CHAPTER 1: PROTOCOL FOR THE EIGHT-HOUR OZONE MODELING OF THE DALLAS-FORT WORTH AREA

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List of Acronyms

AFS – AIRS Facility Subsystem Format
AFWA – Air Force Weather Agency
AGL – Above Ground Level
AIRS – Aerometric Information Retrieval System
AMDA – Air Modeling and Data Analysis Section
APCA – Anthropogenic Precursor Culpability Assessment
AQP – Air Quality Planning
ARD – Acid Rain Data
ATR – Automatic Traffic Recorder
BPA – Beaumont-Port Arthur
CAIR – Clean Air Interstate Rule
CAMS – Continuous Ambient Monitoring Station
CAMx – Comprehensive Air Model with Extensions
CB6 – Carbon Bond Mechanism, Version 6
CENRAP – Central Region Air Program
DDM – Direct Decoupled Method
DFW – Dallas-Fort Worth
DV – Design Value
DV_B – Baseline Design Value
DV_F – Future Design Value
EDP – Emission Density Plot
EGAS – Economic Growth Analysis System
EGU – Electrical Generating Unit
EI – Emissions Inventory
EPA – United States Environmental Protection Agency
EPS3 – Emissions Processing System, Version 3
ERG – Eastern Research Group
GEOS-CHEM – Goddard Earth Observing Systems Chemistry Model
GEWEX - Global Energy and Water Cycle Experiment
GLOBEIS – Global Biosphere Emissions and Interactions System
GOES – Geostationary Operational Environmental Satellite
GWEI – Gulf Wide Emissions Inventory
HDDM – Higher-Order Direct Decoupled Method
HGB – Houston-Galveston-Brazoria
HPMS – Highway Performance Monitoring System
km – Kilometer
Leaf Area Index – LAI
LCC – Lambert Conformal Conic Projection
LULC – Land-use Land-cover
m – Meters
MATS – Modeled Attainment Test Software
MEGAN – Model of Emissions of Gases and Aerosols from Nature
MM5 – Fifth Generation Meteorological Model
MNB – Mean Normalized Bias
MNGE – Mean Normalized Gross Error
MODIS – Moderate Resolution Imaging Spectroradiometer
MOVES – Motor Vehicle Emission Simulator
NAAQS – National Ambient Air Quality Standard
NASA – National Aeronautics and Space Administration

NCAR – National Center for Atmospheric Research
NCEP – National Centers for Environmental Prediction
NEI – National Emissions Inventory
NMIM – National Mobile Inventory Model
NO_X – Nitrogen Oxides
OSAT – Ozone Source Apportionment Technology
OSD – Ozone Season Day
PA – Process Analysis
PAR – Photosynthetically Active Solar Radiation
PBL – Planetary Boundary Layer
PFT – Plant Functional Type
PiG – Plume in Grid
ppb – Parts per Billion
ppm – Parts per Million
PSCFv2 – Potential Source Contribution Factor, version 2
QA – Quality Assurance
QC – Quality Control
REMI – Regional Economic Models, Inc.
RPO – Regional Planning Organizations
RRC – Railroad Commission of Texas
RRF – Relative Response Factor
RRTM – Rapid Radiative Transfer Model
SCC – Source Classification Code
SI – Special (emissions) Inventory
SIP – State Implementation Plan
SMOKE – Sparse Matrix Operator Kernel Emissions
STARS – State of Texas Air Reporting System
TATU – TCEQ Attainment Test for Unmonitored areas
TCEQ – Texas Commission on Environmental Quality
TDM – Travel Demand Model
TexAER – Texas Air Emissions Repository
TexAQS II – Second (2006) Texas Air Quality Study
TexN – Texas NONROAD Model
TLL – Tank Landing Loss
tpd – Tons Per Day
TTI – Texas Transportation Institute
TxDOT – Texas Department of Transportation
UPA – Unpaired Peak Accuracy
U.S. – United States
USGS – U.S. Geological Survey
VMT – Vehicle Miles Traveled
VOC – Volatile Organic Compounds
YSU – Yonsei University
WRF – Weather Research and Forecasting Model
WSM6 – WRF Single-Moment 6-Class Microphysics Scheme

1.1 SUMMARY

This protocol presents procedures the Texas Commission on Environmental Quality (TCEQ) is using or plans to use for modeling ozone formation in the Dallas-Fort Worth (DFW) area with the Comprehensive Air Quality Model with Extensions (CAMx), which is an acceptable photochemical model (see Table 13.1; United States Environmental Protection Agency [EPA], 2007). Under the 75 parts per billion (ppb) eight-hour ozone standard, the DFW area was designated in 2012 as moderate nonattainment, which requires the state to demonstrate that the standard will be achieved within six years. The focus of this modeling is to support a demonstration of attainment of the 75 ppb ozone standard by December 31, 2018. Future case anthropogenic emission inventories will be developed for the 2018 ozone season, but the meteorological and biogenic emission inputs for the modeling will be based on two ozone episodes that occurred during 2006:

- 33-day span from May 31 through July 2, 2006; and
- 34-day span from August 13 through September 15, 2006.

When appropriate, this protocol will reference the former as the June episode and the latter as the August/September episode. When referring to them both collectively, the protocol will call them the 2006 base case. Both of these month-long episodes have an extensive number of days with typical meteorological conditions associated with the formation of unhealthy levels of ozone. Historically, ozone concentrations in the DFW area peak during May/June and August/September. On average, monitored ozone concentrations do not peak in July in both DFW and the rest of Texas due to the steady off-shore southerly wind patterns that tend to dominate during this mid-summer period. Use of these June and August/September episodes from 2006 will help to predict future peak ozone levels in the DFW nonattainment area. This modeling analysis will rely heavily upon data and knowledge gained from previous modeling experience and the second Texas Air Quality Study (TexAQS II). Recent scientific advancements will be incorporated as appropriate and as time allows.

The objective of this modeling protocol is to maintain and enhance the technical credibility of the study by establishing in advance agreed upon procedures for conducting a successful modeling project. A second but potentially even more important objective of this modeling is to continue advancing the understanding of the many complex processes and interactions that cause ozone standard exceedances in north central Texas. Section 2: *Modeling/Analysis Study Design* of the protocol describes the study design, including the background, managerial organizational structure, schedule, and modeling episode selection. Section 3: *Models and Inputs* presents the model selection decisions. The remainder of the protocol describes the structure of the modeling system, the development of required model databases, the plans for model performance evaluation, the procedures to determine whether proposed control strategies are sufficient to show attainment of the eight-hour ozone standard, and the procedures for documenting the study results.

This protocol reflects the current plans of the TCEQ but may be modified to account for new science, better modeling tools, changes in resources, or other events. This protocol should be considered a living document, which changes as necessary to reflect the current plans of the TCEQ in coordination with the EPA Region 6 and attendees of periodic photochemical modeling meetings held in the DFW area.

Current plans are to propose an attainment demonstration State Implementation Plan (SIP) revision based on this modeling in December 2014, followed by adoption in June 2015 and subsequent submission to EPA. The purpose of the SIP revision is to satisfy requirements for an eight-hour ozone attainment demonstration.

1.2 MODELING/ANALYSIS STUDY DESIGN

This modeling protocol describes the procedures that will be used in the development of new ozone modeling for the DFW nonattainment area ozone SIP revision. These procedures generally conform to the recommendations set forth in the EPA *Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, PM2.5, and Regional Haze* (EPA, 2007). This guidance was originally developed for the previous 84 ppb ozone standard and has not been modified for application to the 75 ppb standard. If the EPA releases either draft or final revisions to this guidance, the TCEQ will revise the modeling procedures accordingly provided that such changes will not interfere with meeting the DFW attainment demonstration SIP revision December 2014 proposal and June 2015 adoption dates. As per the EPA guidance, this protocol includes the following sections:

- background for the study;
- schedule and organizational structure for the study;
- rationale for model selection and description of models to be used;
- methods for developing input data;
- methods for evaluating and interpreting model results;
- procedures for using the model to determine whether proposed control strategies are sufficient to ensure attainment of the National Ambient Air Quality Standard (NAAQS); and
- documentation to be submitted to the regional EPA office for review.

1.2.1 Background

The 1990 Federal Clean Air Act Amendments established five classifications for ozone nonattainment areas based on the magnitude of the monitored one-hour ozone design values, and established dates by which each classified area should attain the NAAQS. Based on the monitored one-hour ozone design value at that time, the DFW Consolidated Metropolitan Statistical Area (Collin, Dallas, Denton, and Tarrant counties) was classified moderate with an attainment date of 1996. On October 16, 2008, the EPA published final notice in the *Federal Register* of one-hour ozone standard attainment in the four-county DFW area, and suspended one-hour SIP requirements so long as the standard is maintained.

With the change in the form of the ozone NAAQS from a one-hour standard to an eight-hour standard in 1997, EPA designated Collin, Dallas, Denton, Ellis, Johnson, Kaufman, Parker, Rockwall, and Tarrant counties as a moderate ozone nonattainment area with an attainment date of June 15, 2010. On May 23, 2007, the commission adopted the DFW Attainment Demonstration SIP Revision for the 1997 Eight-Hour Ozone Standard showing via photochemical modeling and corroborative analyses that the DFW area would attain the eight-hour standard. EPA conditionally approved the DFW Attainment Demonstration SIP Revision on January 14, 2009 (EPA, 2009).

Despite showing a reduction of 10 ppb in its eight-hour design value in a three-year period from 2006 to 2009, the DFW area failed to meet the 1997 eight-hour ozone standard by June 15, 2010, missing attainment by two ppb. Because of this failure to attain, the EPA reclassified the DFW area to a Serious nonattainment classification with an attainment date of June 15, 2013. From 2010 through 2012, 15 of the 17 regulatory monitors in the DFW area had three-year ozone design values ranging from 69 to 83 ppb. However, two of these regulatory monitors had three-year ozone design values above the 84 ppb standard. The Keller monitor had a 2012 design value of 87 ppb, and the Grapevine-Fairway monitor had a 2012 design value of 86 ppb. Both of these monitors are located in the northwest quadrant of the DFW area where the highest ozone concentrations are usually measured.

Ozone nonattainment designations under the revised 75 ppb eight-hour ozone standard become effective on July 20, 2012. As shown in Figure 1-1: DFW Ten-County Nonattainment Area, the EPA classified the ten counties of Collin, Dallas, Denton, Ellis, Johnson, Kaufman, Parker, Rockwall, Tarrant, and Wise as moderate nonattainment with a required attainment date of December 31, 2018. This protocol details the schedule, methodology, and procedures for photochemical modeling in support of the required new demonstration of attainment for this 75 ppb standard.

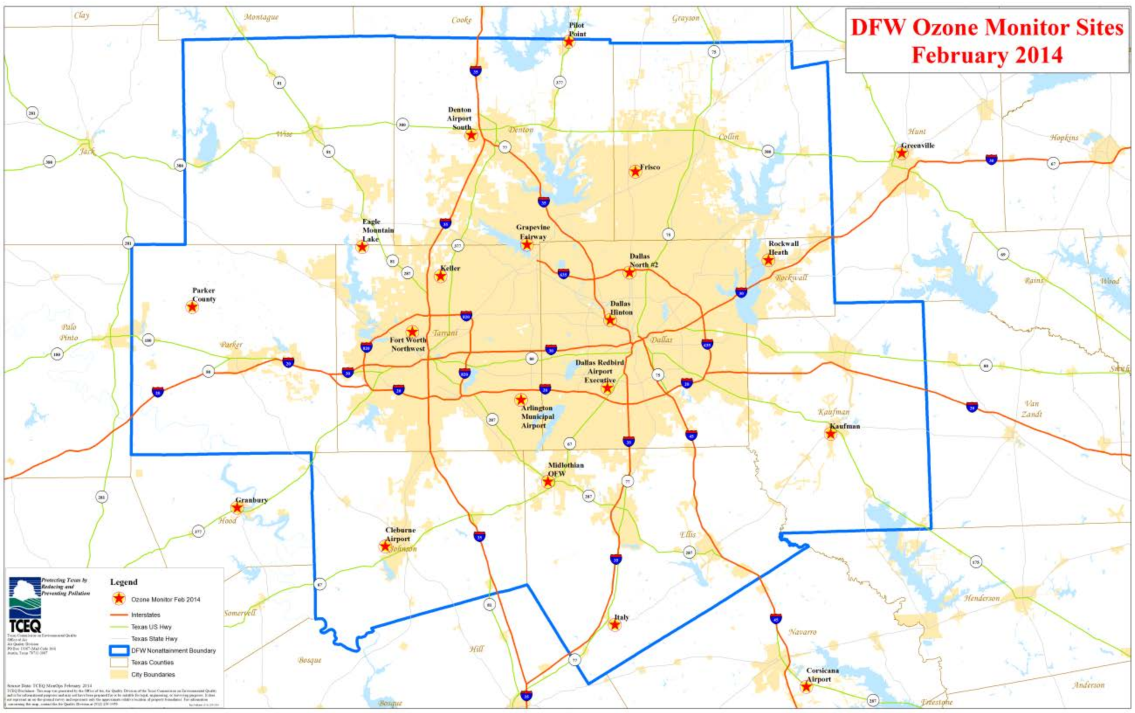

Figure 1-1: DFW Ten-County Nonattainment Area

1.2.2 Management Structure

The Air Modeling and Data Analysis (AMDA) section has the responsibility for planning and conducting the eight-hour ozone SIP modeling. AMDA is part of the Air Quality Division of the TCEQ Office of Air. The Office of Air organization chart is shown in Figure 1-2: TCEQ Management Organization Chart.

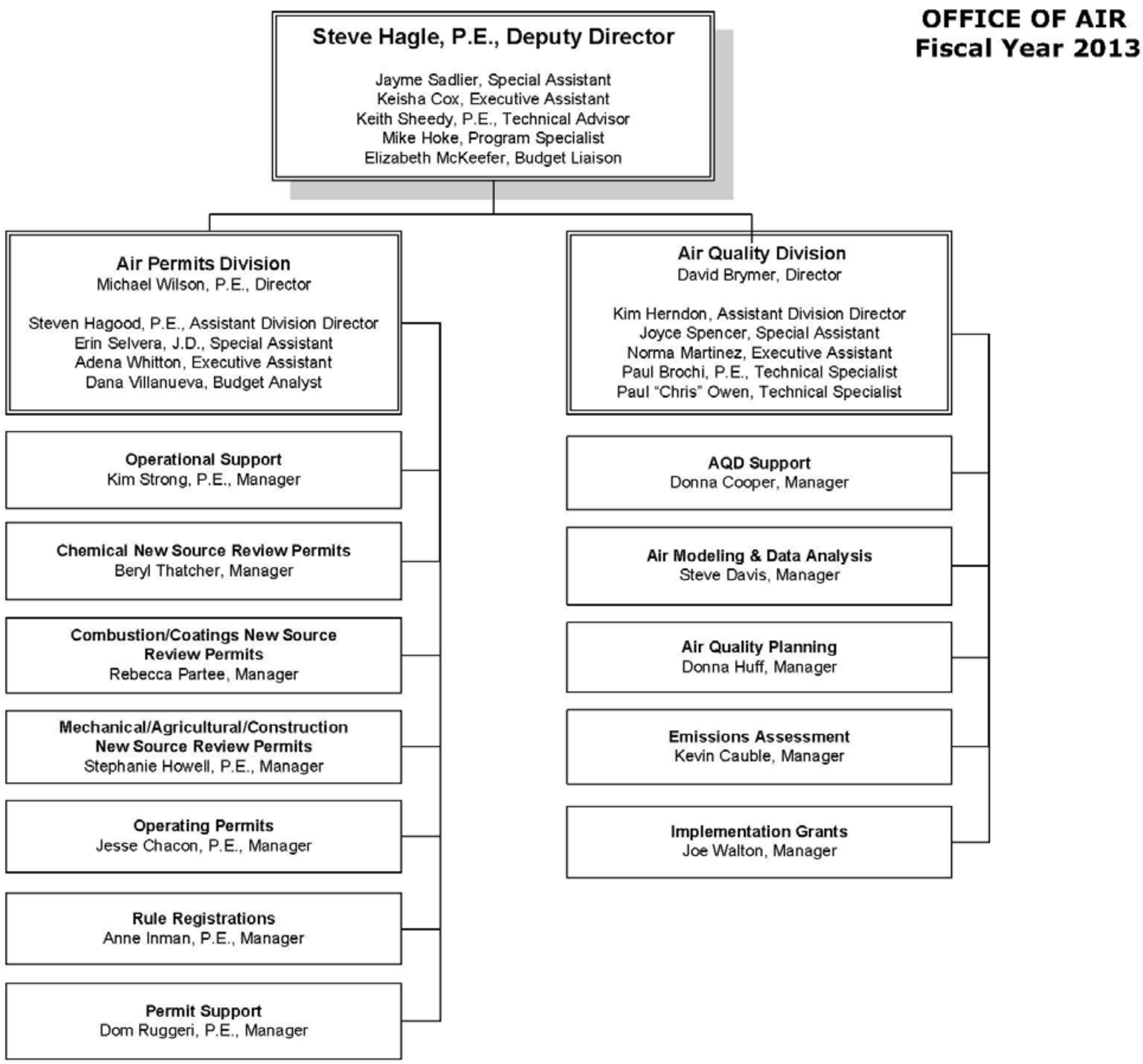

Figure 1-2: TCEQ Management Organization Chart

1.2.3 Technical and Policy Organizations

1.2.3.1 DFW Photochemical Modeling Technical Meetings

Photochemical modeling technical meetings will be held in the DFW area so that local stakeholders may provide technical and scientific input to the ozone modeling process. The TCEQ plans to hold such meetings when technical updates are available. Up until the date of SIP adoption, it is anticipated that four to six meetings will occur annually. Meeting materials (e.g., agendas, technical presentations, etc.) will be posted to the TCEQ website for public access (TCEQ, 2013).

1.2.3.2 Schedule of Modeling Activities

The schedule of activities for this eight-hour modeling analysis is shown below in Table 1-1: Schedule of DFW Modeling Activities. The dates shown are the best current estimates and are likely to change based on problems encountered, emerging research findings, and other requirements. Detailed discussions of most of these activities can be found later in this document.

Table 1-1: Schedule of DFW Modeling Activities

Modeling Activity	Time Frame
Conduct base case and baseline modeling • Develop base case/baseline emissions • Conduct meteorological modeling • Conduct emissions modeling and processing • Conduct model performance evaluations	March 2013 – December 2013
Conduct future baseline modeling with current controls and project future design values • Develop future baseline emissions with applicable growth and current controls • Project future design values • Conduct VOC/NO_X matrix modeling if the future design value is above weight-of-evidence range (estimating additional emission reductions) • Conduct attainment modeling with current and proposed controls • Conduct modeling sensitivity runs • Conduct attainment modeling with possible controls	July 2013 – July 2014

1.2.4 Conceptual Model of Ozone Formation

A previous DFW conceptual model of ozone formation is detailed in the *Conceptual Model for the DFW Attainment Demonstration SIP Revision for the 1997 Eight-Hour Ozone Standard* (TCEQ, 2011). This analysis will be updated with monitoring data collected through the 2012 ozone season for the scheduled DFW attainment demonstration SIP revision proposal in December 2014. If time allows, the conceptual model may be updated with 2013 ozone season data for the scheduled DFW attainment demonstration SIP revision adoption in June 2015.

1.2.5 Episode Selection

The selection of the modeling episode is detailed in Attachment 1: Episode Selection for the DFW Attainment Demonstration SIP Revision for the 2008 Eight-Hour Ozone Standard.

1.3 MODELS AND INPUTS

The modeling system is composed of a gridded photochemical air quality model, a meteorological model, and an emissions processing model. Both the meteorological and emissions models provide input to the air quality model. Therefore, the air quality, meteorological, and emission models selected need to interface effectively.

