REA.)

- **Concentration-response function(s),** which provide an estimate of the relationship between the health endpoint of interest and NO_2 concentrations.

- **Baseline health effects incidence**. The baseline incidence of the health effect in the assessment location in the target year is the incidence corresponding to "as is" NO_2 levels in that location in that year. The baseline incidence can be calculated as the product of the incidence rate (e.g., number of cases per 10,000 population) and the affected population (divided by 10,000, if the rate is per 10,000 population). Alternatively, if an estimate of the incidence in the location of interest is available, that can be used instead.

These inputs are combined to estimate health effect incidence changes associated with specified changes in NO_2 levels. Although some epidemiological studies have estimated linear or logistic C-R functions, by far the most common form (and the form used in the models selected for the NO_2 risk assessment) is the exponential (or log-linear) form:

$$y = Be^{\beta x}, \qquad (3\text{-}1)$$

where x is the ambient NO_2 level, y is the incidence of the health endpoint of interest at NO_2 level x, β is the coefficient of ambient NO_2 concentration (describing the extent of change in y with a unit change in x), and B is the incidence at x=0, i.e., when there is no ambient NO_2. The relationship between a specified ambient NO_2 level, x_0, for example, and the incidence of a given health endpoint associated with that level (denoted as y_0) is then

$$y_0 = Be^{\beta x_0}. \qquad (3\text{-}2)$$

Because the log-linear form of C-R function (equation (3-1)) is by far the most common form, we use this form to illustrate the "health impact function" used in the risk assessment.

If we let x_0 denote the baseline (upper) NO_2 level, and x_1 denote the lower NO_2 level, and y_0 and y_1 denote the corresponding incidences of the health effect, we can derive the following relationship between the change in x, $\Delta x = (x_0 - x_1)$, and the corresponding change in y, Δy, from equation (3-1)[6]:

$$\Delta y = (y_0 - y_1) = y_0[1 - e^{-\beta \Delta x}]. \qquad (3\text{-}3)$$

Alternatively, the difference in health effects incidence can be calculated indirectly using relative risk. Relative risk (RR) is a measure commonly used by epidemiologists to characterize the comparative health effects associated with a particular air quality comparison. The risk of ED visits for respiratory illness at ambient NO_2 level x_0 relative to the risk of ED visits for respiratory illness at ambient NO_2 level x_1, for example, may be characterized by the ratio of the two rates: the rate of ED visits for respiratory illness among individuals when the ambient NO_2 level is x_0 and the rate of ED visits for respiratory illness among (otherwise identical) individuals when the ambient NO_2 level is x_1. This is the RR for ED visits for respiratory illness associated with the difference between the two ambient NO_2 levels, x_0 and x_1. Given a C-R function of the form shown in equation (3-1) and a particular difference in ambient NO_2 levels, Δx, the RR associated with that difference in ambient NO_2, denoted as $RR_{\Delta x}$, is equal to $e^{\beta \Delta x}$. The difference in health effects incidence, Δy, corresponding to a given difference in ambient NO_2 levels, Δx, can then be calculated based on this $RR_{\Delta x}$ as

$$\Delta y = (y_0 - y_1) = y_0[1 - (1/RR_{\Delta x})]. \qquad (3\text{-}4)$$

Equations (3-3) and (3-4) are simply alternative ways of expressing the relationship between a given difference in ambient NO_2 levels, $\Delta x > 0$, and the corresponding difference in health effects incidence, Δy. These health impact equations are the key equations that combine air quality information, C-R function information, and baseline health effects incidence information to estimate health risks related to changes in ambient NO_2 concentrations.

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6 If $\Delta x < 0$ – i.e., if $\Delta x = (x_1 - x_0)$ – then the relationship between Δx and Δy can be shown to be $\Delta y = (y_1 - y_0) = y_0[e^{\beta \Delta x} - 1]$. If $\Delta x < 0$, Δy will similarly be negative. However, the *magnitude* of Δy will be the same whether $\Delta x > 0$ or $\Delta x < 0$ – i.e., the absolute value of Δy does not depend on which equation is used.

3.2 Selection of health endpoint(s)

As discussed in section 3.1.6 of the final ISA, many studies have observed positive associations between ambient NO_2 concentrations and ED visits and hospitalizations for all respiratory diseases and asthma, and these associations appear to be generally robust and independent of the effects of ambient particles or gaseous co-pollutants. Noting that exposure to NO_2 has been found to result in host defense and immune system changes, airway inflammation, and airway responsiveness, the final ISA concludes that “while not providing specific mechanistic data linking exposure to ambient NO_2 and respiratory hospitalization or ED visits for asthma, these findings provide plausibility and coherence for such a relationship” (section 3.1.6.5, p. 3-41).

In summarizing the evidence for a relationship between short-term exposure to NO_2 and respiratory health effects, the final ISA notes that “the body of evidence from epidemiologic studies has grown substantially since the 1993 AQCD and provided scientific evidence that short-term exposure to NO_2 is associated with a broad range of respiratory morbidity effects, including altered lung host defense, inflammation, airway hyperresponsiveness, respiratory symptoms, lung function decrements, and ED visits and hospital admissions for respiratory diseases” (section 3.1.7, p. 3-41). For this risk assessment, we are focusing on respiratory ED visits.

3.3 Selection of urban area(s) and epidemiological studies

Several objectives were considered in selecting potential urban areas for which to conduct the risk assessment. An urban area was considered if:

- it had sufficient air quality data for the 3-year period under consideration;
- it was a location where at least one C-R function for the selected health endpoint had been estimated by a study that satisfied the study selection criteria; and
- it had available relatively recent location-specific baseline incidence data, specific to International Classification of Disease (ICD) codes, or an equivalent illness classification system.

C-R functions for respiratory ED visits have been estimated in two urban areas in the United States – Atlanta and New York City. The selection of an urban area to include in the risk assessment depends in part on the decision of which epidemiological studies to use. An epidemiological study was considered if:

- it was a published, peer-reviewed study that had been evaluated in the final ISA for the pollutant of interest and judged adequate by EPA staff for purposes of inclusion in the risk assessment based on that evaluation;

- it directly measured, rather than estimated, the pollutant of interest on a reasonable proportion of the days in the study; and

- it either did not rely on Generalized Additive Models (GAMs) using the S-Plus software to estimate C-R functions or it appropriately re-estimated these functions using revised methods.[7]

- it preferably included both single- and multi-pollutant models.

Six U.S. studies focused on ED visits and/or hospital admissions. Three of these (Peel et al., 2005 and Tolbert et al., 2007 in Atlanta; Ito et al., 2007 in New York City) evaluated associations with NO_2 using multi-pollutant models as well as single-pollutant models. Tolbert et al. (2007), which updated Peel et al. (2005), evaluated ED visits among all ages in Atlanta, GA during the period of 1993 to 2004. Using single pollutant models, the authors reported a 2% (95% CI: 1%, 2.9%) increase in respiratory ED visits associated with a 23-ppb increase in 1-h maximum NO_2 levels. In a two-pollutant model with CO, NO_2 was positive and still statistically significant (RR = 1.017, 95% CI =1.006, 1.029). In two-pollutant models with PM_{10} and O_3, and in a three-pollutant model with both PM_{10} and O_3, NO_2 was still positively associated with respiratory ED visits albeit no longer statistically significant (RR = 1.007, 95% CI = 0.996, 1.018 in the model with PM_{10}; RR = 1.010, 95% CI = 0.999, 1.020 in the model with O_3; and RR = 1.004, 95% CI = 0.992, 1.015 in the model with both PM_{10} and O_3) (Tolbert, 2008a).

The Atlanta study (Peel et al., 2005 and Tolbert et al., 2007) spanned 12 years, and collected NO_2 monitor data on 4,351 out of a possible 4,384 days – over 99 percent of the days. It satisfies all of the criteria listed above for study selection.

In the study by Ito and colleagues, investigators evaluated ED visits for asthma in New York City during the years 1999 to 2002. The authors found a 12 % (95% CI: 7%, 15%) increase in risk per 20 ppb increase in 24-hour ambient NO_2. Risk estimates were robust and remained statistically significant in multi-pollutant models that included $PM_{2.5}$, O_3, CO, and SO_2.

Due to time and resource constraints, EPA staff selected the Atlanta area and the study by Tolbert et al. to conduct a focused risk assessment for ED visits. Considerations that influenced this choice were the longer time period and more comprehensive coverage of emergency departments in the Tolbert et al. study, the ready availability of baseline incidence data from the authors of this study, and the EPA staff's objective of conducting the risk assessment for the same urban area selected for the population exposure analysis.

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[7] The GAM S-Plus problem was discovered prior to the recent final PM risk assessment carried out as part of the PM NAAQS review. It is discussed in the PM Criteria Document (EPA, 2004), PM Staff Paper (EPA, 2005), and PM Health Risk Assessment Technical Support Document (Abt Associates, 2005).

3.4 Selection of concentration-response functions

Studies often report more than one estimated C-R function for the same location and health endpoint. Sometimes models including different sets of co-pollutants are estimated in a study; sometimes different lags are estimated.

Tolbert et al. (2007) estimated C-R functions in which NO_2 was the only pollutant entered into the health effects model (i.e., single pollutant models) as well as other C-R functions in which NO_2 and one or two co-pollutants (PM_{10}, O_3, CO) were entered into the health effects model (i.e., multi-pollutant models). To the extent that any of the co-pollutants present in the ambient air may have contributed to the health effects attributed to NO_2 in single pollutant models, risks attributed to NO_2 might be overestimated where C-R functions are based on single pollutant models. However, if co-pollutants are highly correlated with NO_2, their inclusion in an NO_2 health effects model can lead to misleading conclusions in identifying a specific causal pollutant. When collinearity exists, inclusion of multiple pollutants in models often produces unstable and statistically insignificant effect estimates for both NO_2 and the co-pollutants. Given that single and multi-pollutant models each have both potential advantages and disadvantages, with neither type clearly preferable over the other in all cases, we report risk estimates based on both single- and multi-pollutant models.

