Louisville, Kentucky-Indiana
Area Designations for the
2012 Primary Annual $PM_{2.5}$ National Ambient Air Quality Standards
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, the 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. The 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 decision to designate areas in Kentucky and Indiana as nonattainment for the 2012 primary annual fine particle NAAQS (2012 annual $PM_{2.5}$ NAAQS).[2]

Consistent with section 107(d), states were 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, Kentucky recommended that all counties in the Commonwealth be designated as attainment or attainment/unclassifiable. Additionally, in December 2013, Indiana recommended that all monitored counties in Indiana be designated attainment and all remaining counties be designated as unclassifiable. After considering these recommendations and based on the EPA's technical analysis as described in this TSD, the EPA is designating the areas listed in Table 1 as nonattainment for the 2012 annual $PM_{2.5}$ NAAQS. The 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 is initially classifying all nonattainment areas as "Moderate" nonattainment areas.

[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 $PM_{2.5}$ Federal Reference Method (FRM), Federal Equivalent Method (FEM) or Approved Regional Methods (ARM) 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.

Table 1. Kentucky-Indiana Recommended Nonattainment Areas and the EPA's Final Designated Nonattainment Areas for the 2012 Annual $PM_{2.5}$ NAAQS

Area	States' Recommended Nonattainment Counties	The EPA's Final Designated Nonattainment Counties
Louisville (KY side)	None	Jefferson Bullitt (partial)
Louisville (IN side)	None	Clark Floyd

In its recommendation letter, Kentucky recommended that the EPA designate as "attainment" or "unclassifiable/attainment" all counties of the Commonwealth. With the exception of a portion of Bullitt County, and the entirety of Jefferson County in Kentucky, as identified in Table 1, and the counties in the Cincinnati Area, the EPA agrees with Commonwealth's recommendation and is designating the remainder of Kentucky as unclassifiable/attainment. This designation is based on the Commonwealth's recommendation, ambient monitoring data collected during the 2011-2013 period showing compliance with the 2012 annual $PM_{2.5}$ NAAQS, and Kentucky's determination/assessment that areas within the Commonwealth are not likely contributing to nearby violations.[4,5]

In its recommendation letter, Indiana recommended that the EPA designate as "attainment" or "unclassifiable/attainment" all counties in Indiana. With the exception of Clark and Floyd Counties, as identified in Table 1, the EPA agrees with Indiana's recommendation and is designating the remainder of Indiana as unclassifiable/attainment based on the State's recommendation, ambient monitoring data collected during the 2011-2013 period showing compliance with the 2012 annual $PM_{2.5}$ NAAQS, and the

[4] Unless a state or tribe has specifically identified jurisdictional boundaries in their area recommendations, when determining "remainder of the state," The EPA will use Federal Information Processing Standard (FIPS) codes maintained by the National Institute of Standards and Technology (NIST), which are used to identify counties and county equivalents (e.g., parishes, boroughs) of the United States and its unincorporated territories (e.g., American Samoa, Guam, Northern Mariana Islands, Puerto Rico, and the US Virgin Islands). Available on the EPA's Envirofacts website at *http://www.epa.gov/envirofw/html/codes/state.html*.

[5] The EPA uses a designation category of "unclassifiable/ attainment" for areas that are monitoring attainment and for areas that do not have monitoring sites but which the EPA believes are likely attainment and does not have emissions sources that are contributing to nearby violations based on the five factor analysis and other available information.

Commonwealth's determination/assessment that areas within the Commonwealth are not likely contributing to nearby violations.[6,7]

2.0 Nonattainment Area Analyses and Final Boundary Determination

The EPA evaluated and determined the final 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), the EPA is designating 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 nonattainment area. As described in the EPA guidance,[8] after identifying each monitoring site indicating a violation of the standard in an area, the 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 site is located. The EPA also evaluated counties adjacent to the CBSA or CSA that have emissions sources with the potential to contribute to the violation. The 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. The EPA's analytical approach is described in section 3 of this TSD.

3.0 Technical Analysis

In this technical analysis, the EPA used the latest data and information available to the EPA (and to the states and tribes through the $PM_{2.5}$ Designations Mapping Tool[9] and the EPA PM Designations Guidance and Data web page[10]) and/or data provided to the EPA by states or tribes. This technical analysis identifies the areas with monitoring sites that violate the 2012 annual $PM_{2.5}$ NAAQS. The EPA evaluated these areas and other nearby areas with emissions sources or activities that potentially contribute to ambient fine particle concentrations at the violating monitors in the area based on the weight of evidence of the five factors recommended in the EPA guidance and any other relevant information.

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[6] Unless a state or tribe has specifically identified jurisdictional boundaries in their area recommendations, when determining "remainder of the state," EPA will use FIPS codes maintained by the NIST, which are used to identify counties and county equivalents (e.g., parishes, boroughs) of the United States and its unincorporated territories (e.g., American Samoa, Guam, Northern Mariana Islands, Puerto Rico, and the US Virgin Islands). Available on the EPA's Envirofacts website at *http://www.epa.gov/envirofw/html/codes/state.html*.

[7] The EPA uses a designation category of "unclassifiable/ attainment" for areas that are monitoring attainment and for areas that do not have monitoring sites but which the EPA believes are likely attainment and does have not emissions sources that are contributing to nearby violations based on the five factor analysis and other available information.

[8] The EPA issued guidance on April 16, 2013, that identified important factors that the 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*.

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

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

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, the EPA identifies violations using data from suitable FRM, FEM, and/or ARM monitors sited and operated in accordance with 40 CFR Part 58.[11] 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).[12] In addition to reviewing data from violating monitor sites, the 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. 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 $PM_{2.5}$, e.g., primary organic carbon (POC) and $PM_{2.5}$organic mass (POM), elemental carbon (EC), crustal material (and/or individual trace metal compounds)), primary nitrate and primary sulfate, and precursor gaseous pollutants (e.g., sulfur dioxide (SO_2), nitrogen oxides (NOx), total volatile organic compounds (VOC), and ammonia (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, the 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 $PM_{2.5}$

[11] 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).

[12] 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.

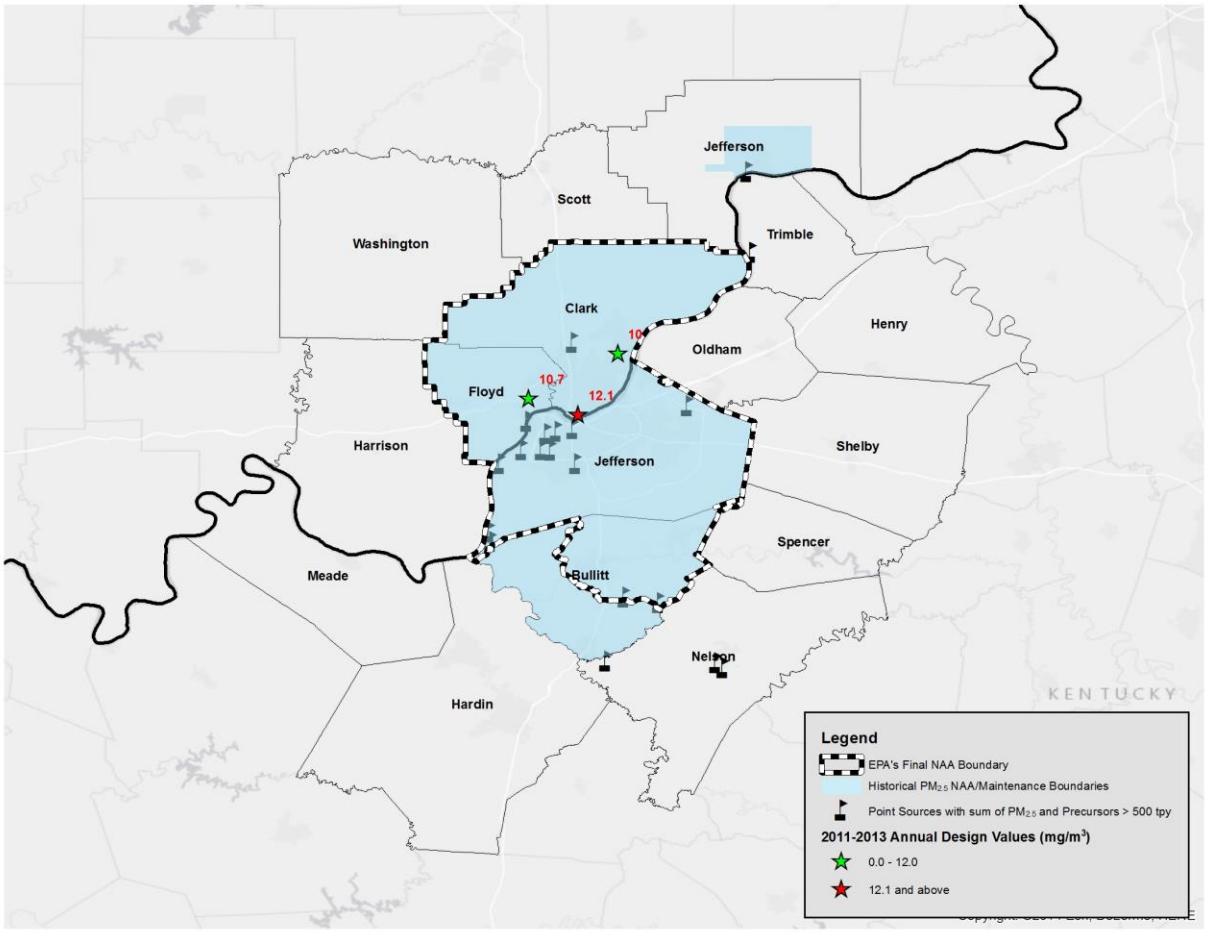
Factor 5: Jurisdictional boundaries. The analysis of jurisdictional boundaries identifies the governmental planning and organizational structure of an area that may be relevant for designations purposes. These jurisdictional boundaries provide insight into how the governing air agencies conduct or might 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, and existing nonattainment areas.

3.1 Area Background and Overview for the Louisville, Kentucky-Indiana Area

Figure 1 is a map of the EPA's final nonattainment boundary for the Louisville CBSA. The map shows the location and design values of ambient air quality monitoring locations, county and other jurisdictional boundaries.

