FY16-17
PGA #-582-16-61361-01
Task 4.7

Northeast Texas Air Care Ozone Advance Action Plan 2016 Update

PREPARED UNDER A GRANT FROM THE
TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

The preparation of this report was financed through grants 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.

Prepared for:
Julie Burnfield
East Texas Council of Governments
3800 Stone Rd.
Kilgore, TX 75662

Prepared by:
Sue Kemball-Cook and Greg Yarwood
ENVIRON International Corporation
773 San Marin Drive, Suite 2115
Novato, California, 94998
www.environcorp.com
P-415-899-0700
F-415-899-0707

July 2016

RAMBOLL ENVIRON

CONTENTS

APPENDIX

TABLES

FIGURES

LIST OF ACRONYMS AND ABBREVIATIONS

APCA	Anthropogenic Precursor Culpability Assessment
BC	Boundary condition
CAMS	Continuous Air Monitoring Station
CAMx	Comprehensive Air Quality Model with Extensions
CEM	Continuous emissions monitor
CO	Carbon monoxide
DFW	Dallas-Fort Worth
DOAS	Differential Optical Absorption Spectroscopy
DV	Design value
DVs	Design values
EGU	Electric generating unit
EPA	Environmental Protection Agency
ETCOG	East Texas Council of Governments
FTIR	Fourier Transform Infrared
Hr	Hour
HRVOC	Highly reactive volatile organic compound
IC	Initial conditions
MDA8	Daily maximum 8-hour average
MeFTIR	mobile extractive Fourier Transform Infrared
MOVES	Motor Vehicle Emissions Simulator
MW	Megawatt
NAA	Non-Attainment Area (for the ozone NAAQS)
NAAQS	National Ambient Air Quality Standard
NETAC	Northeast Texas Air Care
NNA	Near non-attainment area
NO	Nitric oxide
NO_2	Nitrogen dioxide
NOx	Oxides of nitrogen
O_3	Ozone
OSAT	Ozone Source Apportionment Tool
OSD	Ozone season day
ppb	Parts per billion
SCC	Source classification code
SID	Sabine Industrial District
SIP	State Implementation Plan (for the ozone NAAQS)
SO_2	Sulfur dioxide
SOF	Solar Occultation Flux
STARS	State of Texas Air Reporting System
TCEQ	Texas Commission on Environmental Quality
TLM	Tyler-Longview-Marshall
Ton	English short ton (2000 pounds)
tpd	Tons per day

tpy	Tons per year
VOC	Volatile organic compound
WRF	Weather Research and Forecasting Model
yr	Year

EXECUTIVE SUMMARY

Northeast Texas Air Care (NETAC) is participating in the U.S. Environmental Protection Agency's (EPA's) Ozone Advance Program on behalf of the Tyler-Longview-Marshall (TLM) area in Northeast Texas. NETAC is a voluntary stakeholder group that was formed in 1996 to fill the need for an organized and comprehensive approach to improving air quality based on regional needs. NETAC consists of representatives from local government, local business and industry, EPA technical staff, Texas Commission on Environmental Quality (TCEQ) technical staff, Texas Department of Transportation planning staff, environmental interest groups and the general public. The five counties with representation at NETAC are Gregg, Smith, Harrison, Upshur and Rusk. More information on NETAC may be found at http://www.netac.org.

The U.S. EPA sets a National Ambient Air Quality Standard (NAAQS) for ozone in order to protect public health and the environment. The 8-hour ozone NAAQS sets a maximum level for the three-year running average of the annual fourth-highest daily maximum 8-hour average (MDA8) concentration; this quantity is known as the design value. In October 2015, the EPA lowered the ozone NAAQS from the 75 parts per billion (ppb) standard set in 2008 to a more stringent value of 70 ppb. The 2015 NAAQS is violated by a design value of 71 ppb or greater.

Designations of attainment of the 2015 NAAQS will be based on 2014-2016 ozone monitoring data[1]. State recommendations for designations of attainment and nonattainment areas are due to EPA by October 1, 2016 and EPA will finalize designations by October 1, 2017. The ozone design value for the TLM area following the 2015 ozone season is 68 ppb, which is lower than the 70 ppb 2015 NAAQS. The TCEQ Air Quality Division has indicated that it is considering designating Gregg, Smith and Harrison Counties as Attainment and Upshur and Rusk Counties as Unclassifiable/Attainment under the 2015 NAAQS[2]. Because failure to comply with the NAAQS carries adverse public health impacts and significant economic penalties, ozone air quality planning is important for Northeast Texas.

Ozone can affect human lung function and aggravate existing respiratory conditions such as asthma, bronchitis and emphysema, with severity of effects depending on concentration. Certain groups of people are particularly sensitive to ozone. These groups include children, older adults, people with lung diseases, and people who work or exercise vigorously outdoors. Ozone also damages vegetation and crops.

Ozone forms in the atmosphere from emissions of ozone precursors, namely nitrogen oxides (NOx) and volatile organic compounds (VOCs.) High ozone in Northeast Texas typically occurs on days when there is ample sunshine, local temperatures exceed 90 °F, wind speeds are low, and wind directions range between northerly clockwise through southeasterly. These wind directions are favorable for transport of polluted air masses of continental origin into Northeast

[1] https://www.epa.gov/sites/production/files/2016-02/documents/ozone-designations-guidance-2015.pdf

[2] https://www.tceq.texas.gov/assets/public/implementation/air/sip/ozone/2015Designations/Potential_State_Designation_Recommendations_2015ozone.pdf

Texas. High ozone days in Northeast Texas are generally characterized by high background ozone levels plus a smaller contribution from local emissions sources. Although the ozone contribution from local sources can be relatively small, ozone reductions are possible via reductions in local ozone precursor emissions.

Northeast Texas's NOx emission inventory is dominated by emissions from power plants, motor vehicles, and oil and gas exploration and production. The contribution to VOC emissions from biogenic sources such as trees far exceeds the contribution from human activities. The abundance of biogenic VOC ensures that there is always enough VOC available to form ozone so that the amount of ozone formed from local emissions is determined by the amount of NOx emissions. The overall VOC/NOx emission ratio in the TLM area is within the NOx-limited ozone formation regime. As a result, reductions in NOx will be generally more effective in controlling ozone on a regional basis than reductions in anthropogenic VOC. However, highly reactive VOCs (HRVOCs) emitted from petrochemical manufacturing facilities may contribute to rapid localized formation of ozone during days when the meteorology is favorable (e.g. Jobson and Pressley, 2009). Sensitivity tests and source apportionment modeling using NETAC's ozone models confirm that NOx reductions are more effective than VOC reductions in controlling ozone in Northeast Texas. Therefore, local emission control strategies are focused on reducing NOx as well as HRVOCs that have been shown to play a role in ozone formation at the Gregg County monitor in Longview.

Ozone Advance is a voluntary program designed to foster collaboration between the EPA and local governments to reduce emissions of ozone precursors so that current attainment areas can continue to maintain compliance with the NAAQS. EPA's Ozone Advance web site[3] lists the following benefits of participating in Ozone Advance:

- Further improving air quality in attainment areas can help to ensure continued health protection.
- Proactive efforts to improve air quality could better position some areas to stay in attainment. Or, if an area is eventually designated nonattainment, these efforts could either:
  - provide needed reductions that could result in a lower classification and/or
  - feed into a future State Implementation Plan (SIP).
- Reductions targeting one pollutant often result in multi-pollutant co-benefits.
- Areas working voluntarily to reduce air pollution have more flexibility to choose measures that make sense to them; once a nonattainment designation has occurred, less flexibility is available.

NETAC joined the Ozone Advance Program in 2013. As part of its participation in Ozone Advance, NETAC prepared an Ozone Action Plan and submitted it to EPA in June, 2015[4]. The

[3] https://www.epa.gov/advance/advance-basic-information
[4] https://www.epa.gov/sites/production/files/2016-01/documents/tylerplan.pdf

Action Plan summarized NETAC's understanding of ozone formation in Northeast Texas and outlined measures being taken to reduce local ozone levels. In this document, we provide an update to NETAC's Ozone Advance Action Plan that incorporates new information on local air quality as well as on measures/programs aimed at reducing local emissions of ozone precursors. The schedule for implementation of each measure/program is provided as well as the means of verification of emissions reductions, where applicable.

The following measures and programs are being taken in order to reduce ozone in Northeast Texas:

- Reductions in ozone precursor emissions, including NOx and highly reactive VOCs, from local and regional industrial facilities and power plants
- Promoting awareness of the Texas Emission Reduction Program (TERP) and encouraging local counties, cities and private companies to participate in this grant program aimed at reducing NOx emissions through replacement or repowering of eligible vehicles and equipment.
- Cleaner municipal fleet vehicle use by local cities
- Energy efficiency measures implemented by local cities
- Ozone awareness programs enacted by local cities
- NETAC public outreach activities including:
  - Public web site with links to daily ozone air quality forecasts, information on ozone and specific actions citizens can take to improve air quality as well as contact information for citizens who would like to become more involved in addressing local air quality issues
  - Publicizing Ozone Action Days, when high ozone is forecast for Northeast Texas, and providing information on actions that reduce emissions of ozone precursors
  - Radio and television public service announcements

This Ozone Advance Action Plan is intended to be a living document that will continue to be updated annually to incorporate developments in Northeast Texas' air quality planning.

1.0 INTRODUCTION

Northeast Texas Air Care (NETAC) is participating in the U.S. Environmental Protection Agency's (EPA's) Ozone Advance Program[5] on behalf of the Tyler-Longview-Marshall (TLM) area in Northeast Texas. NETAC is a voluntary stakeholder group that was formed in 1996 to fill the need for an organized and comprehensive approach to improving air quality based on regional needs. NETAC consists of representatives from local government, local business and industry, EPA technical staff, Texas Commission on Environmental Quality (TCEQ) technical staff, Texas Department of Transportation planning staff, environmental interest groups and the general public. The five counties with representation at NETAC are Gregg, Smith, Harrison, Upshur and Rusk. More information on NETAC may be found at http://www.netac.org.

EPA's Ozone Advance program is a collaborative effort between the EPA, states, tribes, and local governments to encourage emissions reductions in areas that currently attain the NAAQS in order to proactively maintain that status. Participation in the Ozone Advance program requires submitting an Action Plan to EPA that fully describes each emission control measure or program that participants agree to implement. The Action Plan should also provide an implementation schedule for control measures. Unlike a SIP, the Ozone Advance program represents a voluntary commitment to reduce emissions of ozone precursors, so EPA will neither accept nor reject an Action Plan, and placing a control measure in the Action Plan does not make it enforceable by EPA. EPA recommends that the Action Plan be updated each year to monitor progress on the implementation of emission reduction measures.

NETAC joined the Ozone Advance Program in 2013. As part of its participation in Ozone Advance, NETAC prepared an Ozone Action Plan and submitted it to EPA in June, 2015[6]. The Action Plan gives an overview of ozone air quality and describes the 5-county TLM area of Northeast Texas. In this 2016 Update to the 2015 Action Plan, we review the current attainment status of the TLM area (Section 1), summarize our understanding of ozone formation in Northeast Texas (Section 2) and outline measures being taken to reduce 5-county area ozone levels (Sections 3 and 4). In Section 2, we discuss the TLM area emission inventory of ozone precursors and summarize analyses of ambient monitoring data and photochemical modeling that inform the selection of emissions control strategies. Stakeholder involvement is discussed in Section 3. Finally, in Section 4, we describe the emissions reductions measures and/or programs that have been and will be implemented in the 5-county area. The schedule for implementation of each measure/program is shown as well as the responsible party and means of verification of emissions reductions, where applicable. Plans described in this Ozone Action Plan are effective through June, 2017.

1.1 Updates to the 2015 Ozone Action Plan

The following sections have been updated since the 2015 Ozone Action Plan:

[5] https://www.epa.gov/advance

[6] https://www.epa.gov/sites/production/files/2016-01/documents/tylerplan.pdf

- Section 1.3: Updated TLM population data through 2015
- Section 1.4: Updated ozone trends through 2015 and added discussion of the 2015 NAAQS
- Section 2.1.2: Added description of 2015 SOF emissions study at the Sabine Industrial District (SID) and comparison to SID emission inventories for the same dates
- Section 2.1.3: Updated trend analysis for oil and gas development through 2014-15
- Section 2.1.4: Updated power plant NOx emission trends through 2014
- Section 2.3: Added analysis of trends in local and regional background ozone in Northeast Texas
- Section 3.1: Updated NETAC Committee membership lists
- Section 4.0: Updated Description of Measures and Programs

1.2 Ozone Air Quality: Background

Ozone can affect human lung function and aggravate existing respiratory conditions such as asthma, bronchitis and emphysema, with severity of effects depending on concentration. The U.S. EPA sets a National Ambient Air Quality Standard (NAAQS) for ozone in order to protect public health and the environment. The 8-hour ozone NAAQS sets a maximum level for the three-year running average of the annual fourth-highest daily maximum 8-hour average (MDA8) concentration; this quantity is known as the design value. The NAAQS is based on health impacts for sensitive groups and there are economic penalties for areas that fail to attain it. The TCEQ operates three Continuous Air Monitoring Station (CAMS) ozone monitors in Northeast Texas that determine whether the 5-county TLM area is in compliance with the NAAQS.

Ozone is not emitted directly into the atmosphere, but forms from nitrogen oxides (NOx) and volatile organic compounds (VOCs) in the presence of sunlight. NOx and VOCs are emitted by both natural processes and human activities. Conditions that favor the formation of ground-level ozone in Texas are strong sunlight, high temperatures, and high precursor (NOx and VOC) concentrations. Elevated precursor concentrations in the atmosphere occur when emissions are large and/or weather conditions allow precursors to accumulate. When winds are calm and the atmosphere is stable, emitted precursors do not disperse and are available for ozone formation. On the other hand, if the atmosphere is unstable and winds are brisk, emitted pollutants are transported away from the area so that ozone does not build up.

Ozone is removed from the atmosphere by chemical reactions, photolysis (destruction by sunlight), deposition onto surfaces and uptake by plants. Ozone has a lifetime of several days to weeks at ground level; this lifetime is long enough to allow ozone to be transported thousands of miles. At any given location, therefore, measured ozone is partly due to a contribution from local emissions and partly due to transported ozone, which is often referred to as background ozone. High background ozone exacerbates local ozone problems, but is not a necessary condition for an area to have high ozone. Ozone problems solely from transport can occur, but are rare.

In order to reduce ozone in a given area, the ozone problem must be studied to determine the relative importance of local emissions and transported ozone. Photochemical modeling is used to assess the magnitude of the local and transported contributions. Regional and national emissions control measures such as the Federal vehicle emissions standards aim to reduce the contribution from transported ozone. If local ozone precursor emissions are shown to contribute to ozone levels, then local emissions control measures can be developed. The Ozone Advance Program was developed to assist areas in air quality planning and in developing local emissions control strategies designed to reduce ozone.

1.3 Northeast Texas

The 5-county TLM area lies on the Gulf Coastal plain approximately 100 miles east of the Dallas-Fort Worth metropolitan area and 15 miles west of the city of Shreveport, LA. A map of Northeast Texas and the surrounding area is shown in Figure 1-1. The region is relatively flat, with the highest terrain reaching a height of approximately 200 meters above sea level. The population in Northeast Texas is concentrated in the cities of Tyler, Longview and Marshall. There are smaller towns throughout the area (Figure 1-1), but much of the area in all 5 counties is rural land. Northeast Texas is densely wooded with a mixture of deciduous and coniferous trees. A major interstate highway, I-20, passes through the area. The main population centers in Northeast Texas are connected by I-20.

U.S. Census data (Figure 1-2) indicate that the 5-county area had a population of approximately 507,000 in 2015. During the period 2006-2015, all of the TLM area counties saw moderate (5-15%) growth in population. Smith County has the largest population of the 5 counties, and saw the largest increase in population (28,532) between 2006 and 2015. Figure 1-3 shows that Texas urban areas to the south and southwest of the 5-county area saw significant (>20%) growth in population from 2000 to 2010. The Houston, San Antonio and Austin areas all had two or more counties with >40% growth and these areas can be upwind of Northeast Texas on days that exceed the 70 ppb NAAQS (see Section 2 and Kemball-Cook et al., 2014a).

Northeast Texas overlies productive oil and natural gas fields. There are a large number of natural gas wells in Harrison and Rusk Counties that access conventional natural gas reservoirs as well as the Haynesville Shale. Gregg, Smith and Upshur Counties also have natural gas production, but have fewer wells and lower production levels than Harrison and Rusk Counties. There is oil production in all five counties, with the highest levels of production in Gregg and Rusk. Other industries in Northeast Texas include, but are not limited to, electric power generation and transmission, chemicals and plastics production, and petroleum refining.

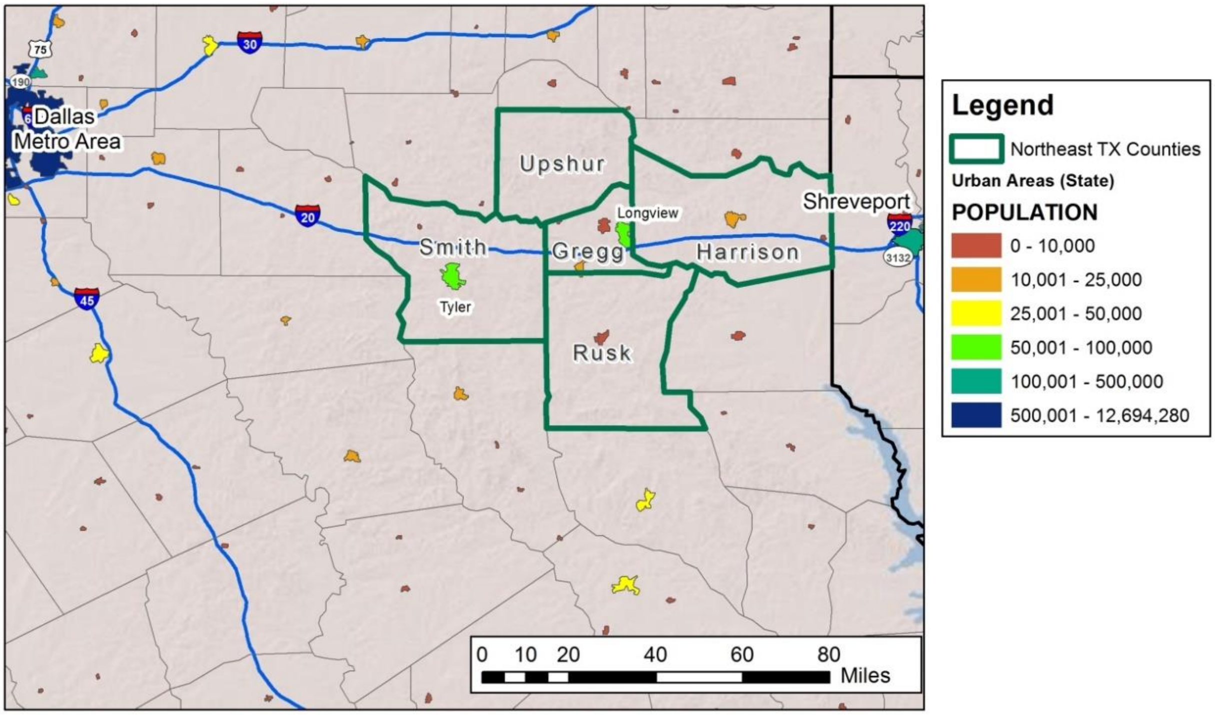


Figure 1-1. Population distribution of Northeast Texas and surrounding region. Urban areas are shaded and color of shading indicates population as of 2012. The 5 NETAC counties are outlined in dark green.

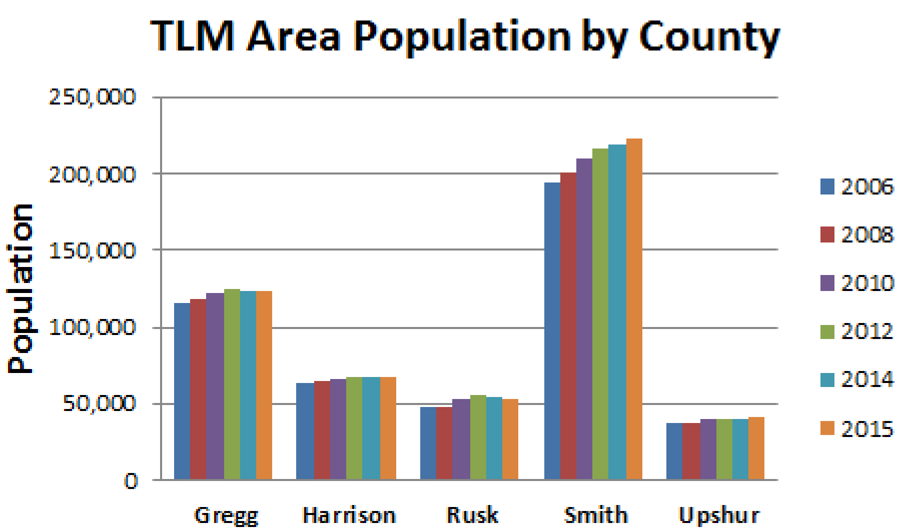


Figure 1-2. Northeast Texas population trends by county based on U.S. Census data[7].

[7] http://www.census.gov/quickfacts/table/PST04521548459,48423,48401,48203,48183

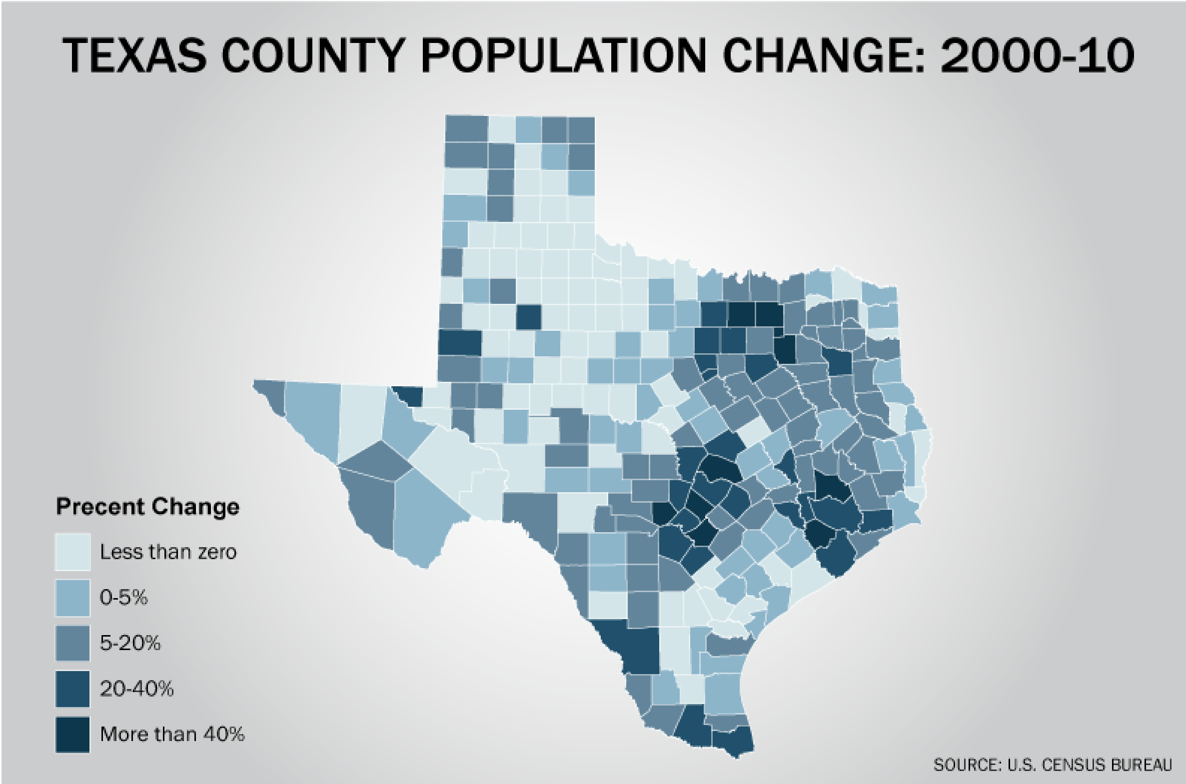


Figure 1-3. Texas population growth from 2000-2010. Figure from the Texas Tribune based on U.S. Census data[8].

1.4 Ozone Attainment Status History of Northeast Texas

The Northeast Texas ozone monitoring data are used to calculate the design values that determine whether the area is in compliance with the NAAQS for ozone. The locations of the three TCEQ CAMS ozone monitors are shown in Figure 1-4. The 5-county TLM area ozone monitors have seen large reductions in ozone during the last two decades (Figure 1-5; Figure 1-6) that have allowed the area to demonstrate compliance with increasingly stringent NAAQS. The TLM area achieved the 1-hour National Ambient Air Quality Standard (NAAQS) for ozone, successfully concluded its Early Action Compact (EAC) in 2007 with attainment of the 1997 0.08 ppm 8-hour ozone standard (dotted red line in Figure 1-5 and Figure 1-6), and demonstrated attainment of the 75 ppb 2008 NAAQS (dashed red line in Figure 1-5 and Figure 1-6). The solid red line shows the current 70 ppb 2015 NAAQS. In this section, we review the definition of the 1-hour and 8-hour ozone standards and give a brief history of the attainment status of the TLM area and the measures taken by NETAC to bring the 5-county area into attainment of each of these standards.

[8] http://www.texastribune.org/library/data/census-2010/

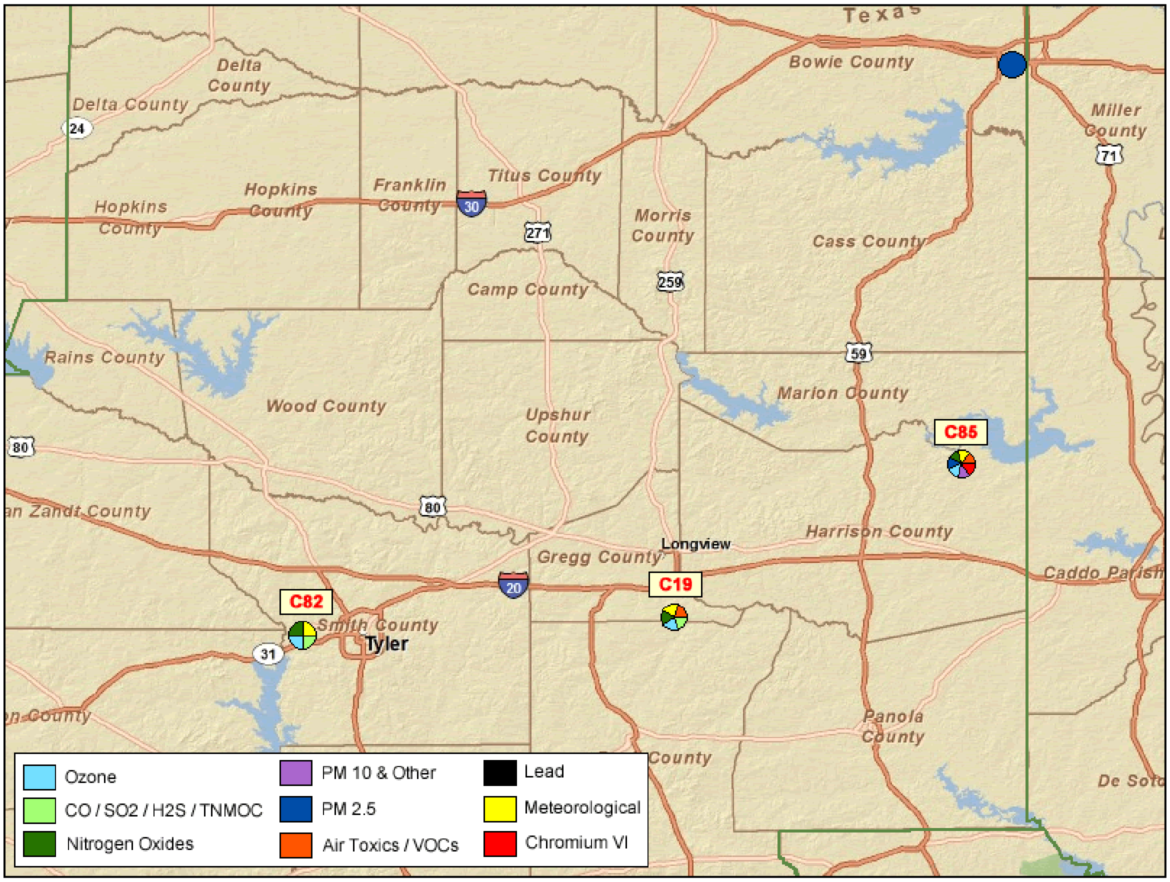


Figure 1-4. Northeast Texas and TCEQ CAMS monitor locations. TCEQ figure.

The 1997 1-hour NAAQS for ozone (no longer in effect) limited the frequency with which the daily maximum 1-hour average concentration can exceed 0.12 ppm to once per year (averaged over three years), while the 1997 8-hour standard set a maximum level (0.08 ppm) for the three year running average of annual fourth highest MDA8 concentration. The 1-hour standard was violated if the fourth highest concentration in a period of three consecutive years exceeded 0.12 ppm. Although a single year of data was not considered sufficient to demonstrate attainment, the value of the second highest daily maximum 1-hour concentration in a year was frequently used as an informal indicator of attainment/nonattainment status. This is referred to as the annual 1-hour design value. The 8-hour standard is violated if the annual fourth highest daily maximum 8-hour average concentration averaged over three consecutive years exceeds a threshold value, which was 0.08 ppm for the 1997 standard, 0.075 ppm (75 ppb) for the 2008 standard, and 0.070 ppm (70 ppb) for the 2015 standard. A single year of data is not considered sufficient to demonstrate attainment; instead, the fourth highest value in a given year is used as an indicator of attainment status (Figure 1-5). Consequently, we refer to this statistic as the annual 8-hour design value (Figure 1-6).

In 1996, the TLM area became a Flexible Attainment Region (FAR) and a mechanism for developing strategies to attain the 1-hour ozone standard was implemented under a Memorandum of Agreement (Flexible Attainment Region Memorandum of Agreement, September 16, 1996). Significant NOx and VOC emission reductions were made by Eastman Chemical Company, TXU (now Luminant) and SWEPCO (also known as AEP-SWEPCO) as part of the FAR and 1-hour ozone SIP that helped the area demonstrate attainment of the 1-hour ozone standard (Table 1-1). Under the 2002 Northeast Texas Region 1-Hour Ozone SIP Revision, Agreed Orders entered into by the Texas Natural Resources Conservation Commission and SWEPCO, Eastman Chemical Company and TXU made enforceable certain surplus voluntary emission reductions of NOx and VOC. The affected companies voluntarily agreed to implement controls to reduce emissions of ozone precursors. NOx emissions reductions affecting Northeast Texas point sources included low-NOx burner projects at SWEPCO's Wilkes, Pirkey and Knox Lee power plants and TXU's Martin Lake and Monticello power plants. NOx emissions reductions programs implemented by Eastman Chemical Company included shutdown of coal-fired boilers and changes to synthesis gas engines, reformer furnaces and heaters, and shutdown of olefin hydration units. Enhanced monitoring programs aimed at reducing HRVOC emissions were implemented.

In May 2002, the Texas Natural Resource Conservation Commission (now the TCEQ) submitted a State Implementation Plan (SIP) for Northeast Texas that demonstrated attainment of the 1-hour ozone standard by 2007.

In 1997, the EPA promulgated a new 8-hour NAAQS for ozone that superseded the 1-hour standard. The 8-hour ozone NAAQS was challenged in court and was eventually upheld in 2002 by the U.S. Supreme Court. However, the Court required that the EPA revise its implementation policy. EPA issued a draft revised implementation policy on June 2, 2003. EPA designated all five NETAC counties as 8-hour ozone attainment areas on April 15, 2004 (69 FR 23858).

On December 20, 2002, local governments in the 5-county TLM area entered into an EAC with the U.S. EPA and the TCEQ. The purpose of the EAC was to develop and implement a Clean Air Action Plan (CAAP) to reduce ground level ozone concentrations in the 5-County area and comply with the 8-hour ozone standard by December 31, 2007 and maintain the standard beyond that date. The EAC included a series of milestones to guide progress toward the development of the CAAP as shown in Table 1-1. On December 31, 2007, all three TCEQ Northeast Texas CAMS monitors had 8-hour ozone design values less than 85 ppb, indicating that the Tyler-Longview-Marshall area was in compliance with the 1997 8-hour ozone standard, thereby meeting its final milestone under the EAC.

In March, 2008, the EPA promulgated a new, more stringent 8-hour ozone standard of 0.075 ppm (75 ppb). The EPA carried out its designation process under the 2008 standard using data from the years 2008-2010. Using 2008-2010 data, the design values for all three Northeast Texas monitors were less than 75 ppb and met the 2008 ozone standard. On April 30, 2012, the EPA designated all Northeast Texas counties as being in attainment of the 2008 ozone standard.

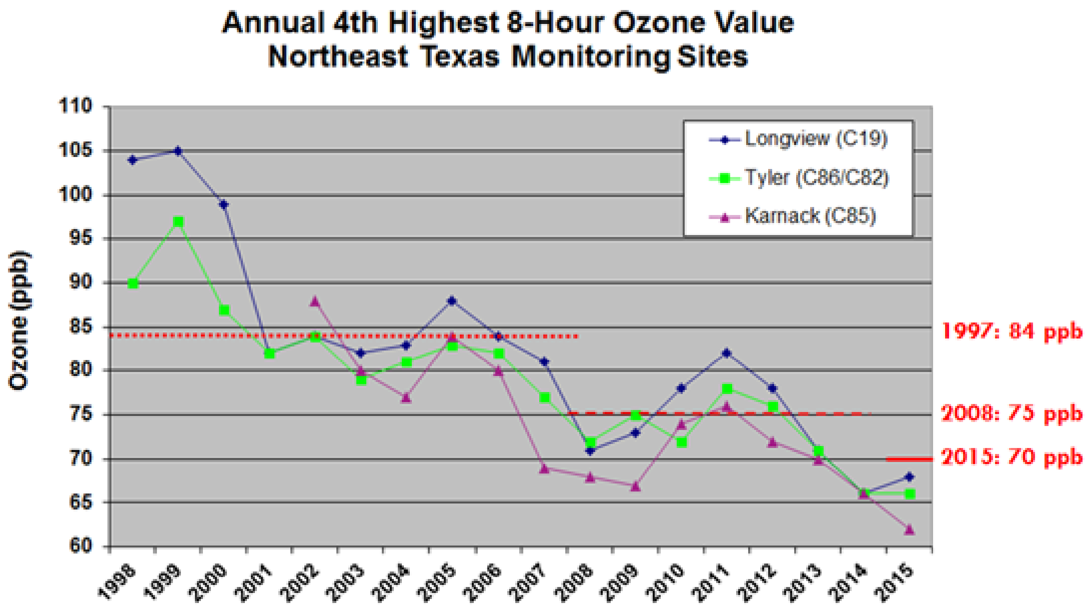


Figure 1-5. Trends in annual 4th highest 8-hour ozone values at the Longview (CAMS 19), Tyler (CAMS 82) and Karnack (CAMS 85) monitors in Northeast Texas. The red lines indicate the 1997 84 ppb, 2008 75 ppb and 2015 70 ppb ozone standards. All data have been validated by the TCEQ.

