APPENDIX B

Local-Scale Assessment of Primary PM2.5 for Three Urban Areas

This assessment quantifies the impacts of local sources of primary PM2.5 within selected urban areas. Local-scale air quality modeling is used to examine the spatial variability of direct PM2.5 concentrations associated with emissions of primary PM2.5 within each urban area and to quantify the impact of specific emissions source groups to ambient PM2.5 concentrations at Federal Reference Method (FRM) monitoring sites. We focused this assessment on three urban areas: Birmingham, Seattle, and Detroit. Each of these areas has different characteristics in terms of the mixture of emissions sources, meteorology, and associated PM2.5 air quality issues. As such, they are representative of other areas across the eastern and western US and therefore this assessment provides insights that may be applicable to these other areas. This assessment has a future focus on the incremental impacts of direct PM2.5 sources within these areas after implementation of the Clean Air Interstate Rule (CAIR), Clean Air Mercury Rule (CAMR), and Clean Air Visibility Rule (CAVR).

Based on 2001 meteorology data and the 2015 CAIR/CAMR/CAVR emissions inventory for primary PM2.5, the AERMOD modeling system was applied to each urban area to provide concentration estimates of directly emitted PM2.5 by species across a specified network of receptors within each urban area. AERMOD computes concentrations by individual sources and/or source groups that can then be used to analyze the relative impacts of different types of emissions sources. The modeling domain encompasses each urban area and surrounding areas that have large point source emissions. It includes both an emissions domain, which consists of the urban area and surrounding counties, and a receptor grid, which consists of a set of evenly-spaced receptors within the urban core and at individual monitoring sites [i.e., Federal Reference Method (FRM) and Speciation Trends Network (STN) monitors].

For each area, AERMOD inputs include 2001 meteorological data from the nearest National Weather Service (NWS) Station, geographic information on terrain, the 2015 CAIR/CAMR/CAVR emission inventory for direct PM2.5 for counties comprising the emissions domain, and receptor locations. Based on these inputs, AERMOD provides an estimate of the pollutant fate and transport in the atmosphere. This modeling predicts how the directly emitted PM2.5 is transported, dispersed, and deposited over the area of interest. Initially, the fate of the directly emitted PM2.5 is largely determined by the source release characteristics. After being emitted into the atmosphere, its transport, dispersion, and deposition are determined by meteorological conditions, terrain characteristics, and deposition rates of the direct PM2.5. The concentration for each PM2.5 species and total mass from each source is estimated at each receptor.

Section I provides an overview of the AERMOD modeling system and the inputs used for this local-scale assessment. Section II summarizes the control strategies available for sources within each urban area, while Section III details the results of applying the AERMOD modeling system in evaluating these direct PM2.5 controls for each urban area.

I. AERMOD Modeling System and Inputs

In 1991, the American Meteorological Society (AMS) and the United States Environmental Protection Agency (EPA) initiated a formal collaboration to develop a state-of-the-science dispersion model that reflected advances in planetary boundary layer (PBL) meteorology and science. This joint effort resulted in the development of the AMS/EPA Regulatory Model (AERMOD), which is a steady-state plume dispersion model for air quality assessments of inert pollutants that are directly emitted from a variety of sources[1,2,3, 4]. Based on an advanced characterization of the atmospheric boundary layer turbulence structure and scaling concepts, AERMOD is applicable to rural and urban areas, flat and complex terrain, surface and elevated releases, and multiple sources (including point, area, or volume sources). The model employs hourly sequential preprocessed meteorological data to estimate concentrations at receptor locations for averaging times from one hour to one year. AERMOD incorporates both dry and wet particle and gaseous deposition as well as source or plume depletion. Through final rulemaking (effective December 9, 2005), the Agency established AERMOD as the preferred air dispersion model in its "Guideline on Air Quality Models." (40 CFR 51, Appendix W)

Figure 1 shows the flow and processing of the complete AERMOD modeling system, which consists of the AERMOD dispersion model and two pre-processors: AERMET and AERMAP. The AERMOD meteorological pre-processor, AERMET, is a stand-alone program that uses meteorological information and surface characteristics to calculate the boundary layer parameters for use by AERMOD to generate the needed meteorological variables.[5] In addition, AERMET passes all meteorological observations to AERMOD. The AERMOD mapping program, AERMAP, is a stand-alone terrain pre-processor that characterizes terrain and generates receptor grids for use by AERMOD.[6]

AERMOD is a steady-state plume dispersion model in that it assumes that concentrations at all distances during a modeled hour are governed by the set of hourly averaged meteorology inputs (Cimorelli et al, 2005; Perry et al, 2005). In the stable boundary layer, AERMOD assumes the concentration distribution to be Gaussian in both the vertical and horizontal. In the convective boundary layer, the horizontal distribution is also assumed to be Gaussian, but the vertical distribution is described with a bi-Gaussian probability density function. AERMOD constructs vertical profiles of required meteorological variables based on measurements and extrapolations of those measurements using similarity (scaling) relationships. Vertical profiles of wind speed, wind direction, turbulence, temperature, and temperature gradient are estimated using all available meteorological observations. AERMOD has been designed to handle the computation of pollutant impacts in both flat and complex terrain within the same modeling framework. In general, AERMOD models a plume as a combination of two limiting cases: a horizontal plume (terrain impacting) and a terrain-following, or responding, plume. Therefore, for all situations, the total concentration, at a receptor, is bounded by the concentration predictions from these two states.

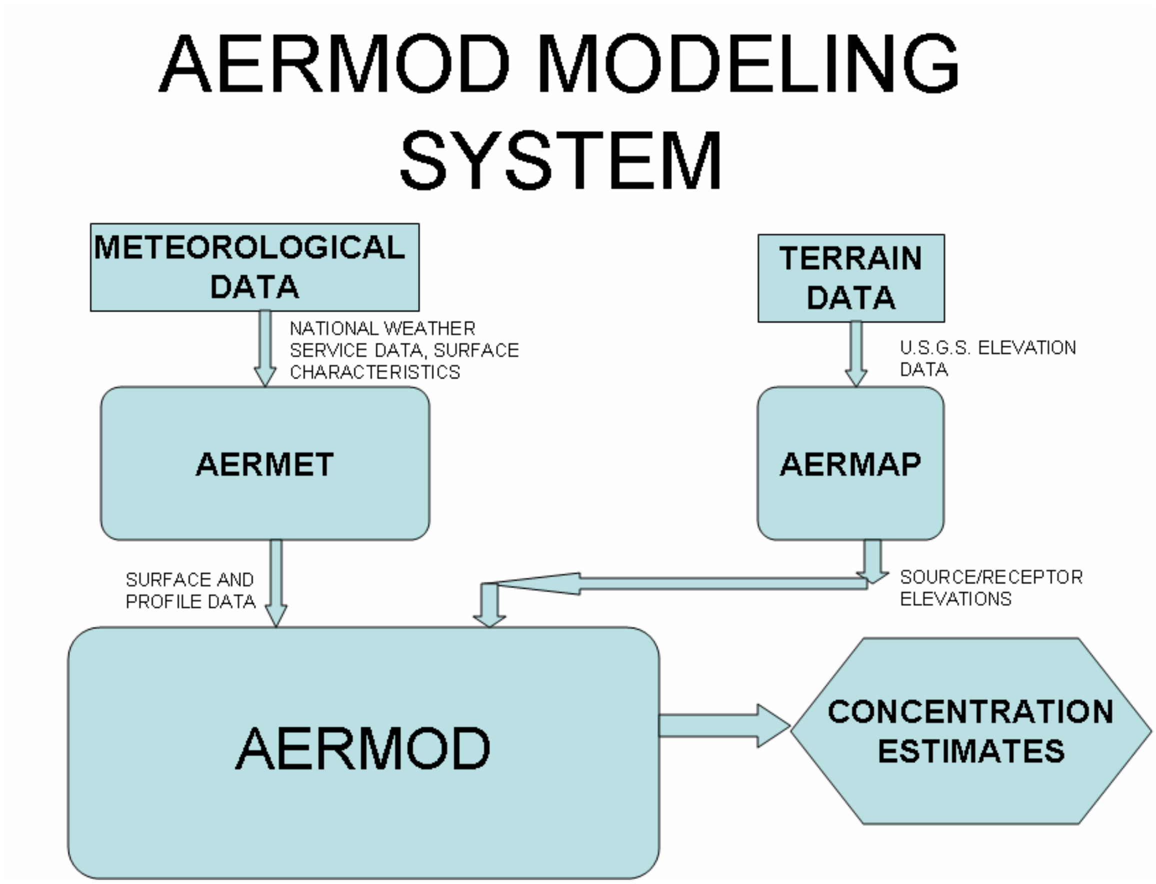

Figure 1. Flow Diagram of the AERMOD Modeling System

I.A Modeling Domain and Receptors

Modeling domains were developed for each of the three urban areas: Birmingham, Detroit and Seattle. These modeling domains were defined such that the urban geographic area and significant sources of direct PM2.5 were captured, and such that receptors within the urban area were placed to determine the spatial gradient with additional receptors placed at monitor locations to allow for the evaluation of impacts of potential controls. The modeling domain consists of an emission domain, defined by counties surrounding the urban area, and a receptor "grid", that includes equally spaced receptors within the urban area and specific receptors placed at individual PM2.5 monitoring sites. Figures 2, 3, and 4 present the modeling domain for each urban area including the associated emissions domain (encircled counties) and receptor grid (boxed area within urban core).

<u>I.A.1 Emissions Domain</u>
For each urban area, an emission domain was developed comprised of counties whose

emissions were expected to potentially contribute to the modeled concentrations in the urban area based on their proximity to the receptor “grid”. The emission domain was developed by visually examining maps of the area, the location of Federal Reference Method (FRM) monitors, and the urban characteristics. Counties comprising the emission domain for each urban area are shown in Figures 2, 3, and 4.

I.A.2 Receptor Grid

A receptor grid domain was placed at the core of the urban areas, with receptors placed at 1 km spacing across a square (e.g., 36 x 36 km in Birmingham) or rectangular area (e.g., 36 by 108 km in Seattle), depending upon the particular urban area. Given that AERMOD can predict PM2.5 concentrations for each of these receptor locations, this dense network of receptors allows for the prediction of the urban gradient for primary PM2.5 based on the AERMOD model results. Additional receptors were also placed at FRM monitoring sites in order to evaluate the contribution of sources to PM2.5 levels at these monitor locations and effectiveness of controls in progressing towards attainment of alternative NAAQS standard options. The receptor grids for each urban area are shown in Figures 2, 3, and 4..