Counties in the Louisville, KY-IN Area include: Bullitt, Henry, Jefferson, Meade, Nelson, Oldham, Shelby, Spencer and Trimble counties in Kentucky, and Clark, Floyd, Harrison and Washington counties in Indiana. For purposes of the 1997 annual $PM_{2.5}$ NAAQS, portions of this area were designated nonattainment. The boundary for the nonattainment area for the 1997 annual $PM_{2.5}$ NAAQS included the entire counties of Jefferson and Bullitt in Kentucky; and Clark, Floyd and a portion of Jefferson counties in Indiana. For this area, the boundaries for the 1997 annual $PM_{2.5}$ NAAQS and the 2012 annual $PM_{2.5}$ NAAQS differs, in that a portion of Bullitt, Kentucky and a portion of Jefferson County, Indiana are not included in the 2012 annual $PM_{2.5}$ NAAQS area boundary.

Figure 1. The EPA's Final Nonattainment Boundaries for the Louisville, Kentucky-Indiana Area



The EPA must designate as nonattainment areas that violate the NAAQS and nearby areas that contribute to the violation. Clark County, Indiana shows a violation of the 2012 $PM_{2.5}$ NAAQS, therefore this county is included in the nonattainment area. The EPA evaluated each county without a violating monitoring site located near the county with a violating monitoring site based on the five factors and other relevant information and determined that Floyd County, Indiana, and Jefferson County and the urbanized portion of Bullitt County in Kentucky contribute to the nearby violation. Data in the Jefferson County, Kentucky portion of this area is invalid because of significant problems with the collection and analysis of $PM_{2.5}$ filter-based samples. EPA and Kentucky audits of the Louisville (Jefferson County) air quality agency found systemic issues with $PM_{2.5}$ lab operations, data handling, record keeping, and quality assurance. However, the EPA evaluated Jefferson County based on the five factors, and on this basis determined that the county contributes to the violation at the Clark County, Indiana monitor. 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.

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, the 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, the EPA assessed air quality data on a seasonal, or quarterly, basis.[13] The EPA also identified the spatial extent of these high $PM_{2.5}$ concentrations. The mass and composition at the design value location represents 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, the 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, the EPA contrasted the approximated mass composition at the design value monitoring site with data collected at IMPROVE[14] 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,"[15,16] which helps differentiate the influence of

[13] 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 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.

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

[15] 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. The 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), the 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, the EPA used alternative analyses to reflect the mix of urban and rural sources contributing to the measured concentrations at violating monitoring sites.

[16] 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

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.[17,18,19]

$PM_{2.5}$ Design Values and Total Mass Measurements – The 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. The 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 AQS. For this designations analysis, the 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 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 ($\mu g/m^3$) 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 Louisville nonattainment area.[20]

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
Bullitt, KY	210290006	No	Monitor shut down 2011		
Clark, IN	180190006	No	13.5	13.2	12.1
Clark, IN	180190008	No	11.4	11.0	10.0
Floyd, IN	180431004	No	12.3	11.8	10.7
Jefferson, KY	211110043	No	Invalid data (awaiting EPA decision)		
Jefferson, KY	211110044	No	Invalid data (awaiting EPA decision)		
Jefferson, KY	211110051	No	Invalid data (awaiting EPA decision)		

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.

[17] 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.

[18] 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*

[19] 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*

[20] 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…."

County, State	Monitor Site ID	State Rec NA?	09-11 DV	10-12 DV	11-13 DV
Jefferson, KY	211110067	No	Invalid data (awaiting EPA decision)		

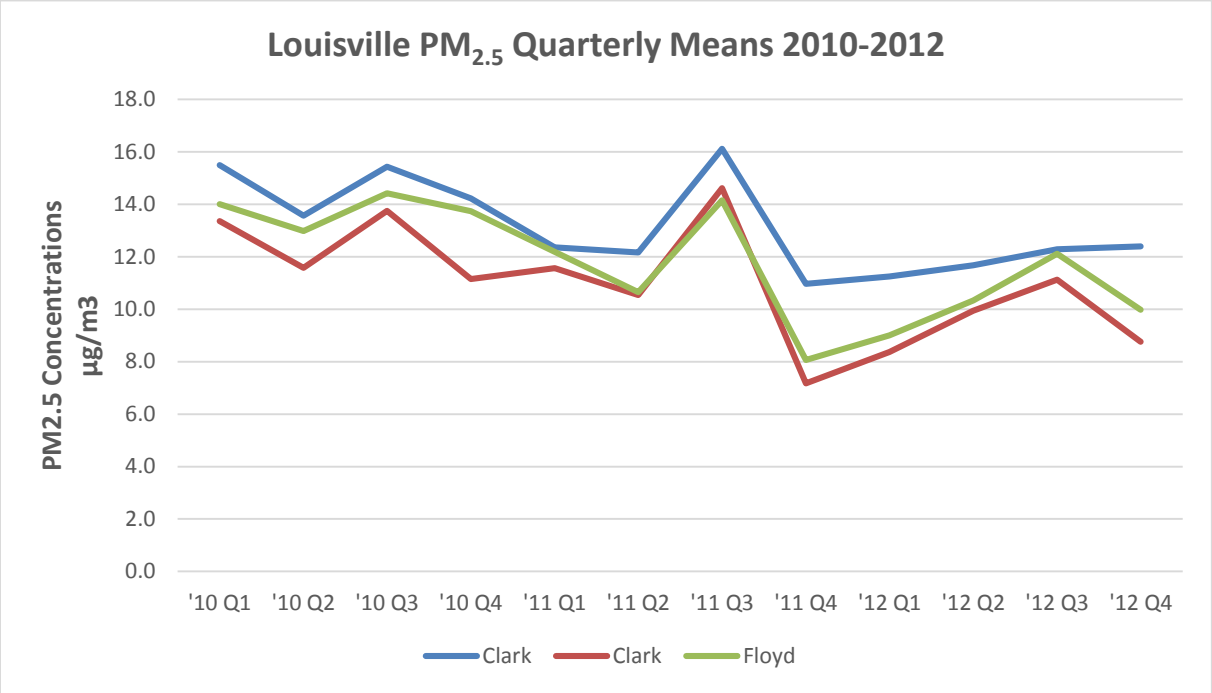
[a] Where a county has more than one monitoring location, the county design value is indicated in red type.

[b] This design value does not include data from Class III FEM monitors that are not eligible for comparison to the NAAQS, as approved by the EPA pursuant to 40 CFR 58.11(e).

The Figure 1 map, shown previously, identifies the Louisville, KY-IN area final nonattainment area, the CBSA boundary, and monitoring locations with 2011-2013 violating DVs. As indicated on the map, there is one monitoring location that is violating the NAAQS in Jeffersonville in Clark County. This monitor has consistently had a higher DV in the region including the 1997 $PM_{2.5}$ designation. There is a second monitor in Clark County to the northeast and one monitor to the west in Floyd County; data from both of these monitors show compliance with the NAAQS. As described previously, there are four monitors in Jefferson County, Kentucky and all have invalid data for this subject time period.

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, non-violating, 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. Louisville $PM_{2.5}$ Quarterly Means for 2010-2012



As shown, quarterly values across the period vary by 5 $\mu g/m^3$ at the Clark County site, with consistent annual peaks occurring in Q3.

$PM_{2.5}$ Composition Measurements - 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, the 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.[21,22,23,24] 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 at the Clark County (180190006) monitoring site based on annual averages for the years 2010-2012.

Figure 3a shows the $PM_{2.5}$ chemical constituent annual average for DV monitor from Clark County monitor.

Figure 3a. Louisville, KY-IN Area Annual Average $PM_{2.5}$ Chemical Constituents (2010-2012)

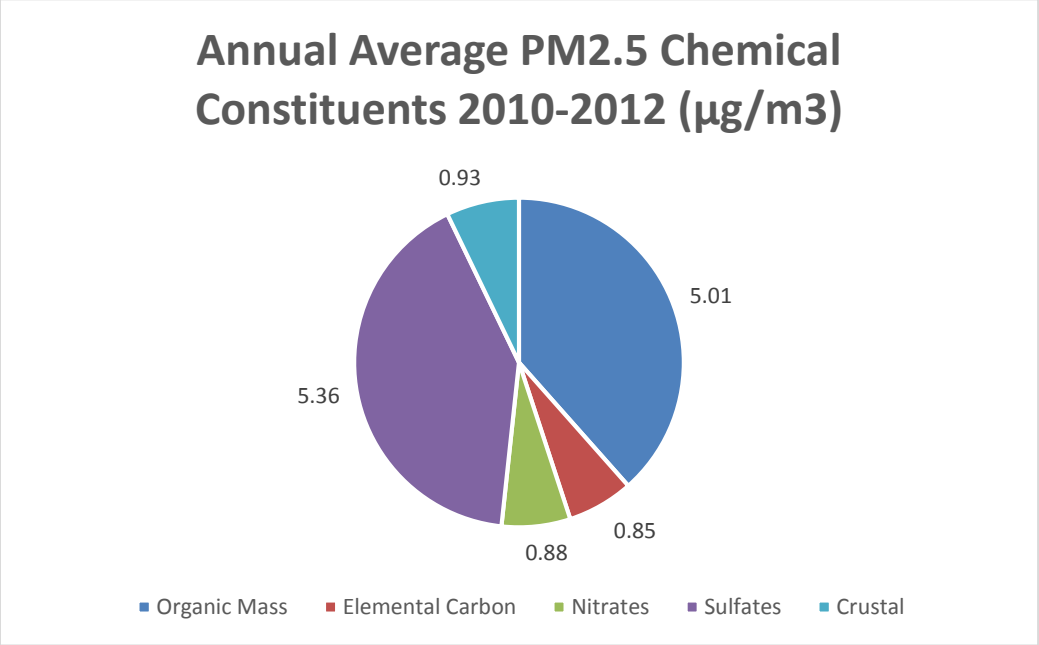


Figure 3b shows annual and quarterly chemical composition profiles and illustrates seasonal and episodic contributors to $PM_{2.5}$ mass. This "increment analysis," combined with the other factor analyses, can provide

[21] 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.

