REVISIONS TO THE STATE OF TEXAS AIR QUALITY IMPLEMENTATION PLAN FOR THE CONTROL OF OZONE AIR POLLUTION

DALLAS-FORT WORTH EIGHT-HOUR OZONE NONATTAINMENT AREA

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY
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DALLAS-FORT WORTH ATTAINMENT DEMONSTRATION SIP REVISION FOR THE 1997 EIGHT-HOUR OZONE STANDARD NONATTAINMENT AREA

Project Number 2010-022-SIP-NR

Adoption
December 7, 2011

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EXECUTIVE SUMMARY

The United States Environmental Protection Agency (EPA) published a final determination of failure to attain and reclassification of the Dallas-Fort Worth (DFW) area from a moderate to a serious nonattainment area for the 1997 eight-hour ozone National Ambient Air Quality Standard (NAAQS) (75 *Federal Register* 79302) effective on January 19, 2011. The DFW nine-county nonattainment area includes Collin, Dallas, Denton, Ellis, Johnson, Kaufman, Parker, Rockwall, and Tarrant Counties. The EPA set January 19, 2012, as the deadline for Texas to submit a state implementation plan (SIP) revision addressing the serious ozone nonattainment area requirements of the 1990 Federal Clean Air Act (FCAA) Amendments. The area's 2010 eight-hour design value was 86 parts per billion (ppb). The DFW area must attain the 1997 eight-hour ozone standard of 0.08 parts per million (or no greater than 84 ppb) as expeditiously as practicable but no later than the attainment date of June 15, 2013. Because the attainment date is early in the 2013 ozone season, the EPA has prescribed that the modeling attainment test be applied to the previous complete ozone season. Thus, 2012 is the attainment year used in the ozone modeling.

This AD SIP revision includes base case modeling of a representative eight-hour ozone exceedance episode that occurred during June 2006. In general, the model performance evaluation of the 2006 base case indicates the modeling is suitable for use in conducting the modeling attainment test. The modeling attainment test was applied by modeling a 2006 baseline year and 2012 future year to project 2012 eight-hour ozone design values. Based on the results of the modeled attainment test, no regulatory monitors in the DFW area are projected to have 2012 eight-hour ozone design values greater than the 1997 eight-hour ozone NAAQS.

Table ES-1: *Summary of 2006 Baseline and 2012 Future Year Anthropogenic Modeling Emissions for DFW* lists the anthropogenic modeling emissions in tons per day (tpd) by source category for the 2006 baseline and 2012 future year for nitrogen oxides (NO_X) and volatile organic compounds (VOC), ozone precursors. The differences in modeling emissions between the 2006 baseline and the 2012 future year reflect the net of growth and reductions from existing controls. The existing controls include both state and federal measures that have already been promulgated.

Table ES-1: Summary of 2006 Baseline and 2012 Future Year Anthropogenic Modeling Emissions for DFW

Category	2006 NO_X tpd	2012 NO_X tpd	2006 VOC tpd	2012 VOC tpd
On-Road Mobile (MOVES2010a)	259	181	111	80
Non-Road (excl. Oil & Gas Drilling)	85	64	60	43
Off-Road	40	37	7	6
Stationary Point Source	51	51	41	39
Area (excl. Oil & Gas)	16	18	213	240
Oil & Gas Production	50	10	72	113
Oil & Gas Drilling	18	9	1	1
DFW Total	**519**	**370**	**505**	**522**

Note: VOC is reported as sum of Carbon Bond 05 (CB05) species

Table ES-2: *Summary of Modeled 2006 Baseline and 2012 Future Year Eight-Hour Ozone Design Values for DFW Monitors* lists the eight-hour ozone design values in ppb for the 2006 baseline (DV_B) and 2012 baseline future year for the DFW monitors. All regulatory monitors have model-projected 2012 eight-hour ozone design values less than the 1997 eight-hour ozone NAAQS. Since the modeling cannot provide an absolute prediction of future year ozone design values, additional information from corroborative analyses are used in assessing whether the area will attain the standard in 2012.

Table ES-2: Summary of Modeled 2006 Baseline and 2012 Future Year Eight-Hour Ozone Design Values for DFW Monitors

Site	Monitor	2006 Baseline Design Value (ppb)#	Relative Response Factor	2012 Future Design Value (ppb)
DENT	Denton C56	93.33	0.825	77.03
EMTL	Eagle Mountain Lake C75	93.33	0.836	78.06
KELC	Keller C17	91.00	0.840	76.45
GRAP	Grapevine Fairway C70	90.67	0.840	76.17
FWMC	Fort Worth Northwest C13	89.33	0.844	75.36
FRIC	Frisco C31	87.67	0.849	74.45
WTFD	Weatherford Parker County C76	87.67	0.829	72.71
DALN	Dallas North C63	85.00	0.837	71.15
REDB	Dallas Exec Airport C402	85.00	0.830	70.58
CLEB	Cleburne C77	85.00	0.834	70.85
ARLA	Arlington C61	83.33	0.844	70.32
DHIC	Dallas Hinton C401	81.67	0.831	67.89
PIPT*	Pilot Point C1032*	81.00*	0.831*	67.35*
MDLT*	Midlothian Tower C94*	80.50*	0.828*	66.63*
RKWL	Rockwall Heath C69	77.67	0.815	63.27
MDLO*	Midlothian OFW C52*	75.00*	0.830*	62.24*
KAUF	Kaufman C71	74.67	0.809	60.42
GRAN	Granbury C73	83.00	0.839	69.66
GRVL	Greenville C1006	75.00	0.799	59.96

* PIPT, MDLT, and MDLO did not measure enough data from 2004 through 2008 to calculate a complete DV_B. The DV_B shown uses all available data.

The 2006 Baseline Design Value (DV_B) is different from the 2006 regulatory design value (DV_R). Figure 3-1: 2006 Baseline Design Value Calculation illustrates how DV_Bs are calculated using the three DVs containing 2006 data. The 2006 DV_R is the average of the fourth high ozone values from 2004, 2005, and 2006.

This AD SIP revision also provides ozone reduction trends analyses and other supplementary data and information to demonstrate that the DFW nine-county nonattainment area will attain the 1997 eight-hour ozone standard by the June 15, 2013, attainment date. The EPA's April 2007 "Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, $PM_{2.5}$, and Regional Haze," states that supplemental analyses should be conducted if the maximum future design value is less than 82 ppb. The quantitative and qualitative corroborative analyses in Chapter 5: *Weight of Evidence* further support a conclusion that this SIP revision demonstrates attainment of the 1997 eight-hour ozone standard.

This AD SIP revision also addresses RACT requirements. Concurrent with this SIP revision, the commission is adopting revised and new RACT requirements in response to the following control techniques guidelines (CTG) documents issued by the EPA from 2006 through 2008 (Rule Project Number 2010-016-115-EN): Flexible Package Printing; Industrial Cleaning Solvents; Large Appliance Coatings; Metal Furniture Coatings; Paper, Film, and Foil Coatings; Miscellaneous Industrial Adhesives; Miscellaneous Metal and Plastic Parts Coatings; and Auto and Light-Duty Truck Assembly Coatings. Concurrent with this AD SIP revision, the commission is also adopting revised and new RACT requirements for VOC storage tanks (Rule Project Number 2010-025-115-EN). Additional detail concerning these updated control measures can be found in the RACT discussion in Chapter 4, Section 4.5.3: *VOC RACT Determination*.

This revision also includes FCAA-required SIP elements, including a reasonably available control measures analysis, a motor vehicle emissions budget (MVEB), and a contingency plan. For the MVEB, see Table 4-2: *2012 Attainment Demonstration MVEB for the Nine-County DFW Area*.

The EPA officially released the Motor Vehicle Emission Simulator (MOVES) model as a replacement to MOBILE6.2 for SIP applications on March 2, 2010. Since the MOVES model was released several months after on-road inventory development work had to begin for this AD SIP revision, its use is not required based on the EPA's MOVES[1] policy guidance. However, the commission has included MOVES2010a (the latest version of the MOVES model) on-road emission inventory estimates in this AD SIP revision based on the model's technical superiority to MOBILE6.2, consistency with future conformity determinations, and comments received regarding the proposed AD SIP revision.

The TCEQ is committed to developing and applying the best science and technology towards addressing and reducing ozone formation as required in the DFW and other nonattainment areas in Texas. This AD SIP revision also includes a description of how the TCEQ continues to use new technology and investigate possible emission reduction strategies and other practical methods to make progress in air quality improvement. For more information, see Chapter 6: *Ongoing Initiatives*.

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[1] Additional information on the EPA's MOVES policy guidance is available at http://www.epa.gov/otaq/models/moves/420b09046.pdf.

SECTION V: LEGAL AUTHORITY

General

The Texas Commission on Environmental Quality (TCEQ) has the legal authority to implement, maintain, and enforce the National Ambient Air Quality Standards and to control the quality of the state's air, including maintaining adequate visibility.

The first air pollution control act, known as the Clean Air Act of Texas, was passed by the Texas Legislature in 1965. In 1967, the Clean Air Act of Texas was superseded by a more comprehensive statute, the Texas Clean Air Act (TCAA), found in Article 4477-5, Vernon's Texas Civil Statutes. The legislature amended the TCAA in 1969, 1971, 1973, 1979, 1985, 1987, 1989, 1991, 1993, 1995, 1997, 1999, 2001, 2003, 2005, 2007, 2009, and 2011. In 1989, the TCAA was codified as Chapter 382 of the Texas Health and Safety Code.

Originally, the TCAA stated that the Texas Air Control Board (TACB) is the state air pollution control agency and is the principal authority in the state on matters relating to the quality of air resources. In 1991, the legislature abolished the TACB effective September 1, 1993, and its powers, duties, responsibilities, and functions were transferred to the Texas Natural Resource Conservation Commission (TNRCC). With the creation of the TNRCC, the authority over air quality is found in both the Texas Water Code and the TCAA. Specifically, the authority of the TNRCC is found in Chapters 5 and 7. Chapter 5, Subchapters A - F, H - J, and L, include the general provisions, organization, and general powers and duties of the TNRCC, and the responsibilities and authority of the executive director. Chapter 5 also authorizes the TNRCC to implement action when emergency conditions arise and to conduct hearings. Chapter 7 gives the TNRCC enforcement authority. In 2001, the 77th Texas Legislature continued the existence of the TNRCC until September 1, 2013, and changed the name of the TNRCC to the Texas Commission on Environmental Quality (TCEQ). In 2009, the 81st Texas Legislature, during a special session, amended §5.014 of the Texas Water Code, changing the expiration date of the TCEQ to September 1, 2011, unless continued in existence by the Texas Sunset Act. In 2011, the 82nd Texas Legislature continued the existence of the TCEQ until 2023.

The TCAA specifically authorizes the TCEQ to establish the level of quality to be maintained in the state's air and to control the quality of the state's air by preparing and developing a general, comprehensive plan. The TCAA, Subchapters A - D, also authorize the TCEQ to collect information to enable the commission to develop an inventory of emissions; to conduct research and investigations; to enter property and examine records; to prescribe monitoring requirements; to institute enforcement proceedings; to enter into contracts and execute instruments; to formulate rules; to issue orders taking into consideration factors bearing upon health, welfare, social and economic factors, and practicability and reasonableness; to conduct hearings; to establish air quality control regions; to encourage cooperation with citizens' groups and other agencies and political subdivisions of the state as well as with industries and the federal government; and to establish and operate a system of permits for construction or modification of facilities.

Local government authority is found in Subchapter E of the TCAA. Local governments have the same power as the TCEQ to enter property and make inspections. They also may make recommendations to the commission concerning any action of the TCEQ that affects their territorial jurisdiction, may bring enforcement actions, and may execute cooperative agreements with the TCEQ or other local governments. In addition, a city or town may enact and enforce ordinances for the control and abatement of air pollution not inconsistent with the provisions of the TCAA and the rules or orders of the commission.

Subchapters G and H of the TCAA authorize the TCEQ to establish vehicle inspection and maintenance programs in certain areas of the state, consistent with the requirements of the Federal Clean Air Act; coordinate with federal, state, and local transportation planning agencies to develop and implement transportation programs and measures necessary to attain and maintain the National Ambient Air Quality Standards; establish gasoline volatility and low emission diesel standards; and fund and authorize participating counties to implement vehicle repair assistance, retrofit, and accelerated vehicle retirement programs.

Applicable Law

The following statutes and rules provide necessary authority to adopt and implement the state implementation plan (SIP). The rules listed below have previously been submitted as part of the SIP.

Statutes

All sections of each subchapter are included, unless otherwise noted.

TEXAS HEALTH & SAFETY CODE, Chapter 382	September 1, 2011
TEXAS WATER CODE	September 1, 2011

Chapter 5: Texas Natural Resource Conservation Commission
  Subchapter A: General Provisions
  Subchapter B: Organization of the Texas Natural Resource Conservation Commission
  Subchapter C: Texas Natural Resource Conservation Commission
  Subchapter D: General Powers and Duties of the Commission
  Subchapter E: Administrative Provisions for Commission
  Subchapter F: Executive Director (except §§5.225, 5.226, 5.227, 5.2275,5.231, 5.232, and 5.236)
  Subchapter H: Delegation of Hearings
  Subchapter I: Judicial Review
  Subchapter J: Consolidated Permit Processing
  Subchapter L: Emergency and Temporary Orders (§§5.514, 5.5145, and 5.515 only)
  Subchapter M: Environmental Permitting Procedures (§5.558 only)

Chapter 7: Enforcement
  Subchapter A: General Provisions (§§7.001, 7.002, 7.0025, 7.004, and 7.005 only)
  Subchapter B: Corrective Action and Injunctive Relief (§7.032 only)
  Subchapter C: Administrative Penalties
  Subchapter D: Civil Penalties (except §7.109)
  Subchapter E: Criminal Offenses and Penalties: §§7.177, 7.179-7.183

Rules

All of the following rules are found in 30 Texas Administrative Code, as of the following latest effective dates:

Chapter 7: Memoranda of Understanding, §§7.110 and 7.119	December 13, 1996 and May 2, 2002
Chapter 19: Electronic Reporting	March 15, 2007

Chapter 35: Subchapters A-C, K: Emergency and Temporary Orders and Permits; Temporary Suspension or Amendment of Permit Conditions	July 20, 2006
Chapter 39: Public Notice, §§39.201; 39.401; 39.403(a) and (b)(8)-(10); 39.405(f)(1) and (g); 39.409; 39.411 (a), (b)(1)-(6), and (8)-(10) and (c)(1)-(6) and (d); 39.413(9), (11), (12), and (14); 39.418(a) and (b)(3) and (4); 39.419(a), (b), (d), and (e); 39.420(a), (b) and (c)(3) and (4); 39.423 (a) and (b); 39.601-39.605	June 24, 2010
Chapter 55: Requests for Reconsideration and Contested Case Hearings; Public Comment, §§55.1; 55.21(a) - (d), (e)(2), (3), and (12), (f) and (g); 55.101(a), (b), and (c)(6) - (8); 55.103; 55.150; 55.152(a)(1), (2), and (6) and (b); 55.154; 55.156; 55.200; 55.201(a) - (h); 55.203; 55.205; 55.209, and 55.211	June 24, 2010
Chapter 101: General Air Quality Rules	May 15, 2011
Chapter 106: Permits by Rule, Subchapter A	May 15, 2011
Chapter 111: Control of Air Pollution from Visible Emissions and Particulate Matter	July 19, 2006
Chapter 112: Control of Air Pollution from Sulfur Compounds	July 16, 1997
Chapter 113: Standards of Performance for Hazardous Air Pollutants and for Designated Facilities and Pollutants	May 14, 2009
Chapter 114: Control of Air Pollution from Motor Vehicles	December 13, 2010
Chapter 115: Control of Air Pollution from Volatile Organic Compounds	February 17, 2011
Chapter 116: Permits for New Construction or Modification	March 17, 2011
Chapter 117: Control of Air Pollution from Nitrogen Compounds	May 15, 2011
Chapter 118: Control of Air Pollution Episodes	March 5, 2000
Chapter 122: §122.122: Potential to Emit	December 11, 2002
Chapter 122: §122.215: Minor Permit Revisions	June 3, 2001
Chapter 122: §122.216: Applications for Minor Permit Revisions	June 3, 2001
Chapter 122: §122.217: Procedures for Minor Permit Revisions	December 11, 2002
Chapter 122: §122.218: Minor Permit Revision Procedures for Permit Revisions Involving the Use of Economic Incentives, Marketable Permits, and Emissions Trading	June 3, 2001

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    5. Regional Strategies (No change)
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ABY	adjusted base year
ACM_2	Asymmetric Convective Model
ACT	Alternative Control Techniques
AD	attainment demonstration
AIRS	Aerometric Information Retrieval System
APCA	Anthropogenic Precursor Culpability Assessment
APU	auxiliary power unit
AQRP	Air Quality Research Program
ARD	Acid Rain Database
ARLA	Arlington Monitor (C61)
auto-GC	automated gas chromatograph
Bcf	billion cubic feet
BPA	Beaumont-Port Arthur
CAIR	Clean Air Interstate Rule
CAMS	continuous air monitoring station
CAMx	Comprehensive Air Model with Extension(s)
CARB	California Air Resources Board
CATMN	Community Air Toxics Monitoring Network
CB05	Carbon Bond 05
CENRAP/RPO	Central Regional Air Planning Association/Regional Planning Organization
CFFP	Clean Fuel Fleet Program
CFR	Code of Federal Regulations
CFV	clean fuel vehicle
CLEB	Cleburne Monitor (C77)
CLU	Common Land Unit
CLVL	Clarksville Monitor (C648)
CO	carbon monoxide
CTG	Control Techniques Guidelines
DALN	Dallas North Monitor (C63)
DACM	AirCheckTexas Drive a Clean Machine
DENT	Denton Monitor (C56)
DERC	Discrete Emission Reduction Credit
DFW	Dallas-Fort Worth
DHIC	Dallas Hinton Monitor (C401)
DISH	DISH Airfield Monitor (C1013)
DV_B	baseline year design value
DV_F	future year design value
DV_P	projected design value
DV_R	regulatory design value
EBI	Euler Backward Iterative

EE/RE	energy efficiency and renewable energy
EGAS5	Economic Growth Analysis System, Version 5.0
EGU	electric generating unit
EI	emissions inventory
EIQ	emissions inventory questionnaire
EMTL	Eagle Mountain Lake Monitor (C75)
EPA	United States Environmental Protection Agency
EPS3	Emissions Processing System, Version 3
ERC	Emission Reduction Credit
ESL	environmental speed limit
ESL	Energy Systems Laboratory
ETH	Ethylene
FCAA	Federal Clean Air Act
FIP	Federal Implementation Plan
FR	*Federal Register*
FSA	Farm Service Agency
FTP	File Transfer Protocol
FRIC	Frisco Monitor (C31)
FWMC	Fort Worth Northwest Monitor (C13)
GAPP	GEWEX Americas Prediction Project
GCIP	Continental-Scale International Project
GEWEX	Global Energy and Water Cycle Experiment
GloBEIS	Global Biosphere Emissions and Interactions System
GOES	Geostationary Operational Environmental Satellite
GRAN	Granbury Monitor (C73)
GRAP	Grapevine Monitor (C70)
GREASD	Greatly Reduced Execution and Simplified Dynamics
GRVL	Greenville Monitor (C1006)
GWEI	Gulf-Wide Emissions Inventory
HB	House Bill
HECT	Highly Reactive Volatile Organic Compound Emissions Cap and Trade
HGB	Houston-Galveston-Brazoria
HONO	nitrous acid
Hp	Horsepower
HPMS	Highway Performance Monitoring System
HRVOC	highly reactive volatile organic compounds
I/M	Inspection and Maintenance
ICI	industrial, commercial, and institutional
IOLE	internal olefins
IOP	increment-of-progress
ISOP	Isoprene
JPL	Jet Propulsion Laboratory
KAUF	Kaufman Monitor (C71)

KELC	Keller Monitor (C17)
Km	Kilometer
Kv	vertical diffusivity coefficient
LCP	Lambert Conformal Projection
LDAR	leak detection and repair
LGVW	Longview Monitor (C19)
LIRAP	Low Income Vehicle Repair Assistance, Retrofit, and Accelerated Vehicle Retirement Program
LULC	land-use/land-cover
MACT	maximum achievable control technology
MDLO	Midlothian OFW Monitor (C52)
MDLT	Midlothian Tower Monitor (C94)
MECT	Mass Emissions Cap and Trade
MM5	Fifth Generation Meteorological Model
MMS	Minerals Management Services
MNB	Mean Normalized Bias
MNGE	Mean Normalized Gross Error
MOVES	Motor Vehicle Emission Simulator
MOVES2010a	Motor Vehicle Emission Simulator 2010a
MOZART	Model for Ozone and Related Chemical Tracers
MPE	model performance evaluation
Mph	miles per hour
MVEB	motor vehicle emissions budget
NAAQS	National Ambient Air Quality Standard
NAM	North American Model
NASA	National Aeronautics and Space Administration
NCAR	National Center for Atmospheric Research
NCEP	National Center for Environmental Prediction
NCTCOG	North Central Texas Council of Governments
NEI	National Emissions Inventory
NHD	National Hydrography Dataset
NLCD	National Land Cover Dataset
NMIM	National Mobile Inventory Model
NO	nitric oxide
NO_2	nitrogen dioxide
NOAH	NCEP Oregon State Air Force Hydrological Research Laboratory
NO_X	nitrogen oxides
NO_Y	total reactive nitrogen oxides
NTCASC	North Texas Clean Air Steering Committee
O_3	Ozone
OFW	Old Fort Worth
OH	hydroxyl radical
OLE	Olefins
OSAT	Ozone Source Apportionment Technology

OSD	ozone season day
PAMS	Photochemical Assessment Monitoring Station
PAR	photosynthetically active radiation
PBL	Planetary Boundary Layer
PEI	periodic emissions inventory
PFC	portable fuel container
PiG	Plume-in-Grid
PIPT	Pilot Point Monitor (C1032)
PLTN	Palestine Monitor (C647)
$PM_{2.5}$	particulate matter 2.5 microns and less
Ppb	parts per billion
ppbC	parts per billion, Carbon
Ppm	parts per million
PPM	Piecewise Parabolic Method
PUCT	Public Utility Commission of Texas
QQ	quantile-quantile
RACM	reasonably available control measure
RACT	reasonably available control technology
RAQMS	Regional Air Quality Modeling System
REDB	Dallas Executive Airport Monitor (C402)
REMI	Regional Economic Models, Inc.
RFG	reformulated gasoline
RFP	reasonable further progress
RKWL	Rockwall Health Monitor (C69)
ROP	rate-of-progress
Rpm	revolutions per minute
RRF	relative response factor
RRF_D	relative response factor denominator
RRF_N	relative response factor numerator
RRTM	Rapid Radiative Transfer Model
RVP	Reid vapor pressure
SAGA	San Augustine Airport Monitor (C646)
SB	Senate Bill
SCR	selective catalytic reduction
SECO	State Energy Conservation Office
SEER	Seasonal Energy Efficiency Ratio
SIP	state implementation plan
SO_2	sulfur dioxide
STARS	State of Texas Air Reporting System
TAC	Texas Administrative Code
TACB	Texas Air Control Board
TCAA	Texas Clean Air Act
TCEQ	Texas Commission on Environmental Quality (commission)
TDM	Travel Demand Model

TEMP	Temperature
TERP	Texas Emissions Reduction Plan
TexAER	Texas Air Emissions Repository
TexAQS 2000	Texas Air Quality Study 2000
TexAQS II	Texas Air Quality Study 2006
TexN	Texas NONROAD
TGIC	Texas Geographic Information Council
THSC	Texas Health and Safety Code
TIPI	Texas Industrial Production Index
TNMHC	total non-methane hydrocarbons
TNRCC	Texas Natural Resource Conservation Commission
TOMS	Total Ozone Mapping Spectrometer
Tpd	tons per day
Tpy	tons per year
TREIM	Texas Railroad Emission Inventory Model
TTI	Texas Transportation Institute
TxLED	Texas Low Emission Diesel
UH	University of Houston
UPA	Unpaired Peak Accuracy
USDA	United States Department of Agriculture
USGS	United States Geological Survey
UTC	Coordinated Universal Time
VMEP	Voluntary Mobile Emissions Reduction Program
VMT	vehicle miles traveled
VOC	volatile organic compounds
WDIR	wind direction
WMBA	Wamba Monitor (C645)
WSPD	wind speed
WTFD	Weatherford Parker County Monitor (C76)

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CHAPTER 1: GENERAL

1.1 BACKGROUND

The *History of the Texas State Implementation Plan*, a comprehensive overview of the state implementation plan (SIP) revisions submitted to the United States Environmental Protection Agency (EPA) by the State of Texas, is available on the Introduction to the SIP Web page (http://www.tceq.texas.gov/airquality/sip/sipintro.html#what-is-the-history) on the Texas Commission on Environmental Quality's (TCEQ) Web site (http://www.tceq.texas.gov/).

1.2 INTRODUCTION

The following history of the one-hour and eight-hour ozone standards and summaries of the Dallas-Fort Worth (DFW) area one-hour and 1997 eight-hour ozone SIP revisions are provided to give context and greater understanding of the complex issues involved in DFW's ozone challenge.

1.2.1 One-Hour National Ambient Air Quality (NAAQS) History

The EPA established the one-hour ozone NAAQS of 0.08 parts per million (ppm) in the April 30, 1971, issue of the *Federal Register* (FR) (36 FR 8186). The EPA revised the one-hour ozone standard to 0.12 ppm in the February 8, 1979, issue of the *Federal Register* (44 FR 4202). The DFW one-hour ozone nonattainment area (Collin, Dallas, Denton, and Tarrant Counties) was classified in 1991 as moderate in accordance with the 1990 Federal Clean Air Act (FCAA) Amendments (56 FR 56694). As a moderate nonattainment area, the DFW area was required to demonstrate attainment of the one-hour ozone standard by November 15, 1996. Ambient air monitoring data for the years 1994 through 1996, however, showed that the one-hour ozone standard was exceeded more than one day per year over the three-year period. As a result, the EPA reclassified the DFW area from a moderate to a serious nonattainment area (effective March 20, 1998) for failure to attain the one-hour ozone standard by the November 1996 deadline (63 FR 8128). The EPA required the State of Texas to submit a SIP revision within one year that demonstrated attainment of the one-hour NAAQS and addressed FCAA requirements for serious ozone nonattainment areas.

1.2.1.1 March 1999

The TCEQ submitted the Attainment Demonstration for the Dallas-Fort Worth Ozone Nonattainment Area SIP revision, which contained a rate-of-progress (ROP) demonstration, to the EPA on March 18, 1999. The photochemical modeling contained in the revision indicated that additional reductions in nitrogen oxides (NO_X) emissions would be needed to attain the standard by November 1999. The following rules were developed and included in the SIP revision:

- reasonably available control technology (RACT) for NO_X point sources;
- nonattainment new source review for NO_X point sources; and
- revisions resulting from the change in the major source threshold for RACT applicability for volatile organic compounds (VOC).

Additionally, the commission indicated that, due to time constraints, the ROP demonstration would not incorporate all rules that were necessary to bring the DFW area into attainment by the November 1999 deadline and that a complete attainment demonstration (AD) would be submitted in the spring of 2000. The EPA determined that the AD and ROP demonstration were incomplete.

Additional local control strategies were necessary for the DFW area to reach attainment. To develop further control strategy options to augment the federal and state programs in the AD and ROP SIP revision, the DFW area established the North Texas Clean Air Steering Committee (NTCASC). The committee members include local elected officials, business leaders, and other community stakeholders. This committee identified specific control strategies for review by technical subcommittee members.

After the attainment deadline of November 15, 1999, for serious areas under the one-hour ozone standard passed, the EPA had not made a determination regarding the DFW area's attainment status. Furthermore, technical data became available suggesting that the DFW area was significantly impacted by transport and regional background levels of ozone.

1.2.1.2 April 2000

On April 19, 2000, the commission adopted a SIP revision and associated rules for the DFW one-hour ozone attainment demonstration. The April 2000 One-Hour Ozone Attainment Demonstration SIP revision contained a number of control strategies and the following elements:

- photochemical modeling of specific control measures and future state and national rules for attainment of the one-hour ozone standard in the DFW area by the attainment deadline of November 15, 2007;
- a modeling demonstration that showed air quality in the DFW area was influenced at times by transport from the HGB nonattainment area (Under the EPA's July 16, 1998, transport policy[2], if photochemical modeling demonstrated that emissions from an upwind area located in the same state and with a later attainment date interfered with the downwind area's ability to attain, the downwind area's attainment date could be extended to no later than that of the upwind area. For the DFW area, following this policy would extend the attainment date to November 15, 2007, the same attainment date as the HGB area.);
- identification of the VOC and NO_X emissions reductions necessary to attain the one-hour ozone standard by 2007. The reductions of 141 tons per day (tpd) NO_X from federal measures and 225 tpd NO_X from state measures resulted in a total of 366 tpd NO_X reductions for the attainment demonstration;
- a 2007 motor vehicle emissions budget (MVEB) for transportation conformity; and
- a commitment to perform and submit a mid-course review by May 1, 2004.

At the time it was submitted, the April 2000 One-Hour Ozone Attainment Demonstration SIP revision would have allowed the EPA to determine that the DFW area should not be reclassified from serious to severe under the conditions of the EPA's July 16, 1998, transport policy.

1.2.1.3 August 2001

The next commission action was required by legislative mandate. Senate Bill 5 (SB5), passed by the 77th Texas Legislature in May 2001, required the repeal of two rules contained in the April 2000 one-hour AD SIP revision. The first rule restricted the use of construction and industrial equipment (non-road, heavy-duty diesel equipment rated at 50 horsepower (hp) or greater). The second rule required the replacement of diesel-powered construction, industrial, commercial, and lawn and garden equipment rated at 50 hp or greater with newer Tier 2 or Tier 3

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[2] Additional information on EPA's *Guidance on Extension of Attainment Dates for Downwind Transport Areas* is available at http://www.epa.gov/ttn/oarpg/t1/memoranda/transpor.pdf.

equipment. The Texas Emissions Reduction Plan (TERP) grant incentive program established by SB5 replaced the NO_X emissions reductions previously claimed for the two programs. The commission implemented the legislative mandate of SB5 by submitting the rule repeals as part of a SIP revision adopted in August 2001.

1.2.1.4 March 2003

On March 5, 2003, the SIP was further revised to include the following:

- the adoption of revised 30 Texas Administrative Code (TAC) Chapter 117 NO_X emission limits for cement kilns;
- the estimation of NO_X reductions from energy efficiency measures, using a methodology that was to be further refined before energy efficiency credit was formally requested in the SIP revision; and
- the commitment to perform modeling with MOBILE6, the latest version of the EPA's emission factor model for mobile sources.

Meanwhile, the EPA's July 16, 1998, transport policy, on which the extension of the DFW area's attainment date to November 15, 2007, was based, was challenged by environmental groups. A suit was filed challenging the extension of the Beaumont-Port Arthur (BPA) area's attainment date based on transport from the HGB area. On December 11, 2002, the United States Fifth Circuit Court of Appeals ruled that the EPA was not authorized to extend the BPA area's attainment date based on transport. The EPA published a final action in the *Federal Register* on March 30, 2004, reclassifying the BPA area to serious with an attainment date of November 15, 2005, and requiring a new attainment demonstration to be submitted by April 30, 2005. Although the court decision was specifically for the BPA area, the direct implication for the DFW area was that the EPA could not approve extensions of the DFW one-hour ozone attainment date past 1999, the date mandated by the Federal Clean Air Act (FCAA) for serious areas. In addition, the EPA could not approve the April 2000 One-Hour Ozone DFW Attainment Demonstration SIP revision.

1.2.1.5 EPA Determination of One-Hour Ozone Attainment

Since the early 1990s, when the DFW area was designated as nonattainment for the one-hour ozone standard, much has been done to bring the area into attainment with federal air quality standards. Contributions to improved air quality in the DFW area include: TCEQ-implemented control strategies, local control strategies adopted by the North Central Texas Council of Governments (NCTCOG), and on-road and non-road mobile source measures implemented by the EPA. Despite the EPA's lack of approval for multiple SIP revisions, air quality in the DFW area continued to improve.

By 2006, ambient monitoring data reflected attainment of the one-hour standard. On October 16, 2008, the EPA published final determination (73 FR 61357) that DFW area one-hour ozone nonattainment counties (Collin, Dallas, Denton, and Tarrant) had attained the one-hour ozone standard with a design value of 124 parts per billion (ppb), based on verified 2004 through 2006 monitoring data. One-hour requirements are suspended so long as the DFW area maintains attainment of that standard.

1.2.2 Eight-Hour Ozone NAAQS History

In 1997, the EPA revised the NAAQS for ozone, setting it at 0.08 ppm averaged over an eight-hour time frame. The final 1997 eight-hour ozone NAAQS was published in the *Federal Register* on July 18, 1997 (62 FR 38856) and became effective on September 16, 1997. On April 30, 2004, the EPA finalized its designations and promulgated the first phase of its implementation rule for the 1997 eight-hour ozone standard (69 FR 23951). These actions became effective on June 15, 2004. The EPA designated the nine-county (Collin, Dallas, Denton, Ellis, Johnson, Kaufman, Parker, Rockwall, and Tarrant Counties) DFW area as nonattainment for the standard with a moderate classification. The TCEQ was required to submit a SIP revision for the 1997 eight-hour ozone NAAQS to the EPA by June 15, 2007, and demonstrate attainment of the standard by June 15, 2010. In the November 29, 2005, issue of the *Federal Register* (70 FR 71612), the EPA published its second phase of the implementation rule for the 1997 eight-hour ozone NAAQS, which addressed the control obligations that apply to areas designated nonattainment for the standard.

In Phase I of its implementation rule (40 CFR §51.905(a)(ii)) and subsequent guidance, the EPA provided three options for areas such as the DFW area that did not have an approved one-hour ozone attainment plan at the time of designation:

A. Submit a one-hour AD no later than one year after designation (by June 15, 2005);
B. Submit an eight-hour ozone plan no later than one year after designation (by June 15, 2005) that provided a 5% increment of emissions reductions from the area's 2002 emissions baseline, in addition to federal and state measures already approved by the EPA, and achieve those reductions by June 15, 2007; or
C. Submit an eight-hour ozone attainment demonstration by June 15, 2005.

Texas selected option B, the 5% increment-of-progress (IOP) plan, as a technically sound and expeditious approach to initiating the reductions ultimately needed for attainment of the eight-hour ozone standard. The 5% IOP SIP revision, adopted by the commission on April 27, 2005, contained several elements:

- 2002 periodic emissions inventory for the nine-county DFW eight-hour ozone nonattainment area;
- a 5% reduction in emissions from the 2002 emissions inventory baseline;
- identification of the control measures to achieve the necessary NO_X and VOC emission reductions; and
- MVEBs for use in transportation conformity demonstrations.

1.2.2.1 May 23, 2007

The commission adopted the May 2007 DFW Attainment Demonstration SIP revision and the reasonable further progress (RFP) SIP revision for the DFW area on May 23, 2007. These SIP revisions were the first step in addressing the 1997 eight-hour ozone standard in the DFW area.

This eight-hour ozone SIP revision for the DFW area contained photochemical modeling and weight of evidence, including corroborative analysis and additional measures not included in the model. In addition to the existing control strategies in the DFW area, the SIP revision included new rules for the following sources:

- DFW area cement kilns;
- DFW area electric generating utilities (EGUs);
- DFW area industrial, commercial, and institutional (ICI) major sources;
- DFW area minor sources; and
- East Texas combustion sources in 33 counties beyond the DFW area.

The SIP revision included additional commitments for Voluntary Mobile Emissions Reduction Program (VMEP) and transportation control measures (TCM). The revision also contained the reasonably available control measure (RACM) analysis, RACT analysis, contingency measures, emissions inventories, and MVEBs.

On July 14, 2008, the EPA proposed conditional approval (73 FR 40203) of the May 2007 DFW AD SIP Revision, providing that final conditional approval was contingent upon the State of Texas adopting and submitting to the EPA an approvable contingency plan SIP revision for the DFW area. The Dallas-Fort Worth Attainment Demonstration SIP Revision for the 1997 Eight-Hour Ozone Standard (Contingency Measures Plan) was adopted by the commission on November 5, 2008, and submitted to the EPA on November 15, 2008. The SIP revision identifies measures to satisfy the EPA's 3% reduction contingency requirement for 2010 for the DFW area, to apply in the event that the DFW area fails to meet the 1997 eight-hour ozone standard by the attainment deadline.

An additional condition stipulated by the EPA for final approval of the May 2007 DFW AD SIP Revision was that the TCEQ adopt and submit rule and SIP revisions to implement an enforceable mechanism to limit the use of discrete emission reduction credits (DERC) in the DFW area by March 1, 2009. The Dallas-Fort Worth Attainment Demonstration SIP Revision for the 1997 Eight-Hour Ozone Standard DERC Program incorporated rulemaking that would amend Chapter 101, Subchapter H, Division 4: *Discrete Emission Credit Banking and Trading* rules to set a limit on DERC use for the DFW area.

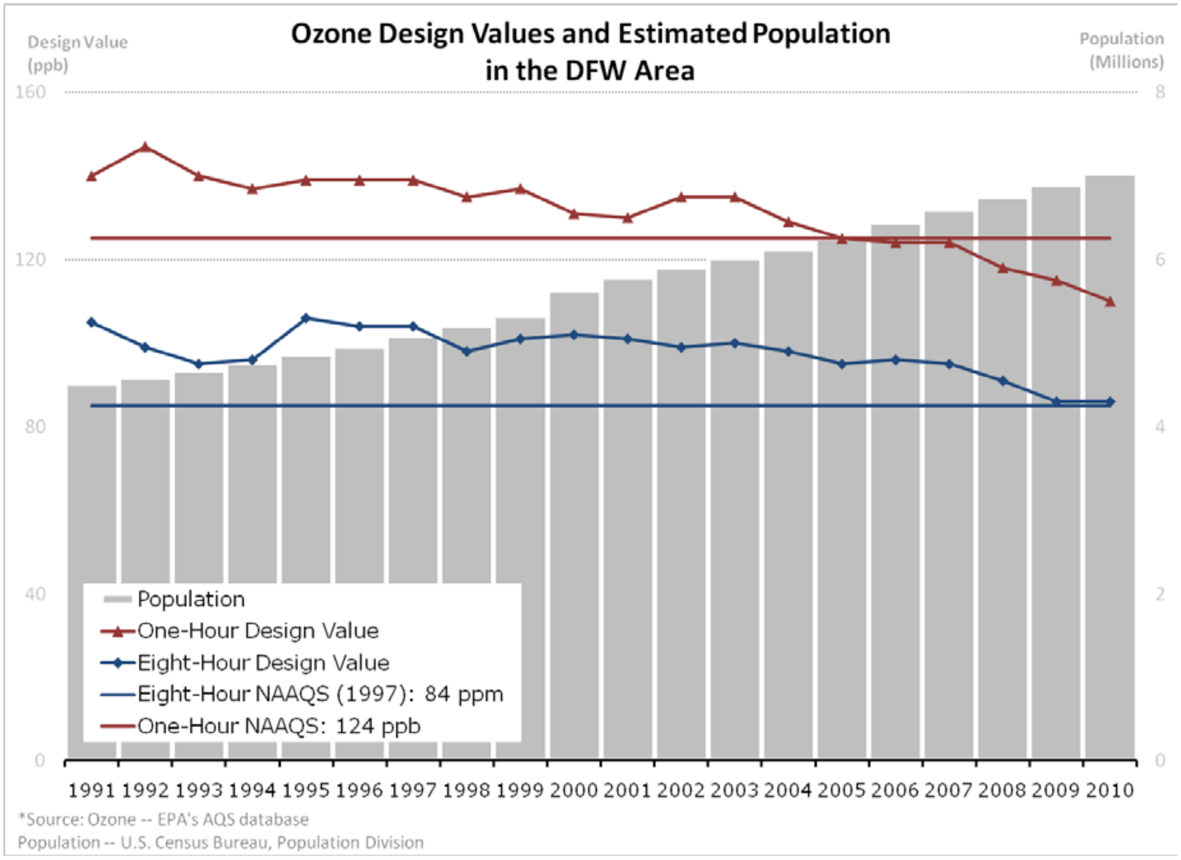
On January 14, 2009, the EPA published final conditional approval of components of the AD SIP revision, including the May 2007 DFW AD SIP revision, the April 2008, and November 2008 supplements. The approval provided conditional approval of the 2009 attainment MVEBs, RACM demonstration, and failure-to-attain contingency plan, full approval of local VMEP and TCMs, full approval of the VOC RACT demonstrations for the one-hour and 1997 eight-hour ozone standards, and a statement that all control measures and reductions relied upon to demonstrate attainment were approved by the EPA.

On March 10, 2010, the commission adopted the DFW RACT Update, 30 TAC Chapter 117 Rule Revision Noninterference Demonstration, and Modified Failure-to-Attain Contingency Plan SIP Revision. This SIP revision incorporated several actions adopted by the commission, and supplemented the 1997 eight-hour ozone AD by demonstrating that the revised Chapter 117 rule does not interfere with the DFW AD SIP Revision.

On August 25, 2010, the commission adopted a SIP revision to convert an environmental speed limit control strategy to a transportation control measure for the 1997 eight-hour ozone standard in the DFW nonattainment area.

1.2.3 Existing Ozone Control Strategies

Existing control strategies implemented to address the one-hour and eight-hour ozone standards are expected to continue to reduce emissions of ozone precursors in the DFW area and positively impact progress toward attainment of the 1997 eight-hour ozone standard. The one-hour and 1997 eight-hour ozone design values for the DFW area from 1991 through 2010 are illustrated in Figure 1-1: *One-Hour and 1997 Eight-Hour Ozone Design Values and DFW Population*. Both design values have decreased over the past 20 years. The 2010 one-hour ozone design value was 110 ppb, representing a 21% decrease from the value for 1991 (140 ppb). The 2010 eight-hour ozone design value was 86 ppb, an 18% decrease from the 1991 value of 105 ppb. These decreases occurred despite a 56% increase in area population, as shown in Figure 1-1: *One-Hour and 1997 Eight-Hour Ozone Design Values and DFW Population*.



*Source: Ozone -- EPA's AQS database
Population -- U.S. Census Bureau, Population Division

Figure 1-1: One-Hour and 1997 Eight-Hour Ozone Design Values and DFW Population

1.2.4 Current AD SIP Revision

The DFW 1997 eight-hour ozone standard nonattainment area is currently classified as serious nonattainment. In 2009, the monitored design value (complete ozone season prior to the attainment date) for the DFW area was 86 parts per billion (ppb). Effective January 19, 2011, EPA finalized a determination that the DFW nonattainment area did not attain the 1997 eight-hour ozone standard by June 15, 2010, the deadline set by the Phase I implementation guidance for the 1997 ozone standard for areas classified as moderate (75 FR 79302). Based on that determination, the EPA reclassified the DFW nonattainment area to serious and set a January 19, 2012, deadline for the state to submit an AD SIP revision that addresses the 1997 eight-hour ozone standard serious nonattainment area requirements, including RFP. The DFW area's new attainment date for the 1997 eight-hour ozone standard is as expeditiously as practicable, but no later than June 15, 2013.

As required by the FCAA, the TCEQ published a notice in the *Texas Register* on May 21, 2010 (http://www.sos.state.tx.us/texreg/pdf/backview/0521/0521is.pdf), implementing the area's contingency measures for failure to attain the 1997 eight-hour ozone standard by the June 15, 2010, deadline.

Concurrent with this AD SIP revision, the commission is adopting revised and new RACT requirements to address the following control techniques guidelines (CTG) documents issued by the EPA from 2006 through 2008 (Rule Project Number 2010-016-115-EN): Flexible Package Printing; Industrial Cleaning Solvents; Large Appliance Coatings; Metal Furniture Coatings; Paper, Film, and Foil Coatings; Miscellaneous Industrial Adhesives; Miscellaneous Metal and Plastic Parts Coatings; and Auto and Light-Duty Truck Assembly Coatings. Concurrent with this AD SIP revision, the commission is also adopting revised and new RACT requirements for VOC storage tanks (Rule Project Number 2010-025-115-EN).

This attainment demonstration includes an MVEB for 2012 that represents the on-road mobile source emissions that have been modeled for the attainment demonstration. The DFW area's metropolitan planning organization must demonstrate that the estimated emissions from transportation plans, programs, and projects do not exceed the MVEB. Additionally, this plan demonstrates that by 2012, the DFW area will meet other serious nonattainment area requirements, including an enhanced Inspection and Maintenance Program (which has already been implemented in all nine counties), Stage II vapor recovery systems at gas stations (which has already been implemented in Collin, Dallas, Denton, and Tarrant Counties) or widespread onboard refueling vapor recovery, a Clean Fuel Fleet Program (which is not required if emissions reductions from the National Low-Emissions Vehicle Program are more than what would be achieved under such a program), TCMs (which have already been implemented in all nine counties, and enhanced monitoring (which will be in place by June 15, 2013, the attainment deadline).

The EPA officially released the Motor Vehicle Emission Simulator (MOVES) model as a replacement to MOBILE6.2 for SIP applications on March 2, 2010. Since the MOVES model was released several months after on-road inventory development work had to begin for this AD SIP revision, its use is not required based on EPA's MOVES[3] policy guidance. However, the commission has included MOVES2010a (the latest version of the MOVES model) on-road emission inventory estimates in this AD SIP revision based on the model's technical superiority to MOBILE6.2, consistency with future conformity determinations, and comments received on the proposed AD SIP revision.

1.2.5 2008 and 2010 Ozone Standards

On March 12, 2008, the EPA lowered the primary and secondary eight-hour ozone standards to 0.075 ppm. The governor recommended to the EPA in March 2009 that 10 counties in the DFW area (those counties already designated as part of the DFW 1997 eight-hour ozone standard nonattainment area and Hood County) be designated as a nonattainment area for the 2008 eight-hour ozone standard. In September 2009, the EPA announced that it intended to reconsider the 2008 ozone standard. On January 19, 2010, the EPA proposed revisions in the *Federal Register* (75 FR 2938) to strengthen the primary eight-hour ozone standard in the range of 0.060 to 0.070 ppm. The EPA also proposed to establish a separate cumulative, seasonal secondary standard within a range of 7 to 15 ppm-hours. The EPA had originally intended to finalize the reconsidered ozone standard in August 2010, but rescheduled promulgation of the final standards to July 2011. On September 2, 2011, the President announced that he requested the EPA withdraw the proposed reconsidered ozone standard. The EPA announced on September 22, 2011, it will be taking action on the 2008 ozone NAAQS, and area designations are expected to be complete by mid 2012.

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[3] Additional information on the EPA's MOVES policy guidance is available at http://www.epa.gov/otaq/models/moves/420b09046.pdf.

1.3 HEALTH EFFECTS

In 1997, the EPA revised the NAAQS for ozone from a one-hour to an eight-hour standard. To support the 1997 eight-hour ozone standard, the EPA provided information indicating that negative health effects can occur at levels lower than the previous standard and at exposure times longer than one hour. High concentrations of one-hour ozone were not shown to correlate well with mortality. Exposure to relatively high levels of ozone can aggravate asthma in some people. Repeated exposures to high levels of ozone can make people more susceptible to respiratory infection and lung inflammation and can aggravate preexisting respiratory diseases, such as bronchitis and emphysema.

Children are at a relatively higher risk from exposure to ozone when compared to adults, since they breathe more air per pound of body weight than adults and because children's respiratory systems are still developing. Children also spend a considerable amount of time outdoors during summer and during the start of the school year (August through October) when high ozone levels are typically recorded. Adults most at risk to ozone exposure are people working or exercising outdoors and individuals with preexisting respiratory diseases.

1.4 STAKEHOLDER PARTICIPATION AND PUBLIC HEARINGS

1.4.1 TCEQ SIP and Control Strategy Development Stakeholder Meetings

The TCEQ held an open-participation DFW 1997 Eight-Hour Ozone SIP Stakeholder Group meeting to discuss concepts for potential control strategies for the nine-county DFW ozone nonattainment area, to hear the public's ideas on potential ozone control measures, and to provide the public an overview of the development of this DFW AD SIP revision. The meeting was held on June 24, 2010, at the Arlington City Council Chambers. In the meeting, the TCEQ presented attendees with an update on the DFW AD SIP revision timeline, an update on modeling efforts, and a draft list of potential control strategy concepts for stationary, area, and mobile sources. Additional information is available on the DFW Eight-Hour Ozone SIP Stakeholder Group Web site (http://www.tceq.texas.gov/airquality/sip/dfw_stakeholder_2.html).

1.4.2 Dallas-Fort Worth Photochemical Modeling Technical Committee

The Dallas-Fort Worth Photochemical Modeling Technical Committee (DFW PMTC) is a TCEQ advisory group organized to assist the agency in addressing technical and scientific issues relating to air quality modeling for the Dallas-Fort Worth (DFW) area. The committee includes representatives from industry, county and city government, environmental groups, and the public. The DFW PMTC holds meetings to share and discuss technical issues related to the photochemical modeling of air quality. Meeting notifications, agendas, and pertinent materials from those meetings will be available on the DFW Photochemical Modeling Technical Committee Web site (http://www.tceq.texas.gov/airquality/airmod/committee/pmtc_dfw.html).

1.5 PUBLIC HEARING AND COMMENT INFORMATION

The public comment period opened on June 24, 2011, and was originally scheduled to close on July 25, 2011; however, the comment period was extended to August 8, 2011. The extension was granted to allow the public 30 days to review and comment on supplemental information[4] concerning on-road mobile source emissions inventories based on MOVES2010a. Notice of public hearings for this AD SIP revision was published in the *Texas Register* and various newspapers. Written comments were accepted via mail, fax, and through the eComments system (http://www5.tceq.state.tx.us/rules/ecomments).

The commission conducted public hearings in Arlington on July 14, 2011, at 10:00 a.m. and 6:30 p.m., and in Austin on July 22, 2011, at 2:00 p.m. During the comment period, which closed on August 8, 2011, the commission received comments concerning the DFW attainment demonstration AD SIP revision from Barnett Shale Energy Education Council, COPPs for Clean Air, Commissioners Court of Denton County, Downwinders at Risk, Earthworks Oil and Gas Accountability, Fort Worth Regional Concerned Citizens, KIDS for Clean Air, Lone Star Chapter of the Sierra Club, North Central Texas Council of Governments (NCTCOG), North Texas Clean Air Steering Committee, Regional Transportation Council of the NCTCOG, State Representative Lon Burnham, Texas Pipeline Association, the EPA, and 393 individuals. Summaries of public comments and TCEQ responses are included as part of this AD SIP revision.

An electronic version of the AD SIP revision and appendices can be found at the TCEQ's Texas State Implementation Plan Web page (http://www.tceq.texas.gov/airquality/sip/texas-sip).

1.6 SOCIAL AND ECONOMIC CONSIDERATIONS

For a detailed explanation of the social and economic issues involved with any of the measures, please refer to the preambles that precede each rule package accompanying this AD SIP revision.

1.7 FISCAL AND MANPOWER RESOURCES

The state has determined that its fiscal and manpower resources are adequate and will not be adversely affected through the implementation of this plan.

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[4] The supplemental information was released on July 8, 2011, and is contained in Appendix J: *On-Road Emissions Supplement to the Proposed Dallas-Fort Worth Attainment Demonstration State Implementation Plan Revision for the 1997 Eight-Hour Ozone Standard Nonattainment Area* of this SIP revision.

CHAPTER 2: ANTHROPOGENIC EMISSIONS INVENTORY (EI) DESCRIPTION

2.1 INTRODUCTION

The 1990 Federal Clean Air Act Amendments require that attainment demonstration emissions inventories (EIs) be prepared for ozone nonattainment areas. Ozone is produced in the atmosphere when volatile organic compounds (VOC) are mixed with nitrogen oxides (NO_X) in the presence of sunlight. The Texas Commission on Environmental Quality (TCEQ) maintains an EI of up-to-date information on NO_X and VOC sources. The EI identifies the types of emissions sources present in an area, the amount of each pollutant emitted, and the types of process and control devices employed at each plant or source category. The EI provides data for a variety of air quality planning tasks, including establishing baseline emission levels, calculating emission reduction targets, control strategy development for reducing emissions, emission inputs into air quality simulation models, and tracking actual emissions. These EIs are critical for the efforts of state, local, and federal agencies to demonstrate attainment of the National Ambient Air Quality Standards.

This chapter discusses general EI development for each of the anthropogenic source categories. Chapter 3: *Photochemical Modeling* details specific EIs and emissions inputs developed for the Dallas-Fort Worth (DFW) area ozone photochemical modeling.

2.2 POINT SOURCES

Stationary point source emissions data are collected annually from sites that meet the reporting requirements of 30 Texas Administrative Code (TAC) §101.10. These sites include, but are not limited to, refineries, chemical plants, bulk terminals, and utilities. To collect the data, the TCEQ mailed EI questionnaires (EIQs) to all sites identified as meeting the reporting requirements. Companies were required to report emissions data and to provide sample calculations used to determine the emissions. Information characterizing the process equipment, the abatement units, and the emission points was also required. All data submitted in the EIQ were reviewed for quality assurance purposes and then stored in the State of Texas Air Reporting System database. At the end of the annual reporting cycle, point source emissions data are reported each year to the United States Environmental Protection Agency (EPA) for inclusion in the National Emissions Inventory (NEI).

2.3 AREA SOURCES

Stationary sources that do not meet the reporting requirements for point sources are classified as area sources. Area sources are small-scale industrial, commercial, and residential sources that use materials or perform processes that generate emissions. Area sources can be characterized by the mechanism in which emissions are released into the atmosphere: evaporative or combustion. Evaporative emission sources include the following: oil and gas production facilities, printing processes, industrial coating and degreasing operations, gasoline service station underground tank filling, and vehicle refueling operations. Combustion sources include the following: oil and gas production facilities, stationary source fossil fuel combustion at residences and businesses, outdoor burning, structural fires, and wildfires.

Emissions are calculated as county-wide totals rather than as individual facilities. The emissions from area sources may be calculated by applying an EPA-established emission factor (emissions per unit of activity) to the appropriate activity or activity surrogate responsible for generating emissions. Examples of activity or activity surrogate data include the following: population, crude oil and gas production, the amount of gasoline sold in an area, employment by industry type, and acres of crop land. The activity data are obtained via surveys, research, and/or investigations. The air emissions data from the different area source categories are collected, reviewed for quality assurance, stored in the Texas Air Emissions Repository database system, and compiled to develop the statewide area source EI. This area source periodic emissions inventory (PEI) is reported every third year (triennially) to the EPA for inclusion in the NEI. The TCEQ submitted the most recent PEI for calendar year 2008.

2.4 NON-ROAD MOBILE SOURCES

Non-road mobile sources include vehicles, engines, and equipment used for construction, agriculture, transportation, recreation, and many other purposes. Non-road vehicles are also referred to as off-road or off-highway vehicles that do not normally operate on roads or highways. This broad category is composed of a diverse collection of machines, many of which are powered by diesel engines. Examples of non-road mobile sources include, but are not limited to: agricultural equipment, commercial and industrial equipment, construction and mining equipment, lawn and garden equipment, aircraft, locomotives, and commercial marine vessels.

A Texas specific version of the EPA NONROAD 2008a model, called the Texas NONROAD (TexN) model, was used to calculate emissions from all non-road mobile equipment and recreational vehicles except aircraft, ground support equipment, and locomotives. While the TexN model utilizes input files and post-processing routines to estimate Texas specific emissions estimates, it retains the EPA NONROAD 2008a model to conduct the basic emissions estimation calculations. Several input files provide necessary information to calculate and allocate emission estimates. The inputs used in the TexN model include emission factors, base year equipment population, activity, load factor, meteorological data, average lifetime, scrappage function, growth estimates, emission standard phase-in schedule, and geographic and temporal allocation.

Emissions for the source categories that are not in the EPA NONROAD 2008a model are estimated using other EPA-approved methods and guidance documents. Airport emissions are calculated using the Federal Aviation Administration’s Emissions and Dispersion Modeling System, version 5.1. Locomotive emission estimates for Texas are based on specific fuel usage data derived from railway segment level gross ton mileage activity (line haul locomotives) and hours of operation (yard locomotives) provided directly by the Class I railroad companies operating in Texas.

2.5 ON-ROAD MOBILE SOURCES

On-road mobile sources consist of passenger cars, passenger trucks, motorcycles, buses, heavy-duty trucks, and other motor vehicles traveling on public roadways. Combustion-related emissions are estimated for vehicle engine exhaust, and evaporative hydrocarbon emissions are estimated for the fuel tank and other non-tailpipe sources from the vehicle. To calculate pollution from on-road mobile sources, emission rates are estimated as a function of county, vehicle type, roadway type, hour, and operating speed. These rates are then matched with appropriate activity from transportation data sources such as vehicle miles traveled (VMT), number of vehicles parked, hours spent in extended idle mode, etc.

Emission factors were developed using the latest version of the EPA's on-road model, which is the Motor Vehicle Emissions Simulator 2010a (MOVES2010a). Various inputs are provided to MOVES2010a to simulate the vehicle fleet in each nonattainment area such as vehicle speeds, vehicle age distributions, local meteorological conditions, type of Inspection and Maintenance Program, and local fuel properties. Separate gasoline and diesel fuel emission factors are developed for the thirteen MOVES2010a vehicle types.

