Cincinnati-Hamilton, Ohio–Kentucky Area Designations for the

2012 Primary Annual $PM_{2.5}$ National Ambient Air Quality Standard

Technical Support Document

1.0 Summary

In accordance with Section 107(d) of the Clean Air Act (CAA), the EPA must promulgate designations for all areas of the country. In particular, EPA must identify those areas that are violating a National Ambient Air Quality Standard (NAAQS) or contributing to a violation of the NAAQS in a nearby area. EPA must complete this process within 2 years of promulgating a new or revised NAAQS, or may do so within 3 years under circumstances not relevant to these designations.[1] This technical support document (TSD) describes the EPA's intent to designate areas in Ohio and Kentucky as nonattainment for the 2012 primary annual fine particle NAAQS (2012 annual $PM_{2.5}$ NAAQS).[2]

Under section 107(d), states are required to submit area designation recommendations to the EPA for the 2012 annual $PM_{2.5}$ NAAQS no later than 1 year following promulgation of the standard, or by December 13, 2013. In December, 2013, Ohio recommended that the counties identified in Table 1 be designated as nonattainment for the 2012 annual $PM_{2.5}$ NAAQS based on air quality data from 2010-2012. Kentucky also submitted recommendations in December, 2013, recommending attainment of the counties listed in Table 1 based on 2010-2012 air quality data.

After considering these recommendations and based on EPA's technical analysis as described in this TSD, the EPA intends to designate the areas listed in Table 1 as nonattainment for the 2012 annual $PM_{2.5}$ standard. EPA must designate an area nonattainment if it has an air quality monitoring site[3] that is violating the standard or if it has sources of emissions that are contributing to a violation of the NAAQS in a nearby area. Legal descriptions (e.g., county boundaries, townships and ranges) of these areas are found below in the supporting technical analysis for each area. As provided in CAA section 188(a), the EPA will initially classify all nonattainment areas as "Moderate" nonattainment areas.

Table 1. States' Recommended Nonattainment Areas and EPA's Intended Designated Nonattainment Areas for the 2012 annual $PM_{2.5}$ NAAQS

[1] Section 107(d) of the CAA requires the EPA to complete the initial designation process within 2 years of promulgation of a new or revised NAAQS, unless the Administrator has insufficient information to make initial designation decisions in the 2-year time frame. In such circumstances, the EPA may take up to 1 additional year to make initial area designation decisions (i.e., no later than 3 years after promulgation of the standard).

[2] On December 14, 2012, the EPA promulgated a revised primary annual $PM_{2.5}$ NAAQS (78 FR 3086, January 15, 2013). In that action, the EPA revised the primary annual $PM_{2.5}$ standard, strengthening it from 15.0 micrograms per cubic meter ($\mu g/m^3$) to 12.0 $\mu g/m^3$.

[3] In accordance with 40 CFR 50 Appendix N, $PM_{2.5}$ measurements from the primary monitor and suitable collocated $PM_{2.5}$ FRM, FEM or ARMs may be used in a "combined site data record" to establish a $PM_{2.5}$ design value to determine whether the NAAQS is met or not met at a particular $PM_{2.5}$ monitoring site.

Area Cincinnati-Hamilton	State's Recommended Nonattainment Counties	EPA's Intended Nonattainment Counties
Cincinnati- Hamilton, OH*	Butler Clermont Hamilton	Butler Clermont Hamilton Warren (partial)
Cincinnati-Hamilton, KY	None recommended attainment	Boone (partial) Campbell (partial) Kenton (partial)

*Cincinnati-Hamilton is a multi-state nonattainment area composed of counties and/or partial counties in Ohio and Kentucky. The technical analysis for this multi-state area is discussed in a separate and stand-alone Technical Support Document for the intended Cincinnati-Hamilton Area. There are additional TSDs for the rest of the state for both Kentucky and Ohio.

2.0 Nonattainment Area Analyses and Intended Boundary Determination

The EPA evaluated and determined the intended boundaries for each nonattainment area on a case-by-case basis considering the specific facts and circumstances unique to the area. In accordance with the CAA section 107(d), EPA intends to designate as nonattainment not only the area with the monitoring sites that violate the 2012 annual $PM_{2.5}$ NAAQS, but also those nearby areas with emissions sources that contribute to the violation in the violating area. As described in EPA guidance[4], after identifying each monitoring site indicating a violation of the standard in an area, EPA analyzed those areas with emissions contributing to that violating area by considering those counties in the entire metropolitan area (e.g., Core Based Statistical Area (CBSA) or Combined Statistical Area (CSA)) in which the violating monitoring sites are located. The EPA also evaluated counties adjacent to the CBSA or CSA that have emissions sources with the potential to contribute to the violations. EPA uses the CBSA or CSA as a starting point for the contribution analysis because those areas are nearby for purposes of the $PM_{2.5}$ NAAQS. Based upon relevant facts and circumstances in each area, the designated nonattainment area could be larger or smaller than the CBSA or CSA. EPA's analytical approach is described in section 3 of this technical support document.

3.0 Technical Analysis

In this technical analysis, EPA used the latest data and information available to EPA (and to the states and tribes through the $PM_{2.5}$ Designations Mapping Tool[5] and the EPA PM Designations Guidance and Data web page[6]) and/or data provided to EPA by states or tribes. This technical analysis identifies the area monitoring sites that violate the 2012 annual $PM_{2.5}$ standard. EPA evaluated this area and other nearby areas with emissions sources or activities that potentially contribute to ambient fine particle concentrations at the violating monitors in the

[4] EPA issued guidance on April 16, 2013, that identified important factors that EPA intended to evaluate, in making a recommendation for area designations and nonattainment boundaries for the 2012 annual $PM_{2.5}$ NAAQS. Available at *http://www.epa.gov/pmdesignations/2012standards/docs/april2013guidance.pdf.*

[5] EPA's $PM_{2.5}$ Designations Mapping Tool can be found at *http://geoplatform2.epa.gov/PM_MAP/index.html*.

[6] EPA's PM Designations Guidance and Data web page can be found at *http://www.epa.gov/pmdesignations/2012standards/techinfo.htm*.

area based on the weight of evidence of the five factors recommended in EPA guidance and any other relevant information.

These five factors are:

Factor 1: Air Quality Data. The air quality data analysis involves examining available ambient $PM_{2.5}$ air quality monitoring data at, and in the proximity of, the violating monitoring locations. This includes reviewing the design values (DV) calculated for each monitoring location in the area based on air quality data for the most recent complete 3 consecutive calendar years of quality-assured, certified air quality data in the EPA's Air Quality System (AQS). In general, EPA identifies violations using data from suitable Federal Reference Method (FRM), Federal Equivalent Method (FEM), and/or Approved Regional Method (ARM) monitors sited and operated in accordance with 40 CFR Part 58.[7] Procedures for using the air quality data to determine whether a violation has occurred are given in 40 CFR part 50 Appendix N, as revised by a final action published in the Federal Register on January 15, 2013 (78 FR 3086).[8] In addition to reviewing data from violating monitor sites, EPA also assesses the air quality data from other monitoring locations to help ascertain the potential contribution of sources in areas nearby to the violating monitoring site[s]. Examples include using chemical speciation data to help characterize contributing emissions sources and the determination of nearby contributions through analyses that differentiate local and regional source contributions.

Factor 2: Emissions and emissions-related data. The emissions analysis examines identified sources of direct $PM_{2.5}$, the major components of direct $PM_{2.5}$ (primary organic carbon/organic mass, elemental carbon, crustal material (and/or individual trace metal compounds)), primary nitrate and primary sulfate, and precursor gaseous pollutants (e.g., SO_2, NO_X, total VOC, and NH_3. Emissions data are generally derived from the most recent National Emissions Inventory (NEI) (i.e., 2011 NEI version 1), and are given in tons per year. In some cases, EPA may also evaluate emissions information from states, tribes, or other relevant sources that may not be reflected in the NEI. One example of "other information" could include an inventory or assessment of local/regional area sources that individually does not meet the current threshold for reporting to the NEI but collectively contributes to area $PM_{2.5}$ concentrations. Emissions data indicate the potential for a source to contribute to observed violations, making it useful in assessing boundaries of nonattainment areas.

Factor 3: Meteorology. Evaluating meteorological data helps to determine the effect on the fate and transport of emissions contributing to $PM_{2.5}$ concentrations and to identify areas potentially contributing to the violations at monitoring sites. The Factor 3 analysis includes assessing potential source-receptor relationships in the area identified for evaluation using summaries of air trajectories, wind speed, wind direction, and other meteorological data, as available.

Factor 4: Geography/topography. The geography/topography analysis includes examining the physical features of the land that might define the airshed and, therefore, affect the formation and distribution of $PM_{2.5}$ over an area. Mountains or other physical features may influence the fate and transport of emissions and $PM_{2.5}$

[7] Suitable monitors include all FEM and/or ARMs except those specific continuous FEMs/ARMs used in the monitoring agency's network where the data are not of sufficient quality such that data are not to be compared to the NAAQS in accordance with 40 CFR part 58.10(b)(13) and approved by the EPA Regional Administrator per 40 CFR part 58.11(e).

[8] As indicated in Appendix N to 40 CFR part 50, Interpretation of the National Ambient Air Quality Standards for $PM_{2.5}$, section 3(a) indicates "Except as otherwise provided in this appendix, all valid FRM/FEM/ARM $PM_{2.5}$ mass concentration data produced by suitable monitors that are required to be submitted to AQS, or otherwise available to EPA, meeting the requirements of part 58 of this chapter including appendices A, C, and E shall be used in the DV (design value) calculations. Generally, EPA will only use such data if they have been certified by the reporting organization (as prescribed by § 58.15 of this chapter); however, data not certified by the reporting organization can nevertheless be used, if the deadline for certification has passed and EPA judges the data to be complete and accurate."

concentrations. Additional analyses may consider topographical features that cause local stagnation episodes via inversions, such as valley-type features that effectively "trap" air pollution, leading to periods of elevated $PM_{2.5}$ concentrations.

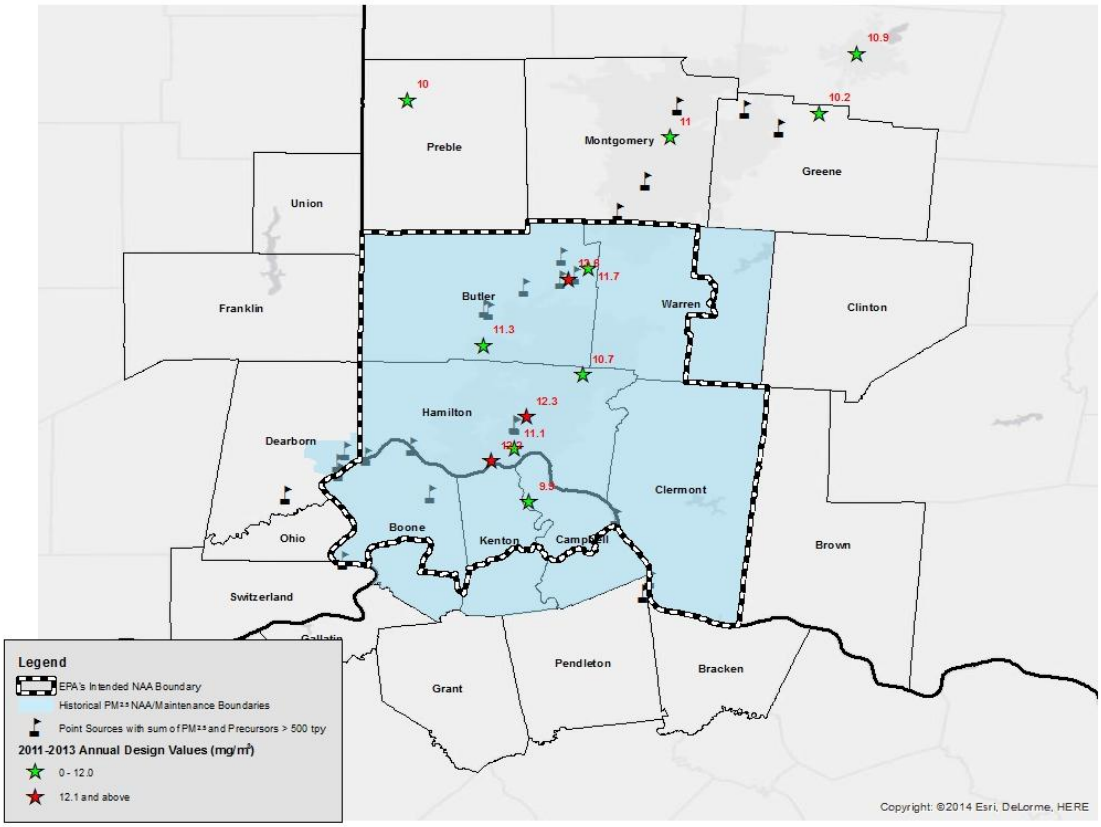
Factor 5: Jurisdictional boundaries. The analysis of jurisdictional boundaries identifies the governmental planning and organizational structure of an area that may be relevant for designations purposes. These jurisdictional boundaries provide insight into how the governing air agencies conduct or might conduct air quality planning and enforcement in a potential nonattainment area. Examples of jurisdictional boundaries include counties, air districts, areas of Indian country, CBSA or CSA, metropolitan planning organizations (MPOs), and existing nonattainment areas.

3.1 Area Background and Overview Cincinnati-Hamilton

Figure 1 is a map of EPA's intended nonattainment boundary for the Cincinnati-Hamilton Area. The map shows the location and design values of ambient air quality monitoring locations, county, and existing 1997 annual and/or 2006 24-hour $PM_{2.5}$ NAAQS nonattainment boundaries.