1.3.1 Model Selection

1.3.1.1 Selection of Air Quality Model

To ensure that a modeling study can be successfully used as technical support for an attainment demonstration SIP revision, the air quality model must be scientifically sound and appropriate for the intended application, and be freely accessible to all stakeholders. In a regulatory environment, it is crucial that oversight groups (e.g., EPA), the regulated community, and the interested public have access to and also can be convinced 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 SIP revision:

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

The only model to meet all three of these criteria is CAMx. The model is based on well-established treatments of advection, diffusion, deposition, and chemistry. Another important feature is that nitrogen oxides (NO_X) emissions from large point sources can be treated with the plume-in-grid (PiG) sub-model, which helps avoid the artificial diffusion that occurs when point source emissions are introduced into a grid volume. The model software and the CAMx user's guide are publicly available. In addition, the TCEQ has many years of experience with CAMx. CAMx was used for previous DFW attainment demonstration SIP revisions, for the Houston-Galveston-Brazoria (HGB) and Beaumont-Port Arthur (BPA) areas, as well as for modeling being conducted in other areas of Texas (e.g., Austin, San Antonio, and Tyler-Longview-Marshall).

At this time, the TCEQ plans to use CAMx 6.00 because it is the most recent version available. If subsequent versions (referenced as CAMx 6.0+) are released prior to the June 2015 DFW attainment demonstration SIP revision adoption date, the TCEQ will review each version for potential improvement to the modeling platform. Updated versions of CAMx will likely be used if they offer such improvements and no operational bugs are identified. Compared to previous versions, CAMx 6.00 includes the following updates:

- revised gridded file formats for meteorology inputs, initial/boundary conditions, emission inputs, output concentration values, and deposition fields;
- photolysis rate updates based on inputs for surface albedo, height above ground, terrain height, solar zenith, clouds, temperature, and barometric pressure; and
- new gas-phase chemistry mechanisms for Carbon Bond 6 (CB6) speciation and CB6 "revision 1" (CB6r1), which revises isoprene and aromatics extensively, and has additional NO_X recycling from organic nitrates.

More information on these updates can be found in Chapter 1 of the CAMx user's guide (Environ, 2013). At this time, a CB6 "revision 2" (CB6r2) is under development that may be utilized to improve base case ozone performance. In addition, the TCEQ plans to use some of the probing tools supported by CAMx 6.00 for sensitivity analyses, including:

Process Analysis (PA) - PA adds algorithms to the CAMx model that store the integrated rates of species changes due to individual chemical reactions and other sink and source processes. By integrating these rates over time and outputting them at hourly intervals, PA provides diagnostic outputs that can be used to explain model simulation in terms of chemical budgets, conversions of chemical species, and effects of transport and other sink and source terms. Process analysis can also improve model validation and ultimately can assist in the selection of precursor reduction strategies (Tonnesen, 2001).

Ozone Source Apportionment Technology (OSAT) - OSAT provides a method for estimating the contributions of multiple source areas, categories, and pollutant types to ozone formation in a single model run. OSAT also includes a methodology for diagnosing the temporal relationships between ozone and emissions from groups of sources.

Anthropogenic Precursor Culpability Assessment (APCA) - APCA differs from OSAT in recognizing that certain emission groups are not controllable (e.g., biogenic emissions) and that apportioning ozone production to these groups does not provide information that is beneficial to control strategies. Where OSAT would attribute ozone production to biogenic emissions, APCA reallocates that ozone production to the controllable portion of precursors that participated in ozone formation with the non-controllable precursor. APCA would only attribute ozone production to biogenic emissions when ozone formation is due to the interaction of biogenic volatile organic compounds (VOC) with biogenic NO_X. When ozone formation is attributable to biogenic VOC and anthropogenic NO_X under VOC-limited conditions, OSAT would attribute ozone production to biogenic VOC while APCA would redirect that attribution to the anthropogenic NO_X precursors present.

Direct Decoupled Method (DDM) and Higher-Order Direct Decoupled Method (HDDM) – DDM and HDDM provide an efficient and accurate methodology for calculating first-order (via DDM) and second-order (via HDDM) sensitivities between output concentrations and model input parameters.

1.3.1.2 Selection of Meteorological Model

The Weather Research and Forecasting Model (WRF) has now largely replaced the Penn State University/National Center for Atmospheric Research (PSU/NCAR) Fifth Generation Mesoscale Model (MM5) for both forecasting and retrospective modeling of historical episodes. The WRF model development was driven by a community effort to provide a modeling platform that supported the most recent research and allowed testing in forecast environments. WRF was designed to be completely mass conservative and built to allow better flux calculations, both of which are of central importance to the air quality community. The model was also designed with higher order numerical techniques than MM5 for many physical calculations. These model improvements over MM5 as well as a decision by NCAR to no longer support MM5 prompted the TCEQ as well as various Texas universities, the Central Regional Air Planning Association (CENRAP), and EPA to adopt WRF for their respective meteorological modeling platforms.

WRF version 3.2 has been used by the TCEQ to develop meteorological inputs for the 2006 base case episodes. As time and resources allow, newer versions of WRF may be used as they become available to revise these inputs. Updated files with new versions of WRF will first receive a quality assurance review to see if meteorological performance is improved. WRF is supported by a broad user community including the EPA, the Air Force Weather Agency (AFWA), the National Centers for Environmental Prediction (NCEP), national laboratories and academia, and is currently being used extensively to develop the meteorological inputs for regulatory air quality modeling analyses throughout the U.S. Attainment demonstration SIP revisions submitted by the TCEQ over the last several years have relied on MM5, so this will be the first attainment demonstration SIP revision to be based entirely on the WRF model.

1.3.1.3 Selection of Emissions Modeling System

Typically, raw emissions inventory databases provide on-road, off-road, non-road, area, biogenic, oil-gas, and point source emission estimates of criteria pollutants, including NO_X and VOC, on an annual, seasonal, daily, and/or hourly basis. The processing of raw emissions data sets into air quality model inputs is accomplished through the use of emission processor tools. These emission processors temporally distribute, spatially allocate, and chemically speciate the emissions to the resolution and chemical mechanism used by the air quality model. When necessary, emission processors are also used to apply adjustment factors to specific combinations of county and source types for simulation of control strategy scenarios.

The two most common emissions modeling systems used to process anthropogenic emissions into the gridded, hourly-resolved, and chemically-speciated inputs needed for an air quality model are version 3 of the Emissions Processing System (EPS3) and the Sparse Matrix Operator Kernel Emissions (SMOKE). TCEQ has selected EPS3 primarily because it is being used for several other air quality modeling projects within Texas, is easily modified to accommodate the complexity of emissions sources and the highly detailed emissions information required, and the TCEQ has years of experience in using EPS3. For on-road emissions inventory development, SMOKE lacks the capability of fully capturing the variable hourly speed associated with vehicle miles traveled (VMT) estimates for each roadway segment from local travel demand models (TDM). Since vehicle emission rates vary as a function of speed, this is important for obtaining the best possible spatial and temporal resolution of gridded on-road emissions in metropolitan areas.

The two biogenic models currently being considered by the TCEQ are version 3.5 of the Global Biosphere Emissions and Interactions System (GLOBEIS) and version 2.1 of the Model of Emissions of Gases and Aerosols from Nature (MEGAN). Previous TCEQ modeling efforts have relied on GLOBEIS, and it has performed satisfactorily. MEGAN is under consideration because it may have emissions estimation advantages for the varying solar radiation and average temperatures that occur at different times of the year. Initial comparisons of the results are showing better isoprene estimation performance from MEGAN compared with GLOBEIS. The DFW attainment demonstration SIP revision documentation will include a justification of why one biogenic model was chosen over the other. In the event that GLOBEIS is chosen for one episode (or part of an episode) and MEGAN for the other, then the SIP will include an appropriate technical justification of why one model's emission estimates were chosen over the other.

1.3.2 Modeling Domains

1.3.2.1 CAMx Modeling Domains

Figure 1-3: CAMx Modeling Domains depicts the modeling domains currently being used by the TCEQ in CAMx. The horizontal configuration of the CAMx modeling domains include:

- tx_4km (outlined in green), which contains 4 kilometer (km) grid cells covering most of eastern Texas and small portions of southwestern Arkansas, western Louisiana, southern Oklahoma, and northeastern Mexico;
- tx_12km (outlined in blue), which contains 12 km grid cells covering all of Texas, Arkansas, Louisiana, Oklahoma, along with portions of Alabama, Colorado, Kansas, Kentucky, Mississippi, Missouri, New Mexico, and Tennessee; and

- rpo_36km (outlined in black), which contains 36 km grid cells covering all of the continental U.S., along with southern Canada, northern Mexico, and portions of the Gulf of Mexico, Atlantic Ocean, and Pacific Ocean.

The tx_4km domain is nested within the tx_12km domain, which in turn is nested within the rpo_36km domain. The large rpo_36km domain was selected to minimize the effects of boundary conditions on predicted ozone concentrations within the eastern tx_4km domain. In addition, rpo_36km is the same large domain used by Regional Planning Organizations (RPO), the EPA, and other regional modeling entities throughout the U.S.

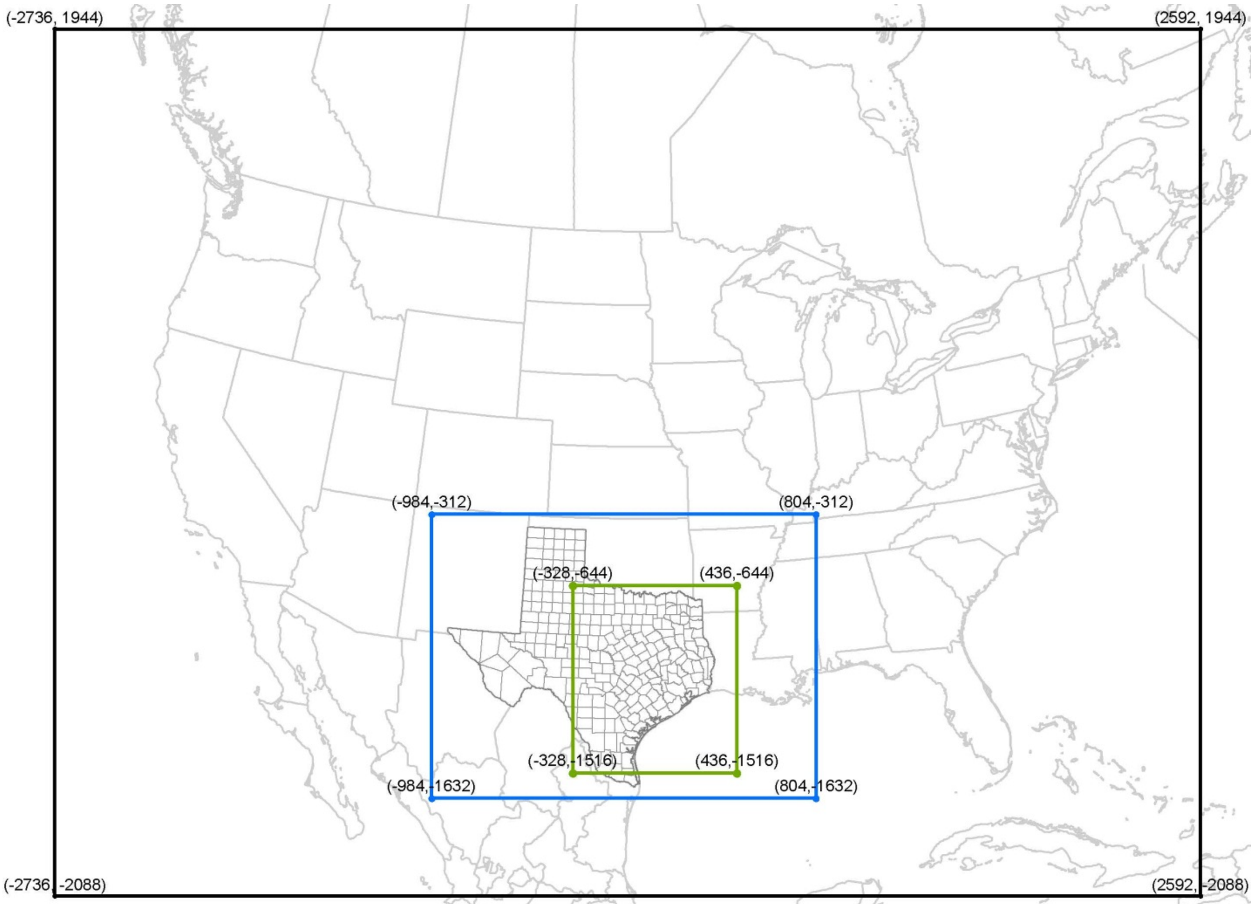

Figure 1-3: CAMx Modeling Domains

All grids are projected in a Lambert Conformal Conic (LCC) map projection with the origin at 97 degrees west and 40 degrees north. The first true latitude (alpha) is at 33 degrees north, and the second true latitude (beta) is at 45 degrees north. Choosing a grid system compatible with an existing large-scale grid system serves several functions, including the ability to directly use existing modeling data such as emissions, spatial surrogates, and boundary conditions, along with the ability to compare model results directly with other modeling applications. The grid dimensions for the CAMx domains are listed in Table 1-2: CAMx Modeling Domain Parameters.

Table 1-2: CAMx Modeling Domain Parameters

Grid Name	Grid Cell Size	Dimensions (grid cells)	Lower left-hand corner	Upper right-hand corner

rpo_36km	36 x 36 km	148 x 112	(-2736, -2088)	(2592,1944)
tx_12km	12 x 12 km	149 x 110	(-984,-1632)	(804,-312)
tx_4km	4 x 4 km	191 x 218	(-328,-1516)	(436,-644)

The vertical configuration of the CAMx modeling domains consists of a varying 28-layer structure as shown in Table 1-3: CAMx Vertical Layer Structure.

Table 1-3: CAMx Vertical Layer Structure

CAMx Layer	WRF Layer	Top (m AGL)	Center (m AGL)	Thickness (m)
28	38	15,179.1	13,637.9	3,082.5
27	36	12,096.6	10,631.6	2,930.0
26	32	9,166.6	8,063.8	2,205.7
25	29	6,960.9	6,398.4	1,125.0
24	27	5,835.9	5,367.0	937.9
23	25	4,898.0	4,502.2	791.6
22	23	4,106.4	3,739.9	733.0
21	21	3,373.5	3,199.9	347.2
20	20	3,026.3	2,858.3	335.9
19	19	2,690.4	2,528.3	324.3
18	18	2,366.1	2,234.7	262.8
17	17	2,103.3	1,975.2	256.2
16	16	1,847.2	1,722.2	249.9
15	15	1,597.3	1,475.3	243.9
14	14	1,353.4	1,281.6	143.6
13	13	1,209.8	1,139.0	141.6
12	12	1,068.2	998.3	139.7
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	609.7	565.0	89.3
7	7	520.3	476.1	88.5
6	6	431.8	387.9	87.8
5	5	344.0	300.5	87.1
4	4	256.9	213.8	86.3
3	3	170.6	127.8	85.6
2	2	85.0	59.4	51.0
1	1	33.9	17.0	33.9

m = meters; AGL = above ground level

A feature pertinent to the modeling domains arising from the application of Relative Response Factors (RRFs) is the modeling grid cell array to use near a monitor to calculate the RRF. EPA's guidance suggests that each monitor is normally representative of conditions within about 15 km of the site, which implies that a 7 x 7 array of 4 km grid cells should be used for RRF calculations. However, use of either a 7 x 7 or 5 x 5 array would lead to total array sizes of 28 km and 20 km per side, respectively, which would cause excessive overlap among the RRF arrays for each monitor. Due to the density of the monitoring network in the DFW area, a 3 x 3 array of 4 km grid cells will be used. Such an approach leads to 12 km RRF array sizes that will not excessively overlap as shown in Figure 1-4: Near Monitoring Site Grid Cell Array Size. The TCEQ initially plans to use the 3 x 3 grid cell array to calculate the RRF for each monitor. Past modeling work has shown that similar RRF results are obtained with using 5 x 5 and 7 x 7 arrays.

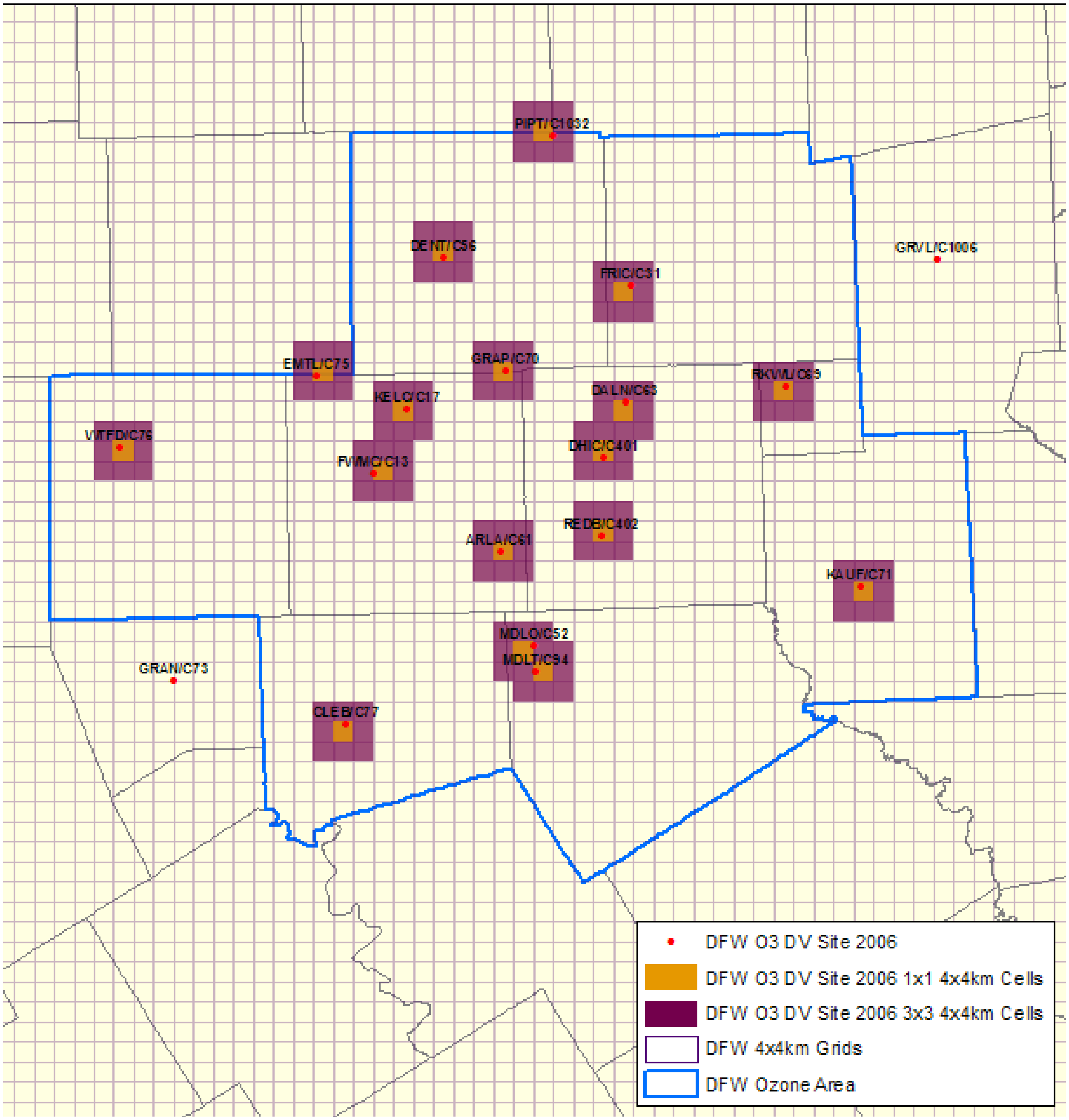

Figure 1-4: Near Monitoring Site Grid Cell Array Size

1.3.2.2 WRF Modeling Domains

WRF and CAMx share the same grid projection described in above sections, which greatly reduces horizontal interpolation errors. Figure 1-5: WRF Modeling Domains includes:

- tx_4km (the predominantly east Texas 4 km grid outlined in green) encompassing eastern Texas, southwestern Arkansas, western Louisiana, southern Oklahoma, and northeastern Mexico;

- sus_12km (southern U.S. 12 km grid outlined in dark blue) encompassing all of Texas, Arkansas, Louisiana, Mississippi, New Mexico, and Oklahoma, along with portions of Alabama, Arizona, Colorado, Florida, Illinois, Indiana, Kansas, Kentucky, Mississippi, Missouri, New Mexico, Tennessee, Utah, and northern Mexico; and

- na_36km (North American 36 km grid outlined in red) encompassing all of the continental U.S., along with southern Canada and northern Mexico.