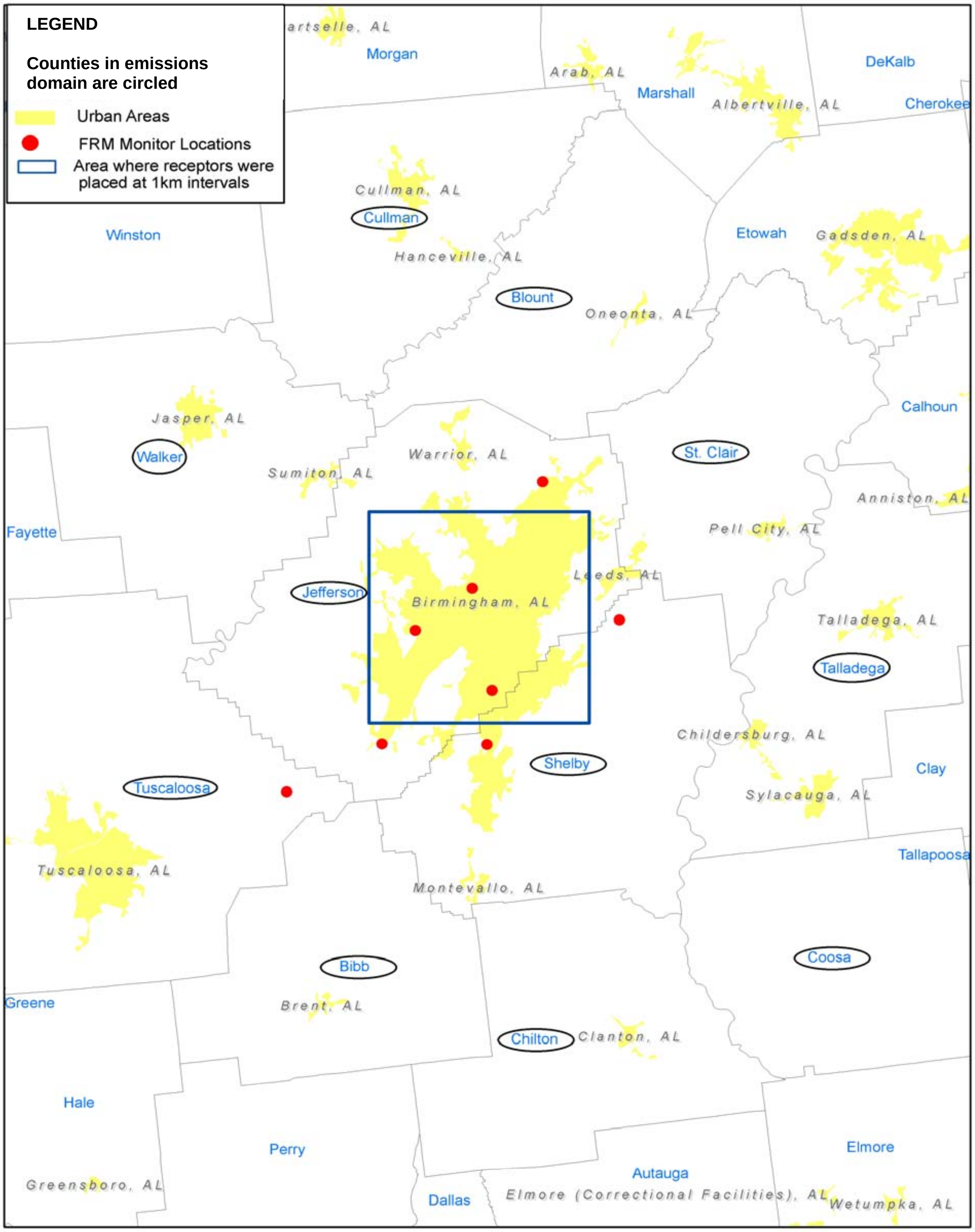

Figure 2: Birmingham Modeling Domain: Emissions Domain by County and Receptor Grid within Urban Area and at Monitoring Sites

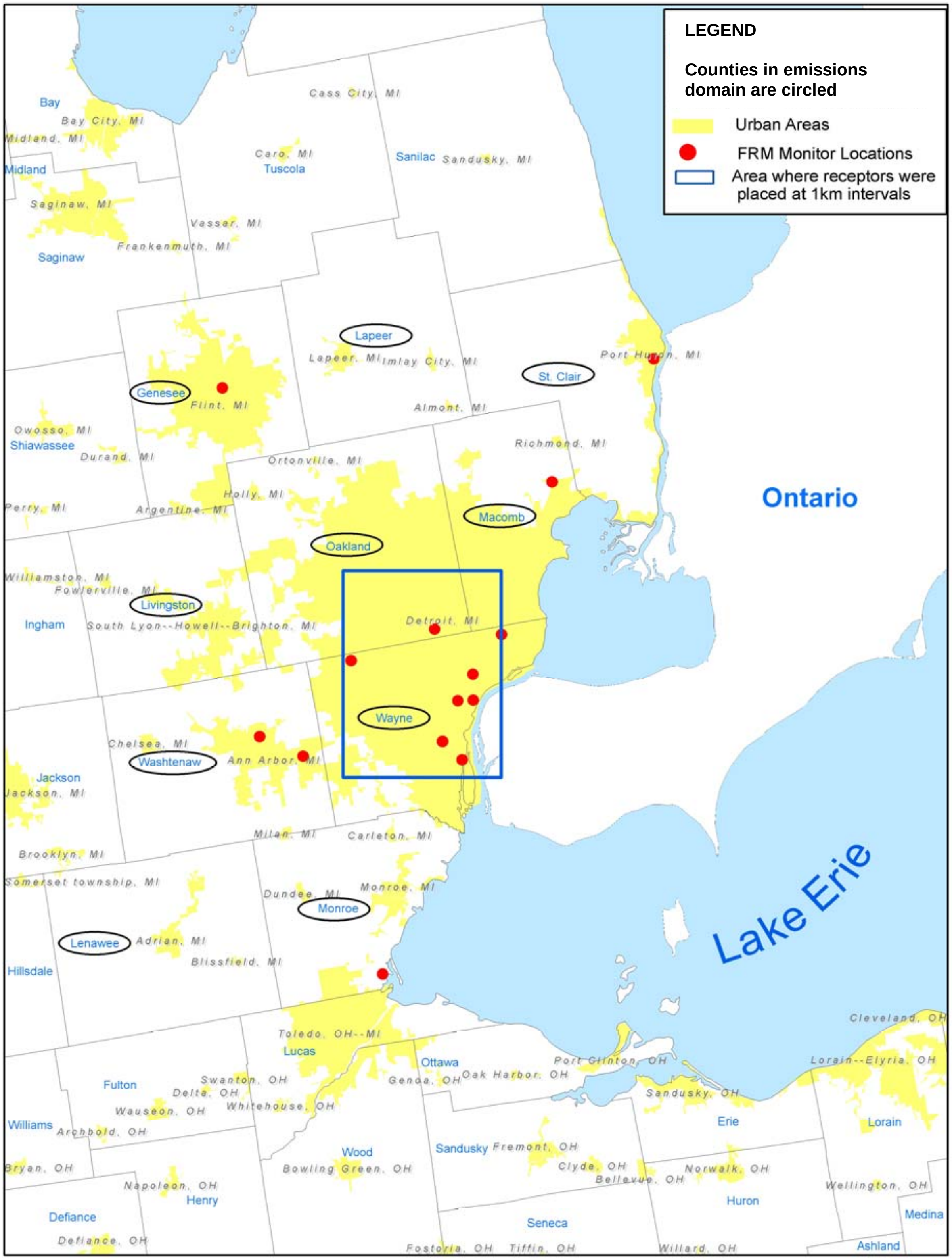

Figure 3: Detroit Modeling Domain: Emissions Domain by County and Receptor Grid within Urban Area and at Monitoring Sites

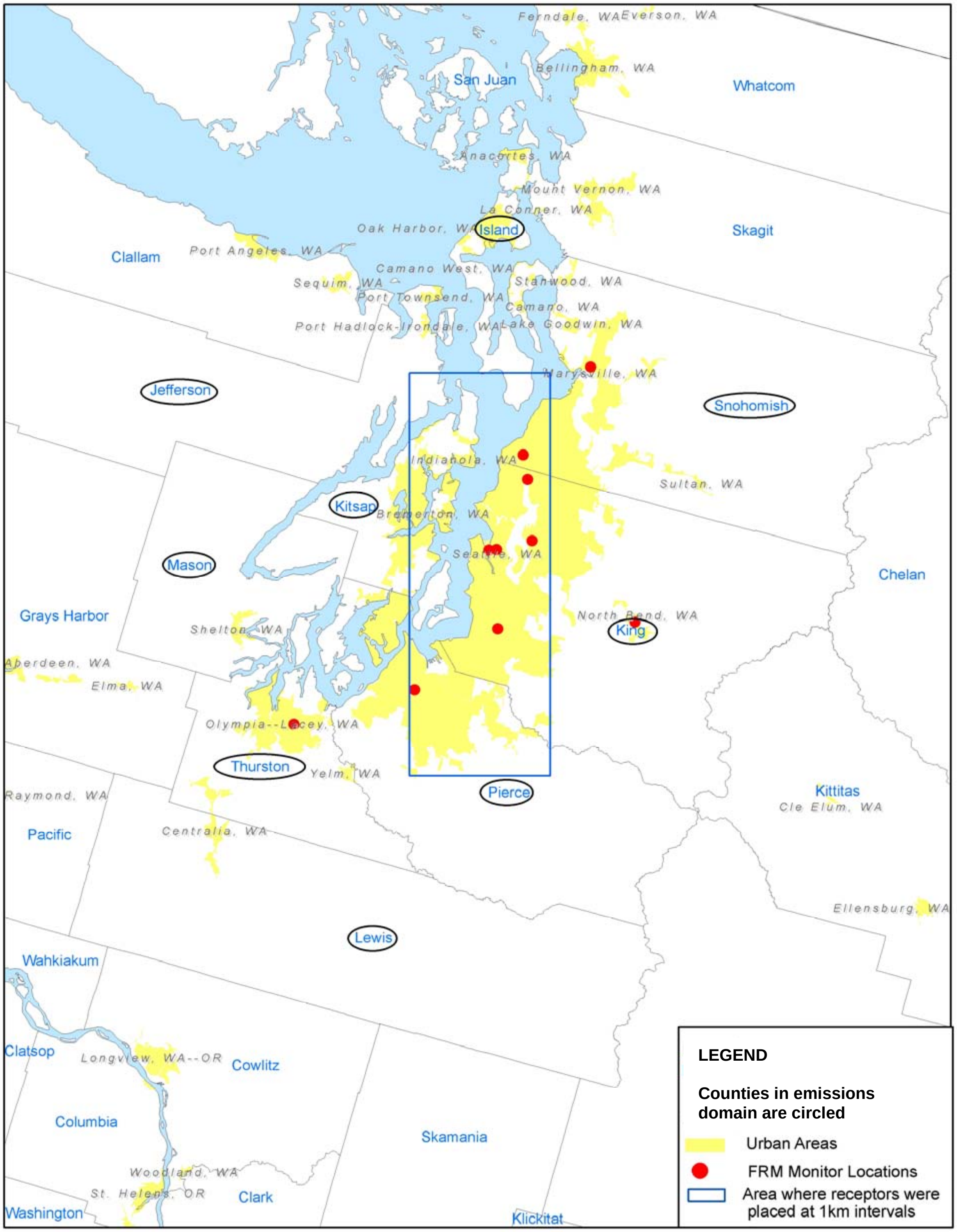

Figure 4: Seattle Modeling Domain: Emissions Domain by County and Receptor Grid within Urban Area and at Monitoring Sites

I.B Emissions Inventory and Processing

The emissions input data used for this local-scale modeling are based on the projected 2015 national emissions inventory reflecting implementation of the Clean Air Interstate Rule, the Clean Air Visibility Rule and the Clean Air Mercury Rule (CAIR/CAVR/CAMR http://www.epa.gov/airmarkets/mp/cair_camr_cavr.pdf). This inventory was used in the Community Multiscale Air Quality (CMAQ) photochemical modeling as part of the EPA's 2005 multi-pollutant legislation assessment (http://www.epa.gov/airmarkets/mp/). As such, it should be noted that this national-scale inventory is not a local scale inventory in that it does not contain all of the parameters typical for use in a local-scale assessment such as building parameters, fugitive and area source release parameters, and dimensions and locations for individual stacks. In addition, although stack-level emissions are provided for facilities in this national inventory, these estimates do not include detailed site specific stack parameters for all sources because, in many situations, stack parameters were defaulted based on either the process or industrial characterization for the facilities. In lieu of a detailed local scale inventory for each of these areas, we employed the national inventory and accepted its inherent limitations.