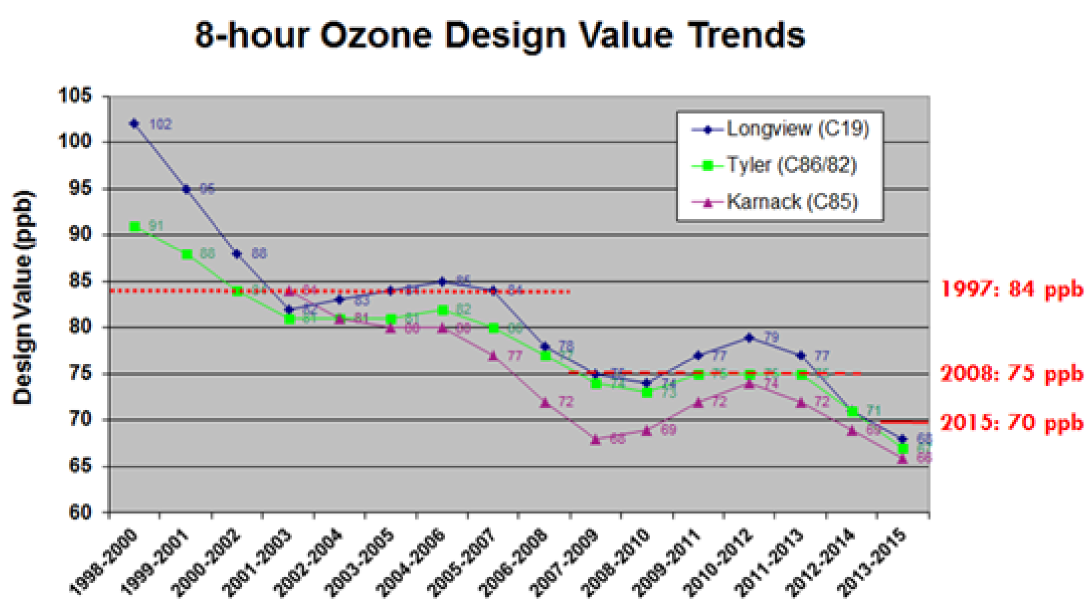


Figure 1-6. Trends in design values at the Longview (CAMS 19), Tyler (CAMS 82) and Karnack (CAMS 85) monitors in Northeast Texas. The red lines indicate the 1997 84 ppb, 2008 75 ppb and 2015 70 ppb ozone standards. All data have been validated by the TCEQ.

Table 1-1. Key milestone dates for Northeast Texas NOx and VOC emissions reductions and the Northeast Texas Early Action Compact.

Date	Item
1999-2000	SWEPCO (also known as AEP-SWEPCO) carried out burner projects resulting in over 5,000 tpy NOx emissions reductions at the Wilkes, Pirkey, and Knox-Lee Power Plants in Northeast Texas
September, 2001	Eastman entered into Voluntary Agreed Board order committing to NOx emission reductions of over 1,000 tpy that were accomplished by May 31, 2003.
2003	TXU (now Luminant) carried out emissions reductions projects resulting in over 21,000 tpy NOx reductions at the Martin Lake and Monticello Power Plants in Northeast Texas
December 31, 2002	Signed EAC agreement
June 16, 2003	Identified/described potential local emission reduction strategies
November 30, 2003	Initial modeling emission inventory completed Conceptual model completed Base case (1999) modeling completed
December 31, 2003	Future year (2007) emission inventory completed Emission inventory comparison for 1999 and 2007 Future case modeling completed
January 31, 2004	Schedule for developing further episodes completed Local emission reduction strategies selected One or more control cases modeled for 2007 Attainment maintenance analysis (to 2012) completed Submit preliminary Clean Air Action Plan (CAAP) to TCEQ and EPA
March 31, 2004	Final revisions to 2007 control case modeling completed Final revisions to local emission reduction strategies completed Final attainment maintenance analysis completed Submit final CAAP to TCEQ and EPA
December 31, 2004	State submits SIP incorporating the CAAP to EPA
December 31, 2005	Local emission reduction strategies implemented 1. Eastman Chemical Company enhanced leak detection/repair (LDAR) 2. Flint Hills Resources (formerly Huntsman Chemical Company) enhanced leak detection/repair (LDAR) 3. NOx reduction strategies for gas compressor engines 4. DOE "Clean Cities Program" voluntary on-road vehicle emission reductions 5. Incentive Grants to Reduce Emissions from Gas Compressor Engines
December 31, 2007	Attained the 1997 8-hour ozone standard

Under the Clean Air Act, the EPA is required to review the NAAQS periodically. On November 26, 2014, the EPA announced their intention to lower the NAAQS to a value in the 65-70 ppb range and to finalize the NAAQS by October, 2015. On October 1, 2015, the EPA lowered the ozone NAAQS from the 75 parts per billion (ppb) standard set in 2008 to a more stringent value of 70 ppb. The 2015 NAAQS is violated by a design value of 71 ppb or greater. Designations of attainment of the 2015 NAAQS will be based on 2014-2016 ozone monitoring data[9]. State

[9] https://www.epa.gov/sites/production/files/2016-02/documents/ozone-designations-guidance-2015.pdf

recommendations for designations of attainment and nonattainment areas are due to EPA by October 1, 2016 and EPA will finalize designations by October 1, 2017.

At the end of 2015, the Longview monitor (CAMS 19) in Gregg County had a design value of 68 ppb, the Tyler monitor in Smith County (CAMS 82) had a design value of 67 ppb and the Karnack monitor (CAMS 85) in Harrison County had a design value of 66 ppb; these design values are lower than the 2015 ozone NAAQS of 70 ppb.

The TCEQ Air Quality Division has indicated that it is considering recommending to EPA designation of Gregg, Smith and Harrison Counties as Attainment and Upshur and Rusk Counties as Unclassifiable/Attainment under the 2015 NAAQS[10]. Failure to comply with the NAAQS carries adverse public health impacts and significant economic penalties; therefore, air quality planning, including participation in EPA's Ozone Advance Program, is critical as Northeast Texas strives to protect public health, the environment and the regional economy.

[10] https://www.tceq.texas.gov/assets/public/implementation/air/sip/ozone/2015Designations/Potential_State_Designation_Recommendations_2015ozone.pdf

2.0 CONCEPTUAL MODEL OF OZONE FORMATION IN NORTHEAST TEXAS

EPA guidance on modeled attainment demonstrations and analyses for ozone (EPA, 2014) indicates that one of the first activities to be completed in ozone air quality planning is the formulation of a conceptual model that qualitatively describes ozone formation mechanisms and provides a rationale for selection of episodes to be modeled. The purpose of the conceptual model is to provide a basis of understanding of ozone in Northeast Texas and a foundation for all ozone air quality planning activities. EPA (2014) specifies that the key components of the conceptual model are analyses of air quality, meteorological and emissions data. Through these analyses, relationships between weather conditions and high ozone events may be established, important emissions sources and trends may be identified, and periods of high ozone suitable for modeling may be selected. Ozone modeling may be used to shed light on the causes of high ozone events as well as the likely effectiveness of proposed control strategies. NETAC has developed a conceptual model for Northeast Texas, and updates this model regularly (e.g. Parker et al., 2015, Kemball-Cook et al., 2014a; Kemball-Cook et al., 2013a; Kemball-Cook and Yarwood, 2010a,b; Stoeckenius and Yarwood, 2004). This section of the Ozone Action Plan document summarizes the conceptual model of ozone formation in Northeast Texas and describes results of recent analyses of air quality, emissions and meteorological data and trends.

2.1 Emissions

In this section, we review the emission inventory of ozone precursors for Northeast Texas. The most important ozone precursors are NOx and VOC. This analysis shows the source categories that make the most important contributions to Northeast Texas' ozone precursor emission inventory.

At the time this Action Plan Update was prepared, 2012 was the most recent year for which a full TLM area emission inventory (i.e. anthropogenic and biogenic emissions) was available. The 2012 emission inventory was developed by the TCEQ for use in ozone modeling by the Texas Near-Nonattainment Areas, and is broken down by emissions source category. The inventories were downloaded from the TCEQ's 2012 ozone modeling web site[11].

Figure 2-1 shows NOx and VOC emissions by source category in the TLM area for 2012. Total TLM area anthropogenic emissions for 2012 are 132 tpd of NOx and 133 tpd of VOC. Point sources are the largest contributor to the NOx emission inventory, accounting for 65 tpd or 49% of the total NOx emissions in 2012. Point sources are typically large, stationary, emissions sources that must submit an emission inventory if they exceed a specified emissions threshold. In attainment areas of Texas, such as the TLM area, any facility that emits a minimum of 100 tpy of any criteria pollutant must submit a point source emissions inventory to the TCEQ.

[11] https://www.tceq.texas.gov/airquality/airmod/data/tx2012

On-road mobile is the next largest contributor to the TLM area NOx emission inventory (30 tpd). On-road emissions were developed by the TCEQ using the EPA's Motor Vehicle Emissions Simulator (MOVES) model (EPA, 2010a, b). The emissions totals represent county-wide emissions for a summer weekday. Oil and gas sources (21 tpd in 2012) are the third largest contributor to NOx emissions. NOx emissions from off-road mobile sources were 13 tpd in 2012. NOx emissions from non-oil and gas area sources (3 tpd) and NOx emissions from biogenics (6 tpd) are relatively small compared to NOx emissions from the other categories.

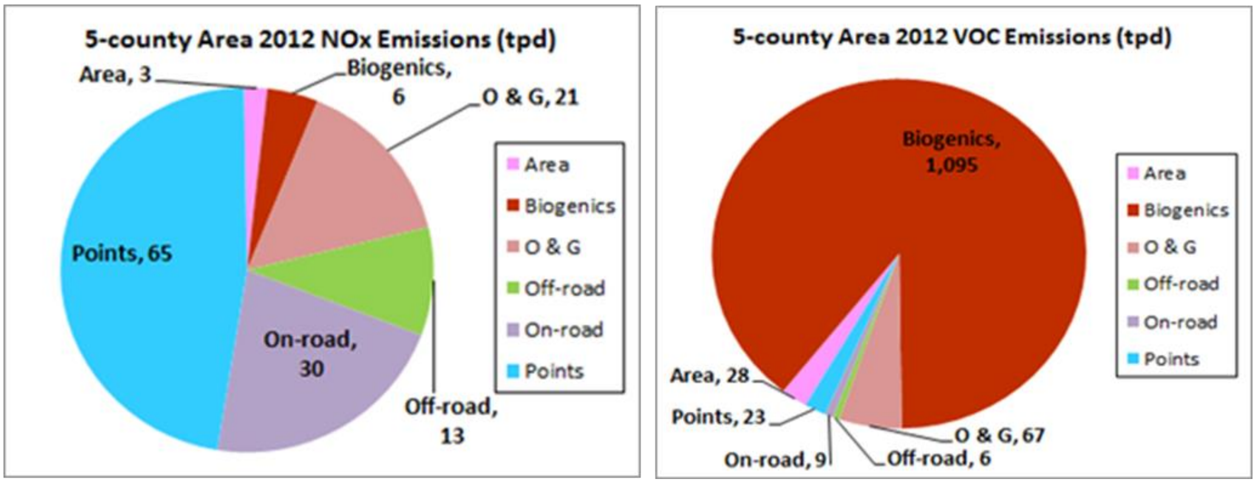


Figure 2-1. TLM 5-county area total 2012 emissions by source category for NOx (left) and VOCs (right). Figure from Grant et al. (2014).

The area (non-point) source inventory treats in aggregate all stationary sources that have emissions below the point source threshold. These are sources that may be spread out geographically and are small individually, but, taken together, may constitute a sizeable amount of emissions. Examples of area sources include dry cleaners, residential wood heating, auto body painting, fires, oil and gas wells, and consumer solvent use. These emissions are typically estimated and reported as county totals and allocated to a finer geographic scale using a surrogate such as population distribution. Area source emissions presented in this section have been divided into two components, non-oil and gas area sources and oil and gas area sources, to facilitate understanding of contributions from oil and gas area sources; oil and gas sources comprise a larger fraction of the area source NOx and VOC inventories than any other single area emissions source category. Oil and gas sources accounted for approximately 6% of TLM area VOC emissions in 2012. Non-oil and gas area sources, on-road vehicles, and point sources are minor contributors to TLM area VOC emissions, each accounting for 1-2% of the total VOC emissions.

Approximately 90% of the 2012 VOC emissions in the TLM area come from biogenic sources. Biogenic emissions are naturally-occurring (i.e., not from human activities) emissions from sources such as trees, agricultural crops, or microbial activity in soils or water. The 2012 biogenic emission inventory was developed by the TCEQ using the Model of Emissions of Gases and Aerosols from Nature (MEGAN; Guenther et al., 2012) version 2.10. MEGAN calculates hourly, day-specific emissions that depend on photosynthetically active solar radiation and temperature as well as other inputs such as land cover. Episode average biogenic emissions were extracted from the TCEQ biogenic emission inventory for the 5-county area for the period June 1-30, 2012. VOC emissions in Northeast Texas are dominated by highly reactive biogenic VOCs such as isoprene and pinenes; anthropogenic sources account for a much smaller fraction of total daily highly reactive VOC emissions in the NETAC area.

2.1.1 Relative Importance of Anthropogenic NOx and VOC Emissions in Ozone Formation

In order to develop emission control strategies for Northeast Texas that will reduce the local contribution to ozone, it is necessary to understand how ozone formation in the area depends on the amount of available NOx and VOC. Ozone formation depends on the amount of NOx and VOC present as well as on the ratio of VOC to NOx, where the ratio is taken in terms of ppbC/ppb, where ppbC stands for parts per billion of carbon. When the VOC/NOx ratio is higher than about 10, ozone formation is limited by the amount of available NOx and reducing NOx tends to decrease peak ozone concentrations. However, if the VOC/NOx ratio is less than about 7, reducing NOx tends to increase ozone levels, and the area is said to be VOC-limited. In this situation, which can occur in urban cores of large cities, ozone is suppressed in the urban area due to titration by large amounts of fresh NO emissions. When NOx emissions are reduced, the suppression of ozone by NO is lessened and ozone increases.

We calculated the VOC/NOx ratio in the June 2012 emission inventories for the 5-county area as a whole (Figure 2-1). The VOC/NOx ratio is 29 ppbC/ppb. The VOC/NOx ratio is far greater than 10, which indicates that the TLM 5-county area as a whole is a region where ozone formation is generally limited by the amount of available NOx. This finding is consistent with the results of NETAC's ozone modeling, which also indicate that ozone formation in Northeast Texas is NOx-limited (Kemball-Cook et al., 2013b, 2014b).

2.1.2 Point Source Emission Inventory

In this section, we summarize the point source emission inventory for Northeast Texas. We treat point sources separately from the remainder of the inventory because of their importance in the TLM area NOx emission inventory. A detailed description of the 2012 point source emission inventory for the TLM area is given in Grant et al. (2014). The TCEQ's 2012 point source emission inventory for Northeast Texas was compiled from data from the TCEQ's State of Texas Air Reporting System (STARS) and the EPA's Acid Rain Program Database (ARPDB). The STARS database is administered by the TCEQ. Each year, the TCEQ sends questionnaires to all facilities that meet the reporting requirements of 30 Texas Administrative Code (TAC) §101.10. The TCEQ collects point source emissions data as well as industrial process operating data. For all sources except electric generating units (EGUs), the TCEQ uses this data to compile Ozone Season Day (OSD) emissions. The OSD emission rate represents average daily emissions during the summer, when ambient ozone in Texas is highest.

Point sources are the largest contributor to NOx emissions, accounting for 49% of the total emissions in 2012. Point source emissions make a minor contribution to total VOC emissions (1.8%). Figure 2-2 shows the location of TLM area point sources in the 2012 TCEQ emission inventory. The size of the facility location circle is representative of the magnitude of facility-level NOx emissions. There are a number of large NOx sources in the vicinity of the CAMS 19 monitor in Longview. While the greatest number of point sources is in Harrison County and Gregg County, Harrison County and Rusk County have the highest point source NOx emissions. Harrison and Smith County have the highest point source VOC emissions (not shown).

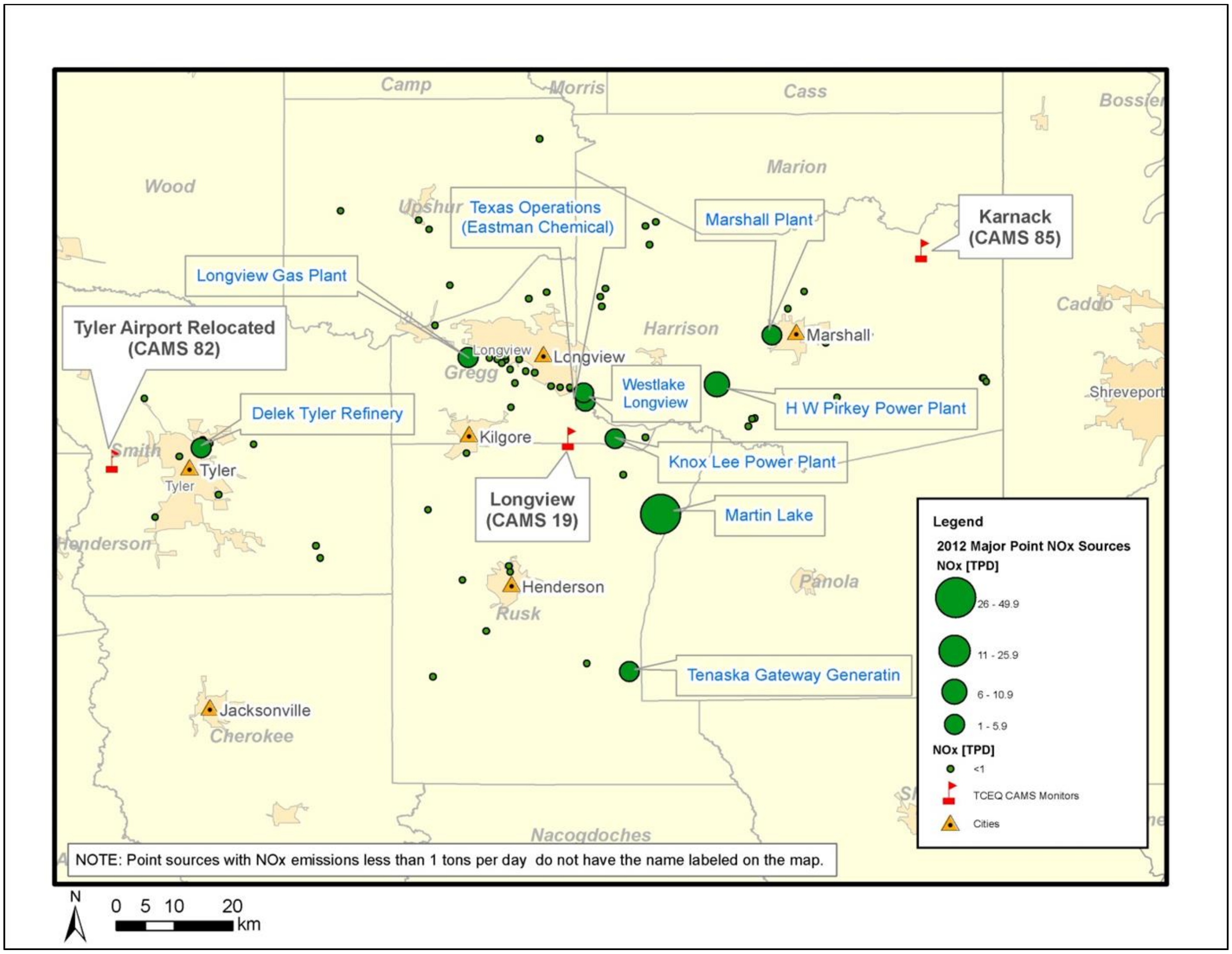


Figure 2-2. Map showing location of TLM 5-county point sources in the TCEQ 2012 emission inventory and their NOx emissions.

Figure 2-2 shows the top 15 NOx emitting point sources in the 2012 emission inventory which comprise 96% of NOx point source emissions in the TLM area. The Martin Lake Electrical Station is by far the largest NOx emissions source, accounting for 51% of point source NOx emissions; the Pirkey Power Plant is the second largest NOx emissions source, accounting for 17% of NOx point source emissions. The Texas Operations facility (Eastman Chemical Company) is the largest VOC point source, accounting for 28% of VOC emissions from point sources. Four of the top 15 NOx emission sources are part of the electric generation sector, five are part of the oil and gas sector, and the remaining six sources are a mix of other types of industrial facilities. The top 15 VOC emissions sources are comprised of two electric generation sector facilities, four oil and gas sector facilities, while the remaining nine facilities are a mix of other types of industrial facilities.

Table 2-1. NOx and VOC point sources in the TLM area ranked by emissions.

Facility	County	2012 NOx tons/day	2012 NOx Percent of TLM point emissions		Facility	County	2012 VOC tons/day	2012 VOC Percent of TLM point emissions
Martin Lake Electrical Station	Rusk	33.3	51%		Texas Operations (Eastman Chemical Company)	Harrison	6.3	28%
Pirkey Power Plant	Harrison	11.0	17%		Westlake Longview	Harrison	3.1	14%
Texas Operations	Harrison	4.0	6%		Delek Tyler Refinery	Smith	2.0	9%
Knox Lee Power Plant	Gregg	2.3	4%		Martin Lake Electrical Station	Rusk	0.8	4%
Delek Tyler Refinery	Smith	2.2	3%		Henderson Lumber Mill	Rusk	0.6	3%
Longview Gas Plant	Gregg	1.9	3%		Republic Industries Inc.	Harrison	0.5	2%
Marshall Plant	Harrison	1.5	2%		Trane Residential Solution	Smith	0.5	2%
Electric Power Generation (Tenaska Gateway Partners)	Rusk	1.4	2%		Marshall Plant	Harrison	0.4	2%
Westlake Longview	Harrison	1.4	2%		Harrison County Power Project	Harrison	0.4	2%
Stateline Compressor Station	Harrison	1.0	2%		Henderson Gas Plant	Rusk	0.4	2%
Eastman Cogeneration Facility	Harrison	0.9	1%		Trinity Industries Plant 19	Harrison	0.3	1%
Crossroads Gas Plant	Harrison	0.3	1%		Willow Springs Plant	Gregg	0.3	1%
Waskom Gas Plant	Harrison	0.3	1%		Rexam Beverage Can Co	Gregg	0.3	1%
Henderson Gas Plant	Rusk	0.3	1%		Crossroads Gas Plant	Harrison	0.3	1%
Joy Global Longview Operation	Gregg	0.3	<0.5%		Longview Gas Plant	Gregg	0.3	1%

The Sabine Industrial District (SID) is a large chemical plant near Longview and includes facilities owned by Eastman Chemical Company, Westlake Chemical Corporation and Flint Hills Resources (Figure 2-3). The SID reports emissions of highly reactive VOCs (HRVOCs; i.e. alkenes such as ethene and propene) as well as NOx; HRVOCs and NOx are ozone precursors. Rapid and efficient formation of ozone is possible downwind of a source that emits both HRVOCs and NOx (e.g. Kleinman et al., 2002). NETAC field studies and modeling efforts indicate that HRVOCs from the SID can play a role in high ozone events at the CAMS 19 monitor in Longview (e.g. Jobson and Pressley, 2009). NETAC's monitoring studies are described in the 2015 Ozone Advance Action Plan[12].

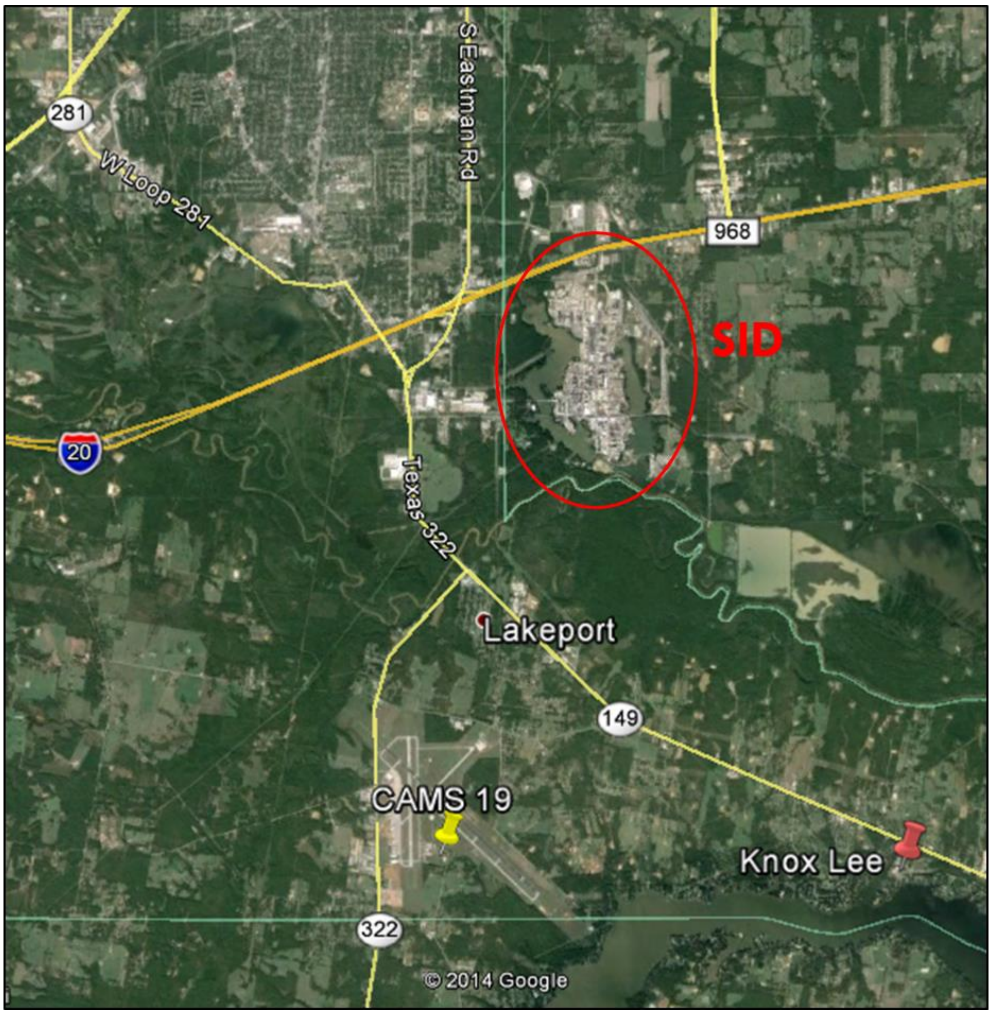


Figure 2-3. Location of the SID, CAMS 19, and other nearby major emissions sources. Map from Google Earth.

Much work has been completed in point source emissions characterization and minimization at the Sabine Industrial District (SID). Significant NOx and VOC emission reductions were made by

[12] https://www.epa.gov/sites/production/files/2016-01/documents/tylerplan.pdf

Eastman Chemical Company as part of the FAR and 1-hour ozone SIP that helped the area demonstrate attainment of the 1-hour ozone standard (See Section 1.4). In addition to these emissions reduction projects, various means of emissions characterization have been employed to support NETAC's modeling efforts. These are described in detail in NETAC's 2015 Ozone Advance Action Plan. In this 2016 Update, we report only the results of the most recent emission inventory and measurement studies aimed at quantifying emissions from the SID. These study results are the most up-to-date and robust available characterizations of facility-wide SID HRVOC and NOx emissions.

2012 and 2015 Solar Occultation Flux (SOF) Studies:

In the spring of 2015, a multi-day SOF (Solar Occultation Flux) and Mobile DOAS (Differential Optical Absorption Spectroscopy) measurement study was performed to quantify gaseous emissions of ethene, propene and nitrogen dioxide (NO_2) from the SID (Yarwood et al., 2015). This study was preceded by a multi-day SOF survey at the SID in the spring of 2012 (Johansson et al., 2012). The 2012 SOF study is described in the 2015 Ozone Action Plan.

The SOF measurement strategy is designed to allow the mass flux of species measured in an emission plume to be calculated. This is achieved by measuring the mass column of the species continuously as the SOF instrument, mounted in a vehicle, is driven crosswind on the downwind side of the emission source (Figure 2-4). A mirror/telescope located at the top of the vehicle tracks the sun and reflects sunlight into a Fourier transform infrared (FTIR) spectrometer, which analyses the infrared radiation from the sun. As light from the sun passes through the plume, molecules (including HRVOCs) in the plume absorb some of the incoming sunlight. Molecules have characteristic absorption spectra that can be used to identify their presence and quantify their abundance. The more molecules of a given chemical species are present in the plume, the more sunlight will be absorbed by those molecules as the solar beam passes through the plume. As the light path of the measured sun light slices through a cross section of the plume, the measured mass column will first increase from some baseline level and then decrease back to the same level. The spectrum of light emerging from the plume is compared with laboratory-measured reference spectra for the pollutants found in the plume. Through comparison of these spectra, the path-integrated column C(x) (in units of mg m^{-2}) is retrieved for chemical species found in the plume (Figure 2-5).

The mass flux in the plume is calculated by integrating the enhancement in mass column along the measurement route, which corresponds to the area under the graph in Figure 2-4, and multiplying with the plume velocity. This is expressed in the following equation

$$Q = \int_P C(\boldsymbol{x}) \cdot \boldsymbol{u} \cdot d\boldsymbol{x}$$

where Q is the mass flux, $C(\boldsymbol{x})$ is the measured column as a function of position $\boldsymbol{x}$ along the measurement path P and $\boldsymbol{u}$ is the plume velocity. The plume velocity used should ideally be the average velocity of all the molecules in the plume cross-section. Since the plume travels with

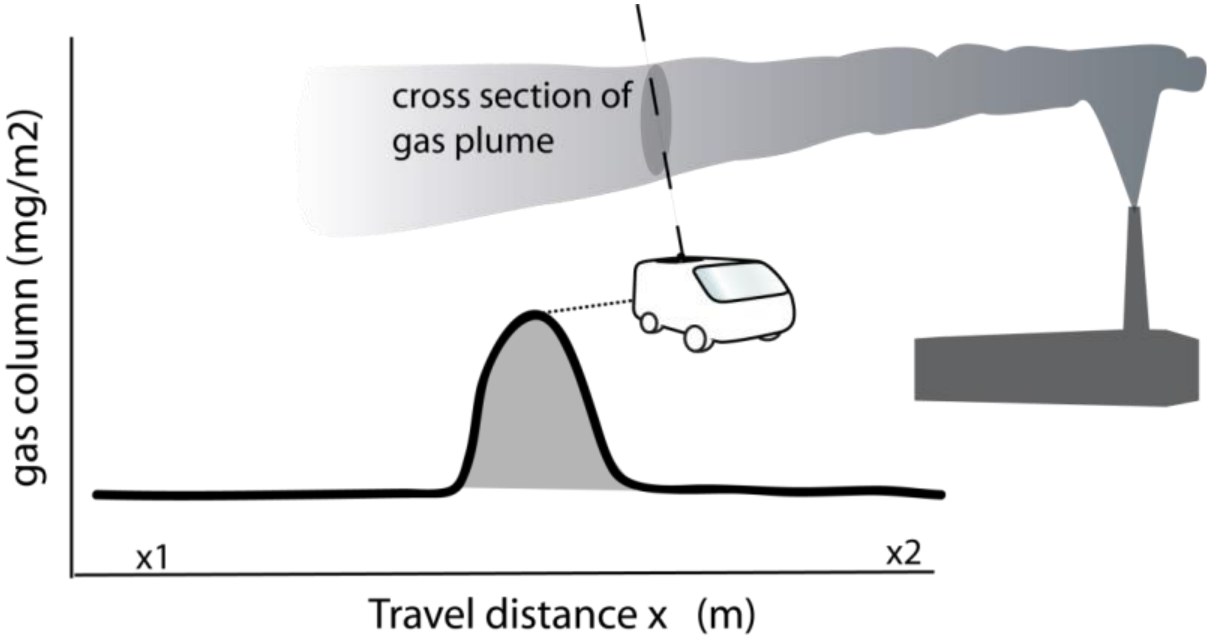


Figure 2-4. Schematic of SOF measurement technique. Figure from Yarwood et al. (2015).

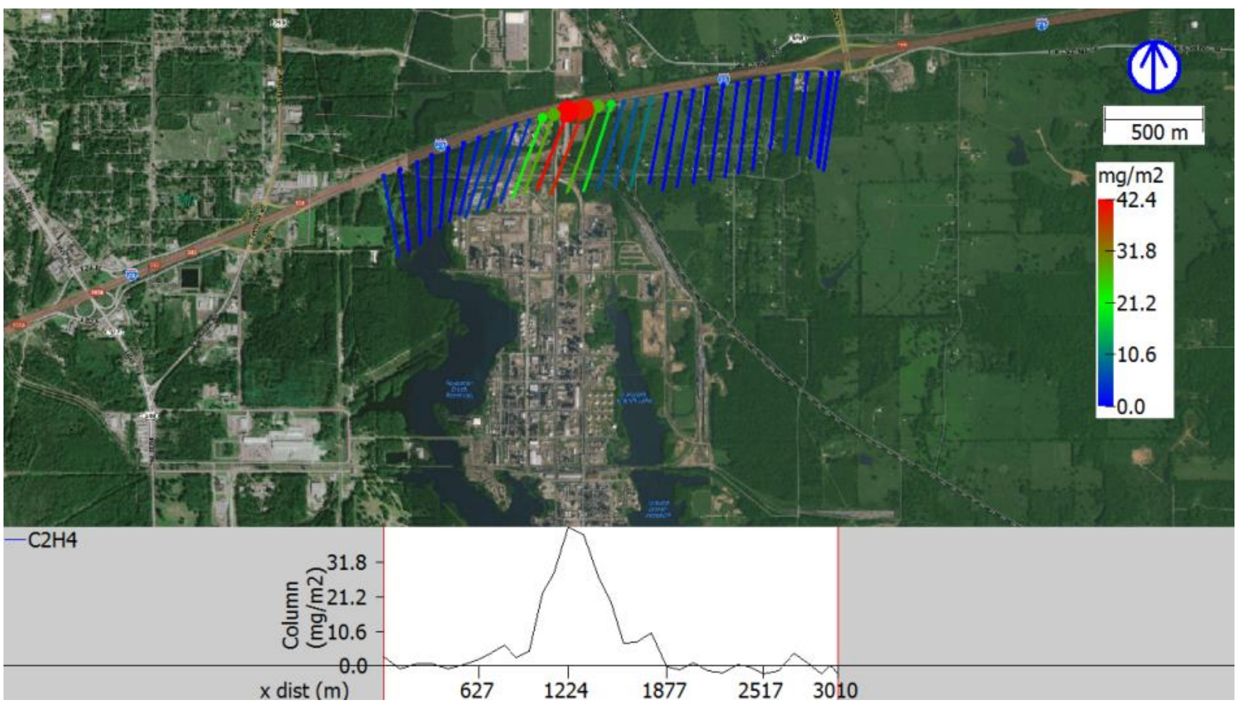


Figure 2-5. SOF measurement transect of ethene on the north side of the Sabine Industrial District on April 6, 2015, around 14:25. Each measured spectrum is represented with a point, with color and size indicating the evaluated integrated vertical ethene column. The ethene column by distance driven through the plume is also shown in the lower part of the figure. A line from each point indicates the direction from which the wind is blowing.

the wind, this is typically the average wind velocity across the extent of the plume. This requires measuring the wind in a way that is representative of the plume's extent. In the general case, this is a challenging task, since wind speed and direction are variable near the ground and then wind speed typically increases with height. The situation is helped by the fact that SOF measurements are done in sunny conditions. This is advantageous because it corresponds to unstable meteorological conditions for which wind gradients are smoothed out by convection.

The SOF technique was used to measure ethene and propene, while a Mobile Differential Optical Absorption Spectroscopy (DOAS) instrument was used to measure NO_2. The principle of flux measurements using Mobile DOAS is the same as for SOF, although the wavelength bands used (infrared for SOF and ultraviolet/visible for DOAS) and spectroscopic techniques differ.

The 2015 SOF study had methodology improvements over the 2012 study in order to produce a more statistically robust dataset. Two main improvements in the methodology were (1) continuous wind profile measurements using a wind LIDAR (Light Detection And Ranging), and (2) plume dispersion height estimation based on ground concentrations measurement using a MeFTIR (Mobile Extractive FTIR) instrument. Both of these improvements increased the accuracy and representativeness of the wind velocity used to calculate emission fluxes in the 2015 study. The wind LIDAR provides continuous wind velocity at heights above ground from 40 to 200 m during each measurement transect, and the plume dispersion height estimate provides a tool to determine the height range that represents the plume velocity.

The main uncertainty for the flux measurements in the SOF and Mobile DOAS measurements comes from the uncertainty in the wind field. Three different methods for measuring the wind speed and direction were used during the 2015 measurement study. The primary method was a Windcube v2 wind LIDAR. The wind LIDAR sends infrared laser pulses into the atmosphere and measures the light backscattered by aerosols. By analyzing the return time and the wavelength Doppler-shift of the backscattered pulse, the instrument can determine the radial wind speed at multiple distances along the measurement path. The major advantage of the wind LIDAR is that it provides continuous high accuracy measurements of wind profiles over the height range of typical interest for SOF measurements. In situ wind measurements were made by the SOF study team using a 15 meter extendable tower and balloon-borne instrument packages that were launched during plume measurements.

Compared to the 2012 SOF Study, the use of the wind LIDAR in the 2015 study, giving continuous vertical wind profiles throughout the survey, adds valuable information to better assess and limit the uncertainties in the wind field. MeFTIR was used to obtain ground level concentrations of ethene and propene. By comparing the ground level concentration to the slant column measured by SOF throughout the plume cross section and assuming a uniformly mixed plume, the plume dispersion height was estimated. Based on 91 transects, the obtained median plume height was 284 m. The key point of this analysis is that the vast majority of the plume is aloft, and not close to ground. This finding reduces uncertainty in the SOF and DOAS emission estimates because most of the plume mass is aloft where the wind speed does not change rapidly with height.