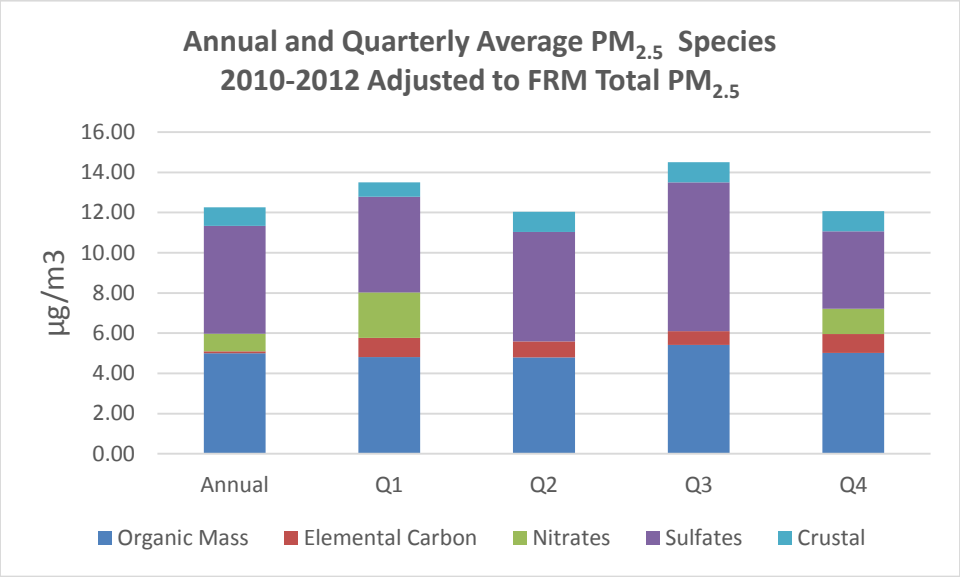
[22] Frank, N. H., SANDWICH Material Balance Approach for $PM_{2.5}$ Data Analysis, National Air Monitoring Conference, Las Vegas, Nevada, November 6-9, 2006. *http://www.epa.gov/ttn/amtic/files/2006conference/frank.pdf*.

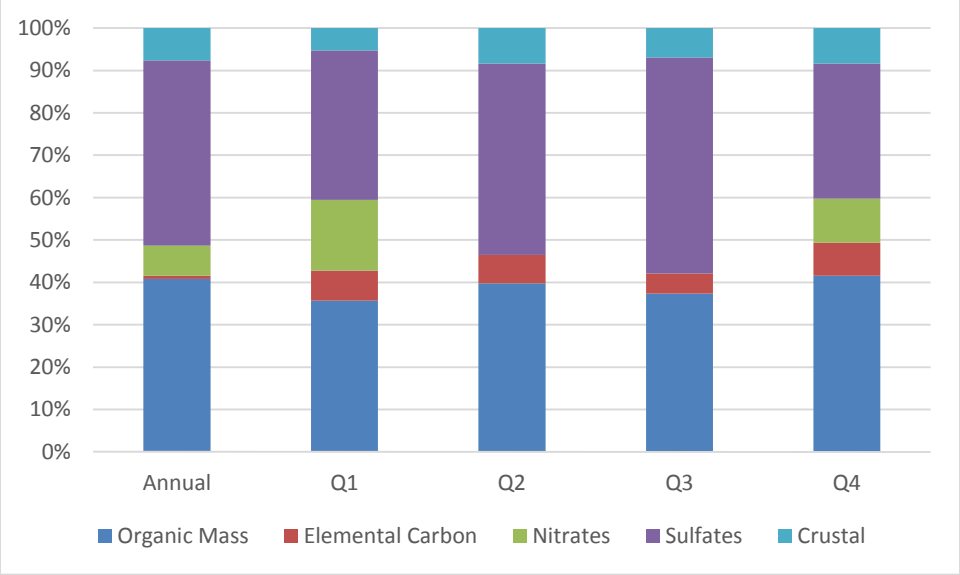
[23] Frank, N. H., The Chemical Composition of $PM_{2.5}$ to support PM Implementation, the EPA State /Local/Tribal Training Workshop: $PM_{2.5}$ Final Rule Implementation and 2006 $PM_{2.5}$ Designation Process, Chicago IL, June 20-21, 2007, *http://www.epa.gov/ttn/naaqs/pm/presents/pm2.5_chemical_composition.pdf*.

[24] 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. Louisville, KY-IN Area Annual and Quarterly Average $PM_{2.5}$ Species (2010-2012)[a]





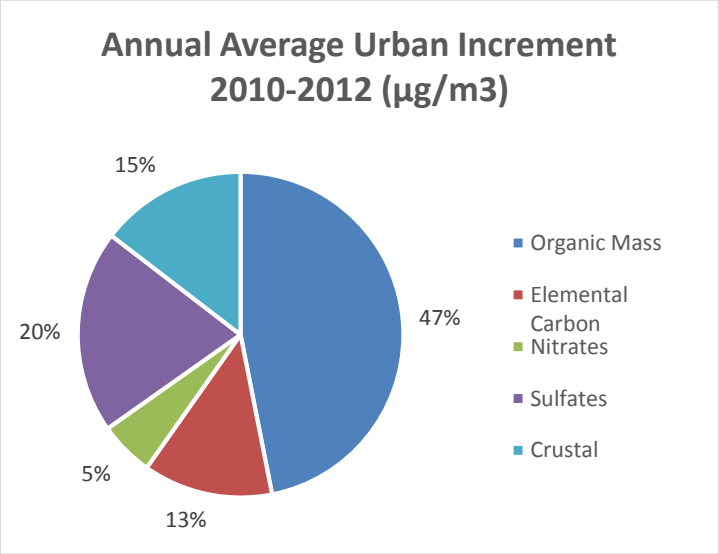
[a] *Adjusted to FRM Total $PM_{2.5}$* indicates that the speciation profile and total mass depicted in this figure are the result of the urban increment calculation for the particular FRM monitor.

Figures 3a and 3b show that sulfate and organic mass are the predominant species overall. Crustal and elemental carbon comprise a small percentage in all four quarters. Sulfate peaks in quarter three. Nitrate is a relatively small component in all quarters, but is slightly higher in Q1 & 4. It is likely that the large sulfate component is

caused by SO_2 emissions from large electric generating units in the area. High levels of organic mass are typically associated with mobile sources, wood or biomass burning and localized combustion sources.[25]

The 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. Louisville, KY-IN Area Urban Increment Analysis for 2010-2012.



[25] The EPA Guidance Memorandum, "Initial Area Designations for the 2012 Revised Primary Annual Fire Particulate National Ambient Air Quality Standard," dated April 16, 2013, Attachment 3.

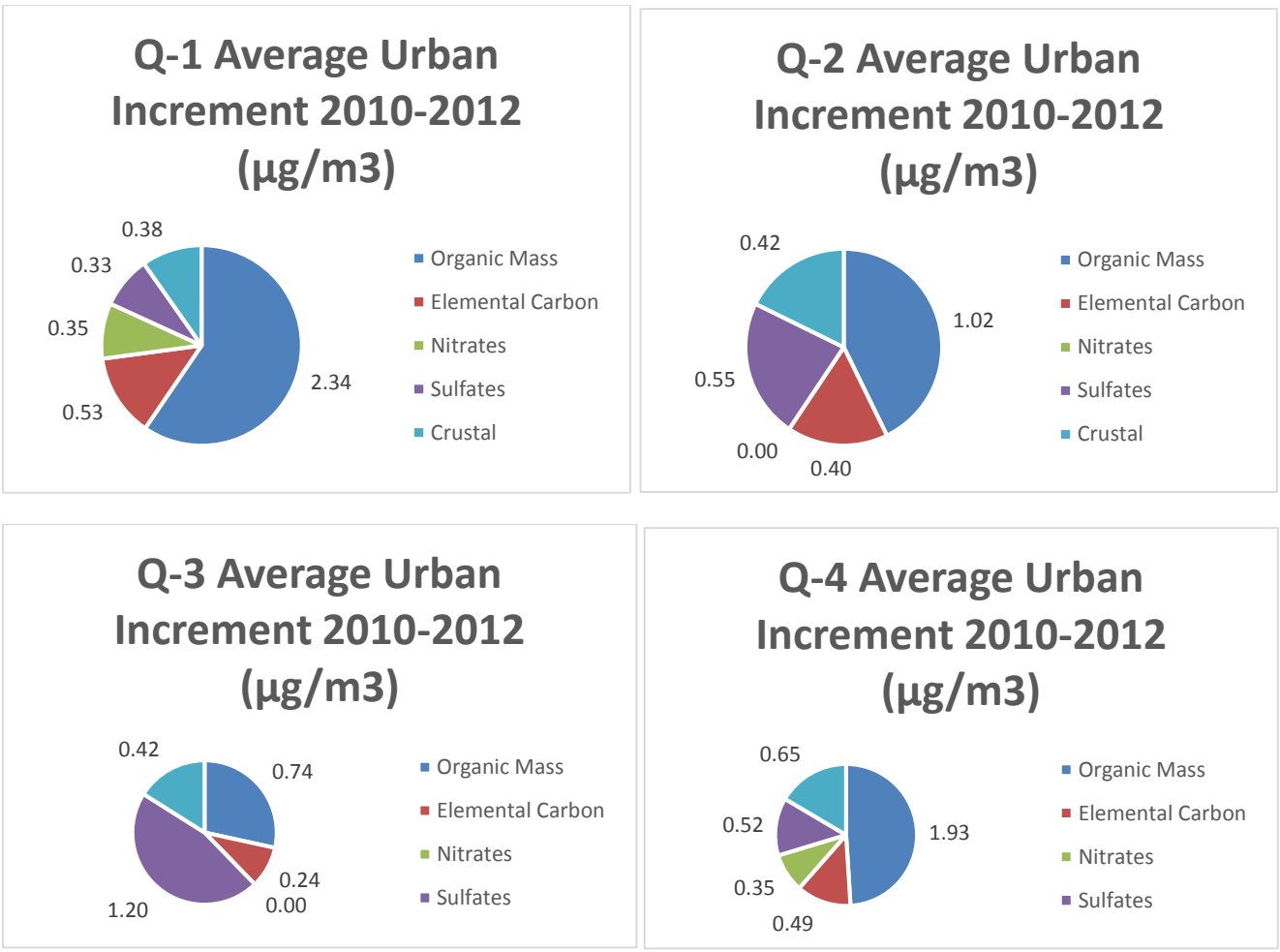
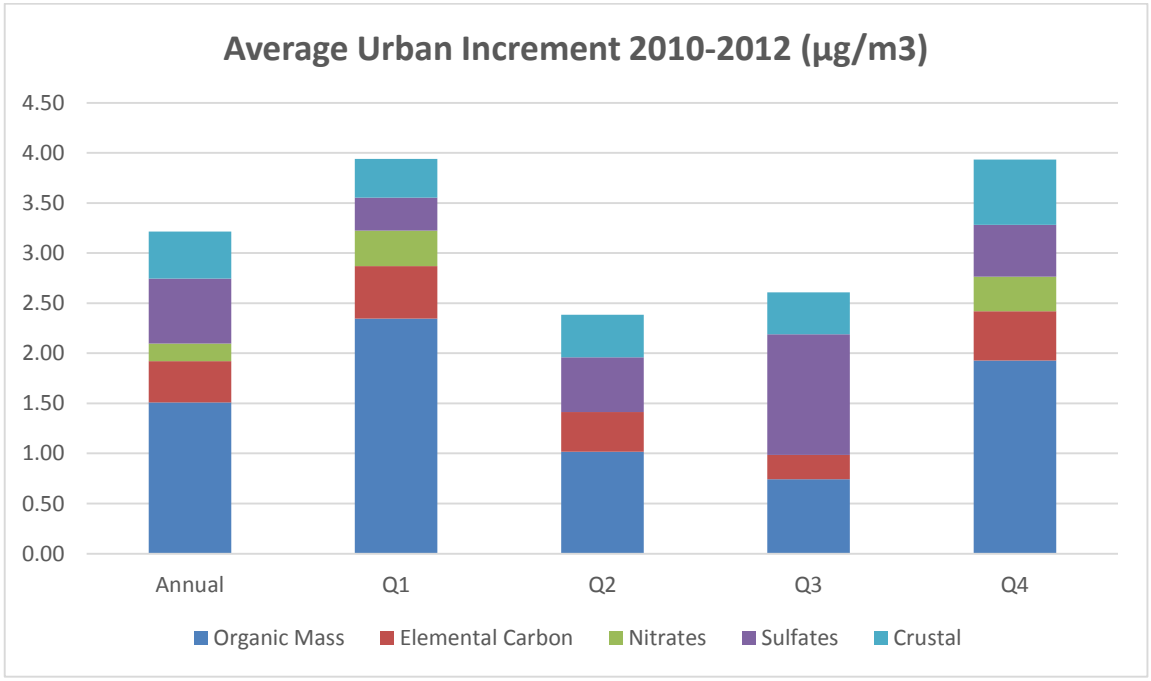