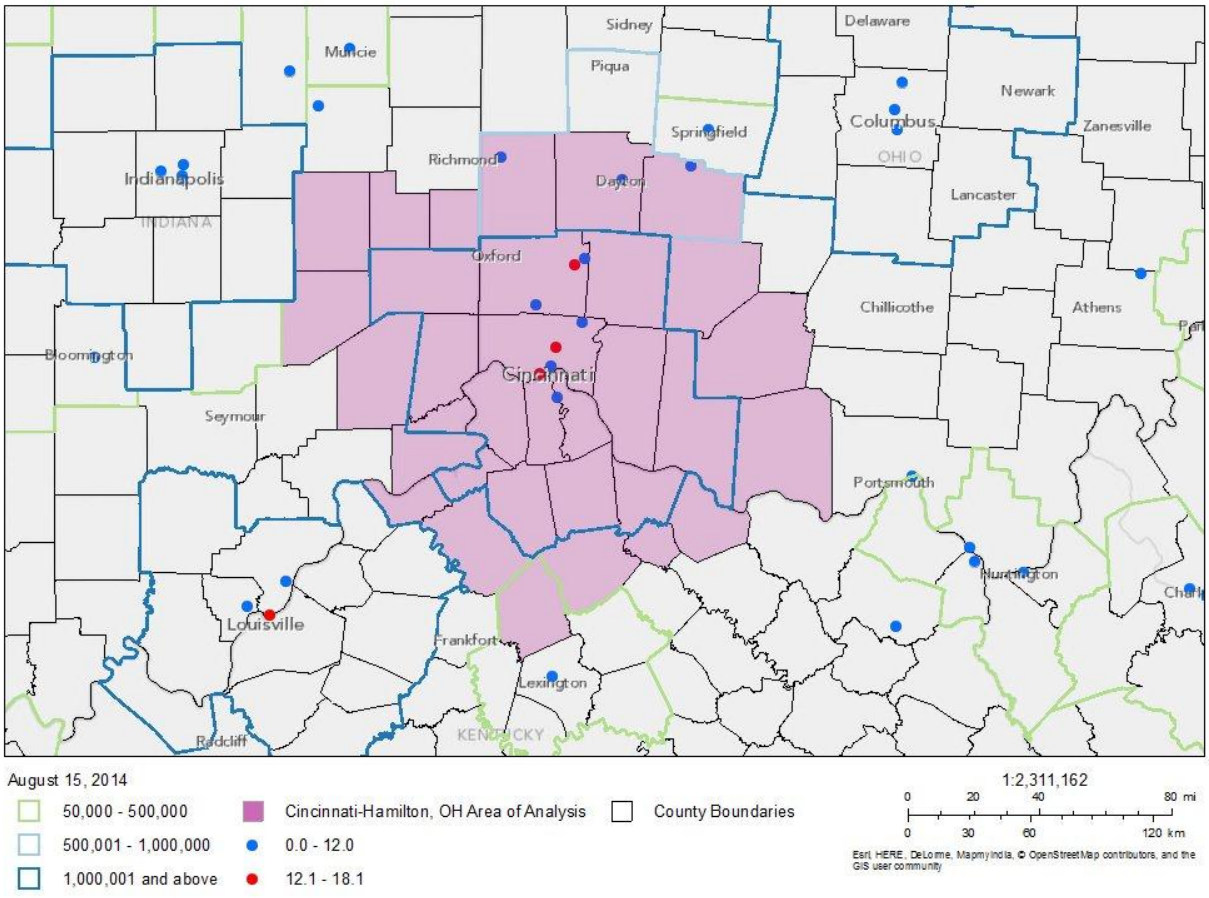
For purposes of the 1997 annual $PM_{2.5}$ NAAQS, this area was designated nonattainment. The boundary for the nonattainment area for the 1997 annual $PM_{2.5}$ NAAQS included the entire counties of Butler, Clermont, and Hamilton (Ohio), and Bonne, Campbell, and Kenton (Kentucky), and parts of Dearborn County, Indiana. For the 2006 $PM_{2.5}$ NAAQS the Cincinnati-Hamilton area was designated attainment. Today's intended boundaries for the Cincinnati-Hamilton nonattainment area are similar to the 1997 boundaries, with the exception of the counties of Boone, Kenton, Campbell (KY), and Warren (OH) having partial boundaries rather than entire counties, capturing the contribution of the urban area and for Boone the point sources. The partial county of Dearborn (IN) is also removed from the intended nonattainment area for 2012 due to the closure of the Tanners Creek power plant as a result of a permanent and enforceable consent decree, which results in the county no longer contributing to the Cincinnati-Hamilton nonattainment area.

Figure 1. Intended nonattainment boundary for the Cincinnati-Hamilton area.



EPA must designate as nonattainment areas that violate the NAAQS and nearby areas that contribute to the violation in the violating area. Hamilton County shows two violations, and Butler County one violation of the 2012 $PM_{2.5}$ NAAQS based on 2011-2013 data; therefore Hamilton and Butler Counties are included in the nonattainment area. As shown in Figure 1b, EPA evaluated each county without a violating monitoring site located near the counties with a violating monitoring site. Based on the five factors and other relevant information and determined that Warren, Clermont, Boone, Campbell, and Kenton contribute to the nearby violation. The following sections describe this five factor analysis process. While the factors are presented individually, they are not independent. The five factor analysis process carefully considers their interconnections and the dependence of each factor on one or more of the others.

Figure 1b. Area of Analysis for the Cincinnati-Hamilton Intended Nonattainment Area



Factor 1: Air Quality Data

All data collected during the year are important when determining contributions to an annual standard such as the 2012 annual $PM_{2.5}$ NAAQS. Compliance with an annual NAAQS is dependent upon monitor readings throughout the year, including days with monitored ambient concentrations below the level of the NAAQS. For the 2012 annual $PM_{2.5}$ NAAQS, the annual mean is calculated as the mean of quarterly means. A high quarter can drive the mean for an entire year, which, in turn, can drive an elevated 3-year DV. Although all data are important, seasonal or episodic emissions can provide insight as to relative contributors to measured $PM_{2.5}$ concentrations. For these reasons, for the Factor 1 air quality analysis, EPA assessed and characterized air quality at, and in the proximity of, the violating monitoring site locations first, by evaluating trends and the spatial extent of measured concentrations at monitors in the area of analysis, and then, by identifying the conditions most associated with high average concentration levels of $PM_{2.5}$ mass in the area of analysis.

In most cases, EPA assessed air quality data on a seasonal, or quarterly, basis.[9] EPA also identified the spatial extent of these high $PM_{2.5}$ concentrations. The mass and composition at the design value location represents

[9] Although compliance with the annual NAAQS depends on contributions from all days of the year, examining data on a quarterly or seasonal basis can inform the relationship between the temporal variability of emissions and meteorology and

contributions from various emission sources including local, area-wide (which may comprise nearby urban and rural areas) and regional sources. To determine the source mix (by mass) at the design value monitoring site, EPA examined the chemical composition of the monitored $PM_{2.5}$ concentrations by pairing each violating FRM/FEM/ARM monitoring site with a collocated or nearby Chemical Speciation Network (CSN) monitoring site or sites. Then, EPA contrasted the approximated mass composition at the design value monitoring site with data collected at IMPROVE[10] and other monitoring locations whose data are representative of regional background. This comparison of local/area-wide chemical composition data to regional chemical composition data derives an "urban increment," [11,12] which helps differentiate the influence of more distant emissions sources from the influence of closer emissions sources, thus representing the portion of the measured violation that is associated with nearby emission contributions.[13,14,15]

$PM_{2.5}$ Design Values and Total Mass Measurements - EPA examined ambient $PM_{2.5}$ air quality monitoring data represented by the DVs at the violating monitoring site and at other monitors in the area of analysis. EPA calculated DVs based on air quality data for the most recent 3 consecutive calendar years of quality-assured, certified air quality data from suitable FEM/FRM/ARM monitoring sites in the EPA's Air Quality System (AQS). For this designations analysis, EPA used data for the 2011-2013 period (i.e., the 2013 design value), which are the most recent years with fully-certified air quality data. A monitor's DV is the metric or statistic

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the resulting $PM_{2.5}$ mass and composition. In some areas of the country where there may be noticeable month-to-month variations in average $PM_{2.5}$, the quarterly averages may not adequately represent seasonal variability. In these areas, air quality data may be aggregated and presented by those months that best correspond to the local "seasons" in these areas.

[10] IMPROVE stands for Interagency Monitoring for Protected Visual Environments and is an aerosol monitoring network in mostly rural and remote areas.

[11] The "urban increment" analysis assesses and characterizes the increase in seasonal and annual average $PM_{2.5}$ mass and chemical constituents observed at violating monitoring site(s) relative to monitoring sites outside the area of analysis (which represent background concentrations). Developing the urban increment involves pairing a violating FRM/FEM/ARM monitor with a collocated monitor or nearby monitor with speciation data. EPA made every effort to pair these data to represent the same temporal and spatial scales. However, in some cases, the paired violating and CSN "urban" monitoring locations were separated by some distance such that the included urban CSN site(s) reflect(s) a different mixture of emissions sources, which could lead to misinterpretations. To generally account for differences in $PM_{2.5}$ mass between the violating site and the nearby CSN site(s), EPA determined material balance of the $PM_{2.5}$ composition at the violating site by assigning the extra measured $PM_{2.5}$ mass to the carbon components of $PM_{2.5}$. Where the general urban increment approach may be misleading, or in situations where non-carbonaceous emissions are believed to be responsible for a local $PM_{2.5}$ concentration gradient, EPA used alternative analyses to reflect the mix of urban and rural sources contributing to the measured concentrations at violating monitoring sites.

[12] The urban monitors were paired with any rural sites within a 150 mile radius of an urban site to calculate spatial means of the quarterly averages of each species. If there were no rural sites within 150 miles, then the nearest rural site was used alone. That rural mean was then subtracted from the quarterly mean of the urban site to get the increment. Negative values were simply replaced with zeros.

[13] In most, but not all, cases, the violating design value monitoring site is located in an urban area. Where the violating monitor is not located in an urban area, the "urban increment" represents the difference between local and other nearby emission sources in the vicinity of the violating monitoring location and more regional sources.

[14] Hand, et. al. Spatial and Seasonal Patterns and Temporal Variability of Haze and its Constituents in the United States: Report V, June 2011. Chapter 7 – Urban Excess in $PM_{2.5}$ Speciated Aerosol Concentrations, *http://vista.cira.colostate.edu/improve/Publications/Reports/2011/PDF/Chapter7.pdf*

[15] US EPA, Office of Air Quality Planning and Standards, December 2004. (2004) Area Designations for 1997 Fine Particle ($PM_{2.5}$) Standards, Technical Support Document for State and Tribal Air Quality Fine Particle ($PM_{2.5}$) Designations, Chapter 3, Urban Excess Methodology. Available at *www.epa.gov/pmdesignations/1997standards/documents/final/TSD/Ch3.pdf*

that indicates whether that monitor attains a specified air quality standard. The 2012 annual $PM_{2.5}$ NAAQS is met at a monitoring site when the 3-year average annual mean concentration is 12.0 micrograms per cubic meter ($\mu g/m^3$) or less (e.g., 12.1 $\mu g/m^3$ or greater is a violation). A DV is only valid if minimum data completeness criteria are met or when other regulatory data processing provisions are satisfied (See 40 CFR part 50 Appendix N). Table 2 identifies the current design value(s) (i.e., the 2013 DV) and the most recent two design values based on all monitoring sites in the area of analysis for the Cincinnati-Hamilton intended nonattainment area.[16] Where a county has more than one monitoring location, the county design value is indicated in red type.

Table 2. Air Quality Data collected at Regulatory Monitors (all DV levels in $\mu g/m^3$)[a,b]

County, State	Monitor Site ID	State Rec NA?	09-11 DV	10-12 DV	11-13 DV
Dearborn, IN	N/A	N	No monitor		
Decatur, IN	N/A	N	No monitor		
Fayette, IN	N/A	N	No monitor		
Franklin, IN	N/A	N	No monitor		
Ripley, IN	N/A	N	No monitor		
Rush, IN	N/A	N	No monitor		
Switzerland, IN	N/A	N	No monitor		
Union, IN	N/A	N	No monitor		
Adams, OH	N/A	N	No monitor		
Brown, OH	N/A	N	No monitor		
Butler, OH	390170003	Y	13.0	12.5	11.7
Butler, OH	390170016	Y	13.0	12.2	11.3
Butler, OH	390170019	Y	12.7	N/A (incomplete)	11.7
Butler, OH	390170020	Y			13.6
Clermont, OH	N/A	N	No monitor		
Green, OH		N	12	11.4	10.2
Hamilton, OH	390610006	Y	12.2	11.6	10.7
Hamilton, OH	390610010	Y	11.8	11.2	11
Hamilton, OH	390610014	Y	13.8	13.4	12.3
Hamilton, OH	390610040	Y	12.8	12.8	11.1
Hamilton, OH	390610042	Y	13.8	13.2	12.2
Hamilton, OH	390617001	Y	13.5	14.1	N/A*
Hamilton, OH	390618001	Y	15.5	17.6	N/A*

[16] In certain circumstances, one or more monitoring locations within a monitoring network may not meet the network technical requirements set forth in 40 CFR 58.11(e), which states, "State and local governments must assess data from Class III $PM_{2.5}$ FEM and ARM monitors operated within their network using the performance criteria described in table C-4 to subpart C of part 53 of this chapter, for cases where the data are identified as not of sufficient comparability to a collocated FRM, and the monitoring agency requests that the FEM or ARM data should not be used in comparison to the NAAQS. These assessments are required in the monitoring agency's annual monitoring network plan described in §58.10(b) for cases where the FEM or ARM is identified as not of sufficient comparability to a collocated FRM…."

Highland, OH	N/A	N	No monitor		
Montgomery, OH	390610042	N	12.9	12.3	11.0
Preble, OH	390617001	N	11.3	10.7	10.0
Warren, OH	391650007	N	11.5	11.5	11.0
Wilmington, OH	N/A	N	No monitor		
Braden, KY	N/A	N	No monitor		
Boon, KY	N/A	N	No monitor		
Campbell, KY	210373002	N	11.1	10.6	9.9
Carroll, KY	N/A	N	No monitor		
Gallatin, KY	N/A	N	No monitor		
Grant, KY	N/A	N	No monitor		
Harrison, KY	N/A	N	No monitor		
Kenton, KY	211170007	N	11.6	12.1	N/A*
Madison, KY	N/A	N	No monitor		
Ohio, KY	N/A	N	No monitor		
Owen, KY	N/A	N	No monitor		
Pendleton, KY	N/A	N	No monitor		
Robertson, KY	N/A	N	No monitor		
Scott, KY	N/A	N	No monitor		

[a]Where a county has more than one monitoring location, the county design value is indicated in red type.
[b]These design values do not include data from Class III FEM monitors that EPA has approved as not eligible for comparison to the NAAQS per 40 CFR 58.11(e).
*Monitor was closed in 2010, design values noted for 2009-2011 and 2010-2012 are incomplete and only represent 1-2 years of data.