Once the winds and in-plume pollutant concentrations are measured, emissions estimates can be made for the plume emission source(s). A rigorous error budget was calculated for all emissions estimates in the 2015 study. The results are shown in Table 2-2. For all measured species, the uncertainty was smaller in the 2015 study than in the 2012 study. In the 2012 SOF study, the uncertainty for ethene and NO_2 flux measurements was 33%, and for propene, the uncertainty was 37%.

Table 2-2. Error budget for emission fluxes in the 2015 SOF Study.

	Wind speed a)	**Wind direction** b)	**Spectroscopy (cross sections)** c)	**Retrieval error** d)	**Composite flux measurement uncertainty** e)
Ethene	16 %	5 %	3.5 %	10 %	20 %
Propene	16 %	5 %	3.5 %	20 %	27 %
NO_2	16 %	5 %	4 %	10 %	20 %

Using 1σ–variability for the 10–200 m range wind profile averages, and studying the sensitivity of the 10-200 m profile average changing the plume distribution range to 10-100 m or 10-350 m.
The 1σ deviation among the 10-200 m wind profiles is within 10º. A plume transect orthogonal to the wind direction would give a 2 % error. For a measurement at 75º angle the error is 5 % (used here).
Includes systematic and random errors in the cross section database.
The combined effects of instrumentation and retrieval stability on the retrieved total columns during the course of a plume transect.
The composite square root sum of squares uncertainty

Following the 2015 SID survey, TCEQ funded a controlled ethene release experiment at the fairgrounds of the Maude Cobb convention center in Longview, TX (Yarwood et al., 2015). The experiment was run as a “blind test”, where the ethene release rates were chosen by an independent official from the City of Longview, and kept secret from the SOF team until they reported back their release rate estimates. Ethene was released from a single point source at 10 m height, and the SOF measurements were done 200 m downwind the source. In three out of four releases, ranging from 1.85-10.85 kg/h, SOF retrieved the true release rate within 15%, whereas in the fourth the SOF estimate was 45% off, biased low. The short plume dispersion time of about only 60 seconds between the single release point and the plume transect road about 200 m downwind from the source exacerbated some sources of uncertainty that are minor for typical industrial SOF measurements, like the SID case. With limited turbulence over the smooth surface surrounding the single release point, dispersion of the plume was not very effective resulting in very narrow plumes, and often also a branched plume with multiple peaks observed. In contrast industrial sites typically have large structures that create wakes, fans and heat introduce strong turbulence, leading to broad and continuous plumes that are easier to locate and measure completely. The experiment described above is consistent with an uncertainty budget of 20–30 %.

NETAC requested the SID companies to record information about plant operations that could influence the site emissions during the March 31 – April 11, 2015 SOF study sampling period. Eastman Chemical reported that unusual emission events occurred on April 7th. During the period 07:00-13:00 cracking plant 3a was shutdown which entailed flaring emissions of 619 lb ethene, 111 lb propene, 112 lb NOx. During the period 13:00-15:00 a maintenance event at cracking plant 4 resulted in propene emissions of 20 lb. For ethene and NO_2 the measurements between 07:00 and 13:00 on April 7th were excluded from the calculation of average emission rate. For propene SOF measurements between 07:00 and 15:00 were excluded. Air Liquide reported unusual event emissions of 78 lb/d ethene throughout the survey period but this is considered an insignificant amount in relation to the measured emissions and thus did not cause any measurements to be excluded.

From March 31–April 11, 2015, the SOF Team sampled ambient air downwind of the SID. 94 ethene measurement transects were conducted downwind of the SID. Eight transects or more were performed on six of these days. Five transects out of 94 were conducted during the April 7^{th} period when SID operators reported upset emissions from some of the facilities, and these measurements have been omitted from the average emission calculation; therefore ethene emissions are based on 89 transects. 88 propene measurement transects were made during the 2015 study. Seven transects or more were performed on six of these days. As for ethene, 12 transects out of 88 were conducted during the April 7^{th} time period when the SID reported upset emissions from some of the facilities were omitted from the average emission calculation. 119 transects for NO_2 were made.

Figure 2-6 shows histogram plots of the observed emissions, i.e. the number of observed transects within specific emission ranges. Periods with upset emissions reported by the SID companies are included in Figure 2-6 to show the full range of variation in the measurements. For ethene and NO_2 there is no obvious pattern of differences during the upset period, but propene seems to exhibit a number of enhanced emission levels during the reported upset period. The average of the propene measurement transects during the upset period on April 7 (sampled 12:02-14:59) was 260±85 kg/h, compared to the regular operations average of 182±59 kg/h. For NO_2 the average during the upset period on April 7 (sampled 12:00-13:00) was 223±53 kg/h, compared to the regular operations average of 165±62 kg/h. The corresponding averages for ethene were 500±95 kg/h for the upset period (sampled April 7, 12:02-12:59) compared to the regular operations average of 440±197 kg/h. Notably, April 7 has the highest daily average ethene emissions with highest variability, 678±308 kg/h, even with the upset period excluded.

Daily Emissions Comparisons:

NETAC requested that the SID operators prepare a day-specific emission inventory for the SOF study period for comparison with the measured emission fluxes. Eastman Chemical, Flint Hills Resources and Westlake Chemical Corporation prepared 2015 study-specific emissions inventories for their facilities within the SID. Each company provided notes to assist in understanding variations in emissions rates. The day-specific emission inventories and notes on emissions variations and inventory preparation methods provided by each company are presented in Appendix A.

For each day from March 31-April 11, Ramboll Environ calculated the total emission rate from the SID for ethene, propene, and NOx by adding the emissions provided by the three SID operators. These daily emissions totals are shown in Table 2-3 along with all comments supplied by the SID operators indicating days on which any atypical operations occurred at their facility that might affect emissions or ethene, propene or NOx. An example of atypical operation is the permitted maintenance/startup/shutdown (MSS) event that occurred on April 2 at the Flint Hills facility. Note that the five SOF transects on April 7th between 07:00 and 13:00 were excluded from the daily emissions shown in Table 2-3 and from the calculation of the average emission rate due to reported unusual emission events.

For each day of measurements, the SOF fluxes of ethene and propene are larger than the emissions inventory for these species. For ethene, the SOF measurements range between 7.5 tpd and 17.9 tpd, while the emissions inventory ranges between 2.75 tpd and 3.75 tpd. The SOF study average ethene flux is 11.6 tpd whereas the average emission inventory is 2.97 tpd. For propene, the SOF measurements range between 4.1 tpd and 6.5 tpd, while the emissions inventory ranges between 0.88 tpd and 1.05 tpd. The SOF study average propene emission flux is 4.8 tpd whereas the average emission inventory is 0.94 tpd. The study average emission rates from the SOF measurements are approximately four times higher than the emissions inventory for ethene and approximately five times higher for propene.

By contrast, the SID total NOx emissions were higher on each day than the NO_2 fluxes measured using the mobile DOAS instrument aboard the SOF vehicle. The NOx emissions inventory ranged from 6.00-7.95 tpd, while measured NO_2 fluxes ranged from 2.7-5.7 tpd. The study average NOx emissions inventory was 7.44 tpd, while the study average NO_2 flux was 4.4 tpd. The NO_2 flux measurements will be biased low compared to the NOx emissions inventory to the extent that NO emissions were not converted to NO_2 in the atmosphere by the time they were detected by the SOF vehicle.

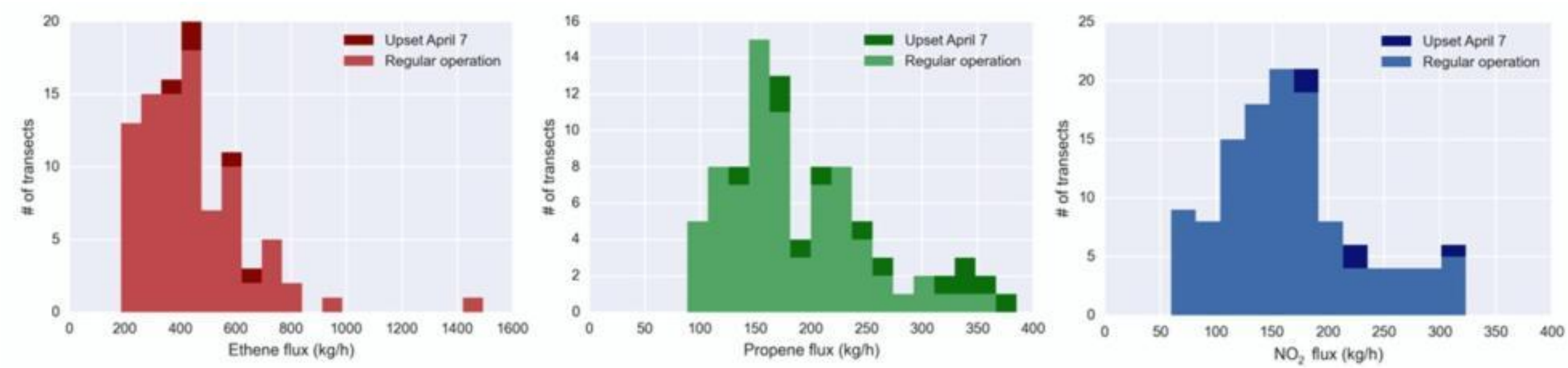


Figure 2-6. Histogram plots of ethene, propene and NO_2 for the SID survey in the spring 2015, including also the periods with reported upset emissions, marked separately. Emission range interval on the x-axis and number of measured transects within each bin on the y-axis.

Table 2-3. Comparison of 2015 SOF Study measured emissions and day-specific emission Inventories prepared by the SID operators: Flint Hills, Westlake and Eastman.

Date	Emissions (tpd)						Comments		
	Ethene		Propene		NOx				
	Inventory	SOF	Inventory	SOF	Inventory	SOF NO_2	Flint Hills	Westlake	Eastman
3/31/2015	2.92	12.3	0.94	6.5	7.95	5.5			
4/1/2015	2.93	9.8	0.94	4.3	7.89	4.9			
4/2/2015	2.93	9.6	0.95	4.7	7.89	5.0	Permitted MSS** event on this day		
4/3/2015	2.94	14.0	0.94	4.5	7.89	3.6			
4/4/2015	2.94	13.0	0.94	4.8	7.89	4.5			
4/5/2015	2.94		0.94		7.89				
4/6/2015	2.91	10.0	0.94	5.1	7.89	4.2			
*4/7/2015	3.13	17.9	0.94	5.2	7.35	5.7	Permitted MSS event on this day		A shutdown occurred on this day on one of our cracking plants.
4/8/2015	3.75		1.05		7.30		Permitted MSS event on this day		One cracking plant was shut down for this time period. Additionally, we had an off-gas stream vent to the air (fully permitted).
4/9/2015	2.81	12.3	0.88	4.3	7.30	3.8			One cracking plant was shut down for this time period.
4/10/2015	2.75		0.88		6.00	2.7		PE-1 facilities shut down for turn-around	One cracking plant was shut down for this time period.
4/11/2015	2.75	7.5	0.88	4.1	6.00	2.9		PE-1 facilities shut down for turn-around	One cracking plant was shut down for this time period.
Average	2.97	11.6	0.94	4.8	7.44	4.4			
Maximum	3.75	17.9	1.05	6.5	7.95	5.7			
Minimum	2.75	7.5	0.88	4.1	6.00	2.7			

* 5 transects on April 7th between 07:00 and 13:00 were excluded from the daily emissions and from the calculation of the average emission rate due to reported unusual emission events

**Maintenance/startup/shutdown

The average emission fluxes for ethene and propene in the 2015 SOF study are compared to the fluxes measured in the preceding 2012 SOF study in Table 2-4. These averages exclude periods when emissions were observed to be unusually high (in 2012) or during a reported upset period (in 2015). Propene emission fluxes are almost the same for 2012 and 2015 but the ethene emission flux is about a factor of two higher in 2015 than in 2012. The uncertainty in the 2015 SOF study is smaller than in the 2012 study because there were more measurement transects and more survey days in 2015 as well as better constrained wind profile data.

Table 2-4. Comparison of study-average emissions from the NETAC 2012 and 2015 SOF Studies with average of daily sum of emissions from Eastman, Westlake and Flint Hills.

Species	NETAC 2012 SOF Study: Average of Daily Emissions	NETAC 2015 SOF Study: Average of Daily Emissions	Emissions Inventory: Average of SID Total Emissions during the 2015 SOF Study
Ethene	5.4 tpd ± 33%	11.6 tpd ± 20%	2.97 tpd
Propene	4.6 tpd ± 37%	4.8 tpd ± 27%	0.94 tpd
NO_2	3.1 tpd ± 33%	4.4 tpd ± 20%	7.44 tpd

Below, we summarize the results of the comparison of measured and calculated emissions fluxes from the SID.

- Propene and NO_2 fluxes from the 2012 and 2015 SOF studies agree with one another within experimental uncertainty, but this is not true for ethene. The 2015 SOF study found study average ethene emission rates that were twice as high as ethene emissions rates measured in 2012.
- The study average measured ethene emission rate during the 2015 SOF study was approximately four times higher than the 2015 study average emissions inventory for ethene.
- The study average measured propene emission rate during the 2015 SOF study was approximately five times higher than the 2015 study average emissions inventory for propene.
- The study average measured NO_2 emission rate during the 2015 SOF study was less than half of the 2015 study average emissions inventory for NOx.

Propene and ethene can form ozone rapidly in the atmosphere and affect air quality in the Longview urban area and at the CAMS 19 monitor. Underestimating the ethene and propene emission inventory can also affect the accuracy of NETAC's ozone modeling. There are a number of possible explanations for the differences, including known uncertainties in both the SOF emission measurements and in the prescribed TCEQ and EPA emissions estimating methods as well as emissions that are currently not well-characterized. It should be noted that discrepancies between emissions inventory and SOF results have been observed in many studies. The 2012 SOF report states "The SOF method has been applied in several larger campaigns in both Europe and the US and in more than 45 individual plant surveys over the last 7 years. In the various campaign studies it has been found that the measured emissions obtained with SOF are 5-10 times higher than the reported emission obtained by calculations" (Johansson et al., 2012).

Our current understanding is that emissions of HRVOCs from the SID can contribute to high ozone at CAMS 19 and that such contributions occur intermittently according to wind direction and/or day-to-day variations in emissions (i.e. 3 out of 64 days in NETAC's 2008 Reactive Alkene Detector HRVOC monitoring study; Jobson and Pressley, 2009). Longview CAMS 19 has historically had the highest design value of the three Northeast Texas monitors and drives the area's attainment status. Measurements of HRVOCs and ozone at CAMS 19 have demonstrated that HRVOC emissions from the SID can increase ozone at CAMS 19. Consequently, NETAC's ozone modeling should use the best possible HRVOC emission inventory in order to identify the most effective emissions control strategies.

The purpose of the 2012 and 2015 NETAC SOF studies was to improve the characterization of emissions from the SID to further our understanding of ozone formation and to increase the accuracy of the HRVOC emissions inventories used for ozone modeling. The lack of agreement between the 2015 SOF study emission rates and the calculated emissions inventory suggests that our understanding of SID facility emission rates and their characterization in NETAC's modeling is not complete. Further work is needed to assess the sensitivity of NETAC's modeling to SID facility emissions. A comparison of modeled and observed ozone at Longview CAMS 19 using first the SOF study emissions rates and then the calculated emissions inventory in the model would show whether the differences between the two inventories affect modeled ozone. This information would assist NETAC in setting priorities for future work, including any emissions characterization efforts at the SID.

2.1.3 Oil and Gas Emission Inventories

Oil and gas emissions make up a large fraction of the 2012 TLM area anthropogenic VOC and NOx emission inventories due to the number of oil and gas wells in the TLM area. As shown in Figure 2-7, there are thousands of oil and gas wells in the TLM area, with the largest number of gas wells in the counties of Harrison and Rusk. Northeast Texas has conventional oil and gas production as well as unconventional natural gas production from the Haynesville Shale. In this section, we give an overview of oil and gas production in the 5-county area from both conventional and shale sources, and then focus on the Haynesville Shale and NETAC's efforts to characterize emissions from its development.

2.1.3.1 Overview of Oil and Gas Production and Emissions in the 5-County Area

Figure 2-8 shows TLM area total estimates of oil and gas production and well count. The number of oil wells in the 5-county area has stayed relatively constant during the last decade, while oil production has declined. Most of the 5-county area oil wells are located in Gregg and Rusk Counties (Figure 2-9). The TLM area natural gas well count increased by more than a factor of two between 2000 and 2015. The growth in the number of new wells was largest over the three year period from 2006 to 2009; Harrison and Rusk Counties each saw an increase of about one thousand natural gas wells during this time (Figure 2-9). This period of intense drilling activity coincided with high natural gas prices and the rapid development of the Haynesville Shale. Harrison and Rusk are the two TLM counties with the largest number of

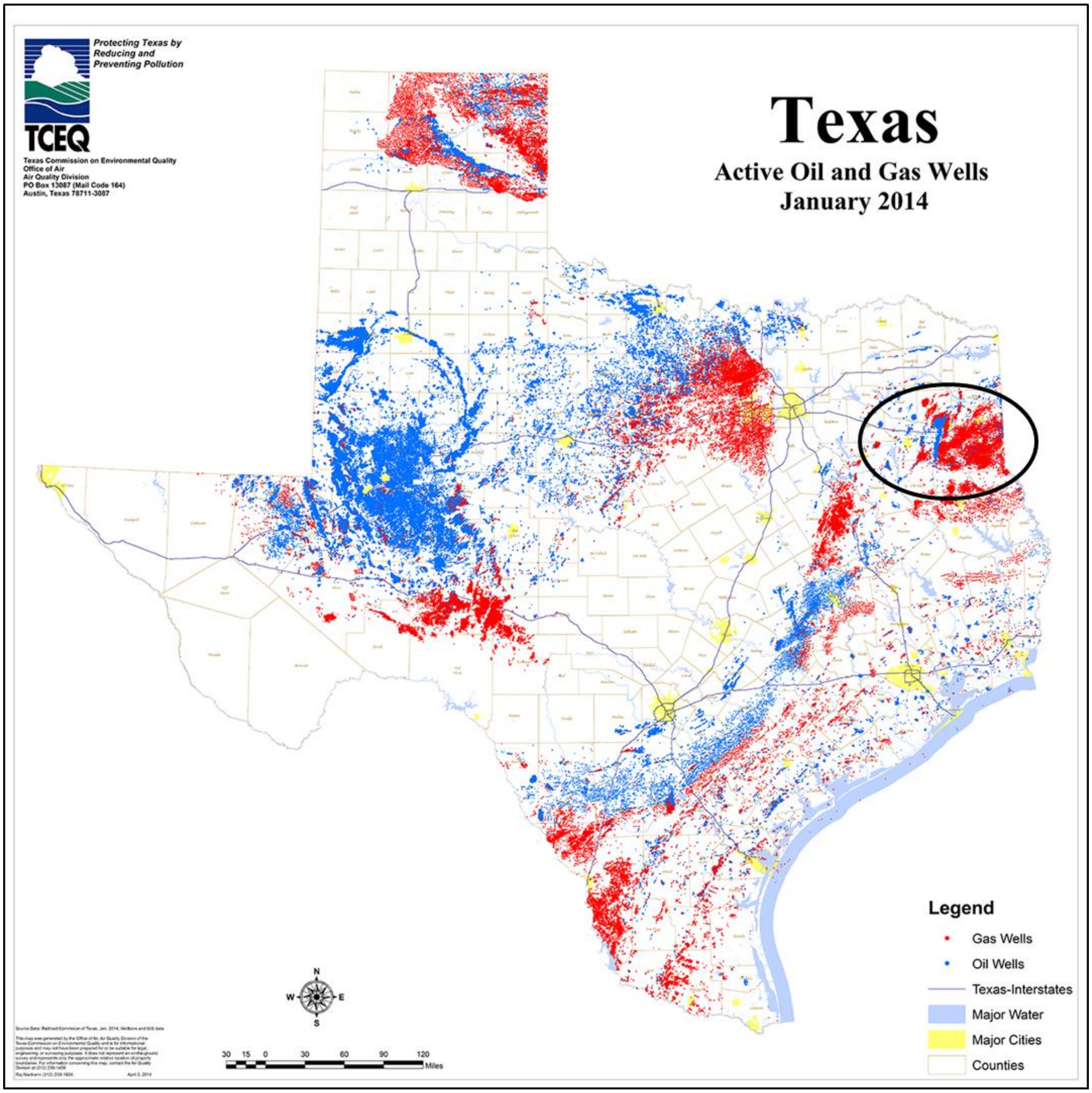


Figure 2-7. Texas oil and gas well locations as of January 2014. TCEQ figure[13]. Black circle indicates the location of the Northeast Texas 5-county area.

Haynesville wells and showed the largest increases in well count and natural gas production of all of the TLM area counties.

[13] http://www.tceq.state.tx.us/assets/public/implementation/barnett_shale/bs_images/txOilGasWells.png

After 2009, drilling slowed due to the economic recession and low natural gas prices. TLM area natural gas production reached its peak in 2008 and then declined through 2012 as the rate of drilling of new wells slowed and production from existing wells declined. Although the number of active wells decreased slightly from 2012 through 2014, gas production increased during this period. While counts of active oil and gas wells have been relatively constant or declined slightly since 2009, factors such as an increase in natural gas price and/or development of liquefied natural gas export facilities have the potential to lead to increase natural gas well development, especially in the Haynesville Shale natural gas formation. Recent reports suggest that liquefied natural gas facilities may be developed in close proximity to the Haynesville Shale which would provide increased demand for Haynesville Shale natural gas. As of July 2015, the FERC had approved eight LNG export terminals, five which are in the Gulf Coast area (Grant et al., 2015). The Haynesville Shale, for many of these LNG facilities, is the closest shale play; however, the natural gas to be provided to these facilities is not expected to be exclusively from the Haynesville Shale. Demand for shale gas from the petrochemical industry may also affect Haynesville production in the future. For example, the South African Fuels Corporation, Sasol, intends to build an ethene cracker and derivatives complex in Lake Charles, Louisiana to take advantage of low cost shale gas[14].

For the period from 2006 to 2012, there was a net decrease in TLM area crude oil production, condensate production, gas production, and oil well counts (gas well counts increase over the 2006 to 2012 period). Given the decreases in all oil and gas activity metrics (excepting gas well counts), a reduction in oil and gas emissions over this period is generally expected; a notable potential exception to this trend is compressor engine emissions, for which activity is dependent on both the amount of gas produced and the field pressure associated with the produced gas.

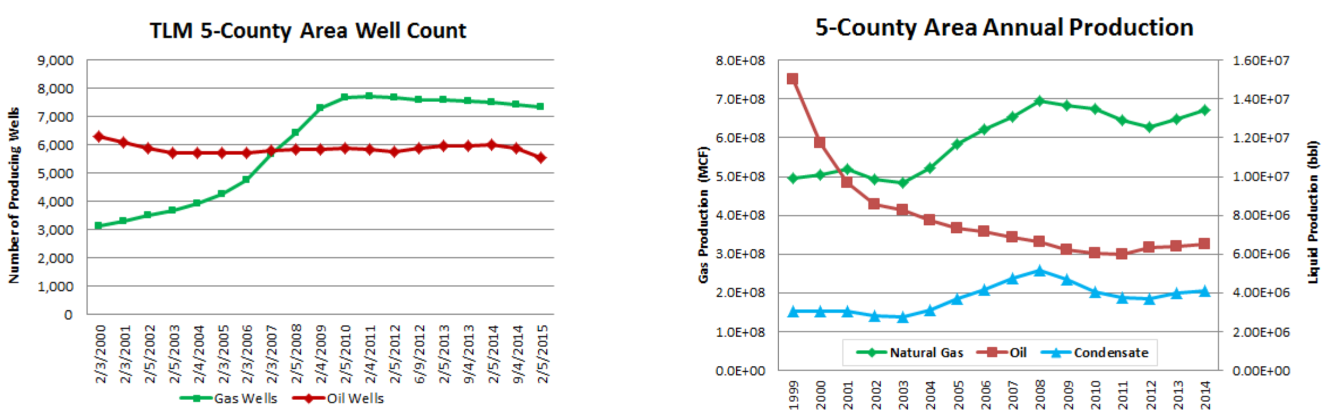


Figure 2-8. 2000-2015 oil and gas well counts (left) and 2000-2014 oil and gas production totals (right) for the TLM area.

[14] "Sasol green-lights big Louisiana chemicals project". Chemical and Engineering News. November 3, 2014.

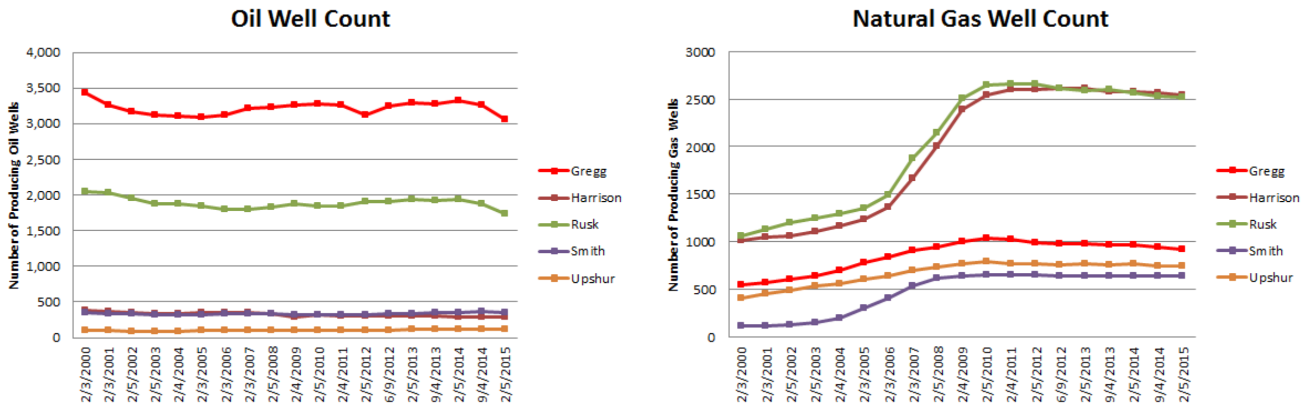


Figure 2-9. 2000-2015 well count for each County in the TLM Area for oil wells (left) and natural gas wells (right).

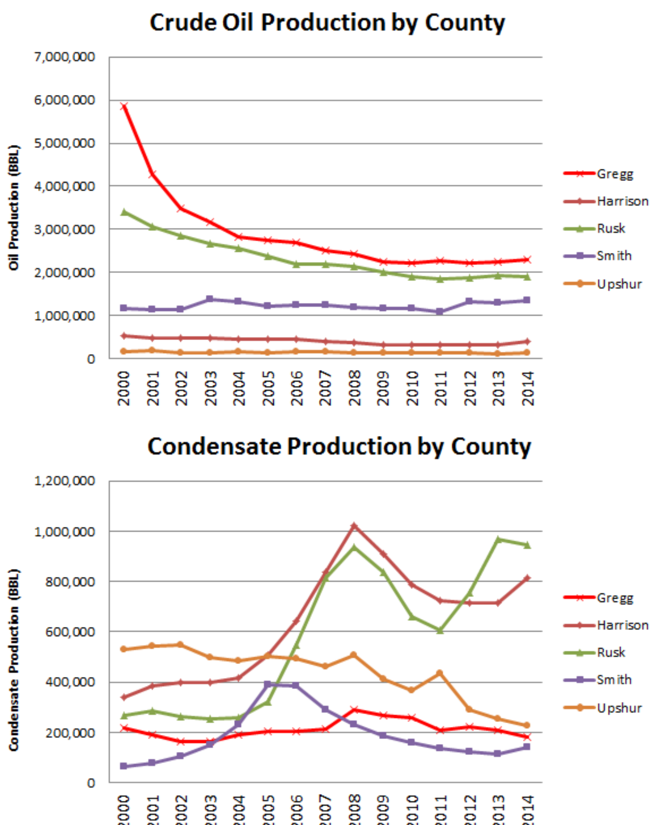


Figure 2-10. Crude oil production for 2000-2014 liquid hydrocarbon production for each County in the TLM Area for crude oil (left) and condensate (right).

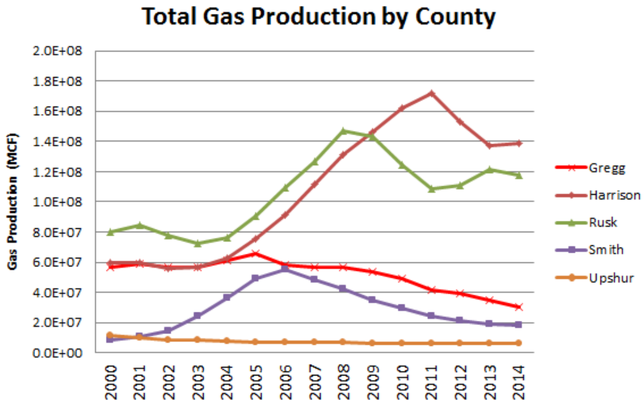


Figure 2-11. Total gas production for 2000-2014 in the TLM Area.

The breakdown by source category for the TLM area 2012 oil and gas emissions is shown in Figure 2-12 and Figure 2-13. The TLM area oil and gas NOx emission inventory is dominated by a single emissions source category. Figure 2-12 shows the contribution from gas compressor engines to the 2012 TLM area NOx emission inventory (18 tpd). Gas compressor engines are used to extract natural gas from a well when reservoir pressures alone are insufficient to bring the gas to the surface. Compressor engines are also used to transmit natural gas along pipelines from the well to gas processing plants and then to consumers. In a mature gas field, such as those found in Northeast Texas, the need for compression to produce the gas increases over time as the subsurface gas reservoir is drained and reservoir pressures drop.

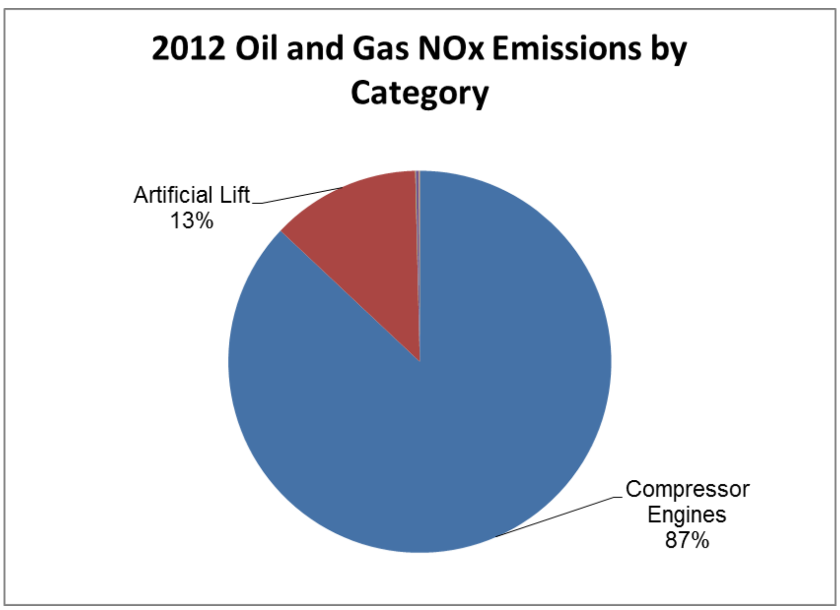


Figure 2-12. TLM 2012 oil and gas source NOx emissions by source category.

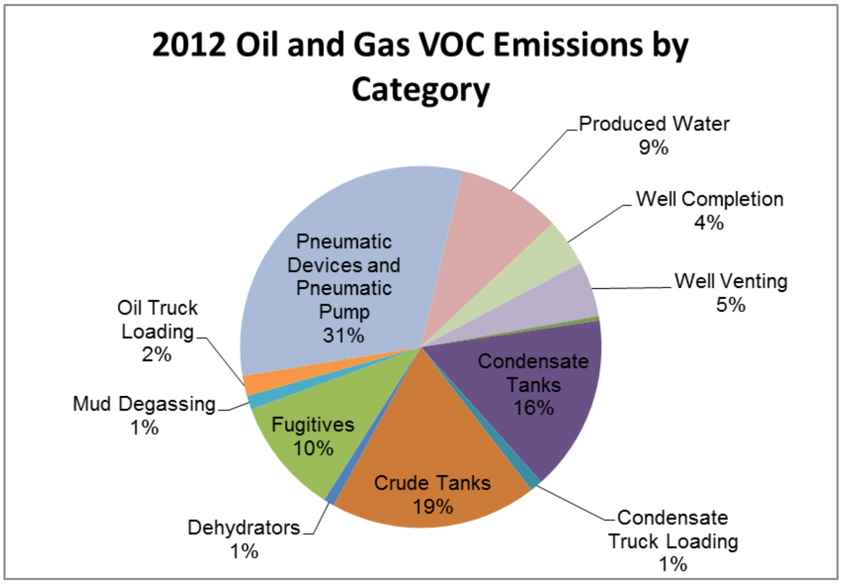


Figure 2-13. TLM 2012 oil and gas source VOC emissions by source category.

The magnitude and distribution of compressor engine emissions influence ozone formation, and accurate characterization of these emissions is important to the success of ozone modeling of Northeast Texas. At the request of NETAC, Pollution Solutions compiled an inventory of ozone precursor emissions from gas compressor engines in the 5-county area of Northeast Texas for the year 2005 (Pollution Solutions, 2006). Pollution Solutions based county-level compressor engine emissions on the county well count and emission factors derived from survey data. The gas compressor engine inventory was checked against the TCEQ point source inventory to avoid double counting emissions, as large engines are already accounted for in the point source inventory. In 2005, gas compressor engines contributed approximately 33 tons of NOx per day in the 5-county area (Pollution Solutions, 2008). The Pollution Solutions study estimated that 94% of the NOx emitted by gas compressor engines in the 5-county area was generated by small gas compressor engines used for wellhead compression (Pollution Solutions (2006); these engines have emissions lower than the threshold for inclusion in point source emission inventories developed by the Texas Commission of Environmental Quality (TCEQ). While an individual wellhead gas compressor engine may have emissions that are too low to trigger emissions control requirements, the total 2012 NOx emission contribution from all gas compressor engines in the 5-county area taken together is of the same order of magnitude as a power plant.

In March, 2010, a Texas emissions reduction measure known as the East Texas Combustion Rule went into effect. The East Texas Combustion Rule requires owners and operators of stationary, rich-burn gas-fired, reciprocating internal combustion engines greater than or equal to 240 HP in 33 East Texas counties (including all five NETAC Counties) to meet NOx emission limits and follow specified reporting requirements. The fraction of engines in the 5-county area that have horsepower < 240 HP and are therefore not required to comply with the East Texas Combustion Rule is not known. A recent NETAC study (Alvarez et al., 2013) reviewed engine test reports made to the TCEQ's Tyler Office and found that the number of owners/operators of engines of

≥240 HP reporting to TCEQ in 2011 under the East Texas Combustion Rule is smaller than expected based on survey data from the Pollutions Solutions Study and more recent TCEQ data from the Barnett Shale. This could be associated with a shift in the TLM area engine population towards lower horsepower (< 240 HP) or to lean burn engines.

The TCEQ has gathered data on engine distribution for other areas of Texas. The TCEQ Special Inventory for the Barnett Shale collected survey data from oil and gas upstream and midstream facilities in order to determine the location, number, and type of emissions sources associated with oil and gas operations in the Barnett Shale formation during 2009. The TCEQ inventory surveys gathered equipment counts for stationary gas fired engines in selected horsepower range bins (0 to 50 HP, 50 to 240 HP and over 240 HP) and by engine type (rich burn versus lean burn). The results of the study show that in the Barnett Shale region as a whole and in Hill County, the majority (about 80 percent of the population) of the gas compressor engines are <240 HP in size. It also shows the majority of the engines in the <240 HP range are rich burn type engines (about 95 percent).

There is no survey data available to determine what fraction of engines with horsepower<240 HP in Northeast Texas are currently uncontrolled, but the Barnett Shale survey data suggests that there may be a significant number of gas compressor engines in the 5-county area that could be considered for low-cost, voluntary NOx emission controls implemented at the local level. In 2005, NETAC implemented a pilot project to demonstrate the effectiveness of retrofitting small (< 500 hp), spark-ignited, rich-burn compressor engines used in natural gas production with exhaust catalysts and electronic air/fuel ratio controllers (Friesen and Yarwood, 2007). At the end of a year-long test period, these controls were achieving an estimated emission reduction efficiency of greater than 90%, or 0.1 ton/day NOx per engine at a cost effectiveness of less than $200 per ton of NOx reduced.