All of the models in Tolbert et al. (2007) used a 3-day moving average of pollution levels (i.e., the average of 0-, 1-, and 2-day lags), so the issue of which of several different lag structures to select does not arise. The issue of how well a given lag structure captures the actual relationship between the pollutant and the health effect, however, is still relevant. Models in which the pollutant-related incidence on a given day depends only on same-day or previous-day pollutant concentration (or some variant of those, such as a two- or three-day average concentration) necessarily assume that the longer pattern of pollutant levels preceding the pollutant concentration on a given day does not affect incidence of the health effect on that day. To the extent that a pollutant - related health effect on a given day is affected by pollutant concentrations over a longer period of time, then these models would be mis-specified, and this mis-specification would affect the predictions of daily incidence based on the model. The extent to which short-term NO_2 exposure studies may not capture the possible impact of long-term exposures to NO_2 is not known. A number of epidemiologic studies have examined the effects of long-term exposure to NO_2 and observed associations with decrements in lung function and partially irreversible decrements in lung function growth. The final ISA concludes, however, that "overall, the epidemiological evidence was suggestive but not sufficient to infer a causal relationship between long-term NO_2 exposure and respiratory morbidity" (section 3.4). Currently, there is insufficient information to adequately adjust for the potential impact of longer-term exposure on respiratory ED visits associated with NO_2 exposures, if any, and this uncertainty should be kept in mind as one considers the results from the short-term exposure NO_2 risk assessment.

3.5 Air quality considerations

Air quality considerations are discussed briefly in section 2 of this document and in chapter 6 of the draft REA. Here we describe those air quality considerations that are directly relevant to the estimation of health risks in the NO_2 risk assessment.

In the first part of the risk assessment, we estimate the incidence of the health effect associated with "as is" levels of NO_2 (or equivalently, the change in health effect incidence, Δy, associated with a change in NO_2 concentrations from "as is" levels of NO_2 to 0 ppm). In the second part, we estimate the incidence of the health effect associated with NO_2 concentrations simulated to just meet a standard (i.e., the current NO_2 standard of 0.053 ppm annual average as well as each of several alternative 1-hour daily maximum standards).

To estimate the incidence of a health effect associated with "as is" NO_2 levels in a location, we need a time series of hourly "as is" NO_2 concentrations for that location. We use monitor data from the Georgia Tech monitor (monitor id =131210048), the monitor that was used in Tolbert et al. (2007), the epidemiology study from which we obtained C-R functions (see section 3.3 above).

For the Georgia Tech monitor site, complete hourly data were available on over 93 percent of the days – 348 days in 2005, 345 days in 2006, and 340 days in 2007. Missing air quality data were estimated by the following procedure. Where there were consecutive strings of missing values (data gaps of less than 6 hours), missing values were estimated by linear interpolation between the valid values at the ends of the gap. Remaining missing values at a monitor were estimated by fitting linear regression models for each hour of the day, with each of the other monitors, and choosing the model which maximizes R^2 for each hour of the day, subject to the constraints that R^2 be greater than 0.5 and the number of regression data values is at least 50. If there were any remaining missing values at this point, for gaps of less than 9 hours, missing values were estimated by linear interpolation between the valid values at the ends of the gap. Any remaining missing values were replaced with the regional mean for that hour. The annual mean, and the 98^{th} and 99^{th} percentiles of daily 1-hr maximum concentrations are shown in Table 3-1, separately for 2005, 2006, and 2007.

Table 3-1. Mean and 98^{th} and 99^{th} Percentiles of the Distributions of 1-Hour Daily Maximum NO_2 Concentrations (in ppm) at the Georgia Tech Monitor: 2005, 2006, and 2007

Year	Mean	98^{th} Percentile	99^{th} Percentile
2005	0.0351	0.0764	0.0794
2006	0.0364	0.0660	0.0694
2007	0.0327	0.0684	0.0780

Because Tolbert et al. (2007) estimated a relationship between daily respiratory-related ED visits and the 3-day moving average (i.e., NO_2 levels on the same day, the previous day, and the day before that) of daily 1-hour maximum NO_2 concentrations, we calculated daily 1-hour maximum NO_2 concentrations at the monitor. Because our lower bound NO_2 concentration is 0 ppm in all cases, for each day Δx in equation (3-3) equals the 3-day moving average of the 1-hour maximum "as is" NO_2 concentration for that day at the Georgia Tech monitor.

The calculations for the second part of the risk assessment, in which we estimated risks associated with NO_2 levels simulated to just meet the current and alternative standards were done analogously, using the monitor-specific series of adjusted hourly concentrations rather than the monitor-specific series of "as is" hourly concentrations.

3.6 Baseline health effects incidence

The most common epidemiologically-based health risk model expresses the reduction in health risk (Δy) associated with a given reduction in NO_2 concentrations (Δx) as a percentage of the baseline incidence (y). To accurately assess the impact of changes in NO_2 air quality on health risk in the selected urban area, information on the baseline incidence of the health effect (i.e., the incidence under "as is" air quality conditions) in the selected location is therefore needed.

We obtained an estimate of the baseline incidence of respiratory ED visits in Atlanta, GA (Tolbert, 2008a). The study notes that there are 42 hospitals with EDs in the 20-county Atlanta MSA. Of these, 41 were able to provide incidence data for at least part of the study period (1993 – 2004). For purposes of the NO_2 risk assessment, we need incidences for the years of the risk assessment (2005 – 2007). Assuming that baseline incidence of respiratory ED visits does not change appreciably in the span of a few years, we used the incidence of respiratory ED visits for the most recent year in the Tolbert study, 2004 – 121,818 respiratory ED visits (Tolbert, 2008a).[8]

There were 38 hospitals operating in the Atlanta MSA in 2004, of which 37 reported data. The study authors estimate that the missing respiratory ED visits, from the single hospital that declined to report data, account for only 2.3 percent of the total number for 2004, so that the 2004 baseline incidence (121,818) includes an estimated 97.7 percent of the respiratory ED visits in Atlanta that year (Tolbert, 2008b). Thus, although the understatement of baseline incidence will result in a downward bias in our estimates of NO_2-related risk, that bias will be very small.

[8] To check on the variability of respiratory ED visits across the years, the study authors provided a table of ED visits, including respiratory ED visits in particular, for years 2002-2004 among the 33 hospitals that contributed data each year. The average annual number of respiratory ED visits in those 33 hospitals during the three-year period (2002 – 2004) was 124,979. The number for those 33 hospitals in 2004 was 114,475, or about 92 percent of the 3-year average (Tolbert, 2008b).

The specific definition of "respiratory-related" ED visits used in Tolbert et al. (2007) included ED visits with the following respiratory illnesses as the primary diagnosis (specified by ICD-9 diagnostic codes): asthma (493, 786.07, and 786.09), COPD (491, 492, and 496), upper respiratory illness (460 – 465, 460.0, and 477), pneumonia (480 – 486), and bronchiolitis (466.1, 466.11, and 466.19). The baseline incidence given above – 121,818 – is thus a count of all ED visits with one of these ICD-9 codes as the primary diagnosis at the 36 hospitals in the Atlanta MSA that contributed 2004 baseline incidence data to the Tolbert study.

3.7 Summary of determinants of the NO_2 risk assessment

The determinants of the NO_2 risk assessment can be summarized as follows:

- Health endpoint: respiratory ED visits among all ages
- Assessment location: Atlanta MSA
- Epidemiological study: Tolbert et al. (2007)
- C-R functions:
    - a single-pollutant C-R function,
    - two-pollutant C-R functions (with CO, PM_{10}, and O_3), and
    - a three-pollutant C-R function (with both PM_{10} and O_3).

  In all C-R functions the count of ED visits on a given day is related to a 3-day moving average of NO_2 1-hour maxima (i.e., NO_2 1-hour maxima on the same day, the previous day, and the day before that).
- Air quality data: 1-hour maximum "as is" NO_2 concentration for each day calculated from hourly air quality data at the Georgia Tech monitor (site id =131210048), the monitor used in the epidemiology study from which we obtained C-R functions. Complete hourly data were available on over 93 percent of the days of the three-year period.
- Baseline incidence: an estimate of the baseline incidence of respiratory ED visits in Atlanta, GA in 2004 (the most recent year in the study) was obtained (Tolbert, 2008a). The estimate, 121,818 respiratory ED visits in 2004, was based on 37 hospitals that reported data (out of 38 hospitals operating) that year (Tolbert, 2008b).

3.8 Addressing uncertainty and variability

Any estimation of risk associated with "as is" NO_2 concentrations, with just meeting the current NO_2 standard, or with just meeting alternative NO_2 standards should address both the variability and uncertainty that generally underlie such an analysis. *Uncertainty* refers to the lack of knowledge regarding the actual values of model input variables (parameter uncertainty) and of physical systems or relationships (model uncertainty – e.g., the shapes of C-R functions). The goal of the analyst is to reduce uncertainty to the maximum extent possible. Uncertainty can be reduced by improved measurement and improved model formulation. In a health risk assessment, however, significant uncertainty often remains. The degree of uncertainty can be characterized, sometimes quantitatively. For example, the statistical uncertainty surrounding the estimated NO_2 coefficients in the C-R functions is reflected in confidence intervals provided for the risk estimates.

Variability refers to the heterogeneity in a population or parameter. Even if there is no uncertainty surrounding inputs to the analysis, there may still be variability. For example, there may be variability among C-R functions describing the relationship between NO_2 and respiratory ED visits across urban areas. This variability does not imply uncertainty about the C-R function in any of the urban areas, but only that these functions are different in the different locations, reflecting differences in the populations and/or other factors that may affect the relationship between NO_2 and respiratory ED visits. In general, it is possible to have uncertainty but no variability (if, for instance, there is a single parameter whose value is uncertain) or variability but little or no uncertainty (for example, people's heights vary considerably but can be accurately measured with little uncertainty).

The NO_2 risk assessment addresses variability-related concerns by using location-specific inputs (i.e., location-specific C-R function, baseline incidence data and air quality data). Because the NO_2 risk assessment focuses on only a single urban area, it does not attempt to portray a larger picture of risk than is relevant to the selected assessment area.

