FY24-25
Contract 582-24-01388
Subtask 4.2

Prepared by:

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December 2025

Final Report: ETCOG Rider 7 $PM_{2.5}$ Local Air Quality Planning Grant

PREPARED UNDER A GRANT FROM THE
TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

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The content, findings, opinions and conclusions are the work of the author(s) and do not necessarily represent findings, opinions or conclusions of the TCEQ.

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CONTENTS

1.0	**Executive Summary**	**1**
1.1	Air Quality in the Tyler-Longview-Marshall Area	1
1.2	ETCOG Rider 7 Activities	2
1.2.1	PM2.5 Emission Inventory Review	2
1.2.2	$PM_{2.5}$ Monitoring	3
1.2.3	Analyzing $PM_{2.5}$ Monitoring, Emissions, and Other Data	3
1.2.4	Statistical Modeling of $PM_{2.5}$ Monitoring Data	3
1.3	Summary of Findings	3
1.3.1	$PM_{2.5}$ Emission Inventory Review	3
1.3.2	$PM_{2.5}$ Monitoring	4
1.3.3	Analyzing $PM_{2.5}$ Monitoring, Emissions, and Other Data	4
1.3.4	Statistical Modeling of $PM_{2.5}$ Monitoring Data	6
1.4	Recommendations	6
1.4.1	Ambient Monitoring	6
1.4.2	$PM_{2.5}$ Emission Inventory	6

Appendices

Appendix A Quarterly Progress Reports
Appendix B Statement of Work
Appendix C Quality Assurance Project Plans
Appendix D Final Report for Subtask 3.1: Review of $PM_{2.5}$ Emission Inventory for Northeast Texas
Appendix E Final Report for Subtask 3.2: $PM_{2.5}$ Monitoring for Northeast Texas
Appendix F Final Report for Subtask 3.3: $PM_{2.5}$ Data Analysis for Northeast Texas
Appendix G Final Reports for Subtask 3.4: Statistical $PM_{2.5}$ Modeling for Northeast Texas

Figures

Figure 1-1. The six county TLMA area, location of CAMS monitors in the area with urban areas and major roadways in the surrounding region. 2
Figure 1-2. TLMA area 2022 $PM_{2.5}$ annual average daily emissions by source category (tons/day). 4
Figure 1-3. Tyler (collocated with CAMS 82) and Karnack (CAMS 85) 24-hour $PM_{2.5}$ Concentrations. 5

List of Acronyms and Abbreviations

CAMS	Continuous Air Monitoring Station
EPA	Environmental Protection Agency
ETCOG	East Texas Council of Governments
FEM	Federal Equivalent Method
LSTM	Long Short-Term Memory statistical method
MAE	Mean absolute error
NAAQS	National Ambient Air Quality Standard
NO	Nitric oxide
NO_2	Nitrogen dioxide
NOx	Oxides of nitrogen
NOAA	National Oceanic and Atmospheric Administration
O_3	Ozone
$PM_{2.5}$	Particulate matter with an aerodynamic diameter less than 2.5 microns
R^2	Coefficient of determination
RF	Random Forest statistical method
RMSE	Root mean square error
TCEQ	Texas Commission on Environmental Quality
TLMA	Tyler-Longview-Marshall-Athens
SVR	Support Vector Regression statistical method
$\mu g/m^3$	Micrograms per cubic meter
VSCC	Very Sharp Cut Cyclone

1.0 EXECUTIVE SUMMARY

The Texas Commission on Environmental Quality (TCEQ) is responsible for air quality planning in Texas to comply with the National Ambient Air Quality Standards (NAAQS) for several air pollutants, including particulate matter with an aerodynamic diameter less than 2.5 microns ($PM_{2.5}$). The Environmental Protection Agency (EPA) sets the forms and levels of the NAAQS for each pollutant. Primary standards protect public health, and secondary standards protect public welfare (e.g., visibility, damage to natural ecosystems and buildings). The $PM_{2.5}$ NAAQS are set for both long-term (annual average) and short-term (24-hour) concentrations. Under the Clean Air Act, the EPA is required to review the NAAQS periodically. On February 7, 2024, EPA lowered the annual primary $PM_{2.5}$ standard from 12 micrograms per cubic meter ($\mu g/m^3$) to 9 $\mu g/m^3$ effective from May 6, 2024. The daily $PM_{2.5}$ standard (35 $\mu g/m^3$) and secondary $PM_{2.5}$ standards did not change as part of this reconsideration. Compliance with the NAAQS is assessed at an individual monitor by comparing the monitor's Design Value to the NAAQS. The annual $PM_{2.5}$ Design Value is calculated as the 3-year average of annual arithmetic mean concentration. The 24-hour Design Value is calculated as the 3-year average of the annual 98^{th} percentile 24-hour average concentration.[1]

Failure to comply with the NAAQS can adversely affect public health and inhibit economic development. $PM_{2.5}$ air quality planning is important to ensure that the Tyler-Longview-Marshall-Athens (TLMA) area of Northeast Texas meets the $PM_{2.5}$ NAAQS. The Texas legislature provided funding to the TCEQ under Rider 7 to support local air quality planning. The East Texas Council of Governments (ETCOG) received a Rider 7 grant (TCEQ contract 582-24-01388) in Fiscal Years 2024 and 2025 and this document reports on how that funding was deployed. The report is structured in accordance with TCEQ's guidance as an Executive Summary followed by appendices that provide details for all activities.

1.1 Air Quality in the Tyler-Longview-Marshall Area

The TLMA area includes Gregg, Harrison, Henderson, Rusk, Smith, and Upshur counties. Figure 1-1 displays the TLMA area's major roadways, urban areas, and the TCEQ-operated continuous air monitoring system (CAMS) locations. Currently, the Karnack CAMS 85 monitor, located in northeastern Harrison County, is the only monitor that measures $PM_{2.5}$ and determines whether the area is in compliance with the $PM_{2.5}$ NAAQS. EPA reports annual Design Values at Karnack (CAMS 85) of 9.5 $\mu g/m^3$ for the 2021-2023 and 2022-2024 periods, which are above the 9.0 $\mu g/m^3$ annual standard.[2] Daily $PM_{2.5}$ Design Values at Karnack (CAMS 85) are not reported for these periods because of insufficient data in Q1 of 2022.

[1] EPA, Air Quality Deign Values. https://www.epa.gov/air-trends/air-quality-design-values. Accessed October 2025.

[2] EPA, $PM_{2.5}$ Design Values, 2023. https://www.epa.gov/system/files/documents/2024-08/pm25_designvalues_2021_2023_final_08_08_24_0.xlsx. Accessed October 2025.

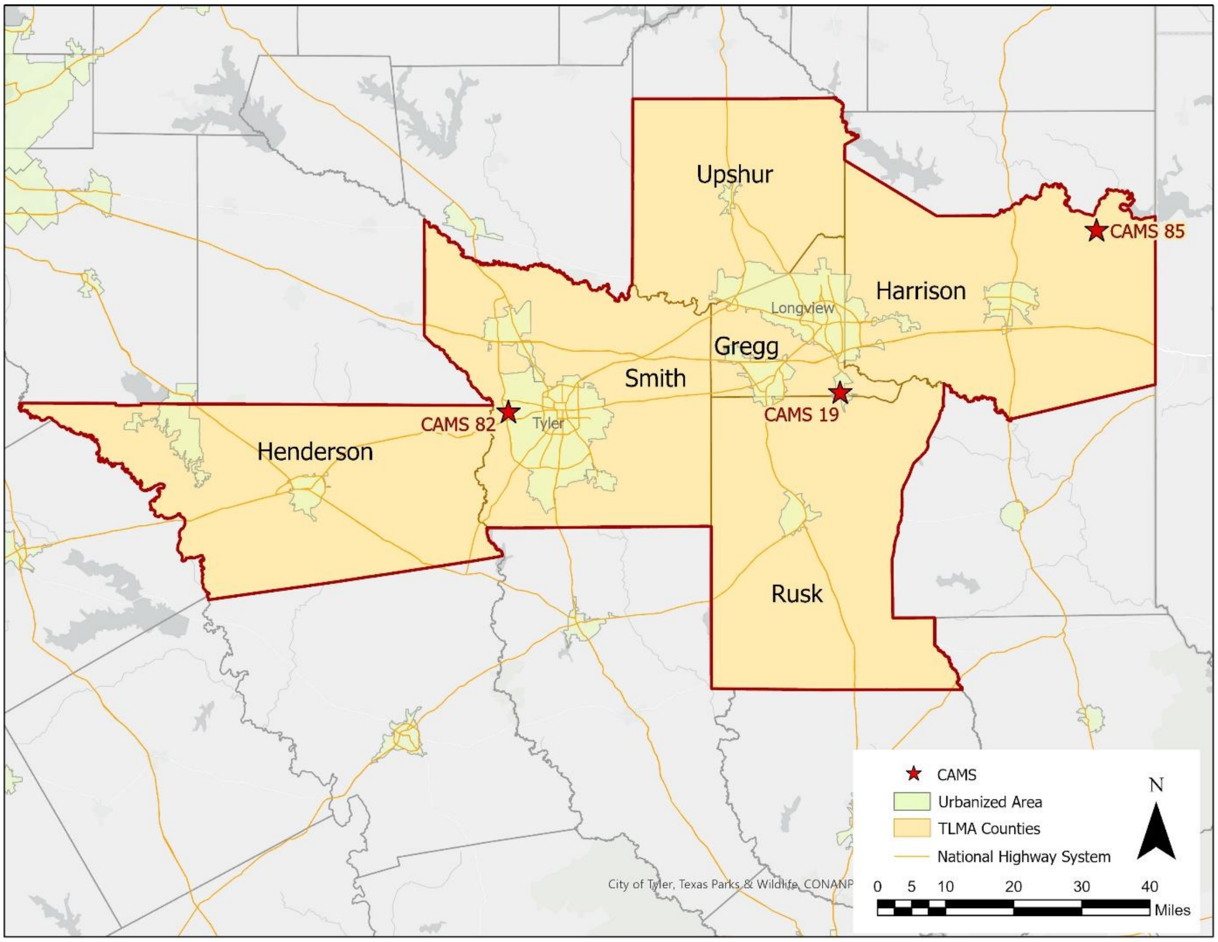

Figure 1-1. The six county TLMA area, location of CAMS monitors in the area with urban areas and major roadways in the surrounding region.

1.2 ETCOG Rider 7 Activities

The Rider 7 Grant allowed ETCOG to understand and improve $PM_{2.5}$ emission inventories and conduct ambient monitoring for the TLMA area, followed by data analysis and statistical modeling activities for the collected ambient $PM_{2.5}$ measurement data. Ambient monitoring for $PM_{2.5}$ complements the data collected by the TCEQ at CAMS in the TLMA area to help characterize $PM_{2.5}$ levels and trends more accurately. ETCOG undertook four projects that are outlined below and described in detail in appendices to this report.

1.2.1 PM2.5 Emission Inventory Review

ETCOG reviewed EPA's calendar year 2022 version 1 (2022v1) emissions modeling platform inventory for the TLMA area to identify sources of $PM_{2.5}$ emissions that are under- or over-estimated, accompanied by high levels of uncertainty, or for which more detailed emissions inventory input at the sub-county level could be provided. The review included a comprehensive analysis of all emission sources, including point sources, area sources, prescribed fires and agricultural burning, on-road and off-road sources, and biogenic emissions. This review provided recommendations to improve the accuracy of the TLMA area emission inventory, see Section 1.4.2.

1.2.2 $PM_{2.5}$ Monitoring

ETCOG deployed a Met One Instruments BAM-1022 beta-attenuation mass monitor for real-time particulate-matter measurements. The BAM-1022 is a U.S. EPA–designated Federal Equivalent Method (FEM) for both $PM_{2.5}$ and PM_{10} and determines aerosol mass by measuring how a collimated ^{14}C beta beam is attenuated as it passes through a glass-fiber filter tape before and after particles are deposited on the tape.[3] Ambient air is drawn through a size-selective inlet at a flow rate of 16.7 L/min, and particles are collected on a filter tape between a beta source and detector. The reduction in detected beta rays, caused by particle accumulation, is used to calculate PM mass. The instrument operates on an automatic hourly cycle: the tape advances to a new spot each hour, and air is sampled for one hour before the next advance. PM concentration is reported in $\mu g/m^3$ or mg/m^3, based on the measured mass and air volume. The instrument was configured with a PM_{10} head followed by a $PM_{2.5}$ Very Sharp Cut Cyclone (VSCC).

The location of the measurements was adjacent to TCEQ's Tyler Airport Relocated site (CAMS 82). Measurements took place from April 1st through September 4th, 2025, hereafter referred to as the "monitoring period".

1.2.3 Analyzing $PM_{2.5}$ Monitoring, Emissions, and Other Data

ETCOG analyzed $PM_{2.5}$ field measurements collected near Tyler (collocated with CAMS 82) and TCEQ data from Karnack (CAMS 85) to understand spatial and temporal variations in $PM_{2.5}$ concentrations across the TLMA area. ETCOG applied traditional data analysis methods to characterize pollution patterns, including time-series reviews, wind and pollution rose plots, and smoke impact screening. The data sources for this analysis included direct $PM_{2.5}$ measurements from the air monitoring at Tyler (collocated with CAMS 82), meteorological data from TCEQ for both sites, and satellite-based smoke maps from the National Oceanographic and Atmospheric Administration (NOAA).

1.2.4 Statistical Modeling of $PM_{2.5}$ Monitoring Data

Using $PM_{2.5}$ measurement data at the Tyler (collocated with CAMS 82) and Karnack (CAMS 85) monitoring sites, ETCOG conducted advanced statistical modeling to identify factors that uniquely influence the two sites. A comprehensive set of features was developed to capture temporal patterns, meteorological influences, and pollutant concentrations. Three advanced statistical modeling approaches were evaluated: Random Forest (RF), Support Vector Regression (SVR), and Long Short-Term Memory (LSTM) neural networks. Each model was trained using 80% of the data and evaluated independently using the remaining 20% of the data. The performance of each model was assessed using a set of metrics, including Root Mean Square Error (RMSE), Mean Absolute Error (MAE), coefficient of determination (R^2), bias, and correlation. Model performance was compared on both training and test datasets for each site. Feature importance analyses were also conducted to identify which variables most strongly influenced $PM_{2.5}$ predictions at each location.

1.3 Summary of Findings

1.3.1 $PM_{2.5}$ Emission Inventory Review

All emissions of $PM_{2.5}$ for the TLMA area in 2022 are shown in Figure 1-2 by major source category. ETCOG's review found that prescribed fires and agricultural burning are the dominant contributors, accounting for roughly half of all emissions, with prescribed burns alone representing 97% of this category. Area sources, such as open burning of residential waste and land clearing debris, fugitive dust from roads and agriculture, commercial cooking, and residential wood combustion, make up

[3] Met One Instruments, BAM 1022 Particulate Monitor Operation Manual. Available at: https://metone.com/wp-content/uploads/2020/02/BAM-1022-9805-Operation-Manual-Rev-C.pdf/. Accessed November 2025.

about 24% of emissions. Point sources, primarily industrial facilities and power plants, contribute 20%, with the Martin Lake Electrical Station alone responsible for over half of point source emissions. On-road and off-road mobile sources are minor contributors, each representing less than 2% of total anthropogenic $PM_{2.5}$ emissions. Overall, the inventory is considered generally accurate and complete in the context of current understanding. ETCOG did not find any emission source categories for which more detailed emissions inventory input at the sub-county level was readily available.

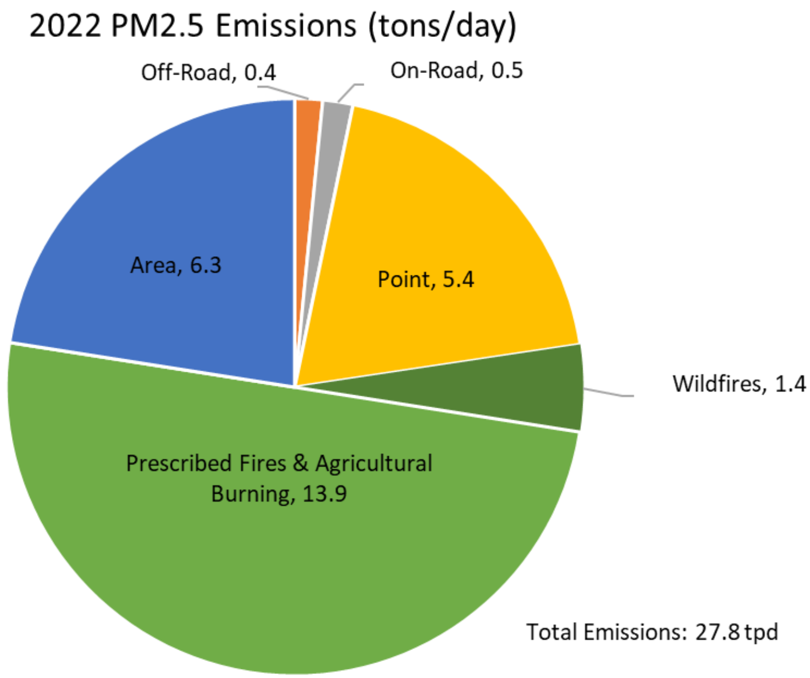

Figure 1-2. TLMA area 2022 $PM_{2.5}$ annual average daily emissions by source category (tons/day).

1.3.2 $PM_{2.5}$ Monitoring

ETCOG compiled the ambient $PM_{2.5}$ measurement data collected near Tyler (collocated with CAMS 82) and Karnack (CAMS 85) during the 2025 monitoring period. All 24-hour $PM_{2.5}$ values stayed below the primary and secondary NAAQS of 35 µg/m³. The highest recorded 24-hour $PM_{2.5}$ concentration was 21.6 µg/m³, and the average over the period was 10.2 µg/m³. Monthly averages ranged from 9.26 µg/m³ in June to 10.94 µg/m³ in September, though the September average was calculated from only four valid days before site decommissioning. Data completeness for 24-hour averages was 86%, exceeding the project target of 75%, despite some data loss in May and June caused by instrument downtime from rainwater ingestion and a power surge. The data recovery target was met for all months except for June, and for the monitoring period in its entirety. Routine site visits and maintenance ensured data quality, and significant events such as severe storms and power surges were documented and addressed.

1.3.3 Analyzing $PM_{2.5}$ Monitoring, Emissions, and Other Data

$PM_{2.5}$ levels at Tyler (collocated with CAMS 82) and Karnack (CAMS 85) reflect a combination of regional background concentrations, persistent southerly transport, episodic smoke intrusions, and local sources. Figure 1-3 presents a time series plot of 24-hour $PM_{2.5}$ concentrations at Tyler (collocated with CAMS 82) and Karnack (CAMS 85) over the monitoring period. Both sites remained well below the NAAQS. Most 24-hour averages at both sites were between 4 to 15 µg/m³, while occasional spikes reached the low 20 µg/m³ range. The two sites shared common peaks on May 15th and 17th as well as June 7th and 17th, which strongly suggest regional $PM_{2.5}$ events. Given the short monitoring period, no clear long-term trend is visible.

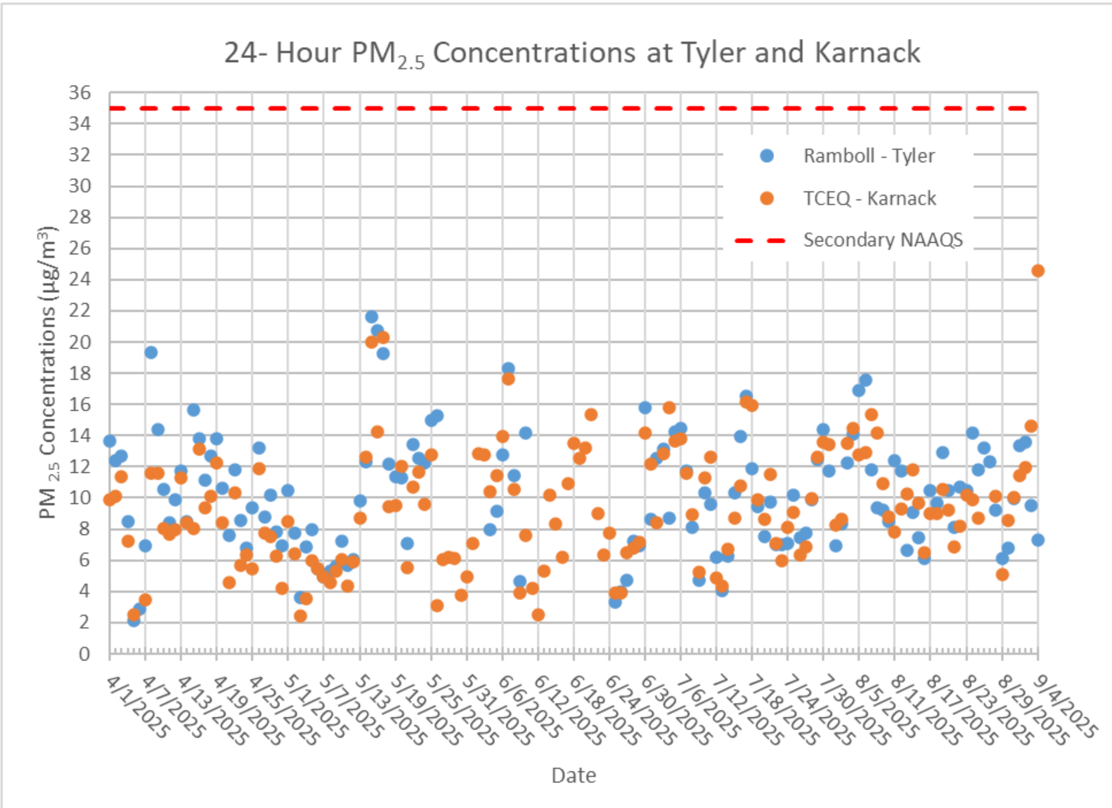

Figure 1-3. Tyler (collocated with CAMS 82) and Karnack (CAMS 85) 24-hour $PM_{2.5}$ Concentrations.

Despite being approximately 60 miles apart, the two monitors share four of their top-ten $PM_{2.5}$ days during the monitoring period and exhibit nearly identical average concentrations, indicating that regional $PM_{2.5}$ in the TLMA area is a dominant driver of air quality at both sites. Wind analyses suggested that at Tyler, peak concentrations occur under persistent southerly winds consistent with prevailing Gulf flow, with both smoke and non-smoke days showing patterns that match regional transport signatures. At Karnack, a dual wind regime is evident. Southerly flow follows the regional component observed at Tyler during smoke-impacted periods, while northerly winds on non-smoke days suggest an additional influence from other local and regional sources.

Although all measured 24-hour average $PM_{2.5}$ values were below the current 24-hour NAAQS, the recent annual design values of 9.5 µg/m³ at Karnack exceed the 9 µg/m³ annual standard. The monitoring duration at Tyler was insufficient to assess compliance with the 24-hour and annual standards. Because the Tyler measurement data spans only April 1 through September 4, 2025, and does not capture full-year variability, these measurements may not represent typical annual conditions. Therefore, continued $PM_{2.5}$ monitoring at Tyler is recommended to better characterize spatial and seasonal patterns within the TLMA region and to assess trends.

1.3.4 Statistical Modeling of $PM_{2.5}$ Monitoring Data

Among the models tested, RF consistently demonstrated the best performance on training data at both Tyler and Karnack, with the lowest prediction errors and highest correlation values. However, when evaluated on independent test data, all models exhibited limited ability to explain variance in observed $PM_{2.5}$ concentrations, particularly at Karnack, where episodic high-concentration events were not well captured. These findings highlight the complexity of local air quality dynamics and the challenges of generalizing model performance across different time periods and emission influences.

The analysis of grouped feature importance reveals that while both Karnack and Tyler share a common set of dominant factors influencing $PM_{2.5}$ levels, namely wind direction, wind speed, temperature, ozone (O_3), nitrogen oxide (NO), and nitrogen dioxide (NO_2), the relative importance of these factors differs between the two sites. At Karnack, temperature is particularly influential, with almost double the importance observed at Tyler. This suggests that atmospheric stability and/or temperature-driven chemical processes may play a more important role in $PM_{2.5}$ formation or accumulation at Karnack. At Tyler, NO_2 ranked as the second highest factor, indicating a stronger association between local nitrogen oxides (NOx) emissions and $PM_{2.5}$ levels. Additionally, wind direction is highly ranked for both sites. Analysis of pollution roses from Task 3.3 shows that both locations experience elevated $PM_{2.5}$ with southerly winds, while Karnack is also affected by northerly and westerly winds. This pattern suggests differences in regional pollutant transport or source influences between the sites. These findings warrant further investigation that will help refine the statistical models.

1.4 Recommendations

The TCEQ is providing new Rider 7 funding to ETCOG for Fiscal Years 2026 and 2027 and the scope of potential activities includes emission inventory improvements, ambient monitoring, and data and chemical transport modeling analyses. This section contains recommendations for activities that could be carried out in the 2026-2027 period.

1.4.1 Ambient Monitoring

Continued monitoring at the Tyler site is strongly recommended to develop a robust trendline and to enhance the understanding of $PM_{2.5}$ air quality sources and conditions. The data collected during the monitoring period demonstrated that $PM_{2.5}$ concentrations remained below regulatory thresholds but also revealed variability in monthly averages. Ongoing measurements will provide a basis for assessing longer-term $PM_{2.5}$ trends and spatial variations in local air quality patterns and likely source contributions.

1.4.2 $PM_{2.5}$ Emission Inventory

Below is a list of low priority recommendations for improvement of the 2022 emission inventory in the TLMA area.

- **Prescribed fires and agricultural burning:** Consider updates based on TCEQ evaluation of available fire emission inventories via air quality modeling.
- **Area Sources:** Consider refinements to specific area source emission inputs to refine TLMA area emissions based on local data:
  - **Open burning, residential household waste**: Consider implementing state or local estimates for waste generation per capita and the fraction of the rural population that burns their waste, if not already incorporated into TCEQ's emission

estimation approach; ensure that residential household waste emissions in Gregg County are not inadvertently omitted

- **Open burning, land clearing debris**: Consider leveraging county-level burn data, if available
- **Fugitive dust, paved roads**: Consider developing local inputs for silt loading, average vehicle weight by roadway type, and controls application (if any) if not already incorporated into TCEQ's emission estimation approach
- **Fugitive dust, unpaved roads**: Consider developing local inputs for unpaved roadway VMT, surface material silt content, surface moisture content, and control application (if any) if not already incorporated into TCEQ's emission estimation approach
- **Fugitive dust, agricultural tilling**: Consider implementing recent TLMA area crop acreage information, as available
- **Fugitive dust, agricultural livestock**: Consider implementing recent TLMA area livestock counts, as available
- **Commercial cooking**: Ensure that deep fat frying emissions are included in the emission inventory

APPENDIX A

Quarterly Progress Reports

December 20, 2024

Quarterly Progress Report

To: Bridget Booty
East Texas Council of Governments
From: Greg Yarwood and Jeremiah Johnson
Subject: PM2.5 Local Air Quality Planning 2024-2025

Period: September 2024 through November 2024

ETCOG is participating in the State of Texas' Rider 7 PM2.5 Air Quality Planning Program that is administered by the Texas Commission on Environmental Quality (TCEQ). Ramboll is assisting ETCOG by performing the following four technical activities called for in the FY24/25 Statement of Work for TCEQ grant number 582-24-01388:

Subtask 3.1: Review PM2.5 Emission Inventories for TLMA
Subtask 3.2: PM2.5 Monitoring
Subtask 3.3: Analyzing PM2.5 Monitoring, Emissions and Other Data
Subtask 3.4: Modeling PM2.5 Monitoring Data

During the period of September through November 2024, Ramboll performed the following work:

- Following approval of Scope of Work and receipt of Notice to Commence on October 7, Ramboll developed draft quality assurance project plans (QAPPs) for all Subtasks on November 6
- Ramboll revised the QAPPs for Subtasks 3.2, 3.3 and 3.4 in response to comments from the TCEQ
- QAPPs for all Subtasks were approved by December 9, 2024.

<u>Deliverables during this reporting period</u>

Deliverable 2.2: QAPPs for all Subtasks.

March 27, 2025

Quarterly Progress Report

To: Bridget Booty
East Texas Council of Governments
From: Greg Yarwood and Jeremiah Johnson
Subject: PM2.5 Local Air Quality Planning 2024-2025

Period: December 2024 through February 2025

ETCOG is participating in the State of Texas' Rider 7 PM2.5 Air Quality Planning Program that is administered by the Texas Commission on Environmental Quality (TCEQ). Ramboll is assisting ETCOG by performing the following four technical activities called for in the FY24/25 Statement of Work for TCEQ grant number 582-24-01388:

Subtask 3.1: Review PM2.5 Emission Inventories for TLMA
Subtask 3.2: PM2.5 Monitoring
Subtask 3.3: Analyzing PM2.5 Monitoring, Emissions and Other Data
Subtask 3.4: Modeling PM2.5 Monitoring Data

During the period of December 2024 through February 2025, Ramboll performed the following work:

- QAPPs for all Subtasks were approved by December 9, 2024
- For Subtask 3.1, reviewed available EPA and TCEQ PM2.5 emission inventories and confirmed that ETCOG will focus on review of the EPA's 2022 emission inventory as TCEQ's 2022 emission inventory will not be ready in time for use.
- For Subtask 3.1, completed review of the Tyler-Marshall-Longview-Athens (TLMA) region 2022 PM2.5 emission inventory from EPA's Modeling Platform.
- For Subtask 3.1, completed the emission inventory review technical report (deliverable 3.1) and submitted to the TCEQ on February 27, 2025.
- For Subtask 3.2, began planning for deployment of a $PM_{2.5}$ monitor adjacent to TCEQ's CAMS 82 Tyler monitoring site.

<u>Deliverables during this reporting period</u>

Deliverable 3.1: Draft Report: Review of PM2.5 Emission Inventory for Northeast Texas

September 25, 2025

Quarterly Progress Report

To: Rebecca Gage
East Texas Council of Governments
From: Greg Yarwood and Jeremiah Johnson
Subject: PM2.5 Local Air Quality Planning 2024-2025

Period: June through August 2025

ETCOG is participating in the State of Texas' Rider 7 PM2.5 Air Quality Planning Program that is administered by the Texas Commission on Environmental Quality (TCEQ). Ramboll is assisting ETCOG by performing the following four technical activities called for in the FY24/25 Statement of Work for TCEQ grant number 582-24-01388:

Subtask 3.1: Review PM2.5 Emission Inventories for TLMA
Subtask 3.2: PM2.5 Monitoring
Subtask 3.3: Analyzing PM2.5 Monitoring, Emissions and Other Data
Subtask 3.4: Modeling PM2.5 Monitoring Data

During the period of June through August 2025, Ramboll performed the following work:

- For Subtask 3.1, received comments on Draft Final Report, prepared responses and delivered initial version of Final Report incorporating responses to comments
- For Subtask 3.2, continued collecting $PM_{2.5}$ measurements adjacent to TCEQ's CAMS 82 Tyler monitoring site.
- For Subtask 3.2, discovered and addressed several instrumentation issues related to weather-related damage sustained in May 2025 that disrupted data collection and required urgent repairs. Multiple offsite repairs performed and key hardware components replaced to restore functionality and minimize data loss.

Deliverables during this reporting period

Deliverable 3.1: Final Report: Review of PM2.5 Emission Inventory for Northeast Texas delivered on August 14

December 20, 2024

Quarterly Progress Report

To: Bridget Booty
East Texas Council of Governments
From: Greg Yarwood and Jeremiah Johnson
Subject: PM2.5 Local Air Quality Planning 2024-2025

Period: September 2024 through November 2024

ETCOG is participating in the State of Texas' Rider 7 PM2.5 Air Quality Planning Program that is administered by the Texas Commission on Environmental Quality (TCEQ). Ramboll is assisting ETCOG by performing the following four technical activities called for in the FY24/25 Statement of Work for TCEQ grant number 582-24-01388:

Subtask 3.1: Review PM2.5 Emission Inventories for TLMA
Subtask 3.2: PM2.5 Monitoring
Subtask 3.3: Analyzing PM2.5 Monitoring, Emissions and Other Data
Subtask 3.4: Modeling PM2.5 Monitoring Data

During the period of September through November 2024, Ramboll performed the following work:

- Following approval of Scope of Work and receipt of Notice to Commence on October 7, Ramboll developed draft quality assurance project plans (QAPPs) for all Subtasks on November 6
- Ramboll revised the QAPPs for Subtasks 3.2, 3.3 and 3.4 in response to comments from the TCEQ
- QAPPs for all Subtasks were approved by December 9, 2024.

Deliverables during this reporting period

Deliverable 2.2: QAPPs for all Subtasks.

APPENDIX B

Statement of Work

East Texas Council of Governments

Rider 7 – PM2.5 Air Quality Statement of Work

Contract (Grant) Number 582-24-01388

Revison1

Proposal for Grant Activities Amount: $ 160,429.00

GRANT NUMBER AND NAME

East Texas Council of Governments (ETCOG) Rider 7 PM2.5 Local Air Quality Planning Grant

ETCOG PROJECT MANAGER

ETCOG - Project Manager
Name: Rebecca Gage
Organization: East Texas Council of Governments
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Phone: 903-218-6499
Fax: 903-218-6499
E-mail: Rebecca.Gage@etcog.org

Alternate personnel in the event the project manager is unavailable to perform assigned tasks:

Name: Lisa Smith
Organization: East Texas Council of Governments
Department: Workforce and Economic Development
Address: 3800 Stone Rd.
City State Zip: Kilgore, TX, 75662
Phone: 903-218-6467
Fax: 903-218-6467
E-mail: lisa.smith@etcog.org

PERSONNEL ELIGIBILITY LIST

A Personnel Eligibility List (PEL) is included in this Work Plan as Attachment B.

SUBGRANTEES TO BE USED UNDER THIS CONTRACT

Ramboll Americas Engineering Solutions

QUALITY ASSURANCE/QUALITY CONTROL PROCEDURES

A Level IV Quality Assurance Project Plan (QAPP) will be prepared for the following subtasks:

- Subtask 3.1 Review TCEQ and EPA PM2.5 Emission Inventories for the TLMA
- Subtask 3.2 Monitoring PM2.5
- Subtask 3.3 Analyzing PM2.5 Monitoring, Emissions, and Other Data
- Subtask 3.4 Modeling PM2.5 Monitoring Data

Technical activities on these Subtasks will not commence until the QAPP is developed and accepted by the TCEQ.

TIMELINE

The schedule for the project is shown below, including project milestones and the work breakdown structure.

Table 1. Project milestones and the work breakdown structure.

Deliverable	**Deliverable Date**
Project Management (Task 1) **Deliverable 1.1:** QPRs **Deliverable 1.2:** FSRs/Invoices **Deliverable 1.3:** Contract Communication	**1.1** Quarterly by the 30th of December, March, June, & September. **1.2** Quarterly by the 30th of December, March, June, & September. **1.3** As needed
Statement of Work & QAPP (Task 2) **Deliverable 2.1:** TCEQ approved Statement of Work **Deliverable 2.2:** TCEQ approved QAPP	**2.1** Within thirty (30) calendar days after Contract is executed by the TCEQ **2.2** Within thirty (30) calendar days after Deliverable 2.1 is approved by the TCEQ
Inventorying PM2.5 Emissions, PM2.5 Monitoring, Analyzing PM2.5 Monitoring, and Modeling of PM2.5 Monitoring Data (Task 3)	

Deliverable	Deliverable Date
Deliverable 3.1: Review TCEQ and EPA PM2.5 Emission Inventories for the TLMA • Technical Report (3.1) **Deliverable 3.2:** Monitoring PM2.5 • Technical Report (3.2.1) • Monitoring Data (3.2.2) **Deliverable 3.3:** Analyzing PM2.5 Monitoring, Emissions, and Other Data • Technical Report (3.3) **Deliverable 3.4:** Modeling PM2.5 Monitoring Data • Technical Report (3.4)	**3.1** October 31, 2025 **3.2.1** October 31, 2025 **3.2.2** October 31, 2025 **3.3** October 31, 2025 **3.4** October 31, 2025
Draft and Final Reports and Project Management (Task 4) **Deliverable 4.1:** Draft Reports **Deliverable 4.2:** Final Reports	**4.1:** See deliverable dates for Task 3 draft reports shown above. The Task 4 overall draft report will be submitted by December 1, 2025 **4.2:** All final reports will be completed 1 month after receipt of TCEQ comments on the draft report and no later than December 31, 2025

BUDGET

The budget breakdown by task is shown below. Technical tasks will be directed by Ramboll under subcontract to ETCOG.

Task	Task Budget	ETCOG	Ramboll
1 – Project Management	$16,042.90	$16,042.90	
2 – Statement of Work	$3,000		$3,000
3.1 – Review TCEQ and EPA PM2.5 Emission Inventories	$22,339.00		$22,339.00
3.2 - Monitoring PM2.5	$69,733.10		$69,733.10
3.3 - Analyzing PM2.5 Monitoring, Emissions, and Other Data	$20,338.00		$20,338.00
3.4 - Modeling PM2.5 Monitoring Data	$22,040.00		$22,040.00
4 – Final Reporting and Project Management	$6,936.00		$6,936.00
Total	**$160,429.00**	**$16,042.90**	**$144,386.10**

The Cost Budget form for the Contract is shown below.

Budget Category	Total Cost for Work to be Performed	Portion that is Administrative Costs
Salary/Wages	$6,966.18	100%
Fringe Benefits	$3,875.46	100%
Travel	$0	0%
Supplies	$0	0%
Equipment	$0	0%
Contractual	$144,386.10	0%
Construction	$0	N/A
Other [(a)]	$2,881.73	100%
Indirect Costs	$2,319.53	100%
Total	**$160,429.00**	**10%**

[(a)] ETCOG's "Other" costs are made up of Direct three budget line items. They are direct costs billed to our grants monthly for our share of space cost in the building, our share of Human Resource cost and our share of Information Technology cost.

ETCOG's indirect reimbursable cost rate of 21.90% is negotiated with the Texas Workforce Commission and is calculated as a percentage of salary and fringe benefits. The indirect costs calculation combines the updated 21.90% rate from Amendment 4 with the previous 21.35% rate from Amendment 3. The same information is shown below in the format of the contract between the TCEQ and ETCOG.

Indirect Cost Reimbursable Rate. The reimbursable rate for this Contract is 21.90% of (check one):

- ■ salary and fringe benefits
- ☐ modified total direct costs
- ☐ other direct costs base

If other direct cost base, identify:

This rate is less than or equal to (check one):

- ■ Predetermined Rate—an audited rate that is not subject to adjustment.
- ☐ Negotiated Predetermined Rate—an experienced-based predetermined rate agreed to by Performing Party and TCEQ. This rate is not subject to adjustment.
- ☐ Default rate—a standard rate of ten percent of salary/wages may be used in lieu of determining the actual indirect costs of the service.

TECHNICAL APPROACH/METHOD

Below are technical descriptions of the tasks and deliverables and the dates that deliverables will be provided to the TCEQ by ETCOG.

Task 1 - Project Management

ETCOG will provide technical and fiscal oversight of the project to ensure all activities and deliverables are acceptable, completed as scheduled and within budget, including ensuring that no more than 10% of costs are spent on administrative expenses. Project management will be documented and provided to the TCEQ Project Manager through a Quarterly Progress Report (QPR) and quarterly Financial Status Reports (FSR).

Subtask 1.1 QPR: ETCOG will electronically submit QPRs to the TCEQ Project Manager via email. QPRs will document all activities performed, the status of each relevant deliverable, and the costs incurred that quarter. ETCOG will submit QPRs by the 30th of December, March, June and September, aligning with the state fiscal quarters. The Final Report deliverable will serve as the final QPR.

Subtask 1.2 FSR: The Performing Party will submit FSRs to the TCEQ Contract Manager in accordance with the Special Terms and Conditions.

Subtask 1.3 Contract Communication: ETCOG's Project Manager, or a knowledgeable designee, must be available for questions from the TCEQ Project Manager at all reasonable times during the performance of work under this Contract, and for at least one month after the Contract has been completed.

ETCOG will maintain regular telephone and/or email communication with the TCEQ Project Manager regarding the status and progress of the project and on any matters that require attention between QPRs. Matters that will be communicated to the TCEQ Project Manager include, but are not limited to:

- Notification a minimum of 30 days before the ETCOG has scheduled public meetings or events, or other major Task activities or developments.

- Notification within 15 days regarding events or circumstances that may require changes to the Budget, Statement of Work, or Schedule of Deliverables.

ETCOG will participate as needed in meetings between the TCEQ, U.S. EPA Region 6, and possibly interested stakeholders either in person or via telephone, internet conference, etc.

Cost: $16,042.90

Task 2 – Statement of Work

Subtask 2.1 Statement of Work: ETCOG will submit and obtain approval of a Statement of Work (this document) detailing the use of Rider 7 funds for inventorying emissions and/or monitoring pollution levels before expending the funds.

Deliverables for Subtask 2.1: Statement of Work (this document)

Deliverable Date: Within thirty (30) calendar days after Contract is executed by the TCEQ

Cost: $3,000.00

Subtask 2.2 Quality Assurance/Quality Control (QA/QC) Procedures: ETCOG will draft and follow QAPPs for Subtasks 3.1 through 3.4. The QAPPs will address the quality assurance process that ETCOG will undertake to ensure the adherence of data or other products to established criteria. The QAPPs will address the technical activities detailed in Subtasks 3.1 through 3.4 following the EPA's Guidance for Quality Assurance Project Plans, EPA QA/G-5. The QAPPs will be provided to the TCEQ for review and technical activities on Subtasks 3.1 through 3.4 will not commence until the TCEQ has approved the QAPPs.

Deliverables for Subtask 2.2: Level IV QAPP for Subtasks 3.1, 3.2, 3.3 and 3.4

Deliverable Date: Within thirty (30) calendar days after Deliverable 2.1 is approved by the TCEQ.

Cost: Cost of QAPP preparation is included in the budgets for Subtasks 3.1, 3.2, 3.3 and 3.4

Task 3 - Inventorying PM2.5 Emissions, PM2.5 Monitoring, Analyzing PM2.5 Monitoring, and Modeling of PM2.5 Monitoring Data

Subtask 3.1 Review TCEQ and EPA PM2.5 Emission Inventories for the TLMA: Emissions inventories (EIs) are used to assess the nature of an area's PM2.5 problem and support the Texas SIP by helping answer questions such as: (1) what PM2.5 emission sources are present in the area and how large are their emissions; and (2) which types of emissions sources are good candidates for emissions controls that would reduce the area's PM2.5 levels, if necessary. The TCEQ prepares emission inventories for the entire State of Texas for use in air quality planning. The EPA prepares a National EI (NEI) by combining information provided by States with emission estimates developed by EPA. ETCOG will review the most recently available PM2.5 EIs from the TCEQ and EPA for the six county TLMA area. This is important to ETCOG because these EIs will be used by the TCEQ, EPA and others to assess the contributions of TLMA area PM2.5 emissions to pollution levels within the region and downwind. This activity will benefit the Texas SIP by improving the quality of the TLMA area EI.

ETCOG will obtain the most recent TCEQ (if available) and EPA PM2.5 EIs for Gregg, Harrison, Henderson, Rusk, Smith and Upshur counties. The most recent emissions data available from EPA is the 2022 Emissions Modeling Platform version 1 which is based on the 2020 NEI with adjustments to account for changes from 2020 to 2022 and compensates for effects of the pandemic in 2020 which made emissions unusual and un-representative. Similarly, the TCEQ is in the process of developing a 2022 modeling platform but hasn't yet released the associated EI. We will contact both the TCEQ and EPA to understand their schedules for releasing updated EIs so that we can analyze the most up-to-date information that will be available by fall 2024 and deliver a technical report in February 2025.

ETCOG will focus the review on EPA's 2022 modeling platform and will compare EPA's 2022 point source EI to TCEQ's 2022 point source EI, if available. We will analyze the

TCEQ and EPA PM2.5 EIs for the TLMA area in detail by county and source sector to develop tabular and graphical emission summaries (examples are shown below under related experience). We will compare emissions between counties, accounting for differences such as population, to assess whether the EIs are consistent with the levels of activity expected for each county. We will identify the largest point source PM2.5 emitters in each county and evaluate whether the reported emissions are consistent with 2022 activity levels (e.g., considering recent power plant closures). We will prepare a map of the TLMA area showing the locations of point sources with larger PM2.5 emissions. We will develop a technical report summarizing the EI analysis and providing recommendations for potential EI improvements.

Deliverables for Subtask 3.1:

- Level IV QAPP submitted for approval by the TCEQ prior to the initiation of technical work.
- Draft and final technical reports. Review of TCEQ and EPA PM2.5 Emission Inventories for the TLMA report will be delivered to the TCEQ Project Manager in Microsoft Office Word and Adobe Acrobat Reader (*.pdf) format.

Deliverable Date: Draft report will be submitted by February 28, 2025. Final report will be delivered within 1 month of receipt of TCEQ comments on the draft report and no later than October 31, 2025. QAPP deliverable date is shown under Subtask 2.2.

Cost: $ 22,339.00

Subtask 3.2 Monitoring PM2.5

TCEQ PM2.5 monitoring data are available for a single location in the TLMA area, CAMS 85 near Karnack. The purpose of this subtask is to collect PM2.5 monitoring data at one additional location to provide additional PM2.5 data in the TLMA area and allow important questions to be answered:

- How representative of the TLMA area are the PM2.5 data collected at CAMS 85?
- How important are local PM2.5 emission sources to PM2.5 concentrations in the TLMA area?
- How important is PM2.5 transport from sources outside the TLMA area?

ETCOG will measure PM2.5 adjacent to Tyler CAMS 82 from April to August 2025 using a Met One Instruments BAM 1022 PM2.5 monitor. This location and time-period are selected to be within another ETCOG monitoring project (NO2 monitoring) which will provide infrastructure to support PM2.5 monitoring. This activity will benefit the Texas SIP by providing data that can be analyzed in activities (3) and (4) to understand how TLMA area and regional PM2.5 sources contribute to pollution within the TLMA area.

In late May 2025, the PM2.5 monitor at the Tyler airport sustained weather-related damage that disrupted data collection and required urgent repairs. To restore functionality and minimize data loss, multiple site visits were made, offsite repairs were performed, and key hardware components were replaced. These unanticipated efforts led to additional costs which are reflected in the updated project budget for this task. Site visit logs and equipment repairs will be documented in the technical report.

ETCOG will submit a Level IV QAPP for approval by the TCEQ prior to the initiation of technical work. During the PM2.5 monitoring, ETCOG will regularly check the data acquisition to identify any data outages that require intervention. ETCOG will submit a technical report summarizing the PM2.5 monitoring data collection and results by the end of September 2025. ETCOG will provide the PM2.5 monitoring data collected in electronic format agreeable to the TCEQ.

Deliverables for Subtask 3.2:

- Level IV QAPP for approval by the TCEQ prior to the initiation of technical work
- Draft and final technical reports summarizing the PM2.5 monitoring data collection and results
- PM2.5 monitoring data collected in electronic format agreeable to the TCEQ

Draft and final technical reports will be delivered to the TCEQ Project Manager in Microsoft Office Word and Adobe Acrobat Reader (*.pdf) format.

Deliverable Dates: Draft report for deliverable 3.2 will be submitted by October 31, 2025 with Final report delivered within 1 month of receipt of TCEQ comments on the draft report and no later than December 1, 2025. QAPP deliverable date is shown under Subtask 2.2.

Cost: $ 69,733.10

Subtask 3.3 Analyzing PM2.5 Monitoring, Emissions, and Other Data:
This subtask will analyze the PM2.5 monitoring data collected in Subtask 3.2 to understand variations in PM2.5 concentrations across the TLMA area. Locations with higher PM2.5 concentrations may indicate influences from nearby PM2.5 sources. By contrast, measuring consistent PM2.5 levels across the entire region may indicate that PM2.5 levels are dominated by emissions from widespread emissions sources, e.g., traffic, and/or pollution transport from upwind areas. A specific focus of the analysis will be to investigate whether smoke from large fires caused elevated PM2.5 levels in the TLMA area during the monitoring conducted for Subtask 3.2.

ETCOG will analyze the PM2.5 monitoring data collected by Subtask 3.2 together with TCEQ monitoring data, meteorological data, satellite data for wildfire smoke, and other relevant data. We will characterize the spatial and temporal patterns of PM2.5 pollution in the TLMA area to draw conclusions about the likely influences of local and regional sources of PM2.5 pollution. This activity will benefit the Texas SIP by better understanding the influences of local and regional sources of PM2.5 pollution in the TLMA area.

ETCOG will begin with the following analyses and follow up with additional analyses depending upon what the data show:

- Maps comparing average PM2.5 at the ETCOG PM2.5 monitor location (from Subtask 3.2) and the TCEQ PM2.5 monitor at CAMS 85 to investigate spatial patterns across the TLMA area.
- Time-series of 24-hour average PM2.5 at both PM2.5 monitor locations to investigate temporal correlation between PM2.5 monitors and identify time-periods with high PM2.5 across the region or at an individual monitor.

- Table of the top 10 PM2.5 readings and occurrence date at both locations.
- If either PM2.5 monitoring location records PM2.5 levels substantially higher the TLMA area average, prepare a map showing the locations of nearby PM2.5 point sources and major roads together with a wind-rose showing the prevalence of different wind directions.

Wildfires and agricultural burning create smoke plumes that can elevate PM2.5 concentrations across large downwind areas. Understanding whether fire smoke contributes substantially to PM2.5 levels in the TLMA area is important for evaluating the extent to which reducing local emissions would be effective for improving air quality. For dates when elevated PM2.5 levels occurred across the TLMA area, ETCOG will perform an analysis that combines data from multiple sources including satellites to assess the potential contribution of fire smoke. An example analysis is shown below for May 26, 2024.

In Figure 2, we present a map showing 24-hour average PM2.5 concentrations at monitoring stations along with National Oceanic and Atmospheric Administration (NOAA) Hazard Mapping System (HMS) smoke areas (grey overlays) and fire locations detected by satellites (red triangles) for May 26, 2024, using a tool developed under an EPA grant. The red triangles show numerous agricultural fires burning in Mexico and Central America that commonly occur during spring. The NOAA HMS smoke product indicates that smoke from these fires travelled northward into East Texas and surrounding states. The red indicator flag highlights Karnack CAMS 85, which registered 24-hour average PM2.5 of 27.5 $\mu g\ m^{-3}$ (TCEQ has not fully validated these measurements at CAMS 85).

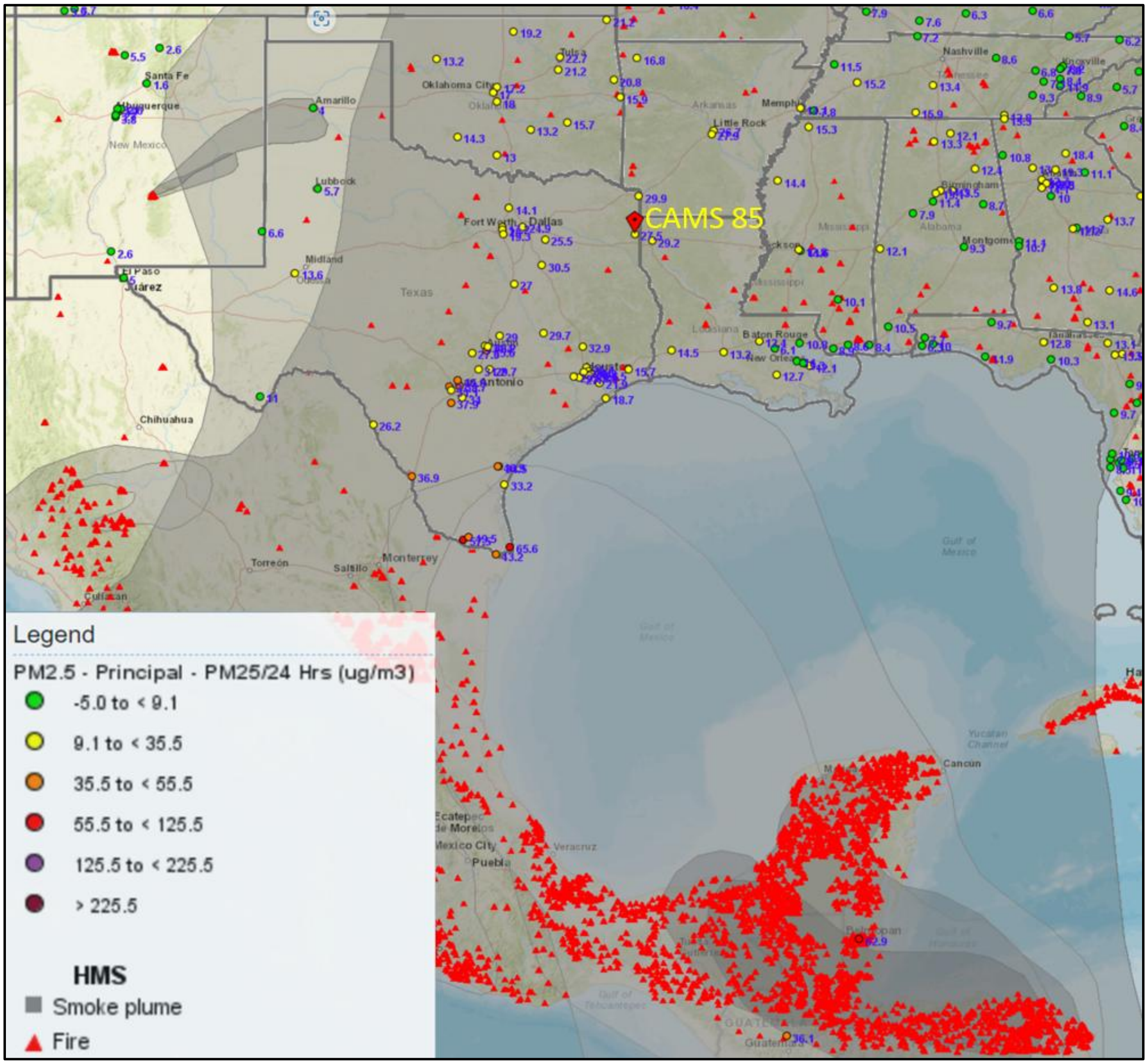

Figure 2. **Map showing 24-hour average PM2.5 measurements (colored circles), fire detections (red triangles), and NOAA HMS smoke areas (grey shading) on May 26, 2024. Smoke from Central American fires was present over Karnack where CAMS 85 recorded 24-hour average PM2.5 of 27.5 µg m^{-3}.**

Deliverables for Subtask 3.3:

- Level IV QAPP for approval by the TCEQ prior to the initiation of technical work
- Draft and final technical reports summarizing the analysis of PM2.5 monitoring data and providing recommendations

Draft and final technical reports will be delivered to the TCEQ Project Manager in Microsoft Office Word and Adobe Acrobat Reader (*.pdf) format.