Figure 4b. Louisville, KY-IN Area Average Urban Increment Analysis for 2010-2012.



Clark County has one monitoring site with a DV exceeding the NAAQS. The urban increment calculated for the Clark County violating monitor reveals a seasonal peak in ambient $PM_{2.5}$ concentrations in quarters 1 and 4.

A comparison of the average urban increment to the total measured $PM_{2.5}$ for the Louisville, KY-IN area indicates that the urban increment is less than one-third of the total. This indicates a significant contribution from regional sources. Looking at speciated components of the urban increment for the Louisville, KY-IN area DV monitor, the organic mass component appears to have the largest urban contribution for quarters 1 and 4. Sulfate is second highest annual urban increment component and peaks during quarter 3, showing a potential contribution from local SO2 sources. Elemental carbon has a large increment in quarters 1, 2, and 4. During all quarters of the year, there is also a relatively high organic mass to elemental carbon ratio, which potentially indicates contribution from wood combustion or biomass burning sources. This analysis points to contribution from both regional and local $PM_{2.5}$ sources.

Factor 2: Emissions and emissions-related data

In this designations process, for the 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 in the area under evaluation. Similar to the air quality analysis, these data were examined on a seasonal basis. The EPA examined emissions of identified sources or source categories of direct $PM_{2.5}$, the major components of direct $PM_{2.5}$ (POM), EC, , 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, 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, the EPA reviewed data from the 2011 NEI version 1 (see *http://www.epa.gov/ttn/chief/net/2011inventory.html*). For each county in the area of analysis, the 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. The EPA also looked at the geographic distribution of major point sources of the relevant pollutants.[26] 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, the 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*.

[26] 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.

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 POC and VOCs[27] contribute to POM; directly emitted EC contributes to $PM_{2.5}$ EC; NOx, NH_3 and directly emitted nitrate contribute to $PM_{2.5}$ nitrate mass (PNO_3); SO_2, NH_3 and directly emitted sulfate contribute to $PM_{2.5}$ sulfate mass (PSO_4); and directly emitted crustal material and metal oxides contribute to $PM_{2.5}$ crustal matter (PCrustal).[28,29] The 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 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, nonroad 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 Louisville, KY-IN area. Table 3b summarizes the directly emitted components of $PM_{2.5}$ for the same counties in the area of analysis for the Louisville, KY-IN area. This information will be paired with the Urban Increment composition previously shown in Figures 4a and 4b.

Table 3a. County-Level Emissions of Directly Emitted $PM_{2.5}$ and Precursors (tons/year)[30]

County, State	Total NH_3	Total NOx	Total Direct $PM_{2.5}$	Total SO_2	Total VOC	Total
Jefferson, KY	915	39315	8163	39233	26406	114,032
Jefferson, IN	468	11841	973	74124	1940	89,348
Nelson, KY	1037	1414	470	247	8268	11,435
Clark, IN	824	4158	1137	1577	3260	10,956
Bullitt, KY	137	3406	590	447	4965	9,544
Floyd, IN	127	3235	375	3027	1694	8,458
Trimble, KY	129	2579	174	3155	493	6,529
Harrison, IN	1654	1760	601	29	1682	5,726

[27] As previously mentioned, nearby VOCs are presumed to be a less important contributor to POMM than POC.

[28] *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.

[29] 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*.

[30] In response to the EPA's intended designations, Kentucky in a letter dated October 29, 2014, stated that they compared the 2011 NEI to the updated 2012 NEI for Jefferson County, Kentucky, and noted that the emissions for NH_3 decreased by 72 tons/year; SO_2 by 1,322 tons/year and NOx by 3,491 tons/year. The EPA has considered this update information in relation to the contribution analysis for the violating monitor in Indiana and still concludes that emissions in Jefferson County contribute to the violations at the Indiana monitor.

County, State	Total NH_3	Total NOx	Total Direct $PM_{2.5}$	Total SO_2	Total VOC	Total
Shelby, KY	629	2539	391	16	2054	5,629
Washington, IN	1261	874	481	23	1309	3,949
Oldham, KY	179	1797	285	13	1271	3,544
Meade, KY	484	1013	291	98	1371	3,257
Henry, KY	407	1270	193	11	802	2,683
Spencer, KY	133	396	167	7	512	1,215

Table 3b. County-Level Emissions for Components of Directly Emitted $PM_{2.5}$ (tons/year) [31]

County, State	POM	EC	PSO_4	PNO_3	PCrustal	Residual	Total Direct
Jefferson, KY	2330	715	443	13	2091	2570	8,163
Clark, IN	406	107	51	12	291	272	1,137
Jefferson, IN	398	77	32	4	218	245	973
Harrison, IN	306	62	7	1	106	118	601
Bullitt, KY	274	107	7	1	78	122	590
Washington, IN	258	47	3	2	86	85	481
Nelson, KY	203	63	7	1	83	114	470
Shelby, KY	146	69	7	1	69	99	391
Floyd, IN	170	65	6	1	55	78	375
Meade, KY	125	36	3	1	57	69	291
Oldham, KY	134	61	3	1	38	48	285
Henry, KY	79	35	2	0	39	38	193
Trimble, KY	48	35	8	1	32	50	174
Spencer, KY	87	20	1	1	27	32	167

Table 3b breaks down the direct $PM_{2.5}$ emissions value from Table 3a into its components. The data were 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, the EPA identified the following components warranting additional review: NOx, POM and SO_2. The EPA then looked at the contribution of these constituents of interest from each of the counties included in the area of analysis as shown in Tables 4 a-c.

Table 4a. County-Level NOx Emissions (tons/year)

	Emissions in average tons/yr		
County, State	NOx	Pct.	Cumulative %
Jefferson, KY	39315	52%	52%
Jefferson, IN	11841	16%	68%

[31] 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).

	Emissions in average tons/yr		
County, State	**NOx**	**Pct.**	**Cumulative %**
Clark, IN	4158	6%	73%
Bullitt, KY	3406	5%	78%
Floyd, IN	3235	4%	82%
Trimble, KY	2579	3%	85%
Shelby, KY	2539	3%	89%
Oldham KY	1797	2%	91%
Harrison, IN	1760	2%	93%
Nelson, KY	1414	2%	95%
Henry, KY	1270	2%	97%
Meade, KY	1013	1%	98%
Washington, IN	874	1%	99%
Spencer, KY	396	1%	100%

Table 4b. County-Level POM Emissions

	Emissions in average tons/yr		
County, State	**POM**	**Pct.**	**Cumulative %**
Jefferson, KY	2330	47%	47%
Clark, IN	406	8%	55%
Jefferson, IN	398	8%	63%
Harrison, IN	306	6%	69%
Bullitt, KY	274	6%	75%
Washington, IN	258	5%	80%
Nelson, KY	203	4%	84%
Floyd, IN	170	3%	88%
Shelby, KY	146	3%	90%
Oldham, KY	134	3%	93%
Meade, KY	125	3%	96%
Spencer, KY	87	2%	97%
Henry, KY	79	2%	99%
Trimble, KY	48	1%	100%

Table 4c. County-Level SO_2 Emissions

	Emissions in average tons/yr		
County, State	**SO_2**	**Pct.**	**Cumulative %**
Jefferson, IN	74124	61%	61%
Jefferson, KY	39233	32%	93%
Trimble, KY	3155	3%	95%
Floyd, IN	3027	2%	98%

	Emissions in average tons/yr		
County, State	**SO_2**	**Pct.**	**Cumulative %**
Clark, IN	1577	1%	99%
Bullitt, KY	447	<1%	100%
Nelson, KY	247	<1%	100%
Meade, KY	98	<1%	100%
Harrison, IN	29	<1%	100%
Washington, IN	23	<1%	100%
Shelby, KY	16	<1%	100%
Oldham, KY	13	<1%	100%
Henry, KY	11	<1%	100%
Spencer, KY	7	<1%	100%