Temporal variability is more difficult to address, because the risk assessment focuses on some unspecified time in the future. To minimize the degree to which values of inputs to the analysis may be different from the values of those inputs at that unspecified time, we used recent input data – for example, year 2005 through 2007 air quality data and recent (2004) baseline incidence data. However, future changes in inputs have not been predicted (e.g., future baseline incidences). To address the impact of variability in NO_2 concentrations from one year to another, we carried out the risk assessment for the years in the three-year period under consideration – 2005, 2006, and 2007 – separately.

A number of important sources of uncertainty in the NO_2 risk assessment are addressed where possible. The following are among the major sources of uncertainty:

- Uncertainties related to estimating the C-R functions, including
    - uncertainty about the extent to which the association between NO_2 and the health endpoint actually reflects a causal relationship.
    - uncertainty surrounding estimates of NO_2 coefficients in the C-R functions used in the analyses.
    - uncertainty about the specification of the model (including the shape of the C-R relationship), particularly whether or not there is a threshold below which no response occurs.

- uncertainty related to the transferability of NO_2 C-R functions from the study time period to the time period selected for the risk assessment.[9] A C-R function in a study time period may not provide an accurate representation of the C-R relationship in the analysis time period because of

    - the possible role of associated co-pollutants, which may vary over time, in influencing NO_2 risk,
    - temporal variation in the relationship of total ambient exposure (both outdoor and ambient contributions to indoor exposure) to ambient monitoring (e.g., due to changes in air conditioning usage over time),
    - changes in population characteristics (e.g., the proportions of members of sensitive subpopulations) and population behavior patterns over time.

- Uncertainties related to the air quality data, including the adjustment procedure that was used to simulate just meeting the current and alternative NO_2 standards.

- Uncertainties associated with use of baseline health effects incidence information – e.g., the extent to which the baseline incidence estimate is downward biased by the lack of data for 6 of the 42 hospitals in the Atlanta MSA.

The specific sources of uncertainty in the NO_2 risk assessment are described in detail below and are summarized in Table 3-2.

[9] Uncertainty about transferability of C-R functions often results not only from differences between the study and risk assessment time periods, but also between the study and risk assessment locations. Because the NO_2 risk assessment is being conducted in the same location as the study from which the C-R functions were obtained, this is not a problem here.

Table 3-2. Key Uncertainties in the NO_2 Risk Assessment

Uncertainty	Level of Uncertainty	Direction of Bias	Comments
Causality	low	Upward, if causality assumption isn't true.	Statistical association does not prove causation. However, the risk assessment considers only a health endpoint for which the overall weight of the evidence supports the assumption that NO_2 is likely causally related based on the totality of the health effects evidence. If the assumption of a causal relationship is incorrect, then a positive estimated coefficient in the C-R function would be upward biased, since it is greater than zero.
Empirically estimated C-R relations	medium	No obvious bias, if C-R model is correctly specified. Otherwise, unclear.	Because C-R functions are empirically estimated, there is uncertainty surrounding these estimates. If the model is correctly specified, there is no bias in the coefficient estimates. If the model is mis-specified, there can be bias. Omitted confounding variables, for example, could cause upward bias in the estimated NO_2 coefficients if the omitted variables are positively correlated with both NO_2 and the health effect. However, including potential confounding variables that are highly correlated with one another can lead to unstable estimators. Because both single- and multi-pollutant models were available, both were used.
Functional form of C-R relation	medium	Unclear	Statistical significance of coefficients in an estimated C-R function does not necessarily mean that the mathematical form of the function is the best model of the true C-R relation. If the "true" functional relationship between NO_2 and a health effect is different from the one specified, there can be bias in the resulting estimates of effect. The direction of the bias will depend on how the specified model differs from reality. For example, if the specified C-R function is log-linear down to 0 ug/m^3, but there is actually a threshold in the true relationship, then the effect will be overstated by the model corresponding to levels of NO_2 below the threshold.

Uncertainty	Level of Uncertainty	Direction of Bias	Comments
Lag structure of C-R relation	low	Downward, if important lags are omitted (e.g., if C-R function includes a single lag, while "truth" is a distributed lag). Unclear, if C-R function includes a single lag, but it's the wrong lag.	The actual lag structure for short-term NO_2 exposures is uncertain. Omitted lags could cause an underestimation in the predicted incidence associated with a given reduction in NO_2 concentrations. The level of uncertainty (in the sense of the *impact* of the uncertainty) may depend on the situation. For example, suppose the health effect is actually affected largely by same-day NO_2 concentrations but the model (incorrectly) includes only a 1-day lag. In this case, the impact on the outcome of the analysis may be minimal if, as is likely, there is a high degree of autocorrelation in NO_2 concentrations from day to day (so that yesterday's NO_2 level would act as a good proxy for today's NO_2 level). If, on the other hand, there is a distributed lag – e.g., if risk of the health effect on day *t* depends on NO_2 concentrations for the entire week leading up to day *t* – and the model includes only a single lag, then the understatement of effect could be substantial.
Transferability of C-R relations	low	No obvious bias.	C-R functions may not provide an adequate representation of the C-R relationship in times and places other than those in which they were estimated. For example, populations in the assessment location/time period may have more or fewer members of sensitive subgroups than the location/time period in which functions were derived, which would introduce additional uncertainty related to the use of a given C-R function in the analysis. This problem was minimized in the NO_2 risk assessment, however, because it relies on C-R functions estimated in a recent study conducted in the assessment location.
Extrapolation of C-R relations beyond the range of observed NO_2 data	low	Unclear.	A C-R relationship estimated by an epidemiological study may not be valid at concentrations outside the range of concentrations observed during the study. This problem should be minimal in the NO_2 risk assessment, however, because the NO_2 concentrations observed in the study from which C-R functions were obtained covered a wide range – from 1 ppb to 181 ppb.

Uncertainty	Level of Uncertainty	Direction of Bias	Comments
Adequacy of ambient NO_2 monitors as surrogate for population exposure	low	No obvious bias.	Possible differences in how the spatial variation in ambient NO_2 levels across an urban area are characterized in the original epidemiological study compared to the more recent ambient NO_2 data used to characterize current air quality would contribute to uncertainty in the health risk estimates. The NO_2 risk assessment uses the same monitor used in the epidemiological study from which the C-R functions were obtained, which should minimize this source of uncertainty.
Adjustment of air quality distributions to simulate just meeting current and alternative NO_2 standards.	medium	Could be in either direction.	The pattern and extent of daily reductions in NO_2 concentrations that would result if the current NO_2 standard or alternative NO_2 standards were just met is not known. There remains uncertainty about the shape of the air quality distribution of hourly levels upon just meeting an NO_2 standard that would depend on the nature of future growth in NO_2 emissions, if any, and future air quality control strategies.
Baseline health effects data	low	Small downward bias.	Data on baseline incidence may be uncertain for a variety of reasons. For example, location- and age-group-specific baseline rates may not be available in all cases. Baseline incidence may change over time for reasons unrelated to NO_2. This source of uncertainty is relatively minor in the NO_2 risk assessment, however, because a baseline incidence estimate has been obtained from the study authors for the assessment area. There is a small downward bias to this estimate, because it is based on 37 of the 38 hospitals operating in the Atlanta study area in 2004; the study authors estimate that respiratory ED visits at those 37 hospitals comprise about 98% of the total for that year (Tolbert, 2008b). The estimated baseline incidence for respiratory ED visits in 2004 also appears to be roughly 8% lower than the average baseline incidence observed during the period from 2002 to 2004.

We handled uncertainties in the risk assessment as follows:

- Limitations and assumptions in estimating risks and reduced risks are clearly stated and explained.

- The uncertainty resulting from the statistical uncertainty associated with the estimate of the NO_2 coefficient in a C-R function was characterized by confidence intervals around the corresponding point estimate of risk. Confidence intervals express the range within which the true risk is likely to fall if the uncertainty surrounding the NO_2 coefficient estimate were the only uncertainty in the analysis. They do not, for example, reflect the uncertainty concerning whether the NO_2 coefficients in the study period and the assessment period are the same.

Not all health effects that may result from NO_2 exposure were included. We focused on respiratory ED visits because it was judged that there was sufficient epidemiological and other evidence to support the hypothesis of a causal relationship. Other health effects reported to be associated with exposure to NO_2 (e.g., increased respiratory illnesses and symptoms) are considered qualitatively in the draft REA. Thus, it is important to recognize that the NO_2 risk assessment represents only a portion of the health risks associated with NO_2 exposures.

3.8.1 Concentration-response functions

The C-R function is a key element of the NO_2 risk assessment. The quality of the risk assessment depends, in part, on (1) whether the C-R functions used in the risk assessment are good estimates of the relationship between the population health response and ambient NO_2 concentration in the study location (which, in this case, is the same as the assessment location), (2) how applicable these functions are to the analysis period, and (3) the extent to which these relationships apply beyond the range of the NO_2 concentrations from which they were estimated. These issues are discussed in the subsections below.

3.8.1.1 Uncertainty associated with the appropriate model form

The relationship between a health endpoint and NO_2 can be characterized in terms of the form of the function describing the relationship – e.g., linear, log-linear, or logistic – and the value of the NO_2 coefficient in that function. Although most epidemiological studies estimated NO_2 coefficients in log-linear models, there is still substantial uncertainty about the correct functional form of the relationship between NO_2 and respiratory ED visits – especially at the low end of the range of NO_2 values, where data are generally too sparse to discern possible thresholds. While there are likely biological thresholds in individuals for specific health responses, the available epidemiological studies generally have not supported or refuted the existence of thresholds at the population level for NO_2 exposures within the range of air quality observed in the studies.

