

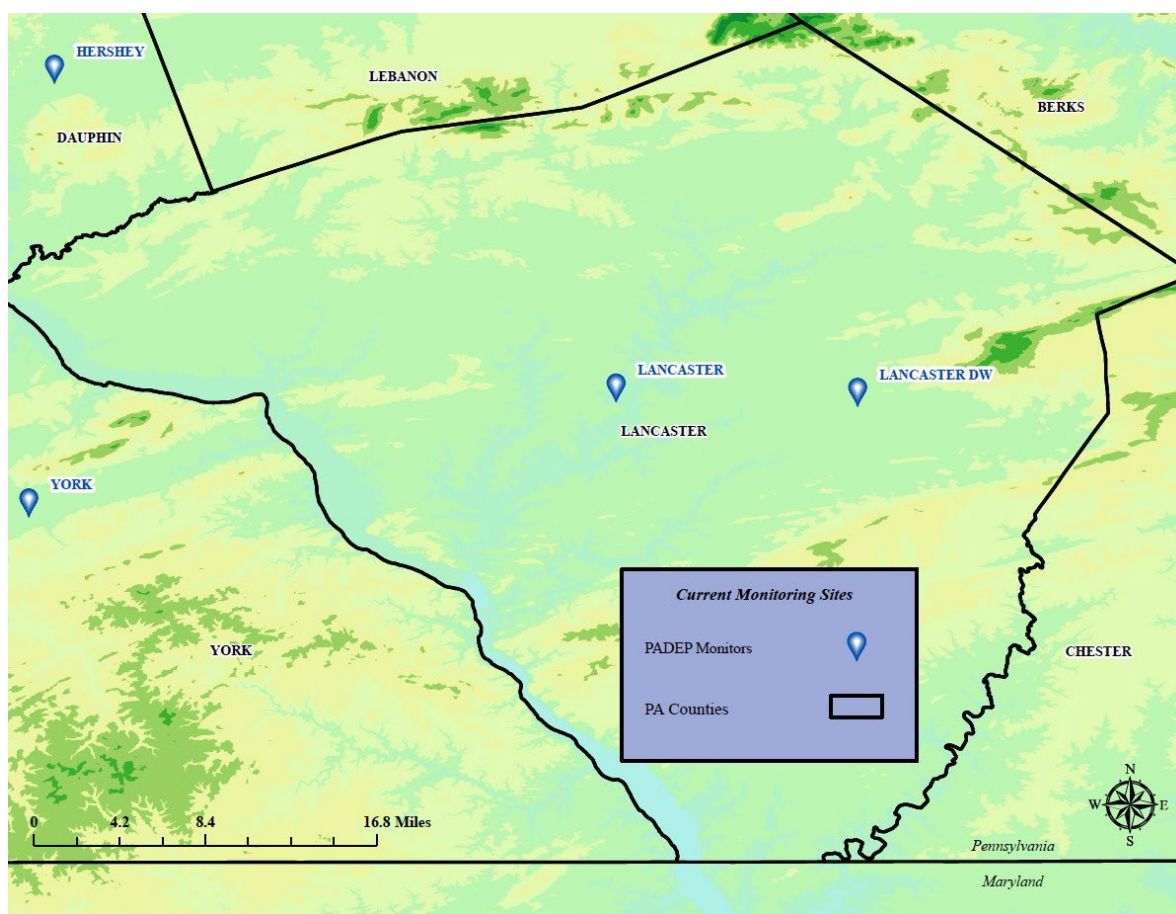
Appendix C-4 LANCASTER COUNTY AREA

PADEP is recommending a Lancaster County annual PM_{2.5} NAAQS nonattainment area consisting of Lancaster County. PADEP completed an analysis of the PM_{2.5} ambient air quality data, which outlines the reason for recommending an area consisting of only Lancaster County. This analysis is provided below.

Analysis of the Ambient PM_{2.5} Data – A Design Value Contribution Analysis

Based on EPA-certified 2023 PM_{2.5} valid design values, one monitor in the Lancaster metropolitan statistical area (MSA) is violating the 2024 PM_{2.5} annual standard of 9 µg/m³. The monitor and its design value is Lancaster Downwind (AIRS #42-071-0012) at 9.5 µg/m³ (in Lancaster County). The Lancaster monitor (AIRS #42-071-0007), by contrast, is monitoring attainment of the standard at 8.8 µg/m³. The Lancaster monitor is also in Lancaster County, located to the west of the Lancaster Downwind monitor. Figure C-4.1 is a map outlining the location of these monitors, along with monitors in attainment in the vicinity of the Lancaster County area.

Figure C-4.1: Lancaster County Area PM_{2.5} Monitoring Map



PADEP'S DESIGNATION RECOMMENDATIONS FOR THE 2024 PRIMARY ANNUAL FINE PARTICULATE MATTER (PM_{2.5}) NATIONAL AMBIENT AIR QUALITY STANDARD

PADEP has completed a design value contribution analysis for all of the PM_{2.5} monitors in the proximity of the Lancaster Downwind monitor. The analysis attempts to determine the daily contribution of PM_{2.5} concentrations to the annual PM_{2.5} design value. Daily PM_{2.5} measurements were grouped into different PM_{2.5} concentration ranges. An analysis of each range's contribution was then conducted to determine which measurements are contributing to the monitor's design value. Dates of these measurements were then further analyzed to determine if there are specific meteorological conditions or sources that are adversely impacting the monitor's design value.

Results from the design value contribution analysis for the Lancaster County area are summarized in Table C-4.1. Ultimately, the type of contribution a given monitor's daily value had on the 3-year design value (by comparing this value to 9 µg/m³) was determined. The daily value for each day a monitor measured PM_{2.5} levels was placed in one of the ten categories. For example, on January 1, 2021, the Lancaster Downwind monitor's 24-hour PM_{2.5} average was 14.8 µg/m³. Since this value falls in the 13.5-18.0 µg/m³ category in Table C-4.1, the calculated daily contribution to the design value was placed in this category. In the first quarter of 2021 (January 1 to March 31), the Lancaster Downwind monitor recorded 88 measurements. PADEP determined that the January 1, 2021, contribution assessment to the 2023 design value was 0.00549 µg/m³. The 0.00549 µg/m³ was calculated by subtracting the standard of 9.0 µg/m³ from the average daily value of 14.8 µg/m³ and then dividing this by the number of measurements for the quarter (88) times 12 (there are a total of 12 quarters in a 3-year design value period). This type of analysis was completed for every day of measurements from January 1, 2021, through December 31, 2023. In Table C-4.1, the sum of the categorical breakdowns for the Lancaster Downwind monitor equals 0.5176 µg/m³, which demonstrates that the design value is 0.5176 µg/m³ above the annual standard of 9 µg/m³.

Figures C-4.2.1 – C-4.2.11 show the design value contribution and category breakdown for the monitors in the Lancaster County area.

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***Table C-4.1: Lancaster County Area
2023 PM_{2.5} Annual Design Value Contribution Analysis***

Site Name	Site ID	Owner	0 - 4.5	4.5 - 9.0	9.0 - 13.5	13.5 - 18.0	18.0 - 22.5	22.5 - 27.0	27.0 - 31.5	31.5 - 36.0	36.0 - 40.5	40.5 - 300.0	Sum
Monitors Attaining 2024 PM 2.5 Standard													
Lancaster	420710007	PA DEP	-1.1620	-1.0743	0.3996	0.5618	0.3457	0.1585	0.1477	0.1396	0.0528	0.2794	-0.1513
Arendtsville	420010001	PA DEP	-1.2559	-1.1795	0.4409	0.4522	0.3403	0.1526	0.1208	0.0549	0.0253	0.5278	-0.3206
Lebanon	420750101	PA DEP	-1.4119	-1.0792	0.4014	0.4472	0.2835	0.2189	0.0510	0.0898	0.0268	0.3375	-0.6351
New Garden	420290100	PA DEP	-1.1664	-1.3380	0.3384	0.3985	0.2223	0.0764	0.0390	0.0729	0.0000	0.4591	-0.8978
Monitors Not Attaining 2024 PM 2.5 Standard													
Lancaster Downwind	420710012	PA DEP	-0.9001	-0.9375	0.5163	0.5835	0.3980	0.2323	0.2125	0.0496	0.0801	0.2829	0.5176
Lancaster Regional Average			-1.1793	-1.1217	0.4193	0.4886	0.3180	0.1677	0.1142	0.0814	0.0370	0.3773	-0.2974

PADEP'S DESIGNATION RECOMMENDATIONS FOR THE 2024 PRIMARY ANNUAL FINE PARTICULATE MATTER (PM_{2.5}) NATIONAL AMBIENT AIR QUALITY STANDARD

Figure C-4.2.1: Lancaster Downwind PM_{2.5} Design Value Contribution (µg/m³)

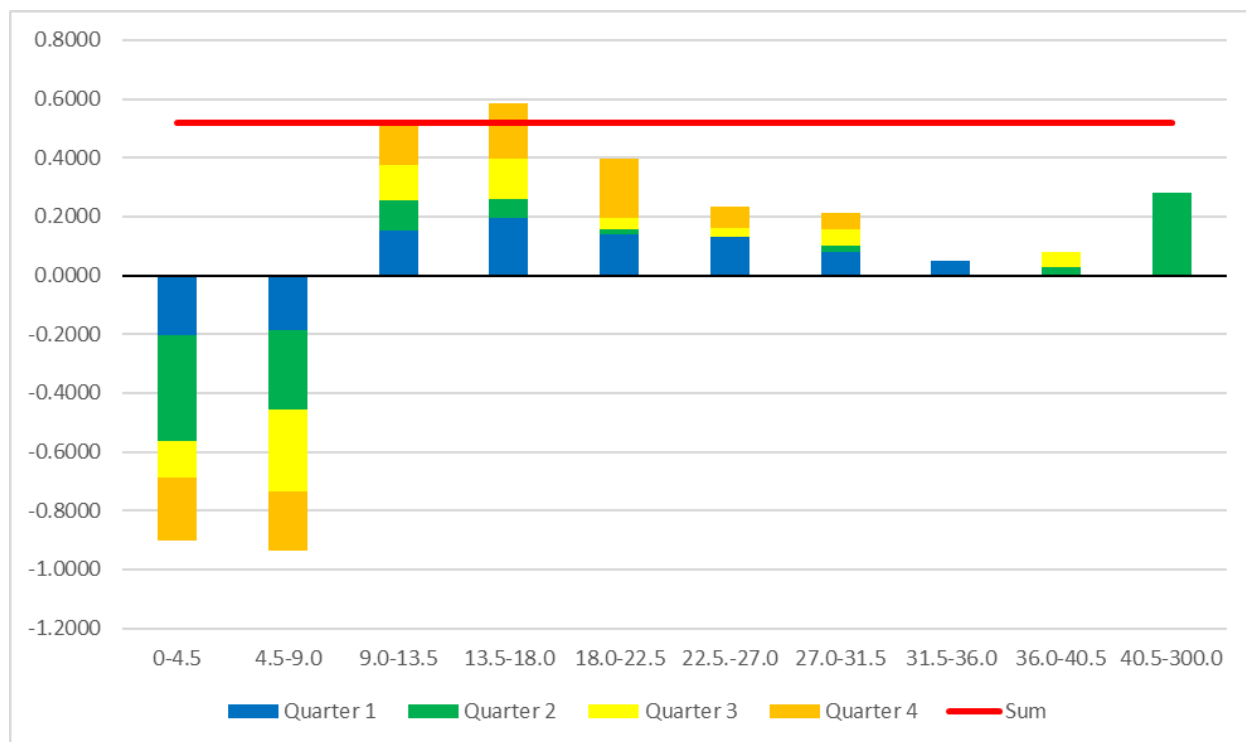
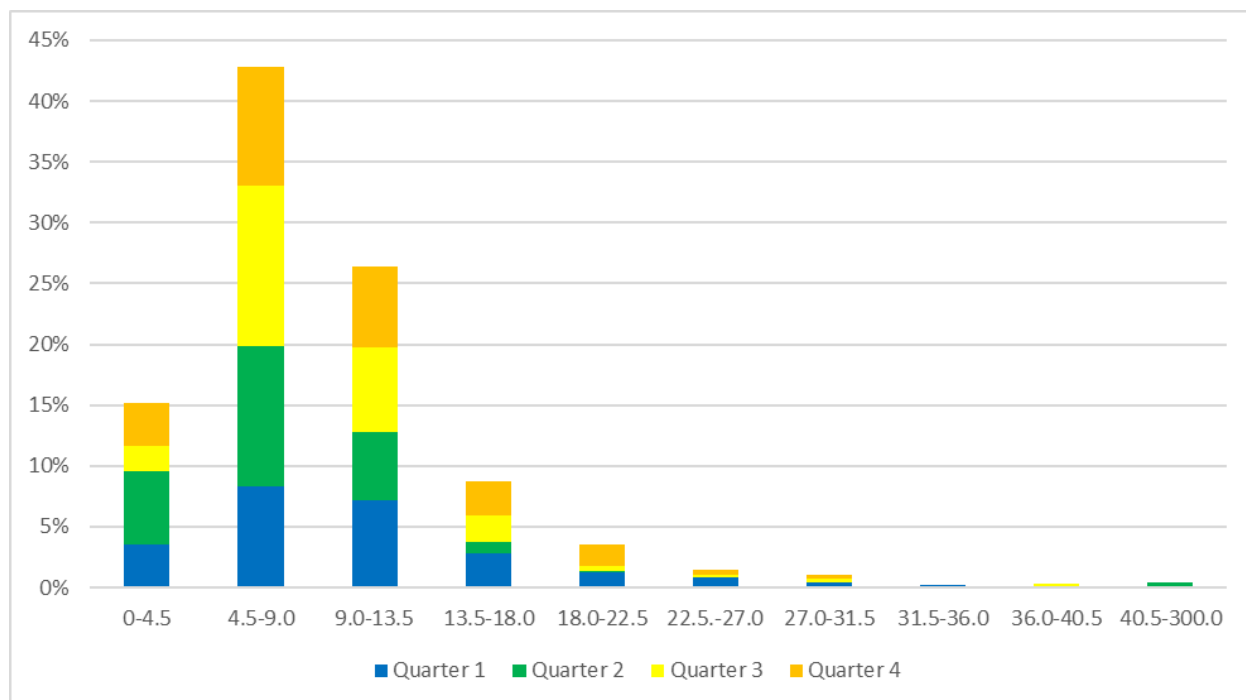