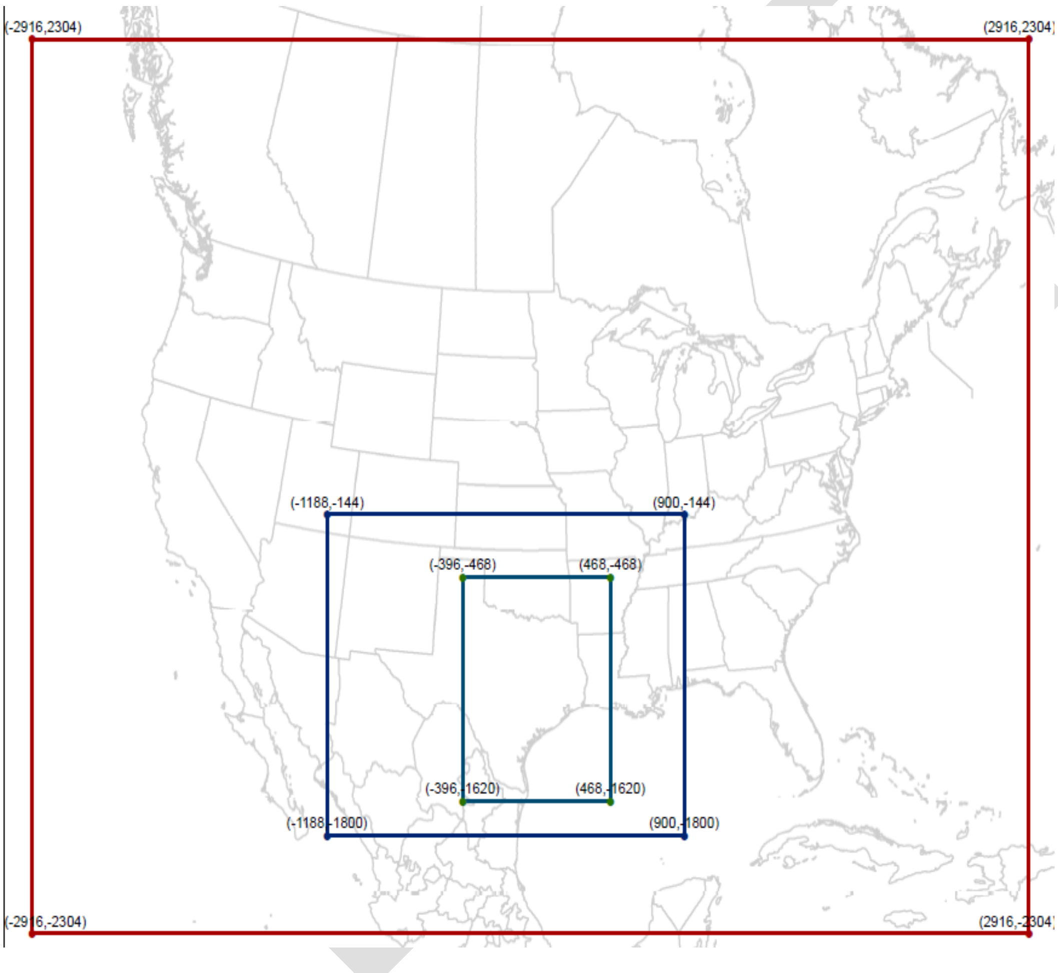

Figure 1-5: WRF Modeling Domains

Table 1-4: WRF Modeling Domain Definitions lists the horizontal grid configurations for the WRF modeling domains. Grid corners are in km (easting, northing) relative to the grid origin at 97 degrees West and 45 degrees North. Note that respective CAMx grids are nested within each WRF grid. Therefore the 36 km CAMx grid is a smaller portion of the 36 km WRF grid, and the 12 km and 4 km CAMx grids are offset within the respective WRF grids. In this manner WRF meteorological data can be provided to the CAMx boundary grid cells.

Table 1-4: WRF Modeling Domain Definitions

Domain	Easting Range (km)	Northing Range (km)	East/West Grid Points	North/South Grid Points
na_36 km	(-2916,2916)	(-2304,2304)	163	129
sus_12km	(-1188,900)	(-1800,-144)	175	139
tx_12km	(-396,468)	(-1620,-468)	217	289

As shown in Figure 1-6: WRF Vertical Layer Structure and Table 1-5: WRF Vertical Layer Parameters, the vertical configuration of the WRF modeling domains consists of a varying 43-layer structure used with all the horizontal domains. The first 21 vertical layers are identical to the same layers used with CAMx, while CAMx layers 22-28 each comprise multiple WRF layers.

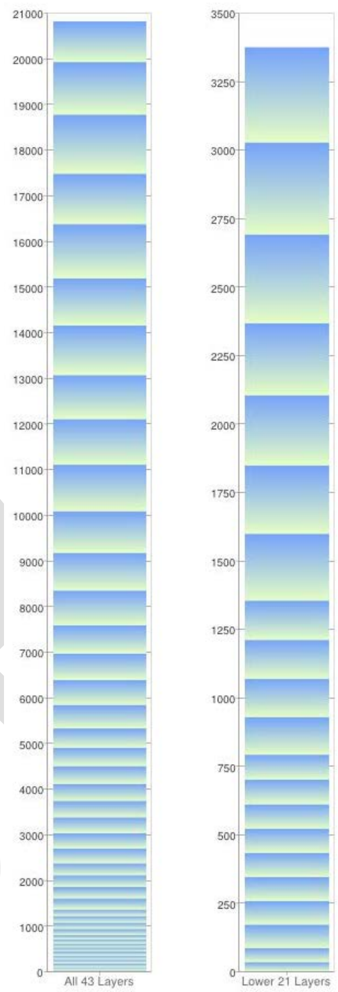

Figure 1-6: WRF Vertical Layer Structure

Table 1-5: WRF Vertical Layer Parameters

Layer	Sigma	Top (m AGL)	Center (m AGL)	Thickness (m)
43	0.000	20,806.8	20,362.1	889.6
42	0.010	19,917.3	19,341.4	1,151.7
41	0.025	18,765.6	18,117.9	1,295.3
40	0.045	17,470.3	16,918.8	1,103.1

Layer	Sigma	Top (m AGL)	Center (m AGL)	Thickness (m)
39	0.065	16,367.2	15,773.2	1,188.1
38	0.090	15,179.1	14,662.7	1,032.8
37	0.115	14,146.3	13,602.4	1,087.8
36	0.145	13,058.5	12,577.6	961.9
35	0.175	12,096.6	11,596.6	1,000.0
34	0.210	11,096.7	10,587.9	1,017.5
33	0.250	10,079.1	9,622.9	912.6
32	0.290	9,166.6	8,752.3	828.6
31	0.330	8,338.0	7,958.1	759.8
30	0.370	7,578.2	7,269.5	617.3
29	0.405	6,960.9	6,671.3	579.2
28	0.440	6,381.7	6,108.8	545.8
27	0.475	5,835.9	5,577.7	516.3
26	0.510	5,319.5	5,108.7	421.6
25	0.540	4,898.0	4,695.9	404.0
24	0.570	4,493.9	4,299.9	388.0
23	0.600	4,105.9	3,919.3	373.3
22	0.630	3,732.7	3,552.8	359.7
21	0.660	3,373.0	3,199.5	347.1
20	0.690	3,025.9	2,858.2	335.5
19	0.720	2,690.4	2,528.1	324.6
18	0.750	2,365.8	2,234.4	262.8
17	0.775	2,103.0	1,974.9	256.1
16	0.800	1,846.9	1,721.9	249.8
15	0.825	1,597.0	1,475.1	243.9
14	0.850	1,353.2	1,281.4	143.6
13	0.865	1,209.6	1,138.8	141.6
12	0.880	1,068.0	998.1	139.7
11	0.895	928.3	859.4	137.8
10	0.910	790.5	745.0	90.9
9	0.920	699.6	654.6	90.1
8	0.930	609.5	564.9	89.3
7	0.940	520.2	476.0	88.5
6	0.950	431.7	387.8	87.8
5	0.960	343.9	300.4	87.0
4	0.970	256.9	213.7	86.3
3	0.980	170.5	127.7	85.6
2	0.990	84.9	59.4	51.0
1	0.996	33.9	16.9	33.9
0	1.000	0.0	0.0	0.0

1.3.3 Modeling Inputs and Outputs

Since the outputs from the WRF model and the emissions modeling system are inputs to the CAMx model, the modeling inputs and outputs for the WRF model and the emissions modeling system are presented before the inputs and outputs for the CAMx model.

1.3.3.1 Meteorological Model Inputs and Outputs

WRF Model Configuration

The TCEQ has tested many physical parameterizations with the WRF modeling platform. The configuration options presented in Table 1-6: 2006 Base Case WRF Setup were selected because the resulting WRF performance was judged to be good across much of eastern Texas. These physical options improve upon those that had been used in MM5 and have continued to be improved in more recent versions of WRF.

Table 1-6: 2006 Base Case WRF Setup

Grid	Nudging Type	PBL	Cumulus	Radiation	Land-Surface	Microphysics
36, 12 km	3-D and Analysis	YSU	Kain-Fritsch	RRTM / Dudhia	5-layer soil model	WSM6
4 km	3-D Analysis Surface Analysis Observational radar profiler	YSU	None	RRTM / Dudhia	5-layer soil model	WSM6

PBL = Planetary Boundary Layer; YSU = Yonsei University; RRTM = Rapid Radiative Transfer Model ;
WSM6 = WRF Single-Moment 6-Class Microphysics Scheme

As time permits, the TCEQ expects to use this configuration as a base to test sensitivities of model options. Some of those sensitivities are expected to include:

- updated land use/land cover data;
- satellite-based sea surface temperature data;
- updated radiation and microphysics options; and
- use of Geostationary Operational Environmental Satellite (GOES) data for cloud assimilation.

Meteorological Model Inputs

The NCEP North American Model (NCEP, 2009) gridded analysis fields are expected to be used for initial, boundary, and analysis nudging conditions as based on experience by the TCEQ, EPA, and the NCAR. Updated land use and land cover, land/water mask, vegetation fraction, soil type, and sea surface temperature data using satellite based inputs are expected to be used as was done for the *2010 Houston-Galveston-Brazoria (HGB) Attainment Demonstration SIP Revision* (TCEQ, 2010a). Base state variables (reference pressures and temperatures) will be set to Texas summertime values to appropriately initialize the model atmosphere. TexAQS II radar profiler data will be used for observational nudging.

Meteorological Model Outputs

The meteorological model outputs a variety of data fields required by the photochemical model including temperatures, wind components, cloud cover, humidity, and vertical mixing parameters. The meteorological model output will be post-processed using the program WRFCAMx to convert the meteorological fields to the CAMx grid and input format (Environ, 2013). The WRFCAMx post-processor options, including vertical diffusivity schemes, will be evaluated to determine the appropriate CAMx inputs.

Where possible, the output parameters from the WRF model and the post-processed CAMx input are compared to monitored data to evaluate the model's performance. The TCEQ uses a performance evaluation package designed to interface with WRF that evaluates the four model parameters of wind speed, wind direction, temperature and humidity. This statistical package generates standardized tables and graphics for each of the four meteorological parameters. Other performance evaluation tools are used to evaluate the meteorological model's ability to represent episode conditions including cloud fraction plots and trajectory tools.

1.3.3.2 Emissions Processing System Inputs and Outputs

For stationary sources (i.e., point and area sources), routine emission inventories constitute the major inputs to the emissions modeling system. For on-road mobile, non-road mobile, and biogenic sources, estimates are derived from emission models of their own. For example, link-based, on-road mobile source emissions are derived from VMT estimates coupled with emission rates from the EPA's Motor Vehicle Emission Simulator (MOVES) model. Non-road mobile source emission estimates are estimated with both the Texas NONROAD (TexN) model and the EPA's National Mobile Inventory Model (NMIM). Models such as GLOBEIS and MEGAN are used to estimate biogenic emissions.

With the exception of the biogenic emissions, for which the GLOBEIS/MEGAN models directly output CAMx model-ready emissions, the emissions for the other source categories will be processed using EPS3 to generate CAMx model-ready emissions that are day-specific, gridded, chemically speciated, and temporally allocated by hour. The TCEQ uses a variety of graphical techniques (e.g., emission density plots) to quality assure (QA) the modeling emissions. Emission density plots (EDPs) used for QA purposes will be developed for each of the major emission source categories (e.g., point, on-road), as well as some sub-categories (e.g., storage tanks, locomotives). Since emissions for most source categories are ozone season day (OSD) with adjustments for weekend days, EDPs used for QA purposes will focus primarily on weekdays. For those sub-categories with higher temporal resolution (e.g., Electric Generating Units [EGU], tank landing loss [TLL]), EDPs will be developed as needed to compare and contrast differences.

Point Source Emissions

Point source modeling emission inventories are based on a number of regional data sets available from CENRAP, national RPOs, the Acid Rain Database (ARD), the Gulf-Wide Emissions Inventory (GWEI), the U.S. National Emissions Inventory (NEI), the Mexico NEI, and the Canada NEI, along with state-level data sets such as the State of Texas Air Reporting System (STARS), adjacent state-level data sets, and local sources such as the TLL special inventory.

For the 2006 base case, point source emission estimates for U.S. regions outside of Texas will rely on the 2008 NEI and CENRAP/RPO data sets adjusted as appropriate to 2006 with substituted hourly ARD emissions. Non-U.S. point source emission estimates include the 2005 GWEI, Phase 3 of the 1999 Mexico NEI, and the 2006 Canada NEI. For Arkansas, Louisiana, and Oklahoma, the TCEQ will use available state-specific point source emission inventories. The Arkansas and Oklahoma inventories will be based on their 2008 NEI submissions, while Louisiana's inventory will be from the more representative year of 2004, since the Katrina hurricane occurred in 2005. All three of these adjacent state data sets will be grown to 2006 via EPA's Economic Growth Analysis System (EGAS). For regions inside of Texas, the TCEQ 2006

STARS data set will be used. Hourly ARD emissions will be substituted where appropriate for the EGU emission estimates. The HGB area TLL emissions used in this base case will be the averaged 2006 baseline TLLs incorporated in the 2010 HGB SIP Revision. The TCEQ will incorporate available updates to these data sets as they become available.

Relevant fields are extracted from each of these data sets to develop Aerometric Information Retrieval System (AIRS) Facility Subsystem (AFS) files that are point source inputs to the EPS3 PREPNT module. For each point source, these AFS files include the appropriate year, county, source classification code (SCC), plant identifier, stack identifier, coordinates, time interval, and pollutant, along with stack parameters for height, diameter, exit gas temperature, and exit gas velocity. To distinguish between low-level and elevated point sources, a plume height cutoff of 30 meters will be used, which essentially matches the 34 meter height of the first CAMx layer. The PiG feature of CAMx will also be used for large point sources, based on a threshold NO_X emission value that varies by distance from DFW from 5 tons per day (tpd) to 25 tpd for the regional states, along with a collocation distance of 200 meters.

For the 2006 baseline non-ARD point sources (including all sources in Canada, Mexico, and the GWEI), the TCEQ will use the same OSD emissions from the 2006 base case. For the 2006 baseline EGUs, the TCEQ will use the average of the 2006 third quarter hourly ARD emissions to provide a typical 2006 summer day.

For the 2018 future year, point source estimates from outside of Texas will be based on the EPA's NEI. The 2008 NEI will be used as a starting point for projection purposes, and then the 2011 NEI will be used when it becomes available. The Clean Air Interstate Rule (CAIR) Phase II allowances will be used for the ARD units. If a substitute program is proposed to replace CAIR, it will be incorporated as time allows. The TCEQ may also incorporate any point source data sets that the EPA is currently developing for a 2018 future year modeling platform.

Within Texas, the STARS data will be used as a basis for projecting the 2018 inventories. There is typically a twelve-month lag time in the availability of the very detailed points source emissions reported to STARS, so 2011 data will initially be used as a basis for projecting to 2018. These future case projections will be updated as complete STARS data sets become available for more recent years. For example, the 2018 projections will be updated sometime in 2014 after a complete 2012 STARS data set becomes available.

For the attainment areas within Texas, the TCEQ will apply the CAIR Phase II allowances to the EGUs as site-specific caps. The EGU emissions will include consideration of newly-permitted sources that may begin operation after 2011/2012. On-the-books controls will be applied to those newly permitted 2011/2012 units for which existing rule compliance dates have not yet passed. For all the other point sources within Texas, growth will be applied via the Texas-specific Regional Economic Models, Inc. Economic Growth Analysis System (REMI-EGAS), the Texas Industrial Production Index (TIPI), or the banked emissions reduction credit (ERC) and/or discrete emission reduction credit programs within the nonattainment areas as appropriate.

For point sources within the DFW, HGB, and BPA areas, emissions consistent with their latest SIP revisions (e.g., emissions cap and trade programs within HGB, refinery expansions within BPA, and cement kiln caps within DFW) will be used. Additionally, the emissions reconciliation for highly reactive VOC (HRVOC) within HGB will be used. The largest oil and gas production facilities are classified as stationary point sources, and these will be incorporated into the point source inventory processing and development. For the DFW area, historical data from the

Railroad Commission of Texas (RRC) will be used along with special studies that the TCEQ has conducted over the last several years for the Barnett Shale formation (TCEQ, 2010d). The latest available historical RRC datasets will be used for projecting future year emissions.

Area Source Emissions

For regions outside of Texas, the TCEQ plans to use area source emissions data from the EPA's NEI. The 2008 NEI data sets will be used for 2006 base case modeling. These same data sets will be used as placeholders for future case modeling, and then replaced with 2011 NEI data sets when they become available. Additional non-Texas area source inventory data sets that will be used include the 1999 Mexico NEI, 2005 GWEI, and the 2006 Canadian NEI.

For regions inside of Texas, the TCEQ will use 2008 and 2011 data from the Texas Air Emissions Repository (TexAER) data base (TCEQ, 2010b), the Northeast Texas 2005 gas compressor inventory, oil and gas production information from the RRC, and drilling rig information from both TexAER and published industry sources (Eastern Research Group [ERG], 2011). The 2008 TexAER data set includes the flash emissions associated with the oil and gas production area source category. 2008 TexAER and northeast Texas 2005 gas compressor emissions will be adjusted to 2006 using the Texas-specific REMI-EGAS growth factors for the 2006 base case episode. Emissions data from these inventories will be processed with EPS3 to generate CAMx model ready emissions that are day-specific, gridded, speciated and temporally allocated by hour. For the 2006 baseline area sources, the TCEQ plans to use the same emissions as used in the 2006 base case.

For the 2018 future year area source emissions outside of Texas, the TCEQ plans to use the 2011 NEI with the latest EGAS growth factors. For the future year area source emissions within Texas, the TCEQ plans to apply the Texas-specific REMI-EGAS growth factors to the 2011 TexAER emissions data base. Future year shale production emission estimates will be based on an Eastern Research Group (ERG) study that provides expected changes for oil, gas, and condensate extracted from the Barnett, Eagle Ford, and Haynesville shale formations (ERG, 2012). These estimates are based on the Hubbert peak theory that predicts a bell-shaped curve for production over time, with a peak production year followed by a decline after new drilling either stops or significantly slows. Since drilling began at different times for each shale formation, different peak production years are estimated. 2018 future year estimates will be projected from the latest full year of data available from the RRC. This baseline year for projection purposes is currently 2011, but may be replaced with 2012 or 2013 production data as they become available. 2018 drilling rig emissions will be developed by applying 2018 drilling rig emission rates to the latest available rig activity information from the RRC.