Emissions sensitivity tests with NETAC's ozone models show that retrofit of compressor engines with catalysts to control NOx emissions can produce ozone reductions in the 5-county area (Kemball-Cook et al., 2010c). Improving our understanding of the TLM compressor engine emission inventory based on local data on compressor engine population, horsepower, and emission factors as a high priority based on the magnitude of NOx emissions from this source category, the uncertainty in the underlying engine data and the cost-effectiveness of potential NOx emission reductions from compressor engines.

2.1.3.2 The Haynesville Shale

The Haynesville Shale is located approximately 10,000-13,000 feet beneath Northeast Texas and Northwest Louisiana (Figure 2-14) and contains very large recoverable reserves of natural gas (EIA, 2011). Intensive exploration of the Haynesville began in 2008, and as of December 2012, there were nearly 3,000 wells producing natural gas from this formation. As of December, 2014, the number of producing wells had grown to more than 3,600. The development of natural gas resources in the Haynesville has been economically important, but also generates significant emissions of ozone precursors within the 5-county area as well as in a region of Louisiana that is often upwind of the TLM area ozone monitors on high ozone days.

During 2009, NETAC developed an emission inventory of ozone precursors for projected future Haynesville Shale development from 2009 through 2020 (Grant et al., 2009). Using well production data from state regulatory agencies and a review of the available literature, projections of future year Haynesville Shale natural gas production were derived for 2009-2020 for three scenarios corresponding to limited, moderate, and aggressive development. These production estimates were then used to develop an emission inventory for each of the three scenarios. The emission inventory covered 5 Texas counties and 6 Louisiana parishes. NETAC's photochemical modeling of the year 2012 using this emission inventory showed that 8-hour ozone impacts occurred within Northeast Texas and Northwest Louisiana as a result of development in the Haynesville Shale, with projected ozone design value increases ranging from 1-5 ppb at Northeast Texas ozone monitors for the aggressive development scenario. Modeled ozone increases due to Haynesville Shale emissions also affected regions outside Northeast Texas and Northwest Louisiana due to ozone transport (Kemball-Cook et al., 2010).

2009 and 2010 were years of rapid development in the Haynesville. In March 2010, there were over 160 rigs drilling in the Haynesville (Figure 2-15); this far exceeded even the aggressive

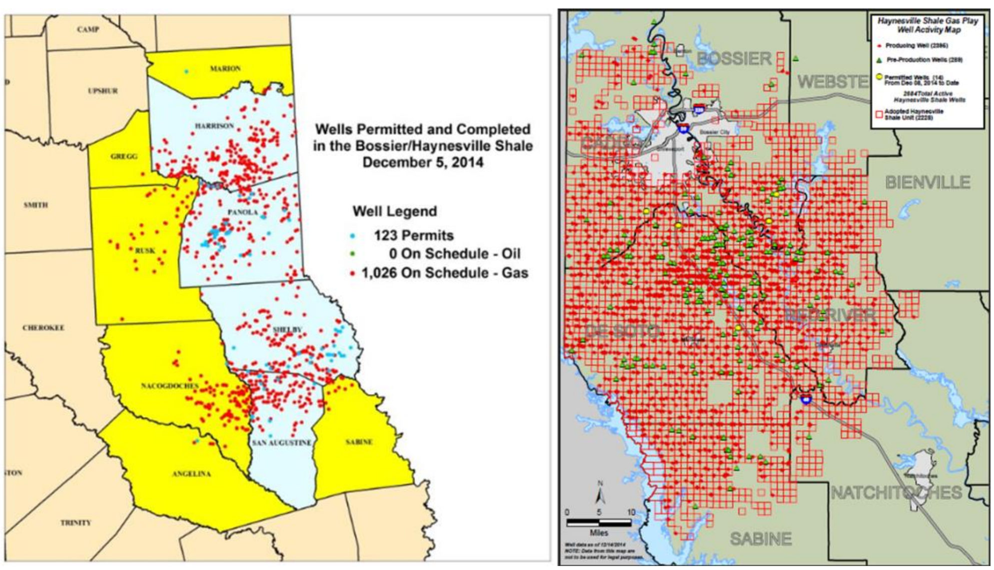


Figure 2-14. Left panel: Spatial extent of the Haynesville Shale in Texas by county and well locations as of December 2014. Figure from the Railroad Commission of Texas web site[15]. Pale blue shading indicates that the TRRC considers that county to be a core Haynesville County. Yellow shading indicates that the TRRC considers that county to be a non-core Haynesville County. Right panel: Extent of the Haynesville Shale in Louisiana as of December 2014[16].

[15] http://www.rrc.state.tx.us/oil-gas/major-oil-gas-formations/haynesvillebossier-shale/

[16] http://dnr.louisiana.gov/assets/OC/haynesville_shale/haynesville.pdf

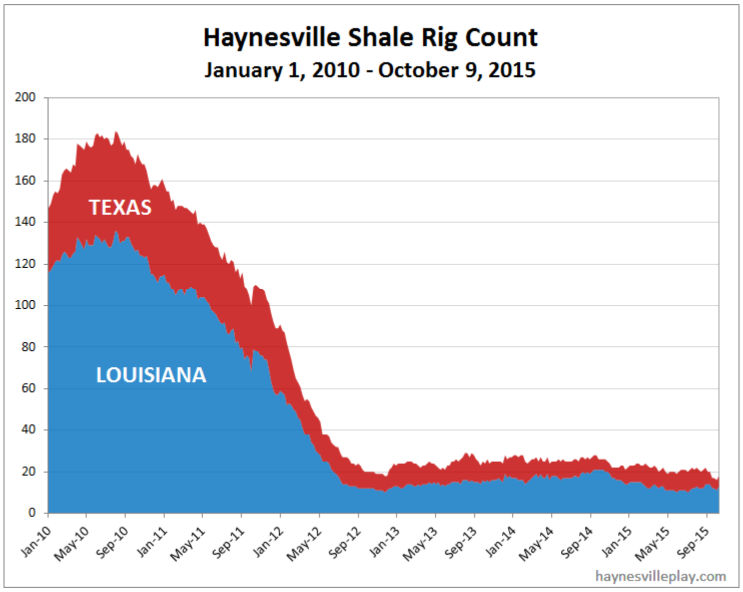


Figure 2-15. Count of drill rigs active in the Haynesville Shale from January 2010-October 2015[17].

scenario prediction of the Grant et al. (2009) study. Figure 2-16 shows historical drilling activity in the five NETAC counties together with Panola County, which is adjacent to the TLM area and has intensive natural gas production activity. Drilling activity for gas wells saw a sharp increase both for conventional gas wells and Haynesville Shale wells during 2010. The resulting increases in active well count are shown in Figure 2-17. Between 2010 and 2014, the pace of development slowed due to low natural gas prices and high oil-to-gas price ratio, which encouraged development of formations that contain hydrocarbon liquids, such as the Eagle Ford Shale. Although active conventional gas wells in the TLM area have far outnumbered Haynesville Shale wells (by an average ratio of 15:1 during 2012-2014, the productivity of Haynesville Shale Texas wells is very high such that they contributed 20-30% of the overall gas production in the 6-county area during 2012-2014 (Figure 2-18). Despite the slower rate of drilling in recent years, production from the Haynesville has risen during each year from 2009-2014.

[17] http://haynesvilleplay.com/HV-runningrigcountchart%28large%29.png, accessed October, 2015

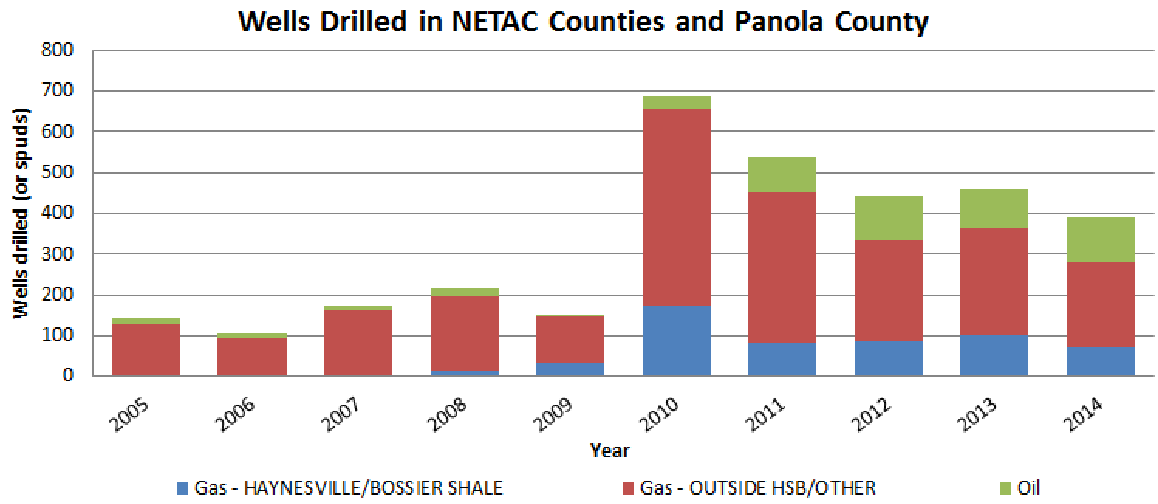


Figure 2-16. Count of wells drilled by well type for NETAC 5-county area and Panola (data source: TRRC, 2015).

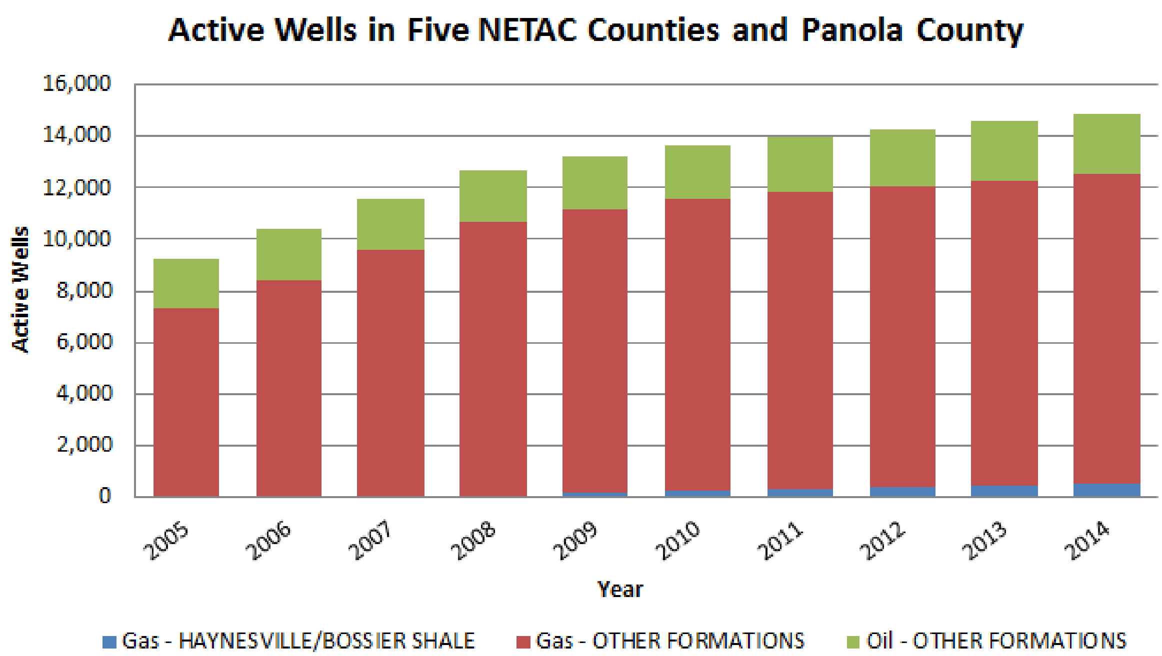


Figure 2-17. Count of active wells by well type for NETAC 5-county area and Panola (data source: TRRC, 2015).

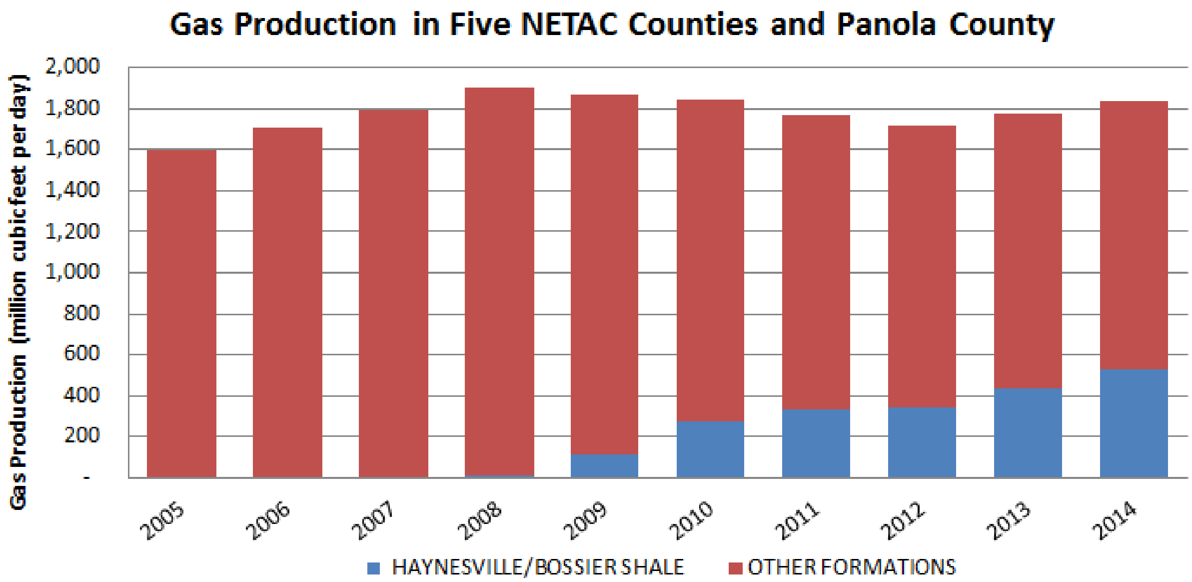


Figure 2-18. Natural gas historical production for the 6-County Area from Haynesville Shale wells and other formations (data source: TRRC, 2015).

In 2013, NETAC revised its Haynesville emission inventory and future year projections to reflect the changes in the rate of development and to incorporate information gathered from Haynesville operators concerning their operating practices (Parikh et al., 2013). NETAC also developed the first emission inventory for Haynesville Shale mobile sources, including truck traffic (DenBleyker et al. 2013), which showed that mobile sources comprised 12% (4 tpd) of the total Hayneville emission inventory in 2012 (Figure 2-19).

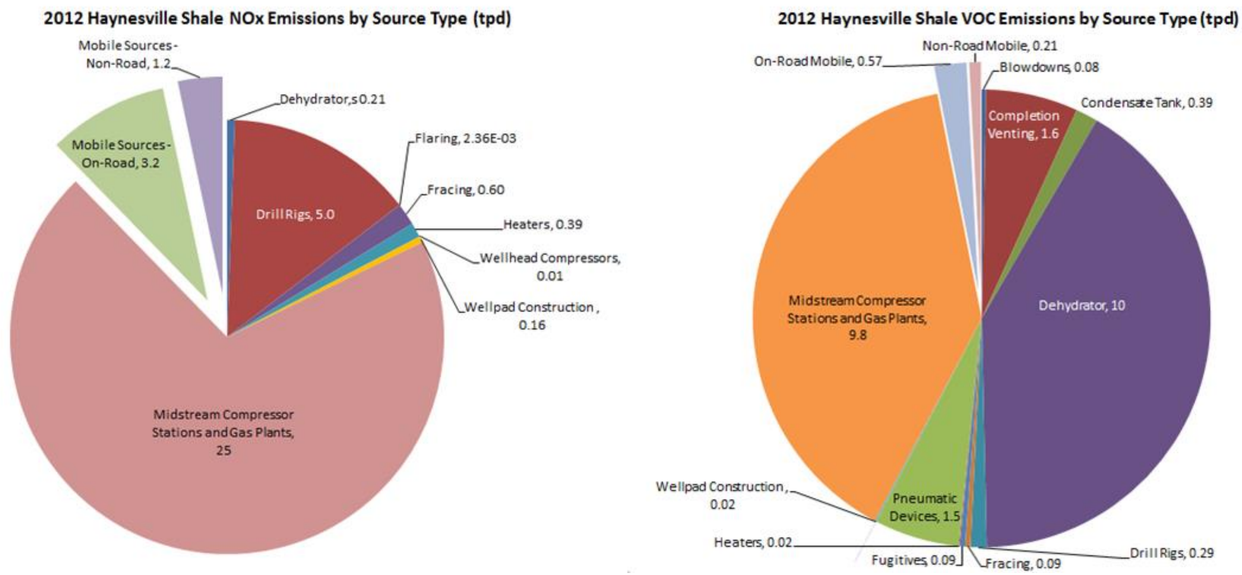


Figure 2-19. 2012 moderate development scenario Haynesville Shale formation NOx and VOC emissions by source category. Mobile source emission inventory is broken out from rest of inventory (protruding sections).

In 2015, NETAC made forecasts of future oil and gas activity for the Haynesville Shale and for conventional oil and gas wells in the 5-county area and adjacent Panola County for the period 2013-2021 (Grant et al., 2015). The forecasts were based on well production data from state regulatory agencies and a review of available literature. The forecasts were developed for three scenarios: (1) a moderate (medium) growth scenario; (2) a low growth scenario; and (3) an aggressive (high) development scenario. These scenarios were developed to cover a range of possible future levels of gas exploration and production activity.

From 2016 to 2021, NOx emissions are predicted to increase with larger emission increases in later years for the moderate (best estimate) scenario (Figure 2-20). Gas production increases in the future are estimated based on projected increases in Haynesville Shale gas production to meet demand from Federal Energy Regulatory Commission (FERC) approved LNG export facilities in the Gulf Coast area. The overall future year NOx emission trend in Figure 2-20 is driven by the Other Haynesville emission trend, while NOx emissions from 6-County area Haynesville and conventional emission sources are forecast to remain relatively constant with time.

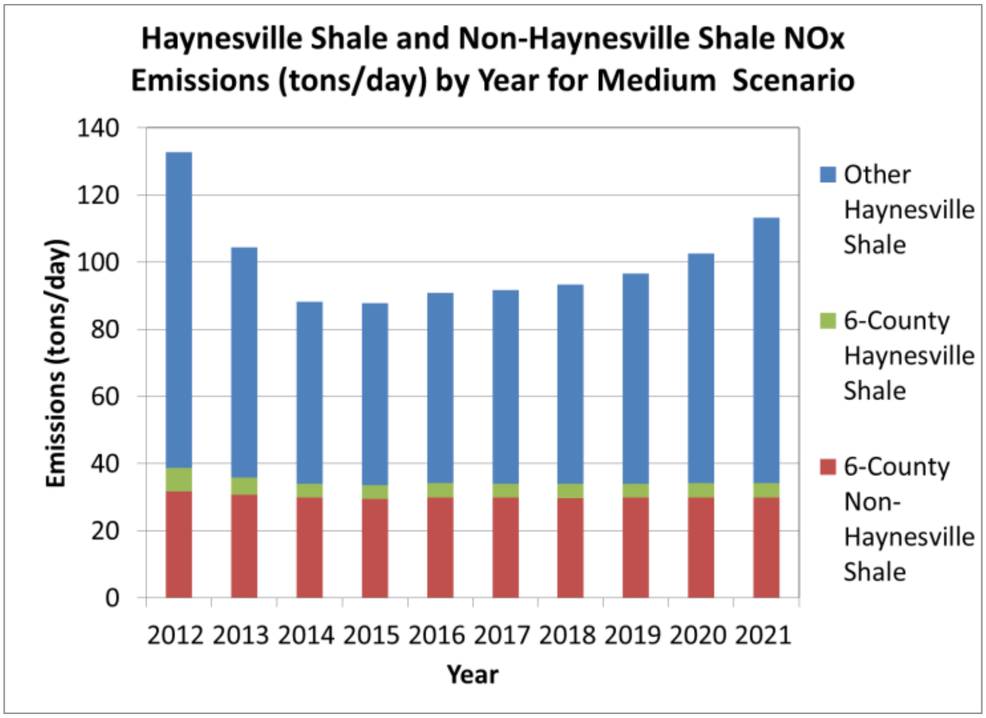


Figure 2-20. Historical and projected NOx emissions for Haynesville and conventional (non-Haynesville) production in the 6-county area defined as the 5-county TLM area and Panola County. The "other Haynesville" category represents NOx emissions from Haynesville sources outside the 6-county area.

The low growth scenario forecasts a gradual decline in Haynesville and conventional emissions, while the high development scenario predicts strong growth in Other Haynesville NOx emissions and relatively constant NOx emissions for 6-county area conventional and Haynesville sources.

Compared to the Haynesville Shale inventory developed in the previous Parikh et al. (2013) study, projected future year Haynesville Shale NOx emissions in the Grant et al. (2015) study have increased substantially. In the Parikh et al. (2013) inventory, it was assumed based on Haynesville operator surveys that less than 1% of Haynesville Shale well sites had compressor engines; whereas the current inventory uses TCEQ's compressor engine emission estimation methodology which results in much higher NOx emissions. These differences highlight the importance of reducing uncertainty in the compressor engine emission inventory for Northeast Texas.

As of April 2016, there are 12 rigs active in the Haynesville[18]. Given the large number of active, producing wells and ongoing development, the Haynesville Shale continues to be an emissions source that must be evaluated and accurately represented in NETAC's ozone modeling. While

[18] http://phx.corporate-ir.net/phoenix.zhtml?c=79687&p=irol-rigcountsoverview

accurate characterization of Haynesville emissions remains a high priority for NETAC, the Haynesville Shale makes up a relatively small fraction of the total 5-county area natural gas production (Figure 2-18), although this fraction increased steadily from 2009 to 2014.

NETAC's recent emission inventory and ozone modeling efforts (Parikh et al. 2013; Grant et al. 2015; Kemball-Cook et al. 2014) show that, despite the decline in oil and gas activity in recent years, conventional and shale production continue to play an important role in air quality and ozone design values in Northeast Texas.

2.1.4 Emissions Trend Analysis

In this section, we provide an overview of recent trends in ozone precursor emissions in the 5-county area. We then focus on trends in activity and emissions for two source categories that make important contributions to the 5-county area's NOx emissions inventory: on-road mobile sources and electric generating units (EGUs). We compare 2006 and 2012 ozone precursor emissions from two emission inventories developed by the TCEQ. The most recent emission inventory review (Grant et al., 2014) and conceptual model update (Parker et al., 2015) included a review of the 2012 and 2006 emission inventories for the NETAC 5-county area developed by the TCEQ for photochemical modeling by the Texas Near Non-attainment Areas.

Anthropogenic emissions for the 5-county area of Northeast Texas were extracted from the 2006 and 2012 state-wide inventories and compared. Both inventories compared here are composed of emissions from equivalent sectors: oil and gas area sources, non-oil and gas area sources, mobile off-road sources, mobile on-road sources and point source emissions. Figure 2-21 shows a side-by-side view of NOx emissions by sector in the 5-county area for a typical summer weekday during 2006 and 2012. Of all sectors, point sources are the largest contributor to NOx emissions in both years, with 85 tpd in 2006 and 65 tpd in 2012. EGUs make the largest contribution to the point source NOx emission inventory in both years.

Total anthropogenic NOx emissions for the 5-county area show a decline in 2012 relative to 2006, dropping from a total of 208 tpd to 132 tpd of NOx. This decrease is attributed to lower 2012 emissions from the point source sector (20 tpd decrease), oil and gas sources (17 tpd decrease), on-road motor vehicle emissions (23 tpd decrease) and area sources (12 tpd decrease). The majority of NOx area source emissions in the reviewed inventories are attributed to industrial, commercial and residential boilers. As a part of the Dallas–Fort Worth State Implementation Plan (SIP) Revision for 1997 Eight-Hour Ozone Standard, various rulemakings aimed at controlling combustion-related NOx emissions have become effective since 2007, such as the East Texas Combustion Rule, the Utility Electric Generation in East Texas and Central Texas Rule, and the Water Heaters, Small Boilers and Process Heaters Rule (all under Title 30) (TCEQ, 2013). It is likely that these regional-scale NOx controls contributed to the change in 5-county area NOx emissions from 2006 through 2012 for internal and external combustion sources in the oil and gas, area and point source sectors; however, further analysis of the 2012 emissions inventory is necessary to precisely determine the effect of these controls on regional NOx emissions.

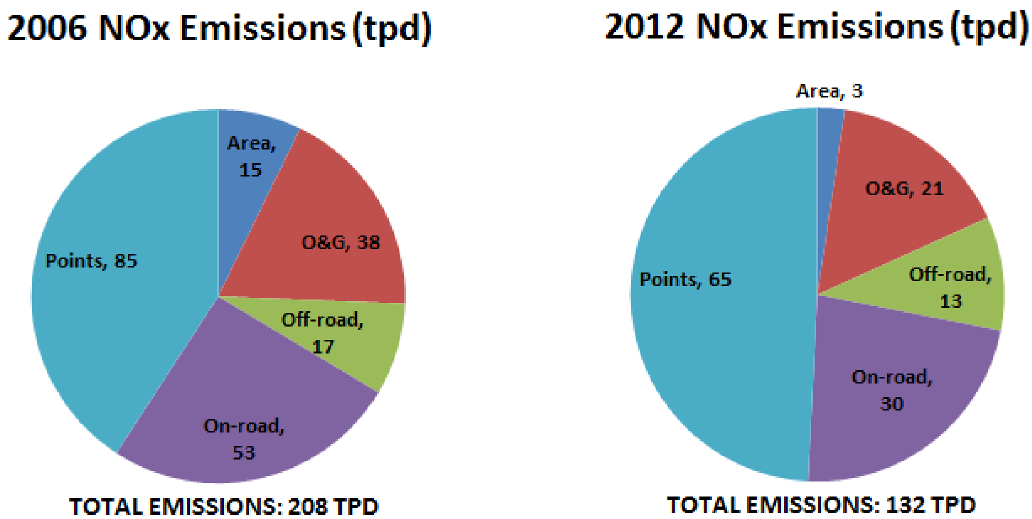


Figure 2-21. Typical summer weekday anthropogenic NOx emissions by sector for 5-county area in Northeast Texas. Comparison between 2006 (left) and 2012 (right) anthropogenic emissions). Oil and gas emissions in 2012 plot are for 2011, as 2012 emissions had not yet been developed at time of report.

While NOx emissions show a significant decrease from 2006 to 2012, the percentage contribution of each source category to the total NOx emission inventory did not change dramatically. Point sources made up 41% of the NOx emission inventory in 2006 and 48% in 2012. On-road mobile sources went from 26% of the inventory in 2006 to 22% in 2012, while off-road sources went from 8% in 2006 to 10% in 2012. Oil and gas area sources were 18% of the total NOx emissions in both 2006 and 2012 and non-oil and gas area sources went from 7% of the inventory in 2006 to 2% in 2012.

A significant decrease in on-road mobile NOx of 23 tpd is also apparent in Figure 2-21; this decrease could be due to fleet turnover to cleaner vehicle engines and/or related to a decrease in driving activity over the six-year period. Figure 2-22 shows summer weekday vehicle miles travelled (VMT) in 2006 and 2012 for Northeast Texas counties; these data were extracted from the TCEQ state-wide mobile source inventories for both years. The majority of Northeast Texas counties experienced a relatively small growth in total VMT between 2006 and 2012, with increases in VMT ranging from 3 to 9% over the six year span.

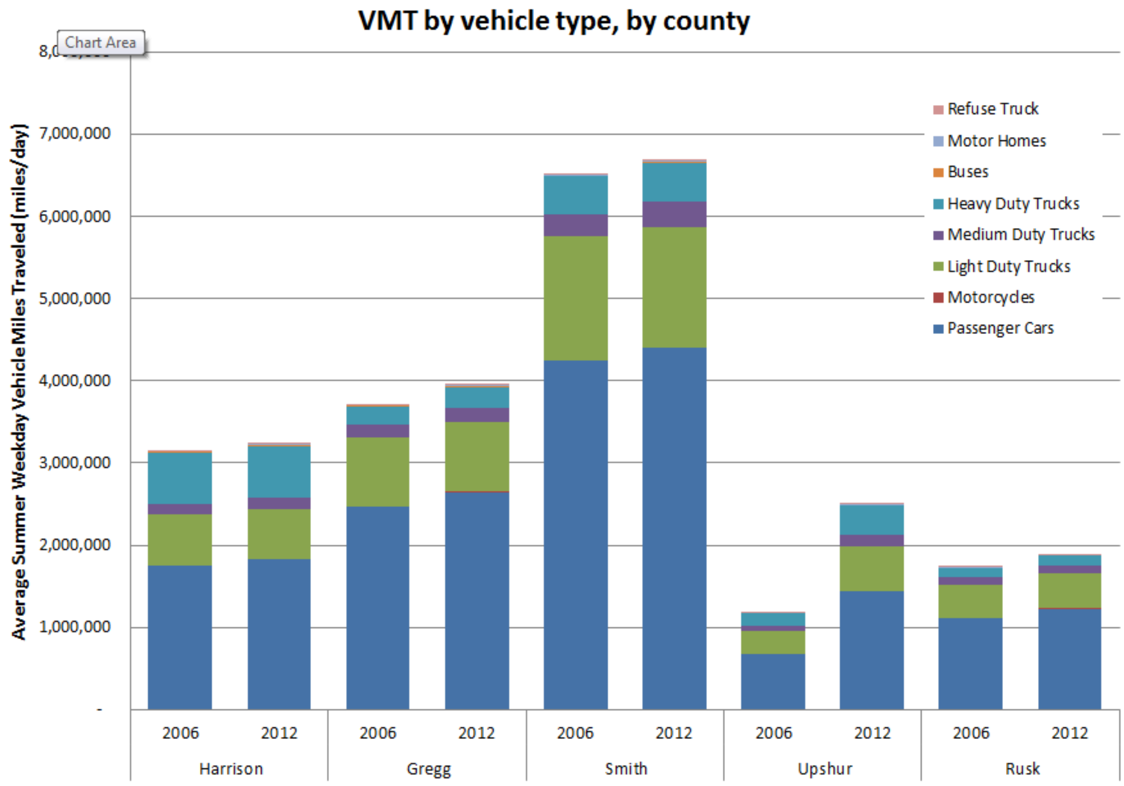


Figure 2-22. Summer Weekday Vehicle Miles of Travel for 2006 and 2012 in NETAC counties.

Overall, the total VMT for the 5-county area increased by 12%. This is broadly consistent with increases in population, shown in Table 2-5. The exception is Upshur County, where VMT changed by 112% between 2006 and 2012. The reason behind the VMT increase for Upshur County is unknown and requires further investigation.

Table 2-5. Population changes in the 5-county area between 2006 and 2012[19].

County	2006	2012	% Change
Gregg	117,743	123,376	5%
Smith	194,792	212,107	9%
Harrison	63,715	66,333	4%
Rusk	48,093	53,685	12%
Upshur	37,379	39,518	6%

The majority of the VMT in the 5-county area is attributed to passenger cars and accounts for about 60% of the total VMT while light/heavy duty trucks make up about 30% of the total. VMT growth between 2006 and 2012 for major vehicle groups such as passenger cars and light/heavy duty trucks was 13% and 9%, respectively, which is similar to the overall change in

[19] http://www.dshs.state.tx.us/chs/popdat/st2006.shtm and http://www.dshs.state.tx.us/chs/popdat/ST2012.shtm.

total VMT across the region, +12%. This small increase in overall VMT within the 5-county confirms that the decrease in NOx emissions from on-road sources from 2006 to 2012 is related to fleet turnover introducing cleaner vehicles rather than changes in driving patterns within the region. This trend is expected to continue into the future, although near-term emission declines may not be as a dramatic as those seen in the last decade (Vijayaraghavan et al., 2012).

Total anthropogenic VOC emissions for 2006 for the 5-county area were 271 tpd, whereas the 2012 inventory shows a 50 percent decrease in VOC emissions to 133 tpd (Figure 2-23). For both 2006 and 2012 inventories, the majority of anthropogenic VOC emissions are attributed to oil and gas sources, a sector for which VOC emissions changed significantly from 2006 to 2012 with a 60 percent decrease. This large decrease in oil and gas VOCs is consistent with decreases in production from 2006 to 2012. Other anthropogenic sources of VOC, including area sources, point sources and mobile sources (off-road and on-road) have remained at relatively similar levels from 2006 through 2012. It should be noted that the total VOC emission inventory is dominated by biogenic emissions (not shown here), which constituted more than 75 percent of the 5-county area VOC inventory in 2006 and 2012, making biogenic sources by far the source category with the largest VOC emissions.

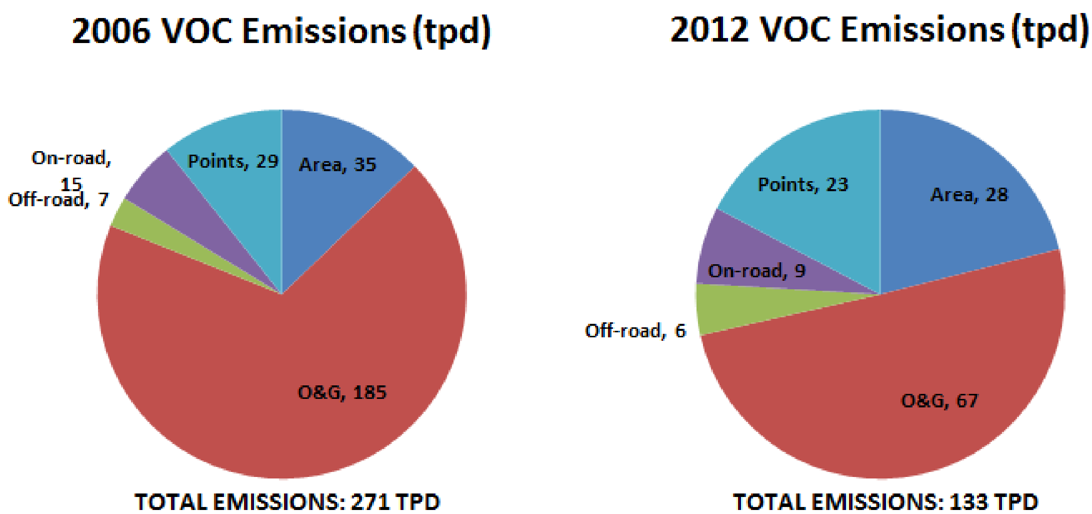


Figure 2-23. Typical summer anthropogenic weekday VOC emissions by sector for 5-county area in Northeast Texas. Comparison between 2006 (left) and 2012 (right) anthropogenic emissions. Oil and gas emissions in 2012 plot are for 2011, as 2012 emissions had not yet been developed at time of report.

Emission inventories for 2006, 2008, and 2010 as compiled in Grant et al. (2013; 2014) were compared to 2012 point source emissions to analyze recent trends in TLM area point source emissions. Figure 2-24 shows TLM point source emissions totals for NOx, VOC, and CO for the years 2006, 2008, 2010, and 2012. Point source NOx emissions decreased from 2006 to 2008, from 2008 to 2010, and again from 2010 to 2012. County-level VOC emissions (not shown) also show decreasing trends across all years for all TLM counties from 2006 to 2010 and from 2010 to 2012; VOC emissions increased from 2010 to 2012 as a results of VOC emission increases across all TLM area counties possibly as a result of economic recovery from the 2008 recession.