3.8.1.2 Uncertainty associated with the estimated concentration-response functions in the study location

The uncertainty associated with an estimate of the NO_2 coefficient in a C-R function reported by a study depends on the sample size and the study design. The final ISA has evaluated the substantial body of NO_2 epidemiological studies. In general, critical considerations in evaluating the design of an epidemiological study include the adequacy of the measurement of ambient NO_2, the adequacy of the health effects incidence data, and the consideration of potentially important health determinants and potential confounders and effect modifiers such as:

- other pollutants;
- weather variables (e.g., temperature extremes);
- exposure to other health risks, such as smoking and occupational exposure; and
- demographic characteristics, including age, sex, socioeconomic status, and access to medical care.

The possible confounding effect of co-pollutants, including other criteria air pollutants, has often been noted as a problem in air pollutant risk assessments, particularly when these other pollutants are highly correlated with the pollutant of interest. As noted above, if other pollutants are included in the model and are highly correlated with NO_2, this will inflate the variance of the estimators of the pollutant coefficients, making them more unstable. However, if other pollutants are causally related to the health effect, are correlated with NO_2, and are omitted from the model, then the resulting single-pollutant model will falsely attribute to NO_2 some of the effect of these other pollutants. NO_2 was only moderately correlated with the other pollutants considered in the models that produced the C-R functions that are used in the risk assessment (see Tolbert et al., 2007, Table 3), although it was fairly highly correlated (corr.=0.7) with CO. Given the advantages and disadvantages of both single- and multi-pollutant models, we report risk estimates based on both the single- and multi-pollutant models from Tolbert et al. (2007). The issue of possible confounding by co-pollutants is discussed in more detail in the final ISA.

The main reason to use a multi-pollutant model is to avoid the potential upward bias in the NO_2 coefficient that may result if other pollutants that are causally related to the health effect are omitted from the model. It might be argued that if all the pollutants in a multi-pollutant model are causally related to the health effect we should consider the changes that would occur in *all* of the pollutants, rather than only the changes in NO_2, as a result of an NO_2 standard being implemented, since considering only the changes in NO_2 will tend to understate the full benefit of just meeting an alternative standard. If one were evaluating total benefits to be derived from an implementation plan for an area, then the total reduction in health effects resulting from reduction in levels for all of the pollutants would be of interest. However, for the purposes of evaluating the adequacy of the current and alternative NO_2 NAAQS, considering the health gains associated with reductions attributable to lower levels of not just NO_2, but other pollutants such as $PM_{2.5}$ and O_3, would effectively result in double counting. This double counting would occur because the health gains associated with reductions in these other pollutants should already have been taken into account in assessments conducted to inform decisions on NAAQS for the other pollutants. Thus, when co-pollutant models are applied in the current risk assessment, only the risks resulting from reductions in NO_2 ambient concentrations are considered; risks that might result from reduction of other pollutants are not considered in this analysis.

One of the criteria for selecting studies addresses the adequacy of the measurement of ambient NO_2. This criterion was that NO_2 was directly measured, rather than estimated, on a reasonable proportion of the days in the study. This criterion was designed to minimize error in the estimated NO_2 coefficients in the C-R functions used in the risk assessment. NO_2 was measured in the Tolbert study on over 93 percent of the days of the study period, so this criterion was well satisfied.

Ambient concentrations at central monitors, however, may not provide a good representation of personal exposures. The final ISA identifies the following three components to exposure measurement error: (1) the use of average population rather than individual exposure data; (2) the difference between average personal ambient exposure and ambient concentrations at central monitoring sites; and (3) the difference between true and measured ambient concentrations (final ISA, section 1.3.2, p. 1-5). While a C-R function may understate the effect of personal exposures to NO_2 on the incidence of a health effect, however, it will give an unbiased estimate of the effect of ambient concentrations on the incidence of the health effect, if the ambient concentrations at monitoring stations provide an unbiased estimate of the ambient concentrations to which the population is exposed. In this case, if NO_2 is actually the causal agent, the understatement of the impact of personal exposures isn't an issue (since EPA regulates ambient concentrations rather than personal exposures). If NO_2 is not the causal agent, however, then there is a problem of confounding co-pollutants or other factors, so that reducing ambient NO_2 concentrations might not result in the expected reductions in the health effect. A more comprehensive discussion of exposure measurement error and its potential impact on the NO_2 C-R relationships reported in community epidemiological studies is given in section 2.5.8 of the ISA and in the ISA Annex section AX6.1.

To the extent that a study did not address all relevant factors (i.e., all factors that affect the health endpoint), there is uncertainty associated with the C-R function estimated in that study, beyond that reflected in the confidence or credible interval. It may result in either over- or underestimates of risk associated with ambient NO_2 concentrations in the location in which the study was carried out. Techniques for addressing the problem of confounding factors and other study design issues have improved over the years, however, and the epidemiological studies currently available for use in the NO_2 risk assessment provide a higher level of confidence in study quality than ever before.

When a study is conducted in a single location, the problem of possible confounding co-pollutants may be particularly difficult, if co-pollutants are highly correlated in the study location. Single-pollutant models, which omit co-pollutants, may produce overestimates of the NO_2 effect, if some of the effects of other pollutants (omitted from the model) are falsely attributed to NO_2. Statistical estimates of an NO_2 effect based on a multi-pollutant model can be more uncertain, and even statistically insignificant, if the co-pollutants included in the model are highly correlated with NO_2. As a result of these considerations, we report risk estimates based on both the single-pollutant and multi-pollutant models from Tolbert et al. (2007).

3.8.1.3 Applicability of concentration-response functions in different locations and/or time periods

The relationship between ambient NO_2 concentration and the incidence of a given health endpoint in the population (the population health response) depends on (1) the relationship between ambient NO_2 concentration and personal exposure to ambient generated NO_2 and (2) the relationship between personal exposure to ambient-generated NO_2 and the population health response. Both of these are likely to vary to some degree from one location and/or time period to another. The relationship between ambient NO_2 concentration and personal exposure to ambient-generated NO_2 will depend on patterns of behavior, such as the amount of time spent outdoors, as well as on factors affecting the extent to which ambient-generated NO_2 infiltrates into indoor environments. The relationship between personal exposure to ambient-generated NO_2 and the population health response will depend on the population exposed. Exposed populations may differ from one location and/or time period to another in characteristics that are likely to affect their susceptibility to NO_2 air pollution. For instance, people with preexisting conditions such as asthma are probably more susceptible to the adverse effects of exposure to NO_2, and populations may vary from one location and/or time period to another in the prevalence of specific diseases. Also, some age groups may be more susceptible than others, and population age distributions may also vary both spatially and temporally. In the NO_2 risk assessment we avoid the uncertainty associated with inter-locational differences, however, by using C-R functions that were estimated in the assessment area. In addition, although we cannot completely eliminate possible temporal changes, we minimize the uncertainty associated with such changes by using relatively recent baseline incidence data.

3.8.1.4 Extrapolation beyond observed air quality levels

Although a C-R function describes the relationship between ambient NO_2 and a given health endpoint for all possible NO_2 levels (potentially down to zero), the estimation of a C-R function is based on real ambient NO_2 values that are limited to the range of NO_2 concentrations in the location in which the study was conducted. Thus, uncertainty in the shape of the estimated C-R function increases considerably outside the range of NO_2 concentrations observed in the study.

Because we are interested in the effects of NO_2 down to 0 ppm, the NO_2 risk assessment assumes that the estimated C-R functions adequately represent the true C-R relationship down to 0 ppm in the assessment location. However, although the observed NO_2 concentrations in Tolbert et al. (2007) did not go down to 0 ppm, the study authors reported the minimum 1-hour NO_2 level observed in their study to be 1 ppb (or 0.001 ppm) (and the maximum to be 181 ppb), so the uncertainty resulting from extrapolation to levels below those air quality levels observed in the study should be minimal.

The C-R relationship may also be less certain towards the upper end of the concentration range being considered in a risk assessment, particularly if the NO_2 concentrations in the assessment location/time period exceed the NO_2 concentrations observed in the study location/time period. Even though it may be reasonable to model the C-R relationship as log-linear over the ranges of NO_2 concentrations typically observed in epidemiological studies, it may not be log-linear over the entire range of NO_2 levels at the location considered in the NO_2 risk assessment. However, because the study was carried out in the risk assessment location and is relatively recent, the uncertainty resulting from extrapolation to levels above those air quality levels observed in the study should similarly be minimal.

3.8.2 The air quality data

3.8.2.1 Adequacy of NO_2 air quality data

Ideally, the measurement of average hourly ambient NO_2 concentrations in the study location is unbiased. In this case, unbiased risk predictions in the assessment location depend, in part, on an unbiased measurement of average hourly ambient NO_2 concentrations in the assessment location as well. If, however, the measurement of average hourly ambient NO_2 concentrations in the study location is biased, unbiased risk predictions in the assessment location are still possible if the measurement of average hourly ambient NO_2 concentrations in the assessment location incorporates the same bias as exists in the study location measurements. Because the NO_2 risk assessment is using the same NO_2 monitor as was used in Tolbert et al. (2007), the estimates of risk should avoid any bias as a result of the monitor estimates of average hourly ambient NO_2 concentrations in the risk assessment location.

Another potential source of uncertainty is missing air quality data. Although NO_2 concentrations were not available for all hours of the 3-year period chosen for the NO_2 risk assessment in the assessment location, they were available for all hours on most days. In particular, complete hourly data were available on over 93 percent of the days – 348 days in 2005, 345 days in 2006, and 340 days in 2007. Missing NO_2 concentrations were filled in, as described above in section 3.5.

The results of the risk assessment are generalizable to other years only to the extent that ambient NO_2 levels in the available data are similar to ambient NO_2 levels in those other years. A substantial difference between NO_2 levels in the years used in the risk assessment and NO_2 levels in the other years could imply a substantial difference in predicted incidences of health effects.

3.8.2.2 Simulation of reductions in NO_2 concentrations to just meet the current or an alternative standard

The pattern of hourly NO_2 concentrations that would result if the current NO_2 standard or an alternative standard were just met in the assessment location is, of course, not known. This therefore adds uncertainty to estimates of risk when NO_2 concentrations just meet a specified standard.