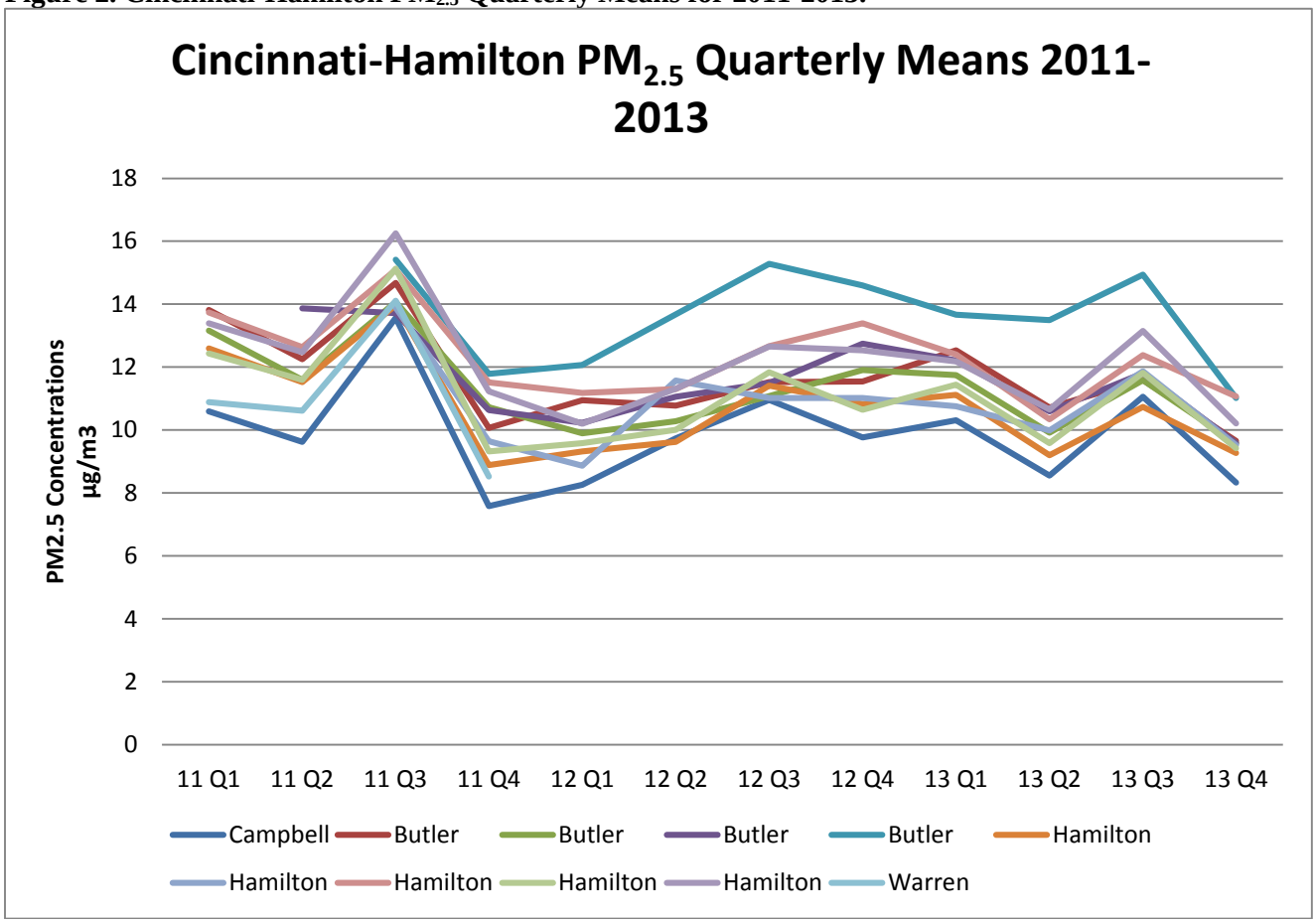
Site # 39-017-0020, known as the Yankee Road site in Butler County, OH, began in the middle of 2011 as a special purpose monitor as required by a permit for the nearby steel facility. Because the monitor has continued to run past the 2 –year special purpose monitor time-frame (40 CFR part 58 subpart C), this monitor automatically becomes comparable to the NAAQS. Given that the monitor had incomplete data, EPA has performed a substitution analysis as defined under 40 CFR part 58 subpart N, resulting in a design value for 2011-2013 of 13.6 mg/m^3. However, the 2015 Annual Ambient Monitoring Plan from the local agency that operates the site includes a request that the site be exempted from comparison to the annual standard given that the intention of the monitor is to measure concentrations specifically at the facility that is a continued requirement of the facilities operating permit. EPA has not yet evaluated this issue, but is considering the very close proximity to the facility as an important factor. EPA's analysis for the Cincinnati area not only took into account this monitor, but the two other violating monitors in Hamilton County, the Cincinnati area and sources in that area that are contributing to 39-017-0020 are also contributing to the violations in Hamilton County. Therefore, consideration or non-consideration of this monitor does not change the outcome of the intended nonattainment area boundaries.

The Figure 1 map, shown previously, identifies the Cincinnati-Hamilton intended nonattainment area and monitoring locations with 2011-2013 violating DVs. As indicated on the map, there is one violation in Butler

County located near a steel facility, and there are 2 violating monitoring locations located in the city of Cincinnati, both just north of the Ohio River.

Seasonal variation can highlight those conditions most associated with high average concentration levels of $PM_{2.5}$. Figure 2 shows quarterly mean $PM_{2.5}$ concentrations for the most recent 3-year period for the highest DV monitoring sites, and other monitoring sites, in each county within the area of analysis. This graphical representation is particularly relevant when assessing air quality data for an annual standard, such as the 2012 annual $PM_{2.5}$ NAAQS, because, as previously stated, the annual mean is calculated as the mean of quarterly means and a high quarter can drive the mean for an entire year, which, in turn, can drive an elevated 3-year DV.

Figure 2. Cincinnati-Hamilton $PM_{2.5}$ Quarterly Means for 2011-2013.



As shown, over the design value period of 2011-2013, quarter 3 (Q3) has consistent peaks for every monitor in the nonattainment area, with a high peak in 2011 Q3 and a smaller peak in 2013 Q1 outside that pattern. Note the high degree of temporal patternfor the 3-year period and across all Cincinnati-Hamilton area monitors. Quarterly values across the period vary by 1-5 $\mu g/m^3$ at each site, with consistent annual peaks occurring in Q3.

<u>$PM_{2.5}$ Composition Measurements</u> - To assess potential emissions contributions for each violating monitoring location, the EPA determined the various chemical species comprising total $PM_{2.5}$ to identify the chemical constituents over the analysis area, which can provide insight into the types of emission sources impacting the monitored concentration. To best describe the $PM_{2.5}$ at the violating monitoring location, EPA first adjusted the chemical speciation measurement data from a monitoring location at or near the violating FRM monitoring site

using the SANDWICH approach to account for the amount of $PM_{2.5}$ mass constituents retained in the FRM measurement.[17,18,19,20] In particular, this approach accounts for losses in fine particle nitrate and increases in sulfate mass associated with particle bound water. Figure 3a illustrates the fraction of each $PM_{2.5}$ chemical constituent based on annual averages for the years 2010-2012.

Figure 3a. Cincinnati-Hamilton Annual Average $PM_{2.5}$ Chemical Constituents (2010-2012)

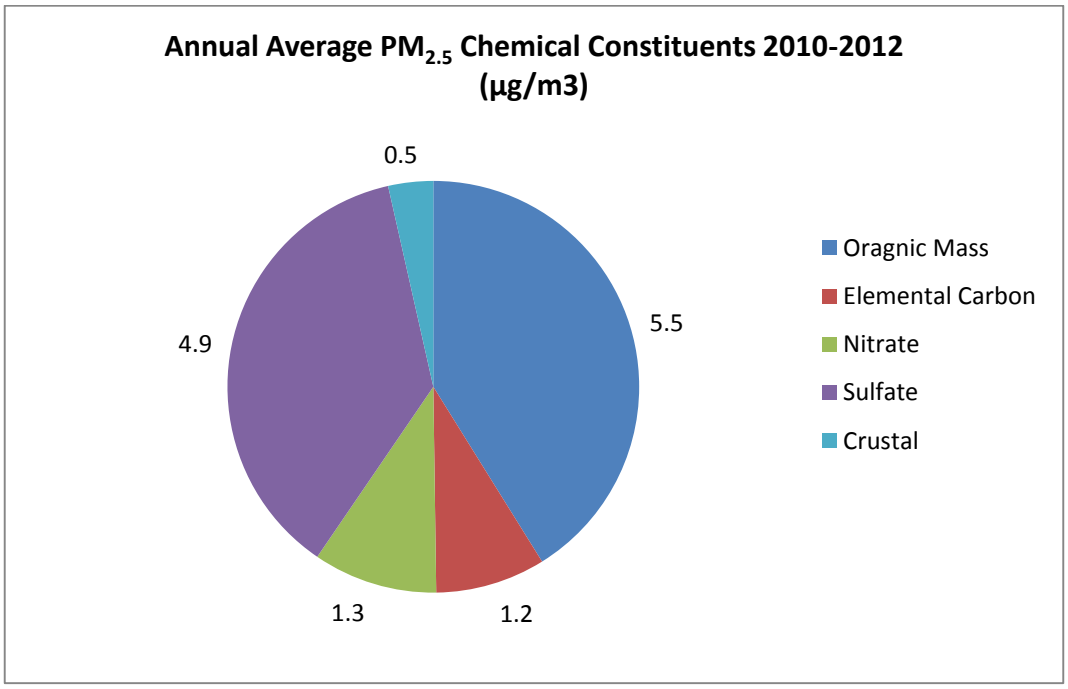


Figure 3b shows annual and quarterly chemical composition profiles and illustrates any seasonal or episodic contributors to $PM_{2.5}$ mass. This "increment analysis," combined with the other factor analyses, can provide

[17] SANDWICH stands for measured **S**ulfate, **A**djusted **N**itrate, **D**erived **W**ater, **I**nferred **C**arbonaceous mass **H**ybrid Material Balance Approach." The SANDWICH adjustment uses an FRM mass construction methodology that results in reduced nitrates (relative to the amount measured by routine speciation networks), higher mass associated with sulfates (reflecting water included in gravimetric FRM measurements) and a measure of organic carbonaceous mass derived from the difference between measured $PM_{2.5}$ and its non-carbon components. This characterization of $PM_{2.5}$ mass also reflects crustal material and other minor constituents. The resulting characterization provides a complete mass closure for the measured FRM $PM_{2.5}$ mass, which can be different than the data provided directly by the speciation measurements from the CSN network.

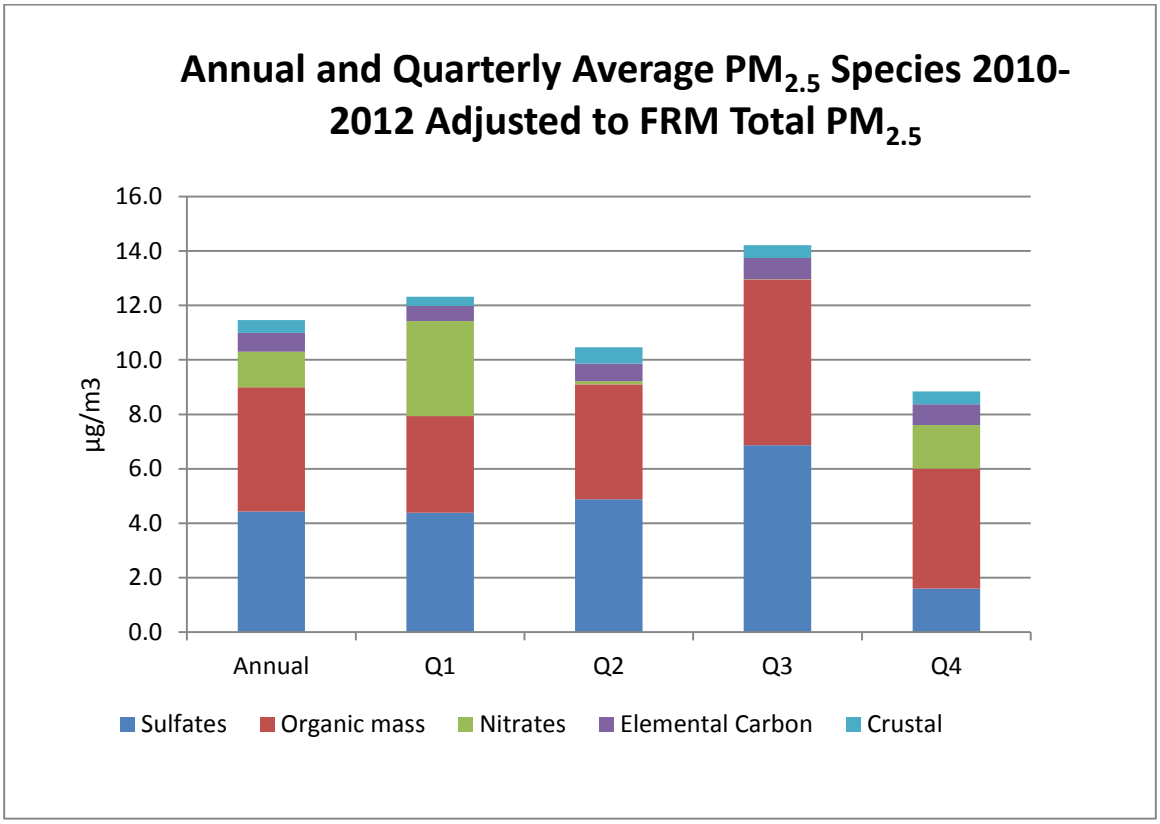
[18] Frank, N. H., SANDWICH Material Balance Approach for $PM_{2.5}$ Data Analysis, National Air Monitoring Conference, Las Vegas, Nevada, November 6-9, 2006. *http://www.epa.gov/ttn/amtic/files/2006conference/frank.pdf*.

[19] Frank, N. H., The Chemical Composition of $PM_{2.5}$ to support PM Implementation, EPA State /Local/Tribal Training Workshop: $PM_{2.5}$ Final Rule Implementation and 2006 $PM_{2.5}$ Designation Process, Chicago IL, June 20-21, 2007, *http://www.epa.gov/ttn/naaqs/pm/presents/pm2.5_chemical_composition.pdf.*

[20] Frank, N. H. *Retained Nitrate, Hydrated Sulfates, and Carbonaceous Mass in Federal Reference Method Fine Particulate Matter for Six Eastern U.S. Cities*. J. Air & Waste Manage. Assoc. 2006 56:500–511.

additional insight as to which sources or factors may contribute at a greater level. Simply stated, this analysis can help identify nearby sources of emissions that contribute to the violation at the violating monitoring site.