Non-Road and Off-Road Source Emissions

2006 base case and 2018 future case non-road source emission estimates within Texas will be developed with the TexN model, which runs the EPA's NONROAD model "under the hood" for 25 distinct equipment sub-categories within each county. TexN 1.6 is the most current version that is available. Updated versions of TexN will be used to develop revised estimates for 2006 and 2018 if they become available. 2006 base case and 2018 future case non-road source emission estimates outside of Texas will be developed with the EPA's NMIM model, which provides output for each U.S. county. For the non-U.S. portions of the modeling domain, the 1999 Mexico NEI and 2006 Canada NEI data sets will be used.

Non-road emission files will be processed with EPS3 to generate CAMx model ready emissions that are day-specific, gridded, speciated, and temporally allocated by hour. Since the NONROAD model cannot account for the effects of variable temperature and humidity on NO_X emissions from diesel engines, the EPS3 CNTLEM module will be used to apply these adjustments by hour for Texas counties.

Off-road emissions are from aircraft, airport equipment, locomotive, and commercial marine sources. The Federal Aviation Administration (FAA) Emissions Dispersion and Modeling System (EDMS) will be used for estimating emissions from the aircraft and airport equipment source categories within Texas. EDMS reports emissions separately for aircraft, ground support equipment, and auxiliary power units. 2006 base case emissions will be based on historical landing/take-off (LTO) activity, while future case LTO activity will be based on Terminal Area Forecast projections done by the FAA. EPS3 will be used for generating CAMx model-ready emissions that are day-specific, speciated, and temporally allocated by hour. Since the inventories are developed for each Texas airport rather than at the county-level, the emissions will be allocated to the grid cell where each specific airport is located.

The 2006 locomotive emission inventories within Texas will be backcast from the 2008 NEI, while the 2018 locomotive emission inventories will be projected from the 2011 NEI. The emission rates will be adjusted based on an EPA memo entitled *Emission Factors for Locomotives* (EPA, 2009b). Emission rates for each year from 2006 to 2040 are available to account for the ongoing fleet turnover effects that are expected to occur, with the most stringent Tier 4 standards being introduced starting in 2015. Activity adjustments will be applied based on transportation sector tables available from the U.S Energy Information Administration.

Commercial marine emission estimates for Texas ports will be modeled as elevated point sources since many of these vessels have tall stacks and/or sufficient plume rise to exceed the 30 meter cut-off threshold. These sources are modeled by placing pseudo-stacks along shipping lanes, such as the Houston Ship Channel and the Intracoastal Waterway. Similarly, emissions from wildfires and controlled burning generate smoke plumes that can rise thousands of feet, and these will be modeled as pseudo point sources if sufficient data are available. A number of Texas port-specific studies have been conducted over the last several years for the HGB, BPA, and Corpus Christi areas. The results of these studies will be used as the basis for backcasting to 2006 and forecasting to 2018 based on expected changes in both emission rates and activity over time.

For non-Texas off-road emissions, the aircraft, airport equipment, locomotive, and commercial marine, inventories will be based on the 2008 NEI for both 2006 and 2018. Once it is available, the 2011 NEI will be used as the basis for developing 2018 emission estimates. As described above, the 2005 GWEI non-road and off-road emissions are included in the area source category.

For 2006, the base case and baseline emission estimates will be the same for the non-road and off-road categories. Wildfire and controlled burning emission estimates will only be included in the base case. Since it is impossible to estimate if and where such burning will occur in the 2018 future case, it is not appropriate to include burning in the 2006 baseline emissions that are used for RRF calculations.

On-Road Mobile Source Emissions

On-road mobile source emission estimates for the DFW area, the remaining portions of Texas, and all non-Texas U.S. counties will be based on the EPA's MOVES model. MOVES2010b is the version currently available, but the MOVES2014 version is expected to be released sometime in 2014 after the EPA finalizes the currently proposed rule for Tier 3 vehicle standards and 10 parts per million (ppm) sulfur gasoline. As currently proposed, the benefits of this rule will begin in

2017 and should have a significant effect on both NO_X and VOC emission estimates in the 2018 future case. If MOVES2014 is released in the first few months of 2014, the TCEQ will use it for estimating on-road emissions for all U.S. portions of the modeling domain. If there are delays in the scheduled release of MOVES2014, the TCEQ will rely on existing on-road emission inventories developed with both MOVES2010a and MOVES2010b. All of the on-road emission inventories developed will include the benefits of current on-the-books rules such as new vehicle emission standards, reformulated gasoline (RFG), low Reid Vapor Pressure (RVP) gasoline, Texas Low Emissions Diesel (TxLED), and vehicle inspection/maintenance (I/M).

The TCEQ has recently contracted with the Texas Transportation Institute (TTI) to develop non-link on-road emission inventories with the MOVES2010b version of the model using Highway Performance Monitoring System (HPMS) data as the basis for VMT estimates for 19 different roadway categories. These MOVES2010b on-road emission inventory data sets include the day types of Monday through Thursday average weekday, Friday, Saturday, and Sunday for both school and summer (i.e., non-school) seasons. The result is eight different combinations of season and day type for all 254 Texas counties based on automatic traffic recorder (ATR) data regularly collected by the Texas Department of Transportation (TxDOT). The summer season inventories will be used for the June 2006 episode, while the school season inventories will be used for the August/September episode since most public schools in Texas opened on Monday August 14 in 2006. These MOVES2010b on-road inventories are available on the TCEQ on-road emissions FTP site.

Link-based on-road emission inventories for both 2006 and 2012 were developed with the MOVES2010a model to support the DFW area attainment SIP adopted in December 2011, and these are available on the TCEQ DFW on-road emissions FTP site. The 2006 on-road inventories will be used for both the 2006 base case and 2006 baseline emission estimates. Assuming that the MOVES2014 model is released in a timely manner, the TCEQ will have link-based emission inventories developed specifically for the DFW area based on the local TDM managed by the North Central Texas Council of Governments. If there is little difference in emission rates for 2006 between MOVES2010a and MOVES2014, then the TCEQ may elect to not have the 2006 link-based emissions inventory updated. The emission rate differences between MOVES2010a and MOVES2014 are expected to be significant for the 2018 calendar year, so a link-based on-road emissions inventory will be developed for the 2018 future case if the latest version of the model is released in a timely manner.

In order for the TCEQ to perform preliminary future case scenarios with CAMx prior to the release of MOVES2014, the TCEQ will project the currently available 2012 link-based emission inventories for the DFW area to the levels estimated in the MOVES2010b non-link inventories referenced above for 2018. The pollutant-specific adjustment factors will vary by county, MOVES fuel type, MOVES source use type, MOVES emission process, and roadway type. The result will be an on-road emission inventory with the totals from a non-link MOVES2010b analysis for 2018, but with the spatial and temporal resolution of a link-based MOVES2010a analysis for 2012.

The HGB area attainment demonstration SIP revision adopted in April 2013 included MOVES2010a link-based on-road emission inventories for both 2006 and 2018, and these are available on the TCEQ HGB on-road emissions FTP site. These will be used in the eight HGB counties of the modeling domain until replaced with MOVES2014 updates. The TCEQ has already run MOVES2010b in default mode for all non-Texas U.S. counties for a July average weekday in both 2006 and 2018. The Texas-based on-road emission inventories will be aggregated by year, season, day type, and hour to develop pollutant-specific temporal emission factor ratios that will be applied to the MOVES2010b default July average weekday emissions using the EPS3 TMPRL module. The net result will be non-Texas on-road CAMx inputs that vary by season, day type, and hour in the same manner as the Texas inventories developed with high resolution by TTI.

The 2006 Canadian NEI includes annual on-road emission estimates that will be divided by 365 days to develop average weekday totals. In order to obtain 2018 Canadian on-road inputs, MOBILE6-Canada will be run to obtain emission rate adjustment factor ratios that vary by pollutant and vehicle type between 2006 and 2018. Unless superior information is made available, the TCEQ will assume an average annual VMT growth rate of 2% between 2006 and 2018. The combination of emission rate ratios and activity growth will be applied to the 2006 Canadian on-road inventory to obtain a 2018 estimate. The same Texas pollutant-specific temporal factors referenced above will be applied to the Canadian on-road inventories to obtain all the necessary combinations of season and day type.

A similar approach will be taken with the 1999 on-road emission inventories available from the Mexico NEI. MOBILE6-Mexico will be run to develop 2006/1999 and 2018/1999 emission rate adjustment factor ratios that vary by pollutant and vehicle type. Similar to Canada, an average annual VMT growth rate of 2% will be assumed from 1999 to 2006 and 1999 to 2018 unless superior information is provided. Also, the same Texas pollutant-specific temporal factors referenced above will be applied to the Mexican on-road inventories to obtain all the necessary combinations of season and day type.

The on-road emissions from each of the different regions will be processed with EPS3 to generate season and day-type specific CAMx model ready emissions that are gridded, temporally allocated by hour, and speciated for the CB6 mechanism using profiles available from the EPA's SPECIATE database. Since the Texas on-road emissions received from TTI are already provided by hour, EPS3 processing will preserve the hourly distribution of the emissions. Within Texas, the on-road emissions processing is generally divided into various processing streams for each area: roadway link-based when such inventories are available; roadway HPMS-based when link-based inventories are not available; off-network estimates for start emissions and evaporative VOC from parked vehicles; and extended idling emission estimates for combination long-haul diesel trucks. Allocation of emissions for link-based inventories is applied to specific roadway segments. For non-link on-road emission inventories, spatial allocation is done with spatial surrogates for interstates, state highways, arterials, population, etc. A more complete description of how this will be done is contained within a ReadMe file available on the TCEQ on-road mobile FTP site.

Table 1-7: Development Summary of On-Road Mobile Source Emissions provides pertinent features of the planned development of on-road mobile emissions in the different regions of the modeling domain as described above.

Table 1-7: Development Summary of On-Road Mobile Source Emissions

On-Road Inventory Development Parameter	Texas Metropolitan Areas	Texas Rural Areas	Non-Texas U.S. Counties
VMT Source	Travel Demand Models (TDMs)	HPMS Data Sets	MOVES Default
VMT Resolution	Roadway Links From TDM	19 Roadway Categories	MOVES Road Types

On-Road Inventory Development Parameter	Texas Metropolitan Areas	Texas Rural Areas	Non-Texas U.S. Counties
Season Types	School and Summer (i.e., non-School)	School and Summer	School and Summer
Day Types	Weekday, Friday, Saturday, and Sunday	Weekday, Friday, Saturday, and Sunday	Weekday, Friday, Saturday, and Sunday
Hourly VMT	Yes	Yes	No
VMT Mix Variation By Day/Time Period	Yes	Yes	No
Roadway Speed Distribution	Varies by Hour and Link	Varies by Hour and Roadway Type	MOVES Default
Spatial Resolution	Excellent	Very Good	Good
Temporal Resolution	Excellent	Very Good	Good
MOVES Source Use Types	13	13	13
MOVES Fuel Types	Gasoline and Diesel	Gasoline and Diesel	Gasoline and Diesel

Biogenic Emissions

The TCEQ is currently planning to use version 2.1 of MEGAN instead of GLOBEIS version 3.5 for estimating biogenic emissions. The estimated isoprene from both models has been compared to automatic gas chromatograph data collected at the Hinton monitor in Dallas, along with the HRM3, Danciger, and Lake Jackson monitors in the Houston area. Both models over-predict measured isoprene concentrations, but GLOBEIS consistently over-predicts isoprene more than MEGAN. The TCEQ will continue to use updated versions of these models along with any updated inputs that become available. The best performing model will be chosen for estimating biogenic emissions, and that choice will be appropriately documented in the attainment SIP.

The default plant functional type (PFT) and emission factor databases will be used as input to MEGAN2.1 (Guenther et al., 2012). Leaf area index (LAI) estimates will be obtained from the Moderate Resolution Imaging Spectroradiometer (MODIS) satellite data product MOD15A2 (National Aeronautics and Space Administration [NASA], 2013). Urban-defined grid cells by MODIS will be filled with the default LAI value from GLOBEIS (TCEQ, 2010d), otherwise biogenic isoprene emissions would not be calculated in cities. Temperature inputs will be derived from the WRF meteorological model.

Photosynthetically active solar radiation (PAR) data for the biogenic emissions modeling will be obtained from the website operated by the Global Energy and Water Cycle Experiment (GEWEX) Continental International Project (GCIP) and GEWEX Americas Prediction Project (GAPP). The data can be downloaded at half-degree resolution and will be reprocessed to match the TCEQ modeling grids. These data are derived from hourly GOES satellite imagery of cloud cover, which have been processed with a solar irradiation model (Pinker and Laszlo, 1992). PAR data from the WRF meteorological model will also be evaluated.

Since the biogenic emissions are associated with meteorological features, the TCEQ plans to use the same episode-specific emissions for the 2006 baseline and 2018 future case air quality modeling. Sensitivity tests may be conducted using LAI estimates from the most current year for the 2018 biogenic emissions.

1.3.3.3 CAMx Modeling Inputs and Outputs

Modeling Inputs

The outputs from EPS3, MEGAN, and WRF serve as the CAMx inputs for emission rates and meteorological parameters, respectively. Additional CAMx inputs include initial and boundary conditions, spatially resolved surface characteristic parameters, spatially resolved opacity, and photolysis rates.

The TCEQ plans to use initial and boundary conditions for CAM_X developed with the Goddard Earth Observing System (GEOS-CHEM) model for the large rpo_36km domain. Boundary conditions will be developed with GEOS-CHEM for each grid cell along all four edges of the 36 km domain and each vertical layer for each episode hour. The TCEQ has ongoing work with Environ to improve these initial and boundary conditions, and these inputs may change as work is completed. One possible change involves use of different initial and boundary conditions for the 2018 future case compared with the 2006 base case.

Surface characteristic parameters, including roughness, vegetative distribution, and water/land boundaries, are 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 U.S. Geological Survey (USGS) Land Use Land Cover (LULC) database. For 12 km and 36 km domains, the TCEQ will use the land-use files developed by Environ for the previous DFW SIP revision approved by the EPA, which were derived from the most recent USGS LULC database. For the 4 km domain, the TCEQ plans to use 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 CB6 mechanism, which is also input to CAMx. The TCEQ will use episode-specific satellite data from the Total Ozone Mapping Spectrometer to prepare the photolysis rates and opacity files.

Modeling Outputs

CAMx outputs CB6 species in molar concentration units of parts per million by volume. Some of the CB6 species are actual chemical species and include ozone, nitric oxide, nitrogen dioxide, carbon monoxide, ethane, ethene, formaldehyde and acetaldehyde. Typically, CAMx is executed to output hourly average concentrations, which are comparable to hourly monitored aerometric parameters. CAMx also outputs limited diagnostic files, including instantaneous concentration files for the last two simulation hours (typically used for restarts), PiG output files (typically used for restarts, but can be used for diagnostic analyses), and a deposition file (typically used for diagnostic analyses).

CAMx can also be executed to output process analysis and source apportionment results. Process analysis, including chemical process analysis and integrated process rate analysis, 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. Process analysis modeling output is typically used as a part of the performance evaluation. Source apportionment, using tools such as OSAT and APCA, estimates the culpability of sources from various regions contributing to local ozone concentrations. Source apportionment modeling output can also be used as a part of the performance evaluation, but more typically, it is used with the future year modeling to quantify the region/source type contributions to the projected future design values.

CAMx can also output analysis results of first and higher order sensitivities of modeled concentrations to model input parameters via the DDM and HDDM tools. DDM and HDDM calculate CAMx's sensitivity to changes in inputs directly as the model is executed, and can be used to evaluate base case performance as well as to assist in control strategy evaluation for future year modeling.

1.3.4 Quality Assurance/Quality Control (QA/QC) Plan

The TCEQ's QA/QC plan focuses primarily on the data input to the models and procedures, and post-processing of the output data used for decision making. The TCEQ conducts extensive QA/QC activities when developing modeling inputs, running the models, and analyzing and interpreting the output. The TCEQ has developed a number of innovative and highly effective QA/QC tools that are employed at key steps of the modeling process. Attachment 2 provides a detailed QA/QC plan developed by the TCEQ to be used during modeling, which is consistent with EPA guidance to ensure the scientific soundness and defensibility of the modeling.

1.4 TEXAS AIR QUALITY STUDY DATA

1.4.1 The Second Texas Air Quality Study, 2006

TexAQS II was an eighteen-month project initiated in the latter part of the summer of 2005 concluding with a field intensive monitoring period from August 1 to October 15, 2006. In addition to a wealth of scientific information that has greatly enhanced the understanding of ozone formation, transport, and destruction processes in eastern Texas, TexAQS II products specific to the DFW area include additional rural monitoring of ozone and precursors and additional radar profiler data collection in North Texas, plus several hours of sophisticated aircraft data collected over, upwind of, and downwind of the DFW area. These TexAQS II data sets will be used to help evaluate model performance.

1.5 MODEL PERFORMANCE EVALUATION

The performance evaluation of the base case modeling measures the adequacy of the model to correctly replicate the relationship between levels of ozone and the emissions of ozone precursors such as NO_X and VOC. The model's ability to correctly replicate this relationship is necessary to have confidence in the model's prediction of the response of ozone to various control measures.

The TCEQ will conduct two types of performance evaluations, operational (e.g., statistical and graphical evaluations) and diagnostic (e.g., sensitivity evaluations). As recommended by the EPA (EPA, 2007), these evaluations will be considered as a whole in a weight-of-evidence approach, rather than individually, to gauge the adequacy of the model.

The TCEQ has incorporated the recommended eight-hour performance measures into its routine evaluation procedures, but will continue to focus primarily on one-hour performance analyses, especially in the DFW area. The high-resolution meteorological and emissions features characteristic of the area require model evaluations be performed at the highest resolution possible to determine whether or not the model is getting the right answer for the right reasons.

The TCEQ also plans to evaluate the model performance at some of the more rural monitors within Texas beyond the DFW area, including TexAQS II special-purpose monitors. Since the modeling resolution is more coarse in some of the rural areas (e.g., 12 km grid), the performance evaluations the TCEQ plans to use will be predominantly based on graphical measures.

1.5.1 Operational Evaluations

1.5.1.1 Statistical Measures

Statistical measures provide a quantitative evaluation of model performance. At a minimum, the TCEQ plans to use the following recommended statistics (EPA, 2007) in evaluating performance of the base case modeling.

Unpaired Peak Accuracy (UPA) - This statistic compares the difference between the maximum modeled ozone concentration and the highest monitored ozone concentration found over all hours and over all monitoring stations for each day simulated. This comparison will be made for both one-hour and eight-hour peak ozone concentrations.

In the past, the EPA recommended an acceptable range for the UPA of plus or minus 15-20% for one-hour ozone. For eight-hour ozone, the EPA has not included the UPA as a recommended statistical measure. However, this statistic will be computed to ensure that the model is generating sufficiently high ozone peaks on each day of the simulation.

Mean Normalized Bias (MNB) - This statistic compares the relative difference between modeled and monitored ozone concentrations, paired in time and space, averaged over all hours and over all monitoring stations. The MNB will be calculated for individual episode days by averaging over all monitoring sites, and individual sites by averaging over all days. The MNB provides a measure of the model's tendency to over-predict or under-predict monitored ozone concentrations. A positive bias indicates that the model's ozone concentrations are too high, and a negative bias indicates the converse. A bias near zero is desirable, although this does not necessarily mean the model is replicating ozone concentrations well since combining large positive and negative relative differences can result in a near-zero MNB.

For one-hour ozone, the EPA has recommended a range of plus or minus 5-15%, and calculating the MNB only when the monitored ozone concentration is 60 ppb or greater. For eight-hour ozone, the EPA also recommends limiting the calculation of the MNB to monitored ozone concentrations over a minimum threshold of 40 or 60 ppb, but no range is given for consideration of suitable performance. The TCEQ plans to compute the MNB for the one-hour ozone concentrations using a minimum threshold of 60 ppb. However, for the eight-hour ozone concentrations, the TCEQ plans to compute the MNB using the daily maximum eight-hour ozone concentrations.