Although the health risk assessment uses air quality data from three years, 2005, 2006, and 2007, it simulates just attaining a standard in each year separately, since we are estimating annual reduced health risks. Design values based on the most recent three-year period available are used to determine the amount of adjustment to apply to each of these years. As can be seen in Table 3-1, the distributions of NO_2 concentrations in the three years are similar.

3.8.3 Baseline health effects incidence

The C-R functions used in the NO_2 risk assessment are log-linear (see equation 3-1 in section 3.1). Given this functional form, the percent change in incidence of a health effect corresponding to a change in NO_2 depends only on the change in NO_2 levels (and not the actual value of either the initial or final NO_2 concentration). This percent change is multiplied by a baseline incidence, y_0, in order to determine the change in health effects incidence, as shown in equation (3-3) in section 3.1:

$$\Delta y = y_0 [1 - e^{-\beta \Delta x}] \quad .$$

Predicted changes in incidence therefore depend on the baseline incidence of the health effect.

3.8.3.1 Quality of incidence data

As noted in section 3.7 above, we obtained an estimate of the baseline incidence of respiratory ED visits in Atlanta, GA (Tolbert, 2008a). There are 42 hospitals with EDs in the 20-county Atlanta MSA, but not all 42 contributed incidence data in all of the years of the Tolbert study (1993 – 2004). We used the most recent year of the study (2004), which had an estimate of baseline incidence of respiratory ED visits in Atlanta based on data from 37 of the 38 hospitals operating in the Atlanta study area in that year. The study authors estimate that respiratory ED visits at those 37 hospitals comprise about 98 percent of the total for that year (Tolbert, 2008b). The estimate of baseline incidence in 2004, which is used as the estimate of baseline incidence in the NO_2 risk assessment for 2005 - 2007, is thus a slight underestimate, resulting in a similarly slight downward bias in the estimates of NO_2-related respiratory ED visits.

A minor uncertainty surrounding hospital or ED visit baseline incidence estimates sometimes arises if these estimates are based on the reporting of hospitals within an assessment area. Hospitals report the numbers of ICD code-specific discharges in a given year. If people from outside the assessment area use these hospitals or EDs, and/or if residents of the assessment area use hospitals or EDs outside the assessment area, these rates will not accurately reflect the numbers of residents of the assessment area who were admitted to the hospital or ED for specific illnesses during the year, the rates that are desired for the risk assessment. This problem is partially avoided in Tolbert et al. (2007) because only residents of the Atlanta MSA, determined by residential zip code at the time of the ED visit, were included in the study. To the extent that residents of the Atlanta MSA visited EDs outside the Atlanta MSA, this would tend to downward bias the estimates of NO_2-related risk of respiratory-related ED visits. However, this is likely to be a very minor problem because emergency visits are likely to be made to the closest ED available, which, for residents of the Atlanta MSA are likely to be within that MSA.

Regardless of the data source, if actual incidences are higher than the incidences used, risks will be underestimated. If actual incidences are lower than the incidences rates used, then risks will be overestimated.

Both morbidity and mortality rates change over time for various reasons. One of the most important of these is that population age distributions change over time. The old and the extremely young are more susceptible to many health problems than is the population as a whole. The most recent available data were used in the NO_2 risk assessment. However, the average age of the population in the assessment location will increase as post-World War II children age. Alternatively, if Atlanta experiences rapid in-migration, as is currently occurring in much of the South and West, it may tend to have a decreasing mean population age and corresponding changes in incidence rates and risk. Consequently, to the extent that respiratory-related ED visits are age-related, the baseline incidence rate may change over time. However, recent data were used in all cases, so temporal changes are not expected to be a large source of uncertainty.

3.8.3.2 Lack of daily health effects incidences

Both ambient NO_2 levels and the daily health effects incidence rates corresponding to ambient NO_2 levels vary somewhat from day to day. Those analyses based on C-R functions estimated by short-term exposure studies calculate daily changes in incidence and sum them over the days of the year to predict a total change in health effect incidence during the year. However, only annual baseline incidence is available. Average daily baseline incidences, necessary for short-term daily C-R functions, were calculated by dividing the annual incidence by the number of days in the year for which the baseline incidences were obtained. To the extent that NO_2 affects health, however, actual incidence rates would be expected to be somewhat higher than average on days with high NO_2 concentrations; using an average daily incidence would therefore result in underestimating the changes in incidence on such days. Similarly, actual incidence rates would be expected to be somewhat lower than average on days with low NO_2 concentrations; using an average daily incidence would therefore result in overestimating the changes in incidence on low NO_2 days. Both effects would be expected to be small, however, and should largely cancel one another out.

4 RESULTS

Results are expressed as (1) incidence of respiratory-related ED visits, (2) incidence of respiratory-related ED visits per 100,000 population, and (3) percent of total incidence of respiratory-related ED visits. Each form of result is shown in three tables, one for each of the three years (2005, 2006, and 2007) of air quality data used in the analysis. As noted in section 2.3, because the current annual average standard is based on two years, the adjustment to simulate just meeting the current standard was applied only to two years, 2006 and 2007. Therefore, results tables for 2005 do not include results associated with just meeting the current standard. The alternative 1-hour daily maximum standards, in contrast, have the form of the 3-year average of the 98^{th} (or 99^{th}) percentile of the daily maximum 1-hour concentrations. Thus, the adjustment to simulate just meeting these alternative 1-hour daily maximum standards was applied to each of the three years, 2005, 2006 and 2007. Therefore, results tables for 2006 and 2007 include results associated with just meeting the alternative 1-hour daily maximum standards as well as results associated with just meeting the current standard. All results tables include results associated with "as is" NO_2 concentrations.

Tables 4-1 through 4-3 show results expressed as incidence of respiratory-related ED visits for 2005, 2006, and 2007, respectively. Tables 4-4 through 4-6 show results expressed as incidence of respiratory-related ED visits per 100,000 population for each of the three years; and Tables 4-7 through 4-9 show results expressed as percent of total incidence of respiratory-related ED visits for each of the three years. Figure 4-1 shows the trends over both years and air quality scenarios, based on the single-pollutant model.

Table 4-1. Estimated Incidence of Respiratory Emergency Department Visits Associated with "As Is" NO_2 Concentrations and NO_2 Concentrations that Just Meet Alternative Standards in Atlanta, GA, Based on Adjusting 2005 NO_2 Concentrations*

Other Pollutants in Model	Incidence of Respiratory Emergency Department Visits Associated with "As is" NO_2 Concentrations and NO_2 Concentrations that Just Meet Alternative Standards**								
	"as is"	Atternative 98th percentile 1-hr daily maximum standards (ppm)				Alternative 99th percentile 1-hr daily maximum standards (ppm)			
		0.05***	**0.1**	**0.15**	**0.2**	**0.05**	**0.1**	**0.15**	**0.2**
none	3600 (1900 - 5300)	2600 (1400 - 3800)	5100 (2700 - 7400)	7500 (4100 - 10900)	9900 (5400 - 14300)	2400 (1300 - 3500)	4700 (2500 - 6900)	7000 (3800 - 10200)	9300 (5000 - 13300)
CO	3100 (1000 - 5100)	2200 (700 - 3600)	4300 (1500 - 7200)	6400 (2200 - 10500)	8500 (2900 - 13800)	2000 (700 - 3400)	4000 (1400 - 6700)	6000 (2000 - 9800)	7900 (2700 - 12900)
O_3	1800 (-100 - 3700)	1300 (-100 - 2600)	2600 (-100 - 5200)	3900 (-200 - 7700)	5100 (-200 - 10200)	1200 (-100 - 2500)	2400 (-100 - 4900)	3600 (-200 - 7200)	4800 (-200 - 9500)
PM_{10}	1300 (-700 - 3300)	900 (-500 - 2300)	1800 (-1000 - 4600)	2700 (-1600 - 6800)	3600 (-2100 - 9000)	800 (-500 - 2200)	1700 (-1000 - 4300)	2500 (-1500 - 6400)	3400 (-1900 - 8400)
PM_{10}, O_3	700 (-1400 - 2800)	500 (-1000 - 2000)	1000 (-2000 - 4000)	1600 (-3000 - 5900)	2100 (-4000 - 7800)	500 (-900 - 1900)	1000 (-1800 - 3700)	1500 (-2800 - 5500)	1900 (-3700 - 7300)

*Estimated incidences of respiratory emergency department visits are based on the concentration-response functions estimated in Tolbert et al. (2007) [results corresponding to Figure 2 in Tolbert et al. (2007) were obtained via personal communication with P. Tolbert]. All models use a 3-day moving average of the daily 1-hr. maximum NO_2 concentration and apply to all ages.

**Incidence was quantified down to 0 ppb. Incidences are rounded to the nearest 100.

***Alternative 1-hr daily maximum standards are characterized by a concentration of m ppm and an nth percentile, requiring that the average of the 3 annual nth percentile 1-hr daily maxima over a 3-year period be at or below m ppm.
Note: Numbers in parentheses are 95% confidence intervals based on statistical uncertainty surrounding the NO_2 coefficient.