Figure 3b. Cincinnati-Hamilton Annual and Quarterly Average $PM_{2.5}$ Species (2010-2012)[a]

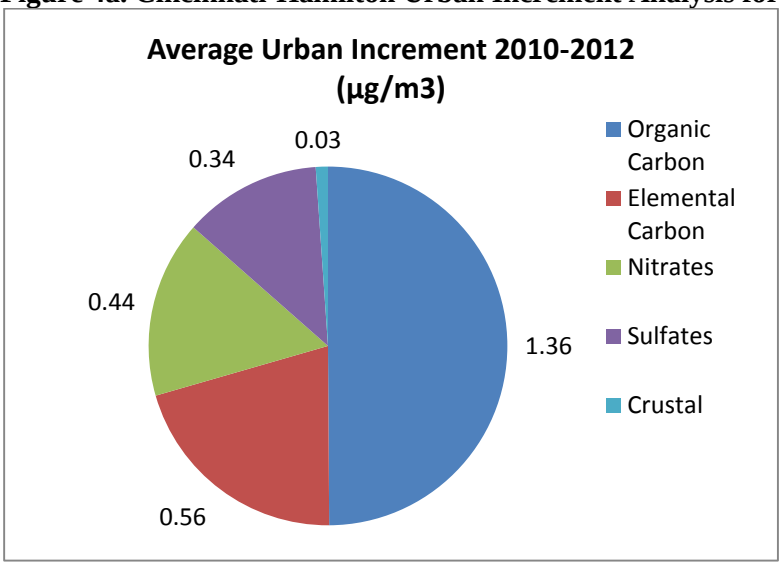


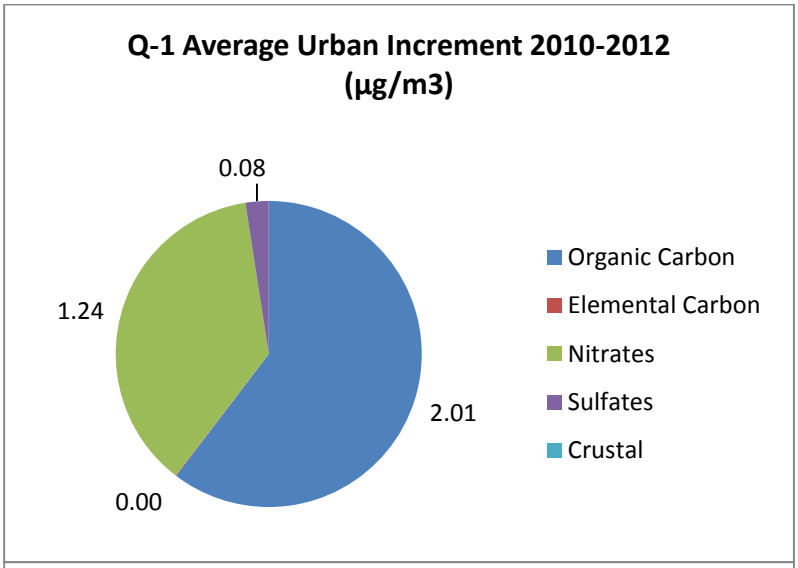
[a]*Adjusted to FRM Total $PM_{2.5}$* indicates that the speciation profile and total mass depicted in this figure are the result of the urban increment calculation for the particular FRM monitor.

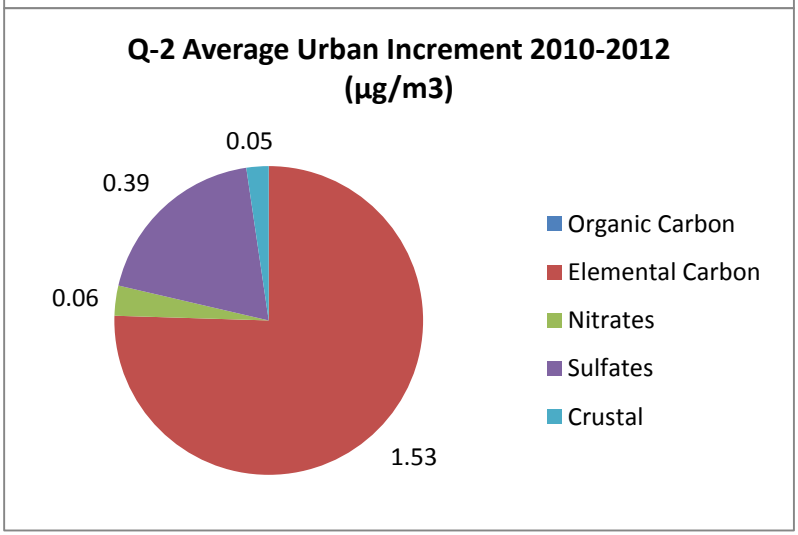
Figure 3b shows that sulfate and organic mass are the predominant species overall, with an exception in Q1 when nitrate comprises an equal fraction to sulfates and organic mass. Crustal and elemental carbon are relatively small components, but is largest in Q2 and Q3, respectively. Figure 3b suggests that sulfate (SO2), organic mass (direct PM), VOCs and nitrate (NOX) sources have the highest impact on the monitored values for the Cincinnati-Hamilton area.

EPA assessed seasonal and annual average $PM_{2.5}$ constituents at monitoring sites within the area relative to monitoring sites outside of the analysis area to account for the difference between regional background concentrations of $PM_{2.5}$, and the concentrations of $PM_{2.5}$ in the area of analysis, also known as the "urban increment." This analysis differentiates between the influences of emissions from sources in nearby areas and in more distant areas on the violating monitor. Estimating the urban increment in the area helps to illuminate the amount and type of particles at the violating monitor that are most likely to be the result of sources of emissions in nearby areas, as opposed to impacts of more distant or regional sources of emissions. Figure 4a includes pie charts showing the annual and quarterly chemical mass constituents of the urban increment. The quarterly pie charts correspond to the high-concentration quarters identified in Figure 2. Evaluating these high concentration quarters can help identify composition of $PM_{2.5}$ during these times. Note that in these charts, sulfates and nitrates have been adjusted to represent their mass in measured $PM_{2.5}$.

Figure 4a. Cincinnati-Hamilton Urban Increment Analysis for 2010-2012.







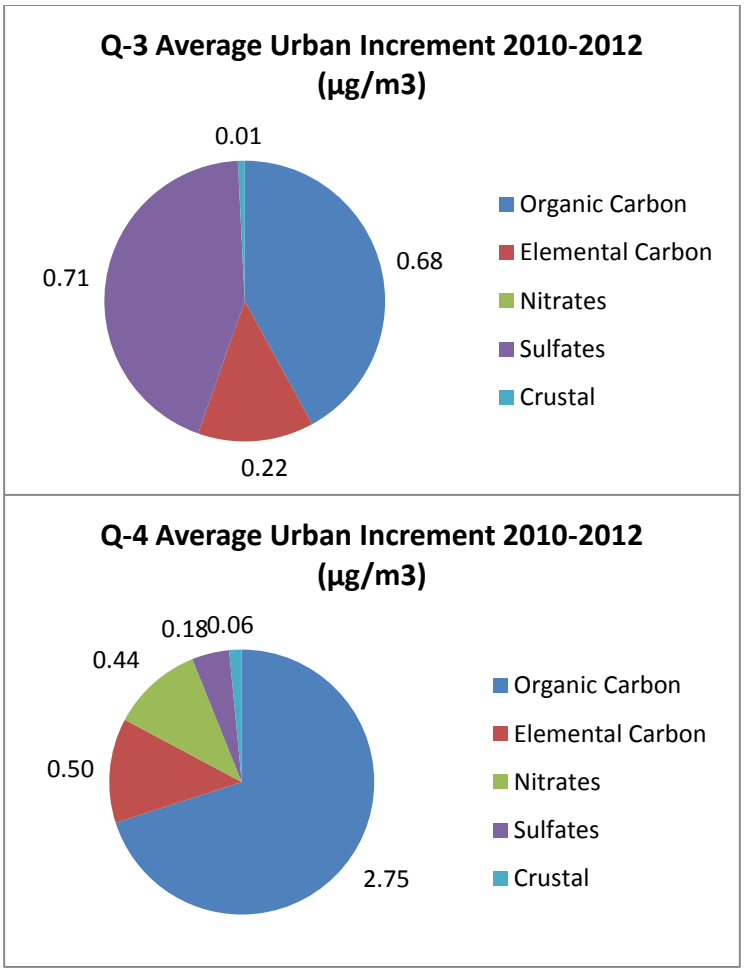
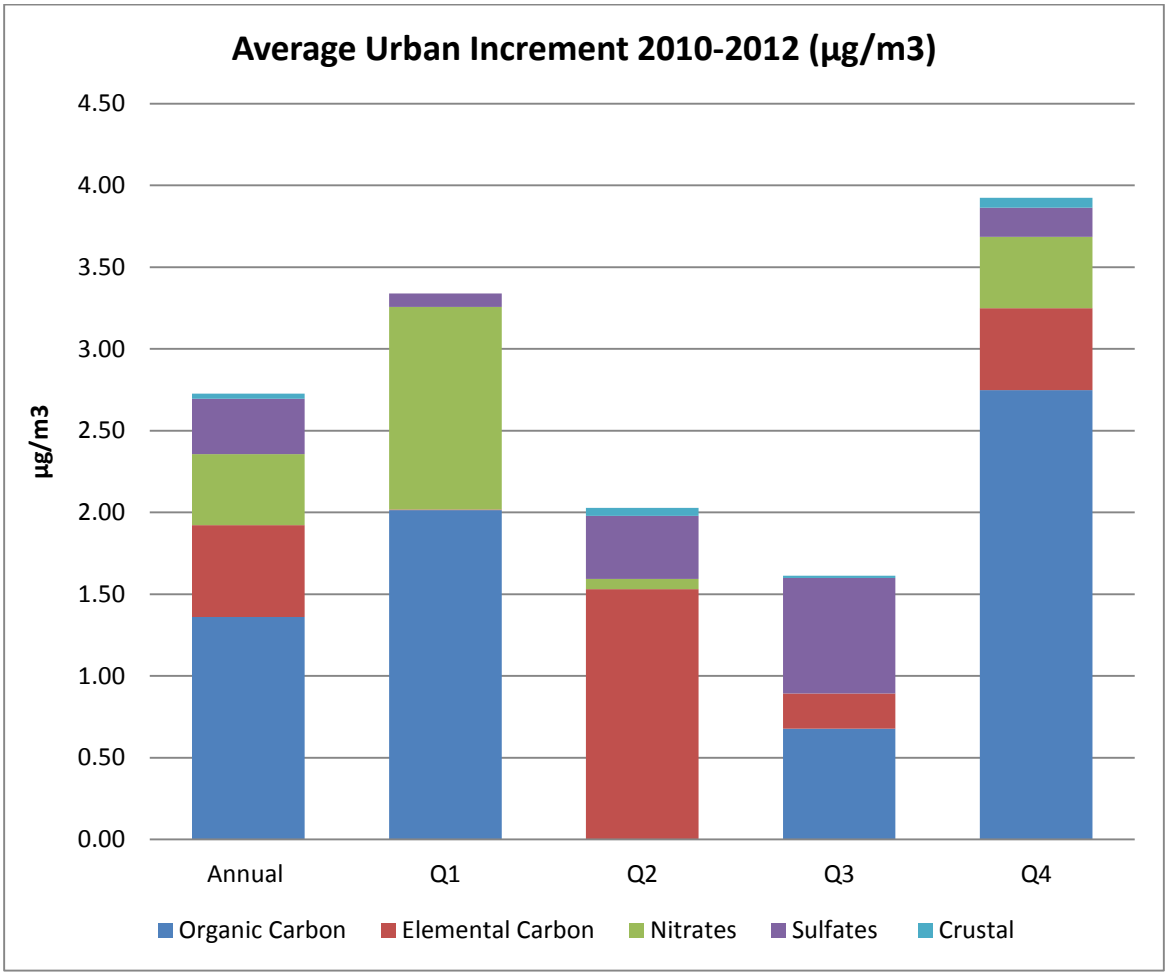

Q-3 Average Urban Increment 2010-2012 (µg/m3)
0.01
0.68
0.71
0.22
Organic Carbon
Elemental Carbon
Nitrates
Sulfates
Crustal
Q-4 Average Urban Increment 2010-2012 (µg/m3)
0.18
0.06
0.44
0.50
2.75
Organic Carbon
Elemental Carbon
Nitrates
Sulfates
Crustal

Figure 4b. Cincinnati-Hamilton Average Urban Increment Analysis for 2010-2012.



Hamilton County has two monitoring sites and Butler County with one with a DV exceeding the NAAQS. In addition, Hamilton and adjoining counties have clear seasonal peaks in ambient $PM_{2.5}$ concentrations in Q1. Butler, Campbell, Hamilton, and Warren Counties during the 2011 Q3 monitored $PM_{2.5}$ concentrations exceeding the NAAQS.

In reviewing the urban increment analysis for the Cincinnati-Hamilton CBSA DV monitor, carbon species are the dominant contribution from the urban area with the sulfate component having small urban contribution – except in Q3 – although conversely a large regional contribution. Nitrate is second highest urban increment component for the Q1 peak, but is quite low in the Q3 peak season, during which carbon components comprise a higher percentage. This analysis points to contribution from local direct $PM_{2.5}$ sources nearby the violating monitor (including motor vehicles that have traveled near the monitor), but sulfate and nitrate reflect contributing sources across a broader area.

Factor 2: Emissions and emissions-related data

In this designations process, for each area with a violating monitoring site, the EPA evaluated the emissions data from nearby areas using emissions related data for the relevant counties to assess each county's potential contribution to $PM_{2.5}$ concentrations at the violating monitoring site or monitoring sites in the area under evaluation. Similar to the air quality analysis, these data were examined on a seasonal basis. Seasonal air quality patterns are not sufficiently different to warrant analysis on a seasonal basis. (Although nitrate is much higher in the cooler months, NOx emissions have similar importance all year due to their role in fostering the photochemistry that causes secondary particulate matter.) Furthermore, for all major emitted pollutants, the mix of sources is similar in all seasons. Therefore, the EPA is only analyzing annual emissions data. The EPA examined emissions of identified sources or source categories of direct $PM_{2.5}$, the major components of direct $PM_{2.5}$ (organic mass, elemental carbon, crustal material (and/or individual trace metal compounds)), primary nitrate and primary sulfate, and precursor gaseous pollutants (i.e., SO_2, NOx, total VOC, and NH_3). The EPA also considered the distance of those sources of emissions from the violating monitoring site. While direct $PM_{2.5}$ emissions and its major carbonaceous components are generally associated with sources near violating $PM_{2.5}$ monitoring sites (or, in the case of motor vehicles, that have traveled to near the sites), the gaseous precursors tend to have a more regional influence (although the EPA is mindful of the potential local NOx and VOC emissions contributions to $PM_{2.5}$ from mobile and stationary sources) and transport from neighboring areas can contribute to higher $PM_{2.5}$ levels at the violating monitoring sites.

Emissions Data

For this factor, EPA reviewed data from the 2011 National Emissions Inventory (NEI) version 1 (see *http://www.epa.gov/ttn/chief/net/2011inventory.html*). For each county in the area of analysis, EPA examined the magnitude of county-level emissions reported in the NEI. These county-level emissions represent the sum of emissions from the following general source categories: point sources, non-point (i.e., area) sources, nonroad mobile, on-road mobile, and fires. EPA also looked at the geographic distribution of major point sources of the relevant pollutants.[21] Significant emissions levels from sources in a nearby area indicate the potential for the area to contribute to monitored violations.

To further analyze area emissions data, EPA also developed a summary of direct $PM_{2.5}$, components of direct $PM_{2.5}$, and precursor pollutants, which is available at *http://www.epa.gov/pmdesignations/2012standards/docs/nei2011v1pointnei2008v3county.xlsx*.