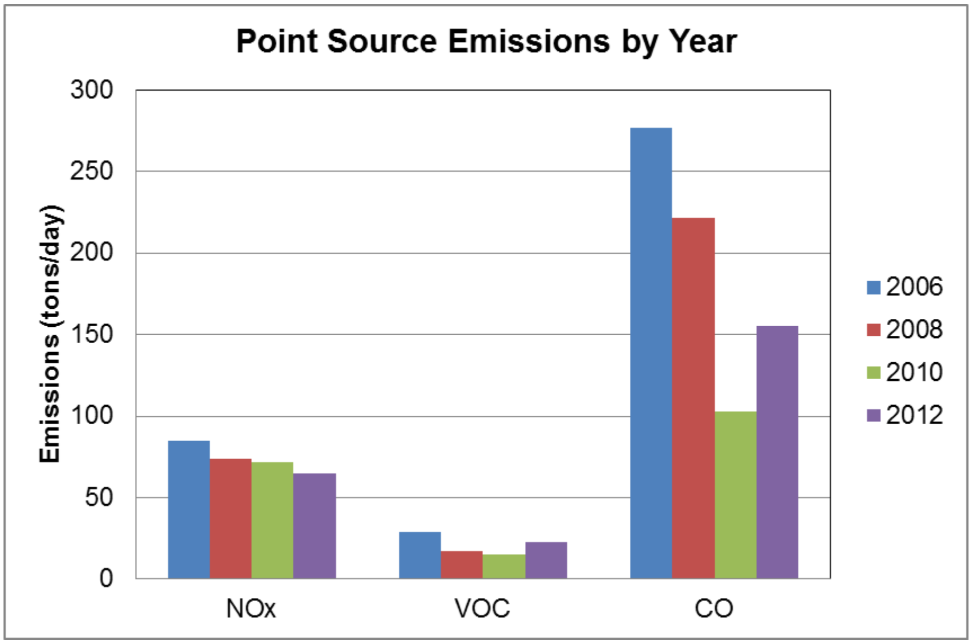


Figure 2-24. TLM area total ozone season day point source emissions for 2006, 2008, 2010 and 2012.

Table 2-6 shows the 2006, 2008, 2010, and 2012 emissions of NOx by facility for the TLM point sources with the largest NOx emissions. The largest changes in NOx emissions from 2006 to 2010 are a 5 tpd decrease at the Martin Lake Electrical Station, a 2.7 tpd decrease at the AEP Pirkey Power Plant and a 2.1 tpd decrease at the Texas Operations (Eastman Chemical Company). The most significant change in NOx emissions from 2010 to 2012 is a 10.7 tpd reduction in NOx emissions from the Martin Lake Electric Station. The inventory data available for this analysis does not allow us to determine the cause of emissions decrease at the Martin Lake Electrical Station from 2010 to 2012, but based on our knowledge of recent operations at this facility, we suspect that any reduction at this facility is likely due to lower activity rather than increased emissions control. We also note that reports[20] indicate that Luminant Energy decreased electricity production at the Martin Lake Electrical Station in 2013 during the winter months by idling one of three units. This unit was brought back online in early 2014[21].

[20] http://www.bizjournals.com/dallas/news/2013/09/18/luminant-will-shut-down-martin-lake.html?page=all, http://www.news-journal.com/panola/news/martin-lake-plant-cutting-output-by-a-third/article_044c0dbc-7f37-5846-b4ad-10ec79abf3c7.html

[21] http://www.dallasnews.com/business/energy/20140204-luminant-to-reopen-3-coal-plants-early.ece

Table 2-6. 2006, 2008, 2010 and 2012 NOx ozone season day point source emissions by year by facility.

County	Facility	SIC	NOx Emissions (tons per ozone season day)			
			2006	2008	2010	2012
Rusk	Martin Lake Electrical Station	4911	49.0	43.3	44.0	33.3
Harrison	Pirkey Power Plant	4911	13.0	11.8	10.3	11.0
Harrison	Texas Operations (Eastman Chemical Company)	2869	4.9	3.6	2.8	4.0
Smith	Delek Tyler Refinery	2911	2.3	1.3	1.3	2.2
Gregg	Longview Gas Plant	1321	1.8	1.9	2.1	1.9
Harrison	Westlake Longview	2821	1.7	1.5	1.3	1.4
Harrison	Marshall Plant	2819	1.6	1.4	1.6	1.5
Rusk	Electric Power Generation (Tenaska Gateway Partners)	4911	1.5	1.0	0.9	1.4
Gregg	Knox Lee Power Plant	4911	1.3	0.8	1.0	2.3
Harrison	Eastman Cogeneration Facility	4931	0.9	0.8	0.8	0.9
Harrison	Waskom Gas Plant	1321	0.6	0.4	0.3	0.3
Harrison	Stateline Compressor Station	4922	0.5	0.8	0.9	1.0
Gregg	Longview 1 Comp Station	4922	0.5	0.1	0.1	0.0
Harrison	Gas Blocker Compressor Station	4922	0.3	0.4	0.3	0.2
Smith	Perry Common Point Compressor Station	1311	0.3	0.1	0.1	0.1
Harrison	Harrison County Power Project	4911	0.2	0.2	0.2	0.2
Rusk	Henderson Gas Plant	1321	0.0	0.2	0.2	0.3
Harrison	Crossroads Gas Plant	1321	0.0	0.1	0.3	0.3
Remaining sources representing approximately <6% of NOx emissions			4.7	4.4	3.4	2.3
Totals			**85.1**	**74.0**	**71.9**	**64.7**

Because of the importance of EGU emissions in the 5-county area, we now focus on trends in Northeast Texas EGU NOx emissions. EGU NOx emissions contribute a large portion of the local 5-county NOx inventory for 2006 and 2012 under the point source category (Grant et al., 2013; 2014 and Table 2-1). NOx emission trends from the largest EGUs within and near the 5-county area over the past 14 years are shown in Figure 2-25 and Figure 2-26. Previous NETAC analyses have shown that emissions from facilities in Titus County (TX), Cherokee County (TX), Marion County (TX) and De Soto Parish (LA) can affect ozone in Northeast Texas (e.g. Alvarez et al., 2006a,b; Kemball-Cook et al., 2006; 2013a). Average summer day emissions shown in Figure 2-25 and Figure 2-26 were obtained from the Acid Rain Program (ARP) through EPA's Clean Air Markets Database (CAMD).

NOx emissions from the Dolet Hills plant in De Soto Parish, LA show a decreasing trend from 2000 through 2014. The Dolet Hills Power Plant in Louisiana had emissions of 39 tpd in 2005, but then implemented NOx controls that reduced NOx emissions to 18 tpd by 2007. Emissions from the Texas EGUs decreased dramatically from 2000 to 2005 and maintained a relatively constant level until 2011, when there was a slight peak for several EGUs, including the H.W. Pirkey and Martin Lake facilities. This increase in EGU emissions was likely related to the Texas heat wave in August 2011 which produced record high peak demands for electricity throughout the state of Texas (EIA, 2011a). Over the past decade, the total NOx emissions from all nearby and local EGUs decreased by 60 tpd, reaching 114 tpd in 2014. Projections of future year EGU emissions are uncertain and will depend upon economic and weather conditions as well as the regulatory environment.

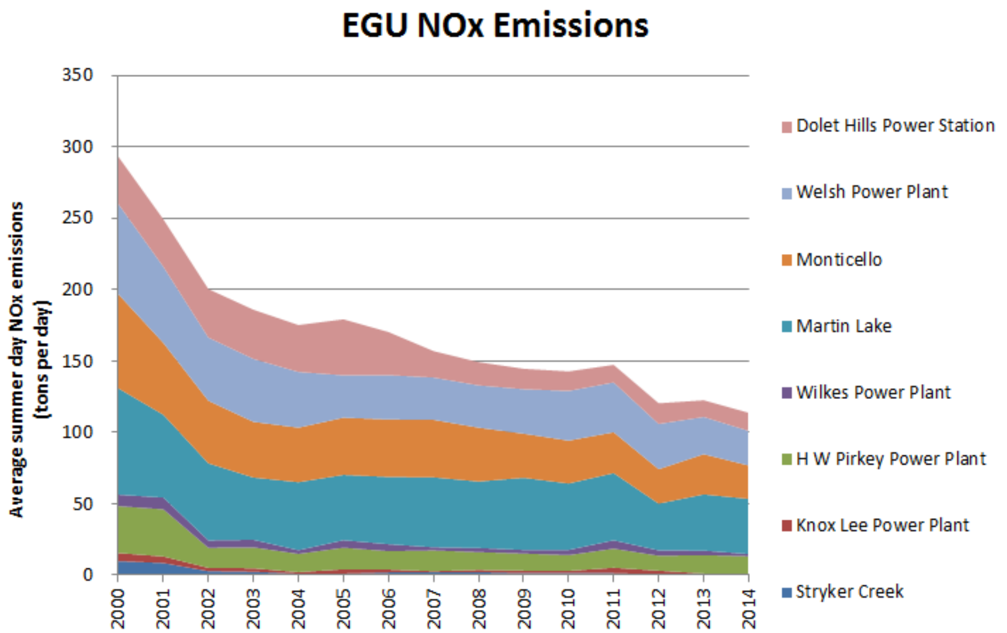


Figure 2-25. Recent trends in Northeast Texas EGU average summer day NOx emissions.

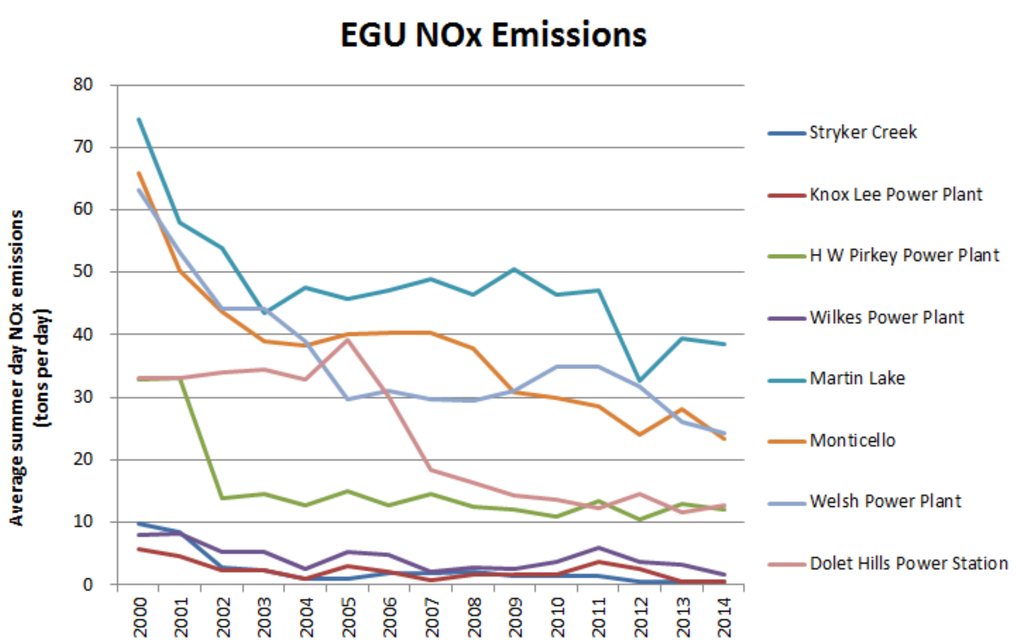


Figure 2-26. EGU NOx emissions by facility for Northeast Texas and nearby counties/parishes.

A reduction in regional EGU emissions occurred in April 2016, when AEP-SWEPCO retired Welsh Unit 2, which is located near Cason, TX, in Titus County (Kelly Spencer; AEP SWEPCO, personal communication, 2013). This unit had NOx emissions of approximately 3,000 tpy in 2012, and the retirement of this unit reduces ozone season NOx emissions that can affect Northeast Texas.

2.2 Meteorology

The Tyler-Longview Marshall (TLM) area is located on the Gulf Coastal Plain, where the lack of major geographic features means that upper level wind patterns are driven primarily by synoptic-scale meteorological influences. Episodes of high surface ozone concentrations in Northeast Texas occur most often between June and September when the area is under the influence of a semi-permanent subtropical high-pressure system, vertical mixing of pollutants in the atmosphere is restricted, skies are clear to partly cloudy, temperatures are high, and winds are light. Most episodes are associated with near-surface winds from either the east/northeast or south/southwest with the latter direction appearing less consistently on the highest days and with greater variability in direction. Episodes can be classified as either “stagnant”, with very little inflow of air from outside of Northeast Texas or “transport”, with pollutants usually arriving in Northeast Texas through northwestern Louisiana, southern Arkansas, or southeastern Texas.

Ozone exceedances at the CAMS 19 monitoring site located at the Gregg County airport just south of Longview are often associated with daytime wind shifts that help keep locally-generated emissions within the area and cause plumes from major point sources to cross over the monitoring site. When these plume impacts occur in conjunction with already elevated regional ozone levels, exceedances of the ozone standard can result. Examination of 2005-6 Longview radar wind profiler data revealed the presence of moderately strong low-level southwesterly winds during the hours between midnight and sunrise on several days. Winds above this low-level flow varied from day to day but ranged from northeasterly to easterly on several of the high ozone days. By mid-day, convective mixing in response to surface heating breaks up the low-level southwest flow and brings the easterly component winds to the surface, causing a rotation of the surface winds from southwest to more easterly. The early morning southwest winds at Longview may represent the northward intrusion of the previous afternoon’s sea breeze from the Gulf of Mexico. Shifts in surface winds on high ozone days are also observed at the Tyler and Karnack monitors.

In this section, we present analyses of winds and transport pathways for days when ozone was high in the TLM area. These analyses were performed as part of NETAC’s most recent conceptual model update that was completed in 2014 (Kemball-Cook et al., 2014a). Several thresholds for defining high ozone were used because these analyses were initially performed prior to the promulgation of the 70 ppb 2015 NAAQS. We examined a range of ozone thresholds corresponding to the range of NAAQS under consideration by the EPA at the time of the study. The wind rose analysis described in Section 2.2.1 is based on data from 2005-2013. The transport pathway analysis (Section 2.2.2) was originally based on 2005-2013 data from Kemball-Cook et al. (2014a) and has been updated with 2014-2015 data for higher ozone days (MDA8 ≥ 65 ppb) that was developed by Jeremy Halland of Luminant Power. In the future, NETAC will update the wind rose and transport pathway analyses to focus on the 70 ppb NAAQS and to incorporate wind data after 2013 in all of the wind roses and in the back trajectory plots for lower ozone (MDA8 < 65 ppb) days.

2.2.1 Wind Rose Analysis

In this section, wind roses are used to characterize station near-surface wind speed and direction at the three Northeast Texas monitors over the 2005-2013 period. In a wind rose diagram, the orientation and length of spokes indicates the frequency with which that wind direction occurs. The spokes show the direction from which wind blows toward the monitor, and the colored bands indicate the percentage of time the winds fall in a given speed range. Both morning (6 am – 11 am local time) and afternoon (12 noon – 6 pm) wind roses are shown. The morning and afternoon wind rose diagrams for each monitor and each MDA8 threshold present wind direction and speed for the same set of days. The difference between morning and afternoon wind rose diagrams is the time of day used to select wind data. The value of the MDA8, not the time of day during which the MDA8 occurred, determines the days that are selected. The number of input data points is the same for the morning and afternoon wind rose plots for each monitor and threshold (unless some wind data are missing). Because there are fewer days with very high ozone (MDA8 ≥ 75 ppb) than days with lower MDA8 (e.g. MDA8 ≥ 65 ppb), there are fewer days included in the MDA8>75 ppb plots than in the MDA8 ≥ 65 ppb plots.

Figure 2-27 shows the wind roses for all three monitors for low ozone days with MDA8 < 65 ppb. Morning and afternoon wind roses are similar at all three monitors. At Tyler and Longview, days with low ozone typically have flow from the south or the north; the incidence of easterly or westerly winds is far lower. Wind speeds fall more frequently in the 6-15 mph range on low ozone days than on days with higher ozone that are discussed below. Higher wind speeds indicate a more rapid flow of air through the TLM area which prevents ozone and precursors from building up. The Karnack wind rose shows that southerly winds occur frequently on low ozone days, as at Tyler and Longview; however, Karnack has a higher incidence of northeasterly and westerly winds on clean days than Longview and Tyler. For Longview and Tyler, this wind direction is more typically associated with transport of polluted continental air into the area.

On the highest ozone days (MDA8 ≥ 75 ppb), afternoon wind speeds are generally lower than on the low ozone days (note the lower frequency of red- and yellow-tipped spokes in the MDA8 ≥ 75 ppb compared with the wind roses for the MDA8 ≤ 65 ppb days). Lower wind speeds are more conducive to the buildup of pollutants as the stagnant air lingers over the TLM area. Wind speeds are generally lower at Karnack than at Longview or Tyler on days with MDA8 ≥ 75 ppb. Wind directions at Karnack on high ozone days are generally southwesterly to southeasterly in the morning and afternoon, respectively; northerly and westerly winds are less frequently associated with high ozone readings at Karnack site compared to Longview or Tyler. At Tyler, afternoon winds are most frequently out of the northeast/east on high ozone days, with a southerly contribution that is smaller than on days with MDA8 in the 65-70 ppb range, as discussed below. Like Tyler, Longview often has afternoon winds out of the northeast on days with MDA8 > 75 ppb, however in contrast, the east/southeasterly wind direction is dominant component for high ozone at Longview. Longview site also has a larger northerly wind component during high ozone days compared to Karnack or Tyler. Such wind direction-ozone correlations are consistent with the geographic distribution of local point sources of NOx emissions, located to the north of Longview but not Tyler or Karnack (see next section). The southwesterly wind direction is less frequent at Longview during periods of high ozone than at Tyler and Karnack in both the morning and afternoon.

On clean days where MDA8 < 65 ppb, the morning and afternoon wind direction and speed distributions are similar to one another at all three monitors. As the ozone level increases however, differences between the morning and afternoon wind distributions grow more pronounced. When MDA8 > 65 ppb, the Tyler monitor morning and afternoon wind directions are similar overall, but in the morning, the southwesterly direction is slightly more prominent than in the afternoon. At the MDA8 > 75 ppb level, this behavior is far more pronounced: in the morning, there are strong peaks in the wind distribution in the southwesterly and the east-southeasterly and east-northeasterly directions. In the afternoon, winds are much more likely to be out of the east/northeast than from any southerly direction. Wind speeds associated with southwesterly morning winds have higher peak speeds than winds from all other directions.

For MDA8 > 65 ppb, the Longview monitor has morning and afternoon wind direction distributions that are similar except that the southwesterly wind component is more pronounced in the morning than in the afternoon; this is similar to behavior noted above for Tyler and in the afternoon, the Longview monitor is more likely to see easterly/southeasterly flow than in the morning. When MDA8 > 75, morning winds are typically from the east/southeast or west/southwest. The afternoon wind distribution has a strong northeasterly component that is absent in the morning.

At Karnack, the morning and afternoon wind direction distributions are similar for MDA8<65 ppb. At the MDA8 > 65 ppb level, the Karnack monitor morning and afternoon differ with more dominant southwesterly component in the morning hours and frequent easterly component in the afternoon. Note that although the morning and afternoon wind direction distributions differ for all three monitors at higher ozone levels, the wind rose data cannot be used to demonstrate that wind shifts often occur over the course of high ozone days at the Northeast Texas monitors. This is because the morning and afternoon wind rose data show aggregated data for many days. However, inspection of data from previous NETAC analyses of high ozone days during the period 2005-2011 indicates that there are many high ozone days when wind shifts do occur at both the Longview and Tyler monitors, with different consequences because of the different distribution of sources around each monitor.

In summary, the wind rose data show that high ozone days in the TLM area are associated with slow wind speeds and winds from the east/northeast or southeast/south/southwest. By contrast, winds are faster on low ozone days and winds blow more frequently from the south.

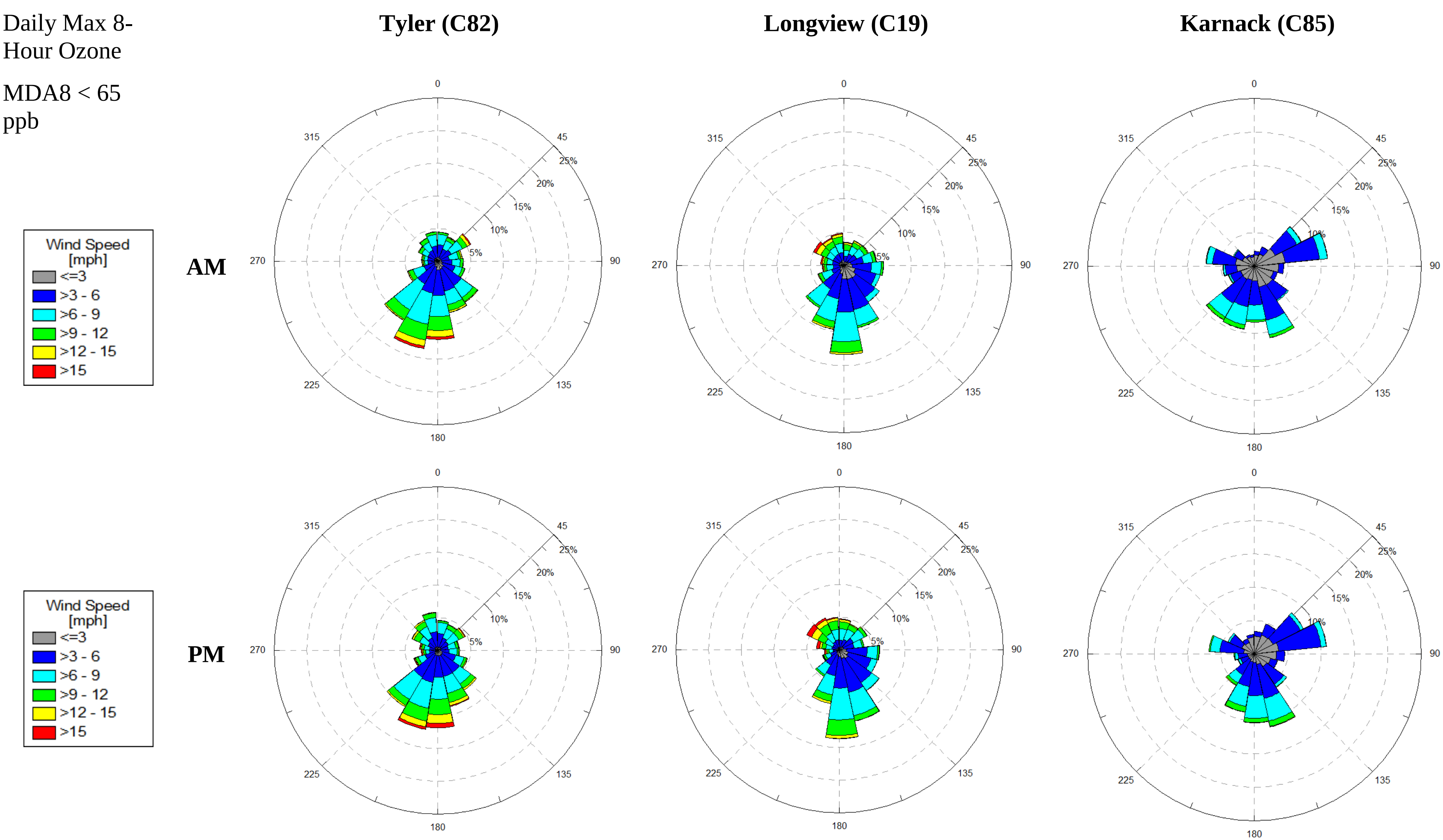


Figure 2-27 Wind Roses for 2005-2013 for the 6-11 am period (upper panels) and 12-6 pm period (lower panels).

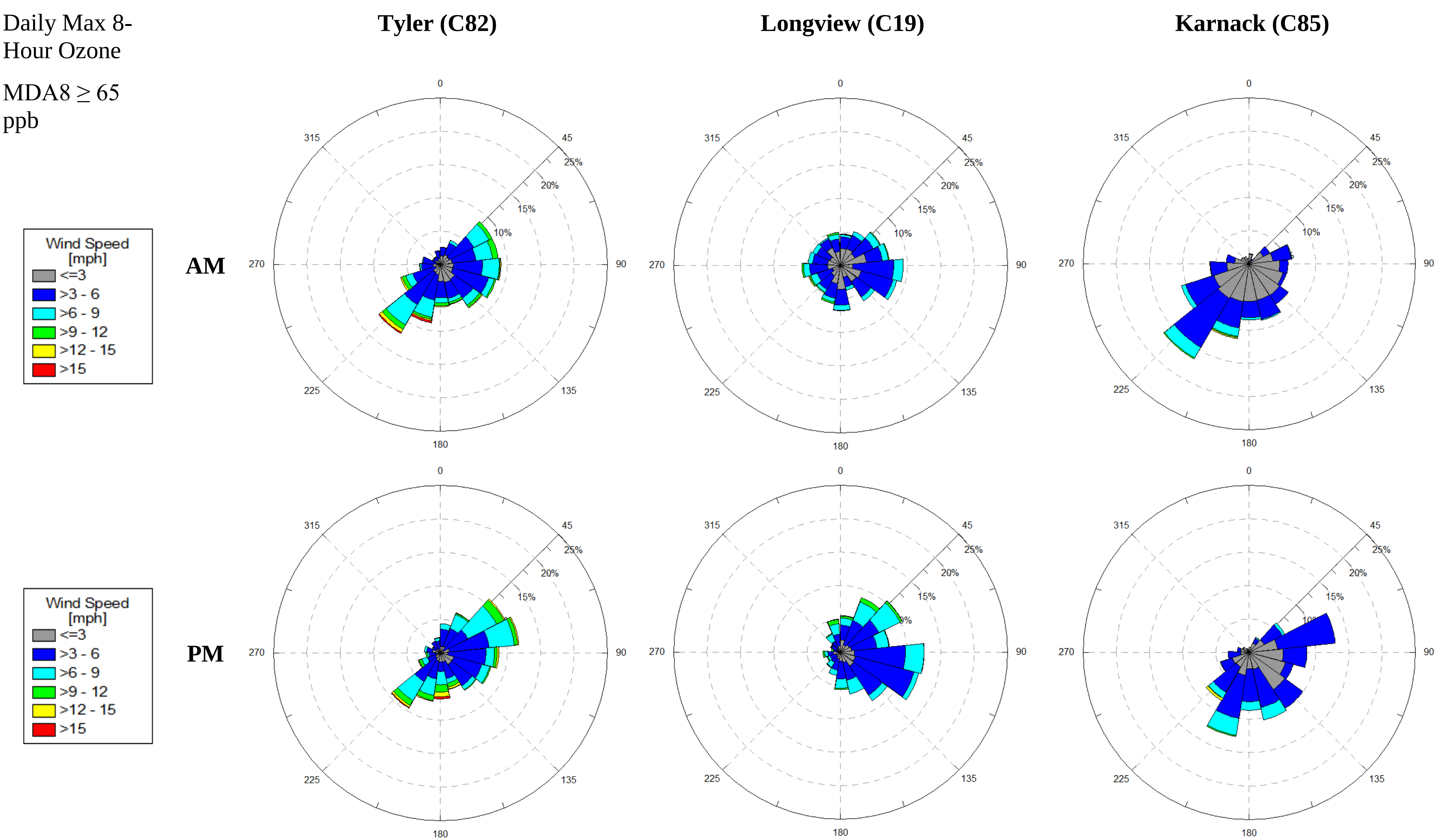


Figure 2-23. (continued). Wind Roses for 2005-2013 for the 6-11 am period (upper panels) and 12-6 pm period (lower panels).

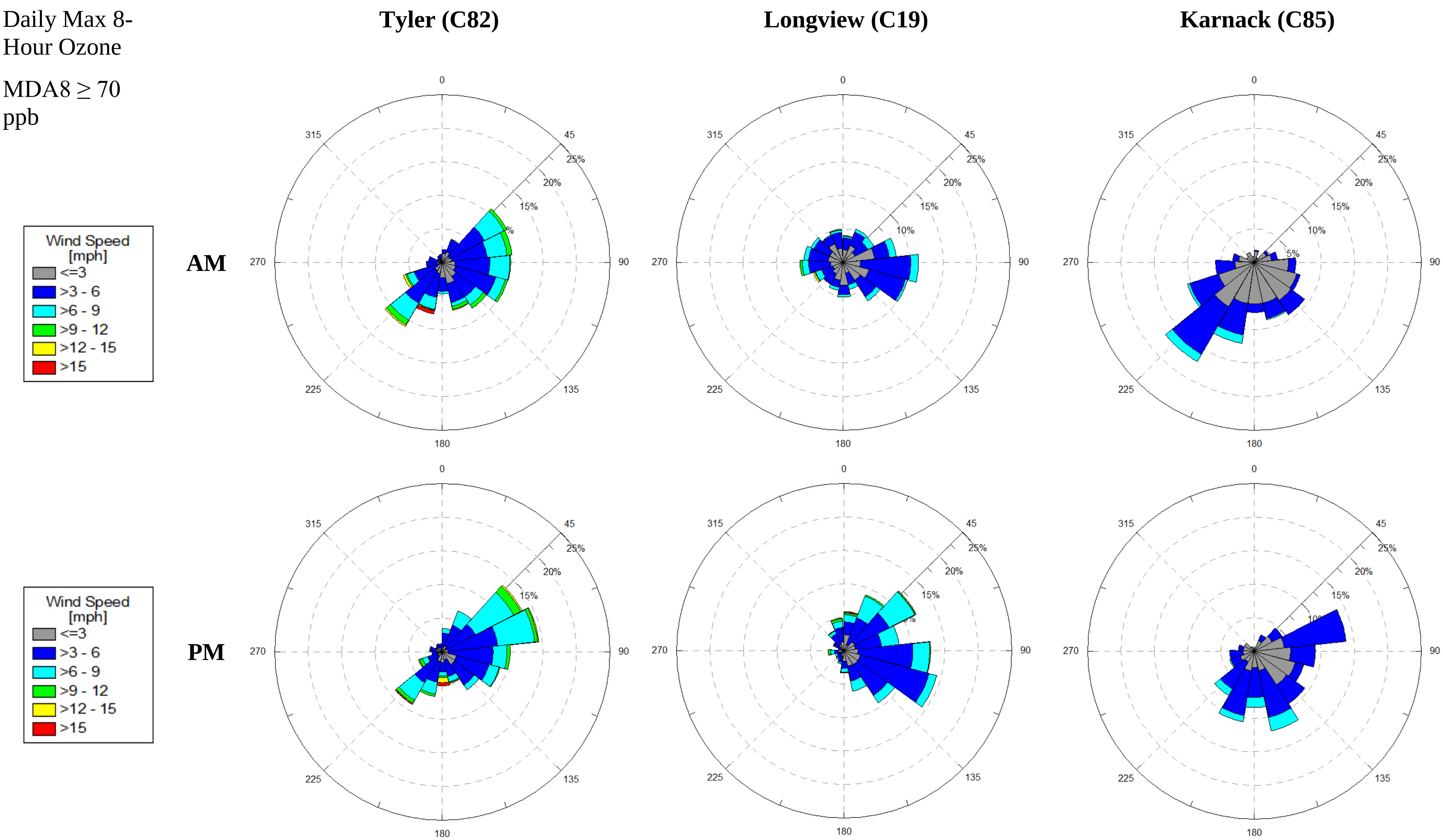


Figure 2-23. (continued). Wind Roses for 2005-2013 for the 6-11 am period (upper panels) and 12-6 pm period (lower panels).

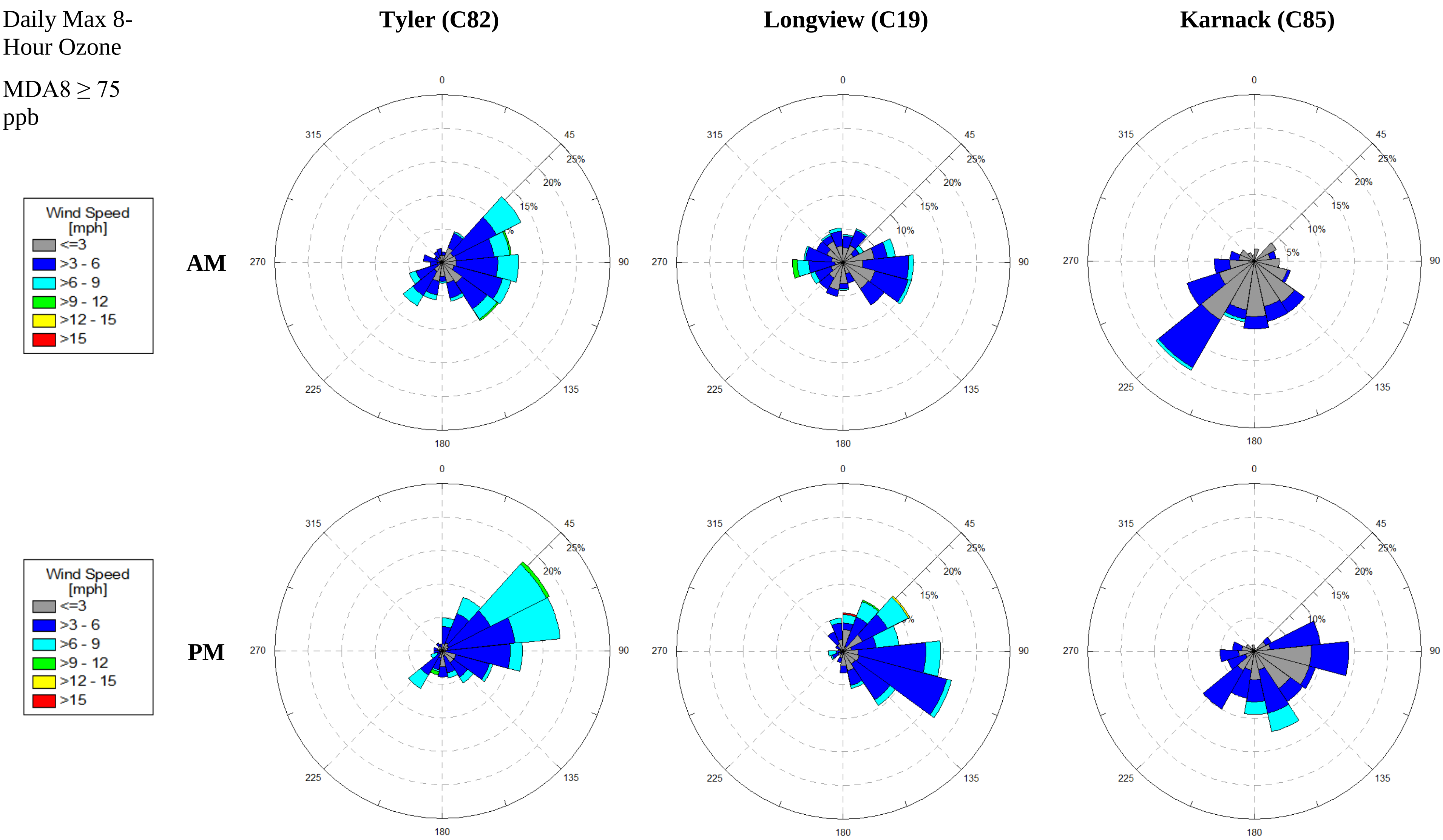


Figure 2-23. (concluded). Wind Roses for 2005-2013 for the 6-11 am period (upper panels) and 12-6 pm period (lower panels).

2.2.2 HYSPLIT Back Trajectory Analysis

In order to determine possible source regions for air arriving in the TLM area on high ozone days, a back trajectory analysis was performed. 24-hour back trajectories were prepared using on-line tools provided by the National Oceanic and Atmospheric Administration (NOAA)[22]. These tools are based on application of NOAA's HYSPLIT model (Draxler et al., 2013) with archived weather forecast model data from the National Center for Environmental Prediction's EDAS forecast model (years 2005-2013) and North American Model (NAM; years 2014-2015). The EDAS data have a horizontal resolution of 40 km and the NAM data have 12 km resolution. Note that back trajectories are a qualitative tool subject to theoretical and data limitations and can only provide approximate information regarding possible source regions for pollutants transported to a monitor.

High ozone days during the 2005-2015 period were identified according to the three thresholds of 65 ppb, 70 ppb and 75 ppb. For each high ozone day during the 2005-2015 ozone seasons (April 1-October 31), back trajectory analysis was used to determine the approximate origin of air arriving at the TLM area monitors during the 8-hour ozone peak. The 24-hour back trajectories were grouped into days with MDA8 ≥ 65, 70 and 75 ppb respectively in order to assess which wind directions were most (and least) likely to affect TLM area ozone at different levels of the new ozone standard.

The three middle panels of Figure 2-28 show the HYSPLIT back trajectory analysis for the Longview monitor on days when the MDA8 was greater than or equal to 75 ppb (top panel), 70 ppb (center panel) and 65 ppb (lower panel). There are several features common to the back trajectory patterns for all three levels of the MDA8 threshold. High ozone days at the Longview monitor occurred most frequently when the flow was from the east, northeast or the south. Many of back trajectories extend back into Louisiana and Arkansas and into the region surrounding the Mississippi River. Winds from the north/northwest occur less frequently than from the other directions for all thresholds of the MDA8.