Figure C-4.2.2: Lancaster Downwind PM_{2.5} Design Value Category Breakdown



PADEP'S DESIGNATION RECOMMENDATIONS FOR THE 2024 PRIMARY ANNUAL FINE PARTICULATE MATTER (PM_{2.5}) NATIONAL AMBIENT AIR QUALITY STANDARD

Figure C-4.2.3: Lancaster PM_{2.5} Design Value Contribution (µg/m³)

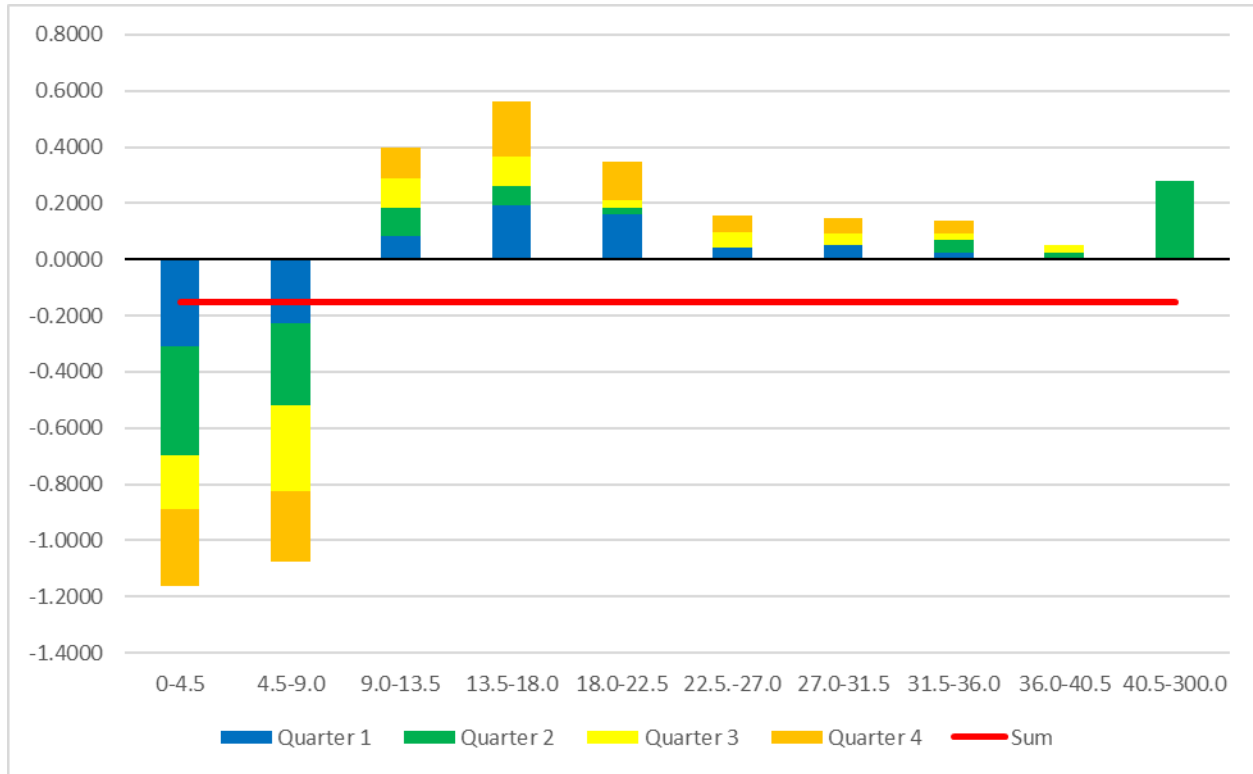
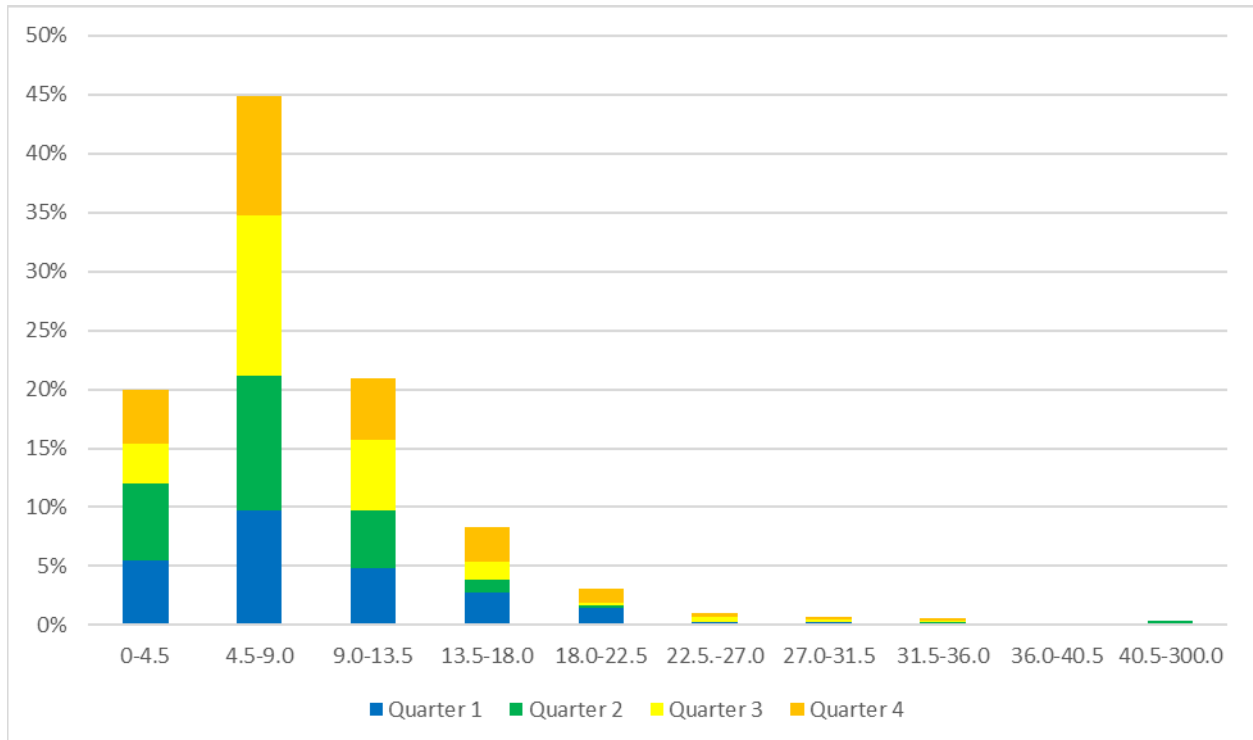


Figure C-4.2.4: Lancaster PM_{2.5} Design Value Category Breakdown



PADEP'S DESIGNATION RECOMMENDATIONS FOR THE 2024 PRIMARY ANNUAL FINE PARTICULATE MATTER (PM_{2.5}) NATIONAL AMBIENT AIR QUALITY STANDARD

Figure C-4.2.5: Arendtsville PM_{2.5} Design Value Contribution (µg/m³)

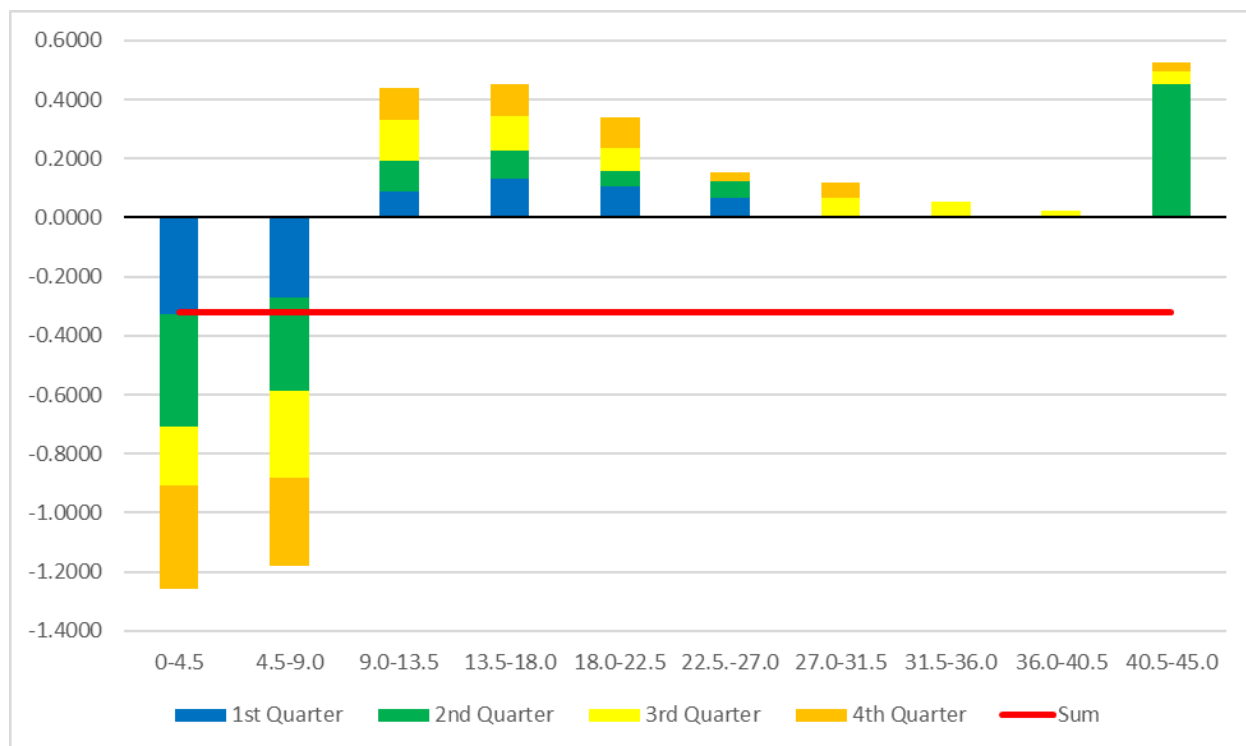
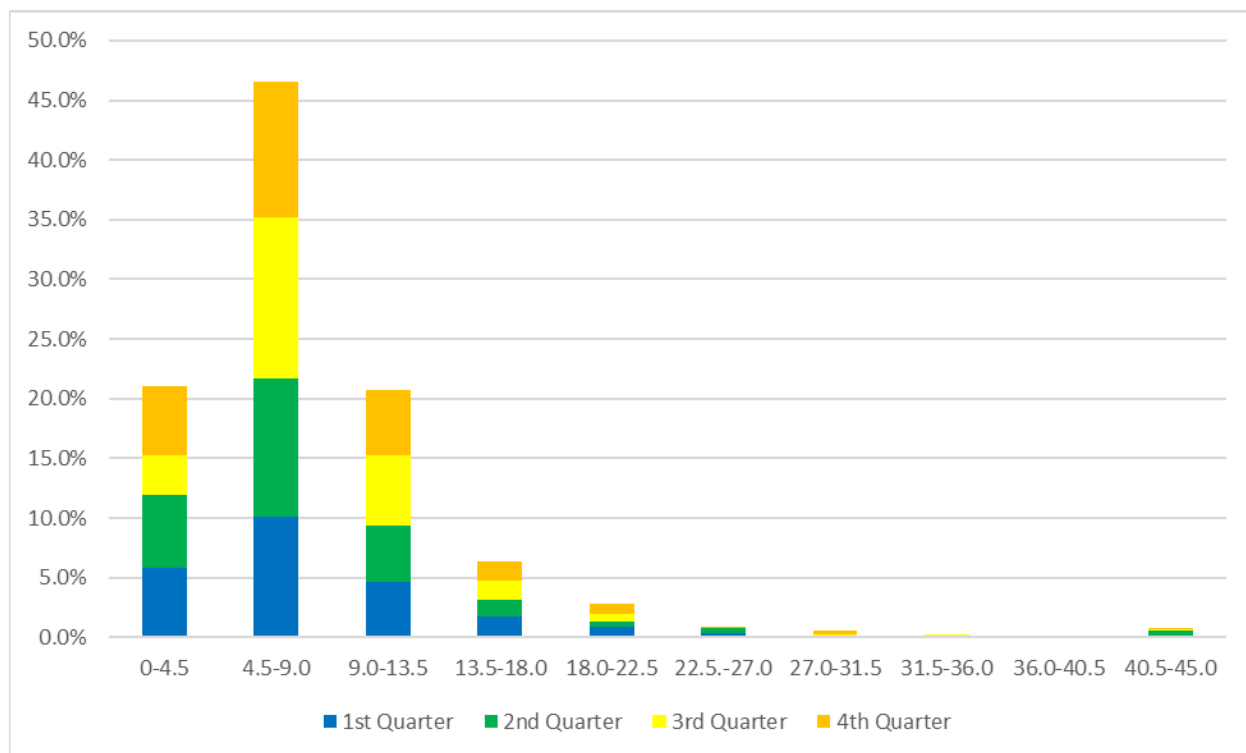