When considered with the urban increment analysis in Factor 1, evaluating the components of direct $PM_{2.5}$ and precursor gases can help identify specific sources or source types contributing to elevated concentrations at violating monitoring sites and thus assist in identifying appropriate area boundaries. In general, directly emitted particulate organic carbon (POC) and VOCs[22] contribute to $PM_{2.5}$ organic mass (OM); directly emitted EC contributes to $PM_{2.5}$ EC; NO_X, NH_3 and directly emitted nitrate contribute to $PM_{2.5}$ nitrate mass; SO_2, NH_3 and directly emitted sulfate contribute to $PM_{2.5}$ sulfate mass; and directly emitted crustal material and metal oxides contribute to $PM_{2.5}$ crustal matter.[23,24] EPA believes that the quantities of those nearby emissions as potential contributors to the $PM_{2.5}$ violating monitors are somewhat proportional to the $PM_{2.5}$ chemical constituents in the

[21] For purposes of this designations effort, "major" point sources are those whose sum of PM precursor emissions ($PM_{2.5}$ + NOx + SO_2 + VOC + NH_3) are greater than 500 tons per year based on NEI 2011v1.

[22] As previously mentioned, nearby VOCs are presumed to be a less important contributor to $PM_{2.5}$ OM than POC.

[23] *See*, Seinfeld J. H. and Pandis S. N. (2006) *Atmospheric Chemistry and Physics: From Air Pollution to Climate Change*, 2nd edition, J. Wiley, New York. See also, Seinfeld J. H. and Pandis S. N. (1998) *Atmospheric Chemistry and Physics: From Air Pollution to Climate Change*, 1st edition, J. Wiley, New York.

[24] USEPA Report (2004), The Particle Pollution Report: Current Understanding of Air Quality and Emissions through 2003, found at: *http://www.epa.gov/airtrends/aqtrnd04/pm.html*.

estimated urban increment. Thus, directly emitted POC is more important per ton than SO_2, partially because POC emissions are already $PM_{2.5}$ whereas SO_2 must convert to $PM_{2.5}$ and not all of the emitted SO_2 undergoes this conversion.

Table 3a provides a county-level emissions summary (i.e., the sum of emissions from the following general source categories: point sources, non-point (i.e., area) sources, non-road mobile, on-road mobile, and fires) of directly emitted $PM_{2.5}$ and precursor species for the county with the violating monitoring site and nearby counties considered for inclusion in the Cincinnati-Hamilton area. Table 3b summarizes the directly emitted components of $PM_{2.5}$ for the same counties in the area of analysis for the Cincinnati-Hamilton area. This information will be considered in conjunction with the Urban Increment composition information previously shown in Figures 4a and 4b.

Table 3a. County-Level Emissions of Directly Emitted $PM_{2.5}$ and Precursors (tons/year)

County, State	Total NH_3	Total Nox	Total VOC	Total SO2	Total Direct PM	Total
Clermont , OH	240	21,423	4,820	109,009	8,507	143,999
Hamilton, OH	895	35,541	20,268	31,498	5,657	93,860
Dearborn, IN	175	8,074	3,106	26,895	705	38,955
Montgomery, OH	852	19,158	13,779	2,543	2,091	38,423
Adams, OH	663	13,140	1,669	16,216	3,803	35,491
Butler, OH	762	13,972	9,012	5,792	2,476	32,014
Boone, KY	224	8,394	5,231	2,181	757	16,789
Ohio, KY	1,251	2,335	1,656	9,761	584	15,587
Greene, OH	801	6,996	3,976	1,207	963	13,943
Warren, OH	350	6,950	5,168	116	841	13,425
Kenton, KY	180	5,106	3,843	53	483	9,665
Decatur, IN	2,918	2,387	2,060	19	577	7,960
Scott, KY	352	2,492	3,862	19	386	7,110
Preble, OH	1,144	2,230	2,051	49	719	6,193
Campbell, KY	132	2,628	2,143	33	306	5,242
Rush, IN	1,527	1,464	1,223	12	582	4,809
Highland, OH	640	1,544	1,774	46	597	4,601
Ripley, IN	668	1,314	1,932	26	580	4,520
Brown, OH	569	1,560	1,621	50	563	4,364
Pendleton, KY	135	1,572	621	869	327	3,524
Gallatin, KY	135	1,784	664	85	330	2,998
Franklin, IN	492	878	998	18	394	2,780
Harrison, KY	471	599	924	13	158	2,165
Fayette, IN	452	617	753	11	288	2,121
Caldwell, KY	483	552	710	14	235	1,994
Union, IN	413	365	511	10	244	1,542
Switzerland, IN	169	342	446	7	155	1,118
Owen, KY	268	321	411	9	105	1,114
Bracken, KY	107	552	319	7	75	1,059

Table 3b. County-Level Emissions for Components of Directly Emitted $PM_{2.5}$ (tons/year) [25]

County, State	PNO3	PSO4	EC	POM	Crustal	Residual	Total Direct
Clermont , OH	4.9	627.4	434.6	663.5	3060.0	3716.5	8506.8
Hamilton, OH	7.5	289.8	771.9	1463.3	1381.4	1743.4	5657.3
Adams, OH	3.0	261.3	169.7	514.9	1289.6	1564.4	3802.8
Butler, OH	8.2	224.1	386.0	787.4	476.5	593.8	2476.1
Montgomery, OH	3.2	44.8	479.0	869.4	340.1	354.0	2090.5
Greene, OH	2.7	18.9	161.4	281.6	268.8	229.7	963.0
Warren, OH	1.2	20.3	184.0	317.2	163.7	154.6	841.0
Boone, KY	2.2	14.3	167.2	294.8	115.0	163.2	756.7
Preble, OH	1.3	5.0	76.6	293.2	194.2	148.5	718.7
Dearborn, IN	2.5	46.1	83.1	309.0	98.9	165.5	705.1
Highland, OH	1.0	4.5	66.9	297.3	120.2	106.6	596.6
Ohio, KY	2.5	15.1	63.0	273.0	92.2	138.4	584.2
Rush,IN	0.6	8.2	33.1	99.6	252.4	188.6	582.5
Ripley, IN	0.9	4.5	56.1	273.2	126.7	118.7	580.1
Decatur, IN	0.7	8.2	49.1	144.2	210.9	163.4	576.5
Brown, OH	1.0	4.3	65.2	275.1	114.8	102.5	563.0
Kenton, KY	0.8	5.0	124.8	248.1	43.2	61.2	483.2
Franklin, IN	0.6	2.6	33.7	158.7	105.5	93.3	394.3
Scott, KY	1.0	10.2	66.8	157.2	44.6	106.5	386.4
Gallatin, KY	0.9	20.9	29.8	70.5	96.0	112.2	330.4
Pendleton, KY	0.9	12.8	27.6	80.4	85.0	120.7	327.5
Campbell, KY	1.0	10.0	64.5	144.6	34.6	51.7	306.4
Fayette, IN	0.3	1.5	22.1	81.6	106.6	75.8	287.9
Union, IN	0.2	1.0	15.9	60.0	98.7	67.9	243.7
Caldwell, KY	1.2	2.0	28.5	121.6	42.1	39.8	235.3
Harrison, KY	0.6	2.1	24.1	77.5	22.7	31.0	158.0
Switzerland, IN	0.3	1.2	15.7	81.6	25.2	30.7	154.6
Owen, KY	0.4	0.9	15.1	61.5	11.3	15.7	104.8
Bracken, KY	0.1	0.7	17.2	30.5	12.2	14.0	74.8

Table 3b breaks down the direct $PM_{2.5}$ emissions value from Table 3a into its components. These data will also be compared with the previously presented Urban Increment composition.

Using the previously described relationship between directly emitted and precursor gases and the measured mass to evaluate data presented in Tables 3a and 3b, EPA identified the following components warranting additional review: The constituents of interest are POM, direct PM, and NOx. EPA then looked at the

[25] Data are based on the 2011 and 2018 Emissions Modeling Platform Data Files and Summaries (*ftp://ftp.epa.gov/EmisInventory/2011v6/v1platform*) available at: *http://www.epa.gov/ttn/chief/emch/index.html#2011* (accessed 02/26/14).

contribution of these constituents of interest from each of the counties included in the area of analysis as shown in Tables 4a-d. Tables 4a and b indicate that Boone, Campbell, Kenton, and Warren Counties are smaller relative contributors, which was one factor that was considered when proposing the partial county areas for these counties. However, Figure 4c shows that all counties in the nonattainment area, except Boone and Warren, are contributing at similar levels to the high organic carbon mass concentrations shown to dominate the urban increment (Figure 4a and b). This indicates that the urbanized portions of Kenton and Campbell Counties are contributing to the concentrations at the violating monitors in the Cincinnati-Hamilton nonattainment area.

Table 4a. County-Level NOx Emissions (tons/year) for the Intended Nonattainment Area

County, State	Total NOx	
Clermont, OH	21,423	23%
Hamilton, OH	35,541	38%
Butler , OH	13,972	15%
Boone , KY	8,394	9%
Warren, OH	6,950	7%
Kenton , KY	5,106	5%
Campbell , KY	2,628	3%
Total	94,014	100%

Table 4b. County-Level PM Emissions (tons/year) for the Intended Nonattainment Area

County, State	Total Direct PM	Percent of Total Area
Clermont , OH	8,507	45%
Hamilton, OH	5,657	30%
Butler, OH	2,476	13%
Boone, KY	757	4%
Warren, OH	841	4%
Kenton, KY	483	3%
Campbell, KY	306	2%
Total	19027.5	100%

Table 4c. County-Level POM Emissions (tons/year) for the Intended Nonattainment Area

County, State	POM	Percent of Total Area
Clermont , OH	663.5	17%
Hamilton, OH	1463.3	37%
Butler, OH	787.4	20%
Warren, OH	317.2	8%
Boone, KY	294.8	8%
Kenton, KY	248.1	6%

Campbell, KY	144.6	4%
Total	3919.0	100%

Table 4d. County-Level EC Emissions (tons/year) for the Intended Nonattainment Area

County, State	EC	Percent of Total Area
Clermont , OH	434.6	20%
Hamilton, OH	771.9	36%
Butler, OH	386.0	18%
Warren, OH	184.0	9%
Boone, KY	167.2	8%
Kenton, KY	124.8	6%
Campbell, KY	64.5	3%
Total	2132.9	100%

In addition to reviewing county-wide emissions of $PM_{2.5}$ and $PM_{2.5}$ precursors in the area of analysis, EPA also reviewed emissions from major point sources located in the intended nonattainment area. The magnitude and location of these sources can help inform nonattainment boundaries. Table 5 provides facility-level emissions of direct $PM_{2.5}$, components of direct $PM_{2.5}$, and precursor pollutants (given in tons per year) from major point sources located in the area of analysis for the Cincinnati-Hamilton area. Table 5 also shows the distance from the facility to the DV monitor for the respective county.

Table 5. NEI 2011 v1 Point Source Emissions (tons/year)

			NEI 2011 v1 Emissions - Tons/Year					
County, State	Facility Name (Facility ID)	Distance monitor (miles)	NH3	NOx	PM2.5	SO2	VOC	Total
Adams, OH	DP&L, J.M. Stuart Generating Station (0701000007)	57	2	7,764	1,935	8,441	189	18,331
Adams, OH	DP&L, Killen Generating Station (0701000060)	64	1	3,616	606	7,721	52	11,996
Adams, OH	General Electric Aircraft Engines: Peebles Facility (0701000001)	65		760	6	5	24	795
Boone, KY	Duke Energy KY East Bend	28	28	2,667	99	2,000	61	4,855
Boone, KY	Cincinnati/Northern Ken	15		740	27	90	151	1,009
Butler, OH	AK Steel Corporation (1409010006)	20	16	2,276	855	2,046	675	5,868
Butler, OH	MillerCoors LLC (1409000353)	18	0	380	41	880	173	1,474
Butler, OH	Wausau Paper Towel & Tissue, LLC (1409010043)	23	0	426	24	540	43	1,033
Butler, OH	Smart Papers - Hamilton	16	24	140	13	724	16	917

	Mill (1409040212)							
Butler, OH	City of Hamilton Department of Public Utilities (1409040243)	15	0	214	6	577	2	798
Butler, OH	SunCoke Energy Middletown Operations (1409011031)	20		60	23	476	6	564
Carroll, KY	KY Utilities Co - Ghent Station	43	81	7,831	2,346	10,982	177	21,417
Carroll, KY	North American Stainless	45		529	96	2	55	683
Clermont, OH	Duke Energy Ohio, W.C. Beckjord Station (1413100008)	17	1	7,538	5,297	90,840	47	103,724
Clermont, OH	Duke Energy Ohio, Wm. H. Zimmer Station (1413090154)	26	5	8,460	767	18,042	55	27,328
Dearborn, IN	AMERICAN ELECTRIC POWER-TANNERS CREEK	22	1	5,367	67	27,331	97	32,863
Dearborn, IN	Lawrenceburg Distillers Indiana, LLC	21	0	536	6	785	961	2,288
Dearborn, IN	ANCHOR GLASS - LAWRENCEBURG	20		296	62	162	10	529
Dearborn, IN	AURORA CASKET CO INC	28		3	2	0	496	501
Greene, OH	CEMEX Construction Materials Atlantic, LLC (0829700165)	49	24	1,175	34	213		1,446
Greene, OH	Wright-Patterson Air Force Base (0829700441)	49	0	336	99	918	6	1,359
Hamilton, OH	Duke Energy Ohio, Miami Fort Station (1431350093)	18	2	6,490	2,106	26,911	96	35,605
Hamilton, OH	DEGS of St. Bernard, LLC (1431394148)	2	0	737	114	2,033	4	2,889
Hamilton, OH	Emery Oleochemicals LLC (1431074278)	2	4	647	25	888	26	1,589
Hamilton, OH	INEOS ABS (USA) Corporation (1431010054)	13	0	190	15	387	24	616
Madison, KY	AGC Flat Glass N America Inc	104		634	14	138	33	819
Montgomery, OH	Cargill, Inc. - Dayton (0857041124)	46	1	468	55	747	357	1,629