The SMOKE modeling system was used to generate temporalized and speciated PM2.5 emissions and sulfuric acid (SULF) from all source sectors emitting these pollutants emissions. The species of PM2.5 emissions generated here are the following:

- PSO4—Primary sulfate,
- PNO3—Primary nitrate,
- POA—Primary organic aerosol,
- PEC—Primary elemental carbon, and
- PMFINE— Primary "other" reflecting the remaining mass not included in above categories.

In addition to the above PM2.5 species, SULF (sulfuric acid), which is generated during SMOKE emissions modeling from SO2, was added to the SMOKE generated PSO4 prior to modeling in AERMOD as this is the approach used in CMAQ modeling.

Table 1 provides the source sectors of primary PM2.5 for the emissions inventory as processed by SMOKE. For each area, the following source sectors were modeled with AERMOD:

- Birmingham—all source sectors
- Detroit—all source sectors
- Seattle—ptipm, ptnonipm and certain oarea (residential wood, commercial cooking and natural gas combustion) and nonroad (airport-related sources and commercial marine vessel).

These source sectors were selected based on a review of their importance from an emissions standpoint within each urban area (see Table 3 for emissions data by sector).

Table 1. Inventory Sectors of Primary PM2.5 Emission Inventory

SMOKE Inventory Sector	Description
ptipm	Point sources: Electric Generating Units from the IPM 2015 CAIR, CAMR, CAVR case
ptnonipm	Point sources: nonEGU
ptfdust	Point sources: fugitive dust
oarea	Stationary non-point sources excluding fugitive dust and fires (county-level)
afdust	Stationary non-point fugitive dust sources (county-level)
avgfires	Fires–average fires used for wildfires and prescribed burning, and open burning (county-level)
Mobile	Onroad mobile sources (county-level)
Nonroad	Nonroad mobile sources (county-level)

The temporal resolution of the emissions generated from SMOKE was different for different source sectors. For fugitive dust sectors, hourly emissions were provided for a representative day for each season. For avgfires, hourly emissions were provided for a representative day for each month. For all other sectors, hourly emissions were provided from SMOKE for a representative Saturday, Sunday, Monday and Tuesday, as well as any special days, mostly holidays in the month. Tuesday was used as a representative weekday (excluding Monday).

The SMOKE generated hourly emissions for representative days were mapped to every day for the relevant months. For each urban area, emissions for four individual months representing each season, were generated for input into AERMOD as follows:

- Birmingham — February, April, June and September,
- Detroit — January, April, July and November, and
- Seattle — January, April, August and November.

AERMOD computes concentrations by source groups that can then be used to analyze the relative impacts of different types of emissions sources. AERMOD can use up to 100 source groups. We assigned source groups within the SMOKE source sectors listed in Table 1 to capture the relative impacts of more refined source groups. The general approach was to capture the largest facilities (i.e., emissions greater than 50 tons per year in the inventory) and large groups of county-level emissions within the other SMOKE source sectors.

Table 2 shows the detailed source groupings used for each urban area as processed by SMOKE in developing model-ready emissions inputs to AERMOD. As shown, for example, area fugitive dust sector is composed of four sub-groupings including agriculture-related, construction-related, road-related, and other. Furthermore, “IPM” and “nonIPM” source groups in Table 2 are an aggregate of those individual point sources not individually distinguished as a separate stationary point source. Tables 3 and 4 provide sector and county total emission summaries of primary PM2.5 emissions for the emission domains for each of the three cities.

Table 2. Detailed source groups used for each urban area in emission processing

Group Number	SMOKE Inventory Sector	Detailed Source Group
00	IPM	IPM sources not categorized as individual sources
01	non IPM	non IPM sources not categorized as individual sources
02	point fugitive dust	point fugitive dust
03	area fugitive dust	area fugitive dust other (i.e., not agriculture, construction or road-related)
04	area fugitive dust	area fugitive dust, agriculture-related
05	area fugitive dust	area fugitive dust, construction-related
06	area fugitive dust	area fugitive dust, road-related (paved/unpaved roads)
07	nonroad	aircraft
08	nonroad	Commercial marine vessel
09	nonroad	locomotives
10	nonroad	nonroad gasoline
11	nonroad	other nonroad (diesel (not including locomotives), CNG, LPG)
12	mobile	onroad gasoline
13	mobile	onroad diesel
14	avgfires	Wildfires
15	avgfires	prescribed burning
16	avgfires	agricultural burning
17	avgfires	open burning
18	oarea	residential wood burning
19	oarea	commercial cooking
20	oarea	natural gas combustion
21	oarea	residential waste burning
22	oarea	other oarea
41-70	individual IPM sources	individual IPM sources
80-99	individual non IPM sources	individual non IPM sources

Table 3. Sector Emissions Summary for Birmingham, Detroit and Seattle AERMOD Emission Domains

		Pollutant Emissions (tons)						
	Sector	**POA**	**PEC**	**PMFINE**	**PNO3**	**PSO4**	**SULF**	**Total PM 2.5**
Birmingham 11-county area	**NonEGU**	2,289	211	7,177	52	2,776	216	12,722
	EGU	1,238	62	3,869	31	990	2,489	8,679
	Afdust	273	21	3,737	4	8	0	4,043
	Other Area	1,314	170	2,045	7	324	64	3,924
	Average Fire	2,848	451	511	9	63	0	3,883
	Nonroad	297	303	32	3	17	0	651
	On-Road	183	168	56	1	9	0	417
	Pfdust	10	1	154	0	0	0	165
	Total	8,452	1,388	17,581	106	4,188	2,769	34,485
Detroit 10-county area	**EGU**	2,417	121	7,545	60	1,932	5,941	18,016
	Afdust	735	56	10,409	11	20	0	11,231
	Other Area	4,717	536	3,723	23	790	388	10,178
	NonEGU	1,103	140	2,692	18	1,212	113	5,278
	Nonroad	822	868	161	7	162	0	2,020
	On-Road	554	474	174	2	28	0	1,231
	Average Fire	338	28	122	1	6	0	495
	Pfdust	1	0	14	0	0	0	15
	Total	10,687	2,222	24,840	122	4,150	6,442	48,463
Seattle 9-county area	**Other Area**	3,128	319	2,488	9	298	23	6,264
	EGU	548	23	1,449	12	395	271	2,698
	Nonroad	882	911	191	7	267	0	2,258
	NonEGU	364	70	1,055	7	536	11	2,043
	Average Fire	1,230	189	234	4	27	0	1,685
	Afdust	96	8	1,206	1	4	0	1,314
	On-Road	403	345	126	1	20	0	896
	Pfdust	0	0	0	0	0	0	0
	Total	6,652	1,865	6,748	41	1,547	306	17,159

Table 4. County-level Emissions Summary in Detroit Birmingham, Detroit and Seattle AERMOD Emission Domains

		Pollutant Emissions (tons)						
	County	POA	PEC	PMFINE	PNO3	PSO4	SULF	Total PM 2.5
Birmingham Counties	Bibb	315	68	213	1	24	1	622
	Blount	238	54	619	1	27	3	942
	Chilton	303	69	371	1	32	4	780
	Coosa	215	46	167	1	13	0	443
	Cullman	338	75	995	2	30	9	1,448
	Jefferson	3,063	413	7,921	54	2,388	1,155	14,993
	St Clair	310	79	550	2	87	3	1,031
	Shelby	1,269	177	2,742	20	743	652	5,603
	Talladega	524	125	1,067	4	327	215	2,263
	Tuscaloosa	1,034	168	858	5	103	22	2,190
	Walker	844	113	2,078	14	417	705	4,170
	Birmingham Total	**8,452**	**1,388**	**17,581**	**106**	**4,188**	**2,769**	**34,485**
Detroit Counties	Genesee	844	200	1,954	5	103	46	3,152
	Lapeer	231	69	1,139	2	32	7	1,479
	Lenawee	400	71	1,476	3	75	8	2,032
	Livingston	573	117	1,783	4	78	7	2,563
	Macomb	862	194	1,487	7	175	65	2,790
	Monroe	1,528	188	5,888	36	1,475	2,782	11,897
	Oakland	1,391	353	2,046	9	214	136	4,148
	St Clair	1,176	184	3,672	21	682	2,038	7,773
	Washtenaw	579	142	1,571	4	80	31	2,407
	Wayne	3,103	705	3,823	32	1,235	1,324	10,222
	Detroit Total	**10,687**	**2,222**	**24,840**	**122**	**4,150**	**6,442**	**48,463**
Seattle Counties	Island	192	53	466	1	19	0	731
	Jefferson	266	48	219	2	140	1	676
	King	2,171	774	957	10	345	14	4,271
	Kitsap	574	105	680	2	34	2	1,398
	Lewis	866	112	1,844	14	409	215	3,460
	Mason	237	50	277	1	16	1	582
	Pierce	902	319	874	7	435	70	2,606
	Snohomish	951	288	894	4	105	2	2,243
	Thurston	494	116	536	2	44	1	1,193
	Seattle Total	6,652	1,865	6,748	41	1,547	306	17,159

I.C Meteorological Inputs and Surface Characteristics

Meteorological inputs for AERMOD were generated by AERMET, which is the meteorology pre-processing program that inputs meteorological and surface information to calculate the boundary layer parameters for use by AERMOD to generate profiles of the needed meteorological variables.[5] AERMET uses meteorological measurements representative of the modeling domain to compute certain boundary layer parameters needed to estimate profiles of wind, turbulence and temperature. For this assessment, we used 2001 meteorological observations for each urban area from National Weather Service (NWS) surface and corresponding upper air stations. Table 5 provides information on the NWS station sites that were used as representative of each urban area, i.e., Birmingham, Detroit, and Seattle. The surface station sites were chosen based on their geographic representation of the area of interest, while the upper air stations were chosen based on their proximity and their meteorological compatibility with the corresponding surface station.

Table 5. Summary of National Weather Service Station Sites For Each Urban Area

WBAN #	Station Name	Lat (degrees)	Lon (degrees)	Elevation (m)
Surface Station Sites				
13876	Birmingham Municipal	+33.57	-86.75	+189
9484	Detroit Metro. Airport	+42.22	-83.35	+194
24233	Seattle-Tacoma Intl	+47.47	-122.32	+122
Upper Air Station Sites				
53823	Birmingham	+33.17	-86.77	
4830	Detroit/Pontiac	+42.70	-83.47	
94240	Quillayute	+47.95	-124.55	

AERMET processes the meteorological data in the following three stages:

1) The first stage extracts meteorological data from archive data files and processes the data through various quality assessment checks.
2) The second stage merges all data available for 24-hour periods (NWS and site-specific data) and stores these data together in a single file.
3) The third stage reads the merged meteorological data and estimates the necessary boundary layer parameters for use by AERMOD.