Figure C-4.2.6: Arendtsville PM_{2.5} Design Value Category Breakdown



PADEP'S DESIGNATION RECOMMENDATIONS FOR THE 2024 PRIMARY ANNUAL FINE PARTICULATE MATTER (PM_{2.5}) NATIONAL AMBIENT AIR QUALITY STANDARD

Figure C-4.2.7: Lebanon PM_{2.5} Design Value Contribution (µg/m³)

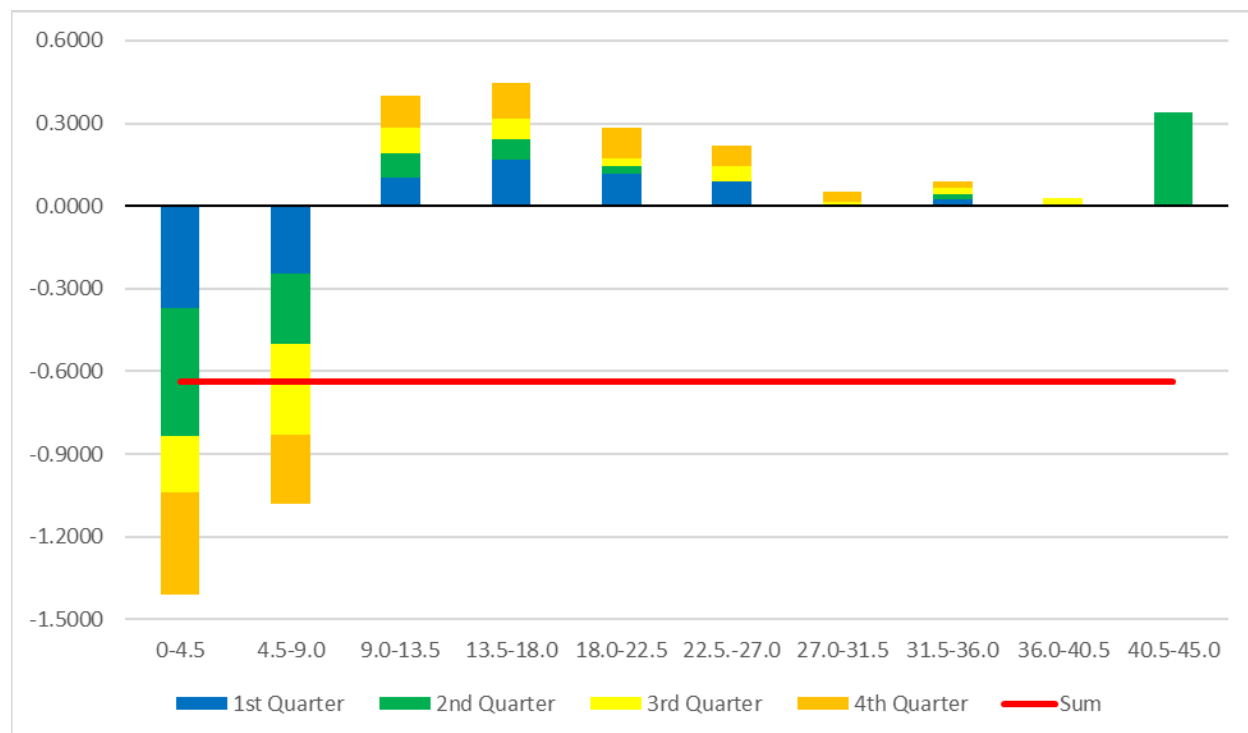
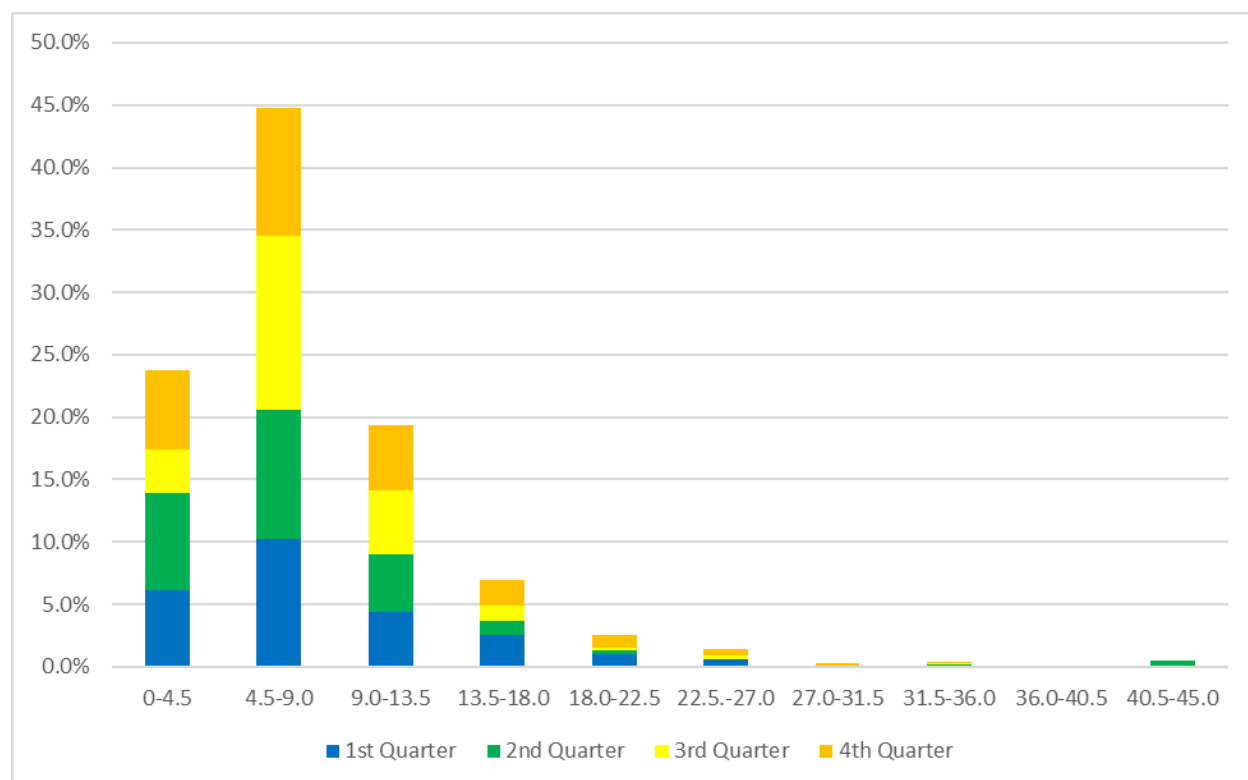
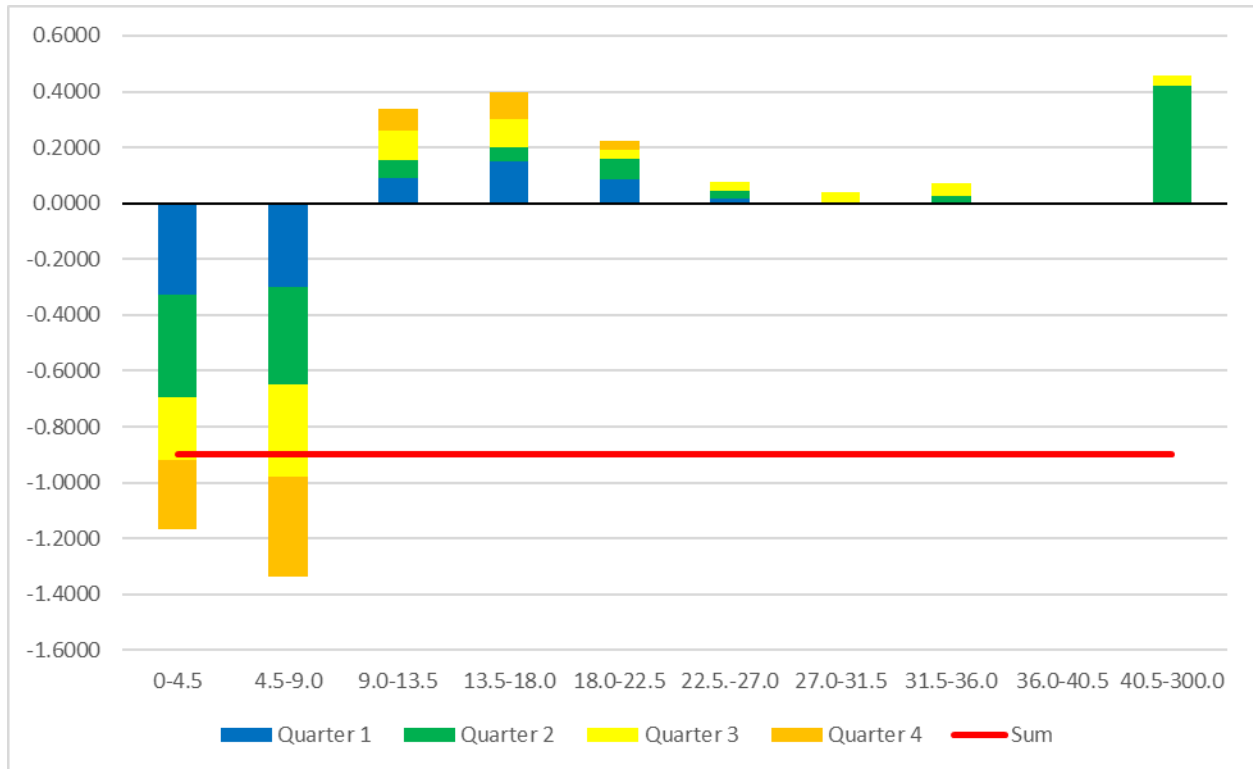


Figure C-4.2.8: Lebanon PM_{2.5} Design Value Category Breakdown



PADEP'S DESIGNATION RECOMMENDATIONS FOR THE 2024 PRIMARY ANNUAL FINE PARTICULATE MATTER (PM_{2.5}) NATIONAL AMBIENT AIR QUALITY STANDARD

Figure C-4.2.9: New Garden PM_{2.5} Design Value Contribution (µg/m³)



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Figure C-4.2.10: New Garden PM_{2.5} Design Value Category Breakdown