The Longview back trajectories indicate that the Karnack monitor serves effectively as an upwind monitor for days with east/northeasterly flow bringing air from Louisiana, Arkansas and beyond. At levels of the MDA8 below 70 ppb, the greater number of southerly trajectories indicates that transport from the south becomes increasingly important. These southerly trajectories frequently show the arrival in Longview of air that had recently been in the vicinity of the Texas Gulf Coast. These trajectories typically show a strong curvature to the right, arriving in Longview from the southwest.

Back trajectories for days when the Longview MDA8<65 ppb tend to be longer than those of the higher ozone days; this indicates that wind speeds are generally faster on the lower ozone days than on the high ozone days (Figure 2-29; back trajectories for 2005-2013 are shown). This is consistent with the results of the wind rose analysis, which showed generally higher

[22] http://www.arl.noaa.gov/ready/hysplit4.html

wind speeds on low ozone days than on high ozone days. High ozone days in Northeast Texas often occur when air is relatively stagnant, allowing the buildup of ozone and precursors. On cleaner days, wind speeds tend to be higher, improving ventilation of the area. Wind directions differ between low and high ozone days as well. Low ozone days in Northeast Texas are often associated with the arrival of clean maritime air from the Gulf of Mexico during episodes of southerly winds. Figure 2-29 shows many back trajectories that originate over the Gulf of Mexico and then come ashore all along the Texas coast. The top left panels of Figure 2-28, on the other hand, shows that on 70 ppb days at Longview and Tyler, southerly trajectories were much more likely to pass over the Houston or Victoria areas while coming ashore and were generally shorter in length than the trajectories in Figure 2-29. Northerly and northeasterly trajectories were far more likely to occur on high ozone days than on low ozone days.

The corresponding HYSPLIT back trajectory analysis for the Tyler monitor is shown in the left hand panels of Figure 2-28. The back trajectories for Tyler are similar in many respects to those for Longview. For all three levels of the MDA8, flow from the east/northeast and the south were typical of high ozone days at Tyler. As at Longview, the frequency of southerly trajectories increases as the MDA8 threshold is lowered. Similar to Longview, clean (MDA8<65 ppb) days are marked by longer 24-hour back trajectories that are more likely to originate over the Gulf of Mexico or over regions to the north of the TLM area. The wind rose wind direction data from Tyler are consistent with the picture from the HYSPLIT back trajectories in which clean maritime air from the Gulf of Mexico enters the TLM area from the south or relatively unpolluted continental air arrives from the north.

The Karnack monitor (right hand panels of Figure 2-28) was even less likely than the Longview or Tyler monitors to have transport from the north on high ozone days; transport from the east or south on high ozone days is most frequent at Karnack. Note that there are large local NOx emissions sources to the north of Longview and the northeast of Tyler, but not Karnack.

The back trajectory analysis shows that high ozone days at the Karnack, Tyler and Longview monitors are most frequently associated with air arriving from the east/northeasterly and southerly directions. As the threshold of the MDA8 is lowered, transport from the south becomes more important. Trajectories that may be traced backward to the vicinity of Texas port cities show significant curvature resulting in their arriving in the TLM area from a southwesterly direction.

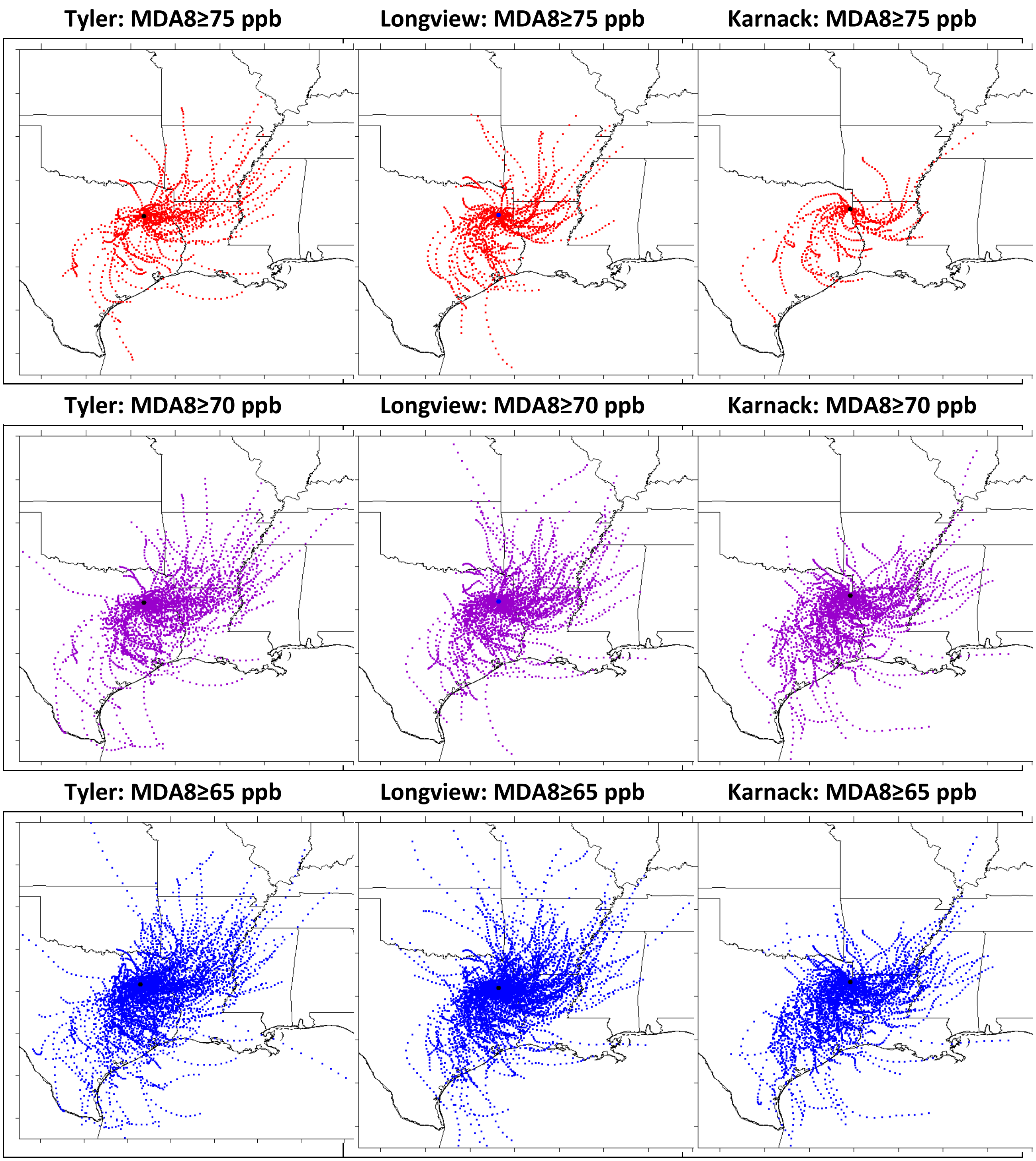


Figure 2-28. **24-hour HYSPLIT back trajectories for the Northeast Texas monitors for 2005-15. Left panels: back trajectories ending at the Tyler monitor at the time of daily maximum 8-hour ozone (MDA8) on days when the MDA8≥75 ppb (top panel), 70 ppb (middle panel), and 65 ppb (lower panel). Center panels: As for the left panels for the Longview monitor. Right panels: As for the left panels for the Karnack monitor. Circles indicate monitor locations.**

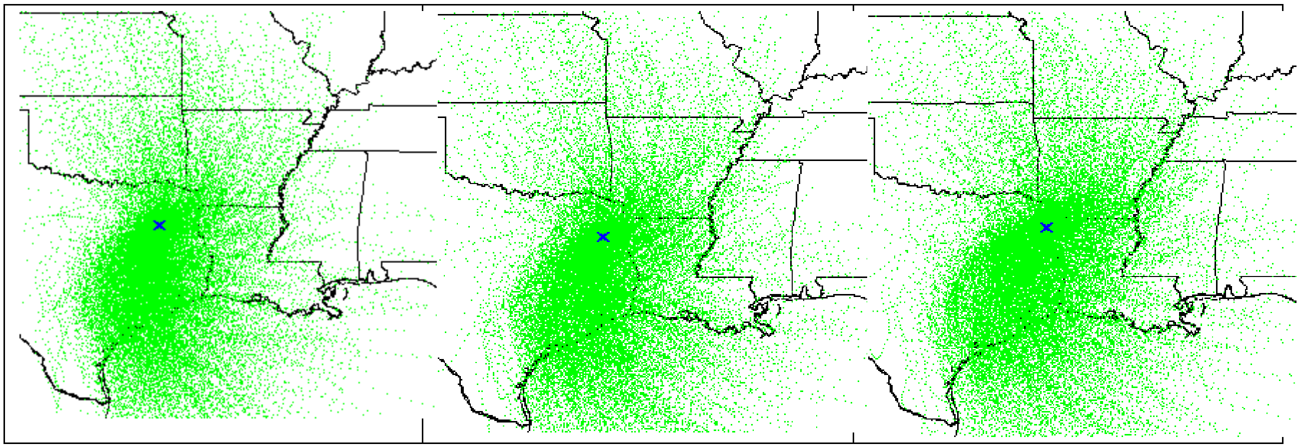


Figure 2-29. 24-hour HYSPLIT back trajectories for the Tyler, Longview and Karnack monitors (marked 'x') for the years 2005-2013. Left panel: back trajectories ending at the Tyler monitor at the time of daily maximum 8-hour ozone (MDA8) on days when the MDA8 was less than 65 ppb. Center panel: As for the left panel but for the Longview monitor. Right panel: As for the left panel but for the Karnack monitor.

2.3 Ozone Transport

The lower ozone standard promulgated by the EPA in 2015 enhances the importance of transported background ozone and precursors, and it is critical to understand the role of the transported background in ozone exceedance days in Northeast Texas. If the area's high ozone days are exclusively due to transport of ozone into the area, local emission control strategies will not be effective in reducing TLM area ozone. Conversely, if the contribution of local sources generally exceeds that of the transported background, then the benefits of local controls may be substantial. In 2002 and 2006, NETAC sponsored aircraft flights along the Texas-Louisiana border that monitored ozone levels aloft. The aircraft measurements showed that on days with easterly winds, high concentrations of ozone were transported across the border into Texas (Buhr et al., 2003; Alvarez et al., 2006; Alvarez et al., 2007). While aircraft flights are useful for looking at ozone transport on a particular day, they are too costly to be undertaken on a routine basis. These flights were made more than a decade ago, and since 2006, significant improvements in ozone air quality have been made within and outside Texas; an updated assessment of Northeast Texas background ozone was needed.

NETAC performed a regional background ozone trend analysis during 2015 as part of its regular update of the conceptual model of ozone formation in Northeast Texas (Parker et al., 2015). Evaluation of trends in regional background ozone can aid in assessing the contribution of reductions in ozone transport to the declining trends in TLM area ozone shown in Figure 1-5 and Figure 1-6.

The trend analysis focused on two questions:

- How is the background ozone entering Northeast Texas changing with time?

- How is local TLM area contribution to ozone at Northeast Texas monitors changing with time?

The analysis used the ozone monitors shown in Figure 2-30. We used the three Northeast Texas CAMS as well as two EPA Air Quality System (AQS) monitoring sites in northwestern Louisiana, the Dixie and Shreveport Airport monitors. We used May-September monitoring data from 2005-2015 for this analysis. The months of May-September were chosen because these are the months that have the highest frequency of days with MDA8 > 70 ppb (Parker et al., 2015). For each day, we defined the background ozone to be the lowest MDA8 ozone value on that day at the five monitors shown in Figure 2-30.

Figure 2-30. Ozone monitoring sites used in the ozone trend analysis.

The local contribution to the MDA8 ozone at a monitor (labelled I) is defined:

Local Contribution (monitor i) = Total MDA8 (monitor i) – Background ozone

This method is similar to the TCEQ method used in Berlin et al. (2013) to analyze background ozone trends in the Houston area. In Northeast Texas, the monitoring network is far less dense, and given the monitor locations, the method will work best when winds are easterly or westerly. Recirculation or large spatial gradient in background ozone will reduce the accuracy of this method. The underlying assumption is that at least one of the monitors will not be directly affected by local emissions, but this may not always be the case. Consequently background ozone may be overestimated in some instances.

Figure 2-31 shows an example of the partitioning of ambient MDA8 ozone at the Longview CAMS 19 monitor into local and regional background contributions during the month of May, 2005. The contribution from background ozone fluctuates from day to day. For example, on May 18, the Longview CAMS 19 monitor had the lowest MDA8 ozone of the five monitors shown in Figure 2-30, and the contribution from local sources is therefore taken to be zero. On May 22, the MDA8 measured at Longview CAMS 19 was 94 ppb; the local contribution was 26 ppb and the background contribution was 68 ppb. The days with the highest values of the MDA8, May 22 and May 27, had large contributions from both background ozone and local emissions sources.

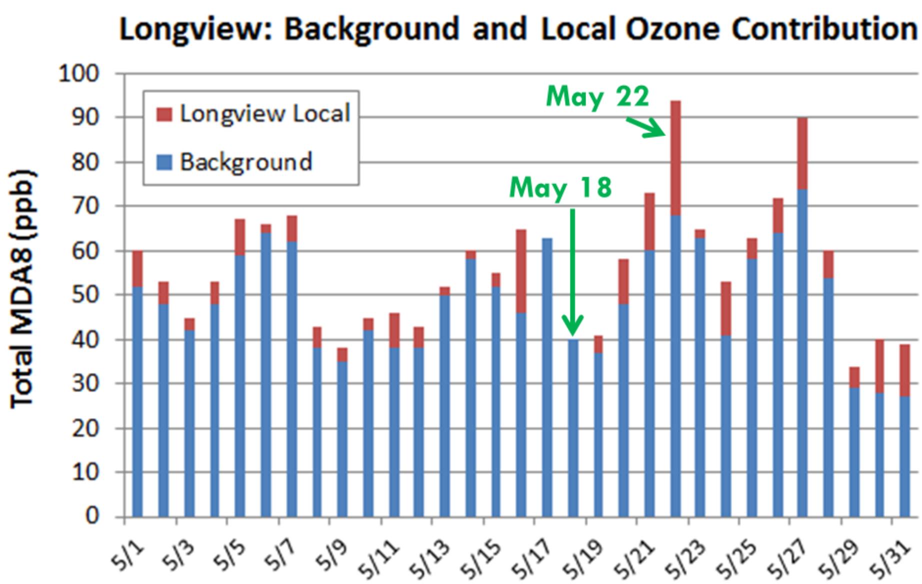
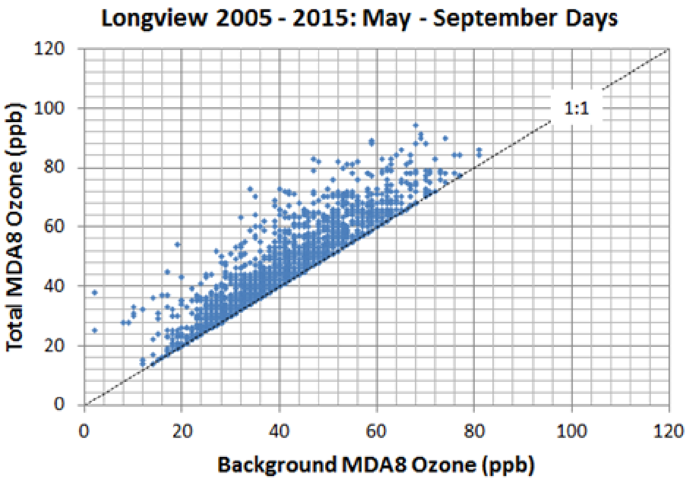


Figure 2-31. Example of background ozone and local contribution for the Longview CAMS 19 monitor for May, 2005.

Figure 2-32 shows the relationship between background and total MDA8 ozone at the Longview CAMS 19 monitor for each May-September day during 2005-2015. The scatter plot shows that Northeast Texas is strongly influenced by background ozone. There are many days when the background ozone in the area exceeds 60 ppb and several days when the background ozone exceeds 80 ppb. Results for the other two Northeast Texas CAMS are similar and are shown in Parker et al. (2015).

During May-September 2005-2014, the average contribution from background ozone to the MDA8 at Northeast Texas CAMS on days with total MDA8 > 70 ppb ranged from 62-67 ppb. The average local contribution on days with total MDA8 > 70 ppb ranged from 9-15 ppb (Figure 2-32) with Longview CAMS 19 having the largest contribution (15 ppb) and Karnack CAMS 85 the smallest contribution (9.1 ppb). On days with total MDA8 > 70 ppb, background ozone was 81-88% of the total MDA8 and explained ~90% of the variance in MDA8 ozone.



Average Local Contribution On Exceedance Days* (ppb)	
Tyler	14
Longview	15
Karnack	9.1

*Exceedance Day: MDA8>70 ppb

Figure 2-32. Left panel: scatter plot of total MDA8 ozone versus background MDA8 ozone for the Longview CAMS 19 monitor. Right panel: average local contribution on days with MDA8 > 70 ppb at the Northeast Texas monitors.

Figure 2-33 shows trends in annual average background MDA8 ozone in Northeast Texas during 2005-2015. We examine trends in the 90th, 50th and 10th percentile MDA8 ozone values. These percentiles translate to approximately the 16th highest, median and 16th lowest background MDA8 ozone concentrations for each year. Figure 2-33 presents these values along with linear regression trend lines and reports the slopes and confidence intervals of the trends.

The slopes of all three trend lines are negative. The steepest slope (-1.1 ppb/yr) is observed for the 90th percentile background MDA8 ozone level, and the smallest slope for the lowest background MDA8 ozone level. This suggests that the greatest reductions of background MDA8 ozone are occurring on days with high background MDA8 ozone. This result is expected since ongoing U.S. emissions reductions programs are more likely to affect background MDA8 ozone concentrations on days when winds are transporting polluted continental air rather than cleaner maritime air.

All three time series exhibit large scatter about the trend lines (R^2 = 0.30, 0.23 and 0.04, for the 90th, 50th and 10th percentiles, respectively) since there is considerable inter-annual variability related to weather conditions. In addition, the slope confidence intervals (for 95% confidence level) include a zero slope as shown in the legend on the figure, so the trends are not statistically significant at the 95% confidence level. The 90th percentile trend line has p = 0.08.

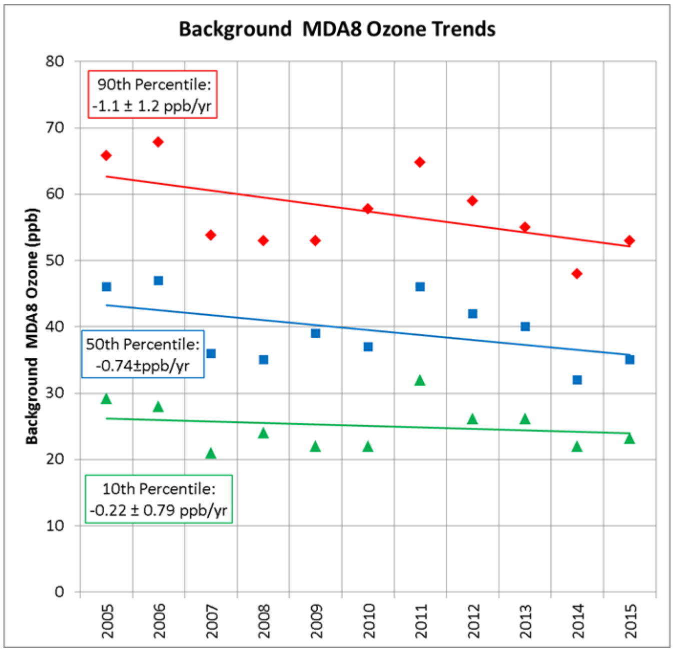
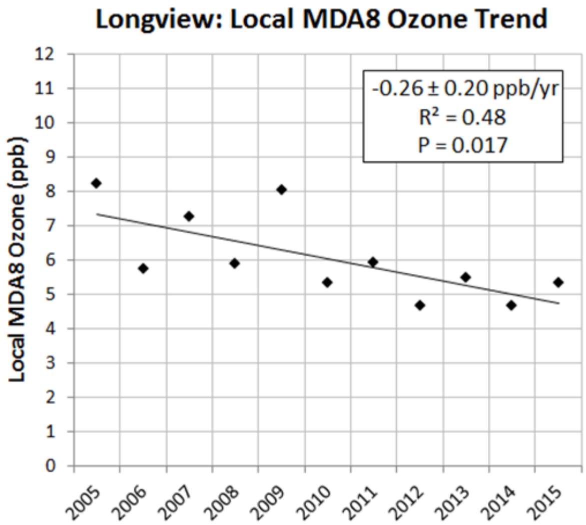


Figure 2-33. Annual average background MDA8 contribution at the Northeast Texas monitors ozone. Slope of linear regression is shown along with the confidence level.

Figure 2-34 shows the annual average local contribution to the MDA8 ozone at the Longview CAMS 19 monitor during 2005-2015. The trend is -0.26 ppb/yr and it is significant at the 95% confidence level. The Tyler CAMS 82 monitor also shows a declining trend in the local contribution to MDA8 ozone of -0.35 ppb/yr. This trend is also significant at the 95% confidence level. At the Karnack CAMS 85 monitor, on the other hand, the trend is also toward lower ozone, but the trend is not statistically significant at the 95% confidence level. The decrease in the local contribution to ozone at the Northeast Texas monitors is consistent with the reduction in TLM area NOx emissions from 2006 to 2012 (Figure 2-21).

In summary, this analysis of ambient ozone data is consistent with the aircraft flights along the Texas border in showing the importance of ozone transport into Northeast Texas. While transport plays an important role in causing high ozone in Northeast Texas, the local contribution is also significant (9-15 ppb on average on days with MDA8 ozone > 70 ppb). The trends analysis indicates that the local contribution has declined by several ppb during the last decade at Northeast Texas CAMS. The trend analysis also suggests that the background ozone entering Northeast Texas has decreased, but this result is not as statistically robust as the trend in the local TLM area contribution at Northeast Texas CAMS.



Local Contribution Trend (ppb/yr)	
Tyler	-0.35
Longview	-0.26
Karnack	-0.17
Shreveport	+0.07
Dixie	-0.40

Figure 2-34. Left panel: annual average local contribution to the MDA8 ozone for the Longview CAMS 19 monitor. Right panel: Trends in annual average local contribution to the MDA8 ozone for each of the monitors in Figure 2-30. Trends shown in black type are statistically significant at the 95% confidence level and trends shown in gray are not.

2.4 Ozone Modeling

In the preceding section, we described NETAC's evaluation of the impact of transport on ozone levels monitored locally using ambient monitoring (Parker et al., 2015) and aircraft flight data (e.g. Alvarez et al. 2006a,b). Photochemical modeling can also be used to determine the relative contributions of source regions both near and distant, and can quantify the importance of transported ozone in causing high ozone days. In this section, we describe recent NETAC efforts to quantify ozone transport into the TLM area.

A June 2006 Comprehensive Air Quality Model with Extensions (CAMx; ENVIRON, 2014) ozone model was developed from inputs provided by the TCEQ to the Texas Near Nonattainment Areas (Kemball-Cook et al., 2013b; 2014b). The nested 36/12/4 km modeling grids are shown in Figure 2-35. The Weather Research and Forecasting Model (WRF; Skamarock et al., 2005) was used to develop meteorological fields (winds, temperatures, pressures, precipitation) for CAMx. Day-specific emission inventories for June 2006 were also developed by the TCEQ.

The June 2006 CAMx model was also run with the 2012 ozone season day emission inventory developed by the TCEQ that was described in Section 2. Using the 2012 inventory in the 2006 modeling platform allowed NETAC to assess how emissions changes from 2006 to 2012 affect Texas ozone under the meteorological conditions of June 2006. Note that this is different from development of a 2012 ozone model.

Figure 2-35. TCEQ 36/12/4 km CAMx nested modeling grids for the Texas ozone modeling of June 2006. 36 km grid is outlined in black. The 12 km grid outlined in blue, and the 4 km grid is outlined in green. TCEQ figure[23].

In order to develop a true 2012 episode, a meteorological model such as WRF would be run for the 2012 period of interest and day-specific biogenic, wildfire and EGU emission inventories for 2012 would be required. At the time the June 2006 modeling was performed, meteorological model inputs for CAMx were under development by the TCEQ, but not yet available. Therefore, we adapted the existing June 2006 modeling platform by removing the 2006 anthropogenic emissions for the 36/12/4 km grids and substituting TCEQ's 2012 anthropogenic emissions, except for the oil and gas emission inventory for counties that had Haynesville Shale natural gas development underway in 2012. For these counties, we removed the TCEQ oil and gas emission inventory and substituted emission inventories developed by ENVIRON for Haynesville Shale natural gas development emissions sources (Parikh et al., 2013) and for conventional oil and gas sources.

A true 2012 ozone model has since been developed by the TCEQ and evaluated for Northeast Texas by Ramboll Environ (Johnson et al., 2015). The model performance evaluation showed that improvements in the model's simulation of ground level ozone must be made before the 2012 model can be used for air quality planning in Northeast Texas. We will report on efforts to improve the model in the 2017 Update to the Ozone Action Plan. Below, we report the results of the comparison of ozone using 2006 and 2012 emissions in the June 2006 modeling platform (Kemball-Cook et al., 2014b).

---

[23] http://www.tceq.texas.gov/airquality/airmod/rider8/modeling/domain

The CAMx Anthropogenic Precursor Culpability Assessment (APCA) source apportionment tool was used to evaluate source regions and emissions categories contributing to ozone in Northeast Texas. The APCA tool uses multiple tracer species to track the fate of ozone precursor emissions (VOC and NOx) and the ozone formation caused by these emissions within a simulation. The tracers operate as spectators to the normal CAMx calculations so that the underlying CAMx predicted relationships between emission groups (sources) and ozone concentrations at specific locations (receptors) are not perturbed. Tracers of this type are conventionally referred to as "passive tracers," however it is important to realize that the tracers in the APCA tool track the effects of chemical reaction, transport, diffusion, emissions and deposition within CAMx. In recognition of this, they are described as "ozone reaction tracers." The ozone reaction tracers allow ozone formation from multiple "source groupings" to be tracked simultaneously within a single simulation. A source grouping can be defined in terms of geographical area and/or emission category. So that all sources of ozone precursors are accounted for, the CAMx boundary conditions and initial conditions are always tracked as separate source groupings. This will allow an assessment of the role of transported ozone and precursors in contributing to high ozone episodes within Northeast Texas.

The methodology is designed so that all ozone and precursor concentrations are attributed among the selected source groupings at all times. Thus, for all receptor locations and times, the ozone (or ozone precursor concentrations) predicted by CAMx is attributed among the source groupings. The methodology also estimates the fractions of ozone arriving at the receptor that were formed en route under VOC- or NOx-limited conditions. This information suggests whether ozone concentrations at the receptor may be responsive to reductions in VOC and NOx precursor emissions and can guide the development of additional sensitivity analyses.

APCA differs from the standard CAMx Ozone Source Apportionment Tool (OSAT) in recognizing that certain emission groups are not controllable (e.g., biogenic emissions) and that apportioning ozone production to these groups does not provide information that is relevant to development of control strategies. To address this, in situations where OSAT would attribute ozone production to non-controllable (i.e., biogenic) emissions, APCA re-allocates that ozone production to the controllable portion of precursors that participated in ozone formation with the non-controllable precursor. For example, when ozone formation is due to biogenic VOC and anthropogenic NOx under VOC-limited conditions (a situation in which OSAT would attribute ozone production to biogenic VOC), APCA re-directs that attribution to the anthropogenic NOx precursors present. The use of APCA instead of OSAT results in more ozone formation attributed to anthropogenic NOx sources and less ozone formation attributed to biogenic VOC sources, but generally does not change the partitioning of ozone attributed to local sources and the transported background for a given receptor.

Figure 2-36 shows the episode average contributions to the MDA8 at the three Northeast Texas monitors from local sources (emissions sources within the 5-county area) and transport from outside the TLM area. The local contribution from 5-county area sources is the contribution that can be reduced via local emission controls. For all three monitors, ozone transport makes a far larger contribution to modeled ozone than do local emissions from the 5-county area in both 2006 and 2012. In 2006 and 2012, the Longview monitor has the largest contribution from local emissions sources, while Karnack's local contribution is the smallest. In both 2006 and 2012, the Karnack monitor has the largest contribution from transport. The Karnack monitor is located closer to the Texas border with Louisiana than the Longview and Tyler monitors (Figure 1-4) zone when the wind blows from the east/northeast and brings polluted continental air into Northeast Texas, as is common on high ozone days (e.g. Figure 2-27). On such days, the local contribution is relatively small because most of the major sources of emissions in the 5-county area (e.g. power plants, most of the oil and gas wells) are downwind (west) of the Karnack monitor.

The importance of transport in determining ozone levels in Northeast Texas under the 2006 and 2012 emissions scenarios is consistent with NETAC's previous modeling of 2002, 2005 and 2012 (Kemball-Cook and Yarwood, 2010d). (Note that 2012 was previously modeled using a projected future year emissions scenario). At all three Northeast Texas monitors, ozone decreases in the 2012 emissions scenario relative to the 2006 emissions scenario. For all three monitors, both the local and transported contributions decline going from 2006 to 2012. The decline of the local contribution is consistent with the decrease in 5-county area ozone precursor emissions from 2006 to 2012 shown in Figure 2-21 and Figure 2-23. The model results therefore show the area to be strongly affected by transport, consistent with the results of previous NETAC aircraft monitoring (Buhr et al., 2003; Alvarez et al., 2006; Alvarez et al., 2007), ground-level ambient data analysis (Parker et al., 2015) and modeling (Kemball-Cook et al. 2010a) efforts.

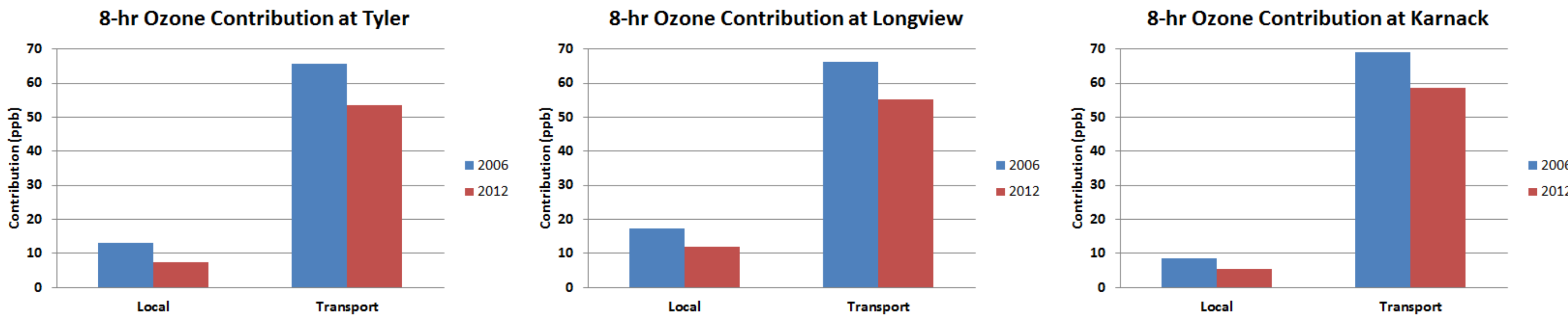
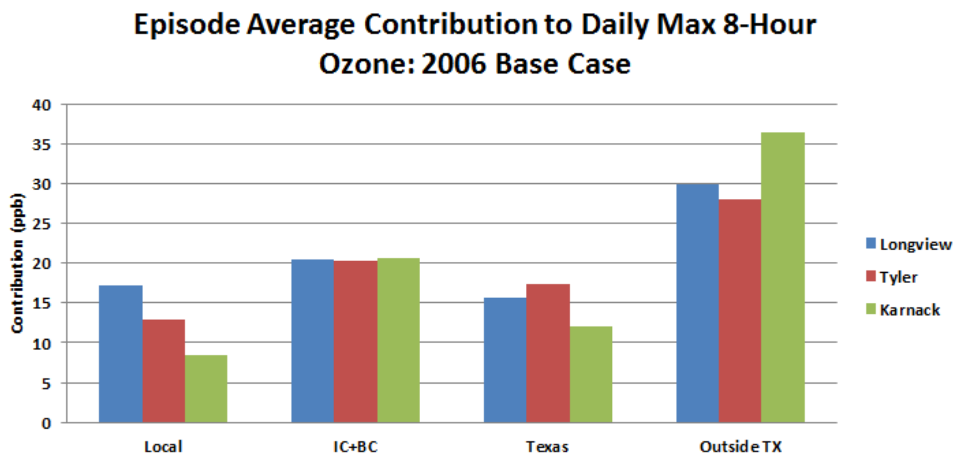


Figure 2-36. Modeled contributions from local emissions sources in the 5-county area of Northeast Texas and transported ozone at the Tyler (left panel), Longview (middle panel) and Karnack (right panel) monitors using 2006 and 2012 anthropogenic emissions in the June 2006 ozone model.

In Figure 2-37, the episode average 2012 ozone transport contribution shown for each monitor in Figure 2-36 is broken down into contributions from initial and boundary conditions and contributions from Texas sources outside the 5-county area and contributions from outside Texas. The 2012 contribution from local emissions sources within the 5-county area is also shown. The sum of contributions from initial and boundary conditions (IC+BC) may be taken as an estimate of the contribution to Northeast Texas ozone from sources outside the U.S. and from the stratosphere. This contribution is on average about 20 ppb and did not change significantly between the 2006 and 2012 emissions runs because the same boundary conditions were used in both simulations. The decrease in the ozone contributions from inside and outside Texas in Figure 2-37 indicates that emissions of ozone precursors are also lower in the rest of the U.S. in the 2012 inventory. This is consistent with the effect of federal controls on NOx emissions from EGUs in the eastern U.S. and controls on motor vehicles nationwide that are expected to lower ozone transport into Texas.



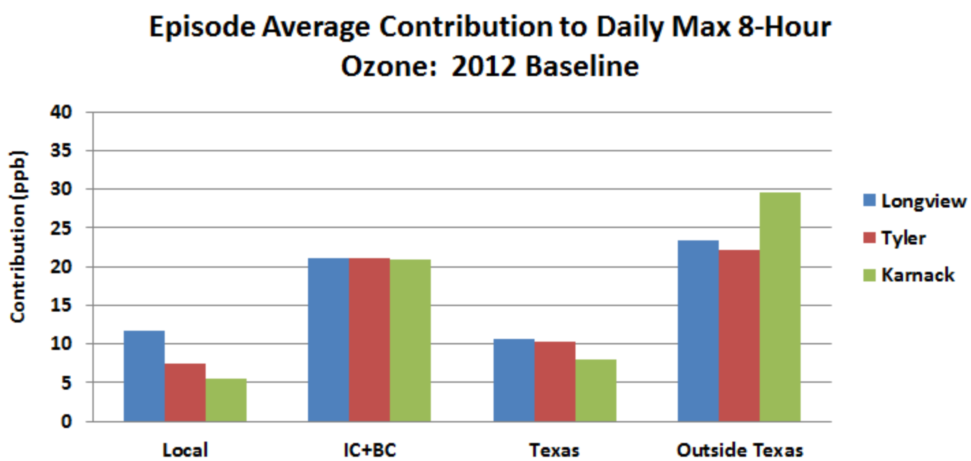


Figure 2-37. Episode average 8-hour ozone contribution to the Northeast Texas monitors from local emissions, the sum of model initial conditions and boundary conditions (IC+BC), sources outside the 5-county area but within Texas (Texas) and from regions outside Texas but within the 36 km modeling domain (Outside TX).

The 2006 APCA modeling results were also used to determine which local emissions source make the largest contributions to the local contribution to ozone shown in Figure 2-37. Figure 2-38 and Figure 2-39 show the breakdown of the local contribution by contribution from each emissions source category. Well head compression refers to the contribution from gas compressor engines in NETAC's emission inventory for the 5-county area and adjacent Panola County. Oil and gas (O&G) refers to the contribution from emissions from O&G sources that are not wellhead compressors.

Area refers to all area sources that are not related to O&G exploration and production. Elevated point sources are sources that emit from individual stacks with buoyant rise that may take their emissions into upper model layers. Most of the elevated point source emissions in Northeast Texas are due to EGUs. Emissions that do not have a buoyant rise are emitted into the model's lowest (surface) layer and are called "surface emissions". All emissions not due to elevated points are surface emissions and surface emissions include those from on-road and off-road mobile sources, area sources, oil and gas sources, and point sources emitted without buoyant plume rise (low points).