In addition to reviewing county-wide emissions of $PM_{2.5}$ and $PM_{2.5}$ precursors in the area of analysis, the EPA also reviewed emissions from major point sources located in the area of analysis. 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 Louisville, KY-IN 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)

		Distance	NEI 2011 v1 Emissions - Tons/Year					
County, State	**Facility Name (Facility ID)**	**monitor (miles)**	**NH_3**	**NOx**	**$PM_{2.5}$**	**SO_2**	**VOC**	**Total**
Bullitt, KY	Four Roses Distillery Inc (2102900004)	26	-	-	-	-	1,216	1,216
Bullitt, KY	Jim Beam Brands Co - Clermont Plant (2102900005)	25	-	86	6	187	1,487	1,766
Clark, IN	ESSROC CEMENT CORP.(00008)	9	0	1,153	217	1,545	60	2,974
Floyd, IN	DUKE ENERGY INDIANA – GALLAGHER (000040	5	1	1,344	12	3,010	11	4,378
Jefferson, IN	IKEC - CLIFTY CREEK STATION (00001)	36	2	10,938	281	74,086	85	85,392
Jefferson, KY	Louisville Gas & Electric Co., Cane Run Station (0126)	10	0	5,596	420	7,824	48	13,888
Jefferson, KY	Kosmos Cement Company (0060)	19	22	1,097	114	187	51	1,472
Jefferson, KY	Ford Motor Company, Kentucky Truck Plant (0073)	11	2	69	17	0	698	787
Jefferson, KY	Louisville Gas & Electric Co., Mill Creek Station (0127)	18	0	8,495	2,780	29,945	130	41,350
Jefferson, KY	American Synthetic Rubber Company (0011)	7	1	549	30	137	256	973
Jefferson, KY	Brown-Forman Distilleries, Early Times (0244)	6	0	80	13	258	1,416	1,767
Jefferson, KY	Heaven Hill Distilleries (0243)	3	0	15	2	0	1,400	1,417
Jefferson, KY	Reynolds Packaging Group, Foil Plant (0186)	4	0	14	3	0	1,306	1,323
Jefferson, KY	Diageo Americas Supply, Inc. (0167)	6	0	1	0	0	1,616	1,617
Jefferson, KY	Louisville Medical Center Steam Plant (148)	2	0	161	31	476	1	669
Jefferson, KY	Louisville Intl-Standif	7	-	1,421	26	136	148	1,732

		Distance monitor (miles)	NEI 2011 v1 Emissions - Tons/Year					
County, State	Facility Name (Facility ID)		NH_3	NOx	$PM_{2.5}$	SO_2	VOC	Total
Nelson, KY	Heaven Hill Distilleries (2117900005)	37	-	1	0	0	1,853	1,855
Nelson, KY	Jim Beam Brands Co - Boston Nelson Co (2117900014)	33	-	72	31	181	2,429	2,712
Nelson, KY	Barton Distillery (2117900020)	36	-	17	2	45	1,403	1,467
Trimble, KY	Louisville Gas & Electric Co - Trimble Co Generating Station (2122300002	28	26	2,088	55	3,112	132	5,413

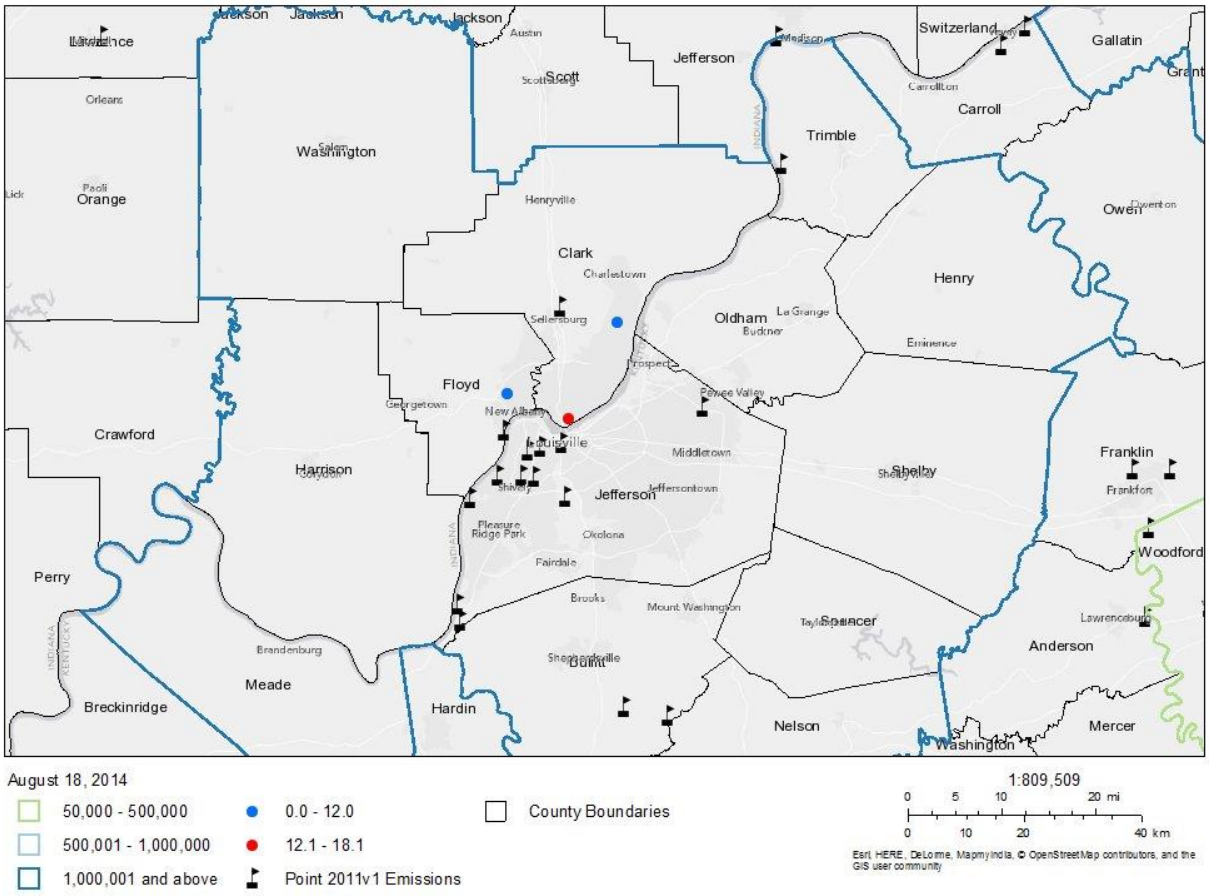
The IKEC-Clifty Creek Station facility located in Jefferson County, Indiana, stands out in Table 5 as having a large level of SO_2 emissions reported in the 2011 NEI (74,086 tpy). Recently, the Clifty Creek facility has installed both flue gas desulfurization systems, as well as selective catalytic reduction systems on multiple units in order to satisfy federal rules controlling SO_2 for transport as well as rules for controlling mercury and air toxics. SO_2 emissions at the facility have decreased from 2011 levels of 36,391 total tpy for units 1, 2, 3, and 37,694 total tpy for units 4, 5, 6 to levels in 2014 of 3,745 and 3,351 total tpy, respectively. The lower levels of emissions in combination with the large distance to the violating monitor and a low frequency of winds blowing from the facility toward the monitor, led to the conclusion that the facility is not contributing to the monitor violation.

Figure 5 shows the major point source emissions (from the 2011 NEI in tons per year) in the area of analysis for the Louisville, KY-IN area and the relative distances of these sources from the violating monitoring location, as depicted by red dot in the center of the map. 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.[32]

As indicated in Figure 5, there are 20 major point sources located within 37 miles of the violating monitor. Eleven of these point sources are located in Jefferson County, Kentucky.

[32] 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.

Figure 5. Major Point Source Emissions in the Area of Analysis for the Louisville, KY-IN Area.



In summary, the EPA's analysis of relevant county-level emissions and the geographic locations of the relevant pollutants showed both Jefferson County in Kentucky, and Clark and Floyd Counties in Indiana had the highest overall emissions. Jefferson County in Indiana also has large emissions, 95% derived from the point source at Clifty Creek Station. Emissions controls has reduced SO2 and NOx emissions by 73% since 2011. Clifty Creek is 36 miles away from the violating monitor and the rest of Jefferson County has low non-point, road and on-road emissions compared to the point source at Clifty Creek. EPA concludes that Jefferson County, Indiana, is not contributing to the violating monitor.

SO_2 are the predominant pollutant emissions in the area. Three of the four largest SO_2 point source emissions are within 18 miles of the violating monitor. With the exception of Nelson County, Kentucky, county emissions levels for the rest of the counties in the CBSA are lower the further away it is from the violating monitor. Nelson County's emissions consist primarily of VOCs, mostly from three point sources. The total VOC emissions from Nelson County are less than one-third of the VOC emissions from Jefferson County and are less than 15 percent of the total VOC emissions in the CBSA. The large distance from Nelson County to the violating monitor and the low frequency of winds blowing from the southeast east, led to the EPA's conclusion that Nelson County is not contributing to the violating Clark County, Indiana, monitor.

Population density and degree of urbanization

In this part of the factor analysis, the 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.