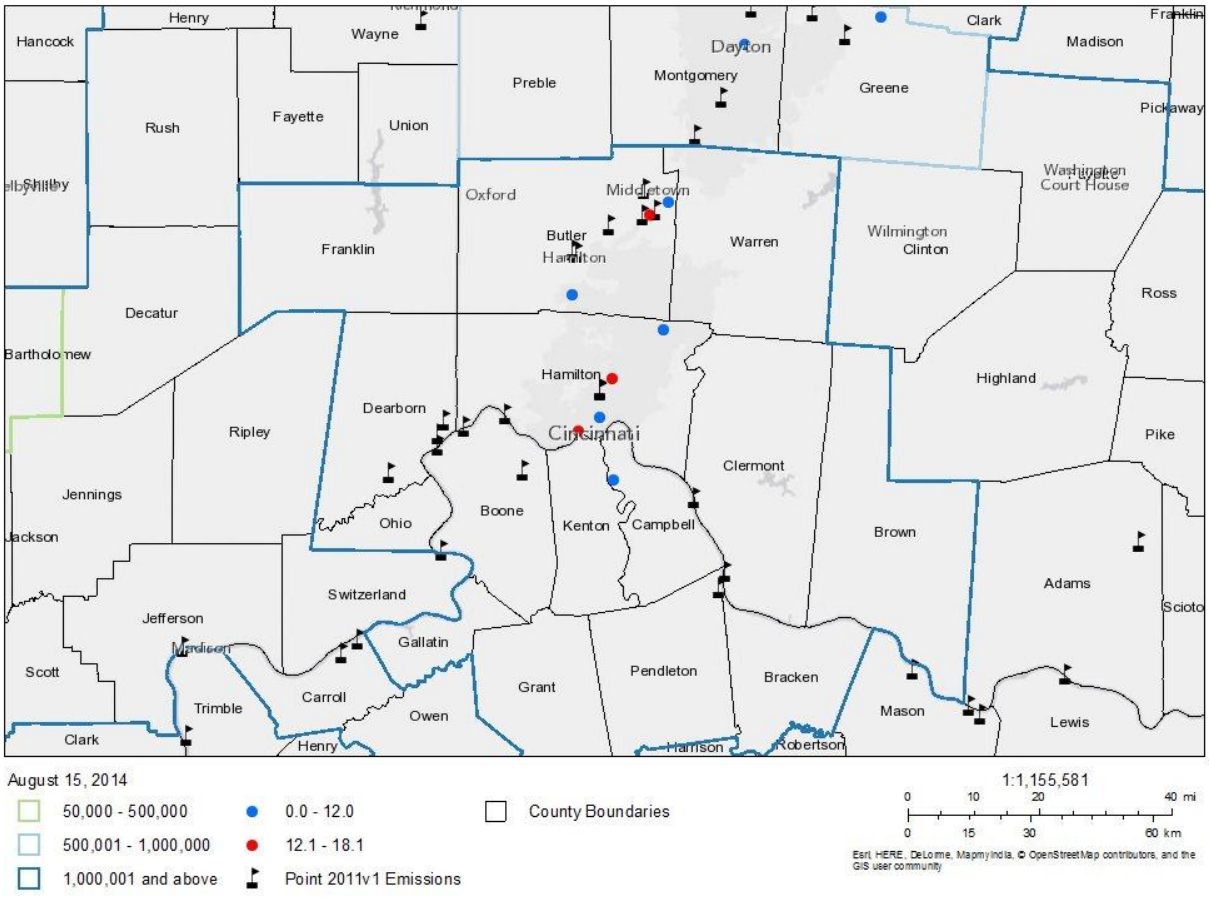
Montgomery, OH	Appleton Papers Inc. (0857190001)	35	1	538	58	938	24	1,559
Montgomery, OH	DP&L, O.H. Hutchings Generating Station (0857780013)	30	1	220	27	649	1	897
Ohio, KY	Big Rivers Electric Corp - Wilson Station	186	263	1,117	76	9,720	54	11,230
Pendleton, KY	Carmeuse Lime Inc	28		821	89	699		1,609
Scott, KY	Toyota Motor Manufacturing Usa Inc	65		62	72	0	1,351	1,486

Figure 5 shows the major point source emissions (from the 2011 NEI in tons per year) in the area of analysis for the Cincinnati-Hamilton Area and the relative distances of these sources from the violating monitoring locations, as depicted by red dots. The actual distance from the point sources to the DV monitoring location is presented in Table 5. The distance from the violating monitoring location is particularly important for directly emitted $PM_{2.5}$. The influence of directly emitted $PM_{2.5}$ on ambient $PM_{2.5}$ diminishes more than that of gaseous precursors as a function of distance.[26]

As indicated in Figure 5, there are 32 major point sources located within the area of analysis, and 14 of those source are in the intended nonattainment area. Four coal-fired? power plants are found in the nonattainment area, two in Clermont County, OH, one in Boone County, KY, and one in Hamilton County, OH. A fifth power plant (American Electric Power Tanners Creek) is located in Dearborn County, IN, but due to its retirement, as outlined in a 2013 Federal consent decree, emissions at that point source will go to zero. Major Hamilton County sources include: Duke Energy which has relatively high NOx, SO2, and direct PM located 18 miles from the DV monitor, and DEGs of St. Bernard and Emery Oleochemicals, both higher NOx and SO2 and both 2 miles away from the DV monitor. These very local sources of SO2 are potentially impacting the higher SO2 speciation data in some quarters, as noted above (Figure 3a and 3b). Butler County has major sources of AK Steel with high direct PM2.5 emissions located 20 miles from the Hamilton county design value monitor, Miller Coors with SO2 emissions 18 miles from the monitor, and Wausau Paper Towel & Tissue, LLC with moderate SO2 emissions 23 miles from the monitor. Clermont County major sources are two Duke power plants emitting high levels of NOx, SO2, and direct PM, located 17 and 26 miles away from the monitor. Although the wind roses in Figure 8 do not show significant winds from this direction the kernel density (Figure 9) of trajectories suggest contribution to the violation, plus the magnitude of the sources likely impact the monitors located in Hamilton County. Finally, Boone County has two major sources, Duke Energy with high NOx, SO2 and direct PM, 28 miles from the monitor, and Cincinnati/Northern with high NOx and PM2.5 emissions, 15 miles from the DV monitor. Wind roses from the South/South West (Figure 8) would indicate that the Boone County sources are impacting the monitors in Hamilton County. Prior PM2.5 designations have added the partial Dearborn County, Indiana, because of the American Electric Power, Tanners Creek facility. However, EPA is removing this partial county from the 2012 nonattainment area due to the retirement of the facility which is considered permanent and enforceable since it is required in a Federal consent decree. Emissions from this facility will be at zero when the facility shuts down in 2015.

Figure 5. Major Point Source Emissions in the Area of Analysis for the Cincinnati-Hamilton Area.

[26] Baker, K. R. and K. M. Foley. *A nonlinear regression model estimating single source concentrations of primary and secondarily formed $PM_{2.5}$.* Atmospheric Environment. 45 (2011) 3758-3767.



In summary, EPA's analysis of relevant county-level emissions and the geographic locations of the relevant pollutants showed that Clermont, Hamilton, Butler, and Boone Counties had the highest overall county emissions, with most of the emissions from Clermont, Butler, Hamilton, and Boone Counties being linked to point source emissions from either power plants or steel industry located within the counties. County-wide emissions from Warren, Kenton, and Campbell also ranked high in total emissions relative to the rest of the area of analysis; however, the emissions from these three counties are primarily from area and mobile sources, with Campbell and Kenton Counties contributing 4% and 6%, respectively, of the total area POM, and 3% and 6% of EC, which constituted a large portion of the urban increments (Figures 4a and 4b). Although the area of analysis looked at county emissions for counties including and surrounding the violating monitor, counties not listed above either had low overall emissions, or were counties that were downwind of the area, such as Adams and Montgomery Counties in Ohio.

Population density and degree of urbanization

In this part of the factor analysis, EPA evaluated the population and vehicle use characteristics and trends of the area as indicators of the probable location and magnitude of non-point source emissions. Rapid population growth in a county on the urban perimeter signifies increasing integration with the core urban area, and indicates that it may be appropriate to include the county associated with area source and mobile source emissions as part of the nonattainment area. Table 6 shows the 2000 and 2010 population, population growth since 2000, and population density for each county in the area.

Table 6. Population Growth and Population Density.

County, State	Population 2000	Population 2010	% Change from 2000	Land Area (Sq. Miles)	Population Density (per Sq. Mile)	%	Cumulative %
Hamilton, OH	845,303	802,034	-5.1%	407	1,969	25%	25%
Montgomery, OH	559,062	535,905	-4.1%	462	1,161	17%	42%
Butler, OH	332,807	368,814	10.8%	467	789	12%	54%
Warren, OH	158,383	213,269	34.7%	400	534	7%	60%
Clermont, OH	177,977	197,759	11.1%	452	438	6%	67%
Greene, OH	147,886	161,625	9.3%	415	390	5%	72%
Kenton, KY	151,464	159,880	5.6%	162	987	5%	77%
Boone, KY	85,991	119,306	38.7%	246	484	4%	80%
Campbell, KY	88,616	90,522	2.2%	152	597	3%	83%
Madison, KY	70,872	83,143	17.3%	441	189	3%	86%
Scott, KY	33,061	47,437	43.5%	285	167	1%	87%
Brown, OH	42,285	44,867	6.1%	492	91	1%	89%
Highland, OH	40,875	43,584	6.6%	553	79	1%	90%
Preble, OH	42,337	42,181	-0.4%	425	99	1%	91%
Ripley, IN	26,523	28,825	8.7%	446	65	1%	92%
Adams, OH	27,330	28,584	4.6%	584	49	1%	93%
Decatur, IN	24,555	25,774	5.0%	373	69	1%	94%
Grant, KY		24,675	10.2%			1%	95%

	22,384			260	95		
Fayette, IN	25,588	24,284	-5.1%	215	113	1%	96%
Ohio, KY	22,916	23,851	4.1%	594	40	1%	96%
Franklin, IN	22,151	23,066	4.1%	386	60	1%	97%
Harrison, KY	17,983	18,818	4.6%	310	61	1%	98%
Pendleton, KY	14,390	14,907	3.6%	281	53	0%	98%
Owen, KY	10,547	10,830	2.7%	352	31	0%	98%
Carroll, KY	10,155	10,798	6.3%	130	83	0%	99%
Switzerland, IN	9,065	10,624	17.2%	221	48	0%	99%
Gallatin, KY	7,870	8,587	9.1%	99	87	0%	99%
Bracken, KY	8,279	8,489	2.5%	203	42	0%	100%
Union, IN	7,349	7,516	2.3%	162	47	0%	100%
Robertson, KY	2,266	2,265	0.0%	100	23	0%	100%
Total	3,036,270	3,182,219					

Source: U.S. Census Bureau population estimates for 2000 and 2010

Population density comparison for the intended nonattainment area counties shows that Hamilton is the densest, followed by Kenton, Butler, Campbell, and Warren as moderately dense, and Boone and Clermont as low relative population density (Figure 6a and Table 6). Population in the moderate and low densely populated counties is centered around the Cincinnati-metropolitan area, and was one factor that was taken into account in creating boundaries for the intended partial counties of Kenton, Butler, Campbell (KY) and Warren (OH) (Figure 6b). Although Clermont has the lowest relative density and has only a small portion of the county associated with the urbanized area, Clermont's contribution to the nonattainment area is associated with the two Duke power plants located in the county (Figure 5). High growth rate is seen in Boone and Warren Counties, but growth and sources are still captured in the intended partial counties.

Figure 6a . 2010 County-Level Population in the Area of Analysis for the Cincinnati-Hamilton Area.

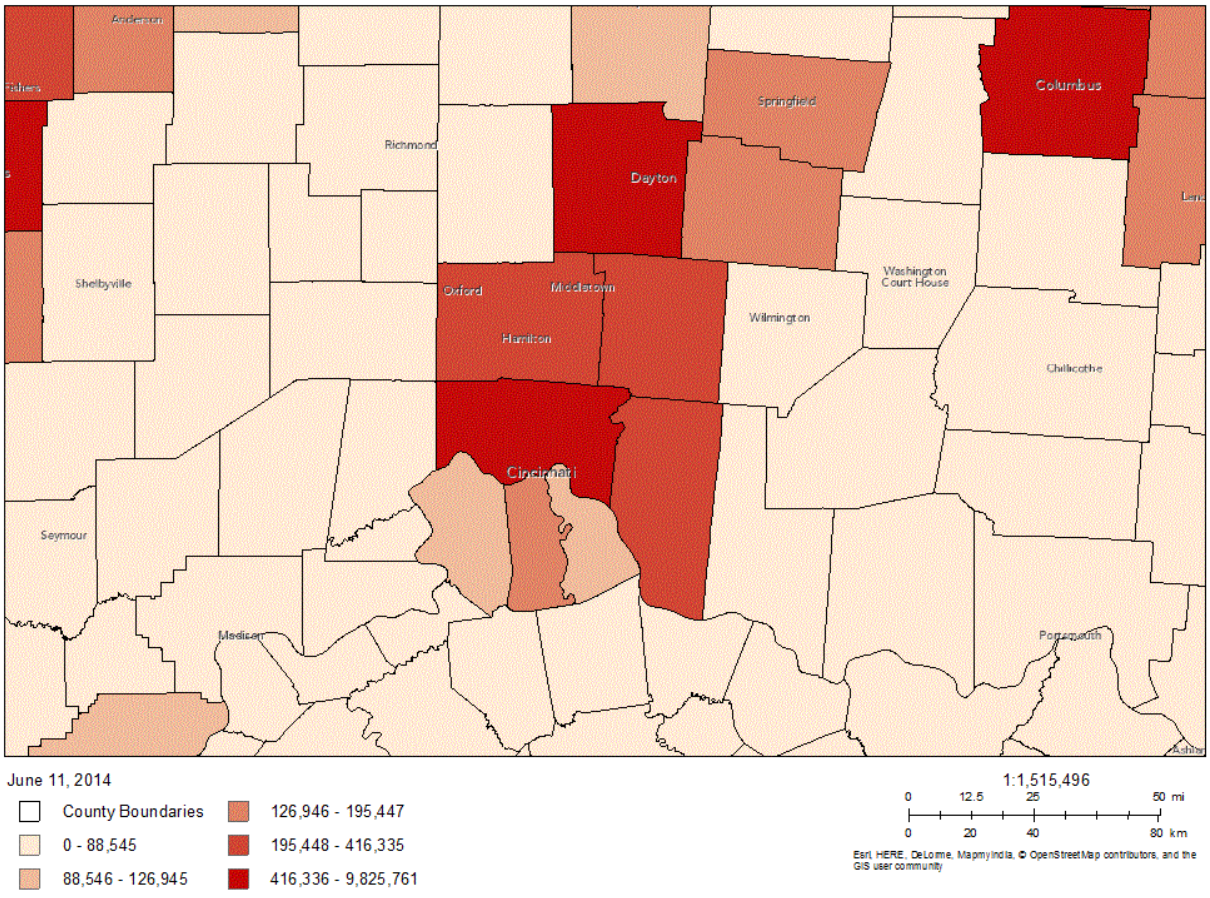
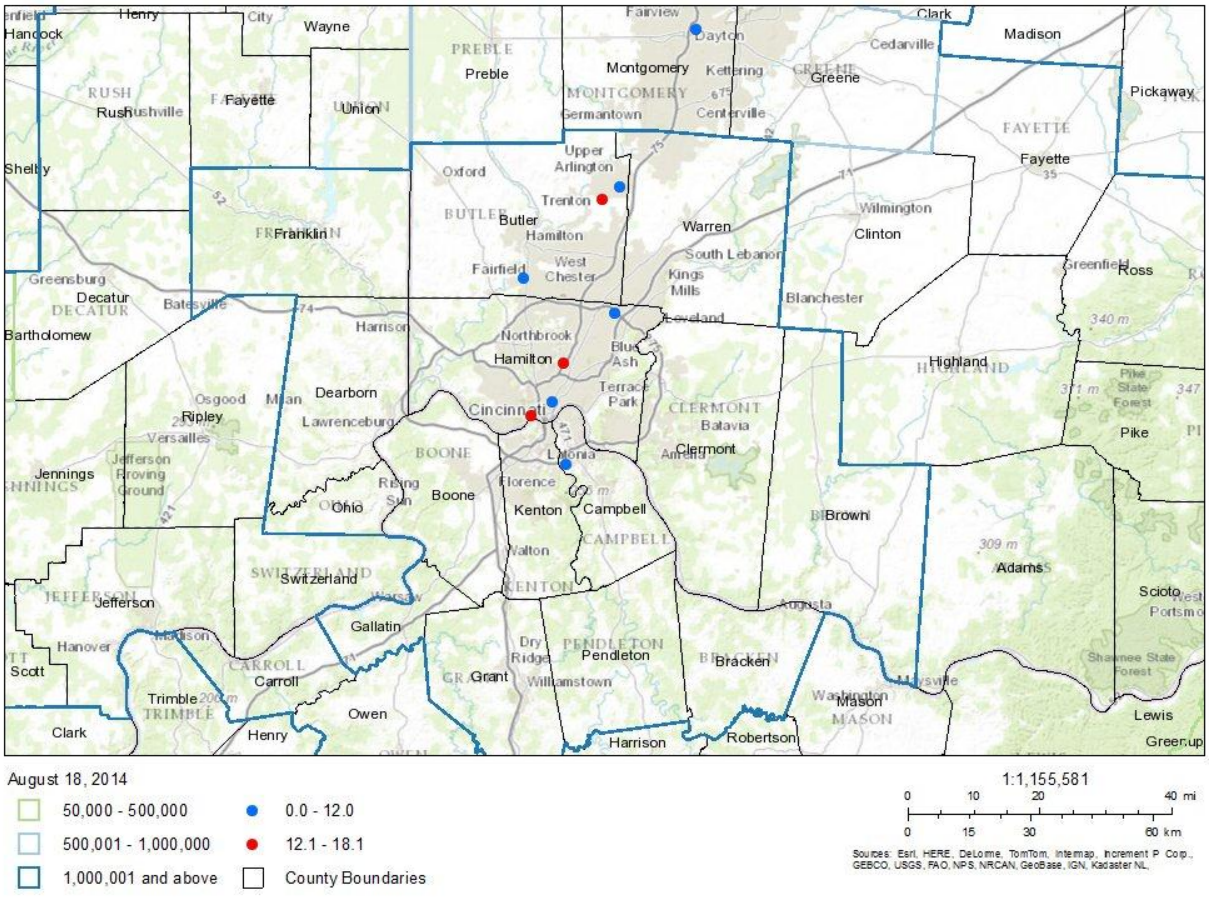