Table 4-2. Estimated Incidence of Respiratory Emergency Department Visits Associated with "As Is" NO_2 Concentrations and NO_2 Concentrations that Just Meet the Current and Alternative Standards in Atlanta, GA, Based on Adjusting 2006 NO_2 Concentrations*

Other Pollutants in Model	Incidence of Respiratory Emergency Department Visits Associated with "As is" NO_2 Concentrations and NO_2 Concentrations that Just Meet the Current and Alternative Standards**									
	"as is"	current annual standard	Alternative 98th percentile 1-hr daily maximum standards (ppm)				Alternative 99th percentile 1-hr daily maximum standards (ppm)			
			0.05***	0.1	0.15	0.2	0.05	0.1	0.15	0.2
none	3800 (2000 - 5500)	10900 (5900 - 15700)	2700 (1400 - 3900)	5300 (2800 - 7700)	7800 (4200 - 11300)	10300 (5600 - 14800)	2500 (1300 - 3600)	4900 (2600 - 7200)	7300 (3900 - 10600)	9600 (5200 - 13900)
CO	3200 (1100 - 5300)	9400 (3200 - 15200)	2300 (800 - 3800)	4500 (1500 - 7400)	6700 (2300 - 11000)	8800 (3000 - 14400)	2100 (700 - 3500)	4200 (1400 - 6900)	6200 (2100 - 10200)	8200 (2800 - 13400)
O_3	1900 (-100 - 3900)	5600 (-300 - 11200)	1400 (-100 - 2700)	2700 (-100 - 5400)	4000 (-200 - 8000)	5300 (-200 - 10600)	1300 (-100 - 2600)	2500 (-100 - 5100)	3700 (-200 - 7500)	4900 (-200 - 9900)
PM_{10}	1300 (-800 - 3400)	4000 (-2300 - 9900)	900 (-500 - 2400)	1900 (-1100 - 4800)	2800 (-1600 - 7100)	3700 (-2200 - 9400)	900 (-500 - 2300)	1800 (-1000 - 4500)	2600 (-1500 - 6600)	3500 (-2000 - 8700)
PM_{10}, O_3	800 (-1500 - 2900)	2300 (-4400 - 8600)	500 (-1000 - 2100)	1100 (-2100 - 4100)	1600 (-3100 - 6200)	2200 (-4200 - 8100)	500 (-1000 - 1900)	1000 (-1900 - 3900)	1500 (-2900 - 5700)	2000 (-3900 - 7600)

*Estimated incidences of respiratory emergency department visits are based on the concentration-response functions estimated in Tolbert et al. (2007) [results corresponding to Figure 2 in Tolbert et al. (2007) were obtained via personal communication with P. Tolbert]. All models use a 3-day moving average of the daily 1-hr. maximum NO_2 concentration and apply to all ages.

**Incidence was quantified down to 0 ppb. Incidences are rounded to the nearest 100.

***Alternative 1-hr daily maximum standards are characterized by a concentration of m ppm and an nth percentile, requiring that the average of the 3 annual nth percentile 1-hr daily maxima over a 3-year period be at or below m ppm.

Note: Numbers in parentheses are 95% confidence intervals based on statistical uncertainty surrounding the NO_2 coefficient.

Table 4-3. Estimated Incidence of Respiratory Emergency Department Visits Associated with "As Is" NO_2 Concentrations and NO_2 Concentrations that Just Meet the Current and Alternative Standards in Atlanta, GA, Based on Adjusting 2007 NO_2 Concentrations*

Other Pollutants in Model	Incidence of Respiratory Emergency Department Visits Associated with "As is" NO_2 Concentrations and NO_2 Concentrations that Just Meet the Current and Alternative Standards**									
	"as is"	current annual standard	Alternative 98th percentile 1-hr daily maximum standards (ppm)				Alternative 99th percentile 1-hr daily maximum standards (ppm)			
			0.05***	0.1	0.15	0.2	0.05	0.1	0.15	0.2
none	3400 (1800 - 4900)	9800 (5300 - 14200)	2400 (1300 - 3500)	4700 (2500 - 6900)	7000 (3800 - 10200)	9300 (5000 - 13400)	2200 (1200 - 3300)	4400 (2400 - 6400)	6500 (3500 - 9500)	8600 (4700 - 12500)
CO	2900 (1000 - 4800)	8400 (2900 - 13700)	2000 (700 - 3400)	4000 (1300 - 6700)	6000 (2000 - 9900)	7900 (2700 - 12900)	1900 (600 - 3200)	3800 (1300 - 6200)	5600 (1900 - 9200)	7400 (2500 - 12100)
O_3	1700 (-100 - 3500)	5100 (-200 - 10100)	1200 (-100 - 2500)	2400 (-100 - 4900)	3600 (-200 - 7200)	4800 (-200 - 9500)	1100 (-100 - 2300)	2200 (-100 - 4500)	3300 (-200 - 6700)	4400 (-200 - 8900)
PM_{10}	1200 (-700 - 3000)	3600 (-2100 - 8900)	800 (-500 - 2200)	1700 (-1000 - 4300)	2500 (-1500 - 6400)	3400 (-1900 - 8400)	800 (-400 - 2000)	1600 (-900 - 4000)	2400 (-1400 - 5900)	3100 (-1800 - 7800)
PM_{10}, O_3	700 (-1300 - 2600)	2100 (-4000 - 7800)	500 (-900 - 1900)	1000 (-1800 - 3700)	1500 (-2800 - 5500)	1900 (-3700 - 7300)	500 (-900 - 1700)	900 (-1700 - 3500)	1400 (-2600 - 5100)	1800 (-3400 - 6800)

*Estimated incidences of respiratory emergency department visits are based on the concentration-response functions estimated in Tolbert et al. (2007) [results corresponding to Figure 2 in Tolbert et al. (2007) were obtained via personal communication with P. Tolbert]. All models use a 3-day moving average of the daily 1-hr. maximum NO_2 concentration and apply to all ages.

**Incidence was quantified down to 0 ppb. Incidences are rounded to the nearest 100.

***Alternative 1-hr daily maximum standards are characterized by a concentration of m ppm and an nth percentile, requiring that the average of the 3 annual nth percentile 1-hr daily maxima over a 3-year period be at or below m ppm.
Note: Numbers in parentheses are 95% confidence intervals based on statistical uncertainty surrounding the NO_2 coefficient.

Table 4-4. Estimated Incidence of Respiratory Emergency Department Visits per 100,000 Population Associated with "As Is" NO_2 Concentrations and NO_2 Concentrations that Just Meet Alternative Standards in Atlanta, GA, Based on Adjusting 2005 NO_2 Concentrations*

Other Pollutants in Model	Incidence of Respiratory Emergency Department Visits per 100,000 Population Associated with "As is" NO_2 Concentrations and NO_2 Concentrations that Just Meet Alternative Standards**								
	"as is"	Atternative 98th percentile 1-hr daily maximum standards (ppm)				Alternative 99th percentile 1-hr daily maximum standards (ppm)			
		0.05***	0.1	0.15	0.2	0.05	0.1	0.15	0.2
none	240 (130 - 360)	170 (90 - 250)	340 (180 - 500)	510 (270 - 730)	670 (360 - 960)	160 (90 - 240)	320 (170 - 460)	470 (250 - 690)	620 (340 - 900)
CO	210 (70 - 340)	150 (50 - 250)	290 (100 - 480)	440 (150 - 710)	570 (190 - 930)	140 (50 - 230)	270 (90 - 450)	410 (140 - 660)	540 (180 - 870)
O_3	120 (-10 - 250)	90 (0 - 180)	170 (-10 - 350)	260 (-10 - 520)	340 (-20 - 690)	80 (0 - 170)	160 (-10 - 330)	240 (-10 - 490)	320 (-10 - 640)
PM_{10}	90 (-50 - 220)	60 (-40 - 160)	120 (-70 - 310)	180 (-110 - 460)	240 (-140 - 610)	60 (-30 - 150)	110 (-70 - 290)	170 (-100 - 430)	230 (-130 - 570)
PM_{10}, O_3	50 (-90 - 190)	40 (-70 - 140)	70 (-130 - 270)	110 (-200 - 400)	140 (-270 - 530)	30 (-60 - 130)	70 (-120 - 250)	100 (-190 - 370)	130 (-250 - 490)

*Estimated incidences of respiratory emergency department visits are based on the concentration-response functions estimated in Tolbert et al. (2007) [results corresponding to Figure 2 in Tolbert et al. (2007) were obtained via personal communication with P. Tolbert]. All models use a 3-day moving average of the daily 1-hr. maximum NO_2 concentration and apply to all ages.

**Incidence was quantified down to 0 ppb. Incidences per 100,000 population are rounded to the nearest ten.

***Alternative 1-hr daily maximum standards are characterized by a concentration of m ppm and an nth percentile, requiring that the average of the 3 annual nth percentile 1-hr daily maxima over a 3-year period be at or below m ppm.

Note: Numbers in parentheses are 95% confidence intervals based on statistical uncertainty surrounding the NO_2 coefficient.

Table 4-5. Estimated Incidence of Respiratory Emergency Department Visits per 100,000 Population Associated with "As Is" NO_2 Concentrations and NO_2 Concentrations that Just Meet the Current and Alternative Standards in Atlanta, GA, Based on Adjusting 2006 NO_2 Concentrations*

Other Pollutants in Model	Incidence of Respiratory Emergency Department Visits per 100,000 Population Associated with "As is" NO_2 Concentrations and NO_2 Concentrations that Just Meet the Current and Alternative Standards**									
	"as is"	current annual standard	Alternative 98th percentile 1-hr daily maximum standards (ppm)				Alternative 99th percentile 1-hr daily maximum standards (ppm)			
			0.05***	0.1	0.15	0.2	0.05	0.1	0.15	0.2
none	250 (140 - 370)	740 (400 - 1060)	180 (100 - 260)	360 (190 - 520)	530 (280 - 760)	700 (380 - 1000)	170 (90 - 250)	330 (180 - 480)	490 (260 - 710)	650 (350 - 940)
CO	220 (70 - 360)	630 (210 - 1030)	150 (50 - 260)	300 (100 - 500)	450 (150 - 740)	600 (200 - 970)	140 (50 - 240)	280 (90 - 470)	420 (140 - 690)	560 (190 - 910)
O_3	130 (-10 - 260)	380 (-20 - 760)	90 (0 - 190)	180 (-10 - 370)	270 (-10 - 540)	360 (-20 - 710)	80 (0 - 170)	170 (-10 - 340)	250 (-10 - 510)	330 (-20 - 670)
PM_{10}	90 (-50 - 230)	270 (-160 - 670)	60 (-40 - 160)	130 (-70 - 320)	190 (-110 - 480)	250 (-150 - 630)	60 (-30 - 150)	120 (-70 - 300)	180 (-100 - 450)	240 (-140 - 590)
PM_{10}, O_3	50 (-100 - 200)	150 (-300 - 580)	40 (-70 - 140)	70 (-140 - 280)	110 (-210 - 420)	150 (-280 - 550)	30 (-60 - 130)	70 (-130 - 260)	100 (-190 - 390)	140 (-260 - 510)

*Estimated incidences of respiratory emergency department visits are based on the concentration-response functions estimated in Tolbert et al. (2007) [results corresponding to Figure 2 in Tolbert et al. (2007) were obtained via personal communication with P. Tolbert]. All models use a 3-day moving average of the daily 1-hr. maximum NO_2 concentration and apply to all ages.