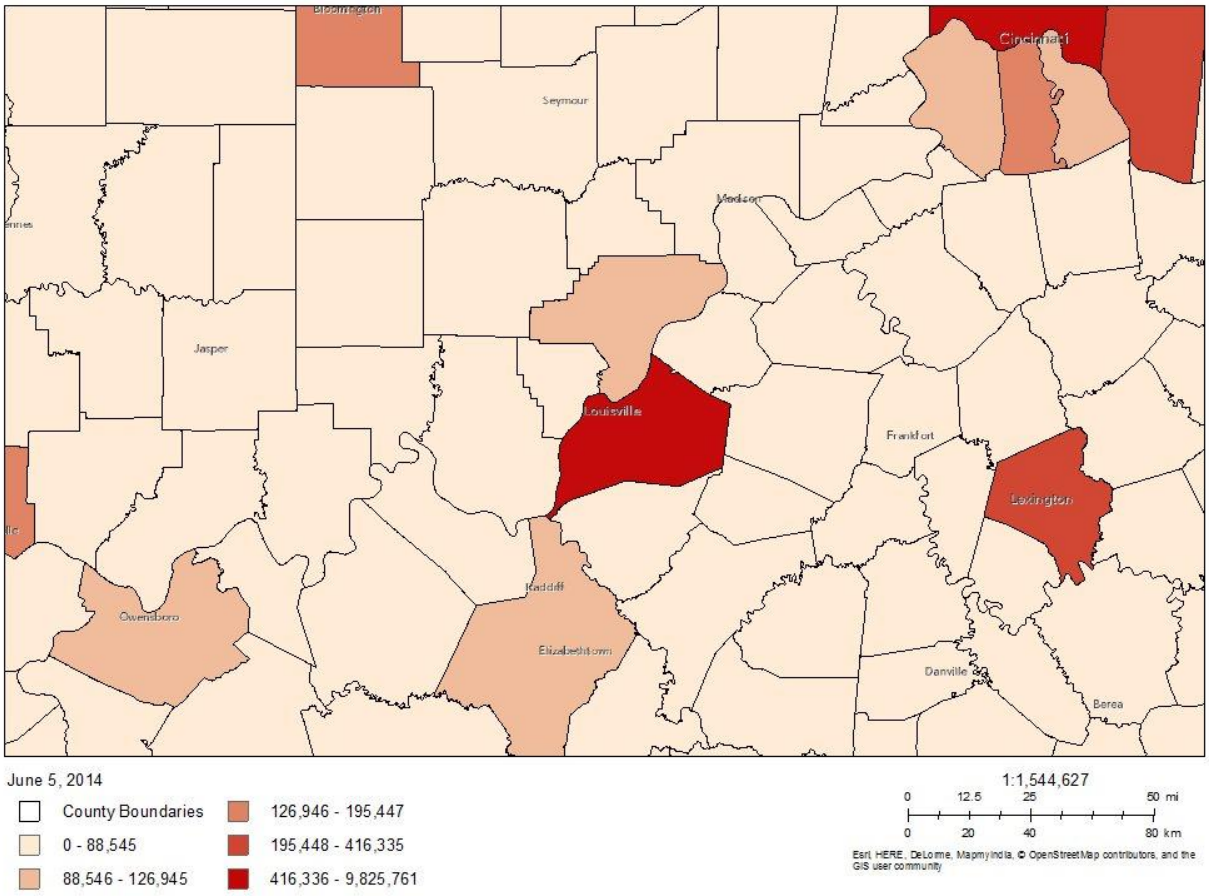
Table 6. Population Growth and Population Density.

County, State	Population 2000	Population 2010	% Change from 2000	Land Area (Sq. Miles)	Population Density (per Sq. Mile)	%	Cumulative %
Jefferson, KY	693,604	742,324	7.0%	385	1,928	58	56
Clark, IN	96,472	110,555	14.6%	375	295	9	65
Floyd, IN	70,823	74,657	5.4%	148	504	6	70
Bullitt, KY	61,236	74,490	21.6%	299	249	6	76
Oldham, KY	46,178	60,420	30.8%	189	319	5	81
Nelson, KY	37,477	43,594	16.3%	423	103	3	84
Shelby, KY	33,337	42,287	26.8%	384	110	3	87
Harrison, IN	34,325	39,357	14.7%	485	81	3	90
Jefferson, IN	31,705	32,455	2.4%	361	90	2	93
Washington, IN	27,223	28,265	3.8%	514	55	2	95
Meade, KY	26,349	28,695	8.9%	309	93	2	97
Spencer, KY	11,766	17,114	45.5%	186	92	1	98
Henry, KY	15,060	15,398	2.2%	289	53	1	99
Trimble, KY	8,125	8,787	8.1%	149	59	1	100
Total	**1,193,680**	**1,318,398**					

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

The four most populated counties in the area are in and adjacent to the county with the violating monitor. Jefferson and Bullitt Counties in Kentucky and Clark and Floyd Counties in Indiana account for 76% percent of the region's population. In order of the most Jefferson County, Kentucky has the highest population density, about four times larger than Floyd County, which has the second highest. The area around the violating monitor is highly urbanized. Bullitt County, Kentucky is the fifth most densely populated with an urbanized area in the north adjacent to Louisville International Airport. Bullitt's population grew 21 percent to 74,490, about 6 percent of the CBSA population. EPA concludes Jefferson and Bullitt Counties in Kentucky and Clark and Floyd Counties in Indiana is contributing to the violating monitor in Clark County, Indiana.

Figure 6. 2010 County-Level Population in the Area of Analysis for the Louisville, KY-IN Area.



Traffic and Vehicle Miles Travelled (VMT)

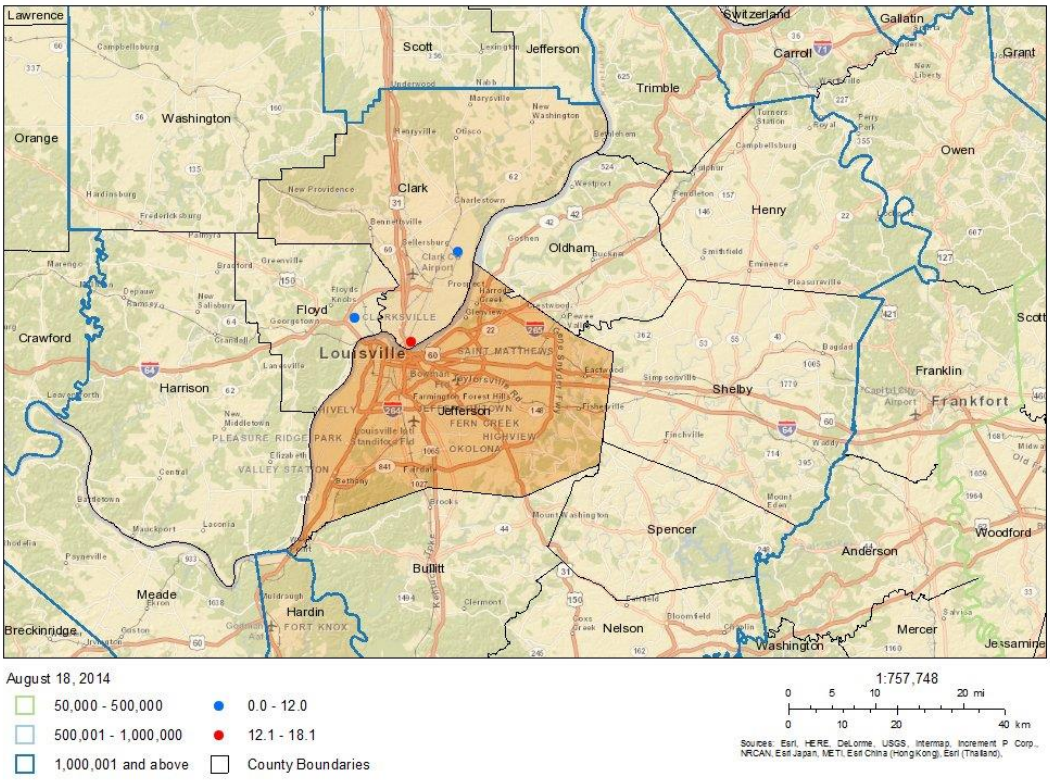
High VMT and/or a high number of commuters associated with a county is generally an indicator that the county is an integral part of an urban area. Mobile source emissions of NOx, VOC, and direct $PM_{2.5}$ may contribute to ambient particulate matter that contributes to monitored violations of the NAAQS 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. This data is from the Federal Highway Administration.

Table 7. 2011 VMT for the Louisville, KY-IN Area.

County, State		Total 2011 VMT	Percent	Cumulative %
Jefferson, KY		7,222,527,493	53%	53%
Clark, IN		1,174,901,566	9%	61%
Bullitt, KY		952,778,343	7%	68%
Floyd, IN		672,638,182	5%	73%
Shelby, KY		648,551,690	5%	78%
Harrison, IN		589,004,275	4%	82%
Nelson, KY		492,911,504	4%	86%
Oldham, KY		467,765,544	3%	89%
Jefferson, IN		322,232,066	2%	92%
Washington, IN		305,724,135	2%	94%
Henry, KY		300,376,674	2%	96%
Meade, KY		287,931,054	2%	98%
Spencer, KY		153,288,071	1%	99%
Trimble, KY		81,444,339	1%	100%
Total		**13,672,074,936**		

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

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



Jefferson County and Bullitt County in Kentucky, and Clark County in Indiana had the largest VMT. More than half of all the VMT in the CBSA is in Jefferson County, Kentucky. It is reasonable to infer that a substantial amount of the traffic is due to inter-county commuters, mainly from Bullitt, Clark and Floyd Counties. Additional analysis for Jefferson County, Kentucky shows that 88 percent of all commuting is from intra-county and less than 7 percent of all commuting traffic comes from Bullitt County. The northern portion of Bullitt County is part of a contiguous, urbanized area and while only 7 percent of the commuters are heading to Jefferson County, a large portion can be attributed to the population centers and VMT from that portion of the county.

Clark and Floyd Counties in Indiana, and Jefferson County in Kentucky consistently rank highest in direct $PM_{2.5}$/key precursor emissions attributable in large part to VMT and population. Jefferson County, Kentucky, contributed more than 82 percent of SO_2 and 83 percent total $PM_{2.5}$ from stationary sources in the CBSA. Bullitt County is mid-ranked in emissions and mid-ranked for population and VMT. Most of the urbanized area of Bullitt County is adjacent to Jefferson, Kentucky. Oldham, Nelson, Shelby, Harrison, Washington, Meade, Spencer, Henry and Trimble Counties have relatively low emissions and relatively low VMT/population counts, and lack large singular point source contributors.