For major metropolitan areas, the primary source of vehicle activity is typically the local travel demand model (TDM), which is run by the Texas Transportation Institute (TTI), the Texas Department of Transportation (TxDOT), or the regional metropolitan planning organization (MPO). For the *Dallas-Fort Worth Attainment Demonstration State Implementation Plan (SIP) Revision for the 1997 Eight-Hour Ozone Standard*, the TCEQ contracted with the North Central Texas Council of Governments (NCTCOG) to develop the on-road mobile source emission inventories. The DFW TDM has been validated using a large number of traffic counts collected in the area by TxDOT. In accordance with federal guidelines, VMT estimates from the DFW area TDM are calibrated to outputs from the Highway Performance Monitoring System (HPMS). VMT is allocated to the appropriate vehicle types based on roadside classification counts collected in the local area by TxDOT. Prior to matching the VMT estimates with MOVES2010a emission rates, hourly operating speeds for each roadway segment are post-processed from the TDM output based on vehicle volume-to-capacity ratios.

2.6 EI IMPROVEMENT

The TCEQ EI reflects years of emissions data improvement, including extensive point and area source inventory reconciliation with ambient emissions monitoring data. The following projects have significantly improved the DFW point source and area source inventory.

- Houston Advanced Research Center project H51C identified thousands of tons of VOC flash emissions from upstream oil and gas operations in the DFW area, which the TCEQ added to the area source inventory.
- TCEQ Work Order Nos. 582-7-84003-FY-10-26 and 582-7-84005-FY-10-29 quantified nitrogen oxides (NO_X) and volatile organic compounds (VOC) emissions from various oil and gas processes and produced water storage tanks at upstream oil and gas operations in the DFW area, which the TCEQ has added to the area source inventory.
- The TCEQ conducted the first phase of a special inventory of companies that own or operate leases or facilities associated with Barnett Shale oil and gas operations. The TCEQ conducted the special emissions inventory under the authority of 30 TAC §101.10(b)(3) to determine the location, number, and type of emission sources associated with upstream and midstream oil and gas operations in the Barnett Shale. The results of the first phase were used to improve the compressor engine population profile in the DFW area. This improved profile was used in determining the area source emissions estimates for this source category. This inventory was the first phase of a planned two-phase special inventory. The second phase of this special inventory requested companies with 2009 production or transmission of oil or gas from the Barnett Shale formation to complete standardized forms detailing source emissions data, source location, information on receptors located within one-quarter mile of a source, and authorization information. For more information on phase two of this inventory, see Chapter 6: *Ongoing Initiatives*, Section 6.2.1: *Barnett Shale Special Emissions Inventory*.

In addition to these projects, the TCEQ *Emissions Inventory Guidelines* (RG-360A), a comprehensive guidance document that explains all aspects of the point source EI process, is updated and published annually. The latest version of this document is available on the TCEQ's Point Source Emissions Inventory Web site (http://www.tceq.state.tx.us/implementation/air/industei/psei/psei.html). Currently, six technical supplements provide detailed guidance on determining emissions from potentially underreported VOC emissions sources such as cooling towers, flares, and storage tanks.

CHAPTER 3: PHOTOCHEMICAL MODELING

3.0 INTRODUCTION

This chapter describes modeling conducted in support of the Dallas-Fort Worth (DFW) Attainment Demonstration (AD) State Implementation Plan (SIP) Revision for the 1997 Eight-Hour Ozone Standard. The DFW ozone nonattainment area consists of Collin, Dallas, Denton, Ellis, Johnson, Kaufman, Parker, Rockwall, and Tarrant Counties. The 1990 Federal Clean Air Act Amendments require that attainment demonstrations be based on photochemical grid modeling or any other analytical methods determined by the United States Environmental Protection Agency (EPA) to be at least as effective. The EPA's April 2007 "Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, $PM_{2.5}$, and Regional Haze" (EPA, 2007; hereafter referred to as "modeling guidance") recommends procedures for air quality modeling for attainment demonstrations of the eight-hour ozone National Ambient Air Quality Standard (NAAQS).

The modeling guidance recommends several qualitative methods for preparing attainment demonstrations that acknowledge the limitations and uncertainties of photochemical models when used to project ozone concentrations into future years. First, the modeling guidance recommends using model results in a relative sense and applying the model response to the observed ozone data. Second, the modeling guidance recommends using available air quality, meteorology, and emissions data to develop a conceptual model for eight-hour ozone formation and to use that analysis in episode selection. Third, the modeling guidance recommends using other analyses, i.e., weight of evidence, to supplement and corroborate the model results and support the adequacy of a proposed control strategy package.

The 1990 FCAA amendments established five classifications for ozone nonattainment areas based on the magnitude of the regional one-hour ozone design value. Based on the monitored one-hour ozone design value at that time, four counties in the DFW area (Collin, Dallas, Denton, and Tarrant) were classified as a moderate nonattainment area. As published in the October 16, 2008, edition of the *Federal Register* (FR), the EPA determined the four-county DFW area to be in attainment of the one-hour ozone standard based on 2004 through 2006 monitored data (73 FR 61357).

With the change of the ozone NAAQS from a one-hour standard to an eight-hour standard in 2004, the EPA classified the DFW area as a moderate ozone nonattainment area with an attainment date of June 15, 2010. Five additional counties (Ellis, Johnson, Kaufman, Parker, and Rockwall) were added to the four original one-hour standard nonattainment counties to create the nonattainment area for the 1997 eight-hour standard. Ozone AD SIP revisions addressing the 1997 eight-hour ozone standard were required to be submitted to the EPA by June 15, 2007. In May 2007, photochemical modeling and other analyses conducted by the Texas Commission on Environmental Quality (TCEQ) were included in the AD SIP revision submitted to the EPA supporting the DFW area's attainment of the eight-hour ozone standard by June 15, 2010. The EPA published final conditional approval of the May 2007 DFW AD SIP Revision on January 14, 2009 (74 FR 1903).

In 2009, the monitored design value (complete ozone season prior to the attainment date) for the DFW area was 86 parts per billion (ppb), 2 ppb above the attainment level. The EPA published the final rule to determine the DFW area's failure to attain the 1997 eight-hour ozone standard and reclassify the DFW area as a serious nonattainment area on December 10, 2010 (75 FR 79302). The attainment date for the serious classification is June 15, 2013. The EPA has prescribed that the attainment test be applied to the 2012 previous ozone season to determine compliance with the 2013 attainment date.

This AD SIP revision uses photochemical modeling in combination with corroborative analyses to support a conclusion that the DFW nine-county nonattainment area will attain the 0.08 parts per million (ppm) 1997 eight-hour ozone standard by June 15, 2013. Also, the limited data collected in the DFW area during Texas Air Quality Study 2006 (TexAQS II) is used to evaluate the model's performance and to improve understanding of the physical and chemical processes leading to ozone formation.

3.1 OVERVIEW OF THE OZONE PHOTOCHEMICAL MODELING PROCESS

The modeling system is composed of a meteorological model, several emissions processing models, and a photochemical air quality model. The meteorological and emissions models provide the major inputs to the air quality model.

Ozone is a secondary pollutant; it is not generally emitted directly into the atmosphere. Ozone is created in the atmosphere by a complex set of chemical reactions between sunlight and several primary (directly emitted) pollutants. The reactions are photochemical and require ultraviolet energy from sunlight. The majority of primary pollutants directly involved in ozone formation fall into two groups, nitrogen oxides (NO_X) and volatile organic compounds (VOC). In addition, carbon monoxide (CO) is also an ozone precursor, but much less effective than either NO_X or VOC in forming ozone. As a result of these multiple factors, higher concentrations of ozone are most common during the summer with concentrations peaking during the day and falling during the night and early morning hours.

Ozone chemistry is complex, involving hundreds of chemical compounds and chemical reactions. As a result, ozone cannot be evaluated using simple dilution and dispersion algorithms. Due to this chemical complexity, the modeling guidance strongly recommends using photochemical computer models to simulate ozone formation and evaluate the effectiveness of future control strategies. Computer simulations are the most effective tools to address both the chemical complexity and the future case evaluation.

3.2 OZONE MODELING

Ozone modeling involves two major phases, the base case modeling phase and the future year modeling phase. The purpose of the base case modeling phase is to evaluate the model's ability to adequately replicate measured ozone and ozone precursor concentrations during recent periods with high ozone concentrations. The purpose of the future year modeling phase is to predict attainment year ozone design values at each monitor and to evaluate the effectiveness of controls in reaching attainment. The TCEQ developed a modeling protocol describing the process to be followed to evaluate the ozone in the urban area and submitted the plan to the EPA as prescribed in the modeling guidance.

3.2.1 Base Case Modeling

Base case modeling involves several steps. First, recent ozone episodes are analyzed to determine what factors were associated with ozone formation in the area and whether those factors were consistent with the conceptual model and the EPA's episode selection criteria. Once an episode is selected, emissions and meteorological data are generated and quality assured. Then the meteorological and emissions (NO_X, VOC, and CO) data are input to the photochemical model and the ozone photochemistry is simulated, resulting in predicted ozone and ozone precursor concentrations.

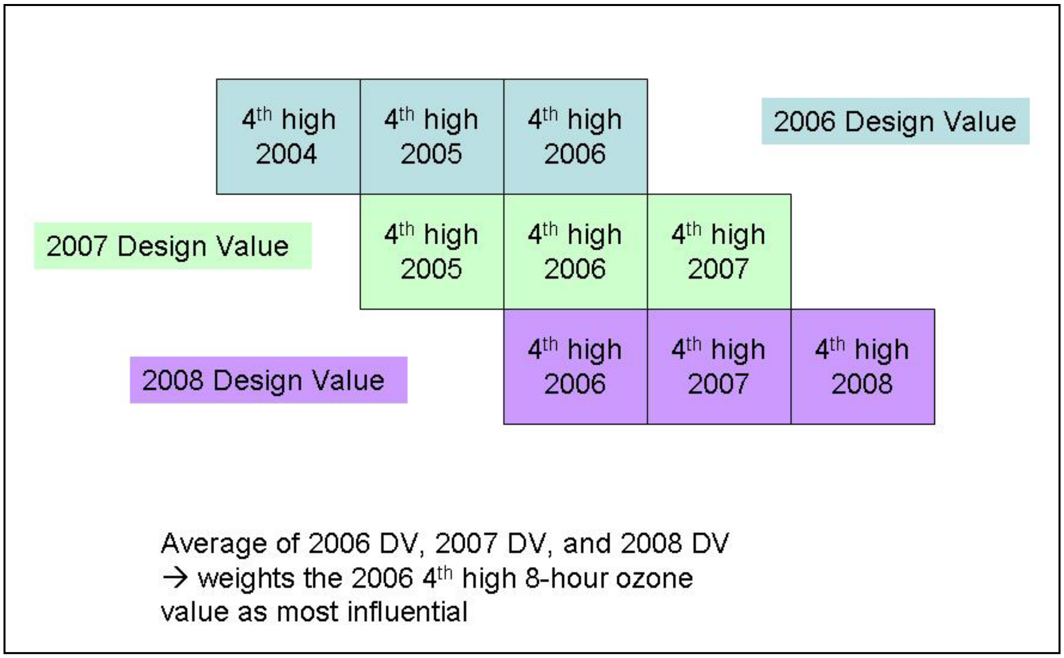
Base case modeling results are evaluated by comparing them to the observed measurements of ozone and ozone precursors. Typically this step is an iterative process incorporating feedback from successive evaluations to ensure that the model is adequately replicating observations throughout the modeling episode. The adequacy of the model in replicating observations is assessed based on compliance with statistical and graphical measures as recommended in the modeling guidance. Additional analyses using special study data are included when available. Satisfactory performance of the base case modeling provides a degree of reliability that the model can be used to predict future year ozone concentrations (future year design values), as well as to evaluate the effectiveness of possible control measures.

3.2.2 Future Year Modeling

Future year modeling involves several steps. The procedure for predicting a future year ozone design value (attainment test) involves determining the ratio of the future year to the baseline year modeled ozone concentrations. This ratio is called the relative response factor (RRF). Whereas the emissions data for the base case modeling are episode-specific, the emissions data for the baseline year are based on typical ozone season emissions. Similarly, the emissions data for the future year are developed applying growth and control factors to the baseline year emissions. The growth and control factors are developed based on the projected growth in the demand for goods and services and the reduction in emissions expected from state, local, and federal control programs.

Both the baseline and future years are modeled using their respective ozone season emissions and the base case episode meteorological data as inputs. The same meteorological data are used for modeling both the baseline and future years, and thus, the ratio of future year modeled ozone concentrations to the baseline year concentrations provides a measure of the response of ozone concentrations to the change in emissions from projected growth and controls.

A future year ozone design value is calculated by multiplying the RRF by a baseline year ozone design value (DV_B). The DV_B is the average of the regulatory design values for the three consecutive years containing the baseline year (see Figure 3-1: *2006 Baseline Design Value Calculation*). A calculated future year ozone design value of less than or equal to 0.08 ppm (84 ppb) signifies modeled attainment. When the calculated future year ozone design value is greater than 84 ppb, additional controls may be needed and the model can be used to test the effectiveness of various control measures in developing a control strategy.



Average of 2006 DV, 2007 DV, and 2008 DV
→ weights the 2006 4th high 8-hour ozone value as most influential

Figure 3-1: 2006 Baseline Design Value Calculation

3.3 EPISODE SELECTION

3.3.1 EPA Guidance for Episode Selection

The primary criteria for selecting ozone episodes for eight-hour ozone attainment demonstration modeling is set forth in the modeling guidance and shown below:

- Select periods reflecting a variety of meteorological conditions that frequently correspond to observed eight-hour daily maximum ozone concentrations greater than 84 ppb at different monitoring sites.
- Select periods during which observed eight-hour ozone concentrations are close to the eight-hour ozone design values at monitors with a DV_B greater than or equal to 85 ppb.
- Select periods for which extensive air quality/meteorological data sets exist.
- Model a sufficient number of days so that the modeled attainment test can be applied at all of the ozone monitoring sites that are in violation of the NAAQS.

3.3.2 DFW Ozone Episode Selection Process

An episode selection analysis was performed to identify time periods with eight-hour ozone exceedance days that met the primary selection criteria. The short time frame available to develop this modeling demonstration necessitated reviewing the applicability of ozone episodes that the TCEQ recently modeled or analyzed. Six high eight-hour ozone episodes from 2005 and 2006 were modeled from TexAQS II for the most recent Houston-Galveston-Brazoria (HGB) AD (TCEQ, 2010). These periods were investigated first since much of the meteorological and emissions inventory data can be leveraged to the DFW area. The extensive monitoring data collected during TexAQS II, including data from radar wind profilers, make these periods even more attractive.

Table 3-1: DFW Eight-Hour Ozone Exceedance Data during TexAQS II Modeling Episodes shows the episodes modeled for the HGB attainment demonstration adopted in 2010 by the TCEQ, as well as one additional episode, the extended June 2006 period. The table also shows the maximum eight-hour ozone exceedance in the DFW area for each episode. There were more days with more monitors above the eight-hour ozone standard in the June periods in 2005 and 2006 in the DFW nonattainment area than in any of the other episodes. Additional special study monitors were installed just prior to June 2006, along with radar wind profilers, which are important for meteorological modeling performance (Knoderer and MacDonald, 2007).

Table 3-1: DFW Eight-Hour Ozone Exceedance Data during TexAQS II Modeling Episodes

Episode	Dates	Days ≥ 85 ppb	Max eight-hour O_3 (ppb) in DFW
2005ep0	May 19 - Jun 3, 2005	4	101
2005ep1	Jun 17 - 30, 2005	**9**	**117**
2005ep2	Jul 26 - Aug 8, 2005	6	115
2006ep0	May 31 - Jun 15, 2006	**11**	107
2006ep0ext*	May 31 - Jul 2, 2006	**17**	107
2006ep1a	Aug 13 - Sep 15, 2006	6	102
2006ep1b	Sep 16 - Oct 11, 2006	0	81

*2006ep0ext not modeled for Houston

In 2008, the Austin and San Antonio areas optimized the TCEQ meteorological modeling setup of the June 2006 episode with alternative physics options to be more representative of non-coastal Texas. The modeling period was also extended to July 2, 2006, to include additional exceedance days, of which there were 17 with maximum eight-hour ozone concentrations in excess of 84 ppb in the DFW area (Emery et al., 2009a). Based on these results the TCEQ focused on the extended June episode (2006ep0ext), improving model performance for the DFW area and central Texas (Emery et al., 2009b).

Figure 3-2: *Eight-Hour Ozone Exceedance Days in DFW* shows the frequency distribution of days with measured daily maximum eight-hour ozone concentrations greater than 84 ppb for the period 1991 through 2010. The distribution for the DFW area is bi-modal with peaks in the frequency of exceedance days, one peak occurs in late spring, and another in summer.

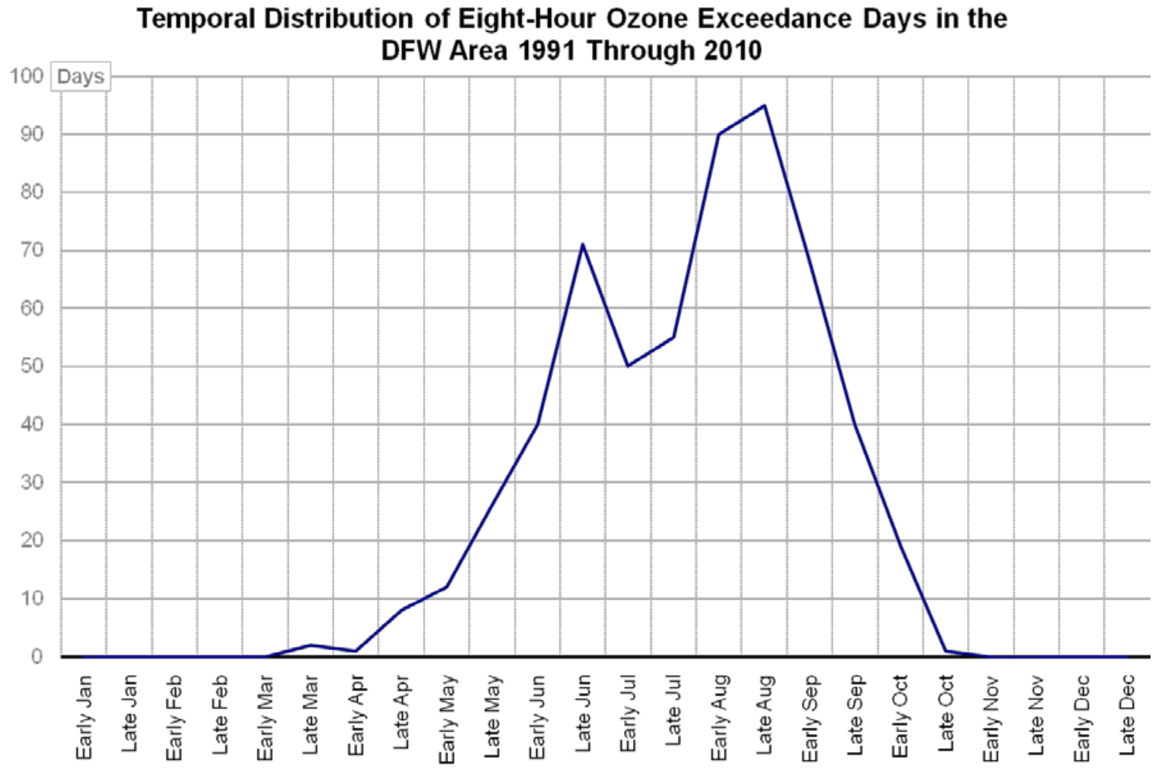


Figure 3-2: Eight-Hour Ozone Exceedance Days in DFW

The extended June 2006 episode is the focus of episode development because of the number of ozone exceedances, availability of special-study monitoring data, availability of existing high-quality modeling databases, and the variety of meteorological conditions.

3.3.3 Summary of the Extended June 2006 Episode

Table 3-2: *DFW Monitor-Specific Eight-Hour Ozone Data During the Extended June 2006 Episode*) shows that each of these key monitors (see Figure 3-3: *DFW Monitor Map*) has at least eight days with an eight-hour concentration of 85 ppb during the 33 day episode. While these key monitors did not observe ten days with ozone measured in excess of 85 ppb, they did measure almost twenty days of eight-hour concentrations of 70 ppb or greater, which can be used for the RRF calculation. All but the Greenville monitor (C1006) had at least 10 days at 70 ppb or above, although its northeast location is not in the typical path of high ozone.

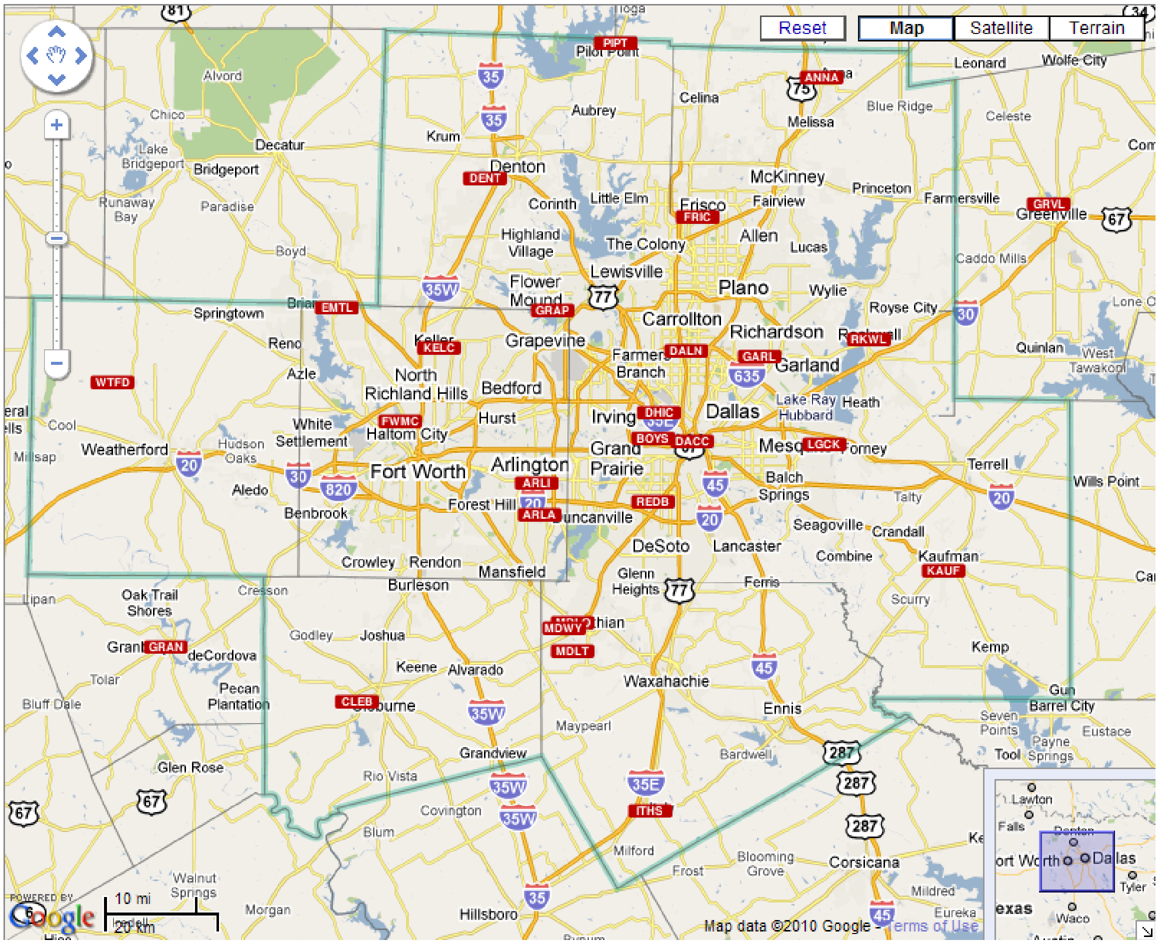


Figure 3-3: DFW Monitor Map

Table 3-2: DFW Monitor-Specific Eight-Hour Ozone Data During the Extended June 2006 Episode

Site	Monitor	Max 8-hour Ozone (ppb)	Days ≥ 90 ppb	Days ≥ 85 ppb	Days ≥ 70 ppb	Site-specific Baseline Design Value (ppb)
EMTL	Eagle Mountain Lake C75	**107**	**5**	8	18	**93.3**
DENT	Denton Airport South C56	106	**5**	**9**	17	**93.3**
KELC	Keller C17	103	4	8	**19**	91.0
GRAP	Grapevine Fairway C70	95	3	5	14	90.7
FWMC	Ft. Worth Northwest C13	101	**5**	8	17	89.3
WTFD	Parker County C76	101	3	5	15	87.7
FRIC	Frisco C31	94	1	7	14	87.7
CLEB	Cleburne Airport C77	98	2	2	15	85.0
REDB	Dallas Exec. Airport C402	91	1	2	17	85.0
DALN	Dallas North No.2 C63	86	0	2	12	85.0

Site	Monitor	Max 8-hour Ozone (ppb)	Days ≥ 90 ppb	Days ≥ 85 ppb	Days ≥ 70 ppb	Site-specific Baseline Design Value (ppb)
ARLA	Arlington Municipal Airport C61	91	1	3	11	83.3
GRAN+	Granbury C73	92	2	3	12	83.0
DHIC	Dallas Hinton St. C401	84	0	0	14	81.7
RKWL	Rockwall Heath C69	78	0	0	11	77.7
GRVL+	Greenville C1006	78	0	0	8	75.0
KAUF	Kaufman C71	78	0	0	11	74.7
PIPT#	Pilot Point C1032	101	4	**9**	14	81.0#
MDLT#	Midlothian Tower C94	98	1	2	14	80.5#
MDLO#	Midlothian OFW C52	96	1	1	11	77.7#
ITHS*#	Italy High School C650	89	0	1	10	NA#

Values are sorted in descending order of monitor-specific baseline design values.

PIPT, MDLT, and MDLO did not measure enough data from 2004 through 2008 to calculate a complete DV_B. The DV_B shown uses all available data.

* Italy High School C650 was a non-regulatory monitor (deactivated 11/07/2006).

+ Granbury C73 and Greenville C1006 are outside the 1997 eight-hour ozone NAAQS DFW nonattainment area.

The 2010 Dallas-Fort Worth Conceptual Model, Appendix D: *Conceptual Model for the DFW Attainment Demonstration SIP Revision for the 1997 Eight-Hour Ozone Standard*, describes the general meteorological conditions that are typically present on days when the eight-hour ozone concentration exceeds the 1997 eight-hour ozone NAAQS. High ozone is typically formed in the DFW area on days with slower wind speeds out of the east and southeast. These prevailing winds also typically bring higher background ozone levels into the DFW area. High background ozone concentrations are then amplified as an air mass moves over the urban core of Dallas and Tarrant Counties, both of which contain large amounts of NO_X emissions. Those emissions are then transported across the DFW area to the northwest, where the highest eight-hour ozone concentrations are observed.

The 2006 modeling episode showed that these conditions were present on the high ozone days. High pressure developed over the area from June 5 through June 10, which resulted in mostly sunny days with high temperatures above 90 degrees Fahrenheit. High pressure also caused winds that were calm or light out of the southeast. With light winds a gradual buildup of ozone and ozone precursors developed over the Dallas – Fort Worth nonattainment area, peaking in an eight-hour ozone concentration of 106 ppb at the Eagle Mountain Lake (C75) and Denton Airport South (C56) monitor sites on June 9 (see Figure 3-4: *June 2006 Episode Eight-Hour Ozone by Monitor*).

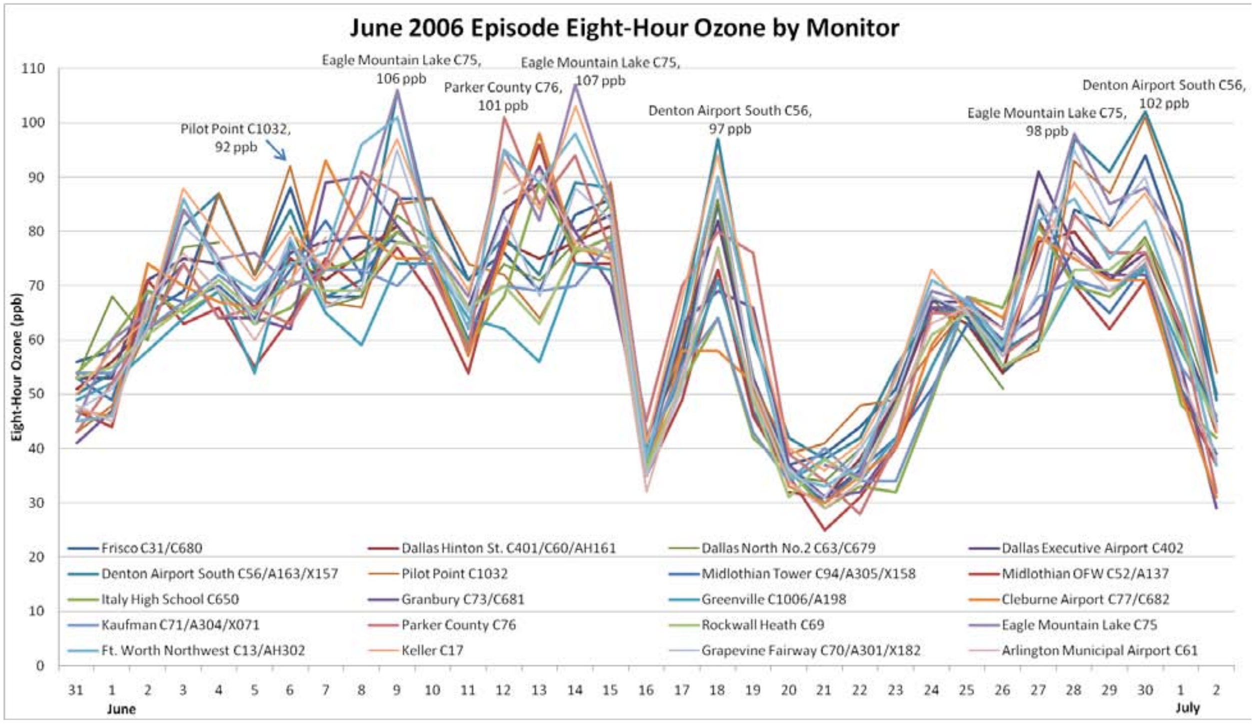


Figure 3-4: June 2006 Episode Eight-Hour Ozone by Monitor

High pressure began to erode away as a weak frontal boundary approached from the north. As wind speeds increased over the area, causing ozone dilution and lowering the eight-hour ozone concentrations over the area. As winds switched directions and began blowing from the east-northeast on the backside of the frontal boundary, ozone concentrations again increased. Winds from the east-northeast have the potential for long range transport from the direction of the Ohio River Valley. Transport from the east-northeast likely contributed to an eight-hour ozone concentration of 107 ppb at the Eagle Mountain Lake (C75) monitor site on June 14. Over the next few days, low pressure moved in to the area from the Gulf of Mexico. This low pressure caused an increase in cloudiness and wind speed, which reduced the potential for ozone formation. High pressure returned to the area from June 27 through June 30. With the resultant high temperatures and low wind speeds, conditions were again favorable for ozone formation.

Back trajectories from the Eagle Mountain Lake (C75) monitor extending backwards in time for 48 hours and terminating at 500 meters above ground level (AGL) are shown for every day of the extended June 2006 episode in Figure 3-5: *Daily 48-Hour Back Trajectories from DFW (May 31 through June 15, and June 16 through July 2, 2006)*. The left panel shows the May 31 through June 15, 2006, period while the right panel shows the June 16 through July 2, 2006, period. The trajectories depict air coming from north, east, and southerly directions. Westerly winds are not common during the summer months in the DFW area, thus, there are no trajectories coming from the west to northwest (see Appendix D: Conceptual Model for the DFW Attainment Demonstration SIP Revision for the 1997 Eight-Hour Ozone Standard). These trajectories illustrate that the extended June 2006 episode includes periods of synoptic flow from each of the directions commonly associated with high eight-hour ozone concentrations as described in the DFW conceptual model.

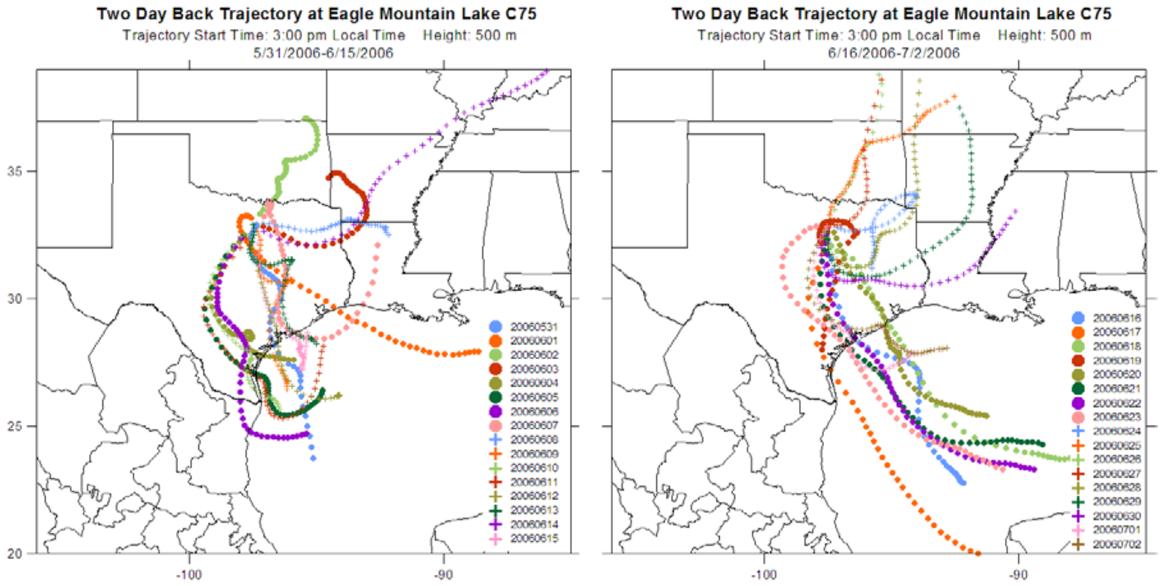


Figure 3-5: Daily 48-Hour Back Trajectories from DFW (May 31 through June 15, and June 16 through July 2, 2006)

3.4 METEOROLOGICAL MODEL

The TCEQ is using the Fifth Generation Meteorological Model (MM5, version 3.7.3) developed jointly by the National Center for Atmospheric Research (NCAR) and Pennsylvania State University (Grell et al., 1994). This model, supported by a broad user community including the Air Force Weather Agency, national laboratories, and academia, is being used extensively for regulatory air quality modeling analyses throughout the United States.

3.4.1 Modeling Domains

MM5 was configured with three two-way nested outer grids (108 kilometer (km), 36 km, and 12 km horizontal resolution) to cover the United States and regional areas of interest. A one-way nested 4 km fine grid covering the eastern half of Texas was used, as shown in Figure 3-6: *MM5 Modeling Domains*. The extent of each of the MM5 modeling domains was selected to accommodate the embedding of the commensurate air quality modeling domains (see Section 3.6 Photochemical Modeling).

Vertically, MM5 is structured with 43 layers from the surface to approximately 20 km (Figure 3-7: *MM5 Vertical Layer Structure*). Twenty layers are within the first 3,000 meters in order to resolve boundary layer phenomena. The same MM5 vertical layering structure is used for all of the domains.

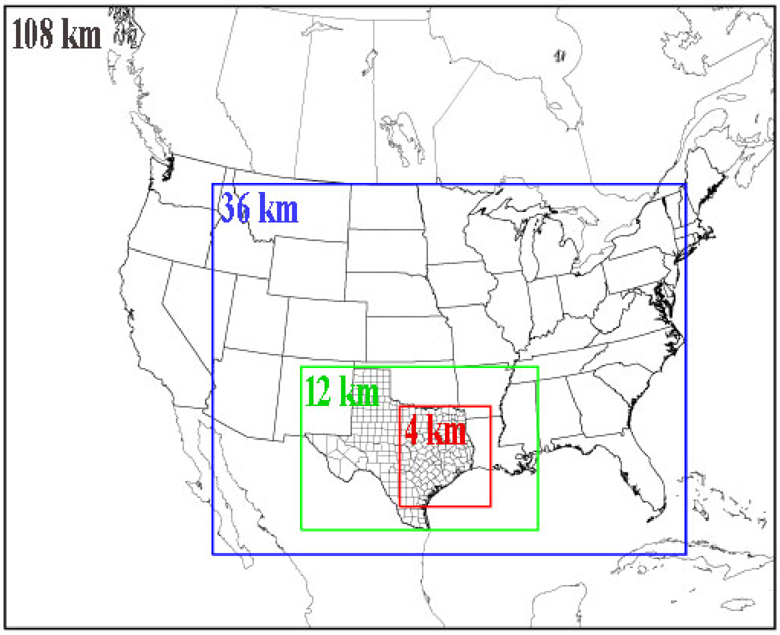


Figure 3-6: MM5 Modeling Domains

Table 3-3: MM5 Modeling Domain Definitions

Domain	Easting Range (km)	Northing Range (km)	East/West Grid Points	North/South Grid Points
108 km	(-2808, 2808)	(-2268, 2268)	53	43
36 km	(-1296, 2160)	(-1728, 972)	97	76
12 km	(-648, 1080)	(-1548, -360)	145	100
4 km	(72, 372)	(-1380, -648)	166	184

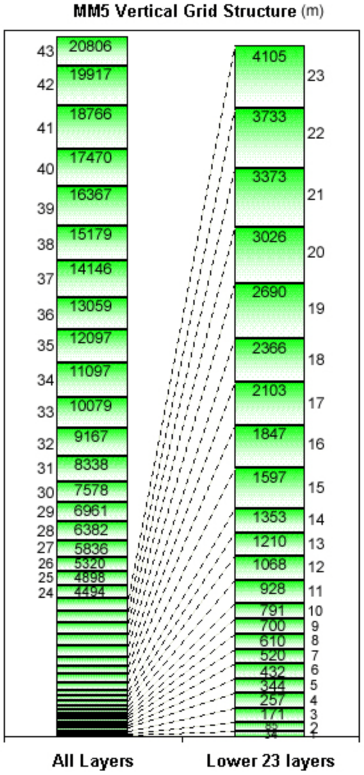


Figure 3-7: MM5 Vertical Layer Structure

3.4.2 Meteorological Model Configuration

Based on past TCEQ modeling efforts, the modeling guidance, support from external experts, and other demonstrations including sensitivity tests and model performance evaluation, the MM5 was configured with parameterizations and improved input data to optimize the performance of the wind field (i.e., wind speed and direction). Wind speed and direction are the most important parameters predicted by the meteorological model for air quality modeling purposes because the wind field determines the transport and dispersion of pollutants. The pre-processing of the MM5 input data followed the standard progression using the TERRAIN, REGRID, and INTERPF (NCAR, 2005) programs. The NESTDOWN program was used to interpolate from the 12 km domain output to the 4 km domain input.

In developing the meteorological modeling of the June 2006 episode for the 2010 *HGB Attainment Demonstration SIP Revision for the 1997 Eight-Hour Ozone Standard* (2009-017-SIP-NR), the TCEQ focused on parameterizations to improve performance of the coastal wind field (TCEQ, 2010). Land use characteristics and sea surface temperatures on all domains were updated with high resolution satellite measurements. In 2008, the Austin and San Antonio areas optimized the TCEQ meteorological modeling of the June 2006 episode to be more representative for central Texas and extended the time period to July 2 (Emery et al., 2009a). Model options were chosen to remove spurious convection and improve the performance of the wind field through analysis nudging (Stauffer and Seaman, 1990; Stauffer et al., 1991; Stauffer and Seaman, 1994) on all domains using the National Center for Environmental Prediction (NCEP) North American Model (NAM) gridded output for winds, temperature, and water vapor.

The TCEQ continued this work on the extended June 2006 episode, which resulted in an MM5 configuration that yielded good performance in the DFW and central Texas areas (Emery et al., 2009b). Observational nudging (blending observations with predicted parameters) using TexAQS II radar profiler data and one-hour surface analysis nudging improved wind performance. Switching from the NOAH (NCEP Oregon State Air Force Hydrological Research Laboratory) Land-Surface Model to the five-layer soil model also improved the representation of precipitation, temperature, and planetary boundary layer (PBL) depths.

The TCEQ continued to improve upon the performance of MM5 for the extended June 2006 episode through a series of sensitivities. The final MM5 parameterization schemes and options selected are shown in Table 3-4: *June 2006 MM5 Configuration*. The selection of these schemes and options was based on the previous modeling experiences described above, MM5 community use, and features of the ozone episode being modeled.

Table 3-4: June 2006 MM5 Configuration

Domain	Nudging Type	PBL	Cumulus	Radiation	Land-Surface	Microphysics
108 and 36 km	3-D and Surface Analysis	MRF	Grell	RRTM / Dudhia	5-layer soil model	Simple Ice
12 km	3-D, Surface Analysis, & Obs	MRF	Grell	RRTM / Dudhia	5-layer soil model	Simple Ice
4 km	3-D, Surface Analysis, & Obs	Eta	None	RRTM / Dudhia	5-layer soil model	Simple Ice

Notes: PBL = Planetary Boundary Layer; RRTM = Rapid Radiative Transfer Model; MRF = Medium Range Forecast; Eta (Mellor and Yamada, 1974)

MM5 output was post-processed using the MM5CAMx version 4.8 utility to convert the MM5 meteorological fields to the Comprehensive Air Quality Model with Extensions (CAMx) grid and input format (Environ, 2010). The MM5CAMx utility was used with the Asymmetric Convective Model (ACM2) vertical diffusivity methodology and a minimum vertical diffusivity coefficient (Kv) of 1.0. The nocturnal Kvs were also modified on a land-use basis to set the minimum Kv within the first 200 vertical meters of the model using the KVPATCH program (Environ, 2005). The patch was applied to limit the build-up of NO_X concentrations in the urban area at night and loss of ozone due to titration (Environ, 2011).

The 2010 HGB AD SIP Revision, Appendix A: *Meteorological Modeling for the HGB Attainment Demonstration SIP Revision for the 1997 Eight-Hour Ozone Standard* provides details on the development of the satellite-based land-use/land-cover (LULC) and sea surface temperature data used in this DFW meteorological modeling (TCEQ, 2010).

3.4.3 MM5 Application and Performance

The final MM5 modeling configuration was applied to the May 28, 2006, 06:00 Coordinated Universal Time (UTC) through July 3, 2006, 07:00 UTC period spanning the eight-hour ozone episode.

A detailed performance evaluation of the June 2006 meteorological modeling episode is included in Appendix A: *Meteorological Modeling for the DFW Attainment Demonstration SIP Revision for the 1997 Eight-Hour Ozone Standard* of this SIP revision. In addition, all performance evaluation products are available on the TCEQ File Transfer Protocol (FTP) site (ftp://amdaftp.tceq.texas.gov/pub/DFW8H2/mm5).

As mentioned, the wind speed and direction are deemed to be the most important meteorological parameters input to the air quality model. The MM5 modeled wind field was evaluated by comparing the hourly modeled and measured wind speed and direction for all monitors in the DFW area. Figure 3-8: *June 2006 Meteorological Modeling Performance* exhibits the percent of hours for which the average absolute difference between the modeled and measured wind speed and direction, for specific monitors and a DFW area average, was within the specified accuracy benchmarks (e.g., wind speed difference less than or equal to two meters per second (WSPD ≤ 2 m/s)). Table 3-5: *DFW Meteorological Modeling Percent Accuracy* provides an additional evaluation of MM5 predictions to stricter benchmarks (Emery et al., 2001).

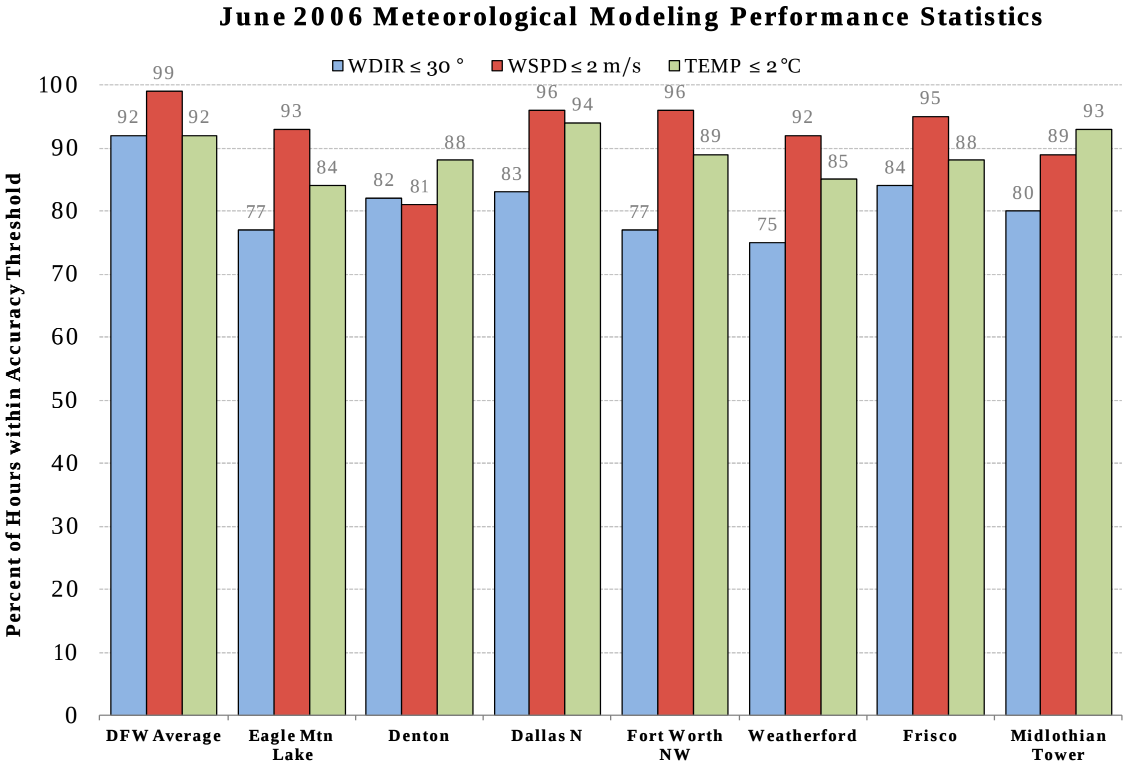


Figure 3-8: June 2006 Meteorological Modeling Performance

Notes: WDIR = Wind Direction; WSPD = Wind Speed; TEMP = Temperature

Table 3-5: DFW Meteorological Modeling Percent Accuracy

DFW Area	Wind Direction (°) Error ≤ 30 / 20 / 10	Wind Speed (m/s) Error ≤ 2 / 1 / 0.5	Temperature (°C) Error ≤ 2 / 1 / 0.5
Area Average*	92 / 84 / 63	99 / 85 / 48	92 / 67 / 39
Eagle Mountain Lake C75	77 / 67 / 40	93 / 64 / 35	84 / 56 / 29
Denton Airport South C56	82 / 70 / 42	81 / 45 / 25	88 / 57 / 31
Dallas North No. 2 C63	83 / 70 / 44	96 / 62 / 32	94 / 79 / 52
Fort Worth NW C13	77 / 67 / 42	96 / 74 / 43	89 / 62 / 36
Weatherford C76	75 / 64 / 37	92 / 63 / 33	85 / 56 / 29

DFW Area	Wind Direction (°) Error ≤ 30 / 20 / 10	Wind Speed (m/s) Error ≤ 2 / 1 / 0.5	Temperature (°C) Error ≤ 2 / 1 / 0.5
Frisco C31	84 / 71 / 48	95 / 69 / 38	88 / 55 / 28
Midlothian Tower C94	80 / 62 / 35	89 / 60 / 33	93 / 70 / 40

* Area Average calculated from mean modeled DFW area parameter – mean observed DFW area parameter

3.5 MODELING EMISSIONS

For the stationary emission source types, which consist of point and area sources, routine emission inventories provided the major inputs for the emissions modeling processing. Emissions from mobile and biogenic sources were derived from relevant emission models. Specifically, link-based on-road mobile source emissions were derived from a travel demand model coupled with the EPA Motor Vehicle Emissions Simulator 2010a (MOVES2010a) emission factor model, and non-road mobile source emissions were derived from the EPA's National Mobile Inventory Model (NMIM), or the Texas NONROAD (TexN) mobile source models. The on-road and non-road emissions were processed to air quality model-ready format using version three of the Emissions Processing System (EPS3; Environ, 2007). Biogenic emissions were derived from the Global Biosphere Emissions and Interactions System (GloBEIS3.13.1) model, which outputs air quality model-ready emissions.

Appendix B: *Emissions Modeling for the DFW Attainment Demonstration SIP Revision for the 1997 Eight-Hour Ozone Standard* provides details on the development and processing of the emissions using the various EPS3 modules. The modules, listed in Table 3-6: *Emissions Processing Modules*, are used to create the chemically speciated, temporally (hourly) allocated, and spatially distributed emission files needed for the air quality model. Model-ready emissions were developed for the May 31, 2006, through July 2, 2006, period. The following sections give a brief description of the development of each type of emissions.

Table 3-6: Emissions Processing Modules

EPS3 Module	Description
PREAM	Prepare area and non-link based mobile sources emissions for further processing
LBASE	Spatially allocate link-based mobile source emissions among grid cells
PREPNT	Group point source emissions into elevated and low-level for further processing
CNTLEM	Apply controls to model strategies, apply adjustments, etc.
TMPRL	Apply temporal profiles to hourly allocate emissions
CHMSPL	Chemically speciate emissions into nitrogen oxide (NO), nitrogen dioxide (NO_2), and various CB05-VOC species
GRDEM	Spatially distribute emissions by grid cell using source category surrogates
MRGUAM	Merge and adjust multiple gridded files for model-ready input
PIGEMS	Assigns PiGs and merges elevated point source files

Notes: CB05 = the 2005 version of the Carbon Bond chemical mechanism; PiG = Plume-in-Grid

3.5.1 Biogenic Emissions

The TCEQ used version 3.1 of the GloBEIS3.13.1 model to develop the biogenic emissions. GloBEIS3.1 tables were modified to accept land cover classes from newly acquired updated land cover. Detailed locality-specific land cover data input to the model is used to generate the mix and density of vegetative species. Photosynthetically active radiation (PAR) was derived from solar radiation data taken from Geostationary Operational Environmental Satellite (GOES) imagery and input to the GloBEIS3.1 model. Further, the GloBEIS3.1 model used hourly temperature data generated from weather station data.

Biogenic Emissions Landuse Data, version 3 (BELD3; Kinnee et al., 1997), a vegetation database for the entire North American continent prepared specifically for creating biogenic emissions inventories, was used for the 36 km domain and the portion of the 12 km domain outside Texas. For the land-use data in the 12 km domain within Texas, the TCEQ used the Texas vegetation database (Wiedinmyer et al., 2001), which was derived from Texas Parks and Wildlife Department vegetation data, agricultural statistics from the National Agricultural Statistics Survey, and 1999 field surveys. Within the 4 km nested domain, a new land-cover dataset from the Texas A&M Spatial Sciences Laboratory was used for land cover input (Popescu et al., 2008). LandSat Thematic Mapper satellite images, with acquisition dates between the years 2000 and 2002, were classified with respect to the Texas Land Classification System implemented by the Texas Geographic Information Council (TGIC) in 1999 by utilizing an object-based classification scheme. The Texas A&M land cover data was enhanced with the use of the 2001 National Land Cover Dataset (NLCD) derived by the United States Geological Survey (USGS), Common Land Unit (CLU) data provided by the United States Department of Agriculture (USDA) – Farm Service Agency (FSA), and the National Hydrography Dataset (NHD) produced by the USGS.

The episode-specific PAR data input to GloBEIS3.1 were obtained from the Web site operated by the Global Energy and Water Cycle Experiment (GEWEX) Continental-Scale International Project (GCIP) and GEWEX Americas Prediction Project (GAPP) (http://metosrv2.umd.edu/~srb/gcip/cgi-bin/historic.cgi?auth=no). The episode-specific temperature data were obtained from weather stations throughout the United States, including data from the National Weather Service, the EPA Aerometric Information Retrieval System (AIRS) air quality database, the National Buoy Data Center, the Texas A&M Crop Weather Program, the Louisiana Agricultural Information Service, and the Texas Coastal Oceanographic Observation Network.

GloBEIS3.1 was run for each day of the modeling episode. Figure 3-9: *Example of Day-Specific Biogenic Emissions* shows the typical magnitude and distribution of biogenic VOC and NO_X emissions in the 4 km modeling domain.

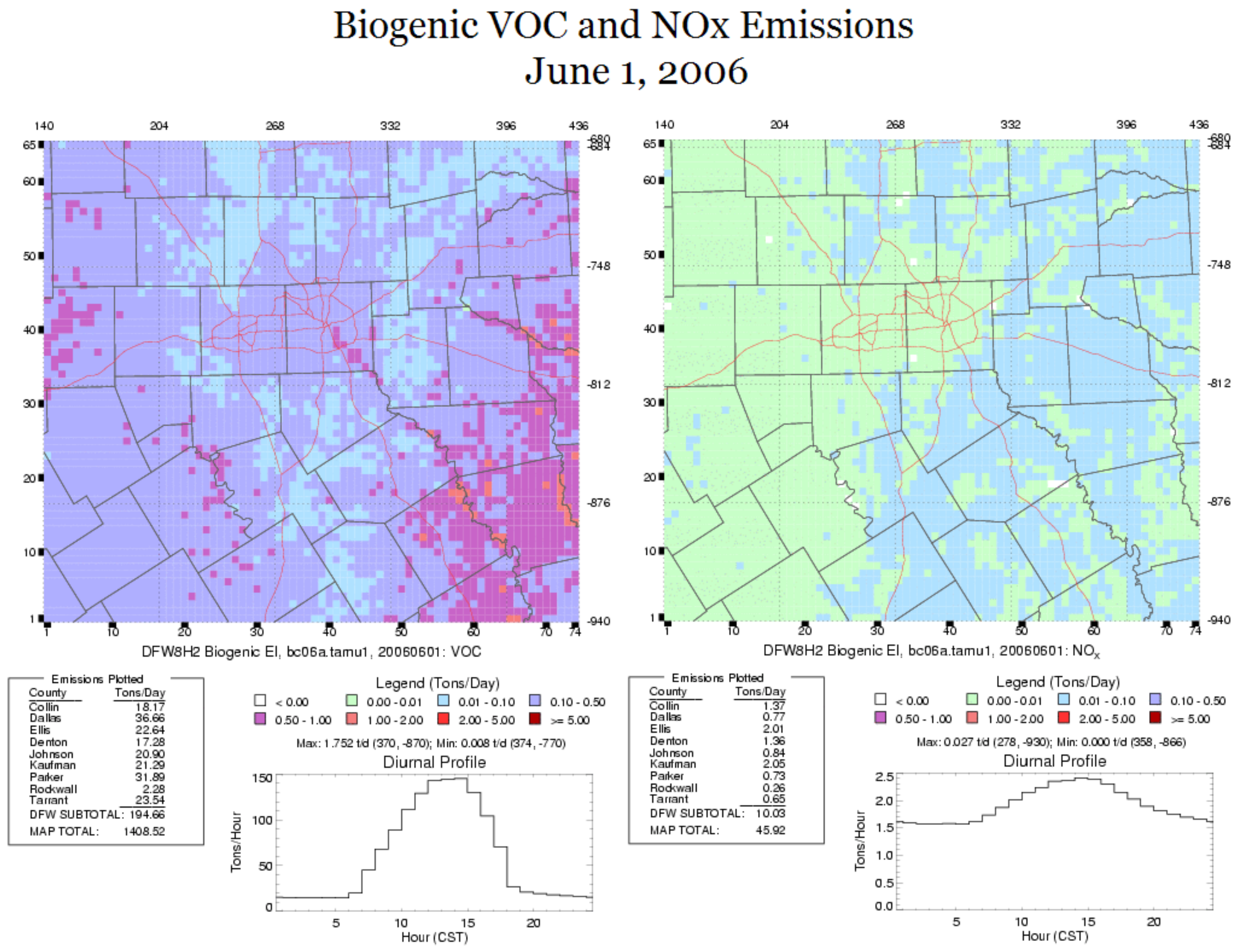


Figure 3-9: Example of Day-Specific Biogenic Emissions

Since biogenic emissions are associated with meteorological features, the same episode day-specific emissions were used as input for the 2006 baseline and 2012 future air quality modeling.

3.5.2 2006 Base Case

3.5.2.1 Point Sources

Point source modeling emissions were developed from regional inventories such as the Central States Regional Air Planning Association/Regional Planning Organization (CENRAP/RPO) emissions database and EPA's Acid Rain Database (ARD), state inventories including the State of Texas Air Reporting System (STARS), and local inventories. Data were processed with EPS3 to generate model-ready emissions, and similar procedures were used to develop each base case episode.

Outside Texas

Point source emissions data for the regions of the modeling domains outside Texas were obtained from a number of different sources. Emissions from point sources in the Gulf of Mexico (e.g., oil and gas production platforms) were obtained from the 2005 Gulf-Wide Emissions Inventory (GWEI) provided by the Minerals Management Services (MMS) as monthly totals. Canadian emissions were obtained from EPA modeling emission files developed for the 2001 Clean Air Interstate Rule (CAIR) base case analysis (EPA, 2005) and Mexican emissions data were obtained from Phase III of the Mexican National Emissions Inventory (National Emissions Inventory (NEI); http://www.epa.gov/ttn/chief/net/mexico.html). The Gulf of Mexico, Canadian, and Mexican inventories were not grown to 2006 due to the lack of historical operations data, applied controls, and/or a projection methodology.

For the non-Texas United States within the modeling domains, hourly NO_X emissions for major electric generating units (EGUs) were obtained from the ARD for each hour of each episode day. Emissions for non-ARD sources in states beyond Texas were obtained from the modeling emissions files used for the 2002 CENRAP/RPO base cases for the Revisions to the State Implementation Plan (SIP) Concerning Regional Haze, with the exception of Arkansas, Louisiana, and Oklahoma. State-specific 2005 point source annual emissions for non-ARD sources were provided by Arkansas and Oklahoma. Louisiana provided their 2004 annual point source emissions since the 2005 annual emissions are incomplete due to hurricane Katrina. The EPA's Economic Growth Analysis System Version 5.0 (EGAS5) was used to grow these emissions to 2006.