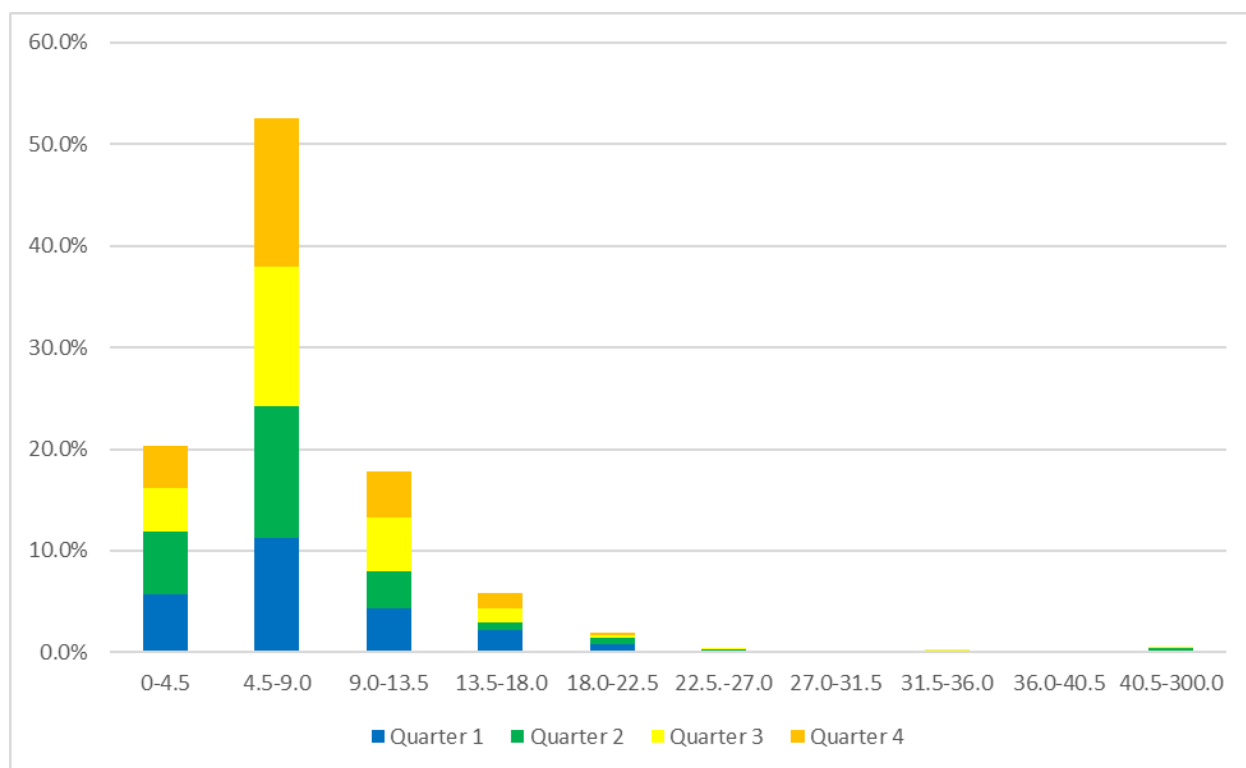


Figure C-4.2.11: Lancaster County Area PM_{2.5} Annual Design Value Contribution (µg/m³)

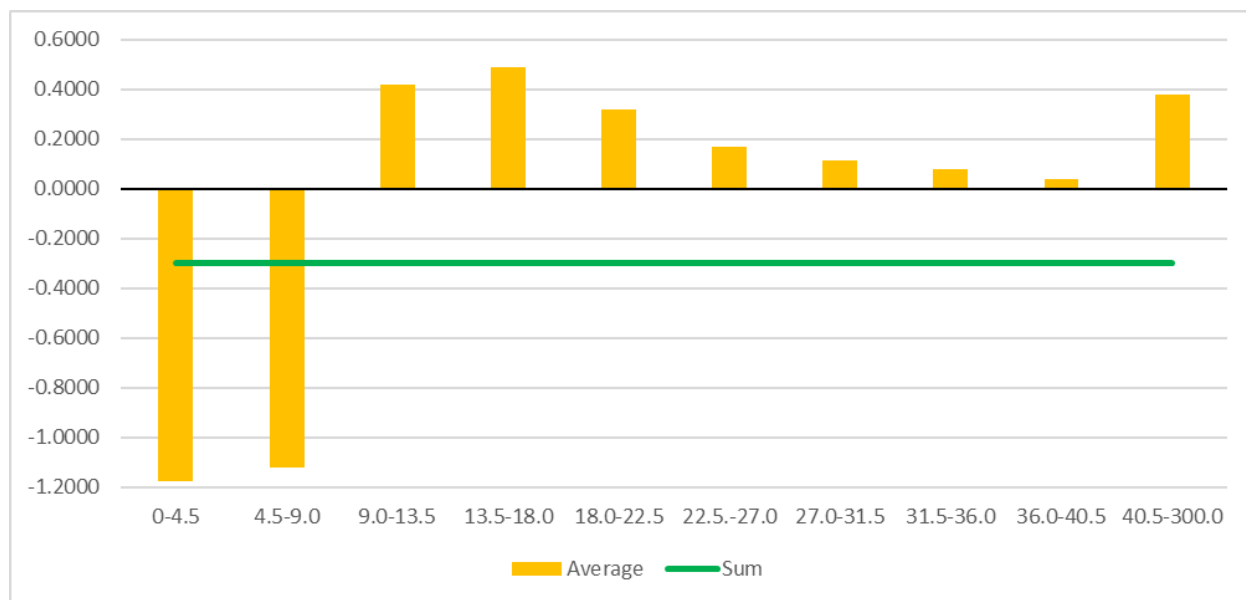


Table C-4.1 illustrates the differences between the monitors that are attaining the 2024 PM_{2.5} annual standard and the monitor that is not attaining the 2024 PM_{2.5} annual standard. The Lancaster Downwind monitor has slightly fewer “clean” days (0-9 µg/m³) than the monitors

PADEP'S DESIGNATION RECOMMENDATIONS FOR THE 2024 PRIMARY ANNUAL FINE PARTICULATE MATTER (PM_{2.5}) NATIONAL AMBIENT AIR QUALITY STANDARD

that are attaining the standard. For example, the Lancaster Downwind monitor's PM_{2.5} contribution to the design value in the 0-9 µg/m³ range was 0.46 µg/m³ lower than the regional average.

The analysis described in the remainder of this Appendix focuses on the Lancaster Downwind monitor because it is the only monitor of concern. Figure C-4.3.1 illustrates the trend of annual averages while Figure C-4.3.2 illustrates the trend of annual design values during the period in the Lancaster County area with valid 2023 PM_{2.5} design values. The Lancaster Downwind monitor has both a 2023 annual average and design value above the 2024 standard. Since 2014, annual PM_{2.5} levels have been in a general decline in the Lancaster County area. It is important to note that 2023 was an extremely active year for Canadian wildfires, leading to an excessive amount of smoke transported into southeastern PA. Days with smoke impacts showed elevated concentrations (beyond what might have been expected), along with several exceedances of the 24-hour NAAQS.

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Figure C-4.3.1: Lancaster County Area PM_{2.5} Valid Annual Averages (µg/m³)

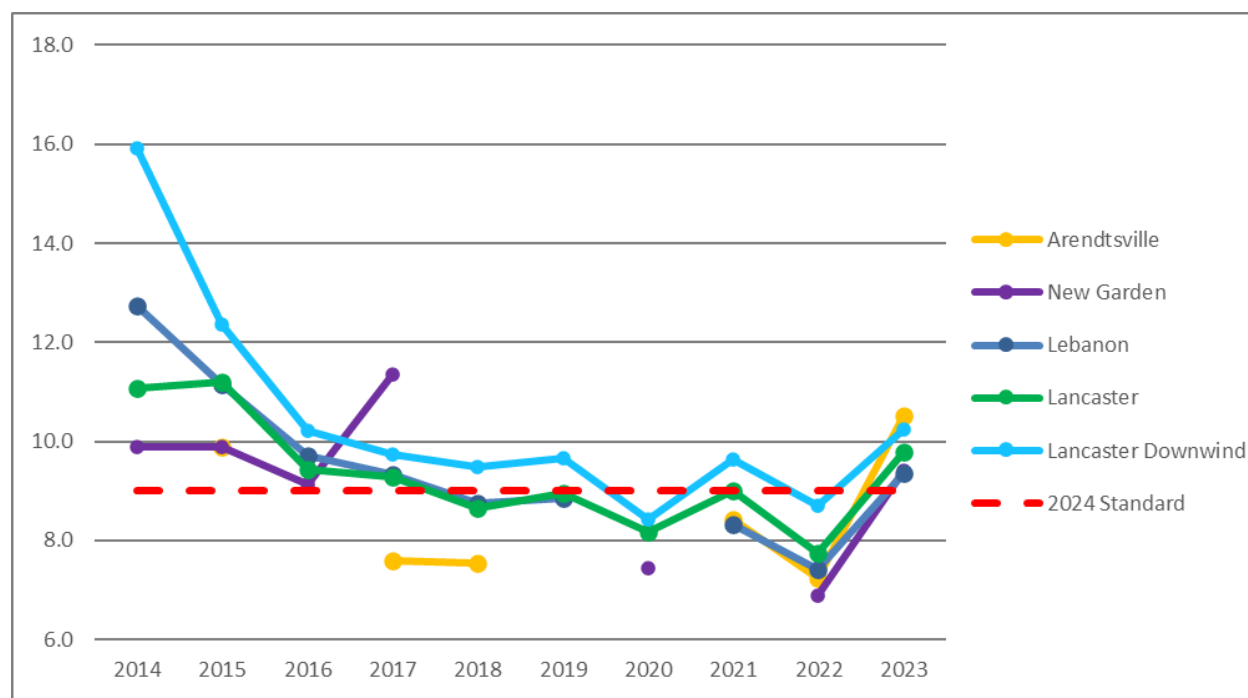
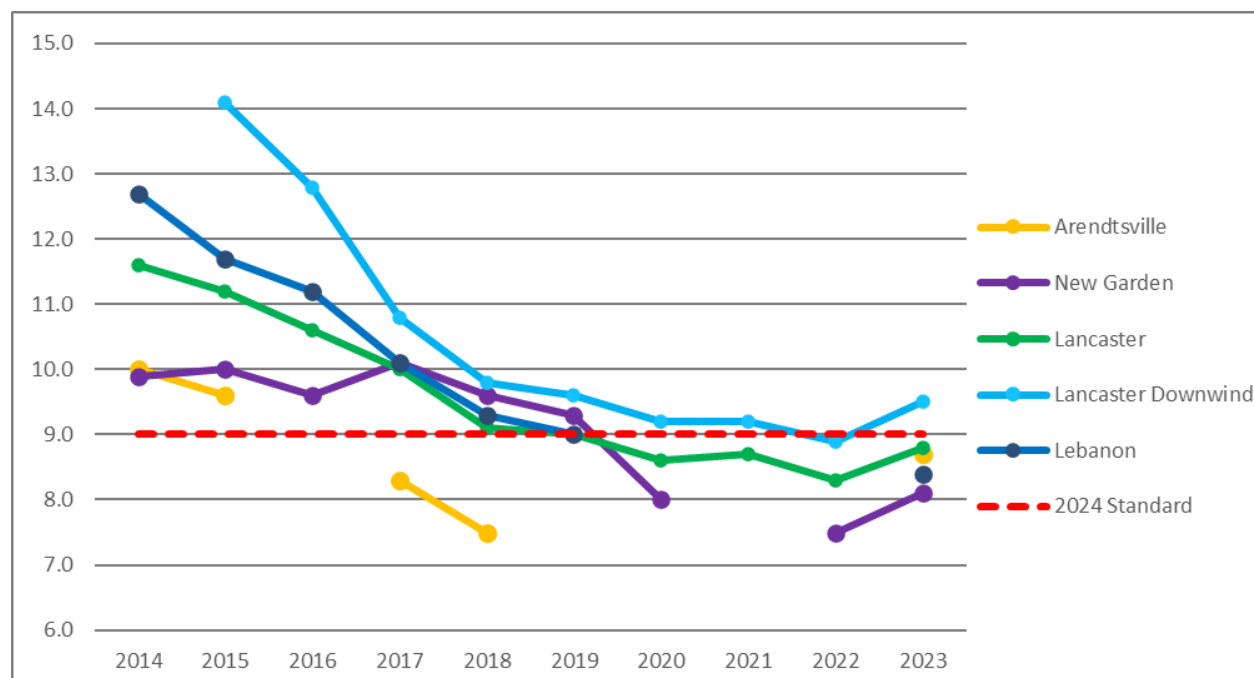


Figure C-4.3.2: Lancaster County Area PM_{2.5} Valid Annual Design Values (µg/m³)



Additional analyses were completed to determine what was contributing to the fewer number of “clean” days at the Lancaster Downwind monitor. PADEP identified days when the Lancaster Downwind monitor’s PM_{2.5} concentrations were relatively high but regional monitoring

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concentrations in the Lancaster area were “clean.” Between 2021 and 2023, PADEP identified 183 days in which the Lancaster Downwind monitor was at least one standard deviation above the regional average while the regional average was at or below 9 µg/m³.