**Incidence was quantified down to 0 ppb. Incidences per 100,000 population are rounded to the nearest ten.

***Alternative 1-hr daily maximum standards are characterized by a concentration of m ppm and an nth percentile, requiring that the average of the 3 annual nth percentile 1-hr daily maxima over a 3-year period be at or below m ppm.
Note: Numbers in parentheses are 95% confidence intervals based on statistical uncertainty surrounding the NO_2 coefficient.

Table 4-6. Estimated Incidence of Respiratory Emergency Department Visits per 100,000 Population Associated with "As Is" NO_2 Concentrations and NO_2 Concentrations that Just Meet the Current and Alternative Standards in Atlanta, GA, Based on Adjusting 2007 NO_2 Concentrations*

Other Pollutants in Model	Incidence of Respiratory Emergency Department Visits per 100,000 Population Associated with "As is" NO_2 Concentrations and NO_2 Concentrations that Just Meet the Current and Alternative Standards**									
	"as is"	current annual standard	Alternative 98th percentile 1-hr daily maximum standards (ppm)				Alternative 99th percentile 1-hr daily maximum standards (ppm)			
			0.05***	0.1	0.15	0.2	0.05	0.1	0.15	0.2
none	230 (120 - 330)	660 (360 - 960)	160 (90 - 240)	320 (170 - 470)	470 (260 - 690)	630 (340 - 900)	150 (80 - 220)	300 (160 - 430)	440 (240 - 640)	580 (310 - 840)
CO	190 (60 - 320)	570 (190 - 930)	140 (50 - 230)	270 (90 - 450)	410 (140 - 670)	540 (180 - 870)	130 (40 - 210)	250 (80 - 420)	380 (130 - 620)	500 (170 - 820)
O_3	120 (-10 - 230)	340 (-20 - 680)	80 (0 - 170)	160 (-10 - 330)	240 (-10 - 490)	320 (-10 - 640)	80 (0 - 150)	150 (-10 - 310)	230 (-10 - 450)	300 (-10 - 600)
PM_{10}	80 (-50 - 210)	240 (-140 - 600)	60 (-30 - 150)	110 (-70 - 290)	170 (-100 - 430)	230 (-130 - 570)	50 (-30 - 140)	110 (-60 - 270)	160 (-90 - 400)	210 (-120 - 530)
PM_{10}, O_3	50 (-90 - 180)	140 (-270 - 520)	30 (-60 - 130)	70 (-120 - 250)	100 (-190 - 370)	130 (-250 - 490)	30 (-60 - 120)	60 (-120 - 230)	90 (-170 - 350)	120 (-230 - 460)

*Estimated incidences of respiratory emergency department visits are based on the concentration-response functions estimated in Tolbert et al. (2007) [results corresponding to Figure 2 in Tolbert et al. (2007) were obtained via personal communication with P. Tolbert]. All models use a 3-day moving average of the daily 1-hr. maximum NO_2 concentration and apply to all ages.

**Incidence was quantified down to 0 ppb. Incidences per 100,000 population are rounded to the nearest ten.

***Alternative 1-hr daily maximum standards are characterized by a concentration of m ppm and an nth percentile, requiring that the average of the 3 annual nth percentile 1-hr daily maxima over a 3-year period be at or below m ppm.

Note: Numbers in parentheses are 95% confidence intervals based on statistical uncertainty surrounding the NO_2 coefficient.

Table 4-7. Estimated Percent of Total Incidence of Respiratory Emergency Department Visits Associated with "As Is" NO_2 Concentrations and NO_2 Concentrations that Just Meet Alternative Standards in Atlanta, GA, Based on Adjusting 2005 NO_2 Concentrations*

Other Pollutants in Model	Percent of Total Incidence of Respiratory Emergency Department Visits Associated with "As is" NO_2 Concentrations and NO_2 Concentrations that Just Meet Alternative Standards**								
	"as is"	Atternative 98th percentile 1-hr daily maximum standards (ppm)				Alternative 99th percentile 1-hr daily maximum standards (ppm)			
		0.05***	0.1	0.15	0.2	0.05	0.1	0.15	0.2
none	3% (1.6% - 4.3%)	2.1% (1.1% - 3.1%)	4.2% (2.2% - 6.1%)	6.2% (3.3% - 8.9%)	8.1% (4.4% - 11.7%)	2% (1% - 2.9%)	3.9% (2.1% - 5.7%)	5.8% (3.1% - 8.3%)	7.6% (4.1% - 10.9%)
CO	2.5% (0.8% - 4.2%)	1.8% (0.6% - 3%)	3.6% (1.2% - 5.9%)	5.3% (1.8% - 8.7%)	7% (2.4% - 11.3%)	1.7% (0.6% - 2.8%)	3.3% (1.1% - 5.5%)	4.9% (1.7% - 8.1%)	6.5% (2.2% - 10.6%)
O_3	1.5% (-0.1% - 3.1%)	1.1% (0% - 2.2%)	2.1% (-0.1% - 4.3%)	3.2% (-0.1% - 6.3%)	4.2% (-0.2% - 8.4%)	1% (0% - 2%)	2% (-0.1% - 4%)	2.9% (-0.1% - 5.9%)	3.9% (-0.2% - 7.8%)
PM_{10}	1.1% (-0.6% - 2.7%)	0.8% (-0.4% - 1.9%)	1.5% (-0.9% - 3.8%)	2.2% (-1.3% - 5.6%)	3% (-1.7% - 7.4%)	0.7% (-0.4% - 1.8%)	1.4% (-0.8% - 3.5%)	2.1% (-1.2% - 5.2%)	2.8% (-1.6% - 6.9%)
PM_{10}, O_3	0.6% (-1.1% - 2.3%)	0.4% (-0.8% - 1.7%)	0.9% (-1.6% - 3.3%)	1.3% (-2.5% - 4.9%)	1.7% (-3.3% - 6.4%)	0.4% (-0.8% - 1.5%)	0.8% (-1.5% - 3%)	1.2% (-2.3% - 4.5%)	1.6% (-3.1% - 6%)

*Estimated incidences of respiratory emergency department visits are based on the concentration-response functions estimated in Tolbert et al. (2007) [results corresponding to Figure 2 in Tolbert et al. (2007) were obtained via personal communication with P. Tolbert]. All models use a 3-day moving average of the daily 1-hr. maximum NO_2 concentration and apply to all ages.

**Incidence was quantified down to 0 ppb. Percents are rounded to the nearest tenth.

***Alternative 1-hr daily maximum standards are characterized by a concentration of m ppm and an nth percentile, requiring that the average of the 3 annual nth percentile 1-hr daily maxima over a 3-year period be at or below m ppm.

Note: Numbers in parentheses are 95% confidence intervals based on statistical uncertainty surrounding the NO_2 coefficient.

Table 4-8. Estimated Percent of Total Incidence of Respiratory Emergency Department Visits Associated with "As Is" NO_2 Concentrations and NO_2 Concentrations that Just Meet the Current and Alternative Standards in Atlanta, GA, Based on Adjusting 2006 NO_2 Concentrations*

Other Pollutants in Model	Percent of Total Incidence of Respiratory Emergency Department Visits Associated with "As is" NO_2 Concentrations and NO_2 Concentrations that Just Meet the Current and Alternative Standards**									
	"as is"	current annual standard	Alternative 98th percentile 1-hr daily maximum standards (ppm)				Alternative 99th percentile 1-hr daily maximum standards (ppm)			
			0.05***	0.1	0.15	0.2	0.05	0.1	0.15	0.2
none	3.1% (1.6% - 4.5%)	9% (4.9% - 12.9%)	2.2% (1.2% - 3.2%)	4.3% (2.3% - 6.3%)	6.4% (3.5% - 9.3%)	8.5% (4.6% - 12.2%)	2% (1.1% - 3%)	4% (2.2% - 5.9%)	6% (3.2% - 8.7%)	7.9% (4.3% - 11.4%)
CO	2.6% (0.9% - 4.4%)	7.7% (2.6% - 12.5%)	1.9% (0.6% - 3.1%)	3.7% (1.2% - 6.1%)	5.5% (1.8% - 9%)	7.3% (2.5% - 11.8%)	1.7% (0.6% - 2.9%)	3.4% (1.2% - 5.7%)	5.1% (1.7% - 8.4%)	6.8% (2.3% - 11%)
O_3	1.6% (-0.1% - 3.2%)	4.6% (-0.2% - 9.2%)	1.1% (-0.1% - 2.3%)	2.2% (-0.1% - 4.5%)	3.3% (-0.2% - 6.6%)	4.4% (-0.2% - 8.7%)	1% (0% - 2.1%)	2.1% (-0.1% - 4.1%)	3.1% (-0.1% - 6.2%)	4.1% (-0.2% - 8.1%)
PM_{10}	1.1% (-0.6% - 2.8%)	3.3% (-1.9% - 8.2%)	0.8% (-0.4% - 2%)	1.6% (-0.9% - 3.9%)	2.3% (-1.3% - 5.8%)	3.1% (-1.8% - 7.7%)	0.7% (-0.4% - 1.8%)	1.4% (-0.8% - 3.7%)	2.2% (-1.2% - 5.4%)	2.9% (-1.7% - 7.2%)
PM_{10}, O_3	0.6% (-1.2% - 2.4%)	1.9% (-3.6% - 7.1%)	0.4% (-0.8% - 1.7%)	0.9% (-1.7% - 3.4%)	1.3% (-2.5% - 5.1%)	1.8% (-3.4% - 6.7%)	0.4% (-0.8% - 1.6%)	0.8% (-1.6% - 3.2%)	1.2% (-2.4% - 4.7%)	1.6% (-3.2% - 6.2%)

*Estimated incidences of respiratory emergency department visits are based on the concentration-response functions estimated in Tolbert et al. (2007) [results corresponding to Figure 2 in Tolbert et al. (2007) were obtained via personal communication with P. Tolbert]. All models use a 3-day moving average of the daily 1-hr. maximum NO_2 concentration and apply to all ages.