The parameterization of the boundary layer and the dispersion of pollutants within it are influenced on a local scale by surface characteristics such as surface roughness, reflectivity (albedo), and the availability of surface moisture (Bowen ratio).

These surface characteristics depend on land-use type (e.g., urban area, deciduous/coniferous forest, cultivated land, calm waters) and vary with the seasons and wind direction. We used land use data at a 30m resolution from the National Land Cover

Dataset (NLCD) provided by USGS and the Earth Resources Observation & Science (EROS).[1] Based on this data, Table 6 provides the percentage of each dense receptor domain falling in each of seven land use categories.

Table 6: Distribution of Land Use within Modeling Domain for each Urban Area

Land Use Category		Percent of Domain (%)		
NLCD Land Use Category[1]	**AERMET Land Use Category[2]**	**Birmingham**	**Detroit**	**Seattle**
Commercial/Industrial/Transportation	Industrial (Urban)	20	34	20
Low & High Intensity Residential	Residential (Urban)	50	42	55
Deciduous Forest & Mixed Forest[3]	Deciduous Forest	20	10	7
Evergreen Forest & Mixed Forest[3]	Coniferous Forest	5	0	7
Grasslands/Herbaceous, Pasture Hay, Row Crops, Small Grains & Fallow	Cultivated Land	5	6	5
Open Water	Water[4]	0	2	6
Woody Wetlands & Emergent Herbaceous Wetlands	Swamp	0	6	0

[1] NLCD land use categories not listed in the table were either not present or minimally represented in the domain.
[2]The surface roughness values for the industrial (1m) and residential (0.5m) land use categories were taken from the CALPUFF User's Guide and the same values were applied for all four seasons. The seasonal albedo and Bowen ratio values were taken from the AERMET User's Guide for urban land use.
[3]For areas labeled by NLCD as mixed forest, 50% of the area was listed as being deciduous forest and 50% as coniferous forest.
[4]To avoid biasing the surface roughness low, the water land use category was incorporated as the percentage of land bordering water, instead of the percentage of the actual domain covered by water.

After having determined the land use categories describing each dense receptor grid and the associated surface characteristic values for each of these categories, we calculated the seasonal surface characteristic values for each area as shown in Table 7.

[1] Descriptions of this data can be found at http://landcover.usgs.gov/natllandcover.asp and data can be downloaded at http://edcftp.cr.usgs.gov/pub/data/landcover/states/.

Table 7: Surface Characteristics Used in AERMET for each Urban Area.

Urban Area	Season	Albedo	Bowen Ratio	Roughness (m)
Birmingham	Winter	0.40	0.5	0.62
	Spring	0.14	0.4	0.72
	Summer	0.15	0.8	0.79
	Fall	0.16	0.8	0.68
Detroit	Winter	0.37	1.5	0.61
	Spring	0.14	0.9	0.66
	Summer	0.16	1.6	0.70
	Fall	0.17	1.7	0.65
Seattle	Winter	0.36	1.5	0.61
	Spring	0.14	0.9	0.64
	Summer	0.15	1.6	0.67
	Fall	0.17	1.7	0.62

Note: Winter corresponds to December, January and February; Spring corresponds to March, April and May; Summer corresponds to June, July and August; and Fall corresponds to September, October and November.

In addition to the boundary layer parameters, AERMET passes all meteorological measurements of wind, temperature, and turbulence in a form AERMOD needs. Meteorological data for each area were processed by AERMET for the following months:

- Birmingham — February, April, June and September,
- Detroit — January, April, July and November, and
- Seattle — January, April, August and November.

Tables 8 through 10 provide 2001 monthly summary statistics for meteorological variables for each of these areas.

Table 8. Monthly Summary Statistics for Meteorological Variable in Birmingham: 2001.

MET Variables	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yr.
Avg. Daily Temp (^{0}F)	40.1	51.0	49.7	64.5	70.5	75.3	80.1	78.5	71.6	60.6	58.6	49.3	62.5
Total Precipitation (in)	5.2	4.4	8.4	7.3	5.3	7.5	3.6	7.4	6.3	2.4	4.2	4.8	66.7
Mean Wind Speed (mph)	5.9	6.8	7.7	6.9	5.4	5.0	4.5	4.2	4.7	5.5	5.0	6.2	5.7
Prevailing Wind Direction	NW	N	N	SW	SW	SE	N	E	N	SE	SE	N	N

Table 9. Monthly Summary Statistics for Meteorological Variables in Detroit: 2001.

MET Variables	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yr.
Avg. Daily Temp (^{0}F)	26.2	29.7	35.1	51.2	61.2	69.6	73.6	74.1	62.3	52.5	47.6	35.9	51.6
Total Precipitation (in)	0.7	2.9	0.9	3.2	3.7	3.4	1.2	2.9	4.3	6.8	2.4	2.2	34.5
Mean Wind Speed (mph)	9.5	11.0	9.7	9.8	8.6	7.4	7.6	7.5	8.2	11.0	9.9	10.2	9.2
Prevailing Wind Direction	SW	NW	NW	E	SW	S	NE	S	N	NW	NW	NW	NW

Table 10. Monthly Summary Statistics for Meteorological Variables in Seattle: 2001.

MET Variables	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yr.
Avg. Daily Temp (^{0}F)	42.0	40.7	45.4	48.0	55.4	57.6	62.5	64.8	59.8	50.9	46.7	41.5	51.3
Total Precipitation (in)	2.7	2.1	2.7	3.2	1.4	3.1	1.0	2.3	0.8	3.1	9.3	5.9	37.6
Mean Wind Speed (mph)	6.8	6.8	7.7	7.5	6.4	6.0	5.5	5.6	5.0	7.9	7.1	9.3	6.8
Prevailing Wind Direction	NE	N	NW	NW	NW	NW	NW	NW	N	NW	NW	SE	NW

I.D Terrain and Elevation Inputs

Terrain and elevation inputs were generated by AERMAP, which is a terrain pre-processor program to AERMOD that reads terrain data from United States Geological Survey (USGS) Digital Elevation Model (DEM) files. Receptor, monitor, and source locations are read into AERMAP to calculate the approximate elevation for each location as well as critical hill height values for each receptor.

The terrain around Birmingham, Detroit and Seattle was examined to determine whether or not terrain data was required for AERMOD simulations, i.e.,

- Birmingham lies at the southern end of the Appalachian Mountain chain. The area consists of valleys and ridges that run generally northeast to southwest. Differences in elevations between valley floors and the surrounding ridge tops are on the order of several hundred feet and so would require terrain as part of the analysis.

- Detroit is on the western side of the Detroit River that flows between Lake St. Clair and Lake Erie. The terrain is relatively flat with a variation of less than 100 feet between minimum and maximum elevations in and around the Detroit area. An area of rolling hills lies in a west-southwest to east-northeast direction with the closest hills located about 20 miles away to the north-northwest of the city.

- Seattle lies along the eastern shore of Puget Sound. On the western shore, mountains rise up to over 7,000 feet. To the east, the terrain rises into the Cascade Mountains where mountain heights are generally over 7,000 feet. These mountain ranges are oriented north-south and are about 40 miles away from Seattle.

Where terrain is significant, AERMOD needs to account for terrain effects on air dispersion. Therefore, we prepared terrain data for Birmingham and Seattle and it was preprocessed through AERMAP. Detroit was modeled as flat terrain and therefore did not require any preprocessing from AERMAP.

II. Control Strategy Assessment

We attempted to identify the both the existing PM controls that may operate at individual point sources or source categories and available incremental PM controls that could be applied to these sources. We focused on those individual sources or source categories that were major contributors to the PM2.5 concentrations at the monitors with the highest concentrations in these three nonattainment areas. The definition of major contributor employed in this effort was a contribution of 1 percent or more to concentrations at the monitors considered in this analysis. Our understanding of existing controls was based upon information in the emissions inventory, multiple MACTs (Maximum Achievable Control Standards), and permit data. As summarized in Table 11, we used this information in conjunction with recent research reports to determine lower and upper bounds for additional PM controls for each point source or source category.[7, 8]

Table 11. Summary of Primary PM2.5 Control Measures Applicable to Source Categories/Groups as Part of Local-Scale Assessment for Three Urban Areas

Source Category	**Control Measures: Description**	**Control Measures: Comments**	**Incremental Percent Reduction: Lower Bound**	**Incremental Percent Reduction: Upper Bound**
Utility Boilers	Electrostatic Precipitator (ESP) upgrades	For utilities, virtually all PM2.5 is emitted from the ESP stack. Estimate a range of 20 (lower bound) to 70 (upper bound) percent for potential emission reductions with the lower bound reflecting new parallel plates, wiring, and other standard upgrades; and the upper bound reflecting application of the Indigo Agglomerator or other advanced ESP upgrades.	20	70
Integrated Iron and Steel Production	Baghouses, cupolas on blast oxygen furnaces (BOFs) and improved operating and maintenance (O&M) (for example bag leak detectors).	Data obtained in development of MACT standard indicate baghouses already on most of these sources, providing 97 to 99% reduction from uncontrolled. Evidence suggests improved O&M techniques such as bag leak detections can yield additional reductions on order of 5%.	5	10
Mineral Wool	N/A	Most mineral wood units already have baghouses installed – no additional control expected. Baghouses yield 97 to 99% reduction.	0	0
Pulp and Paper Mills	Most mills have ESPs or baghouses available as particulate controls.	Baghouses yield 95-99% reductions from uncontrolled. Lower bound estimates for category from pulp and paper mills sector project; upper bound assumes meeting new source MACT levels.	10	24
Portland Cement Production	N/A	Most cement kilns should be controlled already by baghouse or ESPs (95 to 99% reduction from uncontrolled). Limited opportunities for additional controls.	0	0
Petroleum Refineries	Improve performance of controls such as wet gas scrubbers on Fluid Catalytic	Many refineries affected by NSR refinery settlements required to apply new PM controls or upgrade existing	76	76

Source Category	Control Measures: Description	Control Measures: Comments	Incremental Percent Reduction: Lower Bound	Incremental Percent Reduction: Upper Bound
	Converter (FCC) units.	ones. Because wet gas scrubber not required on FCC, assume 90% control for PM available. Available data on emissions suggests 76% reductions available from refineries including in this assessment		
Coke Ovens	1) Reduce "green pushes" – emissions due to incomplete combustion in ovens; (2) Compliance with 2003 MACT opacity limit at combustion stack (3) desulfurize coke oven gas	Assume 60% of coke emissions are from pushing and battery stacks with an estimated 25% reduction (or 15% total reduction). Assume 90% reduction of primary sulfates from coke oven gas desulfurization. Given available information, presume 15% reduction available.	15	15
Natural Gas Combustion	N/A	Overestimation in our current inventories due to new emissions factor (94% reduction) has been accounted for in this assessment.	0	0
IPM sources not categorized as individual sources	N/A	Too aggregated to specify controls	0	0
non IPM sources not categorized as individual sources	N/A	Too aggregated to specify controls	0	0
Point Fugitive Dust	Various measures such as housekeeping practices for truck traffic, chemical suppression, watering, sweeping of paved roads, etc	Expect a modest amount of reduction (~5%) possible via available controls or practices.	5	5
Other Area Sources	N/A	Too aggregated to specify controls	0	0