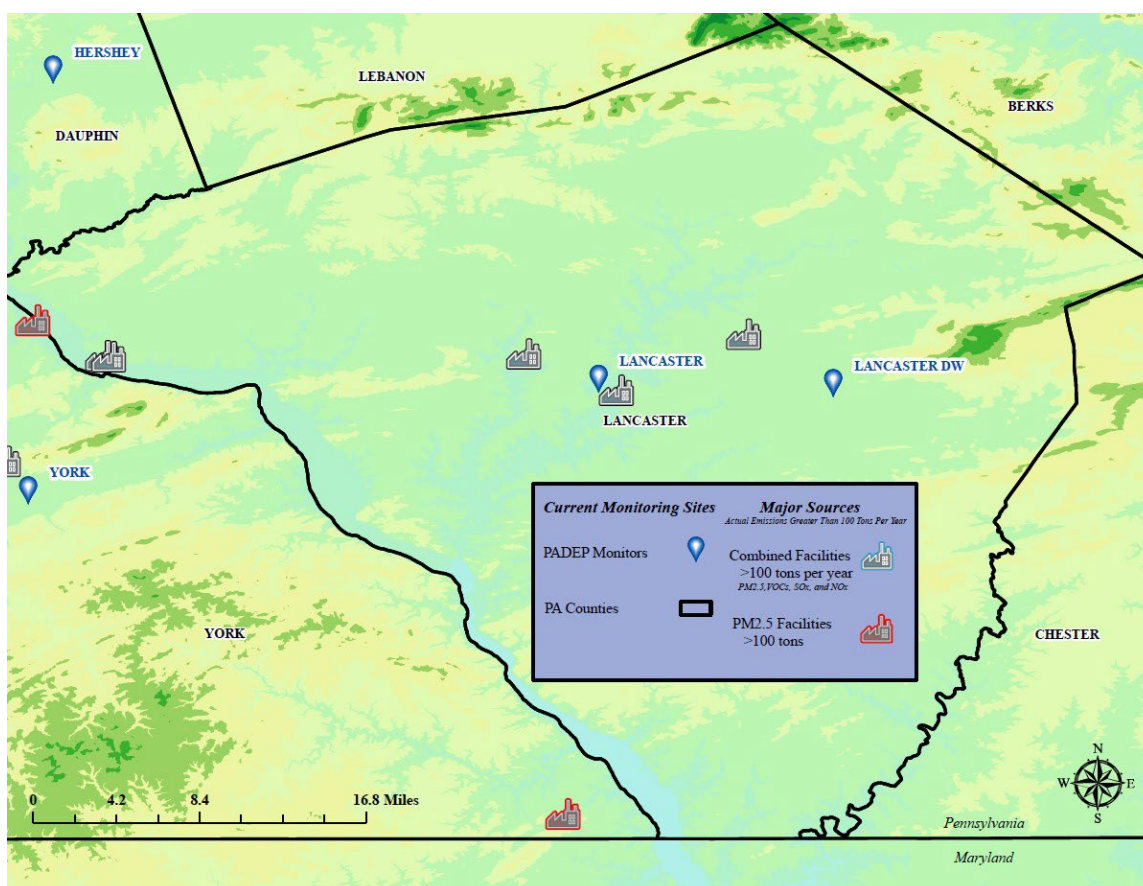
Meteorological Conditions Impacting High PM_{2.5} Days at the Lancaster Downwind Monitor

The Lancaster MSA, made up of Lancaster County, includes the Lancaster air basin per Appendix B, Figure 17. Lancaster County has the most farms and acres of farmland in the Commonwealth. Lancaster County consists of mostly farmlands surrounding downtown Lancaster and the location of the Lancaster and Lancaster Downwind monitor. Elevations in Lancaster County vary from 89 to over 1,300 feet. Wind patterns are generally influenced by weather systems moving from the west.

Figure C-4.4.1 illustrates the sources within the immediate proximity of the Lancaster and Lancaster Downwind monitors. Using the meteorological station at the Lancaster Airport (LNS), Figure C-4.4.2 illustrates the frequency of wind distribution coming from a particular direction.

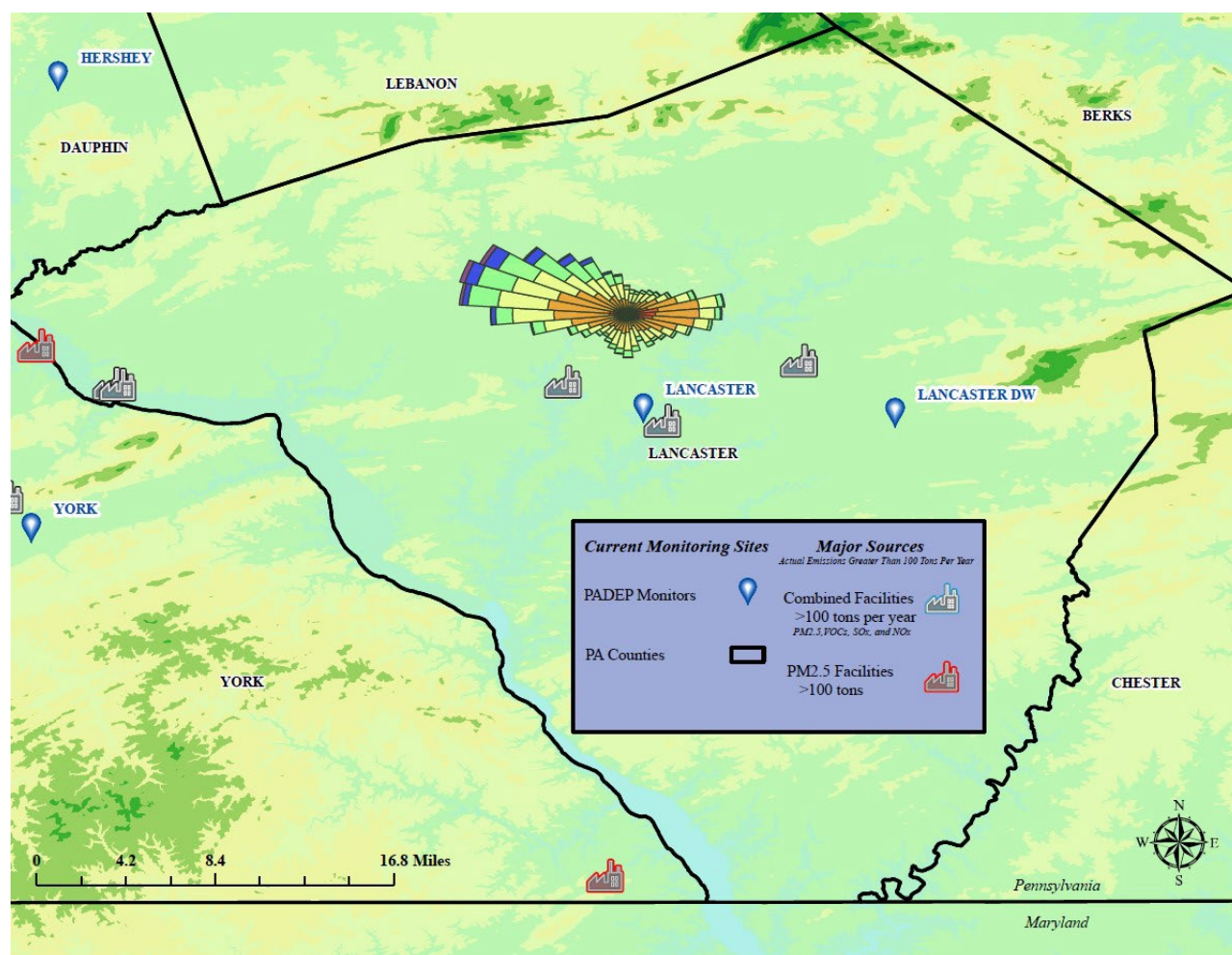
PADEP'S DESIGNATION RECOMMENDATIONS FOR THE 2024 PRIMARY ANNUAL FINE PARTICULATE MATTER (PM_{2.5}) NATIONAL AMBIENT AIR QUALITY STANDARD

Figure C-4.4.1: Lancaster Area
Major Sources (Over 100 Tons Per Year) Based on PADEP 2022 Emission Inventory



The closest major source is located approximately five (5) miles to the northwest of the Lancaster Downwind monitor. Figure B-10 in Appendix B shows that Lancaster County has the largest ammonia area source emission density (in tons per year per square mile) in Pennsylvania. This analysis also illustrates that there is a potential local influence to the high PM_{2.5} concentrations at the Lancaster Downwind monitor.

*Figure C-4.4.2: Lancaster Area
Lancaster Airport (LNS) Wind Rose*



The Change in the Composition of the PM_{2.5}

In the Lancaster County area, PADEP operates speciation monitors at Lancaster and Lancaster Downwind. PADEP also operates a speciation monitor at Arendtsville (AQS ID# 42-001-0001), located in Adams County. We chose to compare seasonal values with what has occurred in Arendtsville which is in a rural location of Pennsylvania and does not have a major nitrogen oxide or sulfur dioxide source within 12 kilometers of the monitor. For that reason, the Arendtsville monitor reflects the transport that is coming into eastern Pennsylvania from areas to the west (prevailing wind flow is from west to east across Pennsylvania).

Figures C-4.5.1 - C-4.5.2, C-4.5.4 - C-4.5.5, C-4.5.7 - C-4.5.8, and C-4.5.10 - C-4.5.11 outline the main speciated components of PM_{2.5} during each quarter. Figures C-4.5.3, C-4.5.6, C-4.5.9, and C-4.5.12 illustrate the difference in the main speciated components of PM_{2.5} from the 2016 to 2018 period to the 2021 to 2023 period.

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Figure C-4.5.1: 2016-2018 Quarter 1 PM_{2.5} Average Speciation Concentrations (µg/m³)

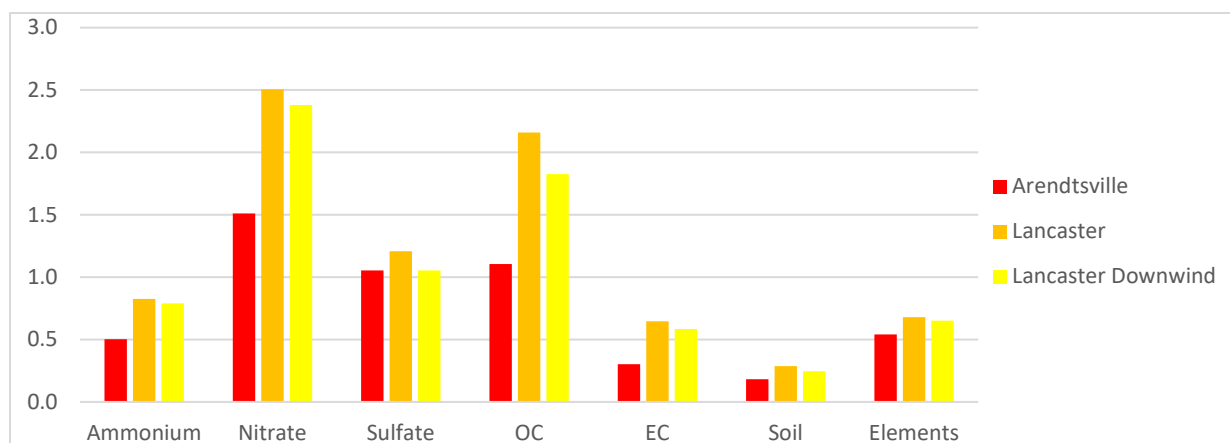


Figure C-4.5.2: 2021-2023 Quarter 1 PM_{2.5} Average Speciation Concentrations (µg/m³)