Mean Normalized Gross Error (MNGE) - This statistic is similar to the MNB, except that the absolute value of the relative differences between modeled and monitored ozone concentrations paired in time and space are averaged over all hours and over all monitoring stations. The MNGE will be calculated for individual episode days by averaging over all monitoring sites and individual sites by averaging over all days. This statistic is representative of the overall deviation between the modeled and monitored concentrations. The MNGE is always greater than or equal to zero.

As for the MNB, the TCEQ will compute the MNGE for the one-hour and eight-hour ozone concentrations using a minimum threshold of 60 ppb for one-hour and the daily maximum for the eight-hour, respectively. For one-hour ozone concentrations, the recommended range for MNGE is plus or minus 30-35%, but no range is specified for eight-hour.

For both the MNB and MNGE, the TCEQ plans to use a modeled value based on a bi-linear interpolation of the ozone concentrations in the grid cells around a monitor.

These statistical measures will be used primarily for ozone concentrations, although they may be applied to some of the ozone precursors. In addition, the TCEQ may use other statistical measures such as mean fractional bias and mean fractional error as deemed necessary in the performance evaluation.

1.5.1.2 Graphical Measures

Graphical measures provide a qualitative evaluation of model performance. At a minimum, the TCEQ plans to use the following recommended graphics in evaluating performance of the base case modeling (EPA, 2007):

Time Series Plots - For monitoring stations in the domain, the hourly monitored and bi-linearly interpolated modeled concentrations can be compared for each hour in an episode. This comparison assesses how well the model predicts diurnal and/or daily variation in the ozone concentrations at specific locations.

The TCEQ plans to develop hourly time series plots for ozone and some ozone precursors (e.g., NO_X, VOC) at appropriate sites. Comparing the modeled versus monitored concentrations of precursors can indicate whether the model is correctly replicating the physicochemical processes by which ozone was actually generated.

Since averaging over several hours smooths the modeled and observed concentrations and obscures important features, TCEQ does not plan to develop time series plots for eight-hour concentrations of either ozone or ozone precursors.

Scatter Plots - Scatter plots of hourly monitored and bi-linearly interpolated modeled ozone concentrations will be developed for appropriate monitors for all episode days. This should show overall patterns of under-prediction and/or over-prediction for an entire episode. Comparing between selected monitors should show any geographically related differences in prediction patterns. The TCEQ plans to develop hourly scatter plots for some ozone precursors (e.g., NO_X, VOC) at selected monitors and for all episode days, as well. Quantile/Quantile (Q/Q) plots indicating the rank distribution of the monitored versus modeled ozone concentrations will also be developed and included on the scatter plots.

Peak Ozone Tile Plots - Tile plots of one-hour and eight-hour daily ozone maxima overlaid with monitored maximum values provide a visual means of assessing where the model predicted peak concentrations compared with observations. The TCEQ will develop plots showing the peak daily concentration (one-hour and eight-hour) simulated in each grid cell.

Ozone Animations - Tile plots of hourly modeled ozone concentrations overlaid with monitored maximum values will be combined into an animated sequence. Animations of ozone precursors (NO_X, VOC) will also be developed as needed. Viewing the sequence of tile plots as an animation provides insight into the model's physicochemical processes, such as how ozone forms, and how it is transported and dispersed by the model.

Aloft measurements - During TexAQS II, numerous aircraft flights collected a rich set of aloft ozone, ozone precursor, and reaction product measurements. Additionally, data were collected at the Moody Tower at the University of Houston at an elevation of approximately 70 meters above ground level. Data from aircraft transects will be compared with model predictions along the flight path. Data collected at the Moody Tower will be compared with model predictions at the appropriate vertical layer using time series plots as described above.

1.5.2 Diagnostic Evaluations

1.5.2.1 Sensitivity Analyses

Sensitivity analyses are designed to check the response of the modeled ozone to changes in model inputs including meteorological parameters and precursor emissions. The results of these analyses indicate the sensitivity of the model to various inputs and can identify which inputs must be scrutinized most closely. In addition, sensitivity analyses can also indicate which modeling inputs may be hindering the performance of the model.

The TCEQ plans to perform one or more of the following analyses to determine the model sensitivity to various model input parameters:

Alternative meteorological characterization – The TCEQ will analyze the sensitivity of the predicted ozone and ozone precursors to changes in the meteorological inputs using a variety of parameterizations/characterizations of the meteorological modeling. The use of different parameterizations/characterizations will change various meteorological parameters, such as the wind speed and the vertical mixing coefficients. These analyses may have the added benefit of identifying the best meteorological characterization for use in this modeling application.

Alternative boundary conditions - Since the fine grid domain over eastern Texas is the area of most interest and is far from the lateral boundaries, the sensitivity to boundary conditions has been relatively small in past modeling applications. However, recent modeling conducted for other Texas areas suggests a higher level of sensitivity to the specification of boundary conditions. The TCEQ plans to analyze the sensitivity of the predicted ozone and ozone precursors to changes in the boundary conditions. In particular, the TCEQ plans to work with staff from Environ in evaluating other sources of episode-specific boundary conditions. It is expected that expansion of the coarse modeling domain to cover most of North America will help to minimize the effects of boundary conditions on estimated ozone levels throughout eastern Texas.

1.5.2.2 Diagnostic Analyses

Diagnostic analyses tend to focus more directly on the model's change in predicted ozone to changes in the ozone precursor emissions. At a minimum, the TCEQ plans to conduct the following diagnostic analyses:

Observational Methods - These methods compare changes in modeled ozone associated with changes in emissions input to the model to changes in monitored ozone associated with changes in actual emissions. The primary analysis of this type which the TCEQ plans to conduct is a modeling scenario to compare the weekday versus weekend differences in ozone and emissions to the monitored weekday versus weekend differences for the area. Another analysis of this type that the TCEQ may conduct involves comparing the changes in the modeled versus monitored NO_X-limitation or VOC-limitation both geographically and temporally over the DFW area.

Probing Tools - These tools are embedded procedures in the CAMx model used to discern the contribution to ozone formation from the various inputs. The primary probing tool the TCEQ plans to use is process analysis. The TCEQ plans to conduct source apportionment analyses (e.g., APCA, OSAT) on the baseline and future case modeling to understand the contribution from source categories in various source regions to the predicted ozone concentrations.

Retrospective Analyses – A retrospective analysis is intended to examine the ability of the model to respond to emission changes by comparing a recent trend or change in observed ozone concentrations to the model-predicted ozone concentration trend or change over the same period. The TCEQ plans to use the model and the attainment test procedure to project year 2012 ozone design values (i.e., forecast from the 2006 baseline to year 2012). The model-projected year 2012 ozone design values will be compared to the actual design values calculated from the ambient measurements. The TCEQ does not anticipate having SIP-quality emission inventory inputs available for 2012 to perform this analysis. However, the best available anthropogenic emission inventory inputs will be used, and they will be processed on the newer modeling domains with CB6 speciation for this retrospective analysis.

These diagnostic analyses should establish the reliability of the model to adequately predict the response of ozone to changes in the emissions, which is paramount in testing possible control measures.

1.6 ATTAINMENT YEAR MODELING AND CORROBORATIVE ANALYSES

The attainment demonstration will consist of the attainment year modeling and the corroborative analyses. The TCEQ plans to conduct attainment year modeling in accordance with the EPA attainment test procedure for eight-hour ozone modeling. Additionally, the TCEQ plans to provide a suite of corroborative analyses providing additional assurance that any control strategy proposed for the DFW area will result in attainment at all monitors.

1.6.1 Attainment Year Modeling

The DFW area was officially designated by the EPA in July of 2012 as a moderate ozone nonattainment area, which requires six years to comply with the 75 ppb standard. The official attainment date of December 31, 2018 requires that the prior full ozone season be used for future case modeling purposes. The TCEQ will develop future year emission estimates that include projected growth and the impacts of current regulatory control measures. As per the EPA guidance, the TCEQ plans to project the 2018 future year design value (DV_F) by applying the RRF test to the 2006 base year design value (DV_B) at each monitor in the DFW area with a 2006 DV_B above 75 ppb.

The TCEQ plans to calculate the RRFs in accordance with the EPA guidance by using the average of the 2006 baseline modeled daily maximum eight-hour ozone concentrations above 75 ppb within a 3 x 3 grid cell array about the monitor. Also per the EPA guidance, if there are fewer than 10 days with 2006 baseline modeled daily maximum eight-hour ozone concentrations greater than 75 ppb, then the threshold will be reduced on a monitor-by-monitor basis until each monitor has ten days above the threshold, or the threshold reaches 70 ppb. If any monitors have less than five days meeting the 70 ppb threshold, the TCEQ will consult with EPA Region 6 modeling staff to determine the appropriate action. This 70 ppb threshold is based on the current version of the modeling guidance that was developed for the 84 ppb standard.

The TCEQ expects that most, if not all, of the 2018 DV_F projections will be within or below the expected 73-78 ppb weight-of-evidence range, which was obtained by applying the 82-87 ppb range for the 84 ppb standard to the 75 ppb one. In the case that not all the 2018 DV_F projections are within or below 73-78 ppb, the TCEQ may conduct sensitivity testing to determine what additional emission reductions may be necessary to demonstrate attainment. In the case that all the 2018 DV_F projections are significantly below 75 ppb, the TCEQ plans to consult with the EPA to determine whether mid-year modeling would be needed to address the "as expeditiously as practicable" provision.

Prior to release of the EPA's Modeled Attainment Test Software (MATS), the TCEQ developed its own procedure for calculating RRFs and DV_F values called the TCEQ Attainment Test for Unmonitored areas (TATU). In addition, TATU performs a spatial interpolation, so like MATS, TATU can also be used to analyze unmonitored areas (i.e., an out-of-network test). While conceptually similar to MATS, TATU was designed specifically to be integrated into the CAMx modeling process. This facilitates the calculation of RRFs, DV_F projections, and the spatial interpolation. For example, MATS requires input in Latitude/Longitude, while TATU works directly with the LCC Projection data used in post-processing modeling applications. Also, TATU can easily handle multi-year base case data, while MATS cannot. Finally, MATS uses a technique called Voronoi Neighbor Averaging for spatial interpolation, while TATU relies on the more familiar kriging technique. The TCEQ staff have conducted an analysis comparing the RRF and DV_F projections resulting from using MATS and TATU and showed very minimal differences. Since the ozone monitoring network for the DFW area has a relatively large spatial extent, the TCEQ does not anticipate having to conduct an out-of-network test. However, should an out-of-network test be necessary, the TCEQ plans to use TATU.

If needed to provide directional guidance in identifying control measures that most effectively reduce ozone, the TCEQ plans to conduct a number of modeling sensitivities. These sensitivities may include an across-the-board percentage emission reductions matrix, a DDM/HDDM analysis, and/or an OSAT/APCA culpability assessment. Using these sensitivity modeling results, specific control measures may be evaluated. If needed to demonstrate attainment, the emissions reductions associated with selected control measures will be incorporated into the 2018 future case modeling to test their effectiveness, and the DV_F projections will be recalculated. Any control strategies approved by the TCEQ will be incorporated in the final 2018 future case emission estimates included in the DFW attainment demonstration SIP revision.

1.6.2 Corroborative Analyses

As per EPA guidance, the TCEQ plans to conduct additional analyses to corroborate the attainment modeling. The TCEQ's corroborative analysis for the DFW attainment demonstration SIP revision will help demonstrate that the processes of ozone formation, accumulation, and transport in the DFW area are now relatively well understood, and therefore the steps needed to make further progress can be discerned. The corroborative analysis will consist of three main sections:

- discussion of the implications of the modeling results and model performance evaluation, including findings from TexAQS II projects and other advanced air quality research studies that have been conducted for the DFW area, and which have contributed greatly to the understanding of the DFW area's air quality;
- discussion of the trend analyses for ozone and ozone precursor concentrations, including ozone metrics such as the design value, fourth highest daily maximum, ozone gradients, number of exceedance days, and precursor metrics such as annual average, annual 90th percentile and daily peak hourly ambient NO_X concentrations, monthly geometric mean

VOC ambient concentrations and monthly geometric mean Total Non-Methane Hydrocarbon (TNMHC); and

- discussion of air quality control measures that are not modeled because they cannot be adequately quantified, but are nonetheless expected to yield tangible air quality benefits, such as marine fuel standards for ocean-going vessels, Smartway Transport Partnerships and Blue Skyways Collaboratives, and energy efficiency measures (e.g. commercial and residential building codes).

The data and analyses presented in the corroborative analysis section will summarize the body of evidence that describes the causes of ozone in the DFW area.

1.7 MODELING DOCUMENTATION AND ARCHIVE

1.7.1 Documentation

The EPA recommends that certain types of documentation be provided along with a photochemical modeling attainment demonstration. The TCEQ is committed to supplying the material needed to ensure that the technical support for any SIP revision is understood by all stakeholders. To that purpose, the TCEQ will document the following items in conjunction with the DFW attainment demonstration SIP revision:

Modeling Protocol - Establishes the scope of the analysis and encourages stakeholder participation in both the study development and the study itself.

Emissions Modeling Appendix - Summarizes the development of the model-ready emissions estimates. This appendix will contain tabular and graphical summaries of the data for the episodic base case, baseline, and future years.

Meteorological Modeling Appendix - Summarizes the development of the meteorological parameters used by the photochemical model. This appendix will contain tabular and graphical summaries of the relevant parameters.

Photochemical Modeling Appendix - As discussed in Section 6: Attainment Year Modeling and Corroborative Analyses, an assessment of the suitability of the model to support emissions control policy will be assessed. The findings of that analysis will be discussed comprehensively in the model performance evaluation section of this appendix. Also, as discussed in Section 6, several diagnostic analyses are planned to determine whether the photochemical modeling results are physically sound.

Description of the Attainment Demonstration Modeling and Weight-of-Evidence (WOE) - Provides an overall description of the modeling, including the future year modeling with additional control measures that may be identified, and WOE arguments based on corroborative analyses, the combination of which suggests attainment will be achieved in a future year.

External Review – The TCEQ will document the review procedures (internal and external) employed in the project. This approach will include instructions provided to interested parties for accessing the study database, including software utilized as part of the technical analyses.

The above list is not all-inclusive and additional documentation will likely be developed in the course of fully documenting the modeling activities. Some items may be documented as part of the actual DFW attainment demonstration SIP revision, while others will be provided as appendices, attachments, supplementary reports, and/or postings to the TCEQ’s FTP site. All relevant documentation will be available electronically, either through the TCEQ web site or by contacting the TCEQ.

1.7.2 Modeling Archive

The TCEQ plans to archive all documentation and modeling input/output files generated as part of the eight-hour modeling analysis conducted to support the DFW attainment demonstration SIP revision. Interested parties can contact the TCEQ for information regarding data access or project documentation.

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ATTACHMENT 1: EPISODE SELECTION FOR THE DFW ATTAINMENT DEMONSTRATION SIP REVISION FOR THE 2008 EIGHT-HOUR OZONE STANDARD

1.1 GUIDANCE

The United States Environmental Protection Agency's (EPA) eight-hour modeling guidance suggests considering the following four main criteria when determining if an ozone episode is appropriate for an attainment demonstration (EPA, 2007):

- meteorological conditions vary and are conducive to eight-hour daily ozone maxima greater than 84 parts per billion (ppb) at multiple monitoring sites;
- the observed eight-hour ozone concentrations are similar to the baseline design value;
- special studies or intensive monitoring are available for data analyses, assimilation, and model performance evaluations; and
- enough elevated eight-hour ozone days are modeled at each key monitoring site to perform the modeled attainment test.

It is understood that these criteria may be in conflict with each other and tradeoffs will occur. Episode(s) may be chosen considering other factors as well, including previous modeling experience. The 84 ppb reference above is from the current version of EPA's modeling guidance from 2007, and it has not been updated for the 75 ppb standard. Where appropriate, this discussion will make reasonable assumptions about how that guidance might be modified for application to the 75 ppb standard.

1.2 BACKGROUND

There are currently twenty ozone design value monitors operating throughout the DFW area. Seven of these began operating prior to 2000, seven began operation in 2000, and six additional ones began operating after 2000. Within any given year, the regional fourth highest ozone value can be measured at any one of these twenty monitors. However, due to the dominant southeasterly wind direction during ozone season, the monitors located in the northwest quadrant of the DFW metropolitan area tend to have the highest regulatory design values. Such monitors include Denton Airport South, Eagle Mountain Lake, Fort Worth Northwest, Grapevine Fairway, and Keller.

Figure 1-1: 75 ppb Eight-Hour Ozone Exceedances by Month for Texas Areas from 1991-2011 shows how ozone exceedance days of the 75 ppb standard have historically peaked in June and then from August through early September. The EPA guidance encourages states to model either full ozone seasons or full synoptic cycles that last roughly 5-15 days. The 33-day May 31 through July 2, 2006 episode developed for the DFW attainment demonstration SIP revision adopted in December 2011 was selected for use with the 1997 eight-hour ozone standard of 84 ppb. Combining this 33-day June episode with the 34-day one from August 13 through September 15, 2006 results in a full 67 days representing multiple synoptic cycles during the peak ozone formation periods in the DFW area. Figure 1-2: DFW Area Ozone Monitor Locations shows the location of ozone monitors throughout the DFW area.