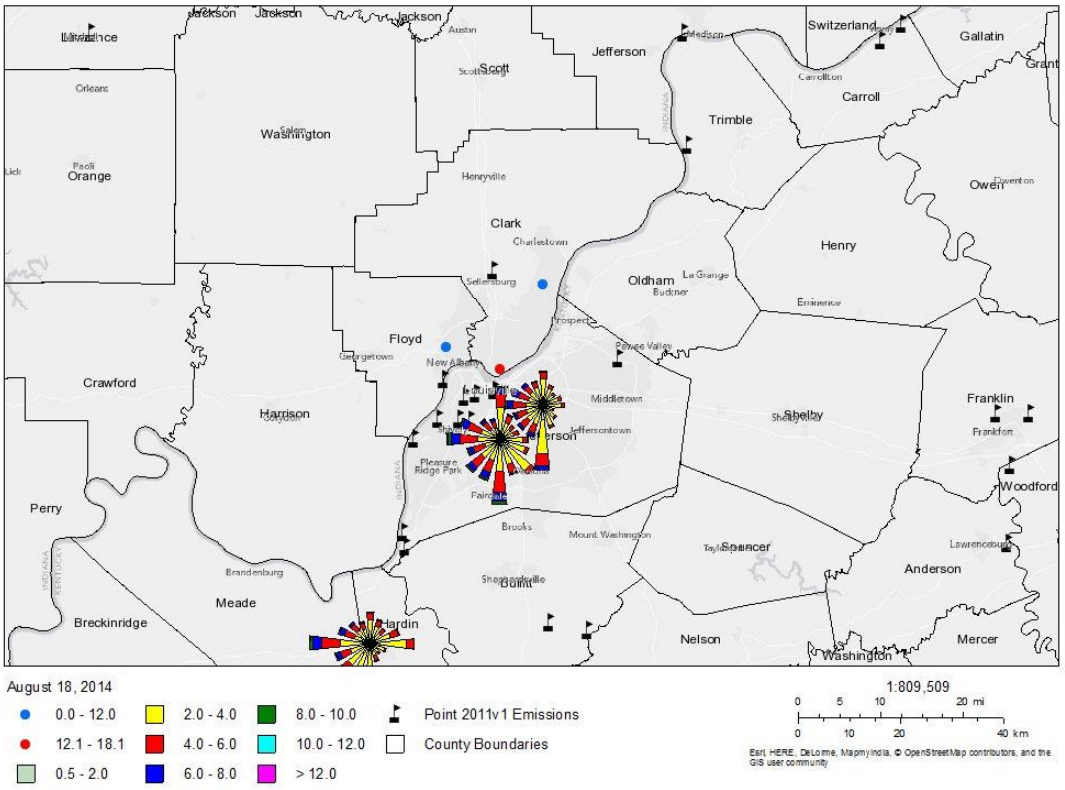
Factor 3: Meteorology

The 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. The 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. The 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.[33] When developing these wind roses, the 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 the EPA generated from data relevant in the Louisville, KY-IN area.

[33] *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 Louisville, KY-IN Area.



As shown in Figure 8, there is a pattern across the CBSA of winds blowing predominantly from the south, west and southwest, and a smaller frequency from the north, mostly at low to mid-level speeds of 2 to 6 meters per second.

In addition to wind roses, the EPA also generated KDE plots to represent HYSPLIT (HYbrid Single-Particle Lagrangian Integrated Trajectory) backward trajectory frequency at violating monitoring sites.[34,35] These KDEs are graphical statistical estimations to determine the density of trajectory endpoints at a particular location represented by a grid cell. The EPA used KDEs to characterize and analyze the collection of individual HYSPLIT backward trajectories.[36] Higher density values, indicated by darker blue colors, indicate a greater

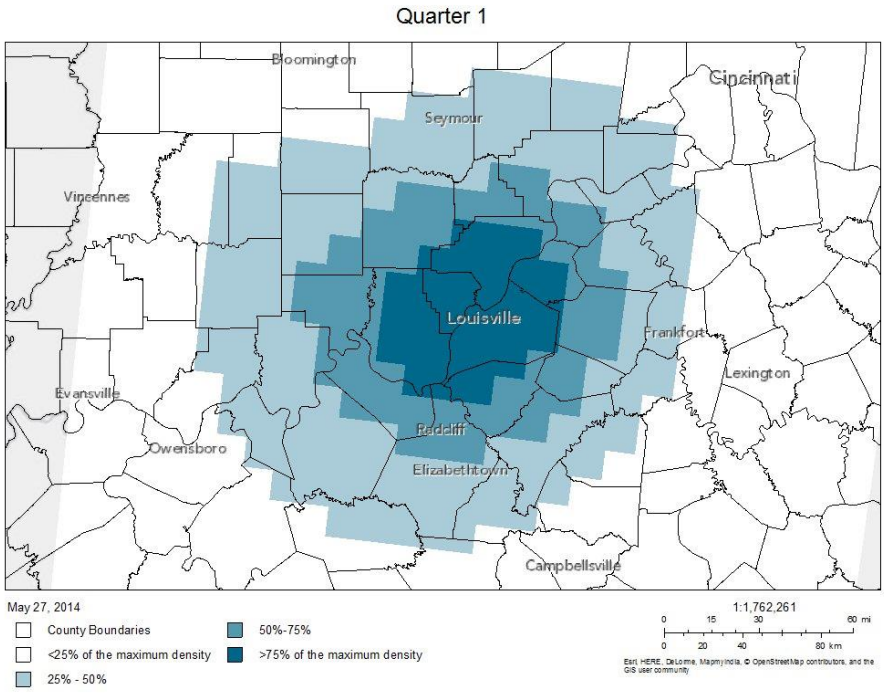
[34] In some past initial area designations efforts, the EPA has used HYSPLIT backward trajectories to assist in determining nonattainment area boundaries. A HYSPLIT backward trajectory is usually depicted on a standard map as a single line, representing the centerline of an air parcel's motion, extending in two dimensional (x,y) space from a starting point and regressing backward in time to a point of origin. Backward trajectories may be an appropriate tool to assist in determining an air parcel's point of origin on a day in which a short-term standard, such as an 8-hour standard or a 24-hour standard, was exceeded. However, for an annual standard, such as the 2012 annual $PM_{2.5}$ NAAQS, every trajectory on every day is important. Plotting a mass of individual daily (e.g., 365 individual back trajectories), or more frequent, HYSPLIT trajectories may not be helpful as this process is likely to result in depicting air parcels originating in all directions from the violating monitoring site.

[35] HYSPLIT - Hybrid Single Particle Lagrangian Integrated Trajectory Model, *http://www.arl.noaa.gov/HYSPLIT_info.php*

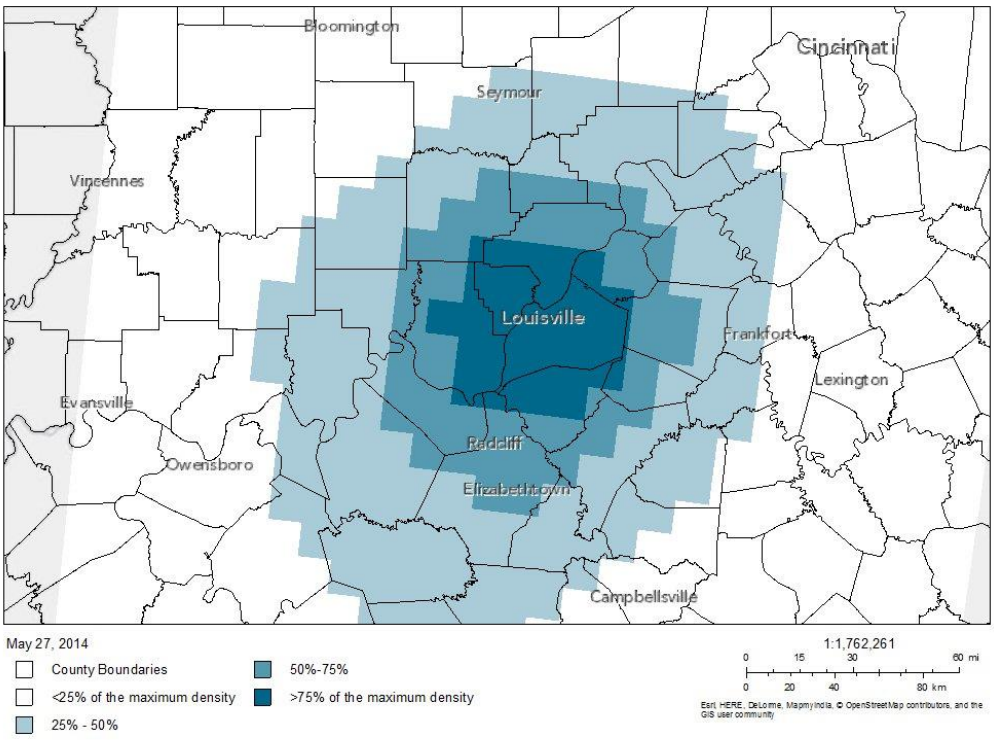
[36] The KDEs graphically represent the aggregate of HYSPLIT backward trajectories for the years 2010-2012, run every third day (beginning on the first day of monitoring), four times each day, and ending at four endpoint heights.

frequency of observed trajectory endpoints within a particular grid cell. Figure 9 shows HYSPLIT KDE plots for the Louisville, KY-IN area summarized by calendar quarter for the 2010-2012 period. The HYSPLIT KDEs are weighted in the south to westerly direction, indicating a greater frequency of trajectories passing over grid cells to the south and west.

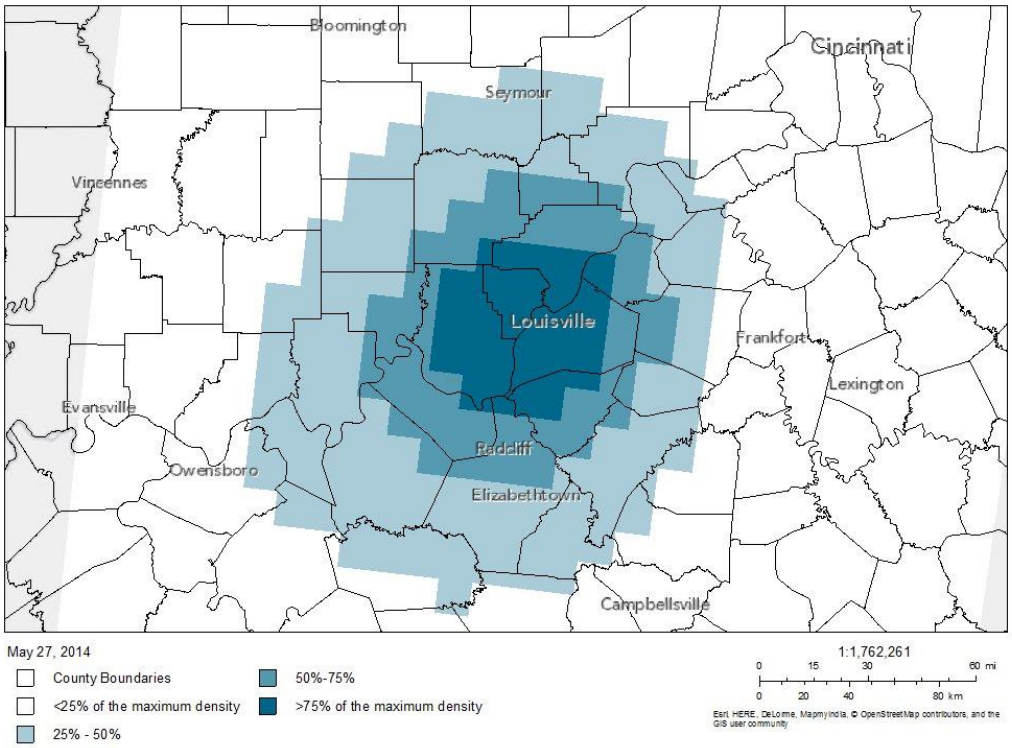
Figure 9. HYSPLIT Kernel Density Estimation Plots for the Louisville, KY-IN Area.