Source Category	Control Measures: Description	Control Measures: Comments	Incremental Percent Reduction: Lower Bound	Incremental Percent Reduction: Upper Bound
Commercial Cooking	Catalyst oxidizer for conveyorized charbroilers, small ESP or scrubber for large restaurant underfired charbroilers, none for other types of commercial cookers>	Catalyst controls for conveyorized: 8% reduction (83 % reduction of 10% of inventory). ESP or scrubber controls for underfired: 7% reduction (assume controls only for largest 10-15% of emitting restaurants). Overall control for entire category: 15 % reduction as a lower bound with 20% as an upper bound.	15	20
Clay refractories	N/A	No controls available for these sources.	0	0
Area Fugitive Dust, Construction-Related	Dust control plans for construction sites	Estimate a 62.5% PM2.5 reduction to be applicable to 15% of controllable emissions.	9	12
Area Fugitive Dust, Road-Related (Paved/Unpaved Roads)	Vacuum sweeping for paved roads, chemical stabilization/suppression, and hot asphalt paving for unpaved roads.	Estimate a 25% PM2.5 reduction expected from either vacuum sweeping or chemical stabilization/suppression for paved roads; 25% PM2.5 reduction for unpaved roads. Presume applicability to 15% of controllable emissions.	4	8
Prescribed Burning	Increase fuel moisture by removing lighter and dryer fueled material or burning in early spring when moisture level are typically higher.	PM2.5 reductions of 50% are possible. Presuming little forestry acreage within this urban area, assume little more than 5% reduction of emissions possible.	5	10
CMV (Commercial and Marine Vessel) – nonroad engine category	Diesel retrofit controls such as diesel oxidation catalysts (DOCs) and catalyzed diesel particulate filter (CDPF). The latter is useful if fuel used is ultra-low sulfur diesel	There is limited data on direct PM2.5 reductions. Some control possible for local marine vehicles (ferries, etc). DOCs can provide 20 to 50% control. CDPFs can provide up to 90% control.	5	10

Source Category	Control Measures: Description	Control Measures: Comments	Incremental Percent Reduction: Lower Bound	Incremental Percent Reduction: Upper Bound
Residential Waste Burning	Episodic ban on open burning	100% control possible per application. The Seattle area already has some of most aggressive open burning programs in US, thus this area will not likely reduce emissions from current levels.	10	20
Residential Wood Burning	NSPS-compliant woodstove changeouts (new woodstoves replacing older, higher-polluting ones), Curtailment programs (i.e., bans on burning for days with expected poor PM2.5 air quality)	Estimate a 98% reduction of PM2.5 based on switch to NSPS compliant woodstoves. Assume 10% replacement to yield an estimated total reduction of 9.8%. Lower bound assumes no additional effectiveness over and above changeout program. Upper bound assumes some additional effectiveness, perhaps by requiring curtailment for both certified and non-certified stoves.	10	30

III. Modeling Results

This section provides results of the local-scale modeling for each urban area. The modeling shows large spatial concentration gradients within the urban areas that are not predicted by the regional-scale, photochemical grid modeling (i.e., CMAQ). Therefore, the local modeling provides important complementary modeling results in evaluating the ability of areas to attain future PM2.5 standards. The results indicate that primary PM2.5 emissions from local sources are a significant contributor to PM2.5 concentrations. The most influential sources varied by receptor location depending on proximity to sources, especially in the case of the daily standard.

This assessment shows that controls on primary PM2.5 emissions from local sources can play an important role in attaining the PM2.5 standards. It demonstrates that known controls can provide significant reductions in incremental concentrations of PM2.5 required to meet an annual and daily standard. Tables 12 and 13 provide summaries of the annual and daily modeling results, respectively, for each urban area.

Table 12 provides a summary of the annual results for local-scale modeling in Birmingham and Detroit for 2015. Seattle is not included in this table because in it projected to attain the current annual NAAQS by 2015. This table indicates that the contributions of primary PM2.5 from local sources are a significant share of concentrations at projected 2015 nonattainment monitors but are not the majority contributor (i.e., roughly 30 percent in Birmingham and between 10 and 23 percent in Detroit). In fact, these local source contributions are higher at each monitor location than the incremental concentrations of PM2.5 required to meet an annual standard of 15 ug/m3. However, based on known controls on these local sources, the potential reductions from these sources is between 20 and 30 percent of the amount needed to attain at monitors in Birmingham and between 17 and 50 percent of the amount at monitors in Detroit.

Table 12. Summary of AERMOD Local-Scale Modeling Results for Birmingham, AL and Detroit, MI: Annual Standard in 2015

				Model Predicted Annual Concentrations (ug/m3)		
					Potential Control Reduction: All Local Sources	
Location	**AIRS Site Code**	**Projected 2015 Annual DV (ug/m3)**	**2015 Ambient Target (ug/m3)**	**Primary PM2.5 Contribution: All Local Sources**	**Lower Bound**	**Upper Bound**
			Birmingham, Alabama			
Jefferson County	10730023	17.36	2.36	5.40	0.53	0.69
				228.9%	22.4%	29.2%
Jefferson County	10732003	17.08	2.08	5.01	0.41	0.57
				240.8%	19.9%	27.5%
			Detroit, Michigan			
Wayne County	261630015	16.21	1.21	3.51	0.32	0.60
				290.0%	26.5%	49.3%
Wayne County	261630033	17.95	2.95	4.05	0.47	0.64
				137.4%	16.0%	21.6%
Wayne County	261630036	15.70	0.70	1.61	0.12	0.28
				230.6%	16.9%	39.9%

Note: Percentages reflect the share of ambient target for the concentration estimate above it.

Table 13 provides a summary of the daily results for local-scale modeling in Birmingham, Detroit, and Seattle for 2015. As shown for the annual results, this table indicates that the contributions of primary PM2.5 from local sources are a significant share of concentrations at projected 2015 nonattainment monitors but are not the majority contributor (i.e., from 30 to 35 percent in Birmingham, from 8 and 21 percent in Detroit, and from 6 to 9 percent in Seattle). In fact, at each monitor location, these local source contributions are greater than the incremental concentrations of PM2.5 required to meet a daily standard of 35 ug/m3. However, based on known controls on these local sources, the potential reductions from these sources is between 20 and 35 percent of the required amount at monitors in Birmingham, between 7 and 34 percent of the required amount at monitors in Detroit, and between 5 and 50 percent of the required amount at monitors in Seattle.

Table 13. Summary of AERMOD Local-Scale Modeling Results for Birmingham, Detroit, and Seattle: Daily PM2.5 Standard in 2015

				Model Predicted Daily Concentrations (ug/m3)		
					Potential Control Reduction: All Local Sources	
Location	AIRS Site Code	Projected 2015 Daily DV (ug/m3)	2015 Ambient Target (ug/m3)	Primary PM2.5 Contribution: All Local Sources	Lower Bound	Upper Bound
			Birmingham, Alabama			
Jefferson County	10730023	41.8	6.8	14.69	1.79	2.33
				216.1%	26.4%	34.3%
Jefferson County	10732003	39.1	4.1	11.80	0.80	1.19
				287.9%	19.5%	29.1%
			Detroit, Michigan			
Wayne County	261630015	38.6	3.6	7.98	0.46	1.22
				221.6%	12.7%	33.9%
Wayne County	261630033	41.5	6.5	7.88	1.06	1.63
				121.2%	16.3%	25.1%
Wayne County	261630001	36.8	1.8	3.05	0.13	0.24
				169.4%	7.2%	13.5%
Wayne County	261630016	39.4	4.4	6.50	0.45	0.83
				147.7%	10.3%	18.9%
			Seattle, Washington			
Pierce County	530330029	38.8	3.8	2.37	0.21	0.46
				62.4%	5.4%	12.0%
Snohomish County	530611007	36.6	1.6	3.41	0.33	0.85
				213.3%	20.4%	53.0%

Note: Percentages reflect the share of ambient target for the concentration estimate above it.

The following sections provide more detailed modeling results for each area including tables with source contributions of primary PM2.5 to monitors of interest (i.e., potential annual and daily exceedences of proposed standard) and graphs illustrating the spatial gradient of primary PM2.5 for the urban area.

Birmingham

Tables 14 and 15 show the AERMOD modeling results for primary PM2.5 impacts at monitor locations in Jefferson County exceeding the proposed annual (15 ug/m^3) and daily (35 ug/m^3) standards, respectively. In addition, Figure 5 provides the spatial gradient of primary PM2.5 for the urban area associated with emissions from all sources. For the annual standard, as shown in Table 14, the Jefferson County monitor #10730023 is expected to exceed 15 ug/m^3 by 2.36 ug/m^3 in 2015. The modeling results indicate that local sources of primary PM2.5 contribute 5.4 ug/m^3 to this monitor location; however, the application of known controls would yield only 0.53 to 0.69 ug/m^3 reduction. Metal processing, mineral/rock wool manufacturing, and other industrial sources contribute significantly to this monitor with a combined contribution of 3.1 ug/m^3 of the 5.4 ug/m^3 total contribution from all modeled sources, or 58 percent. Table 14 also shows that the Jefferson County monitor #10732003 is expected to exceed 15 ug/m^3 by roughly 2.1 ug/m^3 in 2015. The modeling results indicate that local sources of primary PM2.5 contribute 5.0 ug/m^3 to this monitor location; however, the application of known controls would yield only 0.41 to 0.57 ug/m^3 reduction in annual PM2.5 concentrations here. Metal processing and other industrial sources contribute significantly to this monitor with a combined contribution of 3.45 ug/m^3 of the 5.0 ug/m^3 total contribution from all modeled sources, or 69 percent.

For the daily standard, as shown in Table 15, the Jefferson County monitor #10730023 is expected to exceed 35 ug/m^3 by 6.8 ug/m^3 in 2015. The modeling results indicate that local sources of primary PM2.5 contribute 14.69 ug/m^3 to this monitor location; however, the application of known controls would yield only 1.8 to 2.3 ug/m^3 reduction. As with the annual concentrations at this monitor, the most significant contributors are metal processing and other industrial sources in addition to mining operations. Table 15 also shows that the Jefferson County monitor #10732003 is expected to exceed 35 ug/m^3 by 4.1 ug/m^3 in 2015. The modeling results indicate that local sources of primary PM2.5 contribute 11.8 ug/m^3 to this monitor location; however, the application of known controls would yield only 0.8 to 1.2 ug/m^3 reduction in PM2.5 concentrations here. As with the annual concentrations at this monitor, the most significant contributors are metal processing and other industrial sources in addition to point fugitive dust.