Within Texas

Hourly NO_X emissions from EGUs within Texas were obtained from the ARD for each episode day. Emissions from non-ARD sources were obtained from a STARS emissions extract for the year 2006. In addition, agricultural and forest fire emissions for 2006 were obtained from a TCEQ-funded study (Environ, 2008b), which treated fires as point sources. For the HGB area, 2006 event-specific tank landing loss emissions were obtained from a special inventory survey requested by the TCEQ; the average of the non-zero days was used in this AD SIP revision. Highly reactive volatile organic compounds (HRVOC), ethylene, propylene, butenes, and 1,3-butadiene, emissions were reconciled with ambient measurements by comparing concentrations measured by automated gas chromatographs (auto-GCs) in the area with concentrations expected at those locations based on the reported inventory. Appendix B: *Emissions Modeling for the HGB Attainment Demonstration SIP Revision for the 1997 Eight-Hour Ozone Standard* provides more details on the reconciliation of HRVOC emissions.

Table 3-7: *2006 Base Case Episode Point Source Modeling Emissions* provides the state and nine-county DFW point source emissions for June 7, 2006, (a Wednesday) within the 33-day base case episode. Acid rain point source emissions are unique for each day of the base case episode. Non-ARD emissions are an average of reported ozone season day emissions for the entire period of June through August and are the same for each episode day.

Table 3-7: 2006 Base Case Episode Point Source Modeling Emissions

Point Source Type	DFW NO_X (tpd)	DFW VOC (tpd)	Texas NO_X[5] (tpd)	Texas VOC[5] (tpd)
ARD[1]	9.4	0.9	519.6	32.9
Non-ARD[2]	41.6	40.0	744.7	602.2
Tank Landing[3]				6.6
HRVOC[4]				19.3
Totals	**51.0**	**40.9**	**1264.3**	**661.0**

Notes:
1. ARD emissions listed are for Wednesday, June 7, 2006.
2. Non-ARD emissions listed are for ozone season day (OSD) weekday, OSD weekend days are slightly less.
3. Tank landing emissions listed are episode-specific average for days with non-zero emissions.
4. HRVOC reconciled emissions listed are the amounts added to those reported via the emissions reconciliation procedure.
5. Note that the entire state of Texas is not included in the modeling domain.

On-Road Mobile Sources

2006 on-road mobile source inputs were developed using MOVES2010a, which is the EPA's latest available on-road emissions model. The vehicle activity data sets that were used in conjunction with MOVES2010a are:

- the travel demand model (TDM) managed by the North Central Texas Council of Governments (NCTCOG) for the DFW area;
- Highway Performance Monitoring System (HPMS) data collected by the Texas Department of Transportation (TxDOT) for the non-DFW portions of Texas contained within the modeling domain; and
- the EPA default information included with the MOVES2010a database for the non-Texas United States portions of the modeling domain.

The output from these emission modeling applications were processed through EPS3 to generate the on-road speciated and gridded inputs for photochemical modeling applications.

DFW Area

For the nine-county DFW area, link-based on-road emissions were developed by NCTCOG using 2006 TDM output and MOVES2010a emission rates to generate average summer and school season on-road emissions for five day types: Monday, weekday (Tuesday-Thursday average), Friday, Saturday, and Sunday. For the 2006 base case episode, the summer season day-type emissions were used.

Non-DFW Portions of Texas

For the Texas counties outside of the DFW area, on-road emissions were developed by the Texas Transportation Institute (TTI) using MOVES2010a emission rates and 2006 local HPMS data. Average summer emissions by vehicle type and roadway type were estimated for the four day types of weekday (Monday through Thursday average), Friday, Saturday, and Sunday.

Outside of Texas

For the non-Texas United States portions of the modeling domain, the TCEQ used MOVES2010a in default mode to generate 2006 average summer emissions for the weekday and weekend day types available from the model.

Table 3-8: *Summary of On-Road Mobile Source Emissions Development* contains additional detail about the on-road mobile inventory development in different regions of the modeling domain.

Table 3-8: Summary of On-Road Mobile Source Emissions Development

On-Road Inventory Development Parameter	DFW	Non-DFW Texas	Non-Texas States/Counties
VMT Source and Resolution	TDM Roadway Links	HPMS Data Sets 19 Roadway Types	MOVES2010a 12 Roadway Types
Season Types	Summer and School Seasons	Summer Season Only	Summer Season Only
Day Types	Monday, Weekday, Friday, Saturday, and Sunday	Weekday, Friday, Saturday, and Sunday	Weekday and Weekend
Roadway Speed Distribution	Varies by Hour and Link	Varies by Hour and Roadway Type	MOVES2010a Default
MOVES2010a Fuel and Source Use Types	Gasoline and Diesel 13 Source Use Types	Gasoline and Diesel 13 Source Use Types	Gasoline and Diesel 13 Source Use Types

Note: VMT= vehicle miles traveled

Table 3-9: *2006 Base Case Episode On-Road Modeling Emissions for DFW (tpd)* summarizes the on-road mobile source emissions for the 2006 base case episode for the nine-county DFW area.

Table 3-9: 2006 Base Case Episode On-Road Modeling Emissions for DFW (tpd)

On-Road Day Type	NO_X tpd	VOC tpd
Weekday	259.11	111.02
Friday	264.31	114.61
Saturday	189.98	103.25
Sunday	168.95	96.60
Monday	252.43	109.12

Notes: Only summer season emissions are reported.

3.5.2.2 Non-Road and Off-Road Mobile Sources

Non-road mobile sources include vehicles, engines, and equipment used for construction, agriculture, transportation, recreation, and many other purposes. Off-road mobile sources are aircraft, locomotives, and marine vessels. Non- and off-road mobile source modeling emissions were developed using the EPA NMIM, the EPA NEI, TexN, and data from the TCEQ's Texas Air Emissions Repository (TexAER). The output from these emission modeling applications and databases were processed through EPS3 to generate the air quality model-ready non- and off-road mobile source emission files.

Outside Texas

For the non-Texas United States within the modeling domains, the TCEQ used the EPA's NMIM. NMIM generates average summer weekday non-road mobile source category emissions by county and was run for 2006. For the off-road mobile source categories (aircraft, locomotive, and marine) in the non-Texas states, the TCEQ used the EPA's 2002 NEI with EGAS5 growth factors and national controls for locomotives and marine vessels to generate 2006 average summer weekday off-road mobile source category emissions. Summer weekend day emissions for the non- and off-road mobile source categories were developed as part of the EPS3 processing using category specific weekly activity profiles.

Within Texas

The TCEQ used the TexN model to generate average summer weekday non-road mobile source category emissions by county for 2006, except for oil and gas drilling rigs. The county-level drilling rig emissions were based on 2008 emissions (ERG, 2009), adjusted to 2006 according to the ratio of active drill rig counts in 2006 and 2008 from Baker Hughes (Baker Hughes, 2010) and RigData (RigData, 2009). The drill rig emissions were also adjusted according to the non-road engine tier mix in the TexN model (higher emissions in 2006 than 2008). More information on the development of the oil and gas drilling inventory can be found in Appendix B.

County-level off-road emissions for 2006 were estimated by adjusting the 2005 TexAER emissions with the Texas-specific Regional Economic Models, Inc. – Economic Growth Analysis System (REMI-EGAS) growth factors, except for the aircraft/airport emissions, locomotive emissions, and marine vessels in the HGB and Beaumont-Port Arthur (BPA) areas. The 2012 emissions for marine vessels in the HGB and BPA areas were developed using emission trends provided by the HGB and BPA Port Authorities (Starcrest, 2000). No marine vessels (commercial shipping) operate in the DFW nonattainment area. The 2006 aircraft/airport emissions in the DFW area were provided by contract (North Central Texas Council of Governments (NCTCOG), 2011) and are airport-specific rather than county-level. The locomotive emissions were calculated using the Texas Railroad Emission Inventory Model (TREIM) model for 2006, specific for switchers and line-hauls (ERG, 2007). Summer weekend day emissions for the non- and off-road mobile source categories were developed as part of the EPS3 processing using category specific weekly activity profiles.

Table 3-10: *2006 Base Case Episode Non-Road and Off-Road Modeling Emissions for DFW* summarizes the non-road and off-road mobile source weekday emissions for the 2006 base case episode for the nine-county DFW area.

Table 3-10: 2006 Base Case Episode Non-Road and Off-Road Modeling Emissions for DFW

Source Category Type	2006 NO_X tpd	2006 VOC tpd
Non-Road	103.3	61.2
Airports	11.0	5.1
Locomotives	28.7	1.7
Marine	0.0	0.0
Total	**142.9**	**67.9**

Note: VOC is reported as sum of CB05 species

3.5.2.3 Area Sources

Area source modeling emissions were developed using the EPA NEI and the TCEQ's TexAER database. The emissions information in these databases was processed through EPS3 to generate the air quality model-ready area source emission files.

Outside Texas

For the non-Texas United States within the modeling domains, the TCEQ used the EPA's 2002 NEI with EGAS5 growth factors to generate 2006 daily area source emissions.

Within Texas

The TCEQ used data from the 2005 TexAER database (TCEQ, 2011) for non-oil and gas sources. The 2005 TexAER data were projected to 2006 using the Texas-specific REMI-EGAS growth factors for the 2006 base case episode.

For oil and gas production sources, county-specific 2006 oil and gas emissions were calculated based on a TCEQ-contracted research project (ERG, 2010). The emissions were calculated according to 2006 county-specific oil and gas production information from the Railroad Commission of Texas and emission factors compiled in the 2010 ERG report. Emissions and specificity of the 2006 base case oil and gas emissions are detailed in Table 3-11: *2006 DFW Nine-County Oil and Gas Production Emissions*. Previous oil and gas modeling inventories contained only two source categories: onshore and offshore oil and gas. Detailed information on the development of the oil and gas production emissions inventory is described in Appendix B.

Table 3-11: 2006 DFW Nine-County Oil and Gas Production Emissions

Oil & Gas Category	2006 NO_X tpd	2006 VOC tpd
2-Cycle Lean Burn Compressor	1.3	0.0
4-Cycle Lean Burn Compressor	0.8	0.2
4-Cycle Rich Burn Compressor	46.2	1.0
4-Cycle Rich Burn Compressor w/ Catalyst	0.6	0.1
Oil Fugitives (grouped)	0.0	0.0
Gas Fugitives (grouped)	0.0	2.5
Crude Tanks	0.0	0.2
Condensate Tanks	0.0	40.6
Oil Heaters	0.0	0.0
Gas Heaters	1.2	0.1
Dehydrators	0.0	1.3
Pumpjacks	0.1	0.0
Oil Loading	0.0	0.0
Condensate Loading	0.0	0.3
Oil Well Completions	0.0	0.1
Gas Well Completions	0.0	3.0
Oil Well Blowdowns	0.0	0.1
Gas Well Blowdowns	0.0	0.7
Pneumatic Devices	0.0	21.5
Produced Water	0.0	0.5
Total	**50.1**	**72.1**

Table 3-12: *2006 Base Case Episode Area Source Modeling Emissions for DFW* summarizes the area source weekday emissions for the 2006 base case episode for the nine-county DFW area.

Table 3-12: 2006 Base Case Episode Area Source Modeling Emissions for DFW

Area Source Category	2006 NO_X tpd	2006 VOC tpd
Oil and Gas Production	50.1	72.1
Petro Transport & Refueling	0.0	42.9
Architectural Coating	0.0	34.4
Solvent Use	0.0	57.5
Surface Cleaning	0.0	1.0
Industrial Fuel Use	13.5	0.5
Residential Fuel Use	2.2	0.1
Auto Refinishing	0.0	3.9
Waste Treatment	0.0	10.1
Graphic Arts	0.0	1.4
Pesticide Use	0.0	0.0
Leaking Underground Storage Tank	0.0	3.0
Traffic Marking	0.0	0.5
Surface Coating	0.0	49.7
Open Burning	0.5	2.9
Dry Cleaning	0.0	3.8
Asphalt Paving	0.0	0.7
Food/Brewing	0.0	0.9
Area Source Total	**66.3**	**285.3**

3.5.2.4 Base Case Summary

Table 3-13: *2006 Base Case Episode Anthropogenic Modeling Emissions for DFW* summarizes the typical weekday emissions in the nine-county DFW area by source type for the base case episode.

Table 3-13: 2006 Base Case Episode Anthropogenic Modeling Emissions for DFW

Category	2006 NO_X tpd	2006 VOC tpd
On-Road Mobile (MOVES2010a)	259	111
Non-Road (excl. Oil & Gas Drilling)	85	60
Off-Road	40	7
Point Source	51	41
Area (excl. Oil & Gas Production)	16	213
Oil & Gas Production	50	72
Oil & Gas Drilling	18	1
DFW Total	**519**	**505**

Notes:
1. Point source emissions are based on non-startup Wednesday ARD emissions.
2. On-road emissions are summer season-specific weekday emissions.
3. Non-road, off-road and area emissions are year-specific OSD emissions.
4. Off-road emissions consist of airport and locomotive emissions.
5. VOC is reported as sum of CB05 species.

3.5.3 2006 Baseline

The baseline modeling emissions are based on typical ozone season emissions, whereas the base case modeling emissions are episode day-specific. The biogenic emissions are an exception in that the same episode day-specific emissions are used in the 2006 baseline and base case. In addition, the 2006 baseline non-road and off-road and area source modeling emissions are the same as used for the 2006 base case episode, since they are based on typical ozone season emissions. Unlike the base case, fire emissions were not included in the 2006 baseline as they are not typical ozone season day emissions.

3.5.3.1 Point Sources

For the non-ARD point sources, the 2006 baseline emissions are the same as the modeling emissions used for the June 2006 episode, with a couple of exceptions. The 2006 baseline ARD EGUs emissions were estimated using the average of the 2006 third quarter hourly ARD emissions to more accurately reflect EGU emissions during the peak ozone season. The HRVOC emissions reconciliation and tank landing losses in the HGB area developed for the 2006 base case were used for the 2006 baseline. For the Gulf of Mexico, Canada, and Mexico, the 2006 baseline used the same emissions as the base cases.

Table 3-14: *2006 Baseline Point Source Modeling Emissions* provides the state and the nine-county DFW point source emissions for the 2006 typical baseline day. The non-ARD emissions are the same as the base case, since they are ozone season day averages. The averaged baseline ARD emissions are not the same as any specific day in the base case, but typical of the entire episode.

Table 3-14: 2006 Baseline Point Source Modeling Emissions

Point Source Type	DFW NO_X tpd	DFW VOC tpd	Texas NO_X tpd	Texas VOC^5 tpd
ARD[1]	9.1	0.9	548.6	29.8
Non-ARD[2]	41.6	40.0	744.7	602.2
Tank Landing[3]				6.6

Point Source Type	DFW NO_X tpd	DFW VOC tpd	Texas NO_X tpd	Texas VOC^5 tpd
HRVOC[4]				19.3
Totals	**50.7**	**40.9**	**1293.3**	**657.9**

Notes:
1. ARD emissions listed are for Wednesday, June 7, 2006.
2. Non-ARD emissions listed are for OSD weekday, OSD weekend days are slightly less.
3. Tank landing emissions listed are episode-specific average for days with non-zero emissions.
4. HRVOC reconciled emissions listed are the amounts added to those reported via the emissions reconciliation procedure.
5. Note that the entire state of Texas is not included in the modeling domain.

3.5.3.2 On-Road Mobile Sources

The 2006 baseline on-road mobile source emissions are the same as used for the June 2006 base case episode. These are the summer season modeling emissions for each of the day types: Monday, weekday, Friday, Saturday, and Sunday.

3.5.4 2012 Future Base and Control Strategy

The biogenic emissions used for the 2012 future base and control strategy modeling are the same episode day-specific emissions used in the base case. In addition, similar to the 2006 baseline, no fire emissions were included in the 2012 future base and control strategy modeling. Appendix B provides extensive details of the 2012 modeling emissions development.

3.5.4.1 Point Sources

Outside Texas

The non-ARD point source emissions data in the regions outside Texas were derived from a combination of the modeling emissions files used for the 2018 CENRAP/RPO and the 2006 CENRAP/RPO (grown from the 2002 CENRAP/RPO base case files) Revisions to the State Implementation Plan (SIP) Concerning Regional Haze files. Since growth and controls were included in the 2018 files, the TCEQ computed and modeled the average of the 2006 and 2018 files for the 2012 regional non-ARD file. For the Gulf, Canada, and Mexico, the 2012 modeled emissions were the same as the emissions used in the 2006 baseline. The CAIR Phase 1 emission caps were used for the ARD EGU point source 2012 emissions.

Within Texas

Controls pertinent to existing DFW, HGB, and BPA AD SIP revisions were applied to the 2008 STARS future base emissions of the appropriate point source categories (e.g., Mass Emissions Cap and Trade program (MECT), HRVOC Emissions Cap and Trade program (HECT), Ellis County Cement Kiln Cap, and East Texas Combustion Rule), and those specific units were modeled at the previous SIP rule limitations. The remaining non-ARD emissions were projected from the 2008 STARS future base to 2012 using the larger of the Texas Industrial Production Index (TIPI), the Texas-specific REMI-EGAS growth factors, or the Emissions Banking and Trading Registry (the sum of the banked Emissions Reduction Credits (ERCs) and Discrete Emissions Reduction Credits (DERCs)) in the nonattainment areas, including DFW. This growth was constrained by the lesser of the Emissions Banking and Trading Registry or the TIPI-REMI-EGAS growth. The projected growth determines how many future tons of emissions will be needed by 2012, and the bank determines how many tons of emissions are available for purchase to allow for that growth in the DFW nonattainment area. An additional limitation on annual DERC usage for DFW, the DERC Flow Control rule (30 TAC 101.379), did not constrain growth for these four years because of low projected industrial growth.

Similar to the 2012 emissions for ARD sources outside Texas, the ARD sources within Texas used the TCEQ CAIR Phase 1 allocations.[5] The eight-county HGB area is subject to the more stringent MECT rule. The 2012 emissions for ARD sources within the HGB area used the MECT allocations which are more stringent, with the excess being allocated to the other ARD EGUs in the state. Newly-permitted ARD sources were limited to the CAIR 9.5% set-aside for growth. The 2012 tank landing emissions and the HRVOC reconciliation for the HGB area were the same as the 2006 baseline.

Table 3-15: 2012 Future Case Point Source Modeling Emissions provides the state and nine-county DFW point source emissions for the 2012 future case day. Compared to the 2006 baseline (Table 3-14), the future case shows a statewide reduction in NO_X and VOC emissions due to controls. DFW NO_X emissions are higher due to the CAIR cap allocating significantly more NO_X emissions to DFW EGUs than reported in recent years.

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[5] On July 6, 2011, the EPA finalized its CAIR replacement rule, known as the Cross-State Air Pollution Rule (CSAPR) requiring 27 states to reduce power plant emissions. CSAPR yields 10% more NO_X emission reductions outside Texas and 18% more in Texas in 2012 than would CAIR. Modeling the higher 2012 CAIR Phase I NO_X allocations is a more conservative approach for projecting attainment. However, a 2012 modeling sensitivity was conducted using CSAPR allocations for the entire country and is detailed in Appendix C, Section 5.5.1.5.

Table 3-15: 2012 Future Case Point Source Modeling Emissions

Point Source Type	DFW NO_X tpd	DFW VOC tpd	Texas NO_X tpd	Texas VOC[5] tpd
ARD[1]	18.9	0.8	487.6	16.5
Non-ARD[2]	32.0	38.6	706.2	565.0
Tank Landing[3]				6.6
HRVOC[5]				19.3
Totals	**50.9**	**39.4**	**1193.8**	**607.4**

Notes:
1. ARD emissions listed are for Wednesday, June 7, 2006.
2. Non-ARD emissions listed are for OSD weekday, OSD weekend days are slightly less.
3. Tank landing emissions listed are episode-specific average for days with non-zero emissions.
4. HRVOC reconciled emissions listed are the amounts added to those reported via the emissions reconciliation procedure.
5. Note that the entire state of Texas is not included in the modeling domain.

For the nine-county DFW area, the point source NO_X and VOC emissions are comparable for the 2006 baseline and the 2012 future base.

3.5.4.2 On-Road Mobile Sources

2012 on-road mobile source inputs were developed using MOVES2010a in combination with the following vehicle activity data sets:

- the TDM managed by NCTCOG for the DFW area;
- HPMS data collected by TxDOT for the non-DFW portions of Texas contained within the modeling domain; and
- the EPA default information included with the MOVES2010a database for the non-Texas United States portions of the modeling domain.

The output from these emission modeling applications were processed through EPS3 to generate the on-road speciated and gridded inputs for photochemical modeling applications.

DFW Area

For the nine-county DFW area, link-based on-road emissions were developed by the NCTCOG using 2012 TDM output and MOVES2010a emission rates to generate average summer and school season on-road emission for five day types: Monday, weekday (Tuesday-Thursday average), Friday, Saturday, and Sunday. For the 2012 future case, the summer season day-type emissions were used.

Non-DFW Portions of Texas

For the Texas counties outside of the DFW area, on-road emissions were developed by the Texas Transportation Institute (TTI) using MOVES2010a emission rates and local HPMS data projected out to 2012. Average summer emissions by vehicle type and roadway type were estimated for the four day types of weekday (Monday through Thursday average), Friday, Saturday, and Sunday.

Outside of Texas

For the non-Texas United States portions of the modeling domain, the TCEQ used MOVES2010a in default mode to generate 2012 average summer emissions for the weekday and weekend day types available from the model.

Table 3-16: *2012 Future Case On-Road Modeling Emissions for DFW (tpd)* summarizes the on-road mobile source emissions for each of the 2012 future case day types for the nine-county DFW area.

Table 3-16: 2012 Future Case On-Road Modeling Emissions for DFW (tpd)

On-Road Day Type	NO_X tpd	VOC tpd
Weekday	181.40	80.48
Friday	182.24	81.87
Saturday	136.68	74.80
Sunday	124.84	71.37
Monday	175.33	78.97

Note: Only summer season emissions are reported.

For the nine-county DFW area, the on-road mobile source NO_X emissions are reduced by about 30% from the 2006 baseline (259.1 tpd) to the 2012 future case (181.4 tpd), and the VOC emissions are decreased about 28% from the 2006 baseline (111.0 tpd) to the 2012 future case (80.5 tpd).

3.5.4.3 Non- and Off-Road Mobile Sources

Outside Texas

For the non-Texas United States within the modeling domains, the TCEQ used the EPA's NMIM to generate average summer weekday non-road mobile source category emissions by county for 2012. For the off-road mobile source categories, aircraft, locomotive, and marine, in the states beyond Texas, the TCEQ used the EPA's 2002 NEI with EGAS5 growth factors and national controls for locomotives and marine vessels to generate 2012 average summer weekday off-road mobile source category emissions. Summer weekend day emissions for the non-road and off-road mobile source categories were developed as part of the EPS3 processing using category specific weekly activity profiles.

Within Texas

The TCEQ used the TexN model to generate average summer weekday non-road mobile source category emissions by county for 2012, except for oil and gas drilling rigs. The county-level drilling rig emissions were based on 2008 emissions (ERG, 2009), adjusted to 2010 according to the ratio of active drill rig counts in 2008 and 2010 from Baker Hughes (Baker Hughes, 2010) and RigData (RigData, 2009). A 10% growth was assumed from 2010 to 2012 for the Barnett Shale and Haynesville Shale counties. Growth of 20%was assumed in the developing Eagle Ford Shale in south and central Texas. Also, 10% growth was assumed from 2010 to 2012 for all other Texas counties. Drill rig emissions were also adjusted according to the non-road engine tier mix in the TexN model (cleaner in 2012). More information on the development of the oil and gas drilling inventory can be found in Appendix B.

The 2012 aircraft/airport emissions in the DFW area were provided by contract (NCTCOG, 2011) and are airport specific rather than county level. The 2012 emissions for marine vessels in the HGB and BPA areas were developed using emission trends provided by the HGB and BPA

Port Authorities (Starcrest, 2000). No marine vessels (commercial shipping) operate in the DFW nonattainment area. The locomotive emissions were calculated using the TREIM model for 2012, specific for switchers and link-based line-hauls (ERG, 2007). Summer weekend day emissions for the non-road and off-road mobile source categories were developed as part of the EPS3 processing using category specific weekly activity profiles.

Table 3-17: *2012 Future Case Non-Road and Off-Road Modeling Emissions for DFW* summarizes the non-road and off-road mobile source weekday emissions for the 2012 future case for the nine-county DFW area.

Table 3-17: 2012 Future Case Non-Road and Off-Road Modeling Emissions for DFW

Source Category Type	2012 NO_X tpd	2012 VOC tpd
Non-Road	72.5	43.3
Airports	10.1	4.3
Locomotives	26.8	1.7
Marine	0.0	0.0
Total	**109.5**	**49.3**

For the nine-county DFW area, the non-road and off-road mobile source NO_X emissions are reduced by about 23% from the 2006 baseline (142.9 tpd) to the 2012 future base (109.5 tpd) and the VOC emissions are decreased about 27% from the 2006 baseline (67.9 tpd) to the 2012 future base (49.3 tpd).

3.5.4.4 Area Sources

Outside Texas

For the non-Texas United States within the modeling domains, the TCEQ used the EPA's 2002 NEI with EGAS5 growth factors to generate 2012 daily area source emissions.

Within Texas

The 2012 county-level area source emissions were estimated by adjusting the 2005 TexAER emissions with the Texas-specific REMI-EGAS growth factors, except for the oil and gas emissions category.

For oil and gas production sources, county-specific 2010 oil and gas emissions were calculated according to June 2010 county-specific oil and gas production information from the Railroad Commission of Texas and emission factors based on equipment surveys (ERG, 2010; TCEQ, 2009), the East Texas Combustion rule (TCEQ, 2007b), and the 2007 DFW Minor Source rules (TCEQ, 2007a). A 10% growth in production and drilling emissions was assumed from 2010 to 2012 for the Barnett Shale and Haynesville Shale counties as wells continue to be drilled. Growth in production and drilling emissions of 20% was assumed in the developing Eagle Ford Shale in south and central Texas. A 10% growth in production and drilling emissions was assumed from 2010 to 2012 for all other Texas counties as oil/gas well drilling continues. Table 3-18: *2012 DFW Nine-County Oil and Gas Production Emissions* details the emissions for the 2012 future case oil and gas emissions. More information on the development of the oil and gas emissions inventory is described in Appendix B.

Table 3-18: 2012 DFW Nine-County Oil and Gas Production Emissions

Oil & Gas Category	2012 NO_X tpd	2012 VOC tpd
2-Cycle Lean Burn Compressor	0.3	0.1
4-Cycle Lean Burn Compressor	0.5	0.3
4-Cycle Rich Burn Compressor	1.2	0.1
4-Cycle Rich Burn Compressor w/ Catalyst	4.6	3.2
Oil Fugitives (grouped)	0.0	0.1
Gas Fugitives (grouped)	0.0	6.7
Crude Tanks	0.0	0.4
Condensate Tanks	0.0	33.5
Oil Heaters	0.0	0.0
Gas Heaters	3.0	0.2
Dehydrators	0.0	3.6
Pumpjacks	0.1	0.0
Oil Loading	0.0	0.0
Condensate Loading	0.0	0.3
Oil Well Completions	0.0	0.1
Gas Well Completions	0.0	3.3
Oil Well Blowdowns	0.0	0.1
Gas Well Blowdowns	0.0	1.7
Pneumatic Devices	0.0	57.2
Produced Water	0.0	2.2
Total	**9.7**	**113.1**

Table 3-19: *2012 Future Case Episode Area Source Modeling Emissions for DFW* summarizes the area source weekday emissions for the 2012 future case episode for the nine-county DFW area.

Table 3-19: 2012 Future Case Episode Area Source Modeling Emissions for DFW

Area Source Category	2012 NO_X tpd	2012 VOC tpd
Oil and Gas Production	9.7	113.1
Petro Transport & Refueling	0.0	45.0
Architectural Coating	0.0	40.5
Solvent Use	0.0	64.1
Surface Cleaning	0.0	1.3
Industrial Fuel Use	15.3	0.6
Residential Fuel Use	2.4	0.1
Auto Refinishing	0.0	4.6
Waste Treatment	0.0	11.2
Graphic Arts	0.0	1.5
Pesticide Use	0.0	0.0
Leaking Underground Storage Tank	0.0	3.1
Traffic Marking	0.0	0.5

Area Source Category	2012 NO_X tpd	2012 VOC tpd
Surface Coating	0.0	58.5
Open Burning	0.5	3.2
Dry Cleaning	0.0	4.1
Asphalt Paving	0.0	0.8
Food/Brewing	0.0	1.0
Area Source Total	**27.9**	**353.1**

For the nine-county DFW area, the area source NO_X emissions decreased by about 58% from the 2006 baseline (66.3 tpd) to the 2012 future base (27.9 tpd), and the VOC emissions increased about 24% from the 2006 baseline (285.3 tpd) to the 2012 future base (353.1 tpd).

3.5.4.5 Future Base Summary

Table 3-20: *2012 Future Base Anthropogenic Modeling Emissions for DFW* summarizes the typical weekday emissions in the nine-county DFW area by source type for the 2012 future base modeling.

Table 3-20: 2012 Future Base Anthropogenic Modeling Emissions for DFW

Category	2012 NO_X tpd	2012 VOC tpd
On-Road Mobile	181	80
Non-Road (excl. Oil & Gas Drilling)	64	43
Off-Road	37	6
Point Source	51	39
Area (excl. Oil & Gas Production)	18	240
Oil & Gas Production	10	113
Oil & Gas Drilling	9	1
DFW Total	**370**	**522**

Notes:
1. Point source emissions are based on non-startup Wednesday ARD emissions
2. On-road emissions are summer season-specific weekday emissions
3. Non-road, off-road and area emissions are year-specific OSD emissions
4. Off-road emissions consist of airport and locomotive emissions
5. VOC is reported as sum of CB05 species

3.5.5 2006 and 2012 Modeling Emissions Summary for DFW

Table 3-21: *Summary of 2006 Baseline and 2012 Future Base Anthropogenic Modeling Emissions for DFW* summarizes the typical weekday anthropogenic emissions in the nine-county DFW area by source type for the 2006 baseline and 2012 future base modeling emissions. Oil and gas production and drilling have also been separated.

Table 3-21: Summary of 2006 Baseline and 2012 Future Base Anthropogenic Modeling Emissions for DFW

Category	2006 NO_X tpd	2012 NO_X tpd	2006 VOC tpd	2012 VOC tpd
On-Road Mobile (MOVES2010a)	259	181	111	80
Non-Road (excl. Oil & Gas Drilling)	85	64	60	43
Off-Road	40	37	7	6
Point Source	51	51	41	39
Area (excl. Oil & Gas)	16	18	213	240
Oil & Gas Production	50	10	72	113
Oil & Gas Drilling	18	9	1	1
DFW Total	**519**	**370**	**505**	**522**

Figure 3-10: *2006 Baseline and 2012 Future Base Anthropogenic NO_X and VOC Modeling Emissions for DFW* graphically compares the anthropogenic NO_X and VOC modeling emissions for the nine-county DFW area.

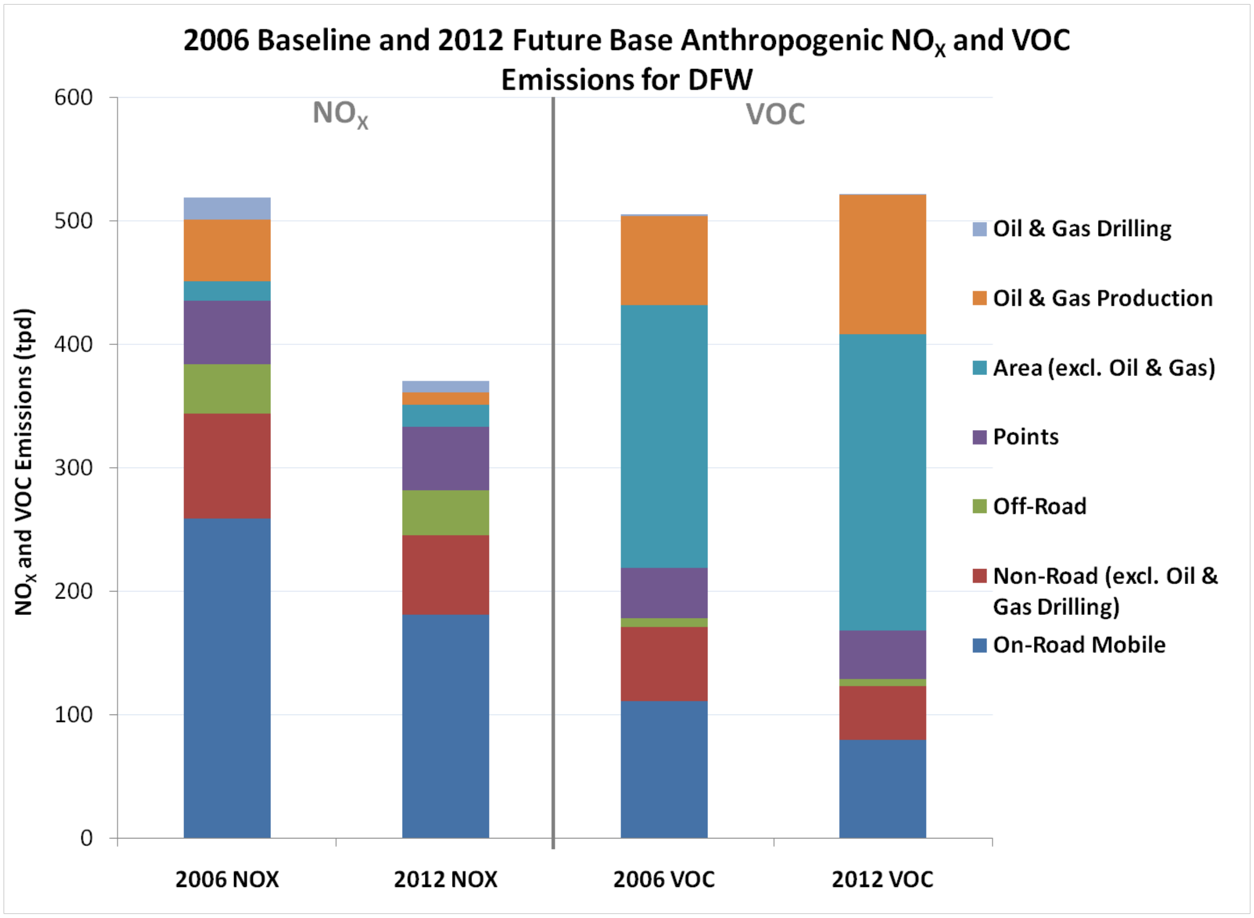

Figure 3-10: 2006 Baseline and 2012 Future Base Anthropogenic NO_X and VOC Modeling Emissions for DFW

3.6 PHOTOCHEMICAL MODELING

To ensure that a modeling study can be successfully used as technical support for an AD SIP revision, the air quality model must be scientifically sound and appropriate for the intended application and freely accessible to all stakeholders. In a regulatory environment, it is crucial that oversight groups (e.g., the EPA), the regulated community, and the public have access to and have reasonable assurance of the suitability of the model. The following three prerequisites were identified for selecting the air quality model to be used in the DFW attainment demonstration. The model must:

- have a reasonably current, peer-reviewed, scientific formulation;
- be available at no or low cost to stakeholders; and
- be consistent with air quality models being used for Texas SIP development.

The only model to meet all three of these criteria is the Comprehensive Air Quality Model with extensions (CAMx). The model is based on well-established treatments of advection, diffusion, deposition, and chemistry. Another important feature is that NO_X emissions from large point sources can be treated with the PiG submodel, which helps avoid the artificial diffusion that occurs when large, hot, point source emissions are introduced into a grid volume. The model software and the CAMx user's guide are publicly available (Environ, 2010). In addition, the TCEQ has many years of experience with CAMx. CAMx was used for the modeling conducted in the HGB and BPA nonattainment areas, previous DFW attainment demonstrations, as well as for modeling being conducted in other areas of Texas (e.g., San Antonio).

CAMx Version 5.20.1 was used for this modeling study. Some of the features in this version include the ability to process in parallel on multiple processors and the following probing tools for sensitivity analysis:

- Process Analysis, which provides in-depth details of ozone formation, showing the various physical and chemical processes that determine the modeled ozone concentrations at specified locations and times;
- Ozone Source Apportionment Technology (OSAT), which estimates the contribution of emissions from multiple geographical areas and source categories (including biogenic emissions) to ozone formation; and
- Anthropogenic Precursor Culpability Assessment (APCA), which reallocates ozone apportioned to non-controllable biogenic emissions to the controllable portion of precursors that participated in ozone formation.

3.6.1 Modeling Domains and Horizontal Grid Cell Size

Figure 3-11: *DFW Photochemical Modeling Domains* depicts the modeling domains used in CAMx. All domains were projected in a Lambert Conformal Projection (LCP) with origin at 100 degrees west and 40 degrees north. The horizontal configuration of the CAMx modeling domains consists of a grid of 4 km by 4 km cells (4 km) encompassing the DFW nonattainment counties (blue box), nested within a grid of 12 km cells covering most of Texas and Louisiana (green box), nested within a grid of 36 km cells covering the eastern part of the United States (black box). The size of the 36 km outer domain was selected to minimize the effect of boundary conditions on predicted ozone concentrations at the finer grid resolutions. The domain specifications are detailed in Table 3-22: *CAMx Modeling Domain Definitions*.

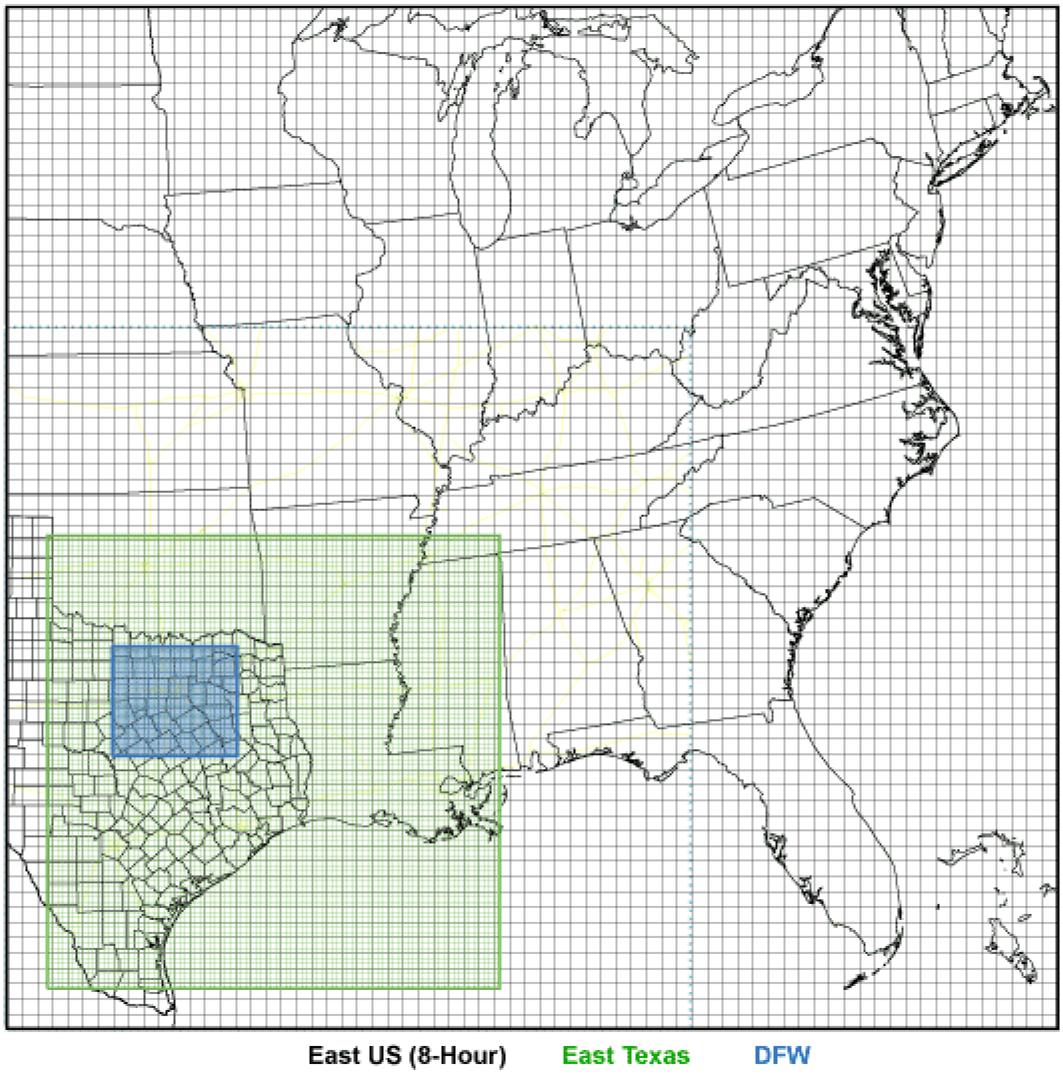

Figure 3-11: DFW Photochemical Modeling Domains

Table 3-22: CAMx Modeling Domain Definitions

Domain	Easting Range (km)	Northing Range (km)	East/West Grid Points	North/South Grid Points
36 km	(-108, 1512)	(-1584, 828)	69	67
12 km	(-12, 1056)	(-1488, -420)	89	89
4 km	(140, 436)	(-940, -680)	74	65

3.6.2 Vertical Layer Structure

The vertical configuration of the CAMx modeling domains consists of 28 layers of varying depths as shown in Table 3-23: *CAMx Vertical Layer Structure*.

Table 3-23: CAMx Vertical Layer Structure

CAMx Layer	MM5 Layer	Top (m AGL1)	Center (m AGL1)	Thickness (m)
28	38	15179.1	13637.9	3082.5
27	36	12096.6	10631.6	2930.0
26	32	9166.6	8063.8	2205.7
25	29	6960.9	6398.4	1125.0
24	27	5835.9	5367.0	937.0
23	25	4898.0	4502.2	791.6
22	23	4106.4	3739.9	733.0
21	21	3373.5	3199.9	347.2
20	20	3026.3	2858.3	335.9
19	19	2690.4	2528.3	324.3
18	18	2366.1	2234.7	262.8
17	17	2103.3	1975.2	256.2
16	16	1847.2	1722.2	256.3
15	15	1597.3	1475.3	249.9
14	14	1353.4	1281.6	243.9
13	13	1209.8	1139.0	143.6
12	12	1068.2	998.3	141.6
11	11	928.5	859.5	137.8
10	10	790.6	745.2	90.9
9	9	699.7	654.7	90.1
8	8	609.5	564.9	89.3
7	7	520.2	476.0	88.5
6	6	431.7	387.8	87.8
5	5	343.9	300.4	87.0
4	4	256.9	213.7	86.3
3	3	170.5	127.7	85.6
2	2	84.9	59.4	51.0
1	1	33.9	16.9	33.9

3.6.3 Model Configuration

The TCEQ used CAMx version 5.20.1, which includes a number of upgrades and features from previous versions. The following CAMx 5.20.1 options were employed:

- parallel processing of the chemistry and transport algorithms;
- CB05 chemical mechanism with Euler Backward Iterative (EBI) chemistry solver;
- Piecewise Parabolic Method (PPM) advection solver;
- improved vertical transport solvers; and
- updated PiG treatment of larger point sources of NO_X using the Greatly Reduced Execution and Simplified Dynamics (GREASD) Lagrangian module.

In addition to the CAMx inputs developed from the meteorological and emissions modeling, inputs were needed for initial and boundary conditions, spatially resolved surface characteristic parameters, spatially resolved albedo/haze/ozone (i.e., opacity) and photolysis rates, and a chemistry parameters file.

The TCEQ contracted with Environ (Environ, 2008b), who collaborated with the National Aeronautics and Space Administration's (NASA) Jet Propulsion Laboratory (JPL) to derive episode-specific boundary conditions from the Model for Ozone and Related Chemical Tracers (MOZART) global air quality model. Boundary conditions were developed for each grid cell along all four edges of the 36 km domain at each vertical layer (28) for each episode hour. This work also produced initial conditions for the episode. The TCEQ used these episode-specific initial and boundary conditions for this modeling study. The top-boundary condition input has been removed as of CAMx version 5.20.

Surface characteristic parameters, including roughness, vegetative distribution, and water/land boundaries, were input to CAMx via a land-use file. The land-use file provides the fractional contribution (0 to 1) of eleven land-use categories, as defined by the USGS LULC database. For the 36 km and 12 km domains, the TCEQ used the land-use files developed by Environ for the DFW AD SIP revision approved by the EPA in 2009, which were derived from the most recent USGS LULC database. For the 4 km domain the TCEQ used updated land-use files developed by Texas A&M University (Popescu et al., 2008), which were derived from more highly resolved LULC data collected by the Texas Forest Service and the University of Texas – Center for Space Research.

The spatially resolved opacity and photolysis rates are input to CAMx via a photolysis rates file and an opacity file, which are specific to the chemistry parameters file for the CB05 mechanism, and also input to CAMx. The TCEQ used episode-specific satellite data from the Total Ozone Mapping Spectrometer (TOMS) to prepare the photolysis rates and opacity files.

3.6.4 Model Performance Evaluation

The CAMx model configuration was applied to the 2006 base case using the episode-specific meteorological parameters and emissions, including MOVES2010a-based on-road emissions unless otherwise noted. The CAMx modeling results were compared to the measured ozone and ozone precursor concentrations, which resulted in a number of modeling iterations involving improvements to the meteorological and emissions modeling and subsequent CAMx modeling. A detailed performance evaluation for the 2006 base case modeling episode is included in Appendix C: *Photochemical Modeling for the DFW Attainment Demonstration SIP Revision for the 1997 Eight-Hour Ozone Standard*. In addition, all performance evaluation products are available on the TCEQ FTP site (ftp://amdaftp.tceq.texas.gov/).

3.6.4.1 Performance Evaluations Overview

The performance evaluation of the base case modeling demonstrates the adequacy of the model to correctly replicate the relationship between levels of ozone and the emissions of NO_X and VOC. The model's ability to suitably replicate this relationship is necessary to have confidence in the model's prediction of the future year ozone and its response of ozone to various control measures. As recommended in the EPA modeling guidance, the TCEQ conducted two types of performance evaluations, operational and diagnostic.

3.6.4.2 Operational Evaluations

Statistical measures including the Unpaired Peak Accuracy (UPA), the Mean Normalized Bias (MNB), and the Mean Normalized Gross Error (MNGE) were calculated by comparing monitored (measured) and four-cell bi-linearly interpolated modeled ozone concentrations for all episode days and monitors. Graphical measures including time series and scatter plots of hourly measured and bi-linearly interpolated modeled ozone and where applicable, some ozone precursors such as nitric oxide (NO), NO_2, ethylene, and isoprene (ISOP), concentrations were developed for each regulatory monitor. In addition, tile plots of modeled daily maximum eight-hour ozone concentrations were developed and overlaid with the measured daily maximum eight-hour ozone concentrations. Detailed operational evaluations for the 2006 base case modeling episode are included in Appendix C.

Statistical Evaluations

The statistical evaluations presented focus on the comparison of the measured and modeled eight-hour ozone concentrations. Figure 3-12: *Peak Eight-Hour Ozone Concentration, Observed versus Modeled for May 31 through June 15, 2006*, and Figure 3-13: *Peak Eight-Hour Ozone Concentration, Observed versus Modeled for June 16 through July 2, 2006*, compare the observed and modeled daily maximum eight-hour ozone concentrations for each episode day of the 2006 base case. Figure 3-14: *MNGE and MNB for 2006 Episode Days* show the MNGE and MNB for monitored eight-hour ozone concentrations greater than 40 ppb for each episode day of the 2006 base case. Although there are no recommended criteria for the eight-hour UPA, MNGE, and MNB, the one-hour levels recommended by the EPA (i.e., plus or minus (±) 20%, 30%, and ± 15%, respectively) were used for statistical evaluations.

The error bars on the daily peak measured eight-hour ozone concentrations in Figure 3-12 and Figure 3-13 represent the ± 20% UPA range for comparison with the daily maximum modeled eight-hour ozone concentrations. For the 33 episode days only seven days have daily maximum modeled eight-hour ozone concentrations outside the ± 20% UPA range. None of those seven days observed an eight-hour ozone exceedance (≥ 85 ppb).

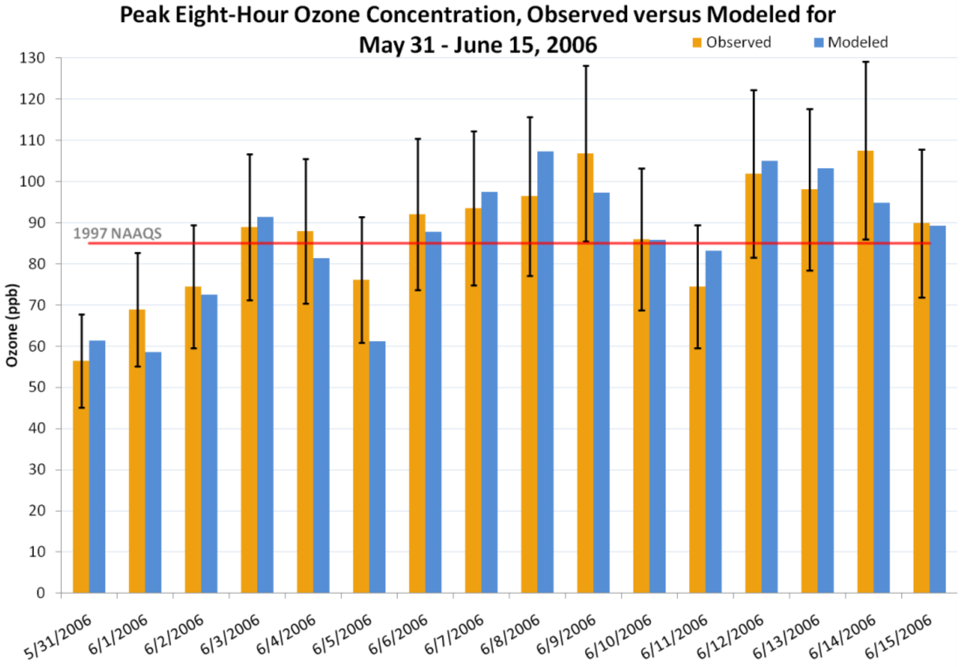

Figure 3-12: Peak Eight-Hour Ozone Concentration, Observed versus Modeled for May 31 through June 15, 2006

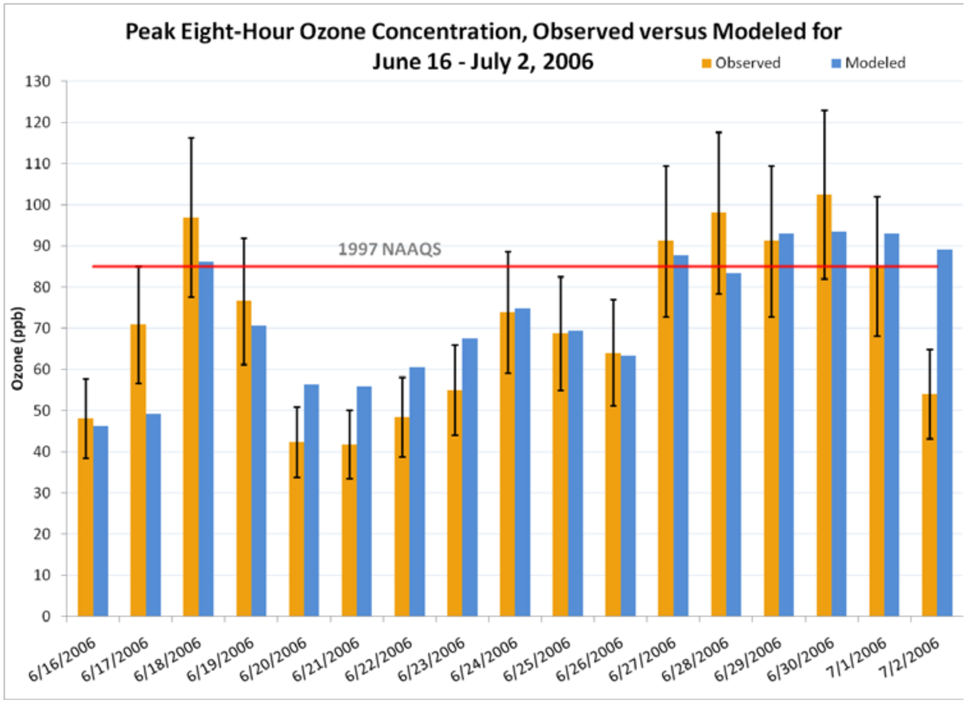

Figure 3-13: Peak Eight-Hour Ozone Concentration, Observed versus Modeled for June 16 through July 2, 2006

The area depicted in Figure 3-14: *MNGE and MNB for 2006 Episode Days* with MNGE ≤ 30% and MNB within ± 15% represents the joint condition for which both the MNGE and MNB are within acceptable ranges. The episode days labeled in red indicate those days for which daily peak measured eight-hour ozone concentrations were greater than or equal to 80 ppb.

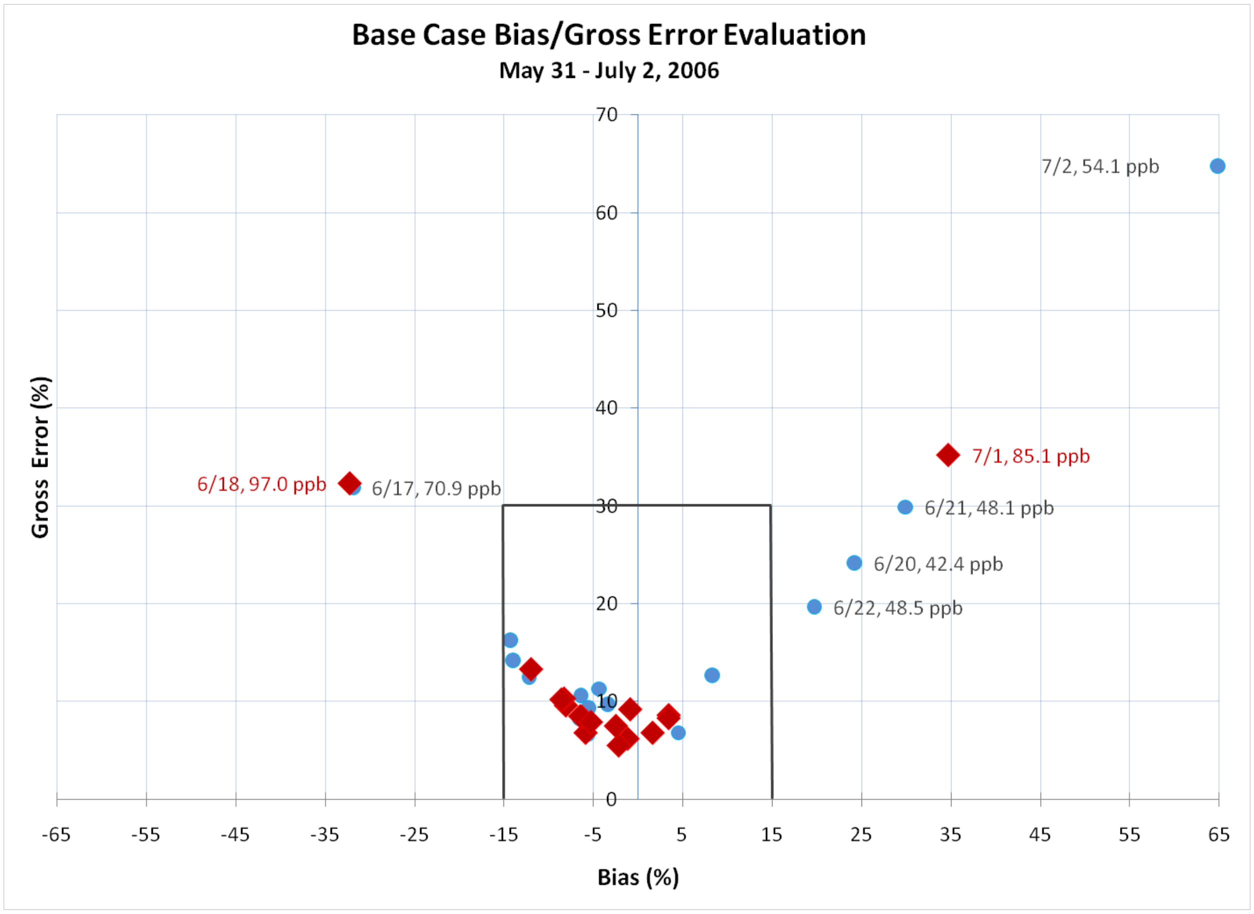

Figure 3-14: MNGE and MNB for 2006 Episode Days

For the 33 days of the 2006 base case episode with daily maximum measured eight-hour ozone concentrations greater than or equal to 80 ppb, 26 days meet the joint condition of having both the MNGE ≤ 30% and MNB within ± 15%. Only two of the days not meeting the MNGE and MNB conditions are eight-hour ozone exceedance days. June 18 experienced a slow-moving frontal passage, which was difficult for the meteorological model to replicate. July 1 was a cloudy day that limited ozone production but the meteorological model predicted fewer clouds, and thus more ozone. The average daily maximum monitored ozone for those 33 days was 79.0 ppb, and the corresponding average daily maximum modeled ozone concentration was 79.3 ppb. The average MNB and MNGE were -0.3% and 14.7%, respectively.

Considering almost all days conformed to the UPA, MNGE, and MNB recommended criteria (and only two eight-hour exceedance days did not), the model suitably simulates the frequency and magnitude of daily maximum eight-hour ozone concentrations at the various monitors.