**Incidence was quantified down to 0 ppb. Percents are rounded to the nearest tenth.

***Alternative 1-hr daily maximum standards are characterized by a concentration of m ppm and an nth percentile, requiring that the average of the 3 annual nth percentile 1-hr daily maxima over a 3-year period be at or below m ppm.

Note: Numbers in parentheses are 95% confidence intervals based on statistical uncertainty surrounding the NO_2 coefficient.

Table 4-9. Estimated Percent of Total Incidence of Respiratory Emergency Department Visits Associated with "As Is" NO_2 Concentrations and NO_2 Concentrations that Just Meet the Current and Alternative Standards in Atlanta, GA, Based on Adjusting 2007 NO_2 Concentrations*

Other Pollutants in Model	Percent of Total Incidence of Respiratory Emergency Department Visits Associated with "As is" NO_2 Concentrations and NO_2 Concentrations that Just Meet the Current and Alternative Standards**									
	"as is"	current annual standard	Alternative 98th percentile 1-hr daily maximum standards (ppm)				Alternative 99th percentile 1-hr daily maximum standards (ppm)			
			0.05***	0.1	0.15	0.2	0.05	0.1	0.15	0.2
none	2.8% (1.5% - 4%)	8.1% (4.4% - 11.6%)	2% (1% - 2.9%)	3.9% (2.1% - 5.7%)	5.8% (3.1% - 8.4%)	7.6% (4.1% - 11%)	1.8% (1% - 2.7%)	3.6% (1.9% - 5.3%)	5.4% (2.9% - 7.8%)	7.1% (3.8% - 10.2%)
CO	2.4% (0.8% - 3.9%)	6.9% (2.3% - 11.3%)	1.7% (0.6% - 2.8%)	3.3% (1.1% - 5.5%)	4.9% (1.7% - 8.1%)	6.5% (2.2% - 10.6%)	1.6% (0.5% - 2.6%)	3.1% (1% - 5.1%)	4.6% (1.5% - 7.5%)	6.1% (2% - 9.9%)
O_3	1.4% (-0.1% - 2.8%)	4.1% (-0.2% - 8.3%)	1% (0% - 2%)	2% (-0.1% - 4%)	2.9% (-0.1% - 5.9%)	3.9% (-0.2% - 7.8%)	0.9% (0% - 1.9%)	1.8% (-0.1% - 3.7%)	2.7% (-0.1% - 5.5%)	3.6% (-0.2% - 7.3%)
PM_{10}	1% (-0.6% - 2.5%)	2.9% (-1.7% - 7.3%)	0.7% (-0.4% - 1.8%)	1.4% (-0.8% - 3.5%)	2.1% (-1.2% - 5.2%)	2.8% (-1.6% - 6.9%)	0.6% (-0.4% - 1.7%)	1.3% (-0.7% - 3.3%)	1.9% (-1.1% - 4.9%)	2.6% (-1.5% - 6.4%)
PM_{10}, O_3	0.6% (-1.1% - 2.2%)	1.7% (-3.2% - 6.4%)	0.4% (-0.8% - 1.5%)	0.8% (-1.5% - 3%)	1.2% (-2.3% - 4.5%)	1.6% (-3% - 6%)	0.4% (-0.7% - 1.4%)	0.7% (-1.4% - 2.8%)	1.1% (-2.1% - 4.2%)	1.5% (-2.8% - 5.6%)

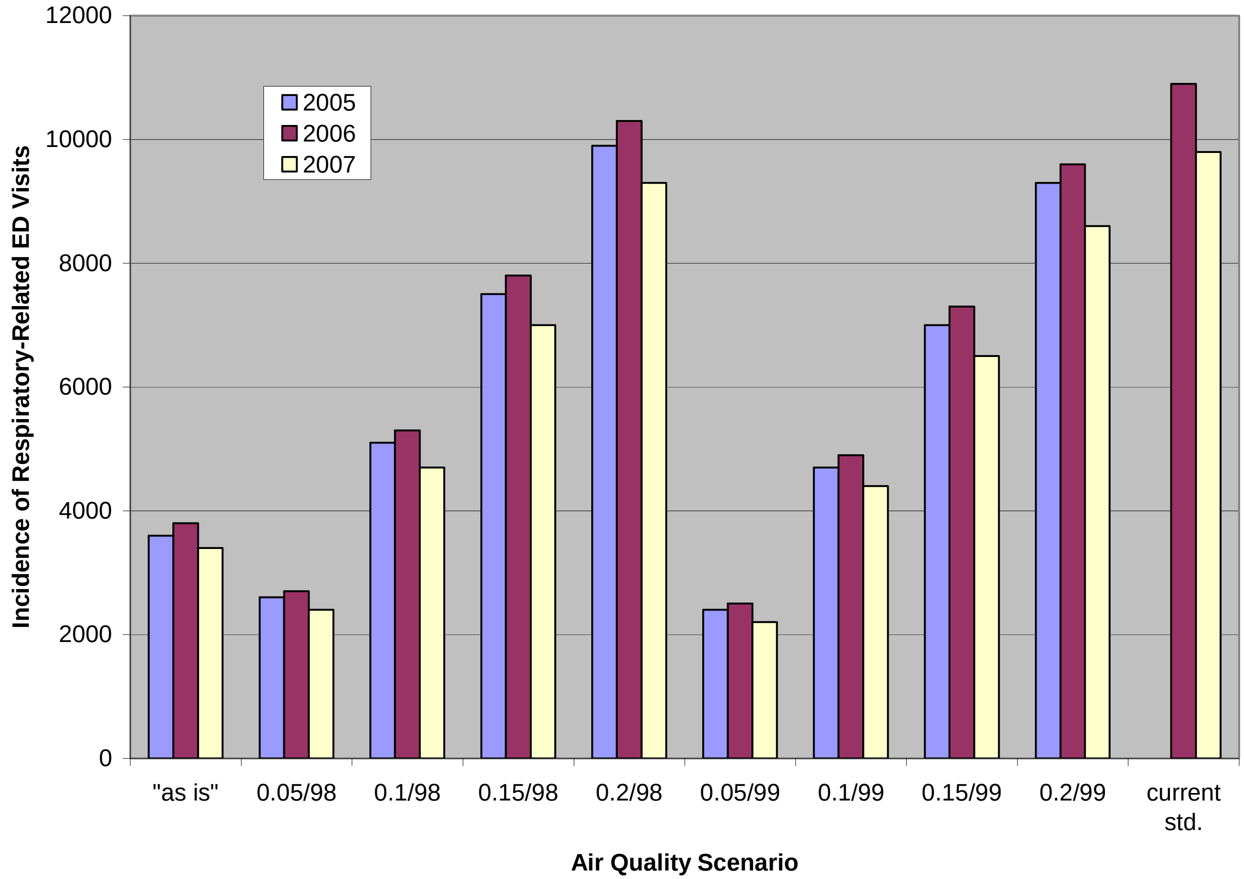
*Estimated incidences of respiratory emergency department visits are based on the concentration-response functions estimated in Tolbert et al. (2007) [results corresponding to Figure 2 in Tolbert et al. (2007) were obtained via personal communication with P. Tolbert]. All models use a 3-day moving average of the daily 1-hr. maximum NO_2 concentration and apply to all ages.

**Incidence was quantified down to 0 ppb. Percents are rounded to the nearest tenth.

***Alternative 1-hr daily maximum standards are characterized by a concentration of m ppm and an nth percentile, requiring that the average of the 3 annual nth percentile 1-hr daily maxima over a 3-year period be at or below m ppm.

Note: Numbers in parentheses are 95% confidence intervals based on statistical uncertainty surrounding the NO_2 coefficient.

Figure 4-1. Incidence of Respiratory-Related Emergency Department Visits in Atlanta, GA Under Different Air Quality Scenarios, Based on Adjusting 2005, 2006, and 2007 NO_2 Concentrations*



*The current standard is an annual average standard of 0.053 ppm. Alternative 1-hour maximum daily standards are denoted m/n, where m (in ppm) is the standard level and n is the percentile. So, for example, 0.05/98 denotes a 98th percentile standard of 0.05 ppm. See section 1 for more detail. All results shown are based on the single-pollutant model in Tolbert et al. (2007).

As can be seen in Figure 4-1, the greatest incidence of respiratory-related ED visits in Atlanta is estimated to occur if the current annual standard were just met – almost three times as high as the incidence associated with “as is” NO_2 concentrations in both 2006 (10,900 vs. 3,800, based on the single-pollutant model) and 2007 (9,800 vs. 3,400). The only alternative standards that are estimated to reduce the incidence of respiratory-related ED visits from the estimated levels associated with “as is” NO_2 concentrations are the two 1-hour daily maximum standards based on 0.05 ppm. The 98th percentile 0.05 ppm standard is estimated to reduce the incidence of respiratory-related ED visits by from 28 percent (in 2005) to 29 percent (in 2007); the 99th percentile 0.05 ppm standard is estimated to reduce the incidence of respiratory-related ED visits by 33 to 35 percent.

In general, the impact of changing the level of the alternative 1-hour daily maximum standards is substantially greater than the impact of changing from a 98th to a 99th percentile standard. For example, changing from a 98th percentile 1-hour daily maximum standard based on 0.05 ppm to one based on 0.1 ppm reduces the estimated incidence of respiratory-related ED visits in Atlanta by about 49 percent in 2007 (from 4700 to 2400); however, changing from a 98th percentile 1-hour daily maximum standard based on 0.05 ppm to a 99th percentile 1-hour daily maximum standard based on 0.05 ppm reduces the incidence in 2007 by only about 8 percent (from 2400 to 2200). The corresponding results for 2006 and 2005 are similar.

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