Table 14. Summary of Modeled Source Contributions of Primary PM2.5 to Monitors with Potential Annual Exceedences in Birmingham: 2015

		Model Predicted Annual Concentrations (ug/m3)		
			Potential Control Reduction	
Source Sectors	Primary PM2.5 Emissions (ton/yr)	Primary PM2.5 Contribution	Lower Bound	Upper Bound
		Jefferson County Monitor #10730023, Annual DV = 17.36**		
Metal Processing	6,142	1.755	0.406	0.512
Mineral/Rock Wool	501	0.874	0.000	0.000
Other industrial sources	2,089	0.496	0.000	0.000
Point fugitive dust	161	0.352	0.018	0.018
Other area	701	0.328	0.000	0.000
Commercial cooking	321	0.303	0.030	0.061
Mining	1,357	0.292	0.043	0.043
Area fugitive dust	3,927	0.276	0.017	0.027
Nonroad (gasoline and diesel)	501	0.148	0.000	0.000
Onroad (gasoline and diesel)	396	0.120	0.000	0.000
Residential wood burning	891	0.097	0.010	0.019
Prescribed/open burning	3,826	0.080	0.003	0.005
CMV, Aircraft, Locomotive	142	0.069	0.000	0.000
Power Sector	8,435	0.057	0.000	0.000
Wildfires	1,423	0.041	0.000	0.000
Paper and Forest Products	1,130	0.032	0.000	0.000
Natural gas combustion*	35	0.029	0.000	0.000
Residential waste burning	1,287	0.026	0.003	0.005
Cement Manufacturing	791	0.017	0.000	0.000
Structural Clay and Bricks	311	0.012	0.000	0.000
Agricultural burning	23	0.000	0.000	0.000
Total, All Sources	34,388	5.402	0.529	0.689
		Jefferson County Monitor #10732003, Annual DV = 17.08		
Metal Processing	6,142	3.064	0.332	0.464
Other industrial sources	2,089	0.393	0.000	0.000
Area fugitive dust	3,927	0.259	0.017	0.025
Point fugitive dust	161	0.209	0.010	0.010
Other area	701	0.165	0.000	0.000
Commercial cooking	321	0.149	0.022	0.030
Mining	1,357	0.144	0.020	0.020
Prescribed/open burning	3,826	0.094	0.003	0.006
Nonroad (gasoline and diesel)	501	0.081	0.000	0.000
Onroad (gasoline and diesel)	396	0.073	0.000	0.000
Power Sector	8,435	0.065	0.000	0.000
Mineral/Rock Wool	501	0.062	0.000	0.000
Residential wood burning	891	0.058	0.006	0.012
Wildfires	1,423	0.048	0.000	0.000
CMV, Aircraft, Locomotive	142	0.033	0.000	0.000
Structural Clay and Bricks	311	0.029	0.000	0.000
Residential waste burning	1,287	0.027	0.003	0.005
Cement Manufacturing	791	0.021	0.000	0.000
Paper and Forest Products	1,130	0.018	0.000	0.000
Natural gas combustion*	35	0.015	0.000	0.000
Agricultural burning	23	0.000	0.000	0.000
Total, All Sources	34,388	5.009	0.413	0.573

*Natural gas combustion emissions are adjusted here to reflect 94 percent reduction in baseline emissions due to new emissions factor.

**Major point sources adjusted to reduce overestimate bias and better reflect incremental contribution to this monitor.

Table 15. Summary of Modeled Source Contributions of Primary PM2.5 to Monitors with Potential Daily Exceedences in Birmingham: 2015

		Model Predicted Daily Concentrations (ug/m3)***		
			Potential Control Reduction	
Source Sectors	**Primary PM2.5 Emissions (ton/yr)**	**Primary PM2.5 Contribution**	**Lower Bound**	**Upper Bound**
		Jefferson County Monitor #10730023, Daily DV = 41.8**		
Metal Processing	6,142	8.442	1.443	1.922
Mining	1,357	1.715	0.255	0.255
Other industrial sources	2,089	0.820	0.000	0.000
Natural Gas Combustion	35	0.589	0.000	0.000
Point fugitive dust	161	0.525	0.026	0.026
Mineral/Rock Wool	501	0.472	0.000	0.000
Other area sources	701	0.405	0.000	0.000
Commercial cooking	321	0.329	0.033	0.066
Prescribed/open burning	3,826	0.317	0.015	0.029
Area fugitive dust	3,927	0.300	0.020	0.030
Nonroad (gasoline and diesel)	501	0.236	0.000	0.000
Onroad (gasoline and diesel)	396	0.166	0.000	0.000
CMV, Aircraft, Locomotive	142	0.111	0.000	0.000
Power Sector	8,435	0.094	0.000	0.000
Paper and Forest Products	1,130	0.071	0.000	0.000
Cement Manufacturing	791	0.042	0.000	0.000
Residential waste burning	1,287	0.025	0.002	0.005
Wildfires	1,423	0.019	0.000	0.000
Structural Clay and Bricks	311	0.009	0.000	0.000
Residential wood burning	891	0.005	0.001	0.001
Agricultural burning	23	0.000	0.000	0.000
Total, All Sources	34,388	14.693	1.795	2.334
		Jefferson County Monitor #10732003, Daily DV = 39.1		
Metal Processing	6,142	9.535	0.716	1.079
Point fugitive dust	161	0.964	0.048	0.048
Other industrial sources	2,089	0.410	0.000	0.000
Area fugitive dust	3,927	0.180	0.012	0.018
Residential wood burning	891	0.125	0.013	0.025
Other area sources	701	0.117	0.000	0.000
Commercial cooking	321	0.101	0.010	0.020
Structural Clay and Bricks	311	0.060	0.000	0.000
Onroad (gasoline and diesel)	396	0.060	0.000	0.000
Nonroad (gasoline and diesel)	501	0.051	0.000	0.000
Wildfires	1,423	0.050	0.000	0.000
Cement Manufacturing	791	0.042	0.000	0.000
Prescribed/open burning	3,826	0.038	0.000	0.000
CMV, Aircraft, Locomotive	142	0.026	0.000	0.000
Natural Gas Combustion	35	0.013	0.000	0.000
Mining	1,357	0.012	0.001	0.001
Residential waste burning	1,287	0.010	0.001	0.002
Mineral/Rock Wool	501	0.004	0.000	0.000
Power Sector	8,435	0.003	0.000	0.000
Paper and Forest Products	1,130	0.001	0.000	0.000
Agricultural burning	23	0.001	0.000	0.000
Total, All Sources	34,388	11.805	0.800	1.193

*Natural gas combustion emissions are adjusted here to reflect 94 percent reduction in baseline emissions due to new emissions factor.
**Major point sources adjusted to reduce overestimate bias and better reflect incremental contribution to this monitor.
***Each daily results reflects the 98th percentile day or the 3rd highest day modeled with AERMOD so for monitor #10730023 that day is June 6th and for monitor #10732003 that day is Feb 14th.

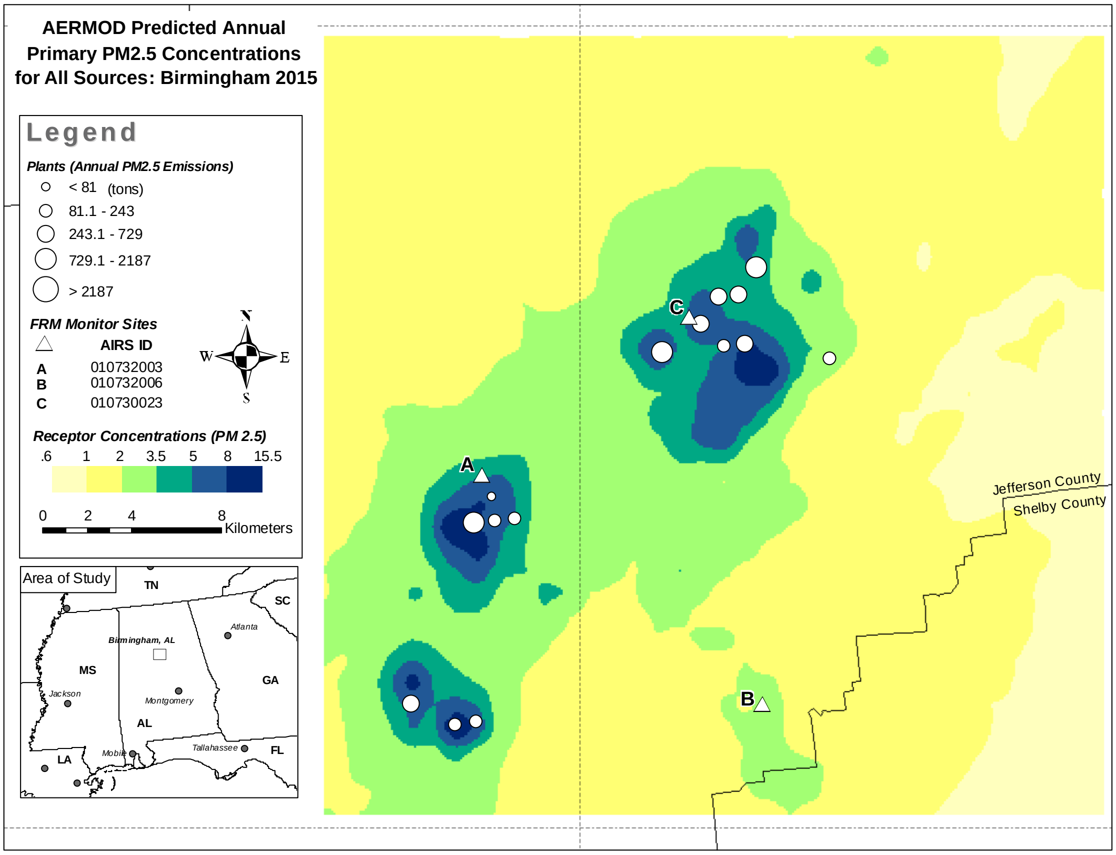

Figure 5. Spatial Gradient in Birmingham, AL of AERMOD Predicted Annual Primary PM2.5 Concentrations (ug/m^3) for All Sources: 2015

Note: Dashed lines reflect the 36km grid cells from regional-scale modeling with CMAQ model.

Detroit

Tables 16 and 17 show the AERMOD modeling results for primary PM2.5 impacts at monitor locations in Wayne County exceeding the proposed annual (15 ug/m^3) and daily (35 ug/m^3) standards, respectively. In addition, Figure 6 provides the spatial gradient of primary PM2.5 for the urban area associated with emissions from all sources. For the annual standard, as shown in Table 16, the Wayne County monitor #261630033 is expected to exceed 15 ug/m^3 by 2.95 ug/m^3 in 2015. The modeling results indicate that local sources of primary PM2.5 contribute 4.1 ug/m^3 to this monitor location; however, the application of known controls would yield only 0.47 to 0.64 ug/m^3 reduction. Table 16 also shows that the Wayne County monitor #261630015 is expected to exceed 15 ug/m^3 by roughly 1.2 ug/m^3 in 2015. The modeling results indicate that local sources of primary PM2.5 contribute 3.5 ug/m^3 to this monitor location; however, the application of known controls would yield only 0.32 to 0.6 ug/m^3 reduction in PM2.5 concentrations here. Wayne County monitor #261630036 is expected to exceed 15 ug/m^3 by roughly 0.7 ug/m^3 in 2015. The modeling results indicate that local sources of primary PM2.5 contribute 1.6 ug/m^3 to this monitor location; however, the application of known controls would yield only 0.12 to 0.28 ug/m^3 reduction in PM2.5 concentrations here.

Table 17 summaries the AERMOD daily concentrations at monitors expected to exceed 35 ug/m^3 in 2015. As shown in the table, the Wayne County monitor #261630033, which shows the highest daily design value (DV), is expected to exceed 35 ug/m^3 by 6.5 ug/m^3 in 2015. The modeling results indicate that local sources of primary PM2.5 contribute 7.9 ug/m^3 to this monitor location; however, the application of known controls would yield only 1.1 to 1.6 ug/m^3 reduction. Results for three other monitors are provided in the table.