The episode maximum and contributions from each emissions source category are shown in Figure 2-38 and Figure 2-39, respectively. The largest values of the maximum and average contribution come from elevated point sources. It is reasonable that Longview should have the largest maximum contribution from point sources, because this monitor has several large point sources nearby and there are several different wind directions that will tend to bring ozone/precursor plumes from these facilities to the monitor (Figure 2-2). On-road mobile sources have the second largest maximum and average contribution at Longview. The Longview monitor lies relatively near Interstate 20, which passes through Gregg County. After on-road mobile, wellhead compression and non-road sources make the next largest contribution.

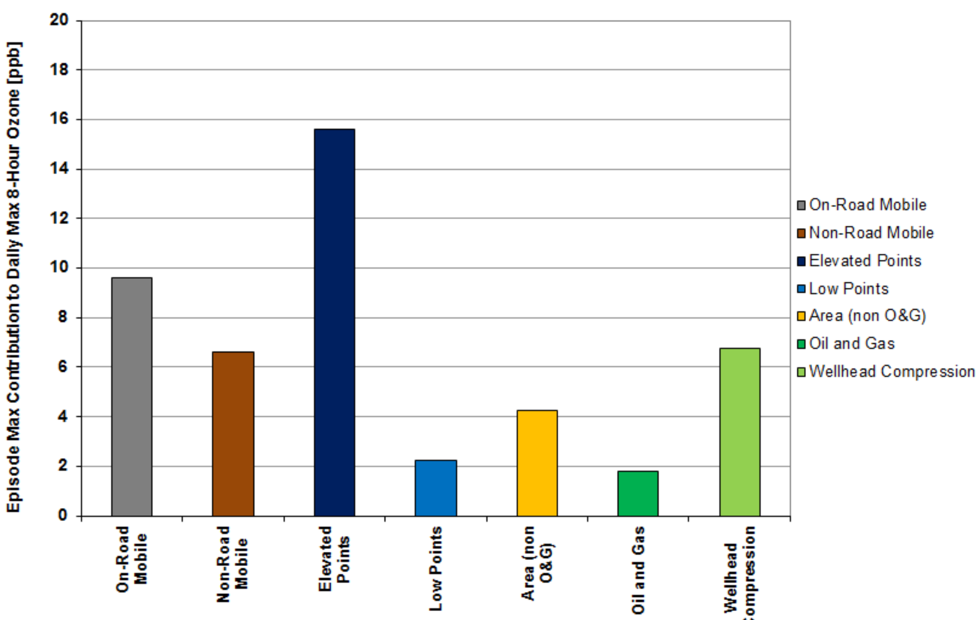


Figure 2-38. June 2006 episode maximum contribution to Longview ozone from 5-county area emissions.

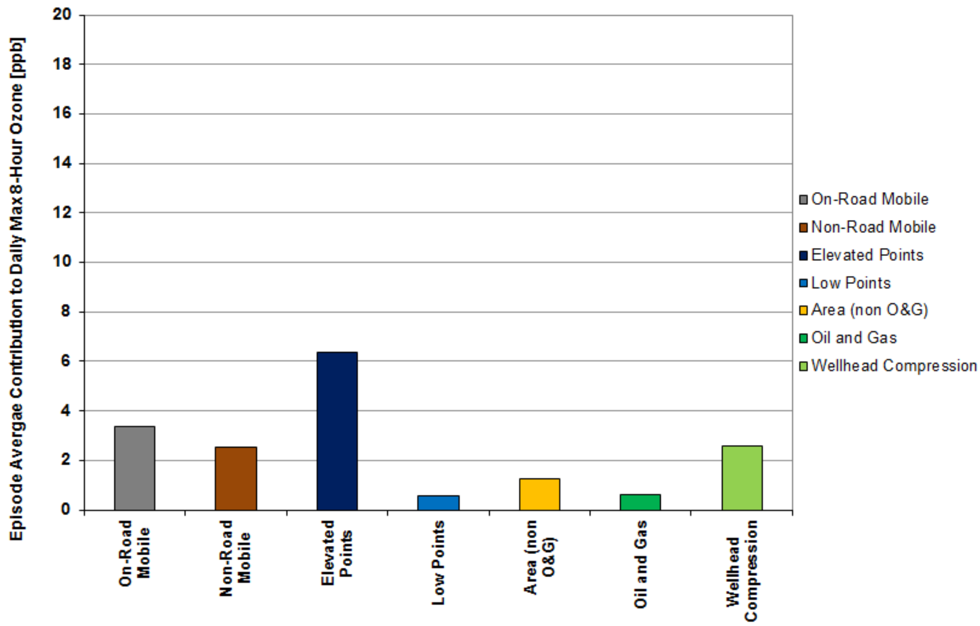


Figure 2-39. June 2006 episode average contribution to Longview ozone from 5-county area emissions.

The episode maximum contribution for each source category and the episode average for each source category for the Tyler monitor are shown in Figure 2-40 and Figure 2-41. Emissions from on-road mobile sources make the largest contribution to both the episode maximum and average. I-20 passes through Smith County near the Tyler monitor and the monitor is also influenced by the Tyler urban plume. The impact of elevated point sources is also apparent at the Tyler monitor, with the second largest episode maximum contribution coming from elevated point sources. Area sources make a larger contribution at the Tyler monitor than at Longview or Karnack.

The episode maximum and episode average contributions at Karnack are shown in Figure 2-42 and Figure 2-43. The contributions from elevated points and on-road mobile sources are of comparable importance at Karnack. The monitor lies to the north of I-20, and has several large power plants nearby.

The largest difference among the three monitors is the magnitude of the elevated point source contribution, which is largest at Longview. Both the episode maximum and average contributions from elevated points are higher at Longview than at either Tyler or Karnack. Figure 2-2 shows the location of the largest point sources of emissions in Northeast Texas. The Longview monitor has several large point sources nearby: Martin Lake power plant, the Pirkey power plant, and the Sabine Industrial District. Several other large power plants (Monticello, Welsh and Dolet Hills) lie further to the north and east. Analysis of wind direction on high ozone days in

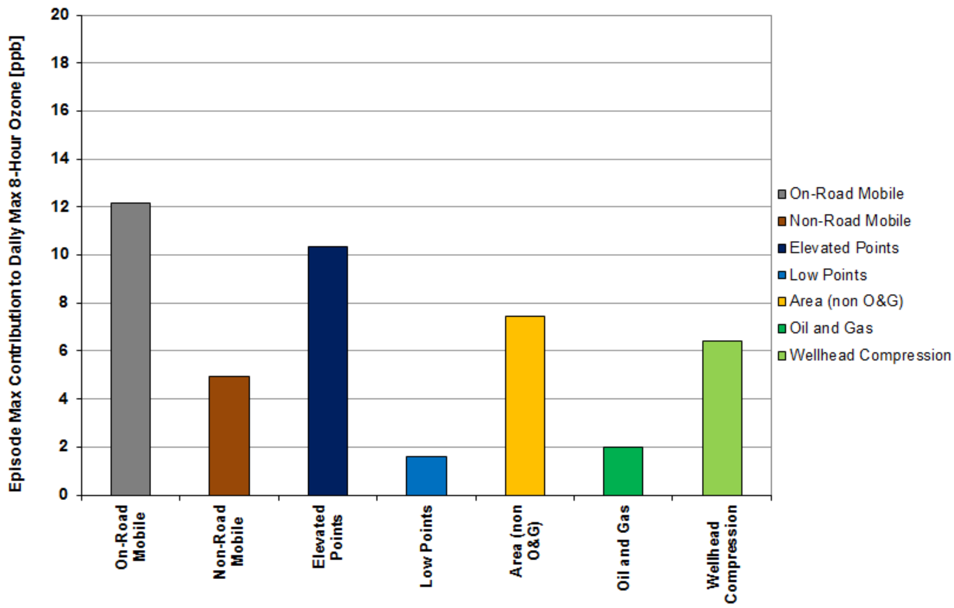


Figure 2-40. June 2006 episode maximum contribution to Tyler ozone from 5-county area emissions.

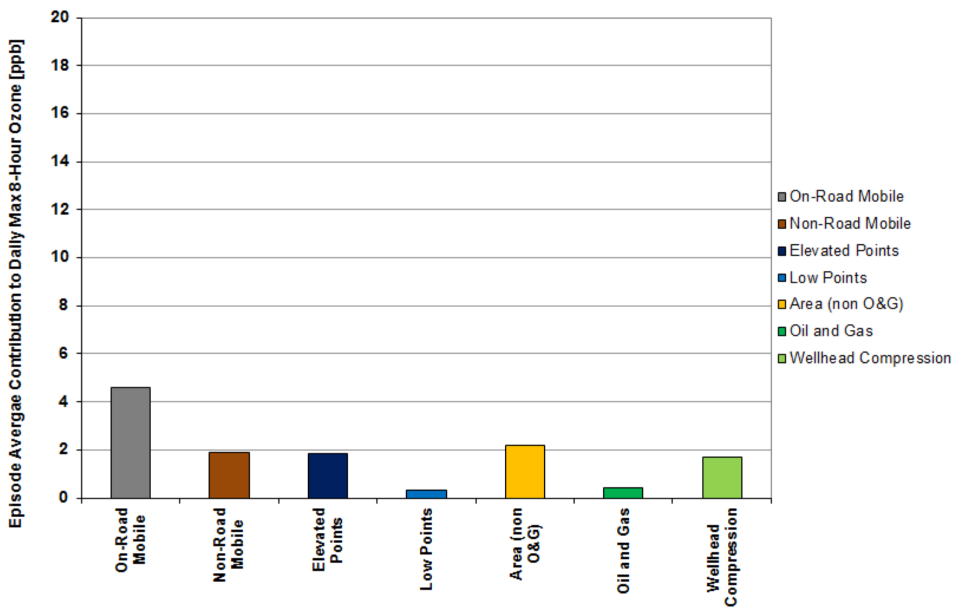


Figure 2-41. June 2006 episode average contribution to Tyler ozone from 5-county area emissions.

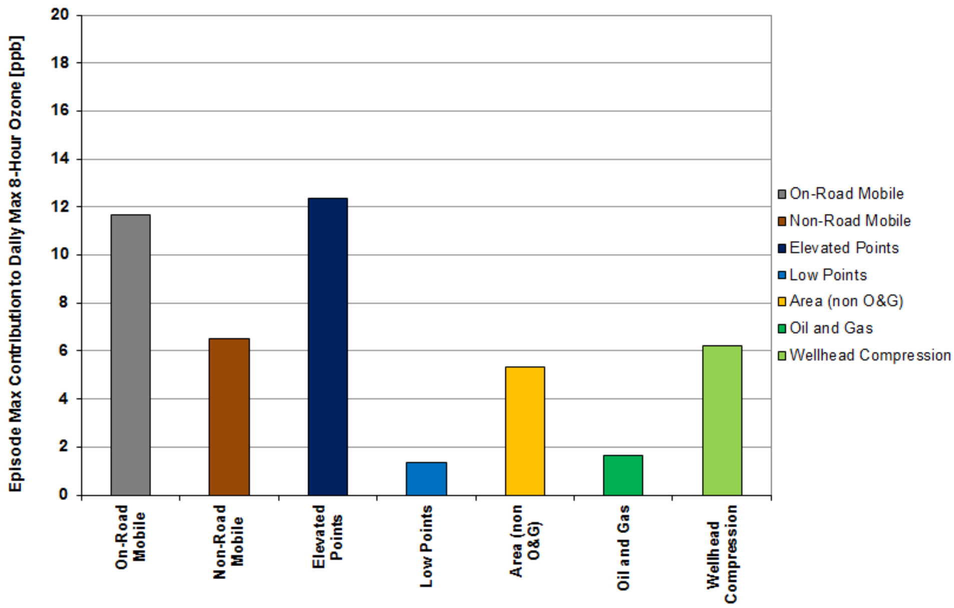


Figure 2-42. June 2006 episode maximum contribution to Karnack ozone from 5-county area emissions.

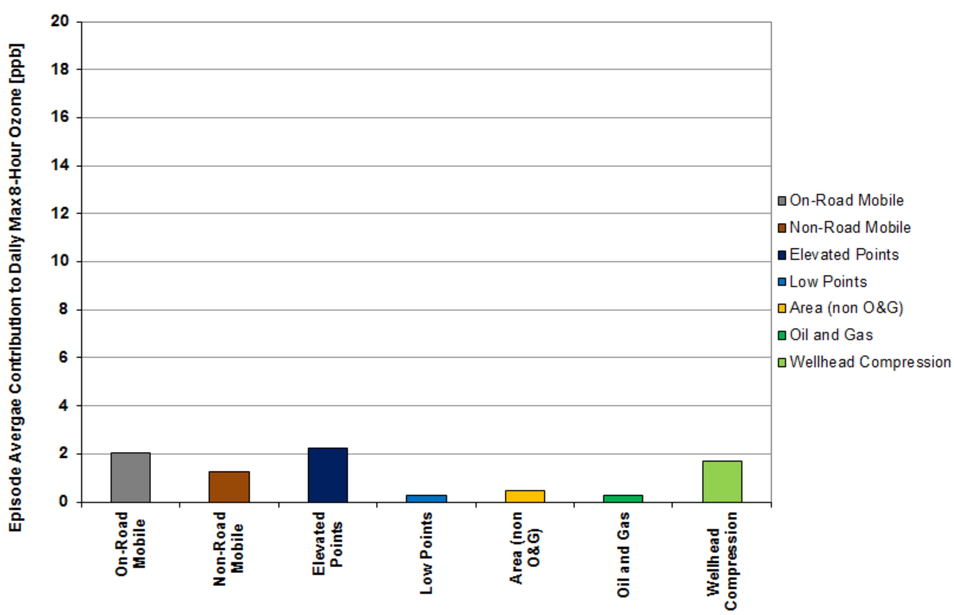


Figure 2-43. June 2006 episode average contribution to Karnack ozone from 5-county area emissions.

(Kemball-Cook et al. 2010a; 2013a) showed that high ozone at Longview occurs most frequently when the afternoon wind is blowing from northeasterly through southeasterly directions. While the Tyler and Karnack monitors also show a strong influence from point sources during the modeling episode these two monitors do not have the same number of large point sources in close proximity and across such a wide range of directions as the Longview monitor.

For all three monitors, on-road mobile source emissions make the second largest contribution after point sources. The contribution from on-road mobile sources is largest at Tyler and smallest at Karnack. Figure 1-4 shows the locations of the three Northeast Texas monitors relative to major roadways. The Tyler monitor lies within 9 miles of I-20, which is the most heavily travelled roadway in the area, and is within 5 miles of the Tyler metropolitan area. The Longview monitor is also located close to (~4 miles) I-20, while the Karnack monitor lies ~12 miles to the north of I-20.

At Longview and Karnack, off-road mobile and oil and gas sources make up the two next largest contributions. Contributions are similar at all three monitors for these distributed sources. Area sources make a larger contribution at Tyler than at Longview or Karnack. This is reasonable because many area source emissions categories are estimated based on population, and the Tyler monitor is closer to a large population center (the Tyler metropolitan area) that tends to be upwind on high ozone days than either the Longview or Karnack monitors.

The June 2006 APCA source apportionment modeling results were used to evaluate whether ozone formation in the TLM area is limited by the amount of available NOx or VOC emissions. Because the CAMx APCA tool was used, only the contributions from anthropogenic emissions are shown. Figure 2-44 shows the contribution to June 2006 episode maximum and average 1-hour ozone at the Northeast Texas monitors due to anthropogenic NOx and VOC emissions from elevated point sources and emissions from surface sources within the TLM area. The ozone contributions from 5-county area NOx emissions far exceed those from anthropogenic VOC emissions. This shows that ozone formation in the 5-county area is limited by the amount of available anthropogenic NOx and indicates that local NOx emissions reductions will be far more effective than VOC emissions reductions in decreasing the local ozone contribution. This result is consistent with the VOC/NOx ratio derived from the TLM area emission inventory, which indicates that there are sufficient biogenic VOCs available for ozone formation and that ozone formation in limited by the amount of available NOx.

NETAC's ozone modeling, ambient monitoring, and emission inventory analyses combine to give a consistent picture of the causes of high ozone in the TLM area. High ozone in Northeast Texas typically occurs on days when local temperatures exceed 90 °F, wind speeds are low, and wind directions range between northerly clockwise through southeasterly. These wind directions are favorable for transport of polluted air masses of continental origin into Northeast Texas. High ozone days in Northeast Texas are generally characterized by high background ozone levels plus a far smaller contribution from local emissions sources. Although the ozone contribution from local sources is relatively small, ozone reductions are possible via reductions in local ozone precursor emissions.

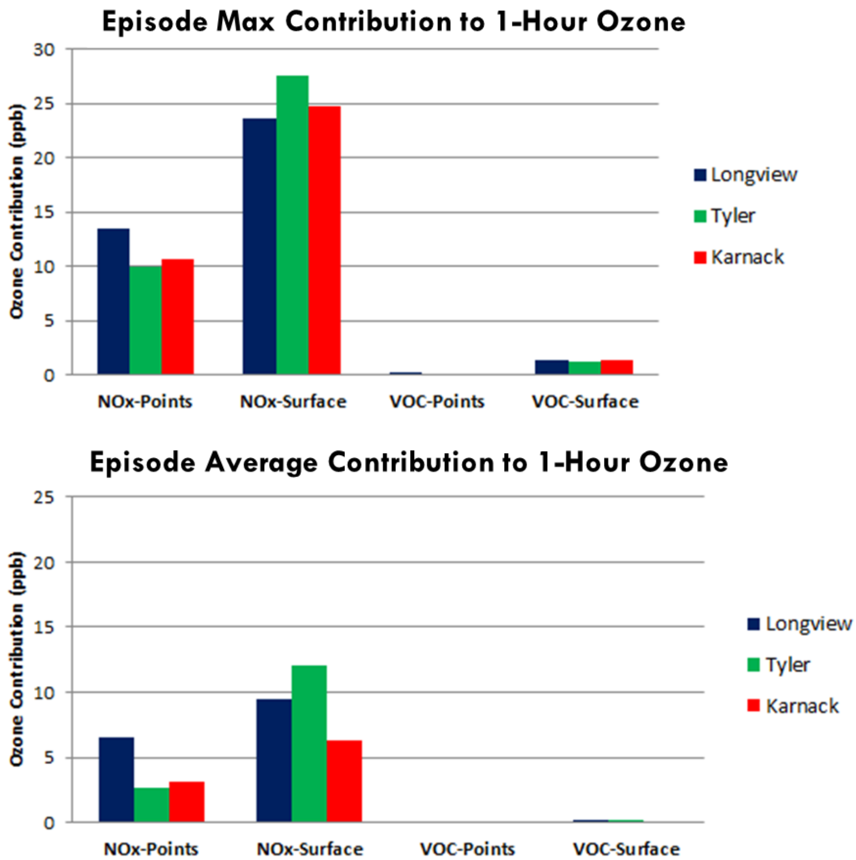


Figure 2-44. June 2006 episode maximum (upper panel) and episode average (lower panel) contributions to 1-hour average ozone from local 5-county area anthropogenic NOx and VOC emissions.

Northeast Texas's NOx emission inventory is dominated by emissions from power plants, motor vehicles, and oil and gas exploration and production. The contribution to VOC emissions from biogenic sources such as trees and other vegetation far exceeds the contribution from human activities. The abundance of biogenic VOC ensures that there is always enough VOC available to form ozone so that the amount of ozone formed from local emissions is determined by the amount of NOx emissions. In addition, highly reactive VOCs (HRVOCs) emitted from petrochemical manufacturing facilities may further enhance ozone. The overall VOC/NOx emission ratio in the 5-county area is well within the NOx-limited ozone formation regime. As a result, reductions in NOx will be generally more effective in controlling ozone on a regional basis than reductions in anthropogenic VOC. Sensitivity tests and source apportionment modeling using NETAC's ozone models confirm that NOx reductions are more effective than VOC reductions in controlling ozone in Northeast Texas. Therefore, local emission control strategies are focused on reducing NOx as well as highly reactive VOCs that have been shown to play a role in ozone formation at the Gregg County monitor in Longview.

3.0 STAKEHOLDER INVOLVEMENT

3.1 Northeast Texas Air Care

In 1996, local elected officials and other leaders in local government, business and industry created NETAC in order to provide leadership and guidance in addressing ozone air quality issues in the 5-county area. A Policy Committee consisting of representatives of local government, business and industry, the general public and environmental interest groups governs NETAC.

From its inception, NETAC has emphasized the need to ensure that air quality planning activities are developed using scientifically sound techniques. In order to achieve this objective NETAC created a Technical Advisory Committee to undertake, supervise, and guide technical studies such as emission inventory development, air quality modeling and control strategy development, and specialized monitoring studies. The Technical Advisory Committee reports to the Policy Committee. The Technical Advisory Committee consists of representatives from local government, local business and industry, EPA technical staff, TCEQ technical staff, Texas Department of Transportation planning staff, and the general public and environmental interest groups.

NETAC is actively involved in public education and outreach programs concerning ozone air quality issues. This work is guided by NETAC's Public Education/Outreach Committee, which consists of representatives from local government, local business and industry, TCEQ staff, and environmental interest groups. The Public Education/Outreach Committee reports to the NETAC Policy Committee.

NETAC receives staff support for its activities from the East Texas Council of Governments (ETCOG), which receives and administers grant funds provided by the Texas Legislature for air quality planning activities through the Rider 8 Program described below.

NETAC and its subcommittees meet on an as-needed basis. All meetings are open to the public and are posted at the East Texas Council of Governments and on the NETAC web site (www.netac.org) and advertised through the distribution of information packets to local media outlets. The individuals comprising the NETAC Technical and Policy Committees are shown below.

NETAC Policy Committee Members

- Gregg County
  - Judge Bill Stoudt, Co-Chair
- Harrison County
  - Judge Hugh Taylor
- Rusk County
  - Judge Joel Hale

- Smith County
  - Judge Joel Baker
  - Cary Nix
- Upshur County
  - Judge Dean Fowler
- City of Gilmer
  - Jeff Ellington, City Manager
- City of Henderson
  - Mayor Pat Brack
- City of Kilgore
  - Scott Sellers, City Manager
- City of Longview
  - Mayor Andy Mack
  - Councilman Gary Smith
- City of Marshall
  - Frank Johnson
- City of Tyler
  - Mayor Martin Heines, Co-Chair
  - Greg Morgan, Project Coordinator
- Marshall Economic Development Corporation (MEDCO)
  - Donna Maisel, Director,
- Longview Economic Development Corporation (LEDCO)
  - Susan Mazarakes-Gill
- Tyler Economic Development Corporation
  - Tom Mullins, Executive Director
- AEP/SWEPCO
  - Keith Honey, General Manager
- Eastman Chemical Company
  - Tim Aldredge
- Luminant Energy
  - David Duncan, Environmental Regional Manager
- WE CAN
  - Tammy Campbell

- Westlake Chemical
  - Eddy Killingsworth

NETAC Technical Advisory Committee Members

- City of Longview
  - Robert Ray, Assistant City Attorney
- Longview MPO
  - Karen Owen, Longview MPO
- City of Marshall
  - Frank Johnson
- City of Tyler
  - Greg Morgan
- Tyler MPO
  - Heather Nick
  - Michael Howell
- EPA
  - Carrie Page
  - Erik Snyder
- TCEQ
  - Doug Boyer
  - Dan Robicheaux
  - Michelle Baetz
  - Leroy Biggers
- NETAC General Counsel
  - Jim Mathews, Mathews and Freeland
- TxDOT
  - Brooke Droptini
- AEP/SWEPCO
  - Kelly Spencer
  - Kimberly Hughes
- CenterPoint Energy
  - Laura Guthrie
  - Patrick Coco

- Eastman Chemical Company
  - Shellie Dalby
- Luminant Energy
  - David Duncan
  - Jeremy Halland
  - Troy Sellers
- Caddo Lake Institute, Inc.
  - Rick Lowerre, Lowerre & Frederick
- Westlake Chemical Corporation
  - Eddy Killingsworth
- Flint Hills Resources
  - Mark McMahon
- BP American Production Company
  - Dana Wood
- Environmental Defense Fund
  - Mr. Ramon Alvarez, Ph.D.
- Norit Americas
  - Amy Clyde

4.0 DESCRIPTION OF MEASURES AND PROGRAMS

In this section, we describe programs and measures aimed at improving ozone air quality in the 5-county area of Northeast Texas. These programs and measures were implemented by NETAC and are either currently in place or are planned for the near future (i.e. 2016-17).

4.1 Participation in Legislative Appropriations for Near-Nonattainment Areas

Since 1997, the Texas Legislature has provided funding for ozone issues in Northeast Texas through riders to the TCEQ's appropriation. Funding under Rider 7 is designed to help Texas Near Nonattainment Areas (NNAs) maintain compliance with the ozone NAAQS. The program is named after the Texas Legislature Rider under which funding was allocated. The name of the program was changed to from Rider 8 to Rider 7 in 2015 following the 2015 session of the Texas Legislature and renewal of the air quality program under a different Rider. The Rider 7 Program is designed to help Texas Near Nonattainment Areas (NNAs) maintain compliance with the ozone NAAQS. This program allows the NNAs to receive funding for their air quality planning efforts and to leverage the TCEQ's ongoing emission inventory development and meteorological and photochemical modeling.

The TCEQ has established the following goals for the Texas NNAs under the Rider 7/8 Program[24]:

- Develop a conceptual understanding of local ozone formation processes;
- Evaluate local emissions inventories developed by the TCEQ (identifying possible areas of improvement);
- Analyze local ambient air quality monitoring;
- Identify local emissions controls for future in-depth study;
- Assess potential local monitoring networks and recommend enhancements or special studies;
- Emissions inventory improvements;
- Implement local emission control strategies;
- Use a photochemical modeling episode developed by the TCEQ to analyze ozone sources and conduct sensitivity tests;
- Improve public understanding of the ozone problem and motivate the public to voluntarily reduce its contribution to ozone pollution; and
- Involve local stakeholders in local air quality planning so that these efforts have broad support within local communities.

Rider 7 program activities align well with NETAC's participation in Ozone Advance.

[24] http://www.tceq.texas.gov/airquality/airmod/rider8/rider8-background

4.1.1 Technical Studies Carried out Under the Rider 7/8 Programs

Under the Rider 7/8 Programs, NETAC has carried out many technical studies including development conceptual model of ozone formation, enhanced ambient monitoring, evaluation of TCEQ emission inventories for the TLM area, analysis of potential local emissions control strategies, and photochemical modeling. Reports summarizing these studies may be found on NETAC's web site www.netac.org.

During 2015, the following technical studies were carried out:

- Update of the conceptual model for ozone formation in the TLM area using data through the end of the 2015 ozone season;
- Detailed review of TCEQ 2012 emission inventory for the 5-county area;
- Update of TLM area oil and gas emission inventories and future year projections for both shale and conventional resources;
- Update of control strategy evaluation performed in 2013;
- Photochemical modeling using 2012 episode developed by the TCEQ; and
- SOF study in the Sabine Industrial District.

During 2016-2017, the following technical studies will be carried out:

- Analysis of Texas Emission Reduction Program (TERP) emissions reductions in Northeast Texas and outreach to encourage additional near-term NOx emissions reduction projects;
- Review of TLM area high ozone days (MDA8 > 70 ppb) during the 2015-2017 ozone seasons and determination of regional background ozone levels, relevant meteorological factors and the influence of local emissions sources; and
- Photochemical modeling using 2012 episode developed by the TCEQ.

Schedule for Implementation: All technical studies will be completed by August 31, 2017.

Responsible Party: All technical studies will be carried out by Ramboll Environ with funding provided through the Rider 7 Program. Review of all technical studies will be provided by the NETAC Technical Committee and the TCEQ.

4.1.2 Public Outreach Programs Carried out Under the Rider 7 Program

NETAC carries out a number of public outreach activities under the Rider 7 Program.

4.1.2.1 NETAC Web site

NETAC maintains a public web site to facilitate public access to air quality information and updates on technical and outreach activities (www.netac.org). The web site provides information on ozone and specific actions citizens can take to improve air quality as well as contact information for citizens who would like to become more involved in addressing local air quality issues. The web site shows TCEQ air quality forecasts for current and upcoming days and notes whether high ozone is expected in Northeast Texas during the current day or the next day. NETAC documents traffic on its web site by counting the number of times the web site is "hit" during each quarter.

4.1.2.2 Outreach to Schools

As part of its outreach to area schools, NETAC purchases and distributes approximately 40,000 school book covers to the areas school districts in the fall of every year (Figure 4-1).

Figure 4-1. Book covers distributed to TLM area school districts by NETAC.

4.1.2.3 Television/Radio Public Service Announcements

Another element of the education/outreach program is the development of television and radio public service announcements (PSAs) concerning citizen awareness and action. The PSAs air on local radio and TV stations throughout the summer and are available on the NETAC web site[25]. Public Education/Outreach funds have also been used for hosting quarterly conference calls of the Technical Advisory Committee.

4.1.2.4 Ozone Season Awareness Event

NETAC hosts an annual ozone season awareness event to increase media and public awareness of ozone air quality issues and to emphasize what the public can do to help the region meet air

[25] http://www.netac.org/493/Public-EducationOutreach.htm

quality standards. In 2016, the Ozone Season Awareness Luncheon was held on May 20, 2016 at the East Texas Council of Governments building in Kilgore, TX.

4.1.2.5 Ozone Action Days

NETAC implements an ozone action day program aimed at encouraging participation by companies and individuals to take voluntary measures that reduce ozone precursor emissions on days that are forecast by the TCEQ to have high ozone levels in Northeast Texas. NETAC describes the program as follows:

> *When a high ozone level is predicted, an ozone advisory for the next day will be issued to businesses, industry, governmental and media organizations. They, in turn, will then notify their employees and the public that the atmospheric conditions are conducive to the formation of high levels of ozone. On days when ozone advisories are issued, everyone will be asked to take certain actions to reduce emissions. These voluntary actions will help maintain our air quality[26].*

NETAC encourages citizens to take the following actions on Ozone Action Days:

- *Drive less. Organize a carpool, walk or ride your bike.*
- *Don't idle the engine of your vehicle for extended periods.*
- *Postpone filling your tank on hot, sunny days until late afternoon.*
- *Keep your car tuned up. Emissions from a poorly maintained vehicle equal that of 25 properly functioning cars.*
- *Insulate and weather-strip your home.*
- *Run dishwasher and washing machines only when there are full loads.*
- *Turn off lights and appliances when not in use.*
- *Set your thermostat between 76 and 78 degrees in the summer.*
- *When using a gas mower, wait until late evening to mow the lawn.*
- *Apply paint with rollers and brushes instead of sprays to cut down on fumes and save paint.*

NETAC encourages industry and local government to take the following actions on Ozone Action Days[26]:

- *Implement an Ozone Action Day plan.*
- *Postpone maintenance activities such as painting, lawn care or tank clean-outs until the Action Day has passed.*
- *Encourage employees to share rides or carpool.*

[26] http://www.netac.org/264/Ozone-Action-Day.htm

- *Use conference calls to avoid travel.*
- *Alter production schedules to avoid heavy production on Action Days.*
- *Coordinate voluntary efforts to reduce emissions through technological advances.*
- *Delay fleet fueling until late in the day.*
- *Restrict permits for outdoor burning.*
- *Publicize Ozone Action Days on government broadcast channels.*

These recommended actions taken by citizens, industry, and local government can reduce local emissions of ozone precursors on days where high ozone is expected. Quantification of emissions reductions from the Ozone Action Day Program is difficult due to the voluntary nature of the program and the effects on multiple emission sources types.

Schedule for Implementation: Ongoing.

Responsible Party: All public outreach programs will be implemented during 2016-2017 by NETAC with funding provided through the Rider 7 Program. Review of outreach programs will be provided by the TCEQ.

4.2 Point Source Emission Control Strategies

Operators of EGUs and petrochemical plants in the Sabine Industrial District each contributed their own assessments of planned and potential future emission controls because they have detailed knowledge of the equipment to be controlled and strategies already employed. Responses were received from America Electric Power, Luminant Power, Westlake Longview Corporation and Eastman Chemical Company. Of the respondents, Eastman Chemical and America Electric Power will be implementing planned emission reductions in time for the 2016 ozone season.

4.2.1 American Electric Power

American Electric Power (AEP) does not have any planned controls for the near future on its two EGUs (Pirkey and Knox Lee) located in the 5-county area. AEP retired Welsh Unit 2 in Titus County effective April of 2016 (Table 4-1). This reduction occurred in time for the 2016 ozone season.

Table 4-1. NOx reduction at AEP.

Unit	Emission Reduction Strategy	NOx Reduction (Tons/Day)
Welsh #2	Retired unit in April 2016.	8.3 TPD (relative to 2012 baseline)

AEP provided the responses below to NETAC requests for information on planned emission controls. (Note that the information in the text boxes below refers to the retiring of Unit #2 in the future tense because AEP supplied this information prior to April, 2016).

> SWEPCO has no planned/potential NOx or VOC emission reduction strategies planned for our facilities. Please note the Welsh Unit 2 (located in Titus County) will be retired on April 16, 2016.

DenBleyker et al. (2014) reported the following detailed response by AEP regarding Welsh Unit 2 in Titus County:

> AEP-SWEPCO will be retiring Welsh Unit 2 (located near Cason, TX, in Titus County) in **April, 2016**. The associated emissions reductions can be included in NETAC's control strategy evaluation.
>
> Below please find the annual estimates for NOx and VOC emissions (tons/year) for Welsh Unit #2 for 2010-2012.
>
> 2010 NOx=3,334.65, VOC=30.65
> 2011 NOx=3,327.10, VOC=29.51
> 2012 NOx=3,014.70, VOC=28.31

4.2.2 Luminant Power

Luminant does not have any planned controls for the near future on its one EGU (Martin Lake) located in the 5-county area. Luminant provided the following response to NETAC's 2015 request for information on planned emission controls:

> Luminant does not have authorization for any NOx or HRVOCs emission reduction projects in what we understand to be your planning horizon and we do not anticipate any such reductions from our Martin Lake facility, our only facility in the 5-county Tyler-Longview-Marshall area.

4.2.3 Sabine Industrial District

NETAC requested information on planned emissions reductions from operators at the Sabine Industrial District: Westlake Longview Corporation, Eastman Chemical, and Flint Hills Resources. The responses received from Westlake Longview Corporation and Eastman Chemical are provided below; no response was received from Flint Hills Resources.

Westlake Longview Corporation does not have any planned or potential emission controls for operations at its facility in the Sabine Industrial District. Westlake Longview Corporation provided the following response to the request for information on planned emission controls:

[Westlake Longview] does not currently have any planned or potential projects that would fall in this category.

Eastman Chemical reported on a recent low emission system that was installed at the Eastman Cogeneration Plant at its facility in the Sabine Industrial District. Eastman Chemical provided the following response to the request for information on planned emission controls:

Last year, we installed and tested PSM's FlamesheetTM Gas Turbine Combustor in Eastman Cogeneration Plant No. 1 and No. 2 Units. This system is a low turn down capable, fuel flexible, low emissions and extended durability combustion system. The system was developed in 2002 by PSM engineers, and was first rig tested in 2004 and engine tested in 2005. The 2015 installation was the first in the world commercial installation. The commissioning was successful and met all objectives. Eastman anticipates that this project will reduce NOx rate-based emissions by 25%.

Please note that with relatively low natural gas pricing and environmental regulatory pressures on the electricity market to move toward highly efficient natural gas combined cycle (NGCC) units such as Eastman Cogeneration (i.e. Clean Power Plan), Eastman Cogeneration may be called upon to increase electricity generation. Given that, it is difficult to estimate a total NOx emissions reduction for this project. However, given that this is ground-breaking technology with a fairly large reduction of lbs NOx per MWHr, we believe that this project is noteworthy.

Emission reductions have not been estimated for the Eastman Chemical project due to the difficulty in assessing emissions reductions from such a rate-based improvement project.

4.2.4 Measures Taken by Cities in the 5-County Area

In this section, we describe measures and programs enacted by TLM area cities as part of their vigorous and ongoing efforts to improve local air quality and reduce energy consumption. City government representatives contributed a written description of their current and planned programs that may benefit air quality.