Deliverable Dates: Draft report for deliverable 3.3 will be submitted by Octboer 31, 2025 with Final report delivered within 1 month of receipt of TCEQ comments on the draft report and no later than December 1, 2025. QAPP deliverable date is shown under Subtask 2.2.

Cost: $ 20,338.00

Subtask 3.4 Modeling PM2.5 Monitoring Data
This subtask will identify any important contributions of local emission sources to PM2.5 levels at the monitor described in Subtask 3.2 and the PM2.5 monitor at CAMS 85. Machine learning (ML) models can complement the data analysis conducted in Subtask 3.3 because they excel at analyzing large datasets such as hourly PM2.5 measurements at multiple locations over a one-year period. The objective of this Subtask is to identify factors that uniquely influence both locations, such as being downwind from a major PM2.5 emission source or a city. This activity will benefit the Texas SIP by providing insight to local influence on PM2.5 pollution in the TLMA area.

As part of the data analysis in Subtask 3.3, ETCOG will compile a dataset that includes hourly averaged PM2.5 measurements at both PM2.5 monitor locations together with meteorological data (wind speed, direction and temperature). Since the objective is to identify what makes each location unique, we will train a ML model for each location to predict how PM2.5 at that location differs from the average PM2.5, taking into consideration the meteorological factors and time of day, day of week and month of year. If Subtask 3.3 finds that smoke contributed to PM2.5, we will use the HMS smoke product (discussed in Subtask 3.3) to identify dates when smoke was present as input to the ML models. Based on past experience, we will test two different types of ML model, known as "random forest" and "support vector regression" models, and select the best performing model type. Model performance is assessed by cross-validation during model training and by withholding a portion of data from the training to use for independent model evaluation. We will use a ML tool known as "feature importance" to determine what factors are most important to PM2.5 levels at each location. For example, finding that rush hour periods are important would indicate that the location is influenced by traffic emissions. Finding that a particular wind direction is important may indicate importance of a local source(s). ETCOG will submit a technical report summarizing the modeling of PM2.5 monitoring data and recommendations by the end of October 2025.

Deliverables for Subtask 3.4:

- Level IV QAPP for approval by the TCEQ prior to the initiation technical work
- Draft and final technical reports summarizing the ML modeling of PM2.5 monitoring data and recommendations

Draft and final technical reports will be delivered to the TCEQ Project Manager in Microsoft Office Word and Adobe Acrobat Reader (*.pdf) format.

Deliverable Dates: Draft report for deliverable 3.4 will be submitted by October 31, 2025 with Final report delivered within 1 month of receipt of TCEQ comments on the draft report and no later than December 1, 2025. QAPP deliverable date is shown under Subtask 2.2.

Cost: $ 22,040.00

Task 4 – Draft and Final Reports and Project Management
ETCOG will analyze the results of all projects and work funded under Task 3. For each Subtask, ETCOG will submit a report to the TCEQ that documents data and findings. In addition, ETCOG will submit an overall report under Task 4 that summarizes all work performed for this Rider 7 grant.

Subtask 4.1 Draft Reports: For each Subtask, ETCOG will provide a Draft Report to the TCEQ Project Manager electronically (i.e., via e-mail) in Microsoft Word and pdf format. The draft report for each Subtask will include the following components:

1. An executive summary or abstract;
2. A detailed description of all work carried out under the Subtask;
3. A detailed discussion of the analyses and findings;
4. A discussion of the pertinent accomplishments, shortfalls, and limitations; and
5. All data and analyses and an evaluation of those results.

Subtask 4.2 Final Reports: ETCOG will address any comments received from TCEQ on the Draft Final Reports on all Subtasks and then provide a Final Report to the TCEQ Project Manager for each Subtask electronically (i.e., via e-mail) in Microsoft Word and pdf format.

Subtask 4.3 Other Electronic Data: ETCOG will retain the materials for 3 years after the project end date. For Subtasks 3.1 through 3.4, ETCOG will provide via FTP all supporting materials including data, scientific literature (citations, not actual articles), analysis results, and other relevant materials that substantiate the conclusions reached in the Final Report for that Subtask. In particular, ETCOG will provide electronically the PM2.5 monitoring data collected under Subtask 3.2 in a format agreeable to TCEQ.

Deliverable Date: Deliverable dates for technical reports are noted under each technical subtask.

Cost: $ 6,936.00

MODELS AND SOFTWARE TO BE USED BY ETCOG

Machine learning models implemented via the scikit-learn Python package.

MISCELLANEOUS INFORMATION OR ELEMENTS

The services, fees and scheduling are subject to circumstances or conditions which may pose a material risk to the health or safety of ETCOG and its subcontractors.

SIGNATURE BY PERFORMING PARTY

East Texas Council of Governments

By: ______________________________

(Authorized Signature)

(Printed Name)

(Title)

(Date)

Attachment B:
Personnel Eligibility List

ETCOG – Grant #582-24-01388 July 29, 2024

Participant		
ETCOG		
Bridget Booty	ETCOG Project Manager. Provide technical and fiscal oversight of the project to ensure all activities and deliverables are acceptable, completed as scheduled and within budget. Carries out QPR and FPRs.	July 29, 2024
Lisa Smith	ETCOG alternate contact. Available in the event that Bridget Booty is unavailable to perform assigned tasks	July 29, 2024
Ramboll		
Greg Yarwood	Principal; Contract oversight, project manager, documentation, QA/QC review.	July 29, 2024
Ralph Morris	Principal; Technical oversight, documentation, QA/QC review.	July 29, 2024
Chris Emery	Principal; Project manager, technical oversight, documentation, QA/QC review.	July 29, 2024
Till Stoeckenius	Senior Managing Consultant; Project manager, technical oversight, documentation, QA/QC review.	July 29, 2024
Jeremiah Johnson	Analysis of PM2.5 Data and Emissions task leader; Senior Managing Consultant; Project manager, technical oversight, documentation, QA/QC review.	July 29, 2024
John Grant	Inventorying PM2.5 Emissions task leader; Senior Managing Consultant; Project manager, technical oversight, documentation, QA/QC review.	July 29, 2024
J.B. Dennison	Monitoring PM2.5 Pollution task leader; Senior Managing Consultant; Project manager, technical oversight, documentation, QA/QC review.	July 29, 2024
Fiona Jiang	Modeling PM2.5 Pollution task leader; Project Manager; technical oversight, documentation, QA/QC review.	July 29, 2024
Marco Antonio Rodriguez	Managing Consultant; Project manager, technical oversight, documentation, QA/QC review.	July 29, 2024
Tejas Shah	Senior Managing Consultant; Project manager, technical oversight, documentation, QA/QC review.	July 29, 2024
Ross Beardsley	Managing Consultant; Project manager, technical oversight, documentation, QA/QC review.	July 29, 2024
Rajashi Parikh	Managing Consultant; Project manager, technical oversight, documentation, QA/QC review.	July 29, 2024
Gary Wilson	Managing Consultant; Technical contributor, documentation, QA/QC.	July 29, 2024
Lynsey Parker	Managing Consultant; Project Manager; Technical contributor, documentation, QA/QC.	July 29, 2024
Jake Zaragova	Senior Lead Consultant; Technical contributor, documentation, QA/QC.	July 29, 2024
Chao-Jung Chien	Senior Lead Consultant; Technical contributor, documentation, QA/QC.	July 29, 2024
Pradeepa Vennam	Senior Lead Consultant; Technical contributor, documentation, QA/QC.	July 29, 2024

Participant	Position or Title and Role in Performing Grant Activities	Date Added to PEL
Trang Tran	Senior Lead Consultant; Technical contributor, documentation, QA/QC.	July 29, 2024
Liji David	Lead Consultant; Technical contributor, documentation, QA/QC.	July 29, 2024
Katie Tuite	Lead Consultant; Technical contributor, documentation, QA/QC.	July 29, 2024
Alex Takeshita	Lead Consultant; Technical contributor, QA/QC.	July 29, 2024
Abe Dearden	Consultant; Technical contributor, QA/QC.	July 29, 2024
Fianna Li	Consultant; Technical contributor, QA/QC.	July 29, 2024
Blake Himes	Consultant; Technical contributor, QA/QC.	July 29, 2024
Janet Lee	Administrative Support, billing	July 29, 2024
Donna Fennell	Administrative Support, billing	July 29, 2024
Christine Kraemer	Administrative Support, document formatting	July 29, 2024

APPENDIX C

Quality Assurance Project Plans

FY24-25
Contract 582-24-01388
Subtask 2

Prepared for:

Bridget Booty
East Texas Council of Governments
3800 Stone Rd.
Kilgore, TX, 75662

Prepared by:

Ramboll
7250 Redwood Blvd., Suite 105
Novato, California 94945

November 5, 2024

Level IV Quality Assurance Project Plan (QAPP) for Task 3.1 (PM2.5 Emission Inventories Review)

PREPARED UNDER A GRANT FROM THE
TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

The preparation of this QAPP was financed through a grant from the State of Texas through the Texas Commission on Environmental Quality.
The content, findings, opinions and conclusions are the work of the author(s) and do not necessarily represent findings, opinions or conclusions of the TCEQ.

RAMBOLL Bright ideas. Sustainable change.

Level IV Quality Assurance Project Plan (QAPP) for Task 3.1 (PM2.5 Emission Inventories Review)

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November 5, 2024, version 1

CONTENTS

List of Acronyms and Abbreviations ii

1.0 Project Description and Objectives 1

1.1 Background 1

1.2 Project Objectives 2

2.0 Project Organization and Responsibilities 2

2.1 Responsibilities of Project Participants 2

2.2 Project Schedule 2

3.0 Scientific Approach 3

3.1 Data Needed to Meet the Project Objectives 3

3.2 Data Sources 3

4.0 Quality Metrics 3

4.1 Data Quality Requirements 3

4.2 Data Quality Audits 3

5.0 Data Analysis, Interpretation and Management 3

5.1 Data Reporting Requirements 3

5.2 Data Interpretation, Summary and Analysis 3

5.3 Data Storage Requirements 4

6.0 Reporting 4

6.1 Project Documentation Requirements 4

6.2 Final Project Deliverables 4

7.0 References 4

Table of Tables

Table 2-1. Ramboll project team participants and their responsibilities. 2

Table 2-2. Summary of project schedule and milestones. 2

List of Acronyms and Abbreviations

CAMS	Continuous Air Monitoring Station
EPA	Environmental Protection Agency
ETCOG	East Texas Council of Governments
NNA	Near Non-Attainment Area
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
PM2.5	Fine Particulate Matter
SIP	State Implementation Plan (for the ozone NAAQS)
TCEQ	Texas Commission on Environmental Quality
TLMA	Tyler-Longview-Marshall-Athens

Distribution List

Quality Assurance Project Plan Officer, Texas Commission on Environmental Quality

Bridget Booty, East Texas Council of Governments

1.0 Project Description and Objectives

Ramboll has prepared this Level IV Quality Assurance Project Plan (QAPP) for the Texas Commission on Environmental Quality (TCEQ). The nature of the technical analysis and tasks to be conducted as part of this project are consistent with quality assurance (QA) Category IV: "projects involving applied research or technology evaluations." The specific nature of the technical analysis and tasks to be conducted as part of this project falls under "Data Evaluation or Use for Secondary Purpose". The appropriate Environmental Protection Agency (EPA) guidance for this type of work was used to develop the QAPP.

1.1 Background

The Northeast Texas Near Non-Attainment Area (NNA) consists of Gregg, Harrison, Henderson, Rusk, Smith, and Upshur counties (hereafter, the Tyler-Longview-Marshall-Athens [TLMA] area). The Texas Commission on Environmental Quality (TCEQ) operates three Continuous Air Monitoring Stations (CAMS) in the TLMA area near Karnack (CAMS 85), Longview (CAMS 19) and Tyler (CAMS 82), as shown in **Figure 1-1**.

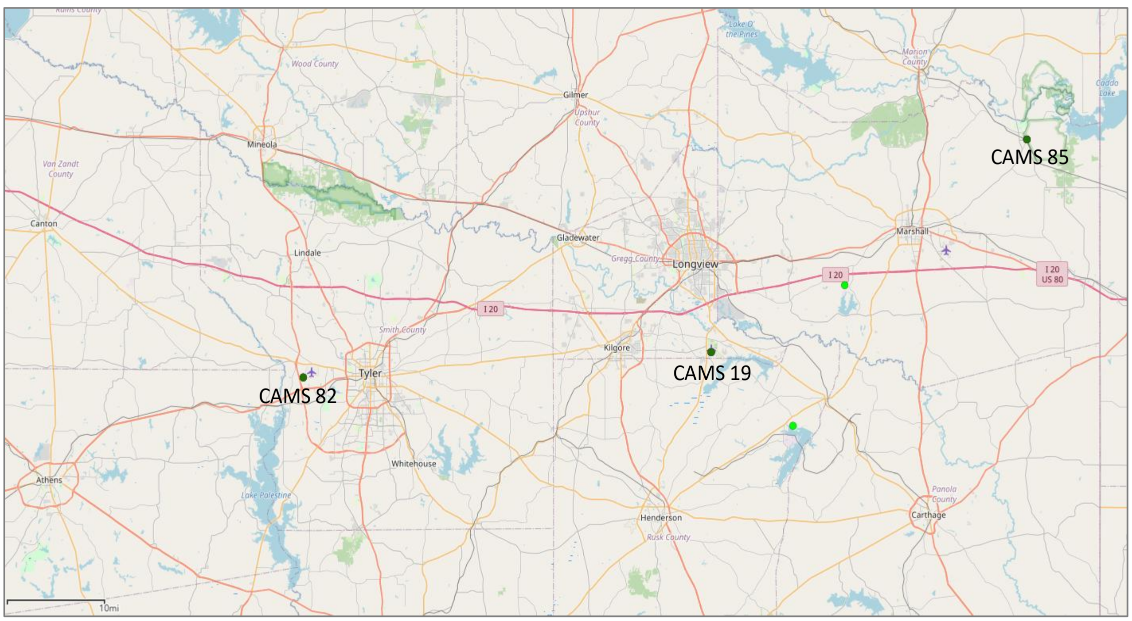

Figure 1-1. Locations of CAMS 82, 19, and 85 in Northeast Texas also showing roads and urban areas (Map from TCEQ GeoTAM[1]).

Fine particulate matter (PM2.5) concentrations vary by location and time of year because they depend on emission sources, meteorological factors, and the extent to which chemistry in the atmosphere produces secondary PM2.5. The Karnack (CAMS 85) monitoring site is the only TCEQ CAMS measuring PM2.5 in the TLMA area.

The TCEQ awarded a Rider 7 PM2.5 Local Air Quality Planning Grant (582-24-01388) to the East Texas Council of Governments (ETCOG). Ramboll is supporting ETCOG by performing several technical activities funded by this Rider 7 grant. For Rider 7 Subtask 3.1, Ramboll will review available EPA and TCEQ PM2.5 emission inventories for the TLMA area. For Rider 7 Subtask 3.2, Ramboll will measure

[1] TCEQ GeoTAM accessed at: https://tceq.maps.arcgis.com/apps/webappviewer/index.html

PM2.5 concentrations adjacent to Tyler CAMS 82 from April to August 2025. For Subtask 3.3, Ramboll will analyze the PM2.5 monitoring data collected in Subtask 3.2 near Tyler (CAMS 82) together with TCEQ data at Karnack (CAMS 85) to understand variations in PM2.5 concentrations across the TLMA area. For Subtask 3.4, Ramboll will apply Machine Learning (ML) modeling to investigate potential contributions of local emission sources to PM2.5 levels at Tyler (CAMS 82) and Karnack (CAMS 85). This QAPP is for Subtask 3.1.

1.2 Project Objectives

The overall goal of Rider 7 Subtask 3.1 is to review and better understand the TLMA area PM2.5 emission inventory. We will review the magnitude of emissions by source category, the spatial distribution of emissions, and other aspects of the emission inventory (e.g., county-level correlation of PM2.5 emissions with human population) and identify potential areas of improvement (if any).

2.0 Project Organization and Responsibilities

2.1 Responsibilities of Project Participants

This study will be conducted by Ramboll under contract to the ETCOG through ETCOG's Rider 7 Local Air Quality Planning Grant from the TCEQ. The ETCOG project manager for this work is Bridget Booty. The Ramboll team working on Subtask 3.1 and their specific responsibilities are listed below.

Table 2-1. Ramboll project team participants and their responsibilities.

Participant	Project Responsibility
Greg Yarwood (Ramboll)	Principal in charge: project oversight; technical consultant; reviewer including quality assurance review; and coordination with other Rider 7 Subtasks
John Grant (Ramboll)	Project manager: oversee day-to-day project activities; direct other Ramboll staff and provide guidance; lead project reporting activities.
Alex Takeshita (Ramboll)	Perform data analysis for Subtask 3.1; Contribute to Subtask 3.1 final report.

In addition, ETCOG and TCEQ staff will review the technical documentation generated during this project.

2.2 Project Schedule

The project includes one major task:

- Subtask 3.1 PM2.5 Emission Inventories Review

Table 2-2 below shows the overall schedule for completion of this project.

Table 2-2. Summary of project schedule and milestones.

Work Element	Completion Date
QAPP submitted to the TCEQ for review and approval	November 7, 2024
Draft report for Subtask 3.1 (Deliverable 3.1)	February 28, 2025
Final report for Subtask 3.1 (Deliverable 3.1)	October 31, 2025

3.0 Scientific Approach

3.1 Data Needed to Meet the Project Objectives

Under Subtask 3.1, Ramboll will perform emission inventory analysis to investigate the distribution of emissions spatially and by source category and to identify potential improvements (if any) to the emission inventory. Ramboll will review the most recently available PM2.5 emission inventories from the TCEQ and EPA for the six county TLMA area.

These activities will benefit the Texas State Implementation Plan (SIP) by better understanding PM2.5 emissions from local and regional sources in the TLMA area.

3.2 Data Sources

(1) 2022 PM2.5 emissions for Gregg, Harrison, Henderson, Rusk, Smith and Upshur counties from EPA's 2022 Emissions Modeling Platform version 1 (https://www.epa.gov/air-emissions-modeling/2022v1-emissions-modeling-platform)

(2) 2022 PM2.5 emissions for Gregg, Harrison, Henderson, Rusk, Smith and Upshur counties from TCEQ's 2022 emission inventory (if available)

4.0 Quality Metrics

4.1 Data Quality Requirements

There are no project-specific secondary data quality requirements. All data to be accessed, analyzed, and reported in this project have been, or will be, developed by the TCEQ, or EPA, each subject to their own independent quality assurance methods and programs.

4.2 Data Quality Audits

Portions of the data accessed and developed in this study will be audited by direct inspection of the data files and graphical products. The quality assurance procedures and results will be discussed in the project Final Report. Data and plots will be assessed for conceptual consistency using expert scientific/engineering judgment. Any data, plots or information that are qualitatively identified as outliers beyond reasonable expectations will be identified and excluded from the analyses and final deliverables.

5.0 Data Analysis, Interpretation and Management

5.1 Data Reporting Requirements

There are no project-specific secondary data reporting requirements.

5.2 Data Interpretation, Summary and Analysis

Ramboll will perform the following analyses for Subtask 3.1:

- Analyze the available EPA and TCEQ 2022 PM2.5 emission inventories for the TLMA area by county and source sector to develop tabular and graphical emission summaries.

- Compare emissions between counties, accounting for differences such as population, to assess whether the emission inventories are consistent with the levels of activity expected for each county.

- Identify the largest point source PM2.5 emitters in each county and evaluate whether the reported emissions are consistent with 2022 activity levels.

- Prepare a map of the TLMA area showing the locations of point sources with larger PM2.5 emissions.

Ramboll analysts will review these data products to draw conclusions about the distribution of TLMA area PM2.5 emissions spatially and by emission source category and to identify potential improvements (if any) to the TLMA area PM2.5 emission inventory.

5.3 Data Storage Requirements

Data generated for this project will be securely archived during the project on redundant hard drives and stored for a period of at least three years following the completion of the project. All data obtained for this project will be stored in electronic format.

6.0 Reporting

6.1 Project Documentation Requirements

The project documentation requirements include:

1. Monthly Progress Reports that detail accomplishments as well as any issues encountered.

2. A Final Report that provides a comprehensive description of all tasks performed in this project, technical issues, and any recommendations for further work (see below).

6.2 Final Project Deliverables

For Subtask 3.1, Ramboll will provide a Draft Report to ETCOG and the TCEQ electronically (i.e., via e-mail) in Microsoft Word and PDF format. The draft report for each Subtask will include the following components:

1. An executive summary or abstract;

2. A detailed description of all work carried out under the Subtask;

3. A detailed discussion of the analyses and findings;

4. A discussion of the pertinent accomplishments, shortfalls, and limitations; and

5. All data and analyses and an evaluation of those results.

Ramboll will address any comments received on the Draft Final Reports on both Subtasks and then provide Final Reports to ETCOG and the TCEQ.

7.0 References

None.

FY24-25
Contract 582-24-01388
Subtask 2

Prepared for:

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November 15, 2024

Level IV Quality Assurance Project Plan (QAPP) for Task 3.2 (Monitoring PM2.5)

PREPARED UNDER A GRANT FROM THE
TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

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The content, findings, opinions and conclusions are the work of the author(s) and do not necessarily represent findings, opinions or conclusions of the TCEQ.

Bright ideas. Sustainable change.

Level IV Quality Assurance Project Plan (QAPP) for Task 3.2 (Monitoring PM2.5)

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CONTENTS

Distribution List **iv**
1.0 Project/Task Organization **1**
1.1 Customers 1
1.2 Project Sponsor 1
1.2.1 TCEQ 1
1.3 Principal Investigator 1
1.4 Field Support 1
1.5 Quality Assurance (QA) and Laboratory Support 1
1.6 Monitoring Data Management and Validation 1
2.0 Problem Definition/Background **2**
2.1 Overview 2
2.2 Decisions to be Made 2
2.3 Uses of Data 2
2.4 Decision Makers 2
2.5 Principal Customers for the Results 2
3.0 Project/Task Description **2**
3.1 Project Overview 3
3.2 Sampling Activities 3
3.3 Standards and Screening Levels 3
3.3.1 NAAQS 3
3.4 Assessment Tools 5
3.4.1 Technical Systems Audits 5
3.4.2 Performance Evaluations 5
3.5 Project Reports 5
4.0 Data Quality Objectives (DQOs) for Measurement Data **5**
4.1 General Project Objectives 5
4.2 Conclusions to be Made 5
4.3 Uses of Data 6
4.4 Measurement Quality Objectives 6
4.4.1 Detection Limits 6
4.4.2 System Contribution to the Ground-based Measurement 6
4.4.3 Precision 6
4.4.4 Accuracy 6
4.4.5 Completeness 6
4.4.6 Representativeness 7
4.4.7 Comparability 7
5.0 Project Narrative **7**
6.0 Special Training Requirements/Certification **7**
7.0 Documentation And Records **7**

7.1 Mechanisms for Documentation of Procedures and Objectives 7
7.2 Mechanisms for Record Keeping 8
7.3 Data Reporting Turnaround Time 8
7.4 Data Storage 8
8.0 Sampling Process Design (Experimental Design) 8
8.1 Site Design 8
8.2 Site Design Rationale 8
8.3 Measurement Validation 8
9.0 Sampling Methods Requirements 8
9.1 Particulate Matter of Aerodynamic Diameter of 2.5 microns or less ($PM_{2.5}$) 9
9.1.1 $PM_{2.5}$ Specifications 9
9.2 Corrective Actions 9
10.0 Sample Handling And Custody Requirements 10
10.1 Sample Handling Procedures 10
10.1.1 $PM_{2.5}$ 10
10.2 Documentation and Custody Requirements 10
10.2.1 $PM_{2.5}$ 10
11.0 Analytical Methods Requirements 10
11.1 Analytical Procedures 10
11.1.1 $PM_{2.5}$ 10
11.2 Corrective Actions 10
12.0 Quality Control (QC) Requirements 11
12.1 $PM_{2.5}$ 11
13.0 Instrument/Equipment Testing, Inspection, And Maintenance Requirements 12
13.1 Instrument Testing/Inspection 12
13.2 Preventive Maintenance Procedures 12
13.2.1 $PM_{2.5}$ 12
13.3 Corrective Maintenance Procedures 12
13.3.1 $PM_{2.5}$ 12
13.4 Availability of Spare Parts and Expendables 12
14.0 Instrument Calibration And Frequency 13
14.1 Field Equipment Requiring Calibration 13
14.1.1 $PM_{2.5}$ 13
14.2 Traceability 14
14.2.1 Primary Flow Standard 14
14.3 Documentation 14
15.0 Inspection/Acceptance Requirements For Supplies And Consumables 14
16.0 Data Acquisition Requirements 14
17.0 Data Management 14
17.1 $PM_{2.5}$ 14
17.2 Data to Users 14

18.0 Assessments And Response Actions 14
18.1 Technical Systems Audit 14
18.2 Performance Evaluations 14
18.3 Data Quality Assessment 15
18.3.1 Specific Procedures to Assess Data Quality 15
18.4 Corrective Actions 15
19.0 Reports To Management 15
20.0 Data Review, Validation, and Verification Requirements 16
20.1 Data Validation 16
20.1.1 $PM_{2.5}$ 16
20.2 Data Custody 16
20.2.1 $PM_{2.5}$ 16
21.0 Validation and Verification Methods 16
21.1 $PM_{2.5}$ 16
21.1.1 Data Review 16
22.0 Reconciliation With Data Quality Objectives 17
22.1 Detection Limits 17
22.2 Precision 17
22.2.1 $PM_{2.5}$ 17
22.3 Accuracy 18
22.3.1 $PM_{2.5}$ 18
22.4 Completeness 18

Table

Table 3.1 Timeline for Project Deliverables 3
Table 3.2 Overview of Sampling Matrix 3
Table 3.3 National Ambient Air Quality Standards (NAAQS) 4
Table 4.1 Reporting Units of Measurements 7
Table 9.1 Criteria Pollutant 9
Table 14.1 Ambient Monitoring Quality Control Activities 13

Appendix A

Appendix B

Distribution List

Below is a list of individuals and their organizations that need copies of the approved Quality Assurance (QA) Project Plan and any subsequent revisions, including all persons responsible for implementation (e.g., project managers), the QA managers, and representatives of all groups involved. Paper copies need not be provided to individuals if equivalent electronic information systems can be used.

Texas Commission on Environmental Quality (TCEQ)
QA Project Plan Officer

East Texas Council of Governments (ETCOG)
Bridget Booty, ETCOG Project Manager
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Barrett Environmental LLC
Tate Barrett, Subcontractor for Field Support
Barrett Environmental LLC
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1.0 Project/Task Organization

Monitoring particulate matter of aerodynamic diameter of 2.5 microns or less ($PM_{2.5}$) near TCEQ's Tyler Airport Relocated monitoring site (CAMS 82) in the Tyler area is performed by Ramboll.

1.1 Customers

This study will be conducted by Ramboll who is under contract to the ETCOG through ETCOG's Rider 7 Program Grant Agreement with the TCEQ. The ETCOG project manager for this work is Bridget Booty.

1.2 Project Sponsor

1.2.1 TCEQ

- Sets the preliminary objectives for the project.
- Determines the ultimate use of the data set developed from the project activities.

1.3 Principal Investigator

Ramboll

Greg Yarwood (PI)

- Coordinates the operations of the project and is the primary contact person.
- Provides project planning.
- Provides QAPP for TCEQ's review and approval.

1.4 Field Support

Barrett Environmental LLC

Tate Barrett, Subcontractor for Field Support

- Assists with operations of the project.
- Assists with project planning.
- Assists with the deployment of monitoring site and sampling equipment.
- Assists with major and minor maintenance

Ramboll

Abe Dearden, Consultant

- Provides support to maintain the monitoring equipment.
- Prepares sites for the monitoring activities.

1.5 Quality Assurance (QA) and Laboratory Support

Ramboll

J.B. Dennison, Senior Managing Consultant

Abe Dearden, Consultant

- Coordinates the QA activities for the project.
- Prepares the project specific final report.
- Establishes procedures to routinely assess data precision, accuracy, and completeness.

1.6 Monitoring Data Management and Validation

Ramboll

Jake Zaragoza, Senior Lead Consultant

- Provides overall coordination of collected data.
- Provides support, maintenance, and management of data validation software.

- Compiles and maintains database of measurements from the monitoring site.
- Maintains dedicated data dashboard that displays collected data from the site.
- Reviews QAPP.
- Prepares data and reporting products.

2.0 Problem Definition/Background

2.1 Overview

The purpose of this project is to collect $PM_{2.5}$ field measurements at one additional location in Tyler to provide additional data in the Tyler-Longview-Marshall-Athens (TLMA) area and allow important questions to be answered including 1.) How representative of the TLMA area are the $PM_{2.5}$ data collected at CAMS 85? 2.) How important are local $PM_{2.5}$ emission sources to $PM_{2.5}$ concentrations in the TLMA area? and 3.) How important is $PM_{2.5}$ transport from sources outside the TLMA area?

2.2 Decisions to be Made

Data collected by this monitoring project will be used as a complement to the existing monitoring in the Tyler area to better understand the chemistry and transport of parameters of interest in large air parcels. Additionally, it will be used to determine the representative of the data collected at CAMS 85. No specific decisions are currently planned.

2.3 Uses of Data

The data collected will benefit the Texas State Implementation Plan (SIP) by providing data that can be analyzed to understand how TLMA area and regional $PM_{2.5}$ sources contribute to pollution within the TLMA area.

2.4 Decision Makers

The goal of this project is to conduct an ambient monitoring study in Tyler that will assist the TCEQ in gaining a more complete understanding of the variations of $PM_{2.5}$ concentrations with the TLMA Area. No decision makers are currently specified.

2.5 Principal Customers for the Results

- TCEQ and ETCOG

3.0 Project/Task Description

This section provides a description of the work to be done, an overall view of the project objectives, activities, assessments, and outputs of the project, identification of applicable ambient air quality regulations and standards, and an implementation schedule for the project.

Table 3.1 Timeline for Project Deliverables

Task	Deliverables	Due Date
3.2.1	Level IV Quality Assurance Project Plan	07-November-2024
3.2.2	Monitoring site operational for 2025	1-April-2025*
3.2.3	Monitoring completed for 2025	31-August-2025
3.2.4	Monitoring draft report with data for 2025	30-September-2025
3.2.5	Monitoring final report with data for 2025	31-October-2025

* Or as soon as practicable thereafter

3.1 Project Overview

The purpose of this project is to make $PM_{2.5}$ field measurements in Tyler and deliver QA/QC'd hourly averages of $PM_{2.5}$ to TCEQ.

The measurements to be made during the project are identified in Table 3.2. Measurements are to be made based on the current guidance where it exists. This guidance includes but is not limited to 40 *CFR* Parts 50, 53, and 58 (PART B), and U.S. Environmental Protection Agency (EPA) *Quality Assurance Handbook* (*Volumes I and II*).

3.2 Sampling Activities

The general sampling activities of the project are detailed in Table 3.2.

Table 3.2 Overview of Sampling Matrix

Target Compound/Group	Analytical Method	Sampling Period	Frequency
$PM_{2.5}$	Beta Attenuation	1 hour	Hourly

3.3 Standards and Screening Levels

$PM_{2.5}$ concentrations are regulated by EPA.

3.3.1 NAAQS

The NAAQS listed in Table 3.3 are health-based standards promulgated by the EPA. The levels are established such that concentrations below them are not expected to cause adverse health impacts. The data to be collected in this project are for scientific rather than regulatory purposes; they are not suitable for comparison to the NAAQS standards listed below. They are for improving scientific understanding to aid in the effort to develop the Texas SIP for $PM_{2.5}$.

Table 3.3 National Ambient Air Quality Standards (NAAQS)

Pollutant [final rule cite]		Primary/ Secondary	Averaging Time	Level	Form
Carbon Monoxide [76 FR 54294, Aug 31, 2011]		primary	8-hour	9 ppm	Not to be exceeded more than once per year
			1-hour	35 ppm	
Lead [73 FR 66964, Nov 12, 2008]		primary and secondary	Rolling 3 month average	0.15 $\mu g/m^3$ (1)	Not to be exceeded
Nitrogen Dioxide [75 FR 6474, Feb 9, 2010] [77 FR 20218, Apr 3, 2012]		primary	1-hour	100 ppb	98th percentile, averaged over 3 years
		primary and secondary	1 year	53 ppb (2)	Annual Mean
Ozone [80 FR 65292, Oct 26, 2015]		primary and secondary	8-hour	0.070 ppm (3)	Annual fourth-highest daily maximum 8-hr concentration, averaged over 3 years
Particle Pollution [89 FR 16202, Mar 6, 2024]	$PM_{2.5}$	primary	Annual	9 $\mu g/m^3$ (4)	annual mean, averaged over 3 years
		secondary	Annual	15 $\mu g/m^3$	annual mean, averaged over 3 years
		primary and secondary	24-hour	35 $\mu g/m^3$	98th percentile, averaged over 3 years
	PM_{10}	primary and secondary	24-hour	150 $\mu g/m^3$	Not to be exceeded more than once per year on average over 3 years
Sulfur Dioxide [84 FR 9866, March 18, 2019] [77 FR 20218April 3, 2012]		primary	1-hour	75 ppb (5)	99th percentile of 1-hour daily maximum concentrations, averaged over 3 years
		secondary	3-hour	0.5 ppm	Not to be exceeded more than once per year

(1) In areas designated nonattainment for the Pb standards prior to the promulgation of the current (2008) standards, and for which implementation plans to attain or maintain the current (2008) standards have not been submitted and approved, the previous standards (1.5 $\mu g/m^3$ as a calendar quarter average) also remain in effect.

(2) The level of the annual NO_2 standard is 0.053 ppm. It is shown here in terms of ppb for the purposes of clearer comparison to the 1-hour standard level.

(3) Final rule signed October 1, 2015, and effective December 28, 2015. The previous (2008) O_3 standards additionally remain in effect in some areas. Revocation of the previous (2008) O_3 standards and transitioning to the current (2015) standards will be addressed in the implementation rule for the current standards.

(4) Final rule published March 6, 2024 (effective May 6, 2024) lowers primary annual $PM_{2.5}$ standard from 12 $\mu g/m^3$. All other $PM_{2.5}$ and PM_{10} standards remain unchanged.

(5) The previous SO_2 standards (0.14 ppm 24-hour and 0.03 ppm annual) will additionally remain in effect in certain areas: (1) any area for which it is not yet 1 year since the effective date of designation under the current (2010) standards, and (2) any area for which an implementation plan providing for attainment of the current (2010) standard has not been submitted and approved and

which is designated nonattainment under the previous SO_2 standards or is not meeting the requirements of a SIP call under the previous SO_2 standards (40 CFR 50.4(3)). A SIP call is an EPA action requiring a state to resubmit all or part of its State Implementation Plan to demonstrate attainment of the required NAAQS.

3.4 Assessment Tools

Assessment tools that will be used are described in this section.

3.4.1 Technical Systems Audits

Completion of this section is not required for a Level IV QAPP.

3.4.2 Performance Evaluations

Completion of this section is not required for a Level IV QAPP.

3.5 Project Reports

The following reports are produced. See Section 19 for more detailed information.

- Quality Assurance reports on data accuracy, precision, and completeness for the study by the Principal Investigator.
- Reports on the operations during the sampling period, including the validated data from the sampling period.

4.0 Data Quality Objectives (DQOs) for Measurement Data

This section presents the quality objectives for the project. A variation of the formal data quality objectives process as described in the U.S. Environmental Protection Agency (EPA) document *Guidance for Planning the Data Quality Objectives (DQO) Process, EPA QA/G-4* has been applied to this project. The results of the DQO process serve to:

- Clarify the intended use of the data;
- Define the type of data needed to support the decision(s);
- Identify the conditions under which the data should be collected; and
- Specify tolerable limits on the probability of making a decision error due to uncertainty in the data.

The quantitative objectives for all measurement data-parameters are listed in Table A1 in Appendix A. These objectives reflect the overall (total) measurement error expected for measurements made during this project. This includes any media preparation, sampling, analysis, data reduction, validation and reporting, etc. The quality control program has been developed with control of the measurement processes within these objectives in mind.

4.1 General Project Objectives

Conduct $PM_{2.5}$ monitoring in Tyler near TCEQ's Tyler Airport Relocated site (CAMS 82).

4.2 Conclusions to be Made

Conclusions to be made are presented in Section 2.2.

4.3 Uses of Data

The potential uses of the data are provided in Section 2.3.

4.4 Measurement Quality Objectives

The approaches used to assess data uncertainty and the measurement quality objectives for $PM_{2.5}$ measurement are addressed in this section. Table A1 in Appendix A presents the quality objectives for the $PM_{2.5}$ measurement method that will be employed. Section 22 details the methods of computation.

4.4.1 Detection Limits

Detection limits are expressed in units of concentration and reflect the smallest concentration of a compound that can be measured with a defined degree of certainty. Criteria pollutants are measured using EPA designated reference or equivalent methods. The detection limits for these methods are specified in 40 CFR Part 53. Because of this, no specific measurements of detection limits are made for the criteria pollutants in this project.

4.4.2 System Contribution to the Ground-based Measurement

For $PM_{2.5}$ the system contribution to the measurement results is determined by a 72-hour background test. This background test is performed at the beginning of the measurement intensive and should only need to be performed once during the study. It involves installing a filter on the inlet, running the analyzer for 72 hours, calculating a new offset, and programming it into the instrument. Full instructions are available in the Met One Instruments Inc. *Operation Manual BAM 1022 Particulate Monitor BAM 1022-9805 Rev F*.

4.4.3 Precision

Precision is a measure of the repeatability of the results. Estimates of precision are assessed in different ways for different measurement technologies. Refer to Table A1 in Appendix A for the DQOs. Specific activities designed to collect precision data are given in Section 18, with Section 22 providing details for calculating data precision.

- This precision check consists of monthly one-point flow rate checks as required by the *Quality Assurance Handbook, Volume II Appendix D*. The one-point checks are then compared to a certified transfer standard and should be within a certain percentage outlined in the *Quality Assurance Handbook, Volume II Appendix D*.

4.4.4 Accuracy

Accuracy is the closeness of a measurement to a reference value and reflects elements of both bias and precision. Specific activities designed to collect accuracy data are given in Section 18, with Section 22 providing details for calculating data accuracy.

Technical system audits are not required for a Level IV QAPP.

4.4.5 Completeness

Data completeness is calculated on the basis of the number of valid samples collected out of the total possible number of measurements. For $PM_{2.5}$, a valid sample is a 24-hour average midnight to midnight period. More details can be found in the *Quality Assurance Handbook, Volume II Appendix D*. Data completeness is calculated as follows:

$$\% \, Completeness = \frac{Number\ of\ valid\ measurements}{Total\ possible\ measurements} \times 100$$

4.4.6 Representativeness

Representativeness is the extent to which a set of measurements reflects actual conditions for a specific application. The representativeness objective for the data is not stated numerically as a quality objective because quantitation is generally not possible.

4.4.7 Comparability

Comparability is achieved when the results are reported in standard units to facilitate comparisons between the data from this network and other similar programs. In order to accomplish this objective, the reporting units for the ambient monitoring measurements are listed in Table 4.1 Data comparisons with the final QA/QC'd data will be performed by Ramboll.

Table 4.1 Reporting Units of Measurements

Parameter	Units	Conditions
$PM_{2.5}$	Micrograms per cubic meter ($\mu g/m^3$)	Ambient

5.0 Project Narrative

Not required for this project.

6.0 Special Training Requirements/Certification

None is required for this project.

7.0 Documentation And Records

Each project participant is expected to maintain records that include sufficient information to reconstruct each final reported measurement from the variables originally gathered in the measurement process. This includes but is not limited to information (raw data, electronic files, and/or hard copy printouts) related to media preparation, sampler calibration, sample collection, sample handling (Chain-of-Custody and processing activities), measurement instrument calibration, quality control checks of sampling or measurement equipment, "as collected" measurement values, an audit trail for any modifications made to the "as collected" measurement values and traceability documentation for reference standards.

Difficulties encountered during sampling or analysis need to be documented in narratives that clearly indicate the affected measurements. All electronic versions of data sets should reflect the limitations associated with individual measurement values.

7.1 Mechanisms for Documentation of Procedures and Objectives

- Published guidance (*Code of Federal Regulations*, U.S. Environmental Protection Agency [EPA], and EPA *Quality Assurance Handbook*)
- Method specific standard operating procedures where they exist

- Instrument manufacturer's technical support manuals

7.2 Mechanisms for Record Keeping

- Instrument calibration data forms
- Electronic and manual monthly activity logs
- Electronic and manual data processing and validation logs
- Electronic and manual data management activity logs
- Records of assessment, such as performance evaluation records

7.3 Data Reporting Turnaround Time

Data from the monitoring programs will be made available to Ramboll, ETCOG and the TCEQ at the end of the project or during the measurement period upon request. Data will be validated by Ramboll weekly and validations will be double-checked monthly to minimize potential errors. A final report will be prepared following the completion of the data collection period.

7.4 Data Storage

Electronic data will be stored locally at the monitoring site and on Ramboll servers as a backup. The $PM_{2.5}$ instrument will also have remote communications capabilities and data will be downloaded remotely by Ramboll at least once per week.

8.0 Sampling Process Design (Experimental Design)

8.1 Site Design

Ramboll will deploy at the existing equipment shelter (site) and make measurements of $PM_{2.5}$ at the previously established Tyler sampling site (32.344071, -95.415800) which is located adjacent to TCEQ's Tyler Airport Relocated site (CAMS 82). Measurements will take place from April through August 2025.

8.2 Site Design Rationale

The sampling site was selected to be within another ETCOG monitoring project (NO_2 monitoring) which will provide infrastructure to support $PM_{2.5}$ monitoring. It was a previously established site for previous studies selected with guidance from Ramboll and the TCEQ in order to be comparable with data from existing monitoring networks.

8.3 Measurement Validation

Sampling and validation efforts are described in Sections 3, 9, and 20. All data will be reviewed by Ramboll for acceptable data quality compliance with objectives prior to delivery to the TCEQ.

9.0 Sampling Methods Requirements

This section addresses the approved sampling methods; the specific collection, preparation, and decontamination procedures of the equipment; the sample requirements, specifically the sampling media, sample preservation methods, holding times, field sample handling procedures; and the procedures to follow in case of a failure in the sampling system. The equipment and operating procedures are specified where the sampling method is automated. Every attempt has been made to be as complete as possible. It should be recognized that some of the procedures might change over the course of the program if logistical or quality related difficulties are encountered.

9.1 Particulate Matter of Aerodynamic Diameter of 2.5 microns or less ($PM_{2.5}$)

Criteria pollutant, $PM_{2.5}$, sampling procedures used in this monitoring program are consistent with U.S. Environmental Protection Agency (EPA) 40 *CFR* Part 58, Appendices A through G, the *Quality Assurance Handbooks for Air Pollution Measurement Systems*, *Volumes I and II*, and the reference and equivalent methods designation criteria outlined in 40 *CFR* Part 53. The criteria pollutant sampling probes are sited in accordance with the EPA *Quality Assurance Handbook*, *Volume II*, Section 7.

9.1.1 $PM_{2.5}$ Specifications

Ambient air is supplied to the continuous $PM_{2.5}$ instrument through two size separation inlets. One inlet, a particulate matter of aerodynamic diameter of 10 microns or less (PM_{10}) omni-directional inlet, removes particulates larger than 10 microns and the second separator, a BGI Inc. Very Sharp Cut Cyclone (VSCC®) removes particulates larger than 2.5 microns. The PM_{10} omni-directional inlet prevents water and larger debris from entering the system.

The pollutant concentrations are automatically sampled and analyzed by the monitor. The output of the monitor is comma separated value (csv) via RS-232 serial or ethernet connection. The outputs from the instruments are collected and sampled by data acquisition software on a PC hourly.

Continuous monitors for criteria pollutants are EPA approved equivalent or reference methods. The measurement parameters, instrument model number, and the EPA method code of the monitor is identified in Table 9.1. Additional information may be obtained from the Geographical Common Table, found in the EPA Aerometric Information Retrieval System Database, Air Quality Systems.

Table 9.1 Criteria Pollutant

Criteria Pollutant Parameter	Instrument and Model Number	Designation/ Method Code	Method
$PM_{2.5}$	Met One Instruments, Inc Beta Attenuation Monitor (BAM) 1022	EQPM-1013-209	Beta attenuation via continuous filter tape

9.2 Corrective Actions

The field technician assigned to the monitoring site is responsible for operating samplers and initiating minor corrective actions on equipment when required. Equipment problems are generally detected through a failed sample run or through performing routine quality control (QC) checks on a routine basis. The QC checks that are performed on the sampling equipment are identified in Section 12.

When a major equipment problem is involved, the technician refers it to the Field and Laboratory Activities leader, who has the responsibility to follow up on restoring the equipment to its proper operating status. This may be accomplished through telephone consultation with the field technician, which may result in the removal of the equipment from the site for repair.

Any equipment problems that can result in the loss of data are addressed with a high priority. All situations requiring corrective action will be documented in site activity logs. Section 11.2 contains additional information on documentation of corrective action.

10.0 Sample Handling And Custody Requirements

When measurement data are collected electronically, each sampling method is required to have procedures that allow for clear custody record keeping for each transfer of information from the collection point to the final data holding mechanism. The record of sample acquisition activities is required to contain minimum information about the time of sampling, location, sampler operational conditions, and any other descriptive data that may be relevant to support the representativeness of the measurement(s) being made. Procedures are expected that allow for clear custody record keeping for each transfer of information related to the analysis of these samples. At minimum, sample data sheets, bound logbooks, or equivalent electronic mechanisms that provide an audit trail of activities should be employed.

10.1 Sample Handling Procedures

10.1.1 $PM_{2.5}$

There are no discrete samples handled by individuals for this method.

10.2 Documentation and Custody Requirements

This section describes the procedures used in this project for documenting and maintaining sample custody from time of collection until disposal.

10.2.1 $PM_{2.5}$

There are no discrete samples handled by individuals for this method. The identity and disposition of samples are documented electronically by the run log associated with the instrument support computer and processing software. Instrument calibration information is recorded on standard data forms and maintained in the permanent record. Information regarding instrument maintenance is maintained in the Activities Logbook.

11.0 Analytical Methods Requirements

11.1 Analytical Procedures

This section presents information regarding the analytical methods used to develop ambient air measurements for this project. Where published methods exist, the method reference has been specified and only exceptions to the published method are discussed here or in referenced documents. Where no published method exists, the analytical method is described.

11.1.1 $PM_{2.5}$

There are no exceptions to established guidance (see Section 9) for these methods.

11.2 Corrective Actions

It is expected that the individual discovering a problem will initiate corrective action appropriate to the situation. Documentation of the problem using site activity logs should be used.

Generally field technicians, in this case Tate Barrett from Barrett Environmental is responsible for all minor and major maintenance of monitoring systems operating at the site, under the direction and supervision of Ramboll. Cost of repairs and travel may dictate that the field technician undertakes major repairs. The field technicians will be guided by Ramboll Field Support (1.4). Barrett Environmental staff have assigned responsibilities as described in 1.4 and expertise on this type of equipment. A backup field technician may be called to the site if the primary technician is not available to solve the problem.

12.0 Quality Control (QC) Requirements

The QC protocol for the $PM_{2.5}$ instrument is discussed in this section. An attempt is made to provide adequate information from which to estimate and control the uncertainty and potential limitations of measurements generated by the monitoring. QC activities are generally applied to portions of a measurement process that are both critical to measurement quality and practically subject to evaluation and control. The portions of any given measurement process that are both critical and subject to evaluation and control vary with the measurement being made and the method used. The QC protocol used for any given measurement process may include some or all of the following:

- Media contribution to the measurements
- Sampling system contribution to the measurements
- Measurement system contribution to the measurements
- Qualitative performance of the method
- Quantitative performance of the method
- Precision of the measurements
- Accuracy (bias) of the measurements

Limitations of resources may restrict the ability of Ramboll to make certain quality assessment measurements. In such cases, review and approval will be performed on a case-by-case basis, by the project coordinator.

12.1 $PM_{2.5}$

Ramboll will train on-site staff to perform monthly checks on critical instrument parameters. These will include a one-point flow verification, one-point temperature verification, one-point pressure verification, and a leak check. monitors in the air monitoring station. The purpose of the one-point verifications is to evaluate drift in the $PM_{2.5}$ instrument between calibrations, evaluate monitor performance, and assess measurement precision.

Data validity decisions are based only on whether a one-point verification exceeds the failure limit. Table 14.1 describes these verification checks and validation rules in detail.

13.0 Instrument/Equipment Testing, Inspection, And Maintenance Requirements

This section describes the procedures to ensure and maintain the readiness of the field equipment throughout all phases of the project. Corrective procedures and responsible staff members for corrective actions on analytical instruments located at the monitoring site are discussed in Section 11.2 of this plan.

13.1 Instrument Testing/Inspection

Prior to deployment of an ambient air monitoring system, whether an air sampler or an instrument air monitoring station, Ramboll powers up the equipment, checks operating parameters, and tests the instruments against various calibration levels. The purpose is to run operational checks to catch problems prior to field deployment; repair all malfunctioning equipment; and familiarize the staff with the equipment.

13.2 Preventive Maintenance Procedures

This section describes the routine preventive maintenance procedures performed on field ambient air quality systems. Generally field technicians, in this case Tate Barrett from Barrett Environmental is responsible for all minor and major maintenance of monitoring systems operating at the site. Cost of repairs and travel may dictate that the field technician undertakes major repairs. The field technicians will be guided by Ramboll. Barrett Environmental staff have assigned responsibilities as described in 1.4 and expertise on this type of equipment. A backup field technician may be called to the site if the primary technician is not available to solve the problem.

13.2.1 $PM_{2.5}$

Routine preventive maintenance procedures and schedules for continuous criteria pollutants are described in instrument service manuals.

13.3 Corrective Maintenance Procedures

This section describes the routine corrective maintenance procedures performed on ambient air quality systems.

13.3.1 $PM_{2.5}$

Corrective maintenance procedures for the Met One Instruments BAM 1022 $PM_{2.5}$ monitor follow the manufacturer's recommendations in the instrument service manual.

13.4 Availability of Spare Parts and Expendables

Currently, no spare parts will be maintained on hand at the site and they will be acquired on an “as needed” basis. Filter tape is part of the sampling ‘medium’ and will always be available to avoid data losses. Additionally, cotton swabs, isopropyl alcohol, and lint free wipes will be stored at the site as they are used to perform the cleaning. Other general expendable items that will be used and stored at this site include lint free towels, distilled water, mild soap, rubbing alcohol, compressed air dusting canisters, and trash bags.

14.0 Instrument Calibration And Frequency

This section identifies the instruments, tools, and standards whose quality must be controlled; the methods and frequency of calibration; the calibration and performance standards; and the traceability of the standards. Table 14.1 contains summaries of the calibration requirements. It is the responsibility of each participant to maintain documentation regarding the traceability of the standard materials used as references for calibration purposes via logbooks or electronic logs.