Figure 6b . Topographic map showing urbanized area for the Cincinnati-Hamilton Area.



Traffic and Vehicle Miles Travelled

High vehicle miles travelled (VMT) and/or a high number of commuters associated with a county is generally an indicator that the county is an integral part of an urban area. Mobile source emissions of NO_x, VOC, and direct PM may contribute to ambient particulate matter that contributes to monitored violations of the NAAQS in the area. In combination with the population/population density data and the location of main transportation arteries, an assessment of VMT helps identify the probable location of nonpoint source emissions that contribute to violations in the area. Comparatively high VMT in a county outside of the CBSA or CSA signifies integration with the core urban area contained within the CSA or CBSA, and indicates that a county with the high VMT may be appropriate to include in the nonattainment area because emissions from mobile sources in that county contribute to violations in the area. Table 7 shows 2011 VMT while Figure 7 overlays 2011 county-level VMT with a map of the transportation arteries. The VMT used in this analysis was obtained from the Federal Highway Administration.

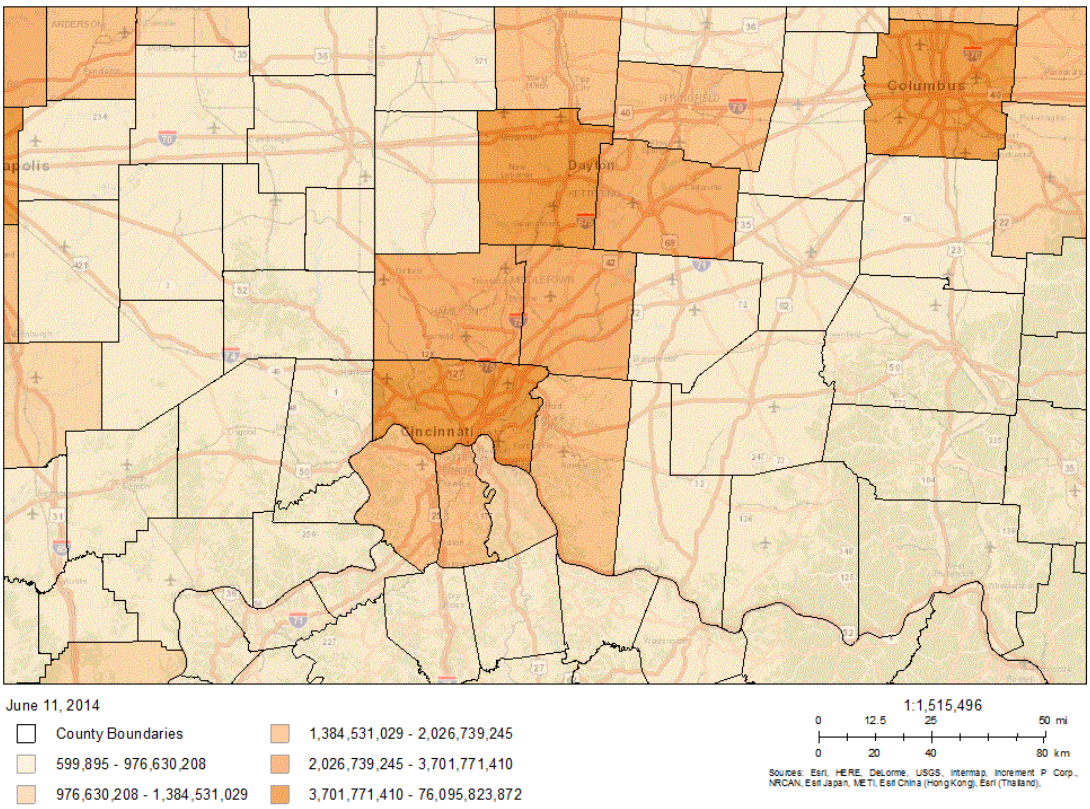
Table 7. 2011 VMT for the Cincinnati-Hamilton Area.

County, State	Total 2011	Percent	Cumulative
Hamilton, OH	9,004,357,566	25%	25%
Montgomery, OH	6,178,222,941	17%	41%
Butler, OH	3,099,030,997	8%	50%
Warren, OH	2,139,774,797	6%	56%
Greene, OH	2,108,654,417	6%	62%
Clermont, OH	1,951,343,156	5%	67%
Kenton,KY	1,720,886,038	5%	72%
Boone, KY	1,558,794,112	4%	76%
Madison, KY	1,017,391,787	3%	79%
Campbell, KY	1,010,009,434	3%	81%
Dearborn, IN	690,348,611	2%	83%
Scott, KY	661,626,556	2%	85%
Preble, OH	562,558,622	2%	87%
Grant, KY	529,145,674	1%	88%
Brown, OH	468,171,663	1%	89%
Ripley, IN	447,014,794	1%	91%
Highland, OH	439,103,611	1%	92%
Decatur, IN	410,435,547	1%	93%
Adams, OH	323,514,179	1%	94%
Franklin, IN	311,990,458	1%	95%
Ohio, KY	311,628,830	1%	95%
Gallatin, KY	245,765,593	1%	96%
Carroll, KY	201,464,322	1%	97%
Fayette, IN	199,216,106	1%	97%
Rush, IN		1%	98%

	196,891,227		
Pendleton, KY	184,074,537	1%	98%
Harrison, KY	172,653,729	0%	99%
Owen, KY	130,203,987	0%	99%
Switzerland, IN	124,623,272	0%	99%
Union, IN	105,444,221	0%	100%
Bracken, KY	104,160,119	0%	100%
Robertson, KY	17,539,124	0%	100%
Total	**36,626,040,026**		

http://www.census.gov/hhes/commuting/data/commuting.html

Figure 7. Overlay of 2011 County-level VMT with Transportation Arteries.



Hamilton County consistently rank highest in direct $PM_{2.5}$/key precursor emissions (VMT and population), followed by Butler, Warren, Kenton, Boone, and Campbell counties. All counties in the intended nonattainment area have greater than 1,000, 000 VMT and contain urbanized areas of high population density (Figure 6a and 6b). In Kenton, Boone, Campbell, and Warren counties – the population and associated VMT are found around the metro-Cincinnati area, and warrant including only the parts of these counties that are relatively urbanized, that have higher VMT and more population, and that are thus emitting direct PM emissions and thereby contributing to the observed violations. (See figure 6b).

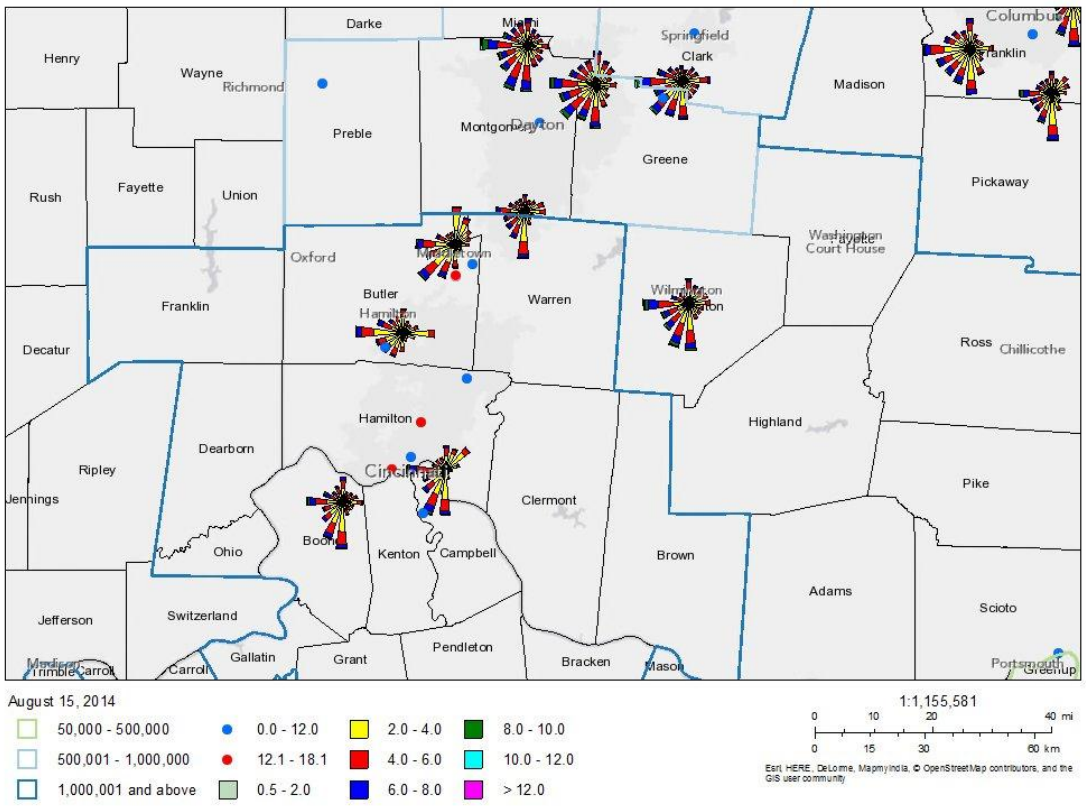
Factor 3: Meteorology

EPA evaluated available meteorological data to determine how meteorological conditions, including, but not limited to, weather, transport patterns, and stagnation conditions, could affect the fate and transport of directly emitted particulate matter and precursor emissions from sources in the area of analysis. EPA used two primary tools for this assessment: wind roses and kernel density estimation (KDE). When considered in combination with area $PM_{2.5}$ composition and county-level and facility emissions source location information, wind roses and KDE can help to identify nearby areas contributing to violations at violating monitoring sites.

Wind roses are graphic illustrations of the frequency of wind direction and wind speed. Wind direction can indicate the direction from which contributing emissions are transported; wind speed can indicate the force of the wind and thus the distance from which those emissions are transported. EPA constructed wind roses from hourly observations of wind direction and wind speed using 2009-2012 data from National Weather Service locations archived at the National Climate Data Center.[27] When developing these wind roses, EPA also used wind observations collected at meteorological sampling stations collocated at air quality monitoring sites, where these data were available. Figure 8 shows wind roses that EPA generated from data relevant in the Cincinnati-Hamilton area.