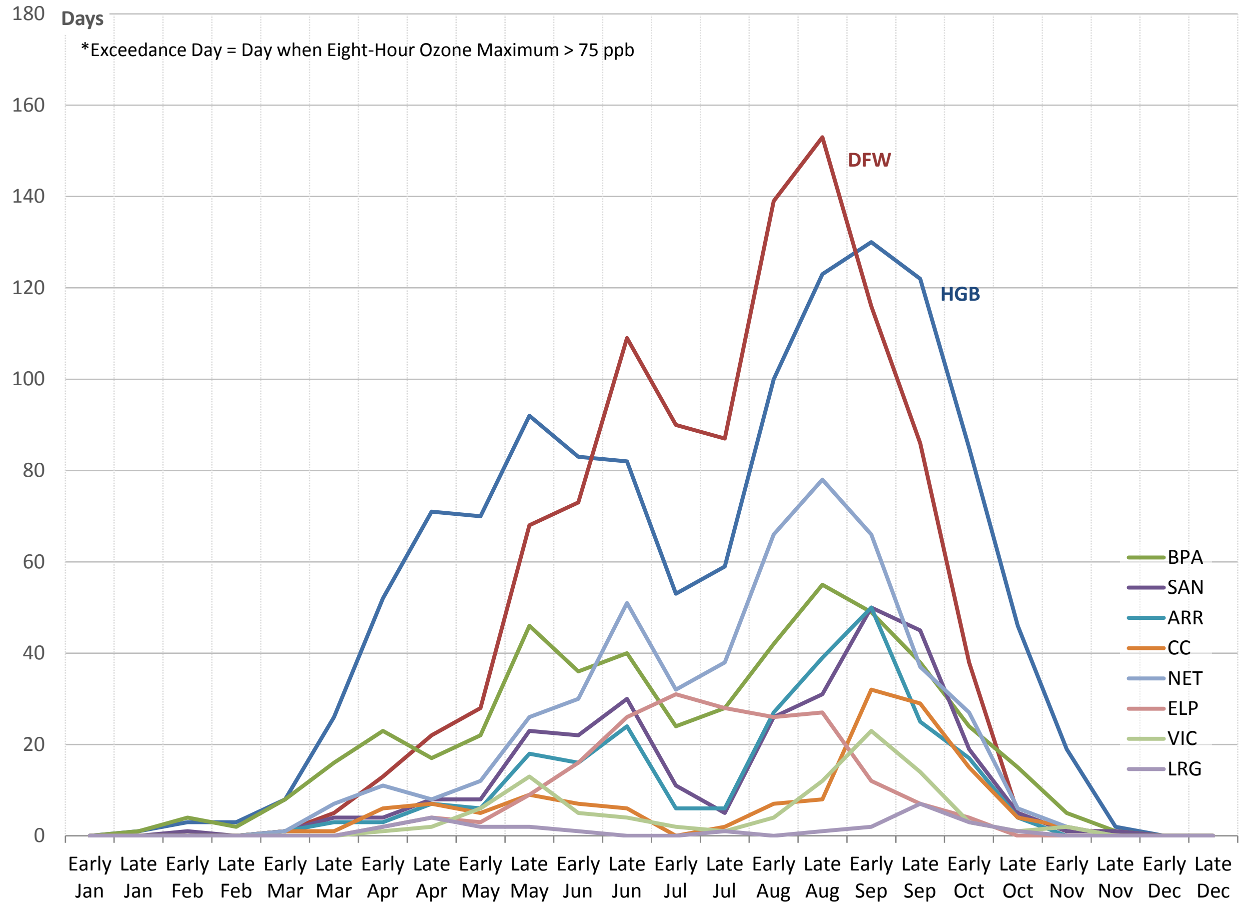

Figure 1-1: 75 ppb Eight-Hour Ozone Exceedances by Month for Texas Areas from 1991-2011

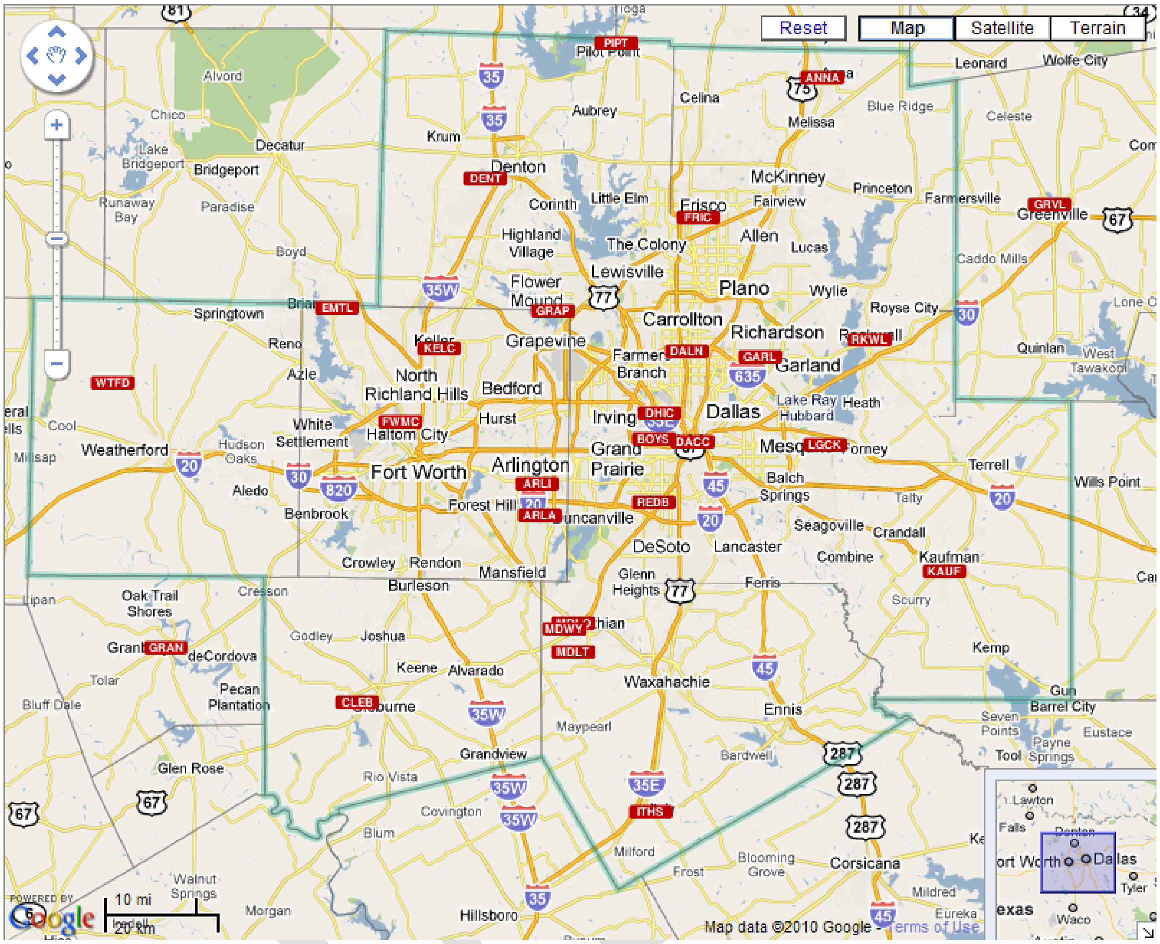

Figure 1-2: DFW Area Ozone Monitor Locations

1.3 EVALUATION OF EPISODE CANDIDATES FROM 2006-2012

Table 1-1: DFW 75 ppb Ozone Exceedance Days by Month from 2006 to 2012 is a monthly summary of the 75 ppb exceedance days at regulatory monitors in the DFW area from 2006 through 2012. For simulating the June and August/September peak periods that are common for ozone exceedances in the DFW area, the most representative candidates are the 2006 and 2012 calendar years. 2006 had 18 ozone exceedance days in June and 13 in August/September for a total of 31. 2012 had 9 ozone exceedance days in June and 12 in August/September for a total of 21. The years of 2007 and 2010 had only 2 and 3 ozone exceedance days, respectively, in the June time period, which makes them less suitable for representative seasonal ozone modeling in the DFW area. 2011 had 4 exceedance days in June and 26 in August/September for a total of 30. This imbalance in the historical peak ozone periods coupled with the extreme drought conditions that occurred throughout Texas during 2011 do not make it a representative candidate for seasonal ozone modeling.

Compared to 2012, 2008 and 2009 both had a slightly lower number of exceedance days in June, and a slightly higher number in August/September. All three years of 2008, 2009, and 2012 had a June/August/September ozone exceedance day total of 21. While 2008 and 2009 cannot be ruled out as suitable candidates for seasonal ozone modeling, 2012 is a much more recent option that can benefit from the use of more recently available emission inventory data sets, such as the 2011 NEI submitted by states to EPA. Also, EPA has a 2011 national scale modeling platform under development that should provide useful data sets for a 2012 Texas ozone episode.

Even though only the DFW area ozone exceedances are shown here, the TCEQ has begun development of a 2012 seasonal episode because it is also a suitable candidate for other metropolitan areas of the state, such as HGB. Since development of a new ozone episode typically takes multiple months and significant resources, it is unlikely that this new 2012 ozone episode will be available in time for use in this DFW attainment demonstration SIP revision. However, if acceptable 2012 base case model performance is achieved in a timely manner, the TCEQ may include a discussion of the 2012 episode as corroborative evidence to support the attainment demonstration.

Table 1-1: DFW 75 ppb Ozone Exceedance Days by Month from 2006 to 2012

Month	2006	2007	2008	2009	2010	2011	2012
January	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0
March	1	0	0	0	0	0	2
April	2	3	1	1	0	2	0
May	3	1	3	5	4	0	4
June	18	2	6	8	3	4	9
July	9	3	5	7	0	6	5
August	8	11	7	8	9	15	11
September	5	5	8	5	2	11	1
October	4	2	0	0	0	2	0
November	0	0	0	0	0	0	0
December	0	0	0	0	0	0	0
Annual	50	27	30	34	18	40	32
June	18	2	6	8	3	4	9
August/September	13	16	15	13	11	26	12
June/August/September Total	31	18	21	21	14	30	21

There is typically a three-year period between the official date of nonattainment designation and the required submission of an attainment demonstration SIP revision. In order to meet the administrative schedule, the technical work has to be mostly complete within two years. Such a short time frame does not allow for full development of a new ozone episode while continuing to optimize the existing platform. Since the TCEQ has operational 2006 ozone episodes already available, this attainment demonstration SIP revision will rely on the full 67 days from May 31 through July 2 and August 13 through September 15. Both of these episodes benefit from the extensive data sets collected during the TexAQS II study, which took place during 2006. 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). 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, broad regional applicability, and previous TCEQ modeling experience.

Figure 1-3: Daily Maximum Eight-Hour Ozone by Texas Area from May 31 - July 2, 2006 shows high eight-hour ozone was observed regionally across Texas during the June episode. Figure 1-4: Daily Maximum Eight-Hour Ozone by Texas Area from September 13 - August 15, 2006 shows that eight-hour ozone exceedances of the 75 ppb standard were also observed throughout the state during the mid-August and early-September periods. Because of this large scale regional applicability, the TCEQ has continued to refine the meteorological modeling of these episodes using the WRF model.

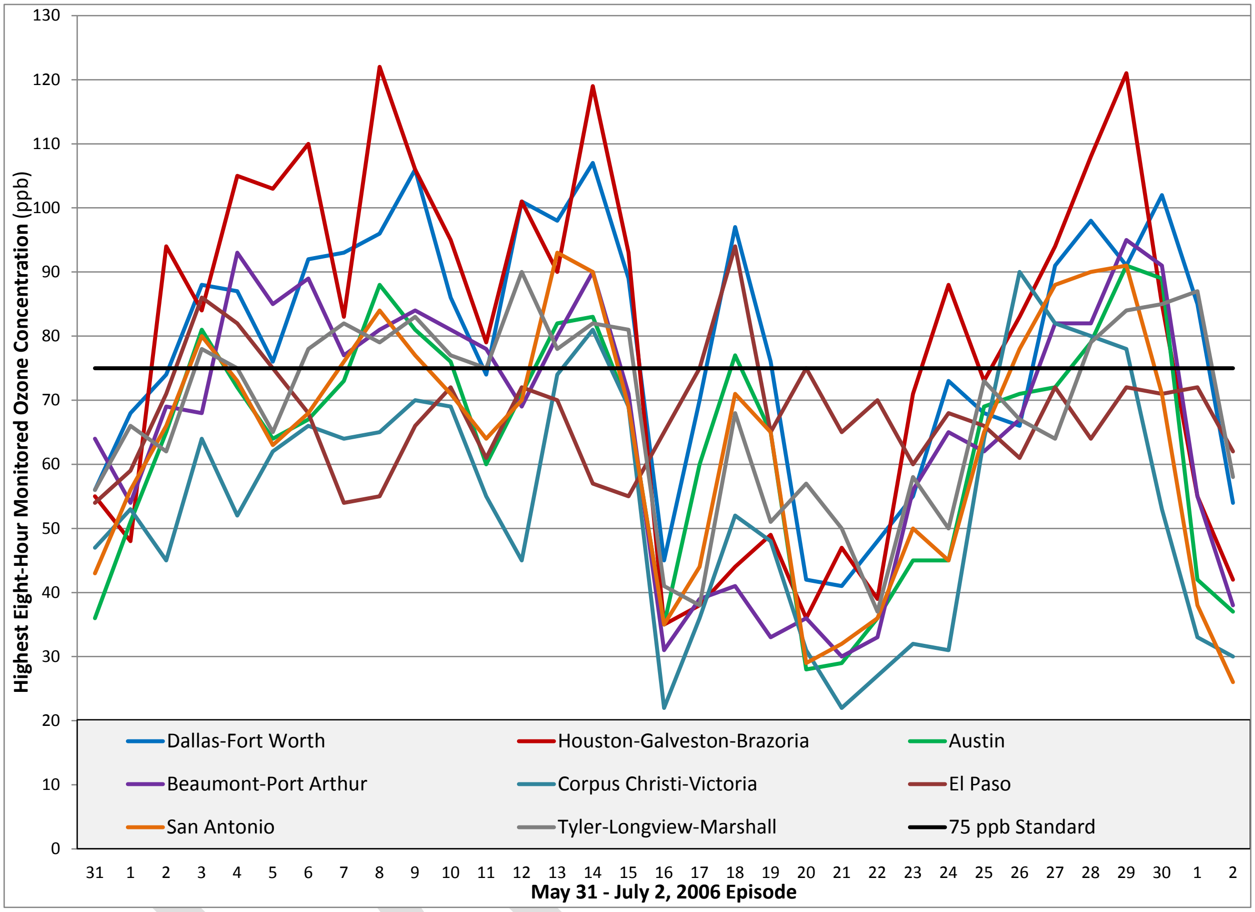

Figure 1-3: Daily Maximum Eight-Hour Ozone by Texas Area from May 31 through July 2, 2006

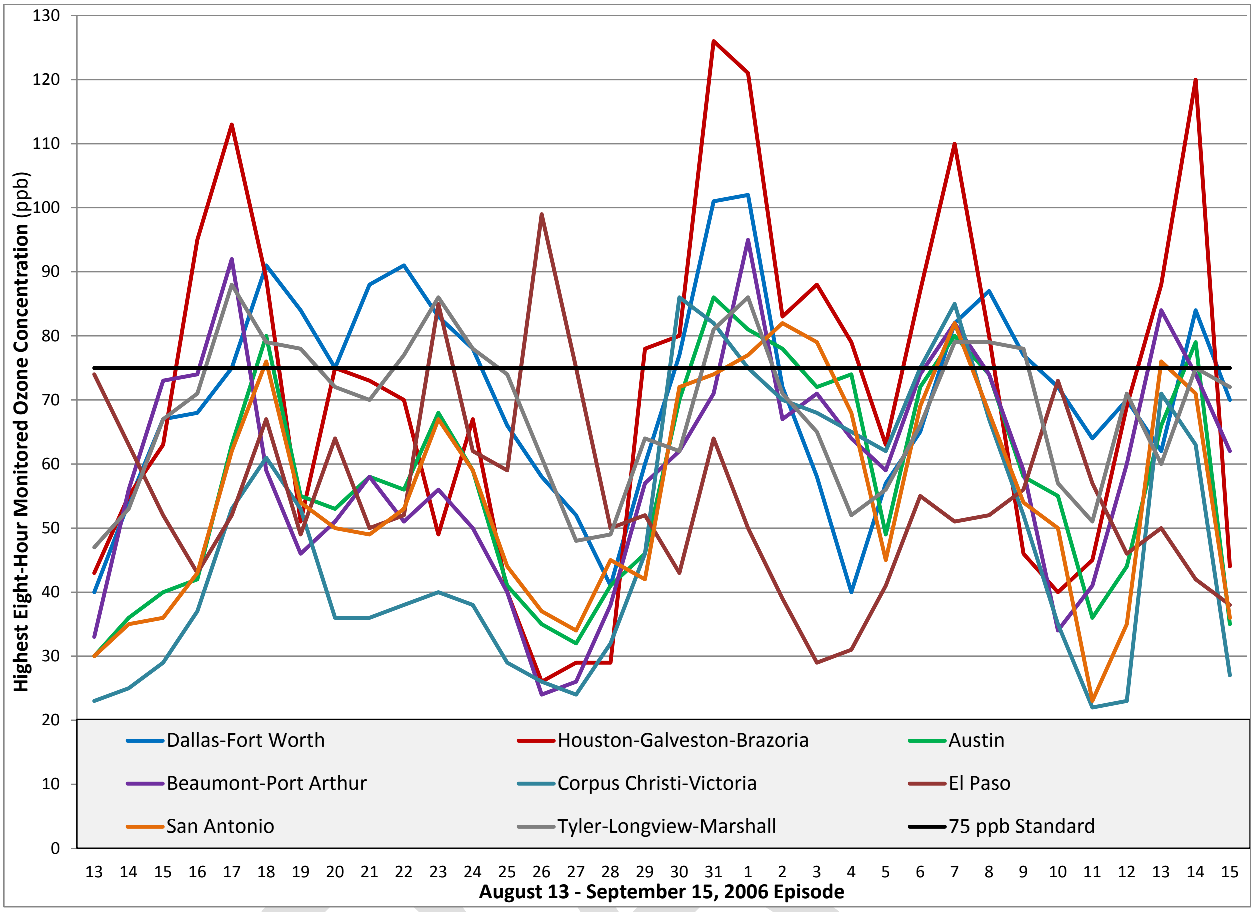

Figure 1-4: Daily Maximum Eight-Hour Ozone by Texas Area from September 13 through August 15, 2006

1.4 SUMMARY OF THE 2006 EPISODES FOR THE DFW AREA

To obtain the most robust Relative Response Factor calculations for DV_F projections, the EPA modeling guidance recommends choosing episodes where there are ten or more days with maximum eight-hour ozone concentrations above 85 ppb at each monitor. It is assumed that this threshold should be changed to 75 ppb when choosing episodes to model for the 2008 ozone National Ambient Air Quality Standard (NAAQS). Table 1-2: DFW Monitor-Specific Eight-Hour Ozone Data During the 33-Day May 31 - July 2, 2006 Episode shows that the June 2006 episode contains nine monitors with at least ten days of exceedances above the 75 ppb standard. Included within this set of nine are the five northwestern monitors with the highest design values: Denton Airport South, Eagle Mountain Lake, Keller, Grapevine Fairway, and Fort Worth Northwest. Table 1-3: DFW Monitor-Specific Eight-Hour Ozone Data During the 34-Day August 13 - September 15, 2006 Episode shows that only the Keller monitor had at least ten 75 ppb exceedances during the 34-day August-September episode. However, the other four of these northwestern monitors had either eight or nine exceedances during this period. Table 1-4: DFW Monitor-Specific Eight-Hour Ozone Data During the 67-Day Combined 2006 Episodes shows that combining these two 2006 episodes results in twelve of the twenty monitors with ten-or-more exceedance days above the 75 ppb standard. The eight monitors with less than ten exceedances during these 2006 episodes are:

- Greenville, Kaufman, and Rockwall Heath along the upwind eastern perimeter of the DFW area;
- Italy High School, Midlothian OFW, and Midlothian Tower along the southern upwind perimeter of the DFW area; and
- Cleburne Airport and Granbury on the southwestern perimeter of the DFW area.

These eight monitors have historically recorded the lowest ozone levels in the DFW area. Due to the dominant southeasterly wind directions during ozone season in the DFW area, it follows that these monitors would not regularly record high ozone. When not all monitors have ten exceedances or more, the EPA modeling guidance recommends having at least five days above 70 ppb for episode selection purposes. Using 70 ppb as the threshold, all of the twenty monitors have at least eleven ozone exceedances during the combined 67-day period.