14.1 Field Equipment Requiring Calibration

14.1.1 $PM_{2.5}$

The one-point checks performed on a monthly basis will be compared to a certified transfer standard. This will be in addition to the installation and decommission checks that will be performed. All results should be within a certain percentage.

14.1.1.1 $PM_{2.5}$ Instrument Checks

The Met One Instruments Inc. BAM 1022 will have verification checks performed on its flow, pressure, and temperature sensor. It will also be subject to leak checks. These checks will be performed upon instrument installation, once per month during each month of operation, and upon instrument decommission. The flow, temperature, and pressure checks will be performed with a certified transfer standard device capable of measuring flow, temperature, and pressure, like a BGI DeltaCal device or similar. The installation and decommission checks will be performed with a different transfer standard than the one used for monthly checks. Table 14.1 below provides more details on the acceptance criteria, frequency, etc of the checks.

Table 14.1 Ambient Monitoring Quality Control Activities

Assessment Parameter	Minimum Frequency	Acceptance Criteria	Corrective Action
Flow	Upon installation, during each month of operation, upon decommission	<±4.1% of transfer standard	Flow calibration or repair
Temperature	Upon installation, during each month of operation, upon decommission	<±2.1°Celsius	Temperature calibration or repair
Pressure	Upon installation, during each month of operation, upon decommission	<±10.1 mm Hg	Pressure calibration or repair
Leak Check	Upon installation, during each month of operation, upon decommission	≤0.42 Liters per minute	Repair

14.2 Traceability

14.2.1 Primary Flow Standard

Ramboll maintains calibrated flow standards for calibrating instrument flowmeters.

14.3 Documentation

It is the responsibility of each participant to maintain documentation regarding the traceability of the standard materials used as references for calibration purposes. Site logbooks, electronic logs, and data are maintained by the site operator.

15.0 Inspection/Acceptance Requirements For Supplies And Consumables

This section is not required for this program.

16.0 Data Acquisition Requirements

This section not required for this program.

17.0 Data Management

Data originates with the activities and individuals associated with implementation of $PM_{2.5}$ monitoring. The final results will be forwarded to ETCOG for review and subsequent submission to the TCEQ.

17.1 $PM_{2.5}$

Data collected for $PM_{2.5}$ by the monitors are obtained through the internal BAM data logger. The BAM 1022 will have remote communications capabilities via IP-based connectivity through a cellular modem. Data collected by the BAM 1022 will be downloaded remotely by Ramboll for further review, screening, and validation. It will also be automatically polled and plotted onto a custom dashboard through the Eagle.io interface.

17.2 Data to Users

Ramboll will provide final QA/QC'd data to the TCEQ and ETCOG in a delimited text file upon completion of the field measurements

18.0 Assessments And Response Actions

Review of process performance is done on a continuous basis. This section addresses the assessment and response actions for this project.

18.1 Technical Systems Audit

Completion of this section is not required for a Level IV QAPP.

18.2 Performance Evaluations

Completion of this section is not required for a Level IV QAPP.

18.3 Data Quality Assessment

Data quality assessment activities consist of:

- Repeatability 1 point data verification checks to establish data precision
- Performance evaluations to establish data accuracy
- Valid data return calculations to determine data completeness

18.3.1 Specific Procedures to Assess Data Quality

18.3.1.1 Data Precision Assessment

Data precision is further discussed in Section 22.2.

18.3.1.2 Data Accuracy Assessment

Data accuracy is further discussed in Section 22.3.

18.3.1.3 Data Completeness Assessment

Ambient monitoring data completeness is calculated as follows:

$$\%\ Completeness = \frac{Number\ of\ valid\ measurements}{Total\ possible\ measurements} \times 100$$

18.4 Corrective Actions

Corrective action is an essential part of any quality system and involves those procedures and actions taken to correct situations causing data quality to fall below established expectations. The need for corrective actions will be minimized by the implementation of applicable quality management plans, quality assurance project plans, and the application of statistical quality control to establish appropriate data quality limits for measurement activities. The person discovering the problem generally initiates corrective action as soon as possible, whether it is by the field operator, an auditor or a data validator. Once a quality concern is identified, verbal and written communication between the affected parties is started and continues until the issue is resolved. Ramboll has the ultimate responsibility for ensuring the correction of any deficiencies.

19.0 Reports To Management

Draft and Final Reports will be delivered to the TCEQ Project Manager electronically (i.e., via file transfer protocol (FTP) or e-mail) in Microsoft Word and Adobe Acrobat Reader (*.pdf) format no later than the deliverable due date shown in Table 3.1. The Reports will detail the methods and results and will include the following components:

1. An executive summary or abstract

2. A brief introduction discussing the background and objectives, including relationships to other studies, if applicable

3. A discussion of the pertinent accomplishments, shortfalls, and limitations of the work completed

4. Recommendations, if any, for what should be considered next as a new study

The Final Report will provide a comprehensive overview of activities undertaken and data collected and analyzed during the work. The Final Report will highlight major activities and key findings, describe problems encountered and associated corrective actions, and detail relevant statistics including data completeness, accuracy, and precision, and report the results the project.

20.0 Data Review, Validation, and Verification Requirements

20.1 Data Validation

Data validation is an integral part of quality management at Ramboll. Ramboll staff closely examines all air pollutant data and the conditions under which they were recorded to determine the validity of the data and whether individual measurements can be included for statistical analysis.

20.1.1 $PM_{2.5}$

Initial data review and validation is performed by Ramboll using the METOne COMET 2 software.

20.2 Data Custody

Custody of data is maintained by ETCOG and Ramboll.

20.2.1 $PM_{2.5}$

Custody of $PM_{2.5}$ data is maintained by ETCOG and Ramboll indefinitely. Only authorized personnel have access to the computer records.

21.0 Validation and Verification Methods

The objective of the data processing and validation effort is to obtain quality assured databases containing the monitoring data in a consistent format. The procedures that will be implemented for data processing and validation will ensure that reported data are valid and comparable quality to those collected by other programs, such as the TCEQ monitoring network.

21.1 $PM_{2.5}$

The analysis and flow of the data from the point of collection to storage of validated concentrations is described in Section 17.

Continuous monitoring data for $PM_{2.5}$ will be validated by Ramboll prior to delivery to ETCOG and TCEQ.

21.1.1 Data Review

If an operator notes any unusual or nonstandard conditions, the operator enters the information in the electronic log, which is reviewed by the data validators. The data validators then determine how these conditions impact the data. Data validators may reject the data based on entries in the operator logs on a case-by-case basis. If, during a review of the ambient data, the data validator discovers abnormal concentrations as compared to expected values based on knowledge of past data, meteorology, and other conditions, the data validator checks electronic logs, span checks, calibrations, and quality control records to determine if there is a reason to invalidate the data in question.

22.0 Reconciliation With Data Quality Objectives

Problems with potential limitations of the data are handled by field technicians, who have prime responsibility for routine field calibrations and sampler repairs, data validators, who monitor the status of the site on a regular basis, and by users of data, such as the QA and Laboratory Support (1.5) and Monitoring Data Management and Validation (1.6) teams who may have questions or want to verify the data quality objectives with a data validator or staff at a later date after data is processed. Issues are reconciled at the lowest level and earliest time possible. The mechanisms for communication between the producers and users of data are the telephone, and the operator's log in the monitoring station data logger.

The validators, analysts, and data managers are empowered to review and question any part of the measurement process and may initiate data reviews and corrective actions to bring the process back into compliance.

To assess the quality of the data produced during the monitoring efforts, the precision, accuracy, and completeness will be assessed in comparison to the data quality objectives as discussed in Section 4 and listed in Appendix A.

22.1 Detection Limits

The detection limits for these methods are specified in 40 *CFR* Part 53.

22.2 Precision

Precision for each method is expected to be determined using the procedures outlined in 40 *CFR* 58, Appendix A.

22.2.1 $PM_{2.5}$

Precision of the BAM 1022 equipment will be assessed with the results of the monthly one-point flow rate verifications. For each monthly flow rate check, the percent difference is calculated with *Equation 1*, where *meas* is the value indicated by the monitor's volume measurement and *audit* is the actual volume indicated by the auditing flow meter. The absolute volume bias upper bound is then calculated using *Equation 2*, where *n* is the number of flow rate audits being aggregated; $t_{0.95,n-1}$ is the 95th quantile of a t-distribution with n-1 degrees of freedom; the quantity *AB* is the mean of the absolute values of d_i and is calculated using *Equation 3* of this section; and the quantity *AS* in *Equation 2* of this section is the standard deviation of the absolute values of d_i and is calculated using *Equation 4* of this section.

Equation 1

$$d_i = \frac{meas - audit}{audit} * 100$$

Equation 2

$$|AB| = AB + t_{0.95,n-1} * \frac{AS}{\sqrt{n}}$$

Equation 3

$$AB = \frac{1}{n} * \sum_{i=1}^{n} |d_i|$$

Equation 4

$$AS = \sqrt{\frac{n * \sum_{i=1}^{n} |d_i|^2 - (\sum_{i=1}^{n} |d_i|)^2}{n(n-1)}}$$

22.3 Accuracy

22.3.1 $PM_{2.5}$

Accuracy of field measurements is determined during the installation and decommission checks in addition to the monthly routine checks. Field instruments are challenged by transfer standards and their accuracy is accepted or rejected.

To quantify flow rate checks probability limits are calculated from the percent differences using Equation 5 and Equation 6 of this section, where m is the mean, described in Equation 7 of this section, k is the total number of one-point flow rate verifications for the year, and S is the standard deviation of the percent differences as described in Equation 8 of this section.

Equation 5

$$Upper\ Probability\ Limit = m + 1.96 * S$$

Equation 6

$$Lower\ Probability\ Limit = m - 1.96 * S$$

Equation 7

$$m = \frac{1}{k} * \sum_{i=1}^{k} d_i$$

Equation 8

$$S = \sqrt{\frac{k * \sum_{i=1}^{k} d_i^2 - (\sum_{i=1}^{k} d_i)^2}{k(k-1)}}$$

22.4 Completeness

Data completeness is calculated as follows:

$$\%\ Completeness = \frac{Number\ of\ valid\ measurements}{Total\ possible\ measurements} \times 100$$

Appendix A

Table A1 Ambient Monitoring Measurement Data Quality Objectives

Parameter (units of measure)	Method Name or Published Reference	Analytical Technique	Sample Period	Detection Limit	Flow Accuracy	Completeness *
$PM_{2.5}$ (µg/m^3)	40 CFR 58	Beta attenuation	1 hour	<4.8 µg/m^3 (hourly, 2σ); <1.0 µg/m^3 (24 hour, 2 σ)	±2%	75%

- Completeness is defined as the number of valid measurements divided by the number of possible measurements for the monitoring period.

Appendix B

References

1. "Ambient Air Quality Surveillance." Title 40 Code of Federal Regulations Part 58.
2. "Ambient Air Monitoring Reference and Equivalent Methods." Title 40 Code of Federal Regulations Part 53.
3. *Guidance for Planning the Data Quality Objectives Process.* U.S. Environmental Protection Agency QA/G-4, Final, September 1994.
4. "National Primary and Secondary Ambient Air Quality Standards." Title 40 *Code of Federal Regulations* Part 50.
5. *Operation Manual BAM 1022 Particulate Monitor BAM 1022-9805 Rev F*. Met One Instruments Inc.
6. *Quality Assurance Handbook for Air Pollution Measurement Systems, Volume I*. U.S. Environmental Protection Agency. December 1984.
7. *Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II.* U.S. Environmental Protection Agency. January 2017.
8. *Quality Management Plan*. Texas Natural Resource Conservation Commission, August 1996.
9. *Requirements for Quality Assurance Project Plans for Environmental Data Operations*
10. U.S. Environmental Protection Agency QA/R-5.
11. Title 40 *Code of Federal Regulations*, Part 58, Appendices A-E.

FY24-25
Contract 582-24-01388
Subtask 2

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December 4, 2024

Level IV Quality Assurance Project Plan (QAPP) for Task 3.3 (Data Analysis)

PREPARED UNDER A GRANT FROM THE
TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

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The content, findings, opinions and conclusions are the work of the author(s) and do not necessarily represent findings, opinions or conclusions of the TCEQ.

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Level IV Quality Assurance Project Plan (QAPP) for Task 3.3 (Data Analysis)

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CONTENTS

List of Acronyms and Abbreviations **ii**
1.0 Project Description and Objectives **1**
1.1 Background 1
1.2 Project Objectives 2
2.0 Project Organization and Responsibilities **2**
2.1 Responsibilities of Project Participants 2
2.2 Project Schedule 2
3.0 Scientific Approach **2**
3.1 Data Needed to Meet the Project Objectives 2
3.2 Data Sources 3
4.0 Quality Metrics **3**
4.1 Data Quality Requirements 3
4.2 Data Quality Audits 3
5.0 Data Analysis, Interpretation and Management **3**
5.1 Data Reporting Requirements 3
5.2 Data Interpretation, Summary and Analysis 3
5.3 Data Storage Requirements 4
6.0 Reporting **4**
6.1 Project Documentation Requirements 4
6.2 Final Project Deliverables 4
7.0 References **4**

Table of Tables

Table 2-1. Ramboll project team participants and their responsibilities. 2
Table 2-2. Summary of project schedule and milestones. 2

List of Acronyms and Abbreviations

CAMS	Continuous Air Monitoring Station
EPA	Environmental Protection Agency
ETCOG	East Texas Council of Governments
HMS	NOAA Hazard Mapping System
NNA	Near Non-Attainment Area
NOAA	National Oceanic and Atmospheric Administration
QAPP	Quality Assurance Project Plan
PM2.5	Fine Particulate Matter
SIP	State Implementation Plan (for the ozone NAAQS)
TCEQ	Texas Commission on Environmental Quality
TLMA	Tyler-Longview-Marshall-Athens

Distribution List

Quality Assurance Project Plan Officer, Texas Commission on Environmental Quality

Bridget Booty, East Texas Council of Governments

1.0 Project Description and Objectives

Ramboll has prepared this Level IV Quality Assurance Project Plan (QAPP) for the Texas Commission on Environmental Quality (TCEQ The nature of the technical analysis and tasks to be conducted as part of this project are consistent with quality assurance (QA) Category IV: "projects involving applied research or technology evaluations." The specific nature of the technical analysis and tasks to be conducted as part of this project falls under "Data Evaluation or Use for Secondary Purpose". The appropriate EPA guidance for this type of work was used to develop the QAPP.

1.1 Background

The Northeast Texas Near Non-Attainment Area (NNA) consists of Gregg, Harrison, Henderson, Rusk, Smith, and Upshur counties (hereafter, the Tyler-Longview-Marshall-Athens [TLMA] area). The Texas Commission on Environmental Quality (TCEQ) operates three Continuous Air Monitoring Stations (CAMS) in the TLMA area near Karnack (CAMS 85), Longview (CAMS 19) and Tyler (CAMS 82), as shown in **Figure 1-1**.

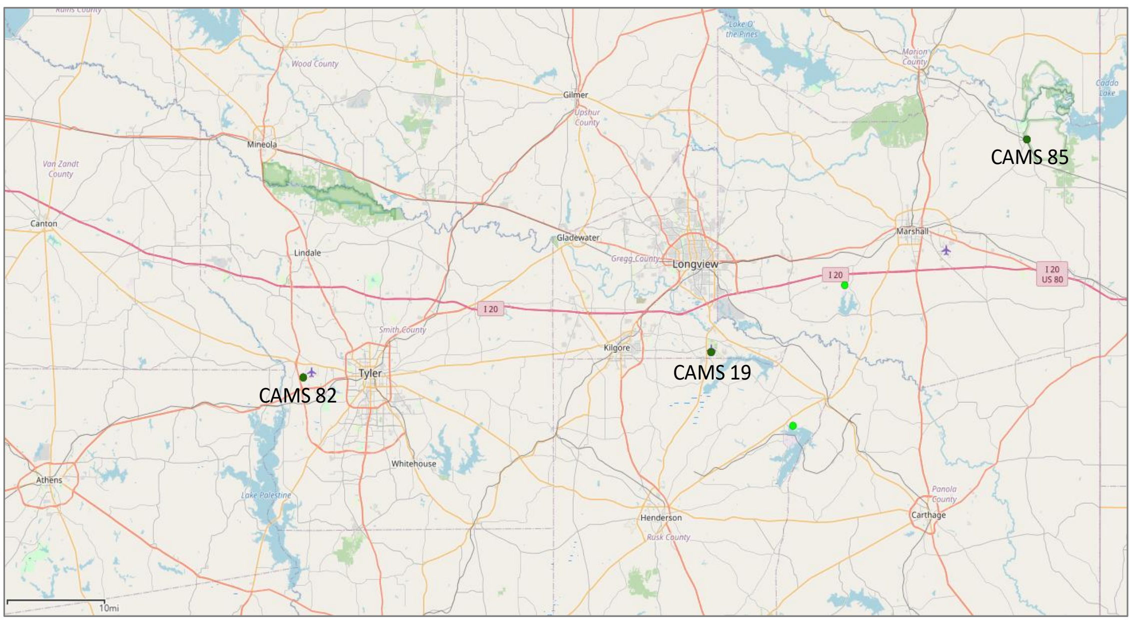

Figure 1-1. Locations of CAMS 82, 19, and 85 in Northeast Texas also showing roads and urban areas (Map from TCEQ GeoTAM[1]).

Fine particulate matter (PM2.5) concentrations vary by location and time of year because they depend on emission sources, meteorological factors, and the extent to which chemistry in the atmosphere produces secondary PM2.5. The Karnack (CAMS 85) monitoring site is the only TCEQ CAMS measuring PM2.5 in the TLMA area and there is a need for PM2.5 monitoring data at more locations to understand spatial variation.

The TCEQ awarded a Rider 7 PM2.5 Local Air Quality Planning Grant (582-24-01388) to the East Texas Council of Governments (ETCOG). Ramboll is supporting ETCOG by performing several technical activities funded by this Rider 7 grant. For Rider 7 Subtask 3.2, Ramboll will measure PM2.5 concentrations adjacent to Tyler CAMS 82 from April to August 2025. For Subtask 3.3, Ramboll will

[1] TCEQ GeoTAM accessed at: TCEQ GeoTam map

analyze the PM2.5 monitoring data collected in Subtask 3.2 near Tyler (CAMS 82) together with TCEQ data at Karnack (CAMS 85) to understand variations in PM2.5 concentrations across the TLMA area. For Subtask 3.4, Ramboll will apply Machine Learning (ML) modeling to investigate potential contributions of local emission sources to PM2.5 levels at Tyler (CAMS 82) and Karnack (CAMS 85). This QAPP is for Subtasks 3.3.

1.2 Project Objectives

The overall goal of Rider 7 Subtask 3.3 is to better understand source contributions to PM2.5 in the TLMA area. Subtask 3.3 will apply traditional data analysis methods for PM2.5 to characterize the spatial and temporal patterns of PM2.5 pollution in the TLMA area and draw conclusions about the likely influences of local and regional sources of PM2.5 pollution.

2.0 Project Organization and Responsibilities

2.1 Responsibilities of Project Participants

This study will be conducted by Ramboll under contract to the ETCOG through ETCOG's Rider 7 Local Air Quality Planning Grant from the TCEQ. The ETCOG project manager for this work is Bridget Booty. The Ramboll team working on this project and their specific responsibilities are listed below.

Table 2-1. Ramboll project team participants and their responsibilities.

Participant	Project Responsibility
Greg Yarwood (Ramboll)	Principal in charge: project oversight; technical consultant; reviewer including quality assurance review; and coordination with other Rider 7 Subtasks
Jeremiah Johnson (Ramboll)	Project manager: oversee day-to-day project activities; direct other Ramboll staff and provide guidance; lead project reporting activities.
Liji David (Ramboll)	Perform data analysis for Subtask 3.3; Contribute to Subtask 3.3 final report.

In addition, ETCOG and TCEQ staff will review the technical documentation generated during this project.

2.2 Project Schedule

In this project Ramboll will analyze PM2.5 monitoring, emissions, and other data. Table 2-2 below shows the overall schedule for completion of this project.

Table 2-2. Summary of project schedule and milestones.

Work Element	Completion Date
QAPP submitted to the TCEQ for review and approval	November 7, 2024
Draft report for Subtask 3.3 (Deliverable 3.3)	September 30, 2025
Final report for Subtask 3.3 (Deliverable 3.3)	October 31, 2025

3.0 Scientific Approach

3.1 Data Needed to Meet the Project Objectives

Ramboll will perform data analysis to investigate the likely influences of local and regional sources on PM2.5 pollution in the TLMA area.

In Subtask 3.3, we will characterize the spatial and temporal patterns of PM2.5 pollution in the TLMA area. For dates when elevated PM2.5 levels occurred across the TLMA area, ETCOG will use data from the National Oceanic and Atmospheric Administration (NOAA) Hazard Mapping System (HMS) Fire and Smoke Product to assess whether fire smoke likely contributed to PM2.5.

These activities will benefit the Texas State Implementation Plan (SIP) by better understanding the influences of local and regional sources of PM2.5 pollution in the TLMA area.

3.2 Data Sources

(1) PM2.5 monitoring data for Tyler (CAMS 82) will be obtained from Rider 7 Task 3.2.

(2) PM2.5 monitoring data for Karnack (CAMS 85) will be obtained from the TCEQ (https://www.tceq.texas.gov/cgi-bin/compliance/monops/select_year.pl).

(3) Meteorological data for both CAMS82 and CAMS 85 will be obtained from the TCEQ (https://www.tceq.texas.gov/cgi-bin/compliance/monops/select_year.pl).

(4) NOAA HMS data will be obtained from https://www.ospo.noaa.gov/products/land/hms.html.

4.0 Quality Metrics

4.1 Data Quality Requirements

There are no project-specific secondary data quality requirements. All data to be accessed, analyzed, and reported in this project have been, or will be, developed by the TCEQ, NOAA, or Rider 7 Subtask 3.2, each subject to their own independent quality assurance methods and programs.

4.2 Data Quality Audits

Portions of the data accessed and developed in this study will be audited by direct inspection of the data files and graphical products. The quality assurance procedures and results will be discussed in the project Final Report. Data and plots will be assessed for conceptual consistency using expert scientific/engineering judgment. Any data, plots or information that are qualitatively identified as outliers beyond reasonable expectations will be identified and excluded from the analyses and final deliverables.

5.0 Data Analysis, Interpretation and Management

5.1 Data Reporting Requirements

There are no project-specific secondary data reporting requirements.

5.2 Data Interpretation, Summary and Analysis

Ramboll will perform the following analyses for Subtask 3.3:

- Maps comparing average PM2.5 at CAMS 82 and CAMS 85 to investigate spatial patterns across the TLMA area.

- Time-series of 24-hour average PM2.5 at both PM2.5 monitor locations to investigate temporal correlation between PM2.5 monitors and identify time periods with high PM2.5 across the region or at an individual monitor.

- Table of the top 10 PM2.5 readings and occurrence date at both locations.
- If either PM2.5 monitoring location records PM2.5 levels substantially higher than the TLMA area average, prepare a map showing the locations of nearby PM2.5 point sources and major roads together with a wind rose showing the prevalence of different wind directions.
- For dates with higher PM2.5 readings (e.g., the top 10 days), prepare maps showing the locations of CAMS 82 and CAMS 85 together with fire locations and fire smoke plumes.

Ramboll analysts will review these data products to draw conclusions about the influences of local and regional sources (including fires) on PM2.5 levels in the TLMA area during the study period.

5.3 Data Storage Requirements

Data generated for this project will be securely archived during the project on redundant hard drives and stored for a period of at least three years following the completion of the project. All data obtained for this project will be stored in electronic format.

6.0 Reporting

6.1 Project Documentation Requirements

The project documentation requirements include:

1. Monthly Progress Reports that detail accomplishments as well as any issues encountered.
2. A Final Report that provides a comprehensive description of all tasks performed in this project, technical issues, and any recommendations for further work (see below).

6.2 Final Project Deliverables

Ramboll will provide a Draft Report to ETCOG and the TCEQ electronically (i.e., via e-mail) in Microsoft Word and PDF format. The draft report will include the following components:

1. An executive summary or abstract;
2. A detailed description of all work carried out under the Subtask;
3. A detailed discussion of the analyses and findings;
4. A discussion of the pertinent accomplishments, shortfalls, and limitations; and
5. All data and analyses and an evaluation of those results.

Ramboll will address any comments received on the Draft Final Report and then provide a Final Report to ETCOG and the TCEQ.

7.0 References

None.

FY24-25
Contract 582-24-01388
Subtask 2

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Level IV Quality Assurance Project Plan (QAPP) for Task 3.4 (Modeling)

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Level IV Quality Assurance Project Plan (QAPP) for Task 3.4 (Modeling)

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CONTENTS

List of Acronyms and Abbreviations **ii**
1.0 Project Description and Objectives **1**
1.1 Background 1
1.2 Project Objectives 2
2.0 Project Organization and Responsibilities **2**
2.1 Responsibilities of Project Participants 2
2.2 Project Schedule 2
3.0 Approach **2**
3.1 Data Needed to Meet the Project Objectives 3
3.2 Data Sources 3
4.0 Model Selection **3**
5.0 Model Calibration **3**
6.0 Model Verification **4**
7.0 Model Evaluation **4**
8.0 Documentation **4**
8.1 Project Documentation Requirements 4
8.2 Final Project Deliverables 4
9.0 References **5**

Table of Tables

Table 2-1. Ramboll project team participants and their responsibilities. 2
Table 2-2. Summary of project schedule and milestones. 2

List of Acronyms and Abbreviations

CAMS	Continuous Air Monitoring Station
EPA	Environmental Protection Agency
ETCOG	East Texas Council of Governments
HMS	NOAA Hazard Mapping System
ML	Machine Learning
NNA	Near Non-Attainment Area
NOAA	National Oceanic and Atmospheric Administration
QAPP	Quality Assurance Project Plan
PM2.5	Fine Particulate Matter
SIP	State Implementation Plan (for the ozone NAAQS)
TCEQ	Texas Commission on Environmental Quality
TLMA	Tyler-Longview-Marshall-Athens

Distribution List

Quality Assurance Project Plan Officer, Texas Commission on Environmental Quality

Bridget Booty, East Texas Council of Governments

1.0 Project Description and Objectives

Ramboll has prepared this Level IV Quality Assurance Project Plan (QAPP) for the Texas Commission on Environmental Quality (TCEQ The nature of the technical analysis and tasks to be conducted as part of this project are consistent with quality assurance (QA) Category IV: "projects involving applied research or technology evaluations." The specific nature of the technical analysis and tasks to be conducted as part of this project falls under "Model Application." The appropriate EPA guidance for this type of work was used to develop the QAPP.

1.1 Background

The Northeast Texas Near Non-Attainment Area (NNA) consists of Gregg, Harrison, Henderson, Rusk, Smith, and Upshur counties (hereafter, the Tyler-Longview-Marshall-Athens [TLMA] area). The Texas Commission on Environmental Quality (TCEQ) operates three Continuous Air Monitoring Stations (CAMS) in the TLMA area near Karnack (CAMS 85), Longview (CAMS 19) and Tyler (CAMS 82), as shown in **Figure 1-1**.

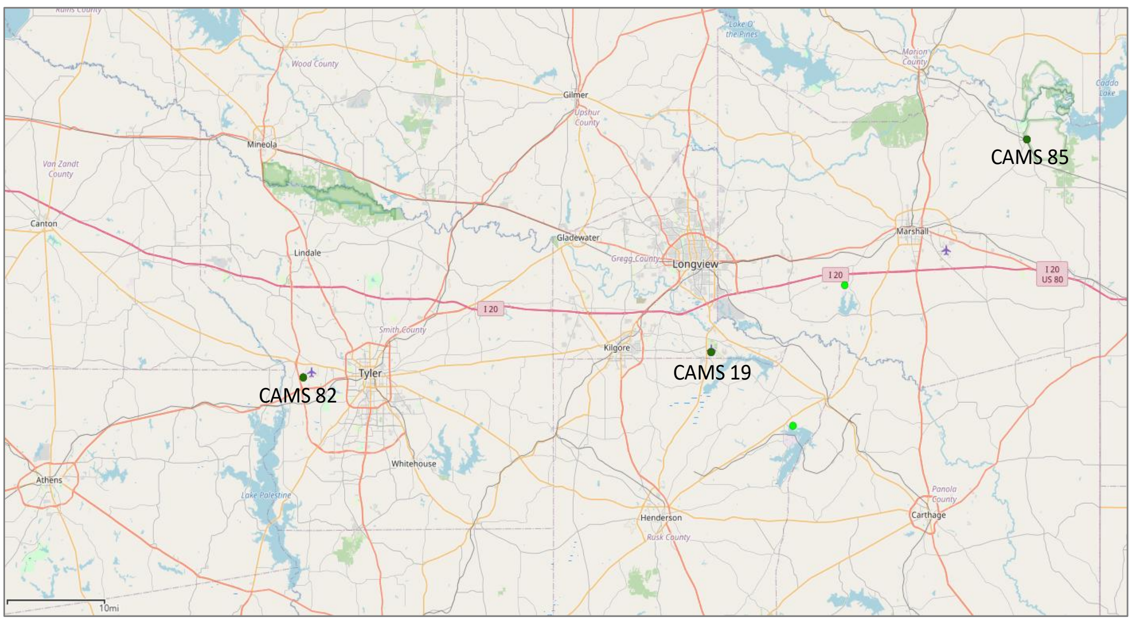

Figure 1-1. Locations of CAMS 82, 19, and 85 in Northeast Texas also showing roads and urban areas (Map from TCEQ GeoTAM[1]).

Fine particulate matter (PM2.5) concentrations vary by location and time of year because they depend on emission sources, meteorological factors, and the extent to which chemistry in the atmosphere produces secondary PM2.5. The Karnack (CAMS 85) monitoring site is the only TCEQ CAMS measuring PM2.5 in the TLMA area and there is a need for PM2.5 monitoring data at more locations to understand spatial variation.

The TCEQ awarded a Rider 7 PM2.5 Local Air Quality Planning Grant (582-24-01388) to the East Texas Council of Governments (ETCOG). Ramboll is supporting ETCOG by performing several technical activities funded by this Rider 7 grant. For Rider 7 Subtask 3.2, Ramboll will measure PM2.5 concentrations adjacent to Tyler CAMS 82 from April to August 2025. For Subtask 3.3, Ramboll will

[1] TCEQ GeoTAM accessed at: TCEQ GeoTAM map

analyze the PM2.5 monitoring data collected in Subtask 3.2 near Tyler (CAMS 82) together with TCEQ data at Karnack (CAMS 85) to understand variations in PM2.5 concentrations across the TLMA area. For Subtask 3.4, Ramboll will apply Machine Learning (ML) modeling to investigate potential contributions of local emission sources to PM2.5 levels at Tyler (CAMS 82) and Karnack (CAMS 85). This QAPP is for Subtask 3.4.

1.2 Project Objectives

The overall goal of Rider 7 Subtask 3.4 is to better understand source contributions to PM2.5 in the TLMA area. Subtask 3.4 will apply machine learning (ML) modeling to identify factors that uniquely influence the Tyler (CAMS 82) and Karnack (CAMS 85) monitors, such as being downwind from a major PM2.5 emission source or a city. The ML modeling will make use of data previously gathered for analysis in Subtask 3.3.

2.0 Project Organization and Responsibilities

2.1 Responsibilities of Project Participants

This study will be conducted by Ramboll under contract to the ETCOG through ETCOG's Rider 7 Local Air Quality Planning Grant from the TCEQ. The ETCOG project manager for this work is Bridget Booty. The Ramboll team working on this project and their specific responsibilities are listed below.

Table 2-1. Ramboll project team participants and their responsibilities.

Participant	Project Responsibility
Greg Yarwood (Ramboll)	Principal in charge: project oversight; technical consultant; reviewer including quality assurance review; and coordination with other Rider 7 Subtasks
Jeremiah Johnson (Ramboll)	Project manager: oversee day-to-day project activities; direct other Ramboll staff and provide guidance; lead project reporting activities.
Fiona Jiang (Ramboll)	Perform ML modeling for Subtask 3.4; Contribute to Subtask 3.4 final report.

In addition, ETCOG and TCEQ staff will review the technical documentation generated during this project.

2.2 Project Schedule

The project will perform ML modeling of PM2.5 monitoring data in combination with emissions and other data. Table 2-2 below shows the overall schedule for completion of this project.

Table 2-2. Summary of project schedule and milestones.

Work Element	Completion Date
QAPP submitted to the TCEQ for review and approval	November 7, 2024
Draft report for Subtask 3.4 (Deliverable 3.4)	September 30, 2025
Final report for Subtask 3.4 (Deliverable 3.4)	October 31, 2025

3.0 Approach

Ramboll will investigate what makes each PM2.5 monitoring location in the TLMA area unique by training a ML model to predict how PM2.5 at each location differs from the average PM2.5 for the TLMA region. For example, finding that rush hour periods are important at a particular PM2.5 monitor would indicate an influence of local traffic emissions. This activity will benefit the Texas State

Implementation Plan (SIP) by better understanding the influences of local and regional sources of PM2.5 pollution in the TLMA area.

3.1 Data Needed to Meet the Project Objectives

The ML modeling objective is to investigate the likely influences of local and regional sources on PM2.5 pollution at monitors within the TLMA area. Ramboll will use data gathered under a separate task (Subtask 3.3: Data Analysis) for the modeling performed in this this task. The data will include PM2.5 monitoring data, meteorological data, and data on whether fire emissions likely contributed to PM2.5 in the TLMA area. Ramboll will use data from the National Oceanic and Atmospheric Administration (NOAA) Hazard Mapping System (HMS) Fire and Smoke Product to assess whether fire smoke likely contributed to PM2.5.

3.2 Data Sources

(1) PM2.5 monitoring data for Tyler (CAMS 82) will be obtained from Rider 7 Task 3.2.

(2) PM2.5 monitoring data for Karnack (CAMS 85) will be obtained from the TCEQ (https://www.tceq.texas.gov/cgi-bin/compliance/monops/select_year.pl).

(3) Meteorological data for both CAMS82 and CAMS 85 will be obtained from the TCEQ (https://www.tceq.texas.gov/cgi-bin/compliance/monops/select_year.pl).

(4) NOAA HMS data will be obtained from https://www.ospo.noaa.gov/products/land/hms.html.

4.0 Model Selection

Ramboll will test two different types of ML model, known as "random forest" and "support vector regression" models, and select the best performing model type. A random forest (RF) regression model is an ensemble method that creates many decision trees (individual models) during training, with the overall model output being the average of the predictions of the individual models.[2] Support vector regression (SVR)[3] applies input data coordinate transformations to obtain more powerful predictors and uses model training algorithms that seek to identify the most useful subset of the training data. The resulting SVR model depends only on this subset of the training data. RF and SVR models have both found success in characterizing air pollution, e.g., the study by Liu et al. (2017) applying SVR to air pollution in Beijing which is cited by more than 100 subsequent studies, and the study by Yu et al. applying RF methods to urban PM2.5 which is cited more than 150 times.

5.0 Model Calibration

ML models are calibrated by model training. Ramboll will divide the available dataset into two portions, a larger portion for model training and a smaller portion for independent model verification. Training will use cross validation procedures to optimize ML model parameters. Ramboll will train a ML model for each location to predict how PM2.5 at that location differs from the average PM2.5, taking into consideration the meteorological factors and time of day, day of week and month of year.

[2] https://en.wikipedia.org/wiki/Random_forest
[3] https://en.wikipedia.org/wiki/Support_vector_machine

6.0 Model Verification

Ramboll will verify the ML models by using the dataset portion withheld from model training (see Section 5). Ramboll will calculate statistical metrics that quantify the model bias, model error and model correlation for the PM2.5 verification dataset. We will use a ML tool known as "feature importance" to determine what factors are most important to the ML model for each PM2.5 monitor location.

7.0 Model Evaluation

Ramboll will evaluate the ML models by considering how well they describe the measured PM2.5 levels at each location (statistical metrics, from Section 6), by considering which factors are important to the ML model predictions (feature importance, from Section 6), and by comparing the model results to inferences drawn from traditional data analysis performed under Subtask 3.3.
Ramboll analysts will review modeling and data analysis results together to draw conclusions about the influences of local and regional sources (including fires) on PM2.5 levels in the TLMA area during the study period. For example, finding that rush hour periods are important would indicate that the location is influenced by traffic emissions. Finding that a particular wind direction is important may indicate importance of a local source(s).

8.0 Documentation

8.1 Project Documentation Requirements

The project documentation requirements include:

1. Monthly Progress Reports that detail accomplishments as well as any issues encountered.

2. A Final Report that provides a comprehensive description of all tasks performed in this project, technical issues, and any recommendations for further work (see below).

8.2 Final Project Deliverables

Ramboll will provide a Draft Report to ETCOG and the TCEQ electronically (i.e., via e-mail) in Microsoft Word and PDF format. The draft report for each Subtask will include the following components:

1. An executive summary or abstract;

2. A detailed description of all work carried out under the Subtask;

3. A detailed discussion of the analyses and findings;

4. A discussion of the pertinent accomplishments, shortfalls, and limitations; and

5. All data and analyses and an evaluation of those results.

Ramboll will address any comments received on the Draft Final Report and then provide Final Report to ETCOG and the TCEQ.

9.0 References

Liu, B.C., Binaykia, A., Chang, P.C., Tiwari, M.K. and Tsao, C.C., 2017. Urban air quality forecasting based on multi-dimensional collaborative Support Vector Regression (SVR): A case study of Beijing-Tianjin-Shijiazhuang. PloS one, 12(7), p.e0179763.

Yu, R., Yang, Y., Yang, L., Han, G. and Move, O.A., 2016. RAQ–A random forest approach for predicting air quality in urban sensing systems. *Sensors*, *16*(1), p.86.

APPENDIX D

Final Report for Subtask 3.1: Review of $PM_{2.5}$ Emission Inventory for Northeast Texas

Contract 582-24-01388
Subtask 3.1

Prepared for:

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August 2025

Final Report: Review of $PM_{2.5}$ Emission Inventory for Northeast Texas

Final Report: Review of PM2.5 Emission Inventory for Northeast Texas

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Contents

List of Acronyms and Abbreviations **iii**

Executive Summary **1**

1 Introduction **3**
1.1 The Tyler-Longview-Marshall-Athens Area 3
1.2 Background and Purpose 5
1.2.1 $PM_{2.5}$ Air Quality Status in the Tyler-Longview-Marshall Athens Area 5
1.3 All Source Emissions Overview 6
1.4 Anthropogenic Source Emissions Overview 6

2 Point Source Emissions Review **8**
2.1 2022 Point Source Emissions 8
2.2 Point Source Emission Trends 11

3 Prescribed Fires and Agricultural Burning Review **13**

4 Area Source Emissions Review **16**
4.1 Open Burning 18
4.2 Fugitive Dust 19
4.3 Commercial Cooking 23
4.4 Residential Wood Combustion 23

5 On-road Source Emissions Review **24**

6 Off-Road Source Emissions Review **25**

7 Conclusions and Recommendations **27**

8 References **28**

Table of Figures

Figure 1-1. The six county TLMA area, location of CAMS monitors in the area with urban areas and major roadways in the surrounding region. 3

Figure 1-2. TLMA area 2022 $PM_{2.5}$ annual average daily emissions by source category (tons/day). 6

Figure 1-3. TLMA area 2022 anthropogenic $PM_{2.5}$ annual average daily emissions by county (tons/day). 7

Figure 2-1. TLMA area 2022 annual average daily $PM_{2.5}$ point source emissions. 9

Figure 2-2. Breakout maps of TLMA area 2022 annual average daily $PM_{2.5}$ point source emissions. 10

Figure 2-3. 2017 to 2022 TLMA area $PM_{2.5}$ annual average daily point source emissions trends (tons/day). 12

Figure 3-1. TLMA area 2022 $PM_{2.5}$ annual average daily anthropogenic fire emissions by source category (tons/day). 13

Figure 4-1. TLMA area 2022 $PM_{2.5}$ annual average daily area source emissions by source category (tons/day). 17
Figure 4-2. TLMA area 2022 $PM_{2.5}$ annual average daily area source emissions by county (tons/day). 17
Figure 4-3. TLMA area 2022 $PM_{2.5}$ annual average daily open burning emissions by county (tons/day). 18
Figure 4-4. TLMA area 2022 $PM_{2.5}$ annual average daily fugitive dust emissions by county (tons/day). 20
Figure 5-1. TLMA area 2022 $PM_{2.5}$ annual average daily on-road emissions by source type (tons/day). 24
Figure 6-1. TLMA area 2022 $PM_{2.5}$ annual average daily off-road emissions (tons/day). 25

Table of Tables

Table 2-1. Top emitting $PM_{2.5}$ point sources during 2022 in the TLMA area. 11
Table 3-1. Prescribed fires and agricultural field burning annual average daily $PM_{2.5}$ emissions. 14
Table 3-2. Prescribed fire 2022 burned area (acres) by county and fuel type. 14
Table 3-3. Prescribed fire 2022 burned area contributions (percent of area) by county and fuel type.[14] 15
Table 3-4. Prescribed fire annual average daily $PM_{2.5}$ emissions (tons/day) by county and fuel type. [14] 15
Table 3-5. Prescribed fire annual average $PM_{2.5}$ emissions contributions (percent of emissions) by county and fuel type. [14] 15
Table 4-1. Open burning emission inventory basis, inputs, and potential local improvements. 19
Table 4-2. Paved roads, unpaved roads, and agricultural livestock and tilling emission inventory basis, inputs, and potential local improvements. 21
Table 4-3. TLMA area commercial cooking annual average daily 2022 $PM_{2.5}$ emissions. 23

List of Acronyms and Abbreviations

$\mu g/m^3$	Micrograms per cubic meter
2022v1	2022 version 1 modeling platform
CBSA	Core-based statistical area
CO	Carbon monoxide
CDB	County database
EGU	Electrical generating unit
EPA	US Environmental Protection Agency
ETCOG	East Texas Council of Governments
FHWA	Federal Highway Administration
GFAS1.2	Global Fire Assimilation System version 1.2
MOVES	MOtor Vehicle Emissions Simulator
NAAQS	National Ambient Air Quality Standards
NASS	National Agricultural Statistics Service
NEI	National emission inventory
NOx	Nitrogen oxides
$PM_{2.5}$	Particulate matter 2.5 microns or less in diameter
PM_{10}	Particulate matter 10 microns or less in diameter
RAVE2.0	Regional ABI and VIIRS fire Emissions version 2.0
RWC	Residential wood combustion
SIC	Standard industrial classification
SMOKE	Sparse matrix operator kernel emissions
SO_2	Sulfur dioxide
SIP	State implementation plan
STARS	State of Texas Air Reporting System
TAC	Texas Administrative Code
TCEQ	Texas Commission on Environmental Quality
TLMA	Tyler-Longview-Marshall-Athens
TPD	Tons per day
TPY	Tons per year
USDA	US Department of Agriculture
VOC	Volatile organic compounds
VMT	Vehicle miles traveled

Executive Summary

The purpose of this study is to review the US Environmental Protection Agency's (EPA's) 2022 version 1 modeling platform (2022v1) calendar year 2022 emission inventory for the Tyler-Longview-Marshall-Athens (TLMA) area on behalf of the East Texas Council of Governments (ETCOG). The aim of the review is to identify sources of emissions that are under- or over-estimated, accompanied by high levels of uncertainty, or for which more detailed emissions inventory input at the sub-county level can be provided. Ramboll reviewed emissions of particulate matter that is 2.5 microns or less in diameter ($PM_{2.5}$) for the 6-county TLMA area comprised of Gregg, Harrison, Henderson, Rusk, Smith, and Upshur counties. This study will benefit the State Implementation Plan (SIP) by informing the basis of the TLMA area emissions in the 2022v1 emission inventory and providing recommendations to improve the accuracy of the TLMA area emission inventory.

We performed the following tasks during the emission inventory review:

1. Extracted $PM_{2.5}$ emissions for the TLMA area from the 2022v1 emission inventory and determined the breakdown of $PM_{2.5}$ emissions by source category;
2. Evaluated recent $PM_{2.5}$ emissions trends for point sources;
3. Reviewed the available 2022v1 emission inventory documentation (EPA, 2024) and supporting files to determine the basis of $PM_{2.5}$ emissions;
4. Identified sources of emissions that are highly uncertain, missing from the inventory or are not currently well-characterized.

Based on Ramboll analyses presented herein, the 2022v1 $PM_{2.5}$ emission inventory for point, prescribed fires and agricultural burning, area, on-road, off-road, and off-road sources are generally accurate and complete in the context of current understanding. Ramboll did not find any emission source categories for which more detailed emissions inventory input at the sub-county level was readily available. Recommendations for emission inventory improvements are all low priority. Ramboll did not make any high priority recommendations because there are no emission inventory improvement recommendations that are expected to result in large changes to the emission inventory. Improvements are expected to result in limited and/or small changes to the TLMA area $PM_{2.5}$ emission inventory. This is the first close review of the TLMA area $PM_{2.5}$ emission inventory; we did not apply checks to ensure that all facilities that should be categorized as point sources have been captured in the point source emission inventory.

Ramboll recommends the following steps to improve the 2022v1 TLMA area emission inventory.

- **Prescribed fires and agricultural burning:** Consider updates based on Texas Commission on Environmental Quality (TCEQ) model performance evaluations of candidate fire emission inventories.
- **Area Sources:** Consider refinements to specific area source emission estimation inputs to refine TLMA area emissions based on local data:
    - **Open burning, residential household waste**: Consider implementing state or local estimates for waste generation per capita and the fraction of the rural population that burns their waste, if not already incorporated into TCEQ's emission estimation approach; ensure that residential household waste emissions in Gregg County are not inadvertently omitted
    - **Open burning, land clearing debris**: Consider leveraging county-level burn data, if available

- **Fugitive dust, paved roads**: Consider developing local inputs for silt loading, average vehicle weight by roadway type, and controls application (if any) if not already incorporated into TCEQ's emission estimation approach
- **Fugitive dust, unpaved roads**: Consider developing local inputs for unpaved roadway VMT, surface material silt content, surface moisture content, and controls application (if any) if not already incorporated into TCEQ's emission estimation approach
- **Fugitive dust, agricultural tilling**: Consider implementing recent TLMA area crop acreage information, as available
- **Fugitive dust, agricultural livestock**: Consider implementing recent TLMA area livestock counts, as available
- **Commercial cooking**: Ensure that deep fat frying emissions are included in the emission inventory

1 Introduction

1.1 The Tyler-Longview-Marshall-Athens Area

This emission inventory analysis focuses on the TLMA area within the ETCOG area in Texas. The TLMA area includes Gregg, Harrison, Henderson, Rusk, Smith, and Upshur counties. Figure 1-1 displays the TLMA area's major roadways, urban areas, and the TCEQ-operated continuous air monitoring system (CAMS) locations. Currently the Karnack CAMS 85 monitor is the only monitor that measures $PM_{2.5}$. The total population in the TLMA area in 2023 was 621,545[1]. The City of Tyler, located in Smith County, and the City of Longview, located in Gregg County, are the largest cities in the TLMA area with 2023 populations of 110,203 and 83,202, respectively[1]. Smith County comprises the Tyler core-based statistical area (CBSA) and had a population of 244,908 in 2023, representing 39% of the population in the TLMA area[1]. Gregg, Harrison, Rusk, and Upshur counties comprise the Longview CBSA and together had a population of 290,956 in 2023[1], representing 47% of the population in the TLMA area. Henderson County is part of the Athens CBSA and had a population of 85,681[1] in 2023, representing 11% of the population in the TLMA area.

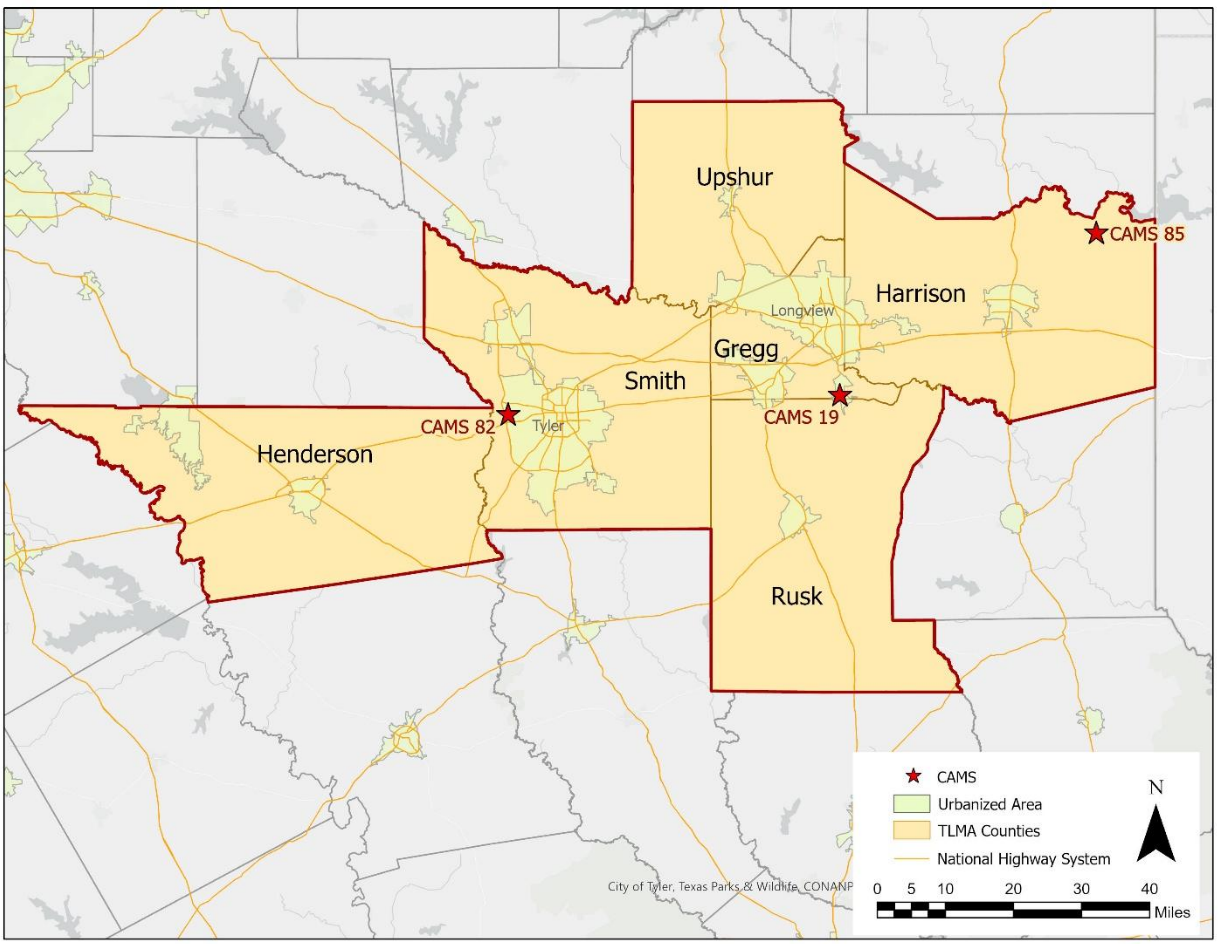

Figure 1-1. The six county TLMA area, location of CAMS monitors in the area with urban areas and major roadways in the surrounding region.

[1] Texas Demographic Center. "2023 Population Estimates: Texas Population Estimates Program". https://demographics.texas.gov/Estimates/2023/. Accessed February 2025.

Emissions inventories are used to assess the nature of an area's ambient air $PM_{2.5}$ pollution problems and can help answer questions such as: (1) what are the major contributors to regional ambient air $PM_{2.5}$ pollution; and (2) which types of emissions sources are good candidates for emissions controls that would reduce the area's ambient air $PM_{2.5}$ pollution levels. Ambient $PM_{2.5}$ pollution may be directly emitted as primary $PM_{2.5}$ or formed in the atmosphere as secondary $PM_{2.5}$ through chemical reactions of gases such as sulfur dioxide (SO_2), nitrogen oxides (NOx), and organic compounds. The purpose of this study is to review the most recent historical primary $PM_{2.5}$ emission inventory available for the TLMA area in order to identify sources of primary $PM_{2.5}$ emissions that are under- or over-estimated, accompanied by high levels of uncertainty, or for which more detailed emissions inventory input at the sub-county level can be provided. Review of the most recent emission inventory will allow for a better understanding of the completeness and accuracy of the anthropogenic $PM_{2.5}$ emission inventory for the TLMA area and prioritization of emission inventory updates to support air quality planning.