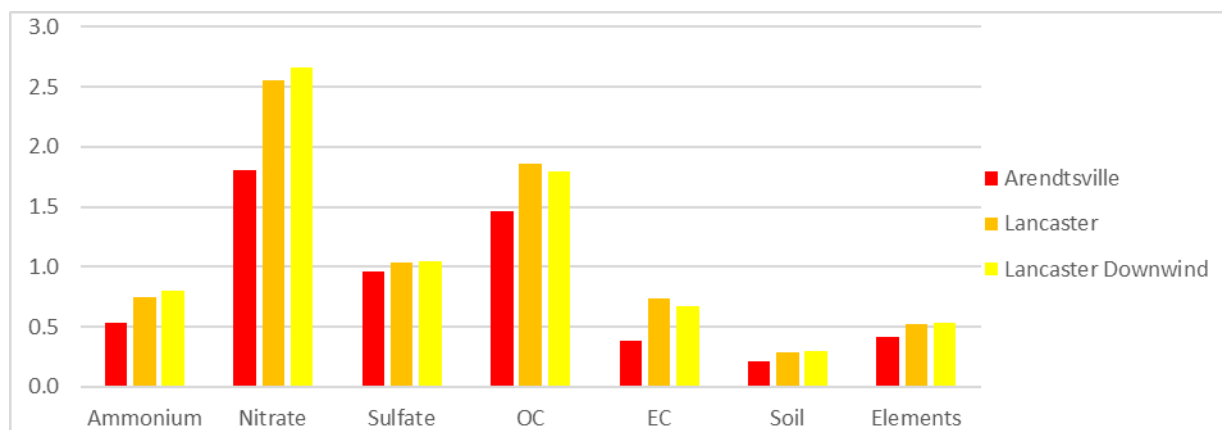
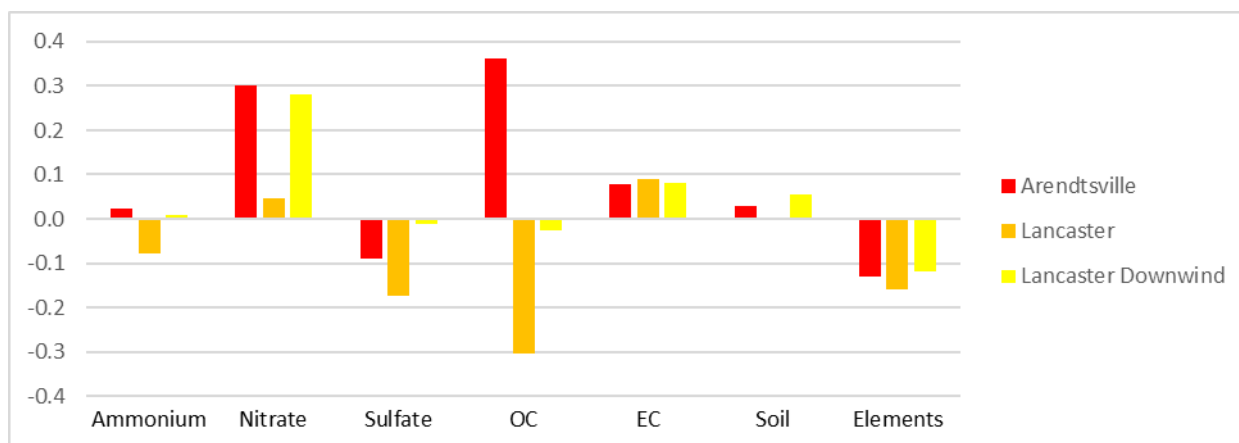


Figure C-4.5.3: Comparison of Quarter 1 PM_{2.5} Average Speciation Concentrations (µg/m³) 2021-2023 minus 2016-2018



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Figure C-4.5.4: 2016-2018 Quarter 2 PM_{2.5} Average Speciation Concentrations (µg/m³)

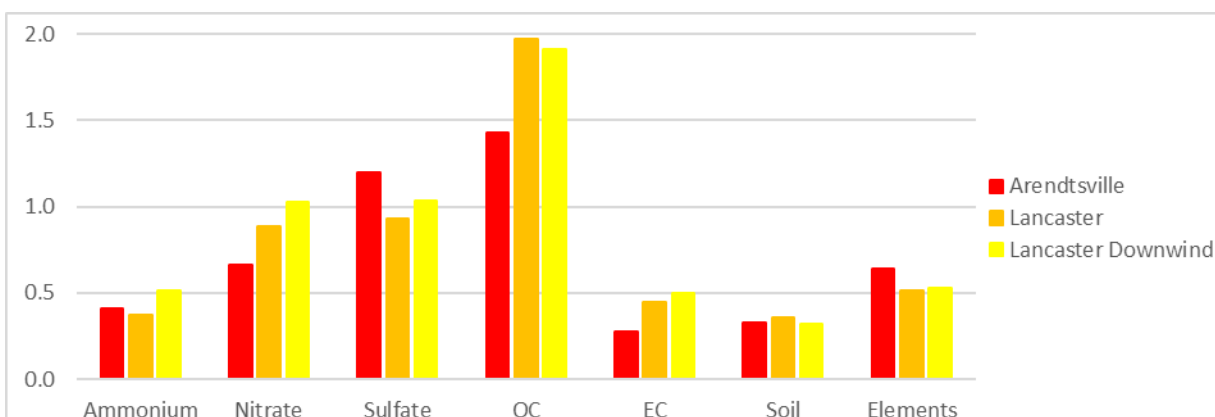


Figure C-4.5.5: 2021-2023 Quarter 2 PM_{2.5} Average Speciation Concentrations (µg/m³)

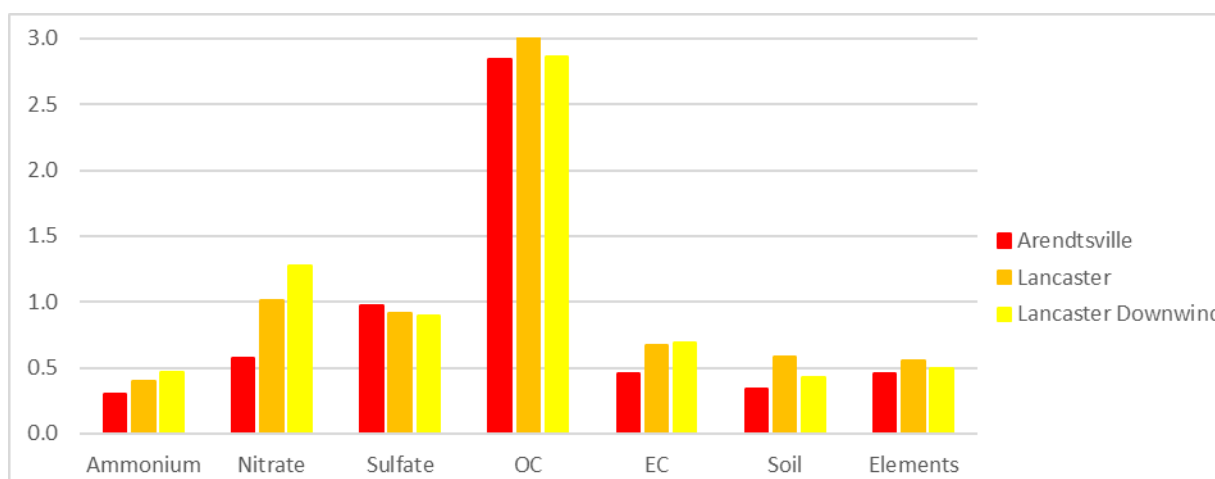
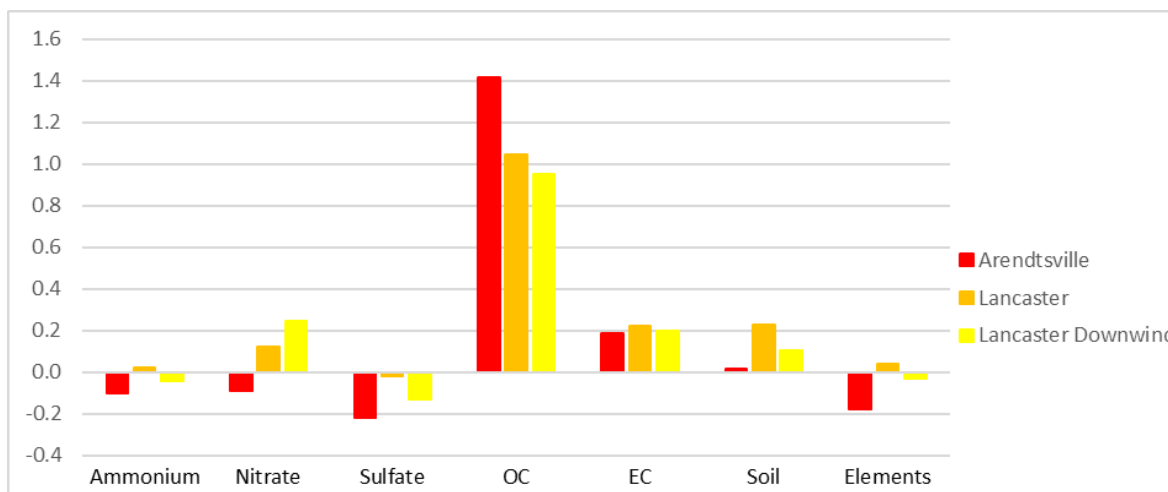


Figure C-4.5.6: Comparison of Quarter 2 PM_{2.5} Average Speciation Concentrations (µg/m³) 2021-2023 minus 2016-2018



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Figure C-4.5.7: 2016-2018 Quarter 3 PM_{2.5} Average Speciation Concentrations (µg/m³)

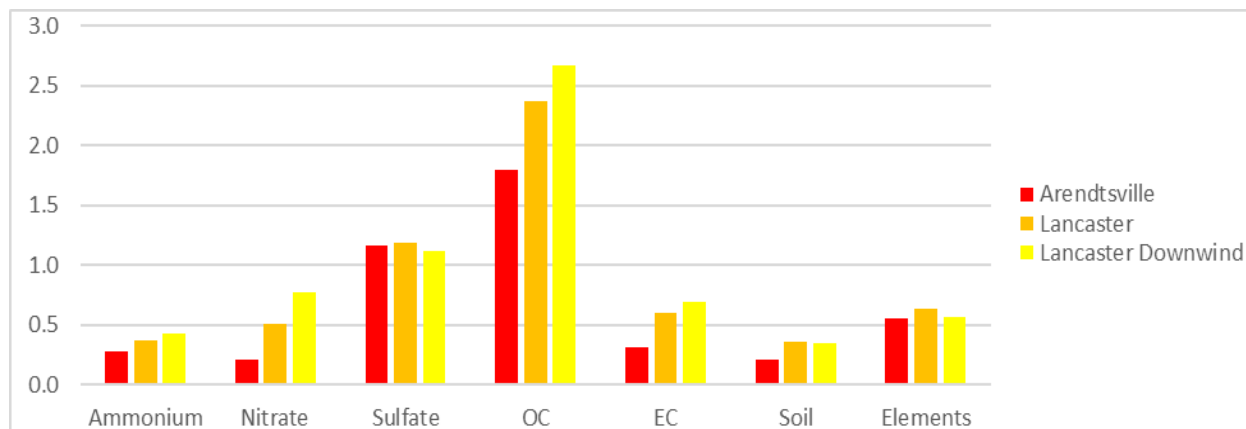


Figure C-4.5.8: 2021-2023 Quarter 3 PM_{2.5} Average Speciation Concentrations (µg/m³)

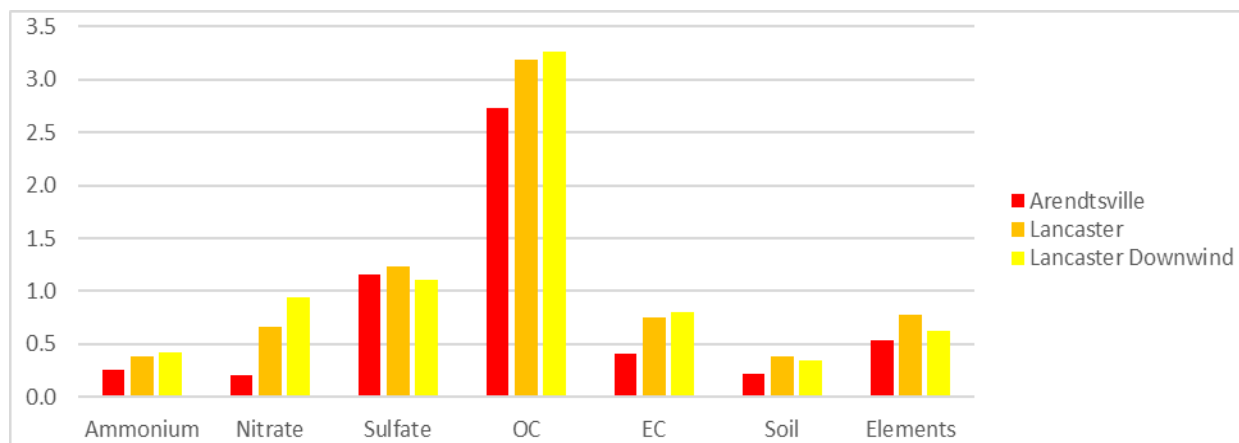
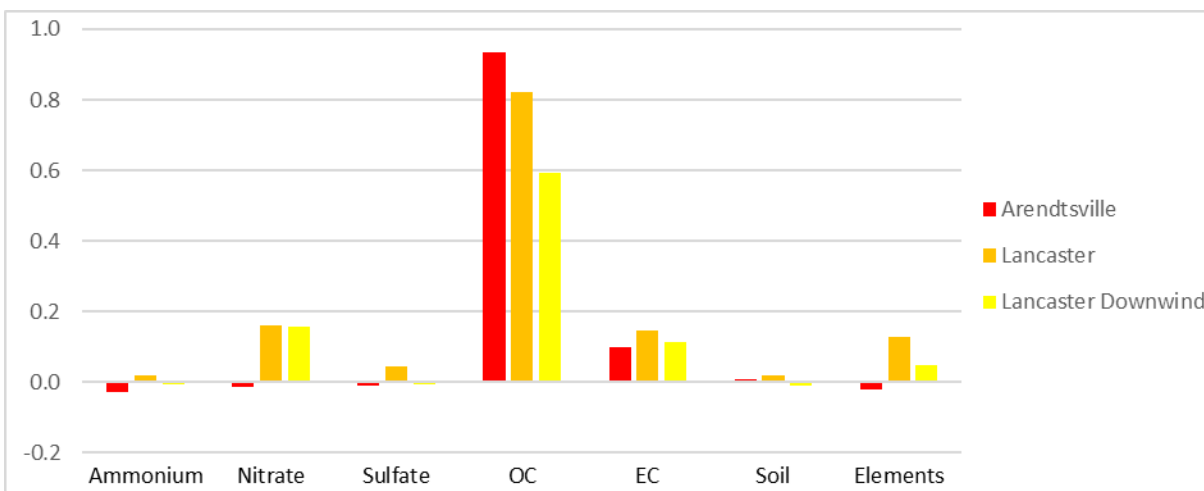