4.2.4.1 City of Tyler (Smith County)

Since 1995, with the execution of the regional NETAC FAR agreement, the City of Tyler has actively participated in addressing air quality issues. Since the passage of Senate Bill 5 in 2001, the City of Tyler has implemented projects to reduce emissions resulting from City service operations. Examples include:

- 2004 Energy Efficiency Management and Modernization Phase II Program-this project consisted of upgrading HVAC systems at ten separate city facilities, facility lighting upgrades at 29 separate locations, upgrading exterior park lighting at 17 city parks, cemeteries and museums, energy management systems upgrades at 21 city facilities and the conversion of all traffic signals from incandescent to LED bulbs. As a result of these improvements, the City of Tyler has realized a 21% (4,653,640 kWh) reduction in annual electricity consumption.
- CNG Vehicle Program-In 2012, the City of Tyler entered into a public/private partnership for the installation of the CNG fueling facility and the addition of 18 light duty and 10 medium/heavy duty CNG fueled vehicles. Through the use of the CNG fueled vehicles, the City of Tyler has realized an emissions reduction of 15,552 lbs., including 81 lbs. VOC and 2,012 lbs. NOx.

NETAC used the US EPA AVoided Emissions and geneRation Tool (AVERT) to estimate emission benefits resulting from the implementation of energy efficiency and renewable energy policy and programs[27] (Grant et al., 2015b). AVERT is used to estimate emission reductions from EGUs based on estimates of electricity consumption reductions. Estimates of electricity use reductions were available for the City of Tyler energy efficiency measures. Reductions were not able to be calculated in AVERT for other city's measures because estimates of actual energy usage reductions were not available.

The City of Tyler 2004 Energy Efficiency Management and Modernization Phase II Program was estimated to reduce electricity consumption by 4,654 MWh annually. NOx emission reductions of 1.7 tons per year were estimated by AVERT for the Texas Reliability Entity (Figure 4-2).

The next Phase of the City of Tyler's ongoing Energy Management and Modernization Program is estimated to reduce electricity consumption by 1,134 MWh annually. NOx emission reductions of 0.4 tons per year were estimated by AVERT for the Texas Reliability Entity (Figure 4-2).

[27] http://epa.gov/avert/

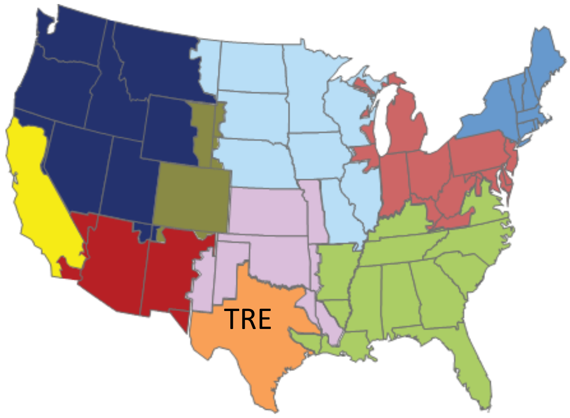


Figure 4-2. AVERT Region Definitions (Texas Reliability Entity (TRE) is shaded in orange).

4.2.4.1.1 Future Programs

The City of Tyler is currently evaluating the next phase of its ongoing Energy Management and Modernization Program, which includes re-commissioning the return sludge activation process at one wastewater treatment plant, installation of high efficiency blowers at three treatment facilities, variable frequency drives for high volume pump motor replacements, space lighting retrofit and the installation of a biogas cogeneration system. The energy savings associated with the proposed projects are projected to be 1,134,000 kWh or a 16% reduction in electricity consumption.

The City of Tyler continues to participate in NETAC.

4.2.4.2 City of Longview (Gregg County)

The City of Longview, Texas has been working diligently since 2001 with the passage of Senate Bill 5, to design projects and manage operations in order to reduce emissions caused by the operations of our various services. These efforts have continued through the enactments of both Senate Bill 12 and Senate Bill 898. From 2001-2006, the City cut energy use by 46% saving more than 215 million kilowatt hours per year.

Below we provide examples of earlier projects and their current status:

- Replacement of equipment with energy-efficient and/or Energy-Star rated whenever possible or practical. This is on-going.
- Installation of energy saving devices such as timers and motion switches whenever possible and practical. On-going initiative.
- Installing LED traffic lights throughout the City. Complete.
- Replaced incandescent with compact fluorescent bulbs, replaced magnetic ballasts with electronic ballasts, and converted fluorescent fixtures from T-12 to T-8. Complete.
- Installed energy efficient windows in constructed or remodeled buildings whenever possible. On-going.

- Total renovation of swimming pools included installation of high efficiency electric motors on centrifugal pumps. Complete.

In 2009, the U.S. Department of Energy, through the President's American Recovery and Reinvestment Act's Energy Efficiency and Conservation Block Grant Program, provided $781,900 to the City of Longview. The City's programs which were approved through the process included:

- A CFL / Incandescent bulb swap program allowed the City to purchase 14,968 FE151S-19W 2700K mini-spiral, 10,000 hour CFL and citizens "traded in" 4 60 watt incandescent bulbs in return for 4 CFL. 3742 households were impacted with an estimated Life Cycle Air Pollution reduction of 12,923,933 lbs. of CO2. Complete
- The installation of technology to reduce, capture and to the maximum extent practicable use methane and other greenhouse gases generated by Wastewater Plant Digesters. The 65kW Biogas Capstone Micro Turbine provides for the energy / electricity generated to be routed back to the Wastewater Treatment Plant grid or to be sold back to AEP / SWEPCO. Energy savings continue.
- The retrofitting of Blowers at the Wastewater Treatment Plant with high efficiency blowers. Valve actuators were added to allow the redundant blower #3 to switch back and forth between aeration subsystems and the master control panel. Savings continue.

Other Projects / Programs:

- During Ozone Season (May 1-September 30) each year, when TCEQ issues "Ozone Action Days," City Crews are instructed to avoid grounds maintenance activities and to not fill-up vehicles due to continuing concerns about air quality. On-going.
- Relamping Street Lights / Parking Lot Lights / Park Security Lighting with more energy efficient technology as need is identified and funding becomes available: examples: Downtown Street lighting on Tyler and Fredonia Street (from Metal Halide to Induction Fixtures,) Cotton Street Parking Lots and converting the picnic pavilion at Flewellen Park to solar. The Fredonia Street relamping project in 2013, per the SWEPCO Commercial Solutions Program is saving 37.4 Metric tons of carbon dioxide equivalent. This program is on-going and is based on funding availability.
- Relamping (ballasts and bulbs) the Fire Training Center and Convention Center Exhibit Building provided incentive payments from SWEPCO of $7,496.43 and $3,652.87 respectively and combined, reduced kW usage by more than 11.
- HVAC decisions are also impacted by the need to reduce energy consumption: the replacement of the Library's Air-Cooled Chiller provided an incentive of $1,227.00. On-going.
- Replacing 200 standard desktop computers (180 watt) with 200 "zero-clients" (36 watt) for an estimated savings of 28,800 watts of comparative use. Energy efficient

technology decisions are on-going with such items as copiers, scanners and replacing desk-top printers with networked printers in office situations.

In FY 2013-14, the following significant actions were implemented:

- The City purchased 8 Heil Multipack CNG Sanitation Trucks and initiated once a week pick up of both refuse and recycling for the 23,000 + sanitation customers in Longview. When comparing the new vehicles and routes to the former collection program, there is an estimated 51.7% reduction in CO_2 emissions.
- The Longview City Council approved the 2011 National Electrical Code (NEC) and the 2012 International Building Code which impact development standards for both new construction and renovation / remodeling. Both codes provide for improved energy efficiency. There are no estimates on emission reductions.

Additionally, the City's Standard Operating Policies call for considering energy efficiency ratings along with final costs when making purchasing / construction decisions. The City of Longview is fully aware of the critical need to continue to reduce emissions and the City's Interdepartmental "Operations Lights Out" Team is tasked with keeping this issue in front of decision makers and co-workers. Simple initiatives like considering energy efficiency ratings along with final cost combine to allow for optimal decisions.

4.2.4.3 City of Henderson (Rusk County)

The City of Henderson has implemented the following Ozone Action Plan. These measures should be implemented immediately during the Ozone season of May through September with no significant impact on cost or productivity. Individual divisions will utilize the guidelines and determine how they can best be applied in specific areas of the City's operations.

- Turn off lights and equipment to reduce power load when not in use.
- Consider work schedules that will reduce equipment and vehicle usage in the morning hours.
- Delay fueling of vehicles until the advisory is over. If fueling is necessary, do so in the late afternoon or early evening. Avoid overfilling the tank and allowing fuel to spill onto the ground.
- Limit vehicle trips as much as possible. Coordinate activities to avoid duplication of trips. If possible, schedule trips for afternoons.
- Avoid idling vehicles unnecessarily.
- Emphasize need to keep vehicles properly maintained to reduce pollutants.
- Schedule the use of heavy equipment for non-ozone action days.
- Limit use of weed eaters, tractors, lawn mowers and power tools. Defer use to afternoon, if possible or delay non-essential use to a non-action day.

The City of Henderson has also implemented energy efficiency programs. The City of Henderson has dedicated itself to reducing energy consumption and complying with Texas

Senate Bill No. 12 and House Bill No. 3693. These bills require municipalities to reduce energy consumption by 5% each year, over the next 6 years. A team of employees has been comprised to monitor, educate, and implement ways to reduce energy use for local government. All municipal building remodeling/retrofitting is incorporated using energy savings techniques as required by energy code standards.

The City will strive to reduce energy usage by purchasing energy efficient equipment, retrofitting existing facilities to maximize the facilities' efficiency and effectiveness from the standpoint of energy use. Educate our directors and employees on day-to-day procedures that reduce energy consumption.

Under the provisions of this plan, the City will:

- Conduct preliminary energy audits to identify ways to eliminate and/or minimize energy waste.
- Using information derived from the energy audits to schedule a detailed Utility Assessment Report to determine precise energy-reducing initiatives that can be implemented by the City.
- Research and utilize agencies that provide programs on energy efficiency improvements and invest in remodeling/retrofitting projects for long term savings.
- Ensure that the construction of all new offices meets energy standards established by State Statutes
- Adopt a campaign to educate employees on ways to reduce energy consumption without sacrificing operational effectiveness or personal comfort.

4.2.5 Airport Measures

NETAC requested information on planned emissions reductions from operators of major airports in the TLM area. A response was received from the East Texas Regional Airport in Gregg County. The East Texas Regional Airport operations director (Bradley Kranzman, personal communication, 2015) indicated that the following energy efficiency measures were implemented as part of a terminal renovation which took place from 2013 to the summer of 2015.

1. Decreased combustion gases and increased efficiency by replacing the boilers. The existing atmospheric boiler was replaced with high efficiency condensing boilers. The new boilers modulate to meet the building load rather than running at full load.

2. Replaced the multi-zone air handler system with a VAV air handler system. This increased energy efficiency due to decreased motor speeds and varying the cooling and heating capacity of the system based on building load rather than just turning the system on.

> 3. Integrated a building management system to allow full control of the HVAC system. Scheduling and zone control for better efficiency.
>
> 4. Day lighting controls were installed.

In the future, the Airport will be evaluating ways to integrate electrically powered maintenance equipment into their fleet (Bradley Kranzman, personal communication, 2015).

4.3 Flint Hills SEP

In 2013, as part of a penalty for violations at the Flint Hills Resources Polymer facility in Harrison County, TCEQ created a Supplemental Environmental Project (SEP)[28]. This SEP, in the amount of $287,000 is called the Clean Buses Project and was specified for use in Harrison County to "retrofit older diesel buses with lower emissions or clean fuel technology in order to reduce air emissions and to purchase lower-emission buses that are model year 2010 or newer to public school districts or public charter schools, and replace a diesel bus that is model year 2006 or older"[28].

The Texas Association of Resource Conservation & Development Areas Inc. (RC&D) oversees the Clean Buses Project. According to the Texas RC&D (2015), the project funds will be used to fund replacement of four buses, two in each of the following school districts: Elysian Fields Independent School District and Waskom Independent School District. Detailed information was not available on the model year of the buses that were being purchased or being replaced.

Emission reductions from bus replacement will vary based on many factors including the model year of the bus that was replaced, the model year of the new bus, and the annual usage of the new and the replaced bus.

Table 4-2 shows the range of potential emission reduction estimates by model year based on MOVES2014 model emission rates for diesel powered school buses. The following assumptions were made to develop the estimates shown in Table 4-2: (1) the new bus is model year 2015, (2) the replaced bus, (3) the new bus has an annual activity of 10,000 miles per year, and (4) the bus is operated for 180 school days per year. Based on these assumptions, NOx emissions reductions of 0.21 to 0.79 tons/year and 0.0011 and 0.0044 tons/day are estimated from all four buses to be replaced as part of this project.

[28] Enforcement Matter – Case No. 47996, Flint Hills Resources Polymers, LLC, RN101618759, Docket No. 2013-2149-AIR-E

Table 4-2. NOx emission reductions resulting from SEP school bus replacement.

Model Year	NOx Emission Rate [g/mile]	NOx Emissions/ bus[a] [tons/year]	NOx Emissions Reduction[b] (one bus) [tons/year]	NOx Emissions Reduction[b] (one bus) [tons/day][c]	NOx Emissions Reduction[b] (four buses) [tons/year]	NOx Emissions Reduction[b] (four buses) [tons/day][c]	Cost Effectiveness ($/ton NOx)	Annual Cost Effectiveness ($/ton NOx/year)
1985-1989	18.39	0.20	0.20	0.0011	0.79	0.0044	$ 36,468	$ 364,676
1990	14.20	0.16	0.15	0.0008	0.60	0.0033	$ 47,645	$ 476,447
1991	13.19	0.15	0.14	0.0008	0.56	0.0031	$ 51,473	$ 514,729
1992-1995	13.19	0.15	0.14	0.0008	0.56	0.0031	$ 51,473	$ 514,729
1996-1997	13.23	0.15	0.14	0.0008	0.56	0.0031	$ 51,303	$ 513,035
1998	12.53	0.14	0.13	0.0007	0.53	0.0029	$ 54,280	$ 542,802
1999-2002	6.75	0.07	0.07	0.0004	0.27	0.0015	$ 104,886	$ 1,048,861
2003-2006	5.21	0.06	0.05	0.0003	0.21	0.0011	$ 139,589	$ 1,395,885
2007-2009	2.65	0.03						
2010-2011	0.86	0.01						
2012	0.56	0.01						
2013	0.55	0.01						
2014-2015	0.54	0.01						

[a] Assumes 10,000 miles driven by each bus, annually.
[b] Assumes replacement with 2015 model year bus.
[c] For school days only; assumes buses are limited to 180 days of operation per year.

5.0 REFERENCES

Alvarez, S., J. Flynn, G. Zanin, M. Shauck, B. Lefer, and B. Rappengluck, 2006a. "Northeast Texas Air Care (NETAC) 2005 Air Quality Study." Baylor Aircraft-Based Air Quality Measurement Data Atlas. Prepared for ENVIRON Corporation, Novato, CA.

Alvarez, S., J. Flynn, M. Shauck, G. Zanin, B. Lefer, and B. Rappengluck, 2006b. "Northeast Texas Air Care (NETAC) 2005 Air Quality Study." Measurement Adjustment Report for Baylor Aircraft-Based Air Quality Measurements. Prepared for ENVIRON Corporation, Novato, CA.

Alvarez, S., T. Compton, L. Kauffman, G. Zanin, M. Shauck, and M. Buhr, 2007. Northeast Texas Air Care (NETAC) 2006 Air Quality Study: Baylor Aircraft-Based Air Quality Measurement Data Atlas. Prepared for Environ, Novato, CA. June.

Alvarez, Y., T. Shah, A. Bar-Ilan, C. Lindhjem, S. Kemball-Cook and G. Yarwood. 2013. "Gas Compressor Engine Study for Northeast Texas: 2011 Update." Prepared for the East Texas Council of Governments, Kilgore, TX. January.

Berlin, S., A.O. Langford, M. Estes, M. Dong and D.D. Parrish. 2013. Magnitude, Decadal Changes, and Impact of Regional Background Ozone Transported into the Greater Houston, Texas, Area. *Env. Sci. Tech*. 47, 13,985−13,992. dx.doi.org/10.1021/es4037644.

Breitenbach, P., 2010. Episode selection for the proposed 2010 standard (June 2006 Texas Ozone Episode). Presentation to the Texas Near Non-Attainment Areas. May 27.

Buhr, M. S. Alvarez, J. Flynn III, S. Higgs, G. Zanin, and M. Shauck, 2003. Northeast Texas Air Care (NETAC) 2002 Air Quality Study: Baylor aircraft-based air quality measurement Data Atlas. September.

Draxler and Rolph, G.D. 2013. Real-time Environmental Applications and Display sYstem (READY) Website (http://www.ready.noaa.gov). NOAA Air Resources Laboratory, College Park, MD.

DenBleyker, A., 2012. Heavy-Duty Truck Extended Idle Activity in Northeast Texas. Prepared for the East Texas Council of Governments. 3800 Stone Road, Kilgore, TX, 75662. November.

DenBleyker, A., Y. Alvarez, A. Bar-Ilan, S. Kemball-Cook and G. Yarwood, 2013. "Haynesville Shale Mobile Sources Emission Inventory." Prepared for the East Texas Council of Governments, Kilgore, TX. December.

Cooper, O. 2012. "Western ozone trends, 1990-2010". Presentation to WESTAR Council & the University of Nevada Conference on Western Ozone Transport. October. http://www.westar.org/12%20Tech%20Conf/Presentations/Cooper.pdf.

Energy Information Administration (EIA), 2011a. Texas Heat Wave, August 2011: Nature and Effects of an Electricity Supply Shortage. September. Accessed online at: http://www.eia.gov/todayinenergy/detail.cfm?id=3010.

Energy Information Administration (EIA), 2011b. Annual Energy Outlook 2011. April. Accessed online at: http://www.eia.gov/forecasts/archive/aeo11/pdf/0383(2011).pdf.

Energy Information Administration (EIA), 2012. Annual Energy Outlook 2012. Release Date: June 25, 2012. Accessed online at: http://www.eia.gov/forecasts/archive/aeo12/.

Energy Information Administration (EIA), 2013. Drilling Productivity Report. Release Date: November 12, 2013. Accessed online at: http://www.eia.gov/petroleum/drilling/.

Estes, M., S. Berlin, A. Langford, M. Dong, J. Smith, F. Mercado, D. Parrish. 2014. "Regional background ozone in Texas: Recent research and future needs". Presented to NASA AQAST Meeting, Rice University, January 16. http://acmg.seas.harvard.edu/presentations/aqast/jan2014/Jan16_AM/JAN16_AM0915_estes_bkgdO3_aqast_jan2014.pptx.

ENVIRON. 2014. "The User's Guide to the Comprehensive Air Quality Model with Extensions Version 6.10" Available from Environ International Corporation, 773 San Marin Drive, Novato, CA. 94998 and at http://www.camx.com.

EPA. 2006. "Air Quality Criteria for Ozone and Related Photochemical Oxidants. http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=149923#Download. Accessed December 2014.

EPA, 2010a. User Guide for MOVES2010a, Assessment and Standards Division, Office of Transportation and Air Quality, U.S. Environmental Protection Agency, August 2010. EPA-420-B-10-036

EPA, 2010b. "Motor Vehicle Emission Simulator (MOVES) User Guide for MOVES 2010b". http://www.epa.gov/otaq/models/moves/documents/420b12001b.pdf.

EPA. 2014. Draft Modeling Guidance for Demonstrating Attainment of Air Quality Goals for Ozone, PM2.5, and Regional Haze http://www.epa.gov/ttn/scram/guidance/guide/Draft_O3-PM-RH_Modeling_Guidance-2014.pdf. December.

Friesen, R. and G. Yarwood. 2007. Summary Report: Continued Testing of Emission Control Systems for Gas Compressor Engines in Northeast Texas. Prepared for the East Texas Council of Governments. 3800 Stone Road, Kilgore, TX, 75662.

Grant, J., L. Parker, A. Bar-Ilan, S. Kemball-Cook, and G. Yarwood, 2009. Development of Emissions Inventories for Natural Gas Exploration and Production Activity in the Haynesville Shale. Prepared for the East Texas Council of Governments. 3800 Stone Road, Kilgore, TX, 75662. http://www.netac.org/UserFiles/File/NETAC/9_29_09/Enclosure_2b.pdf.

Grant, J., S. Kemball-Cook, and G. Yarwood, 2010. Review of TCEQ 2005 and 2008 Area and Off-Road Emission Inventories. Memorandum to the East Texas Council of Governments, Kilgore, TX. September.

Grant, J. S. Kemball-Cook, and G. Yarwood, 2013. Review of Emissions for the East Texas Council of Government Area: Point, Off-road and Area Sources. Prepared for the East Texas Council of Governments. 3800 Stone Road, Kilgore, TX, 75662. December.

Grant, J., R. Parikh, S. Kemball-Cook and G. Yarwood. 2014. Review of Emissions for Northeast Texas: Point, Off-road and Area Sources. Prepared for: The East Texas Council of Governments, 3800 Stone Road, Kilgore, TX, 75662. December.

Grant, J., Y. Alvarez, R. Parikh, L. Huang, A. Bar-Ilan, S. Kemball-Cook and G. Yarwood. 2015. Emissions from Oil and Gas Exploration and Production in Northeast Texas. Prepared for: The East Texas Council of Governments, 3800 Stone Road, Kilgore, TX, 75662. October.

Guenther, A. B., X. Jiang, C. L. Heald, T. Sakulyanontvittaya, T. Duhl, L. K. Emmons, and X. Wang, 2012. The Model of Emissions of Gases and Aerosols from Nature version 2.1 (MEGAN2.1): an extended and updated framework for modeling biogenic emissions, *Geosci. Model Dev*., 5(6), 1471-1492.

Jobson, T. and S. Pressley, 2009. Reactive Alkene Monitoring at CAMS19, Longview, Texas. Final Report. Prepared for ENVIRON International Corporation, 773 San Marin Drive, Novato, CA 94998. April.

Jobson, T. and S. Pressley, 2011. "Event Triggered Can Sampling and Total Alkene Monitoring at CAMS19, Longview, TX: Final Report". Prepared for ENVIRON International Corporation, 773 San Marin Drive, Novato, CA 94998. May.

Johansson, J., Mellqvist, J., Samuelsson, J., Offerle, B., Rappenglück, B., Anderson, D., Lefer, B., Alvarez, S. and Flynn, J. (2011), Quantification of industrial emissions of VOCs, NO2 and SO2 by SOF and Mobile DOAS, AQRP Project 10-006, AQRP report., Texas.

Johansson, J., J. Mellqvist, B. Lefer, and J. Flynn, 2012. "SOF HRVOC emission study at Longview, Texas". Prepared for the East Texas Council of Governments. June.

Johnson, J., B. Koo, A. Wentland, J. Jung, W. Hsieh, S. Kemball-Cook and G. Yarwood. 2015. "Photochemical Modeling of June 2012 for Northeast Texas". Prepared for the East Texas Council of Governments. 3800 Stone Road, Kilgore, TX, 75662. December.

Kemball-Cook., S. and G. Yarwood. 2008. "Analysis of the November 3, 2006 Baylor Aircraft Flight over Northeast Texas." Prepared for East Texas Council of Governments, Kilgore, TX. March.

Kemball-Cook., S. and G. Yarwood. 2010a. "Conceptual Model of Ozone Formation in the Tyler/Longview/Marshall Near Nonattainment Area." Prepared for East Texas Council of Governments, Kilgore, TX. March.

Kemball-Cook., S. and G. Yarwood. 2010b. "Conceptual Model of Ozone Formation in the Tyler/Longview/Marshall Near Nonattainment Area." Prepared for East Texas Council of Governments, Kilgore, TX. October.

Kemball-Cook, S., J. Jung, W. Santamaria, J. Johnson, E. Tai, M. Jimenez, and G. Yarwood. 2010c. “Modeling Northeast Texas Ozone of 2005 and 2012”. Prepared for the East Texas Council of Governments, Kilgore, TX. March.

Kemball-Cook, S., A. Bar-Ilan, J. Grant, L. Parker, J. Jung, W. Santamaria, J. Mathews, and G. Yarwood. 2010d. “Ozone Impacts of Natural Gas Development in the Haynesville Shale.” *Environ. Sci. Technol.*, 44 (24), 9357-9363.

Kemball-Cook, S., L. Parker, Y. Alvarez, T. Pavlovic and G. Yarwood. 2013a. “Conceptual Model of Ozone Formation in the Tyler/Longview/Marshall Near Nonattainment Area-2012 Update”. Prepared for the East Texas Council of Governments, Kilgore, TX. January.

Kemball-Cook, S., L. Parker, Y. Alvarez, T. Pavlovic and G. Yarwood. 2014a. “Conceptual Model of Ozone Formation in the Tyler/Longview/Marshall Near Nonattainment Area-2013 Update”. Prepared for the East Texas Council of Governments, Kilgore, TX. January.

Kemball-Cook, S., J. Johnson, M. Jimenez and G. Yarwood. 2013b. “CAMx Modeling of 2005 and 2006 Ozone Episodes for Northeast Texas.” Prepared for the East Texas Council of Governments, Kilgore, TX. February.

Kemball-Cook, S., J. Johnson, M. Jimenez and G. Yarwood. 2014b. “CAMx Modeling of 2005 and 2006 Ozone Episodes for Northeast Texas: FY13 Modeling.” Prepared for the East Texas Council of Governments, Kilgore, TX. February.

Kleinman, L. I., P. H. Daum, D. Imre, Y.-N. Lee, L. J. Nunnermacker, S. R. Springston, J. Weinstein-Lloyd, and J. Rudolph, 2002. Ozone production rate and hydrocarbon reactivity in 5 urban areas: a cause of high ozone concentration in Houston. *Geophys. Res. Lett. 29*, 1467-1470.

Parikh, R., J. Grant, S. Bhat, A. Bar-Ilan, S. Kemball-Cook and G. Yarwood. 2013.”Emissions from Natural Gas Exploration and Production Activity in the Haynesville Shale.” Prepared for the East Texas Council of Governments, Kilgore, TX. January.

Parker, L., S. Kemball-Cook, T. Pavlovic and G. Yarwood. 2015. “Conceptual Model of Ozone in the Tyler-Longview-Marshall Near Non-Attainment Area: 2015 Update”. Prepared for the East Texas Council of Governments, Kilgore, TX. December.

Parrish, D.D., D. B. Millet, and A. H. Goldstein, 2009. Increasing ozone in marine boundary layer inflow at the west coasts of North America and Europe. *Atmos. Chem. Phys*., *9*, 1303–1323.

Parrish, D.D. and J.-F. LaMarque, 2010. Understanding Historical Ozone Trends at Northern Mid-Latitudes. Presentation to the 19th International Emission Inventory Conference. September, 2010.

Pollution Solutions, 2006. Tyler/Longview/Marshall Flexible Attainment Region. Special Study Relating to Oil and Gas Production. 2005 Emissions from Compressor Engines. Draft Report. Prepared for North East Texas Air Care. October, 2006.

Pollution Solutions, 2008. Tyler/Longview/Marshall Flexible Attainment Region. Special Study Relating to Oil and Gas Production. 2005 and 2007 Emissions from Compressor Engines with Consideration for Load Factor. Prepared for North East Texas Air Care. August 29, 2008.

Stoeckenius, T. and G. Yarwood, 2004. Conceptual Model of Ozone Formation in the Tyler/Longview/Marshall Near Nonattainment Area. Prepared for the East Texas Council of Governments. 3800 Stone Road, Kilgore, TX, 75662. January, 2004.

Skamarock, W. C., J. B. Klemp, J. Dudhia, D. O. Gill, D. M. Barker, W. Wang, and J. G. Powers. 2005. "A description of the Advanced Research WRF Version 2". NCAR Tech Notes-468+STR. http://www.mmm.ucar.edu/wrf/users/docs/arw_v2.pdf.

Texas Commission on Environmental Quality (TCEQ). 2010. "Emissions Modeling for the HGB Attainment Demonstration SIP Revision for the 1997 Eight-Hour Ozone Standard," March, 2010. http://www.tceq.state.tx.us/assets/public/implementation/air/sip/hgb/hgb_sip_2009/09017SIP_ado_Appendix_B.pdf.

TCEQ Rider 7/8 Site, TCEQ Rider 8 Program Modeling Files available from: http://www.tceq.texas.gov/airquality/airmod/rider8/rider8Modeling. Accessed Fall 2013.

Texas Commission on Environmental Quality (TCEQ), 2013. Stationary Source Rules for Northeast Texas Area. Controlling Ozone Pollution. Accessed online at: http://www.tceq.texas.gov/airquality/stationary-rules/netx.

Texas A&M Transportation Institute (TTI), 2013. Development and Production of State-wide, Non-Link-Based On-road Mobile Source MOVES Emissions Inventories. Prepared for Texas Commission on Environmental Quality. August.

Thomson Reuters, 2013. Luminant to shut 3rd Texas coal unit, citing low power prices. September 17. Accessed online at: http://www.reuters.com/article/2013/09/17/utilities-luminant-martinlake-idUSL2N0HD21Q20130917.

Vijayaraghavan, K. , C. Lindhjem, A. DenBleyker, U. Nopmongcol, J. Grant, E. Tai, and G. Yarwood, 2012. Effects of light duty gasoline vehicle emission standards in the United States on ozone and particulate matter. *Atmospheric Environment*. *60*,109-120.

Yarwood, G., J. Samuelsson, J. Johansson, J. Mellqvist, P. Andersson and J. Flynn. 2015. Controlled ethylene release study to evaluate the SOF method. Prepared for the Texas Commission on Environmental Quality. December. https://www.tceq.texas.gov/assets/public/implementation/air/am/contracts/reports/oth/Controlled_ethylene_release_blind_test_2015_15121.pdf.

APPENDIX A

Day-Specific Emissions Data Provided by the Sabine Industrial District Operators for the Period of the NETAC 2015 SOF Study

Appendix A. Day-Specific Emissions Data Provided by the Sabine Industrial District Operators for the Period of the NETAC 2015 SOF Study

In this Appendix, we present data provided by Eastman Chemical, Flint Hills Resources and the Westlake Chemical Corporation for March 31-April 11, 2015, the period of the NETAC Solar Occultation Flux (SOF) Study in the Sabine Industrial District (SID). Emissions data tables are presented as well as information supplied by the Operators along with the data.

5.1 Emissions Data Provided by Eastman Chemical Company in the Sabine Industrial District.

The text below was provided in a 4/14/16 email from Shellie Dalby of Eastman Chemical Company, Texas Operations Environmental Affairs transmitting day-specific Eastman emissions data for the period of the 2015 SOF Study. Emissions in lbs/day (PPD) in the table below were provided by Eastman, and emissions rates in tons per day (tpd) were calculated by Ramboll Environ from the data supplied by Eastman.

<u>2015 SOF-Specific Emissions Inventory Information</u>:
Environmental personnel at Eastman have provided a time-specific emissions inventory based on TCEQ emissions inventory protocols. Due to time constraints, emission inventory calculations specific to the March 31 – April 11, 2015 time period were not completed for *all* EPNs[29] at this plant site. Rather, we used the following protocol to provide the information in the following table:

(1) From 2015 AEI information, identify the top 90 percentile emitters.
(2) Complete TCEQ emissions inventory protocol calculations on each of the top emitters for the March 31 – April 11 time period.
(3) Add to that top emitter ppd emissions the average ppd emissions from the other emitters.

Also, below, please find in the “Comments” field notes that may be helpful in understanding varying ppd rates

[29] An EPN (emissions point number) is a label that uniquely identifies a given emission point.

Table A-1. Eastman day-specific emissions in PPD provided by Shellie Dalby of Eastman Chemical on 4/14/16.

Date	Emissions (PPD)			Emissions (tpd)			Comments
	Ethene	Propene	NOx	Ethene	Propene	NOx	
Average Daily	3,273.73	1,297.45	12,590.47	1.64	0.65	6.30	
3/31/2015	3,168.31	1,339.92	13,073.47	1.58	0.67	6.54	
4/1/2015	3,168.31	1,339.92	13,073.47	1.58	0.67	6.54	
4/2/2015	3,168.31	1,339.92	13,073.47	1.58	0.67	6.54	
4/3/2015	3,168.31	1,339.92	13,073.47	1.58	0.67	6.54	
4/4/2015	3,168.31	1,339.92	13,073.47	1.58	0.67	6.54	
4/5/2015	3,168.31	1,339.92	13,073.47	1.58	0.67	6.54	
4/6/2015	3,168.31	1,339.92	13,073.47	1.58	0.67	6.54	
4/7/2015	3,547.31	1,326.92	12,001.50	1.77	0.66	6.00	A shutdown occurred on this day on one of our cracking plants.
4/8/2015	4,774.31	1,215.92	11,889.60	2.39	0.61	5.94	One cracking plant was shut down for this time period. Additionally, we had an off-gas stream vent to the air (fully permitted).
4/9/2015	2,928.31	1,215.92	11,889.60	1.46	0.61	5.94	One cracking plant was shut down for this time period.
4/10/2015	2,928.31	1,215.92	11,889.60	1.46	0.61	5.94	One cracking plant was shut down for this time period.
4/11/2015	2,928.31	1,215.92	11,889.60	1.46	0.61	5.94	One cracking plant was shut down for this time period.

5.2 Emissions Data Provided by Flint Hills Resources in the Sabine Industrial District.

The text below was provided in a 4/15/16 email from Mark McMahon, Environmental Health and Safety Manager of Flint Hills Resources Longview, LLC, transmitting day-specific Flint Hills emissions data for the period of the 2015 SOF Study. Emissions in lbs/day (PPD) in the table below were provided by Flint Hills, and emissions rates in tons per day (tpd) were calculated by Ramboll Environ from the data supplied by Flint Hills.

2015 SOF-Specific Emissions Inventory Information:
The estimates below were derived from the plant's emission inventory tracking that is conducted on a monthly basis. Average April 2015 normal emissions data was used and prorated to a daily basis and specific MSS[30] events were added to those days. It was verified with plant data that using this method would be consistent as no anomalous upsets occurred during the March 31 – April 11, 2015 time period. Ethylene is only processed periodically in the plant depending on product—the breakdown between ethylene and propylene estimates below is based on overall throughput percentage, consistent with our emission inventory assumptions.

Table A-2. Flint Hills day-specific emissions in PPD provided by Mark McMahon of Flint Hills Resources on 4/15/16.

Date	Emissions (PPD)			Emissions (tpd)			Comments
	Ethene	Propene	NOx	Ethene	Propene	NOx	
Average Daily	6.5	574	28.00	0.003	0.287	0.014	
3/31/2015	6.5	544	28	0.003	0.272	0.014	
4/1/2015	6.5	544	28	0.003	0.272	0.014	
4/2/2015	6.5	557	28	0.003	0.279	0.014	Permitted MSS event on this day
4/3/2015	6.5	544	28	0.003	0.272	0.014	
4/4/2015	6.5	544	28	0.003	0.272	0.014	
4/5/2015	6.5	544	28	0.003	0.272	0.014	
4/6/2015	6.5	544	28	0.003	0.272	0.014	
4/7/2015	6.5	553	28	0.003	0.277	0.014	Permitted MSS event on this day
4/8/2015	6.5	877	28	0.003	0.439	0.014	Permitted MSS event on this day
4/9/2015	6.5	544	28	0.003	0.272	0.014	
4/10/2015	6.5	544	28	0.003	0.272	0.014	
4/11/2015	6.5	544	28	0.003	0.272	0.014	

[30] MSS is maintenance/startup/shutdown.

5.3 Emissions Data Provided by Westlake Chemical Corporation in the Sabine Industrial District.

The text below was provided in a 4/26/16 email from Eddy Killingsworth of Westlake Chemical Corporation transmitting day-specific Westlake emissions data for the period of the 2015 SOF Study. Emissions in lbs/day (PPD) in the table below were provided by Westlake, and emissions rates in tons per day (tpd) were calculated by Ramboll Environ from the data supplied by Westlake.

Table A-2. Westlake day-specific emissions in PPD provided by Eddy Killingsworth of Westlake Chemical Corporation on 4/26/16.

Date	Emissions (PPD)			Emissions (tpd)			Comments
	Ethene	Propene	NOx	Ethene	Propene	NOx	
Average Daily	2,665		2,254	1.33		1.13	
03/31/15	2,659		2,795	1.33		1.40	
04/01/15	2,681		2,678	1.34		1.34	
04/02/15	2,681		2,678	1.34		1.34	
04/03/15	2,699		2,678	1.35		1.34	
04/04/15	2,699		2,678	1.35		1.34	
04/05/15	2,696		2,678	1.35		1.34	
04/06/15	2,646		2,678	1.32		1.34	
04/07/15	2,706		2,678	1.35		1.34	
04/08/15	2,715		2,678	1.36		1.34	
04/09/15	2,678		2,678	1.34		1.34	
04/10/15	2,559		75	1.28		0.04	PE-1 facilities shut down for turn-around
04/11/15	2,559		75	1.28		0.04	PE-1 facilities shut down for turn-around