Several types of emissions sources are described in this review. Point sources are large stationary emissions sources that exceed a specified emissions threshold and therefore are tracked individually in the emissions inventory. Area sources are sources that may be spread out geographically and are small individually (such as roadway fugitive dust), but, taken together, may constitute a sizeable amount of emissions. On-road vehicle emissions are from light duty (e.g., passenger cars and light trucks) and heavy duty (medium- and heavy-duty trucks and buses) vehicles licensed or certified for highway use. Off-road mobile source emissions are from mobile and portable internal combustion-powered equipment not generally licensed or certified for highway use. Fire emissions include wildfires and anthropogenic fires such as prescribed fires and agricultural burning. Wildfire emissions are included within the overall emission source overview for completeness but were not further analyzed as the focus of this analysis is anthropogenic emissions.

Per TCEQ's recommendation[2], Ramboll reviewed the EPA's 2022v1[3] emission inventory for the TLMA area. The 2022v1 emission inventory was analyzed because it is the most recent historical year emission inventory developed for use in air quality planning. The 2022v1 emission inventory was downloaded from EPA's data files and summaries[4]. Available sparse matrix operator kernel emissions (SMOKE) input flat files were used as the basis for all emissions except fugitive dust. SMOKE input files included fugitive dust emissions that do not account for emission reductions resulting from precipitation and transport adjustments; therefore, fugitive dust emissions were taken from a separate summary that included the final, adjusted emissions[5].

In this report we summarize the EPA 2022v1 emission inventory for the TLMA area, examine emissions estimation methodology and identify emissions categories that are overestimated or underestimated, accompanied by high levels of uncertainty, or for which more accurate or detailed emissions are available. The 2022v1 emission inventory is summarized in the following sections:

Section 1: All Sources
Section 2: Point Sources
Section 3: Prescribed Fires and Agricultural Burning Sources
Section 4: Area Sources
Section 5: On-road Sources
Section 6: Off-road Sources

[2] Email from TCEQ (Shantha Daniel) to Ramboll (John Grant). December 19, 2024.
[3] EPA 2022v1 Modeling Platform, https://www.epa.gov/air-emissions-modeling/2022v1-emissions-modeling-platform, Accessed January 2025.
[4] EPA 2022v1 Data Files and Summaries, https://gaftp.epa.gov/Air/emismod/2022/v1/. Accessed January 2025.
[5] EPA 2022v1 Fugitive Dust Adjustments Report, https://gaftp.epa.gov/Air/emismod/2022/v1/reports/nonpoint/2022v1_afdust_adjustments_report.xlsx. Accessed January 2025.

1.2 Background and Purpose

The EPA sets National Ambient Air Quality Standards (NAAQS) for ambient $PM_{2.5}$ pollution. Primary standards protect public health and secondary standards protect public welfare (e.g., visibility, damage to animals, crops, vegetation, and buildings). Under the Clean Air Act, the EPA is required to review the NAAQS periodically for both long-term (annual average, averaged over 3 years) and short-term (daily average, 98th percentile in each year) concentrations. On February 7, 2024, EPA lowered the annual average $PM_{2.5}$ standard for outdoor air from 12 micrograms per cubic meter ($\mu g/m^3$) to 9 $\mu g/m^3$ effective from May 6, 2024. The daily $PM_{2.5}$ standard (35 μg/m3) and secondary $PM_{2.5}$ standards did not change as part of this reconsideration.

Compliance with the NAAQS is assessed at an individual monitor by comparing the monitor's Design Value to the NAAQS. For $PM_{2.5}$, the monitor Design Value is calculated as the 3-year annual average of $PM_{2.5}$ values[6]. Failure to comply with the NAAQS can adversely affect public health and inhibit economic development. To ensure that the TLMA area meets the $PM_{2.5}$ NAAQS, $PM_{2.5}$ air quality planning is important.

1.2.1 $PM_{2.5}$ Air Quality Status in the Tyler-Longview-Marshall Athens Area

The TCEQ operates one continuous air monitoring station (Karnack CAMS 85) in the TLMA area that determines whether the area is in compliance with the $PM_{2.5}$ NAAQS. The location of this monitor is shown above in Figure 1-1. The Design Value is the annual mean concentration, averaged over three consecutive years. EPA estimated a Design Value of 9.5 $\mu g/m^3$ for the 2021 to 2023 period which is above the 9.0 $\mu g/m^3$ standard[7].

Within two years of setting a new or revised NAAQS, the Clean Air Act requires the EPA to designate areas as meeting (attainment) or not meeting (nonattainment) the standard[8]. The Governor of Texas can submit initial area designation recommendations to EPA within twelve months of the revised NAAQS which became effective on May 6, 2024. This recommendation can include whether to designate the Karnack monitor (CAMS 85) as being in attainment or nonattainment and for a nonattainment recommendation what geographic area surrounding CAMS 85 should comprise a nonattainment area.

The EPA suggests that states evaluate five factors in developing $PM_{2.5}$ nonattainment area recommendations: Air Quality Data, Emissions and Emissions-related Data, Meteorology, Geography/Topography, and Jurisdictional Boundaries.

If the EPA plans to issue a designation that modifies a state recommendation, the EPA must notify the state no later than 120 days before the final designation. Thus, the attainment status of the CAMS 85 monitor and, if necessary, the geographic area of a surrounding nonattainment area is expected to be determined within the next 2 years.

[6] EPA. Air Quality Deign Values. https://www.epa.gov/air-trends/air-quality-design-values. Accessed February 2025.
[7] EPA. $PM_{2.5}$ Design Values, 2023. https://www.epa.gov/system/files/documents/2024-08/pm25_designvalues_2021_2023_final_08_08_24_0.xlsx. Accessed February 2025.
[8] EPA. Learn About Particle Pollution Designations. https://www.epa.gov/particle-pollution-designations/learn-about-particle-pollution-designations-0. Accessed February 2025.

1.3 All Source Emissions Overview

TLMA area 2022 $PM_{2.5}$ emissions from the EPA 2022v1 emission inventory are summarized below to establish the relative importance of $PM_{2.5}$ emissions by sector. Figure 1-2 shows the 2022 annual average daily $PM_{2.5}$ emissions by source category in the TLMA area in tons per day (tpd).

In the TLMA area, the largest $PM_{2.5}$ emission sources are prescribed fires and agricultural burns (50%), area sources (23%), and point sources (19%), together accounting for 92% of all $PM_{2.5}$ emissions. The remaining source categories include wildfires (5%), on-road sources (2%), and off-road sources (2%).

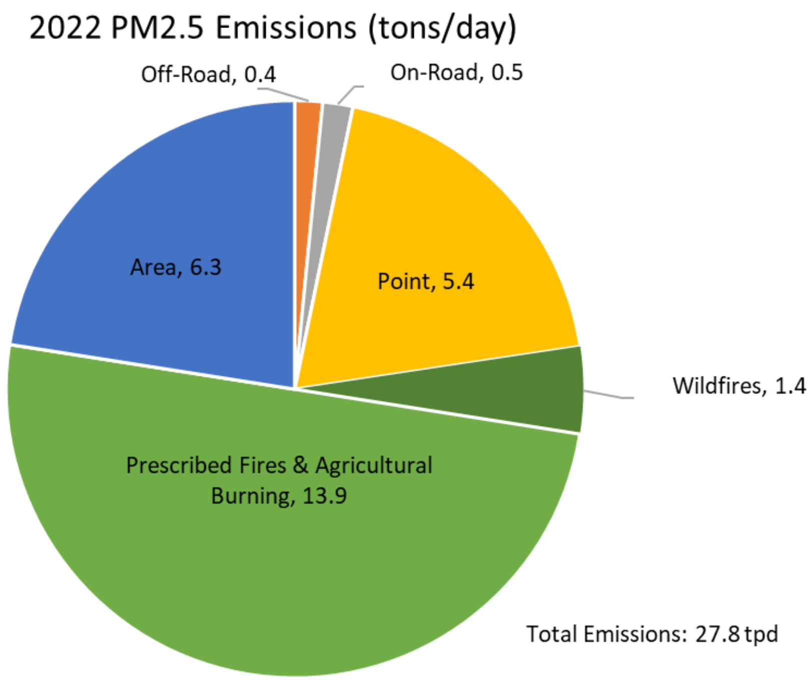

Figure 1-2. TLMA area 2022 $PM_{2.5}$ annual average daily emissions by source category (tons/day).

1.4 Anthropogenic Source Emissions Overview

The EPA 2022v1 anthropogenic emission inventory is summarized below to establish the geographical distribution of point source, area source, anthropogenic fires, on-road, and off-road emissions in the TLMA area. Wildfires have been excluded from the anthropogenic emission inventory. Figure 1-3 shows $PM_{2.5}$ emissions by county for all anthropogenic sources.

87% of the 2022 TLMA area anthropogenic $PM_{2.5}$ emissions are distributed across four counties, Henderson (26%), Rusk (25%), Harrison (19%), and Smith (17%), with smaller contributions from the remaining two counties of 9% (Upshur) and 5% (Gregg). Fires emissions comprise the largest portion of emissions in Harrison (52%), Henderson (80%), and Upshur (69%) counties. Area source emissions comprise the largest portion of emissions in Gregg (42%) and Smith (45%) counties. Point source emissions comprise the largest portion of emissions in in Rusk County (54%). Emissions from on-road and off-road sources are relatively small across all counties.

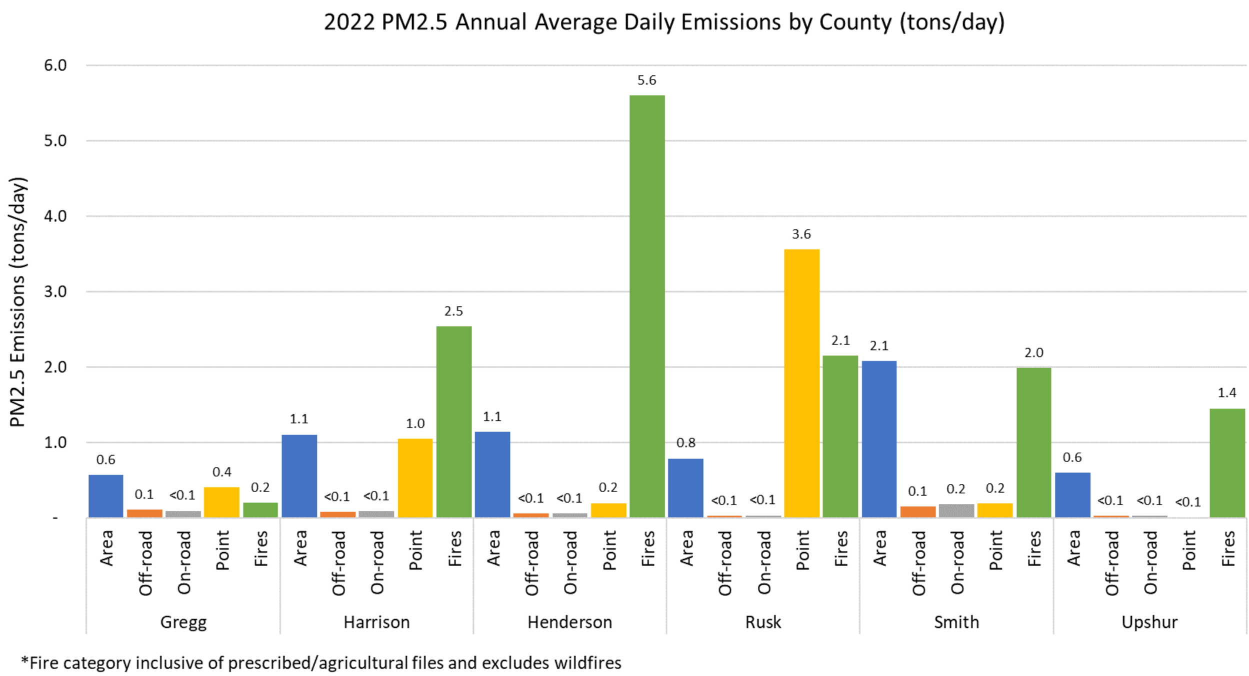

Figure 1-3. TLMA area 2022 anthropogenic $PM_{2.5}$ annual average daily emissions by county (tons/day).

2 Point Source Emissions Review

Point sources are stationary emissions sources that must report their emission data because they exceed a specified emissions threshold. In nonattainment areas, the TCEQ defines a point source to be any industrial, commercial or institutional source that emits actual levels of criteria pollutants at or above the following amounts: 10 tons per year (tpy) of volatile organic compounds (VOC); 25 tpy of NOx; or 100 tpy of any of the other criteria pollutants including carbon monoxide (CO), SO_2, particulate matter that is 10 microns or less in diameter (PM_{10}), or $PM_{2.5}$. In attainment areas of the state, such as the TLMA area, any facility that emits a minimum of 100 tpy of any criteria pollutant must submit a point source emissions inventory to the TCEQ. Point source emissions are frequently but not always released through an exhaust stack. Each point source has a well-defined location (latitude and longitude) as well as ancillary information known as stack parameters that indicate the height at which emissions are released, the diameter of the emitting stack and other factors.

2.1 2022 Point Source Emissions

Detailed documentation of the basis of the 2022v1 modeling platform point source emissions inventory was not available at the time of writing this report. EPA (2024) states that electrical generating unit (EGU) and industrial point source emissions are based on EPA's 2022 National Emission Inventory (NEI).

The TLMA area 2022 point source $PM_{2.5}$ emission inventory is summarized below in several different ways to establish (1) the geographical distribution of point source emissions, (2) the relative importance of point source emissions by industry and (3) the relative importance of emissions sources by the mass of pollutants emitted.

Point sources are the third largest contributor of $PM_{2.5}$ emissions in the TLMA area, accounting for 5.4 tpd (20%) of 2022 total anthropogenic $PM_{2.5}$ emissions in the TLMA area.

Figure 2-1 shows the location of TLMA area point sources in the 2022v1 emission inventory. The area of the facility location circle reflects the magnitude of facility-level $PM_{2.5}$ emissions. Facilities are relatively well distributed across the TLMA area; the highest density of facilities is located in the southern Longview area. The Martin Lake Electrical Station in Rusk County is the facility with the largest $PM_{2.5}$ emissions and accounts for 53% of TLMA area point source $PM_{2.5}$ emissions. Figure 2-2 shows breakout maps of the areas and point source facilities which are in proximity to the three CAMS within the TLMA area.

The coal-fired AEP Pirkey Power Plant was retired in spring 2023[9]. Martin Lake Electrical Station is a coal-fired power plant which continues to operate, but may also be closed in the future[10]. We recommend that EPA's future year emission inventories be checked to ensure that expected changes at these power plants are considered.

[9] https://aepcommunitytransition.com/closures/pirkey/. Accessed February 2025.
[10] https://www.panolawatchman.com/news/new-federal-rules-could-doom-martin-lake-power-plant-and-end-coals-era-in-east/article_929de9c8-1968-11ef-8d52-7fc76930d16f.html. Accessed February 2025.

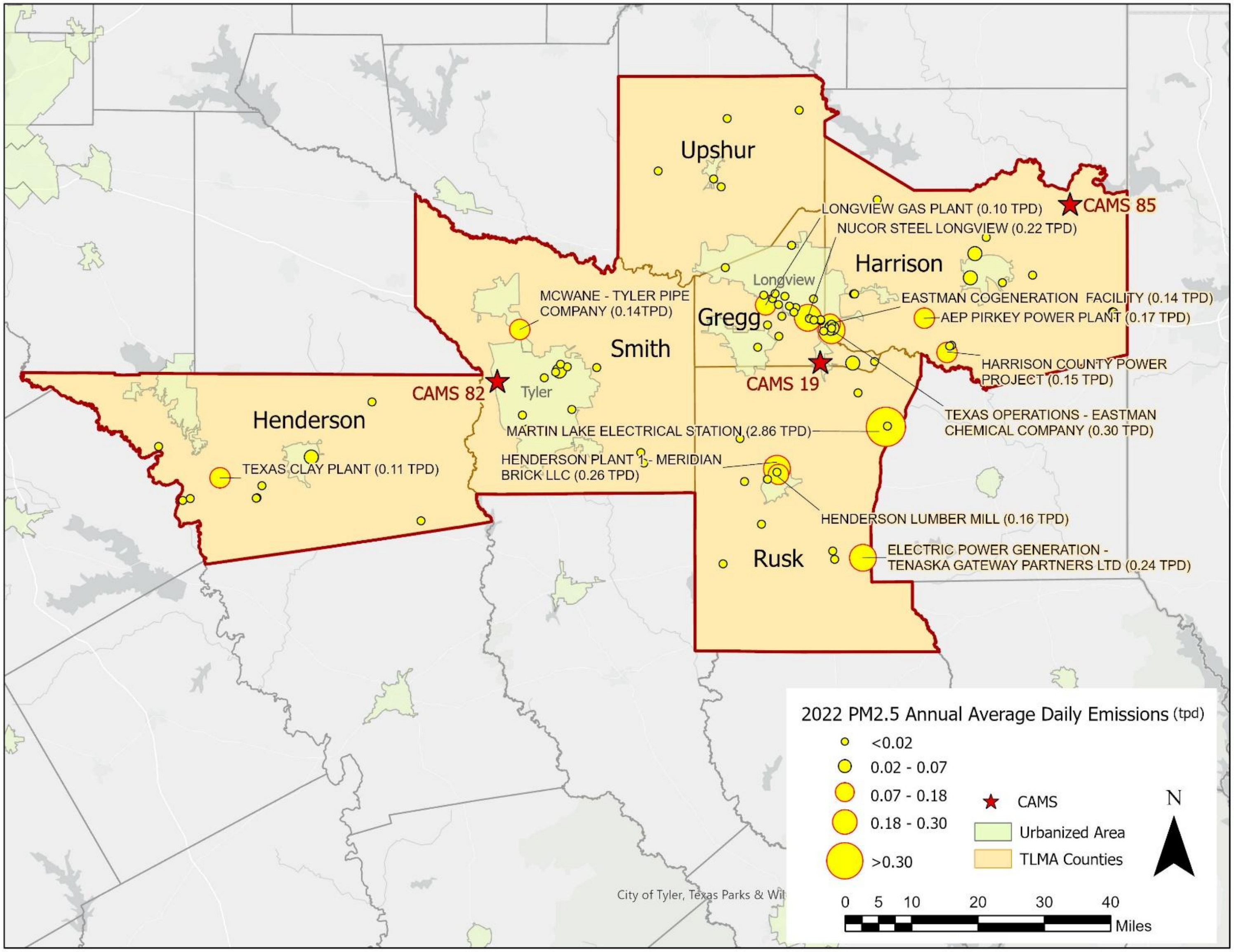

Figure 2-1. TLMA area 2022 annual average daily $PM_{2.5}$ point source emissions.

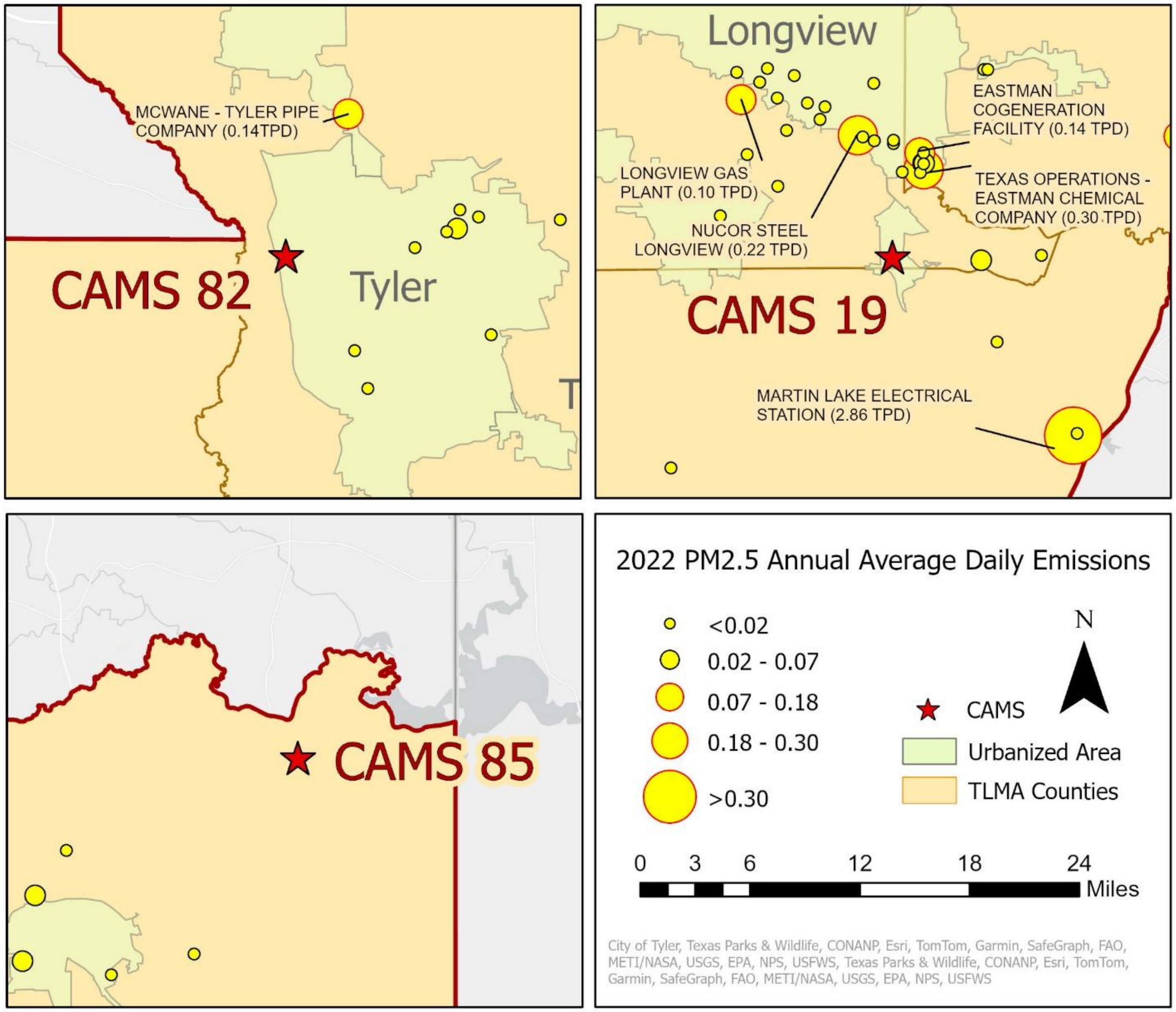

Figure 2-2. Breakout maps of TLMA area 2022 annual average daily $PM_{2.5}$ point source emissions.

Table 2-1 lists the highest emitting TLMA area point source emissions by facility in the 2022v1 emission inventory; the 12 facilities listed account for 88% of 2022 point source $PM_{2.5}$ emissions. Martin Lake Electrical Station is by far the largest $PM_{2.5}$ emissions source, accounting for 52% of all TLMA area $PM_{2.5}$ point source emissions; no other facility accounts for more than 6% of TLMA area $PM_{2.5}$ point source emissions.

Table 2-1. Top emitting $PM_{2.5}$ point sources during 2022 in the TLMA area.

Facility	SIC[a]	SIC[a] DESCRIPTION	Annual Average $PM_{2.5}$ Emissions (ton/day)	Percent of TLMA Area Point Source $PM_{2.5}$ Emissions
Martin Lake Electrical Station	4911	Electrical Services	2.8	52%
Texas Operations – Eastman Chemical Company	2869	Industrial Organic Chemicals, NEC	0.3	6%
Henderson Plant 1	3251	Brick and Structural Clay Tile	0.3	5%
Electric Power Generation - Tenaska Gateway Partners LTD	4911	Electrical Services	0.2	4%
Nucor Steel Longview	3312	Blast Furnaces and Steel Mills	0.2	4%
AEP Pirkey Power Plant	4911	Electrical Services	0.2	3%
Henderson Lumber Mill	2421	Sawmills & Planning Mills General	0.2	3%
Harrison County Power Project	4911	Electrical Services	0.1	3%
Eastman Cogeneration Facility	4931	Electric and Other Services Combined	0.1	3%
McWane Ductile	3321	Gray & Ductile Iron Foundries	0.1	3%
Texas Clay Plant	3251	Brick and Structural Clay Tile	0.1	2%
Longview Gas Plant	1321	Natural Gas Liquids	0.1	2%
All Facilities Not Listed Above	Various	Various	0.6	12%

[a] Standard Industrial Classification

2.2 Point Source Emission Trends

We obtained annual facility-level point source emissions from TCEQ's website for years 2010 to 2022[11]. TCEQ's State of Texas Air Reporting System (STARS) database is administered by the TCEQ. Each year the TCEQ sends courtesy notifications to all facilities that meet reporting requirements of 30 Texas Administrative Code (TAC) §101.10. The TCEQ collects point source emissions data as well as industrial process operating data. Extensive documentation of the point source emission inventory is maintained in the TCEQ file rooms.

Trends in annual point source emissions from EGU and non-EGU industrial sources are shown in Figure 2-3 for the 2017 to 2022 period. From 2017 to 2022, EGUs accounted for a majority (67% to 71%) of TLMA area point source $PM_{2.5}$ emissions. EGU $PM_{2.5}$ emissions remain relatively constant from year-to-year, varying from 3.4 tpd to 3.7 tpd. Non-EGU $PM_{2.5}$ emissions from 2017 to 2020 ranged from 1.4 tpd to 1.5 tpd and from 2021 to 2022 from 1.7 to 1.8 tpd. Non-EGU $PM_{2.5}$ emissions increases from 2021 to 2022 were driven mainly by the Henderson Plant 1 facility (owned by Meridian Brick LLC) for

[11] TCEQ Point Source Emissions Data, Site Level Summary. https://www.tceq.texas.gov/downloads/air-quality/point-source/2010_2022statesum.xlsx. Accessed January 2025.

which emissions increased by 0.2 tpd from 2021 to 2022 and the Texas Clay Plant (owned by Acme Brick Company) for which emissions increased by 0.1 tpd from 2021 to 2022.

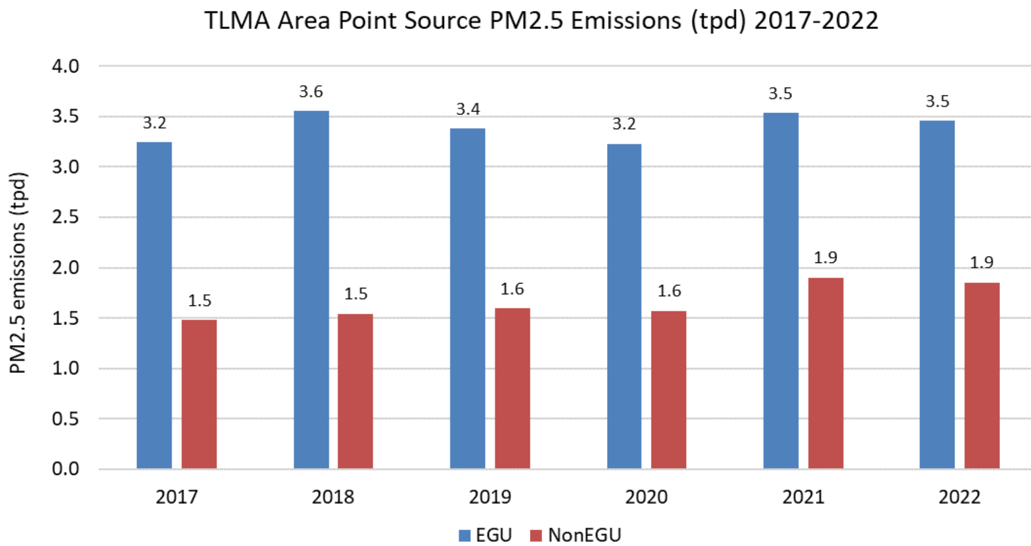

Figure 2-3. 2017 to 2022 TLMA area $PM_{2.5}$ annual average daily point source emissions trends (tons/day).

3 Prescribed Fires and Agricultural Burning Review

Prescribed fires, or prescribed burns, are controlled, low intensity fires that are used to achieve land management goals such as reduction of wildfire risk, habitat restoration, and invasive species removal. Agricultural fires, or agricultural burns, are used to manage vegetation in areas such as agricultural fields, rangelands, and orchards. Agricultural fires can be used to remove crop residues after harvest of crops such as hay and rice.

Figure 3-1 shows emissions from anthropogenic fire source categories in the TLMA area. Fires, including prescribed and agricultural fires, were the largest anthropogenic $PM_{2.5}$ emission source in the TLMA area in 2022, accounting for 53% of total anthropogenic $PM_{2.5}$ emissions. A vast majority of emissions from this source category are from prescribed burning (97%, 13.5 tpd), with a smaller amount or $PM_{2.5}$ emissions from agricultural field burning (3%, 0.5 tpd). Table 3-1 shows emissions with additional detail for agricultural field burning.

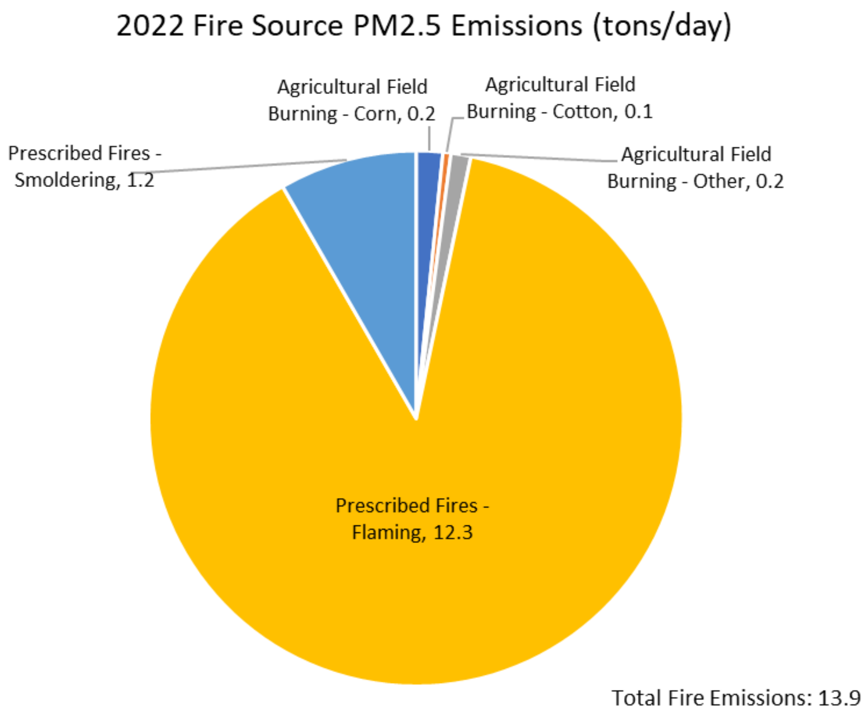

Figure 3-1. TLMA area 2022 $PM_{2.5}$ annual average daily anthropogenic fire emissions by source category (tons/day).

Table 3-1. Prescribed fires and agricultural field burning annual average daily $PM_{2.5}$ emissions.

Emissions Source	$PM_{2.5}$ Emissions (tons/day)	Percent of TLMA Area Prescribed Fires and Agricultural Field Burning $PM_{2.5}$ Emissions
Prescribed Fires Flaming	12.31	88%
Prescribed Fires Smoldering	1.16	8%
Agricultural Burning: Corn	0.22	2%
Agricultural Burning: Cotton	0.07	<1%
Agricultural Burning: Fallow [a]	0.06	<1%
Agricultural Burning: Wheat, Backfire Burning [a]	0.05	<1%
Agricultural Burning: Unspecified crop type and Burn Method [a]	0.03	<1%
Agricultural Burning: Red Beans, Headfire Burning [a]	0.02	<1%
Agricultural Burning: Rice [a]	<0.01	<1%

[a] Grouped in Figure 3-1 as "Agricultural Field Burning – other"

We provide additional information below on prescribed fires as emissions from prescribed fires account for a vast majority of anthropogenic fire $PM_{2.5}$ emissions in the TLMA area. EPA developed emissions from prescribed fires as described in EPA (2024) based on activity data from EPA's SmartFire2 framework. SmartFire2 is used to compile daily acres burned activity by latitude and longitude from federal and state agency datasets. The SmartFire2 activity was applied in the US Forest Service's BlueSky Pipeline to generate emissions. The BlueSky Pipeline assigns area specific fuel characteristics from LANDFIRE[12] and fuel consumption estimates, and applies Smoke Emissions Reference Application (SERA)[13] emissions factors to estimate emissions.

Table 3-2 and Table 3-3 display by county prescribed fire 2022 burned area and burned area contributions, respectively. Table 3-4 and Table 3-5 display by county prescribed fire 2022 $PM_{2.5}$ emissions and $PM_{2.5}$ emissions contributions. The contributions by county and fuel type are similar for acres burned and $PM_{2.5}$ emissions. The forest fuel type accounts 69% of TLMA area burned and 73% of TLMA area emissions. The hay/alfalfa fuel type accounts 30% of TLMA area burned and 26% of TLMA area emissions. Henderson County accounted for the largest fraction of area burned (39%) and $PM_{2.5}$ emissions (40%).

Table 3-2. Prescribed fire 2022 burned area (acres) by county and fuel type.[14]

Fuel Type	Gregg	Harrison	Henderson	Rusk	Smith	Upshur	Total
Forest	846	12,468	20,796	8,646	7,681	7,336	57,773
Hay/Alfalfa	453	2,055	12,127	3,448	5,716	1,792	25,591
Grassland	45	75	171	60	195	62	608
Total	**1,344**	**14,598**	**33,094**	**12,154**	**13,591**	**9,190**	**83,972**

[12] Landscape Fire and Resource Management Planning Tools Program, a vegetation, fire, and fuel characteristic mapping program managed by the U.S. Department of Agriculture Forest Service and the U.S. Department of the Interior. https://landfire.gov/about-landfire.

[13] https://depts.washington.edu/nwfire/sera/index.php. Accessed February 2025.

[14] https://gaftp.epa.gov/Air/emismod/2022/v1/2022emissions/fires/2022FireLoc_Texas.csv. Accessed February 2025.

Table 3-3. Prescribed fire 2022 burned area contributions (percent of area) by county and fuel type.[14]

Fuel Type	Gregg	Harrison	Henderson	Rusk	Smith	Upshur	Total
Forest	1%	15%	25%	10%	9%	9%	69%
Hay/Alfalfa	<1%	2%	14%	4%	7%	2%	30%
Grassland	<1%	<1%	<1%	<1%	<1%	<1%	<1%
Total	**2%**	**17%**	**39%**	**14%**	**16%**	**11%**	**100%**

Table 3-4. Prescribed fire annual average daily $PM_{2.5}$ emissions (tons/day) by county and fuel type. [14]

Fuel Type	Gregg	Harrison	Henderson	Rusk	Smith	Upshur	Total
Forest	0.13	2.22	3.69	1.63	1.18	1.00	9.86
Hay/Alfalfa	0.06	0.27	1.73	0.48	0.75	0.25	3.54
Grassland	0.01	0.01	0.02	0.01	0.02	0.01	0.07
Total	**0.20**	**2.50**	**5.45**	**2.12**	**1.95**	**1.26**	**13.47**

Table 3-5. Prescribed fire annual average $PM_{2.5}$ emissions contributions (percent of emissions) by county and fuel type. [14]

Fuel Type	Gregg	Harrison	Henderson	Rusk	Smith	Upshur	Total
Forest	<1%	17%	27%	12%	9%	7%	73%
Hay/Alfalfa	<1%	2%	13%	4%	6%	2%	26%
Grassland	<1%	<1%	<1%	<1%	<1%	<1%	<1%
Total	**1%**	**19%**	**40%**	**16%**	**14%**	**9%**	**100%**

Ramboll (2024) developed model-ready fire emissions for TCEQ's 2022 SIP modeling platform from two fire emission inventories, Regional ABI and VIIRS fire Emissions version 2.0 (RAVE2.0) and Global Fire Assimilation System version 1.2 (GFAS1.2) and compared those estimates to EPA's 2022 modeling platform beta version fire emissions inventory. The comparison showed considerable differences in $PM_{2.5}$ emissions in Texas from fires between the three analyzed fire emission inventories. TCEQ will base its final fire emission inventory choice on emission comparisons and tests that evaluate model results against observed concentrations for ozone, particulate matter, and other important precursors.

4 Area Source Emissions Review

The area source inventory treats in aggregate all stationary sources that have emissions below the point source reporting threshold. These sources are geographically dispersed and individually equate to insignificant emission quantities, but in sum, may constitute a substantial amount of emissions. Examples of area sources include fugitive dust from paved and unpaved roads, residential wood heating, and combustion exhaust. Area source emissions for many source categories are estimated based on EPA AP-42[15] methods. These emissions are typically estimated and reported as county totals and allocated to a finer geographic scale using a surrogate such as population distribution. For example, if a certain amount of $PM_{2.5}$ emissions are estimated for agricultural tilling in a given county, most of those emissions would be allocated to the locations within the county that have agricultural cropland.

Although all source categories were analyzed, the emissions analysis below focuses on those categories responsible for the preponderance of area source $PM_{2.5}$ emissions in the TLMA area for which emission updates could have significant effects on the emission inventory. Emissions for most area sources in the 2022v1 emission inventory were taken from EPA's 2020 NEI (EPA, 2024).

Fugitive dust emissions included in this report from paved and unpaved roads, agricultural, construction, and mining and quarrying sources include precipitation and transport adjustments. These adjustments are made to reduce dust emissions (i) during times of precipitation and (ii) to account for decreased transport of dust based on capture of some dust by vegetation and buildings near to emission sources which precludes some dust emissions from reaching the broader atmosphere. Precipitation adjustments account for a 24% reduction from uncontrolled dust emissions across the TLMA area and range from 18% to 31% by county[5]. Transport adjustments account for a 58% reduction from uncontrolled dust emissions across the TLMA area and range from 46% to 62% by county[5]. Combined, precipitation and transport adjustments account for a 67% reduction from uncontrolled dust emissions across the TLMA area and range from 56% to 73% by county[5].

Figure 4-1 shows emissions from area source categories in the TLMA area. Area sources were the second largest anthropogenic $PM_{2.5}$ emission source in the TLMA area in 2022, accounting for 24% of total anthropogenic $PM_{2.5}$ emissions. Area sources are the second largest overall contributor of $PM_{2.5}$ emissions, accounting for 23% of total anthropogenic $PM_{2.5}$ emissions in the TLMA area in 2022. Open burning is the largest area source category, accounting for 2.11 tpd (34%) of the area source $PM_{2.5}$ emissions. Fugitive dust emission sources, including paved roads, unpaved roads, agricultural, mining and quarrying, and construction dust, account for 2.90 tpd (46%) of area source emissions in the TLMA area. The largest fugitive dust sources are paved roads (0.99 tpd), agricultural (0.93 tpd), and unpaved roads (0.64 tpd) which together account for 41% of area source and 88% of fugitive dust emissions in the TLMA area. Commercial cooking accounts for 0.46 tpd (7%) and residential wood combustion (RWC) accounts for 0.45 tpd (7%) of area source emissions in the TLMA area.

Figure 4-2 shows $PM_{2.5}$ emissions by county and source. Across all TLMA area counties, open burning and fugitive dust are the largest contributors to area source emissions, together accounting for 60% of Gregg, 80% of Harrison, 85% of Henderson, 81% of Rusk, 82% of Smith, and 83% of Upshur county area source emissions.

[15] AP-42: Compilation of Air Emissions Factors from Stationary Sources. https://www.epa.gov/air-emissions-factors-and-quantification/ap-42-compilation-air-emissions-factors-stationary-sources. Accessed February 2025.

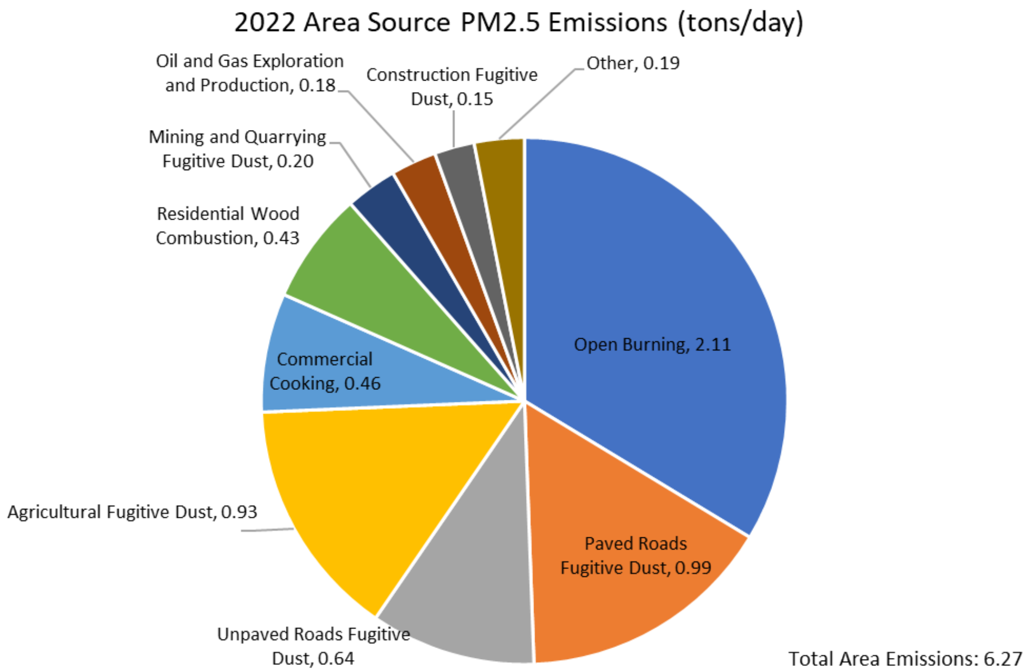

Figure 4-1. TLMA area 2022 $PM_{2.5}$ annual average daily area source emissions by source category (tons/day).

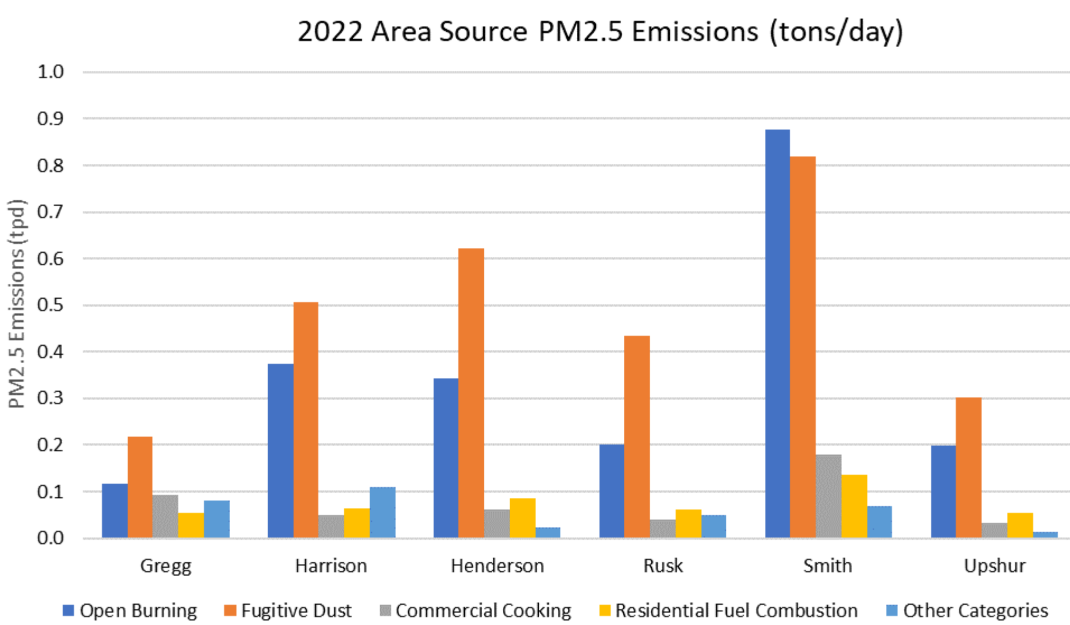

Figure 4-2. TLMA area 2022 $PM_{2.5}$ annual average daily area source emissions by county (tons/day).

4.1 Open Burning

Open burning refers to intentional burning of materials for the purpose of waste disposal. Open burning emissions in the TLMA area are from residential household waste (1.2 tpd) and land clearing debris (0.8 tpd), with minor contributions from yard waste (0.04 tpd). Emissions for all categories of open burning in the 2022v1 emission inventory were taken from EPA's 2020 NEI (EPA, 2024). TCEQ submitted open burning emissions from residential household waste and yard waste to the 2020 NEI (EPA, 2023a).

Figure 4-3 shows open burning emissions by source category and county in the TLMA area. In the TLMA area, Smith County had the largest open burning emissions (0.88 tpd; 41%); emissions in other TLMA area counties accounted for 6% to 18% of open burning emissions. Residential household waste open burning emissions are well distributed across most counties in the TLMA area with each county accounting for 8% to 19% of open burning emissions; the exception is Gregg County which did not have residential household waste open burning emissions. It is unclear why there are not emissions from residential household waste in Gregg County. A majority of land clearing debris emissions were in Smith County.

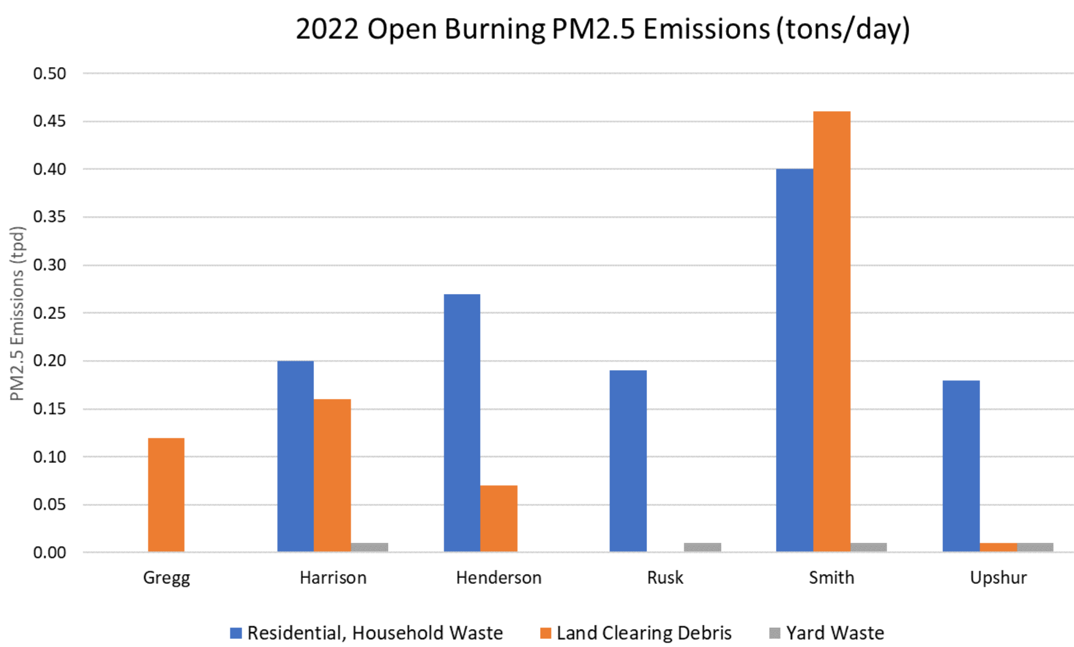

Figure 4-3. TLMA area 2022 $PM_{2.5}$ annual average daily open burning emissions by county (tons/day).

We provide additional information below on the methods by which EPA estimated emissions for the two largest sources of open burning $PM_{2.5}$ emissions, residential household waste refers and land clearing debris in the 2020 NEI. Open burning of residential household waste refers to intentional burning for waste disposal purposes of municipal solid waste. Land clearing debris refers to purposeful burning of debris, such as trees, shrubs, and brush, from the clearing of land for the construction of new buildings and highways. Table 4-1 shows the inventory basis, key national and local emission inventory inputs, and suggested potential local improvements.

Table 4-1. Open burning emission inventory basis, inputs, and potential local improvements.

Open Burning Type	2020 NEI Approach Reference(s)	Main Activity Inputs	Selected Other Inputs	Potential Local Improvements
Residential Household Waste	EPA 2020 NEI (EPA, 2023b)	National waste generation per Capita by waste type per EPA (2018) 24% of rural population assumed to burn their waste	Rural population in each county from the 2010 US Census	Consider local estimate for waste generation per capita and the fraction of the rural population that burns their waste, if not already incorporated into TCEQ's approach
Land Clearing	EPA 2020 NEI (EPA, 2023c)	Readily available metrics such as county-level housing starts and highway statistics Relationship of readily available metrics to land clearing acres burned	County-level fuel loading per acre based on coverage by vegetation type (e.g., hardwoods, softwoods, and grasses)	Consider leveraging county level burn data, if available

4.2 Fugitive Dust

Fugitive dust emissions sources are from paved and unpaved roads, agricultural tilling and livestock, mining and quarrying, and construction sources. As noted above and shown below in Figure 4-4, total TLMA area fugitive dust emissions account for 2.90 tpd (46%) of area source emissions in the TLMA area. The largest fugitive dust sources are paved roads, agricultural, and unpaved roads which together account for 88% of fugitive dust emissions in the TLMA area. Unpaved roads are the largest fugitive dust emissions source in Smith County (0.29 tpd). Paved roads are the largest fugitive dust emissions source in Gregg (0.10 tpd), Harrison (0.19 tpd), Rusk (0.13 tpd), and Upshur (0.14 tpd) counties. Paved roads and agricultural livestock are the largest emission sources in Henderson County, with each accounting for 0.18 tpd of $PM_{2.5}$ emissions. Emissions for all categories of fugitive dust were taken from EPA's 2020 NEI (EPA, 2024). TCEQ submitted paved and unpaved road dust emissions to the 2020 NEI (EPA, 2023a).

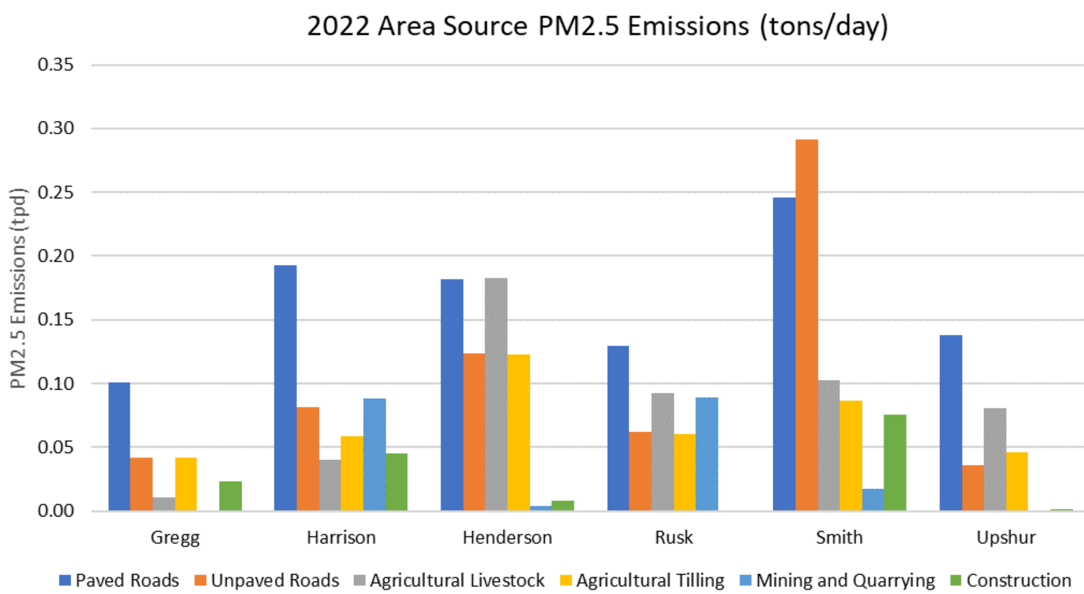

Figure 4-4. TLMA area 2022 $PM_{2.5}$ annual average daily fugitive dust emissions by county (tons/day).

We provide more information below on the emissions sources that comprise a vast majority of fugitive dust emission in the TLMA area, paved and unpaved roads and agricultural livestock and tilling. Table 4-2 shows EPA's typical emission inventory basis, key emission inventory inputs, and potential local improvements.

Table 4-2. Paved roads, unpaved roads, and agricultural livestock and tilling emission inventory basis, inputs, and potential local improvements.