Table 1-2: DFW Monitor-Specific Eight-Hour Ozone Data During the 33-Day May 31 through July 2, 2006 Episode

DFW Area Monitor Name and CAMS Code	Maximum Eight-hour Ozone (ppb)	Days Above 70 ppb	Days Above 75 ppb	Days Above 85 ppb	Baseline Design Value (ppb)
Denton Airport South - C56	106	17	13	8	93.3
Eagle Mountain Lake - C75	107	17	14	7	93.3
Keller - C17	103	19	15	7	91.0
Grapevine Fairway - C70	95	12	10	5	90.7
Fort Worth Northwest - C13	101	17	13	8	89.3
Parker - County - C76	101	14	11	4	87.7
Frisco - C31	94	14	11	6	87.7
Cleburne Airport - C77	98	13	6	2	85.0
Dallas Executive Airport - C402	91	17	13	2	85.0
Dallas North #2 - C63	86	12	9	1	85.0
Arlington Municipal Airport - C61	91	11	9	3	83.3
Granbury - C73	92	11	7	3	83.0
Dallas Hinton Street - C401	84	14	9	0	81.7
Rockwall Heath - C69	78	10	6	0	77.7
Greenville - C1006	78	8	1	0	75.0
Kaufman - C71	78	8	3	0	74.7
Pilot Point - C1032	101	14	11	8	NA
Midlothian Tower - C94	98	13	7	1	NA
Midlothian OFW - C52	96	10	4	1	NA
Italy High School - C650	89	9	5	1	NA

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

Table 1-3: DFW Monitor-Specific Eight-Hour Ozone Data During the 34-Day August 13 through September 15, 2006 Episode

DFW Area Monitor Name and CAMS Code	Maximum Eight-hour Ozone (ppb)	Days Above 70 ppb	Days Above 75 ppb	Days Above 85 ppb	Baseline Design Value (ppb)
Denton Airport South - C56	102	12	9	3	93.3
Eagle Mountain Lake - C75	88	10	8	2	93.3
Keller - C17	94	14	10	4	91.0
Grapevine Fairway - C70	98	14	9	4	90.7
Fort Worth Northwest - C13	86	10	8	1	89.3
Parker - County - C76	77	5	1	0	87.7
Frisco - C31	101	11	9	3	87.7
Cleburne Airport - C77	78	5	2	0	85.0
Dallas Executive Airport - C402	95	11	5	3	85.0
Dallas North #2 - C63	90	7	5	2	85.0
Arlington Municipal Airport - C61	85	7	5	0	83.3
Granbury - C73	77	5	1	0	83.0
Dallas Hinton Street - C401	96	8	4	2	81.7
Rockwall Heath - C69	86	6	3	1	77.7
Greenville - C1006	84	5	2	0	75.0
Kaufman - C71	86	3	2	1	74.7
Pilot Point - C1032	87	9	6	1	NA
Midlothian Tower - C94	82	4	1	0	NA
Midlothian OFW - C52	84	4	1	0	NA
Italy High School - C650	78	5	1	0	NA

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

Table 1-4: DFW Monitor-Specific Eight-Hour Ozone Data During the 67-Day Combined 2006 Episodes

DFW Area Monitor Name and CAMS Code	Maximum Eight-hour Ozone (ppb)	Days Above 70 ppb	Days Above 75 ppb	Days Above 85 ppb	Baseline Design Value (ppb)
Denton Airport South - C56	106	29	22	11	93.3
Eagle Mountain Lake - C75	107	27	22	9	93.3
Keller - C17	103	33	25	11	91.0
Grapevine Fairway - C70	98	26	19	9	90.7
Fort Worth Northwest - C13	101	27	21	9	89.3
Parker - County - C76	101	19	12	4	87.7
Frisco - C31	101	25	20	9	87.7
Cleburne Airport - C77	98	18	8	2	85.0
Dallas Executive Airport - C402	95	28	18	5	85.0
Dallas North #2 - C63	90	19	14	3	85.0
Arlington Municipal Airport - C61	91	18	14	3	83.3
Granbury - C73	92	16	8	3	83.0
Dallas Hinton Street - C401	96	22	13	2	81.7
Rockwall Heath - C69	86	16	9	1	77.7

DFW Area Monitor Name and CAMS Code	Maximum Eight-hour Ozone (ppb)	Days Above 70 ppb	Days Above 75 ppb	Days Above 85 ppb	Baseline Design Value (ppb)
Greenville - C1006	84	13	3	0	75.0
Kaufman - C71	86	11	5	1	74.7
Pilot Point - C1032	101	23	17	9	NA
Midlothian Tower - C94	98	17	8	1	NA
Midlothian OFW - C52	96	14	5	1	NA
Italy High School - C650	89	14	6	1	NA

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

The DFW area conceptual model (Appendix D) describes the general meteorological conditions that are typically present on days when the eight-hour ozone concentration exceeds the ozone National Ambient Air Quality Standard (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 lead to higher background ozone levels entering the DFW area than on days when wind speeds are higher. High background ozone concentrations are then amplified as the air mass moves across the urban core of Dallas and Tarrant counties, which both contain large amounts of NO_X emissions. The urban emissions are then transported across the DFW area to the northwest, where the highest eight-hour ozone concentrations are typically monitored.

The June 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 resulting in mostly sunny days with high temperatures above 90 degrees Fahrenheit. High pressure also resulted in winds that were either calm or light out of the southeast. This resulted in a gradual buildup of ozone and ozone precursors over the DFW area. This peaked at an eight-hour ozone concentration of 106 ppb at the Denton Airport South and Eagle Mountain Lake monitoring sites on June 9, as shown in Figure 1-5: Maximum Eight-Hour Ozone by Monitor from May 31 - July 2, 2006.

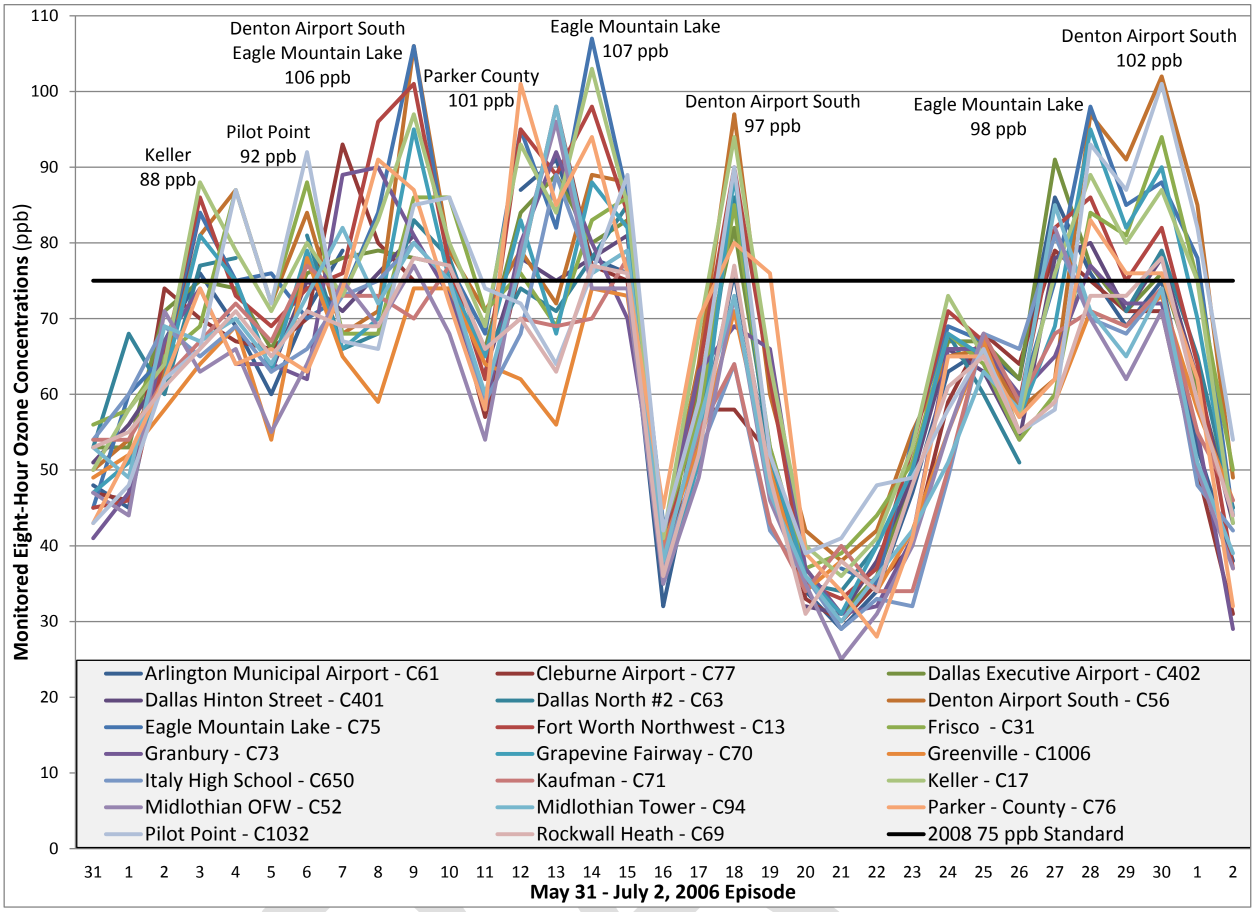

Figure 1-5: Maximum Eight-Hour Ozone by Monitor from May 31 through July 2, 2006

High pressure began to erode away as a weak frontal boundary approached from the north. This resulted in an increase in regional wind speeds, diluting the ozone 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 likely contributed to an eight-hour ozone concentration of 107 ppb at the Eagle Mountain Lake monitor site on June 14. Over the next few days, low pressure moved into the area from the Gulf of Mexico. This caused an increase in both cloudiness and wind speeds, which reduced the potential for ozone formation. High pressure returned to the area from June 27 through June 30. This again resulted in the high temperature and low wind speeds conditions favorable for ozone formation.

As shown in Figure 1-6: Maximum Eight-Hour Ozone by Monitor from August 13 - September 15, 2006, the August/September episode also had conditions favorable for elevated ozone concentrations. Strong southerly winds and a weak warm front kept ozone concentrations below 76 ppb from August 13 until August 17. High pressure settled in by August 18 with clear sunny skies and slow southerly winds allowing for the build-up of ozone concentrations. Another weak front entered the area on August 22, causing winds to shift from the northeast, indicating possible transport of polluted air from the Ohio and Mississippi River valleys. The weak front stalled just north of the DFW area through August 24 keeping winds slow and allowing pollutants to accumulate. Stronger south winds returned by August 25, keeping ozone concentrations low through August 28.

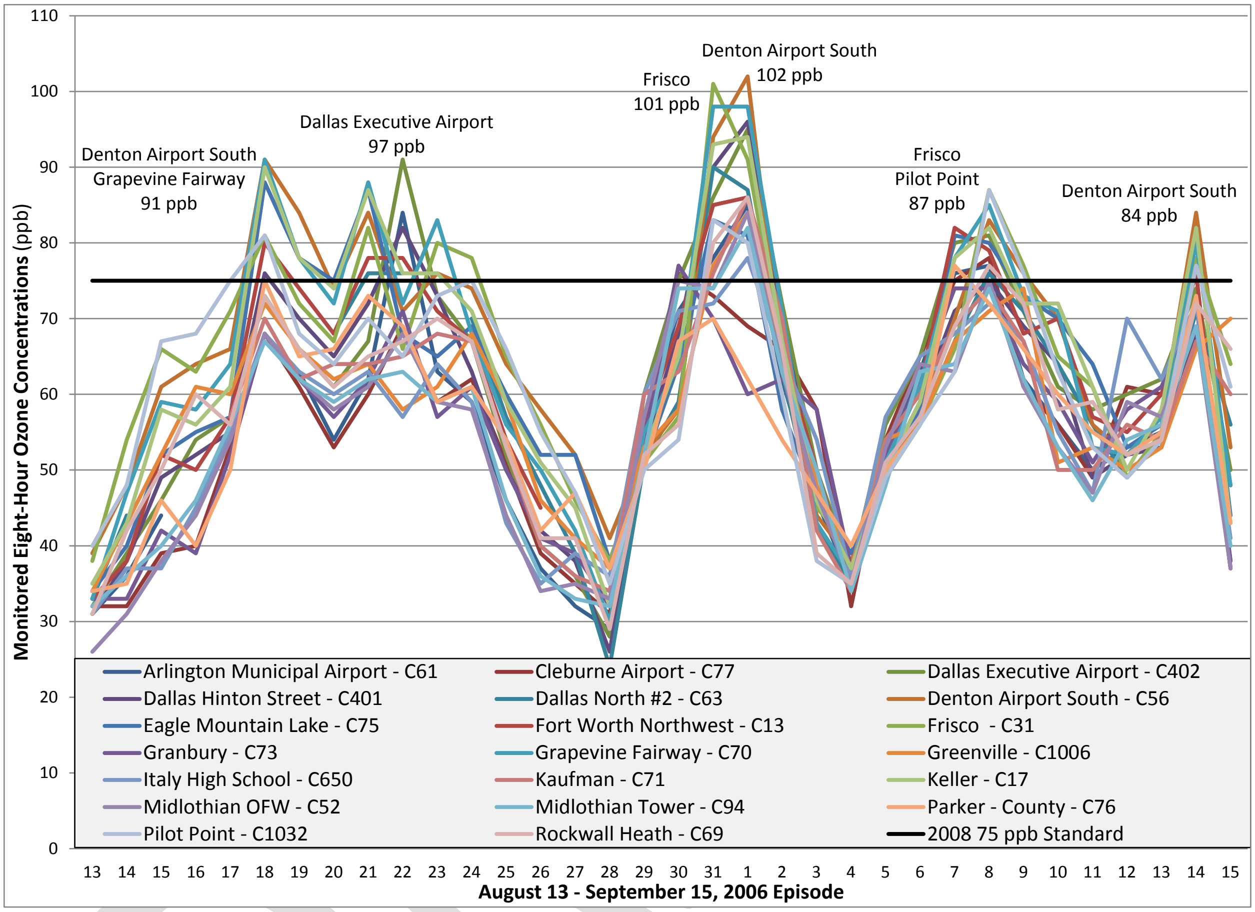

Figure 1-6: Maximum Eight-Hour Ozone by Monitor from August 13 through September 15, 2006

A stronger cold front moved through the DFW area on August 29, bringing north winds and clouds. Clear skies with light north winds followed, which allowed for higher ozone concentrations through September 1. Another cold front brought cloudy skies and cooler temperatures, which limited ozone production. High pressure and ozone-conducive conditions returned from September 7 through 10. Northeast winds after a cold front may have again transported polluted air from areas east and north of the DFW area on September 14.

Back trajectories from the Eagle Mountain Lake monitor extending backwards in time for 48 hours and terminating at 500 meters above ground level are shown for every day of the extended June 2006 episode in Figure 1-7: Daily 48-Hour Back Trajectories from Eagle Mountain Lake from May 31-June 15 and June 16-July 2. The left panel shows the May 31 through June 15 period while the right panel shows the June 16 through July 2 period. The trajectories depict air coming from north, east, and southerly directions. Westerly winds are not common during the summer months in DFW, so there are no trajectories coming from the west to northwest (TCEQ, 2011a). 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 (Appendix D). Figure 1-8: Daily 48-Hour Back Trajectories from Denton Airport South from August 13-27 and August 28-September 15 shows similar 48-hour back trajectories for each day of the August/September episode using the Denton Airport South monitor as the terminus. As shown, southeasterly winds dominated during the first half of this episode from August 13 through 27, while the second half of this episode from August 28 through September 15 had a combination of both easterly and northerly flow.

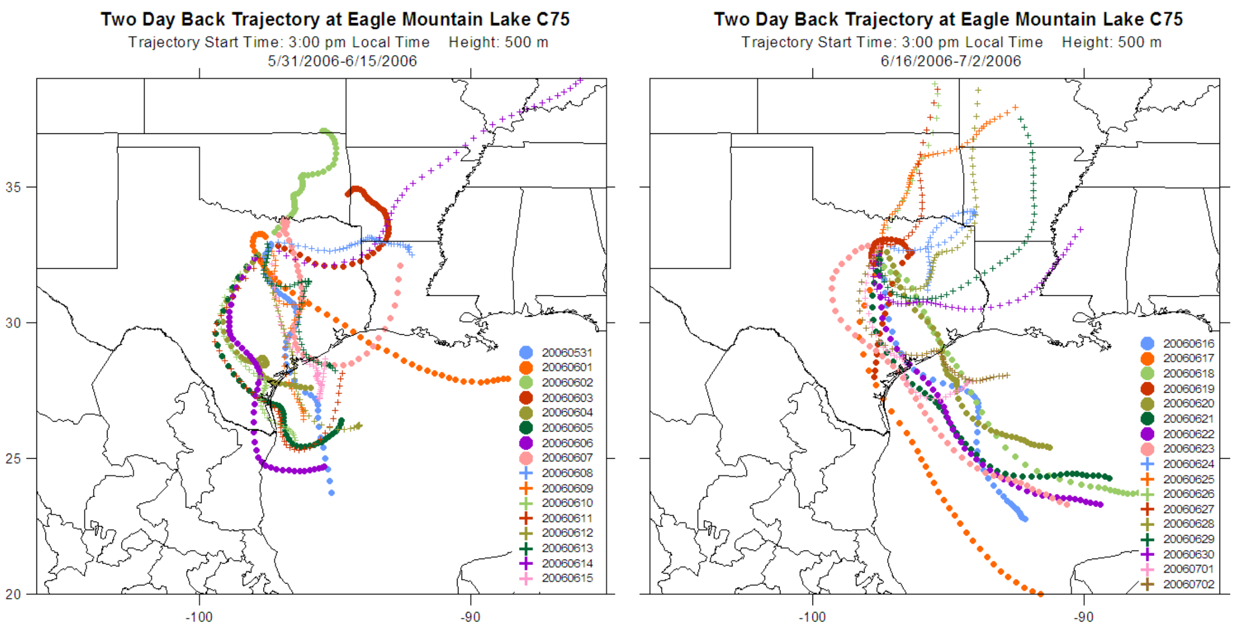

Figure 1-7: Daily 48-Hour Back Trajectories from Eagle Mountain Lake from May 31 through June 15 and June 16 through July 2

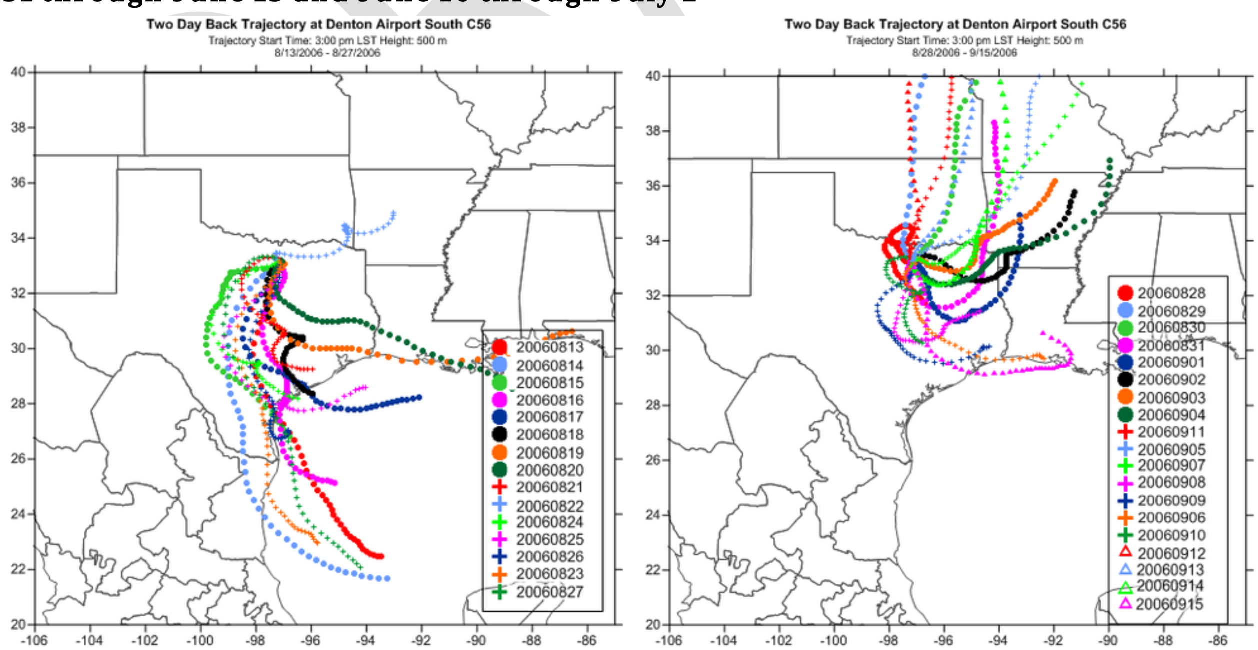

Figure 1-8: Daily 48-Hour Back Trajectories from Denton Airport South from August 13 through 27 and August 28 through September 15

1.5 CONCLUSION

Combining the June and August/September episodes from 2006 is appropriate for DFW attainment demonstration SIP revision modeling since these two periods experienced 19 and 13 days, respectively, above the 75 ppb eight-hour ozone standard. In addition, monitor-specific concentrations during this period were similar in magnitude to the 2006 baseline design values. As shown above in Table 1-4, twelve of the twenty design value monitors had more than ten days above the 75 ppb threshold. The five highest design value monitors located in northwest DFW had between 19 and25 exceedances during these two episodes, which should ensure the robustness of the modeled attainment test. Meteorological conditions varied throughout the combined 67-day episode including the passing of numerous warm/cold fronts, and the primary winds coming in varying directions from the north, south, and east. The addition of the TexAQS II monitoring data, previous HGB SIP modeling experience for these 2006 periods, and existing modeling infrastructure, including the extended meteorological modeling optimized for central Texas, further demonstrate the suitability of the June and August/September 2006 episodes for this DFW attainment demonstration SIP revision.

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ATTACHMENT 2: QUALITY ASSURANCE/QUALITY CONTROL (QA/QC) PLAN

In order to ensure that the inputs to the DFW attainment demonstration State Implementation Plan (SIP) revision modeling are of the highest possible quality, the Texas Commission on Environmental Quality (TCEQ) performs a series of QA procedures on the input files to the various modeling components. All data, whether produced internally or externally by contractors, are examined.