Graphical Evaluations

A detailed graphical evaluation of modeling results is presented in Appendix C. A selection of graphical evaluations is presented in this section.

Six monitors in the nine-county DFW area were chosen for the evaluation on the basis of measured eight-hour ozone, geographic region, and source influences. *Figure 3-15: Selected DFW Performance Evaluation Monitors* is a map of the selected monitors. Eagle Mountain

Lake (C75), Denton Airport South (C56), and Keller (C17) frequently measure the highest eight-hour ozone concentrations. Dallas Hinton (C401) and Keller (C17) are within the urban areas of Dallas and Fort Worth. Greenville (C1006) is east of the urban areas, frequently upwind, and outside of the nonattainment area. Weatherford Parker County (C76) is west of the urban areas and near oil and gas sources of the Barnett Shale.

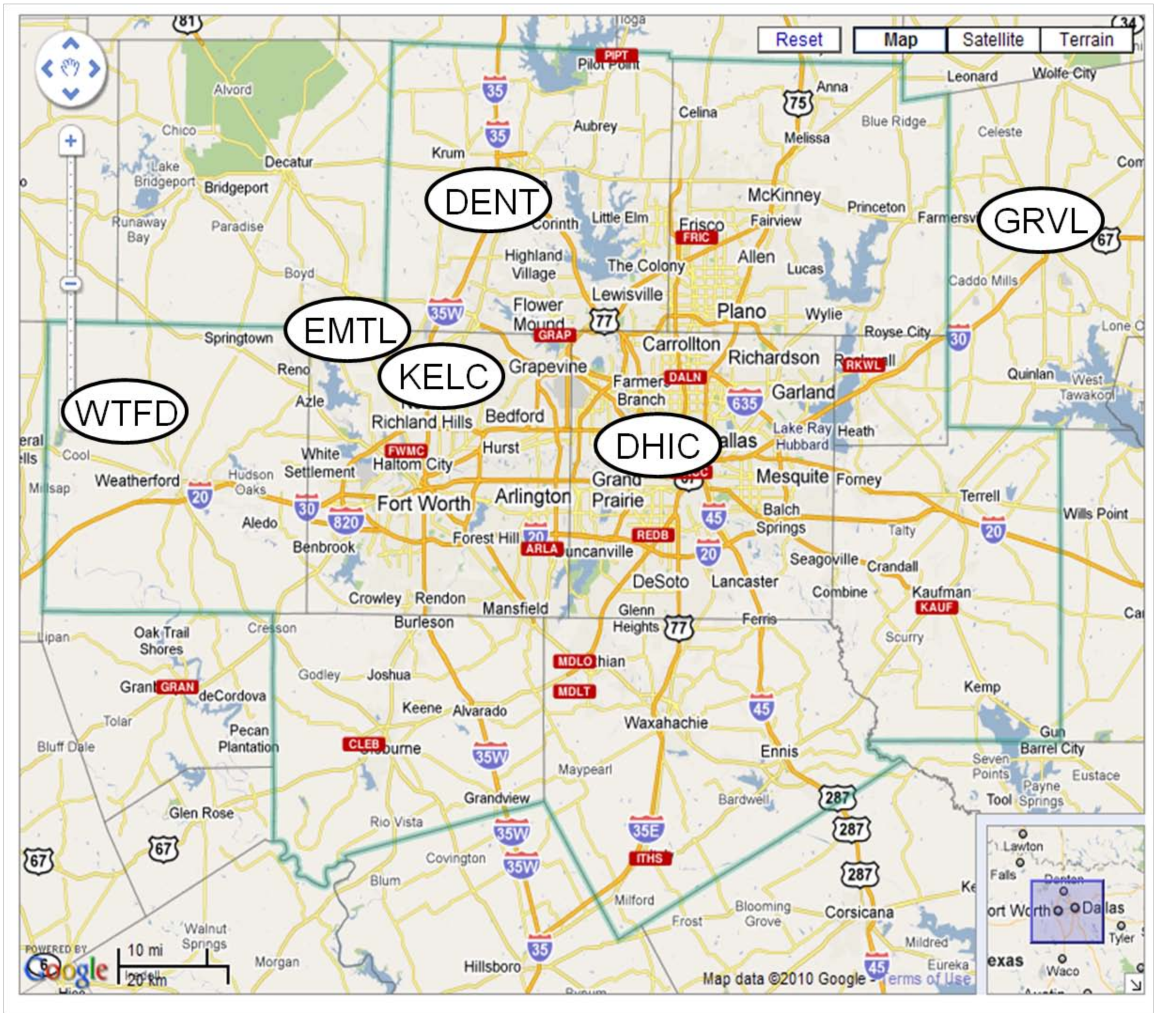

Figure 3-15: Selected DFW Performance Evaluation Monitors

DENT = Denton; DHIC = Dallas Hinton; EMTL = Eagle Mountain Lake; GRVL = Greenville; KELC = Keller; WTFD = Weatherford Parker County

Time series comparing hourly measured (red dots) and modeled (blue line) ozone concentrations are shown below for the six selected monitors. Included on the time-series graphic is the modeled maximum and minimum hourly ozone concentration within the three by three grid cell array around the monitor (green shading). Each day of the episode (May 31 through July 2, 2006) is separated by dashed vertical lines.

Figure 3-16: *Time Series of Hourly Ozone Concentrations at the Denton Airport South (C56), Eagle Mountain Lake (C75), and Keller (C17) Monitors* exhibits that relatively high ozone concentrations were measured at these monitors on several days during this episode. In general, the modeled ozone concentrations, including the three by three cell maximum-minimum range, replicate the diurnal pattern of the observations well. During the early morning hours at the

Denton Airport South (C56) monitor, the model over-predicts ozone concentrations. Meteorological conditions including vertical mixing may be contributing to the overnight over-prediction of hourly ozone. NO_X concentrations (not shown) appear well simulated overnight. At all three monitors, the model under-predicts the peak ozone concentrations, especially on June 9, 14, 18, and 28.

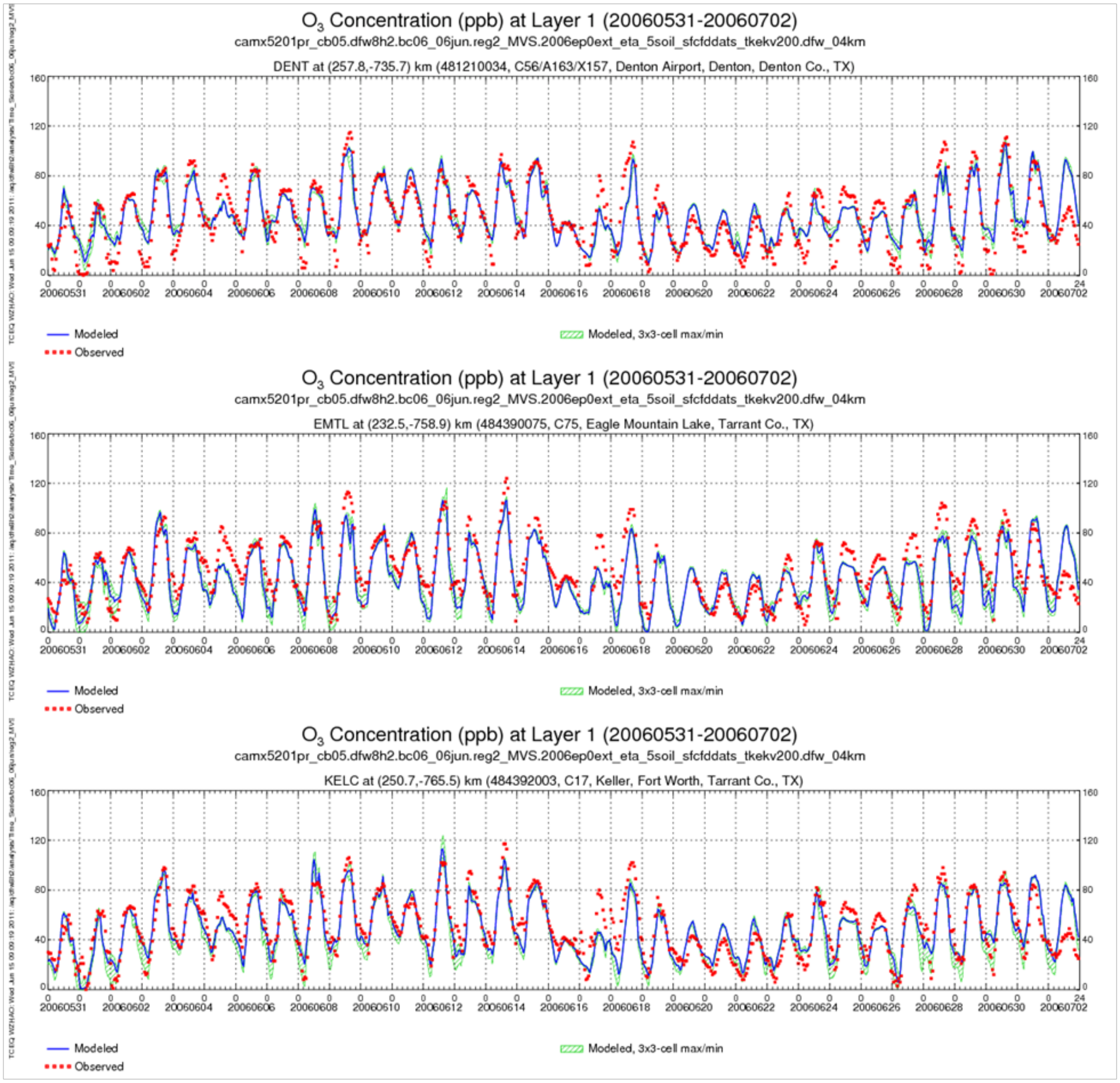

Figure 3-16: Time Series of Hourly Ozone Concentrations at the Denton Airport South (C56), Eagle Mountain Lake (C75), and Keller (C17) Monitors

Figure 3-17: *Time Series of Hourly Ozone Concentrations at the Dallas Hinton (C60), Greenville (C1006), and Weatherford Parker County (C76) Monitors* provides a comparison of measured and modeled hourly ozone concentrations at two rural monitors and an urban monitor. At the Dallas Hinton urban monitor, modeled concentrations replicate the diurnal pattern of the observations well with some over-prediction overnight. At the Greenville (C1006) monitor the model matches the daytime pattern well but poorly overestimates the nighttime ozone concentrations. NO_X concentrations (not shown) appear well simulated overnight so background transport and vertical mixing could be contributors. On the west side of the DFW area at the Weatherford Parker County (C76) monitor hourly ozone concentrations replicate the diurnal pattern very well throughout the episode.

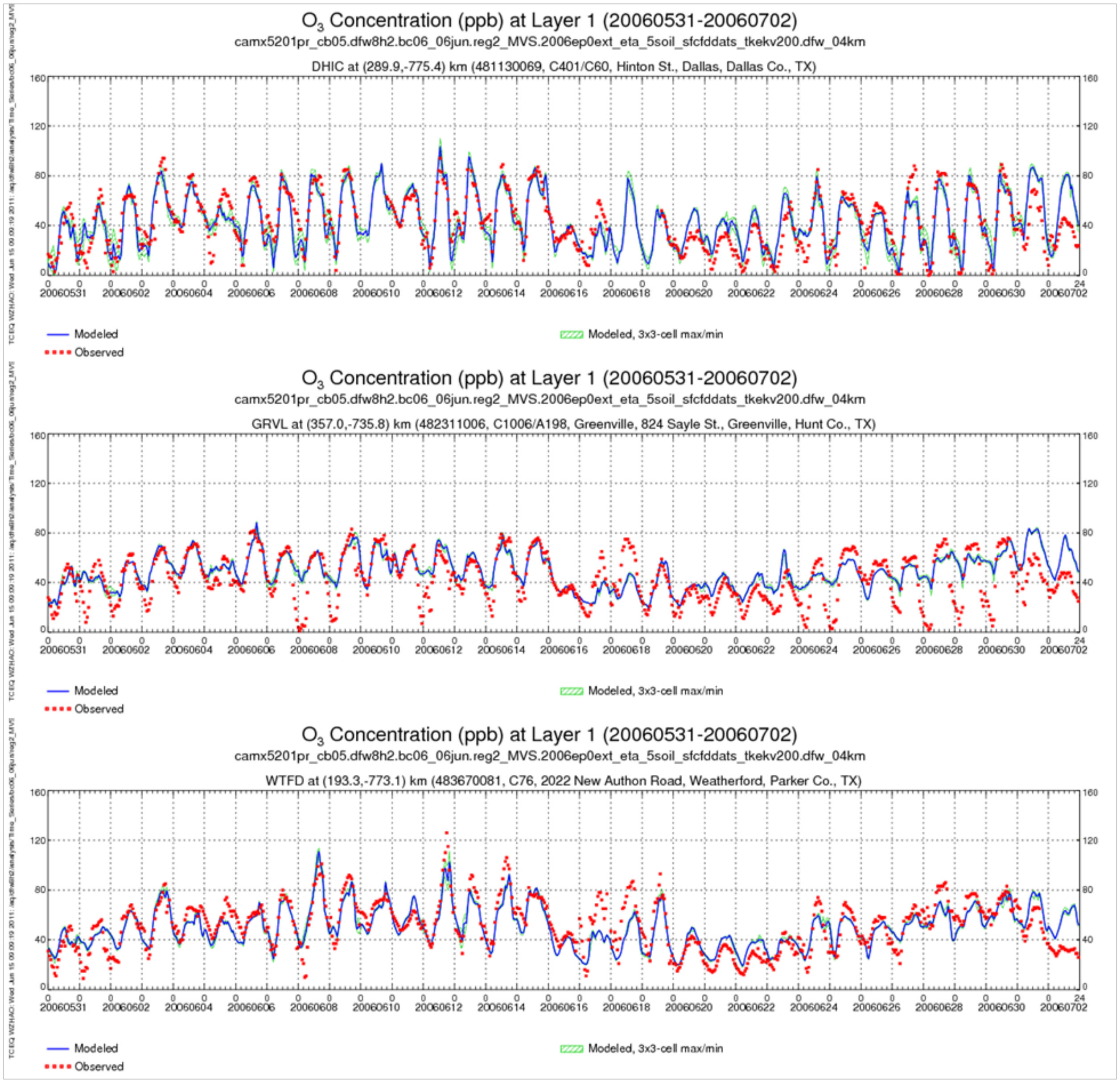

Figure 3-17: Time Series of Hourly Ozone Concentrations at the Dallas Hinton (C60), Greenville (C1006), and Weatherford Parker County (C76) Monitors

Scatter plots comparing the hourly measured and modeled concentrations of ozone (O_3), NO_X, olefins (OLE), and alkanes (PAR) are included in the performance evaluation. OLE is a CAMx chemical surrogate representing olefinic VOC, such as propylene, but excluding ethylene and certain compounds known as internal olefins, such as butenes (internal olefins are represented in CB05 by the surrogate species IOLE). Both ethylene and propylene are HRVOC and can contribute to the fast production of ozone. The DFW area does not have large ethylene and propylene emitters, unlike the Houston Ship Channel, but vehicles do emit small amounts. PAR is a CAMx chemical surrogate representing alkanes (paraffins), such as butane or n-octane, which can be emitted from oil and gas and other sources. Monitor sites included in the graphical representation were the three monitors with the highest daily maximum monitored eight-hour ozone concentrations and the two sites measuring VOCs with auto-GCs, Dallas Hinton (C60) and Fort Worth Northwest (C13).

Included on the scatter plots is the measured versus modeled quantile-quantile (QQ) plot, which first sorts independently both the measured and modeled concentrations, then plots the sorted values together. QQ plot data, shown as red dots, provide a measure of how close the modeled and measured distributions of values are to each other. If the red dots lie close to the diagonal one-to-one line, the model generates the correct proportions of small, medium, and large concentration values.

Figure 3-18: *Scatter Plots of Hourly Ozone, NO_X, OLE, and PAR at the Dallas Hinton (C401) Monitor* shows the scatter plots for Dallas Hinton (C401). For ozone, the model compares favorably with the hourly observations throughout the range of concentrations. NO_X concentrations are slightly over-predicted from 15 to 30 ppb and then under-predicted for the highest concentrations. For OLE, the model under-predicts the lowest concentrations (less than 1 ppb). The model consistently over-predicts PAR concentrations at Dallas Hinton (C401). The OLE and PAR plots are on a logarithmic scale.

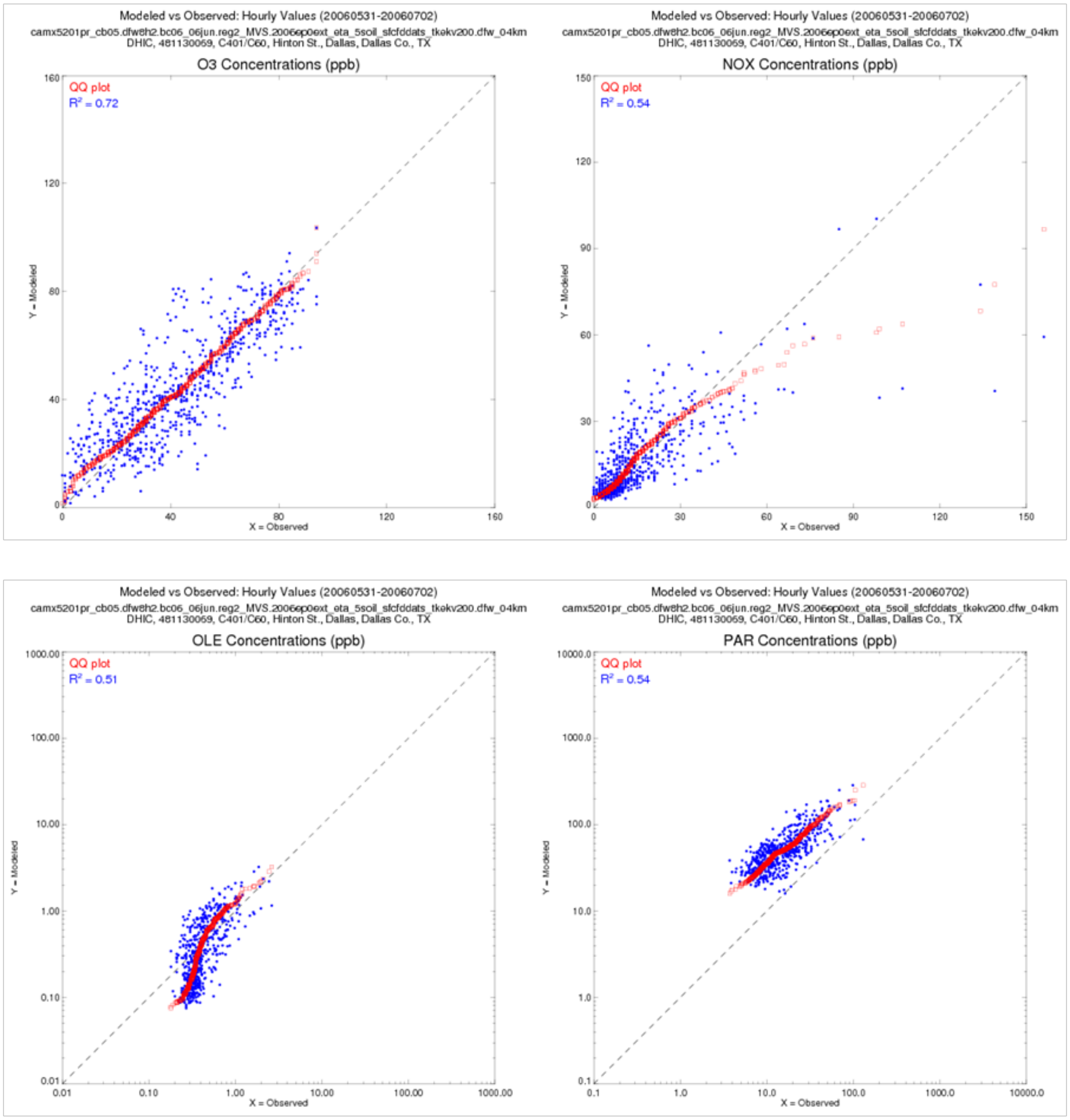

Figure 3-18: Scatter Plots of Hourly Ozone, NO$_X$, OLE, and PAR at the Dallas Hinton (C401) Monitor

Tile plots of the of the daily maximum modeled eight-hour ozone concentrations are also included in the performance evaluation. Selected episode days are shown on which several monitors measured daily maximum eight-hour ozone concentrations greater than 84 ppb. Included on the tile plots are the monitor locations represented by small circles, color coded for the measured ozone concentration. The same scale is used for the measured and modeled maximum daily eight-hour ozone concentrations.

Tile plots of daily maximum eight-hour ozone concentrations for June 9, June 12 and 13, and June 30, 2006, are shown below in Figure 3-19: *Tile Plot of Daily Maximum Eight-Hour Ozone Concentrations for June 9, June 12 and 13, and June 30, 2006*. The model replicates the areas of highest eight-hour ozone for the selected days, although it slightly under-predicts the daily maximum eight-hour ozone concentrations on June 9 and June 30, 2006.

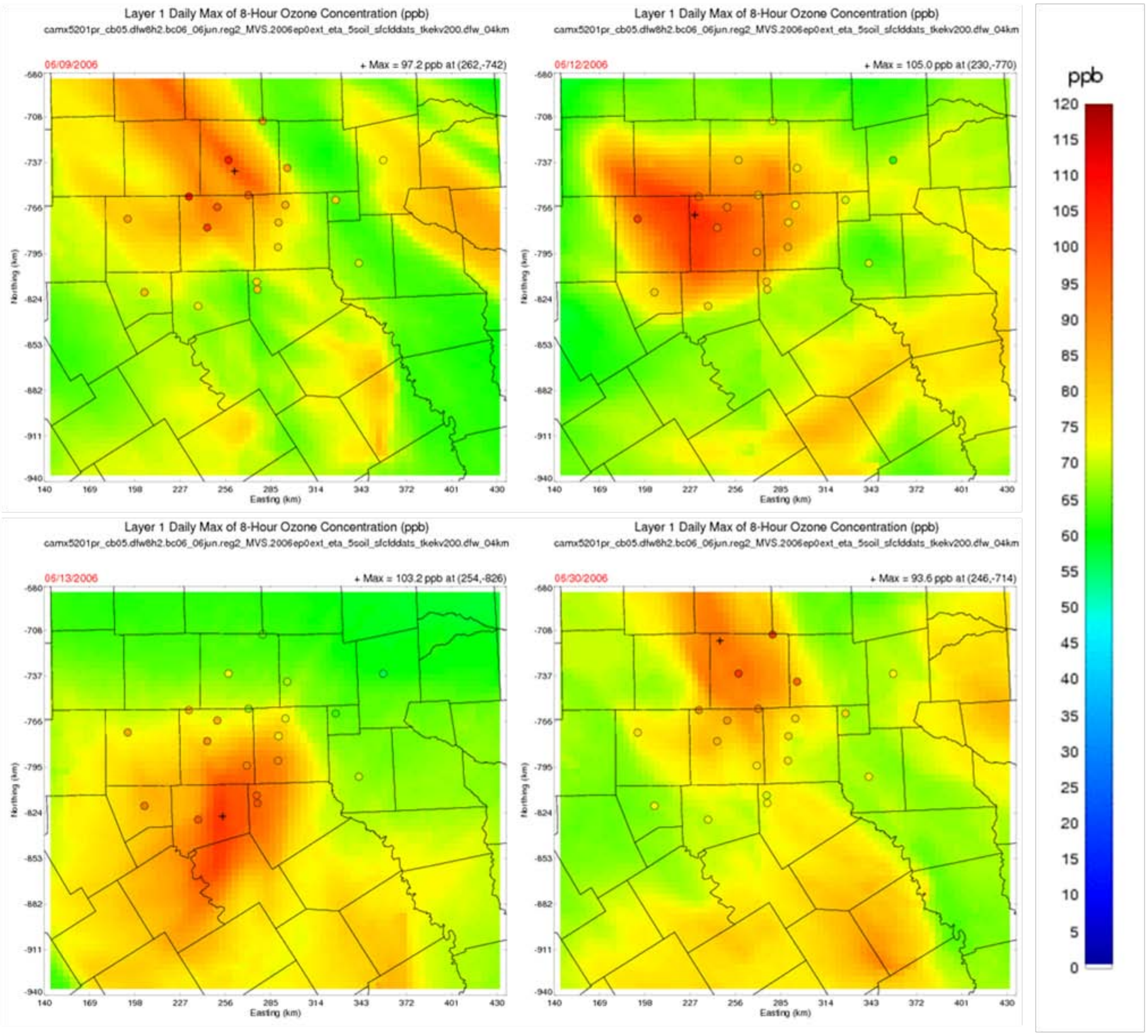

Figure 3-19: Tile Plot of Daily Maximum Eight-Hour Ozone Concentrations for June 9, June 12 and 13, and June 30, 2006

Overall, the graphical evaluation of model performance at key monitors on key episode days indicates the modeling adequately replicates the features that produced high ozone during this episode.

Evaluations Based on TexAQS II Rural Monitoring Network Data

The TexAQS II study included a number of additional surface monitoring sites, which began collecting data in the summer of 2005 and continued until late October, 2006. Figure 3-20: *TexAQS II Monitoring Sites Outside Ozone Nonattainment Areas* depicts the active ozone monitors during the extended June 2006 episode. Data from the Clarksville (C648, CLVL), Wamba (C645, WMBA), Longview (C19, LGVW), Palestine (C647, PLTN), and San Augustine Airport (C646, SAGA) monitors are of particular importance to the DFW area as their locations allow measurement of background concentrations during the typical east through south flow on high eight-hour ozone days. Performance of the base case modeling at the Clarksville (C648) and Palestine (C647) monitors is shown and discussed below. A full discussion of model performance at these and other rural monitors is provided in Appendix C.

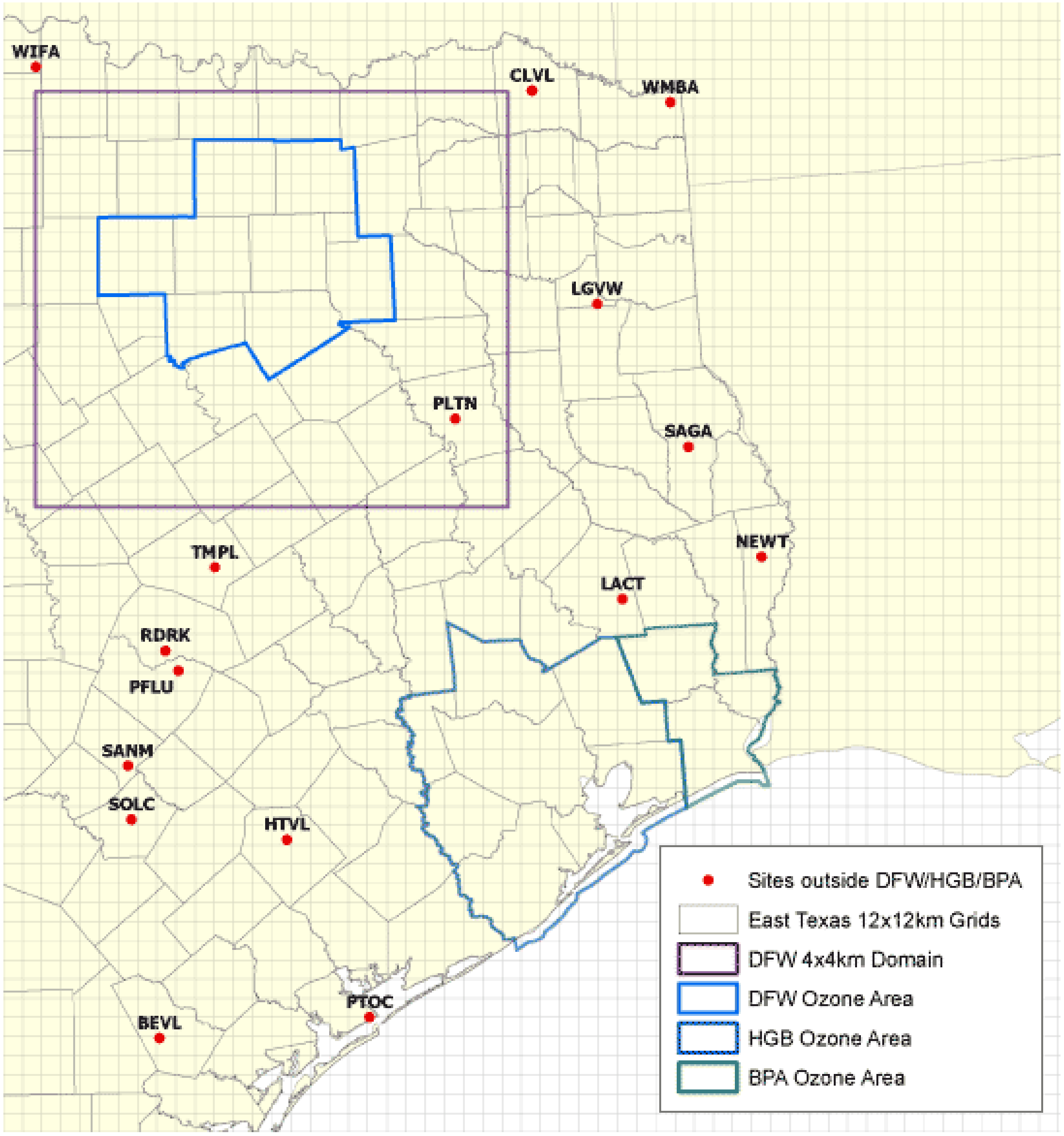

Figure 3-20: TexAQS II Monitoring Sites Outside Ozone Nonattainment Areas

All of the monitors, except for Palestine (C647), are within the 12 km CAMx domain. While finer scale modeling (4 km or less) is necessary to capture plumes and pollutant concentration gradients in the urban areas, the performance of the model at regional sites can be examined to evaluate incoming background air. At the Clarksville (C648) monitor (Figure 3-21: *Time Series of Hourly Ozone Concentrations at the Clarksville (C648) Monitor*), the model follows the general diurnal pattern and trend of hourly ozone throughout the episode. The model under-predicts the highest concentrations and over-predicts the nighttime concentrations near the end of the episode. At the Palestine (C647) monitor (Figure 3-22: *Time Series of Hourly Ozone Concentrations at the Palestine (C647) Monitor*), the model replicates the diurnal pattern of hourly ozone very well during the first part of the episode. After June 16, the overnight modeled concentrations poorly match the observed lows when strong southerly flow occurs. The cause of this discrepancy is still being evaluated.

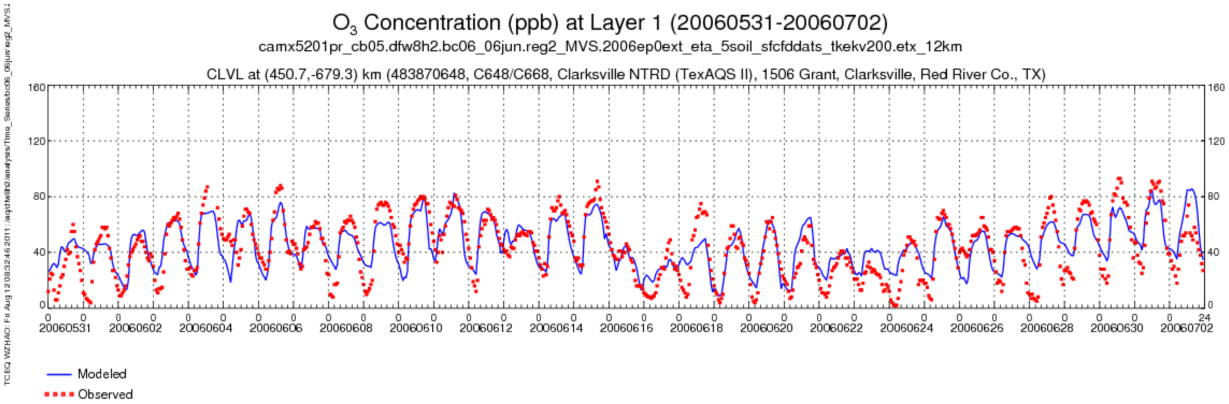

Figure 3-21: Time Series of Hourly Ozone Concentrations at the Clarksville (C648) Monitor

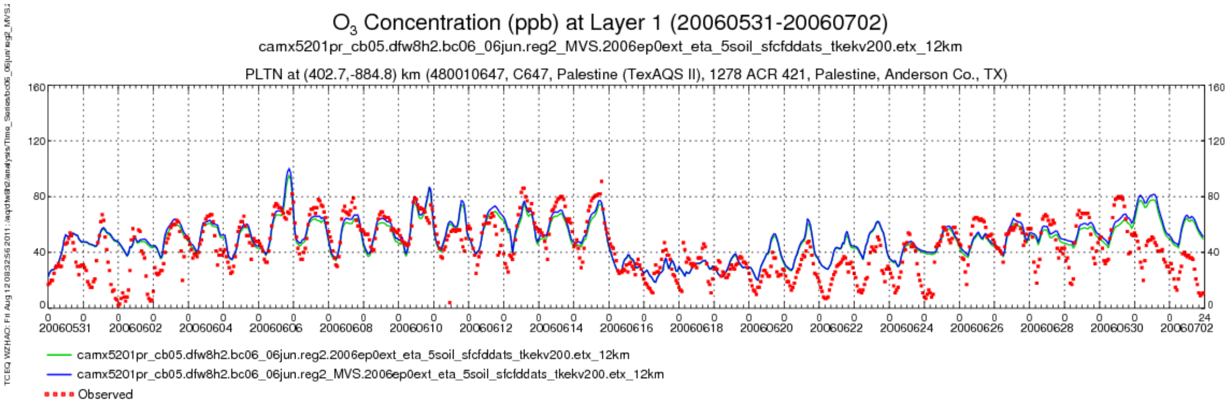

Figure 3-22: Time Series of Hourly Ozone Concentrations at the Palestine (C647) Monitor

3.6.4.3 Diagnostic Evaluations

While most model performance evaluation (MPE) focuses on how well the model reproduces observations in the base case, a second and perhaps more important aspect of model performance is how well the model predicts changes as a result of modifications to its input (Smith, 2010). The former type of MPE is static in the sense that it is based on a fixed set of observations which never change, while evaluating the model's response to perturbations in its inputs is dynamic in the sense that the change in the model's output is evaluated. Dynamic MPE is much less often performed than static MPE, simply because there is often little observational data available that reflects quantifiable changes in model inputs that can be directly related to air quality measurements. Since the attainment demonstration is based on modeling the future by changing the model's inputs such as growth and controls, it is imperative to pursue dynamic MPE. The EPA's modeling guidance recommends assessing the model's response to emission changes. Two such dynamic MPEs are described below: retrospective model analysis and weekday/weekend analysis.

Retrospective Modeling – 1999 Backcast

The goal of this diagnostic analysis is to use the model to forecast (actually backcast) a previous year when air quality was known, and compare the model's predictions with those observations. Retrospective modeling is usually difficult to implement in practice because of the need to create an inventory, but a 1999 inventory was already available from previous modeling applications so little additional inventory development was necessary. Instead of using the 1999 modeling application to model 2006, 1999 was back-cast from 2006 for several reasons, including a longer episode, better meteorological inputs, and improved inventories and boundary conditions available for 2006.

The development of the "predicted" 1999 inventory was analogous to developing a future inventory for an attainment test. Most of the 2006 baseline anthropogenic inventory was replaced with the available 1999 base case inventory (a 1999 baseline inventory would have been preferable, but was not available). As with future-case modeling, the 2006 biogenic emissions were not replaced, and the predictive modeling was conducted using the 2006 meteorology. The 1999 and 2006 inventories used the MOBILE6.2 model for on-road emissions in this analysis as a 1999 MOVES2010a-based on-road emission inventory was not developed.

Since the model predictions of a typical future design value are based on a (baseline year design value) DV_B, which is the average of three regulatory design values (EPA, 2007), the quantity forecast in this test is not a specific future year's design value but rather the year's DV_B. Thus, the regulatory design values for 1999, 2000, and 2001 were averaged in the same manner as the 2006 DV_B was calculated as the average of the 2006, 2007, and 2008 regulatory design values. Only monitors that had at least one regulatory design value in both the 1999 through 2001 and the 2006 through 2008 periods were used. Figure 3-23: *Monitors Used in 1999 Retrospective Analysis* shows the locations of the eight monitors used in this analysis.

Figure 3-23: Monitors Used in 1999 Retrospective Analysis

Once the model was run with the 1999 baseline emissions, RRFs were calculated. In a retrospective analysis, RRFs are generally expected to be greater than one because ozone has decreased since the retrospective year. Table 3-24: *Retrospective Analysis Design Values* shows the observed DV_Bs, calculated RRFs, and the projected 1999 design values (DV_Ps).

Table 3-24: Retrospective Analysis Design Values

Monitor	2006 DV_B (ppb)	1999 DV_B (ppb)	Observed 2006 to 1999 RRF	Modeled 2006 to 1999 RRF	1999 DV_P (ppb)
DENT - Denton C56	93.3	101.5	1.088	1.161	108.4
KELC - Keller C17	91.0	96.3	1.059	1.147	104.4
FWMC - Fort Worth NW C13	89.3	98.3	1.101	1.127	100.7
FRIC - Frisco C31	87.7	100.3	1.144	1.131	99.2
DALN - Dallas North C63	85.0	93.0	1.094	1.128	95.9
REDB - Dallas Exec Airport C402	85.0	88.0	1.035	1.142	97.1
DHIC - Dallas Hinton C401	81.7	92.0	1.126	1.127	92.0
MDLT - Midlothian Tower C94	80.5	92.3	1.147	1.146	92.3
Average	**86.7**	**95.2**	**1.099**	**1.139**	**98.7**

For five of the eight sites (Frisco (C31), Dallas Hinton (C401), Dallas North (C63), Midlothian Tower (C94), and Fort Worth Northwest (C13)), the projections were within 3 ppb of the 1999 calculated baseline values. For the other three sites (Dallas Executive Airport – Redbird (C402), Denton Airport South (C56), and Keller (C17)), the model-projected 1999 DVs were higher than the observed values. The stronger response at those monitors could be due to emission inventory changes and the difference in meteorology from 2006 to 1999. Overall the modeled response was close to the actual airshed's response to 1999-2006 emission changes, which provides confidence in the model's ability to forecast the attainment year.

Observational Modeling – Weekday/Weekend

Weekend emissions of NO_X in urban areas tend to be lower than weekday emissions because of lower vehicle miles travelled. The effect is most pronounced on weekend mornings, especially Sundays, since commuting is much lower than weekdays. This analysis examines the performance of the model in replicating the observed weekday/weekend effect.

The inventories in this analysis used the MOBILE6.2 on-road emissions estimates. The magnitude of emission differences between weekday and weekend day-types using MOBILE6.2 or MOVES2010a is approximately the same. Thus, the results of this analysis are not expected to change by using MOVES2010a.

Figure 3-24: *Comparison of Modeled 6:00* A.M. *NO_X and VOC Emissions for Wednesdays, Saturdays, and Sundays* shows a comparison of modeled 6:00 A.M. NO_X and VOC emissions for Wednesdays, Saturdays, and Sundays. Early morning emissions tend to be especially important in determining peak eight-hour ozone levels (MacDonald, 2010), so the weekday/weekend differences should manifest themselves noticeably in the relative levels of weekday and weekend ozone concentrations. Because there are relatively few Saturdays, Sundays, and Wednesdays (chosen to represent typical weekdays) in the episode, the TCEQ employed a novel approach which allowed each day of the episode to be treated as a Saturday, Sunday, and Wednesday, providing a total of 33 of each day type. This approach is possible since meteorology is independent of day-of-week, so by simply replacing the emissions of any episode day with Saturday (or Sunday or Wednesday) emissions we can obtain a valid representation of that day. The actual modeling procedure involved a series of runs using the 2006 baseline that were designed to ensure that each day-type was preceded by the appropriate predecessor day-type. Each Sunday was modeled following a Saturday, each Saturday followed a Friday, and each

Wednesday followed a Wednesday (baseline modeled Tuesday emissions are very similar to Wednesdays).

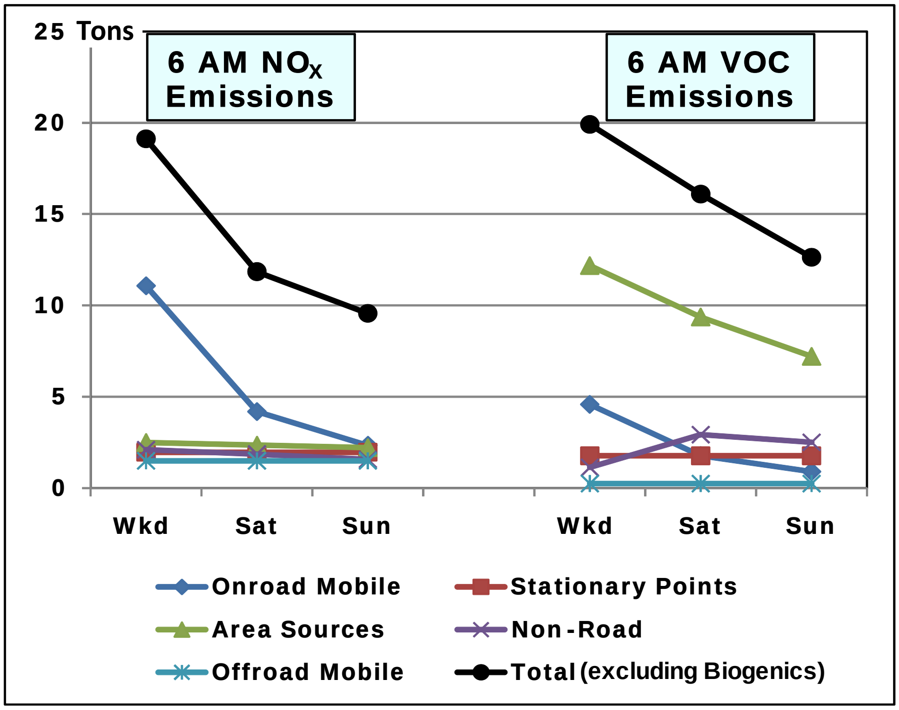

Figure 3-24: Comparison of Modeled 6:00 A.M. NO$_X$ and VOC Emissions for Wednesdays, Saturdays, and Sundays

For comparison with the modeled emissions, median monitored 6:00 A.M. NO$_X$ concentrations were calculated for every Wednesday, Saturday, and Sunday between May 15 and October 15 in the years 2005 through 2009. This approach gives approximately 125 observations for each type of day (less for some monitors because of missing data). *Figure 3-25: Median Observed and Modeled 6:00 A.M. NO$_X$ Concentrations at DFW Monitors as a Percentage of Wednesday* shows observed and modeled 6:00 A.M. NO$_X$ concentrations at 11 sites in the DFW area. All sites show observed and modeled NO$_X$ concentrations that decline monotonically from Wednesday through Saturday to Sunday, except for the Midlothian Old Fort Worth (OFW) (C52) and Midlothian Tower (C94) observations which show essentially no change from Saturday to Sunday. The modeled values have somewhat greater variability than their observed counterparts, with all sites showing declines between 30% and 70% from Wednesday to Sunday, while all the observed sites dropped by between 40% and 70%.

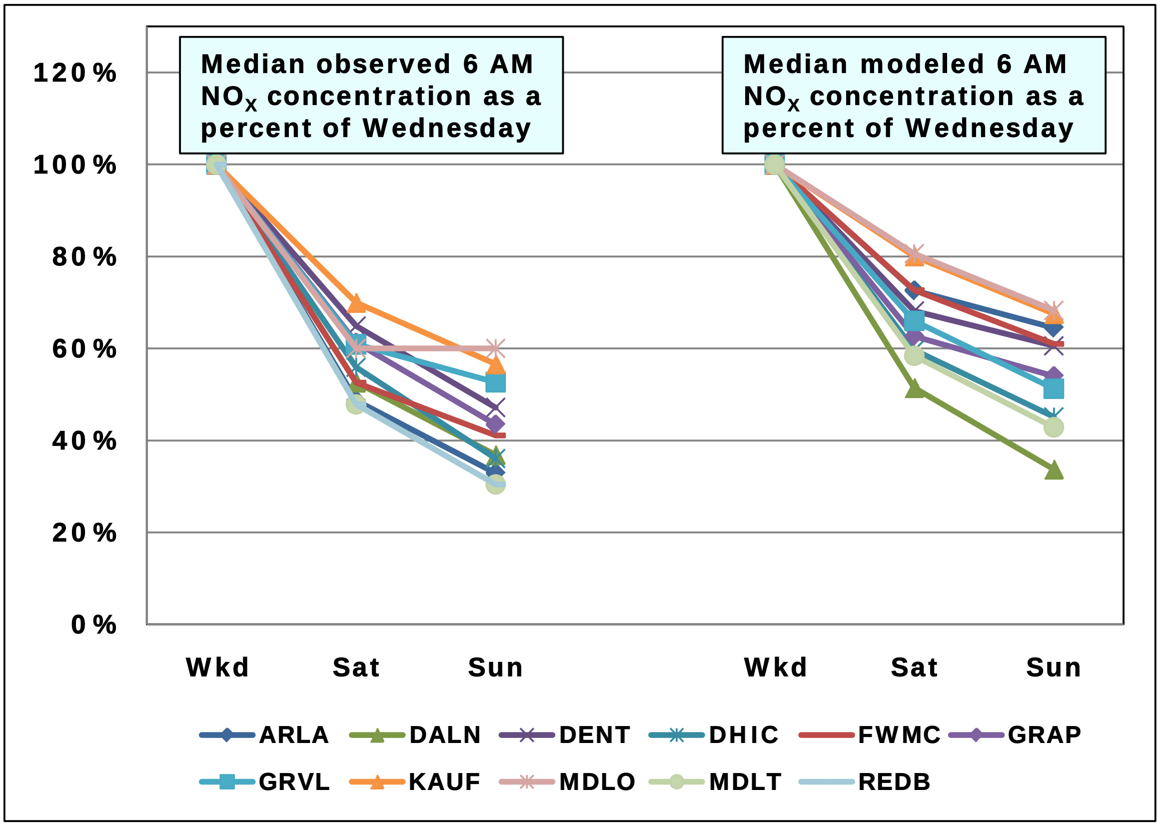

Figure 3-25: Median Observed and Modeled 6:00 A.M. NO_X Concentrations at DFW Monitors as a Percentage of Wednesday

Figure 3-26: *Observed and Modeled Median Daily Peak Eight-Hour Ozone Concentrations as a Percentage of Wednesday* shows observed and modeled median daily peak eight-hour ozone concentrations as a percentage of Wednesdays for 19 DFW-area sites. The observed Saturday ozone concentrations (as a percent of Wednesday) are spread between a 10% increase and a 7% decrease, with more sites increasing than decreasing. Sunday concentrations ranged between a 2% increase and a 16% decrease from Wednesday, with all but three sites showing a decrease. The modeled values consistently decreased between 2% and 4% on Saturday and between 4% and 7% on Sunday (compared with Wednesday), and showed very little spread compared with the observations.

Part of the apparent discrepancy between the observed and modeled concentrations can be attributed to the comparison of observations from the entire ozone season with a modeled episode that was selected specifically to represent a period of especially high ozone concentrations. When the median observation concentrations are replaced with 90th percentile concentrations (representing high ozone days), the behavior of the observed and modeled concentrations is more consistent as seen in Figure 3-27: *Observed 90th Percentile and Modeled Daily Peak Eight-Hour Ozone Concentrations as a Percentage of Wednesday*. The observed 90th percentile concentrations range between a 4% increase and an 11% decrease on Saturday (compared with Wednesday), while on Sunday, all sites decrease from Wednesday, between 2% and 18%. In conclusion, the model is successfully replicating the observed weekday-weekend trends, especially for the higher ozone days.

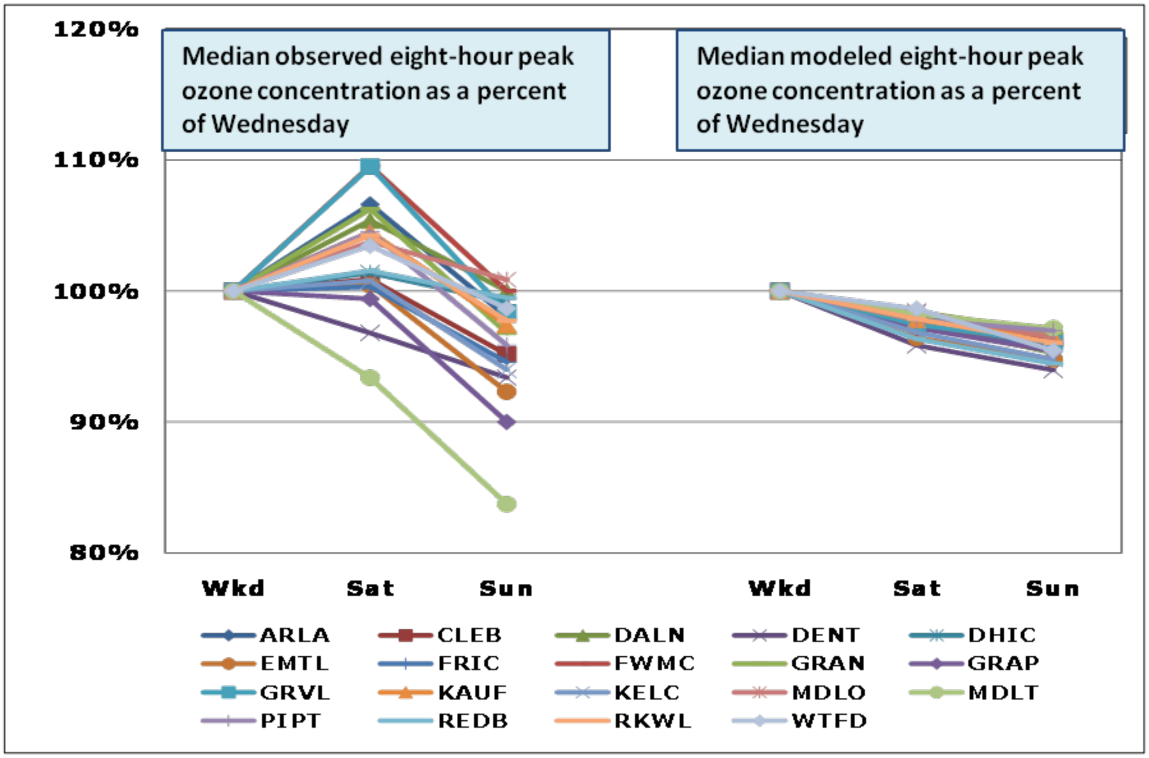

Figure 3-26: Observed and Modeled Median Daily Peak Eight-Hour Ozone Concentrations as a Percentage of Wednesday

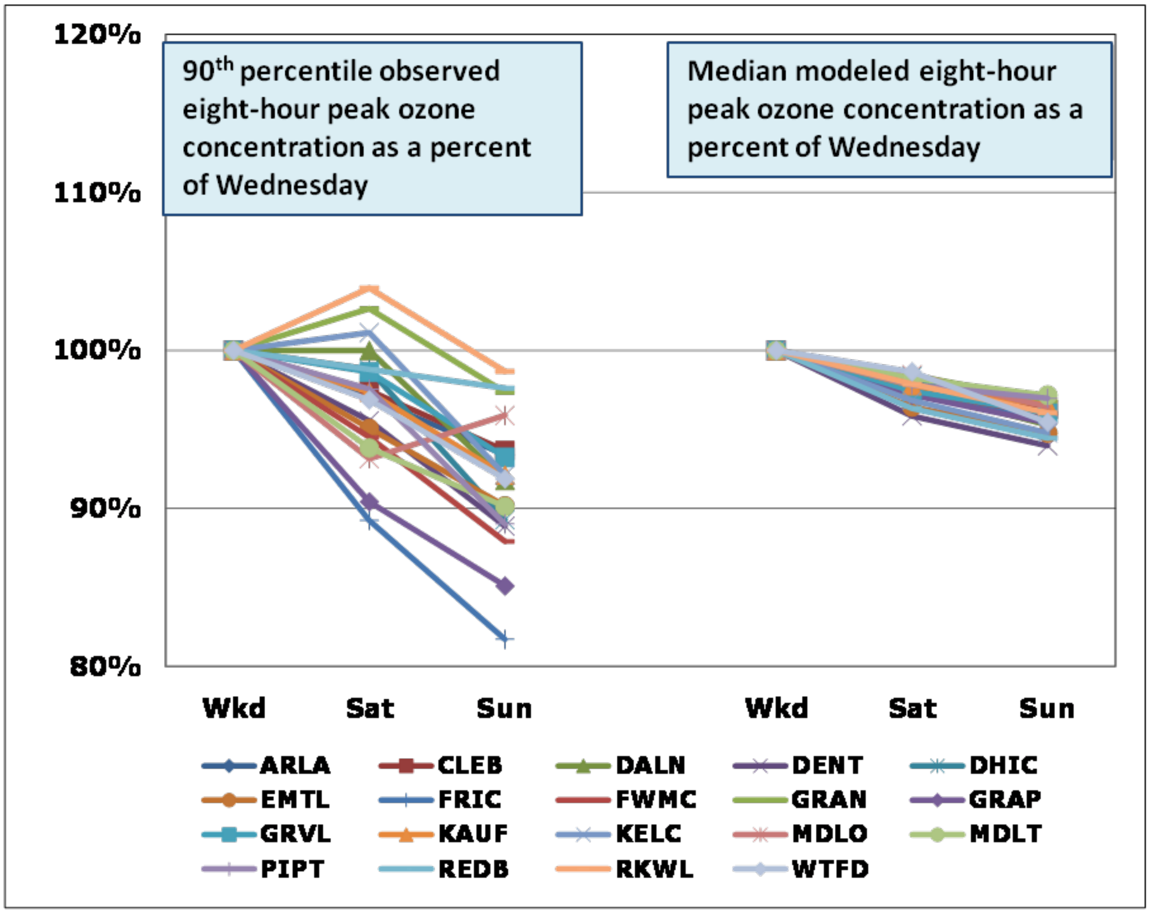

Figure 3-27: Observed 90th Percentile and Modeled Daily Peak Eight-Hour Ozone Concentrations as a Percentage of Wednesday

Finally, the modeled concentrations exhibit very little site-to-site variability compared with the observations. The reason for this small variation is that the modeling procedure applied Wednesday, Saturday, and Sunday emissions to exactly the same set of days. Thus, the day-to-day and site-to-site meteorological variability, which clearly affects the observed concentrations, is absent in the modeled concentrations. Thus, the modeling technique isolated the signal (model response to weekday-weekend emission changes) from the noise (meteorological variability), allowing a clean assessment of the model's response to the emission variability.

3.7 2006 BASELINE AND 2012 FUTURE CASE MODELING

3.7.1 2006 Baseline Modeling

The TCEQ selected 2006 as the baseline year for conducting the attainment modeling. The typical 2006 OSD emissions were modeled for all episode days. Days with modeled concentrations above 70 ppb were used for the modeled attainment test, per the EPA's modeling guidance (EPA, 2007). Figure 3-28: *Near Monitoring Site Grid Cell Array Size* shows a map of the 4 km domain depicting the regulatory monitors and the extent of the three by three grid cell arrays around each monitor. The maximum concentrations from the three by three grid cell arrays were used in the modeled attainment test. Table 3-25: *2006 Baseline Values Used in the Modeled Attainment Test* details the monitor-specific DV_B, average baseline modeled concentrations and the number of days above the 70 ppb threshold.