Dust Type	2020 NEI Approach Reference(s)	Main Activity Inputs	Selected Other Inputs	Potential Local Improvements
Paved Roads	2020 NEI (EPA, 2023d), AP-42 Section 13.2.1[16]	County-level **paved road vehicle miles traveled (VMT)** by roadway class. Total VMT from EPA MOVES is typically reconciled to exclude unpaved road VMT.	**Road surface silt loading** by roadway class per AP-42 Section 13.2.1. **Average vehicle weight** by roadway type. **Control:** Typically, no control is assumed unless the area requires street sweeping as a control measure for a PM_{10} nonattainment area	Consider developing local inputs for silt loading, average vehicle weight by roadway type, and controls application (if any) if they are not already incorporated into TCEQ's emission inventory estimates
Unpaved Roads	2020 NEI (EPA, 2023e), AP-42 Section 13.2.2[17]	**Unpaved road VMT**: Typically, urban roadway types are assumed fully paved. Paved roadway VMT for rural roadways is estimated based on state level unpaved road VMT fractions from the Federal Highway Administration (FHWA) or other sources of unpaved road activity.	**Surface material silt content** is available for Texas from Barnard et al. (1987) **Surface moisture content** is typically assigned based on regional soil moisture and precipitation patterns **Mean vehicle speed** based on state or national average speed estimates by roadway type **Control:** Typically, no control is assumed unless the area requires control under a PM_{10} nonattainment area SIP	Consider developing local inputs for unpaved roadway VMT, surface material silt content, surface moisture content, and controls application (if any) if they are not already incorporated into TCEQ's emission inventory estimates

[16] https://www.epa.gov/sites/production/files/2020-10/documents/13.2.1_paved_roads.pdf. Accessed February 2025.
[17] https://www.epa.gov/sites/production/files/2020-10/documents/13.2.2_unpaved_roads.pdf. Accessed February 2025.

Dust Type	2020 NEI Approach Reference(s)	Main Activity Inputs	Selected Other Inputs	Potential Local Improvements
Agricultural Tilling	2020 NEI (EPA, 2023f)	**Acres of crops** in each county by crop type and tillage type (i.e., conservation use, no-till, and, conventional use) from the United States Department of Agriculture (USDA) 2017 Census of Agriculture[18]	**Silt content of surface soil**: Soil sample data is used to estimate county-level, average silt content and can be taken from the National Cooperative Soil Survey Microsoft Access Soil Characterization Database[19] **Number of passes or tilling** in a year by crop type for each tillage type (i.e., conservation use, no-till, and conventional use)	Consider implementing recent TLMA area crop acreage information, if available
Agricultural Livestock	2020 NEI (EPA, 2023f)	Livestock count by type of livestock can be taken from EPA's Greenhouse Gas emission inventory (EPA, 2018). EPA's Greenhouse Gas emission inventory relies heavily on USDA National Agricultural Statistics Service (NASS) data for livestock head counts[20]	None	Consider implementing recent TLMA area livestock counts, if available

[18] https://www.nass.usda.gov/Publications/AgCensus/2017/index.php, accessed February 2025.
[19] https://ncsslabdatamart.sc.egov.usda.gov/, accessed February 2025.
[20] https://www.nass.usda.gov/, accessed February 2025.

4.3 Commercial Cooking

Commercial cooking refers to the charbroiling and/or frying of meat and French fries and accounts for 0.46 tpd or 7% of area source emission in the TLMA area. Emissions for commercial cooking in the 2022v1 emission inventory were taken from EPA's 2020 NEI (EPA, 2024). TCEQ submitted commercial cooking emissions to the 2020 NEI (EPA, 2023a). The activity typically used by EPA to estimate commercial cooking emissions is the amount of meat and French fries cooked on each device in each county. County-level cooking activity is typically estimated based on (i) the number of restaurants, by restaurant type, (ii) assumptions regarding the percent of each restaurant type with specific cooking devices, (iii) the number of devices per restaurant, and (iv) the amount of meat cooked per device (EPA, 2023g). Table 4-3 shows emissions from commercial cooking device types. Deep fat frying emissions are not explicitly included in the 2022v1 emission inventory.

Table 4-3. TLMA area commercial cooking annual average daily 2022 $PM_{2.5}$ emissions.

SCC	Description	$PM_{2.5}$ Emissions (tpd)
2302002100	Commercial Cooking – Charbroiling Conveyorized Charbroiling	0.05
2302002200	Commercial Cooking – Charbroiling Under-fired Charbroiling	0.33
2302003000	Commercial Cooking – Frying Deep Fat Frying	-
2302003100	Commercial Cooking – Frying Flat Griddle Frying	0.07
2302003200	Commercial Cooking – Frying Clamshell Griddle Frying	0.01
Totals		**0.46**

4.4 Residential Wood Combustion

RWC accounts for 0.43 tpd or 7% of area source emissions in the TLMA area and includes emissions from fireplaces, fireplace inserts, woodstoves, and wood-fired central heaters (indoor furnaces and hydronic heaters). Emissions for RWC in the 2022v1 emission inventory were taken from EPA's 2020 NEI (EPA, 2024). TCEQ submitted residential wood combustion emissions to the 2020 NEI (EPA, 2023a). Activity estimates that are typically used to estimate emissions are the mass of wood or pellets burned for each device type over a geographical area, accounting for use considerations based on an area's climate and the residential setting (e.g., rural versus urban and high density versus low density housing). Emissions for this category can benefit from the use of state and county derived data for wood and pellet use by device type and can be considered for inventory updates if they are not already included in the TCEQ emission inventory.

5 On-road Source Emissions Review

On-road mobile source emissions are from motor vehicles licensed or certified for highway use. On-road vehicles include light-duty vehicles such as passenger cars and pickup trucks and heavy-duty vehicles such as delivery trucks, long-haul trucks, and buses. Vehicle emissions occur on roadways, including limited access interstates and freeways and unlimited access arterial and local roads, and off-network from activities such as heavy-duty vehicle hoteling. On-road $PM_{2.5}$ emissions include exhaust emissions from vehicle tailpipes as well as brake wear and tire wear emissions. On-road emissions were estimated in the 2022 Modeling Platform with EPA's MOtor Vehicle Emissions Simulator (MOVES), version 4 model. VMT data from the Federal Highway Administration (FHWA) was utilized to supplement state-submitted data.

TLMA area on-road $PM_{2.5}$ emissions are 0.47 tpd, representing less than 2% of TLMA area anthropogenic emissions. Fugitive dust emissions from paved and unpaved roads are included in the area source emission inventory. Figure 5-1 shows 2022 on-road emission contributions by source category for the TLMA area for $PM_{2.5}$. Combination long-haul and combination short-haul trucks (mostly diesel-fueled) together account for 31% and passenger cars, passenger trucks, and light commercial trucks (mostly gasoline-fueled) together account for 42% of on-road vehicle $PM_{2.5}$ emissions. Single unit short-haul trucks, light commercial trucks and other vehicle types contribute the remaining 27% of $PM_{2.5}$ emissions.

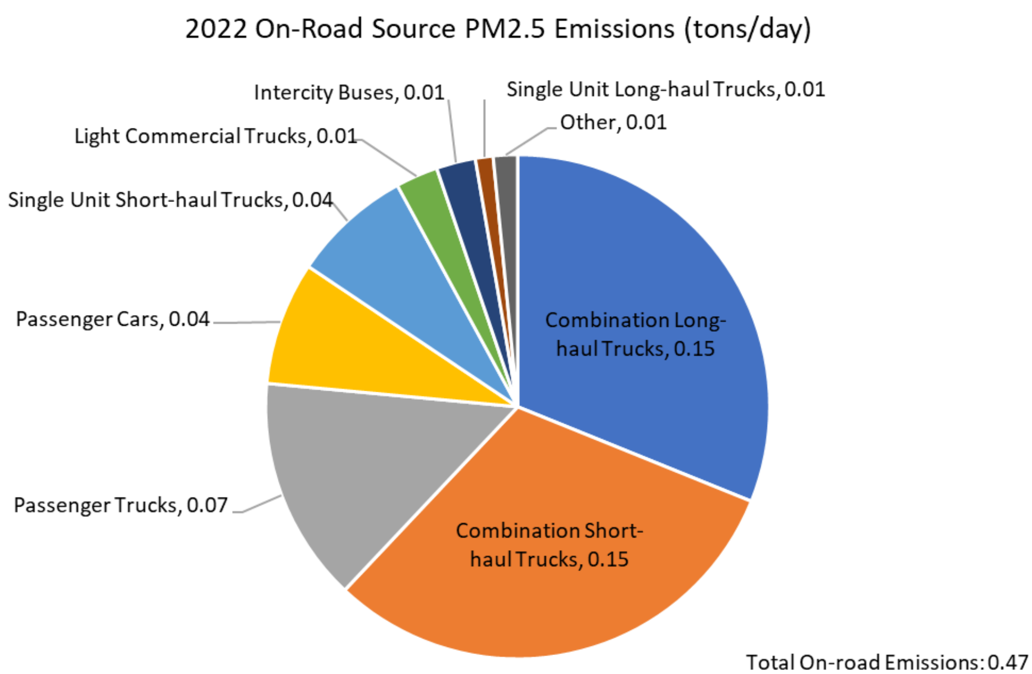

Figure 5-1. TLMA area 2022 $PM_{2.5}$ annual average daily on-road emissions by source type (tons/day).

6 Off-Road Source Emissions Review

Off-road mobile source emissions are from mobile and portable internal combustion-powered equipment not generally licensed or certified for highway use. Off-road equipment categories span a wide range of equipment types such as lawn and garden equipment, heavy-duty construction equipment, aircraft and locomotives. Off-road emissions for many of these categories are calculated using EPA's MOVES model. EPA's NONROAD model, which formerly was used to estimate off-road mobile source emissions, has been incorporated into EPA's MOVES model.

Figure 6-1 shows 2022 off-road emission contributions by source category in the TLMA area for $PM_{2.5}$. Off-road $PM_{2.5}$ emission sources contributed less than 2% (0.45 tpd) of the anthropogenic $PM_{2.5}$ emissions in the TLMA area in 2022. Lawn and garden equipment (0.13 tpd; 30%), construction and mining equipment (0.08 tpd; 19%), and rail (0.08; 19%) together account for close to 68% of off-road $PM_{2.5}$ emissions. Airports (0.04 tpd; 8%) and commercial equipment (0.03 tpd; 8%) are the next largest emission sources.

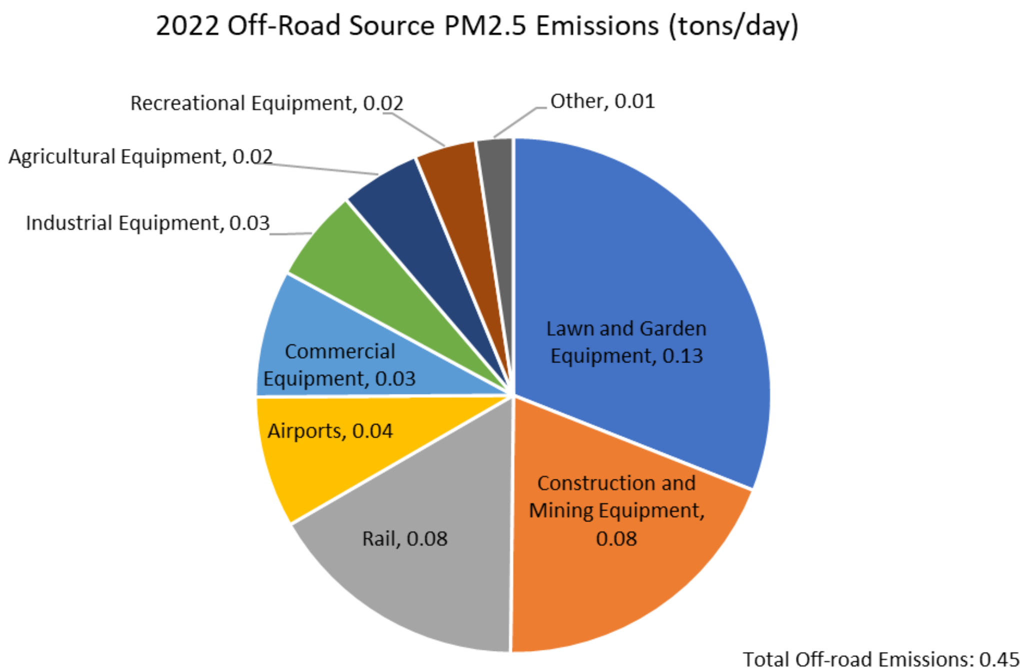

Figure 6-1. TLMA area 2022 $PM_{2.5}$ annual average daily off-road emissions (tons/day).

For the 2020 NEI, TCEQ submitted Texas specific data for most MOVES off-road equipment input parameters (EPA, 2023h). Complete documentation of the 2022v1 emission inventory is not yet available and the extent to which TCEQ submitted MOVES inputs are included in the 2022v1 emission inventory is not yet clear.

TCEQ developed a Texas-specific application of the NONROAD model called TexN for counties within Texas. TexN version 2.5 is the latest update and is compatible with MOVES version 4 (ERG, 2024). According to ERG (2024), TexN "facilitates the generation of MOVES-Nonroad county databases (CDBs) based on the extensive Texas-specific data developed for TexN; automates execution of MOVES-Nonroad runs using these CDBs; compiles results from the MOVES-Nonroad runs; applies post-processing adjustments; and generates reports in a variety of output formats". In TCEQ's 2022 emission inventory, the latest version of TexN will be used to estimate emissions for all TLMA area off-road source categories except airports and rail.

Rail emissions of $PM_{2.5}$ are relatively small (0.07 tpd); a vast majority of rail emissions are from Class I line locomotives; there are much smaller emissions from Class II/III railroad and passenger rail in the TLMA area.

Airport emissions of $PM_{2.5}$ are also relatively small (0.04 tpd); a majority of airport emissions are from two airports: East Texas Regional in Gregg County, Tyler Pounds Regional in Smith County.

7 Conclusions and Recommendations

Based on Ramboll analyses presented in this report, the 2022v1 emission inventory for point, prescribed fires and agricultural burning, area source, on-road, and off-road $PM_{2.5}$ emission inventories are generally accurate and complete. Ramboll's recommendations below may refine or improve the 2022v1 emission inventory by addressing sources of emissions that may be under- or over-estimated, and/or accompanied by high levels of uncertainty. Ramboll did not find any emission source categories for which more detailed emissions inventory input at the sub-county level was readily available. Recommendations for emission inventory improvements are all low priority. Ramboll did not make any high priority recommendations because there are no emission inventory improvement recommendations that are expected to result in large changes to the emission inventory. Recommended improvements are expected to result in limited and/or small changes to the TLMA area $PM_{2.5}$ emission inventory. This is the first close review of the TLMA area $PM_{2.5}$ emission inventory; we did not apply checks to ensure that all facilities that should be categorized as point sources have been captured in the point source emission inventory.

Below is a list of low priority recommendations for improvement of the 2022v1 emission inventory in the TLMA area.

- **Prescribed fires and agricultural burning:** Consider updates based on TCEQ model performance evaluations of candidate fire emission inventories.
- **Area Sources:** Consider refinements to specific area source emission estimation inputs to refine TLMA area emissions based on local data:
  - **Open burning, residential household waste**: Consider implementing state or local estimates for waste generation per capita and the fraction of the rural population that burns their waste, if not already incorporated into TCEQ's emission estimation approach; ensure that residential household waste emissions in Gregg County are not inadvertently omitted
  - **Open burning, land clearing debris**: Consider leveraging county-level burn data, if available
  - **Fugitive dust, paved roads**: Consider developing local inputs for silt loading, average vehicle weight by roadway type, and controls application (if any) if not already incorporated into TCEQ's emission estimation approach
  - **Fugitive dust, unpaved roads**: Consider developing local inputs for unpaved roadway VMT, surface material silt content, surface moisture content, and controls application (if any) if not already incorporated into TCEQ's emission estimation approach
  - **Fugitive dust, agricultural tilling**: Consider implementing recent TLMA area crop acreage information, as available
  - **Fugitive dust, agricultural livestock**: Consider implementing recent TLMA area livestock counts, as available
  - **Commercial cooking**: Ensure that deep fat frying emissions are included in the emission inventory

8 References

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APPENDIX E

Final Report for Subtask 3.2: $PM_{2.5}$ Monitoring for Northeast Texas

Contract 582-24-01388
Subtask 3.2

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November 2025

$PM_{2.5}$ Monitoring for Northeast Texas
Final Report

RAMBOLL

Contents

List of Acronyms and Abbreviations ii

Executive Summary 1

1 Introduction 2
1.1 The Tyler-Longview-Marshall-Athens Area 2
1.2 Background and Purpose 3
1.2.1 $PM_{2.5}$ Air Quality Status in the Tyler-Longview-Marshall Athens Area 3

2 Methods 4
2.1 Ambient $PM_{2.5}$ Measurements 4
2.2 Monitoring Station Site Photos 4

3 Results 7
3.1 Ambient $PM_{2.5}$ Measurements 7
3.2 Site Performance and Data Recovery 8
3.3 Site Activities and Significant Events 9

4 Conclusions and Recommendations 10

5 References 11

Table of Figures

Figure 1.1. The six county TLMA area, location of CAMS monitors in the area with urban areas and major roadways in the surrounding region. 2

Figure 2.1. Southwest Facing Photo of Monitoring Station 5

Figure 2.2. Northwest Photo of Monitoring Station 5

Figure 2.3. Northeast Photo of Monitoring Station 6

Figure 2.4. Southeast Photo of Monitoring Station 6

Figure 3.1. Tyler 24-hour $PM_{2.5}$ Concentrations During the Sampling Period (April 1st to September 4th, 2025) with two periods of missing data labelled (a) and (b). 7

Table of Tables

Table 3.1. Monthly $PM_{2.5}$ Statistics for 24-hour and 1-hour Average $PM_{2.5}$ Concentrations During the Sampling Period (April 1st to September 4th, 2025). 8

Table 3.2. 24-hour $PM_{2.5}$ Data Recovery 8

Table 3.3. Dates of QC Site Visits 9

List of Acronyms and Abbreviations

μg/m^3	Micrograms per cubic meter
CAMS	Continuous Air Monitoring System
CBSA	Core-based statistical area
EPA	US Environmental Protection Agency
ETCOG	East Texas Council of Governments
FEM	Federal Equivalent Method
HEPA	High-Efficiency Particulate Air
NAAQS	National Ambient Air Quality Standards
QAPP	Quality Assurance Project Plan
TCEQ	Texas Commission on Environmental Quality
TLMA	Tyler-Longview-Marshall-Athens
VSCC	Very Sharp Cut Cyclone

Executive Summary

The purpose of this task was to deploy a monitor in Tyler collocated with CAMS 82 that measures particulate matter with an aerodynamic diameter less than 2.5 microns ($PM_{2.5}$). This report presents the results of $PM_{2.5}$ monitoring conducted by Ramboll for the East Texas Council of Governments (ETCOG) in the Tyler-Longview-Marshall-Athens (TLMA) area from April 1st to September 4th, 2025, using a U.S. EPA–designated Federal Equivalent Method (FEM) monitor at the Tyler site (collocated with CAMS 82). Instrument downtime in June, caused by rainwater ingestion and a power surge, reduced data recovery for that month. Despite this, data completeness for 24-hour averages was 86%, exceeding the 75% target. All 24-hour $PM_{2.5}$ values remained below the secondary NAAQS limit of 35 $\mu g/m^3$, with the highest 24-hour value recorded at 21.6 $\mu g/m^3$ and an average 24-hour concentration of 10.2 $\mu g/m^3$. We recommend continued monitoring at the Tyler site to strengthen understanding of $PM_{2.5}$ trends in the region.

1 Introduction

1.1 The Tyler-Longview-Marshall-Athens Area

The Tyler-Marshall-Longview-Athens (TLMA) area includes Gregg, Harrison, Henderson, Rusk, Smith, and Upshur counties. **Figure 1.1** displays the TLMA area's major roadways, urban areas, and the Texas Center for Environmental Quality (TCEQ)-operated continuous air monitoring system (CAMS) locations. Currently, the Karnack CAMS 85 monitor is the only monitor that measures $PM_{2.5}$. The total population in the TLMA area in 2023 was 621,545.[1] The City of Tyler, located in Smith County, and the City of Longview, located in Gregg County, are the largest cities in the TLMA area with 2023 populations of 110,203 and 83,202, respectively[1]. Smith County comprises the Tyler core-based statistical area (CBSA) and had a population of 244,908 in 2023, representing 39% of the population in the TLMA area[1]. Gregg, Harrison, Rusk, and Upshur counties comprise the Longview CBSA and together had a population of 290,956 in 2023[1], representing 47% of the population in the TLMA area. Henderson County is part of the Athens CBSA and had a population of 85,681[1] in 2023, representing 11% of the population in the TLMA area.

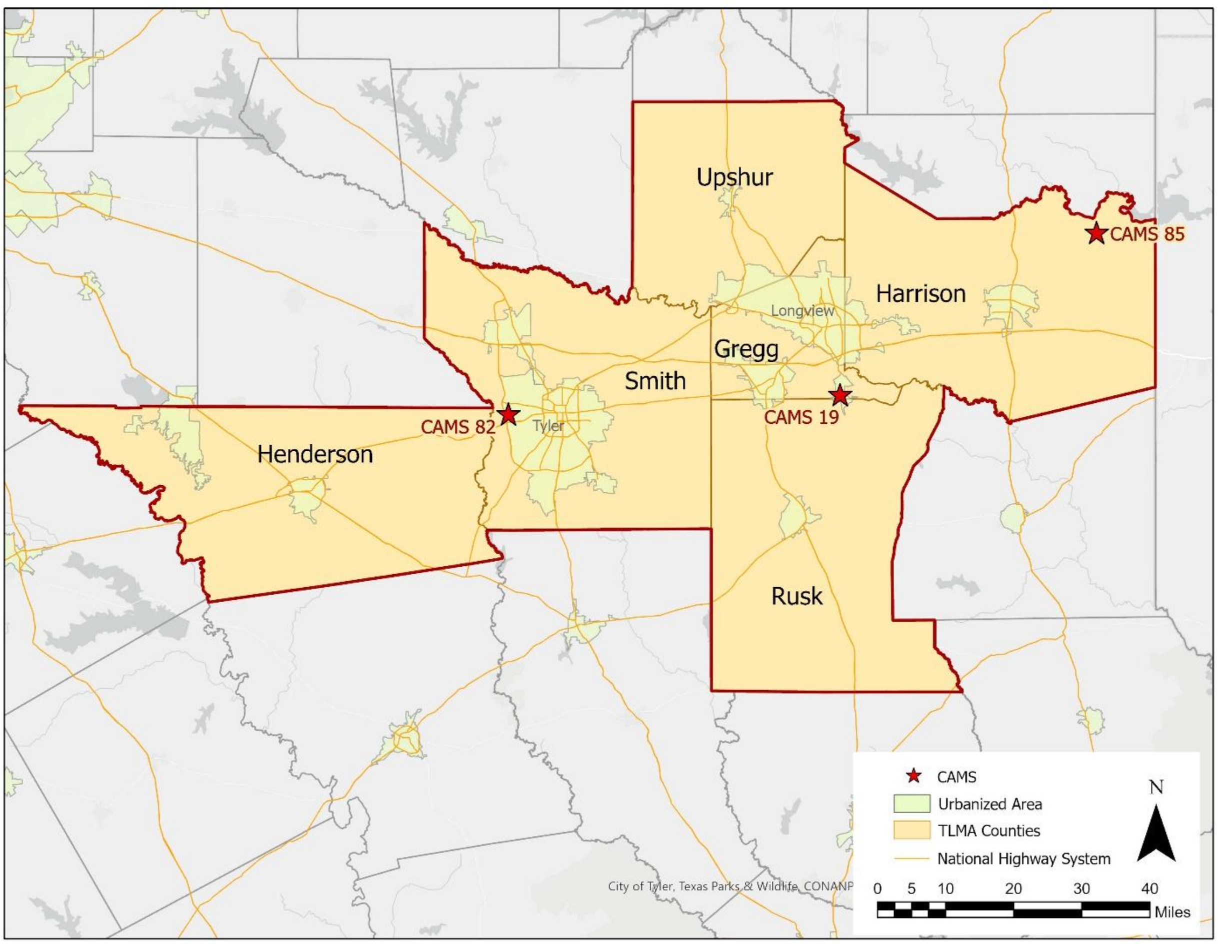

Figure 1.1. The six county TLMA area, location of CAMS monitors in the area with urban areas and major roadways in the surrounding region.

[1] Texas Demographic Center, "2023 Population Estimates: Texas Population Estimates Program". https://demographics.texas.gov/Estimates/2023/. Accessed November 2025.

1.2 Background and Purpose

The US Environmental Protection Agency (EPA) sets National Ambient Air Quality Standards (NAAQS) for ambient $PM_{2.5}$ pollution. Primary standards protect public health, and secondary standards protect public welfare (e.g., visibility, damage to animals, crops, vegetation, and buildings). Under the Clean Air Act, the EPA is required to review the NAAQS periodically for both long-term (annual average, averaged over 3 years) and short-term (24-hour average, 98th percentile in each year) concentrations. On February 7, 2024, EPA lowered the annual average $PM_{2.5}$ standard for outdoor air from 12 micrograms per cubic meter (μg/m^3) to 9 μg/m^3 effective from May 6, 2024. The 24-hour $PM_{2.5}$ standard (35 μg/m^3) and secondary $PM_{2.5}$ standards did not change as part of this reconsideration.

Compliance with the NAAQS is assessed at an individual monitor by comparing the monitor's Design Value to the NAAQS. For $PM_{2.5}$, the monitor Design Value is calculated as the 3-year annual average of $PM_{2.5}$ values.[2] Failure to comply with the NAAQS can adversely affect public health and inhibit economic development. To ensure that the TLMA area meets the $PM_{2.5}$ NAAQS, $PM_{2.5}$ air quality planning is important.

1.2.1 $PM_{2.5}$ Air Quality Status in the Tyler-Longview-Marshall Athens Area

The TCEQ operates one continuous air monitoring station (Karnack CAMS 85) in the TLMA area that determines whether the area is in compliance with the $PM_{2.5}$ NAAQS. The location of this monitor is shown above in **Figure 1.1**. EPA estimated a Design Value at Karnack (CAMS 85) of 9.5 μg/m^3 for the 2021 to 2023 period which is above the 9.0 μg/m^3 standard.[3]

For this project, Ramboll deployed a $PM_{2.5}$ instrument and made measurements at the previously established Tyler sampling site located adjacent to TCEQ's Tyler Airport Relocated site (CAMS 82). Measurements took place from April 1st through September 4th 2025. The sampling site was selected to be within another ETCOG monitoring project (NO_2 monitoring) which provided infrastructure to support $PM_{2.5}$ monitoring. This site was established for previous studies and selected with guidance from Ramboll and the TCEQ to be comparable with data from existing monitoring networks.

[2] EPA, Air Quality Deign Values. https://www.epa.gov/air-trends/air-quality-design-values. Accessed November 2025.
[3] EPA, $PM_{2.5}$ Design Values, 2023. https://www.epa.gov/system/files/documents/2024-08/pm25_designvalues_2021_2023_final_08_08_24_0.xlsx. Accessed November 2025.

2 Methods

Monitoring of ambient $PM_{2.5}$ at Tyler (CAMS 82) began on April 1st, 2025 and concluded on September 4th, 2025, hereafter referred to as the "monitoring period." The measurements for this project were located adjacent to the TCEQ's CAMS 82 trailer (32.344013, -95.415715).

2.1 Ambient $PM_{2.5}$ Measurements

A Met One Instruments BAM-1022 beta-attenuation mass monitor was employed for real-time particulate-matter measurements. The BAM-1022 is a U.S. EPA–designated Federal Equivalent Method (FEM) for both $PM_{2.5}$ and PM_{10} and determines aerosol mass by measuring how a collimated ^{14}C beta beam is attenuated as it passes through a glass-fiber filter tape before and after particles are deposited on the tape.[4] Ambient Air is drawn through a size-selective inlet at a flow rate of 16.7 L/min, and particles are collected on a filter tape between a beta source and detector. The reduction in detected beta rays, caused by particle accumulation, is used to calculate PM mass. The instrument operates on an automatic hourly cycle: the tape advances to a new spot each hour, and air is sampled for one hour before the next advance. PM concentration is reported in $\mu g/m^3$ or mg/m^3, based on the measured mass and air volume. The instrument was configured with a PM_{10} head followed by a $PM_{2.5}$ Very Sharp Cut Cyclone (VSCC).

2.2 Monitoring Station Site Photos

As mentioned above, the $PM_{2.5}$ monitor was sited adjacent to TCEQ's Tyler Airport Relocated site (CAMS 82). **Figure 2.1** through **Figure 2.4** show photos of the monitoring station clockwise in 90 degree increments from the southwest facing view (**Figure 2.1**), northwest facing view (**Figure 2.2**), northeast facing view (**Figure 2.3**), and southeast facing view (**Figure 2.4**) respectively. Note: The PM_{10} head and $PM_{2.5}$ VSCC were not installed at the time the site photos were taken due to the 72-hour zero background checks being run with the High-Efficiency Particulate Air (HEPA) filter installed.

[4] Met One Instruments, BAM 1022 Particulate Monitor Operation Manual. Available at: https://metone.com/wp-content/uploads/2020/02/BAM-1022-9805-Operation-Manual-Rev-C.pdf/. Accessed November 2025.

Figure 2.1. Southwest Facing Photo of Monitoring Station

Figure 2.2. Northwest Photo of Monitoring Station

Figure 2.3. Northeast Photo of Monitoring Station

Figure 2.4. Southeast Photo of Monitoring Station

3 Results

An overview of all ambient $PM_{2.5}$ measurements made at Tyler (adjacent to CAMS 82) during the monitoring period is shown below. All data is presented as 24-hour average measurements unless otherwise noted.

3.1 Ambient $PM_{2.5}$ Measurements

A summary of the 24-hour average $PM_{2.5}$ concentrations during the monitoring period is presented below in **Figure 3.1**. Statistics for both 24-hour and 1-hour average $PM_{2.5}$ concentrations are presented in **Table 3.1**. For a complete set of 24-hour $PM_{2.5}$ concentration data, see the data deliverable accompanying this report.

Figure 3.1 shows that $PM_{2.5}$ concentrations at Tyler remained well below the secondary NAAQS during the monitoring period. Note that there are two periods of missing data: (a) outlines a period where the instrument ingested rainwater and was offline, while (b) outlines a period where the instrument was offline due to hardware issues resulting from a power surge. For more information on the periods, see **Section 3.3** below.

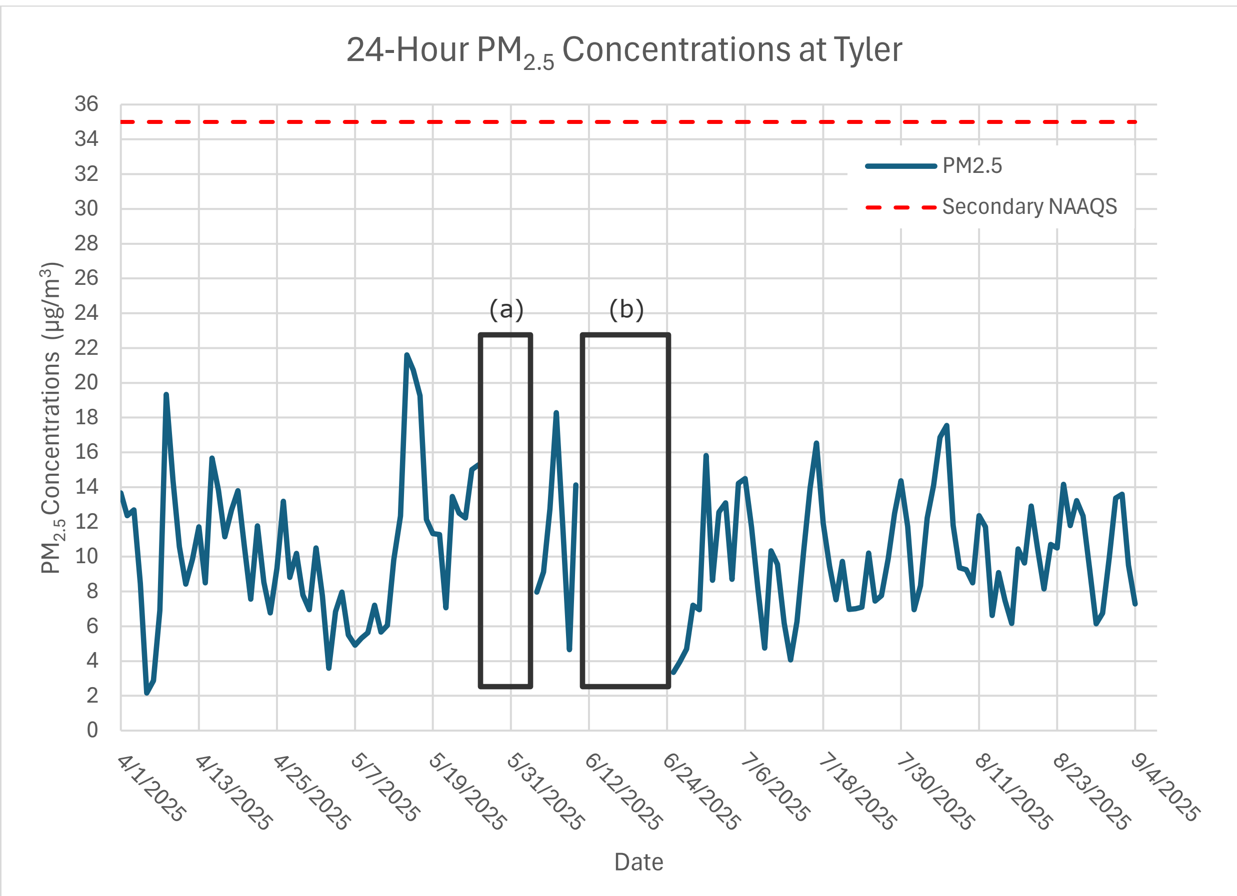

Figure 3.1. Tyler 24-hour $PM_{2.5}$ Concentrations During the Sampling Period (April 1st to September 4th, 2025) with two periods of missing data labelled (a) and (b).

Monthly average concentrations were calculated using valid days only. As shown in **Table 3.1** below, the 24-hour average $PM_{2.5}$ maximum concentration of 21.60 µg/m³ occurred on May 15th, 2025. June had the lowest average concentration of 9.26 µg/m³ while September had the highest average concentration of 10.94 µg/m³. Note that the average for September was calculated using only the first four days of the month (September 1st through 4th) since the site was decommissioned after September 4th. For the 1-hour average $PM_{2.5}$, the maximum concentration of 51.10 µg/m³ occurred on April 8th, 2025, at 21:00 CST. June had the lowest average concentration, at 9.29 µg/m³ while the first 4 days of September had the highest average concentration of 10.94 µg/m³. Note that it is possible for the mass monitor to occasionally record negative hourly values if the actual particulate concentration is very low. This is because the mass monitor has an hourly random noise band of several micrograms.[5] This can also occur during times of rapidly changing RH or at instrument start up. Hourly values below -5 were flagged in the final data set and the cause investigated.

Table 3.1. Monthly $PM_{2.5}$ Statistics for 24-hour and 1-hour Average $PM_{2.5}$ Concentrations During the Sampling Period (April 1st to September 4th, 2025).

Averaging Period (hours)	Month	Maximum Concentration (µg/m³)	Minimum Concentration (µg/m³)	Average Concentration (µg/m³)
24	**April**	19.33	2.16	10.35
24	**May**	21.60	3.60	10.42
24	**June**	18.28	3.35	9.26
24	**July**	16.54	4.06	9.91
24	**August**	17.54	6.14	10.48
24	**September***	13.58	7.29	10.94
24	**All**	21.60	2.16	10.20
1	**April**	51.10	-3.30	10.35
1	**May**	38.50	-6.30	10.29
1	**June**	27.70	-10.20	9.29
1	**July**	23.50	-11.40	9.90
1	**August**	27.40	-12.00	10.49
1	**September***	27.90	1.00	10.94
1	**All**	51.10	-12.00**	10.19

***** September includes only 9/1 through 9/4

**Negative hourly values are possible due to random noise

3.2 Site Performance and Data Recovery

Data recovery statistics for $PM_{2.5}$ are presented in this section in comparison to the 75% target specified in the project specific Quality Assurance Project Plan (QAPP).[6] The data recovery target was met for all months with the exception of June, and the monitoring period in its entirety.

For 24-hour $PM_{2.5}$ values, a day is considered valid if 75% (18 hours) or more of the hours in a day have valid data. During the monitoring period, 22 days were invalid, resulting in a 24-hour $PM_{2.5}$ data completeness of 86%. Table 3.2 summarizes the 24-hour $PM_{2.5}$ data recovery.

Table 3.2. 24-hour $PM_{2.5}$ Data Recovery

[5] Met One Instruments, BAM 1022 Particulate Monitor Operation Manual. Available at: https://metone.com/wp-content/uploads/2020/02/BAM-1022-9805-Operation-Manual-Rev-C.pdf/. Accessed November 2025.
[6] Ramboll, Level IV Quality Assurance Project Plan (QAPP) for Task 3.2 (Monitoring PM2.5). Available by request.

Month	Valid Days	Data Recovery
April	30	100%
May	26	84%
June	13	43%
July	31	100%
August	31	100%
September	4	100%
All	135	86%

*****September includes only 9/1 through 9/4

3.3 Site Activities and Significant Events

Routine downloads of $PM_{2.5}$ data were completed to screen data for issues, and complete data validation took place after the conclusion of the monitoring period. Additionally, monthly site visits were performed by Barrett Environmental to complete flow, temperature, and pressure checks in addition to routine inspection and maintenance including PM_{10} head and $PM_{2.5}$ cyclone cleaning and sampling tape changes as outlined in the QAPP, and consistent with objectives outlined in 40 CFR Part 58 Appendix A*, US EPA Quality Assurance Handbook for Air Pollution Measurement Systems Volume II: Ambient Air Monitoring Program*. **Table 3.3** contains the dates of each QC site visit during the monitoring period. For more details on the monthly site visit routine maintenance, see the complete QC check forms in the data deliverable accompanying this report.

Table 3.3. Dates of QC Site Visits

Dates of QC Site Visits
3/27/25
5/2/25
6/4/25
6/25/25
7/3/25
8/1/25
9/5/25

In addition to brief power outages and routine maintenance, several more significant events caused data invalidation during the monitoring period. During a severe storm in late May, water was ingested by the instrument, causing a data invalidation between May 26, 2025 to June 4th, 2025. A power surge on June 10th, 2025 resulted in a hardware failure that resulted in data invalidation through June 25th, 2025. Seventy-two hour zero background checks were completed both after the initial installation, and after the June 10th incident, to maintain a consistent baseline correction of beta ray attenuation through clean filter tape, which is essential for accurate $PM_{2.5}$ calculations. In total, 337 hours were invalid due to instrument hardware failures, 212 hours were invalid as a result of the large, and smaller, power outages, and 58 hours were invalid due to routine and other maintenance.

4 Conclusions and Recommendations

- The FEM $PM_{2.5}$ monitor at the ETCOG Tyler monitoring location achieved the overall data capture goals for the program established in the QAPP, providing valid data from April 1st to September 4th, 2025.
- Data completeness for 24-hour average $PM_{2.5}$ was 86%, above the 75% target.
- All 24-hour $PM_{2.5}$ values stayed below the secondary NAAQS limit of 35 µg/m³; the highest 24-hour concentration was 21.6 µg/m³.
- The average 24-hour concentration over the monitoring period was 10.2 µg/m³.
- A primary NAAQS comparison is not possible because three consecutive years of data are required to determine a monitor's Design Value to compare to NAAQS.
- Recommendation: continue $PM_{2.5}$ monitoring at the Tyler site for additional years to strengthen understanding of $PM_{2.5}$ spatial and temporal variations within the TLMA region.

5 References

EPA, Air Quality Deign Values. https://www.epa.gov/air-trends/air-quality-design-values. Accessed November 2025.

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APPENDIX F

Final Report for Subtask 3.3: $PM_{2.5}$ Data Analysis for Northeast Texas

Contract 582-24-01388
Subtask 3.3

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November 2025

$PM_{2.5}$ Data Analysis for Northeast Texas
Final Report

Contents

List of Acronyms and Abbreviations **iii**

Executive Summary **1**

1 Introduction **2**
1.1 The Tyler-Longview-Marshall-Athens Area 2
1.2 Background and Purpose 3
1.2.1 $PM_{2.5}$ Air Quality Status in the Tyler-Longview-Marshall Athens Area 3

2 $PM_{2.5}$ Data Analysis Results **4**
2.1 Tyler (collocated with CAMS 82) and Karnack (CAMS 85) Site Comparison 4
2.2 Wind and Pollution Roses 7
2.3 Periods of Interest 10

3 Conclusions and Recommendations **19**

4 References **20**

Table of Figures

Figure 1.1. The six county TLMA area, location of CAMS monitors in the area with urban areas and major roadways in the surrounding region. 2
Figure 2.1. Tyler (collocated with CAMS 82) and Karnack (CAMS 85) 24-hour $PM_{2.5}$ Concentrations 5
Figure 2.2. Scatterplot of 24-hour $PM_{2.5}$ Concentrations at Tyler (collocated with CAMS 82) and Karnack (CAMS 85) 7
Figure 2.3. Tyler (collocated with CAMS 82) Wind Rose 8
Figure 2.4. Tyler (collocated with CAMS 82) Pollution Rose 9
Figure 2.5. Karnack (CAMS 85) Wind Rose 9
Figure 2.6. Karnack (CAMS 85) Pollution Rose 10
Figure 2.7. HMS Smoke and Fire Map for June 7th, 2025 13
Figure 2.8. Tyler (collocated with CAMS 82) Wind Rose, Top 10 Days Not Smoke Impacted 15
Figure 2.9. Tyler (collocated with CAMS 82) Wind Rose, Top 10 Days Smoke Impacted 15
Figure 2.10. Tyler (collocated with CAMS 82) Pollution Rose, Top 10 Days Not Smoke Impacted 16
Figure 2.11. Tyler (collocated with CAMS 82) Pollution Rose, Top 10 Days Smoke Impacted 16
Figure 2.12. Karnack (CAMS 85) Wind Rose, Top 10 Days Not Smoke Impacted 17
Figure 2.13. Karnack (CAMS 85) Wind Rose, Top 10 Days Smoke Impacted 17

Figure 2.14. Karnack (CAMS 85) Pollution Rose, Top 10 Days Not Smoke Impacted 18
Figure 2.15. Karnack (CAMS 85) Pollution Rose, Top 10 Days Smoke Impacted 18

Table of Tables

Table 2.1. Monthly 24-hour PM2.5 Concentration Statistics for Tyler (collocated with CAMS 82) - April 1st – September 4th, 2025 6
Table 2.2. Monthly 24-hour PM2.5 Concentration Statistics for Karnack (CAMS 85) - April 1st – September 4th, 2025 6
Table 2.3. Tyler (collocated with CAMS 82) Top-ten $PM_{2.5}$ Concentration Days, Highlighted Days are Shared with Karnack (CAMS 85) 11
Table 2.4. Karnack (CAMS 85) Top-ten $PM_{2.5}$ Concentration Days, Highlighted Days are Shared with Tyler (collocated with CAMS 82) 11
Table 2.5. Top ten $PM_{2.5}$ days at Tyler (collocated with CAMS 82) and Karnack (CAMS 85) with smoke impacts at each location. 14

Table of Appendices

Appendix A Smoke Maps for Top-ten $PM_{2.5}$ Days at Tyler (collocated with CAMS 82) and Karnack (CAMS 85)

List of Acronyms and Abbreviations

$\mu g/m^3$	Micrograms per cubic meter
CAMS	Continuous Air Monitoring System
CBSA	Core-based statistical area
EPA	US Environmental Protection Agency
ETCOG	East Texas Council of Governments
FEM	Federal Equivalent Method
HMS	Hazard Mapping System
NAAQS	National Ambient Air Quality Standards
NOAA	National Oceanographic and Atmospheric Administration
$PM_{2.5}$	Particulate matter with an aerodynamic diameter 2.5 microns or less in diameter
R^2	Correlation Coefficient
SIP	State Implementation Plan
TCEQ	Texas Commission on Environmental Quality
TLMA	Tyler-Longview-Marshall-Athens

Executive Summary

The purpose of this task was to analyze the $PM_{2.5}$ field measurements near Tyler (collocated with CAMS 82) together with TCEQ data at Karnack (CAMS 85) to understand variations in particulate matter with an aerodynamic diameter less than 2.5 microns ($PM_{2.5}$) concentrations across the Tyler-Longview-Marshall-Athens (TLMA) area. We applied traditional data analysis methods for $PM_{2.5}$ to characterize the spatial and temporal patterns of $PM_{2.5}$ pollution in the TLMA area and draw conclusions about the likely influences of local and regional sources of $PM_{2.5}$ pollution. The overall goal of this project is to better understand source contributions to $PM_{2.5}$ in the TLMA area. Tyler $PM_{2.5}$ data was acquired directly through the Ramboll air monitoring program, while Karnack $PM_{2.5}$ and both Tyler (collocated with CAMS 82) and Karnack (CAMS 85) meteorological data (resultant wind speed and resultant wind direction) were acquired through the TCEQ website on October 1, 2025.[1] Analyses of April 1st–September 4th, 2025 data—including time-series reviews, wind and pollution rose plots, and smoke impact screening—show that the two monitors behaved somewhat similarly, having very similar overall average concentrations and sharing four of the ten dates with highest 24-hour concentrations, which implies an influence from regional background $PM_{2.5}$ in the TLMA area. Seven of Tyler's top ten $PM_{2.5}$ days and four of Karnack's were driven in part by wildfire or agricultural burn smoke identified in National Oceanographic and Atmospheric Administration (NOAA) hazard maps. Tyler's elevated $PM_{2.5}$ aligned with southerly winds, whereas Karnack exhibited a bimodal pattern: elevated $PM_{2.5}$ with southerly winds during smoke events and elevated $PM_{2.5}$ with northerly winds under calm, likely local conditions. Due to the limited temporal extent of the Tyler data collection period (April 1st, 2025 through September 4th, 2025 only), these field measurements of $PM_{2.5}$ may not be representative of year-round $PM_{2.5}$ concentrations, other seasons, or other years. Because the current six-month record covers only part of the seasonal cycle, we recommend extending monitoring at Tyler (collocated with CAMS 82) for at least a full calendar year to improve the understanding of spatial and temporal variations of $PM_{2.5}$ in the TLMA area.

[1] TCEQ, Data by Year by Site by Parameter, Accessible at: https://www.tceq.texas.gov/cgi-bin/compliance/monops/yearly_summary.pl Accessed November 2025

1 Introduction

1.1 The Tyler-Longview-Marshall-Athens Area

The Tyler-Marshall-Longview-Athens (TLMA) area includes Gregg, Harrison, Henderson, Rusk, Smith, and Upshur counties. **Figure 1.1** displays the TLMA area's major roadways, urban areas, and the TCEQ-operated continuous air monitoring system (CAMS) locations. Currently the Karnack CAMS 85 monitor is the only monitor that measures Particulate with an aerodynamic diameter less than 2.5 microns ($PM_{2.5}$). The total population in the TLMA area in 2023 was 621,545.[2] The City of Tyler, located in Smith County, and the City of Longview, located in Gregg County, are the largest cities in the TLMA area with 2023 populations of 110,203 and 83,202, respectively.[2] Smith County comprises the Tyler core-based statistical area (CBSA) and had a population of 244,908 in 2023, representing 39% of the population in the TLMA area.[2] Gregg, Harrison, Rusk, and Upshur counties comprise the Longview CBSA and together had a population of 290,956 in 2023,[2] representing 47% of the population in the TLMA area. Henderson County is part of the Athens CBSA and had a population of 85,681[2] in 2023, representing 11% of the population in the TLMA area.

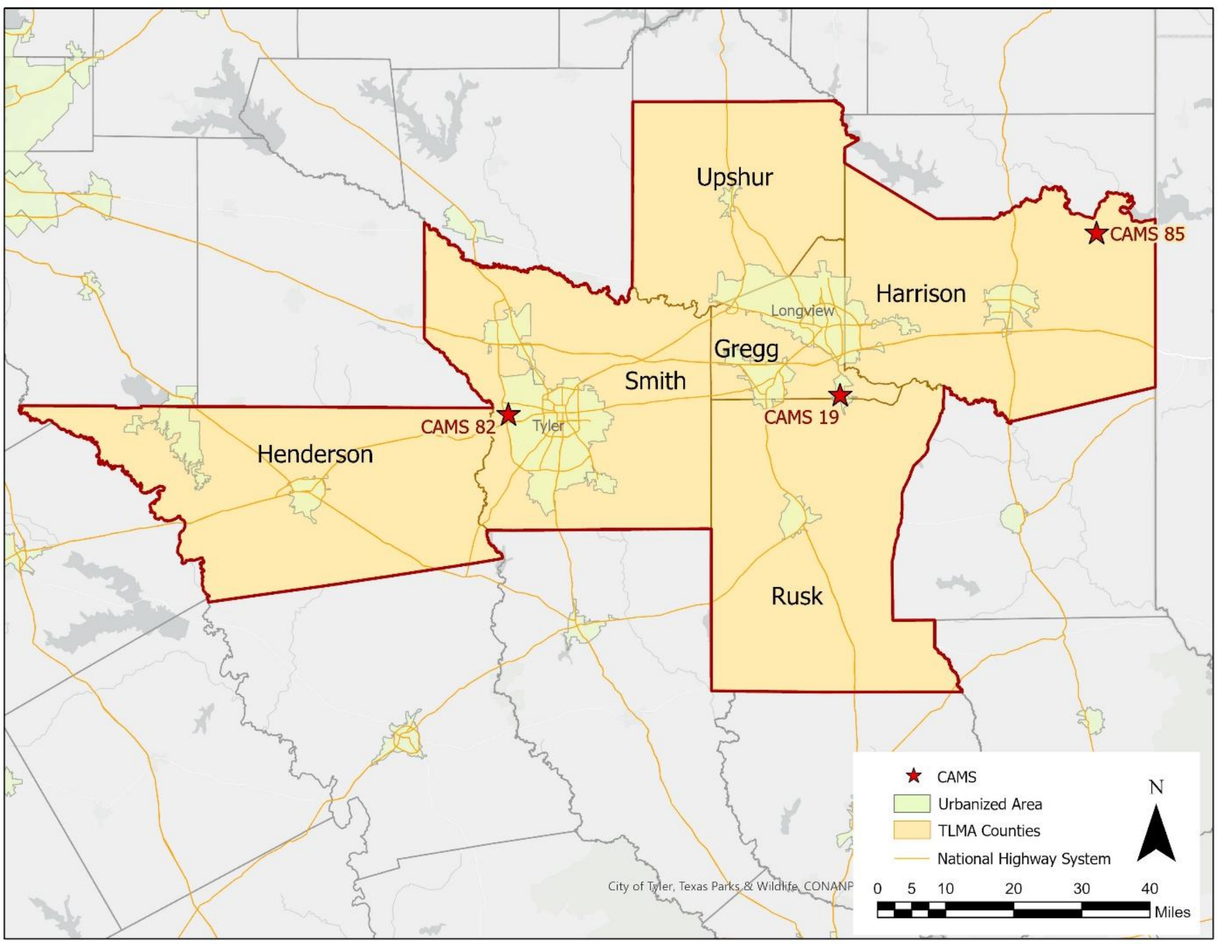

Figure 1.1. The six county TLMA area, location of CAMS monitors in the area with urban areas and major roadways in the surrounding region.

[2] Texas Demographic Center. "2023 Population Estimates: Texas Population Estimates Program". https://demographics.texas.gov/Estimates/2023/. Accessed November 2025.

1.2 Background and Purpose

The US Environmental Protection Agency (EPA) sets National Ambient Air Quality Standards (NAAQS) for ambient $PM_{2.5}$ pollution. Primary standards protect public health and secondary standards protect public welfare (e.g., visibility, damage to animals, crops, vegetation, and buildings). Under the Clean Air Act, the EPA is required to review the NAAQS periodically for both long-term (annual average, averaged over 3 years) and short-term (24-hour average, 98th percentile in each year) concentrations. On February 7th, 2024, EPA lowered the annual average $PM_{2.5}$ standard for outdoor air from 12 micrograms per cubic meter ($\mu g/m^3$) to 9 $\mu g/m^3$ effective from May 6th, 2024. The 24-hour $PM_{2.5}$ standard (35 $\mu g/m^3$) and secondary $PM_{2.5}$ standards did not change as part of this reconsideration.

Compliance with the NAAQS is assessed at an individual monitor by comparing the monitor's Design Value to the NAAQS. For $PM_{2.5}$, the monitor Design Value is calculated as the 3-year annual average of $PM_{2.5}$ values.[3] Failure to comply with the NAAQS can adversely affect public health and inhibit economic development. To ensure that the TLMA area meets the $PM_{2.5}$ NAAQS, $PM_{2.5}$ air quality planning is important.

1.2.1 $PM_{2.5}$ Air Quality Status in the Tyler-Longview-Marshall Athens Area

The TCEQ operates one continuous air monitoring station (CAMS; Karnack CAMS 85) in the TLMA area that determines whether the area is in compliance with the $PM_{2.5}$ NAAQS. The location of this monitor is shown above in **Figure 1.1**. The Design Value is the annual mean concentration, averaged over three consecutive years. EPA estimated a Design Value of 9.5 $\mu g/m^3$ at Karnack (CAMS 85) for the 2021 to 2023 period which is above the 9.0 $\mu g/m^3$ standard[4].