Figure C-4.5.9: Comparison of Quarter 3 PM_{2.5} Average Speciation Concentrations (µg/m³) 2021-2023 minus 2016-2018



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Figure C-4.5.10: 2016-2018 Quarter 4 PM_{2.5} Average Speciation Concentrations (µg/m³)

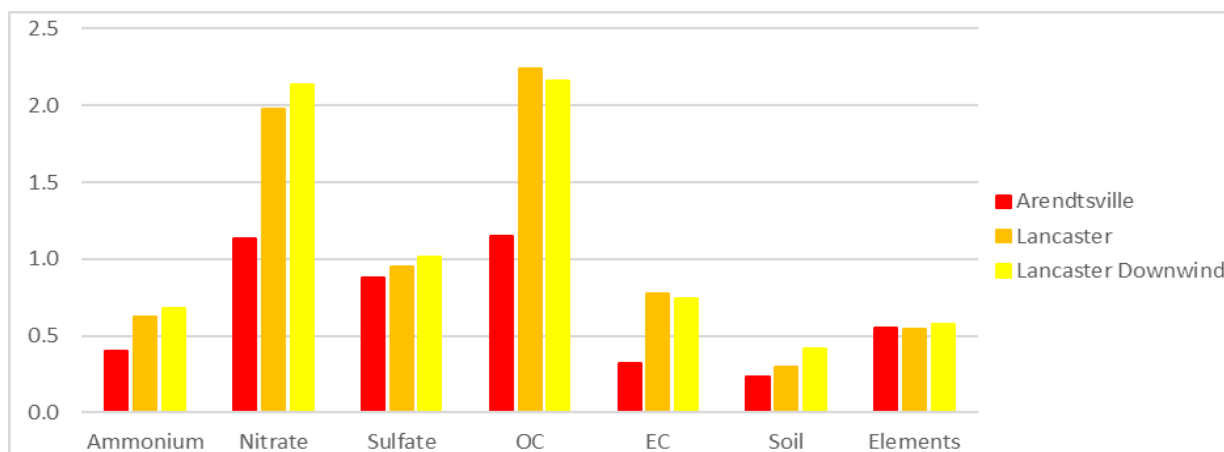


Figure C-4.5.11: 2021-2023 Quarter 4 PM_{2.5} Average Speciation Concentrations (µg/m³)

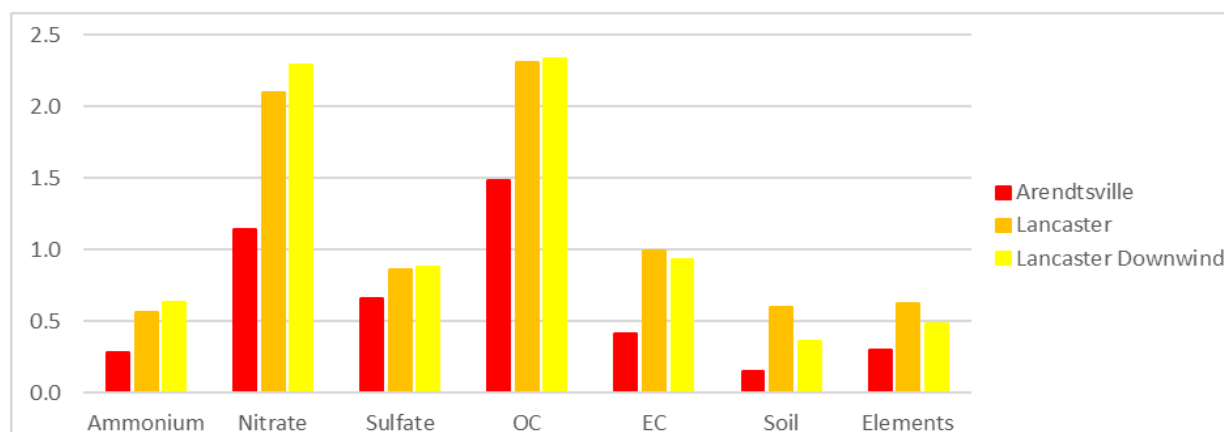
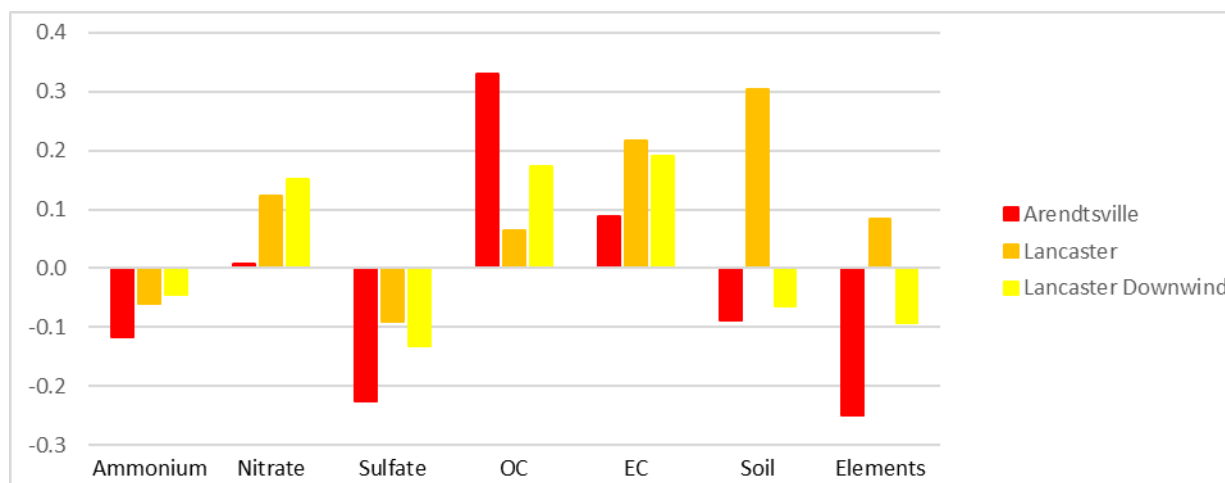


Figure C-4.5.12: Comparison of Quarter 4 PM_{2.5} Average Speciation Concentrations (µg/m³) 2021-2023 minus 2016-2018



During Quarter 1, there have been reductions in sulfate and trace elements concentrations across the sites with reductions in ammonium at Lancaster, reductions in organic carbon at Lancaster and Lancaster Downwind, and reductions in soil at Lancaster. During Quarter 2, there have been reductions in ammonium and trace elements at Lancaster Downwind, and reductions in sulfate at Lancaster and Lancaster Downwind. During Quarter 3, there have been reductions in ammonium, sulfate, and soil at Lancaster Downwind. During Quarter 4, there have been reductions in ammonium and sulfate at Lancaster and Lancaster Downwind, and reductions in soil and trace elements at Lancaster Downwind.

The reductions at Arendtsville are more representative of the reductions observed in eastern Pennsylvania due to emission control strategies of various sources across western Pennsylvania into the Ohio Valley. The data indicates that there have been reductions at the Arendtsville monitor during Quarter 1 for sulfate and trace elements, during Quarter 2 for ammonium, nitrate, sulfate, and trace elements, Quarter 3 for ammonium, nitrate, sulfate, and trace elements, and Quarter 4 for ammonium, sulfate, soil, and trace elements.

Positive Matrix Factorization (PMF) receptor modeling can be applied to the PM_{2.5} speciation data collected from 2021-2023 to quantify the contribution of sources to the measured PM_{2.5} concentration. This analysis serves as supporting and underlying data for the attainment demonstration in the PM_{2.5} 2024 NAAQS State Implementation Plan (SIP) for the Pennsylvania nonattainment area. Understanding PM_{2.5} sources will help to develop effective emission reduction strategies.

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Figure C-4.6.1: PM_{2.5} Urban Excess, Lancaster Downwind vs. Arendtsville, 2021-23 by Quarter

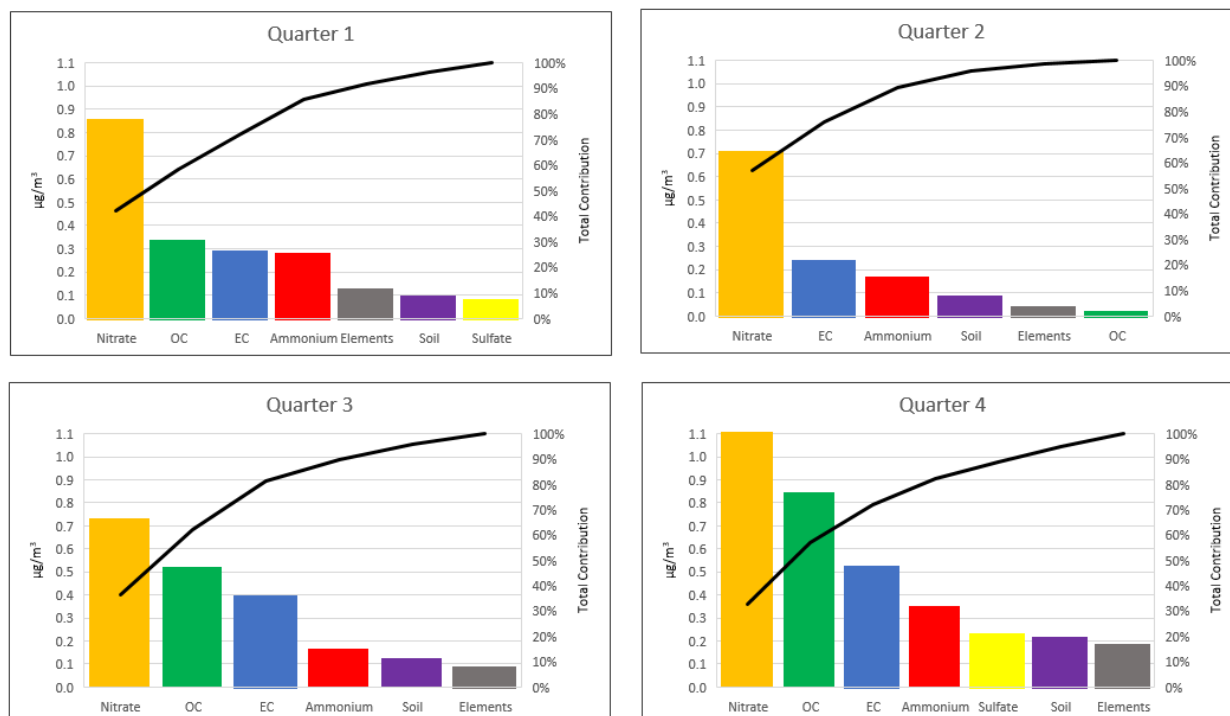
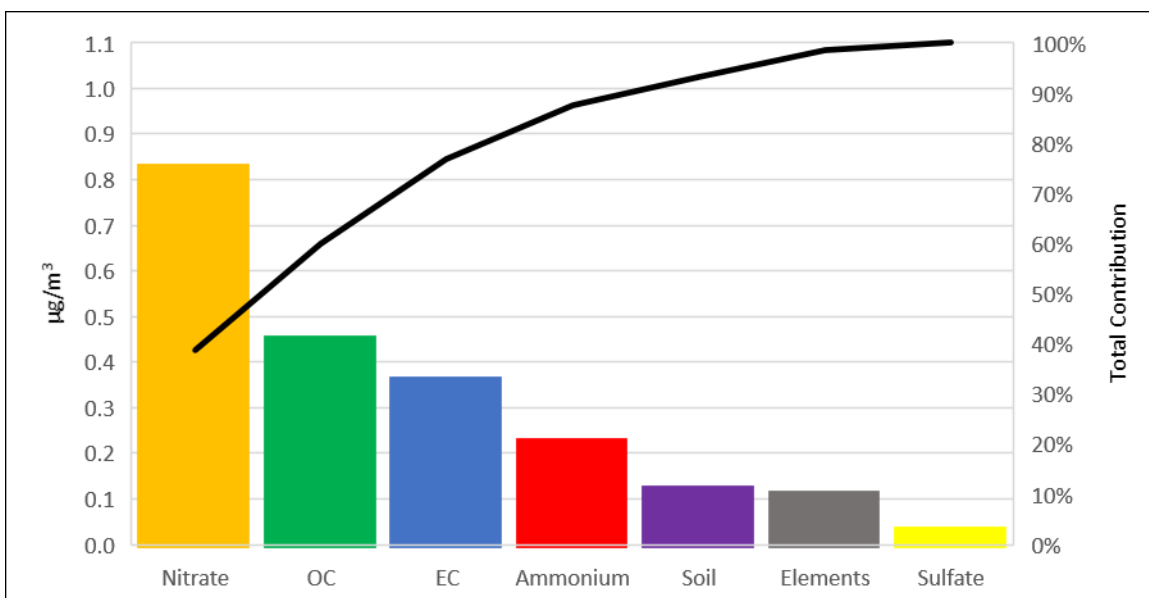