Table 16. Summary of Modeled Source Contributions of Primary PM2.5 to Monitors with Potential Annual Exceedences in Detroit: 2015

		Model Predicted Annual Concentrations (ug/m3)		
			Potential Control Reduction	
Source Sectors	**Primary PM2.5 Emissions (ton/yr)**	**Primary PM2.5 Contribution**	**Lower Bound**	**Upper Bound**
Wayne County Monitor #261630033, Annual DV = 17.95				
Other industrial sources	2,217	1.074	0.189	0.189
Metal Processing	1,049	0.559	0.170	0.183
CMV, Aircraft, Locomotive	640	0.540	0.025	0.049
Onroad (gasoline and diesel)	1,209	0.347	0.000	0.000
Commercial cooking	1,075	0.296	0.044	0.059
Area fugitive dust	11,265	0.271	0.000	0.000
Other area sources	1,134	0.268	0.000	0.000
Power Sector	17,754	0.233	0.045	0.157
Nonroad (gasoline and diesel)	1,595	0.197	0.000	0.000
Residential wood burning	3,942	0.144	0.000	0.000
Natural gas combustion*	140	0.071	0.000	0.000
Residential waste burning	1,781	0.015	0.000	0.000
Glass Manufacturing	439	0.014	0.000	0.000
Cement Manufacturing	922	0.011	0.000	0.000
Auto Industry	589	0.008	0.000	0.000
Prescribed/open burning	471	0.004	0.000	0.000
Point fugitive dust	15	0.001	0.000	0.000
Wildfires	30	0.001	0.000	0.000
Total, All Sources	46,266	4.053	0.473	0.638
Wayne County Monitor #261630015, Annual DV = 16.21				
CMV, Aircraft, Locomotive	640	0.727	0.034	0.067
Other industrial sources	2,217	0.597	0.109	0.109
Metal Processing	1,049	0.492	0.044	0.099
Commercial cooking	1,075	0.398	0.060	0.080
Power Sector	17,754	0.311	0.061	0.212
Onroad (gasoline and diesel)	1,209	0.221	0.000	0.000
Area fugitive dust	11,265	0.210	0.000	0.000
Other area sources	1,134	0.196	0.000	0.000
Nonroad (gasoline and diesel)	1,595	0.147	0.000	0.000
Residential wood burning	3,942	0.131	0.000	0.000
Natural gas combustion*	140	0.029	0.000	0.000
Residential waste burning	1,781	0.013	0.000	0.000
Glass Manufacturing	439	0.012	0.000	0.000
Cement Manufacturing	922	0.011	0.000	0.000
Auto Industry	589	0.008	0.000	0.000
Prescribed/open burning	471	0.003	0.000	0.000
Point fugitive dust	15	0.001	0.000	0.000
Wildfires	30	0.000	0.000	0.000
Total, All Sources	46,266	3.509	0.307	0.567
Wayne County Monitor #261630036, Annual DV = 15.70				
Power Sector	17,754	0.286	0.056	0.195
Commercial cooking	1,075	0.214	0.032	0.043
Area fugitive dust	11,265	0.195	0.000	0.000
Other industrial sources	2,217	0.185	0.019	0.019
Residential wood burning	3,942	0.151	0.000	0.000
Nonroad (gasoline and diesel)	1,595	0.127	0.000	0.000
CMV, Aircraft, Locomotive	640	0.126	0.004	0.009
Other area sources	1,134	0.123	0.000	0.000
Metal Processing	1,049	0.066	0.007	0.014
Onroad (gasoline and diesel)	1,209	0.061	0.000	0.000
Natural gas combustion*	140	0.021	0.000	0.000
Glass Manufacturing	439	0.019	0.000	0.000
Residential waste burning	1,781	0.016	0.000	0.000
Cement Manufacturing	922	0.013	0.000	0.000
Auto Industry	589	0.006	0.000	0.000
Prescribed/open burning	471	0.003	0.000	0.000
Point fugitive dust	15	0.001	0.000	0.000
Wildfires	30	0.001	0.000	0.000
Total, All Sources	46,266	1.614	0.118	0.279

*Natural gas combustion source category results are adjusted to reflect new emissions factor (94 percent reduction).

Table 17. Summary of Modeled Source Contributions of Primary PM2.5 to Monitors with Potential Daily Exceedences in Detroit: 2015

		Model Predicted Daily Concentrations (ug/m3)		
			Potential Control Reduction	
Source Sectors	Primary PM2.5 Emissions (ton/yr)	Primary PM2.5 Contribution	Lower Bound	Upper Bound
	Wayne County Monitor #261630015, Daily DV = 38.6**			
CMV, Aircraft, Locomotive	640	2.082	0.100	0.199
Metal Processing	1,049	2.001	0.101	0.361
Other industrial sources	2,217	1.289	0.015	0.015
Power Sector	17,754	0.730	0.146	0.510
Commercial cooking	1,075	0.582	0.087	0.116
Natural gas combustion	140	0.466	0.000	0.000
Other area	1,134	0.204	0.000	0.000
Onroad (gasoline and diesel)	1,209	0.195	0.000	0.000
Area fugitive dust	11,265	0.177	0.000	0.000
Nonroad (gasoline and diesel)	1,595	0.118	0.000	0.000
Residential wood burning	3,942	0.085	0.009	0.017
Residential waste burning	1,781	0.022	0.002	0.004
Glass Manufacturing	439	0.011	0.000	0.000
Auto Industry	589	0.005	0.000	0.000
Prescribed/open burning	471	0.005	0.000	0.000
Cement Manufacturing	922	0.004	0.000	0.000
Point fugitive dust	15	0.003	0.000	0.000
Wildfires	30	0.000	0.000	0.000
Total, All Sources	46,266	7.978	0.459	1.222
	Wayne County Monitor #261630033, Daily DV = 41.5**			
Other industrial sources	2,217	2.539	0.547	0.547
Power Sector	17,754	0.896	0.178	0.622
CMV, Aircraft, Locomotive	640	0.833	0.038	0.076
Metal Processing	1,049	0.732	0.181	0.214
Commercial cooking	1,075	0.640	0.096	0.128
Area fugitive dust	11,265	0.601	0.000	0.000
Onroad (gasoline and diesel)	1,209	0.490	0.000	0.000
Other area	1,134	0.461	0.000	0.000
Nonroad (gasoline and diesel)	1,595	0.296	0.000	0.000
Residential wood burning	3,942	0.209	0.021	0.042
Natural gas combustion	140	0.063	0.000	0.000
Glass Manufacturing	439	0.033	0.000	0.000
Cement Manufacturing	922	0.032	0.000	0.000
Auto Industry	589	0.025	0.000	0.000
Residential waste burning	1,781	0.022	0.002	0.004
Prescribed/open burning	471	0.006	0.000	0.000
Point fugitive dust	15	0.002	0.000	0.000
Wildfires	30	0.000	0.000	0.000
Total, All Sources	46,266	7.879	1.062	1.633
	Wayne County Monitor #261630016, Daily DV = 39.4**			
Residential wood burning	3,942	3.337	0.334	0.667
Commercial cooking	1,075	0.740	0.111	0.148
Area fugitive dust	11,265	0.739	0.000	0.000
Other area	1,134	0.607	0.000	0.000
Other industrial sources	2,217	0.324	0.005	0.005
Nonroad (gasoline and diesel)	1,595	0.258	0.000	0.000
Onroad (gasoline and diesel)	1,209	0.236	0.000	0.000
Natural gas combustion	140	0.138	0.000	0.000
Auto Industry	589	0.059	0.000	0.000
CMV, Aircraft, Locomotive	640	0.022	0.000	0.000
Residential waste burning	1,781	0.013	0.001	0.003
Power Sector	17,754	0.009	0.002	0.006
Metal Processing	1,049	0.009	0.001	0.002
Prescribed/open burning	471	0.003	0.000	0.000
Cement Manufacturing	922	0.002	0.000	0.000
Glass Manufacturing	439	0.001	0.000	0.000
Point fugitive dust	15	0.000	0.000	0.000
Wildfires	30	0.000	0.000	0.000
Total, All Sources	46,266	6.498	0.454	0.831
	Wayne County Monitor #261630001, Daily DV = 36.8**			
Residential wood burning	3,942	1.011	0.101	0.202
Area fugitive dust	11,265	0.580	0.000	0.000
Other area	1,134	0.366	0.000	0.000
Onroad (gasoline and diesel)	1,209	0.307	0.000	0.000
Nonroad (gasoline and diesel)	1,595	0.236	0.000	0.000
Other industrial sources	2,217	0.225	0.006	0.006
Commercial cooking	1,075	0.106	0.016	0.021
CMV, Aircraft, Locomotive	640	0.025	0.000	0.000
Auto Industry	589	0.024	0.000	0.000
Residential waste burning	1,781	0.024	0.002	0.005
Power Sector	17,754	0.010	0.002	0.006
Metal Processing	1,049	0.008	0.001	0.002
Prescribed/open burning	471	0.008	0.000	0.000
Cement Manufacturing	922	0.003	0.000	0.000
Glass Manufacturing	439	0.002	0.000	0.000
Point fugitive dust	15	0.001	0.000	0.000
Wildfires	30	0.000	0.000	0.000
Natural gas combustion	140	0.113	0.000	0.000
Total, All Sources	46,266	3.049	0.129	0.243

*Natural gas combustion source category results are adjusted to reflect new emissions factor (94 percent reduction).
**Each daily results reflects the 98th percentile day or the 3rd highest day modeled with AERMOD so for monitor #261630015 that day is Nov 18th, for monitor #261630033 that day is Jan 1st, for monitor #261630033 that day is Nov 17th, and for monitor #261630001 that day is Jan 1st.