For this project, Ramboll deployed a $PM_{2.5}$ reference instrument (the Met One BAM 1022) and made measurements at the previously established sampling site located adjacent to TCEQ's Tyler Airport Relocated site (CAMS 82) which is roughly 60 miles from Karnack. Measurements took place from April through August 2025. The sampling site was selected to be collocated with another East Texas Council of Governments (ETCOG) monitoring project (NO_2 monitoring) which provided infrastructure to support $PM_{2.5}$ monitoring.

This report analyzes the $PM_{2.5}$ monitoring data collected at Tyler (collocated with CAMS 82) under this project together with TCEQ monitoring data, meteorological data, satellite data for wildfire smoke, and other relevant data. We characterize the spatial and temporal patterns of $PM_{2.5}$ pollution in the TLMA area to draw conclusions about the likely influences of local and regional sources of $PM_{2.5}$ pollution. This activity benefits the Texas State Implementation Plan (SIP) by better understanding the influences of local and regional sources of $PM_{2.5}$ pollution in the TLMA area.

[3] EPA. Air Quality Deign Values. https://www.epa.gov/air-trends/air-quality-design-values. Accessed November 2025.
[4] EPA. $PM_{2.5}$ Design Values, 2023. https://www.epa.gov/system/files/documents/2024-08/pm25_designvalues_2021_2023_final_08_08_24_0.xlsx. Accessed November 2025.

2 $PM_{2.5}$ Data Analysis Results

This section presents the $PM_{2.5}$ results at both Tyler (collocated with CAMS 82) and Karnack (CAMS 85) to better understand the similarities and differences between these sites in the TLMA area. The period of record, hereafter referred to as the "monitoring period," ran from April 1st, 2025 through September 4th, 2025. This period was chosen to align with the field deployment of the Met One Instruments BAM-1022 beta-attenuation Federal Equivalent Method (FEM) $PM_{2.5}$ mass monitor at Tyler. Results are shown as 24-hour averages unless otherwise noted, where a 24-hour average is valid if 75% or more of the hours in a given day are valid. Tyler $PM_{2.5}$ data was acquired directly through the Ramboll air monitoring program, while Karnack $PM_{2.5}$ and both Tyler and Karnack meteorological data were acquired through the TCEQ website on October 1st, 2025.[5] Note that TCEQ data was not fully validated at the time of download, and is subject to change.

2.1 Tyler (collocated with CAMS 82) and Karnack (CAMS 85) Site Comparison

Figure 2.1 presents a time series plot of 24-hour $PM_{2.5}$ concentrations at Tyler (collocated with CAMS 82) and Karnack (CAMS 85) over the monitoring period. Both sites remained well below the secondary NAAQS. Most 24-hour averages at both sites are between 4 to 15 µg/m³, while occasional spikes reach the low 20 µg/m³ range. The two sites share common peaks on May 15th and 17th as well as June 7th and 17th, which strongly suggest regional $PM_{2.5}$ events. Given the short monitoring period, no clear long-term trend is visible.

[5] TCEQ, Data by Year by Site by Parameter, Accessible at: https://www.tceq.texas.gov/cgi-bin/compliance/monops/yearly_summary.pl Accessed November 2025.

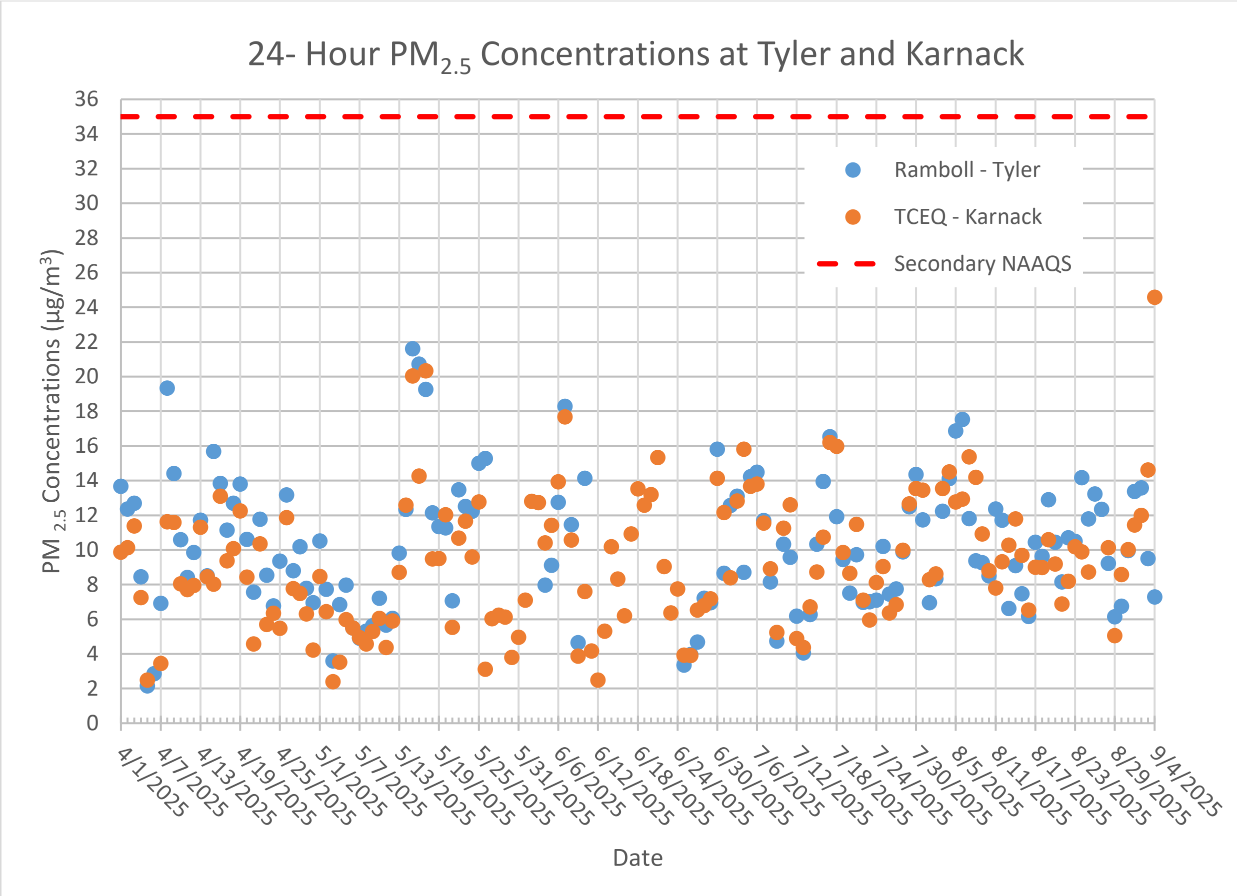

Figure 2.1. Tyler (collocated with CAMS 82) and Karnack (CAMS 85) 24-hour $PM_{2.5}$ Concentrations

Table 2.1 and **Table 2.2** present monthly 24-hour $PM_{2.5}$ concentration statistics for Tyler (collocated with CAMS 82) and Karnack (CAMS 85), respectively. At Tyler, the 24-hour average $PM_{2.5}$ maximum concentration of 21.60 μg/m³ occurred on May 15th, 2025, while at Karnack the 24-hour average $PM_{2.5}$ maximum concentration of 24.57 μg/m³ occurred on September 4th, 2025. Overall average concentrations were less than one (1) μg/m³ different between sites, at 10.20 μg/m³ for Tyler and 9.29 μg/m³ for Karnack.

Table 2.1. Monthly 24-hour PM2.5 Concentration Statistics for Tyler (collocated with CAMS 82) - April 1st – September 4th, 2025

Month	Maximum Concentration (μg/m³)	Minimum Concentration (μg/m³)	Average Concentration (μg/m³)
April	19.33	2.16	10.35
May	21.60	3.60	10.42
June	18.28	3.35	9.26
July	16.54	4.06	9.91
August	17.54	6.14	10.48
September*	13.58	7.29	10.94
All	21.60	2.16	10.20

***September includes only 9/1 through 9/4

Table 2.2. Monthly 24-hour PM2.5 Concentration Statistics for Karnack (CAMS 85) - April 1st – September 4th, 2025

Month	Maximum Concentration (μg/m³)	Minimum Concentration (μg/m³)	Average Concentration (μg/m³)
April	13.10	-0.05	8.09
May	20.33	2.40	8.09
June	17.68	2.49	9.20
July	16.20	4.38	10.22
August	15.37	5.06	10.02
September*	24.57	11.44	15.65
All	24.57	-0.05	9.29

***September includes only 9/1 through 9/4

Figure 2.2 directly compares the Karnack (CAMS 85) to the Tyler (collocated with CAMS 82) measurements of $PM_{2.5}$ (slope = 0.72; r^2 = 0.49). The red line in each scatter plot is a 1 to 1 slope ratio. Based on the slope, Tyler tends to record slightly higher concentrations than Karnack, although the positive y-intercept suggests that Karnack may experience slightly higher background concentrations than Tyler. The data spread is also moderate, with an R^2 of 0.49 meaning about half of the day-to-day variability at Karnack can be explained by what is measured at Tyler, and vice versa. This link between the two sites is consistent with a strong influence by regional background $PM_{2.5}$ on overall $PM_{2.5}$ concentrations at both sites.

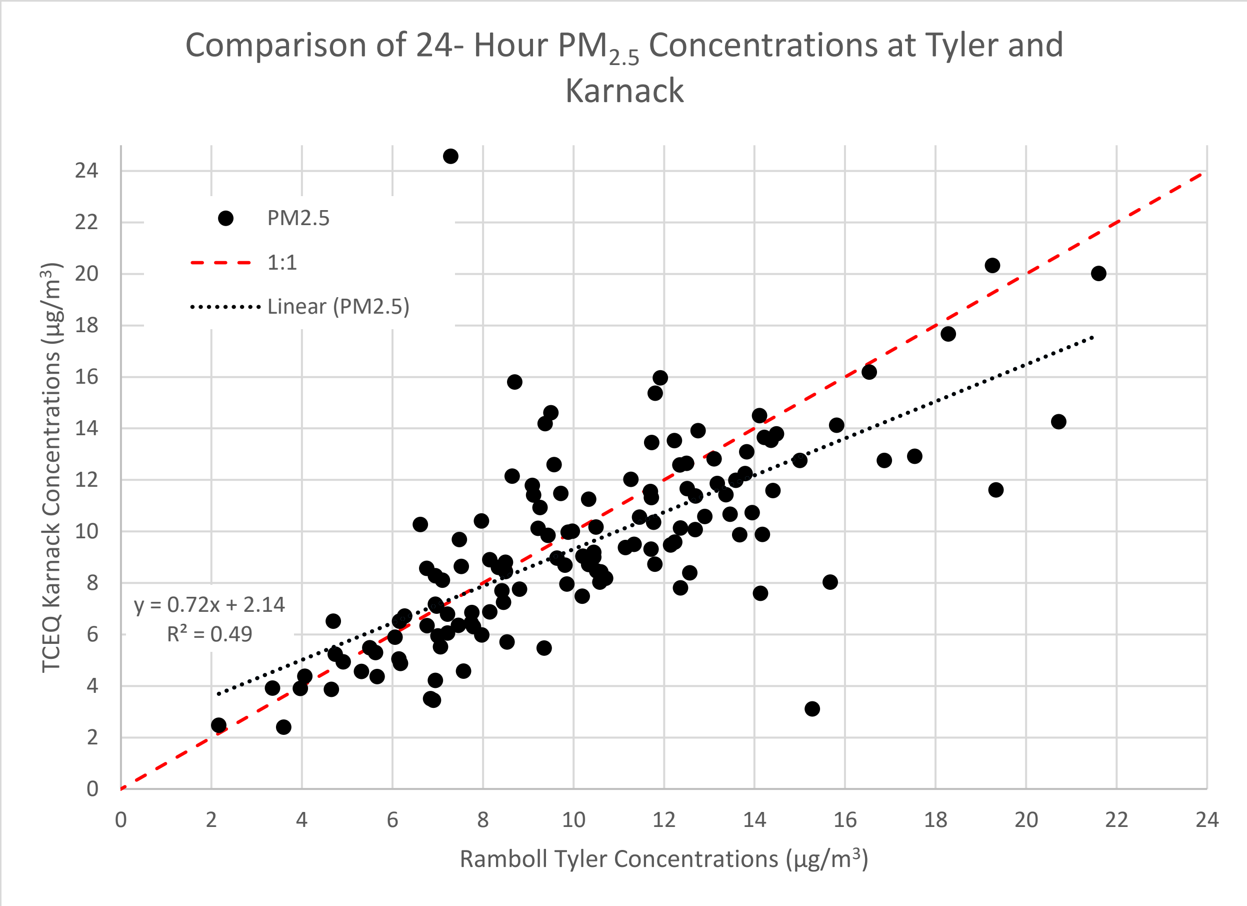

Figure 2.2. Scatterplot of 24-hour $PM_{2.5}$ Concentrations at Tyler (collocated with CAMS 82) and Karnack (CAMS 85)

2.2 Wind and Pollution Roses

Wind roses and pollution roses were generated for each site over the monitoring period to display either wind speeds or pollutant concentrations as a function of wind direction, respectively. Wind roses provide a visual method to analyze how wind direction is associated with wind speed and how often those conditions occurred, while pollution roses allow analysis of the correlation between wind direction and pollutant concentrations. In this case, 1-hour average $PM_{2.5}$ was plotted using pollution roses. This helps us to understand pollutant transport patterns and frequency of occurrence over a given period.

Figure 2.3 through **Figure 2.6** show wind roses and pollution roses at Tyler (collocated with CAMS 82) and Karnack (CAMS 85). Briefly, on each rose, the bars at 0 degrees (°) correspond to wind coming from the North and the bars at 180° correspond to wind coming from the South. The size of each bar is an indication of how frequently the wind comes from a particular direction, based on 1-hour average wind directions. The color of the bars represents the corresponding 1-hour average wind speed (for wind roses) or 1-hour average $PM_{2.5}$ (for pollution roses) when the wind on that day was blowing from that particular direction. Note that for wind roses, the calm threshold used is one (1) mile per hour.

Figure 2.3 shows that winds at Tyler (collocated with CAMS 82) are strongly dominated by southerly and south-southwesterly winds and the strongest winds come from the south. Likewise, **Figure 2.4** shows that the highest $PM_{2.5}$ concentrations at Tyler are also associated with winds from the south. On the other hand, **Figure 2.5** shows that Karnack has a bimodal pattern, with winds frequently from the south and north directions, but, similar to Tyler, the strongest winds come from the south. Similarly, **Figure 2.6** shows that the highest $PM_{2.5}$ concentrations at Karnack (CAMS 85) are primarily associated with winds from the south, and to a lesser extent winds from the north and west. Additionally, Karnack has considerably more calm periods, at 35.7% compared to 1.8% at Tyler. As noted in Johnson et al. (2015), dense tree cover exists near the Karnack (CAMS 85) monitor on three sides, and it is likely that wind speed measurements are affected by these obstructions.

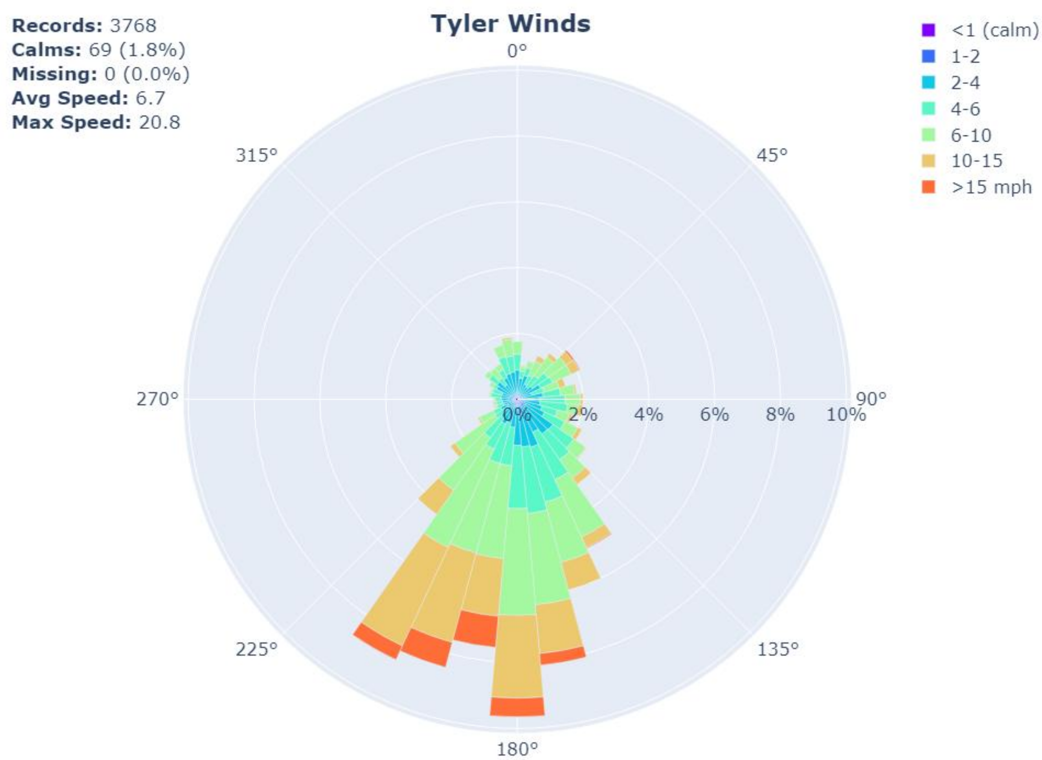

Figure 2.3. **Tyler (collocated with CAMS 82) Wind Rose**

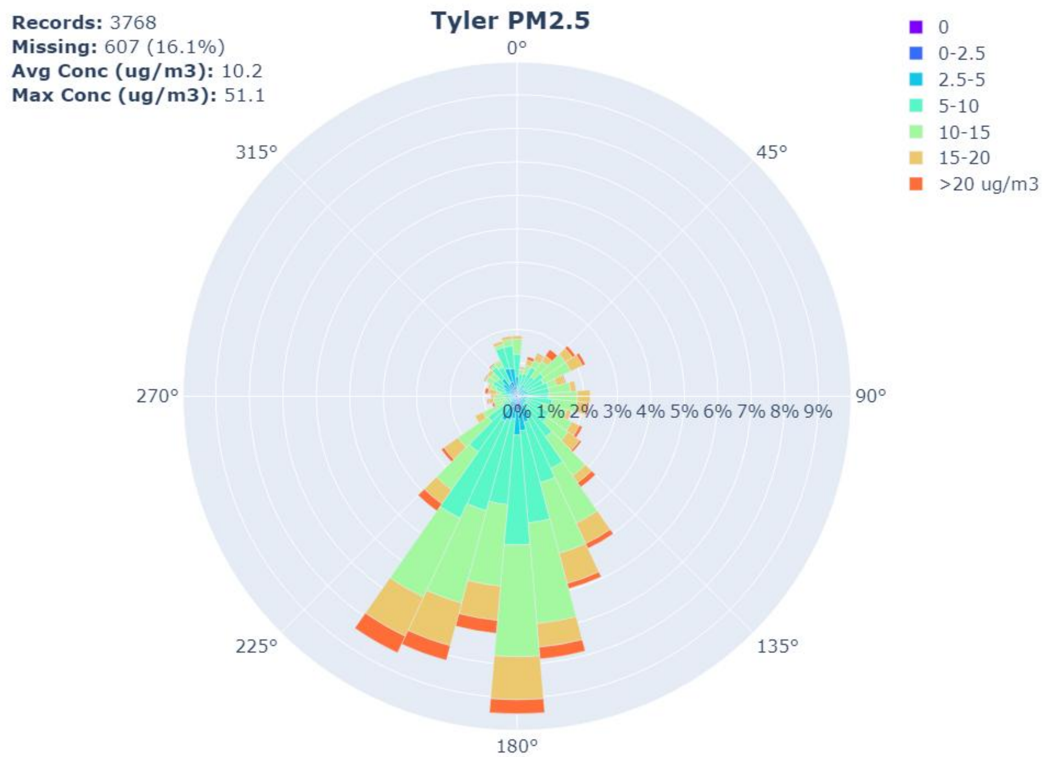

Figure 2.4. Tyler (collocated with CAMS 82) Pollution Rose

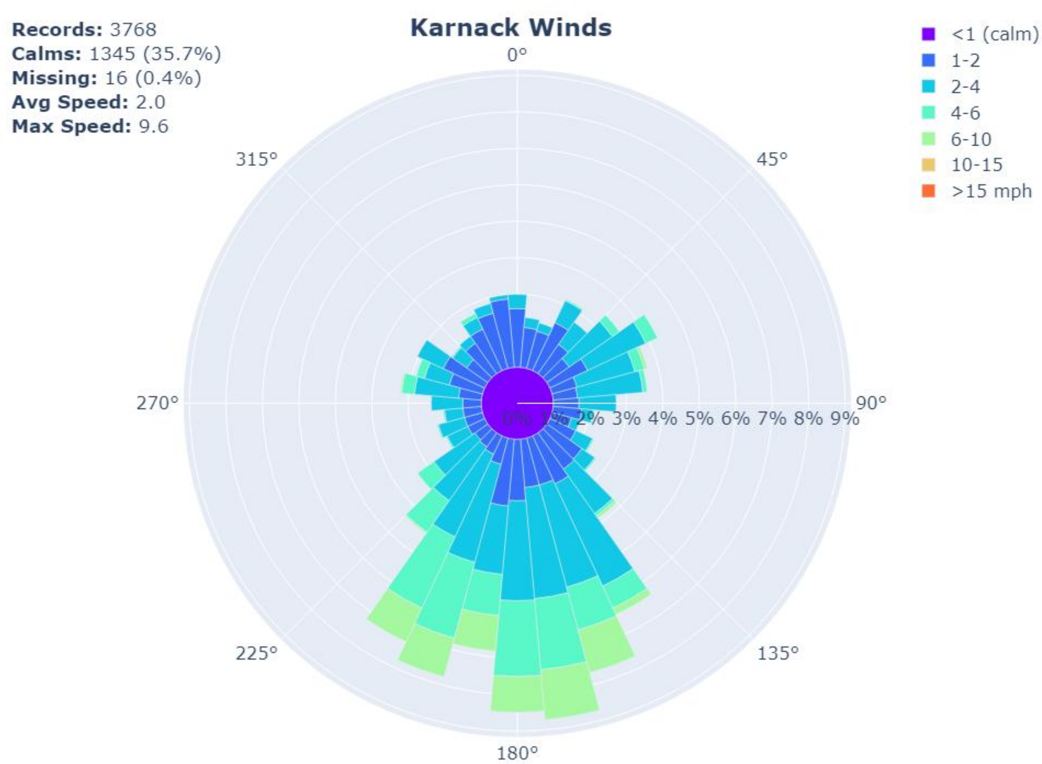

Figure 2.5. Karnack (CAMS 85) Wind Rose

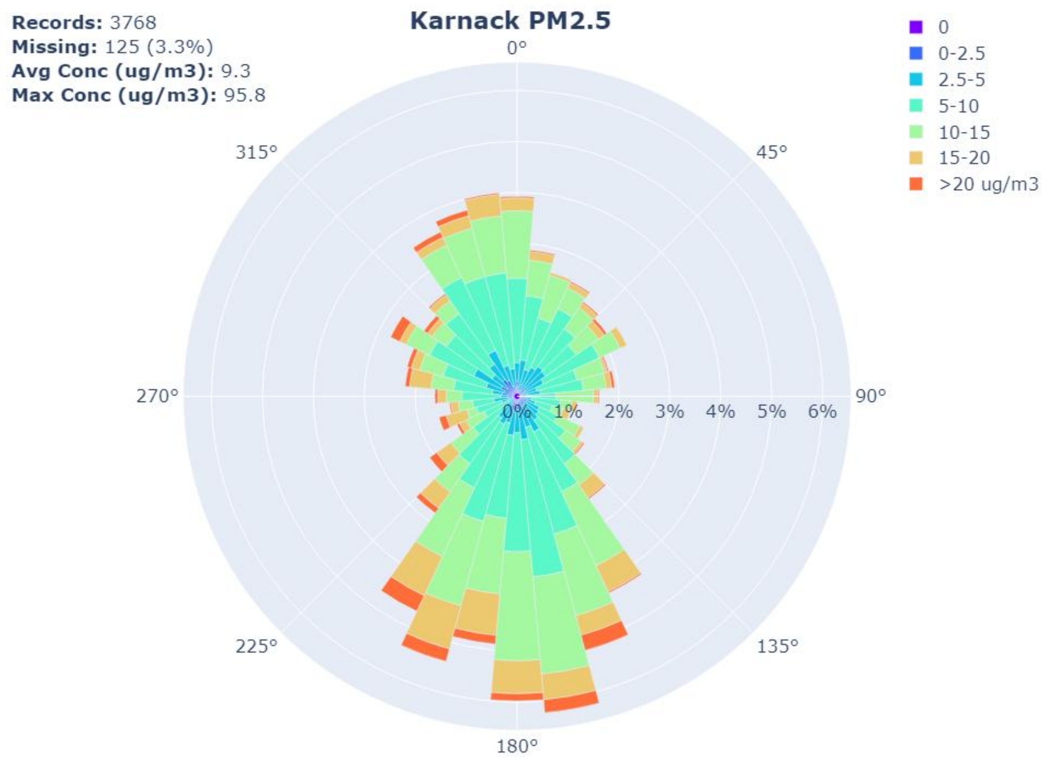

Figure 2.6. Karnack (CAMS 85) Pollution Rose

2.3 Periods of Interest

Several periods of interest were identified during the monitoring period to better understand the distribution of $PM_{2.5}$ concentrations in the TLMA area and potential impacts from smoke. These are discussed in this section. First, the top ten 24-hour $PM_{2.5}$ concentrations were identified at both Tyler and Karnack.

Table 2.3 and **Table 2.4** show the top-ten 24-hour $PM_{2.5}$ concentrations at both Tyler (collocated with CAMS 82) and Karnack (CAMS 85), respectively. On May 15th, 2025 the maximum 24-hour concentration was 21.60 µg/m³ at Tyler. Also on May 15th, 2025 the maximum 24-hour concentration was 24.57 µg/m³ at Karnack. The light blue shading highlights days that were identified in both the Tyler and Karnack top-ten days. There were four (4) common days between Tyler and Karnack, which were May 15th and 17th, June 7th, and July 17th.

Table 2.3. Tyler (collocated with CAMS 82) Top-ten $PM_{2.5}$ Concentration Days, Highlighted Days are Shared with Karnack (CAMS 85)

Top-ten Days	24-hour Concentration (µg/m³)	Date
1	21.60	5/15/2025
2	20.72	5/16/2025
3	19.33	4/8/2025
4	19.25	5/17/2025
5	18.28	6/7/2025
6	17.54	8/6/2025
7	16.87	8/5/2025
8	16.54	7/17/2025
9	15.82	6/30/2025
10	15.68	4/15/2025

* Highlighted cells are dates that also appear on the top-ten list for Karnack

Table 2.4. Karnack (CAMS 85) Top-ten $PM_{2.5}$ Concentration Days, Highlighted Days are Shared with Tyler (collocated with CAMS 82)

Top-ten Days	24-hour Concentration (µg/m³)	Date
1	24.57	9/4/2025
2	20.33	5/17/2025
3	20.03	5/15/2025
4	17.68	6/7/2025
5	16.20	7/17/2025
6	15.97	7/18/2025
7	15.81	7/4/2025
8	15.37	8/7/2025
9	15.33	6/21/2025
10	14.62	9/3/2025

* Highlighted cells are dates that also appear on the top-ten list for Tyler (collocated with CAMS 82)

For the 16 unique top-ten dates at both sites, smoke maps were generated using the National Atmospheric and Oceanographic Administration (NOAA) Hazard Mapping System (HMS) Fire and Smoke Product.[6] Visual inspection of these NOAA smoke maps was employed to divide days into smoke-influenced days, that is, those with mapped smoke plumes overlapping the TLMA area, and non-smoke influenced days, or those without overlapping smoke plumes**. Figure 2.7** presents a

[6] NOAA, Hazard Mapping System Fire and Smoke Product. Accessible at: https://www.ospo.noaa.gov/products/land/hms.html Accessed November 2025.

smoke map example for June 7th, 2025 which is a day that is in the top ten days for both Tyler (collocated with CAMS 82) and Karnack (CAMS 85) (See

Table 2.5 for a full list of which of the top-ten days at each site were smoke impacted). The red triangles show numerous "thermal anomalies", likely to be agricultural fires, burning in Mexico that commonly occur during spring and early summer. The NOAA HMS smoke product indicates that smoke from these fires travelled northward into East Texas and surrounding states. The red indicator flag highlights Karnack (CAMS 85), which registered 24-hour average $PM_{2.5}$ of 15.81 μg/m³ (TCEQ has not fully validated these measurements at CAMS 85). Smoke maps were made for all 16 unique top ten dates between both sites, and are presented in their entirety in **Appendix A**.

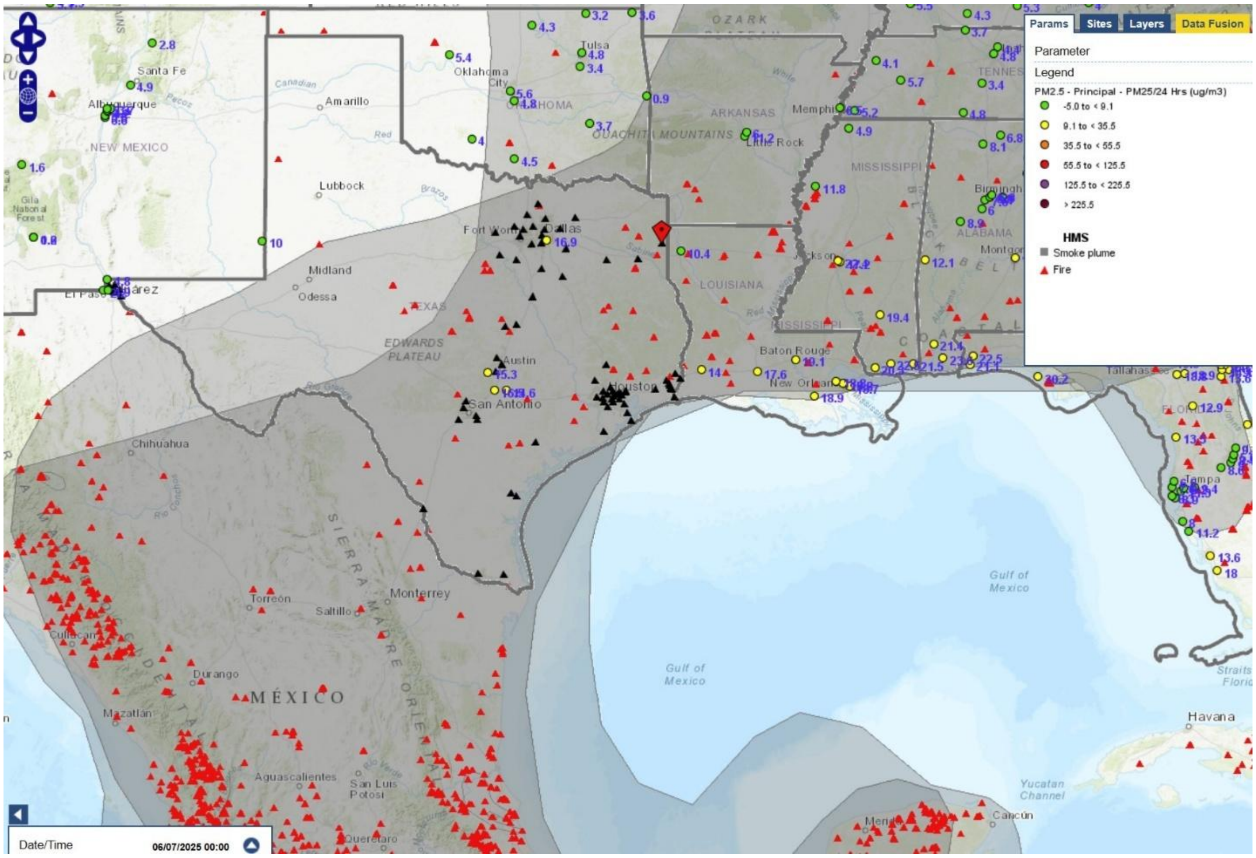

Figure 2.7. **HMS Smoke and Fire Map for June 7th, 2025**

Table 2.5. Top ten $PM_{2.5}$ days at Tyler (collocated with CAMS 82) and Karnack (CAMS 85) with smoke impacts at each location.

Date	Top-ten Day at Tyler	Top-ten Day at Karnack	Smoke Impact at Tyler	Smoke Impact at Karnack
4/8/2025	X		Yes	
4/15/2025	X		Yes	
5/15/2025	X	X	Yes	No
5/16/2025	X		Yes	
5/17/2025	X	X	No	No
6/7/2025	X	X	Yes	Yes
6/21/2025		X		No
6/30/2025	X		No	
7/4/2025		X		No
7/17/2025	X	X	No	No
7/18/2025		X		Yes
8/5/2025	X		Yes	
8/6/2025	X		Yes	
8/7/2025		X		Yes
9/3/2025		X		No
9/4/2025		X		Yes

To better understand the influence of smoke on $PM_{2.5}$ concentrations in the TLMA area, wind roses and pollution roses were developed using the ten highest $PM_{2.5}$ days at Tyler (collocated with CAMS 82) and Karnack (CAMS 85). Using 1-hour $PM_{2.5}$ and resultant wind data from each of the top-ten days, separate roses were created for smoke-impacted and non-smoke-impacted periods—four plots per site in total (see **Figure 2.8** through **Figure 2.15**). **Figure 2.8** through **Figure 2.11** show that, at Tyler (collocated with CAMS 82), smoke-impacted days feature a distinct north-easterly wind component that does not appear on non-smoke impacted days. This suggests that smoke transported from the northeast is a contributor to $PM_{2.5}$ on Tyler's top ten days. On the other hand, **Figure 2.12** through **Figure 2.15** show that, at Karnack (CAMS 85), non-smoke days are dominated by stronger southerly to south-easterly winds than smoke-impacted days. Smoke impacts from this direction are consistent with transport from agricultural fires in Mexico and central America. Note that since only the top-ten days were analyzed, the sample size is relatively small for each figure, with the smallest being **Figure 2.8** and **Figure 2.10**, with only 72 hours shown. Future work could include a smoke impact analysis with a larger scope.

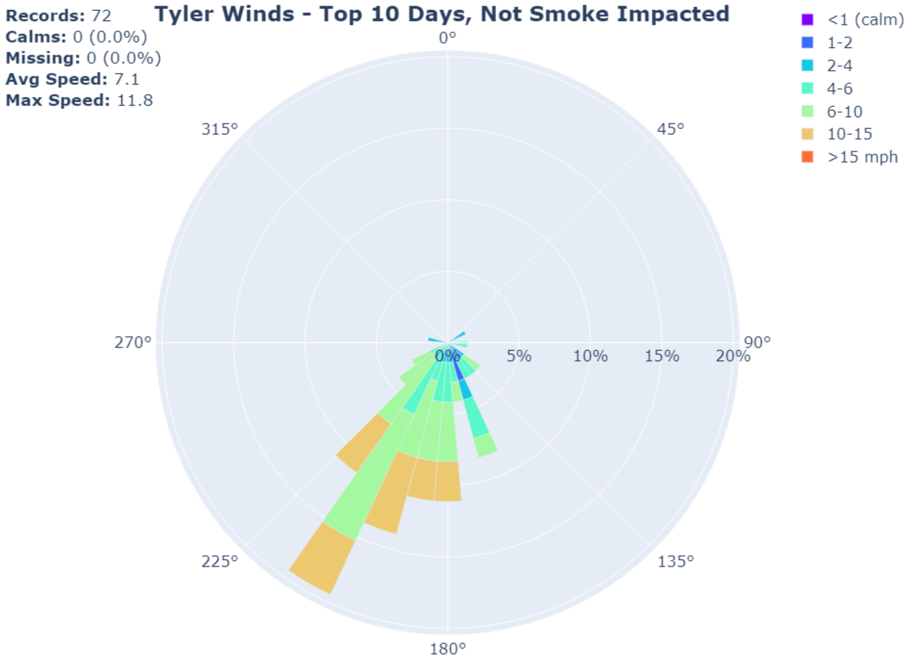

Figure 2.8. Tyler (collocated with CAMS 82) Wind Rose, Top 10 Days Not Smoke Impacted

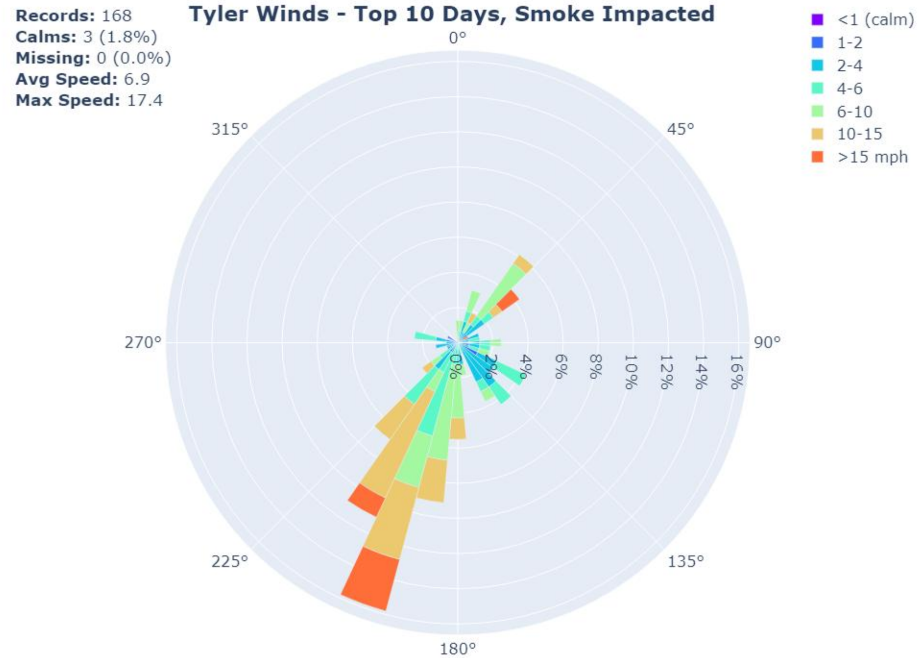

Figure 2.9. Tyler (collocated with CAMS 82) Wind Rose, Top 10 Days Smoke Impacted

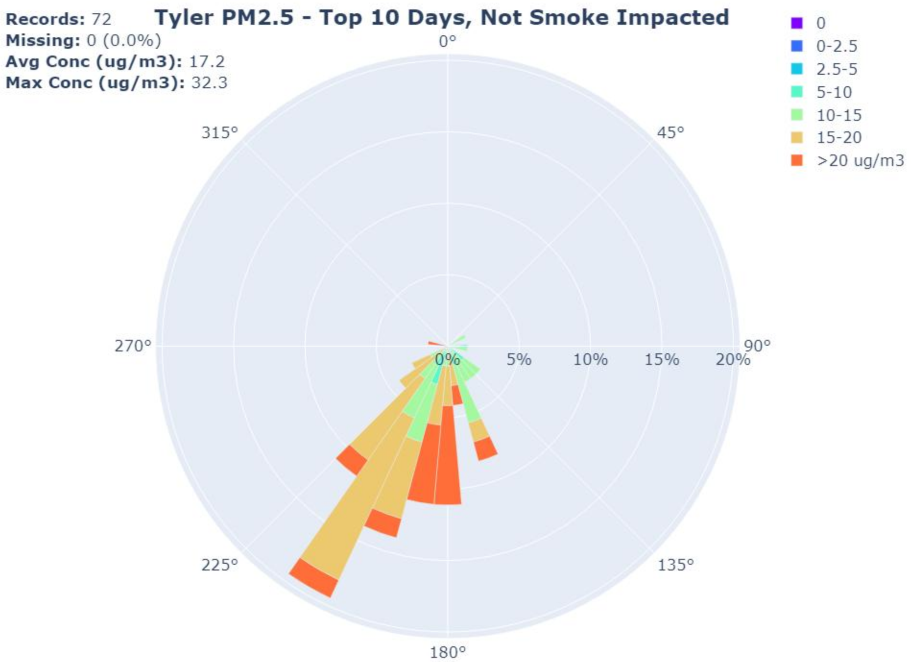

Figure 2.10. Tyler (collocated with CAMS 82) Pollution Rose, Top 10 Days Not Smoke Impacted

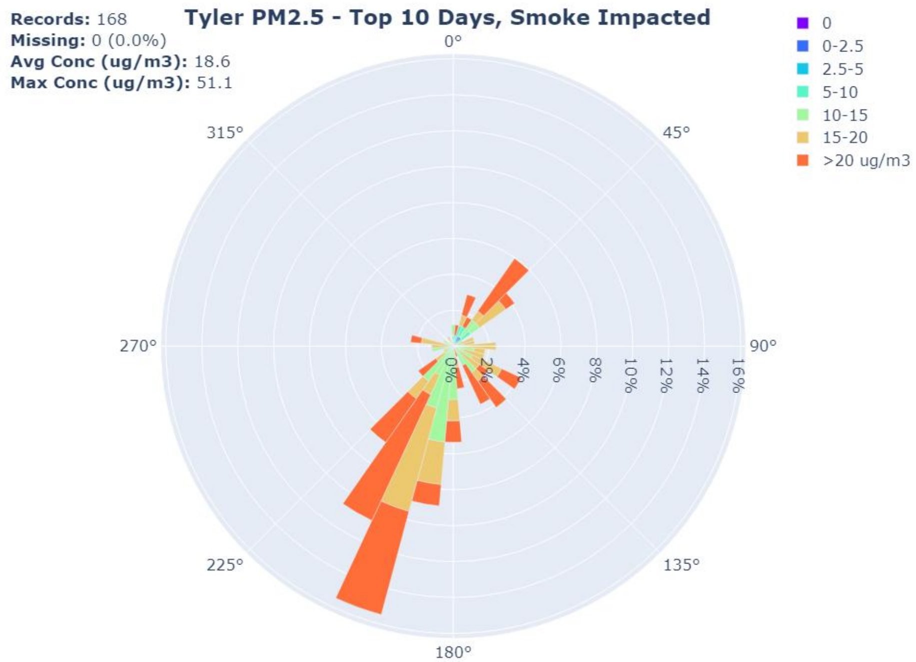

Figure 2.11. Tyler (collocated with CAMS 82) Pollution Rose, Top 10 Days Smoke Impacted

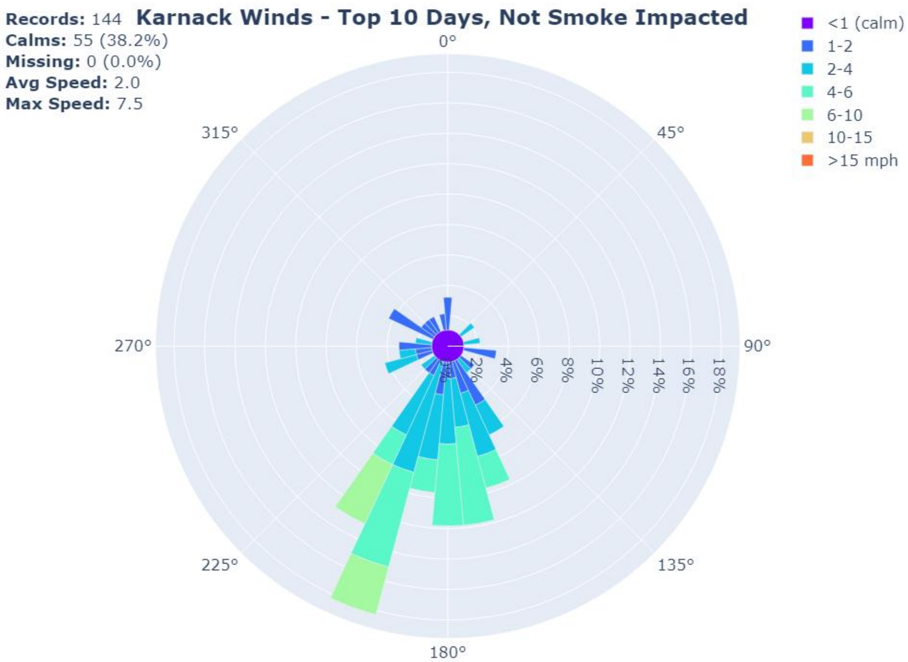

Figure 2.12. Karnack (CAMS 85) Wind Rose, Top 10 Days Not Smoke Impacted

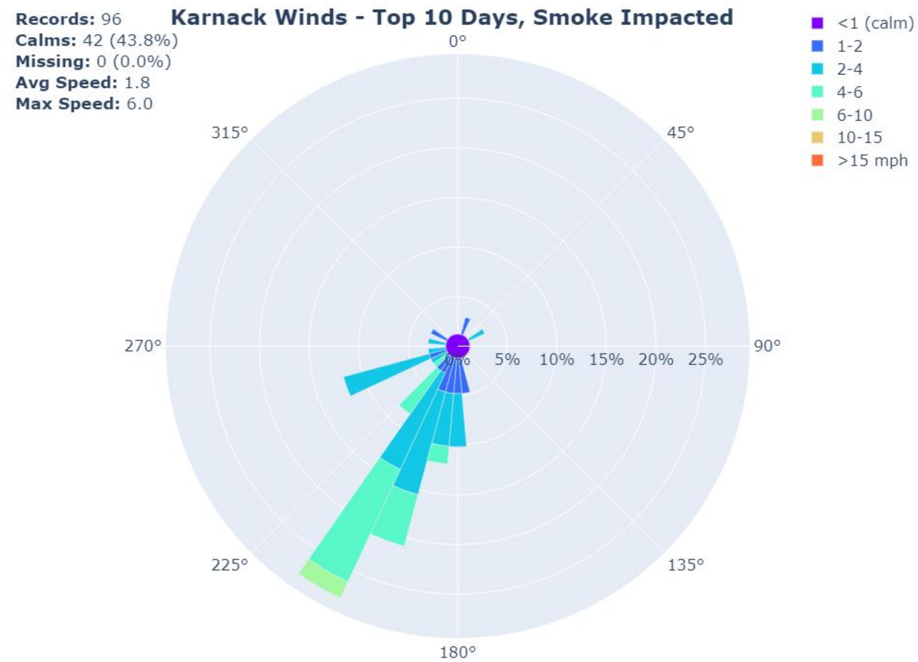

Figure 2.13. Karnack (CAMS 85) Wind Rose, Top 10 Days Smoke Impacted

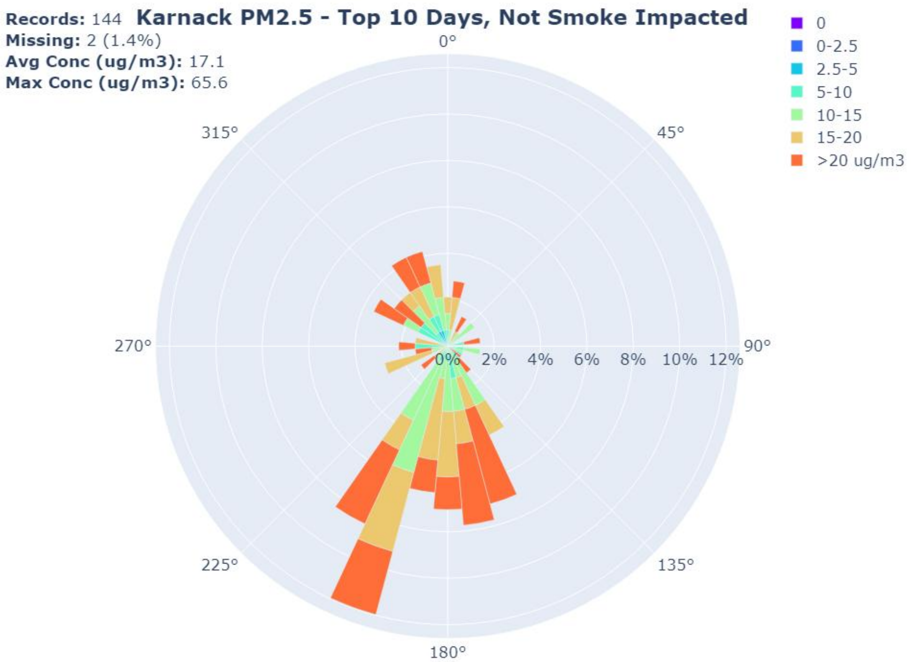

Figure 2.14. Karnack (CAMS 85) Pollution Rose, Top 10 Days Not Smoke Impacted

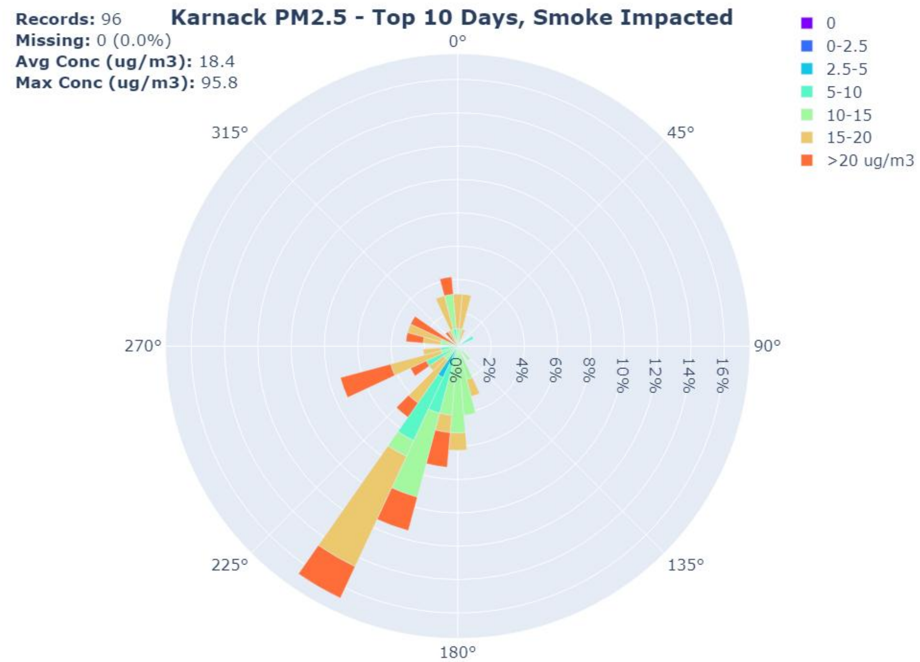

Figure 2.15. Karnack (CAMS 85) Pollution Rose, Top 10 Days Smoke Impacted

3 Conclusions and Recommendations

- $PM_{2.5}$ at Tyler (collocated with CAMS 82) and Karnack (CAMS 85) is characterized by a mix of regional background $PM_{2.5}$, routine southerly transport, and periods of smoke intrusions.
- Despite being 60 miles apart, the two monitors share four of their top-ten $PM_{2.5}$ days in common and very close overall average concentrations, suggesting that $PM_{2.5}$ is driven in large part by regional concentrations in the TLMA area.
- Winds Analysis
    - Tyler (collocated with CAMS 82)
        - Tyler's peak concentrations from strong southerly winds align with the prevailing Gulf wind flow, pointing to potential $PM_{2.5}$ transport from the south with and without the influence of fires.
        - Similarities between wind roses and pollution roses point to regional $PM_{2.5}$ sources.
    - Karnack (CAMS 85)
        - Dual wind patterns (southerly and northerly) reveal both a similar regional component as Tyler during smoke impacted days, but also a potential for $PM_{2.5}$ emissions transported from the north when winds are light under non-smoke impacted days.
        - Winds point to regional $PM_{2.5}$ sources associated with southwesterly winds, but also potentially to more local sources associated with northwesterly winds independent from smoke and concentrations at Tyler.
- Although all 24-hour values remained below the current 24-hour NAAQS, the combined 2021-2023 design value of 9.5 $\mu g/m^3$ at Karnack exceeds the newly lowered 9 $\mu g/m^3$ annual standard. The monitoring period was of insufficient length to compare Tyler (collocated with CAMS 82) to the annual standard.
- Continued monitoring and analysis of $PM_{2.5}$ will be important for the TLMA area in future years to better understand the regional background concentrations and influence of smoke.

Due to the limited temporal extent of the Tyler data collection period (April 1st, 2025 through September 4th, 2025 only), these field measurements of $PM_{2.5}$ may not be representative of year-round $PM_{2.5}$ concentrations, other seasons, or other years. For this reason, we recommend that another $PM_{2.5}$ monitoring study be performed at Tyler (collocated with CAMS 82) to improve understanding of spatial and temporal variations in $PM_{2.5}$ within the ETCOG region.