2.1 EMISSIONS MODELING QA/QC

The modeling emissions, comprised of point, on-road mobile, non-road, off-road, and area sources, will be prepared using EPS3 in a manner commensurate with the Comprehensive Air Model with Extensions (CAMx) modeling domains configuration. The Emissions Processing System, Version 3 (EPS3) is composed of various modules (e.g., PREPNT) for processing emissions to generate CAMx-ready inputs. QA/QC of the EPS3 processing modules is automated, and message and error files for each module processed are reported. The message files report the input and output emissions for each EPS3 module, while the error files report any problems encountered during the processing. The biogenic emissions will be developed using the Model of Emissions of Gases and Aerosols from Nature (MEGAN) emissions model, for which the TCEQ has developed a number of QA/QC procedures discussed below.

To document QA activities, a log file will be created for the processing sequence of each source category. This log file will contain the name and location of the input and output files, the date the files were processed, and a brief description of the processing results.

2.1.1 Point Source Emissions

Point source modeling emissions will be developed using data from a number of regional inventories (e.g., CENRAP, RPO, NEI, ARD, GWEI, GWEI, Mexico NEI, and Canada NEI), state inventories (e.g., STARS for Texas, and NEI for Arkansas, Louisiana, and Oklahoma), and local inventories (e.g., 2006 TexAQS II hourly special inventory and TLL special inventory). In addition, the TCEQ plans to assess the feasibility of using information from the Consolidated Compliance and Enforcement Data System (CCEDS) to identify and quantify significant emission events. The temporal resolution of these data sets varies from hourly (e.g., Electric Generating Unit [EGU] emissions from ARD) to annual (e.g., non-EGU emissions from the National Emissions Inventory [NEI]).

For states outside of Texas in the 12 km and 36 km domains, the emissions for EGUs will be obtained from the ARD. Emissions for non-EGUs in states within the 36 km domain (excluding Arkansas, Oklahoma and Louisiana) will be developed using the NEI with EGAS growth factors. Point source emissions associated with off-shore oil and gas operations in the Gulf of Mexico will be developed using the 2005 GWEI. For the states of Arkansas, Oklahoma and Louisiana, the TCEQ will obtain their latest point source emission inventories. For EGUs within Texas, emissions will also be obtained from the ARD. Non-EGU emissions within Texas will be developed using data from the TCEQ's STARS database, the 2006 TexAQS II hourly special inventory, the TLL special inventory, and from CCEDS if feasible.

The point source emissions from each of the different inventories will be compiled into a consistent AFS file format readable by EPS3. A separate AFS file is typically compiled for each distinct inventory source. For example, one AFS file may include only records compiled from the ARD, while another AFS file may include only records compiled the TLL special inventory. Prior to EPS3 processing, the emissions in the compiled AFS files are checked against the emissions from the original inventory to ensure that no emissions have been added (e.g., double counted) or lost (e.g., not read). For example, the top 100 NO_X- and VOC-emitting points from the TCEQ's STARS database are compared to the top 100 NO_X- and VOC-emitting points in the compiled AFS file. In addition, since an AFS record contains a point source's stack parameters, they can be checked to ensure that they are reasonable. If any stack parameters are determined to be either erroneous or unreasonable, default stack parameters common for the particular source type can be used. Since AFS records include both the county and geographical coordinates where a stack is located, they can be checked to ensure that the geographical coordinates are located within the county. If a stack's geographical coordinates are located outside of the county, they can be changed to the coordinates for either the center of the facility encompassing the stack or the center of the county in the rare event the facility's location is indeterminate.

The point source emissions are processed sequentially through EPS3 with the following modules:

- PREPNT as the entry module for point source AFS files;
- TMPRL as the module for adjusting emissions for different day types and allocating daily emission totals by hour;
- SPCEMS as the speciation module to allocate VOC emissions into Carbon Bond Mechanism, Version 6 (CB6) groups;
- GRDEM as the module for spatial allocation and hourly summing of low-level emissions by grid cell for CAMx input;
- PIGEMS as the module for tracking elevated point sources with large plumes to specific geographic coordinates for CAMx input; and
- MRGUAM as the module to combine various CAMx ready input files.

The PREPNT module outputs two emission files, one for low level point sources and another for elevated point sources. Point sources with stack parameters characterized by high temperatures and/or high exit velocities typically possess enough plume rise that the emissions will be elevated. The two point source emission files are processed independently through the remaining EPS3 modules, except that the low level point source files are not processed with the PIGEMS module, which allows CAMx to separately model plumes from the larger emitting elevated point sources. The final MRGUAM module is used to combine all of the low-level point source files into one CAMx ready input file, and then used again to combine all the elevated point source files into a separate CAMx ready file.

EPS3 reports QA/QC message and error files for each module processed. Since the message files report the input and output for each EPS3 module, emissions can be tracked from the module being processed back to the output from the previous module. Emissions can be tracked all the way back to the AFS files, and, if needed, to the original inventory. Once the CAMx-ready low-level and elevated files are generated, tile plots and time series of the emissions are made to check for reasonableness. Desirable features of the point source emissions include emissions spatially allocated according to their geographic coordinates, a diurnal profile for elevated point sources peaking in mid-afternoon when electrical power generation is highest, and a diurnal profile for low-level point sources that is fairly constant throughout the day.

2.1.2 On-Road Mobile Emissions

On-road mobile source emissions will be developed combining the emission factors from EPA's Motor Vehicle Emission Simulator (MOVES) model with estimated VMT and speeds for various roadway types. However, the spatial and temporal resolution of the VMT and speed estimates will contain less resolution at increasing distance from the nonattainment area of interest. For areas beyond Texas in the 12 km and 36 km domains, the TCEQ will use EPA's MOVES model in default mode to estimate on-road emissions for each non-Texas U.S. county. For all Texas counties, the MOVES model will be run to generate specific emission rates, which will be combined with local vehicle activity and population data. Texas Department of Transportation (TxDOT) traffic data collected under the national Highway Performance Monitoring System (HPMS) program will be used to estimate VMT and speed at a county-wide spatial resolution and an hourly temporal resolution for the four day types of Monday through Thursday average weekday, Friday, Saturday and Sunday. Link-based TDM output from local areas such as North Central Texas Council of Governments will be developed for the nonattainment area of interest. The TDM output includes VMT and speed parameters estimated spatially by roadway link. Using the ATR data available from TxDOT, the TDM output will be adjusted to create an hourly temporal resolution for each day type.

The Texas link-based on-road emissions for metropolitan areas are developed by hour and day type, and will be processed in this order:

- LBASE as the entry module that spatially allocates emissions on links to grid cells;
- SPCEMS as the speciation module to allocate VOC emissions into CB6 groups;
- GRDEM as the module to sum hourly emissions by grid cell for CAMx input; and
- MRGUAM as the module to combine various CAMx ready input files.

The Texas non-link-on-road emissions for remaining counties are developed by hour and day type, and will be processed in this order:

- PREAM as the entry module to only read in specified counties for further processing;
- SPCEMS as the speciation module to allocate VOC emissions into CB6 groups;
- GRDEM as the module for spatial allocation and hourly summing of emissions by grid cell for CAMx input; and
- MRGUAM as the module to combine various CAMx ready input files.

The non-Texas on-road emissions will be processed in a similar way, but need a temporal allocation step since the EPS3 inputs are only available as summer weekday emission totals:

- PREAM as the entry module to only read in specified counties for further processing;
- TMPRL as the module for adjusting emissions to different day types and allocating daily emission totals by hour;
- SPCEMS as the speciation module to allocate VOC emissions into CB6 groups;
- GRDEM as the module for spatial allocation and hourly summing of emissions by grid cell for CAMx input; and
- MRGUAM as the module to combine various CAMx ready input files.

The non-link on-road mobile source emissions will be compiled into the Area and Mobile Source (AMS) record format for input to the EPS3 PREAM module. Link-based on-road mobile source emissions will be compiled into a separate format specifically for the EPS3 LBASE module. Prior to EPS3 processing, the PREAM and LBASE input files are checked against the emission totals from the original inventories to ensure that no emissions have been added (e.g., double counted) or lost (e.g., not read).

In the event that specific control strategies need to be modeled for future case scenarios, the CNTLEM module is used to apply specific adjustment factors that vary by county, source classification code, and pollutant. CNTLEM must be run as a mid-sequence module meaning after either the PREAM or LBASE entry module, but before the final GRDEM step. For the on-road mobile source emission in Texas, summary files are available that have emissions totals for all counties and pollutants. To ensure that no emissions are lost in the EPS3 processing steps, the emissions totals for each pollutant in the message files of LBASE, PREAM, SPCEMS, and GRDEM will be compared to the totals in the Texas Transportation Institute summary files. Once the CAMx model-ready files are generated, tile plots and time series of the emissions will be made to check for reasonableness. Desirable features of the on-road mobile plots include dense allocation of emissions along major roadways, along with differences in emissions totals and diurnal profiles for the various day types.

2.1.3 Non-Road and Off-Road Source Emissions

Non-road and off-road mobile source emissions will be developed using data from a number of inventories. For the states beyond Texas in the 12 km and 36 km domains, the TCEQ will use the EPA's National Mobile Inventory Model to estimate non-road emissions for each non-Texas county. Off-road source emissions outside of Texas will be based on the latest available version of the NEI from the EPA, which could be some combination of the 2008 NEI and/or 2011 NEI. The former will be more suitable for the 2006 base case, while the latter will be more suitable for the 2018 future case. Readily available backcasting or forecasting factors such as EGAS growth adjustments will be applied to these inventories to create more suitable 2006 and/or 2018 scenarios. When such factors are not available, the inventories will be used as received from the EPA. Shipping emissions in the Gulf of Mexico, Atlantic Ocean, and Pacific Ocean will be developed using data from a recent EPA funded study (EPA, 2007). Estimation of non-road emissions for all 254 counties within the state will be done with the TexN model for both the 2006 base case and the 2018 future case. Estimates of off-road source categories within Texas will rely on the TexAER database that is regularly populated with the results of various studies for aircraft and locomotives. When available, growth factors will be used to project these estimates, such as developing 2018 future case emission estimates for a specific county/source combination from a recent 2011 study.

Similar to how the non-link on-road mobile sources are prepared for input to the EPS3 PREAM module, the non-road and off-road inventories will be compiled into an appropriate AMS format. The raw data sources for these non-road and off-road emission estimates are typically available as either annual or summer weekday totals. For the former case, daily AMS file inputs are prepared by dividing the annual totals by an appropriate figure (e.g., 365 when totals do not vary by day type, 250 for Monday through Friday working days, etc.). Prior to EPS3 processing, these AMS file totals are checked against the emissions from the original inventories to ensure that no emissions have been added (e.g., double counted) or lost (e.g., not read).

These non-road and off-road emissions are usually processed in a manner similar to how the non-Texas on-road emissions are processed where a temporal step is added to adjust for other day types and allocate emissions by hour:

- PREAM as the entry module to only read in specified counties for further processing;
- TMPRL as the module for adjusting emissions for different day types and allocating daily emission totals by hour;
- SPCEMS as the speciation module to allocate VOC emissions into CB6 groups;
- GRDEM as the module for spatial allocation and hourly summing of emissions by grid cell for CAMx input; and
- MRGUAM as the module to combine various CAMx ready input files.

The CNTLEM module will be used "mid-stream" to apply adjustments by county, source classification code, and pollutant for modeling specific control strategies. The non-road and off-road CAMx ready files are typically prepared for weekday and weekend day types. When specific factors are available, distinction is made for Saturday versus Sunday day types, Monday through

Thursday versus Friday day types, etc. To ensure that no emissions are lost in the EPS3 processing steps, the emissions totals for each pollutant in the message files of PREAM, TMPRL, SPCEMS, and GRDEM will be compared to the totals from the upstream TexN, TexAER, and/or NEI data sets. Once the CAMx model ready files are generated, tile plots and time series of the emissions will be made to check for reasonableness. Desirable features of the non-road and off-road plots include appropriate allocation according to the surrogate used (e.g., recreational boating on lakes), and appropriate differences by weekday and weekend day types (e.g., more recreational boating on weekends).

2.1.4 Area Source Emissions

Area source emissions development and processing is quite similar to the approach described above for the off-road sources. For the states beyond Texas in the 12 km and 36 km domains, the TCEQ will use the latest available version of the NEI from the EPA, which could be some combination of the 2008 NEI and/or 2011 NEI. The former will be more suitable for the 2006 base case, while the latter will be more suitable for the 2018 future case. Readily available backcasting or forecasting factors such as EGAS growth adjustments will be applied to these inventories to create more suitable 2006 and/or 2018 scenarios. When such factors are not available, the inventories will be used as received from EPA. For the portion of the Gulf of Mexico within the modeling domains, the TCEQ will use the non-point emissions from the 2005 GWEI. Estimation of area source emissions within Texas will rely on the TexAER database that is regularly populated with the results of various studies. When available, growth factors will be used to project these estimates, such as developing 2018 future case emission estimates for a specific county/source combination from a recent 2011 study.

Similar to how the non-road, off-road, and non-link on-road emissions are prepared for input to the EPS3 PREAM module, the area source inventories will be compiled into an appropriate AMS format. The raw data sources for these are source emission estimates are typically available as either annual or summer weekday totals. For the former case, daily AMS file inputs are prepared by dividing the annual totals by an appropriate figure (e.g., 365 when totals do not vary by day type, 250 for Monday through Friday working days, etc.). Prior to EPS3 processing, these AMS file totals are checked against the emissions from the original inventories to ensure that no emissions have been added (e.g., double counted) or lost (e.g., not read).

Similar to how the non-road, off-road, and non-Texas on-road emissions are processed with EPS3, the area source emissions receive a temporal step to adjust for other day types and allocate emissions by hour:

- PREAM as the entry module to only read in specified counties for further processing;
- TMPRL as the module for adjusting emissions for different day types and allocating daily emission totals by hour;
- SPCEMS as the speciation module to allocate VOC emissions into CB6 groups;
- GRDEM as the module for spatial allocation and hourly summing of emissions by grid cell for CAMx input; and
- MRGUAM as the module to combine various CAMx ready input files.

The CNTLEM module will be used "mid-stream" to apply adjustments by county, source classification code, and pollutant for modeling specific control strategies. The area source CAMx ready files are typically prepared for weekday and weekend day types. When specific factors are available, distinction is made for Saturday versus Sunday day types, Monday through Thursday versus Friday day types, etc. To ensure that no emissions are lost in the EPS3 processing steps, the emissions totals for each pollutant in the message files of PREAM, TMPRL, SPCEMS, and GRDEM will be compared to the totals from the upstream TexAER, and/or NEI data sets. Once the CAMx model-ready files are generated, tile plots and time series of the emissions will be made to check for reasonableness. Desirable features of the area source plots include appropriate allocation according to the surrogate used (e.g., higher density populations in urban versus rural areas), and appropriate differences by weekday and weekend day types (e.g., certain industries such as printing that operate less on weekends).

2.1.5 Biogenic Emissions

Biogenic emissions estimates are produced using MEGAN, which requires PFT data, emission factors, LAI inputs, photosynthetically active solar radiation (PAR) data, and hourly temperatures. The TCEQ selected the MEGAN model because it is actively used and updated by a broad community, runs on Linux, and produces emissions similar to the GLOBEIS model and monitored isoprene concentrations.

The default PFT and emission factor data will be used. LAI estimates will be obtained from the Moderate Resolution Imaging Spectroradiometer (MODIS) satellite data product MOD15A2 (NASA, 2013). Urban-defined grid cells by MODIS will be filled with the default LAI value from GLOBEIS (TCEQ, 2010d), otherwise biogenic isoprene emissions wouldn't be calculated in cities.

PAR data are derived from hourly GOES satellite imagery of cloud cover, which have been processed with a solar irradiation model (Pinker and Laszlo, 1992). The data will be downloaded at half-degree resolution, and will be reprocessed to match the TCEQ modeling grids. After processing the PAR data used by MEGAN, tile plots and time series of the PAR data will be made to check for reasonableness. Desirable features of the PAR data include:

- comparison with total solar radiation measurements at ground-based monitors, showing the relationship between PAR and total solar radiation to be linear with slope of 0.5 and a high correlation coefficient;
- evaluation of the time variation of the PAR data compared to the total solar radiation measured data shows the two time variations exhibit the same pattern; and
- evaluation of the effect of clouds on the PAR data, with clouds decreasing overall PAR.

Hourly temperature data will be obtained from the WRF meteorological model. The WRF temperature predictions will be compared to continuous air monitoring station (CAMS) observations using time series and scatter plots to check for reasonableness. Desirable features of the temperature fields include:

- small diurnal temperature variations over the Gulf of Mexico;
- larger diurnal temperature variations over land;
- differences between temperatures in rural and urban areas (e.g., urban areas should have higher overall temperatures; and
- the effect of rain on the temperature (e.g., any rain storms should decrease overall temperatures).

The output emissions from MEGAN are checked by creating tile plots and time series. Desirable features include:

- the timing of isoprene emissions (e.g., isoprene emissions should begin at sunrise and end at sunset); and
- differences between emissions over large water bodies, in urban areas, and in riparian areas (e.g., riparian areas should have higher overall emissions).

To document quality assurance activities, a log file will be created for each MEGAN run. This log file will contain the name and location of the input and output files, the date of the modeling run, and a brief description of the run. Further file traceability will be provided by the tile plots, which are stamped with the name and date of the original file. This provides the opportunity to trace file names from the tile plot back through the log file to the original input files. Quantitative comparisons of the CAMx-modeled versus measured isoprene concentrations will be documented by producing time series and scatter plots with regression statistics. All graphs will be stamped with the file name, date, location, and the date the plot was made.

2.2 METEOROLOGICAL MODELING QA/QC

The TCEQ plans to use the latest version of WRF (version 3.2 or newer). The WRF modeling system is composed of several modules, including the WRF Preprocessing System (WPS), Real (vertical balancing of variables from pressure to sigma levels), ndown (nestdown), and various other modules that create inputs for the WRF model. WRF will be executed in a two-way nested configuration commensurate with the WRF modeling domains.

Application of the WRF modeling system for a given episode requires the specification of initial and boundary conditions, as well as specifying model parameterizations as inputs to the various modules. Some of the inputs to the modules require pre-processing of raw meteorologically related data. The initialization and boundary conditions are derived from global scale modeling performed by the National Centers for Environmental Prediction (NCEP). The NCEP modeling staff conducts rigorous QA/QC of the global analysis fields before they are publicly released. The specifications for WRF include the surface parameters such as soil moisture, a planetary boundary layer (PBL) scheme, and cumulus parameterizations. Updates of and quality assurance of new LULC data and vegetative parameters have been incorporated with the assistance of National Oceanic and Atmospheric Administration IDL (interactive data language) scripting.

In addition, the TCEQ will be using the four dimensional data assimilation capabilities of the WRF modeling system to conduct both analysis and observational nudging. The analysis data are also derived from pre-processing routines. The analysis nudging uses the NCEP Eta Data Assimilation System (EDAS) reanalysis wind fields on the 108, 36 and 12 km domains. The NCEP modeling staff also conducts rigorous QA/QC on the EDAS reanalysis wind fields prior to public release. The TCEQ has built the observational nudging files from radar profiler wind data on the 4 km grid using a combination of SAS programs and Perl scripts. The output from the radar profiler pre-processing routine is graphically inspected to ensure the wind data are reasonable. Desirable features include:

- realistic vertical profiles of wind speed and wind direction; and
- realistic diurnal pattern in the change of wind speed and wind direction.

Running the WRF modeling system requires verification through the namelist.input file that switches and ensures options have been correctly selected. In addition, the surface characteristic parameters (e.g., soil moisture) are graphically inspected after running WPS, Real, and ndown to ensure they continue to be reasonable. To document quality assurance activities, a log file will be created for the processing sequence of each of the pre-processors and WRF modeling system modules. This log file will contain the name and location of the input and output files, the date the files were processed, and a brief description of the processing results.