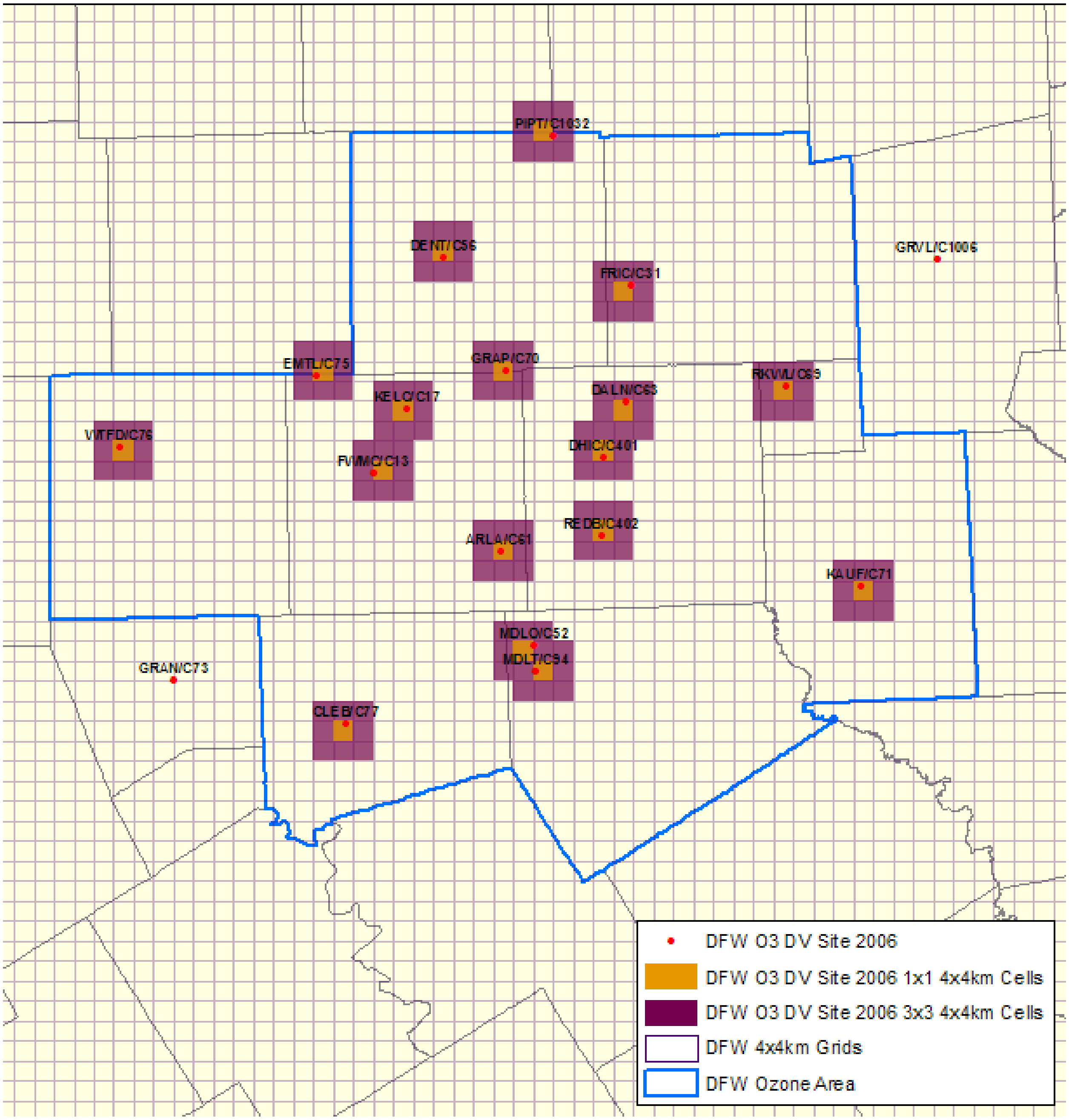

Figure 3-28: Near Monitoring Site Grid Cell Array Size

Table 3-25: 2006 Baseline Values Used in the Modeled Attainment Test

Site	Monitor	2006 DV_B (ppb)*	2006 Modeled Average (ppb)	Modeled Days Averaged
DENT	Denton C56	93.33	87.16	10
EMTL	Eagle Mountain Lake C75	93.33	86.95	10
KELC	Keller C17	91.00	88.33	10
GRAP	Grapevine Fairway C70	90.67	88.26	10
FWMC	Fort Worth Northwest C13	89.33	88.02	10

Site	Monitor	2006 DV_B (ppb)*	2006 Modeled Average (ppb)	Modeled Days Averaged
FRIC	Frisco C31	87.67	83.34	10
WTFD	Weatherford Parker County C76	87.67	81.45	10
DALN	Dallas North C63	85.00	81.00	10
REDB	Dallas Exec Airport C402	85.00	80.49	10
CLEB	Cleburne C77	85.00	80.39	9
ARLA	Arlington C61	83.33	85.01	10
DHIC	Dallas Hinton C401	81.67	81.02	10
PIPT†	Pilot Point C1032†	81.00†	84.23	10
MDLT†	Midlothian Tower C94†	80.50†	79.49	10
RKWL	Rockwall Heath C69	77.67	74.55	10
MDLO†	Midlothian OFW C52†	75.00†	81.17	10
KAUF	Kaufman C71	74.67	75.02	7
GRAN$^{\#}$	Granbury C73	83.00	80.38	10
GRVL$^{\#}$	Greenville C1006	75.00	73.54	9

* DV_B values 85 ppb or greater are shown in red.

† PIPT, MDLT, and MDLO did not measure enough data from 2004 through 2008 to calculate a complete DV_B. The DV_B shown uses all available data.

Granbury C73 and Greenville C1006 are outside the 1997 eight-hour ozone NAAQS DFW nonattainment area.

Three monitors in the DFW area did not have 10 modeled days above 70 ppb. These monitors are not located where the highest area ozone concentrations are typically observed, which is indicated by the 2006 DV_B and the number of days above ozone concentration thresholds in Table 3-2.

3.7.2 Future Baseline Modeling

Similar to the 2006 baseline modeling, the 2012 modeling was conducted for each of the episode days. The projected 2012 ozone season day emissions were used, as previously summarized in Table 3-21. Using the same days as used in the 2006 baseline modeling, the average of the 2012 modeled maximum daily eight-hour ozone concentrations within the three by three grid cell array about each monitor were calculated. The RRF at each regulatory monitor was calculated as the ratio of the baseline/future modeled averages, and the 2012 future year design value (DV_F) at each monitor was estimated as per the EPA's modeling guidance by multiplying the 2006 DV_B by the RRF. Table 3-26: *Summary of the RRF and 2012 Future Design Values* details the 2006 DV_B, RRF, and 2012 DV_F at each of the regulatory monitors.

Table 3-26: Summary of the RRF and 2012 Future Design Values

Site	Monitor	2006 DV_B (ppb)*	RRF	2012 DV_F (ppb)*
DENT	Denton C56	93.33	0.825	77
EMTL	Eagle Mountain Lake C75	93.33	0.836	78
KELC	Keller C17	91.00	0.840	76
GRAP	Grapevine Fairway C70	90.67	0.840	76
FWMC	Fort Worth Northwest C13	89.33	0.844	75

Site	Monitor	2006 DV_B (ppb)*	RRF	2012 DV_F (ppb)*
FRIC	Frisco C31	87.67	0.849	74
WTFD	Weatherford Parker County C76	87.67	0.829	72
DALN	Dallas North C63	85.00	0.837	71
REDB	Dallas Exec Airport C402	85.00	0.830	70
CLEB	Cleburne C77	85.00	0.834	70
ARLA	Arlington C61	83.33	0.844	70
DHIC	Dallas Hinton C401	81.67	0.831	67
PIPT†	Pilot Point C1032†	81.00†	0.831†	67†
MDLT†	Midlothian Tower C94†	80.50†	0.828†	66†
RKWL	Rockwall Heath C69	77.67	0.815	63
MDLO†	Midlothian OFW C52†	75.00†	0.830†	62†
KAUF	Kaufman C71	74.67	0.809	60
GRAN#	Granbury C73	83.00	0.839	69
GRVL#	Greenville C1006	75.00	0.799	59

* DV_B and DV_F values 85 ppb or greater are shown in red.

† PIPT, MDLT, and MDLO did not measure enough data from 2004 through 2008 to calculate a complete DV_B. The DV_B shown uses all available data. The DV_F was calculated using the DV_B shown.

Granbury C73 and Greenville C1006 are outside the 1997 eight-hour ozone NAAQS DFW nonattainment area.

The 2012 baseline attainment modeling projects no DFW area regulatory monitors to have a 2012 DV_F greater than 84 ppb.

3.7.3 Ozone Source Apportionment Tool and Anthropogenic Precursor Culpability Analysis

The TCEQ applied the OSAT and APCA CAMx tools to the 2006 and 2012 baseline modeling. For both types of analyses, emission source groups such as on-road mobile (using MOVES2010a), non-road and off-road mobile, and biogenics, and emission source regions such as the DFW area, east Texas, and non-Texas were defined. OSAT keeps track of the origin of the NO_X and VOC precursors creating the ozone, which can then be apportioned to specific sources groups and regions. APCA is similar to OSAT, but it recognizes that the biogenics source category is not controllable. Where OSAT would apportion ozone production to biogenic emissions, APCA reallocates that ozone production to the controllable or anthropogenic emissions that combined with the biogenic emissions to create ozone. Only ozone created from both biogenic NO_X and VOC precursors is apportioned to the biogenic emission source group by APCA.

APCA results of the June 2006 baseline and 2012 future cases are presented here for the Eagle Mountain Lake (C75) and Dallas Hinton (C401) monitors. The results are graphed as layered area plots for every rolling eight-hour average for the source groups and regions listed in Table 3-27: *APCA Source Groups and Regions*. Figure 3-29: *APCA Source Regions* exhibits the geographic regions applied in the APCA analysis. Appendix C contains a more detailed analysis of the APCA results, including additional monitors.

Table 3-27: APCA Source Groups and Regions

Figure Legend Abbreviation	Description of Source Group and Region
IC	Initial Condition
WSTBC	West Boundary Condition
ESTBC	East Boundary Condition
STHBC	South Boundary Condition
NTHBC	North Boundary Condition
TOPBC	Top Boundary Condition
Non-Texas	All emission source types outside Texas
West Texas	All emission source types in west Texas
South Texas	All emission source types in south-central Texas
East Texas	All emission source types in east Texas
DFW Biogenics	DFW Biogenic sources
DFW EI & Ships	DFW Elevated point sources
DFW On-Road	DFW On-road sources
DFW Non-Road	DFW Non-Road sources
DFW Area	DFW Area sources
DFW O&G PROD/DRILL	DFW Oil and Gas production and drilling sources
DFW Other	DFW Low-level point sources

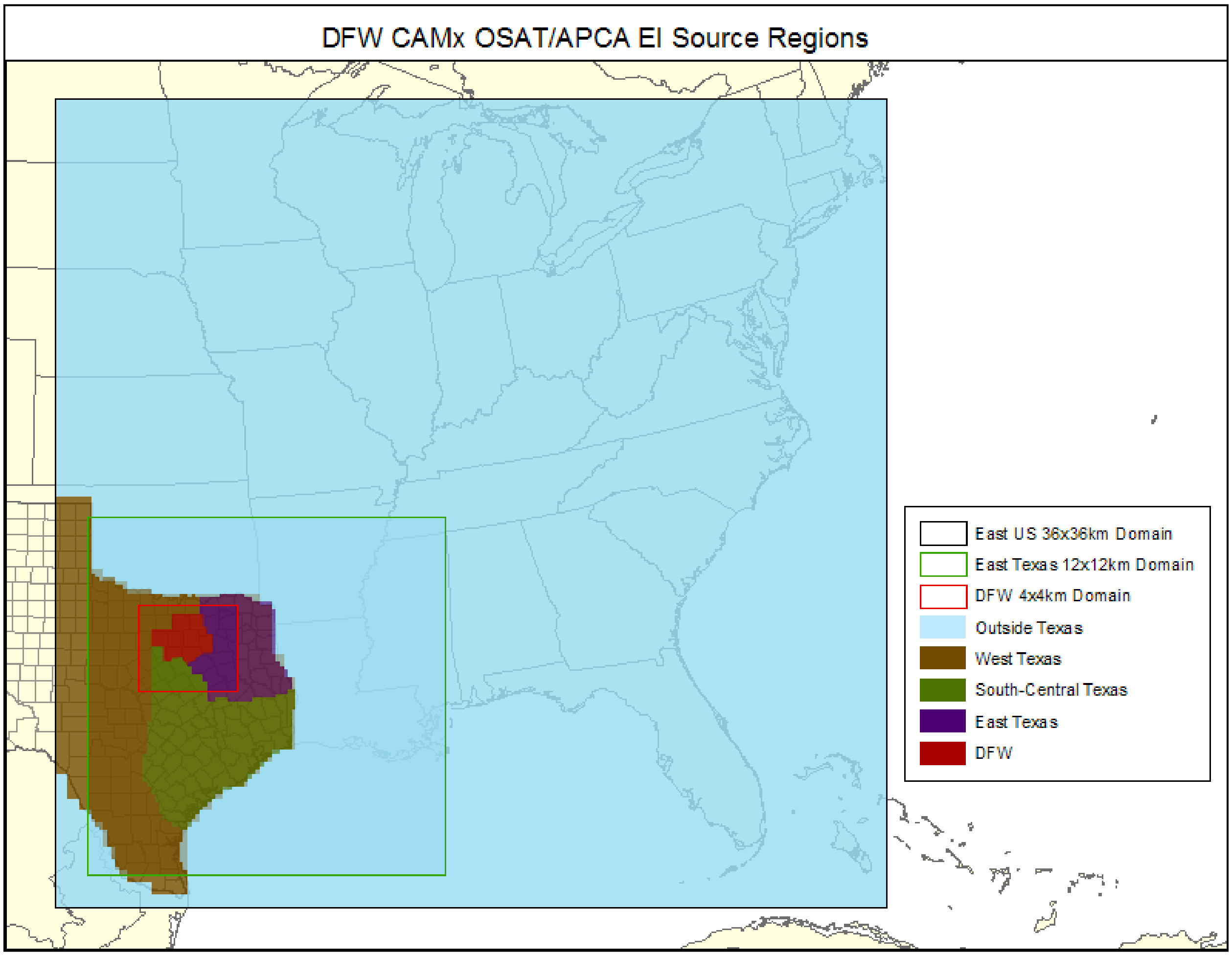

Figure 3-29: APCA Source Regions

Each layer in the figures below represents a source group or type's contribution to the total modeled ozone concentration. The layers are ordered according to the legend at the top of the figure (Initial Conditions on the bottom; DFW Other at the top). The layer corresponding to the initial model conditions disappears after the first few days of the episode are modeled, as expected. Layers corresponding to boundary conditions can give an indication of wind direction and possibly transport on individual episode days.

At EMTL (Figure 3-30: *2006 Baseline Case Eagle Mountain Lake (C75) Eight-Hour APCA with MOVES2010a Results (May 31 through June 15)*, Figure 3-31: *2006 Baseline Case Eagle Mountain Lake (C75) Eight-Hour APCA with MOVES2010a Results (June 16 through July 1)*, Figure 3-32: *2012 Future Case Eagle Mountain Lake (C75) Eight-Hour APCA with MOVES2010a Results (May 31 through June 15)*, and Figure 3-33: *2012 Future Case Eagle Mountain Lake (C75) Eight-Hour APCA with MOVES2010a Results (June 16 through July 1)*) and Dallas Hinton (C401) (Figure 3-34: *2006 Baseline Case Dallas Hinton (C401) Eight-Hour APCA with MOVES2010a Results (May 31 through June 15)*, Figure 3-35: *2006 Baseline Case Dallas Hinton (C401) Eight-Hour APCA Results with MOVES2010a (June 16 through July 1)*, Figure 3-36: *2012 Future Case Dallas Hinton (C401) Eight-Hour APCA with MOVES2010a Results (May 31 through June 15)* and *Figure 3-37: 2006 Future Case Dallas Hinton (C401)*

Eight-Hour APCA with MOVES2010a Results (June 16 through July 1)) non-Texas, South-Central Texas, and DFW sources contribute significantly to the total ozone. West Texas and DFW Oil and Gas sources contribute more at Eagle Mountain Lake (C75) than Dallas Hinton (C401) on certain days as expected based on EMTL's proximity to oil and gas sources as well as the West Texas geographic region. Dallas Hinton (C401) appears to receive more contribution from East Texas sources. From 2006 through 2012, the contribution from local DFW sources decreases, including on-road, non-road, and oil and gas emission sources. Natural gas compressor engine rules from the 2007 DFW AD SIP revision required additional NO_X controls from these oil and gas sources starting in 2009 (TCEQ, 2007a). Less contribution was also observed from the non-DFW source regions in 2012 than the 2006 non-DFW source regions.

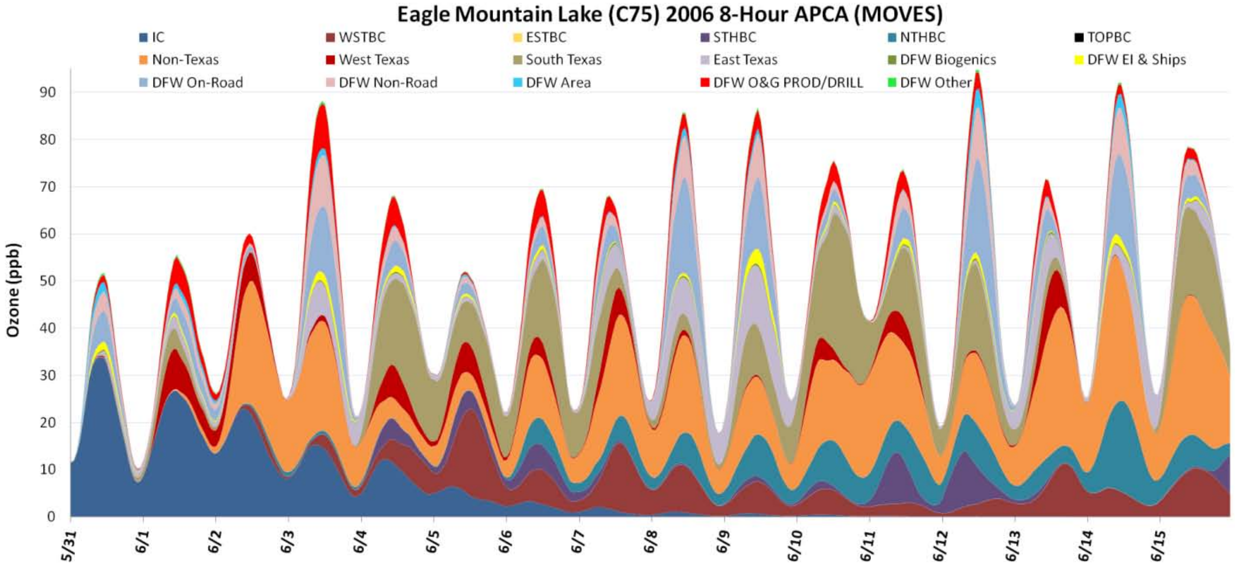

Figure 3-30: 2006 Baseline Case Eagle Mountain Lake (C75) Eight-Hour APCA with MOVES2010a Results (May 31 through June 15)

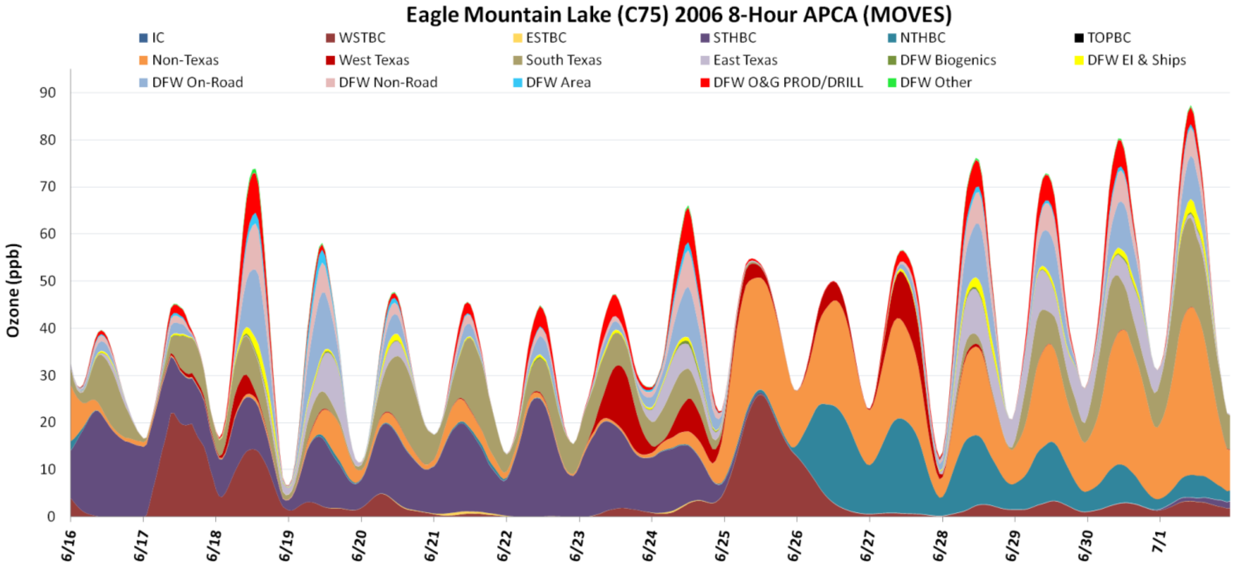

Figure 3-31: 2006 Baseline Case Eagle Mountain Lake (C75) Eight-Hour APCA with MOVES2010a Results (June 16 through July 1)

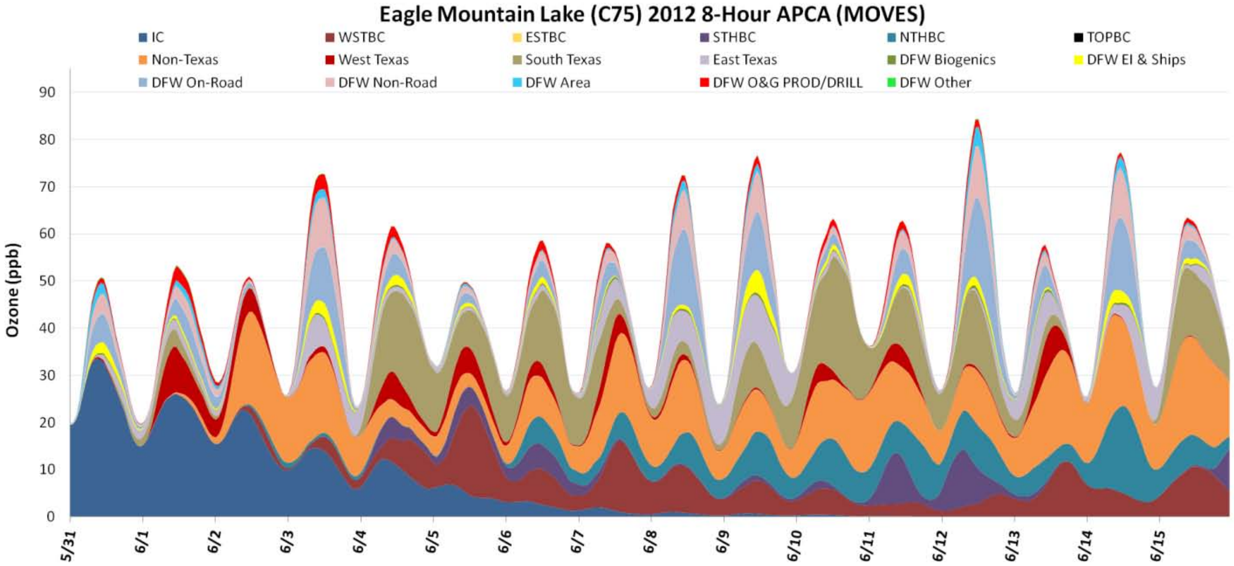

Figure 3-32: 2012 Future Case Eagle Mountain Lake (C75) Eight-Hour APCA with MOVES2010a Results (May 31 through June 15)

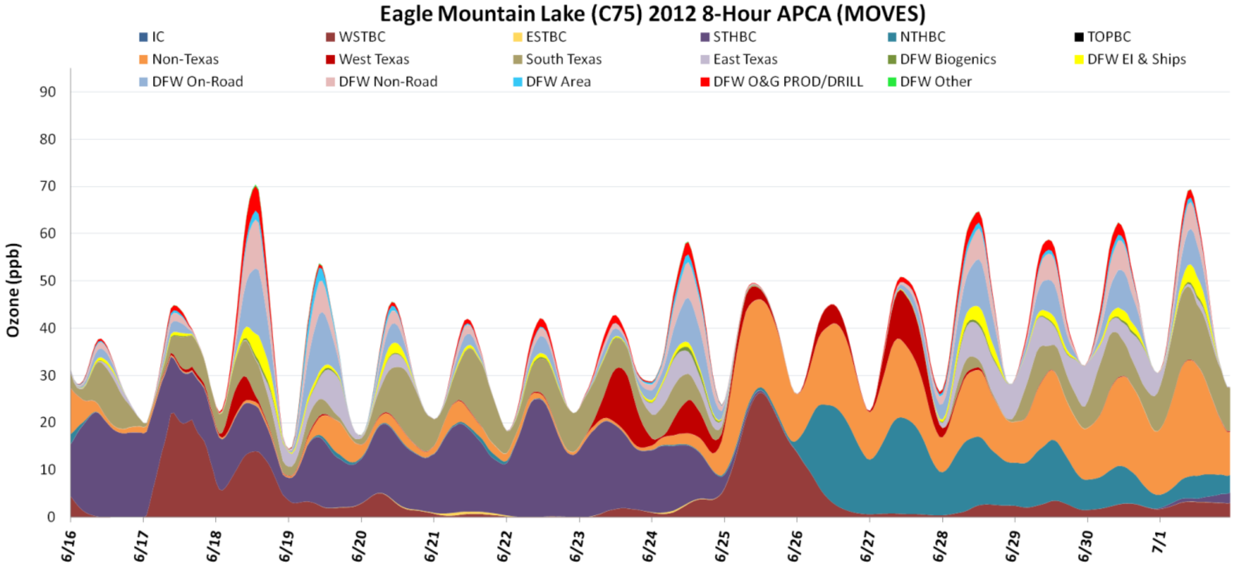

Figure 3-33: 2012 Future Case Eagle Mountain Lake (C75) Eight-Hour APCA with MOVES2010a Results (June 16 through July 1)

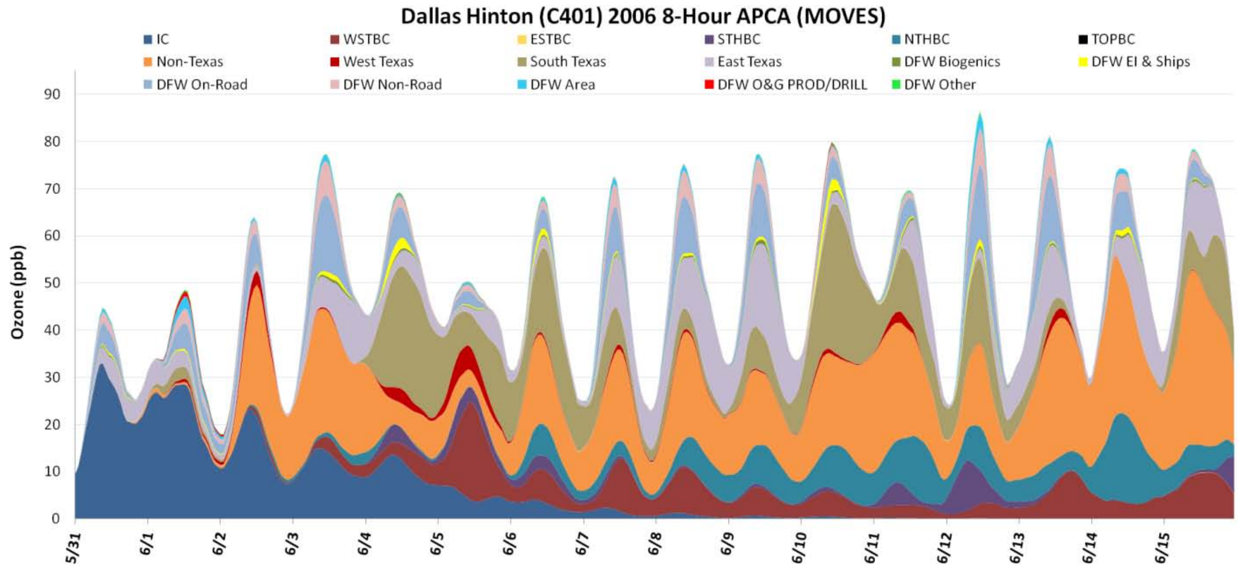

Figure 3-34: 2006 Baseline Case Dallas Hinton (C401) Eight-Hour APCA with MOVES2010a Results (May 31 through June 15)

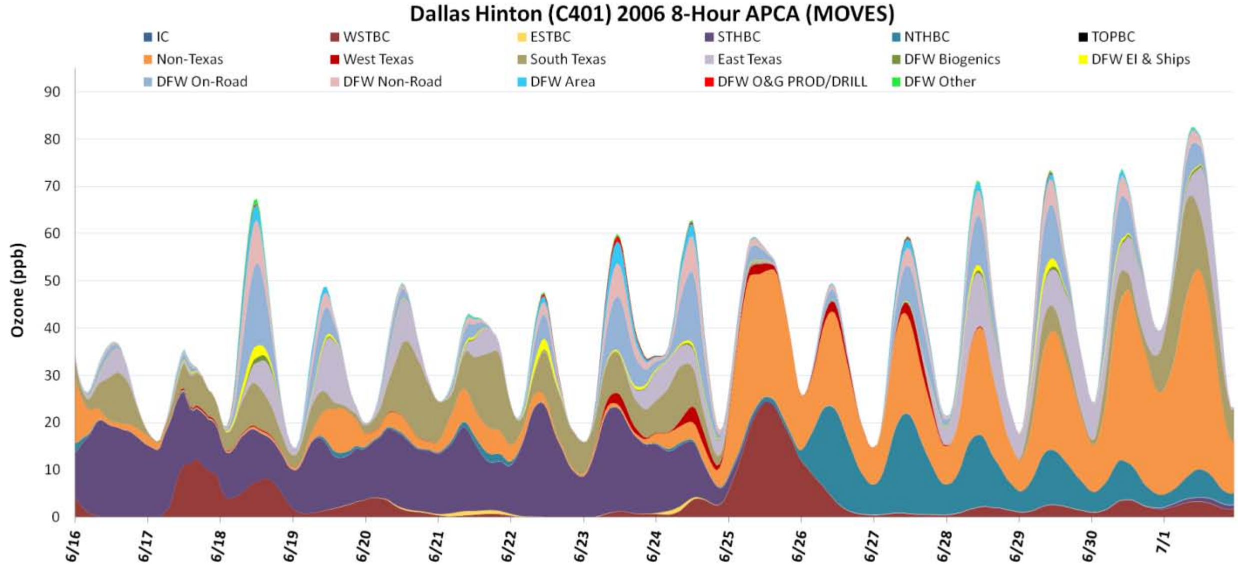

Figure 3-35: 2006 Baseline Case Dallas Hinton (C401) Eight-Hour APCA Results with MOVES2010a (June 16 through July 1)

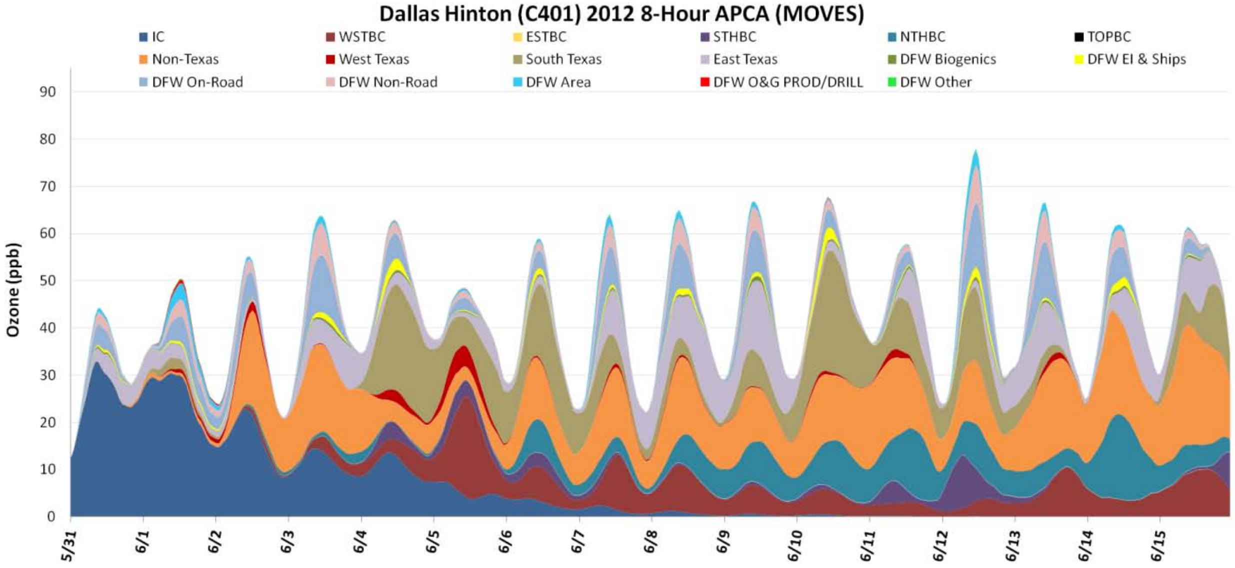

Figure 3-36: 2012 Future Case Dallas Hinton (C401) Eight-Hour APCA with MOVES2010a Results (May 31 through June 15)

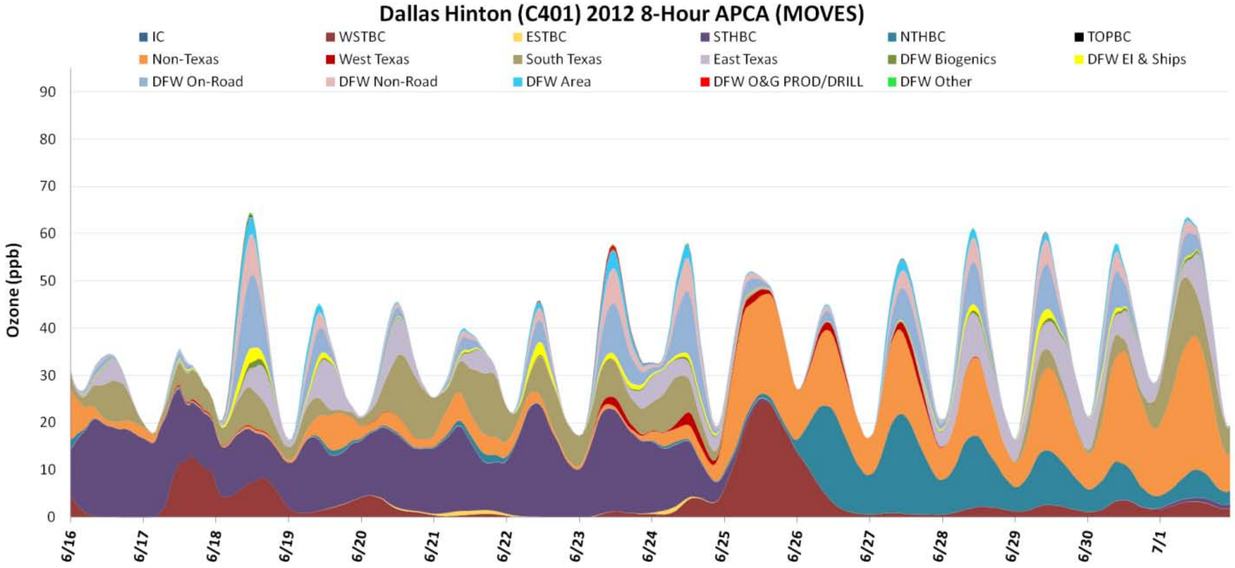

Figure 3-37: 2006 Future Case Dallas Hinton (C401) Eight-Hour APCA with MOVES2010a Results (June 16 through July 1)

3.7.4 Future Case Modeling with Controls

No new controls are being modeled with this AD SIP revision. Two rulemakings are being incorporated into this AD SIP revision as RACT: (1) a rulemaking (Rule Project No. 2010-016-115-EN) to update existing control requirements for certain coatings and other solvent usage operations to implement RACT for certain source categories addressed in Control Techniques Guidelines documents issued by the EPA from 2006 through 2008; and (2) a rulemaking (Rule Project Number 2010-025-115-EN) to update existing control requirements for the storage of VOC to implement RACT for the petroleum liquid storage CTG emission source category. Both rulemakings have compliance dates in March 2013, so neither rulemaking was included in the model for this SIP revision.

3.7.5 Unmonitored Area Analysis

EPA guidance (EPA, 2007) recommends that areas not near monitoring locations (unmonitored areas) be subjected to an “unmonitored area (UMA) analysis” to demonstrate that these areas are expected to reach attainment by the area’s attainment year, in this case 2012. The standard attainment test is applied only at monitor locations, and the UMA analysis is intended to identify any areas not near a monitoring location that are at risk of not meeting the attainment date. Recently, the EPA provided Modeled Attainment Test Software (MATS) that can be used to conduct UMA analyses but has not specifically recommended using its software in EPA guidance, instead stating that “States will be able to use the EPA-provided software or are free to develop alternative techniques that may be appropriate for their areas or situations.”

The TCEQ chose to use its own procedure to conduct the UMA analysis instead of MATS for several reasons. Both procedures incorporate modeled predictions into a spatial interpolation procedure; however, the TCEQ Attainment Test for Unmonitored areas (TATU) is already integrated into the TCEQ’s model post-processing stream while MATS requires that modeled concentrations be exported to a personal computer-based platform. Additionally, MATS requires input in latitude/longitude, while TATU works directly off the LCP data used in TCEQ modeling applications. Finally, MATS uses the Voronoi Neighbor Averaging (VNA) technique for spatial interpolation, while TATU relies on the more familiar kriging geospatial interpolation technique. More information about TATU is provided in Appendix C, Attachment 2: *Spatial Interpolation for Attainment Demonstration*.

Figure 3-38: *Spatially Interpolated 2006 Baseline with MOVES2010a (left) and 2012 Future Case with MOVES (right) Design Values for the DFW Area* shows two color contour maps of ozone concentrations produced by TATU, one for the 2006 baseline with MOVES2010a emissions (left) and one for the 2012 future case with MOVES2010a emissions (right). The figure shows the extent and magnitude of the expected improvements in ozone design values, with zero grid cells at or above 85 ppb in the future case plot. The maximum design value in the domain is predicted at 81.8 ppb.

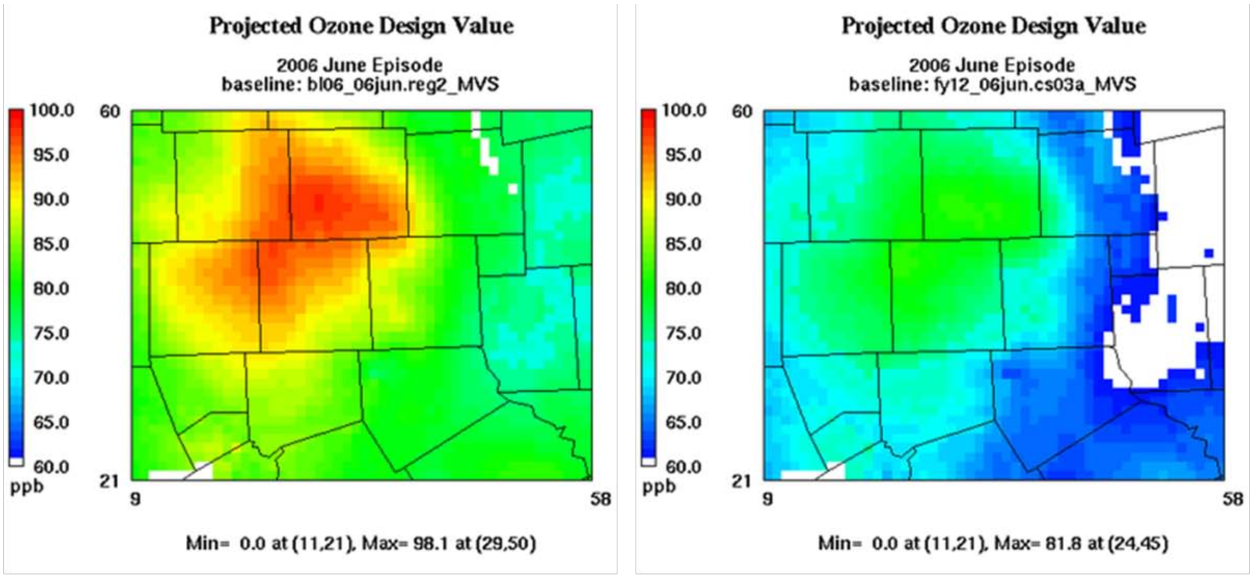

Figure 3-38: Spatially Interpolated 2006 Baseline with MOVES2010a (left) and 2012 Future Case with MOVES2010a (right) Design Values for the DFW Area

3.8 MODELING ARCHIVE AND REFERENCES

3.8.1 Modeling Archive

The TCEQ has archived all modeling documentation and modeling input/output files generated as part of the DFW SIP modeling analysis. Interested parties can contact the TCEQ for information regarding data access or project documentation. Most modeling files and performance evaluation products may be found on TCEQ’s modeling FTP Web site.

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CHAPTER 4: CONTROL STRATEGIES AND REQUIRED ELEMENTS

4.1 INTRODUCTION

The Dallas-Fort Worth (DFW) nonattainment area for the 1997 eight-hour ozone National Ambient Air Quality Standard (NAAQS), which consists of Collin, Dallas, Denton, Tarrant, Ellis, Johnson, Kaufman, Parker, and Rockwall Counties, includes a wide variety of major and minor industrial, commercial, and institutional entities. The Texas Commission on Environmental Quality (TCEQ) has implemented stringent and innovative regulations that address emissions of nitrogen oxides (NO_X) and volatile organic compounds (VOC) from these sources. This chapter describes existing ozone control measures and ozone control measures being adopted concurrently with this state implementation plan (SIP) revision for the DFW area, as well as how Texas meets the following serious ozone nonattainment area SIP requirements: reasonably available control technology (RACT), reasonably available control measures (RACM), motor vehicle emissions budget (MVEB), and contingency measures.

4.2 EXISTING CONTROL MEASURES

Since the early 1990s, a broad range of control measures have been implemented for each emission source category for ozone planning in the DFW area. Table 4-1: *Existing Ozone Control Measures Applicable to the DFW Nine-County Nonattainment Area* lists the existing ozone control strategies that have been implemented for the one-hour and 1997 eight-hour ozone standards in the DFW area.

Table 4-1: Existing Ozone Control Measures Applicable to the DFW Nine-County Nonattainment Area

Measure	Description	Start Date(s)
DFW Industrial, Commercial, and Institutional (ICI) Major Sources Rule	Applies to all major sources (50 tons per year (tpy) of NO_X or more) with affected units Affected source categories included in rule: boilers; process heaters; stationary gas turbines; lime kilns; heat treat and reheat metallurgical furnaces; stationary internal combustion engines; incinerators; glass, fiberglass, and mineral wool melting furnaces; fiberglass and mineral wool curing ovens; natural gas-fired ovens and heaters; brick and ceramic kilns; lead smelting reverberatory and blast furnaces; and natural gas-fired dryers used in organic solvent, printing ink, clay, brick, ceramic tile, calcining, and vitrifying processes Note: these NO_X control requirements are in additional to the NO_X control strategies implemented for ICI major sources in Collin, Dallas, Denton, and Tarrant Counties in March 2002 for the one-hour ozone NAAQS	March 1, 2009, or March 1, 2010, depending on source category

Measure	Description	Start Date(s)
DFW ICI Minor Source Rule	Applies to all minor sources (less than 50 tpy of NO_X) with stationary internal combustion engines	March 1, 2009, for rich-burn gas-fired engines, diesel-fired engines, and dual-fuel engines March 1, 2010, for lean-burn gas-fired engines
DFW Major Utility Electric Generation Source Rule	NO_X control requirements for DFW utility electric generating facilities Applies to utility boilers electric generation facilities with affected sources and auxiliary steam boilers, and stationary gas turbines for RACT purposes Note: these NO_X control requirements are in additional to the NO_X control strategies implemented in for utilities in Collin, Dallas, Denton, and Tarrant Counties in 2001 through 2005 for the one-hour ozone NAAQS	March 1, 2009
Utility Electric Generation in East and Central Texas	NO_X control requirements on utility boilers and stationary gas turbines at utility electric generation sites in East and Central Texas, including Parker County	May 1, 2003, through May 1, 2005
DFW Cement Kiln Rule	NO_X control requirements for all Portland cement kilns located in Ellis County	March 1, 2009
NO_X Emission Standards for Nitric Acid Manufacturing – General	NO_X emission standards for nitric acid manufacturing facilities (state-wide rule – no nitric acid facilities in DFW)	November 15, 1999
East Texas Combustion Sources	NO_X control requirements for stationary rich-burn, gas-fired internal combustion engines (240 horsepower (hp) and greater) Measure implemented to reduce ozone in DFW area although controls not applicable in DFW area	March 1, 2010
Natural Gas-Fired Small Boilers, Process Heaters, and Water Heaters	NO_X emission limits on small-scale residential and industrial boilers, process heaters, and water heaters equal to or less than 2.0 million British thermal units per hour	May 11, 2000

Measure	Description	Start Date(s)
General VOC Control Measures	Additional control technology requirements for VOC sources for RACT purposes including: storage, general vent gas, industrial wastewater, loading and unloading operations, general VOC leak detection and repair (LDAR), solvent using processes, etc (see Appendix D: *Reasonably Available Control Technology Analysis* for more details)	December 31, 2002, and earlier for Collin, Dallas, Denton, and Tarrant Counties June 15, 2007, or March 1, 2009, for Ellis, Johnson, Kaufman, Parker, and Rockwall Counties
Offset Lithographic Printing	Control technology requirements for offset lithographic printing Revision to limit VOC content of solvents used by offset lithographic printing facilities and to include smaller sources in rule applicability	December 31, 2000, in Collin, Dallas, Denton, and Tarrant Counties and March 1, 2009, in Ellis, Johnson, Kaufman, Parker, and Rockwall Counties March 1, 2011, for major printing sources (50 tons of VOC per year or more) and March 1, 2012, for minor printing sources (less than 50 tons of VOC per year)
VOC Rules – Degassing Operations	VOC control requirements for degassing during, or in preparation of, cleaning any storage tanks and transport vessels	May 21, 2011, for Collin, Dallas, Denton, and Tarrant Counties
Voluntary Energy Efficiency/Renewable Energy	Energy efficiency and renewable energy projects encouraged by Senate Bill (SB) 7 from 76th session of Texas Legislature and SB 5 from 77th session of Texas Legislature	September 1, 1999, and September 1, 2001
Automotive Windshield Washer Fluid	VOC content limitation on automotive windshield washer fluid sold, supplied, distributed, or manufactured for use in Texas	January 1, 1995
Refueling – Stage I	Captures gasoline vapors that are released when gasoline is delivered to a storage tank Vapors returned to tank truck as storage tank is filled with fuel, rather than released into ambient air	1990

Measure	Description	Start Date(s)
Refueling – Stage II	Captures gasoline vapors when vehicle is fueled at pump Vapors returned through pump hose to petroleum storage tank, rather than released into ambient air	1992 (Collin, Dallas, Denton, and Tarrant Counties)
Federal Area/Non-Road Measures	Series of emissions limits implemented by the United States Environmental Protection Agency (EPA) for area and non-road sources Examples: diesel and gasoline engine standards for locomotives and leaf-blowers	Through 2007
Texas Emissions Reduction Plan (TERP)	Provides grant funds for on-road and non-road heavy-duty diesel engine replacement/retrofit	January 2002
California Gasoline Engines	California standards for non-road gasoline engines 25 hp and larger	May 1, 2004
Texas Low Emission Diesel (TxLED)	Requires all diesels for both on-road and non-road use to have a lower aromatic content and a higher cetane number	Phase in began October 31, 2005
Texas Low Reid Vapor Pressure (RVP) Gasoline	Requires all gasoline for both on-road and non-road use to have RVP of 7.8 pounds per square inch or less from May 1 through October 1 each year	April 2000
Voluntary Mobile Emissions Reduction Program (VMEP)	Voluntary measures administered by the North Central Texas Council of Governments (NCTCOG) (see Appendix H: *NCTCOG Submittal of On-Road and Non-Road Mobile Emissions Reductions Benefit* of the May 2007 DFW AD SIP Revision for more details)	2007
Federal On-Road Measures	Series of emissions limits implemented by the EPA for on-road vehicles Included in measures: Tier 1 and Tier 2 light–duty and medium-duty passenger vehicle standards, heavy-duty vehicle standards, low sulfur diesel standards, National Low Emission Vehicle standards, and reformulated gasoline	Phase in through 2010
Vehicle Inspection/ Maintenance (I/M)	Yearly treadmill-type testing for pre-1996 vehicles and computer checks for 1996 and newer vehicles	May 1, 2002, in Collin, Dallas, Denton, and Tarrant Counties May 1, 2003, in Ellis, Johnson, Kaufman, Parker, and Rockwall Counties

Measure	Description	Start Date(s)
Environmental Speed Limit (ESL)	Five miles per hour (mph) below what was posted before May 1, 2002, on roadways where speeds were 65 mph or higher ESLs adopted by the commission in April 2000 converted to Transportation Control Measures (TCMs) by the TCEQ in August 2010	September 2001
Transportation Control Measures	Various measures in NCTCOG's long-range transportation plans (see Chapter 4: *Required Control Strategy Elements*, of the May 2007 DFW AD SIP Revision)	2007
Voluntary Energy Efficiency/Renewable Energy	Energy efficiency and renewable energy projects encouraged by SB 5 and SB 7 from the 80th session of the Texas Legislature	December 2000

4.3 UPDATES TO EXISTING CONTROL MEASURES

4.3.1 Updates to Coatings Control Measures

Concurrent with this AD SIP revision, the commission is adopting rulemaking (Rule Project Number 2010-016-115-EN) to update existing control requirements for certain coatings and other solvent usage operations to implement RACT for the following source categories addressed in Control Techniques Guidelines (CTG) documents issued by the EPA from 2006through 2008:

- Flexible Package Printing, Group II, issued in 2006;
- Large Appliance Coatings, Group III, issued in 2007;
- Metal Furniture Coatings, Group III, issued in 2007;
- Paper, Film, and Foil Coatings, Group III, issued in 2007;
- Miscellaneous Metal and Plastic Parts Coatings, Group IV, issued in 2008; and
- Auto and Light-Duty Truck Assembly Coatings, Group IV, issued in 2008.

The pleasure craft and the plastic parts coating subcategories in the 2008 Miscellaneous Metal and Plastic Parts Coatings CTG document represent new control measures, as discussed in Section 4.4: *New Control Measures*. Additional detail concerning these updated control measures can be found in the RACT discussion in Section 4.5.3: *VOC RACT Determination* of this chapter.

4.3.2 Updates to VOC Storage Tank Control Measures

Concurrent with this AD SIP revision, the commission is adopting rulemaking (Rule Project Number 2010-025-115-EN) to update existing control requirements for the storage of VOC to implement RACT for the petroleum liquid storage CTG emission source category. This rulemaking revises existing rules to include additional requirements for low-leaking storage tank fittings and to limit situations when floating roof storage tanks are allowed to emit VOC because the roof is not floating on the liquid. Additional detail concerning these updated control measures can be found in the RACT discussion in Section 4.5.3 of this chapter.

4.3.3 Repeal of State Portable Fuel Container Rule

The EPA adopted a federal portable fuel container (PFC) rule in the February 26, 2007, issue of the Federal Register (72 FR 8432) that set a national standard for gasoline, diesel, and kerosene PFCs. The rule requires all PFCs manufactured on or after January 1, 2009, to comply with the federal standards. The new federal PFC regulations are consistent with the revised PFC regulations adopted by the California Air Resources Board (CARB) on September 15, 2005. The Texas PFC regulations were inconsistent with the new federal standards, because they were based on previous PFC testing methods adopted by CARB in 2001. Therefore, the state repealed its PFC regulations (rule project number 2008-032-115-EN) on February 10, 2010, to rely on the implementation of the federal PFC regulations to control VOC emissions from PFCs used within the state. According to an EPA analysis entitled, Federal Register Rule vs. Texas Register Rule Portable Fuel Containers, the federal PFC rule is more stringent than the repealed Texas PFC rule.

4.3.4 Clean Fuel Fleet Requirement

Participation in a Clean Fuel Fleet Program (CFFP) is required by § 246 of the FCAA for nonattainment areas with 1980 populations greater than 250,000 that are classified as serious or above for ozone. In accordance with this requirement, a CFFP was instituted by rule for the Dallas-Fort Worth, Houston-Galveston-Brazoria, and El Paso ozone nonattainment areas beginning on September 1, 1998. The CFFP required that a certain percentage of fleet purchases after model year 1998 be clean fuel vehicles (CFVs) that meet the standards set forth in §243 of the FCAA.

The most recent federal standards for both light-duty and heavy-duty vehicles have eclipsed the CFV standards because subsequent to September 1, 2005, any new vehicle purchase ranging from 0-26,000 pounds gross vehicle weight rating would have either equaled or, in most cases, exceeded CFV standards. In a letter to manufacturers (EPA, 2005), the EPA stated that "subsequent to publishing its CFV regulations, EPA has promulgated new emission standards that are generally more stringent than or equivalent to the CFV emission standards for light-duty vehicles, light-duty trucks, and heavy-duty engines." This EPA letter, dated July 21, 2005, applied to fleet purchases that began with the 2006 model year (September 1, 2005).

During the 79th Session of the Texas Legislature in 2005, Senate Bill 1032 repealed the Texas Clean Fleet Program in its entirety because the federal standards already in place at that time eclipsed the CFV standards referenced in the FCAA. On April 26, 2006, the TCEQ formally repealed the Texas Clean Fleet Program because no additional benefit could be achieved from new vehicle purchases under CFFP. A revision to the Texas Clean Fleet SIP that reflected the repeal of the Texas Clean Fleet Program was submitted to the EPA on May 15, 2006. FCAA §182(c)(4) allows the EPA to approve measures that substitute for the initial requirement to implement a CFFP as long as the EPA determines the substitute will accomplish equal long-term reductions attributable to the CFFP. However, the EPA has not provided guidance on how states are to address the Clean Fuel Fleet substitution requirement in their AD SIP revision submittals, where more stringent federal standards exist. Since new vehicle purchases subsequent to the date of repeal would meet more stringent federal emission standards, cancellation of the Texas Clean Fleet Program does not necessitate action to substitute this program with a separate emission reduction measure containing equivalent benefits. Such a substitution would only be warranted if a net increase in emissions would occur due to repeal or cancellation of an existing program.

4.3.5 Stage I and Stage II Requirements

The Stage I vapor recovery rules regulate the filling of gasoline storage tanks at gasoline stations by tank trucks. To comply with Stage I requirements, a vapor balance system is typically used to capture the vapors from the gasoline storage tanks that would otherwise be displaced to the atmosphere as these tanks are filled with gasoline. The captured vapors are routed back to the tanker truck and processed by a vapor control system when the tanker truck is subsequently refilled at a gasoline terminal or gasoline bulk plant. The effectiveness of Stage I vapor recovery rules depends on the captured vapors being: 1) effectively contained within the gasoline tanker truck during transit and 2) controlled when the transport vessel is refilled at a gasoline terminal or gasoline bulk plant.

The Stage II vapor recovery program involves use of technology that prevents gasoline vapors from escaping during refueling of on-road motor vehicles. The EPA mandates that Stage II refueling requirements apply to all public and private refueling facilities dispensing 10,000 gallons or more of gasoline per month. The federal throughput constitutes a minimum threshold, but a state may be more stringent in adopting a throughput standard. The TCEQ applies a more stringent throughput standard in the applicable ozone nonattainment counties by requiring all facilities constructed after November 15, 1992, to install Stage II vapor recovery regardless of throughput.

An additional five counties (Ellis, Johnson, Kaufman, Parker, and Rockwall) may be required to meet Stage II requirements because the DFW area was reclassified as a serious ozone nonattainment area. The EPA currently allows states to revise the SIP to allow the removal of Stage II gasoline vapor recovery equipment if the state can demonstrate that widespread use of on onboard refueling vapor recovery has occurred at the gasoline dispensing facilities dedicated to corporate or commercial fleets. ORVR systems are passive systems that force gasoline vapors displaced from a vehicle’s fuel tank during refueling to be directed to a carbon-canister holding system and ultimately to the engine where they are consumed. The EPA is in the process of proposing a rule that will provide a formula for states to demonstrate when ORVR widespread use would occur in the general fleet. If the EPA rule is promulgated and Texas can demonstrate ORVR widespread use, then Stage II would not be required in the additional five DFW counties. A Stage II AD SIP revision, which may include an ORVR widespread use demonstration based on the EPA’s final rule, is due to the EPA on December 10, 2013.

4.4 NEW CONTROL MEASURES

4.4.1 Stationary Sources

4.4.1.1 VOC Storage

In addition to the revised control requirements discussed in Section 4.3.2: *Updates to VOC Storage Tank Control Measures* of this chapter, concurrent with this AD SIP revision, the commission is adopting new rules (Rule Project Number 2010-025-115-EN) to control flash emissions from crude oil and condensate storage tanks with uncontrolled VOC emissions that equal or exceed 50 tons per year (tpy) to implement RACT for major stationary sources in serious nonattainment areas. Additional detail concerning these new control measures can be found in the RACT discussion in Section 4.5.3 of this chapter.

4.4.1.2 Coating and Solvent Usage

In addition to the revised control requirements discussed in Section 4.3.1: *Updates to Coatings Control Measures* of this chapter, concurrent with this AD SIP revision, the commission is adopting new rules (Rule Project Number 2010-016-115-EN) for certain coatings and solvent usage operations to implement RACT for source categories addressed in the following CTG documents issued by the EPA from 2006 through 2008:

- Industrial Cleaning Solvents, Group II, issued in 2006;
- Miscellaneous Industrial Adhesives, Group IV, issued in 2008; and
- Miscellaneous Metal and Plastic Parts Coatings, Group IV, issued in 2008.

Additional detail concerning these new control measures can be found in the RACT discussion in Section 4.5.3 of this chapter. Only the pleasure craft and plastic parts coating categories represent new control measures from the 2008 Miscellaneous Metal and Plastic Parts Coatings CTG document. As discussed in Section 4.3.1 of this chapter, the rulemaking also updates the existing control requirements for miscellaneous metals parts.

4.5 RACT ANALYSIS

4.5.1 General Discussion

The DFW area is currently classified as a serious nonattainment area for the 1997 eight-hour ozone NAAQS (75 FR 79302, December 20, 2010). Under the 1997 eight-hour ozone standard, the DFW area is required to meet the mandates of FCAA, §172(c)(1) and §182(b)(2) and 182(f). According to EPA's final rule to implement the 1997 eight-hour ozone NAAQS (40 CFR §51.912, November 29, 2005), states containing areas classified as moderate nonattainment and above must submit an AD SIP revision demonstrating that their current rules fulfill the RACT requirements for all CTG emission source categories and all non-CTG major sources of NO_X and VOC. The major source threshold for serious nonattainment areas is a potential to emit 50 tpy or more of either NO_X or VOC.

In the September 17, 1979, issue of the *Federal Register* (44 FR 53762), RACT is defined as the lowest emissions limitation that a particular source is capable of meeting by the application of control technology that is reasonably available considering technological and economic feasibility. RACT requirements for nonattainment areas classified as moderate and above are included in the FCAA to assure that significant source categories at major sources of ozone precursor emissions are controlled to a reasonable extent but not necessarily to best available control technology levels expected of new sources or to maximum achievable control technology (MACT) levels required for major sources of hazardous air pollutants. While RACT and RACM have similar consideration factors like technological and economic feasibility, there is a significant distinction between RACM and RACT. To be considered RACM, a control measure must advance attainment of the NAAQS for that area (see FCAA, §172(c)(1)). Advancing attainment of the area is not a consideration when evaluating RACT because the benefit of implementing RACT is presumed under the FCAA.