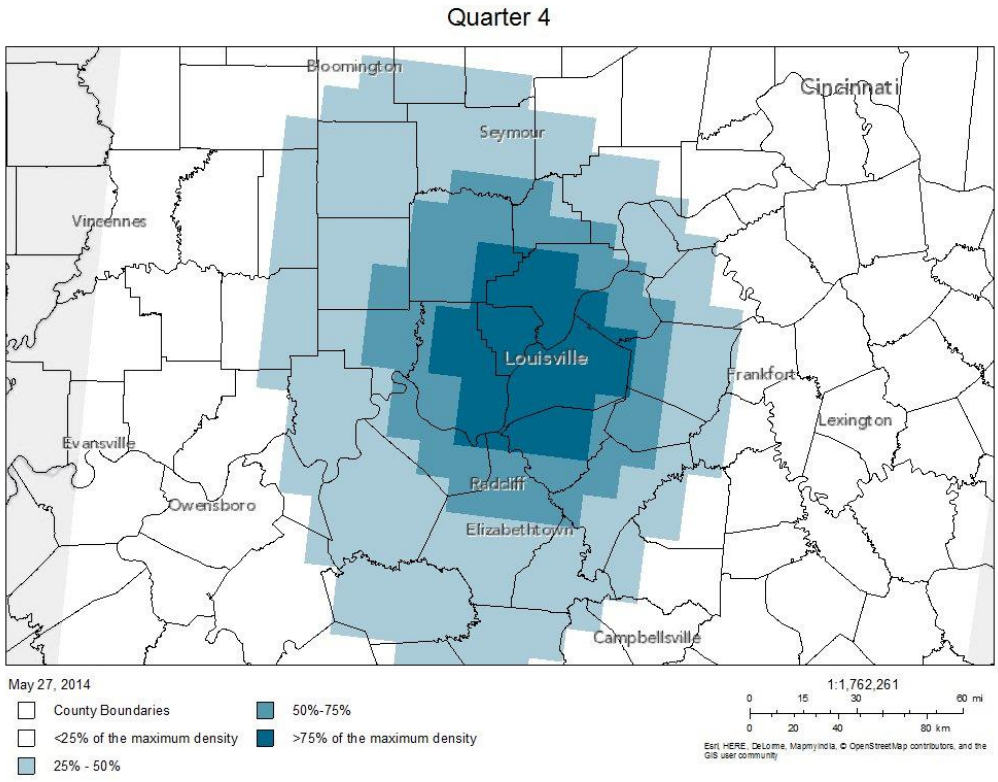


Quarter 2



Quarter 3





In summary, for the violating monitor, the HYPSPLIT KDE plots and wind roses suggest greatest potential contribution of emissions from Jefferson and Bullitt Counties in Kentucky, and Clark, Floyd and Harrison Counties in Indiana. Potential emission contribution from other counties is low, including Jefferson Co. IN, whose large point source is responsible for most SO2 and NOX emissions for that county and it has recently reduced those emissions by over 70 percent.

Factor 4: Geography/topography

To evaluate the geography/topography factor, the 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. The major topographic feature in the area is the Ohio River which forms the boundary between the states of Indiana and Kentucky. The river does not form a significant valley in the area with elevation changes in the 50-100 meter range and does not significantly limit air pollution transport within the air shed. Therefore, this factor did not play a significant role in this evaluation.

Factor 5: Jurisdictional boundaries

In defining the boundaries of the final Louisville nonattainment area, the 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, local governmental organization with the necessary legal authority for carrying out air quality planning and enforcement functions for the final nonattainment 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, the EPA considered other clearly defined and permanent landmarks or geographic coordinates for purposes of identifying the boundaries of the final designated areas.

The Louisville, KY-IN area has previously established nonattainment boundaries associated with the 1997 annual $PM_{2.5}$ NAAQS. The 1997 $PM_{2.5}$ nonattainment area boundary consist of Jefferson and Bullitt Counties in Kentucky, and Clark, Floyd and a portion of Jefferson County in Indiana. The partial county in Jefferson, Indiana utilized Madison Township as the nonattainment boundary. Neither Kentucky nor Indiana have recommended nonattainment boundaries for the 2012 annual $PM_{2.5}$ NAAQS.

Conclusion for Louisville, KY-IN Area

Speciation and urban increment data show high organic carbon and sulfate content. Organic carbon and sulfate components are the most important portions of the total $PM_{2.5}$ mass throughout the year. Organic carbon may indicate biogenic emissions sources or biomass combustion sources. The predominant source of SO_2 emissions is the large point sources in the area.

Indiana

Based on the assessment of factors described above, both individually and in combination, the EPA has concluded that the following counties of Indiana should be included as part of the Louisville nonattainment area because they are violating the 2012 annual $PM_{2.5}$ NAAQS or contributing to a violation in a nearby area: Clark and Floyd Counties. These are the same counties that are included in the Louisville nonattainment area for the 1997 annual $PM_{2.5}$ NAAQS, with the exception that Jefferson County (partial) has been removed for the reasons discussed below.

Clark County has one air quality monitoring site that indicates violation of the 2012 annual $PM_{2.5}$ NAAQS based on the 2013 DV; therefore this county is included in the nonattainment area. Clark County also has the second highest level of direct $PM_{2.5}$ emissions in the CBSA with 1,137 tpy.

Floyd County is a nearby county that does not have a violating monitoring site, but the EPA has concluded that the County contributes to the particulate matter concentrations in violation of the 2012 annual $PM_{2.5}$ NAAQS through emissions from point sources and non-point sources (e.g., area sources) and from mobile source emissions. Floyd County has the fourth highest level of SO_2 emissions in the CBSA with 3,027 tpy. The prevailing winds blow in the direction from Floyd County toward the violating monitor, and there is a source of SO_2 emissions (3,010 tpy), Duke Energy Indiana – Gallagher, five miles north of the monitor.

A small portion of Jefferson County, Indiana, was included in the nonattainment area for the 1997 annual $PM_{2.5}$ NAAQS in order to capture the emissions from the IKEC-Clifty Creek Station facility. As described earlier in this TSD, emissions controls have been installed to satisfy federal rules requiring control of SO_2 for transport as well as rules for controlling mercury and other air toxics. These controls have resulted in SO_2 emissions reductions of over 73 percent since 2011. Additionally, the wind rose and KDE plots presented in the meteorology factor discussion indicate that there is low frequency of winds blowing from the direction of Jefferson County, Indiana, toward the violating monitor and thus do not support contribution. Therefore, the

EPA is not designating the portion of Jefferson County, Indiana that was previously included in the nonattainment area as nonattainment for the 2012 annual $PM_{2.5}$ NAAQS.

Kentucky

Based on the assessment of factors described above, both individually and in combination, the EPA has concluded that the following counties should be included as part of the Louisville nonattainment area because they are contributing to a violation in a nearby area: Jefferson County, and the urbanized portion of Bullitt County.

Jefferson County is a nearby county that does not have valid data from its monitoring sites. The EPA has concluded that this area contributes to the particulate matter concentrations in violation of the 2012 annual $PM_{2.5}$ NAAQS through emissions from point sources and non-point sources (e.g., area sources), and from mobile source emissions. Jefferson County has among the highest emissions of directly emitted $PM_{2.5}$ and $PM_{2.5}$ precursors in the area. Jefferson County ranked relatively high for total emissions levels including high direct $PM_{2.5}$, NOx and SO_2, number of point sources, high population and VMT and high urbanization throughout the county. Additionally, there is a high frequency of winds blowing from the south and the west supporting contribution from the Jefferson County emissions to the violating monitor located to the north in Clark County, Indiana.

Bullitt County is a nearby county that does not have a $PM_{2.5}$ air quality monitor. The EPA has concluded that emissions from the urbanized portion of the county contribute to the particulate matter concentrations in violation of the 2012 annual $PM_{2.5}$ NAAQS. In review of the emissions from Bullitt County in Kentucky, the EPA determined that these emissions were primarily population-based emissions such as mobile and nonpoint sources. Thus, the EPA determined it was most appropriate to capture the urbanized portion of Bullitt County for inclusion in this area. [37] The wind roses and KDE plots presented in the meteorology factor discussion indicate that the predominant wind directions in the area support inclusion of the urbanized portion of Bullitt County. The EPA is using census tracts to define the nonattainment boundary for Bullitt County. The following census tracts are being included within the nonattainment area: 201, 202, 203, 204, 205, 206, 207, 208 and 211. Census tract 211 also includes the two point sources identified in Table 5 (Four Roses Distillery Inc. and Jim Beam Brands Co.).

In the event Indiana elects to early certify the 2012-2014 air quality data and the violating Clark County monitor does not violate the 2012 annual NAAQS, the EPA will designate the Louisville Area (with the same boundary as the nonattainment boundary identified in this TSD) as unclassifiable. The EPA would have to designate this area as unclassifiable instead of unclassifiable/attainment because of the invalid data in Jefferson County, Kentucky for this timeframe.

[37] An Urbanized Area (UZA), as defined by the Census Bureau, consists of a central core and adjacent densely settled territory that together contain at least 50,000 people, generally with an overall population density of at least 1,000 people per square mile. The EPA evaluated the 2000 Census UZA data for Bullitt County in order to help define partial county boundary. The EPA overlaid the UZA areas with census tracts to determine the high population census tracts in Bullitt County, Kentucky.