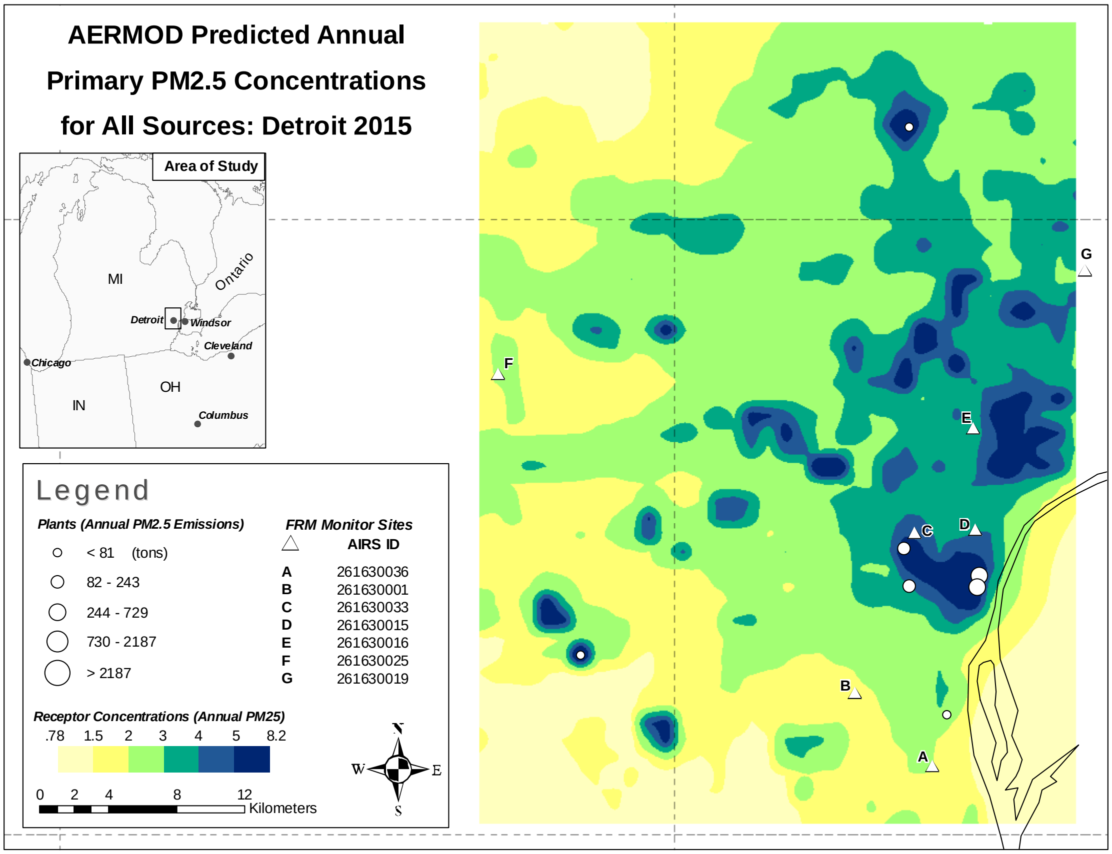

Figure 6. Spatial Gradient in Detroit, MI of AERMOD Predicted Annual Primary PM2.5 Concentrations (ug/m^3) for All Sources: 2015

Note: Dashed lines reflect the 36km grid cells from regional-scale modeling with CMAQ model.

Seattle

Table 18 shows the AERMOD modeling results for primary PM2.5 impacts at monitor locations in Pierce County exceeding the proposed daily (35 ug/m^3) standard. In addition, Figure 7 provides the spatial gradient of primary PM2.5 for the urban area associated with emissions from all modeled sources. For the daily standard, as shown in Table 18, the Pierce County monitor #530330029 is expected to exceed a 35 ug/m^3 daily standard by 3.8 ug/m^3 in 2015. The modeling results indicate that local sources of primary PM2.5 contribute 2.4 ug/m^3 to this monitor location; however, the application of known controls would yield only 0.21 to 0.46 ug/m^3 reduction in PM2.5 concentration here. Paper and forest products plants, commercial and marine vessels, residential wood burning, and commercial cooking contribute significantly to the Pierce County monitor's daily value with a combined contribution of just over 2 ug/m^3 of the 2.4 ug/m^3 total contribution from all modeled sources, or 85 percent. Table 18 also shows that the Snohomish County monitor #530611007 is expected to exceed a 35 ug/m^3 daily standard by 1.6 ug/m^3 in 2015. The modeling results indicate that local sources of primary PM2.5 contribute 3.4 ug/m^3 to this monitor location; however, the application of known controls would yield only 0.33 to 0.85 ug/m^3 reduction in PM2.5 concentration here. Residential wood and waste burning contribute significantly to the Snohomish County monitor's daily value with 3 ug/m^3 of the 3.4 ug/m^3 total contribution from all modeled sources, or almost 90 percent.

As discussed in Appendix A, the Seattle urban area was also evaluated using photochemical grid modeling through application of the Response Surface Model (RSM). There are important differences across these modeling approaches that limit the direct comparability of these modeling results. A major difference is that the RSM includes background and transported concentrations of direct PM2.5 within the urban area but focused only on organic components of primary PM2.5 whereas the AERMOD modeling was limited to only those emissions sources in the city and surrounding counties but included other direct species of PM2.5 like crustal materials. Despite these differences a comparison of results from these assessments provides insights of use here. For comparison purposes, in Snohomish county, the RSM suggests that direct PM2.5 emissions of carbon contribute around 2.2 ug/m^3 to the daily design value in 2015 whereas the AERMOD estimate for modeled sources here is 3.3 ug/m^3. This comparison suggests that there is an additional 50 percent contribution of direct PM2.5 attributable to a combination of direct PM2.5 emissions of crustal materials (which were not evaluated with the RSM approach) and the effect of "local" modeling that provides a more resolved spatial gradient within this urban area. Furthermore, both AERMOD and RSM predict that residential wood burning, which is an area source, is the major contributor at this monitor location. In King County, the RSM suggests that direct PM2.5 emissions of carbon contribute around 2.5 ug/m^3 to the daily design value which is comparable to the AERMOD prediction of 2.4 ug/m^3 from all modeled sources of direct PM2.5 emissions within Seattle. This indicates that background or transported concentrations of primary PM2.5 may be more important at this monitor location.

Table 18. Summary of Modeled Source Contributions of Primary PM2.5 to Monitors with Potential Daily Exceedences in Seattle: 2015

		Model Predicted Daily Concentrations (ug/m3)**		
			Potential Control Reduction	
Source Sectors	**Primary PM2.5 Emissions (ton/yr)**	**Primary PM2.5 Contribution**	**Lower Bound**	**Upper Bound**
	Pierce County Monitor #530330029, Daily DV = 38.8			
Paper and Forest Products	965	0.748	0.074	0.178
CMV	648	0.476	0.024	0.048
Residential wood burning	2,115	0.417	0.042	0.125
Commercial cooking	1,646	0.388	0.058	0.078
Other industrial sources	458	0.116	0.000	0.000
Power Sector	2,671	0.065	0.000	0.000
Residential waste burning	1,696	0.059	0.006	0.012
Metal Processing	283	0.036	0.002	0.015
Aircraft	114	0.027	0.000	0.000
Natural gas combusion	29	0.025	0.000	0.000
Cement and Mining	233	0.013	0.000	0.000
Nonroad (gasoline and diesel)	10	0.003	0.000	0.000
Naval Shipyards	107	0.000	0.000	0.000
Total, All Sources	10,976	2.373	0.205	0.456
	Snohomish County Monitor #530611007, Daily DV = 36.6			
Residential wood burning	2,115	2.114	0.211	0.634
Residential waste burning	1,696	0.891	0.089	0.178
Natural gas combusion	29	0.221	0.000	0.000
Commercial cooking	1,646	0.171	0.026	0.034
Aircraft	114	0.006	0.000	0.000
Paper and Forest Products	965	0.005	0.000	0.000
Other industrial sources	458	0.002	0.000	0.000
Metal Processing	283	0.001	0.000	0.001
Cement and Mining	233	0.001	0.000	0.000
Naval Shipyards	107	0.001	0.000	0.000
Power Sector	2,671	0.000	0.000	0.000
CMV	648	0.000	0.000	0.000
Nonroad (gasoline and diesel)	10	0.000	0.000	0.000
Total, All Sources	10,976	3.412	0.326	0.848

*Natural gas combustion emissions are adjusted here to reflect 94 percent reduction in baseline emissions due to new emissions factor.
**Each daily results reflects the 98th percentile day or the 3rd highest day modeled with AERMOD so for monitor #530330029 that day is Jan 11th and for monitor 530611007 that day is Jan 16th.

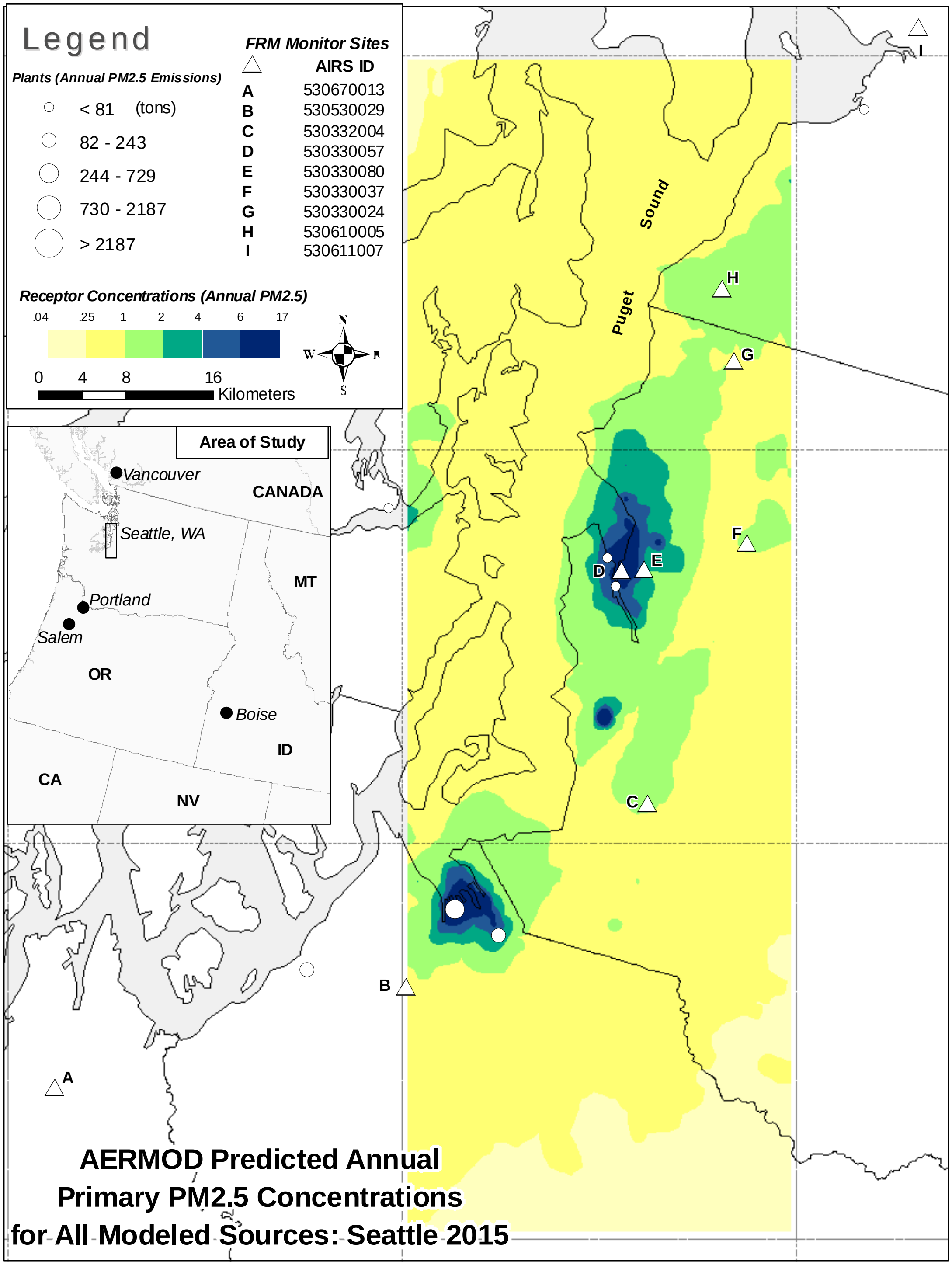

Figure 7. Spatial Gradient in Seattle, WA of AERMOD Predicted Annual Primary PM2.5 Concentrations (ug/m^3) for All Modeled Sources: 2015
Note: Dashed lines reflect the 36km grid cells from regional-scale modeling with CMAQ model.

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