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APPENDIX A. SMOKE MAPS FOR TOP TEN $PM_{2.5}$ DAYS AT TYLER (COLLOCATED WITH CAMS 82) AND KARNACK (CAMS 85)

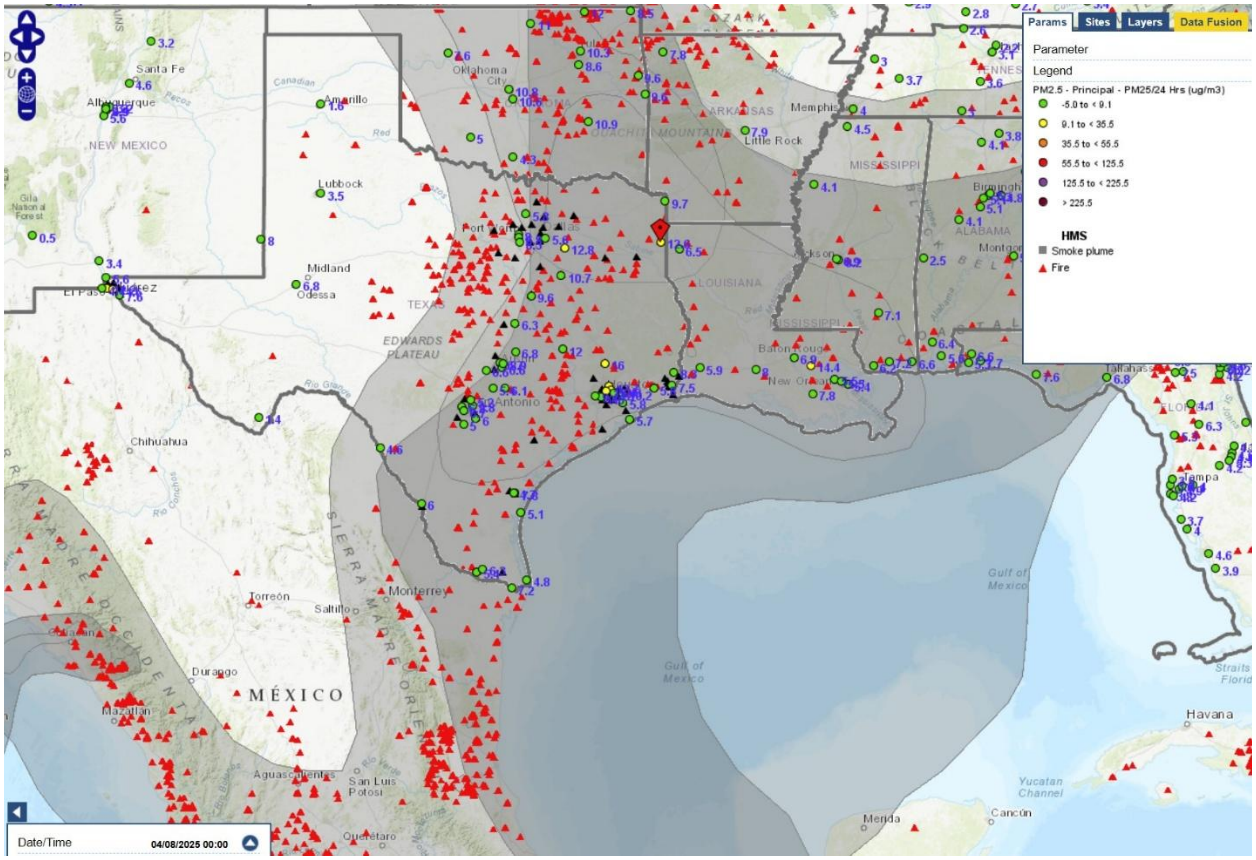

Figure A-1. HMS Smoke and Fire Map for April 8th, 2025.

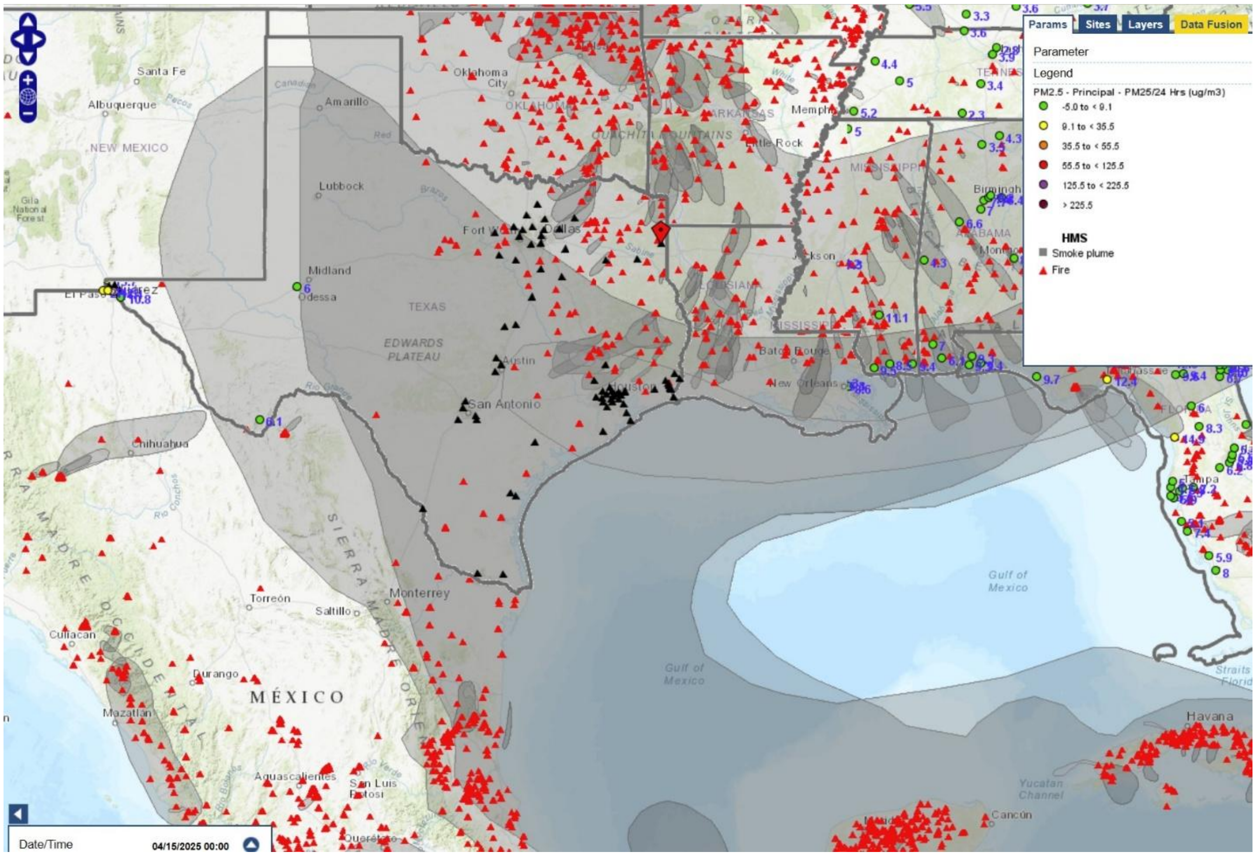

Figure A-2. HMS Smoke and Fire Map for April 15th, 2025.

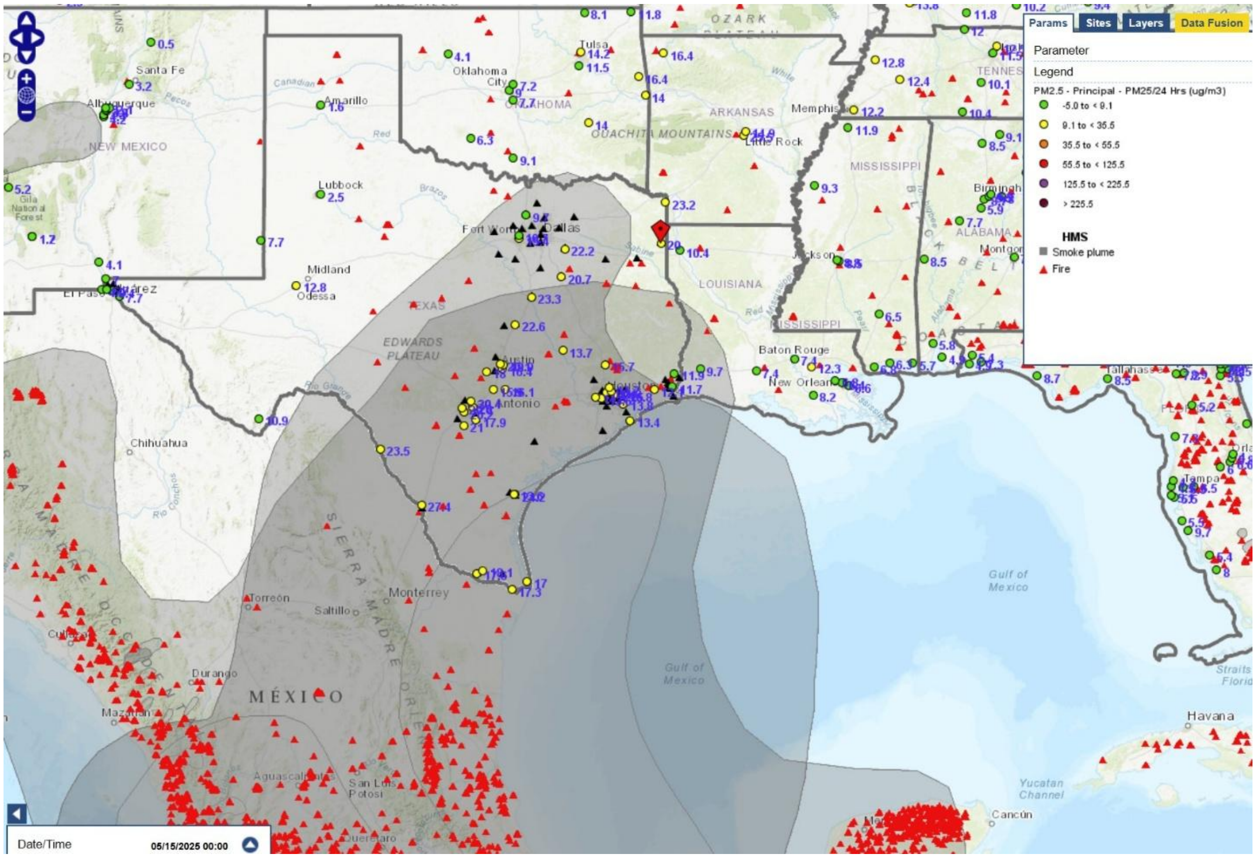

Figure A-3. HMS Smoke and Fire Map for May 15th, 2025.

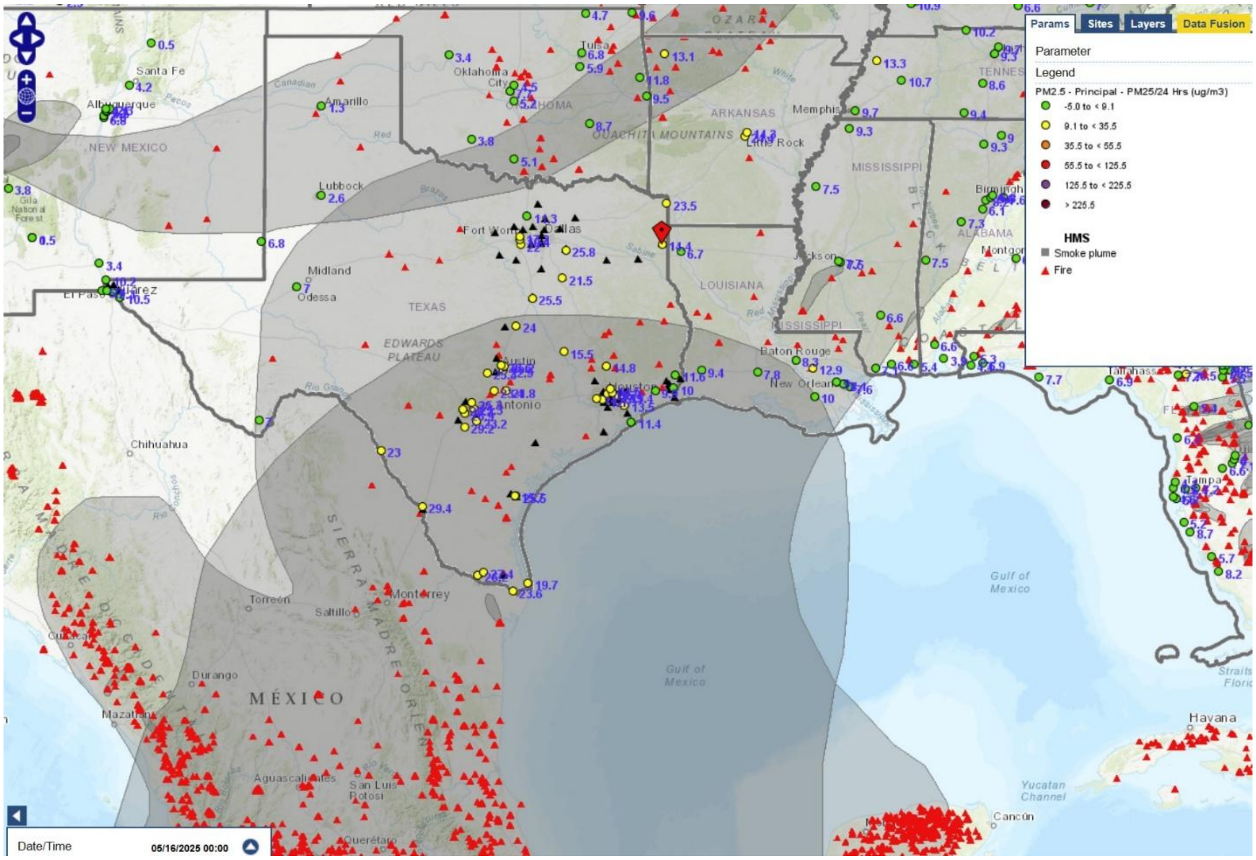

Figure A-4. HMS Smoke and Fire Map for May 16th, 2025.

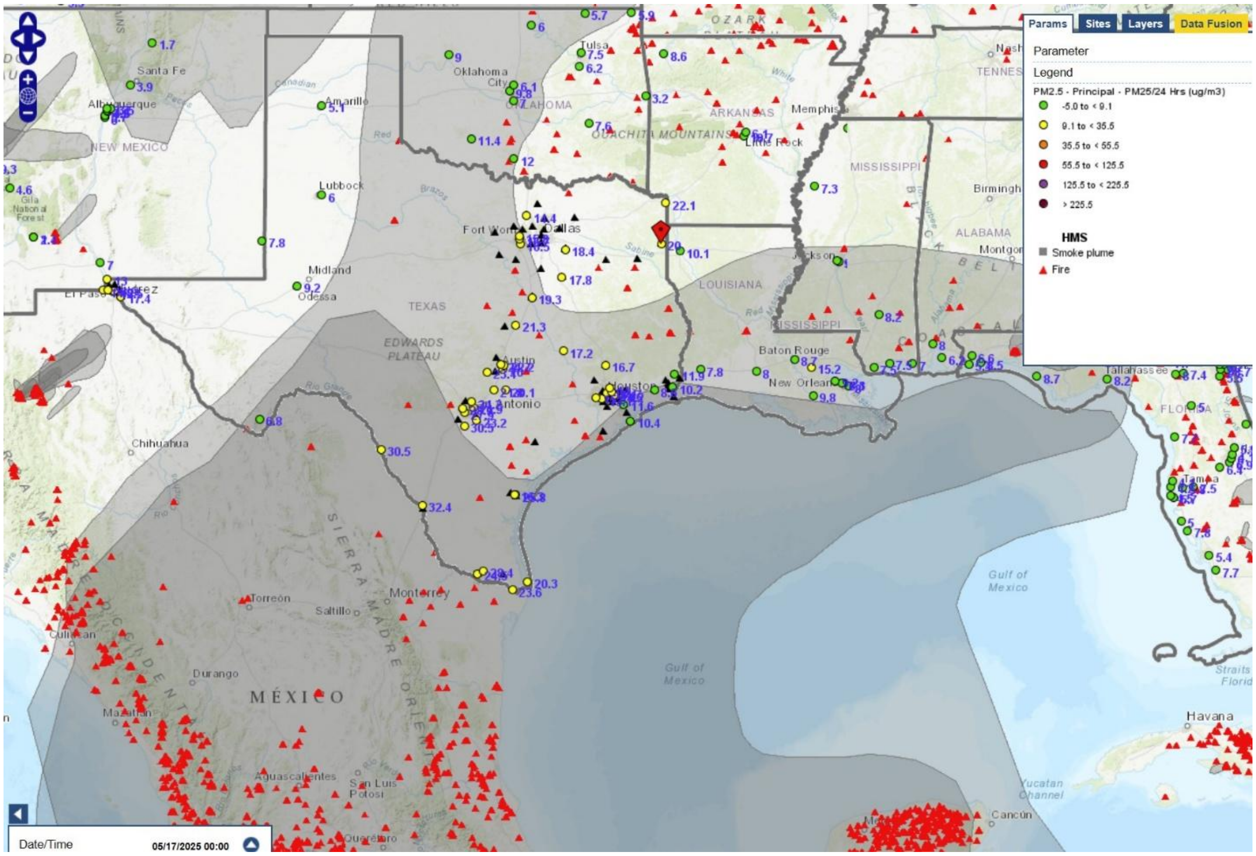

Figure A-5. HMS Smoke and Fire Map for May 17th, 2025.

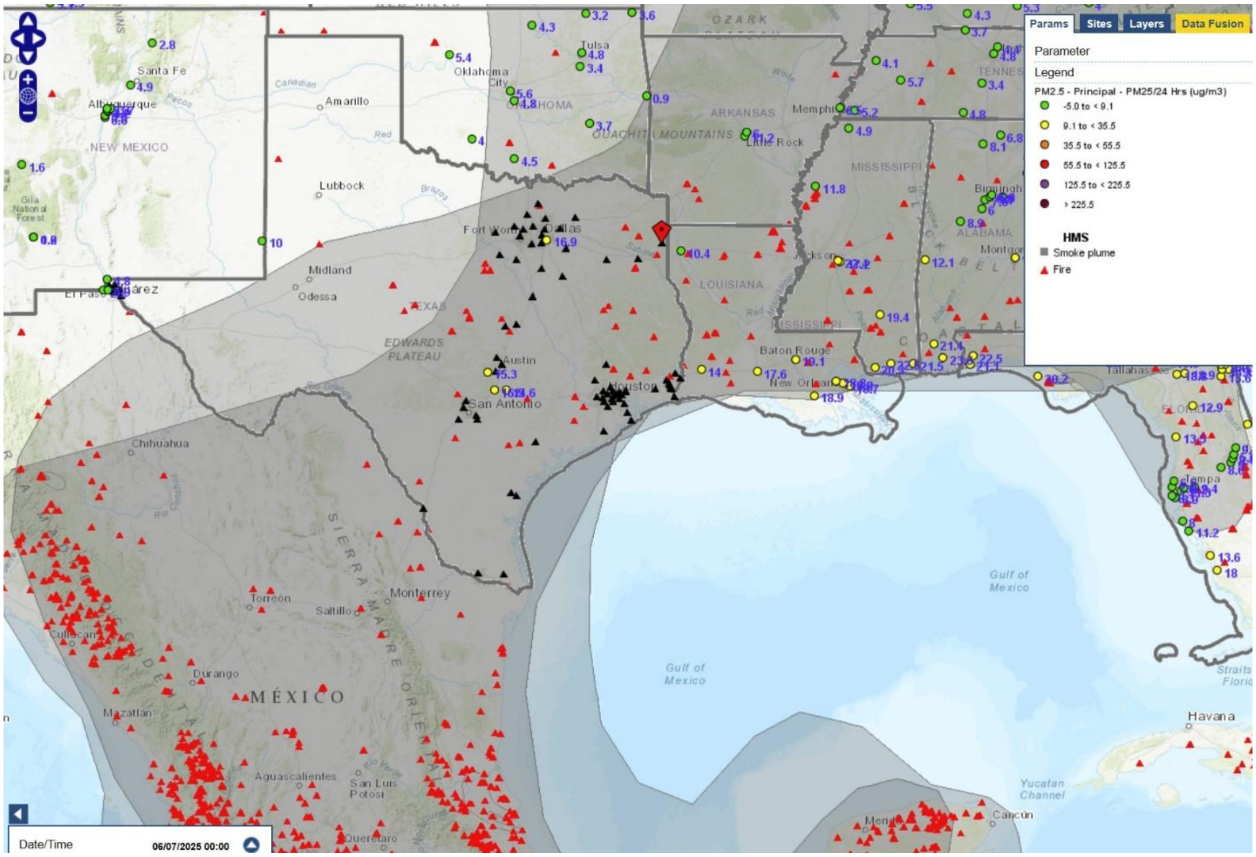

Figure A-6. HMS Smoke and Fire Map for June 7th, 2025.

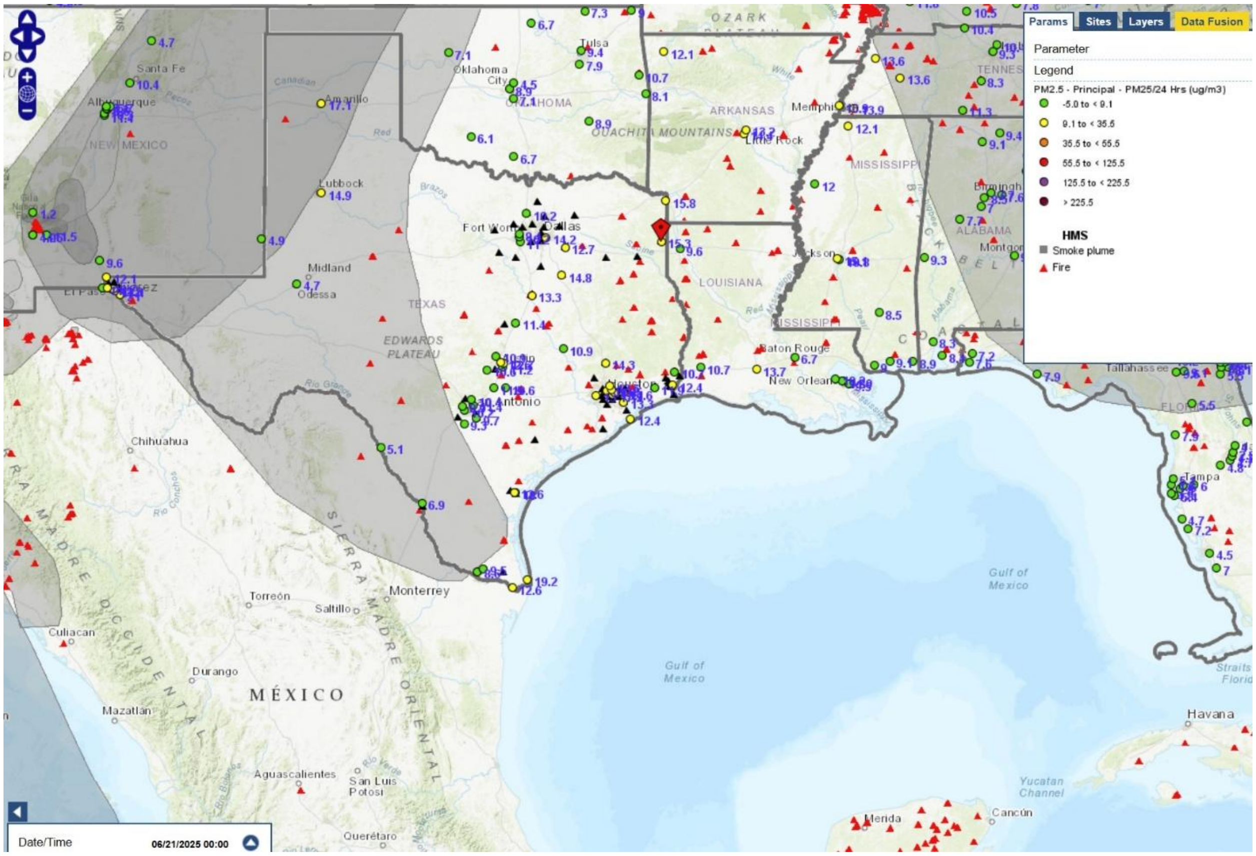

Figure A-7. HMS Smoke and Fire Map for June 21st, 2025.

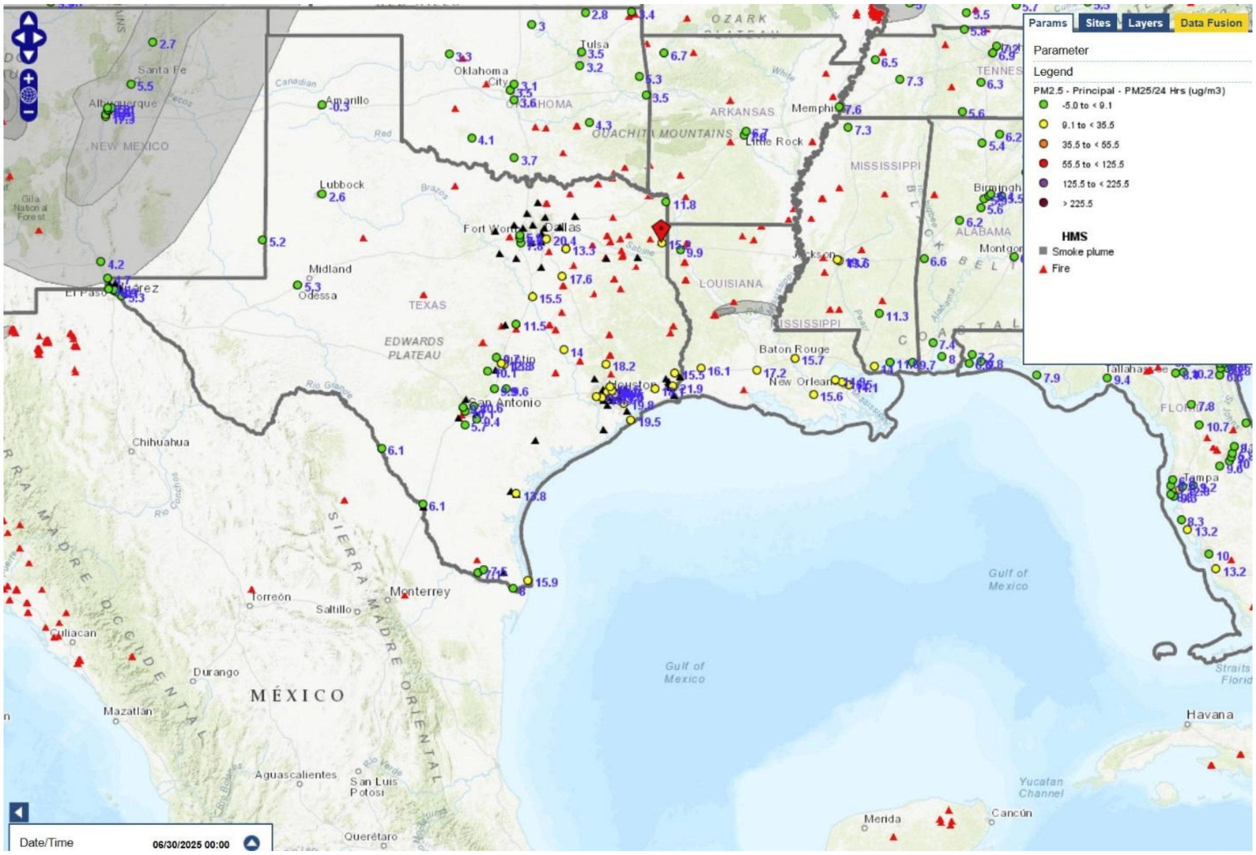

Figure A-8. HMS Smoke and Fire Map for June 30th, 2025.

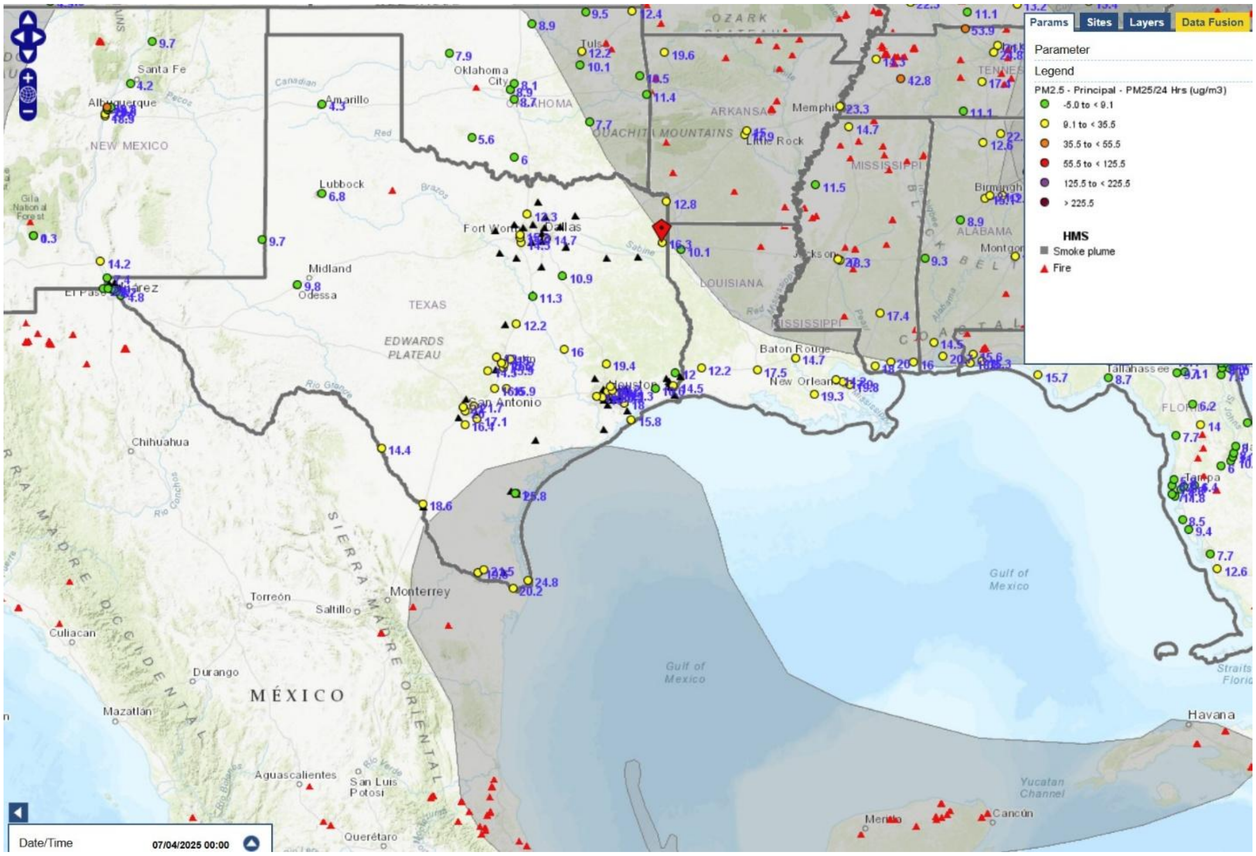

Figure A-9. HMS Smoke and Fire Map for July 4th, 2025.

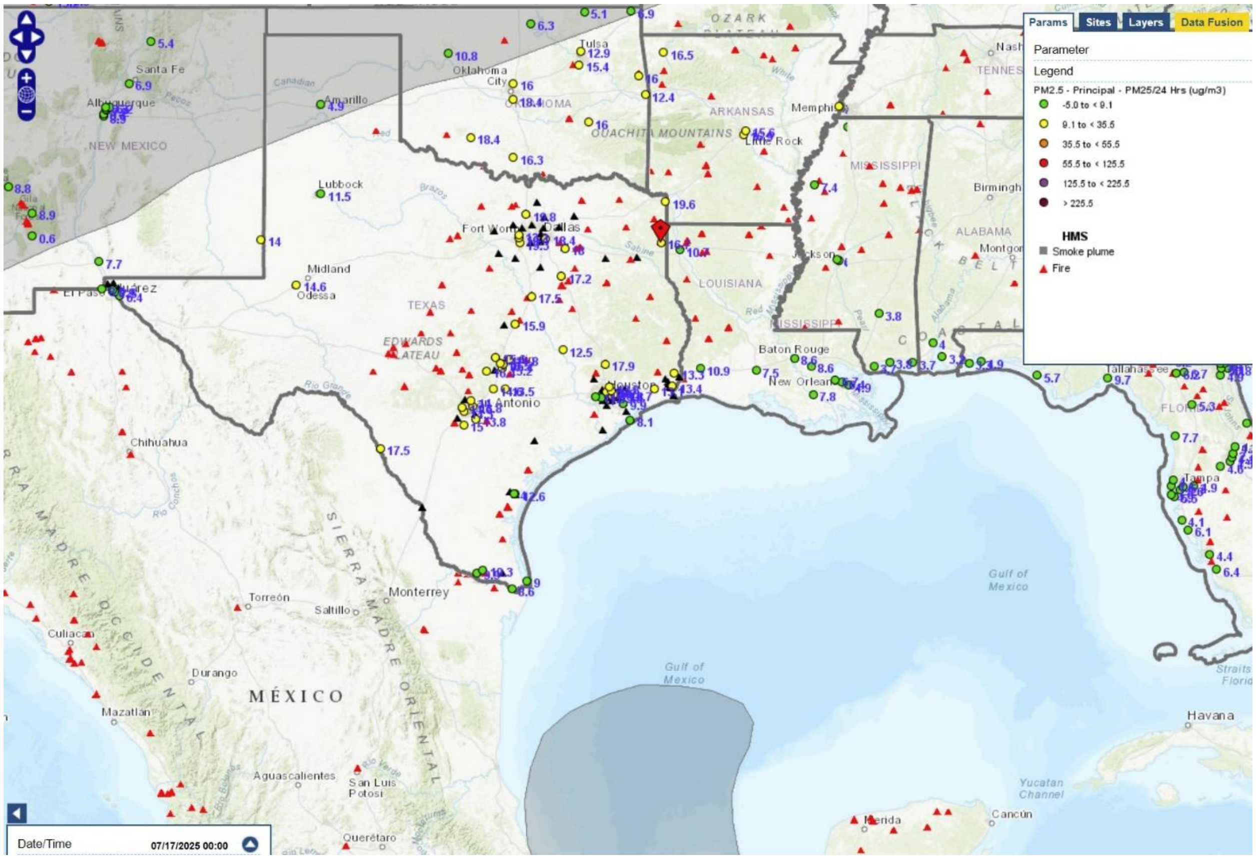

Figure A-10. HMS Smoke and Fire Map for July 17th, 2025.

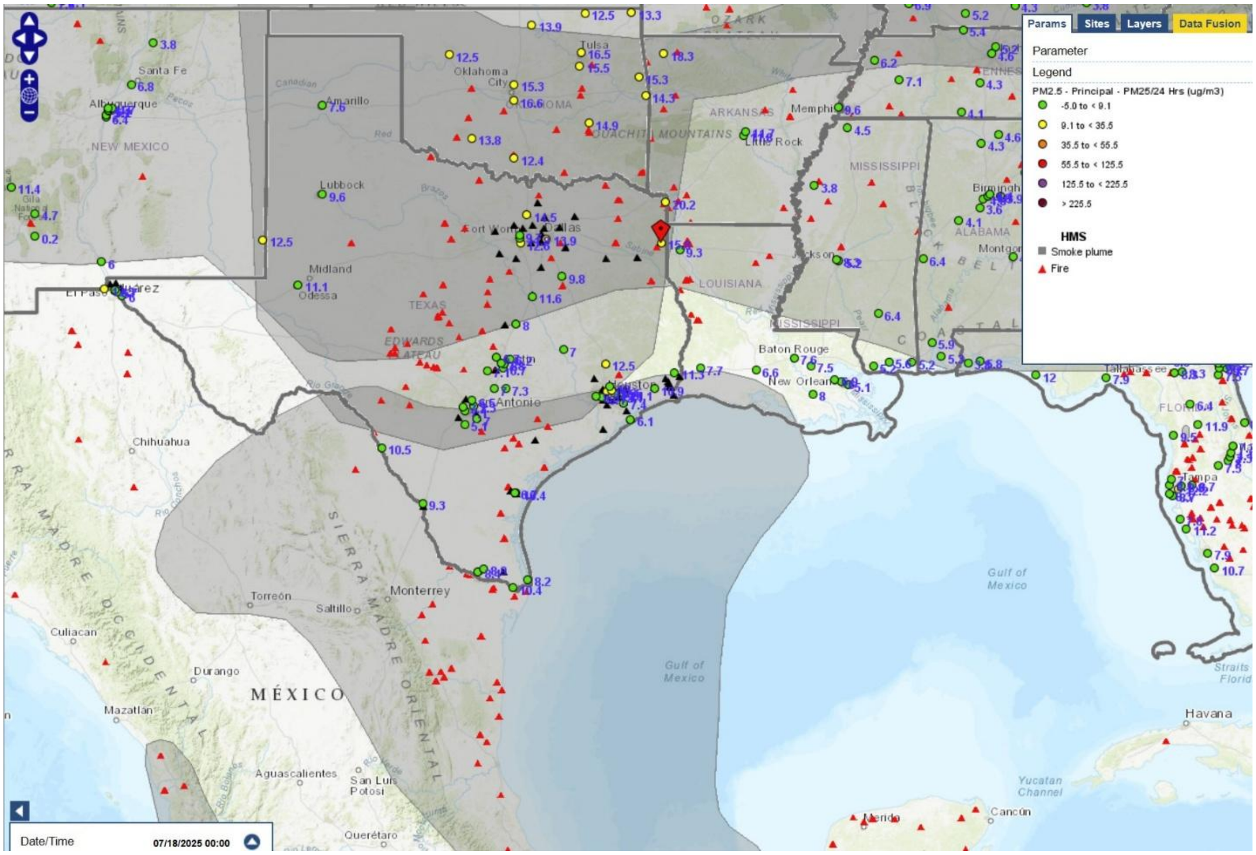

Figure A-11. HMS Smoke and Fire Map for July 18th, 2025.

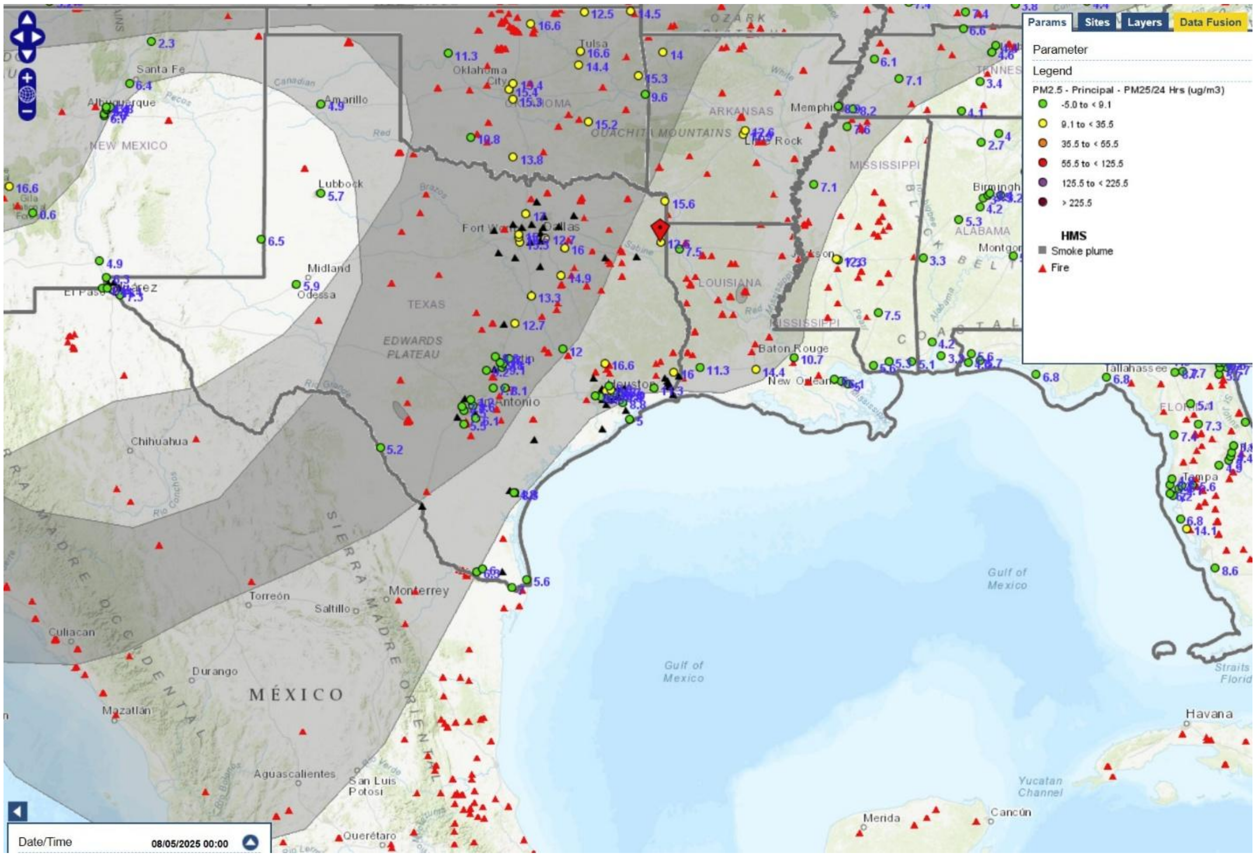

Figure A-12. HMS Smoke and Fire Map for August 5th, 2025.

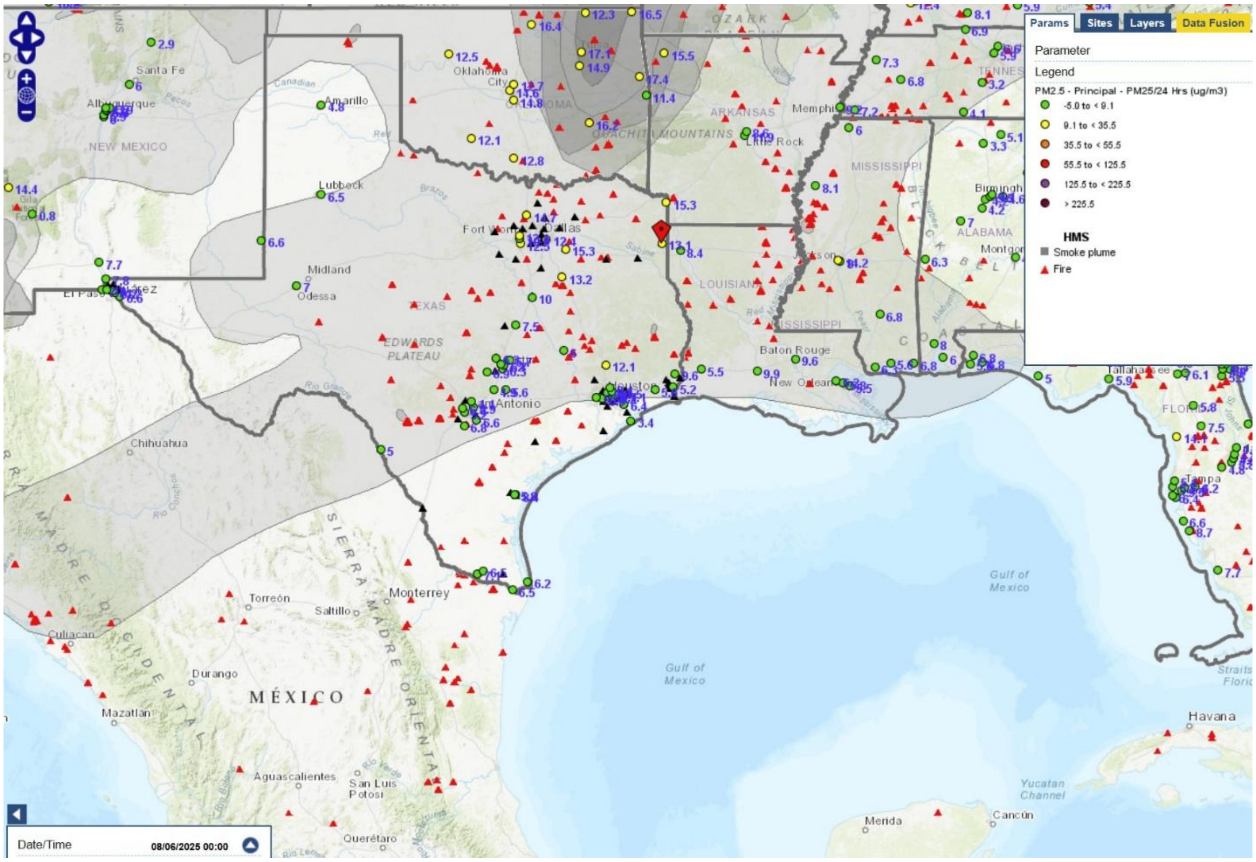

Figure A-13. HMS Smoke and Fire Map for August 6th, 2025.

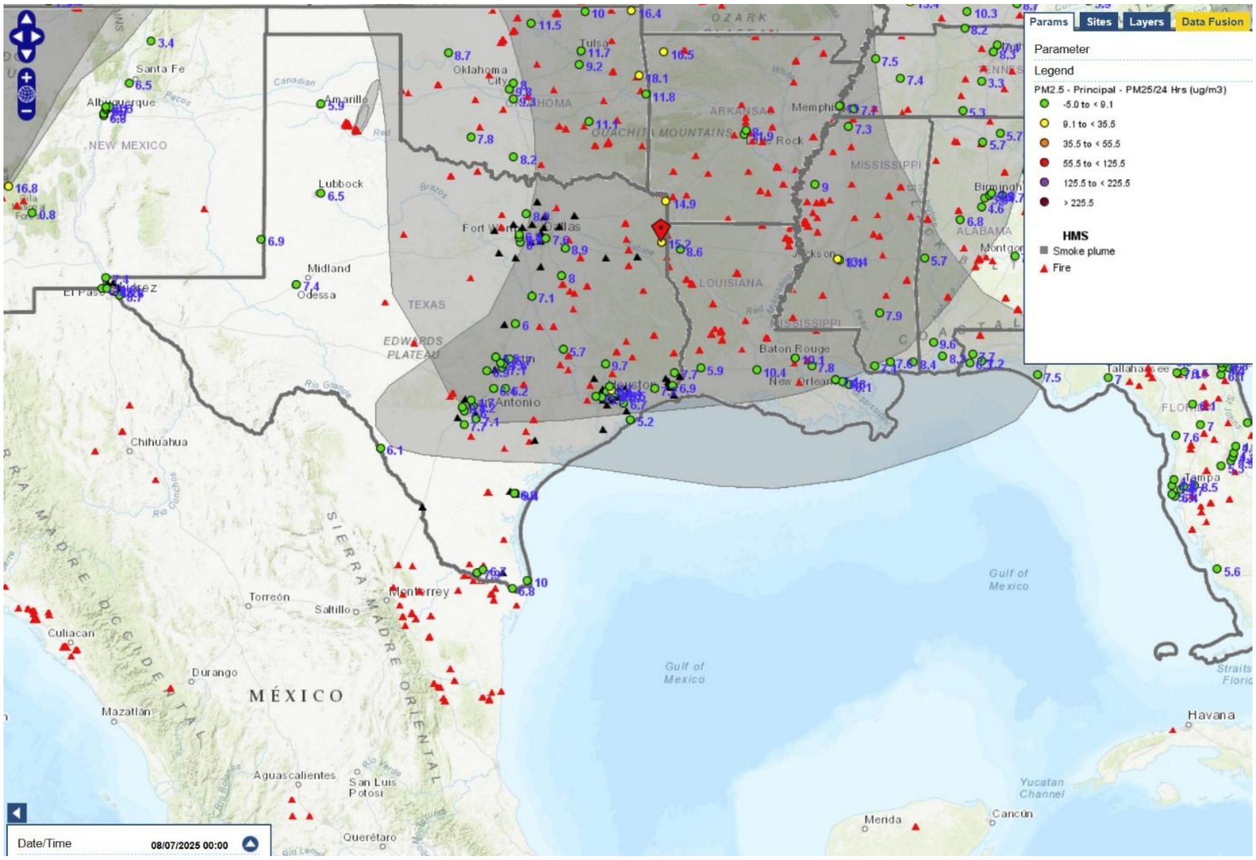

Figure A-14. HMS Smoke and Fire Map for August 7th, 2025.

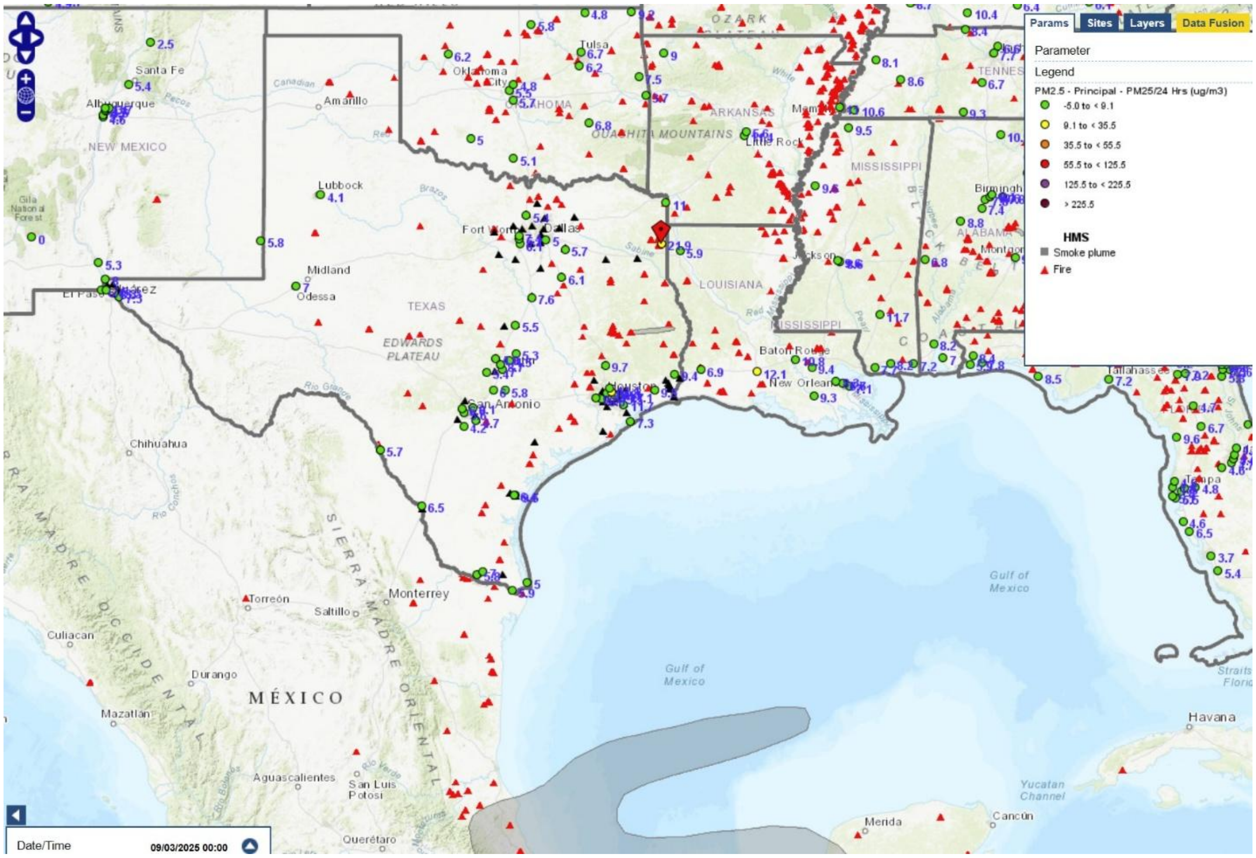

Figure A-15. HMS Smoke and Fire Map for September 3rd, 2025.