Under the current state rules, the DFW area is subject to some of the most stringent NO_X and VOC emission control requirements in the country, and for many source categories, the existing rules are more stringent than recommended RACT standards for those categories. The EPA previously approved the RACT analysis as submitted in the May 2007 DFW AD SIP Revision (74 FR 1903, January 14, 2009) and noted that the DFW VOC rules in 30 Texas Administrative Code (TAC) Chapter 115 and NO_X rules in Chapter 117 were previously determined to meet the FCAA RACT requirements. Therefore, controls to satisfy RACT for most major sources under the 1997 eight-hour ozone nonattainment designation were implemented by the TCEQ and previously approved by the EPA, see Appendix F: *Reasonably Available Control Technology Analysis*.

4.5.2 NO_X RACT Determination

The TCEQ's analysis demonstrates that the current NO_X rules and controls for the DFW area fulfill the FCAA requirements for NO_X RACT. The 30 TAC Chapter 117 rules represent one of the most comprehensive NO_X control strategies in the nation and encompass both RACT and beyond-RACT levels of control. The current EPA-approved Chapter 117 rules fulfill RACT requirements for all CTG and Alternative Control Techniques (ACT) NO_X emission source categories. For all non-CTG/ACT major NO_X emission source categories for which controls are technologically and economically feasible, RACT is fulfilled by the EPA-approved Chapter 117 rules or other federally enforceable measures. Additional details regarding the RACT analysis are provided in Appendix F of this AD SIP revision.

4.5.3 VOC RACT Determination

The TCEQ's analysis demonstrates that the current EPA-approved 30 TAC Chapter 115 VOC rules and controls for the DFW area, or the Chapter 115 VOC rules being adopted concurrently with this AD SIP revision (Rule Project Numbers 2010-016-115-EN and 2010-025-115-EN) satisfy the FCAA requirements for RACT for all CTG and ACT VOC emission source categories. For all non-CTG/ACT major VOC emission source categories for which VOC controls are technologically and economically feasible, RACT is fulfilled by EPA-approved Chapter 115 rules, other federally enforceable measures, or the Chapter 115 VOC rules being adopted concurrently with this AD SIP revision (Rule Project Number 2010-025-115-EN). Additional VOC controls on certain major sources were determined to be either not economically feasible or not technologically feasible. Additional details regarding the RACT analysis are provided in Appendix F of this AD SIP revision.

Concurrent with this SIP revision, the commission is adopting rules in Chapter 115, Subchapter B, Division 1 to implement RACT for VOC storage (Rule Project Number 2010-025-115-EN). To implement RACT for the petroleum liquid storage CTG emission source category, these rules include additional requirements for low-leaking storage tank fittings and limit situations when floating roof tanks are allowed to emit VOC because the roof is not floating on the liquid. To implement RACT for major stationary sources, these rules require control of flash emissions from crude oil and condensate storage tanks with uncontrolled VOC emissions that equal or exceed 50 tpy. Additional discussion regarding the RACT requirements for VOC storage tanks is provided in Appendix F of this AD SIP revision.

The EPA issued 11 CTG documents from 2006 through 2008 with recommendations for VOC controls on a variety of consumer and commercial products. Some of the new CTG recommendations are updates to previously issued CTG documents and some are recommendations for new categories. The TCEQ evaluated these new CTG documents to determine if additional VOC controls were necessary to fulfill requirements.

The RACT analysis included in the DFW RACT SIP revision adopted March 10, 2010, addresses the following CTG documents:

- Flat Wood Paneling Coatings, Group II, issued in 2006;
- Offset Lithographic and Letterpress Printing, Group II, issued in 2006; and
- Fiberglass Boat Manufacturing Materials, Group IV, issued in 2008.

The RACT analysis included in this AD SIP revision addresses the following CTG documents:

- Flexible Package Printing, Group II, issued in 2006;
- Industrial Cleaning Solvents, Group II, issued in 2006;

- Large Appliance Coatings, Group III, issued in 2007;
- Metal Furniture Coatings, Group III, issued in 2007;
- Paper, Film, and Foil Coatings, Group III, issued in 2007;
- Miscellaneous Industrial Adhesives, Group IV, issued in 2008;
- Miscellaneous Metal and Plastic Parts Coatings, Group IV, issued in 2008; and
- Auto and Light-Duty Truck Assembly Coatings, Group IV, issued in 2008.

The following sections provide a brief summary of the TCEQ's determinations regarding these eight CTG documents. Additional details regarding the evaluation of the eight CTG documents are provided in Appendix F of this AD SIP revision.

4.5.3.1 Flexible Package Printing

The TCEQ has determined that portions of the Flexible Package Printing CTG recommendations are RACT for the DFW area. Concurrent with this AD SIP revision, the commission is adopting rulemaking to limit the VOC content of coatings used by flexible package printing operations in the DFW area (Rule Project 2010-016-115-EN). The rulemaking implements the CTG recommendations to reduce the VOC content of coatings and imposes work practices for cleaning materials used during flexible package printing.

4.5.3.2 Industrial Cleaning Solvents

The TCEQ has determined that portions of the Industrial Cleaning Solvents CTG recommendations are RACT for the DFW area. Concurrent with this AD SIP revision, the commission is adopting rulemaking to implement the CTG recommendations to limit the VOC content of industrial cleaning solvents used in the DFW area (Rule Project 2010-016-115-EN). The TCEQ revised the proposed rules for industrial cleaning solvents in response to comments received on the proposed rules and this AD SIP revision. Additional details regarding these changes are provided in Appendix F of this AD SIP revision.

4.5.3.3 Large Appliance Coatings

The TCEQ has determined that portions of the Large Appliance Coatings CTG recommendations are RACT for the DFW area. Concurrent with this AD SIP revision, the commission is adopting rulemaking to limit the VOC content of large appliance coatings in the DFW area (Rule Project 2010-016-115-EN). The rulemaking implements the CTG recommendations to reduce the VOC content of coatings and imposes work practices for cleaning materials used during large appliance coating. The TCEQ revised the proposed rules for large appliance coatings in response to comments received on the proposed rules and this AD SIP revision. Additional details regarding these changes are provided in Appendix F.

4.5.3.4 Metal Furniture Coatings

The TCEQ has determined that portions of the Metal Furniture Coatings CTG recommendations are RACT for the DFW area. Concurrent with this AD SIP revision, the commission is adopting rulemaking to limit the VOC content of metal furniture coatings used in the DFW area (Rule Project 2010-016-115-EN). The rulemaking implements the CTG recommendations to reduce the VOC content of coatings and imposes work practices for cleaning materials used during metal furniture coating. The TCEQ revised the proposed rules for metal furniture coatings in response to comments received on the proposed rules and this AD. Additional details regarding these changes are provided in Appendix F.

4.5.3.5 Paper, Film, and Foil Coatings

The TCEQ has determined that portions of the Paper, Film, and Foil Coatings CTG recommendations are RACT for the DFW area. Concurrent with this AD SIP revision, the commission is adopting rulemaking to limit the VOC content of paper, film, and foil coatings in the DFW area (Rule Project 2010-016-115-EN). The rulemaking implements the CTG recommendations to reduce the VOC content of coatings and imposes work practices for cleaning materials used during paper, film, and foil coating.

4.5.3.6 Miscellaneous Industrial Adhesives

The TCEQ has determined that portions of the Miscellaneous Industrial Adhesives CTG recommendations are RACT for the DFW area. Concurrent with this AD SIP revision, the commission is adopting rulemaking to implement the CTG recommendations to limit the VOC content of miscellaneous industrial adhesives used in the DFW area (Rule Project 2010-016-115-EN). The TCEQ revised the proposed rules for miscellaneous industrial adhesives in response to comments received on the proposed rules and this AD SIP revision. Additional details regarding these changes are provided in Appendix F.

4.5.3.7 Miscellaneous Metal and Plastic Parts Coatings

The TCEQ has determined that portions of the Miscellaneous Metal and Plastic Parts Coatings CTG recommendations are RACT for the DFW area. Concurrent with this AD SIP revision, the commission is adopting rulemaking to limit the VOC content of miscellaneous metal and plastic parts coatings used in the DFW area (Rule Project 2010-016-115-EN). The rulemaking implements the CTG recommendations to reduce the VOC content of coatings and imposes work practices for cleaning materials used during miscellaneous metal and plastic parts coating. The TCEQ revised the proposed rules for miscellaneous metal and plastic parts coatings in response to comments received on the proposed rules and this AD SIP revision. Additional details regarding these changes are provided in Appendix F.

4.5.3.8 Auto and Light-Duty Truck Assembly Coatings

The TCEQ has determined that portions of the Auto and Light-Duty Truck Assembly Coatings CTG recommendations are RACT for the DFW area. Concurrent with this AD SIP revision, the commission is adopting rulemaking to limit the VOC content of auto and light-duty truck assembly coatings used in the DFW area (Rule Project 2010-016-115-EN). The rulemaking implements the CTG recommendations to reduce the VOC content of coatings and imposes work practices for cleaning materials used during auto and light-duty truck assembly coating.

4.6 RACM ANALYSIS

4.6.1 General Discussion

States are required by FCAA, §172(c)(1) to “provide for implementation of all reasonably available control measures as expeditiously as practicable” and to include RACM analyses in the AD SIP revision. In the General Preamble for implementation of the FCAA Amendments of 1990 published in the April 16, 1992, issue of the *Federal Register* (57 FR 13498), the EPA explains that it interprets §172(c)(1) of the FCAA as a requirement that states incorporate into their SIP all reasonably available control measures that would advance a region’s attainment date. However, the state is obligated to adopt only those measures that are reasonably available for implementation in light of local circumstances.

The TCEQ used a two-step process to develop the list of potential stationary and mobile source control strategies evaluated during the RACM analysis. First, the TCEQ compiled a list of potential control strategy concepts based on an initial evaluation of the existing control strategies in the DFW area and existing sources of VOC and NO_X in the DFW area. The EPA allows states the option to consider control measures outside the ozone nonattainment area that can be shown to advance attainment; however, consideration of these sources is not a requirement of the FCAA. Sources of VOC within 100 kilometers (km) of the DFW area and sources of NO_X within 200 km of the DFW area were also considered for this initial evaluation. Draft lists of potential control strategy concepts for stationary and mobile sources were developed from this initial evaluation. The draft lists of potential control strategy concepts were presented to stakeholders for comment at a stakeholder meeting held in the DFW area on June 24, 2010. The TCEQ requested comment on the potential control strategies and invited stakeholders to suggest any additional strategies that might help advance attainment of the DFW area. The final list of potential control strategy concepts for RACM analysis includes the strategies presented to stakeholders in June 2010 and the strategies suggested by stakeholders during the informal stakeholder comment process and by the North Texas Clean Air Steering Committee.

Each control measure identified through the control strategy development process was evaluated to determine if the measure would meet established criteria to be considered reasonably available. The TCEQ used the general criteria specified by the EPA in the proposed approval of the New Jersey RACM analysis published in the January 16, 2009, issue of the *Federal Register* (74 FR 2945).

> *RACM is defined by the EPA as any potential control measure for application to point, area, on-road, and non-road emission source categories that meets the following criteria.*
>
> - *The control measure is technologically feasible.*
> - *The control measure is economically feasible.*
> - *The control measure does not cause "substantial widespread and long-term adverse impacts."*
> - *The control measure is not "absurd, unenforceable, or impracticable."*
> - *The control measure can advance the attainment date by at least one year.*

The EPA did not provide guidance in the *Federal Register* on how to interpret the criteria "advance the attainment date by at least one year." Because modeling shows that the DFW area will be significantly below the NAAQS and as discussed in Section 4.6.2 *Results of the RACM Analysis*, it is not possible to implement control measures quickly enough to attain the NAAQS earlier, sensitivity runs were not needed to evaluate RACM.

The TCEQ also considered whether each potential control measure could be implemented before and reduce emissions prior to the beginning of the ozone season immediately before the attainment date. The attainment date for the 1997 eight-hour ozone NAAQS for the DFW area is June 15, 2013, so suggested control measures that could not be implemented by March 1, 2012, were not considered RACM because the measures would not advance attainment. However, the DFW area must make progress toward attainment of 1997 eight-hour ozone NAAQS as expeditiously as practicable. Therefore, if control measures can be implemented earlier than March 1, 2012, and will help the area make progress toward attainment of the NAAQS earlier than the attainment year, the measure should be implemented as early as feasible.

The TCEQ also considered whether the control measure was similar or identical to control measures already in place in the DFW area. If the suggested control measure would not provide substantive and quantifiable benefit over the existing control measure, then the suggested control measure was not considered RACM because reasonable controls were already in place.

4.6.2 Results of the RACM Analysis

All potential control measures evaluated for both stationary and mobile sources were determined not to be RACM due to technological or economic feasibility, enforceability, adverse impacts, or ability of the measure to advance attainment of the NAAQS. In general, the inability to advance attainment is the primary determining factor in the RACM analyses. As discussed in Chapter 3: *Photochemical Modeling* of this AD SIP revision, modeling shows that the DFW area will be substantially below the 1997 eight-hour ozone NAAQS and additional control measures are not necessary for the area to demonstrate attainment by the attainment date. Furthermore, a control measure would have to be in place by March 1, 2012, in order for the measure to advance the attainment date; therefore, it is not possible for the TCEQ to implement any control measures that would provide for earlier attainment of the NAAQS. The complete list of stationary source potential control measures and additional information and specific details regarding the RACM analysis for the DFW area are provided in Appendix G: *Reasonably Available Control Measure Analysis*.

4.7 MVEB

The MVEB refers to the maximum allowable emissions from on-road mobile sources for each applicable criteria pollutant or precursor as defined in the SIP. The budget must be used in transportation conformity analyses. Areas must demonstrate that the estimated emissions from transportation plans, programs, and projects do not exceed the MVEB. The attainment budget represents the on-road mobile source emissions that have been modeled for the attainment demonstration using MOVES2010a. The budget reflects all of the on-road control measures reflected in Chapter 4 of the demonstration. The MVEB is shown in Table 4-2: *2012 Attainment Demonstration MVEB for the Nine-County DFW Area*. For additional detail, see Appendix B*: Emissions Inventory Development*.

Table 4-2: 2012 Attainment Demonstration MVEB for the Nine-County DFW Area

Nine-County DFW Area	NO_X tons per day (tpd)	VOC tpd
2012 MVEB	181.40	80.48

4.8 MONITORING NETWORK

States are required by 40 CFR Part 58, Subpart B, to submit an annual monitoring network review to the EPA by July 1 of each year. This network review is required to provide the framework for establishment and maintenance of an air quality surveillance system. The annual monitoring network review must be made available for public inspection for at least 30 days prior to submission to the EPA. The review and any comments received during the 30 day inspection period are then forwarded to the EPA for final review and approval. The TCEQ posted the 2011 plan from June 1 through June 30, 2011, on the TCEQ Web site (http://www.tceq.texas.gov/). The document presents the current Texas network of ambient air Photochemical Assessment Monitoring Station (PAMS) monitors as well as proposed changes to the network from July 1, 2011, through December 31, 2011.

This network review includes posting of the TCEQ's EPA-approved PAMS Network Plan which focuses on ozone precursors. The reclassification of the DFW ozone nonattainment area to serious requires carbonyl sampling at a Type 2 PAMS site in the DFW area. Carbonyls are a class of VOC that are involved in ozone formation. Carbonyl measurements can be used to help resolve the role of ozone precursors in local ozone formation and in ozone transport, as well as to help evaluate model performance, control strategy effectiveness, and emissions inventory accuracy.

The TCEQ will conduct the required intensive carbonyl sampling at the Hinton PAMS Type 2 Site (AQS ID 48-113-0069) each year. As preliminarily agreed upon with the EPA, Region 6, the TCEQ will collect a total of 240 carbonyl samples at this site at a sampling frequency of eight three-hour samples per day every three days during June 1 through August 31. In addition to this serious nonattainment area requirement, the TCEQ will also collect one 24-hour carbonyl sample every six days, from September 1 through May 31 at the Dallas Hinton (C401) site and year round at the Fort Worth Northwest (C13) site.

4.9 CONTINGENCY PLAN

AD SIP revisions for nonattainment areas are required by FCAA, §172(c)(9) to provide for specific measures to be implemented should a nonattainment area fail to meet reasonable further progress (RFP) requirements or attain the applicable NAAQS by the attainment date set by the EPA. These contingency measures are to be implemented without further action by the state or the EPA. In the General Preamble for implementation of the 1990 FCAA Amendments of 1990 published in the April 16, 1992, issue of the *Federal Register* (57 FR 13498), the EPA interprets the contingency requirement to mean additional emissions reductions that are sufficient to equal up to 3% of the emissions in the adjusted base year inventory. These emissions reductions should be realized in the year following the year in which the failure is identified (i.e., an RFP milestone year or attainment year).

This 1997 eight-hour ozone AD SIP revision uses the adjusted base year inventory as the inventory from which to calculate the required 3% reduction for contingency. The 3% contingency analysis for 2013 is based on a 3% reduction in NO_X, with no emissions reductions coming from VOC, to be achieved between 2012 and 2013. Emissions inventories analyses were performed on the fleet turnover effects for the federal emissions certification programs for on-road and non-road vehicles. The emissions reductions from 2012 through 2013 were estimated for those programs. A summary of the 2013 contingency analysis is provided in Table 4-3*: 2013 DFW Attainment Demonstration Contingency Demonstration (tpd)*. The analysis demonstrates that the 2013 contingency reductions exceed the 3% reduction requirement; therefore, the attainment demonstration contingency requirement is fulfilled for the DFW area.

Table 4-3: 2013 DFW Attainment Demonstration Contingency Demonstration (tpd)

Contingency Element Description	NO_X	VOC
2012 adjusted base year (ABY) emissions inventory (EI)	630.46	481.97
Percent for contingency calculation (total of 3%)	3.00	0.00
2012 to 2013 required contingency reductions (ABY EI x (contingency percent))	**18.91**	**0.00**
Control reductions to meet contingency requirements		
Excess reductions from 2012 attainment demonstration	0.00	0.00
Subtract 2012 attainment demonstration motor vehicle emissions budget safety margin from excess reductions from 2012 attainment demonstration	0.00	0.00
Federal Motor Vehicle Control Program, inspection and maintenance, reformulated gasoline (RFG), and on-road Texas Low Emission Diesel (TxLED) (Note: This list of controls is the complete list for the nine DFW nonattainment counties; however, RFG is required, and all control reductions are modeled with RFG, only in the four core counties.)	33.22	10.01
Federal non-road mobile new vehicle certification standards	7.45	5.48

Contingency Element Description	NO_X	VOC
Non-road RFG	-0.01	0.08
Non-road TxLED	0.41	0.00
Federal locomotive standards	0.53	0.05
Total attainment demonstration contingency reductions	**41.60**	**15.62**
Contingency Excess (+) or Shortfall (-)	**22.69**	**15.62**

Note: Emissions benefits calculated for contingency are based on incremental reductions from 2012 through 2013. The negative incremental benefit shown for non-road RFG is due to a smaller total benefit and is based on output from the NONROAD model.

4.10 REFERENCES

EPA, 1993. NO_X Substitution Guidance
(http://www.epa.gov/ttncaaa1/t1/memoranda/noxsubst.pdf)

EPA, 2005. Clean-Fuel Vehicle Standards, no. CCD-05-1

CHAPTER 5: WEIGHT OF EVIDENCE

5.1 INTRODUCTION

The corroborative analysis presented in this chapter demonstrates the progress that the Dallas-Fort Worth (DFW) area is making towards attainment of the 1997 eight-hour ozone National Ambient Air Quality Standard (NAAQS) of 0.08 parts per million (ppm). The United States Environmental Protection Agency's (EPA) April 2007 "Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, $PM_{2.5}$, and Regional Haze" (EPA, 2007) states that all modeled attainment demonstrations should include supplemental evidence that the conclusions derived from the basic attainment modeling are supported by other independent sources of information. This chapter details the supplemental evidence, i.e., the corroborative analyses, for this modeling demonstration.

The first section of the quantitative corroborative analysis chapter discusses photochemical grid modeling. Modeling is one of the most important tools available for evaluating progress toward meeting air quality standards. Known issues with photochemical grid modeling and how the Texas Commission on Environmental Quality (TCEQ) addresses the issues are described in the first section as well as overall model performance. Finally, the diagnostic analyses performed by the TCEQ, and the implications of those analyses on the projected attainment status are provided in this section. The second section of the quantitative corroborative analysis chapter provides information on trends in ozone and ozone precursors observed in the DFW area. The third section provides an analysis of recent research into the formation, transport, and accumulation of ozone in the DFW area. The section also examines the quantification of "background ozone." The fourth section describes air quality control measures that cannot yet be adequately quantified but are nonetheless expected to yield tangible air quality benefits. The final section details on-going initiatives that are expected to improve the scientific understanding of ozone formation in the DFW area.

5.2 CORROBORATIVE ANALYSIS: MODELING

Photochemical grid modeling of the DFW area is challenging due to the mix of local emissions sources, frequent meteorological frontal passages, the influence of transport, and the large geographic area covered by the 1997 eight-hour ozone DFW nonattainment region. One purpose of the Texas Air Quality Study 2000 (TexAQS 2000) and the Texas Air Quality Study 2006 (TexAQS II) field studies was to address the uncertainties that affect photochemical grid modeling and its regulatory application. Insights gleaned from the Texas Air Quality Studies and subsequent studies have helped resolve some of these uncertainties.

Several studies have attempted to identify and reduce uncertainties in the photochemical grid models and inputs. Foremost among these efforts are the studies that have sought to quantify underreported industrial highly reactive volatile organic compounds (HRVOC) emissions (Wert et al., 2003; Xie and Berkowitz, 2007; Yarwood et al., 2004; TCEQ, 2002, 2004, 2006; Smith and Jarvie, 2008) and to assess the sensitivities of ozone simulations to underreporting these emissions (TCEQ, 2002, 2004, 2006; Byun et al., 2007; Jiang and Fast, 2004). Other modeling efforts have tested different chemical mechanisms in the Houston-Galveston-Brazoria (HGB) area's photochemical grid modeling, to study the effects of using different mechanisms on ozone model performance and control strategy effectiveness (Byun et al., 2005b; Faraji et al., 2008; Czader et al., 2008). While HGB-focused, these modeling studies are applicable to evaluating the DFW model performance since many of the model inputs and configurations overlap. Modeling sensitivity studies have also been performed to guide selection of model parameters such as vertical mixing schemes, number and depth of model layers, and horizontal grid resolution (Kemball-Cook et al., 2005; Byun et al., 2005b; Byun et al., 2007; Bao et al., 2005).

Mesoscale meteorological modeling is used to drive photochemical grid models, and many studies have examined and reduced uncertainties in these models. One of the most successful efforts improved meteorological simulations of ozone episodes by using radar profiler and other upper level wind data to "nudge" the meteorological modeling (Nielsen-Gammon et al., 2007; Zhang et al. 2007; Stuart et al., 2007; Bao et al., 2005; Fast et al., 2006). Other efforts improved land cover data and land surface modeling (Byun et al., 2005a; Cheng et al., 2008a, 2008b), studied the sensitivity of ozone simulations to solar irradiance and photolysis rates (Zamora et al., 2005; Fast et al., 2006; Pour-Biazar et al., 2007; Byun et al., 2007; Koo et al., 2008; Environ, 2010) and investigated some of the meteorological model's physics options for modeling Texas (Environ, 2009a).

The following list includes some of the most important findings from these meteorological modeling studies.

- Assimilation of radar profiler and other upper air wind data is essential to good meteorological modeling performance.
- Modeling parameterizations need to be chosen carefully to alleviate the common problem of spurious thunderstorms and clouds.
- Accurate simulation of cloud cover is crucial to getting photolysis rates correct in the photochemical grid model, and ozone predictions are very sensitive to photolysis rates.
- An ensemble approach to meteorological and photochemical grid modeling, many iterations with slightly different configurations, may be warranted, given the sensitivity of ozone modeling to relatively small changes in meteorology. While an ensemble approach would allow probabilistic attainment demonstrations to be produced, the current modeling guidance and regulatory framework make implementing this approach problematic.

In the remainder of this section, modeling issues identified by the studies described above are discussed, as well as issues raised by TCEQ-sponsored investigations and other research. Overall performance of the photochemical grid modeling and the implications of the model's ability to accurately simulate ozone episodes are also discussed.

5.2.1 Solving Modeling Problems

The photochemical modeling system is not a perfect tool and has inherent uncertainty (EPA, 2007). Through model performance evaluation, several aspects of ozone modeling shortcomings for the DFW area have been identified. This section discusses some of these issues, and how the TCEQ has attempted to resolve them in this round of modeling.

5.2.1.1 Resolution of Photochemical Modeling Grids

Numerous studies have investigated the effects of grid size on model behavior (Cohan et al., 2006; Esler, 2003; Gego et al., 2005; Valari and Menut, 2008). The main interest in finer grid resolution is that higher resolution can increase concentrations of ozone precursors in narrow plumes, which can affect ozone production rate and sensitivity to volatile organic compounds (VOC) or nitrogen oxides (NO_X) within the plumes. In a city such as Houston, using a higher resolution grid is warranted, given the abundance of industrial point sources, which can generate narrow plumes and concentrations of pollution with a larger grid cell. Researchers during TexAQS 2000 determined that rapid ozone formation occurring within narrow industrial plumes are responsible for the highest observed ozone in the HGB area and for the strong ozone gradients that can form. The DFW area lacks the industrial point source concentration of Houston, and especially sources of HRVOC. The majority of DFW area emissions forming ozone are from mobile, non-road, and area sources that don't appear to form strong ozone gradients where a very fine modeling resolution may be needed to accurately replicate ozone. The TCEQ modeled the DFW area at a finer resolution (4 km) than the modeling guidance suggests (12 km) for urban areas.

In general, the TCEQ has found that modeling with smaller grid sizes can create higher ozone production and can alleviate, in part, the commonly observed low bias for ozone. There are limits to this solution, however; it is inappropriate to decrease grid size indefinitely. Parameterizations in both the meteorological modeling and the photochemical grid modeling are based upon the assumption that turbulence features within the planetary boundary layer (PBL) are much smaller than the grid size. If the grid size is decreased to 1 km by 1 km or lower, the assumption likely no longer holds, and more uncertainty could be added to the modeling as a result of the finer resolution.

Also, where the spatial resolution of the photochemical grid modeling is reduced, the temporal resolution of the meteorological and chemical processes within the model should be reduced, to match the shorter residence time of precursors in each grid cell. In other words, as the size of the box shrinks, the amount of time that a mass of air resides in the box also shrinks, affecting how the ozone chemistry plays out. While the Comprehensive Air Model with Extensions (CAMx) automatically adjusts the time step for chemical processes, the meteorological process time step is fixed, based upon the input data from the Fifth Generation Meteorological Model (MM5). Although extraction of meteorological output with higher temporal resolution may be possible, reduction of the time steps seems likely to cause unusual model behavior. Further, the reduction of time steps in regulatory photochemical grid modeling has not been well studied. In the future, evaluation of and potential use of smaller grid sizes and shorter time steps may be considered. For this round of modeling, the TCEQ has kept the size of the CAMx and MM5 modeling grid cells at 4 km and the temporal resolution, which meets and exceeds the modeling guidance requirements.

5.2.1.2 Incommensurability and Model Performance Evaluation

Swall and Foley (2009) discuss the problems inherent in comparing point measurements to grid cell values. In statistical parlance, this problem is known as incommensurability. A portion of the difference between point measurements and grid cell values is due solely to the fact that measurements made at a monitoring station do not generally represent an average of the conditions for the 4 km by 4 km grid cell in which it resides. The ability of a point measurement to represent the average of the entire grid cell area is related to how much sub-grid variation is observed in the area. If sub-grid variation is small, then the point measurement and the grid cell value are commensurate. If the spatial gradients of the variables of interest are large, the point measurements are less able to reflect the average conditions of the entire grid cell, and therefore they are incommensurate with the grid cell value.

While the DFW area lacks the industrial point sources (especially of HRVOC) for rapid ozone formation like the HGB area, ozone plumes do occur and are difficult to simulate. Swall and Foley demonstrated that incommensurability alone is capable of degrading model performance in areas of steep gradients. Swall and Foley state in their discussion, “This means that, even if the model is performing perfectly and there is no observational error, we cannot expect that in a scatterplot, points representing paired modeled and observed values will lie on a one-to-one line. Our comparison of Gaussian and exponential correlation structures with the same effective range shows that this concern looms larger for correlation structures in which there is a rapid decrease in correlation for small distances relative to grid cell size (like the exponential).” While there are other causes of poor model performance as well, incommensurability is likely to be responsible for some of the differences between model output and point measurements.

5.2.1.3 Ensemble Modeling

A number of researchers have discussed the benefits of using ensembles of models to create more accurate forecasts (Pinder et al., 2009; Zhang et al., 2007). Pinder et al. and Zhang et al. have noted that probabilistic attainment demonstrations could be made using ensemble modeling and have argued that this approach can be more scientifically sound than a deterministic attainment demonstration. The TCEQ acknowledges the potential soundness of the ensemble approach but notes that the current regulatory framework does not easily allow for a probabilistic attainment demonstration. With approval from the EPA Region VI, this type of modeling would best fit as corroborative analysis or weight of evidence according to current guidance (the EPA, 2007).

5.2.1.4 Vertical Distribution of Ozone

To improve the modeled vertical mixing, the TCEQ has implemented the results of recent projects and studies. In order to simulate free tropospheric ozone the TCEQ has obtained global model output of ozone for the appropriate time periods to use as boundary conditions (Environ, 2009b). Where discrepancies still persist, they appear to be related to phenomena that occur between the outermost domain boundaries and the DFW area.

To represent vertical mixing in the meteorological modeling, the TCEQ has improved the land cover data and sea surface temperature data in its latest round of modeling, in an attempt to improve the simulations of surface energy balance. The TCEQ has chosen the Eta PBL scheme (i.e., the Mellor-Yamada-Janjic scheme), which appears to be more effective at simulating PBL dynamics in the DFW area than other available schemes (Zhong et al., 2007). In addition, the TCEQ used the KVPATCH program to modify the vertical diffusivity coefficients on a land-use basis to limit the maximum within the first 200 meters of the model (Environ, 2010).

5.2.1.5 Photolysis Discrepancies Due to Improper Placement of Clouds

Researchers at the University of Alabama-Huntsville examined the effects of modeled cloud cover on ozone performance in the HGB area and found that some of the shortcomings in model performance could be corrected with better depiction of clouds (Pour-Biazar et al., 2007). University of Houston researchers also found that their forecasts were occasionally biased due to poor depiction of cloud cover (Byun et al., 2007). TCEQ-funded research found that higher-order decoupled direct method analysis of modeling sensitivities indicated substantial sensitivity to photolysis rates (Koo et al., 2008). TCEQ-funded research also found that the photochemical model's surface ozone prediction was more responsive to the placement of sub-grid clouds (simulated clouds smaller than the model grid scale, e.g., 4 km) than how photolysis rates were applied (Environ, 2010).

The TCEQ has found similar cloud cover effects in the photochemical modeling for this state implementation plan (SIP) revision and other modeling efforts. The greatest discrepancies tend to involve the model under-predicting cloud cover, and hence, greatly over-predicting ozone on low ozone days. Modeled episode days for which cloud cover problems exist include June 16, 19, 21, 22, 28, and July 1 through 2, 2006. The average mean normalized bias for these days is +16.9%, compared to an average mean normalized bias on exceedance days of -3.4%. TCEQ process analysis shows that most of the radical initiation, propagation, and termination steps are very sensitive to photolysis rates. Hence, improvements in cloud placement could greatly improve ozone and precursor performance, though the greatest improvements will likely occur on low ozone days.

5.2.1.6 Radical Shortage

A number of researchers studying urban photochemistry in Texas and other areas have found that available mechanisms for simulating radical production are unable to replicate the observed radical formation and propagation rates (Mao et al., 2007, 2009; Chen et al., 2009). The process analysis section of Appendix I: *Corroborative Analysis for the HGB Attainment Demonstration SIP Revision for the 1997 Eight-Hour Ozone Standard* of the 2010 Houston-Galveston-Brazoria Attainment Demonstration State Implementation Plan Revision for the 1997 Eight-Hour Ozone Standard (TCEQ, 2010) discusses this issue in detail and compares TCEQ process analyses to the Mao et al. and Chen et al. work. The TCEQ modeling is consistent with the Mao et al. and Chen et al. findings that the current mechanisms are missing something. The atmospheric chemistry community as a whole has not yet resolved the problem or problems with the current mechanisms. Several hypotheses for the missing radical formation mechanism exist, including daytime nitrous acid (HONO) production from nitric acid-aerosol interactions and photolysis (Ziemba et al., 2009); isoprene production of hydroxyl radical (OH) (Lelieveld et al., 2008; North and Ghosh, 2009); formation and decomposition of electronically excited nitrogen dioxide (NO_2) (Li et al., 2008); nitryl chloride ($ClNO_2$) chemistry (Osthoff et al., 2008; Simon et al., 2008); improved aromatic chemistry (Faraji et al., 2008; Hu et al., 2007); and molecular chlorine reactions (Chang et al., 2002; Tanaka et al., 2003; Chang and Allen, 2006; Sarwar and Bhave, 2007). Given the hypotheses and the current lack of a definitive explanation, the TCEQ has not incorporated modified chemical mechanisms into its modeling at this time. However, the TCEQ continues to support investigations for improving chemical mechanisms and is prepared to adopt an improved mechanism when it becomes sufficiently mature.

5.2.2 Model Performance Evaluations: Implications of the Model Performance of the Current SIP Modeling

Model performance evaluations are presented in Chapter 3: *Photochemical Modeling* and in its associated appendices. Based upon these evaluations, the TCEQ makes the following conclusions.

5.2.2.1 Ozone Performance

- The model simulates the location, spatial extent, and relative intensity of ozone relatively well on most of the high-ozone days.
- The model consistently underestimates peak ozone within the highest concentration plumes.
- Process analysis and modeling sensitivity analyses show that peak eight-hour ozone is primarily NO_X-sensitive in much of the domain and on most eight-hour ozone exceedance days.
- According to TCEQ process analyses, VOC-sensitive conditions occur in the urban core and generally during rush hour when NO_X concentrations peak. On all DFW episode days studied, NO_X-sensitive ozone formation was two to five times greater than VOC-sensitive ozone formation.
- Decreases in ozone production rates and other reaction rates correlate with decreases in NO_2 photolysis, implying that most of the ozone formation chemistry is highly sensitive to photolysis, and hence, highly sensitive to cloud-cover errors.
- Based on the Anthropogenic Precursor Culpability Assessment (APCA) source apportionment analyses, background ozone concentrations are important in accurately modeling the DFW area due to the prevalence of contributions from areas outside the DFW nine-county area.

- In rural areas, the model routinely over-predicts nighttime ozone and under-predicts NO_X. The cause of this issue is unknown, but it could involve unreported, underreported, or underestimated NO_X emissions or problems with vertical mixing in rural areas.
- The lack of ozonesonde, aircraft, and other upper air data in the DFW area limits the performance evaluation of the model above the surface layer.

5.2.2.2 Ozone Precursor Performance

- The modeling simulated ozone precursors relatively well, albeit with a large degree of scatter, and the peak concentrations for some species were underestimated.
- The diurnal patterns of NO_X and NO_2 concentrations were well simulated, though the peak concentrations were often under predicted. Nitric oxide (NO) was often underestimated for the peak concentrations, which were usually observed in the pre-dawn hours, i.e., during morning rush hour.
- The highly reactive Carbon Bond 05 species ETH and OLE, which represent ethylene, propylene, and other alkenes, were well simulated at Dallas Hinton (C401) and Fort Worth Northwest (C13) but the concentrations were generally less than 1 parts per billion (ppb).
- The performance of isoprene, represented by the Carbon Bond 05 species ISOP, was mixed, though concentrations were less than 1 ppb. The model showed a high bias at Fort Worth Northwest (C13) and a low bias at Dallas Hinton (C401).
- The model showed a high bias for the paraffins, represented by the Carbon Bond 05 specie PAR at both automated gas chromatograph (auto-GC) sites.
- Formaldehyde data measurements were not available, nor did instrumented aircraft sample in the DFW area during June 2006 as part of TexAQS II.
- In 2006, only two auto-GCs (Dallas Hinton (C401) and Fort Worth Northwest (C13)) were in operation, which limited the performance evaluation of ozone precursors, especially in the areas of highest observed ozone. The addition of auto-GCs at Eagle Mountain Lake (C75), DISH, Decatur, and Flower Mound in 2010 will aid in the understanding of ozone formation and future model performance evaluations in the DFW area (TCEQ, 2011).

5.2.2.3 Meteorological Performance Evaluation

- The meteorological modeling successfully replicated the major features of ozone episodes in the DFW area much of the time, including the passages of fronts.
- Trajectory analyses and vertical wind profiles in the DFW area show that much of the time on high ozone days, the model predicted ozone and precursors at approximately the correct areas and the correct times.
- The model occasionally had difficulty in replicating cloud cover, resulting in high ozone on days when low ozone was observed or vice versa.
- Episode days with strong stagnation were more difficult to model precisely than days for which the winds did not stagnate. The model sometimes simulated nighttime winds that were too brisk, resulting in more dilution of emissions than was actually observed.
- Radar profiler data indicate that for most episode days, the PBL appeared to be modeled with good accuracy.

5.2.2.4 Model Response to Emission Changes

- The base case modeling has been challenged with different emissions inventories in order to evaluate its dynamic response to emission changes (Gilliland et al., 2009).

- Modeled ozone appears to decrease slightly in response to NO_X emission decreases typical of the changes that occur on weekends.
- Modeled ozone increases substantially in response to VOC and NO_X emission increases commensurate with the difference between 2006 emissions and 1999 emissions in the DFW area. When relative response factors are calculated using 2006 as the baseline year and 1999 as the future year, the modeled response to emission reductions is similar to the observed response for most monitors. However, at three monitors the model responded more to the 2006 to 1999 emission changes than what was observed at those monitors. This finding implies that the current modeling appears to estimate the response to emission controls well. If the atmosphere responds to the emission reductions from 2006 to 2012 in a manner similar to its response to the emission reductions between 1999 and 2006, the actual decrease in ozone design value will be similar to what the model predicts.

5.2.2.5 Ozone Formation Sensitivity

- DFW area peak ozone is strongly affected by regional background ozone concentrations.
- Local ozone production in the DFW area can be substantial. The contribution of local ozone production to peak ozone concentration depends strongly upon wind speed and transport conditions.
- In the DFW area, ozone production occurs in NO_X-sensitive conditions over most of the area. NO_X-limited ozone formation appears to contribute more to peak area-wide ozone than VOC-limited ozone formation. Both VOC-sensitive and NO_X-sensitive ozone formation occur throughout the DFW area each day, with VOC-sensitive formation occurring in the morning and NO_X-sensitive formation occurring in the afternoon.
- VOC-sensitive ozone formation is most notable in the urban core and in the vicinity of power plants where large quantities of NO_X are emitted.
- Although DFW total ozone production is similar in magnitude to HGB total ozone production, ozone formation in the DFW area is sensitive to a different group of precursor emissions. In HGB, ozone formation occurs primarily in the VOC-sensitive regime downwind of the industrial areas and urban core but occurs in the NO_X-sensitive regime in much of the domain. In the DFW area, NO_X-limited ozone formation appears to contribute more to peak area-wide ozone than VOC-limited ozone formation.

5.2.3 Additional Modeling Analysis to Measure Progress

Table 5-1: *Changes in the Area and Population Affected by an Eight-Hour Ozone Design Value Greater than or Equal to 85 ppb in Response to Growth and Controls* shows how the area affected by high ozone is expected to shrink dramatically in response to the emission changes projected to occur between 2006 and 2012. Peak ozone drops by 17% and the area with an estimated ozone design value greater than the 84 ppb standard is eliminated completely. Thus, the 2012 population living in the DFW nine-county area is projected to be residing in attainment of the 1997 eight-hour ozone standard, benefiting the residents of the DFW area.

Table 5-1: Changes in the Area and Population Affected by an Eight-Hour Ozone Design Value Greater than or Equal to 85 ppb in Response to Growth and Controls

Run name	Eight-Hour Peak Ozone (ppb)	Area with design value > 84 ppb, km^2	2010 population in area with design value > 84 ppb
2006 baseline (reg2 MVS)	98	2632	4320739
2012 future year (cs03a MVS)	81	0	0

Run name	Eight-Hour Peak Ozone (ppb)	Area with design value > 84 ppb, km^2	2010 population in area with design value > 84 ppb
Percentage decrease from 2006 to 2012	17%	100%	100%

5.2.4 Conclusion

The photochemical grid model performed by the TCEQ for the *Dallas-Fort Worth Attainment Demonstration for the 1997 Eight-Hour Ozone Nonattainment Area* has been rigorously evaluated against observational data. While there are a number of shortcomings that this modeling has in common with other modeling exercises as discussed in Section 5.2.1: *Solving Modeling Problems* and Section 5.2.2: *Model Performance Evaluations: Implications of the Model Performance of the Current SIP Modeling*, modeling for many of the simulated ozone days appears to behave in a manner consistent with most of the atmospheric phenomena of interest.

5.3 AIR QUALITY TRENDS IN THE DFW AREA

Despite a continuous increase in the population of the nine-county area and other factors such as vehicle miles traveled, the area is exhibiting decreasing trends for ozone and its precursors, NO_X and VOC. The eight-hour ozone design values appear to show decreasing trends over the past 20 years. The eight-hour design value in 2010 is 18% lower than the eight-hour ozone design value in 1991, a percentage decrease that nearly equals the one-hour ozone design value decrease. In 2010, the peak one-hour ozone design value was 110 ppb, while the peak eight-hour ozone design value was 86 ppb, which occurred on the northwest side of the DFW area. The number of eight-hour ozone exceedance days over the past 20 years has also decreased significantly, from 26 days in 1991 to 8 days in 2010. Over the same time period the number of ozone monitors in the DFW area more than doubled.

Preliminary analysis suggests that NO_X measured at monitors in the Barnett Shale is well below what is measured in the urban DFW area. This analysis also suggests that the higher NO_X percentile concentrations are observed when the winds are from the DFW region. Caution should be taken when interpreting these results due to the limited amount of data collected to date. The NO_X monitors at Parker County (C76) and Eagle Mountain Lake (C75) have only been operating since March 2010.

5.3.1 Design Values

Trends in ozone and its precursors demonstrate not only the substantial progress the DFW area has made in improving air quality but also the magnitude of the future challenge in attaining the NAAQS for ozone. Trends are also useful as a first look at how ozone concentrations are related to precursor concentrations. Ozone is a secondary pollutant, formed through a photochemical reaction of NO_X and sunlight. VOC can amplify ozone production, causing accumulation in the atmosphere. Decreases in NO_X and VOC demonstrate the effectiveness of regulations and programs to reduce emissions; however, due to its dependence on meteorological variables, ozone may not always exhibit trends identical to its precursors. Separating variations in meteorological factors from trends in ozone and its precursors can highlight whether ozone reductions are caused by decreases in precursor emissions or by year-to-year variability in local meteorology (Sullivan, et al, 2009, Camalier, et al, 2007). This section discusses trends, both temporal and spatial, in ozone and its precursors.

A design value is a statistic used to compare an area's concentrations of a particular pollutant to the pollutant's NAAQS. Design values are commonly used to characterize ambient ozone concentrations because they summarize the severity of a local ozone problem into a single value. The criteria for attainment of the ozone NAAQS have changed over the past 12 years. Until its revocation on April 30, 2004, the ozone NAAQS was 0.12 ppm, averaged over a one-hour period (U.S. EPA, 2004). An exceedance occurred when the fourth highest one-hour ozone concentration in a three-year period equaled or exceeded 0.125 ppm. The eight-hour NAAQS for ozone, set at 0.08 ppm averaged over eight hours, was adopted in 1997 but not implemented until 2004. A monitor exceeds the eight-hour standard when its design value, a three-year average of the fourth highest eight-hour ozone concentration for each year, equals or exceeds 0.08 ppm. The design value of record for an area is the highest design value recorded at any monitor in the area.

This section examines the frequency at which the NAAQS (both one-hour and eight-hour) for ozone are exceeded, with the understanding that the eight-hour standard of 0.08 ppm is currently being used for control strategy development and that the one-hour standard is no longer in effect. However, it is still a useful benchmark for understanding ozone behavior in the DFW area. While the ozone NAAQS is expressed in units of ppm, this section will use the familiar convention of expressing concentrations in ppb. Following EPA attainment convention, the eight-hour ozone NAAQS is often expressed as 85 ppb.

Daily peak eight-hour ozone concentrations for the years 1991 through 2010 in the DFW area are shown in Figure 5-1: *Daily Peak Eight-Hour Ozone Values in the DFW Area*. The majority of days show ozone peaks below 85 ppb, but the highest days, which set the design values, are of particular interest. Annual maximum values and 90th percentile values have decreased over time; however, the median values appear to show no change or a very slight increase. Notable in the figure is the decrease in the number of daily peaks exceeding 84 ppb. The bi-modal character of the annual ozone cycle is identifiable in several years. On an annual basis, ozone tends to peak first in spring and then again in the summer (Nobis, 1998).

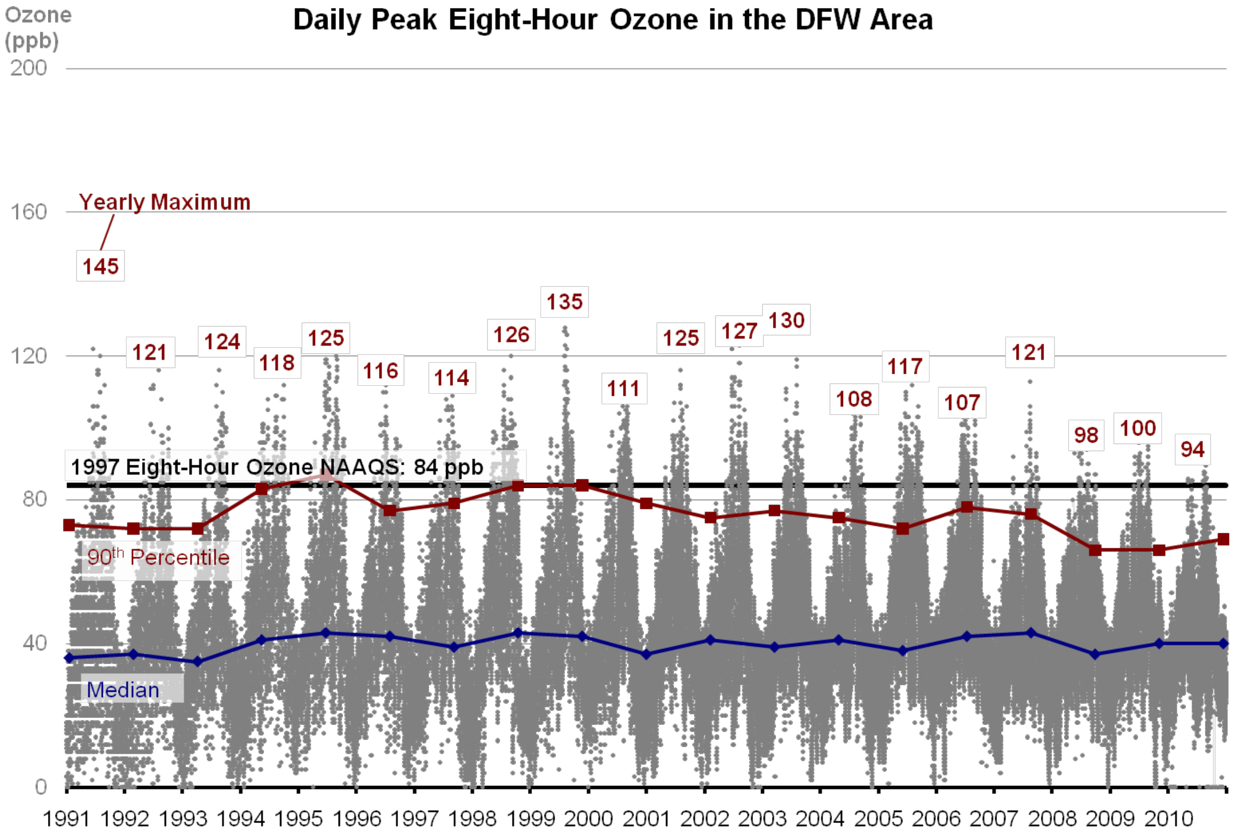

Figure 5-1: Daily Peak Eight-Hour Ozone Values in the DFW Area

The annual cycle of ozone is apparent in Figure 5-1, as daily peak ozone tends to increase throughout the spring, into the summer, and then falls as winter approaches, when it reaches a nadir. This cycle follows the annual pattern of temperature, which also rises as summer approaches, peaks, then falls in winter. Temperature is likely acting as a proxy for solar radiation or other meteorological factors known to strongly influence ozone formation.

The trend in design values is seen more clearly in Figure 5-2: *Ozone Design Values for the DFW Area*. While the DFW area continues to exceed the 1997 eight-hour ozone standard, the eight-hour ozone design value in 2010 was 86 ppb, an 18% decrease from the 1991 design value of 105 ppb. The 2010 value approached the 1997 eight-hour ozone NAAQS of 85 ppb. A regression of design values on year estimates that eight-hour ozone design values decreased at the rate of about 0.66 ppb (0.00066 ppm) per year, which is statistically significant at the 5% level (α = 0.05). If this trend were to continue at that rate, attainment of the eight-hour standard should be reached by 2012.

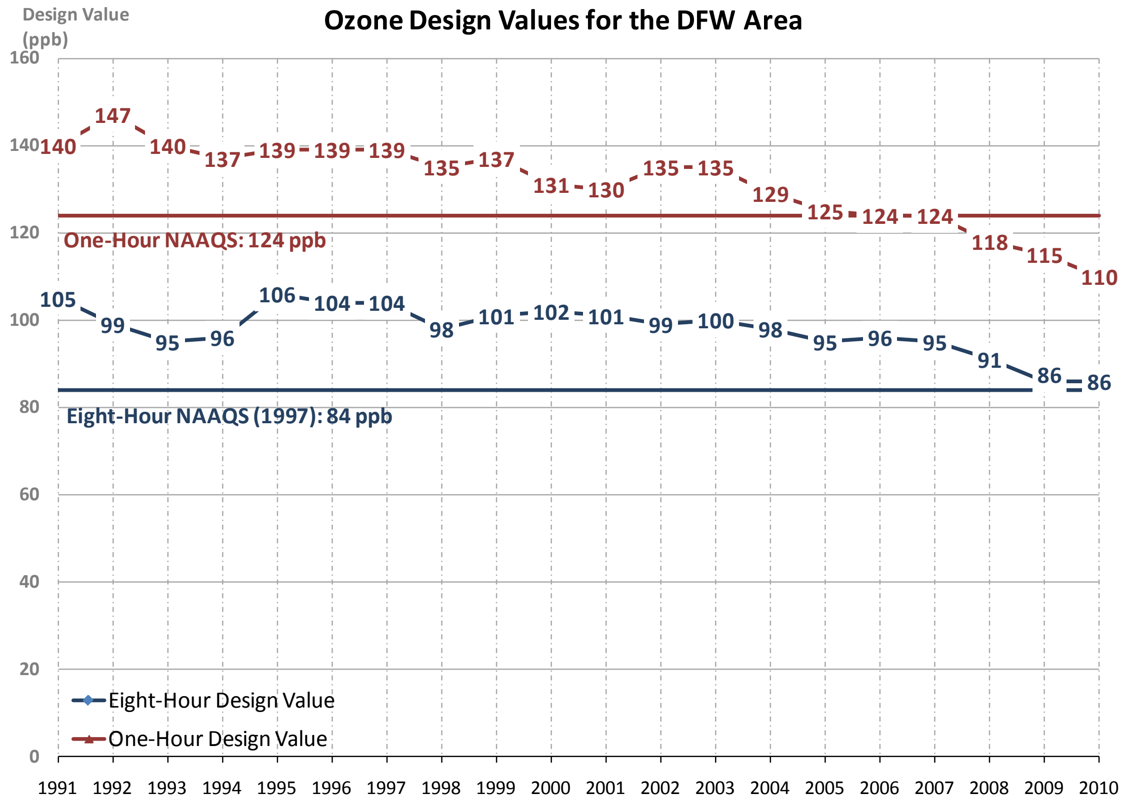

Figure 5-2: Ozone Design Values for the DFW Area

The DFW area one-hour ozone design value in 2010 was 110 ppb, a 21% decrease from the 1991 design value of 140 ppb. The one-hour design value in the DFW area has met the one-hour ozone NAAQS of 124 ppb since 2006. Regression of one-hour design values on year shows a decrease at the rate of 1.49 ppb per year, which is faster than the rate of decline of the eight-hour ozone design value; the slope is also statistically significant at the 5% level ($\alpha = 0.05$).

The design value of record in a metropolitan area is the highest design value of all individual design values at monitors in an area. Because ozone varies spatially, trends at all monitors in an area should be investigated, not just those recording the highest design values. Table 5-2: *Eight-Hour Ozone Design Values by Monitor in the DFW Area* and Table 5-3: *One-Hour Ozone Design Values by Monitor in the DFW Area* contain the eight-hour and one-hour ozone design values at all regulatory monitors in the DFW area from 1991 to 2010.

Table 5-2: Eight-Hour Ozone Design Values by Monitor in the DFW Area

Monitor/CAMS #	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Keller C17	105	99	95	96	106	104	97	92	95	97	97	98	100	98	95	94	92	87	86	86
Eagle Mountain Lake C75												95	96	94	95	96	95	89	86	85
Grapevine Fairway C70												95	100	98	93	93	92	87	84	82
Denton Airport South C56										102	101	99	97	96	93	95	94	91	85	80
Cleburne Airport C77												89	90	90	89	87	85	83	83	80
Ft. Worth Northwest C13	97	94	94	88	92	94	96	97	99	99	97	96	96	94	95	94	91	83	79	79
Arlington Municipal Airport C61														87	87	87	84	79	77	79

Monitor/CAMS #	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Dallas North No.2 C63											93	89	86	87	90	89	86	80	81	78
Dallas Redbird Airport C402							91	91	92	88	84	84	85	87	88	88	85	82	78	78
Pilot Point C1032																		81	77	78
Frisco C31				92	99	99	101	98	101	101	99	93	88	89	91	92	88	83	79	76
Parker County C76												86	89	86	87	88	91	84	81	75
Granbury C73												84	84	81	81	84	84	81	77	75
Rockwall Heath C69												83	81	82	81	80	78	75	75	74
Midlothian Old Fort Worth(OFW) C52/C137																		75	73	72
Italy C1044																				68
Kaufman C71												70	73	73	73	75	76	73	70	67
Greenville C1006															79	79	76	70	66	64
Dallas Hinton St. C401/C60							90	88	91	93	92	91	90	89	90	87	84	74		
Midlothian Tower C94/C158								87	92	97	88	86	82	87	84	83	78			
Sunnyvale Long Creek C74													83	83	84	73				
Anna C68												83	80	80						
Arlington Reg. Office C57										95	86									
Denton Colony	83	78	79	93	101	99	99	94	100											
Dallas North C5	92	90	88	90	97	97	95	89												
Denton Co. Airport C33					100	103	104													
Bonnieview	71	66	67	68																

*Values are sorted in descending order of design values in 2010, then 2009, 2008, etc.

Table 5-3: One-Hour Ozone Design Values by Monitor in the DFW Area

Monitor/CAMS #	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Eagle Mountain Lake C75										112	117	135	135	129	125	124	124	115	111	110
Keller C17	140	147	140	137	139	139	131	128	128	128	128	128	128	126	117	115	117	111	108	107
Dallas Redbird Airport C402					116	118	134	135	125	118	111	103	112	121	121	111	110	109	105	106
Ft. Worth Northwest C13	130	140	140	121	121	126	133	127	133	131	130	126	126	123	123	117	118	109	102	106
Dallas North No.2 C63									129	128	128	118	113	118	120	117	116	101	105	105
Grapevine Fairway C70										98	118	128	128	125	113	112	111	107	108	104
Denton Airport South C56								122	126	126	126	128	122	118	117	118	118	118	115	102
Frisco C31		140	140	126	129	126	132	128	133	130	130	119	113	113	113	113	111	110	102	102
Parker County C76										94	99	111	113	112	116	116	116	106	103	99
Arlington Municipal Airport C61												122	120	120	117	113	113	101	100	97
Pilot Point C1032																107	104	101	94	97
Cleburne Airport C77										108	109	110	110	118	108	106	105	105	104	96
Granbury C73/C681										99	109	108	107	101	104	104	104	98	98	94
Dallas Hinton St. C401/C60	120	120	121	113	121	121	121	120	128	127	125	118	125	118	115	114	114	97	87	89
Midlothian OFW C52/C137																98	103	98	95	88
Rockwall Heath C69										117	102	102	98	108	101	96	93	92	92	86
Corsicana Airport C1051																				86
Kaufman C71										81	88	89	90	91	93	87	89	87	87	84
Italy C1044/A323																		86	86	84

Monitor/CAMS #	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Greenville C1006													93	93	92	92	90	88	79	74
Midlothian Tower C94/C158								130	128	128	117	116	106	116	114	114	104			
Sunnyvale Long Creek C74											89	104	107	107	111	107				
Anna C68										105	105	108	105	103						
Arlington Reg. Office C57								125	137	126	125									
Denton Colony	130	120	120	120	135	127	129	118	128											
Dallas North C5	130	130	122	122	134	134	134	116												
Denton Co. Airport C33			117	137	138	139	139													
Bonnieview	100	100	93	89																
Denton C80		141																		
Terrell C83	110																			
Ennis C82	100																			
Number of Monitors	8	8	8	8	8	8	8	10	10	17	18	18	19	19	18	20	19	19	19	20

*Values are sorted in descending order of design values in 2010, then 2009, 2008, etc.