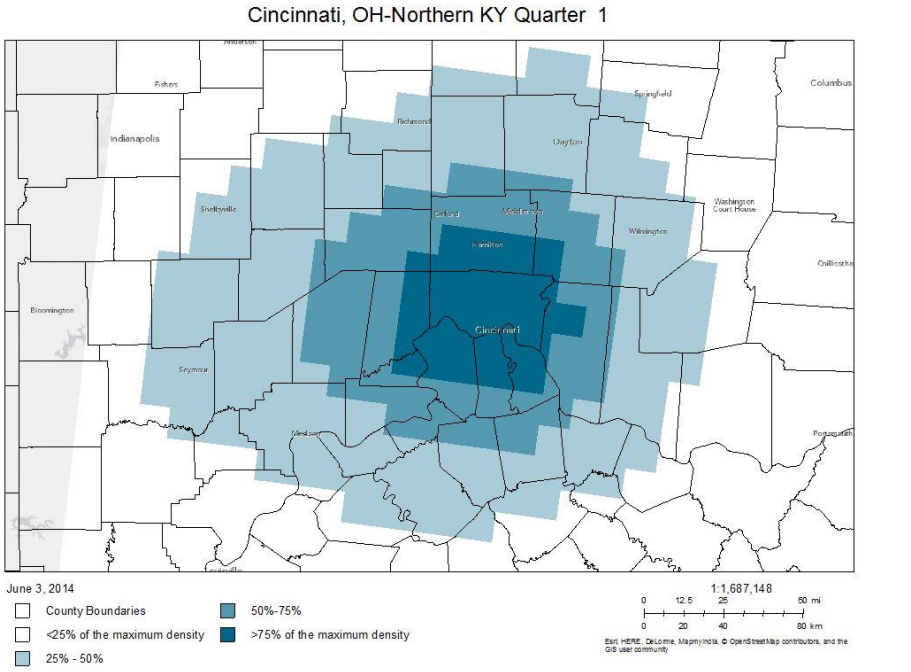
[27] *ftp.ncdc.noaa.gov/pub/data/noaa* or *http://gis.ncdc.noaa.gov/map/viewer/#app=cdo&cfg=cdo&theme=hourly&layers=1&node=gis* Quality assurance of the National Weather Service data is described here: *http://www1.ncdc.noaa.gov/pub/data/inventories/ish-qc.pdf*

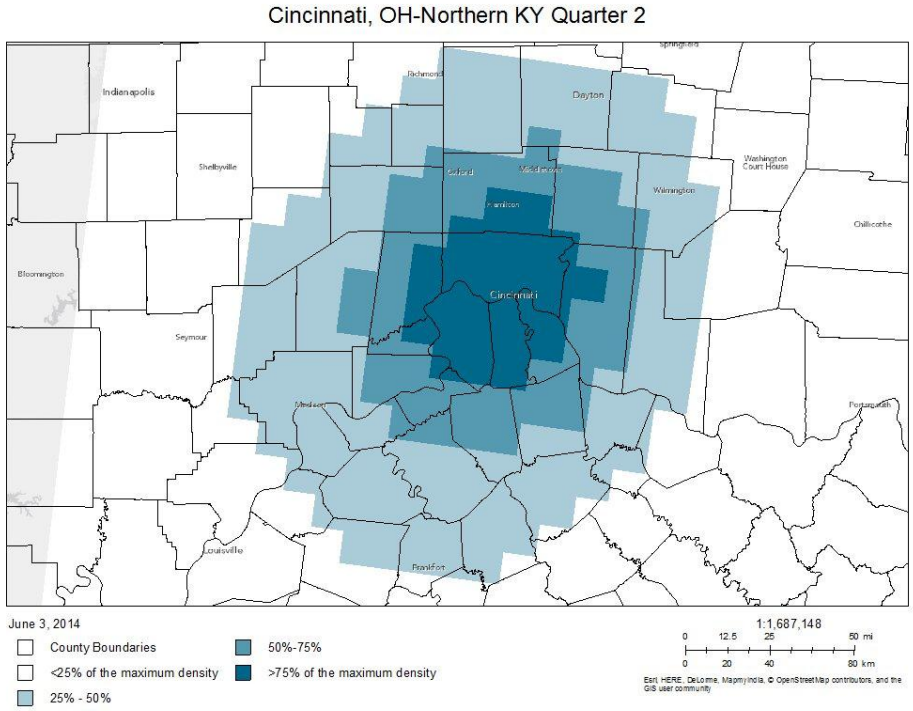
Figure 8. Wind Roses in the Area of Analysis for the Cincinnati-Hamilton Area



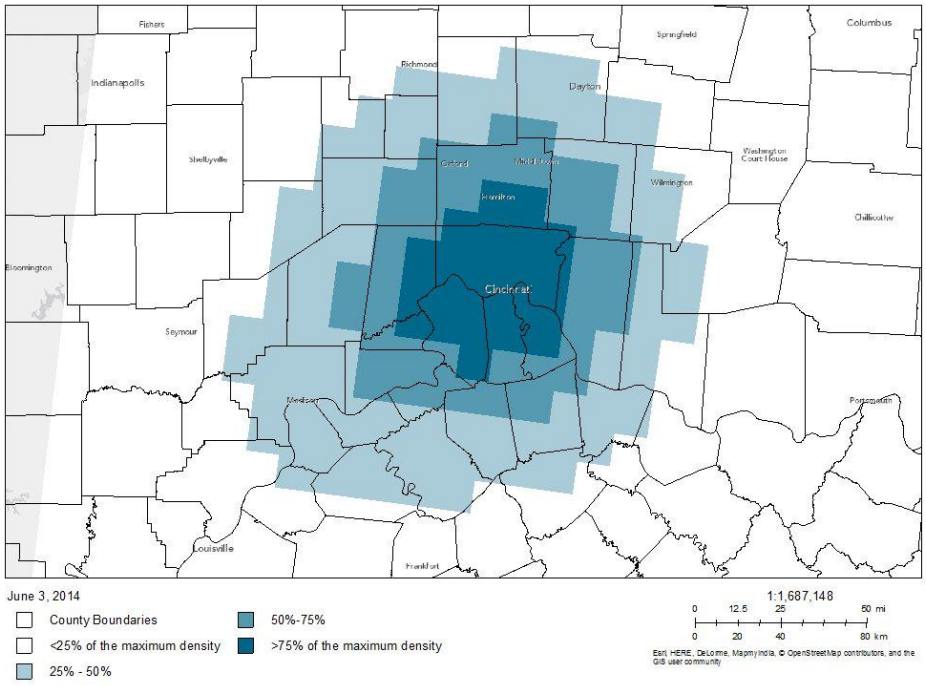
As shown in Figure 8, there is a slightly varying pattern across the CBSA of predominantly south to southwesterly winds, mostly at mid-level speeds of 4 to 8 meters per second, south of the Ohio River in Northern Kentucky and southwesterly to westerly winds, mostly at mid-level speeds of 4-8 meters per second, in the northern part of the Ohio portion of the area. The middle region of the area in Butler County has predominantly westerly winds mostly at mid-level speeds of 4 to 8 meters per second. This generally suggests that potential emission sources in the south-through-west upwind direction most warrant analysis. Emission sources in Clermont County, discussed above, although not from the predominate wind direction, are extremely high in relative magnitude and as shown in the high SO2 component of the speciation and urban increment, as well as the trajectory discussion below, are contributing to the Hamilton County violations. Montgomery and Green Counties are shown to be downwind of the violating monitors, and in fact are upwind of the attaining Montgomery monitor, leading to the conclusion that these two counties are not contributing to the Hamilton County violating monitors.

Figure 9. HYSPLIT Kernel Density Estimation Plots for the Cincinnati-Hamilton Area

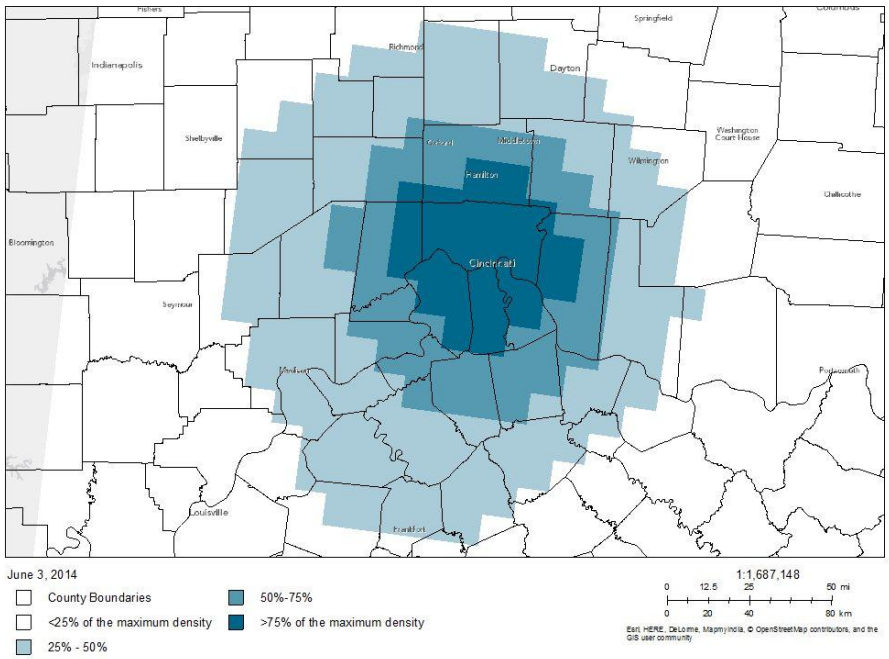




Cincinnati, OH-Northern KY Quarter 3



Cincinnati, OH-Northern KY Quarter 4



In summary, for the violating Hamilton County monitors, the HYPSPLIT KDE plots and wind roses suggest greatest potential contribution of emissions from Boone, Kenton, Campbell (KY) and Hamilton, Butler, Franklin and Clermont (OH) Counties. The HYSPLIT KDE plots indicate low density values in part of Warren County we are proposing to exclude, and shows medium or low density in the excluded partial counties for Boone, Kenton, and Campbell Counties.

Factor 4: Geography/topography

To evaluate the geography/topography factor, EPA assessed physical features of the area of analysis that might define the airshed and thus affect the formation and distribution of $PM_{2.5}$ concentrations over the area. While the Cincinnati-Middletown-Wilmington, OH-KY-IN CSA does not appear to have major geographical or topographical barriers significantly limiting air pollution transport within its air shed, EPA notes that geographically, the northern portions of Kenton and Campbell Counties in Kentucky area are in very close proximity (just across Ohio River) from the core of the downtown Cincinnati area.

Factor 5: Jurisdictional boundaries

In defining the boundaries of the intended Cincinnati-Hamilton nonattainment area, EPA considered existing jurisdictional boundaries, which can provide easily identifiable and recognized boundaries for purposes of implementing the NAAQS. Existing jurisdictional boundaries often signify the state governmental organization with the necessary legal authority for carrying out air quality planning and enforcement functions for the intended area. Examples of such jurisdictional boundaries include existing/prior nonattainment area boundaries for particulate matter, county lines, air district boundaries, township boundaries, areas covered by a metropolitan planning organization, state lines, and Reservation boundaries, if applicable. Where existing jurisdictional boundaries were not adequate or appropriate to describe the nonattainment area, EPA considered other clearly defined and permanent landmarks or geographic coordinates for purposes of identifying the boundaries of the intended designated areas.

The Cincinnati-Hamilton area has previously established nonattainment boundaries associated with the 1997 annual $PM_{2.5}$ NAAQS. The states have recommended different boundaries for the 2012 annual $PM_{2.5}$ NAAQS. Prior PM designations have added the partial Dearborn County, Indiana, because of the American Electric Power, Tanners Creek facility. However, EPA is removing this partial county from the 2012 nonattainment area due to the retirement of the facility which is considered permanent and enforceable since it is required in a Federal consent decree. The remainder of the county is relatively rural with a low population and VMT compared to the counties included in the nonattainment area.

For the intended partial counties in the Ohio portion of the Cincinnati-Hamilton nonattainment area, i.e. in Warren County, the EPA has used townships to define the area included and excluded, with the areas included encompassing the urbanized area and the contributing point sources of the counties. Kentucky does not have defined townships, and so intended partial county boundaries in Boone, Campbell, and Kenton County were defined on the basis of census tracts. The boundaries of the intended nonattainment area within Kentucky are identical to the boundaries of the area designated as nonattainment for the 2008 ozone NAAQS, because the same sources are impacting the PM concentrations.

Conclusion for the Cincinnati-Hamilton Area

Based on the assessment of factors described above, both individually and in combination, EPA has preliminarily concluded that the following counties should be included as part of the Cincinnati-Hamilton OH-KY nonattainment area because they are either violating the 2012 annual $PM_{2.5}$ NAAQS or contributing to a violation in a nearby area: Hamilton, Butler, Clermont, and partial Warren Counties in Ohio, and partial Boone, Kenton, and Campbell Counties in Kentucky. These are not the same counties that are included in the Cincinnati-Hamilton nonattainment area for the 1997 annual $PM_{2.5}$ NAAQS. The air quality monitoring sites in

Butler and Hamilton Counties indicate violations of the 2012 annual $PM_{2.5}$ NAAQS based on the 2011-2013 DVs; therefore these counties are included in the nonattainment area. The rest of the counties are nearby counties that do not have violating monitoring sites, but EPA has concluded that these areas contribute to the particulate matter concentrations in violation of the 2012 annual $PM_{2.5}$ NAAQS through emissions from point sources, non-point sources (e.g., area sources), and from mobile source emissions.

Ohio

Based on the assessment of factors described above for Ohio, EPA has concluded that Hamilton, Butler, and Clermont Counties, and portions of Warren County be included as part of the Cincinnati-Hamilton OH-KY nonattainment area. Hamilton and Butler Counties contribute 30% and 13% of total direct PM for the areas total PM emissions. Hamilton and Butler Counties also contain point sources that are contributing to PM precursors, as well as having high population and VMT that are contributing to the monitored PM violations. Most of these emissions are coming from area sources and the urbanized area in these two counties. Clermont County contains two major power plants that are contributing 73% of total SO2, which has a high impact on the urban increment in Q3, 10% of the total area VOCs, 23% of the areas NOx, and 43% of direct PM for the area. SO2, NOx, dirct PM, and VOCs are primarily associated with the power plants – with some of the VOC, NOx, and direct PM being associated with the urbanized area and VMT in Clermont County that are associated with the Cincinnati-metro area. Clermont point sources are found downwind of the violating monitors and are contributors to the violations currently monitored. Warren County remains as a partial county as it has no point source emissions; with the main contributor to the nonattainment being mobile sources contributing to the direct PM emissions, and reflected in the urban increment. Warren County has similar overall emissions of NOx and direct PM as Campbell and Kenton – contributing 10% of the areas total direct PM, where mobile and area sources dominate the sources contributing. We have intended the partial counties based on the urbanized areas that are correlated with the total VMT, and PM emissions. The wind roses and kernel density indicate that Warren Co is a weak contributor, however, the VMT is having a localized impact with the direct PM, and the VMT is associated with commuting patterns into the Cincinnati area with the violating monitors. EPA, therefore, is designating Hamilton, Boone, and Clermont Counties, and partial Warren County (all townships except Harlan, Massie, Salem, Washington, and Wayne townships).

Kentucky

Based on the assessment of factors described above for Kentucky, EPA has concluded that portions of Boone, Campbell, and Kenton Counties must be included as part of the Cincinnati-Hamilton, OH-KY nonattainment area because they are contributing to a violation in a nearby area. The total of mobile source and area source emissions from these counties comprise approximately 40% of the total mobile source and area source NOx emissions in the Cincinnati-Hamilton, OH-KY area. The total of mobile source and area source emissions from these counties comprise approximately 75% of the total mobile source and area source VOC emissions in the Cincinnati-Hamilton, OH-KY-IN area. Point sources in these counties comprise approximately 50% of the total NOx emissions and 10% of the total VOC emissions with Boone County containing two smaller power plants, and 4% of the total PM emissions in the Cincinnati-Hamilton, OH-KY area. As indicated in the factors above, Boone, Campbell, and Kenton Counties have sources of direct PM, NOx and VOC emissions; rank among the highest VMT contributors for the Cincinnati-Hamilton, OH-KY nonattainment area; have high population densities and high population growth in Boone County. The northern portions of these counties urbanized and associated with the Cincinnati-Hamilton area, as well as being directly upwind of the violating monitors and having strong association with the trajectories shown in the kernel density. As such, EPA is designating portions of Boone, Campbell, and Kenton Counties as part of the Cincinnati, OH-KY-IN nonattainment area. The partial county boundary for Boone, Campbell, and Kenton Counties includes all of the census tracts in these counties except the census tracts 706.01 and 706.04 in Boone County, 637.01 and 637.02 in Kenton County, and 520.01 and 520.02 in Campbell County.