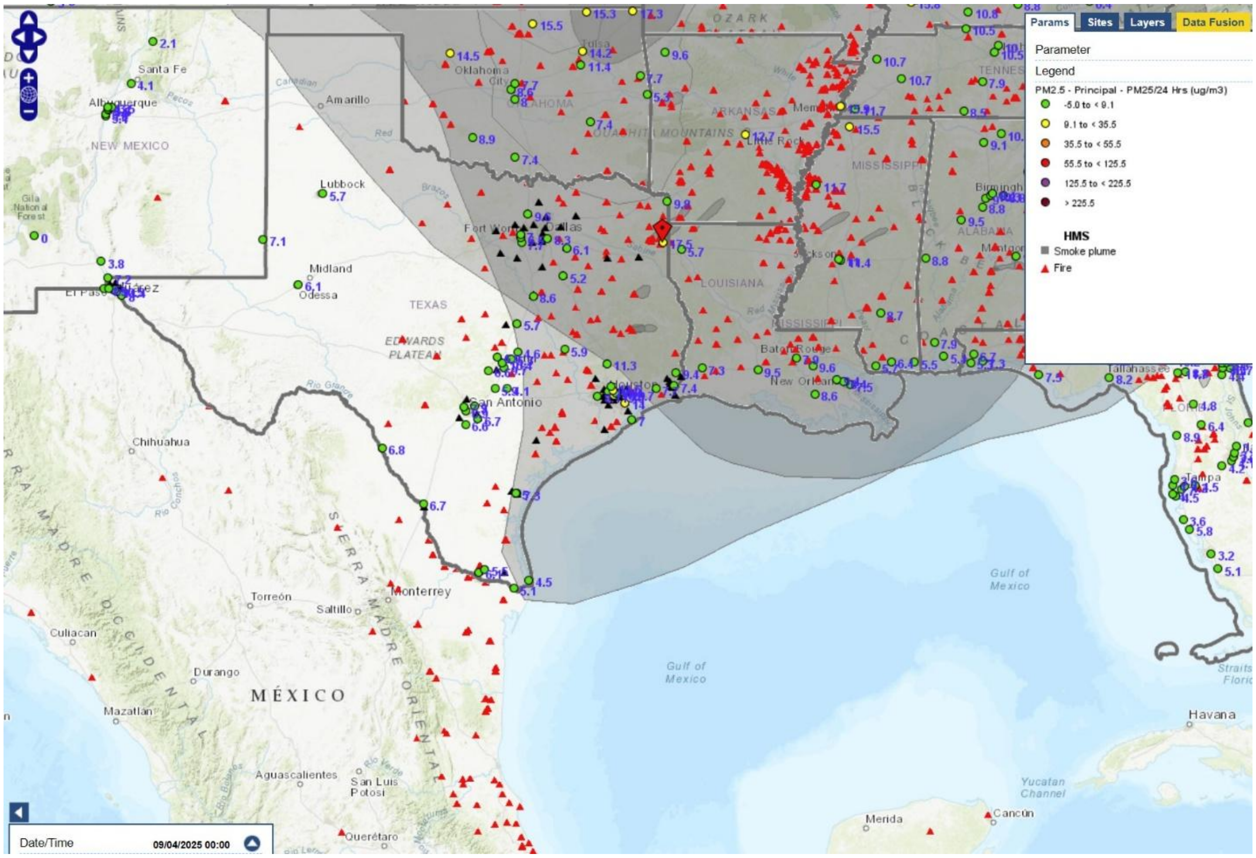

Figure A-16. HMS Smoke and Fire Map for September 4th, 2025.

APPENDIX G

Final Report for Subtask 3.4: Statistical $PM_{2.5}$ Modeling for Northeast Texas

Contract 582-24-01388
Subtask 3.4

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$PM_{2.5}$ Modeling for Northeast Texas
Final Report

$PM_{2.5}$ Modeling for Northeast Texas
Final Report

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Contents

List of Acronyms and Abbreviations **ii**

Executive Summary **1**

1 Introduction **2**
1.1 The Tyler-Longview-Marshall-Athens Area 2
1.2 Background and Purpose 3
1.2.1 $PM_{2.5}$ Air Quality Status in the Tyler-Longview-Marshall Athens Area 3

2 $PM_{2.5}$ Modeling Results **4**
2.1 Feature Engineering 4
2.2 Model Selection and Development 4
2.3 Model Validation 5
2.4 Model Evaluation 6
2.4.1 Comparison of Observed and Predicted $PM_{2.5}$ Concentrations 7
2.4.2 Feature Importance 9

3 Conclusions and Recommendations **13**

4 References **14**

Appendix

Appendix A. Model Features and Definitions

Table of Figures

Figure 1-1. The six county TLMA area, location of CAMS monitors in the area with urban areas and major roadways in the surrounding region. 2

Figure 2-1. Comparison of the Observed and Predicted $PM_{2.5}$ Concentrations at Tyler. 8

Figure 2-2. Comparison of the Observed and Predicted $PM_{2.5}$ Concentrations at Karnack. 9

Figure 2-3. Top 15 most important features for $PM_{2.5}$ prediction at Karnack (left) and Tyler (right) for the training period. 11

Table of Tables

Table 2-1. Training Metrics for $PM_{2.5}$ Prediction Models at Tyler. 6

Table 2-2. Training Metrics for $PM_{2.5}$ Prediction Models at Karnack. 6

Table 2-3. Test Metrics for $PM_{2.5}$ Prediction Models at Tyler. 7

Table 2-4. Test Metrics for $PM_{2.5}$ Prediction Models at Karnack. 7

Table 2-5. Summary of grouped feature importance and cumulative importance for Karnack and Tyler (ranked high to low). 12

List of Acronyms and Abbreviations

$\mu g/m^3$	Micrograms per cubic meter
AQI	Air Quality Index
CAMS	Continuous Ambient Monitoring Station
CBSA	Core-based statistical area
CO	Carbon monoxide
EGU	Electrical generating unit
EPA	US Environmental Protection Agency
ETCOG	East Texas Council of Governments
LSTM	Long Short-Term Memory
MAE	Mean Absolute Error
NAAQS	National Ambient Air Quality Standards
NEI	National emission inventory
NO	Nitrogen oxide
NO_2	Nitrogen dioxide
NOx	Nitrogen oxides
O_3	Ozone
RAQ	Random Forest Approach for Predicting Air Quality
$PM_{2.5}$	Particulate matter 2.5 microns or less in diameter
RF	Random Forest
RMSE	Root Mean Square Error
SIP	State implementation plan
SVR	Support Vector Regression
TCEQ	Texas Commission on Environmental Quality
TLMA	Tyler-Longview-Marshall-Athens
XGBoost	eXtreme Gradient Boosting

Executive Summary

The purpose of this task was to apply advanced statistical modeling techniques to identify factors that uniquely influence the Tyler (collocated with CAMS 82) and Karnack (CAMS 85) monitors. For Subtask 3.3, traditional data analysis methods were applied to particulate matter with an aerodynamic diameter less than 2.5 microns ($PM_{2.5}$) monitoring data near Tyler (collocated with CAMS 82) together with TCEQ data at Karnack (CAMS 85) to understand variations in $PM_{2.5}$ concentrations across the Tyler-Longview-Marshall-Athens (TLMA) area. Advanced statistical models can complement the data analysis conducted in Subtask 3.3 because they excel at analyzing large datasets such as hourly $PM_{2.5}$ measurements at multiple locations over extended periods. The overall goal of this project is to better understand source contributions to $PM_{2.5}$ in the TLMA area.

A comprehensive set of features was engineered to capture temporal (e.g., time of day, day of week, month), meteorological (e.g., wind direction, temperature), and pollutant (e.g., ozone [O_3], nitrogen oxide [NO], and nitrogen dioxide [NO_2]) influences on $PM_{2.5}$ concentrations. Three modeling approaches were evaluated: Random Forest (RF), Support Vector Regression (SVR), and Long Short-Term Memory (LSTM) networks. Models were trained and validated using an 80/20 split of the monitoring period (April 1st to September 4th, 2025), with cross-validation to ensure robustness.

RF consistently achieved the best performance on training data at both Tyler and Karnack, with the lowest prediction errors and highest correlation values. However, all models exhibited substantially weaker performance on the test data, indicating that the factors influencing $PM_{2.5}$ concentrations may differ between the training and test periods. Feature importance analysis revealed that temperature, ozone, and wind direction were dominant predictors at Karnack, while at Tyler, NO_2 and seasonal indicators also played important roles.

These results highlight the complexity of local air quality dynamics and the challenges of generalizing model performance across different time periods and emission scenarios. To improve predictive accuracy and support air quality management in the TLMA area, future modeling efforts should consider incorporating additional data sources (e.g., satellite-based smoke data, expanded meteorological measurements) and exploring additional advanced statistical methods such as Gradient Boosting or eXtreme Gradient Boosting (XGBoost). Extending the monitoring period would also help capture seasonal changes and enhance model robustness.

1 Introduction

1.1 The Tyler-Longview-Marshall-Athens Area

The Tyler-Marshall-Longview-Athens (TLMA) area includes Gregg, Harrison, Henderson, Rusk, Smith, and Upshur counties. Figure 1-1 displays the TLMA area's major roadways, urban areas, and the TCEQ-operated continuous air monitoring system (CAMS) locations. Currently the Karnack CAMS 85 monitor is the only monitor that measures $PM_{2.5}$. The total population in the TLMA area in 2023 was 621,545[1]. The City of Tyler, located in Smith County, and the City of Longview, located in Gregg County, are the largest cities in the TLMA area with 2023 populations of 110,203 and 83,202, respectively[1]. Smith County comprises the Tyler core-based statistical area (CBSA) and had a population of 244,908 in 2023, representing 39% of the population in the TLMA area.[1] Gregg, Harrison, Rusk, and Upshur counties comprise the Longview CBSA and together had a population of 290,956 in 2023,[1] representing 47% of the population in the TLMA area. Henderson County is part of the Athens CBSA and had a population of 85,681[1] in 2023, representing 11% of the population in the TLMA area.

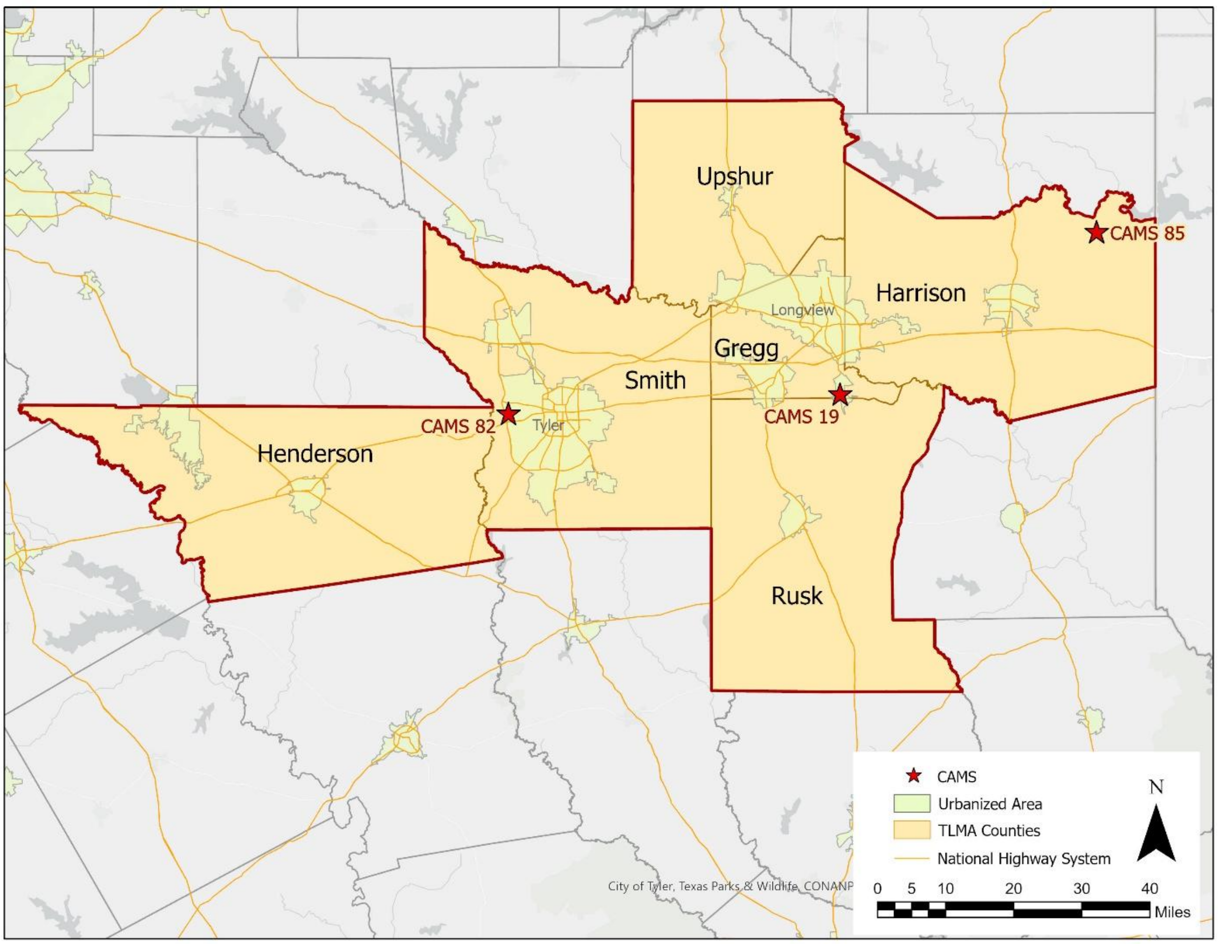

Figure 1-1. The six county TLMA area, location of CAMS monitors in the area with urban areas and major roadways in the surrounding region.

[1] Texas Demographic Center. "2023 Population Estimates: Texas Population Estimates Program". https://demographics.texas.gov/Estimates/2023/. Accessed September 2025.

1.2 Background and Purpose

The EPA sets National Ambient Air Quality Standards (NAAQS) for ambient $PM_{2.5}$ pollution. Primary standards protect public health and secondary standards protect public welfare (e.g., visibility, damage to animals, crops, vegetation, and buildings). Under the Clean Air Act, the EPA is required to review the NAAQS periodically for both long-term (annual average, averaged over 3 years) and short-term (daily average, 98th percentile in each year) concentrations. On February 7, 2024, EPA lowered the annual average $PM_{2.5}$ standard for outdoor air from 12 micrograms per cubic meter (μg/m^3) to 9 μg/m^3 effective from May 6, 2024. The daily $PM_{2.5}$ standard (35 μg/m^3) and secondary $PM_{2.5}$ standards did not change as part of this reconsideration.

Compliance with the NAAQS is assessed at an individual monitor by comparing the monitor's Design Value to the NAAQS. For $PM_{2.5}$, the monitor Design Value is calculated as the 3-year annual average of $PM_{2.5}$ values[2]. Failure to comply with the NAAQS can adversely affect public health and inhibit economic development. To ensure that the TLMA area meets the $PM_{2.5}$ NAAQS, $PM_{2.5}$ air quality planning is important.

1.2.1 $PM_{2.5}$ Air Quality Status in the Tyler-Longview-Marshall Athens Area

The TCEQ operates one continuous air monitoring station (Karnack CAMS 85) in the TLMA area that determines whether the area is in compliance with the $PM_{2.5}$ NAAQS. The location of this monitor is shown above in Figure 1-1. The Design Value is the annual mean concentration, averaged over three consecutive years. EPA estimated a Design Value of 9.5 μg/m^3 for the 2021 to 2023 period which is above the 9.0 μg/m^3 standard.[3]

For this project, Ramboll deployed a $PM_{2.5}$ instrument and made measurements at the previously established Tyler sampling site located adjacent to TCEQ's Tyler Airport Relocated site (CAMS 82). Measurements took place from April 1st through September 4th, 2025. The sampling site was selected to be within another ETCOG monitoring project (NO_2 monitoring) which provided infrastructure to support $PM_{2.5}$ monitoring. This site was established for previous studies and selected with guidance from Ramboll and the TCEQ in order to be comparable with data from existing monitoring networks.

This report identifies important contributions of local emission sources to $PM_{2.5}$ levels at the Tyler and Karnack monitors. Advanced statistical models can complement the data analysis conducted in Subtask 3.3 because they excel at analyzing large datasets such as hourly $PM_{2.5}$ measurements at multiple locations over extended periods. The objective of this task is to identify factors that uniquely influence both locations, such as being downwind from a major $PM_{2.5}$ emission source or a city. This activity benefits the Texas SIP by providing insight into local influence on $PM_{2.5}$ pollution in the TLMA area.

[2] EPA. Air Quality Deign Values. https://www.epa.gov/air-trends/air-quality-design-values. Accessed February 2025.
[3] EPA. $PM_{2.5}$ Design Values, 2023. https://www.epa.gov/system/files/documents/2024-08/pm25_designvalues_2021_2023_final_08_08_24_0.xlsx. Accessed February 2025.

2 $PM_{2.5}$ Modeling Results

This section presents the $PM_{2.5}$ modeling results at both Tyler (collocated with CAMS 82) and Karnack (CAMS 85) to better identify factors that uniquely influence these sites in the TLMA area. The period of record, hereafter referred to as the "monitoring period," ran from April 1st, 2025, through September 4th, 2025. This period was chosen to align with the field deployment of the Met One Instruments BAM-1022 beta-attenuation Federal Equivalent Method (FEM) $PM_{2.5}$ mass monitor at Tyler. Tyler $PM_{2.5}$ data was acquired directly through the Ramboll air monitoring program, while Karnack $PM_{2.5}$ and meteorological data at both monitors were acquired through the TCEQ website on October 1st, 2025.[4] Note that TCEQ data was not fully validated at the time of download, and is subject to change.

2.1 Feature Engineering

To capture the complex temporal and meteorological influences on $PM_{2.5}$ concentrations, we developed a comprehensive set of features. These features provide the foundation for advanced statistical models to identify and quantify the unique factors affecting air quality at each monitoring location.

We created features representing time of day, day of week, and month. Since time is circular (midnight connects to the next midnight), we used mathematical transformations that preserve this continuity. Rush hour and weekend indicators were specifically flagged to assess the influence of traffic and human activity on $PM_{2.5}$ levels.

Meteorological features were engineered to reflect both instantaneous and persistent conditions. Similar to time, wind direction is circular (0° and 360° are the same). We created both continuous representations and categorical indicators for eight cardinal directions (N, NE, E, SE, S, SW, W, NW). This allows the model to learn if specific wind directions are associated with higher pollution concentrations.

We added lag features that look back 1, 3, 6, and 12 hours for key measurements like temperature, wind speed, wind direction, and pollutant concentrations (ozone [O_3], nitrogen oxide [NO], and nitrogen dioxide [NO_2]). These lag features incorporate historical data and capture temporal dependencies.

We calculated rolling averages and variability over 3, 6, and 12-hour windows. These features capture recent trends and stability in meteorological conditions, for example, whether wind direction has been steady or variable, or whether temperature has been increasing or stable. As with the lag features, these rolling averages and variability features were calculated for key measurements like temperature, wind speed, wind direction, and pollutant concentrations.

A full list of model features and their definitions can be found in Appendix A.

2.2 Model Selection and Development

We tested three different types of advanced statistical models, known as Random Forest (RF), Support Vector Regression (SVR), and Long Short-Term Memory (LSTM) networks. A Random Forest regression model is an ensemble method that creates many decision trees (individual models) during training, with the overall model output consisting of the average of individual model predictions. SVR applies input data coordinate transformations to obtain more powerful predictors and uses model training algorithms that seek to identify the most useful subset of the training data. The resulting SVR

[4] TCEQ, Data by Year by Site by Parameter, Accessible at: https://www.tceq.texas.gov/cgi-bin/compliance/monops/yearly_summary.pl Accessed October 2025

model depends only on this subset of the training data. RF and SVR models have both found success in characterizing air pollution. Liu et al. (2017) applied a SVR model for Urban Air Quality Index (AQI) prediction, focusing on the highly polluted cities of Beijing, Tianjin, and Shijiazhuang. The research concluded that the SVR model was reliable, and that geographical location plays a significant role in the effectiveness of AQI forecasting. Yu et al. (2016) proposed the Random Forest Approach for Predicting Air Quality (RAQ) for urban sensing systems, aiming to infer the air quality indications throughout Shenyang by predicting the AQI of unmonitored regions. The RAQ approach achieved an overall prediction precision of 81.5% and outperformed other methods. LSTM networks are a type of neural network designed specifically for time series data. They can "remember" patterns from earlier in the sequence, making them adept at capturing how conditions evolve over hours or days. A more recent paper by Liu et al. (2024) applied the LSTM model to predict the AQI and specific pollutants, achieving a 91.37% goodness-of-fit for AQI predictions and a perfect 100% accuracy for primary pollutant forecasting in the test set.

For all models, we used the first 80% of our data (April 1st through early August) for training and reserved the last 20% (early August through September 4th) for testing. One possible limitation of this approach is that the factors driving elevated $PM_{2.5}$ concentrations may differ between these periods. For instance, agricultural burning in the Mississippi River Valley area typically occurs in early fall and may influence air quality in the TLMA area during August and September. On the other hand, smoke impacts from Mexico and Central America are more common in the spring and early summer. As a result, models trained on data from April to early August may not fully capture the distinct sources or patterns affecting $PM_{2.5}$ during early August and early September.

We trained three models for the two monitor sites separately. To ensure the models generalize to new data, we used cross-validation during the hyperparameter tuning phase. For RF and SVR models, we employed 5-fold cross-validation on the training set. The training data was divided into five segments, and each model configuration was tested five times using different combinations of these segments for training and validation. This process helped identify model settings that performed consistently well rather than just working for one particular data subset. The LSTM model used a simpler validation approach, holding out 20% of the training data to monitor for overfitting and automatically stopping training when performance plateaued. After selecting the best model configurations through these validation procedures, all models were retrained on the complete training set and evaluated on the independent test set.

2.3 Model Validation

Model performance was evaluated for the training set using five complementary metrics that together provide a complete picture of prediction accuracy.

- Root Mean Square Error (RMSE) represents the typical prediction error in μg/m³. Lower values are better as an RMSE near zero would indicate perfect predictions.
- Mean Absolute Error (MAE) is similar to RMSE but gives equal weight to all errors. RMSE penalizes large errors more heavily, so if RMSE is much higher than MAE, it indicates the model occasionally makes large mistakes. Like RMSE, lower is better, and values are in μg/m³.
- R-squared (R^2) measures how much of the $PM_{2.5}$ variation the model explains, typically ranging from 0 to 1. Higher is better. However, R^2 can be negative, which indicates the model performs worse than simply predicting the average $PM_{2.5}$ value for every hour.
- Bias indicates systematic under- or over-prediction. Values near zero are ideal, indicating no systematic error.

- Correlation measures how well predictions track actual changes, ranging from -1 to 1. Higher values (closer to 1) are better.

Table 2-1 and Table 2-2 summarize the model performance metrics on the training data for Tyler and Karnack, respectively. RF consistently achieved the best training performance at both Tyler and Karnack, with the lowest RMSE and MAE, and the highest R^2 and correlation values. This indicates strong predictive accuracy and a robust fit to the training data. SVR also performed well, especially at Tyler, as its error metrics and correlation are close to those of Random Forest, though its R^2 was lower. LSTM trailed behind the other models, showing higher errors and lower R^2 and correlation values, suggesting it was less effective at capturing the underlying patterns in the training data.

Table 2-1. Training Metrics for $PM_{2.5}$ Prediction Models at Tyler.

Model	RMSE (μg/m³)	MAE (μg/m³)	R^2	Bias	Correlation
Random Forest	2.13	1.47	0.86	0.02	0.95
SVR	2.51	1.49	0.81	-0.24	0.91
LSTM	5.11	3.81	0.21	-0.54	0.54

Table 2-2. Training Metrics for $PM_{2.5}$ Prediction Models at Karnack.

Model	RMSE (μg/m³)	MAE (μg/m³)	R^2	Bias	Correlation
Random Forest	1.93	1.34	0.87	0.02	0.95
SVR	3.94	2.80	0.45	-0.45	0.70
LSTM	4.27	3.28	0.35	0.26	0.60

2.4 Model Evaluation

Table 2-3 and Table 2-4 summarize the model performance metrics for the test set for Tyler and Karnack, respectively.

For Tyler, RF had the lowest RMSE (4.40 μg/m³) and MAE (3.45 μg/m³), indicating it made the most accurate predictions overall. Its correlation (0.25) was modest, suggesting some ability to track actual $PM_{2.5}$ changes, but R^2 was slightly negative (-0.07), meaning it did not explain much variance beyond the mean. SVR and LSTM performed similarly, with slightly higher RMSE and MAE. SVR had the highest correlation (0.35), but its R^2 (-0.15) was also negative, and LSTM's correlation was lowest (0.08), indicating limited predictive capability.

At Karnack, SVR had the lowest RMSE (5.90 μg/m³) and MAE (3.47 μg/m³) of the three models. All models had negative R^2 values at Karnack, indicating poor fit to the actual data. RF and LSTM had slightly higher errors and very low correlations (0.02 and 0.01, respectively), meaning their predictions did not closely follow observed $PM_{2.5}$ changes.

For Tyler, RF was the most reliable model for minimizing prediction errors. At Karnack, SVR was marginally better than the other models. Overall, model performance at Karnack was weaker than at Tyler. For both sites, all models showed substantially weaker performance on the test data compared to the training data, with notably lower R^2 values. This large discrepancy suggests that the factors driving $PM_{2.5}$ concentrations during the test period may differ from those in the training period. The following Section 2.4.1 discusses how the best model for each site predicted $PM_{2.5}$concentrations.

Table 2-3. Test Metrics for $PM_{2.5}$ Prediction Models at Tyler.

Model	RMSE (µg/m³)	MAE (µg/m³)	R²	Bias	Correlation
Random Forest	4.40	3.45	-0.07	0.18	0.25
SVR	4.57	3.64	-0.15	-0.51	0.35
LSTM	4.58	3.54	-0.12	-1.19	0.08

Table 2-4. Test Metrics for $PM_{2.5}$ Prediction Models at Karnack.

Model	RMSE (µg/m³)	MAE (µg/m³)	R²	Bias	Correlation
Random Forest	6.12	3.72	-0.11	-0.60	0.02
SVR	5.90	3.47	-0.04	-1.11	0.13
LSTM	6.25	3.66	-0.14	-0.81	0.01

2.4.1 Comparison of Observed and Predicted $PM_{2.5}$ Concentrations

Figure 2-1 compares the observed $PM_{2.5}$ concentrations at the Tyler monitoring site with the values predicted by RF. Figure 2-2 shows the same comparison for the Karnack site, but with predictions from SVR. Each point on the plot represents an hourly measurement during the test period (early August through early September 2025). The red dashed line indicates the 1:1 relationship, where predicted values would exactly match observed values.

At Tyler (Figure 2-1), RF predicted values generally cluster around the 1:1 line, but there is noticeable scatter, especially at higher $PM_{2.5}$ concentrations, suggesting the model struggles to accurately capture extreme events. Similarly, the SVR scatter plot for Karnack (Figure 2-2) shows that the model tends to underpredict higher observed values. It is worth noting that Karnack experienced high $PM_{2.5}$ peaks (up to 92 µg/m³) during the test period, which the model did not fully capture. Because the x- and y-axes in the Karnack plot extend to values over 80 µg/m³, compared to a maximum of 25 µg/m³ in the Tyler plot, the data points in the Karnack plot appear more tightly clustered.

The scatter plots highlight the challenges of predicting $PM_{2.5}$ in the TLMA area using advanced statistical models. While RF and SVR can capture general patterns, their ability to predict specific high or low $PM_{2.5}$ events is limited. The results suggest that further refinement, such as incorporating additional features or data sources, may be needed to improve model performance.

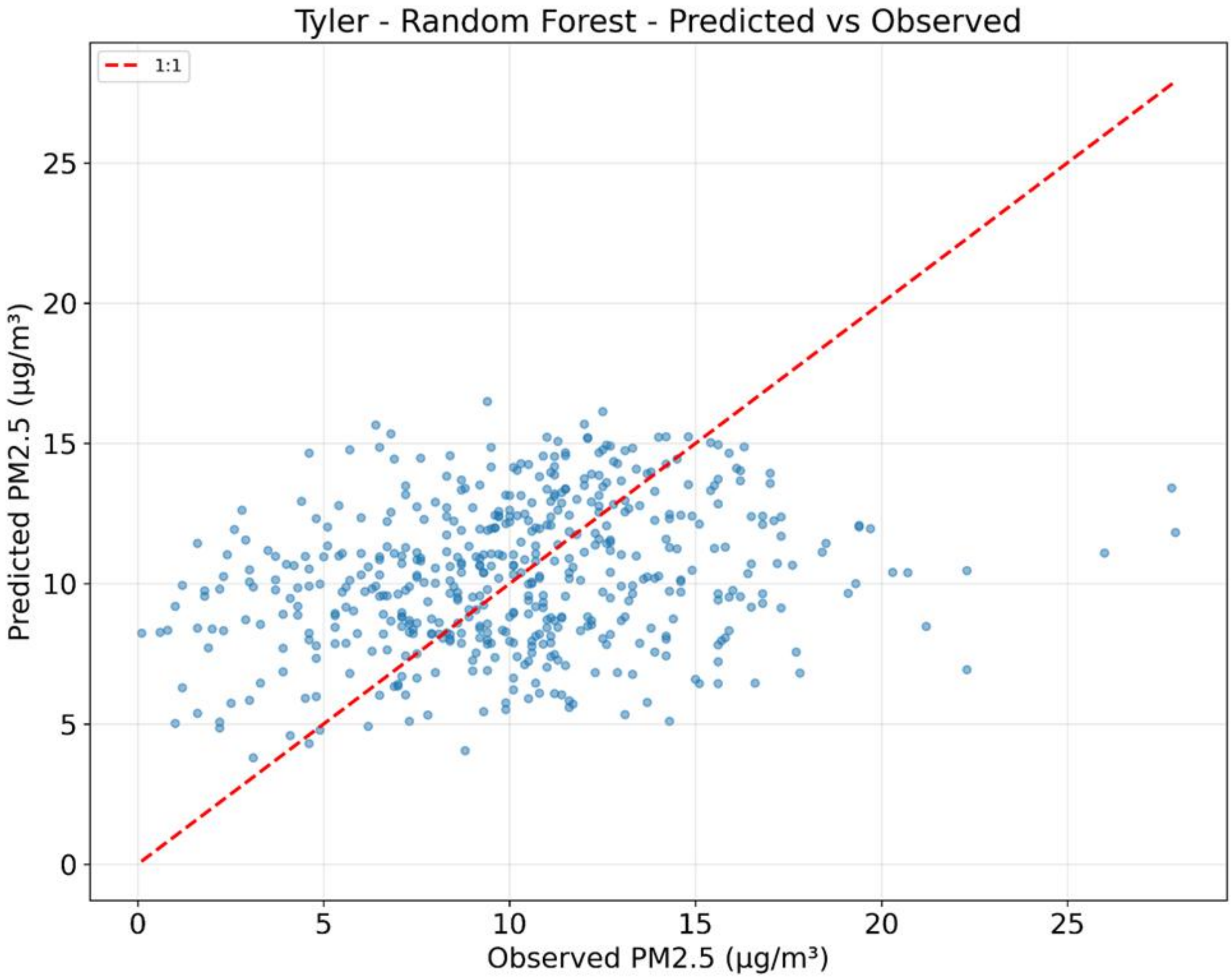

Figure 2-1. Comparison of the Observed and Predicted $PM_{2.5}$ Concentrations at Tyler.

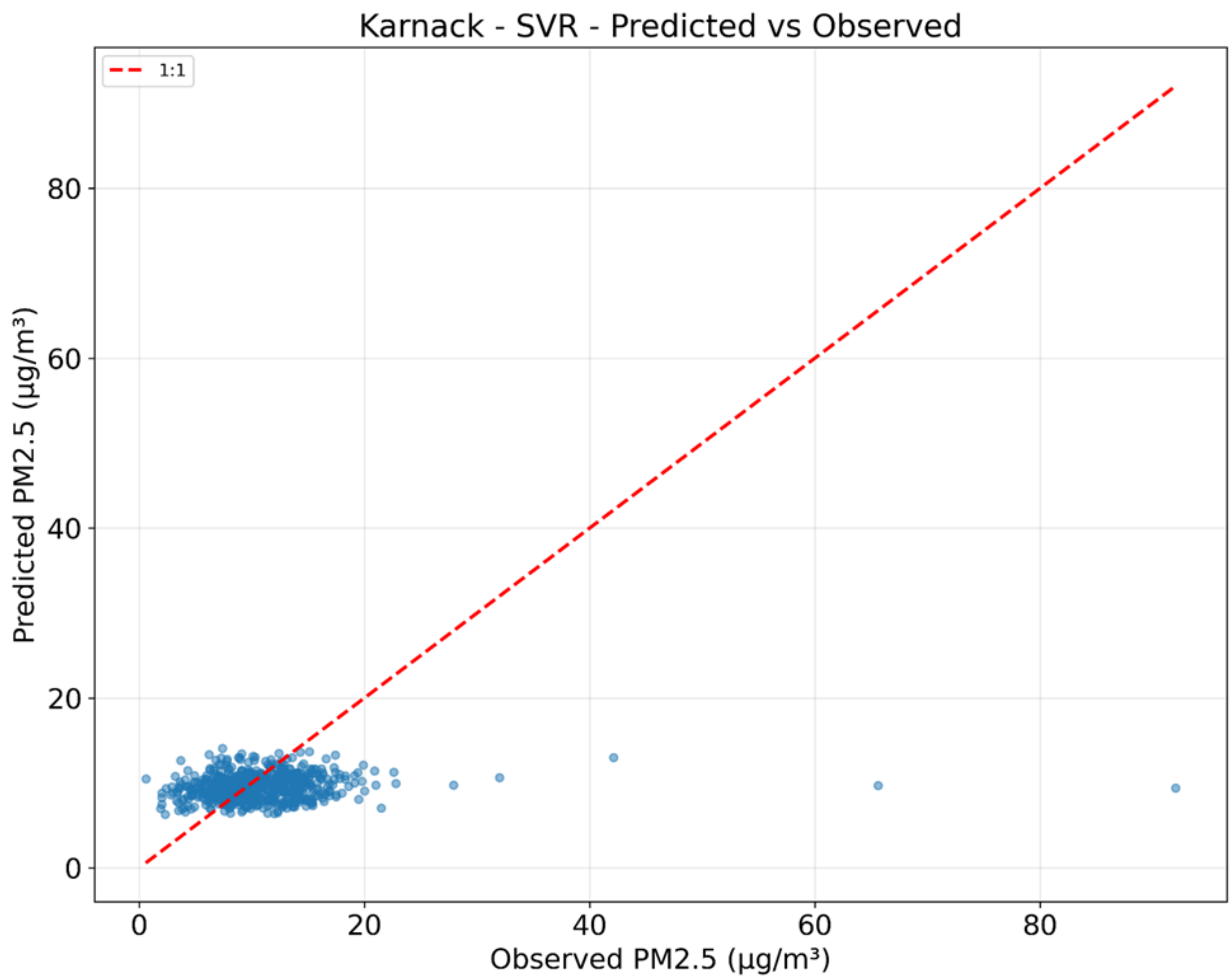

Figure 2-2. Comparison of the Observed and Predicted $PM_{2.5}$ Concentrations at Karnack.

2.4.2 Feature Importance

Feature importance reveals which features the RF model relies on most heavily when predicting $PM_{2.5}$, providing insights into the dominant drivers of air quality at each location. When the Random Forest model makes predictions, it relies on certain features more than others. The importance percentage shows how much each feature helps improve prediction accuracy. Higher percentages indicate more influential features. For example, a feature with 15% importance contributes substantially more to predictions than a feature with 2% importance. These feature importance rankings reflect patterns learned from the training period.

Figure 2-3 illustrates the top 15 features contributing to $PM_{2.5}$ prediction accuracy at the Karnack and Tyler monitoring sites, as identified by the RF model's feature importance analysis. For Karnack (left panel of Figure 2-3), the most influential predictors are rolling averages of temperature (e.g., 3-hour and 6-hour means), as well as lagged ozone and wind direction variables. This suggests that recent temperature trends and ozone concentrations play a significant role in shaping $PM_{2.5}$ levels at this site. In contrast, the Tyler RF model (right panel of Figure 2-3) places greater emphasis on both temperature and NO_2 features, including rolling means and lagged values, along with wind direction and ozone. The NO_2-related features at Tyler could reflect the influence of local traffic and urban emissions. Interestingly, the seasonal indicator, month_sin, was the 2nd most important feature at Tyler but did not appear in Karnack's top 15. This suggests Tyler experiences month-to-month variations in $PM_{2.5}$ that are independent of other meteorological factors. This could be due to fires that bring smoke into Tyler during certain months.

While Figure 2-3 presents the importance of individual features, Table 2-5 summarizes the results of grouped features. Related features are aggregated, e.g., all features that involve temperature are summed together, to provide a clearer overview of which categories of factors most strongly influence $PM_{2.5}$ at the Karnack and Tyler monitoring sites.

The same group of features, namely wind direction, wind speed, temperature, ozone, NO_2, and NO, consistently rank as the most important predictors for $PM_{2.5}$ concentrations at both the Karnack and Tyler monitoring sites. The cumulative importance of these features is high, accounting for 0.96 and 0.93 (out of 1) at Karnack and Tyler, respectively. This indicates that the model's prediction is mainly driven by these features at both locations.

In contrast, the remaining grouped features collectively contribute less than 0.07 (out of 1) to the total importance score at each monitor, indicating that they have minimal influence on model performance. However, it is important to note that some temporal features, such as indicators for weekends or rush hours, may appear to have low importance because their effects are already captured by other variables, such as NO_2, which may more effectively represent temporal patterns in $PM_{2.5}$ levels.

The prominence of wind direction, ranking first or second at both monitors, indicates the strong association between specific wind directions and elevated $PM_{2.5}$ concentrations. This finding aligns with the pollution rose analyses from Task 3.3, which showed that southerly winds are linked to higher $PM_{2.5}$ at both monitors, and potentially northerly and westerly winds at Karnack. Further investigation is recommended to better understand the transport and dispersion of pollutants in the region.

Temperature also appears as an important feature, but its relative importance differs by a factor of two between Karnack (0.327) and Tyler (0.148). Further investigation is recommended to understand the difference. Possible explanations include differences in atmospheric stability or the role of temperature in driving chemical reactions that produce $PM_{2.5}$ from precursors. Incorporating additional model features that are directly related to atmospheric stability could improve both model performance and interpretability.

The high importance of both NO_2 and O_3 at both sites indicates that $PM_{2.5}$ concentrations are closely linked with these pollutants. Ozone tends to be a regional pollutant due to its longer atmospheric lifetime, i.e., O_3 can accumulate more and transport further in the atmosphere than NO_2, while NO_2 pollution is more localized. The high importance of NO_2 at Tyler (where it ranks second) suggests a possible association between local NOx emission sources and $PM_{2.5}$ at the Tyler monitoring location (collocated with CAMS 82) and further investigation into local emission sources near CAMS 82 is recommended.

It is important to note that given the substantial performance drop on the test data, it is likely that different factors or different relationships between features and $PM_{2.5}$ became important during the test period. The feature importance should be interpreted as representative of spring and early summer conditions, not necessarily the entire monitoring period.

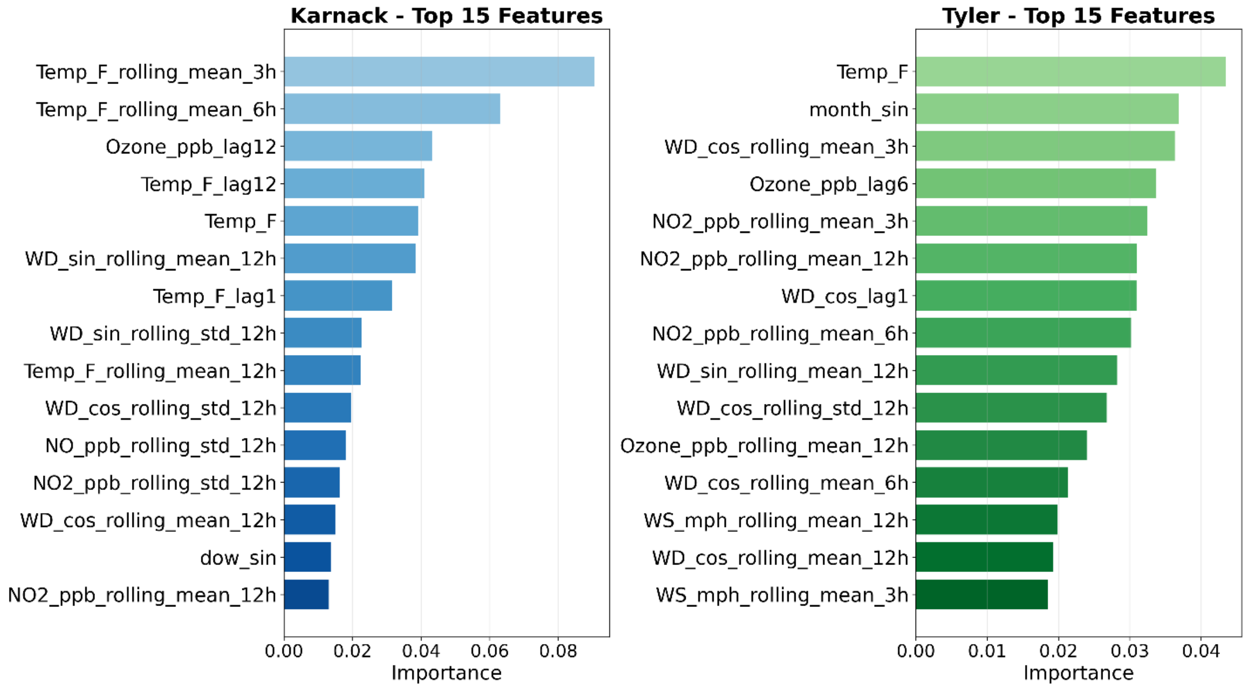

Figure 2-3. Top 15 most important features for $PM_{2.5}$ prediction at Karnack (left) and Tyler (right) for the training period.

Table 2-5. Summary of grouped feature importance and cumulative importance for Karnack and Tyler (ranked high to low).

	Karnack			Tyler		
Rank	**Grouped Feature**	**Importance**	**Cumulative Importance**	**Grouped Feature**	**Importance**	**Cumulative Importance**
1	Temp_F	0.327	0.327	WD	0.295	0.295
2	WD	0.258	0.585	NO2_ppb	0.171	0.467
3	Ozone_ppb	0.109	0.694	Temp_F	0.148	0.615
4	NO2_ppb	0.104	0.798	WS_mph	0.135	0.750
5	WS_mph	0.090	0.888	Ozone_ppb	0.122	0.872
6	NO_ppb	0.068	0.956	NO_ppb	0.057	0.928
7	dow	0.021	0.977	month	0.044	0.972
8	month	0.012	0.989	dow	0.017	0.989
9	Solar_Rad_Lang-min	0.007	0.996	hour	0.006	0.995
10	hour	0.003	0.999	Solar_Rad_Lang-min	0.004	0.999
11	is_weekend	0.001	1.000	is_weekend	0.001	0.999
12	is_rush_hour	<0.001	1.000	is_rush_hour	<0.001	1.000
13	is_daytime	<0.001	1.000	is_daytime	<0.001	1.000

3 Conclusions and Recommendations

This task applied advanced statistical modeling techniques, including Random Forest (RF), Support Vector Regression (SVR), and Long Short-Term Memory (LSTM) networks, to analyze and predict $PM_{2.5}$ concentrations at two monitoring sites in the TLMA area. The models incorporated a comprehensive set of engineered features to capture temporal, meteorological, and pollutant influences on air quality. Among the models tested, RF consistently demonstrated the best performance on training data at both Tyler and Karnack, with the lowest prediction errors and highest correlation values. However, when evaluated on independent test data, all models exhibited limited ability to explain variance in observed $PM_{2.5}$ concentrations, particularly at Karnack, where episodic high-concentration events were not well captured. These findings highlight the complexity of local air quality dynamics and the challenges of generalizing model performance across different time periods and emission scenarios.

The analysis of grouped feature importance reveals that while both Karnack and Tyler share a common set of dominant factors influencing $PM_{2.5}$ levels, namely wind direction, wind speed, temperature, O_3, NO_2, and NO, the relative importance of these factors differs between the two sites. At Karnack, temperature is particularly influential, with almost double the importance observed at Tyler. This suggests that atmospheric stability and/or temperature-driven chemical processes may play a more important role in $PM_{2.5}$ formation or accumulation at Karnack. At Tyler, NO_2 ranked as the second highest factor, indicating a stronger association between local NOx emissions and $PM_{2.5}$ levels. Additionally, wind direction is highly ranked for both sites. Analysis of pollution roses from Task 3.3 shows that both locations experience elevated $PM_{2.5}$ with southerly winds, while Karnack may also be affected by northerly and westerly winds. This pattern suggests differences in regional pollutant transport or source influences between the sites. These findings warrant further investigation that will help refine the models.

To improve predictive accuracy and support air quality management in the TLMA area, future modeling efforts should consider incorporating additional data sources and features, such as satellite-based smoke data. Training the model with an extended period could also better capture seasonal changes in emission patterns and atmospheric conditions and thus enhance model robustness. Advanced ensemble methods such as Gradient Boosting or eXtreme Gradient Boosting (XGBoost) could be explored as alternatives to Random Forest, potentially capturing more complex nonlinear relationships. These steps will help improve the effectiveness of the statistical models for identifying key drivers of $PM_{2.5}$ pollution and informing targeted mitigation strategies in the TLMA area.

4 References

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APPENDIX A

Model Features and Definitions

Appendix A. Model Features and Definitions

Feature	Definition
dow_cos	Day of week encoded as cosine to represent cyclical pattern
dow_sin	Day of week encoded as sine to represent cyclical pattern
hour_cos	Hour of day encoded as cosine to represent cyclical pattern
hour_sin	Hour of day encoded as sine to represent cyclical pattern
is_daytime	Indicator variable for daytime
is_rush_hour	Indicator variable for rush hour
is_weekend	Indicator variable for weekend (Saturday or Sunday)
month_cos	Month encoded as cosine to represent cyclical pattern
month_sin	Month encoded as sine to represent cyclical pattern
NO_ppb	Nitrogen oxide (NO) concentration in parts per billion (ppb)
NO_ppb_lag1	NO concentration in ppb lagged by 1 hour
NO_ppb_lag12	NO concentration in ppb lagged by 12 hours
NO_ppb_lag3	NO concentration in ppb lagged by 3 hours
NO_ppb_lag6	NO concentration in ppb lagged by 6 hours
NO_ppb_rolling_mean_12h	Rolling average of NO concentration in ppb over 12 hours
NO_ppb_rolling_mean_3h	Rolling average of NO concentration in ppb over 3 hours
NO_ppb_rolling_mean_6h	Rolling average of NO concentration in ppb over 6 hours
NO_ppb_rolling_std_12h	Rolling standard deviation of NO concentration in ppb over 12 hours
NO_ppb_rolling_std_3h	Rolling standard deviation of NO concentration in ppb over 3 hours
NO_ppb_rolling_std_6h	Rolling standard deviation of NO concentration in ppb over 6 hours
NO2_ppb	Nitrogen dioxide (NO2) concentration in ppb
NO2_ppb_lag1	NO2 concentration in ppb lagged by 1 hour
NO2_ppb_lag12	NO2 concentration in ppb lagged by 12 hours
NO2_ppb_lag3	NO2 concentration in ppb lagged by 3 hours
NO2_ppb_lag6	NO2 concentration in ppb lagged by 6 hours
NO2_ppb_rolling_mean_12h	Rolling average of NO2 concentration in ppb over 12 hours
NO2_ppb_rolling_mean_3h	Rolling average of NO2 concentration in ppb over 3 hours
NO2_ppb_rolling_mean_6h	Rolling average of NO2 concentration in ppb over 6 hours
NO2_ppb_rolling_std_12h	Rolling standard deviation of NO2 concentration in ppb over 12 hours
NO2_ppb_rolling_std_3h	Rolling standard deviation of NO2 concentration in ppb over 3 hours
NO2_ppb_rolling_std_6h	Rolling standard deviation of NO2 concentration in ppb over 6 hours
Ozone_ppb	Ozone concentration in ppb
Ozone_ppb_lag1	Ozone concentration in ppb lagged by 1 hour
Ozone_ppb_lag12	Ozone concentration in ppb lagged by 12 hours
Ozone_ppb_lag3	Ozone concentration in ppb lagged by 3 hours
Ozone_ppb_lag6	Ozone concentration in ppb lagged by 6 hours
Ozone_ppb_rolling_mean_12h	Rolling average of Ozone concentration in ppb over 12 hours

Feature	Definition
Ozone_ppb_rolling_mean_3h	Rolling average of Ozone concentration in ppb over 3 hours
Ozone_ppb_rolling_mean_6h	Rolling average of Ozone concentration in ppb over 6 hours
Ozone_ppb_rolling_std_12h	Rolling standard deviation of Ozone concentration in ppb over 12 hours
Ozone_ppb_rolling_std_3h	Rolling standard deviation of Ozone concentration in ppb over 3 hours
Ozone_ppb_rolling_std_6h	Rolling standard deviation of Ozone concentration in ppb over 6 hours
Solar_Rad_Lang-min	Solar radiation measured in Langley-minutes
Temp_F	Temperature in degrees Fahrenheit
Temp_F_lag1	Temperature in degrees Fahrenheit lagged by 1 hour
Temp_F_lag12	Temperature in degrees Fahrenheit lagged by 12 hours
Temp_F_lag3	Temperature in degrees Fahrenheit lagged by 3 hours
Temp_F_lag6	Temperature in degrees Fahrenheit lagged by 6 hours
Temp_F_rolling_mean_12h	Rolling average of temperature in degrees Fahrenheit over 12 hours
Temp_F_rolling_mean_3h	Rolling average of temperature in degrees Fahrenheit over 3 hours
Temp_F_rolling_mean_6h	Rolling average of temperature in degrees Fahrenheit over 6 hours
Temp_F_rolling_std_12h	Rolling standard deviation of temperature in degrees Fahrenheit over 12 hours
Temp_F_rolling_std_3h	Rolling standard deviation of temperature in degrees Fahrenheit over 3 hours
Temp_F_rolling_std_6h	Rolling standard deviation of temperature in degrees Fahrenheit over 6 hours
WD_cos	Wind direction represented as cosine
WD_cos_lag1	Wind direction represented as cosine lagged by 1 hour
WD_cos_lag12	Wind direction represented as cosine lagged by 12 hours
WD_cos_lag3	Wind direction represented as cosine lagged by 3 hours
WD_cos_lag6	Wind direction represented as cosine lagged by 6 hours
WD_cos_rolling_mean_12h	Rolling average of wind direction represented as cosine over 12 hours
WD_cos_rolling_mean_3h	Rolling average of wind direction represented as cosine over 3 hours
WD_cos_rolling_mean_6h	Rolling average of wind direction represented as cosine over 6 hours
WD_cos_rolling_std_12h	Rolling standard deviation of wind direction represented as cosine over 12 hours
WD_cos_rolling_std_3h	Rolling standard deviation of wind direction represented as cosine over 3 hours
WD_cos_rolling_std_6h	Rolling standard deviation of wind direction represented as cosine over 6 hours
WD_is_E	Indicator variable for wind direction being east
WD_is_N	Indicator variable for wind direction being north
WD_is_NE	Indicator variable for wind direction being northeast
WD_is_NW	Indicator variable for wind direction being northwest
WD_is_S	Indicator variable for wind direction being south

Feature	Definition
WD_is_SE	Indicator variable for wind direction being southeast
WD_is_SW	Indicator variable for wind direction being southwest
WD_is_W	Indicator variable for wind direction being west
WD_SD*	Standard deviation of wind direction
WD_sin	Wind direction represented as sine
WD_sin_lag1	Wind direction represented as sine lagged by 1 hour
WD_sin_lag12	Wind direction represented as sine lagged by 12 hours
WD_sin_lag3	Wind direction represented as sine lagged by 3 hours
WD_sin_lag6	Wind direction represented as sine lagged by 6 hours
WD_sin_rolling_mean_12h	Rolling average of wind direction represented as sine over 12 hours
WD_sin_rolling_mean_3h	Rolling average of wind direction represented as sine over 3 hours
WD_sin_rolling_mean_6h	Rolling average of wind direction represented as sine over 6 hours
WD_sin_rolling_std_12h	Rolling standard deviation of wind direction represented as sine over 12 hours
WD_sin_rolling_std_3h	Rolling standard deviation of wind direction represented as sine over 3 hours
WD_sin_rolling_std_6h	Rolling standard deviation of wind direction represented as sine over 6 hours
WS_gust_mph	Wind gust speed in miles per hour
WS_mph	Wind speed in miles per hour
WS_mph_lag1	Wind speed in miles per hour lagged by 1 hour
WS_mph_lag12	Wind speed in miles per hour lagged by 12 hours
WS_mph_lag3	Wind speed in miles per hour lagged by 3 hours
WS_mph_lag6	Wind speed in miles per hour lagged by 6 hours
WS_mph_rolling_mean_12h	Rolling average of wind speed in miles per hour over 12 hours
WS_mph_rolling_mean_3h	Rolling average of wind speed in miles per hour over 3 hours
WS_mph_rolling_mean_6h	Rolling average of wind speed in miles per hour over 6 hours
WS_mph_rolling_std_12h	Rolling standard deviation of wind speed in miles per hour over 12 hours
WS_mph_rolling_std_3h	Rolling standard deviation of wind speed in miles per hour over 3 hours
WS_mph_rolling_std_6h	Rolling standard deviation of wind speed in miles per hour over 6 hours

*Only available at the Karnack site.