Table 5-4: *Annual Fourth Highest Eight-Hour Ozone Values and Design Values* (ppb) and Figure 5-4: *One-Hour Ozone Design Value Statistics in the DFW Area* display three summary statistics for the eight-hour and one-hour ozone design values, respectively: the maximum, median, and minimum values computed across all monitors in the DFW area. These figures facilitate assessment of the range of design values observed within a year, as well as how these distributions change over time. From the figures, neither eight-hour, nor one-hour ozone design values exhibited a noticeable trend until about 2000, when both began falling steadily. By 2002, over half the monitors in the area attained the one-hour standard and by 2007, over half of the monitors attained the eight-hour standard, as indicated by the median value falling below the NAAQS in those years. (The median statistic as used here indicates that half the observed design values are above the median, and half below it.) Since 2006, all monitors in the DFW area met the one-hour ozone NAAQS.

The Keller (C17) monitor currently sets the eight-hour design value of record for the DFW area. The 2010 design value, 86 ppb, is calculated (as with all monitors) by averaging the 2008 through 2010 fourth highest concentrations and truncating any decimal. At Keller (C17), these values were 85, 90, and 85 ppb. The only other monitor above the 1997 eight-hour ozone NAAQS is Eagle Mountain Lake (C75) and that monitor would need a fourth-highest eight-hour ozone concentration of 84 ppb or greater in 2011 to violate the NAAQS. The preliminary ozone design value ozone for 2011 is 90 parts per billion (ppb), although 2011 data have not been finalized.

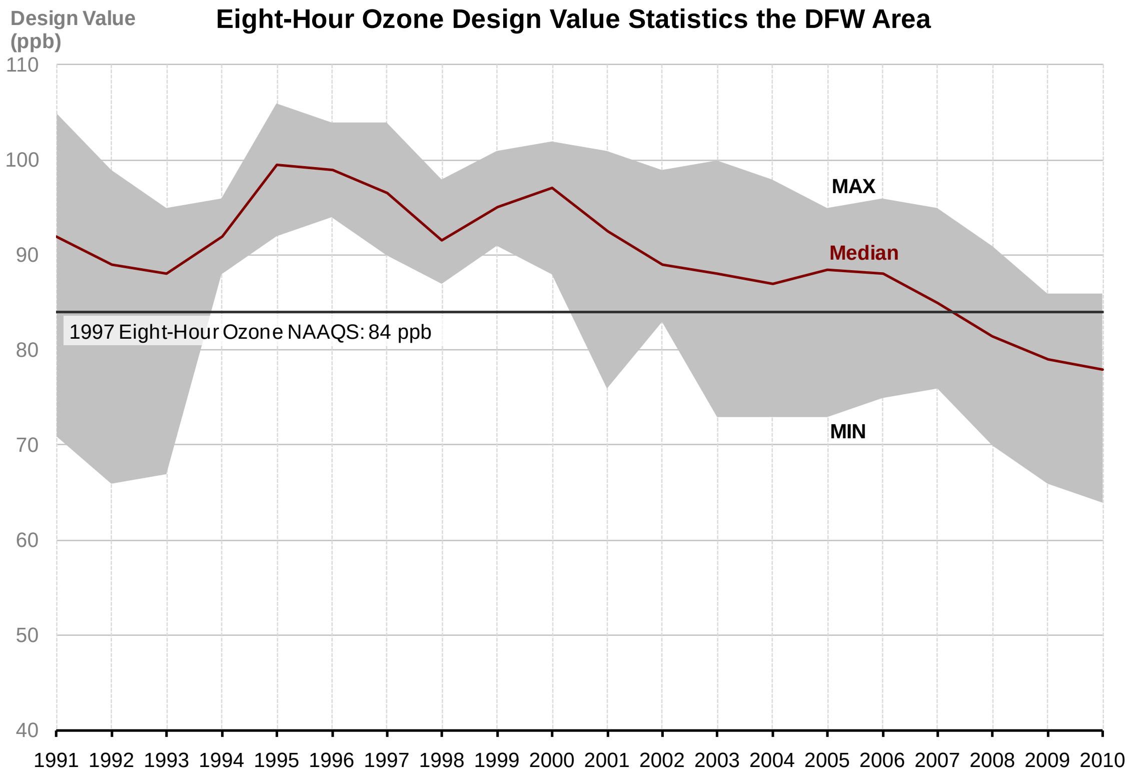

Figure 5-3: Eight-Hour Ozone Design Value Statistics in the DFW Area

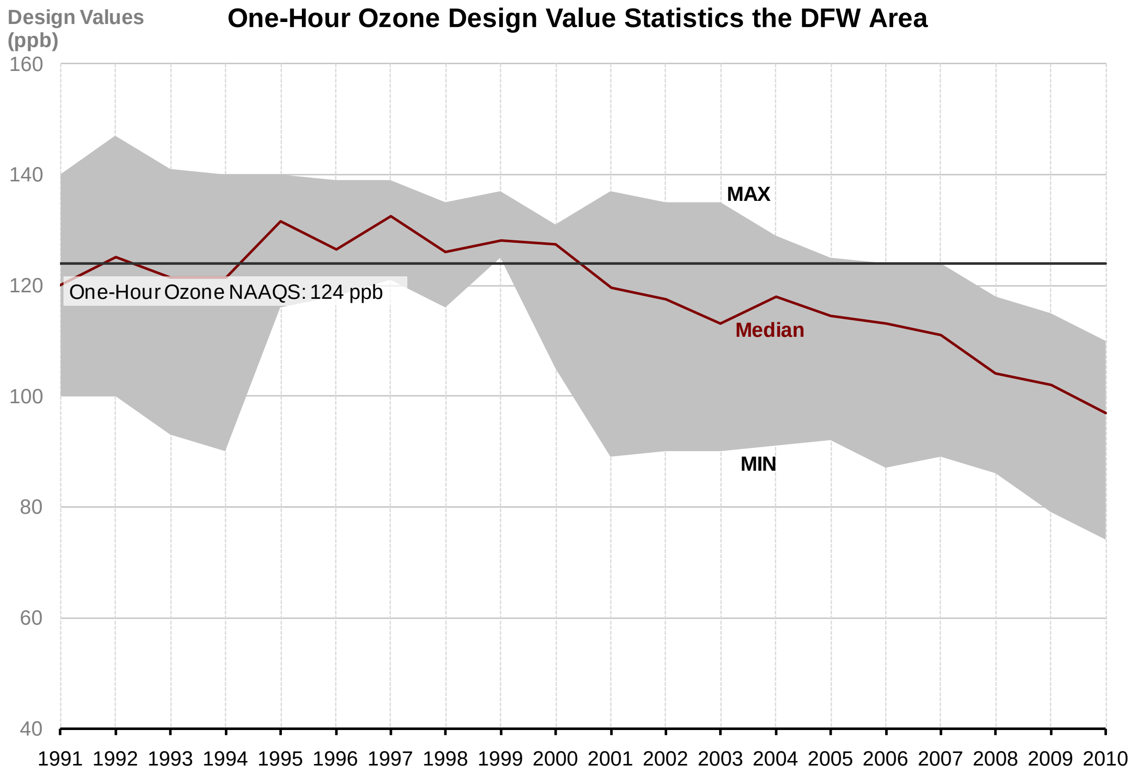

Figure 5-4: One-Hour Ozone Design Value Statistics in the DFW Area

Table 5-4: Annual Fourth Highest Eight-Hour Ozone Values and Design Values (ppb)

Monitor	2008	2009	2010	2010 Eight-Hour Ozone Design Value	2011 Fourth-Highest Needed to Violate the NAAQS
Keller C17	85	90	85	86	80
Eagle Mountain Lake C75	85	91	80	85	84
Grapevine Fairway C70	77	86	83	82	86

* Monitors are sorted in descending order by 2010 design value. The 2010 design value is the average of the 2008 through 2010 fourth high values.

Ozone trends can also be investigated by examining the number of days an exceedance of the ozone NAAQS was recorded, termed an “exceedance” day. An exceedance day for the 1997 eight-hour ozone NAAQS is any day that any monitor in the area measured an eight-hour average ozone concentration greater than or equal to 85 ppb over any eight-hour period. An exceedance day for one-hour ozone is any day that any monitor in the area measures a one-hour average ozone concentration greater than or equal to 125 ppb for at least one hour. Previous research (Savanich, 2006) by the TCEQ has shown that, until 2006, the number of exceedance days was positively correlated with the number of monitors in a particular area. That is, as the number of monitors increases, so does the number of exceedance days recorded, at least until either the area has been saturated with monitors, so that no previously unobserved exceedances are detected or until ozone concentrations truly decrease. Because of this correlation, when examining exceedance-day trends, the number of monitors must always be considered. Thus, it is especially noteworthy that Figure 5-5: *Number of Monitors and Ozone Exceedance Days in the DFW Area* shows that despite an increase in the number of monitors, the number of exceedance days for both one-hour and eight-hour ozone has generally decreased. The decrease is especially pronounced for eight-hour ozone over the past four years. Since 1991, the number of eight-hour ozone exceedance days occurring in the DFW area has fallen 69%. No one-hour ozone exceedance days occurred in the DFW area in 2008, 2009, or 2010; this represents a 100% decrease in the number of one-hour ozone exceedance days from 1991 to the present.

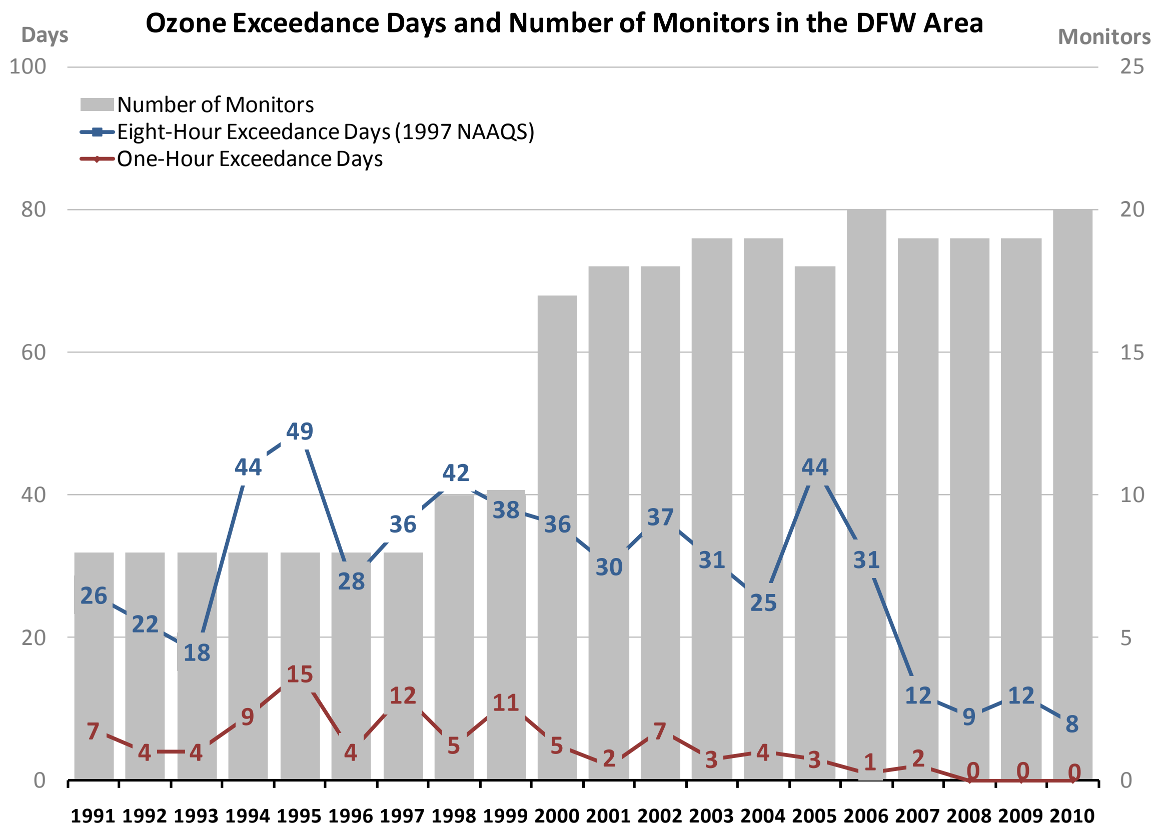

Figure 5-5: Number of Monitors and Ozone Exceedance Days in the DFW Area

An interesting result that follows from evaluation of exceedance days and the number of monitors is exhibited in Figure 5-6: *Eight-Hour Ozone Exceedance Days per Monitor in the DFW Area*. This figure illustrates that accounting for the changing population of monitors in the DFW area actually accentuates the decline in number of exceedance days. Whereas in 1991, the DFW area observed about 3.3 exceedance days on average at each monitor, by 2010, with a much larger monitoring network operating, the DFW area observed only 0.4 exceedance days on average at each monitor for a decline of 88%. The drop to 2010 from the 1995 high of the twenty year series, 6.3 exceedance days per monitor, is 94%. In the absence of real reductions in ozone in the area, an increase in the number of monitors would be expected to increase the number of exceedance days observed where some high ozone events missed by a smaller network would be detected with a larger one. This result suggests that the likelihood of high ozone events escaping detection is diminishing because the network is enlarging at the same time that the number of actual high ozone events is decreasing.

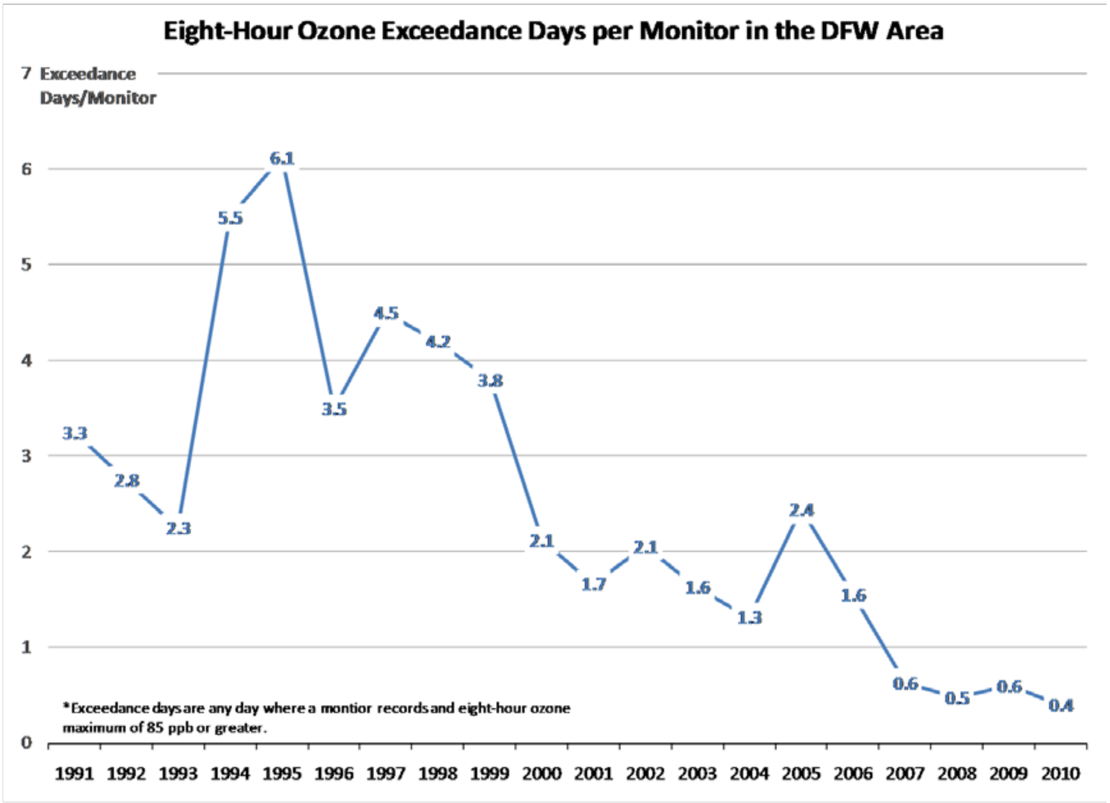

Figure 5-6: Eight-Hour Ozone Exceedance Days per Monitor in the DFW Area

Results for individual monitors, displayed in Figure 5-7: *Number of Eight-Hour Ozone Exceedance Days by Monitor* and Figure 5-8: *Number of One-Hour Ozone Exceedance Days by Monitor*, support this conclusion: the number of exceedance days at individual monitors also appears to be decreasing. These figures highlight two monitors, Eagle Mountain Lake (C75) (blue line) and Keller (C17) (red line), which recorded the highest eight-hour ozone design values. Figure 5-8 also highlights the two monitors, Denton Airport South (C56) (blue line) and Keller (C17) (red line), which recorded the highest one-hour ozone design value. There have not been more than seven one-hour ozone exceedance days per year at any monitor in the DFW area from 1991 through 2010. There have been no one-hour ozone exceedances at any monitor in the DFW area since 2008. Because of the large number of monitors in the DFW area, data from these two figures are presented in Table 5-5: *Number of Days with an Eight-Hour Ozone Exceedance* and Table 5-6: *Number of Days with a One-Hour Ozone Exceedance*.

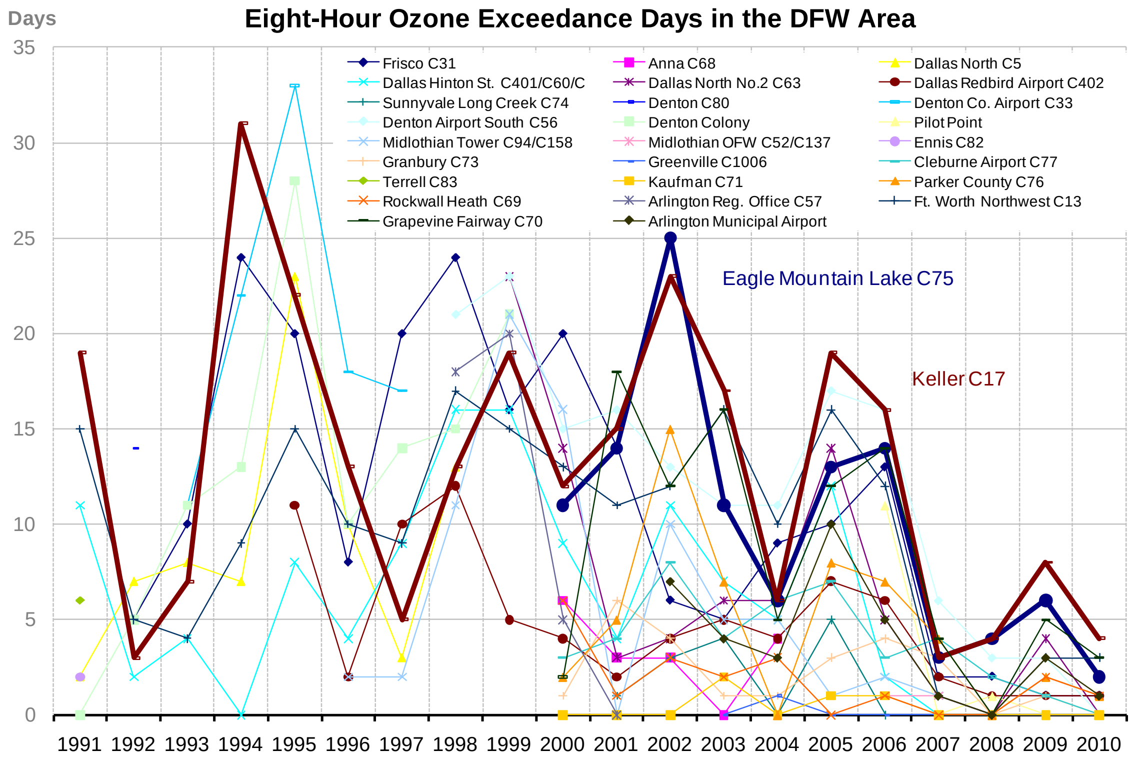

Figure 5-7: Number of Eight-Hour Ozone Exceedance Days by Monitor

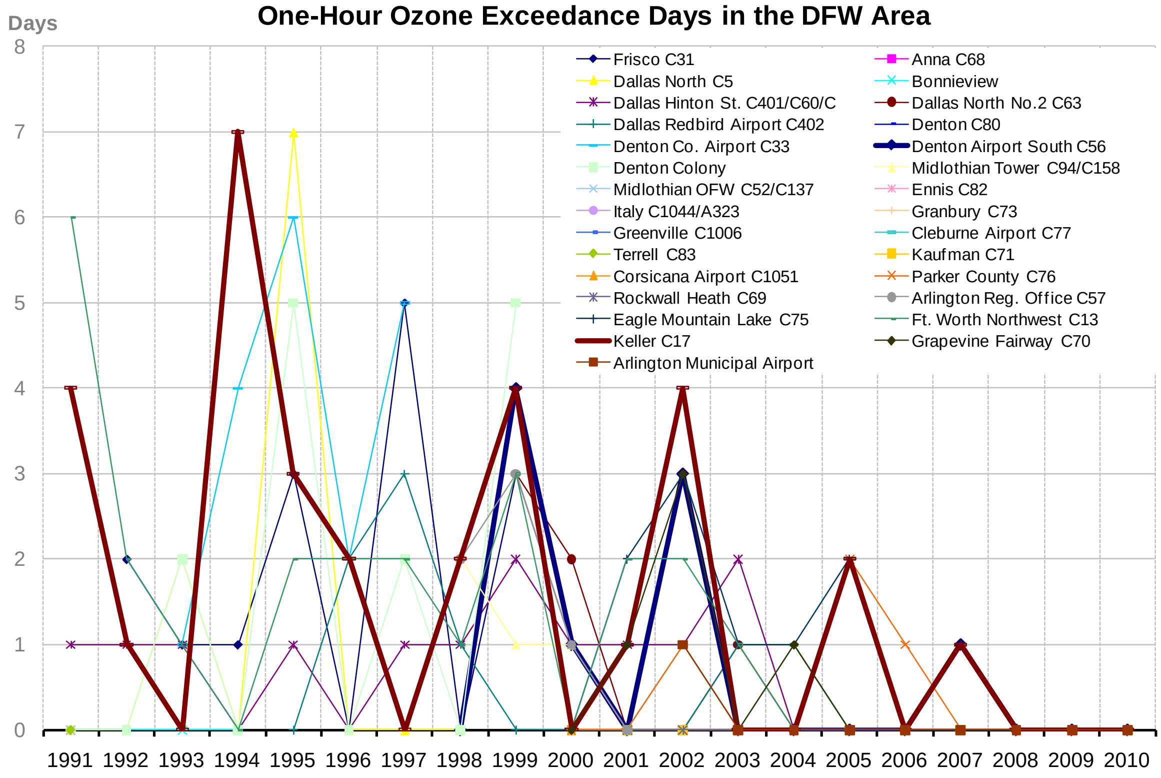

Figure 5-8: Number of One-Hour Ozone Exceedance Days by Monitor

Table 5-5: Number of Days with an Eight-Hour Ozone Exceedance

Monitor	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Keller C17	19	3	7	31	22	13	5	13	19	12	15	23	17	6	19	16	3	4	8	4
Grapevine Fairway C70										2	18	12	16	5	12	14	4	0	5	3
Ft. Worth Northwest C13	15	5	4	9	15	10	9	17	15	13	11	12	16	10	16	12	1	0	3	3
Eagle Mountain Lake C75										11	14	25	11	6	13	14	3	4	6	2
Arlington Municipal Airport												7	4	3	10	5	1	0	3	1
Parker County C76										2	5	15	7	0	8	7	4	0	2	1
Rockwall Heath C69										6	1	3	2	3	0	1	0	0	2	1
Frisco C31		5	10	24	20	8	20	24	16	20	14	6	5	9	10	13	2	2	1	1
Dallas Redbird Airport C402					11	2	10	12	5	4	2	4	5	4	7	6	2	1	1	1
Cleburne Airport C77										3	4	8	4	6	7	3	4	2	1	0
Dallas North No.2 C63									23	14	3	4	6	6	14	5	1	0	4	0
Denton Airport South C56								21	23	15	16	13	11	11	17	16	6	3	3	0
Granbury C73										1	6	4	1	1	3	4	3	0	1	0
Pilot Point																11	0	1	0	0
Midlothian OFW C52/C137																1	1	0	0	0
Dallas Hinton St. C401/C60/C	11	2	4	0	8	4	9	16	16	9	4	11	7	5	12	2	0	0	0	0
Kaufman C71										0	0	0	2	0	1	1	0	0	0	0
Greenville C1006													0	1	0	0	0	0	0	0
Midlothian Tower C94/C158						2	2	11	21	16	0	10	5	5	1	2	1			
Sunnyvale Long Creek C74											1	3	4	0	5	0				
Anna C68										6	3	3	0	4						
Arlington Reg. Office C57								18	20	5	0									
Denton Colony	0	5	11	13	28	10	14	15	21											
Dallas North C5	2	7	8	7	23	10	3	13												
Denton Co. Airport C33			11	22	33	18	17													
Denton C80		14																		
Ennis C82	2																			
Terrell C83	6																			

*Monitors are sorted in descending order by the number of eight-hour ozone exceedance days recorded in 2010, then 2009, 2008, etc.

Table 5-6: Number of Days with a One-Hour Ozone Exceedance

Monitor	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Eagle Mountain Lake C75										0	2	3	1	1	2	0	1	0	0	0
Ft. Worth Northwest C13	6	2	1	0	2	2	2	1	3	0	2	2	1	0	2	0	1	0	0	0
Keller C17	4	1	0	7	3	2	0	2	4	0	1	4	0	0	2	0	1	0	0	0
Denton Airport South C56								0	4	1	0	3	0	0	0	0	1	0	0	0
Parker County C76										0	0	1	0	0	2	1	0	0	0	0
Dallas Redbird Airport C402					0	2	3	1	0	0	0	0	1	1	0	0	0	0	0	0
Cleburne Airport C77										0	0	1	0	1	0	0	0	0	0	0
Grapevine Fairway C70										0	1	3	0	1	0	0	0	0	0	0
Dallas Hinton St. C401/C60/C	1	1	1	0	1	0	1	1	2	1	1	1	2	0	0	0	0	0	0	0
Dallas North No.2 C63									3	2	0	0	1	0	0	0	0	0	0	0
Arlington Municipal Airport												1	0	0	0	0	0	0	0	0

Monitor	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Frisco C31		2	1	1	3	0	5	0	3	1	0	0	0	0	0	0	0	0	0	0
Italy C1044/A323																		0	0	0
Rockwall Heath C69										1	0	0	0	0	0	0	0	0	0	0
Granbury C73										0	0	0	0	0	0	0	0	0	0	0
Greenville C1006													0	0	0	0	0	0	0	0
Kaufman C71										0	0	0	0	0	0	0	0	0	0	0
Midlothian OFW C52/C137																0	0	0	0	0
Corsicana Airport C1051																			0	0
Midlothian Tower C94/C158								2	1	1	0	0	0	0	0	0	0			
Anna C68										0	0	0	0	0						
Arlington Reg. Office C57								2	3	1	0									
Denton Colony	0	0	2	0	5	0	2	0	5											
Dallas North C5	0	0	2	0	7	0	0	0												
Denton Co. Airport C33			1	4	6	2	5													
Bonnieview	0	0	0	0																
Denton C80		2																		
Ennis C82	0																			
Terrell C83	0																			

*Monitors are sorted in descending order by the number of one-hour ozone exceedance days recorded in 2010, then 2009, 2008, etc.

A variety of analyses have been presented for understanding ozone trends in the DFW area. The results of these analyses generally agree that ozone concentrations have been decreasing; however, the DFW area still faces challenges in achieving attainment of the 1997 ozone NAAQS. Because ozone formation depends on a multitude of factors, these factors must be investigated in detail before conclusions as to causes of the observed decreases can be reached.

5.3.2 Nitrogen Oxides Trends

NO_X, an ozone formation precursor, is a variable mixture of NO and NO_2. NO_X is primarily emitted by fossil fuel combustion, lightning, biomass burning, and soil (Martin *et.al.*, 2006). Examples of common NO_X emission sources are automobiles, diesel engines, and other small engines; residential water heaters; industrial heaters and flares; and industrial and commercial boilers. Mobile, residential, and commercial NO_X sources are usually numerous, smaller sources distributed over a large geographic area, while industrial sources are usually large point sources, or numerous small sources, clustered in a small geographic area.

Other sources of NO_X that are important to air quality in the DFW area are large electric generating unit (EGUs) in and around the metropolitan area, as well as other areas upwind of the DFW area. These facilities can produce large concentrated plumes of emissions that can enhance ozone generation. Analyses conducted by the TexAQS II Rapid Science Synthesis Team indicate that NO_X emissions at several EGUs decreased by factors ranging from two to four between 2000 and 2006. These reductions were seen at EGUs that implemented NO_X control strategies, such as selective catalytic reduction (SCR), between 2000 and 2006, suggesting these control strategies were effective (RSST, 2006).

Trends for peak daily NO_X are presented in Figure 5-9: *Daily Peak Hourly NO_X in the DFW Area*. Daily peak NO_X concentrations in the DFW area appear to be decreasing over time. NO_X

concentrations have decreased more in recent years, especially 2009, a year that also recorded some of the lowest ozone concentrations. The graphic also shows that maximum NO_X concentrations typically occur in winter. Although erratic, maximum NO_X levels have decreased by 43%, to 398 ppb, from 1991 through 2009, an average of roughly 18 ppb, or nearly 3% per year. The years 1998, 1999, and 2000 saw anomalously high peak values greater than 900 ppb. The reasons for the high values are not known. Average daily peak hourly NO_X has dropped at an even faster rate than the maximum NO_X levels, falling 65%, or 4% per year, from 78 ppb to 27 ppb, since 1991.

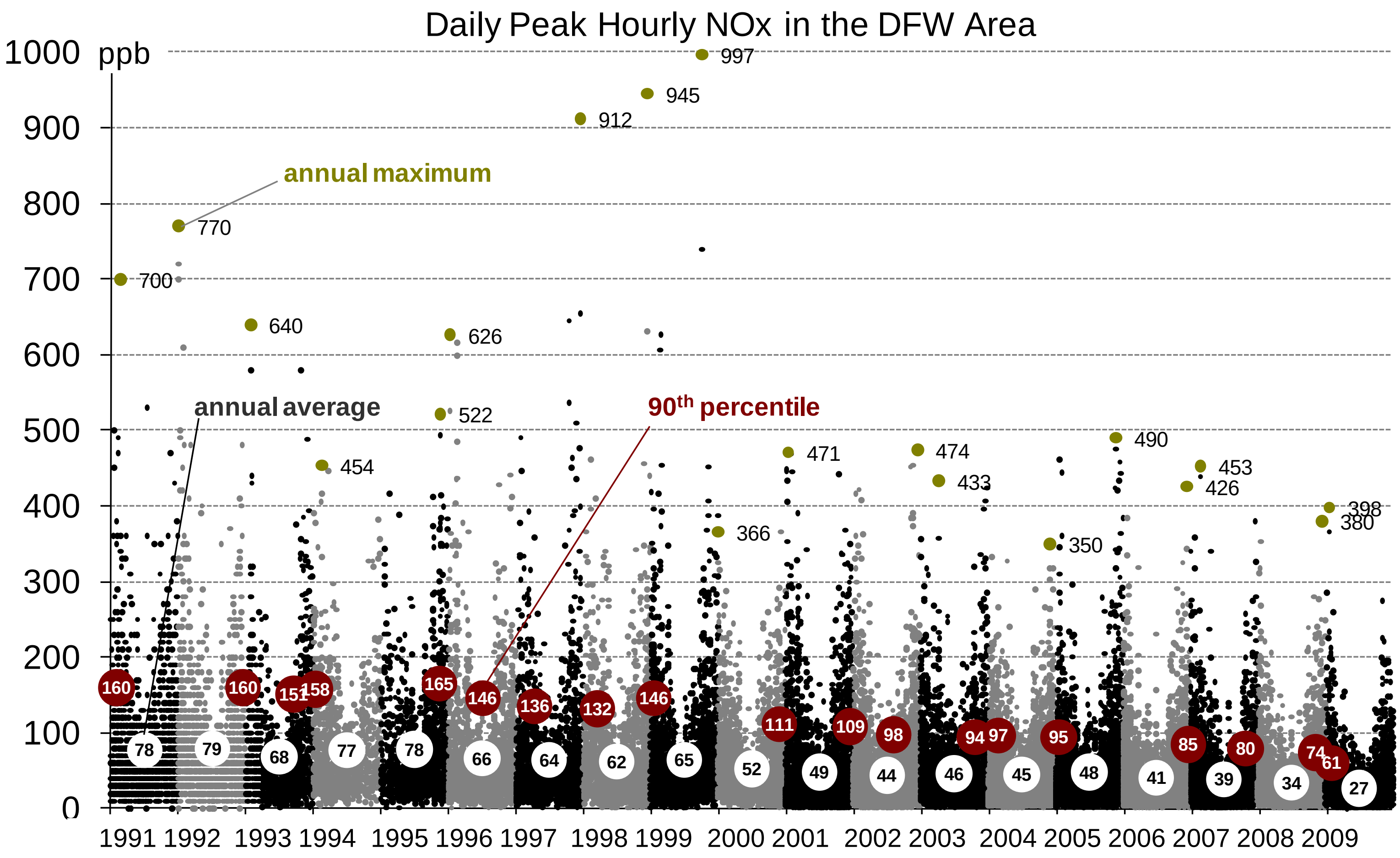

Figure 5-9: Daily Peak Hourly NO_X in the DFW Area

Figure 5-10: *Annual Mean Daily Peak* NO_X shows the annual mean of all one-hour NO_X concentrations in the DFW area from 1991 through 2009. Only years with at least 75% data completeness were included in the figure. Most monitors in the area demonstrate decreasing NO_X concentrations since the late 1990s, with the sharpest decreases occurring since 2007. Monitors that show the smallest decreases, or show no change, are at sites that have traditionally had lower NO_X concentrations.

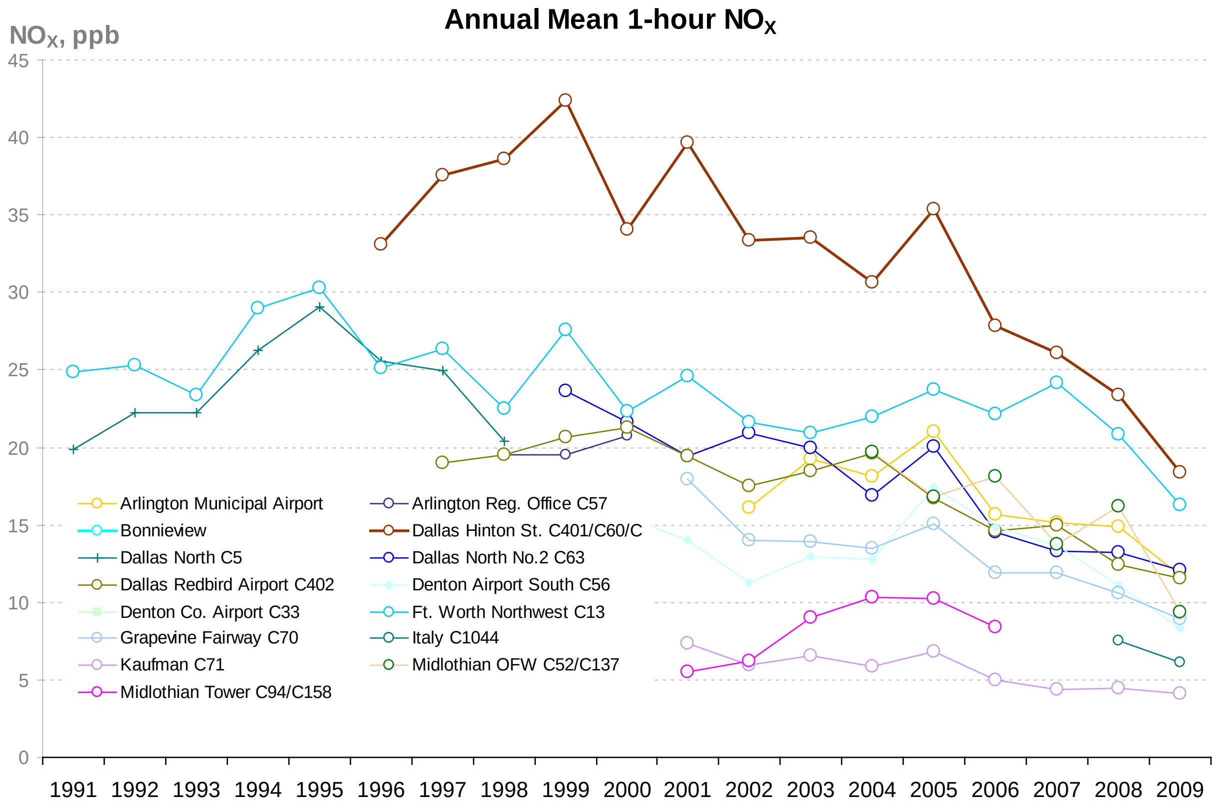

Figure 5-10: Annual Mean Daily Peak NO_X

The largest median NO_X concentrations were measured at the Dallas Hinton (C401) monitor, which is in close proximity to Interstate 35E, and at the Fort Worth Northwest (C13) monitor which is near Fort Worth Meacham International Airport. The location of both monitors, in combination with their similar trends, suggests that they may be measuring decreases in NO_X emissions from mobile sources. Monitors located further from the center of the DFW area, where there are fewer NO_X sources, measured the lowest median NO_X concentrations. Sites recording the highest NO_X concentrations, such as Dallas Hinton (C401), are not necessarily the sites with the highest ozone design values. Ozone may be destroyed through reactions with NO_X near these monitors.

For a more robust examination of the distribution of hourly NO_X concentrations, the 90th percentile was also analyzed (Figure 5-11: *90th Percentile Daily Peak NO_X Concentrations in the DFW Area*). All sites in the Dallas-Fort Worth area appear to exhibit gradual decreases in 90th percentile one-hour NO_X concentrations, with the Dallas Hinton (C401) monitor showing the largest decrease. The Dallas Hinton (C401) monitor showed large variability in 90th percentile NO_X concentrations from the start of monitoring in 1996 through 2001. Since 2001, 90th percentile NO_X concentrations at Dallas Hinton (C401) have steadily decreased and are now within the range of other monitors in the area. This large decrease may be due to decreasing automobile emissions and implemented controls, though this conclusion has not been rigorously tested.

Table 5-7: *Decreases in 90th Percentile NO_X Concentrations* shows changes in 90th percentile measurements since the beginning of data collection at each monitor. While several monitors recorded large decreases in 90th percentile NO_X from 2008 to 2009, most others observed only minimal changes over that same period. These large disparities in patterns of ambient NO_X concentrations across the region are appropriate for further investigation, suggesting that larger decreases are not due solely to variations in meteorological conditions, which would be expected to influence all monitors similarly, though not identically. The differences appear to be related to the relative magnitudes of the overall concentrations: sites with the highest concentrations, which tend to be urban sites, showed the greatest decrease. More rural sites like Kaufman (C71) and Italy (C1044) may reflect slight changes in background values, while more urban sites may reflect local emission changes.

Similar to ozone, NO_X concentrations in the DFW area appear to be decreasing over time, as expected as a result of the comprehensive suite of NO_X-targeted controls implemented since 2000. Stringent point source NO_X standards have been adopted along with numerous state and federal controls affecting mobile source NO_X emissions. Besides normal fleet turnover, as older vehicles are replaced by newer, less polluting ones in the on-road fleet, mobile source NO_X reductions since 2000 are due to improvements in the Air Check Texas motor vehicle Inspection and Maintenance Program, implementation of the Low Income Vehicle Repair Assistance, Retrofit, and Accelerated Vehicle Retirement Program (LIRAP), and expansion of the Texas Emissions Reduction Program (TERP) for diesel trucks and heavy-duty equipment.

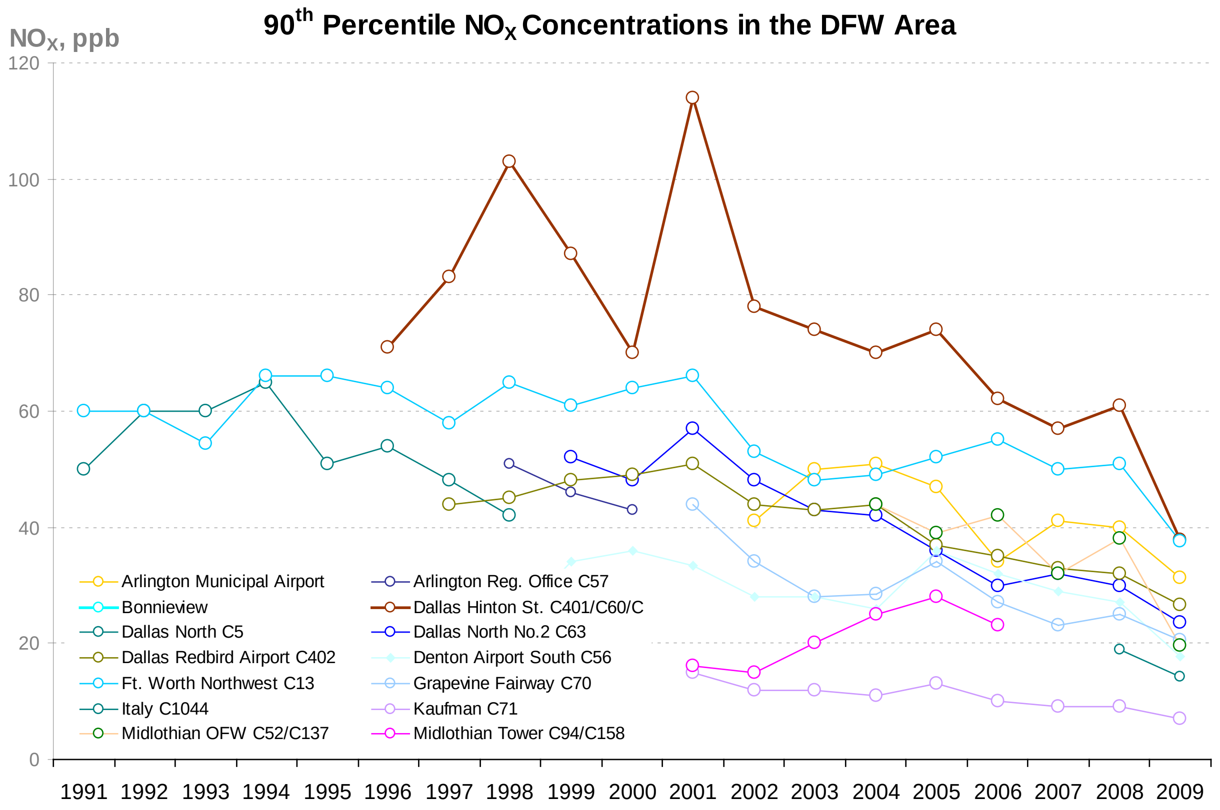

Figure 5-11: 90th Percentile Daily Peak NO$_X$ Concentrations in the DFW Area

Table 5-7: Decreases in 90th Percentile NO$_X$ Concentrations

Monitor Site	Start Year	Percentage Change from Start Year to 2009	Average Annual Percentage Change
Midlothian OFW C52	2004	-55	-10.9
Grapevine Fairway C70	2001	-55	-6.8
Dallas North No.2 C63	1999	-54	-5.4
Kaufman C71	2001	-53	-6.7
Dallas Hinton St. C401	1996	-46	-3.6
Dallas Redbird Airport C402	1997	-39	-3.2
Ft. Worth Northwest C13	1991	-37	-2.0
Arlington Municipal Airport	2002	-24	-3.5
Denton Airport South C56	1998	-22	-2.0

5.3.3 Volatile Organic Compound Trends

VOC emissions play a central role in ozone production. Since the mid-1990s, the TCEQ has collected 40-minute measurements, on an hourly basis, of some 58 VOC compounds using auto-GCs. These instruments automatically measure and report chemical compounds resident in ambient air. Initially, there was only one auto-GC collecting data in the DFW area, Dallas Hinton (C401), but in 2003 a second auto-GC monitor was added at Fort Worth Northwest (C13). The TCEQ also deployed auto-GC monitors in DISH, Eagle Mountain Lake, and Flower

Mound in 2010. While not part of this trend analysis, the data from the 2010 auto-GCs are evaluated routinely.

The TCEQ has also employed two types of canister sampling in the DFW area, one that samples ambient air over a 24-hour period (Community Air Toxics Monitoring Network, or CATMN) and another that samples ambient air for a single hour at a time, usually at four different times of day (Multican, or MCAN). The locations of the two auto-GC monitors, as well as the canisters collecting VOC data in the DFW area are shown in Figure 5-13: *Locations of Auto-GC Monitors and Canisters in the DFW Area*. Some monitors shown have been deactivated (see Table 5-8: *Description of Auto-GC and Canister Monitors in the DFW Area*) but still have data after 1999.

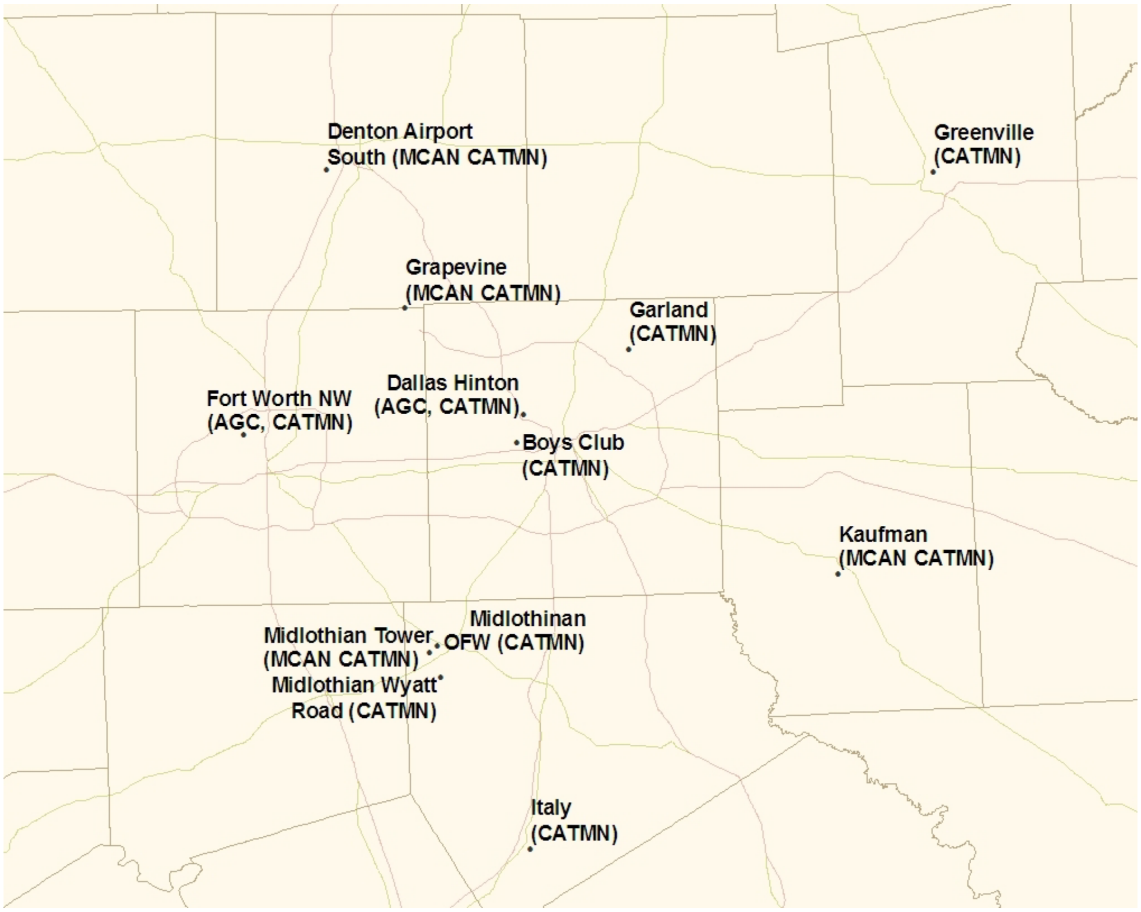

Figure 5-12: Locations of Auto-GC Monitors (AGC) and Canisters (MCAN and CATMN) in the DFW Area

Table 5-8: Description of Auto-GC and Canister Monitors in the DFW Area

Site Name (CAMS Number)	Airs Code	County	Latitude	Longitude	Monitor Type	Currently Active?
Boys Club A134	481130057	Dallas	32.77917	-96.8733	CATMN	N
Dallas Hinton St. C401/C60/AH161	481130069	Dallas	32.81972	-96.86	AGC, CATMN	Y

Site Name (CAMS Number)	Airs Code	County	Latitude	Longitude	Monitor Type	Currently Active?
Denton Airport South C56/A163/X157	481210034	Denton	33.19444	-97.1933	MCAN, CATMN	Y
Ft. Worth Northwest C13/AH302	484391002	Tarrant	32.80583	-97.3564	AGC, CATMN	Y
Garland Hwy Dept C197	481131006	Dallas	32.91056	-96.6692	CATMN	N
Grapevine Fairway C70/A301/X182	484393009	Tarrant	32.98417	-97.0636	MCAN, CATMN	Y
Greenville C1006/A198	482311006	Hunt	33.15306	-96.1153	CATMN	Y
Italy C1044/A323	481391044	Ellis	32.17556	-96.8703	CATMN	Y
Kaufman C71/A304/X071	482570005	Kaufman	32.565	-96.3175	MCAN, CATMN	Y
Midlothian Tower C94/A305/X158	481390015	Ellis	32.43667	-97.0244	MCAN, CATMN	N
Midlothian Wyatt Road C302/A306	481390017	Ellis	32.47361	-97.0425	CATMN	N
Midlothian OFW C52/A137	481390016	Ellis	32.48222	-97.0269	CATMN	Y

AGC = Auto-GC; CATMN = Community Air Toxics Monitoring Network; MCAN = Multican

5.3.4 VOC Trends at Auto-GC Monitors

Trends in total non-methane hydrocarbons (TNMHC) concentrations, a proxy for VOC, provide insight into variation in VOC levels in the DFW area over time. Though this analysis includes data from 2009, the data have not been verified by the EPA and are subject to change.

Figure 5-14: *Daily Peak TNMHC Concentrations in the DFW Area* displays daily peak hourly VOC values at auto-GC monitors in the DFW area. These daily peaks exhibit large variability and range from less than 100 parts per billion, carbon (ppbC) to more than 1,000 ppbC. Because TNMHC measurements are characterized by a small number of extremely high values and a large number of low and moderate values, plotting TNMHC on a logarithmic scale is necessary to display the range of data and show trends. The increasing density and introduction of the new color of points (gray) plotted beginning in 2003 reflect the deployment of the Fort Worth Northwest (C13) auto-GC monitor. To better assess trends at individual monitors, 90th percentile and median TNHMC concentrations by year at each auto-GC monitor are also shown. Because of the scales of the data involved, 90th percentile and median concentrations are plotted on a linear scale, while daily peak TNMHC concentrations, which are skewed by a few very high values, are plotted on a logarithmic scale. Only months with 75% data completeness were used in this analysis.

The 90th percentile TNMHC at Fort Worth Northwest (C13) is much higher than the 90th percentile TNMHC at Dallas Hinton (C401); however, Fort Worth Northwest (C13) shows a much greater decrease, 30 ppbC, over the most recent year compared to a decrease of 2 ppbC at Dallas Hinton (C401). Because TNMHC is a precursor to ozone formation, reductions in the 90th percentile at both locations are beneficial to improving ozone concentrations. Although the Fort Worth Northwest (C13) monitor shows a much higher 90th percentile than Dallas Hinton (C401), its median is only slightly higher. Both medians show downward trends through 2004 and have remained roughly constant since.

Daily peak TNMHC concentrations at Dallas Hinton (C401) show a seasonal trend: higher concentrations of TNMHC in the winter and lower concentrations in the summer. Fort Worth Northwest (C13) also exhibits a similar seasonal trend. The higher summer VOC concentrations at Fort Worth Northwest (C13) could be the reason that the 90th percentile is higher at that monitor.

Approximately 66% of anthropogenic emissions of TNMHC at Dallas Hinton (C401) come from motor vehicle emissions (Qin et al., 2007). This seasonal variation may be due to photochemical removal and dilution of VOC from fluctuations in depth of the atmospheric mixing layer. Because the mixing layer in summer is much deeper than in winter, ground-level emissions tend to become more diluted in the summer (Qin et al., 2007).

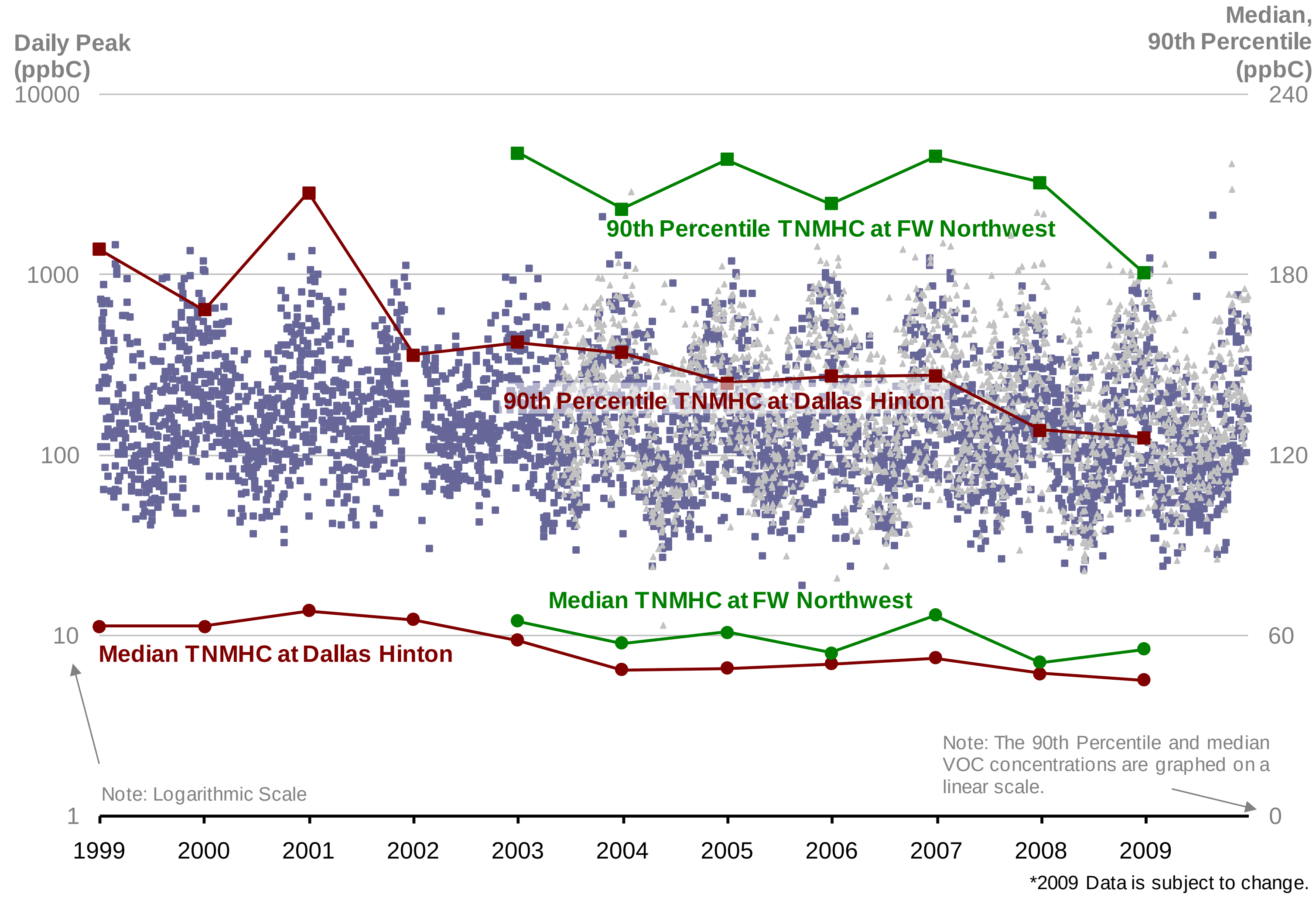

Figure 5-13: Daily Peak TNMHC Concentrations in the DFW Area

Figure 5-15: *90th Percentile and Median TNMHC in the DFW Area* displays 90th percentile and median TNMHC for Dallas Hinton (C401) and Fort Worth Northwest (C13) again, but the values are now shown along with estimated regression lines.

Table 5-9*: TNMHC Yearly Median Linear* Regression reports the results of ordinary least squares regressions of annual 90th percentile and median TNMHC measures against an index of year at the two subject monitors. While all four estimated models exhibit negative slopes, corresponding to downward trends, only the models for Dallas Hinton (C401) are statistically significant at the 90% (α=0.10) level. The regression analysis statistics[6] indicate acceptable models for Dallas Hinton (C401) but not Fort Worth Northwest (C13), indicating that the negative trends detected at Fort Worth Northwest (C401) are not distinguishable from zero, or flat lines, with statistical confidence ($\alpha = 0.05$).