Figure C-4.6.2: PM_{2.5} Urban Excess, Lancaster Downwind vs. Arendtsville, 2021-23



PADEP'S DESIGNATION RECOMMENDATIONS FOR THE 2024 PRIMARY ANNUAL FINE PARTICULATE MATTER (PM_{2.5}) NATIONAL AMBIENT AIR QUALITY STANDARD

Figure C-4.6.3: PM_{2.5} Urban Excess, Lancaster vs. Arendtsville, 2021-23 by Quarter

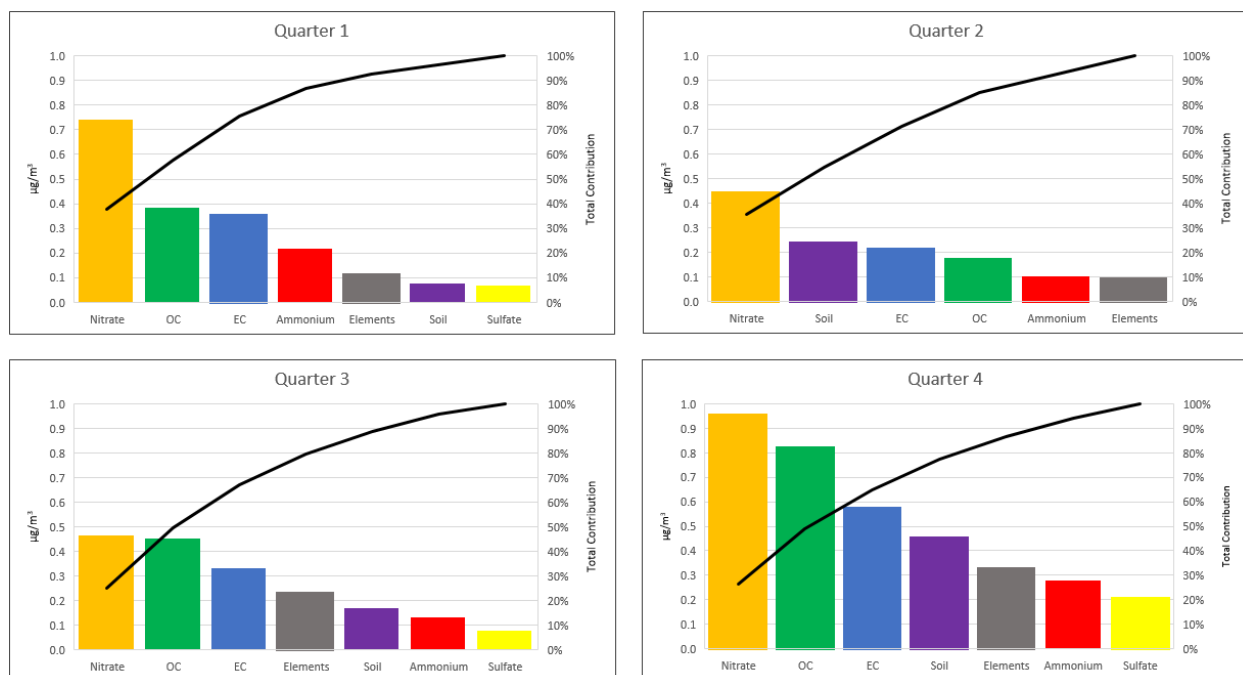
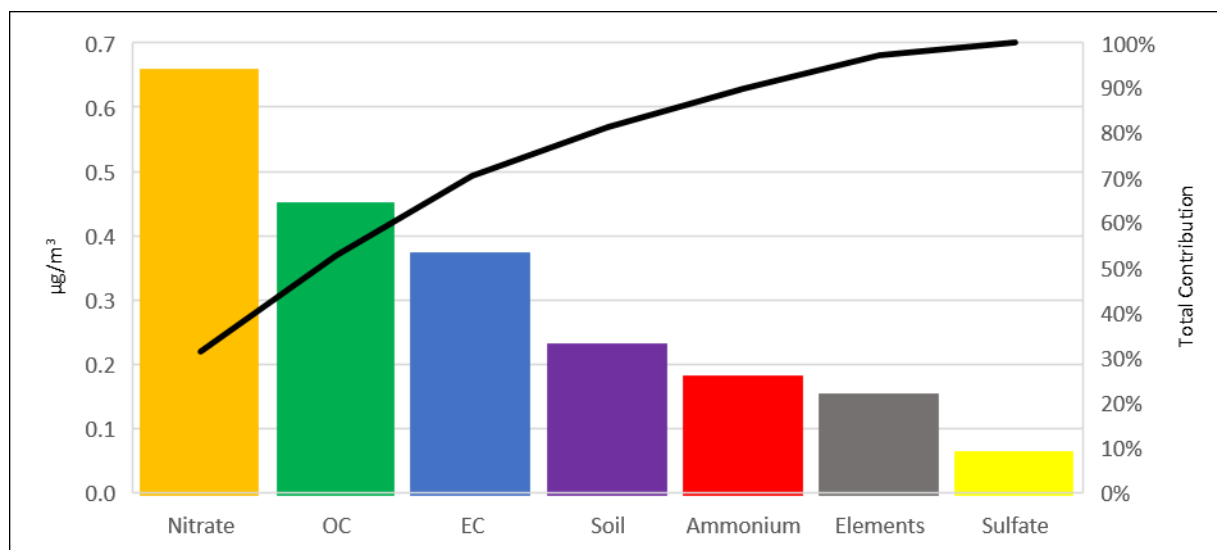


Figure C-4.6.4: PM_{2.5} Urban Excess, Lancaster vs. Arendtsville, 2021-23

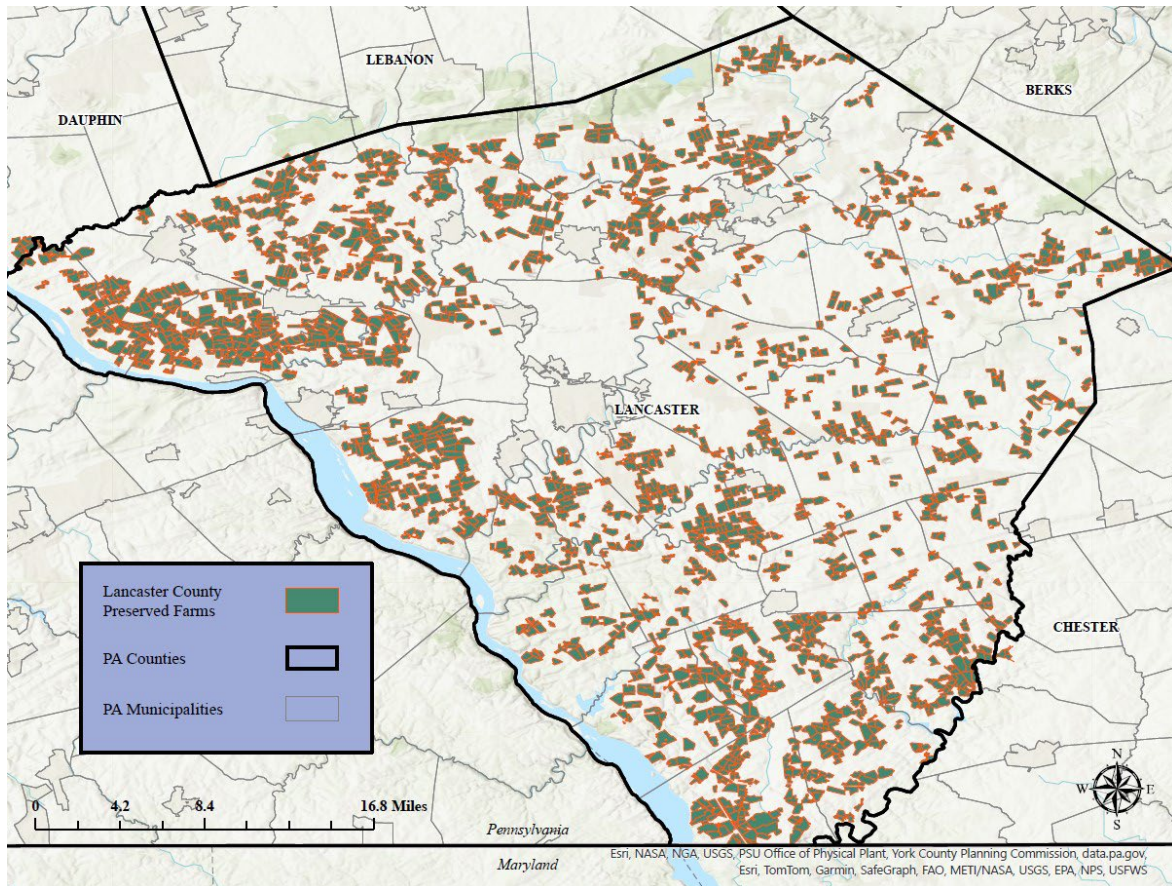


Figures C-4.6.1 - C-4.6.4 display the major constituents of PM_{2.5} at the Lancaster County monitors compared to Arendtsville. In Quarters 1 and 4, Lancaster Downwind and Lancaster have excess ammonium, nitrate, organic and elemental carbon, soil, sulfate, and trace elements compared to Arendtsville, suggesting emissions are local in nature. In Quarters 2 and 3, Lancaster Downwind and Lancaster have excess ammonium, nitrate, organic and elemental carbon, soil, and trace emissions compared to Arendtsville. Lancaster County has a strong tie to the agricultural sector. Lancaster County has the most farms and acres of farmland in the Commonwealth. Lancaster

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County consists of mostly farmlands surrounding downtown Lancaster and the location of the Lancaster and Lancaster Downwind monitor. Ammonia emissions are prevalent in the agricultural sector due to the abundance of manure from livestock and a higher concentration of animals, for instance. The abundance of ammonium during the cold season allows for additional nitrate (from vehicles) to form ammonium nitrate, a constituent of PM_{2.5}. Figure C-4.7 displays a map of Lancaster County and the proximity of preserved farms, which are farms and acres of land preserved for agricultural production, to the Lancaster Downwind monitor.

Figure C-4.7: Preserved Farms in Lancaster County Map



PADEP'S DESIGNATION RECOMMENDATIONS FOR THE 2024 PRIMARY ANNUAL FINE PARTICULATE MATTER (PM_{2.5}) NATIONAL AMBIENT AIR QUALITY STANDARD

Summary

PADEP's analysis illustrates the need for a small nonattainment area consisting of Lancaster County. An analysis of the PM_{2.5} data monitored at the Lancaster Downwind monitor in Lancaster County illustrates that the Lancaster Downwind monitor sees greater concentrations in the 9-27 $\mu\text{g}/\text{m}^3$ range than the regional concentrations in the same range. Lancaster County has the largest ammonia area source emission density (in tons per year per square mile) in Pennsylvania. A further examination into the monitoring data demonstrates that the high concentrations are coming out of two primary directions: northwesterly and easterly. These wind profiles travel over local farms, further illustrating the local issue at the Lancaster Downwind monitor. An analysis of the speciated data at the Lancaster Downwind and Arendtsville monitors illustrates the excess nitrate, ammonium, and organic and elemental carbon at the Lancaster Downwind monitor. The excess ammonium is likely a function of the high number of farms in the immediate vicinity of the Lancaster Downwind monitor. The excess ammonium, when in contact with excess nitrate, forms ammonium nitrate, a large constituent of PM_{2.5} during the cold season. Therefore, PADEP is recommending the Lancaster County nonattainment area encompassing Lancaster County in Pennsylvania be designated nonattainment for the 2024 annual PM_{2.5} NAAQS. A map of the proposed nonattainment area is provided below as Figure C-4.8.

Figure C-4.8: Recommended Lancaster County PM_{2.5} Nonattainment Area