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[6] *R^2 (and adjusted R^2) ranges from 0 to 1 and measures the proportion of total variation in the dependent variable that is accounted for by the model. It is often used to assess the strength of a modeled relationship, usually in comparisons between and among models. There is no R^2 value that is considered "good" or "bad."
**The F statistic measures the possibility that the explanatory variable(s) are not correlated with the dependent variable. It is the (weighted) ratio of the variance in the dependent variable that is explained by the model, to the remaining unexplained variance in the dependent variable. The F statistic is compared to a value from an F distribution (critical value) to make a determination. If the F statistic exceeds the critical value, the model is considered to be acceptable.
***Significance of F is the probability that the reported F value does not exceed the critical value of F from the F distribution. A value of 0.05 (5% probability) or less is generally considered sufficient evidence that the reported F statistic exceeds the critical value of F, that the reported value of F did not occur just by chance, and that the model is acceptable.
****The t-statistic measures the distance, in standard deviations of the explanatory variable, that the slope estimate of the model differs from zero. A value greater than about 2 (positive or negative) is considered sufficient evidence to determine that the slope estimate is valid (statistically significant).
*****The p-value is the probability that the slope is actually zero, given the reported t-statistic, even though the model reported an estimate of the slope that was not zero. A p-value of 0.05 (5% probability) or less is generally considered sufficient evidence that the estimate of the slope parameter is not zero (statistically significant).

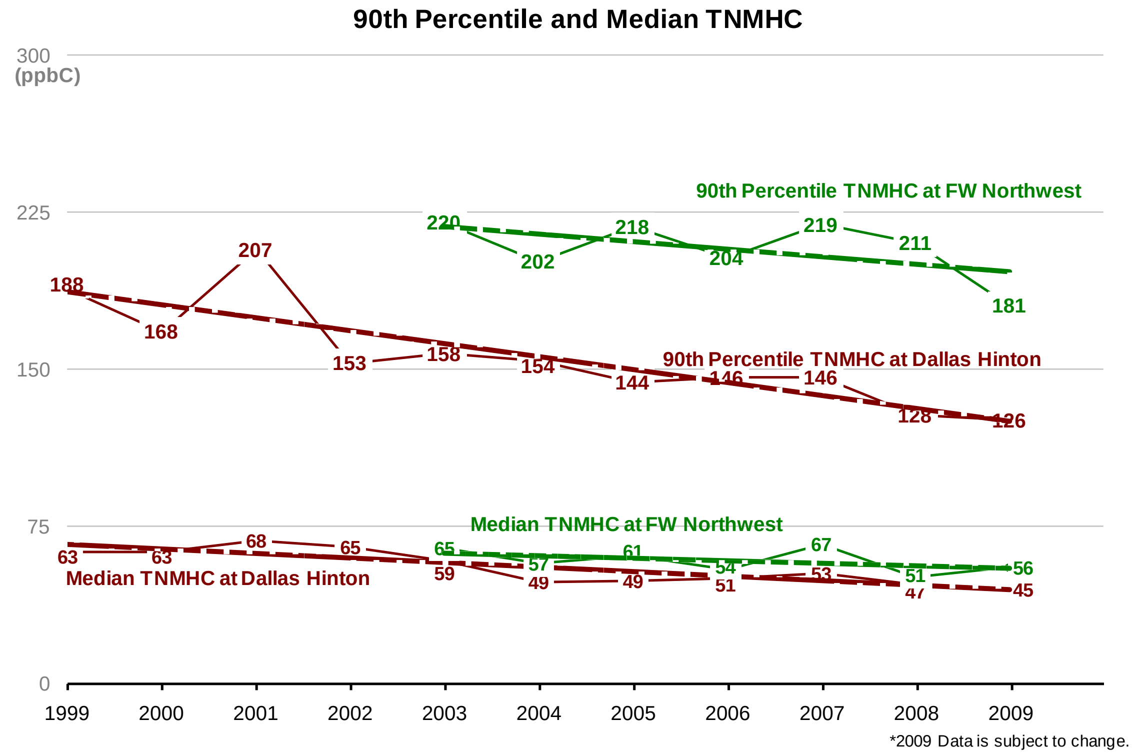

Figure 5-14: 90th Percentile and Median TNMHC in the DFW Area

Table 5-9: TNMHC Yearly Median Linear Regression

Regression Statistic[6]	Dallas Hinton St 90th Percentile	Dallas Hinton St Median	Fort Worth NW 90th Percentile	Ft Worth NW Median
Adjusted R^2	0.693	0.740	0.161	0.069
F	23.621	29.476	2.150	1.445
Significance F	0.001	0.000	0.202	0.283
Slope	-6.209	-2.178	-3.590	-1.260
t-stat	-4.860	-5.429	-1.466	-1.202
p-value	0.001	0.000	0.202	0.283

5.3.5 VOC Trends from Canisters

In addition to continuously operating auto-GC instruments in the DFW area, the TCEQ also collects ambient air samples using evacuated canisters at seven locations throughout the DFW area. Data from these canisters are useful for confirming findings from auto-GCs.

This analysis of TNMHC collected with canisters investigates 24-hour measurements of TNMHC and HRVOC. Twelve Community Air Toxics Monitoring Network (CATMN) canisters that collect 24-hour measurements every sixth day have been active in the DFW area over the past 10 years. Two canister locations coincide with auto-GC instruments: Dallas Hinton (C401) and Fort Worth Northwest (C13). While comparisons with auto-GC measurements may be instructive for observing trends and other patterns, these instruments have different measurement durations and frequencies, potentially yielding incomparable results.

Similar to the auto-GC measurements, quarterly geometric mean concentrations were calculated by computing the natural logarithm of each 24-hour concentration, averaging these by monitor and quarter, then exponentiating the resulting average. Samples that were invalidated and those with warning codes regarding sample accuracy or precision were discarded. Quarters with less than 75% valid measurements (less than 12 samples) were also discarded. 2009 includes data only through the second quarter as the third and fourth quarter data had not been analyzed and quality assured in time for this analysis. Resulting quarterly geometric mean concentrations for each HRVOC species were plotted against time. Quarters that did not meet completeness criteria appear as gaps in the time series.

Values measured at each CATMN canister in the DFW area are shown in Figure 5-16: *Quarterly Geometric Mean TNMHC at CATMN Monitors*. As with auto-GC measurements, there is a distinct seasonal variation at all monitoring sites, possibly due partly to differences in seasonal driving patterns and partly to photochemical removal and dilution due to atmospheric mixing. The mixing layer in the summer extends to a much higher altitude than in the winter, allowing more dilution of the species.

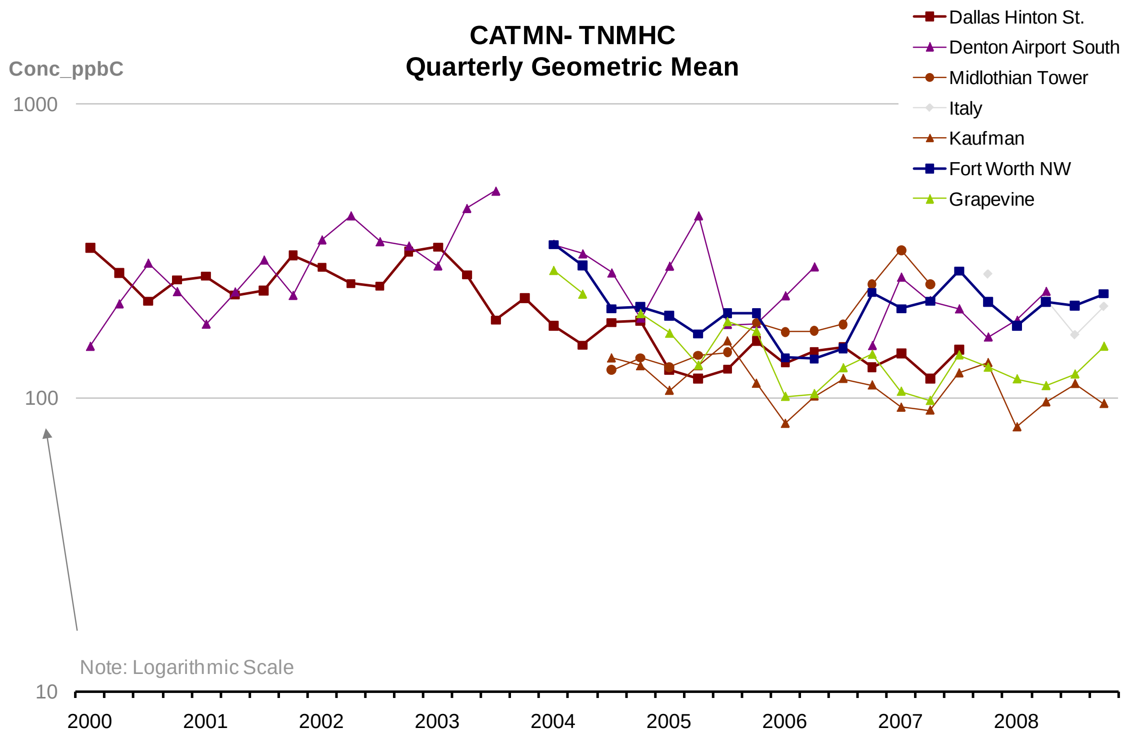

Figure 5-15: Quarterly Geometric Mean TNMHC at CATMN Monitors

Because daily and seasonal variability in these series hamper identification of trends, annual geometric mean TNMHC are shown for each site in Figure 5-17: *Annual Geometric Mean TNMHC at CATMN Monitors*. Visual inspection suggests that annual geometric mean TNMHC concentrations in the DFW area are declining. Linear regressions presented in Table 5-10: *Regression Analysis Results for Annual Geometric Mean TNMHC at CATMN* Monitors provide statistical confirmation of any trends present. Incomplete data from 2009 was excluded from the analysis.

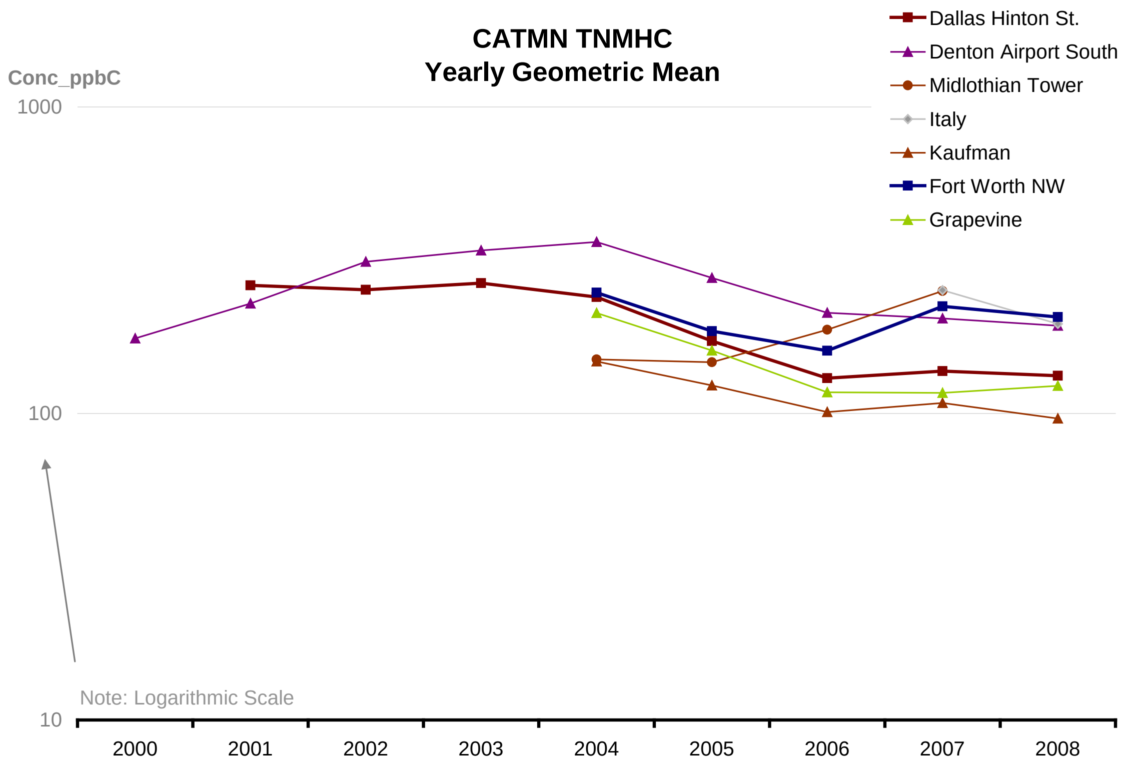

Figure 5-16: Annual Geometric Mean TNMHC at CATMN Monitors

Of the seven sites, statistically significant trends, at the 5% level (α=0.05), were identified for only two, Kaufman (C71) and Dallas Hinton (C401). These two sites exhibit negative slopes of -11.86 and -23.31, respectively, which represent quite large decreases. Two other sites exhibited trends significant at the 10% level (α=0.10): Midlothian Tower (C94) and Grapevine (C70). Midlothian Tower (C94) was the only site that exhibited an increasing trend, which is possibly due to increased quarry operations near that site. Regression analysis from 2004 through 2008 for Denton Airport South (C56), when this monitor began measuring a downward trend similar to the other sites, confirmed the observed downward trend; these values are displayed with emphasis (italics) in the table. Italy (C1044) had too few years of data to estimate regression trends. Results for Fort Worth Northwest (C13) do not show the same significantly downward trend, which may be due to recent increased oil and gas extraction activities in the Barnett Shale formation in Tarrant and Wise Counties.

Table 5-10: Regression Analysis Results for Annual Geometric Mean TNMHC at CATMN Monitors

Regression Statistic6	Dallas Hinton St	Denton Airport South 2000-2008	Denton Airport South 2004-2008	Midlothian Tower	Italy ***	Kaufman	Fort Worth North-west	Grapevine
Adjusted R^2	0.83	-0.11	*0.69*	0.76	NA	0.74	-0.27	0.63
F	35.48*	0.22	*7.75*	10.46**	NA	12.34*	0.14	7.84**
Significance F	0.00	0.65	*0.11*	0.08	NA	0.04	0.73	0.07
Slope	-23.31*	-4.41	*-25.87*	34.34**	NA	-11.86*	-4.56	-22.29**

Regression Statistic6	Dallas Hinton St	Denton Airport South 2000-2008	Denton Airport South 2004-2008	Midlothian Tower	Italy ***	Kaufman	Fort Worth North -west	Grapevine
t-stat	-5.96	-0.47	*-2.78*	3.23	NA	-3.51	-0.38	-2.80
p-value	0.00	0.65	*0.11*	0.08	NA	0.04	0.73	0.07

*Significant at the α=0.05 level.

**Significant at the α=0.10 level.

***Insufficient data.

Analysis of VOC data collected with auto-GCs and canisters revealed statistically significant decreases in total VOC at Dallas Hinton (C401). Although many VOC trends appeared to decrease at Fort Worth Northwest (C13), no trends at that location were found to be statistically significant.

5.3.6 Summary of Trends in Ozone and Ozone Precursors

Identifying and assessing trends in ozone and its precursors provide an initial appraisal of the current ozone situation in the DFW area, the magnitude of progress made to date, and the scale of future challenges. Examination of ozone trends shows that ozone design values have decreased in the DFW area over the past seventeen years. The eight-hour ozone design value of record in 2010 was 86 ppb, an 18% decrease from the 1991 design value of 105 ppb. The 2010 value is only two ppb above the level required to attain the 1997 ozone NAAQS, 84 ppb. A regression analysis of design value by year estimates that eight-hour ozone design values decreased at the rate of 0.6 ppb per year, which is statistically significant at the 5% level (α = 0.05). The one-hour ozone design value in 2010 was 110 ppb, well below the vacated one-hour ozone NAAQS of 124 ppb, and a 21% decrease from the 1991 design value of 140 ppb. Regression analysis of one-hour design values by year show they decreased at the rate of 1.49 ppb per year, which is even faster than the decline in the eight-hour ozone design values.

Examination of design values at individual monitors corroborates these decreases with over half of the monitors at levels below the eight-hour standard by 2008 and below the vacated one-hour standard by 2000. Since 1991, the number of eight-hour and one-hour ozone exceedance days occurring in the DFW area has fallen 69% and 100%, respectively. Decreases in exceedance days are apparent despite an increase in the number of monitors located throughout the DFW area.

A variety of methods has been presented for understanding ozone trends in the DFW area. These methods generally agree that ozone concentrations have been decreasing; however, the area has not attained the 1997 ozone NAAQS. Because ozone formation depends on a multitude of factors, these factors must be investigated and understood in detail before conclusions as to the causes of the observed decreases can be reached.

Similar to ozone, NO_X concentrations in the DFW area are decreasing over time. NO_X concentrations have shown larger decreases in recent years, especially 2009, a year that also recorded some of the lowest ozone concentrations. Maximum NO_X concentrations typically occur in winter, and, while variable, have decreased overall by 43%, to 398 ppb, since 1991, though 1998, 1999, and 2000 saw peak values greater than 900 ppb. This is an average of roughly 18 ppb per year or nearly 3%. Average daily peak hourly NO_X has dropped at an even faster rate, falling 65%, or 4% per year, from 78 ppb to 27 ppb, since 1991. These trends were corroborated with results from individual monitors, which showed decreases ranging from 24% to 55% from the time the monitor started operation to 2009.

VOC data collected with auto-GCs and canisters revealed statistically significant decreases in total VOC concentrations at Dallas Hinton (C401). As noted in Appendix D: *Conceptual Model for the DFW Attainment Demonstration SIP Revision for the 1997 Eight-Hour Ozone Standard* this monitor is determined to be VOC sensitive. Also, VOC trends showed decreases at Fort Worth Northwest (C13); however, these decreases were not found to be statistically significant. The Fort Worth Northwest (C13) monitor is defined as transitional in terms of NO_X and VOC sensitivity. Ozone decreases at this monitor are likely related to reductions in local NO_X as the eight-hour design value at this monitor has dropped from 97 ppb in 2001 to 79 ppb in2010.

NO_X trends from 1991 to 2009, and VOC trends from 1999 to 2009, show that most monitors in the DFW area experienced decreases in both median and 90th percentile concentrations of these pollutants. Most strikingly, 2009 experienced not only some of the lowest ozone design values in seventeen years, but also some of the lowest NO_X and VOC values.

5.3.7 NO_X Concentrations in the Barnett Shale Region

The Barnett Shale is a geological formation of sedimentary rock in north central Texas that contains oil and gas. In the past several years, the quantity of gas produced from active wells has grown from 79 billion cubic feet (bcf) in 2000 to 1,764 bcf in 2009 (Railroad Commission of Texas, 2010). The geological area containing oil and gas is estimated to extend from the city of Dallas in the east, west to Shackleford County, south to Coryell County, and north to the Red River, encompassing roughly 5,000 square miles and 24 counties in Texas.

Because of the proximity of the Barnett Shale formation to the DFW area, questions regarding whether emissions from oil and gas drilling, extraction, and transport activity in this region could be influencing ozone in the DFW area have been asked. The following paragraphs discuss what is currently known about types of emissions from the region.

As stated earlier, NO_X is a precursor to ozone formation, and several activities associated with oil and gas drilling in the Barnett Shale are sources of NO_X. Furthermore, the design value setting monitors for the DFW area are on the eastern edge of the Barnett Shale. Before the addition of two new NO_X monitors in the Barnett Shale area, there was no monitored information about localized NO_X concentrations. Since the installation of the Parker County (C76) and Eagle Mountain Lake (C75) monitors, which are on the eastern edge of the Barnett Shale, NO_X data from this area are available for analysis.

The Parker County (C76) and Eagle Mountain Lake (C75) monitors are located in rural areas west of the DFW urban area, well within eastern Barnett Shale. The Eagle Mountain Lake (C75) monitor frequently sets the design value for the DFW area. With the exception of gas compressors and drilling associated with gas and oil operations, there are no nearby major sources of NO_X. The Parker County (C76) monitor is less populated with fewer possible emission sources, other than the nearby oil and gas activity and further from the DFW area. This rural monitor can measure oil and gas emissions without interference from urban sources.

Though there are only data for one ozone season, the preliminary results suggests that NO_X in the Barnett Shale area is well below the NO_X concentration seen at other sites, such as the mobile source dominated Dallas Hinton (C401) and Fort Worth Northwest (C13) monitors. A more direct comparison is to another similar monitor, such as the Kaufman (C71) monitor. These monitors have similar emission sources nearby except that there is no oil and gas activity at the Kaufman (C71) monitor.

The NO_X means and maxima measured at Eagle Mountain Lake (C75) and Parker County (C76) are very similar to those at the Kaufman (C71) monitor. Kaufman's (C71) mean NO_X concentration is calculated at 4.36 ppb. Eagle Mountain Lake (C75) and Parker County (C76) mean NO_X concentrations are 4.96 and 2.00 ppb, respectively. Similarly, Kaufman's (C71) maximum NO_X concentrations is 84.72 ppb, compared to Eagle Mountain Lake (C75) and Parker County (C76) maximum NO_X concentrations at 50.48 and 60.80 ppb, respectively. For more statistics see Table 5-11: *NO_X Concentrations Statistics at Various Monitors*.

Table 5-11: NO_X Concentrations Statistics at Various Monitors

Rank by Mean	Monitor Name	Mean, ppb	Maximum, ppb	Nearby Emission Types
1	Hinton	14.77	222.24	Urban/Automobile
2	Ft. Worth NW	10.24	191.87	Urban/Automobile
3	Dallas North	9.62	119.35	Urban/Automobile
4	Midlothian	7.47	189.65	Rural/Kiln
5	Denton	6.48	84.67	Small Population/Automobile/Oil & Gas
6	Keller	6.45	85.66	Suburban/Oil & Gas
7	Eagle Mt. Lake	4.96	50.48	Rural/Oil & Gas
8	Kaufman	4.36	84.72	Small Population
9	Parker Co.	2.00	60.80	Rural/Oil & Gas

Note: Monitors ranked by means and values have been rounded.

Further, to evaluate the monitors' NO_X response by wind direction, wind-roses were created at the 90th, 75th, and 50th percentiles. To create the wind-roses, hourly wind data were merged with hourly NO_X data and then grouped into 16 wind bins with percentiles calculated for each wind bin.

The data suggest the Parker County (C76) and Eagle Mountain Lake (C75) monitors observe higher concentrations at all percentiles when the wind is from the East (*Figure 5-18: Wind-Roses Showing 90th Percentile NO_X Concentrations by Wind Direction at Parker County (C76) and Eagle Mountain Lake (C75)*). Aerial photographs were also used to find other possible NO_X sources. For example, the largest nearby NO_X source at the Eagle Mountain Lake (C75) monitor is almost due south of the monitor. This NO_X source is a compressor house less than 1.5 miles away. Given that proximity one would expect a large NO_X signal from the south but there is none. At the Parker County (C76) monitor there are no known large nearby NO_X sources, nevertheless there exists a NO_X signal from the east as previously mentioned. As further evidence that the DFW area is most likely to contribute NO_X to the Eagle Mountain Lake (C75) and Parker County (C76) monitors, the Kaufman (C71) monitor displays a similar NO_X signal, but from the west, given that this monitor is on the east side of the DFW area. A probable explanation is that NO_X from the DFW urban area is transported to these monitors.

To summarize, the two new NO_X monitors in the Barnett Shale area are observing much lower concentrations than urban monitors but similar to the rural Kaufman (C71) monitor. The direction from which NO_X concentrations are the highest at these new monitors is east.

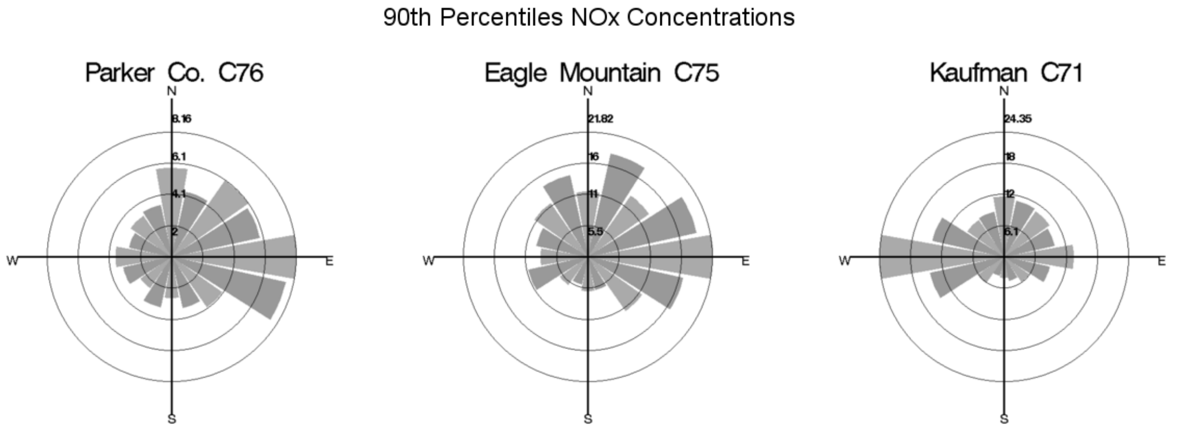

Figure 5-17: Wind-Roses Showing 90th Percentile NO_X Concentrations by Wind Direction at Parker County (C76) and Eagle Mountain Lake (C75)

5.4 STUDIES OF DFW OZONE FORMATION, ACCUMULATION, AND TRANSPORT

The DFW metropolitan area is one of the largest in the United States with a population of over five million people. Like other urban areas of its size, it experiences ozone pollution episodes each year. The DFW conceptual model (see Appendix C) describes in detail the characteristics of ozone pollution in DFW. On-road mobile source emissions are the largest source of ozone precursors in the DFW area, especially of NO_X (see Chapter 3). Other significant precursor sources include the area and non-road emissions that are typical of a large urban area (construction activity, railroads, solvent usage, etc.), electrical power plant emissions, cement kilns and other manufacturing facilities, and oil and gas production, especially hydraulic fracturing operations in the Barnett Shale formation underlying the western portion of the metropolitan area. In addition to these anthropogenic sources, biogenic emissions of VOC are substantial, due to the isoprene-emitting oak species of trees, which are relatively abundant in some parts of the metropolitan area. Finally, regional background ozone plays an important role in ozone pollution episodes in the DFW area.

Most of the air quality studies published in the peer-reviewed literature have focused on determining the relative importance of the different ozone precursor emissions and of the regional background ozone. Several studies have examined the role of regional background ozone concentrations on the ozone pollution in eastern Texas in general. A literature review summarizing recent findings about regional background ozone in Texas and the United States (Estes, 2010) found that:

- Regional background ozone in eastern Texas increases with distance from the Gulf of Mexico (Hardesty et al., 2007). Background ozone associated with transport from the Gulf of Mexico is on average consistent with natural background concentrations of 15-25 ppb (Sullivan, 2009; Chan and Vet, 2009).
- In the DFW area, regional background ozone appears to comprise a greater percentage of the observed maximum concentrations than in the HGB area, in part because some of the HGB area's background ozone arrives from the Gulf of Mexico and therefore is often similar in magnitude to natural background ozone (Nielsen-Gammon et al., 2005).
- Regional background concentrations higher than 60 ppb have been observed along the Louisiana-Texas border, including a few excursions above 85 ppb (Hardesty et al., 2007).

- Regional background ozone varies greatly during the ozone season with highest background ozone observed in late spring and late summer (Nielsen-Gammon et al., 2005; Tobin and Nielsen-Gammon, 2010).
- Regional transport studies indicate that easterly and northerly flow is on average associated with higher background concentrations than southerly flow (Sullivan, 2009; Chan and Vet, 2009). [See also Appendix C: *Photochemical Modeling for the DFW Attainment Demonstration SIP Revision for the 1997 Eight-Hour Ozone Standard*, Chapter 3.4.3, and Chapter 4, Table 4-9, of Appendix D].
- While studies of regional background ozone in some cities in the United States have shown an upward trend in background ozone (such as Cooper et al., 2010; Chan and Vet, 2009), the studies performed by the TCEQ to date have not shown statistically significant upward trends in regional background ozone concentrations in eastern Texas.

Kemball-Cook et al. (2009), one of several recent studies, focused on the DFW metropolitan area. examined regional background ozone in the DFW area using both aircraft observations and modeling in an effort to quantify the regional background ozone contribution to the local ozone maxima. Estimated regional transport of background ozone, based on four upwind-downwind flights, ranged from 40 to 71 ppb, with local ozone contribution ranging from 17 to 27 ppb. Estimates of background ozone using TCEQ ground monitors were consistent with aircraft data.

Using CAMx Kemball-Cook modeled the DFW area with CAMx from June 1 through September 30, 2002. The APCA tool was used to estimate background and local contribution. The APCA results were then compared to TCEQ monitoring data. The relationship between DFW daily maximum eight-hour ozone and estimated DFW contribution was fairly consistent among the CAMx results, monitoring results, and aircraft results. All estimates of background show relatively large contributions from background ozone due to regional transport with background usually exceeding local contributions (Table 5-12: Summary of Ozone Apportionment Between Regional Transport and Local Production on Exceedance Days in the DFW Area). This study's modeling and TCEQ's monitoring date from 2002 and the aircraft data includes only a single flight. Therefore despite the agreement of the modeled and observed data, this study alone cannot definitively answer the questions about the current relative importance of local and background ozone contributions.

Table 5-12: Summary of Ozone Apportionment Between Regional Transport and Local Production on Exceedance Days in the DFW Area

Data Source	Average Local Ozone Production	Average Regional Transport of Ozone	Average Maximum 8-hr Average Ozone
CAMx model (all 2002)	46 ppb (46%)	55 ppb (54%)	101 ppb
TCEQ monitors (all 2002)	34 ppb (35%)	62 ppb (65%)	96 ppb
Aircraft (one flight, on 23 August 2000)	27 ppb (28%)	71 ppb (72%)	98 ppb

A second TexAQS II aircraft study was conducted by Senff et al. (2010). While their study focused primarily on Houston, one flight was conducted in the DFW area. This flight measured ozone within the urban plume downwind of the DFW area, and contrasted ozone concentrations in the plume to those outside the plume, i.e., in the regional background. Senff et al. found an enhancement of only 10 ppb within the plume for the single flight. Since only one DFW flight took place, these results cannot be used to represent the characteristics of ozone formation in the DFW area. However, this study conducted six flights in the Houston area including extensive investigation of how much the Houston urban plume can raise regional background concentrations in east Texas. Houston's urban plume was found to raise the ozone concentrations by 10 ppb over an area of more than 40,000 km^2, which indicates that Houston's emissions likely play a role in elevating regional background, and thus increase the likelihood of ozone exceedances in the DFW area and other cities downwind of Houston.

A third study using aircraft observations was conducted in 2005 by Luria et al. (2008). In this study, twelve flights were made in the DFW area, though only a subset of these was suitable for determining the respective roles of regional background and locally produced ozone. Two flight days showed local ozone production of 30 to 40 ppb. TCEQ monitoring sites for the same time period showed local contributions of 22 to 32 ppb, with background contributions of 52 to 62 ppb.

In addition to these aircraft measurement studies, two recent studies used photochemical grid modeling to estimate the effects of out-of-state emissions on DFW ozone pollution. Kim et al. (2009) modeled two episodes, June 19 through 23, 2005, and August 30 through September 9, 2005, and used the decoupled direct method of sensitivity analysis to estimate the sensitivity of DFW ozone to emissions in three areas: within the nine-county DFW nonattainment area, within Texas but outside the DFW area, and outside of Texas. They evaluated the effects of emission reductions in each of these three areas to see how they differed in their effects upon the DFW area. At the Kaufman upwind monitoring site on the eastern side of the DFW metropolitan area, interstate and within-Texas contributions dominated the ozone concentrations with about half of the ozone supplied by these two categories. At the Eagle Mountain Lake downwind site, however, ozone was dominated by contributions from the DFW urban area.

The Kim *et al*. study, however, may underestimate the contribution of local emissions to DFW high ozone and may overestimate the contribution from out-of-state emissions. The out-of-state emissions used in the modeling were derived from the National Emissions Inventory created for 1999, but the emissions for Texas used an inventory for 2005. The out-of-state emissions inventory did not include any emission reductions that took place between 1999 and 2005, but the Texas inventory did. The effect of this discrepancy is that the out-of-state emissions may appear to play a larger role in DFW ozone attainment in this study than they actually do.

Another modeling study (Kemball-Cook et al. 2010) specifically examined the effects of emissions from the hydraulic fracturing and other oil and gas development in the Haynesville Shale in northern Louisiana and northeast Texas on peak ozone concentrations observed in northeast Texas and the DFW area. Two episodes were modeled, May 20 through 30, 2005, and June 13 through 30, 2005. Ozone was modeled for a 2005 base case, 2012 future baseline, and three 2012 future test cases representing three levels of gas development, low, medium, and high. They found that the greatest effect on the DFW area was an episode average increase of about 2 to 3 ppb in maximum eight-hour ozone. This modest increase was found only under the most aggressive development scenario in the Haynesville Shale area; the two less aggressive scenarios found much smaller effects of 0 to 2 ppb in maximum eight-hour ozone.

A study that combined modeling and satellite observations was performed during 2006 (Pierce et al., 2008). Satellite data and Regional Air Quality Modeling System (RAQMS) air quality modeling were used to determine the importance of background ozone production on high ozone (mean daily eight-hour ozone greater than 60 ppb) observed in Houston and Dallas. Most of the high ozone days observed in the DFW area between July and October 2006 were associated with enhanced background ozone production based on RAQMS modeling. Overall, 7 out of 15 elevated eight-hour ozone days examined in DFW during TexAQS II had enhanced background ozone production (> 10 ppb/day), as determined by RAQMS modeling estimates along the back trajectory calculated at 1:00 PM local time. On average, periods of enhanced background ozone production events in DFW were found to have a broad Great Plains/Midwest/Ohio River Valley source, with the largest net enhanced background ozone production (20-30 ppb/day) due to Chicago, Illinois, and Houston, Texas, NO_X sources.

5.5 QUALITATIVE CORROBORATIVE ANALYSIS

5.5.1 Additional Measures

5.5.1.1 VOC Storage Tank Rule

Concurrent with this AD SIP revision, the commission is adopting rules in 30 Texas Administrative Code Chapter 115, Subchapter B, Division 1 to implement reasonably available control technology requirements for the storage of VOC (Rule Project Number 2010-025-115-EN). The Chapter 115 rulemaking revises existing rules to include additional requirements for low-leaking storage tank fittings and to limit situations when floating roof storage tanks are allowed to emit VOC because the roof is not floating on the liquid. The Chapter 115 rulemaking also requires 95% control of flash emissions from crude oil and condensate storage tanks with uncontrolled VOC emissions that equal or exceed 50 tons per year. The VOC emission reductions anticipated to result from the implementation of this rule were not included in the photochemical modeling for this AD SIP revision since the compliance deadline for this rule is March 1, 2013.

5.5.1.2 Energy Efficiency and Renewable Energy (EE/RE) Measures

Energy efficiency efforts are typically programs that reduce the amount of electricity and natural gas consumed by residential, commercial, industrial, and municipal energy consumers. Examples of energy efficiency include increasing insulation in homes, installing compact fluorescent light bulbs, and replacing motors and pumps with high efficiency units. Renewable energy efforts include programs that generate energy from resources that are replenished or are otherwise not consumed as with traditional fuel-based energy production. Examples of renewable energy include wind energy and solar energy projects.

The Texas Legislature has enacted a number of EE/RE measures and programs. The following is a list of Texas EE/RE legislation since 1999.

- 76th Texas Legislature, 1999
  - Senate Bill (SB) 7 (Regular Session)
  - House Bill (HB) 2492 (Regular Session)
  - HB 2960 (Regular Session)
- 77th Texas Legislature, 2001
  - SB 5 (Regular Session)
  - HB 2277 (Regular Session)
  - HB 2278 (Regular Session)
  - HB 2845 (Regular Session)
- 78th Texas Legislature, 2003
  - HB 1365 (Regular Session)
- 79th Texas Legislature, 2005
  - SB 20 (First Call Session)
  - HB 2129 (Regular Session)
  - HB 2481 (Regular Session)

- 80th Texas Legislature, 2007
  - HB 66 (Regular Session)
  - HB 3070 (Regular Session)
  - HB 3693 (Regular Session)
  - SB 12 (Regular Session)
- 81st Texas Legislature, 2009
  - SB 300 (Regular Session)
- 82nd Texas Legislature, 2011
  - HB 51 (Regular Session)
  - HB 2077 (Regular Session)
  - SB 898 (Regular Session)
  - SB 924 (Regular Session)
  - SB 1125 (Regular Session)

SB 5, 77th Texas Legislature, 2001, set goals for political subdivisions in affected counties to implement measures to reduce energy consumption from existing facilities by 5 percent each year for five years from January 1, 2002, through January 1, 2006. In 2007, the 80th Texas Legislature passed SB 12, which extended the timeline set in SB 5 through 2007 and made the 5 percent each year a goal instead of a requirement. The State Energy Conservation Office (SECO) is charged with tracking the implementation of SB 5 and SB 12. Also during the 77th Texas Legislature, the Energy Systems Laboratory (ESL), part of the Texas Engineering Experiment Station, Texas A&M University System, was mandated to provide an annual report on EE/RE efforts in the state as part of the TERP under Texas Health and Safety Code (THSC), §388.003(e). HB 2129, 79th Texas Legislature, 2005, directed the ESL to collaborate with the TCEQ to develop a methodology for computing emission reductions attributable to use of renewable energy and for the ESL to quantify annually such emission reductions. HB 2129 directed the Texas Environmental Research Consortium to use the Texas Engineering Experiment Station to develop this methodology. With the TCEQ's guidance, the ESL produces an annual report detailing these efforts (*Statewide Air Emissions Calculations from Energy Efficiency, Wind and Renewables)*. The report:

- analyzes power production from wind and other renewable energy sources;
- provides quantification of energy savings and NO_X reductions resulting from the installation of wind and other renewable energy sources;
- describes methodologies developed to quantify energy savings and NO_X reductions from energy efficiency, wind and other renewable energy initiatives; and
- provides degradation analysis for future predictions of power production of wind farms.

The ESL documents methods used to develop estimates of energy savings and NO_X emissions reductions resulting from reductions in natural gas consumption and displaced power from conventional electric generation facilities. The ESL used the EPA's Emissions and Generation Resource Integrated Database to spatially allocate energy use and emission reductions among electric generation facilities. THSC, §389.002 and §389.003 contain requirements that the Public Utility Commission of Texas (PUCT), SECO, and the ESL report to the TCEQ all emission reductions resulting from EE/RE projects in Texas. The ESL analyzed the following areas/programs:

Renewable Energies

The 79th Texas Legislature, 2005, amended SB 5 through SB 20, HB 2129, and HB 2481 to add, among other initiatives, the following renewable energy initiatives, which require: 5,880 megawatts of generating capacity from renewable energy by 2015; the TCEQ to develop a methodology for calculating emission reductions from renewable energy initiatives and associated credits; the ESL to assist the TCEQ in quantifying emissions reductions from EE/RE programs; and the PUCT to establish a target of 10,000 megawatts of installed renewable technologies by 2025.

Residential Building Codes and Programs

THSC, Chapter 388: *Texas Building Energy Performance Standards*, as adopted by the 77th Texas Legislature, 2001, states in §388.003(a) that single-family residential construction must meet the energy efficiency performance standards established in the energy efficiency chapter of the International Residential Code. The Furnace Pilot Light Program includes energy savings accomplished by retrofitting existing furnaces. Also included are Seasonal Energy Efficiency Ratio (SEER) 13 upgrades to single-family and multi-family buildings. In January 2006, federal regulations mandated that the minimum efficiency for residential air conditioners be increased from SEER 10 to SEER 13.

Commercial Building Codes

THSC, Chapter 388 states in § 388.003(b) that all other residential, commercial, and industrial construction must meet the energy efficiency performance standards established in the energy efficiency chapter of the International Energy Conservation Code.

Federal Facilities EE/RE Projects

Federal facilities are required to reduce energy use by Presidential Executive Order 13123 and the Energy Policy Act of 2005 (Public Law 109-58 EPACT20065). The ESL compiled energy reductions data for the federal EE/RE projects in Texas.

Political Subdivisions Projects

SECO funds loans for energy-efficiency projects for state agencies, institutions of higher education, school districts, county hospitals, and local governments. Political subdivisions in nonattainment and affected counties are required by SB 5 to report EE/RE projects to SECO. These projects are typically building systems retrofits, nonbuilding lighting projects, and other mechanical and electrical systems retrofits such as municipal water and waste water treatment systems.

Electric Utility Sponsored Programs

Utilities are required by SB 7, 76th Texas Legislature, 1999, and SB 5, 77th Texas Legislature, 2001, to report these projects to the PUCT. See THSC, §386.205 and Texas Utilities Code, §39.905. These projects are typically air conditioner replacements, ventilation duct tightening, and commercial and industrial equipment replacement.

In addition to the programs discussed and analyzed in the ESL report, local governments may have enacted measures beyond what has been reported to SECO and the PUCT. The TCEQ encourages local political subdivisions to promote EE/RE measures in their respective communities and to ensure these measures are fully reported to SECO and the PUCT.

HB 3693, 80th Texas Legislature, 2007, amended the Texas Education Code, Texas Government Code, THSC, and Texas Utilities Code. The bill:

- requires state agencies, universities and local governments to adopt energy efficiency programs;

- provides additional incentives for electric utilities to expand energy conservation and efficiency programs;
- includes municipal-owned utilities and cooperatives in efficiency programs;
- increases incentives and provides consumer education to improve efficiency programs; and
- supports other programs such as revision of building codes and research into alternative technology and renewable energies.

Emissions reductions resulting from the above programs were not explicitly included in the photochemical modeling because local efficiency efforts may not result in local emissions reductions or may be offset by increased demand in electricity. The complex nature of the electrical grid also makes accurately quantifying emission reductions from EE/RE projects difficult. At any given time, it is impossible to determine exactly where on the electrical grid electricity comes from for any certain electrical user. The electricity for a user could be from a power plant in west Texas, a nearby attainment county or from within the nonattainment area. If electrical demand is reduced in the DFW area due to these kinds of measures, then emission reductions from power generation facilities may occur in any number of locations around the state.

Clean Air Interstate Rule (CAIR) and Cross-State Air Pollution Rule

Under CAIR, 28 eastern states (plus the District of Columbia) were required to comply with a cap on sulfur dioxide (SO_2) and NO_X for EGU emissions. The definition of an EGU for the CAIR program is approximately the same definition as that for a Federal Clean Air Act (FCAA) Title IV Acid Rain unit (i.e., larger than 25 megawatt and more than one-third of its generation going to the public grid for sale). CAIR is a cap and trade program, with each of the CAIR-applicable states given a calculated NO_X budget and a calculated SO_2 budget by the EPA. The EPA modeled all of these states in order to test the effectiveness of controls. A result of the EPA's CAIR modeling was that Texas "significantly contributed" to the nonattainment of the particulate matter of 2.5 microns and less ($PM_{2.5}$) standard of two counties in Illinois, therefore, Texas was included in CAIR for the transport of $PM_{2.5}$. Texas was not covered under the CAIR program for 1997 eight-hour ozone standard contribution.

CAIR was to be implemented in two phases: for NO_X, Phase I covers the years 2009 through 2014 and Phase II is for the years 2015 and later; for SO_2, Phase I covers the years 2010 through 2014 and Phase II is for the years 2015 and later. The Phase I NO_X budget calculated and assigned to Texas was 181,014 tons per year, and the Phase II NO_X budget was 150,845 tons per year.

See Appendix B: *Emissions Modeling for the DFW Attainment Demonstration SIP Revision for the 1997 Eight-Hour Ozone Standard*, Section 2.2.3.1: *EGUs* for the procedural details that the TCEQ used to simulate CAIR Phase I in Texas and the regional states.

On July 11, 2008, the United States Court of Appeals District of Columbia Circuit (Court) (No. 05-1244) vacated CAIR and the CAIR Federal Implementation Plan. On December 23, 2008, the Court issued a revised opinion to remand, without vacating, CAIR to the EPA. CAIR, therefore, remained in effect while the EPA completed rulemaking to replace the program and comply with the Court's July 2008 opinion.

For more information on the ruling, see the EPA's CAIR Web page (http://www.epa.gov/cair/), or the TCEQ CAIR Web page (http://www.tceq.texas.gov/airquality/sip/caircamr.html).

On July 6, 2011, the EPA finalized its CAIR replacement rule, known as the Cross-State Air Pollution Rule (CSAPR) requiring 27 states to reduce power plant emissions that contribute to ozone and fine particle pollution in other states. The rule, effective October 7, 2011, is intended to help eastern states meet FCAA obligations regarding interstate transport of air pollution for the 1997 ozone and $PM_{2.5}$ and 2006 $PM_{2.5}$ NAAQS. The rule requires reductions in ozone season NO_X emissions that cross state lines for states under the ozone requirements and reductions in annual SO_2 and NO_X for states under the $PM_{2.5}$ requirements. Texas is included in both the ozone and the $PM_{2.5}$ program requirements. To assure emissions reductions, the EPA is promulgating Federal Implementation Plans (FIPs) for each of the states covered by the rule. Alternatively, States may choose to develop AD SIP revisions to replace the FIP after implementation. The rule, which was published in the *Federal Register* on August 8, 2011 (76 FR 48208), requires controls to be implemented beginning in 2012.

CSAPR was released during the comment period for this DFW AD SIP revision, so the details of the rule were not available at the time of modeling for this SIP. However, CSAPR yields more emission reductions in 2012 than would CAIR. Specifically, CSAPR reduces modeled Acid Rain Database (ARD) NO_X emissions outside Texas by approximately 10% compared to the CAIR cap. In the three adjacent states of Louisiana, Arkansas, and Oklahoma, modeled CSAPR ARD NO_X emissions total 24% less than CAIR. Modeled Texas ARD sources are calculated to receive an 18% reduction in NO_X allocations with CSAPR compared to CAIR.

A 2012 modeling sensitivity was conducted using CSAPR allocations for the entire country. Note that CSAPR allocations used for the modeling sensitivity were those published in the CSAPR final rule on August 8, 2011 (76 FR 48208). On October 6, 2011, the EPA signed proposed revisions to the CSAPR rule that would revise allowance allocations for several states, including Texas. Given the timing, it was not possible to complete a 2012 modeling sensitivity using those proposed, revised CSAPR allocations. The 2012 modeling sensitivity using the August 8, 2011, allocations is detailed in Section 5.5.1.5: *Alternative Modeling Emissions: Cross State Air Pollution Rule Point Source (CSAPR) Emissions* of Appendix C. In general, ozone concentrations in 2012 with CSAPR were lower than with CAIR.

5.5.1.3 TERP

The TERP program was created in 2001 by the 77th Texas Legislature to provide grants to offset the incremental costs associated with reducing NO_X emissions from high-emitting internal combustion engines. From the beginning of the TERP program in 2001, through July 20, 2011, the TERP program had funded over $890.5 million in grants for projects in Texas ozone nonattainment and near-nonattainment areas. Over $310 million has been awarded to projects in the DFW area since 2001, which will help reduce more than 62,000 tons of NO_X emissions. Of that $310 million, $22 million was awarded to the North Central Texas Council of Governments (NCTCOG) through a third-party grant to administer additional grants in the DFW area.

Additional funds are expected to be awarded to the DFW area in subsequent grant application periods that will result in further NO_X reductions. HB 1796, 81st Texas Legislature, 2009, extended the TERP program beyond its current 2013 date to 2019, which will result in continued reductions in the significant emissions source categories of on-road and non-road engines. The TERP funding appropriation for the 2012-2013 fiscal biennium is about half of the funding level for the previous biennium.

5.5.1.4 LIRAP

SB 12, 80th Texas Legislature, 2007, enhanced the LIRAP, also known as AirCheckTexas Drive a Clean Machine (DACM), to expand participation by increasing the income eligibility to 300% of the federal poverty rate and increasing the amount of assistance toward the replacement of a retired vehicle. HB3272, 82nd Texas Legislature, 2011, Regular Session, further enhanced the LIRAP to expand participation by allowing a motorist to participate if their vehicle has been registered in a participating county for 12 of the 15 months preceding application for assistance. HB3272 also revised program requirements for vehicles available as replacements.

The LIRAP provides $3,000 for cars of the current or previous three model-years; $3,000 for trucks of the current or previous two model-years; and $3,500 for hybrids, electric, natural gas, and all vehicles that have been certified to meet federal Tier 2, Bin 3 or cleaner standards of the current or previous three model-years. Replacement vehicles cannot cost more than $35,000, or $45,000 for hybrids, electric, natural gas, and all vehicles that have been certified to meet federal Tier 2, Bin 3 or cleaner standards before tax, title, and license fees. In addition, replacement vehicles must have an odometer reading of not more than 70,000 miles. The retired vehicle must be ten years or older or have failed an emissions test. The LIRAP also provides up to $600 for repair assistance to qualified motorists of a vehicle that has failed an emissions inspection.

In the DFW area, the LIRAP is available to vehicle owners in nine counties: Collin, Dallas, Denton, Ellis, Johnson, Kaufman, Parker, Rockwall and Tarrant. Between December 2007 and May 31, 2011, the LIRAP/DACM program has repaired 8,976 vehicles and retired and replaced 23,923 vehicles at a cost of $76,187,435. The LIRAP was appropriated $6.25 million for Fiscal Year (FY) 2012 and FY 2013 by the 82nd Texas Legislature.

5.5.1.5 Local Initiatives

The NCTCOG submitted an assortment of locally implemented strategies in the DFW area including pilot programs, new programs, or programs with pending methodologies. These programs are expected to be implemented in the nine-county nonattainment area by March 2012. Due to the continued progress of these measures, additional air quality benefits will be gained and will further reduce precursors to ground level ozone formation. A summary of each strategy is included in Appendix H: *Local Initiatives Submitted by the North Central Texas Council of Governments*.

5.5.1.6 Voluntary Measures

The oil and natural gas industry has in some instances voluntarily implemented controls and practices to reduce VOC emissions from oil and natural gas operations in the DFW area as well as other areas of the state. Examples of these voluntary efforts include: installing vapor recovery units on condensate storage tanks; using low-bleed natural gas actuated pneumatic devices; and implementing practices to minimize VOC emissions during well completions (i.e., “Green Completions”). The EPA’s Natural Gas STAR Program provides details on these and other practices recommended by the EPA as voluntary measures to reduce emissions from oil and natural gas operations and improve efficiency. Additional information on the EPA Natural Gas STAR Program may be found at http://www.epa.gov/gasstar/.

The preliminary results from the TCEQ’s Barnett Shale Special Inventory Phase One and Phase Two support that some companies are implementing such voluntary practices. For example, initial estimates from the survey data indicate that use of low-bleed pneumatic devices by some companies may be more prevalent than expected and that the TCEQ’s estimates used for the DFW AD SIP revision may be conservative. Additional information on the Barnett Shale Special Inventory Phase One and Phase Two preliminary results may be found at http://www.tceq.texas.gov/airquality/point-source-ei/psei.html. While these industry practices are not enforceable under the SIP, these voluntary efforts help reduce VOC emissions in the nonattainment area. The TCEQ supports and encourages these proactive efforts to help improve air quality in the DFW area.

5.6 CONCLUSIONS

The TCEQ has used several sophisticated technical tools to evaluate the past and present causes of high ozone in the DFW area in an effort to predict the area's future air quality. Photochemical grid modeling performance has been rigorously evaluated. Historical trends in ozone and ozone precursor concentrations and their causes have been investigated extensively. The following conclusions can be reached from these evaluations.

First, the photochemical grid modeling performs relatively well. Problems observed with the modeling are those that are known to exist in all photochemical modeling exercises. In spite of the known shortcomings, the model can be used carefully to predict ozone concentrations. The photochemical grid modeling predicts that the 2012 future year ozone design values in the DFW area will be below the 0.08 ppm eight-hour ozone standard. The dynamic model evaluations show that the model response to emission decreases is similar to the response observed in the atmosphere, suggesting that the future design value will attain the 1997 eight-hour ozone standard.

Second, the ozone trend analyses show that ozone has decreased significantly since the late 1990s. The 2010 eight-hour ozone design value has dropped to 86 ppb. NO_X and VOC trends also show significant decreases. Significant decreases in ozone precursors coincide with the decreases in ozone, indicating that the ozone decreases observed in the DFW area are due to local and regional emission controls.

Based on the photochemical grid modeling results and these corroborative analyses, the weight of evidence indicates that the DFW area will attain the 1997 eight-hour ozone standard by June 15, 2013.

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CHAPTER 6: ONGOING INITIATIVES

6.1 INTRODUCTION

The Texas Commission on Environmental Quality (TCEQ) is committed to improving the air quality in the Dallas-Fort Worth (DFW) area and continues to work toward identifying and reducing ozone precursors. Texas is investing resources into technological research and development for advancing pollution control technology and refining quantification of emissions, improving the science for ozone modeling and analysis. Refining emissions quantification helps improve understanding of ozone formation, which benefits the state implementation plan (SIP). Additionally, the TCEQ is working with the United States Environmental Protection Agency, local area leaders, and the scientific community to identify new measures for reducing ozone precursors. This chapter describes ongoing technical work that will be beneficial to improving air quality in Texas and the DFW area.

6.2 ONGOING WORK

6.2.1 Barnett Shale Special Emissions Inventory

The Barnett Shale is a geological formation that produces natural gas and is located in part of the DFW 1997 eight-hour ozone nonattainment area. The Barnett Shale formation extends west and south from the city of Dallas, covering 5,000 square miles. Drilling permits for wells located in the Barnett Shale formation had been issued in 24 counties in north Texas as of 2010. The TCEQ has recently conducted the second phase of a special inventory under the authority of 30 TAC §101.10(b)(3) to gather detailed information about Barnett Shale emissions sources on the source (unit) level, including emissions data and authorization information.

The first phase of this inventory was completed in 2010 and gathered information about the location, number, and type of emission sources associated with upstream and midstream oil and gas operations in the Barnett Shale. The results of the first phase were used to improve the compressor engine population profile in the DFW area. The improved profile was used to determine emissions estimates for the area source category.

The second phase of the inventory began in late 2010 and involved requesting information about emissions. The TCEQ contacted 279 companies in the Barnett Shale area and requested companies with 2009 production or transmission of oil or gas from the Barnett Shale formation to complete standardized forms detailing source emissions data, source location, information on receptors located within one-quarter mile of a source, and authorization information. Data for over 8,000 sites were received in 2011.

Barnett Shale area emissions survey results were still under review at the time of the compilation of the inventory for this DFW AD SIP revision. For activities in the Barnett Shale formation, initial draft NO_X special inventory emissions were commensurate to those estimated for this AD SIP revision, while initial draft VOC special inventory emissions were below those estimated for this AD SIP revision. Final results will be considered to improve emissions estimates in future AD SIP revisions for the DFW ozone nonattainment area.

6.2.2 Statewide Drilling Rigs Emissions Inventory

The improvement or enhancement of drilling rig emission estimates can be used for future attainment demonstration and reasonable further progress SIP revisions and other air quality analyses. The updated inventories will include controlled and uncontrolled drilling rig emissions from 1990 through 2040.

6.2.3 Surface Measurements and One-Dimensional Modeling Related to Ozone Formation in the Suburban DFW Area

Surface measurements of trace gas and radical mixing ratios (VOC, NO_X, carbon monoxide (CO), hydroxyl radical, nitric and nitrous acids, etc.), meteorological properties (including boundary layer height), and aerosol properties (concentration, composition, and size distribution) relevant for ozone formation were made during a field campaign in the DFW suburban area during May and June of 2011. One-dimensional (1D) chemical transport modeling will be used to identify key VOC emissions and atmospheric reactions that lead to ozone formation in the DFW region and to characterize chemical and meteorological conditions in the atmospheric boundary layer that lead to ozone accumulation and National Ambient Air Quality Standard exceedances. The combination of measurements and 1D modeling output will be provided to regional, three-dimensional air quality modelers to inform regional studies on the inclusion of key emissions and chemical processing for improved accuracy of ozone modeling in the region.

6.2.4 DFW Measurements of Ozone Production

To help reduce improve the understanding of the conditions contributing to photochemical ozone production in the DFW area, two new Measurements of Ozone Production Sensors (MOPS) were developed by Pennsylvania State University. The MOPS were deployed to continuously measure ozone production rates in the DFW region. The data are expected to show the temporal and spatial variability of *in situ* net ozone production rates in the DFW area, as well as potential NO_x sensitivity. The fraction of locally produced or transported ozone will also be determined. The measurements of the ozone production rates are expected to improve the performance of photochemical models.

6.2.5 Airborne Measurements to Investigate Ozone Production and Transport in the DFW Area During the 2011 Ozone Season

The University of Houston (UH) aircraft-based Air Quality Monitoring Team conducted, as part of the Air Quality Research Program, an Airborne Measurements Investigation in the DFW area during the 2011 ozone season. The constituents and mechanics of ozone formation and transport of ozone and precursors are the primary concerns of interest for this effort. UH developed a Quality Assurance Project Plan for this project and collected airborne monitoring samples on five flight plans in and around the DFW area during the 2011 ozone season. The aircraft airborne sampling data will be used as a complement to ground based monitoring to better understand the atmospheric chemistry, meteorology, and transport of relevant pollutants in the area.

6.2.6 Quantification of Industrial Emissions of VOCs, NO2 and SO2 by Solar Occultation Flux (SOF) and mobile Differential Optical Absorption Spectroscopy (DOAS)

A measurement study was conducted that will help to locate and quantify industrial VOC emissions (alkanes, alkenes and partly aromatics), nitrogen dioxide, and sulfur dioxide using advanced measurement techniques such as the Solar Occultation Flux and mobile Differential Optical Absorption Spectroscopy. During part of the campaign a mobile extractive Fourier Transform Infrared Spectroscopy was also used. This study followed up previous measurements in 2006 and 2009 to obtain a trend analysis for selected sites, but was also extended to new areas to improve the understanding of short- and long-term variability. Thus the study objectives are relevant for the AQRP priority research area about emissions, emphasizing the need to improve the uncertainty of industrial gas emissions (VOC and NO_X) that lead to the formation of tropospheric ozone. The study areas included locations in the Dallas area.

Appendices available upon request

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